Advanced Remote-Subscription Scheme Supporting Cost Effective Multicast Routing for Broadband Ubiquitous Convergence IP-Based Network

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Abstract. Mobile multimedia services such as TV-call or video streaming are gradually becoming popular in the 3^{rd} or more generation mobile network(IMT-2000). IP-based IMT network platform represents an evolution from IMT-2000. The structure of IP-based IMT network as ubiquitous platform is three-layered model : Middleware including Network Control PlatForm (NCPF) and Service Support PlatForm (SSPF), IP-BackBone (IP-BB), access network including sensor network. Mobility Management (MM) architecture in NCPF is proposed for IP-based IMT network in order to manage routing information and location information separately. The generous existing method of multicast control in IP-based IMT network is Remote-subscription. But Remote-subscription has problem that should be reconstructed whole multicast tree when sender in multicast tree moves to another area. To solve this problem, we propose the way to put Multicast-manager in NCPF.

Keywords: Multicast-manager, IP-based IMT Network, Mobility Management, SSPF, NCPF, Multicast Routing.

1 Introduction

Ubiquitous Network, in charge of future communications, should support wideband seamless mobility management, service and furthermore guarantee transmission of large amount of multimedia traffics which has been increasing explosively by the development of wireless accessing technologies. According that ITU-R suggested a guideline all networks, including telecommunications, it should be converted to IP-based networks [1]. NTT DoCoMo proposed IP-based IMT network platform [2][3] as the next generation All-IP mobile network structure taking IP technologies and rapidly increasing multimedia traffics into consideration. This

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platform was designed to have an ability to transmit large amount of multimedia traffic efficiently and accommodate different kinds of wireless access systems. This platform also supports seamless mobility and application services. The structure of IP-based IMT network is categorized into three layers which consists of middleware including NCPF and SSPF, IP-BB and access network including sensor networks [1][4]. IP-based IMT network, as the next generation backbone network, is designed to support mobility management fundamentally which is not the present networks. This mobility management function plays an important role not only making it easy for seamless mobility of terminals or users but also providing various services which are not even imaginable within conventional infrastructure. Mobile multicast is an important research item. At present, there are multicast techniques taking mobility into consideration such as Remote-subscription, Bi-directional tunneling, Mobile Multicast (MoM) and eXplicit Multicast Mobile IPv6 (XMIPv6) for Mobile IPv6 (MIPv6) and so on. Since Bi-directional tunneling, MoM and XMIPv6 use a technique of transmitting packets as a unicast via Home Agent (HA) when they are routing, they cut down the effect of resource integration of multicast. Therefore, Remote-subscription should be used for effective multicast in IP-based IMT network. It has a problem at present, however, that multicast trees of the whole network have to be reconfigured whenever Mobile Node (MN) for sender travels to another area. In this paper, we proposed a solution for the problem by managing the information of multicast group members with a Multicast-manager in NCPF of IP-based IMT network. In Chapter 2, the mobile cast technique used in conventional IP-based ITM network and its problem are described. In Chapter 3, a solution to the problem is described. Based on a series of simulations, performance comparisons of the proposed technique and the conventional mobile multicast technique are described. And final conclusions in Chapter 5.

2 Conventional Mobility Management of IP-Based Network and Multicast Support Method (MIPv4 / MIPv6)

In Mobile IP (MIP) Multicast, there are Remote-subscription and Bi-directional tunneling method which has been proposed by IETF. In case of Remote-subscription, when MN moves to other access networks, multicast group will be reconfigured by a request of MN itself. This method is comparatively simple in its operation and efficient in case that MN's move is not so frequently. In case that MN receives packets, they are delivered through a certain route, which has been optimized based on multicast routing protocol. In case that MN transmits multicast data, a delivery multicast tree is reconfigured and a sending node transmits packets to FA. After that the packets are delivered to a receiving node through a typical multicast delivery route [5]. Figure 1 shows data receiving route in case that moving nodes (Receiver1 and Receiver2) have been moved from its Home Agents (HA1 and HA2 respectively) to Foreign Agent (FA). And at this time, the packets are delivered through an optimized route without passing through HA. In Remote-subscription, routing routes are maintained adequately and relatively

