Trial of a Hybrid DVB-H / GSM Mobile Broadcast System

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***Abstract*— During 2004, a pilot trial for a hybrid mobile multi-media broadcast system combining terrestrial DVB-H broadcast transmission and cellular mobile radio has been carried out in the city of Berlin. This paper describes the system setup for the trial, the implemented prototype applications and the first results of DVB-H coverage measurement campaigns and application trials with friendly test users.**

Index Terms **convergence, DVB-H coverage, hybrid- platform, mobile TV**

I. Introduction

Convergence of mobile and broadcast networks becomes a real opportunity after the launch of first commercial terrestrial TV broadcast services using DVB-T in Germany and other European countries and the introduction of the DVB-H standard to enable mobile handheld DVB receivers. Different terminal manufacturers have announced GSM mobile multimedia devices with integrated DVB-H receivers to be available on the market in the 2005/06 time frame. Regulation authorities have already started to assign dedicated DVB-T multiplex channels for DVB-H multimedia services and trials.

The combination of the capabilities of cellular mobile networks and digital TV broadcasting offers vast possibilities for mobile network operators, multimedia service and content providers, as well as TV broadcasters to provide new services, applications, and interactive TV formats, which go much beyond pure TV channel reception on mobile multimedia handheld terminals.

In order to explore these possibilities, a pilot trial for a hybrid DVB-H / GSM mobile multimedia broadcast system was set up in the city of Berlin in a joint co-operation programme named “bmco” by Vodafone, Nokia, Philips and Universal [1]. The objectives of this pilot trial were:

- to implement a hybrid mobile multimedia broadcast system using DVB-H transmission with IP Datacast for the downlink and cellular GSM for the uplink,
- to implement prototype applications demonstrating the potential of converged mobile broadcast systems and services,
- to investigate the technical performance of the hybrid system and the achievable DVB-H coverage, and
- to investigate user experience and acceptance for the implemented prototype applications.

In Section 2 of the paper, the trial and system setup is described, and Section 3 gives an overview of the implemented prototype applications. The results of coverage predictions and a measurement campaign for the DVB-H transmission in Berlin are presented in Section 4. Section 5 is devoted to the application trial carried out with friendly test users and a complementary market acceptance research. Section 6 summarises the key findings from the DVB-H mobile broadcast trial and gives some recommendations for further steps towards the development and introduction of DVB-H based mobile broadcast systems and services.

II. Trial and System Setup

A. Overall Trial Setup

The Berlin trial aimed at a hybrid mobile-broadcast network, using DVB-H as broadcast system and the existing GSM/GPRS network as interaction channel, cf. Fig. 1. Both networks were aggregated in a "hybrid network services platform", to which the service provisioning applications were interfacing.

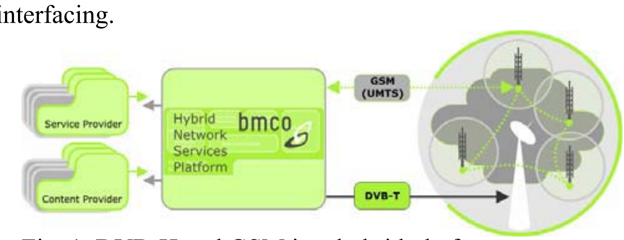

Fig. 1 DVB-H and GSM in a hybrid platform

The hybrid platform provides the interfaces to content providers on the one side and the inter-working between the broadcast and the cellular network on the other side. The signal transmission over DVB-H was accomplished through a DVB-T broadcast network operator [2]. As the DVB-H standard was just being introduced during the trial, a preliminary version of DVB-H with the time slicing feature was used. Also, the Electronic Service Guide (ESG) used was still proprietary.

B. DVB-H Transmission

In Germany, the DVB-T network for commercial terrestrial digital TV transmission is designed to provide portable indoor coverage. This is achieved by the parameter settings of 16 QAM 8 k mode, 2/3 code rate and a guard interval of 1/8 within the bandwidth of 8 MHz. With these settings, a data rate of ~14.75 Mbps can be realised. 8 MHz corresponds to the bandwidth used by one channel of the existing analogue TV broadcast system. As one digital TV channel only needs a bandwidth of about 3.5 Mbps, a total of four digital TV channels, one Electronic User Guide (ESG) and some signalling information for channel detection can be placed within each 8 MHz analogue TV channel. These four channels together are called a “bouquet” or “multiplex” in the DVB-T terminology.

