HMIPv6 네트워크에서 Robust 한 Inter-MAP 바인딩 업데이트 기법

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Robust Inter-MAP Binding Update Scheme in HMIPv6

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Abstract

In a wireless network, handover latency is very important in supporting user mobility with the required quality of service (QoS). In view of this many schemes have been developed which aim to reduce the handover latency. The Hierarchical Mobile IPv6 (HMIPv6) approach is one such scheme which reduces the high handover latency that arises when mobile nodes perform frequent handover in Mobile IPv6 wireless networks. Although HMIPv6 reduces handoff latency, failures in the mobility anchor point (MAP) results in severe disruption or total disconnection that can seriously affect user satisfaction in ongoing sessions between the mobile and its correspondent nodes. HMIPv6 can avoid this situation by using more than one mobility anchor point for each link. In [3], an improved Robust Hierarchical Mobile IPv6 (RH-MIPv6) scheme is presented which enhances the HMIPv6 method by providing a fault-tolerant mobile service using two different MAPs (Primary and Secondary). It has been shown that the RH-MIPv6 scheme can achieve approximately 60% faster recovery times compared with the standard HMIPv6 approach. However, if mobile nodes perform frequent handover in RH-MIPv6, these changes incur a high communication overhead which is configured by two local binding update units (LBUs) as to two MAPs. To reduce this communication overhead, a new cost-reduced binding update scheme is proposed here, which reduces the communication overhead compared to previous schemes, by using an increased number of MAP switches. Using this new proposed method, it is shown that there is a 19.6% performance improvement in terms of the total handover latency.

1. Introduction

To enhance the survivability and the available performance after a failure, we propose a new robust hierarchical mobile IPv6 (RH-MIP) scheme for distributed MAP environment [3]. RH-MIPv6 is an enhanced HMIPv6 method that provides a fault-tolerant mobile service using two different MAPs (a primary and a secondary). Unlike other proposals, RH-MIPv6 has the advantage that it does not require any synchronization between the mobility agents (e.g. the HA and MAP). In RH-MIPv6, a mobile node configures two regional care-of addresses (RCoA) when it received router advertisement messages from multiple mobility anchor points. One is the primary RCoA (P_RCoA) and the other is the secondary RCoA (S_RCoA). Then the mobile node registers these RCoAs via two local binding updates to two different MAPs (primary and secondary MAPs). The binding cache entry should be modified to support the registration of multiple RCoAs in the RH-MIPv6. Studies in [3], show that although RH-MIPv6 has a faster recovery time than HMIPv6 it uses more resources to perform the signalling needed for achieving the faster recovery times. The signalling itself is also thought to require a faster recovery time; if the mobile node is roving rapidly there can be frequent handovers and it is therefore inefficient for guaranteeing the mobility with the high QoS. In [10], an Improved RH-MIPv6 has been proposed to reduce the communication costs in a distributed mobility anchor point environment. This method requires only one local binding update message for registering the two different MAPs; it is necessary to register one binding update to all the correspondent nodes (CNs) so that they can investigate the signalling overhead to compare with the RH-MIPv6 over the MN's frequent movement. Also they focus on the mobile node's movement because if this is excessive it will have an effect on the signalling overhead.

The proposed cost-reduced binding update scheme is based on RH-MIPv6, in which the mobile node registers the first-try MAP and this is also the same procedure with the IRH-MIPv6 registration. However, in the second registration, the mobile node only sends a binding update that is needed to register the P_MAP, and it has the location information of the previous P_MAP on behalf of the S_MAP. So, in case the current P_MAP fails, the new scheme retains the session of the previous P_MAP which should reduce the signalling costs significantly in comparison to previous schemes where the mobile nodes sends binding updates to new the mobility anchor points.

HMIPv6 reduces the handoff latency, but in case of MAP failure, the MN's connection with the MAP will be disconnected. RH-MIPv6 can avoid this situation by using two different MAPs (the primary and the secondary). It shows a faster recovery time of 60% more than that of the

HMIPv6. However, if the mobile node performs frequent handovers in RH-MIPv6, it is necessary to retain the sessions of two MAPs (hence the large signalling overhead). The IRH-MIPv6 scheme can reduce the signalling costs due to frequent handovers of the mobile nodes as the number of MAP switches increase. It has been shown that it is possible to improve performance by approximately 19.6% in the total handover latency.

The remainder of the paper is organised as follows: in section 2, the operation of the HMIPv6, RH-MIPv6 and IRH-MIPv6 schemes are presented; section 3 presents the aims of the proposed cost-reduced RH-MIPv6 method. The performance analysis of the scheme, in terms of the signalling cost, is presented in section 4, and the conclusions are given in the last section.

