This is a PDF of the Word file described below - Future Developments in the Music Market from April 1995.

The original Word 2.0 file is hard to read on modern (later than 2003?) versions of Word. For this PDF version, I have used the correct illustration for Fig 17.6. The Word file and a number of other items, such as a May 1996 update are in a file FDMM.ZIP which you can find at:

http://www.firstpr.com.au/musicmar/mmed.html#fdmm

If you are really interested in this field, please take a look at the zip file. Please also see:

http://www.firstpr.com.au/musicmar/

for a later, shorter, paper *Music Marketing in the Age of Electronic Delivery*. This includes discussions of the limitations of the 1995 draft, such as:

1 - Not anticipating decent quality music could be achieved with such high rates of compression as 10:1, as is done with MP3.

2 - Thinking that ADSL deployment and global high speed data connections would be done primarily for Video On Demand, with Internet access being a secondary function. (Funny now that Internet access is now ubiquitous in the developed world, and that a lot of the bandwidth is spent on YouTube videos and now, ca. 2011 with actual Video on Demand services finally emerging!)

I have Corel Draw and .eps versions of these diagrams, if anyone is interested.

In 2011, I am not actively involved in this field, but have been talking with Liz Guiffre of Macquarie University, who is working on a PhD concerning, amongst other things, the challenges posed to the music industry by Internet communications etc. Her forthcoming thesis concerns broader patterns of challenges to existing methods of communication and how the various industries adapt.

Denizens of later days - if you can’t find her work, please email me at rw@firstpr.com.au and I will forward your message to her.

FUTURE DEVELOPMENTS IN THE MUSIC MARKET

Discussing the Australian Music Industry 1995 to 2010
Draft for the Contemporary Music Summit in Canberra 27 April 1995

Robin Whittle 11 April 1995
Revised copyright notice 4 May 1995

This file is in the Microsoft Word for Windows 2.0 format. This means you should be able to import it into later Word versions for Mac and Windows. Let me know if you have any trouble.

Virtually all the text is meant to be in the TrueType style "Arial". This is the BTCE standard. I am not sure what the best equivalent in the Mac, PostScript world is - any different font may slightly change the formatting and pagination of the document. This document is intended to be printed on A4 paper.

This is fdmm.doc - the full final file including .eps , with the formatting set to ragged right - which I prefer. (The printed version is justified right.) If for some reason you reformat this for different sized paper and want to generate a new table of contents, turn on View Annotations and look at the annotations at the three TOCs. To print on US letter paper, it would probably be easier to change the scaling of your printer driver.

Other versions may be:

fdmm_ng.doc	As above but without the .eps graphics pictures.
fdmm.zip fdmm_ng.zip	Compressed versions of the above. Use PKUNZIP on an IBM PC to de-compress them. (Or stuffit on the Mac).
fdmm_eps.zip	Compressed graphics files in .eps format - import them into various programs and print them on PostScript, and perhaps other, printers.
fdmm_gif.zip	Compressed graphics files in .gif format - import them into various programs and print them on virtually any kind of printer.

The printed version contains a few pasted in diagrams, which I do not have electronic versions of. They are not crucial.

Robin Whittle 4 May 1995

100 copies of this paper were printed by the Bureau of Transport and Communication Economics for the Contemporary Music Summit, as a step towards producing a final BTCE Occasional Paper. 30 copies were printed subsequently for other interested people.

This is an author's draft, _not_ a BTCE document. The BTCE's project officer for *Future Developments in the Music Market* is Jen St Clair - ph -- ---- ----.

First Principles   *Research and Expression*

Robin Whittle (old address) Australia
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WWW   http://www.ozemail.com.au/~firstpr

Note 2011: My website is http://www.firstpr.com.au and email address is rw@firstpr.com.au. The BTCE no longer exists and they never actually published this work, apart from the 100 copies of this draft, as mentioned above. Theoretically it is still copyright by the Commonwealth, but I doubt anyone cares. I have made it available at my site since 1999 or so.

FOREWORD (Revised 4 May 1995)

This paper examines the impact of technological change on different aspects of the music industry, primarily musical production, distribution and marketing. It is an author's draft which explains technology and speculates on future scenarios.

This paper is the result of research which was initially intended to be part of the Communications Futures Project - a major research project by the Bureau of Transport and Communication Economics (BTCE).

The first aim of printing and circulating this draft is to stimulate discussion, especially for the Contemporary Music Industry Summit in Canberra on 27 April. The second aim is to gain feedback from industry to contribute to a final version which the BTCE plans to publish as an Occasional Paper. BTCE Occasional Papers are widely available through the Australian Government Publishing Service. Please contact me with your feedback at the address shown on the previous page before the end of May.

I would like to thank Chris Cheah and Jen St Clair, who initiated and supported this project at the BTCE, and the people who have given me information, critical feedback and support. While the economic importance of the Australian music industry is undoubted, and the technical and social aspects of the communications revolution are fascinating and momentous, it is the music which most motivates me to explore the prospects for this industry. While it is described in this paper as a product, music is really a gift - and I cannot express in writing how wonderful and diverse my music listening (and occasional music making) experiences have been.

I am optimistic for the prospects of the Australian music industry and I hope this paper contributes to its vibrancy.

Robin Whittle 11 April 1995

CONTENTS

Comment [RW1]: Page: 4
Tricks for the TOC dept. To update each of the three TOCs - contents, tables and figures - select View Field Codes, highlight the field code and press F9. When View Field Codes is turned off, the TOC will appear. However :

1 - There is some kind of glitch in the Toc 7 and Toc 8 styles. The styles seem to be OK, but when the TOCs for tables and figures are created, an extra tab stop is inserted just past 2". This upsets the position of the page number on lines which are longer than one line. The solution is to get rid of this tab stop either manually for all the lines, or by reseting the offending lines to their style.

2 - For readability, I want to put page breaks in the contents TOC. This makes it longer, placing the tables and figures TOCs at a higher page number than they were when the contents TOC is generated. This could be fixed by fixing the page number for the tables TOC, but for now I will just edit the page numbers in the contents TOC for these two TOCs.

TABLE OF TABLES

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CHAPTER 1 INTRODUCTION

This paper provides a survey of the foreseeable technical and marketing developments in the recorded music industry over the period 1995 to 2005-2010. It is directed primarily at music industry participants and also to policy makers and academics.

The purpose of this paper is to inform and stimulate discussion about the future of the industry and in particular about how the Australian music industry can make the most of the opportunities and challenges which lie ahead. The focus is on distribution technologies and the changed marketing arrangements which may result from these developments. These changes will affect the subtle and subjective experiences which drive the demand for music - so consideration is also given to the changes in the listener's total experience of music.

The issues discussed here centre on recorded music but are relevant to the entire industry, including live performance. The changes foreseen in recorded music have implications for related industries, including CD-ROM and network based multimedia, radio and TV. Many of these technical and marketing developments will have counterparts in other content industries - including newspaper and magazine publishing, video, advertising and computer software.

THE BTCE COMMUNICATIONS FUTURES PROJECT

The Bureau of Transport and Communication Economics (BTCE) is a Federal Government economic analysis unit attached to the Department of Communication and the Arts and to the Department of Transport. During 1994, the BTCE's Communications Futures Project (CFP) was a major study of how the Communications Revolution will affect existing industries and create new ones. The CFP papers and final report are listed in the bibliography.

The Communications Futures Project does not make policy recommendations. Its role is to provide technical and economic support for planning and policy development processes in government and in industry. The Communications Futures Project has worked closely with the Federal Government's Broadband Services Expert Group - which is directly concerned with policy development.

This paper grew from the Communications Futures Project and has the same aims - except that the focus is on the music industry in particular.

ASSUMED KNOWLEDGE

Limited familiarity with the music industry, sound recording and marketing is assumed. Many existing and new communication and computing concepts will be introduced to enable interested readers without a technical background to think creatively about how they may be utilised.

1994 will be remembered as the year that the Communications Revolution first received a high public profile. A great deal has been written about the prospects for the future and there is controversy over the expected demand for and costs of the communications services which may be introduced in the next ten years. This paper describes the projected technologies and tries to give realistic estimates of introduction dates and costs. However it does not attempt a full discussion of the divergent views on the pace and shape of the Communications Revolution.

Background information can be found in the Australian magazines "Australian Communications" (telecommunications technology and policy) and "Media Information Australia" (cultural issues). An essential reference for the Australian music industry is the *Australian Music Industry Directory* published twice yearly by IMMEDIA. Internationally, "Wired" magazine is the most prominent printed journal of the Internet and global network developments.

The CFP papers provide important background information to this paper - particularly Paper 3 - "New Forms and Media: Commercial and Cultural Policy Implications".

The most important reference points for a discussion of policy for the electronic creative industries are interim and final reports of the Broadband Services Expert Group, both entitled "Networking Australia's Future". The Copyright Convergence Committee's report "Highways to Change" deals specifically with extensions to copyright law in the new communications environment.

APPROACH AND STRUCTURE OF THE PAPER

Chapters 2 to 14 explores the technical fundamentals and musical applications of foreseeable technological developments. This includes data storage, computing, and communication techniques, and specific applications of these for the music business. Chapter 8 discusses how the new forms of media affect the media's content and how consumers use it.

Chapter 13 gives an overview of technical trends - in particular the shift from pre-pressed discs for music distribution, to networked communications and storage on writable optical discs in the home.

Chapter 15 delves into the mind of the listener and examines the factors which affect to the total listening experience - the subjective pleasures which drive the demand for music of all kinds. By starting with the factors at work in today's listening experiences, it is hoped that the effects of new distribution and marketing techniques can best be anticipated - especially the potential for stylistic evolution in the new marketing and listening environments.

Chapter 16 examines recent trends and likely developments in music production techniques - instruments, compositional tools and recording techniques. The diminishing production costs for certain styles of music - and the possibility of producing new styles - are driving forces in musical innovation and the evolution of popular fashion. Musical instruments, production techniques and musical styles are a fascinating subject, but this paper will not be able to cover this field exhaustively because the focus is on distribution technology and new marketing arrangements.

Chapter 17 explores how new and existing technologies can be combined for distribution and marketing. The previous chapters described musical applications in relative isolation. In this chapter the projected future scenarios are envisaged and the use of old and new technologies are considered in their most promising combinations. The most dramatic prospect for the music industry is the prospect of musicians, or "record" companies, selling music directly over the Ubiquitous Broadband Network (also known as the "Information Superhighway") to listeners in their homes - without the need for physical products such as CDs or traditional retailing arrangements. However much of this chapter concentrates on discovery processes for music and musical context - the essential preconditions for selling music by any means.

Chapter 18 leads from the exploration of appropriate marketing techniques into the thorny question of how the structure of the music industry may change. The question of structure is first considered by asking how it would evolve purely for electronic delivery - if there never had been records or CDs. This is a provocative approach to stimulate discussion and to highlight the characteristics of the status quo. However, industry structure will evolve from today's structure, and physical products are unlikely to be displaced substantially by electronic delivery for some time.

Chapter 19 looks at user copying, and commercial piracy of music, as well as the opportunities for reducing copying which is contrary to the interests of the musicians and composers. Chapter 10 shows that copying will be extremely easy in the future and that there are no technical means of controlling it. So the focus is on legal sanctions and community standards as a means of minimising the misuse of intellectual property. There is a detailed discussion of commercial piracy in the networked environment leading to the tentative conclusion that it will be virtually impossible for them to avoid detection and that they would only be able to continue operation in countries with poor legal systems.

Chapter 20 sums up the major challenges and opportunities for the industry. It also discusses common themes - high-level patterns which can be seen from the foreseeable changes to the music industry. These will hopefully be valuable for getting the feel for the future of other content industries and for the future of society.

This paper discusses many technologies, and readers may at first want to skim over some technical sections and return to them when their importance to the reader's musical plans is more clear. For this reason, introductory paragraphs in italics are placed at the start of the technical sections.

Issues which are not addressed in this paper

The music industry is very complex, and this paper does not attempt to describe it fully. In particular, existing types of copyright, and paths of payment for the use of copyright material are not discussed.

There are many legal, practical and business questions regarding copyright in the future environment of extreme information fluidity. Some of these questions are tackled in Chapter 19 on control schemes to reduce copying. However the issues are complex and are best discussed by industry participants themselves. The purpose of this paper is to provide a sound technical basis for that discussion.

This paper does not ask specific questions about industry participants such as "How can musicians be assured of a viable career?" or "How can record companies adapt to electronic delivery?" The paper assumes that there will always be an audience with a strong demand for music, and that musicians and/or the audience will be producing an ever changing variety of music. The focus is on the technical and economic links between the source of the music and those who purchase it.

Although this paper is concerned with the Australian music industry, the issue of Australian content on radio and TV is not given prominence. This is not to say that the question is unimportant. Many of the new developments discussed are networked based - there is no "broadcaster" and sometimes little distinction between content providers and users. The Internet is inherently international and even if the question of its content was applicable, it would be impossible to monitor or control it.

Music broadcasting has been geographically constrained within Australia, because broadcasts from other countries cannot be received here by consumers. So local content requirements could be enforced. Some forms of broadcasting are becoming international - satellite transmissions and "subscription radio" - 30 or more channels of music delivered to the home by cable, satellite or perhaps Digital Audio Broadcasting (DAB).

For instance the DMX 30 channel music service (described in chapter 5) is being delivered to homes in the UK seems to be the US DMX service. It may not be cost effective to produce all channels of such services here, and if they were imported, it would be difficult or impossible to insist on an Australian content level. As music diffusion systems such the Internet and broadcasting become increasingly internationalised, the question of local content for Australian broadcasts may be less important than the question of how we get Australian music on international broadcasts and make it available on the Internet.

Although computer games and interactive applications are growth industries relating to music and popular culture, this paper does not address their future. Currently based on CD-ROMs, in the future they will often be based on network transactions with a central server - for global interactivity, changing content and to avoid the storage restrictions of discs. They may divert some consumer expenditure of time and money from the music market, and they will no-doubt evolve into highly sophisticated activities, but neither games nor interactive audio visual activities can substitute for music - which can be enjoyed whilst doing other things, and is suggestive rather than commanding all the senses.

Economic size and structure of the industry - the MIAC report

The music industry is structurally complex - even when stylistic factors and links to other industries are ignored. It involves several kinds of intellectual property and a multitude of paths by which money flows from consumers to the originators, managers, distributors and retailers of the final product.

The most detailed economic study of the Australian music industry to date is that commissioned by the Music Industry Advisory Council (MIAC) and prepared by Price Waterhouse (MIAC Price Waterhouse 93 & 94). Most of the 96 pages of the original report in 1993 are devoted to describing the industry's structure and economic parameters. A description of the industry in this level of detail is beyond the scope of this paper, but some of the most important points raised in MIAC Price Waterhouse 93 & 94 are presented below. Comments on the MIAC material appear in square brackets [ ].

- The music industry does not fit neatly into a standard industry definition or classification. It is intertwined with the media, entertainment, leisure, electronics information technology and communications industries.

- The demand for contemporary or popular music is highly responsive to shifts in tastes and fashions and to promotion. The market for individual titles is highly unpredictable. Sales may peak within weeks or months and decline to negligible levels after a year. However back catalogue songs of successful artists may be revived at a later date. [However, when music sells steadily for years or decades, this back catalogue is *the* copyright asset base for some record companies.]

- It is commonly thought of in terms of:

Physical product - printed music & sound recordings.	In fact it is largely composed of intangible products based on artistic creative endeavour - intellectual property.
International publishing and sound recording companies.	However much of the value arises from the many creative originators and performers whose talents and services are sought and funded by a diverse mixture of competing local and international companies.
An industry composed of "mega star" originators/performers.	In fact there are a multitude of composers, musicians, producers, managers and support people with full time or part time careers in, or dependent upon, the music industry.

- It is not readily compartmentalised whether it be for economic, cultural or any other form of analysis.

- The flow of product from musicians to listeners can be described in terms of four groups of industry players - Originators, Primary Investors, Secondary Investors and facilitators and Consumers:

Originators	Composers/songwriters Performing artists - musicians	
Primary Investors	Publishers Record companies Promoters	
Secondary Investors and Facilitators	Studios Distributors Venue operators	CD/tape manufacturers Retailers Broadcasters
Consumers - the audience	• Purchasers of sound recordings, videos and printed music. • Audience at performances, discos, movies, karaoke and for background music in shops, restaurants and offices. • Listeners to broadcasts - radio and TV. • Renters of CDs and music videos.	

FIGURE 1.1 SIMPLIFIED FLOW DIAGRAM OF THE AUSTRALIAN MUSIC INDUSTRY

Source MIAC Price Waterhouse 1993

Diagram is pasted in here!

Right of diagram faces upwards - it takes up the whole page.

At this point in the Work in Progress paper, I insert a photocopy of the big diagram from the Price Waterhouse report. There are a number of problems however :

1 - Content - the diagram could be made somewhat clearer

2 - Layout - we want a vertical layout, preferably our own Corel Draw version which is easier to read - rather than a scan, or reduction of the PW diagram.

3 - There is probably a day's work in doing a better Corel Draw version of this and I think that it would be worth doing. Time is precious now, so I will put it on the back-burner and perhaps do for the Occasional Paper.

- Six major record companies dominate the music industry internationally:

TABLE 1.1 OWNERSHIP OF SIX MAJOR INTERNATIONAL RECORD COMPANIES

Company	*Ownership*
BMG - based in New York since its acquisition of RCA.	Bertelsmann publishing and media group in Germany.
EMI - includes Virgin Records.	UK based electronics and defence conglomerate - Thorn EMI.
MCA - based in the USA.	Acquired by Matsushita.
Polygram	80% owned by Dutch electronics giant, Philips.
Sony - previously CBS music, film and video.	Sony - Japan.
Warner Music and Warner-Chappell	Time/Warner entertainment and media conglomerate.

Source MIAC Price Waterhouse 1993

Four of these - EMI, Polygram, Sony and Warner - together have nearly 70% of the world market. These companies, with BMG and Australian independent companies Festival and Mushroom, dominate the Australian recorded music industry.

A notable feature of the major international record companies is that music is not the primary business of the companies which own them - four are owned by electronic hardware manufacturers.

- There are a large number of musical styles and it is difficult to categorise music in a way which enables firm market share figures to be determined. One simple distinction is between "classical" and all styles of music which are not "classical" and so are called "contemporary/popular". By this criteria, approximately 7% of the world music for sound recordings (5% in Australia) is for classical music - but this proportion is growing.

- The value of world retail sales of sound recordings in 1992 was estimated by the International Federation of the Phonograph Industry as US$28.7 billion (A$40 billion). The top five countries accounted for 70% of world sales and Australia was ranked tenth, with 1.7% of world sales - A$694 million.

- Despite the relatively small size of the Australian market, several factors contributed to Australia's position as the third largest supplier of new English repertoire in the international market. These are: a strong live performance scene; investment by publishers and record companies in local repertoire during the 1970s and 1980s; vibrant independent publishing and sound recording companies which challenge the overseas owned majors; and a balanced and internationally respected regime for the protection of intellectual property.

- In one analysis of the 1992/93 industry output at consumer prices, the total value was $1591 million. This is composed of:

Live performances	$627m
Export of goods and services	$206m
Ex-factory value of recordings & printed music	$493m
Sales tax	$96m
Retail/distribution costs	$166m
Other	$3m

Source MIAC Price Waterhouse 1994 page 12

- The first three of these components generated revenues which can be broken down as follows.

Direct imports	$342m
Record companies	$681m
Artists	$430m
Publishers	$100m
Songwriters	$89m
Managers	$25m

Note that these figures involve double counting.

Source MIAC Price Waterhouse 1993 page 13

- The net balance of trade is a deficit of $136m, largely due to imported physical product from the USA, Germany and the UK and similar imbalances in royalty payments and live performance fees to overseas artists. [One music industry manager has pointed out that some of this trade deficit could be attributed to the profit remittance arrangements within international record companies, implying that a significant proportion of overseas record and publishing revenues for Australian artists are re-directed to company profits. This is not to imply that this is illegitimate, but that the earning capacity of Australian artists is higher than the figure of $129.9M quoted in table 1.4.]

TABLE 1.2 IMPORTS AND EXPORTS

1992/93 value in $A million	*Imports*	*Exports*
Trade in physical product	88.2	15.8
Royalties and other services	181.6	166.4
Live performance inc. merchandising	72.4	24.0
Total	342.2	206.2

Source MIAC Price Waterhouse 1994

- Attendance and turnover at public performances is estimated as follows:

TABLE 1.3 ATTENDANCE AND TURNOVER AT PUBLIC PERFORMANCES

1992/93	*Attendance (thousands)*	*Average seat price ($)*	*Estimated turnover ($ million)*
Popular - major venues	8,221	35	287.7
Popular - minor venues	7,200	5	36.0
Opera and music theatre	5,395	29	155.9
Symphony orchestra, chamber and choral	3,178	11.2	35.1
Dance	3,535	11.4	33.4
Total	27,529		548.1

Source MIAC Price Waterhouse 1994

- Perhaps the most complex of the revenue streams is that of publishing - the collection of royalties on behalf of the composer/songwriters. World publishing revenue in 1990/91 was reported as US$4.4 billion - A$6.4 billion. This came from four sources:

Public performance royalty. Primarily from broadcast and public playing of recordings, but also from live performances.	49.5%
Mechanical royalty from the sale of recordings.	34.5%
Printed music royalty.	9.0%
Film and video synchronisation rights, background music and home taping levies.	7.0%

Source MIAC Price Waterhouse 1994

- The industry's contribution to GDP (Australia's Gross Domestic Product) is calculated as $601.7 million - 0.15 percent of GDP. The value added figures for various sectors of the domestic industry are as follows:

> **Comment [RW2]:** Page: 11
> This is based on a GDP figure I got from the ABS of $395,828,000,000, which does not seem quite right with the CIA Fact Book figure of US$339 billion. I would like to check this and compare it with GDP contributions for film, video production, TV, radio, magazines. newspapers. However, although the term GDP sounds impressive, what does it really mean when an industry's contribution to it is calculated?

TABLE 1.4 VALUE ADDED 1992/93

1992/93 A$ million	*Wages & salaries paid*	*Gross operating surplus*	*Value added*
Songwriters/composers		19.7	19.7
Artists		89.4	89.4
Managers	7.6	4.7	12.3
Publishers	8.1	6.2	14.3
Collection agencies	3.4	-0.8	2.6
Record companies	61.8	31.8	93.6
Distribution and retailing	88.5	9.0	97.5
Live performance/merchandising	104.0	55.4	159.4
Indirect taxes			61.2
Overseas royalty/licence fees received minus paid = 129.9 - 181.6			-51.7
Total contribution to GDP			601.7

- Estimates of employment in the industry are approximate at best. The following breakdown by profession gives numbers of people employed full time or part time as a full time equivalent.

TABLE 1.5 EMPLOYMENT 1992/93

Managers staff	310
Publishers staff	270
Collection agency staff	104
Record companies	1,970
Live performance/merchandising	5,055
Retail and distribution	4,350
Total full time equivalent	12,059

Source MIAC Price Waterhouse 1994

The ABS November 1993 estimate for people who identify themselves as "musicians, composers and related professions" is 7,600 people. However the criteria for inclusion in this estimate is that the person be employed in the week of the census and have a three to four year degree. The true number of musicians is clearly higher than this.

A 1991 estimate for full time equivalent employment for music theatre and opera, symphony, chamber, choral and dance in 1991 is 3,020 people.

A study in 1987 by HH Guldberg estimated that in 1984/85 there were 26,000 musicians in Australia - equivalent to 13,500 full time employees.

APRA records indicate there are approximately 13,300 songwriters in Australia - many of whom would also be performers.

- Approximately 0.5% of household weekly expenditure was spent on the music industry. The above employment estimates, which are likely to be conservative, indicate that the industry employs approximately 0.2% of the workforce.

INCOME FLOWS - COPYRIGHT AND LICENCES

Publishing revenues are collected by publishing companies, major, independent and small, as well as three copyright collection societies. Local originators receive income from these organisations for Australian use of their product, and from affiliates for use overseas. An explanation of this is beyond the scope of this paper. The following diagram from the Prices Surveillance Authority on the price of sound recordings (PSA 1990) depicts the flow of revenue within the industry and from the film and video industry.

FIGURE 1.2 COPYRIGHT AND INCOME FLOWS

Diagram is pasted in here!
From PSA Inquiry into sound recordings, page 23.

Source PSA Inquiry into the prices of sound recordings 1990

Figure 1.3 depicts the value of royalties flowing within the industry.

FIGURE 1.3 ROYALTY FLOWS 1992/93

Diagram is pasted in here!
From MIAC Price Waterhouse 1994 page 19.

Source MIAC Price Waterhouse 1994

BREAKDOWN OF REVENUE FROM A CD SALE

In 1990 the Prices Surveillance Authority conducted an inquiry into the price of sound recordings. A breakdown of the retail price of sound recordings was given in the inquiry's report. These figures offer at best a rough guide to how the retail cost of a CD is split in 1995.

The real figures would vary significantly between say a $10 budget classical CD and a $40 imported CD. The figures given for mechanical royalties (to the composer) and artist royalties (to the performer) total 20% of the cost - about $6 for a full price CD. However the composers and performers would receive a fraction of this due to management and licensing fees.

In one example of a track recorded in Australia - which reached number 3 in the UK dance charts - the royalty flows and divisions are complex. The local label A, invested in the recording and licensed the international rights to the track, another single and an album to a UK label B. B paid substantial advances for this - money which would not be repaid by A if the music failed to sell. This brought immediate cash-flow to label A, and was a strong indication of label B's faith in the music.

Label B paid between 13% and 15% of the royalties it received from its UK sales to label A, and 50% of royalties received from sub-licences it made to labels in other countries. In this case the track was included on a Japanese compilation which sold 250,000 copies.

Label A received 50% of the royalties from the Japanese sales plus 15% or less of royalties from UK pressings. Once the total royalties payable by B to A exceeded the advance paid, then B made further payments to A. Label A deducted its recording and promotional costs from the total payments received from B, and split the remainder 50-50 with the artist.

Table 1.6 lists the components of the retail price of sound recordings. 14.3% is the figure for artist's royalties, but only a fraction may go to the composers, performers and their management.

TABLE 1.6 COMPONENTS OF RETAIL PRICE 1989

Retail Margin	27.5%
Sales Tax	12.1%
Earnings before interest and tax	5.7%
Administration	5.7%
Distribution	2.1%
Selling	4.7%
Publicity, advertising and promotion	7.2%
Copyright/mechanical royalties	5.8%
Artist royalties including advances	14.3%
Origination and recording costs	2.5%
Physical product cost	12.6%

Source PSA Inquiry into the prices of sound recordings 1990. These figures cover sound recordings in general, including vinyl and cassettes.

Another perspective on the revenues breakdown of a CD sale comes from two local labels specialising in techno and industrial music. Both labels licence their music to overseas companies who assume the costs of manufacture and distribution - paying royalties on a six month billing cycle. For the local market, they manufacture their own discs here and sell them through a major distributor. This distributor supplies retail shops all over Australia, and sometimes sells discs to overseas distributors and retailers. However in this case, the distributor pays the label less than for a local sale. Both labels also sell discs directly to overseas retailers and consumers.

The distributor holds the label's CDs in stock and pays for them after they have been sold - but only after the purchaser pays the distributor. For one of these labels, the distributor has financed the manufacture and packaging of all the label's discs enabling them to release more music than would otherwise have been possible. However since sales have not yet recouped manufacturing costs of all releases, after two years, the label is yet to receive any income.

The cost of manufacturing CDs may be as high as $2 for a run of 500 with a single colour of screen printing. This may fall to $1.30 for a thousand when the production is organised through the major distributor. Major labels have longer production runs, and large contracts with pressing plants, so their discs may cost less than $1.30. The cost of standard jewel cases, and the labour to assemble the disc, package and printing into a saleable unit is around $1. Printing costs vary enormously - in the case of double sided four colour work on glossy stock, the costs including artwork generation and printing set-up can be significantly higher than the CD.

The physical product costs around $4. The writers and performers - who are often the same person or people in these fields of music - may receive (theoretically) as much as 14% of RRP - but will probably receive considerably less. The high costs of all the other stages (except the $3.40 sales tax) is a function of the administrative costs, storage, handling, display and transport costs - and the risks associated with them. The 33% mark-up for the distributor, without up-front payment seems rather high - but they provide and effective connection with all Australian CD stores.

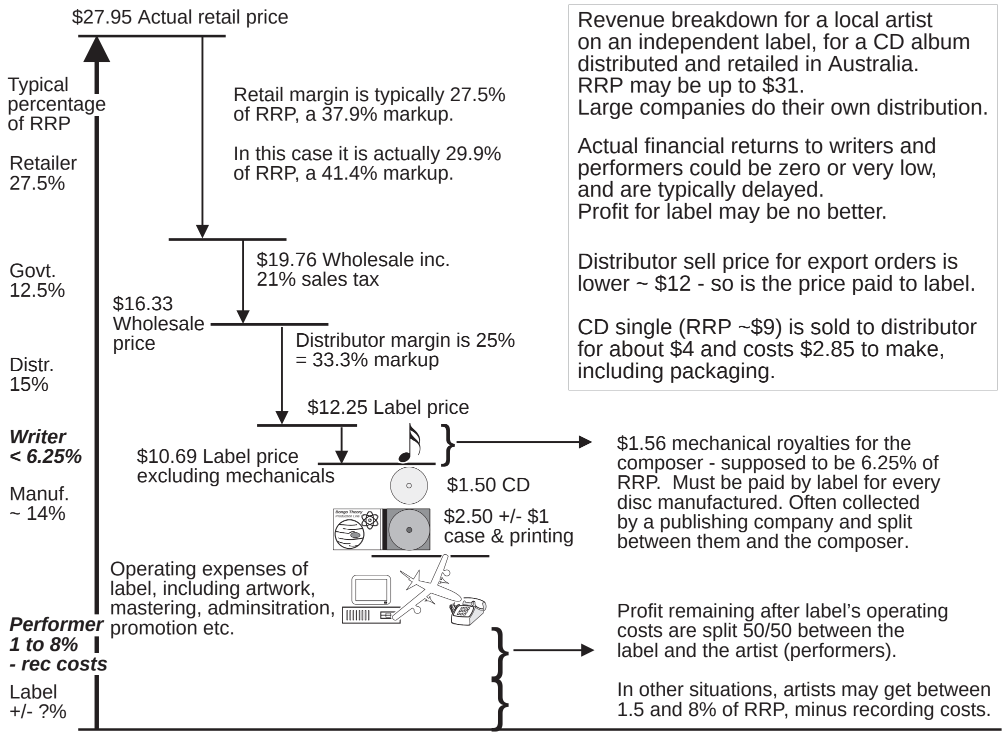
The figures for a large record company with its own distribution arrangements could differ significantly from those given here. While the larger record companies sales account for the majority of the industry's revenue, this example of a small independent label is given because:

1- It represents the entry point for many artists - who may develop successful careers as a result.

2 - Small labels generate the widest variety of music and are often more successful at licensing their music overseas - because they are willing to deal with small niche market companies. In contrast, major record companies look first to their overseas associates, and if there is no interest may not be keen to licence artists to niche labels for returns which they expect to be small compared to their Australian operations.

3 - Small labels release the majority of innovative music - in terms of numbers of releases, although not necessarily in terms of units sold.

FIGURE 1.4 BREAKDOWN OF RRP FOR AUSTRALIAN CD ALBUM - FROM A SMALL INDEPENDENT LABEL



Source Dorobo.

Note that this represents figures for a particular sale and that the retail margin does not accord exactly with the industry standard 27.5%. Retail margin may be between 25 and 30% and the final RRP between $28 and $31. However the actual sale price could vary significantly from RRP - typically less since many shops provide 10% discounts to regular customers and those with subscriber cards for community radio stations.

Other distributors may have lower margins. Performer royalties vary widely with the contract with the label. In this example, any profit after label costs are split between the label and the artist. Larger record companies typically sign artists to multi album contracts with various royalty percentages. They also make large non-recoupable advances to cover recording and other expenses - these must be repaid by the royalties from sales before any further payments are made to artists.

Recorded music volume and revenues

Tables 1.7 and 1.8 show sales of recorded music in the Australian market. The figures are for calendar years and wholesale value - distributor or record company sell price before tax.

Comment [RW3]: Page: 18 I have asked whether this is without tax. It would be good to get a sales tax figure and the 1994 figures from ARIA for the occassional paper.

TABLE 1.7 VOLUME AND REVENUE OF SINGLE SALES

Singles	*1984 Units ,000*	*88 Units ,000*	*92 Units ,000*	*93 Units ,000*	*93 Revenue $,000*
Cassette		288	3,866	3,704	10,627
Vinyl	6,714	5,618	101	30	137
CD		68	3,771	5,458	21,716
Total	6,714	5,914	7,738	9,192	32,480

Source 1994 ARIA Yearbook.

TABLE 1.8 VOLUME AND REVENUE OF ALBUM SALES

Albums	*1984 Units ,000*	*88 Units ,000*	*92 Units ,000*	*93 Units ,000*	*93 Revenue $,000*
Cassette	10,455	16,765	11,655	9,106	79,536
Vinyl	10,066	7,532	28	21	167
CD	385	5,635	22,917	23,755	319,185
Total	27,630	35,846	34,600	32,882	431,368

Source 1994 ARIA Yearbook.

OTHER CHARACTERISTICS OF THE INDUSTRY

Some aspects of the industry's contribution to the Australian economy are large, but impossible to estimate. The international prominence of some Australian artists has a positive impact on international perceptions of Australia. This is likely to significantly enhance the prospects of our tourism industry and our trade in cultural and other products (such as food), for which the demand is affected by subtle perceptions of lifestyle, quality and national identity.

For instance the sales and broadcast of the music of Yothu Yindi, combined with the band's extensive touring of Europe and the USA will have informed, and in many ways enhanced, millions of people's perceptions of Australian culture and social values. This flows directly from musician's role as an ambassador - despite the difficult and controversial nature of some of the issues raised in the band's material.

BOTTLENECKS IN DISTRIBUTION AND PROMOTION

An idealised view of the recorded music industry is a group of composers and musicians - perhaps 20,000 people in Australia and a much larger number overseas - trying to sell their music to an audience around a thousand times larger. This audience is 18 million people here, and approximately 350 million in North America, the UK and Ireland. Another 200 million people in Germany and Japan also constitute a potential market for some Australian music.

Prior to this century, music could only be transmitted acoustically - by the listener being physically present at a performance. However a great deal of musical communication was achieved with printed music notation. With the advent of recordings on cylinder and disc, a new way of experiencing and marketing music became available.

Despite the introduction of magnetic tape and microgroove (45 and 33 RPM vinyl) discs in the mid 1950s, and the introduction of cassettes in the 1970s and CDs in the 1980s, the pattern of recorded music sales has remained the same for eighty years - physical products are made in batches and distributed to retailers for purchase by the consumer.

What has changed is the means of promoting music - by broadcast over radio and TV, but these arrangements have been relatively stable since the 1930s and 1970s respectively.

The recorded music industry can be seen as a bridge between artists on one side and listeners on the other. Record companies, distributors and retailers move music towards the consumer, and move the consumer's money back towards the artists. Only a fraction of either resource makes the complete journey!

There is nothing remarkable about this. In markets such as that for fresh flowers, the costs of production and distribution of a product with a short lifespan, combined with the impossibility of predicting consumer demand, lead to risks and wastage which must be covered by higher prices.

However there are two aspects of the recorded music industry which are quite remarkable:

1 - On its own, it finds it difficult to promote its own wares. Whereas a flower shop can easily show customers exactly what the flower looks and smells like, discs in a shop are mute - providing only graphics to the browsing consumer. Considerable effort must be expended to listen to a disc, and a record shop is often a poor place to listen to the music.

2 - Its products are enormously diverse. New music and new approaches to music are constantly being introduced. Each piece of music is a different product from the next. In addition, each piece of music may be perceived very differently by different individuals.

The first point above is found in some industries - for instance in a greengrocers shop the taste of the fruit cannot typically be ascertained without some effort and the involvement of staff. Buyers need to infer the quality of the fruit from its appearance and by touching it. However, a greengrocer stocks only a few dozen products which people buy repeatedly - so they have years to develop the skills of judging quality without tasting the fruit. A purchase at a greengrocer is also around a tenth as expensive as a $30 CD, so the consumer is not risking a great deal.

The music industry can be likened to a greengrocer with thousands of times more types of fruit, where the correlation between taste and appearance is often minimal, and where it is difficult to taste each unfamiliar style of fruit in the shop. Although, the enjoyment of greengrocer's fruit does depend somewhat on the development of the customer's taste, at least it can be tasted in a few seconds. Music on the other hand requires good listening conditions, particular contexts and often specific mental connections and experience before its full worth can be discerned. Rarely is a record shop a good place to "taste" music, although enthusiastic staff greatly aid the process with guidance and information which helps the listener appreciate the music

The book industry suffers a similar burden of product diversity and difficulty of evaluation to the music industry. However a CD shop is equivalent to a bookshop which displays only covers - where customers must to ask for staff assistance before they can read the pages of the books. Some low price, mass market CD retailers do not support listening to CDs before purchase. This resembles an adult bookshop - where customers see the publication's covers but cannot view their contents. Such mass market CD retailers depend entirely on the efforts of other parts of the industry and on the mass media to tell their customers about the music on the discs in the store.

Like the book industry, no CD shop can stock all the products its clientele may desire, so there is a constant process of trying to anticipate demand and ordering items for customers who know what they want. Once a customer has decided they want some music, it is not so hard to sell it to them. However the effort, and the days, weeks or months it takes to get some discs dampens the demand from many consumers - whose desire for music is an emotional need which seeks instant gratification.

No matter what music someone listens to, sooner or later, they want to listen to something else - usually something related to what they already know, but different. The music industry's greatest single problem is introducing people to fresh music - to stimulate demand for music which exists, but which consumers would not usually find out about as a result of their own effort, or from any direct action of the industry.

While newspapers, magazines and TV play an important role in this diffusion of music, radio is the most important mechanism. However, like the other mass media, radio is not really a part of the recorded music industry. It derives no income from sales of recordings - its clients are typically advertisers, or perhaps the government or community organisations which own the stations.

The industry's frustration with radio has often been apparent, and is a significant issue at present. However if the industry was not so dependent on radio, then there would not be such a problem with commercial radio's desire to serve the interests of its advertisers and their chosen audience. The industry's calls for radio to aid the diffusion of local music, or expose the public to leading edge musical developments, are central to the music industries future, but not to the future of radio - at least in the short term.

This paper emphasises the importance of the diffusion of music - the ability of people to discover fresh music which they would like to buy. Once this is achieved, selling it to them is relatively easy and free of risk.

Before looking into the future, the existing situation with radio as the centre piece of the diffusion system will be analysed. For simplicity, commercial radio will be the focus of this analysis, but it should be remembered that government (JJJ and ABC FM in particular) and many community radio stations play a crucial role in the diffusion of music.

The role of commercial radio

Any critique of commercial radio's shortcomings should begin with consideration of what the music industry's ideal scenario for radio would be, although a commercial radio company may never be able to achieve this ideal.

It is possible to imagine hundreds of radio channels, each dedicated to covering a genre of music in great depth, each providing appropriate commentary and other contextual material suitable for the music. Each station would provide the music without interruptions, and without restrictions on the length and content of the music.

This would be close to an ideal music diffusion system if it were free and available everywhere. With the addition of a selection system and fast forward and rewind, all listeners would be able to hear all new releases as they wished, and to browse categories to find fresh material to suit their tastes. In ten or more years time, something like this may become a reality - although it will probably not be free or available through radio waves.

Thirty channel subscription "radio" systems exist in the USA - via cable and satellite. There are plans to expand them to 90 channels. Telecom recently announced plans to make a 30 channel music subscription service available here via its hybrid fibre/coaxial Pay TV system. If these services are international in scope - with some or all of the 30+ channels being broadcast internationally - then these pose a threat to the Australian nature of the music diffusion process, which is currently based on Australian radio stations. However, if Australian music is played on these international systems, then there is tremendous opportunity for selling our music in the huge markets overseas.

How does today's situation with commercial radio differ from the ideal described above?

Firstly there are less channels - with far to few to cater for the true diversity of people's tastes. Secondly the programming is disrupted by advertisements and other scheduled functions the station must perform. Thirdly, the choice of music follows different criteria to those which would maximise the listener's enjoyment, or maximise the music industry's efforts to sell its products.

Although these issues are well known, it is worth stating them clearly because commercial radio, more than any other factor, is the largest single systemic influence on the development of music and the popular taste for music. Record companies are often regarded as a barrier to fresh musical ideas, but commercial radio is often the source of the problem.

Radio stations choose an audience demographic to target - and this choice is influenced primarily by the advertisers wish to reach people with high disposable incomes - or children who can influence their parent's purchasing.

While television is an ideal means for influencing young children's demand for toys, games, food and clothing, radio is deficient in this regard. Radio advertising centres on spoken words - which must engage the imagination to produce the impact that advertisers seek. So commercial radio stations typically target people from their teenage years up until their income diminishes during retirement. (An detailed opportunities paper on children's radio is available from the Communications Law Centre. It mentions a successful commercial network in the USA with record industry advertisers including MCA, Warners and Disney. CLC 1994)

Aside from sport and talk, well chosen music is the most significant means of attracting listeners. Because the costs of running a radio station are high and can only be recovered from an advertising market for a single city, stations cannot be happy about specialised, niche audiences and must strive to gain the widest possible appeal. If there were hundreds of stations, with national coverage without any extra cost, then each could afford to target a narrower proportion of the population.

Commercial radio's musical preferences

The criteria by which a commercial music radio station choses its music may include:

1 - The music attracts listeners in the targeted demographic.

2 - The music is compatible with the advertising schedule, and the need for station identification and other interruptions. This rules out music of symphonic lengths. This also works against tracks longer than three or four minutes, since the need to break for hourly news makes it difficult to schedule longer tracks without cutting them short.

3 - The music must be something that the advertisers are happy to associate their companies with.

4 - The music must not be at odds with the impact desired by the advertiser. On one level, this means that the conceptual content of the music must not clash excessively with the message of the adverts. On an aesthetic level this means that the advert must not appear too out of place after a long period of music. Ideally the music must prepare listeners to accept the advertisement as part of their listening rather than trying to reject it as anachronism.

5 - Above all, the combination of music and adverts must be listenable - without jarring the listener, which would encourage them to tune out. This is particularly difficult since the advertisers seek maximum impact for their advert, irrespective of how it affects other ads or the music. From the point of view of many listeners, advertisements are a necessary evil. Some commercial stations implicitly acknowledge this with "40 minutes commercial free" segments. However the prominent sound effects, station IDs, and announcements about these segments, interrupt the flow of the music nearly as much as the adverts themselves.

Points 2 and 4 work against a great deal of popular music - or music which would be a lot more popular if it enjoyed promotion equivalent to commercial radio play. Most dance music is intended to be part of a continuum which lasts all night long. The tracks may be long and there may be no vocals. A great deal of popular - or potentially popular - music is relaxing and contemplative, rather than robust and *rocky.*

Point 2 means that tracks must be relatively short. Points 4 and 5 mean that vocal music is preferred - so that the up-front vocal aspect of advertisements is not too much of a shock to listeners. Points 4 and 5 also dictate that the pace of the music not be too slow.

Broadly speaking, these criteria favour music which sounds like adverts. Unlike printed adverts, which can be read at the consumer's convenience over a long period of time, or cut out for future reference, radio adverts have only one chance to do their work - leaving an impression and perhaps some information in the listener's mind. There may be some subtlety in radio advertising, but there is an absolute need to grab the listeners attention - especially since listeners may be concentrating on something else.

If it is accepted that commercial radio typically only plays music which is relatively short, contains vocals, is generally up tempo and demonstrative (without being totally anarchic), then it can be argued that commercial radio's central role in music diffusion has for decades favoured the popularisation of songs at the expense of instrumentals, rock music over gentler forms, and short pieces of music over long ones.

The evolution of popular music in the last forty years cannot be separated from the influence of commercial radio. Radio's support for some styles of music has lead to spectacular creative and commercial success - often for music whose value is shown, with hindsight, to be enduring. Our conception of what is "popular" - based on record sales and its prominence in the mass media - should be qualified by the consideration of what would have been popular with a diffusion system which was effective for all kinds of music.

New diffusion systems for a wider range of music

Gentler vocal music, classical music, music of symphonic length (including modern music made with electronic instruments) and music from other cultures (although some reggae has found a place on commercial radio) all could be more popular than they are today. Despite claims that the general public is unadventurous and wants to be spoon fed, people do like diversity and choice - as well as a sense of belonging to a group with similar tastes. The diversity of subjects found in the magazines sold in newsagents today provides a visible indication of the true diversity of popular interests.

New technology for introducing people to music promises to provide a diffusion system without the narrowing restrictions imposed by commercial radio. The new means of selling music to people promises to provide music faster, cheaper and from an almost unlimited range - in contrast to the restrictions of today's CD retailing.

It is easy for musicians and their audience to blame radio and record companies for adopting a focus which is relatively narrow, but the realities of business leave them little option. These realities are often short term compared to the long development cycle of musical talent and the creation of new forms of music.

The priorities of advertisers are not always bad for the music industry. When some radio stations targeted the baby boom generation in the 1960s and 1970s, this generation was at an age when it favoured innovative music. So this focus on youth music fuelled an unprecedented explosion of creativity - opening new musical territories which have become familiar and stable now.

These older musical territories - from the rock'n'roll of the fifties to the rock and ballads of the seventies - are still favoured by many of that generation, and hence by advertisers and radio stations. However this music represents a cash cow - playing Del Shannon or the Beatles contributes nothing to the "research and development" which must be done to maintain the industry's vitality and open new territories.

In the 1960's, in addition to the tremendous cultural upheavals, radio's focus on the 15 to 30 year old demographic aided the rapid development of new musical styles. (Only a few stations made this focus, but their influence was strong.) The music which young people were interested in was generally compatible with commercial radio - although instrumental surf music was incompatible, like today's techno, and was not played extensively. Nonetheless, the success of new forms of music, and Australian music in particular was dependent on the enthusiasm of certain radio DJs whose crucial contribution continues to be honoured today. Unfortunately, DJs playing their personal choice of music are rarely found on commercial radio today.

Today, a lot of the music of interest to young people and to musical innovators does not suit commercial radio. It is too long, too frenzied, too African, too quiet, too offensive, too eclectic, too abstract - or it lacks melody or words. One perspective is that if some music doesn't sound right playing in a suburban sandwich shop, then it probably isn't right for commercial radio.

Furthermore, young people comprise a lower proportion of the population than they did thirty years ago, and their spending power is lower than in the 1960's - due to the recession and in particular due to huge changes in employment patterns.

Despite the fact that young people still seem to be the most enthusiastic music purchasers, the factors above have meant that they only a small fraction of their music remains in the spotlight of the greatest promotion and diffusion system yet devised - commercial radio.

This means diminished sales to this vital section of the music market. Young people must work really hard to discover and purchase music which is not played on commercial radio. This also means that youth music - the birthplace of most new musical developments - is being neglected.

It is quite appropriate for radio and the recorded music industry to be fully exploiting the tremendous musical resources of the past, including re-discovering music from past centuries, but the future of the music industry depends on the development of fresh musical territory. If this process depended entirely on commercial radio's attention, then such developments today would be greatly attenuated.

Today's proliferation of music and musical styles

Fortunately other means of diffusion, new instrument and compositional technologies, and the tremendous enthusiasm of the swelling ranks of musicians has lead to extraordinary musical developments in the past decade.

Some of this is based on combining existing styles in novel ways. Some of it - primarily in the "electronic" fields - constitutes the invention of whole new types of music and new reasons for listening to it. Elements of these genuinely new approaches can often be integrated into existing styles - such as techno to commercial pop, and industrial to metal music - to extend the older styles and give them drive and freshness.

Today there is a tremendous availability, in principle, of all kinds of music from the past. However most of this music is only discovered by listeners who make significant effort. New musical developments are occurring in some fields at a blistering pace, but the public has no easy way of hearing this music since it is not being diffused by commercial radio.

New methods of diffusion

The sheer quantity of music and diversity of musical styles has outgrown the diffusion and distribution systems. The next ten to fifteen years promise new approaches to diffusion and distribution, which will cope better. They will not be centred on the narrow channels of the mass media. They may involve few music industry professionals - the links between artists and listeners will take place more directly, with relatively few professionals and quite a few highly motivated listeners maintaining those links.

Thus the diffusion of music will no longer depend on its suitability for commercial radio. The anticipated networked diffusion systems for *recorded* music seem to have no inbuilt stylistic biases. However, like commercial radio, they will be directed primarily at recorded music - rather than live music, which was the only form of music until a hundred years ago. The diffusion systems will be largely unaffected by distance and national borders, although language barriers could still be an issue.

When combined with the increasingly flexible and cost-effective means for creating recorded music, this global diffusion system can be expected to fuel the fires of musical development and encourage music sales for a wider range of music, in larger quantities, with greater efficiency and hence lower prices, than is possible today.

Structural changes to the industry

With the exception of the threat of profligate copying, these anticipated developments are almost wholly positive for musicians and listeners - the two foundations of the industry. They challenge the companies who have built today's bridges between the artists and the listeners. These bridges - CD manufacturers, record companies for financing and promotion, distributors and retailers for physical products - could all be bypassed in the coming age of electronic delivery.

Today, telecommunications and computers link to form the Internet - which can link people via text, image and sound - as individuals, as groups or in a more "broadcast" way like a magazine or public forum. In the next five to ten years, global networking will become an everyday experience for many people in Australia. Most of their activity will be for social and recreational purposes. Readers are urged to explore the World Wide Web themselves, and to imagine this operating with full motion video, with the involvement of the majority of the population.

In the foreseeable future, the music industry will no longer depend on mass production, the limitations of "channels" on the mass media and on large record companies to push music through these barriers. The structure of all information industries will be altered enormously when consumers and producers are all permanently linked to a single, global computer network. The distinction between producer and consumer - which is absolute in a mass media - becomes largely a matter of choice in a networked environment. The costs of access to the network are low, and so small companies can make themselves available to customers the world over almost as easily as large companies. Individuals can contribute to global discussions, and make their text, music and images available to anyone via the World Wide Web.

However, physical products and existing distribution and retailing channels will continue to exist. Electronic delivery is unlikely to seriously threaten the sale of discs in the next ten years. Many of the technologies which will make electronic delivery practical can also be used to enhance existing retailing operations.

One thing is certain - consumers will find it increasingly easy to copy music. There are no technical means - and no acceptable legal means - of stopping user copying. Irrespective of how the industry chooses to sell music to the public, it will have to compete with the ease and costs of copying. There are legal and economic aspects to this, and the possibility of incentives to legitimate purchasers. However, the battle against piracy and user copying can only be won by making music easy to find, easy to buy and not too expensive - and by making people feel really good about buying it.

The most important conclusion of this paper can be stated in three sentences:

> *Ultimately, network music sales with electronic delivery will makes it quick, easy and relatively cheap to discover and buy a huge diversity of music, and will support direct (or via stored text, speech and video) two-way communication between listener and artist. As a diffusion process, this will be relatively free of the stylistic biases such as those of today's commercial radio. As a communication and marketing process this can build listener loyalty and both inspire and finance artists to make more music.*

However there are many other aspects of the music industry which can be enhanced with new technology. Some of these developments are well under way - such as the Internet's role in discovering music and related information and the use of the World Wide Web for selling CDs.

CHAPTER 2 HISTORICAL BACKGROUND

The mass market recorded music industry has a dynamic history. Like the book publishing industry, the diversity of its product has long strained the available retail, distribution and promotion systems.

A 1942 catalogue of recorded music lists approximately 13,000 discs by 1700 artists, bands and orchestras - and this is just for Australian distribution of the Columbia, Decca, His Master's Voice, Parlophone, Regal-Zonophone and Odeon labels.

TO THE 1940S

Sound, as variations in air pressure, can readily be converted to and from a varying electrical current (flow of electrons) or voltage (pressure of electrons). These smoothly varying quantities are analog signals, and can be recorded in the shape of grooves on a vinyl record, or in the orientations of magnetic fields in the particles of a magnetic tape. The final quality of the reproduced sounds depends on the recording and playback equipment, the linearity of the recording medium, the noise (random fluctuations) in the recording medium and way it is affected by dust, heat, time and wear and tear.

Analog sound recording and reproduction was first achieved before electronics became available. The first sound recordings were made by Thomas Edison in 1887 on a cylinder covered with tin-foil - with a moving needle driven directly by the sound gathered in a large horn[1]. Applications first started in 1888 with the development of wax coated cylinders. Edison considered music to be a trivial application and saw the future of the phonograph in business.

Ten years earlier, Alexander Graham Bell had started producing telephones, focusing on the business market and regarding social uses as unimportant. It was only in the 1930s that domestic telephone use began.

These "business only" forecasts have contemporary parallels in the original market estimates for mobile phones, and in pessimistic predictions for consumer interest in Video On Demand and networked applications.

Edison cylinders could be replicated from a master, but the process was costly. The solution was developed by Emile Berliner in 1888 - recording on and pressing discs instead. By the turn of the century, 78 rpm shellac disc recordings of opera were being produced and between 1910 and 1920 the

1 Dates in this section are from Macquarie Library 1991 *Encyclopedia of Ideas* and Hellemans and Bunch 1988 *The Timetables of Science,* Simon and Shuster.

industry achieved a mass market. In 1913, multi-disc recordings of Beethoven's Fifth and Sixth symphony became available and the industry's first dance craze was started by Irving Berlin's "Alexanders Ragtime Band".

Electronic amplification first became available around 1907 with triode vacuum tubes. These were first used for radio and in 1913 to amplify telephone signals. When cutting master discs, microphones were connected to early electronic amplifiers, which drove the cutting head. These "electrically recorded" discs had a much greater signal quality, and offered greater recording flexibility, than purely acoustic methods.

Radio broadcasts to consumers started in the mid 1920s and the movie industry was transformed by the development of film sound. Film sound was initially treated as a novelty by many in the industry. Charlie Chaplin is quoted as saying (Robinson 1985) "I'll give the talkies three years, that's all."

The October 1927 release of *The Jazz Singer* was a sensational success - boosting the previously shaky Warner Brothers into prominence. By the end of 1928 1,000 US movie theatres had sound capability. A year later the figure was 8,700. Within two years half the 20,000 movie-theatre musicians, and hundreds of silent-title writers in Hollywood, were out of work. (Paris 1989).

Within twenty years of the invention of electronic amplification, mass markets had been established for popular culture and consumer radio and gramophone equipment. Dynamic new content industries had been established - the record industry, motion pictures and news reporting via newsreels. The new technology altered the political process as well - film sound and public address amplification played a crucial role in Hitler's rise.

By the 1930's the electronics industry and the new understanding of quantum mechanics laid the basis for the development of semiconductors to serve military, commercial and consumer markets. The consumer electronic markets were driven primarily by entertainment - music and film - although news and sport were important factors as well.

The development of some major technologies - such as television and the compact disc - were driven by consumer markets, and today there is an expectation that the Ubiquitous Broadband Network of the future will be built primarily to service the consumer market for Video On Demand.

78 RPM records - packaged in an "album" book for long pieces such as symphonies and operas - were the only consumer form of recorded music until the mid 1950s.

Recording and playback equipment was continuously improved, and modern releases of 1940 direct to disc recordings such as Woody Herman's *Golden Wedding* attest to the wide frequency response and dynamic range which could then be achieved.

TAPE AND VINYL - FROM THE 1950S

Practical magnetic tape recorders were developed in the late 1930s and were first used for creative musical purposes in the late 1940s. One tape technique - editing sound by splicing tape - was exploited by composers, notably Edgar Varesè.

A second technique - multitracking - was first developed by the popular musical couple Les Paul and Mary Ford in the late 1940s. Les Paul - who also pioneered the electric guitar - bounced sound between Ampex 3 track machines, layering guitar and vocals for playback at otherwise impossible speeds. Their playful use of the multitrack was idiosyncratic and most other musicians used tape to capture the "perfect performance" rather than extend their musical palette.

In the 1950s, artists such as Dave Brubeck and Eartha Kitt used three and four track tape machines to make recordings of remarkable technical and musical quality. Tape became the preferred way of making master recordings - which were later mixed and cut into discs for replication. The exploration of tape's musical possibilities was taken up again in the mid 1960s by the Beatles and the Beachboys.

Television achieved mass market status in the 1950s, but until the 1970s, its integration with the marketing of recorded music was generally limited to movies and performances of artists on music and variety shows.

The great innovation in music distribution in the 1950s was the development of the microgroove record - 33 1/3 RPM and 45 RPM vinyl disks. Rock' n' roll recordings around 1955 from Chuck Berry and Elvis Presley were available on both 78 PRM and 45 PRM singles, but microgroove records soon dominated the industry - gaining a prominence they retained for three decades.

Stereo records were introduced in the late 1950s and became standard ten years later. 8 track, quarter inch, tape cartridges were introduced for car sound in the 1960s, but did not achieve mass market status in Australia.

Philips developed the compact cassette in 1963 - purely for the business application of dictating machines. Its slow tape speed was never intended for music, but it became the first mass market consumer recording technology after developments in magnetic materials, recording technology, and in particular Dolby noise reduction made it acceptable for musical use.

The cassette was also used for mass production distribution of music, but its fragility and susceptibility to drop-outs and pitch fluctuations never allowed it to attain the hi-fidelity sound possible with a well cared for vinyl disk.

In the 1970's the music industry developed a new way of presenting fresh material to listeners - the video clip. Some 1960s bands - such as *The Loved*

Ones - made promotional film clips for TV in addition to performing directly for the TV camera. However the development of rock videos is attributed by one writer (Masterton 1994) to the ABC's Countdown. According to this account, Countdown video clips gave many overseas artists their first number one hit anywhere in the world - including Blondie, Billy Idol, Madonna, Abba and John Cougar Mellencamp. Its promotional importance to most Australian artists in the 1970's and 1980's was enormous, not least Skyhooks who appeared on the first show in 1974.

DIGITISATION - THE 1980S

Since 1980, the production of music has been transformed by digital control of instruments and by sampling. These will be examined in Chapter 16.

The first Compact Disk player was released to the Japanese market in 1982 and to the European market in March 1983. The first portable player was introduced in 1985. The CD development was notable for several reasons:

1 - It was aimed directly at the consumer market.

2 - It represented a complete break from existing techniques. However its diameter was chosen so that CD players would fit in existing car radio spaces.

3 - It was not the product of competition or a standards body. Its principles were adapted from two separate and relatively immature technologies. Philips developed the optical and disc replication technology - from laser video discs. Sony developed the standards for sampling, encoding, error correction and organisation of the data from their work with early professional digital recorders.

4 - It brought specially developed state-of-the-art optical and electronic technology directly into the home.

5 - After nearly a century of attempts to improve sound recording technology, it promised perfect sound quality, which would last forever.

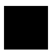
The CD medium was initially dogged by controversy over sound quality. Audiophiles were convinced that CD's perceived loss of high end detail and stereo imaging was an inherent fault of digitisation. These concerns were largely eliminated when the problems were discovered to be caused by phase response problems in the anti-alias filters which drive the Analog to Digital Converters of the Sony PCM-1610 audio processor. PCM-1610s were used to master virtually all CDs until they were superseded in the years 1986 to 1989.

After costs of CD players came down, the mass market for players and discs exploded and ten years after its introduction, CDs largely supplanted vinyl records. The success of the CD shows that ten to fifteen years is quite long enough for an industry to be completely transformed by a new technology.

The CD was a remarkably bold and well designed product. All currently produced audio CDs follow the original specification - except for a few which stretch the original 74 minute length to 78 minutes.

A 74 minute CD contains 783 megabytes of digital audio. It also contains about 32 megabytes of sub-code data which is hardly used, and extra data for error correction. Ignoring these, the CD puts 4 megabytes of audio data on a quarter inch square - enough to store the text of *The Lord of the Rings* or the entire Bible.

Comment [RW4]: Page: 33
Change the size of these rectangles for the Occasional Paper - it will be reduced in the printing process.



This area of a CD contains 4 megabytes of audio data.

Although CD-ROMs use the same low level physical encoding mechanisms as the audio CD, the evolution of their higher level formats has been complex and divergent - as computer technologies typically are.

CDs of the near future

New developments in CD technology are described in chapter 4. A dual layer CD which is read with shorter wavelength red light has ten times the capacity of today's CDs which are read with infra-red light. This should give 7,400 Megabytes of data on a 12 cm disc - about 1 Megabyte per square mm. Using data compression, the text of *The Lord of the Rings* could be reduced to about 1.3 Megabytes. Such a disc could store 5,700 times this quantity of data. This paper, including most of the diagrams, compresses to 0.5 Megabytes, and so on a dual layer red light CD would occupy space equivalent to two full stops..

(Authors note: I find this astounding and have checked the calculations!)

Using compression technology to reduce music to about a third of its usual data rate - with little or no loss of quality - these dual layer discs would hold 36 hours of "CD quality" stereo music.

CHAPTER 3 DIGITISATION, COMPRESSION AND QUALITY

> *Data compression of digitised audio is crucial to conveying music with the smallest possible "bandwidth" - the smallest possible amount of storage or transmission capacity. 2:1 compression will typically produce results which are indistinguishable from the original. 4:1 to 7:1 may produce adequate results casual listening environments. Compression ratios higher than these may be adequate for auditioning music. At the end of this chapter, Table 3.1 contains the data rates for music at different compression rates. These rates are crucial to the later discussion of storing and transmitting music digitally.*

CD QUALITY

The CD system samples the audio signal 44,100 times per second - which means that frequencies as high as 22 kHz can be recorded. The magnitude (voltage or air pressure) of each sample is measured on a scale of 0 to 65,535 - to produce a 16 bit binary number.

Until about 1989, it was virtually impossible to achieve this analog to digital conversion in a way which acceptably minimised problems of noise, distortion and phase response. The technical details of these difficulties are complex, but the solution to all of them was made possible by the development of practical Delta-Sigma (sometimes called "1 bit") Analog to Digital Converters. In 1990 these converters became available in a single chip, and were significantly cheaper, more reliable and more compact than previous approaches - as well as having perfect frequency and phase response, and very low levels of noise and distortion.

First used in DAT recorders, these converters, and their playback equivalents - Delta-Sigma Digital to Analog Converters - are now standard in all digital audio products, including CD players and personal computer sound cards.

When used correctly these converters closely approach all the ideal parameters of 44.1 kHz 16 bit sound. The author contends that this standard is sufficient for the perfect reproduction of almost any musical source in almost any listening environment. Although some Hi-Fi marketers promote higher sampling rates, greater numbers of bits, and less believable enhancements such as special colouring pens for the edges of CDs and exotic audio cables, this paper will proceed on the basis that *CD quality sound (44.1 kHz 16 bit stereo)* is "perfect". (Of course problems in the source material and in recording techniques may mean that the recorded signal is far from perfect.)

Certainly the majority of consumers are happy with the quality of CD sound and "CD quality" is a widely used, although not always appropriate, term of approval for an audio product.

The main problem with sound recorded like this is that it takes a lot of bits to store or transmit it. However audio data can be compressed in a variety of ways - depending on the desired quality.

Compression of digital audio

Compression involves special coding techniques to convey the information content of a message to the de-compressor using a smaller number of bits than would be necessary for the uncompressed message. A simple form of compression is to search for long runs of zeros and ones in the message, and replace them with a shorter instruction for the de-compressor to reconstruct these long runs in the final output. Fax machines use this technique, so they take little time to transmit lines which have long runs of black or white pixels.

In the computer and telecommunications fields, the term *compression* is used in this way - to denote a process for carrying a message with fewer bits than would normally be required. In the music industry, the term *compression* traditionally refers to reducing the range of volume dynamics of a signal. Consequently in musical contexts (such as Digital Audio Broadcasting) the term *data-reduction* is sometimes used instead, to denote a process for carrying a sound signal with fewer bits than would normally be required. This paper uses the term *compression* in all contexts.

The September 1994 issue of the Australian magazine *Connections* carries a detailed article on the various audio compression standards, for stereo and surround sound. The article, by Ted Pine, originally appeared in the US magazine *Mix* (Pine 1994) *.* Another informative article on compression by Ken Pohlmann also appeared in *Mix* (Pohlmann 1993).

LOSSLESS COMPRESSION

This is a lossless method of compression - the de-compressed message is identical to the original. To achieve this with audio data requires elaborate computations, but these can be performed with cost-effective chips, or by the CPUs of fast personal computers. In all forms of compression, less computational power is required to de-compress than to compress the signal.

It is typically possible to compress 44.1 kHz 16 bit stereo music by a factor of 2:1 without degrading the signal in any way. However the ratio depends on the sound - very loud, noisy, random sounds might only be compressible losslessly at 1.5:1 (66% of their original data rate), whilst a flute solo might compress to 4:1 (25%).

Several approaches have been developed for lossless compression and no industry standard has yet emerged. One, from US company Aware, produces a datastream which can be de-compressed to full quality, or to a lower quality if there is a limitation in the processing power available in the decoder. This scalable system is called MultiRate.

The other prominent lossless approach is called H.E.A.R from Great Valley Products and Merging Technology. Unlike most compression techniques, this does not split the sound into multiple frequency bands. Instead the encoder analyses the waveform and describes the waveform as closely as possible with mathematical polynomial formulae. These formulae are stored together with bits which specify exactly how the real waveform deviates from the output of the formulae. The decoder computes the formulae and adds the deviation codes to reconstruct the original waveform exactly.

One of the problems with audio compression systems is the delay inherent in encoding and decoding them. This is not a problem for recordings, but for applications like video conferences - or live broadcasts to remote audiences with audience feedback - the delay is a critical factor. The H.E.A.R system has a total delay of only 22 msec.

Lossless compression methods are not widely used at present. However it is common to read that certain lossy compression systems produce sound which is "indistinguishable" from the original. The truth of this depends on the musical material, the listening environment and the perceptiveness of the listener.

The definition of a lossless compression algorithm is that it is capable of reconstructing the data exactly - providing bit for bit equality with the original.

A truly lossless compression algorithm cannot guarantee a particular compression ratio, because some material can only be slightly compressed. The compression ratio will fluctuate greatly second by second as the music changes. This is ideal for a storage medium such as a CD, where quiet passages in the music would use little space.

However other applications such as broadcast and some networked applications provide a fixed bandwidth. If the data rate is set for a 2:1 compression, there may be certain parts of the music which cannot be compressed perfectly at this rate and so very slight errors would occur. Since these would only be in the most loud and complex passages, it is reasonably safe to assume that the errors will not be heard.

This paper will assume that using "lossless" compression, perfect stereo sound can be transmitted at 50% of the usual bit rate. The H.E.A.R algorithm achieved an average compression rate of 2.7:1 (37% of the original data rate) on a wide variety of material from an EBU test CD.

The usual bit rate for 44.1 kHz 16 bit stereo sound is 44,100 x 16 x 2 = 1,411.2 kbits/sec. So this paper will assume that "perfect" quality audio can be transmitted at around 700 kbit/sec. In a storage medium, the average data rate may well be less than this, due to lower bit rates in quieter, less complex parts of the music, but a 2:1 rate will still be assumed.

Another useful way of defining lossless compression is that the reconstructed sound is indistinguishable from the original under the most stringent listening conditions. Such a compression algorithm may not produce bit-for-bit equality. The phase of the components in the reconstructed signal may vary from the original enough to create quite a different set of numbers at the output - but these phase differences may so small that they are completely inaudible.

LOSSY COMPRESSION

There are a variety of compression techniques which yield good performance at compression ratios of between 4 and 7 to 1. Philips DCC uses a system called Musicam with 4:1 compression. The Sony Mini Disc uses a system called ATRAC at 4.84:1.

Musicam has been accepted as an international standard - ISO 11172-3. It specifies a digital "language" in which elements of sound can be described. Compressed digital audio following the Musicam language can be reconstructed by any Musicam compatible de-compressor. The standard does not specify how sound is to be analysed for compression, nor does it specify a particular data rate or sound quality.

The standard specifies three "layers" or approaches to audio compression. Layer I is computationally simpler and works best at higher data rates. This is the form of Musicam used in the Philips DCC. Layer II is similar in principle, but breaks the sound into finer frequency/time samples. It demands more computation for both compression and decompression, but produces better results at lower data rates - and hence has been chosen for the European DAB (Digital Audio Broadcasting) system. Whilst layer I treats the left and right signals separately, layer II can be used to exploit common elements in the two channels. The bits which are saved with this approach can then be used to specify greater levels of detail. Layer III is for still lower data rates, uses different principles and requires more computational resources.

The sound quality achieved with Musicam depends primarily on the data rate available to carry the compressed data. However for a given data rate and with a particular piece of music the sound quality could vary significantly with the choices made by the compressor as it decides which elements of the sound to carry and which to ignore. So for a given data rate, there is no guarantee of quality. The quality depends on how well compressor anticipates which parts of the music are most likely to be heard by the listener. One compressor may sound best with one piece of music but sound worse than other compressors on another piece.

Both video and audio compression involve a great many factors and it is wrong to use the names of the systems (such as "MPEG-2 quality") to imply a given quality level.

Musicam is sometimes referred to as MPEG or MPEG-2 audio compression, because it has been adopted for these video compression standards. However, several other formats are also likely to be included in the standard and there is continuing controversy about what audio compression methods and data rates are acceptable for the MPEG-2 video standard.

Recent listening tests on surround sound (5 channel) versions of three compression techniques at 384 kbit/sec were reported in the January 1995 edition of *Stereophile* magazine (Mitchell 1995). Musicam, Dolby AC-3 and MPAC (Multichannel Perceptual Audio Coder from AT&T Bell Labs) were tested by 45 experienced listeners with demanding film sound material, including music. Only MPAC was judged to have encoded more than half of the material transparently. There are many factors affecting such tests - however it seems clear that even with the best compression techniques available today, data rates under 400 kbit/sec (3.5:1 compression) are likely to adversely affect music in demanding listening conditions.

A compression system running at a low bit rate will introduce a variety of "artefacts" - audible degradations. Stereo imaging and crispness of top end detail may be affected. Noise may appear where none existed in the original, and quieter parts of the original may disappear because the encoder has decided that that part was likely to be inaudible.

When music travels through a chain of compression systems, these problems add up. Passing a signal through a compress-decompress algorithm several times is a reasonable test of how good it is when the degradation it produces on a single pass is barely perceptible. For instance one test of Musicam (Pine 1994) showed that at a 16 bit 48 kHz (presumably stereo) source compressed to 384 kbit/sec could withstand 15 successive stages of such compression before the noise became "significant". The same material could only stand two cycles of compression at 192 kbit/sec before the noise became "significant". However, it is likely that high end detail and stereo imaging are affected more than this test indicates.

There is controversy about the merits of differing compression systems and data rates and it is possible that no one standard will dominate all applications. However decoder chips are typically based on flexible DSP (Digital Signal Processing) chips and so can be designed with little extra cost to contain programs which decode several different types of compressed audio. In addition, the CPUs of fast personal computers are often sufficiently powerful to execute the decompression algorithms - so only software, rather then dedicated hardware is all that is required. Compression however, is a more onerous computational task.

While the music industry currently uses stereo reproduction, the film and video industry needs surround sound. The audio part of the emerging MPEG-2 standard calls for "5.1" audio channels - two stereo, three surround sound and one 100 Hz special effects channel.

These multichannel sound systems are relevant to the recorded music industry, because when music is distributed in a multi-format digital means (rather than in a fixed stereo format of today's CDs) musicians will be able use all these channels at once.

All these lossy compression techniques analyse the music and try to determine which components of it will be audible and which can be discarded. Figure 3.1 shows two curves which are relevant to decisions about which components of an audio signal to discard for the purposes of data compression. Firstly there is the bathtub shaped threshold of hearing curve. A 200 Hz tone at 10 dBa falls underneath this curve and can be discarded because the human ear will not hear it. However a 2 kHz tone at 10 dBa would be audible and would be included in the data to be sent to the decoder.

The second curve is shaped like a mountain peak - this is the masking pattern for a 70 dBa 1 kHz tone. If such a tone were present, a 2 kHz tone at 10 dBa would be inaudible and could be safely discarded. Even a louder tone - such as 1.5 kHz at 40 dBa could be discarded without affecting the ear's perception of the sound.

Lossy audio compression schemes work by encoding only those components of the music which are above both the threshold curve (which is fixed), and the masking curve which varies constantly with the loudest parts of the music.

Some lossy compression algorithms can be used to give a particular quality - in which case their bit rate varies with the music. They can potentially give a very high quality, in which case their compression ratio is likely to average about 3:1. Alternatively the algorithm can be given a constant bit rate, and it will do the best it can to provide the audible musical details within that limitation.

This paper will not debate the merits of particular compression technologies. These are the subject of intense research and although some improvements may be expected in the future, the data rates and audio qualities in Table 3.1 provide a useful guide to the future.

FIGURE 3.1 PSYCHOACOUSTICAL PROCESS OF MASKING

Diagram is pasted in here!

From Frank Müller-Romer Journal of Audio Engineering Society 1993 March page 160. 3.7" high.

Source Frank Müller-Romer *Directions in Digital Audio Broadcasting* Journal of Audio Engineering Society, March 1993 page 160.

When consumers purchase music, many of them are likely to demand quality which is indistinguishable from today's CDs - even under the most stringent listening conditions. However, because new formats of music delivery - new discs and electronic delivery over the network - will typically use compression, there is a need for a perceptibly lossless compression system.

Most research effort concentrates on compression at data rates between 192 and 384 kbit/sec and these systems are perceptibly lossy in good domestic listening environments. Based on the reports of the H.E.A.R algorithm described above, this paper will proceed on the assumption that perceptibly lossless compression can be achieved at a ratio of 2:1 or, for some pieces of music, 3:1. This means that data rates of 700 kbit/sec, or perhaps as low as 470 kbit/sec, are assumed to be able to provide music which will be indistinguishable from the original in virtually any listening environment.

400 kbit/sec to 200 kbit/sec (4:1 to 8:1 compression) is likely to be adequate for many applications such as video sound and broadcast or low-cost network applications. It is also adequate for auditioning music and for many broadcast or network applications where the customer is not paying for quality. Many styles of music may not suffer perceptible degradation from these compression rates in casual listening situations involving portable stereos, radios, car sound systems or when the music is playing in the background.

In 1992 subjective tests (ITU 1993) using the Musicam compression system, 256 kbit/sec and 192 kbit/sec were found to degrade the stereo signal in a way which was "perceptible but not annoying". The 256 kbit/sec was using two independent 128 kbit/sec data streams for each channel and the 192 kbit/sec was for a "joint stereo" arrangement - where one part of the data stream described signals common to both channels and the other part described how each differed from the common signal. These represent compression ratios of 5.5 and 7.35 respectively.

By comparison, the data rates for MPEG-2 compressed *video* (not counting the audio component) are ten to twenty times higher. About 2 Megabits/sec may be sufficient for some movies, but at least 6 Megabits/sec is required to give satisfactory results for fast action sports. (MPEG 1994).

The degradation caused by lossy compression techniques typically manifests itself as loss of high frequency detail and stereo placement, and anomalies in the decay of sounds such as reverberation. The problems of analogue storage and transmission techniques - background noise, uneven frequency response, distortion and pitch fluctuations are not usually caused by digital compression techniques.

One way of evaluating the operation of a compression algorithm is to subtract the reconstructed signal from the original. A Musicam demo CD from Bayerischer Rundfunk provides tracks with such difference signals for a short passage of orchestral music with sharp transients and complex organ tones. The level of these difference signals for 256 kbit/sec and 128 kbit/sec stereo (128 and 64 kbit/sec per channel) was approximately 32 dB and 18 dB respectively below the original. These are the author's approximate measurements and use A weighting to match the ear's response to low level signals. This implies that 256 kbit/sec of data can reconstruct music with error at about 30 dB below the main signal - so using two or three times this data rate might reduce error to 60 or 90 dB below the signal. Since 16 bit digital audio has a dynamic range of 96 dB, this would lead to a perceptibly lossless compression at around 700 kbit/sec - which approximates the rate achieved by the lossless H.E.A.R algorithm.

TABLE 3.1 DATA RATES FOR COMPRESSED STEREO AUDIO

Compression ratio	*kbit/sec*	*Megabytes/ minute*	*Megabytes/ hour*	*Quality and applications*
1:1	1,411.2	10.6	635	Perfect quality.
2:1	705.6	5.3	317.5	Perceptibly perfect quality can probably be achieved for virtually all music.
3:1	470.4	3.5	211.7	Some algorithms may be able to achieve perceptibly lossless compression with most music at 3:1 or perhaps 4:1 - especially when the simpler passages are averaged with the most complex ones, as they would be on a storage medium like a CD.
4:1	352.8	2.6	158.8	As used with the Philips DCC. 256 to 384 kbit/sec is typically used for the audio component of compressed video.
4.84	291.6	2.19	131.2	Mini Disc ATRAC compression - some degradation noticeable with close listening.
5.5	256.0	1.92	115.2	256 kbit/sec is the most prominent standard data rate for stereo Digital Audio Broadcasting.
7.35:1	192.0	1.44	86.4	Digital Audio Broadcasting can use this rate. Internet Underground Music Archive uses about 200 kbit/sec for providing stereo music.
8:1	176.4	1.32	79.4	Data rates lower than this are not normally used for stereo music, but may be acceptable for auditioning music.
5.5 for mono	128.0	0.96	57.6	Good quality mono - suitable for auditioning music. The two 64 kbit/sec channels of BR-ISDN can support this data rate. Internet Underground Music Archive uses 7.3:1 compression for mono audition samples - 0.72 Megabytes/min.
11 for mono	64.0	0.48	28.8	Mono without crisp high frequency detail - roughly equivalent to AM radio. Suitable for auditioning music - as used by AussieMusic Online. One 64 kbit/sec channels of BR-ISDN can support this data rate.

CHAPTER 4 STORAGE TECHNOLOGIES

This chapter looks at digital storage technologies for delivering music to listeners and for listeners to record on themselves. Red light CDs contain 4.7 times the normal CD data capacity and are likely to become available in 1996. Blue light discs offer double this capacity but may be several more years away. Capacity can also be increased by making multi-layer discs. This chapter describes these new physical formats for pre-pressed discs, write once (CD-R) and re-writable Magneto Optical (MO) and phase change discs.

New data formats are discussed, including the use of compression and the use of directories to facilitate writing CD-Rs in multiple sessions. All these developments are of fundamental importance to the music industry.

This chapter also discusses the retail applications of CD-R discs - containing the music that individual customers want. Another near term application of emerging technology is the use of mass storage systems based on juke-boxes of hundreds of discs for CD browsing in retail shops.

