A Context Transfer Approach to Enhance Mobile Multicast

AISHA-HASSAN A. HASHIM aisha@iiu.edu.my
Faculty of Engineering/ Electrical and Computer Department
International Islamic University Malaysia
Kuala Lumpur, 53100, Malaysia

ABDI NASIR AHMED abdinaser_10@hotmail.com
Faculty of Engineering/ Electrical and Computer Department
International Islamic University Malaysia
Kuala Lumpur, 53100, Malaysia

ABDULRHMAN BIN MAHFOUZ abdulrhman_bm@hotmail.com
Faculty of Engineering/ Electrical and Computer Department
International Islamic University Malaysia
Kuala Lumpur, 53100, Malaysia

Sheroz Khan sheroz@iiu.edu.my
Faculty of engineering/ Electrical and Computer Department
International Islamic University Malaysia
Kuala Lumpur, 53100, Malaysia

Abstract

With the advent of the handheld devices and multimedia applications, there has been an increasing interest for mobile multicast. IETF proposes two approaches. The first approach is Bi-directional Tunneling (BT), where the mobile node subscribes to a multicast group through its home network. The second approach is Remote Subscription (RS), where the mobile node joins the multicast group via a local multicast router on the foreign link being visited. However, in BT approach the home agent is typical far and this will lead to high signaling cost at the same time the home agent represents a single point of failure and introduces scalability issues. RS approach suffers mainly from frequent tree reconstruction. The main aim for this paper is to propose a new mobile multicast approach to reduce the signaling cost and reduce the packet loss especially in case of macromibiliy. The proposed solution integrates Hierarchical Mobile IPv6 with Mobile context transfer. This paper presents and evaluates the proposed solution. Our results shows that compared to BT approach, the proposed solution gives lower signaling cost.

Keywords: context transfer, Hierarchical Mobile IPv6, multicast, signaling cost.

1. INTRODUCTION

Nowadays, the trend of using wireless devices has increased, due to development of the wireless evolutionary systems [1] and the high demand for the Internet. Therefore, offering a large range of wireless mobile services to highly heterogeneous users for a highly effective handover becomes very crucial. However, it is a challenging issue to maintain the simplicity, the reachability of a MN and the continuity of the service offered to the MN when moving from one network to another, in another word during the handover. Basically, the handover is a change in MN's point of attachment to the Internet such that the MN is no longer connected to the same IP subnet as it was previously. In recent years, a great effort of research has been spent on the issue of mobility, and it proposed or resulted in development of the existing architecture and the operation of services based on context as well as specific mechanisms and protocols for support of mobility. This includes proposals on Mobile IPv6 (MIPv6) [5, 6, 9] developed by the IETF Mobile IP Working Group (WG). Also there are other solutions have been proposed for mobility support, Fast Handovers Mobile IPv6 (FMIPv6) [7, 8, 9] and Hierarchical Mobile IPv6 (HMIPv6) [9, 10, 11]. However, these solutions are not able to re-establish both IP connectivity and service context within the time constraints imposed by real-time applications such as Voice over IP. Therefore, Context Transfer Protocol (CXTP) [6, 12, and 13] has been suggested as an alternative way of restoring the service context at the new access network.

The CXTP is designed by the IETF to provide general mechanisms for exchange of context data for moving mobile nodes (MN) between access routers (AR). It gives support of the seamless handover based on service continuation using context and could be used to transfer different kind of control data and resources based services [14]. It aims to contribute to the enhancement in handover performance and proposed for MN for quickly re-establishment of their services when the nodes move and change their access routers.

2. RELATED WORK

Work in [6 and 13] specifies the multicast receiver mobility based on context transfer. Defining the multicast context transfer operations and data structures required for MLDv2. Multicast context transfer block and operational considerations for optimized multicast context transfer based on FHMIPv6 and Candidate Access Router Discovery (CARD) are described. The requirements for MLDv2 context extension and operation at access routers to support multicast context transfer for mobile IPv6 are specified. Interactions of MLDv2 with PIM-SM for multicast routing state update based on multicast listening context transfer are overviewed. CARD protocol is used in [7, 10] to choose "optimal" access networks based on the mobile node's requirements for Candidate Access Router (CAR)'s capabilities. However, more focus is given to multicast listeners.

