An introduction to Internet Radio

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This article – based on an EBU contribution to the WBU-TC *Digital Radio Systems Handbook* – introduces the concept of Internet Radio (IR) and provides some technical background. It gives examples of IR services now available in different countries and provides some guidance for traditional radio broadcasters on how to adapt to the rapidly changing multimedia environment.

Traditionally, audio programmes have been available via dedicated terrestrial networks broadcasting to radio receivers. Typically, they have operated on AM and FM terrestrial platforms but, with the move to digital broadcasting, audio programmes are also available today via DAB, DRM and IBOC (e.g. HD Radio in the USA). However, this paradigm is about to change.

Radio programmes are increasingly available not only from terrestrial networks but also from a large variety of satellite, cable and, indeed, telecommunications networks (e.g. fixed telephone lines, wireless broadband connections and mobile phones). Very often, radio is added to digital television platforms (e.g. DVB-S and DVB-T). Radio receivers are no longer only dedicated hi-fi tuners or portable radios with whip aerials, but are now assuming the shape of various multimedia-enabled computer devices (e.g. desktops, notebooks, PDAs, "Internet" radios, etc.).

These sea changes in radio technologies impact dramatically on the radio medium itself – the way it is produced, delivered, consumed and paid-for. Radio has become more than just audio – it can now contain associated metadata, synchronized slideshows and even short video clips. Radio is no longer just a "linear" flow emanating from an emission mast – audio files are now available on-demand or stored locally for time-shifted playout. It is convenience for the user, rather than the broadcaster-imposed schedule, which matters now.

IR is a relatively recent phenomenon. Nevertheless, during the past ten years, the Internet has become a very important distribution mechanism for audio and video streams and files. Audience statistics show that IR is increasingly popular, especially among young people and users in offices.

Bringing radio to the Internet

Internet penetration worldwide is very close to the one billion users mark. Almost 70% of the American population has access to the Internet from home, and one-third can access the Internet at work. Canada, South Korea, Japan and Germany follow at about 60% uptake. The use of the Internet is growing at a tremendous rate. Recently-published statistics suggest that, on average, 31 connections are made per month, and more than 26 hours are spent browsing the Internet each month to visit 66 sites and view 1268 pages. Eighty-seven per cent of users send e-mail messages, 60% use instant messaging services and 55% download files. Twenty-two per cent of users worldwide have already tried video on the Internet.

In 2005, the American media research company, Arbitron/Edison (www.arbitron.com), released the results of a major study on Internet and Multimedia in the USA. This study suggests that an estimated 55 million consumers use Internet radio and video services each month.

The study identified the following reasons why people listen to Internet Radio, as opposed to off-air radio:

Reason	Percentage
To listen to audio not available elsewhere	17%
To control/choose the music played	15%
Fewer commercials	14%
Greater variety of music	13%
Clearer signal than over-the-air radio	8%
Less DJ chatter	8%
Because it is "new"	7%

Internet listening appears to be concentrated among well-known Internet Radio brands such as America Online's AOL Radio Network [1]; Yahoo! Music, [2] Microsoft's MSN Radio [3], Windows-Media.com [4] and Live365 [5]. Every week, these stations reach an average of 4.8 million listeners aged 12 and older during the hours of 06.00 – 24.00. Listeners to these five major Internet Radio brands account for roughly one in four of the 20 million weekly Internet Radio listeners in the USA.

Some IR peculiarities

Radio over the Internet differs from other delivery media in three ways:

1) It is a relatively new way to experience radio via a computer device. The consumer uses a *new interface* (screen, keyboard, mouse) and is able to search and select different content according to the station name, country of origin, genre or style, as well as viewing the currently played programme ("Now Playing"). The station's frequency (as in FM or AM) or multiplex (as often in DAB) is irrelevant. The users can shortlist their preferences by compiling personalised favourites lists. In addition, it is possible to generate a virtual station schedule according to one's preferences. An "on-demand radio" is also offered by many traditional broadcasters on their websites; this allows the user to click and play the archived programme items which were broadcast via conventional terrestrial channels during the previous seven days or so.

2) IR widens the choice of *service providers*. These can be traditional radio broadcasters, new (Internet-only) stations, portals or independent users.

