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LETTER

Vertical handoff in integrated CDMA and WLAN systems

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Abstract

Future wireless networks are expected to consist of different types of wireless networks such as code division multiple access (CDMA) networks and public wireless local area networks (WLANs). The integrated network will require vertical handoffs between different networks. In this letter, we propose vertical hard- and soft-handoff algorithms and evaluate their performance in commercial wireless networks.

Keywords: Vertical handoff; Interworking; Seamless roaming; Wireless LAN

1. Introduction

Wireless Internet users are growing very fast and they are demanding higher data rate multimedia services. However, due to the delay of third-generation (3G) networks and large investments, cellular operators are increasingly interested in the complementary use of IEEE 802.11a/b/g based wireless local area network (WLAN) technologies. In many countries, WLAN systems have already been widely deployed in public locations, such as hotels, coffee shops, and hotspot streets, as well as in enterprises and homes [1].

WLANs have several advantages over cellular networks, including higher data rate and lower-investment requirements. However, their coverage is typically limited to hotspot areas. Cellular networks, on the other hand, provide wide-area coverage. Hence, future wireless networks are expected to move toward the integration of WLANs and cellular networks where vertical handoffs will be required. Many studies have investigated the cellular-WLAN interworking architecture [2–4]. Moreover, a 3G partnership project (3GPP) has recently taken the initiative to develop this architecture. However, few algorithms for vertical handoff between WLANs and cellular networks have been proposed in practical systems. In this letter, we propose vertical-handoff algorithms and evaluate their performance in commercial networks.

2. Proposed interworking architecture

2.1. Interworking network architecture

We consider a mobile IP-based loosely coupled interworking architecture between WLANs and code division multiple access (CDMA) networks [2]. Vertical handoff involves changing the access interface, which typically results in changing the mobile node's (MN's) IP address. The mobile IP, which is specified by the internet engineering task force (IETF), allows an MN to keep the same IP address, stay connected, and maintain ongoing applications while roaming between different IP subnets.

Fig. 1 shows an MN roaming from a WLAN to a CDMA2000 network while communicating with a correspondent node (CN) without disconnection. A vertical handoff triggers a mobile IP registration message to be sent

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from the MN's "new" location since the change of the access interface involves changing the MN's IP address.

Fig. 2 illustrates the interaction between an MN and the network. In the WLAN hotspot area, an MN performs the IEEE 802.1x authentication procedure after it has associated with an access point (AP) [5]. After the MN has been successfully authenticated, it registers its care-of-address (CoA) with the home agent (HA), which binds the CoA to the MN's home address. Traffic communication between the MN and the CN is subsequently established. Packets addressed to an MN will be encapsulated by the HA with an extra IP header whose destination address is the MN's CoA. Packets from the MN addressed to the CN may be either routed directly from the visited network toward the CN (triangular routing), or tunneled back to the HA and routed from there to the CN (reverse tunneling).

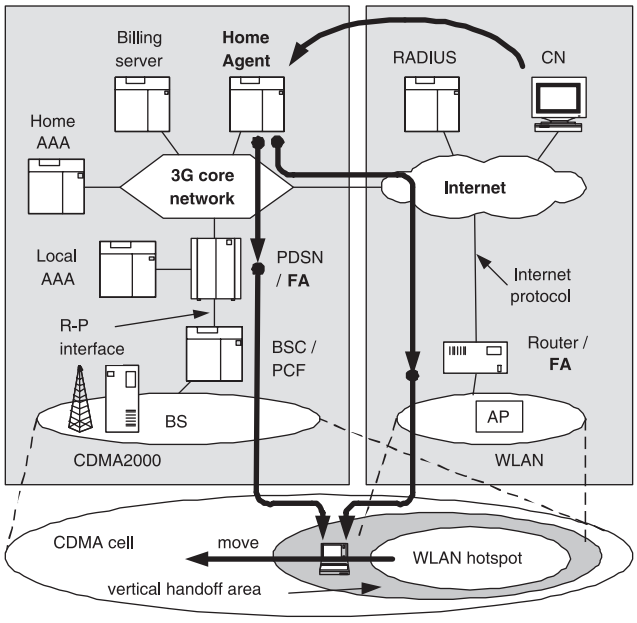

Fig. 1. Vertical soft handoff in an integrated WLAN/CDMA system.

When the MN moves out of the WLAN hotspot area, vertical handoff from the WLAN to the CDMA occurs (at point *A* in Fig. 2). The MN detects the presence of a new available network and initiates a link-level association, i.e. a point-to-point protocol (PPP) connection, after achieving the traffic channel (TCH) from the CDMA2000 network. As soon as the PPP connection has been negotiated, the MN registers its new CoA in the CDMA2000 network with the HA to update its current location. After this (at point *B* in Fig. 2), packets addressed to the MN will be delivered through the CDMA2000 network.

2.2. Interworking mobile node architecture

To support the mobile IP service across WLANs and CDMA2000 networks, the client software should be able to handle multi-interface adapters at the same time. The software architecture for the MN, which we implement for Windows 2000/XP, is shown in Fig. 3. The client software consists of five components: (1) The graphic user interface (GUI) allows a user to login to the network, monitor the status of the physical interfaces, and configure the mobile IP profiles and network interfaces. (2) The protocol module consists of the mobile IP for seamless roaming and the IEEE 802.1x protocol for authentication in the WLANs. (3) The handoff module periodically scans all interfaces and monitors the received signal strength of the available

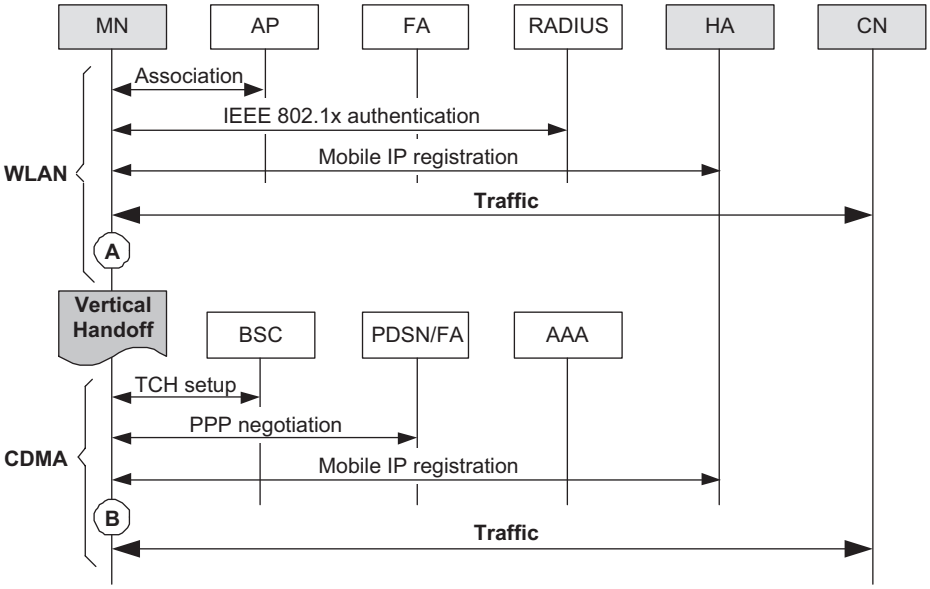

Fig. 2. Mobile IP-based vertical handoff.