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Study of IEEE 802.11 Modified MAC

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Abstract: In some recent researches Distributed Coordinate Function becomes an important mechanism in order to access the medium (Channel). The IEEE 802.11 protocol is based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) with a binary exponential backoff (BEB) algorithm to access the channel as the architecture of 802.11 handles MAC(Medium Access Control) layer and specification of Physical layer for Wireless LANs. The backoff procedure reduces the probability of collision enhancing its performance. In binary exponential backoff (BEB) algorithm with every unsuccessful transmission introduces twice the waiting time of a node than the previous value redundant fast-growing retransmission delays for the backlog traffic. Delay in the retransmission can cause the nodes to move out of the collision range in a MANET waiting for retransmission. Hence the growth of waiting time should be reduced in MANET. The number of redundant retransmissions and frequent collisions in BEB reduces the performance of the network. DCF reduces the Contention Window to the original value after every successful transmission which essentially assumes that each successful transmission is an indication that the system is under low traffic loading. QoS (Quality of Service) is a key problem of today's IP networks.

Keywords: DCF, PCF, IEEE 802.11MAC Layer.

I. INTRODUCTION

A. INTRODUCTION TO WIRELESS LANS

IEEE 802.11 wireless LAN (WLAN) is holding a major place in next-generation wireless communication networks and is one of the widely used wireless technologies all over the world. The major feature of the 802.11 WLAN technologies is that it is simple, flexible and cost effective. The detailed specification of medium access control (MAC) and physical layer (PHY) was released in 1999 in the final version of the standard which gave details for WLAN. The IEEE 802.11 technology is also applied in other areas, such as wireless sensor networks and wireless mesh networks. In addition to it the IEEE 802.11 is also playing an important part in the future 4G telecommunication network, where customers may use voice or even video communication over the IEEE 802.11 network [1].

WLAN works in two modes: infrastructure based and infrastructure-less mode or ad-hoc mode. In infrastructure based mode, a central coordinator or an Access Point (AP) is required for the network operation. The AP resolves concerns related to access to the channel and transfer of information between stations. Access Point based networks are also called as a single- hop networks where the all the information from a source to destination is transferred via the Access point. Stations cannot communicate directly with each other. In the other mode of operation, known as the Mobile Ad-hoc Network (MANET) nodes communicates directly with each other without any central coordinator. This requires that all nodes must act as packet forwards to relay packets between two stations that are outside the radio coverage of each other. This provides greater flexibility and robustness.[7]

In the 802.11 protocol, the basic medium access mechanism is called distributed coordination function (DCF). This is a random access scheme, based on the carrier sense multiple access with collision avoidance (CSMA/CA) protocol. Retransmission of collided packets is managed according to binary exponential backoff rules. The standard also defines an optional point coordination function (PCF), which is a centralized MAC protocol able to support collision free and time bounded services.[6]

B. Introduction to 802.11 Medium Access Control Layer

IEEE 802.11 MAC is a De-Facto standard for WLANs. Three basic access mechanisms have been defined in IEEE 802.11: the mandatory basic access method based on CSMA/CA, an optional method avoiding the hidden terminal problem, and finally a contention-free polling method for time bounded services. The first two methods are also summarized as Distributed Coordination Function (DCF), the third method is called Point Coordination Function (PCF). The MAC mechanisms are also called as distributed foundation wireless medium access control (DFWMAC).[3] The IEEE 802.11 medium access control (MAC) is based on the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) principle and The fundamental MAC layer access mechanism of the IEEE802.11technology is DCF (Distributed Coordination Function); DCF is based on CSMA/CA backoff mechanism for medium access control, where each station implements its own backoff procedure for medium access. However, DCF can only over a best-effort medium access service, where all stations statistically share the medium fairly but it cannot support QoS (quality of service) differentiation. The distributed coordination function (DCF) provides a simple and flexible mechanism for sharing the network medium. DCF defines two media access techniques to be employed for frame transmission: The default scheme is a two-way handshaking technique called the basic access and an optional four-way handshaking technique known as Request-To-Send/Clear-To-Send (RTS/CTS) mechanism [5].

