Multimedia Broadcast Multicast Service (MBMS) in GSM based Wireless Networks

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Abstract

The proposed research paper identifies the system issues involved in supporting the MBMS in the GSM based wireless networks. Radio Resource (RR) management and Mobility Management (MM) aspects are investigated to support the MBMS service architecture. The technical feasibility for the realization of MBMS is considered here starting with the MBMS service requirements, system architecture, and user plane/control plane protocols. This research paper is organized as follows; the system requirements, basic operation (physical layer, layer 2 and layer 3) and architecture principles are covered to realize the MBMS service concept.

1. Introduction

Providing video services to the wireless user is a challenging task. Since the existing second generation wireless networks support voice services using the circuit switched method, 3rd generation wireless systems and packet based wireless networks goal is to support the provision of video services to the consumer. There are lot of research work is going on in the industry to support the high bandwidth video and multimedia applications via wireless networks.

Due to the exciting nature of the video applications and the challenges involved in supporting such applications in the wireless networks there is wide scope exist for the MBMS based applications.

Multicast applications are available in the wire line networks for several years. Wireless Service providers are interested in providing the similar multicast applications in Wireless systems. In general Global System for Mobile communication (GSM) networks support low bit rate data up to 14 kbps. Recently evolutions of the GSM communication networks called General Packet Radio Systems (GPRS) are standardized to support the high-speed data. New service options can be implemented in GPRS based networks. MBMS is one of the evolving service concepts within the 3rd generation networks. MBMS is a user service, which is a combination of both a broadcast service and a multicast service. The practical implementation of this MBMS service may be still 2-3 years further away.

Third generation partnership (3GPP) is working on establishing standards for multimedia broadcast and multicast services. The key goal is to come up with the service architecture, which involves

- Minimum network resource utilization in both access network and core network.
- Continuous delivery of multimedia information taking into consideration of the mobility aspects.
- Scalable and reliable service platforms
- Efficient design of the Um interface (air interface)

This research paper mainly focuses on the radio and core network signalling aspects/protocols that can provide very reliable MBMS functionality with taking in to consideration of the four factors mentioned above.

2. MBMS Main Concepts

A MBNS can be considered as a unidirectional point-to-multipoint service in

which data is transmitted from a single source entity to a group of users in a specific area. The MBMS has two modes: Broadcast mode and Multicast mode. Broadcast and Multicast are methods for transmitting data grams from a single source to several destinations (point-to-multipoint).

The broadcast mode is a unidirectional point-to-multipoint transmission of multimedia data (e.g. text, audio, picture, video) from a single source entity to all users in a broadcast service area. The broadcast mode is intended to efficiently use radio/network resources e.g. data is transmitted over a common radio channel. Data is transmitted in the broadcast service area as defined by the network (Home environment).

Figure 1 gives an example of how a network can be configured to broadcast a variety of high bit rate services to users within the associated broadcast service area.

A broadcast service received by the UE, involves one or more successive broadcast sessions. A broadcast service might, for example, consist of a single on-going session (e.g. a media stream) or may involve several intermittent sessions over an extended period of time (e.g. messages).
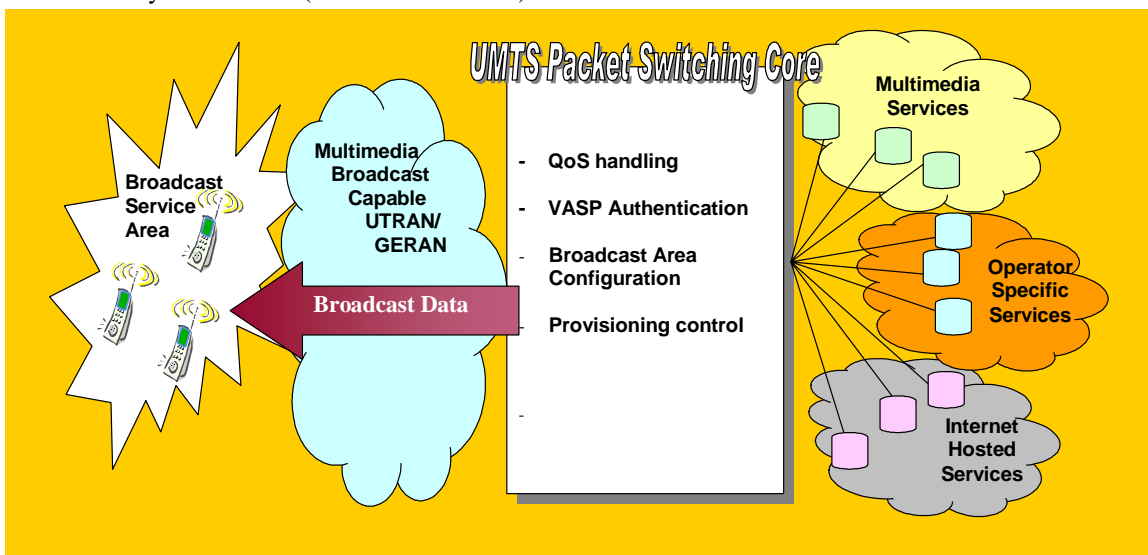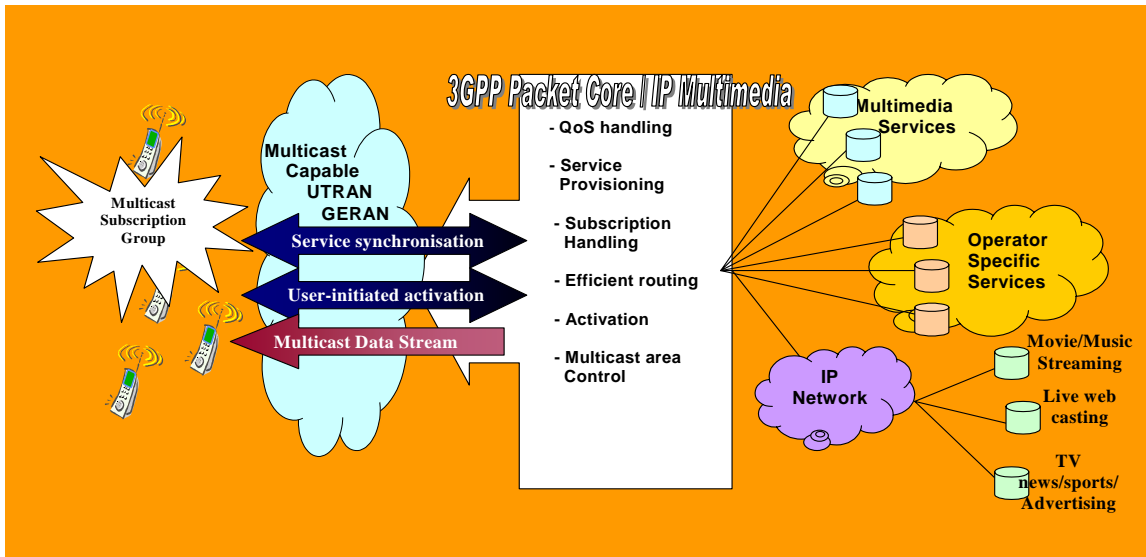

Figure 1: Example of Multicast Broadcast Mode Network

A multicast service received by the UE, involves one or more successive multicast sessions. A multicast service might, for example, consist of a single on-going session (e.g. a multimedia stream) or may involve several intermittent multicast sessions over an extended period of time (e.g. messages).

An example of a service using the multicast mode could be a football results service for which a subscription is required.

Unlike the broadcast mode, the multicast mode generally requires a subscription to the multicast subscription group and then the user joining the corresponding multicast group. The PLMN operator, the user or a third party on their behalf may make the subscription and group joining. Unlike the broadcast mode, it is expected that charging data for the end user will be generated for this mode.

Figure 2: Example of Multicast Mode Network

Multicast mode shall be inter-operable with IETF IP Multicast. This could allow the best use of IP service platforms to help maximize the availability of applications and content so that current and future services can be delivered in a more resource efficient manner.

1.1 Benefits:

It is considered that for some applications, multiple users can receive the same data at the same time. The benefit of multicast and broadcast in the network is that the data is sent once on each link. For example, an SGSN will send data once to an RNC regardless of the number of Node Bs and UEs that wish to receive it. The benefit of multicast and broadcast on the air interface is that many users can receive the same data on a common channel, thus not clogging up the air interface with multiple transmissions of the same data.

With increasing use of high bandwidth applications in third generation mobile systems, especially with a large number of users receiving the same high data rate services, efficient information distribution is essential. Thus, broadcast and multicast are techniques to decrease the amount of data within the network and use resources more efficiently.

