INTEGRATED SERVICES IN MOBILE ENVIRONMENTS

Savitha Ramesh
Department of Computer Science and Engineering, University of Texas, Arlington.
Email: sramesh@cse.uta.edu

Abstract

Integrated Services Architecture can be defined as a framework to provide end-to-end QOS services and it emerged with a motivation to cope up with the real-time QOS demands of the highly sophisticated digital audio and video applications, which is not essentially provided by the Best-Effort service for today's internet. IntServ was also aimed at Controlled link sharing, that is, to manage bandwidth sharing among different traffic classes for a better network utilization. RSVP is the popular protocol that has been promising enough in accomplishing these goals. Yet, the protocol was not designed with mobile environments in mind. Moreover, QOS issues magnify in a mobile environments owing to the constrained resource availability, frequent disconnections and mobility of hosts. Hence this paper emphasizes on the research efforts so far in providing mobility extensions to RSVP.

1 Introduction

Rapid growth of the Internet and most importantly, the advancements in various internet-based applications, have posed various challenges for the service providers, especially in the Quality of Service Management domain. The research aimed at resolving such issues have indeed shown promising results. One of such solutions proposed with respect to the real-time traffic in the internet today is the *Integrated Services (IS)* model. As a first step towards developing this model, the management of resources has been considered as the means to provide service guarantees. The IS model questions the traditional resource guarantee mechanisms in terms of the few assumptions that have been made in its initial design, such as the Availability of infinite bandwidth, adaptive applications and simple priority requirements.[1] The first proposal on the IS model was published in June 1994 as RFC: 1633. Since then, research and deployment of this model has resulted in various developments and also a few arguments relating to the how effective the model is.

Further, the *Resource Reservation Protocol (RSVP*) functional specification was released in September 1997 as RFC: 2205 for the *Integrated Services Packet Network (ISPN)*. RSVP has proved to be quite efficient in fulfilling the QOS guarantees for a traditional internet user. Yet, the need to integrate mobility into the internet, renders the traditional RSVP useless for the mobile users. In the following sections, an effort has been made to explore the work that has been done so far in extending RSVP for mobile environments.

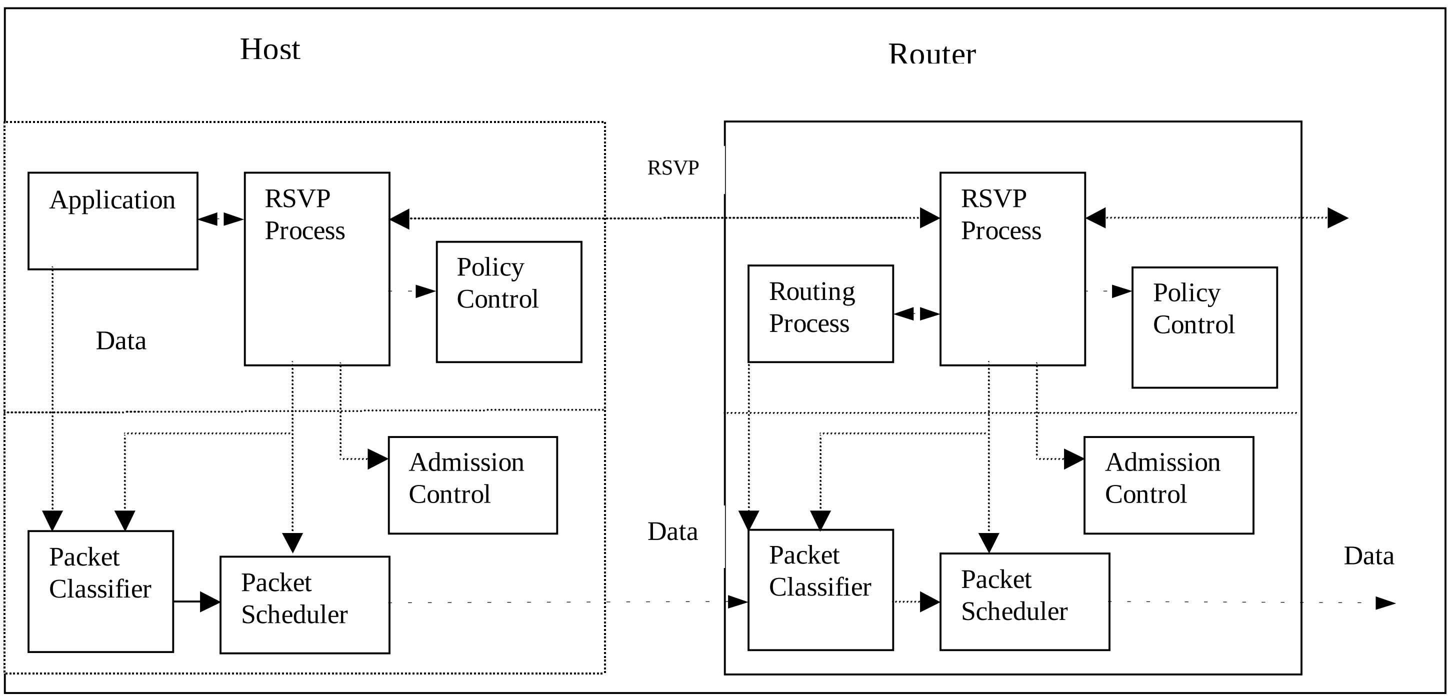
This paper has been organized as follows. In Section 2, the IntServ Architecture is explained briefly, followed by a brief overview of the RSVP standard. In Section 3, various extensions to RSVP necessary to accommodate mobility have been explained. Then in Section 4, the various approaches towards RSVP mobility extensions have been compared and contrasted, followed by discussing a few inferences and conclusions derived.

