Enhanced Mobile IP Handover Using Link Layer Information

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Abstract

The main source of the problem in Mobile handover is the latency and packet loss introduced by the lengthy registration processes. The registration messages must traverse all the way to the home agent (HA) and back. In addition, the packets sent by the corresponding node (CNs) are lost until they receive the binding update (BU) indicating the new care-of-address (nCoA) of the mobile node (MN). To reduce the number of lost packets during this time, the MN can request the old access router (oAR) to forward all its incoming packets to the new access router (nAR)
Mobile IP handovers can be improved through link layer information to reduce packet loss during handovers. It avoids link disruption during Mobile IP handovers and reduces packet loss. Therefore, link layer information allows an MN to predict the loss of connectivity more quickly than the L3 advertisement based algorithm. It is the best choice used to predict a breakdown wireless link before the link is broken. This facilitates the execution of the handover and eliminates the time to detect handover.

Keywords- Mobile IP Handover; Link Layer Information; Fast Handover; Handover Latency; Packet Loss

1. NTRODUCTION

The IP is expected to become the main carrier of traffic to mobile and wireless nodes; this includes ordinary data traffic like HTTP, FTP and e-mail, as well as voice, video and other time-sensitive data. The goal is to allow applications on a Mobile IP node to keep on communicating with other nodes while roaming between different IP networks. Roaming typically occurs when the MN physically moves from its location to a new location and decides to make use of a different access link technology; this can result in the node disappearing from one point on the Internet, and, topologically at least, re-appearing at another point.

Mobile IP is an Internet standards protocol, proposed by the Internet Engineering Task Force (IETF), which enhances the existing IP to accommodate mobility [1, 2]. Mobile IP in wireless networks is intended to be a direct extension for existing fixed/wireline networks with uniform end-to-end Quality-of-Service (QoS) guarantees. In addition, using Mobile IP, seamless roaming and access to applications will make users more productive, and they will be able to access applications on the fly, perhaps giving them an edge on the competition.

Mobile IP handover defined as the process for redirecting IP packet flow destined to the MN's old location to the MN's current attachment point. When MN moves to a new subnetwork, packets are not delivered to the MN at the new location until the Care-of-Address (CoA) registration to HA is complete. Mobile IP doesn't buffer packets sent to the MN during handovers. Therefore, these packets may be lost and need to be retransmitted [3, 4].
During the handover procedure, there is a time period in which a MN cannot send or receive packets, because of the link switching delay. This period of time known as handover latency; Moreover; there is a high Mobile IP handover delay because of the agent discovery and registration periods, eventually Mobile IP handover can cause significant performance degradation, especially in large scale mobility environments

Mobile IP use link layer information to force a handover to a new access network before any mobility at the network layer can be detected [2]. In this paper we propose the use of link-layer information, and the link-layer trigger to enhance the overall performance of the enhanced Mobile IP handover.

2. MOBILE IP HANDOVER LATENCY

The handover time can be defined as the time between reception of the last packet through the old FA (oFA) and reception of the first packet through the new FA (nFA). Throughout the time between the MN leaving the old foreign network and HA receiving the MN registration message, HA does not know the MN's latest CoA and, therefore, it still forwards the packets destined for MN to the old foreign network [5, 6, 7]. These packets will be discarded and lost. The packet losses could cause impossible disruptions for real-time services, degrade the QoS and lead to severe performance deteriorations of upper layer protocols, especially when the handover is frequent and the distance between MN and the HA is great [8,9,10].

3. LINK LAYER INFORMATION

Link layer information allows an MN to predict the loss of connectivity more quickly than L3 advertisement-based algorithms. It is used to predict a breakdown wireless link before the link is broken. This facilitates the execution of the handover, and the elimination of the time to detect handover [11,12].

