Intelligent Fast Handover Scheme for Mobile IPv6-based Wireless Local Area Networks

Li Jun ZHANG[1] Liyan Zhang[2] and Samuel Pierre[3]

[1]Division R&D, Geninov Inc., Montreal, Quebec H2A 1B6 Canada

[2]School of Electronics and Information Engineering, China Dalian Jiaotong University, Dalian, Liaoning 116028 China

[3]Department of Computer Engineering, Ecole Polytechnique of Montreal, Montreal, Quebec H3C 3A7 Canada

Summary
IEEE 802.11-based wireless local area networks (WLANs) have experienced rapid growth for some years. Increasingly ubiquitous, they are deployed in hotspots such as airports, campuses, shopping malls, providing Internet access for mobile users. Meanwhile, Internet service providers can be endowed with substantial increased productivity by enabling roaming users to access data in wireless systems. Such facts render handover management one critical issue for WLANs. Fast handovers for mobile IPv6 (FMIPv6) relies on layer two (L2) pre-triggers to anticipate link prediction; this limits its applicability over WLANs. On the other hand, typical L2 handoff results in at least 250 ms delays, this makes supporting real-time application impossible. Thus new mobility management protocol is essential to improve the performance of FMIPv6 over WLANs. This paper proposes a new intelligent fast handover scheme for mobile IPv6-based WLANs. The new approach consists of equipping mobile nodes with pre-configured mobility pattern to select new access point prior to attachment. And access points are location-aware with new functionality to know the operating channels of its neighborhood. To show the effectiveness, simulations are conducted using a wireless network simulator, SimulX. Of which preliminary simulation results demonstrate that our proposal delivers better performance than FMIPv6 when deploying in WLANs.

Key words:
Fast handover, handover management, mobile IPv6, wireless local area network.

1. Introduction

Wireless local area networks (WLANs) provide users with the flexibility to move around within a broad coverage area while still being connected to the network. They gain a great popularity due to their convenience, cost efficiency, and ease of integration with other networks and network components. They allow users to access network resources from nearly any convenient location within their primary networking environment. However, handovers occur quite often because access points in WLANs only cover a relatively short range. This deteriorates the performance of ongoing communications at mobile station. Therefore, new solutions are needed to fix such problem.

The remainder of this paper is organized as follows. Section 2 provides a comprehensive overview of fast handoff schemes for WLANs. Section 3 describes the proposed intelligent fast handover (iFMIPv6) scheme for mobile IPv6-based WLANs. Section 4 presents performance evaluations through simulations using the wireless network simulator, SimulX. Of which preliminary results show that our proposal delivers better performance than mobile IPv6 fast handovers for 802.11 networks [2]. Finally, Section 5 concludes the paper and outlines future work.

2. Related Work

2.1 IEEE 802.11 Layer Two Handoff Process

Generally, a mobile station makes decision to handover from its current associated access point (AP) to another due to mobility, AP load balancing or signal fading reasons [3]. A typical handoff procedure involves both layer two (data link layer) and layer three (network layer) within the OSI Model. And handoff process in layer two consists of scanning, authentication and re-association.

Scanning procedure aims to determine the characteristics of available Basic Service Sets (BSS) within a mobile station's radio range. Two scanning modes are specified in the baseline standard IEEE 802.11: passive and active scanning [4]. The former allows mobile station (MS) to listen on each existing channel, and wait for beacon frames periodically sent by neighboring APs, while the latter involves the generation of probe request frames and the subsequent processing of received probe

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responses from nearby access points. After discovering accessible APs, an MS will select one AP as its new network point-of-attachment. Subsequently, the mobile launches authentication process with the new AP (NAP) to identify the MS as a member of the specified BSS and to authorize it to communicate with other stations within the same BSS [4]. Two authentication methods are defined in the standard: Open System and Shared Key Authentication [4].

Open system authentication involves the exchange of authentication request and authentication response frames between the mobile and its new AP, while shared key authentication is an optional four-step process using wired equivalent privacy (WEP) key, in which an MS starts authentication by transmitting an authentication request to the new AP. Upon receiving this request, the new AP generates a challenge text using a WEP key and sends an authentication response with such challenge text as a reply. The MS then encrypts the received challenge text with a shared WEP key and returns an authentication request with the encrypted challenge text to the new AP. The new AP subsequently decrypts this request using the shared key and compares the decrypted and the original challenge texts. If they are identical, the new AP transmits an authentication response to confirm a successful authentication.

Regardless of the authentication method used, the IEEE 802.11 standard requires mutually acceptable responses for a successful authentication [4], and also requires authentication to take place before association (or re-association).

