An Approach to Support Mobile QoS in an Integrated Services Packet Network

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Abstract

This paper introduces a new approach to support mobile nodes in an Integrated Services Packet Network. As concept of mobility, we assume that mobile hosts move from one cell to another setting up a continuous path from their initial position to their final destination. In this way, they can foresee the set of locations they will visit and how long it will take them to pass from one region to another. In this scenario, we analyze why immediate reservations are not enough to provide overall QoS guarantees and, therefore, reservations in advance have to be considered. Finally, we introduce a new protocol, the Mobile QoS Protocol (MQoSP), which allows the home agent to establish reservations in the fixed network on behalf of the mobile node.

1. Introduction

During the last few years, wireless communication technologies have found widespread acceptance and the number of mobile users has grown considerably. Nowadays, not only telephony services but also Internet access or real-time services like videoconferencing or video-on-demand are requested. However, real-time applications are very sensitive to delay, and they need some additional mechanisms to obtain a suitable quality of service (QoS). If we consider a real-time session between a mobile host and a correspondent node attached to an Integrated Services Packet Network (ISPN), two different kinds of networks should be considered: the fixed and the wireless one. In this paper, we analyze the problem of supporting mobile hosts in a fixed ISPN, leaving for a further study how a wireless network could also provide QoS and how these two environments should be integrated.

So far, there has been intensive research for providing QoS guarantees in an ISPN. For instance, the IETF has proposed a Resource Reservation Protocol RSVP [1] for QoS signaling in an IP network. While this approach may be suitable for low mobility hosts, which stay in the same cell during the whole lifetime of their sessions, it will not work properly for high mobility hosts. Besides the possible disruptions due to the handover effect, i.e. when the mobile host stops receiving for an access point and starts receiving for another one, high mobility hosts may suffer a service degradation each time they move to another cell. When the mobile host changes its location, a new RSVP session has to be set up in the fixed network along the new path from the server to the current access point. However, it could happen that the links of the new path do not have enough available resources for providing the requested service. Hence, the QoS experienced by a mobile host is highly mobility dependent.

In this paper, we propose a new mechanism to support mobile QoS guarantees in an ISPN based on reserving resources in advance along all the paths the mobile node will visit in the future. To make the reservations intelligently, the mobile host should anticipate the way it will take and an approximation of the duration it expects to stay in each location. Our approach is based on the combination of Mobile IP [2] with a protocol capable of performing resource reservation in advance

in addition to the traditional immediate reservations. For this purpose, we use a RSVP extension, the Resource Reservation Protocol in Advance RSVP-A [5].

This paper is organized as follows: section 2 analyzes the problems for providing QoS guarantees when mobility is introduced. In section 3 a general overview of Mobile IP together with resource reservation in advance is presented. Section 4 describes the Mobile QoS Protocol (MQoSP) proposed in this paper. Related work is considered in section 5. Finally, Section 6 outlines the conclusions of this work.

2. Mobility Problem

We assume that mobile hosts move from one cell to a neighbor cell setting up a continuous path from their initial position to their final destination. They do not move in a random way, hence, they can foresee the set of locations they will visit and how long it will take them to pass from one region to another. At a first glance, it seems that knowing beforehand the interval of time the host will stay in each cell is a strong restriction. However, we can find this situation daily in the normal life. For example, if someone takes a train for going home, he knows the way and the locations he will visit and also the time, with certain error bounds, he will stay in each area. Even mobile users travelling by car usually decide about the route they will take before starting the trip, and they often approximately know how long it will take them to pass from one region to another.

