Broadcast and Multicast Service for LTE and Advanced

1 Introduction

This Article is about broadcast and multicast service, as specified by the 3GPP .According to the 3GPP this service is known as MBMS (Multimedia Broadcast and Multicast Service).
In MBMS at the same time multiple subscribers can get the chance to receive the same data, sent only once on each Downlink. If we consider about the Radio then in a Given Cell we get the pros over the Radio resource cost that required for one transmission in a particular Cell.

MBMS in real provide two different services

a. Broadcast
b. Multicast

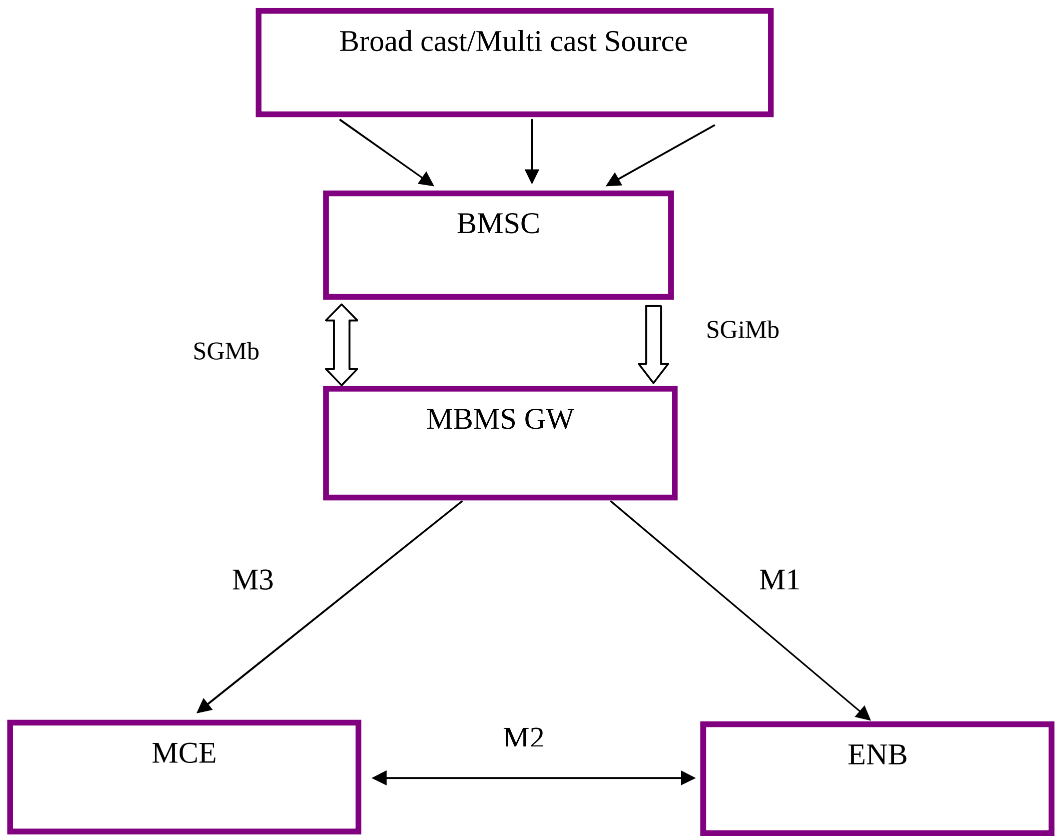
The Broadcast service can be received by any subscriber located in the area in which the service is offered and multicast services can only be received by users having subscribed to the service and having joined the multicast group associated with the service. Both this services are unidirectional point-to-multipoint transmissions of multimedia data and can be highly applied to broadcast text, audio, picture, video from Broadcast Multicast Service Centre to Any user located in the service area.

For such a service, only the broadcast service providers can be charged possibly based on the amount of data broadcasted, size of service area or broadcast service duration. Multicast is subject to service subscription, and requires the end-user to explicitly join the Group in order to receive the service. Because it is subject to subscription, the multicast service allows the operator to set specific user charging rules for this service.

2 Service Architecture

The MBMS service architecture is based on the Packet Core domain, and is compatible with EPS, as well as 2G/GSM or 3G UMTS Packet Core nodes like the SGSN and GGSN.
In EPS networks, there are two additional logical network entities: MCE, MBMS GW.

