

Novel design of eMBMS based on Femtocell

Otgonbayar Bataa^a, Young-il Kim^b, Erdenetuya Dorj^c, Bat-Enkh Oyunbileg^d, Khishigjargal Gonchigsumlaa^e,
Oyu Chuluun^f, Tulga Orosoo^g

^{a, f, g} Wireless Communication Department, ^c Information Network Department, ^d Information Technology Department,

^b Principal member of engineer of ETRI, Korea. Smart Screen Convergence Department.

^e Ph.D candidate student of UST, (ETRI) Smart Screen Convergence Department, ETRI, Korea.

SICT(School of Information and Telecommunication technology) of MUST, Ulaanbaatar, Mongolia

^a b_otgonbayar2002@yahoo.com ^b yikim@etri.re.kr

Abstract – Delivering Multimedia services such as Mobile IPTV over 3GPP/LTE based on Femtocell networks has been a main purpose according to the demand grows in the world. The Femtocell networks, which is a small cellular base station in home and small business environment. It is best solution for operators to improve indoor coverage and network capability. In this paper, we designed functional entities of 3GPP/LTE including standardized IPTV control functions and protocols of IP Multimedia Subsystem (IMS). Our work will mainly focus on system and functional designing of eMBMS extended by Femtocell. The functional designing analysis is carried out to identify the main features supported by eMBMS, including an interface analysis. A Functional designing of eMBMS server includes the following concepts: Application functions, Service control functions and Content Delivery functions. In this paper we apply novel design of eMBMS based on Femtocell to maximizing possibility of access user's equipment depending on mobile user's location.

Keywords: eMBMS, LTE, HeNB, Femtocell, eUTRAN

I. INTRODUCTION

The specifications of the LTE project are formally known as the Evolved UMTS Terrestrial Radio access (E-UTRA) and Evolved UMTS Evolved UMTS Terrestrial radio access Network (E-UTRAN). LTE is developed to meet the requirements set for IMT-A technologies and is called LTE-A [1].

The eNodeB is the most complex part of the LTE access network, and is more complex than a UMTS Node B, since it operates without a central controller (RNC-Radio Network Controller). The functions of the central controller are performed by the eNodeB itself, making it a critical component of new LTE network architecture [2].

Two major limitations for wireless communications are range and capacity. The service providers increase the coverage area by either deploying a macrocell while consuming high power, or using smaller base stations that cover a smaller area but provide high data rates at lower power levels. Femtocells appear to be an effective solution satisfying the coverage and data rate needs of the operators in conjunction in home and small business environment with offer low cost solutions to operators presenting an alternative to high cost high power macrocell base station installations to provide the same Quality of Service (QoS). The three main reasons why current cellular systems need to implement

femtocells are summarized as follows. In this paper also focus on eMBMS based on Femtocell. In the 3GPP terminologies Femtocell is called in UMTS HNB and in LTE HeNB.

Femtocell allows to LTE highest modulation rates and spectral efficiency delivering great services to a large number of usage customers for example Mobile IPTV.

Coverage: Macrocells are inadequate when providing indoor coverage due to the signal attenuation while penetrating the outer walls of the buildings. However, the signal strength is good when there is small distance between the transmitter and the receiver.

Capacity: Since the coverage area of the femtocells is smaller than that of macrocells, there is less number of users in the cells and each user has a larger share of radio resources compared to the macrocellular networks.

Power: The macrocells handle a large number of users. When some users are passed on to femtocell base stations which decreases the load of the macrocells. Hence the air interface is maintained effectively for both outdoor and indoor users and the power consumed at the macrocell is reduced.

II. OVERVIEW OF E-UTRAN HeNB

LTE has been set best performance requirements on physical layer technologies, such as, OFDM and MIMO systems, Smart Antennas to achieve these targets. The main objectives of LTE are to minimize the system and User Equipment (UE) complexities, allow flexible spectrum deployment in existing or new frequency spectrum and to enable co-existence with other 3GPP Radio Access Technologies.

For Femtocell and Macrocell network integration, there are some feasible choices. The E-UTRAN (Evolved Universal Terrestrial Radio Access Network) HeNB architecture discussed in LTE Femtocell standards has not been finalized. The architecture that we want to have would follow the all-IP principles and would integrate the evolved packet core (EPC) smoothly. The HeNB management system is similar to HMS in UMTS. The reference of the LTE Femtocell architecture is shown in Figure. 3.

