DTT Quo Vadis

— Germany as a case study

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This article looks at the prospects for DVB-T and DVB-T2 in Germany, in view of the fact that the future of classical terrestrial TV broadcasting in the country is under discussion and that it may even be terminated before the end of the decade. The article also identifies solutions for media delivery to portable and mobile terminals such as in-car receivers or Tablet PCs which no longer rely on classical terrestrial broadcasting.

Terrestrial broadcasting is the traditional means of delivering live video and audio content to viewers. Whereas in the past, neither cable nor satellite or broadband networks – both wired or wireless – existed or were able to compete with terrestrial content delivery: today, terrestrial networks are just one of several means of reaching the radio and TV audiences.

As a result of the re-unification of Germany some 20 years ago, free-to-air satellite delivery of all relevant radio and TV programmes has become a reality. When Germany was reunited, the 18 million people in the five new states, on the territory of the former German Democratic Republic, wanted to be offered *West-Fernsehen* (western television) immediately – and satellite delivery was the only way of making this happen. Since those days, whoever is able to set up a satellite dish on his/her balcony or roof will have the full range of TV (and radio) programmes available free-of-charge, many of them in HD.

It is important to be aware of this German speciality in order to understand the discussions that are on-going in the country. In many parts of Germany, cable TV is also widely accepted. The introduction of DVB-T, which started in 2003 and which was finalized in 2008, took this situation into consideration. DVB-T parameters were chosen which turned classical terrestrial broadcasting into a means of delivering TV content not only to stationary but also to portable and mobile receivers, thereby taking advantage of the unique feature of terrestrial networks – the ability to reach uncabled devices. In consequence, more than one million cars are equipped with DVB-T receivers and some six million USB sticks etc. – with built-in DVB-T frontends – have been sold. In many households, at least the second TV set in the kitchen, the nursery etc. receives DVB-T using just a small rod antenna.

Using DVB-T, the public broadcasters ARD and ZDF offer 12 TV programmes across Germany. Commercial broadcasters, on the other hand, have been sceptical regarding the commercial case for DVB-T. They decided to transmit their programmes mainly in urban areas where they expected a significant number of households to use terrestrial reception even in the living rooms. It is important to understand that their income from the presentation of commercials is not simply correlated with the number of people watching these commercials. What matters is the number of those people watching their programmes which are part of the audience metering panel operated jointly by all public and commercial broadcasters. People watching TV in cars, on laptops etc., are not included in the audience metering panel and therefore don't create income. In addition, the commercial broadcasters rightly assumed that, outside the urban areas, many people would have no problem setting up a satellite dish and would therefore watch free-to-air satellite TV on their primary television sets.

Fig. 1 shows the percentage of households using DVB-T in the 16 *Laender* (federal states) of Germany. The left column represents the average of all states (12.5%) and indicates the number of TV households in the country (37.977 million) [1]. This diagram carries an important message. In states where commercial programmes are on-air (for instance HB: Bremen, B: Berlin), DVB-T reaches some 26% or 23% of the households. In states where only the programmes of ARD and ZDF are on-air, the percentage of households using DVB-T is very low (for instance SL: Saarland, SA: Sachsen-Anhalt). While considering this fact, it becomes clear that, for classical terrestrial TV broadcast to be accepted by the public, both public and commercial broadcasters have to be present.

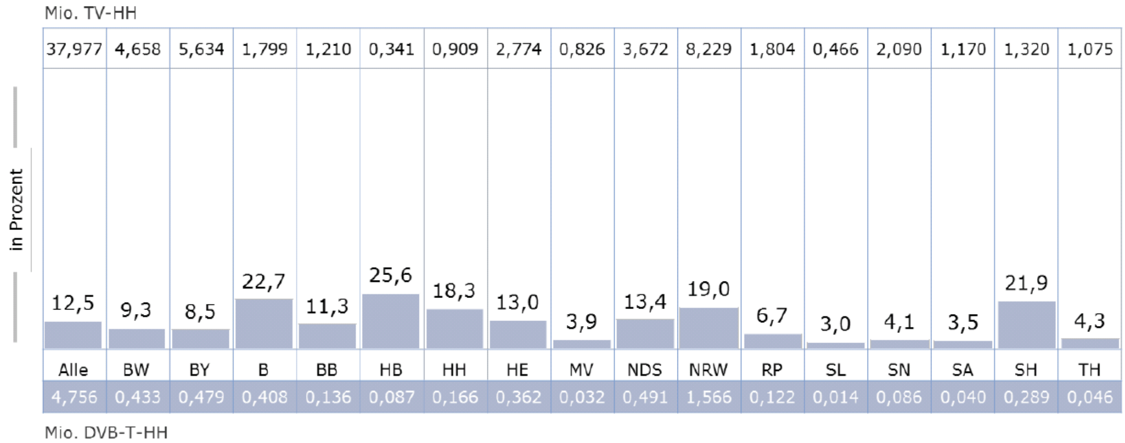

Figure 1
Percentage of households using DVB-T in the 16 states of Germany

Preparing for the introduction of DVB-T2

The second generation DVB system for terrestrial broadcasting (DVB-T2) is already in commercial use in several countries around the world. The primary application of the networks operated in these countries is the transmission of HDTV content to stationary receivers equipped with roof-top aerials. However, the DVB-T2 standard has been developed as a toolbox, offering a significantly wider range of potential application scenarios. Based on the deliberations guiding the introduction of DVB-T, a possible introduction of DVB-T2 in Germany would need to encompass portable and mobile receivers.

