Mobility and Interactivity
– the saviour of digital terrestrial broadcasting?

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The Internet and mobile phone networks are throwing down great challenges to traditional broadcasters. This article offers a gleam of hope to beleaguered broadcasters who are impatient for DAB and DVB-T to really excite the marketplace, in the same way that the WWW, DVDs and WAP-enabled telephones have.

Traditional broadcasting assumes a model where radio and television use autonomous technologies, systems and equipment for transmission and reception. Today, the Internet especially has widened the scope of broadcasting to include webcasting and networked multimedia services. Broadcasters are becoming increasingly 'agnostic' about the delivery mechanism and have to publish their content via whatever channels to whatever devices that are required to reach their viewers and listeners.

Digital broadcasting systems provide several mechanisms for transmitting data services to enhance conventional radio and TV programmes, and they allow the introduction of new multimedia services. The inherent mobile characteristics of DAB and the possibility to broadcast DVB-T signals for mobile reception have prompted broadcasters, network operators and others to develop a number of new services for mobile users. In doing so, they begin to compete on overlapping markets with mobile network operators, who may wish to introduce almost identical service concepts, but need to put charges on them in order to generate revenues. However, broadcasters may also benefit from revenues obtained from third-party service providers to finance new digital broadcast networks and the simulcasting of their programmes.

Second generation (2G) mobile networks can be used to implement return or interaction channels for mobile services. To that end, the imminent deployment of broadband and third generation (3G) mobile networks has provoked some concern that traditional broadcast networks might become obsolete. In particular, UMTS has been seen as potentially making DAB redundant. Apart from the very dissimilar coverage and access characteristics of DAB and UMTS, as presently planned, economic factors tend to make this scenario less probable.

The opportunities for using mobile broadcasting systems for non-broadcast types of services have also been recognized by network operators, telecommunications manufacturers, the car industry and others. Substantial development efforts are being undertaken to make DAB and DVB-T parts of the mobile information society. New business models, based on the convergence of networks, services and user terminals, are widening the range of opportunities for all parties involved.

This article will focus on some of these aspects, recognizing that the new media environment requires continuous development of the broadcast chain to allow the introduction of new services adapted to new user and market requirements. Therefore a discussion has been included on how mechanisms for the downloading of software applications to receivers may give broadcasters similar tools to those available on the Internet and in mobile phones.

The widening scope of broadcasting

Today, many broadcasters find themselves confronted with the need to publish content in a multitude of formats via several channels. Because of the different characteristics of analogue and digital broadcast systems, and of the Internet, this is not necessarily a matter of automated transcoding to the different outlets. For example, making reference to a data service in DAB makes little sense if the programme is received via FM.

Abbreviations

API	Application programming interface
CCC	Common control channel
DAB	Digital Audio Broadcasting
DRiVE	Dynamic Radio for IP Services in Vehicular Environments
DVB	Digital Video Broadcasting
DVB-RCT	DVB - Return Channel via Terrestrial
DVB-T	DVB - Terrestrial
GPS	Global positioning system
GSM	Global system for mobile communications
HTML	Hypertext markup language
IP	Internet protocol
ITS	Intelligent transport service
MHP	(DVB) Multimedia Home Platform
PCMCIA	Personal Computer Memory Card International Association
PDA	Personal digital assistant
PSTN	Public switched telephone network
SFN	Single-frequency network
SMS	Short message service
TPEG	Transport Protocol Experts Group
UMTS	Universal mobile telecommunication system
URL	Uniform resource locator
WAP	Wireless application protocol

Putting services on the web allows networked interactivity, on-line downloading etc. which are not presently available in mobile and portable receivers.

A few observations made by the ACTS INTERACT project are worth quoting here, because they point to essential features needed in future broadcast chains [1]:

- future programmes will be combinations of linear programming and multimedia;
- it is possible to define the stages for a phased introduction of both programme-related and stand-alone services;
- Executable content will become indispensable for introducing new services.

Therefore broadcast operations will tend to become very complex. The service provided may differ between channels. It may consist of elements that come from many sources – within or outside the organization. The introduction of software decoding in receivers may lead to a proliferation of customer groups. The old “what goes in one end comes out the other” model of broadcasting no longer applies.

