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ScienceDirect
Computer Communications 31 (2008) 2016–2029
computer communications
www.elsevier.com/locate/comcom

Enhanced fast handoff scheme for heterogeneous wireless networks

Christian Makaya *, Samuel Pierre

Mobile Computing and Networking Research Laboratory (LARIM), Department of Computer Engineering, Ecole Polytechnique de Montreal, P.O. Box 6079, Station Centre-ville, Montreal, Que., Canada H3C 3A7

Received 10 April 2007; received in revised form 4 January 2008; accepted 6 January 2008
Available online 26 January 2008

Abstract

Mobility management, integration and interworking of existing wireless systems are important factors to obtain seamless roaming and services continuity in next generation or 4G wireless networks (NGWN/4G). Although, several IPv6-based mobility protocols as well as interworking architectures have been proposed in the literature, they cannot guarantee seamless roaming, especially for real-time applications. Moreover, mobility management protocols are designed for specific needs, for example, the purpose of IPv6-based mobility schemes consists of managing users roaming while ignoring access network discovery. This paper proposes an efficient handoff protocol, called *enhanced Handoff Protocol for Integrated Networks* (eHPIN), which carries out localized mobility management, fast handoff, and access network discovery. It alleviates services disruption during roaming in heterogeneous IP-based wireless environments. Performance evaluation results show that eHPIN provides significant gain with respect to signaling traffic overhead cost, handoff latency, packet delivery cost, handoff failure and packet loss compared with existing IPv6-based mobility schemes.

Keywords: Mobility management; IP mobility; Quality of service; Heterogeneous wireless networks; Handoff; Seamless roaming; Services continuity

1. Introduction

Fourth or next generation wireless networks (4G/NGWN) are expected to exhibit heterogeneity in terms of wireless access technologies, user-oriented services and greater capacities. Users will have increasing demands for seamless roaming across different wireless networks, support of various services (e.g., voice, video, data) and quality of service (QoS) guarantees. Hence, with this heterogeneity, users will be able to choose radio access technology (RAT) that offers higher quality, data speed and mobility which is best suited to the required multimedia applications. Moreover, technological advances in the evolution of portable devices make it possible to support different RATs. Heterogeneity in terms of RATs and network protocols in 4G/NGWN requires common interconnection element. Since the Internet Protocol (IP) technology enables the support of applications in a cost-effective and scalable way, it is expected to become the core backbone of 4G/NGWN [1]. Thus, current trends in communication networks evolution are directed towards an all-IP principles in order to hide heterogeneities of lower-layers technologies from higher-layers and to achieve convergence of different networks.

Mobility management, with provision of seamless handoff and QoS guarantees, is one of the key topics in order to support global roaming of mobile nodes (MNs) in NGWN. Providing seamless mobility and service continuity (i.e., minimal service disruption during roaming) support based on intelligent and efficient techniques is crucial. This means that seamless handoff schemes should have following features: minimum handoff latency, low packet loss, low signaling overhead and limited handoff failure or blocking rate. Handoff latency represents the time interval during which an MN cannot send or receive any data traffic during handoffs. It is composed of L2 (link switching) and L3 (IP layer) handoff latencies. The overall handoff latency may be sufficiently long to cause

* Corresponding author. Tel.: +1 514 340 4711x2126.
E-mail addresses: christian.makaya@polymtl.ca (C. Makaya), samuel.pierre@polymtl.ca (S. Pierre).

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doi:10.1016/j.comcom.2008.01.026

packet loss, which is intolerable for real-time applications such as voice over IP (VoIP). Furthermore, subscribers are more sensitive to session/call blocking during handoff than to session blocking during call initiation. The handoff blocking probability refers to the likelihood that a session connection is prematurely terminated due to an unsuccessful handoff over a session lifetime. Hence, minimization of handoff blocking probability is crucial for mobility management schemes. The signaling traffic overhead is defined as the total number of control packets (for registration, binding update and binding refresh procedures) exchanged between an MN and a mobility agent (e.g., home agent).

