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The Performance of IEEE 802.11g with Capture Effect for Lightning Remote Sensing

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Abstract: ***This paper focuses on the enhancement of MAC protocols particularly the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) for IEEE 802.11g standard. In this paper, the protocol was analysed in term of throughput and transmission delay by using an improved analytical approach using MATLAB.The saturation throughput analysis of CSMA/CA is controlled by using slotted analytical model combined with captured effect probability model. The performances of MAC protocols with propagation loss and shadowing scenarios are analysed. The proposed modification significantly reduced the probability of collision and recorded better performance. The maximum throughput of MAC protocol is dependent on the normalized propagation delay. In other words, smaller normalized propagation delay gives better performance of throughput. On the other hand, shorter distance has higher throughput and lower transmission delay for both path loss and shadowing scenarios, in comparison to the longer distance. With the deployment of MAC protocols with capture effect, the average transmission delay significantly shows better performance.***

Keywords **:** ***IEEE 802.11g,throughput,transmission delay***

I. INTRODUCTION

Medium access control (MAC) with collision avoidance is specifically designed for wireless networks. The access medium is shared based on the rules of the devices, to enable communication between devices. Therefore, multiple devices are able to utilize the same medium due to the nature of wireless medium [1]. MAC protocol for wireless networks has been studied widely since early 1970s. ALOHA was the first method that transmitted data immediately once a node is ready for transmission. Since all nodes in the same networks share the same radio channel, collision might occur when two or more nodes attempt to transmit at the same time. Initially, all data transmission could not be detected and read correctly [2]. Slotted ALOHA was an improvement to ALOHA where time is divided into many slots. Frame transmission for each node was only allowed at the beginning of slot. Should there be any collision, all nodes will hear or detect the collision before the slot ends.

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Colliding frames will be buffered and retransmission will take place after a random retransmission delay, with probability value between 0 and 1 [3]. Carrier Sense Multiple Access (CSMA) with collision avoidance was developed to reduce collision probability, which was an enhancement to the previous version. In this method, nodes have to listen first to the medium before any transmission. The node transmits immediately when it senses idle channel, and delay or retry transmission when the channel is busy [4].
This paper focus on the enhancement of CSMA/CA protocol with capture effect. Communication channel with capture effect should be able to manage and improvise the following issues;

- The hidden terminal problem (two out of range nodes hidden by each other)
- The near-far-effect (attenuation due to distance)
- Multipath Fading and shadowing experienced in communication channel
- Effect of co-channel interference caused by the use of the same frequency band in adjacent channel

The performance of IEEE802.11g Local Area Network / Metropolitan Area Network (LAN/MAN) are studied in this paper. Section II discussed on the critical review, while model of CSMA/CA protocol are discussed in Section III. Results of throughput and average transmission delay are analyzed in section IV and Section V concludes the paper.

II. RELATED WORK ON THE METHOD

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 [6], the author proposed the analytical model for IEEE 802.11 DCF protocol using slotted analytical model under saturated. This analysis method used the slotted analytical model to represent the capture probability. However, this method also provide close-form expression of its normalized saturation throughput. In[7], the author discussed the analytical model for ALOHA based on experiments conducted with Iris nodes equipped with AT86RF230 radio transceivers. This analysis method used the capture coefficient to represent the performance of wireless sensor networks. However, to program the nodes and to observe data exchange on computer through a base station it used TinyOS-2.x. In [8], the author discussed the analytical model for IEEE 802.11 DCF for stations to share the medium under WLAN.

This analysis method used Differentiated – Received – Power Transmit Power Control (DRP – TPC) to represent the performance of the contention efficiency. And,[9], the author proposed the analytical model for IEEE 802.15.4 for new class of wireless transmission scheme decoupling synchronization headers from payloads to create new transmission primitives involving a second sender. This analysis method are explore in two scenario which are crossing a network chasm all receiving nodes are informed to record the packet to the best their ability and investigate the insertion of short high-priority packets into longer lower-priority.

III. NETWORK MODEL

Communication channel is defined as a medium where data transmission takes place between a transmitter and receiver, also known as transmission media or communication media. The communication channel with and without capture effect is modelled as follows. Without the capture effect, there is zero transmission failure and the signal powers received at the access point from user terminals are the same. This is because it follows the most fundamental model in the evaluation of access protocol.