Mobile multicast in the framework of HMIPv6 approach is discussed in [10]. The multicast packet forwarding is based on mobility anchor points defined for the HMIPv6 architectures. However this proposal suffers in case of inter domain mobility. In [13], different approaches are overviewed to achieve sender and receiver multicast mobility in internet environment. It describes the problems faced by the multicast senders and multicast receivers, as well as the available solutions to senders and receivers.

3. DESIGN OF THE PROPOSED SOLUTION (HMMCT)

- Problem Statement

The main goal of the mobile IPv6 is to re-establish the service for the mobile device as long as it moves to a new network. In another words, the Mobile IPv6 maintain the reachability while moving in the IPv6 network. At the same time, the group communication has also become a need for the people, because of its use in variety of application including video conferencing, voice over IP, and massive multiplayer gaming. As a result, the integration of both the multicast IP and mobile IP (multicast mobility/mobile multicast) become a crucial in our daily life. Mobile multicast becomes the backbone for numerous applications ranging from the multimedia conference scenarios where the host can be the sender or the receiver, to the real-time communication such as voice over IP which require seamless handover to limit the disruptions or delay. Unfortunately, the existing mobility support specification does not support the multicast. As a result, the possibilities of using multicast in mobile environment suffers so many problems such as packet loss, packet latency, join latency, tree reconstruction, and higher signaling cost and so on. As a consequence the IETF proposed two solutions based on the MIPv6 which are bidirectional tunneling and remote subscription. However, these two solutions are not efficient and effective especially, during the hand off period.

- Current Challenges

The difficulties or the challenges of mobile multicast can be summarized as follows:

- The existing IP multicast protocols does not satisfy the needs of nods for mobility.
- The handoff time of MN and the delay in rejoining multicast group is too long, so it cannot meet the QoS yet.[4]
- The reconstruction of multicast tree caused by MN handoff increase the signaling cost
- The existing IP multicast protocols have the problem of triangular route and tunnel convergence. [15, 16].
- The reconstruction of the multicast tree as the MN transfer to a new network. The MN will be receiving the multicast data in the old network, although it moves to the new network and the cost associated with tree construction is high.
- As the mobile nodes handoff to another network, the MN suffers from packet loss and joins delay.
- In case the foreign network does not support the multicast, all the multicast traffic will be rejected.
- As long as tunnel used, the process of encapsulation and decapsulation must take place, which in turn it increase the size of the header and therefore increases the cost.
- Packets out of order, and also, Packets Duplication, when receive different multicast data from different multicast router.

- The Architecture of the Proposed Solution (HMMCT)

The proposed solution, Hierarchal Mobile Multicast Context Transfer uses the multicast HMIPv6 to maintain the intra-domain mobility and uses the multicast context transfer to provide the inter-domain mobility. This HMMCT has been proposed to provide a seamless handover and to reduce the disruption for the mobile nodes whether they move within the same MAP domain or different domains and to allow the mobile nodes to receive the packets during the handover efficiently especially for real-time services and applications. As it has been said earlier the M-HMIPv6 protocol used to provide a seamless handover for the MH when moving within the same MAP domain, since the MAP works as a local home agent. However there are some limitations come with the HMIPv6 mobile multicast when a mobile host moves to a new MAP domain as stated in the design issues. So the proposed architecture HMMCT concerns to solve these problems, by utilizing the multicast context transfer between two different MAPs. The context transfer can reduce the time needed to re-establish the service since the multicast context transfer block will be transferred between the two MAPs before the handover is completed, so all the information needed for the MH to join the multicast group is already transferred and the MH can join the multicast group as soon as the mobile node moves to the new MAP domain. Also the signaling cost will be reduced since the communication is localized between the two MAPs and the mobile node doesn't need to send the group membership message again to the new MAP since the new MAP already received the information needed for that in the multicast context transfer block. Fig (1) shows the proposed architecture.