2 Integrated Services Architecture for the Internet

Integrated Services was introduced as an IETF standard, with an idea to extend the internet architecture mainly for real-time traffic. A few extensions were added to the best-effort data delivery, without modifying the internet architecture itself. The various components of the IntServ framework *(Figure 2.1)* have been identified as: [1]

- Admission Control
- Packet Classifier
- Packet Scheduler
- Reservation Setup Protocol.

Figure 2.1 – RSVP in Hosts and Routers [2]



Admission Control is a per-flow decision algorithm implemented at the routers. This component provides a mechanism to make a local accept/reject decision at the routers based on the QOS request per flow. Additionally, applying any administrative policies, authentication and accounting are the other functions of this mechanism. *Packet Classifier* is used at each router along the path of the flow to classify flows by mapping each incoming packet to a particular classification based on header information and any other classification number, which in turn determines the treatment for that packet local to that router. *Packet Scheduler*, unlike the strict FIFO queuing discipline, which offers the same QOS service to all packets, provides variable queuing mechanisms to provide different QOS for different flows. This is called Traffic Control. [1]. The last component is *the Reservation setup protocol*, namely the RSVP, which has been presented in the following section, based on RFC 2205.

2.1 Resource Reservation Protocol (RSVP)

RSVP works as a transport protocol and has been designed to work for both Ipv4 and Ipv6. As the name implies, this protocol works to reserve resources for single/multiple receivers along the path of the data flow and this is accomplished by establishing sessions. It works in coordination with the other three components of the IntServ architecture and provides the flow setup for the requesting receivers. Each RSVP session is identified by a 3-tuple [2]: *(DestAddress, ProtocolID, DstPort)*

2.1.1 RSVP Messages and Reservation Setup

It should be noted that RSVP also supports multiple-to-single point transmissions in addition to point-point and point-to-multipoint flows. In RSVP, the reservation setup is primarily done using two messages sent as IP Datagrams: *Path* message from sender(s) to receiver(s) and *Resv* messages from receiver(s) to sender(s).

A Path message contains

1. *Sender Template*, which is used like a Filter Spec to select a sender's packets during a session.
2. *Sender Tspec* that Specifies the Traffic characteristics of the packets generated by the sender.
3. *Adspec* namely the Advertising information used to predict end-to-end QOS information from time to time.

A Resv message from a receiver carries a Flow Spec along with a Filter Spec.

1. *Flow Spec* includes a RSpec (R for Reservation) which specifies the desired QOS and a Tspec (T for Traffic) which describes the data flow.
2. *Filter Spec* is a part of a session specification, that defines the set of data packets for a particular Flow Spec,. This helps to set parameters in the packet classifier and select a sub-set of packets based on the Sender Template.

Following are the steps towards resource reservation setup and data flow in a RSVP Session. [2]

1. Receiver joins a multicast group using IGMP.
2. Sender starts sending RSVP path messages to the DestAddress (Multicast address)
3. On receiving a Path message, the receiver sends Resv message with desired Flow Specifications (Flow Spec).
4. On receiving the Resv messages, sender starts sending data packets.

