

A Flow Transparent Multicast Pre-reservation Modification of RSVP for Providing Real-time Services in Wireless Mobile Networks

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Abstract — Resource Reservation Protocol (RSVP) is used to sufficiently reserve the resources between fixed endpoints. To support it for host mobility, several methods have been proposed in the literature to address the challenging problems of minimizing the handoff resource reservation delays and wastage of resources. Although, these methods minimize intra-subnet handoff resource reservation delays with minimum wastage of resources; but for inter-subnet handoffs, these methods need more resource reservation delays and more wastage of resources. In this paper, we propose a flow transparent multicast pre-reservation modification of RSVP to solve these problems to make the handoffs completely opaque to the user. In this method, a Multicast Group (MG) of cells is selected for each Boundary Cell (BC), and the resources are pre-reserved in this group only to the newly added path instead of whole path between source and destination when the Mobile Node (MN) performs an inter-subnet handoff towards that group. Simulation results demonstrate that the number of cells in the MG and resource reservation delays for inter-subnet handoff of the proposed method is always smaller than that of all other existing methods and has tolerable call blocking probabilities

Keywords — *RSVP, Boundary Cell, Center Cell, Multicast Group, Quality of Service*

I. INTRODUCTION

Third Generation (3G) network architecture is based on Internet technology for simultaneous real and non-real time services. Predominant mobile real-time services in the 3G Internet architecture such as wireless mobile Internet telephony require both Quality of Service (QoS) and mobility support. RSVP is the resource reservation setup protocol for the internet. It is used by hosts to obtain specific QoS from the network for particular application data streams or flows. It also used by routers to deliver QoS requests to all nodes along the path of the flows and to establish and maintain state to provide the requested service [1]. It does not support mobility. So, it needs to be modified to support both mobility and to provide sufficient QoS in wireless mobile networks. For this purpose, there are many approaches are proposed by many researchers.

A number of studies on inter-working to support both mobility and to provide sufficient QoS in wireless mobile networks are found in the literature. Most of them are based

on Internet Protocol version 4 (IPv4). However, due to the intrinsic shortcomings in IPv4 such as limited IP addresses, poor accommodation for QoS and mobility, Internet Protocol version 6 (IPv6) has been designed by IETF. Talukdar et al. [2] proposed Mobile RSVP (MRSVP) for the provision of QoS guarantees to MNs independent of their movement throughout the access network. It has limitations that more resources are reserved which may never be used; but they can be used for other requests. Chen et al. [3] proposed a new signaling protocol based on IP multicast. Although, it can minimize service disruption due to rerouting the data path during handoff, it has disadvantages such as overload to manage multicast tree dynamically due to resource reservation in advance. Terzis et al. [4] proposed a simple QoS signaling protocol by combining RSVP tunnels with Mobile IPv4. Although, it can be easily implemented with minimal changes to the Internet Architecture, but it has limitations like triangle routing problem when the MN moves far away. Jain et al. [5] proposed a scheme, called Mobile IP with Location Registers for 3G cellular systems. It is efficient, but requires more delay for location update to Home Location Register (HLR) when the MN performs location update. Chiruvolu et al. [6] recently proposed an RSVP and Mobile IPv6 integration model. It has problems like long resource reservation delays and signaling overheads during handoff. Each time an RSVP renegotiation has to be performed end-to-end, no matter how significant the handoff affects the path between CN and MN. Huang et al. [7] proposed a modification of RSVP to support real-time services in Hierarchical Mobile IPv6 (HMIPv6). For intra-site mobility, the concept of QoS Agent (QA) is proposed to handle the RSVP QoS update messages and to provide the advanced reservation models to adjacent locations just around the cell residing the current MN for real-time services where the MN may visit in future. For inter-site mobility, when the MN moves into the edge of a site, IP multicast is used to invite inter-site QAs to make pre-reservation to cells where the MN may visit in future. Although, this method minimizes the service disruption caused by re-routing the data path during handover, but pre-reserve and reserve the resources end-to-end although the path change may include only a few routers between the sender and receiver and has a high call blocking probability. Shen et al. [8] proposed a