3) Radio content on the web can differ from radio broadcasting that has evolved over the last century. Whereas on terrestrial networks the choice of stations is relatively limited, there are thousands of IR stations. It is often possible to choose from a list of most popular stations or to

1. AOL Radio Network: **http://site.aol.com/product/radio.adp**
2. Yahoo! Music: **http://music.yahoo.com/**
3. MSN Radio: **http://radio.msn.com/**
4. WindowsMedia.com: **http://www.windowsmedia.com**
5. Live365: **http://www.live365.com**

find a station which is playing a particular song from a “Top 50” list. Since computers can use hard disc memory, it is possible to time-shift the play out.

One of the fundamental differences between IR and conventional radio is the absence of barriers to public transmission. Consequently, even a small local station can potentially become a global player, or at least an international station.

IR as a complement to established radio services

Since 1995, most traditional broadcasters have set up websites in order to provide complementary information for their listeners and viewers. These websites can provide a variety of textual and pictorial on-line services, as well as on-demand audio or audio/video clips associated with news events and live (continuous) reproduction of existing radio and television programmes.

For conventional broadcasters, IR could usefully complement existing on-air broadcasts. IR works best as a narrow-cast medium targeting a small number of concurrent users. Should this number increase to more than a thousand (or several thousand), the Internet streaming servers are generally not capable of providing the streams economically. In other words, IR is only really useful if it is kept relatively small. For example, it is probably not very sensible to use Internet for big one-off events such as *Live 8* on 2 July 2005 [6], as satellite or terrestrial networks can reach many more people.

IR is best suited to niche content, such as education, specialist music, and programmes aimed at ethnic minorities, which may be of interest to a relatively small number of people. Often it is considered too extravagant to use scarce spectrum for such programmes.

IR can offer a solution for communities scattered across the world. For example, there may not be enough fans of gypsy music in a given part of the world to justify a local broadcast station, but if we add listeners around the world who are interested in this kind of entertainment, the potential audience will look a lot healthier.

While it is easy to introduce a new IR stream for niche radio programmes, it is more difficult, if not impossible, to find spectrum for new FM stations, particularly in some large agglomerations where spectrum is already very congested. One example is ***SR International’s*** Immigrant Languages Service, which is primarily intended for immigrants within Sweden, but also reaches audiences abroad through its webcasts.

The scalability of IR is a major issue. When audiences are relatively small (e.g. several hundred concurrent listeners), the required bandwidth – and thus the cost – is reasonable. However, when audiences increase, the operational costs may escalate. In a way, a station may become a victim of its own success. A peer-to-peer (P2P) approach may help reduce the distribution costs. Multicast is also an option, but it requires multicast-enabled routers which may not be readily available everywhere. Also, multicast excludes on-demand delivery.

IR is inherently interactive. IR websites are places for listeners to interact not only with the station, but also with each other. These interactions are usually achieved through text messages, e-mail forums or chat rooms as well as, in a growing number of cases, audio and video messages. Indeed,

6. Musicians and artists from around the world joined together to influence the struggle to end global poverty. There were pop music concerts from nine different places around the globe on the same day with several hundred million people watching on TV and listening to the radio. Among others, WorldSpace UPOP Music Channel 29 transmitted the concerts in real time (live).

listeners may become active contributors to the website audio-visual content. For example, programme files could be mailed in from around the world direct from artists or music groups. As an example of interactivity and audience active participation, ***NRK*** – and other European broadcasters – have organized country-wide contests of amateur pop groups, allowing users to vote and select the most popular group.

IR websites have a unique possibility to offer both live and on-demand audio programmes. Many radio stations have created on-demand online archives enabling their listeners to hear programme items that were originally broadcast on-air, for example, up to seven days before. One example is the ***BBC Radio Player***. This on-demand service allows users to time-shift broadcasts and frees them from the constraint of adhering to station schedules. On-demand services transfer control to the listeners: they can create their own schedule of programmes.

Web radio has the advantage of allowing broadcasters to measure audience directly (see the section entitled *Measuring the audience* on page 9). Broadcasters using a Windows Media Server, or other streaming media, will have detailed reports of the streams played, while those using web servers can estimate audience sizes by viewing the traffic statistics found in the web-server log file, an automatically-generated list of all the files served.

IR adds a global audience which may be important for ethnic minorities scattered around the world. While terrestrial radio is generally limited to a certain geographical territory, IR's audience is effectively global and is redefined according to shared interest. IR radio introduces a concept of a multitude of niche audiences spread globally and not necessarily limited to one geographical region or country.