DAT

The Digital Audio Tape recording system was introduced in 1987 - as a consumer digital recording medium. Although it gained a consumer market in Japan, its success elsewhere has been limited to the professional audio market. Most music production is now mastered onto DAT, from which it is copied digitally, perhaps with some digital manipulation, to form the master tape for CD manufacture.

DAT records at 44.1 kHz, 16 bit linear stereo - just like a CD. It can also operate at 48 kHz and 32 kHz. Concern over home taping lead to a controversy in the USA which thwarted its early marketing to consumers. DAT machines were made which would not record digitally at 44.1 kHz in an attempt to defuse these problems. Later a weak form of copy protection - SCMS - was adopted in a bid to ease it into the consumer market - without upsetting the record companies. The record company's involvement was thought to be crucial since only with their consent could pre-recorded tapes be made available to enhance its attractiveness as a consumer item.

SCMS did not stop digital copying from a CD, but it stopped a further digital copy being made from that DAT tape. SCMS can be bypassed with suitable equipment, or copying can be done with the analog inputs, so it was never a strong disincentive to home taping.

In the West, most DAT recorders are used by musicians who are typically mastering their own music. The SCMS system can cause inconvenience and so is often referred to as "scums" or "scams".

The failure of consumers to adopt DAT can be explained by its late introduction, high cost and the fact that the recording medium was a tape - which precludes the easy access and handling of a small disc.

DAT tapes are extremely small, and are read by microscopic heads on a small rotating drum - like a video recorder. The close tolerances mean that the tapes are fragile and may not play reliably on other machines. They are unsuited to consumer use because of their susceptibility to heat and dust.

DCC

Philips and Sony each developed rival consumer digital recording systems based on data compression - so that they could use media with lower data storage capacity than the 1.411 Megabit/sec of the CD. Sophisticated audio data compression was not available when the CD and DAT systems were developed.

Philips chose to use a special tape packaged similarly to a compact cassette - so that the DCC deck's analog head could play consumers' existing cassettes. A separate precision 9 track head reads and writes the digital tape.

Despite good promotion, and a reduction in price to bring the units within reach of ambitious consumers, the DCC failed completely to gain a foothold in the market. Perhaps the reasons were similar to the consumer failure of DAT - high prices, fragile media, and the delays involved in fast-forwarding and rewinding . A major factor against both DCC and Mini Disc is their reliance on lossy data compression - precluding their use for a high fidelity recording.

Mini Disc - a Magneto-Optical Disc

Sony's Mini Disc is based on a re-writable magneto-optical disc in a plastic case which looks like a miniature floppy disc. Like a CD it offers ease of handling, random access and reliability. The Mini Disc has not gained a mass market yet, but it is being adopted by some musicians - not for mastering, but for playing what were previously backing "tapes" (DAT and compact cassette) during a "live" performance. The blank discs retail for about $20 each.

The Mini Disc uses 4.84:1 compression and although its sonic performance can be faulted on close listening, the Mini Disc is better in most respects than a compact cassette - which suffered noise, dropouts, fluctuating frequency response and linear rather than random access to tracks. Tracks can be added and the replay order changed without re-recording the tracks. The disc nature of the medium, together with memory in the player, enables the music to be stored as files and accessed as required with no gaps in the playback.

Like the CD, the maximum playing time is 74 minutes. In addition to recordable discs, Mini Disc players can play pre-pressed (non-writable) discs containing commercial music releases. These discs are pressed in a manner similar to normal CDs.

Mini Discs are re-writable magneto-optic discs. These use an infra-red laser for reading and writing a magnetic surface which is enclosed inside the plastic of the disc. Like the CD, but unlike any tape or vinyl record, this means the recording surface is protected from dust and scratches.

During recording, the laser heats up a small spot - which moves along the pre-defined track as the disc rotates. When it cools, it "remembers" the magnetic field imposed by a small electromagnet resting just next to the disc surface. Reading is accomplished by using the laser at a lower power. The magnetic state of the track is read by sensing the changes in the polarisation of the light it reflects. This change is very slight and the optical read signal is very subtle compared to the robust signal returned from a pre-pressed CD.

Magneto-optical discs can be re-written millions of times. The principle has been used for data storage on computers, but conflicting standards and rapid advances in both magneto-optic and the competing magnetic hard discs have meant that the market developed slowly and without a common standard. The A Mini Disc computer peripheral has been released - storing 140 Megabytes of data.

Magneto-optical drives will never offer the fast data transfer speed or the rapid access of magnetic hard-discs. The primary reason is that the reading head involves optics which cannot be further miniaturised and are several hundred times heavier than those of a magnetic hard disc.

MAGNETIC HARD-DISKS

Magnetic hard-disks are never likely to be a consumer sound recording medium. Removable cartridges are now available offering 270 megabytes in a package three times as thick as a standard 3.5" floppy disk. However these cost over $100 per cartridge and are delicate - for the fundamental reason that magnetic hard disks heads fly like a hovercraft very close to the disk surface - which must be mirror flat. The head flies on a cushion of air which is thinner than the diameter of a particle of smoke. Dust, scratches and fingerprints must be excluded - so hard-disk cartridges are not tough enough for consumer use.

However the sealed, non-removable *fixed* hard-disk has an important role to play in the future music market because all home personal computers will contain such a drive with enough capacity to store several hours of music with 2:1 compression.

Since their introduction in 1956, magnetic disks have increased in performance by about 25% per year - until the last few years when the rate has climbed to about 60%. A number of technological advances, together with a huge world commodity market in drives for personal computers have caused the recent jumps in capacity and speed together with drops in price.

A 1 Gigabyte hard disk retails now (April 1995) for about $700 - in November 1994 it was $900 and at the start of 1994 it was at least twice this. The street price of a 2 Gigabyte SCSI drive has dropped as low as $990. The standard drive in a personal computer is now 540 Megabytes, at a retail cost of around $320. Five years ago the standard drive was 40 Megabytes - for more than twice that price. In mid 1987, the standard 20 Megabyte drive was selling for between $900 and $3000 and the largest available drive - 800 Megabytes - retailed for $18,000[2]. In early April 1995, an 850 Megabyte drive costs $490. Over 8 years this represents at a 76:1 increase in the Megabytes per dollar ratio for the most common drives found in personal computers - a performance gain of 72% per annum.

Given the huge demand, and the fact that several avenues of technological improvement remain to be exploited, it is likely that the average personal computer in 2000 will have a disk capacity of between 2 and 6 Gigabytes.

Personal computers in the future are likely to be storing large amounts of software and even larger quantities of music and especially video data. This raises the always difficult question of back-up. CD-Rs, described in the next section, are a likely candidate for solving this backup problem and performing other useful functions. So are re-writable discs based on Magneto Optical and phase change technologies.

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2 Past prices come from Australian Personal Computer - Hardware Buyers Guide.

CD-RS - WRITE ONCE CDS

> *The following sections on optical discs explores low-level physical and data storage issues. For those readers who want to skip the details and concentrate on the big picture, the summary is:*
>
> *Pre-pressed, write once (CD-R) and re-writable (Magneto-Optical) discs will increase in capacity and decrease in cost. The most immediate change is that it will soon be cost effective for retailers to make CD-R discs for customers containing the music they want. By 1998, a significant number of music buyers may be able to afford CD-R writers themselves, and so be able to make their own audio CDs and CD-ROMs.*

In 1982, the CD system designers did not anticipate that a CD could be written, rather than pressed. However there are now techniques for using a laser to permanently change a dye or metal layer buried in the disc in a way which makes it readable by a standard CD player.

These "Write Once" CDs are called CD-R for CD Recordable. Prices of CD-R writers have dropped to about $4000 (from $20k+ in 1990) and the blank discs cost around $20. However it is likely that with increasing demand - especially at lower prices - that CD-R recorders will become consumer items like CD-ROM drives are today and that the cost of the discs will drop to around five dollars each.

CD-R writers are computer peripherals. Their primary application is for backing up the huge quantities of data which accumulate in businesses - especially those in the graphics field where a single photo may take 200 megabytes of storage. In this application, the result is a CD-ROM containing up to 683 Megabytes of files, which can be read by any CD-ROM reader.

CD-R writers are also being used increasingly to make one-off or small production runs of CD-ROMs for interactive applications.

With appropriate software, the same hardware can be used to create an audio CD which can be played in any CD player. An article reviewing such software appears in the November 1994 *Mix.* As with many CD-ROM formats, the disc must be written in one session without interruption. The directory of a standard audio CD is at the start of the disc and must be written first. This means that all the music for the disc has to be loaded onto the personal computer's hard-disk beforehand, the track schedule must be defined, and the recording must proceed in one unbroken session. Some CD-R writers can write at twice or four times the standard speed - so a 74 minute audio CD could be written in 19 minutes.

The fact that the audio CD's directory is at the start means that it cannot be updated with a write once medium such as CD-R. Although tracks could be added at a later date, the directory could not be changed to point to them, so a standard CD player would not find them.

Several years ago, Tandy Radio Shack announced that it had purchased a start-up company which had devised a way of making an *erasable* writable disc which could be read by a standard CD player. Nothing has been heard of this technology, but if it is ever developed, it could have a profound impact on the music industry.

CD-R is also the basis of the Kodak Photo-Disc. This failed to gain a consumer market but is being accepted as a professional tool, although its image quality is not sufficient for the most demanding applications. In this case the directory structure is extensible so that even with a write-once medium, new files can be added. The ability to add data to a CD-R disc is called "multi-session". This requires that the directory structure be extensible, and that the CD-R writer and driver software can work with that directory structure.

CD-R writers have a mechanical system similar to a standard CD player, but they have finer optics and a special higher powered semiconductor laser. They also require extra electronics to perform the elaborate error correction encoding required for the CD. They require a SCSI computer interface and appropriate driver software. CD-R writers can be plugged into a computer much like a CD-ROM reader.

Their cost is dropping and the demand for their data storage capacity is rising. It is widely believed (and/or hoped) that their cost will come down precipitously in the next few years and that they will become standard equipment on high end personal computers for business and home applications. The electronics can be integrated at a low cost in mass production, and the driver software costs amortised. The laser and optical costs can be greatly reduced in mass production.

Given the huge demand for high capacity back-up onto a permanent, low cost, easily read medium, it is quite possible that CD-R writers will become a consumer item. By 1998 they may be as common in personal computers as CD-ROM drives were in 1994. However CD-Rs face a strong challenge from new re-writable Magneto Optical disc systems which offer 650 Megabytes of storage in a cartridge similar in size to, but twice as thick as, a 3.5" floppy disc.

Although removable hard-disk cartridges are attractive for computer backup because of their speed and re-useability, they are not likely to approach the low cost of a CD-R disc - which could sell for $5 and be capable of holding 683 Megabytes of data as a CD-ROM or 74 minutes of music.

However, before their costs come down to consumer levels, CD-R writers will be cost-effective for retail applications such as creating an audio CD in-store while the customer waits.

NEW CD DATA FORMATS

In this section and the next, the term CD is used broadly - to encompass 12 cm discs which may be pre-pressed discs with fixed data or are write once CD-Rs. The focus is on discs which are based on existing CD technology rather than on Magneto-Optical principles.

The "data" format is the way the data is arranged on the disc, while the "physical" format refers to how the information is written into the recording layer inside the disc.

For instance an audio CD has a different data format to a CD-ROM. Their physical formats are identical at the level of pits, bits and low level error correction. However their directory structure, and the way the main body of data is organised varies greatly. In fact there are many types of CD-ROM - each with a different data format, but the software in personal computers tries to hide the differences.

Audio CDs and CD-ROMs all have a directory (like a table of contents) at the start of the disc. However some applications of CD-R discs require that this directory be modified or replaced as new data is added in separate recording sessions. Since the physical medium is not rewriteable, a new kind of data format is required which specifies that any reader should search for the most recent directory - which will be near the end of the recorded portion of the disc. Such a data format is required if the CD-R is used for multiple backup sessions on a single disc.

It would be possible to create a data format such as this for the storage of music - so that tracks could be added at different times and a new directory added at each writing session. Such a disc would not be recognised by today's audio CD players.

CD players could be built to read a disc with this data structure as well as that of standard audio CDs. There would be no extra cost other than adding slightly to the firmware (fixed, inbuilt software) in the CD player's microprocessor. Such changes, however are only likely to take place when an international standard is accepted, or when a major manufacturer or consortium introduces it. At present, there is no need for such an up datable data format for audio CDs - since very few people have CD-R writers.

If a new data format was to be adopted for audio CD players, it is highly likely that it would incorporate other features. The most obvious feature is that the audio could be compressed in a variety of ways to increase the amount of music which could be stored on a single disc.

Three rates of audio compression are provided in the Compact Disc Interactive standard - which was established in 1986. These used ADPCM (Adaptive Delta Pulse Code Modulation) compression which records the changes between successive samples, rather than the absolute value of the samples. This is a lossy compression algorithm which is less sophisticated than toady's approaches which are based on a model of what the ear can and cannot hear.

These three rates are described (Pohlmann 1988) as having sound qualities comparable to a vinyl LP, FM and AM radio, with maximum capacities on a disc of 4.5, 9 and 19 hours respectively. These compression schemes and other more modern ones are used in multimedia discs - but so far consumer audio CD players have not been designed to use them.

CD-ROM formats have been continuously evolving despite efforts to arrive at definitive, open standards. There are now efforts to define a standard which encompasses the audio CD standard, and provides for CD-ROM data and multi-session CD-R writing. The plan is to provide a common framework which allows for new styles of data storage - such as compressed audio and video - and the mixing of different styles.

This proposal - "CD-Plus" is based on the audio CD format so that all such discs can be played in a standard audio CD player (Fox 1994). (However since this was written in December 1994, a lot has happened in CD standards - especially the High Density Multimedia CD described below.) Perhaps only a fraction of the disc will be used for standard audio, or none at all, but the standard ensures that the disc can be played in a standard audio CD player without causing problems. Existing CD-ROM formats produce extremely loud noises when played in some audio CD players.

Sydney company Pacific Advanced Media Studio achieved a world first by combining CD-ROM data on an audio CD with the GF4 *Sooner or later* 6 track CD single. This plays normally on any CD player and is recognised as a CD-ROM by standard Mac and IBM PC software.

These new flexible data formats for CDs have obvious applications in multi-media, but there are quite a number of valuable audio applications. Some of these applications could be realised in standalone CD players - in the home and car, and in portable equipment.

- Increased audio capacity in proportion to the compression ratio. Lossless compression at 2:1 gives 158 minutes. 6:1 compression gives 7.4 hours.

- New types of data could be included on the disc - including data for computer applications, compressed video or text.

- One of the new types of data could be one or more "playlists" - the orders in which the tracks should be played. A disc with 7 hours of music could have multiple playlists which included different subsets of tracks. More sophisticated playlist functions could be implemented - such as advanced shuffle play facilities. Using such a scheme, it would be possible to make a self shuffling aerobics CD which specifies to the CD player how to make random choices from one set of tracks for the warm-up, and from other sets for the various phases of the work-out.

- The disc could contain extra information about the music tracks relating to the exact timing of their beats - so that the player could automatically mix on the beat from one track to another using a memory buffer.

- Additional information on the disc could provide information about the tracks - lyrics and information about the performer and composer.

- The information could aid selection of the music according to mood, style tempo and key signature.

- CD-R discs could include user specified information about playlists and advanced shuffling strategies as described above.

- CD-R discs can have tracks written onto them in separate sessions.

- CD-R discs can have their directories re-written to "delete" old tracks and include new ones.

The aerobics playlist application is a good example of using relatively simple computing concepts to greatly increase the value that people derive from the music they purchase. Aerobics music has to be *right,* but the music choices must vary in certain ways through the session and ideally should be different from one session to the next for variety. Even with a mass produced CD, it would be possible to use suitably designed players (or personal computer software) to control the playing just the way the user desired. Players can be designed with non-volatile memory to store the user's playlist options - and these could be automatically applied when a particular disc is inserted.

Some user specified playlist functions are now found in software to control audio CDs in the CD-ROM drives of personal computers. Playlist functions with non-volatile memory are also found in some domestic CD players - especially those which hold multiple discs. Such functions are of limited value with a 74 minute disc, but would be useful and probably necessary with a disc which contained 7 hours of music.

Advanced and user definable playlist functions are equally applicable to "ordinary" music - although some albums have tracks which are intended to be played in a particular sequence. Such functions allow great scope for crafting personal ambient music environments, ambient music for noisy parties - or supermarket background music.

These playlist functions allow considerable value to be added to the music, with negligible storage costs and only moderate hardware costs in the more complicated software and user interface of the playback equipment.

The combination of standard audio with CD-ROM data on one disc is being used by US company SelectWare (Attwood 1994). They have formed a council for "Enhanced Audio Products" to develop interim standards for the technique. Their first disc *MusicROM Blues* contains 13 classic blues tracks and data from the All Music Guide including 700 biographies and a guide to 5,000 blues titles. However the first audio tracks function as CD-ROM tracks and the user is warned not to play the first tracks on an audio CD player. SelectWare plans to release a series of such discs covering different musical genres and to provide CD-V video data on some discs as a promotional tool.

There are a plethora of non audio CD formats and it is beyond the scope of this paper to explore their characteristics.

One extension of the audio CD format is called "HD CD" - High Definition CD, not to be confused with the HDMM CD physical format described in a following section. These discs can be played in standard audio players with standard 16 bit performance and frequency response, but supposedly reveal greater detail when processed with special electronics - whose principle of operation remains secret. An HD CD player is reviewed in the February 1995 issue of the UK magazine *Hi Fi World.* The HD CD system was developed by a US company called Pacific Microsonics, and it is claimed that a suitable decoder produces a 20 bit resolution output, and that 24 bits would be feasible if such DACs were available. The latter claim in particular is difficult to believe.

The reviewer's glowing appraisal for HD CD's sound quality needs to be considered in the light of similar appraisals of the sound quality of esoteric products reviewed in such magazines, including products whose improved performance cannot be measured or understood by objective physical means. The review listed a total of ten HD CD discs. This format seems unlikely to grow beyond the hi-fi market, particularly since it faces a challenge from new physical formats which allow higher resolution and higher sampling rates without the need to squeeze data inaudibly into the standard CD format.

The International Standard Recording Code

There has been one extension to the audio CD data format which is for internal use by the music industry, rather than by the end user - the International Standard Recording Code (ISRC), which is a numbering system for individual music recordings. The ISRG is intended to aid administration within the industry - especially the work of the copyright collection societies. The standard was adopted in 1986 by the International Organisation for Standardisation (ISO). In Australia, ARIA has responsibility for the administration of the numbering system. Anyone involved in releasing recorded music should be aware of the scheme - explanatory material is available from ARIA.

Each recording - including each separate mix - should be assigned a unique code at the time of its creation. An example of an ISRC code for a particular track is:

```
ISRC   AU-MU0-95-00278
```

`AU` refers to Australia. `MU` identifies the company which first owns the recording - these two letter codes are assigned by ARIA. `0` specifies that the recording is audio - `8` would be used for video. `95` is the year the recording was created and `00278` is the unique number assigned to it by the company.

The two character company code provides 676 combinations of alphabetic characters, or 1296 combinations of alpha-numerics - assuming that upper and lower case is not used. This may be a bottleneck considering the number of companies which could be recording music in the future.

Another potential problem is wrap-around after the year 2000. Recordings made before 1940 should use the year that the ISRC was first assigned, so problems should only occur after 2040 for those companies which have been active for over 100 years.

This numbering system is intended to be used in many aspects of music industry administration. To aid this, it should be recorded in the sub-code of digital recordings - most prominently the audio CD. Sub-code data accompanies the audio data on a CD, but is largely unused. It does not affect the sound in any way, but can be transmitted through the digital interface to other equipment. CD players in radio stations - or equipment attached to the CD players - can display the ISRC code for the track being played, or convey it to a computer.

Audio compression algorithms and computer audio file formats typically work with only the audio data - so the ISRC code would not be included in them.

NEW CD PHYSICAL FORMATS

A full description of the physics of optical disc recording would require extensive diagrams and is not attempted here. Three references which provide better explanations are Pohlmann 1998, Pohlmann 1991 and Pioneer 1992.

Optical discs such as the CD use the tightly focused light of a laser to read - or write - the features of the recording surface. The data density is limited by the ability of the light beam to resolve fine features, and this is determined primarily by the wavelength of the light. Shorter wavelengths (towards blue) can be focused into smaller spots to resolve greater detail.

The CD was designed around a laser made from a semiconductor chip - for reasons of cost, reliability, size and power consumption. A near infra-red laser with a wavelength of 780 nm (0.78 um = 0.00078 mm) was chosen. This is focused to a spot about 1.7um in diameter and is used to scan pits which are arranged in tracks with a separation of 1.6 um. Thirty of these tracks would fit in the diameter of a human hair.

The data is encoded on the disc by varying the lengths of the pits and of the gaps between them. There are 8 different lengths - varying in steps of 0.277 um. The presence or absence of the pits affects the amount of light reflected from the disc and the optical detector picks up the varying light levels and converts them to an electrical signal. This is done with sufficient accuracy to enable a 2.770 um pit to be distinguished from a 2.493 um pit.

Comment [RW5]: Page: 56
A diagram would be really good here, showing pits and their varying lengths, with some indication of the scale.

If the wavelength was halved, then the tracks could be spaced at half the distance (0.8um), and the data encoded with twice the linear density by using pit and gap lengths which vary in length by only 0.138 um. Thus halving of the wavelength would quadruple the data density of the disc.

There are other enhancements which are possible without changing the wavelength of the laser. These involve finer optics, with better tracking to enable the track spacing to be reduced - and more elaborate methods of encoding the data and providing error correction.

The ability to build semiconductor lasers depends on the fundamental properties of materials and huge investments in basic and applied research. Two new wavelengths will be available in the future for optical discs. Firstly, 635 nm visible red light from semiconductor chip lasers - which are available now. Secondly, blue light of approximately 425 nm - from either a semiconductor chip laser, or from a frequency doubling material driven by an 850 nm laser.

635 nm red light discs

Since the CD system was designed, semiconductor lasers have become available with 670 nm visible light - as used in lecture pointers. A new CD system has been proposed based on visible red laser light at 635 nm. (Fox 1995a).

There are several proposals, including plans from Toshiba and Matsushita. However the most promising one is from the original CD developers Philips and Sony, who have been working with US company 3M (Philips 1995). The Sony-Philips proposal provides 3.7 Gigabytes of data on a single disc which is similar to today's pre-pressed CDs, except that its tracks are closer and contain pits which are smaller and with finer variations in their lengths, and in the distances between the pits.

In March, Sony, Philips and 3M showed a prototype disc which contains two layers of pits - for a total capacity of 7.4 Gigabytes. The double layer disc uses a transparent film embossed with a second layer of pits. The surface on the main disc is partially reflective so the laser can detect the pits on this disc, but can also see through them to the pits in the film.

The single layer discs can be manufactured on existing CD presses with only minor modifications - so they should cost no more than standard CDs to manufacture. The double layer discs require a single layer disc, with a special semi-reflective coating, equipment to emboss the film, align it with the disc and cure an adhesive with ultraviolet light. No estimates are given of the manufacturing costs of the double layer discs, but the process is at least twice as complex as a standard CD manufacturing operation.

This system is called the HDMM CD - for High Density Multi Media. (The term HD CD has been copyrighted for a special kind of audio CD which was described earlier in this chapter.)

Players for these CDs use 635 nm light, finer optics and more sophisticated electronics than a standard CD or CD-ROM player. However, when quantity production is achieved, there is no reason why they should be significantly more expensive than today's players. The new players will be able to read standard CDs.

The HDMM CD is aimed primarily at the digital video and computer CD-ROM markets, rather than the music market. However the double layer disc could contain 11 hours and 36 minutes of music at the CD standard of 44.1 kHz 16 bit stereo.

In addition to the standard 12 cm disc, the HDMM CD proposal also provides for 8 cm discs - with capacities of 1.15 and 2.3 Gigabytes for single and dual layer versions respectively. This smaller disc is aimed at CD-ROM applications in portable computers.

The following discussion assumes a 3.7 Gigabyte capacity for the 635 nm Sony-Philips proposal compared to 0.784 Gigabyte for a standard 74 minute audio CD using 780 nm light. This is 4.7 times the data capacity of a standard

CD. The double layer discs are not considered in this discussion, although they will no-doubt be used for music in some way.

Part of this improvement may come from the 4% of unused "sub-code"[3] data on the audio CD. The shorter wavelength alone would provide a data density of 1.51 times the original by allowing the tracks to be spaced closer together and by allowing finer steps in the lengths of pits and gaps. The tracks of the HDMM CD are 0.84 um - nearly twice as densely packed as those of a standard CD. This leaves a factor of three improvement (+200%) in data density which must have been achieved by other means such as better optics, tracking and pit length coding systems.

Existing CD video discs use the standard 0.783 Gigabyte capacity of audio CDs and are limited to using 1.4 Megabit/sec with MPEG-1 - so they do not provide full quality video. The HDMM CD is intended to carry MPEG-2 video data at an average data rate of 3.6 Megabit/sec. With stereo or surround sound taking between 0.192 and 0.384 Megabits/sec, this should give good video quality for movies. At this data rate, the single layer disc plays for 135 minutes - which should be adequate for most movies. The double layer disc could play for 270 minutes - which seems more than sufficient for most anticipated applications. The Philips press release states that this is ideal for "epic-length motion pictures, movies with sequels, interactive movies and movies with interactive games."

While this capacity seems to be overkill for movies, it will surely be fully utilised in computer CD-ROM applications - especially games involving video and graphics. The press release makes no mention of music applications - which is ironic since the CD was developed especially for music, at a time when most computers would have been incapable of using a CD-ROM's data capacity.

Market prospects for red light discs

The future of at least the single layer version of the red light disc seems assured. A factor of 4.7 increase in capacity is quite sufficient to warrant a new round of disc readers in consumer equipment. There is no reason why the new readers should be much more expensive than existing CD mechanisms.

The single layer discs will compete with video cassettes in the rental and sell-through markets, and their success in this respect will in turn compete with subscription TV and later with Video On Demand.

The CD-ROM applications of these discs are obvious - with some games already spilling onto two or more discs. Any musical applications of red light discs will have to be based on computers with the new red-light compatible HDMM CD readers.

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3 Sub-code data is an additional data stream on an audio CD which is only partially utilised - for track identification. It is used in a CD-ROM to aid error correction.

Stand-alone CD players and existing CD-ROM drives will not read the new discs. This presents little problem for CD-ROM market - which is rapidly growing and will adopt the new HDMM DC drives as soon as their costs are comparable to standard drives. The new CD-ROM readers will be able to read the old 780 nm CD-ROMs and will plug straight into existing computers with little or no change to the rest of the system.

The broader music market - which uses a large installed base of audio CD players - will be much more resistant to adopting a new format. Standalone audio CD players for red light discs are likely only to be produced once a new red light audio data format is well established. Any new format is most likely to arise from CD-ROM applications, and is likely to involve some kind of data compression, so a single layer disk with 2:1 (lossless) compression would play for over 11 hours.

Hi-resolution red light music discs

There are niche markets in which the long playing time of a new disc format would be particularly advantageous. Some classical and ambient music works would benefit from uninterrupted playing beyond the current 74 minute limit.

Another application of the HDMM CD is to provide music recorded at higher sample rates, with greater resolutions than the CD standard.

The up market section of the hi-fi market is characterised by a constant striving for better performance (or for esoteric approaches to sound reproduction) and there is a demand for music recorded with 20 bit precision at sampling rates higher than 44.1 kHz. Despite doubts that this would reproduce sound which most people would perceive as superior to that of 16 bit 44.1 kHz, this market has consumers who are prepared to pay handsomely for "high end" products.

There is a significant prestige factor in this market and high prices can be part of the attraction of a product. The perception of some of these consumers is influenced by factors beyond the physical sound which reaches their ears - and the mystery and excitement associated with exotic equipment and techniques is part of the experience they are willing to pay for.

The January 1995 edition of Stereophile carried an editorial affirming the sound quality improvement attainable by cryrogenically freezing CDs and by colouring their edges with green pens - both of which can have no effect on the data read from the disc. The sonic benefits which are apparently perceived by some purchasers of US$199 power cords, or of US$15,000 speaker cables (Stereophile 1994a) are similarly impossible to ascribe to physical processes.

Nonetheless this is a market, and a Stereophile reader survey (Stereophile 1994b) indicated that their 70,000 readers bought 2.8 million CDs a year. Hi-fi buffs and some music lovers are likely to provide sufficient demand for the establishment of red light disc audio formats offering longer playing times, increased sampling rates and 20 bits or more of resolution - probably without compression.

The diffusion of disc technology and the electronics required for 20 bit reproduction is now quite rapid. It is quite possible that high resolution red light discs and playback hardware will become available around 1997.

Audio books and spoken word

There is a growing market for audio books (see report in Billboard 22 October 1994) where abridged or unabridged versions of books are read aloud. Many people use these to "read" books while they are driving or working on something which precludes them reading text. Audiobooks are of immense value to blind people and those with poor sight. Audio-books started on cassette but are increasingly being released as multi CDs sets instead.

Speech could probably be compressed to around 120 kbit/sec with negligible loss of quality - especially since there are many pauses between words and sentences. A standard CD-ROM could thus provide around 13 hours of reading, and a red light CD-ROM could provide over 60 hours.

In either case, the discs could only be read on a computer or on a specially developed player - which unlikely to become a standard consumer item in the short term. In the long term audio books would benefit from new data and physical formats - because any book would fit on a single disc.

A speech quality audio data format has been available via the CD-I standard since 1988. It uses 4 bit ADPCM (Adaptive Delta Pulse Code Modulated) encoding to provide an 8.5 kHz bandwidth signal with a quality roughly equivalent to AM radio. This provides 19 hours on a 12 CM CD, and although this would be ideal for audio books, CD player manufacturers have never perceived that sufficient demand exists for this to make it a feature of their consumer players.

Spoken word recordings, often with some music, are a growth area in the popular "music" industry as reported in 13 August 1994 Billboard (pages 60 to 69). This extensive article reports on many successful releases, on record stores holding poetry readings and on how Lollapalooza 94 had a spoken word stage.

Adverts accompanying the article listed several spoken word releases which ran for 3 hours on two cassettes, and a *Star Trek Movie Memories - The book read by William Shatner* on four cassettes. This is clearly an area where longer capacity discs would be an advantage.

Red light discs - conclusion

It is likely that HDMM CD red light pre-pressed discs will be adopted rapidly in 1996-97 for video applications, and that the standard data formats - and probably the home player units - will also enable them to be used for primarily musical applications with a variety of compression techniques. However a large consumer installed base of HDMM CD players would probably need to develop before the music industry finds it attractive to produce music only discs for them.

If multi-channel "Home Theatre" hardware is the birthplace of HDMM CD red light disc formats dedicated to music, then this may change the way music is mixed and created.

If red light discs were not developed in the next few years, there would have been rapid progress in new compressed audio data formats for 780 nm CDs. For consumer equipment other than computers, these data formats would require new hardware in CD players to de-compress the audio data. It seems likely that the HCMM CD red light discs and their compressed data formats will be the focus of industry attention, and that little more development will take place on new data formats for 780 nm discs.

The question facing the music industry is "When will consumers have enough red light players to warrant releasing music on red light discs?" The answer lies partly in the availability of the discs. If music was the only market driving these developments, then the chicken and egg impasse might persist for some time, since the standard 74 minute audio CD seems to be well suited to the majority of musical applications.

However, the adoption of red light pre-pressed discs for computer CD-ROM applications seems assured over the next few years. Likewise a consumer video market seems assured, as does a niche audiophile market for high resolution recordings.

While the CD industry was originally founded entirely on a consumer market for music recordings, the musical applications of red light discs may well be led by other industries based on home video and computerised multimedia.

With the new 3.7 Gigabyte capacity, and compression, perhaps red light discs intended for music will rarely carry sound only. They may contain 30 minutes of video material - video clips, biographies etc. at 4 Megabit/sec. This would take 0.9 Gigabytes - leaving 2.6 Gigabytes for music. At 2:1 compression, this is 8 hours.

Since all HDMM CD players will be capable of playing the double layer discs, there will rarely be a need to issue any foreseeable music product on two discs. The extra cost of the two layer disc is likely to be less than the cost of providing a second single layer disc and dual disc packaging.

The consumer adoption of pre-pressed red light HDMM CD audio only discs *in preference* to the existing CD format is likely to take many years, and may never occur. Ideally the music industry needs to release its product on one physical format, and as long as the music product is less than 74 minutes, then a standard CD is ideal since it can be played on all existing CD players as well as the HDMM CD players.

Because of the extreme cost sensitivity of consumer market for audio hardware, it is unlikely in the foreseeable future that consumer audio CD players would incorporate the finer optics and more advanced electronics required to enable them to play HDMM CDs, unless there was a substantial number of music only HDMM CD discs available. This would only happen if the music industry found that:

1 - A significant number of its music products were longer than 74 minutes, or benefited from multimedia extensions, or from features such as sophisticated shuffle play options - and so could not be released on the standard CD format; and

2 - There were sufficient consumers with HDMM CD players to warrant marketing the product in the new format.

Since HDMM CD players are likely to be primarily installed in computers and "home theatre" situations, the portable (Walkman) and mobile (in car) use of these music products would be precluded.

For music only situations - portable and mobile listening where visual and interactive aspects of the product are generally unusable - this is the classic chicken and egg situation.

425 nm blue light discs

Blue light semiconductor lasers are not thought to be practical for consumer equipment in the foreseeable future. The Japanese company Pioneer report in 1992 states that the lasers only operate when cooled with liquid nitrogen. Limited lifetime and efficiency are also problems, but in the longer term - 2005 and beyond - it is likely that these can be solved and blue lasers will be cost-effective for consumer applications.

However there is a way of producing blue light by "frequency doubling" the light from an 850 nm infra-red laser. This can be achieved by focusing the light intensely in a special non-linear crystal, which distorts the electromagnetic signal - like an overdriven guitar amplifier - and produces a second harmonic distortion. Alternatively the light can be passed through a fibre of a similar material to achieve the same effect. At twice the frequency, this light is deep blue with half the wavelength - 425 nm.

Theoretically, a 425 nm system has a data density of 2.23 times that of a 635 nm system ($635^2/425^2 = 2.23$). If these gains could be realised over the 635nm system, then pre-pressed discs with 10.5 times the capacity of an audio CD could be produced. - a capacity of 8.3 Gigabytes.

This assumed 2.23 ratio in data density due to wavelength reduction would only be realised if there are no limiting factors due to optics, vibration and the materials used for discs. This ratio of data densities matches that of Pioneer's claims in its December press release (Pioneer 1994) for their red and blue light discs - 5.5 and 12 Gigabytes respectively. This paper assumes a more conservative figure of 8.3 Gigabytes for blue light pre-pressed discs.

Pioneer, who has been developing the frequency doubled 425 nm light source is quoted in New Scientist in mid1994 as predicting that it will not be ready for consumer use for "at least another five years". Their December 1994 press release challenging the 625 nm red light proposal from Philips and Sony, promises a prototype early in 1995.

This frequency doubling distortion mechanism is weak and only occurs at high input powers. The 1992 Pioneer report states that efficiencies of 2 to 5% have been achieved. This implies high power requirements for the 850 nm laser which pumps the distortion medium and these power requirements may be a problem with battery powered equipment. CD-R or MO discs require higher powers for writing - and so the use of blue light for battery powered disc recorders will depend on the efficient generation of blue light, by frequency doubling or direct from a laser chip.

However, cost, high power requirements and a limited operating life will not necessarily stop blue light systems being adopted in higher value commercial applications. One such application is backup for commercial computer systems. The most prominent application of blue light CD-Rs is in a Video Server - a central storage for huge quantities of audio, video and computer information.

It may be tricky to make 425nm optics read 635nm and 780nm discs, but a means can probably be found to make the drives backwards compatible with older media.

Market prospects for blue light discs

This is difficult to predict - it depends on the success of the red light discs and on advances in the blue light sources. It seems likely that blue light technology will be adopted as soon as it is cost effective for video server applications - where CD-R or MO technology will be combined with mass disc storage systems (large juke-boxes) to provide low cost storage of Terabytes (a Terabyte is a thousand Gigabytes) of compressed video material.

However the emergence of consumer music discs based on blue light technology seems unlikely in the next 8 years. Some computer standards can change incrementally - for instance the evolution from the 4.7 MHz 8088 CPU to the 90 MHz Pentium. Other standards can only be changed by abandoning old investments in hardware and software. These are highly resistant to change despite obvious deficiencies in their performance. For instance the MSDOS with its 640 kbyte memory limit cannot be changed without abandoning the old system entirely.

Since blue light technology is likely to lag between two and five years behind red light systems, it could be a long time before they are used in large quantities for consumer music applications. However since more and more home listening may centre on the home computer, the modular upgradability of the disc player in this system makes it easier for consumers to read the latest types of discs.

The dual layer red light HDMM CD represents a tenfold jump in capacity over the standard CD which has been an established consumer product for over a decade. Blue light pre-pressed discs promise to double this, and the addition of a third or perhaps fourth layer cannot be ruled out.

It is clear that the tenfold improvement of HDMM CD is marketable, primarily because of the computer and video applications. Blue light CDs may be similarly important for delivering HDTV data on a disc - which is typically 20 Megabit/sec instead of the 3 to 6 Megabit/sec for PAL quality MPEG-2.

How important blue light discs will be to music only discs is questionable. A dual layer HDMM CD with 2:1 compression provides 23 hours of music, and a blue light dual layer disc could provide two days instead. While this would be an ideal basis for sophisticated shuffle play and mixing from a massive source of musical material for the purposes of ever-changing ambient music, the majority of today's popular music seems to fit will onto 74 minute discs.

However the same could be said of popular music fifty years ago fitting well onto four minute 78 shellac discs. In the foreseeable future - the next fifteen years, it seems unlikely that blue light discs will be used for music only applications except in niche markets.

CD and CD-R data capacities and availability

The evolution of red and blue light pre-pressed discs cannot be predicted with certainty in early 1995, but the prospects are bright for red light discs for video and multimedia applications.

Pre-pressed discs combine the distribution of content with the means by which the consumer accesses it. In terms of distribution, pre-pressed discs compete with video tape, distributive systems (VHF, UHF, cable, MDS and satellite) and with networked delivery of information - the Internet and in future the Ubiquitous Broadband Network.

Part of the demand for CD-R discs can be attributed to their distributive function. For instance a consumer purchases a disc with the music, video or computer data that they desire from a retailer. This function is in competition with distributive and networked means of delivering data to the consumer.

However if CDs or CD-Rs are not used to deliver the content to the consumer and it is sent by distributive or networked means, then CD-Rs provide an excellent means for the consumer to store that content for future use. Although CD-Rs are not consumer items at present, their utility is immense and they will achieve a mass consumer market for a number of uses if and when the price of the CD-R writers declines sufficiently. Magneto Optical discs and phase change discs (described later in this chapter) have even higher utility because they can be rewritten. The development of these re-writable systems may parallel or overtake that of CD-Rs.

Neither CD-R or MO discs are likely to achieve the same data density as a pre-pressed disc using a similar wavelength of light. A light beam of a given size (determined by the wavelength) can read smaller pre-pressed pits with closer track spacings than it can write with heat - using CD-R or MO techniques. This is not apparent with standard CDs - where the CD-R discs have the same capacity as the pre-pressed discs. In this case, the original design of the discs was conservative (by today's standards) for the 780 nm wavelength.

The 3.7 Gigabyte capacity for 625 nm red light pre-pressed discs could not be achieved with a CD-R using the same wavelength. It is not clear what capacity could be achieved, but this paper assumes that only 60% of that figure could be achieved. A similar assumption is made for blue light discs. Dual layer CD-R and Magneto Optical discs are probably quite impractical, since this would involve the first layer being semi-transparent, when it also has to absorb energy and reflect light when being read.

A second factor is the relationship between the capacity of a disc for video and audio, which can tolerate a low level of errors, and the capacity for computer data, where errors cannot be tolerated at all. A 74 minute audio CD carries 784 Megabytes of data, but CD-ROMs, which use the same physical format, carry a maximum of 682 Megabytes because some of the raw data is used for error correction to improve the robustness of the user data against manufacturing defects, dust, finger marks and damage to the disc.

540 Megabytes is sometimes quoted as a practical limit for CD-ROM discs. This may have been due to reliability problems at the edge of the disc. It is common now to find CD-ROMs approaching the 682 Megabyte limit - recent cover discs on *CD-ROM Today* magazine have contained between 650 and 660 Megabytes. This paper assumes that data stored with CD-ROM reliability will incur a 15% loss of raw data capacity.

Table 4.1 lists storage capacities and cost-effectiveness dates for pre-pressed and CD-R discs using three wavelengths of light. The cost of the discs is unlikely to vary significantly between the wavelengths once mass production commences. The dates and data capacity of the blue light discs are necessarily speculative. The dates of the red light HDMM CDs are firmer, since the next two years will see them introduced as quickly as possible by their developers to head off competition from alternative formats, and indirectly from the biggest threat to pre-pressed optical discs - Video On Demand. Note that the capacities claimed by Pioneer for their pre-pressed red and blue light discs are 50% greater than the figures assumed in this paper.

These figures are for single surface discs which can be manufactured using existing techniques. The double layer HDMM CD will be feasible and cost-effective for applications requiring its huge capacity.

If blue light pre-pressed discs were competing with just the red light discs and the existing technology, they would surely win a substantial portion of the video and CD-ROM market. However, by that time - 2000 to 2005 - discs of all kinds will be competing with broadband delivery technologies into the office and home, which will connect more and more consumers with the global network for specialised data, and with local video servers for video news, entertainment and education.

TABLE 4.1 CD AND CD-R FORMATS

	Wavelength	*780 nm Standard CD*	*635 nm Red Light HDMM CD single layer*	*425 nm Blue Light single layer*
Pre-pressed discs	*Cost-effective for commercial use*	1983	1996?	1998?
	Cost-effective for consumer use	1984	1997?	2002?
	Capacity of pre-pressed discs - Gigabytes	0.783 0.683 for data	3.7 [a] 3.1 for data	8.3 [a] 7.0 for data
Writable discs - CD-R [c]	*Cost-effective for commercial use*	1989	1996-97?	2000?
	Cost-effective for consumer use	1998 - 2002?	1998 - 2000?	2002 - 2005?
	Capacity of writable discs - Gigabytes	0.783 0.683 for data	2.2 [a b] 1.9 for data	5.0 [a b] 4.25 for data

a These capacities are for audio or video data. For computer applications, more raw data bits need to be used for error correction, so the useable capacity is around 85% of this.

b The capacity of a CD-R system will not be as high as for pressed discs. Pressed discs can be manufactured with greater accuracy than the CD-R writing can achieve. The assumption has been made that only 60% of the capacity is available for CD-R due to the need for wider tracks and looser tolerances on the pit lengths. This does not apply to existing 780 nm discs since these CD-R discs are close to optimum performance while the pressed discs (based on the 1982 design) are sub-optimal compared to the performance which could now be achieved with 780 nm.

c The capacities and dates for CD-R are a rough guide to what may be achieved with re-writable optical discs - Magneto Optical and the new phase change discs.

Business applications of pre-pressed CD-ROMs of any capacity are likely to be affected by the increased availability of up-to-date data direct from the source over the global network - from databases far larger than could be held on any disc. In addition data suppliers may be less willing to sell their entire data product on CD-ROM because of the increased ease of copying it with CD-R and over the network. They may prefer to sell it in smaller quantities via the network. For business, a key factor against CD-ROMs is that the data they contain is likely to be out of date by between one and six months.

The introduction of secure automatic funds transfer with no operator involvement will make the network sale of data very attractive to both the seller and the buyer and so the current practice of selling the entire data set on a CD-ROM is likely to diminish.

The same arguments apply to consumer discs for music, video and computer data - by the time blue light pre-pressed discs become well established, a substantial proportion of the market will be able to source the information they want from the network.

However, for both business and consumer markets, the long-term prospects for blue light *writable* discs - CD-R and MO - are very bright, because of the increasing need to store the large quantities of data obtained from the network.

Magneto-Optical vs. CD-R discs

CD-R discs are written by a laser heating and deforming a dye layer, so that optically it resembles the pits of a pressed CD. These deformations cannot be re-written.

Magneto-optical (MO) discs also heat a layer buried inside the disc, but the layer retains a magnetisation pattern as it cools. These magnetisation patterns slightly rotate the polarity of the reflected light and these changes can only be read by an optical system which is quite different from that required for reading standard pre-pressed CD pits. However it *may* be possible to make an optical unit which could read both MO and standard CD tracks - both pre-pressed and CD-R.

Further, it may be possible to make an optical system capable of writing both MO and CD-R discs - including those intended to be read with both 780 nm and 635 nm light. So in the future, backward compatible CD readers and writers may appear, but they would only be likely to appear if both MO and standard CD discs were the same size. This has not occurred so far - all MO discs are physically different in size and packaging from the standard CD - primarily because the standard CD has no case to protect against dust and scratches.

It seems likely that MO discs (both re-writable and pre-pressed) and drives will follow a separate development path from the discs and drives intended for CD-

R and pre-pressed discs based on the original CD pit system. The two reasons are:

1 - Both pre-pressed and writable discs for the MO system have quite different optical characteristics to discs following the original CD system.

2 - MO discs are likely to be enclosed in cartridges - to protect the disc and the valuable user data it contains. CD readers which remain backwards compatible with audio CDs and CD-ROMs are likely not to accept discs in cartridges, but remain with the bare disc approach of audio CDs.

This bare disc approach makes the discs vulnerable to damage from handling, but is mandated by the need for backwards compatibility, cheap packaging and thinness. The thinness of the disc is crucial when they are distributed as magazine cover discs, when they are sold in multi-disc sets and when they are used in large jukeboxes.

The 12 cm naked disc physical form of the audio CD may become such a strong standard that MO discs will have to follow suit to be used in jukebox and desktop computing applications.

If there were no installed base of discs and drives following the old system, then it is likely that all new optical disc developments would be based on MO principles, with a compatible pre-pressed format to suit. MO is not inherently more costly than CD-R - either in the drives or the media.

Mass data storage on removable media in personal computers is currently provided, if at all, primarily by tape cartridges or DAT drives. These are typically used for backup. Removable cartridge magnetic hard discs (such as the popular Syquest 270 Megabyte 3.5" units used widely by musicians), CD-R writers and MO drives will compete for the rapidly growing removable mass storage market and it is impossible to predict the outcome.

The ISO standard for 3.5" MO discs with 128 Megabytes capacity have been available for some time, but have not sold well. They are not as fast for reading as a magnetic hard disk, and writing is significantly slower still, since each track needs three passes - for erase, write and verify.

This ISO standard has recently been upgraded to 230 Megabytes and drives are not available which read both kinds of discs. However their capacity is too low for most backup applications, and the drives are slower and more expensive than the Syquest 270 Megabyte magnetic hard disks. Magneto Optical drives have not yet achieved a mass market.

The ISO 3.5" MO standard is expected to be extended to 640 Megabytes later this year (Dvorak 1995), with drives able to read and write both the 640 and 270 Megabyte discs. A 640 Megabyte capacity makes the system much more attractive for backup, and as a removable storage medium capable of storing data equivalent to a CD-ROM.

The ISO standard for MO discs is supported by IBM, Fujitsu, Matsushita and others and faces a direct challenge from Sony, supported by Hitachi, 3M and others. Sony plans to release a 3.5" Magneto Optical drive in mid 1995 with a capacity of 650 Megabytes, which is targeted at a mass market. This system eliminates the erase pass, and requires just two revolutions for erase/write and for verification.

Magneto Optical discs are inherently cheaper and more reliable than magnetic hard disk cartridges, and while Syquest is promising an upgrade to 540 Megabytes, the MO discs have a good chance of success because their discs may cost $40 or so - less than half that of the magnetic hard disk cartridges.

The advantage of CD-R writers is that they can produce CD-ROMs and audio CDs - which most computers can read. MO drives cannot do this, but their discs can be rewritten just like a floppy disc.

A large part of the market for mass storage is to do daily backups for small businesses. The CD-R creates a permanent set of backup discs - but the operating costs are high because the discs cannot be recycled. However some larger businesses require a permanent record of all backups - so CD-Rs are ideal.

Other rewriteable optical technologies

In addition to the now well researched CD-R and Magneto Optical systems, other technologies may offer re-writable optical storage. One is "phase change" where the recording material is changed between crystalline and amorphous states - each which reflects light in a different way. This heats the recording medium buried in the disc, as do other technologies, but in this case the heat is sufficient to melt it. Depending on the heating and cooling process, the material can assume crystalline or amorphous states.

One such system is the 12 cm 650 Megabyte "Par Disc" recently announced by Matsushita. The Par Disc drives - as computer peripherals - have not been released yet. They can read and write their own discs and read existing audio CDs and CD-ROMs. According to a report (Dvorak 1995) by noted industry commentator John C. Dvorak, from which information in this section was sourced, Compaq will use these drives in the near future.

Another phase change system is being developed by Toshiba - with 1.3 Gigabytes being stored on a 3.5" disc.

A report in March (Fox 1995b) indicates that Philips is working with 20 other companies to define a CD drive standard which can read pre-pressed discs (presumably including the HDMM CD), write and read CD-Rs (presumably including higher density formats than today) and write and read phase change discs. An announcement was planned for April and Matsushita was described as having "jumped the gun" with the announcement of a drive for CD-ROMs and phase change discs - the one mentioned above.

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For the Occasional Paper, these details should all be known and the future of optical storage - crucial to the music industry - should be somewhat clearer.

Exotic mass optical storage techniques using holographic principles in solid blocks of storage media are being researched and may be used for later generation Video Servers, but they are unlikely to be used in the home in the next twenty years. This also applies to other techniques based on altering individual atoms and molecules.

The market for data storage will grow continuously and research is proceeding on many possible techniques. Ten years is long enough for a previously unknown or secret technology - such as the CD - to evolve into a significant consumer product. The cross-pollination of advanced technologies is likely to lead to storage systems capable of holding hundreds of gigabytes. For instance the application of CD, CD-R, Magneto Optical or advanced hard-disk magnetic technologies to tape based systems could provide huge storage capacities, because the area of tape in a cassette far exceeds the area of a disc.

The purpose of this section has been to show the scope for various forms of pre-pressed and writable storage developments in the next five to ten years. The picture is confusing, but the imminent announcement of a common drive for CD-ROMs, CD-Rs and phase change re-writeable "CD-E" discs should clarify things somewhat.

SUMMARY OF OPTICAL STORAGE DEVELOPMENTS

Despite some confusion about how these technologies will evolve, several things are clear:

1 - The HDMM CD proposal is highly likely to succeed, offering a tenfold leap in pre-pressed storage capacity, with little cost increase in the discs or the CD compatible drives that read them.

2 - There will be a contest between the writeable disc technologies - CD-R, two types of Magneto Optical, and perhaps two approaches to phase change discs. The CD-R and one of the phase change discs have the advantage that their drives can read existing CDs and perhaps the new HDMM CDs.

3 - Mass market audio applications will remain tied to the existing CD format for some time. They will only migrate to new pre-pressed formats after the equipment has been adopted widely for other purposes - CD-ROM and video.

4 - As businesses and homes connect to the global network at higher speeds, and as consumers wish to record digital video, a huge market will develop for read/write removable media systems approaching and exceeding a Gigabyte in capacity. CD-Rs have certain advantages - compatibility with CD-ROM and HDMM CD readers. Magneto Optical and phase change discs may be more flexible and cheaper since they can be rewritten.

    One or perhaps two standards of writeable optical storage disc is likely to emerge in the next four years, primarily for computer and video applications. These discs, will be cheap and capable of holding between one and three hours of music, or more with compression.

CD-R RETAIL APPLICATIONS

This section briefly describes the technology required for retailers to produce CD-R discs containing the music which customers want. A more expansive discussion is in Chapter 14. Chapter 17 discusses CD-R retailing further - exploring its position in the broader context of music discovery.

At its most basic level, CD-R retailing involves a customer going into a shop, and having a CD-R recorded with the music they choose. The disc is in the standard audio CD format - or in the future, one of the standard audio formats - so it can be played on a standard CD player. There are a number of variations on this theme, which are explored in Chapters 14 and 17. In this section the focus is on the low level technology.

Some CD-R recorders available now can write a disc at four times normal speed, so the customer might have to wait 19 minutes for a 74 minute disc to be created for them. It will be assumed that this time is not a significant impediment to the success of CD-R retailing. It will also be assumed that the cost of a blank disc to the retailer comes down to around $5. Labelling the disc and printing the packaging are discussed in Chapter 14. The copyright issues and business arrangements for collecting payments are clearly a major issue, but only the technical basis for supporting such arrangements are discussed in this paper - in Chapter 14.

In its most basic form, CD-R retailing could involve someone walking into a shop and asking for a particular CD - which is normally available as a pre-pressed disc. If demand for the disc is high and the stock of pre-pressed discs has been sold, the shop retains one copy of the disc and uses it as a master to replicate a CD-R copy. If demand is extremely strong, they may do a few discs at a time, so they can be sold to customers immediately. Alternatively, the disc may be replicated while the customer waits.

This involves no complex decisions on the customer's part about what is placed on the CD-R. The master CD is placed in a four times speed CD-ROM reader, and the blank CD-R is placed in a similar speed CD-R writer. These are connected to a computer, and relatively simple software reads the raw data from the master and writes it onto the CD-R. To a CD player, the CD-R is a "clone" - indistinguishable from the original.

To the customer, the disc is physically different because it is different from the usual silver colour, and the lack of the usual printing on the disc. The shop may print out a simple track listing, or photocopy the original CD's cover. Perhaps the shop could subsequently mail the customer a properly printed slick and booklet set, within a few weeks. These would be identical to what is included in the standard pre-pressed release and could constitute a "certificate of ownership" to the customer.

However much of the attraction for customers in buying a CD-R is the ability to choose exactly what tracks are on it - perhaps from a number of different artists. This is no longer a clone of an existing product, so the pre-printed slick and booklet does not apply. There needs to be an efficient way that customers can choose their music, and communicate their desires to the retailer. In a retail shop, if this was done with browsing of CDs via manually operated CD players, and the requested track list were hand-written, then the process would be prohibitively error prone and labour intensive.

There are excellent prospects for automating the browsing of music in general, the selection of tracks for a CD-R, and the creation of that CD-R from a music library. However these all rely on mass storage of music at the retailer's location and/or the use of telecommunications links from a mass storage facility somewhere else. Telecommunications links are discussed in Chapter 6.

The remainder of this chapter discusses mass storage systems for music, video and other data. These mass storage systems play a central role in the communications revolution - whether they hold a few hundred CDs in a retail shop or they store Terabytes of compressed video data for instant access from a million homes.

In addition to using CD-Rs to make discs to sell to customers, CD-Rs are likely to play a crucial role in the storage of music in a retail shop. They will typically be in a jukebox, and may have higher capacities than standard audio CDs - due to the use of red light for higher data capacity and the use of compression.

Although the following discussion refers to retail shops, similar uses may be made of CD-Rs and mass storage systems by the other kinds of retail operation who connect with their customers via the World Wide Web, or via mail or phone orders.

MASS STORAGE SYSTEMS FOR DISCS

There are many data storage applications which do not require the near instant access speed of magnetic hard-disks, and whose capacity requirement outstrip the capacity of an affordable array of hard-disks. Optical discs, or tape systems such as DAT, offer capacities in the Gigabyte range for between $10 and several hundred dollars per Gigabyte. Automated jukebox systems have been constructed for Magneto Optical rewriteable discs, DAT tapes and other cartridge based storage media.

This section will concentrate on the use of bare 12 cm optical discs in large jukeboxes. These discs may be pre-pressed or CD-R, formatted as audio CDs or CD-ROMs. In the future these will include discs based on red and blue light technology and may include Magneto Optical and phase change re-writable discs as well. (However all existing Magneto Optical discs are housed in cartridges.)

The bare disc form of storage has significant cost and space advantages when large numbers of discs are stored in a single juke box. Automated handling inside a dust free cabinet ensures there is no problem with dust and scratches.

Jukebox technology is likely to evolve rapidly as the market for them develops. Existing products are relatively expensive because they sell in low volumes. However as CD-Rs are being used more extensively for backing up corporate LAN servers, there is an increasing need for automated access to those backup discs.

Another market for CD jukeboxes as for the standard audio jukebox function for parties, pubs and clubs. Pioneer Australia is one of several companies supplying such jukeboxes to venues. The video equivalent of music jukeboxes can also be achieved with discs when full quality red light MPEG-2 video CDs arrive in the next few years. Previous video jukeboxes were based on video cassettes. These jukeboxes are typically operated by customers, and the proceeds split between the jukebox owner and the venue. The jukebox owner pays no special royalties beyond those inherent in the purchase of the CD, but the venue operator pays APRA public performance fees.

Related to these traditional jukeboxes are "automated music presentation management systems" which are controlled by the management of the venue. These comprise a CD jukebox, a controlling computer and software enabling the management to program how tracks are selected and played. Sophisticated control can be achieved by specifying how the style, tempo and volume of music will change at different times of the day. UK company *Data Beat* (+44 635 521 353) supply such systems based on jukeboxes made by Pioneer and other manufacturers, with capacities of 100 or 300 discs.

The music retail applications of jukeboxes is a major theme of this paper. The retail industry can take advantage of the jukebox technology being developed for other markets and use it for a number of purposes:

1 - Auditioning audio CDs in a retail shop.

2 - Auditioning audio CDs via phone. US retailer MusicLine (described at the end of chapter 14) enables customers to play selected pieces of music - but it seems they use samples on hard-disk. This gives fast access, but the customer cannot browse more than one or two tracks of the CD they are thinking of purchasing. A jukebox system would overcome this restriction and eliminate the need for large hard-disk systems.

3 - Auditioning music via the World Wide Web.

4 - Providing a source of music for CD-R creation for retailers operating from shops, WWW, mail or phone order.

Several manufacturers produce 100 disc jukeboxes for the home market. These are very compact and have a single player. The discs are stacked on edge in a doughnut shaped rack which rotates on a vertical axis. One UK company uses a Sony 100 disc CD jukebox to enable musicians to browse sample library CDs in a music shop.

However greater capacities are required for most music retail applications. Three jukeboxes are described below:

- Sony CDK-3600 360 disc audio jukebox. Two players provide analogue and digital outputs. The jukebox, players and the pitch and volume of the players is controlled by a computer via a serial cable (RS-232 or RS-485). A number of companies sell control software suitable for this and other jukeboxes. Like Pioneer, Sony do not provide control software themselves. Loading time is less than 15 seconds. The dimensions in millimetres are

800(H) x 430(W) x 452(D). The system can be rack mounted. Retail price $15,609 including tax.

- Pioneer CAC-V3000 300 disc audio jukebox. Similar to the CDK-3600 but with fewer discs and a 19 second maximum loading time. Dimensions 590 (H) x 360(W) x 360(D). Retail price $10,500 ex-tax.

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?? I should check the sales tax rate and make these prices inclusive of tax - 21% I think.

- Pioneer DRM-5004X 500 disc audio, CD-ROM and CD-R jukebox. Has potentially four drives which can be any mixture of CD-ROM readers (with analog audio out for audio CD signals) or CD-R writers. The mechanism and each drive has its own SCSI interface, and these can be chained onto one cable or accessed by separate cables leading to separate computers. Discs are stored in easily removable 100 disc modules. Average disc change time is 18 seconds. The drives operate at four times normal speed. The standard unit has two CD-ROM drives and costs $26,500 ex-tax. CD-ROM readers are $1750 each and CD-R writers - which can create both audio and CD-ROM discs - cost $7500. The drives can be exchanged easily, so when red light discs become available, new drives can be installed by a service engineer. Dimensions are about the same as a three drawer filing cabinet - 1159(H) x 453(W) x 507(D).

  This is the largest commercially available jukebox and is aimed primarily at corporate applications such as automatically writing large numbers of CD-Rs, and providing access to banks of pre-pressed and CD-R CD-ROM discs.

These jukeboxes transform the way that huge quantities of data can be accessed - they may become a crucial technology for music marketing. A 500 disc jukebox could store 1850 Gigabytes with single layer red light pre-pressed discs - 5,800 hours of music at 2:1 compression.

MASS STORAGE SYSTEMS FOR MUSIC AND VIDEO DATA

Another approach to mass storage of music is to digitise it and store it on hard-disk. Perth company Ogenic (previously PKE) specialise in hardware and software for managing large quantities of audio - primarily for broadcasting and court reporting. In one system costing around $100,000, 16 users have flexible and completely random access to all sound files on the system, whilst sound may be input on a number of channels simultaneously. Various compression schemes are supported and there can be multiple independent accesses to the same sound file. With falling disk drive costs and production in larger quantities, Ogenic estimate that prices could fall to 20% of what is charged for the custom built systems they currently manufacture. Their system is extensible to over 100 audio input or output ports.

A hard-disk system can be combined with a jukeboxes containing CD-Rs to provide flexible storage. Music may be received from a CD or via a telecommunications link and stored directly to hard-disk. It may then be automatically written to a multi-session CD-R disc in a jukebox. This frees hard-disk space whilst enabling the data to be stored cheaply for future access. Similarly, rewriteable Magneto Optical and phase change discs could be used as well.

Such a system would be ideal for a music retailer. It could provide music browsing facilities accessible from listening stations in the shop, phone calls or WWW sessions, and provide the source of music for creating CD-R discs for customer requirements. When telecommunication costs decline, and speed improves, it could also be used as the source of music for electronic delivery. The jukebox may contain a mixture of pre-pressed and CD-R discs encompassing audio CDs, standard CD-ROMs and red light discs.

The development of such systems for Terabyte storage will be driven by the needs of large corporations and companies working with graphics and video - as well as by music retailers and recording studios. These hybrid combinations of computers, hard-disks, and CD-R discs in a large jukebox may sound rather awkward at present - but it is a common solution to a variety of storage requirements and it is likely that such systems will be sold as an integrated, expandable package.

By far the most demanding application of digital mass storage systems is for the Video Server - the heart of a Video On Demand system. There will probably be many Video Servers owned by a variety of network operators and content providers. They will need to provide up to 6 Megabit/sec data streams of compressed video and other data to hundreds or perhaps hundreds of thousands of users simultaneously, whist responding to commands from the viewers and receiving and recording video data from external sources.

Video Servers will need elaborate switching hardware and control software. In addition to RAM memory chips and hard-disks for immediate storage, they will use optical discs and perhaps tape based storage as well. Thousands of these discs and tapes will be accessible by multiple readers and writers via an elaborate "jukebox" system.

Although these large Video Servers - and the network infrastructure which connects them to customers - will be built primarily for delivering digital video, they will be equally useful for music applications. A recording company or retailer might rent space on another company's server because it is cheaper and more reliable than setting up their own system. A similar situation exists today where these music companies use the World Wide Web servers of other companies for their marketing activities.

Hewlett Packard is reported (Pescovitz 1995) to be doing extensive development work specifically directed at a Video Server. Existing equipment performing Video Server functions in VOD trials at present is based on computer systems designed for other purposes. A practical Video Server has mass storage requirements equalling or exceeding that of the largest existing computer systems - a Terabyte or more. The recall and switching of thousands of multi megabit/sec data streams cannot be based on any existing system and will probably use the new ATM switching technology - so a practical system will require several years of intensive development.

CHAPTER 5 DISTRIBUTIVE TECHNOLOGIES

> *This chapter discusses audio and video broadcasting and distributive techniques including those based on satellite, microwave (MDS), and cable technologies. These may carry analog or digital signals and programming may be free, available only by paid subscription or by payment for individual programs.*

INTRODUCTION

Today's consumer broadcasting services - AM and FM radio, VHF and UHF TV - are being joined by a number of distributive systems based on radio waves, or radio like signals being sent through a coaxial cable to the home.

It is unlikely in the foreseeable future that homes will be connected directly to optical fibre. The basic costs of the optical equipment and the physical inflexibility of the fibre make it costly and awkward compared to coaxial cable. The "Hybrid Fibre/Coax" systems being installed by Telecom and Optus for subscription TV use fibre to carry signals to and from a coaxial cable which connects to 500 homes. (The 500 home limit applies to Telecom's plans. The details of the Optus system are not yet available.)

Originally both systems were planned to carry analog TV signals and later a mix of analog and digital signals. However Telecom has announced that it will use a digital video transmission system based on the European DVB standard and will not use analog video transmission at all.

Ultimately, both the Telecom and Optus systems are likely to be upgraded to carry signals which encode purely digital data, to and from the home. The cable system will then provide individual links to each home and will be part of the telecommunications system, rather than a broadcast system. The future digital operation of the cable systems are considered in the next chapter on telecommunications Networks. This chapter considers how the cables are used distributively - with analog and perhaps digital data being sent to all homes on the cable.

ADSL (Asymmetrical Digital Subscriber Line) is a technology for sending video rate (6 Megabit/sec) digital data on existing telephone wires - while the standard phone operates normally. Although this is really a telecommunications technology, it is discussed here because it will probably be introduced during a period of distributive programming. This chapter also considers satellite and MDS transmissions, and Digital Audio Broadcasting.

FUNCTIONAL EVOLUTION TOWARDS THE GLOBAL NETWORK

The evolution towards the global network is a continuous process. For the purposes of this paper, Australian developments will be discussed in three stages:

1 - 1995 onwards. Cable and other links are installed and used primarily for distributive video (pay TV). Optus' cable system will also be used for telephony (and perhaps BR-ISDN and data communications?). Telecom has not announced any plans to use its coaxial cable in this way.

2 - 1999 onwards. Video On Demand (VOD). The cable TV systems start to use digital techniques to allow video and other programs to be sent to each home individually. Other communication functions such as telephony and global network access will also be supported by the cable.

3 - Global network integration. This will be a continuous process starting now with ATM at a basic technical level, and with Internet, LANs, WANs and later VOD at a functional level - culminating in a global communication network which supports all electronic communication needs using common standards. These integration efforts could bring efficiency gains in the telecommunications infrastructure starting now (with ATM for WANs) with noticeable functional improvements affecting consumers around 1999. Perhaps the harmonisation of all telecommunications will be complete for the majority of the market in developed countries by 2015.

SUBSCRIPTION TV - LEADING TO A BROADBAND LINK TO THE HOME

Free to air (FTA) television can be viewed as an anachronism caused by the inability to individually control the delivery of video to consumers. If it was possible to provide programs only to those who paid for them, then there would have been no need to broadcast them so that anyone could watch them for free. However this was not technically feasible in the 1950's when TV was introduced.

The fact that free to air commercial television is supported entirely by advertising revenue is a result of a market failure caused by the technical inability of the producers to distribute their product to consumers in any form other than as a "public good" - a product which anyone can use, without detracting from its value to others. It is remarkable that the product of the TV industry - perhaps the most significant content industry of all[4] - is more freely available to many urban consumers than sunlight and fresh air.

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4 Most significant in terms of its impact on consumers and society in general, despite its revenues being less than those of print media.

To sell video material to consumers individually, the programs must be transported to the consumers by some means - such as radio waves or via a cable - and consumer's consumption of each program must be controlled by the producer.

Irrespective of the delivery mechanism, this control can only be achieved by some kind of scrambling for analog signals - or encryption of digital signals. Early scrambling systems were imperfect and could often be bypassed when a market develops for electronic "keys" to access programs without payment (Platt 1994). However later analogue scrambling systems have not been cracked despite the obvious incentives to do so. A properly designed digital video encryption system, with a home decoder based on a tamper proof chip with a unique serial number - gives the network operator uncrackable control over which consumers receive which programs.

Video channels which are available without cost are transmitted without modification, while those which are available only on subscription are scrambled or encrypted before being distributed by cable, MDS or satellite.

The descrambling or decryption is performed in the customer's home - typically in what is called the "set top unit". Each unit has a serial number and can be individually addressed by commands coming from the central office of the cable, MDS or satellite system. These commands are used to enable and disable the de-scrambling or decryption according to whether the customer has paid for particular channels or programs.

It is not practical to deliver analog subscription TV by VHF or UHF radio transmissions as free-to-air TV is transmitted today. There are not enough channels to provide consumers with sufficient choice of programs. In addition, the VHF and UHF channels often do not provide a picture quality suitable for paying customers.

MDS

One form of radio transmission which is practical in some locations is MDS - Microwave (or Multipoint) Distribution System. This uses higher frequencies (shorter waves) than UHF. It is a microwave system using frequencies around 2.0 to 2.4 Gigahertz - a wavelength of about 14 cm. (Knowles 1993.) These waves are transmitted from one or more sources in a city and received by a 0.5 metre curved antennae on each home. The short wavelength causes problems with reflections from buildings and difficulties receiving a signal at all if there are obstacles such as buildings or hills. MDS can provide up to 19 channels of analog TV, but only 6 are available in Melbourne and Sydney. In the future, these could be used for transmission of compressed digital data This would provide more video channels and the potential for other one-way services, including digital audio.

MDS provides coverage of metropolitan areas, subject to obstacles. This allows relatively localised programming compared to satellite distribution. Its primary limitation is that it does not provide a "backchannel" - a link from the customer back to the program suppliers. The limited number of channels and potential degradation in signal quality due to reflections and heavy rain are also drawbacks.

MDS channels could be used to carry digital signals for video and/or audio services. Using similar techniques to those used by DAB and DTTB (Digital Audio Broadcasting and Digital Terrestrial Television Broadcasting - described at the end of this chapter), the problems caused by reflections would be eliminated, and more channels of video could be provided because several digital compressed channels can be sent on the same 7 MHz bandwidth of one analog channel. There are also some techniques for reducing the impact of MDS's reflection problems on analog TV transmissions. However MDS's short wavelength means that it hardly diffracts around obstacles - there typically needs to be line-of-sight between the transmitting and receiving aerials.

Satellite

Distribution by satellite is primarily of interest to rural consumers who can afford the receiving dish and electronics. The size of the dish depends on the signal strength, which varies with location. Like MDS, satellite subscription TV has limited channels, however the area covered by each satellite beam from the satellite is larger than a city, so programming cannot be as localised as with MDS or coaxial cable.

The Optus B satellites which are used for direct broadcasts satellite TV transmissions to the home have a variety of beams and transmitters. One beam covers NSW, Victoria and Tasmania. A second covers Queensland. A third covers NT and SA, with energy concentrated on Darwin and Adelaide. The fourth beam covers Western Australia.

A fifth "high performance" beam targets 90% of the Australian population. Known as the banana "beam", it concentrates most of its energy into a curved area encompassing Adelaide, all of Victoria, and a coastal strip reaching around 300 km inland up the coast to Rockhampton. Hobart is at the very edge of this concentration, but a second concentration of energy targets Perth. A weak signal is received by Darwin - probably intended for a large Earth station rather than domestic dishes.

Choice of the beam and transmitter channels for satellite TV depends on the availability of the 15 transmitters in the satellite and technical issues to do with switching these to various beams, polarisation of the beams and received signal strength in various locations. The four "state sized" beams allows more locally specialised programming and reduces problems arising from time zone differences.

The Galaxy satellite subscription TV service will use MPEG-2 digital compressed video and sound. Transmissions to homes are being delayed until later in 1995 when domestic decoders with MPEG-2 capability become available. Like MDS, satellite provides no backchannel. Viewer commands to subscribe to particular channels or pay to watch particular programs must be relayed to the Galaxy head office by some other means, such as by telephone.

Fibre to the home vs. "Hybrid Fibre/Coaxial"

If cost were no problem, then all homes and offices would be connected to the outside world via their own fibre-optic cable - or via a single fibre shared between a few hundred homes. Perhaps this will occur in 2010 to 2020. While the cost of a single fibre cable is typically less than that of a thick coaxial copper cable, the costs of interfacing each home to the fibre are prohibitive for the foreseeable future. Each home would need an interface which includes a semiconductor laser, and a number of optical components which are currently difficult to mass produce cheaply. In addition there are costs for splicing the fibre in the street to create branches to homes. Fibre cannot be bent sharply, so it is more difficult to install in homes than thin coaxial cable.

HCF - the coaxial cable link to the home

In the foreseeable future it is clear that for homes, an adequate link to the outside world can best be provided with a coaxial cable (like a stiff 15 to 20mm thick guitar lead) running along the street, with thinner cables leading to each home. Each thick cable may serve 500 homes, and can carry DC power to power home equipment (such as a telephone) independently of the mains power - something that cannot be achieved with optical fibre.

Each 500 home coaxial cable is driven by electronics in a box in the street. This box receives signals from two optical fibres and drives these onto the coaxial cable - where they can be received by all homes. Customer equipment in homes can send signals onto the coaxial cable, and the street box receives these signals - the "back channel" and drives them onto a third optical fibre. The fibre cable runs to a "head end" - the office in each city where the programming comes from. "Head end" is a cable TV term, and in the initial stages of operation, it is likely that the signals sent to homes on one 500 home coaxial cable will be identical to those sent on other cables all over the city.

This is a distributive system - suitable for Pay TV. Later, when the system is used for Video On Demand and telecommunications, the aim is to send specific signals carrying digital video data to individual homes, whilst receiving digital information from them as well, so each 500 home cable would be driven with signals specific to those homes. In this scenario, the system functions as a telecommunications network, and the "head end" term is inappropriate. Signals to and from the 500 home coaxial cable will still be carried by the fibres, but the fibres may lead to an exchange, either locally or in a distant, centralised site.

This is the Hybrid Fibre/Coaxial (HFC) system currently being installed by Telecom, with Optus planning a separate system along similar lines. Details of the Optus system are not public, but it plans to use the system with analog video signals for Pay TV and signals carrying bidirectional digital data so that it can offer telephone services independent of the Telecom twisted pair wires which are currently used for all telephones in Australia.

Strategic significance of the Australian HFC systems

Telecom originally planned to use analog signals for Pay TV, and introduce digital video later, but in March it announced that all video services on its system would be carried digitally. This is a significant step, since the electronics for carrying multi megabit/sec data to homes on via coaxial cable are just being developed, and the electronics required for de-compressing MPEG-2 video data are only just becoming available.

Although there are several trials of such technology in the US and Europe, most homes in developed countries are wired to large coaxial cable systems in which tens of thousands of homes all receive the one set of signals, and where there is little or no provision for a backchannel to send data out of the home. These systems use cable with a lower bandwidth than is being planned for Australia, and could not easily be re-engineered into the 500 home separate systems - with fibre links to a central exchange - which is required to use the cable for fully bidirectional high capacity digital communications.

So Australia could be the first major country to provide a large proportion of its population with direct links to a broadband telecommunications network. If this is achieved, then Australia may be the first major music market to support high speed digital networking (including Internet access) - which will make electronic delivery of music practical and economical.

How HFC works

The Telecom coaxial cable system uses cables which are designed to carry frequencies up to 750 MHz. This is not a hard and fast limit, but signal strength at higher frequencies will drop off more sharply with longer lengths of cables. Many older cable TV systems overseas typically are limited to 500 MHz.

Comment [RW8]: Page: 84
Some diaagrams would be good here. The HFC system is the single most important communication link to homes in Australia's foreseeable future. One diagram would be for the fibres, box (node) coaxial cable and customer equipment. Another one would show frequency allocations.

Each "500 home cable" may actually consist of a star or tree structured series of coaxial cables emanating from the box which connects to the fibres. The coaxial cables may have amplifiers installed along their length to boost signal strength. These amplifiers direct signals above a certain frequency downstream to the home, whilst signals below this frequency pass through a second amplifier driving the cable upstream - to send signals from the home to the fibre. Irrespective of the layout and amplifiers, the homes on the cable share the one 750 MHz bandwidth where most of that bandwidth is signals coming from the fibres to the homes, and the rest is for signals from the homes back to the fibre.

All signals sent to and from homes carry digital data by modulating carrier frequencies by one means or another - so each stream of data is carried by a band of frequencies resembling a radio station. However the signals are transmitted in the cable, rather than being sent as radio waves.

One internationally standardised method of encoding multi-Megabit/sec digital information on a carrier signal for cable delivery to the home is defined in the European DVB (Digital Video Broadcasting) standard. It uses a 8 MHz bandwidth, QAM-64 (Quadrature Amplitude Modulation) modulation scheme and Reed-Solomon error correction (as used in CDs) to provide a highly reliable data rate of 38.015 Megabit/sec. Since MPEG-2 compressed digital video programs take between 2 and 8 Megabit/sec, this datastream can carry between 5 and 19 video programs in 8 MHz of the bandwidth of the cable. This is the same bandwidth required to carry a single PAL video signal using analogue techniques.

Frequencies below say 65 MHz are used for data being sent from individual homes to the cable, and via a fibre back to the head-end or exchange. Only small amounts of information need be sent from the home for selecting video programs, but telecommunications applications (discussed in the next chapter) could require hundreds of kilobits - or perhaps several Megabits - to be sent from each home. The transmission system from the home would probably use QAM modulation, but each home would use a much narrower slice of bandwidth than 8 MHz.

The DVB cable modulation scheme provides 4.75 bits per Hertz - so every Megahertz of bandwidth provides 4.75 Megabits of data. Looking at this system simplistically, and assuming an average of 4.5 Megabit/sec per video program, a HFC cable system could deliver one video program for every Megahertz of bandwidth. This translates into simultaneous 665 video programs between 85 MHz and the 750 MHz limit of the cable.

This is a simplistic view of the Hybrid Fibre Coaxial system. In fact some frequencies would not be used to minimise interference with broadcast services due to leakage from the cable. Some frequencies could be used to carry analog video signals or signals carrying digital data in a different format.

Telecom's cable system is being installed now in the ducts which carry the existing twisted pair telephone cables. Optus plans to suspend its 20 mm thick cable from power poles where possible, and to install new underground ducting where this is not possible. There are 6 million homes in Australia and Telecom plans to have its cable running past 600,000 homes by the end of 1995 and past 4 million by 1999. Optus plans to pass 100,000 and 3 million homes by the end of 1995 and 1999 respectively.

Both companies announced in March that services would commence in August. Optus plans to carry 20 channels of analogue Pay TV and to supply its own telephone services from the cable as well.

Telecom plans 20 channels of Pay TV and to use 120 channels to provide "near video on demand" (explained below). They also plan to offer a 60 channel subscription music service - comparable to the US Music Choice or DMX services (also described later in this chapter).

The Federal Government has mandated that both the Optus and Telecom cables be open to programming from sources outside these companies in 1999. This content/carrier separation is intended to ensure that consumers have a wide choice of programming.

In the USA, major telecommunications company Bell Atlantic sees Hybrid Fibre/Coax as a major means of delivering broadband services, but not the only way. CEO Ray Smith (Kline 1995) sees a fibre serving thirty or so houses, each with a coaxial cable and a twisted pair for telephony as the preferred architecture. HFC, with each coaxial cable serving "a few hundred homes" is seen as the best option where costs must be lower. Their HFC system is planned to carry up to 37 analog TV channels, 188 digital TV channels and between 272 and 464 "pointcast" channels, each or which is used for sending a program to an individual home as required. The system will also carry telephone services.

