Introductory scenarios for interactive television

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This article has been adapted from a report [1] prepared within the European Union's ACTS INTERACT Project [1]. It concerns the choice of options for the introduction strategies for inter-active television services. Interactive television has been seen as an exciting addition or even an alternative to traditional "passive" participation by the viewing audience, since it offers the viewer more overt opportunities for responding and contributing to programmes.

Options are considered for the introduction of interactivity into the existing analogue television broadcasting environment, and also for the new digital domain where return-channel technology may be a prerequisite for Conditional Access security and to enable payment for the programmes. The success or otherwise of such new services is seen to depend vitally on the simultaneous co-existence of three factors: Technology, Infrastructure and Content.

The market for interactive services offers much potential in Europe, especially for attracting the younger generation of viewers. However, it is recognized that there is, as yet, no clear "killer application". The particular market drivers and the possible future roll-out of interactive services are considered, against the background of very different national situations among the countries of Europe.

1. Introduction

The concept of *interactive television* covers a wide range of services and systems. In itself, it simply means that the viewer is able to provide some personal input or feedback that has an influence in what he/she sees, hears or is subjected to. This feedback may go no further than the internal electronics of the television, or it may be sent back to the service provider or programme provider via an "interaction channel".

The impact of this feedback can range from some means of participation in an activity which is created by the receiver (e.g. a game), via voting in response to the programme being broadcast, to directly selecting the entirety of the programme being viewed.

In addition to understanding that interactivity covers a wide range of systems and services (i.e. the degree of interaction and its possible impact on the programme), it also has to be

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Abbreviations

ADSL	Asynchronous digital subscriber line
API	Application programming interface
CATV	Community antenna television
DAM	DECT authentication module
DAVIC	Digital Audio-Visual Council
DECT	Digital enhanced cordless telecommunications
DSP	Data services profiles
DTH	Direct-to-home
DVB	Digital Video Broadcasting
DVB-RC	DVB - Return Channel
EDB	Enhanced digital broadcasting contour
ETSI	European Telecommunication Standards Institute
FSN	Full service network
GSM	Global system for mobile communications
HTML	Hyper-text markup language
IB	In-band
IDB	Interactive digital broadcast contour
IF	Intermediate frequency
ISDN	Integrated services digital network
ISO	International Organization for Standardization
LAN	Local area network
LMDS	Local multipoint distribution system
MPEG	(ISO) Moving Picture Experts Group
OOB	Out-of-band
OSI	Open systems interconnection
PPV	Pay-per-view
PSTN	Public switched telephone network
SFDMA	Synchronous frequency division multiple access
SMATV	Satellite master antenna TV
SMC	Subscriber management centre
STB	Set-top box
TCP/IP	Transmission control protocol / Internet protocol
TDMA	Time-division multiple accessl
URL	Uniform resource locator
VDSL	Very high bit-rate digital subscriber line
VBI	Vertical blanking interval
VoD	Video-on-demand
WRS	Wireless relay system

understood that concepts of interactivity are now often intimately bound up with the concepts of *multimedia*. Multimedia can be taken to mean literally a programme, presentation or recording that is made up of elements of video, audio, graphics, text and any other viewable manifestations. However, in practice, these programme elements (sometimes called *programme objects*) are connected to each other in ways that often have a degree of interactivity, in the sense that the viewer or user is able to control the assemblage of picture elements, or move from one to another by a feedback process. Multimedia in practice is the combination of (i) the use of a number of programme objects and (ii) interactivity.

The issue of media interactivity is also virtually synonymous with the issue of *media convergence*: the gradual overlapping of the technologies used for broadcasting, telecommunications, computers and publishing. It is these forces which are leading the broadcasters towards interactivity, and providing the technical tools to make this possible.

In order to provide the viewer with an interactive service, a vast range of possibilities can be covered. At the time of writing there is no universal agreement, or indeed, no large body of evidence, about which type of interactivity will represent the best step forward for the media delivery world (moving beyond today's linear broadcasting services).

Some systems and ideas have been tried and tested, others have not. Some are based on extensions of existing services; others are entirely new options for the programme-maker and the viewer. The media delivery world awaits guidance with clear signs of the directions that should best be taken.

2. ACTS INTERACT project

The ACTS INTERACT project has studied one general class of interactive systems and, within that, two particular implementations. The class of systems studied is that where a return channel (or, more generally, an interaction channel) is added to an existing broadcast channel. The two implementations are:

- the use of a UHF over-air path for the return channel, probably via the viewer's existing receiving antenna and a local-area UHF collector receiver;
- the use of a cable channel to provide both the forward and return paths (in another part of the cable frequency band).

Even though this technology is constrained, it would allow a relatively wide range of interactive services to be provided.

Notions of digital broadcasting have evolved since the INTERACT project was started, and will continue to do so. The new model for digital broadcasting is that it will be a container for digital data, rather than a transport mechanism for a specific television or radio programme channel. The data will be combinations of *linear programming* and *multimedia*.

In a sense, European analogue television today has some elements of a similar philosophy, in that it is a combination of linear programming and off-line broadcasting, known as teletext. It could be argued that teletext, as an information service, was the precursor of multimedia. The new multimedia, which will take over the role of teletext in the digital environment, will certainly provide the same kind of information services (such as news, weather and sports information). However, they will be more attractive visually, in that they will allow elaborate arrangements of stills, moving pictures, audio, captions, texts and diagrams. They may look like extensions of today's glossy colour magazines.

The features of multimedia broadcasting in the digital age will not stop there. It will be possible to link elements of the multimedia directly to the broadcast programmes being aired. They will probably be accessible during the programme itself by means of icons. Furthermore, the multimedia is likely to include programming that can perform tasks within the receiver. In computer jargon, they would be described as *executable content*. This executable content will run in real time while the viewer is using the service, and possibly while a linear programme is running.

In looking forward to future digital broadcasting scenarios that include interactivity, we need to take into account the use of broadcasting to deliver executable multimedia.

2.1. "Greek temple" model

In our analysis of the introductory strategies to be used for interactive TV, we can use models to understand the critical factors. One recent analysis [2] suggests that a "Greek temple" model applies for the success or failure of new media systems. The model proposes that success is like the roof of a Greek temple, which is held up by three pillars. If any one of the pillars is weak, the roof will fall. Only by having three strong pillars at the same time will the roof hold. The pillars of interactive TV are *technology, infrastructure* and *content*.

The **technology** pillar poses the question: *can the system be made and is the technology available for consumer production?* If the answer is yes, the technology pillar is strong.

The **infrastructure** pillar asks: *is the infrastructure available to deliver the technology? Are the delivery means (i.e. the transmitters, distributions links and receivers) available, or likely to be available, at a cost that matches the perceived added value of the services that will be provided?* If so, the infrastructure pillar is strong. It can be considered to have a series of segments that correspond to the different parts of the value chain from programme production to the user. This layer model for the value chain was also used in the INTERACT requirements analysis [3].