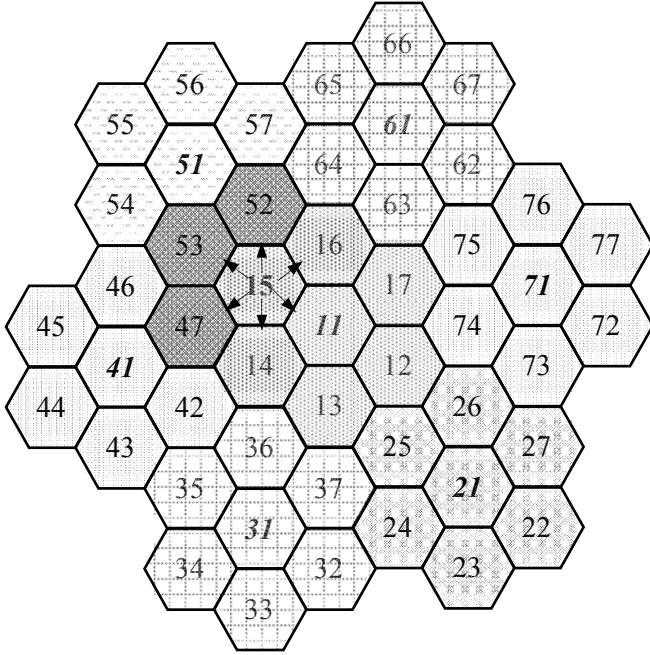


Figure 1: Configuration of Center and Boundary cells.

method to solve the drawbacks in the existing IPv6 QoS with mobility support model, namely long resource reservation delays and large signaling overheads. Pre-reservation is not performed in it. When the MN performs a handoff, the RSVP renegotiation process and resource reservation occurs only within the newly added portion of the path between CN and MN instead of the whole path between CN and MN. Although, it minimizes signaling overhead and resource reservation delays, but it is not best suited for systems where there are more inter-subnet handoffs; because, it provides more resource reservation delays for inter-subnet handoffs and the result is service degradation.

In this paper, we propose a method to automatically limit the handoff RSVP renegotiation process within the newly added portion of the path between CN and MN. Thus, handoff resource reservation delays and signaling overheads can be minimized which in turn minimizes the handoff service degradation

The rest of the paper is as follows. Section II describes the proposed method. Simulation and performance evaluation are presented in section III. Finally, section IV presents the conclusions of this paper.

II. PROPOSED METHOD: FLOW TRANSPARENT MULTICAST PRE-RESERVATION MODEL

In this proposed method each MNs location is denoted by M_{vc} , where M is the MN number, v is the Visitor Locator Register (VLR) number and c is the cell number that the mobile M resides. If V is the total number of VLR in the HLR, then v is in the range of 1 to V . Similarly, if C is the total number of cells in the VLR, then c is in the range of 1 to C . If cells are numbered according to Fig. 1,

there are seven VLR in this figure and the BC and Center Cell (CC) for a VLR v of MN number M is computed as follows.

$$M_{vc} = \begin{cases} \text{Boundary Cell,} & \text{if } c \neq 1 \\ \text{Center Cell,} & \text{if } c = 1 \end{cases} \quad (1)$$

For each BC, the corresponding VLR maintains a MG of adjacent cells just around that BC except that are in the same VLR. Mathematically, if A is the set of all adjacent neighbor cells around the BC B and G is the MG of B , then G is the subset of A containing the cells such that $VLR[B] \neq VLR[A]$. For example, if 17 is the BC, then 63, 75, and 74 are the MG of 17. The objective of the selection of the MG is to select appropriate reservation mechanism. The reservation mechanisms are as follows

1. If the MN residing in the BC continuing exchanging data and moving towards the MG, then the resources are pre-reserved in the MG to support the possibility of future inter-subnet handoff. The pre-reservation of resources in the MG are performed only to the newly added path between CN and MN's future location in the MG.
2. If the MN residing in the BC or CC continuing exchanging data, the reservation mechanism is the same as that of [8] for intra-subnet handoffs. In this case, the RSVP renegotiation and resource reservations are immediately performed to the newly added path between CN and MN that is formed as a result of intra-subnet handoff.
3. If the MN residing in the BC or CC not exchanging actual data, then for intra-subnet or inter-subnet handoff it only performs location update to the Nearest Common Router (NCR) or VLR between CN and MN instead of resource reservation.

