EBU Technical Review 2008-Q4

Editorial

Articles

Editeur Responsable: *Lieven Vermaele*

Editor-in-Chief: *Mike Meyer*

E-mail: tech_review@ebu.ch

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EBU Technical Review

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Downturns, upturns and media development

How far away is the "bottom" of the trough in the current economic downturn? Do we know what measures are needed to bring economic stability to the world?

The answer is "No, not yet" (at the time of writing). The economic engine has to be steered with great care to avoid going into the ditch on either side of the road. Governments are still "learner drivers", it seems.

The problem is that the economy is a highly complex system with many inter-related variables. Nevertheless, however irritating and "out-of-our-hands" that things may seem, we can be certain that there will be an upturn. Complex systems like this, whether they define the weather or the economy, are cyclic. The need for now – for those of us outside of governments – is to work out where we should be when the upturn eventually comes around.

Whenever it occurs, the laws of economics will still apply, and this is a good time to reflect on what it will take for media to be successful in future.

The articles in this edition are all linked to market economics, because their success depends on the "business case" that is found for them. If there ever was a world where brilliant technical ideas were simply carried by the wind to success, this is not it.

Some of the "rules" for success are:

- The more attractive the programme content, the greater the chance of success of the service. People do not want wires and resistors, they want programmes. All the technology in the world does not make up for boring programmes.
- If people are going to have to pay for the programmes, they must do more than just want them... they must want them enough to pay the going price.
- The lower the cost of making the programmes and the equipment needed to receive them, the greater the chance of success.
- The lower the cost of the technical infrastructure needed to provide the service, the greater the chance of success.
- The fewer alternative ways of getting the same kind of service ("substitutes"), the better the chance of success.
- The greater the number of services which add to the experience or use the same equipment ("complements"), the better the chance of success.
- Experience with technology in the past is that viewers will not pay a massive increment for a new version of what they have already.

Bearing in mind these “rules”, readers may care to evaluate the chance of success of the great ideas and systems described in this edition, and form their own opinions as they read about them.

Objectively, it doesn’t take long to see that the highest prospect of success probably comes with Internet applications such as catch-up TV. It has a lot on its side. Users and broadcasters need no investment in equipment or infrastructure – the users already have PCs.

Digital terrestrial television has matured now and works particularly well when the analogue “substitute” service is switched off. But it doesn’t take long to see that the job will be tougher for newer digital radio or television systems (e.g. DVB-H), because new broadcast infrastructure and new receiving equipment will be needed, and there will be “substitutes”. However, this doesn’t mean they cannot succeed.

The idea from CRC Canada is brilliant, but it will need work from the broadcasters to convince manufacturers to make open source handheld receivers.

Through all the economics, we must never forget that however difficult the job is, it will always be easier if there are common technical standards. We must continue to encourage new ideas; and, when they arrive, strive for common standards.

The economic downturn may be a barrier to new investment, but if we hold on to the rails and look where we are going, we can learn to drive well, and inventiveness and discipline will win through.

Lieven Vermaele
Director, EBU Technical

David Wood
Deputy Director, EBU Technical

15 December 2008

Editorials Archive

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Evolution of the BBC iPlayer

Anthony Rose
Controller, Vision and Online Media Group, BBC

For more than ten years, EBU Members have been developing and refining their web sites in order to enhance and augment their core radio and television broadcasting activities. The web is no longer merely an information medium (providing textual and pictorial information) but has become an audiovisual content-distribution medium for the internet-connected PC user – for both linear (scheduled) programmes ("channels") as well as for non-linear ("on-demand") programmes.

The BBC's development of the iPlayer is undoubtedly one of the best examples of how broadcasters can exploit the internet as a new media delivery mechanism. It can thus serve as a blueprint for other broadcasters to develop their broadcast services on the internet.

This article is based on a series of phone-calls in August 2008 between Franc Kozamernik (EBU Technical) and Anthony Rose, BBC Controller Vision & Online Media Group, which includes the iPlayer.

For the uninitiated, some background information on the iPlayer is provided in the box on *Page 2.*

Franc Kozamernik (FK): *There is a lot of interest among EBU Members in the BBC's iPlayer developments. The EBU Delivery Management Committee (DMC) set up a Project Group D/WMT (Web Media Technologies) chaired by Paola Sunna (RAI), in order to develop and evaluate a similar development termed the "EBU Media Player", which will be capable of delivering all kinds of content including the streams received from satellite, terrestrial, cable and IPTV channels as well as VoD and catch-up TV. What advice could you give to the group?*

Anthony Rose (AR): The biggest problem in developing services such as the iPlayer is typically not so much the web site and media playout, or even the transcoding system, but rather the metadata and the content ingestion.

In the case of the proposed EBU project, a key design questions is whether it will be an automated system that will capture content from satellite or other source, or whether there will be a team who manually process and ingest content.

FK: *Our provisional idea is that our system will be fully automated. The system will allow users to find content via a variety of categories and other criteria. The metadata used will be broadcast via DVB-SI and TV Anytime, as appropriate.*

AR: There are a number of important questions which I think need to be addressed before one starts a project such as this. For example, is it the EBU's intention that each broadcaster creates their own website to where users can access this captured content, or will the EBU provide a so-called white label solution, which means that the EBU develops a fully working website, which each broadcaster can then “skin” or brand to make it look like their own site? Will broadcasters need to arrange rights clearances for each territory, or can the EBU arrange this on behalf of all? Where will you source detailed metadata from (e.g. actor names, full programme descriptions, etc.)? Would you pull it from the DVB feed or will editors log in separately to apply enhanced metadata?

Perhaps the EBU project is more similar to the Redux project developed by BBC Research rather than the iPlayer? Redux is a technical trial using a fully-automated media ingest and capture system, is largely built on open-source technologies, and does not use DRM. Redux is being used within the BBC as a means for transcoding and providing content to BBC platforms. It is a very convenient and flexible input system.

In contrast, the BBC iPlayer is a well-staffed 24/7 operation with significant viewer traffic. We make sure that a comprehensive metadata scheme is exactly right. An essential asset of iPlayer is the right level of content protection for files and streams, as well as geo-protection, to address licence fee and content owner issues.

It is more likely that Redux can be made available to the EBU for testing rather than the iPlayer, given the sheer amount of resources that have been spent on making the iPlayer a viable commercial product. Many European broadcasters approach us with an interest in licensing the iPlayer. The question is whether they want a complete end-to-end system or whether they want individual pieces of the iPlayer production system, playout system or website. We spent several million pounds of taxpayers’ money and could not give away that technology readily. However, in the case of Redux, the investment is substantially lower and the technology could perhaps be more readily available to 3rd-party broadcasters.

FK: *We would like you to focus on the iPlayer now. What was the BBC’s motivation to develop the iPlayer?*

AR: Our motivation for designing the iPlayer has been to develop a consumer proposition to satisfy the end user, i.e. the BBC listener and viewer, in an age where people are acquiring their entertainment from the internet, not just from their TV set. What does the user really want? They do not care about codecs and metadata taxonomy, they want to find content that interests them. We did not want the iPlayer to become a regular video-sharing site like YouTube or a music store like iTunes, where people would need to sort through thousands of programmes to find one of interest. This is a different use case. The reason why people like to come to the iPlayer site is because it allows them to find a particular programme that they missed on TV or radio. They want to catch up with what

The BBC iPlayer in a nutshell

The iPlayer is a web application – available at **http://www.bbc.co.uk/iplayer** – that allows internet users in the UK to download and stream BBC television and radio programmes for up to 7 days after the broadcast.

Users are able to download and stream programmes as soon as they have been broadcast on BBC TV and Radio. Users can keep downloads and watch them as many times as they like during the following 30 days.

For selected series, all episodes of the series are available for up to 13 weeks, known as Series Stacking. The iPlayer will in due course allow users to subscribe to a programme series and automatically download each programme after it is broadcast.

Recently, simulcast streaming was added, allowing users to watch TV live in addition to the on-demand catchup services.

The iPlayer services can be accessed on broadband internet-connected devices such as PCs, Apple Macs and Linux computers as well as Apple iPhone, Nintendo Wii and Sony PS3 gaming consoles, Nokia N96 mobile phones, Windows Media compatible portable media players, and Virgin Media set-top boxes.

To follow new developments of the iPlayer, go to **http://www.bbc.co.uk/blogs/bbcinternet/iplayer/**.

The iPlayer now has over 1 million users per day, and up to 1.7 million stream and download requests each day. The iPlayer should reach the 300 million play-request milestone early in 2009.

they know exists but were unable to enjoy at the time of broadcast. It is possible that over the coming months and years, the iPlayer will become a general browsing proposition, with demand driven by you or your friends rather than by the linear broadcast schedule. However, today it is focused on catching up with regularly-scheduled BBC radio and TV programmes.

When we launched iPlayer streaming at Christmas 2007, the home page had only six featured programmes and that was all. The BBC marketing team chose these six featured programmes. If you liked one of these programmes, you were in luck as this was exactly what you could easily find, right on the home page. The problem was if you did not want one of those programmes, you had to do a bit of work and browse by category, by day or search by name and so on. That might have been a complex (or even unsuccessful) operation, so we tried to make it easier to find a programme.

The first home page design was essentially "*the BBC chooses what you watch*". Then we added a "*most popular*" zone on the home page – this was about what other viewers (rather than the BBC) recommended that you should watch. And then we also added a "*just in*" feature for those items that have just arrived and "*the last chance*" feature for items that would disappear soon. Finally, we also added a "*more like this*" option as a sort of recommendation system (similar to that used by Amazon). These content-selection mechanisms proved to be extremely useful and popular among iPlayer users.

***FK:** The iPlayer does not use any ratings, as opposed to ZDF's Mediathek in Germany. Why?*

AR: Indeed, we have considered adding a rating mechanism, but we feel it's only useful where applying a rating is a means of recommending that programme to your friends, rather than rating the programme in the way it's done on YouTube. If you have a video website with a million videos, possibly uploaded by the users themselves and often of mediocre quality, then you need a rating system so that users can say which are worth watching and which are not. In contrast, when you only have 600 programmes of professional quality, it adds little value to invite viewers to rate them. For example, how do you rate a Parliamentary channel? Rating BBC programmes would not add much value for the iPlayer user. In one sense, the programmes are all pretty good and marketed for different demographics.

However, we need to develop more personal recommendations – which programmes are good for "you". When we changed the site by adding the above selection mechanisms such as *most popular*, we made it much easier to find programmes. Before launching these features, we asked ourselves whether:

- people would watch more programmes because they can find more programmes;
- they would make fewer page views (because navigation is better);
- they would make more page views (because they may browse more, as browsing is easier);
- people would watch more programmes but would watch for less time (they may see recommendations for other programmes and would just click on something else before finishing the current programme)?

Before we introduced these recommendation changes, there were about ten web-page views for every programme played. After these changes were introduced, the number of pages viewed dropped by 30% while the number of programmes played went up by 30%. These numbers showed

Abbreviations

CDN	Content Delivery Network	**LLU**	Local Loop Unbundling
CPU	Central Processing Unit	**PoP**	Point of Presence
DRM	Digital Rights Management	**RTMP**	(Adobe) Real-Time Messaging Procol
DVB-SI	DVB - Service Information	**RTMPE**	RTMP – Encrypted
HTTP	HyperText Transfer Protocol	**RTSP**	Real-Time Streaming Protocol
IP	Internet Protocol	**VoD**	Video-on-Demand
ISP	Internet Service Provider	**WMV**	(Microsoft) Windows Media Video

that our changes actually helped people to find their programmes more easily. Finally, the number of page views per programme watched settled to about five and stayed there.

It is interesting that the average viewing time per programme did not change. We found that people watch a programme they chose for an average of 22 minutes. We also found that, on average, people watched two programmes per day, giving an average viewing time of about 40 minutes per person per day. About 35% of programmes are viewed all the way to the end. This is an excellent outcome, because our programmes are usually 30 or 60 minutes long.

FK: *What is the editorial relationship between the BBC website and iPlayer? How are they differentiated?*

AR: The iPlayer is a destination within the BBC website. In many cases a given programme is available both within iPlayer and elsewhere on the BBC site, allowing users to discover and view the programme in the context in which they were browsing the BBC site. For example, most people used the BBC sports site rather than iPlayer for the Beijing Olympics. We're promoting the iPlayer as the home for long-format content. The sports site, the news site and other BBC sites are typically focused on shorter formats, like news clips and programme trailers. They also cover live events such as the Opening Ceremony at Beijing: live streaming was watched by over 100,000 simultaneous users on the **http://ww.bbc.co.uk** website. A total stream capacity of 45 Gbit/s was provided by the Akamai content distribution network (CDN). For video coding, the On2 VP6 flash format was used.

The consumption of Olympic programmes on the iPlayer was also very good. Many people who could not watch the Olympic events while broadcast on terrestrial, cable or satellite networks were able to use the iPlayer and watch those programmes delayed. For example, the Opening Ceremony was the most-viewed programme on iPlayer. It added more than 20 percent to the iPlayer traffic after the event [1].

FK: *How would you describe the structure of the iPlayer system? Which are the principal layers?*

AR: The iPlayer basically contains four layers, as follows:

- iPlayer destination portal site – this is what everybody sees;
- embedded media player – a Flash player which is used for media playout both in iPlayer and across the BBC site;
- media production – to create the content that can be used by the Flash player and is invisible to most people;
- a media distribution system.

FK: *Could we start perhaps with the latter one first, please?*

AR: For On2 VP6 streaming, we currently use the Akamai CDN, whereas for H.264 streaming we currently use the Level 3 CDN, which is one of the biggest CDNs in the USA (in August 2008, Akamai did not provide for H.264 streaming).

FK: *Why does the BBC iPlayer not use a Peer-to-Peer solution?*

AR: The BBC has explored a range of distribution solutions, but P2P does not currently provide the optimal proposition for streaming. First, viewers do not want to install any specific plug-ins. Currently to use P2P you need to install extra software. Second, P2P uses a computer's CPU and bandwidth, and most users generally do not like it.

If you are going to download some content via BitTorrent, you may agree to use P2P, and many people are happy to trade their bandwidth for free content. But in the case of the BBC, where people have to pay a licence fee of £130 a year, some are less than happy if we require that they use their bandwidth and install special software. This is especially true for people with low bandwidth and those who pay additional charges if they exceed a certain download limit. There were definite and substantial benefits from using P2P two years ago, but in that time the price of bandwidth has declined dramatically, such that today the use of P2P no longer provides substantial benefits. Of course nothing stands still in the technology world and, in a year or two, P2P may again be the preferred choice.

1. This interview was held during the Olympic Games. During the second week, as the Games moved into the final stage, the iPlayer consumption even increased by about 40%.

Of course, we know about Octoshape, Rawflow and a few others, and we have investigated using them for iPlayer distribution. But we are very happy with our current CDN-based streaming system; you click on play and the stream starts to render in about 300 ms. The only reason not to use a direct streaming facility could be cost and potential savings.

For downloading, we currently use the Kontiki P2P system which currently gives us a bandwidth saving of about 60 percent, so it halves our bandwidth bill for downloads. But we have to run a very complex server farm to make up the cost associated with it.

Actually the BBC is running a massive server farm itself, with over 200 computers, and we have 92 percent free peering. In fact, our bandwidth really does not cost us very much, at least not for downloads. If you look at all these various pieces, you wonder about the benefits of P2P. We believe that P2P works really well in some cases, particularly if you have a few programmes or a few files which are downloaded by many people, because then there is a good peering efficiency. It does not work well if you have an enormous catalogue, because the downloaded file only resides with a few peers.

For the Kangaroo project [2], P2P might work well for the 50 most popular programmes, but it will not be optimal to use P2P for a catalogue with lots of items.

We believe that the right approach is not P2P but caching at the edge of the network. We only have 500 hours a week of video content, which means that one TB of storage is enough to store our entire catalogue. This can be more efficiently done by simply putting a caching service in our network.

It may be a solution that, for the primary proposition, the user need not install any plug-ins. But you can have a secondary proposition which could offer better quality (say, high-definition TV). In this case, the use of a P2P plug-in may be justified, because distribution costs for HD streaming are very high and could be significantly lower by using P2P.

***FK:** How about a combination of P2P and CDN, which is now increasingly used by both CDN and P2P providers?*

AR: With the iPlayer we have a bandwidth bill which is not insignificant, but it is something we can afford. We do something like 100 TB per day of streaming traffic. This is a fairly significant amount of traffic. The cost of bandwidth is falling very rapidly and there is a lot of competition between the CDNs.

At the moment the cost is not too excessive. But imagine in a year or two when we have a TV set-top box with an integrated iPlayer and millions of people using it, and each of them consuming 1.6 Mbit/s for a TV stream. The bandwidth required would be 10 times what it is now. Obviously, if this happens we will have a problem. The question is, what is the best solution for this problem. Is it P2P, should we make this new box with P2P or shall we build an edge-caching solution in conjunc-

2. Wikipedia article: http://en.wikipedia.org/wiki/Kangaroo_(video_on_demand)

tion with other broadcasters and ISPs? We do not know the answer but we need to build an agile architecture that allows different transport layers to be plugged in. We should separate the delivery layer from the content delivery formats, the DRM and the download manager, so that we can flexibly glue in different propositions at short notice as needed.