The **content** pillar addresses the question: *do the contents bring significant added value to the consumer in order to justify the cost of the equipment or subscriptions?* In the final analysis, the content pillar is always decisive for new media systems. People do not buy wires and resistors or raw technology; they buy the means to watch the programmes they enjoy or to receive the services they want. Without compelling content, any amount of new technology has no value.

If we use these tools, we should find an insight into whether a new media delivery system is likely to be successful, or not.

One of the startlingly successful interactive media delivery systems is the *World Wide We*b. The run-away success of the Web (Internet) suggests that its three pillars are very strong. Indeed, it clearly has very strong infrastructure and content pillars. There is a vast range of available content on the Web which is largely unavailable elsewhere ("TV with 5 million channels"). The infrastructure is strong because the receiver is the home PC that already exists in large numbers.

Arguably, the technology pillar associated with the Web is not very strong. The technical system of the Internet has been built up over the years and few would regard it as well-engineered in the traditional sense. However, it works, and this is what matters.

Success is less clear for broadband networks or Full Service Networks (FSNs). There have been over a dozen trials throughout the world, with Video-on-Demand (VoD) as the core service. The results of these trials can be seen at best as ambivalent. At the time of writing, no operator of a VoD/FSN trial has announced plans to continue the services beyond the trial period (as reported in the ACTS BIDS project). In most cases, these trials have only been moderately successful. This is usually perceived to be because the available content has only been of modest interest to the viewer, and probably not dramatically better than that available from other outlets such as over-air broadcasts or video tapes. The technology for the VoD systems has often been very good indeed. Its technology pillar is very strong. This has not however made the system a success. There is a lesson here for the introduction of new media technology in general.

If its infrastructure costs are out of balance with the content value, a new system will not succeed or, at best, will have a very slow roll-out.

3. DAVIC model

Another important element to consider is the development in the Digital Audio-Visual Council (DAVIC) project on interactive systems. The DAVIC project has adopted a generalised model of interactive delivery systems that is intended to cover all classes of systems, but was initially intended to meet what was seen as the most pressing need – a model for the delivery of VoD or services-on-demand. The model is thorough and appropriate for this context.

We can note that in the DAVIC project there is disappointment that the DAVIC systems for VoD are not being used in practice. This is not because there are technical defects with the technology proposed. It is rather because there are no concrete plans to introduce VoD services. This may be largely for the reasons given above – a lack of sufficient compelling content.

However, DAVIC has recently turned its attention to the development of specifications for hybrid delivery systems that combine the use of a digital broadcast channel with the Web. It has developed an *Enhanced Digital Broadcasting* (EDB) contour with two variants. The first variant supplies Web-format signals in a one-way digital broadcast channel, alongside a linear programming channel. The second variant couples the digital forward channel to an Internet channel, which provides the interactive capacity for the Web-delivered pages. This can in turn be made to provide feedback for the linear channel if needed.

This EDB contour seems particularly relevant for interactive television, and needs to be considered carefully when formulating the introduction strategies.

4. Analogue television

Starting from the perspective that there is a long-established popular TV service or bouquet of competitive / complementary programme services in every European country, we can examine the ways in which interactivity can be added to the programming. Local interactivity is already well established through the medium of teletext. There is a very large installed base of teletext receivers and the typical viewer makes use of this service for a number of minutes per week.

The bugbear of teletext has always been the long waiting time experienced by the viewer. Although this aspect has been improved over the years by (i) the addition of more memory in the receivers (up to a certain cost limit) and (ii) by the use of more transmission capacity (up to the maximum that the vertical blanking interval (VBI) of PAL and SECAM signals can support), there still remains the question of how to manage the memory intelligently in order to anticipate the use that will be made by the viewer. The teletext page must already be stored in the receiver before the viewer selects it.

Ultimately, there remains the problem of channel-changing which requires a fresh start in storing the contents of the teletext magazine. Although teletext has been in use for over twenty years, developments continue [4]. Teletext is a well-understood model for the management of any interactive data broadcast that uses the “carousel” approach.

In order to provide full interactivity, a return channel must be provided. The fundamental problem that must be overcome is the traditional cycle of “the chicken and egg”, applied to the investments made by broadcasters and consumer manufacturers. For the broadcaster, a new service will only justify important investments in programme content when the potential audience that is equipped to receive and use the service is large, i.e. there are many receivers in the field. Equally, for the manufacturer, the market for consumer products will only justify large-scale production runs and achieve the economies of scale needed for consumer products to be competitively priced, if the services offered by broadcasters are sufficiently attractive to the viewers.

The initial start-up phase is therefore difficult. The traditional approach has often been for the broadcaster to start a new type of service that can only be received by a very small audience equipped with expensive prototype receivers. Only then may the consumer manufacturers gear up for mass production, a process which usually accounts for a delay of 18 to 24 months. Hence the broadcaster may need to justify operating a new service with a near-zero audience for up to two years. A faster start-up may require the purchase by broadcasters of large numbers of first-generation products, or subsidies from the broadcaster to encourage the purchase of products which in the early days may seem too expensive to the public.

In the case of analogue television services, the added value of interactive services – as perceived by the viewer – must equate to, and justify, the added cost brought about by the inevitable subscription fee and the purchase or rental of the necessary set-top box (STB).

Two models of possible full interactive services are emerging, based on two different approaches to the interactive experience. In the first model, the viewing public is seated in the comfort of their sofas and armchairs, watching the programming on a TV set but interacting with it via hand-held control units (possibly several). An example of this would be represented by *Two Way TV* ™ [5].

In the second model, a lone viewer is seated at a PC, watching TV in a “window” which occupies perhaps a quarter of the monitor screen. Other windows on the screen provide tools for navigation, such as directory trees, while others contain information related to the TV programming. One such example of this would be the *Intercast* ™ system [6].

Two Way TV ™ model

This model adds formal interactivity through the use of electronic equipment to what was an informally interactive situation – the “family viewing experience”. *Two Way TV* ™ has identified that an attractive feature of games shows is the competition which takes place within the small audience in one home, against each other and against the benchmark set by the contestants on the TV programme. The *Two Way TV* ™ technology formalises the game between viewers by allowing them to record their performances (speed of response, number of correct answers) in the set-top unit, and subsequently to compare their performances with the studio competitors and ultimately with all other interactively-equipped players.

The list of programmes originally used for the trials consisted of mainly quiz / games shows, soap operas and sports events. It was offered to 200 homes without payment and subsequently was offered to subscribers who also had to rent or purchase an STB, The presentation of the added interactive material was carefully arranged to match the programme material so that, for instance, an overlay of text giving an update on the “story so far” would not obscure the action at that moment.

