

# On Cost-Reduced Channel Changing for Mobile IPTV Services in LTE-Advanced Systems

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**Abstract**— Due to the development of mobile communication technologies, multimedia services for mobile devices or other services have begun to be commercialized. In this paper, we propose a method that minimizes channel switching time by pre-computing the user's preferred channels in the LTE-Advanced System. The existing composition of the Multimedia Broadcast Multicast Service (MBMS) using the Internet Group Management Protocol (IGMP) transfers data using multicast from the Broadcast Multicast Service Center (BM-SC) to evolved Node B (eNB), and with broadcast from eNB to the User Equipment (UE). Therefore, in the case of channel switching, the IGMP Join report should be transferred to the BM-SC, where it then waits for the user's content to be retransferred from eNB. However, in the case of our proposed method, the subscriber channel technique of priorities is used to minimize the wait times between channel switching as the UE broadcasts its favorite channels in advance. Our performance is evaluated using mathematical modeling and shows that the delay time can be reduced from approximately 30 to 79% in terms of the channel switching time.

**Keywords**-LTE-Advanced; MBMS; MBSFN; IGMP; Mobile IPTV; Content Database.

## I. INTRODUCTION

The use of the Internet has increased greatly due to multimedia services. It is expected to increase by at least 1000-fold by 2020 [1]. In wireless environments, as the quality of the internet connection has improved, the demand for multimedia services such as Internet Protocol Television (IPTV), Video on Demand (VOD), and Voice over IP (VoIP), using a mobile IPTV is steadily increasing. IPTV is a communication and broadcasting convergence service based on IP that provides a broadcast service to the user terminal, and it can provide an interactive service according to the user's demands. In particular, mobile IPTV is mobility-granted to the existing IPTV. The Multimedia Broadcast Multicast Service (MBMS) initially appeared in Release 6. The MBMS was introduced in order to provide a service in Wideband Code Division Multiple Access (WCDMA). The most important technique of the MBMS is the Multimedia Broadcast Multicast Service Single Frequency Network (MBSFN) transmission scheme, which has been added in Release 7. The 3GPP has standardized tasks to provide Long-Term Evolution (LTE) standardization and evolved MBMS (eMBMS) in Release 8, as well as including eMBMS

standards in Release 9. In addition, the eMBMS features (counting techniques to determine the number of user terminals interested in a multimedia broadcast, the broadcast service to support the mobility of the receiving user terminal technology) have been added in Release 10/11, and are progressing towards standardization in Release 12 [2].

The MBMS is an effective method for delivering multimedia content to multiple destinations by allowing for the sharing of resources more efficiently. The LTE-Advanced system has two methods for supporting the MBMS. One is a single-cell MBMS transmission method used to transmit the MBMS content to users in a single evolved Node B (eNB). Another is a multi-cell MBMS transmission method for simultaneously transmitting MBMS content to the users that belong to a group of eNBs. The MBSFN transmission scheme is greatly improved in terms of the spectral efficiency in order to improve the Signal to Interference-Plus-Noise Rate (SINR) with compared to the Universal Mobile Tele-communications System (UMTS) for MBMS. This is very useful for the cell edge, which is considered to be inter-cell interference in the UMTS, because the interference signal is decreased and the received signal is increased simultaneously. The MBSFN generally provides better performance compared to single-cell Point to Point (PTP) or Point to Multipoint (PTM) transmission [3]-[4].

As a result, the MBMS transmits content by linking one eNB to multiple UEs. If any UE requests are connected to the applicable eNB, even if the UE does not request the specific channel, along with the channel requested by the other UE, the MBMS can receive content due to the broadcasting method. When the UE changes channels, if the UE is already receiving the channel via broadcasting, there is no time delay related to the channel change. If not, it can be received after sending the desired channel to the Broadcast Multicast Service Center (BM-SC) via the Internet Group Management Protocol (IGMP) Join report. To support the improved content in LTE-Advanced/eMBMS environments, we propose a method for minimizing the channel switching time by using channel priority assignment interlinked with the Content Database.