With the selected parameter set it is possible to simultaneously broadcast standard TV services together with DVB-H based services in one channel (transport stream). In the trial, the bandwidth of one TV service (3.5 Mbps) was used for DVB-H, cf. Fig. 2. The IP Datacast system subdivided this bandwidth into 3 DVB-H channels of 1.05 Mbps each. Each of these again can be individually subdivided into service sub-channels of 3 x 350 kbps, 4 x 260 kbps, or 5 x 210 kbps. This allows for a flexible configuration of 9 to 15 DVB-H service channels within the given bandwidth of 3.5 Mbps. One of these channels is reserved for service announcements (ESG, Electronic Service Guide).

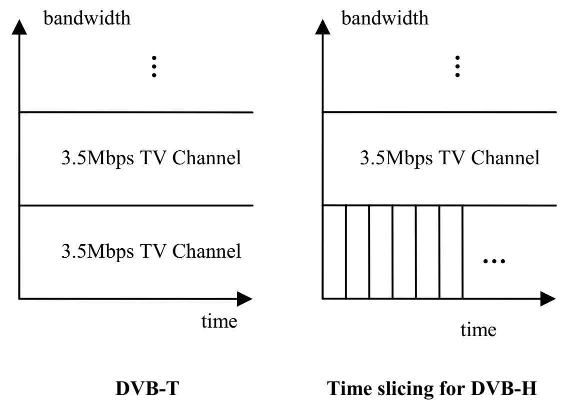

Fig. 2 Time slicing for DVB-H on one DVB-T multiplex

All DVB-H content, including audio and video streams is transmitted via IP multicast. Therefore an IP Encapsulator converts the IP streams generated by the service applications into a DVB transport stream using Multiprotocol Encapsulation (MPE). The encapsulator adds the DVB-H specific features, such as time-slicing and MPE-FEC (Forward Error Correction) when needed. Via fiber optics the transport stream is then sent to the broadcast network operator, where it is multiplexed with other DVB-based services. Finally, the signal is transmitted over a DVB-T single-frequency network (SFN) comprising two broadcast towers, one at Berlin Alexanderplatz with 10 kW ERP and one at Berlin Schäferberg with 5 kW ERP.

On the receiver side, an IP Datacast enabled mobile terminal was used, made up of a GSM multimedia terminal with an operating system based on Symbian Series 90 and an additional DVB-H receiver and IP Datacast module. With time slicing as one of the key DVB-H features allowing the terminal to decode only a part of the DVB stream, a battery lifetime of up to 3 hours of continuous DVB-H reception was achieved.

In the future, a dedicated DVB-H multiplex is planned in Berlin. As an alternative to 16 QAM, which was used in the trial, QPSK is currently under evaluation in order to reach the same coverage compared to DVB-T and to guarantee good indoor coverage for mobile devices [3]. With QPSK the link budget could be improved, but the available data rate would drop to one third of a DVB-T multiplex to approx. 5.5 Mbps. Another drawback of QPSK is that simulcast within a DVB-T multiplex would not longer be possible.

III. Services and Applications

A. Overview

The spectrum of DVB-H based services and usage type’s ranges from streaming to download of content with all sorts of combinations possible. Using streaming mode, a large number of services can be transmitted simultaneously in real-time. This mode is typically used for TV-type services.

In download mode, application data is packaged and downloaded without a strict time relationship to the consumption, therefore the real-time requirements are relaxed. The download transmission is organized with a data carousel and the reception may be scheduled in advance so it can occur unattended by the end user in the background. This mode is typically used for push services, where users receive data regularly once they have subscribed to the service.

In the pilot trial, three types of services were realised:

- Mobile TV:
  streaming of TV-like content to mobile terminals
- Interactive TV and streaming media:
  meeting the demands of response TV by providing voice call-in, SMS or mobile web access as return channel
- Service and content download:
  characterised by using service and content in-dependently from transmission time with different return channel options

B. Mobile TV

For the transmission of TV-like services to mobile DVB devices, the streaming data rate is to be reduced for the following reasons:

The small handheld display exhibits far fewer pixels than a standard TV set and has a limited resolution for image details.

It is necessary to limit the power consumption for receiving, decoding and rendering of the services.

In the trial set-up, the date rate reduction was achieved by re-encoding the audiovisual streams received as DVB-S MPEG-2 based services in QCIF resolution with approx. 12 frames per second, cf. Fig. 3. For the re-encoding, H.263 and MPEG-4 encoding was used for video and AAC for audio. The future DVB-H standard arranges for H.264 and High-Efficiency AACplus V2 for video and audio encoding, respectively.

