Throughput Dependence on SNR in IEEE802.11 WLAN Systems

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INTRODUCTION

The widespread growth and popularity of the internet and wireless devices have placed greater demand on the need for wireless local area networks (WLANs) (Motchanov, 2010). WLANs are presently being used to enable many users share available network resources in a fast and convenient way (Obaidat et al., 2008).

WLANs popularity began when the United States Federal Communications Commission (FCC) opened up the Industrial Scientific and Medical Band (ISM) to the public (Obaidat et al., 2008). Several companies developed wireless solutions during this period but these solutions did not interoperate among themselves.

The IEEE802.11 WLAN working group addressed this issue by developing different IEEE802.11 WLAN standards which can be followed by different vendors. They defined the physical layer to specify multiple communication data rates to be selected for transmission depending on the quality of the current link (SNR observed) (Metreaud, 2006).

The degree of performance enjoyed by WLAN users depend largely on the network design. Throughput is an important network parameters identified to be directly influenced by the SNR received by the end users (Metreaud, 2006). Throughput depends on the selected communication data rate which is also directly dependent on the SNR observed.

This chapter presents a background study on 802.11 WLANs, their network performance metrics (throughput, SNR, Received Signal Strength Indication, etc.), interactions between TCP throughput, losses, link adaptation and SNR in WLANs. Cross layer modelling principles and research that models throughput based on SNR only are also presented. Throughput which is largely dependent on the observed SNR is identified in this chapter as a major metric for characterizing IEEE802.11 WLANs.

BACKGROUND OF STUDY

IEEE 802.11 WLANs

The first IEEE802.11 WLAN standard which supported data rates up to 2 Mbps was released in 1997 (Obaidat et al, 2008). The standard defined both the physical layer and the medium access control (MAC) layer. Other IEEE802.11standards such as IEEE802.11a, IEEE802.11b, IEEE802.11g, IEE802.11n, (with higher data rates), IEEE802.11e (for better quality of service support) and IEEE802.11i (for security), IEEE802.11ac, IEEE802.11ax have been developed since then.

At the physical layer IEEE 802.11n can provide data rates up to 54Mbps in a 20MHz band with at least 100Mbps at the MAC data services access point using only mandatory features specified in the standard (Metreaud, 2006). Newer standards such as IEEE802.11ac and IEEE802.11ax offer up to 1,300Mbps and 2Gbps respectively (Jamie, 2015). The popularity of the IEEE802.11 "family of standards" has continued to increase due to their convenience and the reduction in prices of their hardware. The discussion in this chapter is however limited to the base standards because

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available in literature are throughput models which predict throughput directly from observed SNR only for these base standards.

Radio frequency (RF) based WLANs (which are more common than the IR-based ones) operate in the International Scientific and Medical (ISM) band which does not require any licensing from the US FCC (Obaidat et al., 2008). They use RF signals which can pass through obstacles to transmit and receive data through the air without any connecting cables thus providing freedom and flexibility unmatched by Wired LAN.

OSI Model and the IEEE802.11 Physical Layer

Open System Interconnect (OSI) was created by the International standards organization to provide a design standard and reference model to explain how different networking technologies work together and interact (Rachelle, 2001). Network protocols do not necessarily have to follow the OSI model. Seven layers are specified by the model, namely: physical, data link, network, transport, session, presentation and application layers as shown in Table1. Table 1 also shows the TCP/IP model layers.

Each layer in the OSI model is responsible for specific functions. All layers in the model interact correctly to move data through the network. Understanding and Implementation of networks would be tedious without the OSI model because it allows networks to be broken up into small pieces that can be easily managed. It also provides a general language which explains components and their functions.

Specifications of connector and interfaces and the cable requirements or medium are defined by the OSI model physical layer. The physical layer handles all aspects of physically moving data from one node to the other and ensures data conversion from the upper layers into 1s and 0s before they are transmitted over the media.

The IEEE802.11 standard defines two physical layer methods: (i) the frequency hopping spread spectrum and (ii) the direct sequence spread spectrum. The base IEEE802.11 DSSS physical layer supports two rates: 1Mbps and 2Mbps. Subsequent IEEE 802.11 standards support higher rates (5.5Mbps, 11Mbps, 54Mbps, 100Mbps, 1,300Mbps, 2Gbps, etc.). Table 2 shows a summary of the different Physical layer alternatives of some IEEE802.11 standard.

Performance Comparison of some IEEE802.11 WLAN Products

Table 3 shows the performance comparison of Wireless LAN products on the market published by Khanduri and Rattan (2013).

Although IEEE802.11g and IEEE802.11n allow higher data rates, the presence of an IEEE802.11b device in the network forces them to function at lower rates (Sarkar and Sowerby, 2009).

Table 1. Description of layers in the OSI model

Layer	OSI Model Layers	TCP/IP Layer	Information or Message Type	
7	Application	Process layer	Data	Mostly software
6	Presentation		Data	
5	Session	Host to host layer	Data	
4	Transport		Segment	
3	Network	Internet layer	Packet	Mostly hardware
2	Data Link	Network Access layer	Frame	
1	Physical		Bit	

(Paul, 2006; Rachelle, 2001)