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Seamless and Prediction in Multicast Mobile IP Network

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Abstract – In this paper we presented 2 different methods in Mobile IP Network to optimize Wireless Network Bandwidth and also to reduce the Latency for reconfiguration of Multicast Tree. Displacement of Mobile Host (MH) and "Dynamism in Membership of MHs", will cause considerable changes in "Multicast Tree". We have shown that by means of these methods, based on prediction of the next Cell which the "MH" is moving towards, it will be possible for the "MH" to enter a cell, in which it had been admitted as multicast member, ahead of time. Finally, we modified the two methods which are optimum in terms of the "Latency for reconfiguration of Multicast Tree" and also "Bandwidth utilization". Finally, with regards to the "Simulation results", the "Modified PNCMM" method has been shown to be "Optimum" in "Mobile IP Networks".

Key-Words: Multicast, Mobile IP, PNCMM, SACMM, Home Agent, Foreign Agent, Predictive Multicast.

1. Introduction

A Mobile Host (MH), in addition to "Joining" or "Leaving" a specific group, changes its physical location as well. So, a Mobile Multicast Protocol should consider the dynamism in the location of members as well as membership.

The current Multicast Protocols, namely: Distance Vector Multicast Routing Protocol (DVMRP), Multicast Open Shortest Path First (MOSPF), Core Based Tree (CBT), Protocol Independent Multicast (PIM) have not considered the mobility of members [1, 2]. The arrival of "MHs" into cells which are not already member of Multicast Tree, will cause rapid change of Multicast Tree and some time (Latency Time) will be needed for reconfiguration of Multicast Tree. This will reduce the efficiency and QoS of the network in particular during the "Cell hopping periods". Data packets will not reach an assumed "MH" in a specific "Cell" unless the concerned "Cell" has joined the "Multicast Group" ahead of a time called "Multicast Membership Latency Time". Therefore, the existing multicast protocols can not function effectively over Mobile Communication Networks. The existing "Mobile IP Protocol" makes use of two methods namely: "Unicast" and "remote Membership". A "MH" joins itself to several networks called "Foreign Networks" or FN. In each "FN" a "Temporary Address" is assigned to thise "Joined MH" which is different from its "Unique Address" assigned by its "Home Network". In IP routing, the datagram belonging to "MH" will be sent to its associated "Home Agent" even though the concerned "MH" is not in its respective "Home Network". To solve this problem, following solution is provided.

Each "MH" has a permanent unique address in the "Routing Table" of its related "Home Agent Router" called briefly Home Agent (HA). HA is connected, both to the "Wired Network" and to the "Wireless Network" [3].

2. Types of Topologies in Mobile Networks

We have studied and compared the functionality of 3 different types of topologies in mobile networks as follows:

1: Fully Centralized;
2: Fully Distributed;
3: Dynamic Addressing.

In the following, we deal with these Topologies:

2-1 Fully Centralized

In this method, the mobile network is equipped with a Central Data Base: CDB. This CDB contains two types of information concerning "Static Table" and "Dynamic Table" [4]. In "Static Table" the addresses of NICs (Network Interface Cards) of all MSRs and MHs associates with their MSRs will be registered. This table will generate a "Mapping" between MSRs and their related local MHs. These MSRs treat as HAs for their MHs and treat as FAs for foreign HAs. This table provides two sets of information as follows:

- Authentication of MHs in entire Mobile Network;
- Accounting & Billing information.

In "Dynamic Table", all NIC Cards addresses related to MHs will be registered as shown in Table 1 and Table 2.

Table 1 contains the NIC addresses associated to MSRs and NIC addresses related to MHs which are available in their related coverage area and the temporary IP addresses which are assigned to each MH as shown in figure 1. In Dynamic Table of CDB, all MAC addresses belonging to HAs which are available in each Network Cell will be registered temporarily. By means of these tables the location of MHs in each cell will be identified. These MHs will be located inside their associated "Local Cell" as "Homes" or inside a "Foreign Network" as "Visitors".

