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Review

Comparative study of broadcast and multicast in 3GPP and 3GPP2 networks

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ABSTRACT

Multicast can greatly save network bandwidth because only one copy of data is transmitted in the shared paths. Applications such as video conferences and network games usually can benefit from multicast. Although mobile multicast has been studied for years, it is still a challenge and has not been widely realized in today's Internet. Both 3GPP and 3GPP2 have defined architectures and protocols for multicast. This paper presents the multicast architectures and operations defined in 3GPP and 3GPP2. Besides, this paper also provides a systematic comparison of them. In addition to system architectures, various issues including mobility, QoS, and security are discussed. Moreover, we discuss the challenges in radio resource management (RRM), power control, scalability, and complexity. This paper could be a reference for those seeking the perspective often difficult to obtain from standards specifications.

1. Introduction

Multicast is used for *one-source-many-destination* communications. In multicast, various receivers may share some common paths. Unlike conventional unicast transmission, only one copy of data is transmitted in the shared paths in multicast. Therefore, multicast can greatly save network bandwidth. It could also reduce the sender's load. Applications such as video conferences and network games usually can benefit from multicast. Both IPv4 and IPv6 provide a set of IP addresses for IP multicast. Research on multicast for the Internet has been developed for decades. Many well-known IP multicast protocols have been proposed.

3GPP and 3GPP2 have also defined architectures and protocols for multicast. Although the packet core networks in 3GPP and 3GPP2 can transport IP packets, existing IP multicast protocols can not apply to them directly. Conventional IP multicast protocols usually do not consider mobility. Although mobile multicast has been studied for years, it is still a challenge and has not been widely realized in the Internet. 3GPP and 3GPP2, however, are designed for mobile and wireless communications. In addition, although the packet core networks of 3GPP and 3GPP2 are based on IP, the architectures are quite different from today's Internet architecture. Besides, standard IP routing is not used. Instead, IP packets are *tunneled* inside 3GPP and 3GPP2 packet core networks [1]. Therefore, 3GPP and 3GPP2 have defined their own multicast architectures and protocols.

This paper presents an overview of the 3GPP and 3GPP2 broadcast and multicast architectures and protocols. We also provide a systematic comparison of them. We assume readers are familiar with the overall architectures and operations of 3GPP and 3GPP2 systems already. This paper focuses on broadcast and multicast only.

2. Multimedia broadcast/multicast service (MBMS) in 3GPP

In 3GPP, two multicast/broadcast services have been proposed: *cell broadcast service (CBS)* and *multimedia broadcast/multicast service (MBMS)* [2,3]. The CBS is based on *short message service (SMS)* developed in GSM. It provides only text-based service. The MBMS is newly developed for both multicast and broadcast services. It provides not only messaging services but also multimedia services. Furthermore, it is also compatible with Internet multicast services. The following sessions describe the MBMS architecture and its operations, respectively.

2.1. MBMS architecture

Fig. 1 illustrates the MBMS architecture. The architecture is extended from the original 3GPP packet switched (PS) domain. The *broadcast multicast service center (BM-SC)* is a newly introduced component to support MBMS services. The *content provider* and *multicast broadcast source* are the sources of multicast data. They generally work together as one component although they can also be separated into different entities. The multicast broadcast source only provides multicast data sources. The content provider, however, is also responsible for control information, including subscription, group addresses, and other multicast/broadcast related

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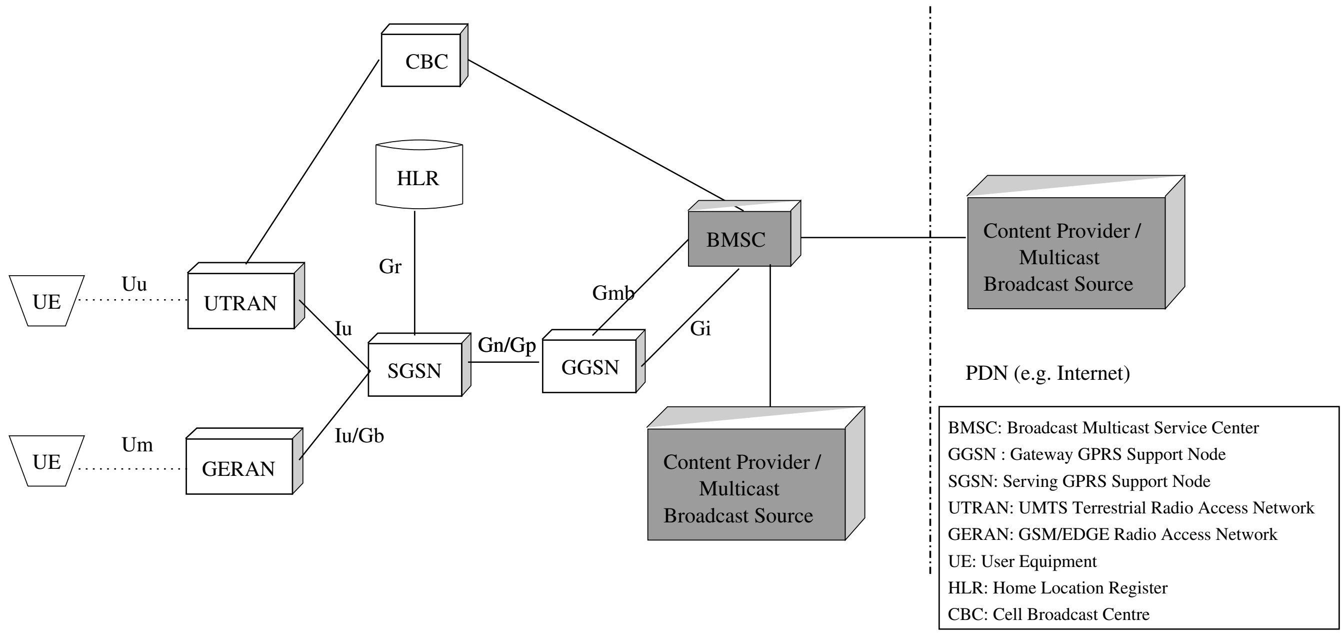

