Predicting the future of broadcasting

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Will broadcasting be supplanted by the Internet?

Will "convergence" lead to a single delivery system for multimedia services?

Which broadcast delivery systems (terrestrial, satellite or cable) will become dominant for digital TV?

Will the reduction in costs of computer hardware affect broadcasting?

Will computers merge with TV sets?

This article attempts to answer such questions, both by looking "sideways" at the world of computers and the Internet and by analyzing some technological trends.

1. Introduction

Nobody can accurately predict the future, especially in broadcasting where technological developments will be a major driving force.

Fig. 1 shows the approximate dates of introduction of various technologies in broadcasting and related sectors. It is clear that the pace of technology is accelerating. Although *Fig. 1* shows that some technologies have lasted a very long time, rapid changes in technology mean that there is little prospect of such stability in the future.

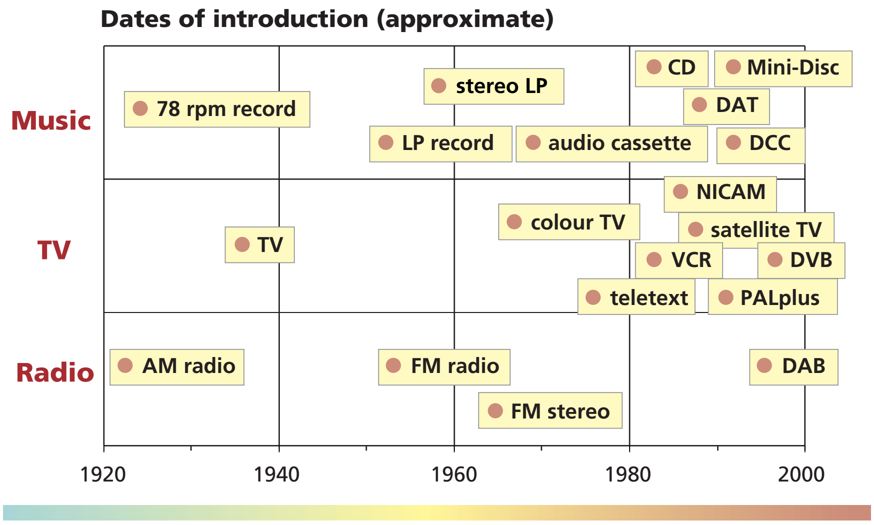

Figure 1
Technology is accelerating.

As broadcasters need to assess the risk of their favoured new technology becoming obsolete within a few years, we need to address the question: *"Is technology truly unpredictable?"*

Those making bold predictions about the future should be aware that many predictions made in the past have proved to be dramatically wrong – even when made by experts with impeccable credentials. For example, the eminent scientist Lord Kelvin stated in 1895 that *"Heavier-than-air flying machines are impossible"* and in 1897 compounded this error by saying that *"Radio has no future"*. In 1943, the chairman of IBM, Thomas Watson said: *"I think there's a world market for, maybe, 5 computers"*. In 1977, Ken Olsen, the founder and president of Digital Equipment Corporation said: *"There is no reason for any individual to have a computer in their home"*.

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One problem is that incumbents tend to under-estimate the importance of new competing technologies. For example, in 1876 an internal memo in the telegraph company Western Union said: *"This 'telephone' has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value for us"*. Similarly, H.M. Warner (one of the Warner Brothers) said in 1927: *"Who the hell wants to hear actors talk?"*. Perhaps these examples should be borne in mind by broadcasters who confidently assert that the Internet will have little or no impact on broadcasting.

Nevertheless, we would be equally foolish to believe that all new technologies will automatically replace all old technologies. For example, radio broadcasting has not been replaced by television. Neither has the cinema been replaced by television. In fact, both radio and the cinema have gone from strength to strength – despite intense competition from the newer technologies.

Prediction is obviously a risky business. Rather than being reluctant to make predictions because we might be wrong, we should try to understand the underlying causes of technological change and then postulate how these could affect products and services in the future. We will not always be accurate, but long-term planning must be based on a rational analysis of likely future technologies.

2. Exponential growth

The rapid growth of the Internet and, especially, of the World Wide Web (Web) has surprised almost everybody. It is often quoted as an example of the sheer unpredictability of our technological age. *Fig. 2* shows the growth of the Internet, as measured by the number of "host" computers. It appears to indicate that the growth of the Internet "exploded" around 1995, coinciding roughly with the establishment of the Web. Looking at this graph, it is hard to believe that anybody could have predicted this sudden "take-off". However, if the numbers of hosts are plotted on a logarithmic scale, as in *Fig. 3*, it is clear that there was no sudden change around 1995. In fact, it appears that the Internet has had a long history of sustained exponential growth. Although there are limits to exponential growth, ultimately set by the population of the world, it is obvious that the use of graphs with a logarithmic scale would have given us "early warning" about the phenomenal growth of the Internet.

