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IPv6 based relay gateway protocol in hybrid networks

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ABSTRACT

During the past few years, WMAN (Wireless Metropolitan Area Network) and WLAN (Wireless Local Area Network) provided fast, convenient and reliable solution for all kinds of users. With the development of the communication technology, the future wireless networks will allow mobile users access Internet anywhere, anytime. Therefore, it is a natural trend to combine different wireless networks to provide a seamless roaming for users. It is feasible for mobile terminal which have multiple modes to handoff between different networks. A relay gateway protocol for the WLAN-mode nodes (mono-mode WLAN nodes and dual-mode nodes) in the hybrid network of IEEE 802.16 WMANs and IEEE 802.11 WLANs is proposed to provide wider mobility. Dual-mode mobile nodes with good service can provide WLAN links to nearby WLAN-mode nodes with bad service or out of the WLAN coverage. Simulation results show that the relay gateway scheme can improve network performance of the hybrid networks. Moreover, the relay gateway method can bring additional service coverage and increase the capacity of WMANs and WLANs.

1. Introduction

The IEEE 802.11 standards (IEEE WG, 1997, 1999a,b, 2003a, 2007, 2009a) grow rapidly in the past few years. The IEEE 802.11 WLANs can provide fast, secure, reliable and fully featured service. But there is a restriction for WLAN mobile node (MN) in its movements because of the limit coverage area of WLANs.

The IEEE 802.16 (IEEE WG, 2003b, 2009b) WMAN can provide high speed Internet access in wide area. It provides operators with a common platform which accelerates performance improvements unachievable with proprietary approaches and T1/E1 level and "on demand" broadband services.

A natural trend is the combination of WMAN and WLAN to create a complete wireless solution for delivering high speed Internet access to businesses, homes and hot spots. Figure 1 shows the integration of the IEEE 802.16 WMANs and IEEE 802.11 WLANs.

For dual-mode device with both WMAN interface and WLAN interface, it is very convenient to roam across the wireless networks seamlessly. When a dual-mode device in the WMAN enters WLAN, the mobile device will handoff from WMAN to WLAN because the WLAN can provide high bandwidth and lost cost. But when WLAN has heavy traffic or the dual-mode device's velocity is too high, it is better to persist in the WMAN. When a dual-mode device leaves WLAN and enters WMAN, the mobile device will handoff from WLAN to WMAN. Handoff from a WMAN to a WLAN and handoff from a WLAN to a WMAN are vertical handoffs.

But there are a lot of mono-mode devices without two interfaces. When the device is a mobile device with only WMAN interface, it can communicate freely in wide area because WMAN can offer large-scale network access. But when the device is a mobile device with only WLAN interface, it can only work within limited area because WLAN can only provide Internet access at limited places. How to solve the problem and how to provide better service for both dual-mode nodes and mono-mode nodes?

At present, there are a lot of works on mobility management in hybrid networks. Inayat et al. (2004) proposed a seamless handoff for dual-interfaced mobile devices in WLAN and GPRS hybrid wireless access networks, utilizing the signal-to-interference ratio of physical level to decide the handoff. In Zhang et al. (2003) and Guo et al. (2004), a novel seamless and proactive end-to-end mobility management system is presented. This solution is suitable for the vertical handoff between high bandwidth networks and low bandwidth networks, but it was not extended to the handoff between two high bandwidth networks. There are some works on cellular relay too. In Wei and Gitlin (2004a,b), a two-hop-relay architecture is considered as a system-level macro-diversity technique to achieve increased system capacity of cellular networks in integrated WLAN and cellular networks, but all devices are dual-mode devices and the performance of WLAN has not been improved in evidence. In addition, there is no consideration of quality parameter bandwidth and signal strength. In Okada et al. (2005), a mechanism for establishing

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connections and relaying packets between mobile stations in CDMA radio access networks is proposed. The mechanism is capable of reducing dead spot mobile stations and improving throughput with only limited modifications to conventional systems. The mechanism is used for cellular networks but not for integrated networks. Paper (Wang et al., 2007) developed a dynamic network selection scheme to determine the connecting system in a new "WLAN to hybrid WLAN/WiMax" handoff scenario, which considers both the vertical and horizontal handoffs. The proposed scheme requests the station to wait an additional network selection time before the selection to maximize the amount of delivered bits during a dwelling time. In Niyato and Hossain (2008), a noncooperative game is used to obtain the bandwidth allocations to a service area from the different access networks available in that service area. The Nash equilibrium for this game gives the optimal allocation which maximizes the utilities of all the connections in the network. Based on the obtained bandwidth allocation, to prioritize vertical and horizontal handoff connections over new connections, a bargaining game is formulated to obtain the capacity reservation thresholds so that the connection-level QoS requirements can be satisfied for the different types of connections.