Table 1. Mapping MAC addresses of MHs toMSR's HA

HA	MAC address of MHs
MSR#1	MH#1, MH#4
MSR#2	MH#2, MH#5,MH#6
MSR#3	MH#3,MH#7

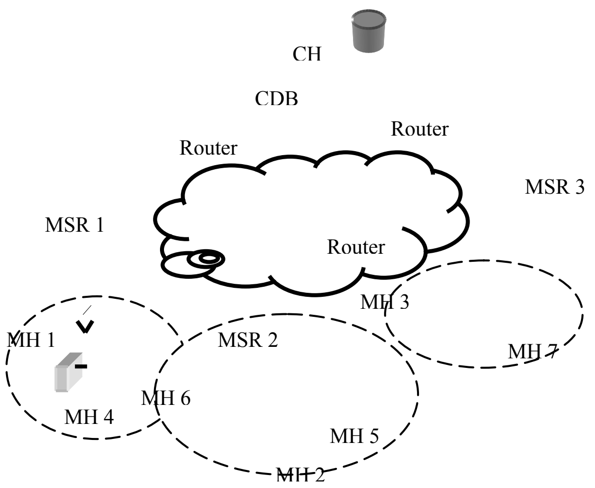

Fig. 1. Fully centralized allocation

Table 2. IP address alocation table

MSRs	MAC address of MHs			MACtoIP Address
MSR 1	*MH1*	*MH4*	*MH2*	IPAddress allocation
MSR 2	*MH3*	*MH5*	*MH6*	IPAddress allocation
MSR 3		*MH7*		IPAddress allocation

2-2 Fully Distributed Topology

In this case each MSR in the mobile network has a Dedicated Data Base (DDB) which stores all the data relating to the static and dynamic Tables. In this method, any changes in the network caused by movement of the MHs throughout the mobile network will be broadcast for all DDBs and update their dynamic and static tables upon reception of the above mentioned data. dynamic tables will change in case of displacement of an MH from one cell to another, but the static Tables will not incur any changes. When a new member is registered in the network in any location (or HA), the static table, and subsequently the dynamic table, will be updated.

Multicast Method

As it was mentioned in call processing phase, each Router updates regularly its DDB based on broadcasting any changes in DDBs in the network. The protocol used here could be DVMRP. Each DDB knows its neighboring DDBs and exchanges the status information with its neighbors.

Now, when an MH intends to transmit data packets to a group of MHs, a Multicast Tree will be constructed according to the status data in the DDBs. This tree has its root in the transmitting MH and its leaves distributed in the member MHs. Membership of one or more MHs will cause automatic membership of the associated MSRs and their relevant cells. The Accounting and Billing procedure will be completed locally by the transmitting MSR, since its DDB is quite familiar with the latest status of all MHs in the network. We have to implement this capability in all DDBs on a distribution basis, because each DDB can perform as a Transmitter or as a Receiver.

2-3 Dynamic Addressing

In this method, each MSR and each non_MSR in the network has a data base, called Local Data Base (LDB), containing the "Static Table" which stores fix addresses of MHs..

Multicast Method

Similar to Unicast format, the transmitting MSR (Source) sends a message for its group members to locate its group members. All MSRs which have concerned members will reply that query message. The protocol used for membership (Joining) of the members is IGM. There after, the location of each member will be identified and the associated MSR will request membership in Multicast Tree. Therefore by using DVMRP Protocol, a Tree will be constructed which has its Root in Source MSR and its Leaves in MSRs which have member MHs under their Cells coverage.

3. Prediction based Multicast Method

In previous section we noted that the Multicast Method is the best way for group communication. In this Method, the main problem is the Latency Time for reconfiguration of Multicast Distribution Tree.

