Mathematical Evaluation of a Context Transfer-Based Approach to Improve Handover in Mobile Multicast Environment

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***Abstract*—Mobile networking environments have been developing very rapidly in line with the increase demand of users. Multicast is defined as the delivery of data to a set of selected receivers. When a mobile node (MN) moves to a new subnet it needs to continue certain services that have already been established at the previous subnet. It is a difficult problem to maintain simplicity and reachability of a MN when moving (handover) from one network to another. Context transfer (CXTP) gives support of the seamless handover based on service continuation using context. 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. This paper focuses on evaluating the performance of predictive method employed by CXTP to enhance the handover performance in hierarchical mobile multicast environment namely M-HMIPv6. Our research aims to improve the performance of the mobile node during handover in a multicast session; this is done by reducing the mobile node's service recovery time and signaling cost. The evaluation is carried using mathematical analysis. The performance metrics used are service recovery time, and signaling cost.** *(Abstract)*

Keywords-component; service recovery timey; signaling cost; performance (key words)

I. INTRODUCTION

With the fast progress of different type of wireless technologies and building of heterogeneous mobile networking environments, the importance of improving the existing architecture or operation of services based on context increases. This includes mobile multicast networking environments. When a mobile node (MN) moves to a new subnet it needs to continue certain services that have already been established at the previous subnet. It is a difficult problem to maintain simplicity and reach ability of a MN when moving from one network to another.

The challenge is to offer a large range of wireless mobile services to highly heterogeneous users for a highly effective handover. One of the importances is to improve the existing architecture or operation of services based on context is to minimize the impact of handover. 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. Many proposals have been introduced in order to solve this issue. This includes proposals on Mobile IPv6 (MIPv6), Fast Handovers Mobile IPv6 (FMIPv6) [1, 3, 9, 19, 20], Hierarchical Mobility IPv6 (HMIPv6) [12, 19, 32] and Context Transfer Protocol (CXTP) [4].

CXTP [4] 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 [1]. 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.

II. CHALLENGES AND OBJECTIVE

When a MN moves to a new subnet it needs to continue certain services that have already been established at the previous subnet. It is a difficult problem to maintain simplicity and reach ability of a MN when moving from one network to another. High latency could leads to packets being forwarded to the outdated path and lost which means the increase of packet loss rate. Eventually cause service interruption, degrade performance especially the performance of real-time and delay sensitive application.

The main objective of this research is to improve the performance of MN during handover in a multicast session. The performance metric chosen are based on this objective. The performance metrics used for simulation evaluation are handover latency, packet loss and bandwidth overhead. The proposed extension will be benchmarked with the standard HMIPv6.

III. RELATED WORK

Many proposals are introduced to improve handover performance in MIPv6. Work in [1, 3, 8] 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. CARD protocol is used in [1, 3, 6] to choose "optimal" access networks based on the mobile node's requirements for Candidate Access Router (CAR)'s capabilities.

In [16] uses the remote subscription approach, the mobile node could join the multicast group on the next access network without having to wait for the binding of its new care-of address thus reducing the delay for multicast service re-establishment. However, during the handover multicast packets could be lost and in case of frequent handovers there is an increasing overhead at the mobile nodes to re-join multicast groups [11]. The multicast mobility mechanisms usually solve only the problem of multicast group membership and multicast routing for mobile hosts during their movement between access networks. Due to this, [11] suggest integration of error and flow control techniques for the delivery of the data to the mobile receivers without packet loss for a reliable mobile multicast.

Mobile multicast in the framework of HMIPv6 approach is discussed in [12]. The multicast packet forwarding is based on mobility anchor points defined for the HMIPv6 architectures. In [15], 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.

In [19] a MIPV6, FMIPV6 and HMIPV6 handover latency study using analytical approach are discussed. It recommended on the implementation of both HMIPv6 and FMIPv6 to improve signaling load, latency, packet losses and handover.

There are proposals of agent assisted handovers compliant to the unicast real-time mobility infrastructure of FMIPv6 [31], the M-FMIPv6 [30,20], and of HMIPv6 [32],and the M-MIPv6, which have been thoroughly analyzed in [23].

Work in [25] proposes to employ binding caches and to obtain source address transparency analogous to MIPv6 unicast communication. Initial session announcements and changes of source addresses are to be distributed periodically to clients via an additional multicast control tree based at the home agent. Source tree handovers are then activated on listener requests.