The DVB-T2 standard foresees a variety of algorithms for potentially increasing its performance, e.g. Rotated Constellations, Multiple Physical Layer Pipes (M-PLPs), transmit diversity (Multiple Input Single Output, MISO), or a sophisticated time-interleaver. Due to the fact that in other countries the introduction of DVB-T2 focused on stationary reception, the performance of the available parameter configurations for portable and mobile reception was not really field-tested and only predicted through simulations. To verify the existing simulation results and to identify the optimal parameter configuration, a consortium of several institutions and companies evaluated DVB-T2 for stationary, portable and mobile reception in a “DVB-T2 field trial in Northern Germany”. The field trial started in August 2009 and ended in July 2012. Many participants were involved, e.g. German media authorities, public and commercial broadcasters and network operators. The *Institut fuer Nachrichtentechnik* (IfN) of *Technische Universitaet Braunschweig* was the technical coordinator. The project was supported by many guests, including equipment manufacturers, the car industry represented by VW etc. Besides evaluating DVB-T2 in all its facets, another main objective of the field trial was to define a potential introduction strategy for DVB-T2 in Germany.

In order to analyze the DVB-T2 system under realistic conditions, a DVB-T2 network was established in the region south of Hamburg. This trial network consisted of two transmitters which were about 45 km apart and which operated at 690 MHz. Furthermore, the transmitters were operated in an SFN (Single Frequency Network) mode, i.e. both transmitters radiated identical signals – synchronized in time and frequency – and used the same carrier frequency.

One transmitter was located in Rosengarten (with an antenna height of about 150 m above the average terrain level), operating at an output power of 10 kW ERP. The other transmitter was situated in Lueneburg (antenna height about 130 m above average terrain) and was operated at a power of 5 kW ERP. Both SISO (Single Input Single Output) and MISO operation were supported by this network. The signal transmitted from Lueneburg was vertically polarized, whereas the transmitter in Rosengarten delivered a horizontally-polarized signal. During MISO operation, the transmitter in Rosengarten transmitted MISO group 1 and the transmitter in Lueneburg MISO group 2.

The measurements carried out within the trial network focussed on portable and mobile reception. *Fig. 2* shows the three different areas which were selected for portable measurements. Seevetal is located near the Rosengarten transmitter. Therefore, this transmitter mainly contributes to the reception there. Winsen is located exactly in the centre of the SFN network. In Lueneburg, the signal from the Lueneburg transmitter was dominant. During the measurement campaign, which lasted for six weeks, 35 sets of parameter configurations were investigated. Almost all parameter configurations were measured in all three measurement areas, leading to 87 measurement locations in the entire area. In total, 3162 individual results were collected.

