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5G Wireless Broadband Continues To Roll Out: How Might It Impact Conventional Broadcasting? – p. 28

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5G Broadcast – A New Era Of Content Delivery

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For decades, mobile cellular networks have been based primarily on a unicast bidirectional communication model that provides various services to their end users. Consumers can now enjoy watching a huge amount of premium content, including a large percentage of live media services. Moreover, mobile user behavior and expectations are trending increasingly in the direction of higher quality of service, more features and better accessibility from the service providers in order to enjoy the best experience ever while using network resources. However, this places pressure on mobile network resources and pushes these mobile networks to the limits of the unicast paradigm.

In this context, there is a critical question that needs to be asked: will the unicast delivery mechanism alone be sufficient to handle high congestion situations, or will additional broadcast/multicast delivery methods be required?

This paper provides an answer to this question and helps discover how to deliver high-quality, personalized live experiences to meet the growing demands of audiences.

Selecting The Right Technology

The next quantum progression for technology supporting mobile communications networks, 5G, promises to provide new and radically different technological and business opportunities. It not only enhances mobile broadband, but also brings new broadcast and multicast capabilities to the whole ecosystem, as it provides network operators and broadcasters significant opportunities in several new business areas while creating higher spectral efficiency and reducing costs.

For network operators or media content providers/owners in the mobile telco industry, this means a completely new range of business models for data delivery to very large numbers of consumers without affecting the cellular 5G mobile network.

This new technology enables consumers to access high-quality media over a range of smartphones and SIM-less devices with greater coverage and lower latency. 3GPP— since Release 14 and up to Release 16—specifies the Further Enhanced Multimedia broadcast multicast service (FeMBMS) as new broadcast/multicast enhancements for both dedicated and mixed modes. (FeMBMS is also known under the name of LTE-based 5G Terrestrial Broadcast, or is sometimes even shortened to 5G Broadcast.)

Using broadcast and/or multicast over 5G, mobile network operators can deliver premium content to mobile consumers still attached to cellular networks with consistently high quality of service (QoS) and higher quality of experience (QoE). This is accomplished either via an overlay network or with the supplemental downlink (SDL) concept.

5G Broadcast/Multicast Verticals

5G clearly holds the promise of original business opportunities. In fact, it's bringing new broadcast and multicast capabilities to the whole ecosystem by enabling new applications. Although live video distribution is very important, 5G Broadcast does not necessarily mean mobile TV.

5G is not only capable of delivering media and entertainment to smartphones but can also provide smart vehicles with over-the-air (OTA) updates, enhanced positioning and navigation, media and entertainment, as well as updating GPS maps. Live event multicasting makes more sense when using this feature. 5G Broadcast can transmit public safety multicasts such as urgent weather and community information, thus simplifying the relationship between community members and governing bodies.

Several other services could be optimized using multicast over 5G. These include OTA multicast for centralized configuration and control, live commerce, and rural eLearning where no Internet connection is available. In addition, 5G Broadcast enables venue casting that combines a live experience with the comforts of home.

The new technology is creating opportunities for broadcast network operators to make their infrastructure more dynamic and help them discover new distribution features. It also supports mobile network operators in offloading their heavy streaming and data loads to avoid infrastructure overprovisioning. As a result, they can serve consumers with higher quality of service while reducing both their capital expenditures and operating expenses.

The Main Advantages Of 5G Distribution

5G affords both wider coverage and spectrum efficiency. Broadcasting/multicasting information via overlay networks is much more efficient than sending it hundreds of thousands of times to mobile network cells. Thanks to greater cell coverage, this improved flexibility can substantially reduce deployment and operation costs. There's also a better quality of service and a higher quality of experience. Consumers expect higher quality with HD and UHD television, as well as a high dynamic range for better picture quality. With the lower latency and higher flexibility that 5G Broadcast offers, the consumer experience can be improved with more real-time apps.

Release 14 was a significant enhancement to the previous eMBMS, and is thus referred to as "Further evolved Multimedia Broadcast Multicast Service" (FeMBMS) or "enhanced TV" (EnTV). It's considered to be the first mobile broadband technology standard to incorporate a transmission mode designed to deliver terrestrial broadcast services from conventional High-Power High Tower (HPHT), Medium-Power Medium Tower (MPMT) and Low-Power Low Tower (LPLT) broadcast infrastructures, thus addressing the exact needs of broadcast network operators.

