Analysis of Per-Station Throughput in WLAN using CAMA/CA

Seung-Joon Seok* and Wookwon Lee**
*Department of Computer Engineering, Kyungnam University
**Department of Electrical Engineering, University of Arkansas
sjseok@kyungnam.ac.kr, wookwon@uark.edu

Abstract

A number of studies on the throughput analysis for WLAN system almost has been based on some assumptions for simplifying the analysis. There are two key assumptions that motivate our work. One is the condition of no channel error, and there are a finite number of stations with asymptotic condition when each station always has a packet available for transmission. The former was treated in a preceding Dr. Lee's paper [1] and the latter is being discussed through this paper. Actually, the objective of this paper is to make a performance model for a mobile station with its traffic characteristics in the under-loaded condition.

I. Introduction

With rapid growth of mobile communication networks, Internet services, and portable communication devices, mobile Internet service has been issued. As a result of intensive efforts to promote the Wireless Local Area Network (IEEE 802.11 WLAN), it has been a fundamental infrastructure for the future Internet service. The basic access method in the 802.11 MAC protocol is the distributed coordination function (DCF) which is best described as the carrier sense multiple access with collision avoidance (CSMA/CA) protocol. In addition to the DCF, the 802.11 also incorporates an alternative optional access method known as the point coordination function (PCF). The CSMA/CA is designed to reduce the probability of collision during a transmission in wireless random access environments where transmitting stations cannot listen to the medium while transmitting in order to detect any collision on its transmission as early as possible. The DCF has two kinds of access method: Basic access and RTS/CTS. Basic access uses two-way handshaking technique for the packet transmission and the mechanism, known with the name RTS/CTS uses four-way handshaking technique [2, 3]. This paper concentrates on the performance evaluation of DCF basic access scheme.

The CSMA/CA has attracted many researchers in academia and industry for research on the performance and possible enhancements to the current CSMA/CA. In literature, the work performed by Bianchi [2] provides a framework for an analytical model to study the system throughput performance of the CSMA/CA adopted for the IEEE WLAN through a stochastic model for binary slotted exponential back-off process. In his work, a discrete-time Markov chain model is devised for the CSMA/CA back-off procedure with an assumption that the probability of collision is constant for all stations and independent of the number of retransmissions for a successful transmission of a packet. Following the same approach, Wu et al. [4] provides a modified model for a situation where the back-off window size is unconditionally reset immediately after an allowed maximum number of retransmission attempts for a packet. Kim and Lee [8] also derive a mathematical model based on a renewal theory for system throughput and packet delay, and Tay and Chua [7] present another mathematical model based on mean-value approximation for the maximum throughput. For all of these mathematical models, it is assumed that all stations in the system are homogeneous in traffic generation, generating packets of the same length, and also that the wireless channel is ideal so that retransmission occurs only due to a collision.

Almost literature dealt with the system performance when WLAN system is in asymptotic condition. In this paper, however, we focus on the per-station performance, in the condition when WLAN system is loaded under its limit. We adopt and modify a previous analysis approach presented by [2] to order to include the traffic characteristics of mobile station. In Section 2, we proposed a modified stochastic model for a station performance in WLAN. Then, using the model, we mathematically analyze per station throughput. In Section 3, the result of this analysis is validated through the comparison with that of simulation. Concluding remarks are given in Section 4.

II. Mobile Host Performance Analysis

The core contribution of this paper is the analytical evaluation of the saturation throughput of a mobile station. In this paper, we adopt and modify the discrete time Markov chain model presented by [2] to release the asymptotic condition for mobile station and also include the maximum retransmission time [2] did not consider. The latter point was also considered in [4, 5].

2.1 Modified Back-off Process Model