1.2 MBMS Applications:

- Mobile Auctions,
- Game score updates
- Distribution of contents (news, advertisements, stock information's and e-coupons)

1.3 MBMS Service Requirements

- The user shall be able to continue receiving broadcast services throughout the broadcast service area. For example, in case of handover and presuming that a certain broadcast service is offered in the target cell, it should be possible for the user to continue receiving the service in the target cell.
- The user shall be able to discover what broadcast services are available at the user's current location and outside of the current location.
- The user shall be able to enable/disable the reception of specific broadcast services and can receive simultaneously more than one MBMS service.
- The user may be able to define service preference for reception. A priority procedure may be implemented to allow the user to select between simultaneous broadcast services e.g. while receiving commercial broadcast service a new multicast service may interrupt this.
- While receiving one or more broadcast services, it shall be possible for the user to be informed about incoming voice calls or the availability of other MBMS services.
- Dependent on terminal capabilities, it shall be possible for the user to participate in other services, while simultaneously participating in MBMS services. For example

the user can originate or receive a call or send and receive messages whilst receiving advertisements.

- The PLMN operator shall be able to configure the quality of service for each individual broadcast service. It should be possible to adapt the MBMS data transmission to different RAN capabilities or different radio resource availability.
- The home environment shall be able to set priority to select which simultaneous broadcast services are supported when there is a limit on the resources available.
- Network and radio efficiency - The PLMN operator shall be able to use network and radio resources in an efficient manner.
- The operator shall be able to schedule a certain broadcast service at predetermined times.
- MBMS in The broadcast mode shall be transparent for the transferred data packets independent of the type of service being transmitted, will support a number of services, and permit support of and therefore transfer all data types e.g. Audio, Data, Video or combinations thereof.
- A minimum number of data types may need to be identified to enable interoperability.
- In addition to supporting their own broadcast services the PLMN shall as well support broadcast services from third parties.
- The PLMN operator shall be able to provide service announcements for a broadcast service within and outside of the broadcast area defined for the service.

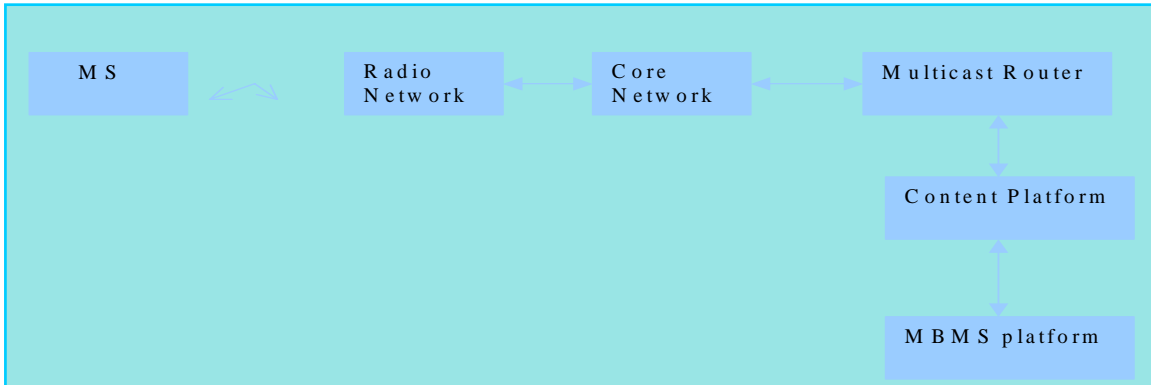## 2. Description of the Architecture and Signaling procedure:

The figure 3 shows the basic service architecture to realize the MBMS.

The signaling procedures can be combined in to the following basic steps,

3. MBMS resource allocation
4. MBMS data flow
5. MBMS session termination

2.1 Processing Stages

1. Session initiation
2. MBMS notification

Figure 3: **Architecture aspects for MBMS**

The wireless operator (service provider) or content provider indicates the MBMS availability to the wireless users via a special MBMS based service announcement and discovery procedure. The MBMS service announcement method basically allows the wireless network to inform the subscribers about the new service availability. The next procedure is the service discovery, which allows the users to request information about the MBMS services from the wireless network. There are various methods available to discover the MBMS such as Short Messaging Services (SMS) and Wireless Application Protocol (WAP). Any specialized platforms such as MBMS platform or MBMS controller can be used to provide information to the subscribers about the MBMS contents and schedules.

Service announcement method allows the network to provide information about the MBMS services to the subscribers such as content name, IP addresses and related service specific parameters.

After the information acquisition process MS obtains the necessary radio configuration related information from the Base Station Subsystem (BSS). The MS also does the

After the discovery of the MBMS services, the interested users who wish to get more service related information will contact the wireless operator or log in to the service providers internet web page for subscription. All the authentication and related security mechanisms will be carried out between the wireless service provider's network and the mobile users. After the initial validation, the users can subscribe to the MBMS services anytime.

The next step is the MBMS information acquisition procedure. This procedure allows the mobile subscribers to communicate with the MBMS platform to acquire the MBMS session related information. For example Multicast IP address and Transport layer port number, which is used to uniquely identify MBMS program flow over the air interface.

One MBMS program may have multiple IP flows based on the different content and application specific information's. For example a basic video flow, an audio flow and an enhanced video flow.

notification procedure with the network to inform the flow ID's. MS also establishes the bearer path after the notification procedure. The

actual information flow transfer takes place (MBMS flow) as a next step.

When the Radio Access Network (RAN) determines that there is no active information flow, the system will release the bearer path
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associated with the corresponding multicast IP flow(s) to save the system resources. The network also informs the MS about the release process
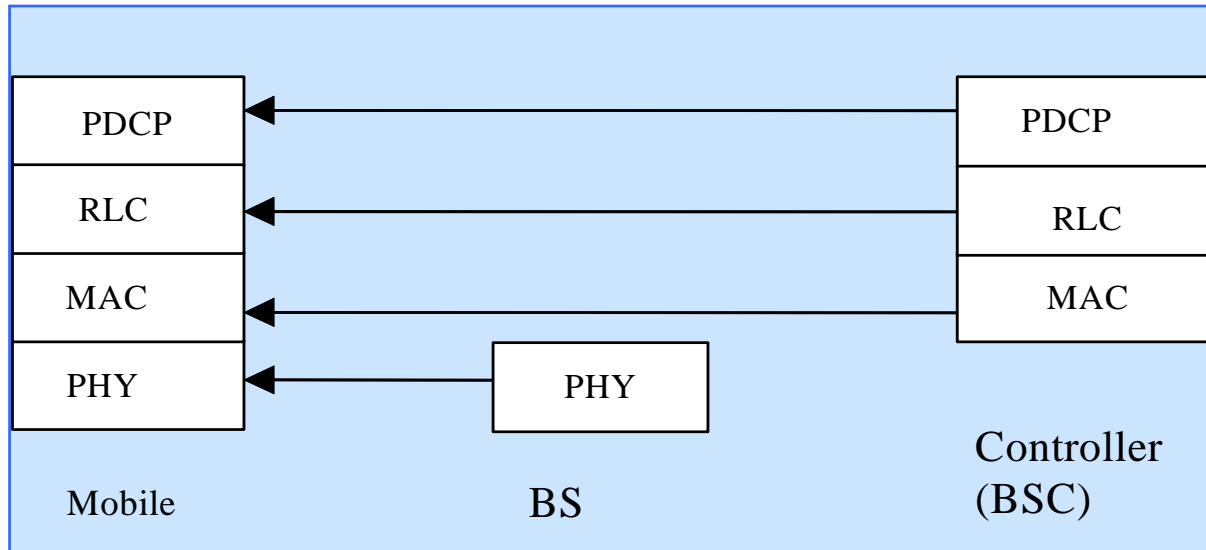
3. User Plane Protocol Stack:

Figure 4: User plane protocol stack

PDCP sub-layer performs header compression/decompression for the MBMS traffic.

PDCP sub-layer may operate with RFC 3095 header compression protocol. In that case, header compression should be performed under RFC 3095 U-mode.

In the UTRAN side, there is one PDCP entity per cell supporting MBMS or MBMS Cell Group for each MBMS service in each RNS. The shared PDCP entity in the UTRAN duplicates all PDCP PDUs to every RLC entity for every cell belonging to one MBMS Cell Group.

In the UTRAN, there is one RLC entity for each MBMS service in each cell or cell group in case of utilization of selective combining or maximum ratio combining in TDD, and one MAC entity for each cell.

In the UE side, there is one PDCP and RLC entity for each MBMS service in each UE. In each UE there is one MAC entity per received cell when UE is performing the selective combining between these cells.