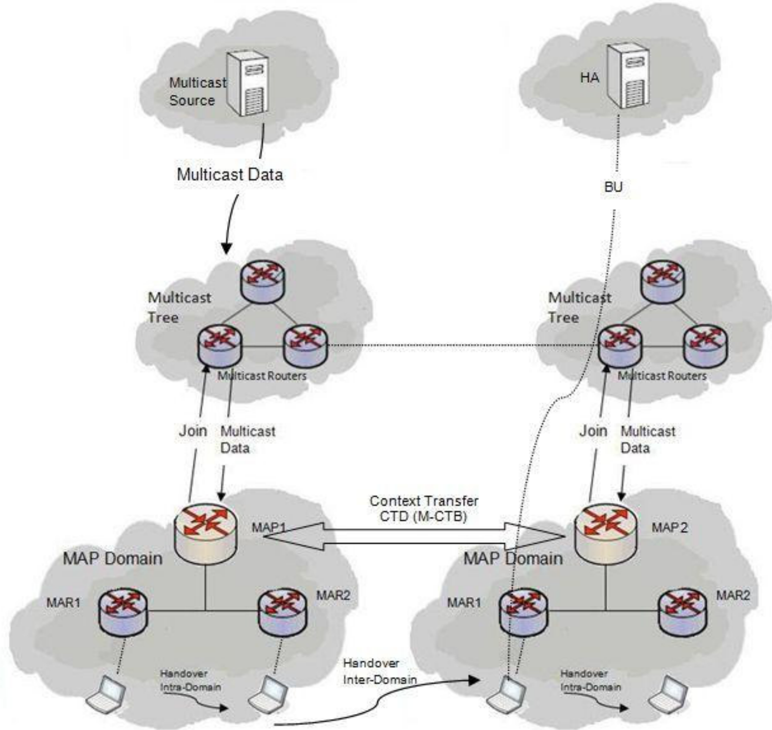

FIGURE 1: HMMCT architecture.

- How HMMCT Works

The Hierarchical Mobile IPv6 scheme introduces a new function, the MAP. A MN entering a Multicast enabled MAP's domain will learn about the regional Care-of-address, RCoA of the M-MAPs through MLD membership query. After receiving the MLD membership query, the MN sends an MLD membership report message to subscribe to a multicast group by using its on link care-of-address, LCoA. Upon reception of a tunneled MLD listener report, the M-MAP will record multicast group membership in its Binding Cache, observe and maintain multicast group membership on its specific tunnel interface, checks the MNs current group membership, and forward multicast group traffic to the MN. So the M-MAP is acting as a local HA, and will send the join message to the multicast senders and the M-MAP will receive all the multicast packets on behalf of the mobile node it is serving and then will encapsulate and forward them directly to the mobile node's current address. If the mobile node changes its current address within a local MAP domain LCoA, it only needs to register the new LCoA address with the M-MAP by sending a binding update to binds its LCoA with the RCoA of the M-MAP. Hence, the mobile node can receive the multicast packets without the need to send MLD membership report, because only the RCoA needs to be registered with correspondent nodes and the HA, and the RCoA does not change as long as the MN moves within a MAP domain. This way of handling the mobility makes the mobile node's mobility transparent to the correspondent nodes it is communicating with. But if the MN detects an inter-domain mobility, the MN will send a message to the previous M-MAP to activate the context transfer or the context transfer can be triggered by link layer 2. Specifically, a predictive multicast context transfer is used. After the context activation, the multicast context transfer block (M-CTB) is built at the previous M-MAP in interaction with multicast information in the previous M-MAP. The M-CTB includes the multicast addresses required for the multicast services of the moving mobile node. M-CTB is sent from the previous to the next M-MAP in the Context Data message. When the next M-MAP receives the context data with the M-CTB, the next M-MAP will provide the context data to the MLD for updating the multicast context and establishment of an individual node MLD context. Therefore, once the MH moves to the next M-

MAP, the MH will be able to receive the multicast packets immediately through tunneling form the next M-MAP, because the next M-MAP already sent the join message to the multicast source. Then the MLDv2 supplies the information from the M-CTB to the multicast routing protocol to build the routing context for the multicast addresses. Fig (2) shows the signal flow of HMMCT.