However, the above steps need not to be followed strictly in the same order. Path message and Data packets can be transmitted together by a sender, even before Resv messages may be received. In such cases, data packets might be dropped before receivers appear or a few packets may not be delivered with desired QOS, as the sender will not be aware of the receivers' Flow Spec until the Resv messages are received.

2.1.2 Management of Reservations.

The reservation process as explained in the previous section is only a basic specification about the protocol functionality. There is more to the protocol than just setting up a preliminary reservation path. The various scenarios envisioned by the Working group towards managing the reservation path are as follows:

1. In the event of multiple reservation requests in the same session with the sane Filter Spec at a particular interface, RSVP sets up only one reservation. And this is done by merging Flow Specs. The largest of the Flow Specs is found and forwarded further.

2. In the process of setting up a path using Resv and Path messages, a "Soft State" is created in the routers along the reservation path. Periodic Resv and Path messages refresh this state. After a "Cleanup Time Interval" [2], if a matching refresh message is not received for a particular soft state, it is deleted.

3. Soft state can also be updated by sending revised Resv and Path messages, in the event of any changes in the QOS request or set of senders during the same session. This mechanism thus proves to be dynamic.

4. For terminating a reservation session, a "Teardown" message may be sent from a sender or receiver. This deletes the reservation states at the routers for the particular session along the path.

5. PathErr and ResvErr are the two RSVP error messages sent to a sender and receiver respectively, when there is a failure in setting up the path.

3 Why extend RSVP to Mobile Environments?

RSVP as an efficient protocol for real-time QOS guarantees is definitely questioned due to the various shortcomings such as the overhead of maintaining a soft state at every router along the reservation path, providing only for simplex data flows and the message overhead required to maintain the soft state updated. Yet, the following are some of the RSVP characteristics favoring its use in mobile environments.[2]

1. The first observation made about RSVP is that it has been designed to work on both Ipv4 and Ipv6.
2. It can inter-operate with the existing and future unicast and multicasting protocols in the internet.
3. Also RSVP is not a routing protocol, but depends upon present and future routing protocols.
4. A variety of applications can be supported by RSVP, as it makes use of reservation styles that suit different application needs.
5. RSVP also works well for dynamic group membership and heterogeneous receiver requirements.
6. RSVP's reservation overhead turns out to be logarithmic rat her than linear in the number of receives, because in this model, the receivers initiate the request and the request is carried along the reverse data path, only till the path joins the multicast distribution tree.

The main reason RSVP does not accommodate mobility can be understood when there is a hand-off of a mobile host. If the user makes a resource reservation in a domain, it has to re-establish reservations once again when it moves into a new domain. This involves a lot of message overhead and packet losses, which is totally undesirable. Also a similar QOS cannot be assured in all the domains.

The following sections explore the different models proposed to resolve the above problem and make RSVP work well in mobile environments.

- Token-bucket Filter Approach
- Neighbor Mobility Agent Discovery and Mobile Reservation Update Protocol
- Mobile RSVP Protocol
- Hierarchical Mobile RSVP Protocol

3.1 A Token-bucket Filter Approach [4]

In this approach, the authors propose a service model based on guaranteed and predictive services. However, assumption made in this model is that , mobility of a user is predictable. Three service classes, that a mobile user may subscribe to., have been defined.

- Mobility Independent Guaranteed Service. (MIG)
- Mobility Independent Predictive Service.(MIP)
- Mobility Dependent Predictive Service. (MDP)

The MIG model provides *guaranteed* service for *intolerant applications* that need absolute bound on packet delay, while the MIP and MDP models offer *predictive* service to *tolerant* applications that can compromise on services occasionally. To build the above models, it is not enough to reserve resources only from sender to the current location of the mobile host, but also in domains that the mobile host is expected to visit over time. This results in classifying the flow into Active and Passive types.

3.1.1 Flow Types

In Active flow, the path is currently reserved and used by a particular flow whereas in Passive flow, reservation is active, yet there is no data flow for that session over that path, thus characterizing advanced reservation of resources in all potential domains that a mobile user may visit in future. The scheduling algorithms for such flows have also been given. For guaranteed service, a Weighted Fair Queuing Algorithm is used while FIFO discipline is used in the predictive service models.

