A MAC Protocol Mechanism for Mobile IP over Wireless LANs

Il-Young Moon, Jae-Sung Roh and **Sung-Joon Cho**, *Member, KIMICS*

Abstract—Recently, the use of TCP/IP protocols over wireless LANs poses significant problems. In this paper, we have analyzed transmission control protocol (TCP) packet transmission time for mobile IP over wireless local area networks (LANs) using a proposed a new random backoff scheme. We call it as a proxy backoff scheme. It is considered the transmission time of TCP packet on the orthogonal frequency division multiplexing (OFDM) in additive white gaussian noise (AWGN) channel. From the results, a proposed proxy backoff scheme produces a better performance than an original random backoff in mobile IP over wireless LANs environment. Also, in OFDM/quadrature phase shift keying (QPSK) medium access control (MAC), we have obtained that the transmission time in wireless channel decreases as the TCP packet size increases.

Index Terms—Mobile IP, Wireless LANs, IEEE 802.11 MAC Protocol, IEEE 802.11a Physical Layer

I. INTRODUCTION

TCP/IP based protocols provide an excellent platform for high-speed wired LANs with constant connections [1]. Advances in digital wireless communication have accelerated the progress of mobile computing. In the increasingly competitive world of today, professional are constantly relying on wireless data communication to access up-to-date information from the network when they are out in the field or moving about in the premises. The growing popularity of IEEE 802.11 has made wireless LANs a potential candidate technology for providing high-speed wireless access services. Also, by supporting mobile IP, wireless LANs can meet demands for expanded wireless access coverage while maintaining continuous connectivity from one wireless LAN to another [2],[3]. Mobile IP is to enable mobile stations to roam transparently throughout networks, automatically maintaining proper IP-based connections to their networks. This avoids the impracticality of changing the IP address in the appliance when operating in a different area of the network [4]. Since the drafting of the mobile IP Standard, educational institutes as well as commercial bodies have developed mobile IP over several platforms. Most of the mobile IP implementations are based on either wireless LAN or wired network. Implementation of mobile IP on a wireless LANs, such as WaveLAN, has geographical limitation for wireless coverage. Wireless LAN is normally used within a building or in a specific compound. In addition, mobile IP over wireless LAN implies that the mobile node needs to perform handoff when it travels between different cells to minimize packet loss [5].

In this paper, we have studied the institute of electrical and electronics Engineers (IEEE) 802.11 MAC protocol to enhance transport ability for mobile IP over wireless LAN and propose a proxy backoff scheme for the distribution coordination function (DCF) of MAC protocol. The DCF is designed for asynchronous data transmission by using carrier sense multiple access with collision avoidance (CSMA/CA). In addition, as an environment for our study we have simulated 802.11a OFDM/QPSK. As illustrated in the simulation, we can accomplish a greater efficiency in TCP packet transmission time using a proxy backoff scheme as opposed to a original DCF backoff scheme.

II. OVERVIEW OF MOBILE IP OVER WIRELESS LANS

A. Overview of Mobile IP and Wireless LANs

Mobile IP is developed by the internet engineering task force (IETF) to standardize the mechanism for allowing a computer host to roam freely on the Internet while still maintaining the same IP address [6]. Mobile IP architecture defined in RFC 2002 evolves around three entities, namely, mobile node (MN), foreign agent (FA), and home agent (HA). A MN is a host that changes its point of attachment from one network to another. It has the capability of retaining its unique IP address and is able to communicate with other Internet hosts even in a different network. A FA is a special router at the network where the MN visits. The basic function of a FA is to provide routing services to the mobile node while registered so that IP transparency can be provided. Finally, a Home Agent at the MN's home network is needed mainly to manage the location information of the MN, messages route to it and facilitates host authentication.