While with a capture effect, quality of the communication channel is time-variant. The model takes into consideration the propagation loss as well as shadowing. Propagation loss depends on the distance between node and access point. On the other hand, shadowing is caused by any obstruction between the node and access point.

The node or access terminal is assumed to generate packets independently and randomly. Packet generation follows Poisson distribution model, where it has three types of characteristics. The first one is independence, when packet generation is independent of the previous packet generation. The constancy is the second type that has probability the packet does not change in each of time slot during simulation. Last one is the rareness where it has probability of more than two packets generation, which can be disregarded due to the very small period.

Number of packets generated complied with Poisson distribution model, while the period until a packet is generated follows exponential distribution. During transmission, collision occurs when several packets collided and those packets will be destroyed on communication channel without capture. Packet transmission is regarded as failure because of the same signal level for all packets. It is assumed no collision occurs if the packet is received successfully at the destination.

Communication channel with capture effect has a distinguished power for each packet. The position of access terminal and condition of communication channel determined the received power of each packet. Packets with higher received power transmitted successfully while small received power is likely has collision. The situation is known as capture effect.

Shall there be no collision, the condition of the communication channel is worse when a packet – transmission error occurs because the received power at the access point is smaller than the required power. If transmission packet failed, it will generate back the access protocol. While in the case of successful transmission, it will measure the packet's transmission delay. The offered traffic is the total number of the packets including the newly generated packets, as well as retransmission packets at the access point in a time interval. Figure 1 is show the basic propagation loss.

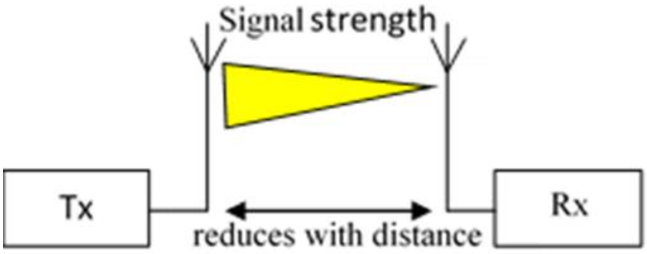


Fig.1. Basic Propagation loss

Protocol model is described in Figure 2. It represents the communication channel and derives capture effect, which represents the channel with successful packet transmission, propagation loss and shadowing.

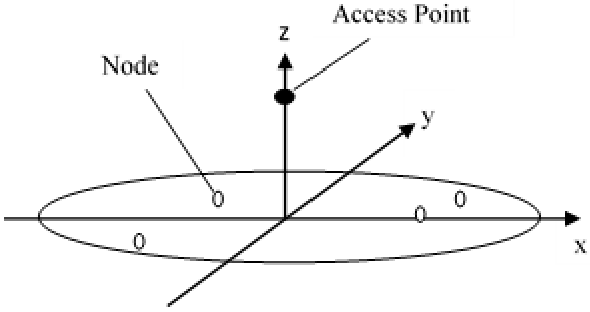


Fig. 2. Model of protocol

IV. PERFORMANCE ANALYSIS

CSMA/CA protocol has been modelled as per flowchart shown in Figure 3. Four important parameters need to be defined prior to the simulation, which are number of nodes, offered traffic, radius and capture ratio. All users shall have different position in the cell, with its centre as the origin. Positioning of the access nodes as well as access points needs to be specified with input arguments of r, n and h defined as follows;

r : cell radius

n : users with random position in a circular coverage, and radius r

h: average height for each access nodes

Communication channel are modelled into two types which are with and without capture effect. In the case of without capture effect, there is zero transmission errors, while the access point received the same signal powers as per user terminals. This is due to the properties of fundamental model in access protocol evaluation. While with a capture effect, quality of the communication channel is time-variant. The model takes into consideration the propagation loss as well as shadowing. Propagation loss depends on the distance between node and access point.

On the other hand, shadowing is caused by the obstacles between the node and access point.

Once modelling type of the communication channel has been decided, access protocol will be generated. All access terminals are expected to perform packet generation in random and independent manners according to Poisson distribution behaviour. Throughput is defined by the total number of successful packets transmitted to the access point in a time interval. At time t, a packet will be generated at an access terminal. After certain transmission delay, the packet will be transmitted and received by the access point.

