Design & Modeling of Hidden Nodes WLAN and MAC Layer Protocol Simulated By NS-2

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Abstract

In wireless network, we are facing a problem to transmitting simultaneously to same receiving node. So that performance of network not same as normal network (may be Central control or ad-hoc network). Normally such type problem solves MAC layer protocol using RTS/CTS, but not only RTS/CTS, also need appropriate protocols parameter. In this paper, Design & modeling hidden nodes WLAN Network and optimized the performance of network. Performance analysis depends upon packet delivery ratio, received packets, loss packets, data rate and end to end delay. Network Simulation is under the basic scheme MAC Layer protocol (DCF). The effect of RTS/CTS, packet length, receiver sensitivity, capture sensitivity and Control Rate are analysis. Here we use NS-2 simulator for model of hidden nodes wireless network and analyze the performance.

Keywords: *MAC layer, hidden nodes, Ready-to-send (RTS)/Clear-to-send (CTS .*

1. Introduction

Wireless technology is a necessity in the world. Wireless LAN is most demanding in wireless technology. The demand of world is replace wire line technology to wireless technology. Researcher tries to overcome custom of wireless technology to replace wire line to wireless. Basic difference in data transmission wire line and wireless are physical layer protocol and lower Data link layer (MAC Layer), upper layers are same. Limited frequency spectrum shared appropriate number of user using MAC layer mechanism. MAC layer protocol support to retransmission process, basic data rate control, PLC control, different data rate, frame fragmentation, security, quality of service, so that MAC layer is a heart of wireless network. MAC layer also operate two different mode contention or contention free. The basic scheme of MAC layer is Distributed Coordinate function (DCF), also support RTS/CTS mechanism. MAC layer have also Point Coordinate function (PCF) and hybrid (DCF &PCF) [1, 2]. Wireless network are several issues due to shared medium, environment of wireless access, along with performance parameter low received data rate, higher delay. When two opposite node are transmitting to third node at same time, it is called hidden node problem, this is a serious problem in the wireless network. MAC layer RTS/CTS mechanism minimized hidden node problem, but not only RTS/CTS mechanism, also need appropriate MAC layer Parameter [3, 14, 19, 20].

2. MAC Layer of WLAN

Data link layer is a second layer of network layer. Data link layer divided in upper layer logical link and lower layer Medium access control layer. Wireless LAN controlling access is control by MAC layer Protocol, it have two mechanisms to access DCF and PCF.

2.1 Distributed Coordination Function (DCF)

DCF is a basic access protocol to shared automatic wireless medium between nodes with physical layer compatible. Wireless LAN use a carrier sense scheme CSMA/CA in place of wired line LAN CSMA/CD, CSMA/CA (carrier sense multiple access/ collision avoidance) protocol sharing wireless medium. A node to transmit, if the sensed medium sensed is idle for a distributed inter frame space (DIFS) period, the node can transmit instantly, transmission was successful than receiver node sends an acknowledgement to the sender after a short inter frame space period (SIFS) period. If the medium is busy, the transmission is deferred till the end of the present transmission, at the end of the present transmission, if here is no collision than node waits for another DIFS, if collision is occur, then the node defers its transmission by extended inter frame space (EIFS) period, after this node begins a random back-off. At what time the back-off timer expires than node can transmit. If there is one more collision, then contention window is twice and a new back-off timer is started [2, 3, 11, 12, 14]. In DCF have same priority to medium access for all nodes, so that does not provide service differentiation, implementation is easy. DCF cannot guarantee quality of service, because of not support unambiguous specification of jitter, delay and requirement of B.W by upper layer data application. Contention period is an operation of DCF time period [8, 11, 12, 14].

2.2 Point Coordination Function (PCF)

PCF have priority based medium access, so that provide service differentiation. PCF provide quality of service, it is support specification of jitter, delay and requirement of B.W by upper layer data application. PCF have contention free, it is optional coordination function and critical processing time for information transfer. PCF is supported to centralized control network. PCF generally not used back-off, because it is operate contention free mode. PCF and DCF can be combined, for specific time period application PCF is required for example video & audio transmission. PCF would be greater complexity and overhead [3, 5, 8, 12, 13, 14].