We are of course monitoring the developments of Tribler and other future-generation P2P approaches, as well as hybrid systems where P2P is backed to a caching box, for example.

FK: *The BBC is renowned for its trials on IP multicasting. Could that be an option for iPlayer distribution too?*

AR: BBC Research has been trialling IP multicasting for a while. Different parts of the BBC may have slightly different objectives. In our case, we just want the iPlayer to work for everybody: go to the iPlayer site, find a programme on the home page, click it and play it. Other parts of the organization, such as BBC Research, look further into the future, and would like ISPs to build IP Multicast in their networks. Of course, we would like this as well, but the reality today is, as the UK statistics indicate, that only 5 percent of users are multicast enabled. It is probably not worthwhile to put much effort into making a multicast system for such a small number of IP multicasting-enabled users. It is really a chicken and egg situation.

Nevertheless, we are considering in the forthcoming months to use JavaScript or other means to detect if users are multicast-enabled, and if so, we may be able to give these users a higher quality stream. If they are not multicast-enabled, they would only get a lower quality stream. In this way, both ISPs and the users would have an incentive to introduce multicasting. The users are likely to choose those ISPs that have been able to upgrade their routers and can offer higher quality streams.

FK: *There has been recently a lot of noise in the UK about the increase in network load caused by the iPlayer traffic. It seems that some ISPs have filed complaints with the telecom regulator?*

AR: The press largely misrepresented the situation by saying that due to the iPlayer, the internet will collapse and everything will come to an end. Of course, this is not true. We spent a lot of time talking to ISPs and we continue to meet with them regularly. The reality is that about 7% of peak UK internet usage is due to the iPlayer. So, the iPlayer service is only a small fraction of the overall traffic and will certainly not cause internet failure.

In the UK, there are three classes of ISP delivery networks: cable (example: Virgin Media), LLU (Local Loop Unbundling) and IP stream.

The cost of reaching the end user with cable is very low. In the case of LLU, the ISPs invested a lot of money in putting some equipment in the local exchange, resulting in a very low cost-per-bit. The third class, so-called IP stream, is a rented bandwidth from BT Wholesale.

If you are looking for some figures, there are in total about 5000 points of presence (POPs) around the UK. About 1500 of them are LLU enabled. About 30% of users are on cable. For cable and LLU the cost is relatively low, while for IP stream the cost of bandwidth is very high. This hurts those ISPs. There is no problem with the amount of bandwidth as the iPlayer is no way near reaching the bandwidth limit. However, our audience statistics show that iPlayer usage peaks in the hours between 6 and 11 p.m., which is also peak traffic for ISPs. The ISPs license the bandwidth for IP stream, based on peak usage. For this reason, iPlayer traffic is costing those ISPs. It is not just iPlayer, all traffic from YouTube, Facebook and other services is costing them. Our statistics indicate that this traffic is even larger than the iPlayer's traffic.

The situation is quite complicated as some ISPs like Virgin Media (cable) are offering 50 Mbit/s packages. This encourages people to use more bandwidth. Virgin Media is happy with the iPlayer and higher bandwidth consumption. Other ISPs that offer an IP Stream service are less happy because the iPlayer traffic is costing them more.

FK: *So the situation is very complex, isn't it? How do you plan to resolve it?*

AR: The future lies in tiered services. What we need to do is to create the iPlayer services at different quality levels and then let ISPs offer different bandwidth propositions to users. For example, the user who enjoys higher bandwidth connections would pay more, and those who are satisfied with lower bandwidth connections would pay less. Of course, nobody should get a worse experience than today. We were offering streaming initially at 500 kbit/s. Today we are also offering 800 kbit/s and in three months time we might be offering 1.5 Mbit/s.

Some people will stay with 500 kbit/s, so they will not be able to experience our high-quality streams. If you sign up with Virgin, you will be on a 20 Mbit/s plan and you can download a film in 6 minutes, rather than in one hour if you only have a 2 Mbit/s line. So we could introduce a new scalable business model. For example, the user can get a good quality iPlayer service for, say, £10 a month but for £20, a much better iPlayer quality would be available.

If we can create iPlayer in tiers, then ISPs will be able to work out how to sell that. Every content provider should create such quality tiers and then ISPs will be able to build business models around these propositions. This can lead to win-win situations and ISPs will see video services as a profit centre rather than a cost burden.

FK: *Which bitrates are actually being used for streaming and downloading?*

AR: Back at Christmas 2007, we started with 500 kbit/s for live streaming and 1.2 Mbit/s for downloads coded in WMV (Windows Media Video). Now, we have introduced 800 kbit/s as well. In the future there should be no difference between downloads and streams but we are going to make a range of different bitrates, for example, 500, 800 and 1500 kbit/s.

The other thing we are going to do is pre-booking. The user will be able to download automatically a programme during the night. If you leave your computer on and if, for example, you watched Dr Who last week and the week before, it is likely that you will want to watch Dr Who next week. For ISPs, peak bandwidth is very expensive, but it is cheap during the night. We know that our top 20 programmes account for about 70 percent of all our bandwidth. In this way, most of our programmes could be delivered during the off-peak hours, downloaded and stored on the user's local hard drive. Thus, peak bandwidth usage could be significantly reduced. This is really a mixed economy where the difference between streaming and downloading is getting blurred.

In this scenario, our programmes will all be DRM'd and you will be able to either stream them or download them. A person with a good network connection will be able to stream, whereas the user with a poorer connection speed will download it and watch after the download completes or even during downloading.

The prime user experience is and will always be the iPlayer website. Imagine you go to the iPlayer website and you want to play something. Of course, you should not look at your hard drive to find out what is on it, your web page should now be smart enough to find out whether the programme is already stored on your local hard disk, and if it is, play it from there, rather than from the BBC server. This complete seamless integration of on-line and local playout is what we would like to implement in 2009. Another advantage is that users can simply unplug their computer and watch the downloaded programme offline, for example, while on an airplane.

FK: *Recently the BBC introduced the H.264 codec for the iPlayer and some users complained about poor accessibility. Why?*

AR: H.264 requires more processing power and better graphics cards. We have spent quite some time looking at this problem. There are a few H.264 compression settings that produce brilliant results but which require a high-end computer and graphics card. If you have a dual-core processor with a high-end graphics card, it looks fantastic, you can do HD at 4 Mbit/s. However, if you have a low-end portable computer, the quality is terrible, with the video running at 10 frames per second or less. So you need to carefully select the profile you use to ensure the video plays back seamlessly on a wide variety of target computers.

H.264 allows for three profiles – Base, Main and High – and for each profile you can turn on different features. We have gone for Main profile and we also turned on hardware scaling for full-screen playback, as the default. In fact, we have now found that H.264 does not use more CPU power for the configuration we have chosen, compared to the On2 VP6 codec. Rather, the contrary is true in full screen mode and, because we use hardware acceleration, it uses less CPU power. The answer is that, if you are not careful, H.264 is unplayable on low-end machines, but if you choose carefully, H.264 could be a pretty good user proposition. It is bit more complicated than that because the older Mac computers have problems with H.264 and can play On2 VP6 more successfully. With some older computers there is a problem. But with newer computers, again if you choose wisely, you can actually get a better experience.

MPEG-2 is old and no longer in the running, as bitrate requirements are far too high. Two other candidates for encoding are Microsoft VC-1 and On2 VP6 or indeed On2 VP7. Many people have evaluated these, and other codecs, and the outcome is that H.264 is generally thought to be the winner. But it is not always that clear cut. For lower-end computers, On2 VP6 is the best choice. On the other hand, if you are targeting Windows computers and full-screen playback, I think Microsoft has done a really good job with the Windows renderer, so that VC-1 plays back beautifully, even on lower-end Windows machines, but it does not work well for the Mac.

Microsoft Silverlight is a cross-platform application but it does not yet have the hardware-rendering capability that Window Media Player has, which is unfortunate.

FK: *Is this issue the reason why the BBC also considers Adobe AIR?*

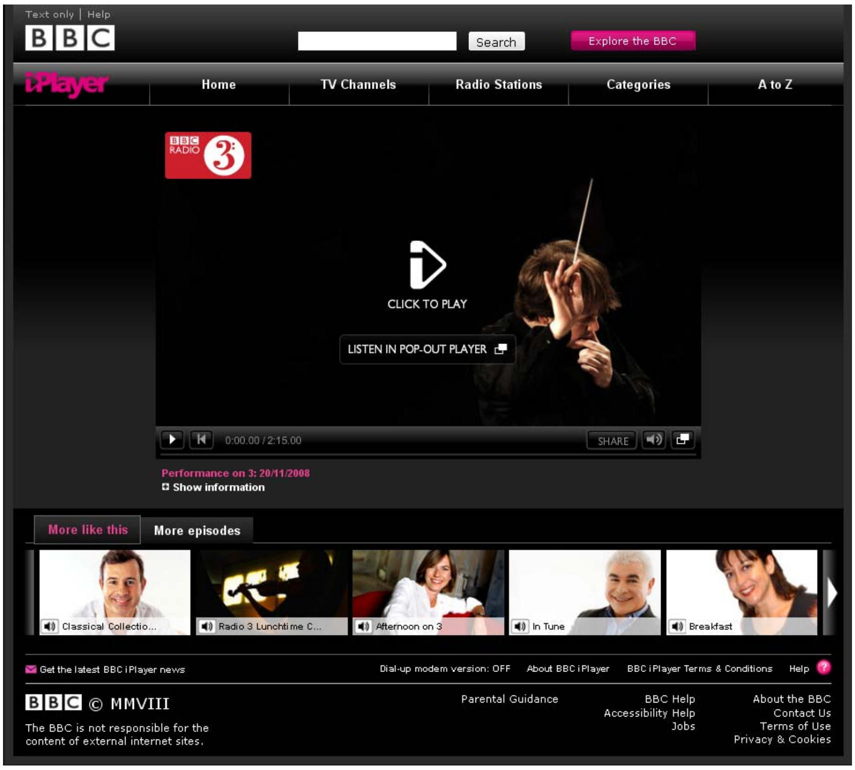
AR: Adobe AIR works fine with H.264 and is a clear candidate for the download solution with its DRM system, partially because we have a requirement to be fully cross-platform, and AIR runs on PC, Mac and Linux.

FK: *Broadcasters often face the problem of codec licensing. What is your experience?*

AR: iPlayer is now using H.264 and the question of licensing does not arise. If you use Flash, Adobe's agreements cover the playback licence fees. The BBC believes that there is no H.264 per-stream fee involved.

FK: *BBC Research is developing an open source, licence-free codec called "Dirac". The EBU plans to evaluate its technical merits, as many EBU Members are potentially interested in using it for internet delivery. Does the iPlayer have any plans to migrate to Dirac?*

AR: At the moment we believe Dirac is probably better focused on high-quality video encoding rather than on internet transmission. If you look at what is needed for successful internet transmission and for putting in the production workflow (using TeleStream, AnyStream or some workflow software), you need a codec that you can put in the workflow software. Then, you need a streaming



server with a CDN that understands that particular codec format. You also need to have a rights protection model (DRM) and the user's computer needs a plug-in with a good renderer that can do frame-rate adjustments and so on. So, there are actually quite a lot of pieces that need to come together.

Currently Dirac is a stand-alone encoder and has not yet been worked into the different workflows. The Dirac player is not quite apt for real time on lower-end machines. There is no integration with CDNs and no plug-in has been developed, as of yet. Therefore it is premature for Dirac to be a consumer proposition at the moment but that will come with time.

FK: *How important is Digital Rights Management (DRM) for the iPlayer?*

AR: It is too narrow to look only at streaming and downloading. For general analogue or digital broadcast we do not have any DRM or any obfuscation, so people can do what they want, whenever, with the content received. Live broadcasting is readily recordable and there is no attempt to prevent people from recording it.

As far as streaming on the internet is concerned, we do not use DRM (in the conventional sense of the word) but we use some stream obfuscation technologies. Essentially, a stream must remain a stream, it must not become a download. So if a stream remains a stream, we believe we do not need to DRM it. In order to prevent a stream from turning into a download, we use technologies such as RTMP or other technologies that make sure a stream remains a stream.

FK: *What experience with using RTMP do you have?*

AR: If you link to a media file served from an HTTP server, your media player will pop up and begin playing it and that is called a progressive download. The played file would probably end up in your browser's cache and it would be very easy to copy this link and place it in another application which lets you save it. The problem with this approach is that it becomes easy to save a file that is meant to be streamed only. So we do not do that. Instead, a lot of companies offer streaming solutions which do not let you easily save the file. It will let your media player throw away the segments of the file after they've been played, rather than allowing them to be saved to your hard drive.

Microsoft has a solution and the product is called MMS. Then there is RTSP (Real Time Streaming Standard) which is an open standard, and Adobe has a proprietary standard called RTMP (Real Time Messaging Protocol) and another one, RTMPE, which is an encrypted version. The latter one offers better protection but requires more CPU power on the user's machine. Currently we do not see the need for it, as there is no widespread evasion or hacking. We monitor regularly whether content hacking occurs and, at the moment, this is not the case. Also, as the same programme was broadcast in the clear the evening before, the cost benefit is not there and we do not really see the need to DRM our streaming content.

Now, for downloading our position is different. For downloading, we have to DRM our files for two reasons. First, the rights holders expect that the content will be available in the UK only. Second, content must only be available for a limited amount of time, so it can be commercially exploited, as is the case with BBC Worldwide's licensing of the Top Gear programme. Broadcasters in the USA who pay BBC Worldwide millions of pounds for broadcast rights would probably pay less if there was no DRM, as the content would be available elsewhere. This is the main reason why the rights holders demand DRM. In addition, it is a requirement of the BBC Trust (the BBC governing body) that files are only available for 30 days after download and seven days after being broadcast. So these are the reasons why we have to apply DRM to downloads.

Not all content owners however demand DRM. For example, we do not need DRM for our parliamentary channel. However, with time and usage restrictions still in force, we do need to apply it. We have, of course, the open source community saying that we should not use DRM at all.

FK: *You clarified why DRM should or should not be used for the iPlayer content, but then the question is which DRM do you use to control iPlayer usage?*

AR: The open source community criticises us for using Microsoft DRM and tells us we should use an open-source DRM solution. We have done a lot of due diligence and we have investigated all the viable DRM solutions. We have met with companies that develop them and we looked at the technologies themselves and evaluated them. The reality is that, until quite recently, Microsoft was the only viable one. It is free, secure and approved by Hollywood labels and approved by rights holders. It is easy to put on servers and clients. The problem is, however, that it is Windows only.

Other companies with DRM, for instance Apple, do not give access to the DRM system. The only way to allow content to be available using Apple DRM is to put content on the iTunes store and that really means disaggregating our content. Therefore, we do not have BBC iPlayer content available in the iTunes store. Apple would like us to give them our content and put it in a bucket with a million other programmes. For us that is equivalent to the BBC taking the content of BBC 1 programmes and giving it to competitors to put on their sites. This is clearly not acceptable. We have asked Apple for access to the DRM but so far they have not given us access.

The good news however is that other companies like Adobe are developing cross-platform DRM products. Adobe AIR now has DRM available for the PC, Mac and Linux. We hope to have a cross-platform solution by the end of this year based on Adobe AIR and Adobe DRM.

FK: *iPlayer services are not available outside the UK. At my home in Switzerland I received a message "Not available in your area". Why do you constrain iPlayer to the UK territory?*

AR: Two reasons: one is the rights reason. Licence holders sell their content in each territory. Traditional broadcasts are geographically targeted by the transmitter radiation and TV is generally very short range. But on the internet, streams can go anywhere. Licensing models change dramatically, they are still limited by, or are working within, a TV broadcast framework. The BBC is licensed to broadcast in the UK and these are the licence rights we typically acquire.

The other reason is less obvious: public services are funded by licence-fee payers in the UK. As there is always a distribution cost on the internet, it is not fair for a licence payer in the UK to pay for distribution to someone in the USA watching the content. Even in cases where we have rights to broadcast outside the UK or make content available outside the UK, we would not do it in such a way that UK licence payers fund the distribution. BBC Worldwide might fund it or may cover the distribution costs or may have ads to support the model. For these two reasons, we need geo-locking.

FK: *Which geolocation system do you use and how effective is it?*

AR: The answer is pretty simple. We use look-up tables of UK IP addresses, stored in a Quova database. These lists are regularly updated. We check the user's IP address and if it is located in the UK it is good and, if not, we say "sorry you can't have it".

Why do we not use the Akamai Geolocation database? First, it would lock us into exclusively using Akamai and we do not want to use Akamai for all services. In fact, H.264 content is now being

distributed via Level 3 Communications Inc. It is strategically better that we have our own central control system. Second, we need to maintain the whitelists and blacklists, so for example sometimes we want to set up a proxy to try and access iPlayer outside the UK, so we need the means to control this ourselves and not to rely on Akamai.

Another reason for not relying on a CDN company's geo-location service is that we really want to alert the user that the video won't be available to them as soon as they view the iPlayer web page, rather than waiting for them to click the Play button and receiving a streaming error.