Facing this, a number of broadcasters might hesitate to explore the full potential of mobile interactive services.

Why mobile interactive services?

DAB

The introduction of DAB and DVB-T has not been met with the same customer acclaim as have the Internet, mobile phones and DVD players. Lack of services and expensive receivers have been mentioned as explanations. In addition, political interference and migration matters have become hurdles in many countries.

Broadcast mobile interactive services may help to present customers with a more comprehensive range of services, offering added value. It is important for broadcasters to recognize the trends of the mobile society, and to fulfil expectations from the user “on the move” [2]. In doing so, broadcasters will become more competitive with other media sectors.

The advantages of using broadcast distribution for certain mobile services can be illustrated by traffic and travel information (TTI) [3]. The BBC’s concept TPEG receiver (see *Fig. 1*) illustrates the great expectations attached to this versatile service. TPEG services can be delivered via DAB, DVB-T or the Internet, because they are independent of the delivery mechanism. There are also similar commercial services aimed at mobile phones – with a price attached. One might speculate about the viability of such services when comparable broadcast services can be

DVB-T

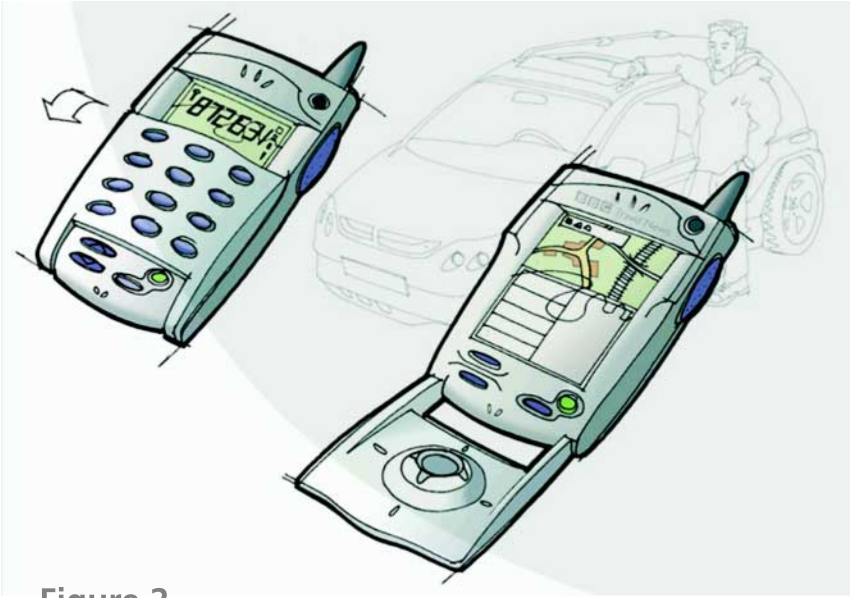


Figure 2
The BBC's vision of displaying a TPEG service on a PDA with integrated DAB receiver and mobile telephone.

received, virtually free of charge, in small, hand-held devices.

Mobile interactive services create opportunities for commercial broadcasters to generate revenues, for example from e-commerce. "Listen to the music – buy the CD" has almost become an icon for this type of services. There is also a potential for broadcast multiplex operators to offer transparent carriage of third party data services, rather than acting as the originator of the service.

Such services may facilitate migration to digital broadcasting by generating additional sources of income. In many countries, the costs of establishing new digital broadcast networks of comparable coverage with present analogue ones may otherwise be prohibitive. An interesting discussion relating to DVB-T is given in [4].

Digital broadcasting: a versatile platform

DAB and DVB-T are excellent channels for data broadcasting. A number of useful services are being introduced, exploiting local interactivity in receivers. The merits of such services should not be underestimated. The concept DAB receiver designed in Norway by NRK, P4 Radio and Norkring (*Fig. 2*) allows the listener to replay downloaded audio files from a memory, to browse HTML pages and play games to complement the normal programme flow, hence fulfilling much of INTERACT's vision.

