WIVE Deliverable 2.7: Report on infrastructure options for broadcast in mobile networks

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1 Introduction

This deliverable considers infrastructure options for broadcast in mobile networks. It extends from WIVE deliverables 2.4 *eMBMS capability for TV broadcasting* and 2.6 *Report on dynamic use of eMBMS and unicast.*

Section 2 discusses the infrastructures used in digital terrestrial television broadcasting and mobile networks and the potential convergence of these technologies. Section 3 discusses the use of LTE Broadcast/eMBMS for mobile broadcasting and the potential evolution of 3GPP mobile broadcast in 5G. Section 4 concludes the deliverable.

2 Mobile and broadcast infrastructures

The existing infrastructure used to broadcast digital terrestrial television (DTT) transmissions is characterized by very tall towers and high transmission powers. Transmissions of this type are known as high power high tower (HPHT), while the typical mobile network transmissions are low power low tower (LPLT). The height of HPHTs is typically around 300 meters, while the LPLT heights are typically below 50 meters.

A journal paper *On the Coverage and Cost of HPHT Versus LPLT Networks for Rooftop, Portable, and Mobile Broadcast Services Delivery* [1] analyses possible infrastructures with HPHT and LPLT and makes a study where the coverage, number of sites, and network deployment/maintenance costs associated to three different network configurations (i) HPHT only, ii) LPLT only, and iii) mixed HPHT + LPLT) for rooftop, mobile, and portable indoor/outdoor DTT service delivery are compared. The study is based on coverage simulations in a practical network planning scenario in Basque country. The main results are that i) LPLT network would require 3.3 times more base stations at a cost three times higher to provide the same coverage than HPHT and that ii) the current HPHT networks networks fail to give sufficient portable and mobile coverage in urban areas. The coverage study is not tied to any specific standard and thus does not compare the efficiency of different standards.

European Telecommunications Standards Institute (ETSI) Mobile and Broadcast convergence (MBC) specification group [2] studies the convergence of mobile and DTT networks and aims to integrate mobile and broadcasting networks into one technological solution to for example eliminate the need for separate DTT receivers. This would allow to dynamically use the network to deliver linear or personalized content. However, delivering the linear content through other solutions than the HPHT broadcast transmitters would impose huge requirements for the core network. As all the transmitters and receivers would need to be replaced, a large-scale adoption to a completely new technology (such as 5G, which is expected to provide feasible system for mobile broadcasting in the future, as discussed in Section 3.1) will not happen in the sort term.

The MBC group published a group report to discuss the potential of mobile - broadcast convergence for the distribution of audio-visual media content in June 2018 [3], where the following is stated: "*Broadcast technologies and business models are currently unable to reach out to mobile devices due to several challenges, including the low penetration of broadcast technologies in mobile devices. Mobile unicast technologies and business models cannot deliver audio-visual services to mass audiences at fixed costs.*" Thus, the current technologies have not yet reached the maturity level required for large-scale mobile broadcasting.

The past and present media broadcasting technologies are introduced in 5G-Xcast Deliverable 5.1 [4], which discusses and analyses the lessons learnt from technologies like DVB-H, MediaFLO, ISDB-T One-Seg, T-DMB and LTE Broadcast/eMBMS.

3 LTE broadcast/eMBMS limitations and evolution towards 5G

EBU stated that implementations of LTE networks for a large-scale TV broadcast were not envisaged using the 3GPP Releases up to 12 [5]. As described in Deliverable 2.4, Release 13 and especially Release 14 introduced major improvements and could thus be considered for TV broadcasting, at least on a smaller scale. However, these Releases still have some major limitations, as described below.

3GPP Release 13 eMBMS system is limited to a maximum cyclic prefix of 33.3 μss even with the added 7.5 kHz OFDM subchannel bandwidth. When deployed in SFN mode, this allows a maximum distance of only 10 km between adjacent transmitters. This is much shorter than the coverage radius of 90 km in the typical DTT broadcasting systems. It is potentially expensive to deploy mobile broadcasting services using the Release 13 eMBMS, given the limitations in the physical layer design.

3GPP Release 14 introduced a longer cyclic prefix of 200 μs, which means that the Inter-Site-Distance (ISD) between the transmitters can be increased up to 60 km. The evolution of LTE Broadcast in Release 14 is called Further evolved Multimedia Broadcast Multicast Service (FeMBMS). 3GPP Release 14 includes some major improvements for mobile broadcasting in the form of *Enhancements for TV services (EnTV)*. FeMBMS makes it also possible to dedicate separate carriers for MBMS transmissions, but the SFN areas and transmissions are still statically configured, and thus the FeMBMS lacks the dynamicity needed for efficient broadcasting. The different subframe types in Release 14 also cause potential coverage limitations[6].

