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Technical Notebook

COOPERATION AND CONVERGENCE BETWEEN BROADCASTING AND MOBILE SERVICES USING LTE NETWORKS

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CITEL
Inter-American Telecommunication Commission
1889 F St.NW #1020
Washington, DC
United States
http://citel.oas.org

For additional information please contact:
José Costa
Tel.: +1 613 963-8288
E-mail: jose.costa@ericsson.com

or
Executive Secretary of CITEL
Tel: +1 202 458 3004
Fax: +1 202 458 6854
E-mail: citel@oas.org

TECHNICAL NOTEBOOK[1]

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CITEL uses Technical Notebooks when:

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e) Documenting standards, completed or in progress, for new or existing services, which may be considered for future development into a CSD in accordance with the approval procedures of the Technology Working Group.

The members of CITEL have not approved the contents of this document.

[1] PCC.I/RES. 142 (XV-01)

CONTENTS

Scope

This Technical Notebook on "Cooperation and convergence between broadcasting and mobile services using LTE networks" provides information to plan the deployment of broadband services using a variety of access platforms and it is in fulfillment of Decisions PCC.II/DEC. 146 (XX-12)[2] and PCC.II/DEC. 151 (XXI-13)[3]. This Technical Notebook will be updated in the future when further information and experience with deployments becomes available.

Abstract

Wide-spread provisioning of TV services has convincingly shaped cultural developments since the last century; terrestrial radio broadcast transmission (linear has been the original form of TV distribution. In recent years linear TV has been complemented by several forms of video on-demand services, be it IPTV based movie stores or web-based video clips services. As part of further developments, content providers and program makers are exploring new distribution channels, including fixed and mobile broadband networks.

This Technical Notebook describes current trends in multimedia delivery and provides an overview on the Multimedia Broadcast/Multicast Service (MBMS) that in recent years has been introduced in 3GPP specifications, including LTE, as one solution for live streamed TV as well as podcasting. Furthermore, this paper discusses opportunities to enable new forms of multimedia delivery, while continuing the original form of delivery of terrestrial TV broadcasting services.

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[2] http://www.oas.org/citeldocuments/Download.aspx?id=2062

[3] http://www.oas.org/citeldocuments/Download.aspx?id=2275

1. Introduction

Broadcasting offers an effective way of distributing traditional (linear) programming to large populations in real time and with the use of recording devices the delayed consumption and archival of programming by users may also be possible. However, there are also the consumers' increasing demands to access programming "a la carte" anywhere, anytime. In recent years linear TV has been complemented by some form of video on-demand, be it IPTV based movie stores or web-based video clips services[4]. Indeed, the web sites of broadcasters, which are among the largest and with most traffic at national levels, offer proof of the growing popularity of innovative, streamed media services. Users employ a variety of devices to access such programming "a la carte", ranging among Internet-enabled TV sets, desktops, laptops, tablets, c-boards, and smartphones, among others that continue to proliferate.

Mobile broadband user terminals, such as smartphones and tablets, are increasingly important for access to media content and services. Innovative media services are among the main drivers of broadband take-up. Mobile broadband is becoming a significant delivery platform for broadcasters and it also enables more dynamic and interactive access of content.

However, the full potential of mobile broadband for the delivery of broadcasting content and services to large audiences is still unknown. A somewhat limited understanding between mobile and broadcasting communities may present an obstacle in this regard. For example, studies have been conducted within CITEL PCC.II as part of the work on the digital dividend spectrum resulting from the digital television transition and opportunities for application convergence, and the Cooperative Terrestrial Networks (CTN)[5] program of the European Broadcasting Union (EBU) including its CTN-Mobile Group[6] whose activities are described in the following three paragraphs.

The EBU CTN-Mobile Group aims to define a common terminology between broadcasters and mobile broadband communities in order to formulate conditions (for example operational, technical, economic or regulatory) that would have to be fulfilled in order to make the mobile broadband a viable platform for the delivery of broadcasting content. It also plans to investigate for which use cases and usage patterns the delivery of broadcasting content using mobile broadband technologies would be feasible and beneficial for public service broadcasters, taking into account their current and future requirements and constraints.

The scope of work of the CTN-Mobile Group is to study the relevant technical, operational and regulatory issues associated with the delivery of broadcast services, both linear and nonlinear, over mobile broadband networks. The principal objectives are to:

- Establish a constructive forum where broadcasters and the mobile industry can explore the future developments, including possible links between mobile broadband and terrestrial broadcasting.
- Build a knowledge base within the EBU community about mobile broadband technologies and their potential benefits for broadcasters.
- Provide an opportunity for the mobile industry to gain insight into broadcasting options that may contribute to meeting a growing user demand for media services.
- Identify possibilities for cooperation, including viable business models.

Currently discussed issues include:

- Broadcasters' requirements related to the delivery of content and services over mobile broadband.

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4 For a description of linear and non-linear TV see, for example: http://www.hans-bredow-institut.de/de/forschung/linear-and-non-linear-television-viewers%E2%80%99-perspective

5 http://tech.ebu.ch/groups/ctn

6 http://tech.ebu.ch/groups/ctnmob

- Features of the LTE specifications that may be important for the delivery of broadcast content.
- A case study on delivery of high-definition television (HDTV) over LTE eMBMS (evolved Multimedia Broadcast / Multicast Service).

The purpose of this Technical Notebook is to explore some of these activities and results to date with regards to relevant items related to convergence of applications, such as:

- types of services and applications that might be introduced;
- available technology choices including support for possible convergent offerings between digital television; broadcast providers and mobile broadband service providers.

This Technical Notebook considers previous contributions on convergence, such as CCP.II-RADIO/doc. 2601/11 entitled “Possible convergent offerings between digital television broadcast providers and mobile broadband service providers, including technology choices” and CCP.II-RADIO/doc. 2809/11 entitled “Proposed study on review of regulatory framework for converged video distribution services”.

Section 2 provides an overview of IP-based media services and Section 3 describes the LTE Multimedia Broadcast and Multicast Service. More technical aspects in the case of ATSC such as spectrum requirements and power consumption are presented in Sections 4 and 5 for ATSC and DVB-T, respectively. Furthermore, DVB-T is covered as a case study in Annex 1. Finally, Section 6 contains a summary and an outlook for the potential for further cooperation and convergence between Broadcasting and Mobile Service using LTE networks. Annex 2 provides examples of current and planned deployments of LTE broadcasting networks that are described in this Technical Notebook. Annex 3 provides a list of the abbreviations used.

2. Examples of IP-based Media Services

New IP-based media services are being developed, refined and made accessible over fixed and mobile broadband networks. Traditional as well as a new variety of content is developing, including social media, texting and chatting that is engaging and entertaining a growing audience. In particular the younger and middle-aged audience groups are establishing these new behaviors where media content, in addition to the living room based TV set, is also consumed on desktops, laptops, tablets and smartphones. Whatever the case may be in terms of future consumption, access to radio and TV-based content over broadband networks is becoming an essential element of future IP-based media services.