Intercast ™ model

The *Intercast* ™ development is closer to a PC style of usage than that of a TV set. The presentation could be viewed on a TV, but the method of use comes from the experience of the Internet and “Windows”, extended to link with broadcast TV. This imposes a somewhat reduced role on the TV programme which is displayed in one window on the screen (as a “picture within a picture”). The moving TV image is surrounded by areas that provide features in common use on a PC. Hence there is a File Manager / Directory Explorer by which the further features of the programme-related add-ons can be selected and displayed.

Local interaction can be provided where the broadcast data can be accessed at will by the user, and full interactivity with hot-links to Internet URLs by modem and Internet connection.

4.1. Return channel technology options

Clearly, the cable medium offers a natural bi-directional signalling capability, and networks which have been constructed fairly recently may be capable of handling return path traffic. In general however the most widely available option for the return path for analogue television services is the telephone modem link. The penetration of telephone lines into the homes of the viewing public makes the possibility of attachment universal. This does not imply that there are no difficulties in doing so, and it may be that it is often inconvenient to make the physical connection between the STB and the telephone line. The point of entry of the antenna and cable feeds is often not close to the telephone termination point.

4.2. Interaction channel protocol options

Using the telephone network for the return/interaction channel, two options of connection are possible. In the first, a call is established to the Interactive Service Operator; in the second, the call is made to an Internet Service Provider after which the interaction messages are passed between the Interactive Service Operator and the user via the normal Internet protocols. Both connection types may take advantage of local telephone call charges by the use of special numbers and by automating the call-routeing.

For the present, set-top boxes, such as those used for *Two Way TV* ™, dial directly to the service operator using an interaction protocol of proprietary design. This has the primary advantage of being under close control and relatively rapid for call set-up and close-down. Where there is already synergy with the Internet, such as in the *Intercast* ™ service, the Internet protocols of TCP/IP and World Wide Web data structures such as HTML are a natural choice. The *Intercast* ™ system uses TCP/IP adapted for one-way delivery via the television VBI, and HTML data structures for the Web-style additional material which accompanies the TV programme.

For the majority of interactive services, where telephone call times have to be kept to a minimum (for many reasons including call charges, other phone users, rapid response, automatic recovery from network congestion), the preference would be to make direct connections to the Interactive Service Operator via a local-call-charge automatic router if available.

4.3. Types of programming possible

The novelty of interactive TV has made some people set out to seek the “killer application” which would establish a mass-market need. The ensuing income from such services would make it economically viable to install the return-channel infrastructure and to invest in additions to the programming content. A large number of trials have embarked on identifying such an application but without any common result. It has often been found that particular features of programming attract significant numbers of users in each trial, but when aggregated these become a collection of highly individual market niches which could only be fully exploited by developing the services and content in depth and breadth.

The populations who have been exposed to interactive trials have usually shown significantly higher interest in the interactive programming than in the passive version of such programmes, or in the other content offered.

Most trials have provided a similar offer of services including additions to games shows, sports programmes (multi-camera angles and updates to the results statistics), current affairs (voting/polling), home shopping, home banking, advertising-linked promotion responses, and educational programmes.

The experience of the many trials has led to some caution amongst potential service providers, with the concept gaining ground that there will be no instant and massive popular demand (the killer application) but that the growth of interest will be slow but steady, and only ultimately will justify the investment. If the introduction of interactive services is seen as a long-haul operation, then a major part of the process will be educating the public to become interested in them and getting them to use the interaction capabilities. There may be more stages of transition from the wholly-passive viewing experience to the fully-interactive experience. In particular, we may anticipate that local interaction may remain an important feature of the development of interactive broadcasting. This would apply especially where true broadcasting to mass audiences of millions of viewers could precipitate an active response which could be overwhelming.

4.4. Different national environments

The continent of Europe provides very diverse examples of broadcasting infrastructures. Consequently, there is considerable diversity in the possible scenarios for the introduction of interactivity.

Some countries have almost no cable distribution infrastructure, while others are virtually 100% cabled. Some countries have only just installed their second national terrestrial analogue programme service, which was provided for in the frequency plan laid down in Stockholm in 1961. Others have many more programme services than originally planned, the limiting condition often being the interference from non-authorized transmissions.

The reasons for such differences are complex with some obvious influences such as the terrain geography, and less obvious ones such as history, commercial economics and political deregulation. Within the limited resources of the INTERACT project, the differences in national environments have been noted.

5. Digital television

Digital television broadcasting is a very new business. A number of programme services via satellite were launched in 1996. The operators of these pioneering services have found it sufficiently important or necessary for business reasons to manage the whole of the delivery chain — from programme provision to STB manufacture. Several examples of what are known as "vertical operations" are now in place, and it can be instructive to look at the differences in what may be considered the relative success achieved by these in the short-term.

Most digital services were launched with interactive features from the very beginning. The technology required by the consumer represents a major investment by the service providers, who have specified in total detail the features of the STB, and negotiated with one or more manufacturers to make large quantities of such boxes. The specification of the STBs, even in the first phase of manufacture (expensive), has had to offer features that are sufficient to provide for its service lifetime which, for consumer equipment, may be 5 - 7 years. The commercial business plan of the new digital services has been largely focused on the attraction to the public of "premium" movies and sport for which a subscription is charged, often with pay-per-view (PPV) supplements.

Where PPV is a critical element, direct interaction between the STB and the subscriber management centre (SMC) is important, and set-top boxes have been furnished with modem facilities. Thus the driver for building an interactive infrastructure has been the need to charge the user payments for his / her TV programme viewing. Once provided, the return channel / interaction channel infrastructure offers distinct security benefits to the conditional access (CA) system which can interrogate the STB smartcard. It may be made further available for other debit transfers, such as for home shopping, or for using Bank Cards which from 1999 will be standardized in Europe.

The digital broadcasting era demands investment in new receiving equipment, whether subsidised and rented to the viewer, or cross-subsidised by the "vertical" service operators (by bringing the retail price down to make an attractive offer to the customer). In either case, the extra cost of including a simple modem in the STB is small. However, as mentioned earlier, it may not be very convenient for the viewer to make the necessary connection to the telephone service, particularly if the socket is in a different room.

For delivery media other than satellite, there has been a different route to developing the services and receiver products. Cable operators have already made very high investments in their analogue technology infrastructure. Some of the older systems are very limited in their capacity, and there are pressures to "go digital" in order to relieve the bottleneck this presents.

In some countries, this overcrowding is seen as an opportunity to overlay the analogue infrastructure with digital terrestrial networks, in order to provide a significant and rapid increase in the transmission capacity. As cable operators often work within restricted environments (franchised or licensed), many of them have formed associations to bring about economies of scale in the manufacture of cable STBs. These associations have developed common STB specifications which have been issued to the prospective equipment manufacturers.