Followed by successful authentication, re-association is launched by the mobile station. Note that the IEEE 802.11 standard requires each MS to be associated with a single AP at any given time [4]. During re-association, the MS sends a reassociation request to the new AP. Such frame contains the concerning MAC address of the MS, its previous service set identifier (SSID), the MAC address of the old AP (oAP). Upon receipt of this request, the new AP launches the inter-access point protocol (IAPP) to deliver MS-related security context from the oAP [6]. In doing so, the new AP sends a RADIUS access-request message to the RADIUS (Remote Authentication Dial-In User Service [7]) server, which then looks up the IP address of the oAP and verifies the SSID, before returning a RADIUS access-accept message to the new AP. The access-accept message contains the IP address of the oAP and security block items required to establish a secure communication channel between the involved APs. After exchanging security elements through Send-Security-Block and ACK-Security-Block packets, both APs own sufficient information to encrypt all further packets. Thereafter, the new AP sends an encrypted MOVE-notify packet to the oAP requesting for the context of the mobile. Upon verifying the MS' association, the oAP removes the MS from its association table and returns an encrypted MOVE-response packet to the new AP, including the pertaining Context Block. Then, the new AP adds the MS into its association table and broadcasts a Layer 2 Update frame to inform all layer 2 devices, such as bridges and switches, of updating their forwarding table for the MS. Finally, the new AP sends a reassociation response to the MS [6], [8], [9], thus completes the overall handoff process.

2.2 Existing Approaches

Numerous studies have been conducted in order to improve L2 handoff performance in terms of handoff delays and packet loss rates for mobile hosts roaming in IEEE 802.11 networks. Since probe delays consist of the main contributor to the overall L2 handoff latency [10], most recently proposed handoff schemes aim to reduce this lengthy delay. These schemes can be further classified into: fast scanning, bypass scanning and cross-layer design approaches.

Since our proposed fast handoff scheme are based on the concept of cross-layer design, here we only present several approaches in this category, such as Beacon with sufficient IP layer information [11] [12], which allows an enhanced AP to assist and handle fast new address configuration by inserting IP layer information into beacons. This approach drastically decreases overall handoff latencies (both at MAC layer and IP Layer). IP-IAPP scheme [13] [14] enhances APs with advanced routing functionalities so that they act as mobility agents for mobile stations, and are responsible for IP-layer (L3) mobility management. Link layer (L2) triggers and topology information-aided fast handoff [15] scheme use pre-handoff triggers to discover agents or address configuration before network layer handoffs. Additionally, post-handoff triggers are applied to eliminate movement detection delays.

3. Proposed Intelligent Fast Handover Scheme

Since mobile IPv6 fast handovers (FMIPv6) relies on L2 pre-triggers, which are usually based on link anticipation mechanisms, this limits its applicability over wireless LANs. This motivated us to improve its performance. On the other hand, layer two (L2) handoff results in at least 250 ms delays, supporting real-time application for mobile stations roaming in WLANs is impossible. Thus it is very important either to reduce or to eliminate the lengthy handoff latency. At the same time, we noticed that the utilization of pre-scanning technique brings about uncertainty in the provisioning of quality of service (QoS), and location-aware technique usually requires the installation of a server in the network, which becomes a bottleneck where the performance or capacity of the entire network is limited by such a single component. In this context, we propose an intelligent fast handover scheme for wireless LANs. First, we assume that location information is distributed at access points, which has pre-knowledge of its neighborhood such as their operating channel, their identifiers and coordinates. Second, we assume that an intelligent mobile station is pre-configured with mobility pattern which allows knowing the next stop of its movement (e.g. their coordinates). The details of this proposed intelligent fast handovers for mobile IPv6/WLAN (iFMIPv6) are elaborated as follows.

When a mobile station (MS) associates with an AP, the AP inserts its neighbors' information (operating channels, AP identifier and their coordinates) into the reassociation response frame and sends it to the mobile during reassociation. The MS then calculates the distance of these APs to the next movement stop, and selects the nearest AP and obtains the corresponding AP identifier. Afterwards, FMIPv6 handoff procedure is carried out accordingly [1]. At the moment of handoff, the MS only scans the selected AP by probing the corresponding operating channel. As a result, only 1 channel is examined for L2 handoff. If the newly selected AP is broken down or shut down, the MS has to scan all available channels operated on the old AP's neighborhood. In this case, a subset of channels will be probed; as a result, scanning delay can be reduced significantly.

Upon receipt the probe response from the new AP, the mobile station performs authentication and reassociation according to the IEEE 802.11 standard. During reassociation, the new AP sends the MS its neighborhood information, and the mobile calculates and selects the candidate AP for its next movement. After successful L2 handoff, the normal FMIPv6 procedure is carried out by the mobile station and it sends out an unsolicited neighbor advertisement (UNA) to the new access router.

4. Preliminary Simulation Results

To evaluate the efficiency of our proposal, simulations were conducted with the wireless network simulator, SimulX [16], which is a C++ simulator developed at Louis-Pasteur University in France. This simulator is especially designed for IEEE 802.11 networks, and it also provides implementation of mobility support in IPv6 networks. The IEEE 802.11b standard [17] with 14 channels, and mobile IPv6 protocol [18] were already implemented. Based on these codes, we implement the mobile IPv6 fast handovers for 802.11 networks [2] in case of APs operating on 11 channels, and our proposed iFMIPv6 scheme while mobile stations scan 1 and 11 channels. Table 1 shows the preliminary simulations results.