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I. Y. Moon is with the Dept. of Inform. & Telecomm. Eng., Graduate School of Hankuk Aviation Univ., Koyang-Si, Kyounggi-Do, 412-791, Korea (Tel : +82-2-3158-1518, Fax : +82-2-3158-1935, E-mail : iymoon21@mail.hangkong.ac.kr)

J. S. Roh is with of the Dept. of Inform. & Comm. Eng., Seoil College, Myunmok-8 Dong, Jungrang-Gu, Seoul, Korea (Tel : +82-2-490-7206, Fax : +82-2-490-7407, E-mail : jsroh@seoil.ac.kr)

S. J. Cho is with the School of Electronics, Telecomm. and Computer Eng., Hankuk Aviation Univ., Koyang-Si, Kyounggi-Do, 412-791, Korea (Tel : +82-2-3158-1518, Fax : +82-2-3158-1935, E-mail : sjcho@mail.hangkong.ac.kr)

IEEE 802.11 technologies have been standardized at a rapid pace and are expected to offer part of the capabilities for systems beyond third generation technologies. The resulting high-speed network access will expand the possibilities for real time applications such as audio and video streaming, voice over IP, teleconferencing, and rapid data downloads. One of various IEEE 802.11 technologies, 802.11a is new specification that represents the next generation of enterprise-class wireless LANs. Among the advantages it has over current technologies are greater scalability, better interference immunity, and significantly higher speed, up to 54 Mbps and beyond, which simultaneously allows for higher bandwidth applications and more users. 802.11a MAC layer uses the same technology as 802.11b with CSMA/CA. CSMA/CA is a basic protocol used to avoid signals colliding and canceling each other out. It works by requesting authorization to transmit for a specific amount of time prior to sending information. The sending device broadcasts a request to send (RTS) frame with information on the length of its signal. If the receiving device permits it at that moment, it broadcasts a clear to send (CTS) frame. Once the CTS go out, the sending machine transmits its information. Any other sending devices in the area that "hear" the CTS realize another device will be transmitting and allow that signal to go out uncontested.

B. Architecture of Mobile IP over Wireless LANs

In mobile IP over wireless LANs, mobile IP provides IP level mobility to allow these mobile nodes to roam around wireless LANs without disrupting transport sessions. By locating the FA in each wireless LAN, packets destined for the mobile node are forwarded via the HA in the home network of the mobile node and the FA in the visited wireless LAN. Figure 1 illustrates such a wide area wireless access network, where each wireless LAN is composed of access points and this wireless LANs are connected with FA.

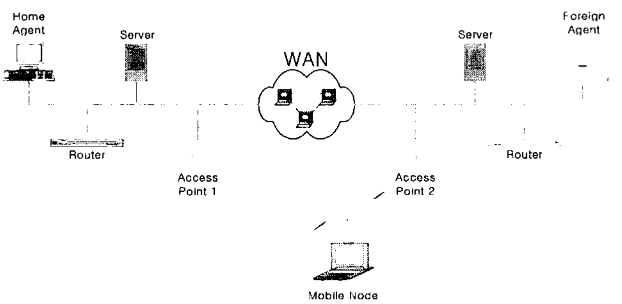

Fig. 1 Wireless LANs service with Mobile IP

The logical link control layer (LLC) is the higher layer of the IEEE 802.11 reference model and provides functions similar to the traditional data link control protocol. The purpose of the LLC is to exchange data between end user across a LAN using 802.11-based MAC controlled link. The LLC provides addressing and data link control, and it is independent of the topology, transmission medium, and medium access control technique chosen. Higher layers, such as TCP/IP, pass user data down to the LLC expecting error-free transmission across the network. The LLC in turn appends a control header, creating an LLC protocol data unit (PDU). The LLC uses the control information in the operation of the LLC protocol. Figure 2 shows the end-to-end link control over 802.11-based wireless LANs.

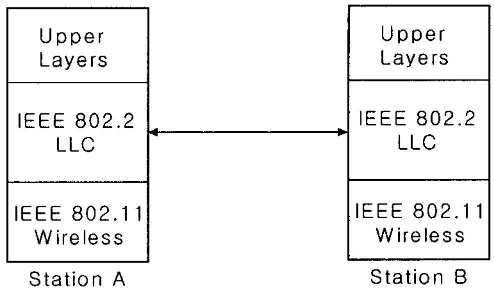

Fig. 2 End-to-End Link Control over 802.11-based Wireless LANs

Figure 3 depicts mobile IP over wireless LANs protocol stack for a combined mobile IP and wireless LANs [7].