Typical of these, the *Eurobox* from the European Cable Communications Association will make use of the cable connection for interactivity (and will operate alongside other applications such as telephony).

The digital terrestrial market, which will use the DVB-T standard, is now building up to launch in several countries. The terrestrial broadcasting market is the most long-established and, in many countries, has had the express aim of approaching 100% coverage of the population. Until now this market, which is almost entirely free-to-air, has operated "horizontally" where manufacturers are free to offer to the public a range of products for direct purchase to enable them to watch whatever programming they are able to receive. Broadcasters in this market are normally subject to rigorous regulation, and the manufacturer who offers an incompatible or sub-standard product is soon "punished" by the consumer market.

Since the introduction of digital terrestrial transmissions could threaten to interfere with the existing established services, the national regulators are closely involved in the service introduction plans.

In general terms, the introduction of digital broadcasting necessitates the sale or rental of STBs which are, at least initially, relatively expensive pieces of technology. In the consumer market, the first implemented products may need to be amortised over a 5-7 year period. During this time they must continue to function and, if possible, should be able to accommodate the new services and added-value features, the precise details of which are not fully defined in advance. Set-top boxes have therefore been developed to include flexibility, by permitting the future upgrading of the software (e.g. the operating system, the API, the EPG, or even the "look and feel" of the user interface).

Such upgrading may be carried out by a number of different methods but the ability to interrogate the STB via an interactive path offers the prospect of efficient upgrade management and control.

Hence there is little argument for omitting interactive features from digital STBs, especially since the cost of providing a simple modem is very small in comparison with the remainder of the technology.

5.1. Interaction channel technology options

Interactive television requires the addition of both a forward and a return channel, as illustrated in *Fig. 1*. In particular, a new mechanism is required to transfer the data back to the broadcaster (the return interaction channel).

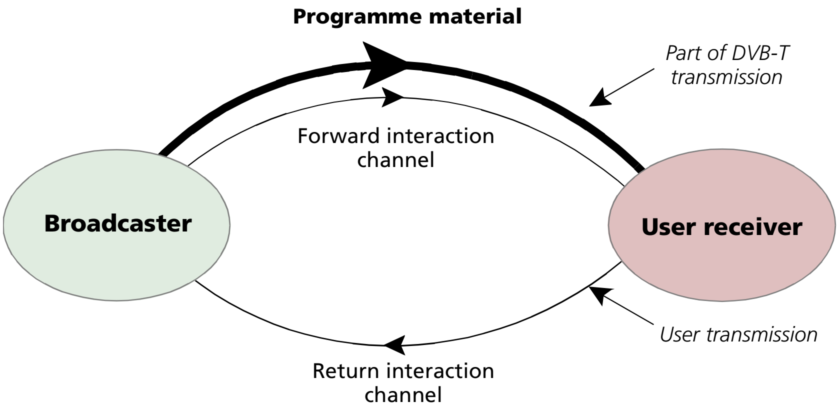

Figure 1
Interactive television system.

5.1.1. Forward channel

In digital television, the forward channel information can be multiplexed as part of the DVB broadcast transmission, possibly as a "private" data service. The bit-rate associated with the forward channel is controlled by the service provider, and hence its capacity may vary depending on the type of programme material.

A shopping channel, for example, may choose to allocate a high bit-rate to the forward channel and a relatively low bit-rate to the actual programme material (the broadcast video). It will concentrate its limited overall resources on meeting the specific requests of the users (e.g. the specification of items, or information about ordering products), rather than on general programming content.

At the other extreme of interactivity, a programme channel which includes opinion polling may require only a very low bit-rate forward channel, for transferring the questions to the user.

5.1.2. Return channel

The return channel is more complex than the forward channel, as additional features must be added to both the users' and the broadcasters' equipment. It is unlikely that a single optimum solution will ever be created. The various alternatives must therefore consider:

- the usage costs;
- the equipment costs (for the user);
- the broadcasting infrastructure.

A number of return channel alternatives have been proposed and these are summarized in *Table 1*. Wherever possible, use of the existing infrastructure is beneficial. However with either terrestrial or satellite television, there could be an operational benefit in maintaining the return channel under the total control of the system operator and not by using third-party services (e.g. PSTN). There may be disadvantages in areas of high user density, where local distribution points may be needed, thus increasing the infrastructure requirements.

Method	ETSI Standrd	User Usage costs	User equipment costs	Broadcaster infrastructure costs	Required technical development
PSTN	Yes	High[a]	Very low	Low	Little[b]
Cable	Yes[c]	Service-defined	Medium	Low	Some
UHF terrestrial	Preliminary draft within DVB	Service-defined	High	High	High
DECT	Yes[d]	High	Medium	High[e]	Medium
SMATV	Yes[f]	Service-defined	Very high	Low[g]	Medium

a. Currently a call must be created for each user response and as this uses a standard telephone line, this can be an important cost feature. Future systems may be based on a pay-per-usage basis.
b. It can also take full advantage of any improvements in general Internet access technologies.
c. Submitted for final voting proposal.
d. Other alternatives are under discussion within INTERACT and elsewhere.
e. It is possible that an existing infrastructure exists for general telecommunications.
f. Various alternatives have been suggested, some of which are still being discussed in the DVB Project.
g. Could possibly be high if assistance is offered in order to reduce the user equipment costs.

Table 1
Return-channel technologies.

a) PSTN

The simplest solution for a return channel is to use a modem over a standard telephone line, and this approach is adopted on current systems. Due to the low infrastructure costs, both at the user and the broadcaster ends, it is suitable for small pilot operations and can easily be scaled up to larger operations as the user-base increases.

The maximum return channel capacity via a V-series individual modem connection is restricted to 56 kbit/s, with no sharing of facilities being necessary. This is likely to be sufficient for virtually all currently-envisaged interactive applications.

The equipment required for a PSTN return channel is given in *Table 2*, and the relative advantages and disadvantages are shown in *Table 3*.

An ETSI standard is available for a return channel over PSTN [7].

A number of trials are also being made with new "xDSL" technologies (ADSL, VDSL etc.) to increase the capacity with higher potential bit-rates, or to provide mechanisms which do not tie up the standard telephone service.

User	Broadcaster
Telephone line	Modem bank
Modem	Telephone line capacity

Table 2
Equipment for PSTN.

Advantages	Disadvantages
Simple user equipment	User call charges
Minimal broadcaster equipment	Revenue gained by telecom operators and not service providers, unless using premium lines
Usable with all forward channels	Telephone line tied up
Relatively large return channel bandwidth	Must be close to telephone access point – reduces portability

Table 3
Relative advantages and disadvantages of PSTN.

b) Cable

A cable return channel is the obvious solution for an interaction channel in those areas with a cable connection. It offers relatively large bandwidth and does not affect other services. Increased forward-channel capacity is also possible by devoting a spare frequency channel for this purpose.

