Mobility management in IP networks providing real-time services

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Abstract

The evolution of IP toward the complete interworking among fixed and mobile hosts is called mobile IP. Several issues related to different aspects of the mobile IP definition have been singled out: impact of mobility on TCP/IP performance, route optimisation, authentication, reliability, location, addressing etc.

An important topic in the IP evolution is the provisioning of real-time services by employing signalling protocols like RSVP. A further step in this evolution will be to allow such real-time communications also between mobile hosts. This issue is addressed in this paper and a proposal for extending real-time services also to mobile hosts is presented.

1 Introduction

The evolution of IP toward the complete interworking among fixed and mobile hosts is under study in the IETF (Internet Engineering Task Force) mobile-IP Working Group. Several issues related to different aspects of the mobile IP definition have been singled out: impact of mobility on TCP/IP performance, route optimisation, authentication, reliability, location update etc.

An important topic, in the TCP/IP evolution, is the provisioning of Integrated Services (IS) on Internet (i.e. real-time services beyond traditional best-effort ones), by employing resource reservation setup protocols like RSVP. A large-scale deployment of IS-capable devices (hosts and routers) would allow full development of services such video-conferencing, VOD, interactive-TV and telephony over Internet.

A further and logical step in this evolution will be to allow such real-time communications also between mobile and fixed hosts. This seems to be a very interesting research topic since mobile devices will account for a large portion of the installed computer base, in the near future, and most of them will want to access real-time services as well as fixed hosts.

This issue is addressed in this paper and a proposal for real-time services between mobile hosts is presented.

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The organisation of this paper is the following. Section 2 and 3 briefly recall the mobile-IP and IS/RSVP paradigms. In Section 4 RSVP-over-mobile IP issues are summarised, while in Section 5 we present a scheme for the transparent support of real-time services between fixed and mobile hosts. Section 6 recall some security considerations and finally Section 7 addresses some conclusions.

2 IP extensions for mobility support

Several solutions for the support of communications between mobile IP hosts have been proposed [3, 4, 5]. The mobile-IP paradigm [1] is based on the forwarding mechanism summarised below (see Fig. 1); this mechanism allows transparent routing of IP datagrams to mobile nodes in the Internet.

Each mobile host (MH) is permanently registered in a *home network* where a *home agent* (HA) functionality is placed. The home agent maintains a *home list* identifying all the mobile hosts that it is configured to serve. When a mobile host moves out of its home network and it has to be served by a different network, it obtains a temporary address, called *care-of-address*, and it is temporarily registered in the *visitor list* of the current network. A location information is sent to the home network that must know the current *care-of-address* of all the mobile hosts of its *home list*.

Packets sent to a mobile host by whatever node in the net (step 1, Fig. 1) are captured by its home agent. The home agent encapsulates the original IP packet in another IP datagram (with one of the several encapsulation methods available), assigns the care-of-address of the mobile host as the destination address of the outer IP header, and then forwards the packet (*tunnelling*, step 2). At the end of the tunnel a foreign agent (FA) receives the packet, decapsulates the inner IP packet and sends it to the mobile host (step 3). The forwarding mechanism from the home agent to the foreign agent is called *tunneling* because the IP packet seems to move inside a tunnel. In the reverse direction, packets originated by the mobile node are typically delivered to their destination using standard IP routing mechanism, i.e. not necessarily passing through the home agent (steps 4 and 5).