In case of p-t-p transmission, DTCH is used for MBMS transmission and the protocol termination for DTCH mapped on DCH and RACH/FACH

4. Control Plane Protocol Stack:
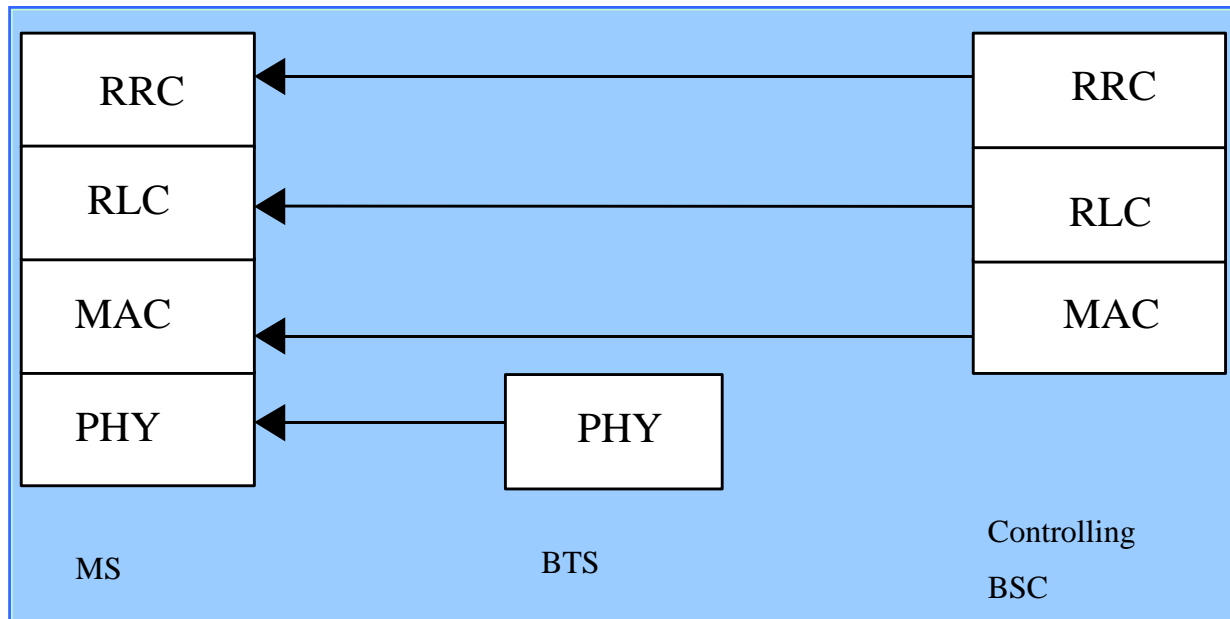
Figure 5: Control plane protocol stack

Figure 5 illustrates the protocol termination for MCCH in MBMS, which is p-t-m control channel.

MBMS functionalities are included in MAC and RRC.

In case of p-t-p transmission, DCCH is used for MBMS and the protocol termination for DCCH mapped on DCH and FACH.

5. Forward Error Correction Schemes for MBMS based on MPEG-4

MPEG-4 codec support is evaluated in the 3GPP standardization to demonstrate the service quality at the receiver, applying different Forward Error Correction strategies for MBMS delivery over a point-to-multipoint connection.

5.1 Service Quality Measurements

The service quality was again measured in terms of PSNR as well as in terms of audio and video frame losses for the demonstration video described in the next section. These are depicted in table for the repetition scheme at RLC and for the outer coding scheme.

Sequence	Audio – 16 kbits/s	Video – 44 kbits/s
Audio packet loss /	7.1 % (54 of 760)	-
Video frame loss	-	27.7 % (135 of 487)
PSNR	-	14.16

Table 1: Service quality for MPEG-4 video and audio at receiver (repetition scheme at RLC layer).

Sequence	Audio – 16 kbits/s	Video – 44 kbits/s

Audio packet loss /	2.2 % (17 of 760)	-
Video frame loss	-	2.7 % (13 of 487)
PSNR	-	29.5

Table 2: Service quality for MPEG-4 video and audio at receiver (outer coding scheme at RLC layer).

5.2 Layer 2 Analyses:

This section depicts the modeling of the RLC layer used for the MPEG-4 transport over the wireless networks. The coding schemes are based on EGPRS, MCS-5 and MCS-8 being used. A block diagram is shown in Figure 6.
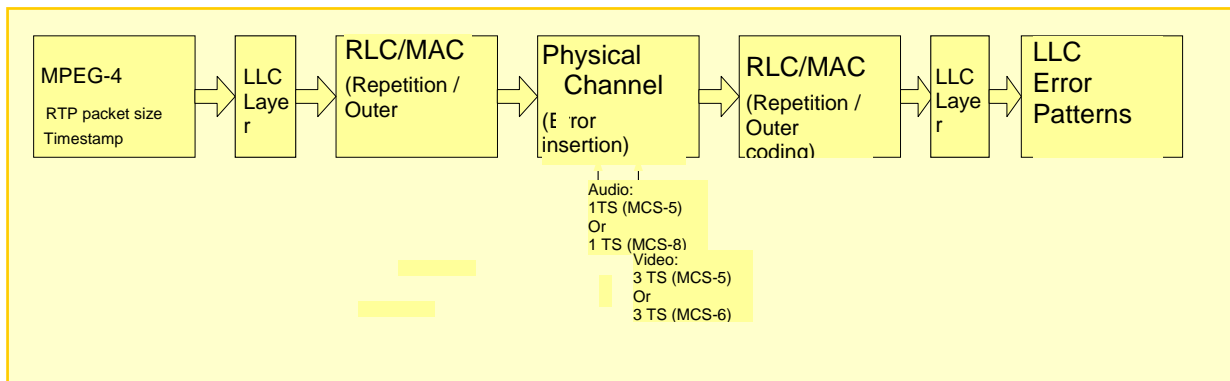
Figure 6: RLC layer analysis block diagram.

The video is transported over 3 timeslots for both options. Within the 3GPP standards, a two-stage approach was selected to evaluate the service quality of MPEG-4 multimedia traffic. The lower stage, the RLC layer simulation, creates LLC error patterns separately for audio and video stream, which are used at the upper stage, including MPEG-4 encoder and decoder, before the MPEG-4 decoder. The changed simulation parameters of the RLC layer and the LLC layer can be found in Table 3.

No. of RLC/MAC blocks simulated	Approximately 5000.
Logical channels	Pseudo-dedicated. No Feedback
QoS	Target SDU FER of 10^{-2} for both audio and video.
Video/Audio multiplexing	Video and audio are transported on separate timeslots. Multiplexing and synchronisation is achieved at the application (RTP) layer.
Radio Channel Profile	TU 3 with ideal frequency hopping. Fixed CIR of 10 dB.
Multislot traffic channel	High fading correlation between slots. The same interference is assumed for both timeslots.
Error Protection	Equal Error Protection (EEP).
Link Adaptation	None.
Header Compression	No header compression. 40 byte RTP/IP/UDP header.
SNDCP functionality	SNDCP header: 2 bytes
LLC functionality	LLC is operated in unacknowledged mode. LLC header size: 2 bytes. FCS:

| | 3 bytes. |
| | LLC frame concatenation. Frames discarded after an LLC discard time of 3 seconds. Frames that are in the process of being transmitted are not discarded even if their lifetime exceeds the LLC discard time. Buffer size = 4 LLC frames. |

Table 3: Simulation parameters for RLC and LLC layer.

5.3 Service Quality Evaluation

Overview

The service quality evaluation campaign is shown in Figure 7.
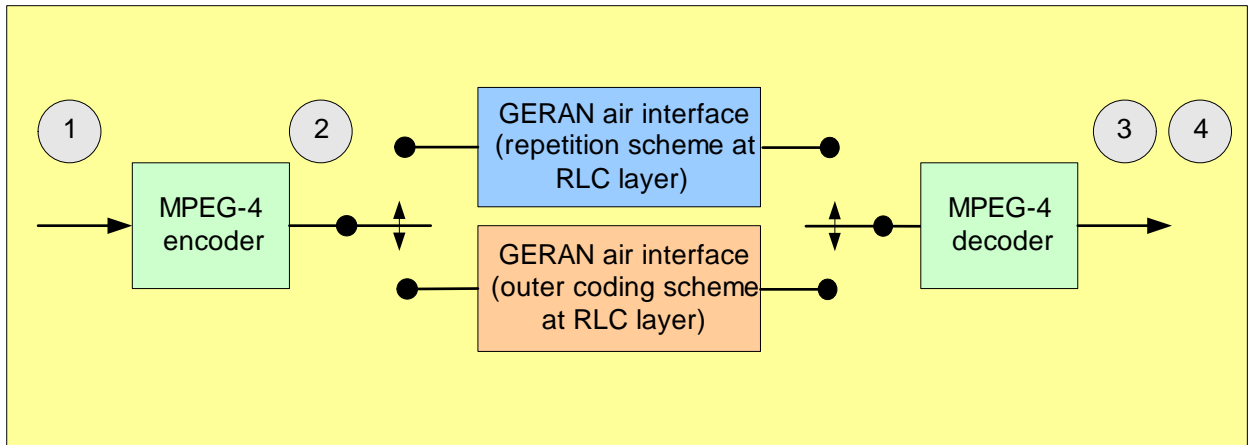
Figure 7: Service quality evaluation campaign for MPEG-4 transport over GERAN.