A. Analysis and Discussion

This section discussed the performance of basic CSMA/CA in IEEE 802.11g. To investigate the performance impact on the communication channel, three scenarios has been created which are 30, 50 and 100 number of stations. IEEE802.11g specifications for CSMA/CA modelling were described in Table 1. As shown in Figure 4, the normalized propagation delay effect for the capture protocol is 10dB, while the radius for service area is 35m. Figure 6 shows the same value of normalized propagation delay (10dB), with higher radius of service area up to 140m. The impact reveals that shorter radius offers better performance. The result clearly showed that 35m radius of service area has better performance, compared to 140m radius of service area.

When the distance between access point and access terminal is decreased, the normalized propagation delays also decreased concurrently. Signal processing time showed good performance when the number of access terminal is increased.

Results revealed that all four normalized propagation delay has different curves. The protocol's throughput performance decreased, as we increased the normalized propagation delay, where it has impact on capture effect and non–capture effect. In terms of throughput, smaller normalized propagation delay gives better throughput performance. Shorter distance also resulted in higher throughput and lower transmission delay, for both path loss and shadowing scenarios.

Table- I: IEEE 802.11g with capture effect in Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)

Parameters	Value
Normalized Propagation Delay	0.01
	0.02
	0.03
	0.04
Service Area Radius (m)	38
	140
Length of Packet (Symbols)	125
Data Rate (Mbps)	54
Symbol Rate (kbps)	259

In Figure 5, the normalized propagation delay effect of the protocol for non–capture effect with the service area radius is 38 m while in Figure 7, the normalized propagation delay effect of the protocol for the non–capture effect with service area radius is 140 m. As seen, the curves are different for four different normalized propagation delays. Since all nodes share the same radio channel, when two or more nodes begin at the same time a collision occurs. If no collision occurs, the generated packet is successively to the destination. On the other hand, the system with capture effect has higher performance than the non – capture effect.

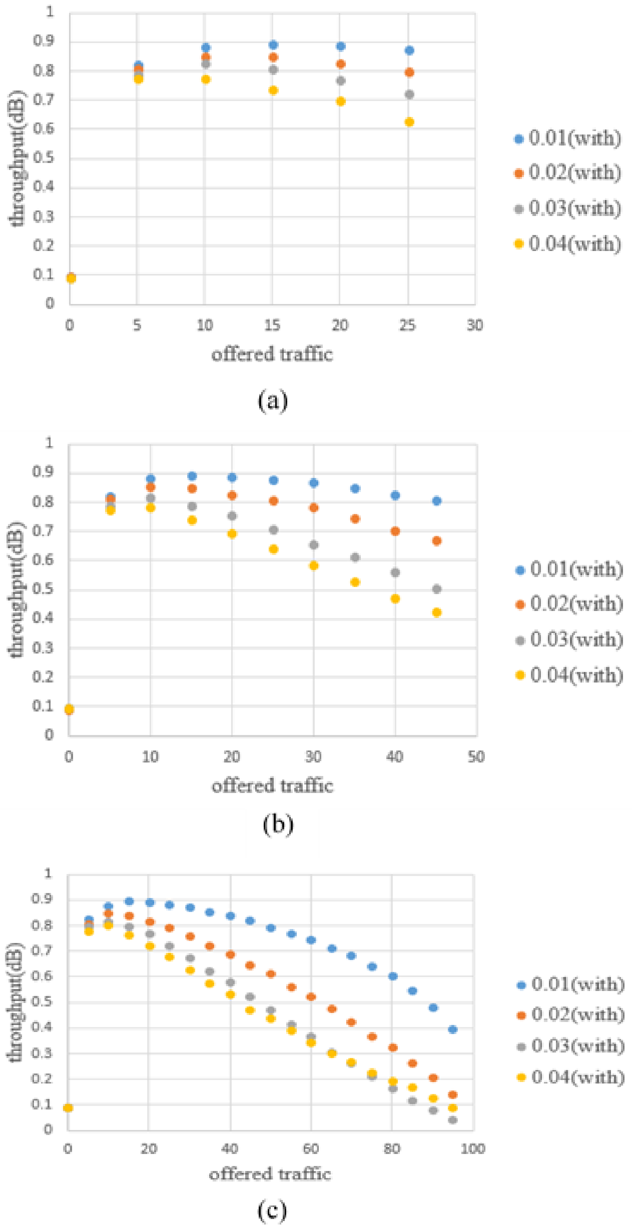
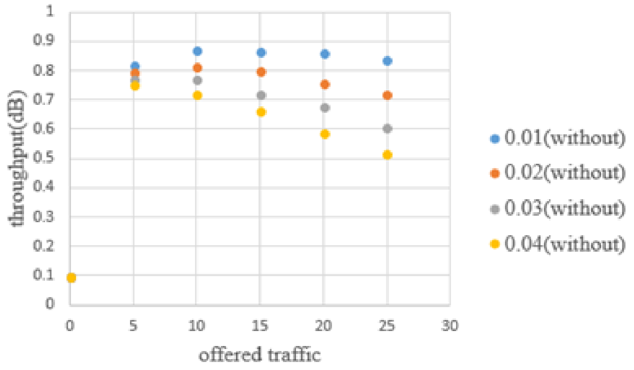