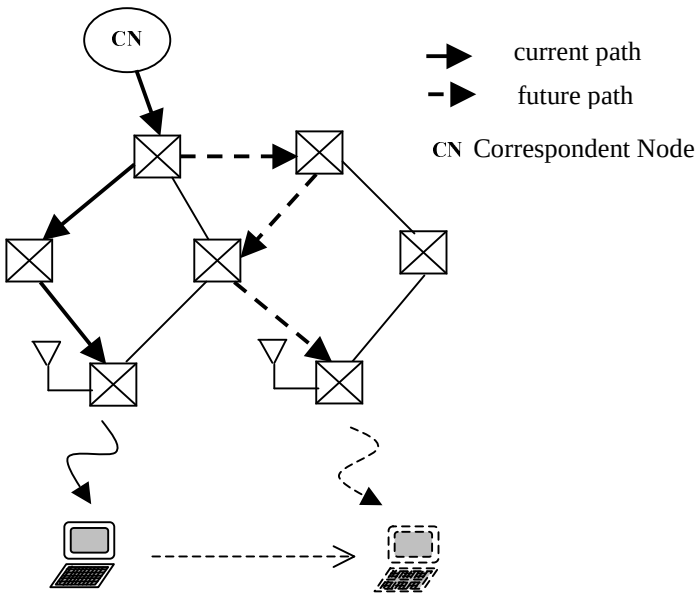

Figure 1: Mobility problem

Mobility adds complexity for guaranteeing a certain QoS. Let us suppose a scenario like the one showed in Figure 1 where a mobile host sets up a session from its initial position to the correspondent node. When the mobile host moves to another location, the path the data packets follow in the fixed network changes as well. In this new scenario, the mobile host should set up a new resource reservation in the fixed network, which has two main implications. First, some time is required for setting up the new reservation which means the potential loss of service during a certain interval of time (besides of the disruption caused by the handover when the mobile node

ceases receiving data from one access point and starts receiving data from another one). But even worse, it can happen that at the moment of setting up the new reservation, not enough resources are available, the session is rejected and the user gets only a best-effort service. Resources are limited and therefore expensive, so the user wants to ensure that he will receive the resources he asked for. For these reasons, we can argue that immediate reservations are not suitable for high mobility nodes.

But, if the mobile node can anticipate the route it will follow, it might also establish in advance the reservations for the access points it will visit in the future. In this way, its current service is not degraded due to the lack of resources in the new path.

If the mobile user is aware of the access points he will visit and the time he will stay in each location, he can create a mobility configuration file containing this information. This mobility configuration file may be used not only for setting up resource reservations in advance, but also for Mobile IP optimization by allowing, for example, registration in advance at the foreign agents. We should also remark that only the mobile user can control the mobility configuration file, other network agents like the home or the foreign agents can not modify it in any way.

In this paper we analyze the advantages of having a mobility configuration file for setting up advance reservations using RSVP-A. Of course, the behavior of the mobile node may not be the same as it had been anticipated. For instance, a car could be involved in a traffic jam or the train could be later than scheduled. For these situations, RSVP-A considers how to enlarge or modify the reservations booked in advance. Reservations in advance allow service providers to make a better scheduling of network resources, however, they should be used carefully since an inadequate policy could lead to a major waste of resources and, to an important reduction in the utilization of the network.

3. Operation of Mobile IP with RSVP-A

Before introducing the Mobile QoS Protocol presented in this paper, we give a general overview of our approach. Several components are involved such as the routing protocol and the resource reservation signaling in the fixed network. Although our scheme of using a mobility configuration file does not depend on the protocols used for routing or resource reservation signaling, we have chosen Mobile IP and RSVP (or rather RSVP-A) as being the protocols widely proposed in the Internet. Finally, we analyze how to accommodate resource reservations in the tunnels established by Mobile IP.

3.1 Mobile IP

Mobile IP is the routing protocol that allows mobile nodes to communicate with other hosts using always the same IP address regardless of its current point of access to the Internet. A mobile node gets two IP addresses: a permanent IP address (*home address*) belonging to its original network; and a temporal address (*care-of-address*) associated to the network he is attached to at that moment. Two elements play an important role in this protocol: the *Home Agent* (HA) and the *Foreign Agents* (FA). The HA is the access point to which the mobile node is originally attached. Initially, the HA receives the packets from another host in the Internet and forwards them to the mobile node. When the mobile node changes its location, it attaches to another access point (FA) and notifies its HA about its new reachable IP address, i.e., its *care-of-address*. This change of location is transparent for the correspondent node, which still sends the packets using the same IP address as before. The HA gets all the packets and forwards them to the FA by establishing a tunnel. A “triangle” effect is produced due to the fact that all the packets must pass first through the HA even if the current access point belongs to the same network as the correspondent node (Figure 2). Hence, this is a

major drawback of Mobile IP; data packets from the correspondent node to the mobile host are frequently forwarded via routes significantly larger than the optimum one.