While still covering a significant consumer base, as well as large geographical areas, the current analogue or digital terrestrial broadcasting technologies are the primary, or the only, means of delivering TV services to a living-room based TV set using a fixed antenna, in numerous countries. It would be exceptionally demanding to substitute these technologies for the purpose of modernization and adaption to the new behavior of consumers and the new variety of content provisions. The reality is that both forms of access will coexist and evolve in their own ways for a long time and win-win solutions need to be developed for the cooperation and convergence between Broadcasting and Mobile Services.

For example, an upgraded TV network may not be available in sparsely populated areas for a considerable period of time, nor may the radio frequency spectrum be available in sufficient amounts in populated areas to provide for an early transition to digital TV technologies. It is therefore expected that the current terrestrial broadcasting technologies will remain in use for years to come, both for FM radio and TV services. In some countries, the availability of terrestrial TV program channels and TV viewing time is still on the increase. However, in other countries the increase of viewing time is now becoming more flat, or even having a somewhat negative trend with regard to linear TV viewing [1], particularly with regard to the younger TV audience.

Television watching now is becoming a social event as people are using social media to discuss what they are watching. Indeed, the referred study [1] shows "Social TV: sixty-two percent of people use social networking sites and forums while watching TV on a weekly basis and this number is growing. Of these people, forty percent will be discussing what they are currently watching on TV over social networks."

Notably, studies have shown that consumer behavior is changing in terms of freedom of location, time and choice when accessing content, as well as improved quality, quantity and interaction. One other significant change in behavior is the growth of non-linear content. Accordingly, a trend is emerging with broadcasting focusing on live events whereas stored content will increasingly be made available by streaming.

An essential question to consider when satisfying the new demands of media consumers is how to provide access to linear and non-linear content while using different devices and different sized screens. Broadcasting networks are suitable for linear content, and TV receivers are now being equipped with broadband access. Fixed and mobile broadband networks are well suited for non-linear content with interactive use, and the devices primarily used on those networks are highly flexible with regard to usage and mobility, though not currently equipped with broadcast TV receivers.

In February 2010, the Canadian Radio-television Telecommunications Commission (CRTC) released a report entitled "Navigating Convergence: Charting Canadian Communications Change and Regulatory Implications", an analysis of many of the trends, opportunities and challenges that faced the industry at that time. Since the document was published, many of the trends it identified have not only continued, but also accelerated. The 2011 follow-up report [2] entitled "Navigating Convergence II: Charting Canadian Communications Change and Regulatory Implications" describes an environment characterized by greater-than-anticipated consumption of content from Internet sources, further consolidation within the communications industry, substitutability of services, a proliferation of communications devices, and network traffic growth for both fixed and wireless networks. The report focuses on the evolution of wired and wireless networks, media-consumption trends and consumer-related issues.

Furthermore, in the 2012 annual "Communications Monitoring Report", which provides an overview of the Canadian communications sector, it is shown that Canadians are consuming more content, both traditional television and radio broadcasts and digital media content [3]. On a weekly basis, they watched an average of 28.5 hours of television, up from 28 hours in 2010, and listened to an average of 17.7 hours of radio, up from 17.6 hours the previous year. Canadians also actively consumed digital media content. Typical users watched 2.8 hours of Internet television per week, an increase from 2.4 hours in 2010. Four per cent of Canadians report only watching television programming online, while 4% watched programming on a smartphone and 3% on a tablet. Additionally, Canadians also stream the signal of an AM or FM station over the Internet.

Support for wireless feeds for news gathering applications

In addition to the demands of media consumers, mobile broadband networks also provide interesting opportunities for supporting wireless feeds for news gathering applications for program development in the domain of Electronic News Gathering/Outside Broadcasting services (ENG/OB). This mobile broadband application provides real time feeds for broadcasting; the users could be professionals (e.g., camera people on a motorcycle following an event and transmitting the feed using LTE) or consumers (e.g., people with Blackberry terminals sending videos to newspapers and broadcasters). Indeed, the more advanced LTE networks enable the transmission of high-definition (HD) video streams from live cameras with the low latency and high quality required for studio feeds. This has been demonstrated in several events, including:

- Swedish Crown Princess' Royal Wedding in 2010, where Swedish TV companies broadcasted live from the celebrations in Stockholm, as well as being available live from the official website of the wedding [2];
- Japanese Nippon TV reporting from the Nobel press conference in Stockholm 2010 [3];
- YouTube streamed the entire wedding of Prince William and Kate Middleton's event live from The Royal Channel, which was built specifically for wedding. BBC provided full streaming of the event at BBC News' dedicated wedding site. It was possible to watch the entire event live on a smartphone or other Internet devices such as tablets [4].
- For the Summer Olympics 2012, Bell Mobility and Rogers set up Canada's Olympic Broadcast Media Consortium (in both English and French) to broadcast live events from London over the Internet, TV, and mobile. One week into the Games, 61% of the traffic on the Consortium's digital platforms was powered by mobile devices, receiving nearly 90 million page views and indicating an enthusiastic shift in consumer behaviour as viewers took the Games with them wherever they went [4]; and
- Viewer statics for BBC on Olympics 2012 are available at http://www.bbc.co.uk/blogs/bbcinternet/2012/08/digital_olympics_reach_stream_stats.html.

Compared to using alternative dedicated/transportable links for ENG/OB, LTE networks can be more readily setup with less overhead. The LTE quality of service framework ensures priority for the ENG/OB services above other types of traffic in the LTE network, thereby providing carrier-grade performance. The LTE quality of service framework ensures priority for the ENG/OB services above other types of traffic in the LTE network, thereby providing carrier-grade performance.

Cooperation and convergence between broadcasting and mobile services

For these reasons, it is necessary to address further the opportunity of new advanced IP-based mobile broadband radiocommunication technologies to offer a complement to the current terrestrial broadcasting technologies with the aim of improving the consumer experience.

Traditional linear TV distribution networks and LTE networks are complementary and can be used in cooperation very effectively in order to support the evolving consumer demands. The combination of the two modes of delivery enables the easy introduction of new advanced services and applications and supports successful convergent offerings between digital television, broadcast providers, and mobile broadband service providers.

Currently mobile operators have sufficient capacity for the additional traffic generated by the discussed new service offerings. The future rapid increase in the traffic volume, however, calls for additional capacity and new solutions. The rest of this paper is addressing these challenges.

An overview of the Multimedia Broadcast / Multicast Service (MBMS) that has been introduced in 3GPP specifications in recent years, including for LTE, is presented, as one solution to cope with live TV as well as podcasting. One advantage of MBMS is that it enables the use of single frequency networks (SFN) in TV broadcasting. LTE-MBMS is based on SFNs and therefore an overview of a study of the spectrum requirements for TV broadcasting over LTE is presented.

3. LTE Multimedia Broadcast and Multicast Service

A broadcast mode for mobile broadband transmission has been standardized for the WCDMA based radio access standard in 3GPP Release 6 as part of the Multimedia Broadcast and Multicast Service (MBMS). An overview of the main features is reproduced in this section from [5].