Several IPv6-based mobility schemes such as Mobile IPv6 (MIPv6) [4], Hierarchical Mobile IPv6 (HMIPv6)[7] and Fast Handovers for Mobile IPv6 (FMIPv6) [8], have been proposed by the Internet Engineering Task Force (IETF) to enable an MN to remain reachable when moving out of its home network. However, these protocols are hindered by several drawbacks such as signaling overhead, handoff latency and packet loss. To achieve seamless mobility across various access technologies and networks, an MN needs to have information regarding the wireless network to which it can attach. To enable this, Candidate Access Router Discovery (CARD) protocol [10] was proposed by the IETF. When coupled with CARD protocol, traditional fast handoffs schemes may work inefficiently since some operations may be redundant, which results in higher handoff delay and wastage of network resources.

Enhancing those protocols for efficient mobility management in heterogeneous NGWN is highly necessary. This paper proposes a mobility management scheme, called *enhanced Handoff Protocol for Integrated Networks* (eHPIN), that enables seamless roaming, services continuity and QoS guarantees for real-time applications in heterogeneous IPv6-based wireless environments. eHPIN performs access network discovery, localized mobility and fast handoff management. In other words, eHPIN aims to provide efficient access network discovery and roaming support in order to alleviate services disruption during handoff. It is designed for both heterogeneous and homogeneous wireless networks. The main contributions of this paper can be summarize as follows:

(i) The proposal of an appropriate usage of fast handoff, media independent handover (MIH) and access networks discovery concepts in one suite protocol that provides efficient mobility management in heterogeneous wireless environments.
(ii) To further reduce handoff delay and packet loss, we propose the anticipated binding update procedure and tunnels establishment as well as efficient context transfer.
(iii) Performance evaluation is done based on the proposed analytical model in order to compare eHPIN with some existing IP-based mobility management protocols.

The remainder of this paper is organized as follows. In Section 2, an overview of basic concepts and related work are depicted. An interworking architecture for 4G/NGWN is presented in Section 3. The proposed mobility management protocol, eHPIN, is described in Section 4. Performance analysis and numerical results are shown in Sections 5 and 6, respectively. Finally, Section 7 concludes the paper.

2. Background and related work

Mobility management enables a communication system to locate roaming terminals in order to deliver data packets (i.e., *location management*) and to maintain connections with them as they move into a new subnet (i.e., *handoff management*). Handoff management is a major component of mobility management since an MN can trigger several handoffs over a session lifetime as it will be the case in NGWN. It is crucial to provide seamless mobility and service continuity support based on intelligent and efficient techniques. Various schemes have been proposed in the literature and by the IETF for mobility management in IP-based wireless networks.

Mobile IPv6 (MIPv6) [4] was proposed for mobility management at the IP layer and allows MNs to remain reachable in spite of their movements within IP wireless environments. Each MN is always identified by its home address, regardless of its current point of attachment to the network. While away from its home network, an MN is also associated with a care-of address (CoA), which provides information about the MN's current location. After acquisition of CoA, an MN sends a binding update (BU) message to the home agent (HA), informing it of the new address and also to all active correspondent nodes (CNs) to enable route optimization. However, MIPv6 has some well-known drawbacks such as signaling traffic overhead, high packet loss rate and handoff latency, thereby causing user-perceptible deterioration of real-time traffic [5,6]. These weaknesses led to the investigation of other solutions designed to enhance MIPv6 and support micro-mobility of MNs.

Two main MIPv6 extensions proposed by the IETF are Hierarchical MIPv6 (HMIPv6) [7] and Fast Handovers for MIPv6 (FMIPv6) [8]. HMIPv6 handles local handoffs through a special node called Mobility Anchor Point (MAP). The MAP, acting as a local HA in the network visited by the MN, limits the amount of MIPv6 signaling outside its domain and reduces delays associated to location update procedure. However, HMIPv6 cannot meet the requirements for delay sensitive traffic, such as voice over IP (VoIP), due to packets loss and handoff latency. FMIPv6 was proposed to reduce handoff latency and to minimize services disruption due to MIPv6 operations during handoffs such as movement detection, binding update and addresses configuration. The link layer information (L2 trigger) is used either to predict or respond rapidly to handoff events.