Sensors & Transducers, Vol. 167, Issue 3, March 2014, pp. 170-174

Sensors & Transducers

Reliable Mobile IP Multicast Based on Hierarchical Local Registration

Huanming ZHANG, * Quanlong GUAN, Zi Zhao ZHU, Weiqi LUO
Network and Education Technology Center, Jinan University, Guangzhou, Guangdong, China
* E-mail: gql.jnu@gmail.com

Received: 7 March 2014 Accepted: 29 March 2014 Published: 31 March 2014

Abstract: In a mobile wireless networks, mobile link transmission is unreliable, the packets are easily lost, and the mobility of nodes may cause asynchronous problem. In order to resolve the problems of multicast reliability in wireless networks, a framework architecture of the mobile IP multicast is proposed, which is a reliable multicast architecture based on hierarchical local registration. Hierarchical management is taken use to shield the movements of mobile nodes in the domain. As a surprising result of that, the stability of multicast forwarding trees is improved. Besides, the switching delay and the resulting packets loss are reduced. A multicast information exchange center is set in the root node. The arrived multicast data is cached in the center until it is received by all mobile nodes in the domain. When any exchanges occur in nodes, the retransmission message is sent to the exchange center to retransmit the lost packets. In that case, the synchronization problem can be solved, and reliable multicast services for mobile nodes are provided. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Mobile IP, Multicast, Hierarchical architecture, Hierarchical local registration, Wireless network.

1. Introduction

There are a lot of new challenges in providing mobile IP multicast services for mobile nodes. In multicasting, the mobility of a sender may lead to serious problems. When the sender moves, the full delivery tree may fail so that multicast datagrams cannot be forwarded to all receivers [10]. Therefore, we should not only deal with dynamic group membership, but also maintain the group membership and multicast propagation trees when the nodes switch to a new network. The maintenance and adjustment of multicast trees will bring excessive processing costs and network loads. Therefore, when the adjustment process runs, long switching delays and data loss problems may occur. The applied multicast protocols only consider the static group members at present. Thus they are not well adapted to the mobile environment.

IETF (Internet Engineering Task Force) defines two basic multicast methods in Mobile IP [2]: Bi-directional Tunnel and Remote Subscription. In the Bi-directional Tunnel algorithm, mobile nodes join and exit multicast groups through bi-directional tunnels established between the mobile nodes and their home, then they send and receive multicast data packets through the tunnels. If the node is far away from the home network, multicast data packets have to be forwarded and received through the remote home agent. This algorithm is free from packet losses due to roaming [11]. However, it suffers from large link costs and inefficient routing. Remote Subscription algorithm can present the characteristic of sharing links which is promoted by IP multicast, in order to make better use of advantages of multicast. When the mobile nodes change their network location every time, they re-join the multicast group and re-adjust the corresponding multicast trees. Even in the foreign network, mobile nodes use the same method of multicast applications as static nodes. However, the moving and switching of nodes will lead to frequent reconstruction of multicast trees, and the large maintenance costs of multicast trees will be a waste of bandwidth. Therefore, there are still many problems in the two basic multicast methods. They can not be well applied in mobile environment at present.

Since IP multicast employs a one-to-many communication model, it does not use the reliable and inherent End-to-End transmission mechanism applied in TCP. IP multicast packets use UDP (User Datagram Protocol) mechanism, which is a best-effort protocol. It means in the communication process, IP multicast data may be delayed, repeated, scrambled, and lost. Therefore the reliable multicast is still an area to be studied.

The problems existed in IP multicast can be summed up in four aspects: switching delay, multicast costs, packets loss and routing efficiency. Several researchers have proposes some good methods about IP protocol analysis [6, 9]. This paper proposes a kind of framework architecture of applied IP multicast in mobile environment, which is called LR-RHMM (local registration based reliable hierarchical mobile multicast architecture). LR-RHMM can effectively reduce the multicast costs caused by switching, and provide reliable multicast for the switching nodes.

2. LR-RHMM Architecture

2.1. LR-RHMM Network Model

On purpose of reduce the adverse effects brought by moving of the nodes, LR-RHMM manages mobile multicast with hierarchical structure (Fig. 1). The introduction of hierarchical mobility management can shield the mobility of nodes to the external and share the mobility of nodes with the main multicast forwarding trees. Since the network is constituted by different sizes of domains, a number of physical adjacent wireless cellular subnets are organized to form a certain domain by LR-RHMM. There is a DIR (Domain Internal Router) in each domain, which is responsible for forwarding multicast data in this region. In the root node of each region is a MISC (Multicast Information Switching Center). The MISC is located in the first layer of the whole tree structure, taking responsibility for the mobile multicast management in its jurisdiction, data transmission, and creation and maintenance of multicast trees. As the bottom leaf nodes, home agents (HA) and foreign agents (FA) take charge of the information transmission directly with mobile hosts.