As in Australia, the system is open for the carriage of programming from companies not associated with the owner of the cable. In the US, the government decision mandating open access is known as "Video Dialtone". This perplexing term refers to the idea that a consumer can use the cable to receive video data from several providers, as a dial tone on a phone is an invitation to connect to anyone. However this decision does not imply that an individual consumer "dials" the material they want to watch.

It applies equally to distributive video (Pay TV) and to Video On Demand, and implies an absence of commercial restrictions on video content sources. Confusingly, the term "Video Dialtone" is sometimes used as a synonym for Video On Demand - even by technical writers.

ADSL

Asymmetrical Digital Subscriber Line (ADSL) is a means of using the existing twisted pair telephone wires between the exchange and the home to carry up to 6 Megabit/sec of data from the exchange to the home. (For a full description of ADSL, see Whittle 1994a and 1994b.) In addition it can provide up to 640 kbit/sec duplex (both directions at once) communications for program selection, telephony and data communications. It achieves this by using frequencies between 20 kHz and 1.1 MHz - so the standard analog phone can still be used normally.

ADSL is technically ambitious and field trials of it began in 1994. It is likely to play an important role in providing digital video and data communications to homes in suburban streets which do not yet have coaxial cable installed. This is a potentially large proportion of the Australian market, but ADSL's development has been slowed by the lack of comparable markets in the USA and Europe - where most homes already have access to coaxial cable.

ADSL's performance depends on the characteristics of the phone wires and it is unlikely to deliver 6 Megabits/sec to homes more than 4 km from the exchange, although 2 Megabits may be feasible for distances of 10 km or more.

ADSL's performance on real phone wires is still being researched, but it seems that it could bring 6 Megabit/sec to 80 to 95% of the urban population. ADSL's great advantage is that no new cables need to be laid. It does require relatively expensive equipment at the home and at the exchange, but these prices would drop if it achieves a mass market.

Technically and economically, fibre/coaxial is the superior means of delivering broadband services - once the coaxial cable and fibres are installed. The cost of the advanced digital receiving/transmitting electronics for coaxial cable will be less than for ADSL, but probably not radically so by 1998.

ADSL is unlikely to be ready for mass introduction before 1998, and it must be used with MPEG-2 compressed video - it is a digital system and cannot carry analog video signals. By then coaxial cable may have reached several million homes, and ADSL may be use to connect to those homes beyond the reach of the fibre/coaxial systems.

Ray Smith, CEO of Bell Atlantic (Kline 1995) sees ADSL as a transition technology - for consumers in areas which do not yet have access to HFC or fibre. The ADSL units would be connected to the existing twisted pair phone lines, and removed when the HFC cable was installed. He says that ADSL is "an interim technology which will be with us for 40 years." - which is a much more positive assessment than some other observers have given it.

VIDEO APPLICATIONS

Several channels of analog subscription Pay TV are currently being delivered by MDS. The Optus satellite is being used to distribute these signals to the MDS systems, but will not be used for direct broadcasts to homes until MPEG-2 decoder chips are cost-effective and integrated into decoder units. Although the satellite could transmit analog video, the Federal Government has mandated that digital encoding be used. Optus plans to have analog Pay TV services on its fibre/coaxial system starting in August 1995.

MPEG-2 Pay TV services are planned to begin on the Telecom cable system in August as well. Telecom has a 300 home ADSL trial starting in early 1995 and it seems that the earliest that ADSL could be a cost-effective solution is in 1997 or 1998.

While analogue video distribution technology is mature and relatively cheap, digital techniques, via satellite, fibre/coax or ADSL all involve a number of ambitious technologies which are immature and relatively expensive. Each home requires a receiver (or "modem") to convert the analogue signals received from the satellite, coaxial cable or twisted pair phone line into an error corrected digital data stream at about 6 Megabits/sec. This data is mainly MPEG-2 compressed video and sound. The decoder chips for these are just starting to be produced in quantity.

There are also hitches with the MPEG-2 equipment in the "studio" - the source of the programming. Converting film or video signals to their MPEG-2 compressed form is far more complicated than de-compressing the MPEG-2 signal. Movies can be converted "off-line" - a whole day can be spent converting the movie, and the several Gigabytes of resulting data can be stored for broadcast at a later date. However to provide live sports broadcasts and news, real-time MPEG-2 compressors are required - which are enormously expensive.

The utilisation of subscription TV channels is a matter of debate and commercial wrangling. Technically, some channels can be provided free, others can be sold by subscription on a monthly basis, and particular channels at particular times can be sold to particular customers who pay to see a "premium" event or movie. This is called "pay-per-view". Both MDS and the satellite will have limited channel capacities, but sufficient to support these applications.

Near video on demand

Telecom's digital fibre/coax system is capable of carrying hundreds of video channels simultaneously. Initially only twenty or so will be used for subscription TV as described above. 120 "channels" are planned to be used for "near video on demand" which is a flexible form of pay-per-view - and is very different from "Video On Demand".

Normal pay-per-view involves viewers paying to see a program which is transmitted at a particular time. Near video on demand uses several channels to show a single movie, with staggered starting times so as to make a small number of popular movies available conveniently. If a two hour movie is played on 8 channels at once, with each channel starting the movie 15 minutes after the previous one, then a viewer will only have to wait 15 minutes at the most to see it. If the viewers want to take a 15 minute break, they come back to the same point in the movie, taken from a different channel. On this basis, Telecom's system could show 15 movies - with viewers waiting no more than 15 minutes to start viewing each one.

Pay TV is a distributive process, whether it is analog or digital. This is a necessary consequence of the fact that there are fewer channels available on the distribution media than there are customers on that media. Compared to free to air broadcasts, it offers more choice, potentially higher picture quality, and the ability to pay for programming directly rather than have it interrupted by adverts. It also enables programs to be shown which are not compatible with advertising - either because the program cannot be interrupted by adverts, or because advertisers would not wish to be associated with the program.

Despite the increase in the number of channels, the limitations of viewers sharing channels is Pay TV's biggest drawback. If there were enough "channels" so that each viewer has their own - then each viewer would have an individual link to the source of programming. If the source had a Video Server, which can replay digital video programs at any time for individual viewers, this link would enable them to watch any program at any time. This is Video On Demand. The concept of a "channel" disappears and the system is no longer distributive, but resembles a telecommunications network - with specific digital data being sent to each home, and from each home to the Video Server to control the selection and replay programs, and for control of other options.

ADSL inherently provides such a direct link to each home. Depending on how a fibre/coaxial system is used to carry digital data, and depending on how many homes are on each cable, these systems can also be used to provide individual links to each home. Although the cable carries all the signals for the 500 homes, the data for each home is encrypted separately so that only the decoder at its proper destination can decipher the MPEG-2 video data.

So Video On Demand and telecommunications services are only possible when the home is connected via ADSL or a Hybrid Fibre/Coaxial cable which carries digital data. Neither the satellite nor MDS can provide individual links to each home. In the future, fibre to the home, or short range super-high-frequency (28 GHz) microwave links may also provide such individual links to each home.

Although "interactivity" is often mentioned in the context of subscription TV, even where there is a backchannel, the viewer cannot receive a program specific to their home. They may be able to influence the outcome of a talent quest or contribute in some other way to a program. With a sophisticated home decoder, they may be able to see simple text or graphic images directed personally at them, but it is not possible to send large quantities of information to individual homes via a distributive means with limited channels.

In addition to the individual link to each home, Video On Demand requires a Video Server - and these are only just starting to be developed. Practical Video Servers may become available in 1998 - the only ones in existence today are adaptations of existing computer systems and are impractical for large scale operations. A Video Server is an extremely demanding combination of digital hardware and software, and it is unlikely that mass production of mature Video Servers will commence before 2000.

ADSL may be used to bring subscription TV to homes outside the reach of the coaxial cable system and reliable MDS reception. ADSL can only carry one 6 Megabit/sec video signal to the home or two 3 Megabit/sec channels. So the equipment in the home does not "tune" to a channel as it does in a distributive system. If ADSL is used with the same programming sources intended for distributive systems, then the viewer's programming commands will control a switch in the local exchange which controls which MPEG-2 data stream is to be sent via ADSL to their home.

Until Video Servers are practical, ADSL is likely to be functionally equivalent to analog or digital coaxial distributive systems. However ADSL, and fully digital coaxial systems provide the direct links to the home required for Video On Demand. When Video Servers become cost effective and are used with ADSL and fully digital coaxial cable, then Video On Demand will be possible. The use of coaxial cable for individual links to each home is discussed in the next chapter. Video On Demand is discussed in chapter 7.

CABLE DELIVERY OF DIGITAL AUDIO

It is practical today to deliver digital audio over a standard coaxial cable TV distribution system which is used for analog video channels. Such a cable carries each video program in a 7 MHz wide channel, and one or more of these channels can be used to carry signals which can be decoded into digital data. The data contains multiple channels of compressed digital audio. It is also possible to use 7 MHz wide satellite or MDS channels which are normally used for analog TV for this purpose, but the following discussion relates to coaxial cable.

In the USA, two companies currently offer around 30 channels of "music subscription" primarily for domestic customers, via cable, but also via satellite and for commercial customers as well. (These details come from three articles: Wiesenfelder 1994, Attwood 1994b and Mitchell 1994.)

The customer uses a decoder box which looks like an FM tuner and connects directly to the coaxial cable - where it tunes a carrier signal similar to an analog video channel, but which carries compressed digital data.

Comment [RW9]: Page: 91
?? Number of 7 MHz channels used for 30 audio channels? Bit rate for audio channels? Compression scheme? - I will try to find these out.

The decoder is controlled by an infra-red remote, and its audio output drives the home HiFi system. There are plans for decoder boxes to have a digital output to drive a Mini Disc, DAT or DCC. The SCMS copy protection scheme would be used to inhibit copies being made from these recordings.

In some cases the decoder receives text information about the music - name, performer, album and other data. This is sent to the remote control where it is displayed on an LCD screen when a button is pressed. There are no advertisements and none or only a few of the channels have spoken announcements. The customer can tune between dozens of different genres of music - each operating without a break 24 hours a day. Sound quality is reported as being close to CD and better than most FM stations. Domestic subscribers to the cable service pay about US$10 per month. Costs are higher for business subscribers.

In mid 1994, one service - DMX by International Cablecasting Technologies - had 350,000 households subscribing. This is 2.3% of the 14.7 million households which could receive the signal. In October, the other company - Music Choice - had 150,000 subscribers from around 8 million homes on 200 cable systems. Both companies expect growth due to better marketing and to their signals being distributed to more homes. Both companies plan to add channels for "news, talk, sports, foreign language, pay-per-listen and simulcast offerings, some of which will be commercial supported."

Music Choice is backed by "a bevy of corporate investors" including Sony, Warner and EMI. It produces over 50 channels of music and distributes them via satellite to cable system all over the country. Each cable operator chooses which channels to make available on their system.

In September 1994, Music Choice started a 28 channel service as part of the DirecTV direct to the home satellite broadcast service - which can be received with a small 50 cm dish.

Tim Kregor, Music Choice's senior VP of marketing, says "There are no consecutive songs by the same artist. We never play an entire album. There is not a pre-announcement for upcoming songs. This won't necessarily prevent someone from taping the digital transmissions, but it will help deter it.". Two channels follow the format of traditional radio, with concert broadcasts and "host-driven specialty programming". Regular hosts include Ray Manzarek and Larry Carlton. The Music Choice library is 400,000 songs deep, according to Kregor, "Most of our formats have thousands of selections per channel. Compare that to the typical radio station, which only has a few hundred songs in its library at any given time."

Peter W. Mitchell, writing in *Stereophile,* comments "When I began listening to Music Choice, I was startled to discover that the people operating the service know nothing about the music they play, and may not even be listening to the signal they are putting out. The people behind the scenes who plan the programming for each of the 30 channels know their repertoire, but evidently no one monitors the signal or is available to correct errors immediately. I've encountered incorrect identifications of what selection is being played, and have heard selections that suddenly are cut off in the midst of a track as the pre-programmed CD changer jumps to the beginning of the next selection."

This is the digital-audio equivalent of analog subscription TV, and since it uses the analog subscription TV infrastructure, similar services could be introduced in Australia using the Hybrid Fibre/Coaxial cable, MDS or satellite.

Telecom plans 60 channels of audio on its HFC system, and although details are not yet available, (?? I will try to find them out!) this is a new form of music broadcasting of great interest to the music industry. On one hand it poses a challenge to the existing radio stations, and may break the traditional link between DJs and broadcast music. For the listener, it provides variety, with particular styles of music available 24 hours a day, without distractions. For musicians, it provides a new means of promoting their music - an alternative to commercial radio.

A similar 30 channel subscription radio system has begun operation in the UK. A report (McAleer) in October 1994 indicates that it was available in Leicester, Bradford and Bristol with and soon in other areas - so it is almost certainly a re-transmission of the DMX service from the USA. Within two years, there are plans to distribute a total of 90 channels via the Astra satellite. One listener's experience of the DMX service is described in a thoughtful letter to *Hi-Fi News and Record Review* January 1995. The letter, from Julian Stevens of Bristol, is quoted here in full.

Comment [RW10]: Page: 93
Conceptually, this excellent commentary on the DMX system belongs in a marketing chapter, however I will leave it here for now - it helps bring some musical insterest into these early chapters which concentrate on technology.

Having now lived with DMX for around seven months, I'm beginning to weigh up its potential for affecting both listening and buying patterns, both for hardware and software.

Firstly, it's highly addictive. The sound quality is high, you can choose your preferred type of music from any of 30 channels (soon to double), there's no tiresome DJ prattle and you can access comprehensive data on each track playing. The convenience leap is similar to the difference between playing records and CDs.

I listen to DMX now more than to any other source and whenever I do play records or CDs, I find myself wondering what I may be missing on the radio. It's also the most convenient thing to have on if you're reading or doing other things about the house (like writing to hi-fi magazines).

A possible downside to hearing a great deal of just one or two channels is that you can sometimes "over audition" certain albums. I would like to see the roster of different artists, at least on my favourite channel (14), expanded beyond the present 160 or so.

Having said that, its possible to hear enough of most albums being played to formulate a pretty complete assessment of them. Some of those you might well have purchased on the strength of hearing a couple of tracks just a couple of times, you may decide not to bother with. How many albums, overall live up to the promise of their best few tracks? Not very many at all, but with DMX you can take your time and become very selective. It has also been my experience that DMX do tend to play the best tracks and leave out the duffers. So impulse purchases may well decline.

What may happen ultimately is the subscribers will come to enjoy listening to a constantly rolling and updated compilation of the favourite material on their chosen channel. As a result, they'll become less and less bothered about buying albums from just one artist.

On the other hand, maybe DMX will broaden presently narrow markets and increase sales overall as a result. One of my prime reasons for subscribing to DMX was to hear music otherwise totally inaccessible to me here, in which respect it's a resounding success. Were I representing a small record company, I would be trying very hard indeed to get my wares on the DMX playlist.

It would be interesting to know if any subscribers in the US feel that DMX has influenced their buying habits, either towards software or hardware, if at all. One thing's for sure - the power of the media is increasing all the time, and specialised subscription radio is going to be part of that process.

DIGITAL AUDIO BROADCASTING

Digital Audio Broadcasting (DAB) has been the subject of intense research in Europe since 1987 - with the Eureka 147 project. Some research along these lines was conducted in Australia and a November 1992 discussion paper "Policy Issues for the Introduction of Digital Audio Broadcasting to Australia" is available from the Broadcasting Policy section of the Department of Communication and the Arts. The Department has a Digital Sound Broadcasting Committee, but in early 1995 it was relatively inactive, awaiting overseas developments.

A good introduction to this was written by Frank Müller Römer in the March 1993 Journal of Audio Engineering. Another good article is by Peter Willis - *CD on the air* - Gramophone October 1994.

There is another stream of research being conducted in the USA which seeks to add digital signals to existing AM and FM broadcasts - but there are fundamental technical difficulties with this approach which virtually rule out its widespread adoption. The primary problem is that both AM and FM are prone to reception problems in a mobile situation because of interference and in the case of FM in particular, because of reflections causing nulls in the signal strength of a given channel. Some observers believe these attempts at piggybacking digital audio onto existing transmissions are motivated primarily by the desire of existing broadcasters to retain their established markets.

Although no policy decisions have been made in Australia about which approach to DAB to adopt, this paper will concentrate on the Eureka approach. This approach is well researched and accepted. It has been subjected to extensive public field trials - which is not the case for the American piggyback alternatives.

The Eureka approach to DAB has totally different system characteristics from AM or FM. There would be a network of transmitters, or a satellite beam, or a satellite beam strengthened by local terrestrial transmitters. This would give blanket coverage to a large area, with perfect reception in all situations including hand-held and car mounted receivers. Most importantly, a DAB service would carry many channels of digitally coded music, which could originate from many program suppliers - the equivalents or today's radio stations. Each channel could be encrypted so that the program suppliers could offer both free-to-air and subscription services. The data stream could be used flexibly to suit the audio requirements of different musical tastes, for low quality services such as traffic reports.

In addition there could be data to identify the music being played and to provide special features such as dynamic range management. This involves the music being transmitted with a particular range of volume dynamics together with extra data which enables the receiver to compress or expand the dynamics in a musically acceptable way to match the listener's requirements. For instance some classical music has a very wide dynamic range and when listening in a car or in a noisy work environment, the receiver could use the auxiliary data to change the volume to make the quiet parts louder and the loudest parts quieter. A compressor could achieve this, but the data accompanying the music can be used to manage the dynamics with fewer audible problems.

The ownership of the transmission network is unlikely to be dominated by any one program supplier. The Department of Communications and the Arts Discussion paper on DAB November 1992 states: "Transmission system planning will need to take into account some aspects of 'common carrier' principles in order to ensure fairness and economic efficiency in access to transmission by a range of service providers needing to share the same transmission mode." The shared nature of the distribution medium means that some DAB policy issues are analogous to those for coaxial cable systems.

The chief executive of the UK Radio Authority (regulator of independent broadcasters), Peter Baldwin predicts that DAB will have even greater impact than the advent of FM. The long term prospects for DAB seems bright, but no one is sure how long it will take for a large number of consumers to invest in the new equipment they will need to receive it.

DAB sound quality

DAB uses Musicam to compress the stereo or mono audio signals. The assignment of data to sound channels is flexible, but it seems that 256 kbit/sec is becoming an accepted standard for stereo, with 128 kbit/sec for mono. This is 5.5:1 compression.

The useable bit rate available from one 1.5 MHz block (explained below) depends on what proportion of the raw data is devoted to "protection" bits - error correction data to correct for problems in the raw data caused by interference and noise. A typical approach seems to be to use 50% of the raw data for protection - leaving 1152 kbit/sec for music or other applications.

This gives four stereo channels and one mono channel in a block. The BBC transmissions starting in September 1995 will use this arrangement.

DAB typically gives more reliable reception than FM radio, but its quality is not superior in all respects to that of a strongly received FM signal. Andy Gemmel-Smith, whose business is technical support for UK independent radio stations, is quoted in *Gramophone* "My personal view was that it was quieter than FM, but not as crisp and clean. It lacked something. It didn't suffer interference as FM did, but when the FM reception was good, it seemed better than DAB - it had more life to it and sounded sweeter. (Compression systems) do lose something that you can hear." Many stations now store their music libraries using compression and transmitting the decompressed audio through another compression system (256 kbit/sec Musicam for DAB) ". . can become quite awful to listen to."

DAB transmission technology

The following description of transmission technology relates to the Eureka 147 approach as used by Germany and the UK.

The digital signals are transmitted using a technique called COFDM (Coded Orthogonal Frequency Division Multiplexing). Each "block" of DAB transmission spreads the data over 1536 separate carriers over a 1.5 MHz area of spectrum[5]. The technical details are beyond the scope of this paper, but it is clear that COFDM is capable of providing a reliable digital signal in the presence of multi-path interference (reflections and signals from multiple transmissions) and movement between the transmitter and the receiver. The latter point is particularly relevant when the transmitter or transmitters are located on satellites in low or elliptical orbits.

COFDM is ideally suited to covering a wide area with multiple transmitters - each transmitting the same signal on the same frequency. One option is to have a satellite transmitting to a large area of the country, with slave transmitters boosting the signal where it is weakened by buildings and terrain.

This is in contrast to AM and FM signals which must have a single transmitter providing a strong signal in the primary service area. A single transmitter must be used to avoid nulls in the signal strength - the troughs of one wave cancelling the crests of another. To avoid any perceptible interference, transmitters in adjacent areas must use different frequencies - even if they are transmitting the same audio signal.

COFDM is applicable to transmissions in the VHF and UHF bands, the 1.5 GHz "L band" and at higher frequencies. Higher frequency transmissions have shorter wavelengths and so are more affected by terrain and buildings. This means that to cover a given area, the number of terrestrial transmitters increases with the frequency, but the power of each decreases. At the World Administrative Radio Conference in 1992, 40 MHz of bandwidth between 1.452 and 1.492 GHz was reserved for satellite and terrestrial DAB.

Satellites are a cost effective way of covering large areas and the Optus satellites have transponders capable of delivering DAB to Australia at 1.5 GHz. There are various beams available on the Optus B1 and B3 satellites allowing coverage of particular areas of Australia - as discussed earlier in this chapter.

In urban environments, particularly those of Melbourne and Hobart where the satellite is closer to the horizon, some low powered transmitters may be needed to provide additional signal strength because of the effects of buildings and

5 This is for VHF transmissions, for UHF and transmissions above 1.5 GHz, fewer carriers are used, but the data rate remains approximately the same. There is no need, other than standardisation, to adopt a 1.5 MHz bandwidth - COFDM can be used over any bandwidth at any frequency. This multi-carrier approach is similar to that used in Discrete Multitone ADSL.

local interference. They transmit exactly the same signal as the satellite and the combined signal from terrestrial and satellite transmitters floods the area. Nulls may occur at particular frequencies within the 1.5 MHz bandwidth, so some of the 1536 carriers in that block may be lost, but the data is spread over the carriers with sufficient error correction redundancy to allow the full data stream to be recovered - even from a moving vehicle or small handheld receiver.

However, satellites have broad footprints which precludes localised programming. Another approach to DAB is to use VHF frequencies such as TV channel 12 (223 MHz) or channel 8 (189 MHz). This can use existing transmitter towers and infrastructure and perhaps the existing antennas. The transmit power of DAB is typically 10% of that for analog TV and so interference problems with adjacent channels are minimised. (Analog TV cannot receive a TV signal properly when there is a strong signal on an adjacent channel - hence a TV transmission on channel 8 would upset both channels 7 and 9. There is an extra space between channels 9 and 10 which means they can be used simultaneously.)

Localised programming with terrestrial DAB transmitters

In Germany, there are plans to commence DAB broadcasts on VHF TV channel 12 in 1995. Existing TV transmitter sites will be used to provide coverage of the entire country. Fitting DAB into 7 MHz wide TV channel frequency assignments allows for four independent blocks of 1.5 MHz - each of which may carry 5 or 6 audio signals.

In the UK, 217.5 to 230 MHz has been allocated to DAB. There are plans for the BBC plans to start one block of transmissions in September 1995 - for its five national stations in addition to their existing FM and AM slots. Ultimately, this block and a second one for independent stations will be transmitted nationally. Five remaining 1.5 MHz blocks are available and these will be used to carry more localised programming. One or two of these five remaining blocks are likely to be received properly at any one locality. So DAB will provide a total of between 15 and 24 channels of audio at any one location.

There is a need for both national and localised programming, and a 7 MHz band can provide both. The band is used for four blocks of 1.5 MHz COFDM signals - blocks A, B, C and D. These would all share a single transmitter and antenna.

National programs would be transmitted on block A in all parts of the country. There would be no problem with interference, for example between transmitters located in Melbourne and Ballarat. The block A signal floods the entire area. However localised programming for Melbourne would be on block B, and for Ballarat on block C. So the main Melbourne transmitter on Mt Dandenong, and any fill-in transmitters at the periphery, would be transmitting on blocks A and B. If peripheral transmitters were required to boost signal strength around the edge of Melbourne - for instance at Portsea - then they would have low powers and use directional antenna to fill only the area of concern.

Similarly the Ballarat region could be served by a number of transmitters operating on blocks A and C. In a regions such as Geelong or Bendigo which are adjacent to both Ballarat and Melbourne, blocks A and D would be used. So Geelong and Bendigo would both use these blocks, but each set D would contain their localised programming. This means that block A can be received anywhere. Listeners in Portsea could receive the Melbourne localised programming on block B. They would probably also be able to receive the Geelong localised programming on block D, either directly or via the local Portsea transmitter. The receiver might also pick up the block D signals from the more distant Bendigo, but these would be at a low enough level not to upset the data coming from Geelong. Portsea residents may pick up block B from Ballarat, but if it was received at about the same strength as another block B - say from South Gippsland - then the interference would mean that data from neither set could be recovered. However a directional receive antennae could be used to pick up either signal in preference to the other.

Comment [RW11]: Page: 98 ?? Do a diagram of this? Not everyone knows where these locations are.

To achieve reliable reception for mobile receivers, the data rate for COFDM is relatively low - typically up to 2 bits per hertz, so a 1.5 MHz bandwidth is capable of transmitting around 3 Megabit/sec of raw data. After allowing for overheads for control and error correction this would provide about six stereo signals at between 6:1 to 8:1 compression. The utilisation of the data would be flexible and would allow for low quality audio services and for computer data distribution.

On the above basis, it seems that DAB will not provide limitless "radio" channels, but this is using only 7 MHz of spectrum space. If additional VHF or low UHF TV channels, or part of the 20.5 MHz wide VHF FM band were made available, then the number of channels could be increased much further.

There are many uncertain technical, policy and commercial factors which make it impossible to predict how DAB would be introduced into Australia. With improvements in compression and digital technology and the consequent development of mass markets for receivers overseas, it would not be surprising if DAB achieved some market penetration in Australia towards the end of the 1990s. Since it needs a completely new kind of receiver, it is unlikely to dominate AM or FM services before 2005 or after. Although it is a radio transmission system, its administrative and technical characteristics are quite unlike existing radio, and have more in common with an analog cable or digital network distribution system.

DAB proponents believe that over 20 years or so, DAB will replace FM because of its superior quality (depending on the data rate) and in particular due to its immunity from fading and interference even with mobile receivers. They consider the existing FM band to be a valuable spectrum resource which could be more efficiently used - by DAB and other services.

Digital Terrestrial Television Broadcasting - DTTB

DAB is similar to Digital Terrestrial Television Broadcasting - which uses the same transmission principles at higher data rates. However it is not designed to cope with moving transmitters and receivers. This enables a higher data rate to be achieved - such as 20 Megabit/sec on a 7 MHz channel.

This means that a 7 MHz channel could carry a single HDTV channel or between three and eight standard quality TV signals. Other advantages of DTTB over analog transmission are the ability to use adjacent channels - such as 8 and 9 - and greater immunity from interfering signals on the same channel from other areas.

There are many technical, economic and administrative issues to be resolved, so DAB and DTTB are likely to take off slowly - especially as they will be competing with MDS and cable systems in urban areas. In the long term, they can provide a higher quality of service, with the potential for subscription services via encryption. They cannot provide either audio or video on demand because their limited channels are shared by hundreds of thousands or millions of listeners and viewers. Nationwide, they could provide all existing broadcast TV and radio services on perhaps 30 MHz of spectrum space - freeing most of the spectrum between 88 and 220 MHz which these currently use, and freeing another 100 MHz at the bottom of the UHF TV band around 600 MHz.

These frequencies have immense potential value for mobile personal data services and so there are long term economic reasons for migrating existing FM and TV services to their digital equivalent. DTTB has been the subject of an inquiry by the Department of Communications and the Arts. The inquiry's report is due for release in March 1995.

CHAPTER 6 TELECOMMUNICATIONS NETWORKS

> *Digital links to the home are currently limited to dial-up modems and Basic Rate ISDN. Both these can be used for Internet music marketing and auditioning of music, but are too slow and costly for electronic delivery of music. This will be possible only when individual broadband (greater than 2 Megabit/sec) links to homes are available. These will be provided by subscription TV coaxial cable systems being converted to all digital operation, or by ADSL over existing phone wires.*
>
> *Neither of these broadband links are likely to be common before 2000 or later, but retailers and musicians may find it cost-effective to use high speed telecommunications before this.*
>
> *The Internet and World Wide Web (WWW) are introduced. These are becoming important channels for the diffusion of musical awareness and for selling CDs.*

DIAL-UP MODEMS AND BASIC RATE ISDN

Although this paper concentrates on the higher speed telecommunications of the future, consideration must be given to existing technologies. The term "Broadband" is typically used to describe a digital communications link which is capable of 2 Megabit/sec or more. This is the minimum required for compressed video, although 6 Megabit/sec is required for fast action sports.

It is likely to be 1998 at the earliest before a significant number of broadband links are available to musicians or consumers. Two slower technologies will have to suffice until then - dial-up modems and Basic Rate ISDN.

Dial-up modems

Dial-up modems connect a computer to an analog phone line, and typically transmit 14.4 kbit/sec full duplex (both directions at once). Fax machines use a 9600 bit/sec modem which operates in only one direction at once. Many modems sold in 1995 and beyond operate at up to 28.8 kbit/sec and no further improvement is considered possible. These all operate on standard phone lines which are guaranteed to have a frequency response up to 3.6 kHz. There is a fundamental limit to the data rates which can be achieved with an analog phone line, because all inter-exchange links are carried digitally at 64 kbit/sec (8bit samples at 8kHz).

Dial-up modems cannot be used in all telephone situations. For instance they do not work reliably over analog mobile phones. Modems cannot be used with digital mobile phones because the complex modem tones cannot survive the compression system used in GSM phones - which is designed to compress speech - using a special algorithm designed for speech - to the low bit rate of 13 kbit/sec. 10,000 remote homesteads and settlements are served by Telecom's Digital Radio Concentrator System. Its 1.8 kHz frequency response precludes the use of faxes and modems, but its is being upgraded to provide normal quality links which will support faxes and modems.

Another limitation is the link between the modem and the personal computer - which is typically an RS-232 cable and a relatively simple serial communications chip. These chips are not always capable of buffering higher speed data and so special versions of the chips must sometimes be installed to optimise performance.

Dial-up modems initiate phone calls with tone (or pulse) dialling. This, together with the delays in the network, the time taken for the remote modem to answer and the time taken for the two modems to agree on communications speed and protocols means that the call set-up time is between 10 and 20 seconds. Only a fraction of a second of this is caused by the phone network itself - which can connect a call very rapidly once the number has been dialled.

The highest data rate for a dial-up modem is 28.8 kbit/sec, which is a sixth the speed required to transfer 8:1 compressed stereo audio.

Basic Rate ISDN

Basic Rate ISDN (BR-ISDN) is a special kind of phone connection to the local exchange. ISDN stands for Integrated Services Digital Network - which is a long term plan for upgrading the world's telecommunications system. BR-ISDN provides two independent duplex data channels of 64 kbit/sec, with a 16 kbit/sec channel for controlling the data channels and for other purposes. It provides this over the same twisted pair wires used for an analog phone service. However the line must typically be shorter than about 4 km, and the exchange must be ISDN capable, or contain a multiplexer for BR-ISDN services which links to an exchange which does handle ISDN.

Comment [RW12]: Page: 102
?? Major UK band the FSOM - Future Sound Of London - have released a CD of their performance from their studio via BR-ISDN links. The name of the CD. . . . *ISDN*.

Figures are not available, but Australia now has a high level of ISDN availability in urban areas - much higher than in the USA where the plethora of phone companies lead to conflicting standards and slower development.

Telecom has been a world leader in ISDN rollout, but so far it has viewed BR-ISDN as a specialist product and has done virtually no marketing. This can be expected to change because of the greatly increased demand for BR-ISDN and perhaps in response to competition if Optus uses its planned fibre/coaxial cable system to provide a BR-ISDN service.

Telecom is under pressure from customers, and several inquiries into Australia's telecommunications future - including the Broadband Services Expert Group - to lower its rental prices for BR-ISDN and to encourage its adoption. Sources within Telecom (in conversations with the author) indicate that although BR-ISDN is widely available at present, this is via small, specialised multiplexers and fibre links to ISDN capable exchanges.

Widespread adoption of BR-ISDN will only be cost-effective as Telecom completes its ambitious "Future Mode of Operation" which calls for all Australian telephone services to be served by only 200 exchanges. These exchanges will be of only two types, simplifying the current network which is composed of many more exchanges of different types. All the new exchanges will be ISDN capable and will link to the areas they serve via fibre links to multiplexers. These multiplexers will support two kinds of line driver electronics - one type of circuit card for driving phone lines in the usual analog way and another for BR-ISDN.

There is a huge gulf between the 0.03 Megabit/sec data rates of dial-up modems and the promised 2.0 to 6.0 downstream (to the home) data rates promised by ADSL or fibre/coaxial systems. BR-ISDN is the only intermediate technology - offering 0.128 Megabits/sec if both 64 kbit/sec channels are used in parallel.

There are two other ISDN terms which should not be confused with Basic Rate ISDN. Firstly PR-ISDN stands for Primary Rate ISDN - thirty 64 k data channels and a 64 kbit/sec control channel, using two pairs with stringent distance limits. PR-ISDN is typically used to connect a large office phone system without using dozens of wires. This kind of link can also be use as a 2 Megabit link for general data communications such as linking LANs in separate offices or providing a fast connection to the Internet. Secondly B-ISDN stands for Broadband ISDN - a more abstract concept for data rates of 2 Megabits and above.

BR-ISDN provides two independent 64 kbit digital links to the phone network. These match exactly with the digital links used throughout Australia for carrying voice calls between exchanges. Each of the 64 kbit/sec channels can support a voice call - including dial-up modem calls and standard Group 3 fax calls. The main advantage of BR-ISDN is that each channel can be used for a data call to another BR-ISDN channel - providing a direct 64 kbit/sec link between the two. Data calls cost marginally more than the standard voice call rates, and Telecom guarantees a 64 kbit/sec link, free of compression and other compromises which are sometimes applied to voice calls.

Currently local calls, both data and voice, made from a BR-ISDN service are timed. The rental for the service is currently $960 pa. - compared to $274 and $140 for analog business and domestic services respectively. The BR-ISDN service provides for two calls at once, and can support a number of computer interface cards, and analog phones or faxes - each with a different phone number for a small extra charge.

The BR-ISDN service provides the link to a wall mounted interface - called an NT-1, which draws its power via the twisted pair wire from the exchange. The NT-1 has a small "S-Bus" socket which is used to interface to the customers equipment. Multiple pieces of equipment are connected with a daisychain of S-Bus leads. A computer interface connects directly to the S-Bus and is typically capable of using both 64 kbit/sec channels independently. Analog phones, faxes and modems can only be connected to the S-Bus using an analog adaptor - the cost of which can be expected to decline as the market for them grows. Special phones which plug straight into the S-Bus are also available, but until production volumes increase, their cost is much higher than a standard phone.

Both the computer interface and analog adaptor (or S-Bus phone) receive data about incoming calls, and send requests to initiate calls, using digital data packets on the 16 kbit/sec channel. Because of the high speed of most of the national phone network, a call can be set up and connected in less than half a second. Depending on the application, the computer software may spend a second or two identifying itself to the software at the other end. However, BR-ISDN has the capacity to provide reliable, high speed (compared to modems) data communications to the majority of businesses and homes in urban areas and many regional cities and towns.

BR-ISDN typically requires a special interface card to be plugged into the computer - or via a SCSI or PCMCIA connection. Standard RS-232 interfaces cannot cope with the data rates it requires. This means that it cannot be used with communication software which was designed for modems.

Microsoft has recently defined a Windows Application Programming Interface (API) for BR-ISDN. This is a specification for how application programs - such as communication, wordprocessing or sound editing programs - work with the software which is specific to any BR-ISDN interface card. This standardises all BR-ISDN operations so that application programmers do not need to know about particular BR-ISDN interface cards. The BR-ISDN API is analogous to the video and printer APIs which enable any Windows program to run with almost any video board or printer.

The use of BR-ISDN for commercial applications is expected to grow rapidly. It can be used for Wide Area Networking - integrating the LANs (Local Area Networks) of geographically separated offices. It is also the technology of choice for telework (telecommuting) - which may be just the same as Wide Area Networking. There may be a significant market for BR-ISDN in the residential consumer market as families want to provide a data link to the outside world for recreational and educational purposes - especially Internet access - without cutting off the standard phone service. In theory this could be provided with two analog phone services into each home, but there is a shortage of spare twisted pair wires in the cables buried in the street.

64 kbit/sec or (dual channel) 128 kbit/sec Internet access is already available from commercial service providers. One provider, connect.com, offers a package with one hour of 64kbit/sec BR-ISDN access per day for around $2,700 PA. This compares favourably with their rate of $2,200 for 1.5 hours a day access with a 28.8 kbit/sec modem. (Both services have a $300 establishment fee). Connect.com's customers are mainly companies, schools and professional people. Other Internet service providers target consumers and they will be able to offer BR-ISDN access on an hourly basis just as they offer modem access today.

It is likely that the demand for Internet access will grow until it becomes at least as common as mobile phones are today. For most of the people who use it, speed is likely to be a crucial issue because they will be accessing Internet resources through the World-Wide-Web using browsers such as Mosaic and Netscape. A lot of the interesting material on the World-Wide-Web consists of still and moving images, sounds and music, so there will be a strong demand for speed - which only BR-ISDN can deliver until ADSL or digital fibre/coax systems are introduced in 1999 or so.

Musicians may have a professional interest in using BR-ISDN to communicate samples and music tracks between themselves directly. Many musicians will use the Internet and World Wide Web to learn about and contribute to global musical cultural developments. BR-ISDN's speed advantage over dial-up modems would make this a lot easier.

This discussion of Basic Rate ISDN has described it as a service coming through an NT-1 box, via a twisted pair phone line less than about 4 km long. However exactly the same service, with the same protocols and the same internationally standardised S-Bus, can be provided over any duplex communication link which runs at 144 kbit/sec or faster. For instance, it could be provided as part of the function of a coaxial cable interface box which is used primarily for receiving 6 Megabit/sec digital video from the cable, but also supports several hundred kbit/sec duplex communication. If an ADSL transceiver has a duplex channel of around 200 kbit/sec, then 144 kit/sec of that can be used to support a BR-ISDN service. It would also be technically possible to provide a mobile radio linked BR-ISDN service - although this would use a lot of bandwidth - equivalent to a dozen or so GSM phones.

BR-ISDN, with its protocol, 16 kbit/sec control channel, two 64 kbit/sec data channels and its S-Bus connection is likely to remain a standard for many years.

BR-ISDN is probably not fast enough for widespread electronic delivery of music to consumers. As described in chapter 14, with both 64 kbit/sec channels operating at once, it would take four hours to deliver an hour of music compressed 3:1. Before faster means become available, some highly motivated listeners may use BR-ISDN to purchase music with electronic delivery.

DIGITAL BROADBAND LINKS TO THE HOME

MDS and satellite links are unidirectional broadcast media - they cannot be used to provide individual duplex (both directions at once) links to homes.

The available technologies are optical fibre to the home, digital coaxial cable, ADSL and super-high frequency (SHF) microwave links to each home. Except where ADSL is limited by distance or other problems, all these links are likely to provide 6 Megabits or more of digital data to the home, with a several hundred kbit/sec duplex link for controlling programs on the 6 Megabit/sec link, and for providing other services like telephony and computer networking.

It seems unlikely that optical fibre will be used for connecting homes in the foreseeable future because of the cost of the optical interfaces, the physical inflexibility of the fibre and the difficulty of splicing the fibre. Another reason is that fibre cannot supply electrical power. Coaxial cable can provide electrical power to devices in the home - such as telephones which must operate reliably independent of mains power.

ADSL and SHF microwave links

SHF links may be cost-effective in a few years - primarily where homes are spread out too much to warrant installing coaxial cable. These links may operate over a kilometre or two with a line-of-site path.

ADSL was described in the previous chapter. It provides a separate digital link to each home, typically with 6 Megabits to the home and up to 640 kbit/sec both to and from the home, although its performance on real cables in Australia is yet to be tested.

These data links can be used in variety of ways at once. Two video programs could be received - one at 2 and the other at 4 Megabit/sec. The programming commands from the viewers' remote control are at most a few hundred bits per second. The 640 k duplex channel could be used for several purposes at once. A phone or fax call is 64 kbit/sec and computer links could be up to hundreds of kbit/sec. A BR-ISDN service could be provided with 144 kbit/sec of this 640 kbit duplex data link - with computer interfaces plugging into an S-Bus socket on the ADSL transciever unit.

ADSL and SHF microwave links are only likely to be used where coaxial cable has not yet been installed.

Digital use of coaxial cable

The main technology for providing individual broadband links to the home will be a local coaxial cable to 500 or so homes, carrying signals which encode digital data. This cable is connected to amplifiers which drive and receive signals between the coaxial cable and several optical fibres - which connect to the "central office" or the local exchange.

In the early years of introduction - before Video Servers become cost effective, the downstream signals to the homes on the fibre and coaxial cables will generally be the same throughout a city or town - except for those signals used for telecommunications. So the digital video data sent to one group of 500 homes will be identical to that of the next group.

To provide Video On Demand, individual digital links to each home are needed, and each fibre/coaxial cable system will carry a set of signals specific to the 500 homes it serves.

The following description is based on the technical fundamentals of coaxial cable digital technology, rather than Telecom's plans - which are not available.

Since the cable can carry signals up to 750 MHz, the 250 to 750 MHz area could be used to send data to the 500 homes, and the 0 to 250 MHz area used to receive data from the homes. This gives each home 1 MHz of bandwidth for receiving data on. This can carry at least 4.7 Megabit/sec of data using the existing modem (modulator/demodulator) technology, and probably up to 10 or 12 Megabit/sec with advanced approaches - depending on the signal to noise ratio which can be achieved.

It is likely that the frequencies used for transferring information will by dynamically allocated to suit the needs of individual homes, providing flexibility to accommodate higher demand in some homes at certain times.

The aim will be to provide 6 to 8 Megabit/sec to each home, primarily for MPEG-2 compressed video, whilst providing a several hundred kbit/sec duplex channel for other telephony and data communications - such as Internet access.

It may be possible to provide 2 or 6 Megabit/sec upstream links *from* the home for those customers who want to send large quantities of data, but since this will not be the typical use of the system, it will be optimised for relatively small quantities of data coming from the home.

The cable carries the signals of all the communications to and from the homes - so equipment in one home can read the signals sent and received by another home. The signals will encode digital data, but each steam of data will be encrypted in a way which makes it impossible for anyone else to decipher the data. This encryption is essential for both privacy and security. Effectively uncrackable encryption is described in Chapter 9.

Despite the shared nature of the cable, homes will not communicate directly over the cable. The cable provides secure links to an exchange or a number of switches for different kinds of data - such as Internet, telephony and MPEG-2 VOD data. Communication between homes on the cable will be the same as between homes on different cables - through the exchange.

Whether a home is connected to broadband telecommunications network via coaxial cable, ADSL, SHF microwave or optical fibre, the link will be functionally equivalent and will be used for the same purposes. How the use of these communication channels will be charged for is a matter of debate at present. The long-term plan is to build digital links to homes to support telephony, networking and MPEG-2 delivery - with a lot of the revenue coming from the latter. It seems unlikely that the consumer will pay more than $5 for the delivery of a movie to them - so there is debate about how this major telecommunications infrastructure will be funded. Nonetheless, the infrastructure is being built!

It is widely believed that these digital broadband links will ultimately be built to the majority of homes. This paper assumes that the individual links will first be introduced to around 2000 - when Video Servers start to become cost effective - but will take many years to reach 70% of homes.

TOWARDS A GLOBAL NETWORK

At the time this paper was completed (April 1995), it is clear that the communications revolution is gathering pace. There is widespread agreement that at some stage in the future, the developed world will be served by a global network which connects to homes, offices, schools and to phones and computers which are mobile - in cars or hand-held.

The network will be capable of transferring up to 6 Megabit/sec of data into homes - this is necessary for fast action digital video. Individual digital video feeds to each home will probably be the most difficult task the network must perform - and one of the most valuable.

However there is widespread disagreement about how this network will evolve, and how it will be used. Some analysts think that the average consumer does not want to pay for individual video programs or personalised news - that they do not want to make decisions and would prefer to watch the same material as everyone else. Others consider that consumers will gladly pay for choice and quality programming - just as they abandoned the horse and train for the flexibility, expense, stress and responsibility of driving their own car.

It is not possible in this paper to consider all the divergent views on the communications revolution. Instead a future scenario will be presented which conforms roughly with that put forward in CFP Paper 6 *Towards the networked home: the future evolution of residential communications networks in Australia.* The scenario presented here is more optimistic about early introduction of individual broadband links than that of Paper 6 - for the following reasons:

1 - The demand for high speed Internet access, driven by World Wide Web (WWW) usage, will escalate and provide a high value market for duplex data communications. This will drive development of the Internet technically and in terms of its "content". As it become more popular and used for a wider variety of purposes, the desirability of providing video data through the WWW will grow dramatically.

2 - The WWW "protocol" or language - HTML (Hypertext Markup Language) - will mature and be expanded to support video on LANs (Local Area Networks) - which can support the necessary data rates.

3 - The technical developments in networks and switching will support video speed World Wide Web - or Video On Demand, which may be a very similar thing - as soon as the local links to the home are available.

4 - Developments in magnetic and optical discs will merge with switching and software developments to provide Video Servers on a cost effective basis around the year 2000.

When this happens, Video On Demand will be a practical and highly saleable service, and the coaxial cable systems will be changed from their distributive, subscription TV role, to providing individual links to each home.

The purpose of this scenario is to facilitate discussion about the music industry, so specific dates - such as 2000 for the start of VOD - are reference points to aid discussion, rather than firm predictions.

The recorded music market will use the future network, and may contribute between 1% and 5% of its revenues. However the direction of the communications revolution will be directed mainly by the markets for telephony, video distribution, electronic mail, interactive applications and business communications.

There can be no doubt that ultimately one network will emerge to support the convergence of telecommunications, audio and visual content industries, and computing. Technically this single global network will be composed of many technologies - such as optical fibre, coaxial cable, twisted pair phone wires and various terrestrial and satellite radio links. Its components will be owned by many operators, but will function as one system, with common protocols - just as today's telephone system does.

Common protocols

The market forces driving global communications standardisation are immense, but it may take decades for the standardisation to occur. The cost of electronic equipment can be expected to continuously decline while its sophistication increases. The eventual harmonisation of all forms of electronic communication is facilitated by the fact that one kind of duplex (bi-directional) electronic link can be configured to behave like another kind - within the limits of its maximum speed.

This means that the global network will be unified by common protocols and data formats - rather than uniformity of equipment or physical communication links. One such low level data transport protocol is being developed now - Asynchronous Transfer Mode (ATM). This is a packet switching technique based on short 53 byte data packets which can be switched instantly by hardware, rather than requiring computers and software. ATM has been designed to support all kinds of data transfer, from low speed data communications, through telephony up to the broadband multi-Megabit/sec data streams of digital video. It is equally suitable for local office computer networks and for networks which span the globe.

ATM packets can be sent over existing data links of all kinds. It is widely believed that ATM switching is both necessary and sufficient to provide the low level functions required for all global network developments which are currently foreseen. Further work is proceeding on global addressing systems and flow control protocols for ATM traffic, as well as on the hardware which performs the switching. It seems that with continued work the global network will be entirely feasible.

Today's Internet is an example of a heterogenous global network with a common protocol. A link to the network via a standard phone line with a modem and personal computer is all that is required to create a fully functional connection to the Internet - limited only by the speed of the modem. This protocol is a packet switching technique called TCP/IP. Although it is suitable for today's Internet, the protocol, its variable length packets and its limited addressing scheme mean that TCP/IP is not a suitable basis for a global broadband network. So while the Internet will continue to grow, its low level protocols will increasingly be carried over links which use ATM. Proposals to expand the Internet addressing system have been made and there is debate about whether this or some other scheme will adequately serve all future needs.

The higher level functions of Internet are likely to persist and increase their currently unstoppable momentum. These include Usenet News, email, File Transfer Protocol, Gopher and particularly the World Wide Web global hypermedia system. These are likely to evolve into permanent fixtures in global communications on the user level. In the future, these functions may be interfaced to voice and fax telephony, and to Video On Demand services.

Telephony, Internet, existing LAN and WAN (Local and Wide Area computer Networks) technologies, and the early VOD services will all have their own high level addressing schemes - like telephone numbers and email addresses. They all have differing functionalities and protocols.

In the future, a new low level addressing scheme will be required to allow ATM to be used transparently across the globe. This low level addressing scheme must be extensible to cover every sub-function of every piece of communication hardware which is likely to exist in the next 50 years - no easy task. This low level addressing scheme and the ATM protocol which uses it will not be visible to users.

How the existing global telecommunications system will be upgraded to work with new addressing schemes and protocols, whilst supporting the low and high level protocols of existing systems (telephony, Internet etc.) using ATM, is a matter of debate and research.

THE INTERNET

The readers of this paper are assumed to know something about the Internet - its use for electronic mail, discussion groups and file transfer. However not all will have direct experience or will have used the World Wide Web (WWW) using browsers such as Netscape or Mosaic. The World Wide Web shows today the point and click hypermedia (text, image and sound) user interface which is likely to be used for many future consumer applications - especially Video On Demand. It also demonstrates the global nature of the network. The World Wide Web will play an increasingly important role in the diffusion of music and information about music.

There are now many books on the Internet. One good one is *The Whole Internet* by Ed Krol 2nd Edition 1994 O'Reilly and Associates. To access the Internet you need a computer, modem and an account with an Internet service provider. To access the World Wide Web aspect of Internet, you need a "SLIP" or "PPP" account with your service provider and appropriate software for Macintosh or Windows - which your service provider will supply.

A good magazine for learning about the Australian Internet situation is *Internet Australasia* a monthly magazine avialable in newsagents. Each issue of *Internet Australasia* carries a listing of Internet service providers.

Reasonably up-to-date lists of Australian service providers can be found at:

```
http://www.cs.monash.edu.au/~zik/netfaq.html
http://www.iinet.com.au/index/isp.html
```

World Wide Web addresses - such as http://. . .

For those not familiar with the World Wide Web, this is a URL (Universal Reference Locator) address which can be typed into a Web browser program such as Netscape or Mosaic so that the browser will retrieve a particular file and display it on the screen.

The address:

```
http://www.iinet.com.au/index/isp.html
```

is composed of the following elements.

`http://`

Hypertext Transport Protocol

`www.iinet.com.au`

The World Wide Web server function of a computer called *iinet*, in the *com*mercial subgroup of Internet computers in *Au*stralia.

`/index/isp.html`

Instructs the WWW server to look in its *index* subdirectory for the *isp.html* file. html stands for HyperText Markup Language - a simple set of codes which tells the WWW browser how to display the text and how to find images, sounds and other

WWW files from the same computer or anywhere on the Internet.

This paper makes reference to many resources with such addresses. All these are accessible to anyone with Internet access, using a graphic WWW browser such as Netscape or Mosaic, or a text based browser such as Lynx.

A partial list of Australian WWW servers - computers which contain WWW documents - can be found at

`http://www.csu.edu.au/links/ozweb.html`

Accessing the Internet

It is impossible to develop an adequate understanding of the future of communications without using the Internet and spending many hours exploring the World Wide Web. The Web is the most dynamic, graphic and musical aspect of the Internet - and the easiest to use.

Readers are urged to get online and explore this themselves. It is not good enough to read about it or watch over someone's shoulder! All it takes is an IBM PC or Macintosh, a modem, an account with an Internet service provider accessible with a local phone call, and a few hours work. It is well worth purchasing a guidebook to the Internet, reading its introductory section and keeping it as a reference.

Atari and Amiga computers can be used for text based access, suitable for email, Usenet news groups, file transfer and text based WWW with Lynx. The April issue of *Internet Australasia* describes how to use an Amiga for full graphic Mosaic WWW access.

Service providers vary considerably, with some low cost services catering for non-commercial users who do not need fast access. Other major service providers, such as OzEmail, Australia Online and AUSNet services provide a more professional service at prices such as $25 to $95 registration, $8 an hour during business hours and $5 an hour at other times (or less). Access fees may vary significantly and in the long term will become cheaper than this.

Internet access in Australia is undergoing rapid expansion, whilst the technical nature of the Internet is being upgraded to cope with the growth of traffic. There is something of a frontier flavour to getting access, and the Internet itself contains many frontiers.

Despite reports in the press, using a modem to link a computer to the Internet poses no security risk, however any programs which you download *could* contain a virus - but the likelihood is low. It is possible to connect a LAN to the Internet, however this does raise security issues and should only be done by a qualified network manager.

Most students at tertiary institutions are able to have some kind of Internet access. Some public libraries are providing Internet access from library terminals, and via modem. The Victorian State Library has announced a low cost scheme with 48 modem lines which is aimed at people who would not otherwise have access to electronic information.

Internet access and costs are rapidly evolving. The function of AARNET is under review and Australia's networking needs have been the subject of several reviews, including the Broadband Services Expert Group and The Australian Science and Technology Council in their report *The Networked Nation* September 1994[6].

One major development due in August 1995 is the release of Microsoft Windows 95 operating system, with built in access to a global Microsoft Network service. This will be a separate service to Internet, but will provide access to Internet including the World Wide Web via its own browser program. Access will be via a modem call to a local phone number in the capital cities of most of the developed world. The service will be charged for at moderate rates and it will require virtually no user effort to access.

Microsoft promises powerful search engines for finding information within its own network and the wider Internet. A secure electronic payment system would be integrated into the network, and would work with major credit cards, for a small fee. Some functions which are currently performed by standalone programs will lead directly to an interchange over the network. For instance asking for help in a spreadsheet program may lead the user into a discussion group or support forum for that aspect of the spreadsheet's use.

Some analysts (Ashcroft 1995) believe that the Windows 95 release to 60 million users could add 10 to 20 million additional people to the 20 to 30 million who currently use Internet.

The use of the World Wide Web for music marketing is discussed in chapters 14 and 17. There are many music resources on the Internet, including public file access sites and mailing lists - which are closed discussion groups. The following is a list of some Internet resources specific to music.

Usenet Newsgroups

Internet newsgroups are public discussion groups - like "Letters to the Editor" about a particular subject. Their proper name is Usenet newsgroups - they exist on the Internet but are accessible from other systems such as CompuServe, America Online and Delphi. The term "newsgroup" is a

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6 This report can be read on the WWW at http://astec.gov.au/astec.html, where it is also available in text and postscript forms. It is also available from the Australian Government Publishing Service.

misnomer. The text material is written by ordinary users so it has no resemblance to mass media news. Nor are they groups - there is nothing to join. Anyone can read the postings and post material themselves, but some newsgroups have an editor (also called a moderator), who may change or reject the contribution. In many cases, newsgroups have no editor - so they are often a free-for-all. Most newsgroups are accessible internationally, even if they deal primarily with issues in one country.

alt.music.alternative alt.music.techno
alt.rave aus.music
comp.music
rec.music.info (There are 22 other groups under rec.music)
rec.music.makers.bass rec.music.makers.synth

The World Wide Web

The following descriptions give the URL (Universal Reference Locator) to access the resource. Just type the entire URL into your browser and it will get the text and images from that location. Each of these pages will contain hot-links to other pages at the same location or to pages from anywhere else in the world. World Wide Web resources are changing and growing rapidly. These are starting points, from which other resources can be found.

Aussie Music is a specialist retailer selling distinctive Australian CDs to consumers in other countries. They offer 60 second stereo audio samples and cover graphics of all the discs they carry. This service commenced in February 1995 and is a good example of how CDs can be marketed using the WWW.

    http://www.aussiemusic.com.au

Internet Underground Music Archive. Songs, excerpts and graphics from many unheard of artists - mostly unsigned. There are separate sections for labels, ranging from the obscure to Warner Brothers.

    http://www.southern.com/IUMA/

Hyperreal - the Techno/Ambient/Rave Archive. Dedicated to cyberculture, dance and techno music. Links to catalogues and audio samples of many record labels and to a good collection of audio software.

    http://www.hyperreal.com/

Polyester Records and Books. Music and book catalogue of the Fitzroy shop. Listings. Ordering is by email, fax phone or snail (normal postal) mail.

    http://www.polyester.com.au/PolyEster/index.html

A better approach to selling CDs lists the discs and gives buttons to click for the CDs to be ordered, with a running total of dollars spent at the top of the screen. There is an option for building a "Wish List" of discs you may want to buy in the future. One such service in the USA is Noteworthy Music, accessible via NetMarket at:

`http://www.netmarket.com/`

NetMarket is run by a 21 year old programmer and acts as a network and credit card gateway for a number of services including Noteworthy Music - who stock 17,000 CDs.

US retailer CDNow boasts 140,000 CDs, cassettes and mini-discs.

`http://cdnow.com`

A more elaborate service involves display of cover graphics, song lyrics and the capability to download short samples or entire songs, as well as order the CD. An example of this - for one CD only - is local band the Ergot Derivative.

`http://www.maths.monash.edu.au/people/ernie/ergot/`

Another example, again for a single CD is Violet Arcana, who offer news, samples, graphics, reviews, discography, interviews, lyrics, poetry, a mailing list for fans and a multimedia program for the Macintosh.

`http://www.teleport.com/~arcana`

Boom Crash Opera have their own web site, which includes graphics, sound and a biography which is evidently the cogitations of someone who has bitten off more of the late twentieth century than they could handle.

`http://werple.mira.net.au/~bco/`

As BMG artists, this site is pointed to by the BMG site:

`http://www.bmg.com.au/bmg/`

A major record company site in the USA is:

`http://www.music.sony.com/`

Inter-Music carries its own material relating to certain artists and has an extensive list of links to other music sites.

`http://www.ozonline.com.au/TotalNode/AIMC/`*Inter-Music*

Next has material relating to music and video games, includes some information from the Australian Music Industry Directory and a good list of music sites.

`http://www.next.com.au`

Weekly music magazine *Beat* claims to be the first to place its entire contents on the World Wide Web.

`http://www.ozonline.com.au/beat/`

US "music, technology and style" magazine *Axcess* has a web site, with some articles from the current and previous issues. In addition, a collection of articles is available in Adobe's PDF (Portable Document Format). There are links to Adobe's site where an Acrobat PDF viewer program (for Mac and Windows) can be downloaded without charge. This enables the Axcess PDF file to be viewed and printed. PDF files are self-contained hypertext documents which allow finer graphic and typographic content than is currently possible with the World Wide Web. However, a recent agreement between Adobe and Netscape Communications will enable PDF documents to be accessed in small portions over the WWW.

`http://www.internex.net/axcess`

The author's WWW site contains material relevant to this paper (including updates), and links to various music resources of interest. Its contents are available to anyone on the Internet 24 hours a day. Although setting up a Web site involves some work, it is not too difficult - nor in this case, too expensive. This 5 Megabyte space on the OzEmail computer can be expanded for an annual fee. The standard 5 Megabyte space is a standard part of the OzEmail Internet access service. This costs $25 to set up and $5 an hour (off peak) to use for accessing the Internet and setting up the Web site. Unless people retrieve a very large amount of data from the site, there is no extra charge for how much it is used.

`http://www.ozemail.com.au/~firstpr`

The Netscape WWW browser program is available for Mac and IBM computers. It is constantly being updated and it is difficult to retrieve from the Netscape corporation's server - which is often busy. One good Australian source is at Adelaide university. From a WWW browser, type:

`file://ftp.adelaide.edu.au/pub/WWW/Netscape`

From an FTP program, go to `ftp.adelaide.edu.au` and then to the `pub/WWW/Netscape` directory.

Searching the World Wide Web

There is a search facility called Lycos which builds a database of the text of all the WWW documents it can find - over 2.6 million in April 1995. Some of these documents it knows only the name of, while for others it knows many keywords from the text contained in the document.

By typing in a few words, the search engine returns a list of documents which contain these words with summary information about these documents. By clicking on one of the titles of these documents, that document is loaded. This is an excellent way to fish for information. A WWW page listing various search facilities is available from the Netscape *Directory - Internet Search* menu item. The Lycos server at Carnegie Mellon University is at:

`http://lycos.cs.cmu.edu/`

After typing in "Midnight Oil" into the on-screen form provided by Lycos, it takes a few seconds to return various references, one of which is to the extensive "Oilbase" database created by Midnight Oil fans.

`http://www.stevens-tech.edu/~dbelson/oilbase/`

A new commercial search service is InfoSeek. It can search the full text of all the WWW documents, whereas Lycos only searches the start of the text of some documents. Info-Seek can also do full text searches on the last five weeks of Usenet news and supply the news item - a remarkable feat. It can also search quite a number of other information resources which are not available by other means. Searches are typically 5 US cents each, except for certain premier services. A free trial with 100 searches is available:

`http://www.infoseek.com/Home`

A search for "Plastikman" returned links to 6 WWW documents and 43 news item for the US techno artist. A search for Australian techno artist Zen Paradox returned links to one WWW document and 6 news items, including one regarding a rave in Switzerland he recently played at.

Since a search service is highly valuable, and becomes technically more difficult as the number of resources and the number of users both increase, it is likely that the best services will be those paid for by users. Info-seek seems to be reasonably priced and to offer an excellent means of scanning Internet resources.

Such global search facilities facilitate finding out what people are saying about an artist and finding any of the artists music and other resources which are available. This search facility would make it difficult for pirates to persist in announcing their wares - because a vigilant artist or manager could easily find them.

There is no master index for all the resources on the World Wide Web. Nonetheless, some people have devoted considerable effort to making extensive indexes. One set of indexes is at:

```
http://akebono.stanford.edu/yahoo
```

No written document can adequately describe the Internet or the World Wide Web - the reader is encouraged to explore for themselves.

File transfer and archie

Many files are available from publicly accessible file transfer sites - including a great deal of samples, MIDI files, software and other material of interest to musicians. Special FTP (File Transfer Protocol) programs can be used to access these sites, but Netscape is adequate for most purposes, and is often more convenient.

The names of the millions of files in these public sites can be searched using a service called Archie. The most convenient way of accessing it is through a WWW interface, which presents the results of the search on the screen, so the user can click on the files they want to download.

```
http://www.gh.cs.su.oz.au/Utils/archieplexform.html
```

Internet Relay Chat and voice communications

IRC is a real time, one line of text at a time, conversational system. By using a special IRC program, users may join one or more of thousands of groups on a variety of topics - or start their own. Groups can be secret, and text conversations can also take place between two individuals. The system is international, and is primarily a social forum. More detailed discussions are best achieved with Usenet newsgroups or mailing lists. People typically use this to make friends and discuss matters of common interest - including music. Details of IRC can be found on the `alt.irc` newsgroup.

Recently, programs have been developed which enable similar communications to take place with voice. One program "Internet Phone" uses a Windows based PC with a sound card and a modem of at least 14.4 kbit/sec baud to enable spoken conversation - like a two way radio - between individuals. This requires a "solid" connection to the Internet - where only the modem limits the data transfer between the computers. That is to say that the Internet service provider's computers and data links are working properly and not limiting the flow of data. On certain popular service providers today, such a situation is far from common as the companies struggle to support the numbers of users they have signed in the past few months.

Judging by the performance of this program with speech at 14.4 kbit/sec, it seems likely that music may be quite recognisable, especially at 28.8 kbit/sec.

This raises the possibility of talking about music and playing the music to people. If this method can be used for real-time auditioning of music over existing modems, then this could play an important role in music discovery.

Other programs enable video conferencing - with slow scan, limited resolution video and sound being transmitted between computers anywhere on the Internet. Such a program is CuSeeMe - for the Mac. A Windows version only works with video. These techniques are in their early stages. They will be more useable when Internet access at full 28.8 kbit/sec modem speed becomes relatively common.

Real-time conversations and group discussions with voice, text, music and limited resolution video will become practical and relatively common in the future when 64 kbit/sec Basic Rate ISDN links to the Internet are more widely available.

CHAPTER 7 VIDEO ON DEMAND

> *Video On Demand (VOD) is the ability to chose to watch any video material at any time. It represents much more than instant access to a video library. VOD is not based on broadcast and channels. It is based on a high speed telecommunications network and powerful storage systems called Video Servers. It is equally capable of providing digital audio, telephony and computer networking - supporting applications such as telework and Internet access.*
>
> *Significant consumer use of VOD is likely to start around 2000. This chapter describes VOD and the infrastructure which will be needed to provide it.*

Video On Demand will bring a complete transformation in the supply of video, information and audio. It is a radical change from the broadcast and distributive electronic media. Most of the following discussion relates to its video applications, but these points are relevant to musical applications as well. VOD completely changes the relationship between the viewer and the program they watch. The economic relationships between viewer and program provider are likely to be totally different from those of the present commercial TV and radio industries.

THE VOD INFRASTRUCTURE

Video On Demand refers to a technical capability for the viewer to select from a wide range of live and pre-recorded video programs, and view them without delay, with full control over fast-forward, rewind and pause. This can only be provided when there is an individual link to each home - so it can only be provided to homes with a digital fibre/coaxial cable system, ADSL or SHF duplex link. The video programs will be compressed with MPEG-2. However the link is likely to be based on ATM and support a number of services concurrently - such as video, telephone calls and computer networking.

To provide this, there must be a "VOD Infrastructure" with three major components:

1 - One or more Video Servers - capable of storing and replaying digital compressed video information. These will be in central locations - initially one site in each major city, but as costs are reduced, they will also be installed in phone exchanges, or other locations closer to the consumer. This wider distribution of video servers will be done to reduce transmission costs - the need for long, high capacity multi fibre cables capable of

serving hundreds of thousands of homes. These distributed Video Servers will provide a local source for the most popular material.

Video Servers are specialised combinations of computers, switching hardware, huge arrays of magnetic hard disks, and arrays of magneto-optical (re-writable), write-once CD, and CD-Video disc drives accessing discs in an automated jukebox storage system. The Video Server also digitises live video signals, and stores and reproduces video, audio, music and general computer data to provide the moment to moment needs of individual customers in their homes. Video Servers are a new and demanding application of all the above technologies. They are unlikely to become cost-effective before 1998.

2 - Some means of conveying this data to a "distribution point" which is within a few kilometres of the home. This link is almost certain to be by optical fibre. The distribution point for fibre/coaxial system is the "optical hub" which drives the 500 home coaxial cable - it will be located in a street cabinet. For ADSL, the distribution point is the "upstream ADSL transceiver rack" which drives the twisted pair phone lines. This is likely to be the existing telephone exchange, but it too could be located in a street cabinet.

3 - An individual "last mile" link from the distribution point to each home - with typically 6 Mega bit/sec downstream and some upstream capacity for the program control commands. This could be fibre, digital coaxial cable or ADSL. This link could also be achieved with SHF microwave links - to fixed or perhaps mobile users. In the foreseeable future, only digital fibre/coaxial cable and ADSL are likely to be used, and both these are unlikely to be widely used before 2000.

This VOD infrastructure will be designed primarily for handling MPEG-2 video data, but the system will also be used for music and what we currently think of as radio programs.

So starting around 1998 to 2000 we can expect VOD to play an increasing role in the supply of video programming. Since it is an interactive, personal networked supply of digital data streams, it can also be used for audio purposes - which only require between 0.050 and 0.7 Megabit/sec, whilst video requires 2 to 6 Megabit/sec.

The VOD infrastructure can also support data communications - since the data links to and from the home can simultaneously carry many separate streams of data. This is discussed below in the "VOD and the UBN" section.

VIDEO APPLICATIONS

VOD is often thought of as being no more than a video library accessible from an armchair with a handheld remote control. This greatly underestimates the capacity of VOD to provide a wide range of programs and information. There are many valuable applications which are only practical with VOD - or are much more cost-effective with VOD than with other approaches which utilise limited channels. These applications include:

- Personalised, interactive news, up-to-date at any time.
- Live sports - with viewer controlled action replay and choice of camera.
- Recorded sports - with viewer of controlling skipping over the dull parts.
- Movies.
- Typical "TV" productions, including replays of free to air programs.
- Programs from overseas.
- Programs on specialist topics from the local area, Australia or overseas.
- Non-professional video productions and video magazines.
- Community programs from local and national organisations.
- "Informercials" - programs providing information about products and services.

The application of VOD to movies is easy to imagine - it is just like a VCR with instant and immense choice.

However news is a much more diverse and complex product than a linear movie. The application of VOD to news completely alters the relationship between the producers, packagers and consumers of video news materials. Traditional broadcast news programs are linear, unstoppable and consist of a relatively small number of stories which may be edited to a degree which severely degrades their value to the viewer because of compromises in depth and accuracy.

VOD News

Today's TV news is hardly related to the recorded music industry, but it is worth exploring VOD news for two reasons. Firstly it gives some insight into the demand for VOD and hence how quickly the VOD infrastructure will be developed. Secondly, it shows that VOD news can lead to other applications which are currently not though of as being "News" but which could include access to specialist information - including news about recording artists, complete with music and video clips.

A VOD news session would present the stories of interest to the viewer in the desired order - for instance sport could be first. These preferences would be known to the central computer system, which provides the VOD news service, through a combination of the viewer's explicitly entered preferences and from their previous choices as they watched or skipped different types of news. In addition, news stories would be accessible via a text menu - sorted into a variety of classifications. Each story could be rewound, paused and fast-forwarded. Perhaps the most commonly used button on the remote control will be "Skip to the next story".

Each story may exist in a variety of depths - a short summary, or an in-depth report. In an advanced system, hyper-links to other stories would exist so viewers could click their cursor on an icon or press keys on the remote control to jump to a related item. Viewers would be able to compare reports of the one incident from several different reporters or news editors. Some news may be live, and certain kinds of stories could be prioritised to break into normal viewing as soon as they become available.

Since news programs are amongst the most popular on TV, it can be seen that VOD news could be a product which could generate huge revenues - which could surpass that of newspaper retail sales. (Sales comprise only 41% of total newspaper revenues - the rest is from advertising (BTCE 1994a).) This transformation of video into a less linear medium with more potential depth than the thickest newspaper, could hasten the decline of printed newspapers - particularly if hard-copy from video becomes cost-effective for consumers. (Printing from digital video is discussed Chapter 8.)

This expansion of the concept of "news" is typical of the blurring of distinctions between the current applications of linear media such as radio, TV and printed books and magazines. This is a result of interactive applications bypassing the divisions which currently lead to these distinctions. These divisions may be based on:

1 - Physical media. For instance the distinction between a CD and a radio program.

2 - The need to classify existing materials for the purpose of program scheduling in existing linear distributive media. For instance the distinction between news and current affairs - on the basis of depth and immediacy.

3 - Traditional or legal distinctions which have less impact in an interactive system.

The advantages of VOD over distributive approaches to video include:

1 - Access to programs at any time, via an on-screen menu, rather than at particular times only, after referring to a printed program guide.

2 - Full control over the program, with rewind and VCR like controls. This enables educational programs to be more valuable. It also enables a change in the structure of the programs - which can be made in the knowledge that viewers will skip over the parts which do not interest them, or replay the parts which they want to concentrate on.

3 - Revenue for the VOD service and programming is gathered directly, automatically and efficiently according to the viewers consumption - rather than by the circuitous and inefficient means of charging advertisers for access to audiences.

4 - The ability to charge the viewer directly for whatever they choose. Charges can be directly related to the quality of the programming - so there will be an incentive to produce programs of intense appeal to both large and small audiences. This contrasts with current TV advertising revenue which is determined by audience numbers - rather than by how much each viewer values what they watch.

Initially content will come mainly from the established film, video and TV industries. However content will increasingly be made specifically for the VOD market, or be tailored so that it is more marketable via VOD. Compared to commercial TV, VOD removes two important restrictions. Firstly it is no longer necessary to plan for commercial breaks. Secondly there is no need to make programs fit into 30 minute or 60 minute time slots.

When VOD becomes a dominant market for a particular type of content, there are specific hypermedia features which can be incorporated which have no equivalent in conventional video. A VOD program producer will be able to assume that the viewer can easily pause, press a button on a remote control, navigate a menu and move a cursor. This enables the viewer to make choices about the flow of the program. This could be something as simple as "Click now if you want to skip the detailed discussion of the disease". It could offer multiple choices such as "Select ending: happy, sad or mystery." It could be a link to a retailer such as "Click on the hero's gamma-ray scimitar if you would like to print an order form so your parents can buy you one." For music, these hyperlinks could lead from a movie, variety show, news program or pop video program to a retailer who sells the music or related material.

This means that a sophisticated VOD program could have a non-linear structure with branches and loops within the program. From this it is a short step to linking to points within other programs from the same supplier - or to linking into other programs from anywhere else. Likewise links could also point to other types of resources beyond VOD such as hypermedia documents on the World Wide Web, or lead to direct sessions with the vendors of products or services.

Such hypermedia links are likely to be of immense economic importance. They would be easy to provide and program once the VOD infrastructure supports them in a consistent way. Since the World Wide Web will have been established for six years or so before VOD commences in earnest, VOD will link to existing WWW resources. It is possible that by then, the WWW will have evolved in sophistication and speed, so that the WWW will be the framework in which VOD is delivered.

AUDIO APPLICATIONS

The VOD infrastructure can easily supply one or more digital audio streams into each home - with little effect on the ability to receive video programs at the same time. Applications could include:

- Replay of the last weeks commercial, community and ABC radio programs. Listeners may be happy to pay moderate fees to hear what they would otherwise get for free. They could scan programs for music or other items which interest them. They could listen to programs which are broadcast when they are normally working, travelling, sleeping or doing something else. They could listen to programs which a friend tells them about.
- Local community programs, and "audio newsletters".
- Live and recorded sports - with a wider variety of matches or races being available than is possible with channel limited distributive systems.
- News and programs from overseas - such as the BBC World Service.
- Specialist music and spoken word programs. These could be from free to air radio, or the could be produced specifically for the VOD medium and sold on subscription or per use to listeners with specialist tastes. These programs could be compiled by non-professionals who want to share their interests or by professionals who derive income from sales of their programs. Examples of these specialist VOD audio programs include:

  Readings of the Bible or other religious texts.

  Readings of classic novels and romantic fiction.

  Readings of local and overseas newspapers (in a variety of languages) for the sight impaired or for people who can listen while they work - as the RPH radio stations do now, but with random access to the articles of interest.

  Historical reviews of the blues, gospel or 16th century French organ music. Listeners can skip over the commentary if they want.

  Dance sets by local and overseas DJs.

  Aerobics sessions.

  Top 40 countdowns with commentary - for specialised musical genres and from other countries.

In all these applications, the listener is able to fast-forward, rewind and pause. This enables them to maximise the value they gain from the program and so they are likely to be happy about paying both for the program and for the "VOD" supply of it.

One aspect of the increased utility to the listener is the opportunity to scan programs for music they like, to rewind and to tape (or record to hard-disk) the music they really like.

VOD CONTENT SOURCES

The applications in the previous section assume that there are one or a small number of video servers which provide video and audio through the VOD infrastructure. Initially this will be the case as video servers will be very expensive and tightly integrated with the telecommunications infrastructure which supports early VOD. These video servers are likely to be owned and operated by the telecommunications companies which provide the distributive and "last-mile" links to the homes. So initially, video servers are likely to be owned by Telecom, Optus and any other companies who develop substantial cable infrastructures. This could include companies which are now installing cable in regional cities such as Cairns and Rockhampton primarily for subscription TV.

The question of content-carrier separation is a major policy issue at present. Without legislated separation, the consumer may suffer from a monopoly in the content provision industry. However since most profits are predicted to lie in content rather than delivery services, strong content-carrier separation legislation may deter private investment in the cable and other infrastructure which will provide broadband links to the home.

Although the video servers will be centrally owned and controlled, there are two reasons why the content available from them is likely to come from a variety of sources.

1 - Government regulation to ensure content-carrier separation - at least in the longer term. Without such regulation there could be restrictive pricing, reduced choice for consumers, or even political bias.

2 - No single organisation could provide the immense diversity and volume of material that consumers will want. Video server owners will typically charge customers for the use of their server by volume of usage. They will maximise usage revenues by opening their servers to other content providers, rather than by trying to exclude them. Alternatively for "informercials" the usage could be paid for by the advertisers, and again the incentive would be to expand the capacity of the video server to accommodate the widest range of content.

The sources can be large and small companies, and individuals. Commercial TV air time is precious and subject to audit for standards (such as community standards and censorship), so only professionally produced programs are aired. These restrictions may not apply to the content carried by a Video Server since it is not broadcast and the characteristics of one item of content do not adversely affect the value of other items - as they could in a broadcast.

As the VOD infrastructure matures, it will provide for more of consumers' communication needs - such as sending email, files and even video material to other consumers. Part of this evolution towards a Ubiquitous Broadband Network will involve customers wanting to access Video Servers which are not owned by the operators of the VOD network to which they are connected. No operator can provide the full range of material that their customers desire, so there will be economic incentive to allow them to access other Video Servers and charge them for the carriage of material instead of carriage and content.

However there are fears that a consumer may have no alternative but to use one VOD network, so the operator could use their monopoly position to restrict access to other sources of content in order to maximise the revenues from their own. Assuming that customers do have access to other Video Servers, this will provide further incentive for the operators to enhance the attractiveness of their own Video Server with lower prices and a wider range of content.

In most cases the consumer will neither know nor care which Video Server they are accessing. They will however know what they are getting and what it will cost them - the total price of communication, switching, Video Server access and programming.

Ultimately this means that the VOD infrastructure allows almost anyone to supply content. So the distinction between content producers and consumers will become a matter of personal choice - anyone with the technical means can supply content to the server for free or for sale.

VOD AND THE UBIQUITOUS BROADBAND NETWORK (UBN)

As the VOD infrastructure becomes used more for communication, it starts to resemble a general purpose digital telecommunications network, with capabilities ranging from email, telephony, voicemail, file transfer, games, computer networking, audio distribution and broadband data transfer - especially video. From both technical and administrative perspectives, the only way of managing such heterogenous activities is to provide technical and administrative regimes which standardise and simplify all these kinds of transactions - and the new kinds of transactions which emerge continuously.

This mirrors the development of telephone exchanges in the early 1960s. Exchanges were hardwired, and to add a new type of telephone function, the hardware had to be redesigned. AT&T abandoned this cumbersome process and developed computer controlled exchanges so that new functions could be implemented in software.

As well as meeting the needs of those customers connected to a particular local network - such as one based on a network of fibre/coaxial systems - the operator will need to provide transparent links to the outside world. Later next decade, the desirable characteristics of a global broadband network will be more clear than they are now. The progress in hardware, software and communications protocols will enable it to be planned and constructed.

The greatly increased value which consumers derive from their telecommunications activities will provide the long-term revenue which will drive the major investments required to upgrade the local and global networks. The promise of greater revenues from improved services and the imperative of conforming with global standards is likely to lead to a global broadband network becoming part of everyday life around 2010 to 2015.