3. Hidden Node Wireless LAN Network LAN

Wireless nodes have limited transmission range, so that any one node cannot communicate to everyone node in the network. In a wireless network two transmitting node transmitting simultaneously to same receiving node is known as hidden node. Hidden node problem is one of the most common problems in WLAN. Such type problem overcomes using MAC layer protocol with RTS/CTS mechanism [3, 14, 19, 20].

3.1 RTS/CTS Mechanism

CSMA/CA is a basic access method of MAC layer DCF, it also incorporate RTS/CTS Mechanism. RTS/CTS mechanism is assuming same values carrier sense range, interference range and transmission range. RTS/CTS are four handshaking schemes, it deign to resolve hidden node problem and leading multiple access collision avoidance. In RTS/CTS process a node ready to transmit, before transmit data send a short request RTS frame, if receiver node ready to receive to send CTS frame and blocks all traffic surrounding nodes. When CTS frame received, reserve the channel for a transmission length and send the data. After receive a data frame, receiver send a acknowledge frame to sender [3, 6, 8, 14, 19, 20]. Figure 1 show RTS/CTS process, when a node source 2 sends RTS frame to destination, then destination send the CTS to all nodes in destination coverage area. Source 1 not send data to destination after receiving request CTS frame from destination and wait until successfully frame transmission source 2.

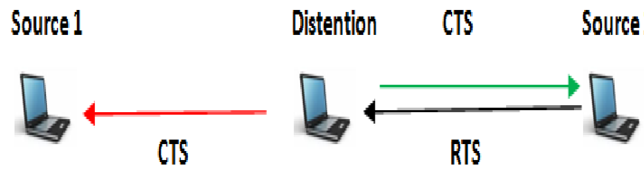

Fig. 1 RTS/CTS Process

4. Performance Evaluation

We create the model a hidden node wireless LAN ad-hoc network, and implemented by NS-2 simulator. A network model show in Fig. 2, it consist of 12 nodes, 12 nodes divided into 3 columns and 4 rows, column 1 & 3 are source 1 & 2 and column 2 destination for both source. In this model distance between source and distance 200 meters and distance between two source node in a column 150 meters. In this network every row as hidden node problem.

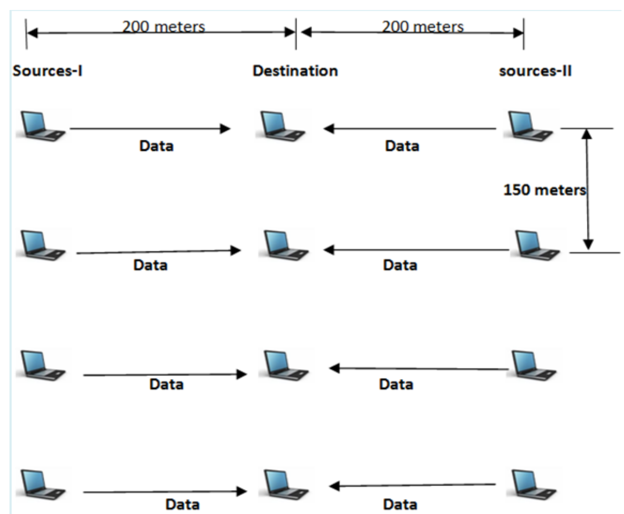

Fig. 2 Model of hidden node wireless LAN ad-hoc network

The above model of hidden node wireless LAN ad-hoc network show in Figure 2, Implemented with help of NS-2 simulator show in Figure. 3