5G-Xcast Deliverable 3.1 provides an extensive performance evaluation of 3GPP Release 14 via extensive link level, system level and coverage simulations. The deliverable concludes that the rigid OFDM numerology in the current LTE eMBMS limits the available types of network deployments and makes it difficult to implement deployments which could provide for example high coverage and high mobility. The spectral efficiency of LTE eMBMS in large area deployments is also very limited.

The current LTE eMBMS requires separate user-plane infrastructure for connectivity with the radio access network. This leads to increased infrastructure investments and additional implementation complexity in the terminals. Annex A of 5G-Xcast Deliverable 4.1 [7] analyses the limitations of 3GPP Release 14 from core network perspective.

The following aspects are recognized to play a role it the lack of commercial success of LTE eMBMS/Broadcast [4]:

- Lack of compatible handsets
- Lack of standardized APIs
- Lack of flexibility in management of MBMS Service Areas
- Inflexible cell resource allocation
- Long switch times with MooD
- Unclear billing functionality
- Lack of Multicast Backhaul
- Lack of interoperability testing

3.1 LTE Broadcast evolution towards 5G Broadcast

3GPP Release 15 is the first 3GPP release of 5G. It does not include new broadcast functionalities due to the priority of other features. 5G New Radio (NR) will include for example scalable OFDM numerology, meaning that the sub-carrier spacing is also scalable [8]. 3GPP Release 15 will be completed in 2018 and is structured to three phases: i) non-stand-alone (NSA) version, which requires LTE for the control plane, ii) stand-alone (SA) version including the 5G core network (5GC), and iii) the third phase with more architecture options for hybrid LTE and 5G NR deployments using the 5GC.

In December 2017, Qualcomm was assigned to lead the e-mail discussion on broadcast in the future 3GPP Releases. The discussion [9] led to a proposal of two different solutions at Radio Access Network (RAN) meeting #79: Terrestrial Broadcast and Mixed Mode Multicasting. The discussion continued between RAN 79 and RAN 80 and focused on the scope of each solution and the supporting companies. Two proposals were submitted to RAN 80 in June 2018:

1. Draft Work Item on 5G Terrestrial Broadcast (RP-181342)
2. Draft Study Item on 5G NR Mixed Mode broadcast/multicast (RP-180669)

Study Item Description (SID) LTE-based 5G Terrestrial Broadcast was approved for 3GPP Release 16 in 3GPP RAN plenary 80. Thus 3GPP aims to develop the 5G Terrestrial Broadcast system, dedicated only for broadcasting, in 3GPP Release 16. The Mixed Mode Multicasting (including both downlink and uplink) was noted in the same plenary and might be considered for 3GPP Release 17.

The main features of the proposed Terrestrial Broadcast and Mixed Mode Multicasting are shown in Table 1.

Terrestrial Broadcast	**Mixed Mode Multicasting**
Proposal to use 3GPP Rel'14 EnTV as a basis	Equivalent of MBMS into New Radio
Broadcast only	Switched broadcast/unicast
DL-only	Potentially mixed DL & UL
Large & static transmission areas: - Nationwide to large number of cells - Requires a standardized coordinator across cells	Moderate & dynamically configured transmission areas: - Few cells to one cell
Enhancements (if any) needed to meet 5G requirements from TR 38.913, Clause 9.1. Additional requirements from TR 22.261, if needed.	Common physical layer design (but flexible) to accommodate for different types of broadcast (e.g. from single cell to large area SFN transmission)

Table 1. The main features of the proposed terrestrial broadcast and mixed mode multicasting [9].

Terrestrial Broadcast enables a dedicated downlink only broadcast-only network, which is suitable for DTT in both HTHP and LTLP deployments leveraging cellular technology. Mixed Mode Multicasting would allow to dynamically switch between unicast point-to-point and multicast point-to-multipoint for more efficient content delivery. Mixed Mode Multicasting will use 5G New Radio as a basis and considers diverse use cases from media, Internet of Things, Vehicle-to-everything (V2X) and public safety in the solution design.

3GPP Rel'14 EnTV is used as a basis in developing the Terrestrial Broadcast to meet the 5G requirements for multimedia broadcast services [10]. A gap analysis will be performed to evaluate which 5G requirements are not met by 3GPP Rel'14 EnTV.

The objectives of the Terrestrial Broadcast SID are:

– Identify which of the broadcast requirements in TR 38.913 are relevant for dedicated terrestrial broadcast networks.
– Capture the gap analysis and potential solutions (if needed) to meet the broadcast requirements in a TR.