Some analysts are less optimistic, and point to historically robust limitations in the expenditure of time and money and find it difficult to see how these advanced networks can be funded in the foreseeable future. (BTCE 1994b) However, genuinely new services may change expenditure patterns. Examples include mobile telephones, cars and motion pictures. If broadband services were simply a replacement for TV and video rentals, then such an analysis would carry a lot of weight. However broadband services, including all the developments arising from the Internet in the remainder of the decade go far beyond the familiar entertainment and broadcast industries which such an analysis is based on.

Nonetheless, the costs of the broadband network, the prospects of repaying the investment and the potential costs to consumers if the investment is inappropriate are matters of intense debate in the telecommunications industry. During a conversation with a senior planner from Telecom, the author formed the opinion that the infrastructure was being built because if it was not, then a competitor would do so. The question of how it would be funded were to be sorted out later - in the knowledge that competitors would face the same problem. This of course is not Telecom's official position, but there has been no clear evidence to disprove the pessimistic opinions about high costs and low returns such as those of BTCE 1994b.

The appropriateness of the current plans to install two competing HFC systems in Australia are a matter of intense debate. However the author believes that the investments are basically well targeted - once the cables are installed, and the systems used digitally to provide individual broadband telecommunications links to each home, the value and variety of applications will greatly exceed almost all current projections, and the cost of the electronics to achieve it will be somewhat lower than currently anticipated.

In the longer term, the costs of the network infrastructure are less significant. The infrastructure involves investment, administration, installation, cables and electronic equipment. The latter will drop rapidly in cost and the whole network seems unlikely to cost as much in real terms as the roads, public transport, water, power and defence infrastructures built over previous decades - but it will be at least as valuable as any of these.

This will be a Ubiquitous Broadband Network, and although it may take decades to reach 97% of the population, its will have an earlier impact on the most economically active 30% of the population. It will be Ubiquitous because it will carry telephony and other types of communication - including the broadband data streams needed for VOD. It will allow communication between any connected person or equipment - limited only by the speed of the local link.

Costs of international data transfer

However costs for transfer of broadband data via satellite and long (international) fibres are likely to be prohibitive except for commercial applications. It may cost a few dollars to get a 3 Gigabyte movie transferred to the home from a local Video Server, or a few dollars to get a 300 Megabyte file containing an hour of compressed music from any city in Australia. These costs could rise enormously for transferring the same data from overseas.

This means that the distribution of video and, to a lesser extent, audio data are likely to be handled by agents in regions, so that consumers are not buying large quantities of data over expensive long-distance links.

This important to the Australian music industry, since it means that there will be significantly greater costs for electronic delivery of music from retailers outside Australia. This protects our local retailers to a certain extent from foreign competition, just as freight costs and delays are now a disincentive to Australian consumers ordering CDs from the USA. However the same costs mean it is harder to sell music electronically to customers overseas. We will need to operate through agents overseas, or conduct the transaction here, but supply the music from mass storage systems in the customer's country.

The ubiquity of computers

The computer will be the main tool for accessing the network just as the telephone is used now. Computing functions are more likely to be tied to the information sources available via the network than they are with today's necessarily isolated computers. A computer which is not connected to the net will be as unusual as a disconnected phone is today.

The applications of the Ubiquitous Broadband Network include all functions now performed by phone, answering machines, fax, email, Internet, wide area networking and a great deal of the functions now performed by CDs - both audio CDs and CD-ROMs. The applications include all those listed above for video and audio via the VOD infrastructure.

The applications include those below - some of which exist or are feasible on today's Internet. Some of these new applications will become possible because of the network's broadband data capacity. However many of them do not require large amounts of data to be transferred - the network will enable their development primarily because of the network's ubiquity.

The local link to the global network will support many activities at once, 24 hours a day. Many of these activities will be handled automatically by the network - such as redirecting data to where the customer is currently located. Others will be handled or initiated by the customer's home or portable computer.

The network is quite different from a telephone, which can only do one thing at once and typically requires manual effort to make it do anything. This will change perceptions of connectedness - as everyone will be potentially connected to everyone else, or at least to their computers and phones. This feeling of connectivity has political and cultural implications (Jones 1993) as well as the more direct personal and commercial implications.

Mobile links to the UBN

The local links to the UBN will typically be on the coaxial cable systems now being installed or planned for subscription TV. Some links may be via ADSL over wires which were installed decades ago for a standard phone. In the future some links may be provided by optical fibre, or by duplex short distance point-to-point SHF microwave links.

Cellular mobile links will exist for phones and computers - but it is unlikely that these will support video or be cost-effective for consumers listening to their own individual Audio On Demand program. Finally, if the proposed Low Earth Orbit satellite systems (such as Motorola's Iridium) are implemented, then the global network will extend to mobiles anywhere on the surface of the Earth except the poles. However these satellite links are likely to be costly and restricted to low bandwidth applications such as voice, fax and email.

This paper focuses on the cultural and commercial implications for the music industry. To set the scene, the following applications of the UBN are foreseeable - beyond the video and audio applications of VOD which were listed previously. Many of these are quite feasible on today's Internet.

- Secure, private, funds transfer, via credit cards or digital cash. This is likely to become commonplace on the World Wide Web within the next two years. See chapter 9.
- Newsgroups, discussion groups, mailing lists and the World Wide Web.

- Live video programs - with viewer response and participation.
- Live audio programs - radio.
- Electronic newspapers, magazines and bulletin boards exchanging text, audio and video data.
- Selection services - the functions currently provided by some advertising, letterbox leaflets, business guides, the Yellow Pages, classified advertising, the White Pages and directory assistance could all be combined in a system for searching for products, services and businesses, finding out about their products, making personal contact and placing orders.
- Video phones and conferencing.
- Personal mobility with phone, video, text and image mail being redirected to the current location - including mobile phones and computers.
- Network music sales and delivery, perhaps with automatic music identification. These are discussed in chapter 14.
- Telework (telecommuting).
- Collaboration between workers in graphics, music and video.
- Specialised graphics input and output - scanning and printing.
- Remote access to recording studios with audio, graphics and MIDI links.
- Education.
- On-line encyclopedias.
- Systems for searching and retrieving technical and academic literature.
- Voting and participatory democracy, such as referenda.
- Children's programs.
- Personal counselling.
- Personal contact services.
- Religion.
- Games and other diversions
- Erotica and personal sexual audio/visual services.
- Gambling.

In a submission to the Broadband Services Expert Group, the author explored the many applications of the broadband network - some of which can be realised on the Internet now. An updated version of this exploration will be available via the World Wide Web:

`http://www.ozemail.com.au/~firstpr`

CHAPTER 8 DIGITISATION AND VOD - IMPLICATIONS FOR CONTENT AND HOW IT IS USED

The previous two chapters discussed how interactive hypermedia of the World Wide Web and later Video On Demand, bring fundamental changes in the way that content is accessed, presented and linked with other content.

This chapter discusses new ways that consumers can use video material when it is provided in digital compressed form. This applies to VOD, but it also applies to distributive digital video systems which are commencing now - such as satellite subscription TV. Digitisation enables consumers to use program material and advertising in new ways. It makes it possible to ignore unwanted advertising and make better use of desirable advertising. The implications of this for advertisers and viewers are explored.

The impact of advertising on today's commercial radio has had profound effects on the direction of popular music. This is examined because listeners may be better able to ignore the advertising and new forms of audio distribution and Audio On Demand may be free of advertising.

Comment [RW13]: Page: 133
This chapter is a re-written and much shorter version of what I originally wrote for this paper. The more detailed version will hopefully form the basis of an article - maybe for Wired. No-one I have read has forseen much of this fluidity and its two effects on advertising - ingnoring the rubbish and making the most of the good stuff.

DIVERSION OF VIDEO AND AUDIO MATERIAL TO OTHER CONSUMERS

With encryption, a subscription TV or VOD provider has absolute control over whether a particular consumer receives a deciphered MPEG-2 data stream or not. However, the program provider cannot control what happens to this data once it has been deciphered. Typically it will go to the MPEG-2 decompressor to drive the consumer's TV, however if the program is being sold at a high cost to the consumer, they may be tempted to send the data to their friends - who would chip in and share the cost of the program.

With a video data stream of 6 Megabit/sec, there are technical barriers which would make it difficult for a non-technical consumer to do this. Broadband networks to consumers will have 6 Megabit/sec downstream links to the consumer, but each consumer will typically have a more limited upstream link to the outside world - typically to the broadband exchange which could route their data to the phone system, to the Internet, or to another consumer's home.

Most consumer applications require modest upstream capacity and so most ADSL and digital coaxial cable systems are typically designed to have no more than 0.6 Megabit/sec upstream capacity. This is too small to carry a video program to other consumers. However suitably motivated people could create separate radio or coaxial cable link to feed the data, video and audio or an RF modulated video signal to neighbours - who would share the cost of buying the program. Faced with the prospect of regularly paying $10 or so for major sports events, many consumers could become sufficiently motivated to do this. This only makes sense for linear programs that they all want to watch at the same time - such as major sports events.

For compressed digital audio, a 0.6 Megabit/sec limit on upstream data out of the home is no problem, since 5:1 compressed audio takes only half that capacity. Assuming consumers can send data to each other via the upstream links and exchanges, then it would be technically feasible for consumer A to pay for an audio program and simultaneously relay it to one or more other consumers - with encryption if necessary to avoid detection. This will only occur to a significant degree if the network facilitates this practice with ease, at a cost which makes it attractive compared to each consumer buying the program directly.

If the savings are high enough, consumers will be tempted into illegal copying or sharing arrangements. As the cost of copying comes down, economic pressure will encourage lower prices for program sales - just as the availability of consumer CD-R writers will exert pressure on pre-pressed CD prices.

THE CHANGED ROLE OF ADVERTISING WHEN VIDEO IS DIGITISED

One function of new technology is to deliver video programs in a way that the consumer can be charged directly - so no advertising would be required.

Irrespective of these developments, there may be many situations where video programs do carry advertisements. Increasingly, video will be delivered to the home in a digital form - as a data stream of 2 to 6 or so Megabit/sec of MPEG-2 compressed video and audio. Digital video is used for satellite TV now and will be used for coaxial cable delivery later in the decade. It may also be used for MDS delivery. ADSL video delivery must be digital as must Digital Terrestrial Television Broadcasting and future HDTV systems. Video On Demand, via ADSL, coaxial or fibre-optic cable, must be delivered digitally because this is the only way to provide individual links to each home. Red light CDs may become a major source of digital video material, but it seems unlikely that it would contain much advertising.

There will be many sources of digital video programming and in many instances - including VOD - there may be a desire to use advertising to generate revenue.

Television advertising today suffers from many limitations. The adverts must be short so as not to deter viewers from watching. The viewer typically has no way of saving the advert or creating hard copy - as can easily be achieved with a printed publication. Consequently the adverts cannot impart much information - their impact can only be left in the viewer's mind. Many adverts are attention grabbing and concentrate on brand promotion rather than carrying the detailed information which can be printed in a magazine or newspaper.

From the viewer's perspective, the adverts interrupt programs and are hard to avoid - unless the entire program is taped and the adverts are manually skipped during playback - which is still inconvenient and the advertising images still must be watched in fast motion. This is unlike a magazine, where even the largest adverts can be skipped in a second or two, or can be read carefully and cut out for future reference.

When video is delivered digitally, it is relatively easy (compared to analog video) to give the viewer much greater control over what they watch. This new fluidity could be provided by either a personal computer or a stand-alone unit which is connected into the set-top unit after the MPEG-2 video data is decoded and before it sent to the MPEG-2 decompressor which reconstructs the analog signals suitable for sending to a video monitor.

At 6 Megabit/sec, ten minutes of MPEG-2 video would take up 450 Megabytes - perhaps a quarter of the hard-disk capacity of a 1997 personal computer. The personal computer could manipulate the data in a variety of ways before passing it to the MPEG-2 decompressor to be displayed on the monitor.

One application is for instant personally controlled slow motion replay. Another is to store sections of video for replay at a later date. In either case, most of the 450 Megabytes would be used to store the last ten minutes of video, so the viewer could rewind and view things again. For instance, after a distraction, the last ten minutes of a cricket match could be scanned at high speed to find the most interesting action.

This digital fluidity has two significant effects on advertising. The first is the ease with which viewers could automatically skip over adverts - so they never see them at all. If a 60 minute program had 10 minutes of adverts, then the computer could start writing the program to hard-disk and play the start of the program ten minutes after it was received. For the rest of the program the computer would decode parts of the digital stream - with software or dedicated hardware - and determine where the adverts were. It could then deliver an uninterrupted 50 minutes of program to the viewer.

To the extent which people adopt these methods, adverts will not be seen by those who do not want to see them. This would cause advertising to loose much of its effectiveness, reducing the revenue streams needed to provide programs to consumers who are unwilling or unable to pay directly for their viewing.

If this was the only effect of digitisation, then "free-to-air" programming would further decline against the competition from subscription video and VOD.

However, the fluidity offered by digitisation enables advertisements to be used much more constructively by the viewer. Firstly, the fluidity enables them to scan a program for adverts of interest. Secondly it enables the ads to be rewound, replayed and paused. Thirdly it enables the ads of interest to be stored for future reference on hard-disk - a 30 second advert would take around 22 Megabytes. This enables them to be shown to other members of the family - for instance children storing ads so they can show their parents what they want for Christmas.

When this fluidity is achieved with a personal computer, it is a simple matter to decode frames in the computer using software, and to print screen images from both programs and adverts. This vastly improves the value a consumer can derive from an advert and could be used to deliver entire price lists with illustrations to consumers. With compression, about four detailed frames could be delivered a second, a 60 page TV resolution colour catalogue could be sent in fifteen seconds.

The fluidity offered by digital video delivery cannot be achieved with analog video, because real-time MPEG-2 compressors are extremely expensive and are likely to remain so for the foreseeable future.

The fluidity offered by digital video delivery makes unpleasant adverts less useful to advertisers - because people will choose not to see them. It makes informative or enjoyable adverts of much greater value to viewers and advertisers alike. This fluidity changes the linear nature of video and makes it more like a magazine or newspaper in terms of skipping and focusing on advertisements. With a personal computer it enables hard-copy printouts.

For these reasons, advertising in digital video is likely to be quite different to that of TV - with benefits for both advertisers and viewers. It will require a new approach to video advertising.

Fluidity of digitised audio

In principle, digitisation can provide the same fluidity for audio as described previously for video. However the fluidity is not dependant on the audio being delivered in a digital form, since any audio signal can easily be digitised, and with suitable hardware, compressed in real-time. Real-time compression via software on personal computers or on the sound card hardware itself is becoming available now. Since compressed digital audio has a twentieth or less the bit rate, it is even easier to store and manipulate than video.

However there is no hard-copy function, and audio adverts can never be as informative as video and audio combined so there is less to be gained by digital manipulation making informative adverts more useable.

Another factor is that audio applications typically take place as a background activity for the listener - who may not want to fuss with manipulating what is being received. Since storage of audio will be an increasingly trivial task for personal computers, it could be easy for the computer to buffer whatever the listener is tuning in to. If the listener really likes a song - or an advert - they can find it in the buffer and store it for future reference.

Fluid control over any audio source, including AM, FM radio and Digital Audio Broadcasting can be achieved with existing sound cards and personal computers - if suitable software is written. With future hard-disk capacities, whole radio shows could be buffered. This would enhance the value of the program to the listener, and would enable them to hear programs which were transmitted at inconvenient times.

It could also enhance the value of the radio program as a promotional tool for the music it contains. This is because the listener can hear the track several times, and even give copies to their friends - perhaps by transferring the compressed sound file via the network. This also makes home recording from any radio source much more likely - with positive effects for promotion, but potentially negative effects on sales.

This application could be realised today, although the transfer of sound files to friends (over the Internet, through BBSs or direct to their computer) would be slow using today's 14.4 kbit/sec dial-up modems. A stereo 5 minute track compressed 6:1 is 8.8 Megabytes. This takes nearly an hour and a half at 14.4 kbit/sec. However a mono, three minute track compressed 12:1 and would take only 12 minutes if transferred with new 28.8 kbit/sec modems.

The digital manipulation of radio for storage is an example of the greatly enhanced fluidity of all data and all content - music, text and video. This generalised fluidity has profound effects on advertising, promotion and sales of music. The positive and negative effects of copying are discussed in Chapter 18.

CHAPTER 9 NETWORK TRANSACTION SECURITY AND FUNDS TRANSFER

The Internet, future broadband networks and mobile digital communications rely on cryptography for security and privacy. Public key cryptography provides absolutely solid security, privacy and authentication functions, without the need to exchange secret cryptographic keys.

Cryptography may be needed when delivering music over an electronic network - so that it can be decrypted only by its intended recipient.

Electronic commerce depends on a secure, convenient electronic funds transfer system. This field is evolving rapidly, and the application of cryptography to credit card and "electronic cash" transactions is discussed. "Electronic cash" is a new concept and is described in some detail.

CRYPTOGRAPHY

When information is transferred on any digital network, it can be intercepted without the knowledge of the communicating parties. Whether the transaction involves personal messages, music or funds transfer, there is a need to protect against the messages from being read by anyone. Although legal and technical barriers may be erected to stop interception, the only way that security can be ensured is to use encryption. The encryption techniques which are available today are too complex to explore in detail here, but their capabilities will be described.

When these techniques are applied fully, "complete" security can be provided - the encryption is not likely to be broken by the most intensive known techniques using the world's fastest computers in a reasonable time, say ten years.

Cryptography relies on keys - long numbers, or a hundred or so characters of text - which are used to encrypt messages into ciphertext, and decrypt the ciphertext to recover the original message. The security of a cryptosystem does not rely on secrecy about how the system works. It relies on two things alone:

1 - The security of the key needed for decryption.

2 - The difficulty of finding the right key by searching through all the possibilities.

The only way of breaking a properly designed cryptosystem is to try every possible number as the key in the hope of finding the one which works. This is made much more difficult by using a longer key. For instance, if decimal number were used as keys, it would take ten times as long to search for all possible 32 digit keys as for 30 digit keys. (Due to the fact that only some numbers are suitable as keys, the number of possible keys is proportional to the square root of the longest possible key.) So a 60 digit key would take a million billion times longer. It is not much more difficult to use a 60 digit key or a 100 digit key for encryption than is to use 30 digits, so there is no technical problem in making a cryptosystem extremely secure from cracking - including by government security services.

There is continuing debate about the problems raised by this, but since the cryptographic techniques are well known, it does not seem likely that governments will be able to stop their widespread use. Austel's Law Enforcement Advisory Committee has an "Encryption Working Group" which is considering these issues.

Security from interception

The most obvious use of encryption is for sending electronic mail, or perhaps a sound recording, to someone over a network. This could be the Internet, or a future broadband network. The aim is to ensure that if the message is intercepted, no one will be able to decrypt it.

In older cryptosystems, this was achieved with a single key, which was known to both parties, but which must be kept secret from anyone else. This is difficult or impossible to achieve, but there is a solution which does not require that the parties share a secret key.

Public key cryptography

Public key cryptography was developed by Whitfield Diffie in 1976 (Diffie 1976) and is now widely used. A good report on its development and on the history of PGP (a widely available program which provides bulletproof public key encryption) appears in Wired, November 1994 (Levy 1994).

Comment [RW14]: Page: 140
Note - where I specifically name the magazine and date etc. instead of leaving it in the references, it is because I want to encourage the reader to read it. If nothing else, the frequent references to Wired should encourage people to read the latest copies - which is an excellent way of staying in touch with latest developments.

If person A wants to send a message to person B using public key cryptography, B uses a computer program to generate two unique but related keys, each of which may be a hundred or so decimal numbers or characters. One of these is the private key which B keeps secret. The other - the public key - can be sent to person A, and in fact can be made public.

A uses B's public key to encrypt the message into ciphertext, and sends the ciphertext to B. This ciphertext can only be decrypted by B's *private* key - so it does not matter if it is intercepted or made public.

Thus anyone can use B's public key to send totally secure messages to B. If A publishes a public key, then A and B can send messages to each other over an insecure network with no possibility that their messages can be decrypted by anyone else.

A prominent example of the use of public key cryptography is PGP - Pretty Good Privacy. This is a widely available program which encrypts text messages such as electronic mail with long text based keys such as:


```
-----BEGIN PGP PUBLIC KEY BLOCK-----
Version: 2.6

mQCNAi7sTQkAAAEEAJe6XIdVJeRWzA14C64R5oyYUnGQ/5QmElW8/RCMyep/yObS
+ky2tNl6GU8UKXcuXY/xQymFgsU32kOj7pnNnYFfwa3IHF2/h5oj0eqBZ08tS+Ks
Pd0+YkIcro4T2Xg67q8PKZ8JxSrzstHPg1hxSkhCbEqNNcVpTyoDgh42omoFAAUR
tChSb2JpbiBXaGl0dGxlIDxyd2hpdHRsZUBvem9ubGluZS5jb20uYXU+
=8LOM
-----END PGP PUBLIC KEY BLOCK-----
```


Like other well designed public key encryption systems, there is no known way to decipher a PGP encrypted message in a reasonable time without using the proper private key. The PGP computer program source code is public and well understood by cryptographers - so all its security resides in the secrecy of the private key and in the strength of its algorithms, rather than in secrecy about the algorithms.

The key above is the author's public key. It is a text representation of a 1024 bit key. Using existing search techniques, with a 100 MIPS (Million Instructions Per Second) computer, it would take 28,000 billion years to crack. Using the same techniques, a 429 bit key would take 46 years - which is close to how much computer effort was required to crack the 429 bit RSA129 key in April 1994, using multiple computers (Abelson 1994).

Validation

Public key cryptography, can be used to verify that a message came from a particular person, and that the entire contents of the message have not been altered in any way. If person A wanted to send a message to B, or to the public in this way, they would use their private key to create a validation block - a few lines of random looking text at the end of the message. Other people can then use A's public key to test the message - which can prove that the message has not been altered and was in fact created using A's private key.

Both encryption and validation are functions performed by PGP (Pretty Good Privacy). For an introduction to this and public key cryptography see *Prophet of Privacy,* Wired, November 1994.

There are other methods of validation which are suited to one computer verifying that it is communicating with another - rather than an imposter. One widely used method is Kerberos (Neuman 1994 and Stallings 1995).

Practical applications

Despite the bulletproof security afforded by sophisticated cryptographic techniques using long keys, the computational requirements for using these techniques are relatively modest and can be performed by personal computers, dedicated chips and the small computers in smart cards. So a single chip or a personal computer with publicly available software is quite powerful enough to provide encryption which the worlds biggest supercomputers would take decades or centuries to crack.

There are few communication costs involving encryption - the ciphertext is typically a fixed length longer than the original message - perhaps a few hundred bytes at the most. Many applications such as email and electronic funds transfer can use public key directly. Other applications involve a much greater quantity of data - such as a telephone call (8 k bytes a second) or a digital video program sent along a shared medium like a coaxial cable. In these cases it is computationally more efficient, and no less secure, to use a two level process which means that the main stream of data is processed more simply by an use of an intermediate key, which itself is the product of a secure cryptographic transaction (Chang 1994).

The only security problem which remains with public key cryptography is the possibility that a person's private key is subsequently revealed - enabling the decryption of all previous messages encrypted using the corresponding public key. This weakness can be solved by building a chip which generates a pair of private and public keys for a particular two way communication session. The public key is sent to the other correspondent and the communication proceeds, with the chip using the private key to decrypt the incoming ciphertext. The chip is designed so it is physically impossible for it to reveal the private key, and at the end of the session, the private key is erased. So after the session has ended, it is impossible for someone who recorded the ciphertext to decrypt it.

This means that any two pieces of equipment - computers, mobile phones or military radios - can communicate over insecure channels with complete security from the messages being read by anyone else - then or at any time in the future. Hence a totally secure "pipe" can be created between two systems using well known software techniques.

Cryptography can also be used to secure the data stored on a storage medium such as a CD-ROM, magnetic hard-disk or writable optical disc.

DIGITAL PAYMENTS OVER NETWORKS

Although the Internet is being used increasingly for commerce, the most convenient way of paying for something is to send a credit card number to the vendor. The Internet is insecure - all packets of data could be scanned by software in any one of the computers it passes through en-route to the vendor. Such software could be installed by crackers and could be programmed to record messages which appear to contain credit card numbers. The only way of stopping this is to use encryption, or to send the credit card number by ordinary mail or a voice or fax phone call.

Some World Wide Web transactions are protected by encryption, so it is safe to transfer credit card numbers in this way. The encryption standards are being finalised, and should become a standard feature of WWW browser programs, which run on the user's computer, and the server programs which provide the information.

Before the Internet or any future network can be a suitable channel for doing business, there must be some means of transferring funds securely simply be exchanging information. This could involve digital "cheques", digital "credit-card transactions" or digital "cash" - in which a packet of data carries value, but does not identify who spent it.

Commercial uses of encrypted credit card numbers are beginning. Significant digital cash applications may begin in 1995. These transactions can take place on the Internet, future broadband networks and via smart-cards. There is one digital cash system operating in January 1995 - by a US company called NetBank. A 2% commission is taken by both NetBank and the Cyberstores which accept their money. Products can be purchased with this form of digital cash at the Australian World Wide Web music site, Wood and Wire Indie Cyberstore:

`http://www.magna.com.au/woodwire/`

Developments in digital cash and networked funds transfer are proceeding rapidly and it is too early to foresee the final outcome. However major banks and credit card operators are working with the major on-line service operators, and the companies which write WWW software - such as Netscape Communications - to define standards.

Payment systems linked to credit or debit cards, or to other kinds of bank accounts, can be made secure with encryption and on-line verification between the vendor and the financial institution. There are ways of verifying that the purchaser is who they pretend to be, and ensuring that an audit trail is created. Such systems could also be automated from the purchaser's perspective - so they would not need to manually enter their credit card or account details for each purchase. One potentially important function these systems cannot provide is anonymity for the purchaser.

David Chaum's electronic cash

To protect the privacy of the purchaser who wishes to remain anonymous, while paying for something simply by sending some data to a vendor, is no easy task. However the creative use of cryptography enables this to be achieved.

Such a system is called "digital cash" and the most promising approach has been developed by David Chaum of DigiCash in Amsterdam. This is a functional description of the DigiCash system. An explanation of *how* it works would involve a great deal of cryptography.

The process starts when a consumer purchases from their bank (with real money) some packets of data - each of which constitutes a promissory note from the bank to pay a certain amount of money - such as a dollar or ten dollars - to the bearer of its serial number. During a two way communication session, the consumer purchases these "digital bills" in such a way that their bank is sure that they are going to the consumer, but the bills cannot later be traced to that consumer. This means the consumer can spend the "digital bills" as they wish, and when they are returned (or their serial numbers are returned) to the bank by vendors for conversion into real money, they cannot be traced to the consumer. This is achieved with a "signature blinding" approach where the consumer generates the serial number of each bills she purchases, and the bank uses them to create the equivalent of a signed promissory note - without ever being able to read the serial number. Large random numbers are used for the serial numbers to ensure that no two bills have the same serial number.

When the consumer Alice wants to purchase something from vendor Bob (Alice and Bob are cryptography's favourite characters), she sets up a two way communication channel between her computer and Bob's. Alice does not actually transfer the full data in the "digital bill" to Bob. However, Bob's computer asks Alice's computer a series of questions which enables it to be sure that Alice has a "digital bill" which has been cryptographically signed by the bank. Bob's computer also gains the serial number of that bill, and remembers all the answers which Alice's computer gave when it proved that it had the bill.

At the same time, before handing over the goods, Bob's computer can check with the bank to make sure that the bill with this signature has not been redeemed by another vendor - which would indicate that someone had already spent it. This step is not necessary, but would only take a second or so via the network and assures Bob that the bank will pay him the money.

In normal circumstances, this is all that happens - Bob is paid the money by the bank when he claims (or proves) that someone has "paid" him with a uniquely numbered "digital bill" which was signed by the bank.

However if Alice subsequently uses the same bill when buying goods from another vendor - Charlie - then the plot thickens. When Charlie's computer checks the serial number with the bank, he finds that it has already been spent. So Charlie halts the sale, and sends all the answers he received from the session with Alice's computer to the bank. The bank also contacts Bob and collects the answers his computer got from Alice's computer.

The questions which lead to these answers which gave both Bob's and Charlie's computer proof of the serial number and the bank's signature. However each of the questions could have been asked in two ways, X and Y, and Alice's computer insists that each question be asked just once. Furthermore it insists that each vendor ask the questions in a random pattern of X and Y ways.

The answers Bob gets prove that the purchaser has the signed "digital bill" but do not tell him anything about her identity - so if Alice wants to purchase something anonymously, she can do so. However, when the answers her computer gave to Bob's and to Charlie's computer are collated, many of the answers are for questions which were asked in both the X and Y ways. This gives the bank enough information to reveal Alice's identity. In fact, David Chaum states that it can be used to directly generate a signed confession by Alice that she spent the "digital bill" twice! The proposed system can also work with cryptographically signed digital receipts for purchases.

This digital cash is like ordinary cash in that it is anonymous (if spent only once) and it comes in discrete units - the equivalent of coins and notes of fixed denomination. However it cannot be handed securely through a series of people like physical cash.

The "digital bills" are generated in a communications session between Alice and her bank. She must spend them with a vendor which has an account with the bank, and typically a direct communication link with it to verify the bill has not been spent previously before he hands over the goods.

Alice could give a copy of the bill - which is just a list of numbers, perhaps no more than a thousand bytes, to a friend Dennis, and then he could spend it with a vendor just as Alice did. However this would only work if Alice and Dennis trusted each other so as to ensure that the bill was only spent once.

Digital cash is relatively complicated compared to credit card number based transactions, with or without encryption. It requires two way communications between the consumer and their bank, between the consumer and the vendor, and between the vendor and their bank. The banks need not be the same, since they will represent each other just as the cheque clearing system works today.

In a networked environment, this two way communication is easily achieved. The digital cash is handled by smart cards and computer programs, and these could be designed to guard against mistakes, and behave in a simple way.

One advantage of the system is that the numbers which constitute the consumer's "digital bills" can be backed up, for instance in the home computer. Alice could copy the numbers representing $1000 to her smart card. If the card was lost during a shopping trip in which $500 was spent, there may be no way she could be sure which of the bills had been spent. She would contact her bank, revealing all the numbers for the $1000 worth of bills. When the bank knew which bills had been spent, it would credit Alice's account with the value of those which had not been. This would compromise her privacy about the bills which she did spend - but this is typically preferable to the physical cash alternative of losing a wallet with $500 in it.

Digital cash and smart cards

Digital payments can also be made using smart cards. These payments can be made anonymous using "stored value" cards - such as the system being introduced now by the CabCharge company for taxi fares and other small transactions.

Communication to and from the card may be by close proximity to a transmitter - holding a card near a reader, rather than plugging it in. This would be encrypted to protect against someone else receiving the signals.

David Chaum proposes smart cards which contain two separate computer chips, which work together but do not trust each other. One contains the owner's private information, including digital cash data. The second is designed by the bank and ensures that proper procedures are followed in all transactions.

DigiCash was established in 1990, holds patents on the technology and has other hardware based products. The system is apparently solid, but is in a trial phase - it is not operating with real money.

An in depth report on digital cash appeared in the December 1994 issue of *Wired* (Levy 1994). An article in Scientific American (August 1992) by the leader in the digital cash field, David Chaum, describes some of the principles behind it and discusses the application of smart cards (Chaum 1992).

Electronic commerce is an area of intense development at present. The best place to gain up-to-date information is via the World Wide Web. The three most prominent sites point to a variety of other resources as well.

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http://www.research.att.com/www-buyinfo/

http://akebono.stanford.edu/yahoo/Business/
        Electronic_Commerce/Digital_Money/

http://ganges.cs.tcd.ie/mepeirce/project.html
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The last of these contains the best information on digital cash. It contains a copy of David Chaum's *Scientific American* and a detailed explanation of how his system protects the consumer's privacy if they spend the digital cash once, whilst revealing their identity it if they spend it twice.

The development of digital cash is thought to be a necessary precondition for the flourishing of many kinds of electronic commerce. The reasons are:

1 - It enables money to be spent without leaving a trace - so privacy is assured. Credit card use leads to statements and potentially to other organisations building personal profiles of consumers.

2 - If a WWW browser has an electronic cash facility, it is very easy to sell things to people - they do not have to go through the procedure of authorising a credit card transaction, which typically involves proving to the vendor who they are.

3 - Small purchases can be made conveniently. There are many opportunities for selling information in small quantities.

However digital cash is likely to be used for only a proportion of payments in electronic commerce. There will be many situations in which the existing pattern of credit/debit card transactions will be appropriate - because the card operator has some hold over the vendor, and can help ensure that the vendor's promises about goods and services is met.

These possibilities raise taxation and law enforcement issues - particularly since transactions could take place over international boundaries. Nonetheless, the imperative of efficient business transactions over the network may force governments to adapt to the new fluidity of money.

CHAPTER 10 COPY PROTECTION SCHEMES FOR MUSIC, MULTIMEDIA AND COMPUTER PROGRAMS

> *It is impossible to prevent music, video and other linear media from being copied. Potential technical approaches to copy protection are examined to demonstrate why they are ineffective.*
>
> *Computer programs, or complex arrangements of music and/or video which rely on computer programs, are somewhat more amenable to technical methods of copy protection.*
>
> *The methods by which authors can control the use of such programs, and programs which always on computers connected to the global network, are explored.*
>
> *We are entering an era of extreme information fluidity, with users having access to advanced storage, communication and encryption technologies. Technical approaches offer virtually no protection against unauthorised use of intellectual property. The social, legal and economic approaches are discussed in Chapter 18 and 19.*

Although community standards and copyright law play an important role, most of the protection content producers currently have against unlicensed replication of their work depends upon the physical difficulty of copying the content.

Since linear media - text, sound, still and moving images - are increasingly being stored and transmitted digitally, it is increasingly easy for users and commercial pirates to copy the content.

In the past, it was difficult to copy or transmit the hundreds of Megabytes which make up an hour of music, but this will become very easy within the next five to fifteen years. Chapter 18 contains a full analysis of technical, legal and marketing aspects of copying. In this section, the technical means for copy protection are examined. Music is considered separately from computer programs - which are an essential part of multimedia - because while both may be copied with ease, there are somewhat better prospects for controlling unauthorised use of the latter.

COPY PROTECTION SCHEMES FOR MUSIC AND OTHER LINEAR MEDIA

For the purposes of this discussion, "linear media" describes a product which humans hear and/or see which has a continuous path in space and time. A printed page, film, or music recording is linear. A video game is not linear - its behaviour changes with user input and its internal processes. A printed encyclopedia may not be used linearly, but it consists of a number of pages, whose appearance and order never changes - so it is linear.

In all cases linear media are used by presenting sounds and/or images to people. These can be recorded - creating a copy of the original - although perhaps using a different storage medium. This copy can be used to present the same sounds and/or images as the original, so the copy is functionally equivalent to the original.

This becomes more difficult with a non-linear medium such as an interactive game. The images and sounds from one or more games can be captured, but these cannot be used to create something functionally equivalent to the game, since the user expects the game to make decisions about what happens. Since these decisions are made by a computer, the game can be protected from copying by special techniques relating to electronics - techniques which cannot be applied to the images and sound which are the content of linear media.

In the future music consumers will find it even easier to copy music for themselves, and to send it to their friends, or perhaps even attempt to sell it to other people. If there was a bulletproof way that the originator of the music could stop this copying, then they could be assured of retaining their income in the face of the copying which could become commonplace in the future.

Unfortunately it seems that no such mechanism exists or could exist - for music or for any other linear electronic medium such as text, still images, or moving images combined with sound. The reason is that in order to be consumed, these items of intellectual property have to be provided to the consumer in an electronic form free of blemishes. At whatever point this occurs, the consumer may posses equipment to capture that stream of data - or analog signals - and store them digitally. This is a fundamental property of linear media.

Despite these poor prospects for technically restricting unauthorised copying, it is worth exploring the options which do exist - to learn about their limitations. People with a non-technical background may believe that a magic bullet could be developed in the future to copy protect music or video. This is impossible - just is it is impossible to create a printed page which cannot be photocopied. However technical approaches could discourage some people from unauthorised copying.

Filtering the music

In the debate leading to consumer DAT marketing in the USA, one proposed scheme involved filtering a very narrow band out of the signal of the music to be copy protected. This was a narrow notch filter in the middle of the audio band - affecting only a few Hertz. The proposal was that a DAT recorder would automatically refuse to record if it was fed music with this notch in its audio spectrum.

The advantage of this is that it would work for both analog and digital inputs. The disadvantage was that it degraded the music - and so the proposal was never adopted.

SCMS

The Serial Copy Management System was developed for the consumer introduction of DAT recorders, and is also used with the Mini Disc. It relies on bits of information - flags - which are recorded on the tape or disc, and which can be received and transmitted by the digital interface. The system only affects digital copying - so copying via the analog inputs and outputs can always be achieved.

See the previous discussion of DAT in Chapter 4 for details of how SCMS works. Since modern Analog to Digital Converters and Digital to Analog Converters have performances closely approaching the theoretical limits for 16 bit 44.1 kHz stereo audio, even a fifth generation copy made with analog connections is likely to be indistinguishable from the original - assuming the digital recording medium was like DAT or CD-R and introduced no degradation.

In the case of the Mini Disc, the cumulative degradation of repeated compression and decompression would cause audible degradation after perhaps only two generations - irrespective of whether the analog or digital connections were used for copying.

So SCMS is unlikely to affect consumer copying of music.

Special codes attached to the music file

In this proposal, all music files transmitted on the global network have a special format which enables them to be read by special stations which monitor network traffic to deter and detect illegal copying. This approach fails because people can transfer music in any form they like - even in multiple files of text using a process called UUencoding. The only hope for such a scheme would be for the government to mandate that all communications are unencrypted and that their file type and their contents be readily monitored. This would be impossible and undesirable.

Copy identification with a "watermark"

It is impossible to put something into an audio signal itself which renders it incapable of being copied. However it is possible to add low level signals which carried unique identification codes, but which are inaudible. Practical application of this is unlikely, but will be explored - to demonstrate the fundamental limitations of this approach[7].

The idea of a watermark is to identify *individual* legitimate copies of a piece of music - so it has no function if the music is broadcast or if multiple identical copies are distributed. It is applicable in a situation where music to individual customers via the network or CD-R. Each copy would be slightly different in a way which was inaudible, but detectable by the originator. Its primary purpose would be to discourage the legitimate owner from allowing their copy to be used for unauthorised purposes - for instance by allowing it to be copied to a publicly accessible site where others could copy it freely, or allowing copies to be sold illegally.

The watermark signals could be at all audible frequencies, but at such a low level that they would not be audible below the music. With loud passages of music, the watermark signal could be correspondingly louder, but still remain inaudible due to Psychoacoustical masking (see Figure 3.1). This shows a fundamental limitation of the idea - if the watermark is inaudible, then it will be lost or severely degraded by any lossy compression system - which only transfers what can be heard by humans.

Each copy of the piece of music would have a unique watermark added to it - by a suitable computer program. In one approach, the watermark is a random looking noise signal which is generated from a serial number. The watermark could be impossible to distinguish from the music by analysis so a pirate would have no technical means of removing it - apart from lossy compression.

This means that if the music is pirated, then the distributor of the music could subtract the original from the pirate copy to reveal the watermark - which could then be processed to determine the serial number which generated it. This would index into the sales database to reveal which legitimate owner of the music allowed it to be copied. This would be reasonably powerful, except that a determined pirate could sell a version of the music created by mixing several legitimate copies of the music - to the point where each individual watermark was indistinguishable.

Another application is to make the watermark readable by freely available software. In this case it could contain a text message - such as "This music is licensed to Johanna Silver". This *might* discourage people from passing on pieces of music they bought - in the knowledge that their name was indelibly imprinted in the music. They could run the software on their copy of the music

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[7] These proposals were developed by Craig Beard and the author, but have no-doubt been thought of by others.

and prove to themselves that their name was buried in it. However if the watermark was readable by publicly available software, its structure would be known and a program could be written to remove it. Again the watermark could be rendered unreadable with lossy compression, by mixing several different legitimate copies or by splicing pieces of them together, so that each spliced section was too short to reveal the embedded message.

So there seems to be no way of adding inaudible signals which would survive lossy compression, and even if there was it seems that little would be achieved.

A report in Billboard (1 October 1994 page 90) quotes Godfrey Rust of the U.K.'s Mechanical Copyright Protection Society as proposing an "International Standard Work Code that will embed undetectable digital fingerprints in the audio track of any program.". A standards proposal to ISO was to be made by the end of 1994. The purpose of this code is not clear from the report, but it seems to be similar to the ISRC (described in Chapter 4) which is separate from the audio track. No-doubt the signal would be inaudible, rather than undetectable, but if it was inaudible, it would not survive a compression scheme such as that used by Mini Disc.

A similar system for image files has recently been proposed (Arthur 1994), but the developers admit the same problem - that whatever they add which is invisible, will not survive compression.

The only way that individual copies of a piece of music could carry any identification would be if each piece was audibly different - with notes having different timing, pitch or volume. This would only be feasible for certain kinds of computer generated music - in which case each customer could be given a unique version.

The above discussion refers to music, but applies equally to images and video.

An extensive article in New Scientist (Lawrence 1995) describes with cautious optimism a number of protection schemes for linear media, including text. However none of these schemes stands up to scrutiny - they either change the material perceptibly, or cannot survive compression.

One scheme is based around a computer program containing a "tamper proof software module". All software can be analysed, understood and modified, so it may be tamper resistant, but never tamper proof. However tamper resistant software, and software which depends on hardware (which can be made tamper proof) does offer some means of protection for non-linear media which depends on computer programs. Such programs can be used to unlock linear material from a CD-ROM - so they may have some role to play in the protection of linear media. Such a program is described in the next section.

COPY PROTECTION FOR NON-LINEAR MEDIA INCLUDING COMPUTER SOFTWARE

> *The remainder of this chapter discusses the limited options for copy-protecting, or run-protecting, computer software and multimedia applications which rely on it.*
>
> *One section describes a method of "unlocking" linear media - such as music, graphics or text - from a CD-ROM.*
>
> *Today's CD-ROM multimedia applications have no copy protection other than the fact that consumers cannot easily replicate CD-ROM discs. However in a few years, cheap CD-R writers, fast telecommunications and large hard-disks will greatly reduce these barriers.*
>
> *Two other approaches to gaining revenue from easily copied software are discussed - shareware and crippleware.*

The recorded music industry plays a major part in multi-media applications - any product which supplies sound and/or vision in a non-linear form. "Non-linear means that the sounds and/or images are presented in a way which does not follow a set path and depends on decisions of a computer program which is part of the work. The program may play back sound and images and/or create them or modify stored material according to a variety of factors including:

- The actions of the user - for instance through a pointing device, keyboard, data glove or voice analysis system.
- Events received from the outside world - such as from a computer program on another computer, or the actions of someone else who is sharing the gameplay with the user.
- Events generated within the computer program - such as random changes in sound or image.

This section assumes that the computer program is part of the package, and hence is effectively written by the author of the work. An example which does not fit this criteria is a CD player with advanced shuffle or other programming functions. The software which controls this is part of the CD player, and although it may depend from a database of track characteristics supplied by the author of the work, this database is not a computer program and so does not allow the creation of copy protection mechanisms discussed below.

Computer programs can be in one of two forms - source or compiled. A program in source form is readable by humans and can be modified. This means it is pointless to write copy protection schemes into it, because they could simply be edited out. Examples of programs in source form are programs written in Basic, or in a macro language for a multimedia package and supplied to the user in a form which can be read directly.

Compiled programs are written in one or more languages, but translated into computer code so that it is very difficult to modify them or understand how they work. Most computer programs running on personal computers and games machines are compiled programs. However, experienced programmers with the right tools can analyse any program so they can understand it and modify it.

Assuming that the audio-visual control mechanisms are implemented in a compiled computer program which is part of the product, then there are a number of protection methods available which are not applicable to linear sounds and images. An example would be a game or interactive application delivered on a CD-ROM may look like sound and images to the user, but it is based on a computer program contained on the CD-ROM, which is executed by the customer's computer.

Such an application may contain many fragments of music, image and video - each of which could be copied. For instance the GF4 *Sooner or Later* CD-ROM contains 120 movie files, 63 still picture files and 41 sound files which can easily be copied, viewed and edited.

However at least some part of the application's value to the consumer depends upon the correct operation of a computer program which controls the presentation of the sound and images. The GF4 multimedia presentation is controlled by a large compiled program and several data files.

Hardware keys

Computer programs cannot be copy protected - they are just a list of binary numbers which tell a computer what to do. However, the programs can be written in such a way that they only function when certain conditions are true. These conditions may be the presence of a hardware key, or the establishment of a communications link to a central site.

The hardware key approach is typically used for expensive computer software. This is often referred to as copy protection, but it is really "run" protection. When the program only runs when a hardware key is plugged into the computer, this key is often called a "dongle". However the same principle could work with a games cartridge or a smart-card - both of which could contain hardware which behaved in a particular way which the program expected.

The hardware key and the software which checks for their existence is typically complex and designed to be hard to understand - because if a cracker could understand them, then they could prepare a modified form of the program which always worked perfectly without looking for the hardware key. Once that had been achieved the copy could be sold or given to anyone.

The most prominent instance of this in the musical field is the cracked version of the Atari sequencer program *Cubase* which has been widely used for several years.

There is no sure way to write a program so it will only work with its hardware key and will be immune to analysis. In principle, any program can be analysed, understood and modified. However if the authors of the program invest a lot of effort, it can be very difficult for a cracker to find all the ways in which the program checks for the presence of the key. This is why cracked versions of *Cubase's* competitor - *C Lab Notator* - are never fully functional.

"Meterware" and super-distribution - with a hardware key

These terms refer to a way of metering the use of freely distributed software - so that the originator gains financial return in proportion to the use of the program. The program itself could be distributed publicly, but would only run when it finds a sophisticated hardware key which maintains a kind of "credit balance" and is resistant to cracking. The key keeps a record of how the program is used and reduces the credit balance appropriately. When the balance runs out it tells the program not to operate any more.

The balance is updated by some secure transaction when the customer transfers funds to the owner of the program, or the operator of the "Meterware" system. With a generalised system, hundreds or thousands of programs could use the one standardised hardware key, and the operators of the key system would distribute payment to the programs' authors according to how their programs were used.

Such a system has been prototyped for certain Macintosh computers and is described in September *Wired* (Cox 1994). (A critique of this article and a response and qualification by the author can be found in Herschman 1994.) To gain critical mass, such a system would have to be internationally standardised - probably for each of the computer or games platforms. The key hardware would need to be relatively cheap and it would have to be extraordinarily resistant to cracking.

The security of the system - and hence of all programs which use it - depends on the *behaviour* of the hardware key. It may seem that all the program must do is check for its physical presence, but this is not something which can be known by the program. A program may instruct the computer to read and write certain locations which normally connect to the hardware key. If the program elicits the right response from what seems to be the key, it will run normally. However a computer program can be run in an environment inside the computer which simulates the physical presence of the hardware key - there is nothing a program can do to tell if this is occurring. Consequently if a cracker wrote a program which emulated the behaviour of a hardware key with sufficient credit, then this would enable all the dependant programs to run. This emulator program could be sold or copied and would rapidly render the entire scheme useless.

Likewise the means for recharging the credit balance in the key must be totally secure from cracking, otherwise a program or an illegitimate operator could top up the credit balance. Another weakness is that a cracker could sell their own hardware key which always behaved like a legitimate key with a positive credit balance. A cracker could even give away hardware keys which behaved like legitimate keys - but the credit balance would need to be topped up by a communication session which involved paying a fee to the cracker.

The security of the system for any one program relies on the difficulty of the program being modified to work without the hardware key. It is impossible to write a computer program which cannot be fully understood by a cracker, so in principle any run protected program can be modified to run without the hardware key. The program can be written in a way which makes the cracker's task extremely difficult, but with a sufficient understanding of the key's behaviour, suitable software analysis tools and the right experience, a determined cracker could modify the program to operate without a key.

This would need to be done for each individual program, and the only way that the authors could combat this threat would be to spend a great deal of effort making their key interface software structurally different from that of any other program. This is inherently labour intensive - any automated means of introducing key checks into the computer program would operate in a pattern which could be seen by a cracker.

Alternatively, the authors could accept that their program is likely to be cracked within a few months, and release new improved versions so that customers would rather pay to use the uncracked legitimate version. Once the program is reasonably mature, there would be little incentive for a user to do this.

It seems likely that public key cryptographic principles could be used to secure the hardware key and its communication links to the system operator. However the weak point is the software in the program itself which checks for the presence of the key and its credit balance. The operation of the computer program is visible to the cracker, and so the protocol could be understood. With this knowledge, a key simulator program could be written.

"Meterware" and super-distribution - with the global network

A similar concept to Meterware with a hardware key is to use the global communications network to link to an authorisation site - rather than to a physical key in the computer. This will be quite feasible when computers are permanently connected to the global network as many university computers are connected to the Internet today. There are some security problems - how could the system administrators be sure that the necessarily encrypted communications were not in fact a form of spying on their own computer systems? One approach is to use a hardware key for most of the authorisation but have the key perform more limited communications with the authorisation site so that security risks can be demonstrably minimised.

The primary problem remains that described above - writing the application program so that its interface to the authorisation site or hardware key cannot be understood by a determined cracker. In the case of an industry standard hardware key, this understanding could compromise the entire system. In the case of network based authorisation, each program would have its own authorisation site - typically at the premises of its authors. So a cracker may find out how to make one program, or the programs of one company, run without legitimate authorisation, but this knowledge may be not be applicable to the programs of another company.

Client server software

Extending the networked authorisation model of "Meterware" to make it more resistant to cracking, certain crucial functions of the application could be missing entirely from the software. These would be performed by the authorisation site and so a cracker would be forced to understand and replicate these functions in order to create a modified version of the program which would run independently.

This approach creates a client server relationship between the application program and the authorisation site. It is likely that the crucial functions would require substantial amounts of data to be transferred. Since the data is the user's data it would need to be encrypted. This would slow the operation of the program and make it difficult to prove that the program was not a security risk.

Extending this to the stage where a substantial amount of the functionality of the application is performed at the central site, then it becomes a true client server application, which is essentially impossible to crack because the cracker will never be able to replicate the functions performed by the server at the central site. Thus a true client server application cannot be used without the involvement of a central site, which could charge each customer according to their use. Client server applications today typically span a corporate LAN or WAN (Local or Wide Area Network). However there is no technical reason they cannot work on a global network such as the Internet. For reasons of speed, it is likely that the server would run on a "central site" computer physically near the customer's site - within the same country to avoid the 200+ ms round trip delay of a signal travelling by fibre to reach a central site on the opposite side of the Earth.

The need for protecting software

Despite the difficulties noted above, it is possible that a significant proportion of software based applications - from multimedia to personal computers application programs - will move towards a Meterware key or client server model. As the global network becomes faster and more ubiquitous, illegal copying of software will become even easier, so hardware key Meterware, or a client server model with automatic funds transfer would become increasingly attractive to authors.

If copying of unprotected software became sufficiently prevalent, then authors would be discouraged from releasing product in this form, and would release it as Meterware or as a client server application - which would only run on sites which collect funds for them.

This may not seem a likely prospect today for a relatively low value application such as a game on a CD-ROM, which sells for $70. However there are other reasons for making it at least partly a client server application - when communication costs are low enough and speeds high enough.

One reason is that the program could be up-to-date - because the server part of it is always the latest version. This is ideal for "serious" applications which the user would otherwise have to update manually as improvements were made.

A second reason is that the function of the program - especially a game - could be made to vary. This could include modified gameplay, interaction with other players all over the world, and the use of fresh images and sound.

For both "serious" applications and games, once communication costs and performance limitations are small enough, there will be need to distribute a client program to users at all. Every time the application is run, an up-to-date client part of the software is retrieved from the server site, and the processing is shared between the client and the server. So with an advanced ubiquitous network, there is no need to sell or distribute computer programs, on floppy disc, CD-ROM or on the network. The application is run simply by opening a session with a particular site. However for many applications, the security risks of sharing data with any server site are unacceptable, so this would not be an option, and standalone versions of the application would be required.

Unlocking data from a CD-ROM

There are two other means of protecting software or data which are not usually applied to linear media. They may be applicable to music and non-linear interactive applications. One is unlocking encrypted data from a CD-ROM. The other approach is shareware or crippleware. These techniques are explored because in the future, it may be necessary to consider any available form of distribution and revenue protection - to make the most of an environment where the copying of data will be very easy, and the promotion and distribution of physical products comparatively much more difficult.

One form of data distribution is the "locked" CD-ROM. An example of this is the AgfaType collection of 2,300 typefaces, which comes on a CD-ROM with a Windows program to unlock them. This disc is sold at a nominal cost, and can be used to supply each of the typefaces once a licensing fee - such as $50 - is paid for each one. The program installs itself and creates a complex configuration file which is based on many unspecified (and necessarily secret) low level details of the computer it is running on.

Typefaces graphical intellectual property which are often the product of great design effort. Computers use them as Postscript or Truetype fonts, which are pairs of small files containing copyrighted instructions for printers and display devices on how to form characters. A set of four typefaces containing bold, italic and bold-italic versions may cost $150 and occupy 170 kbytes of storage - equivalent to one second of music on a CD. They are valuable to many people and easy to transmit to others by disc or email, yet it there are no obvious sites on the Internet where copyrighted typefaces can be found. The apparently successful protection of typefaces from widespread piracy may contain valuable lessons for the music industry. These are discussed in Chapter 18.

When the user wants to purchase one or more typefaces, they select the one they want, and the program produces a 14 character customer key. This is faxed to the typeface supplier, with payment, and they return a 14 character access key which enables the software to unlock the typefaces from their encrypted form on the CD-ROM. The same process could be achieved with email or be automated in a few seconds over the World Wide Web.

The operation of the keys depends on the configuration file - part of which records the low level details of the personal computer which the program was running on when the typeface selection was made. These low level details may include disk directory and memory contents and hardware attachments. The aim is to ensure that the access key only unlocks typefaces on the same computer which produced the customer key - otherwise another computer user with the CD-ROM could unlock the fonts by copying someone else's configuration file and access key.

So if the computer was reconfigured before the access key was used, then the software would be programmed to respond as if the key was being used by another person and would refuse to unlock the typefaces. This approach works well for a once-off unlocking, but it is unsuitable for controlling the running of a program - since a reconfiguration or upgrading of the computer would render the access key useless.

Some aspects of this system could be cracked by understanding how the software works, but it is likely that this alone would not unlock the typefaces - because the access key would contain information specific to the encryption of each font. Each CD is identical and contains perhaps $100,000 worth of typefaces - yet the system is widely used and not obviously compromised by crackers. Part of the reason for this would be the threat of legal action from the large companies who own the typefaces. This threat would typically not exist if the material was owned by a small recording company.

In principle this system could be used to unlock music - for instance a red light disc could hold 12 hours of compressed music and be distributed for free. Individual pieces of music could be unlocked in the way described above. The user must generate a customer key and forward it with payment before receiving an access key.

This system is used for typefaces and certain other relatively valuable pieces of data and software. It is not clear how applicable it would be for music. The lower number of music products available on one disc and the lower value of the music compared to type faces would render it feasible only with a very efficient means of transferring keys and funds.

Shareware and crippleware

Shareware is fully functional software which the user is encouraged to copy and use for a trial period. However they are supposed to pay a moderate licence fee if they continue using it. Shareware has virtually no distribution costs for the author, and even if only one percent of regular users pay for it, the returns could be favourable compared to those resulting from marketing the program as a physical product through retail channels.

Shareware products typically have gentle reminders that the program is unauthorised - but these can be disabled with a hidden command which is only revealed to those who send payment to the author. The author has a delicate psychological task in making people happy enough about the program to want to pay for it, whist regularly reminding those who have not payed yet to do so. Some programs have time limits or file size limits accompanied by a "please register" message. Others, which have awkward time delays and prominent messages, may be known as "annoyware".

Shareware is not directly applicable to music because an audio signal does not contain information about the author, the shareware status of the product or where to send money too. It would be possible to add words to this effect, and if the music was freely distributed on networks, this would amount to busking in cyberspace. However the danger is that listeners will simply edit out the plea for remuneration and pass the edited copy on to their friends. The same applies to video and still images.

Crippleware is shareware software which does enough to give the user a feel for its capabilities, but has important functions disabled. This means that when payment is made to the author, the user is supplied with special commands to enable all functions, or alternatively a fully functional version of the program.

Like normal shareware, the crippleware author typically has few distribution costs as the program is freely copied on bulletin board systems, the Internet or supplied on a CD-ROM on the cover of a magazine. This form of distribution is hardly applicable to music - unless only half a song is supplied, ending in a verbal request for payment.

The shareware and crippleware distribution approach is typically used by new entrants to the market - who have little to loose. Some such software grows in sophistication to the point where the authors decide to make future versions available as commercial products. The shareware phase functions as a self funded development period in which their product may become the defacto standard in the field.

Another approach to shareware is to make it free for non-commercial use, but to charge corporate users a handsome fee. This is hardly applicable to musical products.

There are some parallels between computer software, interactive applications and linear media such as music, but the differences are significant. A computer program - such as PKZIP (a hugely successful file compression program which is the IBM PC industry standard) is a functional tool which the user rarely needs to update.

Entertainment products such as multi-media and music have a shorter period of usefulness for any one consumer. They will soon be looking for more - probably from the sources that brought them pleasure in the past. This leads to the loss leader approach - give away some copies in the hope that the listener will want to buy more.

CHAPTER 11 ADVANCES IN PERSONAL COMPUTERS

> *The personal computer of the future will play an important role in searching for and listening to music. The multitude of services available from a broadband telecommunications network can best be exploited by a home based computer.*
>
> *This chapter discusses the foreseeable advances in personal computers to the year 2010.*

RECENT TRENDS

In trying to predict the technological environment over the next fifteen years, it is worth remembering a prediction which has proved remarkably true in the 25 years since it was made - Moore's Law. Gordon E. Moore was one of the founders of Intel in 1968 and he predicted that the that the number of transistors on an economically producible integrated circuit would double every 18 months.

This progress can be seen in the growth of memory chip capacity since Intel's 1 kbit chip around 1970 to 16 Megabit chips in 1994. Although the downward spiral of memory prices has flattened in the last two years, the pace of CPU, hard-disk and video card improvements have continued unabated.

The average price of a new IBM PC has remained around $3000 for the last ten years or so[8]. This price is for a mid-range model suitable for the major home and office applications of the day. This price, which has been slowly dropping in real terms, probably represents the psychological and economic limits of the mainstream purchasers - the computer industry has always been able to offer higher priced models.

If purchasers had remained happy with 1985 levels of performance, then in 1995 they would have been paying less than $1000 for their computers. However expectations of performance have increased. The computational demands of GUI (Graphic User Interface) software and WISIWIG (What You See Is What You Get) word processing and graphics programs have required ever faster computers with more memory and hard-disk space. (In fact WISIWIG is now taken for granted and the term is falling into disuse.) Video displays and printers have similarly advanced.

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8 The median price probably has changed, but not as dramatically as the performance/cost ratio of the computer systems. In "real" terms as defined by inflation as measured by the CPI (which must ignore computer technology), this $3000 median price has become progressively cheaper.

The advances in personal computers are the product of fundamental technical advances and economies of scale delivering more advanced products to a growing market. The software and hardware capabilities of mid range personal computers in 1995 is equivalent to that of state of the art computers in research institutions in 1990.

This has raised questions about why many consumers buy hardware and software whose operation they struggle to understand and whose power they rarely, if ever, use. Some of this demand can be attributed to the desire to keep up with perceived trends, to give children access to new technology and to the lust for possessing the fastest, newest technology. It is clear that the utilitarian aspect of computing only partially explains consumer demand. For instance an advertisement for computers may be headed "Give your kids a future now!"[9].

THE COMPUTER AS AN INFORMATION ENGINE OR EXPLORATION VEHICLE

An important function of the home computer is to be an "information engine" - a vehicle for navigating a world of digital data sourced from outside the home. If computers only performed their 1985 functions of enabling the user to generate their own text and graphic documents, then they would be no more attractive than a TV which could only show videos generated by its owners.

Home computing for recreational and educations applications requires fresh content from outside the home. Initially this arrived on floppy disc or via slow modems from local bulletin boards. Today it also arrives on CD-ROM and by faster modems from the Internet.

The broadband network, with individual links to each home, dramatically raises the capacity of a home computer to access content. Today's speed limitations of modems and CD-ROM disappear with a 6 Megabit link. The limitations of the CD-ROM with its month's old, fixed 683 Megabytes disappear when the global network can be accessed in less than a second. Economic limitations imposed by the cost of transporting large quantities of data on international links will probably remain, limiting most high bandwidth consumer data gathering to sources within Australia.

When consumers have broadband access to the global network, their personal computer is likely to be the primary tool they use for navigating the outside world, and for managing and using the information they retrieve. This is particularly true of music when it is delivered electronically to the home.

There is continuing debate about whether "computers" or TV "Set-Top-Units" (STUs) will dominate consumers access to Video On Demand and the broadband network. This paper assumes that personal computers will evolve to perform this task. Home computer diffusion is likely to accelerate with

9 The Age *Green Guide* 26 January 1994 page 17.

demand driven by the content delivery channels of CD-ROMs and the World Wide Web. Even if STUs are introduced for VOD, the capabilities which consumers will desire of them - such as the ability to record, buffer and print incoming video - will ensure that they are functionally equivalent to personal computers.

In 1984, an IBM personal computer costing at least $3000 was a 5 MHz 8bit bus machine with around 256 k of memory, two floppy disks and a monochrome character based display. Hard disks and graphic displays were not common.

In April 1995, $3000 purchased a "Multimedia PC" - 66 MHz 32 bit bus 486DX CPU, with 4 Megabytes of RAM, 800x600 32,000 colour graphic display, 540 Megabyte hard-disk, CD-ROM drive, sound card, mouse and a 600 x300 DPI Hewlett Packard colour inkjet printer. Software included the MS Works multi-application bundle games and the Encarta CD-ROM encyclopedia. For $1500 more, the system would had the fastest CPU available - a 90 MHz Pentium - and 8 Megabytes of RAM. This example comes from Pacific Microlab - who call the above system a "Fox family pack". This was their low-end package - the "Arrow performance pack" was faster and had 16 Megabytes of memory, an 850 Megabyte hard-disk and a "Stingray" graphics accelerator card. (There are striking resemblances here with motor car marketing.) Comparable Macintosh systems cost more.

This pace of performance/price improvement is likely to continue for the next ten years or so. Personal computers are becoming more of a commodity market and at last it is possible to see a convergence of the two major software architectures - Macintosh and Windows - on the one piece of hardware - the Power PC. The Power PC architecture is based on 1992 computer design techniques, whereas IBM compatible PCs today are still suffer from limitations which date back to Intel's 1978 design for the 8086 microprocessor.

The personal computer is turning into a broadband information appliance. However the battle between IBM and Power PC architectures is a stumbling block to user acceptance.

Future CPU speeds, RAM capacities and hard-disk capacities can only be guessed, but the following offers a guide for new mainstream personal computers. Features in brackets are those which are technically possible but not widely used yet.

HOME COMPUTERS IN 2000 AND 2005

Tables 11.1A and 11.1B show the projected performance of a new personal computer purchased in early 1995, and in 2000 and 2005. These projections are necessarily speculative, but the speed, RAM and hard-disk projections are conservative compared to both historical trends and foreseeable developments.

One important component of the personal computer - the video monitor - is not mentioned in these tables. While improvements over the past ten years have been dramatic, displays are likely to improve modestly in the future, in terms of size and speed. Some future video cards will have MPEG-2 decoding as standard, so the personal computer's monitor will be capable of displaying full quality video.

However it is likely that a larger sized screen, more centrally placed in the lounge room, will be used for general viewing. This screen may be flexible and optimised for displaying MPEG-2 video. This means it may be capable of 50 or 60 progressive scans/sec rather than TV standard scans which are interlaced - displaying odd numbered lines in one scan and even numbered lines in the next. This large screen in the lounge would also include a tuner so it could be used as a TV for receiving analog VHF and UHF transmissions.

Another crucial computer technology is the Local Area Network. The speeds of LANs are likely to improve greatly, but this is assumed not to be an issue for home computers because there is typically only one computer in the home. Business computers will communicate with the global network via their LANs and a business may have a multi Megabit/sec duplex link to the global network.

These projections are for home based computers costing the equivalent of today's $3000 - the price point for a complete system (not counting a laser printer) at which most home computer purchases are made. The 1995 performance is for an IBM compatible or Macintosh. The 2000 and 2005 performance is for machines based on IBM evolution or the Power PC architecture which is expected to take over from the Mac and (hopefully) the strained IBM compatible architecture. Similar functions can be expected in portable computers at higher prices.

TABLE 11.1A PROJECTED PERSONAL COMPUTER PERFORMANCE

	1995	**2000**	**2005**
CPU speed - Millions of instructions /sec[1]	60	200	500
RAM Megabytes	8	32	64
Hard-disk Gigabytes	0.54	4	10
Pre-pressed CD-ROM Gigabytes	0.68	3.1 red light (single layer)	7.0 blue light (single layer)
CD-R Gigabytes	(Too expensive for consumers)	1.9 red light	1.9 red light or 4.2 blue light
High quality music on a pre-pressed single layer disc[2]	1.2 hours - audio CD	11.6 hours - red light disc with 2:1 compression	26 hours - blue light disc with 2:1 comp.
Hours of high quality music stored on a CD-R or other writable disc[2]	-	6 hours - red light disc with 2:1 compression	13 hours - blue light disc with 2:1 comp.
Modem connection to outside world Megabit/sec	0.0144 or 0.0288	0.0288	Not used
Megabytes/hour[3]	4.9 or 9.7	9.7	
Duplex digital link to outside world Megabit/sec	None. (0.128 BR-ISDN - becoming affordable for consumers in 1997?)	0.128 BR-ISDN via twisted pair, HFC coax or ADSL. Possibly 6.0 to home and ~0.6 duplex via coax / ADSL.	0.128 BR-ISDN or ~0.6 duplex via coax / ADSL. 6.0 downstream to home. Possibly more upstream capacity on demand with coaxial cable.
Megabytes/hour duplex[3] Downstream to home	43	43 or 200 2000	43 or 200 2000
Time to get data equivalent to a pre-pressed CD-ROM from the global network[4]	0.0288 = 70 hours[5]	0.128 BR-ISDN = 72 hr 6.0 Megabit/sec = 1.5 hr	6.0 Megabit/sec = 3.5 hr

TABLE 11.1B PROJECTED PERSONAL COMPUTER PERFORMANCE

	1995	***2000***	***2005***
Audiovisual subsystems	16 bit sound card. (MPEG-2 video card in 1995-97.)	Sound card as before but with digital interfaces and DSP for music synthesis, voice recognition and synthesis. MPEG-2 video. (VR headset system.)	As before, but with high performance VR headsets and more elaborate DSP for music and video synthesis and processing.
Special hardware for music synthesis	FM synth chip and sampling. Stereo recording and editing, with compression. MIDI sequencing.	As before, but with DSP for more flexible synthesis. 8 track digital recording and mixing should be relatively cheap.	As before, but more powerful DSP, hard-disk and CD-R backup make personal computer based multitracking much more practical.
Video editing capabilities	None	Playback of MPEG-2 is fine, but compression cannot be done in real-time - Video must be dumped to hard-disk in sections for compression.	Real-time compression more likely via special card.
Printer	Inkjet or 300 DPI laser.	Colour inkjet/ dye/wax. 600 DPI PostScript laser.	Fine 400 DPI colour printer, with 600 DPI laser printer for B/W printing.

1 Instructions take one or more clock speeds on CPUs such as the Intel 486, but superscalar CPUs such as the Pentium and Power PC, several instructions can often be executed in one clock cycle.

2 Audio compression will be a mature technology by 2000. Today, a "typical" lossless compression ratio may be 2.7:1. Many consumers may be happy with slightly lossy compression with ratios such as 3.5:1, so these times could be almost doubled for many types of music. Pre-pressed discs will also be available with two layers - doubling these times again.

3 A 25% protocol overhead is assumed for all data transfers - so a 28.8 kbit/sec modem delivers 0.162 Megabytes/minute.

4 The single layer red light CD-ROM capacity is assumed for 2000, and the single layer blue light CD-ROM capacity for 2005.

5 At current costs for casual Internet access via 28.8 kbit/sec modem, 683 Megabytes would cost $350 (70 hours @ $5/hour). Costs today vary between $1.33/hour and $8/hour with extra charges for higher quantities of data. So the cost could be as low as $93 under ideal conditions.

The projection for personal computers having access to the global network via ADSL or coaxial cable in 2000 may be optimistic - it is likely that only a small proportion of homes would have such access, and the costs and sophistication may be prohibitive for obtaining Gigabytes of data. By 2005, many more homes are likely to have broadband links to the global network.

The relationship between the speed and cost of global network access and the cost of CD-ROMs is a crucial one. It affects whether people buy physical products - audio CDs and CD-ROMs, or whether they get their data from the network and store it on their own CD-R discs. The cost of obtaining a CD-ROM's worth of data from the Internet in early 1995 is at least $93 (70 hours at 1.33, assuming only the 28.8kbit/sec modem limits the speed), but more likely to be several hundred dollars. The costs in 2000 are hard to predict, but in 2005, the cost of transporting a 7 Gigabyte CD-ROM's worth of data from a local source should be little more than the cost of watching two or three VOD movies.

CD-ROMs are likely to remain competitive for large quantities of information, which do not have to be up-to-date, or link with other resources, and where the consumer typically wants to access the whole body of data. Movies and music fit this criteria in many cases. Encyclopedias do not. An encyclopedia should be continuously updated and have links to resources outside the encyclopedia itself. It should have bottomless depth and provide video wherever possible. An encyclopedia is ideally suited to a huge database (or more likely many interlinked databases) accessible via the global network, than it is to a CD-ROM or printed books.

The relationship between pre-pressed discs, CD-Rs (and other writable optical discs) and networks is explored further in Chapter 13.

CHAPTER 12 NEW FORMS OF MUSIC

Before this century the music industry delivered its product in two forms - live performance and music notation on paper. This century has seen a third form dominate - sound recordings.

The next century will see a new form of music delivery, which may combine elements of a score, a recording, a computer program and a user controllable application or service. For want of a better term, these are referred to as "Music Objects". They are bodies of data, including computer programs, when are executed on a computer to produce musical sound. Typically this will be done on the listener's computer - but it could be done at a central site and the sound transferred to the listener over the broadband network.

Music objects may become commercially viable forms of music delivery in the next ten years. This section contains a description of Csound - a software based music generation system which may be of interest to musicians for their own use.

This chapter considers the sound, and the means of delivering, controlling and in some cases, creating the sound which reaches the listener's ears. This sound is only one part of the total musical experience - which is a listener's total perception of sound and perhaps many other related images, sensations and thoughts. Chapter 15 focuses on these other inputs, social factors and on the subjective experience of the listener.

HISTORICAL BACKGROUND

Although the idea of computer generated music in the home may sound rather futuristic and/or simplistic, it is technically possible and has a history going back to the early 1960s - although not in the home.

Special languages in the MusicN series were created to follow the composer's instructions and create sound files mathematically. This was a laborious process for both the composer and the expensive mainframe computers of the 1960s - whose performance was less than that of personal computers which became obsolete in 1986. Many days of calculations were required to yield a few minutes of music. Before that, composers including Percy Grainger struggled to build mechanical systems to generate music according to the algorithms they wished to define.

Two mechanical musical objects found wide acceptance in homes in the past - piano rolls and music boxes. Piano rolls are paper rolls with punched holes instructing the player piano when to play notes. Some of them were recorded live by great musicians. The piano roll is a predecessor of the MIDI file - and a large industry developed based on this international standard form of machine playable score. Music boxes in the nineteenth century reached great levels of sophistication for those who could afford them.

Unlike music boxes and player pianos, the wind-chime has survived the competition of recorded music. This may be attributable to its non-repeating sound output, which maintains a fixed harmonic structure, some consistency of melodic structure and responds dynamically to the wind outside the home. The wind chime may also be a more successful music object than a music box, or player piano because it is cheaper, and its minimal, understandable mechanism enhances its appeal.

MUSIC GENERATION AT HOME - LEADING TO MUSIC OBJECTS

Most of the discussion in this paper has related to music as a pre-defined, linear audio signal. The exception was a sophisticated shuffle play system for playing CD tracks to give variation which the listener values - for instance for background or aerobic workout music.

Many personal computers are equipped with 16 bit stereo sound generation facilities and their computational power enables them to play back sounds and to mix and create sounds in real time. Some sound boards contain specialised DSP (Digital Signal Processing) CPU chips which greatly speed such operations. These sound boards usually contain chips specifically designed for music production - typically a Yamaha 24 note FM synthesiser chip in an area of the board the size of a postage stamp. Together with appropriate software running on the main CPU, these boards are capable of producing a wide range of musical sounds. They cost only a few hundred dollars and typically interface to a CD-ROM drive as well.

In this paper, the term "musical object" is used for any software and related data which can produce a musical signal - typically a piece of music - without actually being a recording of that piece. The musical object may depend on other hardware and software, and it may produce a single musical output without user intervention or it may produce a variety of outputs and be partially controlled by the user.

Music objects usually require less bytes of storage than would the music they create. Typically a music object can be altered by the user, and in many cases, the entire structure of the object is available for editing should the user want to change it, or take pieces of it for inclusion into another object.

This paper concentrates on the entertainment value of music and music objects, however there are some unique educational applications of music objects. One is to explore composition. Another is to provide musical accompaniment for a student practicing singing or learning an instrument - where the pitch, speed and complexity of the accompaniment can be adjusted with ease.

MIDI files

The most common example of a musical object is a MIDI file. This consists of information about notes and which voices from a semi-standardised set of 128 General MIDI voices to play the notes on. Sound synthesis may be performed on an IBM PC sound card, on standalone musical instruments or on a mixture of the two. The General MIDI assignment of instruments is typically used for commercially produced MIDI files, but this need not be adhered to.

A MIDI file produces a linear piece of music, but every aspect of the file can be edited. MIDI files are used professionally by musicians who use a MIDI sequencer and MIDI synthesisers as on-stage backing for live performance. Since a large part of the live performance market is for songs currently in the top 40, the musicians typically source their files from small companies in Australia and overseas who specialise in the production of files for classic and contemporary hit music (Sly 1994). They edit the files to suit their own performance style and to match the capabilities of their equipment. They use a computer, or a stand-alone sequencer to play the file to the sound synthesis equipment via MIDI leads.

Sequencers have been used like this since MIDI was introduced in 1983, but the MIDI file, and the General MIDI voice assignment scheme provides an internationally standardised format for conveying sequence files. One Roland product - the MT120 - looks something like a portable stereo cassette/radio, but has a floppy disc drive, front panel and LCD display for playing, recording and editing MIDI files. However such MIDI file players are not about to replace portable CD players because their sound quality cannot compare with a CD, which may be the product of a million dollars worth of studio equipment, of vocal performances and of musical instruments which provide greater expression than is possible with MIDI.

MIDI is a fixed language, based on a rock keyboard paradigm. Nuances of expression available to singers, guitarists and almost all physical instruments typically cannot be translated into MIDI. There has been much discussion of an upgrade to MIDI to enable greater expression, but like the audio CD, the old system works for many purposes and it is hard to foresee it being changed.

MIDI files are currently used by people with an active involvement in music - rather than by consumers to produce music purely for listening enjoyment. However virtually all IBM sound cards have hardware for FM and sample based synthesis and come with software which can play MIDI files on this hardware, so it would be relatively easy to sell MIDI files, or software to generate MIDI in real time, with musical variation, if it resulted in a musical experience which people enjoyed. Such software would not require much CPU time and could run in the background while the computer performed many tasks.

MOD files

A MOD (Music Module) file is a compact file which contains audio samples and sequence data about the timing, volume and pitch of the notes that use those samples. The MOD file format started on the Amiga computer, but software for creating, editing and playing them is available on other types of personal computer as well. New file formats have been devised to circumvent the original limitations of four tracks of 8 bit samples. MOD files typically have no relation to MIDI, and editing requires a good knowledge of hexadecimal numbers.

They are mainly used by people who have access to computers with sound capabilities, but who do not own MIDI equipment. The sound quality is often poor, but new file formats, software and sound cards enable high quality reproduction. The MOD file includes samples of all sounds it uses - so there is no dependency on synthesis hardware. However some formats also carry MIDI information for the sound card's FM synthesiser or for external synthesisers.

No commercial market exists for MOD files - they and the software which support them are produced by young computer hobbyists. These people communicate via the Internet and organise competitions and Top 100s MOD charts[10].

However the MOD file concept could be extended to higher quality as CPU power and software sophistication increases. The sequencing aspect of the file could contain user options - such as how long the piece was to run for, how raunchy it is or how much randomness it would contain. For greater compactness and flexibility the sounds could be defined in a language which is interpreted by the main CPU or the DSP CPU on the sound card. There could be further instructions about mixing, EQ and reverberation.

MOD files are complete musical objects. They contain every sound and instruction required to create music. Provided the MOD player software works properly, the MOD file will produce identical music on any computer. MIDI files rely on external hardware (or perhaps software) to generate and mix the sound - they are not as self-contained as a MOD file.

Mod files are far less standardised or widely used than MIDI files. However they are being downloaded from bulletin boards and Internet because people like to listen to them.

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10 MOD files and software for IBM compatibles can be found at some local bulletin boards and on Internet sites including ftp://ftp.eng.ufl.edu/pub/msdos/demos/music/

Higher quality musical objects - Csound

With sufficient computational power, a computerised sequencing and sound production system could create any sound and follow any compositional algorithm the composer desired, so that a relatively compact file could produce a piece of music according to composer-defined, random and listener-defined parameters. This music could be constantly changing, and could even vary with the time of day.

To produce sound of a quality equivalent to even a small MIDI studio, a great deal of computer power is required, and until recently, the only commercially available system which can do it in real-time is the Kyma system from Symbolic Sound, which uses nine 24 bit DSP chips and costs around US$9000.

However a more accessible approach is to use the CPU of an IBM, Mac or Power PC computer to calculate the music directly. Depending on the complexity of the piece and the CPU power, the computer may be able to calculate the music in real time. If it cannot, then the file must be written to hard-disk for playback later.

There are several software packages which do this. The most prominent is Csound[11] - a public domain program from MIT Media Lab, written by Barry Vercoe who has been active in computer music since the 1960's.

Csound can be driven from MIDI files and/or its own text based score file. A separate orchestra file contains computer programs which generate and process sound data. All computations are done with high precision yielding a 144 dB signal to noise ratio. The program can read in sound files and will generate mono, stereo or quad output file at any sample rate.