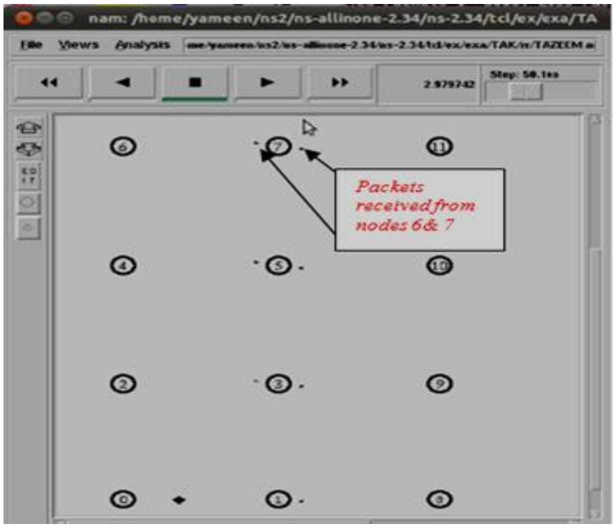

Fig. 3 Snapshot NS-2 hidden node wireless LAN ad-hoc network, simultaneous transmission columns 1&3 to destination node column 2

Our simulation conduct is based on a mac protocol IEEE 802.11 and set the simulation parameters. MAC layer are set different payload, different basic rate and basic access method of MAC layer DCF without and with RTS/CTS Mechanism. Our simulation parameters MAC and physical protocol listed in table 1.

Table 1: Simulation Parameters

Parameters	***Values***
No of nodes	12
Slot time	20us
SIFS	10us
Preamble Length	64
PLCP Header Length	128
PLCP Data Rate	4.0e6
Short Retry Limit	4
Long Retry Limit	7
CW Min	31
CW Max	1023
Basic rate	2.0e6
Data Rate	11.0e6
CPThresh_	10
CSThresh_	3.1665e-10
RXThresh_	6.310e-10
frequency	2.4e9
Propagation	Two Ray Ground

4.1 Simulation and Analysis:

We simulate the basic access method of MAC layer DCF without & with RTS/CTS Mechanism as per given parameters, test-1 payload 500 bytes, test-2 payload 1000 bytes and test-3 payload 2000 bytes. Performance results are show in Fig. 4, Fig. 5 and Fig. 6 for different payload of MAC layer DCF without & with RTS/CTS mechanism.

We are analysis Delay and throughput as per our scheme simulation results, number of packet received as compare to expected packet, loss packets, data rate and end to end delay. As per our design network, 4 hidden nodes simulation simultaneously and results show in 4 discrete time after 10, 20, 30 and 40 second. We seen in the Fig 4 Fig 5 and Fig. 6 are four hidden node simulation results in four discrete time slots, results shown in the form of no. of packets receive, expected packets, packets loss, packet loss ratio and end to end delay.

Performance Analysis using the following equation:

$$Average\ No.of\ Received\ Packets = \frac{Total\ No.of\ Received\ Packets}{No.of\ Hidden\ Node} \quad (1)$$

$$Average\ No.of\ Expected\ Packets = \frac{Total\ No.of\ Expected\ Packets}{No.of\ Hidden\ Node} \quad (2)$$

$$Average\ No.of\ loss\ Packets = \frac{Total\ No.of\ Loss\ Packets}{No.of\ Hidden\ Node} \quad (3)$$

$$Average\ packet\ delivery\ Ratio = \frac{Total\ No.of\ Received\ Packets}{Total\ no.of\ Expected\ packets} \quad (4)$$

$$Average\ loss\ Ratio = \frac{Total\ No.of\ loss\ Packets}{Total\ no.of\ Expected\ packets} \quad (5)$$

4.1.1 Test-1

In this section simulate the purposed scheme as per given parameters and pay load 500 bytes. Performance results are show in Figure 4 and Figure 5 without RTS/CTS and with RTS/CTS respectively.