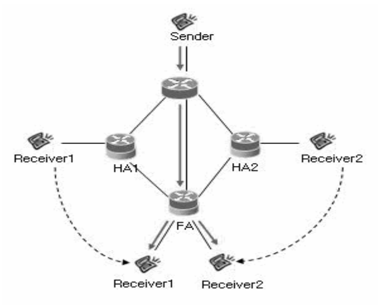

Fig. 1. Remote-subscription

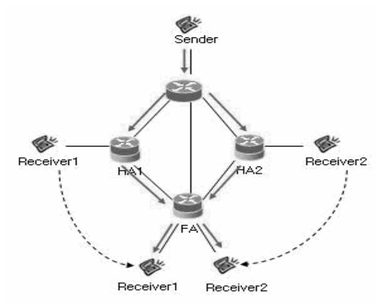

Fig. 2. Bi-directional Tunneling

simple. However, network load will be increased by multicast tree reconfigurations. Bi-directional tunneling is an HA-based multicast method. When MN moves to other access network, the moved MN will send and receive data by tunneling with HA. In case that MN on passage transmits data, MN will send data to HA by using its Home Address in Received Address Field (RAF) of IP header. The transmitted packets are delivered to multicast group members via a certain delivery route. In case that MN receives data, HA will capture multicast packets, which are on the way to MN, and capsulate it into unicast datagram, whose destination is MN's home address, to conduct tunneling to FA [5]. Figure 2 shows the route of data receiving when Receiver1 and Receiver2 is moving from HA1 and HA2 respectively into FA. As for this method, it is possible to send or receive data without any relationship with other group members and maintain compatibility to existing networks. However, the method has shortcomings of non-optimized delivery route and damaged resource integration effects resulted from unicast transmission when tunneling. XMIPv6 originated from MIPv6, has been proposed to provide multicast services. When MN moves to other access network area, MN transmits its data packets by tunneling with HA at first. MN, which has received multicast data, sends Binding Update (BU) message to other MN, which transmitted the data. Then MN, which received the message, comes to be able to communicate directly with multicast group members without passing through HA [6]. Even though this method is able to communicate through optimized route after BU, there are still unresolved problems that it is required to pass through HA at least one time and inefficiency caused by tunneling. Bi-directional tunneling and XMIPv6 are conventional multicast techniques which uses tunneling between HA and MN. Since these conventional techniques use unicast transmission, they decrease resource integration effect. For this reason, Remote-subscription method has been used in IP- based IMT network. In Remote-subscription method, however, overall multicast tree has to be reconfigured whenever sending node moves. Consequently, network traffic increases and problems of message loss are caused. To solve those problems, we propose a method of placing Multicast-manager in NCPF of IP-based IMT network. In the proposed method, Multicast-manager manages the information of sending/receiving nodes and conducts a series of procedures to improve the efficiency of resource.

3 A Proposal for IP-Based IMT Network Mobile Multicast

3.1 Group Member Management Using Multicast-Manager

In Remote-subscription method, the whole multicast tree has to be reconfigured whenever the sender, which offers multicast service, is moved. Therefore, there are some problems that network traffics are increased and some messages are lost during multicast tree reconfiguration. To resolve the problems, it is proposed to place a Multicast-manager in NCPF of IP-based IMT network. The Multicast-manager has information about sender and receiver, which belongs to Multicast Service Group (MSG), and IP host address (IPha) and IP routing address (IPra) are managed simultaneously to update IPra of MN after MN is moved. Therefore, the efficiency can be improved by changing the single route between sender and Multicast-manager only, not by changing the overall multicast tree of the network after sender, which transmits multicast data, is moved.

3.2 Multicast Operation

In this chapter, the roles of Multicast-manager are described using a designated example. It is assumed that there are one sender (S1) and three receivers (R1, R2, R3) in an arbitrary domain of IP-based IMT network and it is also supposed that any required procedures for multicast services can be conducted using Multicast-manager. Multicast service consists of the following four steps: (1) Initialization of multicast session, (2) Join of MN requiring multicast service, (3) Mobility support procedure when MN moves during multicast service, (4) Ending the multicast service.