MN monitors any advertisements, records the lifetime and updates the expiration time when a new advertisement is received from a new network. When the advertisement lifetime of the current Mobile IP's FA expires, the MN assumes that it has lost connectivity and attempts to execute a new registration with another FA [5]. Although the MN might already be informed about the availability of the nFA, the mobile agent defers switching until the advertisement lifetime of the oFA is expired [27].. Mobile IP handovers that are based on movement detection being handled by the network layer are not appropriate to provide seamless and lossless connectivity of MNs, such movement detection causes packet loss and detects movements after the previous link has been broken [13.14].

4. RELATED WORKS

There are present two techniques in [15]. to support delay-sensitive and real-time applications in Mobile IPv4: pre-registration and post-registration. The pre-registration is based on link layer triggers, proxy agent advertisements and agent solicitations. In advance of a handover, the neighbouring FAs exchange agent advertisement messages with each other. A link layer trigger at the MN, or the old or the new FA triggers the handover.

Note that this happens before the actual L2 handover. The MN receives a proxy agent advertisement from the nFA relayed by the old foreign agent (oFA). Now, the MN can issue a Registration Request *(ReReq)* to the nFA via the oFA. This allows the MN to use the oFA until the registration completes. If the L2 handover is scheduled to the same moment that the registration completes, the overall handover latency will be reduced only to the L2 handover latency.

The post-registration method forms tunnels between FAs to forward arriving packets to the current location of the MN. Packets from the HA are first received by an anchor FA. The anchor FA is the FA that relayed the last Registration Request/Reply pair to the HA, it forwards packets to the subnet of the FA that currently serves the MN. There is no need for further registrations until the anchor FA has to be changed. The MN can postpone the registration to a time that it sees the most appropriate. Tunnels between FAs are established by a Handover Request *(HReq)* and a Handover Reply *(HRep),* the messages that are exchanged upon the L2 trigger that indicate the handover [16]..

Development of the link layer hints that are used as an input to the handover decision process [9]. An algorithm for handover initiation and decision has been developed based on the policy-based handover framework introduced by the IETF. A cost function was designed to allow networks to judge handover targets based on a variety of user and network valued metrics. These metrics include link layer hint parameters, as well as other QoS metrics. Evaluation of this method considered only the network controlled side, while mobile control was not mentioned, which in fact makes a difference between both of them.

The proposed a scheme in [17]. involving a Layer 3 handover which is able to reduce packet loss and provide more seamless handover without buffering. The proposed scheme uses L2 triggers and applies the tunnel mechanism and pre-registration method of the low latency handover scheme in Mobile IPv4.

However, the direction of the established tunnel of this scheme is opposite to that of the low latency handover of post-registration, in that data traffic arriving at the nFA is tunnelled to the oFA. When an L2 trigger is issued, the MN sends a seamless fast registration request (*SF_RegReq*) to the nFA, this message should carry the oCoA to create a tunnel between the nFA and the oFA.

Upon receiving *SF_RegReq*, the nFA forwards it to the HA, creates a *HRqst* message and sends it to the oFA to make the oFA is ready to create a tunnel with the nFA. Then, the data traffic for the MN is able to be transferred to the nFA. After receiving a seamless fast registration reply (*SF_RegReply*), which is replied to by the HA, the nFA encapsulates the data traffic received from HA and transmits it to the oFA. Therefore, the MN, which is still connected to the oFA, can receive the data traffic. When an L2 handover to the nFA completes, a link-up trigger is generated at both mobile and network sides. Then the nFA removes the tunnel and starts swapped these round data traffic to the MN [18].

5. PROPOSED ALGORITHM

Link layer information, such as signal strength, is continuously available, providing important information about the accurate link's quality. Therefore, link layer information allows an MN to predict the loss of connectivity more quickly than the L3 advertisement based algorithm. It is the best choice used to predict a breakdown wireless link before the link is broken. This facilitates the execution of the handover and eliminates the time to detect handover.