Interactivity comes natural in television, because the screen can be used for creating simple-to-use graphical interfaces. The prospects of net-

Figure 2
A concept receiver, designed by NRK, P4 and Norkring.

Among other things, the top button starts replaying stored audio which can be prompted from the screen.

worked interactivity were recognized early by the DVB Project [1], as the set-top box can be connected to a return channel (cable, telephone modem, DVB-RCT etc.).

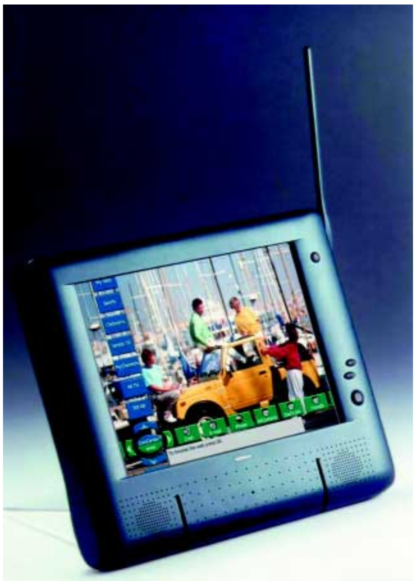


Figure 3
Nokia's Media Screen combines mobile DVB-T reception with GSM to provide mobile broadband delivery capabilities.

The MOTIVATE Project has carried out extensive tests to show the feasibility of mobile DVB-T services [5]. A number of experimental networks have focused on reception in cars or public transport vehicles [6]. Recently the first portable device combining DVB-T, GSM and IP was presented (*Fig. 3*).

The API defined by the Multimedia Home Platform (MHP) creates an open environment in DVB for enhanced and interactive broadcasting services as well as Internet services [7]. It paves the way for horizontal markets and new services. In addition to defining how to download new applications to set-top boxes, MHP has identified a number of necessary management functions in software-based receivers/terminals, in particular for managing network access, applications, navigation, selection of services and security. Similar resources, and others, will also be needed in integrated mobile terminals.

A changing media environment

While DAB and DVB were being developed, the Internet has grown from being a network used by academia and communication specialists to becoming what some observers call the foundation of the new economy. Mobile telephony is growing rapidly, and is forecast to supersede fixed telephony within a few years' time (*Fig. 4*). WAP has been a hype word for more than one year, and today any media person with minimal self-esteem is able to distinguish between

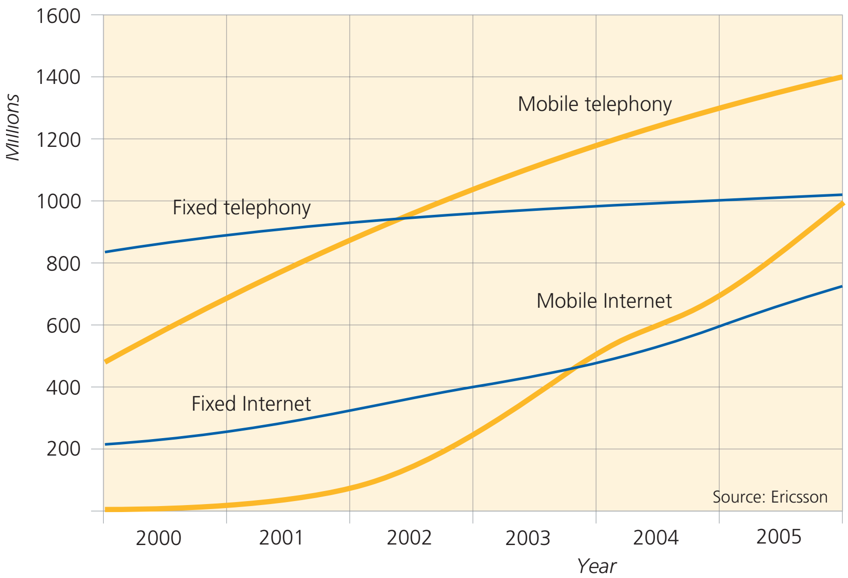


Figure 4
Subscriber forecasts for fixed and mobile telephony, and fixed and mobile Internet.

