A Dynamic Service Range-Based Multicast Routing Scheme Using RSVP in Mobile IP Networks

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Abstract - **In this paper, we propose a multicast routing scheme for an efficient and reliable support of multicast service to mobile hosts in IPv6 based networks. The purpose of this paper is to develop an algorithm to reduce both the number of multicast tree reconstruction and the multicast service disruption time. The proposed multicast routing scheme is a hybrid method using the advantages of the bi-directional tunneling and the remote subscription proposed by the IETF Mobile IP working group. The proposed scheme satisfies the maximum tolerable transfer delay time and supports the maximum tunneling service. The simulation results show that the proposed scheme has better performance in the number of multicast tree reconstruction and the time of multicast service disruption than the previous schemes does.**

I. INTRODUCTION

The recent exponential growth of internet user and rapid progress in hardware technology have led to the internet user's mobility and a large variety of multimedia services. In particular the widespread demand of various multicast service such as video-conferencing or VOD service is an important issue with the growth of wireless internet services [1],[2]. The well-known mobile multicast schemes are the remote subscription[3] scheme and the bi-directional tunneling[3] scheme, both of which are proposed to support the mobile multicast in the recent version of IETF Mobile IP Working Group. The remote subscription scheme, whenever a mobile host moves new foreign network, always resubscribe to its desired multicast groups. This scheme is simple and has the advantage of delivering the multicast data on the shortest paths from source to receivers. However a frequent handoff brings about the overhead of reconstructing multicast tree since the number of multicast tree reconstruction is dependent on the frequency of handoff of mobile hosts. In bi-directional tunneling scheme, mobile hosts send and receive all multicast data using the unicast Mobile IP tunneling service from their home agent (HA). This scheme does not reconstruct multicast tree and so reduces the cost of multicast tree reconstruction. However the scheme has the long routing path and the tunnel convergence problem. To solve the tunnel convergence problem of bi-directional tunneling, the MoM[4] scheme uses the Designated Multicast Service Provider (DMSP) and avoids duplicate data being tunneled to the common foreign agent (FA). This scheme has the advantage of reducing the multicast traffic. However, as the number of handoff of mobile hosts is increased, this scheme requires frequent DMSP's handoff and registers process and has the problem of long routing path. The RBMoM[5] scheme is a hybrid scheme of the remote subscription and the bi-directional tunneling. This scheme reduces the cost of tunneling by employing the idea of the *service range* and *Multicast Home Agent* (MHA). But this scheme does not provide a certain criterion for determining an optimal service range. In addition, when a mobile host moves to foreign network out of a service range that does not join a multicast group, the service disruption time is occurred.

To solve the problems of the RBMoM scheme, we propose a multicast routing scheme to reduce the number of multicast tree reconstruction and the service disruption time. The proposed scheme joins the neighboring foreign agents to multicast group in advance before a mobile host is out of the service range and moves to the foreign network. The rest of the paper is organized as follows. The proposed multicast routing scheme is described in Section II. The performance comparisons of proposed scheme with the other schemes are presented in Section III. Finally the concluding remarks are included in Section IV.

II. THE PROPOSED MULTICAST ROUTING SCHEME

A. Basic concepts

Service range is a very important parameter for the performance of the RBMoM scheme since if the service range is a big value, the routing path becomes long like the bi-directional tunneling and for a small service range, the number of multicast tree reconstruction is increased like the remote subscription because every MHA has the same service range. The RBMoM scheme decides the value of *service range* simply according to the handoff rates of mobile hosts and the number of multicast group members. However, the above two measures cannot be a criterion to determine an optimal value of the service range since they change

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dynamically in real circumstances. In this paper, we define a special system parameter called *dynamic service range* as the maximum tunneling path length satisfying with the maximum tolerable transfer delay time. Each MHA has its own value of *dynamic service range.* The *dynamic service range* defined in this paper is determined to satisfy the QoS requirements within the maximum allowed transfer delay time. The MHA has the optimal tunneling length in terms of its *dynamic service range* and thus the number of multicast tree reconstruction is greatly reduced.

Another problem of the RBMoM is the service disruption time that occurs when a mobile host moves away out of the present service range and moves to another foreign network. In this case if the foreign network is not a member of the present multicast group, the service disruption time corresponding the amount of time required to join the present multicast group occurs. To solve this problem we employ the RSVP mechanism[6],[7]. We define a new terminology called *boundary foreign agent* (BFA) in this paper. The BFA is a foreign agent that is located at the distance equal to the *dynamic service range* away from MHA. If a mobile host moves to the BFA, the neighboring foreign agents join the multicast group in advance using the RSVP scheme to reduce the multicast service disruption time.