3.1.2 Admission Control Scheme

The admission control scheme has been designed to scale across numerous mobile users. The scheme follows a token-bucket filter approach in which the bucket of depth *b* is said to generate traffic at a rate *r* as long as the bucket is full (b *tokens*). A packet is said to be admitted into the network only if there are enough tokens in the token bucket (*r,b*) whenever a packet is generated.[4] For all the three service models, the criteria to admit a particular traffic flow is determined by the admission control scheme, that replaces the worst case delay computations for each type of service model by an equivalent token bucket filter [4]. Hence admitting a flow in a cell is determined by checking if the targeted link utilization of a link does not exceed and also that the requested delay bounds of the existing and new delay bounds of service models are not violated.

3.1.3 Handling Hand-offs

When a mobile user switches cells, prevention of violations to MIG and MIP services are given priority. Also existing flows, which may have been passive, are given preference over new flows.

Further to accommodate a high priority service model, the MDP class traffic is converted to Best-effort traffic if necessary.

Further in this research, simulation experiments are being conducted to test the service model proposed in the paper.

3.2 Using Neighbor Mobility Agent Discovery and Mobile Reservation Update Protocol [5]

This approach is also based on providing passive reservations over the domains that a mobile user may visit during a session. They use two simple protocols namely: *Neighbor Mobility Agent Discovery* and *Mobile Reservation Update Protocol* to achieve the reservations. The key reasoning this paper is based on is that, a mobile user is more likely to move to the neighboring domains, rather than to a far off domain and hence the authors propose mechanisms to reserve resources only in the neighboring domains.

3.2.1 Neighbor Mobility Agent Discovery Protocol (NMADP)

This protocol works above the Mobile IP where the mobility agents (MA) which may be a Home Agent (HA) or Foreign Agent (FA) in the neighboring domains discover each other. This is achieved by considering two different scenarios: One in which the neighboring routers know of each other – *Direct method* and the case in which routers do not know of each other – *Indirect method*. In the Direct method, each MA sends a *Neighbor Mobility Agent Message (NMA)* to its neighboring router. If the receiver router is also a MA, it records sender NMA and responds with an acknowledgement with its own mobility handling capability.

In the Indirect method, the routers do not know of each other. Hence they use *Distributed Discovery* and *Centralized Discovery* to find the neighboring MA s. In the Distributed approach, a MA discovers neighbors while it plays the role of HA. When a mobile host with an open connection moves to a new domain, the HA of this host discovers a neighboring agent from the registration request sent by that FA. However in this approach, as prior reservations were not made in a new domain, the issues of hand-offs and re-establishment of reservations persist. The NMA information matures over a certain period of time.[5]. In the centralized approach, the HA can discover hidden neighbors over a period of time. For example, a host moves from home domain to foreign domain with FA1, the NMA information is achieved by distributed discovery. Again on moving to a domain with FA2, HA discovers FA2 as its neighbor too. Now HA can initiate NMA information between FA1 and FA2 [5]

3.2.2 Mobile Reservation Update Protocol (MRUP)

This protocol has been aimed at providing the resource reservation assurances through out the lifetime of an open session, even when the user moves from one subnet to another. Three different states are associated with each resource in a domain and state transitions among states are made. A resource at any time may be *free, reserved or in-use*. This mechanism also described the way in which passive reservations are made and when they are converted to active flow paths. Following are the steps taken by the MRUP for resource reservations.

1. When a mobile host requests a guaranteed connection, any available free resources are set to in-use, otherwise request is denied.