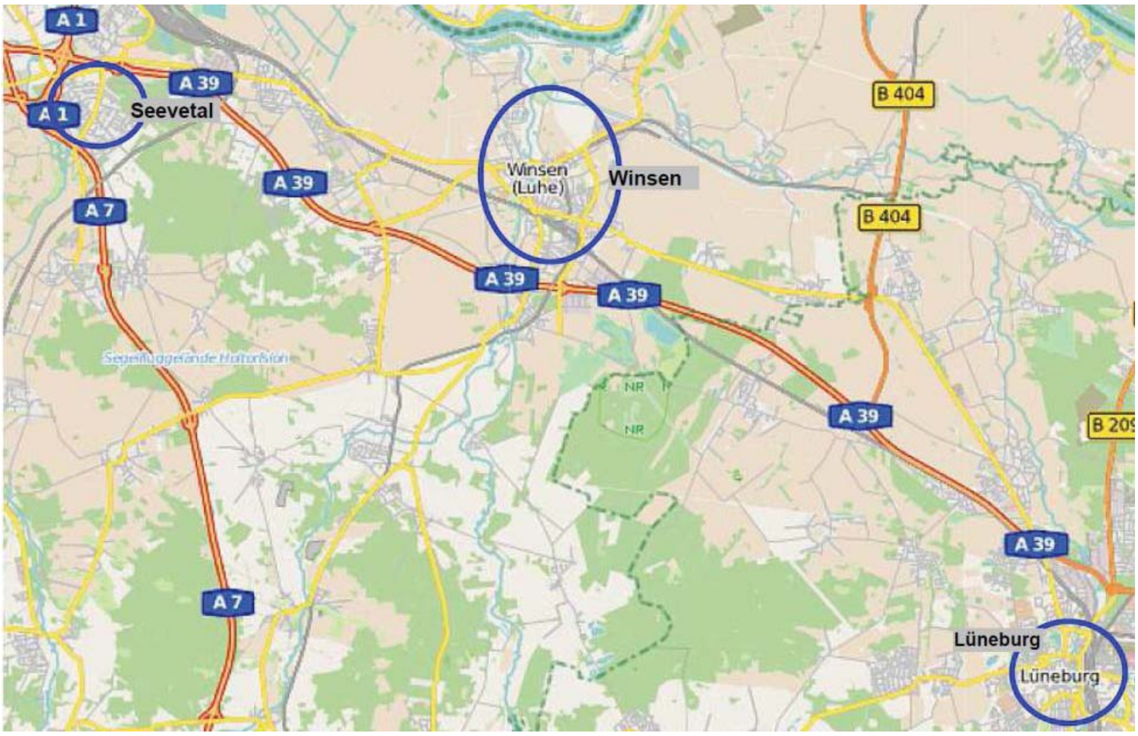

Figure 2
Geographic location of the three measurement areas in the DVB-T2 trial network
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For our evaluation of the mobile reception of DVB-T2, no test receivers were available on the market. Therefore, a mobile DVB-T2 measurement receiver was developed by the IfN team, which is based on a “software defined radio” concept [2]. This means that the actual decoding is performed in software on a high-performance standard PC. Thus, the measurements were done in two steps. In the first step, the complete channel was sampled using a generic hardware frontend and the resulting data was stored on a hard disk. In the second step, the data was decoded in non-real-time on this PC. In addition to the decoding of the recorded signal, the receiver is also able to determine the local and momentary characteristics of the transmission channel. During the measurements, GPS data was simultaneously recorded. Hence, the receiver links the measurement data with their geographical positions and depicts them on a map.

The route used for measuring the performance of mobile reception comprised different areas with different reception characteristics (*Fig. 3*). These areas included town centres (e.g. Winsen) with heavy traffic, dense buildings and a maximum allowed speed of 50 km/h, as well as country roads (up to 100 km/h) and the “Autobahn” between Lueneburg and Rosengarten which has no speed limit. The measurement route also included a tunnel (the Elbtunnel), where no signal reception was possible. This tunnel was used to determine the noise level of the receiver.

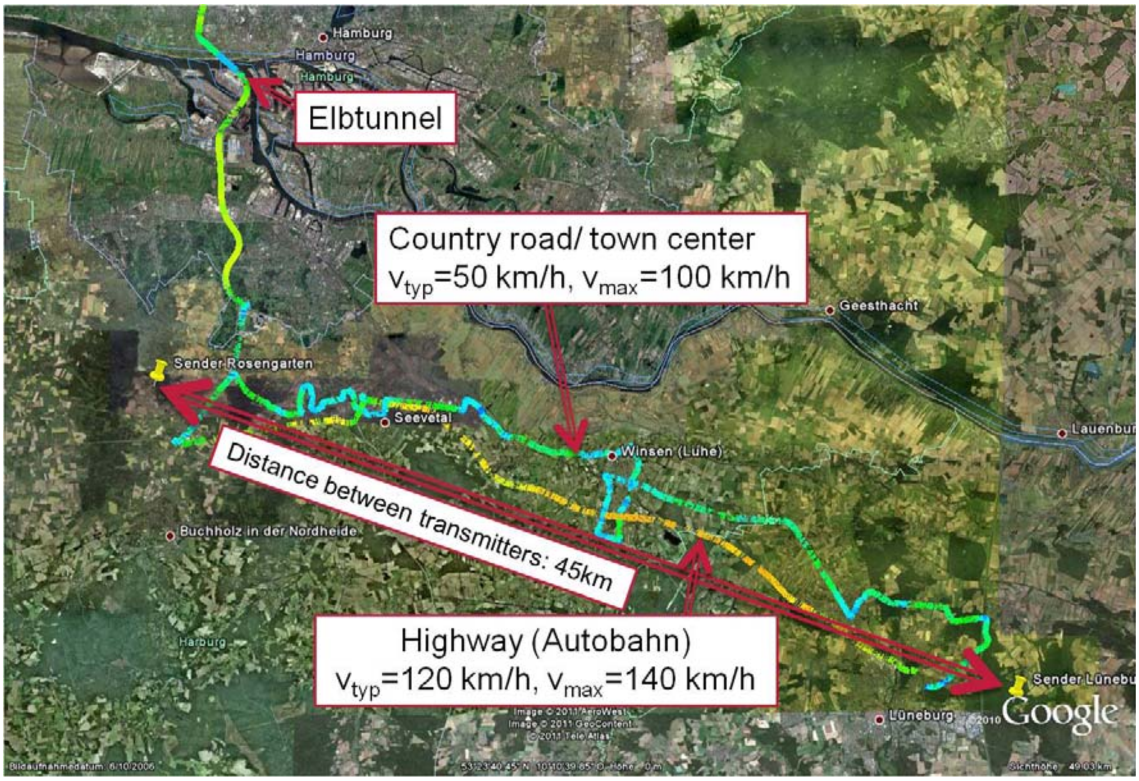

Figure 3
The measurement route used for the mobile tests. The two yellow pins show the positions of the transmitters.
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The focus of the measurements was on the region in the centre of the SFN, accompanied by measurements in some areas where the received signal was dominated by the signal from one transmitter. The region in the centre of the SFN exhibits a very difficult channel condition, especially since the direction of the Autobahn used for some of the tests is in parallel to the direct line between Rosengarten and Lueneburg (resulting in a maximum positive plus negative Doppler shift).

The length of the measurement route was about 114 km. In total, a distance of 1600 km was travelled. During a single test drive, a data volume of around 300 GB was recorded.