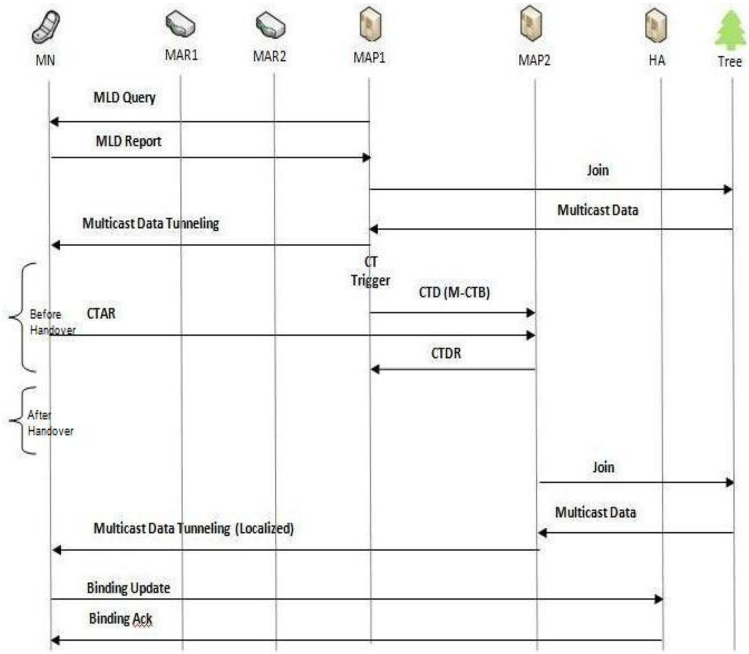

FIGURE 2: The signal flow of HMMCT

4. PERFORMANCE EVALUATION OF THE PROPOSED ARCHITECTURE

In this paper the analytical approaches will be used. The parameters used to be evaluated are the service recovery time, and signaling cost. These two different approaches will be explained next.

- Service recovery time

Referring to the signal flow diagram of HMMCT and BT, the total service recovery time is calculated and compared to each other. In the case of bi-directional tunneling, after the handover of the MN from one network to another, the total service recovery time is calculated by:

Trec. BT = T1+T2+T3

Where
T1: is the time taken to send BU message from MN to HA
T2: is the time taken for the HA to send ACK to the MN
T3: is the time taken to receive the multicast data.

The handover in HMMCT is divided in to two parts, the inter-domain mobility and intra-domain mobility. In inter domain mobility, the MN only sends BU message to the MAP and MAP reply by sending ACK to the MN, and hence the total service recovery time in this case can be calculated by:

Trec. HMMCT, inter = T4+T5+T6

Where
T4: is the time taken to send BU from the MN to the MAP
T5: is the time taken to send ACK from the MAP to MN
T6: is the time taken to receive the multicast data

The second case of the HMMCT is the intra-domain mobility, where the MN handoff from one MAP to another MAP. In this situation the context transfer protocol is used to reduce the service recovery time, and the total service recovery time for HMMCT, intra is calculated by:

Trec. HMMCT, intra = T7+T8

Where
T7: is the time taken to send the join message from the MAP to the multicast tree
T8: is the time taken to receive the multicast data.

The first case that is the BT take the highest time in order to recover the service, and this is due to the large distance between the MN and the HA, and this has been proved mathematically from the above equations. The inter domain mobility is the best and this is due to the short distance between the MN and the MAP, and even the intra-domain mobility recovery time is reduced by using the context transfer which implements the predictive signaling.