3.3 Initialization of Multicast Session

As an example of generating a multicast session, Multicast-manager in NCPF is asked to make a new Multicast session when MN (S1) within the area of Base Station (BS1) wants to be a sender of multicast service. Figure 3 and 4 show the initialization procedure for multicast session by mobile node, S1, and the message flow. 1) S1 sends multicast session address M1 and new session message including IP host address of S1, HaS1, to Multicast-manager which is located in NCPF. 2) Multicast-manager receives IP routing address of S1, Ra1a, from RM. 3) Multicast-manager makes Multicast-manager table having multicast group ID, M1, and stores IPha of S1 (HaS1) and IPra of S1 (Ra1a) to the table. 4) Multicast-manager sends multicast group ID (M1) and IPha / IPra of S1 to AR1, to which S1 belongs. 5) AR1 makes Table for Multicast Sender (TMS) in cache and stores multicast group ID (M1), IPha of S1 (HaS1) and IPra of S1 (Ra1a) to the table. 6) AR1 sends reply message to S1. By this message, S1 is notified that Multicast-manager table is generated in Multicast-manager and a new multicast session is started.

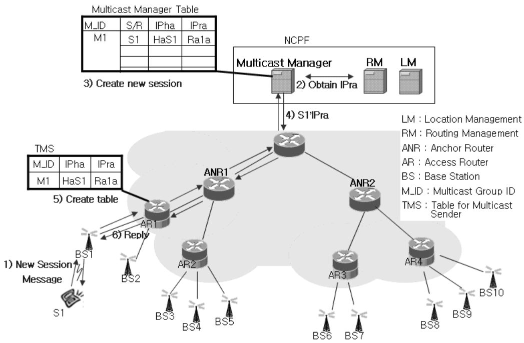

Fig. 3. Initialization of Multicast Session

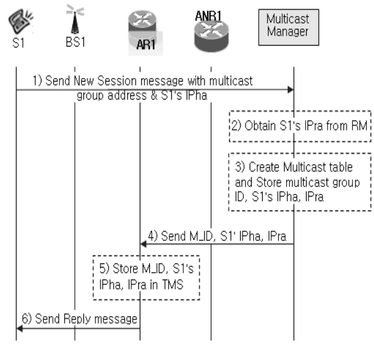

Fig. 4. Message Flow

3.4 Joining Multicast Session

Nodes who want to join with multicast session will go through the following procedures. It is supposed that Multicast-manager already has managing table (MMT : Multicast-manager Table) of M1 which is generated in the preceding procedure. Figure 5 and 6 show the procedure of MN, R1, joining multicast group, M1, and message flow between Multicast-manager and the other network elements. 1) R1 sends join query, which contains multicast group ID (M1), IP host address of R1, HaR1, to Multicast-manager. 2) Multicast-manager obtains IP routing address of R1, Ra2b, from RM. 3) Multicast-manager stores IPha

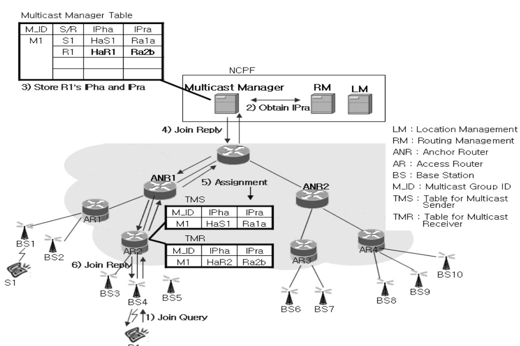

Fig. 5. Joining Multicast Session

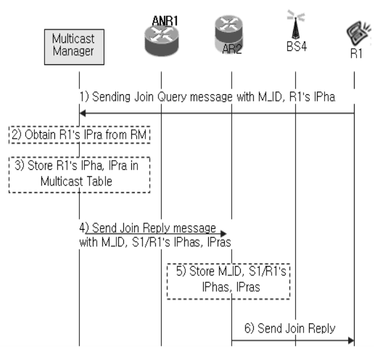

Fig. 6. Message Flow

and IPra of R1 (HaR1, Ra2b respectively) to Multicast-manager table having group ID, M1. 4) Multicast-manager sends M1, IPha and IPra of S1 and IPha and IPra of R1 to AR2, to which R1 belongs. 5) AR2 generates TMS and Table for Multicast Receiver (TMR) in its cache and stores the information about S1 and R1 (S1 / R1's group ID, IPha and IPra) to TMS and TMR respectively. 6) AR2 sends join reply message to R2 to notify it has been joined multicast group M1.