Internet-only stations: IR portals and music portals

There are a number of Web radio sites that offer customisable programming using their own players or ones already loaded onto your PC. Most sites feature dozens of different musical genres from baroque to zydeco and some allow you to tune in to live broadcasts from around the globe.

There are also Internet portals which help the user find a suitable IR station. Portals such as radio-locator.com [7] allow users to search for stations according to genre (or format), name, location (city, state or country), frequency (if the station is already on the air) or even the owner. Often several thousand stations are available on such portals. Some radio portals are listed in the Appendix.

Lists of FM and AM radio stations can be made available over the Internet to mobile devices such as a Palm OS or Windows CE handheld computer using suitable software.

Streaming technologies for radio services

With recent technological improvements such as rapid adoption of high-speed connectivity and ever increasing computer processing and storage power, streaming over the Internet (sometimes called *webcasting*) has become a mainstream media delivery platform. Universal standards for audio and video delivery have emerged to gain widespread adoption in the marketplace. In addition, user experience of watching video and listening to audio online has improved dramatically. Issues such as incompatible formats and versions, or browser incompatibility, are now less critical.

7. Radio Locator: **http://radiolocator.com/**

There are different standards for encoding and delivering audio files and streams online. Following the pioneering developments of RealNetworks, Windows Media and QuickTime, it now seems that ***MPEG-4*** will dominate. MPEG-4 represents a major step forward in audio/video coding, as it supports new types of media objects, such as 3D and synthetic objects. It supports interactivity at the client and server side. It is highly scalable and covers video resolutions from a thumbnail size suited to mobile applications to HDTV for home cinema, and from monophonic audio at 20 kbit/s to multichannel audio in the Mbit/s range.

The streaming system architecture comprises four elements: capture and encoding, serving, distribution and delivery, and media player.

Capture and encoding takes the source audio from the microphone and exports it into a compressed (encoded) computer file. These files are stored on a content server which controls the real-time delivery of the stream. The distribution channel (usually the Internet) connects the server to the player. The media player renders the media on the PC or another device (hand-held wireless devices, games consoles, interactive TV, etc).

As the Internet is overlaid on telecommunications infrastructure, IR is now widely available via a variety of two-way communication networks, both wired and wireless – narrow-band (dial-up) at home and broadband connections in offices, and via WLAN hot spots in airports, congress centres and other public places. The number of listening hours is staggering.

Broadband access is obviously a big plus and some of the streams are so good you can enjoy them over your home stereo system.

Server-client

Unicasting is a classical approach to radio streaming. Requests from clients (users) to receive a stream are managed by a server or a cluster of servers. In the case of clustering, load balancing is used to improve reliability of the stream delivery, especially if one of the servers breaks down. The server cluster feeds a common Internet line used to transmit the streams to the clients. The total bandwidth provided by such a server farm is proportional to the number of clients and the bitrate of the streams. This means that doubling the number of clients or doubling the bitrate will double the system capacity and thus the costs.

Unicasting also has a “scaling” problem. Since all the streams are transmitted to the Internet from one source, a server quickly reaches its upper capacity limit, resulting in a “server busy” message.

Distribution networks

The ***Content Delivery Network*** (CDN) consists of a large number of “edge” [8] servers (typically several thousand) situated around the world. Each server uses the same home page and is uploaded with the same content. The user gets content from the nearest server, so that the access delay is minimal. The CDN approach distributes the load among the geographically separated servers and increases the possible number of concurrent requests and streams that may be handled. The CDNs can potentially cater for several thousand simultaneous streams but are very costly. For example, Akamai’s globally-distributed edge computing platform comprises more than 15,000 servers in more than 1,100 networks in 70 countries.

8. The word “edge” is used here to mean “close to the user”.

Abbreviations

3G	3rd Generation mobile communications	**IBOC**	In-Band On-Channel
AM	Amplitude Modulation	**IP**	Internet Protocol
CDN	Content Delivery Network	**IR**	Internet Radio
DAB	Digital Audio Broadcasting (Eureka-147)	**P2P**	Peer-to-Peer
DRM	Digital Radio Mondiale	**SMIL**	Synchronized Multimedia Integration Language
DSL	Digital Subscriber Line	**SR**	Swedish Radio
DVB	Digital Video Broadcasting	**TTSL**	Total Time Spent Listening
FM	Frequency Modulation	**WLAN**	Wireless Local Area Network