The enhancements introduced in this release include system architecture and interface simplifications, as well as extensions to the LTE Physical Layer. It establishes the foundation for 5G Broadcast as it fulfills the majority of ITU requirements for broadcast/multicast distribution in next-generation networks.

With respect to the Physical Layer, the main improvements in FeMBMS are support of larger inter-site distances for single frequency networks and the ability to allocate 100 percent of a carrier's resources to the broadcast payload, with self-contained signaling in the downlink.

From a system architecture perspective, a receive-only mode enables free-to-air (FTA) reception with no need for an uplink or SIM card, thus enabling the reception of content without registration of legacy user equipment with a network. Broadcast and Multicast options are planned for implementation with 5G New Radio (NR) under the name of NR Broadcast and Multicast. This is to be standardized in 3GPP from Rel.17, and is expected to be ready from Q3 2022 onwards.

An Enhanced Feature Set

In relation to the 3GPP Release-14 feature set presented by the first introduction of EnTV/5G Broadcast within the standard, enhancements made to the system architecture also include:

- an xMB interface through which broadcasters can establish the control and data information of audio-visual services while using different content types such as DASH, HLS and CMAF
- a new Application Programming Interface (API) for developers to simplify access to eMBMS procedures in the User Equipment (UE)
- The support of multiple media codecs and formats (SD, HD, UHD, HDR, etc.)
- a transparent delivery mode to support native content formats over IP without transcoding (e.g., reusing existing MPEG-2 Transport Streams over IP and compatible equipment)
- support of shared eMBMS broadcast by aggregating different eMBMS networks into a common distribution platform
- a Receive-Only Mode (ROM) that enables devices to receive broadcast content with no need for uplink capabilities, SIM cards or network subscriptions; i.e., free-to-air reception.

From the radio layer point of view the most significant enhancements include:

- the possibility of establishing dedicated FeMBMS carriers that allocate up to 100 percent of the radio resources to terrestrial broadcasting (i.e., with no frequency or time multiplexing with unicast resources in the same frame). There's self-contained signaling and system information in the downlink
- a new, reduced overhead subframe containing no unicast control region
- support for larger inter-site distances in single frequency networks, along with a higher spectral efficiency with a new OFDM transmission mode through 1.25 kHz subcarrier spacing (SCS) and a 200 μs cyclic prefix. These OFDM transmission mode changes are the most significant, as the longer OFDM symbol duration, occupying one subframe, made it necessary to design a new subframe structure, known as the Cell Acquisition Subframe (CAS), to allocate the synchronization and control channels, transmitted with much reduced periodicity (one in every forty subframes).

In addition, Release 16 brought new improvements to the Radio Access Network (RAN):

- SCS for fixed reception (Δf= 370Hz/ CP=300μs) / mobility < 120 Km/h
- SCS for fixed reception (Δf= 1.25KHz/ CP=200μs) / mobility ≈ 120 Km/h
- SCS for mobile reception (Δf= 2.5KHz/ CP=100μs) / mobility ≈ 250 Km/h
- SCS for mobile reception (Δf= 7.5KHz/ CP=33.33μs) / mobility > 250 Km/h
- Improved CAS content Physical Broadcast Channel (PBCH

Along with broadcast content, mobile broadband subscribers who have a SIM card can enjoy enriched service offerings when combined with independent unicast for interactivity, in a similar way to conventional HbbTV (hybrid broadcast broadband TV) sets. The introduction of a ROM and the new framing and OFDM transmission mode options may make FeMBMS suitable for use with conventional broadcast infrastructure (including high-, medium- and low-power sites).

The Technical Solution With Regard To The 3GPP Standard

As per 3GPP specifications starting from Rel.14, the main architectural approach has been defined via the deployment of 5G Broadcast/Multicast via an overlay network in the RAN using either HPHT or MPMT for a wide coverage. The Broadcast/Multicast core network is, of course, part of the End-to-End (E2E) solution where the new roles are defined as follows (see Figure 1):

- **The BM-SC (Broadcast Multicast Service Center)** provides membership, session and transmission, proxy and transport, service announcement, security, and content synchronization. It supports various MBMS specific user services such as provisioning and delivery. The BM-SC sets up the e-MBMS session, initiates delivery of the content by pulling it from the content server, applies an appropriate codec for the content, and collects the reception receipt from the UEs for certain kinds of content.