First a high quality video consisting of a video sequence and an audio sequence are encoded into one MPEG-4 video and one MPEG-4 audio stream. A reduced video codec rate of 38 Kbits/s can be used to evaluate the quality. This provides still reasonable video quality and can be encoded within 3 DL timeslots.

Sequence	Audio – 16 kbits/s	Video – 44 kbits/s
Original sequence	44,1 kHz 16 bit, Stereo	Size: 176 x 144 (QCIF) Video Frame Rate: 10 frames per second
Encoded sequence	Format: AAC 16 kHz 16 bit, mono Rate: 15,2 kbps	Format: MPEG4 Video Simple Profile (QuickTime Codec). Rate: 38 kbps PSNR: 30.73 (compared to 31.7 for video codec rate of 48 kbps in Variable bit rate (VBR) mode. 38 kbit/s. Total bit rate required including all header: 44 kbps Maximum RTP packet size: 1400 bytes.

		I-VOP at least every 2.5 s. Medium video quality, poor rate control.

Table 4: Characterization of video and audio streams.

Then both streams are separately conveyed over the GERAN air interface utilizing either a repetition scheme (configuration 1) or outer coding scheme (configuration 2) at RLC layer as depicted in Table 5.

The receiver, i.e. the MS, decodes both MPEG-4 streams erasing all RTP packets with corrupted UDP checksum and determines the PSNR (pseudo-SNR) ratio. Note, a PSNR ratio of 30 or more usually leads to sufficient service quality.

The service quality of following stages exists:

1) Original video and audio sequence

2) Video and audio sequence after MPEG-4 encoder

3) Video and audio sequence after MPEG-4 decoder (repetition scheme at RLC)

4) Video and audio sequence after MPEG-4 decoder (outer coding at RLC)

Sequence RLC Configuration	Audio – 16 kbits/s	Video – 44 kbits/s
Repetition scheme	1 timeslot. 3 repetitions. MCS-8 with IR. @ C/I=10dB.	3 timeslots. 2 repetitions. MCS-6 with IR. @ C/I = 10dB.
Outer coding scheme	1 timeslot. RS (88, 64). MCS-5 @ C/I = 10dB.	3 timeslots. RS (96, 64). MCS-5 @ C/I=10dB.

Table 5: Configuration of the GERAN RLC layer utilizing repetition or outer coding scheme.

6. Reference to the GERAN technical contribution (Simulation Results)

6.1 Simulation MPEG4 Video + Audio

6.1.1. Video Sequence
File after MPEG4 encoding
- Video
    1. Format: MPEG4 Video Simple Profile
    2. Rate: 38 kbps
    3. PSNR: 30,73
- Audio:
    1. Format: AAC
    2. 16 kHz
    3. 16 bit, mono
    4. Rate: 15,2 kbps

6.1.2. Video Sequence
Encoded file after simulation with repetition scheme (C/I = 10 dB):
- Video:
    1. Frame loss: 135 of 487 (27.7%)
    2. PSNR: 14.16
- Audio:
    1. Packet loss: 54 of 760 (7.1%)

6.1.3. Video Sequence
Encoded file after simulation with outer coding (C/I = 10 dB):
- Video:
    1. Frame loss: 13 of 487 (2.7%)
    2. PSNR: 29.5
- Audio:
    1. Packet loss: 17 of 760 (2.2 %)

6.2 System Requirements for Broadcast and Multicast Modes

6.2.1 Home environment requirements

6.2.1.1 Broadcast services

The PLMN operator shall be able to provision one or more broadcast services within his PLMN.

The operators sharing a network shall be able to provide one or more broadcast services for their own subscribers and inbound roamers from roaming partners only. This shall be applicable for sharing of radio network and for sharing of radio network and the core network entities connected to the radio network.

A broadcast area is configured individually for each broadcast service. Broadcast areas associated with different broadcast services are independent of each other and may overlap.

6.2.1.2 Quality of service

The PLMN operator shall be able to configure the quality of service for each individual broadcast service. It should be possible to adapt the MBMS data transmission to different RAN capabilities or different radio resource availability.

The home environment shall be able to set priority to select which simultaneous broadcast services are supported when there is a limit on the resources available.

6.2.1.3 Network and radio efficiency

The PLMN operator shall be able to use network and radio resources in an efficient manner.
NOTE: Allocation of resources based on actual need in the broadcast service area is not applicable for the broadcast mode.
The operator shall be able to schedule a certain broadcast service at pre-determined times.

6.2.1.4 Types of data services

MBMS in The broadcast mode shall be transparent for the transferred data packets independent of the type of service being transmitted, will support a number of services, and permit support of and therefore transfer all data types e.g. Audio, Data, Video or combinations thereof. A minimum number of data types may need to be identified to enable interoperability.

A broadcast service shall be able to distribute different content data to different locations, i.e. local broadcast areas. This allows the user to receive broadcast data depending on his location (e.g. a "nationwide traffic service" with localized traffic reports) only one location specific version of content data is distributed to each of the individual local broadcast areas, i.e. in any location a user will never receive different content data from a single broadcast service.

It shall be possible to define a broadcast service for only the subscribers and inbound roamers of one of the operators sharing network. The broadcast services transmitted in a broadcast service area of operator A shall only be available to the subscribers and inbound roamers of operator A. The broadcast areas of different sharing operators may cover the same geographical area. This shall be applicable for sharing of radio network and for sharing of radio network and the core network entities connected to the radio network.

6.2.1.6 Sources of data services

In addition to supporting their own broadcast services the PLMN shall as well support broadcast services from third parties (i.e. HE-VASPs or VASPs)

6.2.1.7 Broadcast service announcements

The PLMN operator shall be able to provide service announcements for a broadcast service within and outside of the broadcast area defined for the service

6.2.2 User requirements for MBMS

6.2.2.1 User mobility

The user shall be able to continue receiving broadcast services throughout the broadcast service area. For example, in case of handover and presuming that a certain broadcast service is offered in the target cell, it should be possible for the user to continue receiving the service in the target cell.

6.2.2.2 User selectivity

The user shall be able to discover what broadcast services are available at the user's current location and outside of the current location.

The user also shall be able to enable/disable the reception of specific broadcast services and can receive simultaneously more than one MBMS service.

The user may be able to define service preference for reception. A priority procedure may be implemented to allow the user to select between simultaneous broadcast services e.g. while receiving commercial broadcast service a new multicast service may interrupt this.

While receiving one or more broadcast services, it shall be possible for the user to be informed about incoming voice calls or the availability of other MBMS services.

Dependent on terminal capabilities, it shall be possible for the user to participate in other services, while simultaneously participating in MBMS services. For example the user can originate or receive a call or send and receive messages whilst receiving advertisements.

7. Multicast mode

7.1 Home environment requirements

7.1.1 Multicast services

The PLMN operator shall be able to provision one or more multicast services. A multicast area is configured individually for each multicast service. Multicast areas associated with different multicast services are independent of each other and may overlap.

Multicast service areas may cover part(s) of one or more PLMNs.

A multicast service shall be able to distribute different content data to different locations, i.e. local multicast areas, within the multicast service area as shown in figure 4. This allows the user to receive multicast data depending on his location (e.g. a "nationwide traffic service" with localized traffic reports) only one version of location specific content data is distributed to each of the individual local multicast areas, i.e. in any location a user will never receive different content data from a single multicast service.

7.1.2 Multicast subscription groups and multicast groups

The PLMN operator shall be able to provision one or more multicast subscription groups. The home environment shall be able to make a user a member of a multicast subscription group (subscription).

On receipt of a request to join a multicast group, the PLMN shall check that the user is a member of the applicable multicast subscription group. The home environment shall be able to join users to the multicast group e.g. at the request of the subscriber.

7.1.3 Quality of service

The PLMN operator shall be able to configure the quality of service for individual multicast services. It should be possible to adapt the MBMS data transmission to different RAN capabilities or different radio resource availability.