To correct this problem, an extension to Mobile IP, known as *route optimization* [4], has been proposed (Figure 3). This extension allows to route data packets from the correspondent node directly to the mobile node without passing through the HA. This is possible by using a binding cache at the correspondent node that keeps track of the current position of the mobile node, i.e. its *care-of-address*. The mobile node sends a message *Binding Update* to the correspondent node notifying its *care-of-address*. In case the correspondent node sends the packets towards the mobile node and if there is an entry in the binding cache, this address is used to send the messages directly to the mobile node. Otherwise, the correspondent node sends the packets towards the HA like in the normal Mobile IP operation.

However, although the routing is much more efficient by using route optimization, this approach has other important disadvantages. With route optimization, the correspondent node has to support all the mechanisms concerning the mobility and it has to be aware that it is sending messages to a mobile node. The main goal of Mobile IP, i.e. ensuring that mobility is transparent for applications, is violated. Therefore, we have chosen the traditional Mobile IP operation, although our approach works with route optimization as well.

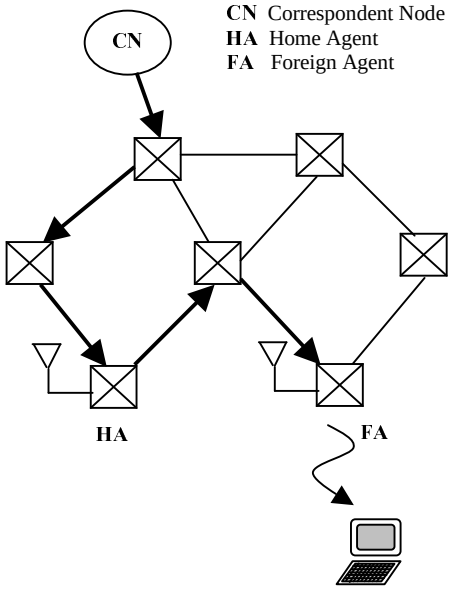

Figure 2: Mobile IP

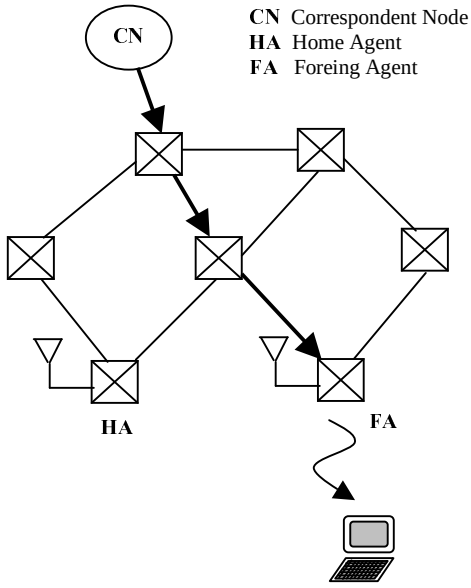

Figure 3: Mobile IP with route optimization

3.2 RSVP-A

RSVP-A is an extension of RSVP for setting up reservations in advance in the Internet in addition to the traditional immediate reservations. RESV messages are extended with two timing parameters, the *initial time* and the *duration*. Advance reservations become active when the *initial time* is reached and last during the interval of time specified by *duration*. At any time, it is possible to extend, to shorten or to modify reservations by sending RESV messages with new values. Resources are released automatically when the final time (*initial time* plus *duration*) is reached. From this moment, if there are still some data to send, they will get a best-effort service.

3.3 RSVP over IP Tunnels

Another main issue is how to accommodate reservations in the Mobile IP tunnels. Mobile IP encapsulation adds an outer IP header to the data packets [3], and all the packets traversing the same IP tunnel carry the same IP header. However, data packets that require resource reservation within a tunnel must provide, in addition to the IP addresses, some other information visible to the intermediate routers, so that the routers may distinguish between packets belonging to different RSVP sessions.

