Semi-soft FMIPv6 for 802.11 Network

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Abstract. Mobility support in the wireless network enables us to be served continuous service. Fast Handover for Mobile IPv6 (FMIPv6) is proposed to support a faster handover than that of Mobile IPv6. Unfortunately, FMIPv6 shows too long handover latency to serve smooth video traffic flows. We proposed semi-soft FMIPv6 handover to minimize the handover latency to serve video traffic efficiently. The proposed scheme clarifies the handover procedure by separating the handover preparation and the actual handover. We also clarify the use of L2 triggering by introducing four triggers and triggering time scheme. With our experimental implementation, the proposed scheme has shortened the handover latency below 50ms and this low handover latency helps to reduce the buffered packet size in access routers.

1 Introduction

Mobility support is a key feature in wireless network environment. Mobility support provides continuous service for mobile nodes when they move from one wireless point of attachment to another in a different subnet. In IEEE 802.11 wireless network, communication disruption period exists between current attachment point and new attachment point. And additional process time to update mobility information is required according to mobility support protocol. Handover latency is a traditional metric that measures network disruption period.

Mobile IPv6 (MIPv6)[1] is a well-known protocol to support mobility in IEEE 802.11 wireless network. Handover latency in MIPv6 is more than one second excluding layer 2(L2) handover latency and it is considered too long to serve multimedia service such as video traffic. Fast Handover for Mobile IPv6 (FMIPv6)[3] is proposed to shorten the handover latency as a micro-mobility approach. FMIPv6 provides a faster handover than MIPv6. According to [6], handover latency in FMIPv6 is about 160ms. FMIPv6 has reduced the handover

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latency, but the handover latency still has to be reduced further to serve multimedia service such as video smoothly. Moreover, buffering in an access router to provide seamlessness needs to be minimized.

In this paper, we propose semi-soft FMIPv6 handover to minimize the handover latency to support video traffic smoothly. In semi-soft FMIPv6 handover, we separate handover preparation and actual handover clearly. We can configure the address configuration and tunneling setup before actual handover is occurred during handover preparation phase, so we call semi-soft FMIPv6 handover. We perform experiment to verify the operation of proposed handover procedures in test bed.

2 Semi-soft FMIPv6 Handover

2.1 FMIPv6

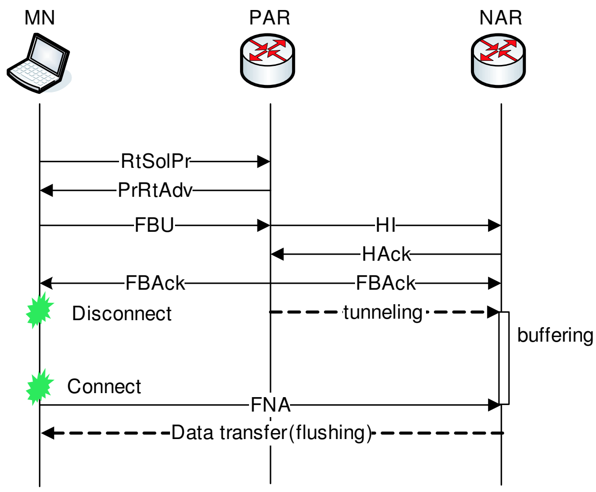

Fig. 1. The handover procedure of FMIPv6

FMIPv6 is proposed to reduce the handover latency of MIPv6. FMIPv6 predicts mobile movement and prepares the movement before actually the movement occurs. Fig. 1 shows the sequence of message for FMIPv6. In FMIPv6 over IEEE 802.11 network, FMIPv6 handover procedure is as follows:

1) MN performs a scan to see which APs are available. The result of the scan is a list of APs including physical layer information, such as signal strength. MN selects one or more APs by its local policy.
2) MN exchanges Router Solicitation for Proxy (RtSolPr) and Proxy Router Advertisement (PrRtAdv) with the current AP to get the new subnet prefix of the selected AR.