We really need to know the geo-location at the time we render the web page, so that we can give the user a nice message saying that the content is not applicable to the user: "Sorry you are not in the UK, you cannot play TV but you can play radio". If we just relied on the CDN company's streaming service to enforce the geo-location, then the user would receive a stream error message and no explanation why they cannot see the content.

Things are getting more complex now with 3G access. For example, you may have a roaming arrangement with Vodafone UK. If you are in France, our system may think that you are still in the UK, even though you are actually in France. This is a new challenging area. It is not a widespread problem yet because roaming access is so expensive that it would probably cost you a fortune to receive BBC programmes abroad via a mobile phone and hence few people try. However, we will need to tweak the IP lists and work with 3G vendors to make sure that you are in the UK, even if Vodafone UK has a roaming agreement with France.

FK: *What kind of arrangements do you have with the ISPs to provide you with the users' IP numbers?*

AR: Quova makes those arrangements and it regularly updates the look-up tables. There is a way for ISPs to also update this information. We are quite happy with these arrangements; there is 99.9% effectiveness.

FK: *You have ported the content to mobile devices such as the Nokia N96 mobile phone. Can you please outline the process for doing this?*

AR: We have addressed the content creation not only for PCs but also for some portable devices. Previously, if you used Windows Media Video (WMV) files and downloaded them onto your portable media player, the WMV files may either have been refused by the device or they were played with significant frame dropping. As of September, we are now creating content specifically for Windows Media compatible mobile devices. We are creating a special low-resolution version which is small enough to download and play nicely on these devices.

Anthony Rose is Controller of the Vision & Online Media Group at the BBC, where he heads a team of over 200 people who are responsible for the BBC iPlayer, embedded media player, social media, syndication, programme websites and other projects within the BBC's Future Media & Technology division.

Mr Rose joined the BBC in Sep 2007, prior to which he was at Kazaa/Altnet. During his six years with them, he worked on a host of projects and patents covering P2P networks, DRM-based content publishing and social networking services.

Prior to joining Kazaa/Altnet, Anthony Rose was Vice President for Technology at Sega Australia New Developments, developing real-time 3D animation and 3D graphics engines.

The standard resolution on these devices is 320 by 240 pixels. At the moment the resolution of our main PC profile is 720 by 544 non-square pixels, which gives best quality on a PC but it is not suitable for small devices, so we plan to make a number of special encoded formats for these portable devices. As far as downloading these formats is concerned, we will offer a number of different options. These formats may still be primarily available from the iPlayer site intended for a PC, but we will develop several custom websites intended for downloading content to different mobile and portable devices, such as the Nokia N96 etc.

For certain devices which we think offer a great user experience, we plan to design a special version of the site. Such a site will tailor the content automatically to the characteristics of the mobile device (screen size, resolution, etc). The first of those devices was the iPhone. So if you go to the iPlayer site on an iPhone, you get a nicely tailored web version. The BBC will produce a custom version of the site for a selected number of other mobile/portable devices, so that the media will play automatically in the right format for that device.

***FK:** Do you plan to bring the iPlayer to STBs and consumer devices such as TV sets?*

AR: The answer is yes. The challenge is that these devices often try to aggregate different content into one portal. To the extent that the box is just a playout device like Windows Media Extender devices [3], the answer is broadly that we would like the iPlayer content to be there. To the extent that device manufacturers are able to offer the iPlayer site experience, we would like to work with them. But, to the extent that they would like to take the BBC programming and put it in their own interface, broadly speaking, that does not work for us. It is not acceptable for the BBC to just give away its content to other websites that can then build a consumer business proposition around it.

If you Google "BBC IPTV", you will see announced plans to work on IPTV set-top boxes that are already open and available to either everyone or selected parties. This is a very good second-generation IPTV proposition. One of the problems is that often there are not many of these boxes on the market and it is really very hard to get onto these STBs. In other words, it creates a huge amount of work for us but few consumers would use it. The cost benefit really does not work out, which is why we are currently not working on this project. Today there are quite a few different providers and the market is still relatively small, say, several hundred thousand subscribers. But this may change in the future.

***FK:** Thank you for clarifying the most burning issues relating to the iPlayer. I am sure that the EBU Members will find this article very interesting and useful. Should they have any further questions, could they approach you directly?*

3. **Windows Media Center Extender** is a set-top box which is configured to connect via a network link to a computer running Microsoft Windows XP Media Center Edition or Windows Vista to stream the computer's media center functions to the Extender device. This allows the Media Center and its features to be used on a conventional television or other display device. The household's Media Center can be physically set up in a location more appropriate for its role, instead of being in the living room. Additionally, with an Extender, the Media Center can be accessed at the same time by several users. The Xbox 360 gaming console is a very popular example of a Media Center Extender.

AD: Sure. You can give them my email address if appropriate.

Note from FK: Since the interview (which took place in August 2008), the iPlayer has been undergoing constant software development, with new features and functionality added almost every week.

At the Microsoft Professional Developers Conference in October, Anthony Rose successfully demonstrated the syncing of iPlayer content across computers and mobile devices, using a Microsoft desktop application called Live Mesh cloud, which is based on cross-platform Silverlight technology. The application automatically synchronizes downloaded shows across all the iPlayer-compatible devices on the person's Mesh network. That includes Mac computers, which also have a download client for iPlayer.

The new prototype iPlayer also featured several social-networking features, such as lists of the most popular shows watched by friends on the MSN Messenger list and updates on which shows each of the contacts had watched and downloaded. iPlayer users will also be able to rate scenes from the show as they go along – using the "Lovemeter" – which shows the parts of shows that people like the most.

Erik Huggers, the BBC's Director of future media and technology, recently stated [4] that the success of the iPlayer is proof that the corporation is right to bet its future on the internet. He stated that the online TV catch-up service has served 248 m items of content since it launched officially on Christmas Day 2007. The iPlayer service that is available through Virgin Media's cable service alone has served 49 m videos since June 2008. The soap drama, EastEnders, which pulls in an average of 18.9 million TV viewers each month on BBC1 and BBC3, attracts around 457,000 viewers on the iPlayer. The CBBC digital channel programme, MI High, has a far higher proportion of viewership on the iPlayer: it has a TV audience of 145,000, while 30,000 watch it on the iPlayer. Huggers insisted that the online audience did not cannibalise the TV audience. The iPlayer is popular during office hours through the day but, as viewership peaks in the evening around 9 pm, heavy usage typically continues for an hour longer than TV viewing.

The BBC's user data shows that the iPlayer is used by a range of ages. 15- to 34-year-olds account for 37% of viewers and 35- to 54-year-olds account for 43%. A further 21% of users are aged 55 or over and Huggers credited the iPlayer's popularity to it being easy to use.

The priority is to make the iPlayer available on as many digital platforms as economically possible. PC users still account for the vast majority of iPlayer viewers with 85% of the audience, with Nintendo Wii and Linux both accounting for 1%. The popularity of the iPhone and iPod Touch had taken the BBC future media and technology team by surprise. Apple Mac users now account for 10% of iPlayer viewers, while iPhone and iPod Touch owners account for a further 3%.

Here are three conclusive quotes from Erik Huggers:

> ***" The situations we're seeing are interesting – mum and dad are watching linear TV in the living room but the kids are watching in a different way ... on the iPhone, iPod Touch or a laptop. "***

> ***" Having seen all this and understanding more about the success of the service, the sort of users, when they watch it and what they watch ... I think the BBC is absolutely betting on internet protocol in a way where it's not just for the distribution side of what the internet enables. "***

> ***" We are completely re-engineering the way in which we make fantastic programming. "***

4. Guardian story: **http://www.guardian.co.uk/media/2008/nov/07/bbc-erikhuggers**

Open source Handhelds
— a broadcaster-led innovation for BTH services

François Lefebvre (Project Leader), Jean-Michel Bouffard and Pascal Charest
Communications Research Centre, Canada

Emerging *Broadcasting to Handhelds* (BTH) technologies could be used to convey much more than the usual audio or video programming. For a long time now, broadcasters have imagined and standardized many new multimedia and data applications which, deplorably, did not succeed in the market.

In the first part of this article, we suggest that the *open source handhelds* which have become prominent as a consequence of recent technological trends, could also bring the emergence of broadcaster-led applications on mobile devices. In the second part, we will introduce the Openmokast project and describe how the CRC was able to produce, with very limited resources, the first open mobile-phone prototype, capable of receiving and presenting live broadcasting services.

There is a growing enthusiasm today for BTH services as presented in EBU Technical Review by Weck & Wilson [1]. These services can either use broadcast standards such as DAB/DMB and ATSC-M/H or the standards proposed by the mobile telecommunications industry such as DVB-H or MediaFLO. These technologies provide efficient delivery mechanisms for up-to-date information, popular media and valuable data services to mobile users. In the present interest for rich media convergence, BTH and mobile technologies have complementary features. BTH infrastructures promise to transmit large volumes of valuable content in one-to-many communications while wireless telecommunications networks could provide the channels for one-to-one exchanges.

This interest has led to the development of many new standards for BTH services in the context of DAB: MOT transport, Broadcast Web Site (BWS), SlideShow, DLS, TopNews, EPG and TPEG. But only a few of these standards have actually been implemented on commercial receivers. For example, BWS, which could be used to provide very attractive information services, is generally not supported on current receivers. In the remainder of this article, we will refer to those unsuccessful applications as the *missing apps*.

The stagnation of BTH technological advances could be explained by the innovative and competitive wireless communications ecosystem that is thriving today. Several kinds of new wireless communications technologies are emerging in the quest to reach mobile users wherever they are with a maximum throughput.

It appears as if BTH is standing at a juncture between broadcasters and mobile network operators (MNOs). Their business models are in conflict. Broadcasters are naturally inclined to pursue and extend their current free-to-air (FTA) services which are monetized by public funding, licence fees and advertising. MNOs, on the other hand, plan to deploy BTH services to generate new revenue streams through cable-like subscriptions and pay-per-view models.

The Internet is also challenging the traditional broadcasting model. It has lead to rapid innovation cycles that produce direct and disruptive benefits to end-users. For example, webcasting, peer-to-peer streaming and podcasting all represent new and attractive alternatives to broadcasting.

We suggest here that one of the key limiting factors for broadcaster-led innovation lies in the broadcasters' limited control over the implementation of their standards into receivers. The market for broadcast receivers is horizontal. Implementing broadcaster-led standards into mobile phones is an even bigger challenge because these devices are part of a vertical market. That is, MNOs have a firm control over which feature sets get implemented into "their" devices. Understandably, they will likely promote their own feature sets before those of broadcasters. As a consequence, we can expect that BTH innovations that are broadcaster-led are less likely to be implemented into mobile phones. Von Hippel's theory [2] would suggest that as empowered "users" of the mobile phone technology, MNOs stand in a much better position to innovate and compete.

The following section will introduce emerging trends that could create new opportunities for broadcaster-led innovations in the BTH space. Please see *Appendix A: "Anatomy of a Handheld"* for an overview of the components and terminology that will be referred to throughout the remainder of this article.

NOTE: Throughout this paper, the term *handhelds* is used to refer to generic pocket-sized computing devices which may provide connectivity to any kind of networks. On the other hand, mobile phones are a specialized category of handhelds that connect to MNOs' infrastructures.

Trends towards broadcaster-led innovation

Specialized hardware goes generic

The manufacturing of handhelds is expensive. Mass-production is imperative to reach profitability. This results in steep barriers to entry for newcomers in the field. Fortunately, the relentless push of Moore's law has permitted the implementation of generic, compact and powerful integrated circuits. These components can be produced affordably and run on little power. This benefits smart phones too.

Inside today's mobile devices, specialized hardware components are increasingly being replaced by generic ones. Flexible application processors (APs) can be re-used in the design of many types of devices, thereby lowering the overall production costs associated with specific applications.

Functionality goes software

In early-generation mobile phones, user applications were performed by low-level software loaded directly on the device's permanent storage. Only basic tasks were supported: dialler, phonebook, device settings or ringtone selection. There was no room for new applications. Nowadays, generic and powerful APs coupled with large storage capacities have lead to better capabilities. This has also significantly raised the importance of software in handhelds.

As a consequence, functionality features – based on software – present much lower barriers to entry than for hardware because of the fundamental properties of software:

- it can be duplicated at no cost;
- it can be distributed instantly and at no cost;
- it can be developed with low-cost or free tools;
- it can be modified, fixed and enhanced with no impact on the manufacturing chain.

Software goes open

The software industry is experiencing changes as open source software (OSS) is gradually entering the domain. With OSS, the global level of collaboration adds significant value to the software development chain. Individual programmers and organizations work at innovating and solving issues with a "let's-not-reinvent-the-wheel" approach. Instead, they build together a solid common core which sustains their respective business models.

In our opinion, the qualifying term "open source" is not in itself very significant. The important factor is to apply the proper rights to the code, once it is written. This is where software licensing comes into play. Projects are said to be free/libre Open Source Software (FLOSS) when their licensing terms offer flexibility in the usage rights while remaining accessible to the largest possible community. The Free Software Foundation classifies software licences and promotes those that are, in accordance with their criteria, genuinely open. The Open Source Initiative (OSI) is also a recognized reference body that leads the reviewing and approving of licences that conform to the Open Source Definition [3].

There is an obvious trend in motion now. Industry has adopted many open source software solutions. Several OSS products are widely deployed: GNU/Linux, Apache, OpenOffice, Firefox, Asterisk, Eclipse and MySQL. Companies using these tools see several benefits in the form of flexibility, independence, ability to fix, to enhance and to tweak the software that they need. For all of those involved, OSS is a key to success.

The popularity of OSS has even reached one of the technology-sector bastions. We can now purchase consumer electronics (CE) products that do "run" on OSS. Here are some important examples of such devices:

- The Linksys WRT54G Wi-Fi wireless router [4] is a product for which the GNU/Linux firmware was released. Since this release, users have enhanced its functionality to enterprise-grade routers.
- Neuros [5], an Internet set-top box manufacturer, will shortly release its next product called OSD2. Neuros relies partly on users and external developers to create or integrate new applications for their platforms which also use OSS.
- The DASH Express [6] is a new type of GPS car navigation system with a two-way telecommunication data channel. It can receive real-time traffic data information and can also offer Internet search for points of interest. The DASH device came on the market a year ago and seems to be very successful in the USA. Interestingly, DASH is based on the FIC Inc. Openmoko first hardware release. The DASH is a good example of a vertically-integrated device. It is a great case study of how OSS can be used with the right licensing scheme on closed business models.
- Some developers have also enabled OSS frameworks on top of closed CE devices. The Rockbox project [7] creates open source replacement firmware for several brands of portable digital audio players like Apple, Archos and iRiver. Audio codecs are amongst the numerous features added: FLAC, WavPack, AC3 (A/52), AAC/MP4 and WMA. These were not available on the iPod models sold by Apple.

Handhelds go open source

Today, there is an important push towards OSS on handhelds promoted by many industry players. Their interest to participate in the mobility value chain is motivated by the current trends described above. Some key projects with the potential to impact BTH are described in this section.

Openmoko

Openmoko [8] is an OSS project that was initiated by First International Computer, Inc. (FIC Inc.), an important manufacturer of motherboards for personal computers. Early on, the company made the bet that their best option to become competitive with their new smartphone products was to open up a complete software stack that would enable and leverage user innovation. In July 2007, FIC Inc. released its first “developer preview” prototype called the Neo 1973 with the Openmoko software stack.

To many developers, the Neo represents the first truly open mobile phone platform. The Neo incorporates several interesting connectivity options: GSM, GPRS, GPS and Bluetooth. Interestingly, the Neo 1973 initially shipped with a primitive software stack that did not even allow the completion of phone calls. We had to wait a few more months before the “phoning feature” became available through software updates.

The Neo FreeRunner (GTA02), was the next version of the device. It was released in June 2008 with enhanced usability, hardware improvements and Wi-Fi connectivity.

Openmoko was conceived to enable various business models. Openmoko Inc., the company, does sell devices for profit. Independent developers can sell proprietary software applications thanks to the LGPL licence which covers the Openmoko software stack. With the DASH Express, FIC Inc. has also hinted that vertically integrated devices could be constructed on Openmoko. With such a framework, both closed and open applications are on a level playing field for competition. In this environment, users are just “one click away” from one or the other type of applications. The end-user will decide which best fits his/her needs.

Another interesting fact is that shortly after the release of the FreeRunner, another developer community was able to successfully port the Qtopia OSS distribution onto the device. Qtopia had been developed some years before by Trolltech, a company acquired by Nokia in 2008. At the current time, Koolu, a Canadian company, announced that it will port Android (another OSS distribution introduced in the next section) to the FreeRunner by the end of November 2009. This shows how organic and efficient an OSS ecosystem can be. Just a few months after its introduction, the FreeRunner device can already host several new software platforms.

Android

Android [9] was originally conceived to be the fundamental building block of new mobile devices. It is a software distribution that includes an operating system, a middleware layer and some key applications. It is being developed by the Open Handset Alliance (OHA), a consortium of 34 members including Google, HTC, T-Mobile and other important players in the field.