The huge amount of results that was generated by the field trial cannot possibly be presented in this article. It has been published in a book written in German [3]. We translated the most significant part of this book into English and made that translation available to DigiTAG. We expect that DigiTAG will offer this document to interested parties in the near future. Some key findings are:

- the use of MISO and Rotated Constellations is neither recommended for portable nor for mobile reception;
- the use of Extended Carrier Modes is recommended;
- for portable and mobile reception at speeds up to 50 km/h, the 32k FFT is a good option;
- Pilot Pattern PP4 is only recommended at the moment for portable reception – for a higher mobility, PP2 is more suitable;
- for reception at high speeds, the 16k FFT with Pilot Pattern PP2 is a suitable option.

In view of the results of the trial, the partners agreed on three possible scenarios for the introduction of DVB-T2 in Germany and decided the DVB-T2 modes that would be best suited for these three scenarios — assuming that, for video coding, H.264/AVC MPEG-4 part 10 will be used and that statistical multiplexing will be implemented.

Service scenario 1

Primarily addressed are portable and mobile terminals.

The image quality is defined as **SDTV**, teletext is offered, a stereo audio signal is sufficient, and HbbTV is supported. In this case, for each programme, 1.4 -1.6 Mbit/s is required for the video signal, 270 kbit/s for teletext, 128 kbit/s for the audio signal and 10 bit/s for the HbbTV signalling. This adds up to between 1.8 and 2.0 Mbit/s per programme.

In this scenario, the appropriate DVB-T2 mode is 16k FFT, 16 QAM and code rate 3/5. For reliable reception, a signal-to-noise ratio of 11 dB for stationary and portable reception and 14 dB for mobile reception is needed. The data rate available for the complete multiplex is 14.8 Mbit/s of which 14.1 Mbit/s remains after deducting 0.7 Mbit/s for PSI/SI data and null packets. This data rate is sufficient for the transmission of about 7 to 8 SDTV programmes.

Service scenario 2

Primarily addressed are stationary as well as portable and mobile terminals.

The image quality in defined as **SDTV+**, teletext is offered, two stereo audio signals are required, sub-titles have to be transmitted and HbbTV is supported. In this case, for each programme, 2.1 - 2.4 Mbit/s is required for the video signal, 270 kbit/s for teletext, 256 kbit/s for the audio signals, 100 kbit/s for the sub-titles and 10 kbit/s for HbbTV signalling. This adds up to between 2.8 and 3.1 Mbit/s per programme.

In this scenario, the appropriate DVB-T2 mode is 16k FFT, 64 QAM and code rate 3/5. For stationary and portable reception, a signal-to-noise ratio of 16.4 dB is needed, and for mobile reception, 24.4 dB. The data rate available for the complete multiplex is 22.2 Mbit/s of which 21.5 Mbit/s remains after deducting 0.7 Mbit/s for PSI/SI data and null packets. This data rate is sufficient for the transmission of about 7 to 8 SDTV+ programmes. Alternatively, 4 to 5 SDTV+ programmes and a single HDTV programme can be accommodated in the multiplex.

Service scenario 3

Primarily addressed are stationary, HDTV-capable receivers.

The image quality is defined as **HDTV**, teletext is offered, multichannel sound is necessary, sub-titles have to be transmitted and HbbTV is supported. In this case, for each programme, 6.3 - 7.2 Mbit/s is required for the video signal, 270 kbit/s for teletext, 384 kbit/s for the audio signal, 100 kbit/s for sub-titles and 10 kbit/s for HbbTV signalling. This adds up to between 7.1 and 8.0 Mbit/s per programme.

In this scenario, the appropriate DVB-T2 mode is 32k FFT, 64 QAM and code rate 2/3. For reliable reception in stationary and portable reception environments, a signal-to-noise ratio of 17.0 dB is required. The data rate available for the complete multiplex is 27.3 Mbit/s of which 26.6 Mbit/s remains after deducting 0.7 Mbit/s for PSI/SI data and null packets. This data rate is sufficient for the transmission of just 3 to 4 HDTV programmes.

Dynamic Broadcast

Today, state-of-the-art TV sets (iDTVs) and set-top boxes (STBs) are equipped with an Ethernet interface and/or Wi-Fi modem. In addition, such “hybrid” iDTVs and STBs provide built-in hard disks (HDDs) or at least interfaces to an external storage device connected via USB or the local area network. Hence, today’s most modern receivers provide new functionalities, aimed at enhancing the viewer experience.

Firstly, the presence of a storage device in the receiver enables the implementation of personal video recorder (PVR) functionalities. Secondly, the extended connectivity of hybrid iDTVs and STBs allows the users to gain access to online services such as video-on-demand (VOD), games, programme information, news and many more. Currently, a number of receiver manufacturers use this connectivity in order to offer their own, individual web portals. But this connectivity can also be used by television networks for offering additional data services synchronized to the current TV programme, by making use of middleware standards such as HbbTV. In doing so, additional TV-related content can be delivered via a broadband network to be combined with the broadcast content in the receiver.

Dynamic Broadcast goes beyond the concept of "additional services" as it allows real interworking between the two delivery media: **broadcast** (BC) and **broadband** (BB). Although "comfort functions", such as today's access to web applications, can be implemented in a Dynamic Broadcast system, the focus of the concept lies in minimizing both the cost and the spectrum consumption of the content delivery. *Fig. 4* provides a simplified system overview. A more detailed description can be found in [4], [5] and [6].