This paper is organized as follows: Section 2 describes the related work. In Section 3, we describe the improvement of the content transmission using the channel priority scheme with an IGMP. Section 4 shows the numerical results with the analytical model, and finally we conclude with Section 5.

II. RELATED WORK

This section describes the LTE-Advanced System, Mobile IPTV and eMBMS.

A. LTE-Advanced System

LTE (Rel. 8/9) is based on the OFDM transmission scheme, and can be described as the evolution of 3G mobile communication technology, such as Code Division Multiple Access (CDMA), WCDMA and 3.5G High Speed Packet Access (HSPA). The LTE system operates at a rate three times higher than the 3.5G transmission system in the Downlink and the latest standard for LTE, LTE Advanced, seeks to achieve a rate more than twice as high as that found in LTE [5]-[8].

LTE and LTE-Advanced technologies increase the data transmission rate, and many technologies are being studied in order to support seamless service. Multiple Input Multiple Output (MIMO) technology in particular is being studied to make high transmission rate a core technology of LTE and LTE-Advanced systems. MIMO technology has an advantage in that there is no help from electric power or frequency, and it can obtain an antenna number proportionate to the channel capacity. Increasing the performance of mobile communication systems represents an important avenue of research. MIMO technology has rapidly evolved from Single-User MIMO to Multi-User MIMO, and recently to Mass-MIMO [14].

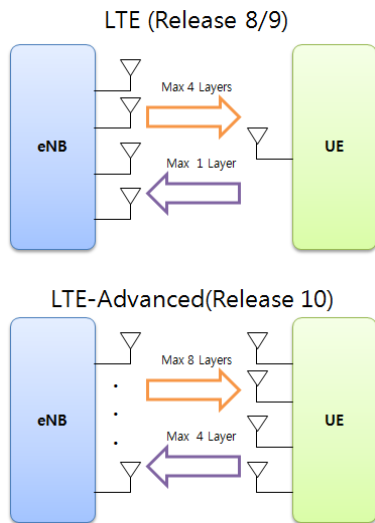


Figure 1. Antenna techniques of LTE and LTE-Advanced.

Figure 1 shows the antenna port and the spatial multiplexing layer in LTE (Rel. 8/9) and LTE-Advanced (Rel. 10) (Assuming that the UE has 4 receivers – 4 x 4). The downlink of LTE is up to support four transmit spatial layers, and the uplink (assuming that the eNB use the diversity 1 x 2) is up to support one per UE. LTE is not supported by a multi-antenna transmitter in order to simplify the baseline UE. However, multi-user spatial multiplexing (Multi-User MIMO) is supported. For MU-MIMO, the 2 UEs transmit in the same frequency and time, and eNB has to separate the

UEs based on the spatial attributes. The gain of the uplink capacity, including multi-user spatial multiplexing, is generated. The maximum data transfer rate of a single user is not improved. To improve the peak data rate of a single user, in order to meet the requirements of the ITU-R (radio communication sector) for spectrum efficiency, LTE-Advanced may designate up to 8 downlink layers. This allows for 8x8 spatial multiplexing on the downlink where eight receivers are required for the UE. The UE has been specified to support up to four transmitters. Therefore, when combined with the four receivers, the eNB allows for the transmission of a 4x4 uplink.