The LTE radio access network E-UTRAN architecture is improved dynamically from 3G/3.5G radio access network UTRAN. The functions of eNB in E-UTRAN include not only

base station (NodeB) to terminate radio interface but also RNC to manage radio resource. The E-UTRAN consists of eNB, providing the evolved UTRAN U-plane and C-plane protocol terminations towards the UE. One of the biggest differences between LTE network and legacy mobile communication system 3G is a base station. There used to be intelligent and centralizing node like RNC (Radio Network Controller) in 3G for example, and it needed to control all the radio resources and mobility over multiple NodeB (3G base stations) underneath in hierarchical radio access network. All NodeB need to do is behave exactly according to command from RNC through Iub interface. In LTE, on the other hand, eNB as base station have to manage radio resource and mobility in the cell and sector to optimize all the UE's communication in flat radio network structure. Therefore, the performance of LTE eNB depends on radio resource management algorithm and its implementation. According to overview of 3GPP the eNB hosts the following functions:

- Radio Resource Control
 - Radio Bearer Control
 - Radio Admission Control
 - Connection Mobility Control
 - Dynamic allocation of resources to UEs in both uplink and downlink (scheduling)
- IP header compression and encryption of user data stream
- Selection of an MME at UE attachment when no routing to an MME can be determined from the information provided by the UE
- Routing of User Plane data towards Serving Gateway
- Scheduling and transmission of paging messages (originated from the MME)
- Scheduling and transmission of broadcast information (originated from the MME or O&M)

Femtocells are low-power wireless access points that operate in licensed spectrum to connect standard mobile devices to a mobile operator's network using residential DSL or cable broadband connections. Femtocells offer many benefits to both consumers and operators, including increased performance, better coverage, and traffic offload from congested macro cells. Femtocell deployments have major challenges include scalability, security, mobility, ease of deployment, and interoperability. Femtocells are a popular method to extend mobile network coverage and to enhance the system capacity with special characteristics for femtocells; for example, femtocells have a small communication range, low power, and low cost [2,3,4]. Femtocells can also be used in home or indoor environment.

III. NOVEL DESIGN OF EMBMS ARCHITECTURE WITH HOME ENODE

eMBMS is designed to provide efficient delivery of broadcast and multicast services, both within a cell as well as within the core network. The eMBMS broadcast mode can be used to deliver IP services to all terminal in a certain area or the whole the network. If the broadcast mode is used, a transmission bearer is setup for all cells in which the service

should be available and is continuously transmitting as long as the service is up and running. Sometimes, in broadcast mode eMBMS does not require an uplink connection and only use downlink connection. For broadcast transmission across multiple cells, it defines transmission via single-frequency network configurations. Target applications include mobile TV and radio broadcasting, as well as file delivery and emergency alerts.

The multicast mode works very similar to IP multicasting. A terminal which wants to receive information to a particular multicast channels "joins" one or several content channel. The information is processed in the routing layer of the core network and used for optimizing the data delivery path. "Optimizing" means that over connections shared by receivers of the same multicast channels, data is transmitted just once to corresponding multicast group. This makes eMBMS a very resource efficient way of delivering services to larger user groups. Therefore eMBMS multicasting is less suitable for mobile TV services, which usually require a low TV channel switching delay. The main application of eMBMS multicasting is for download or podcast and video on demand.

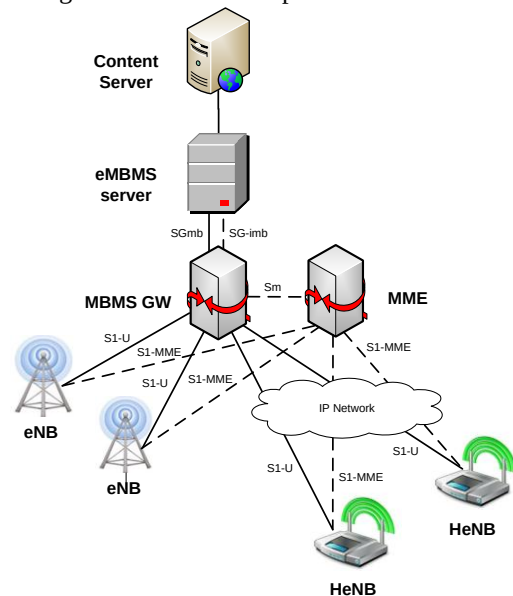


Figure 1. A Network architecture of eMBMS with HeNB

In the Figure 1 and Figure 2 shows the logical view of the HeNB access network architecture and reference model. The HeNB connects to the mobile network through the HeNB-GW (Figure 2). The HeNB GW appears to the MME as an eNB. The HeNB-GW appears to the HeNB as an MME. The S1 interface between the HeNB and the EPC is the same, regardless whether the HeNB is connected to the EPC via a HeNB- GW or not.

