Impact of L2 Information on Handoffs Process in Mobile IP Environments

Mohammed Alnaas[1], Osama Alhodairy[2], Rowaida Ertimi[3]

[1]Department of Computer Science, Libyan Academy, Tripoli, Libya
m.alnaas@gmail.com
[2]Department of Computer Science, Libyan Academy, Tripoli, Libya
osamaalhodairy@gmail.com
[3]Department of Computer Science, Libyan Academy, Tripoli, Libya
rowaida.4489@gmail.com

Abstract

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 handoffs can be improved through l2 information to reduce packet loss during handoffs. It avoids link disruption during handoff process and reduces packet loss. Therefore, L2 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 handoff and eliminates the time to detect handoff.

Keywords: *Mobile IP Handoff; L2 Information; Fast Handoff; Handoff Latency; Packet Loss*

1. INTRODUCTION

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 [1, 2].

Mobile IP is an Internet standards protocol, proposed by the internet engineering task force (IETF), which enhances the existing IP to accommodate mobility. 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 [3].

Mobile IP handoff 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 handoffs. Therefore, these packets may be lost and need to be retransmitted [4, 5].

During the handoff 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 handoff latency. Moreover; there is a high Mobile IP handoff delay because of the agent discovery and registration periods, eventually Mobile IP handoff can cause significant performance

degradation, especially in large scale mobility environments. Mobile IP use L2 information to force a handoff to a new access network before any mobility at the network layer can be detected [6].
In this paper we propose the use of L2 information to enhance the overall performance of the enhanced Mobile IP handoff such as handoff latency, packet loss and registration message.

2. LATENCY OF HANDOFF

The handoff 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. These packets will be discarded and lost [7, 8].
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 handoff is frequent and the distance between MN and the HA is great [9, 10].

3. INFORMATION OF L2

L2 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 handoff, and the elimination of the time to detect handoff [11].
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 [12]. 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 [13, 14].
Mobile IP handoffs that are based on movement detection being handled by the L3 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.

4. LITERTAURE REVIEW

Pre-registration and post-registration schemes used in advance of a handoff, the neighbouring FAs exchange agent advertisement messages with each other. A L2 trigger at the MN, or the old/new FA triggers the handoff [15, 16].
The MN receives a proxy agent advertisement from the nFA relayed by the 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 handoff is scheduled to the same moment that the registration completes, the overall handoff latency will be reduced only to the L2 handoff 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 [17].
Tunnels between FAs are established by a handoff request (*HReq*) and a handoff reply (*HRep*), the messages that are exchanged upon the L2 trigger that indicate the handoff.
Development of the L2 hints that are used as an input to the handoff decision process [18, 19]. An algorithm for handoff initiation and decision has been developed based on the policy based handoff framework introduced by the IETF. A cost function was designed to allow networks to judge handoff targets based on a variety of user and network valued metrics [20].
These metrics include L2 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 scheme uses L2 triggers that applies the tunnel mechanism and pre-registration method of the low latency handoff scheme in Mobile IPv4.
However, the direction of the established tunnel of this scheme is opposite to that of the low latency handoff of post-registration [21, 22].

5. PROPOSED ALGORITHM

We propose Enhanced Mobile IP (E-Mobile IP) handoff using L2 information, such as signal strength, network prefix, bandwidths and link indicator, which is continuously available, providing important information about the availability of new links.

