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ScienceDirect
Computer Networks 51 (2007) 2049–2066
Computer Networks
www.elsevier.com/locate/comnet

On the design of mobility management scheme for 802.16-based network environment ☆

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Received 2 May 2006; received in revised form 4 October 2006; accepted 13 October 2006
Available online 9 November 2006

Responsible Editor: W. Kellerer

Abstract

In this paper, we investigate the characteristics of IEEE 802.16 and conclude that it is better to equip BS (base station) and SS (subscriber station) with Layer 3 functionality. Therefore, an 802.16 network can act as the backbone network of different subnets for better deployment. Based on the two IEEE Specifications, 802.16-2004 and 802.16e, we propose two kinds of paradigms of the 802.16 network technology for mobile networking. In the first paradigm, a novel concept called middle-domain mobility management in between macro- and micro-domain for 802.16-2004 is proposed. The management scheme of middle-domain is designed to accommodate different micro-mobility protocols in an 802.16-2004 network environment. Moreover, a mathematical analysis and simulation study are presented for performance evaluation. In the second paradigm, by comparing with traditional overlay networks (e.g. GPRS/WLAN), we have found that the characteristics for the 802.16e/802.11 overlay network are actually different from traditional overlay networks. To provide more efficient vertical handoff, a novel protocol called speed-based vertical handoff scheme (SVH) is proposed. A Simulation study has demonstrated that SVH can achieve a better performance than its WLAN-first counterpart in terms of less signaling and fewer packet losses.

Keywords: 802.16; BWA; Mobility management; Wireless overlay network; Vertical handoff

1. Introduction

Broadband Wireless Access (*BWA*) technology provides an easy, time-saving, and low-cost method for deployment of next generation (beyond 3G) network infrastructure. Since 1998, IEEE 802.16 working group has launched a standardization process called *Wireless Metropolitan Area Network* (*Wireless*

☆ This work was supported in part by the National Science Council, Taiwan, R.O.C., under grant no. NSC94-2219-E-260-004.
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doi:10.1016/j.comnet.2006.10.007

MAN^{TM}) for BWA. The newly released specification of 802.16 (*IEEE Std 802.16-2004*) [1] focuses on fixed location wireless access and can support up to 134 Mbps bit rate. Moreover, IEEE 802.16 working group is currently working on the standardization of a new 802.16 interface, 802.16*e* [2], to support wireless access with high mobility. The *WiMax Forum* (*Worldwide Interoperability for Microwave Access*) [3], a wireless industry consortium with about 100 members including major vendors such as *AT&T*, *Fujitsu*, *Intel*, and *Siemens Mobile*, is supporting 802.16 technology and promoting its commercial use, which means 802.16 is becoming the most important technology in BWA.

As illustrated in Fig. 1, a typical 802.16 network consists of a *base station* (*BS*) and a couple of *subscriber stations* (*SS*) that connect to the BS via a high-speed wireless link. The BS acts as a gateway to the Internet. Legacy LANs or even more complex subnet systems can connect to the 802.16 network via SS. An 802.16 network (including the Legacy LANs that connect to SS) can cover a large geographical area since the distance between BS and SS can be up to 30 miles (in the case of 802.16-2004).

Similar to other 802 protocols, IEEE 802.16 defines the specification in physical layer (Layer 1) and MAC layer (Layer 1.5). Thus, from the viewpoint of layering architecture in networking, an 802.16 network is basically a subnet and the BS or SS acts as a Layer 2 (L2) device (bridge, for instance). However, it is improper to view an 802.16 network as a subnet like 802.3 or 802.11 LAN, since (1) an 802.16 network can cover a large geographical area and (2) a large number of users (including mobile hosts) in the network would cause serious performance degradation if the whole 802.16 network is only a single broadcast domain.

For example, *Address Resolution Protocol* (*ARP*) requires the ARP request frame to be broadcast in the whole 802.16 subnet in order to get the mapping from the logical IP address to the physical address.

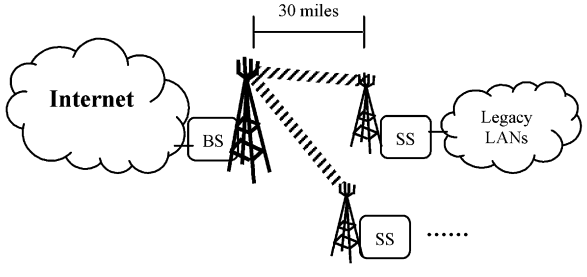

Fig. 1. General view of 802.16 network.

Moreover, in order to support mobile computing in 802.16, L2 mobility management as well as L2 handoff control [4] require the handoff frames to be broadcast in the network, creating more annoyed broadcast frames in the 802.16 network.

Therefore, we conclude that it is better to equip BS and SS with Layer 3 (L3) functionality such that 802.16 network acts as the backbone network of different subnets to enhance 802.16-based network deployment. This kind of network deployment (heterogeneous subnets interconnected by L3 802.16 BS/SS) is actually a form of internet, and it is called *802.16 network environment* in this paper.

There are two approaches to support mobility for users in an 802.16 network environment: (1) mobile hosts equipped with 802.11 interface roaming among WLANs or cellular systems that connect to SS (in the case of 802.16-2004), or (2) mobile hosts equipped with 802.16e interface connecting to the BS directly. In this paper, we aim to design appropriate mobility management schemes for each of the two approaches respectively as briefly explained in the following.

Deployment of 802.16 technology by approach (1) for mobility supporting is called the paradigm of "*802.16-2004 mobile network environment*" in this paper. Given that 802.16-2004 BS and SS are equipped with L3 functionality as discussed above, an 802.16-2004 mobile network environment is beyond the ability of a Layer 2 mobility management scheme. Hence, we investigated the feasibility of applying existing L3 mobility management schemes in the paradigm. We have found that the current two-tier mobility management (*macro-mobility* + *micro-mobility*) [5,6] cannot fit in 802.16-2004 mobile network environment well. Therefore, a new concept of *middle-domain* mobility management is proposed.

On the other hand, mobile hosts with 802.16e interface in approach (2) act like mobile subscriber stations that connect to 802.16e BS directly. In this case, there is only one single 802.16e cell for mobile hosts and it does not require elaborate mobility management. Thus, we are more interested in the extension of approach (2) in which WLANs are connecting to stationary SS and mobile hosts are equipped with both 802.16e and 802.11 interfaces. Deployment of the extension is called the paradigm of "*802.16e/802.11 overlay network environment*" in the paper. As in traditional overlay networks (e.g. GPRS/802.11 overlay networks) [7], mobility management for 802.16e/802.11 overlay network environment needs to deal with not only horizontal