WiMAX

WiMAX is a new IP-based communications technology based on the IEEE 802.16 standard which will provide broadband wireless access to portable devices such as laptops, personal digital assistants (PDAs) and smartphones. WiMAX will complement fixed DSL and WiFi networks by providing mobility and portability. It will offer seamless hand-over between WiMAX, WiFi and mobile 2G/3G networks. It will bring a new dimension (mobility) to broadband TV and Radio. For more information, see **www.wimaxforum.org**

Multicasting

Multicasting is a solution to serve a single stream to multiple users. The multicast-enabled network routers clone (replicate) the Internet datagrams (packets) for each user requesting the stream. Therefore the same content is conveyed to a group of users. Multicasting cannot use automatic rate changing and is not suitable for on-demand services. If multicasting is to be used for several sites at the same time, then Virtual Private Networks (VPN) should be used to bring the stream from the originator to these sites, and then multicast it locally.

P2P networks

Peer-to-peer (P2P) networks refer to computers that communicate directly with other computers without passing through intermediaries. It enables users to pool resources, such as processing power, storage capacity and bandwidth to overcome the problems of congested internet links and server crashes. Internet radio broadcasters are beginning to use P2P systems to distribute their content in what looks like developing into a win-win situation, with consumers obtaining a more reliable service and broadcasters benefiting from drastically reduced bandwidth fees.

Since P2P networks have the potential to create distribution channels which are more efficient than traditional broadcasting, some analysts have gone as far as to suggest that this will inevitably bring about a massive paradigm shift. In a P2P scenario, runs the argument, there would be no need for the “middleman” – consumers would download content directly from programme producers. This would lead to a massively reduced role for traditional broadcasters who would be relegated to providing only live sport and breaking news.

All this has led to speculation about new business models where, for example, advertisers would pay content-makers, enabling European consumers to continue receiving free television programmes. However, such scenarios forget the role of public service broadcasting and ignore the likely repercussions for quality programme-making, particularly in the areas of arts, current affairs, comedy and drama. And in a future without schedules, it is difficult to see – as has been suggested – how social networks such as Friendster or LinkedIn could help users to navigate successfully through a vast sea of online content.

P2P systems use several distinct techniques to distribute files more efficiently. One of the most widespread is “swarming”, which was pioneered by BitTorrent. In this technique, peers share

portions of data: files are broken down into small pieces and then distributed randomly between peers who exchange the pieces in order to complete a sort of jigsaw puzzle.

The Danish-based company Octoshape, which has worked closely with Danish Radio, claims that its GridCasting solution [9] saves 97% of bandwidth compared to the traditional server farm solution. As with other P2P technologies, the more people who download files, the faster they download. Other potential benefits include higher quality bitrates, instant play, no buffering and fewer interruptions.

In Britain, the BBC is working with Kontiki P2P technology to provide a new online service that will allow viewers to download radio and TV programme from the previous seven days, free of charge.

The EBU plans to organise a workshop early next year (2006) to raise awareness among broadcasters of the emergence of P2P as a potentially viable and attractive technology for the distribution of live and on-demand media. The workshop will look at the opportunities and challenges to existing business models, as well as the impact of P2P on consumer behaviour.

Podcasting

Podcasting is a way to "subscribe" to radio programmes and have them delivered to your personal computer. Subscribers to Radio podcasts can automatically receive the latest edition of the programme in the form of a file. This file can then be easily transferred to a portable mp3 player. To do this, users need an Internet connection and a piece of podcast software which is usually available free of charge. This software can check the radio station for content updates and automatically download them to the player as soon as they are available. As a general rule, programme files can be made available shortly after broadcast, but in some cases this may be several hours later.

There is a multitude of podcasting software available from **www.podcastingnews.com**. This software varies from one computer platform to another (Windows, Apple Mac, Linux, etc). The same website also provides software for publishing podcasts.

Internet Radio terminals

Internet Radio terminals are user devices which can reproduce streaming content. In the beginning, streams could be played by a software application on the PC. Now we are seeing media players in mobile devices and in home entertainment products such as the set-top box. Today, a PC user may have three or more players installed to provide support for different codecs available on the market. Thankfully, PC makers have made it easy with pre-loaded music players, from Apple's iTunes and QuickTime, to Real Player and Windows Media Player.

Players can be used in three different ways: as a content portal, a stand-alone player or a plug-in to a web browser. In the latter case, the streaming content may become an integral part of a synchronized rich media experience, combining text, graphics, audio and video (using SMIL[10]).