As part of the same service, it should be possible for the operator to provide the UEs with multiple successive sessions with different quality-of-service for each session.

The home environment shall be able to set priority to select which simultaneous multicast services are supported when there is a limit on the resources available.

7.1.4 Network and radio efficiency

The PLMN operator shall be able to use network and radio resources in an efficient manner.

Within the multicast service area, the network may distribute the data across the whole multicast service area or parts of the area. The decision to distribute to only parts of the multicast service area may be based on: a) multicast group members are present in a given part of the multicast area b) resources are not available in parts of the multicast service area.

The operator shall be able to schedule a certain multicast service at pre-determined times.

7.1.5 Types of services

The multicast mode shall be independent of the type of service being transmitted, will support a number of services, and permit support of all data types e.g. Audio, Data, Video or combinations thereof. A minimum number of data types may need to be identified to enable interoperability

7.1.6 Sources of services

In addition to supporting their own multicast services the PLMN shall as well support multicast services by third parties (i.e. HE-VASPs or VASPs).

7.1.7 Multicast service announcements

The PLMN operator shall be able to provide service announcements for a multicast service within and outside of the multicast area defined for the service.

7.2 User requirements for MBMS

7.2.1 User mobility

The user shall be able to continue receiving multicast services throughout the multicast service area in which the service is provided. For example, in case of handover and presuming that a certain multicast service is offered in the target cell, it should be possible for the user to continue the session in the target cell. It is possible that data loss will occur due to user mobility.

7.2.2 User selectivity

The user shall be able to discover what multicast services are available at the user's current location and outside of the current location. The user shall be able to select between different multicast services provided to the user and can receive simultaneously more than one MBMS service.

The user may be able to define service preference for reception. A priority procedure may be implemented to allow the user to select between simultaneous broadcast/multicast services e.g. while receiving commercial broadcast service a new multicast service may interrupt this.

While receiving PS or CS services it shall be possible for the user to receive notification of MBMS multicast sessions.

While receiving one or more multicast services it shall be possible for the user to be informed about incoming voice calls or the availability of other MBMS services.

Dependent on terminal capabilities, it shall be possible for the user to participate in other services, while simultaneously participating in MBMS services. For example the user can originate or receive a call or send and receive messages whilst receiving MBMS video content.

7.2.4 Multicast subscription groups and multicast groups

The subscriber shall be able to subscribe to or unsubscribe from a multicast subscription group. (The subscription mechanism is outside the scope of these TS.)

The user shall be able to join a multicast group only if he is a member of the applicable multicast subscription group. The user shall be able to leave a multicast group if he is a member of that group.

7.3 Availability

MBMS in multicast or broadcast mode shall be available to all users that are registered/attached to a PLMN, in case of non-shared network.

In the case of two or more operators sharing infrastructure (e.g. parts of the radio network or sharing of radio network and the core network entities connected to the radio network), it shall be possible for a sharing operator offering MBMS in multicast or broadcast mode to prevent access to these MBMS services by subscribers and inbound roamers of the other operator(s) sharing the same infrastructure.

Within the broadcast or multicast service area, it shall be possible to inform users of up-coming MBMS sessions which they may receive. This may be useful e.g. to initiate UE processes for the reception of MBMS data.

In case of roaming a user should also be able to subscribe and join Multicast Services that are provided locally in the visited network, as allowed by the user's home environment.

7.4 Security

In multicast mode it shall be possible to ensure that only those users who are entitled to receive a specific multicast service may do so. It should be possible to choose whether a given multicast service is to be delivered with or without ensured group privacy.

7.5 Layer 3 - SIGNALING PROCEDURES
& Basic Operation

7.5.1 MBMS Initiation
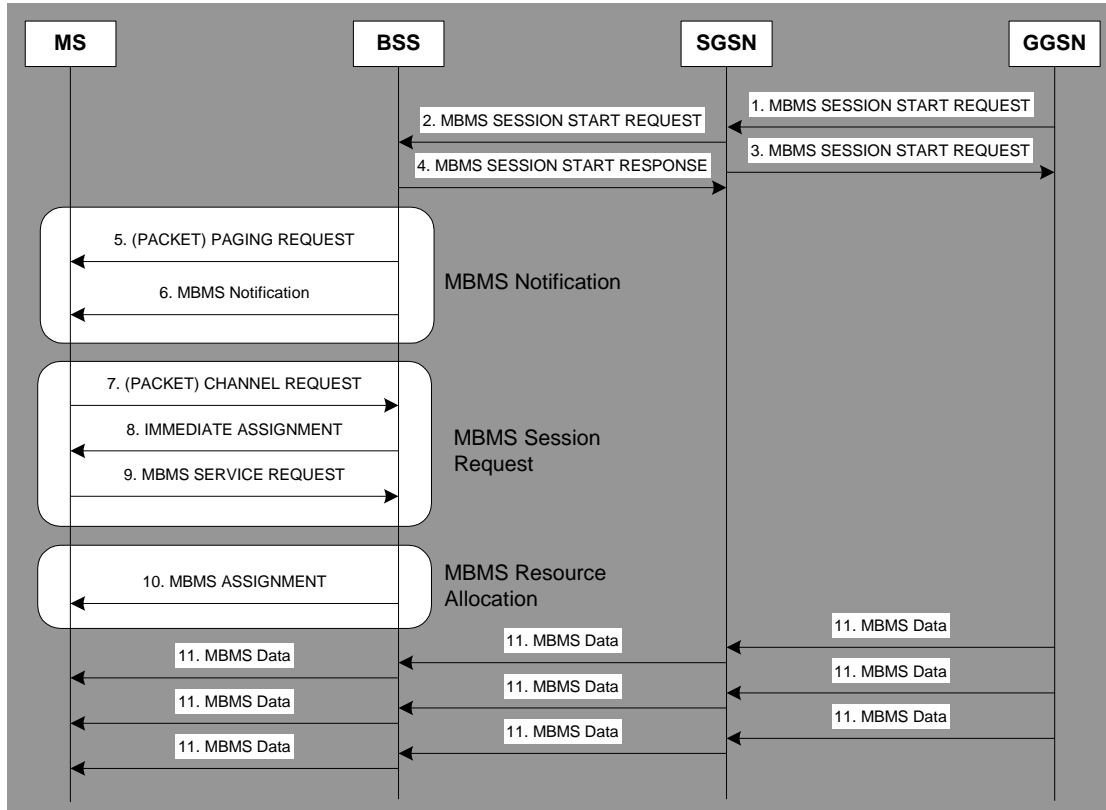
Figure 8: MBNS Initiation

1. / 2.   The MBMS SESSION START REQUEST message is passed along the chain of registered nodes, BM-SC → GGSN → SGSN → BSS, when the MBMS Session is about to start. When the BSS receives the indication that the MBMS session is immanent the BSC stores the session attributes in the MBMS Service Context and initiates the MBMS Notification Process. These messages need to include information

3. / 4.   The MBMS SESSION START RESPONSE message is sent to acknowledge the receipt of the MBMS SESSION START REQUEST message.

5.   An "MBMS Active" indication is included in all the messages sent on PCH and PPCH channels for the paging groups.

6.   An MBMS Notification message is broadcasted by the BSS on the MBMS Notification Channel providing the MBMS information to the mobiles. The Notification includes information such as: the clip number of the MBMS session, an indication whether this MBMS clip will be repeated and Spreading/randomizing factor of the MBMS session requests.

7. / 8.   The MS waits a random time before initiating the MBMS Session Request Procedure. The MS then requests and is allocated resources to send an Extended Measurement Report to the network.

9.   The MS sends an MBMS Service Request message, which includes the TLLI of the MS and the TMGI of the requested MBMS service. The MS starts timer T (A) and enters the MBMS_ACTIVE

State. Whilst Timer T (A) runs the MS listens to the (P) AGCH. If the Timer T (A) in the MS expires, the MS drops back to idle mode.

10. Once the BSS has received enough MBMS Service Requests the BSS can either allocate:

An MBMS point-to-multipoint bearer; or

Command the mobile to initiate the point-to-point repair mechanism.

If the MBMS point-to-multipoint bearer is allocated on a cell then the MBMS Data is passed down the allocated resources.

7.5.2 MBMS Resource Allocation

Once the BSS has a rough guide of the number of MS interested in an MBMS service, the BSS then decides whether:

There are sufficient resources on the cell to allocate an point-to-multipoint channel; or

It is efficient to allocate a point-to-multipoint channel depending on if there is a legacy TRX controlling the cell i.e. no CFCH support; and

There is to be another transmission of the MBMS session.