The MCE (Multi-cell/multicast Coordination Entity) is a new logical entity, responsible for allocation of time and frequency resources for multi-cell MBMS transmission. The MCE actually does the scheduling on the radio interface. The MCE is a logical node which may be integrated as part of the eNodeB (in which case, the M2 interface becomes an internal eNodeB interface).



The MBMS GW (MBMS Gateway) is the entry point of incoming broadcast/multicast Traffic. Its role is to broadcast the packets to all eNodeBs within a service area, as well as MBMS session management (like Session Start and Session Stop). It is also in charge of Collecting charging information relative to the distributed MBMS traffic for each terminal having an active MBMS session.

The Broadcast Multicast Service Centre (BM-SC), already present in 2G and 3G MBMS Architectures, is the functional entity in charge of providing the service to the end-user. For that purpose, the BM-SC serves as an entry point for content providers or any other broadcast/multicast source which is external to the network.

The BM-SC is in charge of the following main functions:

- Responsible for providing
- Authorization for terminals requesting to activate an MBMS service.
- Scheduling of broadcast and multicast sessions.
- Integrity and confidentiality protection of MBMS data.
- MBMS session announcement

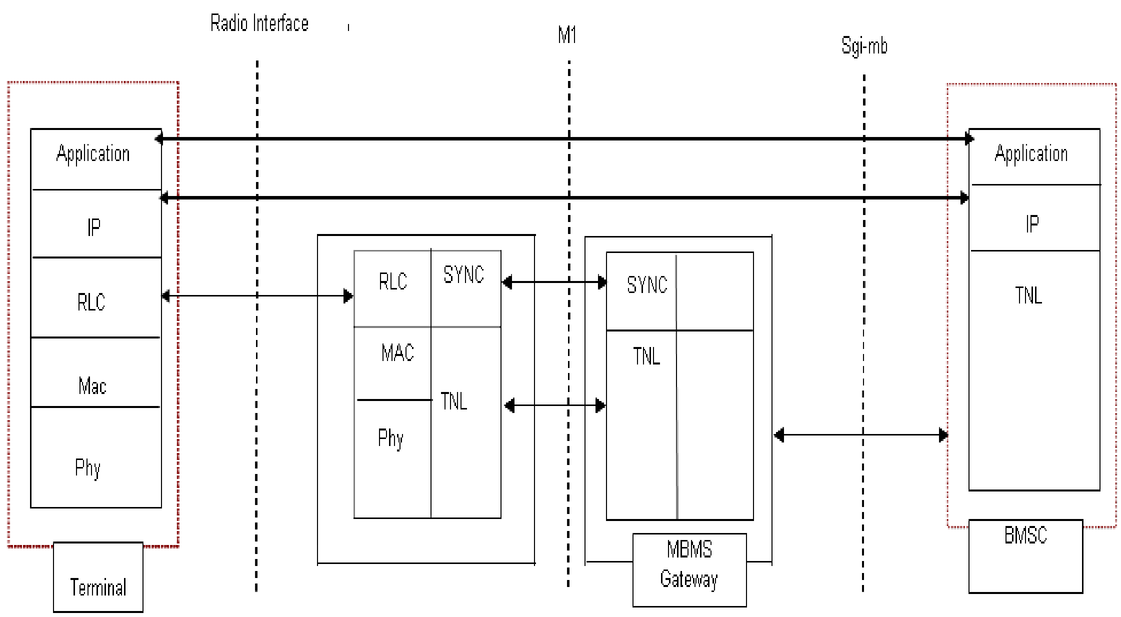
The SGmb interface supports MBMS bearer signalling for setting up and releasing context at MBMS session establishment and termination. The SGmb also supports user-related signalling, e.g. for Multicast session authorization, or user session joining or detach.

The SGi-mb interface supports the MBMS traffic plane.