Audio-only players are still very popular, as there is huge demand from music lovers to download tracks over the Internet. They serve as a jukebox to organize music libraries and set up playlists. They can also rip CDs, store mp3 files on the hard drive and download to

9. See the article on Octoshape in EBU Technical Review No. 303, July 2005 **http://www.ebu.ch/departments/technical/trev/trev_303-octoshape.pdf**

10. Synchronised Multimedia Integration Language.

portable music players such as the iPod. Examples include WinAmp (from NullSoft), iTunes (from Apple) and MusicMatch Jukebox (now owned by Yahoo!).

Music download is now a feature of 3G mobile phones. Motorola and Apple joined forces to market a device combining an iPod with a mobile phone – the Motorola ROKR. For the moment, downloading songs from the iTunes music store still has to be carried out via the Internet and the user's PC, although in the near future the mobile phone could do it direct via 3G networks.

It is also worth mentioning the possibility of attaching a small FM transmitter to a portable iPod player for listening on car radios. This is important, as radio listening in the car may be affected. Some people may choose to listen to their personal collection of pre-recorded files on iPods, rather than listening to local FM or AM stations. Just as commuters are catching up to the idea of satellite radio for their cars, a new wireless approach called "Roadcasting" will allow you to tune your radio to music playlists coming from other cars on the motorway.

A special category of IR terminal devices are the disguised computers which look like old radios but can connect to Internet Radio stations. An early example of this approach was Kerbango from 3Com (no longer available on the market).

More recently, Reciva has produced an Internet Radio module which it is offering to global brand-name radio manufacturers and consumer electronics companies for use in their Internet Radio products. It has also produced several custom and reference IR designs such as the one shown on the right.

http://www.reciva.com/

Other emerging terminals that do not need to be connected to a PC (but do require you to have a home Wi-Fi network in order to play radio or music through a home stereo system) include Acoustic Energy's Wi-Fi internet radio (in partnership with Reciva), Roku's SoundBridge Radio Wi-Fi Music System, the Solutions WebRadio (available, for example, from PenguinRadio) and the Squeezebox from Slim Devices.

http://www.acoustic-energy.co.uk/contact/radio.html

http://www.rokulabs.com/products/soundbridge/SoundbridgeRadio/index.php

http://www.penguinradio.com/index.php

http://www.slimdevices.com/

http://www.streamium.com/

Another consumer electronics device which allows consumers to listen to Internet radio and Internet music is Streamium from Philips. The concept here is different because you need a separate PC and a broadband Internet connection. The PC and Streamium can be located in two different rooms (which is convenient because of the fan noise of the PC) and are connected wirelessly using an integrated 802.11g connection (bandwidth 54 Mbit/s). An LCD display shows audio metadata (song titles, artist names, remaining and elapsed play time, etc.), so you do not need to have your TV turned on when listening to your music or radio.

Internet Radio's relationship with traditional radio

The comparatively low entry barriers for broadcasters have led to a proliferation of Internet Radio sites. This has increased the importance of promotion and product differentiation. However, public service broadcasters enjoy a significant competitive edge. They benefit from both strong brand recognition and the ability to cross-promote across Internet, radio and TV networks.

In order to promote their Internet services, broadcasters must communicate the all-important web addresses to listeners. It is not the aim of this article to explore marketing techniques, but suffice to say that broadcasters can achieve this in a variety of ways: during live programmes; in advertising campaigns on radio, TV, the Internet or in print; and with e-mail marketing campaigns, press releases and give-aways.

Where Internet Radio really comes into its own is as a marketing tool in its own right. Radio is an "experience product" which the consumers must sample before they become regular listeners. There is evidence from the BBC and others that Internet Radio players can boost listening figures for traditional radio by encouraging listeners to experiment and discover new programmes. In addition, some shows already have as many "catch-up" listeners online as they do for the original live broadcasts.

One way that the BBC encourages users of its radio player to discover new shows is by providing links and lists of the most popular programmes by topic and genre. It is likely that later versions of the player will offer a suggestive service, along the lines of the "if you liked that, you may enjoy this" feature of Amazon and Q-Magazine. As things stand, the BBC claims that its player adds millions to the overall listening figures.

Internet Radio is also a useful platform for collecting data and for building communities of dedicated listeners. Message boards and chat rooms create communities, with the added benefit that in order to register, listeners must fill out customer profile forms and give their contact details. Information gathered in online competitions can also contribute to listener databases for the purposes of market research.

