RSVP for QoS in Mobile Networks

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Abstract: *Real-time applications are an essential part of computing. Nowadays, Internet access through mobile devices has become commonplace. Providing real-time applications on mobile devices requires the similar QoS requirements as in the wired network. Reservation Protocol (RSVP) is the standard for QoS guarantee for the Internet. But, the mobile environment has its own impairments, and hence the present version of RSVP cannot be directly employed to the mobile networks. MRSVP and HMRSVP are two, similar, models proposed to make these enhancements to RSVP. Although they do not comprehensive address all the issues, many issues are solved. Furthermore, issues like resource pre-reservation, RSVP message tunneling, common path identification and mobile proxy are introduced. This is a survey of issues and proposed solutions in adapting RSVP to Mobile Networks.*

1. Introduction

Quality of Service is essential for real-time applications like audio and video applications. As the world goes mobile and wireless internet is becoming an essential part of life providing services like video conferencing and other real time services on mobile devices is becoming vital. There is a growing need to provide Quality of Service (QoS) for mobile and wireless applications due to increase in real time applications and availability of wireless networks.

In wired networks the basic way to provide QoS is to provide differential service for certain packet level or session level treatment for: (1) giving one user priority over another and/or (2) to control the bandwidth usage for certain users so that QoS can be assured. Traffic management to provide differential services follows two different approaches:

(1) The Integrated Services (IntServ): this is a reservation based model where the network resources are explicitly identified and reserved. Network nodes classify incoming packets and use the reservations to provide QoS.

(2) The Differential Services (DiffServ): this is a reservation less model in which resources are not explicitly reserved. Instead, traffic is differentiated into a set of classes and network nodes provide priority based treatment on these classes.

Currently both these methods are used for wired networks, but with the growing popularity of the wireless networks it is important to extend them to the wireless networks.

In this paper I intend to survey the proposed mechanisms for QoS for Mobile Networks by enhancing the Reservation Protocol (RSVP). The paper starts with a brief introduction of RSVP. Section 3 gives a short description of MRSVP which seems to be the most inspiring model proposed since many other models are based on enhancing and rectifying this model. Section 4 describes HMRSVP which uses the hierarchical subnets to rectify certain drawbacks in MRSVP. These models will bring into perspective the issues with RSVP in Mobile Networks. Section 5 some prominent issues and states some solutions to it.

2. Mobility and RSVP

RSVP is a signaling protocol for Internet resource reservations. It supports unicast as well as multicast communications. Two types of messages, PATH and RESV, are used in RSVP to setup resource reservation states on the nodes along the path between a sender and a recipient. Initially, the sender sends a PATH message to the recipient to find a path from the sender to the recipient for a specific flow. When a router receives a PATH message, it will record which upstream router the PATH message was received from and forwards the PATH message to a downstream router. The PATH message is then passed from one to another downstream router and finally received by the recipient. The recipient will respond with a RESV message to make a resource reservation for the specific flow. The RESV message will be transmitted in reverse along the same path as the PATH message was originally transmitted. Upon receiving a RESV message, each router or host on the path will reserve resources for the specific flow if sufficient resources are available.

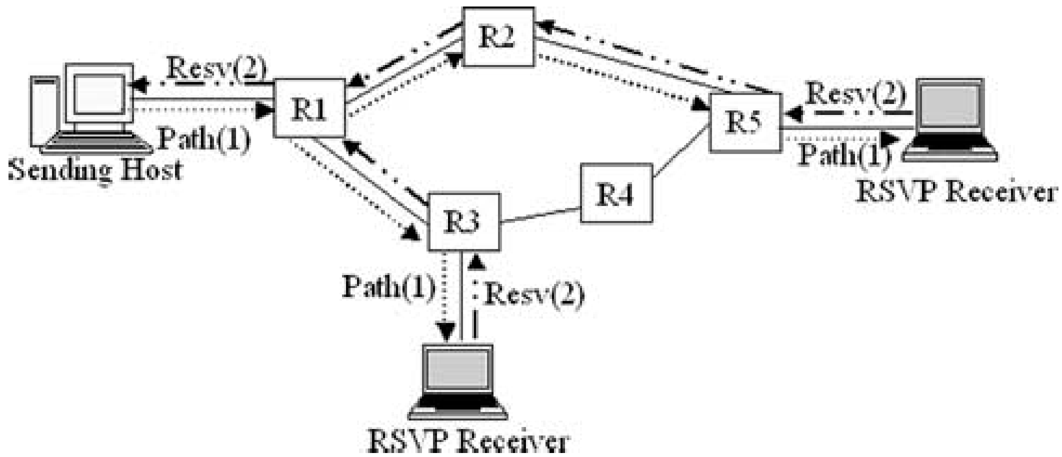


Figure 1. RSVP operation example.