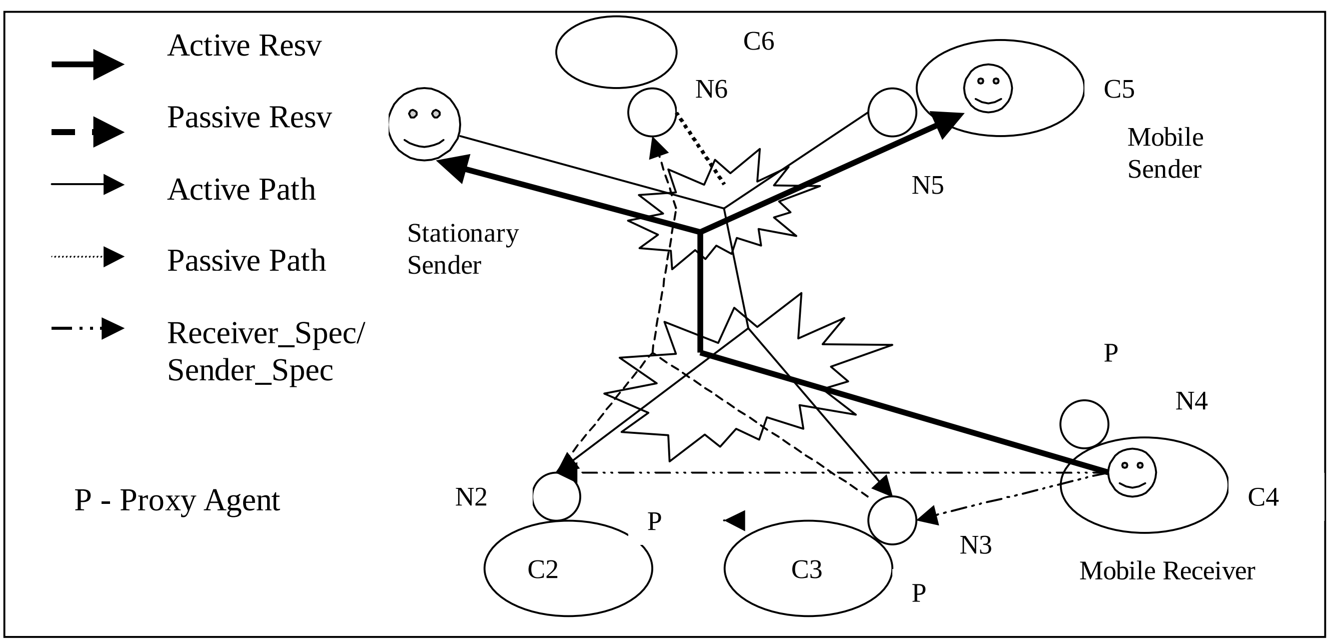
2. On accepting a request, a Reserve Resource Message is sent to its neighboring MAs with the information about resources requested by the mobile host, so that passive reservations can be set up in the neighboring domains.
3. Reservation Refresh messages are also periodically sent to the neighboring MAs, until it finds that the host is no longer in its subnet.
4. On receipt of Reserve resource message, a few resource states are changed from free to reserved.
5. When a MA receives a registration request from a mobile node, if there is an already existing resource reservation for that host, the state of the resources is changed from reserved to in-use.

Simulation experiments for the model have been presented but they are very limited. Only a single cell has been simulated and also call dropping probabilities have been measured for scenarios with and without reservations. The experiments demonstrate that hand-off real time calls may be dropped as non-real time calls are not preempted in a no-reservation mechanism. However, number of hand-off calls dropped significantly reduces when using prior reservations.

3.2 Mobile RSVP Protocol [3]

In this protocol, use of proxy agents has been stressed upon to make reservations for receivers when both the sender and the receiver may be mobile. A proxy discovery protocol is said to discover the IP addresses of the proxy agents. In addition, there are *Active* and *Passive path* messages and Active and Passive Resv messages.*(Figure 3.2.1)* Other messages added to the RSVP message set are *join_group, Receiver_Spec, Sender_Spec, Receiver_Mspec, Sender_Mspec, Forward_Mspec and Terminate.* Authors propose two designs for Mobile RSVP.

Figure 3.2.1 – MRSVP Overview [3]



In Design I, following are the cases considered. *Sender is Mobile*: Local proxy agent acts as a sender anchor node to handle unicast and multicast flow. *Receiver is mobile*: A receiver anchor node is used which may be a proxy agent in the home-subnet or the Sender anchor node when the sender is mobile. For multicast flows, two messages are sent by the mobile host – Join-group message with multicast address of the group and Receiver_Spec message with flow specification to each of its remote proxy agents.