Fig.4. Throughput versus offered traffic of basic CSMA/CA for varying of the propagation delay (distance = 38, capture effect = 10 dB) number of access terminal (a) Case 1 (b) Case 2 (c) Case 3



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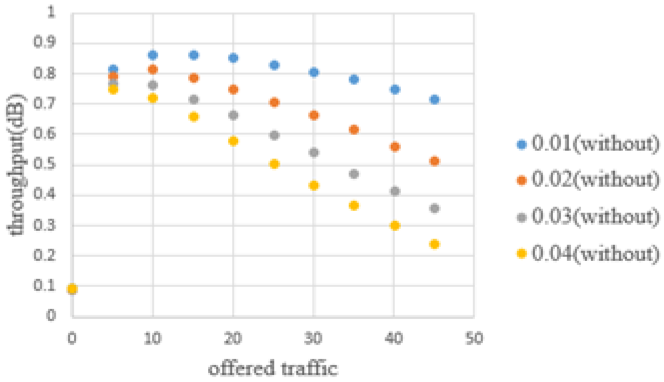

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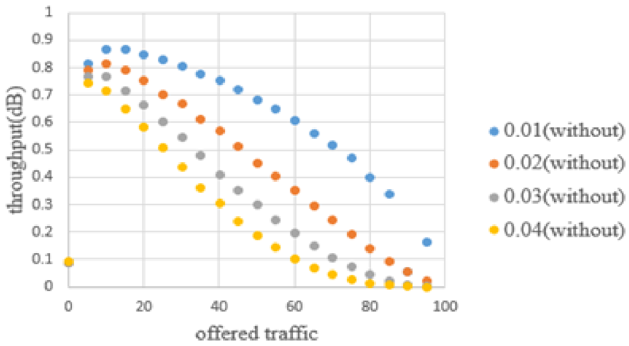

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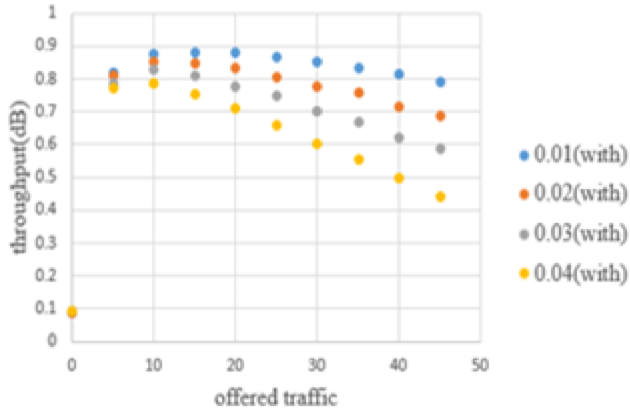
Fig.5. Throughput versus offered traffic of basic CSMA/CA for varying of the propagation delay (distance = 38, non - capture) number of access terminal (a) Case 1 (b) Case 2 (c) Case 3



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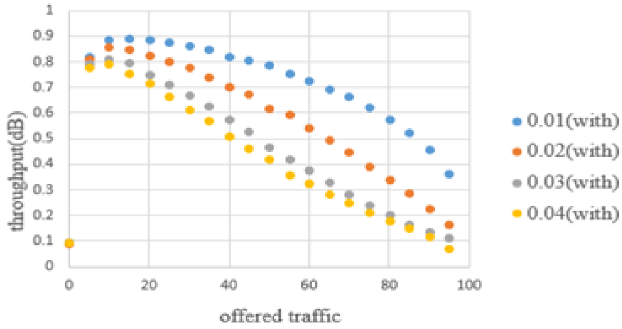