- **The MBMS-GW (eMBMS Gateway)** distributes MBMS user-plane data to eNBs using IP multicast and performs MBMS session control signaling towards the E-UTRAN via MME. It creates the MBMS bearer and receives the user-plane MBMS traffic from the BM-SC. Once received, it allocates a multicast transport address and performs the GTP-U encapsulation of the MBMS data.
- **The MCE (Multi-cell/multicast Coordination Entity)** manages MBMS content and resources.

If this above-mentioned architecture is not so easy to understand, we can still make things simpler for the network operators and thus provide a simplified architecture for Multimedia Services (as shown in Figure 2):

5G Broadcast/Multicast Interfaces

Within the overall infrastructure presented by 5G Broadcast, multiple important interfaces need to be considered:

- **Sm:** located between the MME and the MBMS-GW, receives MBMS service control messages and the IP Multicast address for MBMS data reception from the MBMS-GW. It also carries the EPS GTPv2-C messages:
- MBMS Session Start messages
- MBMS Session Update messages
- MBMS Session Stop messages
- **SGi – mb:** is the reference point between BM-SC and MBMS-GW function for MBMS data delivery
- **SGmb:** is the reference point for the control plane between BM-SC and MBMS-GW.
- **M1:** is the reference point between MBMS GW and E-UTRAN/UTRAN for MBMS data delivery. IP Multicast is used on this interface to forward data. The protocol used here is GTPv1-U.
- **M2:** M2 signaling bearer provides the following functions:
  - Provision of reliable transfer of M2-AP message over M2 interface
  - Provision of networking and routing function
  - Provision of redundancy in the signaling network
- **M3:** The M3 interface provides the reference point for the control plane between the MME and the MCE (E-UTRAN). The M3 Application Protocol (M3AP) supports the functions of the M3 interface by providing:
  - Support for both IPV4 and IPV6 addresses at MME endpoint.
  - Session Management - This overall functionality is responsible for starting, updating, and stopping MBMS sessions via the session control signaling on the SAE bearer level.
  - M3 Setup functionality for initial M3 interface setup for providing configuration information.
  - Reset functionality to ensure a well-defined re-initialization on the M3 interface.
  - Error Indication functionality to allow a proper error reporting.
  - MCE Configuration Update function to update the application-level configuration data needed for the MCE.
  - xMB: To simplify the access to eMBMS system functionalities content providers and broadcasters can now establish the TV service through the standardized xMB (broadcasting application programming) interface,