3) MN itself configures its prospective new CoA (NCoA) based on the new subnet prefix.
4) MN sends Fast Binding Update (FBU) to current(previous) AR (PAR) to tunnel packets from PAR to new AR (NAR).
5) PAR exchanges Handover Initiation(HI)/Handover Acknowledgement(HAck) message with NAR. After receiving HI, NAR does Duplicate Address Detection(DAD) and protects the NCoA from other nodes in the subnet until MN arrives this subnet. In addition NAR prepares to buffer tunneled packets from PAR.
6) MN should wait Fast Binding Acknowledgement(FBAck) message, if possible, when it still presents on the previous subnet. If MN receives FBAck in the previous subnet, it should move to NAR as soon as possible. If the MN does not receive FBAck in the current subnet and cannot sustain current association (e.g., signal strength is very low), MN should move to NAR without waiting FBAck.
7) After PAR sends FBAck, PAR forwards every packet towards MN to NAR, and NAR starts buffering. Buffering continues until NAR receives Fast Neighbor Advertisement(FNA).
8) When MN moves into new subnet, it sends FNA to NAR and receives buffered packets in NAR.

FMIPv6 uses predictive scheme to reduce handover latency and also uses tunneling and buffering to support seamlessness. With buffering, the handover latency is critical to NAR. Large handover latency for high volume traffic flow may cause buffer overflow. If there are several such flows in a MN or several MNs does handover to NAR simultaneously, this situation can be very serious.

2.2 Semi-soft FMIPv6 Handover

To use FMIPv6, it must be considered practical issues. The issues are as follows:

1) FBU causes HI/HAck. Because DAD procedure in NAR takes one second, HI/HAck exchanges consume at least one second. According to [3], FBU can be considered as handover signal to network. If the MN is disconnected from current AP as soon as FBU is sent, all packets arrived before receiving HAck are lost due to non-existence of the forward tunnel. If packets, which are sending from PAR after FBU received, are buffered in NAR, this may cause excessive burden to NAR buffer.
2) How a MN knows candidate APs without communication disruption with one antenna?
3) In [3], the use of L2 trigger is strongly recommended. But [3] does not mention when the L2 trigger occurs because this is implementation issue.

1) may cause excessive delay for real time traffic in FMIPv6, and 2) and 3) are implementation issues.

The delay problem is caused by the unclearness of preparation phase and handover phase in FMIPv6. If FBU is sent too early, all packets are forwarded to NAR so the MN cannot receive packets from PAR anymore and the buffering overhead of NAR is increased due to long buffering time. On the other hand, sending FBU too late may cause incomplete fast handover process and packet is lost because the link is disconnected before tunnel is set up. This phenomenon is due to the dual usages of FBU as preparing handover and handover signal. It is much better to sperate FBU's two functions into two signals. One is used to prepare handover - doing HI/HAck and tunneling setup and the other is actual handover signal. We restrict FBU function as the first role and propose new messages called Movement Notification (MvNoti) and Movement Acknowledgement (MvAck) to do the second function. This makes the separation of handover preparation and actual handover phases much clear in FMIPv6. Because FMIPv6 uses predictive method, we consider that the separation of handover preparation and actual handover is more desirable.

Even if the handover preparation is done before actual handover, the number of messages to be used in handover must be minimized as well. The needs of RtSolPr/PrRtAdv exchange is to generate NCoA based on NAR's RA by the MN. If network allocates NCoA rather than the MN, this exchange is not required. In semi-soft FMIPv6, RtSolPr/PrRtAdv exchange is eliminated and NAR allocates NCoA. The information sent in RtSolPr is included in FBU. PAR selects the NAR using its CAR (Candidate AR) table based on information sent in FBU. When NAR receives HI message from PAR, NAR allocates pre-configure duplicate-free NCoA address to MN in order to avoid DAD procedure. The NCoA is sent back to PAR using HAck. PAR uses the NCoA for tunneling preparation and gives it to the MN via FBAck. The allocation of duplicate-free address using advance DAD[5] instead of DAD is optional. The option is used to reduce DAD delay in HI/HAck exchange. When the preparation phase is end, the forwarding path setup is completed. We call this status as Semi-soft.