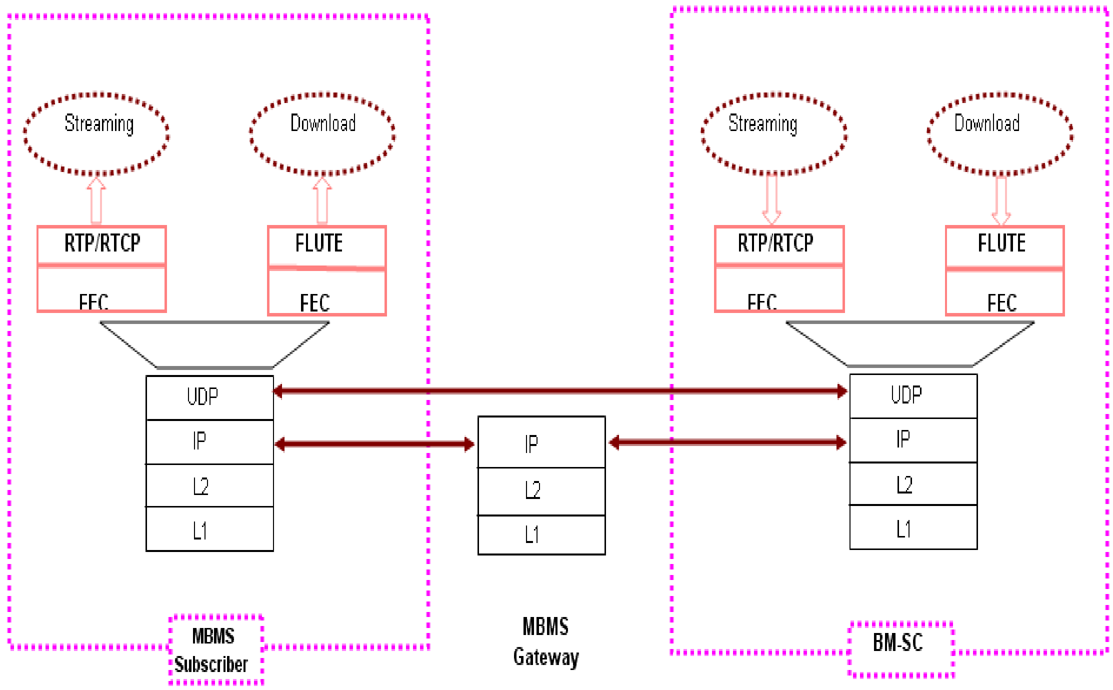
The M1 interface, associated to the MBMS data (or User plane) makes use of IP multicast protocol for the delivery of packets to eNodeBs.

The M3 interface supports the MBMS session control signalling, e.g. for session initiation and termination.

The M2 interface is used by the MCE to provide the eNodeB with radio configuration data.



MBMS user plane Architecture



MBMS Data Plane

The MBMS data transfer can be categorically be based on the type of service.

- If the service is for Streaming then the data transfer will follow on RTP/RTCP,
- If the service is download services the it use the File delivery over unidirectional Transport system

Both streaming and download application services are eventually supported over a UDP/IP Transport scheme. In addition to those protocols, specific to data transfer, MBMS makes use of other existing layers: The 3GPP NAS (Non Access Stratum) protocol for packet session management has been modified, as MBMS requires the terminal to open a MBMS context.. This new type of packet context is equivalent to the classical PDP context for an IP multicast address.

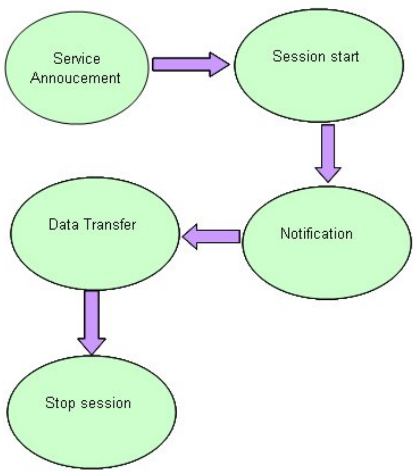
A FEC (Forward Error Correction) block is appended to each RTP data packet to allow error detection and possibly correction at the receiving end. It allows the receivers to reconstruct missing portions of the source block.