We propose Enhanced Mobile IP (E-Mobile IP) handover using link layer information, such as signal strength, network prefix, bandwidths and link indicator, which is continuously available, providing important information about the availability of new links [18]. Therefore, E-Mobile IP uses link layer information to allow an MN to predict the loss of connectivity more quickly than network layer advertisement based algorithms. Figure 1 describes the overall E-Mobile IP protocol message flow.

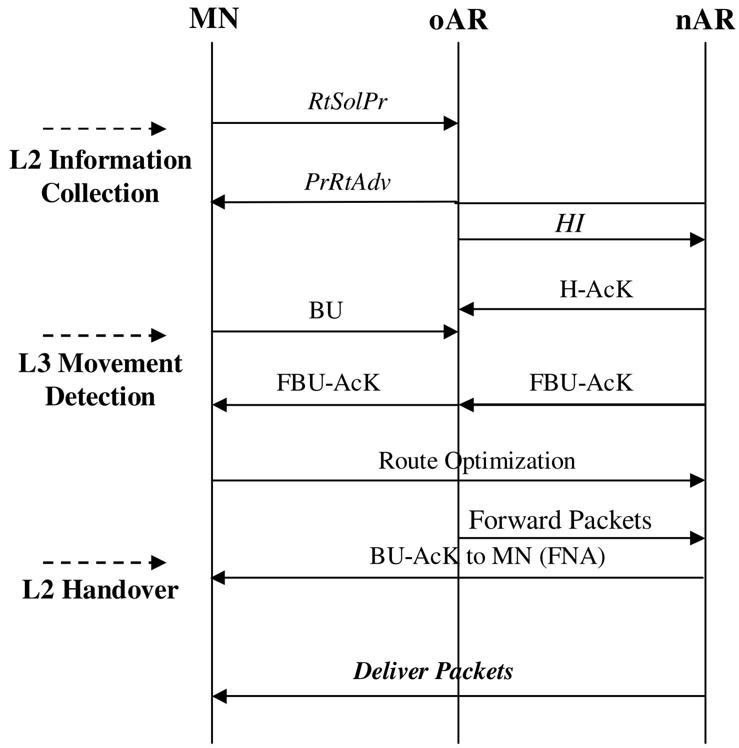

FIGURE 1: E-Mobile IP Protocol Message Flow

The π-Calculus E-Mobile IP handover system is described in terms of the following actions.

5.1 Handover system

The handover system is made up of the MN and access routers as follows:

$$System \overset{def}{\equiv} \mathrm{MN}\langle CoA \rangle \mid \mathrm{oAR} \mid \mathrm{nAR} \mid$$

5.2 Mobile Node (MN)

The MN will receive a link from the nAR, which is used to communicate with it. Then, the MN sends *RtSolPr* to inform the oAR that it is going to handover to the nAR.

$$MN(CoA) \overset{def}{\equiv} \overline{RtSolPr}\langle CoA \rangle . PRtAdv\,(nCoA, Link\ Information, LinkIdentifier)$$
$$\overline{BU}\langle new \rangle\ .\ FBU\text{-}AcK.\ FNA.\ MN\langle\, nCoA \rangle$$

MN will initiate L3 handover by sending an *RtSolPr* message to the oAR, if the L2 trigger is received at the mobile-initiated handover. On the contrary, the oAR will send *PRtAdv* to the MN, if the L2 trigger is received at the network controlled handover [12, 19].

Then; MN checks the neighbour cache to determine the link layer address of the next nodes, a neighbour is considered reachable if it has recently received confirmation that packets sent to the neighbour have been received [16,20].

An MN obtains an nCoA while it is still connected to the oAR; it performs this by receiving the RA included in the visited network information from the nAR.

5.3 Old Access Router (oAR)

The oAR is made up of the following components:
RtSolPr: a process utilized by the MN, sent to its current AR to request information about likely candidate APs and handle the MN initial request for the handover.
Forward: a process which passes both new and old CoAs.
HI: a request message sent to the nAR to make the handover process.