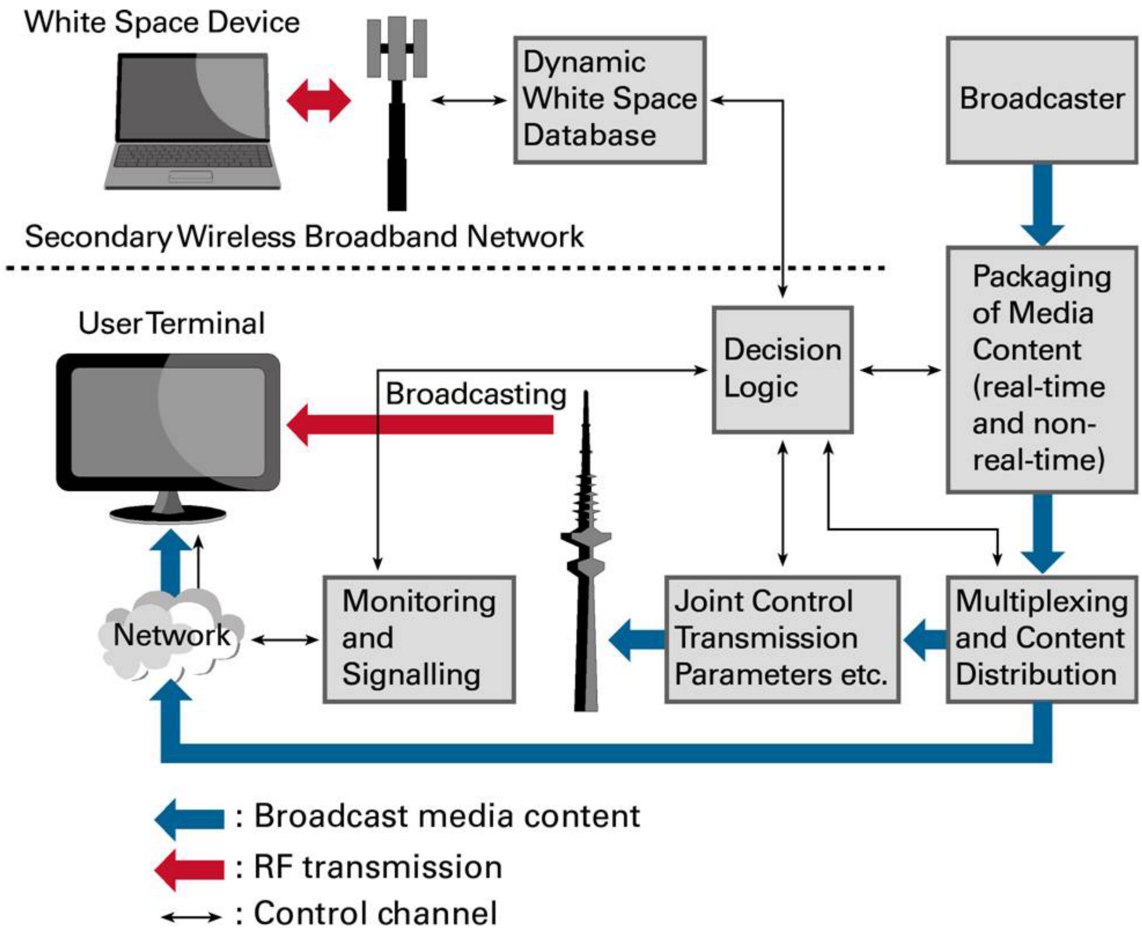

Figure 4
Dynamic Broadcast system overview

System description

In Dynamic Broadcast, linear TV services can be transmitted equally well via a BC or a BB network. Furthermore, the bidirectional BB connection is also used to exchange information such as monitoring, signalling and scheduling data between the receivers and a network management unit. This communication channel allows the receivers to be informed whenever changes in the heterogeneous network occur, so that the distribution channels of each single TV service can be changed dynamically, even during a running TV programme.

As a result, Dynamic Broadcast no longer uses the static assignment of TV services to pre-determined distribution channels but allows deciding, dynamically, over which of the networks, BC or BB, a certain piece of content corresponding to a certain TV programme will be delivered. For instance, the delivery via BC is optimal if there are a large number of viewers watching a TV programme, whereas a small audience would lead to the decision that BB is the ideal distribution channel. The receiver then constructs linear TV services out of individual pieces of content delivered via different channels and thereby becomes an active network component that switches between different delivery networks seamlessly and automatically. Hence, the network management system is capable of optimizing the use of spectrum allocated to BC as well as the load on the BB network, so that the cost of delivery can be minimized. As can be seen from *Fig. 4*, the complete picture of the Dynamic Broadcast system also includes an interface to potential users of managed TV White Spaces. Hence, the availability of TV White Spaces – dynamically generated through Dynamic Broadcast – is signalled, allowing the use of these White Spaces by operators of wireless broadband networks in a fashion controlled by the broadcast network operator.

Beyond the connections to BC and BB networks, a local storage device built-in or connected to the receiver is of great importance. The pre-transmission of content, which is available in advance (pre-produced content), provides another degree of freedom for the network optimization, as it allows distinguishing the content delivery time from the presentation time. The time-shifted delivery via BC, for example during the night, allows lowering the number of receivers that will have to receive the corresponding TV programme live on the next day. Only those receivers that did not record the programme will then have to receive the live stream via BB while the rest is able to play back the content from the local storage device. On the other hand, in order to reduce the load of the BB network during daytime, a pre-download of the content via BB during low traffic hours can be used. The time-shifted delivery of TV content even allows creating virtual TV channels that entirely consist of pre-stored content.