3.5 Mobility Support Procedure

Figure 7 and 8 show the procedure of updating the information of IPra of S1, which moved from BS1 to BS7 when sender of S1 and receivers of R1, R2 and R3 are within multicast group of M1. 1) S1 moves from BS1 to BS7. 2) After S1 receives advertisement message which is sent by BS7 periodically, S1 sends join query message, including multicast group ID of M1 and IP home address of S1, to Multicast-manager. 3) Multicast-manager obtains the new IP routing address of S1, Ra3b, from RM. 4) Multicast-manager updates IP routing address of S1 in Multicast-manager table having group ID of M1. 5) Multicast-manager sent the new IP routing address of S1 to AR1, to which S1 was belongs, and to ARs (AR1, AR2 and AR3) , to which members of group M belong. 6) ARs, to which members of group M belong, update IP routing address of TMS in their cache and delete TMS in their cache since AR1 does not has multicast member any longer. 7) After S1 moved, AR3, to which S1 is currently belong, sends join reply message to S1 and consequently S1 is notified that it has been joined multicast group M1 after its move. Figure 9 and 10 show message flow and the procedure of updating

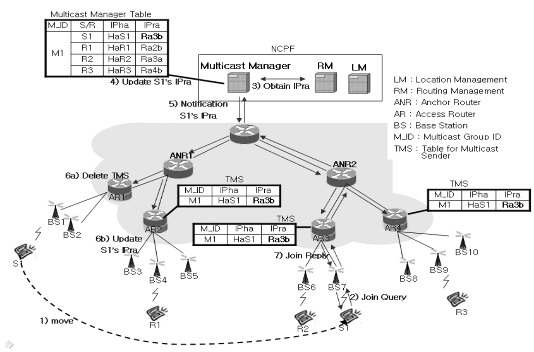

Fig. 7. Movement of Sender

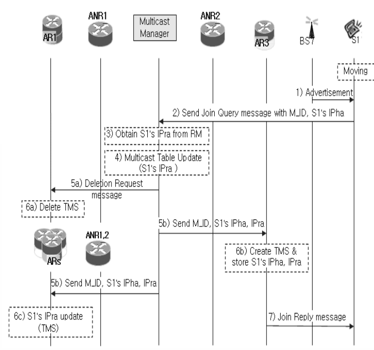

Fig. 8. Message Flow

the information of IPra of R1 in case that R1 moved into the area of BS8 on condition that sender S1 and receiver R1, R2 and R3 belong to multicast group M1. 1) R1 moves from BS4 to BS8. 2) R1 receives Advertisement message, which is periodically transmitted by BS8, and sends join query message, which includes multicast group ID M1 and IP home address of R1, to Multicast-manager. 3) Multicast-manager obtains Ra4a, the new IP routing address of R1, from RM.

4) Multicast-manager updates IP routing address of R1 in Multicast-manager table having group ID M1. 5) Multicast-manager sends old and new IP home address of R1 to AR2, to which mobile node R1 was previously belongs, and AR4, to which R1 is presently belongs, respectively. 6) AR4, to which R1 is presently belongs, stores IP home address and IP routing address of R1 to TMR in its cache and deletes TMR in its cache since AR2, to which R1 was belong, does not has multicast member any longer. 7) AR4, to which R1 is currently belong after its move, sends join reply message to R1. Therefore, R1 is notified that it has been joined multicast group M1 after its move.

