ON REDUCTION OF GTP TUNNELS FOR MBMS DATA TRANSFER IN UMTS

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Abstract

Multimedia Broadcast Multicast Service (MBMS) permits the efficient usage of radio and core networks by sharing the network resources. However, this efficient usage of resources has not been explored for the case where source and destination of the MBMS service belongs to the same Gateway General Packet Radio Service support node (GGSN) implying that one of the user equipment acts as a source of MBMS data. This paper considers a new mechanism for MBMS service for this particular scenario and compares its performance with existing scheme in Universal Mobile Telecommunication System (UMTS). The proposed scheme has been simulated and results are presented.

Keywords: *MBMS, UMTS, GGSN, SGSN*

1. Introduction

Multicast is an efficient method for data transmission to multiple destinations. Its advantage is that the sender's data are transmitted only once over the links which are shared along the paths to a targeted set of destinations. Third Generation Partnership Project (3GPP) identified the need for multicast routing in UMTS networks and started the standardization of MBMS framework [1].

In the MBMS mechanism [7,9,13] Broadcast Multicast Service Centre (BMSC) [8] provides the multicast data. But considering the scenario where one of the user equipment acts as a source of MBMS data, then data needs to be transmitted to BMSC and then it is multicast to the subscribers almost through the same path. But in this case the efficient use of bandwidth may not apply for the network. So an efficient scheme proposed for this particular scenario by the authors

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[14] which makes the better use of network resources by defining neighbor routing node lists in RNCs and SGSNs.

This paper is organized as follows: Section 2 presents an overview of the standardized MBMS service, while the design of the proposed scheme is discussed in section 3. Section 4 presents the simulation topology and results and finally section 5 gives the concluding remarks.

2. Overview of UMTS and MBMS

A. Basic UMTS Architecture:

The basic UMTS is split in to two parts: the User Equipment (UE) and the Public Land Mobile Network (PLMN). The PLMN is further divided into UMTS Terrestrial Radio-Access Network (UTRAN) and the Core Network (CN) Figure 1 gives UMTS Architecture. The UTRAN handles all the radio-related functionalities and CN is responsible for maintaining subscriber data as well as for switching voice and data connections. The UTRAN consists of two kinds of nodes Radio Network Controller (RNC) and the Node B. A single RNC and the Node Bs constitute a Radio Network Subsystem (RNS).

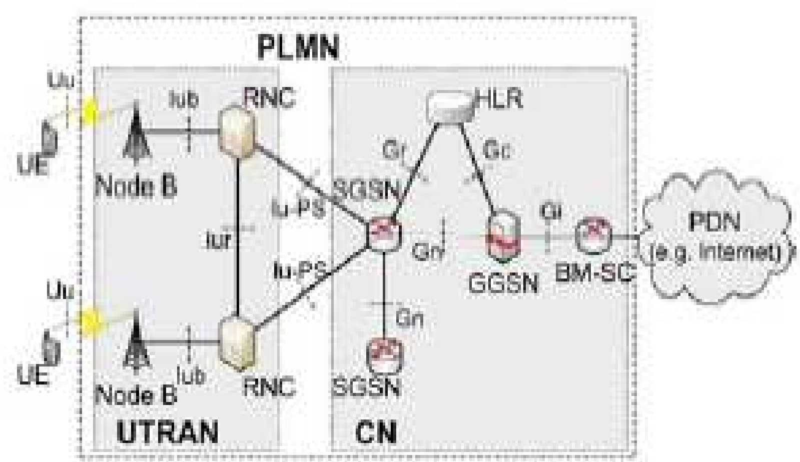

Figure 1. UMTS Architecture [10]

The CN is logically divided into Circuit-Switched (CS) domain and the Packet-Switched (PS) domain. All of the voice related traffic is handled by the CS-domain, while the PS-domain handles the transfer of data packets. The PS-domain is more relevant to the multicast data transmission which is the scope of this paper. The PS-domain of the CN consists of two kinds of General Packet Radio Service (GPRS) Support Nodes (GSNs), namely the Gateway GSN (GGSN) and the Serving GSN (SGSN).

B. *MBMS service:*

The most significant modification for MBMS service is the addition of a new node called Broadcast Multicast–Service Center (BM-SC) as shown in fig 1. For simplicity reasons, functionality of the BM-SC incorporated in the GGSN. The reception of an MBMS multicast service is enabled by certain procedures. These are: Subscription, Service Announcement, Joining, Session Start, MBMS Notification, Data Transfer, Session Stop and Leaving [7].