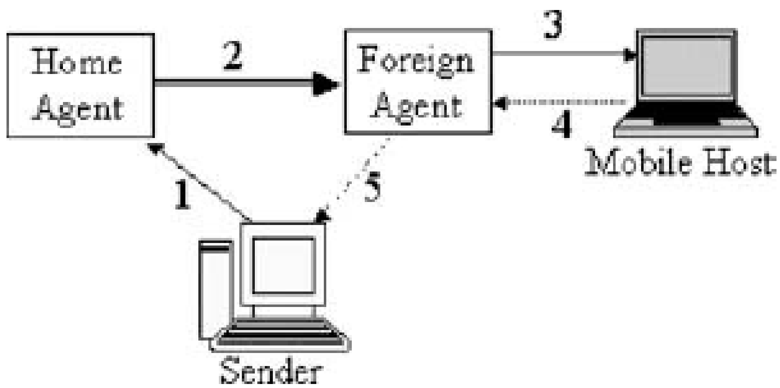


Figure 2. Datagram routing in MIP.

Impact of Mobility on RSVP:

- RSVP is not aware of mobility. According to the original RSVP signaling protocol, the resource reservation path cannot be dynamically adapted along with the movement of a mobile host. When the mobile host (MH) handoffs to a new region, its prior reserved resources are no longer available and the service quality of the MH may degrade significantly due to the lack of resources reserved for the MH in the new region.
- IP-in-IP makes RSVP messages invisible. Mobile IP uses an IP-in-IP encapsulation technique to route IP packets correctly to an MH that is away from its home network. If the RSVP protocol is applied, RSVP messages, PATH and RESV, will be encapsulated in an IP-in-IP encapsulated packet with a protocol

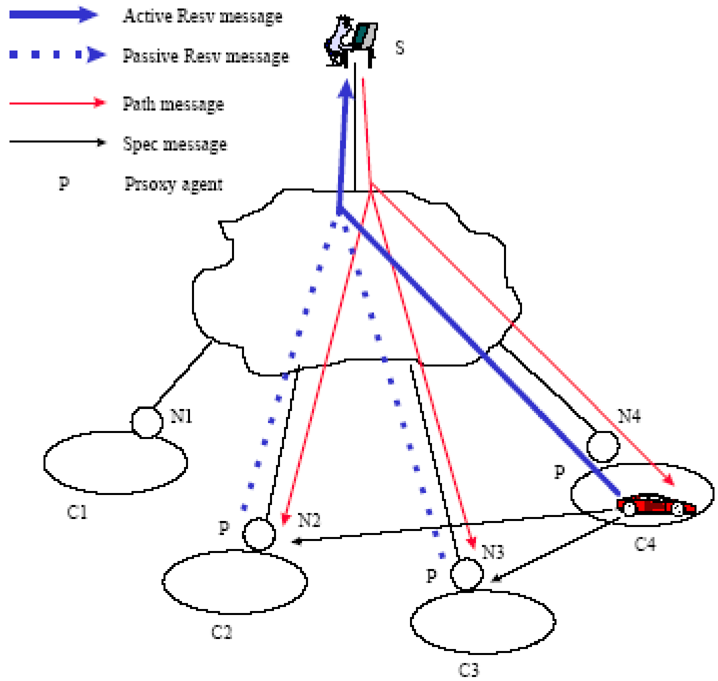
number as integer 4 in the outer IP header, concealing the original RSVP protocol number 46 in the inner IP header. As a consequence, the routers on the path of an IP tunnel cannot correctly recognize RSVP signals to provide the required QoS.

3. MRSVP

Mobile RSVP (MRSVP) is proposed by Talukdar et al. an extension to RSVP in mobile networks. It relies on RSVP to make the basic resource reservations and furthers it by making advance reservations in the locations where the mobile node (MN) might traverse. This is done by employing the *Mobile Specification* (MSPEC) which has the set of locations the mobile host will visit while it participates in the flow. Thus, the MN can achieve the QoS when it moves into a new location since the resources are reserved in advance.