2 Related work

2.1 RH-MIPv6

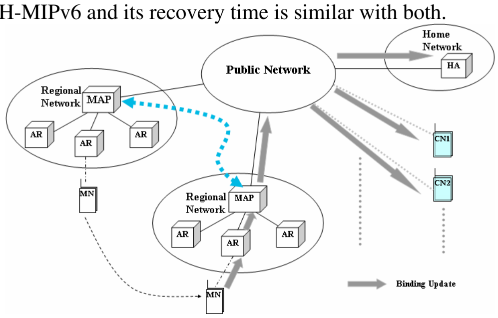
In the RH-MIPv6 method, the mobile node entering a MAP domain receives router advertisements containing information on one or more local MAPs and chooses two serving MAPs (primary MAP and secondary MAP). The MN configures the primary RCoA and the secondary RCoA and performs a local binding update to the primary MAP. After binding a RCoA to a home agent and correspondent nodes (the primary binding updating procedure), the secondary binding update procedure that does not effect the latency of the primary BU procedure is performed. It is proposed to extend the binding update message which is configured in two indicated flags (P, S flags) to separate the primary BU from the secondary BU. For two BUs, MN and CN should maintain two binding cache entries. The secondary MAP (S_MAP) takes the role instead of the P_MAP when the P_MAP fails using a failure detection and recovery scheme.

In the HMIPv6 method, MAP failure can be detected by checking the router advertisement (RA) information which contains an invalid lifetime [2]. However the detection time is too long because the interval of the RA message is set at only a few seconds. In RH-MIPv6, a MAP failure can be detected by utilizing an internet control management protocol (ICMP) during MN or CN, sending or receiving any packets. Therefore MAP failures can be detected faster than using the RA messages during the broadcast interval.

Failure detection is achieved by the mobile and correspondent nodes. The MN can detect MAP failure after sending a packet to the correspondent nodes and receiving the ICMP error messages [5]. On the other hand, the mobile node can detect MAP failure through receiving the packet from the S_MAP instead of the P_MAP. The correspondent nodes can also detect MAP failure after sending the packet to the mobile node and from receiving the ICMP error messages and rerouting through an S_MAP after modifying its binding cache. Of course, the mobile node can detect the MAP failure by the RA messages when it does not communicate with any other nodes. If the mobile node detects a P_MAP failure, it then changes its serving MAP to the S_MAP from the failed P_MAP. The S_MAP changes to a serving mapping table by using a backup mapping table when the S_MAP received the packet from the mobile nodes. The MAP maintains the serving and backup mapping tables in the RH-MIPv6 scheme [3].

2.2 IRH-MIPv6

An improved RH-MIPv6 (IRH-MIPv6) is shown to reduce the costs between the distributed MAPs, only one binding update (BU) message is required for its registration to two MAPs and correspondent nodes (CNs). The mobile node (MN) sends a binding update message including the S_MAP registration to the P_MAP. In other words, the MN encapsulates the S_BU message to register the S_MAP within the P_BU and then sends it to the P_MAP. It shows a more efficient signalling cost than the previous schemes [6] for two different MAP registrations. Secondly, the mobile node sends the biding updates including RCoA to the CNs. The RCoA includes an option to exchange the CNs and therefore, signalling costs are reduced. IRH-MIPv6 also requires the additional entry for binding caching and flag for the BU. The failure-recovery mechanism is same as that of RH-MIPv6 and its recovery time is similar with both.