Measuring the audience

One of the outstanding features of Internet Radio is that audiences can be measured with precision and accuracy, as every hit of the keyboard key or mouse is logged. In conventional broadcasting,

research results may depend on user behaviour, the methodology used and the audience sample taken, so these results are often open to argument and criticism.

Measuring a web audience and understanding web user behaviour is vital to online businesses. Consumer statistics data is used to keep a record of a website's hits and traffic patterns and can help in understanding visitor behaviour. This data may provide the overall number of visits to the website during the specified time frame in terms of parameters such as Page Views, Unique Visitors, Most Popular Pages, Most Visited Documents, Most Visited Dynamic Pages and Forms, Top Downloaded Files, Most Accessed File types, and others.

As modern websites tend to be dynamically created and designed, and can embed *audio and/or video files and streams*, Media Monitoring statistical evaluations are needed. Early attempts involved Arbitron [11] Internet radio listening and the way the popularity of Internet Radio stations was assessed. Arbitron's MeasureCast Rating gives total time spent listening (TTSL) estimates and provides regular weekly and monthly webcast audience reports. TTSL is the sum total of hours that listeners tune in to a given station or portal (network).

For example, during the week of 28 October 2002, *Clear Channel Worldwide* was the top ranked Web radio network with 1'566'183 Total Time Spent Listening (TTSL). *MusicMatch* was ranked number 2 with 1'205'175 and *StreamAudio* was third with 1'006'579 hours of listening. In addition to duration of listening, Arbitron also publishes demographic highlights such as the peak listening day, peak listening time, geography, age and gender categories, etc.

While such statistical evidence is very useful, it does little to help media service providers and webcasters who need much more detailed insight into user behaviour. To this end, media statistics products or services should be used.

Compared to static web pages, streaming media requires much more bandwidth (more data is transferred in the same time unit) and is more sensitive to Internet infrastructure problems, such as latency (delays), packet loss and jitter, resulting in poor audio.

Because of the large performance variations that occur on the Internet, it is important for content providers to measure the performance of their media to gain an objective view on what their users are experiencing. The media monitoring statistics may help content providers to learn how their sites are performing, how they compare to the competition and where they can actually make improvements. Measurements can reveal geographic differences that may be related to the ISP services, backbone problems that can be identified quickly and repaired, insufficient caching or server power that should be beefed up, etc.

Media Monitoring statistics may be standalone or can be integrated with other visitor data. It provides answers to questions like: *How many visitors start the audio or video stream? How long do they watch or listen? How often do they click on "Play", "Pause" or "Stop"? What is the quality of the reception?* It allows content providers to find out, for instance, if the online sales of a particular CD increase after visitors have listened to it online, or whether visitors return to the website more often after they have seen a video.

Modern Media Monitoring statistics also provides a possibility for visitors to use "bookmarks" and measures how often web pages are being added to the "favourites" of visitors. In addition, the measurement of visitor loyalty has been improved. For every visitor, it can now be determined

11. Arbitron: **http://www.arbitron.com/home/content.stm**

(often by using cookies) whether they are visiting the site for the first time, or if they have been there before.

In providing streaming media there are several parameters that are analogous to those monitored for the websites. If we replace “Web pages” with “Streams” and “Visitors” with “Requests”, we may consider the following parameters for media monitoring:

- number of requests for each stream (per day, week, month, etc);
- origin – where do requests for streams come from (e.g. which IP number, organization, country);
- most demanded streams or most demanded parts of streams;
- peak number of successfully provided streams.

Some additional specific media-related parameters are those related to media players, quality delivered and user behaviour, as follows:

- which Media Player (Audio/Video/Graphics)?
- which speed (bandwidth) for a combination of audio and video programme?
- start-up time;
- audio quality for a given bandwidth;
- video quality, including video frame rate for a given bandwidth;
- connect time;
- redirect time;
- initial buffer time;
- recovered, lost and dropped packets;
- number of successful buffering attempts;
- duration of buffering (average);
- total playing time for each user / average playing time for each stream;
- hits and Duration Chart for each stream / all streams;
- number of finished Streams (who and how many have seen it to the end);
- number of linear Hits (without Stop or Pause);
- number of loops made.