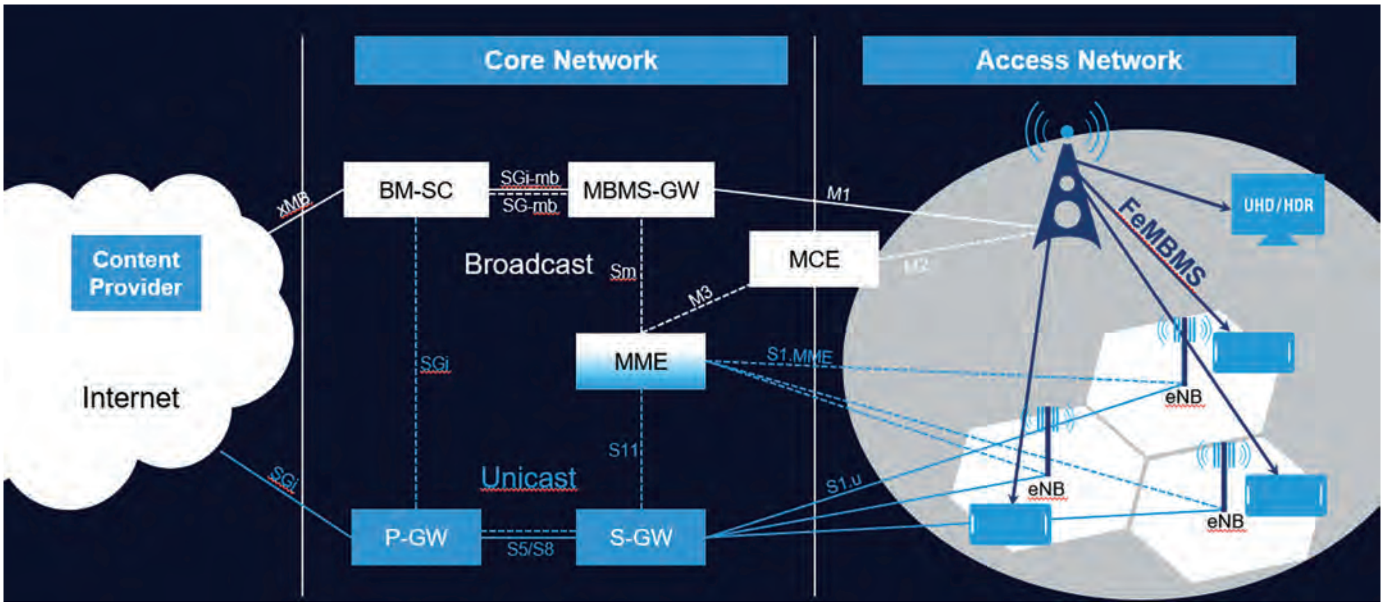

Figure 1. 5G Broadcast overall architecture.

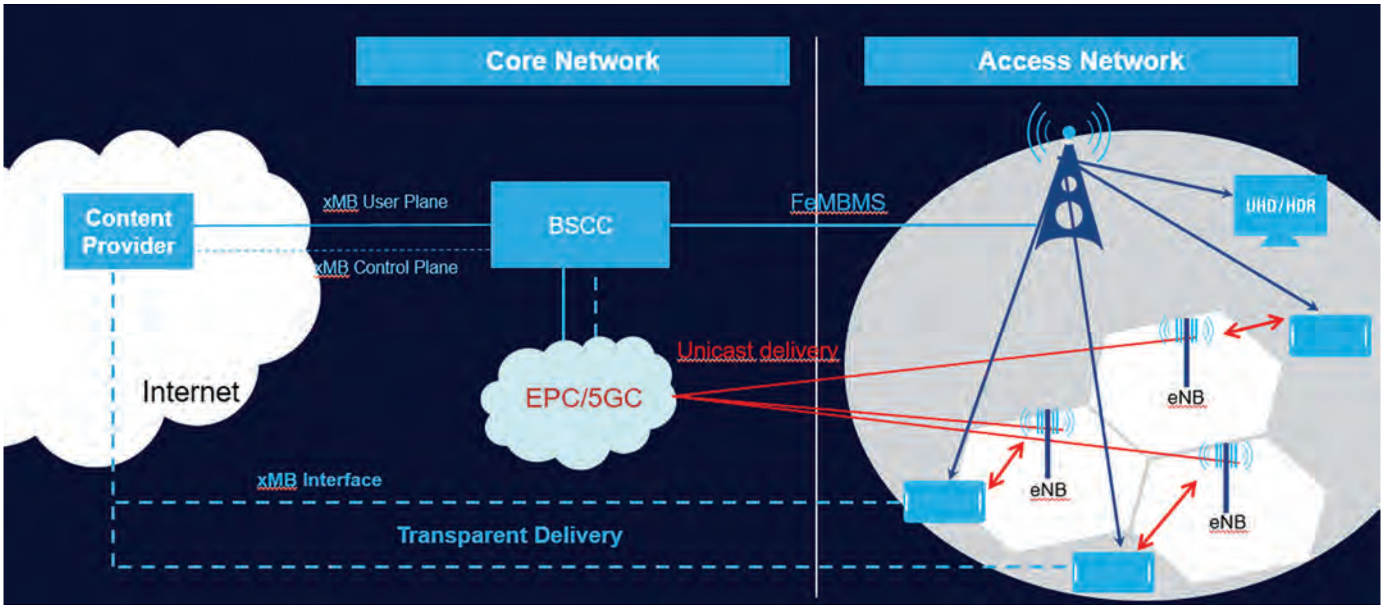

Figure 2. 5G Broadcast simplified architectural model.

which has two aspects: xMB-C for control, and xMB-U for delivery of media content to the BM-SC. 3GPP allows the inclusion of unicast distribution as a mobile system service, for example using eMBMS-operation-on-Demand (MooD) or unicast fallback.