3-1 Simultaneous Adjacent Cells Membership Method (SACMM)

To overcome the shortcomings of previous method (Conventional Method), we propose the following method:
As shown in Figure 2, assume that MH is a member of a

Multicast Group and is receiving data packets in Cell#1 via MSR1. To avoid any kinds of disconnection of communication link or packet loss, we propose to add other

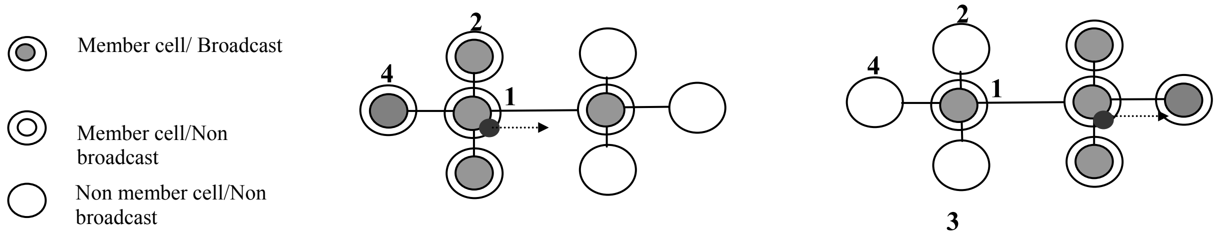

Fig. 2. SACMM Architecture

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adjacent Cells to Cell#1, (i.e Cell#2, Cell#3, Cell#4, and Cell#5), to the member Cells even though there is no active member inside each of these Cells. This means that the data packets destined for MH in member Cell#1 will also be receivable in other four adjacent Cells which might have no receiving member.

This take place as soon as Cell#1 is admitted as a member in Multicast Group. When MH moves towards Cell#3 and crosses the intersection area of two successive cells (Cell#1 and Cell#3) and enter Cell#3, it could easily hand over to MSR#3 without any problem, because MSR#3 has already been added to the group and is transmitting the same data packets inside its related Cell (Cell#3). This method could bring about a "Seamless Communications" in Mobile IP

Network, in particular in Multicast Communications. The same mechanism is applicable to the neighboring Cells of Cell#3. It is obvious that Cell#1 will remain member (assuming that no member is inside that Cell) until MH leaves Cell#3 and moves further. At that time Cell#1 will be pruned from the Multicast Tree.

This Method has also some disadvantages which include increase in Cost of Communications due to usage of more Bandwidth. It should be noted that the Latency Time for concerned MH to hand over from Cell#1 to Cell#3 in this case is negligible. The reason of adding 4 (or more) adjacent Cells to the concerned member Cell is that, the exact direction of movement of this MH is not known ahead of time.

3-2 Modified SACMM method

By means of the following approach we can make some modifications in our proposal:

We employ a new technique in the MSRs devices to add an additional feature to them. What we are looking for is to modify the existing Protocol by which the member MSRs don't propagate any data packets unless there would be at least one member MH in its related Cell. This mechanism will help us to control start time of propagation of a specific MSR which should replace the former propagating MSR. Based on this manner we can increase the efficiency of this method by saving the Network Bandwidth. In our example as shown in Figure 3, when MH leaves Cell#1 and enters Cell#3 it hands over from MSR#1 to MSR#3 very quickly because MSR#3 had been taken as a group member ahead of time.

But, propagation of MSR#3 starts as soon as it receives a go ahead message from the incoming MH. It is obvious that data packets reache member MSRs, but are not broadcast inside the related Cells unless any of the member MSRs makes sure that it has a member MH inside its associated Cell.

3-3 Predictive Next Cell Membership Method: (PNCMM)

In this method, we tried to decrease the Cost of Communication as much as possible. To acheive this goal, we used Prediction Mechanism. We try to guess the next Cell which MH intends to enter in. To make this happen, we have to predict the "Path" of the movement of the concerned MH among the Cells in the service area of a Mobile IP Network. If we could predict the next cell, then, besides the main Cell, only one additional cell at a given time will be taken as member, not more. The other procedures are the same as described in previous method. In the example shown in Figure 4, MH1 has left Cell#1 and entered Cell#2 and is continuing towards Cell#3. According to the "Prediction Mechanism" the next Cell will be predicted, as Cell#3. The