An ETSI standard has been prepared for a return channel over cable [8][9]. However for Community Antenna Television (CATV), there is also a rival US standard [10] and, since in the UK most cable operators are subsidiaries of US companies, there is pressure to adopt this standard in the UK in preference to the European standard. A review article of the various cable alternatives is given in [11].

Fig. 2 indicates a possible spectrum allocation for CATV. Although not mandatory, a guideline is provided to use the following preferred frequency ranges:

- 70 - 130 MHz and / or 300 - 862 MHz for the forward channel (downstream OOB);
- 5 - 65 MHz for the return channel (upstream), or parts thereof.

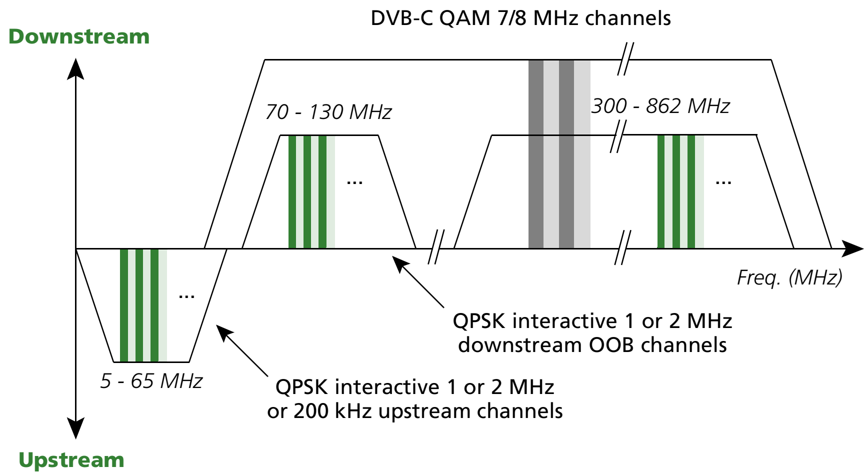

Figure 2
DVB-preferred frequency ranges for CATV interactive systems.

To avoid filtering problems in the bi-directional video amplifiers and in the STBs, the upper limit (65 MHz) for the upstream flow shall not be used together with the lower limit (70 MHz) for the downstream flow in the same system.

The user equipment necessary for cable is fairly minimal and may already largely be available to cable users in order to provide wideband Internet access.

The cable specification permits up to 3.088 Mbit/s in the return channel which is shared amongst all users.

The equipment required for a CATV return channel is given in *Table 4*, and the relative advantages and disadvantages are shown in *Table 5*.

User	Broadcaster
Cable user	Receiver for additional frequency channel
Cable modem	

Table 4
Equipment for Cable.

Advantages	Disadvantages
Relatively simple user equipment	User must have cable access
Minimal broadcaster equipment	
Large return channel bandwidth	

Table 5
Relative advantages and disadvantages of Cable.

c) LMDS

The Local Multipoint Distribution System (LMDS) specification [9] is very similar to the Cable specification. However, in this case the final delivery is via a short-range microwave link in which the forward channel can use an IF within the 950 to 2150 MHz frequency band. The system is aimed at providing a high-speed local distribution from a general distribution network without direct cabling to each terminal.

For the return channels, two different choices can be identified:

- *Out-of-band (OOB) signalling.* In order to maintain compatibility with current equipment which accords with the ETS 300 800 specification [8], 70 - 130 MHz can be used for the forward channel and 5 - 65 MHz for the return channel.
- *In-band (IB) signalling.* Taking into account backward compatibility with the current cable specifications, and in order to give major capacity for future interactive and multimedia services, the frequency allocation is 5 - 305 MHz.

This is summarized in *Fig. 3*.

The LMDS forward channel provides 3.088 Mbit/s for the OOB signals and multiples of 8 kbit/s for the IB signals. It is expected that up to 1000 users of the return channel can be supported.

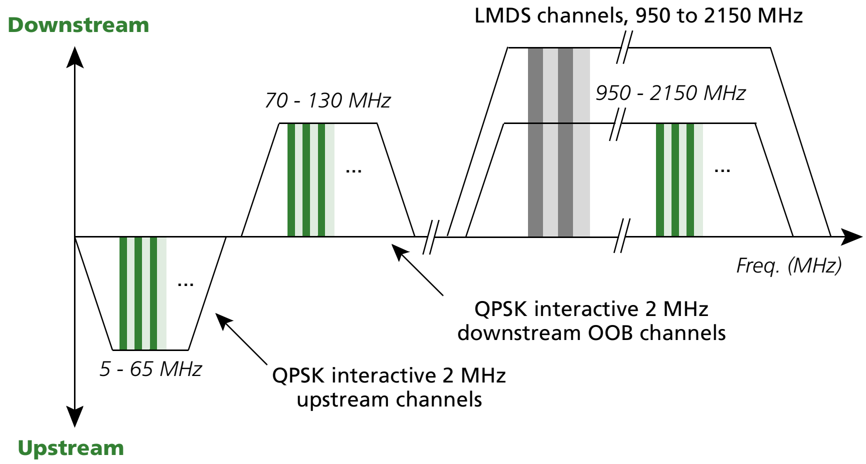

Figure 3
DVB-preferred IF ranges for LMDS interactive systems (OOB).

The equipment required for an LMDS return channel is given in *Table 6*, and the relative advantages and disadvantages are shown in *Table 7*.

User	Broadcaster
High-frequancy microwave link equipment	Local distribution points
Cable modem	Receiver for additional frequency channel

Table 6
Equipment for LMDS.

d) UHF terrestrial

There could be advantages for terrestrial broadcasters if the whole interactive system were kept within their own domain. Thus a return channel transmitted within the UHF frequency band that is allocated to broadcasting would appear to be very beneficial. However, there is a problem with this approach. While the provision of UHF television services is independent of the user density, the provision of a UHF return channel *is* dependent on the user density: a UHF return channel can work very effectively in rural areas (where the user density is low) but can be very restricted in urban areas (where the user density is high).

A solution to this problem has been proposed by INTERACT [12], based on a cellular infrastructure. By enabling four alternative operating modes, the SFDMA modulation scheme enables a scalable architecture in which additional cells can be added as the user base increases, without affecting any existing users. The roll-out of such a system could therefore be highly incremental, with initial large cells (up to 75 km) being gradually replaced with smaller cells (down to 1.15 km). Since only a 1 MHz slot is required for each cellular station, the facility for frequency re-use is possible – with only neighbouring cells being restricted to different frequencies. The total bandwidth required for the system is therefore minimal.