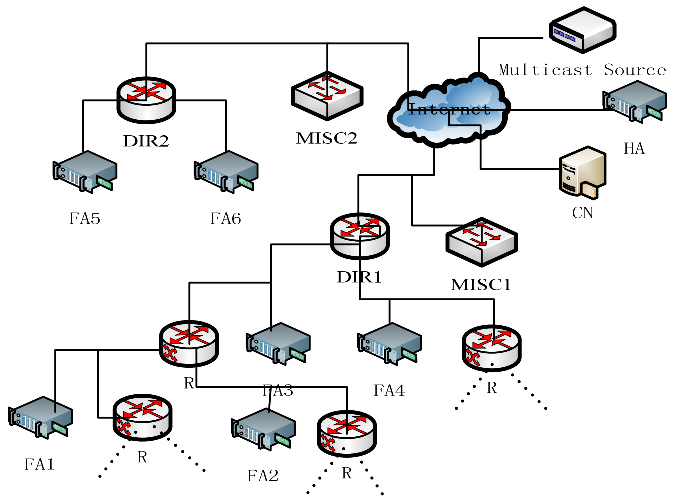

Fig. 1. LR-RHMM network structure.

2.2. MN Joined in the Multicast Group

MN sends a MLD (multicast listener discovery) [3] message to FA, requesting to join the multicast group (G, *), Fig. 2. First FA1 queries in the " corresponding table of the domain multicast group ", which is also known as DTMG table (domain translate multicast group table). If FA1 finds some table entries relative to (G, *), MN will be added to the group members list. If FA1 can't find any relevant group information in DTMG table, then FA1 forwards MLD to FA3 which is at a higher level in order to inquire DTMG table. If some table entries relative to (G, *) are found in FA3, FA1 directly adds to the (G, *) group members list of FA3. In that case, FA1 receives group messages on behalf of MN, and then forwards them to MN. If no relevant table entries are found in DTMG table in FA3, then FA3 sends a new message, which is called DIR_Req message, forwarding the request to DIR. Received the DIR_Req message, DIR establishes the transmission path with the multicast group source. That is, DIR adds to the multicast group (G, *), and establishes a multicast message transmission path from MN to DIR and then to the multicast source.

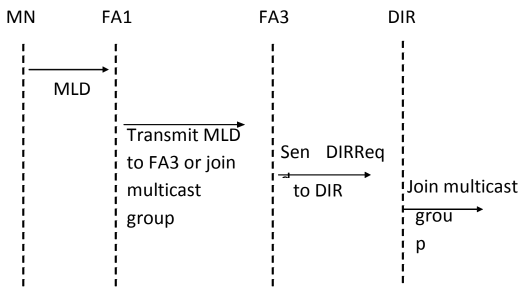

Fig. 2. MN Join multicast group procedure: reliable Multicast Data transmission

There is a table in DIR to record the next level of FA which the subscribed multicast group data belongs to. Received the multicast data, DIR queries in the local data tables, and then forwards the data packets to the next level of corresponding FA. DIR repeats these steps in each FA layer until the lowest level of FA receives the subscribed multicast data.

As the error rate of data packets transmission is relatively high in wireless links, in order to receive reliable multicast group data, DIR needs to backup the received multicast data. It would not delete the corresponding backup until all ACK messages of group members are received. After a mobile node receives a multicast message each time, it will send an ACK message to the FA which provides services. When any mobile nodes detect an error (such as packets loss and wrong serial number), the strategy is select repeat. That is, the received wrong message (for instance, the multicast group ID is wrong) would be abandoned. However the subsequent arrived messages of multicast group are the right messages without sequential order. The receiver caches the subsequent message and sends an NAK (negative acknowledgement) to FA. Then FA forwards the NAK to DIR. The NAK can intrigue the retransmission action without waiting for the corresponding confirmation timer to expire. Therefore the NAK can improve performance. As the following Fig. 3, the messages with sequence number 1, 2, 3, 4 are correctly received, and Ack1, Ack2, Ack3, Ack4 are sent to FA. FA establishes a confirmation table list of Ack table for each confirmed message. The table records serial numbers of the received messages and the group members those receive the messages correctly. FA also establishes a table list of NAK. The table records the negative record of confirmation serial numbers, which means that the messages of those numbers have not been confirmed. The message with serial number 5 means it isn't correctly received. When NAK5 is sent to FA, NAK messages list table in FA records the negative confirmation serial number. Then FA forwards the NAK5 to DIR, requiring DIR to retransmit the lost message. If the retransmitted multicast message reaches another FA, it will be discarded.