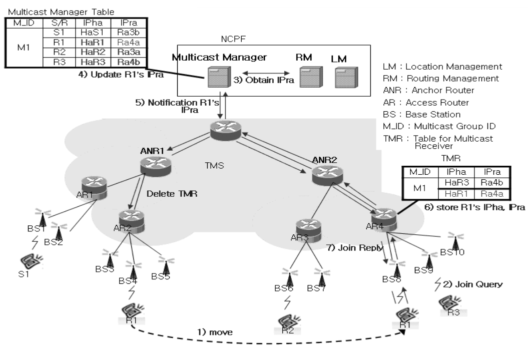

Fig. 9. Movement of Receiver

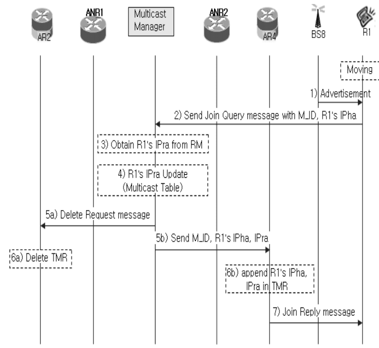

Fig. 10. Message Flow

3.6 Finishing Multicast Service

Figure 11 and 12 show the procedure of ending the service of multicast group M1 and message flow for finishing multicast service. 1) S1 sends termination message with multicast group ID M1 to Multicast-manager. 2) Multicast-manager deletes Multicast-manager table of group ID M1 from its date registry. 3) Multicast-manager sends termination message to AR1, AR2, AR3 and AR4, to which

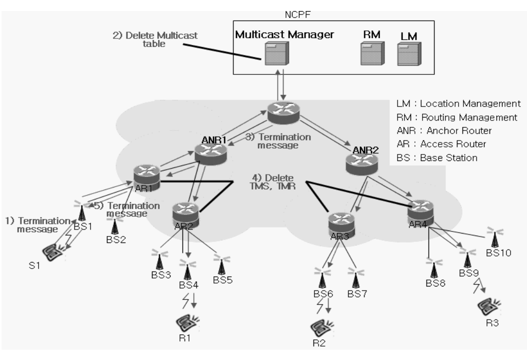

Fig. 11. Finishing Multicast Service

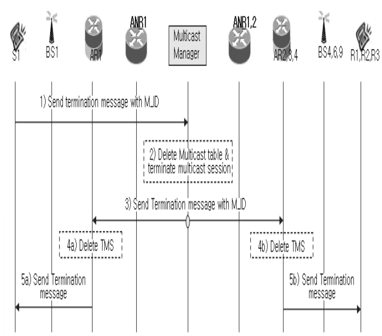

Fig. 12. Message Flow

members of M1 belong. 5) AR1, AR2, AR3 and AR4 sends Termination message to S1, R1, R2 and R3, which are members of AR1, AR2, AR3 and AR4 respectively. Therefore, all multicast group members is notified that multicast service has been finished.

4 Simulation

For the simulation for the proposed method of using Multicast-manager, topologies and simulation scenarios are organized using 2 anchor routers, 4 access routers and 10 base stations. Simulations of multicast tree reconfiguration are conducted by two parts: one part is a simulation after handoff of sender and the other is the one after handoff of receiver. For reliable test, performance analysis for each group member is conducted with 4 20 multicast group members on the assumption that mobile nodes are moving with constant velocity and a fixed direction.

4.1 Case of Sender's Mobility

Control traffic amount and delay of the network when mobile node S1 (sender) reconfigures multicast tree after handoff are measured. In figure 13 14, traffic and delay of Remote-subscription method is compared with those of the proposed method respectively. Table 1 shows the comparison result of delay and traffic, which is the number of signaling message in case of join query generation according to the number of groups. In addition, the relative performance

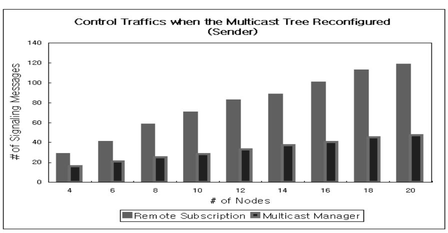

Fig. 13. Control Traffic (sender)