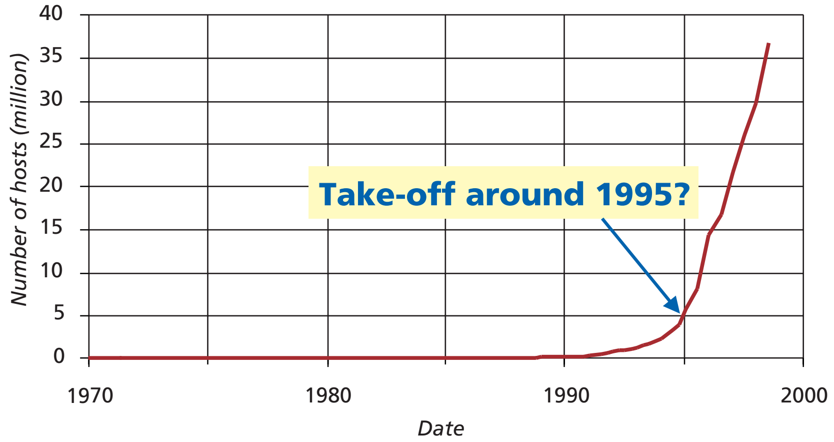

Figure 2
Growth of the Internet.

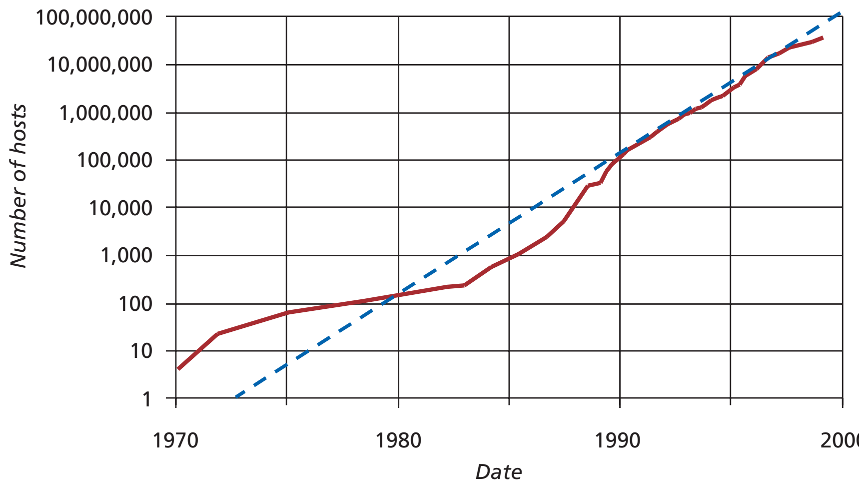

Figure 3
Growth of the Internet (logarithmic scale).

Having quoted several erroneous predictions by eminent people, it is only fair to acknowledge the most successful prediction of our technological era. In 1965, Gordon Moore (the co-founder of Intel) was asked to make a prediction about the future of the integrated circuit. He noted that, in the previous six years, the number of transistors on a silicon chip had doubled every year. He postulated that this doubling process could continue indefinitely. As he did not think that this very rapid growth could be sustained, he suggested a doubling period of 24 months – which was later modified by others to 18 months. This simple hypothesis is now known as Moore's Law.

As can be seen from *Fig. 4*, the number of transistors on the Intel series of microprocessors has increased dramatically over the past 25 years. It is easy to fit a straight-line approximation to this curve. As the graph has a logarithmic vertical scale, a straight line represents exponential growth – in this case doubling every 24 months. This diagram confirms that Gordon Moore's prediction has been remarkably accurate.

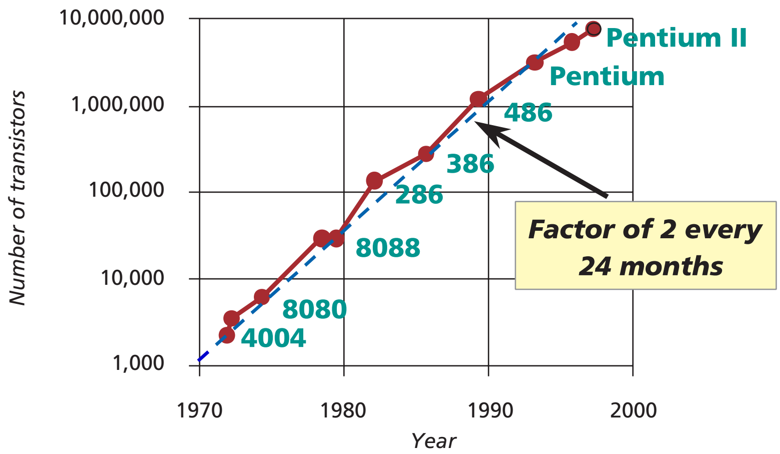

Figure 4
Micro-processors.