In contrast to PVRs, where the recording of a TV programme is initiated by a user request, the pre-transmission of TV content requires the automatic recording by the receiver, which is initiated by scheduled signalling messages received from the network management.

At last year’s *Internationale Funkausstellung* show in Berlin (IFA 2012), we demonstrated a complete Dynamic Broadcast System – including the use of dynamically-allocated TV White Spaces by a Wi-Fi extender, thereby increasing the data rate on the Wi-Fi link through the use of a momentarily freed-up TV channel in the UHF band.

Germany — a country without classical terrestrial broadcast?

One way of looking at Dynamic Broadcast is to assume that classical terrestrial broadcasting exists in a country and that the pressure on spectrum requires new approaches to the optimized allocation of spectrum in such a way that, from the point of view of the TV audience, the traditional broadcast experience remains unchanged whereas the pressure on TV spectrum is reduced by dynamically offering this spectrum to secondary users. But what if classical terrestrial broadcasting is terminated?

On 16 January 2013, the RTL group – one of the two leading commercial TV broadcasting organizations in Germany – announced that they will stop broadcasting their four currently-available programmes via DVB-T from 1 January 2015. In regions where their existing contracts with the broadcast network operator ends earlier, they will stop distributing their programmes via DVB-T accordingly. In the Munich area, RTL will go off-air as early as August 2013. The regional media authority expects that some 360’000 households will be affected in this region. RTL mentions two reasons for this decision: (i) the commercial viability of classical terrestrial broadcast no longer exists and (ii) they are afraid that, in Germany, the long-term availability of spectrum is not guaranteed. The second leading commercial TV broadcasting organization indicated that they will decide about their future commitment to classical terrestrial broadcasting before the end of March 2013.

The consequences of this decision by RTL seem to be easily predictable:

1) DVB-T2 will not be introduced;
2) as soon as the RTL programmes disappear, the affected audience will start to move away from DVB-T;

3) the use of cable, satellite and IPTV networks will increase;
4) the percentage of households relying on DVB-T will drop to levels which have been explained earlier in this article for those federal states (*Laender*) which already today lack commercial TV programmes in the DVB-T networks;
5) a discussion will start about the economic viability of the remaining terrestrial TV services since an audience share of just a few percent will raise the question of economic viability even for the public broadcasters ARD and ZDF;
6) as a consequence, DVB-T will be switched off eventually;
7) terrestrial radio stations will have a serious problem in financing the broadcast infrastructure, such as transmitting stations with their towers and masts, since they will have to carry the full costs alone;
8) the only way of distributing video content to portable and mobile devices will be through Wi-Fi, cellular networks or via yet-to-be-developed technologies.

Extending LTE by a Tower Overlay

With LTE, and soon with LTE-Advanced (LTE-A), the 3GPP organization provides a new standard for mobile radio communications. A flat network architecture and innovation on the physical layer support low latencies of 10 to 50 ms and a maximum shared gross data rate of up to 100 Mbit/s (LTE) and 1 Gbit/s (LTE-Advanced) within a single network cell. These new features open the market for online gaming, they promise faster Internet access and also enable point-to-multipoint (P2MP) services such as live TV on small-screen mobile devices through the use of eMBMS (evolved Multimedia Broadcast Multicast Service). Due to those new services and the ever-growing number of video-enabled mobile user terminals – such as smartphones, tablet PCs, notebooks etc. – a strong increase in the data traffic carried by mobile radio networks has been predicted by many organizations.

Fig. 5 [7] shows a typical prediction for the global data traffic in wireless networks (i.e. a nearly exponential growth pattern over time). It assumes that mobile video will play an important role in the near future. It should be understood that in 2017 – according to the source of this diagram – some 46% of the data traffic will not be distributed over cellular networks but will be offloaded to networks such as