B. Dynamic service range

The proposed multicast routing scheme determines the tunneling path length according to the parameter of *dynamic service range*. So the method determining the value of *dynamic service range* is an important key in this paper. When the multicast tree is set up, each MHA determines the value of *dynamic service range*. An impact factor for determining the value of *dynamic service range* is the maximum tolerable transfer delay time. To guarantee the required transfer delay time, the total multicast data transmission delay time must not exceed the required transfer delay time. Then the value of *dynamic service range* at each MHA must satisfy (1).

$$\text{dynamic service range} \leq \frac{T_{TD} - TD_{S\text{-}MHA} - TD_{TUNNEL}}{TD_{LINK}} \quad (1)$$

where T_{TD} and $TD_{S\text{-}MHA}$ are the maximum tolerable transfer delay time and the multicast data transmission delay time from source to MHA, respectively and TD_{TUNNEL} and TD_{LINK} the processing delay time to tunnel a data packet at MHA and packet transmission delay time between a link. We can see that if the value of $TD_{S\text{-}MHA}$ is larger than or equal to the value of T_{TD}, then the value of *dynamic service range* of MHA is zero. The value of *dynamic service range* of MHA closer to multicast source is larger than that of MHA far away from multicast source, resulting in having the larger tunneling service range. The proposed scheme satisfies the maximum tolerable transfer delay time and the maximum tunneling service range. The *dynamic service range* of proposed multicast routing scheme is represented in Fig. 1.

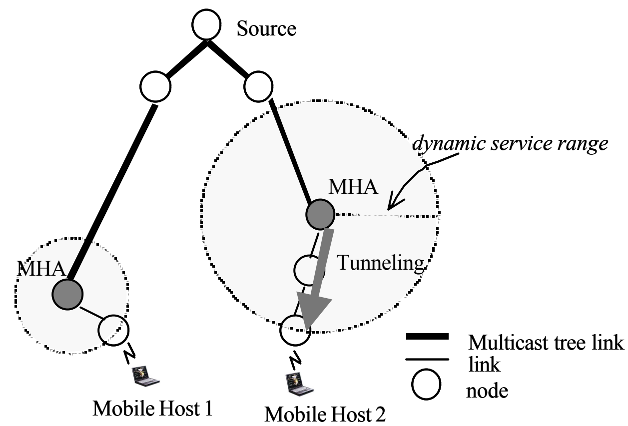

Fig. 1. The dynamic service range of the proposed scheme

C. RSVP Mechanism

When a mobile host moves to the foreign network that does not join the multicast group, the service disruption time is occurred to the mobile host. The service disruption time can be given by (2).

$$T_{SD} = H_{JOIN} \times (2 \times TD_{LINK} + TD_{GROUP}) + TD_{GROUP} + TD_{REG} \quad (2)$$

where T_{SD} and H_{JOIN} are the service disruption time and the hop count for joining to the multicast group, respectively and TD_{GROUP} and TD_{REG} the delay time relevant for joining to the multicast group at agent and delay time which moving MH is registered at MHA. According to network size and handoff rate of mobile hosts, the service disruption time is frequently long[6]. If network size is large and the number of handoff of mobile hosts is increased, the service disruption time is long and the loss rate of multicast packet is increased. So the service disruption time becomes a disastrous problem to mobile hosts. To solve this problem, in this algorithm, neighboring foreign agents join the multicast group in advance using RSVP mechanism, when the mobile host moves to a BFA.

For this purpose, we use signaling messages defined in RSVP mechanism and new messages are defined below.

- Join_multicast_group : This message is sent by a mobile host to its neighboring foreign agents to request them to join a multicast group. It contains the multicast address of the group to join.
- Pre_join : The neighboring FAs which received a Join_multicast_group message sends this message to join a multicast group.
- Release_join : This message releases a reserved multicast link.

We assume that a mobile host in BFA can send the message, Join_multicast_group, to neighboring foreign agents. The operation for joining the neighboring foreign agents to multicast group is represented in Fig. 2.

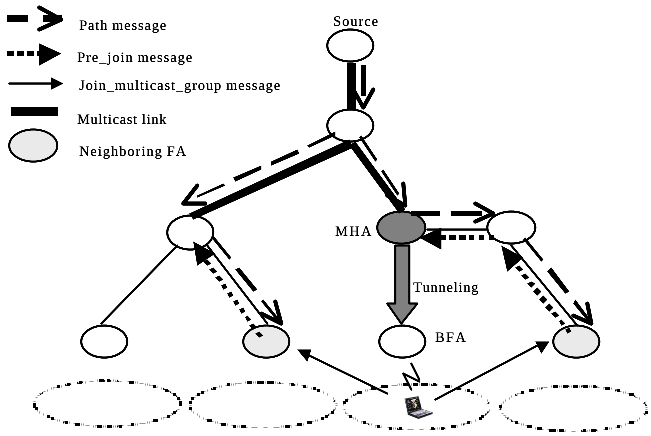

Fig. 2. The operation for joining the neighboring foreign agents to multicast group