The importance of Moore's Law is not simply that more and more transistors can be squeezed on to a silicon chip. Each new generation of microprocessor offers improved performance at roughly the same price – because the area of the silicon is the dominant factor in the cost of production of chips.

3. Price trends

The upper curve of *Fig. 5* shows the UK retail price of Random Access Memory (RAM) as measured in price per MB over the past few years. Although there is a clear downward trend in the price of RAM, there has also been considerable price volatility. It is worth noting that the price increase during 1993 is commonly attributed to a fire which damaged a factory at Kobe in Japan. It seems that this single factory was the world's principal source of a special form of epoxy resin used in integrated circuits. The other fluctuations in price are caused by mismatches between supply and demand. It is clear that RAM has become a commodity in which producers occasionally overestimate or

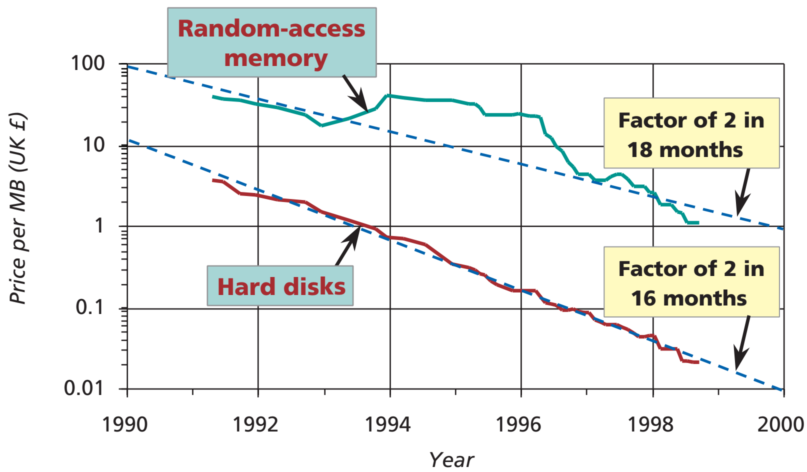

Figure 5
RAM and hard disks.

underestimate the demand, causing the price to vary accordingly. Manufacturers of RAM and computer manufacturers are keen to avoid holding stocks of RAM because, on average, its value will drop by more than 10% in 3 months. On the other hand, it is difficult for them to predict demand from consumers.

The lower curve of *Fig 5* shows that the price of hard disks has dropped consistently throughout this period. Although most people now expect devices based on silicon, such as microprocessors and solid-state memory, to obey Moore's Law, it is a surprise for many to learn that similar exponential trends also apply to complex electro-mechanical devices such as hard disks. It is even more surprising to discover that the price per MB has fallen faster for hard disks than for RAM!

Strictly speaking, because Moore's Law refers to the number of transistors on a chip, it could not possibly apply to the storage capacity of hard disks. Some other explanation is needed to explain these price reductions. In early 1991, computers typically had a 40 MB hard disk – with a retail price of about UK £160 or £4 per MB. By 1998, 6.4 GB (6,400 MB) hard disks had become commonplace at prices around £130 or £0.02 per MB. In other words, although the price of a hard disk has remained roughly constant, there has been an astounding increase in the capacity of hard disks. It is not appropriate in this article to explore how this has been achieved, other than to note that it has been achieved by numerous incremental improvements of disk technology, allowing more disk platters and higher densities of magnetic storage.

Such patterns have long been observed in the manufacturing industries, where they are known as "learning curves". When a new product is introduced, the manufacturing costs per item can be very high, but fall rapidly with mass production. Continuing refinements to the manufacturing processes result in improved output, better quality and higher productivity which lead eventually to lower prices for consumers.

The media rarely report advances in production engineering, concentrating instead on reporting "scientific breakthroughs". Although production engineering may sound mundane, it has arguably had more impact on ordinary people than the "scientific breakthroughs" – many of which never achieve any practical application.

We should not dismiss the importance of scientific advances, but we need to recognize that broadcasting and consumer electronics are based on only a few "big ideas", such as:

- the invention of radio;
- the cathode ray tube;
- the silicon chip;
- the laser;
- digital communications;
- digital compression of video and audio signals.

4. Exploiting Moore's law

If prices reduce *or* performance improves by a factor of 2 every 18 months, there are important long-term consequences. A factor of 2 every 18 months is equivalent to:

- a factor of 10 every 5 years *or*;
- a factor of 100 every 10 years.

These sustained long-term trends are responsible for transforming the computer industry and will also transform broadcasting.