The SID is planned until March 2019. If gaps are found 3GPP may can start a Work Item towards standardisation of new solutions to fulfil the gaps until December 2019.

3.2 5G-Xcast vision

5G-PPP phase 2 project 5G-Xcast aims to develop a flexible, self-organizing content delivery network (CDN) which can combine unicast, multicast, broadcast and caching to deliver content cost-effectively at scale. Wideband transmissions with frequency reuse 1 may bring a series of advantages in terms of capacity, coverage, and transmit power saving [11].

In summary, the 5G-Xcast vision [4] for content delivery in 5G consists of:

– CDNs for global reach, including the use of Network Functions Virtualisation (NFV) for allowing caches to move ever closer to the edge.
– Point to Multipoint (PTM) in the form of multicast or broadcast for efficient synchronous delivery at the edge of the network to improve efficiency of spectrum usage or last mile of the fixed network.
– Treating PTM as an internal optimization capability for network operators which does not need to be exposed as an externally consumable network service in its own right. The use of a PTM capability should be dynamic, following consumption patterns and business rules.
– The use of local, or on-device storage to allow synchronous, pre-emptive delivery of content efficiently using a PTM capability,
– Application-layer intelligence is preferred over network features, particularly where the requirements on latency and packet loss are relatively relaxed, such as in typical media delivery scenarios.

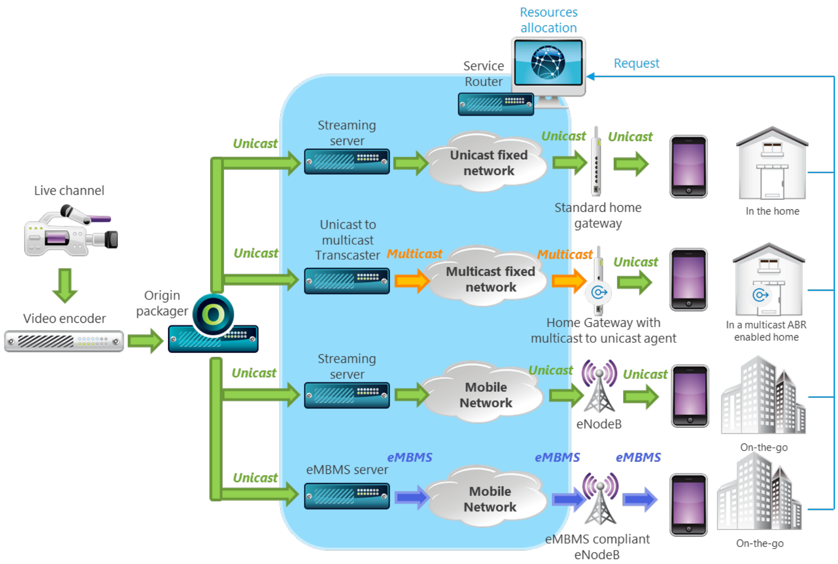

Fig. 1. The 5G-Xcast Unicast/Multicast/Broadcast convergent video delivery framework [4].

Figure 1 shows how the unicast/multicast/broadcast flows are converged in the proposed 5G-Xcast solution. The Figure shows how content can flow through unicast/multicast/broadcast connection types over mixed network types comprising of fixed and mobile networks. More detailed technical considerations are available in 5G-Xcast Deliverable 5.2 *Key Technologies for the Content Distribution Network* [12]. 5G-Xcast Deliverable 4.2 describes the key drivers, benefits and use cases for full fixed and mobile network convergence, which is essential in providing a seamless user experience. Annex D of 5G-Xcast Deliverable 3.1 [13] discusses other recent spectrum and spectrum sharing related proposals for mobile broadcasting. 5G-Xcast also publishes Deliverable 5.3 on *Application and Service Layer Intelligence* in 5G-Xcast solution in November 2018.

4 Conclusions

Different network architectures are needed for different services in different environments, such as urban, suburban and rural. The architecture of a broadcast network is always a compromise between the quality of service and associated costs. The currently available versions of LTE Broadcast/eMBMS have technological constraints, which limit the available broadcast network deployment topologies. Using only LPLT architecture is expensive and the HPHT architectures seem to have difficulties in providing sufficient coverage for mobile or portable reception.

3GPP Release 14 is technically sufficient for the creation of SFN areas for mobile broadcast in areas where the network architecture is able to provide sufficient coverage, but the lack of compatible handsets seems to be a major factor limiting the success of 3GPP Release 14 broadcast.

5G will provide more flexibility in numerologies and thus allows more flexible infrastructure options for content delivery through broadcast. A combination of HPHT and LPLT transmitters is likely to provide the most cost-effective infrastructure solution in a majority of scenarios.

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