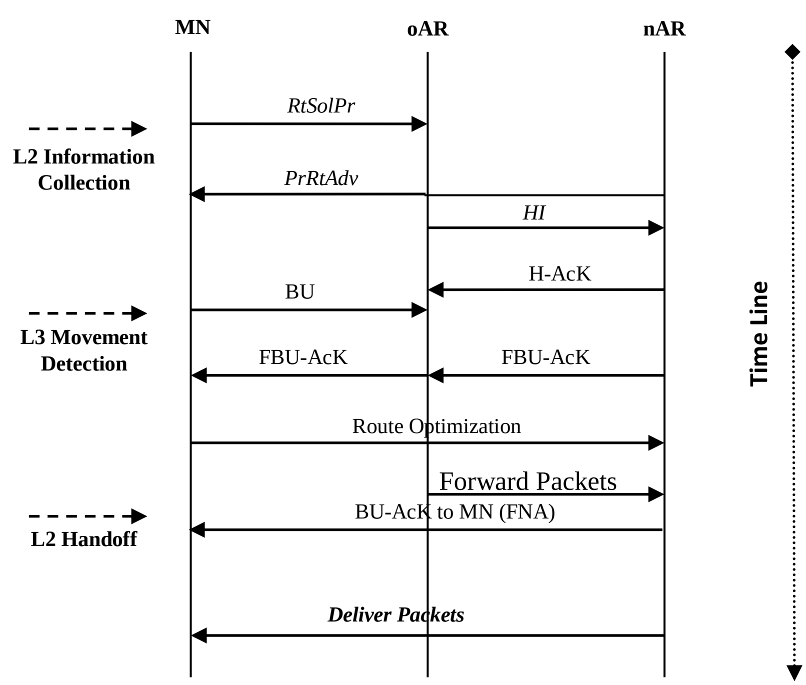

Fig 1: E-Mobile IP Protocol Message Flow

Therefore, E-Mobile IP uses L2 information to allow an MN to predict the loss of connectivity more quickly than L3 advertisement based algorithms. Fig 1 describes the overall E-Mobile IP protocol message flow. The π-Calculus E-Mobile IP handoff system is described in terms of the following actions.

5.1 SYSTEM

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

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

The E-Mobile IP handoff system is made up if parallel compositions of a MN primitive to (CoA) communicate with both oAR and the nAR

5.2 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 handoff to the nAR.

$$\begin{aligned}\text{MN}(\text{CoA}) \overset{def}{\equiv}\ & \overline{\text{RtSolPr}}\langle \text{CoA}\rangle.\text{PRtAdv} \\ & (\text{nCoA}, \text{LinkInformation}, \text{LinkIdentfier}) \\ & \overline{\text{BU}}\langle \text{new}\rangle.\text{FBU-AcK}. \\ & \text{FNA}.\text{MN}\langle \text{nCoA}\rangle\end{aligned}$$

MN will send a disassociation request including all other requirements to the oAR to let it know that it is going to make a handoff to the nAR. MN will initiate L3 handoff by sending an RtSoIPr message to the oAR, if the L2 trigger is received at the mobile-initiated handoff. On the contrary, the oAR will send PRtAdv to the MN, if the L2 trigger is received at the network controlled handoff [23].

Then; MN checks the neighbour cache to determine the L2 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.

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 oAR

The oAR is made up of the following components:

RtSolPr: an action utilized by the MN, sent to its current AR to request information about likely candidate APs and handle the MN initial request for the handoff.

Forward: an action which passes both new and old CoAs.

HI: a request message sent to the nAR to make the handoff process.

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

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

The oAR will validate the nCoA and send a handoff initiation (HI) message to the nAR to establish the bi-directional tunnel process between oAR and nAR.

After the oAR receives the BU, it must verify that the requested handoff 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 nAR

The nAR is made up of the following components:

Forward: an action 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 handoff to the nAR.

$$nAR \overset{def}{\equiv} Forward(oCoA).\overline{PRtAdv}$$
$$\langle nCoA, LinkInformation, LinkIdentfier\rangle.$$
$$HI.H-AcK.\overline{FBU\text{-}Ack}.\langle Forward\ Packets\rangle.$$
$$\overline{FNA}.nAR$$

The nAR will respond with the handoff 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. PERFORMANCE EVALUATION

The simulations are carried out using network simulator ns-2 version ns-allinone-2.31 [24], implementations of the E-Mobile IP handoffs. The simulator is modified to emulate IEEE 802.11 infra-structured behaviors with multiple disjoint channels. This modification forces L2 handoff 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.

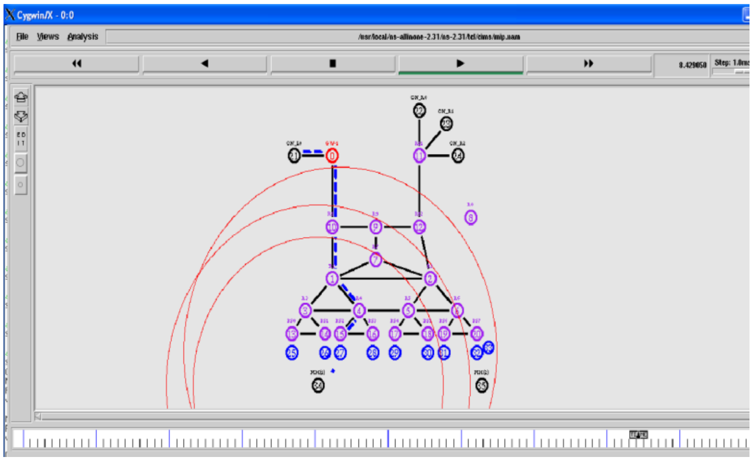

Fig 2: Simulation Snapshot

The network features three MNs connected to it; the first will move sequentially from AR to AR, starting at AR1. 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.