Csound generates sound from first principles - using basic mathematics and DSP constructs. It can deal with any pitch and use oscillators, filters, variable time delays, fourier transforms and anything which can be constructed from these. For sophisticated applications, Csound is not fast enough to make music in real time, so it is not applicable to the many types of music which require immediate human involvement. It is more like baking a cake, with the results being heard after a few hours of computing - typically overnight for large pieces. Still, this is faster than composing for an orchestra.

Many musicians familiar with MIDI would find Csound difficult to use - it is a terse programming language. However it can be used to produce music of great depth and sophistication if enough effort is invested. Csound is public domain software and is available through the Internet for IBM, Mac and Power PC computers. There is a mailing list which enables users to keep in touch and

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11 Public domain versions of CSound are available for Atari, Mac and IBM PC via Internet ftp from *ftp.maths.bath.ac.uk* in directory */pub/dream*. The URL for the Csound page on the WWW is *http://www.leeds.ac.uk/music/Man/c_front.html*

resolve problems. Details of the software and mailing list can be found from the author or from:

    http://www.leeds.ac.uk/music/Man/c_front.html

The author's experience with Csound is not extensive, but led to a piece of music which has received favourable comments. A day was spent writing code for three programs or "instruments" - a sound source, a flanger and a cyclic left/right pan function. The score file activated 16 instances of the sound source program to produce four Major 7th chords in different octaves, each with its own waveform. Each note of each chord ran for 8 minutes with slow attack and decay times, but some of them had a very slow tremulant as well. Each signal from the four chords was processed by its own flanger and cyclic panning unit - all with differing, very slow cycle times. The result was an 8 minute piece of minimal, gently moving music, with a rhythmic pulse from the flanger accentuating harmonics in the bass Major 7th chord.

The Csound program ran on a 33 MHz 486DX computer and took 5 hours to execute these orchestra and score files. The musical result was a 44.1KHz 16 bit stereo file which could then be played through a PC sound card with quality identical to a CD. A fast Pentium or PowerMac would have taken less than an hour to calculate this music. A Silicon Graphics 150 MHz Indigo workstation would have taken 12 minutes.

The 8 minute sound file occupied 84 Megabytes, while the orchestra and score file which generated it was only 9 kbytes. Stripped to their bare essentials and compressed, these files totalled 2.2 kbytes. However most 8 minute pieces would occupy 10 to 30 kbytes compressed because they have thousands of notes. Such small files can easily be emailed - whereas an 84 Megabyte file would be awkward and expensive to transfer.

The orchestra and score file constitute a complete self-contained, high quality musical object. They will produce the same sound on Csound running on any computer.

Like MIDI and MOD files, Csound files can be read and edited - so they are like "source" programs as described in chapter 10. This means that the composer of a Csound musical object cannot keep any of its contents secret. Anyone wanting to know how a particular sound is created can read the file, and use the instrument code in their own creations - even if they do not understand how the program for the instrument works.

This is much more powerful than sampling from sound recordings - where a snippet of a song can be played back by the sampler. It is the equivalent of the musician giving all the musical score, and all the instruments, reverbs and mixers to the listener, who can use them as they wish and modify them.

However it would be possible to define a language analogous to MOD files or Csound which was "compiled" (see chapter 10) so it would be difficult - but not impossible - for someone to understand and copy its internal components.

Such a language would only be developed to aid commercial sales of music objects whilst protecting their creators against casual copying of their source code. This is similar to the need to distribute the control programs of multi-media applications in a compiled form to protect the intellectual property they embody.

APPLICATIONS OF MUSICAL OBJECTS

MIDI and Csound are all typically used by musicians to create recorded music, but they are discussed in this chapter because they could also be used as a means of selling music to consumers - or selling consumers the means to make their own music. MOD files seem to be used primarily by neophyte musicians, but their function is solely to produce music on a computer for other people to enjoy. There does not seem to be an exchange of recordings of MOD files, which would take many Megabytes - it is much easier to transfer the MOD files themselves, which are typically a quarter of a Megabyte.

Many new approaches to musical objects will be developed - primarily for recreational, educational uses as well as for musicians to make recordings. The examples given in this chapter show the basic characteristics rather than the detail of future approaches.

For musical objects to be part of the recorded music industry, they need to be valuable enough for people to want to buy them. In addition, musicians need to be happy about selling them - and typically giving the purchaser access to all the sound producing algorithms or samples they use, and any sophisticated composition algorithms the piece contains.

Music objects could provide:

- Variation from one rendition to the next, in keeping with the composer's and listener's desire for fresh musical experience.
- Listener alterable aesthetic parameters - such as tempo, key or mood.
- The ability for the purchaser to take parts of the object and modify them or combine them with others to create new ones.
- Compactness in file size compared to a recording of an equivalent piece of music.

An example of music object which could be realised with today's hardware is a CD-ROM with several hours of compressed natural sounds including birdsong, rain etc. The software contained on the disc could play these back in endless combinations with sophisticated aesthetic control by the user. A similar approach could be used with mechanical and distorted musical sounds for listeners who seek a more industrial ambience.

Substantial research has been done on computerised compositional and synthesis techniques - typically in university music departments[12]. These techniques - such as Csound - are becoming practical on consumer equipment.

One application where musical objects are needed is in video games - where music must be generated in a way which responds to the gameplay, but where storage space is very limited. MOD files were first developed to provide sound within computer games. As the visual and acoustic aesthetics of multimedia productions become more sophisticated, there will be an increased demand for high quality musical objects and for the people with the musical and programming skills to create them.

Music objects raise some daunting copyright issues, but these may not stand in the way of musicians selling music objects once home computers are powerful enough to calculate attractive music in real time. Pleasant music typically involves sophisticated sound synthesis and reverb algorithms - which are computationally intensive, so real-time music objects which sufficiently please consumers may depend on home computers having the computational power of today's $20k+ workstations - however that will probably occur between the years 2000 and 2005.

Musical objects could still be valuable if the listener's computer could not calculate them in real-time - provided the time taken did not inconvenience the listener and the music could be stored on hard-disk. Both Windows and Macintosh operating systems are multi-tasking, so a music object could be running with whatever computer resources were not required for normal applications. The music object could run at full speed overnight and take a few hours or even a few days to generate an hour of music - to be stored on hard-disk. The music could then be played and recorded for convenient playback at a later time. Such hard disc capacities are becoming feasible in home computers.

It is easy to imagine a prominent composer such as Brian Eno selling a music object to create, for instance, a distinctive range of music for ambient listening situations. The program could combine elements of chance with user input to control the music generation process. The program could be left to run overnight, with the prospect of hearing a unique piece of music in the morning. To a listener with sufficient disc space - such a music object would be highly valuable.

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12 See *Computer Music Journal* MIT Press and *Chroma* The Australian Computer Music Association ph (03) 479 3651 email rossb@klang.latrobe.edu.au.

Eno's work is based on the creative use of chance and many people would happily pay for a music object which could continuously generate an ever changing stream of his music. Each piece of music could be unique - never likely to be the same as any other product of the same music object. There would be no technical limits on how long the music could run for - if the computer could calculate it in real-time, it could run for years.

In creating such a music object, there would be a tradeoff between the variety and the aesthetic quality of the music it produced. It would be very difficult to create an object which consistently produced a wide variety of music where all the output was worth listening to. So with more adventurous music objects, the listener may select various outputs according to their tastes - as some would be much more attractive than others. While Brian Eno works with chance, he is also very selective - releasing only about one percent of what he records.

Comment [RW15]: Page: 179
I have the source for this in an interview about 8 years ago, but it could be tricky to find.

Copyright of music objects and the music they produce

When a "listener" uses a music object with user controllable parameters, the resulting music is partially a product of the listener's creative input. A music object could produce a huge variety of possible outcomes - far more than the creator of the object could have imagined. Who would hold the copyright to the resultant music? A really flexible musical object resembles a musical instrument - its output is heavily dependent on how it is used. With creativity and perseverance, someone may use a music object to create a marketable piece of music - or some sound which is used as part of another piece of music.

Existing copyright law does not seem to cover this situation where the music object could be considered as both a piece of music and as an instrument for creating music. If the law, or the object's licensing contract, gave the object's author some rights over the music it produces, how practical would it be to enforce such laws? A sophisticated object could make music which its creator may or may not recognise. It may be impossible for the object's creator to create a similar piece of music without knowing all the parameters which were used by the "listener". Even if the parameters were known, random processes in the object could produce different music each time.

The value of variety

The copyright aspects of music objects are daunting. However their ability to provide pleasing background and contemplative music makes them more valuable to some consumers than fixed recordings. A sophisticated composer could create a music object, which produced distinctly different music each time it was used - and each piece of music could go beyond "ambient" sensibilities and satisfy more intent listeners as well.

Variety is a valuable part of many human pleasures. For instance the constantly changing visual variety of a garden or forest, or the audible variety of birdsong add a great deal of value to a home or tourist destination.

Despite lack of airplay, ambient music is a highly marketable form - as reported in the feature article of Billboard 23 July 1994. The music encompasses natural sound, low-key acoustic washes and acoustic and electronic music of great artistry. It is a form which would benefit greatly by continual variation in which music objects can provide with ease. With CDs, this can only be achieved to a limited extent by using multiple players to listen to two or more CDs in shuffle play.

Ambient music evidently has broad appeal - an example of the technical, stylistic and marketing diversity of this field is given in Billboard 22 October 1994 (page 67). A company has been producing audio-visual works targeted at confined, frustrated urban dwellers. Their first product in 1989 contained sound and images of squirrels and birds chirping and hopping about. This video cassette proved successful in the feline niche market and was entitled *Video Catnip*.

COPYRIGHT AND PATENTS

Copyright law covers sound recordings, printed music notation, and elements contained within these - down to a certain level. A melodic phrase from a song is subject to copyright, but three notes from it are not, unless perhaps they are played with timing and timbre which is perceptibly similar to the original.

Musical objects could be made the subject of copyright law, from the perspectives of their audible musical output, or the programming code which is contained in their software. A musical object is essentially a music generating mechanism - just like a music box or piano roll - even if the object and the system which "plays" it are both implemented in software.

The commercial sale of music objects would probably need to be accompanied by extensions to copyright law. The intellectual property they embody would be vulnerable to unauthorised use because despite any efforts to conceal the internal algorithms, a music object would typically yield all the secrets of its compositional and sonic structure to anyone who wanted to use them for their own work.

It would probably be unrealistic to distribute a musical object containing samples, or Csound instrument programming, whilst copyrighting these elements and expecting to be able to enforce that copyright. Even if the laws were amended to encompass samples and compositional or sound synthesis algorithms, it may be impossible to prove that someone has used the element or a modified form of it in a recording. It would only be possible to prove copyright infringement if they appear in someone else's musical object. This raises questions of what level of musical structure copyright law should apply to and what practical limits there are in enforcing such law.

Another approach to protecting intellectual property is the contentious practice of patenting software - the patenting of algorithms which can be implemented in computer programs. For instance if someone patented an algorithm for placing sound in a simulated three dimensional space, and the patent covered implementations of this in Csound or any other programming language, then legally speaking no-one is permitted to use such a program implementing the algorithm for commercial purposes during the life of the patent - typically 17 years.

This would be true if the algorithm was used to create a commercial recording as well as if the algorithm was implemented in the program of a commercially marketed music object. It would be true even if the person who used the algorithm developed it independently and did not know that it was covered by a patent. It would be true whether the algorithm covered sound placement or generation - or musical composition functions which created melodies and rhythms.

For instance a software algorithm could be developed to generate rhythms and basslines with particularly valuable characteristics for dance music. If the algorithm was found to be novel, useful, practical and non-obvious - then it could be patented. These claims would need to be accepted by the court if an infringement case was defended vigorously - because the court could rule that the patent was invalid.

However even the most legally robust patents cannot be fully enforced without the financial and legal resources required to win a protracted court case against someone who infringes it - assuming the case is vigorously defended. On the other hand, the owner of a patent can often obtain a court restraint on business activities which seem to be infringing a patent, and the purported infringer can only carry on business after mounting an expensive legal defence.

Patents are potentially very valuable to large and small companies alike. Yamaha's patents on the DX7 synthesis technology[13] are probably violated by anyone selling a program which replicates the DX7 algorithms in software. These algorithms are available in publicly available Csound programs and so any commercial use of that program would constitute a patent infringement - if the patent covered software as well as hardware implementations.

There are tens of thousands of patents covering musical instruments because it is a commercially valuable field. When a musical instrument is implemented in

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13 For the sake of discussion, this assumes that the synthesis algorithms of the DX7 are patented - the patents may well have expired by now. These arguments would apply to the doubtless many patents which protect the "physical modelling" synthesis technology Yamaha now uses in its extraordinary VL-1 synthesiser.

software rather than hardware, a well drafted patent for an algorithm also covers the software implementation. If there was an unauthorised software implementation of a musical algorithm, as long as a musician used the software in a studio to create a recording, it is unlikely that they would be detected or taken to court. If they sold a piece of software, or a piece of music as a music object program, which contained that algorithm, then they would be open to legal action.

Patents originally applied to physical mechanisms, or processes for making products. They now cover software algorithms. If music is sold as software to generate sound, then it could be subject to patent law - just as patents cover the mechanisms inside music boxes.

CHAPTER 13 OVERVIEW OF TECHNICAL TRENDS

The previous chapters have explained the foreseeable technological developments in the information technology field and explored a little of how they may be used for musical purposes. Further chapters will explore the musical applications in greater depth. The scope of this paper covers 15 years of rapid change and although it is impossible to reliably predict future developments, a framework is needed to facilitate discussion.

This chapter provides overviews of the future from two perspectives. Firstly the changing roles of broadcasts, storage and telecommunications networks in satisfying consumer demand for the delivery and reproduction of musical material. Secondly there is a brief description of how the communications revolution is likely to unfold.

This chapter concentrates on technical issues. The next chapter considers how this may affect the listener's total experience - and hence the structure of demand. Chapter 17 contains overviews from several marketing perspectives.

DISC STORAGE AND TELECOMMUNICATIONS

The last ten years has seen little new technological change in the delivery of music to consumers. Today's CDs are based on 1982 technology.

The last ten years has seen changes to data communications from the home from 300 bit/sec modems to 28,800 bit/sec. However these have had no impact on music delivery and only with the World Wide Web are starting to change the music discovery process.

The changes in computers and hard-disks have been extraordinary in the past ten years - but they have had no effect on music delivery and only now with the WWW and CD-ROMs are they beginning to change the discovery of music.

Broadcasts, video cassettes, vinyl and CDs all bring large quantities of information into the home - but only in the form of linear images and sound. The CD-ROM is the first cost-effective means of bringing hundreds of Megabytes of fresh data into the home - data which can include image and sound, and the software to structure it non-linearly. This fresh flow of information, and the flow of more immediate, personally selected information from the World Wide Web is driving the use of the home computer as a navigation and management tool for information from the outside world - just as the radio, TV and VCR have been for information sourced from broadcast channels.

Broadcast technologies have remained static, except for stereo TV. The distributive technologies for subscription TV are radically different, but are just starting operation.

This may be the calm before the storm, because foreseeable technological developments will have many musical applications.

The two most important foreseeable changes are.

1 - The ability to store hundreds or thousands of Megabytes on write once CD-R discs - or rewritable MO discs.

2 - After about 2000, the ability to use broadband individual links to the home to access the global network and deliver hundreds or thousands of Megabytes into the home on demand.

These fundamental changes, when combined with the rapid incremental improvements in computers and hard-disks, have the capacity to totally alter how information is delivered to the home and how - or whether - it is stored.

Storage and communication technologies provide three distinct functions:

1 - Deliver new information to the user.

2 - Enable the customer to save their own information.

3 - Enable the customer to give or sell their information to someone else.

Computers and display/playback devices knit these functions together for generation, and use, of the information.

The following tables and analysis concentrates on the communications and storage technologies.

For simplicity, it ignores the details of what the user information is - it could be digital video, audio, text or other kinds of information - such as elaborate data sets relating to games, which must be saved or communicated to others. Personal communication services such as the telephone are not considered. Rural, poor and disabled people are not considered in this analysis which looks at mainstream trends amongst the middle class urban consumers who are most likely to be spending money on music and equipment.

The left column - *Broadcast and Distributive* - includes:

- Free to air (FTA) AM and FM radio.

- FTA analog TV via VHF, UHF, MDS and coaxial cable.

- Subscription analog video via MDS, satellite and coaxial cable.

- Subscription and FTA digital video via MDS, satellite, coaxial cable, optical fibre and Digital Terrestrial Television Broadcasting (DTTB). These are distributive applications where viewers tune from a limited number of shared channels - so it includes "near video on demand". It does not include true Video On Demand, where viewers chose exactly what they want - this is covered in the right column under *Network*.

- Similar to the above, subscription and FTA digital audio via MDS, satellite, coaxial cable, optical fibre or Digital Audio Broadcasting (DAB).

This analysis concentrates on electronic media, but printed media - newspapers, magazines, books and directories - are similar in some ways to both the above *Broadcast and Distributive* category and the *Pre-pressed* category that follows.

The second column - *Pre-pressed discs* - refers to any mass produced, physical means of conveying data to consumers:

- Audio CDs, CD-ROMs and future types of pre-pressed optical disc. It does not include writable CD-R or MO discs, either written in the home or by retailers for individual customers.

- Pre-written floppy disks.

- Prerecorded video and audio cassettes.

The third column - *Writable discs* - refers to any kind of write once or rewritable high capacity storage:

- CD-R and other kinds of write once discs.

- Magneto Optical (MO) discs (such as Mini Disc) and any other rewriteable discs, whether written in the home or by a retailer to suit the needs of individual customers.

- Removable hard-disk cartridges. It does not include fixed hard-disks - these are assumed to be present in everyone's computer.

Tape systems such as DAT and future optical tape systems fit this category but are not considered in this analysis. To a lesser extent so do analog tapes such as audio and video cassettes. The focus here is on the convenient disc format, however tape based technologies are likely to play some role in future developments.

The fourth column is *The Network* - a bi-directional digital data network which provides local and global connectivity between consumers and content suppliers - including consumer to consumer links. Today's telephone network is not included in this definition, although many people will access the Internet by using modems and the phone network.

The definition of "The Network" changes. In 1995 it is the Internet, with most users accessing it via 14.4 and 28.8 kbit/sec modems - although businesses and a few consumers will have faster links such as Basic Rate-ISDN. Irrespective of the local link, the Internet itself is too slow and expensive to allow economical distribution of audio or video data. The Internet's role in music discovery is not considered in this analysis - here the focus is on the delivery of large quantities of audio and video data.

In 2002, "The Network" will probably include whatever the Internet evolves into, and its backbone may be a variety of networks which were built for specific purposes such as computer networking or video and audio delivery. Video On Demand will be reaching a mass market.

In 2009, "The Network" is a much faster, more integrated, cheaper version of the above. Video On Demand will be available to most urban consumers, as will high speed (64 kbit/sec to 640 kbit/sec) duplex data links to support intensive global networking from homes and offices. Depending on the nature of the local link, higher data rates from the home may be available when needed. The data link into the home is likely to be at least 6 Megabit/sec - to support one high quality video channel, or two video programs of less demanding material.

The concept of the network is central to understanding people's use of storage technology. This may not be obvious, since today we have no network for music or video.

If there was a high speed network, with minimal costs, to every location - including in cars and trains - then there might be little need for storage technologies like discs, including pre-pressed discs. Music and video might be sourced directly from the network as needed. Although some people would insist on using their own physical storage for personal information, the need for consumers to possess storage is generally a reflection of the fact that the network does not provide all their needs.

TABLE 13.1 1995 INFORMATION SUPPLY AND STORAGE

1995	*Broadcast & Distributive*	*Pre-pressed discs*	*Writable discs CD-R / MO*	*Network*
Technology	FTA & Pay TV & Radio	780 nm audio CD & CD-ROM 0.78 Gigabyte	Not widely used by consumers 0.78 Gigabyte	Early Internet. Local link is typically a dial-up modem
Supply of Information	Music and Video	Music and increasingly video	Hardly used	Early adopters - too slow for audio or video
Storage for backup	na.	na.	Early adopters	No
Home use	Video viewed live & stored on VCR	Music	Not used	No
Mobile use	AM & FM Radio	Music - CDs for Walkman	Not used	No

1995

The network is too slow, awkward and expensive for anything but low volume transactions such as email, text based discussion groups, text and still image hypermedia (World Wide Web) and file transfer such as the downloading of software. Broadcast industries are primarily competing with video cassette and subscription distributive systems (pay TV). Many people are eager for music sales over the global network and for affordable CD-R writers, but they remain too expensive.

CD-ROMs continue to grow in popularity. They give many consumers their first taste of the power of computers linked to large quantities of data. The Internet, despite its rough beginnings suddenly becomes easy to navigate via the World Wide Web. The limitations of CD-ROMs become clear to anyone with Internet experience, however they remain popular since they are a lot more cost-effective for large quantities of data than a network link and hard-disk.

As Ted Nelson, founder of Project Xanadu, said [14] "CD-ROM represents a Pre-Columbian view of data storage. Once you reach the edge, you fall off."

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14 Interview on "Einstein a Go-Go" 3RRR 6 May 1994. Project Xanadu is a proposed means of electronically publishing text and other information, retaining ownership and gaining payment for use of the material, whilst making it available for anyone to use and incorporate into their own work. Details are available from http://www.glasswings.com.au:70/1/xanadu

TABLE 13.2 2002 INFORMATION SUPPLY AND STORAGE

2002	*Broadcast & Distributive*	*Pre-pressed discs*	*Writable discs CD-R / MO*	*Network*
Technology	FTA & Pay TV & Radio DAB & DTTB? Some distributive material via the network	780 nm discs - 0.78 gbyte 3.7 Gigabyte 635 nm red light discs	Business and some consumer use of 635 nm discs with 2.2 or 1.9 Gigabytes	Mature Internet Link via coax cable for computer data, music and video Early Video On Demand
Supply of Information	Music and video	Music and video sold on standard CD & red light discs - including new formats with several hours of music	Retail supply of music & data	Music sales over network becomes cost competitive with discs, and starts to become a mass market
Storage for backup	na.	na.	Business and advanced consumers	No
Home use	Video viewed live & stored on analog VCRs Digital video stored on digital VCRs or home computer hard-disk and writable discs.	Music, video, some computer applications	Personal storage of music, data and video purchased and collected from all sources.	Networked games and education are common. Networked "audio on demand" becomes cost-effective. VOD starting to take off.
Mobile use	AM & FM Radio DAB - Digital Audio Broadcasting	Music - CDs for Walkman	Walkmans play discs written at home - which play for several hours.	Early use of mobile data networks for computing and communications, but not for music because of cost.

2002

This is the transitional stage towards the Ubiquitous Broadband Network - which is rapidly being built. The coaxial cable systems which originally carried analog signals are being converted for fully digital operation to provide individual links from each home to the broadband network. ADSL is likely to be used in some areas and provide similar functionality. These links will be used for early VOD applications and the subscription TV channels will still be available.

Video On Demand provides a selection of general programming, movies and sport. It is something of a luxury but rapidly becoming a part of ordinary life - as mobile phones are today. Personalised news services are in the early stages of development.

Homes with digital coax or ADSL have high speed links to the Internet / World Wide Web (or whatever they have evolved into). Many other homes use modems or BR-ISDN. WWW is commonly used for educational, recreational and business purposes - including searching for and purchasing products and services.

Music sales over the network are starting to take off - for the highly motivated music fans with specialist interests and money to spend. This boosts the prospects of many musicians who had not previously connected with their audience because they did not fit well into the traditional hit-driven, physical product retail and distribution chain. From this point on, the history of music becomes more diverse and difficult to document, since the music is no longer flowing through identifiable channels of record companies and radio stations, and no obvious physical trace of it may remain.

The global network is a part of ordinary business life, and email, files and voice mail is transferred routinely irrespective of the destination. Commercial computer applications are increasingly built on the assumption that they are running on a computer connected to all other business computers on the global network. This profoundly changes day-to-day activities and business attitudes to customers and competitors. Popular notions of distance change, with email costing little or nothing to any destination, and WWW links to anywhere in the world.

2009

The global network reaches into most homes and all offices. Video On Demand is widely used as costs decline and variety improves. Music sales over the network (electronic delivery) becomes more cost-effective and convenient than buying a disc in a shop. People buying music over the network must have a computer with a writable optical disc drive, but this will be relatively common equipment - for music and for video.

The global network link to each home supports multiple communication sessions at once. It is permanently connected to one or more home computers and so the home link and always ready to send, receive and redirect data. These high speed links to the global network are not universally adopted. People with low incomes and those who are geographically isolated are typically not connected.

If these scenarios eventuate, then the broadcast and distributive media and the distribution of pre-pressed discs will decline over fifteen years. *A large proportion of consumer information needs will be met by a good connection to the global network, and high capacity writable optical storage for home and mobile use.*

This represents a decline of two mature forms of distribution - broadcasting and physical discs - and the rise of two industries which are currently in their infancy - writable optical storage and global networked telecommunications.

TABLE 13.3 2009 INFORMATION SUPPLY AND STORAGE

2009	*Broadcast & Distributive*	*Pre-pressed discs*	*Writable discs CD-R / MO*	*Network*
Technology	FTA services decline - audience & programs are lost to VOD & distributive operators. DAB & DTTB widely used	780 nm discs - 0.78 Gigabyte 635 nm red light discs 3.7 Gigabyte 8.3 Gigabytes 425 nm blue light discs	Near universal use of 635 nm discs giving 1.6 or 1.2 Gigabytes 5 Gigabyte blue discs for commercial use	Internet, VOD and telephony are merging into a global network with standard addressing and communications protocols.
Supply of Information	Music and Video	Music sold on standard CD & red light discs - as before, but distribution costs and inflexibility mean that sales decline.	Increased use by shops and mail/network-order music & data. This enables customers exact needs to be met.	Music sales and VOD over the network have achieved mass markets. Music is stored on magnetic hard-disk, then is transferred to CD-R or MO optical discs.
Storage for backup	na.	na.	Widespread home and business use	Public data repositories *may* be competitive with personal storage discs.
Home use	Video viewed live & stored on VCR. Digital video stored on home computer and writable discs or tape.	Music, video and some computer applications.	Personal storage of music, data and video purchased and collected from all sources.	Networked games and education are common. Networked Audio and Video On Demand are widely used.
Mobile use	AM & FM Radio DAB	Music - CDs for Walkman.	Walkmans play discs written at home - which play for several hours.	Mobile data networks are part of the global network, but seldom used for music because of cost.

FUTURE SCENARIOS FROM A MUSIC PERSPECTIVE

All of the technological developments listed above are thought to be feasible in the next ten to fifteen years. Many are technically feasible now and are likely to substantially alter the music distribution environment when policy, finance, planning, production and installation steps are taken.

Future developments cannot be predicted with certainty, but the following scenarios are presented as an aid to further discussion. These projections concentrate on the discovery of music and how it is purchased, delivered and listened to.

The 1997 music scenario

Personal computers are more ubiquitous and powerful than they are now. Mac and IBM compatibles still dominate, but the common platform of the Power PC is of growing importance. Most personal computer users have 28.8 kbit/sec modems and some will have BR-ISDN. Many users have Internet access for email, World Wild Web, discussion groups (newsgroups) and file transfer. Most people between the ages of 10 and 30 understand roughly what the Internet is and many people use it for personal and cultural pursuits as well as for work and study.

Communication costs and speeds are prohibitive for music sales over the network, but it is practical for the keen music listeners to audition music using World Wide Web browsers and to order CDs for delivery by mail. Secure methods of funds transfer will be in general use on the World Wide Web, and many businesses will make their services available in this way.

CD-R writers for CD-ROM and audio applications are more common on personal computers - but only a few consumers have them. The CD-R drives can write discs for today's CD and CD-ROM drives as well as for the red light CD-ROM drives which are standard. However the main music market will still be served by standard audio CDs and a few CD-Rs recorded for the customer by retailers.

Consumer acceptance of MiniDiscs is likely to be much higher than in 1994. Audio cassettes are on the way out and vinyl records are used only by DJs.

Digital Audio Broadcasting and subscription music over coaxial cable, MDS and satellite may be used by a small part of the market, but they hardly affect the mainstream market for music.

Subscription TV is relatively common, but digitisation of the coaxial cables and Video On Demand for the mass market is still a few years away.

Many people will have experienced the world-wide connectivity of the World Wide Web and there will be a clear demand for the same kind of user control for selecting video and audio material for entertainment, education and for browsing and purchasing products and services.

The 2000 music scenario

Distributive digital audio systems - DAB and via coaxial cable or ADSL are becoming more widely used, but FM and AM radio are still dominant. Technically there are dozens of channels available in addition to AM and FM transmissions. Some of these are likely to be simulcasts of AM and FM stations. Others may be new community stations or commercial subscription channels.

CD-R writers or MO drives are becoming common for home personal computers - originally for backup but also for recording music cheaply. A blank red light CD-R disc would cost about $10 and could store around 12 hours of music at 4:1 compression.

Digitisation of coaxial cable systems is starting and early Video On Demand is available for a small proportion of the population. Where they are available, digital coaxial cable system and ADSL will be will be used for Internet access at broadband data rates. Where these are not available, modems and BR-ISDN will be used.

People with broadband Internet access will be able to buy music over the network and copy it to friends although at a slower rate and perhaps with greater expense. However the costs and small market base will ensure that electronic delivery will only be used by the most highly motivated music consumers. These will include many of the "opinion leaders" as described in chapter 17 - so the trends in music will begin to be influenced by electronic delivery.

The mass music market will continue to be served by standard audio CDs, perhaps by enhanced capacity formats with compression and the use of 635 nm lasers, and by retail sales of CD-R discs for individual customers.

Some artists and recording companies, will be able to sell their music directly to consumers over the consumer's broadband links to the Internet or local video servers. The revenues will not rival those of conventional retailing, but will be welcome to the musicians - who may not have been able to earn much through the conventional channels.

Automatic Music Identification (discussed in chapter 14) may be technically feasible however it is difficult to predict when market conditions would support its development.

The 2005 music scenario

The VOD Infrastructure reaches the majority of the urban population and computers are found in most homes. A hyper-media interface similar to that used now for the World Wide Web is used for most consumer choices and virtually everyone will be comfortable using it at home and in shops.

Music sales over the network are economic and are a vital part of giving the consumer the choice and low price required to entice them to buy music rather than copy it from friends or from the many distributive systems. The income generated from music sales over the network starts to rival that of the existing revenue streams.

Automatic Music Identification may be useable for some genres of music. This enables a consumer to play a small sample of an unidentified piece of music into their computer, and it will send it to a server, which returns the name of the piece and the artist, with a hyper-links to where more of the music can be purchased.

Several factors combine to stimulate diversity, quantity and quality in recorded music sales:

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1 - Reduced costs for production and distribution.

2 - Listeners buy exactly what they want. This provides direct and immediate critical and financial feedback to the musicians.

3 - Musician's musical horizons can be even wider than they are today, because it will be so easy for them to browse all available forms of music and keep track of fashions on a day to day basis.

The 2010 music scenario

Video and Audio On Demand will be widely used in urban areas. Most people will use email and have a mobile phone with sophisticated management of voicemail and email.

In fifteen years time, music will be distributed, copied and sold in an environment of extreme information fluidity. Pre-pressed discs will still be sold, but they may be smaller, or play for longer. The marketing structure of the music industry will be transformed and there will be minimal entry costs for any artist to achieve world-wide distribution. New structures will evolve to introduce people to new music, and to guide them when they want to buy more of it.

CHAPTER 14 MUSIC MARKETING TECHNIQUES

This chapter explores how the technologies described in earlier chapters can be applied to marketing music. This includes promotion and helping people to discover new music as well as the selling and delivery of music.

The integration of these techniques, and how they evolve over time, are discussed in chapter 17.

Several existing music marketing techniques are not explored in this chapter. These include retailing through music clubs and the hire/loan of CDs to prospective mail-order purchasers[15] - who may return them after a few weeks for a moderate fee if they do not want to purchase them.

Another significant marketing development not discussed here is the sale of second-hand CDs. This is could be greatly facilitated by up-to-date on-line catalogues and purchasing arrangements via the World Wide Web.

This chapter discusses the most prominent new music marketing techniques - many of which are in direct competition with retail shops. However the prospects of the retail CD shop can be greatly improved by the use of sophisticated browsing systems and by the sale of CD-Rs made to customer requirements

MUSIC MARKETING WITH PRINTED CATALOGUES

One example of a CD catalogue is the "CD Plus" catalogue from Canada which was sold in many Australian newsagents for $9.60. This contained some articles and adverts, but the bulk of its 500 pages were are listing of 58,000 CDs - grouped by artist and with the name, price and catalogue number. Australians could order by phone, mail or fax and pay by credit card.

This form of marketing relies on the customer being familiar with what they are about to buy - there are no critical or aesthetic details in the catalogue. In addition there is uncertainty about delivery times since the CD may not be in stock.

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15 Advertisement for *Bill Wilson Stereo Library* mentions "Try before you buy". October 1994 *Gramophone* page 224. In the same issue on page 214, *Quires Gate Music Centre* offers UK resident members of their club a 60p per week hire service for CDs sent out three at a time. The loan fee is cancelled if the CD is purchased. The company is run by Ivan March, the editor of the *Penguin CD Guide* and seems to apply to discs from a range of over 3000 he has selected.

Music marketing with CD-ROMs

An innovative marketing system is to distribute a CD-ROM every month at nominal cost, which contains samples of music, text and graphics from hundreds of CDs. With compression, several hours of audition quality music can fit on one disc. The software on the disc automates the ordering procedure, takes the customer's credit card number, and uses the modem to dial the company and place the order for mail delivery.

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This is a promising marketing system, although it requires significant investment by the retailer or distributor. Since the promotional benefits accrue to the artists even if the customer elects to buy the CD from another supplier, the artists and their record companies may be prepared to financially support such a system.

However the CD-ROM is a transitionary technique because it still requires a month or so to prepare and is a physical product which must be distributed.

CD marketing over the World Wide Web

The Internet is too slow and expensive to sell quality music to consumers. However CD marketing over the Internet started in 1994 - using the hypermedia documents of the World Wide Web. In its most primitive form, there is just a text listing of CDs and customers order via mail or phone. However the listing can be completely up-to-date and of unrestricted length, because it is accessed one section at a time according to stylistic and alphabetical criteria.

Chapter 6 describes the World Wide Web and contains some addresses of WWW music retailers and of music lists which point to other retailers. There is great scope for developing WWW CD retailing and the reader is urged to explore the WWW to experience the latest developments. Chapter 17 discusses the desirable features of a WWW CD retailing system.

In the future it is likely that detailed marketing support could be given for tens of thousands of CDs. When VOD is available, the support would include video clips, but more importantly, the VOD infrastructure would support the cost-effective delivery of the music itself to the customer - with no need for physical products.

Combining CD retailing with electronic delivery

There is a "half-way-house" which combines elements of CD retailing and electronic delivery (described below). This relies on being able to deliver at least some of the music to the customer electronically at the time of purchase - but perhaps with reduced quality.

It could be attractive when the customer has a few hundred megabytes of spare hard-disk space for a few weeks, and does not have a CD-R writer attached to their computer. It could also be attractive when slow telecommunications speeds and/or high costs make delivery of hours of high quality music too expensive. A local link based on BR-ISDN could be such a scenario.

Before purchasing the music, samples of it are browsed as they are today on the WWW. On purchase, one or more complete tracks are sent to the customer for them to play in then next few days or weeks. The seller then mails out a pre-pressed CD or a CD-R containing the music. This would typically be an audio format disc, but could also be a CD-ROM with high capacity and lossless compression.

This enables the customer to enjoy some of the music which they will keep on their hard-disk until the disc arrives in the mail. It gives all the benefits of CD retailing, but reduces somewhat the urgency of delivery.

This approach could be feasible in the period 1996 to 1999, when slow telecommunications and higher costs of CD-R writers make full electronic delivery too expensive, but BR-ISDN makes partial electronic delivery possible. CD-R writers are not too expensive for music sellers to use, and if the blank discs become cheap enough, it may be feasible to sell custom CD-Rs in this way in the next few years.

NETWORK MUSIC SALES DIRECT TO THE HOME - ELECTRONIC DELIVERY

Chapter 17 discusses the desirable features of a music retailing system for electronic delivery. This section discusses the technical and economic constraints of when it will become feasible, and how the costs will be affected by distance between the consumer and the retailer.

Retailing music over today's Internet is impractical due to the speed limitations of the local link and the cost of the time and traffic charges. 60 minutes of music compressed (nearly losslessly) 3:1 constitutes 212 Megabytes of data. Over a 28.8 kbit/sec modem, at 12 Megabytes and hour (12.9 minus and allowance for protocol overhead), this would take 17.6 hours. This is not an acceptable way to sell music to consumers - they would need a dedicated phone line and would have to wait for a day for delivery. With existing Internet access charges of $5 and hour, this would cost $88. Some providers charge as little as $1.33, so this would reduce the cost to $24 - which is probably still to high for almost any music consumer. These are only the consumer's costs - the company sourcing the data within the Internet would also face costs for such a large transfer. Of course the data could be transferred directly from one computer to another via modems with a local phone call - which would cost 25 cents.

Modems - which can never be faster than 28.8 kbit/sec - are too slow for electronic delivery of music with a quality which consumers would be willing to pay for.

Basic Rate ISDN for electronic delivery

However, Basic Rate ISDN may provide a practical means of selling music to highly motivated listeners. It is probably too slow for mass market use, but it is worth considering what conditions must be met before most motivated music fans would start to buy music and have it delivered electronically:

1 - The listener has a computer with sufficient hard-disk storage to hold the music temporarily. If the music is to be decompressed to be stored on a CD-R audio format disc, then there needs to be an additional 783 Megabytes of spare hard-disk space to make an "image" of the CD-R to be written, because the writing must be done in one pass.

2 - They have a way of storing it permanently - on CD-R (compressed on a CD-ROM data disc or as a standard audio CD), or on a rewritable optical disc - Magneto Optical or phase change. The permanent storage medium should not cost too much - no more than $20 an hour. These technologies are expensive today, but will probably be cheap in several years time. Today the music could be stored on DAT or MiniDisc - although the latter would involve sound quality loss from a second stage of data compression.

3 - The listener has access to a telecommunications network, having paid the installation costs and purchased the interface card to their computer. They must also pay for rental of the service.

4 - The time and convenience factors in transferring the data are acceptable.

5 - The costs to the listener, and to the provider of the music, must be acceptable - almost certainly below $20 for an hour of music.

In principle, these conditions could be met today, if the consumer had a 1 Gigabyte hard-disk ($700 or so) a substantial Macintosh or IBM PC ($2,500), a DAT recorder or MiniDisc (~$1000), a sound card with a digital audio output (relatively rare - perhaps $800 minimum), a BR-ISDN interface card (also rare - perhaps $800) and a BR-ISDN service ($395 to install and $960 per year to rent).

Basic Rate ISDN could be deliver this amount of data. With both 64 kbit channels of BR-ISDN operating, this would take around four hours - so it might be practical to download the data overnight. With today's off-peak local call rates (1 cent a minute for each call, and there are two channels and hence two calls), this would cost $4.80 - which is quite acceptable.

The listener could connect to the Internet, via one or two 64 kbit/sec channels and browse music conveniently in real-time. They would select which music to purchase, and transfer the funds. The transfer of data could take place over the Internet, in which case hourly Internet access fees would need to be paid as well. Alternatively, a computer which supplies the music make a pair of ISDN data calls, using both 64 kbit/sec channels, directly to the listener's computer - typically during off-peak times when they were not wanting to use their BR-ISDN service. If the calls came from the same local call zone, then the transfer would cost $4.80. If these calls were made in business hours, the cost would be $18.85. If it came from another capital city (assumed to be over 745 km away) outside business hours, the transfer would cost $160.

Some dedicated music fans would pay this $4.80 an hour delivery cost, to buy music they are passionate about. However this is only applicable if the music is sourced from a computer in the same local call zone, or is brought through the Internet to a BR-ISDN service in their call zone at relatively low additional cost. This precludes bringing the music directly from overseas.

While this may be technically feasible now, the number of Australian music fans with a BR-ISDN service and the other required equipment would be very low - probably zero.

However, looking ahead two years to mid 1997, it is possible to imagine BR-ISDN costing less and being installed in significant numbers. Hard-disk and personal computer costs may be no problem, and the BR-ISDN interface card might cost only a few hundred dollars. They are almost entirely digital devices and hence able to be highly integrated, while a 28.8 kbit/sec modem contains substantial analog electronics.

The storage problem would remain. This could be achieved with a DAT or MiniDisc and a digital audio interface - total cost just over $1000. Alternatively a CD-R writer, or MO/phase-change rewritable optical disc drive may cost just over $1000 as well.

If there was a critical mass of music lovers with the above equipment - and the equipment could be owned by a group of friends - then there would be the beginning of a market for electronic delivery of music. The demand would be for specialised music - not for music readily available on CD at local shops.

Music suppliers would need similar equipment, and larger hard-disks to store many hours of pre-compressed music. There would need to be business arrangements appropriate to the sale of music electronically - but this would be no barrier for small companies dealing directly with artists or other small music companies from overseas. This may not be a highly profitable business, considering the limited market and how diverse thinly spread its demand for music would be - but the love of music which sustains independent record companies now would motivate the move into electronic delivery via BR-ISDN.

In conclusion, a small market for electronic delivery of relatively obscure music may develop in 1997 - with the music being delivered via:

1 - A BR-ISDN call (or pair of calls) from a computer in the same local call zone, outside business hours; or

2 - From a computer connected to the Internet in Australia (perhaps by permanent BR-ISDN or a faster link) through an Internet service provider with BR-ISDN local calls (made by the listener) to the listener's computer.

This is likely to be of little consequence to the mass market for music, however, it will greatly facilitate the diffusion of music amongst opinion leaders - musicians, journalists, ardent fans and club and radio DJs.

Although locally produced music would be a significant part of the music sold in such an early electronic delivery market, the bulk of it would come from overseas. It may come into the country on CD, DAT or via the Internet.

On first impressions, it would seem that it would be difficult for the overseas owners of this intellectual property to monitor its sale and promotion here. This has always been a problem when licensing music to overseas record companies. However, since all browse and purchase transactions, and probably most deliveries, would take place via the World Wide Web, it would be easy for the copyright owners to browse the "shop-front" aspect of the Web site just as any customer might do. In addition, they could insist on privileged access to the seller's database - or that part of it which contained the sales information for their music.

They could ensure the seller's integrity by monitoring the database regularly, and having a few local people purchase their music on their behalf - to check that all normal sales were accounted for properly. Of course this does not prevent the sellers or anyone else making illicit copies over the network - but such copying could happen irrespective of how the music was sold. Copying via the network, CD-R, MiniDisc or DAT will be technically easy. The aim of the artists would be to make it as convenient as possible for listeners to buy it legitimately.

Mass market music sales by electronic delivery - by the HFC network

Electronic music sales could grow considerably as BR-ISDN and the related computer and storage requirements become cheaper and more avialable. One possible contributor to this is the prospect that Telecom and Optus might provide BR-ISDN services via their Hybrid Fibre/Coaxial networks.

As this happens, the number of buyers and sellers would increase, and the increased range of music available electronically, with the reduced costs, would attract more participants into something which was started by the most dedicated music fans.

However, as long as the communications link is BR-ISDN, then an hour of music, compressed 3:1 would take four hours to deliver to the home. In addition to the inconvenience to the consumer, this places an upper limit on the number of hours of music a day that a standard Internet connected server computer could deliver, unless it had a very fast link to the main Internet backbone. (There could be several "backbones" and it would be practical for a music seller's computer to be located in a building containing a router for that backbone - it need not be in the seller's home or office.)

For electronic music delivery to satisfy an mass market, there needs to be:

1 - Faster links from the "network" to the home, where network means some city or Australia wide communications network - the phone system (which is too slow) the Internet (which may be fast enough) or a purpose build network for delivering Video On Demand.

2 - Faster switching (routing) to enable hundreds of megabytes to be sent to homes without blocking other traffic.

3 - Faster server computers, with large capacity magnetic and optical discs and magnetic hard-disks.

All these requirements will be met easily by a network built for Video On Demand. A 2 hour movie, at 3 Megabit/sec is 2,700 Megabytes, and the HFC network will be designed to transport that from a local (city based) Video Server for $5 or so. So it is clear that when a VOD network is operational, that the same infrastructure - and probably the same server computers - could easily provide a fast, cheap electronic delivery system for music.

This may happen around 1999 to 2002 - after the HFC network is widespread and operating as a distributive Pay TV system and as soon as Video Servers become cost-effective.

Once this system of music selling becomes established, its cost to the consumer (excluding their computer and storage costs) is potentially very low because there is no physical product or transport, no stock being held by the sellers, and hence no money tied up or at risk. Today's economics of a CD sale (see Figure 1.4) typically see the retailer and distributor taking more money than the artist or recording company - but the distributor and retailer have significant costs of doing business, and must risk some of that expense for every CD they stock.

The economics of electronic delivery are likely to be very different. There may be no need for a three level structure - "manufacturer", distributor and retailer. One retailer may suffice for a country - or even the world. That retailer would deal directly with the artist, or the artist's recording company - or the artist or recording company would do the retailing themselves.

This is likely to lead to tremendous improvements in the diversity of music which can be discovered, browsed and purchased. Risks, costs and layers of distribution are reduced or eliminated. The system facilitates more direct critical, financial and even social connections between artist and audience. These issues, and the way an electronic delivery system may function, are explored more fully in chapter 17.

Table 14.1 contains a speculative cost breakdown of a sale of one hour of music via electronic delivery via a reasonably established HFC VOD infrastructure - around 2004. This is to stimulate discussion - no-one could be sure about the timelines and costs of the scenario used in this paper.

TABLE 14.1 COST BREAKDOWN FOR NETWORK MUSIC SALE WITH ELECTRONIC DELIVERY - WITHOUT SALES TAX

Communication costs. Includes the browse, select and purchase session via the equivalent of the World Wide Web, and the delivery of 212 Megabytes of 3:1 compressed music - near lossless compression.	$2 - 5
Margin to company which operates the music distribution computer In addition to profit, this covers costs incurred in promoting the distribution service as well as operating it.	$3 - 6
Licensing cost of music. Fees to composer, performers and their management and investors - their recording company.	$4 - 10
Cost of blank CD-R (or other kind of writable optical disc), or portion of disc required to store an hour of music permanently - and provide a convenient means for the listener to enjoy the music.	$1 - 4
Total cost to consumer, excluding network rental costs and equipment.	$10 - 25

The above figures are approximate at best. There is no sales tax other than that paid on the blank optical disc - which by 2004 would probably store several Gigabytes.

The cost of the consumer's hardware may seem rather daunting at present - but electronics becomes very cheap after a few years of development and competition in a global mass market. Since any kind of optical disc drive (MO, phase change or CD-R) is much simpler - electronically and mechanically - than today's VCRs, there is every reason why they will be common household devices - just like VCRs are today.

The arrival of cost-effective music sales over the network will be determined primarily by the rate of progress in building a broadband network with Video Servers. The very first applications of VOD may not require enough network flexibility to allow network music sales. However after VOD becomes more widely used, the network will need to support a growing number of Video Servers to cater for the growing diversity of demand. Such a network would certainly have links to the global network - whatever the Internet evolves into - and the music sales could be conducted from Video Servers, from computers connected directly to the local (city-wide) broadband network, or to the wider global network.

The technical demands of the music distribution computer are not high by the personal computer standards likely for 2000 and beyond. With relatively small sales volume a personal computer with a five Gigabyte hard-disk and a fast network connection could supporting four customers at once, with each session involving a mixture of auditioning and delivery of music.

For mass market operations - the equivalent of a large record company - the load could be shared by a number of similar personal computers, or perhaps by some specialised hardware - a special Audio Server, or by suitable software to control a Video Server. Since the most efficient Video Servers are likely to be large systems, it may be attractive for recording companies to hire space on them, rather than invest in their own hardware which would be rapidly outdated. Large Video Servers will be very well connected to the network and are likely to be built for flexibility to accommodate a wide range of functions beyond the provision of just MPEG-2 video data.

Music Sales over the network involves a similar level of interactivity to World Wide Web or VOD, and a similar or larger diversity of products being available from a larger number of distribution computers. It will use the network infrastructure which is developed for VOD and other forms of communication, but its data rates will be modest compared to video. Video may vary between 900 and 2700 Megabytes per hour, whilst music may be between 80 and 300 Megabytes per hour.

This means that it will often be possible to deliver an hour of music (compressed 2:1) into a home in ten minutes or so - if the coax/ADSL link is not being used for much else at the same time[16]

Writing 74 minutes of music onto a CD-R disc with an audio CD format might take 20 minutes or so. If the music was stored in a 2:1 compressed format, then it would only take ten minutes. However it is unlikely that the network music sales session would write directly to the CD-R disc. The data would typically be stored on magnetic hard-disk so the customer could decide which CD-R disc they want to put it onto. In the case of a CD-R disc which is compatible with and today's audio CD, the disc would have to be written in one session, because the audio format directory cannot be updated.

A substantial market for direct music sales to the home will develop only when three conditions are present:

16 This assumes 6 Megabit/sec with a 25% protocol overhead - 34 Megabytes/minute.

1 - A high speed network connects to many homes, with telecommunication costs of under 4 cents a megabyte - transport costs for 74 minutes of music at 4:1 compression would be $7.96.

2 - CD-R writers drop in cost from $4k (1994) to about $700 - the price at which CD-ROM drive sales grew rapidly. This would mean that many consumers can afford to install a CD-R writer in their computer.

3 - CD-R blank discs halve in price to $10 each or less.

Points 2 and 3 can be expected around 1998 to 2000 as the use of CD-R for computer backup increases. Point 1 is likely to take longer and will probably only occur after VOD has become established - some time after 2000. However, if the World Wide Web and the general public's interest in the Internet grows at its present rate, then the HFC systems will be functioning as telecommunications networks with at least BR-ISDN speeds by 1998-99. This may not be sufficient to make electronic music sales grow beyond a "fan" market.

However, when Video Servers become cost effective, the HFC systems will rapidly be converted away from the distributive function of Pay TV, and used as a telecommunications network - for the individual multi-megabit links to each home to provide Video On Demand. This re-engineering would not alter the cable, but would involve a major investment in network infrastructure and probably updated transceivers (replacing "set-top-units") in the home. This upgrade would certainly give provision for duplex communication, including the possibility that some homes could send several Megabit/sec upstream to the network.

This will be ideal for electronic music delivery, and it may be practical for the server computers for relatively obscure music to be located in private homes.

Physical constraints on electronic delivery

Even when local links to the home operate at 6 Megabit/sec, and the costs of transporting 300 Megabytes within a city or country are reduced to a few dollars, there will be a much higher cost for transferring the same amount of data from an overseas site.

On today's WWW, if a customer is browsing or buying a product from a seller, all the customer's communication is typically with the seller's computer. If the quantities of data are low, there is almost no cost penalty with dealing with a seller overseas compared to a local operation.

However, network music sales by electronic delivery do involve hundreds of megabytes which would make this approach prohibitively expensive for retailing to customers via overseas links.

There is another approach, by which most of the transactions takes place with the overseas seller, but the music is sourced from a "buffer" server computer much closer to the customer.

In the following example, the seller is an artist in Detroit, who operates their own computer, which handles all electronic delivery sales to customers throughout the world - no other distributors or retailers are authorised to sell the artist's music electronically. The artist is established and successful, and rents space on a number of computers in the major countries where their music is popular - there are several servers in Europe, one in Japan, one in Singapore and one in Sydney. These servers are computers with fast links to the network so they can supply hundreds of megabytes of data as instructed. They do not need to be Video Servers or have any special music related capabilities. The companies which own and operate these computers do not need to know anything about music, and may be totally unaware of what is being transacted. They sell the storage space and communication services to the artist in Detroit.

When a customer in Canberra wants to browse and buy music by this artist, they type in the address of the Detroit computer and receive text and small graphics files. Only relatively small amounts of data are sent by the customer to the artists computer - when the customer clicks on a hyperlink or types some text. Small amounts of data such as text and small graphics files are sent from the artist's computer to the customer. There is a very small cost in sending these small quantities of data internationally.

However when the customer wants to browse some music, or purchase it, then they need to receive tens or hundreds of Megabytes. In this example, the Detroit computer would instruct the Sydney buffer computer to make certain music data available, and the customer's computer in Canberra would be given a special address which points to the Sydney computer. So the tens of megabytes of data for browsing, and the hundreds of megabytes for delivering the purchased music, are sent from Sydney to Canberra for only a few dollars.

This splitting of the seller's computer resources over different continents is feasible with today's World Wide Web. The special Sydney address given to the Canberra computer enables it to access the data intended for it, without making that data available to the public. The instructions the Sydney computer receives from the Detroit computer ensure that the data is only available to the Canberra computer at that time.

This means that it is technically possible for an artist to centralise all electronic retailing of there music onto one computer - their own or that of their recording company. This does not mean that all artists would choose to do this - there are likely to be many benefits of appointing distributors and retailers. However the approach outlined above means that distance is no barrier to centralised retailing, provided the artist is selling enough music to pay for the costs of renting the computers to buffer their music in distant countries - and transmitting the music data to them in the first place. This transmission could be done on a low-priority, off peak, basis, so the costs would be minimal.

Chapter 17 contains further discussion of electronic delivery marketing arrangements.

CD-R SALES VIA RETAIL SHOPS

During 1994, there were several reports of proposals to sell customers CD-Rs, with the music they desire, in retail shops. However, no instances of this occurring could be found.

The high cost of the CD-R writer is not an impediment to an intensive commercial application such as this, and the cost of the blank discs may be reduced because they are purchased in bulk at wholesale prices.

Unless the system is used simply to copy entire CDs, there are significant problems to be solved regarding administering the system, letting the customer choose the music, sourcing the music and printing the CD booklet and slick.

The means by which the music is sourced is likely to determine how customers browse the system to decide which music they want. Ideally they would have a keyboard and screen, with headphones or in a listening booth, and be able to search the catalogue of available music, listening to tracks, viewing information about the tracks and artists and selecting which tracks they want on their disc.

The following discussion looks at the technical and economic issues of providing such a service in Australia in the next four years. There are other factors which are not considered here - including the administration of such a system to collect royalties, and the printing of booklets and slicks to accompany the disc.

Telecommunications costs

If the retailer sources the music from an external source, then telecommunication costs still need to be quite low. A 60 minute audio CD-R disc should have music of identical quality to a normal CD, so compression rates of 2:1 or 3:1 are required. So about 250 Megabytes (or 392 for 74 minutes at 2:1) of data must be transported from a central site which contains the source music.

BR-ISDN is too slow for this. A data link operating at about 2 Megabit/sec is required. A Primary Rate ISDN link could be used, and 30 parallel 64 kbit/sec data calls could transfer the data in 17 minutes. At current costs, during business hours, with the data coming from the local call zone, this would cost[17]

[17] ISDN prices based on Telecom price list October 1994.

$25.20. After-hours prices are about a quarter of this. An alternative arrangement for ISDN is to have 30 "Semi Permanent Connections" for an annual fee, so that there is no charge for calls. This would cost $15,660 to a site within 12 km. In either case, a Primary Rate link for the shop would cost $15,774 pa.

There are other approaches to such telecommunications needs - such as Telecom's Fastpac 2 Megabit/sec packet switch system, which could be significantly cheaper than this. Telecommunications services are proliferating and costs of high speed data links can be expected to fall dramatically in the next few years - due to new technology, greater competition, and a rapid growth in demand for WANs - Wide Area Networks, of which this music retailing system is an example.

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I would like to find out what the FastPac and other alternatives cost.

Local hard-disk storage

An alternative to sourcing the music from an external site is to use a computer with large mass storage. Music could be stored on multi Gigabyte magnetic hard-disks - which will soon retail for $0.50 a Megabyte, and perhaps half this by late 1996. At this price, it would cost $125 to store the 250 Megabytes required for an hour of music.

It is difficult to calculate when this would be more cost-effective than buying ordinary pre-pressed CDs, but it may not require a large number of sales. A $125 investment in hard-disk space is roughly equivalent to buying six copies of the CD at wholesale prices, and as long as that part of the hard-disk contains the music, any number of customers can be satisfied. Once sales of the music decline below a certain level, then it can be erased and the space used for music which is in greater demand.

With a mass storage system with costs like this, the costs of sourcing of the music data to write to the hard-disk is not the dominant cost - provided this cost is spread over several sales of the music. It could come from a telecommunications link (perhaps operating at off-peak rates), from a standard CD, or in a pre-compressed form from a CD-ROM.

Local optical disc storage

Functionally similar to hard-disks are rewritable Magneto Optical discs. They are slower and use removable cartridges with a lower capacity than the biggest hard-disks - however the cost of the storage medium is much lower than hard-disk. By 1997, it is likely that MO cartridges with about 1 Gigabyte capacity will cost $50 or so - so the cost per Megabyte is $0.05, less than a tenth of today's hard-disk cost.

With manual feeding of cartridges, or a jukebox system, MO storage of 2:1 compressed music could be the most attractive way to source music for CD-R retailing.

Another alternative is to access the data directly via a jukebox player which uses audio CDs or CD-ROMs with pre-compressed data, together with the graphics data for the booklet. The CD-ROMs could be pre-pressed, CD-R or phase change rewritable discs - perhaps MO rewritable if these are made the same physical size as a CD. This costs more for the jukebox, but does not require large hard-disks.

The first option - audio CDs - has the virtue of simplicity and means that the system could be applied to any CD. This would constitute an on-demand CD replicating service or a service for compiling an audio CD-R with the customer's personal choice of tracks from many CDs. The use of standard CDs is primarily a convenience for the retailer in not having to stock more than one copy of a CD - but it results in greater choice and availability for the customer. Customised CD-Rs are finely tuned to the customer's needs and would be a valued service for many people. It is possible that some customers would pay up to twice the price of a standard CD to purchase a CD with just the tracks they want. This enables the retailer to add higher value to their stock, by providing a broad range of music to choose from, and providing the means for the customer to exercise their choice.

The second option - special CD-ROMs with compressed music and booklet files - is more flexible, and can contain information to position the music in the selection menus of the browsing system. If these CD-ROMs are CD-Rs - especially 1.9 Gigabyte red light CD-Rs, then this is a write once version of the MO rewritable approach described above. If the CD-ROMs are today's pre-pressed CD-ROMs, they could barely hold 2 CD's worth of music at 2:1 compression - so there may be little advantage over ordinary audio CDs.

However red light pre-pressed CD-ROMs are used, then their 3.1 Gigabyte capacity enables 7 or 8 CD's worth of 2:1 compressed music to be stored, or less if the disc contains substantial amounts of promotional video material for the browsing system, or graphics for printing booklets and slicks. The main problem with this is that these CD-ROMS would need to be manufactured and distributed - a process which could take a month or two. This requires the music distributors to produce this second form of disc, but it reduces the retailer's workload - which is important to containing costs and improving reliability. The retailer may only have to place the disc in the jukebox and have the system read its indexing information into its browsing database, so that the music on the disc will appear in the selection menus automatically.

Thus it may be technically possible for a music retailer to have a CD-R replication system, capable of handling 10 browsing customers and capable of producing twenty or so 74 minute audio CD format CD-R discs per hour. Such an automated music vending system might be composed of:

- Two 500 disc jukeboxes, each containing 500 3.1 Gigabyte red light CD-ROMs - each containing 8 hours of compressed music and accompanying graphics. Each jukebox would be comparable to the Pioneer DRM-5004X described in chapter 4, and would have up to four players for red light CD-ROMs. These could also read today's audio CDs and CD-ROMs.

- Eight CD-R writers operating at four times normal playing speed. These can be fed blank CD-R discs from an internal supply, record the music, label the disc with a printed sticker or ink-jet printer, and then eject the disc to the customer or sales staff.

- A computer system to control these with 10 Gigabytes of hard-disk storage for buffering the music data between being read from the CD-ROM and being played to the customer or written to the CD-R writer. Part of the disc capacity would be dedicated to excerpts from all the music in the library, so customers could browse the excerpts quickly without the need for discs to be loaded into players.

- Ten customer browsing stations consisting of headphones, video monitor, keyboard, trackball and credit card reader - where they select music from menus, audition it, and choose what will be on their disc.

- A master computer to control the above subsystems, to generate sales and royalty reports and perform credit authorisations - via a telecommunications link.

Although the components of this system may be available in 1996, it would take a year or two for a manufacturer to integrate all the hardware and write the appropriate software. Industry standards would be required for the format of the CD-ROMs and for making royalty payments.

A 1000 disc system could hold 8000 hours of music occupy space equivalent to about four filing cabinets.

This is a substantial investment - costing $150k or more, if they were made in moderate quantities. If this was to serve only a single retail shop, then sales would need to be brisk. However, the central part of the system - the control computer and jukeboxes - could be linked to browsing stations and CD-R writers via a dedicated telecommunications link. This means that the one system could serve a number of shops - typically within the one city.

The other promising way of extending the reach of this CD-R retailing system is to make it available to customers over the World Wide Web. This is particularly attractive since a lot of WWW activity would occur during shop hours.

This extension to the WWW enables the shops entire catalogue and stock availability to be browsed by potential customers. They could order CDs or their custom CD-Rs from home - without taking up precious space at the in-store browsing stations. They could pick up the discs in person the next day or wait for delivery by mail. In areas of high population density, it might even be feasible to distribute the CD-R writers around the suburbs and provide home delivery - using the same drivers currently used for restaurant delivery to homes.

This may seem rather far-fetched, but it is an example of how an established retailer in 1995 can use emerging technology to consolidate their position in the face of competition from WWW based CD and CD-R retailers. They will become WWW based retailers themselves - and the customer browsing stations in their shops would probably use the WWW interface, but be connected via a LAN rather than through the Internet.

With a substantial system such as this, it may be profitable to install small CD-R kiosks in retail centres in the same city or state. These could be connected with a dedicated telecommunications link - the costs of which will no-doubt decline in the next few years. These remote kiosks would only take a few metres of floor space and would consist of a keyboard, screen and headphones - with the CD-R writer housed behind the counter of the store that housed the kiosk. The kiosk would require some supervision by the staff, but they would need little specialist knowledge. The public could browse music as they please and order their CD-Rs without the help of staff, other than to collect payment - before the disc is written - and to pick up the disk and packaging after ten or fifteen minutes.

Custom CD-R retailing enables an enormous range of music to be sold at a shop without the need to buy stock - so the variety can increase to the limits set by the library rack.

A second benefit is that even the fastest selling music is never out of stock.

A third benefit is that with music being distributed by telecommunications links, the music can be very up-to-date. A recording of a concert anywhere in the world could be available globally in music shops the next day.

A benefit to the music companies and musicians would be daily reports on how often their music was listened to and purchased, with breakdowns of this according to geographical location, individual shops and perhaps even individual listeners.

CD-R SALES AT LIVE VENUES AND NIGHT-CLUBS

An extension of the above concept is selling personalised music discs to venues where music is played by DJs - or performed live.

Before leaving a disco, rave or dance club, patrons could order a CD-R disc with particular sections of the night's mix on it. This could be a set by their favourite DJ. The CD-R could be mailed out to them, but it is probably easier to make it on the spot - since CD-R writers can now operate at 3 and 4 times normal speed. This would be attractive to the consumer - they could vouch for the value of the music they are buying, having just enjoyed it in an ideal setting. From the marketer's point of view, the customer is offered a product at the time when they are most enthusiastic about it. Further marketing attractions may include the fact that the product is relatively unique and that the customer is in a money spending mood.

Although there are no existing mechanisms for collecting copyright on such a music sale, a proportion of it should go to the DJ who selected and mixed the music - some of it perhaps only sections of songs. The balance should be divided amongst the artists whose music appears on the final disc. It would be essential to have an automated management system for copyright payments based on the IRSC code on each track played. IRSC codes are discussed in chapter 4 - they uniquely identify tracks stored on CDs and other media. An advantage of this system is that there are no distributor costs, and the retail and manufacture operation are rolled into one, with no transport costs. This may enable a high proportion of the sale price to be devoted to royalty payments.

The live performance version of this might involve a CD-R being made available directly after the concert, containing the entire concert or highlights from it. However this would entail significant technical difficulties. Listener's may not want to stay for long after a concert, and there are practical difficulties producing hundreds of CD-R discs within twenty minutes or so. In addition, artists may be wary of selling legitimately a product they have not listened to, and which could have many technical and artistic shortcomings.

CD sales after concerts do not have these problems. Such sales make a valuable, or crucial, contribution to the income of many artists including those playing small gigs. One advantage is that all the money can go to the artist, rather than the fraction which remains from a CD's normal path to the listener.

AUTOMATIC MUSIC IDENTIFICATION

> *This section discusses the possibility of developing a computerised system for identifying the name and artist of a piece of music - when an audio sample of the piece is played into the system. Such a system could be globally accessible from the World Wide Web and point listeners to where they could purchase the music.*

If it were possible to use a twenty second fragment of a piece of music to find out its name, composer, performer and where it could be purchased, then the marketing of recorded music would be greatly facilitated. This is particularly true of instrumental music, more obscure artists, music which is played on radio without announcements or music which is copied by some means which gives no text based details about its title and originator.

In principle, such a system could be built, because it is "simply" a matter of matching the sample against a database of known pieces. However the reference database demands a lot of hard-disk storage. The following discussion is based on the author's exploration - it is not known if anyone else is considering such a system. A more detailed technical discussion of automatic music identification can be found at the author's World Wide Web site:

`http://www.ozemail.com.au/~firstpr`

Technical hurdles

To achieve critical mass in a particular market - say classical music, or electronic dance - an automatic music identification system might need to cover 100,000 tracks in a particular genre. The server computer which performed the searches would be accessible to listeners via the Internet. It would need to have a large hard-disk system containing reference files which identify the 100,000 or so tracks in its database. A crucial factor is the number of bytes needed for each reference file, such that the most distinctive audible elements of the track are specified and can be searched for quickly.

It would not make sense to have an entire compressed version of each track in the database. Since a lot of tracks contain repeats of similar musical passages, it would be sufficient to store only those parts of the music which most distinguish each track from all others. The choice of these distinctive elements of the music could best be made by the creators of the track.

Similarly, the listener who submits a sample of music should select the most distinctive part of the music they can find. In principle, only a tiny fragment is needed - perhaps only a second or two of a distinctive piece of singing. For instance one second of the glockenspiel melody from Tchaikovsky's *Dance of the Sugar Plum Fairy* is quite unlike any other music, and an automatic music identification system should be able to reliably find the name of the track and its composer. It may have a dozen different performances in its database, and with a minute or so of the sample music would it be able to distinguish reliably between them.

Assuming that on average, each piece could be distinguished on the basis of 30 seconds of sound - snippets from various parts of the track - and these were reduced to mono and then compressed 50:1, then this is 53 kbytes per track. With 100,000 tracks, this is 5.3 Gigabytes. This is not an astronomical amount of data, however there would also need to be extensive indexing files to direct the search for the best matching reference files. Each reference file would also have 10 kbytes or so of data relating to the track.

The process of searching a hundred thousand reference files is non trivial. There would need to be a process to quickly narrow the search to a few thousand or less in most cases. This should be possible by the identification server software building a tree (a widely used data structure for indexing large amounts of data) which points to the references according to their overall sound. For instance, the reference file for a *Palestrina* mass would be on a different branch of the search tree than that of a *Mahler* symphony or a *Hunters and Collectors* song. This search tree could be designed manually, but it is more appropriate to have the software analyse the music and re-organise the tree as certain areas of it become heavily loaded - for instance due to a proliferation of music based on bongo drumming - or if whole new branches need to be created when new forms of music are developed.

Technically such a system is likely to become feasible in the next ten years. It is probably feasible now on a fast workstation computer. An automatic music identification system would need to be designed very carefully and be accepted as a standard, because the effort put into creating the reference files could be wasted if the system needed to be changed. Not enough research has been done to quantify the difficulty of providing such a service, but even a factor of 10 uncertainty in technical difficulty means about a 5 to 7 year uncertainty in when it will become feasible.

Applications

Dance of the Sugar Plum Fairy is a prominent example, where an automatic system would probably be as useful as a classical music shop assistant - who could identify the track if a customer whistled just a few notes. However the system could be available globally via the WWW, and be accessed at any time from listener's homes.

Its value would be more apparent with more obscure pieces of music - for instance a CD retailer may be able to identify a piece of music as being a 16th century mass, but not be sure whether the composer was Lassus, Palestrina or someone else. An automatic music identification system should be able to pick the exact composition, provided it is given a sufficiently distinctive sample.

The value of an automatic music identification system would be immense in a field where new material was constantly being added - where it would be physically impossible for even the most experienced music retailer to identify by ear more than a fraction of the music in a genre. With new music, enhancing the consumer's ability to find their favourite music quickly will enhance the development of new styles.

Assuming that the artists promptly entered the reference files for the music they produce, then the system would be capable of identifying leading edge, obscure music and giving an address or phone number and/or a WWW address for where to buy the music locally.

This would be the musical equivalent of the text based Lycos search engine. It should be possible to play 20 seconds of music into a home computer, which would compress it, send it to the music identification server via the WWW, and in a minute or so, the listener would have one or more hyperlinks on their screen to where they can buy the music, and to information about the composer and performer. Within a few minutes they could be browsing and buying the track and related music.

There are technical and administrative issues about who would pay for the service - the people making the query or the companies who provide the reference files of their music in the hope of selling more of it. Probably both should pay, if only to discourage frivolous searches, and to discourage loading the server database with reference files that no-one was searching for.

There is little need for automatic music identification for a piece of music which is currently riding a wave of publicity in a hit driven marketing environment, but it is of value later on when the piece is obscure. It is of particular value for obscure new pieces of music, and could be a factor in encouraging sales which bring the piece the prominence it deserves.

If music was primarily songs, with a song title clearly identifiable from the lyrics, then there would be little need for automatic music Identification. However for instrumental music of all kinds - acoustic, classical and electronic - it would greatly enhance the promotional power of radio and other forms of music distribution.

Identification has been a perennial problem in the classical field. *A Dictionary of Musical Themes* by Harold Barlow and Sam Morganstern (Crown New York 1948) provides a means of finding the name of a piece from its melodic structure. Apparently, a Macintosh Hypercard stack has been written which achieves the same purpose when the listener enters a simplified version of the melody.

Ideally an automatic music identification system would proceed on a globally standardised basis - to maximise the utility of the servers and the common database of reference signatures which they would each have a copy of. However it would need to reach critical mass in at least one area of music to encourage a sufficient proportion of the available music to be represented in the database - otherwise the likelihood of a successful query would be too low for many consumers to use it.

Classical music is unlikely to be the first area of music to attain critical mass. Distributive systems typically identify classical music very well with spoken announcements and sometimes with printed programs. It has a relatively fixed repertoire and many retailers have the expertise to identify styles and assist music purchasers.

It seems more likely that contemporary music - particularly instrumental music - would benefit most from automatic music identification and that critical mass could be achieved in an environment of high demand and rapid generation of musical titles. The great majority of music is not likely to be subject to the spotlight of expensive marketing, but there are good prospects for selling it with little or no paid advertising by distributing it for free via radio etc, and having potential customers find its source with automatic music identification.

If such a system existed today, it would direct listeners to the CD catalogue number and to a nearby distributor or retailer. In the future it would point to the network address where the listener could hear more music and purchase it as a CD to be delivered by mail, or as data to be delivered over the network electronically.

When network music sales are commonplace, it would be simple to integrate the identification function with the audition and purchasing function - just as a menu leads to an online catalogue and potentially to a purchase on the World Wide Web today. Ultimately, this will mean that a piece of music could be played into a home computer, and within a minute the listener could be browsing a menu with this and related pieces of music. With a few keystrokes, mouse clicks or voice commands they could listen to the music, read about it, view still and moving images and make a purchase.

There would be other applications once the system is running. It may be helpful for copyright collection agencies in determining the source of music played.

RETAILING VIA PHONE, FAX AND EMAIL ORDERS

Some retailers encourage customers to mail or phone their orders for CDs, but this typically needs to be supported by a printed catalogue. One attempt to bypass the need for a catalogue is to claim "if its in print - we can supply it" in the hope that people will call and request whatever they want.

This is the approach of *CDs by Phone* in Pennsylvania (+1 610 758 8500), who claim in their advertising (*CD Review* October 1994) "Over 140,000 titles, your source for imports, all labels, all types of music". Orders can also be made by fax or email. In November 1994, they had no World Wide Web access.

Matt Connolly of *CDs by Phone* says[18] that they initially targeted of the mainstream music market, but now do a lot of their business with highly motivated specialist music fans looking for obscure discs - "People are dying for maxi singles from England, Japan or Australia or whatever that have a couple of bonus tracks or live versions of songs that are normally studio recorded. We couldn't *believe* the number of (specialist music fans), the collectors, the hard-core highly motivated buyers - and they want everything they can get by their favourite artists."

CDs by Phone stocks 160,000 titles (or has direct access to them) and can supply another 40,000 import titles sourced from US distributors. They have released a 28 page fine print catalogue listing recent releases. Evidently their "we can supply anything" service is satisfying a part of the market which cannot find what they want in local retail shops, and is prepared to make phone calls (on a toll free number) and wait for several days before they receive their disc.

A phone or mail order company which does not print a catalogue tends to rely on other means of music and context discovery to build consumers' demand for their stock. However a large phone, fax, or email retailer can help people discover music within certain limits. They may ask "Have you got any new Nirvana picture discs or maxi singles?" and be told "Yes, there is a Brazilian

18 Conversation with the author 23 November 1994.

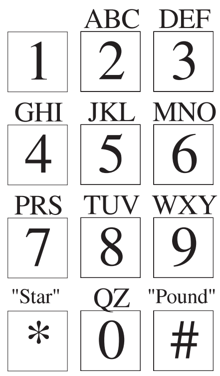
picture disc with one previously unreleased track - and do you know of the new release by . . . ."

Browsing and purchasing music by phone

A telephone browsing system makes browsing available to almost anyone, with a potentially huge range of music, subject to limited sound quality and telephone call charges if the site is distant from the listener. There may only be one phone browsing CD retailer at present - Music Line in New York. They can be called at +1 212 333 4000. Using a touchtone phone, samples of tracks from each CD may be auditioned, either by keying in a code number or by entering an alphabetic name to search for.

The instructions for using the system are on the recorded message which is heard if no keys are pressed. However to use the system, it helps to have some code numbers to select a few songs to audition. At any time an artist or song code can be pressed. Some song codes are:

Plastikman	21746		
Tori Amos	502174	502175	502176
Prodigy	22282		
Boingo	502674	502675	502676
NIN	501941	502854	501942



For entering names of artists or styles to search for, press * and then keys to spell the word. Song titles can be searched in a similar way by pressing * twice. Here is a diagram of how the letters of the alphabet are assigned to the phone keys.

The sound quality is a serious limitation, and there is currently no provision for fast forwarding or rewinding within a sample track. Since many songs take a minute or develop momentum, this can be very frustrating.

The response time to a song code is a small fraction of a second, so it seems that all the samples of the tracks are stored on hard-disk. With 6000 tracks of two minutes each, this is 200 hours of music. At the standard phone data rate of 64 kbit/sec (8kHz 8 bit samples) this is 5.76 Gigabytes of storage. Such a system could be implemented with special software, a small LAN, with a server and a number of personal computers with sound cards and DTMF tone decoders.

Music Line has been operating since November 1993 and in December 1994 had 6000 tracks on their browsing system. They typically allow browsing of 6 tracks from each CD they sell, so they have around 1000 titles available. This is less than 1% of what is available from large manual phone (or email) order operations such as *CDs by Phone*. It seems that Music Line is not yet very successful, but the possibilities for interactive phone services in music marketing need to be kept in mind.

There is another service which does not seem to be a retailer - Music Access - which plays music over the phone. Each issue of *Wired* contains reviews of ten or so CDs and music - probably just a track - is available for three months on Music Access by dialling (in the USA) 900 454 3277. The number cannot be reached from Australia through Telecom, but perhaps it can be through Optus. The service offers volume control and fast forward. The service is charged for at *US$0.95 per minute!* If a company can charge around A$1.30 a minute, (*Wired* states that an average call is 2.5 minutes), then there is clearly some demand for even this limited browsing of fresh music, with the convenience and poor quality of a telephone. A World Wide Web equivalent of this would be much more effective, and more appropriate to the readership of Wired.

CHAPTER 15 THE CHANGING MUSICAL EXPERIENCE

The structure of the demand for music is highly complex and can best be discussed from the listener's perspective - rather than thinking of markets or products - such as copyrights, sounds or discs.

The listener's experience of music depends on the listening environment, expectations, previous experience and on perceptions of many things which relate to the music.

This chapter takes discusses the listening experience, and music discovery process from several personal perspectives. Chapter 17 builds on this to discuss trends in music discovery from a market perspective.

INTRODUCTION

The product of the recorded music industry is usually considered to be discs and tapes, or the music which is contained on them. However the music can be seen as the most significant of several inputs leading to a complete musical experience, and that subjective experience can be seen as the "product" which the listener pays for . The value of music to the listener depends on many personal factors and the principle function of music marketing is to influence listeners so they are receptive to new pieces or styles of music. In this context "new" means new to the listener - so it includes introducing both the music and the context of Elvis or Bach to young people who are not familiar with them.

It is impossible to enumerate all the factors which affect the listening experience, or the consumer's decision to buy. However a discussion of some of the processes will be attempted, because new distribution techniques will alter the environment in which music is promoted, sold and listened to.

The focus of attention in this chapter is the listener's mind and the experiences which affect the listener's perception of music. The aim is to understand the structure of demand from the perspective of the individual listener.

The question of why people enjoy listening to certain sounds with rhythmic, melodic, harmonic, timbral and vocal content is fundamental to the music industry. Although higher level cultural attributes are typically an important part of many musical experiences, at least some of the pleasure must be a product of biologically determined human psychology. Children, babies and unborn babies respond to music and so do members of other species.

Part of music's appeal must lie in the sounds we have evolved to live with. Such sounds as thunder, rain and later fire are fundamental to human life. Other sounds such as the rustle of a small furry animal trying to escape the human hunter, or the thumping footsteps of a large nearby predator, evoke strong emotions because our response to these sounds determined whether we would eat or be eaten.

Rhythmic sounds and singing come from people - typically of our own tribe - and so we naturally respond with feelings of belonging and of wanting to join in the dancing and singing. There are many communal activities common to most cultures which have been suppressed in our own culture in recent decades. Community singing in public and in the home was common until the early 1950s. Dancing has always been in vogue, but formalised, highly social styles gave way in the wilder, less social 1960s. Contemporary electronic dance music, with its electronic kick drum in place of the tribal drummers, is experienced by many as a homecoming to a shared tribal experience.