The HeNB GW shall connect to the EPC in a way that inbound and outbound mobility to cells served by the HeNB GW shall not necessarily require inter MME handovers. One HeNB serves only one cell. The functions supported by the HeNB shall be the same as those supported by an eNB and the procedures run between a HeNB and the EPC shall be the same as those between an eNB and the EPC [2].

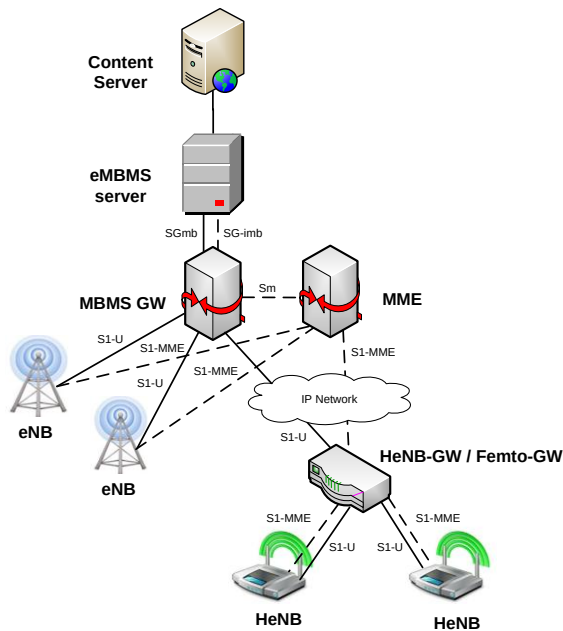


Figure 2. A Network architecture of eMBMS with HeNB GW.

A proposed design of eMBMS system architecture with HeNB is illustrated in the Figure3. A Functional designing of eMBMS server includes the main following concepts: Application functions, Service control functions and Content Delivery functions. These functions defined by required procedures to receive eMBMS broadcast and multicast services.

In application function included service announcement and subscription which is included establishment of the relationship between the UE and the eMBMS, which allows the user to receive and subscribe the related information of the MBMS broadcast and multicast services (Figure 4).

A Service control function from content server to the UE is defined by the interoperability of MBMS-GW, MME, HeNB, and eMBMS server. It contains joining, leaving, resource management (resource allocation and release), session start, stop and notification functions. After establishing the service delivery path between the MBMS-GW and HeNB by the tunneling, content delivery function delivers the ordered content from the content server to the UE (Figure 4).

TABLE 1. A Comparison of advantages of Network architecture of eMBMS and Network architecture of eMBMS with HeNB GW

A Network architecture of eMBMS with HeNB (Figure 1)	A Network architecture of eMBMS with HeNB GW (Figure 2)
Advantages	Advantages
If one HeNB network element fails below the MME/S-GW, the other HeNBs are not affected.	HeNB-GW serves as a concentrator for the C-Plane and also terminates the user plane towards the HeNB and towards the Serving Gateway.(MBMS-CP).
Simple flat architecture and few operating network elements; macro architecture consistency	No overload of MME even when the number of HeNBs in the network is increased.
Lower latency and system level processing is reduced.	Using HeNB-GW, S-GW is not overloaded when the number of HeNBs in the network increases.
less upgrade and compatibility issues in supporting new features	Reduction of number of S1 connections and more simple HeNB implementation.
Disadvantages	Disadvantages
Does not provide SCTP/GTP-U connection in concentrated setups.	Processing load as regards U-plane is proportional to traffic.
In case of increasing number of HeNBs in the network, the SCTP heartbeat messages (per SCTP association) might cause an overload situation in MME.	If the eHomeNB-GW fails, it is not possible to receive the MBMS services for ALL eHomeNBs.
In direct MME-HeNB connections, high CPU usage or even overload may occur when user switches HeNB on and off frequently	
When number of HeNB in network increases, S-GW overload may occur or the period for GTP-echo messages needs to be increased to avoid an overload situation in S-GW.	
Support of S1 flex would introduce additional complexity in HeNB implementation.	

