Overview and Comparison of Methods for Minimizing HandOff Latency in Mobile IP

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Abstract

In this paper we discuss about Mobile IP and the proposed handoff schemes, their pros and cons and some areas where they can be improved. The reasons for handoff latency are examined and the schemes are discussed by their genres. We observe that combining different methods results in a better performance. Issues like cross-layer design and context-awareness improve the handoff latency but also bring overhead. We conclude with the proposal that both IP and TCP layers should be considered to minimize handoff and to provide end-to-end QoS.

Keywords:
Handoff, Mobile IP, QoS

1. Introduction

Mobile IP [1] was developed to enable computers to maintain Internet connectivity while moving from one Internet attachment point to another. Common terms to describe Mobile IP architecture are :

- The *Mobile Host (MH)* or *Mobile Node (MN)* is a device such as a personal digital assistant, or laptop whose software enables network roaming capabilities.
- The *Home Agent (HA)* is a router on the home network serving as the anchor point for communication with the Mobile host. It tunnels packets from a device on the Internet, called a Correspondent Host, to the roaming Mobile Host.
- The *Foreign Agent (FA)* is a router that may function as the point of attachment for the Mobile Host when it roams to a foreign network, delivering packets from the Home Agent to the Mobile Host.
- The *care-of address (CoA)* is the termination point of the tunnel toward the Mobile Host when it is on a foreign network. The Home Agent maintains an association between the home IP address of the Mobile Host and its care-of address, which is the current location of the Mobile Host on the foreign or visited network.
- *Binding* is the triplet that contains the mobile node's home address, its care-of address and the registration lifetime- how long the mobility agent may use the binding.

Each mobile host (MH) has a *home agent* (HA) that acts as a location registry, maintaining the binding from the MH's *home address* and its foreign *care-of-address*. Each time the MH moves, this binding is updated. Correspondent hosts (CHs) send messages to the MH's home address and the HA forwards this message to the MH via *IP tunneling* or *encapsulation*. MHs gain their care-of-addresses (CoA) by contacting a foreign agent. The foreign agent assigns the care-of-address and updates the MH's binding by contacting the HA. This updating requires some authentication information.

2. Reasons for handoff latency

Whenever a mobile node (MN) moves to a foreign network, it needs a new address as the point of attachment is changed. Recovering a new access point (care-of address) takes some time. After finding a point of attachment in the new network, the MN must inform its home network about the new address. This also takes time. So, coarsely we can outline that handoff latency is caused by Address Reconfiguration and Home Network Registration.

3. Discussion on techniques for improving handoff latency

3.1 Protocols Based on Hierarchical Structures

As the name implies, this scheme localize the effect of handoff. It is proposed in [2] where the FAs in one region are managed according to a hierarchical structure. When MH is moving within the region, MH only needs to register to the common FA which is the closest one on both the old and the new routes to MH. Only when the MH moves out of the region, it needs to register to HA.

Different types of proposals are given by enhancing the basic hierarchical architecture. Resource Reservation Protocol [3] is combined with the hierarchical structure to get Hierarchical Mobile RSVP [4]. Here a GFA (Gateway FA) is used that reserves a channel with the CH and locality based constraints are imposed on resource reservations.

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As IPv6 will be the future technology, some protocols are built by deploying IPv6 on the hierarchical structure. These include Hierarchical Mobile IPv6 (HMIPv6) [5] and RSVP in MIPv6 [6]. Since MIPv6 utilizes neighbor discovery [7], an FA is no longer required, and the MN will always have a collocated CoA while roaming. The literature mentioned in [5] and [6] are based on this observation.

3.2 Previous FA Notification Scheme

[8] Proposes the previous FA notification scheme. It deploys a buffer at FA to cache some packets sent to MH. After handoff, MH informs the new FA the source IP address and the ID of the last 1P packet it received from the old FA. Then the new FA forwards them to the old FA. So the old FA can deduce which packets MH hasn't been received yet, and then forwards these packets to the new FA, then to MH. This scheme can effectively decrease the packet losses, but how to set the capacity of the buffer is a difficult problem. Besides, new protocol should be defined to support the communication between the new and old FAs.

3.3 Multicast Scheme

In order to decrease the packet losses and the delay variation, [9] proposes to use IP multicast technology to realize handoff. Each MH is assigned a unique IP multicast address. FA periodically advertises its reachability message in its range, and MH traces the agent advertisement message to judge its current location and movement trend and determine which FAs' ranges it will enter. Then MH notifies these FAs to join the multicast group. The packets destined for MH arrive at MH's home network firstly, and HA intercepts them and encapsulates them with multicast address, which is the difference with the traditional Mobile IP. MH itself does not join the multicast group, nor does it receive multicast packets. MH can designate an FA to forward the decapsulated packets to it. The disadvantage of this scheme is the complicated implementation of multicast and the large overhead.

