Abstract: As demand for deployment and usage is increased in WLAN environment, achieving satisfactory throughput is one of the challenging issues. Initially as WLAN environment is data centric, the best effort delivery based protocol serve the purpose up to a certain extent. With multimedia traffic protocol fails to deliver required traffic. The requirement of satisfactory network performance is delivery of QoS. The QoS demand controlled jitter and delay, dedicated bandwidth etc. This triggers various approaches of modifying existing protocol to achieve acceptable throughput to satisfy user requirement. In this paper we will use OPNET to evaluate the performance of RTS/CTS mechanism to improve performance in wireless environment with Hidden Nodes.

Keywords: RTS/CTS, WLAN, OPNET.

I. INTRODUCTION

There are a number of issues present in wireless networks as a direct result of the shared medium nature of wireless access. Among these are performance problems such as low throughput and high delays for all nodes in networks which are populated by many stations. As the number of nodes and amount of traffic increases on a wireless LAN, these issues become more serious. The “hidden node problem” is well known in wireless networks where two communicating nodes can communicate with a third station, but cannot directly communicate with each other due to physical or spatial limitations. One of the emerging wireless LAN standards, IEEE 802.11 provides three mechanisms to deal with the contention phase: Distributed Coordination Function (DCF), Point Coordination Function (PCF) and Hybrid Coordination Function (HCF). The DCF is the most popular method that operates in a true distributed manner without any central arbitration and provides the RTS/CTS mechanism to avoid the “hidden node problem”. Bianchi presents a Markovian model for throughput analysis of wireless networks employing DCF in [1]. Wu, et. al. in [2] extends it to include station retry limits. However, nobody has done the throughput analysis of DCF in presence of hidden nodes based on analytical models. I intend to do so with motivation of quantifying the effect(s) of the “hidden node problem” on wireless network throughput with and without RTS/CTS access methods of DCF.

II. 802.11 MAC COORDINATION METHODS

The 802.11 Medium Access Control (MAC) layer is concerned with controlling access to the wireless medium. It specifies two mechanisms for accessing the wireless medium: DCF and PCF. This section gives a description of the two mechanisms.

A. Distributed Coordination Function (DCF)

The mandatory distributed coordination function is the primary access protocol for the automatic sharing of the wireless medium between stations and access points having compatible physical layers (PHYs). Similar to the MAC coordination of the 802.3 Ethernet wired line standard, 802.11 networks use a carrier sense multiple access/collision avoidance (CSMA/CA) protocol for sharing the wireless medium. A wireless station wanting to transmit senses the wireless medium. If the medium has been sensed idle for a distributed inter frame space (DIFS) period, the station can transmit immediately. If the transmission was successful, the receiver station sends an acknowledgement to the sender after a short inter frame space period (SIFS) period. If the medium is found to be busy, the transmission is deferred till the end of the current transmission. At the end of the current transmission, if there is no collision, the station waits for another DIFS, but if there is a collision (frame is received in error), then the station defers its transmission by extended interframe space (EIFS) period. After the deferral period, the station begins a random back-off. The back-off is in the range 0 to CW (contention window). The value of CW depends on the PHY characteristics of the medium. The back-off time is calculated as

\[ \text{Back-off time} = \text{Random}(\cdot) \times \text{slot time} \]

Where Random(\cdot) generates a pseudorandom integer in the range [0, CW] and slot _time equals a constant value found in the station’s Management Information Base (MIB). Back-off timer decrements the back-off time if the medium is idle for one-slot. When the back-off timer expires the station can transmit. If the transmission is not successful this time (if there is another collision), then the size of the contention window is doubled and a new back-off timer is started. The station with the smallest back-off wins the contention for the medium and transmits. After a successful transmission a station is required to perform another back off prior to transmitting additional packets. Though DCF is easy to implement, it does not provide prioritized access, as it suffers from the serious drawback of service differentiation. DCF does not support explicit specification of delay, jitter and bandwidth requirements by higher layer data applications and hence cannot guarantee QoS performance. All stations and data traffic are given the same priority to access the wireless medium. Time periods when DCF is in operation are called Contention Periods (CP).