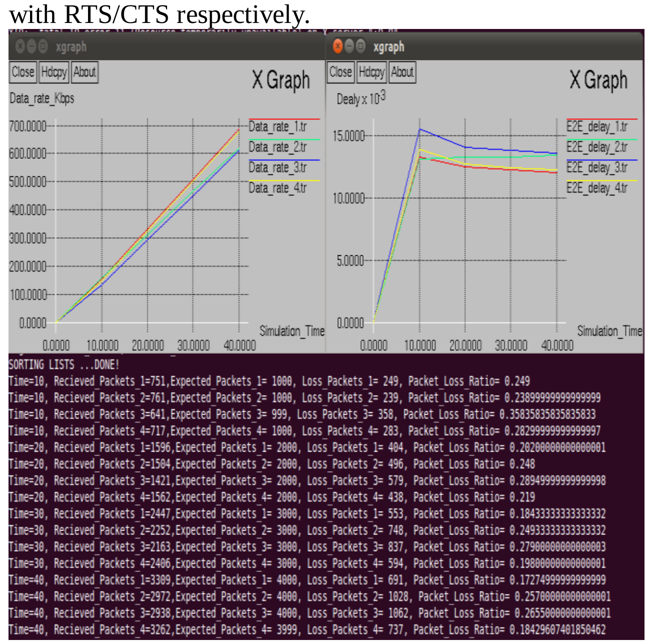

Fig. 4 Performance of hidden node WLAN ad-hoc network pay load 500 Bytes using MAC layer DCF without RTS/CTS mechanism in the form of receive packet, expected packets, packets loss, data rate and end to end delay.

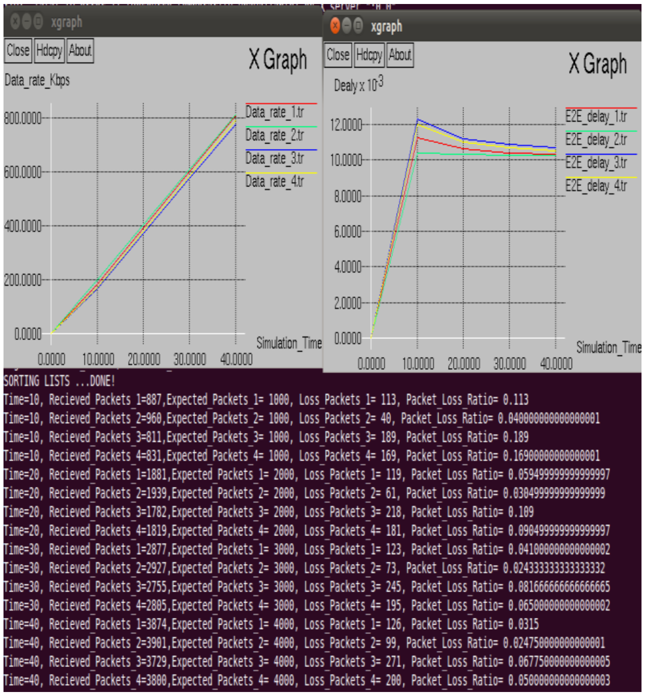

Fig. 5 Performance of hidden node WLAN ad-hoc network pay load 500 Bytes using MAC layer DCF With RTS/CTS mechanism in the form of receive packet, expected packets, packets loss, data rate and end to end delay.

Analysis: We are analysis receive, expected and loss packets without & without RTS/CTS protocol, also analysis average packets delivery ratio and average loss ratio are shown in equations 6, 7, 8 & 9.

Without RTS/CTS

Total received packets = 3309+2972+2938+3262 = 12481
Total Expected packets = 4000+4000+4000+3999 = 15999
Total loss Packets=691+1028+1062+737 =3518

$$Average\ packet\ delivery\ Ratio\ = \frac{12481}{15999} = \ 0.7801 \quad (6)$$

$$Average\ loss\ Ratio\ = \frac{3518}{15999} = \ 0.2198 \quad (7)$$

With RTS/CTS

Total received packets = 3874+3901+3729+3800=15304

Total Expected packets = 4000+4000+4000+4000 = 16000

Total loss Packets=126+99+271+200 =696

$$Average\ packet\ delivery\ Ratio\ = \frac{15304}{16000} = 0.9565 \ \ldots (8)$$

$$Average\ loss\ Ratio\ = \frac{696}{16000} = 0.0435 \ \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

4.1.2 Test-2

In this section simulate the purposed scheme as per given parameters and pay load 1000 bytes. Performance results are show in Figure 6 and Figure 7 without RTS/CTS and with RTS/CTS respectively.

