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The Performance of Medium Access Control Protocol with Capture Effect for Lightning Remote Sensing

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Abstract. In this paper we investigate the capture phenomenon for IEEE 802.11b standard. The proposed model allows us to derive the indoor and outdoor of approximate range in propagation loss and shadowing for various applications in remote sensing and monitoring. We estimate the network performance by considering the path loss and shadowing for two distance values which are 35 m and 140 m. We can conclude that that shorter distance has higher performance in path loss and shadowing than the longer distance. These results can be used as a useful guide to scientist and engineers before the communication network deployed to transfer captured data to the gateway or control centre.

1. Introduction

Medium access control (MAC) is developed for wireless network. The medium accesses are shared, based on the rules of the devices. It can communicate with each other. The multiple devices can access at the same time because the nature of wireless medium [1].

In the early 1970s, wireless MAC protocols have been studied widely. The first method is ALOHA, when a node is ready for a transmission, it transmits the data immediately. Since all nodes share the same radio channel, when two or more nodes begin the transmissions at the same time, collision occurs. All the data transmission cannot be detected and read correctly [2].

Slotted ALOHA is an improvement of ALOHA, the time is divided into slot of sizes. Each node start to transmit frames only at the beginning slot. If two or more frames collide in a slot, then all nodes detect the collision event before the slot ends. The colliding frames are buffered and retransmit after random retransmission delay. It attempts retransmission with probability number between 0 and 1 [3].

The method has been enhanced with the addition of the detection process before transmitting. In order to decrease the collision probability, Carrier Sense Multiple Access (CSMA) was developed. In

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this method, nodes listen to the medium before transmitting. If it senses idle node, it transmits immediately whereas if it senses busy node, it delays access and retries later [4].

In this paper, we focused on a Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) protocol. The main purpose of CSMA/CA is to avoid the collision. This method uses handshaking process. In order to reduce the duration of collision, it uses small Request-to-send/Clear-to-send (RTS/CTS) packets exchanged at the basic control rate to reserve the medium before large packets are transmitted [5]. The transmitter sends a RTS to intended receiver, when it has DATA packet to send. All nodes in the transmitter region keep silent, while the receiver sends back a CTS packet to the intended transmitter. All nodes in the receiver region keep silent too. The transmitter sends DATA to the intended receiver, while the receiver replies back with an acknowledgement packet to the transmitter after successfully receives DATA [5].

In this paper we study the performance of IEEE 802.11b Local Area Network/Metropolitan Area Network (LAN/MAN) standard [6]. IEEE 802.11 is the WLAN MAC and Physical Layer (PHY) specifications [7]. In wireless services it has several of services which are support data, voice and video. The advantages of wireless are better mobility, cost effective, VOIP facility and scalability.

This paper is organized as follow. In section II, the model of protocol of CSMA/CA protocol is described. The throughput and average delay of CSMA/CA are analyzed in section III. Lastly, concluding remark is provided in Section IV.

2. Critical Review

There is growing interest in the research community to design and develop model of protocol to examine the performance, potential and operation in communication system. In [11], the authors proposed the influence a capture effect with L-fold antenna diversity at the access point over IEEE 802.11b DCF at data rate 11Mbit/s. In this paper it designed in IEEE 802.11b Basic Service Set (BSS) for indoor communication. In order to theoretically predict the saturation throughput of the single IEEE 802.11b BSS at 11Mbit/s under influence of the capture effect in Rayleigh, the author applied obtained analytical results for the maximum selection and the ideal selection diversity strategy. It compared with the capture model non diversity, capture model with 2-fold maximum selection and 2-fold ideal selection diversity.

In [12], the authors proposed to achieve quality-of-service (QoS) differentiation in IEEE 802.11 wireless LAN in dual transmission power. In this paper it designed the QoS differentiation in IEEE 802.11 wireless LAN by allocating a higher transmission power to hosts requiring a higher service priority, where compare with high-power transmissions have a higher chance and low-power ones to capture the channel in the event of mutual collision. Lastly, the author confined their analysis to single-cell system because the effect of using several transmission power levels in a multiple cell context.

3. Protocol model

Communication channel is the path that data takes from transmitter to the destination. Communication channel also known as transmission media or communication media. Communication channel is divided into types which are guided (wired) and unguided (wireless).

