Webcasting
– the broadcasters' perspective

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This article is based on the work carried out by the former EBU Webcasting Group [1]. It provides an update on the extremely fast developments in the area of webcasting that have occurred since the publication of the Group's document, "BPN 022 – Practical Webcasting". It also outlines some of the opportunities and challenges provided by webcasting and gives some indication of the future prospects.

In particular, the article explores the impact of the Internet on the broadcasting sector. We are witnessing the process of convergence between the Internet and the emerging digital terrestrial and satellite broadcast systems. The convergence of the PC and digital broadcast terminals is bringing about the delivery of new services as part of the multi-channel offerings from digital radio and television broadcasters.

1. Introduction

The World Wide Web (WWW or Web) is the multimedia dimension of the Internet and allows audio-visual material to be accessed using a standard web browser. In recent years, many radio and television broadcasters have created websites and have established themselves on the Internet. In parallel, as radio and television chains are being digitized, these new infrastructures are being used to carry web content at high speed to DAB and DVB receivers. For the broadcasters, web technology is becoming an interesting tool to produce, contribute, distribute and broadcast radio and television programmes.

Since the beginning of the 90s, EBU members have been introducing new digital technologies in their studio production facilities, and developing new digital transmission technologies for DAB, DVB and, more recently, Digital Radio Mondiale (DRM). Conventional broadcasting – using traditional delivery mechanisms (satellite, cable and terrestrial networks) – reaches hundreds of millions of people, and provides nearly complete country-wide coverage: furthermore, the technical quality of the audio and video signals, as received at home and on the move, is largely seen to be satisfactory. Radio and TV receivers are widely available and are relatively non-expensive.

Abbreviations

64-QAM	64-state quadrature amplitude modulation
ADSL	Asynchronous digital subscriber line
API	Application programming interface
ASF	(Microsoft) Advanced Streaming Format
CSS	Cascaded style sheets
DAB	Digital Audio Broadcasting
DRM	Digital Radio Mondiale
DSL	Digital subscriber line
DSM-CC	Digital storage media – command and control
DVB	Digital Video Broadcasting
DVB-C	DVB - Cable
DVB-S	DVB - Satellite
DVB-SI	DVB - Service Information
DVB-T	DVB - Terrestrial
FTP	File transfer protocol
HTML	Hypertext markup language
HTTP	Hypertext transfer protocol
IEEE	Institute of Electrical and Electronics Engineers (USA)
IETF	Internet Engineering Task Force
IP	Internet protocol
ISDN	Integrated services digital network
ISP	Internet service provider
MPEG	Moving Picture Experts Group
MVDS	Multipoint video distribution system
PDF	(Adobe) portable document format
PNG	Portable network graphics
PSTN	Public switched telephone network
RRMP	Restricted reliable multicast protocol
RTCP	Real-time control protocol
RTP	Real-time protocol
RTSP	Real-time streaming protocol
SIP	Session initiation protocol
SMATV	Satellite master antenna TV
SVG	Scalable vector graphics
TCP	Transmission control protocol
TDC	(DAB) transparent data channel
UDP	User datagram protocol
URL	Uniform resource locator
USB	Universal serial bus
W3C	World Wide Web Consortium
WAP	Wireless application protocol
WML	Wireless markup language
WWW	World Wide Web
XML	Extensible markup language

The Internet, on the other hand, is a very convenient and successful means for sending e-mails, and for e-commerce, e-banking and other forms of electronic communication. However, at the present time, it is a very poor mechanism for carrying audio and, in particular, video broadcast signals. It is far from being able to offer the high quality of reception that the new digital broadcasting systems readily provide. Compared to relatively cheap radio and television receivers, the Internet requires more expensive PCs and – of great significance – only several hundred (or thousand) computer receivers can be on-line at any given moment, depending on the capacity of the web server. And, as the use of the Internet for broadcasting is not very cheap either, it is not surprising that it is being considered by many broadcasters as purely a secondary medium.

So why bother with such a “poor” delivery medium at all?

Not only does the Internet have an enormous potential for quality improvement, but it also seems to have two important and far-reaching features that conventional broadcast systems seem to lack:

- ⇨ it is inherently “global”;
- ⇨ it is truly “interactive”.

The term “global” means that any computer connected to the Internet is able to communicate to any other computer. The Internet is a *de facto* worldwide network: national borders present no obstacles when accessing it. In other words, a listener can select not just tens, but thousands and thousands of new radio stations from all over the world, in all possible languages.

The term “interactive” means that any user can receive information from, and send it to, anybody else. This feature opens the door to a host of new broadcast applications and expands the very notion of broadcasting. The Internet may in principle allow any individual, or a group of people, to become a publisher or a “content provider”. The Internet may effectively blur the difference between the big and the small, the poor and the rich. It may even bring all broadcasters onto an equal footing. Since the geographical location of the Internet-user has become irrelevant, and the time of access is becoming less important, this may lead to a cultural and linguistic blend.

It is beyond any doubt that the Internet will have a dramatic impact on all future broadcasting activities. Therefore, it is vital for broadcasters to become aware of, and to understand, all the technological, legal, social, economic, cultural and commercial consequences that the Internet brings with it.

This article looks mainly at the technology-related aspects of webcasting. Other aspects – such as legal, regulatory, sociological and commercial – are, of course, equally important and even vital for the success of on-line services, but are not the subject of this article.

2. The WWW phenomenon

In order to understand how important the Internet is for broadcasters, it may be useful to describe it in some detail. The Internet may be characterized as a physical information network that logically connects together millions of computers by using a globally unique address space, based on the TCP/IP suite of protocols. The Internet has no single control centre, nor a hierarchical structure. It allows the connection of any kind of computers (PC, Mac, UNIX, etc) and is a global phenomenon.

The World Wide Web was first conceived in 1989 by Tim Berners-Lee as a project to improve collaboration at CERN (the European Laboratory for Particle Physics in Geneva) [2]. It was devised as a seamless model in which all the information on the Internet could be accessed in a simple and consistent manner – from any computer, in any country, by any authorized user. Anyone with a computer and the appropriate "extras" could connect to it, become part of the Web and use it to send and receive information in a variety of forms, with an easy-to-use interface.

Although the Web soon spread outside the CERN labs, it did not take off until late 1992. Its sudden success was due to the popularity of *Mosaic*, a graphical browser created by NCSA (National Centre for Supercomputing Applications). *Mosaic* later evolved into *Netscape Navigator/Communicator.* Today, the Web is the most popular and fastest growing information system deployed on the Internet.

The Internet offers many diverse resources, such as:

- e-mail, including the sending and receiving of attached files;
- Usenet (a vast system of discussion groups);
- Gopher (menu-based information) with the Veronica search engine;
- FTP (file transfer protocol) with the Archie search engine;
- Telnet (for connecting to and using a remote host);
- "Newsgroups" (where people can communicate on any subject);
- "Chat" programmes (which let people communicate with others in real-time – much like a written phonecall);
- E-commerce (which enables people to purchase books, software, CDs, travel tickets, etc.);
- On-line newspapers;
- Music downloads;
- Interactive games;
- Real-time radio (and even television) stations;
- Video teleconferencing;

⇨ Long-distance telephony.