B. Mobile IPTV

IPTV is a the TV service provider that provides services to the user via the IP network. In addition, the user has received the enhanced TV service instead of the traditional TV service through a technique called IP. Already we have been using a similar service, such as videos and web search using a computer or laptop via the Internet. The opportunity is in mobile IPTV, where users cannot watch TV services as one-way, but instead watch real-time two-way [13]. In addition, it is possible to use the enhanced TV service over the desired configuration. Moreover, once Korea had obtained popular mobile TV, such as DMB, it had a technique where you can always watch where you want. It is a concept known as Take-Out TV. However, this model of mobile TV technology extends the existing fixed-TV service, which had limitations with traditional TV services, where in particular there was still dissatisfaction with the one-way service [2]. In order to solve this problem, techniques for two-way service were introduced using mobile IPTV-based IEEE802.16, 3GPP and a variety of communication technologies (for example, 3GPP2 / BCMCS, Qualcomm / MediaFLO, IMNA / BCAST, etc.). Figure 2 shows the configuration of a mobile IPTV.

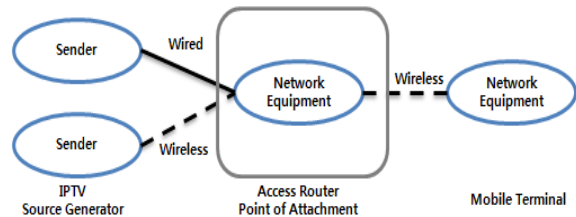


Figure 2. Configuration of mobile IPTV.

Mobile IPTV can support services anywhere, anytime and also supports seamless mobility in the wireless environment, even when moving to another radio link with a mobility supporting technology, such as the handover duration of the IPTV service. Especially if there are characteristics of a different radio link, technical issues can occur, but these technologies are expanding the research scope of the technology because they are able to expand the available range of mobile IPTV standardization that organizations are required to have [14]. In addition, the mobility studies in the Next Generation Network (NGN), ITU-T SG13 and SG19 in charge of the mobile

communication network standards fall jointly under the NGN-SGI (Global Standards Initiative) to form a group called Mobility Management, and the standardization progress and issues, such as Fixed Mobile Convergence (FMC), are also being studied at the same time [5]. Recently, mobile IPTV technology has been secured for the QoS and QoE of the content, security, interoperability and openness, anytime and anywhere, which aims to provide services across any device, through the combining of the next generation of web technology oriented user engagement and personalization and service convergence [16].

C. eMBMS

3GPP has introduced 3G / 4G user multicast information, as well as MBMS (Multimedia Broadcast / Multicast Service). MBMS may share resources efficiently, as it is an efficient method for providing multimedia content to multiple destinations. MBMS in the "LTE" context of 3G systems are evolving to become eMBMS [2]. LTE's eMBMS aims to provide broadcast and multicast service combining the high efficiency of the spectrum capacity. LTE-Advanced is designed to share services, such as digital video / audio broadcast.

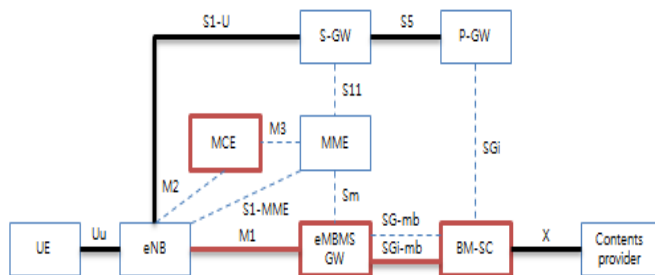


Figure 3. eMBMS architecture.

In Figure 3, eMBMS shows the UE how to perform the broadcast / multicast in the LTE-Advanced network [9]. It can send a media signal simultaneously to multiple receivers in the same area using the same eNB. In addition, the interactive features of the eMBMS system can dynamically interact with the broadcast network. To support the eMBMS service without having to change the entire structure of the existing service, the addition of a new node such as BM-SC can be supported. The eMBMS architecture is compatible with the SGSN and GGSN, such as 2G / GSM or the 3G UMTS packet core node based on the packet core domain. The eMBMS configuration of the 3GPP / LTE is shown in Figure 3. An eMBMS gateway exists between BM-SC and the eNB and performs functions such as MBMS packet transfer to the eNB by IP Multicast, user plane data header compression, and session control signaling (session start / stop). The MCE is responsible for allocating radio resources used by all eNBs belonging to one MBSFN area [15].