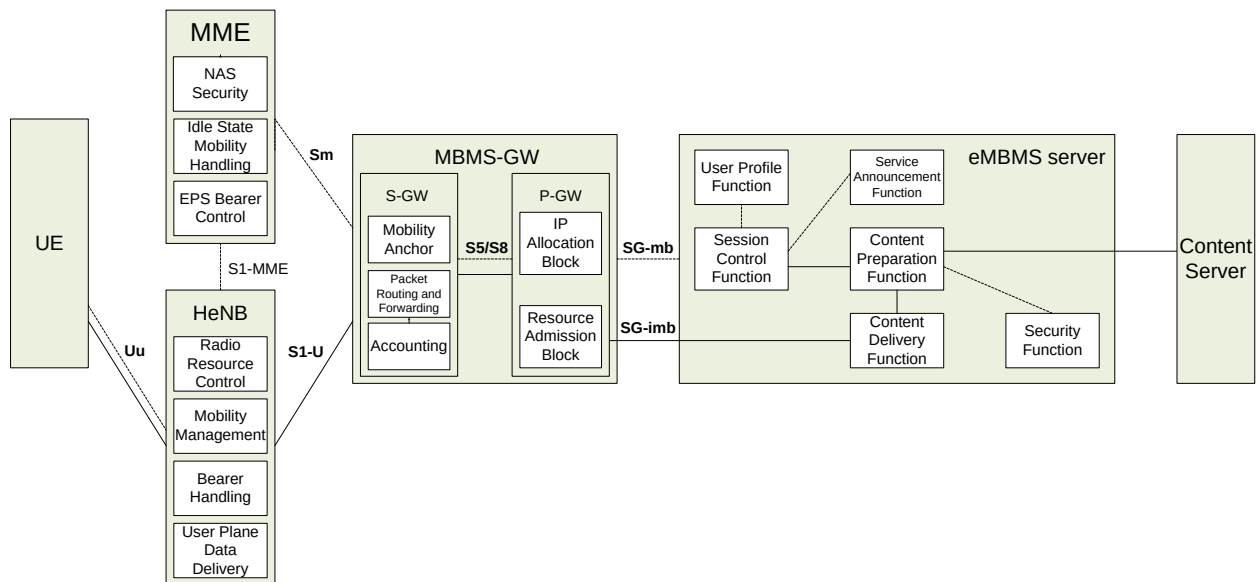


Figure 3. Novel system architecture of eMBMS with Femtocell

IV Logical Elements in Novel System Architecture of eMBMS with Femtocell

Typically User Equipment (UE) is a hand held device such as a smart phone or a data card to a laptop. UE also contains the Universal Subscriber Identity Module (USIM) that is often called the Terminal Equipment (TE). Functionally the UE is a platform for communication applications. It includes mobility management functions such as handovers and reporting the terminals location. In other side the UE provides the user interface to the end user so that applications such as a VoIP client can be used to set up a voice call.

The eNodeB is a radio base station to control of all radio related functions in the fixed part of the system. Functionally eNodeB acts as a layer 2 bridge between UE and the EPC, and relaying data between the radio connection and the corresponding IP based connectivity towards the EPC. The eNodeB is also responsible for many Control Plane (CP) functions. The eNodeB is responsible for the Radio Resource Management (RRM) and constant monitoring of the resource usage situation. In addition, the eNodeB has an important role in Mobility Management Entity (MME). The eNodeB controls and analysis radio signal level measurements carried out by the UE.

Mobility Management Entity (MME) is the main control element in the EPC. In addition to interfaces that terminate to MME in the architecture as shown in Figure 4, the MME also has a logically direct CP connection to the UE, and this connection is used as the primary control channel between the UE and the network. The following lists the main MME functions in the basic System Architecture Configuration: Authentication and Security, Mobility Management and Managing Subscription Profile and Service Connectivity.

In principle the MME may be connected to any other MME in the system, but typically the connectivity is limited to one operator network only.

