

An Optimization Handover Scheme Based On HMIPv6

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Abstract. The process that mobile node still maintains its connectivity when moved from one access router (AR) to another access router is called handover. The handover technology is one of the most important technologies for the quality of real-time operation. In order to reduce the handover delay, Fast Mobile IPv6 (FMIPv6), Hierarchical Mobile IPv6 (HMIPv6) and Fast Hierarchical Mobile IPv6 are studied. Then, an optimization method based on HMIPv6 is advanced. On the basis of mobile anchor point (MAP), this scheme introduces the concept of regional anchor point (RAP) with the purpose of reducing the binding update messages between mobile node and home agent (HA) or correspondent node, thus lowering the handover delay.

1 Introduction

The rise of wireless communications and computer technology promotes the rapid development of the society on the direction of high-tech and information technology, which make people become more and more dependent on network. The integration technology for mobile communication technologies and wireless network satisfies people to visit internet at any time by mobile terminals and realizes dynamic link between mobile terminals and Internet, and achieves to maintain a seamless connection with Internet without reconfiguration network terminals, even without disruption of the network conversation.

The mobile IPv6(MIPv6) protocol, based on IPv6, has provided support for those mobile network users. Its working principle is shown in Fig.1. ①An MN detects that it has moved to a new subnet when it roamed[1]. Then it may use either stateless or stateful address auto-configuration to form one or more care-of addresses. ②The association made between the home address and the care-of address is known as a binding, and binding update (BU) is sent to HA and CN. Its HA and CN will store BU in their binding cache once they obtained the BU and send a binding

acknowledgement (BACK) to MN. ③The HA uses the neighbor advertisement (NAdv) to intercept the data packets intended to MN, then encapsulates and forwards them to the care-of address by tunnels. ④The data packets are directly sent to care-of address by routing extension header of home address included in data packets, which can prevent forming triangular routing between CN and MN due to HA.

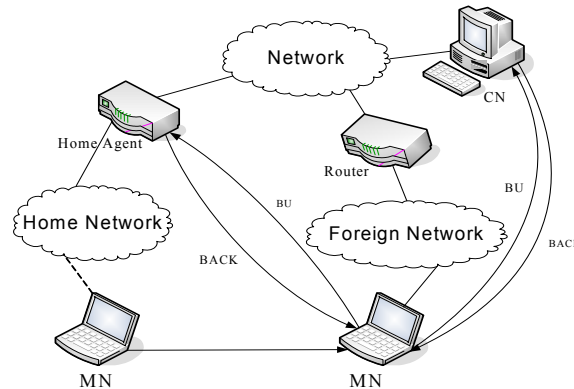


Fig.1. IPv6 working principle

2 Handover methods of mobile IPv6

In mobile IPv6, MN registers its care-of address to HA after it leaves home address, and constructs a bidirectional tunnel with HA. Then the data groupings communicating with CN will be forwarded by HA. But this kind of bidirectional tunnel leads to serious grouping latency, the protocol advanced a method for routing optimization, namely, any CN which communicates with MN and has the foundation of mobile IPv6 can maintain a cache to bind the MN care-of address. Therefore, MN can communicate with CN directly, reducing the handover latency. The MN will perform the handover process of MIPv6 when it moves from one IPv6 network to another IPv6 network.

The MIPv6 handover technology can be divided into three categories: the first is smoothness handover (also called low grouping handover). Its characteristic is almost not to loss any grouping, which is used to the text transmission business not sensitive to latency and allowing poor performance. The second is fast handover (also called low latency handover), which requires MN' process of handover fast and the grouping latency as low as possible. At present, it's mainly applied to more and more real-time multimedia business on Internet, which can abide grouping loss on some degree, but more care about the latency and handover wobble. The third is seamless handover, which merges the virtues of the former two, and implements low latency and low grouping loss handover, so it's the ultimate objective.

2.1 Mobile IPv6 fast handover

The model of fast Mobile IPv6 (FMIPv6) based on MIPv6 accelerates the handover by increasing set of message mechanisms[2], such as router solicitation for proxy (RtSolPr), proxy router advertisement(PrRtAdv), handover initiate(HI), handover Acknowledgement(HACK), fast binding update(FBU), fast binding Acknowledgement(FBACK), fast neighbor advertisement (FNA) and so on. FMIPv6 allows MN to obtain the information of new AR and its subnet proxy when it stays on its old AR. Therefore, it can anticipate new care-of address, which can reduce the latency for configuring care-of address by some operation after handover.

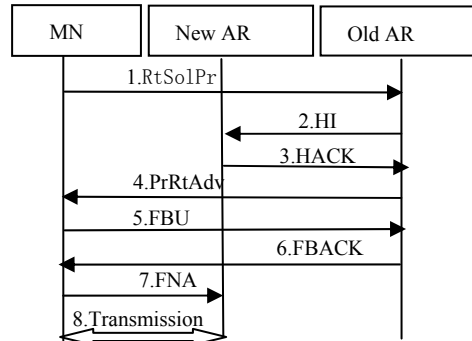


Fig. 2. Principle of fast handover

Simultaneously, MIPv6 requires MN to set up a tunnel between the old AR and the new AR when it has attained the new care-of address. In this case, MN can still receive the grouping sent from CN on the period of handover. The grouping will be intercepted by the old AR and forwarded to the new AR through the tunnel. The new AR firstly cached the grouping before it receipted the MN' advertisement and won't forward the new care-of address until the MN sends advertisement indicating it truly moves to the AR. The process of fast handover is shown in Fig.2.