- Total Signaling Cost

It is assumed that the signaling cost is the summation of the binding update cost and the packet delivery cost. In this analysis of the signaling cost, the HMMCT is compared with the bi-directional tunneling which is the proposal of the IETF.

Firstly, the binding update cost is discussed. Each time the mobile node moves from one subnet to another subnet, the mobile node needs to send a binding update to the home agent in order to update its location. The cost of binding update is affected by different factors that are, the number of the mobile nodes, residence time of the mobile node in the subnet or the frequency of changing the subnet, the length of the path that the binding update follow in term of numbers of hops, and the encapsulation and dencapsulation processing time. The HMIPv6 divides the mobility into two parts which are micro-mobility (intra-domain) and macro-mobility (inter-domain), and this reduce the frequency of changing the sub-network because the movement is localized. So the round trip delay is minimized by localizing the movement of the MN because the MAP acts as the HA, and this leads to reduction in the total signaling cost. The binding update cost is calculated from the following equation:

C, BU =L*e*N*f

Where
L= distance the BU message travel.
N=number of mobile nodes
e= processing time for encapsulation and dencapsulation
f=frequency of changing the network ant it is equivalent to 1/T where T is the residence time

It is clear that the binding update messages cost for BT is higher than the HMMCT, this is because each time the MN handover a binding update message is needed to be sent to the HA in BT, however, binding update message is needed only when there is an intra domain-mobility and this would involve processing cost. So as the number of the MNs increase the cost would increase as well. The residence time in HMMCT is higher because the movement is localized.

Secondly, the packet delivery cost is discussed. The packet delivery cost is assumed to depend mainly on the length of the path taken by the packets to be delivered mobile node. Bi-directional tunneling (BT) suffers from high signaling cost, and this is due to the large distance between the mobile node and the home agent, and the encapsulation and dencapsulation process which is taking place every time there is a movement. This high signaling cost is because of the triangular routing problem which experience by the BT. HMMCT suffers from less signaling cost due to localization of the movement. The packet delivery cost can be calculated by:

Cost = distance* encapsulation processing cost.

For the BT, the packet delivery cost can be calculated by:

C, PD, BT= D1*e1+D2*e1

The packet delivery cost for HMMCT calculated by:

C, PD, HMMCT=D3*e2+D4*e2

Where
D*1*: distance from MN to HA.
D2: distance from HA to the multicast data source.
D3: distance from MN to MAP.
D4: distance from MAP to the multicast source.
CPD, BT: packet delivery cost for BT
CPD, HMMCT: packet delivery cost for HMMCT

The D1,D2 distances is larger than D3,D4, and in the BT there will be a lot of encapsulation and dencapsulation process which leads to the increase of the packet delivery cost and the signaling cost.

Fig (3) shows the total signaling cost verses the number of the MN, and the graph shows the higher signaling cost for the BT and especially as the number of MNs increase.

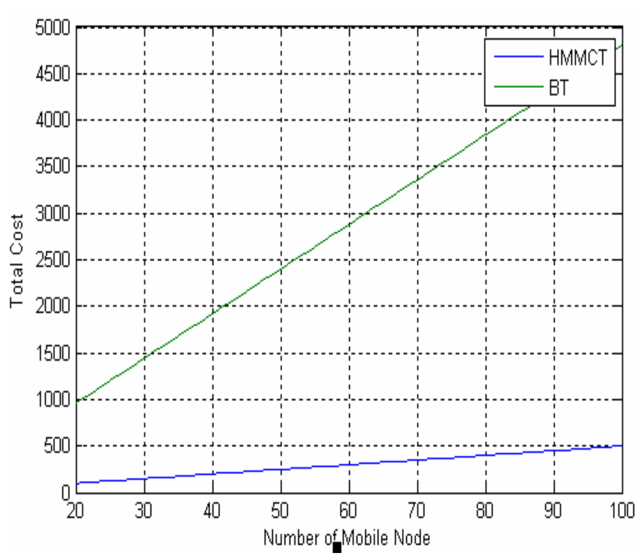

FIGURE 3: The signal cost vs. number of mobile node (for BT and HMMCT).