We first define a new interface SGi-mb and SG-mb for the BM-SC and MBMS Gateway communication. The SG-mb interface delivers authentication information and service management to the control plane. IP packets of the

multimedia data are transmitted through the user plane interface's SGI-mb.

IGMP is split into two versions. It is a protocol for managing the large group membership of a multicast router and identifying a member of a multicast group on a network host. IGMPv1 is described in RFC 11/12 and IGMPv2 is described in RFC 2236. IGMPv2 is used by default in the router [10]. The operation is performed through joining, monitoring, member continuation, and leaving, as well as when a multicast group joins the router and sends a General Query message at 125-second intervals, and notifies the router to leave (IGMPv1 does not inform). Recently IGMPv3 has been under development by RFC 3376 [11]. An IGMP message is composed of 8 bytes, where the first four bits discriminate the IGMP version. Consisting of 16 bits in the checksum, there is a group consisting of a 32-bit address (IP address of Class D). The time to query is when the group address is set to zero, since that is when the report has a value that represents the address of the group.

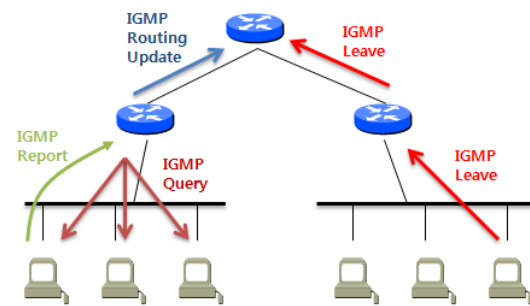


Figure 4. IGMP flow.

Figure 4 is a schematic view showing the basic operation of the IGMP. When the first process is to participate in the group, the host sends an IGMP Join message. The host does not send the report when the first process and last process leaves the group, while the router periodically sends an IGMP Query message to check whether the host is part of a group. The host then sends an IGMP Report message for each group belonging to its own process, and responds to the IGMP Query message.

Numerous standards and research papers for the Mobile IPTV service are presented and most of them address the cost by cell range. Our research, on the other hand, focuses on the improvement of the quality of user experience through minimizing the time of channel switching concerning MBMS service in LTE/LTE-A system.

III. SERVICE CONTROL OF CONTENT DATABASE

At present, several UEs are connected to one eNB, and the eMBMS transmits the content using a point-to-multipoint method. Therefore, the UE receives not only the requesting channels, but also unsolicited channels. Other UEs then request content in the same eNB. The channel change using IGMP is shown in Figure 5. After sending the IGMP JOIN report from the UE to BM-SC, the channel content packet may be transmitted from the eNB to UE.

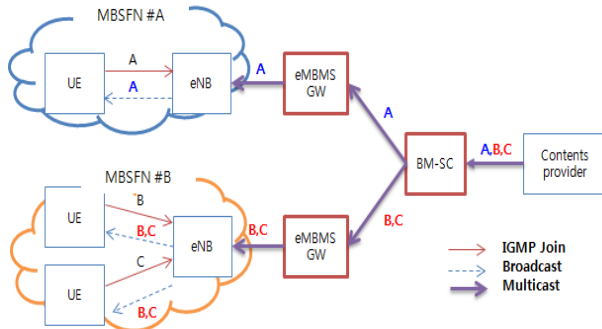


Figure 5. Channel selection procedure in eMBMS.

Figure 6 describes the process for channel change. If a UE changes from channel#1 to channel#2, the IGMP JOIN message for channel#2, the IGMP LEAVE message for channel#1, and transmits the content for channel#2, this is a source of service quality degradation due to the waiting time to perform the channel change.