Work in [26] suggests handover improvements by employing anchor points within the source network, supporting a continuous data reception during client initiated handovers. Client updates are to be triggered out of band. However it is a receiver oriented tree construction in SSM thus remains unsynchronized with source handovers

IV. PROPOSED SCHEME

This research is focused on evaluating the performance of predictive method employed by CXTP to enhance the handover performance in hierarchical mobile multicast environment [39]. A new extension to the current HMIPv6, by proposing the integration of M-HMIPv6 with CXTP (M-HMIPv6/CXTP). A MN entering an M-MAP domain will need to update its Multicast Listener Discovery (MLD) context to the next M-MAP. This scheme improves the multicast session process.

The architecture used for M-HMIPv6 in this research is shown in "Fig. 1". The architecture consists of two domains with each domain contains one multicast mobile anchor point (M-MAP) and access router (AR).

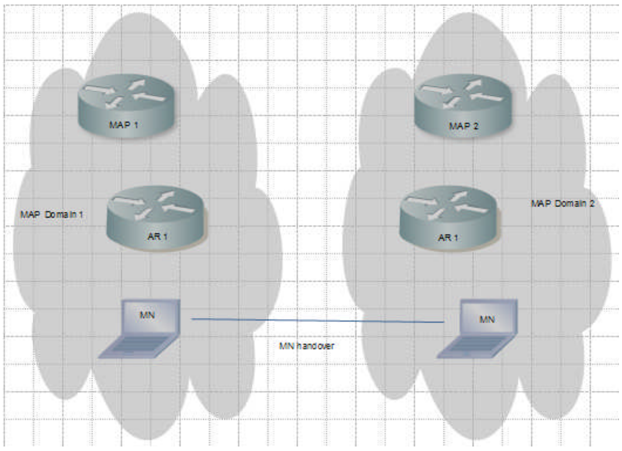

Figure 1. M-HMIPv6 Architecture

In predictive method of CXTP there are two scenarios for the triggering of a context transfer. The scenarios are MN controlled triggered by the MN as shown in "Fig. 2" and network controlled, initiated by previous AR as shown in "Fig. 3" [39]. When it is a MN controlled triggered scenario, the process is initiated by the MN, by sending context activation message to its previous AR. While for network controlled scenario, it is initiated by the previous M-MAP.

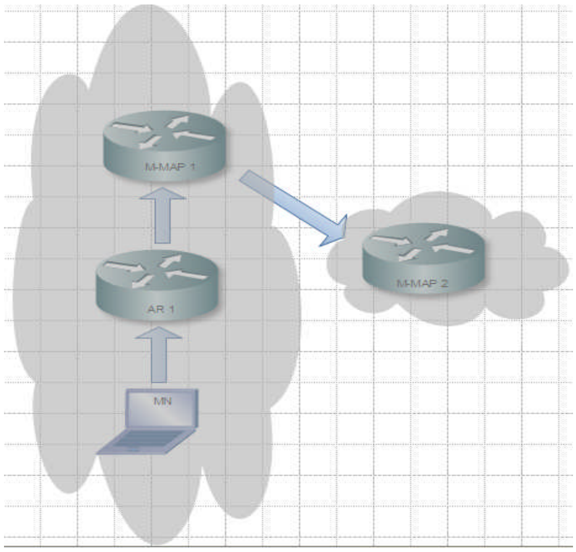

Figure 2. Mobile node triggered

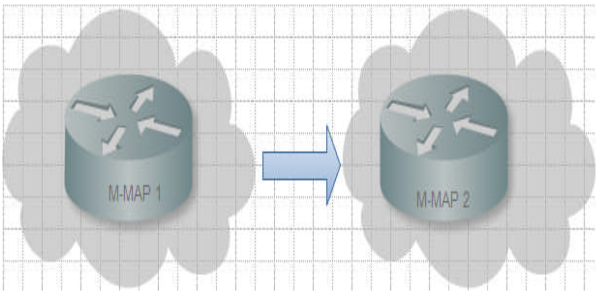

Figure 3. Network controlled triggered

The MN handover flow for both scenarios of M-HMIPv6 with CXTP is shown in "Fig. 4" [39].