Table 1 Preliminary Simulation Results

	L2 HO (ms)	L3 HO (ms)	Packet losses
FMIPv6 for WLAN	234.30	29.62	1.8%
iFMIPv6 (1)	39.69	7.66	0.4%
iFMIPv6 (11)	211.39	22.92	0.5%

5. Conclusion

This paper proposes an intelligent fast handover (iFMIPv6) scheme for mobile IPv6-based WLAN, which improves handoff performance for mobile stations roaming in WLANs with ongoing real-time applications. Our proposal allows mobiles to actively scan only a subset of all accessible channels during MAC layer handoff. In case of optimal, the station only needs to scan one channel, instead of scanning all available channels on which APs are operating. As a result, handoff latency is reduced significantly, making the support of real-time ongoing services in WLANs possible.

In the near future, large-scale simulations will be conducted for performance analysis and novel effective mobility management schemes will be proposed while seamless mobility is taken into consideration.

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Li Jun ZHANG received the B.Sc. degree in mathematics from China Jilin University, Changchun, China in 1993, the M.A.Sc. and Ph.D. degrees in computer engineering from Ecole Polytechnique of Montreal, University of Montreal, Montreal, Canada in 2007 and 2008 respectively.

She worked as Software Engineer, Systems Analyst, Systems Integrator, Database Design Engineer, and Database Administrator at China Construction Bank, Dalian China, from July 1993 to May 2001. She worked also as Research Assistant at the Mobile Computing and Networking Research Laboratory, Ecole Polytechnique of Montreal from September 2003 to August 2008. She worked as R&D Engineer and Associate Research at Ericsson Canada from January 2004 to June 2008. Since September 2008, she works as R&D Project Manager at Geninov Inc., Montreal, Canada, where she is in charge of R&D, IT and Telecom projects management, and technical coordination. At the same time, she supervises several undergraduate and graduate students for their internships within the company. She filed 3 US patents application, published 3 book chapters, and 8 journal and conference papers.

Dr. Zhang was a student member of IEEE and ACM from 2006 to 2008; a member of Polytechnique Alumni Association (ADP) since 2008.

Liyan Zhang received the B.Eng. and M.A.Sc. degrees in information engineering from Harbin Engineering University, Harbin, China in 1998 and 2000 respectively, the PhD degree in information engineering from Dalian University of Technology, Dalian, China in 2009.

She worked as Lecturer at China Dalian Jiaotong University, dalian China, from 2000 to 2003. Since 2003, she works as Assistant Professor at the School of Electronics and Information Engineering, Dalian Jiaotong University, Dalian China, where her research interests focus on information and signal processing, communication and information system, microphone array speech enhancement and location, etc. She supervises more than 50 undergraduate and graduate students. She published 7 journal papers and about 10 international conference papers.

Dr. Zhang was a member of IEEE and ACM. Since 2003, she obtained from National Natural Science Foundation of China more than 800,000 RMB research grants.

Samuel Pierre received the B.Eng. degree in civil engineering in 1981 from Ecole Polytechnique of Montreal, Quebec, the B.Sc. and M.Sc. degrees in mathematics and computer science in 1984 and 1985, respectively, from the University of Quebec at Montreal, Montreal, the M.Sc. degree in economics in 1987 from the University of Montreal, and the Ph.D. degree in

Electrical Engineering in 1991 from Ecole Polytechnique of Montreal.

From 1987 to 1998, he was a Professor at the University of Quebec at Trois-Rivieres prior to joining the Tele-University of Quebec, an Adjunct Professor at Laval University, Ste-Foy, Quebec, an Invited Professor at the Swiss Federal Institute of Technology, Lausanne, Switzerland, then the University Paris 7, France. He is currently a Professor of Computer Engineering at École Polytechnique of Montreal where he is Director of the Mobile Computing and Networking Research Laboratory (LARIM), chair-holder of the NSERC-ERICSSON Chair in Next Generations Mobile Networking Systems and Director of Mobile Computing and Networking Research Group (GRIM). His research interests include wireline and wireless networks, mobile computing, artificial intelligence, and tele-learning.

Dr. Pierre is a senior member of IEEE and a member of ACM. He is a Regional Editor of the Journal of Computer Science, an Associate Editor of IEEE Communications Letters, IEEE Canadian Journal of Electrical and Computer Engineering and IEEE Canadian Review, and serves on the editorial board of Telematics and Informatics edited by Elsevier Science. He has received many distinctions, such as the Prix Poly 1873 for excellence in teaching (2001 and 2005), Fellow of Engineering Institute of Canada (2003), among others. He is a Fellow of the Canadian Academy of Engineering (2008). He is a Chevalier of the Ordre Nation of Quebec (2009).