Utran Architecture for Multimedia Broadcast Multicast Service (MBMS)

Ashok Kumar (ashokk@hss.hns.com)
Hughes Software Systems
Electronic City, Plot-17, Sector 18 Gurgaon 122015, Haryana, INDIA.

Abstract

With the arrival of 3rd generation cellular networks it is expected that a lot of new cellular services will be available to the mobile users like video calling, location based services etc. Similarly MBMS is one such service which is targeted for 3G mobile users for viewing talk shows, live sport events etc. One shall view this service like a small portable T.V being carried by the mobile user. The user watches the programs of his liking by joining if he wishes.

In this paper we focus on the possible UTRAN architectures to provide MBMS service within UMTS networks. The paper primarily focuses on the requirement aspect, notification aspect and the mobility aspect. The paper lists many options for notifications and elaborates on them in terms of pros and cons. In the end the paper conclude with an UTRAN architecture for MBMS service which meets the requirements of this service as well as makes minimum changes to the existing UTRAN architecture while attempting to save terminal power for this service.

1. INTRODUCTION

The success of 3rd generation cellular networks will depend upon the new and innovative services which are made available to cellular users through these networks. MBMS is one such service, which looks very promising. With this service the mobile user can potentially view anything of his liking on the move.

The paper will start with the overall description of MBMS service and then concentrate on possible UTRAN architectures for the same. The MBMS service consists of two modes namely Broadcast and Multicast. The broadcast mode does not require any subscription as well as activation/joining with the cellular network by the mobile user for receiving this service; as no charge is applied by the operator. The multicast mode requires subscription, to receive the service as there is charging associated. The mobile user has to activate/join the multicast service, for receiving the MBMS service. Similarly, the user shall be able to de-activate/leave the multicast service at anytime.

In UMTS the mobile user has two main states within UTRAN namely IDLE and CONNECTED. In connected state there are further four sub-states namely Cell_PCH, URA_PCH, Cell_FACH and Cell_DCH. In Cell_PCH and URA_PCH connected states the mobile user can not receive any data from the network and can only receive certain control channels. The mobile user has to transition to either Cell_FACH or Cell_DCH states to receive data from the network. In these two states the user can receive data and control from the network.

The key requirement of MBMS service is that the mobile user shall be able to discover as well as receive this service in any mobile user state. This service shall not in anyway impact any ongoing non-MBMS service. The user capability to simultaneously receive non-MBMS and MBMS services will be dependent on UE capability. Similarly, the user capability to simultaneously receive multiple MBMS services will be dependent on UE capability.

Another key requirement of this service is that the user shall be able to activate/join the MBMS service either before the start of service or anytime during the service. This means the notification shall be continuous during the service as some users may activate/join the MBMS service in between. In this paper we will focus on all the requirements of notifications as well as various alternative means of notifications. Notification means, letting the users know that the service is starting or has started as well as the respective radio bearer configuration; so that the mobile users can start receiving the MBMS service.

The efficient use of radio resource for MBMS service is also one of the key requirement. The MBMS service can be delivered to a user in a point to point manner (PTP) or point to Multi-point (PTM) manner. The number of users in a cell activating this service shall decide the manner of delivery for efficient usage of radio resources. It is also likely that during the reception of MBMS service, some users move out from one cell to another or some new users activate/join the MBMS service in the same cell. It is also very important to keep the data loss minimum during mobility of the user from one cell to another cell.

In this paper an attempt is made to explore many alternatives of implementation within UTRAN while meeting most of the above stated requirements. This paper covers in details all activities within UTRAN required from the start of the MBMS service to the end of the MBMS service. In the end the paper conclude with an optimal architecture within UTRAN to implement MBMS service in an efficient as well as with minimum changes to the existing procedures within UTRAN.

2. PHASES OF MBMS SERVICE

[Figure 1] illustrates the various phases of MBMS multicast service. First phase is called the subscription phase where an agreement is reached between the user and the service provider for the related MBMS multicast service. Subscription information for MBMS service is stored in the operators network. This phase does not require any new support from UTRAN. The broadcast service does not require this phase.

The next phase is called the service announcement phase whereby the user comes to know about the MBMS services available to him in the cellular network. It is also possible for users who have not subscribed to MBMS service to get announcements about MBMS services available in the network. There are many possible ways of service announcement like CBS, SMS, Web URL etc. Service announcement is used to distribute the information related to service activation/joining and also the service start time.