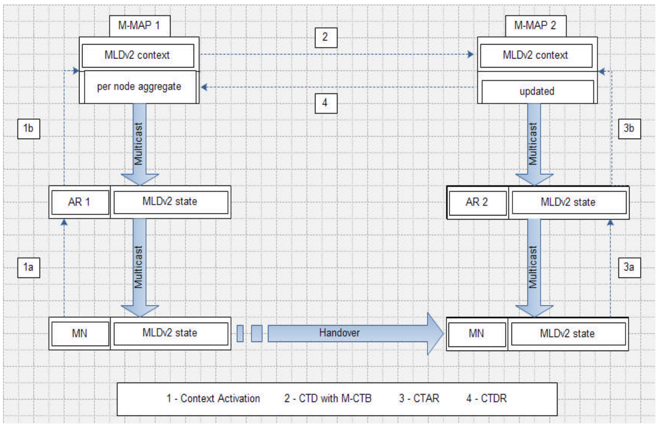

Figure 4. MN handover flow in M-HMIPv6 with CXTP

Referring to the handover flow, when it is a mobile node controlled triggered, the flow starts from 1a, and the mobile node sends a message to the previous access router to activate the context transfer at the previous M-MAP. Context transfer is started with the context activation by the mobile node sending a message to the previous access router. After the context activation, the multicast context transfer block (M-CTB) is built at the previous access router M-MAP in interaction with MLDv2.

While when it is a network controlled initiated, referring to "Fig. 4", the flow starts from step 2 whereby the previous M-MAP initiates the context transfer. The multicast context transfer block (M-CTB) for the multicast services of the mobile node is built in the previous M-MAP with input from the MLDv2 router entity and transferred to the next M-MAP. The M-CTB includes the multicast addresses required for the multicast services being used by the moving mobile node. Therefore, once the MN moves to the next M-MAP the MN 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 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.

From this flow, it can be seen that by applying the M-HMIPv6 with CXTP, the time needed to re-establish the service can be reduced since the multicast context transfer block will be transferred between the two M-MAPs before the handover is completed so all the information needed for the MN to join the multicast group is already transferred and the MN can join the multicast group as soon as the MN 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 MAP since the MAP already received the information needed for that in the multicast context transfer block.

V. Performance Evaluation

We use mathematical analysis to evaluate our proposed schema. In our enhancement proposal, the selected metrics are service recovery time and total signalling cost. Our implementation particularly refers to the M-HMIPV6 proposal in [12], MLDv2 extension in [3] and CXTP in [4].

The parameters being consider are not too difficult to obtained and understand as it only requires simple mathematical understanding from the process flow in an inter domain handover process. The mathematical equation s involved additional function and based on few assumptions. The overall flow of how the mathematical method is obtained is shown in "Fig.5".

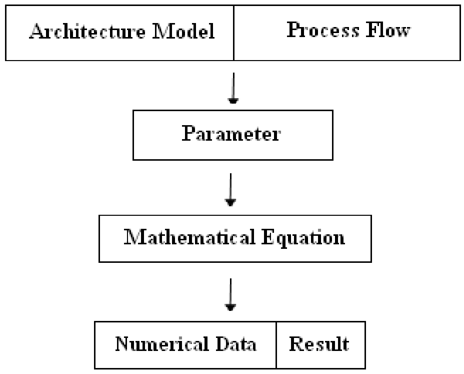

Figure 5. Mathematical Process flow

A. *Performance metrics*

We evaluate the mathematical based on the following performance metrics:

Service recovery time is defined as the time used to resume the service to normal state. As for the enhanced scheme the parameters needed to be considered in finding the total service recovery time after the handover to M-MAP2 domain are:

$T_{1HMIPv6}$: time taken to send the MLD message from M-MAP2

$T_{2HMIPv6}$: time taken to receive the MLD message from MN

$T_{3HMIPv6}$: time taken to send the join message from M-MAP2 to the tree

$T_{4HMIPv6}$: time taken to receive the multicast packets

The total service recovery time = $T_{1HMIPv6} + T_{2HMIPv6} + T_{3HMIPv6} + T_{4HMIPv6}$ (1)

While as for the M-HMIPv6 with CXTP, the parameter needed to be considered after the handover to M-MAP 2 domain (inter domain mobility) are:

$T_{1M\text{-}HMIPV6/CXTP}$: time taken to send the join message froM-MAP2 to the tree

$T_{2M\text{-}HMIPV6/CXTP}$: time taken to receive the multicast packets

The total service recovery time = $T_{1M\text{-}HMIPV6/CXTP} + T_{2M\text{-}HMIPV6/CXTP}$ (2)

The signaling cost can be defined as the messages involved in packets transmission other than the data itself such as the control message and the process of encapsulation and decapsulation. In this paper, it is assumed that the total signaling cost for the handover is equals to the summation of the packet delivery cost and binding update messages cost [38]. It is noted that for each parameter symbol a is used for HMIPv6 while symbol b is used for HMIPv6 with CXTP.