III. Performance Evaluation

A. Simulation model

To evaluate our proposed scheme, we use a discrete-event simulation language SIMSCRIPT II.5. We assume that network topology is 25 LANs(5 ×5 mesh network). The initial multicast tree is established for a randomly selected set of network nodes. We randomly determine the number of mobile hosts from 10 to 100, which are initially placed on 25 local networks and are roaming across the network node during the simulation time. The initial MHA of a mobile host is set to be its HA. The handoff number of mobile hosts varies from 1 to 15. Only one multicast group and one multicast source that is static node are assumed in this simulation. Table 1 summarizes the parameters used in our simulation model where TD_{LINK}, TD_{GROUP}, TD_{TUNNEL} and TD_{REG} are those referred to the previous study[8].

TABLE I
SIMULATION PARAMETERS

Parameters	Description	Value
N	Number of LANs	25 (5×5)
M	Number of multicast group	1
g	Number of multicast members	10…100
S	Sources per multicast group	1
h	Average number of handoff of multicast group member	1…15
D	Delay path length (delay hop count)	8
μ	Average service time	3 min
d	Direction probability	1/4
TD_{LINK}	Packet delivery time (packet propagation delay plus routing delay between one hop)	3.5 msec
TD_{GROUP}	Delay time which the router joins multicast group	10 msec
TD_{TUNNEL}	Protocol processing time to tunnel a data packet	7 msec
TD_{REG}	Delay time which moving MH is registered at MHA	3 msec

B. The evaluation of simulation results

The proposed scheme is compared with the remote subscription, the bi-directional tunneling and the RBMoM scheme by changing the number of handoff of mobile hosts and the number of multicast group member. The main features considered are the number of multicast tree reconstruction, the average service disruption time per a mobile host and the average delivery path length per a mobile host. The simulation results are shown from Fig. 3 to Fig. 7.

The delay hop count means the maximum tolerable transfer delay time, T_{TD}. The value of *dynamic service range* at each MHA is calculated by (1). If the value of $TD_{S\text{-}MHA}$ is larger than that of T_{TD} , the value of *dynamic service range* at MHA is zero.

Fig. 3 and 4 show the number of multicast tree reconstruction when the number of multicast group member is 10 and 50. The remote subscription scheme has the worst performance because it always resubscribes to its desired multicast groups whenever a mobile host moves to new foreign network. The RBMoM scheme shows better performance than the remote subscription scheme. However, the performance of this scheme is dependent on the value of *service range* because every MHA has the same value of *service range*. The bi-directional tunneling scheme is excluded from this simulation because this scheme does not reconstruct multicast tree. The proposed scheme reduces the number of multicast tree reconstruction than the other schemes and is suitable for dynamic network because it shows a stable result regardless of handoff rate.

Fig 5 and 6 show the average service disruption time when the number of multicast group member is 10 and 50. The remote subscription scheme has the worst performance since the service disruption time occurs whenever a mobile host moves to new foreign network. The RBMoM scheme shows that the service disruption time occurs when a mobile host is out of *service range* of its MHA and the average service disruption time increase as handoff rate of mobile hosts is going up. The proposed scheme has better performance when the multicast group member is 10 than 50.

Fig. 7 shows the average delivery path length per a mobile host when the average number of handoff of a mobile host is 5. The remote subscription scheme has the optimal delivery path length since each delivery path is always shortest. The bi-directional tunneling scheme is no limit for the tunneling path and has the worst delivery path length among other schemes. This figure shows that the RBMoM scheme has less delivery path length than the bi-directional tunneling scheme. The proposed scheme is not optimal but has the similar performance to the RBMoM scheme.

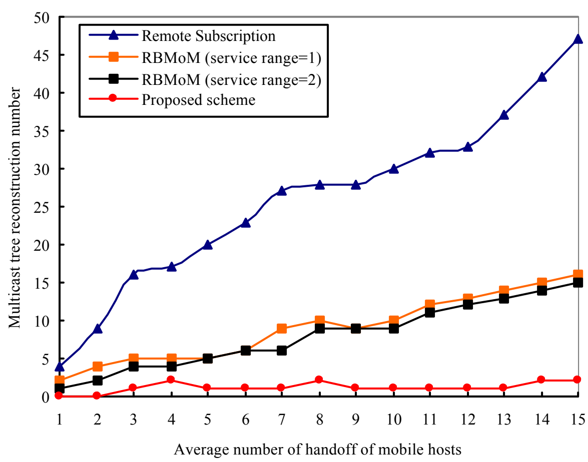

Fig. 3. The number of multicast tree reconstruction (multicast group member = 10)