In Figure 4 shows Serving Gateway (S-GW), the high level function of S-GW is UP tunnel management and switching. When the S5/S8 interface is based on GTP, the S-GW will have GTP tunnels on all its UP interfaces. Mapping between IP service flows and GTP tunnels is done in P-GW6. All control is related to the GTP tunnels, and comes from either MME or P-GW. The S-GW has a very minor role in control functions. It is only responsible for its own resources, and it allocates them based on requests from MME, P-GW. For all data flows belonging to a UE in connected mode, the S-GW relays the data between eNodeB and P-GW [5].

Packet Data Network Gateway is the edge router between the EPS and external packet data networks. It is the highest level mobility anchor in the system, and usually it acts as the IP point of attachment for the UE. It performs traffic gating and filtering functions as required by the service in question.

The E-UTRAN architecture may deploy a Home eNB Gateway (HeNB GW) to allow the S1 interface between the HeNB and the EPC to support a large number of HeNBs in a scalable manner. The HeNB GW serves as a concentrator for the C-Plane, specifically the S1-MME interface. The S1-U interface from the HeNB may be terminated at the HeNB GW, or a direct logical U-Plane connection between HeNB and S-GW may be used (as shown in Figure 1) [3]

The S1 interface is defined as the interface:

- Between the HeNB GW and the Core Network,
- Between the HeNB and the HeNB GW,
- Between the HeNB and the Core Network,
- Between the eNB and the Core Network.