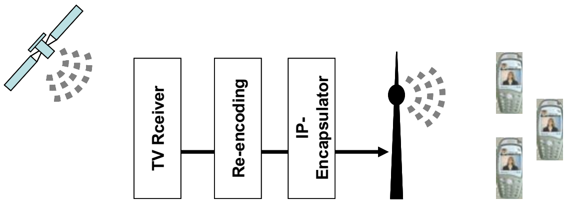

Fig. 3 Service platform for pure mobile TV via DVB-H

A pure mobile TV service does not take advantage of the GSM/GPRS interaction channel, which leads us to the next type of service realised in the trial.

C. Interactive Mobile TV

This type of application starts off from a TV-like service on the broadcast channel and makes extensive use of the GSM/GPRS return channel to enable individual user interactions of any kind. In the trial, an interactive music clip TV programme giving the user the possibility to vote for the next clip or to buy the respective mobile phone ring tone was implemented on the hybrid platform.

Interactive mobile TV is based on video, audio and an auxiliary data stream in the downlink containing additional meta information and data to be rendered synchronously in an application-defined layout on the mobile terminal screen. This layout rendering enables split-screen broadcasts, which are used in standard TV services today, to be viewed with readable text after the QCIF size reduction. Bandwidth is efficiently used for audio and video, while additional text elements are transmitted character-encoded (along with graphics and other elements) and only rendered in the terminal device to the final layout. Examples include tickers, voting lists and interaction links. The auxiliary data rendered on the screen contains buttons that the end user may use to browse information, issue votes and initiate other interactions with the service. The auxiliary data is originated at the content source and is combined with the audiovisual stream in a synchronised "mini-carousel" by the IP Encapsulator, cf. Fig. 4.

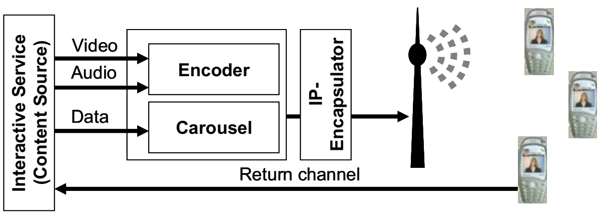

Fig. 4 Hybrid platform for interactive TV and streaming media

On the end-user terminal an application programme is used which receives the three streams, renders the content appropriately and handles all interactions initiated by the end user. Interactions like voting for music clips were realised by SMS messages sent via GPRS to fit into the application's existing infrastructure. IP connections to the service applications can be used as well, e.g. to direct the user to a portal of individualised content for this application.

D. Download Applications Mobile TV

The download method has the advantage that data can be sent during time spans when resources are available e.g. at night or in the background with low priority. The data is stored at the hybrid platform and broadcast with a data carousel at scheduled times. A scheduling mechanism was developed to allow the mobile terminal to tune in efficiently at the times the carousel is on-air. The carousel mechanism allows the terminal to receive the whole data package with the desired content, missing pieces, or just updates. The mobile device stores the received data, which can be completed or updated the next time the data is sent out.

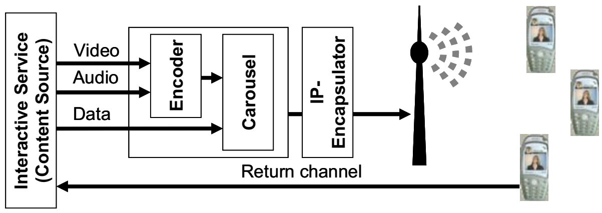

Fig. 5 Hybrid platform with data carousel for content download

In the trial, the content data base of a local event magazine was converted into a data base suitable for a Symbian 90 operating system and connected with interactive and streaming applications. Once the data package was downloaded successfully to the DVB-H enabled mobile terminal, the user was able to use the data in an offline browsing mode. An interactive connection was established by the downloaded application to add additional, personalised information as required. With increasing storage space in the mobile terminal, this option of content distribution becomes more interesting in the future.

IV. Measurement Results

Within the Berlin DVB-H trial, drive tests were carried out to investigate the coverage situation of a DVB-T/H network for mobile outdoor and indoor reception. As the coverage depends mainly on the modulation pattern, DVB-T was used for coverage research instead of DVB-H. The DVB-H specific features like forward error correction, which have an impact on receiver sensitivity and hence coverage, had to be treated theoretically as no fully DVB-H compatible broadcast network and measurement equipment where available during the field test.