2G and 3G – second and third generation mobile networks. The latter are designed to provide enhanced communication services, multimedia, mobile Internet and – who knows – possibly broadcast radio and television. In addition, the emerging broadband networks are claimed to become the major delivery channel for radio and television in the future.

These developments introduce fundamental changes in the way people use media and interact with communication infrastructures. Broadcasting is becoming increasingly affected by these trends. They will have a profound influence on what services will be appropriate for broadcast delivery, how they will be produced and distributed, and which technologies have to be adopted.

Internet – the driving force

INTERACT believed that the technical influence of the World Wide Web on broadcast services would not be significant, and questioned the success of broadband networks. Only two years later, the real situation appears to be radically different.

There are many services on the Internet that would be perfectly suitable for porting onto broadcasting. Web sites published by broadcasters can be re-purposed for downloading and browsing locally in mobile receivers. But in addition, many third-party services, for instance real-time information services, may be appropriate for "broadcast Internet" [8]. Since it is usually expected that this kind of services is available free of charge on the web, it is most unlikely that users would accept a service charge. But without upsetting the business model, they could be ported onto a digital broadcast channel.

Figure 5
By means of a wireless link from an Internet-connected PC, the Kerbango receiver can "tune in" to Internet radio stations. The unit also includes an FM receiver.

New formats for normal types of broadcast content may have an even greater impact on broadcasting. For example, mp3 files are becoming a major source of music content for the young generation. The distinction between "broadcast radio" and streamed "Internet radio" becomes insignificant in new products developed to allow "reception" from the Internet as well as off-air (*Fig. 5*). The technology could obviously be developed for hand-held devices as well. Internet television today is a poor companion to broadcast services, but this may change as more bandwidth becomes available. DVD-compatible video files, including 5.1 surround sound, will be offered by broadband operators. There is a big new market waiting out there that broadcasters cannot ignore. But in order for broadcasters to exploit it, they have to eventually adopt the new formats.

The success of the Internet can be attributed to open standards and simplicity to introduce new services. Tens of thousands of software engineers worldwide are writing new applications and plug-ins that can be down-loaded by millions of users, usually free of charge. For example, all DAB on-air channels in the Munich area, including data services, have been put on the Web by a research project at the Technical University of Munich [9]. “DAB” can be received anywhere using a plug-in with WinAmp, a popular freeware application that runs under Windows [10]. By contrast, even simple additions to broadcast systems may take months or years to standardize. This is detrimental to the further evolution of broadcasting.

The Internet and the World Wide Web are setting a number of de facto technical standards for coding, presentation, interactivity etc. that broadcasters have to take into consideration. The common denominator is IP transport. IP tunnelling of services and of applications to software decoders will become crucial for introducing many new broadcast services.

The case for mobility and interactivity

As can be seen from *Fig. 4*, mobile telecommunications will supersede fixed telephony in 2002, and, perhaps more interestingly, mobile Internet access is predicted to dominate from 2003 and onwards.

People “on the move” are becoming accustomed to remaining reachable at all times and to be able to reach whichever person or whatever information they want. Information and communication resources are being exploited to increase personal productivity, flexibility and responsiveness [2]. Advanced mobile services and network functions may create new expectations and habits – personalised services can be adapted to the user’s context and preferences, but also to the available access channels or cost.

The telecommunications industry is making immense investments in 3G frequency licences and the implementation of 3G networks and services. “Localised services” and “mobile Internet” are envisaged to generate revenues to pay back the investments. However, this “mobile Internet” may not necessarily be synonymous with the public Internet. “Portals” may be used to promote services offered by the local network operator, hence creating risks for “locking in” the customers. But similar to the public Internet, mobile Internet services, available on hand-held devices, will set a norm for interactive mobile multimedia content, which has to be recognized by broadcasters in order for them to remain competitive. The difference, which will be discussed later, may be the cost. Broadcasting is free-to-the-air. UMTS is not.