C_{pd}^{HMIPv6}: packet delivery cost for HMIPv6.

$C_{pd}^{M\text{-}HMIPv6/CXTP}$: packet delivery cost for M-HMIPv6 with CXTP.

C_{BU}^{HMIPv6}: binding update cost for HMIPv6.

$C_{BU}^{M\text{-}HMIPv6/CXTP}$: binding update cost for M-HMIPv6 with CXTP.

D1: distance from MN to M-MAP.

D2: distance from M-MAP to source.

N: number of binding updates messages.

e: factor affected by the encapsulation process.

T: time the MN reside in a network.

L: distance the BU message travel.

The packet delivery cost and the binding update for HMIPv6 and M-HMIPv6 with CXTP can be calculated by:

$$C_{pd}^{HMIPv6} = [D1 + D2] * e_a \quad (3)$$

$$C_{pd}^{M\text{-}HMIPv6/CXTP} = [D1+D2]*e_b \quad (4)$$

$$C_{BU}^{M\text{-}HMIPv6/CXTP} = \frac{N_b * e_b * L_b}{T_b} \quad (5)$$

$$C_{BU}^{M\text{-}HMIPv6} = \frac{N_a * e_a * L_a}{T_a} \quad (6)$$

Therefore the total Signaling Cost = $C_{pd} + C_{BU}$ (7)

B. Mathematical results and evaluation

"Fig. 6" shows the signal cost against the number of mobile nodes, it can be seen that the signalling cost for HMIPv6 is higher than the enhanced scheme. This is due to additional binding update needed after the handover for HMIPv6. With more mobile nodes, meaning there is more MLDv2 messages to be delivered.

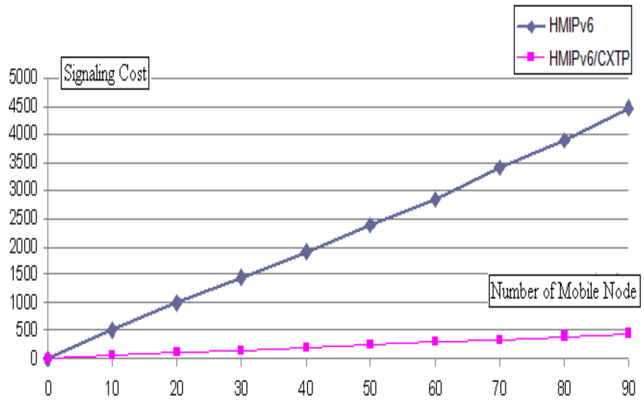

Figure 6. Signaling Cost versus Number of Mobile Node

From the equations and the results for service recovery time, it can be proved that the time needed to recover the service in HMIPv6 approach is larger than the time for the enhanced scheme M-HMIPv6 with CXTP.

By using the CXTP the service recovery time will be reduced even more since there is only two parameters involved, and there is only one join message, so that once the MN moves to the new M-MAP domain it will join the multicast group and the service recovery time will be reduce more.

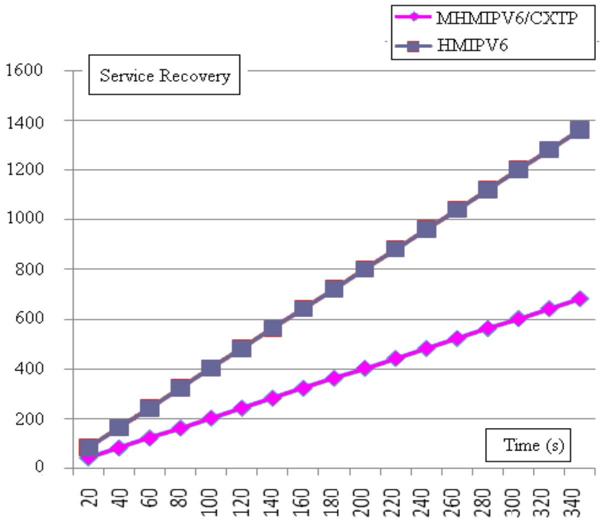

Figure 7. Service Recovery versus Time

CONCLUSION

This paper presents a new mobile multicast approach to reduce the service recovery time and reduce the total signaling cost after the handover in inter domain mobility of M-HMIPv6. The proposed solution integrates M-HMIPv6 with CXTP.

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