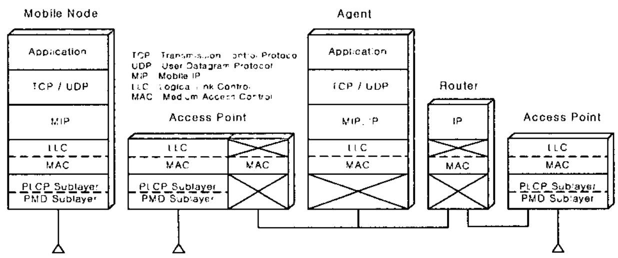

Fig. 3 Mobile IP over Wireless LANs protocol stack

C. IEEE 802.11a Physical Layer

The IEEE 802.11 OFDM physical layer delivers up to 54 Mbps data rates in the 5 GHz band. 802.11a uses OFDM, a new encoding scheme that offers benefits over spread spectrum in channel availability and data rate [8]. Channel availability is significant because the more independent channels that are available, the more scalable the wireless network becomes. The high data rate is accomplished by combining many lower-speed subcarriers to create one high-speed channel. 802.11a uses OFDM to define a total of 8 non-overlapping 20 MHz channels across the 2 lower bands; each of these channels is divided into 52 subcarriers, each approximately 300 KHz wide.

III. IMPROVEMENT OF TRANSPORT ABILITY FOR MOBILE IP OVER WIRELESS LANS

A. IEEE 802.11 DCF MAC Protocol

The distributed coordination function is the primary access protocol for the automatic sharing of the wireless medium between stations and access points [9],[10]. Similar to the MAC coordination of the 802.3 ethernet wired line standard, 802.11 networks use CSMA/CA protocol for sharing the wireless medium. The CSMA/CA protocol avoids the probability of collisions among stations sharing the medium by using a random backoff if the station's physical or logical sensing mechanism indicates a busy medium. The period of time immediately following a busy medium is when the highest probability of collisions occurs, especially under high utilization. The reason for this is that many stations may be waiting for the medium to become idle and will attempt to transmit at the same time. Once the medium is idle, a random backoff defers a station for transmitting a frame, minimizing the chance that stations will collide. Figure 4 and 5 shows a basic access method and operating flowchart of the contention-based CSMA/CA in IEEE 802.11 DCF MAC protocol.

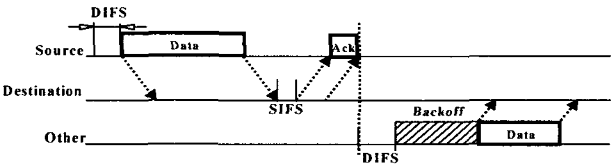

Fig. 4 Basic Access Method

B. Proposed Proxy Backoff Scheme in IEEE 802.11 DCF MAC Protocol

The proposed proxy backoff algorithm enhances data transmission ability than original method by retransmit scheme for random backoff in DCF protocol. The procedure for the proposed method is summarized in following step:

1) A station with a new packet is ready for transmission senses whether or not the medium is busy.
2) If the medium is detected idle, the station starts packet transmission.
3) Otherwise, the station continues to monitor the medium busy or idle status.
4) After finding the medium idle, the station starts to treat medium time in units of slot time.
5) If the second carrier sense (collision_num=2) find the medium idle=NO or collision = YES, the station sends the second carrier sense to a proxy backoff.
6) And then, the second carrier sense is sent to the start by a proxy backoff. (Retransmit)
7) Except for the second carrier sense, the other carrier senses send to an original random backoff directly.