Performance of the existing scheme [13] is evaluated by considering the tree like topology and Routing List (RL) in every node of the network apart from the UEs is introduced. In the RL of a node, information is kept about which nodes of the lower level connect the current node with the UEs belonging to a specific multicast group. Consequently, there is one RL for each multicast group in each node (except for the UEs). The packet forwarding during the Data Transfer phase is based on the RL processing in each node. If an incoming multicast packet, reaches a node, the corresponding RL is scanned. If RL is non-empty, the packet is duplicated and is transmitted once to each lower-level node existing in the RL. This procedure is repeated recursively in the lower-level nodes until each copy of the packet reaches its destination.

In the existing scheme all the UEs participating in a multicast session receives the data from a content provider through BMSC. But when one of the UE itself acts as a source of data, then data needs to be uploaded to BMSC and then it is multicast to the subscribers. Here even though the multicast source and the destination subscribers are within the same RNC or within same SGSN or same GGSN, the same multicast packets are uploaded through the same higher level nodes and again follows the same downstream path while multicasting to users. Hence results in waste of bandwidth and increase in end to end delay.

To overcome the above said problem an efficient scheme was proposed by the authors[14] which defines two additional routing lists neighbor RNC lists(NRL) and neighbor SGSN lists(NSL) in RNC and SGSN respectively. But this scheme [14] limits the number of RNCs and SGSNs to maximum of two which makes it suitable for smaller geographical areas.

3. Proposed scheme

In order to overcome the problems listed above with the scheme [14] this paper proposes schemes that will multicast the data to UEs at the level of RNCs, SGSNs while it is uploading the data to BMSC itself. This paper concentrates on data transfer phase of MBMS service. The proposed mechanism makes use of tree like topology of UMTS network for this scenario. In addition to this, one more routing list called multicast group member list (MGML) defined in GGSN.

The UE wishing to act as a multicast source, informs its corresponding higher level nodes RNC, SGSN which are called source RNC (SRNC), source SGSN(SSGSN) respectively in this case. Each RNC maintains a list of UE in the routing list (RL) for that multicast group. Similarly each SGSN maintains a list of RNCs participating in that multicast group and each GGSN also maintains a routing list that contains list of SGSNs participating in that group.

The performance of this scheme is evaluated under three different cases.

Case (i): In this case the multicast source (UE) and destination UEs are considered under same RNC. If a multicast packet from UE which addresses to a multicast group reaches RNC, then RNC processes its routing list and If RL is non-empty, the packet is duplicated and is transmitted once to each lower-level node existing in the RL. Here the number of GTP tunnels used are reduced from 4 to 0 and hence decrease in the end to end delay.

Case (ii): This case considers the multicast source and destination UEs under same SGSN. Whenever a multicast packet from UE which addresses to a multicast group reaches SSGSN, RL is also scanned and duplicated packets are tunneled over Iu-Ps interface to those RNCs present in the routing table except SRNC and also the original multicast packet is transmitted using GTP tunnel to its upper level node GGSN. Here two GTP tunnels are reduced and it results in decrease of end to end delay.

Case (iii): This case considers the source and destination UEs under same GGSN. GGSN processes the incoming multicast packet from SSGSN and delivers the original packet to BMSC and duplicated packets to SGSNs present in RL except for SSGSN. Even though numbers of GTP tunnels are not reduced, the end to end delay is reduced. It is important to note that each and every routing list including MGML is updated whenever an UE joins or leaves the service.

In the existing scheme for UE acting as multicast source, the end to end delay between the multicast source and the subscriber UE for corresponding multicast group is nothing but the time taken by multicast source (UE) to upload the data packets to BMSC plus the time taken by these packets to reach subscriber UE from BMSC. Our aim is to reduce the number of GTP tunnels and end to end delay for the subscribers located under the same GGSN as that of multicast source.

Here it is important to note that all other nodes except SRNC and SSGSN processes their incoming packets as per the existing multicast scheme [1] . The entries of the RL considered for simulation are shown in Table 1, 2 and 3 respectively.

Pseudo code for SRNC:

Step 1: Update the routing list (RL), for every join and leave Request
Step2 If the multicast packet is from source UE , scan its RL.
Step 3: If size of (RL) =! 0, then duplicate packets and transmit them to the UE entries in RL.
Step4: send the original multicast packet from UE to its higher level SGSN called SSGSN.