In FMIPv6, it uses L2 triggers to the starting point of preparation and actual handover procedure. [3] mentions that a MN must prepare the scan list of APs before starting FMIPv6 procedure. Unfortunately, IEEE 802.11 network adapter has only one antenna and it cannot usually be used to scan after an association with an AP is made. Therefore to scan APs, the association must be terminated and made re-association after scanning APs. This means current connections may disconnected due to scanning. This is unpractical. To solve this problem we use two antennas in one interface. One is used for communication and the other is used to scan APs passively. This does not violate any current IEEE 802.11 specification. Passive scanning antenna does not send any messages, so the power consumption will be minimal. The role of passive scanning module is selecting a candidate AP based on incoming signal strength and triggering L2 signaling for FBU and MvNoti. The triggering time is equivalent to RtSolPr and FBU in FMIPv6.

To make L2 triggering time for each step clear and to make handover procedure stable, we introduce four triggers: 1) Link Quality Cross the Target(LQCT), 2) Link Going Down(LGD), 3) Link Switch(LS) and 4) Link Up(LU) triggers. LQCT, LGD, and LU triggers are sent from L2 layer and LS trigger is sent to

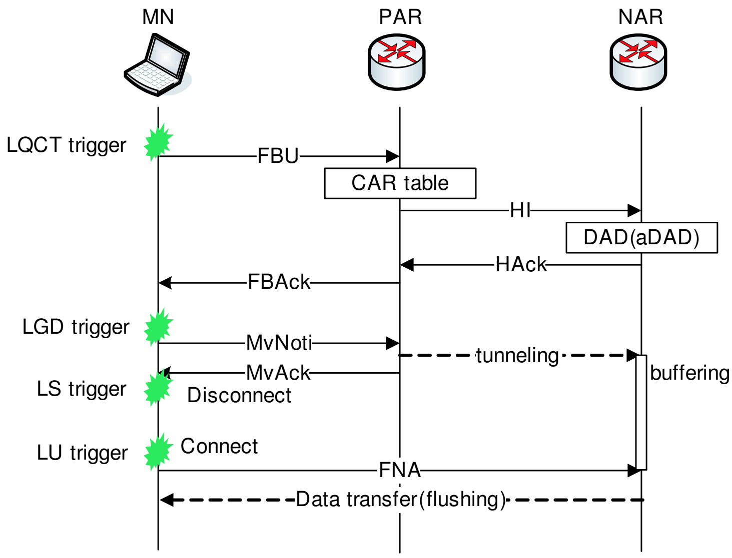

Fig. 2. The handover procedure of semi-soft FMIPv6 handover

L2. L2 maintains neighbor AP list from periodical passive scanning. The entry of neighbor AP list contains all information about neighbor AP such as AP's MAC address and signal strength. Neighbor APs are divided into candidate APs list and detected APs list. An AP in candidate APs list has enough signal strength that the MN can do handover to it. Among candidate APs, the AP having the highest signal strength becomes the target AP. LQCT trigger is generated when the signal strength of currently associated AP crosses that of the target AP. This cross point is called as THR I. The signal strength of any AP is varying, so THR I cannot be a fixed value. The second threshold, THR II, is set to certain signal strength as high as MvNoti can be surely sent before the association is terminated with current AP. When the signal strength of the current AP is going down to THR II, LGD trigger is sent to semi-soft FMIPv6 handover. When LGD is received, semi-soft FMIPv6 sends MvNoti to PAR. If semi-soft FMIPv6 receives MvAck, LS trigger is sent to L2 layer to start L2 handover. In FMIPv6, FMIPv6 does not mentioned when L2 layer should perform L2 handover. We make it clear by sending LS. When L2 handover is completed LU trigger is sent to semi-soft FMIPv6. LU trigger cause semi-soft FMIPv6 to send FNA to NAR. When NAR receives FNA from MN, it flushes all buffered packets. After this, the process of semi-soft FMIPv6 handover is done and the MN in new subnet can receive data packets and starts L3 handover using MIPv6. Fig. 2 shows semi-soft FMIPv6 handover flows including triggers.