It seems that these trends in improved performance and/or reduced costs will continue for some years. The consensus in industry is that the advances in performance of microprocessors, memory and hard disks will continue for at least 10 years at the current rate. What impact will these trends have on broadcasting technology?

The computer industry exploits Moore's Law to add extra features and higher performance, whilst keeping the retail price constant or even reducing the price. So far, the computer industry has also achieved the remarkable feat of persuading users that they need to replace their computers very frequently. Rapid improvements in the performance of computer hardware are matched by the marketing of new software that relies on or, often, anticipates the arrival of improved hardware. This means that users of older computers cannot run the latest software without upgrading their hardware. This inflationary spiral results in rapid obsolescence of hardware and software, which naturally benefits both the hardware and the software industries.

Manufacturers of televisions have much greater problems. Ordinary TV sets cannot evolve to products with greater functionality. It is true that new features can be added, such as widescreen, surround sound and high-definition, but a television essentially remains a television. Furthermore, consumers expect their TV sets to "last for ever".

Broadcasters have long placed great emphasis on compatibility with equipment used by consumers: for example, existing receivers were not made obsolete by the introduction of FM stereo, RDS, colour TV or stereo sound for TV. Broadcasters should be praised for protecting the interests of the public, whereas the computer industry pays minimal attention to the principle of assured compatibility with previous equipment. These contrasting attitudes demonstrate that broadcasters cannot hope to match the speed of developments in the computer industry.

Unlike the computer industry, broadcasters do not benefit from the effects of Moore's Law except when they change technologies (e.g. analogue to digital). Indeed, without these exponential changes, the transition to digital broadcasting would simply not be possible. The use of complex digital modulation schemes, such as OFDM, and the digital compression of video and audio signals requires immense processing power in DAB and DVB receivers. Without the advances predicted by Gordon Moore, the receiving equipment for digital broadcasts would simply be too expensive for consumer applications.

The "parallel universe" of computers and the Internet obeys a weird law of economics, radically different to that of the "real world". Unless broadcasters find ways of benefiting from the impact of Moore's Law on a continuing basis, the competitive advantage of broadcasting will be rapidly eroded.

5. Local storage

One opportunity for broadcasters would be to take advantage of the falling price of storage. Storage is unusual in radios and TVs, mainly because of cost constraints. Looking ahead, falling costs will change this situation. For example, RAM costs UK £1 per MB today, but we can expect it to cost £0.10 per MB in five years and £0.01 per MB in 10 years. Similarly, hard disks cost £20 per GB today, but this will reduce to £2 per GB in five years and £0.20 per GB in 10 years. These low prices will almost certainly trigger the availability of receivers with considerable processing power and local mass storage.

5.1. Data broadcasting

Data broadcasting will become much more common in the era of digital broadcasting. Most data-broadcasting systems are based on the concept of a data carousel in which the entire contents of the data service are repeated frequently so that the user has to wait only a short time to receive the desired portion of the data.

A similar approach is used in teletext transmissions on analogue TV services. Teletext services have been hampered by the fact that, until recently, most TV sets had only enough memory to store a single teletext page. This meant that every time you requested a new teletext page you had to wait for it to be transmitted by the broadcaster. In the case of teletext, a complete rotation of the carousel (i.e. transmission of all data) typically takes 20 seconds and, hence, the average waiting time is 10 seconds. If, however, you have a teletext receiver (or a TV card in a computer) with enough capacity to store 100 pages or more, the requested page is probably available immediately from its local memory. In other words, the use of storage at the receiver can dramatically improve the usability of teletext services. Furthermore, local storage would avoid the need for repeated re-transmission of data throughout the day, even though most of the data has not been modified since the last transmission. Local storage would result in better utilization of the digital multiplex and, hence, give better spectrum efficiency.

Combining local storage with other forms of broadcast data services would also offer considerable benefits. Whereas data received over the Internet is rarely transferred at the nominal data-rate of, say, 28.8 kbit/s, a broadcast data channel can offer a sustained continuous data-rate. This means that, for example, a 64 kbit/s broadcast data channel can deliver 30 MB in just over one hour. Special broadcast data services on DAB could be targeted at receivers with, say, 16 MB or 32 MB of local storage. Special DAB receivers or lap-top computers fitted with DAB cards could offer sophisticated multimedia information services, which would be continuously up-dated and instantly available to consumers.

5.2. Storage of audio and video

As mentioned above, £130 will today buy a 6.4 GB hard disk which can store approximately three hours of video (encoded at a rate of 5 Mbit/s). At the same price in five years, we can expect 30 hours of storage and, in 10 years, 300 hours. This prediction does not take into account any improvements in compression technology, which would further increase the number of hours of video storage.