If the BSS decides to allocate the point-to-multipoint bearer then the BSC sends an MBMS ASSIGNMENT message to all the mobiles listening to the (P) AGCH that are waiting for the MBMS assignment.

The message needs to include the following information:

If the BSS decides to instruct the MS requesting the MBMS service to use the point-to-point repair mechanism, then the message to the MS needs to include the following information:
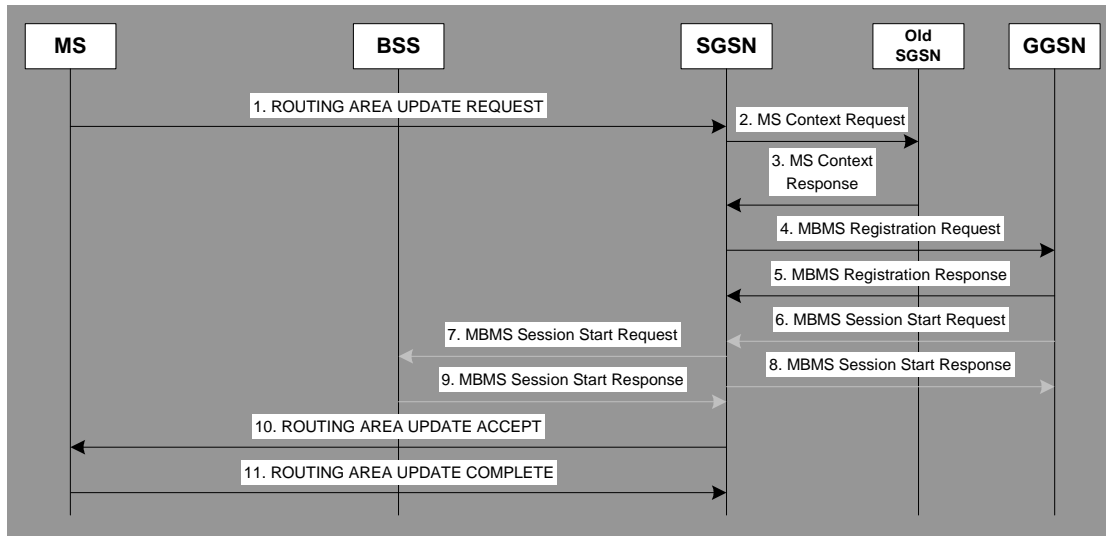
Back off time

Randomization information

(Optional) MBMS Server Address

7.6 Mobility Management Aspects

7.6.1 Routing Area Update

Figure 9: Routing area update

1.   The MS sends the Routing Area Update Request message to the SGSN.

2. / 3.   The new SGSN requests the context information from the SGSN controlling the Routing Area from which the MS has arrived. This MS Context information includes the list of MBMS service to which the MS has subscribed.

4. / 5.   If the SGSN is not registered for the all the MBMS Services contained within the received MS Context information then the SGSN requests these services from the GGSN by sending the MBMS REGISTRATION REQUEST message. The GGSN acknowledges the request for the MBMS service with the MBMS REGISTRATION RESPONSE message, which includes information such as the TMGI.

6. - 9.   If the MBMS service is currently active then the SGSN receives an MBMS Session Start Request message from the GGSN, which is then passed down to all the BSS controlling cells in the same Routing Area. The BSS stores the MBMS Context information and does not initiate the MBMS Notification. The MBMS Session Start Response message is used to acknowledge the Request.

10. /11.The SGSN and MS complete the Routing Area Update Procedure by sending the ROUTING AREA UPDATE ACCEPT message and ROUTING AREA UPDATE COMPLETE messages.
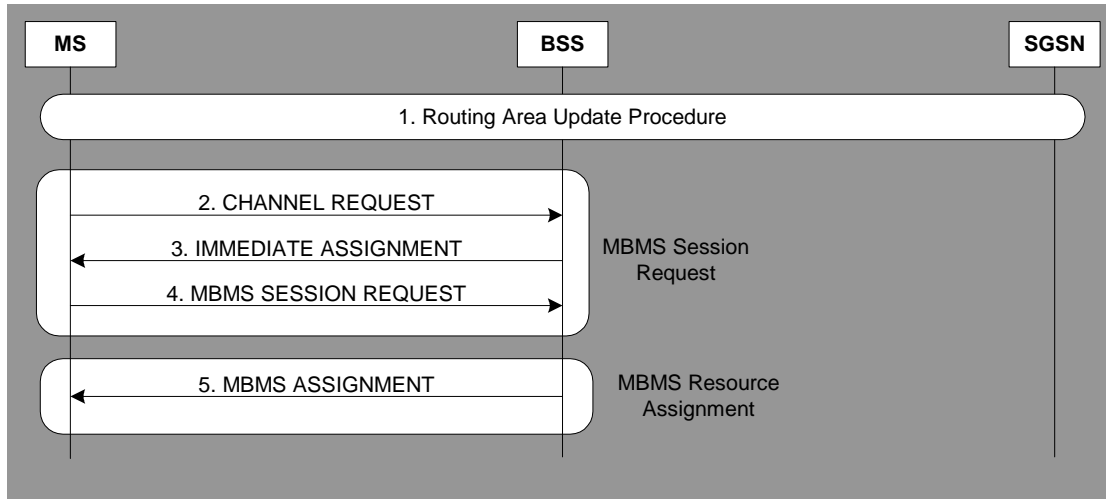
7.7 Cell Change

Figure 10: Cell change

1. On arriving in the new cell the MS completes the Routing Area Update procedure if the MS has changed Routing Area. The modified Routing Area Update procedure, documented in the sub-clause 0, provisions the MBMS service in the SGSN and BSC.

2. / 3. The MS waits a random time before initiating the MBMS Session Request Procedure. The MS then requests and is allocated resources to send an Extended Measurement Report to the network.

4. The MS sends an MBMS Session Request message, which includes the TLLI of the MS and the TMGI of the requested MBMS service. The MS starts timer T (A) and enters the MBMS_ACTIVE State. Whilst Timer T (A) runs the MS listens to the (P) AGCH. If the Timer T (A) in the MS expires, the MS drops back to idle mode.

5. Upon receiving the MBMS Service Requests the BSS can either:

Instruct the MS to move to an active MBMS point-to-multipoint bearer; or

Allocate an MBMS point-to-multipoint bearer to the MS; or

Instruct the mobile to initiate the point-to-point repair mechanism.

MBMS Session Stop

If an MBMS point-to-multipoint bearer is allocated on a cell then the MBMS Data is passed down on the allocated resources.

2. / 3. The MBMS SESSION STOP REQUEST message is passed from the BM-SC → GGSN →

SGSN → BSC. The BSC initiates the removal of resources allocated to the MBMS session.

4. / 5. The MBMS SESSION STOP RESPONSE message is passed back from the BSC → SGSN and includes some usage information for the MBMS session, e.g. the number of MBMS point-to-multipoint bearers allocated by a BSC.

6. The PACKET MBMS RELEASE message is then sent to the mobiles releasing the resources allocated to the MBMS session. The BSC includes a Back Off time and a randomization parameter in the PACKET MBMS RELEASE message allowing the mobiles to calculate when they can initiate point-to-point repair.

7.7.1 MBMS Paging Co-ordination

It is assumed that mobiles requiring paging co-ordination for MBMS will only be informed once for each MBMS session and that is when an MBMS session is about to start. These mobiles in CS connection or PS sessions will not therefore receive any subsequent periodic MBMS notifications for an ongoing MBMS service, whilst the mobiles stay in that state.