The measurement was done with a portable DVB-T measurement device collecting 150.000 measurement points during outdoor drive tests. In addition, the indoor coverage in 40 selected buildings was investigated. With these measurements, the field strength prediction model for the radio planning tool Atoll was calibrated. Fig. 6 shows the measured and simulated values. The figure shows a good correspondence between measurement results and prediction model.

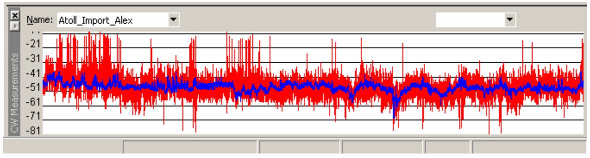

Fig. 6 Comparison of measurement data with field strength prediction

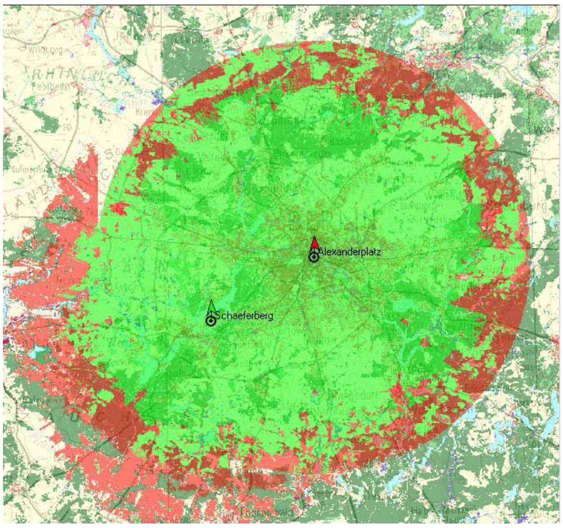

Fig. 7 Outdoor coverage with 66/59 dBµV/m for 95 % and 70 % coverage probability

As shown in Fig. 7, a good outdoor coverage can be achieved by the two broadcast towers used in the trial with a height of up to 300 m. The outdoor coverage was calculated for signal strength of 66 dBµV/m and 95 % reception probability (green). The coverage threshold assumed in Fig. 7 ensures a roof top antenna reception for DVB-T programs. For a mobile indoor reception further parameters have to be taken into account, e.g. the expected gain of the mobile terminal antenna. In the simulations for this trial, a negative gain of –7 dB was assumed. Another parameter is the expected indoor penetration loss. Two figures (15 dB and 20 dB), which are typically used in cellular network simulations, were used for the simulations.

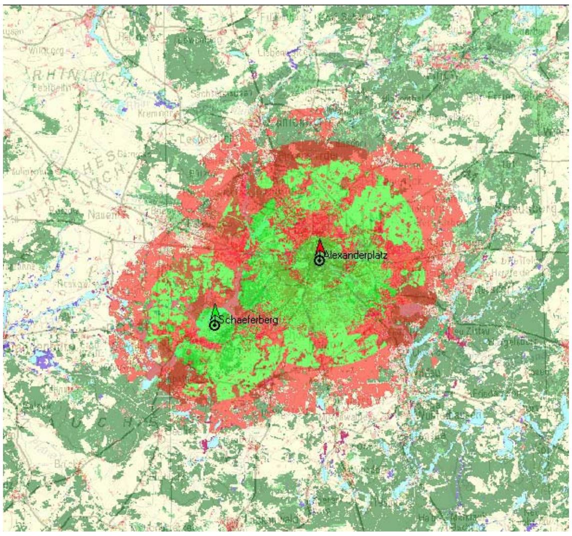

Fig. 8 Indoor coverage with 81/74 dBµV/m for 95 % and 70 % coverage probability (15 dB penetration loss)

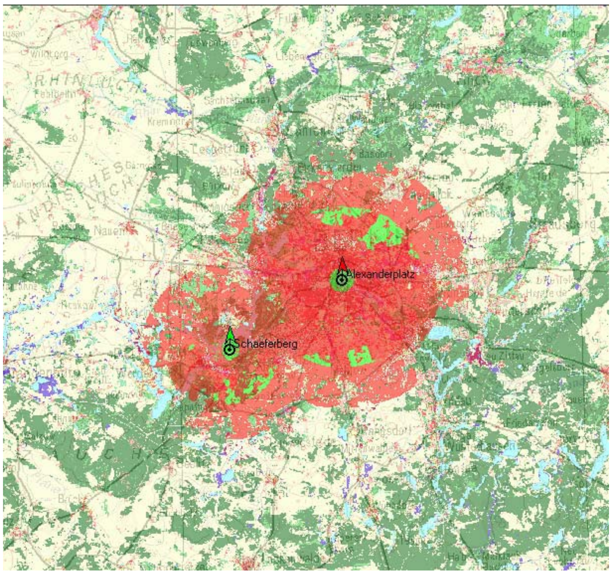

Fig. 9 Indoor coverage with 86/79 dBµV/m for 95 % and 70 % coverage probability (20 dB penetration loss)