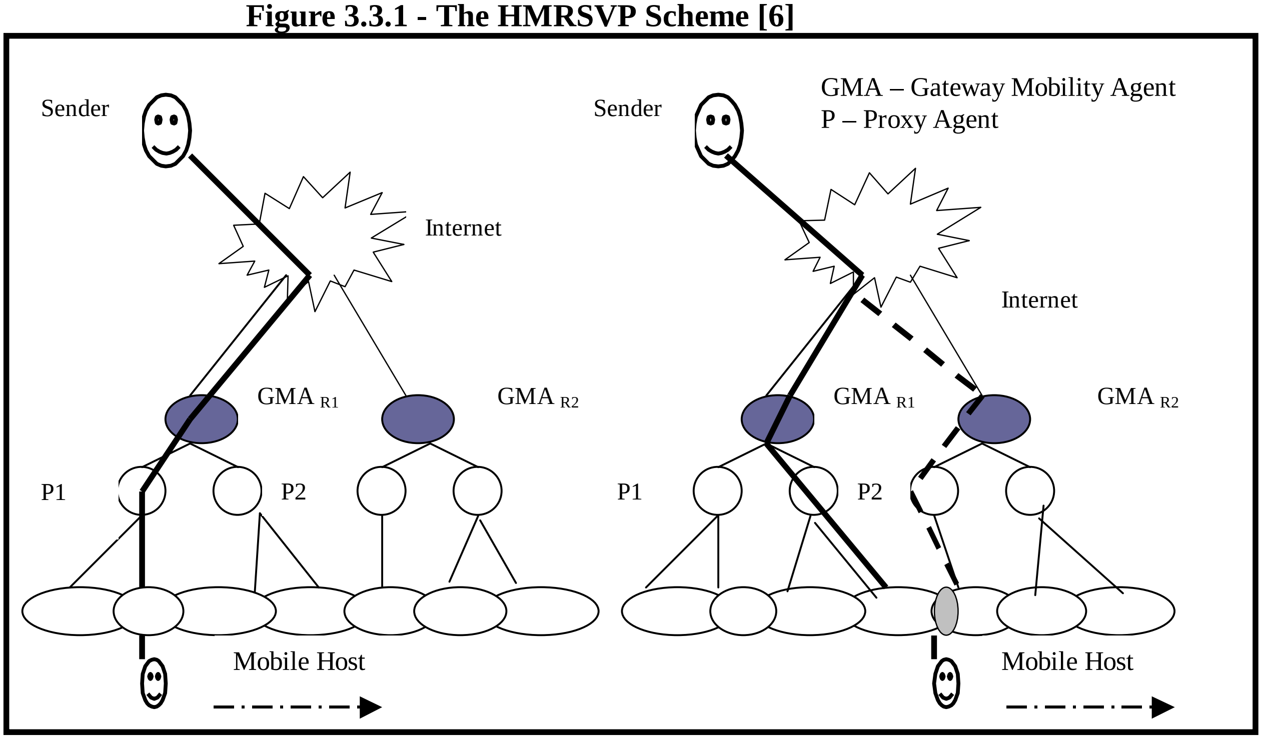
In Design II, again both the cases of sender and receiver mobility have been considered. Yet, an effort has been made to improve network utilization, by using some additional objects in RSVP messages and also by extending the message processing at the routers. MOBILE_ID is the RSVP object used with the active and passive path messages. This object contains the home IP address and the RSVP source port number of the mobile sender. This object may also be used to forward Resv messages when there are mobile receivers.

The status of this research has been stated to be proceeding in lines of implementation of the protocol and also investigations of the issues related to scalability and security.

3.3 HMRSVP : Hierarchical Mobile RSVP Protocol [6]

This approach demonstrates enhancements to the above approaches by overcoming a few shortcomings in them. The assumption made about mobility of hosts in the previous approaches is questionable. In HMRSVP, this assumption is replaced by making resource reservations by predicting if an inter-region movement may actually happen, instead of relying on mobility specifications. The prediction about inter-region movements is made when the mobile host finds itself in the overlapping areas of two cells. Passive reservations are not made until the host moves into this overlapping region and thus preventing excessive reservations in advance. This is achieved by deploying the hierarchy of Gateway mobility Agents (GMA) and Proxy Agents (P) GMAs perform the regional tunneling for all mobile hosts in the subnets. An active reservation in this model is defined as the combination of GMA-P tunnel with end-to-end RSVP tunnel. *(Figure 3.3.1)*

Figure 3.3.1 - The HMRSVP Scheme [6]



When the receiver is mobile, the resource reservation in the new domain takes place in conjunction with the process of hand-off performed by Mobile IP. The receiver sends Receiver_Spec message to the new Mobility Agent, when it enters the overlapping area. Once the host has completely switched domains, passive state is changed to active state.