Several solutions are proposed for delivering better quality services and providing a higher quality of experience with reduced costs:

- Solution 1 – overlay NSA (Non-Stand Alone) / SA (Stand-Alone) for use in rural and suburban areas (see Figure 3)
- Solution 2 – SDL (Supplemental Downlink) NSA/SA for use in dense urban areas (see Figure 4)
- Solution 3 – combined overlay and NSA/SA.

A more concrete way to enhance the existing cellular network could involve adopting Solution 1 for suburban areas and rural environments where line-of-sight is usually available. Here, an overlay network using HP/MP transmitters for greater coverage makes more sense in combination with either an existing non-standalone or standalone architecture.

However, in order to establish localized broadcast/multicast on a cellular level, Solution 2 would be more convenient in dense and/or urban areas, by deploying add-on low-power transmitters (LP Tx) within existing cellular sites with minimal costs. The low-power add-ons are purely software-based, and could potentially be easily integrated in the future into an existing cloud RAN (C-RAN) without additional hardware.

Furthermore, neither Solution 1 nor Solution 2 would prevent a network operator from choosing and deploying Solution 3. A combination of Solutions 1 and 2 in order to achieve nationwide deployment of broadcast and multicast applications can be easily imagined.

Market Tendencies

During the last decade, there have been several false dawns in connection with commercial high-quality mobile media broadcasts. What looks “fantastic” in an R&D lab or on a tradeshow stand has rarely lived up to expectations when it is applied to real world scrutiny.

5G Today was the very first project to test broadcast and multicast capabilities over 5G officially launched between July 2017 and February 2020 with project partners including the

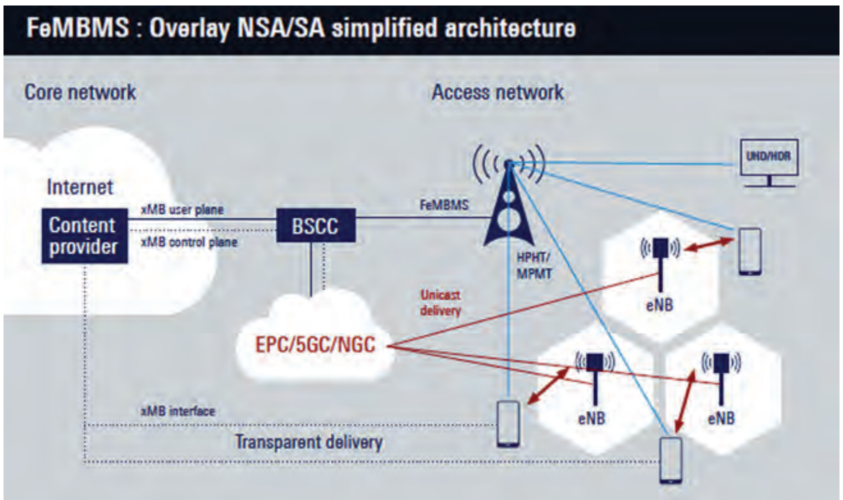

Figure 3. 5G Broadcast overlay NSA/SA simplified architecture.

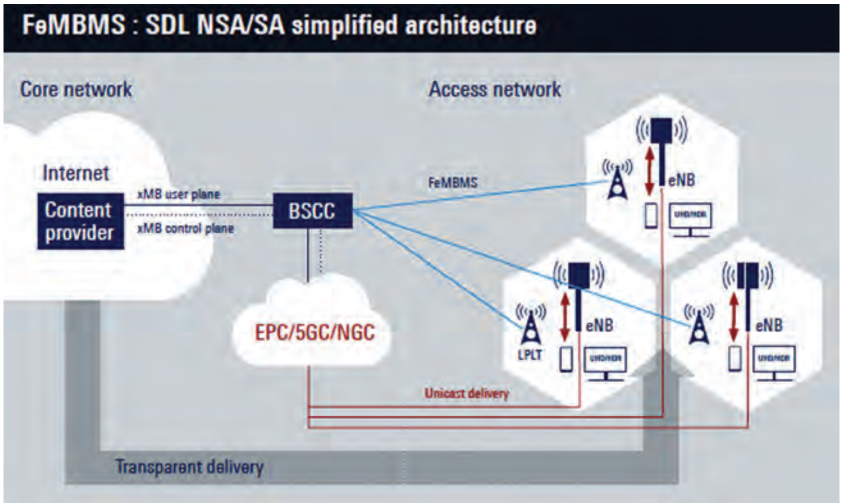

Figure 4. 5G Broadcast SDL NSA/SA simplified architecture.