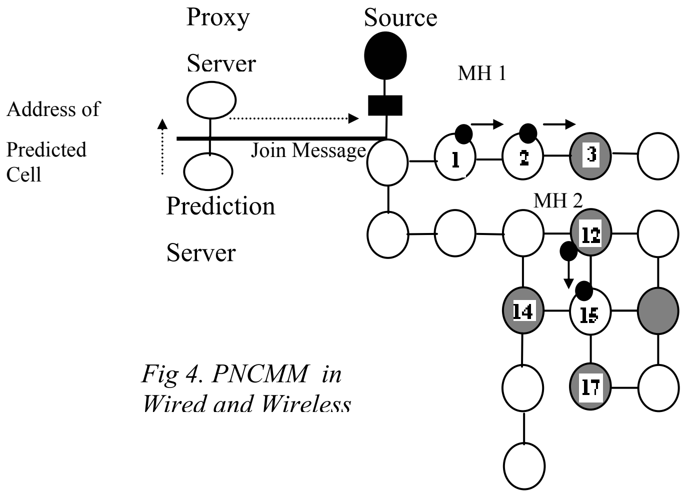

Fig 4. PNCMM in Wired and Wireless

"Prediction Procedure" is performed in a specific Server, called Prediction Server (PS) in the Network. This PS server could be either a single server which serves the entire Network on a centralized basis, or the Network could have multiple servers distributed in the whole network. The address of Cell#3 will be sent to central "Proxy Server" which then sends a "Join Message" on behalf of Cell#3 to "Next Hop Router" to join Cell#3 to the Multicast Group. We call this kind of Join Request as "Virtual Join Request", because it is not sent actually by Cell#3. The Next Hop

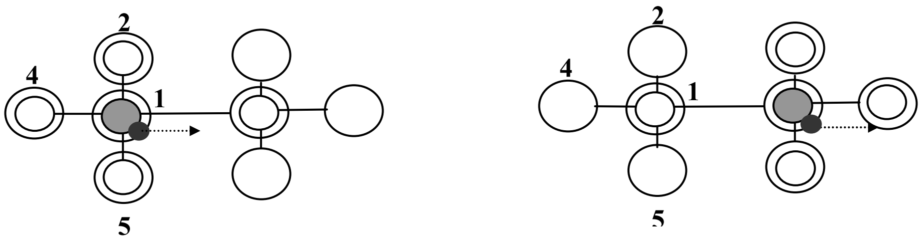

Fig.3 Modified SACMM Architecture

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Router will receive this virtual message and by means of IGMP Protocol will perform membership procedure for Cell#3 in the Multicast Group. Therefore, when MH1 enters Cell#3 it will find Cell#3 as a group member without facing any Latency and any kinds of packet loss. In the same Figure (Figure 4), you find MH2, another Mobile Host, with different conditions compared to MH1. MH2 leaves Cell#12 and enters Cell#15. In this example 4 cells are in vicinity of Cell#15. Now it is not clear in which direction MH2 will move and into which next cell it will enter. Therefore, to make sure that in either direction MH2 could find a member Cell, four adjacent Cells should be taken as Multicast Group member ahead of time by the same before mentioned Mechanism. According to this example, if Cells are distributed in linear Mode (like in Roads), the accuracy of prediction will be very high. In other cases, when the cells are distributed in surface Mode (like near or in cross roads area in a campus), the accuracy of prediction will decrease. Therefore, more Cells without any active members should be added to the Multicast Group.

3-4 Modified PNCMM

As mentioned before, we can simply improve performance of

this Method by incorporating the Mechanism stated in (5-2) in this approach. This mechanism will avoid propagation of the Cells, whatsoever, unless at least one active MH has entered the concerned Cells (fig. 5).

3-5 A Modification to "Range Based Mobile Multicast" (RBMoM) Method

As shown in Figure 6 assume an MH is a member of Mobile Multicast Group in Cell#1as its MHA (Mobile Home Agent). According to RBMoM Method proposed in [5] Cell#1 takes care of membership of its neighboring Cells by using Unicast mechanism. Therefore, when MH enters Cell#2 it will receive its corresponding data packets via Cell#2. Thus, the Latency Time for membership of Cell#2 in this