MRSVP uses proxy agents to make reservations along the paths in the MSPEC. MRSVP proposes two types of reservations – active reservation and passive reservation. Active reservation is sent by the MN from its current location, done by *local proxy agent* and passive reservation is made from the MSPEC of the MN to the locations in the MSPEC, done by *remote proxy agent*. Proxy agents are discovered using the *Proxy Discovery Protocol*. The MSPEC is updated and is sent as a *Receiver_MSPEC* message to the sender that initializes the flow to the MN. The sender examines the *Receiver_MSPEC* message and obtains the locations where the recipient MN may possibly visit. The MN also sends a *Receiver_SPEC* message to all remote proxy agents recorded in MSPEC. The remote proxy agents retrieve the QoS-guaranteed parameters for the recipient MN. PATH and RESV messages are exchanged between the sender and recipient to make an *active resource reservation* from the local proxy agent of the sender to the local proxy agent of the recipient. The *passive resource reservation* paths are built from the remote proxy agents of the sender to the remote proxy agents of the recipient. Thus the active reservation path is the only path on which the packets are actually transmitted and the passive reservation paths are only reserved in case the MN moves to that location, and do not have and packets transmitted on them. When the MN moves to a new location, MRSVP changes the passive reservation of the new visited location into an active state and the original active reservation is altered into a passive state. In this way, the needed resources for the MN in the new region can be retrieved rapidly because the resources were preserved in the original passive reservation path. Thus a seamless handoff for QoS guarantees can be retained using the MRSVP protocol.

MRSVP introduces additional messages to the existing RSVP messages. There are two types of Resv messages: *Active Path, Passive Path, Active Resv, And Passive Res.* Other messages are: *Join_group*- This message is sent by a mobile receiver to its remote proxy agents to request them to join a multicast group. It contains the multicast address of the group to join. *Receiver_Spec*- This message is used by a mobile receiver to send the FLOWSPEC and the flow identification (i.e. the SESSION object) to its remote



Mobility specification of the mobile host is C1, C2 and C3.
Spec message is sent to the remote proxy agents at nodes N2 and N3.
Active Resv message is sent from the mobile host via node N4.
Proxy agents at nodes N2 and N3 send Passive Resv messages.

proxy agents. *Sender_Spec*-A mobile sender uses this message to send its SENDER_TSPEC, ADSPEC and the destination address of a flow to a proxy agent. *Receiver_Mspec*-This message is used by a mobile host to send its MSPEC to the appropriate node who sets up the routes of active and passive reservations. It contains the addresses of proxy agents of the locations in the MSPEC of the mobile host. *Sender_Mspec*- This message is used by a mobile sender to send its MSPEC to a proxy agent, which sets up the routes of active and passive reservations for the mobile sender. *Forward_Mspec*- This message is used by a mobile sender to forward the MSPEC of a mobile receiver to its local proxy agent. *Anchor_Spec*-This message is used by a sender_anchor to forward the flow-specific information to the mobile sender and its proxy agents. *Terminate*- This message is used by the mobile host to request its remote proxy agents to terminate reservation.

This model solves the timing delay problem for QoS reestablishment.

4 Hierarchical MRSVP (HMRSVP)

MRSVP has the following disadvantages:

- It demands too much bandwidth in making advance resource reservations. This excessive resource waste may degrade system performance significantly.
- RSVP has to be enhanced to support passive reservations.
- The introduction of several proxy agents together with their communication protocol augments the complexity of the network.
- MRSVP is that it relies on the MH to supply its mobility specification

HMRSVP solves few of the above mentioned problems with MRSVP. HMRSVP uses the hierarchical concept of Mobile IP regional registration and makes advance resource reservations for an MH only when the MN visits the overlapped area of the boundary cells between two regions. As the MN enters the overlapped region of the two neighboring cells HMRSVP will establish a passive reservation from the new cell anticipating that the MN will move into the new cell. HMRSVP uses a hierarchy of proxy agents within the subnet. HMRSVP works as follows:

Case 1: Receiver is a mobile

The path from the sender to the receiver has two RSVP tunnels, one from the mobile to the gateway mobility agents (GMA) and other from the GMA to the host. Initially, MN will send a Receiver_MSpec message to inform sender that MN is visiting a subnet within the service area of receiver GMA (GMA1). When the MN is away from home region the HMRSVP will intercept the Active Path message and tunnel it to GMA1 and the HMRSVP module of sender will send a tunnel Active PATH to initiate the reservation of the RSVP tunnel sender–GMA1. Then the GMA1 will send the original message to proxy agent. GMA1 will also send a tunnel Active PATH to initiate the reservation of the RSVP tunnel GMA1– proxy agent. The proxy agent will then decapsulate the end-to-end Active PATH message tunneled from GMA1 and forward the end-to-end Active PATH message to MN. MN will reply with an Active RESV.