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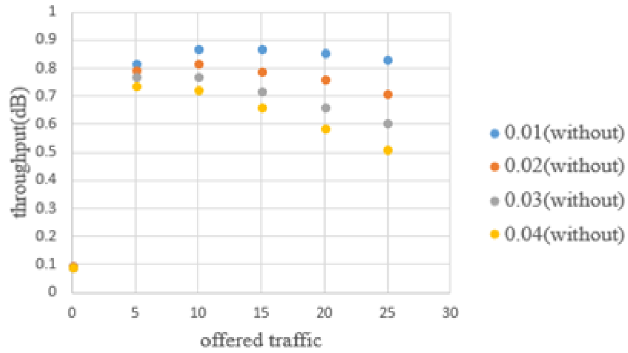
Fig.6. Throughput versus offered traffic of basic CSMA/CA for varying of the propagation delay (distance = 140, capture effect = 10 dB) number of access terminal (a) Case 1 (b) Case 2 (c) Case 3



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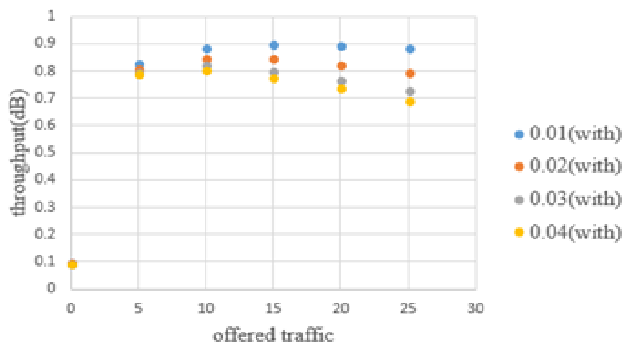

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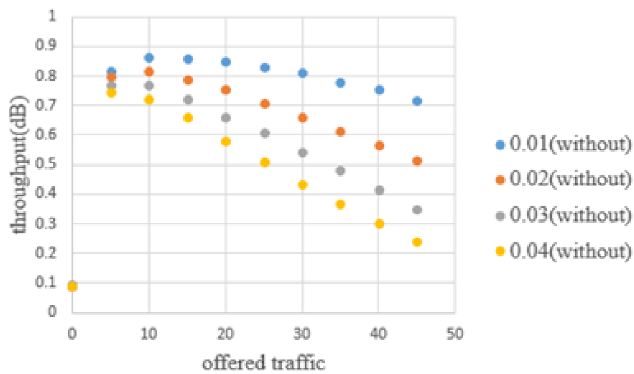

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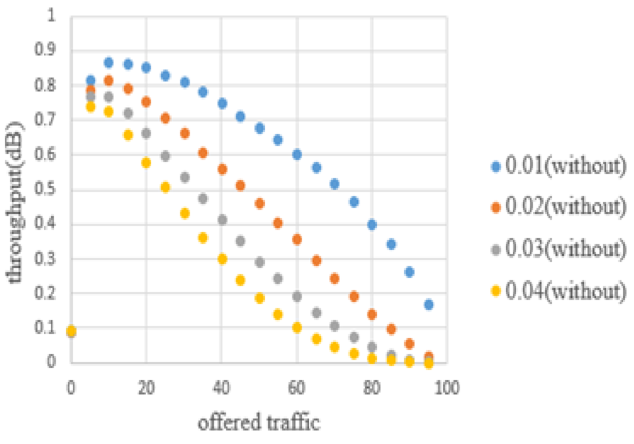
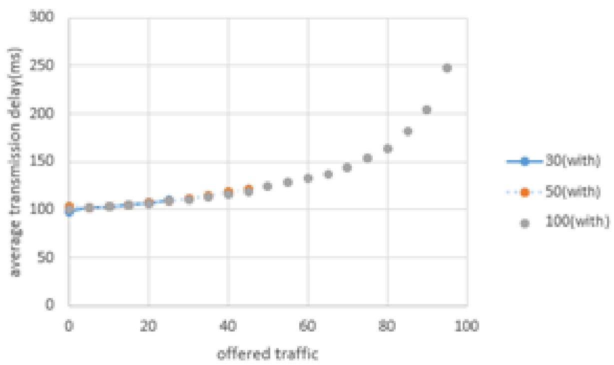