Case studies

VRT

The Belgian public service broadcaster, VRT Radio, started broadcasting on the Internet in 1997. VRT’s radio player offers a mix of six traditional radio stations and three exclusive digital services. Of the more than 300,000 unique visitors it attracts every month, more than 80 per cent listen to live streams, while 10 to 15 per cent listen to both live and on-demand programmes. VRT has seen its bandwidth consumption double over the past year and currently uses up to 45 terabytes of bandwidth a month.

VRT automatically records and uploads all of its on-demand content. News bulletins are available on-demand roughly three minutes after the live broadcast is over. Programmes more than 60 minutes long are available about 20 minutes after the broadcast. VRT's radio player works on both Windows and Mac platforms and is a browser-embedded application that requires Flash 7 and Windows Media Player or QuickTime Player. VRT streams in two formats: mp3 at 6, 32 and 96 kbit/s; and WMA at 20 and 64 kbit/s.

VRT has a global rights agreement with organizations including IFPI (the International Federation of the Phonographic Industry) covering both live and on-demand streaming. This is quite common in Europe and contrasts with the situation in North America, where broadcasters usually pay a fee per listener.

Virgin Radio

Virgin Radio boasts one of the world's most successful Internet radio networks. According to Virgin Radio, which uses the Limelight LUX tool to monitor its online traffic, it reaches 1.1 million con-sumers who listen for an average of 4.4m hours a month. In 2005, Virgin won two prestigious online awards, scooping both the Webby Award and the People's Voice Webby Award for radio. (The Webby Awards is the leading international prize honouring excellence in Web design, creativity, usability and functionality.) Earlier this year, Virgin became the first UK station to make a daily podcast.

Virgin Radio has been available on the net for nearly a decade. In 1996, Virgin was the first station in Europe to broadcast 24 hours online, initially using Real Player. Nowadays, Virgin has four radio stations, which are available online in a variety of different formats and speeds. Virgin stations are currently available in the following formats:

- Windows Media 20k mono;
- Windows Media 64k stereo;
- Real SureStream 8k-32k mono;
- Streaming mp3 32k mono;
- Streaming mp3 128k stereo;
- Ogg Vorbis ~20k mono;
- Ogg Vorbis ~160k stereo.

In addition, Virgin Radio is available in Real AAC 128k stereo, and Quick-Time 64k stereo.

Virgin concentrates on UK listeners – who are the majority of those that listen online – and is fully licensed for broadcasting to the UK over the internet. This is covered by Virgin's music licensing fees, which cost over £1.2 million a year.

Swedish Radio multichannel audio distribution

In addition to some 15 web radio channels which are regularly broadcast from www.sr.se, Swedish Radio has been distributing multichannel audio files via their web-site on-demand, since midsummer 2001. The audio content is coded in 5.1 DTS (Digital Theater System) format. The SR website posts nearly 40 audio-only clips of downloadable multichannel material, ranging from about one minute duration to shows of over one hour.

There has been a huge interest for downloading these audio programmes world-wide: to date more than 4 million successful downloads have been made. Users can play these files directly from the hard drive or from a CD and reproduce them via a surround sound loudspeaker system. The cost incurred for broadcasters is very minor.

Summary and Conclusions

Conventional radio broadcasting on AM has been around for about a century and on FM, since the 1950s. New digital broadcasting technologies such as DAB, XM radio, DRM and others are becoming very popular in many parts of the world. Traditional on-air radio has many strengths and is still a vibrant medium. It is likely that it will remain the principal delivery mechanism of radio content for quite some time.

The Internet has opened up a new possibility for radio enthusiasts. During the last ten years or so, Internet Radio has been a major focus of technical innovations and operational experiments. Now Internet Radio has become a mature medium with its distinctive characteristics. There are many tens of thousands of Internet Radio stations worldwide, ranging from big portals down to small local and individual streaming stations.

The main assets of Internet Radio are its global reach, interactivity and personalisation. While today the users need a computer device and a broadband connection to access Internet radio stations, in future they will be able to enjoy it on a number of portable wireless devices. Internet Radio will become ubiquitous.

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He started his professional career as an R&D engineer at Radio-Television Slovenia. Since 1985, he has been with the EBU Technical Department and has been involved in a variety of engineering activities covering satellite broadcasting, frequency spectrum planning, digital audio broadcasting, audio source coding and the RF aspects of various audio and video broadcasting system developments, such as Digital Video Broadcasting (DVB) and Digital Audio Broadcasting (DAB).