Table 1. RL entries for SRNC(node 0)

Nodes(UEs)	Multicast group id
10	
11	

Pseudo code for SSGSN:

Step1: update the RL in SSGSN for every join and leave request
step 2: set the status bit of all RL entries with a default value of 1
Step 3: If sizeof(RL)=!0 and source address of multicast packet==SRNC then set status=0 for SRNC entry in RL.
Step 4: if size of(RL)=!0 then scan its RL and flag bits. Else go to step 7
Step 5: if status==0 don't send packet to that RL entry.
Step 6: if status==1duplicate packets to its Entries through GTP tunnels.
Step 7: The original packet received from SRNC is Tunneled to GGSN through GTP tunnel.

Table 2. RL entry for SSGSN (node 24)

RNC entry	Multicast group id	status bit
0		0
1		1

Pseudo code for GGSN:

Step1: update the RL in GGSN for every join and leave request
step 2: set the status bit of all RL entries with a default value of 1
Step 3: If sizeof(RL)=!0 and source address of mcast packet==SSGSN then set status=0 for SGSN entry in RL.
Step 4: if sizeof(RL)=!0 then scan its RL and status bits. Else go to step 7
Step 5: if status==0 don't send packet to SGSNs of RL entry.
Step 6: if status==1duplicate packets to its Entries through GTP tunnels.
Step 7: The original packet received from SSGSN is transmitted to BMSC.

Table 3. RL entry for GGSN

SGSN list	Mcast group id	Status bit
24		0
25		1

The entries of the RL for the simulation topology shown in the figure 2 are as follows. Here node 8 acting as a source UE and UEs with the node addresses 10, 11, 13 15, 16, 18 are the subscribers for multicast group. For simplicity only one multicast group is considered.

4. Simulation Results

Network Simulator NS-2.31 with EURANE extension patch has been used to simulate and compare the performance of the proposed scheme with the existing scheme.

The topology considered for simulation is as shown in fig.2 and results are shown in Table 4,5,6 respectively.

In this simulation node 27 acting as BMSC is connected to a GGSN (26). And GGSN (26) is connected to two SGSNs (node 24 and 25). And each SGSN is connected two RNCs which are in turn connected to 4 UEs. Nodes 0,1,2,3 represents RNCs and nodes 4,5,6,7 represents nodeBs and nodes from 8 to 23 are UEs. Here node 8 acts as multicast source and node 0 is SRNC and node 24 is SSGSN. The average end to end delay for an RTP packet of size 512 bytes is used to evaluate the performance.

In the existing approach [6] average end to end delay between multicast source and all subscribers under same GGSN as that of source is given by

Delay1= 2(Tu + Tr+ Ts +Tg)+4(Ex+Dx)

where,

Delay1= average end to end delay for existing scheme[13]

Ex= Dx= Encapsulation time at the beginning of the tunnel = Decapsulation time at the end of the tunnel for RNCs , SGNSs , and GGSN.

Tr= Time to tunnel packets between RNC and SGSN.

Ts=Time to tunnel packets between SGSN and GGSN.

Tg= Transmission delay between GGSN and BMSC.

Tu= Time for packet to reach RNC from UE= time to reach UE from RNC.

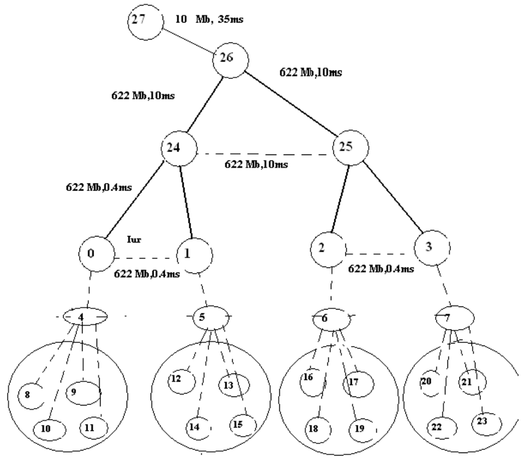

Figure 2. Topology considered for simulation

Average end to end delay for the proposed scheme is given below.

Case(i): For multicast source and subscriber UEs Under same RNC

In the simulation topology node 8 is considered as a source of multicast data and subscriber UEs are nodes 10 and 11 are the destinations. Here the average end to end delay is given by

D1= 2Tu

Where D1=end to end delay between multicast source and destinations of same RNC.

The comparison of end to end delay for the existing scheme [13], [14] and proposed scheme is given in the table 4.