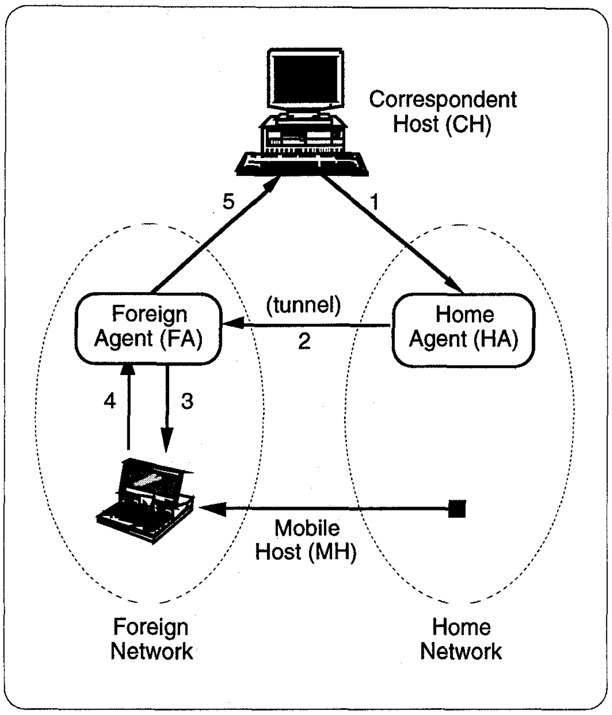

Fig. 1 -Basic forwarding mechanism provided by mobile-IP protocol (triangle route)

It is worth noting that mobile IP proposal is targeted toward the solution of "macro" mobility management problems (portability), and it is less well suited for "micro" (e.g. handover management) mobility.

It is also remarkable that, when using mobile IP protocol, correspondent hosts (CHs, i.e. the senders) not necessarily must be aware if the destination is a mobile or a fixed node.

Several improvements to the basic mobile IP mechanism, mainly based on early mobility notifications (*binding update*), have been proposed to achieve optimal routing [2]; however, the impact of the mobility on real time services does not seem to have been thoroughly investigated.

3 Integrated Services on Internet and RSVP

Internet is based on a connectionless, packet-oriented paradigm that was conceived to support *best-effort* data communication services. To support real-time, multi-media communications it is necessary to define a mechanism to guarantee specified quality of service by reserving communication resources. IETF is developing a general framework to enhance the service model provided by the Internet, to comprise real-time services along with traditional best-effort services; the new architecture is usually referenced as the *Integrated Services on Internet* (**IS**) model [7].

The key architectural concepts through which it will be possible to realise the IS model are *resources reservation* (bandwidth, buffers space, CPU time) for traffic flows, realised through a soft-state, receiver-initiated mechanism, and *admission control*. IS implementation requires deep modifications in hosts and routers basic architecture, actually defined in RFC 1122/1123 and RFC 1812.

RSVP (Resource ReSerVation Protocol, [6]) is the basic control and signalling protocol for reservation setup being actually developed by IETF. RSVP establishes *soft states* in routers, that is, states that expire after a defined time period unless they are periodically refreshed. To manage states establishment and, if necessary, teardown, RSVP defines two types of messages: *Path Messages* (PM) and *Reservation Messages* (RM); both of them are encapsulated in IP datagrams. Sources wishing to transmit data to a multicast group (in the general case) send PMs to the IP multicast address of that group, specifying their outgoing traffic characteristics by a suitably defined *flow specification (flowspec)*. The PMs follow a path through the internet (according to the routing tables of the intermediate routers) to the destinations, establishing *Path States (PSs)* in the routers along the way. PSs simply record the incoming link from which the PMs came from and which outgoing links they are forwarded to; PSs may also record (and this is required in some cases) an identification of the source associated with a particular PM.

Let us now suppose that a receiver *R* in a multicast group, having received at least a PM, wishes to receive data from a source. *R* sends a *Reservation Message* upstream to the source, specifying: i) the requested QoS (in a flowspec), ii) the desired *reservation style* (i.e., if the requested resources have to be reserved to the information flow coming from a single source or have to be shared between information flows coming from different sources), iii) a *packet filter* (to characterise packets that have to be associated to the requested resources). When a RM arrives at a RSVP router, it has to pass an admission control test; if this succeeds, the requested resources are allocated for the specified flow.

This is implemented with a *packet classifier* (which classifies incoming packets via packet filters) and a *packet scheduler* (which allocates resources according to the flowspecs). The tuple <reserved resources, packet filter, reservation style> defines a *Reservation State* (RS); the latter is also a soft-state and it may include an identification of the particular receiver *R* (this is required in some cases). RMs are forwarded upstream by using the PS in the router.

It is worth noting that: i) reservations are receiver-initiated (to allow dynamic changes in multicast groups and to fit the needs of heterogeneous receivers), ii) RSVP is routing-adaptive (paths and reservations follow dynamically the variations in the IP routing).