At first sight, the prospect of using hard disks to record video might not seem to be a significant development. After all, videocassette recorders (VCRs) are already widely used by consumers. Although VCRs perform their basic functions well, most people have experienced all of the following problems:

- incorrectly pre-setting a VCR to record a programme at a later time;
- not being able to locate previously recorded items;
- accidentally over-writing previously recorded items.

The use of hard disks promises to offer numerous advantages over VCRs, such as:

- automatic self-indexing of recordings (using metadata transmitted by broadcasters);
- random-access capability offering rapid access to all recorded material;
- replay whilst recording.

As hard disks can play back material whilst recording other material, broadcast video material could be routinely recorded on the hard disk so as to offer pseudo video-on-demand (VoD) facilities. This facility would allow viewers to "pause" a broadcast programme (e.g. to answer a telephone call) and then to resume watching the rest of the programme with full control such as play, stop, rewind, etc.

Existing broadcast services could be much enhanced by the use of local storage. For example, consumers might designate a portion of their hard disk to be under the control of a broadcaster, who would ensure that the disk contained the latest version of the news. Consumers would thus have the choice of watching either a traditional "linear" broadcast of a news bulletin – or having instant access to individual news items (in the order determined by the user rather than the news editor), in the knowledge that each item is continuously updated by the broadcaster.

By such means, local storage could enable the broadcasters (and their consumers) to "break free of the constraints of linear broadcasting".

6. Convergence

The term "convergence" means different things to different people. Digital technology could precipitate a merger of the previously separate industries of telecommunications, computers and broadcasting/publishing. Although this concept became very fashionable in the early 1990s, it seems unlikely that these industries will actually converge into a single industry. However, there will be numerous cross-industry ventures and alliances.

Many observers are excited by another form of convergence, that of convergence of consumer hardware. In particular, many expect that the TV set and the personal computer will merge into a single consumer appliance. The Author does not subscribe to this theory because of differences in the way that the two devices are used. Firstly, the viewing conditions are very different. TV sets are viewed from a considerable distance, typically 6 - 10 times the picture height, whereas computer users are much closer to the screen, typically less than 2 times the picture height. This difference means that text and graphics for TV viewing must be much larger than the ideal size for computer applications.

Secondly, TVs are often viewed passively by several people simultaneously, whereas computer usage is generally a solitary and heavily interactive activity. The reality is that interactivity and communal viewing do not mix – except if you are the one with the remote control! Although TVs are unsuited to interactivity, computers will undoubtedly be increasingly used to display TV programmes. So, in the Author's opinion, convergence will be a one-way process – TV reception will become a standard feature of computers, but you will not use your TV set as a "word processor".

7. Delivery systems

Digital technology is the source of convergence. A bit is a bit – whether it represents an element of text, software, graphics, audio or video. Does this mean that delivery systems will converge into a single broad-band "pipe" into people's homes? Will broadcasting be supplanted by the Internet or its successors?

Fig. 6 shows several alternative means of delivering real-time multimedia "content", in addition to the usual broadcast delivery systems (i.e. terrestrial, satellite and cable).

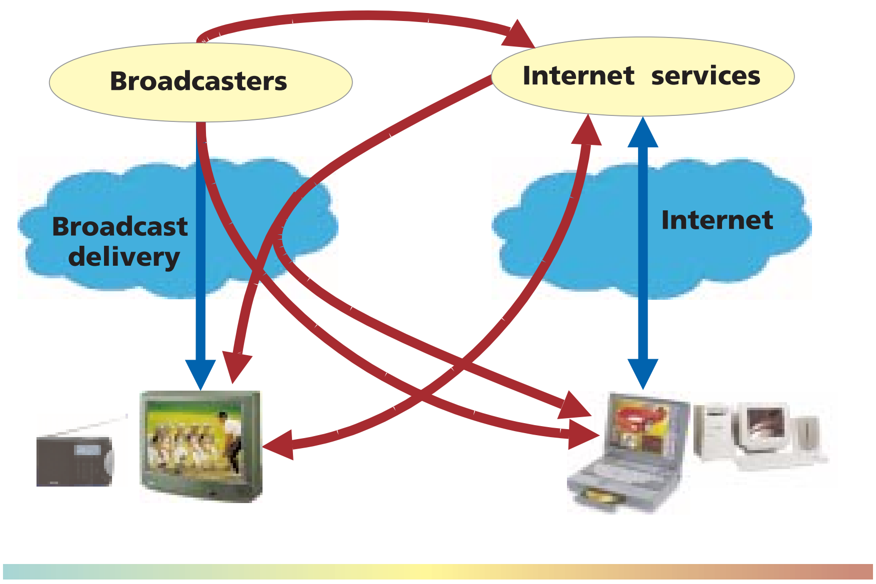

Figure 6
Convergence or divergence?