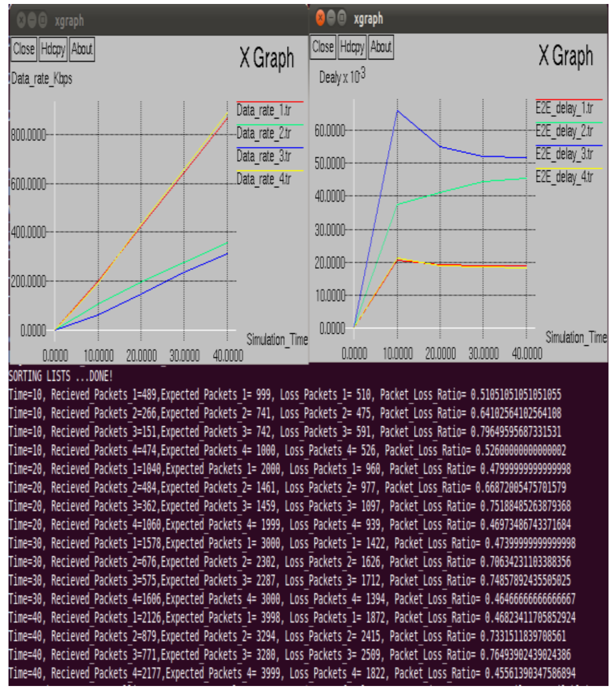

Fig. 6 Performance of hidden node WLAN ad-hoc network pay load 1000 Bytes using MAC layer DCF without RTS/CTS mechanism in the form of receive packet, expected packets, packets loss, data rate and end to end delay.

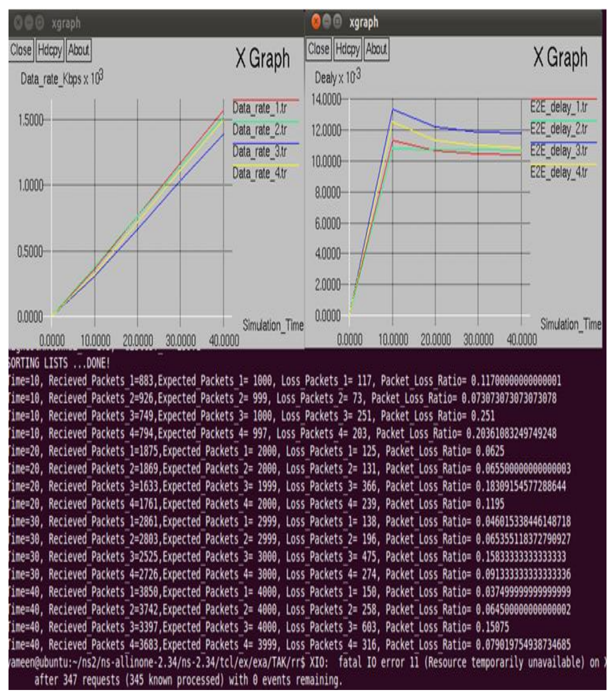

Fig. 7 Performance of hidden node WLAN ad-hoc network pay load 1000 Bytes using MAC layer DCF) With RTS/CTS mechanism in the form of receive packet, expected packets, packets loss, data rate and end to end delay.

Analysis: We are analysis receive, expected and loss packets without & without RTS/CTS protocol, also analysis average packets delivery ratio and average loss ratio are shown in equations 10, 11, 12 & 13.