In wired communication information is transferred between two or more nodes using wires while in wireless communication information is transferred between two or more nodes that are not connected using electrical conductor. An information is transmitted via open space known as radio waves [8].

Radio waves are generated by radio transmitter and received at the radio receiver. During the transmission from a transmitting antenna to a receiver, path loss occurs due to the propagation medium. The basic propagation loss is shown in Figure 1.

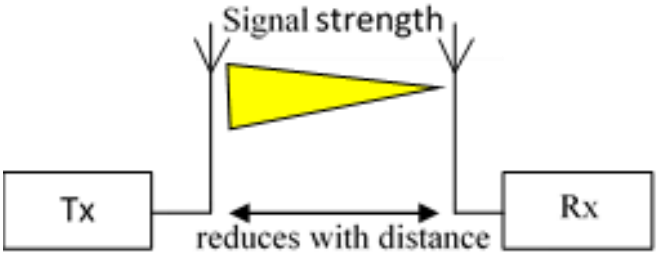


Figure 1. Basic Propagation loss

Propagation loss can attenuate the transmitted signal. In general, to measure the signal strength transmitted packet decrease with the distance between the access point and node is increase.
The propagation loss model can be categorized into two types which are indoor environment and outdoor environment. In indoor environment, the signal strength is much smaller range of access point and other node separation and the variability of environment are much greater and vice versa in outdoor environment.

The effect that the received signal power fluctuates due to the obstructing the propagation path between transmitter and receiver is known as shadowing [9].
In the propagation path, the signal strength of a radio signal is attenuated by obstructions. By using the same frequency, the node with stronger received signal can successfully transmit its packet to the access point even though two or more nodes simultaneously transmit their packet. This scenario is called capture effect [10].

In general, if two signals are received on the same channel, only the stronger of the two appears in the output. To allow the stronger signal to capture the channel, the threshold will be set at the receiver limiter called capture ratio. In this work, we present a communication channel and approximately derive capture effect, which is defined as the channel successful transmit the packet, propagation loss and shadowing. The model of protocol is shown in Figure 2.

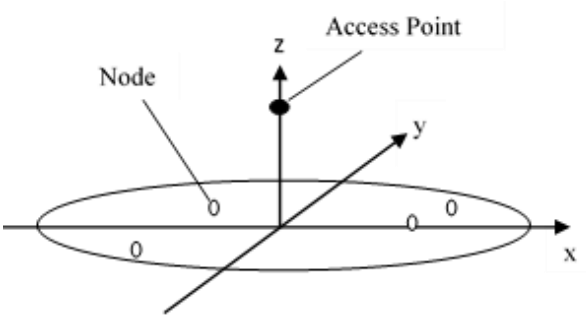


Figure 2. Model of protocol

4. Performance analysis

The modification of the traditional CSMA protocol, the CSMA/CA has been proposed by adopting the concept of back off time to perform collision avoidance. In this scheme, is to solve the hidden problem by informing the communication channel conditions from the access point to the users.

Based on the algorithm of CSMA/CA, each node must wait a period of time is known as backoff time. When the access point receives packets from the user it will sends a busy signal to all users. On the other hands, if the access point not receiving any packet it will send idle signal. In IEEE 802.11 standard, random backoff time is shown as BackoffTime = Random() x SlotTime. Where random is represents the pseudorandom integer [0, CW]. The CW is an integer within the range of value of 0 and CWmax. In cases, if the transmission not successful, the CW will be double until it is equal to CWmax while the transmission is successful the backoff timer will decrease to 0. CW process in random backoff time is shown in Figure 3.