Table 1: Simulation Parameters

Simulation Parameter	Value
Simulator	Ns-allinone-2.31
Network Range	600m×600m and 1000m×1000m
Transmission Range	25m
Mobile Nodes	3 and 7
Traffic generator	CBR
Bandwidth	2Mbps
Packet Size	512 bytes
Packet Rate	10 packet per second
Simulation Time	900s and 1200s

In order to allow fast registration this system defines a network initiated handoff which is faster than the MN initiated handoff. This allows us to forward data to the nFA while the MN is still on its way to the nFA [neighbours], therefore, with prediction it is possible to prepare an L3 before the L2 handoff to reduce latency and packet loss.

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. Some of these results are shown in Fig 3, values are averages over several measurements made on the receiving process for CN to MN downs stream traffic.

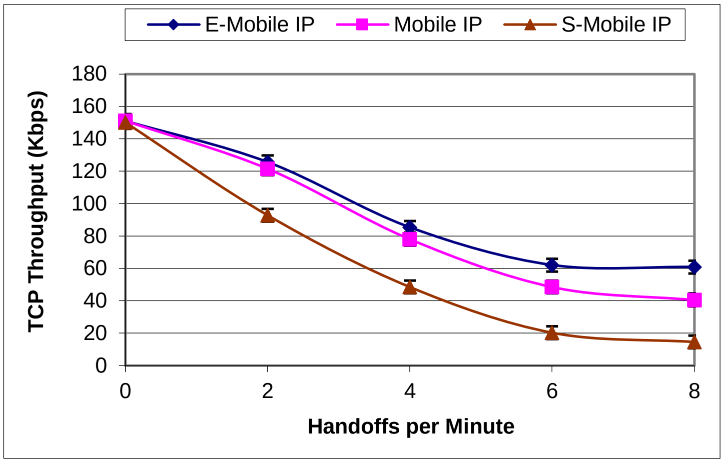

Fig 3: TCP Throughput for Data Transfer from CN to MN

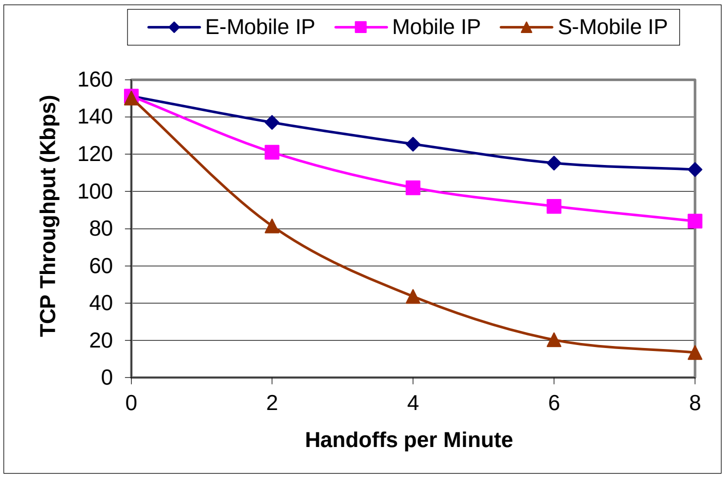

Fig 4: TCP Throughput for Data Transfer from MN to CN

Measurements of TCP throughput in Fig 4 are also made for upstream traffic from the MN to the CN. The throughput degradations using Mobile IP with an increasing number of handoffs 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 handoffs, data packets following the handoff message are already taking the right path for transferring packets, due to the route update TCP acknowledgments may be lost during this time though, accounting for the slight degradation in throughput as the handoff rate increases.

In Fig 5 the expected number of lost packets is shown as a function of the buffer size at the oFA, the three schemes on the nFA path are increased to 10ms each.

Obviously, whenever the buffer size is increased the loss in the buffer at the oFA is decreases. However, it possibly contributes, in the latter case, to the number of lost packets at the nFA.