(c)

Fig.7. Throughput versus offered traffic of basic CSMA/CA for varying of the propagation delay (distance = 140, non - capture) number of access terminal (a) Case 1 (b) Case 2 (c) Case 3

The curves obtained are different for three cases which are 30, 50 and 100 number of access terminals. With decrement the number of access terminal, the better performance of average transmission delay. It affects the capture effect and non–capture effect. It is proven that decrement number of access terminal with capture effect, compared to the other number of access terminal. Therefore, number of access terminal is 30 are the best performance average propagation delay (packets) at the protocol. From 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.



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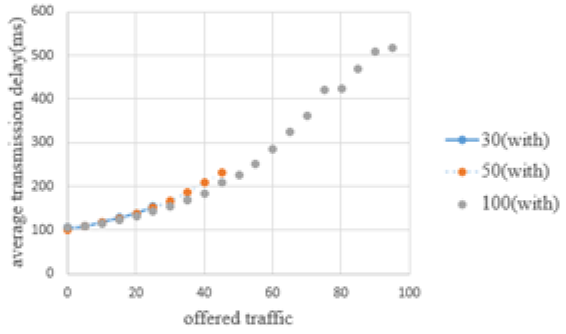

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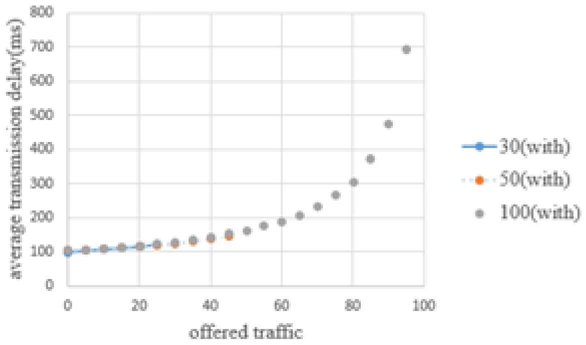

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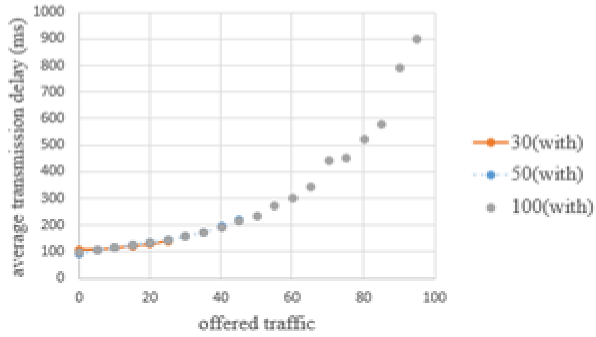
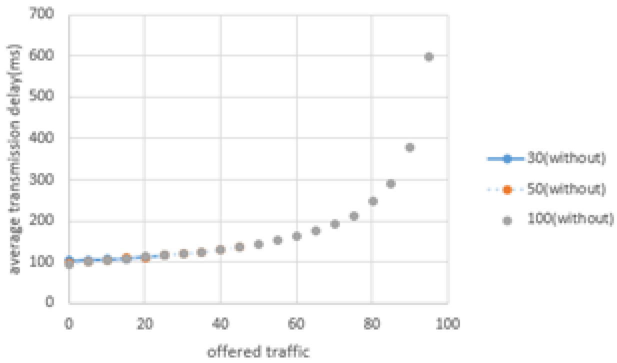


(d)

Fig.8. Average propagation delay (packets) versus offered traffic of basic CSMA/CA for varying of the access terminal (distance = 38m, capture effect =10 dB) (a) 0.01 (b) 0.02 (c) 0.03 (d) 0.04



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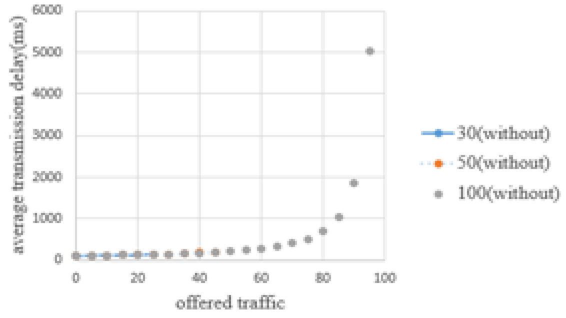