The oAR first receives the handover request from the MN, and then sends it directly to the nAR:

$$\begin{aligned} oAR \overset{def}{\equiv} & \ \mathrm{RtSolPr}\,(\mathrm{oCoA}).\,\overline{\mathrm{Forward}}\,\langle \mathrm{oCoA} \rangle.\,PRtAdv\,(nCoA, Link\ Information, LinkIdentifier). \\ & \overline{PRtAdv}\,(nCoA, Link\ Information, LinkIdentifier).\overline{\mathrm{HI}}.\ \mathrm{HAcK} \\ & BU.\ FBU\text{-}Ack.\ \overline{FBU\text{-}AcK}.\ \langle\ Forward\ Packets\ \rangle.\ oAR \end{aligned}$$

The oAR will validate the nCoA and send a Handover Initiation (HI) message to the nAR to establish the bi-directional tunnel process between oAR and nAR [16].
After the oAR receives the BU, it must verify that the requested handover is accepted as it was indicated in the H-AcK message.

The oAR starts forwarding packets addressed for the oCoA to the nAR and sending a Binding Update Acknowledgement (BU-AcK) with a Fast Neighbour Advertisement (FNA) to the MN.

5.4 New Access Router (nAR)

The nAR is made up of the following components:
Forward: a process which passes both new and old CoAs.
PRtAdv: the response by the present AR, containing the neighbouring router's advertisement for the link information and network prefix.
H-Ack: a confirmation sent back to the oAR to make the handover to the nAR.

$$\begin{aligned} nAR \overset{def}{\equiv} & \ Forward\,(oCoA).\,\overline{PRtAdv}\,\langle nCoA, Link\ Information, LinkIdentifier \rangle. \\ & HI.\,H\text{-}AcK.\ \overline{FBU\text{-}Ack}\ .\ \langle Forward\ Packets \rangle.\ \overline{FNA}.\,nAR \end{aligned}$$

The nAR will respond with the Handover Acknowledgment (H-AcK) message. Then the MN sends a BU to the oAR to update its binding cache with the MN's nCoA.

When MN receives a *PrRtAdv*, it has to send a BU message prior to disconnecting its link.
Upon verification of the variables, nAR will send the Acknowledgment (*ACK*) to confirm its acceptance; then the oAR will start sending the buffered packets to the nAR distend to the MN.

6. SIMULATION SCENARIO and CONFIGURATION

The simulations are carried out using network simulator ns-2 version ns-allinone-2.31, implementations of the E-Mobile IP handovers [21, 22]. The simulator is modified to emulate IEEE 802.11 infra-structured behaviours with multiple disjoint channels. This modification forces L2 handover operations, where stations only receive data packets via one AP at a time. The domain contains eight ARs, each one managing a separate IEEE 802.11 cell.

The network features three MNs connected to it; the first will move sequentially from AR to AR, starting at AR1, performing handovers at a rate of a 30 handovers/min. In each test, the MN1 will be the receiver of a CBR or FTP traffic source, generating either UDP or TCP packets. This traffic originates from the CN1 outside the network, or inside the domain from CN2. All presented results are taken as the average of multiple independent runs, coupled with a 95% confidence interval.
For simplicity we assume that there is no change in direction while the MN moves inside the overlapping area. The best possible handover point occurs at position A, as shown in Figure 2.

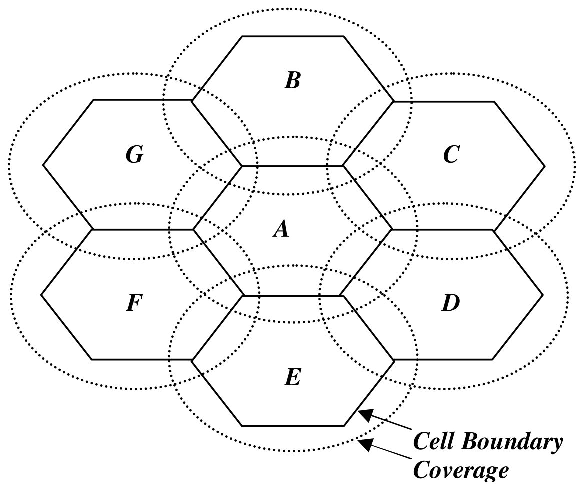

FIGURE 2: Overlapping Coverage Area

The coverage area can be defined in terms of signal strength; the effective coverage is the area in which MNs can establish a link with acceptable signal quality with the AP. The coverage radius is defined as the distance from an AP to its coverage boundary. The cell radius is the distance from an AP to its cell boundary.