Fig. 1. 3GPP MBMS architecture.

information, in addition to providing multicast data sources. Both of content provider and multicast broadcast source can be either within the local domain or outside the 3GPP network. In addition to the three newly introduced components, existing components, such as gateway GPRS support node (GGSN), serving GPRS support node (SGSN), and user equipment (UE), need to support MBMS as well.

The BM-SC is the entry point in 3GPP network for MBMS services. It is located between content provider/multicast broadcast source and GGSN. It supports several functions, including *membership*, *session and transmission*, *proxy and transport*, *service announcement*, and *security* functions. Fig. 2 illustrates the relationship between the five functions. The *membership function* authorizes the UEs that want to activate MBMS services. The *session and transmission function* schedules the transmission of MBMS sessions. The *proxy and transport function* acts as a proxy agent for signaling and MBMS data between other functions and GGSN. The *service announcement function* announces available MBMS services. The *security function* distributes MBMS security keys for data integrity and confidentiality.

The GGSN receives IP multicast traffic from BM-SC. It then routes the traffic to the corresponding SGSNs by using GPRS tunnelling protocol (GTP). If there is no *multicast bearer* established already, the GGSN will initiate the process to establish the multicast bearer. It will also tear down the multicast bearers when the bearers are not needed.

The SGSN mainly works on per-user service control, including authentication, authorization, and mobility management. By storing the *MBMS UE context*[1] of each activated user, SGSN can aggregate the users of the same multicast group into one GTP tunnel. That is, SGSN should de-tunnel the packets from GGSN and forward them to the corresponding UEs. Besides, SGSN should support intra-SGSN and inter-SGSN mobility management. When MBMS data is transmitted to a user, the SGSN should establish I_u and G_n bearers. It should also tear down the bearers when they are not used.

UTRAN/GERAN is enhanced for efficient MBMS data transmission. It is responsible for delivering MBMS data from core network to designated UEs. It also needs to deliver MBMS related information, such as MBMS service announcement and paging. Like that in the original 3GPP PS architecture, UTRAN/GERAN is also responsible for intra-RNC and inter-RNC mobility management for MBMS users.

To support MBMS, UE needs to be enhanced as well. It must be able to receive MBMS service announcement and paging information from the core network. It should also be able to activate and deactivate MBMS services. After activating certain MBMS services, an UE then can receive MBMS data.

The *temporary mobile group identity (TMGI)* is used to identify a specific MBMS bearer. It contains public land mobile network (PLMN) ID and local MBMS bearer service identifier. Therefore, it is globally unique. When UE activates a MBMS service, BM-SC will allocate a TMGI for this service and deliver it to the UE.

Like the *packet data protocol (PDP) context* in 3GPP PS domain, *MBMS UE context* is used to store UE-related MBMS bearer information. It is created by UE, SGSN, GGSN, and BM-SC when an UE activates the MBMS service. In UE and SGSN, MBMS UE context is part of the *mobility management (MM) context*, which is maintained for each UE. In GGSN, however, there is only one MBMS UE context shared by group of UEs which belong to the same MBMS service.

The *MBMS bearer context* stores information about the MBMS bearer. The information includes quality of service (QoS) parameters, number of UEs, and a list of routing areas that the UEs join. The MBMS bearer context is created and preserved in the nodes which need to transmit MBMS data. MBMS bearer context has two states: standby state and active state. In standby state, no MBMS bearer exists for MBMS data delivery. On the other hand, there is a MBMS bearer to transmit MBMS data in active state. The transition of the two states is triggered by *session start* or *session stop* which will be discussed in next section.

2.2. MBMS operations

This section presents the procedures for using MBMS services. Fig. 3 depicts the procedures for *multicast* mode. The *broadcast* mode is same except that it does not include steps (1) subscription, (3) joining, and (8) leaving.

In *Step (1) subscription*, users establish connection to service providers in order to receive MBMS related information. The sub-

[1] Details of *MBMS UE context* will be described later.