2.2 Hierarchical mobile IPv6

The model of hierarchical mobile IPv6 (HMIPv6)[3] is an amelioration of MIPv6 that imports a function entity—mobile anchor point (MAP, which is a router in any layer of HMIPv6). Then the care-of address in MAP domain is divided into link care-of address (LCoA, which is a temporary address conserved in a MAP)[4] and regional care-of address (RCoA, which is a MN' MAP address conserved between HA and CN). When MN moves in the same MAP, its RCoA doesn't change, so it only needs to register a new LCoA to MAP. The MAP updates its couple of address [RCoA, LCoA] in the binding cache and intercepts the MN' RCoA data packets sent to its own domain, then forwards them to MN' LCoA through tunnel. Its network configuration is as shown in Fig.3.

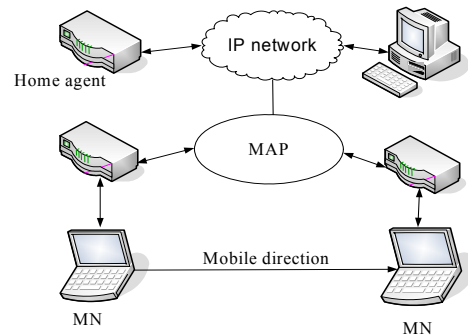


Fig.3. Network configuration of HMIPv6

The handover process of HMIPv6 has two instances: ①MN moves in the same MAP domain, namely micro-movement. In this instance, MN just needs to register the LCoA and not change its RCoA, so MN doesn't need to rebind to HA and CN. ②MN moves in different MAP domains, namely macro-movement. When moving to a new MAP domain, MN will perform the detection operation, and obtain two care-of addresses by AR: RCoA and LCoA. Then MN sends a binding update message which produces new RCoA and makes the LCoA as its original address. Ensuingly, MAP returns a BACK message indicating the registration successful or not. After MN received the BACK message, the following operation is just like MN moving in a common IPv6.

3. Optimization handover method of HMIPv6

Based on the above description on the working principle of FMIPv6 and HMIPv6, it is easy to conclude that FMIPv6 makes MN anticipate the care-of address produced after handover, which reduces the latency related with matching care-of address after moving. Meanwhile the tunnel set up between the old AR and the new AR degrades the data packets loss rate because of handover. But FMIPv6 doesn't consider the alternation of a great deal of binding messages when registering update. On the other hand, HMIPv6 has solved the problems, such as reducing the link efficiency and network throughput and increasing the handover latency, produced by handling a large number of update messages for HA and CN. But it ignores that the using of MAP increased the grouping transmission router between MN and CN and also adds the handover latency at some degree. Otherwise, HMIPv6 only applies to MN moving in the same MAP. Aimed at tackling the shortcomings of FMIPv6 and HMIPv6, the paper, coming from the purpose on reducing the number of registering update messages and degrading handover latency, advances an optimization scheme based on HMIPv6.