II. DISTRIBUTED COORDINATION FUNCTION

DCF is the main fundamental access method of IEEE 802.11 MAC. It is based on carrier sense multiple access with collision avoidance (CSMA/CA) with binary exponential backoff (BEB) algorithm. when multiple stations access the same medium the DCF is used to reduce collision probability. DCF is the basic medium access mechanism for both infrastructure based and infrastructure less modes.DCF works as "LISTEN BEFORE TRANSMISSION" scheme. The DCF must be implemented in all stations, for use within both ad-hoc and infrastructure network configurations. When a station wants to transmit, it shall sense the medium first to determine if another station is transmitting. If the medium is not determined to be busy, the transmission may proceed. The CSMA/CA distributed algorithm mandates that a gap of a minimum specified duration exists between contiguous frame sequences before attempting to transmit, a transmitting station ensures that the medium is idle for the required duration. If the medium is busy the station defers transmission till the end of the current transmission. the defered station reattempts transmission after a selected random back off interval and should decrement the back off interval counter while the medium is idle.

III. OPERATION MODE OF CONVENTIONAL DCF

In 802.11, the DCF is the fundamental access method used to support asynchronous data transfer on a best effort basis. As specified in the standards [1] that the DCF must be tolerable and enforceable to all the workstations within a Basic Service Set (BSS). The DCF is mainly based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). CSMA/CD is not used because a station is unable to listen to the channel for a collision while transmitting. In 802.11 CS is performed both at the physical layer, which is also referred to as the physical carrier sensing, and at the MAC layer, which is known as virtual carrier sensing. The PCF in the 802.11 is a polling-based protocol, which is designed to support collision free and real time services.[3] DCF allows medium sharing between nodes using CSMA/CA protocol. Two channel access mechanisms are used in DCF: Basic Access Mechanism & RTS/CTS Mechanism. The default one is a two-way handshaking mechanism, also known as (ACK) is transmitted by the destination station to signal the successful packet transmission. The other optional one is a four-way handshaking mechanism, which uses request-to-send/clear-to-send (RTS/CTS) technique to reserve the channel before data transmission. Before transmitting a packet, a station operating in an RTS / CTS mode "reserves" the channel by sending a special Request-To-Send short frame. The destination station acknowledges the receipt of an RTS frame by sending back a Clear-To-Send frame, after which normal packet transmission and ACK response occur. Since collision may occur only on the RTS frame, and it is detected by the lack of CTS response, the RTS/CTS mechanism allows to increase the system performance by reducing the duration of a collision when long messages are transmitted. As an important side effect, the RTS/CTS scheme designed in the 802.11 protocol is suited to combat the so-called problem of Hidden Terminals, which occurs when pairs of mobile stations result to be unable to hear each other. However, the drawback of RTS/CTS mechanism is increased overhead for short data frames.

When a station wants to transmit a data packet, it first monitors the channel activity. If the channel is idle for a period of time equal to a distributed inter-frame space (DIFS), the station transmits.

Otherwise, if the channel is sensed busy (either immediately or during the DIFS), the station persists to monitor the channel until it is measured idle for a DIFS. At this point, the station generates a random backoff interval before transmitting (this is the Collision Avoidance feature of the protocol).Random backoff interval (timer) is uniformly chosen from [0,cw] ,Where cw = current size of contention window ,initially cw=31.This minimize the probability of collision with packets being transmitted by other stations. In addition, to avoid channel capture, a station must wait a random backoff time between two consecutive new packet transmissions, even if the medium is sensed idle in the DIFS time.

IV. LITERATURE SURVEY

S No	Publication	Description
1	Hongqiang Zhai and Yuguang Fang [12] "Performance of Wireless LANs Based on IEEE 802.11 MAC Protocols" 2004	the probability distribution of the MAC layer service time has derived. To obtain this distribution, he expand the Markov chain model to the more general case for the exponential backoff procedure in IEEE 802.11 MAC protocols. Accurate discrete probability distribution and approximate continuous probability distributions are obtained in this paper. Based upon the distribution of the MAC service time, he comes up with a queueing model and evaluate the performance of the IEEE 802.11 MAC protocol in Wireless LANs in terms of throughput, delay, and