7.8 MBMS Paging during CS connections
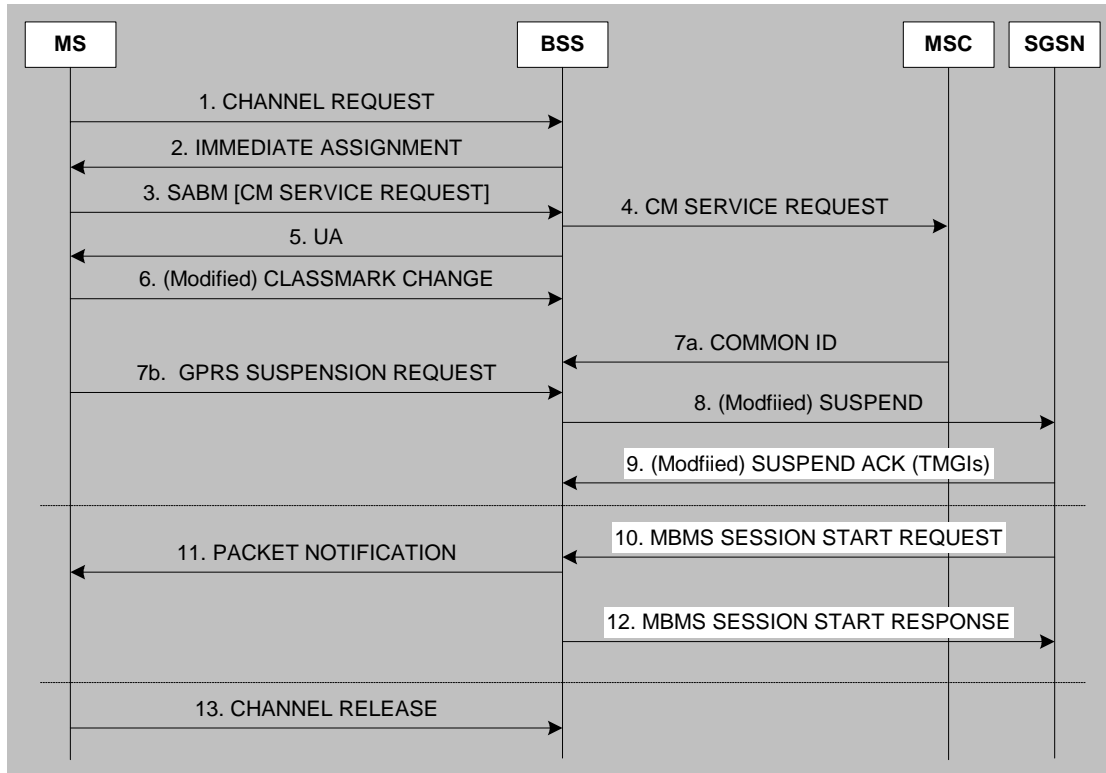
Figure 11: CS connections

The MS requests the allocation of radio resource from the BSC, to allow the MS to send the Service Request, by sending the CHANNEL REQUEST message.

The BSC allocates radio resources to the mobile using the IMMEDIATE ASSIGNMENT message.

The MS sends the CM SERVICE REQUEST message to the BSC encapsulated in the SABM message.

The CM SERVICE REQUEST is then passed to the MSC to initiate the CS connection.

A UA message is acknowledges to the mobile the correct reception of the SABM message.

The modified CLASSMARK CHANGE message is then passed up to the BSC. The modification to this message consists of the introduction of MBMS Active Flag, which informs the BSC that the MS has 'Joined' an MBMS service.

7a. The BSC of a Dual Transfer Mode capable mobile should receive the IMSI in the COMMON ID message from the MSC once the mobile has entered dedicated mode.

7b. a class B mobile on entering dedicated mode initiates the GPRS Suspension procedure and sends the GPRS SUSPENSION REQUEST message to the BSC, including the TLLI/RAI of the MS.

The BSC sends a (modified) SUSPEND message to the SGSN including the IMSI or TLLI/RAI of the mobile, as well as indicating: whether the GPRS or/and the MBMS service is available to the mobile.

The SGSN returns a (modified) SUSPEND ACK message to the BSC. If the SGSN has any MBMS services in the profile stored for the mobile then the TMGIs for these services are included in the SUSPEND ACK message.

The BSC is then passed the MBMS SESSION START REQUEST message to the BSC.

The BSC co-ordinates between the TMGI received in the MBMS SESSION START REQUEST message and the TMGIs stored in the profiles of the mobiles currently in dedicated mode. The mobiles that are interested in this MBMS service are then passed a PACKET NOTIFICATION message.

The MBMS SESSION START RESPONSE message is sent by the BSC to acknowledge to the SGSN the

Receipt of the MBMS SESSION START REQUEST message.
The CHANNEL RELEASE message sent when the mobiles leaves dedicated mode, triggers the BSC to delete the MBMS information stored for the mobile.

Note: An optional improvement to this mechanism would be to include the TMGIs of the MBMS service into the HANDOVER REQUIRED and HANDOVER REQUEST messages, such that a mobile can be informed of a commencing MBMS service in the new BSC.
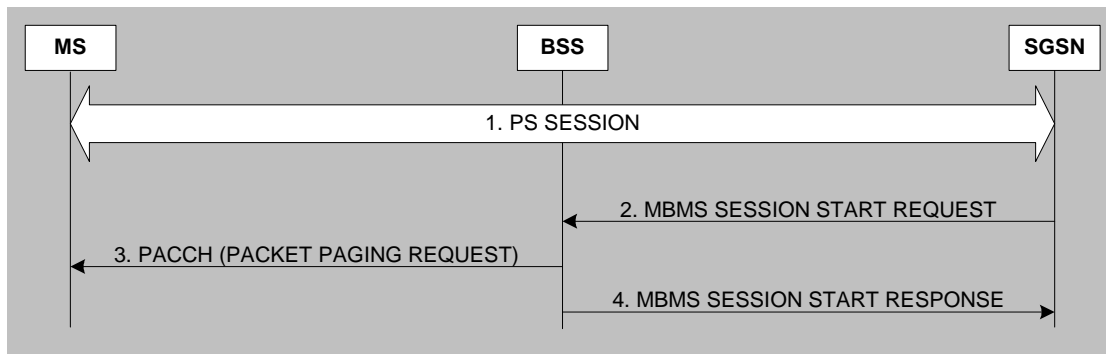
7.9 MBMS Paging during PS Sessions

Figure 12: PS sessions

The mobile is in packet transfer mode and the SGSN knows the mobile is in Ready State.

When an MBMS service starts, the SGSN looks up those mobiles that are interested in the TMGI received from the GGSN in the MBMS SESSION START REQUEST message. The SGSN then includes a list IMSIs, associated with the mobiles, in the MBMS SESSION START REQUEST messages sent down to the BSS.

The correlates the list of IMSIs with the PS sessions and passes a PACKET PAGING REQUEST message to each mobile including the TMGI of the MBMS service.

The MBMS SESSION START RESPONSE message is sent by the BSC to acknowledge to the SGSN the receipt of the MBMS SESSION START REQUEST message.

7.9.1 Resource management procedures

7.9.1.1 Session start

General
Upon receiving a session start message from the SGSN, the GERAN shall initiate MBMS channel establishment in each cell belonging to the MBMS service area. The channel establishment procedure consists of a broadcast message notifying all MBMS

users in the cell of the MBMS service, which is starting a data transmission, followed by an optional counting procedure and a channel assignment message. The type of channel assigned may depend on the number of users in the cell who respond to the notification in the counting procedure.

7.9.1.2 Notification of session start

A cell-wide notification is broadcast in each cell within the MBMS service area to all MBMS users (for broadcast) or a group of MBMS subscribers (for multicast) informing them of the session start.

7.9.1.3 Initial counting procedure

An MBMS channel shall not be established if there are no interested users in the cell at the time of the session start notification message. The network using such a mechanism shall therefore wait for at least one response from an MBMS user in each cell before sending the channel assignment message.

Multicast only: The notification message may optionally initiate a counting mechanism (i.e. to count up to above or below an operator-defined user threshold > 0) to ascertain how many interested users are present in each cell. This may be used in

Order to select the type of MBMS radio bearer to establish (either p-t-p or p-t-m). For a given MBMS multicast service, the counting instruction in the notification message can be enabled / disabled on a per-cell basis.

Delivering MBMS notifications to an MS involved in a CS call

If BSS paging co-ordination for PS paging is available (this is linked to the network support of DTM), the MS would expect to receive PS paging in-band (as a PACKET NOTIFICATION message) on the associated control channel belonging to the CS traffic channel.

So, in the case where DTM procedures are supported, the MS is not expecting to have to listen to the common control channels and therefore will not receive the MBMS notifications, which are broadcast in the whole cell.

There are three main options:

To mandate the presence of the Gs interface and re-use the CN paging co-ordination procedure as a basis for delivering MBMS notifications.

To reuse the BSS (IMSI) paging co-ordination for PS paging (currently only supported for DTM-capable MSs and in DTM-capable networks)

To introduce a new procedure (MS-initiated?) to provide either the SGSN or the BSS with the necessary information to perform the new co-ordination function.

8. MBMS Notification proposal

Solution Principles

The solution borrows from a number of solutions, which have already been proposed in GERAN WG2 and is intended to bring together the different proposals in a single solution.

The principles of this notification procedure are:

The pre-notification indication flag is sent on the PCCCH (if present) or the CCCH to trigger MS to read the channel on which the notification is sent.

The notification message is sent on either the PCCCH (if present) or the CCCH and contains at least the identifier of the MBMS service for which a session is starting.

If an uplink channel description is included in the notification message, the MS shall send access bursts on the indicated channel in order for the BSS to count the number of MS in the cell that are interested in a given service.