In order to increase the benefits of their efforts, it is probably about time now for broadcasters to abandon the old autonomous broadcast model and investigate synergy effects with 2G and 3G networks and services. Having taken the step from linear broadcasting to web publishing, broadcasters may as well take the necessary steps to offering similar competitive services in the mobile environment.

New opportunities for broadcasters

An ever-increasing number of programme-related or stand-alone interactive services are being devised and tested. A number of these require the use of a return or interaction channel, to be discussed later. Some generic examples are

- Broadcast or Internet distribution of streamed audio/video or downloading of files for automatic storage in large memories. Allows play-back at any time and creation of "personalised" programme profiles. This can be seen as an enhancement of normal broadcasting based on the re-purposing of already available broadcast content.
- Programme-related data services such as EPGs, programme info, sports results etc.
- User involvement or contributions using a return channel. There are several options. The "phone-in" concept can be developed by using SMS messages, e-mail, etc. Audio or video files can be submitted via the Internet and used in normal programmes. In the near future, live audio or video may be sent via UMTS and included in news programmes etc.
- Access to supplementary content using non-broadcast channels ("tell me more").
- Access to archives using non-broadcast delivery channels.
- Non-broadcast type interactive services in addition to normal programmes. These may be third-party services, or services offered by the broadcasters in competition with other sectors. There may be adaptation of services for fixed and mobile users. All sorts of e-commerce fall within this category.
- Integration of live broadcasting over-the-air and on the Internet.
- etc.

All these services may well be received by mobile devices. As can be seen, there will be various combinations depending on the use of forward, return or interaction channels, receiver storage and broadcast vs. personal download of information.

Competition in overlapping markets

It is interesting to note that most examples in the above list could equally well have been taken from a 3G mobile service provider's notebook. Obviously there will be overlaps between services offered in broadcast networks, and similar services offered in mobile networks. It has been suggested that streamed media will become the first kind of widely deployed service which is common to both [11]. Mobile network operators may even find it more profitable to actually use broadcast technology to distribute some of their own services.

The user is not primarily interested in the underlying technology or what network is used. Conversely, he/she may be rather interested in the price to be paid. In simple words, broadcast mobile interactive services will only be viable if they offer a better total economy than competing solutions. This may well be the case.

In the case of broadcast vs. mobile telecommunication networks, it is possible to make rough estimates of the transmission cost per time or data unit, based on actual mobile phone fees, broadcast network transmission costs and audience statistics. They reveal that it is unlikely that mobile networks will become even remotely competitive with broadcast networks in terms of transmission costs for "one-to many" types of services. In present networks, the difference may be several orders of magnitude. Surprisingly low numbers of users may be needed to make file down-loading via a broadcast channel cost-effective when compared to other delivery mechanisms, even in large SFNs. Obviously there are opportunities to draw up viable business models for new services in DAB and DVB-T.

Alternatively, if for example, radio is to be distributed via a mobile network, the transmission costs will have to be subsidised by revenues from other services. The capacity requirements of these other services will remain just a fraction of that of continuous radio listening, until the introduction of new interactive services requiring continuous transfer of streamed audio or image signals. Even then the fees will have to be decreased significantly compared to current rates, otherwise customers will be presented with astronomic bills. There is nothing that suggests that transmission costs can be decreased by several orders of magnitude in UMTS.

UMTS

Constraints that may help or upset

In principle, broadcasters would seem to have a competitive advantage. However, the regulatory frameworks in individual countries may restrict the degree to which spectrum which has been allocated to traditional broadcast services may be used for other purposes, and the extent to which broadcasters and network operators will be allowed to compete within the telecommunications market. But this may actually constitute a protection against allegations of unfair competition, as most broadcasters have obtained their frequency licences at marginal cost compared to mobile operators. On the other hand, the current regulatory regime may prevent a successive evolution towards the most cost-effective mix of mobile telecommunications networks and broadcast networks for mobile reception.

Towards convergent networks and services

Networked interactivity is already possible

Well-informed decision-makers in the mobile telecommunications industry have certainly been aware of the above conditions for quite some time. For example, the UMTS Forum points to the increasing importance of interconnecting broadcasting networks with telecommunications networks to provide a return channel [12].