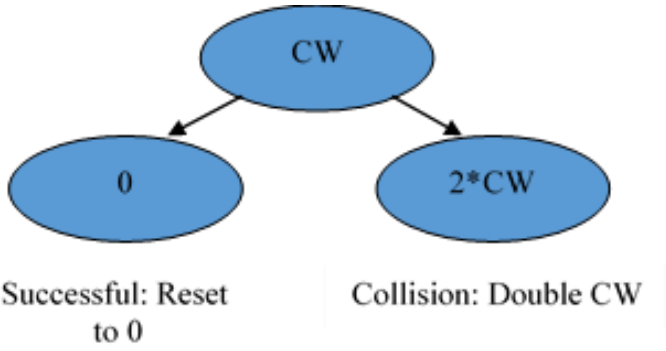
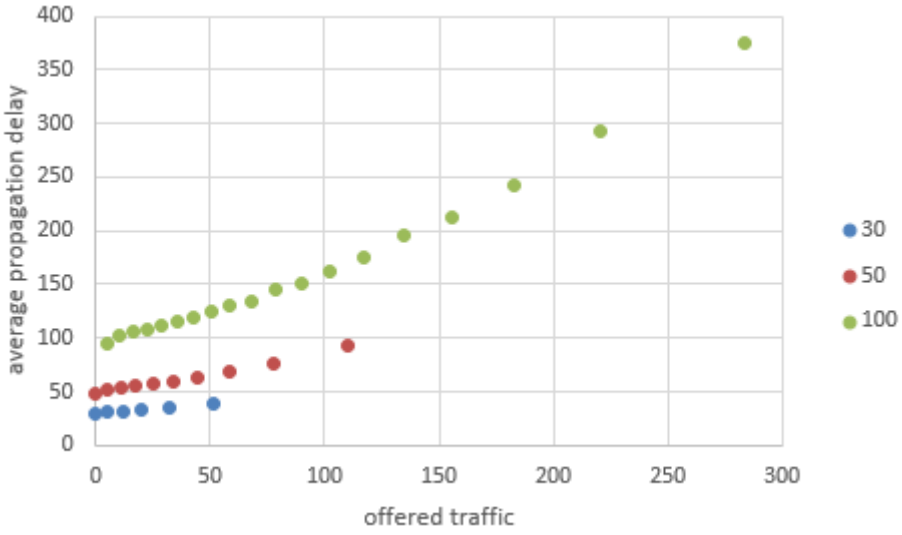


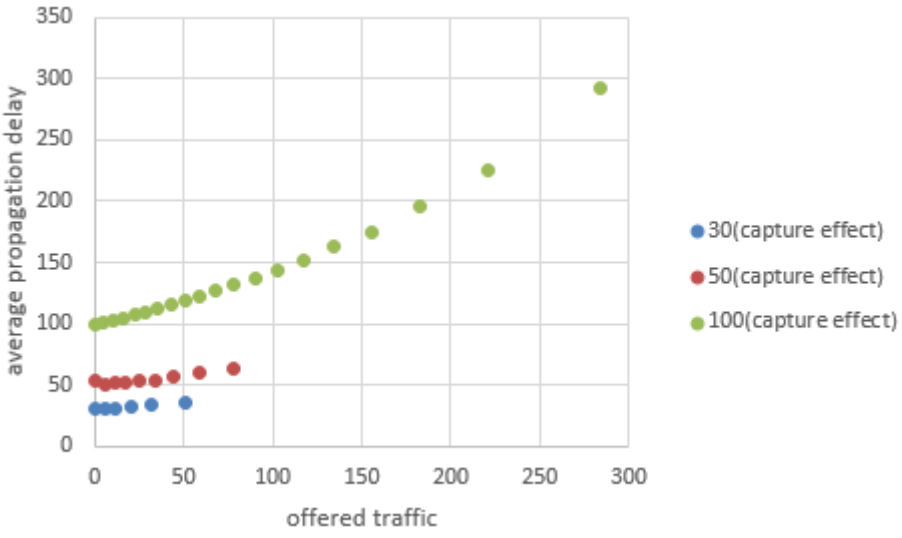
Figure 3. Random Backoff Time

In this section, we analyze the performance of basic CSMA/CA in IEEE 802.11b. The first comparison is made by varying of the number access terminal. From Figure 4, we can infer obvious change in the average delay packets with offered traffic. In other words, the lower number access terminal of performances is better than the highest number access terminal. While considering the impact of the capture effect the performance of average delay packets is better than the without capture effect.

Figure 5 plots the number of access terminal versus offered traffic of basic CSMA/CA. We observe that, the number of access terminal is decreased at an access terminal, transmitted to the access point while the distance between the access point and an access terminal is decreased and signal processing time at access point is better than number of access terminal is increased. Besides that, we considering, the impact of the capture effect the performance of average delay packets is better than the without capture effect.