Over 80% of all Internet traffic now comprises applications based on HTTP, which allows navigators (browsers) to move easily from one document to another, via hyperlinks. Web pages – containing text, graphics, sounds, animations, audio, video and links to other web pages – can be created using HTML and these pages are referred to as HTM files.

HTML is a set of tags – i.e. text enclosed by the "lesser-than" (<) and "greater-than" (>) symbols – which identify the structure of the document. The essential characteristic of the Web is its hyperlinks. To the user, a hyperlink is either text (usually signified by being underlined and in a colour different from other text) or a graphic image that you can click on with your mouse to access the target resource (usually another document). The target resource can either be on your hard-drive or anywhere else in the world that is connected to the Internet. The address of a resource on the Internet (i.e. an Internet site) is given by its URL.

The Internet is spreading like wildfire. One striking illustration of how quickly the Internet is evolving, is the time it has taken for various communication technologies to reach a threshold level of 50 million users. While it took around 75 years for the telephone, 38 years for radio, 16 years for the PC and 13 years for TV to reach 50 million people, it is estimated that the WWW reached the 50 million mark in less than four years. In September 1999, the Web achieved more than 50% penetration in five major American cities [3].

Another development that reflects the booming growth of the Internet market is the number of ISPs. In the world of telephony, where monopolies have dominated the sector for several decades, the opening of the market has lead to a rapid growth in the number of service providers. The number of international *telephony carriers* worldwide has grown from less than five hundred in 1996 to more than a thousand in 1998. However, these figures are dwarfed by the growth in ISPs; some estimates suggest that more than twenty thousand ISPs are operating presently around the globe.

3. Webcasting

The Internet provides for some radically new models for delivering broadcast content, including audio and video programmes, to the end users. Webcasting is the term used to indicate the production, transmission and delivery of hyperlinked documents consisting of text, audio and visuals (i.e. video and graphics) – for presentation via a browser-like interface. Contrary to conventional broadcasting which is one-way only, webcasting allows the audience to interact with the originator, and to shape what is delivered. The simplest form of webcasting involves *streaming media* (audio, video and text) where the production centre determines the context. A more complex webcasting form is *audio-*

on-demand or *video-on-demand* whereby the consumer determines the context and depth of what is delivered.

Technically, streaming is a relatively new technology. In the early phases of the Internet, the entire audio and video files had to be downloaded to a customer's hard-drive before they could be played out by the client's player. Therefore, the user had to wait until the whole file had been downloaded successfully to his/her computer. The downloading method is still used extensively for music delivery, if quality is an important requirement. For instance, the downloading of a compressed audio bitstream at 128 kbit/s (e.g. in the MP3 format) would require a hard-disk space of slightly less than 1 Mbyte per minute of audio duration. The downloading time will depend on the "bandwidth" of the Internet channel and on the actual modem connection speed. Assuming a 28.8 kbit/s modem, the net bit-rate will be about 20 kbit/s. Thus a musical clip of three minutes duration would be downloaded in about 20 minutes.

It can be deduced that the "download-first-and-then-play" technology can be suitable for short programme clips, but not for on-line radio listening or even for watching video clips. The *streaming* technology, on the other hand, allows for immediate playback. Modern players, such as for example *RealPlayer* ™, are able to read the file stream as it is coming in, and can begin playing it before the rest of the file has arrived. In order to make the playback smooth, the player uses a process of buffering. During buffering, a number of the streaming packets are collected before playing them out. As the player begins to play out the file, it continues to collect packets in reserve. If there are minor delays in receiving the packets, playback will still be continuous.

4. Some statistics

Around 220 million people worldwide now have access to the Internet and the number of on-line connections is growing steadily by about 100 000 a day. The question to be asked is how this growth is affecting the broadcasters and whether or not television may be loosing its eyeballs!

A recent study by Arbitron NewMedia [4] – about consumer media behaviour and new media preferences in the USA – showed that the Web is often used in conjunction with radio and television, and that the Web does not significantly lower the levels of TV viewing. The heaviest web users are also avid consumers of traditional media. The study found that, during the peak hour for web use at work (9 – 10 a.m.), 26% of heavy web users reported that they listened to Internet radio. During the peak hour for both web and TV use at home (8 – 9 p.m.), 52% of heavy web users reported that they also watch television during this period, only slightly lower than that of all web users (55%). *This points to the possibility of some innovative cross-media promotion and synergy, and the complementarity of programming. Thus, the traditional media should continue to extend their brands and franchises into cyberspace.*

The Internet radio audience in the USA has doubled in the last half year. The above-mentioned study (made in January 1999) found that about 31 million people, or 13% of the US population, have listened to Internet radio, compared with only 6% in an earlier study. Increases in modem speeds at home, and Internet connections at work, have meant that Internet radio now sounds better. Also, there are more sound cards installed in PCs at the workplace.

A study conducted by NPD in conjunction with the on-line newsletter, Iconocast, found that 57% of US users have the ability to use their TV and their PCs at the same time. Of those who "multitask", 86% actually watch TV and surf the Internet simultaneously. According to the authors of the report, these results suggest that the TV and the PC will not converge. Among those who multitask, 91% said that they had visited a site on-line after being exposed to television advertising. The study also found that 75% of multi-taskers go on-line during TV commercial breaks. 20% of users said that they visited the site of a TV programme while watching the programme. Users were far more likely to respond to URLs advertised in commercials.

As the Internet has become the all-purpose medium to deliver both business and pleasure, it is already possible to tune to very many radio stations. However, it should be stressed that, since the Internet is a huge and complex entity with many random variables, it is not easy for its performance to be guaranteed. It is generally beyond the control and the responsibility of the broadcaster to ensure a certain minimum quality of the signal received. In its report of March 99, Edison Research [5] stated that user-awareness of Internet radio in the USA was growing rapidly: at the beginning of 1998, only 8% of users were aware of it, by the end of 1998 this figure had grown to 18% and, by March 1999, it had reached 27%. As the awareness of Internet radio grows, the number of people listening to it is growing as well. In parallel to this, the number of audio webcasters is also growing.

The following statistics about audio webcasting are quite impressive *(status: September 1999 – source: BRSMedia.com)*:

- ⇨ 6800 radio stations on the Web;
- ⇨ 2616 radio stations worldwide with continuous audio streaming (in 1998: 1652);
- ⇨ 1296 radio stations in the USA and Canada;
- ⇨ 1071 international radio stations;
- ⇨ 196 internet-only radio stations;
- ⇨ 52 radio networks.