MBMS has been further enhanced in 3GPP Release 7 and Release 8 [7]. The LTE radio access standard, for which MBMS support has been introduced in 3GPP Release 9 [8], is designed for reception by mobile and handheld devices but supports signal reception equally well for fixed receivers (e.g., with rooftop antennas). MBMS based on WCDMA has been included in Recommendation ITU-R BT.1833 on *broadcasting of multimedia and data applications for mobile reception by handheld receivers* [9]. The enhanced MBMS of Releases 7-9 based on WCDMA and LTE has also been proposed to ITU-R as a candidate radio technology for a new draft Recommendation ITU-R BT.[DMB2NDGEN] on the *second generation of broadcast systems of multimedia and data applications for mobile reception by handheld receivers* [10].

MBMS enables synchronized transmission between multiple transmitters in the form of *single frequency network* (MBSFN) operation. In this way, identical signals are being broadcasted by multiple transmitters synchronously and do not mutually interfere with each other – they amplify each other and thus improve the overall signal quality. Another advantage of SFN operation is that it allows a direct frequency reuse (i.e., reuse factor 1) in all broadcast transmitters providing the same signal. Thereby it can be avoided that large amounts of spectrum are blocked in neighboring regions.

If in contrast, different signals are sent out by different transmitters these can of course interfere if they are transmitted from sites that are too close to each others. Such transmitters typically belong to different MBSFN areas and must be separated by a frequency reuse distance. An MBSFN area therefore needs to be surrounded by a guard area where transmission of different signals on the same channel is prohibited. Due to the small distance between MBMS sites using cellular infrastructure, also the reuse distance can be made much smaller than that for a traditional TV transmitter. A cellular architecture also allows greater control over the availability of coverage in populated areas, thus minimizing the size of the guard areas. Typical reuse distances for cellular architectures are only a few times the inter-site-distance. Furthermore, MBMS supports MBSFN area specific reference symbols so that an advanced receiver can estimate the channels to the wanted and interfering MBSFN transmitters [11]. This can be exploited for interference cancellation algorithms in the receiver.

The LTE MBSFN is similar to the Distributed Transmission System (DTS) of ATSC in radiating the same signals over a covered area with multiple transmitters. On the physical layer, while ATSC uses a single carrier transmission, LTE uses multi-carrier transmission based on Orthogonal Frequency Division Multiplexing (OFDM). The long data symbol duration in OFDM helps mitigate inter- symbol-interference (ISI) caused by delayed signals from distributed remote co-channel interferers. OFDM in LTE furthermore uses a guard interval. Delayed signals arriving within the guard interval after the first signal to which the receiver is synchronized do neither cause ISI nor inter-carrier-interference (ICI) between the OFDM sub-carriers. The use of OFDM with a guard interval enables a very simple receiver design. In contrast, DTS-ATSC receivers have to apply time domain equalization of the very high delay spread introduced by the DTS multi-site transmission. Delay spread is particularly large for a high distance between transmitters. In addition to the OFDM-specific ISI immunity, the higher site density of a cellular infrastructure that is typically used for MBMS leads to reduced delay spread compared to the low transmitter density of ATSC infrastructure. Finally, ATSC does not provide transmitter or DTS specific reference or training symbols. Cancelling interference from transmitters not belonging to the DTS is therefore difficult.

MBMS is tightly integrated into the WCDMA and LTE standards. With a firmware or software upgrade, User Equipment (UE) can gain MBMS capability, as it uses a common physical layer and MAC layer framework with the LTE unicast (i.e. mobile broadband) services. The technology entry barrier for supporting MBMS in the general LTE UE is therefore particularly low. LTE-MBMS can also be used in a downlink only fashion, which means that no return link is required from the broadcast receiver to the transmission infrastructure. MBMS can also be time- multiplexed with mobile broadband services, which can also be used to enable interactivity for the broadcast services or upcoming "Hybrid-Digital-TV" services [12].

LTE-MBMS supports stream based and file based delivery methods. The stream based method delivers a continuous flow of IP packets using the real time protocol (RTP) whereas the file based method delivers content file by file. Some recent services that appear to the end user as streaming are actually using file based transmission where the entire media file is divided into fragment files that are transmitted sequentially, using e.g. the Dynamic Adaptive Streaming over HTTP (DASH) protocol [13]. The file based distribution also can be used for podcasting, where users subscribe to a service to receive multimedia files regularly. The file distribution can work in the background and gets stored locally on the terminal flash memory so that it is available on-demand by the user.

LTE-MBMS is also suitable for classical TV and audio broadcast distribution. The dense deployments enable a better utilization of the frequency band that is allocated to TV. Deployment of LTE networks for cellular mobile broadband communication in the market has already started and a strong build-out is expected.

4. Spectrum Requirements for TV over LTE

In order to provide the capacity required by the rapidly growing demand in mobile multimedia as well as ENG/OB services over LTE some countries have defined targets in their National Broadband Plans. For example, the U.S. national broadband plan [6] has expressed the target to provide additional 500 MHz of spectrum to mobile communication systems in the next 10 years, of which 300 MHz shall already be provided within the next 5 years. Some if this frequency spectrum is supposed to come from the spectrum band that is currently allocated to TV services. The spectrum could be made available mainly by a combination of efficiency measures, e.g. channel repacking, channel sharing, better network architectures, including cellular-like architectures. This was the motivation for evaluating TV distribution over LTE for fixed roof-top receivers in [5]. The paper considers 4 market areas in the USA, each extending over several hundreds of kilometers. The areas have been selected from sparsely as well as densely populated areas. Using TV channel coverage data extracted from the Federal Communications Commission (FCC) database, the maximum number of overlapping channels in each market area has been determined. The highest number of overlapping channels is present in the San-Francisco Bay Area (SFBA) with 20 channels, as shown in Figure 1. It is assumed that the typical service offering on a TV channel is 1 HDTV plus 1 SDTV program resulting in a total service rate $S \approx 13$ Mbit/s. The aggregate peak service rate in the SFBA is 260 Mbit/s.

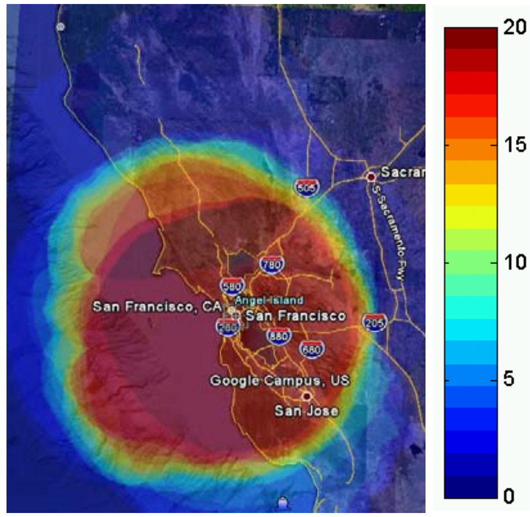

Figure 1 NUMBER OF LOCALLY AVAILABLE ATSC CHANNELS IN TV MARKET SAN FRANCISCO BAY AREA

Next, the spectral efficiency for TV distribution over LTE-MBMS has been determined by simulations, based on 3GPP propagation models but modified in order to reflect rooftop reception with Yagi antennas.