(a)



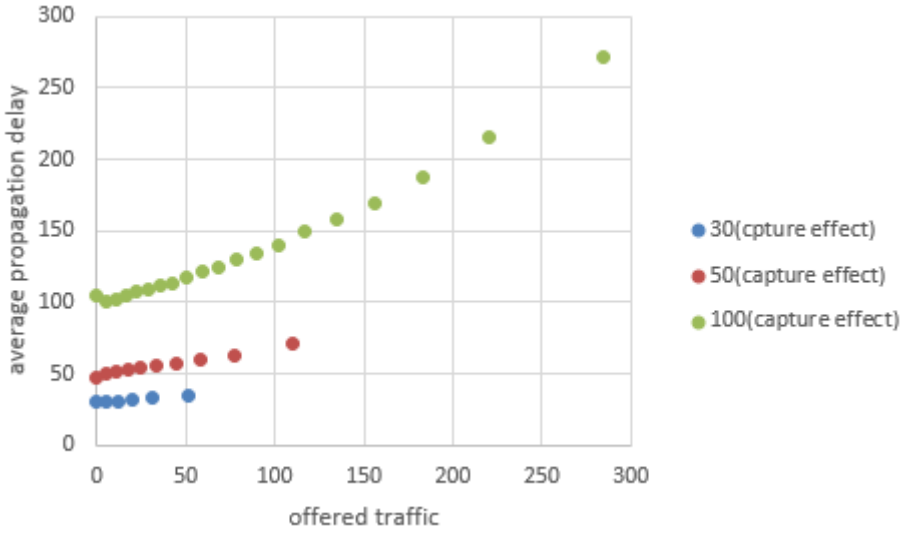
(b)

Figure 4. Average propagation delay versus offered traffic of basic CSMA/CA for varying of the of access terminal (distance = 140 m, capture effect=10 dB) (a) with capture effect and (b) without capture effect

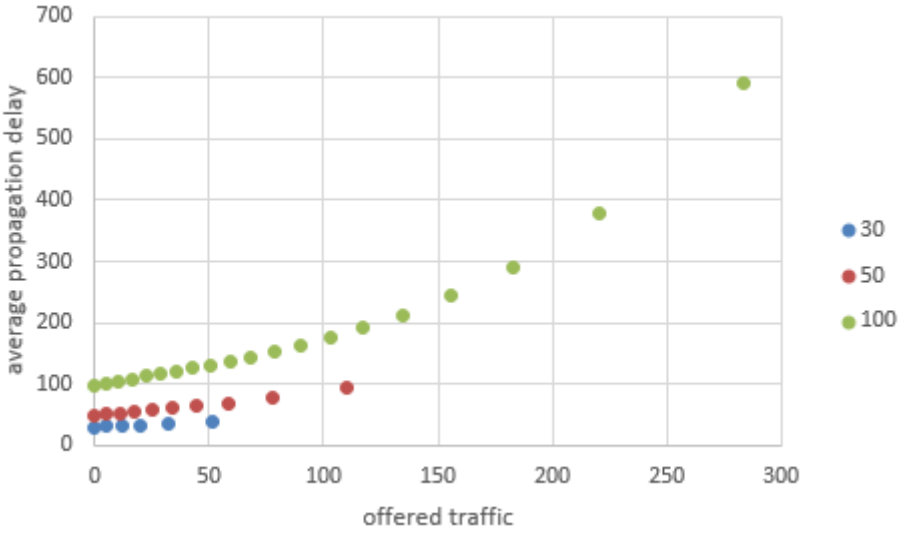
As shown in Figure 6, the third analysis is to discuss the effect on the normalized propagation delay of the offered traffic. The system with capture effect has higher performance than the without capture effect. We observe that, as normalized propagation delay is decreased the system has better performance than the increased normalized propagation delay.

Last analysis is to discuss the effect on the normalized propagation delay on the offered traffic. We observe that, the normalized propagation delay is decreased when the distance between the access point and an access terminal is decreased and signal processing time at access point is better than number of

access terminal is increased. On the other hand, the system with capture effect has higher performance than the without capture effect.