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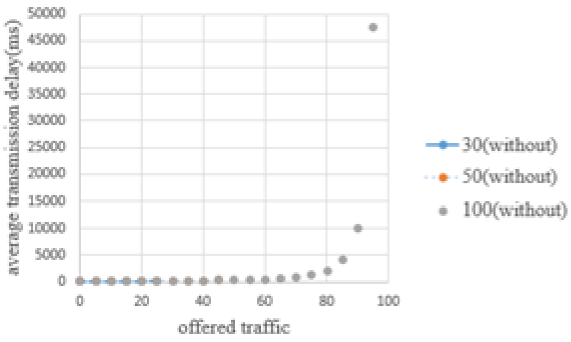

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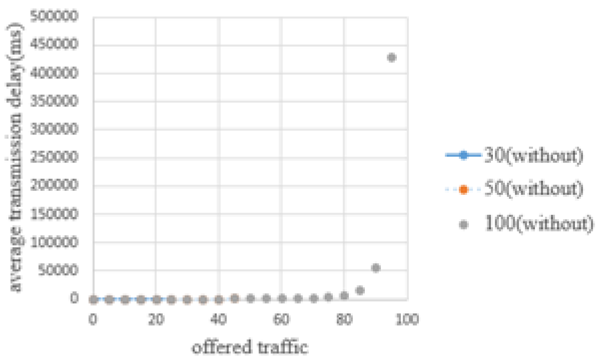
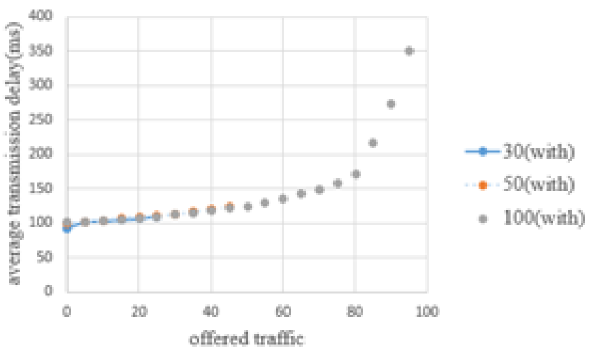


(d)

Fig.9. Average propagation delay (packets) versus offered traffic of basic CSMA/CA for varying of the access terminal (distance = 38 m, non – capture) (a) 0.01(b) 0.02 (c) 0.03 (d) 0.04



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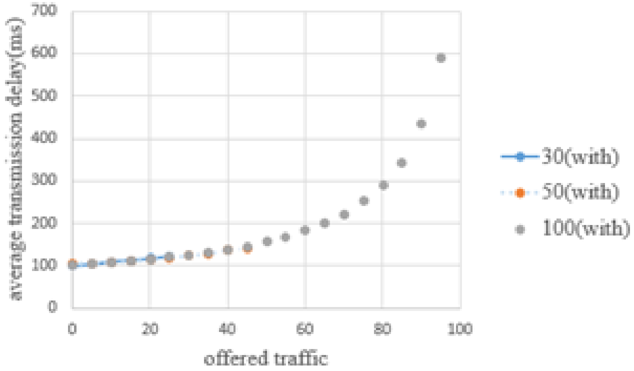

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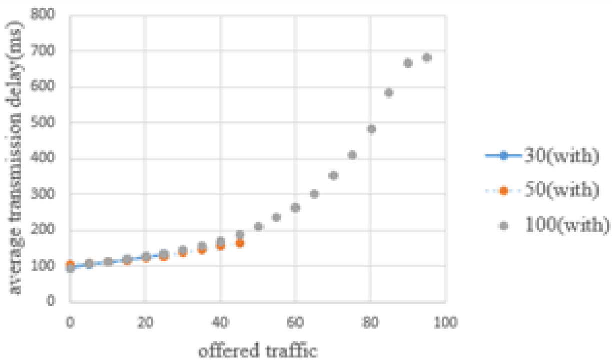