Dance bands from the twenties to the fifties were primarily instrumental - a vocal component would have interfered with conversation between couples. The volume of amplified music often reduces the capacity for participants to speak to each other, but its social functions are still a vital part of its appeal.

Most of this chapter looks at auditory and cultural aspects of the listening experience. However much of the demand for music comes from the way it arouses our emotions, stimulating our memory and our instinctual desires for sex, tribal life and connection with the natural world. Even social ballroom dancing, which seems genteel by modern standards, is strongly connected with sensual, romantic, social and sexual drives, as the author was reminded one evening on his way to ballroom dancing classes. The fatherly advice was "Ballroom dancing is a vertical expression of a horizontal idea."

Music is often a stimulus - an addition to the environment, perhaps masking the environment and masking out other thoughts. At its most extreme, music becomes a totally dominating experience and all remnants of conventional behaviour and thought can be suppressed - leading to a "total experience" involving physical and emotional extremes. In a social setting - for instance a mosh pit - listeners may depart from normality entirely. Their individuality may dissolve completely in an orgiastic communion with the seething throng.

Comment [RW19]: Page: 220
Note to BTCE - this is written from personal experience - it is an absolutely fantastic experience and one which consumers are willing to pay handsomely for.

On the other hand, music may be enjoyed because it calms the listener, perhaps simplifying their thoughts and masking unwanted aspects of their environment. Except in times of catastrophe, our ancestors would never have understood the need for this kind of music. However, in a world increasingly full of noisy machines, noisy people and electronic sound sources - music to relieve stress can highly valuable.

A great deal of popular music is listened to in a social context - as a background to interaction with other people. However many older people listen to the popular music of decades past whilst living on their own. They listen a lot to the radio, because it is inexpensive and provides constant variety. Older people often speak of the radio and music *keeping them company*. Here the music, and the radio announcers, provide a valuable substitute for a social situation. For most listeners at some time in their life, music helps makes up for a lack of human company. The personalities and spiritual drives of the artists are communicated to the listener purely through a sound recording.

Apparently deeper than the social and personal functions of music, many listeners feel strongly that it links them to aspects of reality beyond everyday life. People are often highly motivated to exchange money and other worldly things for music which touches them in this way. Whether personal or institutional, and whether mystical or devotional, music has long played an important role in our attempts to link with the world beyond.

COMPONENTS OF THE MUSICAL PACKAGE

There are instances when music alone is pleasurable to particular listeners, without depending on prior knowledge or external factors like fashion. However it is much more common for the perceived musical sounds to be part of a package of perceptions arriving by several paths.

For example, sitting near the back at a Tori Amos concert, the listener hears her singing, playing piano and speaking. Because of the distance, only simple body language is perceptible - her facial expressions cannot be seen. Lighting and smoke machines are part of the experience, as is the context of a concert, which thousands have paid to attend. The audience reaction (including women and men calling out "I love you Tori!") is an important part of the experience.

There are three main aspects to the music, the sound of her piano, the words of her songs, and her singing - the emotional and musical content of her voice. Individual perceptions of the piano and vocal parts of her performance will vary from person to person. Music typically works best when it both satisfies and teases the expectations of the listener, and so people who have heard a song before, will have a different experience to those who have not.

Probably the biggest factor affecting the perception of Tori Amos' performance is the listener's knowledge of her lyrics. This is because the artist's expression is so stylised that it perhaps only one in five words she sings in a concert situation can be understood. This problem may be slightly reduced when listening to a CD at home. So the first problem a listener faces is in perceiving the words. This can be solved by reading the lyrics printed in a CD booklet, or from another source such as a magazine or Internet newsgroup.

The artist's songs are intensely personal, so knowing the words is essential to experiencing her work fully. However even with the printed lyrics, the meaning - the emotional content of the words - may not be obvious to all. Clues may be found in interviews with the artist, by talking to friends or by reading or starting discussions on the rec.music.tori-amos newsgroup.

Information about the artist's physical appearance and personal style may be an important determinant of a listener's appreciation of the music. A magazine article with photos and interview, or a TV interview or performance may give much more information about the artist as a person than is available through attending a concert or buying a CD.

Beyond such direct and indirect products of the artist, one person's perception of the artist is likely to be influenced by factors of fashion and peer group pressure. For instance, if a group of people who the person does not identify with are great fans of the artist, then this may negatively affect the perception. If fans of the artist behave in a manner which offends the taste of the person - then they may be further put off. For example in the mid seventies, Leonard Cohen fans often played his records so often that many people who may have liked his music put off by the behaviour of his most prominent admirers.

These processes can operate in positive ways as well, and the major role of popular music marketing is to create a total package of visual images, lyrics, interview text, public personas, clothing styles, and identification with existing trends and subcultures - to complement the sounds, images and text delivered on a CD which is offered for sale.

Listening to a piece of music typically invokes memories of other types of experience - other situations where the music was heard, video clips, graphics on a CD cover or World Wide Web music page, pictures and text in a magazine, personalities and behaviour of the artist and of their fans.

These links evolve over time, and not always in ways the artists control or agree with. For instance, after 1994 certain Abba songs will forever be linked in Australian minds with the film "Priscilla - Queen of the Desert". The aura surrounding Led Zeppelin's music at the time of its creation can never be re-created. This is partly because the youth culture of the day has disappeared, and partly because of the efforts of Dread Zeppelin and Rolf Harris - which could never have been anticipated by the artists.

LISTENING TO RECORDED MUSIC

Leaving aside many of the points listed above, and focusing on the act of listening, there are auditory, sensual and social factors which greatly affect the listening experience, and the motivations people have for buying and/or playing recordings.

Headphones - the walkman experience

Listening to a tape or CD on headphones with a Walkman is a private experience - linking the artists performance, frozen in time, directly with the listener. In the presence of other people, at home or in public, the Walkman excludes others and creates a cocoon of experience. There may be positive aspects to this, including a feeling of aloofness and remoteness from the immediate surroundings, but there can be problems if the listener taps their feet, smiles, sings along or talks too loud.

The headphones give a direct auditory experience, but one which typically lacks bass response and completely lacks the chest vibrating bass which is an important part of many popular music styles. Recorded music is typically mixed to be recreated in a room through loudspeakers, and so the headphone experience is not what the artist intended. Because of this, some music has been mixed specifically for headphones or recorded binaurally to give spacious reproduction on both headphones and loudspeakers.

Headphones can be used almost anywhere, including whilst lying in bed and travelling, whilst causing little or no impact on other people.

Listening in the car

Depending on the background noise, amplifiers, loudspeakers and their placement, the car can be a good place to experience music with full bass response and a feeling of immersion. However the high level of background noise typically submerges many subtleties of the music so that only the loudest signals are audible. This in not a problem for many styles of rock music and dance music, which are mixed to achieve a consistent volume level suitable for radio and dance party PAs. However folk music and a lot of instrumental and classical music relies on finer acoustic sensations - many of which are submerged in the noise of moving car.

Socially speaking, the car listening environment is a shared experience for all occupants and may function as a unifying influence for all on board. Singalongs are a possibility, although young people have strong social inhibitions against this compared to people who grew up before the 1960s - before the era of the TV pop star. Music extends the metaphor of the car as a spaceship, by providing a soundtrack which propels the listeners into a mental world unrelated to their immediate surroundings.

With the windows wound down, car sound systems may have a completely different function - the projection of personal influence. The driver who disturbs people in their homes and cars with their chosen music typically knows exactly what they are doing, but seems oblivious as they fill the surrounding area with something which only they control. Young men in particular, for social and biological reasons, feel the need to project their personality in this way. Rap is an example of a style which suits this application of music.

One important factor about the car is the amount of time which many people spend in them - typically more time than at nightclubs.

Discussing their latest album, Paul Hartnoll of *Orbital* (Ward 1993) discusses the anticipated listening environment for their music.

> I'd still call it dance music. . . Although the way we've been doing the tracks for an album, I couldn't necessarily see DJs playing them in night clubs. Although it's still essentially dance music, I'm not sure whether the dance floor is the obvious place for it.
>
> You know its going to be played around the coffee table, or especially in the car. I think the car is the most significant place where people listen to music today.

In the adolescent's bedroom

Teenagers playing discs in their bedroom have a lot in common with the young adult's use of the car sound system. They are defining their own territory, turning their bedroom into a spaceship, making themselves heard and felt in the home and perhaps the neighbourhood.

Here the physical aspects of the sound - who hears it, how it shakes the floor - combine with the aesthetic influence of the music on *other* people to satisfy the needs of the adolescent. Negative perceptions of the music in the minds of others could be central to the music's effectiveness in these situations.

Young people need to reject accepted mores and experiment with alternatives. They only know they have found something which steps beyond society's boundaries when someone protests that they can't stand it any more. So the transmission of sound from one room to another is a fundamental part of the function of the musical experience for these consumers.

Even if the music is contained within the adolescent's bedroom, it is still functional because it ensures a parent free zone there.

Listening to music on headphones provides none of this. An important function of the music is the effect it has on other listeners, especially those who are subjected to it against their will.

Teenage rebellion was an easy matter in the 1960s as parental sensibilities were easily offended. Teenagers today face greater challenges. Developments such as death-metal music, and some of the more extreme types of rap and techno may be attributed to the need to find the limits of parents who were fans of the Sex Pistols. Without a constant stream of customers ready to buy music relating to teenage rebellion, the rock music industry would not exist.

Intensive listening

It is difficult to estimate how often people sit down, and give their undivided attention to listening to a piece of music. In this situation, the aim is for immersion in the music - alone or in the company of friends. For this kind of listening, low background noise levels, good loudspeakers and good speaker placement are important factors in a satisfactory experience. Although the listener may want to turn up the volume to maximise the experience, they may be inhibited by the disturbance it would cause to other people.

A great deal of classical and popular music is produced to suit this kind of listening environment.

Background listening

This is probably the most common use of music - to play whilst reading, working, cooking, cleaning or talking to friends. Music is uniquely suited to providing an aesthetic and emotional backdrop to other activities - something which video and interactive media cannot achieve.

Instrumental music hardly affects the verbal mental processes used for talking, reading and writing, but vocal music - unless in an unfamiliar language - may interfere with these activities. Nonetheless, some people are able to work at demanding jobs involving precise verbal communication - such as retailing electronic components - whilst listening to commercial radio.

Despite the lofty intentions of most musicians in the creation of their art, a great deal of music is consumed in a casual listening environment.

Music in retail spaces

Clothing shops typically play popular music as part of the total fashion experience they provide for their customers. This may come from commercial radio, or perhaps JJJ, but typically comes from CDs played by the staff. The choice of music is not restricted by the need for compatibility with advertisements and there may be a desire to create something of a dance-club ambience, in keeping with the social activities of the customers.

By playing music, or music videos, the other aspects of the total musical package are associated with the clothes offered to customers - such as the personalities of the performers and the glamorous or rebellious nature of the music.

Discotheques and dance clubs

Since the late seventies disco boom, a great deal of music has been specifically created for playback by DJs at dance clubs. This is typically studio music which could never be performed live in the traditional sense of people singing and making sound entirely by manual playing of instruments. Each track is made to be compatible with the music which precedes and follows it.

Although this music may be played on radio and purchased by some consumers, it is usually heard by hundreds or thousands of people in exactly the environment it was crafted for. The music is intended for a total immersion experience - a room full of dancing people with an excellent sound system, lights, refreshments and no interruptions.

This music often makes little sense outside this dance club context. Disco video clips on Countdown in the early eighties gave no clue as to the experience of dancing to the entire track at a disco.

Many people attend all night dance clubs in search of a shamanistic group experience. This need for transcendence from day-to-day concerns is a powerful force in the demand for music in many cultures.

Viewed from outside, the music may appear to be mindless and repetitive, but in the proper context, other factors may be revealed, or its mindless, repetitive nature can be a positive attraction. The author remembers the disdain he and others felt for a hugely popular dance song - *Blue Monday* by New Order - and the moment of revelation when he found himself dancing to it joyously and mindlessly.

Music of this nature resists intellectual inquiry, and it may make little sense on radio, but there is enormous demand for it in dance clubs. The shared experience of all-engrossing dance music satisfies fundamental needs in many people. It has a strong influence on other forms of music - especially more mainstream popular music.

Other contexts

The demand for music is far too diverse to characterise comprehensively. A listener may appreciate just one piece of music for many reasons - perhaps not always at the same time. Many human activities have a musical aspect, from football to religious services, from birth, through courtship and marriage and to death. Music for shopping centres and advertising, music for social protest and to repulse parents, music for romance and for frenzied dancing, music to incite fear in the enemy in times of war - and unity amongst soldiers in battle.

As production and marketing arrangements have improved, the universe of music has expanded to perform novel functions, satisfying innate human needs and those created by our increasingly complex culture.

This process can be expected to continue as network and storage innovations make the universe of music available to consumers in their homes 24 hours a day. Existing forms of music and existing contexts will probably continue, but will be supplemented by forms and contexts which cannot now be imagined. The intensity and diversity of today's derivatives of house and techno music could not have been imagined by the disco musicians of fifteen years ago, and disco could not have been imagined by those who were involved in the 1960's explosion of popular music.

The structure of demand for music has its roots deep in the human psyche and in trying to predict the future of the music industry, we need to allow for a broadening of the scope of music similar to what we have witnessed in the recent past. Human culture evolves continuously and rapidly in an environment of technological change. Older forms may not be replaced immediately, but they loose their prominence, and may over time be lost due to lack of relevant inspiration, or by loss of audience and artists' skills due to competition from other forms.

Competition between musical forms operates on an aesthetic, demand level but it also operates at the level of cost. A new form of music which is cheaper to produce can depose an older form, even though it is no more attractive to the listeners. The demise of big dance bands because of competition from smaller amplified bands and record players is one example. A more recent example is the demise of four and five piece rock bands in clubs and restaurants as a result of economic competition from duos with sequencers and drum machines.

THE BROADER CONTEXT

The development of styles

Virtually all music relates to existing styles of music. Occasionally a piece may break new ground, opening an area of musical endeavour which develops and becomes a permanent part in the musical landscape. One such example is Brian Eno's 1978 *Music for Airports* which was so different from most of his earlier work, that it may not have been immediately obvious what this new musical style was "for".

From an industry perspective, the development of new musical styles, and in particular the popularisation of these styles is crucial to the growth of musical markets. From the perspective of the listener, getting to know new styles is crucial to developing breadth and depth of musical experience.

The difficulty for a listener is that an unfamiliar style may seem alien and unenjoyable until they have experienced sufficiently in a context conducive to its aesthetic. The context of the ambient music style - of which *Music for*

Airports is often seen as a starting point - is completely at odds with commercial radio, and so most listeners discovered ambient music through other radio stations, or through friends.

In the case of *Music for Airports* the artist already had an established reputation from his own solo work, and with his work with Roxy Music. So, many Eno fans discovered the new musical style when they played the new disc at their record shop. Eno's collaboration with David Bowie and U2 remains highly marketable on commercial radio today, and his prominence continues to draw listeners interested in one aspect of his work towards other aspects which may be equally pleasurable, but cannot be promoted in the same way.

The development of the style broadly called "ambient music", may well have got off to a slower start without Eno's contribution, his prominence and without his credibility in other areas of music.

The development of styles is typically more of a collective, evolutionary process. Sub-styles drift, find promising new musical territory and flourish into musical movements with visual and cultural contexts different from their roots.

The primary factor in this is the inventiveness of musicians, fired by their contact with other musicians and existing music. To a large extent, musicians' musical horizons depend on the musical diffusion processes which are directed at consumers.

The popularisation of new musical styles depends on these diffusion processes as well.

Diffusion processes

Today, these processes are primarily radio, television, and music magazines. Diffusion occurs between friends, at performance venues (live and DJs playing recordings) and in record shops. For some people, one of these may be their major link with new music.

For instance learning about it from friends, is an ideal way of discovering music, since the new material has already been filtered by people with similar tastes, may come with personal approvals and strong social associations, and typically provides an opportunity to browse an entire CD in a realistic listening situation before deciding to purchase it.

An individual listener's discovery process may be the last link of several diffusion processes, starting with the artist or record company. The last link may through friends and local resources such as radio stations, these links typically depend for their fresh input on more global diffusion processes based on the mass media.

Ideally, the music shop is one place where new music would easily be discovered - a customer picks a few discs of music they are unfamiliar with and listens to them. Some shops make this very easy by promoting a limited number of discs on dedicated listening stations. The major problem is that the music will typically be listened to on headphones, whilst loudspeakers fill the shop with something quite different. Music retailers do suggest discs to their customers, broadening their musical horizons. This adds value to their stock and is greatly appreciated by the listeners who take such opportunities.

However only a tiny proportion of the public avail themselves of such browsing in record shops or through retailers. It typically involves waiting for a staff member to become available and asking them to do a few minutes work finding the disc and putting it on a CD player. If customers could listen to the music within a few seconds of seeing a CD in a rack, then shops would become a much better means of discovering new music.

Such browsing is important to the early development of niche music markets, and is especially important to the broadening the experience of musicians. However, retail browsing has virtually no impact on the development of mass markets for emerging musical styles, because most people do not discover new music in the shop - except for discs which are already hits, or promoted as hits.

These diffusion processes will remain, but the potential for retail browsing will grow enormously when CDs are marketed via a network with the facility for auditioning the music easily, or via a retail shop with improved listening facilities.

Diffusion processes introduce people to new music. They are central to the development of music at many levels. From the macro level of musical styles to the micro level of individual tracks. From the macro level of reaching entire audiences, to the micro level of reaching individuals. From the production aspect of broadening artist's musical horizons to the consumption aspect of introducing individual consumers to fresh music.

Music discovery is explored in the tables 15.1 to 15.6 below and in chapter 17.

The purchasing decision

Consumer demand is often modelled on the basis of needs, products satisfying those needs and rational decisions based on competing products and financial factors.

However many music purchases are made without careful listening to the music beforehand. CD's may be bought purely because of the artist's reputation and past work or because of a rave review or recommendation from a friend. CD's may even be bought as collectibles - where the possession of the artefact is more important than the listening experience. Collecting amongst dedicated fans can be a lucrative revenue stream for small and large record companies, who produce special releases with extra tracks and unusual packaging. The collector's desire may be behind many CD purchases in all fields of music - including classical music (Greer 1994).

Another perspective on CD purchases is one which also applies to books and computer software - that some people buy them to make themselves feel good and to enhance their status - by having them sitting on their shelves.

Music does its work in the mind of the listener, and since it is quite abstract, that work can be greatly influenced by associations. Classical music is typically associated with formality and a tension between emotional and naturalesque imagery on one hand, and the precise, labour intensive deliberations of the performers on the other. These factors are a considerable barrier to many music purchasers who are used to more playful, less remote styles.

However classical music can be marketed so as to influence the purchasing decision - and probably the listening experience - by breaking the association with formal performances and sartorial style and replacing them with suggestions of a more personal, sensual and romantic experience.

One example of this is the US chain of up-market lingerie shops - "Victoria's Secret" - who market their own-brand classical albums with huge success. Of the ten classical albums which have reached one million-plus sales in the US, five are from "Victoria's Secret" (Greer 1994).

Another example of changed associations leading to huge sales is EMI's successful marketing of a double CD set of Gregorian chants recorded by Spanish monks in 1973[19]. This builds directly on the success in 1991 of Enigma's *MCMXC a.D* which mixed house music, Gregorian chants and intimate female vocals.

NEW LISTENING EXPERIENCES AND DIFFUSION PROCESSES

It is difficult to neatly compartmentalise the factors at work in the diffusion of music and the factors affecting the listening experience or the purchasing decision. However an analysis will be attempted to give some insight into how new technology will provide new possibilities for listening experiences, for diffusion and for building the linkages between the various aspects of the total music experience.

Ten listening situations are analysed below. One of the most important means of music diffusion is home taping, or in the future recording on CD-R or transferring music and other material to friends over the network. The following table indicates how amenable these ten situations are to being recorded by the listener.

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19 Canto Gregoriano - Coro de monjes del Monasterio Benedictino de Santo Domingo de Silos.

TABLE 15.1 LISTENING SITUATIONS AND RECORDING BY THE LISTENER

	Complete tracks	*Audition samples*	*Text and graphics*
1 - Concert - live performance	A few people record concerts.		Programme
2 - Dance club - recordings played by DJs	-		Handwriting
3 - Playing a CD or other pre-recorded media	Yes. Ideal for recording as the source is controlled by the listener.		Photocopier, scanner or handwriting.
4 - Listening to AM or FM radio	Yes. Recording must be immediate since source cannot be rewound.		Programme guide or handwriting.
5 - 30 channels of subscription audio via cable, MDS or satellite	As above, but there is no warning of what is to be played.		Track title can be written down.
6 - Audio On Demand - specific music programs with pause, rewind and fast forward, but without direct access to complete albums.	Good for recording, but it could be difficult to compile a recording of a complete album.		Written down or perhaps stored on computer and printed.
7 - Browsing pre-pressed CDs at a retail shop	-		Handwritten wish list.
8 - Browsing a database of music and selecting tracks to be written onto a CD-R in a retail shop.	-		Printed wish list, track lists and graphics may be provided for promotional reasons.
9 - World Wide Web sales of CDs with graphics and limited audition capability	-	Samples on hard disk can be sent to friends over the network.	Electronic and printed lists, track details and graphics can be given to friends.
10 - WWW browsing and purchasing of music for electronic delivery - be written onto a CD-R in the home.	Tracks, when purchased, can be copied to friends, via CD-R or the network.	As above, but with higher quality.	As above.

Comment [RW20]: Page: 232
One of my reviewers - Philip Jackson - suggested that tables 15.2 to 15.6 should be restructured so they follow the format of 15.1. So each of the ten situations would appear on one page and one or two aspects of it would be discussed on each page - Sonic and other content; Personal control; Browsing; Social; Temporal and other aspects. This could be a good idea, but I like the way the listening experiences are paired.

TABLE 15.2 LISTENING EXPERIENCES - CONCERT AND DANCE CLUB

	1 - Concert - live performance	*2 - Dance club - recordings played by DJs*
Sonic and other content	Loud sound, lights, stage presence of artists. Sound will be different from recordings, because of technical and creative factors.	Loud sound, lights, hundreds of dancing people. Excellent sound system. refreshments and music at its peak, rather than compromised by the need for live performance.
Personal control	None except for calling out to the artists.	None except for making requests to the DJ. Choice between staying in the dance room or retiring to somewhere quieter.
Browsing	Names of songs and albums may be mentioned.	Very limited - names of songs and albums may be mentioned. Otherwise only an enquiry to the DJ or another patron will provide information about the music.
Social	Powerful, focussed shared experience. May be impossible to talk to friends.	Powerful, focussed shared experience, where the audience and individual dancers are the stars of the show, with the lighting controller and DJ leading the proceedings.
Temporal and other aspects	Immediate connection with the artist's work in progress.	At the mercy of the DJ's whims - playing the most exiting mixture of familiar and unfamiliar recordings.

TABLE 15.3 LISTENING EXPERIENCES - CD AND AM/FM RADIO

	3 - Playing a CD or other pre-recorded media	*4 - Listening to AM or FM radio*
Sonic and other content	Excellent sound quality. Graphics and text in the CD booklet, including song name, performer, composer, critical comment and explanatory text.	Sound only, of variable quality. Material presented by a DJ, typically with name of song and performer, and often with background information. In some cases - like ABC FM - there may be a printed program which provides further details.
Personal control	Complete control, moment to moment, of pause and track skipping, or listening to a different recording.	At the mercy of the DJ's whims - or a fixed playlist. There is no pause or rewind, but with a flick of the dial or press of a button, another station can be selected. Phoning the station with requests for music or further information.
Browsing	Excellent ability to browse the contents of the disc and the printed material - but the disc must first be purchased, hired or borrowed.	Names of songs and artists are usually mentioned, but they need to be remembered or written down immediately.
Social	Individual or shared with other people in the room or car. In a less direct sense, there is a social aspect to listening to recordings which are known to be appreciated by others.	Shared experience with thousands of other listeners. If the DJ makes decisions moment to moment about what they play and say, then there is a one way personal link from the DJ to the listener and to other listeners. Listeners may phone the DJ to make requests and give feedback.
Temporal and other aspects	Connection with the artist's best studio or live work, frozen in time. However the listener controls the playback and so is not "subject" to the will of the performer or a DJ. A conscious decision must be made to play a recording.	Radio costs no money. A positive aspect of radio is that the music is a gift - when the DJ plays a track you like, it can be more pleasurable than putting it on yourself even if you already own it. The extra pleasure has a social aspect because someone else thought of the music, gave it to you as a surprise and shares your appreciation. Particular times of the day and week relate to particular DJs and music styles.

TABLE 15.4 LISTENING EXPERIENCES - SUBSCRIPTION AUDIO AND AUDIO ON DEMAND

	5 - 30 channels of subscription audio via cable, MDS or satellite	*6 - Audio On Demand - access to specific music programs with pause, rewind and fast forward, but without direct access to complete albums*
Sonic and other content	Good sound quality. Text display of the current track in on the LCD of the remote control.	Excellent sound quality. Programs may contain text and graphic information, and may have spoken announcements - which can be skipped.
Personal control	Fine selection between musical styles, but no pause and track skipping, and no notice of what is going to be played. The automated nature of the system probably precludes phone requests.	Depending on the sophistication of the delivery system, the hypermedia sophistication of the program and the content of the program, a wide range of choices may be available - especially rewinding a track, or jumping to a similar track instead of continuing with the program.
Browsing	LCD display greatly aids purchase or browsing of the music by other means.	Names of songs and artists are likely to be available as text or spoken commentary. In an advanced system, the program could contain hypermedia links to networked music sales for the particular pieces of music being played.
Social	Without spoken commentary or program notes, there is a mysterious, anonymous aspect to this form of music diffusion. Actual track selections are probably performed by computer, and it is likely that no-one at the studio is listening.	Depends entirely on the nature of the program. Sophisticated systems may allow for listener feedback for requests, voting for favourite tracks or critical feedback to the programmers and artists.
Temporal and other aspects	Connection with the artist's best studio or live work, frozen in time and played in a context of similarly styled music, but not in the context of complete albums. Small cost per month, but no hourly usage costs.	Likely to be charged on a dollars per hour basis. Programs could include standard radio programs, live concerts, special interest documentaries and promotional programs for particular styles and artists.

TABLE 15.5 LISTENING EXPERIENCES - RETAIL CDS AND CD-RS

	7 - Browsing pre-pressed CDs at a retail shop	*8 - Browsing a database of music and selecting tracks to be written onto a CD-R in a retail shop.*
Sonic and other content	Initial input is usually visual - looking at the CD cover, but sometimes fresh music of interest is heard over speakers or in a headphone browsing station. Unless played on the shop sound system, the music must be listened to on headphones. This gives poor sound quality due to lack of bass and interference from the shop loudspeakers.	Initial input is graphics and text, with instant availability of some samples of the music. Music can be indexed in a variety of ways. Additional material may contain track listings, biographical details, photos and critical commentary. Listening would be on headphones in a quiet space, or in a small booth.
Personal control	Selection between tracks if listening on headphones. Sometimes the ability to browse several CDs without bothering the staff.	The whole recording would be available for audition, and the listener would have excellent control over their browsing and purchasing decisions. There would be little reliance on staff.
Browsing	At the level of CD covers and booklets, browsing is easy - for those discs which are in stock. Easy comparison at this level with other discs. Audio browsing is difficult since it requires staff to get the disc and place it in a CD player.	Names of songs, performers and artists are presented directly. Links exist to bands and artists related stylistically or by common members. Wish lists can be stored and printed out for tracks a listener likes but cannot yet afford.
Social	Personal contact with staff and other customers can be pleasurable and lead to new musical discoveries.	Staff may guide the listener. With a large choice, the browsing process would be an enjoyable voyage of discovery which could be shared with a friend.
Temporal and other aspects	Connection with the artist's best studio or live work, frozen in time and presented as complete CD albums. Requires a trip to a shopping centre during business hours.	Some tracks could be very recent releases, because they could be loaded into the system by telecommunications links, rather than waiting for physical product. The product is a highly personalised disc which the customer has had the opportunity to maximise the value of.

TABLE 15.6 LISTENING EXPERIENCES - NETWORK CD SALES AND NETWORK MUSIC SALES WITH ELECTRONIC DELIVERY

	9 - World Wide Web sales of CDs with graphics and limited audition capability	*10 - WWW browsing and purchasing of music for electronic delivery - be written onto a CD-R in the home.*
Sonic and other content	Text arrives quickly, graphics take a minute or so and low quality mono audition files arrive in real time with a 64 kbit/sec BR-ISDN link, or at slower speeds with modems. Hyperlinks to other recordings and artists of interest.	Excellent sound quality with the potential for full motion video and hyperlinks to anything else. May contain text and graphic information, and may have spoken announcements. Sophisticated systems may respond to voice commands.
Personal control	Excellent control over the music being listened to. The main problem is the tradeoff between quality and sample length, and the time required to receive the audio data.	No technical limits on how the listener navigates through the choices.
Browsing	Excellent browsing, ordering and wish list maintenance. Graphics, text and samples can be stored on disc and played or given to friends at a later date.	The only limit on the browsing is that if a substantial portion of a track is played, then the listener is deemed to have purchased it.
Social	Browsing activities can be conducted from home 24 hours a day in the company of friends, and with contacts with friends over the network at the same time.	
Temporal and other aspects	Connection with the artist's best studio or live work, frozen in time, pressed onto disc and loaded into an ordering system. Excellent choice from large centralised retailers or direct from the artist's music company. A CD order would result in a disc arriving within a few days (stock permitting) or longer from overseas.	Totally up-to-date track availability with multiple mixes and no problems with stock. Potential for direct critical feedback to the artist. Instant gratification from direct music delivery so it could be enjoyed immediately. This could be particularly important in a social situation where one person browses and buys music and their friends can all enjoy it immediately - like a powerful juke box, at home, where you get to keep the music forever.

New musical listening techniques

In this section, future trends in the personal listening environment are considered. In 1995, most personal listening is based on pre-pressed CDs or radio transmissions. For simplicity, pre-recorded and home recorded tapes are not considered in this analysis.

Towards the year 2000, the use of CD-Rs (or Magneto Optical or other re-writable optical discs) and new physical and data formats for CDs and CD-Rs will increase. This provides flexibility and performance improvements in several ways:

- CD-Rs produced at retail shops will more closely match the music the individual listener wants to hear.
- New CD and CD-R formats will contain larger quantities of music and may contain extra data to work with sophisticated playback systems - such as shuffle play and inter-track mixing systems.
- Home recorded CD-Rs and Mini Discs will provide higher sound quality and greater playback flexibility than audio cassettes.
- Sophisticated playback facilities may be implemented in software on personal computers and built into consumer CD players.

In addition, some consumers may use disc players which hold many discs and have sophisticated means of controlling disc and track selection, so the listener can program it to create a musically consistent experience, with variation as desired to counter fatigue from hearing tracks in the same order on several occasions. Consumer CD players which hold a hundred discs have been produced, and with sufficiently sophisticated control software, the listener could make it play tracks from their disc library - selected for particular tastes and occasions. Such systems are commercially available for hotels and other public commercial venues - from UK company DataBeat.

Blending from one track to another will be possible by storing music in memory. This memory buffer would be essential to eliminate delays between tracks as one disc is returned to the library and another is retrieved.

Digital Audio Broadcasting and audio delivery by the cable, MDS or satellite channels used for subscription TV will increase the choice of music available by distributive means. There is a limit to how sophisticated the control of this can be - since personal control of the channels is not possible. However with a personal computer, it will be feasible to buffer the digital audio on hard-disk so that the listener can decide at any time while a track is playing, that the entire track should be written to hard disk (or some form of re-writable optical disc), perhaps later to be written to CD-R. This facility, and the use of personal computers to copy tracks from CDs and CD-Rs to another CD-R enables the listener to easily gather the music they like from disc, radio DAB and "cable" audio and build their own collection.

Audio On Demand is at first likely to provide specialist music programs analogous to radio shows, but available at any time with fast forward, pause and rewind. This will greatly enhance the listener's ability to discover and copy the music they like. With Audio On Demand, the listener will typically be purchasing specific programs and paying much more than for a distributive music service. Such a program might be considered sufficiently close to today's concept of "musical product" that a significant proportion of its revenues would be paid to the copyright owners of the tracks used in the program. As the cost of the program rises, so does the listener's feeling of ownership of the material. A sufficiently specialised program, with extensive coverage of particular artists comes very close to electronic delivery of the artists intellectual property as a retail sale. The legal, economic and business aspects of what seems to be a "radio broadcast" is thus bent to the point where it is almost indistinguishable from selling music to the listener.

Although the program may resemble a radio show, it is not a form of broadcasting at all. It is a body of data presented on demand via a telecommunications network for a fee. While it may package the work of one or more artists in a way which the listener appreciates - with contextual information, DJ banter and DJ mixing, from the point of view of the musician it may be much closer to a sale of their music than a radio broadcast is.

Technically, Audio On Demand could also provide the specific tracks a listener wanted - but it is likely that for legal and business reasons, this would be classified as "electronic delivery" and would be administered as a browse and buy retail session.

It would also be technically possible to provide the listener with a personalised mix of music from an external library - perhaps with sophisticated track to track mixing. The listener could specify "Beatles tracks from 1967 and 1968 which are not too slow and are shorter than 5 minutes" or "disco hits from 1979 to 1982 with on-the-beat cutover, but no Abba".

In the more distant future, real-time digital sound synthesis at home, or at a remote site and delivered to the home via the network, would provide personalised music with variety and listener controllable parameters. A simple application may be background music composed of melodic material and/or wildlife recordings. A sophisticated application may use a high level musical object - created by a composer - which is capable of generating sound roughly equivalent to a symphony, but with user defined parameters for length, tempo and higher level aesthetic aspects of the music such as tension or simplicity. It would be possible for the listener to combine and conduct several musical objects - such as one or more objects for score and one or more for instrumentation.

Chapter 17 contains diagrams depicting projected adoption rates for these methods of listening to music. Figure 15.1 depicts these methods of listening to music, grouped according to whether they are based in distributive systems, the listeners own recordings and equipment or on services available from a broadband network.

Time lines are estimates which show how the sophistication of distributive systems (free to air and subscription audio broadcasts) has an upper limit which is likely to be reached in the next five to seven years. However if more channels are made available for distributive services, each one can be more finely tuned to particular tastes. In contrast, as personal equipment and network services become more flexible, there are no absolute limits on the sophistication of music and musical control which an individual listener can enjoy. In the longer term, as massive (by today's standards) CPU power becomes readily available, music objects become a viable source of music for general listening.

Increasing variety and strength of music

The above discussion has concentrated on the mechanics of listening and considered briefly the basic drives for listening to music. How does all this combine in the listener's mind - where the music really performs its service?

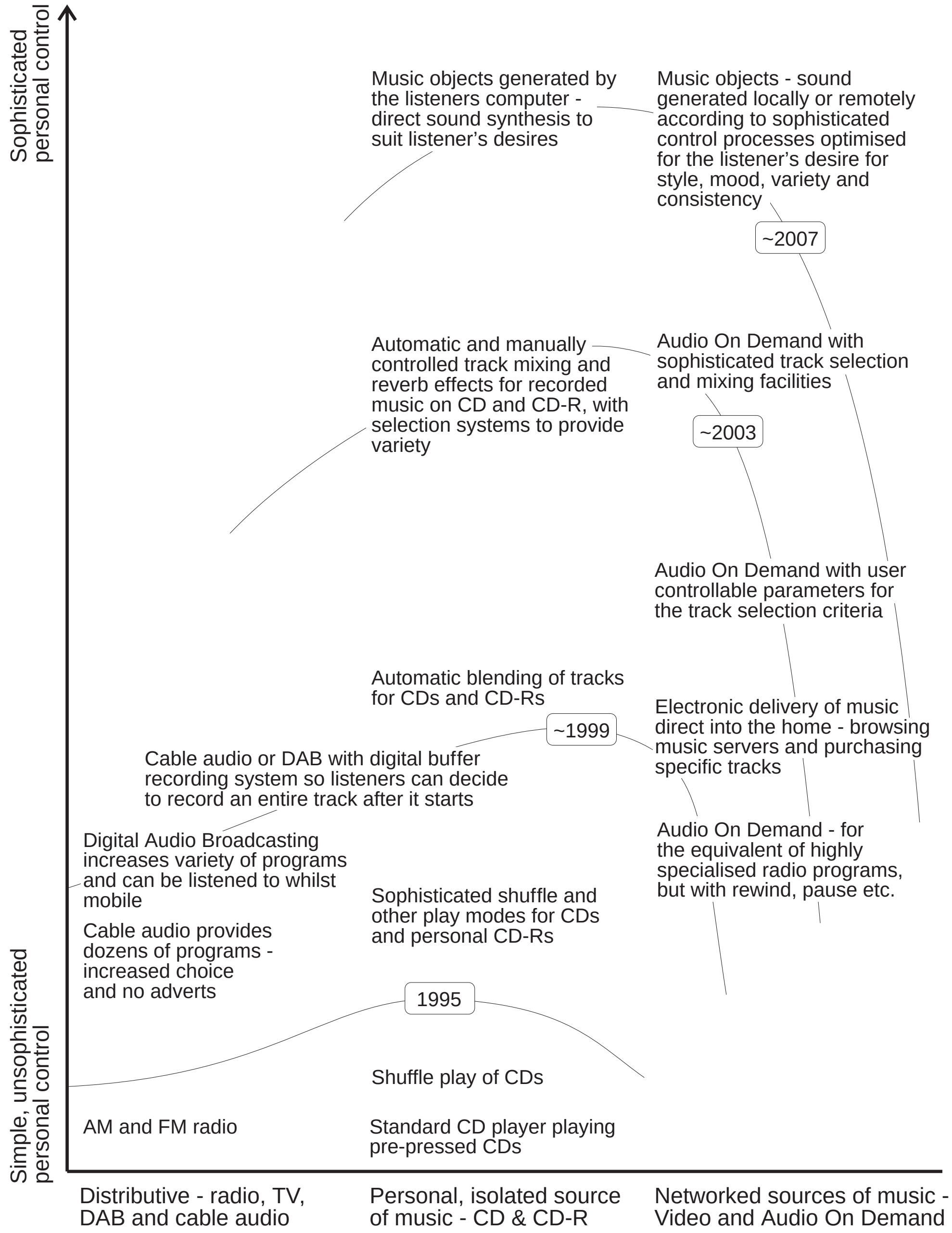
The reader is assumed to be sensitive to the extraordinary range of musical material which is available, the many listening environments, the wide divergence of personal preferences and reasons for listening.

What trends in listening experiences can be expected in the future? How might these affect the aesthetics of music and further broaden the demand for music?

The superb sound quality of CDs and moderate price of CD players, together with the greatly increased variety of music has enabled listeners to follow increasingly personal choices - to make their listening more their own, independent of the choices of the people around them.

This has stimulated the release of a greater variety of music and the opening up of new musical territories. Music may be likened to software for the mind - with the function of providing aesthetic, verbal and emotional stimulus. Computer software is typically functional and one version can provide satisfaction for years. Even the most functional music - such as for marching, aerobics or for background music in lifts - quickly palls with use.

FIGURE 15.1 SOPHISTICATION OF THE PERSONAL LISTENING ENVIRONMENT



Source: author's estimates

Recreational music performs a high-level stimulus function which means that fresh material from familiar territory is constantly required. Many music consumers are keen for stylistic variety so their musical tastes branch out from the territory they are familiar with.

As variety increases, with consumers spread more thinly over a broader musical territory, it is less likely that an individual's musical tastes will coincide with those of their geographic neighbour's or workmates. One of the great pleasures of music is sharing it with others, and so in the 1960s, when virtually everyone appreciated the Beatles, an important social aspect of the listening experience was the knowledge that the pleasure was being shared with millions of people all over the world.

Today, there is a lot of music which people enjoy as intensely as the Beatles' music was enjoyed. The music is different from the Beatles, but just as valuable to its listeners. However for a given piece of music, the proportion of the population which appreciates it has grown smaller as the supply of music has increased. So the potential for a mass shared experience with a given style of music has decreased with the proliferation of styles. This is a genuine loss, since that mass shared experience was a valuable - and certainly marketable - part of the 1960's experience. The intensity and breadth of that shared experience fed back to the musicians and inspired their creative efforts even further.

Reduced costs in creating and distributing music have lead to a proliferation of styles and product, and the listening experience of many consumers has become more lonely in terms of their geographic neighbours. However printed and electronic communications help listeners bridge geographic barriers and share their experiences with people with similar tastes.

The technical advances in music production, distribution and reproduction, together with increasingly powerful musical styles, lead to increasingly powerful listening experiences. Power, for the sake of this discussion may be defined as the ability to satisfy listeners desires. This may involve intense emotional and associated physical sensations, or a relaxing sensation - to the point of no sensation if that is what the listener is seeking. Listeners often want to be surprised and delighted, so they may have no idea of what they want before they experience it. In this context, "power" has a direct bearing on enjoyment and on the willingness to pay for the music.

The power may be in a rhythmic, communal, dance direction, in vocally communicative emotional directions, or in contemplative or decorative directions - the power of many forms of music is increasing due to technical and stylistic advances.

At the same time, people become accustomed to it, so the increased strength or value of the music is not necessarily apparent. If the most powerful dance tracks of the 1980s and 1990s were somehow played in the Merseyside clubs of 1964, musicians and audience alike would have been stunned at their musical intensity.

Old and new musical territory

As music spreads into new aesthetic territory, in terms of the new aesthetic it is more powerful or valuable than older music. However according to the older aesthetic, it is not necessarily more valuable or powerful than the older music. The new music may be distasteful to those who favour the tradition of the familiar musical territory, but the new music may be the start of a new tradition. For listeners seeking music they are stylistically familiar with, the old musical territory is a gold-mine.

For listeners seeking something "different", something fresh and exciting, it could be generalised that once a particular territory has been well worked over, it becomes increasingly difficult to find valuable music within it. This amounts to loss of productivity for a given musical style or aesthetic territory - and it is a pervasive phenomenon which is worth examining further. Examples abound in almost every field of music. Few great rock-n-roll or rockabilly songs have been written since the late 1950's and few popular symphonies since 1900. This perspective is also valid if stylistic development is seen as the "research and development" section of the industry - opening new fields of music.

It does not seem likely that all the viable combination of melodies, chords and lyrics becomes exhausted. However the stylistic space between particular pieces may become crowded by derivative compositions.

This loss of productivity for an established style may seem a question of content creation, but it is examined here, because the most likely cause for the low productivity of established musical territories lies in the listening experience. The total listening experience for the audience, and especially for the musicians, consists of a variety of inputs as discussed previously - for instance the Tori Amos musical experience described at the start of this chapter.

The most creatively productive time in a new musical territory is the time when a critical mass of musicians and audience first discover it. The excitement of finding new stylistic directions, of creating new music that sounds like nothing that has been played before, the thrill of sharing it with other musicians and listeners and the development of a social movement which identifies with the new style - all these are powerful catalysts to the musical innovation which drives the entire industry.

Examples include the era of the big bands, the rock-n-roll of the 1950s, the mid sixties pop revolution, the megabands (Yes, Pink Floyd, Led Zeppelin etc.) of the early 1970s, the punk movement of 1976, disco shortly after that, and various movements leading to rap and the current proliferation of electronic dance music.

Some new musical territory is opened up by advances in musical instrument and recording technology. Some result from extensions to existing forms, reactions against existing forms or combining elements of existing forms. For instance disco can be seen as an escape from shabby day-to-day reality and punk as a rejection of supergroups and bourgeois social values. Synth pop such as the Human League can be seen as adopting disco music sensibilities, and the punk ethos of "anyone can make music".

Pop musicians' creativity is fired by the excitement of the total listening experience - including social aspects such as fashion, politics and identification with particular subcultures.

The rise and fall of musical movements

As the movement picks up momentum, established parts of the music industry invest financially and the popular growth phase begins. After a few years, the field becomes crowded, the audience looks for something fresh, and unless the style evolves, it will lose its productivity and settle into a period of dormancy, interrupted perhaps by revivals.

It is impossible to accurately model the leading edges of creative endeavour, however some metaphors are valuable aids to understanding. The onset of productivity in a stylistic territory can be viewed as a wave rising to a peak, followed by a period of less dramatic activity. The revival process can be seen as the spotlight of public attention returning to old styles which are fresh to a new generation of listeners and a contrast to styles currently in decline. The gold-rush analogy is particularly apt, except that in a gold rush, the discoverers of new territory have no difficulty in convincing consumers of the value of their find.

However when musicians discover - or more properly, invent - new musical territory, only a few people may be attuned to the value it contains. They may play the music for several years before it finds the right social and aesthetic conditions to develop critical mass. Sometimes a new musical form arises from disparate elements which never reach a mass market on their own. For instance, Kraftwerk's music made a crucial contribution to the development of rap music. The music of Men At Work received an enormous revival when it became associated with Australia breaking a century of US dominance over the America's Cup. Often such cultural connections are made deliberately. For instance the Three Tenors' connection with World Cup soccer probably brought benefits to both parties in this rather odd couple.

Lower thresholds for musical developments achieving critical mass

The emerging musical marketing and distribution arrangements will lower the threshold for a given style of music to become financially viable and attain an enthusiastic audience, because the average consumer will have direct access to a greater number of styles and tracks than can now be made available through radio and CD retailing.

Likewise electronic networking will enable communities of fans to reach critical mass almost irrespective of their geographical distribution. Internet newsgroups and mailing lists can arise rapidly and without cost. They are easily accessible to millions of people and form ideal communication channels for people with common musical interests. World Wide Web sites can be started quickly, for minimal cost (compared to publishing a printed magazine) and can be easily found by fans seeking information, graphics and audio samples relating to a particular band or musical style.

These new methods of diffusing music and related information - together with established means such as TV and printed publications - all contribute to the total listening experience for an individual musical consumer.

New distribution techniques and better audience networking lead to a reduction in the critical mass of audience interest which is needed for a new musical style to become self sustaining. These also enable a greater number of styles to be evolving at once - compared to dissemination by CD, radio and printed magazine. The critical mass of listeners and musicians may be spread all over the globe and may be at an almost insignificant level at any one geographical location.

Thus a musical revolution may be occurring (or less subjectively, a new style may be evolving), and its participants may not know anyone in their geographical neighbourhood who is aware of what is happening. This revolution would be lacking the mass culture momentum which made the 1960s, or the punk revolution so exciting. These revolutions are likely to be more private and less dramatic developments than they would have been if they had occurred in the 1960s, when there were few other musical revolutions taking place. This is not due to any weakness in the music - but to the dilution of public attention.

The increased number of concurrent musical revolutions will lead to increasingly blurred boundaries between the various developments. Some musicians and listeners will be exploring several developments simultaneously - perhaps starting a new development themselves.

An example of such cross-pollination is "Officium: polyphonic music from the twelfth to fourteenth centuries" by Jan Garbarek (saxophones) and the Hilliard Ensemble. Classic CD magazine (October 1994) describes it: "Three years in the making, it is an audacious disc, bizarre even - Gregorian chant with sax accompaniment? - but beguilingly and beautifully executed." Stylistically the magazine states there are "No comparable recordings".

This is a clear example of new musical territory being opened by a small group of explorers. It is a disc which may achieve cult status and huge sales. It may inspire derivative works, but it is unlikely that any one will generate the excitement of the original, since the territory is now partly explored, and because those that follow are unlikely to spend as long as three years on their work.

This raises the question of why new musical explorations take place. Sometimes it may be simply a mistake which is attractive and leads to a new direction. Perhaps some musicians deliberately blend existing genres in the hope that the results will be marketable - twelve century vocal music with sax, Led Zeppelin with reggae or Jimi Hendrix guitar music performed entirely by acappella scat singers. More likely these ideas originate in the fertile minds of musicians, driven to create something unique and exciting for their own enjoyment, with the prospect of financial returns no more than a mirage in the distance.

One second order effect of the larger number of simultaneously developing musical territories is that the interest of musicians is diluted between them. In the past - when, for argument's sake, there was a new musical development every two years - a large number of musicians would focus on one musical development. Now with more simultaneous developments, musicians' interest in any one development is divided, just as the new music's sales potential is increasingly divided by competition from other styles. This means that a new development - such as those pioneered by Enigma, Deep Forest or Jan Garbarek and the Hilliard Ensemble - is increasingly likely to be left to its originators, rather than swamped by derivative work from other musicians. On the other hand, there are now more musicians than in the past.

This trend away from "jumping on the bandwagon" is strengthened by the increasingly sophisticated aesthetics and musical resources required to operate in some new musical territories. Few musicians have access to singers familiar with early music - so it would be difficult to imitate the Hilliard Ensemble. Enigma followers may have to make do with sampling Gregorian chant rather than using an experienced choir. Deep Forest followers can sample Pygmy song from old Folkways records as Deep Forest did - but it is not easy to create the attractive musical results achieved by these artists.

In other musical territories there is no desire for attractiveness or refinement and the sounds, skills and equipment are readily available - so many musicians do jump on the bandwagon. There are a huge number of guitar based bands and "me-to" techno outfits who aim at the centre of their chosen musical territories rather than at the edges or beyond. There is nothing wrong with this, but they usually contribute little to discovery of new musical territories. Perhaps they even wear out the excitement of the territories they occupy if listeners are exposed to a lot of their music - which is less creative than that of the leaders.

In the past, when new musical territories were few and relied on readily available musical skills and instruments - such as Jimi Hendrix's opening up of new rock music territory - hundreds of thousands of musicians were able to pursue the new aesthetic. A similar situation exists today with sequenced dance music - where the equipment and basic musical skills can easily be acquired.

If "Officium" is considered as a pioneering work in a new musical territory, then the processes driving its development was in the listening experience rather than resulting from new instrument and recording technologies. In this case, there have never been technical barriers to combining early music with jazz sax. What has changed is the listening experiences of the potential audience, and especially the listening experiences of the musicians and the recording companies who invest in their work - in this case, ECM.

Wider musical horizons and easier access

The increasing diversity of music available via CDs, and on some radio stations has led to an audience and a community of musicians with wider musical horizons, and an increasingly experimental attitude to music.

As the diversity of music increases with new distribution technologies, this process can be expected to intensify to the point where any consumer or musician can browse or buy virtually any style - or piece - of music that has ever been recorded. The discovery of new musical territories, and of pleasing bridges between established territories will become more frequent, and the discoveries will increasingly blend into each other. This is likely to create difficulties for critics and historians in the maintenance of their musical taxonomies, but increase the pleasure for musicians and listeners alike.

Economically this means that the proliferation of styles, and the increasing ease by which people can discover and appreciate these styles, provides a "bottomless pit" of diverse, quality product which could keep the adventurous consumer buying music continuously. This should lead to increased productivity for the entire music industry as a result of greater knowledge amongst producers and consumers, and increased availability of material which stimulates innovation and adventurous consumption.

However it also means there will be a huge amount of music produced and greater difficulty in classifying it in terms of style and quality. So there will need to be new selection methods by which consumers can navigate through current and past products of the music industry. Selection methods are discussed in chapter 17.

This process can be likened to the evolution of cuisine in any one country, which was originally based on traditional dishes constrained by available ingredients and limited innovation. With modern transport, communications and travel, each country (or at least Australia) has access to produce and recipes from all over the world, while the public and the chefs (at home and in restaurants) have broader culinary horizons and a more adventurous attitude to food.

The processes described above do not affect all originators and consumers of musical or culinary product equally, and a considerable proportion of the market is likely to remain satisfied by generic products. However, in the food industry, generic products succeed partly due to their low cost. Cost differentials are likely to be less significant in the music market. There may be little difference in retail price between the musical equivalents of an exotic restaurant and a franchised fast food outlet.

Variety is not the only aspect of music which is likely to change in the next decade or so. Ease of access will improve dramatically, so that almost any music is available at any time at the listeners home. The culinary equivalent of this would be instant sampling and home delivery from any restaurant in the world - or from the cellars of any vineyard.

Collecting music - the thrill of the hunt

Part of the listening experience is the search for fresh material, and the pleasure of finding and owning exotic music and music related materials. A significant part of the music market caters to highly motivated collectors, and there is a healthy trade in used, rare and antique discs.

The extremities of the collector market[20] are of little significance for the trade in new product, however a thriving aspect of the popular recorded music industry is based on limited edition releases, with bonus tracks, special mixes and special printing on the discs and packaging.

For the consumer, a great deal of the value of these products lies in their rarity. If all recorded music was globally available via networked music marketing and electronic delivery, then the restricted availability of the music itself would cease and would no longer contribute to the broader listening (or consumption) experience which collectors are willing to pay for.

Even if the music is not made available commercially via the network, listeners will have no difficulty using the network to exchange the music between themselves. So the musical content of even the most rare discs - such as an LP "ASD429 De Vito/Bach" for which £600+ was offered in an advert in *Gramophone* magazine - could be shared between friends and would probably become available widely through a publicly accessible part of the global network, largely irrespective of the any applicable copyright laws. Such recordings already take place so the music itself is no longer rare. Collectors crave rarity, significance, authenticity and possession, and so the focus of the hunt turns to the physical objects on which the music was distributed or associated with.

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20 Collectors and traders advertising in *Gramophone* typically offer £80 to £150 for rare classical LPs. A similar trade exists for popular music singles, EPs, LPs and CDs.

Possession of sought-after music is likely to be widespread via commercial or personal copying channels. However the hunt for artefacts such as original discs, Beatles tickets or guitar picks used by famous musicians will continue as it does today, through catalogues, personal contacts and searching for treasure in second-hand and collector shops.

The search for music itself would be from home, at any time through the network - searching for a legitimate place to purchase the music, somewhere to copy it for free, or someone who will provide it illegally for free or in return for payment of a favour.

Packaging and musical paraphernalia

Collectors and dedicated fans form a substantial market for physical artefacts related to their favourite music. These items may be marketed over the network, but their production, limited availability and need for physical delivery will be unaffected.

A consumer buying a CD today gets more than the music. They get a physical disc, with colour printing, the possession of which is proof (piracy not withstanding) of ownership of the music and having contributed financially to the artist's income. The disc provides a convenient means of storing and reproducing the music, whereas with electronic delivery, storage is an additional cost for the consumer.

A purchased CD also comes with a case with colour printing including graphics, information about the music and lyrics and about the composer and performer. The packaging and the disc also identify the recording company and contains a title and catalogue number which can aid friends in purchasing the same disc. Disc packaging may also list other music available by the same composer or performer, or list music in a similar style or from the same recording company.

All these may be valued by the consumer - or valued as a marketing tool by the artists and recording company. However they are not essential to the demand for music. Some music industry players, when considering the prospects of electronic delivery comment "But people will still want to buy a disc with its packaging". This may be true of part of the market, but the prevalence of home taping, and the enjoyment people derive from listening to the radio proves that a substantial demand exists for music even when it is devoid of physical accoutrements.

Physical artefacts are an important part of the listening experience, and the demise of 12" LP covers has meant a loss of value to consumers and of a marketing tool to producers. In the USA, this has resulted in a protracted dispute over whether CDs should be sold in CD sized boxes (as they are in Australia) or in elaborate 12" high cardboard packages with extra graphics. These high packages were designed to fit in existing LP racks, but add significantly to the cost of production, distribution, display and, for mail order houses, delivery. They are now being abandoned in favour of selling CDs are they are in Australia, in their jewel boxes or similar packaging

12" LP covers and the potentially large printed materials which could be enclosed, were undoubtably of value to consumers - but not enough for them to pay for them as separate items, or as attachments to the smaller CD packages. Electronic delivery represents a further shrinkage of the packaging - to nothing. It does however support the delivery of electronic attachments equivalent to all the contents of CD and LP covers, with the possibility of including data for video and interactive applications, pointers to similar music, and other functions.

All materials delivered electronically are inherently copyable and so their value to the consumer will not be based on long-term exclusivity. However when demand is rapidly changing, driven by fashion and excitement, and satisfied by impulse purchases, it is likely that music and accompanying material can be sold commercially despite the knowledge that in a few weeks or months it will be freely, if not legally, available from many sources at minimal cost.

The consumer will need to make further investment of time and money to convert accompanying material into printed images on paper. However the electronic nature of this material aids its storage and access - assuming consumers have CD-R writers.

The fact that both the music and its related material can be easily given to friends increases its value to the original purchaser. For instance part of the value derived from purchasing a CD today is that tracks from it can be put on a tape for a friend. However since colour photo-copiers are expensive and inaccessible, the elaborate colour graphics of the packaging cannot be easily copied. So the value of the colour graphics for the original purchaser is limited to the value they derive from their own enjoyment of the packaging.

Packaging contributes significantly to the listening experience. The demise of physical packaging will be a loss in some ways, but in the future, the electronic nature of the "packaging" enables it to travel to wherever the music is copied. So electronic delivery enables a more complete musical experience to be easily sold and delivered, and for it to be easily transferred from one person to another.

However the conversion of "packaging" to the electronic form does not depend on the music's availability by electronic delivery. World Wide Web sites already provide text and graphics about the music, lyrics and artists. These can be printed out or copied to friend's computers.

As CD formats become more flexible, the equivalent of the packaging can be provided electronically on the disc as well as on the printed packaging. An example is the GF4 CD single / CD-ROM which contains no mention of the band member's names on the physical packaging but contains video, sound and still images including interviews with the members. This material can be accessed as part of the interactive application or the files can be viewed separately. Video and still images can be printed and pasted to other applications for editing.

The trend from physical packaging towards electronic forms of providing additional material is most evident with low priced CD-ROMs. These may have minimal printed material - or none at all. When there is no printed material, the only physical images and text associated with the disc are whatever is printed directly on it - and these can be minimal. All accompanying information is contained as files on the CD-ROM, from simple read-me files to elaborate help systems.

The trends evident with the transition to CDs, CD-ROMs and electronic delivery indicate that the costs associated with physical packaging ultimately mean its demise unless the packaging forms an essential part of the value the consumer derives from the product - and with music this is not usually true.

Beyond the context of one disc at a time

The need to turn over an LP after 25 minutes or so was generally a nuisance which detracted from the continuity of the musical experience, and dictated that the music be constructed around the 25 minutes per side limitation. However it had advantages in a social situation when an unpopular disc was played - only 25 minutes elapsed before someone had to make a fresh choice about the music.

CDs may extend this time for over 70 minutes, but they have the great advantage, with most CD players, that just particular tracks can be played and the order of play be specified or left to chance.

With both vinyl records and CDs there is one player and one disc, with silence when the disc is being changed. This means that the listening space is typically in the context of a particular disc at any one time. Consumer recorded CD-Rs and Mini Discs provide greater customisation of what may be on any one disc - so breaking the "album oriented" context of personal listening from one track to the next.

Personal computers and future CD players will be able to buffer music between disc changes, and provide off-line cuing so the operator can browse and schedule tracks just as a DJ does today, but with the benefit of a memory buffer for providing a continuous music replay while other tracks are being browsed and selected.

A personal playback system based on hard-disks and/or on automatic CD and CD-R changing from a library, removes the importance of the contents of individual discs as an influence on what track to play next. Track selection can proceed on purely aesthetic criteria, with the tracks being chosen without concern for where they are in the listener's music library.

Such systems also break down the discrete and serial nature of track playback which is common with today's consumer equipment. Music in the library could be indexed by tracks or by locations within tracks. One track could be faded as a new one is mixed in - while the new track may be timed to start after the introductory section. This reflects the way a DJ typically mixes dance tracks and is in keeping with the intention of the artists.

In the context of dance music, such systems enable consumers to add value to the music in their collection by manipulating it as a DJ does. Automated on-the-beat track synchronisation enables aesthetically pleasing results to be obtained without the skills DJs currently need to bring a track into time with its predecessor.

This greater creative involvement of the consumer in the playback process is a part of the listening experience of the consumer at the controls, an enhancement of the listening experience of their friends and an additional social aspect of the shared listening experience.

CHAPTER 16 PRODUCTION - RECORDING THE MUSIC

> *This paper focuses on the changing marketing arrangements for recorded music, but changes in the production techniques need to be considered as well.*
>
> *This chapter considers new composition, recording and performing techniques, especially performances which blend pre-recorded material with traditional playing.*

INTRODUCTION

Musicians and other people in the music industry are well aware of the rapid developments in musical instruments and recording techniques. This chapter looks at the likely developments in the origination and performance of music over the next ten to fifteen years.

Some developments can be predicted with confidence, but success of the more novel developments, such as the musical objects described in the previous paragraph, depends on technical and demand factors which are difficult to predict in 1995. One trend that clearly will continue is the use of computers and software instead of mixing desks, multi-tracks and outboard processing hardware. The flexibility and cost reductions available from this shift to computer based recording are likely to dramatically influence how music is made, and who can make it.

There is every reason to believe that the pace of technological development will continue at the rapid clip of the last decade or so. Some idea of the scale, if not the detail, of future developments can be gained from considering that in 1980:

- Drum machines and sequencers were virtually unheard of and were used only in disco music and by relatively obscure electronic bands.
- The only sampler used for popular music was the high-end Fairlight CMI.
- Virtually all instruments heard in popular music were physical instruments, played manually.
- Analogue methods were used for multi-tracking, mastering and distribution.
- Consumer's typically never heard music with the clarity and depth that was attainable in the studio. (The only limit today is loudspeakers and headphones - which remain a significant barrier.)

NEW PRODUCTION PARADIGMS

The "semi-professional" studio equipment market has boomed in the last decade and most popular music is originated in home studios. Final recording of mainstream popular music is typically done in large studios which bring together precise acoustics, elaborate recording, processing and mixing techniques and the professional skills to use these to create a polished product.

For any music which requires recordings of physical sound sources - especially voice, piano and drums - a properly equipped studio is essential. It is inconceivable that future technological developments will remove this need for rooms with controlled acoustics, good microphones and the skills to use them.

However more and more music is being developed in home studios, and there is a trend to using multitrack tapes from home as the basis for full studio productions - often because the excitement of the original takes cannot be duplicated.

Another option is to develop the music at home to create a sequence file and details of all synthesiser settings - which can often be included in the file. Then the synthesisers are taken to a studio with the sequence file (and the computer it runs on if the studio does not already have one). Additional instruments in the studio can be used as well, but the main reasons for going to the studio is to use its accurate monitor speakers, audio processing equipment (reverbs etc.) and especially its automated mixing desk. Andy Van from Vicious Vinyl reports that his company is able to record and mix three dance tracks in a 24 hour session at a major studio - a fraction of the time taken for most rock projects with physical instruments.

In some cases the music is sequenced and mixed directly to DAT in the home studio. This recording may go straight onto the CD or it may be manipulated in a "Digital Audio Workstation" to change sonic parameters such as volume and frequency response, to add reverb and to remove noise. Melbourne electronic label Psy Harmonics works in this way, taking their DAT tapes to Sydney where they are brought into final shape with the artist's intentions being executed by a producer operating a Sonic Solutions workstation. In some cases, the DAT tracks are longer than desired for the CD and whole sections are edited out and pasted together. EQ and reverberation is added after this and the result is a seamless track which makes the most of the track recorded in the "home" studio in Melbourne.

Some specialised work must be done to a collection of DAT recordings to create a master tape which can be used for CD production. Audio levels need to be standardised, starts and ends of tracks edited and aligned and track times needs to be entered to create the directory of tracks. In addition, ISRG (International Standard Recording Code - as described in chapter 4) data for each track needs to be entered at this stage.

ELECTRONIC INSTRUMENTS

The technology of physical instruments has changed little in the last decade, but electronic instruments have undergone several revolutions and there is plenty of scope for improvement. Electronic instruments typically excel in:

- Reliability, stability and low cost.
- Flexibility of sound production.
- Automation of sound attributes and of the playing of notes.
- Minimisation of the physical and mental skills required to produce musically useful results.

It is often thought that electronic instruments are more sophisticated than physical instruments, because of their greater flexibility and number of controls and components. However, in general, the sophistication of their sound production algorithms does not match those of physical instruments. No electronic instrument is capable of generating in real-time a signal as complex as that produced by a single plucked steel guitar string or a cymbal.

Electronic instruments typically pale in comparison to physical instruments in the domain of subtle control. A saxophone, guitar and especially the human voice all offer musically valuable control channels which surpass those of electronic instruments.

A discussion of the future of electronic instruments is beyond the scope of this paper. There is every reason to believe that in the next five to fifteen years, electronic instruments will offer more sophisticated sound production and greater subtlety of control. Sound synthesis and processing purely in software on standard computers or specialised DSP chips is an extremely promising area - see the discussion of Csound in the last chapter.

NEW COMPOSITIONAL TECHNIQUES

Higher level musical constructs - above the level of notes and sound - are likely to become more important in certain kinds of music which are currently sequenced directly. Existing sequencers typically work at a score level - rigidly specifying the characteristics of individual notes. Some programs also provide algorithmic approaches to composition, combining rules, probability and the composer's decisions to produce musical notes which can be played by a sequencer.

There is further scope for developing semi-autonomous processes which play notes and manipulate sounds. These processes would be controlled by the score, and by other processes. Composition could be transformed from the current approach to sequencing - which is like using a word-processing program - to a more abstract approach akin to training musicians, or compositional assistants, tweaking sophisticated equipment and then conducting the resultant ensemble. The results could still be augmented with traditional playing and singing.

Some of these compositional techniques can result in musical objects which can be given or sold to listeners and other musicians, with the possibility of flexibility in how they are used, and the option of modification to form new objects. As such objects become widely used, they could lead to the resultant music sounding the same, or they could be used creatively to produce results which are unexpected by the composer and the listener. Such accidental results provide an excellent basis for musical innovation.

The deliberate or accidental use of chance, either manually or via technology, has contributed enormously to the development of contemporary music. The use of low level compositional algorithms involving chance is a feature of many sequencing programs today.

However technology's greatest contribution to contemporary music is that it is so cheap. This has meant that hundreds of thousands of musicians (tens of thousands in Australia) can record and compose music, make mistakes, discover new directions at home, at minimal expense. It is difficult to estimate the number of home studios in Australia which produce saleable product, but it would be in the hundreds and perhaps thousands.

Comment [RW21]: Page: 256
If I contacted Teac/Tascam and the Fostex distributors and found out how many 8 track recorders they have sold, then added in the ADATs (8 track digital multi-tracks), this would give a reasonable figure for the number of home studios. Another approach is to find out how many DAT recorders have been sold in Australia - since every studio typically has one, and they are hardly used by anyone else.

Cost reductions in electronic instruments and audio equipment can be expected to continue, providing an increasingly fertile ground for musicians to learn their craft. The focus of these developments is changing from the multi-track tape recorder and mixing desk to the personal computer, and many functions which used to require expensive hardware are now performed in software which can be sold very cheaply.

Ultimately sophisticated music may be created purely by software processes running on the composer's computer - as has been done for the last twenty years in university music departments. With sufficient power in the listener's computer, these processes can be sold as music objects and customised by the listener to produce the music they desire.

MULTI-TRACK RECORDING

Only a fraction of musical styles can be generated by electronics and/or software. For voice and physical instruments, recording equipment will be needed. High quality microphones, and perfect quality DAT recorders can be used to capture a performance with little capital expenditure.

In a great deal of music, however, there is a need for multitrack recording. The future for multitrack technology can be seen clearly and its development is likely to be rapid - relying mainly on cost reductions in storage media and increasing sophistication of the control software.

Multitrack analog tape recorders and their digital equivalents are both widely used today. Digital machines offer better sound quality - although the idiosyncrasies of analog tape machines can be musically useful.

Both lock their tracks together - so it is difficult to manipulate tracks in the time dimension. Hard-disk recording systems eliminate the need for synchronisation between tracks. All the recorded material can be kept as separate files and manipulated in time as desired. Signal processing such as EQ, delay, reverb and noise reduction can often be performed by these systems. An important feature of hard-disk recording systems is that they integrate tightly with MIDI sequencers and time code for synchronisation to video material.

Hard-disk recording systems are evolving rapidly at present. The price of the hardware is falling precipitously, but some elegant solution to the backup problem is needed - with cheap CD-R or Magneto Optical Disc drives.

TECHNOLOGICAL EFFECTS ON THE CONTENT OF THE MUSIC

Over the next few years, the sophistication of the software control of hard-disk recording systems will mature - to offer fluid control over sound to suit most existing musical requirements. These new recording techniques will no-doubt give rise to new musical forms - just as sampling contributed to hip-hop, rap and other forms of music. One enormous advantage a hard-disk system has over tape based multi-tracks is the ability to make backups, and to "undo" changes. This encourages greater playfulness in the recording session - which in many respects enhances the productivity of the musicians.

New musical instruments and recording techniques have often been the impetus to new musical developments. The resultant music may influence other forms which do not rely on the technology at all. For instance in *The Wire* magazine (May 1994) a CD by solo singer Sheila Chandra is reviewed:

> *"The Zen Kiss"* works as an intricate tapestry of vocal traditions freed from specific temporal and geographic locations. . . . Sheila gives a little unexpected credit to recent developments in music technology when she refers to the track *"Speaking in Tongues"* as a "post-sampling thing; I couldn't have written it without hearing what a sampler can do.".

However, the flexibility provided by sophisticated hardware and software, and by musicians with broad musical horizons, does not mean that the product will be superior in all ways to that produced in the past. The process of mixing diverse influences can produce results which are unpalatable to some or all listeners. This mixing and matching approach may be fine for western entertainment music, but there are other areas of music where purity of purpose and integrity are crucial to a successful result. Traditional music may benefit in some ways from modern techniques, but it may suffer from over-production and by being taken out of its original context.

There are bright prospects for musical innovation resulting from new production techniques. However some listeners might favour a return to traditional forms and to simple sounds and compositional techniques.

BLENDING "LIVE" MUSICAL EXPRESSION TECHNIQUES

Current group musical experiences can be classified according to how live or pre-recorded the music is. At one extreme is the live performance - where all vocal and instrumental music is performed by musicians physically present at the venue - such as an orchestra, dance band or singer/guitarist. At the other extreme is a discotheque - where one whole track is played after another, with the only localised creativity being the DJ's choice of tracks.

A variety of intermediate stages have developed from each of these polarities, and further technical and aesthetic developments can be expected to fill in the gaps so that a continuum of expression techniques becomes available.

From the live end, the use of MIDI sequencers and/or samplers has given rise to "live" performances which are to a greater or lesser extent automated. In a minimal situation, a drum machine may keep time for what seems to be a totally live band - the drummer listens to a click track. This gives regularity to the performance, but restricts live response options such as tempo changes to suit the desires of the audience and musicians.

The next level is a sequencer controlling many of the instruments on or off stage, with vocals and some instruments being played live. Beyond that samplers can be used for vocals - with embarrassing results when the "singer" drops the microphone. Further still, the performance can be based on a backing tape - perhaps a DAT or multitrack with time-code, which synchronises a sequencer.

Such techniques are typically required because of the exacting nature of the music demanded by the audience - and the inability (due to lack or resources and/or talent) of the people on stage to play it reliably. When this is done with music - such as rock - which is "supposed" to be played live, then the performers may try to hide the sequencing.

This pretence that no sequencers are in use is harder to achieve with forms such as electronic dance music which is always totally sequenced in their natural environment of the studio. A performer may be flown from overseas to play one or two keyboards to a DAT recording of the rest of the track - and the event is billed as "100% live". On occasions when these keyboards can hardly be heard, this situation is almost the same as a DJ playing tracks - except the originator of the music is playing/miming to maximise the audience's enjoyment. From the point of view of other musicians, this may seem farcical, but it can be carried off successfully with appropriate stagecraft - especially in a dance environment where the thousands of dancers are the focus of the show and the musicians and lighting controllers are the facilitators.

Starting at the simple "track after track" disco scenario, there are two levels of musical control. One is the musicians' work on the recorded tracks. The second is the DJ's selection and manipulation of the tracks. Instead of complete tracks being played, with on-the-beat fading or cutovers, shorter parts of them can be played and there is the potential for extended fades between them. Tracks may be synced in beat or running out of time.

This raises the level of local creativity as the DJ uses tracks as raw material to create a final sound performance. In some cases, records are made with deliberately repetitive, minimal beats - little more than drum loops - and the DJ spins two discs, radically changing the speed of the discs beyond the usual 33 to 45 RPM range.

DJs can also add their own voices and instruments and manipulate the sounds with samplers and reverbs. Such DJ performances may be recorded and released as a fresh musical product. This blends live performance singing, playing and sound manipulation with pre-recorded music from discs and/or from samplers.

A good report on the conceptual and creative aspects of DJing is *Gimme Two Records and I'll Make You a Universe - DJ Spooky Tha Subliminal Kid* in August 1994 Wired. (Gallagher 1994)

Comment [RW22]: Page: 259
"Tha" is the way the title spells it.

The next step from this is live selection and manipulation of sequences - something which can be done at a bar to bar level with drum machines and similarly structured synthesisers such as the Roland Bassline which have inbuilt bar-orientated sequencers. These techniques, pioneered in the 1970s have contributed greatly to the popular electronic dance forms of recent years.

So the gulf between live performance and discotheques has been bridged from both ends in the last fifteen years, and vigorous new styles of music have flourished in the new musical territory which this opened up.

In the future, sequencing technology, real-time direct digital sound synthesis (music objects) and live control of both of these will enable new forms of music which combine live performance as sophisticated as any instrumentalist - but directed to controlling semi-autonomous musical processes which themselves generate the notes and sounds the audience hears. This could become a form of composition, or of conducting a composition.

Teams of musicians may collaborate on stage - or in the recording studio - with some preparing musical objects for the others to play or conduct. These objects could be the equivalent of instruments or of melodies and rhythms. These performances could incorporate any mixture of traditional instrumental work and singing, with musical material being generated at a variety of levels - sounds, melodies, sub-structures and overall structures. The material could be totally improvised, modified from pre-composed material or be pre-composed entirely. The pre-composed material can be stored in computers and/or the musician's minds.

It is commonly thought that music which relies on computerised instruments and sequencers cannot be played "live". This is often the case, because the music on CDs is typically the product of a studio full of equipment, and many days of work. However this is a "supply side" restriction of a technical nature - the musicians are certainly keen to play live. There is a tremendous audience *demand* for techno and other forms of music to be played live.

One Australian artist Steve Law - Zen Paradox - has toured Europe twice playing dance music solo. A few instruments are sequenced, but most of the music comes from drum machines and analogue synthesisers running from inbuilt sequencers. No notes are played manually - all the work is in the manipulation of the sequences and sounds. While some elements are pre-programmed, many aspects of the music are improvised in the heat of the moment.

With more robust packaging, computers will be practical to use for truly live performances. With sophisticated real-time interactive sequencer and algorithmic composition software, one or more musicians can blend pre-programmed music with improvised sonic and compositional manipulations as well as playing instruments manually.

Comment [RW23]: Page: 260
I spoke to Steve Law (Zen Paradox) about these details of his performances. He plays a a DAT tape only when changing all the equipment for another piece. This style of performance is something that some musicians are really keen about.

These increasingly complex forms of musical expression break down the traditional distinction between composer and performer. Some recorded music already is roughly equivalent to a multi-disciplinary team composing a symphony, playing it and designing the instruments for the orchestra all in parallel. This is currently a slow process performed in the studio, but increasingly sophisticated software and synthesis hardware will enable these functions to be performed in real-time for live performance. Further advances will reduce the costs of sophisticated hardware and software to the point where one or two people can use it for relatively low key performances such as in restaurants.

Instrument manufacturers have catered for this market by providing automated accompaniment instruments which provide drums, bass and accompaniment in response to pre-programmed styles and key changes - for instance the Korg Supersection, introduced in 1984. These instruments usually restrict the music to familiar styles, but enable musicians to provide music cost-effectively without having to program or play every note. This use of instruments which automatically play bars of music is primarily to reduce the effort in generating MIDI sequences of popular music - or to allow the musician to direct the structure of the accompaniment whilst playing another instrument on stage.

These auto-accompaniment instruments are utilitarian and relatively unadventurous compared to the stage and studio use of wilder musical objects created by musicians. However they provide productivity enhancements which enables live entertainment to be provided with fewer musicians and fewer hours in preparation for a given breadth of repertoire.

Remote performances

The group musical experiences discussed above form a continuum between playing records, performing pre-composed songs live, and even composing pieces and designing instruments in front of an audience.

Emerging technology will add another dimension - the ability for the performer and audience to be well connected even when they are not in the same location. Digital data links already enable a performance from a studio in one part of the world to be transmitted to an audience somewhere else. With sound and video feeds operating in both directions, a band may have a better idea of how its audience is responding than many performing today in a blaze of lights - where the audience is invisible.

The exclusivity of a performance may still exist - with the musicians performing for only one audience, or alternatively a number of audiences my gather in the capital cities of Australia for a performance from a band from their studio in Europe. Links between the venues and genuine response to the audience would make for a real shared experience between the collective audience and the performers.

This arrangement is at odds with traditional live, personal contact, forms of music - and may be inappropriate for blues or chamber music concerts. However for the increasingly large proportion of popular music which relies on elaborate studio infrastructures, the audience is likely to enjoy their own personal "transmission" from the band's studio more than the band performing to DAT, or attempting - and probably failing - to bring their studio to the same venue as the audience. Despite the use of large video screens and sophisticated remote control for venue lighting, this "remote performance" concept is less appropriate for performer centred rock music forms than for audience centred dance and contemplative forms.

Nonetheless, the extremely high costs of touring major rock bands will provide a powerful economic incentive for audiences accepting remote performances in place of the personal presence they would prefer.

For music which is amenable to remote performances - this represents an export opportunity for Australian musicians, who may play concerts in many parts of the world when their music is most in demand, without the delays and costs of touring.

There are benefits other than cost for the audience in a remote performance. Firstly, the flexibility means that a performance can take place with less planning than at present, and when the performer is at the peak of their popularity rather than months later, on the last leg of a world tour. Another benefit is that the performers are likely to be more fresh - since they will not need to perform so often.

Extrapolating this remote performance further so that the audience is in smaller groups, for instance pubs or homes - and we arrive at the existing concept of the live video broadcast.

Today, such broadcasts from overseas require the use of expensive satellite or fibre channels, and they can only be sold on free-to-air networks. For commercial channels, the performance must be punctuated by adverts, which detracts from the momentum of the experience for both performers and listeners.

However, in the future, the costs of international audio and video transport will fall, so it will be much cheaper to provide duplex audio and video links between the audience and performer. Subscription TV and especially Video On Demand will greatly enhance the revenues which can be raised, and will enable the performance to be economically delivered to a more specialised audience.

So in the future, remote performances are likely to be increasingly better matched to the needs of both specialised and mass audiences and be increasingly cost competitive with transporting acts from overseas.

With the duplex capabilities inherent in Video On Demand, there can be audience participation from individual homes - such as applause and requests for songs to play next. Furthermore, viewers may be able to select from a variety of camera angles or other visuals to accompany the music, or even control their own audio mix of the band's instruments[21].