7.1. Broadcasting

It is inevitable that the future of broadcasting will be digital. However, many people make the assumption that the transition from analogue to digital will inaugurate the "digital super-highway". In practice, digital transmission will not, by itself, change the essential nature of broadcasting. Over-air broadcasting will remain, inherently, a "passive", "one-to-many", "one-way" communications system. As shown in *Fig. 6*, there will be many opportunities to add interactivity to traditional broadcasting.

Digital technology will multiply the number of available broadcast services, including:

- free-to-air services;
- subscription services;
- near-video-on-demand services;
- pay-per-view services.

Fig. 7 shows the penetration of cable and satellite TV services in Europe. It is immediately obvious from this diagram that there is little uniformity. Thus, it would be unwise to make generalized predictions about the future of delivery systems across Europe.

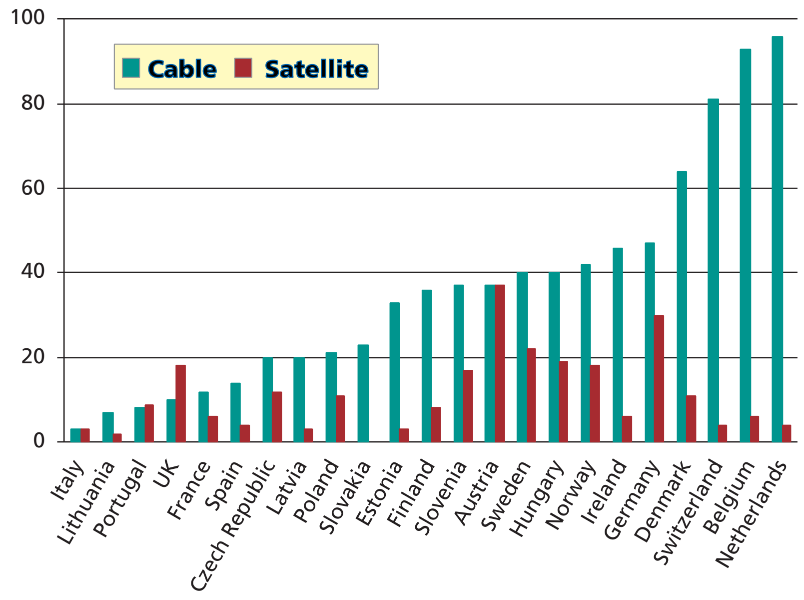

Figure 7
Cable and satellite penetration.

Each delivery system has its own particular strengths and weaknesses. It is clear that there will be no universal solution. Individual broadcasters will need to choose the most appropriate digital delivery mechanism for their markets. However, as consumers are certain to demand increased portability and mobility, delivery of services from terrestrial transmitters will remain an essential element of broadcasting.

7.2. The Internet

The Internet often suffers from serious congestion, especially when too many users attempt to retrieve information from a particular site or at "busy" times of the day. Such problems do not occur with any form of broadcasting. Nevertheless, the lack of interactivity inherent in broadcast delivery systems is a serious shortcoming. As more and more users become exposed to the Internet (and other future interactive services), they will be reluctant to accept this lack of interactivity. They may also be frustrated by the limited content available on broadcast systems.

Many broadcasters already use the Web to offer programme-related information, audio services and limited video services. Indeed, many of the web-sites operated by EBU members are very successful – in several countries, the most popular web-sites are those operated by EBU Members.

The Internet will become very important for broadcasters as a new delivery mechanism for: broadcast services; on-demand services and, especially, the delivery of services to international audiences. The Internet will undoubtedly develop to offer a wide range of enhanced services, including good-quality video and audio. However, unlike broadcasting, it is not well suited to the simultaneous delivery of programme material to large audiences and it cannot offer services to mobiles and portables (without consuming huge amounts of the radio spectrum).

The most challenging goal is that of using the Internet to deliver "broadcast-quality" video (i.e. good-quality full-screen images with accurate motion portrayal at 25 or 30 frames per second). Current performance is far below this standard. It is clear that today's Internet cannot deliver high-quality broadcast video or video-on-demand. However, it is inconceivable that this limitation will be permanent. Almost every element of the Internet will have to be replaced to solve this problem – but it will still be called the "Internet".

