SUPPORTING MICRO-MOBILITY WITH MULTI PROTOCOL HANDOFF MECHANISM

Ye Liang
Dalhousie University
Faculty Computer Science
liangye@cs.dal.ca

Allan G. Jost
Dalhousie University
Faculty Computer Science
jost@cs.dal.ca

A. Nur Zincir-Heywood
Dalhousie University
Faculty Computer Science
zincir@cs.dal.ca

Abstract

In this paper, we examine micro-mobility protocols, and present a distributed handoff and mobility mechanism for IP micro-mobility, combining the strengths of the Cellular IP and Hawaii IP protocols. The enhancement consists of a modified handoff mechanism, allowing the mobile node to perform handoff at an appropriate time with the more efficient choice of handoff scheme, as a function of the signal strength of the access points. The results show that the proposed mechanism improves both the throughput and the handoff delay by 50% compared to the Cellular IP and Hawaii IP protocols. A T-test analysis shows that this improvement is significant at the 99% confidence interval.

Keywords: Wireless networks, micro-mobility, Mobile IP.

1. INTRODUCTION

Today's micro-mobility protocols try to solve the problem where mobility and frequent handoffs within the foreign domain cause a large amount of signaling traffic and communication interruption when standard Mobile IP [3] is employed. The Cellular IP (from Ericsson Research Labs) and Hawaii IP (from Lucent Technologies) protocols achieve faster and more seamless local mobility support in limited geographical areas, and have been submitted to the IETF Mobile IP Working Group for mobile IP enhancement discussions [1]. However, there are still shortcomings and inefficiencies with these protocols. The Cellular IP protocol does not support seamless handoff when a mobile node attaches to a new access point and loses contact with the previous one. The Hawaii IP protocol can handle this situation but does not handoff as quickly as the Cellular IP protocol does.

This paper presents a distributed micro-mobility IP handoff mechanism, which tries to contribute further improvement in local mobility and seamless handoff. The presented handoff mechanism employs two handoff schemes, building on the semi-handoff of Cellular IP and Multiple Stream Forwarding (MSM) handoff of Hawaii depending on whether the mobile node can maintain contact with both access points or loses one of them during the handoff. The proposed multi protocol handoff mechanism (MPHM) makes the mobile node employ a specific handoff scheme in terms of the handoff situation indicated by the signal strength from the access points. In addition, this mechanism is able to avoid spurious handoffs by predicting mobile node movement.

The paper is organized as follows: a brief introduction of related micro-mobility issues and problems is presented in section 2. The multi protocol handoff mechanism is described in section 3. In section 4, the simulation environment and results are detailed. Finally, conclusions are drawn and future work is suggested in section 5.

2. CELLULAR IP AND HAWAII IP PROTOCOLS

Both the Cellular IP and Hawaii IP protocols include their own handoff schemes for local mobility. Cellular IP supports two handoff schemes: Hard Handoff and Semi Handoff [1,2]. The Cellular IP hard handoff scheme simply discards the old path when a new path is established. This results in data loss and communication interruptions. However, by using the semi handoff scheme, Cellular IP can achieve a smooth handoff with minimum data loss by maintaining the two paths (old and new) at the same time for the mobile node.
The Hawaii IP protocol uses four handoff schemes: Single Stream Forwarding (SSF), Multiple Stream Forwarding (MSF), Unicast Non-forwarding (UNF) and Multicast Non-forwarding (MNF) [7]. There are advantages and disadvantages to each of these schemes. For instance, MSF causes multiple streams of disordered packets to arrive at the mobile node due to the buffered and new packet traffic. On the other hand, SSF routes packets in a single stream by updating the forwarding entries of the crossover router, whereas UNF and MNF dual-cast packets to both the new and the old base stations. In both the UNF and MNF schemes, the configuration of the new path to the mobile node is established as the path setup message travels from the new base station to the old base station. Thus, the new route takes the same path as the old route from the crossover router (intermediate nodes) to the DFA. In some cases, this may cause the packets to travel an unnecessarily long route. In such cases, the use of the Cellular IP Semi handoff scheme would have solved this problem. The new path would have been established by sending path setup messages from the new base station to the DFA directly.

On the other hand, the Cellular IP semi handoff scheme requires that the handoff take place within the area where the new and old base stations overlap [2]. However, if the mobile node is temporarily out of radio contact with its old base station during the handoff, then the packets cannot be diverted to both base stations. This results in data loss and communication interruption. As a remedy, the packet-forwarding scheme solves this problem by asking the old base station to forward the stored packets to the new base station, after the mobile device has lost radio contact with its previous base station.

In other words, the semi handoff scheme works well when the mobile host is in the overlap area, whereas the MSF scheme works well when the mobile host is not in the overlap area. However, neither of the schemes deal well with frequent handoffs within their areas [1,2,3]. Under such scenarios, the communication efficiency of the mobile host decreases and the load on the network increases. Thus, in this work our objective is to develop a distributed handoff and mobility mechanism, combining the strengths of the Cellular IP semi handoff and Hawaii IP MSF protocols. The enhancement consists of a modified handoff mechanism in which the mobile node performs handoff at an appropriate time with the more efficient choice of handoff schemes, as a function of the signal strengths of the two base stations.