The Android Java-based software development kit (SDK) was released in November 2007 to allow application development long before any Android device was even produced. Since then, an application development contest sponsored by Google was initiated to stimulate the development of new Android applications. A total of US$5 million was awarded to 50 submissions featuring the most innovative applications [10]. The first Android-based mobile phone (T-Mobile G1) was released in October 2008 in selected markets.

Initially, the degree of openness of Android was limited despite the fact that the SDK was available for free. The OHA recently decided to release the Android open source project [11] which will encompass most components of the Android platform. With the Android OS and virtual machine becoming open, new exciting development projects are now possible. This could even lead to the creation of new hardware components. Details to come about the licensing and the governance of the project will ultimately reveal to what extent Android will be open. But in its current configuration, Android still presents a compelling option for the design of open source handhelds.

Other open mobile platforms

Other open platforms which do not include mobile phone network interfaces are available to create new handhelds as well. These devices represent potential candidates for broadcast reception.

The Nokia Internet tablet computers based on Maemo [12] are such devices. The Maemo platform provides lots of functionalities and shows great potential for many useful usage scenarios. Maemo is a software platform that is based on OSS projects such as Debian GNU/Linux and GNOME.

The Ubuntu Mobile Edition is another example of a GNU/Linux based software stack that could fulfil the requirements for new handhelds. This effort was launched by Canonical Inc. to support the development of an OSS distribution for mobile internet devices.

Another potential major advance for OSS on mobile phones could come from Nokia. The company announced the creation of the Symbian Foundation and the release of its Symbian OS as an open source software [13]. This OS was designed for mobile devices and comes with libraries, user interface frameworks and reference implementations. Symbian, with a market share currently surpassing 50%, is still the platform deployed on most smart phones in the world.

The Openmokast project

None of the open software frameworks and devices encountered in our study did support digital broadcasting hardware. Since BTH is a main field of research for our group at the CRC, we were motivated to explore the possibility of integrating broadcast functionality into such an open device. When FIC Inc. announced in February 2007 the launch of their open mobile phone prototype using the Openmoko framework, we decided to initiate the **Openmokast** ("OPEN MObile broadKASTing") project in our lab.

The aim of the project was to integrate a DAB receiver in a fully-functional mobile phone. We would design, build and test, with a live DAB signal, a prototype capable of decoding typical DAB audio services as well as some of the *missing apps*. Based on our previous experience in the lab, we chose to work with GNU/Linux and other OSS packages. We have learned that using OSS accelerates the integration of a prototype by reusing common SBBs found in those packages. In order to build a final product, we had to find a DAB reception platform and integrate it into the prototype. Other major software components such as the receiver control unit, the bitstream demultiplexer and the decoder had to be developed from scratch. We even had to manufacture a physical extension to the original handset to be able to embed the small USB DAB receiver and its required antenna into our prototype.

The Openmokast software platform

CRC-DABRMS is a stable software platform developed previously at the CRC to control commercial computer-based DAB receivers. This original effort provided access to raw DAB bitstreams on typical personal computers. CRC-DABRMS can decode signalling information contained in the fast information channel and dispatch desired sub-channels to various types of outputs. This in turn permitted the demonstration and testing of new applications geared toward DAB but not yet standardized. This system had been implemented for Windows and GNU/Linux platforms.

The GNU/Linux version of CRC-DABRMS was ported to the Openmoko platform and renamed *Openmokast*. Porting it involved recompiling the application for the new target AP. It also meant adapting the code while verifying that all required libraries would be available on the new platform at runtime. The architecture of the Openmokast middleware is shown in *Fig. 1*.

The original interface of Openmokast was the command line. Later we developed a GUI using Openmoko's GTK libraries. Screenshots of a running Openmokast are shown in *Fig. 2*. At start-up, Openmokast presents a menu where the input device must be selected *(Fig. 2a)*. The system can also accept, as input, a locally-stored DAB multiplex file. This feature enables off-line testing and development of new applications without the need for a physical receiver and a live signal.

Different applications were either developed or were direct integrations of existing OSS projects. The standard DAB radio application was done with an HTTP wrapper which forwards MP2 audio to the Mplayer media player. A package for Mplayer was readily available. The DAB+ application was constructed in the same manner except that the transport protocol had to be removed prior to forwarding the AAC+ stream to Mplayer.

Two data applications were integrated by reusing source code made available under the OSS project called Dream [14]. Dream is an SDR receiver for DRM which includes an MOT transport protocol decoder, as well as two of the *missing apps*: Journaline and Slideshow *(Fig. 2c)*. The packet mode decoder had to be developed in-house. Since we were able to re-use code from other OSS projects, these applications could be developed quickly and efficiently. This experience reinforced our views that OSS carries significant benefits for developers.

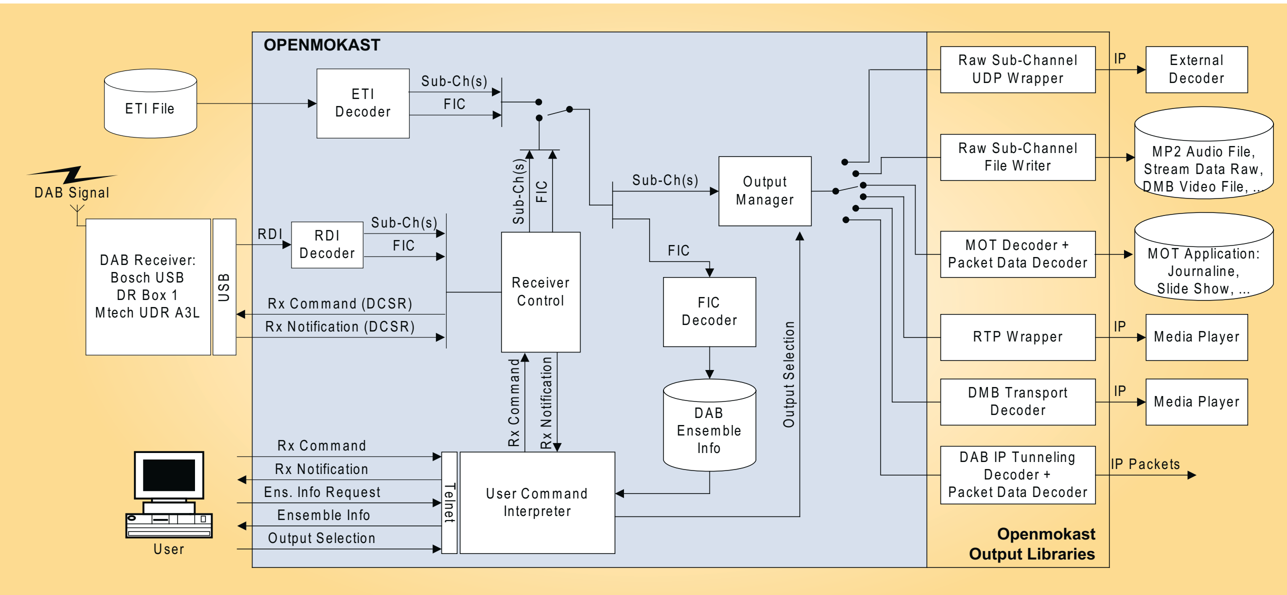
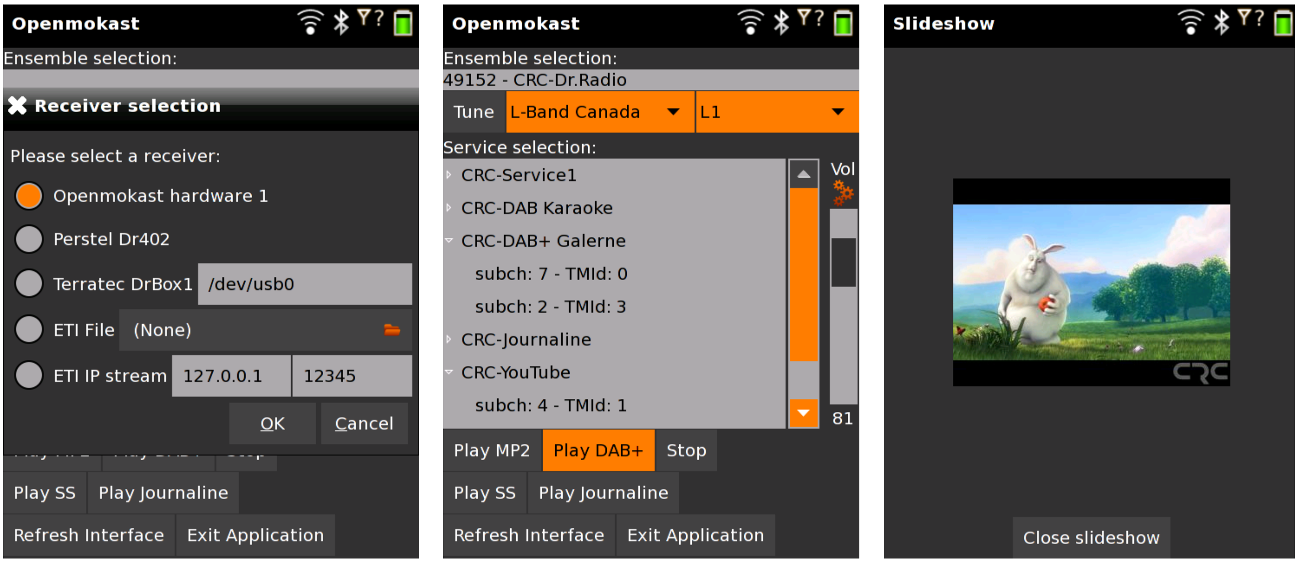


Figure 1
Architecture of the Openmokast middleware



(a) (b) (c)

Figure 2
Screenshots of a running Openmokast device

The DAB receiver

A fundamental component required in the design of the prototype was a DAB receiver. Our early analysis suggested that a USB receiver could be a good fit for the unit. First, the FreeRunner has one USB port available. We also knew that the FreeRunner's AP was not powerful enough to perform DAB signal demodulation in real-time. We therefore searched for a USB component where this task could be performed efficiently on silicon.

We first tested the USB Terratec DrBox. The device drivers (DABUSB) for this device were already included in the Openmoko kernel. This should have made the integration task easier but unfortunately, the firmware for the unit could not be uploaded correctly. We had similar experiences with other USB receivers that did not succeed our initial test runs.

An alternative in our quest for the appropriate receiver was to obtain development kits offered by chipset makers. We contacted many companies but none could provide the components required. In general, their offerings did not meet the needs of a research development project like ours. Those companies were unwilling to support our initiative which would likely not lead to significant device sales. Furthermore, the development kits offered are expensive and the USB device drivers provided are usually built for Windows instead of GNU/Linux, and the usage of those kits requires the signature of non-disclosure agreements. We did not want to follow such a path of development and were stalled for a while.

We continued our research and found an off-the-shelf product which could fulfil our requirements. The MTECH USB key model UDR-A3L had all the features we needed. The libusb library was chosen to communicate with it. Libusb is a Unix suite of user-mode routines that control data transfer between USB devices and the host systems. We were able to establish basic communications between the MTECH key and the FreeRunner USB port. A reference to this key was added as a new input source in Openmokast (hardware 1 in *Fig. 2a*).

Prototype construction

Figure 3
ABS extension for FreeRunner

The openness practices promoted by the Openmoko project went beyond our initial expectations. We found that even the CAD drawings for the FreeRunner mechanical casing were released to the public and available freely for download. Using those drawings for reference, we then modified the original mechanical design and produced a clip-on plastic extension which provides the extra space inside the device to embed the stripped down USB key. *Fig. 3* shows this extension.

To manufacture the physical extension part, we contracted the services of a 3D printing shop. We sent them the modified Pro/Engineer formatted 3D file and received the finished ABS part within 48 hours for the price of US$90. We were happy to find that just like with OSS, even mechanical hardware components of a prototype benefit from the "democratization" of production means. The CRC will release the schematics of this extension under a non-restrictive *creative commons* licence.

Figure 4
Comparison of thickness between the original device and the Openmokast prototype

Fig. 4 shows the thickness of the final Openmokast prototype.

The MTECH receiver was connected directly onto the internal USB test points on the printed circuit board. In this configuration, it could draw its power from the device's main battery. This setup also had the advantage of freeing the external USB connector on the handset. This port remains the most convenient way to recharge the device. Once disassembled, the FreeRunner and extension exposed enough internal free space to install the dedicated L-Band antenna.

Figure 5
Inside the Openmokast prototype

Figure 6
The final Openmokast prototype

Fig. 5 shows the prototype's internals while *Fig. 6* shows the final product. Notice the colourful "skin" with our organization's brand as well as the Openmokast logo.

Some results

We are satisfied with the overall test results of the Openmokast prototype so far. This device was put together by a small team in a short period of time and it has performed well since its release. The form factor of the device is appreciated by current testers. Some DAB *missing apps* which are usually not available on commercial receivers could be demonstrated.

The Openmokast prototype was introduced at the IBC 2008 exhibition and was hailed as the first open mobile broadcasting handset .

Abbreviations

- **ABS** Acrylonitrile Butadiene Styrene (thermoplastic)
- **AP** Application Processor
- **ATSC** Advanced Television Systems Committee http://www.atsc.org/
- **BTH** Broadcasting To Handhelds
- **BWS** (DAB) Broadcast Web Site
- **CAD** Computer-Aided Design
- **CPU** Central Processing Unit
- **DAB** Digital Audio Broadcasting (Eureka-147) http://www.worlddab.org/
- **DLS** (DAB) Dynamic Label Segment
- **DMB** Digital Multimedia Broadcasting http://www.t-dmb.org/
- **DRM** Digital Radio Mondiale http://www.drm.org/
- **DVB** Digital Video Broadcasting http://www.dvb.org/
- **EPG** Electronic Programme Guide
- **FLOSS** Free/Libre Open Source Software
- **FTA** Free-To-Air
- **GPRS** General Packet Radio Service
- **GPS** Global Positioning System
- **GSM** Global System for Mobile communications
- **GTK** Graphical user interface Tool Kit
- **GUI** Graphical User Interface
- **HTTP** HyperText Transfer Protocol
- **IP** Intellectual Property
- **LGPL** (GNU) Lesser General Public Licence http://www.gnu.org/licenses/lgpl.html
- **MNO** Mobile Network Operator
- **MOT** (DAB) Multimedia Object Transfer
- **OHA** Open Handset Alliance http://www.openhandsetalliance.com/
- **OS** Operating System
- **OSI** Open Source Initiative http://www.opensource.org/
- **OSS** Open Source Software
- **SDK** Software Development Kit
- **SDR** Software Defined Radio
- **TPEG** Transport Protocol Experts Group http://www.tisa.org/

The overall performance of the receiver component is good. The MTECH provided good signal reception in the L-Band and Band III frequency ranges, under various conditions. The device could receive signals coming from either the CRC-mmbTools LiveCD transmitter [15] or from standard commercial equipment.

The total CPU computational load measured for real-time DAB and DAB+ audio decoding on the FreeRunner was low. The GNU/Linux *tops* utility was used to estimate the processing cycles for two audio decoding scenarios *(Table 1)*.

Table 2 shows the power autonomy estimates based on measurements made during three different usage scenarios.

Table 1
CPU usage for two audio decoding scenarios (%)

	Codec type	Bitrate (kbit/s)	Mplayer	Open-mokast	DAB+	Total
Scenario 1	Musicam	192	12.70%	1.00%		13.70%
Scenario 2	HE-AACv2	64	14.30%	0.60%	0.60%	15.50%

Table 2
Openmokast power consumption and autonomy with 1200 mAh battery

	Source	Measured consumption	Estimated autonomy
Scenario 1	Receiver in Band III	650-670 mA	1h49
Scenario 2	ETI file	220-230 mA	5h20
Scenario 3	None	190 mA	6h19

The Openmokast software was installed and tested on typical GNU/Linux PCs. The code could execute successfully on an emulator of the Neo 1973 available through the Openmoko project. In this setup, both Openmoko as well as the Openmokast GUI could be tested. We could not repeat a similar test for the FreeRunner configuration since no emulator for this device exists to date.

Openmokast's software could also be tested directly on two different GNU/Linux distributions, without the need for an Openmoko device emulator. We can conclude from these experiments that we could deploy Openmokast on other platforms and operate DAB devices in those environments.

Opening Openmokast

During this project, we had to face the issue of Intellectual Property (IP) in relation to OSS implementations. In fact, it is important to realize that implementing most of today's international open broadcast standards implies using proprietary IP. As a consequence, an implementation like Openmokast has to include proprietary algorithms or techniques to fully implement such a standard. Most of the time, licence fees must be paid to the rightful holder for each implementation of technology "sold".

Consequently, standards including proprietary IP appear to be a barrier to OSS implementations for two reasons. OSS projects are given away for free and do not generate revenues. It is also impossible to control the distribution of such software. Therefore, it would be very hard to collect any licence fees. Some countries have recognized the need for free standards and are promoting the adoption of new standards that are freely available and that can be implemented at no charge. The issue of open source and standardization was discussed in a report commissioned by ETSI in 2005 [16].