7. PERFORMANCE ANALYSIS and EVALUATION

In our simulation, we use a 600m × 600m and a 1000m × 1000m area with a 3 to 7 MNs [5, 11]. The network bandwidth is 2 Mbps and the medium access control (MAC) layer protocol is IEEE 802.11 [23]. The packet size is 10p/s which will generate enough traffic when we increase the number of connections for example at 40 connections of source-destination pairs, it will generate 400 packets per second for whole scenario. Other simulation parameters are shown in Table1. These parameters have been widely used in the literature [24, 25.26].

Simulation parameter	Value
Simulator	Ns-allinone-2.31
Network range	600m×600m and 1000m×1000m
Transmission range	25m
Mobile nodes	3 and 5
Traffic generator	Constant bit rate
Bandwidth	2Mbps
Packet size	512 bytes
Packet rate	10 packet per second
Simulation time	900s and 1200s

TABLE 1: Simulation Parameters

The main purpose behind the proposed approach is to reduce the handover latency and the number of packets loss. As a result, end-to-end delay can also be reduced and the throughput can be improved.

The TCP throughput between MN and CN was measured for the E-Mobile IP, Standard Mobile (S-Mobile IP) and previous study of Mobile IP [24, 25.27]. Some of these results are shown in Figure 3, values are averages over several measurements made on the receiving process for CN to MN down stream traffic.