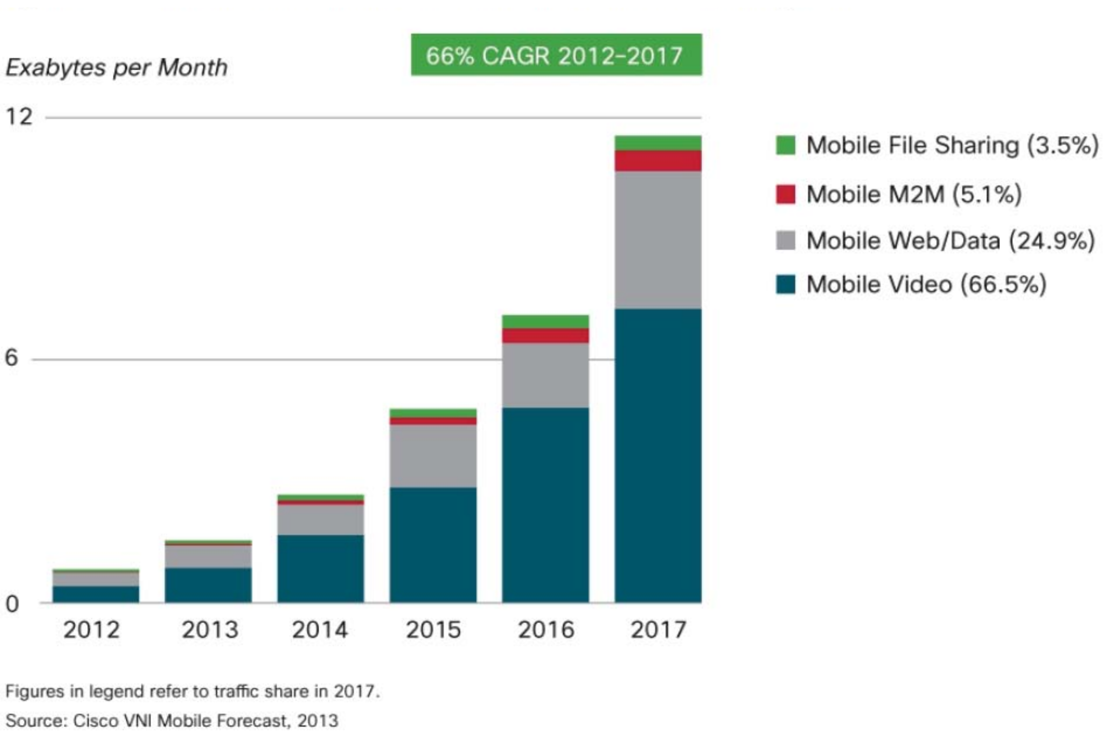

Figure 5
Global forecast of data traffic over wireless networks [7]

Wi-Fi. Wi-Fi is typically used in private homes or in public hotspot areas. 54% of the data traffic will be generated by people in other locations and will therefore have to be delivered over cellular networks.

The need to handle a growing amount of video is one reason for operators of cellular networks to push for the availability of more spectrum. The "digital dividend" has led to the reallocation – to cellular services – of the UHF band between 790 and 862 MHz, which had previously been allocated to TV broadcasting. Decisions made at the World Radio Conference in 2012 (WRC-12) will lead to a possible second digital dividend as a result of the up-coming WRC-15 conference. The co-primary use of the 694 - 790 MHz band by broadcast and mobile radio technologies may be a possible outcome of that conference.

Considering the case of Germany, where classical terrestrial TV may eventually no longer be in operation, such a second digital dividend may be quite meaningless. In this country, it can be expected that mobile video not only means on-demand streaming over LTE or LTE-Advanced in a unicast mode (e.g. downloading a YouTube clip), but also the delivery of live video.

The Multimedia Broadcast Multicast Service (MBMS), first integrated in the 3GPP UMTS standard with release 6, had initially been deployed in order to support the delivery of short low-resolution video clips. It was discarded later due to the lack of available resources within UMTS networks and in consideration of the fact that unicast services offered a higher potential for an economically viable network operation. After enhancements of the UMTS standard such as HSPA, and HSPA+ became available, the idea of a broadcast-like service in cellular networks was revitalized.

In release 9 of the 3GPP standard, eMBMS (evolved MBMS) is defined. It takes advantage of the innovative features of LTE such as the use of OFDM on the physical layer and therefore not only supports the transmission of P2MP (point-to-multipoint) data in a single network cell, but also supports single frequency networks (SFNs) consisting of multiple cells covered by multiple, time synchronized eNBs (evolved Node B – the network base stations) transmitting the same data on the same frequency (called carrier). This operation is termed MBSFN (Multimedia Broadcast over a Single Frequency Network). The SFN network topology is well known from DAB, DVB-T and DVB-T2. A set of eMBMS services, being transmitted within an SFN over multiple cells, defines an MBSFN area. Up to eight different MBSFN areas are supported within a single cell. Each MBSFN

Abbreviations

3GPP	3rd Generation Partnership Project
AVC	H.264 / Advanced Video Coding, MPEG-4 part 10
BB	Broadband
BC	Broadcast
DAB	Digital Audio Broadcasting (Eureka-147
DVB	Digital Video Broadcasting
DVB-T	DVB - Terrestrial
DVB-T2	DVB - Terrestrial, version 2
eMBMS	Evolved Multimedia Broadcast Multicast Service
ERP	Effective Radiated Power
FFT	Fast Fourier Transform
GPS	Global Positioning System
HbbTV	Hybrid Broadband Broadcast Television
HSPA	High-Speed Packet Access
iDTV	Integrated Digital (or Decoder) TeleVision
IFA	*Internationale Funkausstellung* (Berlin consumer electronics exhibition)
IPTV	Internet Protocol Television
ITU	International Telecommunication Union
LTE	Long Term Evolution (4th generation mobile networks)
MBMS	Multimedia Broadcast Multicast Service
MBSFN	Multimedia Broadcast over a Single Frequency Network
MCH	Multicast CHannel
MISO	Multiple Input, Single Output
OFDM	Orthogonal Frequency Division Multiplex
P2MP	Point-to-MultiPoint
PSI	(DVB) Programme Specific Information
PVR	Personal Video Recorder
QAM	Quadrature Amplitude Modulation
RF	Radio-Frequency
SFN	Single-Frequency Network
SI	(DVB) Service Information
SISO	Single Input, Single Output
STB	Set-Top Box
UHF	Ultra High Frequency
UMTS	Universal Mobile Telecommunication System
USB	Universal Serial Bus
WRC	(ITU) World Radiocommunication Conference

area can carry multiple Multicast Channels (MCHs) with different scheduling assignments and specific modulation and coding schemes applied to the eMBMS services that are multiplexed within.