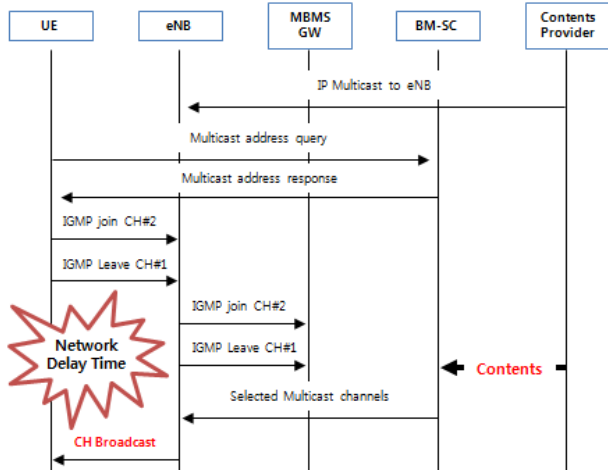


Figure 6. Flow of channel selection in mobile IPTV.

As shown in Figure 6, the channels are transmitted by multicasting from the content provider to the eNB, and then the channels requested by the UEs are transmitted by broadcasting from the eNB to UE. Therefore, when the UE changes the channel for new contents, if the UE already receives the new contents representing the requested information by broadcast message, we assume that there is no delay time for the channel change. However, there cannot be an inefficient waste of broadcast packets for all channels regardless of the subscriber. We propose a method of broadcasting with respect to the expected channel to be used.

Figure 7 shows a representation where a database node for the user to analyze the existing eMBMS system has been added. When the channel change request comes from the UE, if the channel is currently being broadcast, it sends the content of the immediately changed channel. If the channel is not being broadcast, it sends a message to the BM-SC requesting the content of the requested channel. This is the same method as the existing transmission system. Since the BM-SC has a preference pattern for UE channels, it is

transmitted to the UE by the broadcast channel with selected channels that are decided by the BM-SC / content database. This method eliminates the delay time according to the channel change of the UE. The communication between the content provider / content database and BM-SC using this method is performed in the system backend, which reduces the burden of the UE and does not affect the existing channel switching time.

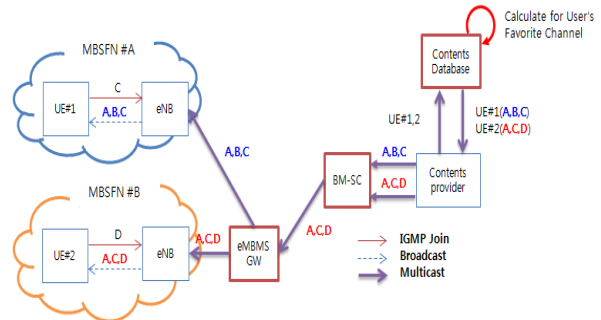


Figure 7. User rating channel database additional configuration.

#### IV. PERFORMANCE EVALUATION

In this section, we perform a mathematical analysis to assess the performance of MBMS channel switching time in terms of the delay time, and present some numerical results to evaluate the comparison of the channel change.

##### A. Modeling Time Cost Analysis

Table I describes the parameters which were evaluated in the case with and without a subscriber's favorite channels for the channel change time.

TABLE I. PARAMETERS USED IN NUMERICAL ANALYSIS

Parameter	Description
$I_{U_u}$	IGMP messages via the Uu interface
$I_{U_u-BC}$	Air channels transmitted by a broadcast message
$I_{M1-SG}$	M1/SG-mb interface using IGMP message (M1: Interface among BM-SC ↔ GW ↔ eNB)
$I_{U_u-query}$	Multicast Address Query messages via the Uu interface
$I_{query}$	Multicast Address Query message between eNB and BM-SC
$I_x$	Subscriber-specific favorite channel request / response messages
$I_{x2}$	Subscriber-specific favorite channel request / response messages
$I_{x2-Sort}$	Calculated per subscriber channel preferences at the content database
$I_{mc}$	Multicast message from the BM-SC
$I_{MBMS}$	Total time of MBMS