Table 4

Protocol (end to end delay for source and users of MBMS)	Existing approach[13] (in sec)	Existing approach[14] (in sec)	Proposed approach
Under same RNC	0.100918	0.010	0.010

Here the average end to end delay of a proposed scheme for this particular case remains same as it was evaluated by the scheme in [14].

Case (ii): source and destination UEs under same SGSN (except for UEs under SRNC).

D2= 2Tu+2Ex+2Dx+2Tr

Where D2=end to end delay between multicast source and destinations of same SGSN.

In this case also the node 8 acts as a source of multicast data and the nodes 12, 14, 15 are the destination of multicast data. Here the nodes which come under SRNC are excluded.

The end to end delay for the existing scheme [13], [14] and proposed scheme is given in the table 5.

Table 5.

Protocol (end to end delay for source and users)	Existing approach[13] (in sec)	Existing approach[14] (in sec)	Proposed approach (in sec)
Under same SGSN	0.100918	0.010407	0.010814

Case (iii): source and destination UEs under same GGSN (excluding the UEs under SSGSN).

Here the end to end delay is given by

D3=2Tu+2Tr +2Ts +4Ex+4Dx

Where D3=end to end delay between multicast source and destinations of same GGSN (excluding the UEs under SSGSN)

In this case node 8 acts as a source of multicast data and the nodes 16, 18, 20 are the destination of multicast data. Here the nodes which come under SSGSN are excluded.

The end to end delay for this case is compared with the values of the existing scheme [13],[14] and proposed scheme is given in table 6.

Table 6

Protocol (end to end delay for source and users)	Existing approach[13] (in sec)	Existing approach[14] (in sec)	Proposed approach (in sec)
Under same GGSN	0.100918	0.020815	0.030816

Average end to end delay is calculated with the help of trace file obtained during the simulation and it shows the drastic reduction in the end to end delay for the proposed scenario. And this reduction is due to distribution of multicast packets at the level of RNC, SGSN while the data is being uploaded to BMSC.

Figure 3 depicts the plot of end to end delay for the existing [13] and proposed scheme which shows the comparable reduction in the end to end delay in the proposed scheme.

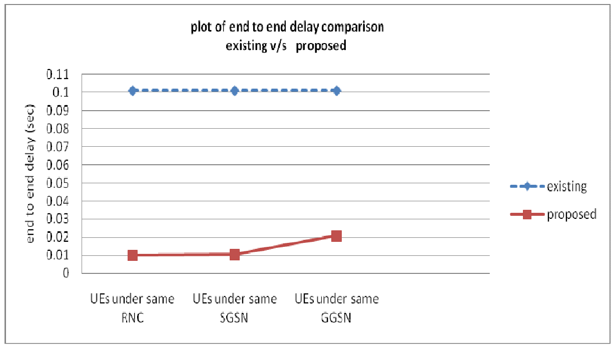

Figure 3. End to end delay comparison for existing[13] and proposed approach.

Figure 4 visualizes the result of comparison of end to end delay for existing [14] and proposed scheme.

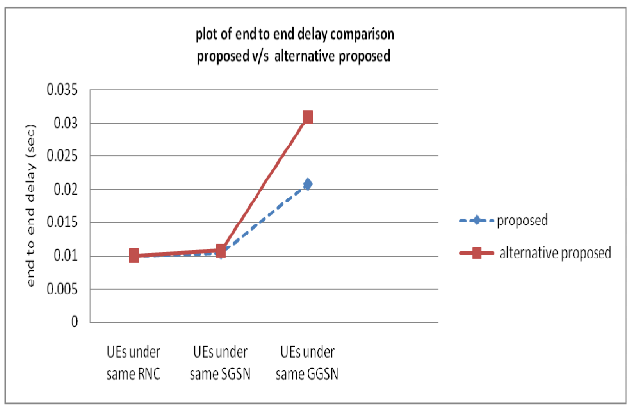

Figure 4. End to end delay comparison for [14] and proposed approach.

5. Conclusion

In the existing MBMS scheme, data is available at BMSC through content providers connected to it. However for a scenario where one of the UE acting as a source of multicast data, the existing scheme[13,9] results in higher end to end delay for the subscribers under the same GGSN on account of more tunnel propagation. The scheme given in [14] reduces the end to end delay and GTP tunnels but it is limited for smaller geographical areas since the number of RNCs and SGSNs are limited to maximum of two. Hence a new scheme has been proposed and it is evident from the simulation that end to end delay as well as GTP tunnels can be reduced compared to the scheme discussed in [13,14].As a future enhancement mobility of UEs is being researched.

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