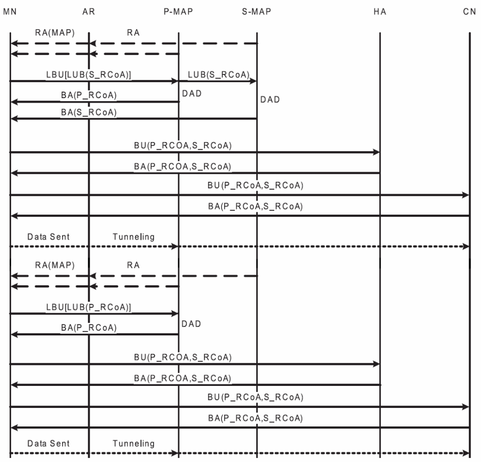


(**Fig. 1**) Inter-MAP Movement in RH-MIPv6

3 Failure Detection and Recovery Scheme for Inter-MAP Binding Update

The RH-MIPv6 method has very high signalling costs for achieving the faster recovery times when the mobile node moves frequently and is therefore inefficient for guaranteeing the mobility with high QoS in wireless network systems. As the wireless link quality (i.e., the frame error rate (FER)) is not to be trusted, it affects signalling costs due to the recovery time because frequent movements of the mobile nodes result in frequent handovers. In the Improved RH-MIPv6 illustrated in Fig.1, only one binding update (BU) message for registering the two different MAPs and CNs is required which reduces the signalling costs in the distributed MAP environment. The registration of two different MAPs is performed by the one binding update (BU) message which encapsulates the registration of the Secondary MAP and is sent to the Primary MAP. Thus the mobile node sends an S_BU, encapsulated within the P_BU, via the Primary MAP to the Secondary MAP; the two MAPs send back a BA (Binding Acknowledgement) to the mobile node for the binding procedure. The BU procedure, carried out in a wired network between two MAPs, shows better performance compared with two binding updates for the registration of two different MAPs in a wireless network. For registration of CNs, the mobile node sends the BU which includes the second RCoA within an alternate care-of address (ACoA) option to the CN which reduces the signalling costs. However, handover latency time can be increased due to frequent handover between the primary and secondary mobility anchor points. Hence the proposed RH-MIPv6 scheme has reduced signalling due to the reduced number of message transmissions from the mobile node.

In the cost-reduced RH-MIPv6, first-try MAP registration is based on the RH-MIPv6 scheme, when the mobile node first enters the MAP domain; it receives several router advertisements (RAs) from the neighbouring MAPs and selects the two exchangeable MAPs. At the same time it sends a binding update (BU) message to the P_MAP for the registration of the primary and secondary mobility anchoring points. In other words, the mobile node sends a P_BU message including the encapsulated S_BU message for registering S_MAP to P_MAP. After the P_BU message is sent to P_MAP, P_MAP sends the S_BU message to S_MAP. In this way, the process to register P_MAP and S_MAP is completed. The mobile node sends the binding update message including P_RCoA and S_RCoA to the correspondent nodes for its registration. The RCoAs include the option to change the correspondent nodes' care-of addresses for reducing the signalling overhead. After the mobile node moves to another MAP, the proposed scheme can skip the S_MAP registration when the mobile node registers the new P_MAP, this means that P_MAP takes on the role of the S_MAP. The mobile node only sends a binding update message to the previous P_MAP, as it holds only the location information of the previous P_MAP. If the mobile node fails to connect with the current P_MAP, it can communicate with the previous P_MAP. When the mobile node registers to its new correspondent nodes,, the secondary regional care-of address inside the binding update message for registering the previous P_MAP indicates the failure that has occurred. Fig. 2 shows the handover procedures of the Cost-Reduced RH-MIPv6.



(**Fig. 2**) Cost-Reduced Binding Update process in the RH-MIPv6 scheme

The Cost-Reduced RH-MIPv6 also needs to add an additional entry to the binding cache and a new flag to the binding update message. A failure recovery mechanism is performed on the same principle in the improved RH-MIPv6 and therefore the recovery time is similar to that in the RH-MIPv6 method. The proposed scheme shows more efficient signalling cost than RH-MIPv6 despite using the same resources.

4 Performance analysis

In this section, an analysis is made of the total handover delay and the signalling costs in the RH-MIPv6, IRH-MIPv6 and Cost-Reduced RH-MIPv6 approaches. The analysis of the handover delay focuses on the delay as a function of the frame error rate (FER) between the mobile nodes and the radio access network (RAN). The handover is affected by two binding updates, the frame error rate FER for the MAP, and the correspondent nodes in the RH-MIPv6 scheme. On the other hand, IRH-MIPv6 performs only one binding update to each of the mobility anchor points and the correspondent nodes. The analysis of the signalling costs in IRH-MIPv6 shows it has lower costs of signalling than the RH-MIPv6.

The following notations are used:

- t represents the delay.
- The delay which the mobile node receives the RA from MAP is $Tt(Adv)$.
- The delay between the MN and the radio access network (RAN) is t_{MN_RAN}, which is the time to send a message over a wired or wireless link.
- The delay between the MN and the AR is t_{MN_AR}.
- The delay between the AR and MAP is t_{AR_MAP}.
- The delay between the P_MAP and the S_MAP is t_{P-S_MAP}, which is the time to deliver on wired.
- The delay between the MAP and HA is t_{MAP_HA}.
- The delay between the MAP and the correspondent nodes is t_{MAP_CN}.

Since the RH-MIP, IRH-MIP and Cost-Reduced RH-MIPv6 have almost the same time of DAD and packet processing, previous to performance analysis, it was assumed that it is not necessary to consider the time needed by DAD and the packet processes. Also the wired pass between the P_MAP and the S_MAP will be reliable. In order to consider the frame error rate (FER), error is a random process and we ignore the error correcting codes.