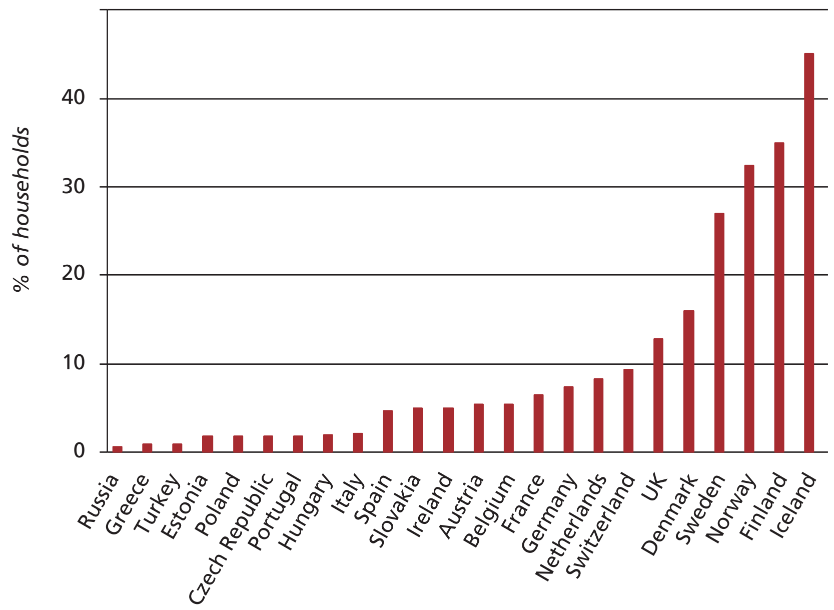

Figure 8
Internet penetration.

The rapid growth of the Internet is certain to continue. *Fig. 8* shows current estimates of the penetration of the Internet in various European countries. This shows that there are large disparities between different countries. In particular, the Nordic countries are far ahead of the rest of Europe in their use of the Internet.

Within 10 years, 50% of homes in Western Europe could be connected to the Internet and may also be able to receive on-demand video services – even if the quality does not quite meet the goal of "broadcast quality". This prediction may be dismissed as wildly optimistic but, if true, it implies that the remaining 50% of homes would still be dependent on traditional broadcasts.

7.3. Broadcasting to computers

Some computers are already fitted with TV cards that permit reception of analogue TV broadcasts. This feature will probably become more common with the advent of digital broadcasting. Microsoft has predicted that *"50% of PCs sold in the USA in the year 2000 will be capable of receiving digital TV broadcasts"*. This obviously represents a new and expanding market for normal broadcast TV services. It could also permit important new forms of broadcast multimedia services, using the processing power and storage capability of computers.

7.4. Internet on TV sets

Various commercial services allow consumers to display Web pages on standard TV sets. They use special set-top boxes connected by a modem to a normal telephone line. A key feature of such services is that they are easier to use than computer-based access to the Internet.

As Web pages are designed for viewing on computers, the pages must be magnified and re-formatted to ensure legibility on TV screens. The result is that many graphics cannot be accurately displayed and only part of the page is visible without scrolling.

It could be unfair to suggest that such services offer a "poor person's Internet with limited capability", especially as these services are primarily targeted at the many potential consumers who are totally perplexed by computers. There may be a significant market for such services.

Abbreviations

DAB	Digital Audio Broadcasting
DVB	Digital Video Broadcasting
OFDM	Orthogonal frequency division multiplex
RAM	Random-access memory
RDS	Radio Data System

7.5. Broadcasts of Internet content

Data broadcasting can be used to deliver pages from the Web. Some use the vertical blanking interval of analogue TV services, whilst others use digital television transmissions which offer much greater capacity.

Some services offer pages from, say, 100 of the most popular web-sites. This technique certainly overcomes the problems of slow telephone connections to the Internet as experienced by most users of the Internet. However, one of the great attractions of "web-surfing" is that you embark on a voyage of discovery, rather than being confined to some predetermined and extremely limited subset of the content available on the Web. Imagine the contrast between very rapid access to certain "favoured" sites and having to use a normal dial-up modem every time you wanted to click on links to "other" sites.

Some satellite operators have devoted an entire digital satellite transponder to data broadcasting, thus offering full interactive high-speed access to the Internet. A normal telephone line is used to request data from the Internet, but the content from the Internet is delivered by high-speed data broadcasts from the satellite. Users of such services can achieve data rates of 0.5 Mbit/s or more. However, as the digital multiplex delivers a total of 30 - 40 Mbit/s, a moment's reflection reveals that a continuous data-rate of 0.5 Mbit/s can be sustained only if there are less than 80 simultaneous users across the entire footprint of the satellite service (typically the whole of Europe).

7.6. Convergence or Divergence?

Fig. 6 raises the question *"Are we all entering an era of convergence or divergence?"* One certainty is that we will not "converge" on a single delivery mechanism. There will be many competing technologies for delivery of multimedia services.

It is worth remembering that success in the consumer market is not determined by technology, but by other factors such as:

- the range of features;
- ease of use;
- cost of equipment;
- cost of use;
- content (quantity and quality).