MBMS can be configured with a core symbol duration of 66.7 µs, guard interval of 16.7 µs and subcarrier spacing of 15 kHz or a core symbol duration of 133.3 µs, guard interval of 33.3 µs and subcarrier spacing of 7.5 kHz. For fixed roof- top reception the more appropriate long guard interval is assumed in the simulations. An interference model has been applied taking into account MBSFN self interference.

MBMS can be operated using QPSK, 16QAM or 64QAM, together with a fine granularity of turbo code rates. This allows optimal selection of the modulation and coding scheme (MCS) for the achievable SINR. In this example the MCS is set so as to achieve 95% service availability considering uniformly distributed receiver locations, i.e. reception will fail with a 5% location probability. The failure criterion is a block error ratio (BLER) of 10^{-3}. The failure behavior is very sharp, so that the result would not change significantly if a lower BLER was considered.

The MBMS spectral efficiency depends on the inter- site-distance between LTE sites. Figure 2 shows a typical result, assuming that an LTE carrier is dedicated to MBMS, not time multiplexed with unicast data.

The peak spectral efficiency is 3.1 bit/s/Hz and is maintained up to an ISD of 2 km and 3 bit/s/Hz can be maintained up to an ISD of almost 4 km. Beyond that ISD, MBSFN self interference starts to degrade the performance.

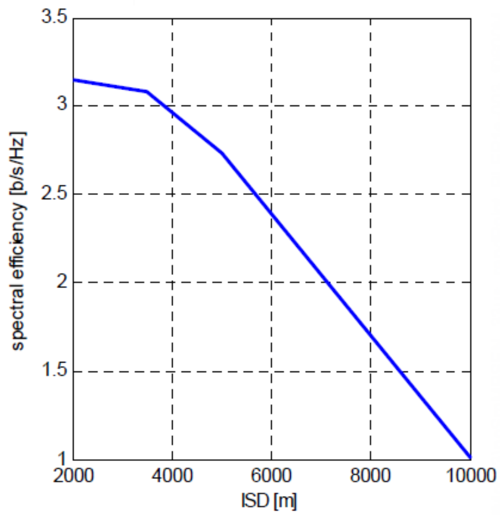

Figure 2 MBMS SPECTRAL EFFICIENCY FOR FIXED ROOFTOP RECEPTION

It is also assumed that an ISD of 2 km is prevalent in the densely populated areas such as the San-Francisco Bay Area, where the number of available TV channels is also highest. In order to provide the total maximum service bit rate of 260 Mbit/s assumed to be in use today by ATSC TV services, the total spectrum requirement for MBMS is:

260 Mbit/s / 3.1 bit/s/Hz = 84 MHz

It is noted that the more efficient spectrum usage of MBMS (84 MHz) compared to ATSC (300 MHz) can be assigned to two different effects. Currently, TV stations are not efficiently packed into the physical 6 MHz channels. In this example of one HDTV and on SDTV station being transmitted via one ATSC channel, only 13 Mbit/s are transmitted via a ATSC channel that is capable to transport up to 19.2 Mbit/s. Consequently, 32% of the spectrum saving (i.e., 1-13 Mbit/s/19.2 Mbit/s) is due to multiplexing TV programs, so that no unused capacity remains in the MBMS system. The remaining saving is due to the MBSFN transmission mode and short reuse distances against neighboring MBSFN areas. The spectral efficiency when neglecting the reuse distance is very similar between MBMS and ATSC, for which the efficiency can be calculated to 19.2 Mbit/s/6 MHz=3.2 bit/s/Hz.

5. Power Consumption

Using a dense network for TV distribution instead of a sparse network raises the question of the impact on total power consumption. The total EIRP required for a desired coverage area as well as the power consumption has been investigated in [8], for a classical TV roof-top reception scenario, based on assumptions listed in TABLE I.

TABLE I ASSUMPTIONS FOR POWER COMPARISON

parameter/model	**value/description**
carrier frequency	600 MHz
Bandwidth	8 MHz
propagation model	Recommendation ITU-R
SNR target	18 dB
noise figure	9 dB
receive antenna gain	10 dBi
transmit antenna gain	10 dBi
shadowing margin	9.9 dB

For the (DVB-T) TV transmitter it is assumed a power efficiency of 23% [14]. For the LTE transmitters the power consumption information provided in [15] is used, representing a state-of-the-art transmitter of the year 2010. For the power amplifier (PA), an efficiency of 26% can be calculated for a macro base station, which is quite close to the DVB-T transmitter efficiency. The PA establishes an output power dependent power consumption. Cooling power is not considered for both MBMS and DVB/T. To the PA power a fixed power consumption has to be added for the baseband as well as RF signal generation and reception part. In [8] this is calculated as 17.7 W. Since a dense LTE network uses many sites to achieve the same coverage area as a single TV transmitter, the question is how this EIRP-independent power overhead will impact the total power consumption.

Considering that a dedicated carrier for MBMS will likely be added to an existing eNB rather than deploying an eNB dedicated to MBMS, there could be some power related synergies. Such are, however, not considered in this model, for the sake of a pessimistic power consumption assessment.

Figure 3 shows the total power consumption of a single TV transmitter site of 500 m height above average terrain and for a cellular network with omnidirectional transmitters of 37.5 m height and varying ISD. For the TV transmitter curve the shape is given by the propagation model. For the cellular network the curves are straight lines representing the square growth of the number of sites with the intended coverage radius. The total EIRP decreases with decreasing ISD, because the number of sites increases with a power of 2 whereas the path-loss decreases with a power larger than 2.

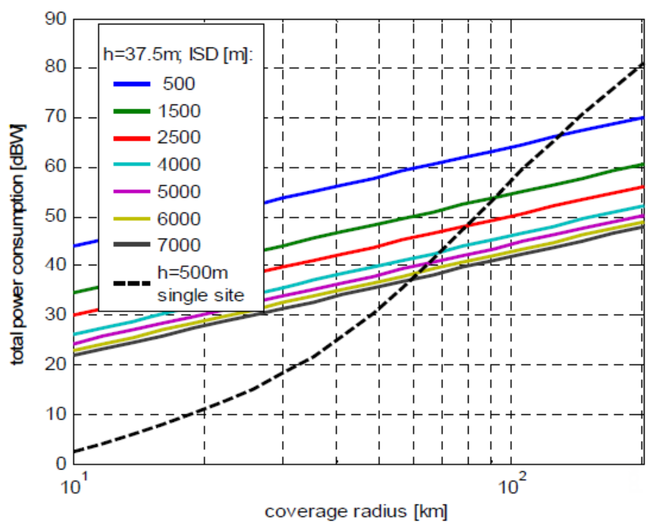

Figure 3 TOTAL POWER CONSUMPTION OF A SINGLE HIGH TOWER TRANSMITTER AND A NETWORK OF LOW TOWER TRANSMITTERS FOR THE SAME TOTAL COVERAGE RADIUS

The total power consumption, however, decreases with increasing ISD up to a value of 7000 m whereas beyond that ISD the power consumption increases again (not shown). The reason is that each cellular site has an EIRP-independent power overhead of 17.65 W and this becomes dominant when decreasing the ISD towards 500 m. For the TV transmitter the curve is simply shifted by the antenna gain of 10 dB and power efficiency of about -6 dB. For the power consumption optimal ISD, the cellular network consumes less power than the single high site for a coverage radius exceeding 60 km.