There are over two hundred live streaming television stations. Last July (1999), the *broadcast.com* website transmitted 410 live continuous radio, and 49 TV channels, as well as on-demand music from its CD Jukebox with 3000 titles. The number of new web-streamed channels and networks entering the arena is huge and it is now almost impossible to provide up-to-the-minute figures.

5. Opportunities for broadcasters

It is evident that more and more broadcasters around the world are re-routing some portion of their programming output to the Internet. As the medium becomes more widely accepted and as new sources of advertising revenue are sought, an increasing number of broadcasters are drawing up plans to extend the reach of their signals to embrace the Internet.

By using their websites, broadcasters could possibly attract more listeners/viewers than they can do through their conventional over-air radio and television services. They could possibly extend their audience base and thus generate more income streams from subscriptions. The Web could be used to achieve the following:

Improved marketing communication: Provide the web viewers and listeners (sometimes called *viewsers*) with some additional information about the broadcasting company, its people, its strategies, its successes and its challenges.

Greater information on programmes: Such information could include details about the past, current and future programmes, it could offer supplementary information about the actors, producers, etc. and could publish interviews with them. Conventional programmes could be augmented with a package of text-based statistics, pictures and video clips of sports stars, etc.

Improved customer contact: Communication through the Web could enable the contact with each customer to be more personal. Broadcasters could gather information about their customers and build up a long-term fidelity relationship with them. They could learn how large their market is and the size of their audience at any given time, by measuring the number of hits. In the case of commercial broadcasters, such information would help to attract additional targeted advertising.

Increased merchandising of content: Broadcasters could make their extensive libraries and archives of content available for people to visit, consult, pre-view and pre-listen, and eventually to buy (download) the chosen content. However, watermarking and digital signature technologies must be developed and implemented first.

All this aside, public service broadcasters might see the Web as (i) a natural extension of their current public service activities and (ii) an excellent mechanism for promoting their well-established brand.

Many broadcasters are using the Web as an additional broadcasting outlet. Some stations have initially opted for a 90/10 approach, whereby 90% of their programming is broadcast by conventional means and 10% is webcast on the Internet. This approach has recently been changed by some broadcasters more towards the 50/50 approach. These broadcasters have already realized the Internet's potential for a wider audience and new revenue sources. Many broadcasters have now realized that major changes in station workflow are required; for example, creating separate Internet departments with standalone hardware and specialized technical support. Others have realized that both conventional and Internet activities can exist side by side, using a common integrated production base.

A new company, Omneon Video Networks [6] has recently introduced its Video Area Network (VAN), based on an IEEE 1394 architecture. It consists of five building blocks:

- a high-capacity storage disk array;
- a "Director" to control disks and manage files;
- multi-format codecs;
- an intelligent packet-switch for routing IEEE 1394 streams and for transmitting low bit-rate streams;
- a network Manager.

The VAN is an integrated system, which provides a full range of conventional and Internet capabilities. High bit-rate streams are routed to conventional transmission pathways and the low bit-rate streams are routed to the Internet (via the packet-switch). Using the gigabit Ethernet port, the Internet stream is pushed to an ISP or web-hosting facility for splitting and distribution. Two independent commercial play-lists may be configured, one for conventional and one for Internet audiences. Using this integrated approach, a station's news and production departments benefit from shared storage, production and archiving facilities, and shared management control. The overall workflow is streamlined because the physical movement of media from department to department is eliminated.

Traditionally, to a great extent, international radio broadcasting has been the role of government-sponsored international broadcasters, using short-wave transmissions. But, gradually, more and more people are now tuning to Internet radio for listening to the services in their mother tongue, or a local radio station located perhaps on another continent. In the case of some radio stations – such as RTE Ireland, Swiss Radio Internationale or Radio France Internationale – there is a limited (or no) short-wave alternative.

The Internet also represents an opportunity for integrating the Web with television. Web content may be used to augment the existing analogue and digital television broadcasts; for example, programme-associated special offers, programme guides and reviews, background information on sports teams etc. Television displays could also be used to present web-type pages on such topics as news, weather, stock exchange and other information – not specifically linked to a particular programme. People expect television to work reliably, leading to a great emphasis on a universal approach and a correct implementation of web standards in this area.

It should be pointed out that, although the traditional broadcasters have been relatively quick to adapt to the Internet environment, they have not yet been able to gain the lion's share of traffic and advertising revenue on-line. Instead, new Internet media companies – such as AOL, Yahoo, Excite, Lycos and Infoseek – have created so-called "portal sites" and have gained the lead in stimulating traffic and advertising revenues. The power of portals, however, has not gone unnoticed by the big media players who have been active in acquiring stakes in major portal companies. For example, Disney took a 43% stake in Infoseek, and Bertelsmann has put some 10 million US$ into a partnership with Lycos to create portals in all the main European markets.

A portal commonly refers to the starting point, or the gateway, through which users navigate the Web. However, the term "portal" is an evolving concept, as new functionalities are constantly added. Portals are projected to take an important market share in the future; they may acquire 20% of on-line traffic and 30% of on-line advertising revenue by 2003. There are two main types of portals: horizontal and vertical. A horizontal portal is a website that provides a wide range of services, such as e-mail, forums, search engines and shopping malls, and is geared to the mass audience (examples: Yahoo and AOL). A vertical portal (sometimes referred to as a "vortal") focuses on a specific content area and targets a particular niche audience.

6. Basic webcasting technologies

In order to perform webcasting, original broadcast programmes should be transformed into an Internet-ready audio-visual stream. This is not a simple process and involves several important programming and technology-related steps, as shown in *Panel 1*.

The "push" method of delivery is real-time broadcasting, whereby the video/audio programme feeds are simultaneously pushed out to the Internet users, in much the same way that we broadcast our conventional terrestrial, cable or satellite feeds. This method is used successfully by several web broadcasters, such as CNN, the BBC and MTV.

Panel 1
Basic webcasting technologies

Capturing: This process involves selecting the programme to be webcast. The programme could be an original Internet production or an adaptation of existing radio and television programmes for the Web, or a combination of the two.

Editing: This step involves editing the captured programme so that the presentation which the consumer receives is what the content provider intended. This step uses web-publishing and authoring tools.

Encoding: This step implies the use of an appropriate compression scheme and a streaming technology to covert the programme into a file that can be streamed over the Internet.

Delivery: The encoded file must then be placed on a special streaming server, and can be pushed to, or pulled by, the user.

The "pull" method is the transmission of hosted audio/video clips. Pre-produced clips are pulled on demand by a customer from special streaming servers. These programmes are usually encoded off-line and stored on the server for this purpose. There are currently several hundred websites which provide the capability for customers to click and view an entire news story.