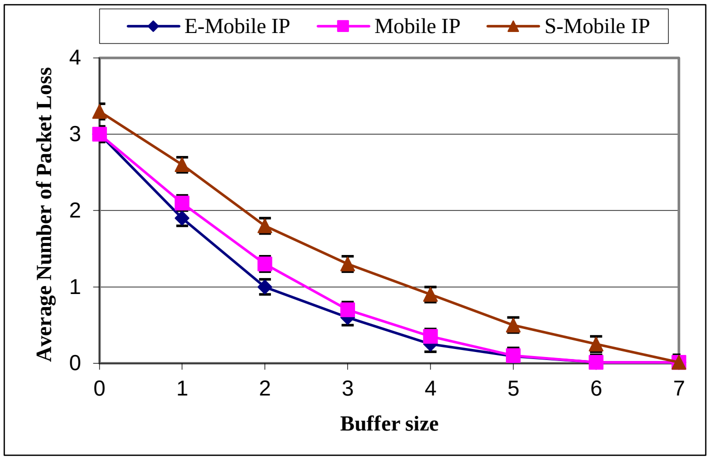

Fig 5: Packet Loss as a Function of the Buffer Size (Delay 10ms)

This is especially true for the case of the 10ms-link delay on the nFA-oFA path, because the all buffered packet will early reach the destination of the nFA before the registration reply (*ReRep*) message from the nFA reaches the oFA. More precisely, when the delay is going to be long on the nFA path, if a packet is not dropped at the oFA, it is considered to be lost at the nFA.

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 of the distance between each of (nFA; HA) (nFA; oFA).

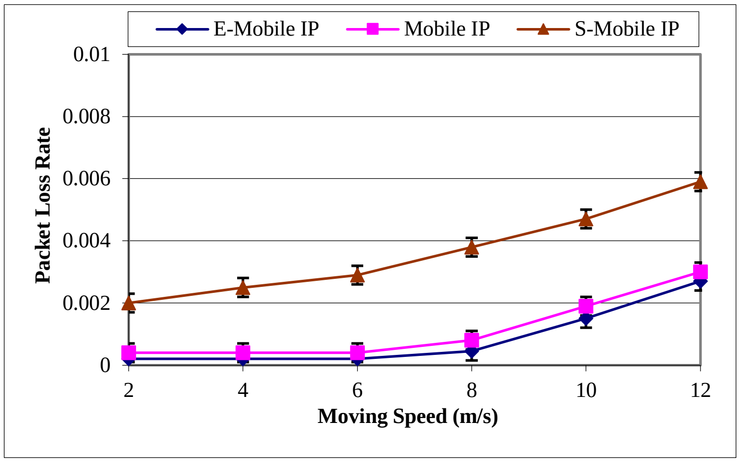

Fig 7: Impact of Moving Speed and Beacon Period on Packet Loss Rate

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.

When the MN moves faster than 6m/s, S-Mobile IP experiences a higher packet loss rate in Figure 7 and decreased throughput in Fig 8 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

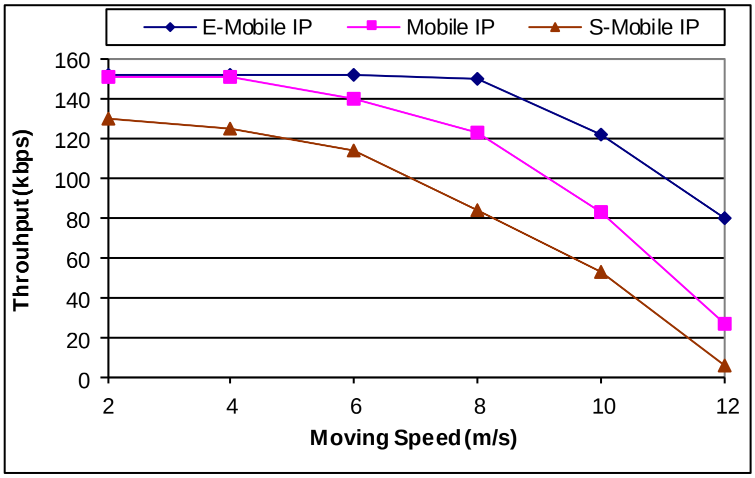

Fig 8: Impact of Moving Speed and Beacon Period on Throughput

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.

7. CONCLUSION

In this paper, the proposed scheme of the E-Mobile IP handoff using L2 information scheme is enhanced and analyzed, then compared the experimental results with the results of the Mobile IP and S-Mobile IP. The performance indicates that the use of L2 information with location information helps to minimize packet loss and improve the throughput of Mobile IP handoff.
It 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, evaluated the impact of L2 setup on different performance measures of Mobile IP, together with handoff latency, packet loss and throughput. The simulation results show that E-Mobile IP handoff 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 handoff 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 handoff. Simulation results in this paper demonstrate that in most cases the L2 information handoff scheme improves the TCP and UDP performances.

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