During his years at the EBU, Mr Kozamernik has coordinated the Internet-related technical studies carried out by B/BMW (Broadcast of Multimedia on the Web) and contributed technical studies to the I/OLS (On-Line Services) Group. Currently, he is the coordinator of several EBU R&D project groups including B/AIM (Audio in Multimedia), B/VIM (Video in Multimedia) and B/SYN (Synergies of Broadcast and Telecom Systems and Services). He also coordinates EBU Focus Groups on Broadband Television (B/BTV) and MultiChannel Audio Transmission (B/MCAT). Franc Kozamernik has represented the EBU in several collaborative projects and international bodies, and has contributed a large number of articles to the technical press and presented several papers at international conferences.

Michael Mullane has worked as a broadcast journalist and new media manager for organizations including the BBC World Service and Swiss Radio International (SRI). As Deputy Head of SRI's Asset Management Department and the swissinfo Web Factory, he helped to turn the Swiss international broadcaster into a multi-platform operation and was responsible for the strategic development of new services. He was part of the team that re-launched the website www.swissinfo.org.

At the European Broadcasting Union, Mr Mullane is active in the areas of Radio and New Media. He is a member of several key EBU interdisciplinary groups, covering issues as diverse as archiving, digital rights management and Traffic and Travel Information.

Internet Radio has proved to be most successful if associated with conventional radio broadcasting over terrestrial or satellite networks. Nevertheless, many standalone Internet Radio stations have reached a break-even point to become commercially successful.

Internet Radio redefines radio content. Not only does it introduce new music and speech formats, but also can embellish them with text, graphics and video. It allows users to listen to a wide selection of audio items when and where it is convenient. These on-demand radio services may dramatically affect the pattern of listening and listening habits.

Internet Radio has highlighted many legal and regulatory issues that need to be addressed. These issues relate to copyright, licensing, content regulation, merchandising, advertising and security. However, these topics exceed the scope of this article.

Appendix
Some important Radio portals

Beethoven

http://www.beethoven.com

Features include live requests, free e-mail accounts, chat rooms, contests, classical music news and special offers. Users can tune in to either a free low-bandwidth stream at 28 kbit/s using Windows Media Player or a commercial 96 kbit/s stream with Real One Player. The navigational bar is not uniform throughout the site so it is difficult to get to certain areas.

Launch: Music on Yahoo

http://launch.yahoo.com

As well as listening to Internet Radio, users can watch music videos, shop for ringtones, search for song lyrics, play games and customize a station to play favourite artists. A “Turn Off Explicit Lyrics” option allows parents to control what their children are playing.

Live 365

http://www.live365.com

Live 365 broadcasts from over 100 countries, in 22 genres, and boasts more than 600 million unique listeners since its launch in July 1999. Users can add artists to a favourites list, rate songs and stations and see which tracks have recently played.

Radio VH1

http://www.vh1.com/radio

Radio VH1 has more than 70 stations plus music news. Within each station is a description of the music, the line-up of musical acts and the DJs. Currently, VH1 is not available for Mac users.

IM Tuning

http://www.sonicbox.com

Users need to download free IM Radio Tuning Software – with the minimum requirements of a 56K modem – to access the hundreds of Real stations. Enhanced sound quality is available via the IRhythm Remote Tuner, which uses wireless technology to play Internet music over home stereos.

Last FM

http://www.last.fm

Features, include show business gossip and a forum for launching new artists. By typing in three favourite singers, users can obtain a list of stations featuring these performers. As users add tracks they build a profile which can be compared with others who have similar tastes. If users skip a song or give it a bad rating, they will never hear it again.

MTV Radio

http://www.mtv.com/mtvradio

MTV aims to appeal to a wide variety of musical tastes. Users can choose from four radio stations: On Air, MTV.com, Celebrity and International. Although the player has VCR-like controls and artist ticker features, users must return to the site to see the full list of stations they want to change.

Radio-Locator

http://www.radio-locator.com

Radio-Locator provides a broad list for finding a US radio station, Internet streaming radio and world radio. It claims that it is the only website which provides a comprehensive list of radio stations world-wide. It has links to over 10,000 stations and over 2,500 online streams in 148 countries. There are drop-down menus to search for stations.

SHOUTcast

http://www.shoutcast.com/

SHOUTcast is Nullsoft's Free Winamp-based distributed streaming audio system. It allows anyone on the Internet to broadcast audio from their PC to listeners across the Internet, or any other IP-based network.