In the push mode, both *unicast* and *multicast* streams can be generated. With unicast, the server generates a unique video stream and routes it to a single web viewer, after he/she has clicked on the chosen video clip. This method is largely prevalent today but is not the most efficient. In the case of multicast, a broadcaster's web stream is first routed to local switching points and from there it is distributed to the users. In either method, multiple web viewers can watch the same stream but, with multicast, the traffic on the Internet backbone is eased because the majority of the splitting occurs on a regional basis. In order to generate multiple streams, the stream is routed from the server to multiple computers known as *splitters*. By cascading multiple layers of splitters, thousands of simultaneous streams can be generated. In order to broadcast sufficient streams over the Internet, large server "farms" are required. Examples of such farms are in use by Real Networks and Broadcast.com. CNN Interactive (CNNin) is supported by as many as 150 servers, about 50 of which are front-end computers available for the users to type in a CNNin URL address. Twelve machines serve the advertisements and another six are used to stream the video.

It should be pointed out that, especially with the more popular clips, thousands of clips may be requested at the same time. In order to cope with such a huge demand, large server farms must be utilized. Many ISPs offer this service, but the network traffic associated with these clip "players" requires much higher bandwidths than the access traffic to normal web pages. It is due to the extensive webcasting traffic that the Internet is often congested at peak times, thus turning the Web into a temporary "World Wait Web" network.

7. Is the Internet suitable for real-time services?

Whereas conventional television and radio transmission channels (both analogue and digital) usually provide very good quality, the Internet at present offers only barely-intelligible speech and low-definition pictures. This is because the Internet was not designed and built for real-time streaming transmissions. Rather, it was designed for the downloading of files, for example from an FTP server: a connection between the server and the client is established and the data is transferred to a local storage device. After the file has been transferred in its entirety, the data can be processed locally using an application that can interpret the format of the data received. In a streaming configuration, on the other hand, the browser starts to reconstruct some parts of the incoming file while the loading of other parts is still in progress. As soon as the file has been received completely, the connection between the server and the client is closed.

The Internet is basically an asynchronous environment: the time taken between sending and receiving (and presenting) the information can vary in a non-predictable manner. In addition, there is no synchronization between the different kinds of data carried over the Internet.

Some of the basic problems with the Internet, particularly from a webcasting viewpoint, are identified in *Panel 2*.

8. Real-time protocols

The most common Internet protocol is HTTP [1]. This protocol is used for communications between the server and the host, and enables the host to gain access to the files and drives on another host. However, this protocol is not designed to carry multimedia and it

Panel 2
Basic problems with webcasting

Packet loss: The digital bitstream is split in packets called datagrams. If the Internet is congested or overloaded with traffic, or if a node or link has failed, packets may be lost or corrupted. The corrupted packets are discarded by the client. In real-time traffic, the missing packets cannot be retransmitted or reconstructed. While audio is very sensitive to packet continuity, the loss of video packets can be tolerated more easily.

End-to-end packet delay: This consists of the processing delays at the sending and receiving ends, plus the transmission time. In the case of traffic congestion, packets may have to queue in routing buffers during transmission. For full-duplex applications such as IP telephony or videoconferencing, this delay should be limited to a few hundred milliseconds. For simplex applications, such as audio/video-on-demand or webcasting, it can be higher but should not exceed a few seconds. The time delay may affect the synchronization between different components of a multimedia presentation. This may be critical but the degree of criticality will vary from application to application.

Delay jitter: Delay jitter is the variance in delay of consecutive packets. The time taken between sending and receiving (and presenting) the information can vary in a non-predictable manner. In addition, there is no synchronization between the different kinds of data. The packets may travel through the network over different routes, and therefore the delays may be different. This may cause some packets to arrive out of sequence. As the terminal has to wait for the out-of-sequence packets to arrive, the picture may be frozen. In one-way streaming, buffering can be used to smooth out the effect of delay jitter. In multi-way streaming, such as web-conferencing, buffering cannot be used because the delay may cause confusion amongst the communicating parties.

End-to-end bandwidth: When using the public Internet, a connection speed of a few tens of kbit/s cannot be exceeded. The available bandwidth may vary during transmission. Therefore the encoding techniques have to provide very high levels of compression. The resulting audio and video quality is therefore generally very poor.

has no provision for the time reconstruction of datagrams, or for loss detection, security and content identification. HTTP is used in conjunction with TCP which is used to break messages into packets and send them individually across the network. Although TCP has many advantages (e.g. the transport is fully reliable and it goes through firewalls), its stream control mechanism is not suitable for real-time applications. The congestion control (i.e. slow start, increasing packet-rate until dropped, decreasing packet-rates) is not suitable for delivering a continuous stream over IP. The UDP protocol, on the other hand, is suited for real-time services because it is able to deliver a continuous stream. However, unlike TCP, it makes a "best effort" to deliver data and is not fully reliable – if a transmission error occurs, the packet is simply discarded, since there is no feedback from the receiver.

There are currently five protocols in use for providing real-time services via the Internet [7]:

- ⇨ RTP/RTCP;
- ⇨ RTSP;
- ⇨ H.323;
- ⇨ T.120;
- ⇨ SIP.

For broadcasters, the most important are the first two protocols. RTP provides end-to-end network transport functions that are suitable for applications which transmit real-time audio or video over unicast or multicast networks. RTP does not address resource reservation and does not guarantee the quality of service. The transport is augmented by a control protocol (RTCP) to allow monitoring of the data delivery and to provide identification functionality. RTP and RTCP are independent of the transport and network layers.

RTSP is a popular application-level protocol, which enables controlled on-demand delivery of real-time audio and video streams. This protocol is intended for controlling multiple data-delivery sessions, and provides a means for selecting the delivery channels (such as TCP, UDP or multicast UDP) and the delivery mechanisms (such as RTP).

9. "High-speed" Internet

While the potential of the Internet as a cost-effective global communication channel has long been recognized, it will never be fully exploited until its chronic bandwidth limitations have been effectively addressed. In order to deliver video and data-rich services and applications, the existing speed restrictions currently faced by Internet users must be overcome.

1. **HTTP-NG (Next Generation)** is being developed by W3C and IETF to accommodate the future needs of the Internet. While still supporting existing uses of the Web, a new HTTP architecture will be developed, based on simplicity, modularity and layering.

The advent of high-speed connections to the home, whether they take the physical form of a telephone wire, a cable television line or a satellite link, will give rise to an entirely new set of applications at an affordable price. Several approaches may be used for connecting homes and offices to high-speed data communications networks, as outlined in *Appendix 1*.