In the Activation/Joining phase the user gives its consent to receive the MBMS specific service. This phase is not required for MBMS broadcast service. This phase enables the network operator to charge the user for the multicast service as well as efficiently using network resources based on the number of users. This phase can also occur after the session start phase.

The next phase is called the session start phase whereby the network is ready to deliver the data for the respective MBMS service. Session start occurs independently of activation/joining of the service by the user. Session start phase also triggers the establishment of network resources for MBMS data delivery.

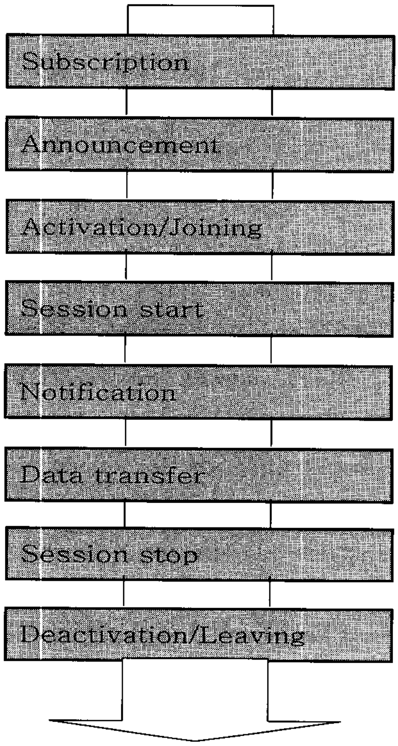
In the notification phase which starts just after the session start phase, whereby users are informed about the forthcoming and potentially about on-going MBMS services data transfer. This is the phase where most of the UTRAN requirements and many possible architectures for MBMS, explored in this paper.

The next phase is called the data transfer phase. In this phase the MBMS service related data is transferred to the users. The mobility related requirements are explored in this phase.

The session stop phase means that there is no MBMS service related data and the network resources shall be released.

The next phase is called the de-activation/leaving phase, whereby the user no longer wants to receive the MBMS multicast service. This phase is not required for MBMS broadcast service.

It is also important to know that subscription, activation/joining and leaving phases are performed per user. The other phases are performed for a service for all users. Also subscription, activation/joining, service announcement and MBMS notification may run in parallel to other phases.



[Figure 1] Phases of MBMS Multicast Service

It is the session start phase, which requires new MBMS specific procedures. All the phases before this phase dont require in particular any new procedure within UTRAN. The next section details the UTRAN alternatives for this phase. It is assumed that the MBMS Multicast contents are encrypted at the application level and the keys for decryption are provide to the user during activation/joining phase. This will ensure that only subscribed user will be able to receive the MBMS Multicast service.

3. Iu INTERFACE ALTERNATIVES

When the session starts the core network (CN) has to inform the UTRAN about the commencement of a particular MBMS service. It is only the CN, which knows about the users, which have already activated/joined the MBMS service. The following options are available to the CN:

- The CN intimates the UTRAN about the session start per activated user basis with an individual signaling connection on the Iu Interface.
- The CN intimates the UTRAN about session start for all activated users with a common signaling connection on the Iu Interface.
- The CN intimates the UTRAN about session start for only connected users, which have activated MBMS service with a common signaling connection.
- The CN intimates the UTRAN about session start for connected users on their respective signaling connections and for others on a common signaling connection.
- The CN intimates the UTRAN about session start without any activated users related information with a common signaling connection.
- Multiple CN nodes intimate the UTRAN about session start for the same MBMS service. Shall the UTRAN establish data path with multiple CN nodes or with only one CN node for the same MBMS service. This happens when Iu-flex is supported by

UTRAN.

It is likely that many MBMS service users may have gone to IDLE state after service activation/joining, before the session start. It is required that all activated/joined MBMS service users shall come to know about the session start before the data transfer starts irrespective of their states.