A disadvantage of eMBMS is the requirement to co-exist with unicast services on the same carrier, to ensure a simultaneous reception of P2MP and unicast services. In consequence, eMBMS is bound to the dense cellular infrastructure of typical mobile communication networks. Future research and (hopefully) field trials will be required to evaluate the technical and economic feasibility of eMBMS for the use case of live video delivery to portable and mobile devices. Currently, an issue with eMBMS is the fact that in countries such as Germany, a number of cellular network operators have built individual cellular networks (four in Germany). Today's smartphones and tablet PCs are required to use a SIM card in order to connect to one of these networks. Would it therefore be necessary to deliver live video in four cellular networks in parallel in order to reach the population of terminals out there?

Another issue is the kind of usage conditions offered by today's cellular network operators. True flat rates have been replaced by volume tariffs (i.e. monthly data caps). When a certain amount of data has been downloaded (for example 10 GByte per month), the data rate available to the individual user is reduced to, for example, 384 kbit/s. Assuming that a live video service that provides an SDTV+ video quality (appropriate for a tablet PC) requires a data rate of 2.5 Mbit/s (see Scenario 2 above), the monthly data cap of 10 GByte will be extinct after just 9 hours!

As a possible solution for an effective transmission of broadcast and multicast data, which overcomes the limitations of the classical cellular network, we suggest a Tower Overlay network topology as shown in *Fig. 6* [8]. The main characteristic is a wide coverage area achieved by using a relatively small number of transmission towers. Such a Tower Overlay network would ideally be a single network jointly supported by all national cellular network operators.

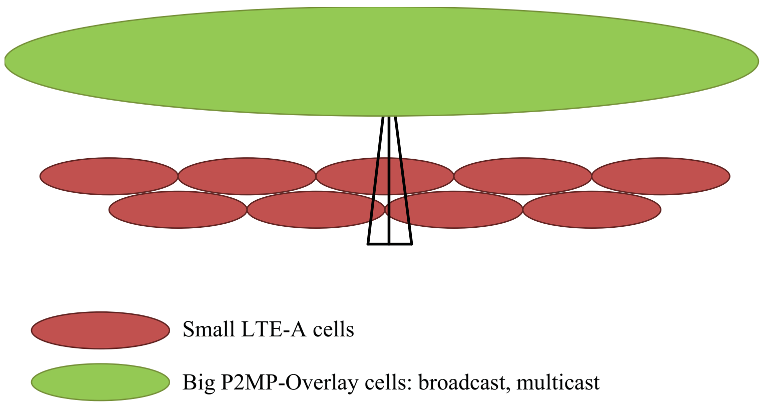

Figure 6
The concept of a Tower Overlay over cellular networks

In order for the user terminal (e.g. smartphone or tablet PC) to be connected to the cellular network of an individual network operator, in addition to being able to receive P2MP data over the Tower Overlay network, it is logged in to the cellular network and handles the unicast services via that network. The required simultaneous provisioning of both P2MP and unicast services is achieved by carrier aggregation, one of the key features of LTE-Advanced since release 10 of the 3GPP standard. The general idea behind this technology is the aggregation of up to five contiguous or non-contiguous LTE release-8 carriers to increase the available bandwidth within one cell and thus increase the maximum available data rate per user.

These so-called component carriers support all current LTE bandwidths from 1.4 MHz up to 20 MHz and can be located within the same or different frequency bands. We extend the idea of carrier aggregation by using one or more carriers for the cellular unicast services and one more carrier for the Tower Overlay network. One of the unicast carriers provides the user terminals with all required system information for both the cellular and the Tower Overlay network. A possible scenario would be a unicast carrier located in the 2.6 GHz band – used in many LTE networks today – and the P2MP carrier located in the UHF band to provide a large coverage area.

Future "release 10" user equipment that supports non-contiguous carrier aggregation will provide the required multiple RF units for this dual-link reception. Some extensions of the current LTE-Advanced standard will be required for the Tower Overlay concept to become real. A consortium of organizations is currently considering our proposal and may eventually support its presentation in 3GPP.

Conclusions

Classical terrestrial TV broadcasting is an important element in the world of electronic media in many countries of the world – but less so in Germany. It is to be expected that DVB-T2 will never be introduced and that a somewhat historic decision may be taken in only a few years time – to give up DVB-T altogether. Wi-Fi and cellular networks will be the only means for the delivery of video content to smartphones, tablet PCs and other portable devices. It is to be expected that today's technologies such as LTE or LTE-Advanced will not be able to provide the required services in an economically viable way. In order to be able to deliver live video streams in particular, extensions of the cellular networks will be required. With the concept of a Tower Overlay over LTE-A, we propose one possible solution to the problem.

Readers interested in our proposals for the possible future allocation of (parts of) the UHF spectrum to the various stakeholders – such as TV broadcasters (if any), operators of cellular networks, programme-making special events (PMSE) services and public protection and disaster relief (PPDR) organizations etc. – may wish to download an English version of reference [9] from the website of the German Federal Ministry of Economics and Technology (BMWi), which should become available soon.

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