10. Mobile web services

It is commercially attractive to offer ubiquitous access to web services, not only on fixed-line platforms and devices such as a PC or television, but also on different mobile devices such as cellular phones, pagers, palm-top computers, personal organisers, in-car radio sets and others. Some analysts expect mobile phones to replace the personal computer as the main delivery channel for the Internet over the next decade. Some projections have been made that the mobile Internet could quickly outnumber the fixed-line Internet marketplace. Presently there are more than 375 million mobile users worldwide, many of whom are in Europe. By 2003 the number of digital mobile phone users will jump to about 550 million, creating an enormous potential base of mobile Internet and e-commerce users. The European m-commerce (mobile commerce) market will grow from €323 million in 1998 to about €23 billion by 2003. Further predictions by industry

Panel 3
Main players in the mobile Internet market

Hardware:

- Alcatel
- Casio
- Compaq
- Ericsson
- Hewlett-Packard
- Matsushita
- Motorola
- Nokia
- Palm Computing
- Psion

Operating systems:

- Microsoft (Windows CE)
- Palm Computing (Palm OS)
- Symbian (Epoc)

Applications:

- AvantGo
- Microsoft (teamed up with Ericsson)
- Palm Computing
- Phone.com
- Symbian (partnership of Psion, Nokia, Ericsson, Motorola and Matsushita)

Networks and services:

- Bertelsmann
- BT Cellnet
- Deutsche Bank
- Mannesmann
- Reuters
- Telecom Italia
- Virgin
- Vodafone Airtouch

analysts say that more than 10% of e-commerce will be conducted through mobile handsets within three years and that more than 600 million internet-enabled mobile phones will be sold between 2002 and 2006. The main players in the mobile Internet market are given in *Panel 3*.

Mobile Internet phones, using the Wireless Application Protocol (WAP), will initially deliver only e-mails. Other value-added services will follow: entertainment-on-demand, continually updated news, up-to-date sports scores, share quotes, time tables, weather data, etc. Over the next four years, higher-capacity data services using the so-called 3-G (3rd generation) technology will enable a wide range of other value-added and multimedia services to be accessed from a mobile Internet device, including graphics, audio clips and mobile video telephony. By 2002, a new generation of mobile phones will enable voice-activated commands.

A special WAP has been developed to allow mobile phones to browse web pages. This protocol is based on existing web technologies – such as TCP/IP, HTTP1.1, XML and the standard web URL addressing scheme. A mark-up language called WML (Wireless Markup Language), based on XML, has been designed to meet the constraints of handheld devices. The WAP system is being actively promote by the WAP Forum [8].

W3C's Mobile Access Activity will ensure that the Web protocols and data formats used in different mobile devices worldwide will maintain the integrity of the global Internet. W3C wishes to facilitate the important role that mobile devices have to play in a world where Internet-based global communications is increasingly being used.

The importance of the mobile Internet market has been recognized by some broadcasters. For example, in December 1999, BBC News Online linked up with Vodafone Airtouch which is currently one of the biggest mobile phone operators with 31m customers worldwide. The BBC will provide content, such as news, and will develop multimedia news services for people on the move.

11. Current web languages and protocols

There is no doubt that HTML is a *lingua franca* for publishing on the Web and remains the most important display technology. Since its use became widespread during the mid 90s, HTML has evolved and added many new features. The most recent version is HTML 4.01 which is the current W3C Recommendation.

HTML defines a fixed set of tags which describe a fixed number of elements. There are several versions of HTML, each defining a specific number of tags. Following the success of W3C's HTML 4.0, the Consortium is designing the next generation of this markup language. The new HTML, called XHTML, is being re-cast as XML (see *Section 12.1*). XHTML is fully modular, making it easy to work on a range of different browser platforms including desktops, television set-top boxes, wallet-sized wireless communications devices, etc. The modularity of XHTML reflects the fact that browsers vary significantly in their capabilities; for example, a browser in a cell phone has a smaller display and a smaller memory than the browser in a top-of-the-range multimedia desktop PC.

XHTML is being designed so that HTML can be used in combination with other XML applications. For example, a document may be written in HTML, but could include a mathematical formula written in MathML. Also important is the ability to create subsets of HTML for simpler client needs or for particular devices that have a specific display characteristic. The next generation of HTML will also see style sheets and other tools used to tailor documents according to the needs of different classes of browser. Transformation of markup can be done on the primary server, on a proxy server or at the client. However, HTML pages are generally static (with a few minor exception such as when special ActiveX controls are used, or form fields are changed). The only way to change a screen display with HTML alone is to load another page. In Internet Explorer 4/5, Document Object Model (DOM) enables any HTML element to be manipulated at any time, even if the page has already been loaded. Thus, plain HTML is turned into Dynamic HTML.

Displaying multimedia elements on a web page is not new to the latest browser versions. You could also do it in previous browser versions by using ActiveX control, Java applets or special plug-ins. The latest browsers include a wide variety of controls necessary for using multimedia. For instance, Internet Explorer 4 includes multimedia features such as those shown in *Panel 4*.

The key feature of all these multimedia components is that they are scriptable. All multimedia creations for the Web can be authored and played back by using HTML code and script code. Thus pages that contain these multimedia components can be very small and will download quickly.

Many other tools are now available on the Web [9], ranging from scriptlets and behaviours to data-binding and XML (see *Section 12.1*). The data-binding facility, for instance, allows you to attach (or *bind*) all the data directly to a page and send such a page, together with the data attached, from the server only once. Users can then modify views of the data, using different filters, without going back to the server with an additional request.

12. Advanced Web-technology developments

There are two international bodies that cater for further development of the Web: W3C [10] and IETF [11]. These two bodies are described in some detail in the *Appendix*. The following sections discuss the main areas of advanced Web development which W3C and IETF are responsible for.

12.1. Extensible Markup Language (XML)

As opposed to HTML, XML describes the structure and semantics, and not the formatting of the document. It is a meta-markup language that defines a syntax used to specify other domain-specific, semantic, structured markup languages. XML ensures modularity, interoperability and scalability. It is a language in which you make up the tags that you need for different applications. The tags you create can be documented in a Document Type Definition (DTD). A browser does not need to know each and every tag in advance, but it discovers the tags as it reads the document, or its DTD. For example, the XML structure is suitable for other domain-specific languages such as:

- MusicML to display music notation;
- VoxML (from Motorola) for the spoken word;
- MathML to present mathematical formulae and expressions;
- ChemicalML (CML) to show complex chemical formulae;
- Open Software Description (OSD) for updating software automatically;
- Scalable Vector Graphics (SVG), etc.

Panel 4
Multimedia features of Microsoft Internet Explorer 4

Media Player: This media control allows you to add audio, video and ASF (Advanced Streaming Format) to your web page. There are currently more than 20 different Internet media players on the market. They were specifically designed to cope with the Internet channel and generally use very high compression schemes and split the whole bitstream into packets to allow live streaming [1].

Cascading Style Sheets, Filters and Transitions: CSS can be applied not only to the text but also to other objects including graphics, videos, or even the page itself.

Structured Graphics Control: This control helps to create complex, light-weight and scalable vector graphics. These graphics are small in file size and can be rotated in 3-D space, providing attractive effects on a page.

Sequencer Control: This provides precise timing and lightweight animations. It determines the timing of various events on a page through scripts.

Path Control: This allows the movement of elements over a page, over a period of time. A path can be a simple straight line or a complex curve.

Sprite Control: This allows you to build animation into your page by manipulating images with frame-level control. The frames can be individual images or just a section of an image source that allows multiple images to be part of one file.