3. MULTI PROTOCOL HANDOFF MECHANISM

As discussed, the semi handoff in Cellular IP protocol can achieve fast and smooth handoff, but it does not work properly when the mobile node loses contact with its previous base station; the MSF handoff in Hawaii IP protocol avoids data loss since incoming packets are stored in the old base station and forwarded to the new base station during the handoff. However, it cannot perform handoff as quickly as the semi handoff does, and it can result in inefficient traffic routing for the mobile host. Based on that, we propose a handoff determination mechanism for the mobile host which chooses multi-path handoff if it can maintain a communication channel to the old base station during the handoff process, and chooses buffer handoff when the mobile host determines that its connection quality with the old base station is too low to maintain communication (probably the mobile host is about to go out of range from the old base station). Here, the multi-path handoff and buffer handoff schemes are adapted handoff schemes, similar to the semi handoff scheme and the MSF handoff scheme respectively. This multi protocol handoff mechanism (MPHM) results in fast and smooth handoff when the mobile node’s connection quality to both base stations is good, and at least no data loss in a handoff when the mobile host loses contact with its old base station.

The approach of MPHM is to design a handoff detection mechanism which makes the mobile host perform handoff at an ideal time. The mechanism initiates handoff when first, the mobile host is moving to the new base station coverage area and the mobile host has already received a strong signal from that base station, and second, the connection quality of the new base station is better than the one with the old base station. This design allows the mobile host to maintain a high quality communication channel via the new attached base station after the handoff process. Also, it can avoid spurious handoffs while the mobile node is undergoing irregular movement.

Moreover, to reduce wasted duplicate packets after a multi-path handoff, we include a duplicate
packet notification procedure, which removes the routing cache of the mobile host in intermediate nodes along the old path. During a multi-path handoff, the path setup packet only needs to create a new routing entry for the mobile host in those nodes between the new base station and the crossover node. (The crossover in multi-path handoff refers to the node where the paths from the old base station to the DFA and the path from the new base station to the DFA meet.) To reduce the path setup trip, we arrange that the path setup packet travels from the base station to the crossover node, stopping there instead of at the DFA.

4. RESULTS

To evaluate the three different protocols, testing models for Hawaii IP (with MSF), Cellular IP (with semi handoff) and our MPHМ were built. The performance of MPHМ was examined and compared with the Cellular IP and the Hawaii IP protocols. Three groups of experiments were set up. One was to do performance tests under different scenarios with only the mobile host’s downloading traffic: this is called “optimal case”. The second was to evaluate performance under random background traffic environment: this is the “background case”. Finally, we tested performance under the worst condition (heavy traffic load and irregular movement), called the “worst case”. A T-test was performed to evaluate the significance of the simulation results between the different protocols. The simulations for all the protocols were built on the CIMS environment [4], as created at Columbia University as an extension part for supporting micro-mobility in the ns2 network simulator [5]. All wireless communication issues and collision controls between base stations and the mobile host were managed by ns2 (layers one and two) which follow the IEEE 802.11 specification. In order to compare MPHМ to the Cellular IP and Hawaii IP protocols, physical interface parameters were set to make them behave like the 914MHz Lucent WaveLAN DSSS radio interface. The simulation environment was run on a Linux Mandrake 8.3 platform installed on a computer with an AMD 266 processor.

In all simulations, intermediate nodes, base stations and DFAs are implemented in special node agent objects, which can process messages and perform protocol-specific operations. In addition, each base station has a buffer with a specified size for storing incoming packets, and a wireless interface, which can communicate with the mobile host over the air. The base stations broadcast their beacons every 0.5 seconds. Simulation results were obtained using a single mobile host, moving between base stations at a speed of 20 meters per second. Mobile host movements varied in different scenarios. There is a 30 meter overlap area for the base station and its left/right neighbor base stations. The connection between wired nodes uses a 10Mb duplex link. The tree topology used in [1] was used for the MPHМ simulations (Fig. 1).

The simulation modeled the mobile host’s traffic by simulating a continuous FTP download from the source node to the mobile host. The Reno congestion control was used for the TCP session with a packet size of 200 bytes. Background traffic also employed TCP/Reno with varied multiples of TCP’s formal size (1460 bytes). All background traffic was generated in source nodes, chosen randomly among all wired nodes (including base stations) and destined to randomly chosen base stations. The background traffic started at the time that the mobile host began its download from the source node and lasted until the simulation finished. Detailed results for all “cases” can be found in [6].

![Fig. 1. An example of a domain network (HA: Home agent, , Nx: Intermediate node x, Bx: Base station x)](image)

Different scenarios were employed for each “case” described above. In these scenarios, the movement direction (B1–B4) and duration (10s–35s) in the movements of the mobile host, the distances (60m–140m) between the base stations, and the number of source nodes are varied to test different types of handoffs. Fig.2 and Fig. 3 show the throughput and the handoff delay for the 20 different runs of the worst-case scenario. In this case, the four
base stations are: B1 and B2 60 meters apart, B2 and B3 140 meters apart, B3 and B4 90 meters apart. From 1 to 10 seconds, the mobile host moved along a straight line from the left to the right. From 10 to 15 seconds, the mobile host moved on a straight line from the right to the left. From 15 to 35 seconds, the mobile host moved again on a straight line from the left to the right. The intent was to test handoff performance while the mobile host was doing irregular movement, where the background traffic was: packet size = 1460x3, and source nodes = 10. It should be noted that Cellular IP with semi handoff could not cope with this scenario, so the results below are only for MPHM and Hawaii IP with MSF.

5. CONCLUSION

In this paper, we introduced a simulation environment where we compare our MPHM protocol to the Cellular IP and Hawaii IP protocols. The results show that MPHM achieves fast, smooth, seamless handoff under different kinds of conditions and substantial improvement in handoff quality and network efficiency compared to the Cellular IP and Hawaii IP protocols. Tests for the performance of dynamic configuration of base stations and matching to multiple DFAs is an issue that needs to be studied further.

References