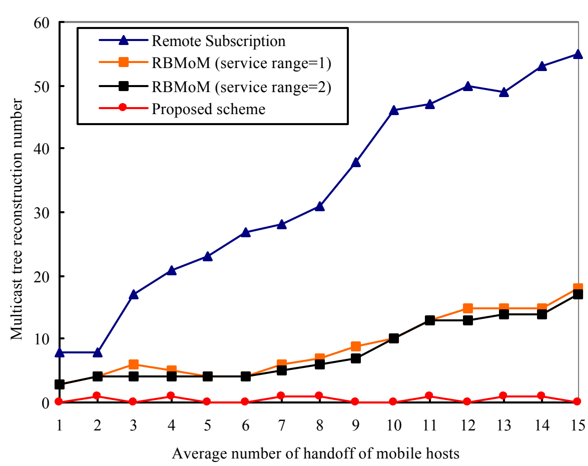

Fig. 4. The number of multicast tree reconstruction (multicast group member = 50)

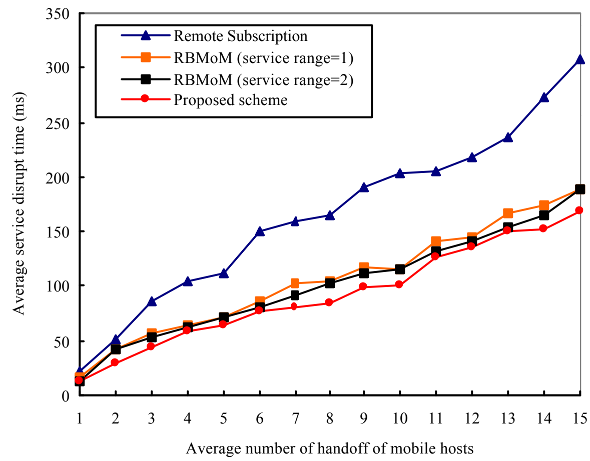

Fig. 5. The average service disruption time (multicast group member = 10)

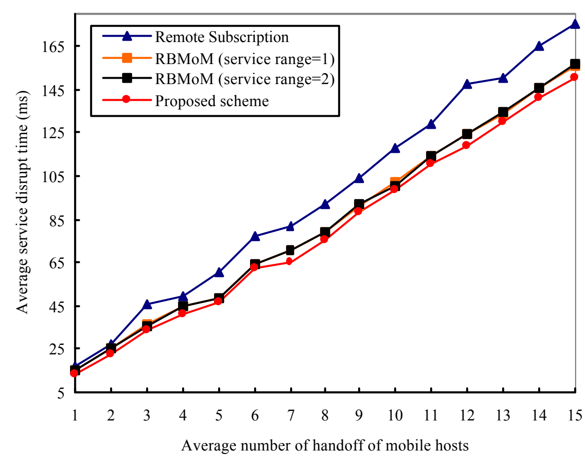

Fig. 6. The average service disruption time (multicast group member = 50)

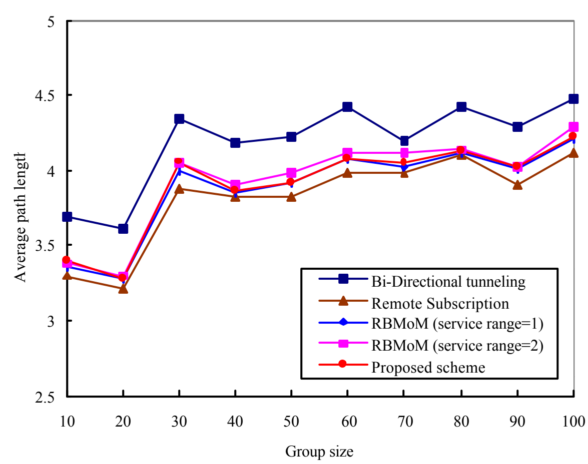

Fig. 7. The average delivery path length (The average number of handoff of mobile hosts = 5)

IV. CONCLUSIONS

In this paper, we propose a reliable multicast routing scheme to reduce the number of tree reconstruction and the service disruption time in IPv6 based network. For this purpose, we define a system parameter called *dynamic service range* and employ the RSVP mechanism. The proposed scheme satisfies the maximum tolerable transfer delay time and gets the maximum tunneling service from the MHA. The number of multicast tree reconstruction is much reduced than the previous schemes. In our proposed scheme, when a mobile host is out of *dynamic service range* of its MHA and moves to a new foreign network, the neighboring foreign agents join to the multicast group in advance using the RSVP mechanism. In this way, the multicast service disruption time appeared during the handoff of a mobile host is much decreased. Our simulation results demonstrate that the performances of the proposed scheme are improved over the existing solutions in terms of the number of multicast tree reconstruction and the time of multicast service disruption.

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