Hence, The MBMS time is calculated as follows;

$$I_{MBMS} = K_{air} \cdot [2(I_{U_u}) + I_{U_u-BC}] + K_{core} \cdot [2(I_{M1-SG}) + I_{mc}] \quad (1)$$

Using improved functionality, the MBMS time can be classified into two. The first is when it contains a subscriber's favorite channels when broadcasting channel information:

$$I_{MBMS-with\_CH} = K_{air} \cdot [2(I_{U_a}) + I_{U_a-BC}] + K_{core} \cdot 2(I_{M1-SG}) \quad (2)$$

The second is when it does not contain a subscriber's favorite channels in broadcasting channel information:

$$I_{MBMS-with\_CH} = K_{air} \cdot [2(I_{U_a}) + I_{U_a-BC}] + K_{core} \cdot [2(I_{M1-SG} + I_x + I_{x2}) + I_{x2-sort} + I_{mc}] \quad (3)$$

$K_{air}$  is a proportion of the air interface and  $K_{core}$  is a proportion of the core interface ( $K_{air} + K_{core} = 1$ ) [12]. In the LTE system, we made calculations by setting a different weight for the latency time. However, the actual value of the air interface and the system performance is determined.

### B. Numerical Results

Based on the analysis given so far, we compare the performance of the existing and proposed schemes. For numerical analysis, we configure the parameter values, as described in Table II, in which some of the values are taken from [12]-[16].

TABLE II. PARAMETER VALUES FOR PERFORMANCE EVALUATION

Parameter	Values
$K_{air}$	$0 < K_{air} < 1$ , (if $K_{air} + K_{core} = 1$ )
$K_{core}$	$0 < K_{core} < 1$ , (if $K_{air} + K_{core} = 1$ )
$I_{U_a}$	0.5
$I_{U_a-BC}$	0.5
$I_{M1-SG}$	2.5
$I_{U_a-query}$	0.5
$I_{query}$	2
$I_x$	1
$I_{x2}$	1
$I_{x2-Sort}$	1.5
$I_{mc}$	2.5

$K_{core}$  specifies the proportion of a real-world environment to be larger than  $K_{air}$ . The content database node increases and the subscriber may encounter a delay according to the calculation for the wireless channel. In this paper, the weight of  $K_{air}$  and  $K_{core}$  was confirmed by setting three assumptions.

If there are none of the subscriber's favorite channels, as shown in Figure 8, the proportion of  $K_{air}$  and  $K_{core}$  may be increased compared to the conventional MBMS channel

switching time if the subscriber's preferred channel is included (if it is broadcast). Accordingly, the proportion of  $K_{air}$  and  $K_{core}$  can confirm the degree of improvement from 22.7 to 30.7% compared to the existing procedures. Of course, the delays are reduced when the proportion of  $K_{core}$  is large.

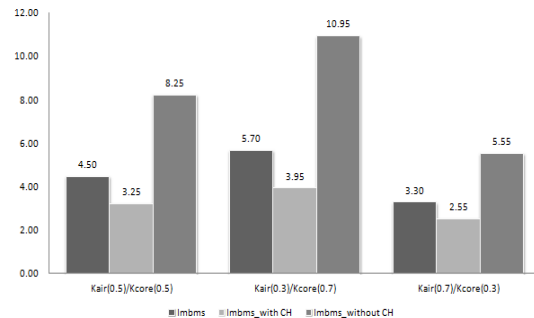


Figure 8. Comparison of the channel change.