Broadly speaking, this electronic sophistication brings the performers to the audience "virtually", rather than the performers, their equipment and the audience converging on a venue physically - with the expenditure of time and money for transport.

Although the experience of a concert venue full of excited people cannot be replicated by these remote means, there are significant advantages in terms of

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21 This raises some interesting questions since this gives consumers - or a group of consumers each recording a single instrument at home - access to the individual instrumental tracks of the performance. This would enable them to manipulate the music and issue their own mixes - which would not be authorised and could be sold to dedicated fans.

sound quality, personal control over sound level and immediacy of sound. Even with the best sound equipment, large concert venues often suffer from echoes and significant time delays because of the distance between the loudspeakers and the audience.

Although a TV video image comes a poor second to the experience of sitting in front of the performers, it is typically much better than what audience members see if they are sitting near the back of a venue which holds more than a few thousand people.

From an export point of view, these remote performances provide a saleable product or a more powerful extension to the promotional functions now achieved with video clips, or in the future, CD and network based audio-video works.

Whenever a remote performance is delivered into the home, it can be captured for replay by the consumer. When many homes are equipped with CD-R writers, those homes who pay to receive the performance will typically record it for posterity.

Such user copying of the material could be avoided if the remote performance was limited to certain venues, and so never reaches consumer premises where it can be recorded. However there could be strong economic incentives for the performance to be sold to homes either immediately, or at a later time, because more people are likely to pay for it in this form than would attend a venue at a given time - just as the release of a movie through cinema, video and TV is staggered.

There are some fundamental problems with remote performances over international links. Digital and audio signals would take at least 140 msec to reach Europe via optical fibre[22] and so the round trip delay of about 0.3 seconds would detract from the direct connection that the audience and performer traditionally enjoy. Audio compression and decompression would add between 0.2 and 0.4 seconds to the round trip, and video compression would add even greater delays.

If the audience's and performer's experience of each other is to be musically transparent, then neither audio nor video compression can be employed - which increases the capacity required for the communications links. Fibre optic delays from Brisbane to Perth - amount to 23 msec in each direction - equivalent to the time it takes sound to travel about 23 feet in air. So remote performances within Australia are likely to have "immediate" connectivity between audience and performers if no compression is used.

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22 Signals travel at light speed in quartz, which is 69% of the speed in air or vaccum, and the fibre cable does not take a direct route. Links via geostationary satellites would take much longer. Links via low earth orbiting satellites might be as fast as through fibre.

However, compression must be used to get audio and video into consumer premises, so it will be technically impossible to have musically transparent two way connections between performers and home audiences. International remote performances will similarly be burdened by delays which mean that the audience receives the performance around 140 msec after it occurred and the performer receives their response at least another 140 msec later. (Delays to the USA and Asia would be less.) This is primarily a difficulty for the performers - especially if they want the audience to sing along.

CHAPTER 17 MARKETING AND DISTRIBUTION

> *The new technologies and techniques for marketing and delivering music have been discussed in previous chapters. Projections are made about the adoption of these techniques over the next fifteen years.*
>
> *Particular attention is paid to how people discover music and information about music.*
>
> *The integration of some of these techniques is explored from two perspectives. Firstly, how can the consumer best discover, purchase and take delivery of music? Secondly, how will new marketing techniques affect the business structure of the industry.*

INTRODUCTION

The music industry involves a complex flow of musical and other materials from creators to consumers, with financial feedback coming from consumers to creators by a variety of paths for some of the material they receive. The role of investors and content organisers - managers and recording companies - is crucial to facilitating this process. They work with other content industries, such as radio, TV and printed media, to facilitate the flow of material which typically generates no income - such as interviews, photos, video clips and advertising.

All these activities take place in, and contribute to, a social context for the music. Social and aesthetic factors are entirely subjective, and a piece of music may make little sense to an individual if it is experienced in an inappropriate context. The music industry can be seen as a two level process. At the first level, people's minds are influenced by a variety of means to enhance their receptivity to new music. At a second level, products are sold and income is generated.

The Communications Futures Project models content industries in four functional elements which could be applied to CDs - creation, organisation, distribution and retail. (See CFP Paper 3 *New Forms and New Media: Commercial and Cultural Policy Implications* pages 6 and 7.) This model applies to the flow of music from creator to consumer, but is not appropriate for modelling all the marketing, promotional and diffusion activities.

The core business activity of selling music takes place in a complex aesthetic and social milieu. The music industry attempts to change and extend this milieu to introduce new music to potential customers. However the marketing departments of record companies are not the sole players in the social and aesthetic field - musicians, dedicated fans and people in related industries all make essential contributions.

Previous chapters have described the nuts and bolts of the music industry, and the subjective experiences of consumers and creators. This chapter looks at how all these aspects of the industry may work together in the immediate future, and in the longer term, when electronic delivery will play a significant or dominant role in the market.

This chapter discusses many technical, business, aesthetic, social and subjective factors in an industry which is already very complex. This cannot be done comprehensively. The aim is to explore some of the most promising combinations of activities so as to stimulate discussion.

TRENDS IN COMMUNICATION TECHNOLOGY

Two fields of technological development will drive the major changes in music marketing. Firstly, new optical storage techniques as described in chapter 4 and summarised in Table 4.1.

Secondly, the speed of telecommunications to the home will improve by a factor of around 200. Table 17.1 shows telecommunications data rates on a logarithmic scale, with a comparison of the data rates required by various applications and provided by four delivery systems. Most of the population will have to wait at least until after about 2002 before they have access to data rates worthy of the term *super*highway - broadband rates (above 2 Megabit/sec) which will bring MPEG-2 video and electronic delivery of music to each home.

To visualise trends in the next fifteen years, a number of diagrams are presented below. These diagrams form a basis for discussion and are not intended as firm predictions. For a discussion of the evolution of broadband networks to the home, see BTCE paper 4 and its attachment and paper 6. The scenario presented below is more optimistic about high demand and early roll-out than the BTCE papers just mentioned. The two additional factors which lead to this scenario are:

1 - The expected growth of the Internet - fuelled by demand for the World Wide Web - and its widespread utilisation by business and consumers in the years 1995 to 2000.

2 - Significant electronic cost reductions for network and related personal computers equipment can be expected post 2000 when broadband services become widespread here and overseas.

Over the ten to fifteen year timeframe, radical changes in technology utilisation and performance are possible. For instance, in the seven years 1987 to 1994, handheld mobile phones dropped in price from $5000 to around $500, while the performance, in terms of size and battery life improved significantly. In the same time period, the Megabytes/dollar ratio of the typical hard-disks used in personal computers improved by a factor of about 50, while their speed and reliability improved and while their size, power consumption and noise levels were reduced.

The most dramatic transformation in communications will take place when the coaxial cables currently being installed for analog subscription TV are converted to carry individual digital links to and from each home. This will involve changes to a few amplifiers connected to the cable, and the installation of new electronics in the home and exchange. However this electronics will drop rapidly in price as the global market expands. So the changeover to digital coaxial cable signals can be quite rapid compared to the time taken to run the cable past 50% of homes.

Figure 17.1 shows data rates required for major applications alongside the rates available from four types of links to the home. The applications are:

1 - Internet access for World Wide Web. 14.4 kbit/sec is regarded as the minimum acceptable speed if graphics and limited sound samples are to be accessed. There is no upper limit to the speed which would be desirable for WWW access, but 128 kbit/sec is shown as an upper limit for today's WWW activities. For many domestic users, there would be little gain from faster rates in 1995 due to limitations in the speed of their computer, of the Internet backbone and of most WWW servers.

    However, as these improve over the next five years, and it becomes more economical to deliver large bodies of data - such as sound, video and higher resolution images - then local link speeds will be increasingly desirable.

    When broadband links to the home become available, it is likely that WWW activities will include full motion video, so the range of data rates will extend from 14.4 kbit/sec to 6 Megabit/sec.

2 - Electronic delivery of music to the home awaits cost reductions and speed improvements. It likely that music would be delivered in a 2:1 to 4:1 compressed form and that the consumer would not want to wait more than an hour to receive an hour of music. This means that about 400 kbit/sec is the minimum data rate - beyond the reach of BR-ISDN at 128 kbit/sec. However some highly motivated listeners may be so keen to buy music electronically that they will choose to use BR-ISDN to deliver an hour of music in about four hours - until faster alternatives become available.

    Ideally music would be delivered at the maximum rate supported by the local link. For instance, a 6 Megabit/sec digital coaxial or ADSL link could deliver an hour of 2:1 compressed music (0.7 Megabit/sec) in about 10 minutes if the link was not being used for anything else at the time (allowing for a 25% protocol overhead).

3 - MPEG-2 video. Depending on the program material, this may require between 2 and 6 (or perhaps more) Megabit/sec for image and sound.

In all the above applications, the data rates refer to the downstream link - to the home from the outside world. These applications require only minimal data to be sent upstream.

Other significant applications not shown on the diagram are:

1 - Voice telephony - typically 64 kbit/sec in both upstream and downstream directions.

2 - File transfer - for instance via Internet - from the home to somewhere else. In this case the upstream link determines how fast data can be transferred.

3 - Video telephony and video conferencing. Depending on the compression and quality of video, this could require from 128 kbit/sec to 1 or 2 Megabit/sec in both upstream and downstream directions.

The local link technologies are:

1 - Dial-up modems as used today, 14.4 and 28.8 kbit/sec. (Chapter 6.)

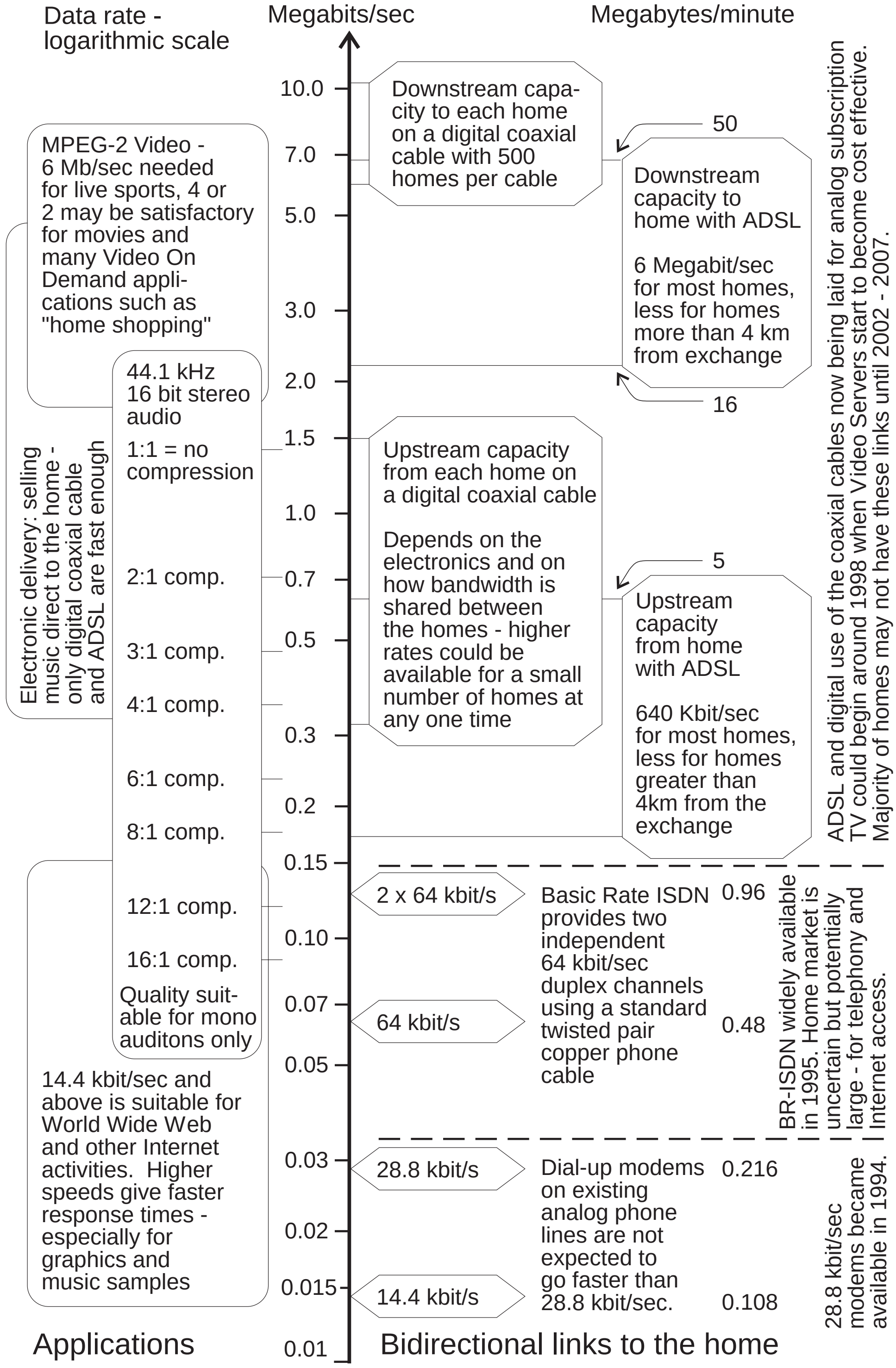
2 - Basic Rate ISDN (Integrated Digital Services Network). (Chapter 6.)

3 - Coaxial cables without analog TV channels, but carrying signals which provide individual, secure, digital data links to each of 500 homes on each cable. This is often referred to as "digital HFC" - Hybrid Fibre Coaxial. (Chapters 5 and 6.)

4 - ADSL - Asymmetric Digital Subscriber Line. (Chapter 5.)

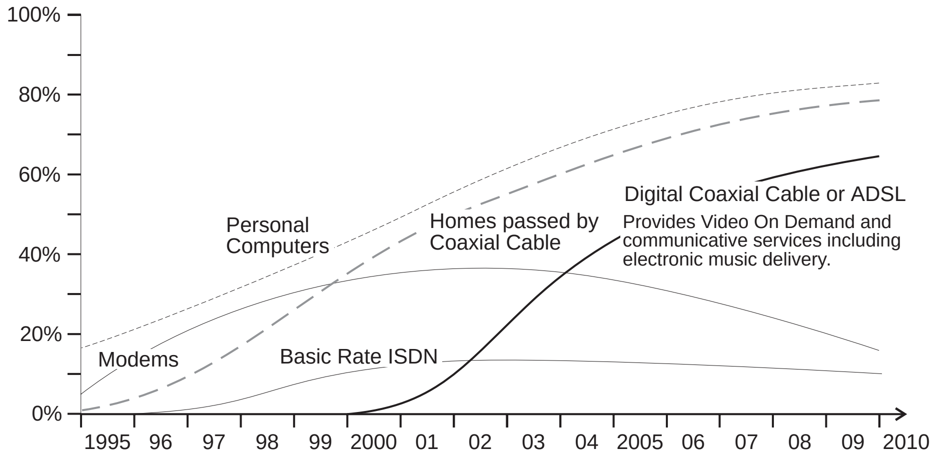
Basic Rate ISDN is currently available from Telecom in most urban areas, but is currently regarded as a specialist product and is used primarily for wide area networking and telework. If the rental tariff was reduced to the equivalent of two domestic phone lines, and if it was marketed well, this could become popular in homes. Its two 64 kbit channels can be used flexibly - for instance one for Internet access and the other for a phone call. BR-ISDN does not require any new cables to be installed, but some work may need to be done on the existing cables to ensure reliable operation.

FIGURE 17.1 DATA RATES OF APPLICATIONS AND LINKS TO THE HOME



In the years 1995 to 1999, the domestic demand for digital communications must be satisfied by dial-up modems and BR-ISDN, because it unlikely that ADSL or digital use of coaxial cable will be widespread before then. Subscription TV is adequately supported by analog use of coaxial cable (and MDS or satellite transmissions). When Video Servers become cost effective towards the end of the decade, Video On Demand will become a profitable service and can only be delivered with ADSL or by converting the coaxial cables to entirely digital signals so that each home has its own bi-directional channel of communication. (Perhaps individual links for some homes could be provided whilst analog video signals were still in use.)

FIGURE 17.2 PROJECTED HOME MARKET PENETRATION RATES FOR COMMUNICATION TECHNOLOGIES



See notes below Figure 17.3 for derivation of personal computer curve.

Figure 17.2 depicts home penetration rates for the four bi-directional data links described above. The adoption of digital coaxial and ADSL are summed into one curve since they provide comparable performance. These projections are purely for the benefit of the discussion of marketing - in 1995, no-one can reliably predict how these technologies will be adopted.

The diagram shows a 6% rate of modem usage in homes at the start of 1995. This is a rough estimate based on 3.9% reported by the Australian Bureau of Statistics *February 1994 Household Use of Information Technology* (Catalogue No. 8128.0). The standard error for this figure is 0.5% so there are two chances in three that the true percentage for the 6.39 million homes would be between 3.4% and 4.4%.

The same survey gives 23% (standard error = 1.1%) as the percentage of households where computers are used frequently - more than one hour a week. This would include computers which are not the Macs or IBM compatibles which are assumed to be required for the mainstream multimedia and Internet activities this paper is concerned with. Hence the 18.8% 1995 penetration rate for IBM/Mac computers used in Figures 17.2 and 17.3 seems realistic.

The burgeoning interest in the Internet, and the bundling of communication service software in operating systems (such as in Windows 95, OS/2 and Macintosh system 7.5) is likely to see the use of modems rise rapidly in the next few years. This integration of Internet protocols, access and application software into personal computers will provide a tremendous boost to the public's use of the Internet, and hence their knowledge of perspectives and information sources which are very different from those found through the mass media.

The projection for Basic Rate ISDN is based on the optimistic assumption that its annual rental will be reduced (from $960 to around $300), that it will be well marketed and that equipment costs for phones and computer interfaces will fall significantly. Under these circumstances, domestic demand could be strong since it will enable many families to let children access Internet or their school for educational and recreational activities - whilst still allowing telephone calls to be made and received. This adoption rate is a rough estimate. BR-ISDN is likely to be adopted by music industry opinion leaders - whose music browsing activities on the WWW would be greatly enhanced by using one or both 64 kbit/sec channels.

Around 2000, digital coaxial cable electronics, video servers and ATM based network infrastructure will be rapidly developing and dropping in cost. The next few years is likely to see a rapid replacement of analog subscription TV services with digitisation of the coaxial cables so that each home has its own bi-directional link. The same subscription channels would still be available over these digital links, but the links will enable access to Video On Demand - not just movies but all the applications described in chapter 7. Many of these services will already be flourishing via the WWW and so the digital links will enable more people to access them faster.

These broadband links will also be capable of supporting fully communicative applications such as voice and video telephony. With sufficient upstream capacity, they would be able to support computers at home which are permanently connected to the Internet to act as WWW servers - supplying WWW data to people all over the world. Many small servers today operate over a BR-ISDN line using one or both 64 kbit/sec channels. ADSL and digital coaxial cable should provide several times that capacity to each home.

One such WWW server application is music browsing and/or retailing. Electronic delivery of music from a home based server would require significant upstream rates which would probably rule out ADSL or a coaxial cable system which could not provide more than 600 kbit/sec. Typically, 4 Megabit/sec or more would be required - so as not to create a bottleneck for delivering music to consumers whose downstream link rate and computer storage speed may be this fast. A digital coaxial cable system could be designed to provide flexible upstream bandwidth from homes with suitable electronics. This bandwidth could vary with demand on a second by second or minute by minute basis - rather than being permanently reserved and paid for. Businesses will constitute a high value market for such upstream capacities and many will be located in residential areas. It is likely that telecommunications carriers will be able to satisfy these demands for upstream bandwidth by one means or another.

The primary purpose of the broadband digital links is to provide VOD to the home. Some observers believe that fully communicative functions - such as Internet access - will take some years to develop, because of the sophistication required in the switching software. A counter argument to this is that by the time broadband links arrive, the demand for high speed Internet connectivity will be so strong that this will be at least an equal priority for the carriers as the provision of movies, video news and sport etc. Assuming that the architecture of the broadband link system is based on ATM, supporting an Internet protocol link to the Internet backbone should not be so complicated as to require years of development - it will probably be part of the initial design of the system.

The take-up rate for digital coaxial (and ADSL) links depicted in this diagram is not as steep as the actual take-up rate for colour TV - which reached 50% of the population after three years. (See BTCE CFP Paper 4 Attachment 1 page 229 for a graph of colour TV, VCR and CD player adoption) The real cost to the consumer of digital links (not counting the required network infrastructure) is likely to be less than that of colour TVs in 1976, and the improvement in utility is far greater than the addition of colour - so the adoption rate projected here may prove to be conservative.

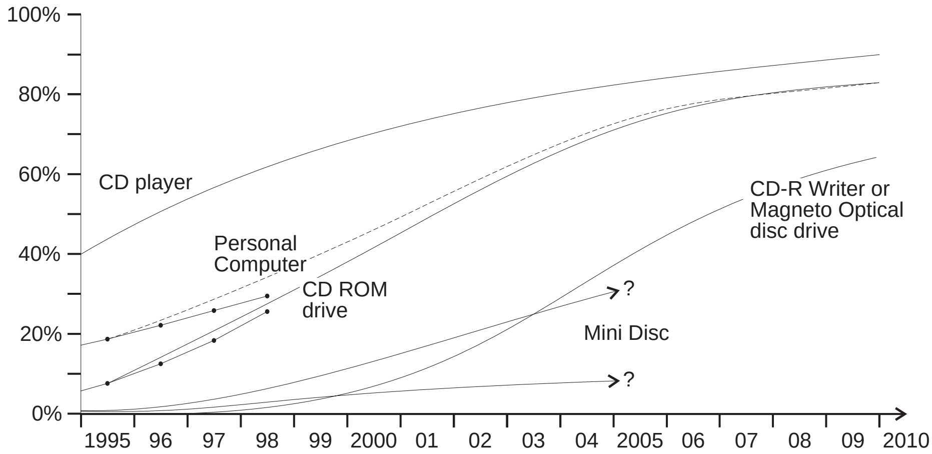
As with modems and BR-ISDN, it can be assumed that many of the music industry opinion leaders will be amongst the first to adopt digital links for VOD and communicative applications. The availability of digital links is likely to follow the pattern of coaxial cable installation - where the most inner suburban areas were judged to be the most profitable markets and so were targeted for the earliest introduction.

Trends in mass storage technology

Except when music is received directly from the network or a distributive system, it must be played back from a mass storage device. Developments in semiconductor memory - Dynamic and Flash RAM - are unlikely to be cost effective for storing music for several decades, by which time mass storage devices will be even more cost-effective.

Tape based systems such as DAT or DCC are not considered in this discussion on marketing - however the use of tapes for video and music storage cannot be ruled out. Magnetic hard-disks may be used for temporary storage of music, but the main storage technology for consumers will be optical discs. These range from standard pre-pressed audio CDs to multi-gigabyte blue light CD-Rs and rewritable Magneto Optical discs. These technologies were discussed in Chapter 4. For the purpose of discussion marketing, some assumptions must be made about their likely adoption.

FIGURE 17.3 PROJECTED HOME MARKET PENETRATION RATES FOR STORAGE TECHNOLOGIES



Personal computer rates include IBM compatible Mac and Power PCs. These projections of consumer use of computers and CD-ROM drives to the end of 1998 are derived from IDC predictions published in Cutler and Company's report for DIST, CSIRO and BSEG in September 1994 - *Commerce in Content*. These figures are marked by dots. The number of homes in Australia is assumed to be 6.9 million - CFP paper 4 page 15. The homes which adopt this equipment are likely to have more than the average number (2.6) of residents. The main curve depicting computer adoption is higher than the IDC figures to allow for the influence of more widespread use of World Wide Web than was anticipated in that report. The curve for CD-ROM includes all CD-R writers - which can read CD-ROMs.

Figure 17.3 shows projected home adoption rates for technologies which can store music digitally. In this context, the term "CD player" includes any stand-alone audio player which can read pre-pressed discs or CD-R discs. The performance of mass market discs is likely to change with new physical and data formats, so while the CD player of 1995 can only read CD discs conforming to the 1982 audio standard, a CD player purchased in 2008 is likely to also read CD-Rs and pre-pressed discs using blue light for higher physical densities, using a variety of data formats and several compression algorithms. However, CD players last for many years, so only a fraction of the installed base of players will play the latest formats. This means that while optical disc technology may make several performance leaps in the next 15 years, only major changes are likely to be adopted sufficiently by the market to warrant new standards of players and discs.

Likewise, the definition of "CD-ROM drives" will change to accommodate the major developments in disc technology. CD-ROM drives are computer peripherals and will also be able to play the audio CD formats which were standard when the drive was manufactured. CD-ROM drives which are part of dedicated games machines are not included in this projection. Despite the likely improvements in CD-ROM capacity over the next ten years, their attraction will fade as high speed access to the global network becomes increasingly available. CD-ROM today performs a distributive function - but the network will provide totally up-to-date information in exactly the quantities which are required - rather than in a dated bundle on a disc of limited capacity. This will result in an increased demand for CD-R writers - to store the data received from the network for later use.

CD-R writers are computer peripherals which can write CD-R discs - the technical details of which are likely to change over time. In 2008, this may well include blue light discs capable of storing 4.2 Gigabytes - 13 hours of music at 2:1 compression. CD-R writers will be able to read all CD-ROM and audio CD discs.

It is possible that mass storage in the home will be provided by high capacity Magneto Optical (MO) re-writable drives as well. MO discs cannot be read in standard CD players and unlikely to be read by future CD players which remain backward compatible with today's CDs. The Mini Disc is a MO disc with a capacity of 140 Megabytes. Mini Disc computer peripheral drives are available now, but because of their low capacity, are not considered in the main CD-R writer/MO drive curve.

These projections for writable disc storage - CD-R, Mini Disc and high capacity MO discs are necessarily speculative. However the demand for multi gigabyte home storage will increase progressively for backing up hard-disks and for storing data received from the WWW. The demand will escalate dramatically when digital video and music is delivered to the home. This demand is likely to be satisfied by some combination of the above technologies. When a mass market for these technologies is fully developed around 2005, it is likely that in real terms (using 1995 dollars) the blank discs would cost no more than $5 to $10 and the drives would cost no more than $600.

These projections are intended as a basis for the discussion of marketing - not as a detailed prediction of how disc technology will evolve.

The projections for the Mini Disc are based on the assumption that the format survives and finds a niche as a home recording technology. Whether this will happen is another matter. It could be argued that cheap CD-R writers would displace them - because consumers could make their own standard audio format CDs which they could play in all their existing players. The counter-argument is that CD-R is less convenient to record on. A standard audio format CD disc must be written all in one session, so all the music must be loaded into a computer and organised by the user. By comparison, the Mini Disc is far more convenient. It is as easy to use as a cassette recorder, it is re-writable and the organisation of tracks can be changed as desired.

Costs of disc vs. electronic delivery

The single most significant economic factor affecting the recorded music industry is the relationship between the costs of providing product in a physical form - on a CD or CD-R disc - of by delivering it electronically via a broadband network. In the latter case, the consumer must take responsibility, and incur costs, for storing the music temporarily on a hard-disk and then transferring it to a CD-R or a MO rewritable disc.

It is difficult to quantify the cost of delivering music on a disc. If it was only the cost of pressing and packaging the disc, then it may be only a few dollars. However, distribution and the risks inherent in purchasing, transporting and stocking the disc in a retail store, add a great deal to the total cost of delivering music in the form of pre-pressed physical product. CD-R discs made to customer requirements in a retail shop remove many of the risk and transport costs, but introduce other costs to do with administration, telecommunications, recording the disc and printed the material to accompany it.

Electronic delivery costs will be quite different. There is no physical transport and no risk from stocking products in the hope they will sell. However there are equipment, telecommunications and other costs which may vary widely over time, with the scale of the operation and with the distance to the customer.

There is no clear way of depicting how this relationship between the costs of these two different delivery methods will change over time. Part of the problem is that they have rather different capabilities and provide differing benefits to both buyer and seller.

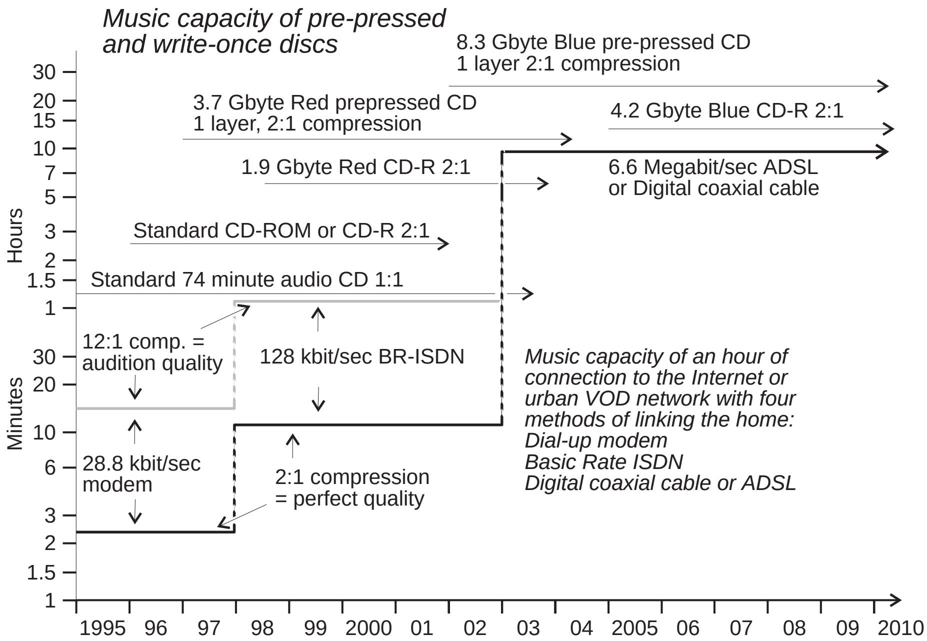
One aspect of this relationship which can be visualised is the quantity of music which can be received on either a disc, or via an hour of connection to the network. These are rather different sources of music, but have similar costs - or similar enough in the context of the huge changes which we are considering. The "network" in 1995 means a link to the Internet via a 28.8 kbaud modem. In 2003, it means a link via a 6 Megabit/sec digital coaxial cable link.

Figure 17.4 depicts these trends in very general terms - as a basis for discussion about marketing. 2:1 compressed music is assumed to be perfect quality, 5:1 may be adequate for many applications and 12:1 will probably be adequate for auditioning music. A logarithmic scale is used to indicate how much music can be delivered. Where not otherwise indicated, the graph shows times for 2:1 compression. It is quite possible that 2.5:1 or 3:1compression will be adequate for the great majority of music. Note that red light - and probably in the future, blue light - pre-pressed CDs will be available in dual layer versions - doubling the capacities beyond those shown in the diagram.

This diagram is based on Table 4.1 (CD formats) and Figure 17.1 (network data rates). BR-ISDN is assumed to be introduced in 1998 and digital coaxial (or ADSL) links at 6 Megabits in 2003. These times represent roughly the dates at which keen opinion leaders and consumers in metropolitan areas are likely to start adopting the technologies in sufficient quantities to influence sales and affect the evolution of music.

Not shown on this diagram is the increasing capacity of the typical personal computer's hard-disk to store music. If half the capacity of a 1995 standard 540 Megabyte disc was used for 2:1 compressed music, the time would be 51 minutes. In 2005, this could grow to perhaps six or as many as twenty hours.

FIGURE 17.4 PERFORMANCE OF MUSIC DELIVERY AND STORAGE TECHNOLOGIES



Internet evolution and the World Wide Web

In the years 1995 to 1998, Internet usage is likely to increase enormously. The World Wide Web (WWW) is becoming established as the ideal electronic method of exchanging information, promoting and conducting business. The WWW, email, Usenet newsgroups and ftp (file transfer protocol) are all supported by web browser software such as Netscape, which also supports the secure transactions required for transferring credit card numbers. With a personal computer, this software, a modem and an Internet account at an educational institution or commercial service provider, people can easily pursue their interests - saving and printing data as they wish. The Internet is unlikely ever to be as organised as a library, but navigational guides will evolve to ease the difficulty of finding things in a continuously expanding environment.

The Internet will be of interest and value to an increasingly large number of consumers. Sales of computers - and modems in particular - are likely to increase as a result. A number of commercial "on-line" services will commence in 1995 - from Microsoft, Apple and IBM. Demand pressures will ensure that these offer full Internet access including easy access to World Wide Web resources.

People with interests in global, specialised, rapidly changing fields will find Internet access an indispensable means of staying in touch. Printed magazines and other existing media are unlikely to be displaced - but Internet gives anyone access to discussions and developments as they happen.

Web access for local interests and businesses is likely to grow rapidly - for instance classified advertising and the Yellow pages could both be made accessible - perhaps through the one menu system. By the time individual broadband links to the home arrive - 2000 and beyond - the public will be well aware of the global connectivity of the Internet and of how it can help them with their day-to-day needs for information and for buying products and services.

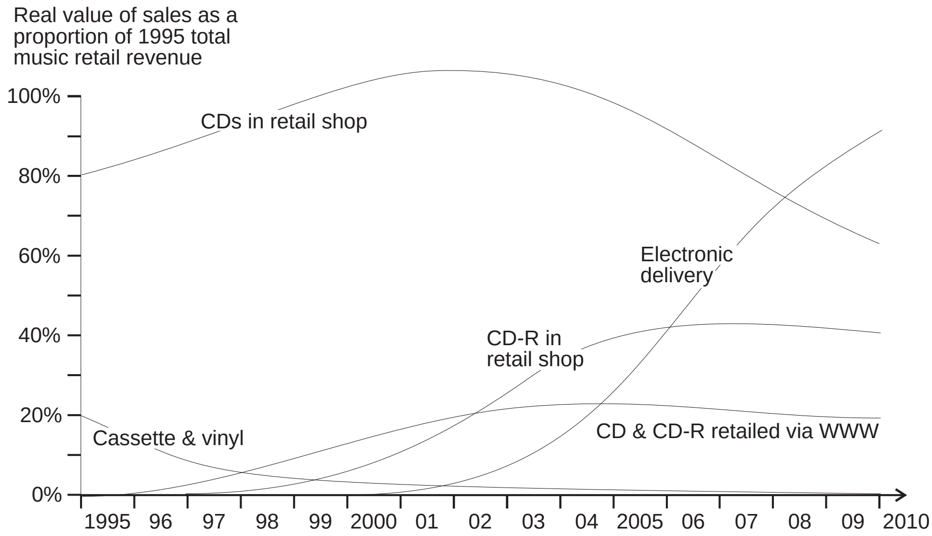
This means that when VOD arrives, it will support access to whatever the Internet has evolved into - as well as providing movies etc. VOD will not *introduce* "home shopping" - it will provide a faster link to existing WWW home shopping services, fast enough to support full motion video. Significant technical developments such as new Internet protocols and ATM will be needed for this, but work on these is well under way in 1995. Work on secure WWW information transactions, and electronic payment systems involving credit cards and digital cash is progressing rapidly at present. The security issue has almost been finalised and business and technical arrangements for funds transfer are likely to lead to the first substantial operational systems by the end of 1995.

By 2000, CD marketing over the Internet is likely to be well established, and when broadband links to each home are available, electronic delivery of music will be feasible for the first time.

Music retailing trends

Figure 17.5 depicts trends in revenues of recorded music retailed by various methods. Again, this is to provide a basis for discussion - these cannot be predicted with any certainty.

FIGURE 17.5 IMPORTANCE OF MUSIC RETAIL TECHNIQUES BY REVENUE



The source of the 80% figure for CD market share in 1995 is from the Business Economics and Forecasting Group, Uni of NSW, quoted in the ARIA 1994 Annual Report. The balance is sales of cassettes. Vinyl sales volumes are insignificant in the national context, but play an important role in the dance music market where 12" discs are purchased by DJs and opinion leaders.

Some assumptions need to be made about music retailing - in order to discuss future marketing issues. For the purposes of this discussion, cassette, vinyl and mail-order CD sales will be ignored. Three major trends in music retailing are considered:

1 - World Wide Web (WWW) marketing of pre-pressed CDs - music samples and related information are made available on the Internet, leading to direct sales with credit card payment over the network. However these activities also stimulate sales in retail shops. WWW marketing of CD-Rs recorded to customer order may also become significant, but this in included in the WWW curve.

2 - Retail shops selling CD-R discs recorded with complete albums of music, or with specific tracks to suit the customer's requirements. The development of this is difficult to predict, but it is assumed to be significant.

3 - Electronic delivery. When broadband links to each home become available (via Digital coaxial cable or ADSL) the WWW music marketing

operations will be able to deliver the music over the network rather than by mailing a disc.

In the early days of all these developments, the impact on total sales will be small, but the impact on musical evolution will be significant because the opinion leaders will be amongst the first to use these new channels of buying music.

WWW CD retailing will be low cost, since no retail shop is needed and the process is highly automated. This will be attractive to mainstream and niche market music consumers alike. Its impact on the market will be determined largely by how many people can access WWW from home, and are prepared to wait a few days for their music, rather than going to a shop during business hours and (hopefully) taking possession of it immediately.

Large WWW CD retailers in the USA already offer tens of thousands of discs, and if several discs are purchased at once (to minimise shipping costs) the cost is well below Australian retail. As WWW access becomes more ubiquitous, this will internationalise the competitive pressures on Australian CD wholesale and retail prices.

CD-R and electronic delivery will be relatively high cost at first - and so will serve mainly opinion leaders in niche markets. By 2005 to 2008, it is quite likely that the cost effectiveness of electronic delivery (and the concomitant costs of writing the music onto CD-R at home) will be highly competitive with physical disc retailing - so CD prices in retail shops will come under further pressure. It is impossible to predict the outcome, but for this discussion it is assumed that:

1 - Real CD prices in retail shops will hold for several years before falling due to competition with WWW retailers, CD-Rs and ultimately electronic delivery.

2 - CD volumes in general (shop and WWW) will grow significantly due to expansion of the range of music available and improvements in the customer's ability to browse music - over the WWW, in shops and via more specialised broadcast channels such as DAB and subscription audio.

3 - In the long term, the quantity of music on a single disc - CD or CD-R - increases significantly. For instance a red light pre-pressed CD with 2:1 compression could hold 11 or more hours of perfect quality music. Standard format audio CDs are likely to remain in production, but more music will be sold on higher density formats.

4 - The reduced costs in delivering music on disc or via telecommunications links is likely to reduce the average cost of music to consumers

significantly. By 2010, it is quite likely that the average cost will be less than $10 an hour in real terms, compared to $20 to $30 an hour today.

5 - The curves shown here show a doubling in retail revenues - perhaps this is overly optimistic. This may seem to indicate that the overall demand for music is highly elastic with respect to price. The assumption is that the average cost per hour is a third of today's cost, and six times the music (measured in hours) will be sold. This may seem to indicate that the overall demand elasticity for music is -2. The actual demand elasticity for individual music products would vary widely with the intensity of the demand for them at a given time (hit music at the time of release, a year after release or a hundred years after - classical music). Factors other than price which would lead to an increased consumption include:

   a - The increased variety and sophistication of music - consumers can choose from an ever increasing range of past and contemporary music, where new music may satisfy their desires more strongly than in the past. In other words, the music gets better, there is more of it and all the old music is still available.

   b - It will be easier to discover new music, and easier to purchase it than today. This ease of purchase results from browsing and ordering from home, rather than going to CD shops, and is quite separate from the reduced cost.

   Like the rest of these estimates, this is an educated and optimistic guess. The optimism is based on the observation that almost everyone likes music, and many people are passionate about it. However in 1993, Australians bought 1.62 CD albums and singles per capita, so there is scope for selling more music if it was cheaper, better and easier to find. (See Table 1.7 and 1.8.)

6 - Whatever the total revenue figure, a greater proportion of it than today is likely to go to the originators of the music - the composers, musicians, their primary investors and the studios. This is a pervasive trend, since the new marketing technologies are designed to reduce direct costs and reduce risks - both of which are high in the current CD retailing environment. These direct costs and risks fall on record companies and account for a large proportion of the customer's money which does not flow to the originators.

7 - The proportion of music sales in niche markets is likely to rise for a variety of reasons discussed elsewhere in this paper - particularly the development of new ways of discovering music which do not suffer from the restrictions of commercial radio.

Since these retailing techniques will be evolving in competition with each other, their cost-effectiveness to the consumer is likely to be roughly equivalent to each other despite the dramatic changes in storage and delivery technologies. For mass market music, price and ease of purchase are likely to be of greatest importance to consumers - so the music can be expected to be reasonably cheap.

In the niche markets, the consumer will be prepared to spend more money for a browsing and retail system which gives them access to the music which they seek. This can be seen as consumers paying more for the "personalised" service they require to satisfy their desires. Providing a huge variety of music with a good browsing ability will involve significant cost for the musicians and retailers and/or for the person browsing or purchasing music.

DISCOVERING MUSIC AND MUSICAL CONTEXT

Individuals must discover new music before they buy it. When new genres of music are discovered, the listener typically must become attuned to the broader context in which the new music exists - as discussed in Chapter 15.

One way is to hear the music, perhaps on the radio, through friends or at a retailer. This will be referred to as *discovering music.*

Another way is to hear or read about the music or about related aesthetic and social developments. This will be referred to *discovering context*.

The distinction is based on the medium involved. Music can only be discovered by listening to music. Context can be discovered by reading or hearing *about* music. For instance reading a CD review is "discovering context", because the music is not heard, but the reader discovers what a reviewer thinks of a CD. Listening to new music on the radio or at a friend's home is "discovering music", but hearing a review of the music on the radio, or learning the friend's opinion of the music is "discovering context".

Listening to new music at a retail shop is "discovering music". Reading CD covers at the shop - or reading anything about new music or anything related to new music - is "discovering context".

Opinion leaders and music consumers

Although this chapter is concerned with selling music, it concentrates on the diffusion of music and musical context to listeners before they buy the music, and how they in turn diffuse awareness of the music to others.

The study of diffusion processes is typically applied to major new products - such as the telephone or CD players. An overview of diffusion studies is provided by BTCE consultants *Entertainment Business Review* on pages 191 to 198 of Attachment 1 to CFP Paper 4. This covers the mathematical Bass approach and the Rogers approach which classifies consumers into innovators, early adopters, early majority, late majority and laggards.

For the purposes of this discussion, the population will be divided into three groups.

1 - Opinion leaders

This is the two percent or so of the population who most actively pursue new music. They buy music magazines, engage in frequent musical context interchanges - such as discussion with friends and via Internet - and they buy a lot of music. They listen to music more intently and talk about it with greatest enthusiasm. They are the first to tune into new music and new musical territory.

Most important amongst this group are the musicians themselves and the people from management and recording companies. This group includes DJs, journalists and producers in related industries who play and review music and convey musical context via mass media.

The most dedicated music fans (fanatics) make up the remainder of the group. They may organise fan clubs and communicate with musicians and other opinion leaders. Their influence on consumers may seem to be limited compared to the journalists, but is nonetheless significant. For instance in a high-school with 1000 students, one or two individuals may be recognised opinion leaders in certain genres of music, and their views of what is "cool" have a great influence on their music buying colleagues. Dedicate fans are crucial to the early stages of marketing new music.

Opinion leaders buy a lot of music on an individual basis, but their purchases probably do not amount to more than 10% of total sales. Their significance is in influencing others, especially musicians, and in buying promising music before it has become popularly recognised.

2 - Music consumers

This is the proportion of the population who purchase most of the music outside the 10% bought by the opinion leaders - say another 80%. Perhaps 20% to 30% of the population could be described as music consumers - however the exact figure is not important for this discussion. They do not lead trends, but if they adopt a trend set by the opinion leaders, then they consolidate it and provide most of its long-term revenue.

Most of their purchases are in response to exposure to the music by mass media, including specialised magazines which are available at newsagents. Their major influences are radio, TV and magazines - and the opinions of their friends.

3 - Non-participants

Since about 40% of homes have CD players, it can be seen that not everyone buys significant amounts of recorded music. These may include older people who cannot afford CDs or tapes - but who may listen to a lot of music on the radio. This group may make the last 10% of music purchases not attributed to the opinion leaders or music consumers. Their purchases are of limited economic importance, but most importantly, they play almost no role in the development of trends.

These distinctions are rather loose and related to a person's activities, rather than constituting population groups as the percentages above may imply. For instance one individual may be an opinion leader in the death-metal field and a non-participant in reggae. These distinctions are made to aid the discussion of the diffusion process rather than as a taxonomy of individuals.

Another aspect of the fluidity of the above distinctions is how they may change over time. New marketing techniques may make it easier for people to buy music - because of price, variety and accessibility - and so the proportion of the population who are now "non-participants" may shrink.

One dimension to the accessibility of music purchasing is the 24 hour availability of World Wide Web CD marketing and later, electronic delivery. This has important social aspects - including the privacy with which browsing may be conducted. Outwardly conservative people who would feel shy about listening to a Madonna CD or other risque music in a public retail shop may not feel such inhibitions in a "shop from home" situation.

Ian Tilley[23], from *Boom Crash Opera*, hopes that the new marketing channels will reach people who today would never hear or consider purchasing the band's music.

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23 Conversation with author May 1994.

Non-participants are not considered further in this analysis, however there is tremendous scope to expand the market for recorded music as the product becomes more powerful, diverse, personalised and accessible. Any changes which make music cheaper will certainly expand the market - because virtually everyone enjoys music.

Diffusion of music and context

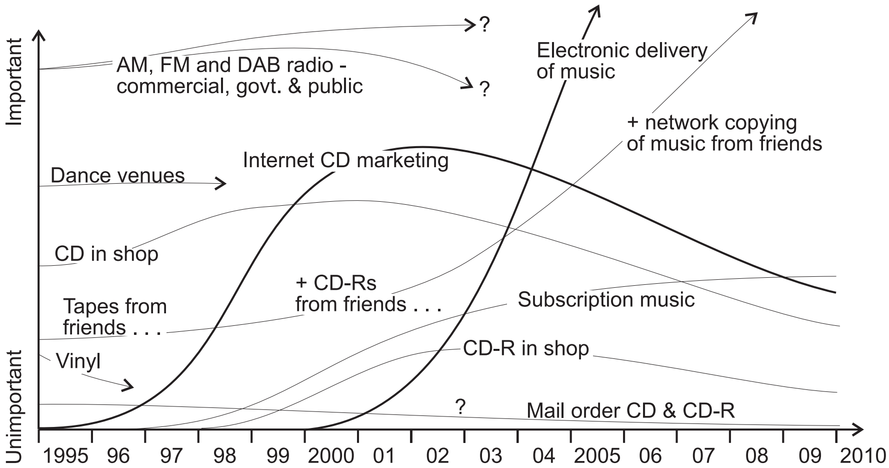
The focus here will be on diffusion in the non-classical fields of music - where new repertoire and musical directions are constantly being produced. However it is relevant to "classical" diffusion because similar processes introduce individuals to the many genres of music which are no longer developing.

One definition of Western classical music is that it starts with medieval music and ends with musical movements which waxed and waned in the last two decades. The definition is constantly being extended. Classical music sales and diffusion is distinctive because there can be no influence on the creation of the music. It does however influence trends in interpretation and provide broader musical horizons for contemporary musicians and composers.

Music discovery for opinion leaders

Figure 17.6 is a speculative graph which depicts the importance of different technologies in helping *opinion leaders* discover music. The graph does not depict quantity of music, but rather importance in terms of the influence the discovery technique has on the development of viable musical trends - which is the most important function of the opinion leaders. So while opinion leaders in 2005 may listen to 2 hours a week browsing music over the network and 15 hours a week listening to radio, if the former lets them discover cutting-edge music and the latter only gives them an hour of this music, then the network browsing is twice as important as the radio.

FIGURE 17.6 IMPORTANCE OF MUSIC DISCOVERY TECHNIQUES FOR POPULAR MUSIC OPINION LEADERS (THIS IS THE CORRECT DIAGRAM - RW, 2011-01-04)



Music retailed on audio cassettes is typically for consumers and so does not appear in this diagram. An important means of discovering music within the music industry is cassettes, DATs, CDs and CD-Rs made in small quantities to promote artists. These are not shown in the diagram because they are internal to the industry and their influence is unlikely to be changed by technological developments.

However "Tapes from friends" is a significant means of discovering new music within and outside the industry. Opinion leaders who receive and send tapes made from any source are exposing themselves and others to new music which someone was enthusiastic about. As CD-Rs become more cost-effective, they will be used for this activity - which is essentially "comparing notes", sharing recently discovered musical treats with friends.

To a limited extent, with Internet (via modem and BR-ISDN), this activity can be done by file transfer of short samples of music. However this may cost a few dollars for a few megabytes - which translates into a few minutes of music. When broadband links become available, many opinion leaders will be amongst the first to adopt them. With the reduced costs and greater convenience, it is likely they will be sending samples or entire tracks to each other over the network. There is a lot of spirited discussion about music on the phone and via email. If it is easy to send the music in question to a friend - perhaps by dragging a music file icon onto the icon representing the friend - then the most interesting pieces of music could be circulated amongst friends very rapidly. There is likely to be no distance limit - but telecommunications costs are likely to be much higher for sending a 30 Megabyte track to someone in another country than to a friend nearby.

One significant means of discovering new music which is not shown in either Figures 17.6 or 17.7 is listening to music at a friend's place. This includes exploring their CD collection and playing tracks there, or borrowing the CDs for a while. This typically provides valuable contextual information - the friend's recommendation and knowledge of the music.

CD rental shops and libraries (including public libraries) are another means of discovering new music. They offer a deep experience of the music without the risk of the full purchase price.

It is also possible to browse and buy CDs via phone - as described in chapter 14. This operates from any home, or even from mobile phones. It is accessible to anyone but is difficult to use without printed instructions, a printed listing of the CDs or artists available and the code numbers for tracks. It could provide contextual information about the artists and music. It could function as a music discovery technique if listeners spent the time to browse artists they had not heard before. However this would require someone - most likely the caller - to pay for the phone call to the central server.

Vinyl 12" records in shops are typically browsed and bought by DJs and other keen opinion leaders. Their sales volumes are low compared to the rest of the industry, but they are an essential part of marketing dance music because DJs prefer vinyl records which they can manipulate on the turntable. How long this preference will persist is hard to tell - perhaps CD players will be designed to give DJs the intimate control they need. Dance music is at the cutting edge of musical territories which may develop into top selling musical movements. It has a major influence on other fields of pop music.

Dance music develops income and public recognition via a two level process of consumption - with the DJ as the first level purchaser (and re-packager) and the public as the second level purchaser through ticket sales and bar profits, which finance the DJs. Club and radio DJs browsing vinyl and CDs in shops is a crucial part of the dance music discovery process.

Similarly, seeing a new CD in a retail shop, and either listening to it there or purchasing it (in hope or on some recommendation) is a crucial part of the music discovery process for opinion leaders in all areas of music. The curve for this goes up partly on the basis that new technology will make it easier to listen to the music of CDs in a retail shop. The other reason it goes up is that the proliferation of music magazines and the increasing importance of Internet discussion fora and WWW music promotional activities all provide contextual information about new music and names of discs to ask for. These channels are not usually capable of providing a proper listen to the music - but will lead opinion leaders and consumers into a CD shop with the right leads to find the music they are most likely to enjoy.

Most important of all music discovery mechanisms is radio. For opinion leaders in specialised fields, some of Australia's public/community radio stations such as 2SER, 3PBS, 3RRR and 4ZZZ play the dominant role in exposing music consumers and opinion leaders to fresh music. From all reports, we are very fortunate in this regard compared to other countries. Public radio's role in marketing music is discussed later in this chapter.

Radio's influence on opinion leaders may decline - as the diagram depicts - if these people spend less time listening to it and more on network browsing. Alternatively, its influence may increase with increased numbers of specialised programs, or with greater ease of listening to the programs - via network distribution techniques such as Audio On Demand, which might provide any radio program in the last two weeks for a small fee. Radio DJs may receive the support of their station for network browsing (Internet CD marketing and later, electronic music delivery) so they will be even more in touch with the latest developments than they are now.

The influence of commercial radio on opinion leaders is harder to estimate. Part of the problem is that commercial radio rarely plays new genres of music - so the new material it plays must be in an existing musical territory which is compatible with the station's format. At the level of exposing new tracks, commercial radio is very agile and can bring new songs to the attention of the majority of opinion leaders and consumers alike within a few days - something which is less feasible on public radio where each genre of music may have only one or two weekly programs. Commercial radio's role in marketing music, and the challenges it faces from other services, is discussed later in this chapter.

Personalised CD-R retailing in shops could have a significant effect on exposing opinion leaders to new music - but only if there is a sophisticated browsing system. If the system is limited to replicating albums, or selecting tracks from a text menu, then it will not enable the discovery of new music.

The two most important developments affecting opinion leaders' discovery of music are World Wide Web CD marketing, and later the browsing of music via a broadband network, for purchase and electronic delivery. Many opinion leaders will pursue these avenues as soon as they become available - before they become cheap and convenient enough to affect mainstream music consumers. The opinion leaders' insatiable curiosity about new music will keep them browsing as long as they can afford it and as long as they occasionally find something precious they could not have found by any other means.

A good World Wide Web CD retailer which enables people to listen to samples is like record shop, which does not run out of the most popular titles (at least as far as browsing is concerned) and typically has the new ones in stock quickly. The artist and track details can be browsed almost instantly. The cover artwork may take a minute or so to download (depending on the detail and the speed of the modem or BR-ISDN link) and brief music samples of at least some of the tracks should be available after a few minutes wait. Hyper-links to related artists and music will keep keen music fans browsing. However WWW retailers may not provide links out of their pages - they want to keep the customer "in the store". (AussieMusic OnLine provides links to other sites, but the Australian BMG WWW site does not.)

Opinion leaders will discover a great deal of new music by browsing WWW retailers who provide samples. They may discover new music there by random or genre based browsing. See the IUMA for an example of both - where there is a page with links to the most recently added artists. They may be led to the retailer or the artist by contextual material gained from network based discussion fora (newsgroups and mailing lists) and WWW pages maintained by recording companies, artists and fans.

As a means of discovering new music, WWW CD retailers will only be eclipsed by full electronic delivery of music. The high speed local links enable track details and graphics to appear within a second or so. Most importantly, the entire contents of the music can be browsed - rather than the samples chosen by the retailer. The costs of browsing must be paid for directly by the browser, or by the seller - and hence ultimately by the purchaser.

Opinion leaders will be the first to avail themselves of this, whenever they can find access to high speed local links. This may be in the workplace - especially for those opinion leaders who work in the music industry.

Not shown in the above diagram, is the influence of TV, subscription TV (MTV 24 hours a day?) and later, Video On Demand. These are not shown, primarily so that the diagram is not overly complex. However, their influence is bound to be significant. TV music programs can be likened to radio, with 24 hour a day MTV likened to commercial radio. Music Video On Demand will offer something like the browsability of an electronic music delivery system - but without the variety and probably not for free.

A broadband network supporting Video On Demand is likely also to support hyper-links to the whatever the World Wide Web evolves into. It is possible that Video On Demand activities, such as menus and watching movies, sports and news will take place entirely *within* whatever the World Wide Web evolves into. In either case, a VOD video clip of a pop song is likely to have a hyper-link to where the consumer can purchase the CD - or purchase the music and receive it over the network. There are tremendous applications for hyper-links leading consumers from one activity to another - typically to one where they will be tempted to purchase something.

By the time VOD arrives, it is likely that VOD music videos will be integrated tightly with music marketing activities. The consumer may browse video clips, view one, and with only one or two presses of the remote control be ready to purchase the music. Video clips today could include a scrolling text message showing the URL of the artist's home page on the WWW.

The CD cover discs on printed music magazines are an excellent way of discovering new music. Full pieces of high quality music are presented in the convenient CD format and the magazine typically contains related contextual information. Printed magazines are discussed later in this chapter. For simplicity, they are not shown on either of these diagrams, but their role in introducing both opinion leaders and consumers to new music is likely to increase.

Also not show, but nonetheless significant is the exposure to new music in live performances - at pubs and in large concerts. This is typically not a means of discovering fresh musical styles. Its significance is unlikely to be affected by developments in technology - as long as the live performance scene remains economically and musically viable.

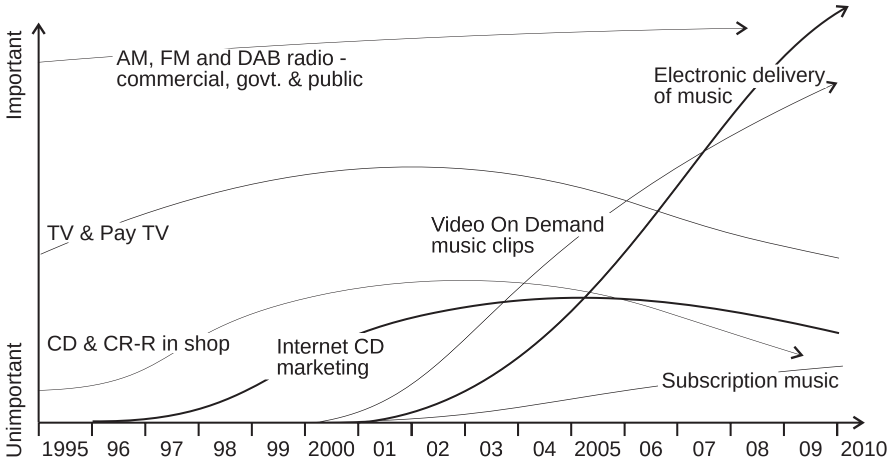
Music discovery for consumers

Figure 17.7 depicts trends in music discovery techniques for mainstream popular music consumers. Consumers discover less new music than opinion leaders - or rather the music they discover is not as new. However the music is new to them. They are less active in their search for new music, and in many cases may be totally passive. For instance they may not listen to the radio with the intention of discovering fresh music, but when they hear something they really like, they buy it.

These differences are largely a function of the distinctions between opinion leaders and consumers which were made for the sake of the discussion. However the distinction is a valuable one since opinion leaders contribute 80% to the development of trends but only 10% to the volume of sales.

Several means of music discovery shown in Figure 17.6 are not shown here - vinyl, mail-order discs and dance venues. These are not significant means of musical discovery except for those consumers who do go to dance venues, or similarly to pubs and concerts.

FIGURE 17.7 IMPORTANCE OF MUSIC DISCOVERY TECHNIQUES FOR POPULAR MUSIC CONSUMERS



The exchange of tapes between consumers is likely to remain a significant means of music discovery, and CD-R and network file transfer will perform the same functions when they are available and cheap enough. For simplicity, this is not shown on the diagram.

Consumers are likely to continue their reliance on radio and TV to introduce them to new music. Pay TV music channels will increase the number of video clips which consumers can see - and hopefully the range of music as well.

VOD music clips are likely to be a significant new means of discovering music. Consumer's participation in Internet CD marketing and in electronic delivery will lag behind that of the opinion leaders. When a consumer has fast access (28.8 kbit/sec at least and preferably BR-ISDN) to the World Wide Web, there is every reason why they will use its CD retailers - because of the convenience of shopping from home. In addition, WWW retailers may have cheaper prices than local stores.

Likewise, automated browsing systems for CDs and CD-Rs in retail shops would be attractive to consumers and greatly encourage them to search for new music.

Consumer use of electronic music delivery can be expected to grow rapidly once it is cost competitive with buying CDs or CD-Rs by some other means. This will require the consumer's home to have a broadband link to a network with low charges per megabyte for Internet access. The consumer will need a substantial computer with a CD-R writer to store the music. Widespread consumer use of electronic delivery is likely to lag several years behind that of the opinion leaders.

DISCOVERY OF MUSICAL CONTEXT

Musical context can come from many sources:

- CD covers - including whilst browsing in a retail shop.
- In store advertising and discussions with sales staff.
- Reading newspapers and magazines.
- Interviews and discussions on radio and TV
- Discussions with friends - in person, via phone and email.
- Networked group discussions via mailing lists and newsgroups.
- Text and images seen or saved and/or printed whilst browsing WWW music sites - such as provided by fan clubs, magazines and CD retailing and electronic music delivery companies.

In the case of mass media, the content of the programs and articles comes entirely from opinion leaders. In the more interactive fora such as fan clubs and networked discussion groups - mailing lists, newsgroups and some WWW applications - consumers can contribute to the content. However since most participants in these may read hundreds of times more than they contribute, the contributions they do make *may* influence many people's opinions. ("*May*" because some contributions lack content and so are ignored.) When a consumer's contribution does influence hundreds or thousands of participants, they may be considered an opinion leader - at least for the time while their contribution is active.

Context discovery channels may cover a broad range of material - including fashion, politics, cultural background and history. An example of the latter three would be any magazine, newsgroup or WWW page which discussed the Mabo native title legislation, and Aboriginal and European aspects of Australian history. These would constitute contextual material of great value to appreciating music such as Yothu Yindi's - even if the material made no mention of music at all.

A valuable aspect of the music industry is the way that music and music context material exposes millions of people to information about Australia which enhances (hopefully!) our international prospects, not least in terms of trade and tourism. An example of this is a discussion of Mabo in the midst of an article on a San Francisco band called *Trance Mission* in the June 1994 issue (Vol II No. 3) of US magazine *Axcess.* Their music is described as "ethnic ambient techno tribal post industrial trance". This two page article also mentions didgeridoos, The Kronos Quartet, The Residents, Snakefinger, *Nosferatu, Metropolis,* Circus Oz, Captain Cook, Arab and Chinese trade with northern Australia 500 years ago, a Korean bamboo oboe, The New York Early Music Ensemble and the band's 1991 CD *Sound Column* which is on Extreme, a Melbourne label.