One possible solution for implementations of non-IP-free standards in OSS is to design frameworks with licensing schemes that allow the integration of IP-free as well as non-IP-free modules. With this approach, the non-IP-free components must be extracted from the overall distribution. A carved-up framework can be widely distributed along with the IP-free modules. The non-IP-Free components have to be distributed separately with provision for the correct attribution of the licensing fees. We plan to use this approach for the Openmokast project. The framework could be distributed openly without the module that requires special licensing (MP2 and HE-AACv2 decoding, etc..).

Conclusions

In this article, we have identified trends shaping the current environment that can impact the development of new BTH services. For a long time now, Moore's law has been the driver for advances in hardware and functionality that previously was provided by specialized circuits – but is now done on generic chips. The shift to software in the implementation of powerful handhelds is also a well-established trend. With software and its flexibility, developers have been able to create in a few months, thousands of new innovative applications for an Android or an iPhone.

We believe that a transformational force may be laying beyond the possibilities created by Moore's law and flexible software. The most important trend that we have identified during our study is that Open Source Software, once integrated on handhelds, carries an enormous potential for innovation. This is a revolution in the making that could reach its true potential once the right mix of collaboration and openness is found. Broadcasters, if they choose to follow this trend, could find new opportunities to promote their technologies. This could catapult broadcaster-led applications in the foreground and push further the deployment of new BTH networks.

François Lefebvre joined the Broadcast Technologies research branch at the Communications Research Centre, Canada, in 1999 to lead its Mobile Multimedia Broadcasting team. Since then, he has contributed to numerous national and international standardization efforts and R&D projects. His recent work has focused on creating and developing open software building blocks for next-generation mobile broadcasting networks, devices and applications.

Mr Lefebvre graduated from Laval University in Electrical Engineering where he also completed his M.A.Sc. in 1989. He then moved to Europe where he worked for ten years as an engineer in R&D laboratories and as a freelancer on several multimedia and Internet projects in Germany.

Jean-Michel Bouffard graduated in Computer Engineering (B.A.Sc.) in 2003 from Sherbrooke University, Canada. He then joined the Broadcast Technologies research branch at the Communications Research Centre, in Ottawa, where he is involved in projects related to mobile multimedia broadcasting systems.

Mr. Bouffard's expertise in multimedia communications and his interest in convergence led to studies about the applications of the participatory Web concepts to broadcasting and mobility. In the same vein, his current occupation focuses on enabling and promoting broadcasting on open mobile devices. He is also completing his M.A.Sc in Systems and Computer Engineering at Carleton University.

Pascal Charest graduated in Computer Engineering (B.A.Sc.) in December 2000 from Laval University, Quebec City, Canada. He then joined the Broadcast Technologies research branch at the Communications Research Centre, in Ottawa, as a Research Engineer. He has been involved in several research projects in the area of mobile multimedia broadcasting.

Mr Charest's recent work has focused on system building blocks and open source software, with emphasis on encoding, decoding, modulation, device control and system integration. In addition, he is a member of the Club Linux Gatineau where he has served both as the Vice-President and President in the past.

In this article, we presented several open handset projects, similar consumer electronics devices and the Openmokast prototype developed at the CRC. We believe, following our study, that broadcasters have an opportunity now to sponsor the development of broadcaster-led handhelds. If they did, chipset manufacturers could be encouraged to participate in the process. In fact, the Openmokast framework could easily be adapted to support other technologies such as DVB-T or ATSC-M/H by exploiting current building blocks redundancy.

In an open device with both BTH and mobile telecommunications network interfaces, we could hope that some synergies would happen. It is a simple matter of providing software on the handheld to bridge those two networks. With Openmokast, we can claim at last that we have reached convergence.

In an attempt to support our vision of convergence and the new opportunities that arise from it, the CRC plans to release, as open source software, several tools which were developed for the Openmokast project (**http://www.openmokast.org**).

Acknowledgements

The authors would like to thank their colleague Martin Quenneville for his work on the Openmokast prototype. Particular thanks should go to Karl Boutin for his thorough review and to André Carr, René Voyer, Bernard Caron, Silvia Barkany and Bruce Livesey for their comments and support.

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Appendix A: Anatomy of a handheld

Fig. 7 depicts typical hardware and software components on today's handhelds. The hardware building blocks (HBBs) operate around an application processor (AP). Given the portable nature of handhelds, special features support mobility: wireless connectivity, GPS and accelerometers are such examples.

Although APs can run most processing tasks, some of the "heavy lifting" has to be performed by specialized processors such as Digital Signal Processors (DSPs). The AP just does not have the processing power needed. Besides, even if it could manage the computational tasks, the related energy consumption requirement would be prohibitive. Instead, DSPs are used and these tasks can be efficiently accomplished while consuming less energy.

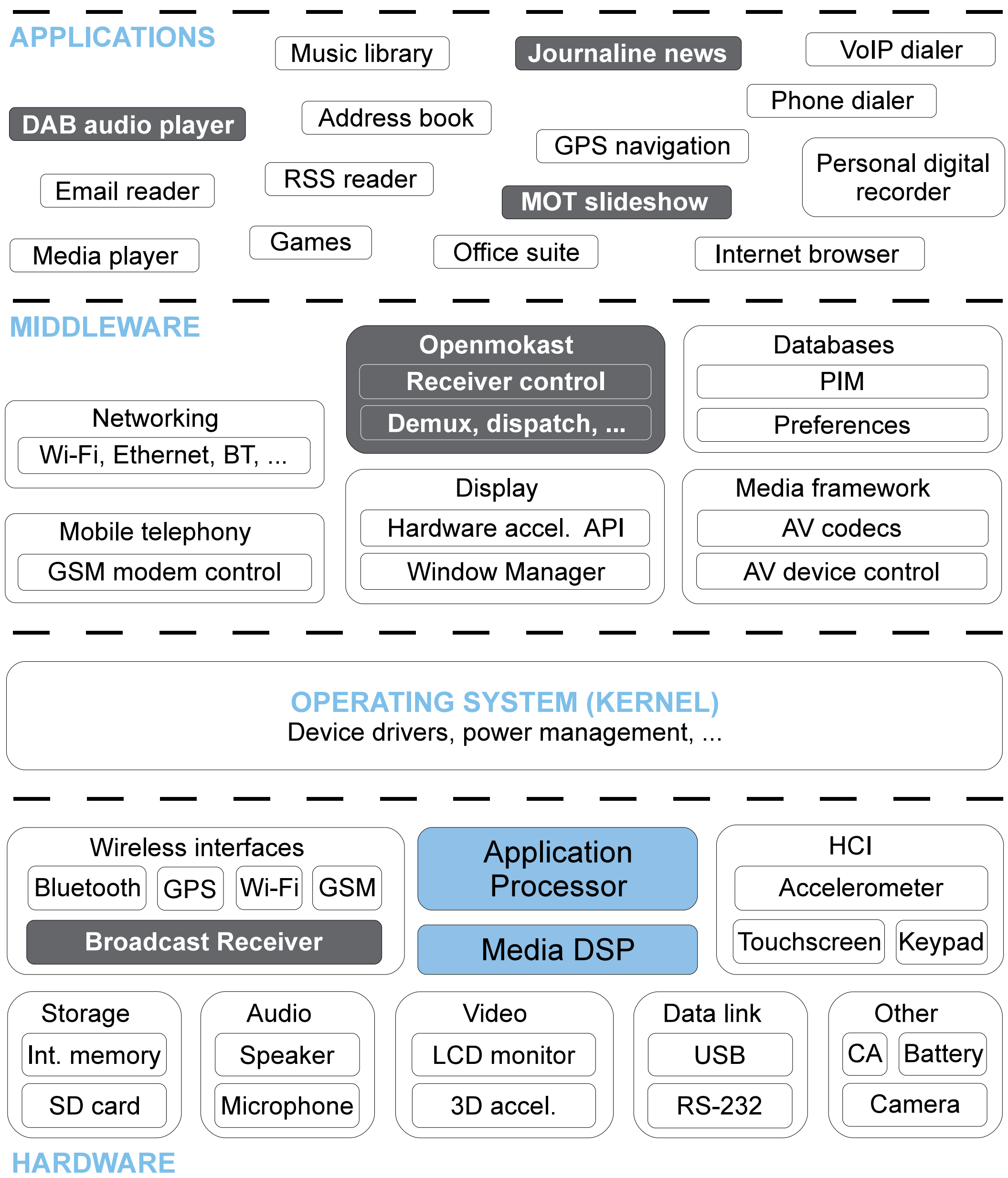


Figure 7
Typical hardware and software components of a contemporary handheld

One such set of DSPs are the wireless Hardware Building Blocks (HBBs) found on the receiver presented in *Fig. 7*. As an example, the broadcast receiver front-end filters the signal then digitizes and translates it. The signal then emerges at an intermediate frequency or directly at baseband. At this point, a DSP performs the demodulation to produce a bitstream that can be processed by the AP.

Media processing normally requires some degree of powerful yet efficient processing and is performed using DSPs. Most current systems include specialized media processing units to decode media streams such as H.264 video and AAC audio.

Another typical hardware component that needs consideration in the design of a handheld is the conditional access HBB. This function usually relies on hardware to perform access management for pay services. Fortunately, since this is not a requirement for FTA services, the design of broadcaster-led handhelds is simplified.

The rapid evolution of APs makes us believe that in the foreseeable future, software defined radios (SDRs) will perform the demodulation of broadcast and other signals in real-time, with versatile wideband front-ends and A/D converters on the AP itself.

Three main levels of software are also depicted in *Fig. 7*: the operating system (OS), the middleware and the application layer. There is no clear separation between the layers and some software building blocks (SSBs) could actually overlap two or three of those layers. A complete implementation, including all SBBs required to operate a device, is often referred to as a software stack or a distribution. It provides the device with all of the basic software needed to operate.

In the software stack described above, the lower layer components provide their "Application Programming Interfaces" (APIs) to the upper layer components. Device drivers present the APIs of HBBs to upper software components.

Mobile TV standards: DVB-T vs. DVB-H

Gerard Pousset
DiBcom

Yves Lostanlen and Yoann Corre
Siradel

Although there is widespread interest in mobile television, there are growing concerns over business model issues (infrastructure costs and revenue sharing). Many DVB-H launches are being delayed because of lack of agreements – between mobile network operators and broadcasters – on the best business model to use. Consequently, some MNOs have decided to launch mobile phones that take advantage of free-to-air DVB-T reception, such as in Germany, thus questioning the viability of DVB-H pay-TV services.

This article compares DVB-T and DVB-H coverage performance for several classes of receivers. It concludes that DVB-T will not kill DVB-H! Some countries will start with DVB-T and add DVB-H later, while others will do the opposite. In the end, DVB-T and DVB-H will co-exist.

DVB-T status across Europe

The DVB-T standard was planned to replace analogue TV progressively, and most analogue switch-offs are scheduled for around 2009 - 2012).

As the map in *Fig. 1* shows, it appears that the number of countries that opted for a sophisticated modulation scheme – such as 64-QAM which enables a bitrate of approximately 20 Mbit/s per multiplex (MUX), yielding roughly six TV channels – is greater than those that selected 16-QAM, which is more robust but limits the rate per MUX to about 10 Mbit/s (roughly four TV channels).

Despite the disparity in modes, new types of portable DVB-T receivers such as PC USB sticks, PMPs, PNDs, car STBs and even mobile phones (see *Fig. 2*) have surfaced on the market and work well in both outdoor and light-

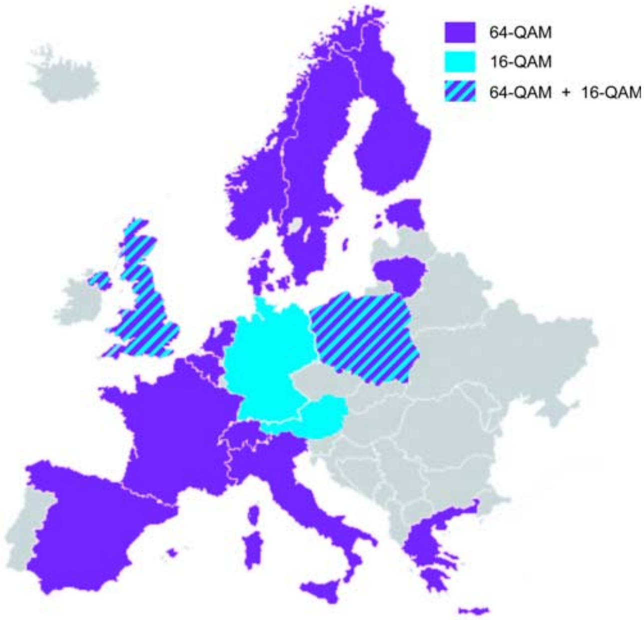


Figure 1
DVB-T across Europe

indoor environments.

In the most challenging cases (64-QAM, deep indoors or at high moving speeds), the quality of reception can be increased, thanks to the use of two antennas in "diversity mode".

Figure 2
New mobile phone offering DVB-T

DVB-H standard

In order to offer adequate and reliable reception on battery-powered handheld devices, such as mobile phones, a new transmission standard had to be developed.

DVB-H originates from DVB-T, and adds:

- A "time slicing" function which allows a 90% cut in power consumption, by functioning in "burst mode".
- An MPE-FEC code (forward error correction) which increases the sensitivity of the receiver.

However, business model issues (infrastructure cost and revenue split) between wireless operators and broadcasters are becoming a concern. Many DVB-H launches are being delayed because of lack of agreements on the business model. Consequently, some MNOs have decided to launch mobile phones that take advantage of free-to-air (FTA) DVB-T reception, such as in Germany.

This puts the viability of DVB-H pay-TV services in question.

So, DVB-T or DVB-H?

This article compares DVB-T and DVB-H coverage performances for several classes of receivers by mostly using:

- the Link Budget models developed by two independent organizations: the international *Broadcast Mobile Convergence Forum* (BMCO) and the French industry consortium *Forum TV Mobile*;
- two types of coverage prediction models: the basic *Okumura-Hata* model for main tendencies and the advanced *Volcano* tool developed by Siradel for more accurate coverage prediction.

Link budget evaluation

A three-step process, based on [1] and illustrated in *Fig. 3*, is used to compute the minimum median equivalent outdoor field strength required at 1.5m above ground level (agl).

1) we first calculate, in dBm, the *required minimum RF level* (C_{min}) at the front-end tuner input.
2) then we calculate, in dBμV/m, for a given antenna gain, the *required field strength* (E_{ant}) near the receiving antenna.
3) and finally we evaluate the *required outdoor field strength* (E_{out}), assuming good margins for indoor or outdoor coverage with a given percentage of covered locations (usually 95% or 99%).

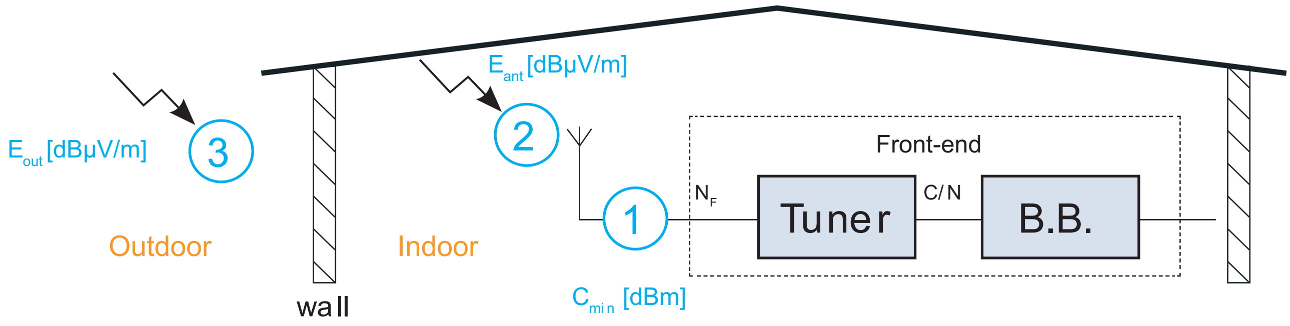


Figure 3
Reference model for link budget calculation

Step1: minimum RF level required at the receiver input

The minimum required RF input level (C_{min}) is related to the Carrier-to-Noise Ratio (C/N), the receiver Noise Figure (N_F) and the spectrum Bandwidth (B) by using the following formula:

$$\frac{C}{N} = \frac{C_{min}}{N_F k T_0 B}$$

Where: k = Boltzmann's Constant (k= 1.38 x 10^{-23} {Ws/K})
T_0 = Absolute temperature (T_0 = 290° {K})
B = Receiver noise bandwidth (B = 7.61 x 10^6 {Hz})

(1) $$C_{min_{[dBm]}} = \left(\frac{C}{N}\right)_{[dB]} + N_{F_{[dB]}} - 114 + 10\log(B_{[MHz]})$$

Table 1 gives the C/N values (MBRAI specification [2] and DiBcom values), for several classes of Single Receivers and the mostly used DVB-T/H constellations in Europe.