Advantages	Disadvantages
No cabling required from local network to individual houses	Provision of micro-wave link and associated cabling
Large return channel bandwidth	Line-of-sight operation

Table 7
Relative advantages and disadvantages of LMDS.

Spectrum availability is limited and hence the return-channel bandwidth must be shared amongst all users. Whilst it is sufficient for many of the applications that are foreseen for interactive television (e.g. tele-voting, tele- shopping etc), it does not compare to that available from PSTN or cable.

User	Broadcaster
Set-top box including UHF modulator and transmitter	Cell reception infrastructure

Table 8
Equipment for UHF terrestrial.

The user equipment is relatively complex with a requirement for a low- power UHF transmitter. However with no connections required to other services, the receiver can be readily moved around the home as required.

The equipment required for a UHF return channel is given in *Table 8*, and the relative advantages and disadvantages are shown in *Table 9*.

Advantages	Disadvantages
Keeps all of system within control of UHF broadcaster	User equipment cost
Mobility of equipment (i.e. no outside connection is required)	Broadcaster infrastructure
Easy user set-up	Limited return channel bandwidth
	System interference
	Available UHF spectrum allocation

Table 9
Relative advantages and disadvantages of UHF terrestrial.

The UHF approach offers an expandable solution within the constraints of the existing UHF broadcast band. Whilst the economics are dependent on the number of users, the UHF approach is ideally suited to areas with few users and poor infrastructure (i.e. where a single reception site is sufficient), for example in third-world countries for educational programmes, and for transportability of equipment (e.g. loaning of equipment for market surveys).

There are still some outstanding interference issues to be resolved, in that each user transmission could interfere with the neighbouring reception of TV channels. This is currently being studied within the INTERACT project. A very high rejection ratio is required for transmission of the return channels that are adjacent to existing television channels; placement of the return channel at one end of the available UHF band is probably required (which would have to wait for the next formal reallocation of radio frequencies). A separate band could however cause problems when the user transmission is returned via the existing receiving antenna, as it may be bandwidth limited. The receiving antennas that are already in use have often been in place for many years, and it may not be wise to rely on the re-use of this infrastructure “resource”.

e) Digital Enhanced Cordless Telecommunications (DECT)

In areas of high population density (such as apartment blocks), a cellular system requires microcells and hence the infrastructure is very expensive. A relatively cheap alternative which offers microcells is the DECT system. Operating in the frequency band 1880 to 1900 MHz, it acts as an access network and can distribute the data via other networks (ISDN, PSTN, GSM etc.). However at these frequencies, communication is severely attenuated by walls and other solid objects and, hence, near-line-of-sight operation is necessary.

DECT has features that could be suitable in an interactive DVB system [13] in which the final delivery from the DECT receiver to the broadcaster uses standard PSTN or ISDN facilities. DECT can handle a lot of users in a small area (urban and suburban situation) and can support a broad range of services. A Wireless Relay Station (WRS) can be used to extend the coverage. There is no need for traditional frequency planning as DECT uses dynamic channel selection.

The maximum communication range is limited and hence the number of microcells required is very large. It is therefore unsuitable for rural areas. Since the latter is well served by the UHF terrestrial approach, it could be that these two technical solutions could be seen as complementary. However, broadcasters or users may not be able to afford to implement both technologies.

The net bit-rates for standard DECT are:

➩ 8 kbit/s B-field (traffic) per half slot (unprotected mode);

➩ 6.4 kbit/s B-field (traffic) per half slot (protected mode);

➩ 32 kbit/s B-field (traffic) per full slot (unprotected mode);

➩ 25.6 kbit/s B-field (traffic) per full slot (protected mode);

➩ 80 kbit/s B-field (traffic) per double slot (unprotected mode);

➩ 64 kbit/s B-field (traffic) per double slot (protected mode);

➩ 6.4 kbit/s A-field (control/signalling) per half slot, full slot and double slot.

The DECT standard includes data services. The services and relationships of the different profiles are described in [14]. The data services profiles (DSPs) are a family of profiles which build upon and extend each other, aimed at the general connection of terminals that support non-voice services to a fixed infrastructure, private and public. The application determines which profile type to use, due to parameters such as data rate, latency, reliability and power consumption. They all exploit the powerful lower-layer data services of DECT, which are specifically oriented towards LAN, multimedia and serial data capability. Each member of the profile family has been optimized for a different kind of user service.

DECT has algorithms for authentication of both the base station and the terminal, as well as a simple encryption scheme: DAM (DECT authentication module) card support.

The equipment required for a standard DECT return channel at approximately 1900 MHz is given in *Table 10*, and the relative advantages and disadvantages are shown in *Table 11*.

User	Broadcaster
Set-top box including DECT equipment	Infrastructure for microcells (may already be present for telecommunications)

Table 10
Equipment for DECT.

Advantages	Disadvantages
Resonable return channel bandwidth	Small cell sizes requiring a large infrastructure
Mobility of set-top box	Unsuitable for long distances
	Near-line-of-sight operation

Table 11
Relative advantages and disadvantages of DECT.

The technology is currently being studied within INTERACT. Its suitability for the implementation of interactive services has been considered, and different modifications have been proposed in order to improve its efficiency and to make it more suitable for interaction purposes. Amongst these, changes in the modulation scheme, the channel equalization and the implementation of an efficient packet access mode (True Packet Mode) are under study.

f) Satellite

The increase of DTH satellite transmissions indicates the requirement for a satellite interactive system. The ideal system would therefore transmit directly back from the user to the satellite, similar to the proposed terrestrial system.

However, whilst satellite receivers have reduced considerably in cost, a similar reduction in transmission equipment has not been seen. It is therefore unlikely that direct transmission to satellite will be cost-effective in the foreseeable future [2].

A system similar to SMATV reception is therefore envisaged in which multiple users are connected to a satellite distribution point, and solutions via a low rate TDMA coax section [15] or a DECT coax section are being studied [13][16]. The user STB must therefore be capable of this local transmission and various alternatives are possible.

Another alternative is a direct user link to the satellite as either Ka / Ku, Ku / Ku or Ka / Ka frequency band solutions, and this is currently being investigated by DVB-RC. However, at the present time, individual user transmitters are prohibitively expensive.

The advantage of satellites is that there is a relatively large bandwidth which could be utilized. However cost factors indicate that probably only a limited bandwidth will be available in practice.

User	Broadcaster
VSAT transmitter (probably shared)	Additional satellite channel
Access to above	

Table 12
Equipment for Satellite.

The equipment required for a satellite return channel is given in *Table 12*, and the relative advantages and disadvantages are shown in *Table 13*.

g) GSM

A solution using GSM has also been proposed [17]. However this has still to be passed to DVB-RC for initial approval. A possible solution is being proposed by the ACTS MEMO project.