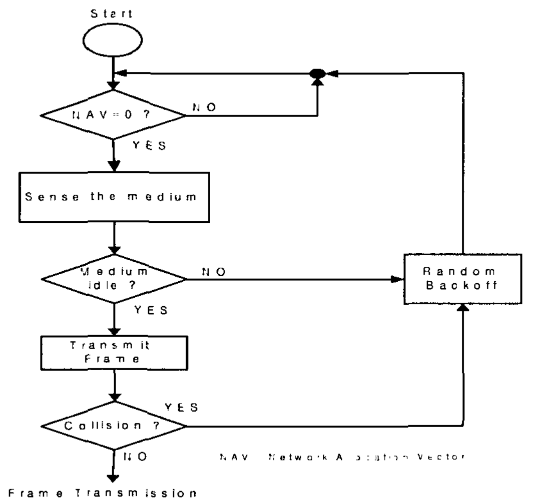

Fig. 5 Flowchart of IEEE 802.11 DCF MAC protocol

The reason why only use a proxy backoff scheme at the second carrier sense is to prevent unnecessary backoff time delay. This random backoff mechanism does a good job of avoiding collision. However, stations on the networks with high utilization have experience substantial delays while waiting to transmit frames. Figure 6 depicts flowchart of a proposed proxy backoff scheme.

C. OFDM/QPSK Modulation Transmission

In the baseband, an OFDM signal is represented as

$$s(t)=\frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} x_k \cdot e^{j2\pi\frac{k}{T}t} \qquad (1)$$

where N is a number of subcarrier on the OFDM system, T is the OFDM symbol period and x_k is the QPSK modulated data symbols. The N serial data symbols are converted to the parallel form by the serial-to-parallel (S/P) converter. The parallel data symbols are all added, multiplied by the carrier, and then transmitted to the channel. Practically, the parallel subchannels are performed by an inverse fast fourier transform (IFFT), and combined to be up-converted.

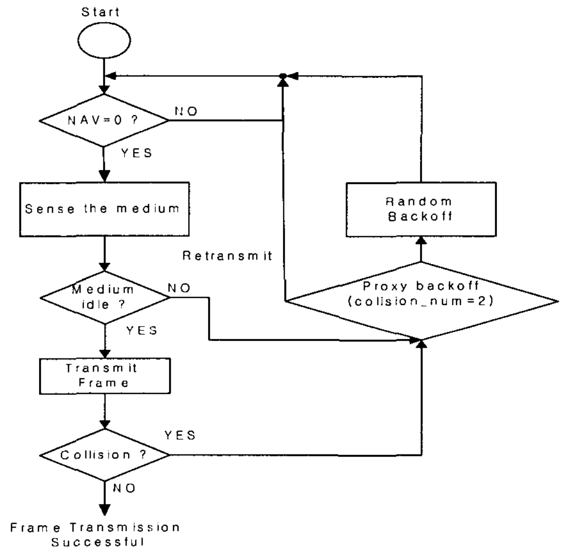

Fig. 6 Flowchart of a Proposed IEEE 802.11 DCF MAC protocol

To simulate mobile IP over wireless LAN system, we used OFDM/QPSK modulation method in wireless environment. In Figure 7, it is shown the block diagram of an OFDM/QPSK system with AWGN.

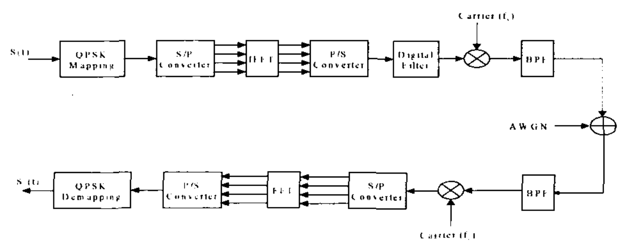

Fig. 7 Simulation model for Mobile IP over OFDM Wireless LANs

IV. SIMULATION OF TCP PACKET TRANSMISSION OF MOBILE IP OVER WIRELESS LANS

In this paper, we have analyzed TCP packet transmission time for mobile IP over wireless LANs using a proposed a new random backoff scheme.

The simulation scenario is to transmit the packet from mobile node to foreign agent, when mobile node moved from home agent to foreign agent. To evaluate the performance of the proposed scheme, by changing E_b/N_o in wireless channel, we acquire transmission time of packet and analyze BER performance of OFDM/QPSK using a proxy backoff scheme in AWGN channel. Also, it is studied the transmission time of mobile IP TCP packet compared a proxy backoff scheme with an original backoff. For achieving transmission time of TCP packet for mobile IP over wireless LANs, total message transmission time is simulated when a size of total message of upper layer TCP is at 5000 bytes and E_b/N_o is 4 dB and 8 dB in AWGN channel. In addition, TCP packet size is analyzed by fragmenting from 100 to 2000 bytes.