1. An article on the streaming technologies specifically designed for the Internet will be published in the next issue of EBU Technical Review.

All these languages are at an early stage of their development and are not yet a polished commercial project. In future, however, there may be several thousand different markup languages, including those used for specifying multimedia. An XML program could include a small Java program that could sort and filter a database, without involving the server. Thanks to this approach, the Internet traffic may be reduced. A standard for XML-based hyperlinks, named Xlink, is due later this year from W3C. Contrary to conventional hyperlinks, Xlink will allow us to choose from a list of multiple destinations. Microsoft's Internet Explorer 5.0 browser and the new Mozilla browser, which is an open-source browser being developed by Netscape, are both supporting XML.

12.2. Synchronized Multimedia Integration Language (SMIL)

SMIL [2] is one of the newest language sets on the Web and is based on the XML structure. It is a W3C-recommended XML application for writing "TV-like" multimedia presentations for the Web where audio, video, text and graphics are combined. SMIL is a declarative language which is as easy as HTML for authors to use. SMIL documents provide a framework for a synchronized multimedia presentation; they do not describe the actual content (i.e. the audio and video that are reproduced) but rather where and when they are played, either in parallel or in sequence. SMIL can position individual graphic elements on the display and attach links to multimedia objects. For example, at the same time as the video and sound are being played, a text could be subtitling the presentation, the lyrics could be shown and you could browse through stills from the concert. W3C published SMIL Recommendation 1.0 in June 1998. The SMIL specification has been implemented by RealPlayer Plus G2 [12], allowing the different player components (i.e. RealAudio, RealVideo, RealPix, RealText, RealFlash) to be synchronized and presented in a separate space on the screen.

12.3. Style sheets

Style sheets are needed to provide precise control over the presentation of web pages. Using the style sheets specified by W3C, web designers can specify the rendition of visual and audio (speech) effects. For relatively simple publishing tasks, the Cascading Style Sheet (CSS) language is being specified. For more complex documents and for converting XML documents into HTML, W3C is developing the Extensible Style Sheets Language (XSL). XSL is itself an XML application and has two major parts. The first part defines the vocabulary and includes XML tags for trees, nodes, patterns, templates and other elements needed for transforming XML documents from one markup language to another. The second part defines an XML vocabulary for formatting the transformed XML document produced by the first part.

2. SMIL is pronounced "smile".

12.4. Graphics

In 1996, W3C recommended the PNG format. This format has enjoyed widespread support on the latest generation of browsers, offering true colour, real transparency and fast incremental display. More recent work concerns the SVG format. Vector graphics are superior to the bitmap GIF and JPEG images currently used on the Web. Rather than sending pixel values, it is more efficient to send instructions for drawing lines (vectors) and filling shapes – techniques used by many of the popular drawing packages such as Adobe Illustrator and CorelDraw. In addition, the SVG instructions are written in XML and support features such as transparency, anti-aliasing, additive colour, hypertext, animation, and hooks to enable search engines to extract text from the graphics. None of these features are needed for the classical ink-on-paper graphics formats of PostScript and PDF. SVG will mean that web documents will be leaner, faster, more interactive and displayable on a wider range of device resolutions, ranging from small mobile devices to office computer monitors and high-resolution printers.

12.5. Document Object Model (DOM)

DOM is a standard internal representation of the document structure. It facilitates the programmers to access components and add to, delete and edit their contents, attributes and styles. DOM offers a consistent programming interface for manipulating the document with programming languages such as Java and ECMAScript. DOM can be applied to both HTML and XML. The DOM level 1 Specification is now a W3C Recommendation and work continues on support for manipulating style properties and events.

12.6. Metadata

The Web now holds a tremendous amount of information. If we want machines to help us navigate this information, then we need some way of describing and cataloguing the information, in a format that the machines can usefully process and query. W3C completed its work on the basic Resource Description Framework (RDF) specification. This specification is a knowledge representation/relational database language for resources on the Web. These resources may be a web page, a particular paragraph or image on a web page, or an entire website. Future work may focus on query languages and reasoning engines for metadata across the Web. An early example of metadata is PICS – the Platform for Internet Content Selection. With PICS it may be possible to distribute information about Web content in a simple, computer-readable form. PICS could help parents and others to filter out undesirable material, or could direct children to sites that may be of special interest to them.

12.7. Privacy

Users want to know whether they should entrust personal information to a given website. W3C's Platform for Privacy Preferences Project (P3P) allows users to be informed of the site's practices. Users may then negotiate with the site over its privacy policy and come to a mutually-acceptable agreement.

12.8. Digital signature

Digital signatures serve to identify the origin of a document and to ensure that the information has not been tampered with *en route*. Digital signatures allow users to check that downloaded information has come from a reputable source. This is especially important for documents which imply commitments – such as contracts, price lists, press releases, etc. Future work will address the digital signing of XML and RDF as this is critical for a variety of electronic commerce applications, including payment tolls.

12.9. Micropayments

W3C is developing a common markup language for payment information, and an API to support such very small payments. For example, when users clicked on a desired item, the browser would display the cost, currency and any other data associated with the item and then ask the user to pay for the item via an electronic wallet. Different electronic wallets may be available for different payment systems in use.

12.10.Channels

Channels are the means by which Internet Explorer implements webcasting. Webcasting is a technology whereby content from the website seems to be pushed to the user, instead of the user having to get it. Channels are really just a more sophisticated form of subscriptions, in which the parameters for a subscription are set by the website and are therefore tuned specifically for that site. When you subscribe to one of the sites on your favourites menu, you are telling Internet Explorer that you want to keep in touch with that site, to be automatically notified when it has new material and, optionally, to have that material downloaded to you. You can specify exactly how much content you want to download and when.

13. Service-provision cost

In addition to the normal production and staffing costs, web broadcasters initially incur considerable costs when purchasing their web server equipment, and are subject to ongoing (running) costs, in particular from the ISP.

As an example, an ISP in Germany (UUNET) charges a broadcaster typically about 1 CHF per listener/hour for a 16 kbit/s stream over a PSTN network. This means that a broadcaster will have to pay around 100 CHF per hour to feed 100 listeners at any time. The total cost for a broadcaster would be about 60 000 CHF a year to provide the streams for just 100 simultaneous listeners around the clock. Since an average listening time is around 20 hours a week, the "coverage" of such a webcast is estimated at 800 to 1000 persons. Of course, such an audience is ridiculously small by usual broadcasting standards. To this end, broadcasters tend to set up "server farms" which are capable of delivering several thousand streams simultaneously, to cope with the peak traffic demand. Such an investment may be significant.

It is expected that this cost will go down rapidly as the number of ISPs and listeners grow. Some predictions indicate that a dramatic reduction by a factor of 100 could occur in the next three years. Currently the prices in the USA are lower than in Europe by at least a factor of 20.

The situation may vary from country to country. In future, the cost may also be reduced significantly due to the new emerging IP-Multicast standard.