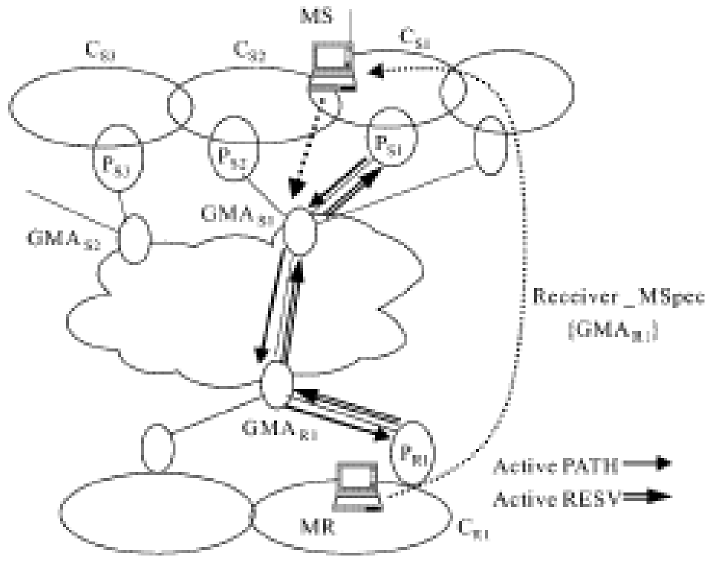


Figure 4. MS makes an intra-region handoff.

Intra-region handoff

When MN moves to the neighboring subnet, the registration message sent by MN is transmitted only up to GMA1. On receiving the registration message, the Mobile IP module of GMA1 informs the HMRSVP module of GMA1. The HMRSVP modules of GMA1 and new proxy agent, by exchanging an Active PATH and an Active RESV message, will establish a new RSVP tunnel between GMA1 and new proxy agent. The original active reservation tunnel from GMA1 to proxy agent will be torn down after the new active RSVP tunnel, GMA1–new proxy agent, is established. The new reservation can be performed very quickly because proxy agent and new proxy agent both reside within the same region served by GMA1.

Inter-region handoff

When MN moves into the overlapped area of the boundary cells it performs a home registration by sending a Multiple Simultaneous Registration to acquire a new care-of-address from the new proxy agent. The new proxy agent will send this registration message to GMAR2, which will then forward this message to MN's HA. The HA will add the GMAR2 care-of-address into the care-of-address list of MN and then return a Registration Reply message to GMAR2. GMAR2 will send this reply message to MN through the new proxy agent. MN then sends a Reciever_Spec message to inform the new proxy agent of the original QoS parameters. MN also sends a Receiver_MSpec{GMA1,GMAR2} message to inform sender that MN is visiting an overlapped area of the boundary cells of GMA1 and GMAR2. On receiving the Receiver_MSpec message, sender tunnels an end-to-end Passive PATH to GMAR2 and GMAR2 in turn re-tunnel the end-to-end Passive message to the new proxy agent. However, the new proxy agent will not forward the original end-toend Passive PATH to MN. Instead, the new proxy agent itself will return an end-to-end Passive RESV to sender through the two RSVP tunnels GMAR2–the new proxy agent and GMAR2–sender. These two RSVP tunnels constitute a passive resource reservation path from sender to the new proxy agent. The passive reservation path from sender to the new proxy agent will be changed to active, whereas the original active reservation path from sender to new proxy agent will be altered to passive.