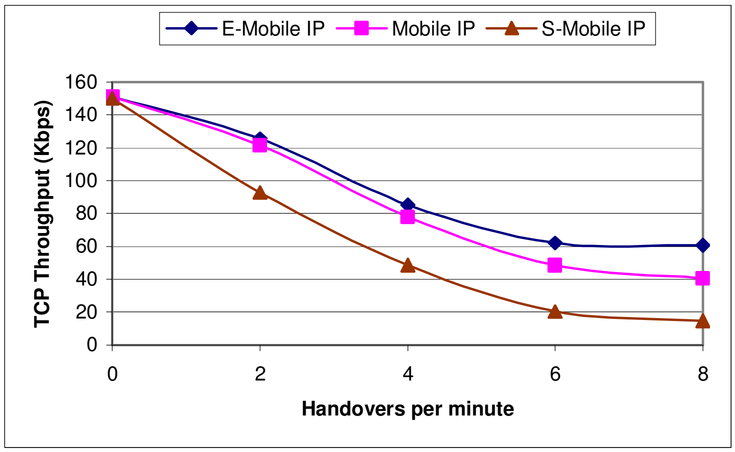

FIGURE 3: TCP Throughput for Data Transfer from CN to MN

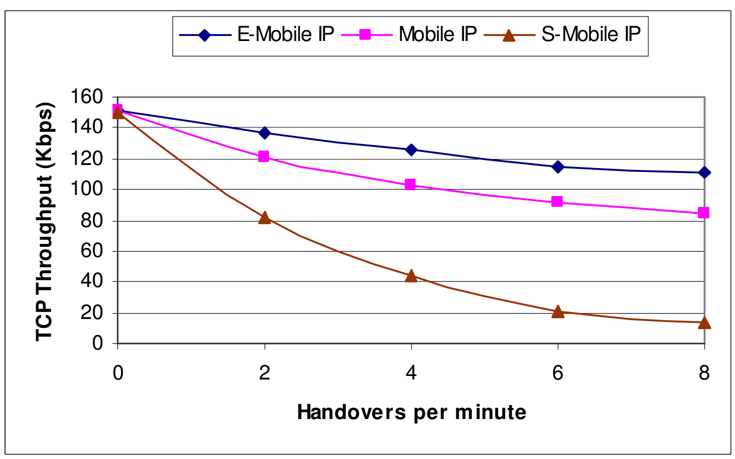

FIGURE 4: TCP Throughput for Data Transfer from MN to CN

Measurements of TCP throughput in Figure 4 are also made for upstream traffic from the MN to the CN. The throughput degradations using Mobile IP with an increasing number of handovers per minute are similar in this case to the previous case. These are not unreasonable values for Mobile IP, where HA and FA could be very far away from each other, the resulting degradation in performance is evident.

However, E-Mobile IP performs better in upstream direction, because, even before the crossover node is aware of the handovers, data packets following the handover message are already taking the right path for transferring packets, because due to the route update (TCP acknowledgments may be lost during this time though, accounting for the slight degradation in throughput as the handover rate increases).

In Figure 5 and Figure 6 the expected number of lost packets is shown as a function of the buffer size at the oFA. Figure 5 shows that the results for link delays are equal to 5ms on every scheme of the simulated Mobile IP, whereas in Figure 6 the three schemes on the nFA path are increased to 10ms each.

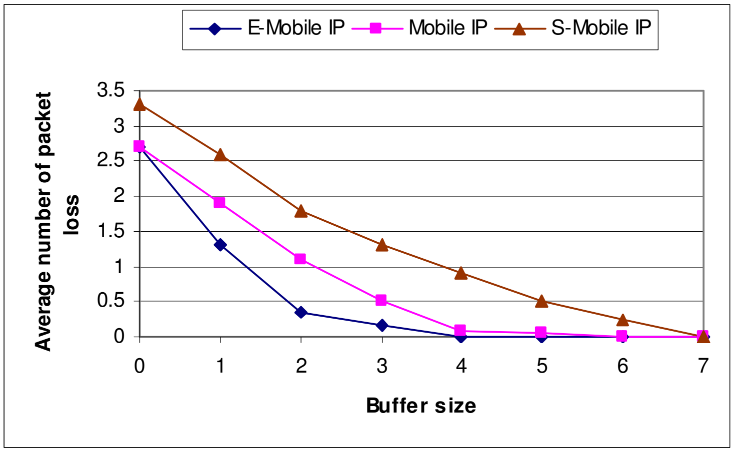

FIGURE 5: Packet Loss as a Function of the Buffer Size

Obviously, the loss in the buffer at the oFA decreases when the buffer size is increased. The packets that are lost in the case of a very small buffer size do go through the buffer when this buffer size increases.

However, it possibly contributes, in the latter case, to the number of lost packets at the nFA. This is especially true for the case of the 10ms-link delay on the nFA-oFA path, because then the whole buffer is likely to arrive too early at the nFA (that is, before the registration reply (*ReRep)* message from the nFA has arrived). In other words, in the case of a long delay on the nFA path, if a packet is not dropped at the oFA, it will most likely be lost at the nFA.