5. CONCLUSION & FUTURE WORK

This paper presents and suggests a new solution to the mobile multicast issues which suffers from high signaling cost, packets drop and packets latency. The new protocol is compared with the bi-directional approach. The paper integrates the Hierarchical Mobile IPv6 with Mobile context transfer. It has shown in this paper that the HMMCT suffers less signaling cost. In the future, this new protocol would be simulated and evaluated using network simulator 2 (ns-2).

6. ACKNOWLEDGEMENT

We would like to acknowledge the research centre management at the International Islamic University Malaysia for their support for this research.

7. REFERENCES

1 R. Berezdivin, R. Breining, and R. Topp. *"Next-Generation Wireless Communications Concepts and Technologies". IEEE Commun. Mag.*, vol. 40, Mar. 2002, pp. 108–16.

2 Karan Singh, R. S. Yadav, Ranvijay. *"A Review Paper on AD HOC Network Security".* International Journal of Computer Science and Security, Vol.1, Issue 1, 2007.

3 A.K. Othman. *"GPS-less Localization Protocol for Underwater Acoustic Networks".* International Journal of Computer Science and Security, Vol. 1, Issue 1, 2007.

4 R.Asokan, A.M.Natarajan, C.Venkatesh. *"Ant Based Dynamic Source Routing Protocol to Support Multiple Quality of Service (QoS) Metrics in Mobile Ad Hoc Networks".* International Journal of Computer Science and Security, vol. 2, issue 3, 2008.

5 C. Perkins, *"IP Mobility Support",* RFC2002, Oct. 1996.

6 I. Miloucheva, K.Jonas. *"Multicast Context Transfer in mobile IPv6"*. SATCOM, 2005.

7 R. Koodli, E. Perkins, *"Fast Handovers and Context Transfer in Mobile Networks"*, Nokia Research Center, 2004.

8 Xia, F. and Sarikaya, B. *"FMIPv6 extensions for Multicast Handover",* draft-xia-mipshop-fmip-multicast-00.txt, (work in progress), September 2006.

9 X. P. Costa, R. Schmitz, H. Hartenstein, M. Liebsch, *"A MIPV6, FMIPV6 and HMIPV6 Handover Latency Study: Analytical Approach"*, NEC EUROPE Ltd, Heidelberg, 2005.

10 T. C. Schmidt, M. Waehlisch. *"Seamless Multicast Handover in a Hierarchical Mobile IPv6 Environment"*. IETF, December 2005.

11 Soliman, H., Castelluccia, C., El-Malki, K., Bellier, L. *"Hierarchical Mobile IPv6 mobility management"*. RFC 4140, August 2005.

12 J. Loughney, M. Nakhjiri, C. Perkins, R. Koodli. *"Context Transfer Protocol*". RFC4067, 2005.

13 H. Santos, A. Mantos*. "Context Transfer of Mobile IPv6 Multicast Listeners"*. Internet Draft (work in progress expired), February 2006.

14 I. Miloucheva. "*Context Management for Efficient Mobile Multicast Service"*. FOCUS, 2004.

15 Schmidt, T. *"Multicast Mobility in MIPv6: Problem Statement and Brief Survey"*. Draft irtf-mobopts-mmcastv6-ps-01.txt (work in progress), July 2007.

16 J. Kempf. *"Problem Description: Reasons For Performing Context Transfers Between Nodes in an IP Access Network".* IETF, September 2002.

17 J. Xie and I. F. Akyildiz. *"An optimal location management scheme for minimizing signaling cost in Mobile IP". IEEE International Conference on Communications (ICC)*, New York, pp. 3313–3317, April 2002.

18 S. Fu, M. Atiquzzaman, L. Ma, and Y. Lee. *"Signaling cost and performance of SIGMA, A seamless handover scheme for data networks". Accepted by Journal of Wireless Communication Mobile Computing*, 2005.