6. Summary

This Technical Notebook has presented a view on current trends in multimedia distribution in general and TV in particular. Access to radio and TV-based content over broadband networks is becoming an essential element of future IP-based media services. The opportunity that LTE networks offer as a complement to the current terrestrial broadcasting technologies with the aim of improving the consumer experience has been investigated.

In addition to the demands of media consumers, mobile broadband networks also provide interesting opportunities for program development in the domain of ENG/OB. LTE networks enable transmission of HD video streams from live cameras with the low latency and high quality required for studio feeds.

Specifically, an overview of the LTE Multimedia Broadcast/Multicast Service (MBMS) has been presented as a solution for mass multimedia distribution over LTE. The spectrum requirements to provide roof-top reception TV service using a cellular network deployment and MBMS has also been investigated. The spectral efficiency of MBMS for this application has been determined by simulations.

The simulations show that MBMS has a spectral efficiency of 3.1 bit/s/Hz up to a cellular ISD of 2 km. With this, 84 MHz of spectrum are sufficient to provide the desired aggregate service rate. Comparing this to the 300 MHz used by TV services today, the potential savings in spectrum are significant. It is noted that spectrum requirements could be further reduced by replacing MPEG2 with H.264, for which bit-rate efficiency gains of 30-50% have been reported. H.264 has been defined as one codec to be used with MBMS; however, for TV services targeting large screens, additional H.264 profiles will have to be mandated for MBMS.

Therefore, traditional linear TV distribution networks and LTE networks are complementary and can be used in cooperation very effectively in order to support the evolving consumer demands, thus paving the way towards more complete convergence and synergism in the future (win-win strategies). The combination of the two modes of delivery enables the easy introduction of new advanced services and applications and supports successful convergent offerings between digital television, broadcast providers, and mobile broadband service providers.

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Annex 1

COOPERATION AND CONVERGENCE BETWEEN BROADCASTING AND MOBILE SERVICES USING DVB-T AND LTE NETWORKS

1. Introduction

The studies described in the main body of this Technical Notebook have shown that traditional linear TV distribution networks and LTE networks are complementary and can be used in cooperation very effectively in order to support the evolving consumer demands, thus paving the way towards more complete convergence and synergism in the future (win-win strategies). The combination of the two modes of delivery enables the easy introduction of new advanced services and applications, and supports successful convergent offerings between digital television, broadcast providers, and mobile broadband service providers.

Content delivery will not only be distributed using the most suitable vehicle, but also consumers will use multiple vehicles in combination. Indeed, users watching a live event either in person or on television will likely simultaneously use their BlackBerry devices to request different camera angles, replay key plays/sequences, interact with other viewers, monitor other events, etc.

In Sections 3 and 4 of the main body of this Technical Notebook the case of ATSC has been considered and the purpose of this annex is to study the case of DVB-T, using the evolved Multimedia Broadcast and Multicast Service (eMBMS). For a description of MBMS refer to Section 3 in main body of this Technical Notebook.

2. eMBMS service probability analysis

The performance of eMBMS is assessed here for a hypothetical LTE deployment, exemplified in the area of Cologne, Germany, a city of about 1million inhabitants in a radius of 11.3 km.

The service quality requirements are applied as specified for DVB-T in Germany using the so called Quasi Error Free (QEF) reception, meaning less than one uncorrected error-event per transmission hour. For eMBMS it is assumed Dynamic Adaptive Streaming over HTTP (DASH) based video transmission with DASH segments of 1 s and each segment forms a source block for the Application Layer Forward Error Correction (AL-FEC). The tolerable AL-FEC block error rate is therefore 1s/3600s = 2.78e-4.

For DVB-T in Germany, good portable indoor coverage is a planning goal. The coverage verification test specifies that the receiver antenna is placed at optimum position in a disk of 0.5 m radius (Reference 1). This is mimicked in the eMBMS simulations by choosing the optimal position within a 1m straight line of the random initial user position. Once optimal position has been selected, the channel is assumed to be static.

For this case study one of the existing 3G networks is used. In the area of Cologne, there are 240 sites in a 10 km radius and 431 in a 20 km radius. These are too large numbers to model all sites in detail in an eMBMS radio network and protocol simulation. Therefore, from the site data only the inter-site-distance (ISD) is taken into account as the major factor that impacts the service probability. eMBMS simulations are performed for a uniform ISDs and the uniform ISD is varied between simulations. Table 1 shows the eMBMS simulation parameters. The antenna heights and propagation model are according to 3GPP case 1 (Reference 2), but scaled to 700 MHz and using only 8 dB indoor loss, taken from DVB-T assumptions.

TABLE I
eMBMS simulation parameters

Parameter/Model	value/description
carrier frequency	700 MHz
bandwidth	5 MHz
propagation model	3GPP Spatial Channel Model urban macro
indoor loss	8 dB
transmit power	20 W
sectorisation	3-fold
eNB antenna height	32 m

The DVB-T transmitter covering the Cologne area is configured for a transmission rate of 13.27 Mbit/s, which corresponds to a spectral efficiency of 1.66 bit/s/Hz. For eMBMS, an all the considered sites are assumed to belong to one Multicast-Broadcast Single Frequency Network (MBSFN). Therefore the same physical layer Modulation and Coding Scheme (MCS) and AL-FEC code rate has to be chosen for all sites. The AL-FEC code rate is set to 0.98, i.e. applying only a minimal amount of redundancy on the application layer, because it has turned out it is more efficient to apply most redundancy on the physical layer in this static reception scenario. A small amount of AL-FEC here ensures an error floor of the physical layer is compensated for. Finally the MCS is chosen so as to most closely match the spectral efficiency of DVB-T: MCS index 18, using 64QAM, gives a payload spectral efficiency of 1.6 bit/s/Hz.

From the simulation the eMBMS service probability is obtained, i.e. the percentage of randomly distributed users for which the QEF criterion is met. The results indicate technology potential. No implementation margins have been considered. Figure 1 shows the service probability versus the ISD. For small ISD up to 5 km, the service probability is about 95% and then decreases with increasing ISD.