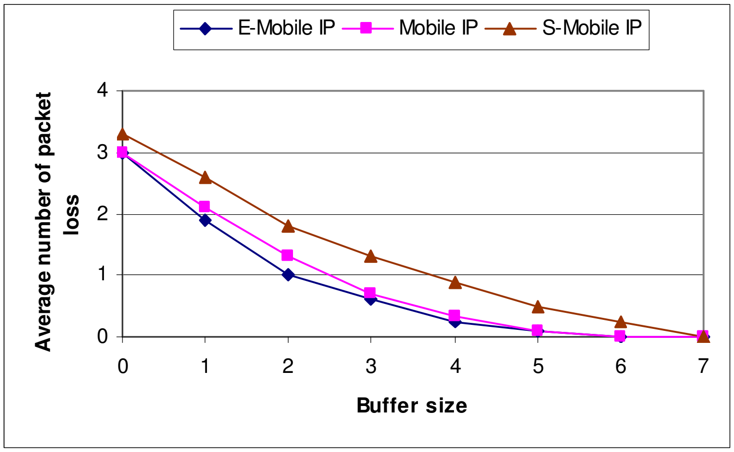

FIGURE 6: Packet Loss as a Function of the Buffer Size

In order to avoid packet loss at the oFA, the dimensions of the forwarding buffer need to be such that it can store packets in the order of the product bit rate of the stream times delay (MN; nFA; oFA). The loss at the nFA, on the other hand, depends on the difference between the distance (nFA; HA) (nFA; oFA). If the latter is smaller than the former, then packets may get lost. A possible solution would be to provide the nFA with a buffer to store temporarily unauthorized traffic until the *ReRep* from the oFA arrives at the nFA.

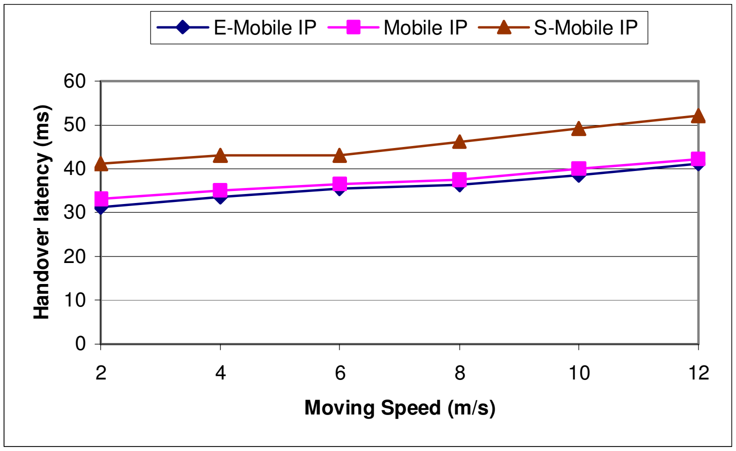

FIGURE 7: Impact of Moving Speed and Layer 2 Beacons

Next we vary the movement speed of MN from 2m/s up to 12m/s, and vary the L2 beacon period from 20ms to 60ms. As shown in Figure 7, when MN's moving speed is less than 5m/s, the impact of moving speed is not obvious. When MN moves faster, the whole Mobile IP scheme will experience higher handover latency due to MN having insufficient time to prepare for the handover. Therefore, there is a higher possibility that the packets are forwarded to the outdated path and are lost. The time instance during which MN can receive packets from a new path will be postponed and the handover latency increases accordingly.

Comparing the curves of different L2 beacon periods in Figure 7, we can see S-Mobile IP generates the highest handover latency at low moving speeds (under 50m/s). This is because of too small a beacon period (for example, 12ms) produces a high volume of beacons. The packet loss rates for the signalling packets thus increase, and require additional retransmission time to deliver them successfully. The handover latency will, therefore, increase. However, at higher speeds (more than 5m/s), the small L2 beacon period can help the MN to detect the nAP and begin the L2 connection setup earlier, thus reducing the possibility that packets are forwarded to the outdated path, resulting in a decrease in the handover latency.