The movement of a MN towards the MG is determined by measuring the change in signal strength of that MN in BC. If the MN is in the BC continuing exchanging data, the signal strength is measured in regular interval. If the signal strength is decreased, then the resources are pre-reserved in the MG. But, this actually does not mean that the MN moving towards the MG. In this case, the MN may also move towards the cells in the same VLR. From Fig. 1, it is observed that when MN is in BC 15 and moving towards the indicated directions, the signal strength is decreased and cell 47, 53 and 52 are in the MG but cell 14, 11 and 16 are in the same VLR. The relaxation of pre-reserved resources, formation of new MGs and leaving a MN from a MG are performed according to the following rule

1. When the MN determines that it is moved towards cells in the same VLR not towards the MG, it immediately releases the pre-reserved multicast resources. It also releases the pre-reserved multicast

resources if the measured signal strength of the MN in BC or CC increases or remain constant.

2. After the movement of the MN to a cell in the MG, the resources of the remaining cells of that MG and the previous cell of the MN are released and the new MG of that MN is formed again.
3. When a MN enters into the BC of a system, it immediately joins into its MG of that BC.
4. When a MN enters into the CC of a system, it does not immediately join into any MG. But, when it first moves into any BC, it immediately joins into the MG of that BC.
5. When a MN residing in BC leaves the system, it leaves from its MG.
6. When the MN residing in CC leaves the system, it does not need to leave from MG, because in CC the MN has no assigned MG.

When the MN leaves the system, the corresponding cell sends the *leave message* to the NCR for that MN, but when the MN performs a handoff to another cell, the previous cell sends the *leave message* and the current cell sends the *join message* almost at the same time to the NCR for that MN. So, only one delay is the result for the notification of handoff (*join message* delay or *leave message* delay). These messages are used to differentiate between handoff and leaving of MN from the system. These messages are also used for releasing the resources of MN's previous location and the unused pre-reserved resources of the remaining MG after the handoff of the MN from BC to MG. The decision of whether the MN performing a handoff or leaving from a system and relaxation of resources from the MNs previous cells can be determined by the following procedure

1. If NCR receives only a *leave message* but not *join message* from a cell for a MN almost at the same time, then the MN leaves the system.
2. If NCR receives both a *leave message* and a *join message* from two cells for a MN almost at the same time, the MN performs the handoff. This *join* and *leave messages* are comparable to *PathReq* or *Binding Update* message of [8].
3. For inter-subnet handoff, the resources of the MNs previous location from which NCR receives *leave message* and that of all the remaining cells of the MG except the cell from which the NCR receive *join message* are released.

III. SIMULATION

To evaluate the performance of the proposed method and to show its effectiveness, we simulate it using **java** language and analyze the simulation results with respect to no. of cells in the MG, handoff signaling delay, and call blocking probability for Hierarchical Mobile IP Version 6 (HMIPv6) [7], Flow Transparent (FT) [8], and the proposed Flow Transparent Multicast Pre-reservation (FTMP). Each parameter is tested in four different scenarios and the scenarios are explained in the subsequent subsection.

Fig. 2 shows the network configuration of our simulation which is also used by Shen et al. [8] and like them we

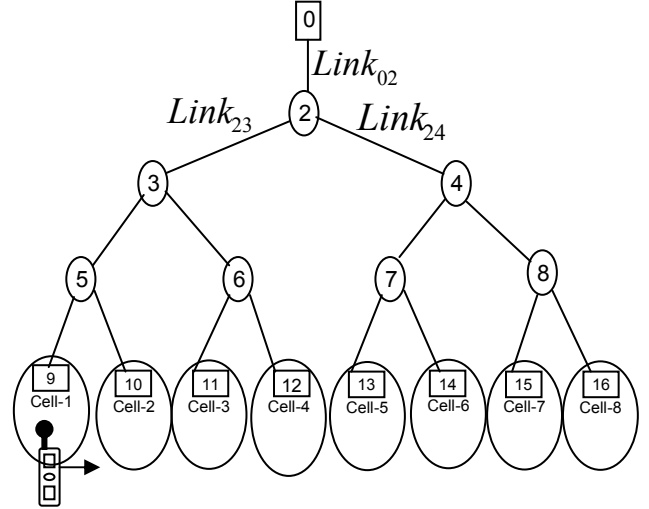


Figure 2: Network Configuration for Simulation.