2. The next generation of satellites will permit mobile communication via satellites. However the call charges and equipment costs would indicate that this is still unlikely to be viable for a standard user interactive facility.

5.1.3. Which technology option?

There is probably no single technical solution which can provide the optimum return channel for all users throughout Europe. Broadcasters and manufacturers of consumer receivers must therefore acknowledge this and should design their applications and equipment to be suitably modular in order to support the various alternatives.

The system operators would ideally wish to maintain complete control of the interactive system within their domain. Hence, terrestrial broadcasters would prefer a terrestrial network, and satellite operators a satellite network. However, there remain several technical and infrastructure issues to be overcome.

Advantages	Disadvantages
Wide area coverage	Local infrastructure required to link to VSAT equipment
Minimal broadcaster equipment	Expensive user equipment (if personal VSAT terminal)
Return channel capacity is variable	High user charges
Keeps service within control of satellite operator	
User satellite facilities could be used for other services	

Table 13
Relative advantages and disadvantages of Satellite.

At present, the telephone network is used for the interaction channel in operational systems, and further developments will lessen the various inherent disadvantages that were described above. To the broadcaster, it offers the advantage of limited infrastructure cost (and this is readily scalable as the number of users increases). To the user, it offers a relatively cheap entry cost at the expense of usage charges.

Hence, apart from cable networks which also offer a readily-available return channel medium, it is expected that the telephone network will continue to occupy the major proportion of future interactive system development.

5.2. *Interaction channel protocol options*

The DVB project uses an open system interconnection (OSI) layer model to define the interaction protocol generic system reference. This has helped to maintain consistency and to keep as many features in common as possible (e.g. the protocol stacks across the various distribution and interaction media).

A simplified system reference model is shown in *Fig. 4*.

The DVB project began elaboration of commercial requirements and the development of technical specifications for interactive services some years after it began its study programme. Some features of the earliest implementations of interactive services do not necessarily comply with the more recently established DVB-preferred approach. This is unlikely to have important consequences since these pioneering applications are those of the “vertical market” where interoperability is not normally essential. If this situation changes over time, interoperability could be achieved by means of duplicated services.

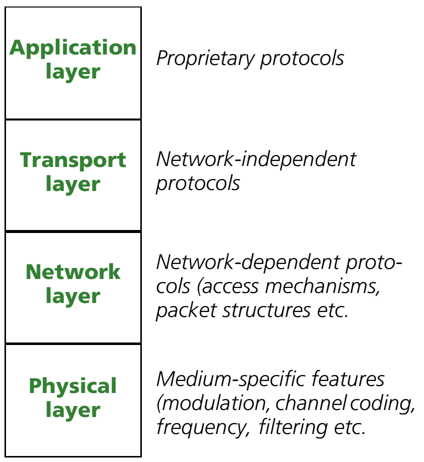

Figure 4
Simplified system reference layer model.

The operation of various protocols for interaction will more and more become the subject for standardization or, at a minimum, for agreement between associations of service providers. Where the set-top box is not a proprietary unit but is an open standard platform, it will be important that any service operator should be able to address the functions and make use of features such as the interaction channel in a consistent and standardized way. Access from a common API to the hardware and software facilities of the unit will need to be standardized to permit the user to choose services from the widest possible range of providers over any delivery and interaction media.

5.3. Types of programming possible

The range of interactive services which are available now, and which will become possible in future with digital broadcasting, is limited only by the creativity of the service providers and the capability of the STBs and other consumer products. At any point in time there is an optimum processing and memory "footprint" which can be included in the receiver, without grossly distorting the cost of ownership by the consumer (whether the retail price or the monthly rental cost).

Once this footprint has been defined for a particular service, it will become effectively frozen and all interactive services will then be constrained to operate on this "legacy" platform until they can finally be replaced, possibly 5 - 7 years later. The users' perception of the speed and power of the available interactive services will then depend on the bitstream capacity chosen by the service provider for data delivery to the platform, and on the efficiency of the interaction paths, instead of being restricted by the processing power and memory storage capacity of the receiver.

There may be some options for plug-ins or "sidecar" add-ons to augment the processing power of the STB as time progresses, provided that the requirement is foreseen and a suitable interface is provided.

Until recently, it has proven difficult to consult with the creative conventional programme-making fraternity on what they would do with interactivity if they had the option. Such people are usually focused on today's problems. There are signs now, however, that today's problems are the planning of programmes and services for new digital delivery media. Many broadcasters have launched, or are launching, satellite digital services, and digital terrestrial services are set to begin in 1998. Given that the technology readily provides interactive functions, the programme-makers are now getting down to planning what to use them for.

In the broadcasting environment, there is an understanding that the public must be encouraged to take up new services at their own pace, and not at the breakneck speed of the PC hardware/software upgrade cycle. It is expected that the introduction of interactive services and features will benefit from a step-by-step phased introduction over a relatively long period. This will permit time for corrective feedback as experience is gained, and will avoid confusing the viewer with too rapid a change-over from passive to interactive viewing. Possible phases in the introduction of interactivity can be separated between stand-alone and programme- related additional features:

Stand-alone additional services – stages of phased introduction:

⇨ much improved look and feel for teletext, making use of the processing and display facilities of MPEG technology, and with some source material collected from the Web;

- ➩ development of a parallel stream of loosely programme-associated information, created in an Internet authoring environment to provide a new-look "push" information service (i.e. control of programme and service selection will be included);
- ➩ introduction of a return / interaction channel to permit ordering and payment for products and support packs, for voting and for multi-household game play;
- ➩ interaction path used to personalise requests for information (local weather, traffic etc.);
- ➩ full Internet access with the advantage, when compared with modem- dialled calls, of rapid downloading of popular pages.

Programme-related interactive services – stages of phased introduction:

- ➩ provision of static information database which can be accessed without reference to programme broadcast time;
- ➩ some loose synchronization of dynamic information to track the programme during broadcast presentation;
- ➩ tight time synchronization for such material as play-along quizzes;
- ➩ use of return path to enter a community quiz show or national competition.

A number of issues must be tackled during the development of interactive programming, and the education of the viewing public to make use of the additional features. For instance, a linear programme with interactive features must still be engaging as a linear programme on its own. Interactivity could divert audiences away from a (carefully-) scheduled sequence of programmes, and a programme event could elicit a very large audience interaction at a certain moment (return path overload).

At the editorial level there are also many issues to be addressed. Content production is expensive, and the addition of interactive features is likely to add a significant extra cost. Re-use of material and single authoring for multiple delivery options will be important to keep down the overall programme costs. The presentation of material on a TV set may need a different design approach to that on a PC. The best ways of handling the sheer size, speed and interest of an interactive audience need to be planned for carefully.