In [7] it is described how to enhance an IP-in-IP tunnel with RSVP capability. In order to discriminate between RSVP sessions, an IP+UDP encapsulation is needed, which implies to add an UDP header to the IP encapsulation. In the tunnels, RSVP sessions are distinguished only by the source port. The source address, the destination address and the destination port can be the same for all the sessions traversing the tunnel. The source UDP port is chosen by the tunnel entry point at the moment it sends the initial PATH message for a new RSVP session within the tunnel.

Figure 4 shows an overview of the integration of the three components described above (Mobile IP, RSVP-A and RSVP-A over IP tunnels).

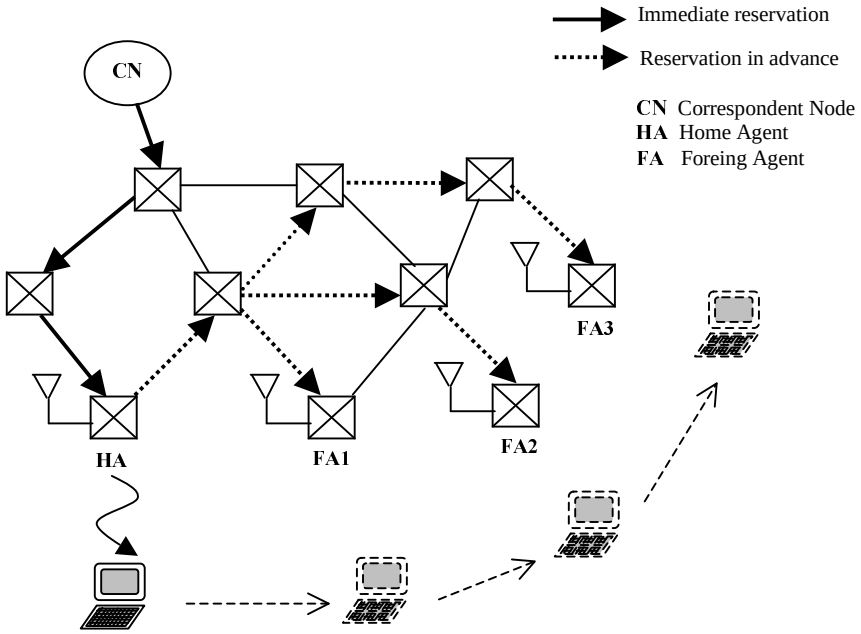

Figure 4: Overview

4. Mobile QoS Protocol

The Mobile QoS Protocol (MQoSP) allows the exchange of information between the mobile node and its home agent to request a certain QoS guarantee. This protocol uses the mobility configuration file introduced in Section 2 and provides a set of messages (see Table I) to set up resource reservations in the network. Although in this paper we only consider the fixed network, reservations should be also carried out in the wireless network to provide an overall QoS guarantee. In the following, the basic operations of MQoSP for the MN as a receiver are described.

Message	Sender	Receiver	Parameters
MQoSP_REQUEST	MN	HA	session_id, correspondent node, configuration file, service class, service parameters
MQoSP_RESPONSE	HA	MN	session_id, list {FA, result}
MQoSP_RELEASE	MN	HA	session_id

Table I: MQoSP Messages

a) Reservations set up

Figure 5 shows the actions carried out for all the participants for setting up the reservations. Dashed lines show the actions related with RSVP-A reservations while continuous lines are associated with the MQoSP protocol. Arrows with same numbers identify actions that may occur in parallel.