Figure 8 is a BER performance of wireless LAN system according to OFDM/QPSK modulation and data transmission rate (12 Mbps) in AWGN channel.

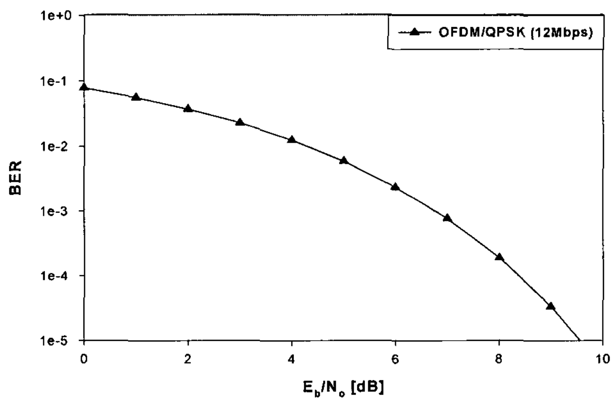

Fig. 8 BER performance of wireless LAN system

In figure 9, the parameter E_b/N_o is set at 4 dB to compare a proxy backoff scheme with an original backoff in AWGN channel. In figure 9, when the TCP packet size increases from 100 to 2000 bytes, packet transmission time of both proxy backoff scheme and original backoff is less than the transmission time of an initial TCP packet 100 bytes. In figure 10, the parameter E_b/N_o is set at 8 dB to compare a proxy backoff scheme with an original backoff in AWGN channel and the simulation result is approximately same as figure 9.

From these results of figures 9 and 10, a proposed proxy backoff scheme produces a better performance than an original backoff in mobile IP over wireless LANs environment. In addition, we can get that the TCP packet size should be increased in order to decrease the transmission time in wireless channel. To obtain a suitable TCP packet size, we also considered the BER in a wireless channel. In the case of optimal TCP packet size (about 500 byte) in AWGN channel, the TCP packet transmission time - considering trade-off between total message transmission time and TCP packet size - is about 345 ms when E_b/N_o = 4 dB and 315 ms when E_b/N_o = 8 dB in AWGN channel.

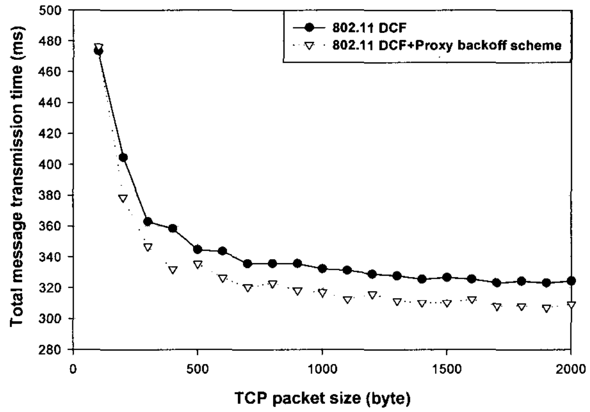

Fig. 9 Total message transmission time of Mobile IP over Wireless LANs (E_b/N_o = 4 dB)

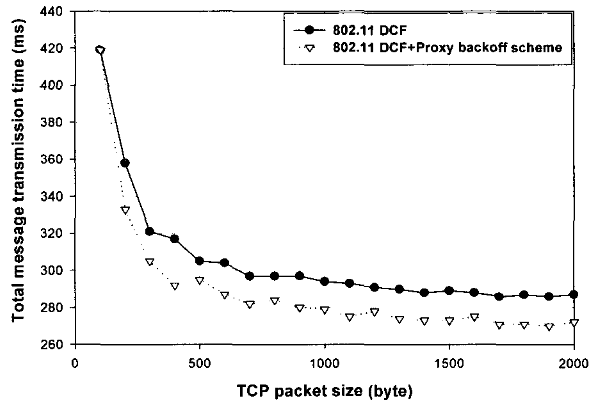

Fig. 10 Total message transmission time of Mobile IP over Wireless LANs (E_b/N_o = 8 dB)