For all the above works, they are not fit for the mono-mode devices with only WLAN interface in the hybrid networks. When a mono-mode WLAN device leaves WLAN coverage and enters a WMAN, the device will lose the connection with the Internet. Therefore, it requires an efficient mobility support for mono-mode WLAN device in the hybrid networks. In this paper, a relay gateway protocol is proposed for mono-mode mobile devices' mobility extension. When a mono-mode WLAN device is out of the coverage of WLAN AP (Access Point) or find that a relay gateway can provide better service than WLAN AP or WMAN BS (Base Station), it will send the packets to the CN (corresponding node) through the relay gateway in the WMAN. The relay gateway is the dual-mode device that has both WMAN and WLAN radio interfaces. For instance, the relay gateway can be a mobile device that voluntarily performs the relay functionality. In the traditional hybrid networks, mobile devices in IEEE 802.11 WLAN only use the WLAN service provided by the WLAN AP. But sometimes, there is better WLAN service provided by the relay gateways. In the proposed relay gateway protocol, a mono-mode device with only a WLAN interface can utilize the dual-mode device in the WMAN to access the WLAN of better service.

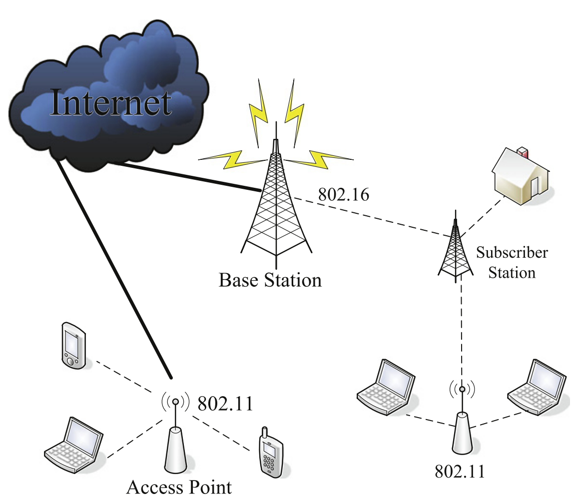

Fig. 1. Integration of WLANs and WMANs.

The rest of the paper is organized as follows. The related work of IEEE 802.11 WLAN and IEEE 802.16 WMAN is introduced in Section 2. Section 3 introduces a decision algorithm for WLAN service, and then proposes a relay gateway protocol for hybrid networks. The communication procedure and the channel access method of the relay gateway protocol are described in detail. Then the relay gateway protocol is evaluated and analyzed by simulation in Section 4. Section 5 concludes this paper.

2. Related work

2.1. IEEE 802.11 standard-DCF

In the IEEE 802.11 standards (IEEE WG, 1999a,b, 2003a, 2007, 2009a), the fundamental access method of the medium access control (MAC) is a Distributed Coordination Function (DCF) known as carrier sense multiple access with collision avoidance (CSMA/CA). A transmitting station shall ensure that the medium is idle for this required duration before attempting to transmit. If the medium is determined to be busy, the station shall defer until the end of the current transmission. Prior to data transmission, the transmitting and receiving station exchange short control frames [request to send (RTS) and clear to send (CTS) frames] after determining that the medium is idle and after any deferrals or backoffs (IEEE WG, 1999a, 2007). The RTS/CTS frames define the duration of the following frame and acknowledgment. The duration/ID field in the data and acknowledgment (ACK) frames specifies the total duration of the next fragment and acknowledgment. This is illustrated in Fig. 2 (IEEE WG, 1999a, 2007).

2.2. IEEE 802.16 standard

(1) Frequency Division Duplex (FDD): In an FDD system, the uplink and downlink channels are located on separate frequencies and the downlink data can be transmitted in bursts. A fixed duration frame is used for both uplink and downlink transmissions (IEEE WG, 2003b, 2009b). It also allows simultaneous use of both full-duplex subscriber stations (SSs) and optionally half-duplex SSs. Figure 3 describes the basics of the FDD mode of operation (IEEE WG, 2003b, 2009b).

(2) Time Division Duplex (TDD): In the case of TDD, the uplink and downlink transmissions occur at different times and usually share the same frequency (IEEE WG, 2003b, 2009b). A TDD frame (see Fig. 4) has a fixed duration and contains one downlink and one uplink subframe. The frame is divided into an integer number of physical slots (PSs). The TDD framing is adaptive in that the bandwidth allocated to the downlink versus the uplink can vary (IEEE WG, 2003b, 2009b).

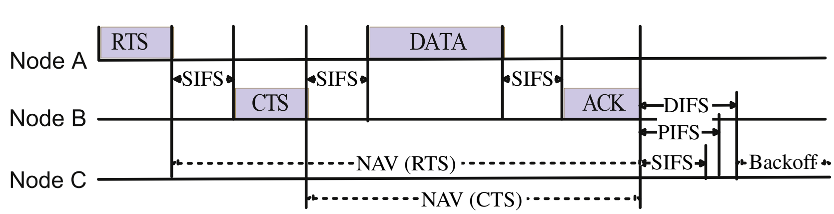

Fig. 2. RTS/CTS DCF.