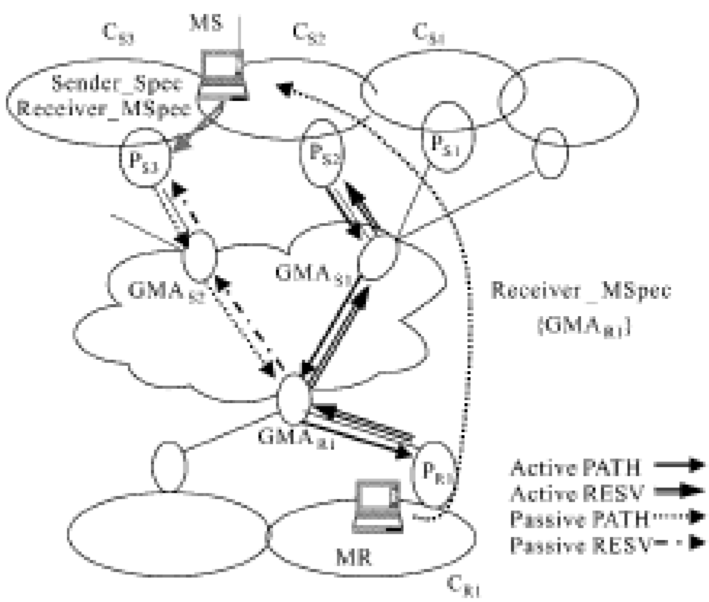


Figure 5. MS makes an inter-region handoff.

Case 2: Data sender is also a mobile:

HMRSVP will establish three RSVP tunnels PS1–GMAS1, GMAS1–GMAR1, and GMAR1–proxy agent along the RSVP reservation path from the sender to the receiver. The registration message sent by the sender is only transmitted through the original proxy agent to GMAS1. When the sender visits the overlapped area of the boundary cells CS2 and CS3 of the regions GMAS1 and GMAS2, respectively, it performs a home registration by sending a Multiple Simultaneous Registration to HA through the new proxy agent and GMAS2. Upon receiving a successful registration from the sender's HA, the sender issues a Sender_Spec message and a Receiver_MSpec message to inform the new proxy agent of the original QoS parameters and the proxy agent of the receiver, respectively. The new proxy agent then tunnels an end-to-end Passive PATH to GMAS2. GMAS2 tunnels the end-to-end Passive message to GMAR1. The resources on the path from GMAR1 to proxy agent are already reserved in advance by the active reservation. Thus, GMAR1 is the end point of a passive RSVP tunnel. The end-to-end Passive PATH is only tunneled to GMAR1, which will then return an end-to-end Passive RESV message to the new proxy agent through the two RSVP tunnels GMAS2–GMAR1 and GMAS2–the new proxy agent. Therefore, only two new RSVP tunnels, the new proxy agent–GMAS2 and GMAS2–GMAR1, will be established and these two RSVP tunnels constitute a new passive resource reservation path from the new proxy agent to GMAR1. The passive reservation path from the new proxy agent to GMAR1 will be changed to active, whereas the original active reservation path from the original proxy agent to GMAR1 will be altered to passive.

5 Issues with Mobility and RSVP

1. ***Resource pre-reservation***

When the MN moves in to the new subnet, i.e. when handoff occurs, the MN has to be provided with identical resources in the new subnet. If this does not happen then the QoS service will be disrupted. This problem is sufficiently solved in MRSVP. But this gives rise to two problems;

- there is wastage of bandwidth in the neighboring subnets
- Predicting the subnets that the MN will visit.

The former is addressed in HMRSVP. The latter can be solved by using a concept of *shadow cluster.* A shadow cluster is a set of cells that will be influenced by the current active cell. Probability theory is used to calculate how many resources should be reserved for each cell in the cluster. Furthermore, Global Positioning System (GPS) or predictive models can be used to predict which cell the MN may move into and thus make reservation for that cell only.

Advance reservation of resources decreases handoff-dropping but increases the new call blocking rate. Solution to this problem is to classify the reserved resources into active, where the resources are currently used by the mobile host, and passive, where the resources are reserved but not used. The passive reserved resources can be used by other hosts temporarily and will be withdrawn from them when the mobile host needs the resources.

2. RSVP tunneling

When a corresponding host sends a Path message to the mobile host, if the mobile host does not reside in its home subnet, the home agent will intercept the message and resend it to the foreign agent by building a tunnel and using IP-in-IP encapsulation. To encapsulate an IP datagram using IP-in-IP encapsulation, an outer IP header is inserted before the datagram's existing IP header.

The original Path message is invisible to the intermediate routers in the tunnel. Thus the RSVP states are not established between the home agent and the foreign agent. The solution is to build an RSVP tunnel between home agent and foreign agent by separately building a RSVP session between the home agent and the foreign agent. This RSVP session can exist independently (pre-configured) from the end-to-end session or it can be triggered by the end-to-end session.