14. Conclusions

This article was completed on the day when America Online (AOL), the Internet service provider, unveiled a $164 billion takeover of Time Warner, the US media conglomerate. The press reported that this deal, the largest ever, represented a major milestone and will revolutionize the way in which news, entertainment and the Internet are delivered to the home. This merger will probably open the way for other media and Internet companies to pursue the same convergence strategy.

The distinction between conventional broadcasting and the Internet begins to blur.

And yet, the Internet and webcasting are still in their infancy. The Internet is currently too slow and unreliable, and the technical quality of the web services it provides is still inadequate. Today's 28.8 kbit/s bit-rates are insufficient to allow high-quality entertainment via the Web. Developing the regulatory environment, in relation to the conver-

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Currently, Mr Kozamernik is the co-ordinator of several EBU R&D Project Groups, including B/AIM (Audio in Multimedia), B/WB (Webcasting) and B/MM (Mobile Multimedia). He represents the EBU in several collaborative Projects, i.e. the Eureka-147 DAB, S3M, Hypermedia and TeleWeb projects. He is also the Project Director of the World DAB Forum.

gence of traditional media and interactive broadcasting, has already started. The rules over data and consumer security, as well as copyright protection, should be provided. Much work is needed to establish suitable economic and commercial models. And last but not least, new attractive services and applications need to be developed.

Many public broadcasters are putting their energies and funding into exploring the extraordinary potential of this nascent medium. Broadcasters need to understand better the Web's potential, so that they will be able to make use of it for future multimedia delivery. Although the Internet was not designed for broadcasting and multimedia delivery, the Web is undoubtedly an extremely powerful new medium. It will influence all elements of the broadcast chain: contribution, production, post-production, distribution, transmission and reception. Many consumer products will embrace it. The Internet beyond the PC will use radio and TV sets and, in particular, mobile phones.

Broadcasters will need to address seriously some strategic issues. Many challenges of a technological, legal and commercial nature have emerged and many more are yet to appear. Efforts should be taken to exploit all the possibilities, to improve the technical quality, to develop new attractive applications, to protect consumer privacy and to promote security.

Broadcasters need to integrate webcasting into their normal operations as soon as possible.

However, the Internet phenomenon should be treated with some caution: it has great potential but it could represent an important destabilizing factor due to its intrinsic globalization and commercialization tendencies.

The subject of webcasting is simply all too important to be mishandled.

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Appendix 1
High-speed methods of connecting to the Internet

Hybrid fibre-coax (HFC): This approach involves the use of the existing cable TV infrastructure. Coaxial cable TV networks were partly upgraded in the late 1980s with fibre-optic lines, installed between the key signal distribution points and the principal residential areas. The original coaxial cable continued to be used over the last section, i.e. for distributing the signals to individual homes. This partial use of optical fibre, where it was most needed, improved the television signal quality while making it possible to carry two-way Internet and telephone traffic. Assuming the DVB-C 64-QAM system, an 8 MHz television channel can carry about 38 Mbit/s of data. In an HFC system the data channel is shared among the homes which are linked by coax to the end of the local fibre-optic line. Thus, the actual data-rate achieved in any individual home depends on the number of users sharing the channel at a given time. A well-designed system can give each user bursts of data from the Internet at speeds of around 10 Mbit/s. There is also a lower-speed channel in the reverse direction to carry data from the home back to the Internet.

Digital subscriber line: The telephone industry has developed a number of novel techniques to transmit data at high rates over the existing (copper-wire pair) network. ISDN has been around for years and can carry up to 128 kbit/s. The new promising telephone technology is DSL. The most widely developed version of it is ADSL which is capable of delivering 3 to 4 Mbit/s to the home, together with a slower rate back from the home.

Multipoint Video Distribution System: Another promising technology to carry Internet is MVDS, which is called "wireless cable" by some people. This terrestrial system uses a cellular-type network at frequencies above 40 GHz.

DVB and DAB: The digital broadcast channels provided by DAB and DVB are suitable for high-speed datacasting services via satellite, cable and terrestrial radio/television channels. The DVB standard offers a data throughput potential of several Mbit/s, depending on the delivery medium and whether the full channel or only part of the channel is used for data transmission. For example, DVB-T allows for data capacities of between 6 and 25 Mbit/s, and DVB-S – up to 38 Mbit/s. DAB would normally be able to carry data speeds of up to 1.5 Mbit/s. However, data broadcasting services would typically use only a portion of the total channel capacity that is available. In practice, most of the capacity is taken by the usual radio and television programme services, coded as MPEG audio and video data streams.

The data-broadcasting opportunities provided by DVB and DAB are well documented. The DVB Data Broadcasting Specification is based on MPEG-2 DSM-CC and is designed to be used in conjunction with the DVB-SI standard [13][14]. In the case of DAB, the TDC specification provides the ability to transport data streams using a variety of DAB data-transport mechanisms [15]. Both systems include the specifications for IP tunnelling and return-channel specifications.

IP SatCast: One possibility for a high-speed Internet solution is to use a secure, satellite-based, multimedia platform. Last year, British Telecom's Broadcast Services launched the first commercial service for delivering high-speed Internet, corporate intranet and business TV services to a PC at broadcast speed and quality. This platform is called *IP SatCast*.

The system uses industry-standard technologies to support video and data applications based on the TCP/IP Internet standard and the DVB standard for digital TV.

In a corporate communications application, where a company has to reach its employees working in different countries all over Europe, the system can provide multimedia broadcasts such as interactive distance learning. The presentation screen can be split between a video presentation, and supporting data or graphical information such as financial charts, tables and sales figures. IP SatCast has a “store and forward” capability, so that people who missed the initial broadcast can retrieve the video file and watch it at a time which suits them. The service offers an opportunity to mirror the asymmetric way the Internet works, with the vast majority of data flowing to the user. With terrestrial circuits, it would be necessary to pay for the same bandwidth in either direction.

The S3M Project [16] was an EC-funded project that ended in December 1999. The Project developed the required infrastructure for the provision of interactive services in SMATV networks. Users living in large buildings will be able to receive interactive programmes, and interact with them via the satellite and the coaxial network inside the building. One of the major achievements of the Project was to develop and test PC-based applications such as unicast (e.g. file transfer, remote login and web browsing) and multicast (e.g. audio and video distribution, video conferencing, multicast backbone and push services). The Project developed and tested three different applications:

- ⇨ DataCast Push Software Suite;
- ⇨ DataCast SatNews;
- ⇨ DataCast SatMail.

These applications either run directly on top of the TCP/IP or they utilize the IP multicast protocol. In the latter case, the traffic generated by these applications can reach all users by sending the data information only once and, therefore, it uses the satellite channel efficiently. IP multicasting is the transmission of an IP datagram to a host-group, identified by a single IP destination address (group address). A multicast datagram is delivered to all members of its destination host group, with the same best-effort reliability as regular unicast IP datagrams, i.e. the datagram is not guaranteed to arrive intact at all members of the destination group, or in the same order relative to other datagrams.