Without RTS/CTS

Total received packets = 2126+879+771+2177= 5953
Total Expected packets = 3998+3294+3280+3999 = 14571
Total loss Packets=1872+2415+2509+1822 = 8618

$$Average\ packet\ delivery\ Ratio = \frac{5953}{14571} = .4085 \quad \ldots (10)$$

$$Average\ loss\ Ratio = \frac{8618}{14571} = .5914 \quad \ldots\ldots (11)$$

With RTS/CTS

Total received packets = 3850+3742+3397+3683 = 14672
Total Expected packets = 4000+4000+4000+4000 = 15999
Total loss Packets=150+258+603+310= 1327

$$Average\ packet\ delivery\ Ratio = \frac{14672}{15999} = .9170 \ldots (12)$$

$$Average\ loss\ Ratio = \frac{1327}{15999} = .0829 \quad \ldots\ldots\ldots (13)$$

4.1.3 Test-3

In this section simulate the purposed scheme as per given parameters and pay load 2000 bytes. Performance results are show in Figure 8 and Figure 9 without RTS/CTS and with RTS/CTS respectively.

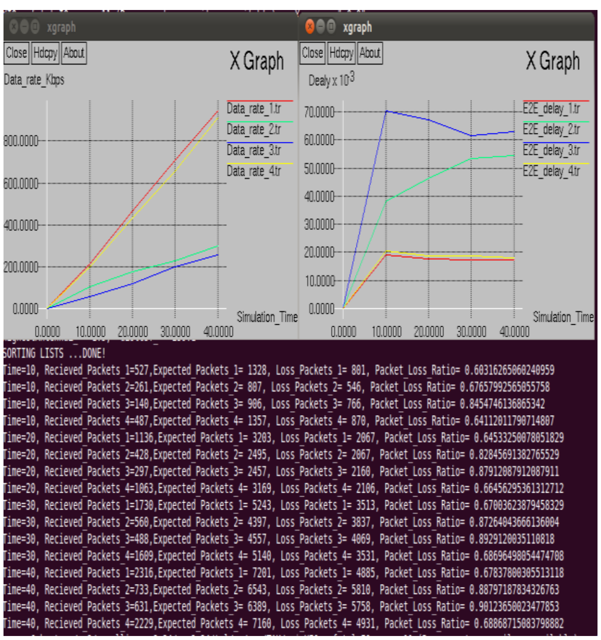

Fig. 8 Performance of hidden node WLAN ad-hoc network pay load 2000 Bytes using MAC layer DCF With RTS/CTS mechanism in the form of receive packet, expected packets, packets loss, data rate and end to end delay.

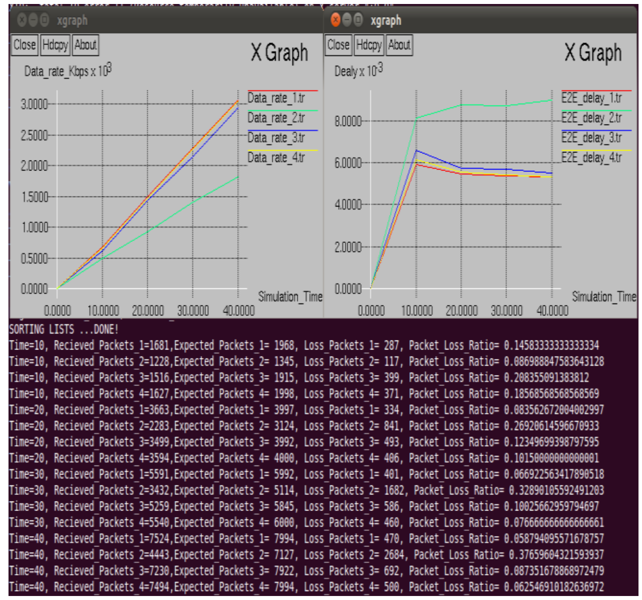

Fig. 9 Performance of hidden node WLAN ad-hoc network pay load 2000 Bytes using MAC layer DCF without RTS/CTS mechanism in the form of receive packet, expected packets, packets loss, data rate and end to end delay.

Analysis: We are analysis receive, expected and loss packets without & without RTS/CTS protocol, also analysis average packets delivery ratio and average loss ratio are shown in equations 14, 15, 16 & 17.