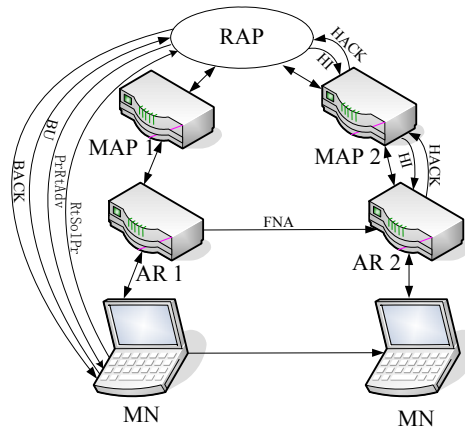


Fig.4. Handover process in different MAP of the same RAP

The optimization scheme is based on HMIPv6, combining some neighboring MAP domains to form a bigger domain, so a new function entity is introduced – regional anchor point (RAP)[5-8]. It acts as a temporary HA just like MAP, but its management area is broader than MAP'. When MN moves in this model, its care-of address consisted of three parts: link care-of address (MN' temporary address which conserved in MAP domain), regional care-of address (MN' temporary address conserved between MAP and RAP domain) and local care-of address (MN' address conserved between HA and CN). When it moves in the same MAP domain, MN keeps its regional care-of address and local care-of address as the same as before, but changes its link care-of address. On this time, MAP acts as MN' HA and intercepts the IP data packets sent to HA or CN. Then these data packets will be forwarded to MN' link care-of address by tunnel. Those operations are totally transparent to the MN' HA, CN and RAP. When MN moves in the same RAP but different MAPs, RAP acts as MAP' HA and MAP acts as RAP' mobile node. Here, MN' local care-of address still keeps invariability but its link care-of address and regional care-of address both changed. We can operate fast hierarchical handover in this layer handover. First of all, MN directly sends an RtSolPr to RAP. Once RAP receives the RtSolPr message, it returns a PrRtAdv to MN as soon as possible and matches a new regional care-of address and link care-of address with MN. In order to maintain communication between the old and the new link, MN needs to send fast binding update message to RAP. After that, RAP forwards the information of care-of address to the new MAP through AR and sends HI information. Ensuingly, MAP sends HI information to the new AR, which will detect the validity of link address continuously, then send HACK message to the new MAP. Once the new MAP obtained the HACK message, it quickly sends HACK message to RAP. Hence, a bidirectional tunnel is set up between the new AR and RAP. After MN obtains the connection information sent from the new AR, it will send a fast neighbor discovery message to the new AR. At this moment, the new AR can forward data groupings to MN. Figure 4 shows its handover process.

4. Performance Analysis

During the process of network handover, the mobile IP handover delay formula is:

$$T_{\text{handoff}} = T_{\text{md}} + T_{\text{reg}} \dots\dots\dots(1)$$

T_{md} is mobile detection delay (here, we take the method of ESC, Eager Cell Switching), and T_{reg} is MN registered delay.

Assuming that T_{Mp} 、 T_{MAPp} 、 T_{RAPp} 、 T_{Hp} respectively represents the registration packet processing time by MN, MAP, RAP and HA; T_{MMbu} and T_{MMba} respectively stands for the link latency time caused by MN sending BU to MAP and MAP returning BA to MN. Similarly, $T_{\text{MHbu}}/ T_{\text{MHba}}$ is the BU/BA delay time between MN and HA, and $T_{\text{MRbu}}/ T_{\text{RMba}}$ is the BU/BA delay time between MAP and RAP.

When MN moved in a network without RAP, the movement from MAP1 to MAP2 is a macro-movement, on this time,

$$T_{\text{reg}} = T_{\text{Mp}} + T_{\text{MMbu}} + T_{\text{Mp}} + T_{\text{MAPp}} + T_{\text{Hp}} + T_{\text{MMba}} + T_{\text{MHbu}} + T_{\text{Mhba}} \dots\dots\dots(2)$$

Hence,

$$T_{\text{handoff}} = T_{\text{md}} + T_{\text{Mp}} + T_{\text{MMbu}} + T_{\text{Mp}} + T_{\text{MAPp}} + T_{\text{Hp}} + T_{\text{MMba}} + T_{\text{MHbu}} + T_{\text{MHba}} \dots\dots\dots(3)$$

When MN moved in the same RAP but different MAPs, the movement from MAP1 to MAP2 is a micro-movement, on this time,

$$T_{\text{reg}} = T_{\text{Mp}} + T_{\text{MMbu}} + T_{\text{Mp}} + T_{\text{MAPp}} + T_{\text{MMba}} + T_{\text{MAPp}} + T_{\text{MRbu}} + T_{\text{RAPp}} + T_{\text{RMba}} + T_{\text{MAPp}} \dots\dots\dots(4)$$

Hence,

$$T_{\text{handoff}} = T_{\text{md}} + T_{\text{Mp}} + T_{\text{MMbu}} + T_{\text{Mp}} + T_{\text{MAPp}} + T_{\text{MMba}} + T_{\text{MAPp}} + T_{\text{MRbu}} + T_{\text{RAPp}} + T_{\text{RMba}} + T_{\text{MAPp}} \dots\dots(5)$$

Compared (3) with (5), we can easily draw a conclusion that, aside from the same parts, (3) has its own unique parts of $T_{\text{MHbu}} + T_{\text{MHba}} + T_{\text{Hp}}$, but (5) has peculiar parts of $T_{\text{MAPp}} + T_{\text{MRbu}} + T_{\text{RAPp}} + T_{\text{RMba}} + T_{\text{MAPp}}$. Although the latter has one more handover process than the former, the HA will deal with numberless BU and BA at the same time, and the frequent BU and BA will lead to HA overload, even information block. That is to say, T_{MHbu} and T_{MHba} account for a big proportion throughout the process of handover. The improved HMIPv6 is through two times handover to alleviate the burden of HA, therefore reduce handover latency.

5. Conclusion

Although the ameliorative HMIPv6 has decreased the handover latency in a bigger area and reduced the management of registering update message between HA or CN and MN in greater degree, it also increases the hidden security troubles among MN, MAP and RAP. They must include authentication and integrity protection and have a capability of preventing replaying attack. Lack of any protection will make malicious node to imitate arbitrary legitimate nodes, even a MAP or a RAP. Any attack of those kinds will exert bad influence on the communication between MN and CN. Though there are still some problems on MIPv6 handover in one way or another, it can be true that with the development of technology and the depth of research, the handover latency and wobble will gradually disappear and eventually achieve a seamless handover.

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