focused our simulation on the case where MN acts as a receiver. For the proposed model, the VLR resides in node 5, 6, 7 and 8. Although, there are two nodes under each VLR as shown in Fig. 2, but there are seven nodes under a VLR like Fig. 1. The MN is moving in a straight line through four VLRs

The initial location of MN is cell 1, where RSVP negotiation has already been conducted so that a 500 kbps bandwidth is reserved from the CN to cell 1. The MN is supposed to perform the first handoff from cell 1 to cell 2 at 100s and subsequently move through neighboring cells until cell 8 every 10 seconds. As a consequence, the MN encounters seven handoffs totally which are spread 10 seconds apart. There are two major types of links in the network configuration, link₀₂ emulates a link between the CN and the gateway router of edge network through the Internet; all other links resides inside the edge networks. The exact value of these links is not important because our intention is to obtain relative results. link₀₂ is given a link delay of 30 ms while all other links with a delay of 5 ms. The link bandwidth is adjusted for four scenarios according to the different places that traffic congestion might happen at the network [8].

Scenario I: The edge network has sufficient bandwidth and traffic congestion happens at the core network. In this scenario link₀₂ is given 2Mbps and all other links 10Mbps.

Scenario II: The core network has sufficient bandwidth and traffic congestion happens at the edge network. In this scenario link₀₂ is given 10Mbps band width and all other links 1Mbps.

Scenario III: Traffic congestion happens at both networks. In this scenario link₀₂ is given 2 Mbps and all other links 1Mbps.

TABLE I: COMPARISON OF NO. OF CELLS IN THE MG OF DIFFERENT METHODS.

| Method | Is MG formed? | No. of cells in the MG |
|----------|---------------|------------------------|
| FT | No | N/A |
| HMIPv6 | Yes | 6 |
| Proposed | Yes | 3 |

Scenario IV: Both parts of the networks have sufficient bandwidth so no traffic congestion happens. In this scenario all links are given 10Mbps.

A. RSVP signaling delay, binding update delay, and call blocking probability

The RSVP signaling delay is the time from the MN entering a new cell to resources being successfully reserved at the new path of the flow.

Binding Update (BU) delay $d_{binding_update}$ can be calculated as follows:

$$d_{binding_update} = \sum_{i=1}^n \left(\frac{s_{binding_update}}{bw_{link_i}} + d_{link_i} \right) \quad (2)$$

Where, $s_{binding_update}$ is the BU packet size. bw_{link_i} is the bandwidth of link i . n is the number of links that the packet traverses, and d_{link_i} is the link delay of the i^{th} link. Handoff RSVP signaling delay (Signaling Delay) d_{RSVP}

$$d_{RSVP} = t_w + d_{Path} + d_{Resv} \quad (3)$$

Where, t_w is the waiting time before the handoff *path message* is sent. d_{Path} is the delay for transmission of the *path messages* along the new path after handoff. d_{Resv} is the delay for processing the *resv messages* along the new path after handoff. The *path message* delay incurred in link 02 , d_{Path} can be approximated as follows

$$d_{Path} = \frac{s_{path}}{bw_{RSVP}} \quad (4)$$

Where, s_{Path} is the size of *path message* which is 164 bytes for IPv6. bw_{RSVP} is the bandwidth reserved for RSVP messages to prevent them from getting lost in case of congestion and is set to 1000bps in our simulation.

Call blocking probability depends on the amount of resource pre-reservation and the number of active simultaneous mobile calls. More resource pre-reservation

increases call blocking probability. Also if the total number of active calls at any time exceeds the maximum capacity, it forms blocking.