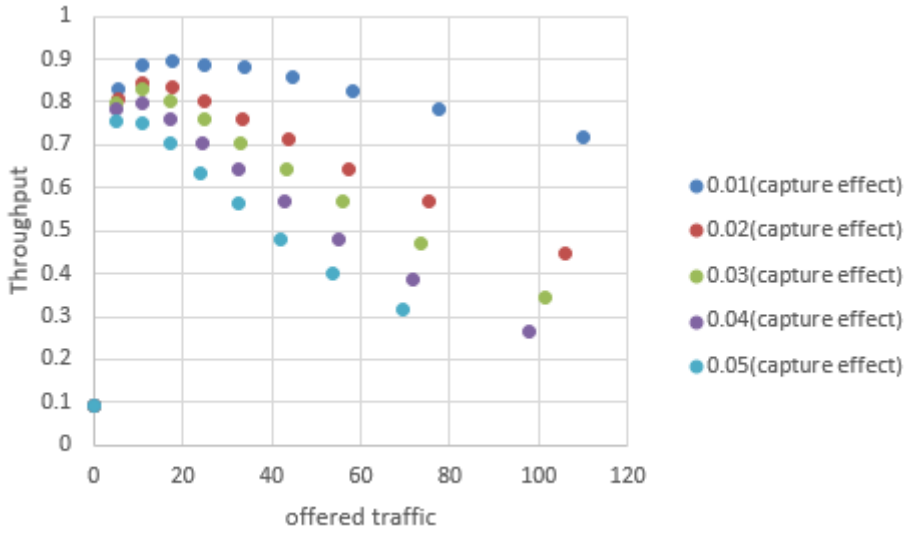


(a)

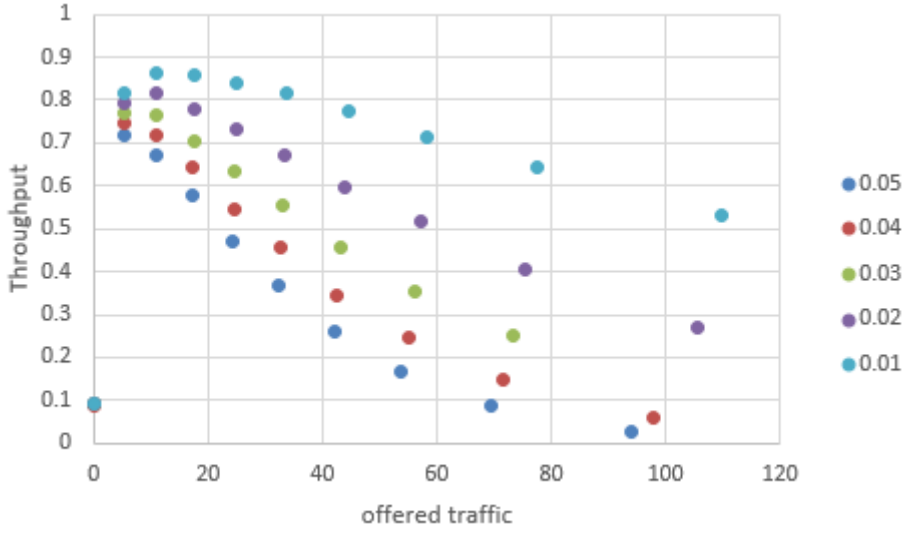


(b)

Figure 5. Average propagation delay versus offered traffic of basic CSMA/CA for varying of the of access terminal (distance = 35 m, capture effect = 10 dB (a) with capture effect and (b) without capture effect



(a)



(b)

Figure 6. Throughput versus offered traffic of basic CSMA/CA for varying of the of propagation delay (access terminal = 50, distance = 140 m, capture effect = 10 dB) (a) with capture effect and (b) without capture effect

5. Conclusion

In this paper, different MAC protocol models in IEEE802.11b are used to estimate the network performance by considering the path loss and shadowing for two distance values which are 35 m and 140 m. We can conclude that that shorter distance has higher performance in path loss and shadowing than the longer distance. These results can be used as a useful guide to scientist and engineers before the communication network deployed to transfer captured data to the gateway or control center.

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