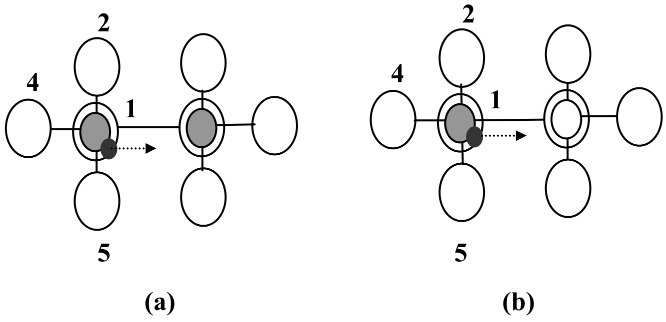

Fig. 5 Modified PNCMM to improve the

respect is equal to zero. But when MH moves out of the range of Cell#1 and enters C3 the latter Cell should be added to Multicast Tree as a member and act as an MHA for the incoming MH and for its "Range" (see Figure 6-b). Here, the MH is subject to a latency time for reconfiguration of the Multicast Tree. And as a result it is subject to packet loss. The weakness of RBMoM method could be rectified by in corporation of our proposed predictive method is RBMoM method. To realize this we make some modification in the network as follows we add special "prediction and Proxy servers" to the CH associated "Next Hop Router". Now by means of the said servers, the next Cell (ie Cell#3) could be guessed by prediction server and its address will be sent to proxy server. Now the proxy server sends a " Virtual Join Message" to "Next Hop Router" "for Cell#3" by means of IGMP protocol before MH enters Cell#3. This prediction and taking Cell3 in to the Multicast Group ahead of time removes the shortcoming of the RBMoM method and protect the network against packet loss due to the latency which is now equal to zero (see Figure 6-c). The same "Modified SACMM method" stated in (5-2) could be applied to RBMoM method to prevent any Cells from broadcasting before entering any group members into them (see Figure 6-d).

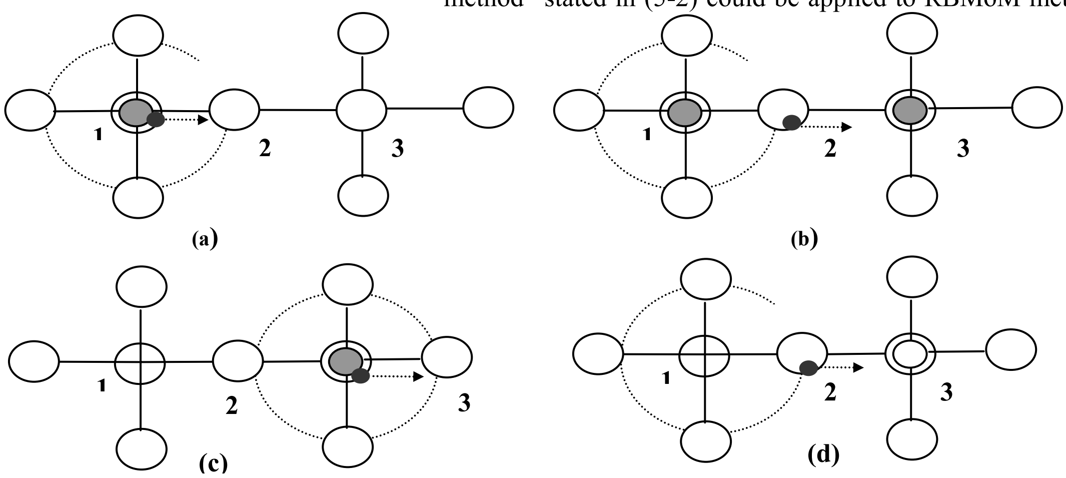

Fig.6 A Modification to RBMoM Operation

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4. Simulation Results

We assumed a Mobile IP Network is 25 Cells with 5 MHs admitted as members in a specific Multicast Group. These 5 MHs moves around these cells and cause membership of these cells in a dynamic Multicast Distribution tree based on a special mechanism. We moved these 5 MHs on a random basis in these 25 Cell in 30 fix Frames (pictures). Based on these assumptions, we depicted and associated "curves" and showed the results of 6 deferent methods proposed in our paper i.e "SCAMM", "PNCMM", predictive RBMoM and their respective modifications. In all cases assumed that our "predictions" have been correct (equal %100). In "Graph a", 3 "Curves" are shown. "Carves#1" shows the result of SACMM method. "Cave#2",which is depicted by "dots", shows the result of PNCMM method. "Curve#3", which is depicted by "line" shows the result of RBMoM method.