Table 1
Required (C/N) values for several classes of Single Receivers

				$(C/N)_{min}$ [dB] SINGLE Antenna					
				PI		PO		TU6@10Hz	
				Light, Good, Deep *Portable Indoor*		Pedestrian *Portable Outdoor*		*Car/Roof-Antenna* or *Mobile In-Car*	
Mode	**Constell.**	**Code rate**	**MPE-FEC**	**MBRAI**	**DiBcom**	**MBRAI**	**DiBcom**	**MBRAI**	**DiBcom**
DVB-T	16-QAM	2/3		18.0	**16.5**	19.5	**18.0**	24.0	**23.0**
DVB-T	16-QAM	3/4		20.5	**19.0**	22.0	**20.5**		**26.0**
DVB-T	64-QAM	2/3		22.8	**21.0**	24.3	**22.5**	30.0	**29.0**
DVB-H	QPSK	2/3	7/8	10.4	**10.4**	11.4	**11.0**	14.5	**13.0**

In **diversity** mode, using two antennas and Maximum Ratio Combining (MRC), the required C/N values, shown in ***Table 1***, are 6 dB lower in PI/PO modes and 8 dB lower in TU6 mode [3].

Using the C/N values of *Table 1* together with N_F = 5 dB and B = 7.61 MHz in equation (1) above gives the minimum required RF input level (C_{min}) for Single Receivers *(Table 2)*.

Table 2
Required RF input level C_{min} for several classes of Single Receivers (N_F = 5 dB and B = 7.61 MHz)

				C_{min} [dBm] SINGLE Antenna					
				PI		PO		TU6@10Hz	
				Light, Good, Deep *Portable Indoor*		Pedestrian *Portable Outdoor*		*Mobile In-Car* or *Car/ Roof-Antenna*	
Mode	**Constell.**	**code Rate**	**MPE-FEC**	**MBRAI**	**DiBcom**	**MBRAI**	**DiBcom**	**MBRAI**	**DiBcom**
DVB-T	16-QAM	2/3		-82.2	**-83.7**	-80.7	**-82.2**	-76.2	**-77.2**
DVB-T	16-QAM	3/4		-79.7	**-81.2**	-78.2	**-79.7**		**-74.2**
DVB-T	64-QAM	2/3		-77.4	**-79.2**	-75.9	**-77.7**	-70.2	**-71.2**
DVB-H	QPSK	2/3	7/8	-89.8	**-89.8**	-88.8	**-89.2**	-85.7	**-87.2**

Step2: Minimum field strength required at the antenna input

The input RF level (Watt or dBm) is usable in the laboratory, but in the field or in an anechoic chamber, we need to measure the field strength (dBµV/m) instead. Assuming a receiving antenna gain (G_{ant}) and a working frequency (F), the required field strength is calculated versus the minimum RF input level (C_{min}) by using the following formulas:

$C_{min} = Aa \times \Phi_{min}$

Aa = Effective antenna aperture {dBm²}
Φ_{min} = Minimum power flux density at receiving place {dBW/m²}

$$\text{with } \Phi_{min} = \frac{(E_{ant_{min}})^2}{120\pi}$$

$E_{ant_{min}}$ = Equivalent minimum field strength near the antenna {dBmV/m}

$$\text{and } \quad Aa = G_{ant} \times \frac{\lambda^2}{4\pi}$$

λ = Wavelength of the signal (λ = *c/F*) {m}
G_{ant} = Antenna Gain compared to isotropic antenna {dBi}

And finally, a combination of the three previous formulas gives:

$$(2) \qquad E_{ant_{[dB\mu V/m]}} = C_{min[\text{dBm}]} + 77.2 - G_{ant_{[dBi]}} + 20\log(F_{[\text{MHz}]})$$

Abbreviations

16-QAM 16-state Quadrature Amplitude Modulation
64-QAM 64-state Quadrature Amplitude Modulation
agl Above ground level
BMCO Broadcast Mobile Convergence Forum
http://www.bmcoforum.org/
C/N Carrier-to-Noise ratio
DVB Digital Video Broadcasting
http://www.dvb.org/
DVB-H DVB - Handheld
DVB-T DVB - Terrestrial
ERP Effective Radiated Power
FEC Forward Error Correction
FTA Free-To-Air
MNO Mobile Network Operator
MPE (DVB) Multi Protocol Encapsulation
MUX Multiplex / multiplexer
PMP Portable Multimedia Player
PND Portable Navigation Device
QoC Quality of Coverage
QPSK Quadrature (Quaternary) Phase-Shift Keying
STB Set-Top Box

As an example, the minimum field strength required at the antenna input is shown in *Table 3* for an antenna gain (G_{ant}) = –2.4 dBi (external antenna) and a carrier frequency F = 600 MHz.

Table 3
Required field strength (E_{ant}) values near the antenna for several classes of Single Receivers (N_F = 5 dB, G_{ant} = –2.4 dBi, F = 600 MHz)

				E_{ant} [dBμV/m] SINGLE Antenna					
				PI		PO		TU6@10Hz	
				Light, Good, Deep *Portable Indoor*		Pedestrian *Portable Outdoor*		Mobile *In-Car or Car/Roof-Antenna*	
Mode	Constell.	Code rate	MPE-FEC	MBRAI	DiBcom	MBRAI	DiBcom	MBRAI	DiBcom
DVB-T	16-QAM	2/3		53.0	**51.5**	54.5	**53.0**	59.0	**58.0**
DVB-T	16-QAM	3/4		55.5	**54.0**	57.0	**55.5**		**61.0**
DVB-T	64-QAM	2/3		57.8	**56.0**	59.3	**57.5**	65.0	**64.0**
DVB-H	QPSK	2/3	7/8	45.4	**45.4**	46.4	**46.0**	49.5	**48.0**

Step3: Minimum outdoor median field strength with coverage margin

Macro-scale variations of the field strength are very important for the coverage assessment. For outdoor signals, the standard deviation value of σ_o= 5.5 dB is commonly used.

For indoor signals, the given variation corresponds to the cumulative of the outdoor signal variation and the indoor or in-vehicle variation. As outdoor and indoor macro-scale variations of the field strength were found to follow a “log Normal” law, the combined standard deviation (σ) is given by:

$\sigma = \sqrt{(\sigma_o^{\,2} + \sigma_p^{\,2})}$ where σ_p is the standard deviation of the indoor penetration loss.

For portable reception, the Quality of Coverage (QoC) is said to be “good” in a given area if at least 95% of receiving locations at the edge of the area are covered (for P = 95%, the corresponding inverse of the standard normal cumulative distribution is μ = 1.64). For mobile reception, the required QoC is usually 99% (μ = 2.33). Finally the minimum median electric field strength, assuming a given QoC, can be calculated as follows:

$$(3) \qquad E_{out_{[dB\mu V/m]}} = E_{ant_{[dB\mu V/m]}} + L_p + \mu \times \sigma$$

Where L_p is the median indoor penetration loss and σ is the standard deviation, given in *Table 4*.

When using a simple propagation model like Okumura-Hata, the output of the third step given on *Page 2*, and shown in *Fig. 3*, consists of evaluating the *required outdoor field strength* (E_{out}) assuming a good indoor coverage with a given percentage of covered locations (95% or 99%).

According to the process previously defined, the minimum median outdoor electric field strength assuming a good coverage with a DiBcom receiver is calculated for the most used DVB-T/H modes across Europe and is shown in *Table 5*.

Table 4
Median penetration loss, standard deviation and quality of coverage

	Portable Indoor (PI)			Portable Outdoor (PO)	Mobile Car (TU6@10 Hz)	
	Light	Good	Deep		In-car	Car roof-top
L_p (dB)	11	14	17	0	7	0
Good QoC (%)	95	95	95	95	99	99
μ	1.64	1.64	1.64	1.64	2.33	2.33
σ_{out} (dB)	5.50	5.50	5.50	5.50	5.50	5.50
σ_p (dB)	5.00	5.00	6.00	0.00	0.00	0.00
σ (dB)	7.43	7.43	8.14	5.50	5.50	5.50
$L_p + \mu\sigma$ (dB)	**23.2**	**26.2**	**30.4**	**9.0**	**19.8**	**12.8**

Table 5
Minimum outdoor electric field strength required for a portable DiBcom receiver
(N_F = 5 dB, G_{ant} = –2.4 dBi, F = 600 MHz)

					E_{out}[dBµV/m] for a DiBcom Single Antenna Receiver $E_{out} = E_{ant} + L_p + \mu\sigma$					
					Portable Indoor (PI) QoC=95%			Port. Outdoor (PO QoC= 95%	Mobile Car (TU6) QoC=99%	
Mode	Constel.	Code rate	MPE-FEC	Country	Light	Good	Deep		In-car	Car roof-top
DVB-T	16QAM	2/3		Germany	**74.7**	**77.7**	**81.9**	**62.1**	**77.8**	**69.4**
DVB-T	16QAM	3/4		Austria	**77.2**	**80.2**	**84.4**	**64.6**	**80.8**	**72.4**
DVB-T	64QAM	2/3		France	**79.2**	**82.2**	**86.4**	**66.6**	**83.8**	**75.4**
DVB-H	QPSK	2/3	7/8	France	**68.6**	**71.6**	**75.8**	**55.1**	**67.8**	**59.4**

When using a more sophisticated propagation model such as *Volcano* by Siradel, the penetration losses are inherently computed by the model. This mode directly provides an estimation of the outdoor and indoor fields. The service coverage maps are assessed by considering similar thresholds as those in *Table 5* but without L_p.

Outdoor and indoor coverage estimation in Greater Paris for DVB-T and DVB-H

Context

A large part of mobile multimedia communications takes place inside buildings, especially in densely populated areas (home, office, shopping mall, railway station, airport). Consequently a knowledge of indoor coverage is of great concern to Mobile TV network operators.

Numerous methods exist to provide an estimation of indoor coverage. After a short review of common methods, a refined solution designed by Siradel is presented. This method has been used to obtain the various signal strengths and service coverages for DVB-T 16-QAM / 64-QAM and DVB-H.

Summary and limitation of existing methods

Several approaches have been proposed in the literature for estimating the indoor and outdoor coverage.

COST-HATA models [4] and ITU rec ITU-R P.1546 [5] are methods based on empirical results to obtain path-loss and field-strength estimations, depending on (i) the environment (rural, suburban, urban), (ii) the frequency and (iii) the height of the transmitters and receivers. A rough estimation of the covered surface is possible and the cell radii may be roughly determined. To obtain the indoor coverage, these models are associated with methods called *path loss margin* [6] that consist of adding to the outdoor path loss, a margin that can depend on the land usage type. Generally, low-resolution geographical map data (typically 50m) are used to classify the environments.

Recommendations ITU-R P.1546 [5] and P.1812 [7], and BMCO forum work [1] on planning for indoor fixed digital TV reception, present similar margins. The latter reference distinguishes between “light”, “good” and “deep” indoor conditions. Thus, most techniques recommended by the ITU, EBU and ETSI for the planning of mobile digital TV reception fall into this category. Besides, a “height loss” value, corresponding to a margin, is added to the predictions made at a receiver height of 10m to account for possible losses encountered at street level and inside the ground floor.

Some solutions called *height gain model* estimate the coverage according to floor levels by a semi-empirical height gain that may vary according to the LOS and NLOS conditions [8]. These methods are also used on high-resolution geographical map data.

However these methods fail to represent correctly the penetration of the direct path or the multipath occurring in urban areas. Alternative solutions, also based on high-resolution geographical map data, compute the outdoor-to-indoor field strength on several distinct floor levels.

Okumura-Hata coverage prediction method

The Okumura-Hata model gives the *median path loss* in urban areas. It is based on measurements carried out by Okumura, and parameterized by Hata [9].

The model does not provide any analytical explanation, but is only based on the measurement results collected by the campaign in Japan during 1968. The model is suited for base-station-to-mobile-station scenarios with large cell sizes (a transmitter-receiver separation of larger than 1 km). Furthermore it does not take into account the actual Earth relief. Consequently, this basic model cannot be used for accurate coverage estimation but only for rough evaluations. *Table 6* shows some covered distances, estimated from the field strength thresholds given in *Table 5*, using the Okumura-Hata method in the Paris area (Eiffel Tower transmitter with ERP = 20kW) – for urban, suburban and open/rural areas.

Fig. 4 illustrates the covered distance versus the electric field strength for “Outdoor Pedestrian” and “Good Indoor” reception at ground floor level in urban, suburban and rural areas. Around Paris the area is much more “urban”. But at a distance greater than 15-20 km, we can consider “suburban” as a valid propagation model in some places.

The maximum covered distance (around 69 km) is given by the horizon limit at 1.5m agl.

The DVB-T 64-QAM, DVB-T 16-QAM and DVB-H thresholds are shown horizontally in the graph of *Fig. 4*.

Table 6
Covered radius given by Okumura-Hata propagation model
***Receiver*: N_F = 5 dB, G_{ant} = –2.4 dBi, hm = 1.5m**

Eiffel Tower / ERP = 20kW	hb = 324m / F = 600MHz	Good Indoor			Outdoor Pedestrian			Horizon
		DVB-T	DVB-T	DVB-H	DVB-T	DVB-T	DVB-H	
		64QAM 2/3	16QAM 2/3	QPSK 2/3	64QAM 2/3	16QAM 2/3	QPSK 2/3	
Thresholds ($E_{dB\mu V/m}$)		82.2	77.7	71.6	66.6	62.1	55.1	48.1
R (km) Okumura-Hata	Urban	**4.4**	**6.3**	**10.3**	**15.5**	**22.3**	**39.3**	
	Suburban	9.0	12.9	21.2	32.0	46.0	68.7	68.7
	Open Rural	38.4	55.3	68.7	68.7	68.7	68.7	

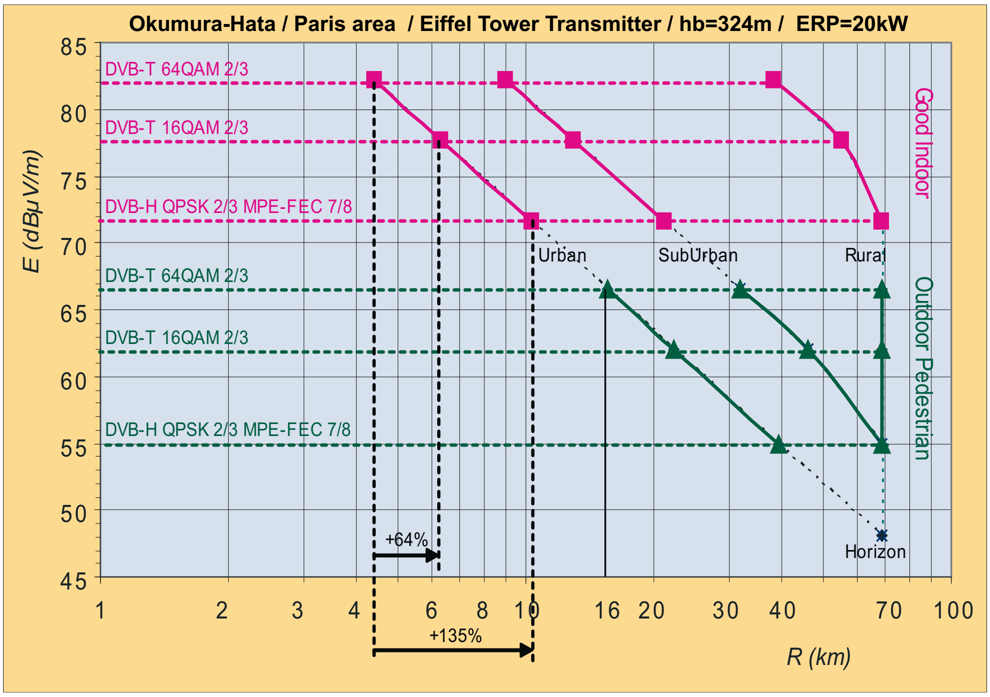


Figure 4
Covered distance vs. electric field using Okumura-Hata propagation model in the Paris area
***Receiver*: NF = 5 dB, G_{ant} = – 2.4 dBi, hm = 1.5m, F = 600 MHz**

It clearly appears that, for the same ERP, DVB-H (QPSK 2/3 MPE-FEC 7/8) performs much better than DVB-T, especially in 64-QAM mode. For example, for “Good Indoor”, in both Urban and Suburban areas, the covered DVB-H radius improvement is around 135% compared to DVB-T 64-QAM, and 64% compared to DVB-T 16-QAM.

Note: The normally accepted limitations for the Okumura-Hata simulation method are 200m for the transmitter height and 1 to 20 km for the covered distance range. Nevertheless, even with hb = 324m and a calculated coverage radius up to 55 km, correlation between the basic Okumura-Hata model and the sophisticated Volcano simulations remains acceptable (see *Tables 6* and *8*). The Okumura-Hata model can be considered here as a theoretical extension for providing an overview. If one wants a better accuracy, ITU-R Rec. P.1546 or Volcano can be used.

Advanced outdoor-indoor penetration methods

The approach implemented by Siradel was partly designed and developed in the frame of the French research project RECITENT and the European project FP6-IST-PLUTO [10] to predict large DVB-T and DVB-H indoor coverage maps. The in-building penetration is now implemented in the core Volcano products.

The main characteristics of the advanced outdoor-indoor penetration method is that the rays (radio waves) resulting from the (possibly multiple) interaction with the outdoor urban environment are prolonged and fully exploited from outdoor to indoor.