B. Point Coordination Function (PCF)

The optional point coordination function provides contention-free frame transfer for processing time-critical
information transfers. PCF uses the point coordinator (PC) as the polling master. The PC resides in the AP of the wireless network. At the beginning of the contention-free period (CFP), the point coordinator has an opportunity to gain control of the medium. The PC first senses the medium. If the medium is idle for a point coordination function interframe space (PIFS) period, the PC sends a polling packet to the wireless station asking it for data packets during the contention free period. The polled station then sends the packet to the AP after a SIFS period upon which the AP sends an ACK to the polled station after a SIFS period. If the medium is found to be busy, the AP (and hence the PC) defers access till the end of the current transmission. The AP then waits a PIFS period and sends out a polling packet to the station requesting the data packet. The polled station sends out the data packet and receives an ACK after the expiration of a SIFS period. In general back-off is not used for PCF as it operates in a contention-free mode unlike DCF. Both DCF and PCF can be combined within a BSS, with CFP and CP alternating over time. During the CFP, PCF is used as the access mechanism and during the CP, DCF is used as the access mechanism. In most cases DCF would suffice. However, for time-bounded applications such as audio and video PCF would be needed. The PCF, though, would impose greater overhead and complexity due to the transmission of the polling packets and the additional protocols required.

III. PROBLEM DEFINITION

A. The Hidden Terminal Problem

The Hidden terminal or hidden node problem is one of the most common problems in wireless networks. As every station in a wireless network has limited radio transmitting range, it cannot communicate with every other station in the network. A consequence of this is that two stations may try to communicate with the same third station simultaneously which may result in a collision at the third station. This problem can be overcome by incorporating the RTS/CTS mechanism in the network.

B. RTS/CTS Mechanism

The wireless station ready to transmit is made to send a short Request To Send (RTS) frame before each data frame transmission. A collision of the RTS frame is less probable than the collision of the actual data frame due to a difference is size. If the receiver station is ready to receive, it acknowledges the RTS frame by sending a Clear To Send (CTS) frame to the sender and thus blocks all traffic from other wireless stations. When the source receives the CTS frame, it sends the data frame as the channel has been reserved for the entire length of transmission. Finally, the receiver sends the ACK frame to the sender upon receiving the frame. Hence, using this 4-way handshake mechanism the hidden terminal problem can be resolved.

C. Quality of Service (QoS)

Quality of Service (QoS) is a broad term used to describe the overall experience a user or application will receive over a wireless network. QoS is measured using standard parameters such as bandwidth, network availability, media access delay and Packet Loss Rate (PLR). In this paper, the performance of DCF and PCF are evaluated based on data dropped (PLR), media access delay, and throughput metrics.

IV. OPNET WIRELESS MODELER

OPNET Modeler is the industry’s leading network simulation commercial software. Modeler supports all major network types and technologies. The application areas include:

1. Network planning (both LAN and/or WAN) and analysis of performance and problems prior to actual implementation
2. Wireless and Satellite communication schemes and protocols
3. Microwave and Fiber-optic based Network Management
4. Protocol Development and management
5. Routing algorithm evaluation for routers, switches, and other connecting devices.

The OPNET Modeler Wireless Suite provides high fidelity modeling, simulation, and analysis of a broad range of wireless networks. Modeler Wireless Suite supports any network with mobile devices, including cellular (GSM, CDMA, UMTS, IEEE802.16 WiMAX, LTE, etc.), mobile ad hoc, wireless LAN (IEEE 802.11), personal area networks (Bluetooth, ZigBee, etc.) and satellite.

The OPNET WLAN model provide high-fidelity modeling, simulation, and analysis of wireless LAN networks, including the RF environment, interference, transmitter/receiver characteristics, and full protocol stack, including MAC, routing, higher layer protocols and applications. Furthermore, the ability to incorporate node mobility and interconnection with wire-line transport networks provide a rich and realistic modeling environment.