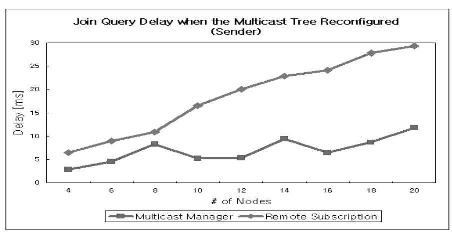

Fig. 14. Join Query Delay

Table 1. Network Traffic Increase and Delay (Sender) when Tree Reconfigured

Multicast Group members		4	6	8	10	12	14	16	18	20
Traffics	Remote-subscription	28	40	58	70	82	88	100	112	118
	Multicast-manager	16	21	25	28	33	37	40	45	47
	Improvement rate -MM	42.9	47.5	56.9	60	59.8	60	60	59.8	60.2
Delay (ms)	Remote-subscription	6.45	8.97	10.87	16.59	20.06	22.92	24.15	27.78	29.28
	Multicast-manager	2.87	4.53	8.26	5.21	5.34	9.42	6.43	8.70	11.76
	Improvement rate	55.5	49.5	24.1	68.6	73.3	58.9	73.4	68.7	59.8

improvement rate of the proposed method is also listed in the table. The proposed method showed average traffic reduction of 57.07

4.2 Case of Receiver's Mobility

Control traffic and delay of the network when mobile node R1 (receiver) reconfigures multicast tree after handoff are measured and shown in figure 15 16. Horizontal axis stands for the number of multicast group members and vertical axis for generated traffic in case of tree reconfiguration.

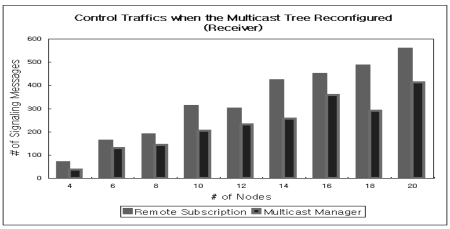

Fig. 15. Control Traffic (receiver)

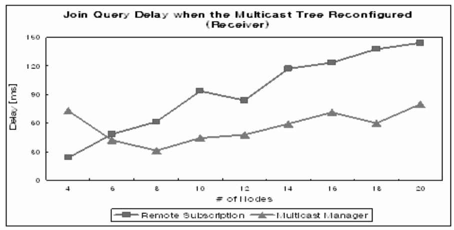

Fig. 16. Join Query Delay

Table 2. Network Traffic Increase and Delay (Reciever) when Tree Reconfigured

Multicast Group members		4	6	8	10	12	14	16	18	20
Traffics	Remote-subscription	68	162	188	310	298	422	448	484	556
	Multicast-manager	36	129	144	205	232	256	359	291	413
	Improvement rate -MM	47.1	20.4	23.4	33.9	22.1	39.3	19.9	39.9	25.7
Delay (ms)	Remote-subscription	23.75	48.37	61.32	93.79	83.99	117.0	123.4	138.0	144.3
	Multicast-manager	73.0	42.1	30.89	44.43	47.61	58.95	71.11	59.92	80.04
	Improvement rate	55.5	49.6	24.1	52.6	43.3	49.6	42.3	56.6	44.5

In figure 15, it is shown that, in case the number of multicast group member is 5, Sender and Receiver come closer each other and traffic of Remote-subscription method is smaller. As the number of multicast group member is increased, however, control traffic and delay of the proposed method, which uses Multicast-manager, is significantly reduced compared with Remote-subscription method. Table 2 shows that, in case of the proposed method, the average reduction of control traffic and delay are 30.2.

5 Conclusion

In this paper, a method for implementing multicast in IP-based IMT network by placing Multicast-manager in NCPF was proposed. In conventional mobile multicast method, there are problems that transmission route is not optimized when sender moves and overall multicast tree has to be reconfigured whenever sender moves. With the proposed method, however, network load resulted from tree reconfiguration can be reduced by placing Multicast-manager in NCPF to manage MN's moves and consequently to reconfigure the route between sender and Multicast-manager only, not reconfiguring the overall multicast tree. Simulation results show that, when Sender moves, the average control traffic and delay of the proposed method are reduced by 57.07 For future works, a study on techniques to guarantee unique of multicast group ID, in case that sender's transmits new session message to Multicast-manager, has been underway.

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