Fig. 3 shows an example of the relation between two thresholds and signal strength. AP1 is currently associated AP, and AP2 and AP3 are neighbor APs. AP2 can be selected as the target AP and AP3 is a detected AP. LQCT trigger

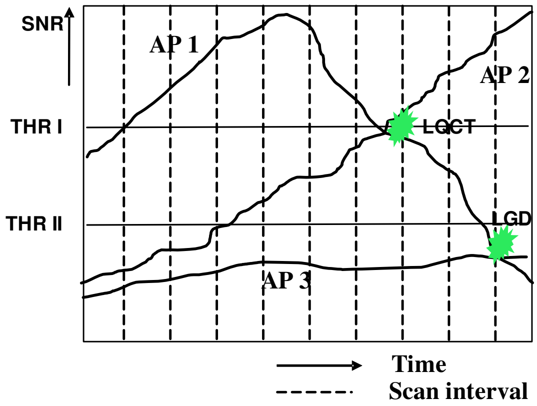

Fig. 3. Relation between threshold and signal strength

is occurred when the signal strength of AP1 and AP2 is crossed. As scanning is performed periodically, the actual trigger may not exactly matches the cross point. LGD is triggered when the signal strength of AP1 is below the THR II.

3 Experimental Implementation and Results

We perform experiment to verify the operation of semi-soft FMIPv6 handover procedures in test bed and to estimate the performance. Fig. 4 shows the network configuration of experimental environment. There are two client systems perform as a MN and a CN. The CN is fixed PC system and the MN has *Samsung Atmel* WLAN adapter for data communication and *Lucent Orinoco USB client silver* WLAN adapter for passive scanning. As the device driver of Atmel WLAN adapter did not supply enough information to do scanning manually, we have to use different adapter instead of using the same two Atmel WLAN adapters. The device driver of Orinoco WLAN adapter included in Linux kernel 2.4.20 is modified not to receive any packets and to do scanning periodically. PAR and NAR are modified to include semi-soft FMIPv6 handover functions and advanced DAD module based on Linux kernel 2.4.20 and for L3 handover, we used MIPv6 supplied by Samsung AIT. The test was performed using VLC streaming client[8] on MN and CN. We used the video stream sent from CN. The stream was transferred with UDP over RTP and the transmission speed of video was 300 Kbps.

We measured the handover latency in the MN and buffered packet count in NAR. The handover is performed periodically from AR1 to AR2 and AR2 to AR1; the MN moves between two APs periodically. The measurement of handover latency is done by capturing data with ethereal[9] at MN and calculating the time differences between last data packet before handover and first data packet after handover. Fig. 5 shows the captured packets with ethereal at MN when a single handover is performed. It shows the semi-soft FMIPv6 handover

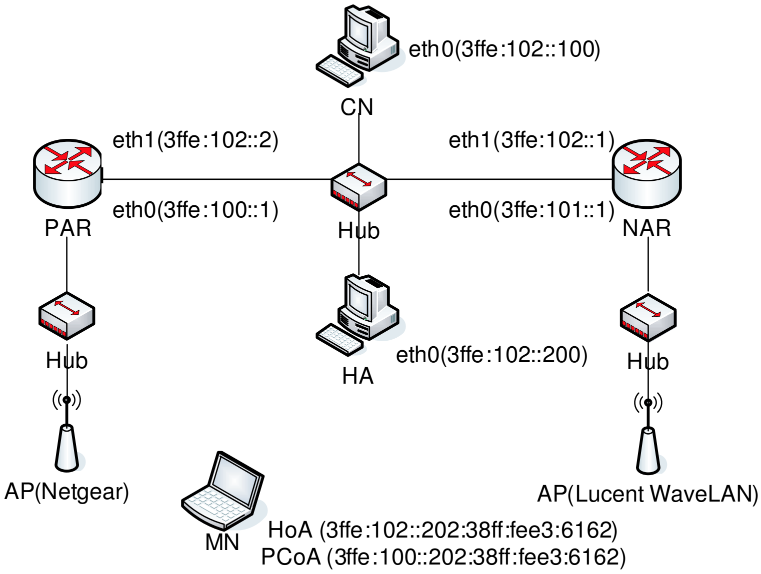

Fig. 4. Experiment test bed setting

processes of MN. Note that HI and HAck messages are not shown in fig. 5 because these messages are exchanged between PAR and NAR.