When the mobile host moves to new location, it informs the home agent of its new location with CoA. After the home agent learns about the mobile host CoA, it initiates two actions:

1. It sets up a Tunnel RSVP session between itself and the foreign agent.
2. It encapsulates Path message from the sender and sends them through the tunnel towards the mobile host's new location.

When the foreign agent receives a Path message from the home agent through the tunnel, it decapsulates the message and sends it to the mobile host. Then the mobile host should send a Resv message right away to minimize the disruption of service. When the foreign agent receives a Resv message from the mobile host, it will go through the following processes:

1. It will send a Resv message for the corresponding Tunnel session between itself and the home agent.
2. After sending the reservation request, the foreign agent waits for a confirmation from the home agent that the reservation over the tunnel was successful.
3. After receiving the confirmation for the tunnel reservation, the foreign agent encapsulates the end-to-end Resv message and sends it to the home agent.

Tunnel support for RSVP has the advantages that modification to RSVP is required only at the home agent and foreign agent. No additional change to support tunnel reservations is required at intermediate routers, leading to a simpler deployment.

In MIPv6 the Correspondent Nodes (CNs) usually send packets directly to MN's CoA when the Mobile Node (MN) is the receiver. Mobile IPv6 also substitutes the MN's home address in the source address field of outgoing packets with the MN's Care-of-Address when the MN is the sender, while placing the home address in the Home Address Option in the destination option header. Thus the tunneling problem is eliminated.

3. Common path identification

When a new RSVP reservation path needs to be established due to roaming or pre-reservation, it is highly likely that the new path and old path overlap considerably. Hence, only a small portion of the path needs to set up the RSVP states. The new path and the old path have many common intermediate routers The lowest common ancestor router in the tree from source to the mobile host is called a gateway mobility agent. In MIPv6 the sender uses the Care-of-Address directly in communicating with the mobile host and the Care-of-Address changes frequently and hence cannot be used to identify the common flow and the common path. Instead, flow labels can be used to identify the common flow and find the common path. When the mobile host moves into a new location, the resource re-reservation request is transmitted upstream to the sender. Routers along this request path will examine the request flow label in its flow label table. The first router to find the request flow label in its table is the critical intermediate router.

The critical intermediate router has to release the old RSVP downstream path and send the resource re-reservation acknowledgement to the new downstream routers. The crossover router and the gateway mobile agent do the same work as the critical router.

4. Mobile proxy

RSVP's soft states need to be refreshed periodically. That is, a mobile host needs to transmit constantly for this refreshing. This will deplete the limited battery power of a mobile device. To alleviate this problem, it seems the only solution is to reduce the times that mobile host sends the Resv message or to have someone (some non-battery-powered device) doing this for the mobile host. This device is called a mobility proxy

A proxy agent is said to be a local proxy agent if it is within the subnet where the mobile host currently visits. The proxy agents, which reside within the neighboring subnetworks, are the remote proxy agents. The local and remote proxy agents are recorded in a Mobility Specification (MSPEC). The MSPEC indicates the set of agents where an MH may possibly visit in the near future to assist the resource reservation in advance. The mobile proxy has different capacities and functions. The important problems are where the mobile proxy should reside, what are their functionalities, should there be hierarchies among proxies, and so on. Mostly, the mobile proxy's function is added in the base station or access point. In spite of the function of mobile proxy, the major goal of a mobile proxy is to improve the mobile QoS guarantee.

6. Conclusion

In this paper, I have focused on modifying the RSVP protocol to adapt to the mobile environment. MRSVP and HMRSVP gives an inside perspective to the issues in internetworking RSVP to Mobile IP. Few of these problems have been solved through efforts from the research community, but there is much more to be done. Some of the issues are:

- Timing and extent of pre-reservation – how long before the MN moves into the new cell should the resources be reserved and how much of the resources should be reserved

- Management of common path to reduce passive and active RSVP control signaling- overheads introduced by the new models can be a burden on the mobile, especially considering the limited battery power available to the mobile.
- Designing a mobile proxy that can support mobile RSVP efficiently with minimum system changes.

Most of these problems arise from the fact that the emerging wireless technologies have to merge with the well established wired technologies. Mobile Hosts are generally impaired by factors like low battery power, losses in wireless medium, low bandwidth and mobility. These factors have to kept into perspective.

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