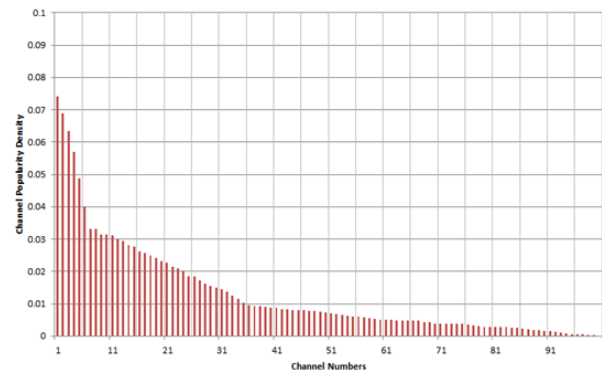


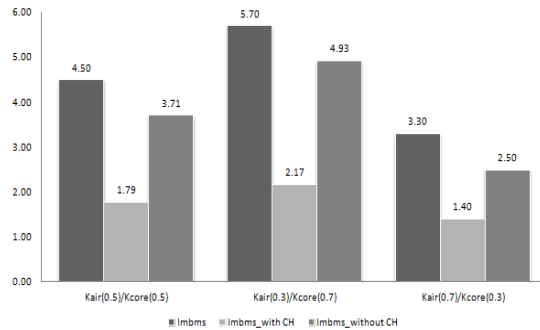
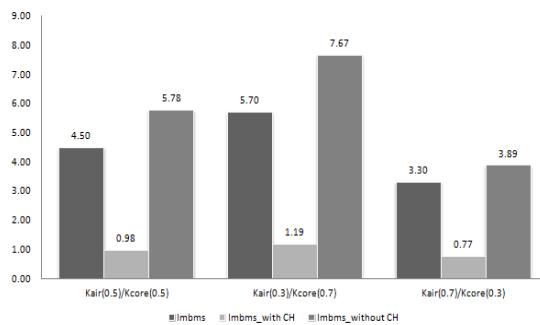
Figure 9. Channel popularity density [13].

According to [13], with respect to channel 96 for the popularity investigation result of the TV viewing conditions,  $0 \leq X \leq 10$  is 45% as shown in Figure 9,  $0 \leq X \leq 15$  is 65%, and  $0 \leq X \leq 20$  indicates a probability of 70% for 5 or more channels if the shared content can be sent without channel change time.

The channel change time for the subscriber's favorite channel is analyzed. Figure 10 shows that it is possible to reduce the delay time from 57.5 to 61.8% in the case of  $0 \leq X \leq 10$ . Figure 11 shows that it is possible to reduce the delay time from 76.8 to 79.2 % in the case of  $0 \leq X \leq 20$ .

If the most popular 96 channels are shared in a service node, the probability of a viewer choosing among the channels is 0.618. Figures 10 and 11 show the cumulative channel duplication probability of 10 independent trials when total numbers of most popular shared channels are 10 and 20. Notice that the newly proposed method is able to let viewers immediately watch on the shared mobile IPTV without channel change time using the enhanced group join and leave process for LTE / LTE-A systems, when more than 5 channel requests are made for most popular channels.



Figure 10. Comparison of channel change ( $0 \leq X \leq 10$ ).Figure 11. Comparison of Channel Change ( $0 \leq X \leq 20$ ).

## V. CONCLUSION

In this paper, we analyze channel change techniques and conduct a performance evaluation for mobile IPTV in LTE-Advanced environments. The proposed method, which is a curtailment of channel change time, can be effective for eliminating the delay time by broadcasting from the eNB in advance after analyzing the channel pattern of the accessing user in the content database. This method also reduces the burden of the UE and doesn't affect the existing services at all because it is performed in the back end of the BM-SC and content database system after the user initially connects. For the performance evaluation, we analyze the transmission of the content without the IGMP message using the duplication probability of the selected channel for the shared channel. If the computational accuracy of the subscriber priority channel in the content database is able to be increased, we can expect to provide a better service for MBMS and improve the performance of MBMS.

In future work, we will seek to increase the accuracy of the method for calculating the preferred channels of the subscriber in the content database.

## ACKNOWLEDGMENTS

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