Table 1 shows the test result. The average semi-soft FMIPv6 handover time measured in the MN is about 28.4 ms. This result is possible because L2 layer does not perform any scanning but it just tunes to the specific channel which is supplied by passive scanning module. According to [7], L2 handover time varies between 53.3ms and 420.8ms depending on WLAN adapters, AP makers, and AP models, and L2 scanning delay accounts for more than 90% L2 handover time. Therefore semi-soft FMIPv6 handover delay takes nearly a half of the best L2 handover time. Semi-soft FMIPv6 handover delay includes all semi-soft FMIPv6 handover delay and L2 handover time. The average buffer packets in NAR is 8.5 packets per 28.5ms. If the handover latency is one second, the average buffer packets should be 298 packets for 300Kbps flow. If several handovers with one second handover time had occurred simultaneously, NAR must have faced serious buffering problem.

4 Conclusion

Mobility support in the wireless network enables us to be served continuous service. Fast Handover for Mobile IPv6 (FMIPv6) is proposed to support a faster handover than that of Mobile IPv6. Unfortunately, FMIPv6 shows too long handover latency to serve smooth video traffic flows.

We proposed semi-soft FMIPv6 handover scheme. FMIPv6 may be unsuitable for video traffic due to excessive handover delay. The excessive delay is caused

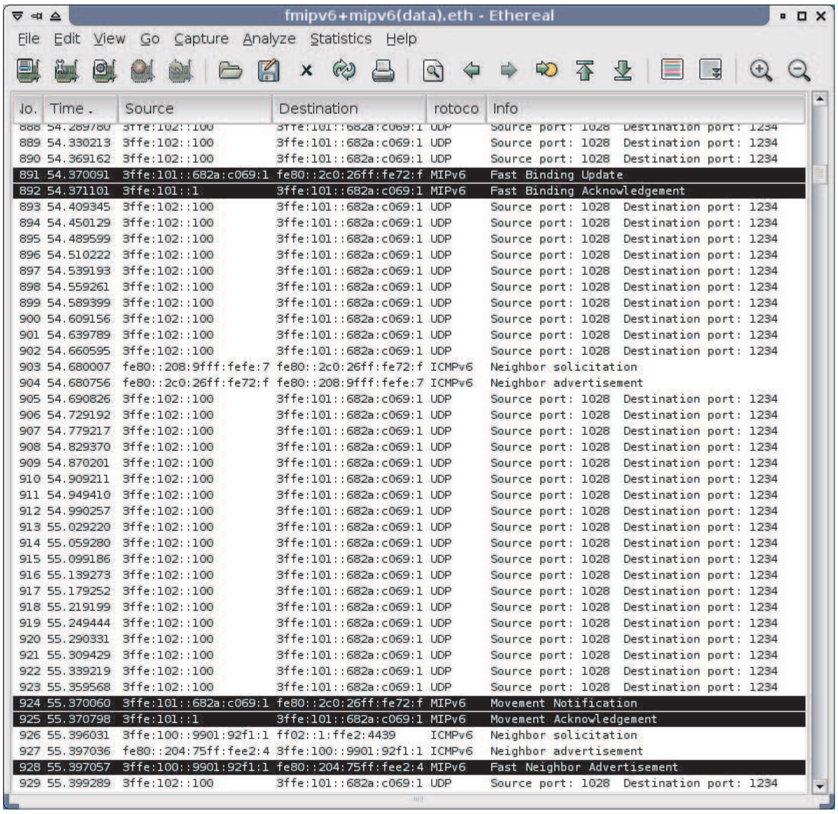

Fig. 5. Packet flows of semi-soft FIMPv6 handover with a single handover

Table 1. Total handover latency and buffered packet count of semi-soft FMIPv6 handover

Trial	Handover latency(ms)	Buffered packets(count)
1	22.89	3
2	27.748	4
3	26.592	8
4	23.206	2
5	33.03	16
6	31.245	15
7	31.982	9
8	35.814	2
9	24.808	9
10	26.816	17
Average	28.413	8.5

by unclearness of handover preparation and handover itself. Semi-soft FMIPv6 handover makes the separation of preparation and handover phase clear and optimizes message flows. In addition, we clarify the use of L2 triggering by introducing four triggers and triggering time scheme. Our test result shows the handover latency of semi-soft FMIPv6 handover is about 28.4ms. The latency is less than a half of most L2 handover latency of various WLAN devices.

With semi-soft FMIPv6 handover procedure, video traffic can serve more smoothly and the overhead of buffering at access routers also reduced so that access routers can support handover more efficiently.

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