4 Interoperability issues between mobile-IP and RSVP

Mobile-IP protocol (with or without route optimisation extensions) and RSVP signalling seem to be not interoperable. Actually, if we tried to use the mobile-IP proposed scheme along with RSVP we would not be able to extend Integrated Services to mobile hosts, at least in an efficient way.

When trying to use RSVP over mobile-IP, in fact, two kind of problems arise:

1. If a correspondent host sends a Path message to the unicast address corresponding to a moved host, its home agent intercepts the message, encapsulates and forwards it to the care-of address as any other IP datagram. With the actual RSVP specifications, however, both RSVP messages and reserved data flows are invisible to intermediate tunnel routers, so that it would not be possible to build the path state (and the corresponding reservation state) between home and foreign network (step 2, Fig. 1).
2. Also if RSVP succeeded in providing Integrated Services over tunnels (RSVP WG is actually working on this issue, and we will suppose the general availability of such a method in the following), the resulting RSVP-over-mobile-IP behaviour could be highly sub-optimal: let us think to resources' waste for setting up the reservation path along the triangle route. If a host moves from Europe to US, for example, and a US-based fixed host wants to setup a reserved communication with it, network resources should be reserved in both directions along transatlantic links!

For these two reasons we think that RSVP should include explicit support for mobility, to assure transparent and efficient setup of reserved data path between all kind of hosts, included the mobile ones.

5 Including mobility support into RSVP

One possible way to extend IS to mobile hosts is to embed explicit support to mobility inside RSVP.

In the following we will consider the simplest mobility case, in which a mobile host on a foreign network does not change location while a reserved communication is in act (i.e. no handover issues are considered). We will do a further assumption by considering the correspondent host (i.e. the sender) to be a fixed host. This turn to be not so limitative, because most reserved data flow will source from fixed, big capacity servers (e.g. video-servers).

Two different cases must be considered:

1. *Destination is an IP multicast group address:* this case turns to be rather trivial: if the mobile receiver has joined a multicast group in its home network, it can transparently access real-time communications for that group also in a foreign network simply by joining the multicast group in the new network (via IGMP, the Internet Group Management Protocol [8]), and provided that the new subnet makes use of multicast routing protocols like DVMRP or MOSPF. In this case mobility turns to be a simple side-effect of the IP multicast mechanism.
2. *Destination is an IP unicast address:* in this case IP multicast does not supply any help, and mobility support must be added to RSVP. It is worth noting that, while RSVP has in general been designed to accommodate fully scalable multicasting, and while unicasting is usually a special case of multicasting, in this case this assumption fails: unicasting mobility can not be derived from multicast mobility.

An efficient way of including mobility support in RSVP is based on a "mobility notification method", i.e. on an early notification of the current position of a mobile host to the sender, performed by the home agent in a similar way to the route-optimisation mobile-IP extensions.

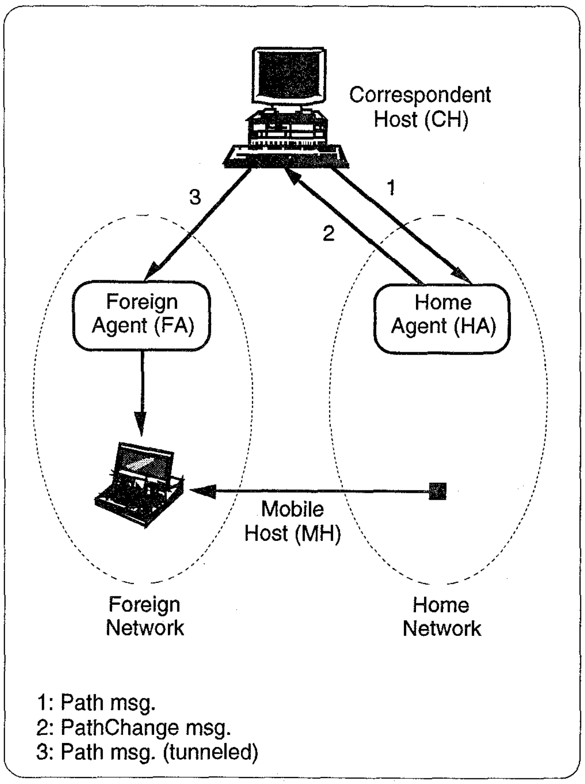

Fig. 2 - Reservation setup for mobile hosts

Let us summarise the proposed algorithm. When a (fixed) correspondent host wants to setup a real-time communication with a mobile host (Fig. 2):