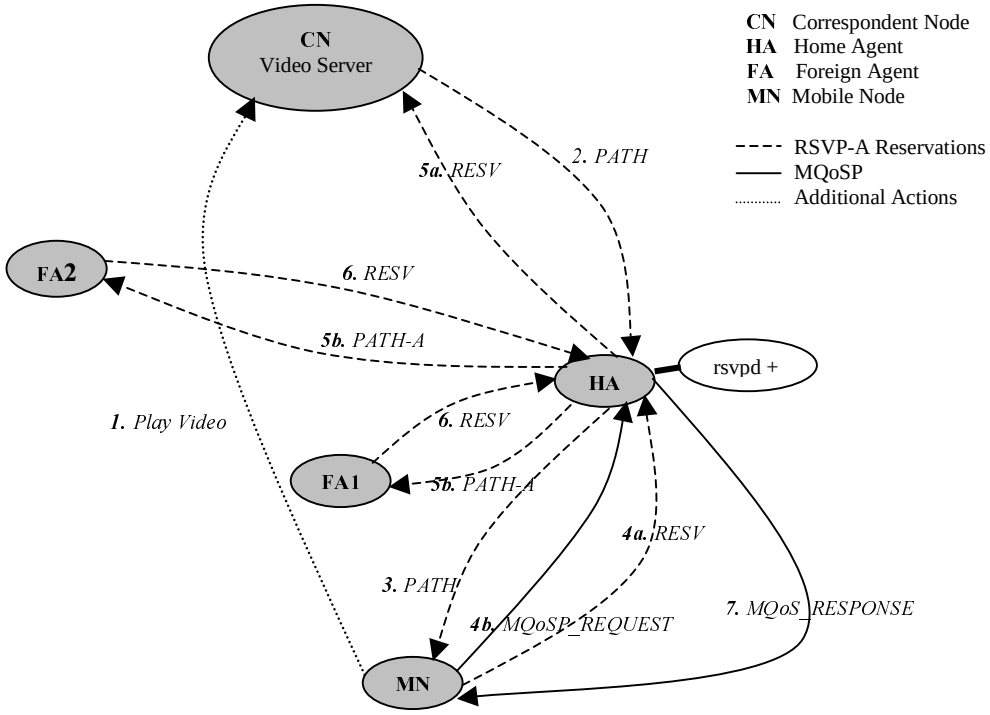

Figure 5: Set up reservations

The overall operation works as follows:

- First the mobile node notifies to its correspondent node, a video server in our example, its intention of starting a video session (1).
- The correspondent node sends a PATH message addressed to the mobile node (MN), so that the MN can start a RSVP reservation (2). Following the routing that Mobile IP establishes, the PATH message arrives at the HA, which forwards it to MN (3).

- On receiving the PATH message, the MN sends a RESV message to its correspondent node. RESV messages follow the inverse path of PATH messages, this means that the RESV message sent by the MN will pass through the HA as well (4a). The HA forwards the RESV message to the CN establishing an immediate reservation along the path from the CN to the HA (5a).
- The MN sends a MQoSP_REQUEST message to its HA (4b). The information provided in this message includes a session identification, the configuration file with the FAs it will visit and the time parameters, the correspondent node from which it wants to receive data, the class of service, for example controlled load or guaranteed, and the parameters the service requires.
- On receiving the MQoSP_REQUEST message, the *rsvpd+* module, the extended RSVP demon capable of advanced reservations, at the HA creates PATH-A messages and sends them to all of the FAs that appear in the mobility configuration file (5b). The PATH-A message is an extension of the PATH message, which provides an additional RSVP object for carrying timing information.
- The FAs set up reservations in advance along the paths from themselves to the HA by sending RESV messages (6).
- When the HA is aware of the reservations of each FA, it sends to the MN a MQoS_PRESPONSE message to notify which reservations in advance have been set up (7). As many MQoS_PRESPONSE messages as needed are sent. Each of them contains the result of all the new advance reservations set up since the last MQoS_PRESPONSE message was sent.

The mobile node must resolve what to do when not all the advance reservations have succeeded. It can decide, for example, not to start the session, trying to start it later or starting the session and try to set up at the same time the reservations that failed.

At any time the mobile node can try to modify the route, to prolong or shorten the durations, to change the initial times or to modify the parameters of the service (bandwidth, delay...), by sending a MQoSP_REQUEST message to its HA with the new values.

b) Reservation release

Resources are released automatically when the time specified for each location passes. Then, the HA or the FA release the resources by sending RSVP_PATH_TEAR or a RSVP_RESV_TEAR messages respectively.

As illustrated in Figure 6, the mobile node can finish voluntarily the session by sending a MQoSP_RELEASE message to its HA. On receiving this message, the HA will send a RSVP_ PATH_TEAR to all the RSVP sessions maintained for this mobile node and a RSVP_RESV_TEAR message to the correspondent node.