Erlang's formula [9] states that the blocking probability b is

$$b = \frac{(\lambda\tau)^C}{C!} \left(\sum_{n=0}^C \frac{(\lambda\tau)^n}{n!} \right)^{-1} \quad (5)$$

Where, $\lambda\tau$ = Average no. of call arrival to any cell during interval $[0, \tau]$

C = Maximum no. of call supported by the bandwidth of a certain cell

But for this simulation the equation is modified as follows

$$b = \frac{(\lambda\tau)^K}{K!} \left(\sum_{n=0}^K \frac{(\lambda\tau)^n}{n!} \right)^{-1} \quad (6)$$

Where,

$$K = C - r - \frac{Max}{Link02} - \frac{Max}{Link23or24} \quad (7)$$

r = Total no. of pre-reservation holds in a certain cell made by other cells

Max = Maximum bandwidth of the simulation (10Mbps)

Link02 = Bandwidth of the link Link02

Link23or24 = Bandwidth of the link Link23 or Link24 (Actually they are same)

B. Performance Evaluation

Table I compares the no. of cells in the MG among FT, HMIPv6, and proposed methods. It shows that only HMIPv6 and proposed method use MG and the proposed method reduces 50% cells in the MG compared to HMIPv6.

Fig. 3 shows that the handoff signaling delay of proposed method for scenario I, II, III and IV are always smaller than that of the existing methods for 110s, 130s and 150s and equal to that of FT method. It is also smaller than that of the HMIPv6 method for 100s, 120s, 140s and 160s. The reason behind this that the proposed method pre-reserves the resources only for the inter-subnet handoff at time 110s, 130s and 150s only to the newly added path instead of whole path between CN and MN and all the handoff signaling is handled by the NCR. But, FT method does not pre-reserve the resources to its future locations although its handoff signaling is handled by the NCR, and HMIPv6 pre-reserve the resources only to the newly added path between CN and MN but its handoff signaling is maintained from end-to-end. For intra-subnet handoff at time 100s, 120s, 140s and 160s, the proposed method do not pre-reserve the resources to its future locations and handoff signaling is handled by NCR like FT, but for HMIPv6, the handoff signaling is performed end-to-end although it