5.4. Different national environments

The introduction of digital broadcasting services in Europe has exposed clear differences between countries. The pressure to introduce digital services has come mainly from pioneering operators who have started services to fill gaps they have identified in the broadcasting market in particular countries. There has been no simple pattern of introduction and, although a number of digital satellite services were expected to commence in 1995, they were all subsequently delayed for a number of reasons.

Once formally launched, the market for digital satellite services has been particularly successful and competitive in France where, historically, there was little analogue satellite penetration. Three services are offered from Canal+ (Canal Satellite), TPS (Television par satellite) and AB Sat. This compares with a much lower number of installations of digital satellite receivers in Germany over a similar period of time. Two factors which clearly differentiate between Germany and France are the very different levels of investment in cable, and the existing offer of analogue programming by satellite. In Germany, Deutsche Telekom has installed cable facilities massively over the last ten years to reach more than 80 % of the population; all terrestrial national and regional programmes are offered in simultaneous broadcast by satellite.

In the UK, analogue satellite services have been earning significant revenues for the major operator BSkyB, and it could be argued that early announcements of impending digital satellite service launches would have had an adverse destabilising effect on analogue STBs and subscription sales. In the event, BSkyB plans to launch digital services on Astra 2A (which has itself been delayed) in summer 1998. This new launch date may be linked more closely with the competition expected from digital terrestrial television services in late 1998, rather than to simple consumer demand. The launch plans for digital satellite in the UK do include a significant element of interactivity, and are notable by the creation of a strategic alliance known as BIB (British Interactive Broadcasting) formed from BSkyB in conjunction with British Telecom, a bank and a consumer equipment manufacturer.

Quite different commercial and political situations exist in other European countries.

6. Conclusions

There is a range of technologies and protocols possible for introducing "interactive television" in its widest sense. There are no ways of predicting with certainty which will be successful, and those which will not be. The best that can be done at this time – or probably at any other time in a climate of rapid technological evolution – is to identify which routes seem to offer the greatest prospect of success.

The successful introduction of a new technology relies on the combined strength of the *technology, infrastructure* and *content*. The strength of content is particularly important and must be measured in terms of the difference between the new system, and what is already available.

There may well need to be different formulae to achieve success in *different geographical areas*, because the already- available content and the available infrastructure will be different. This will condition the shape and strength of the success pillars. For example, in general terms, the tradition for using the written word (literature) in leisure activities is greater in Northern Europe than in Southern Europe. There is also considerable disparity in the available delivery infrastructures for interactive systems, differences in telephone tariffs, etc.

There may well be different formulae needed for success within a given national or local environment, since distinct *patterns of behaviour* are emerging for media systems within a given society. One recent classification separates the national user audience into four groups who exhibit different media behaviour:

- knowledge workers;
- time-constrained individuals;
- leisure seekers;
- PC enthusiasts.

Each of these may be attracted to interactive services, to a greater or lesser extent.

In order to be successful, an interactive system will need a sensibly-sized mass audience – it must be of value to at least one, and preferably more than one, of the user groups mentioned above. It also probably needs to be of interest to more than a single European state, in order to benefit from mass sales.

An important starting point for an analysis needs to be *content*. The essential issue for the user is content: *what type of content, and at what cost, would deliver sufficient added value for one or more of the user groups mentioned above, in more than one European State?*

The evidence gathered from field trials of the full service networks is ambiguous. Although thsee trials have certainly not failed, the fact that no permanent Services-on-Demand have yet been announced suggests that "interactive television", in the sense of broadband services-on-demand, will take many years to arrive in Europe. However, there may well be a non-uniform take-up of the system across Europe.

The evidence of the universal success of the World Wide Web is clearer. It shows that, given that the infrastructure is available and that a sufficient range of content is available which cannot be obtained conveniently by other means, there is a large body of users who will adopt the new technology.

Lying between on-line services on the one hand and normal linear television broadcasts on the other hand is the interactive television "nebula". Services which are most likely to succeed could be expected to be those which draw on, and exploit, the proven features of broadcasting and on-line. These are likely to be the constellation points in the nebula, and the ones that deserve most attention.

Since the Internet is a demonstrably popular service, and equally this is the case for broadcast television, we are drawn to the conclusion that the most successful route is via services that combine these two. This might be called *Internet Television*.

Services that provide for viewers the option of linear programmes coupled with fast access to the Web seem currently to offer the greatest chance of success.

The DAVIC project has developed protocols for broadcast services that combine television with Web features. These are the *Enhanced Digital Broadcast Contour* — which allows for down- loadable Web pages that can be locally interactive in the receiver — and the *Interactive Digital Broadcast Contour* which allows for down-loadable Web pages and for an additional Internet connection that can be used at the same time as the programme. The latter contour is thus critical to the success of interactive television.

The services which are most likely to succeed will be those which cannot be found elsewhere and which are highly desirable. These are likely to include services that link the programme content itself with the Web pages. This would include audience interaction for quiz shows, commerce and additional information.

In an environment where much use of the Web services is made via an IDB system, the television programme provider would occupy a particular *position of strength* in capturing and holding the audiences. He may also be able to occupy a *dominant position* as an Internet Service Provider if he so wishes.

The delivery system for the Internet interaction channel may be:

- PSTN;
- ISDN;
- a UHF terrestrial broadcast forward-and-return channel;

- cable networks with return channels in the low-frequency band;
- V-SAT via collector, or another network.

The most viable system to use may depend on the available national infrastructure. For example, some broadcasters do not have the option of using PSTN because of the lack of universal availability of telephone lines.

Given that a country does have a well-developed and reliable PSTN service, this *will probably offer the route to interactivity with the lowest infrastructure costs.* In this case, the system could evolve to an ISDN-based system, as ISDN became implemented. The attractiveness of the service would be severely hampered if the cost of local access to the Internet server is anything more than marginal.

Given that a country or area has a *less well-developed or less reliable PSTN service*, the use of a *terrestrial UHF return channel* system may present a viable option. If a *cable system* were available, this would clearly be the best infrastructure to implement the interaction channel.

An Interactive Digital Broadcasting system is likely to be of most interest to "knowledge workers", "time-constrained individuals" and "PC enthusiasts" rather than "leisure seekers". Over a period of time, the service use may spread to a greater proportion of leisure seekers, as succeeding generations become more computer literate. Nevertheless, in the initial phases of an interactive service, it seems reasonable to concentrate on using the interactivity for programme-related items that would appeal to the three early user groups.

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At the EBU, Mr Wilson was responsible for co-ordinating developments in data broadcasting technology. From the commencement of the DVB Project in 1993, he has been closely associated with many aspects of its work and until the end of 1997 was Head of the DVB Project Office. Ed Wilson is presently concentrating his attention on helping to implement DVB terrestrial services as Project Manager of DigiTAG (the Digital Terrestrial Television Action Group).

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