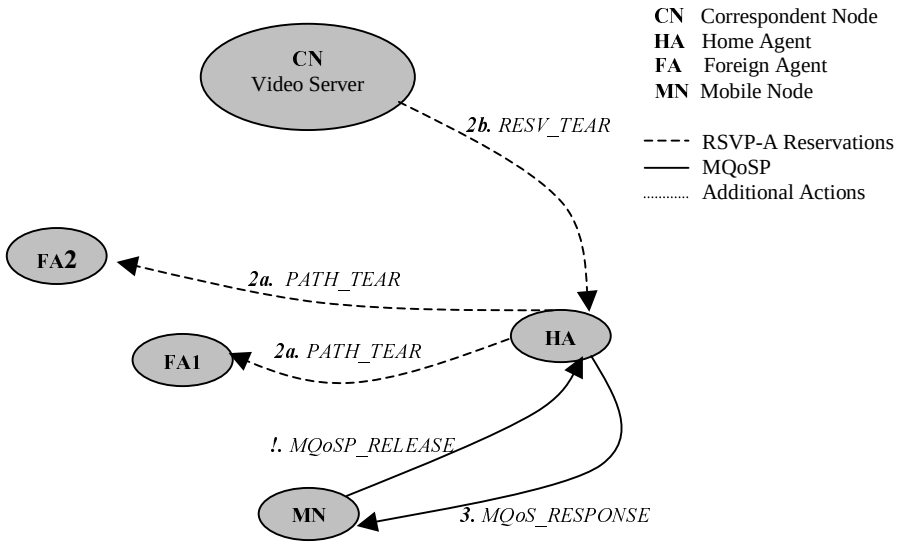

Figure 6: Release reservations

MQoSP messages do not need any refresh because both, the MN and the HA, know if the other one is still active by means of Mobile IP. An additional problem is that the wireless link has a high probability of losses and errors and therefore, the messages exchanged between the mobile node and its HA might be lost. To solve this problem, the MN and the HA establish a TCP connection for sending MQoSP messages in a reliable way.

Mobile node as a sender

The scene discussed above considers only the case, that the mobile node acts as a receiver. Figure 7 shows the case of a sending mobile node (for consistency with the previous example, we show the case of a video playback from a mobile node). The major difference between both schemes is that for mobile senders, reservations in advance are set up from the FAs to the correspondent node (or from the sender FAs to the receiver HA if both, sender and receiver, are mobile). The set of MQoSP messages should be extended in order to support the exchange of information between the HA and the FAs. Furthermore, the MN has to communicate to the correspondent node if the advance reservations have succeed because the correspondent node does not have any knowledge about the sender mobility. If the correspondent node has no guarantees of getting the requested QoS, it can decide not to start the session. It should also be desirable that the correspondent node anticipates an approximation of the duration of its session, in order to consider only the FAs the sender node will visit during this interval of time.