The average values of the Curves 2 and 3 are shown in "Graph d". In these Graphs, "+ Sign" is related to RPMoM. In "Graph", we depicted the curves of the modified version of SACMM and PNCMM methods. The average values of these carves are shown in "Graph e". In "Graph c", we depicted the "Latency Time" need for the "Multicast Distribution Tree" to reconfigure itself in PNCMM and PRBMoM methods. We have to take in to account that this "Latency Time" will elapse, before the moving MH enters the next Cell. Actually, this curve shows the time needed for Multicast Tree to construct or reconfigure itself before the moving MH enters the next Cell.

The average value of these carve is shown in "Graph f". As shown in related "Graphs", in PNCMM method lesser Cells are used to ensure a seamless communications, where as in SACMM method, more Cells are taken as member of multicast group to provide the same result.

5. Conclusion

By Applying the SACMM and PNCMM method in construction of Multicast Tree and its reconfiguration mechanism, the associated "Latency Time" will reach its minimum possible and possibly to zero.

According to simulations, we can conclude that: If the concentration of the group members, in a specific "Service area" of a Multicast Tree which consist of several Cells close together, is high, the use of SACMM method will be better because of less complexity. But if the concentration ration of the group members is low, in other words the members are distributed more evenly around the network, the use of PNCMM method will be better to remove the Latency Time.

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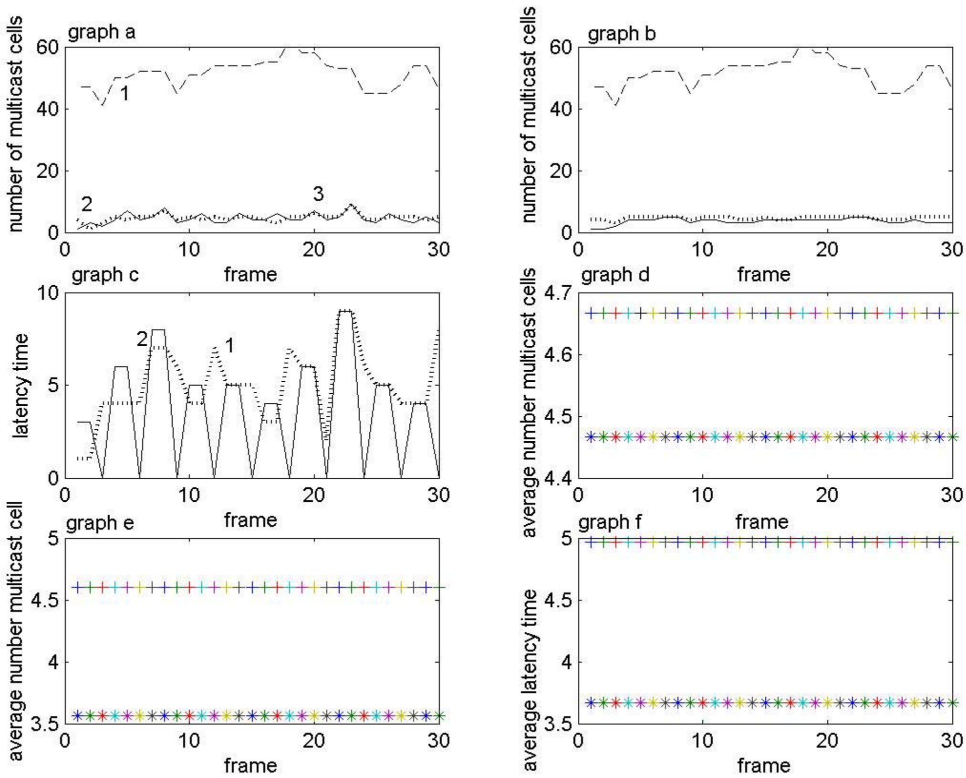

Simulation result datagram