3 Process Involved in Broad cast & Multicast

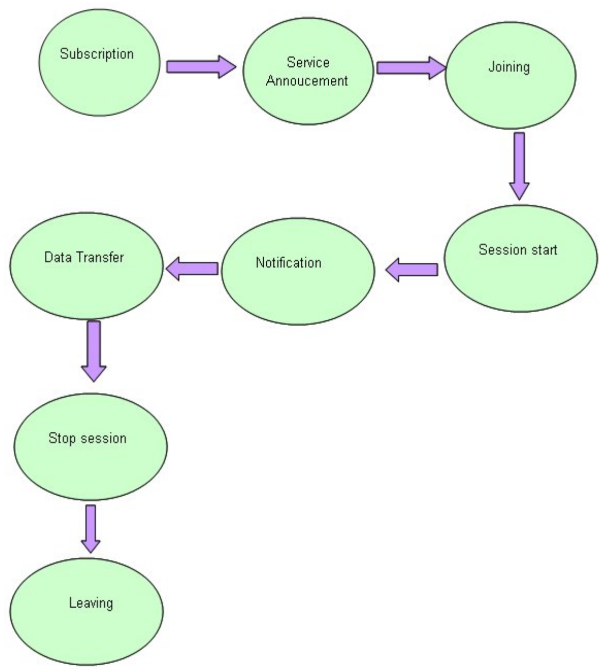
The Subscription is only apply for multicast. It is to ensure to get the subscription/service from the service or content provider, so that the end-user is allowed to receive the multicast service. In the subscription phase USIM updated with the service key and the user key which it can use in the process of deciphering the data it received. The Service announcement is to intimate the end user about the available MBMS Services.Joining phase, is only meant for multicast, here the subscriber indicates its willingness to listen for a specific service, so that it can be charged for the multicast data.

The Session start phase is the actual start of the MBMS session. The Network resources to Support the MBMS bearers are reserved and established at that time. The MBMS notification phase is used to inform users about the upcoming MBMS sessions. During the Data transfer phase, the MBMS data are transferred to the terminals. At Session stop, network resources previously allocated are released by the network.
At the end, the Leaving phase corresponding to the joining is an explicit indication to the User that it is no longer willing to follow the session and is not receiving anymore.

Broadcast service Process



Multicast service Process



4 MBMS Security

When compared to point-to-point communications, multicast service security faces some new specific challenges. In the MBMS context, ciphering has a different purpose, as MBMS subscribers have no real interest in broadcast or multicast privacy. However, encryption is a key feature for operators and content providers, as it is the only way to prevent unauthorized customers from receiving the data for free.

MBMS security mechanisms like ciphering need to be designed in a way which is suitable for point-to-multipoint communications. In addition, those mechanisms shall prevent any bypass attempts from subscribers, by exchanging keys or passwords, for example. This is the reason why MBMS security mechanisms are quite specific, involving complex key structures and frequent key updates.

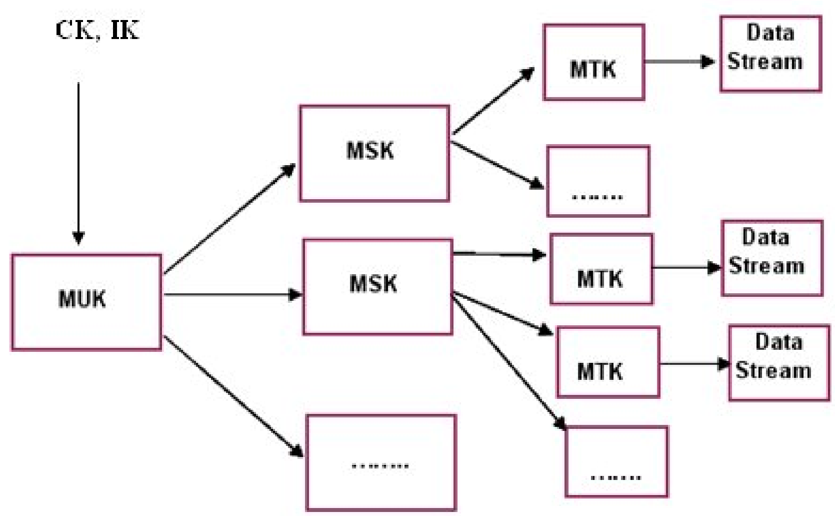
- The MUK -MBMS User Key
- A set of MSK -MBMS Service Key per MUK.
- A set of MTK -MBMS Traffic Key per MSK.

As opposed to most point-to-point communications, MBMS security is not applied on a Specific part of the transmission path (like the radio segment) but is rather performed end-to end, between the BM-SC and the subscribers. The basis of MBMS security is that the multicast data are protected by a symmetric key (the MTK), which is a secret key shared by both the sender (the BM-SC) and the receivers (the MBMS subscribers.

At first, each terminal builds its own unique secret MUK, derived from CK (Ciphering Key) and IK (Integrity Key), both stored on the terminal USIM. Those references are also stored Within the HSS, so that the network can also build its own reference of the MUK. The MUK is further used by the terminal to retrieve the MSK provided by the BM-SC during the authorization process.