Projects such as ACTS MEMO and others have shown the feasibility of combining DAB and DVB-T, respectively, with GSM [5][13]. Broadcasters can use these platforms for introducing new mobile services offering networked interactivity. The DIAMOND project further integrates the MEMO architecture with GPS and car navigation systems to create a powerful ITS (Intelligent Transport Services) system for cars and public transport [14].

In this context, network planning and network topology are very important aspects. The large SFN networks now being deployed for DAB and DVB-T will certainly offer good spectrum economy for traditional broadcast services. However, if additional revenue streams from non-broadcast services are required to create viable business models, a cellularized approach might have been more appropriate [4].

Three scenarios

The analyses above make it possible to define three different scenarios.

1) DAB and DVB-T remain traditional broadcast networks offering some added-value data services. Data services requiring only local interactivity in mobile receivers, or exploiting a return channel in fixed receivers (PSTN, DVB-RCT), can be introduced.

2) DAB and DVB-T are combined with some other mobile network (GSM) to implement a return/interaction channel for mobile services, but there is no co-ordination between networks. Mobile services requiring networked interactivity can be introduced, but any downloading of personal data must use the interaction channel.

3) DAB and DVB-T are combined with other networks and become integrated parts of a co-ordinated infrastructure for communication, information dissemination and broadcasting. The degree of integration can be discussed; for example, the use of common system elements or the possibility to choose between networks when requesting a service.

In principle, scenarios 1 and 2 may be realized, based on present topologies of broadcast and mobile telecommunications networks. Scenario 2 could however generate significant added benefits if the networks could be planned in a more flexible way (e.g.

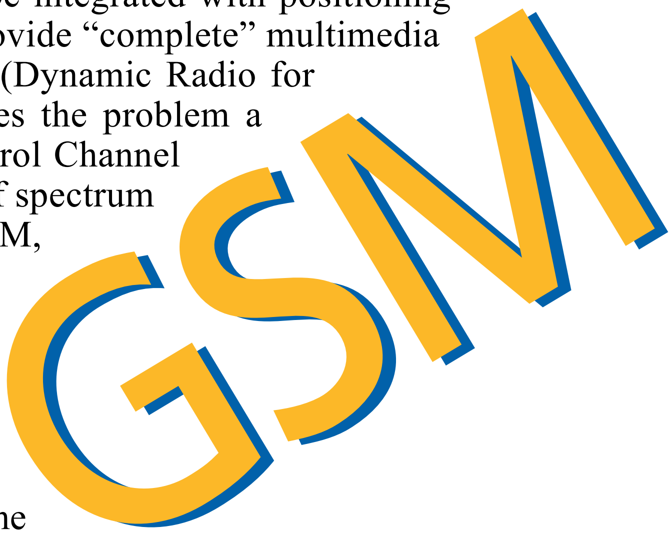
cellularized broadcast networks). Scenario 3 obviously requires fundamental changes of the regulatory regime for broadcast networks, probably also for mobile networks.

Scenario 1 can be seen as an extrapolation of principles that have governed terrestrial radio and television broadcasting so far. They are characterized by significant political interventions. Frequency licences may be heavily regulated and based on political or other criteria, or on spectrum auctions. The possibilities for broadcasting ancillary services and data are usually constrained, for instance to just a certain percentage of the capacity. As a result, the distinction between mobile and fixed services may become academic – broadcasters have to produce services that can be received in any environment.

In this case, migration from analogue to digital services might be slow. The implementation costs will primarily have to be covered by broadcasters themselves, and the possibilities for earning money from other services are limited. In addition, this scenario offers somewhat limited opportunities for broadcasters to compete with sophisticated interactive services already available on the Internet and which may be introduced over 3G networks.

Scenario 2 may not change the basic principles, or make more capacity available for non-broadcast services. However, it would certainly permit the introduction of new types of services offering new business opportunities, especially for commercial broadcasters. Public broadcasters may benefit as well, for instance from “tell me more” type services. But entirely new models for broadcasting could also be devised. Local broadcasting can be a problem, as a number of channels are needed to fill a DAB or DVB-T multiplex. If, for example, the major share of the capacity in a DAB ensemble could be used for providing mobile access to asymmetrical data services, enough revenues may be generated to allow a small, local broadcaster to set up a DAB transmitter. In most cases this would probably require a new regulatory framework.