The counting procedure shall be terminated either by the assignment of an MBMS bearer (implicit stop) or by an explicit stop command sent on a channel which is monitored by those MS which have performed counting.

8.1 MBMS notification phases

Phase	Messages required prior to initiating an MBMS data transmission	Performed at every session start?	Logical channel(s) on which this message may be sent
1	Indication message [BSS → MS]	Yes	(P)PCH
2	Notification message [BSS → MS]	Yes	(P)PCH
3	Counting Instructions [BSS → MS]	No	Information is either included in notification message or is sent on the downlink of channel where counting is to be performed
4	Counting Responses [MS → BSS]	No	Using access bursts on some type of random access channel
5	p-t-m channel assignment message [BSS → MS]	No (BSS may decide not to transmit the MBMS data in this cell)	Either in notification message or on downlink of channel where counting is to be performed
6	Counting Stop message [BSS → MS]	No	Either on the (P)AGCH or on a downlink control channel associated to the channel where counting is to be performed e.g. PACCH of PDTCH or MAGCH

Table 6: MBNS Notification phases

8.2 Description of the phases of notification

8.2.1 Pre-notification indication

When the pre-notification indication flag is set on the (P) CCCH, the MS shall begin to monitor the MBMS notification channel in order to receive MBMS notification message(s).

8.2.2 Notification

In this proposal, the channel on which the notification message is sent is either the paging channel (PCH) or the notification channel (NCH) or their packet equivalents.

The notification message contains at least the following information (possible coding is provided in Annex A)
TMGI
(Optional) parameters relating to a counting algorithm
(Optional) an uplink resource description for the counting procedure (e.g. USF and frequency)

(Optional) a channel assignment description for the p-t-m MBMS channel (it is FFS whether this assignment description will fit into a notification message)

8.2.3 Counting start

Counting may be enabled or disabled per MBMS session
Counting can be performed on the RACH, PRACH or a new random access channel on which access bursts are sent (referred to as MRACH).
It is mandatory for the MS to support counting on the MRACH, but optional for the network to support this feature.
A multi-step counting procedure may be used where a proportion of MS respond in step 1, a higher proportion in step 2 of the counting etc. The probability of any MS accessing the RACH, PRACH or MRACH channel may be provided in the notification message.

Access to the MRACH is as a normal TBF (based on USF scheduling), combined with RACH-like access behaviour.

Responses to the notification should stop when an assignment message is sent from the BSC to the MS on the PACCH/D corresponding to the UL channel on which the MRACH is located or on the (P) AGCH.

8.2.4 Counting responses

If counting on the RACH is indicated then the MS shall send access bursts on the RACH in order for the BSS to count the number of MS in the cell, which are interested in a given service.

8.2.5 MBMS channel assignment

If the counting is being performed on the MRACH then the p-t-m channel assignment shall be sent on the PACCH associated with that MRACH.

8.3 Notification message flow

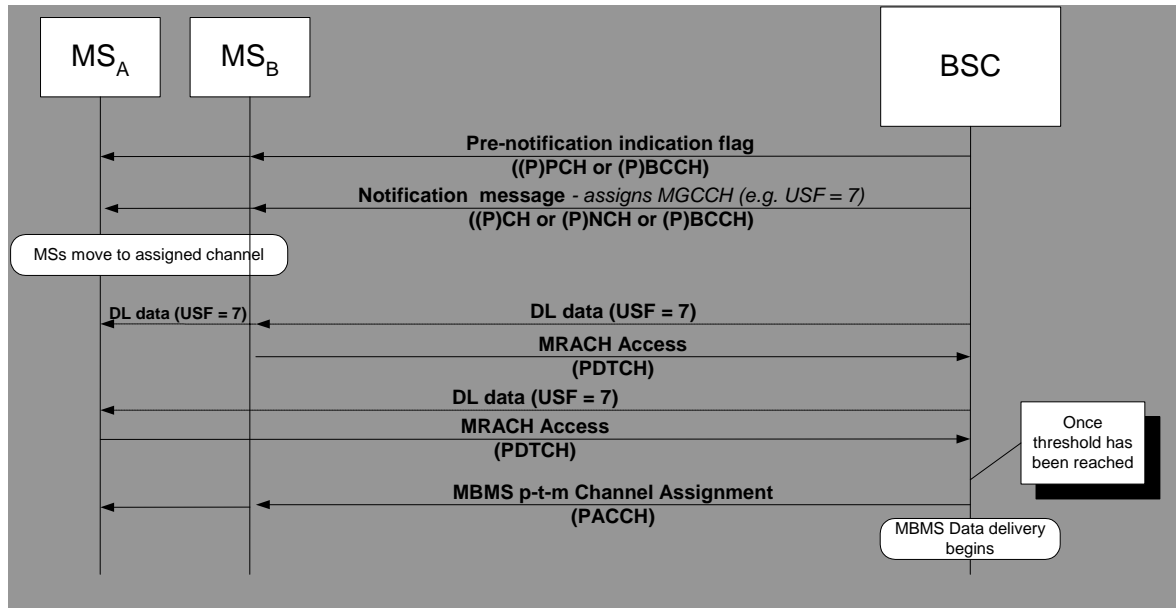The overall procedure can be seen in figure,

If the counting is being performed on the (P) RACH then the p-t-m channel assignment shall be sent on the (P) AGCH.

If no counting is being performed, then the p-t-m channel assignment shall be sent in the notification message.

Note: Whether the full p-t-m information fits into a single notification message is FFS.

The counting procedure shall be ended by the MBMS channel assignment (implicit stop) or an explicit stop command sent on the PACCH (or MAGCH) associated with an assigned PDTCH (used for counting) or on the (P) AGCH.

8.2.6 Counting stop / Counting channel release

The stop message will be sent when the counting procedure does not result in the establishment of a p-t-m bearer and is used to prevent the MS in a cell from continuously accessing the cell.

Figure 13: Notification sequence diagram

9. Conclusion

In Summary, MBMS standardization will take few years to complete and the deployment of the MBMS based systems and services are 2-3 years away. Most exciting applications are possible for the mobile users using the rich contents delivered via MBMS platforms.

This research paper mainly focuses on the MBMS technology, concepts, architecture and system requirements to realize the MBMS services. There will be many standardization changes in the MBMS technology aspects in future. Whatever may be the technical realization path for MBMS, it will provide excellent service option and benefits for the consumer, vendors and the wireless operators.

Definitions:

Broadcast service area: The area in which a specific broadcast service is available. It is defined individually per broadcast service. The broadcast service area may represent the coverage area of the entire PLMN, or part(s) of the PLMN's coverage area. The broadcast service area is the sum of all local broadcast areas offering the same service.

Local Broadcast Area: The area of a broadcast service, where the service content is the same. One broadcast service may have different content in different local broadcast areas.

Broadcast mode: The part of MBMS that supports broadcast services.

Broadcast service: A unidirectional point-to-multipoint service in which data is efficiently transmitted from a single source to multiple UEs in the associated broadcast service area. Broadcast services may be received by all users who have enabled the specific broadcast service locally on their UE and who are in the broadcast area defined for the service.

Broadcast session: A continuous and time-bounded reception of a broadcast service by the UE. A single broadcast service can only have one broadcast session at any time. A broadcast service may consist of multiple successive broadcast sessions.

Mobile Station (MS): Defined in 3GPP TS 24.002. (The abbreviation "UE" in this specification refers both to MS and User Equipment.)

Multicast transmission activation: The process by which the network activates the transmission of Multicast data.

Multicast service area: The area in which a specific multicast service is available. It is defined individually per multicast service. The multicast service area may represent the coverage area of an entire PLMN, or part(s) of the PLMN's coverage area. The multicast service area is the sum of all local multicast areas offering the same service.

Local multicast area: The area of a multicast service, where the service content is the same. One multicast service may have different content in different local multicast areas.

Multicast mode: The part of MBMS that supports multicast services.

Multicast joining: The process by which a user joins a multicast group.

Multicast session: A continuous and time-bounded reception of a multicast service by the UE. A single multicast service can only have one multicast session at any time. A multicast service may consist of multiple successive multicast sessions.

Multimedia Broadcast/Multicast Service (MBMS): A unidirectional point-to-multipoint service in which data is transmitted from a single source entity to a group of users in a specific area. The MBMS has two modes: Broadcast mode and Multicast mode.

Multicast group: A group of users that have an activated MBMS in multicast mode and therefore are ready to or are receiving data transmitted by this service. The multicast group is a subset of the **Multicast subscription group**. Multicast subscription group members may join the corresponding multicast group.

Abbreviations
For the purposes of the present document, the following abbreviations apply:

MBMS Multimedia Broadcast/Multicast Service
MS   Mobile Station
UE   User Equipment

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