MSK and MTK key sets are the actual keys to secure MBMS data. They are both generated by the BM-SC. Each MTK corresponds to a unique data flow (either a streaming or FLUTE file download flow) and is used to cipher the data block for this flow. The set of MTK is transmitted to the authorized subscribers by the BM-SC in a secured way, protected by the MSK.

As a way of enhancing security, it is then possible for the BM-SC to define two different sets of MSK (and associated MTK) and update the MTK during a service or a session by indicating to the authorized receivers the new MSK to use.MSK and MTK are usually updated in a subscribers terminal using unsolicited push procedures from the BM-SC. The protocol used to perform this update is MIKEY (Multimedia Internet Keying) – a key-distribution protocol



MBMS key Structure

5 MBMS service deployment in LTE

LTE is quite flexible and offers many possible options for MBMS service deployment. In MBMS, the operator has the possibility of reserving a frequency layer to MBMS Transmissions. In this case, the cells belonging to this layer only offer MBMS service. In those dedicated cells, there is no support for unicast (or point-to-point) service.
In contrast, when no specific frequency is reserved for MBMS, mixed cells provide Simultaneous unicast and MBMS services.

In parallel, there may be two types of MBMS data transmission in LTE

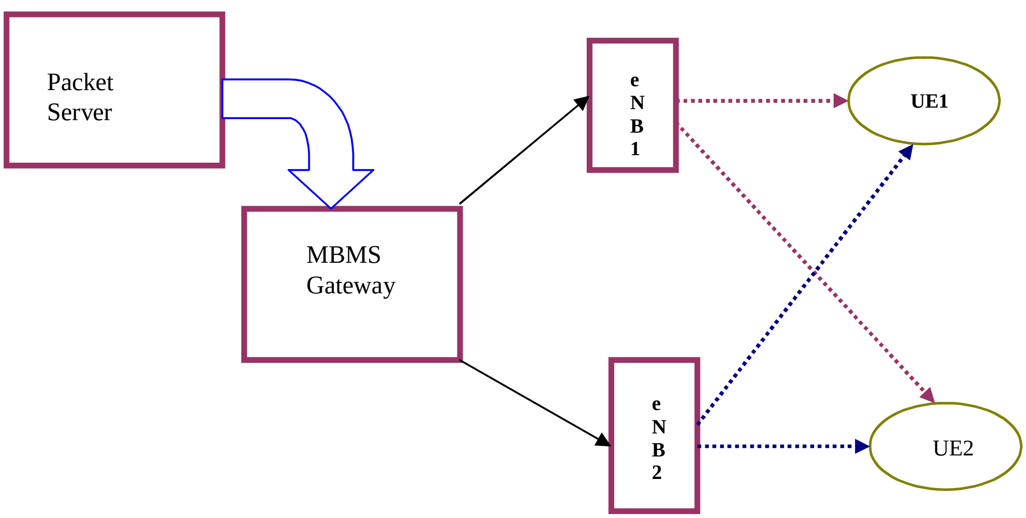
- Single-cell transmission – in this case, MBMS data are only provided and available over the coverage of one single cell.
- Multi-cell transmission – in this case, the MBMS data sent in the different cells are tightly synchronized. This allows the receiving terminal to recombine the signals received from various cells and improve the signal-to-noise ratio, as compared with conventional point-to multipoint transmission.

5.1 MBMS on Single Frequency Network

The MBMS that is going to see in LTE and its advanced is called as E-MBMS and it is considered as an important component in the EPS Architecture. MBMS should be supported in paired or unpaired spectrum.
E-MBMS provides a transport feature to send the same content information to a given set of users in a cell to all the users (broadcast) or to a given set of users (multicast) for which a notion of subscription applies in order to restrict the multicast services to a given set of users.

As EPS is based of Flat IP architecture, and we have already IP multicast feature available so how can a end user visualize this on EPS, and its is very important not mixed up IP multicast with MBMS.In IP multicast there is no sharing a given Radio Resource in-between the user as it is purly a way of duplication of IP packets on some routers on the network.

E-MBMS (which is the evolved version of the legacy MBMS system) will be going to use of some MIMOs open loop scheme. In E-MBMS, there will be a single (single-cell broadcast) or multiple transmitting e-Node Bs and multiple receiving UEs. E-MBMS is a good application to demonstrate what MIMO can bring to the system. Indeed, in the case of broadcast of the same signal on the same frequency band the transmission power has to be chosen so that the far mobiles should receive the signal with good quality. To reduce the required power, increasing the number of transmit and receive antennas is a good solution. MIMO options, like spatial multiplexing, is possible in the MBMS context.