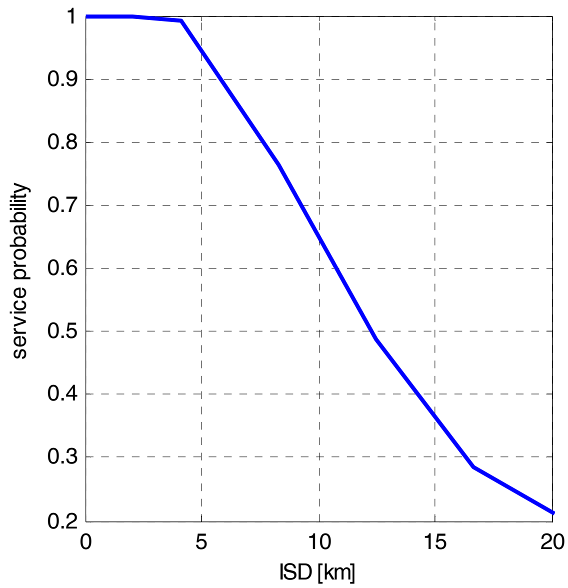

Figure 1. Service probability versus the ISD

Figure 2 shows the map of greater Cologne with a 10 km radius circle and Figure 3 shows the ISD Cumulative Distribution Function of the 3G sites in the 20 km radius as well as in a 10 km radius. In the center 10 km radius the ISD is obviously smaller as the network is more dense due to increased 3G mobile broadband capacity requirements.

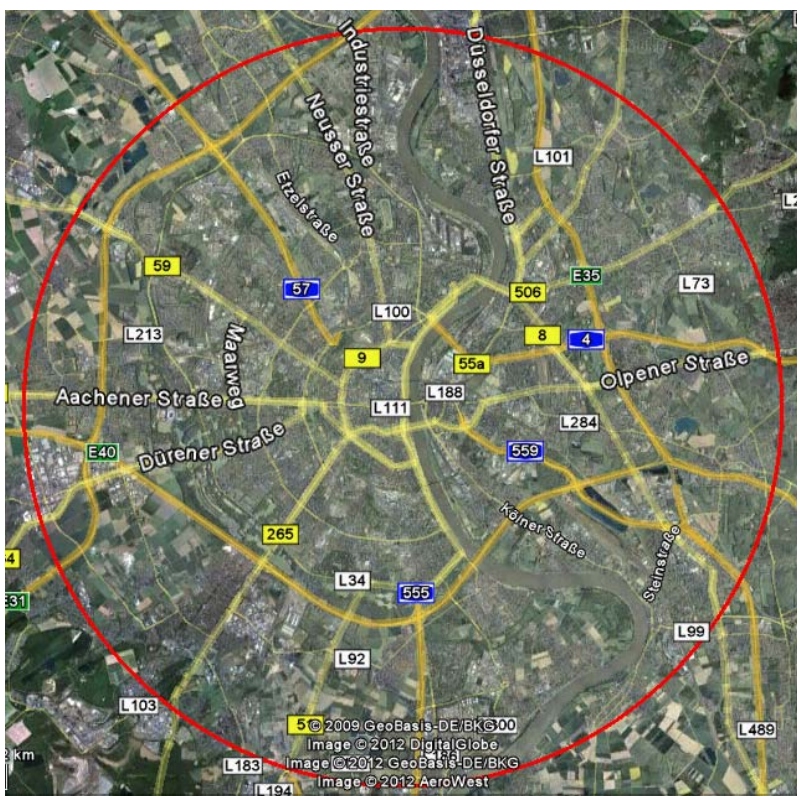

Figure 2. Map of greater Cologne, Germany, with a 10 km radius circle.

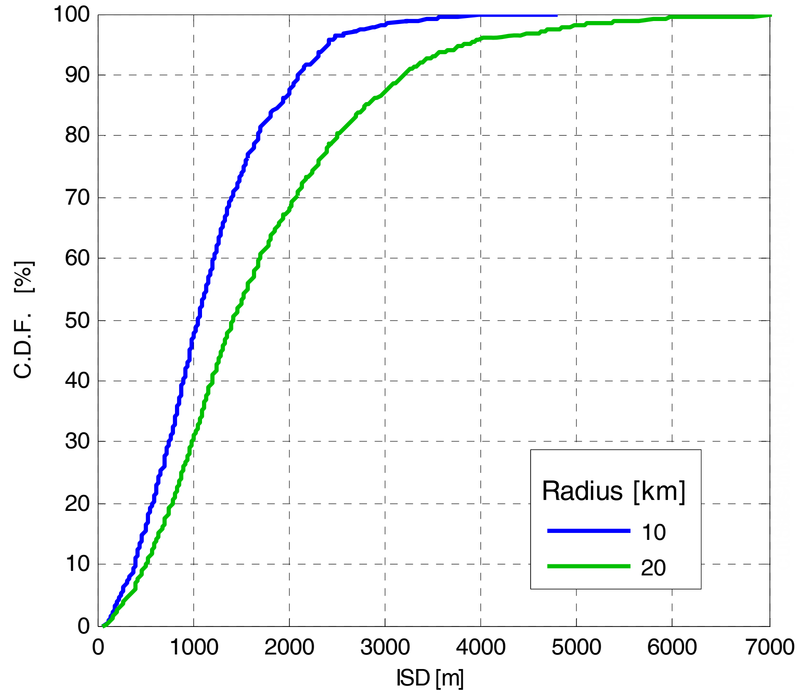

Figure 3. ISD Cumulative Distribution Function (CDF) of the 3G sites in the 20 km radius as well as in a 10 km radius.

For each site the mean ISD is determined to its neighbor sites (defined by Voronoi tesselation). Then the corresponding service probability of each site is determined using the graph in Figure 1. Figure 4 shows a map of the area with the polygons served by each site colored according to the service probability. In the center 10 km radius where most of the population lives, the service probability from all sites is above 95%. In the ring between 10 km and 20 km the probability decreases as the ISD is larger here but still 93% of the sites provide service probability better than 95%.

The service probability of the existing DVB-T transmitter in the area is shown in Figure 5, where the green color represents better than 95% portable indoor, and the inner 10 km radius is largely colored in green. In the outer ring, the beige patches dominate, representing a lower service probability, of only 70% and only for portable outdoor reception. Visually, the DVB-T percentage of area with >95% indoor service is not better than what can be achieved with eMBMS on the existing 3G sites. For mobile broadband capacity requirement reasons, the networks will also be further densified in the future, and the eMBMS service probability will then also benefit.

Using DVB-T2 instead of DVB-T, the service probability of Figure 5 can be achieved at a higher data rate of 22.0 Mbit/s, corresponding to a spectral efficiency of 2.74bit/s/Hz. When selecting at MCS index 26 for LTE, a similar spectral efficiency of 2.78 bit/s/Hz can be achieved. As the transmission is less robust than in the previously discussed case, the service probabilities provided by each LTE site decreases where the ISD is large. Figure 6 shows the resulting service probability map. Still all sites in the 10 km radius provide service indoor probability above 95% and all sites in the 20 km ring provide indoor service probability above 70%, so the overall coverage appears no worse than that of the DVB plot.