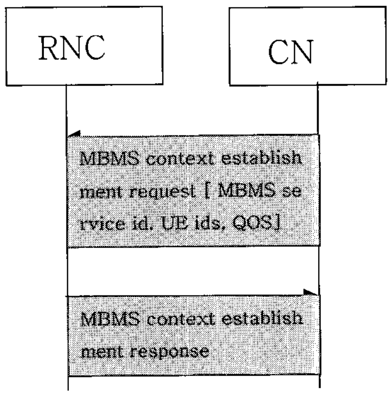
The session start phase, can also be termed as MBMS context establishment phase in UTRAN. The CN provides the RNCs within UTRAN with the service id, connected users ids, QOS related parameters etc. in the MBMS context establishment request message. The RNCs, which dont have any activated users, shall also receive this request.

It is best to pass the connected user ids to the RNCs during session start. Otherwise RNC has to notify each and every connected user within RNC about the session start, which is a lot of unnecessary signaling over the Uu interface. It is advantageous to use a single common signaling connection over Iu interface for MBMS service. It is assumed here that the CRNC will always provide the MBMS data to the user instead of SRNC. There is no Iur interface usage for MBMS data delivery.

In the case of Iu-flex interface, the CRNC will have multiple Iu signaling connections, one with each CN node, which initiated the session start with this RNC. There are two options for MBMS data path for CRNC in case of Iu-flex. The options are listed below:

- Establish MBMS data path with each CN node and select one for delivery over the Uu interface.
- Establish MBMS data path with only one CN node.

Having multiple paths has some advantages. It is possible that a CN node may terminate the data path with CRNC as all users within the CN node have either de-activated the service or have moved to other nodes. The CRNC simply selects an another MBMS data path with an another CN node. In the other case the CNRC has to establish the MBMS data path with an another CN node on the fly, which may result in MBMS data loss. Figure 2. Illustrates the session start phase between CN and RNC.



[Figure 2] Start Session procedure

The RNC establishes the MBMS context within the RNC for the respective MBMS service. The RNC may establish the MBMS data bearer with CN before the notification phase or the MBMS data bearer establishment may take place after the notification phase. It is advantageous to establish the MBMS data bearer even if there are currently no users willing to receive the MBMS service. This will help the RNC provide immediate access to MBMS service to a user, which moves to this RNC while receiving the MBMS service from an another RNC.

After the MBMS session start phase, which results in creation of a MBMS context within the RNC, starts the notification phase. The details of notification are provided in the next section.

4. Uu INTERFACE ALTERNATIVES FOR NOTIFICATION:

Once the MBMS session start procedure is started by the CN towards an RNC; it is required that all the mobile users are notified irrespective of the current UE states by the respective RNC about the upcoming MBMS service. Therefore, the notification procedure shall address all UEs, which have activated a specific MBMS service, regardless of the state of the UEs. As the user can be in any state, the notification procedure shall try to minimize the terminal power consumption. There are many options possible for this purpose which are listed below:

- Service specific paging using PICH
- Service specific notifications using a new MBMS control channel named MCCH.
- Service specific paging using PCCH.

Currently paging type 1 RRC message is used for notification for any dedicated service for UEs in IDLE, URA_PCH and Cell_PCH states. For UEs in Cell_FACH and Cell_DCH states, the notification is currently done using the paging type 2 RRC message. In principle similar mechanisms shall also be used, for MBMS notification. The following steps describe the notification procedure for MBMS:

- IDLE, CELL_PCH and URA_PCH state UEs, shall monitor paging occasions on PICH where DRX is used.
- The RNC initiates the MBMS notification by appropriately setting the unused bits in the PICH channel.
- After the MBMS notification has been detected on the PICH, the UEs start listening to the new MBMS control channel (MCCH).
- The RNC sends the notification on the MCCH channel, by identifying the MBMS service.

As the users in CELL_FACH and CELL_DCH states, dont monitor PICH channel. Their notification is sent on DCCH channel using paging type 2 procedure. It is assumed that the PICH channel 12 unused bits will be used for notification. It is also likely that the scheduling of MCCH is also indicated on PICH, to save terminal power. Otherwise the UEs have to continuously read the MCCH channel. It is also assumed that the RB mapping of MCCH channel is continuously broad-caste on BCCH channel either by extending SIB5 or by a new MBMS SIB. The notification on the PICH channel for MBMS service shall continue till the session stop phase, as it is likely that some users activate/join the MBMS service after the session start.

Once the users, who have activated/joined the MBMS service, come to know about the session start by notification procedure; the next step is to inform the users about the RB bearer configuration for the MBMS data delivery. There are two means of delivery namely point to point channel (PTP separate data pipe for each user) or point to multi-point channel (PTM shared data pipe for all users).