Attractive content is the most important factor in the success of any multimedia product.

The prospect of new delivery systems does not imply the "death of broadcasting". Broadcasting is, and will remain, ubiquitous. The Internet will become very important. Broadcasters will almost certainly be major suppliers of services and content for services delivered via the "enhanced" Internet. The other delivery mechanisms have yet to prove themselves, but broadcasting to computers will probably be a very large market.

Broadcast transmissions will, of course, eventually become digital, but analogue services will continue for another 15 - 20 years. For historical reasons, terrestrial transmission has been the dominant form of delivery for radio and TV services. However, in the future, broadcast services will be delivered by a multiplicity of methods:

- ➪ **Wireless** – terrestrial, satellite and microwave multi-point video distribution (MVDS);
- ➪ **Wired** – cable, telephone lines and optical fibre.

The prospect of a rich variety of on-demand services is enticing to consumers, but the reality is that the production of high-quality material is expensive and, consequently, the product must be consumed by a large number of people.

Although the number of TV services available to the average consumer has increased dramatically in the last few years, expenditure on new programmes has not expanded in the same ratio. Many of the "new" TV services rely heavily on the recycling of programme material previously shown elsewhere. Furthermore, although on-demand services will become increasingly important, it is obvious that many events, such as sports and news, need to be transmitted "live" and consumed simultaneously by millions of people. Despite the transition from analogue to digital delivery, there is still a long-term need for "traditional" broadcasting.

Two trends appear inevitable:

- ➪ *portability* and *mobility* will become major requirements – even for TV reception which has, hitherto, been an essentially static application;
- ➪ *interactivity* will blur the distinction between "traditional" broadcasting and wired services, including those delivered by the Internet (and its successors).

There will be huge problems of spectrum availability if members of the public insist on combining "interactivity" with "portability" and "mobility".

From a technical perspective, the Internet is a "powerhouse of technology" (such as streaming audio/video, downloadable software and push technology). Such technologies require user terminals with considerable processing power and local storage. However, broadcasting standards have historically been designed to minimize the complexity of receivers, so as to reduce the costs for consumers. This constraint will become less necessary because of the falling costs of computer processing and storage. Broadcasters will embrace the Internet, adopting and adapting the new technologies to benefit from the advantages of broadcast delivery.

8. Conclusions

We cannot foresee which specific technologies will be successful. It is tempting for engineers to believe that the "best" technology will always succeed in the market place. In practice, there have been numerous occasions where the "best" has been soundly defeated by inferior technologies. Success or failure is determined primarily by timing and by marketing tactics – not solely by technical superiority.

Although technology is evolving rapidly, we can be reasonably confident about the general trends. For example, over a period of 5 years, it is safe to assume that performance will increase by a factor of 10 (at the same price) or the cost will reduce by a factor of 10 (whilst delivering the same performance).

These sustained trends have already transformed the world of computers. It has been said that "*there are two types of technologies":*

- ➪ *"exponential" technologies* (those demonstrating exponential changes in performance or cost);

- *"unimportant" technologies*.

As a result of "exponential" technologies, the "parallel universe" of computers and the Internet seems to obey a weird law of economics, radically different to that of the "real world".

Unless broadcasters find ways of benefiting from the impact of exponential technologies, the competitive advantage of broadcasting will be eroded. One opportunity will be triggered by the rapidly falling costs of storage, which will enable new types of broadcasting:

- A modest amount of storage (e.g. 16 MB of RAM) at the receiver, in conjunction with a data channel of, say, 64 kbit/s on DAB transmissions, would permit a sophisticated multimedia electronic information service to be offered to consumers "on the move". The stored information would be instantly available to the consumers and could be updated when necessary by the broadcasters.
- Much larger amounts of random-access storage (e.g. hard disks of 10 GB or more) at the receiver will challenge the supremacy of the videocassette recorder by offering greater ease of use and new features, such as simultaneous recording and replay. More importantly, such storage would allow broadcasters and consumers to break many of the constraints of "linear" broadcasting by offering "on-demand" services using content delivered by broadcasters and stored at the receiver for later use.

"Prediction is difficult – especially of the future"

Storm Petersen, Danish humorist

In standardization, there is a tendency to make "safe" decisions by opting for readily available (and cheap) technologies. Given the relentless march of technology, such short-term decisions often mean that the standard becomes obsolete before consumers have had a chance to buy products or services based on that standard. Nevertheless, we also need to recognize the dangers of the opposite extreme – that of being too ambitious by adopting very immature technologies. The key element of success in standardization is timing – neither being too early nor too late!

Many new forms of multimedia services become possible with the introduction of digital delivery. It is impossible to predict which new services will be successful in the market place, but attractive content is certain to be the key factor.