In the present method, all ray contributions penetrate inside the buildings. The propagation of rays inside the building is done along straight horizontal paths. An interface loss is added to the path loss while penetrating inside the building. The interface loss can be different for different land usages (e.g. monument, building, shopping mall) of the geographical map data. An in-building loss is added to the path loss while propagating inside the building. It is calculated from a statistical linear clutter loss γ (in dB/m) that can vary according to the land usage.

γ represents the average loss per metre caused by in-building walls, objects and furniture.

At greater reception heights, the ray can penetrate inside the building through the rooftop and top floors. In that case, the interface loss associated with the land usage is used to compute the floor attenuation. The floor horizontal surfaces are assumed to be separated by 3 metres.

The global indoor path loss results from the combination of all the ray contributions intercepted at the receiver location. Large measurement campaigns were realized in the framework of the afore-mentioned research projects for testing DVB-T/H networks to validate the approach [11][12].

In cases where no high-resolution geographical map data are available, techniques similar to the path loss margin are used. Dedicated methods provide a seamless coverage between heterogeneous areas, avoiding a break at the interface between low and high resolutions.

The main advantages of this solution for predicting outdoor-to-indoor propagation are:

- to provide a fast and precise prediction of the wave propagation from one outdoor base station to mobile or portable stations located inside buildings on different floors.
- to provide in-building coverage maps for outdoor radio networks for fixed and mobile digital TV, over large urban area; the coverage can be predicted on the ground floor only, to assess the worst coverage case, or on different floors.

Application

A transmitter located at 324m agl, on the Eiffel Tower, illuminates a large part of the Greater Paris area. A transmitter omni-directional antenna is used in this scenario and the ERP is 20 kW.

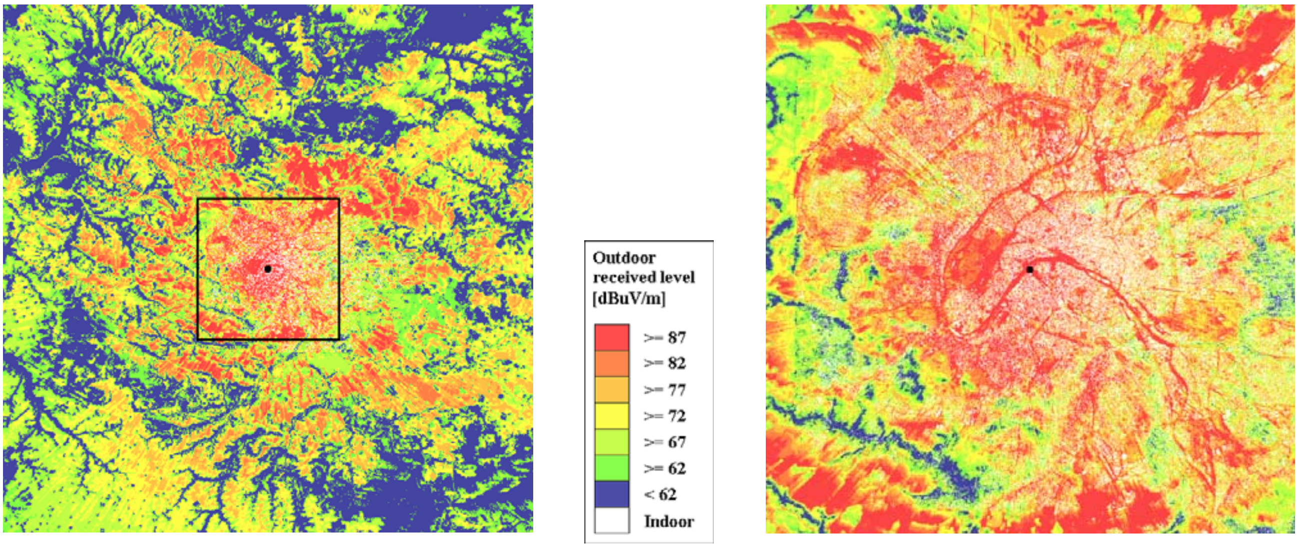


Figure 5
(Left) **Outdoor field strength in Greater Paris area, 120km*120km**
(Right) **Zoom in Central Paris, 32km*32km. Indoor field strength is not computed (white colour)**

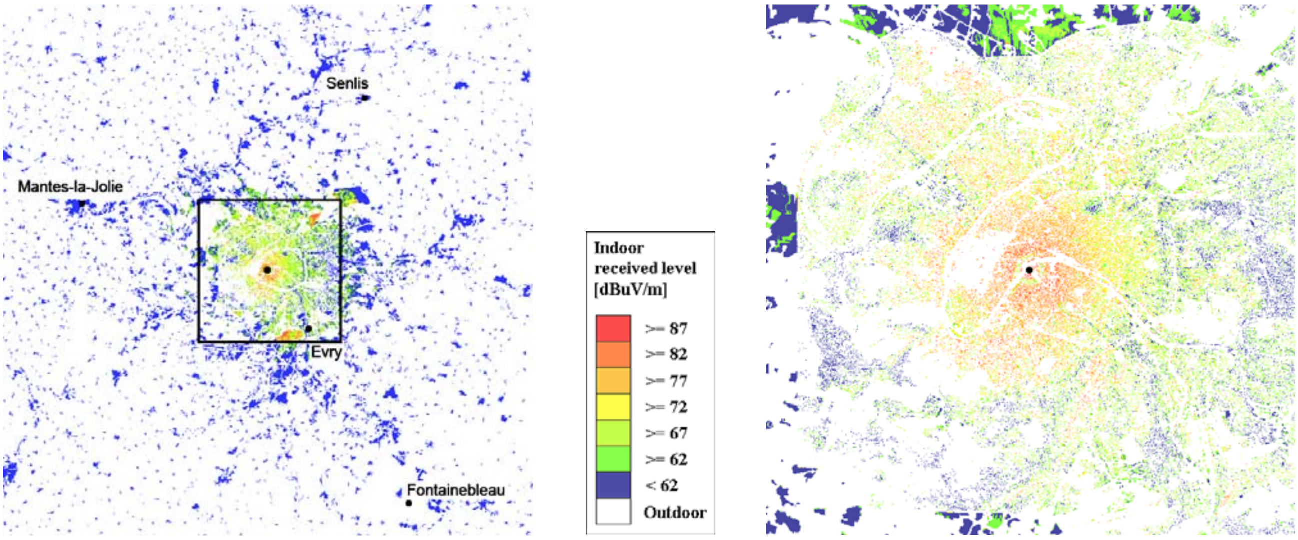


Figure 6
(Left) **Indoor field strength (at 1.5m agl) in Greater Paris area, 120km*120km**
(Right) **Zoom in Central Paris, 32km*32km. Outdoor field strength is not computed (white colour)**

The outdoor and indoor coverages are evaluated for three DVB schemes: DVB-T 64-QAM 2/3, DVB-T 16-QAM 2/3 and DVB-H QPSK 2/3 MPE-FEC 7/8.

Fig. 5 shows the outdoor field strength estimated by the described method. The higher levels are observed around the transmitter and at larger distances with a line-of-sight. The impact of relief and land usage (buildings, vegetation) is observed. On the left-hand side of *Fig. 5*, a 120km*120km area is represented and the computation was made with low- and high-resolution geographical map data. On the right-hand side, a zoom at high resolution is made for a 32km*32km area. In this Figure the indoor reception fields are not computed (represented in white).

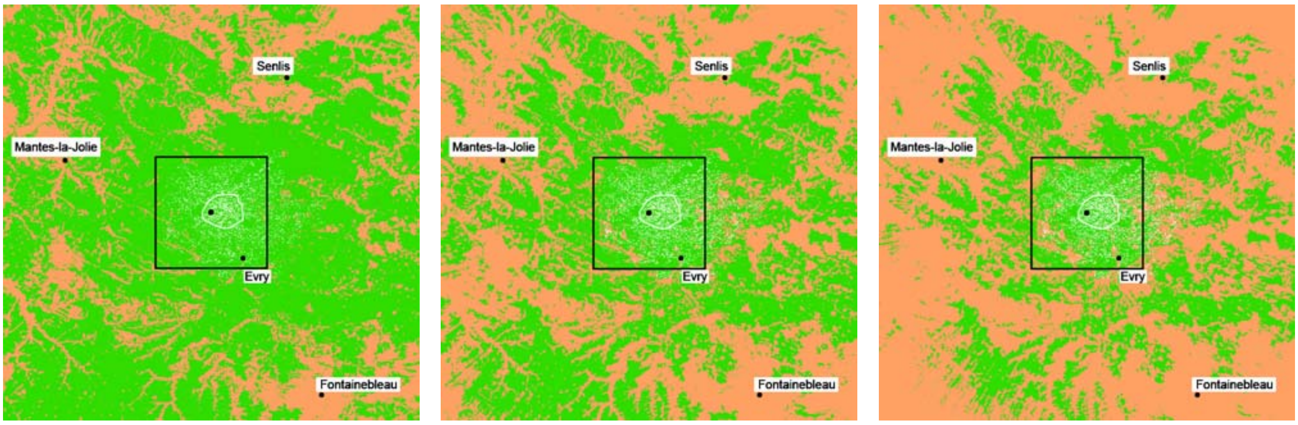
On the contrary, in *Fig. 6* only the indoor fields are illustrated for the same areas. Here, the outdoor fields are represented in white.

Note that the predicted field strengths already include the losses from in-building penetration. Therefore the thresholds for indoor coverage do not have to take into account an additional median indoor penetration loss. Applying the thresholds given in *Table 7* over the areas shown in *Fig. 5* and *Fig. 6*, the service areas are assessed and represented in *Fig. 7* and *Fig. 8* respectively for outdoor and indoor conditions.

Table 7
Minimum indoor electric field strength required in Volcano's simulations for a portable DiBcom receiver (N_F = 5 dB, G_{ant} = –2.4 dBi, F = 600 MHz)

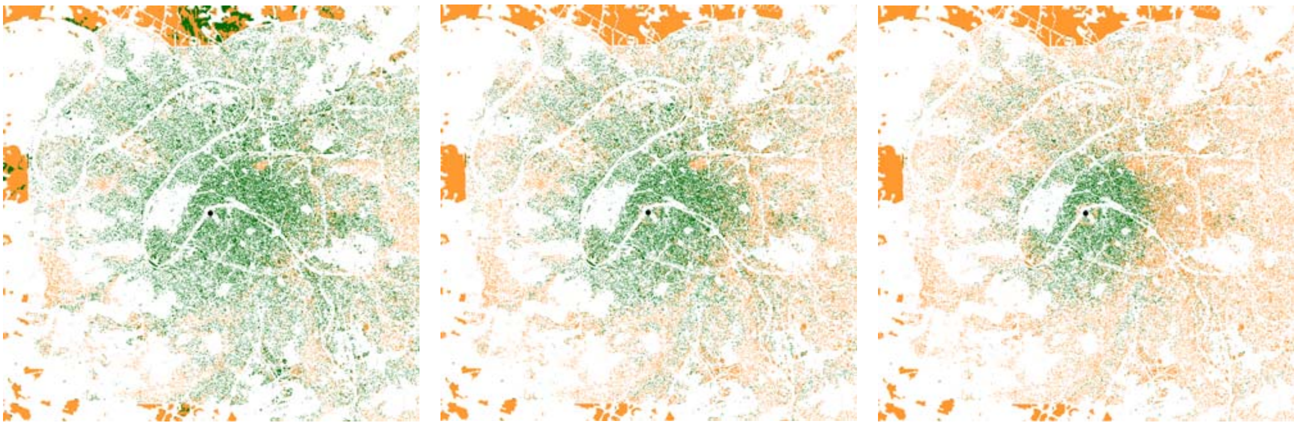
					Thresholds ($E_{dB\mu V/m}$) as shown in *Table 7* for a DiBcom single antenna receiver $E_{indoor} = E_{ant} + \mu\sigma$	
					Portable Indoor (PI) QoC = 95%	Portable Outdoor (PO) QoC = 95%
Mode	Constel.	Code rate	MPE-FEC	Country	Good Indoor	
DVB-T	16QAM	2/3		Germany	63.7	62.1
DVB-T	64QAM	2/3		France	68.2	66.6
DVB-H	QPSK	2/3	7/8	France	57.6	55.1

The covered areas (green colour) are larger for DVB-H than for DVB-T. The 16-QAM DVB-T scheme is received at larger distances than the 64-QAM scheme.



DVB-H 2/3 MPE-FEC 7/8 **DVB-T 16-QAM 2/3** **DVB-T 64-QAM 2/3**

Figure 7
Outdoor coverage for a 95% QoC
(green = covered; ochre = non-covered; white = not computed, i.e. indoor)
120km*120km area



DVB-H 2/3 MPE-FEC 7/8 **DVB-T 16-QAM 2/3** **DVB-T 64-QAM 2/3**

Figure 8
Indoor coverage at ground level for a 95% QoC
(green = covered; ochre = non-covered; white = not computed, i.e. outdoor)
32km*32km area

Table 8
Covered radii given by Volcano propagation model
***Receiver*: N_F = 5 dB, G_{ant} = –2.4 dBi, hm = 1.5m**
***Transmitter*: hb = 324m, ERP = 20 kW**

				Mean radius of coverage in km			
				Outdoor		Indoor (urban)	
Mode	Constel.	Code rate	MPE-FEC	Rural	Urban	Ground floor	3rd floor
DVB-T	64QAM	2/3		31.5	14.8	4.9	8.8
DVB-T	16QAM	2/3		42.9	20.3	7.7	12.4
DVB-H	QPSK	2/3	7/8	>60.0	31.5	11.0	22.6

The estimation of the Volcano coverage mean radii for the different DVB schemes are summed up in *Table 8*. We observed that the mean radii are of the same order of magnitude as the ones computed by Okumura-Hata (see *Table 6*). However the coverages are quite different and only the service coverages presented in *Fig. 7* and *Fig. 8* can be used for reliable radio network planning for heterogeneous areas (urban, suburban and rural).

Moreover, deterministic tools such as Volcano offer the possibility to compute finely the multi-floor coverage. It is observed from the radii given in *Table 8* that the coverage on the third floor is about twice as large as the ground floor coverage.

DVB-T coverage measurements in Europe

Fig. 9 and *Fig. 10* show outdoor field tests carried out respectively in Berlin and Paris. It clearly appears that the Berlin DVB-T coverage using 16-QAM 2/3 performs much better that the Paris DVB-T coverage using 64-QAM 2/3.

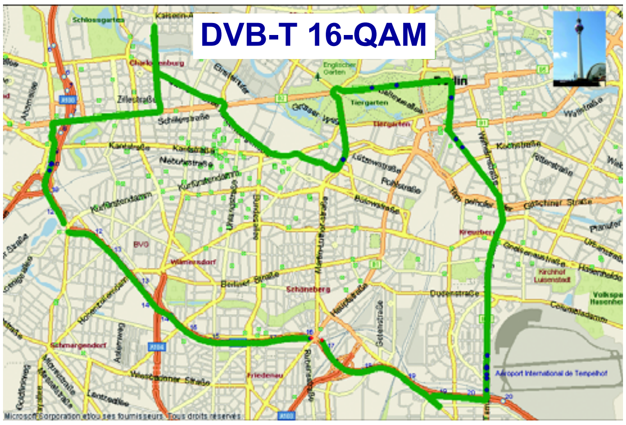


Figure 9
Perfect DVB-T coverage over Berlin from Alex-anderPlatz, with a single-antenna receiver

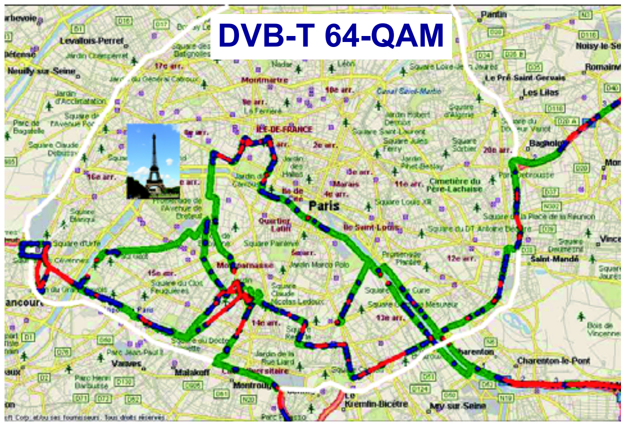


Figure 10
Far-from-perfect DVB-T coverage over Paris from the Eiffel Tower, with a single-antenna receiver

Will DVB-T kill DVB-H, or can they co-exist?

No, DVB-T will not kill DVB-H! Some countries will start with DVB-T and add DVB-H later, while others will do the opposite and finally DVB-T and DVB-H will co-exist.

As shown in this article, the feasibility of receiving Mobile TV via DVB-T is much easier in countries using 16-QAM (C/N in the range of 17-23 dB) while it is clear that DVB-T 64-QAM is not perfectly suited for mobile TV reception (C/N in the range of 21-29 dB), except if diversity reception mode is used. Performance is key for Mobile TV reception, not only to attract a large number of users but also to retain them.

Another important element to enable the market is the availability of devices to provide users with a large choice of models. Manufacturers can design DVB-T devices today for the 16-QAM markets, and update them later with DVB-H (software upgrade only, with low to zero cost!) for the many countries that are launching a handheld service soon.