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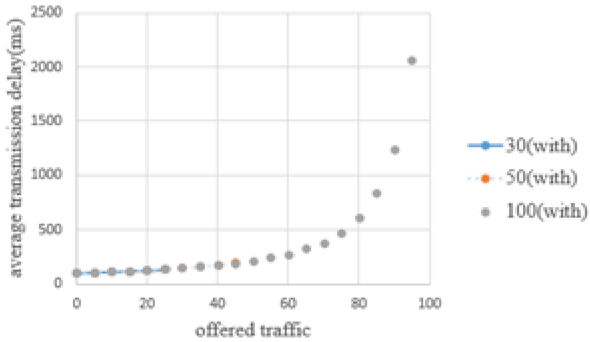
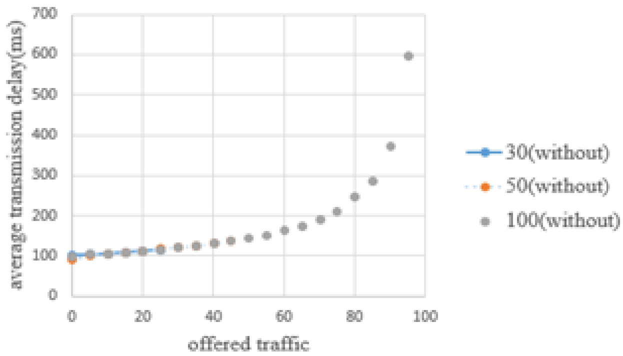


(d)

Fig.10. Average propagation delay (packets) versus offered traffic of basic CSMA/CA for varying of the access terminal (distance = 140 m, capture effect =10 dB) (a) 0.01 (b) 0.02 (c) 0.03 (d) 0.04



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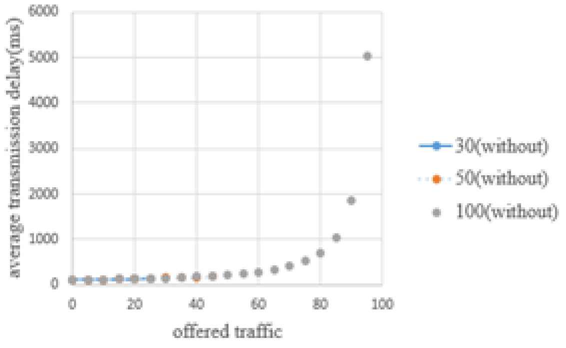

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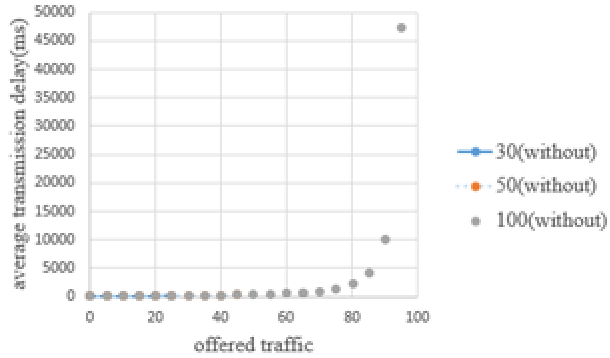

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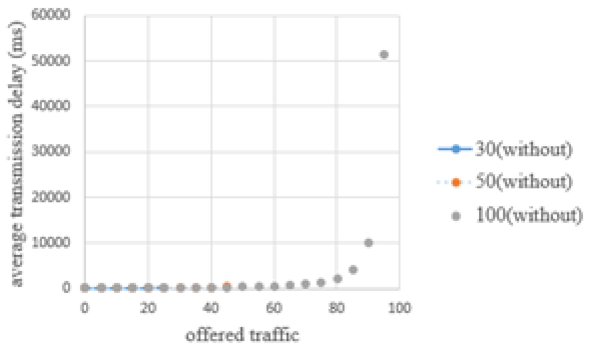

(d)

Fig.11. Average propagation delay (packets) versus offered traffic of basic CSMA/CA for varying of the access terminal (distance = 140 m, non – capture) (a) 0.01(b) 0.02 (c) 0.03 (d) 0.04

V. CONCLUSION

This paper investigates the performance of IEEE802.11g, where few different MAC protocols has been modelled with consideration to the path loss and shadowing effect. Result showed that shorter distance has recorded higher performance for both path loss and shadowing. In addition, capture effect also has positive impact on the performance of average transmission delay. The findings may provide insights before deployment of communication network, to transfer captured data to the gateway or control center.

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