1. CH sends a *Path* message to the receiver (MH)
2. If MH has moved, HA captures the RSVP Path message and reply to CH with a *PathChange* message containing the care-of address of the mobile host and its own address (MOBILITY_NOTIFICATION Object, see below), without tunnelling the original Path message to FA
3. CH receives the PathChange message, caches the binding between MH's IP address and care-of address and sends a new Path message to the MH, tunneling it to the care-of address. From now on, reservation setup works in the traditional way, with the possible exception of tunnels usage.

This method implies that a new message (PathChange) and a new object class (MOBILITY_NOTIFICATION) has to be added to RSVP:

- PathChange messages should be directly routed to the sender (not routed hop-by-hop, like PathErr messages), and should have the following format (see [6]):

<PathChange msg.> ::= <Common Header> [INTEGRITY]
<SESSION> <MOBILITY_NOTIFICATION>
<sender descriptor>

- IPv4 MOBILITY_NOTIFICATION object:

IPv4 Home Agent address (4 bytes)
IPv4 care-of-address (4 bytes)

- IPv6 MOBILITY_NOTIFICATION object:

IPv6 Home Agent address (16 bytes)
IPv6 care-of-address (16 bytes)

The early mobility notification provided by *PathChange* is similar to the binding update message proposed in [2], and allows for rapid and efficient reservation setup (compared to setup via mobile-IP triangle route).

6 Security considerations

The proposed mobility notification mechanism for RSVP is subject to the same problems of the basic route-optimisation protocol [9]. *PathChange* messages from home agents to correspondent hosts should be authenticated, and that would require alternatively:

1. a secret-key sharing between CH and HA; this is very difficult to achieve in the general case in which CH and HA can belong to different administrative domains;

2. some generalised authentication and key management mechanisms deployed along the Internet, possibly based upon public key algorithms. This is technically feasible but also a rather far objective to achieve, at the moment, because of patent restriction and export controls.

7 Conclusions

In this paper a RSVP extension has been proposed to allow real-time communications setup between mobile and fixed hosts in TCP/IP networks. While the proposed method has some pros and cons (simple, efficient and of limited impact on the actual RSVP proposal, but security issues must be resolved), we think that the whole issue of extending the furthercoming Integrated Services on Internet model to include host mobility deserves the greatest attention.

References

[1] IETF mobile-ip working group, "IP Mobility Support", Internet draft, December 1995, work in progress

[2] IETF mobile-ip working group, "Route Optimization in Mobile IP", Internet draft, February 1996, work in progress

[3] F. Teraoka, K. Uehara, "Mobility Support in Ipv6", Proc. INET 95, 1995

[4] A. Myles, D. Johnson, C. Perkins, "A Mobile Host Protocol Supporting Route Optimization and Authentication," IEEE Journal on Sel. Areas in Comm., Vol. 13, No. 5, June 1995, pp. 839-849

[5] G. Cho, L. F. Marshall, "An Efficient Location and Routing Scheme for Mobile Computing Environments", IEEE Journal on Sel. Areas in Comm., Vol. 13, No. 5, June 1995, pp. 868-879

[6] R. Braden, L. Zang, S. Berson, S. Herzog, J. Wroclaswki, "Resource ReSerVation Protocol (RSVP) - Specification", Internet draft, May 1996, work in progress

[7] R. Braden, D. Clark, S. Shenker, "Integrated Services in the Internet Architecture: an overview", RFC 1633, June 1994

[8] S. E. Deering, "Host Extensions for IP Multicasting", RFC 1112, August 1989

[9] D. B. Johnson, D. A. Maltz, "Protocols for Adaptive Wireless and Mobile Networking", IEEE Personal Communications, February 1996