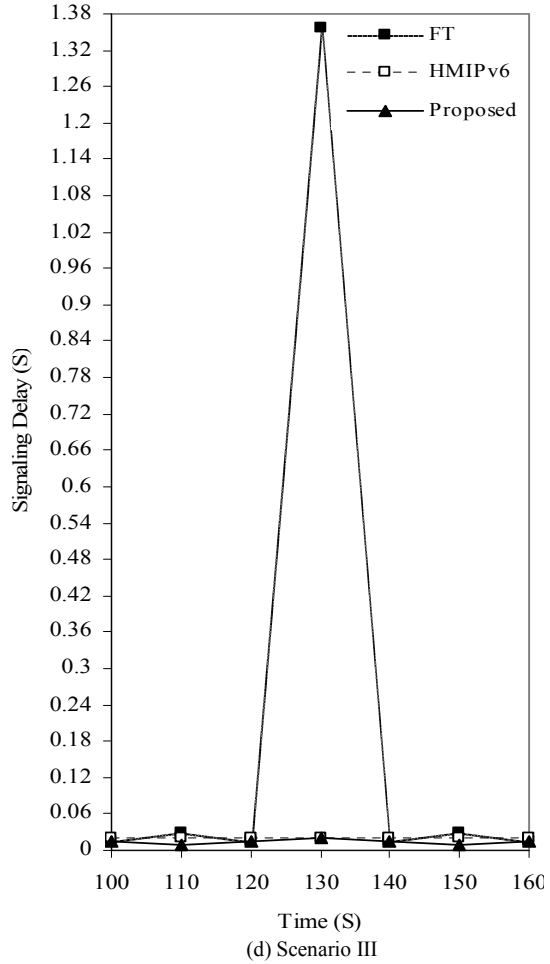
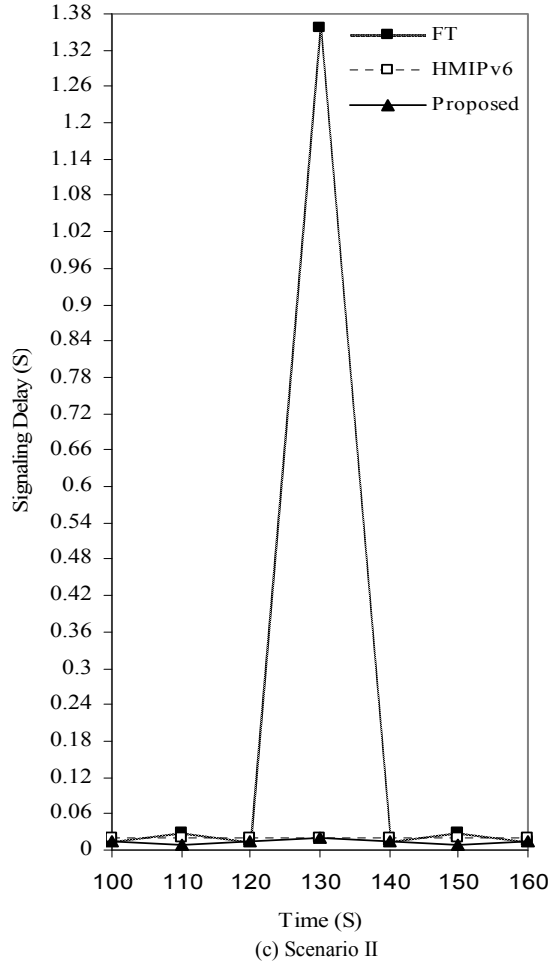
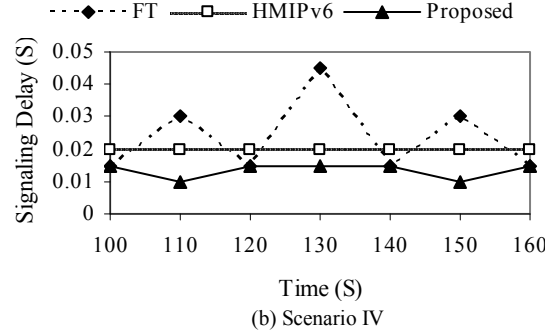
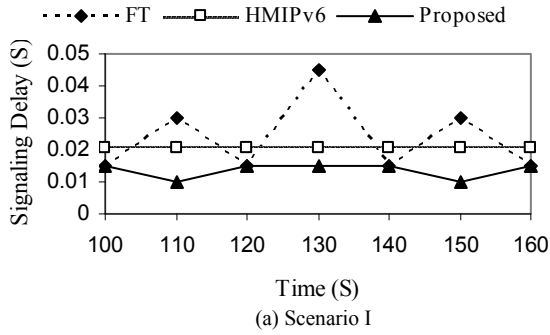


Figure 3: Handoff signaling delay for four scenarios.

pre-reserve the resources only to the newly added path between CN and MN. At 130s for Scenario II and III, the handoff signaling delay is much more than that of all others, because in these two Scenarios $Link_{23}$ and $Link_{24}$ are congested and an inter-subnet handoff is performed.

Fig. 4 shows that the call blocking probability of proposed method for scenario I, II, III and IV lies between FT and HMIPv6 and like a saw tooth shape which are equal to the FT method for intra subnet handoffs. The reason behind this that the values of r for proposed method is 0 and 3 for intra-subnet and inter-subnet handoffs respectively.

But, the value of r is 0 and 6 for FT and HMIPv6 respectively for both intra-subnet and inter-subnet handoffs. In this simulation the value that is used for C is 36.

IV. CONCLUSIONS

This paper examined the existing problems of RSVP for providing real-time services in wireless mobile networks. HMIPv6's pre-reservation exhibits high call blocking probabilities, and end-to-end RSVP signaling exhibits more RSVP signaling delays. FT method does not pre-reserve resources to MNs future locations and RSVP signaling is