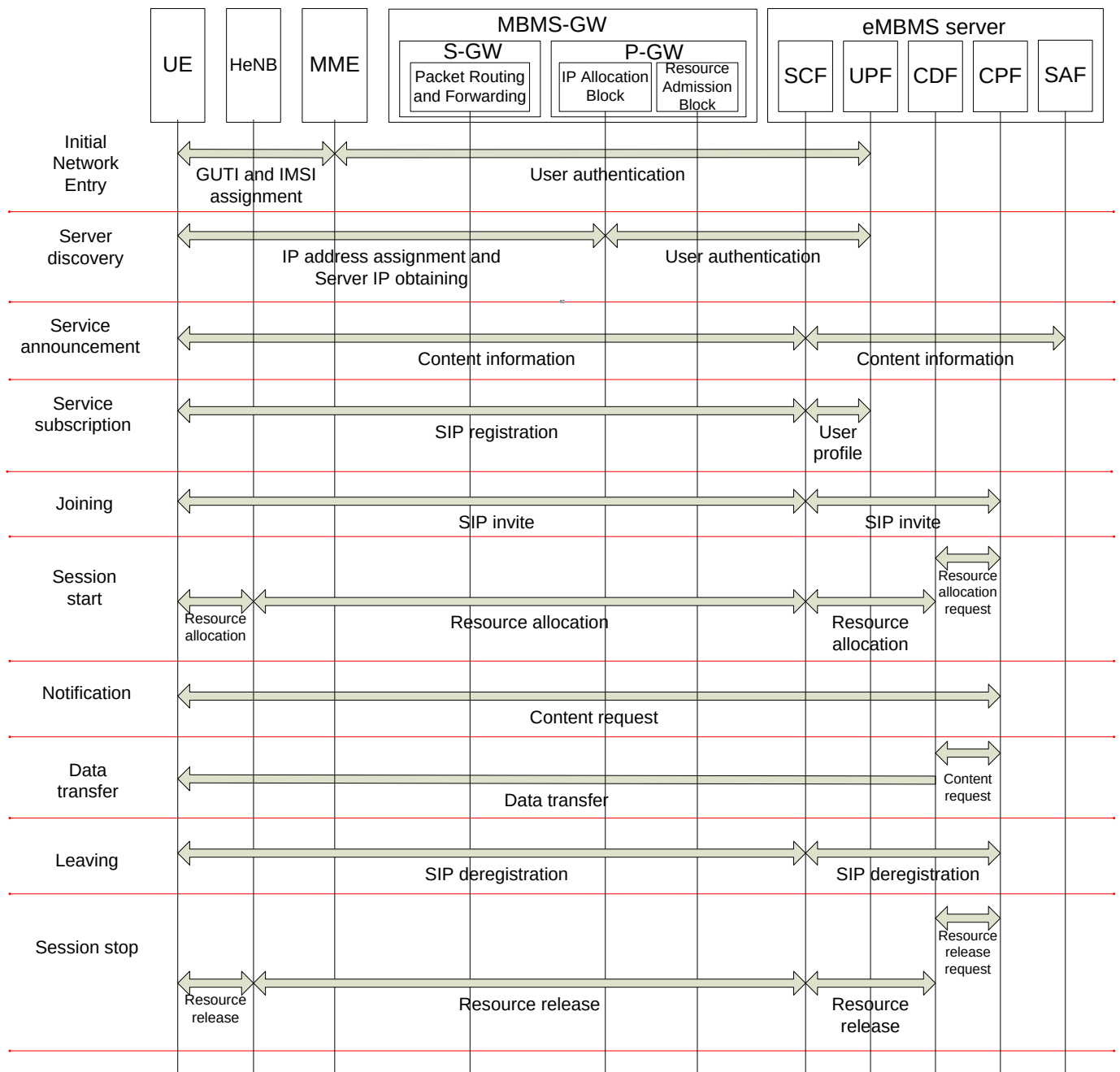


Figure 4: Basic setup procedure for eMBMS based Femtocell

- **At Initial network entry** UE attaches to the access network and requests the user authentication and authorization in order to obtain the GUTI (Globally Unique Temporary Identifier) and IMSI (International Mobile Subscriber Identifier) address and establish the link.
- **Server discovery:** The access network sends the user authentication request to the home IP Allocation block. After the completion of the user authentication and authorization, the access network assigns the valid IP address to the UE and establishes the link.
- **Service announcement:** receiving content information
- **Service Subscription:** The access network obtains the user policy rules from the home Resource admission block through the visited Resource admission block and opens the gate for signalling messages.

- **Joining:** The UE executes the SIP registration mechanism with the session control functions including the user profile. The UE sends a SIP INVITE message to the session control functions in order to request the eMBMS application session. The Session Control Functions then send it to the content preparation functions.
- **Session start:** The content preparation functions request the resource allocation for the UE to the content delivery functions. The content delivery functions request the resource allocation for the UE to the Session control function. The session control functions then send the content information (e.g., IP address, port number, content type and bandwidth) to the HeNB so that the HeNB can request the visited HeNB to open the gate on the access network for the content. Policy rules can optionally be allocated to the access network.
- **Notification:** The UE requests the application functions to send the content.
- **Data transfer:** The application functions request the content delivery functions to start sending the content. The eMBMS terminal receives the content from the content delivery functions.
- **Leaving:** The UE sends a SIP deregistration message to the session control functions in order to request the eMBMS application session stop. The Session Control Functions then send it to the content preparation functions a SIP deregistration message.
- **Session stop:** The content preparation functions request the resource allocation for the UE to the content delivery functions. The content delivery functions request the resource release request for the UE to the Session control function. The session control functions then send the resource release to the HeNB so that the HeNB can request the visited HeNB to close the gate on the access network for the content.

V CONCLUSION AND FUTURE WORK

This paper gave an overview of eMBMS design developments on standard and presented our novel design based on Femtocell. We have analysed a functional design of eMBMS based on femtocell depending on procedures to deliver multicast and broadcast services. Ongoing and future work will focus on further developments of the implementation of eMBMS server. Regarding the presented network architecture of eMBMS based on femtocell and network entity designs were proposed and discussed. Service discovery and session discovery procedures are also crucial in a LTE environment and will be investigated.

ACKNOWLEDGMENT

This work was supported by the IT R&D program of KCC and MKE [2010-10035206, The Development of IMT-Advanced Mobile IPTV core technology], Electronics and Telecommunications Research Institute of Korea and by MUST of Mongolia.

REFERENCE

- [1] 3GPP TS 23.246 Technical Specification Group Services and System Aspects; Multimedia Broadcast/Multicast Service (MBMS); Architecture and Functional description (Release 10); 3GPP Organizational Partners, 2011.
- [2] 3GPP TS 36.300 Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 10); 3GPP Organizational Partners, 2011.
- [3] 3GPP TS 32.771 Technical Specification Group Services and System Aspects; Telecommunication management; Home Node B (HNB) Subsystem (HNS); Network Resource Model Architecture (NRM); Integration Reference Point (IRP); Requirements (Release 9); 3GPP Organizational Partners, 2010.
- [4] 3GPP TS 23.830 Technical Specification Group Services and System Aspects; Architecture aspects of Home NodeB and Home eNodeB (Release 9); 3GPP Organizational Partners, 2009.
- [5] Harri Holma and Antti Toskala, LTE for UMTS – OFDMA and SC-FDMA based Radio Access; John Wiley & Sons Ltd, 2009, ISBN: 978-0-470-99401-6.