When the Sender is Mobile, multiple RSVP tunnels may be built as the sender keeps moving. Once a tunnel is established between a GMA and Proxy Agent, the previous one is torn down. Passive reservations that occur at the over-lapping regions are converted to active ones when the node completely enters the foreign domain.

Simulation experiments for this proposal have been performed using NS2 and results have been presented for HMRSVP, MRSVP and RSVP. The measurements made were:

- *Reservation blocking probabilities* – Less in HMRSVP than MRSVP, as MRSVP makes excessive reservations in other domains, thus blocking useful reservations.
- *Forced Termination Probabilities* – This was found to be high in MRSVP too, as the offered load is more in this compared to HMRSVP.
- *Session Completion probabilities* – This is a combination of the above two parameters. More the offered load as in the case of MRSVP, lesser is the probability that a session will attain completion.

From the above measurements, authors express confidence in the protocol's efficiency in providing Independent QOS guaranteed services.

4 Comparative Study

In Table 4.1, comparison has been made for various parameters, for the different resource reservation protocols discussed so far.

Table 4.1

Parameter	RSVP	Token-Bucket-Filter Approach	NMADP and MDUP	MRSVP	HMRSVP
Receiver Mobility Support	No	Yes	Yes	Yes	Yes
Sender Mobility Support	No	No	No	Yes	Yes
Host Mobility Assumptions	Assumes Nil Mobility	Assumes that mobility of a host is predictable and depends on mobility specifications.	Assumes that mobility is most probable towards adjacent domains	Relies on Mobility Specifications	Doesn't make any assumption about host mobility until the host starts moving into the new domain area

Passive Reservations	No	Yes. In all the domains specified in the Mobile Specification	Yes. Only in the discovered neighboring domains	Yes. Passive reservations in all domains specified in the Mobile Specificatio n	Yes. Passive reservation only in the domain where the host is most likely to move.
Use of Proxy Agents	No	No	No	Yes. Proxy agents make reservations along all the paths in the Mobile Spec	Yes, Proxy agents along with GMA s are used for RSVP tunneling and also for sender and receiver mobility

5 Discussion

The implementation framework proposed by IETF has worked quite well in traditional Internet and also experiments have been conducted to evaluate its performance in providing a comparable QOS guarantees for real-time traffic when mobile users exist in the network. Study so far on the different protocols proposed to extend RSVP to mobile environments, indeed seem to show promise. Yet, the drawbacks that existed in RSVP are also present in its mobile extensions. One such parameters being scalability. Maintaining soft states of flows across the routers adds more load on the routers. Moreover in the protocols discussed for mobility, where passive reservations are made, there is unnecessary wastage of resources. Also the message overhead involved as a result of RSVP signaling is quite significant.

Among the various protocols discussed, the Hierarchical Mobile RSVP protocol seems to overcome the overheads identified above to a considerable extent. It avoids maintaining unnecessary soft states in routers of foreign domains, which the mobile host may never visit during an open session. Also the reservation and path messages with respect to this passive reservation are also avoided by making a dynamic decision about passive reservations. This protocol also is feasible in today's internet because it is designed to work with Mobile IP, which is widely used today. And RSVP was also designed with existing and future routing protocols in mind.

6 Conclusion

In conclusion, it has been observed that despite a few overheads, the mobility extensions to RSVP seem to provide less call dropping probabilities, during hand-offs. It was also observed that an alternative and competing concept for handling QOS issues in conjunction with mobility being the DiffServ architecture. Yu Cheng et al. propose a registration-domain-based scheme in the DiffServ domain that handles mobility as well as QOS guarantees. In this scheme, resource allocation is adjusted based on the network condition, thus minimizing hand-off call drop probabilities and new call- blocking probabilities. The resource requirement is mentioned in the Service Level Agreement between the registration domain and a service provider, as is the idea of the DiffServ architecture.

But it is also to be noticed that a combination of DiffServ and IntServ models can be used to provide better QOS guarantees than using either of them, from the results presented in the paper by Jarmo Harju et al. DiffServ architecture suit the static QOS needs of the user. It is inferred from the work so far that, when QOS requests become more specific and dynamic and end-to-end guaranteed services are needed, a combination of the two models will be a good idea to deploy.

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