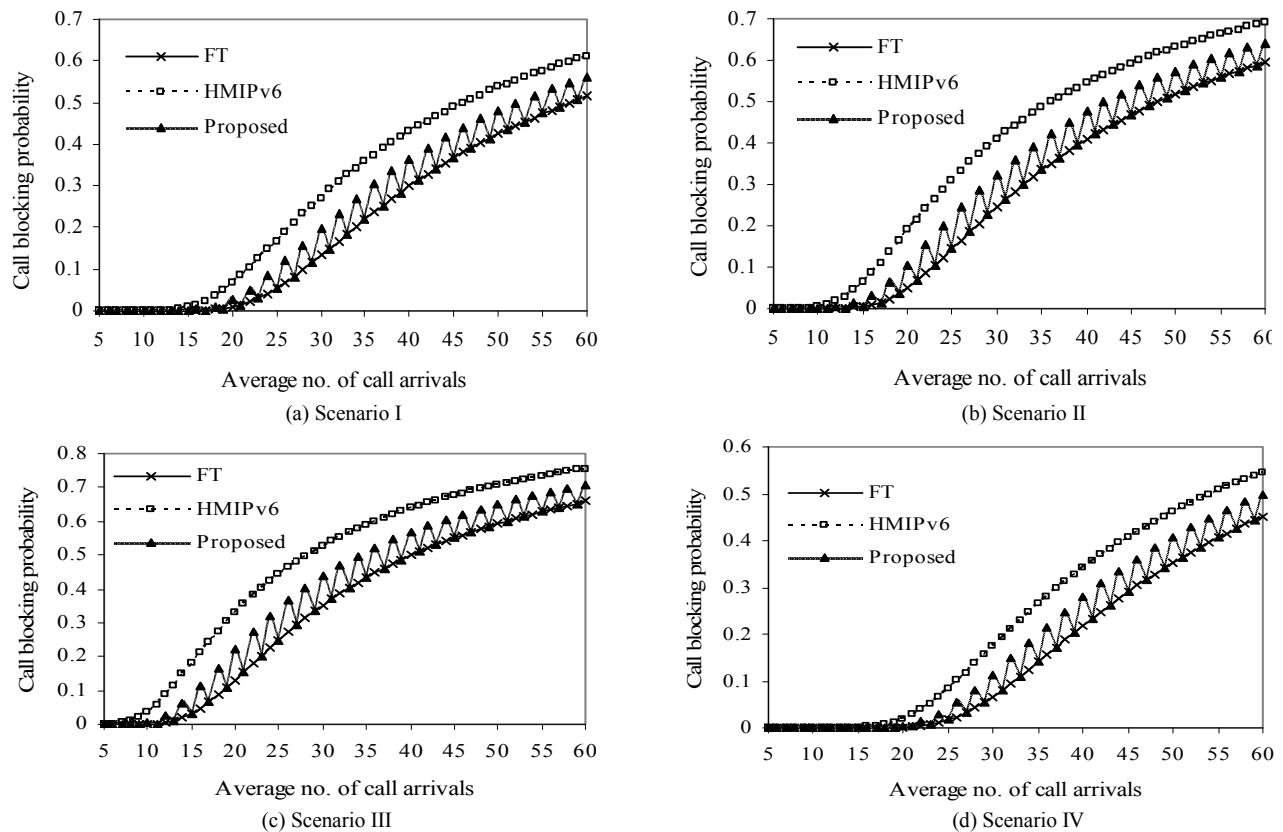


Figure 4: Call blocking probability for four scenarios.

performed only to the newly added path instead of whole path between CN and MN which is formed due to handoff, but exhibits more delays for inter-subnet handoffs and low call blocking probabilities for both intra and inter-subnet handoffs. To minimize the call blocking probability and RSVP signaling delay, a flow transparent multicast pre-reservation method is proposed. In this method, resources are pre-reserved to a MG of cells when the MN resides in a BC and is ready to perform inter-subnet handoffs towards that MG. For both intra and inter-subnet handoffs, RSVP signaling is performed only to the newly added path between CN and MN and there is no pre-reservation in case of intra-subnet handoffs. Simulation results demonstrate that, it performs low call blocking probabilities in case of intra-subnet handoffs due to its no pre-reservation; and low RSVP signaling delay for both handoffs due to its exchange of RSVP signaling only to the newly added path between CN and MN. It also shows that the total number of cells in a MG is smaller than that of existing methods which uses MG.

We are currently investigating into the issues related to mobile tracking algorithm and its implementation to find the exact movement of MN during handoff to pre-reserve the resources only to the exact cell instead of MG. The successful implementation of this algorithm to the proposed method will exhibit the low call blocking probabilities.

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