The decision to deliver the MBMS data over PTP channel or PTM channel depends on the number of users wishing to receive the MBMS service contents in a cell. The PTP channel requires less power than PTM channel in general because of closed loop power control. Also the user has to be in CELL_DCH state to receive PTP channel. On the other hand PTM channel can be received in any UE state. The RNC does not know the number of users in a cell who have activated a particular MBMS service. There are two options possible after notification to count the users and deliver the MBMS service. The possible two options are listed below:

- The activated MBMS service users are required to setup an RRC connection after notification to receive MBMS service.
- The activated MBMS service users are not required to setup an RRC connection after notification to receive MBMS service.

In the first option an IDLE state UE who has activated the MBMS service shall establish an RRC connection with the RNC. The users in CELL_PCH and URA_PCH state shall communicate to RNC using MCCH channel that they want to receive the MBMS service. This way the RNC can count the number of users within a cell wishing to receive MBMS service, and decide on the mode of MBMS data delivery either PTP or PTM. If the PTP mode is decided then all the users shall be in CELL_DCH state for receiving the service and the RB configuration for MBMS data delivery can be either provided to them on MCCH or DCCH channel.

As the number of users receiving MBMS service in a cell change dynamically based on the mobility of receiving users; it is possible that the mode of MBMS delivery chosen in the beginning is not optimum anymore. This requires continuous re-counting mechanism. It also involves a lot of signaling on Uu as well as on Iur/Iub interface. It will also involve changing the delivery mode PTP or PTM for MBMS service dynamically, based on the number of users in a cell. Normally, delivery mode change, will lead to MBMS data loss during service. It is also a known fact that the major power advantage in a dedicated mode, comes from soft-handover, which is not used in PTP mode for MBMS service.

In the second option the MBMS activated

users receive the RB bearer configuration on the MCCH channel without establishing a contact with the RNC. It may happen in this approach that the MBMS data delivery takes place in a cell without any activated users. This results in lot of radio resource wastage, which is required to be used efficiently used.

In the subsequent sections, a hybrid of the above two options, is proposed to be used for MBMS data delivery. The following steps describe the hybrid approach:

- The data delivery mode is always PTM using common MBMS traffic channel named MTCH.
- The users in IDLE and URA_PCH state change to CELL_PCH state to receive MBMS service.
- The users in CELL_PCH, CELL_FACH and CELL_DCH state dont change their state.
- The MBMS data delivery across multiple cells for the same MBMS service shall be synchronized, so that the transmission power of PTM channel can be minimized, by taking advantage of multiple paths like soft-handover.

This approach for MBMS data delivery is much simpler and does not require lot of changes to the existing specifications for UTRAN. The CELL_PCH state helps the RNC to track user mobility across cells. The user does a CELL UPDATE whenever it moves from one to another cell. This way the RNC can stop the transmission of MBMS data delivery for a cell if there are no users receiving MBMS service within that cell. The CELL_PCH state, does not require any dedicated codes to be allocated to the user for MBMS signaling.

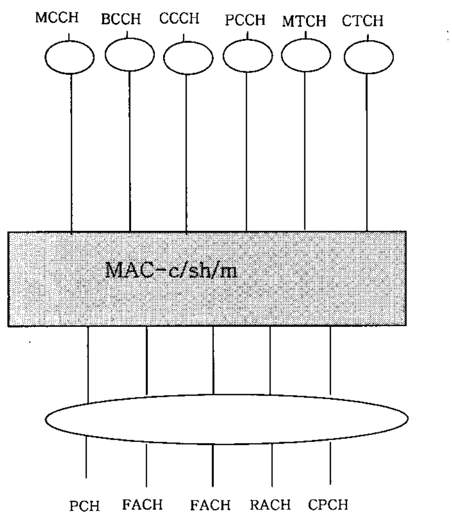
Consider a user moving from one cell to another cell and the two cells are being controlled by different RNCs. The user does a regular CELL UPDATE. The SRNC comes to know about this the DRNC. The SRNC removes the user from its list for the respective MBMS service while the DRNC adds the respective user in its list for the respective MBMS service. Now the DRNC becomes the CRNC for the user if there is no signaling connection for this user with the CN. Otherwise the DRNC becomes the CRNC for this user for MBMS service only.