V. CONCLUSION

In this paper, we have studied IEEE 802.11 MAC protocol to enhance transport ability for mobile IP over wireless LAN and propose a proxy backoff scheme for DCF of MAC protocol. A proposed proxy backoff scheme produces a better performance than an original random backoff in mobile IP over wireless LANs environment. We have measured the transmission time of TCP packet on the OFDM/QPSK in AWGN wireless channel. Also, we have analyzed the TCP packet transmission time by varying E_b/N_o (4 dB and 8 dB) in AWGN channel. As a result, we can find that a proxy backoff scheme algorithm decreases TCP packet transmission time than an original backoff scheme. In addition, we can obtain that the transmission time in wireless channel decreases as the TCP packet size increases in OFDM/QPSK MAC protocol. Furthermore, we can expect the correlation between TCP packet size and the transmission time, allowing for an inference of the optimal packet size in the TCP layer. This paper will be able to propose on improvement of a network quality of service (QoS) and performance improvement of mobile IP over wireless LAN system.

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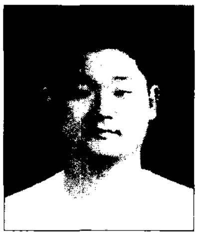
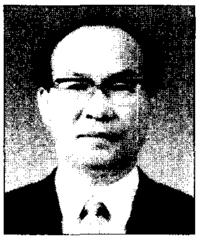


Il-Young Moon, Member KIMICS
Received the B. S. and M. S. degrees in telecommunication and information engineering from Hankuk Aviation University, Kyounggi-Do, Korea in 2000 and 2002, respectively. He is currently completing the Ph. D. degree in information and telecommunication engineering at Hankuk Aviation University, Kyounggi-Do, Korea. His research interests are in the areas of mobile IP, wireless LANs, wireless TCP, Ad hoc Network. He is a member of Korean Institute of Communication Sciences, a member of Korea Institute of Electronics Engineers, a member of Korea Navigation Institute, and a member of Korea Institute of Maritime Information & Communication Sciences.

Jae-Sung Roh, Member KIMICS
Received the B. S. and M. S. degrees in the telecommunication and information engineering from Hankuk Aviation University, Kyounggi-Do, Korea in 1990 and 1992, respectively. He received the Ph. D. degree from Hankuk Aviation University, Kyounggi-Do, Korea in 2000. He is currently an assistant professor of the Dept. of Inform. & Comm. Eng., Seoil College, Seoul, Korea. His research interests are in the areas of wireless security and performance evaluation of mobile network. He is a member of Korean Institute of Communication Sciences, a member of Korea Electromagnetic Engineering Society, a member of Korea Navigation Institute, and a member of Korea Institute of Maritime Information & Communication Sciences.



Sung-Joon Cho, Member KIMICS
Received the B. S. degree in telecommunication engineering from Hankuk Aviation University, Kyounggi-Do, Korea in 1969, the M. S. degree in the telecommunication engineering from Hanyang University, Seoul, Korea in 1975 and the Ph. D. degree in telecom-munication engineering from Osaka University, Osaka, Japan in 1981. Since 1972, he has been a professor in the School of Electronics, Telecommunication and Computer Engineering, Hankuk Aviation University, Kyounggi-Do, Korea. In Hankuk Aviation University, he was a dean of Student Affairs Division from 1989 to 1990, a dean of Academic Affairs Division from 1991 to 1992 and in 1996, a chief of Research Institute for Electronics, Information and Telecommunication from 1993 to 1996, a dean of Graduate School Aviation Industry from 1996 to 1998, and a dean of Graduate School from 1999 to 2002. He received the medal of Science Research in 1984, 1994, 1995, and 2002. His research interests are in the areas of wireless communication, mobile communication, and electromagnetic interference. He is a member of Korean Institute of Communication Sciences where he was a vice president in 1998, a member of Korea Electromagnetic Engineering Society where he was a vice president from 1996 to 2001, a member of Korea Navigation Institute where he was a president from 2001 to 2002, a member of Korea Institute of Maritime Information & Communication Sciences, a member of IEEE, and a member of IEICE(Japan).