In order to improve the best-effort reliability of simple IP multicast, a new protocol – RRMP – has been developed. It adds an additional forward error-correction layer (Reed-Solomon Erasure codes, RSE) which is able to cope with packet losses. The parameters for the RSE are freely adjustable and can even be changed during transmission. Furthermore, RRMP facilitates a connectionless multicast connection management, that allows the joining and leaving of multicast connections during the connection lifetime. The protocol provides frame-based rate control which facilitates the flow and congestion control.

The DataCast framework has been implemented on top of the RRMP protocol. It provides a means for transmitting files from one sender to multiple receivers. One of the advantages of DataCast is that it does not require a return channel, so that the narrowband return-channel remains entirely available for traditional applications such as web browsing.

The ASTRA satellite system [17] is an example of the rapidly evolving satellite-based systems which are able to provide high-speed Internet access, webcasting, Business TV, interactive shopping channels, access to archives, world stock market information, fast download of videos or 3D games and other services for the consumers. The service combines the visual quality of television with the interactive capabilities of the Internet. It offers satellite webcasting services for Internet users – at speeds which are more than 100 times faster than wired modem connections.

The commercial launch of the LuxSAT webcasting services in Europe started in the autumn of 1999. Two types of subscriptions are offered: LuxSAT-NET and LuxSAT-TV. The former service is designed for PC users. The subscriber's PC must be connected to a satellite DVB decoder (via the USB port) supplied by LuxSAT. The consumer package includes the rental of the decoder and access to the Internet webcasting services for a modest monthly fee. The LuxSAT-TV® solution is essentially a one-stop shop. It provides a LuxSTATION® terminal, based on PC architecture, a satellite decoder, a DVD player and a large data-storage capacity. It connects simply to either a TV or a computer monitor.

Appendix 2
W3C and IETF activities

W3C activities

The Internet employs open standards. As the Web is such a vast and rapidly growing system, it is probably impossible to keep all the developments under control and to foresee the evolution of the Web. In order to attempt, at least, to co-ordinate the entire Web development effort, the World Wide Web Consortium (W3C) was founded at the Massachusetts Institute of Technology (MIT) in Cambridge, Massachusetts, in 1994. The Consortium established a European presence in partnership with France’s National Institute for Research and Computer Science and Control (INRIA) in April 1995. As the Web’s influence continued to broaden internationally, the resulting growth in W3C membership created the need for an Asian host. In August 1996, Keio University in Japan became the Consortium’s third host institution. W3C provides a vendor-neutral forum for its members and aims at producing free interoperable specifications and sample code. The Consortium’s Advisory Committee is composed of one official representation from each member organization. The EBU became a member of W3C in October 1999.

It may be useful for broadcasters to understand better how W3C works. The activities of W3C are divided into four domains: Architecture, User Interface, Technology and Society, and the web Accessibility Initiative. Each domain is responsible for several activity areas which are critical to the Web’s global evolution and interoperability (see *Panel 5)*.

IETF activities

The Internet Engineering Task Force (IETF) is the principal technical and operational body engaged in the development of new Internet standards. It specifies the protocols and the architecture of the Internet. The actual technical work of the IETF is done in its working groups, which are organized by topic into several areas (e.g., routing, transport,

Panel 5
W3C in a nutshell *(Status: December 1999)*

The World-wide Web Consortium (W3C) was created in 1994 at the initiative of the Web inventor, Tim Berners-Lee.

Main objective: The development of common protocols that enhance the interoperability and promote the evolution of the Web.

Director: Tim Berners-Lee

Chairman: Jean-Francois Abramatic

Head of Public Relations: Janet Daly

Head of member Relations: Josef Dietl

- ⇨ Advisory Committee
- ⇨ Advisory Board
- ⇨ Seven W3C offices worldwide
- ⇨ 60 visiting engineers and scientists

Hosts:

- ⇨ MIT Laboratory for computer science (LSC), USA
- ⇨ National Institute for Research in Computer Science and Control (INRIA), France
- ⇨ Keio University, Japan

Members:

- ⇨ 363 (90 full members, 273 associate members)

Architecture Domain:

- ⇨ HTTP
- ⇨ HTTP-NG
- ⇨ Jigsaw
- ⇨ TV and the Web
- ⇨ Web Characterisation
- ⇨ XML

User Interface Domain:

- ⇨ Amaya
- ⇨ DOM
- ⇨ Graphics
- ⇨ HTML
- ⇨ Maths
- ⇨ Mobile access
- ⇨ Style Sheets
- ⇨ Synchronized Multimedia

Technology and Society:

- ⇨ Digital Signatures
- ⇨ Metadata
- ⇨ Micropayments
- ⇨ Privacy

Web Accessibility Initiative:

- ⇨ WAI International Programme Office
- ⇨ WAI Technical Activity

Web site:

- ⇨ http://www.w3c.org

Panel 6
IETF in a nutshell *(Status: December 1999)*

Mission: The Internet Engineering Task Force (IETF) is a large open international community of network designers, operators, vendors and researchers, concerned with the evolution of the Internet architecture and the smooth operation of the Internet.

Beginning: The first IETF meeting was held in January 1986 in San Diego.

Membership: There is no membership. It is open to any interested individual.

Organization: There are four levels:

- **The ISOC (Internet Society) and its Board of Trustees:** a professional society concerned with the growth and evolution of the worldwide Internet
- **The IAB (Internet Architecture Board):** a technical advisory group of the ISOC
- **The IESG (Internet Engineering Steering Group):** is responsible for technical management of the IETF activities and the Internet standardization process. The IESG is formed by the area directors and the IETF/IESG Chair

The IETF itself is divided into **8 functional areas** as follows:

- Architecture
- Internet IP: Next Generation
- Network Management
- Operational requirements
- Routing
- Security
- Transport
- User services

Each area may have several working groups of a finite lifetime. Areas may also have **Birds Of Feather (BOF)** sessions in order to determine if there is enough interest to form a working group.

Current IETF/IESG Chair: Fred Baker

security, etc.). Much of the work is handled via mailing lists. The IETF holds meetings three times a year. The IETF working groups are grouped into areas, and managed by Area Directors, or ADs. The ADs are members of the Internet Engineering Steering Group (IESG).

Providing the architectural oversight is the Internet Architecture Board, (IAB). The IAB also adjudicates appeals when someone complains that the IESG has failed. The IAB and IESG are chartered by the Internet Society (ISOC) for these purposes. The General Area Director also serves as the chair of the IESG and of the IETF, and is an ex-officio member of the IAB. The Internet Assigned Numbers Authority (IANA) is the central co-ordinator for the assignment of unique parameter values for Internet protocols. The IANA is chartered by ISOC to act as the clearinghouse to assign and co-ordinate the use of numerous Internet protocol parameters (see *Panel 6* for further information)**.**