The only disadvantage of this approach is the sudden signaling load generated by IDLE state users to establish RRC connection with the RNC. The URA_PCH users will also generate signaling load to change their state to CELL_PCH. If the RRC connection establishment/state change load is staggered using user class then it is possible that all the activated MBMS users will be able to either establish RRC connection or change state with RNC in a reasonable time without creating sudden load at RNC.

There is another option which is again a derivative of the above hybrid approach. In this approach the activated MBMS users establish RRC connection in CELL_DCH state with the RNC. The reasoning behind this approach is that the activated MBMS users shall be able to provide feedback about the MBMS reception, which can be used to control the transmission power of the PTM channel.

The disadvantage of this approach is that it requires channelisation code for each RRC connection. It is also difficult to use the feedback from different users in a constructive manner. Consider a scenario where some activated MBMS users report bad reception while others are receiving very well. In this scenario it is not easy to decide whether the transmission power of PTM channel shall be increased or decreased.

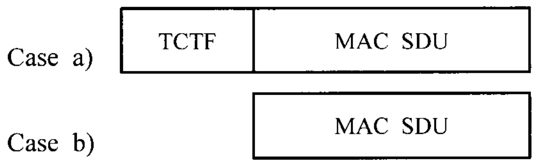
[Figure 3] illustrates the new MAC architecture for supporting MBMS service.



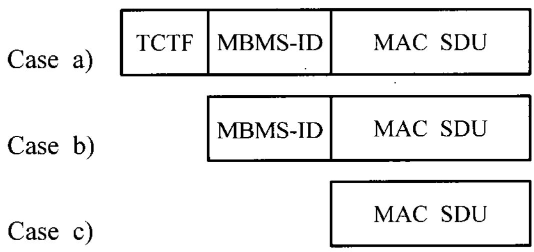
[Figure 3] UTRAN side MAC architecture

To support MBMS data and control a multicast functionality is added in the MAC-c/sh, namely MAC-m. The combined MAC entity is named MAC-c/sh/m. A new logical channel for control is added in the down-link direction for transfer of control information for MBMS service. UEs shall be able to listen to this new channel in all states. The control information on this channel is MBMS specific and is sent to UEs in a cell with activated MBMS service. Another traffic channel is added in the down-link direction for the transport of MBMS data. Both these channels are mapped on FACH transport channels.

Figure 4, illustrates the MAC PDU format for the MCCH logical control channel for MBMS and Figure 5 illustrates the MAC PDU format for the MTCH logical data channel for MBMS.



[Figure 4] MAC data PDU format for MCCH



[Figure 5] MAC data PDU format for MTCH

As the MCCH and MTCH logical channels are mapped on common transport channels, FACH transport channel is the best candidate for these logical channels for mapping on transport channel. The reason for this is that all UEs listen to this transport channel for various purposes depending on the UE state except CELL_DCH state. It is a must requirement for UEs in CELL_DCH state receiving non-MBMS services to be simultaneously able to listen to common channels for MBMS services, if these users want to simultaneously receive MBMS and non-MBMS services.

There are two cases of MCCH mapping on FACH transport channel defined in Figure 4. The case a) assumes that the FACH transport channel also transports other logical channels like PCCH, CCCH along with MCCH. So, a new target channel type field is needed in the MAC header to distinguish the data from MCCH channel. In case b) it is assumed that the FACH transport channel only transports the data of MCCH logical channel and the MAC will forward any data received on this channel to the MCCH logical channel.

There are three cases of MTCH mapping on FACH transport channel defined in Figure 5. The case a) assumes that the FACH transport channel also transports other logical channels like CTCH along with MTCH. It also assumes that each MTCH logical channel carries data for one MBMS service. There are multiple MTCH channels mapped on the same FACH transport channel. So, the MAC header has to add a new target channel type field along with the MTCH channel Id or MBMS service Id. In case b) only data from multiple MTCH logical channels is mapped on the same FACH transport channel. For this the MBMS id is required in the MAC header to distinguish the data of one MBMS service from the other. The case c) assumes that only one MTCH channel is mapped on the FACH transport channel. In this MAC simply forwards the data to the MTCH channel which is mapped on this FACH transport channel.