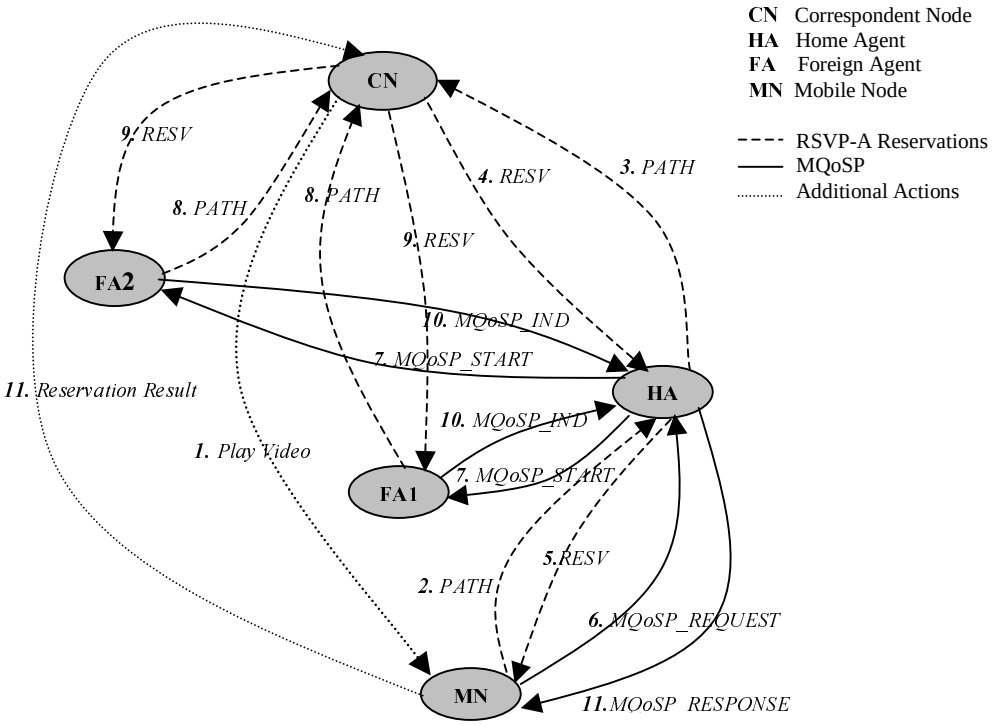

Figure 7 Mobile node as sender

5. Related Work

So far, not much work has been performed in the area of providing QoS guarantees for mobile hosts in an ISPN. In [6], a service model and an extension of RSVP (MRSVP) for accommodating mobile hosts in an ISPN is proposed. The Integrated Service model is extended by adding three new service classes that the mobile nodes may request: *Mobility Independent Guaranteed*, *Mobility Independent Predictive*, and *Mobility Dependent Predictive*. The extension of RSVP consists of a set of new messages to handle the mobility. This is different to our approach that considers the IntServ classes and proposes a new protocol for the exchange of mobility information between the mobile node and its Foreign Agent. MRSVP sets up two kinds of reservations: active reservations and passive reservations. The mobile host specifies his so-called mobility profile and establishes an active reservation to its current access point and passive reservations to all the access points in its mobility profile. Passive reservations are similar to our reservations in advance. The major difference between our approach and MRSVP is that MRSVP does not consider any temporal information. But temporal information is essential for reservations in advance, in order to make a good scheduling and to achieve a high utilization of network resources.

6. Conclusions and Future Work

In this paper, we present an approach to support mobile nodes in an Integrated Services Packet Network. We analyze why immediate reservations are not enough to provide overall QoS guarantees and therefore, reservations in advance have to be considered for high mobility hosts. We introduce a new protocol Mobile QoS Protocol (MQoSP), which allows the home agent to establish reservations in the fixed network on behalf of the mobile node. The main assumption is that the

mobile node knows the path it will follow and has available an external tool, which is able to predict the set of foreign agents it will visit during its trip. Although we currently do not have such a tool, it could be implemented by integrating three components: a geographical tool capable to predict the way from the current position to a destination point, a map with the shape and size of the real cellular systems, and a map with the available FAs. Furthermore, for ease of use a high level tool using these components would be needed. We leave for a future work the implementation of this tool.

Working together with Mobile IP and RSVP-A, MQoSP allows to set up reservations in advance from the home agent to each of the foreign agents in the mobility profile. In this paper, only reservations in the fixed network are considered, but in order to provide overall guarantees, resource reservations in advance should also be established in the wireless network.

The major inconvenience of our scheme is the "triangle effect" of packets routing. Due to Mobile IP, all the packets addressed to the mobile node should pass through its home agent. Furthermore, the home agent is also in charge of requesting the advance reservations on behalf of the mobile node. Then, the home agent becomes the bottleneck, which could lead to scalability problems. Actually, this is a Mobile IP problem and to solve it, an extension to Mobile IP called route optimization has been proposed. By using route optimization, reservations can be set up directly from the correspondent node to the FAs, bypassing the HA. Although our scheme also works with route optimization, we prefer not to use it because with route optimization the correspondent node must be aware of the mobility.

The MQoSP protocol provides the mechanisms to modify the route or the parameters of the reservations. If the user can anticipate that he will not get for any reason the resources he asked for, he can release or modify the reservation using the messages this protocol provides.

So far, we only consider the case of mobile node as a receiver. For taking into account mobile senders as well, the MQoSP should be extended with some other messages that allow the exchange of information between the home and the foreign agents. By example, we show how the sender version could work, although we leave this study for a future work. Finally, extensions should also be made in order to provide multicast support.

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