MBSFN Visualization

In E-UTRAN, MBMS transmissions may be performed as single-cell transmissions or as multi-cell transmissions. In the case of multi-cell transmission, the cells and content are synchronized to enable for the terminal to soft-combine the energy from multiple transmissions. The superimposed signal looks like multipath to the terminal. This concept is also known as Single Frequency Network (SFN). The E-UTRAN can configure which cells are parts of an SFN for transmission of an MBMS service.

A MBMS Single Frequency Network is called a MBSFN. MBSFN is envisaged for delivering services such as mobile TV using the LTE infrastructure, and is expected to be a competitor to DVB-H-based TV broadcasts.
In MBSFN, the transmission happens from a time-synchronized set of eNodeBs using the same resource block. The Cyclic Prefix (CP) used for MBSFN is slightly longer, and this enables the UE to combine transmissions from different eNodeBs located far away from each other, thus somewhat negating some of the advantages of SFN operation.

There will be six symbols in a slot of 0.5 ms for MBSFN operation versus seven symbols in a slot of 0.5 ms for non-SFN operation. For MBSFN operation, 3GPP is working on a SYNC protocol between the E-MBMS
Gateway and the eNodeBs to ensure that the same content is sent over the air from all the eNodeBs. A broadcast server is the source of the MBMS traffic, and a gateway (E-MBMS gateway) is responsible for distributing the traffic to the different eNodeBs of the MBSFN area.IP Multicast can be used for distributing the traffic from the E-MBMS gateway to the different e-NodeB

3GPP has defined a control plane entity, known as the MBMS Coordination Entity (MCE) that ensures that the same resource block is allocated for a given service across all the eNodeBs of a given MBSFN area. It is the task of the MCE to ensure that the RLC/MAC layers at the eNodeBs are appropriately configured for MBSFN operation.3GPP has currently assumed that header compression for MBMS services will be performed by the E-MBMS gateway. In this case, the scrambling should be identical for all cells involved in the MBSFN transmission. In general each of the broadcasting cells used its own frequency/scrambling code, even if the same content is broadcasted from multiple cells, their signals interfere due to scrambling.

The MBMS traffic is going to share the same carrier with the unicast traffic or be sent on a separate carrier.In the case of subframes carrying MBMS SFN data, specific reference signals are used.MBMS data are carried on the MBMS traffic channel (MTCH) as a logical channel is mapped either on the MCH transport channel or on the DL-SCH downlink shared channel. In the case of mapping on the MCH channel, the physical channel associated is the PMCH.

When used with several cells, the reference symbols needed for MBMS reception are Identical in all cells to be considered for combining and transmission scheduling has to be such that received packets are received in a range substantially less than the cyclic prefix.MBMS transmissions may share the same carrier with unicast, or dedicated traffic.

In case MBMS transmissions are handled using a separate carrier:

- There is only TDM multiplexing between different services.
- Only long CP is considered

When used with MBMS, feedback signalling from the UE may not be feasible, including CQI. In the case of multi-codeword spatial multiplexing, dynamic adaptation of modulation and coding, etc. for each codeword is not possible due to the absence of channel quality feedback. However, different codewords can potentially use different modulation and coding and/or power offsets in a semi-static fashion in order to enable efficient interference Cancellation at the UE receiver.

Since the baseline UE has only two antennas, the number of broadcast codewords are limited to two. E-MBMS for UE limited to single codeword reception capability should be further considered. E-MBMS signals from NodeB with more than two transmit antennas should be transparent to the UE.

6 References

3GPP technical specifications:

22.146	Multimedia Broadcast/Multicast Service (MBMS): Stage 1.
22.246	Multimedia Broadcast/Multicast Service (MBMS) User Services: Stage 1.
23.246	Multimedia Broadcast/Multicast Service (MBMS): Architecture and Functional Description.
26.346	Multimedia Broadcast/Multicast Service (MBMS): Protocols and Codecs.
33.246	3G Security; Security of Multimedia Broadcast/Multicast Service (MBMS).
32.273	Multimedia Broadcast and Multicast Service (MBMS) Charging.
36.440	General aspects and principles for interfaces supporting Multimedia Broadcast Multicast Service (MBMS) within E-UTRAN

Book

LTE and SAE Evolution by Pierre Lescuyer and Thierry Lucidarme