Bavarian Broadcasting Corporation (Bayerischer Rundfunk, BR), the Broadcast Technology Institute IRT, Kathrein, Rohde & Schwarz, as well as Telefónica Germany, all jointly testing broadcasting options for future 5G technology.

Beijing was the second city to witness the start of another big 5G Broadcast project. The Academy of Broadcasting Science (ABS), as part of the governmental authority of the Chinese National Radio and Television Administration (NRTA), set up a proof-of-concept trial, which started in August 2019, and is still running as this paper is being written. This marked the first step of the long-term strategies pursued by both parties, which might comprise potential future 5G Broadcast commercial deployments.

Another metropolitan area trial was conducted in Rio de Janeiro, Brazil. Rio Globo, the largest Brazilian and Latin American TV network, recently conducted a 5G Broadcast field test, which began in October 2021 with the transmission of a rock music festival in 4K video via 5G Broadcast technology.

Other 5G Broadcast trials are taking place, or are scheduled, in Italy, France, Austria, Finland, Spain and the Philippines.

While 5G Broadcast is still an embryonic technology, it is demonstrating its capability to transform the mobile entertainment and information market. Today's trials will be tomorrow's commercial pioneers, with the big winners being the early adopters.

Technology Perspectives

From a specifications perspective, since March 2021, 3GPP has introduced fundamentally new enhancements to the LTE-based 5G terrestrial broadcast system in order to support new bandwidths of 6, 7 and 8 MHz. This recent improvement in 3GPP Rel-17 will provide broadcasters with the ability to roll out 5G Broadcast in the future using their UHF spectrum.

Also, a new ETSI specification (ETSI 103 720) has been recently introduced to the broadcast industry, enabling broadcasters to employ LTE-Based 5G Broadcast as a broadcast technology, enabling a mobile broadcast use case.

At a higher level, ITU WP6A is leading the discussion of officially including LTE-based 5G Broadcast as worldwide broadcast technology. At the upcoming World Radio Conference (WRC23), the future use of the remaining UHF bands (470 MHz to 900 MHz) will be determined in Europe, Middle East and Africa, i.e. ITU Region 1 on the basis of the review in accordance with Resolution 235 (WRC-15). Mobile operators are looking at the spectrum with greater appetites, while broadcasters will try to keep as much as possible of it.

The important question is "who will take the lead in the UHF band—mobile operators or broadcasters, or maybe both?" A "win-win "scenario might be the right choice over an "either/or" discussion.

Together with the 700 MHz, L-band, 2.6 GHz (SDL bands) and sub-1 GHz band deployment potential, 5G broadcast/multicast technology is awash in possibilities. It is therefore is no longer a question of "if," but rather a question of "when." The marketplace decision will soon be known.

References:

ETSI TS 103 720 V1.1.1 (2020-12)

3GPP TS 24.117 TV service configuration Management Object (MO)

3GPP TS 23.285 Architecture enhancements for V2X services

3GPP TS 26.347 Multimedia Broadcast/Multicast Service (MBMS); Application Programming Interface and URL

3GPP TS 26.346 Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs

3GPP TS 23.246 Multimedia Broadcast/Multicast Service (MBMS); Architecture and functional description

3GPP TS 22.816 3GPP enhancement for TV service

3GPP TS 23.002 Network architecture

3GPP TS 33.246 3G Security; Security of Multimedia Broadcast/Multicast Service (MBMS)

5G Broadcast/Multicast, R&S Booklet, Mohamed Aziz Taga, Version 01.00

5G Broadcast/Multicast, R&S Infographic

5G Broadcast/Multicast R&S All-In-One Core Network

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