A 15 dB indoor penetration loss leads to a significant decrease of the covered area, cf. Fig. 8. For a deep indoor mobility even 20 dB penetration loss can be assumed. The results of this scenario are shown in Fig. 9.

The gathered drive test data of Fig. 10 for a deep indoor coverage with 20 dB indoor penetration loss confirm the simulation results shown in Fig. 9.

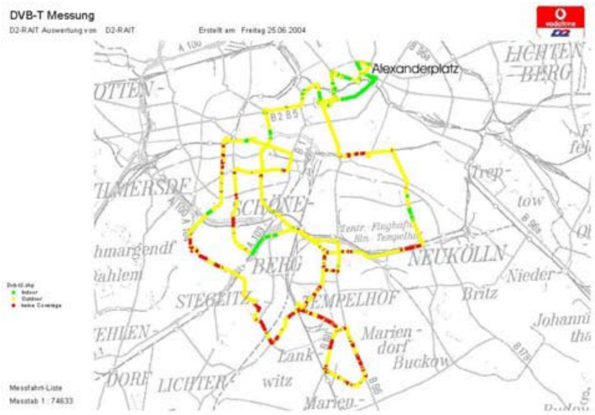

Fig. 10 Drive test analysis with 20 dB indoor penetration loss

According to Fig. 10, deep mobile indoor coverage can only be achieved in a small area around the transmitter and in areas with direct line of sight to the transmitter.

V. Friendly User Trial

A. *Friendly User Trial*

The goal of the Berlin trial was not only to show the technical feasibility of mobile-broadcast convergence, but also to investigate the user acceptance for such new products and services.

A friendly user trial was set up with 20 users in total, 60 % male and 40 % female users with an average age of 35 years. To assure statistical relevance of the usage results, users have been chosen who live and work in good coverage areas. Six different TV channels with sport, news, shopping, entertainment and music content were made available to the friendly users on DVB-H enabled mobile terminals. In addition, a new interactive format based on music clip voting was offered.

The services offered in the trial were well received by the test users. It turned out that the most frequently used service has been sports while shopping was the least frequently used. The experienced reception of the DVB-H channels during the trial has been 58 % usage with "permanent reception" and 37 % usage with "partial reception".

In addition to the friendly user trial, a market survey has been carried out which revealed a high user interest in interactive TV formats and a high willingness to pay for these kind of services.

VI. Conclusion

The Berlin trial has clearly demonstrated the technical feasibility of a hybrid DVB-H / GSM mobile multimedia broadcast system. New and attractive interactive mobile TV formats and multimedia download services were implemented end-to-end successfully, starting from new interfaces for content delivery at the one end, up to the integration of the new applications into a DVB-H enabled mobile multimedia terminal at the other end.

The DVB-H outdoor coverage achieved in the Berlin trial was excellent. Indoor coverage, however, is critical and depends heavily on parameters such as transmitter height and power, indoor penetration losses, as well as DVB-H system and receiver parameters which are not yet finally fixed. This needs to be elaborated further as the layout and cost for a DVB-H transmitter network providing good mobile indoor coverage is crucial for the viability of a business case for commercial DVB-H service.

The user feedback on the tested prototype applications in Berlin was excellent, too. The accompanying market research study has revealed a high user acceptance for TV-like content on mobile devices, as well as a serious willingness to pay for these kinds of services, in particular if interactivity is involved.

It is expected that the positive findings from the Berlin trial will help to promote the development of converged mobile-broadcast systems, services and devices in the manufacturer, mobile operator and broadcast community. What is urgently needed to pave the way for this new and promising field of business is

- on the standardisation side, the rapid finalisation of the relevant standards, especially in the area of content interfaces, mark-up languages and interactive middleware for mobile terminals,
- on the regulatory side, a nation- and european-wide harmonised availability and accessibility of DVB-H capacity for converged mobile-broadcast multimedia services.

Acknowledgment

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