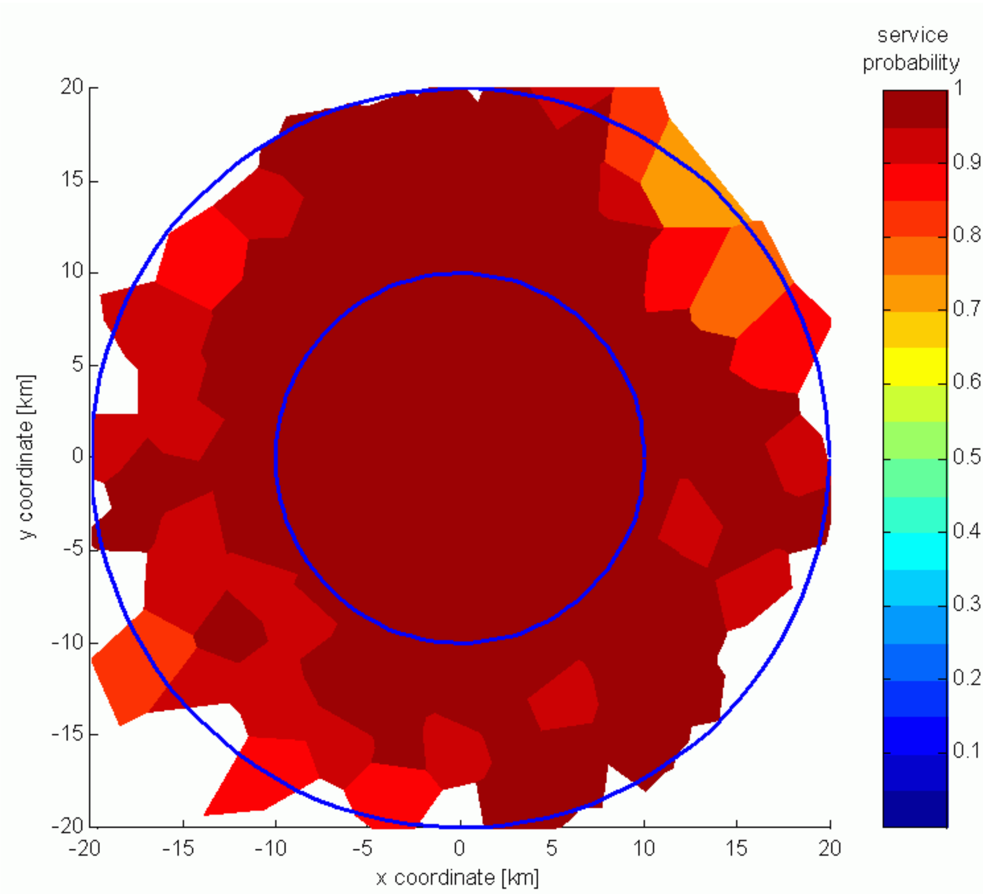

Figure 4. LTE broadcast coverage map with the polygons served by each site colored according to the service probability.

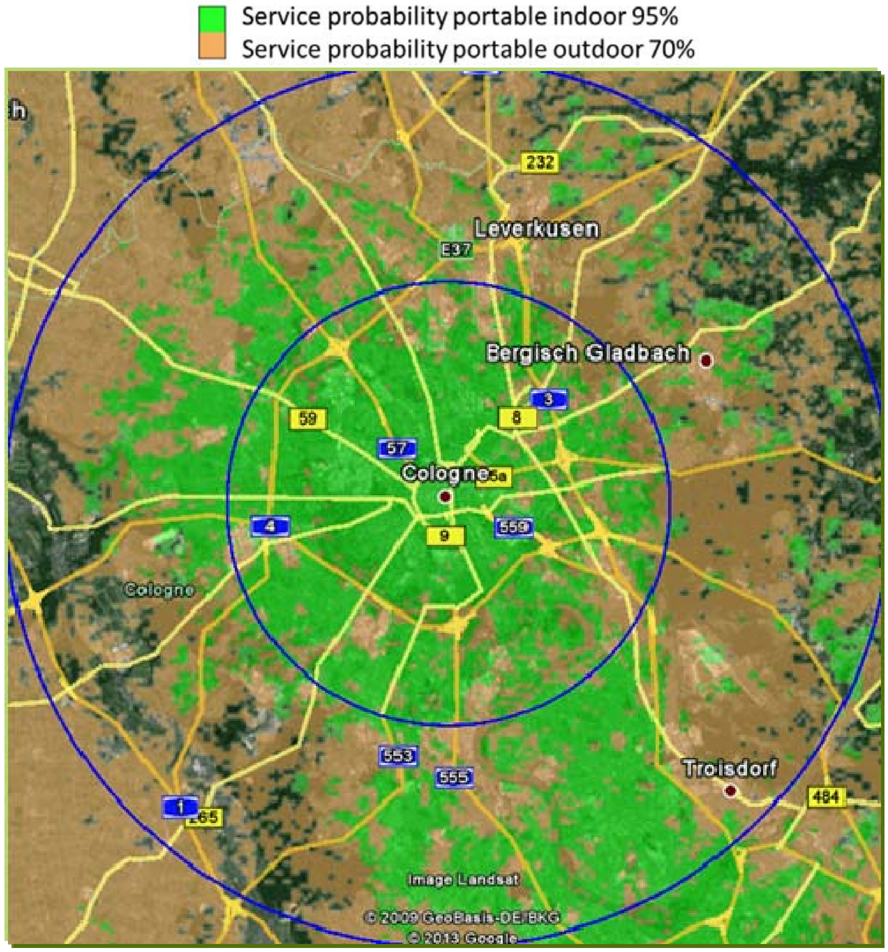

Figure 5. Service probability of the existing DVB-T transmitter in the area.
Service map overlay source: Media Authority of North Rhine-Westphalia; Germany map: (c) Google