Although the main attraction of DVB-T is free-to-air TV, DVB-H brings many other benefits such as:

- deep indoor reception (C/N in the range of 7-14 dB thanks to MPE-FEC and denser infrastructure);
- reception at high-speeds (thanks to MPE-FEC);
- enabling Interactivity for a better user experience and revenue generation (advertisements);

- low power consumption for longer battery life (5 to 7 hours with DVB-H thanks to Time Slicing, instead of 3 to 4 hours with DVB-T).

Conclusions

DVB-H offers an opportunity to gain new revenues by delivering existing and mobile-specific content to a new audience of mobile viewers watching at new prime times.

DVB-T and DVB-H are both very viable for Mobile TV offerings. They can complement each other nicely, even within the same market, by attracting users with FTA TV and then offering them more flexibility, new services, and specialized and adapted content. The number of users that will want DVB-T free-to-air as a gizmo will initially be higher than the ones ready to pay for DVB-H. So DVB-T will be a market enabler, since manufacturers will be more willing to add it to their line-up for immediate higher volumes, whereas operators will seek more DVB-H capable models, hence accelerating their return on investment with a faster growing subscriber base.

Gerard Pousset is currently the Technology Marketing Director at DiBcom. His technical background – combining deep knowledge of Digital TV technology and products with previous marketing experience – positions him well to play a key role in the company's strategy and to represent it in several industry bodies and forums.

Before joining DiBcom in 2001, Mr Pousset was Product Leader and Account Manager for DTT set-top boxes at Sagem. Prior to that, and after graduating, he joined SAT/Sagem where he managed several projects on radio links, digital TV and signal processing, which involved the development of complex integrated circuits (equalizers, digital demodulators, etc...).

Gerard Pousset graduated from *Ecole Nationale Superieure d'Electronique, d'Electrotechnique d'Informatique et d'Hydraulique* (ENSEEIHT) in Toulouse, France.

Yves Lostanlen obtained a Dipl.-Ing from the National Institute for Applied Sciences (INSA) in Rennes, France. He gained a European Ph.D. in Electrical Engineering at University College London and INSA Rennes.

He is currently Vice President and Wireless Chief Technology Officer at Siradel. He manages an R&D department of radio planning consultants, software developers, software support staff, researchers and radio R&D engineers, carrying out research into RF propagation applied to Radiocommunication Systems and Digital TV.

Dr Lostanlen is a telecommunications expert and manager with experience and involvement with the government, operators and manufacturers. He acts as a consultant for public, military and private organizations including major wireless industry players. He is currently Task and Work Package Leader in the FP6 and FP7 European projects, dealing with Mobile TV (Pluto) and next-generation wireless systems (UCELLS, WHERE, POSEI2DON).

Yves Lostanlen regularly holds lectures, tutorials, seminars, workshops and training sessions in industrial and academic institutions

Yoann Corre obtained a Dipl.-Ing and M.Sc. in 1999 from the National Institute for Applied Sciences (INSA) in Rennes, France, and University College London. He is currently an R&D Engineer in the Radio Department at Siradel, Rennes, where he is working on radiowave propagation applied to various domains such as radiocommunication systems and Digital TV.

Mr Corre has been involved in the European IST-PLUTO project and many collaborative R&D projects at the regional and national levels.

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DiBcom is an active member of both “bmcoforum” and the French “Forum TV Mobile”.

The **Broadcast Mobile Convergence Forum** (bmcoforum) is an international non-profit organization, aiming to shape an open market environment for mobile broadcast services.

The more than 110 members of bmcoforum join forces to identify relevant content and services, support technology standardization and implementation, as well as lobbying for spectrum and a suitable regulatory framework, to accelerate commercial implementations of new user experiences in receiving broadcast services and initiating interactivity on mobile devices.

Website: **http://www.bmcoforum.org/**

The **Forum TV Mobile** comprises 50 active companies today, covering the whole eco-system: wireless operators, terrestrial and satellite broadcasters, content providers, TV channels, device manufacturers, network operators, SW vendors, audience measurement institutes…

The forum was established in 2004 by the French Ministry of Industries and has since contributed a great deal to the development of Mobile TV in France.

Website: **http://www.forum-tv-mobile.com/fr/index.php**

DSO — the Swedish experience

Per Björkman
Sveriges Television AB

One of the most interesting, complicated, intriguing and political questions for the upcoming years in Europe will be the question of how to handle the spectrum in the UHF band (470 - 862 MHz). Up to now, this has been the frequency space used for analogue television but with the approaching analogue switch-off, this will change.

In Sweden, the last analogue transmitter was shut down a year ago and the process for a new spectrum allocation is up and running at full speed. This article takes a closer look at the situation in Sweden.

In Sweden, digital terrestrial transmissions started relatively early. Sweden was actually the second European country to launch DDT services, in March 1999, just a couple of months after the UK. During the subsequent years, it was expanded to five multiplexes (muxes), providing national coverage. Mux 1 is the Public Service (PS) bouquet with an outstanding coverage of 99.8% of the Swedish population. Muxes 2 - 4 cover some 98% of the population and Mux 5 about 70%. Today there are 30+ channels in the digital terrestrial network, most of them on subscription from the pay-TV operator Boxer. However, there is also a free-to-air choice comprising the PS channels and some commercial and local channels.

In 2005, the close-down of the three analogue channels started. SVT had two channels – SVT1 on VHF and SVT2 on UHF – and the commercial broadcaster TV4 had one channel in the UHF band. During the close-down period, SVT, TV4, Teracom and the "Swedish Digital Commission" joined forces and launched a massive information campaign to prepare all households for the coming switchover. It was a sequential switch-off, area by area and, in October 2007, the very last analogue transmitter (in the south of Sweden) was switched off.

Overall, it was quite a smooth transition to digital and it went much easier then some might have thought in advance. This could partly be explained by the long period of parallel transmissions (simulcating) that were provided for the Swedish population to prepare for the digital age of television.

About 25% of Swedish households are dependent on terrestrial reception, but if 2nd and 3rd TV sets are included, this figure rises. The penetration of cable is about 55% in Sweden and the majority of cable networks are still analogue. Satellite services are available in 25% of the households.

In the all-digital age of television, any broadcaster that wants to transmit on the terrestrial network in Sweden has to apply for a licence in any of the muxes 2 - 5. From 2008 onwards, this is being handled by the Swedish Radio & Television Authority *(Radio & TV-verket)*, whereas previously it was handled directly by the government. There is no auction process; instead, the Radio & Television Authority has the difficult task of creating a diverse mix of different types of channels, i.e. it is more of a so-called "beauty contest". The licence period is six years and the broadcaster can choose either a free-to-air or subscription model, the latter using a common CA card.

At the moment there is only one terrestrial pay-TV operator in Sweden (Boxer), but a change in the regulations in 2007 has opened up the market for other operators to establish themselves in the DTT marketplace. The digital network itself is operated by Teracom, a state-owned PTT operator. Mux 1 is dedicated to public service transmissions from SVT. It is free-to-view and regulated directly by the government.

The digital dividend

So now we come to the difficult question of the “digital dividend”: How big is it?

Sweden, like many other countries in our region, was granted seven national muxes in the UHF band at the Geneva planning conference in 2006 (GE06). We have five muxes in operation at present and have closed down two analogue UHF networks. Therefore the digital dividend would come to two muxes.

However, the EU has another definition, where the digital dividend is the frequency space left when the analogue services are converted to digital. According to this definition, the digital dividend in Sweden works out at 6½ muxes.

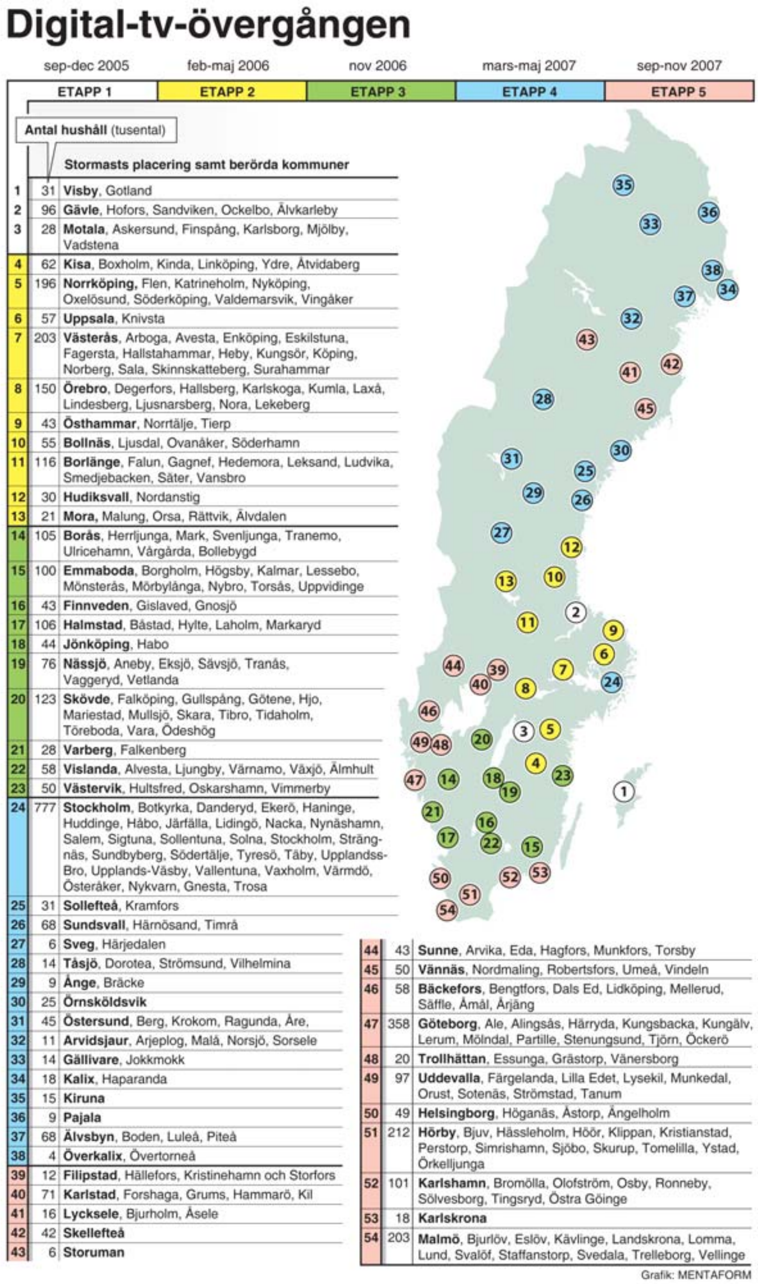

Figure 1
The five stages *(Etapp)* of digital switchover in Sweden

One could argue about this, but the fact remains; in the UHF band, Sweden has five muxes containing some 30+ TV channels, the majority of them for pay-TV services. All of them are broadcast in standard definition and coded in MPEG-2. A maximum of only two more muxes are available for further expansion or new services, and at this point we have not taken into consideration the very large demand and lobbing activity from the telecom industry for more spectrum, preferably in the attractive UHF band.

And this is why all the broadcasters with licences to broadcast on the Swedish DTT network joined forces in September 2007 and came up with a proposal. In short, we suggested that the government should let the TV industry use the complete UHF band until 2014. In return, we would use the extra frequency space to make a complete migration to MPEG-4 and maybe even DVB-T2, both more efficient ways of using the valuable spectrum.

With this plan, it would make it easier to release bandwidth to the telecom industry at a later stage – and still have the possibility of developing the terrestrial network and introducing HDTV. We believe that this would be a win-win situation for everybody and would also fit in with the European timetable for reusing the digital dividend.

The idea here, of course, is to take advantage of the fact that Sweden is very advanced in this process and could use this advantage, over the rest of Europe, to "upgrade" the terrestrial network by using the extra frequencies available after digital switchover. This upgrade should even make it possible to release more frequency space later on to the telecom industry than is possible today.

On the 19th of December 2007, the Swedish government announced their decision regarding the digital dividend. They decided that the upper part of the UHF band should be cleared of television broadcasts, thereby making it possible to introduce other types of communication services. The first step was to give the Swedish regulator PTS *(Post & Telestyrelsen)* an assignment to investigate a new frequency plan that would accommodate six muxes below 790 MHz. This work was scheduled to be finished by December 2008.

This means that transmitters working above channel 60 must be moved down and fitted into the space between 470 and 790 MHz. It also means that a new frequency plan must be done for the future 6th mux. This work is currently in progress and we do not foresee any big problems. There are only a handful of main transmitter sites that use frequencies above channel 60 and they could later be moved quite easily. A little more tricky are all the gap-fillers that SVT is using to achieve the 99.8% population coverage. There are some 500+ gap-fillers and 34 of them operate above 790 MHz.

Even the 6th mux should be possible to squeeze in. There will be some need for international coordination with our neighbours, particlularly involving the south and west coastal areas of Sweden which have a signal path over water to Norway, Denmark, Germany and Poland. This could be extremely difficult to address, but hopefully there will be a solution.

The 7th mux however is no longer possible to achieve in the UHF band. Instead, the government also decided that the VHF mux granted in the GE06 agreement could be used for television broadcasts. They also decided that the Radio & Television Authority now could grant licences for the 6th mux. These new services should be in standard definition but – and this is a new thing – they must be coded in MPEG-4, thus taking the first step towards a migration for all services.

During the spring of 2008, all the licences for muxes 2 - 5 were renewed. At the same time, the Swedish Radio & Television Authority also granted 10 new licences for mux 6. These licences were granted on the condition that MPEG-4 is used, and the plan is that they will all be in operation in early 2009. After that, there will probably be some decision on the VHF mux and hopefully it could be in operation during 2010.

This is also linked to the parliamentary decision in spring 2009 for new regulations and licences for the public service broadcasters, which might include something about HDTV. During 2009, there might also be some progress in the new use of the 800 MHz band.

From SVT's point of view, there are still several questions that need to be answered. For us, the possibility of providing HDTV services on the terrestrial network is very important. Our newest channel, SVT HD, is available both on cable and satellite, but we need terrestrial distribution to fulfil our requirement for covering the entire population. For this purpose, the new VHF mux is very interesting. Hopefully, this is where we could find the necessary space to introduce this next level of television. But still, the question of finance for this new capacity is far from solved. And in the long term, it would not be enough with only one mux for HDTV – it is absolutely necessary to develop the whole DTT network. The first logical step is of course MPEG-4, but DVB-T2 is probably close behind. In the end, our strategic goal is to fit all our channels in HD into one mux. If the new efficient coding

Abbreviations

DTT	Digital Terrestrial Television	**Mux**	Multiplex
DVB	Digital Video Broadcasting http://www.dvb.org/	**PTT**	Post, Telephone and Telegraph administration
DVB-T2	DVB - Terrestrial, version 2	**UHF**	Ultra High Frequency
		VHF	Very High Frequency

Per Björkman is Head of Strategic Development at the Public Service broadcaster Sveriges Television AB (SVT) in Sweden. He has been with SVT since 1997 and has held a number of management positions within the technical department, among them head of SVT Media Lab and head of SVT Technical Development. Prior to that, he started his professional career at TV4, a commercial broadcaster in Sweden, as production technician and project manager. And before that, he gained an M.Sc. degree in Electrical Engineering from Chalmers University in Gothenburg, Sweden.

Per Björkman specializes in video coding technologies and has been deeply involved in SVT's migration into file-based production systems – both for news and post production. He has also been engaged as a lecturer for university courses on Video & Images processing.

techniques will be enough, or if a reduction in the PS channels will be necessary, remains to be seen.

One could say that the digital dividend – defined as the space actually left over after analogue shutdown – has been equally divided between the TV and Telecom industries: one mux each. There will be no more changes of frequency allocation until 2015. What happens next therefore depends on how well the broadcasters manage to migrate to more spectrum-efficient technologies. This could enable new broadcast services, i.e. HDTV, and hopefully also more spectrum for new telecom services. Maybe there will be a 2nd digital dividend! We will definitely continue our discussions with the telecom industry and follow the technology developments on both sides.

So you might ask; "Did the Television industry win the battle for spectrum?". Well, maybe not completely, but more important, we did not lose. The government has set out some kind of framework for the next few years and we broadcasters feel that we have had some influence in that decision – probably much to do with the fact that we managed to speak up as a united industry. In the end it was very important that some sort of decision was made. If not, then a continuing intensive lobbying from the Telecom industry would probably have made it much harder for us, further down the road.

But there are still some difficult problems and tough challenges ahead. In this round, the Telecom industry got 72 MHz of bandwidth. Some people within the Telecom industry predict that the long-term need for spectrum in the future is 1 GHz. The DTT platform is a mature market and all six of the available muxes are in use. So what will be the driving force for replacement of MPEG-2 boxes with MPEG-4 equipment? Should PS broadcasters have a special role in this process? How will the business model change on pay-TV when there will be competition between different pay-TV operators? And most important; how will DTT stand in competition with other platforms such as cable, satellite and, not to forget, the growing IPTV industry.

Even if Sweden is ahead of most countries in Europe in this process, there are still a number of issues that needs to be handled carefully over the next few years.