Some articles from back issues of Axcess can be read via the World Wide Web, and this article should soon be available at:

```
http://www.internex.net/axcess
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Comment [RW24]: Page: 293
The editor told me he would make this article available. He was very keen about this paper, so I expect it will happen.

This illustrates the eclecticism of musicians and their audiences, and the connectivity paradigm - finding common connections between things which are geographically and conceptually disparate.

As encyclopedias become networked applications, rather than books or CD-ROMs, almost any of the above references can be explored by the reader whose interest has been stimulated. It is likely that World Wide Web resources will increasingly be indexed and accessible with a keyword search, so readers will find WWW music context material linked both to and from other non- WWW material. Some of these links will lead to music samples and CD retailers. Ultimately the links will lead to music sales over the network.

It is difficult to quantify the importance of the various channels of context discovery. New technology will enable increasingly specialised printed magazines due to falling production costs. It may lead to increasingly specialised radio shows - due to the availability of more channels. Audio On Demand will increase the accessibility of these radio shows by making them available at any time, and making shows from other cities and countries accessible locally. This would greatly enhance the ability of keen music fans to discover both new music and its context.

Network sources of contextual material

Networked discussion groups provide international fora for casual discussion and for the regular distribution of discographies, tour dates and up-to-date FAQs - files which answer "Frequently Asked Questions" about an artist. The World Wide Web makes many of these activities and resources easy to browse and easy to find.

Whilst writing this paper, the Internet link was started and Netscape WWW browser used to search for musical context. Clicking on the Internet Search menu item, a search of the WWW was made using the Lycos search engine at Carnegie Mellon University (http://lycos.cs.cmu.edu/) for the word "Gwar". This is the name of a band interviewed in Axcess Vol II No. 2. *Gwar's* photo and interview made other metal bands look like humourless introverts. Within two seconds the screen filled with "hits" - descriptions of, and hyper-links to, WWW documents which included the word "Gwar". Twenty such hits were received and in a few minutes printed out for future reference. It was clear that most of them pointed to related pages on the IUMA - the Internet Underground

Music Archive. Clicking on a hyperlink brought in the main Gwar page from the IUMA (http://www.iuma.com/GWAR/), with beautifully formatted text and graphics - titled *GWAR Internet Slave Pit*.

At the start was a big picture file, which was taking several minutes to load. Under that were hyper-links to the various other Gwar resources on the IUMA - to GWAR Comics, Bios, Catalogue, Movies and Music.

Below that was some contextual material for the band, an edited version of which appears below:

> MILLIONS of years ago **GWAR** rampaged across the galaxy with a gang of Space Pirates called **The Scumdogs of the Universe**. Falling out of favour with their Master they were imprisoned on the most remote mudball planet in the universe... Earth.
>
> KILLING off the dinosaurs and inadvertently creating the human race by having sex with apes, GWAR began to influence the development of the planet until after that wild gig in Atlantis when it was decided that they should be entombed in Antarctica to prevent them from screwing up the Earth any worse.
>
> SEVERAL thousand years later Sleazy P. Martini, known pimp, pusher, pornographer, and record business executive for Capitalist Records, accidentally stumbled into their Antarctic tomb and woke them up. He took them to New York, gave them electric guitars and began to market them as his latest Rock 'n' Roll sensation.
>
> SOME of GWAR's adventures are chronicled in their albums, comics and videos but there are still many GWAR stories waiting to be told. Check out GWAR on the Intergalactic Wrestling Tour! If you would like your corpse to join the food chain, consider sending email to GWAR at (gwar@infi.net)!

Now the contextual big picture had been revealed, a decision was made to go straight to the music section, where excerpts and mono or stereo versions of several tracks could be loaded onto hard-disk. A 1.8 Megabyte mono version of *Saddam A Go Go* was selected and in the twenty minutes it took to download, work on this paper continued.

When it was received, an MPEG audio decompression program was used to play it on continuous rotation, and the volume was maximised in accordance with the aesthetics of the piece. The track ran for 1 minutes 52 seconds before it abruptly terminated - and started again. The music could be described as heavy metal with a tasteful horn section and a *TISM* like intellectual thrust. While this was playing, the biography for band member *Oderus Orungus* was loaded into Netscape and printed. This contextual material is more explicit and interested readers are referred to the original source.

Comment [RW25]: Page: 294 Note to BTCE - *TISM* is the well known and respected Australian band *This Is Serious Mum.*

As *Saddam A Go Go* played continuously, the GWAR Comics hyper-link was activated. This lead to the first page of a story in which Gwar fought their manager who was determined to sell them to the record company which owned all the other bands in the universe. While the many image files were loaded, work continued on the paper.

After about ten minutes the monochrome images were all received - about three screenfulls. An attempt was made to print the images, but Netscape crashed (Netscape often crashes with large print operations - the problem could be with the author's computer setup). The pursuit of Gwar contextual material was postponed to a later date and the continuous repeat playback of *Saddam A Go Go* was stopped.

The Lycos search process was repeated for "Gershwin" and a variety of promising hits were made - including links to CDs containing Gershwin's music which were available from retail shops with WWW servers. No detailed contextual information was found, but a description of a 1984 *Residents* recording of the music of George Gershwin and James Brown was found.

The process was repeated for "Tallis" in the hope of finding material about the great 16th century choral composer Thomas Tallis. Some hits referred to this composer or to the *Tallis Scholars*, but most lead to a person of the same name who heads an Australian indie band and has a WWW server and hyperstore called "Wood and Wire". One promising link seemed to be to a discussion of the *Tallis Scholar's* misuse of tempo variations, but this link failed - probably because the server it pointed to was inoperative.

No hits were found for *2 Unlimited*, but excellent contextual information was found for another dance act *Culture Beat* - on a Sony music WWW server.

A search for *Arrested Development* lead to a review of the band's latest album, a list of the band's members and two short music samples. It also lead to a number of resources which were concerned with chromosomal abnormalities leading to arrested biological development.

All this contextual material was retrieved without stopping the Word for Windows program being used to write this paper, and without leaving the computer except to retrieve pages from the printer.

A good example of a fan supported WWW resource is Oilbase. This can easily be found with the Lycos engine by searching for "Midnight Oil".

`http://www.stevens-tech.edu/~dbelson/oilbase/`

This contains photos, album covers, discography, details of solo projects and a related band (Ghostwriters), lyrics to all songs (unauthorised with a disclaimer that it is not a challenge to the band's copyright), notes on the band's attitude to Oilbase (interested, but not involved) and to live tape swapping (cautious and concerned it does not become commercial). There is an extensive list of performances, some of which list the bands they played with and the songs played.

Oilbase is compiled by the "Powderworkers", who also run a mailing list for discussing the band and related issues such as the merits of Greenpeace and clear-cutting of forests. Discussions started on this list which are not directly related to Midnight Oil, such as about other Australian bands, take place between interested people via personal email. The list has around 100 members, of which about a dozen are considered truly "active". Message volume may be a few per day, rising to 30-40 a day when a new album or tour is being discussed. Anyone with email (including people on networks other than Internet) can join the mailing list by sending email to `MAJORDOMO@CS.COLARADO.EDU` with no subject, with the text `SUBSCRIBE POWDERWORKS` in the first line of the message.

Variety of music available by browsing

The book industry faces similar problems to the music industry in making its huge range of product available to customers to browse and buy. However, books can be read by browsing in a bookshop. Some shops encourage people to read at length and provide comfortable chairs for this purpose

Perhaps the most ironic aspect of the music browsing situation today is how poor retail shops are - despite the thousands of CDs they stock. The CD cases are mute. Browsing for artist names, song titles and related graphics is easy, but it is likely that the music heard in the shop at the time is at odds with the music being searched for. Browsing for music is tiresome - the shop staff must locate the CD, put it in a player and the potential customer must listen on headphones whilst some music of contrary aesthetics is still audible from the shop's loudspeakers. Options for improving browsing of retail shops are discussed later in this chapter. Retail shops contribution to music browsing is currently very limited except for the most dedicated of opinion leaders who are prepared to listen to a handful of CDs they have never heard before.

The music industry can be seen as a chaotic proliferation of aesthetic diversity and saleable product. There is scope for further expansion in quantity before all potential consumers are saturated. There is scope for expansion in aesthetic range since it is unlikely that all musical territories have been discovered yet.

In terms of both sales and range of product, the music industry can be thought of as a colony of diverging organisms - which would grow over a period of decades to a size bounded by certain constraints. Growth in the industry is largely a result of those bounds being expanded by a reduction in constraints such as the cost and quality of sound replication technology.

A highly significant factor affecting the proliferation of genres and the generation of sales is the range of music which can be browsed or listened to without expense. Radio improved this enormously. The World Wide Web is about to expand the range significantly, and when electronic delivery becomes established, it is likely that every genre of music - and most of each genre's constituent pieces - will be browsable at a minutes notice from consumer's homes.

This vastly improved ability to browse music greatly enhances the productivity of the industry's marketing operations. Two central functions of music marketing are consumers being passively exposed to new music and actively browsing for it. Selling the music as discs or files is relatively straightforward once a customer has found what they want and is ready to make a purchase.

Second order effects of new browsing techniques

If a listener could accurately gauge a piece of music's real value by listening to 30 second samples of the music, then improved browsing techniques and range would be unproblematic. However this is not the case. Some music which is ultimately of the most value does not click in the listener's mind at first. Since the most valuable music is that which leads to new territories, it is bound to be unfamiliar at the first listening.

If the only way of discovering music was browsing - even under ideal conditions with the option to browse freely entire tracks - then the outcome may not be totally satisfactory as strange music could easily be rejected.

Bypassing these restrictions are several processes which lead people to music they ultimately appreciate, but may have rejected in a simple browsing situation.

1 - The listener is aware of context which encourages them to keep listening. This may be a recommendation from a friend or reviewer, or a more generalised impression that the music is worth pursuing because of fashion or high sales.

    This does not always lead to a listener satisfaction, because the friend's or reviewer's tastes may be fundamentally different to the listener's.

2 - The listener is exposed repeatedly to the music through it being played by friends or by hearing it on the radio, at dance clubs or at live performances. During this experience, they discover what the music has to offer.

3 - The listener buys a CD because of certain tracks and plays it in its entirety, despite not liking other tracks. This repeated exposure can reveal positive aspects of the less favourite tracks which were not immediately apparent. This can also happen within a track - new aspects are revealed with repeated listenings which were motivated by more obvious attractions.

On the remote control of a CD player used for customer browsing at a CD shop, the most worn keys are "skip to the next track" and "fast forward within the track". To the extent that music has to market itself in a browsing environment, it will be most successful if it is immediately attractive near the start. This means that there are strong reasons for putting the most accessible and/or the best tracks at the start of a CD. Pop songs sometimes follow this pattern by giving a taste of their most memorable moments in the first 30 seconds.

If people's introduction to music was purely by a massive browsing system, they could be tempted to browse very shallowly - so as to cover the maximum possible material. Fortunately, networked browsing systems are likely to be accompanied by valuable contextual information about the secrets the music may hold.

This can be done with printed magazines as well - with a cover disc containing complete pieces of music and extensive commentary, graphics and information about the artist.

OPTIMISING BROWSING IN THE RETAIL SHOP

Chapter 4 described mass storage systems for audio CDs, CD-Rs and red-light CD-ROMs as a means of providing music for writing customer CD-Rs and to allow them to browse the music the shop stocks. Such mass storage systems could be used simultaneously for one or more retail shops and for WWW access.

The aim of this section is to answer the question "What is the most attractive, productive means of encouraging customers in a retail shop to buy music in that shop?". The capabilities of emerging technology have been discussed and the focus here is on satisfying the customer.

Ideally, one person or a small group of people could walk in and just by touching a CD cover in a rack, would hear the music at their preferred volume level over the shop loudspeakers. Ideally they could browse the CD track-by-track and skip forwards and backwards in each track. They could look through the CD's booklet, and use a computer screen to read biographies of the artist, watch video clips, search for other CDs by the artist and by related artists. This would enable and encourage them to discover many of the reasons why they would like to purchase the CD.

Since shops have to cater for several customers at once, and those customers only want to hear the music they are interested in, loudspeakers in the shop usually can't be used. This leaves the options of listening booths or headphones. Listening booths take up valuable floor space and could be hard to sound-proof adequately. They preclude browsing through racks of CDs. However listening booths provide immersion in the music, and they allow the main shop floor area to have music over loudspeakers.

Headphones could be attached to listening stations, or they could be movable, with an electronic tag to prevent people from walking out of the shop with them. The listening stations could have a minimal display and controls or a full colour video screen and keyboard. They could be mounted above the CD racks, so that people use them immediately they find a CD they want to hear. They could be mounted adjacent to the racks so as not to clutter the racks with listeners and headphone cords.

There needs to be a simple way that customers can choose which CD to listen to. Perhaps the easiest way is for each CD cover to have a small sticker with a 5 digit number on it. Alternatively each CD could have a bar-code sticker so the customer can place it on or in front of a scanner.

Mobile headsets

Ideally, the headphones would be *mobile* - driven from a small rechargeable battery powered transceiver which hangs around the customer's neck. It could receive its audio via an FM radio link which operates within the shop. Controls and an LCD on the box enable the listener to key in code numbers for CDs they want to hear, and to skip between and within the tracks. The LCD would show the track and artist details, the price, and confirm that the disc was in stock. There could also be a prominent "Buy" button, which adds the current CD to their shopping list.

This enables customers to wander around the shop browsing CD covers as usual, but listening to the music they choose. Since part of the value of the CD is in the package, customers need to pick them up and browse the booklet. A totally screen based browsing system would break the traditional connection between shopping and picking up the physical objects they want to take home. This is an instinctual hunter-gatherer approach to finding things and is a a highly satisfying experience which only a retail shop can provide. The mobile headphones approach allows the existing merchandising techniques to be used to full effect - in-store advertising and of racks containing dozens of the same title, ready to be picked up.

To maximise the social aspect of CD shopping, two or more people should be able to share the same browsing session - with the controls on one or more of the transceivers controlling the selection of discs and tracks. Alternatively each person could control their own browsing session, but anyone else in the shop could listen to their music. So three people could enter the shop and don mobile headphone/transceivers. Each could browse independently, and when they find something really hot, their friends could "tune" there transceiver to listen in, by pressing a special button and the number of their friend's transceiver. This shared browsing experience could also be achieved by plugging multiple headphones into the one transciever, but this would lead to tangles and breakages.

The social aspects or browsing can be very significant - tapping into peer approval and the knowledge that friends have of the music. It is especially important because it allows one person to share their enthusiasm with someone else - this enhancing their own enjoyment and spreads the word about good music.

Although the mobile headset approach is technically more difficult than fixed listening stations, it saves on the space and wiring required for fixed stations, and supports normal shopping behaviour.

Finalising the purchase

At the end of the browsing session, customers take their headsets back to the counter and the staff pick out the discs they "bought" from racks behind the counter, or from the main browsable racks. In a highly automated system even this could be automated. At this stage, the customer decides which discs they really want to buy or can afford, and which to leave - perhaps for another time. Some discs may be out of stock, so they may need to be back ordered.

The aim is to make browsing an enjoyable, social, relaxed, brainstorming experience, where the customer presses the "buy" button for any CD they are reasonably interested in - so it is on their "list". This is the first level of gathering - without a commitment to spend money. Once a CD has been added to their list, they can easily browse its tracks without having to enter its code number again. Comparison between two CDs would be facilitated with such a system. This may be particularly valuable when trying to decide which performance of a classical piece to purchase.

Irrespective of what is finally purchased, the customer should be able to walk out of the shop with a printed list of the CDs they pressed the "buy" button for. This forms a wish list for the next visit, and provides a valuable physical memento of their visit to the shop. In a sophisticated system the list could contain more than just the CD's name, artist and price. It could contain a copy of the cover art, a track list and names of musicians. This hard-copy would have the shop's name prominently printed on every page. Each page could be on fine paper, with attractive colour logos and contact details for the shop. The "shopping" list details could be printed by a laser printer - black and white text and graphics would be fine.

The printed wish list could be a short list of CD titles. However sometimes it would be desirable for there to be an A4 page devoted to each disc. This could come from a file supplied by the CD's recording company containing text and graphics about the CD and the artist. This should be smaller than A4 to allow for the letterhead of the retailer, and a space at the bottom where the retailer prints any other information - such as the price.

Such an A4 sheet would constitute a "flyer" for each CD. This would also help the staff recommend music to customers. In addition to the staff member showing the customer a disc box or playing the music for them, they could key in the names of a few CDs, and print out the flyers. Giving them to the customer they could say "Here are details of some discs which I think you might enjoy - have a listen to them now or next time you come in." These flyers could provide valuable contextual information which the customer could follow up with friends, via newsgroups or by finding WWW pages relating to the artist. The URLs of the WWW pages and newsgroup could be printed on the flyer.

The approaches described above would require some sophisticated software and some specialised hardware to support several dozen independent bidirectional links to the headsets. There would need to be some large jukeboxes. There is a world market for such systems, so they may become relatively standardised and cost-effective in five to ten years time.

This is a substantial investment, but it could be used to serve a number of retail shops in the same city - or with cheap enough telecommunications - within Australia.

The system would require some management, such as entering new discs into the database, together with files for cover art and track listings etc. to be printed on the shopping list and displayed on the computer console. These files are relatively small and can easily be retrieved via the Internet from the site of the CD's recording company or distributor. However, the system would automatically manage stock levels and eliminate some labour intensive administrative and customer service duties.

Extending a shop system for CD-Rs and WWW

Most of the resources of the above retail browsing system would be directly applicable to providing a WWW browsing and retailing system. Orders made from home in the evening could be processed by the staff the next morning, ready for the evening post, or courier pickup after lunch for delivery in the afternoon.

Most of the technical barriers to retailing CD-Rs to customer specification are to do with the browsing and administration systems which would be required. (The legal barriers are significant too.) The above browsing system could be adapted to compile a customer order for specific tracks. They could edit the track order and decide how to fit their chosen tracks onto one or more discs, and which tracks to leave on the wish list for the next visit. These operations would best be done with a computer screen.

The system would copy the tracks from the CDs, CD-ROMs and CD-Rs in the jukeboxes to the CD-R writer, and drive the printer to create the CD cover booklet and slick. It would also add the details to the royalty payment database.

CD-R retailing - ensuring royalty payments are made

In any CD-R retailing environment, the owners of the intellectual property need to be sure that the retailers will not be deceiving them about the quantity of music they have sold. This could be achieved by an industry body setting standards for the behaviour of any CD-R retailing system, and the use of independent consultants to validate a system's compliance with that standard. Software can be written so that it complies with the standard and so that neither the software itself nor the audit trail it leaves can be tampered with secretly. The CD-R retailing system could be connected to the Internet, so that its internal state could be monitored by a supervisory body.

All CD-R discs sold to customers would carry a unique serial number and logo identifying that the disc was made in a system conforming to industry standards.

OPTIMISING WORLD WIDE WEB CD RETAILING

WWW CD retailing commenced in 1994, and rapid developments are expected in 1995. Readers are referred to the web sites themselves to discover the latest approaches. Chapter 6 has some URLs for retailers and lists of music sites. This section explores the attributes of an ideal WWW retailing operation.

The system should clearly show whether the disc can or cannot be supplied - this could be shown as an availability time. Some discs will be in stock and available immediately, others may be available from a distributor, but with a one or two day delay. Other discs may be on order, with a shipment due in two weeks. It may also be desirable to show stock levels.

An unscrupulous retailer could fudge this information to trick customers - or other retailers who browse the system, but hopefully market pressures and self regulation by industry associations would minimise this. There may be a conflict between the benefits of giving prospective customers detailed information on stock levels and delivery times and allowing that information to be used by competitors.

The system should show an image of the CD cover, and potentially any other associated graphics. It should provide a track listing, with times, and a listing of musicians and composers. Ideally parts of any track would be available for audition, however it will typically only be possible to provide samples of highlights of one or more tracks - highlights chosen by someone familiar with the music. The samples should be short and long, in stereo and mono, high quality and low - to suit the customer's desire to take a quick listen, or immerse themselves deeper.

The screen display for each CD should contain links to other CDs and artists. Some of these links should (for the benefit of the person browsing) point outside the retailer's system - for instance to Oilbase for information about Midnight Oil. However the retailer may be reluctant to do this, because the person browsing may be distracted and not come back. Distraction is not inevitable - WWW browser programs such as Netscape have a "back" button to step back through the pages previously loaded, as well as a "forward" button to step through the pages to the most recently received. This is usually done from a local hard-disk buffer memory so it only takes a few seconds.

There needs to be a way that a customer can leave a "wish list" at a retailer so they can easily listen to the CDs they like during a later visit. Several retailers provide this now. The retailer's WWW server cannot automatically find the identity of the person who is browsing - so the wish list function can only operate if an account is established. This is typically easy to do - like filling in a form.

Any WWW retailer will need to offer secure transfer of credit card information, and accept payment in digital cash. It would be desirable for them to explicitly state their policy on re-use of customer details for their own marketing purposes or for sale to other companies. There are some consumer rights and fair trading issues unique to WWW commerce, especially over international borders - for instance the fraudulent use of credit card numbers, and the resolution of disputes. CD retailing is highly suitable for the WWW, so music retailers will find themselves at the cutting edge of a new commercial and legal frontier.

One issue which requires particular attention is that of territorial licensing of CD sales. For instance an Australian company retailing CDs from an Australian label to customers in the US, may need to consider US distribution deals already made by the label.

OPTIMISING ELECTRONIC DELIVERY MUSIC RETAILING

> *Electronic delivery of music is potentially totally different from today's retail system. In addition to the flexibility, speed, convenience and relative independence from geography, it offers the capability of the purchaser and artist interacting in meaningful ways.*
>
> *Network music sales can occur directly from the artist and their computer to the listener. In many instances, for technical and legal reasons, there would be intermediate layers - but they could function as transparent gateways so the direct link between listener and the artist is preserved.*

Many of the points listed above for WWW CD retailing apply to a system which can deliver music electronically to the customer. This discussion looks to the years 2005 to 2010, when electronic delivery is likely to be cost effective for many consumers.

Chapter 14 describes a way that the browsing and purchasing session can be conducted with a computer located anywhere, while the music is delivered from a server located close to the customer.

Customers need to be sure they are buying music from a legitimate source. Industry associations, and WWW lists of licensed distributors will assist in this. When an artist or recording company appoints an overseas agent, they need to be assured their agent's distribution system will keep accurate records. Industry associations, independent auditors, and direct Internet access at any time by the recording company into the royalty database of their distributors should keep fraud to a minimum. Indeed it may be an improvement over current arrangements with physical products where the recording company has to accept the overseas licensee's word for how many discs have been made and sold. Another advantage is that the automated system should be able to generate payments on a monthly cycle or less - better than the 6 monthly cycle common in today's record industry.

Electronic delivery retailers - and CD retailers post 1995 - will be operating in a new era of extreme information fluidity. In addition to competing with other retailers they are competing with the temptation the potential customer may have to copy the music from somewhere for free.

There are several approaches to these challenges:

1 - Make buying from a legitimate source really easy and as cheap as possible. These sources should be really easy to find and operate.

2 - Make the browsing and purchasing process feel really good. It should be enjoyable, give the purchaser the feeling that they are doing the right thing

and assure them that a high proportion of the money they pay goes to the artist.

3 - Make copying, or purchasing, from an illegitimate source feel really bad. There is a limit to what can be achieved in this respect - especially with a rebellious and poor youth market.

The structure of the music retail industry in the era of electronic delivery is likely to be quite different from today's arrangement of shops in cities, towns and suburbs. Whether there is one or several legitimate retail sources of a particular piece of music, there needs to be a clear procedure by which purchasers can be sure of finding the legitimate source(s). This may be a WWW master list of licensed retailers maintained by the appropriate industry association. This will be difficult to administer because there will be constant additions of artists to the list, and artists need to be free to appoint large or small retailers and to change their arrangements with ease.

However it is achieved, the consumer should be able to go to a particular industry endorsed page in the WWW and type in the artist's name and the name of the track or album. The system would respond with hyperlinks to the legitimate retailer(s) of that music. The order and manner in which these are presented would significantly affect the pattern of consumer purchases, so some mechanisms would be needed to eliminate anomalies which would bias the consumer for or against particular retailers. Since this is an industry endorsed consumer guidance mechanism, evenhandedness is vital. It must deny any benefit to retailers who operate from multiple business names or call themselves something like *AaBaaBaa Music* to unfairly increase the likelihood of consumers choosing them over other retailers.

Assuming the customer is sure they are buying from a legitimate retailer, the browsing and purchasing process needs to be as agreeable as possible. It should always be easy for the customer to change their mind and they should always be clearly shown what they are about to purchase. The total cost and the cost per track needs to be clear. A well designed browsing and purchasing interface makes people relaxed about choosing tracks in the first place. It would be desirable to provide a two level approach as suggested in the section above on retail browsing - a shopping list of tracks is assembled casually and when the customer is ready, they go through it, thinking about costs and priorities. These tracks should be instantly browsable. They may purchase some tracks, discard others and leave the remainder on a shopping list for next time. They should be able to print out their shopping list, or store it on their own computer for future reference.

Special characteristics of networked music retailing

The above points are sensible in any retail environment. However there are some unique characteristics of networked music marketing which can lead to benefits for both customers and artists.

Some of these relate to enhancing the likelihood that people will buy from legitimate sources. The following chapter explores options for minimising theft of intellectual property. When consumers have access to powerful encryption, storage and telecommunications, virtually nothing - or absolutely nothing - can be done to prevent people from illicit copying. So the industry in general and artists in particular must ensure that the legitimate purchasing experience is really positive for the consumer. The network sales session is the main battleground where the war against piracy and profligate consumer-to-consumer copying must be won.

The points listed previously about convenient browsing and choosing which tracks will be ordered are all valid, but are based on an "identical products off the supermarket shelf" paradigm of retailing. This paradigm is appropriate to buying functional items from faceless corporations - for instance buying typefaces or computer programs from an international company.

There are rich possibilities for enhancing and personalising music retail transactions because both producer and customer are emotionally involved in the product and/or in each other. The interactive networked environment provides methods for building customer loyalty - which are unheard of in traditional retailing.

In the following discussion, it will be assumed that the customer is at home, using their computer for a WWW session (or its VOD equivalent in 2005 - 2010) to buy music from one artist. In particular it is assumed that they are conducting a WWW session directly with the artist's computer. This would be feasible if both customer and artist were in the one country, or if it is located anywhere else and has a local server for the music - as discussed in chapter 14. However, all aspects of this example are also feasible using an authorised retailer's computer which maintains links with the artist's computer over the network.

This would mean customers in Launceston, Sydney, Osaka and Glasgow would all purchase music in the same way through their local retailer irrespective of where the artist's computer was. For simplicity this discussion assumes the artist does their own retailing and distribution. In practice it is likely that a recording company would handle this for many artists.

Personalised messages and music

Whether the customer is connected directly to the artist's computer, or to a retailer's, they have the impression that they are dealing with the artist. There are some obvious ways this personalised connection could be used, like the artist's face and voice appearing at the end of the transaction - saying "Thanks Bruce for buying my music. Catch you on the flipside!". Another cloying approach would be to substitute the customer's name in the love songs they buy - so instead of the vocals being "Oooh baby, got to have your love!" they become "Oooh Bruce, got to have your love!". The market prospects for such an approach were positive in the case of Slim Dusty's 1970s song "I'd like to have a beer with Duncan" - where multiple pressings were distributed, each with the name of a local DJ substituted for "Duncan".

Such approaches could be valuable, but this discussion focuses on more substantial communication between consumer and artist - with the aim of building a stronger relationship between them. The focus here is on increasing the loyalty of the listener to the artist and so enhancing the chance that:

1 - They will continue to acquire the artist's music, and recommend it to their friends.

2 - They will continue to acquire the music through legitimate retailers and encourage their friends to do the same.

3 - They will keep a watch for any commercial piracy or profligate copying of the artist's music. If a significant proportion of the highly motivated fans of the artist are opposed to such theft of intellectual property - its occurrence will be greatly reduced.

However there are other benefits for the listener:

1 - Increasing feeling of involvement with the artist and potentially a feeling of having affected the creative direction of the artist's work in addition to having financing it.

2 - A greater understanding of the context of the music - such as knowledge of the artist, composer and related cultural and political factors.

Electronic fan mail

The benefits to the artist of the above points are obvious, but the networked retailing environment provides tremendous opportunities for artists to better know and enjoy their audience. In a network environment it is easy to imagine artists receiving a torrent of email - and responding to it if and when they feel like it. However the network of 2005 - 2010 will also support voicemail, graphics and video. So if an artist inspires passionate adoration amongst five million fans - and passionate hatred amongst fans of other music - then their network "In tray" will have a constant stream of people writing to them, people talking, yelling, singing to them, people dressing up and pulling faces at them in still and moving images.

This electronic fan mail is likely to be more prevalent than the its paper based equivalent, because it is offers the fans casual and immediate contact with the artist. Artists may choose to ignore this input themselves, but to ignore all such input from customers may be counter-productive. Successful artists may need to hire staff to sort through the material to respond to some of it and pass some to the artist. It is likely that some of the input from fans can be used to enhance the artist's creative and/or business activities.

Additional information when browsing

When the customer is browsing the available tracks, the track names and playing times (and perhaps recording dates and prices) would appear in text on the screen. It would also be possible to show how many copies of the track had been sold, and to display this as a bar-graph or curve showing trends in sales since it was released. This may help fans to quickly pick the most promising tracks. It also helps the customer to see that their purchase makes a difference and that the total sales will forever be one higher after their purchase.

However in the case of a major artist selling millions of copies, six figure sales figures (multiplied in the customer's mind by the price) may make the customer feel insignificant and make them more likely to copy the music from their friends - especially if the figures keep ticking upwards before the customer's eyes. Sales graphs could also be provided by region - so it could be seen that a track was taking off in Nashville but not in Tamworth.

When a customer buys a track, the artist's system would typically keep a record of their name and their email and postal addresses. It might also store their nickname or even a small photo or graphic image sent by them.

Subsequent browsers may be able to see the names, nicknames or images of the people who have previously bought the track. This could be unwieldy when more than a hundred sales have been made, so there would be a way of sorting which purchaser's details would be sent to the person browsing. One criteria would be to send only those people in the same country or city - however this could be hard to determine, and communities of friends will not be so bound by geography in the future.

Another approach is for the person browsing to send the artist's computer a "peer list" of nicknames or names of people they know, or whose musical tastes they respect. The artist's computer could then show which of these people had previously bought the track. For this to work in a multi-retailer environment, the purchaser details must be sent back to the artist's computer - and hence the list of purchasers for each track must be sourced from there by the various retailers. There are three valuable things to be gained by this approach:

1 - The person browsing can instantly perceive peer group interest in the track. Perhaps it has been discovered and purchased by some people who are known to be discerning and adventurous listeners. This provides a strong incentive for the person browsing to listen more carefully to the track, or to buy it anyway on the basis that its true value will be revealed on repeated listenings.

2 - It provides a powerful means of directing peer group pressure so as to encourage the purchase rather than the copying of the music. For instance if Jason knows that both his friends Kate and Luke have recordings of a piece of music, he can quickly find out which of them purchased it legitimately. If Kate and Luke (or their nicknames) are on his peer list, and the artist's computer reveals that only Kate purchased it, then Jason knows that Luke has copied it illegally.

3 - After a person purchases a track, their name or nickname becomes visible to their friends who subsequently browse the artist's system. This accentuates the thrill of the hunt - as if to say "I found this before you did!" or "I found this music and think it is really great".

Customer feedback - to the artist and other customers.

Whenever a person is browsing or purchasing music, they should be able to leave a message giving their comments. This can be text - just a word, a few lines or a lengthy essay. The comments could be for the artist in general, but could also apply to each track. These could be voice or video messages too. This would capture the feelings of the listeners when they first heard the music, or after they had purchased it and listened to it.

This encourages listener feedback to the artist. Rather than writing an email, specifying a particular track, giving their comments on it and then sending it, the simply click a button and type "Wow!!!!", "Too laid back for me.", "Uhh?" or "ZZzzzzz", and hit return. Alternatively they could click another button, pick up their microphone and say it verbally - with all the personality and passion that the voice conveys.

These messages are stored by the artist's computer and used in several ways:

1 - The comments can appear to people subsequently browsing the music along with the commentator's name or nickname, as described in point 1 above. This can even be a means of leaving messages for friends regarding a specific track. For instance Kate may have been the first in her peer group to discover a track. She may think she is the first because none of her friends have bought it yet, so she leaves a self-congratulatory message, or perhaps something more constructive like "Jason! Check this one out!"

2 - The artist can browse the comments at their convenience. This provides valuable critical feedback and encouragement - perhaps within an hour of the music becoming available on the system.

In the case of the voice or even video feedback, the prospect of listening to a thousand little bursts of personal comment from fans may be both wearing and fascinating. From a marketing point of view, this intimate customer feedback should be valuable. The artist may be tempted to appropriate these voices and images of fans in subsequent musical pieces - or in video clips.

The artist may be inspired by some fan feedback to respond with text or voice - so encouraging fans to give feedback and bringing them into a closer relationship with the artist.

Follow-up material in the mail

After a purchase, or perhaps at three monthly intervals, the artist's system could print and mail a number of items to the customer:

1 - A "certificate" including the customer's name and confirming which tracks were purchased and when. It could include a serial number of the copy purchased - 00027 for instance signifying that the customer was the twenty-seventh purchaser. This provides a physical proof of ownership for the customer, and gives physical feel to what would otherwise be a purely electronic transaction. Amongst keen fans, certificates showing early purchases of significant tracks could be a badge of honour that the fan had tuned in quickly to the new music.

The certificate could be laser printed (perhaps in colour) on elaborately printed paper - signifying the importance of the purchase and the authenticity of the document. The paper could be of a distinctive formulation and may be embossed with a reflective hologram.

In moderate sales volumes, the certificates could be signed by the artists, or be given a traditional seal such as embossed wax.

Such a certificate could be used like a title - the ownership of the certificate being transferable. However this could be counter-productive because original purchasers could then legitimately sell the music and certificate, whilst keeping their own copy.

2 - Cards or booklets specific to the tracks purchased. These would be four colour printed en-masse, although they may still be personalised with an inkjet printer with a serial number or customer's name.

These would provide track, and musician details, with graphics relevant to the tracks. They could be the same size as CD booklets so that the customer could stow them in the jewel case of their CD-R which holds the music, or store them in the same racks used to house the CD-Rs.

3 - Flyers and brochures promoting music by the artist and related artists.

4 - Colour posters specific to the artist or to individual track - for instance to be stuck on the bedroom wall.

5 - An audio CD or CD-ROM (pre-pressed or CD-R) containing promotional material, graphics files and/or interactive games.

6 - An audio CD or CD-ROM (pre-pressed or CD-R) containing the music which has been purchased over the network. This provides the music in a convenient format without the need for the consumer to have a CD-R writer. This is the "half-way-house" between CD and electronic delivery retailing discussed in chapter 14.

All of the above enhance the consumer's feeling of having purchased something, of having a connection with the artist. These items could be collectable and only made available to those who purchased the music legitimately.

An extension of any music marketing system is to sell badges, clothing and other artist endorsed merchandise. Some of this could be sold only to legitimate purchasers of the music to enhance the status of those purchasers.

Another way of reinforcing the link between artists and fans is for fans to request an email message the moment new material becomes available.

The above discussion assumes that the artist is alive and active and that listeners are motivated to communicate with them. These assumptions do not apply to the composers of many classical pieces. In some cases, the performers may no longer be alive or active. Furthermore the performer may not be interested in having any contact with their listeners.

Nonetheless, the market prospects of such approaches rely primarily on the perceptions of the listener - which may be far removed from conventional wisdom. For instance the opportunity to buy music from and communicate with Elvis Presley is likely to be all the more successful because of the widespread belief that he is dead.

MUSIC SALES BY SUBSCRIPTION AND STANDING ORDER

When electronic delivery becomes established, it is no longer necessary to package music into albums. Nor is it necessary to release only an hour or two of music each year. There is no real limit to the number of mixes and songs an artist can make available.

When costs for electronically delivering music become low enough, it will be possible to automate the delivery to customers who have previously indicated they want the music. One of the ways of administering this is to offer listeners pre-paid subscriptions to artist's work, a year at a time.

For instance a fan may tire of constantly browsing their favourite artist's computer, so they take out a one year deluxe subscription for everything the artist releases. This may amount to many hours of recordings, including various mixes of songs and live performances. Such a subscription for say $80 brings early revenue to the artist, and enables them to serve their customers with minimal administrative costs.

As soon as an artist completes a track and puts it on their computer, the computer sends copies of it to fans. The fans' computers would typically be able to receive files 24 hours a day, so off-peak telecommunication costs could make the system relatively efficient.

The keenest fans may want everything the artist releases. Some may even pay a premium to have it delivered to their computer immediately. Their computer could be configured to suspend other operations as soon as the track is received - and play the track. This amounts to fans all over the world being directly connected to the artist's creative output. Within minutes of a track being completed, people all over the world could be listening to it, providing critical feedback and telling their friends about it.

Another approach is a subscription to particular genres or classifications of an artist's work. Artists may work in several fields and a fan may only be interested in one of them. Artists make judgements about their work. Some pieces may be regarded by artist and fans as being superb, whilst others may be lower key, or alternative mixes only of interest to aficionados.

Subscription plans could take these consumer preferences into account. In addition, the artist may be unsure about how productive they will be, and so would be unwilling to accept a pre-payment for a year's work. So the subscription may become a standing order such as "Until further notice, please send me whatever work you do in a particular genre, and which you think is really good - and charge me at $10 and hour for it." This way, every time the artist completes a track, it will be distributed to those who have a standing order and critical and financial feedback will arrive within hours or days.

CHOOSING STRUCTURES

Assuming a consumer wants to find a particular piece of music, explore the work of a particular performer or composer, or explore a particular genre, what means are available to guide them to CDs and electronic delivery methods of buying music?

The various methods of discovering music and music context, discussed earlier in this chapter, function as informal choosing structures. The focus of this section is on formal structures which intended to guide consumers.

Printed guides to various genres of music have a long history, either as catalogues or containing critical commentary and contextual information.

All-Music Guide CD-ROM and via network retailers

The All-Music Guide is the leading database of popular music. It lists artists tracks, albums, singles and links them with biographies and a relatively simple value judgement scheme about the quality of each recording. The product of Michael Erlewine, a staff of ten and a number of critics, the All-Music Guide is available in a number of forms - as a 1,200 page book, a CD-ROM and via the World Wide Web. An article in *Wired* February 1994 describes the database and how music listeners are invited to contribute to and correct the contents of the database.

One WWW CD retailer, CDNow (http://cdnow.com/) has integrated the database with their catalogue so that track details, quality ratings, biographies, discographies and links to related artists can be seen whilst searching for CDs. They also provide a form for people to contribute to and correct the All Music Guide.

The guide aims to cover every artist who made a record since Enrico Caruso - a seemingly impossible task which Erlewine is keen to complete. There is a lot of work to be done. The reviews are sometimes cursory and written from a perspective quite remote from that of the artists. For instance its description of the successful (a million copies sold worldwide) 1989 release *Max Q* is:

> INXS lead singer Michael Hutchence and Ollie Olsen from the Australian band Whirlywirld collaborate on a one-off project. Good songs with a somewhat political slant. Midnight Oil watered down with INXS.

The biography for the artist, also called *Max Q* is:

> Music Style: Rock, Alternative pop/rock

> Max Q was a 1989 side project for INXS lead singer Michael Hutchence and Ollie Olsen of Australian alternative group Whirlywirld. The result is a more political, harder-hitting effort than Hutchence's work with INXS.
>
> -- Rick Clark, All-Music Guide
>
> Roots and Influence: Michael Hutchence   Similar Artists: Inxs, Whirlywirld

There is no information in the All Music Guide for *Whirlywirld.* There is no reference to Olsen's work in since its demise in 1980, with *Hugo Clang*, *Orchestra of Skin and Bone* and *No*. Nor does it make clear that all the lyrics and music were written by Olsen and that some of the songs were from these earlier bands. The music of *Max Q* is difficult to describe, but "Midnight Oil watered down with INXS" is derisory and inaccurate.

Compilers of comprehensive music guides face enormous difficulties with the quantity of music they try to cover, and the highly subjective nature of describing it and rating its quality. However they try to define pathways through the musical jungle, they will be outpaced by the growth of music - there are many more musicians than guidemakers.

A January 1994 version of the All Music Guide occupies 391 Megabytes. It is available on CD-ROM from Advanced Multimedia Distributors (03) 374 1410.

Network based searches and lists

The Lycos search engine can be used to search for words in documents available on the World Wide Web. This can be a way of finding a CD in a catalogue, but it cannot comprehensively search everything which is available on the WWW. Many retailing operations generate customer specific information for each enquiry. The Lycos system does not find such information to add to its database.

It seems likely that a system similar to Lycos could be operated, purely to search for the names of pieces of music, performers and artists. Anyone selling music, or providing musical resources would want to register their resources with the system so that people could easily find it. How such a system would be funded and administered is not clear, but the task could be performed for the next few years on a high-end personal computer with a good connection to the Internet.

The above approaches are purely word based searches working from an automatically compiled database. It is possible to imagine a "genre" based search system which would lead to both names of artists and any WWW addresses which are relevant to their music.

The All Music Guide classifies music into over 500 popular musical styles, but the range of categories relevant to musical developments of the last four years, and the contents of those categories, makes this seem inadequate. As the pace of musical development quickens, it is hard to imagine how any one centrally maintained database could keep up with developments even in the cursory form of the *Max Q* reference above.

It is possible to foresee global, centralised, network based, musical choosing structured based on:

- A database indexed on composer, performer and track title, or CD catalogue number which would point to all relevant WWW resources.
- A similar database which points to the legitimate electronic delivery retailers for that music.
- A sophisticated guide and choosing database such as the All-Music Guide. This currently provides performer, composer (for classical music) and CD catalogue number. Ultimately an on-line version of this could index into one of the above databases.

In addition there would be many musical resources, each which attempted to cover a smaller area of musical territory. These could be used by music consumers as choosing guides. These would be supported by:

- Major recording companies
- Small or local recording companies
- Retailers, small and chains of stores.
- Artists
- Media - radio, TV and magazines, who may make some of their content available on the WWW.
- Industry associations of all of the above. For instance Top 40 charts.
- Artists collectives, such as Australia's Clan Analogue.
- Fans - personal WWW home pages, newsgroups and mailing lists

There is scope for the creation of network resources such as on-line magazines and lists which are specifically aimed at helping people choose music, but are not supported by one of the above groups. These could maintained by enthusiastic volunteers, or they could be funded by their users, or perhaps by some other source of funds, such as an industry association.

One example might be a "filtered" list of newsgroup articles and other network resources relevant to a particular genre of music. This list could contain the material, or point to it on the WWW. Such a list might point to items of interest regarding early music, gospel or the latest gabber[24] releases. The compilers of the list would spend a lot of time searching the network for material, selecting only that of sufficient relevance and quality. They may edit some of this material to suit their purposes. They might then sell access to their list, which would save many people a great deal of time, and provide them with resources they would not find on their own.

Given the proliferation of network based material, and the high value many people place on their time, it seems likely that commercial filtering services may appear - but the author is not aware of any so far in music or in other fields.

All the above systems require textual input, and lead to information in the form of text, graphics and audio.

In addition to this, an automatic music identification system would accept an audio input, and produce the name of the track, composer and performer. This could be used to index into the one of the three global databases listed above. Automatic music identification systems - if they are developed - are only likely to support those genres of music which people need to search for - these are likely to be popular, rapidly evolving genres.

24 Gabber is a scattered high-speed techno genre which originates from Rotterdam.

CHAPTER 18 CHANGES TO THE STRUCTURE OF THE INDUSTRY

The following discussion explores the "natural" business structure of a music industry based purely on electronic delivery. With consumers dealing directly with artists and any intermediate layers being relatively transparent, this would be a radically different structure from today's.

This extreme scenario is then considered in the light of the evolution which must take place from existing business and legal structures.

This is intended not as a prediction, but as a starting point for a more informed discussion by industry participants.

In the long term - ten, twenty or thirty years - it is clear that the structure of all content industries will be profoundly changed by the communication revolution. In the case of the recorded music industry, the three biggest questions are:

1 - How will the greatly increased fluidity of information affect the industry's ability to sell substantial quantities of music in any form, given that consumers will find it very easy to copy it amongst themselves?

2 - To what extent will music be delivered electronically, rather than on physical discs?

3 - How will the potential down-sizing implied by question 1, and the new business structures appropriate to electronic delivery sit with whatever is left of the existing CD based industry structure?

The first question is discussed in the next chapter. The second question is hard to answer - it is hard to imagine CDs being eliminated entirely, but it is possible that in 2015, the majority of music will be delivered electronically.

One way of tackling the third question is to imagine a world dominated by electronic delivery, optimised for customers and artists as described above, and ask what role would other players have - such as today's retailers, distributors and record companies. This will provide an extreme scenario, which deliberately ignores existing industry structures. Such a scenario might represent an end-point in the evolution of the structure of the industry, but the reality will always be leavened by many other factors.

AN ELECTRONIC DELIVERY SCENARIO

If the recorded music industry was starting from scratch, based on electronic delivery rather than discs, with a global broadband network, with all consumers having computers with large hard-disks and CD-R recorders, driven by easy to use software - what structure would emerge? An artist would either control the selling of their music themselves, or sub-contract it to a "Network Sales Operator" - a company which assumes all responsibilities for selling the music globally. If the artist was defined as the musicians and their personal management, and the artist required no external financial or creative input, then the business structure could be simple - either the artist alone or the artist and the Network Sales Operator.

For the purposes of the following discussion, NSO is defined as either the artist (who organises global sales of their music themselves) or a company they contract to do it - a Network Sales Operator.

The NSO could conduct electronic delivery sales with customers all over the world, and rent space on localised servers to provide a source of the music closer to customers - as discussed in chapter 14. The successful operation of network sales will be a highly skilled and reasonably capital intensive business. It is likely that the most successful NSO operators would be large companies, whose economies of scale would enable them to provide cost-effective services to their clients (the artists) and the artist's customers. In this example, the NSO provides a conduit between customer and artist - and may be paid a proportion of revenue minus costs or something similar.

Retailers with a customer focus

There may be reasons why the NSO subcontracts some retailing to retailers in specific areas, or operates in parallel with licensed retailers. Perhaps a WWW retailer in a particular "area" has a lot of customers and can promote the products they sell so well that the sales they generate, minus their commission, provides greater profits than if customers in their "area" had to deal directly with the NSO. However the term "area" does not necessarily imply a geographical dimension. For instance if a particular company provided specialised network services to medical practitioners all over the world, they would have a special connection with this "area" of the customer world and would be in a good position to retail products to them.

It is hard to predict how effective explicit "promotion" will be in an era dominated by VOD and digital video in which advertisements can easily be avoided - or stored, replayed and printed. (See chapter 8.) However regional VOD companies and established retailers with shops offering customised CD-R discs are examples of companies with strong connections to potential customers.

Perhaps the majority of customers would deal directly with the NSO, but there would be some situations where the NSO would be wise to "sub-contract" the selling to a specialised retailer. This could take the form of supporting the retailer with all the data and communications so they could provide the customer to artist transactions as described earlier - perhaps within their own format, rather than in the format normally used by the NSO. For instance cultural and especially language differences could enable some retailers to offer a much better service to their Arabic or Korean customers than could an English language based NSO.

A retailing arrangement could also take the form of the local retailer simply acting as a gateway for the standard sales session with the NSO. This would save both companies a lot of trouble - and the retailer would not actually be doing the selling - they would be providing customers for a commission. Perhaps they would be handling the payment from the customer - so the customer does not have to deal financially with the NSO.

So as far as this simplistic exploration is concerned, for electronic delivery there seems to be no need for small retailers - because there seems to be no means by which a small retailer can draw customers better than a globally available site operated by a network sales operator. This is probably true of retailers based on geographical divisions with relatively small populations, since geography makes no difference for WWW transactions. However there could still be small retailers with strong customer bases for reasons other than geography.

Retailers with a music focus

One such reason might be a retailer's personal knowledge of certain music genres. This is valuable to the customer in the form or personal advice and because the retailer attempts to find every possible source of music in their chosen genre. Many specialist music retailers provide such a service - an example is Melbourne's *Hound Dog's Bop Shop* which specialises in genres including gospel, blues and rockabilly.

If a listener had a specific genre of music in mind, rather than a specific artist, then they need a choosing structure to guide them to the relevant artists. They may want some contextual information about the artists - such as how they were influenced by artists in other genres. They will need a convenient retail source of the music which provides the opportunity to listen to samples of the music before purchase.

A customer enquiring about a genre - say Western Swing - finds a section in the shop devoted to this music, and the proprietor provides links to the music which it evolved from. A customer enquiring about an artist - say the *Sons of the Pioneers* - will find their music from the 1940s and 1950s released on a dozen different labels. A customer seeking a particular aesthetic approach to gospel will find several discs which include work by artists of whom virtually nothing is known - artists whose extant recordings may number only one or two tracks. Contextual information on the record covers provides valuable understanding and links to other relevant music

These examples show how the retailer and record companies provide essential choosing structures and support as the listener ventures into musical territory which is far from today's mainstream, although some of it was mainstream when it was released.

How will this level of service be provided in an age of electronic delivery? If all the recordings were available electronically somewhere in the world, then a "retailer" with specialised knowledge of a genre could produce an on-line guide which contained:

1 - As much of their knowledge and opinion as possible.

2 - Links to the sources of the music.

3 - The opportunity for users to interact - asking questions and adding to or alter the knowledge on which the guide is based.

Such a guide could be funded by a fee for access, and/or by a commission on the sales it generates. However there could be reasons why the customers want to buy the music from the person with the specialised knowledge, rather than be pointed to disparate music retailers all over the world. This leads to a retail structure similar to toady's specialised music shop - they would sell and supply the music on behalf of other artists or recording companies.

In specialised areas of music, the retailer can add a great deal of value to music by seeking it out from the most obscure sources, guiding the customer to the best of it and supplying it conveniently.

This would be possible with WWW CD retailing and electronic delivery. The more common parts of the retailer's knowledge may be available at all times in text and links to other text and music. Other knowledge would be available on request. The great advantage for the specialised retailer with networked retailing is that their "catchment area" for customers is no longer limited by geography. This enables them to specialise on the music which most interests them - rather than spending time with other music to gain sufficient local trade to pay for overheads.

Their knowledge of the music could become more intense and its value to their customers would rise accordingly. Networked music retailing can multiply the number of potential customers by several hundred. This makes if possible for one retailer to concentrate their energy into a smaller area of music which, assuming they do not have many competitors, maintains or increases their revenue. So a retailer such as *Hound Dogs Bop Shop* may concentrate primarily on rockabilly and become the world leader in this field. Another retailer, perhaps in San Francisco, who previously covered several genres may decide to concentrate on a pre WWII gospel.

These retailers maintain their interest in related genres, but refer customers - or provide gateways for electronic access - to the leading retailers for each genre. In this situation the value of the retailer's knowledge is paramount in the customer's choice of how to purchase music.

As either retail business, or fees for using a choosing structure, the knowledge of specialised music retailers can be exported effectively, and that knowledge can become even more finely attuned to the music and the interests of listeners.

Distributors in the electronic age

While there will still be a need for recording companies - to develop new talent and to find and package material from the past - the role of distributors seems less assured.

Although they provide choosing structures and contextual material to retailers, their primary functions are to:

1 - Obtain stock of physical discs when retailers ask for them, or buy the stock and let retailers know about it.

2 - Transport the discs to the retailers.

3 - Provide greater ease of ordering and payment than if the retailer dealt directly with a number of record companies. Contributing factors to the current difficulties are:

  a - Differing time zones between retailer and recording company.

  b - Differing financial systems and high relative costs of making small international payments.

  c - Recording company's reluctance to deal with thousands of small retailers.

The issues in points 1 and 2 disappear in an electronic delivery environment. In a sophisticated electronic delivery environment, the difficulties listed in point 3 become less important and artists, recording companies and their network sales operators operate globally, automatically 24 hours a day, with electronic funds transfers.

There seems to be almost no role for a distributor layer between the customer and the artist. In principle, the customer can deal directly with the artist's computer - if the artist chooses to take responsibility for it. If they do not, then they subcontract it to a Network Sales Operator - who is one layer between customer and artist. When the NSO finds that certain groups of customers can be reached better via a retailer, then the retailer forms a second layer. The NSO is a layer which exists for the artist's convenience, and the retailer (unless it has its customers bound to it in some way) has established itself as a layer for the customer's benefit because of the services it offers to the customers who choose to use it.

There may be a role for a distributor who can bridge a major cultural or linguistic barrier which is beyond the ability of the NSO and certain retailers to negotiate. Perhaps a Japanese company could act as a gateway between an Australian or European based NSO and a number of Japanese based retailers.

PHYSICAL AND ELECTRONIC DELIVERY

However there will be more than network sales to the future music market. Sales of CDs and CD-Rs in shops will continue. The CD-Rs require a source of music, and so retailers who provide this service will typically need to source the music from the network via the NSO.

Selling CDs or CD-Rs via retail shops or via home delivery or local postage, brings geography and locally effective promotion back into the picture - since these retailers will not typically be chosen by the global network choosing structures mentioned previously.

Pre-pressed CD manufacture, distribution and retailing can be expected to follow existing patterns - which depend on geography and the separate businesses necessary for operating in different countries. The discussion so far indicates that the business arrangements for electronic delivery system may be quite independent of the arrangements for pre-pressed discs.

However as long as pre-pressed CDs remain a significant part of the industry, their geographical based business structures will need to co-exist with the network based structures.

EVOLUTION FROM EXISTING BUSINESS STRUCTURES

This discussion has deliberately looked at business structures as if they might evolve in a vacuum, without existing structures. However the existing business structures, and the copyright laws which protect them against movements of music across national borders, are entrenched. The electronic business structures do not yet exist, and the most likely source of investment and musical product is from the existing business structures of today's record industry.

In today's industry, geography and national borders are extremely important, because they determine:

1 - The ability of a company to conduct business.

2 - The geopolitical limits to the reach of the country's copyright law.

3 - The propagation of the radio waves which carry the radio and TV signals which are vital for introducing people to new music. (In contrast, specialist music magazines often have an international range.)

4 - The costs and delays in distributing discs from a warehouse to retailers.

5 - The strong connection between retail shops and the customers who live nearby.

6 - The geographical factors affecting who will come to a concert by an artist.

In some countries the cultural differences based on race and geography are an issue too, but not in Australia, where we are culturally compatible with Britain, and North America and in some musical respects, with parts of mainland Europe.

In a scenario where physical products are not significant, and WWW transactions and electronic delivery operate irrespective of national borders, the only two points of the six above which remain are points 2 and 6.

Point 2 are legal constructs which will become increasingly difficult to enforce as activities are conducted purely electronically. Copyright law may change to harmonise with the reality of international networked transactions, so that the intellectual property laws give less effect to national boundaries - as is the trend in Europe.

Point 6 will remain - but the promotion of concert tours and the sale of tickets will increasingly be done via the network as well.

For simplicity, this discussion has ignored the investment (from record companies) which many artists need to record music and develop their careers.

Similarly it ignores the importance of well financed promotional activities - in whatever forms are appropriate to a market based more on the network and customer choice than on broadcast and distributive channels.

Also, the ingrained purchasing habits of consumers have not been considered. A change from CDs to electronic delivery is much more radical than from vinyl records to CDs. However many music purchases are by young people, who are just developing their shopping habits.

While it seems unlikely that the sale of physical discs - pre-pressed CDs and CD-Rs - will ever be insignificant, to the extent that they loose significance to the potentially borderless technique of electronic delivery, the competitive pressures and business structures of the recorded music industry will be similarly internationalised.

CHAPTER 19 COSTS AND BENEFITS OF COPYING AND COPY CONTROL SCHEMES

> *Listeners copy music for a variety of purposes. Some of this copying helps the artist, by introducing their music to new listeners. Some copying is essential to the purchaser's enjoyment of the music - so preventing it would detract from the music's value.*
>
> *Other forms of copying are detrimental to the artists income or contrary to their intentions about how their music will be used. Some illegal copying is on a large scale - purely for financial gain.*
>
> *There are no effective technical methods for preventing the copying of music. Legal methods are of diminishing effectiveness in a networked environment of extreme information fluidity. This leaves two approaches to making copying unattractive - psychology and making legitimate purchase more attractive than copying in terms of convenience and/or cost.*
>
> *This chapter explores the various types of copying, the changing copying technologies, and the approaches to minimising copying which is detrimental to the artist or recording company.*

An important article on the future copyright appeared *Wired* in March 1994. *The Economy of Ideas: A framework for rethinking patents and copyrights in the Digital Age (Everything you know about intellectual property is wrong)* by John Perry Barlow - lyricist for the Greatful Dead and co-founder of the Electronic Frontier Foundation. Copyright and censorship issues are frequently discussed in the Internet (Usenet) newsgroup *comp.org.eff.talk,* where the EFF newsletter can also be found.

COPYING CATEGORISED BY ITS EFFECT ON THE ARTIST

Probably the music industry's greatest fear about the future is that profligate copying of music will reduce legitimate sales far more than existing levels of home taping and commercial piracy. This fear is well founded. In the future, listeners will be able to transfer hundreds or thousands of megabytes of music through the telecommunications network with bulletproof encryption - so there is no systematic means of detecting such copying.

User copying today involves the time consuming process of recording on cassette, and writing down artist's and track names by hand. Copying will be more convenient in the future. An hour or two of music - with track listings, graphics and other data - may be compressed into a single file on the listener's hard-disk, and just by dragging its icon onto the icon representing a friend, that music could be copied to the friend's computer. Two people could be conversing by phone, discussing music, and with a few seconds movement with the trackball or mouse, the music could be copied.

In some situations, listener to listener copying helps the artist and so it should be encouraged, or at least not prevented by copy control measures. (However one band manager states "The copying does not help. The ability to talk about the new artist or music and then hear it helps - not necessarily via copying.") In other situations copying is contrary to the artist's interests. Which methods are cost-effective in reducing these kinds of copying?

For the purposes of this discussion, copying is split into five categories:

1 - Purchaser copying The purchaser making copies for their own use.

2 - Listener sharing Any listener (the purchaser, or someone who received the music by other means), making copies to give to a friend - but in circumstances where the friend would not have bought the music anyway. In some instances, this action will cause the friend to become interested in the music and buy more from a legitimate source.

3 - Listener theft Any listener giving away one or more copies of the music to people who otherwise would have purchased it - but not for financial gain.

4 - Listener piracy Low volume copying for financial gain - by people who bought the product primarily for their own enjoyment or who obtained it by some other means. For instance, spend $30 on a CD, but make 6 copies for friends at $15 each on CD-Rs, for which the blanks cost $10. This means the original purchaser recovers the cost of the CD.

5 - Commercial piracy Copying or manufacture of counterfeit products for commercial gain.

This typology does not draw a distinction between copying music from live performances (bootlegging), from radio programs or from commercially available recordings. Only in the first category - user copying - is the copying done by the legitimate purchaser of the music. In the other categories, it is not important whether the copier actually bought the music or not.

The term *purchaser* means someone who paid for a recording of the music through a channel authorised by the artist - whether the music was delivered on disc or electronically over the network. The term *listener* describes either the original purchaser, or any person who has a copy of the music by any means, including copying it from the radio, but does not have the legal right to give away or sell copies of the music. *Listener* implies that the primary motivation for the person is musical enjoyment and its related social activities.

Pirate refers to any person or company who makes copies of music primarily for financial gain. Thus a pirate could be someone who makes one off copies of music on cassette or CD-R for individual customers, someone who mass produces copies of music on cassette or disc (whether or not the products appear to be legitimate or not) or someone who sells music over the network but is not authorised by the artist to do so.

One activity which may fit any of the categories 2 to 5 is the practice of making music available for electronic download from a bulletin board, or by some other publicly available distribution system. If the operators of a commercial system are aware that illegal copying is taking place on their system, and are making money from it, then this amounts to commercial piracy - even though they may not have put the music there themselves. User piracy might be a more appropriate term if such activities occurred on a hobby bulletin board which charged fees for access.

When a listener makes a recording available to the public, or a group of people - for instance via a bulletin board or Internet ftp site - the effects of their actions depends on who copies the music from that site. One person may copy it, and decide to buy more of the music from a legitimate source (listener sharing). Another person may copy it as an alternative to buying it legally (listener theft).

This discussion does not cover misuse of the music by other artists or producers of films, videos and multimedia products. These are serious but well known problems in the industry, although a proliferation of networked and CD-ROM multimedia products could make things worse.

This discussion concerns linear music, however many of the issues are also relevant to video, graphics and text, to non-linear media (hypermedia and interactive applications) and to computer programs.

The aim of this chapter is to find ways of optimising the control that artists have over the use and sale of their music. For simplicity, the term *artist* will include the performer and composer, and all organisations they authorise to manage their intellectual property. This includes record companies, publishers and copyright collection societies. Like the performer and composer, these organisations also have an interest in preventing misuse of music, and in maximising its legitimate use and sale.

METHODS OF CONTROLLING COPYING

Chapter 10 showed that there are no effective technical means for stopping people copying music, so technical approaches will not be considered in this discussion. The remaining methods are based on copyright law, community standards, the relationship between the artist and the listener and on the economics and convenience of copying or purchasing the music legally.

Technical developments in the next five to fifteen years will drastically affect the costs and convenience of both copying and legitimate purchase. Copyright law is likely to change and the attitude of listeners to artists, recording companies and retailers is likely to change as well. The following sections discuss these approaches to controlling copying in general terms, how they are likely to change over time and how they might be optimised to protect the interests of the artist.

At the start of each section is a table describing the applicability of the method to the five kinds of copying identified above, both now, and in the future - when electronic delivery and user copying via the network are fully developed.

Copyright law

Copyright law affects community attitudes and the personal relationship between listener and artist. This section considers its more immediate role in deterring and preventing the various types of copying. Table 19.1 shows the *practical* applicability of copyright law, today and in the future. From a purely legal point of view, the law may apply more broadly than this. The author does not posses legal expertise and the table is not intended to show the specific details of copyright law.

The table depicts a best case situation, where the law is well directed towards protecting intellectual property, well drafted, and enforced by reasonable (rather than draconian) means. This table shows how the combination of the law and practical means of enforcing it apply to the five types of copying.

The effectiveness of a regulatory system depends on a chain of legal and real-world mechanisms. The most important aims of a copyright regulatory scheme are that it should deter the undesirable copying (rather than catch those who do copy) and that it should not have too many adverse side effects. For instance a draconian scheme may deter purchasers from copying for their own listening purposes. This would lessen the value they derive from the music and so reduce the price they are prepared to pay.

TABLE 19.1 PRACTICAL APPLICABILITY OF COPYRIGHT LAW TO MUSIC COPYING

	Today	*In the future*
1 - Purchaser copying	Copyright laws typically apply to any copying, including by purchaser or anyone else - except where home taping is specifically allowed. However most purchasers ignore such laws because they are not subject to their enforcement procedures and because they believe that the intent of the law is to prevent more serious abuses.	
2 - Listener sharing	As above.	
3 - Listener theft	As above.	
4 - Listener piracy	As above.	
5 - Commercial piracy	Disc based commercial piracy is directly targeted by copyright law and related enforcement mechanisms in developed countries. It can only succeed in the long term through secrecy regarding the production, importing and sale of discs.	Network based commercial piracy should be detectable with relative ease - compared to tracing the source of counterfeit discs. However if the pirate operates from another country, enforcement may be difficult unless copyright law is harmonised internationally and made applicable to network transactions.

A draconian scheme could cost too much to enforce, or worse still, it could threaten civil liberties. For instance, it could be argued that no communications should take place without an encryption system which the government can decipher, to stop music - or state secrets - being copied. This would unacceptably threaten privacy and commercial security. The same applies to laws enabling authorities to inspect the contents of any computer storage medium and force its owner to decipher all encrypted files it contained - to prove they contained material which that person had a legal right to possess. Both these examples of attempts to control information by brute force would be expensive, unacceptably degrade privacy and be largely ineffective against someone who was organised and motivated to avoid detection.

The four steps in enforcement

Four types of mechanisms are involved in a regulatory attempt to control copying - definition, detection, enforcement and deterrence.

Definition

Copyright law is based on statute law, common law, international agreements and/or contractual arrangements between supplier and purchaser of the music. In all cases, words are used to define how the law applies to various situations. Since there are many grey areas in copying, the definition is typically expansive so as to eliminate loopholes.

However it may be understood by the authors of the law and by the public that the law will only be enforced in a subset of the circumstances in which it technically applies. For instance even before home taping was legalised, people who taped their CDs so they could listen to the music in the car knew they would not be prosecuted.

Detection

Apart from any moral influence which the law may create, the law is only of practical value in situations where its breach may be detected. Because the state does not conduct raids on the homes of music listeners, the copying activities of listeners will not be detected and so are practically unaffected by the law.

In the commercial field, detection needs resources from government and from industry based organisations such as Music Industry Piracy Investigations, and from the companies whose material is being pirated. In the case of well made counterfeit discs, this would be a difficult task - particularly if they are being sold to consumers from an overseas source.

Since an electronic pirate has to be reasonably prominent on the network in order to do business, they should not escape detection for too long - particularly if some listeners are keen to expose them. Another means of deterring pirates is the automatic searching and indexing of publicly available network material - for instance the Lycos and InfoSeek search databases (described at the end of chapter 6). Since these search on the *contents* of news items and World Wide Web documents, it is relatively easy to spot a pirate offering the work of an artist, or to find someone writing about this activity. Any kind of announcement - or publicly visible word of "mouth" discussion would have to avoid using the names of the artists and tracks being copied.
For instance, a pirate would have to avoid using a band name like *Midnight Oil* - they would have to substitute which made sense to the potential purchasers of pirate copies of their intellectual properties. The name would have to avoid any

search methods the band's lawyers or fans may use. In the case of *Midnight Oil* the pressure to avoid detection would be intense, because:

1 - Some of the band members *are* lawyers.

2 - The band travels internationally and is not afraid to take on anyone.

3 - The band has loyal fans who are very active on the Internet, many of whom would be targeted by any commercial pirate's sales methods.

So any pirate, who used some code name to refer to the material they were selling - such as *Noon Water* - would only escape detection as long as this term was kept secret from the band's supporters. Discussions between groups of people can be kept secret - by using a mailing list. The contents of this are never available to the public or any search engine, unless one member of the list makes them so. However, could a commercial pirate succeed in advertising their wares without doing so in public, and without letting a loyal *Midnight Oil* fan find out?

It is hard to imagine how commercial piracy - in the electronic domain, or with CDs and tapes - could avoid detection for long in an environment where tens of thousands of fans are interested in their activities, and all public discussion forums can be scanned by search engines. The Internet may provide the strongest method yet of *detecting* or *deterring* the activities of commercial pirates - provided there are practical methods of taking action against those pirates, wherever they are located.

It is possible to conceive of a pirate operating behind some kind of anonymous shield, accepting electronic cash in payment for illicit recordings. However if the consumer tells the bank the serial numbers of their "electronic bills", then the bank can trace whoever tries to redeem them for real money. There are many variations on these themes, but it is hard to foresee how a pirate could escape detection.

Enforcement

The question of enforcement for international pirates is much more difficult. Electronic pirates could operate over international borders, although the costs of delivering hundreds of Megabytes of data internationally might be relatively high. Traditional approaches to preventing unwanted imports rely on borders. But encryption means there is no practical way of detecting or preventing information traversing borders.

Information cannot be fenced in or out of a country. Enforcement of legal sanctions against pirates would depend on the legal system in a country in which they lived or conducted business with real money. This could be the weak link, just as it is with drugs and weapons. With a WWW server operating from a third world country with a shaky legal system and a desire for any kind of foreign trade, a pirate may be able to operate with impunity for some time.

It would be possible for network operators to agree not to handle data to or from the computer of the suspected pirate, but this raises questions of how such judgements should be made, to ensure that this extreme penalty is applied only to someone when their guilt has been proven - and to ensure that no-one else is affected. The pirate could move to another physical site, or use the same equipment with a different data link and/or network address.

Legal enforcement of a copyright breach is likely to be expensive and time consuming. Like the investigation phase, most of the value the industry derives from enforcement is derived from the deterrent effect it has on other people considering piracy, or on their potential customers.

Enforcement and detection typically involve physical evidence. In a networked environment, such evidence could be difficult to gather in a form which is admissible in court. However the music industry is one of many which needs laws enforced in the international networked environment and it is likely that legislation will be introduced to facilitate this.

However, when a pirate sells music via electronic delivery, there may be many difficulties arising from the transitory and non-physical nature of their operation. Since the music is likely to be delivered in an encrypted form, and privacy considerations may make it impossible to monitor network transactions, a sting operation may be the best approach. An investigator posing as a customer would complete a transaction involving piracy, and use their own records and that of the funds transfer mechanism to prove the case in court.

Deterrence

The most important outcome of copy control regulations is deterrence. A scheme's effectiveness as a deterrent relies largely on the perceived risks of being caught, multiplied by the perceived costs of being caught and perhaps prosecuted.

Since detection and enforcement activities are expensive for the copyright holder, they are typically only conducted against the biggest offenders. This means that the activities of listeners are largely unaffected by copyright laws. If copy protection laws were enforced on listeners, the investigators could only target a proportion of the population. This is likely to have negative impact on public opinion about copyright - as large companies would be seen to be picking on randomly chosen individuals, while the risk of the average person being detected would still be remote.

Piracy of products similar to music

Whilst considering network based piracy, it is worth considering the current situation with computer software - how much illicit copying takes place over the Internet which is genuinely harmful to the owners of the intellectual property? The equivalents of the last three categories of music copying are user theft (copying instead of buying), user piracy (user selling in small quantities) and commercial piracy (deliberate large scale copying for profit).

There is no evidence whatsoever of the latter on the Internet today. This is despite the fact that commercial programs are more valuable than music, and can be sent with complete secrecy by converting them to ASCII text and encrypting them with PGP. Although commercial software may amount to five or ten Megabytes of data, this is not impractical to send over the Internet.

There are cases of user theft over the network - in one case known to the author, the entire Windows for Workgroups (maybe 15 megabytes) was sent in text via email between two acquaintances, a process which took several days. Most people would be happy to pay the retail price just to get the printed documentation. In the case of music, this is equivalent to the CD booklet and slick, but only collectors would pay full retail price just for these. There have been cases of bulletin boards (computers not connected to the Internet but accessible by modem) carrying commercial software, sometimes apparently to increase the profits of the owners.

Despite the sensationalist reports from journalists, it is apparent that the Internet, heavily populated as it is by relatively poor people with a fondness for anarchy and little respect for large software companies, has resulted in very little obvious software theft using publicly available channels. The author cannot recall seeing commercially software available in public ftp sites - perhaps a search would reveal some.

Social pressures of users probably play little role in this - since most users already copy at least some commercial software using floppy discs. However social pressures within the Internet - and potential moral pressure not to abuse copyright - seems to be sufficient to keep any organised copying at a low level, much lower than commercial piracy.

Considering that social pressures - community standards - would probably favour artists more than commercial software companies, it seems that the likelihood of the network being used for large scale commercial piracy is remote.

Community standards

Community standards are the generalised attitudes to copying, to respect for intellectual property in general and for music in particular. This is composed of many factors including:

- Knowledge of the law, and respect for its intentions and how it is enforced.

- Perceptions of the music industry - particularly of the proportion of the consumer's money which goes to retailers, record companies, government taxes and the artist.

- Perceptions of what other people - especially members of the listener's peer group - think about copying.

These public perceptions can be influenced to a certain degree by a public education campaign - which would be costly, and must be very carefully targeted to avoid a contrary reaction amongst the youth market.

Another major factor affecting the public's attitude is how easy and cheap it to copy music, compared to the ease and cost of a legitimate purchase. Things which come easily are typically not highly valued. Since the entire functional part of a computer program can be copied illegally with a few keystrokes, it is easy for someone to place very little value on a product which can be so easily copied - and to be contemptuous of paying several hundred dollars to use the program legally.

One factor affecting the general respect for products and laws is how easy it is to do something which is supposedly wrong. Illegal copying of music and computer software seems to be a victimless crime, which can be accomplished very easily.

Even if copying is regarded initially as wrong, if someone, their friends, or the majority of the community regularly do copy music - for economic reasons or due to the difficulty of purchasing the music legitimately - initially they will be acting against their own moral standards. Repeated violations of a person's moral code weakens it - particularly when there are no perceived negative consequences for the copier or the artist.

This is explained by the theory of cognitive dissonance - that our conscious thoughts, emotions and actions "should" be in harmony. If one or two of them are changed, the other(s) will ultimately follow. If this did not happen then the person would be deeply unhappy and unable to function properly. This change of beliefs and feelings about conduct which was previously thought to be wrong does not necessarily take place deliberately - it may be an automatic adaptation to changed circumstances.

An example of this is the ease with which the tax department can be defrauded by understating income or overstating expenses. The effect is to defraud the government and therefore all residents of Australia - but hardly anyone thinks it is a serious matter. Lots of people do it, few get caught and the negative consequences are invisible. Likewise illegal use of computer software is generally regarded as socially acceptable.

The mass psychology of attitudes to music copying is a major determinant of how well the industry can control the use of its intellectual property. The ease with which moral positions can change to accommodate convenient and inexpensive actions should not be underestimated.

There is considerable linkage between the moral positions on copying different kinds of intellectual property - for instance music, videos, books and computer programs. When a friend of the author purchased an IBM PC from a backyard dealer, it came already loaded with over a thousand dollars worth of the best word processing, graphics and spreadsheet software. When questioned about how acceptable she thought this practice was, she replied that the dealer had told her "Many people think it is just like copying CDs onto tape". This casual justification, her own need as a PhD student for the software, and her limited funds all served to water down a previously held moral position against copying software.

In the future, it will be trivially easy to copy both computer software and music - much easier than today's approaches based on floppy discs and cassettes. This will contribute to a widespread attitude which places a diminished value any product which can so easily be replicated.

However the music industry can use the new technology to make legitimate purchases cheap and convenient as well. If this is achieved, then the cost and convenience factors which favour copying will be minimised. This may enable more people to retain their moral position which is in favour of making a legitimate purchase.

This reluctance to paying full retail price has at least three components:

1 - The discrepancy between the retail cost and the cost of copying illegally.

2 - The perception that a lot of their money goes to retailers, taxes and record companies.

3 - Perceived wealth of the artist. This is not a serious problem except for the biggest selling artists.

Large record companies do not seem to be held in high regard by music consumers. This is partly a reflection of the gripes about record companies so commonly expressed in interviews with artists. It is also a reflection of general distrust of large companies - particularly multinationals.

New music marketing techniques diminish the many of the risks involved in today's market. This should reduce the percentage of retail cost that recording companies need to take. In addition new techniques may bypass the need for recording companies. Music retailing may increasingly take place as an interaction between the customer and the artist.

In general, new means of physical and electronic distribution should increase the efficiency of the music marketing system and so a greater proportion of the customer's dollar will go directly to the artists. Assuming this happens, and that community attitudes reflect this, then listeners will be happier about paying the full retail price for the music they want.

TABLE 18.2 APPLICABILITY OF COMMUNITY STANDARDS TO MUSIC COPYING

	Today	*In the future*
1 - Purchaser copying	It is acceptable for the purchaser to copy music to aid their own enjoyment.	
2 - Listener sharing	It is acceptable to copy music if it does not impact on sales or if it is likely to promote sales.	
3 - Listener theft	Depends a lot on perceptions of where the consumer's money goes to. At present many people think that between 5% and 20% of the cost of a pop disc goes to the performer and composer. Where the performer and/or composer are either dead or extremely wealthy, there may be no negative judgement about copying their music. Copying today is relatively awkward - as is legitimate purchase.	New marketing arrangements will be more efficient, so the consumer will believe that more of their money flows directly to the artist. Both copying and legitimate purchase will be cheaper and more convenient. Purchases can be made without the need to go to a shop - music can be browsed and bought at any time from home.
4 - Listener piracy	As above, but if the listener is making (or saving) money from their copying activities, then community attitudes will be relatively less important to them.	
5 - Commercial piracy	Community attitudes have no influence on commercial pirates themselves. As long as their product is indistinguishable from the original, then the consumer's attitude to piracy has no effect either. If their products are perceived to be pirate copies, then negative community attitudes will diminish the price they can be sold for.	Network based piracy for electronic delivery will probably not be feasible on a large scale. So customers buying from pirates will probably recognise they are paying for illegitimate copies. They will be affected by community attitudes and so be likely to pay less than from an authorised source.

Personal relationship with the artist

Today, the vast majority of artist - listener relationships are based on a flow of mass replicated content from the artist to the listener (including by indirect routes such as interviews in magazines) and a flow of anonymous money from the listener towards the artist - with just a fraction surviving the journey to the artist's bank account.

Networked music marketing - especially for electronic delivery - has the potential to completely alter this and provide genuine communications between listeners and artists at the time they browse and buy their music. Although the interaction may be mediated through the artist's computer (and several layers of computers between it and the listener) there is great potential for building listeners feeling of personal involvement in the artist's career. (See discussion in chapter 17).

These experiences are likely to change listener's beliefs, feelings and actions - particularly regarding theft of the artist's intellectual property. Initially these changed beliefs and feelings are specific to each artist the listener feels a personal connection with, and are in addition to - and perhaps in conflict with - the listener's default attitudes which are derived from community standards. The relationship with the artist could be at least as influential as the influence of the listener's peers and community.

The listener's relationship with one artist will affect their feelings about many other comparable artists - and so their attitude to copying (amongst other things) in general will change. As more music consumers are affected by the experience of buying music direct from the artist, the community attitude to copying will be strongly affected.

There are many reasons why artists would want to use network marketing techniques to develop strong relationships with their audience. One of them is to minimise the misuse of their music by their purchasers and by people whose actions are affected by the purchaser's opinions. This will apply to the purchase of pirate copies of their music and to any listener copying which is contrary to the interests of the artist.

Public attitudes could be finely tuned by the artist to suit their preferences - and are more adaptable to individual situations than copyright law. For instance, an artist may state that they are happy about people swapping recordings of live concerts provided it is not for profit. This opens a channel of listener involvement in spreading the music - which may lead to increased sales, reduced in effort in deterring bootleggers, and a generally enhanced public perception of the artist. The Greatful Dead apparently adopted this attitude several years ago and the consequences for their sales of recordings and concert tickets seem to have been entirely positive.

TABLE 18.3 PERSONAL RELATIONSHIP WITH THE ARTIST AND MUSIC COPYING

<table>
<tr><th></th><th>Today</th><th>In the future</th></tr>
<tr><td>1 - Purchaser copying</td><td colspan="2">It is acceptable for the purchaser to copy music to aid their own enjoyment.</td></tr>
<tr><td>2 - Listener sharing</td><td colspan="2">It is acceptable to copy music if it does not reduce sales or if it is likely to promote sales.</td></tr>
<tr><td>3 - Listener theft

4 - Listener piracy</td><td>Personal relationship is limited due to the lack of listener contact with the artist, and the mass produced nature of all material coming from the artist to the listener.

Theft and piracy may continue because the artist seems so remote and unaffected by this misuse of their intellectual property.</td><td>Network music marketing enables genuine communication in both directions and a greater feeling of involvement in the artist's work.

Listener's support for the artist and their income will be strengthened - diminishing the attraction and acceptability of theft and piracy.</td></tr>
<tr><td>5 - Commercial piracy</td><td>Commercial pirates have no personal relationship with the artist.</td><td>Listeners may be highly motivated to seek out pirate network sales sites and report them directly to the artist. It is hard to imagine how significant levels of piracy could persist in the face of opposition from the artist's most motivated fans.</td></tr>
</table>

Economics and convenience of copying and legitimate purchase

For both legitimate and illegal copying of music, costs will drop and transactions will become more convenient. The greatest threat is that a pirate company could sell music into Australia from another country which placed it beyond the reach of Australian copyright law.

Fortunately for the legitimate sellers, fundamental technical and economic factors combine to make this an unlikely prospect in the foreseeable future. Music sales via electronic delivery requires the cheap transport of hundreds of megabytes of data - and it is expected that the cost of this will be prohibitive for most consumers if the data has to be delivered over international links.

At some time in the future this restriction on the geographic range of electronic delivery will no longer apply. Before that, a pirate operator could use cheap off-peak rates to deliver music - or perhaps use illegal methods in their own country to gain access to the network at below market rates.

The great convenience of copying music between friends will no-doubt lead to an increase in copying compared to today's use of cassettes. Some of this activity will reduce legitimate sales and some will boost sales by aiding the diffusion of new music.

TABLE 18.4 ECONOMICS AND CONVENIENCE OF MUSIC COPYING

	Today	*In the future*
1 - Purchaser copying	Today this is typically only from CD or vinyl to cassette.	With electronic delivery, copying music for the listener's own use will be a routine and necessary part of purchasing it. The music arrive via the network and be stored temporarily on hard-disk. Then the listener will make at least one copy onto optical disc (CD-R or MO) for their own use - and probably onto another disc for backup.
2 - Listener sharing	As above.	It will be much lot more convenient to share music with friends using the network.
3 - Listener theft *4 - Listener piracy*	As above. The cost of CDs is relatively high because of the risks of producing, distributing and stocking them, so copying can be economically attractive.	Both copying and legitimate purchasing will be cheap and convenient. If someone copies music from a friend over the network, they need to pay for telecommunications and blank optical discs just as they do for a legitimate purchase. The extra expense in a legitimate purchase goes to the artist and their retail operation. The telecommunications costs of the legitimate retailer may be less than those of the person who sends music to a friend from home, because of the retailer's high speed network link and bulk usage.
5 - Commercial piracy	Commercial pirates need to produce physical products and distribute them - so their costs and risks are comparable to those of legitimate sellers.	Commercial piracy via electronic delivery would be easy to set up in any country, but without buffer facilities in the consumer's country, the costs of delivering hundreds of megabytes of music are likely to be prohibitive. As long as the cost of international telecommunications remains high, overseas pirates would need local facilities and so be subject to local laws.

RESPONDING TO THE COPYING PROBLEM

This paper has shown that technical approaches to copy protection can have no significant impact. It has discussed the many difficulties inherent in enforcing copyright law against listeners.

The most promising approaches seem to be:

1 - Make legitimate purchase as cheap, convenient and attractive as possible.

2 - Influence community attitudes as to the long-term benefits of favouring legitimate purchase over copying. This will be easier when the marketing system is more efficient and a greater proportion of the retail price goes to the artist.

3 - Make the most of the network's capability to provide direct communication between the listener and the artist. This will raise public awareness of the value of legitimate purchases and boost the enthusiasm of fans for reporting commercial pirates.

Despite difficulties in enforcing copyright law, the law is the foundation for the protection of intellectual property. Ideally it should be independent of technology and reflect the day-to-day uses of intellectual property which are acceptable to both producers and consumers.

The real world of music copying has many grey areas - for instance the difference between listener sharing and listener theft (as defined above) is dependent on the behaviour of the recipient. Listener sharing encourages the recipient to buy more music, whilst listener theft discourages them. One is to the benefit of the artist and the other is to their detriment.

If the law is to make a distinction between these, should it be on the basis of the actions of the copier or of the recipient? Should it be on the basis of their attitudes at the time of copying or on the subsequent actions of the recipient?

If copyright law does not distinguish between these two activities then it will not distinguish between the worst effects of home taping (and later listener to listener copying over the network) and the best effects of listener sharing - which are analogous to radio play by introducing listeners to new music.

This chapter has taken a utilitarian view of copying and copyright law. The purist, deontological view that all copying must be eliminated is clearly inappropriate.

Copyright legislators face the difficult task of framing laws which can be interpreted in a wide variety of situations, whilst technology is changing rapidly and while people explore far more combinations of technology and business structures than can be anticipated.

Blank tape levy

One approach to the listener copying issue is to make legal provision for it and place a levy on the media which is used for it. Today this is known as the blank tape levy. A tax would be placed on blank tape and the funds distributed to artists via a new copyright collection society or via existing societies. In May 1994, the High Court disallowed the new blank tape levy legislation, ruling that as it was a tax, it should be part of taxation legislation rather than copyright legislation. There are proposals to re-introduce a similar levy as a new tax, but there is reluctance to introduce a new special purpose tax, and concern about how relevant the tax will be in the future.

A home recording media levy raises questions about how the funds raised would be distributed to artists, given the difficulty of surveying which artists were actually recorded by listeners. It also raises questions of the economic efficiency of the scheme.

However, the most serious problem is that it is increasingly difficult to identify a recordable medium which is used solely for home taping of music. Cassette tapes are used for other purposes as well. In the future CD-R and MO discs would be used for home recording and many other applications. It would be impractical to tax all sales of such multi-purpose media to provide remuneration for the artists whose music is recorded on these discs. Furthermore, in an electronic delivery environment, the purchaser must store the music on their own media - so it would by unjust to tax them for recording music they have already purchased on this basis.

Towards a more informed discussion

There are many perspectives in this field and many complications relating to existing law, difficulties in framing new laws and making sure that Australian intellectual property legislation is compatible with that of other countries.

Transborder flows of information are increasingly the subject of legislation and international agreement - particularly in the European Community. The concern is that the security, privacy and intellectual property rights upheld on one country should not be threatened by transmitting the information to another country with lower standards. So discussion of copyright law within Australia needs to encompass discussion of similar laws in other countries. Other countries may not enact adequate legislation and so it is in our interests to inform and participate in the international debate on intellectual property.

The Australian Government has established an Intellectual Property Task Force, which includes representation from the Department of Communication and the Arts.

This paper has described the foreseeable technologies and some of their applications. The discussion on copying is intended as a starting point for a more informed discussion within industry and government.

CHAPTER 20 CONCLUSION AND COMMON THEMES

MAJOR CHALLENGES AND OPPORTUNITIES

The most prominent challenges are:

- Starting in 1995, CD retailers operating through the World Wide Web will challenge traditional retailers in terms of price, stock, the accessibility of their "shop" and the ease with which the potential customer can audition the music and learn about related music and musical context. Some of these WWW based retailers operate from outside Australia.
- In the late 1990s, the development of cheap optical storage discs (CD-R or MO) for home use. This could increase home recording to the detriment of legitimate purchases. (However it could also lead to greater diffusion of knowledge of new music.)
- Between 1995 to 1998, it will become technically feasible for retailers operating via shops and the WWW to offer customers their choice of music on personalised CDs made with write-once CD-Rs. This would be a very valuable service, but the sourcing and customer selection of the music is a challenge, and copyright laws and industry arrangements would need to be developed to cater for this new kind of retailing.
- Starting around 1997 or later, the new distributive forms of music (described in chapter 5) - Digital audio via cable, MDS or satellite, and Digital Audio Broadcasting will challenge existing AM and FM broadcasters.
- Some time after the year 2000, electronic delivery of music is likely to challenge physical distribution of discs. In the long term it seems clear that electronic delivery will dominate.
- The increased diversity of music will further strain the existing promotion and retail channels - radio, TV and retail shops.
- The position of distributors in the industry is based largely on physical products, geographical factors and national business and legal boundaries. All these will be of diminishing importance with the advent first of WWW CD marketing and later electronic delivery.

The most prominent opportunities are:

- For artists and record companies - the opportunity to provide music samples, photos, contextual and promotional material to any of the growing millions of music fans who use the World Wide Web.

- For musicians, a more direct link with their audience. Starting with World Wide Web retailers and other WWW sites now, and leading into electronic music sales, there are many business and creative advantages to be gained from sustaining a two way dialogue with fans. Their help in the fight against profligate copying is likely to be invaluable.
- For all participants in the music industry, the use of email, mailing lists, newsgroups and the World Wide Web to exchange information and ideas, to monitor and contribute to musical trends and industry debates.
- For all participants in the music industry - especially retailers - the ability to use the Internet to facilitate ordering and searching for CDs and other music products from distributors and recording companies.
- For retailers - the opportunity to use the World Wide Web for marketing CDs and related material. Later, the use of jukebox and other technologies to improve the customer's ability to audition music, both in the shop and via the WWW.
- For retailers with a highly specialised knowledge of particular genres of music, the WWW presents a relatively low cost method of making this knowledge available to customers all over the world - either as a component of retail sales or as a paid information service. It also provides a means to refine and extend that knowledge through interactions with specialists, musicians and fans all over the world.
- For retailers and artists - the ability to make CD-R discs to exactly suit he customer's requirements. This integrates well with a shop or WWW based automated music browsing and ordering system.
- For artists and recording companies, the possibility of reaching customers (through the WWW), and ultimately selling music directly to them, without having to get the music onto radio, or into shops and without the need to arrange interviews in magazines.
- For some artists, the possibility of selling music directly to customers without the need to work with a recording company.
- Increased ease of copying music from radio and other distributive media, and the possible development of automatic music identification will facilitate the diffusion of new music.
- For artists, the opportunity to create music and other aesthetic material using musical objects and multi-media - both of which can offer listener control and interactivity.
- For artists, the opportunity to collaborate with other artists anywhere in the world. Transfer of MIDI files and samples is practical today. Transfer of digital audio is expensive now and limited by slow local links, but costs will diminish. After 2000, it might be common to send digital recordings (including multi-tracks) via the Internet to other artists anywhere in the world - for their musical contributions and mixing skills.

Comment [RW26]: Page: 346
I have not explored these internal functions of the industry in this paper. They are relevant to the future structure of the industry. It think these applications will be fairly obvious as the industry starts to use the Internet for other purposes.

MAJOR THEMES OF CHANGE

Certain themes are evident in the foreseeable evolution of the music industry. These are also likely to be relevant to other content industries such as film/video, magazines, newspapers and printed directories such as phone books, classified advertising and industry guides.

Physical to electronic

The physical media of discs (or printed paper and floppy discs) is replaced by direct data transfer over the network.

Network growth - size, speed, scope and ubiquity

Today the network is the Internet, later it will be whatever Internet evolves into in an environment where Video On Demand is common. Ultimately the term *network* will refer to the disparate physical networks which interoperate and share common protocols and addressing structure - to support the functions of today's phone system, pagers, Internet, VOD, LANs and WANs.

Demise of mass media in favour of personalised, on-demand services

Although some of the content and supporting infrastructure for Video On Demand will be based on broadcast and distributive services, VOD represents the abandonment of these mass technologies in favour of a personalised service based on a telecommunications network.

In the longer term, the content carried on VOD will be designed for it rather than for linear broadcast and distributive channels. This enables links to be built into material intended for both entertainment and functional purposes. These links could point anywhere in the world and link from news and functional material to entertainment and retailing activities.

The World Wide Web is the starting point for the many applications of VOD which do not require full motion video. Its development will be rapid as it gives many consumers their first taste of global interconnectivity for many kinds of pursuits.

Consumers gain bi-directional communications with the outside world

The phone service supports bi-directional communications, but only for voice and typically only between one person and another. The Internet provides a variety of modes of contact with several kinds of communication - text, graphics and later voice and video. This will change consumers understanding of the world and change their expectations of how to do business. They may choose not to deal with a local distributor or retailer if better service can be gained directly from the originator of the product.

The dissolution of geographic and temporal barriers

Email, WWW and electronic delivery of music reduce or eliminate previously existing barriers caused by long distances and time zone differences.

Information technology helps both small and large businesses

The traditional view of computers was that only big companies could afford them. Similarly the "Big Brother" view of technology saw it as a means for large organisations to control individuals. The personal computer, the Internet and public key cryptography show that the benefits of information technology flow to individuals and smaller organisations in perhaps greater measure than they do to larger organisations.

This is evident in the music industry as the traditional music selling process is being bypassed by WWW CD retailing and later by electronic delivery - both of which can be operated by individuals and small companies.

Many ways when there were few

This "many ways where there were few" theme operates on many aspects of the music industry:

1 - Promotional activities.

2 - Distribution and playback technologies.

3 - Musical packaging styles - originally singles and albums.

4 - Diversity of an artist's output, the names under which they operate and collaborate with others.

5 - The distinction between recording and score.

6 - The gap between playing recordings and performing live has already been bridged from both ends. New instrument technology will enable more sophisticated use recordings and musical objects on stage.

7 - Concepts of "composition" and "performance" are already blurred with sampling and remixes by people independent of the originator. With increasingly sophisticated "music object" technology - particularly when these objects are distributed publicly in a playable and modifiable form - users and other originators can take parts or the whole of pre-existing objects and fashion their own versions for private use, distribution to friends or for sale.

8 - Styles of control during listening - previously track to track from CD to CD. Later, track to track from any collection of music. Later, changes to the structure of the track while it is playing. Later, multi-variable controls for musical objects and the generation of music without a fixed duration.

Introduction of new ways

For each instance of the "many ways" aspects of the music industry listed above, several things can usually be said:

1 - The existing ways are still available.

2 - The new ways arise primarily from technological innovation and the industry exploiting new niches which were previously impossible.

3 - The significance of the existing ways is typically reduced because they no longer have the same dominance in the field.

4 - The cost effectiveness of the existing ways may fall in absolute terms because of reduced usage - for instance broadcast TV as it loses market share to subscription TV and VOD.

5 - The cost effectiveness of the existing ways may increase due to price competition. For instance, CD prices dropping because of competition from overseas WWW retailers, listener copying and electronic delivery.

6 - The cost effectiveness of the existing ways may increase because the old way uses new ways to achieve the same purpose. For instance retailers may be able to afford high speed telecommunications connections and CD-R writers 3 to 5 years before consumers, and so the new flexible techniques give the old way - the CD shop - enhanced cost effectiveness.

7 - Ten years is quite long enough for a previously dominant way of doing things to be completely outmoded - for instance vinyl records.

The pace of change

The rate of technological change shows now signs of slowing down. With the exception of automatic music identification, all the technologies in this paper are widely regarded as feasible, although there is debate about their speed of development and ultimate market success. Information technologies cross-pollinate and hybrid vigour is apparent in the many applications which bring together novel combinations of techniques for new purposes.

The computer and the Internet are the two most important technologies of the 1990s. They greatly improve the productivity of people who develop new technologies, new content and new ways of marketing content.

The time frame for planning a business, and building it into a successful operation is typically two to five years - except for the really large corporations which usually take decades to grow. This is shorter than the major cycles in technology of the past - which may have a growth spurt of five to twenty years, and a lifetime of several decades. However when technological change is rapid, startup companies can rise to dominant positions within five years - for instance Apple and Microsoft.

The pace of musical development in the "techno" field in the last four years has been similarly dramatic - despite traditional distribution and promotional channels being ill-suited to it. The music industry thrives on material from fresh creative territory - music which challenges preconceptions of what music can be. Sony Australia dance promotions manager Geoff Grainger comments on the techno music explosion "Its heading in many directions at once. There's the youth orientated hardcore, the ambient market which sells lots of albums, the commercial side and so on. People once thought that the techno scene would die and go away, but in reality, its taking over. Every dance club plays techno of some kind" (Trish 1995).

There are thousands of genres and sub-genres of music. The communications revolution promises to make a vast range of music available for browsing and purchase from the home at any time.

Musicians can look forward to being able to sell their music and have better contact with their audience, with less reliance on radio play and retail shops.

Recording companies, distributors, retailers and broadcast media face challenges and opportunities as the mass forms of contacting people and selling product are supplemented by network based techniques. The network enables people's individual needs to be satisfied directly, rather than by choosing a one-size-fits-all mass produced product or service.

The World Wide Web today provides tremendous opportunities for personalised services and specialised retailing - without temporal or geographical restrictions. However it takes time for businesses to chart their course and bring their plans to fruition.

In early 1995, the World Wide Web is the focus of many new music marketing developments. There are a growing number of artist and recording company sites on the WWW, together with retailers and fan driven resources and discussion fora.

The communications revolution promises to be one of humanity's greatest adventures and the rollercoaster is gathering speed. Musicians and listeners are driven by their imagination to realise their wildest dreams. New ways of making music and the global communication and music delivery technologies provide fertile ground for musical experiences we cannot yet imagine.

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