3.4 Fast Mobility Detection

The effect of mobility detection is incorporated in [10]. It proposes to use the link layer knowledge to realize fast mobility detection. In wireless networks, every wireless link has its own link identifier (LID), which is sent periodically. According to the LID, MH can determine whether it has changed the access point or not. The sending frequency of LID is far higher than that of the agent advertisement message. This property is exploited. Here, a link identifier option is added to the agent advertisement message, whose content is the list of the LIDS of all the links in the range of FA. Generally, FA only sends the agent advertisement message with this option in response to MH's agent solicitation message. Once MH changes the link or access point, it will receive the new LID immediately. It passes up the LID to Mobile IP layer. Mobile IP checks whether this LID is included in the list it received just now. If so, indicating that MH is still in the same FA's range, it doesn't need handoff; otherwise, it means that MH has left the old FA's range, and then MH registers immediately. MH sends agent advertisement solicitation message actively. As response, FA will send agent advertisement message with the LID list option. This scheme only describes the address reconfiguration part; the home network registration part is not highlighted. This may cause an overall latency.

3.5 Low Latency Protocols

Low Latency address configuration is about configuring an address for the MN in a network that it is likely to move to, before it moves. The Low Latency handoff proposal [11] describes two methods of achieving this, namely Pre-registration and Post-registration. With Pre-registration handoff, the MN is assisted by the network to perform L3 (layer-3) handoff before it completes the L2 (layer-2) handoff. It uses L2 'triggers', which arises as a result of beaconing signals from the network the MN is about to move to, to initiate a IP layer (L3) handoff. Post-registration handoff triggers are like linked up events that occur in an AP or MN after an MN successfully completes the reassociation phase.

3.6 Topology-aided Cross-layer protocols

A combination of cross-layer design and the topological information is proposed in [12]. The protocol uses pre-handoff triggers for agent discovery or address configuration prior to layer-3 handoffs, and applies post handoff triggers to eliminate the move detection delay. An independent location association server (LAS) is proposed here, which maintains location information, handoff-to relationships, and AP/MA or AP/DHCP association for a set of APs. LAS can be implemented either as a standalone server or as an add-on software module in MAs, DHCP Proxies, or RADIUS servers. However, the implementation of LAS is not very clear in this proposal.

3.7 Seamless Handoff Architecture

The Seamless Handoff architecture for Mobile IP (S-MIP) [13] provides a different approach than what we have discussed so far :

- It combines the node movement tracking and handoff algorithms, thus provides better result.
- A new entity name Decision Engine (DE) is introduced which is similar as a MAP. DE tracks the movement of the mobile node and takes decision whether handoff is necessary and in which direction.

The movement pattern of the node can be linear, stochastic or stationary in between two routers. S-MIP acts differently in these cases and guesses the possible direction of the MN from its history of movement. After the handoff decision is

made, the MAP sends packets to both PAR and NAR which is buffered by them. Later those packets are delivered.
This scheme has drawbacks in cases when the MAP predicts a movement for the MN but the MN stays on its previous network for some time. As a result, the MN receives packets from PAR and when it goes to the NAR network, it would receive the same packets. The duplicated acknowledgement sent by the MN can cause problems in case of TCP. [14] proposes some modification on this scheme which uses some bits to differentiate two types of packets and ensures they are distributed on a mutually exclusive manner.

3.8 Fast Handover Protocols

Fast handover [14] is a combined method of pre and post registration where pre-registration works and if the handover is not completed, the tunnel built in post-registration comes to work. It is actually low latency handoff in the IPv6 platform. This scheme usually has three steps: Handover initiation, Tunnel establishment and Packet forwarding. The tricky part is the initiation of the packet forwarding as it is done more on an anticipating manner. So, forwarding the packet too early or too late may be a problem as it is difficult to determine a generalized time interval.
This scheme can be more localized by introducing hierarchical handover protocols. Then the MAPs deal with the local mobility management and the MN does not need to update with HA each time it moves around. An alternative way to packet forwarding is also proposed, namely Simultaneous Binding Framework. Here, the problem of not knowing the place where the MN would go is eliminated by sending packet to the MN's current location and other n locations.

4. Future directions

The pros and cons of the particular schemes are discussed in the previous section. We observe that some of the schemes consider only the link level modification whereas some others deal with network and transport layer. It can be concluded that whatever the scheme is, that should cause as little modification as possible to the existing protocol stack. This way a comprehensive backward compatibility can be ensured. Moreover, the issue of TCP and IP should be blended together to generate an efficient cross-layer handoff mechanism. Some schemes like S-MIP and Fast Handover shows good results in lab simulations, but more extensive work has to be completed to apply them onto a practical environment.

5. Conclusion

In this paper we gather the idea of Mobile IP and discuss the various schemes to minimize the handoff latency in Mobile IP environment. We analyze the advantage and disadvantage of the proposed schemes and introduce some ideas to get a better solution. The study has demonstrated the fundamental points of concern related with efficient handoff designs.

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