Scenario 3, finally, has not yet been studied in any detail. To that end, there are some new projects in the IST (Information Society Technologies) programme that deserve particular attention. MCP (Multimedia Car Platform) studies how IP-based broadcast and communication services can be integrated with positioning systems on a vehicle software platform to provide “complete” multimedia in the vehicular environment [15]. DRiVE (Dynamic Radio for IP-Services in Vehicular Environments) takes the problem a bit further by studying how a Common Control Channel (CCC) may be used for dynamic allocation of spectrum to different access channels, including GSM, UMTS, DAB and DVB-T [11][15]. The selection is to be based on customer demands for bandwidth, quality of service, cost, localisation etc.



WorldDAB is carrying out a study which is less ambitious but of principal interest. In the

MEMO system, the connection between DAB or DVB-T and GSM is made at the Winsock level of a PC. WorldDAB is studying the possibilities for a deeper integration in DAB by using a number of system features in GSM, including the SIM card. This would enable broadcasters to use security, billing and revenue sharing mechanisms already deployed in GSM networks. In addition, it would allow downloading of new software to receivers, for instance localised and personalised services using the positioning mechanisms of GSM. Results are not available yet.

Software-defined broadcast systems

DAB and DVB were developed with the aim of providing stable specifications requiring minimal subsequent revisions. All basic services were defined so as to be decodable in hardware or by native software applications.

Standardized receiver functionalities have been considered an effective means for simplifying the task of the manufacturers. WorldDAB has defined a minimum set of DAB receiver functionalities, including voluntary restrictions on screen size and HTML features [16]. These allow manufacturers to build receivers based on hardware decoders or native software applications.

The DVB project realized that digital broadcast systems need mechanisms for downloading and installation of new software applications in receivers. To that end, the MHP DVB-J API fulfils a number of requirements, but mainly for set-top boxes. A corresponding solution for DAB is underway, which may also comprise mobile telephony APIs in order to avoid duplication of functionalities already implemented in GSM.

A multitude of end-user devices

When facing the new media landscape, broadcasters soon came to realize that for them to produce services for different outlet channels, "convergence" actually means "divergence". The combinations of distribution and return channels, local or networked interactivity, transport protocols, user adaptation etc. are manifold. The receiver/terminal capabilities deserve special attention. In recent years, a whole new range of mobile/portable devices have been introduced on the market, which may be further developed to become receivers/terminals for interactive services.

Possible examples include:

- Mobile phone with integrated or attached FM receiver (DAB underway?);
- PDA or pocket PC with PCMCIA card or integrated DAB/GSM chip;

- ⇨ MP3 players with FM/DAB receiver;
- ⇨ Wireless Web radios with base station attached to PC.
- ⇨ Nokia Media Pad with DVB-T receiver.

Obviously, as receiver/terminal characteristics and capabilities proliferate, it will not be possible for broadcasters to tailor services to any specific type. In the long run, this hampers or even makes it impossible to develop new services. This is perhaps the single most important disadvantage of broadcast delivery systems today. Services in competing delivery systems use application software that can be upgraded or replaced at any time. In addition, the vast range of services, content, sources of information, and communication capabilities on the web can be used for comparison. To remain in business, broadcasters need to produce services of comparable attractiveness to those delivered via the Internet.

Software downloading

The situation for broadcasters is radically different from that of Internet-based or mobile service providers. Software downloading to broadcast receivers cannot be compared with downloading another Windows plug-in. Probably a vast majority of users are not expecting to become software support engineers for their radios or TV sets. Even if this may change over time, a fundamental difference remains: on a PC, the user decides when he/she wants to download and install a new application, whereas broadcasters wish to install the new applications in as many receivers as possible to ensure a market for the new service.