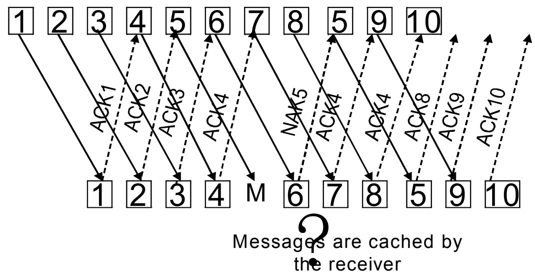

Fig. 3. Reliable multicast data buffer transmission Figure.

FA establishes a list of confirmation messages for each confirmed group, which records the serial numbers of confirmed messages and the group members who received the messages. FA can generate aggregated ACK messages [4] to DIR according to the case of confirming. Then DIR can understand the receiving state of MN and delete the corresponding backup.

2.4. The Switching Management of MN

If the group members of mobile multicast reach a new foreign link which already has some members of that multicast group, it only needs to notify the multicast router in that subnet when switching. So rapidly switching can be done. That means, the only thing need to do is re-joining the multicast group directly without recalculating the multicast forwarding tree. However, each subnet receives multicast messages with different time delay due to the dynamic network. As a result of that, "out-of-synch Problem" [5] happens uniquely in mobile network. That is to say, Multicast messages may be lost when the mobile node switches. As the Fig. 4 shows, subnet 1 receives the multicast message with serial number 3, and at the same time subnet 2 receives multicast message with serial number 7. When the mobile node moves from subnet 1 to subnet 2, it will miss the multicast messages with serial number 4, 5, 6, even if the switching delay is neglected.

As shown in Fig. 2, MN roams in the domain from FA1 to FA2. MN sends a local registration request packet to FA3, which is the common ancestor of FA2 with the current provision of services for MN and FA1 with previous provision of services for MN. Multicast transmission path from FA3 to current FA2 is established in the data table in FA3 without modifying the transmission path from the common ancestor FA3 to DIR. As a result, the multicast propagation tree would not be greatly affected. According to the binding information recorded in the multicast message, DIR forwards the received multicast message to the foreign agent of the node. Suppose there is another group member receiving data in the current network. MN receives multicast message with serial number 3 in FA1 while receives multicast message with serial number 7 in FA2 due to the switching delay. Therefore, MN has to send NAK4, NAK5 and NAK6 to FA2. Then FA2 forwards them to DIR, requesting DIR to retransmit multicast messages with SEQ = 4, SEQ = 5, SEQ = 6 to FA2. Next, DIR sent them to MN. As those steps, the switching of MN would not make any packets loss. If there are not any other group members receiving the multicast group messages in the current network, then the multicast packets data transmission path is established to FA2 directly.

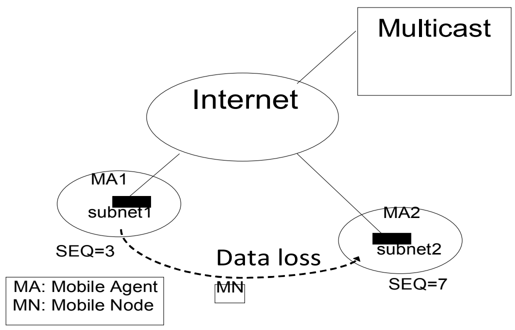

Fig. 4. The Switching Management of MN.

When the mobile node MN roams in the domain, it sends the subscription request MLD message immediately to the new foreign agent FA in order to inquire its group members list. If there have been other group members in the new subnet receiving the data of this multicast group, MN can regain the reception of multicast data rapidly. Since the missing data exists in the previous DIR, the mobile node has to establish a Bi-directional Tunnel transmission path with the previous DIR. DIR sends messages lost by mobile nodes through the tunnel to the mobile node. If the mobile node can receive multicast data through the current network, the node requests the previous router in the domain to remove the established Bi-directional Tunnel in order to stop forwarding multicast data.

2.5. Data Structure

For the sake of realizing domain multicast routing, there is a MISC data structure table used to transmit multicast information in MISC, which takes the responsibility for domain multicast management and multicast information transmission center; there are FA data structure tables in foreign agents taking charge of providing roaming services for mobile nodes. As shown in Fig. 5.

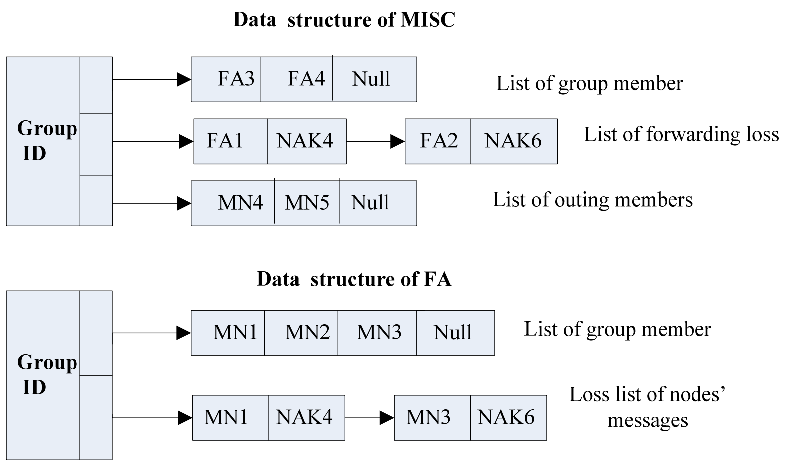

Fig. 5. Data structure of MISC and FA.