V. IMPLEMENTATION AND SIMULATION NETWORK IMPLEMENTATION

In this paper we will evaluate the performance of the RTS/CTS under no Hidden Node environment and with Hidden Node environment. A small and simple wireless LAN network with 5 nodes has been created. Please see the Topology of the RTS/CTS network. The Node 0 in the center acts as AP and receives data from the Nodes 1-4. The Nodes 1 acts as Hidden Node to the Node 2-4. The “Rx Group Configure” is introduced here to make the Node 1 as Hidden Node. In the Rx Group Configure, we define the Distance Threshold to 220m, so the Nodes 2-4 can hear each other and become a receive group. The Nodes 1 is 300m away, it is beyond the communication distance and it will not hear the Nodes 2-4. From the
attribute of the “Rx Group Configure” we can also define the Channel Match Criteria or Path loss Threshold to make the Nodes 1 as the Hidden Node. The distance parameter is the easiest way. So we use this method to define our Hidden Node. Below is the network topology

VII. FURTHER STUDY UNDER HEAVY TRAFFIC

We further study the RTS/CTS feature under heavy traffic environment. 20 nodes were created to build an Ad hoc network. Each node sends packets larger than 2000 bytes to random destination in order to create more collision. From the results, we notice that in a heavy big packet traffic network RTS/CTS can dramatically avoid the high chance of collision to improve performance like the throughput and delay.

VI. SIMULATION RESULTS

The important statistic parameters such as throughput and collision of the AP, the delay of the sending nodes have been collected to evaluate and analyze the different scenario. The simulation time is 60 minutes. Different random seeds have been chosen for each scenario. Figure 2,3,4 and Table 1 are shown in Appendix. From above simulation results we find that the Hidden Nodes has dramatically decreased the network throughput (green line in throughput), increases the collision (the value is the average number of sum of collision status of rx channel, in our project all collision points this value) and average delay. By turning the option feature RTS/CTS on with the default threshold, the performance is increased (blue line in throughput). When we further reduce the threshold of the RTS/CTS at presentence of Hidden Node, The performance is further improved (red line in throughput). As we can expect without hidden node, the network has highest performance (pink line in throughput). The option of RTS/CTS and will bring some negative affect to the network due to the overhead bring by the RTS, CTS and ACK frames. However this affection is very limited (pink line and cyan line in throughput).
VIII. CONCLUSION
From the simulation we mentioned above, the key features such as RTS/CTS, Fragmentation, and back-off Algorithm have effectively improved the performance of the IEEE 802.11 network in a wireless network. However it also shows that these features do not work well in some environment. Reasonable implementing these features and optimizing the parameters is a key work to run the IEEE 802.11 network in high performance. The RTS/CTS handshaking provides positive control over the use of the shared air medium. The main function of this feature is to minimize collisions among hidden stations. The increase in performance using RTS/CTS is the net result of introducing overhead (i.e., RTS/CTS frames) and reducing overhead (i.e., fewer retransmissions). If there is no or slight hidden nodes problem, then the use of RTS/CTS will only increase the overhead, which reduces throughput. One of the best ways to determine if the RTS/CTS should be set on is to monitor the wireless LAN for collisions. If there is a large number of collisions and the users are relatively far apart and likely out of range, and then try enabling RTS/CTS.

REFERENCES

AUTHOR’S PROFILE
Dr Mumtaz Ahmad Khan has received his B. Tech.(Electrical Engineering) from Jamia Millia Islamia, New Delhi, M. Tech. (Electrical Engineering) from Aligarh Muslim University, Aligarh and Ph.D (Electrical Engineering ) from Jamia Millia Islamia, New Delhi in 1992, 1995 and 2005 respectively from India. Before joining to the academics in 1998, he served in the industry in India and in KSA around 4 ½ Years. He is involved in teaching and research since then. Dr Khan has served BITS, Pilani-Dubai for Five years, from 2005 to 2010 as Assistant Professor, EEE and currently he is the Professor/Head of Electrical Engineering in Electrical Engineering Section, Faculty of Engg. & Technology, JMI Central University, Govt. of India. New Delhi, India. Dr Khan is having many publications to his credit in the national and international Journals and conferences. He has supervised one Ph.D. in BITS-Pilani, Dubai on Intelligent Buildings and three are under supervision in India. His areas of research are Intelligent applications in Electrical & Computer Engg, Intelligent and Energy Efficient Buildings, Wireless communications etc. He is an active member of IEEE and other national & International bodies.

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APPENDIX

Fig 2 Throughput
Table 1: Simulation Parameter

<table>
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<th>Parameter</th>
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<th>4</th>
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<td>$\text{exp}(10)$</td>
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<tr>
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<tr>
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