Currently Streaming and Background classes of services are targeted for MBMS. Both these classes of services will be delivered to the activated MBMS users using an unacknowledged mode (UM) of RLC. So, the RB for the new logical channels MTCH and MCCH will use an unacknowledged mode of RLC. This does not require any change in the RLC protocol.

When the session stop is initiated by the CN towards the RNC, the RNC has to stop the notifications for the respective MBMS service and release the RBs associated with the MBMS service. The MTCH logical channels will be released while MCCH logical channel will remain configured. The activated MBMS users listen to this channel only after receiving notification for the MBMS service. The MBMS service stop will be indicated to all receiving users on MCCH channel. Subsequently, the MBMS users shall de-activate/leave the MBMS service.

5. CONCLUSION:

With no doubt, MBMS service has a great

potential for the success of 3rd generation cellular networks. The MBMS services shall be very carefully selected for this application. It is expected that only those services will be targeted using MBMS, which will do well on the small screen of mobile users in the beginning.

As mentioned in the paper, the UE shall have the capability of receiving data on common channels while simultaneously receiving data on dedicated channels. Otherwise, simultaneous reception of MBMS service and non-MBMS service is not possible. In this paper, the UTRAN architecture proposed for MBMS delivery makes use of the existing RRC procedures and UE states. Some, changes are required in some states for simultaneous reception. The proposed architecture also takes into consideration of MBMS data loss during session, due to user mobility and DRX cycle used by user terminals to save terminal power in various UE states.

6. OPEN ISSUES:

- The MBMS user terminals will have varying capability. Some MBMS services may require very high capability in UE to be received completely. Shall the same MBMS service be transmitted with different QOS over the air or the same MBMS service contents are segregated by some marking? The UEs with different capability shall be able to receive the same MBMS service with QOS.

■ REFERENCE

[1] 3GPP T5 25.346 V1.4.0 (2003-02). Introduction of the Multimedia Broadcast Multicast Service (MBSM) in the Radio Access Network (Release 6).

[2] 3GPP TR 25.992 V1.1.0 (2002-05). Multimedia Broadcast Multicast Service (MBMS) UTRAN/GERAN Requirements.

[3] 3GPP TS 25.331 V3.12.0, RRC Protocol Specifications

[4] 3GPP TS 22.146 Multimedia Briadcast/ Multicast Service; Stage 1

[5] 3GPP TS 25.321 V3.a.0, Medium Access Control (MAC) Protocol Specifications.

[6] R2-030046, MBMS notifications mechanism

[7] R2-022037, Notifications solution using PICH.

[8] R2-022929: Signaling MBMS RB parameters to UE.

[9] R2-030073: MBMS Notifications in different RRC states.

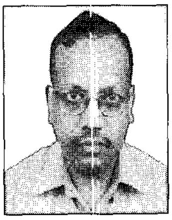
[10] R2-022821: MAC architecture for MBMS.

[11] R2-022082, Considerations on PTP.PTM configurations for MBMS.

[12] R2-022609, Simulation Results on DL power.

[13] R2-030078, On the issue of switching between PTP and PTM channels.

Biography



I am currently working as a Senior Consultant at Hughes Software Systems (HSS) in India on 2.5G (GPRS/EDGE) and 3G (UMTS) technology. In my role as a consultant, I am involved with tracking the 2.5G and 3G specifications from various inter- national bodies, providing consultancy to various projects on 3G and providing the product direction for the 2.5G and 3G products at HSS.

I have been involved in the design and development of Telecommunications systems both Wireline and Wireless for over 15 years. Prior to the present assignment, I have worked in organisations like Centre for Development of Telematics (C-DOT), Siemens and Interwave Communications in the United States of America. The assignments in my previous organisations involved development of DSS1 switch , Wireless office , cummunity wireless networks supporting N-ISDN , GSM, DCS ,PCS technologies. I have also worked as system analyst for GPRS systems and training faculty for GSM/GPRS .

I have published papers On Mobile IP in Cellular Networks and WLAN-3GPP interworking Architectures. I have been an invited speaker at IEEE conference in India on convergence of Wireless Communication and Internet and IBC asia conference in Singapore on All IP networks .

I obtained my B.E(Hons) in Electrical & Electronics Engineering in 1983 with distinction from Birla Institute of Technology & Science , in India.