Multicast group ID is mainly used in inquiring mobile nodes, joining multicast groups and leaving multicast groups. MISC is in charge of maintaining a list of group members, a list of forwarding loss and a list of outing members. A list of group members records serial numbers of the foreign agents receiving multicast data. A list of forwarding loss records those FA which need to receive missing messages and their serial numbers from DIR. Outing members lists record mobile nodes those need reliable multicast services provided by DIR, though these mobile nodes have been removed out of the current domain. MN also depends on the previous DIR to forward the lost messages. MISC could judge which message has be received by all the group members in the domain according to the forwarding loss lists, so the corresponding backup in storage area can be deleted.

FA maintains a list of group members and a loss list of nodes' messages. The list of group members records the mobile nodes those are receiving multicast group data. The loss list of nodes' messages records the lost messages by MN and the serial numbers of retransmissions requested. When FA receives the retransmitted group, FA sends it to the corresponding MN according to the nodes messages loss lists. If the missing message is received and confirmed correctly by MN, the serial number can be deleted.

3. Conclusions and Further Work

LR-RHMM proposed in this paper is a kind of comprehensive solution architecture for mobile multicast. It gives great solutions in three aspects: multicast costs, routing efficiency, switching delay and loss rate. The performance analysis shows that LR-RHMM has advantages in less multicast costs and high multicast packet delivery efficiency. This proved LR-RHMM is a highly efficient mobile multicast solution. The next work is specific performance analysis and simulation with LR-RHMM architecture.

4. Acknowledgment

This work was supported by Major Program of National Natural Science Foundation of China (No. 61133014, No. 61272415, No. 61272413), the CEEUSRO project of Guangdong province, China (No. 2012A080102007, No. 2011B090400324, No. 2010A011200038, No. 2012B040305008), Science and Technology Planning Project of Guangzhou city (No.11A12070544, No. 2013Y2-00071), the Project for Engineering Research Center of Guangdong Province (No. GCZX-A1103), and the Fundamental Research Funds for the Central Universities (No. 21613336, No. 21613415).

References

[1]. Romdhani I., Kellil M., Lach H. Y., IP mobile multicast: Challenges and solutions, *IEEE Communications Survey &Tutorials,* 6, 1, 2004, pp. 18-41.

[2]. Charles P., IP Mobility Support, RFC-2002, *Mobile IP Working Group*, October 1996.

[3]. Vida R., Costa L., Multicast listener discovery version 2 (MLDv2) for Ipv6, *RFC*, 3810, 2004.

[4]. Omar H, Saadawi T, Lee M., An Integrated Platform for Reliable Multicast Support in the Regional Mobile-IP Environment, *Mobile Computing and Communications Review*, 6, 2, 2003, pp. 37-54.

[5]. Lai J., Liao W., Mobile Multicast with Routing Optimization for Recipient Mobility, *IEEE Transactions on Consumer Electronics*, 47, 1, 2001, pp. 199-206.

[6]. Guan Quan-long, Ye Saizhi, Yao Guo-xiang, Research and design of internet public opinion analysis system, *SSME,* 2009, pp. 173-177.

[7]. Harrison T. G., Williamson C. L., Mackrell W. L., Mobile multicast (MoM) protocol: Multicast support for mobile hosts, *Proceedings of the 3rd Annual ACM/IEEE International Conference on Mobile Computing and Networking (ACM MOBICOM)*, Budapest, 1997, pp. 151-160.

[8]. Ye Min-hua, Liu Yu, Zhang Hui-min, The Implementation of Multicast in Mobile IP, *Journal of Beijing University of Posts and Telecommunications*, 2004, Vol. 27, 3, pp. 78-82.

[9]. Yao, Guo-Xiang, Guan, Quan-Long, et al., Research and implementation of next generation network intrusion detection system based on protocol analysis, *CCCM,* 2008, pp. 353-357.

[10]. Chang, R. S., Yen, Y. S., Multicast routing protocol with dynamic tree adjustment for mobile IPv6, *Journal of Information Science and Engineering*, 2004, Vol. 20, 6, pp. 1109-1124.

[11]. Choo Y. Y., Huh, Y., Kim, C., Efficient multicast support exploiting mobility of hosts, *IEICE Transactions on Communications,* 2002, Vol. E85B, 6, pp. 1213-1217.