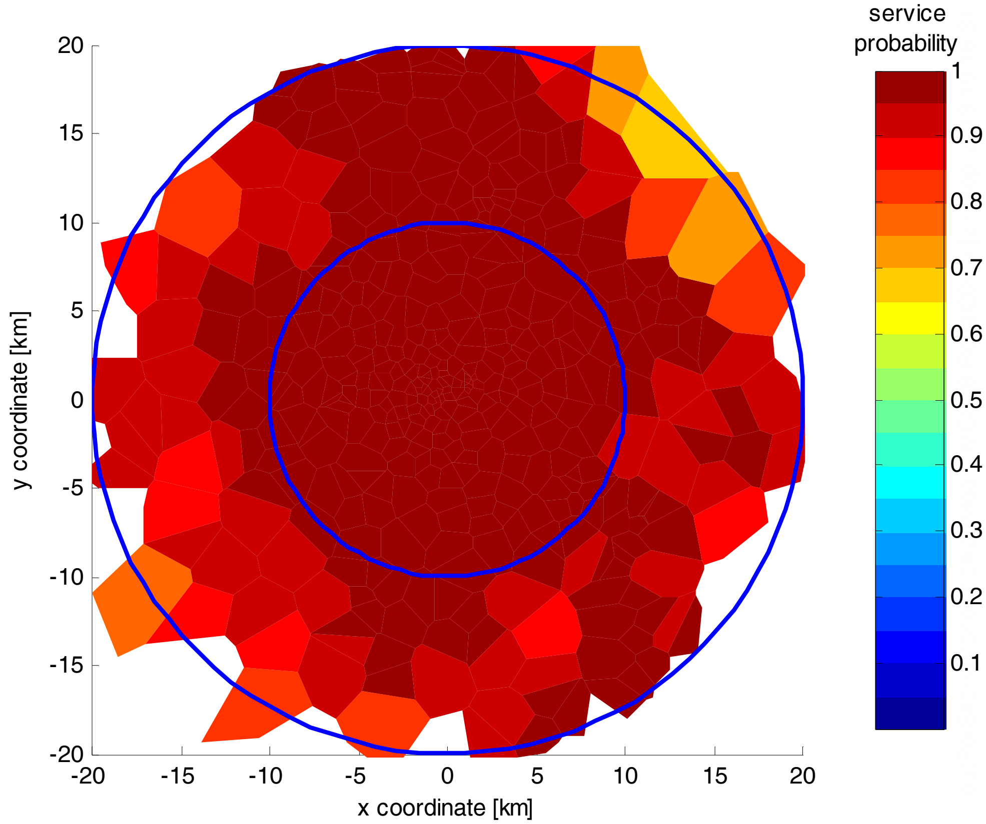

Figure 6. LTE broadcast coverage map with the polygons for MCS selected to match DVB-T2 spectral efficiency.

3. eMBMS large-scale SFN benefit

LTE networks are designed so that the same carrier frequency can be used in all cells. eMBMS further exploits this fact by using MBSFNs. An MBSFN can be as large as the geographical area in which the same information shall be broadcast. In contrast, DVB-T networks usually use different frequencies for adjacent transmitters although the same content is broadcast. The main reasons are to prevent inter-symbol-interference due to very large transmitters distances and because of cross-border constraints. The drawback is obviously the less efficient use of spectrum, contributing to the so called TV white space.

For example, in the main cities of Germany 6 DVB-T multiplexes are used. Five of them carry content for nation-wide distribution, but different frequencies are used geographically, in total 320 MHz. The remaining DVB-T multiplex carries regional programs.

With eMBMS, a channel can be used nation-wide. For ease of illustration assume that eMBMS could be operated with 8 MHz channel bandwidth like DVB-T, and that both have the same spectral efficiency as shown in the example of the previous chapter. Then, for each of the 5 DVB-T nation-wide multiplexes, one eMBMS channel is required, i.e. in total only 40 MHz.

At the border of a considered MBSFN area, the neighbor cells belonging to another MBSFN area must not use the same timeslots on the same channel to prevent interference to the considered MBSFN area.

Therefore, in the border, e.g., between the areas where different regional programs are broadcast, different time-frequency resources need to be used in each of the regions, leading to increased time-frequency resource requirements. This implies reduced capacity for unicast is available in these areas, which in turn may imply increased network density to provide the unicast capacity or increased spectrum requirements in these border area. However, the border area where this kind of coordination is necessary typically extends only over a few (macro) cells, in contrast to high tower TV networks, where the coordination distances can be several hundred kilometers. This benefit of small cell networks also greatly alleviates cross border coordination issues.

Referencias

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Annex 2

EXAMPLES OF DEPLOYMENTS OF LTE BROADCASTING

Current deployments

On 28 October 2013 Australia's leading telecommunications provider, Telstra, announced that it has completed the world's first LTE Broadcast session on a commercial LTE network. The LTE Broadcast Solution was successfully activated and tested on Telstra's live network with the transmission of concurrent video feeds and large files to enabled devices. During the demonstration, the devices received different video feeds, including a sports match replay, sporting network news, horse racing coverage and news. Additionally, the devices received a large file using the single LTE Broadcast channel. Broadcast highlights how LTE networks can deliver the highest-quality video content to anyone, anywhere, anytime without buffering.

Further information:

http://online.wsj.com/article/PR-CO-20131028-900827.html

Planned deployments

In the USA AT&T and Verizon are planning deployments of LTE broadcast.

AT&T plans to use the 700 MHz Lower D and E Block licenses it acquired in 2011 for an LTE Broadcast service. AT&T's focus is now almost "all about architecting networks to deliver video". AT&T is developing a "broadcast capability" to remove video traffic from its wide-area wireless networks.

Further information:

http://www.fiercewireless.com/story/att-use-lower-700-mhz-d-and-e-block-spectrum-lte-broadcast/2013-09-24

Verizon is working to deploy LTE Broadcast in 2014. Verizon is currently conducting LTE Broadcast lab trials and is preparing for future field trials.

Further information:

http://www.fiercewireless.com/tech/story/verizon-exec-2014-definite-launch-lte-broadcast-service/2013-03-17

Annex 3

ABBREVIATIONS

3GPP	3rd Generation Partnership Project #1
AL-FEC	Application Layer Forward Error Correction
AM	Amplitude modulation
ATSC	Advanced television systems committee
BBC	British Broadcasting Corporation
BLER	Block error ratio
CDF	Cumulative Distribution Function
CRTC	Canadian Radio-television Telecommunications Commission
CTN	Cooperative Terrestrial Networks
DASH	Dynamic Adaptive Streaming over HTTP protocol
DTS	Distributed Transmission System
DVB	Digital video broadcasting
DVB-T	Digital video broadcasting - terrestrial
EBU	European Broadcasting Union
EIRP	Equivalent isotropically radiated power
eMBMS	Evolved Multimedia Broadcast / Multicast Service
eNB	e Node B
ENG/OB	Electronic News Gathering/Outside Broadcasting
FCC	Federal Communications Commission
FM	Frequency modulation
HD	High definition
HDTV	High-definition television
ICI	Inter-carrier-interference
IP	Internet Protocol
IPTV	Internet Protocol Television
ISD	Inter-site-distance
ISI	Inter-symbol-interference
LTE	Long Term Evolution
MAC	Media access control
MBMS	Multimedia Broadcast / Multicast Service
MBSFN	Multicast-Broadcast Single Frequency Network
MCS	Modulation and coding scheme
MPEG	Motion Picture Expert Group
OFDM	Orthogonal Frequency Division Multiplexing
PA	Power amplifier

QAM	Quadrature amplitude modulation
QEF	Quasi Error Free
QPSK	Quadrature phase shift keying
RF	Radio frequency
RTP	Real time protocol
SDTV	Standard definition digital television
SFBA	San Francisco Bay Area
SFN	Single frequency network
SINR	Signal and Interference to Noise Ratio
SNR	Signal to Noise Ratio
TV	Television
UE	User equipment
WCDMA	Wideband code division multiple access