The handover delay of the RH-MIPv6 scheme is given as:

$$Tt_{RH-MIPv6} = Tt(RAdv) + 5Tt(BU) + 5Tt(BA) + 10(t_{MN\_AR} + t_{AR\_MAP}) + t_{MAP\_HA} + 4t_{MAP\_CN} \quad (1)$$

The handover delay of the IRH-MIPv6 method is given as:

$$Tt_{IRH-MIPv6} = Tt(RAdv) + 3Tt(BU) + 4Tt(BA) + 4(t_{MN\_AR} + t_{AR\_MAP}) + t_{P-S\_MAP} + t_{MAP\_HA} + 2t_{MAP\_CN} \quad (2)$$

The handover latency of the Cost-Reduced RH-MIPv6 method for the first-try MAP domain is given as:

$$Tt_{Cost-Reduced} = Tt(RAdv) + 3Tt(BU) + 4Tt(BA) + + 7(t_{MN\_AR} + t_{AR\_MAP}) + t_{P-S\_MAP} + 2t_{MAP\_HA} + 2t_{MAP\_CN} \quad (3)$$

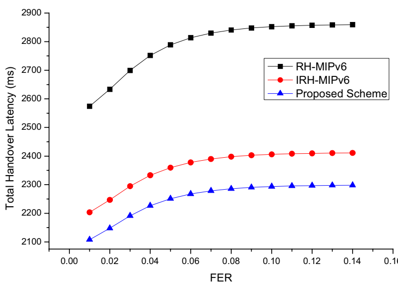
The handover latency for the Inter-MAP movement is given as:

$$Tt_{Cost-Reduced} = Tt(RAdv) + 3Tt(BU) + 3Tt(BA) + 6(t_{MN\_AR} + t_{AR\_MAP}) + 2t_{MAP\_HA} + 2t_{MAP\_CN} \quad (4)$$

As shown in Equation (4), the Cost-Reduced RH-MIPv6 scheme sends a binding update message, which contains the registration information for P_MAP and S_MAP, to only P_MAP for the first-try MAP registration. From the second MAP movement, the mobile node sends the new P_MAP registration information, and binding update message, including the previous P_MAP information to the home agent and the correspondent nodes. This procedure is repeated for every Inter-MAP movement as the mobile node moves. Therefore, it should not be necessary to register the S_MAP when the mobile node changes its MAP as with the IRH-MIPv6 method.

Previous analysis results are presented, which show the latencies for the RH-MIPv6, IRH-MIPv6 and the Cost-Reduced RH-MIPv6 schemes in the handover process. For the results, it is assumed that Inter-MAP movements occur 3 times as in Fig. 3, and we set t_{MN_AR} = 11 ms as in [6] considering 10 ms of the wireless link bandwidth and t_{AR_MAP} = 2 ms, t_{P-S_MAP} = 5 ms and t_{MAP_HA}, t_{MAP_CN} = 100 ms. Also, D = 10 ms, τ = 1 ms and N_m = 6 are set, and a 128-kb/s channel is considered. For the analysis of the handover delay, as the frame error rate (FER) between 0% and 15%, it is assumed that the size of each message and the values of the exponential back-off timer are as those obtained in [1]-[2].

Total handover latencies for RH-MIPv6, IRH-MIPv6 and Cost-Reduced RH-MIPv6 are calculated by (3). In Fig. 3, total handover latencies for RH-MIPv6, IRH-MIPv6 and Cost-Reduced RH-MIPv6 are illustrated. The result shows that the IRH-MIPv6 and the Cost-Reduced RH-MIPv6 methods have a more efficient handover process than the RH-MIPv6 scheme, because of the lower number of exchanged messages over the wired and wireless links.



(Fig. 3) Total handover latency of the IRH-MIPv6 method against RH-MIPv6, in case of 3 movements for Inter-MAP

The RH-MIPv6, IRH-MIPv6 and Cost-Reduced RH-MIPv6 handover latencies are increased with respect to the frame error rate. These results are affected by the increasing signalling costs of re-transmission, although increasing signalling is important for the analysis of the difference between the three methods. The results for FER show a slight difference between the RH-MIPv6 and IRH-MIPv6 methods including the Cost-Reduced RH-MIPv6 approach, however, if the probability of a packet re-transmission increases, the difference of the two schemes also increase. Additionally, frequent movement of the mobile node in the MAP domain results in local handover management, the difference of total handover latency is increased further. Overall, the new proposed scheme (the Cost-Reduced RH-MIPv6) has been shown to give an improvement over the performance obtained using the RH-MIPv6 method by 19.6% and over the IRH-MIPv6 scheme by 4.7%.

5 Conclusions

The paper has focussed on reducing the high signalling overhead due to the handover process that occurs in RH-MIPv6 systems. The process of binding the mobility anchor points (P_MAP, S_MAP) is reduced through one binding update message, this aspect is confirmed by the result analysis. Also, it was confirmed that the frame error rate and the number of exchanged messages affect the handover latency. The new RH-MIPv6 scheme has a faster recovery time than the HMIPv6 approach. However the handover process in the RH-MIPv6 method results in the above problem. The proposed scheme is expected to improve the performance by 19.6%.

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