Without RTS/CTS

Total received packets = 2316+733+631+2229=5909
Total Expected packets = 7201+6543+6389+7160=27293
Total loss Packets=4885+5810+5758+4931=21384

$$Average\ packet\ delivery\ Ratio = \frac{5909}{27293} = .2165 \quad \ldots\ldots (14)$$

$$Average\ loss\ Ratio = \frac{21384}{27293} = .7834 \ldots\ldots\ldots\ldots\ldots\ldots (15)$$

With RTS/CTS

Total received packets = 7524+4443+7230+7494=26691
Total Expected packets = 7994+7127+7922+7994=31037
Total loss Packets=470+2684+692+500=4346

$$Average\ packet\ delivery\ Ratio = \frac{26691}{31037} = .8599 \quad \ldots\ldots (16)$$

$$Average\ loss\ Ratio = \frac{4346}{31037} = .1400 \quad \ldots\ldots\ldots\ldots (17)$$

4.2 Combine result

The following table 2 & Fig 10, 11 Graphs shows the combine result of average Packet Delivery Ratio (PDR) and average Packet Loss with varied Payload.

Table 2: Combined results PDR and Average Loss Ratio

Payload (Bytes)	*Average Packet Delivery Ratio (PDR)*		*Average Loss Ratio*	
	Without RTS/CTS	With RTS/CTS	Without RTS/CTS	With RTS/CTS
500	0.7801	.9565	0.2198	.0435
1000	.4085	.9170	.5914	.0829
2000	.2165	.8599	.7834	.1400

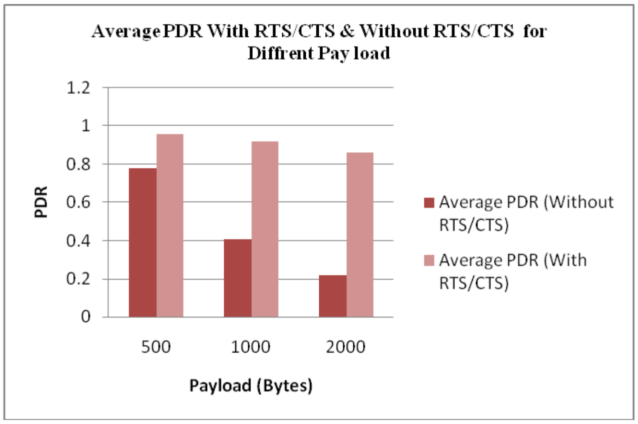

Fig. 10 Average Packet Delivery Ratio vs. Payload

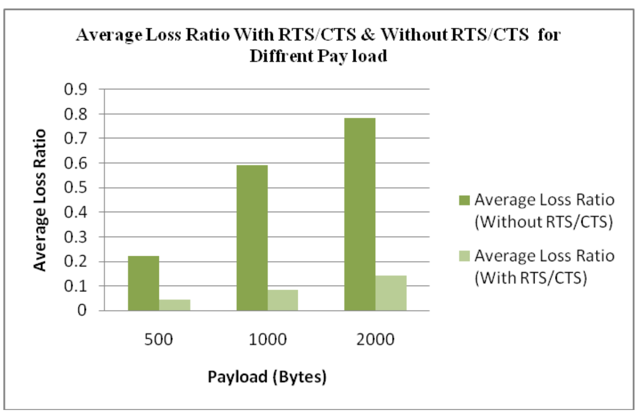

Fig. 11 Average Loss Ratio vs. Payload

5. CONCLUSION

In this model, we study about hidden node wireless LAN network for MAC layer with & without RTS/CTS protocol. In this simulation model, consists 4 hidden nodes out of 12 nodes and performance analyze in the form of average value. We can seen the results in fig.4 to fig9 as appearance of received packet, expected packets, packets loss, packet loss ratio, data rate and end to end delay. Our performance analyze packets delivery ratio and packets loss ratio is using MAC protocol for different payload shown combined results in fig 10 & fig 11, for payload 500 bytes packet delivery ratio 95.65% & packet loss ratio is 4.35 %. Therefore it is very suitable for ad-hoc network applications. OTcl script code for the model is simulated on NS2.34 software. This study may be extended for further improvements in terms of different sensitivity, nodes density and distance.

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