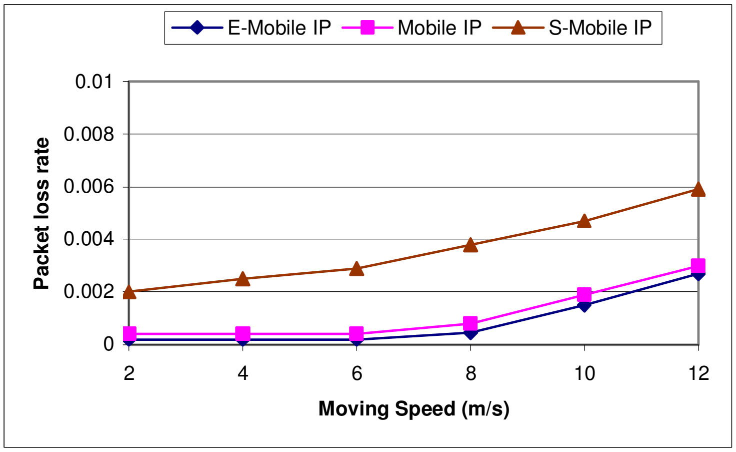

FIGURE 8: Impact of Moving Speed and Beacon Period on Packet Loss Rate

When the MN moves faster than 6m/s, Mobile IP experiences a higher packet loss rate in Figure 8 and decreased throughput in Figure 9 when compared with those of a low moving speed. This is because the possibility of packets being forwarded to an outdated path increases with an increase in the speed

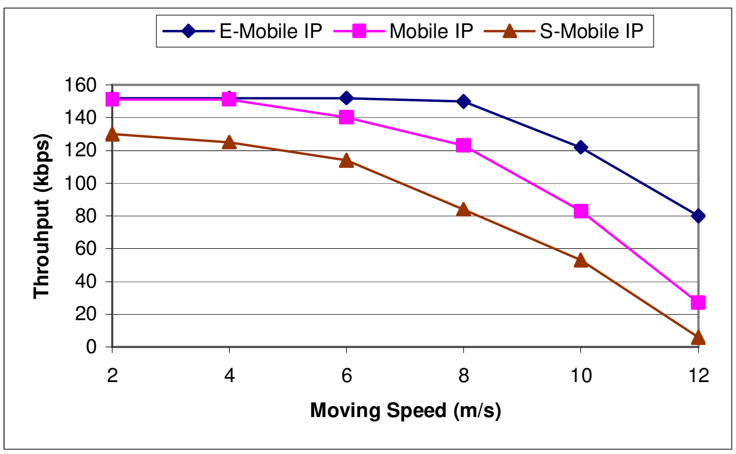

FIGURE 9: Impact of Moving Speed and Beacon Period on Throughput

These packets are dropped by AR1/AR2, either because they are not aware of MN's current location or because the buffer space is full. We can also notice that reducing the L2 beacon period somewhat offsets the impact of high speed by detecting the nAP and beginning the L2 connection setup earlier. Therefore, there will be a smaller probability that the packets are sent to an outdated location and get dropped by the AR.

8. CONCLUSION

In this paper we developed and analyzed the proposed scheme of the E-Mobile IP handover using link layer information scheme, we then compared the experimental results with the results of the Mobile IP and S-Mobile IP. The performance study in this chapter indicates that the use of link layer information with location information helps to minimize packet loss and improve the throughput of Mobile IP handover.

We have seen that the starting point for packet loss could happen in two ways: first, packets may get lost in the oFA when the forwarding buffer overflows and secondly, packets may get lost in the nFA when, upon their arrival, the *ReRep* from the HA has not arrived in the nFA. The first reason for loss may be avoided by appropriately dimensioning the forwarding buffer. This buffer should be able to store arriving packets at least during a time equal to the delay on the nFA and oFA path. The second loss is more difficult to deal with. It is determined by the difference between the delays of the paths oFA, nFA and nFA, HA.

In addition, we evaluated the impact of L2 setup on different performance measures of Mobile IP, together with handover latency, packet loss and throughput. The simulation results show that E-Mobile IP handover latency is not too sensitive to L2 setup latency and beacon periods compared to the other schemes of Mobile IP. Moreover, E-Mobile IP can achieve a fast and seamless handover if MN's moving speed is not too high, but is within reasonable limits.

The reasons for the improved performance of the proposed scheme include the exploitation of location information and the use of the powerful entity RA for complex tasks. In the proposed scheme the powerful RA was used for most of the decision processes necessary for handover. Simulation results in this chapter demonstrate that in most cases the link layer information handover scheme improves the TCP and UDP performances.

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