Technically this can be done in many ways – solutions exist for example in MHP and for mobile phones. Data carousels can be used for continuous delivery of all applications in use to all receivers. However, as the number of applications increases, this scheme becomes unwieldy. Restricted transmission capacity may introduce unacceptable delays when receiving, installing and executing all the applications required by new receivers, or receivers moving from one service area to another. Adaptations to specific types of receivers/terminals is of course out of the question.

Another approach will become necessary. An interaction channel, such as GSM, allows each receiver to be individually addressed – indeed it could have a unique IP address. Rather than transmitting the software applications themselves, a metadata file containing a list of valid applications can be transmitted, including URLs from where they can be downloaded. Version numbering and other metadata should also be supplied. The user may be alerted to new services, or just browse a directory of services. When a particular service is selected, the receiver checks if the appropriate application is installed, otherwise it automatically downloads it via the mobile network and installs it.

This process may include several steps, for instance checking that the receiver has sufficient capabilities to decode or present the service, or invoking billing mechanisms if the application is not free of charge. Authentication of the terminal, security and pri-

A true story

Andrea, twelve years old, shows her mobile phone to her father. “There are two dolphins on the display – how did you get them there?” he asks. “Well, I went to this web site and ordered them. I had to pay 20 kroner via snail-mail”.

Father doesn’t understand it at all, and asks his colleagues the next day: “Do you know how this could have been accomplished?” Nobody there knows either. How could they, they are R&D engineers in broadcasting!

So father asks his daughter again that evening: “I just don’t understand how you could install these dolphins on your mobile phone!” “But dad,” she says, “it was easy – the web site just CALLED my phone and the dolphins arrived almost immediately!”.

vacy issues are probably other important aspects. Hybrid schemes could be envisaged whereby new applications are broadcast for a limited period using a data carousel, and afterwards the mobile network is used as a fall-back or for providing up-dates or device-dependent code.

No technical solution is proposed here, suffice it to say that several software techniques are available today. Some are already implemented in consumer type equipment. The technology could be applied to broadcast receivers with reasonably small development efforts.

If a system like the above were implemented, a number of useful features could be included. In particular, remote management of receivers/terminals would allow broadcasters to offer customer support and minimize user involvement in technical maintenance of their equipment. It would even be perfectly possible for any user to visit a special website to remotely check the status of his/her own equipment and perform managing tasks. As the panel (*above*) shows, even a child can do that. The possibilities are indeed manifold.

Conclusions

Interactive mobile services may provide new means for broadcasters to remain competitive in the mobile information society by:

- offering user-demanded services that are comparable with those of other media sectors;
- offering added value for users “on the move” and creating possibilities for generating new revenue streams;
- exploiting synergy effects, using DAB/DVB-T networks for mass distribution and 2G/3G networks for return/interaction;

Kjell Engström graduated from the Royal Institute of Technology in Stockholm in 1972, where he worked with the Department of Telecommunication Theory for ten years. In 1980 he joined the Research and Development Department of the Swedish Broadcasting Corporation (SR) and was appointed Head of Research in 1988. The SR Group was reorganized in 1993 and Kjell Engström became Senior research engineer in the new (radio-only) company.

Kjell Engström has been working with most new systems for radio and television broadcasting. For example, he defined the novel Nordic multiplex system for satellite broadcasting proposed to the EBU in 1983 and the digital studio-quality transmission system for audio which is now ITU-R Rec. 724.

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- ⇨ stimulating the definition of appropriate software-based receivers/terminals, thereby allowing continuous development of new applications and services as well as providing means for broadcasters to offer active management of user terminals.

Technology seems to be the smallest of problems in all these scenarios. The main hurdles are more likely to be: planning and implementing suitable networks; bridging the gap between the broadcast and telecommunications sectors by creating appropriate alliances; adapting the legal and regulatory structures to satisfy both sectors, and avoiding the new technologies being used to create new vertical markets rather than open, horizontal ones. If these problems can be overcome, success may well follow the pattern of the Internet: once the tools are in place, creative developers and new actors not dragged by procedural, organizational, legal or other constraints will repeatedly introduce new "products" on the market to the benefit of all parties along the broadcast chain.

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