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		other queue characteristics. The results show that at the non-saturated status, the performance is dependent on the total traffic and indifferent to the number of transmitting stations. And at saturated status, the number of transmitting stations affects the performance more significantly.
2	Qiang Ni*, Lamia Romdhani, Thierry Turletti [13] "A Survey of QoS Enhancements for IEEE 802.11 Wireless LAN 2004	This survey analyzes the QoS limitations of the original IEEE 802.11 wireless LAN MAC layer. He evaluates and classify different QoS enhancement techniques proposed for IEEE 802.11 wireless LAN and Study their advantages and drawbacks. Research activities and performance evaluations of the upcoming IEEE 802.11e QoS enhancement standard are also introduced and analyzed. As described, many QoS enhancement schemes have been proposed to improve the performance of original 802.11 wireless LAN.Among them the upcoming queue-based 802.11e standard offers some improvements. But it has not been finalized yet and needs to be analyzed more.
3	Teerawat Issariyakul, Dusit Niyato, Ekram Hossain, and Attahiru Sule Alfa atc[8], proposes "Exact Distribution of Access Delay in IEEE 802.11 DCF MAC" 2005	.It have modeled the channel access delay for IEEE 802.11 DCF MAC as having phase-type distribution. It used the special structures of the transition probability matrices to reduce the computational complexity and the memory requirements to an acceptable level. It has observed that the access delay distribution in the system with fixed data length is non-continuous. The envelope of the distribution resembles a *hyper-exponential* distribution. Therefore, it could be reconstructed by using only a few parameters such as the probability of a slot being idle, data length and collision length. The *pmf* could be very useful in the design of more efficient MAC protocols as well as for queuing analysis in an IEEE 802.11 network
4	Yoshifumi Nishida proposes [9] "Enhancing 802.11 DCF MAC for TCP/IP Communication" 2005	It proposes two schemes, Partial Retransmission and TCP ACK suppression that can improve TCP/IP communication performance under 802.11 networks. In this the Partial Retransmission scheme increases throughput in a very lossy environment, while the existing 802.11 MAC scheme performs poorly. This scheme can be applied to all IP communications. The TCP ACK suppression scheme that alleviates self- contention in TCP communication can improve TCP throughput about 10% when BER of an 802.11 network is 0. Although the TCP ACK suppression scheme delays the transmission of TCP ACK packets slightly, the performance degradation caused by the delays should be minor. This is because TCP ACK suppression can improve the TCP performance even with the side-effect of the delay if networks are

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		congested due to bulky TCP connections. Besides that, it will not be activated in non-congested networks where most TCP connections are interactive.
5	Vivek Jain, Anurag Gupta, Dhananjay Lal, Dharma P. Agrawal atc [10], proposed "IEEE 802.11 DCF Based MAC Protocols for Multiple Beam Antennas and their Limitations" 2005	Its investigated employing IEEE 802.11 DCF based MAC protocols for multiple beam antennas. It used several different variants of such protocols and studied their performance over multiple beam antennas. His analysis shows that no more than 16% of packets can be received concurrently with such protocols even after using as many as 16 multiple beams.They conclude that asynchronous protocols are not suited for medium access control over multiple beam antennas. It has shown tangible gains by employing unified backoff counters and omnidirectional transmission of control messages. It also provided guidelines for the development of a new MAC protocol which can make best use of the antenna array. They believe that substantial performance improvements can be obtained for multiple beam antennas when nodes synchronize their NAVs with their neighbors.
6	Azade Khalaj, Nasser Yazdani[14] "The Effect of Decreasing CW Size on Performance in IEEE 802.11 DCF" 2005	The result of any modifications in the calculation of the CW size after a successful transmission has been calculated. He also employs some mechanism to provide service differentiation between traffics. In the simulations, he has considered delay, Throughput, and jitter. The purpose of this modification was to study the effect of CW size on these parameters. The results of the simulations showed that when CW size remains larger, the gained throughput is better, although it leaded to higher jitter. It seems to keep CW larger is better for data traffic, while using the main scheme used in DCF method is better for multimedia Traffics. The simulations also showed the scheme used in DCF causes starvation in low priority traffic when load increases, while the schemes which keep CW larger, provide better fairness among priority classes. Our future work will include employing different schemes; scheme I or 2 for data and scheme 3 or 4 for multimedia traffics and study the coexistence of these different schemes on performance of DCF method.
7	C. Rama Krishna, Saswat Chakrabarti and Debasish Datta atc[2], "A MODIFIED BACKOFF ALGORITHM FOR IEEE 802.11 DCF BASED MAC PROTOCOL IN A MOBILE AD HOC NETWORK" 2004	Its examined a modified backoff algorithm for IEEE 802.11 DCF-based MAC protocol, with due consideration to hidden terminals and link break detection in a MANET.It is observed that the modified backoff algorithm with b = 1.8 improves the packet delivery ratio compared to BEB when the nodes move with higher speed (i.e., >15 m/s). The end-to-end packet delay is better with modified

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		backoff algorithm compared to BEB for heavy offered load (i.e., 25 SDPs) and high node mobility (i.e., >15 m/s)
8	Taka Sakurai, Member, IEEE, and Hai L. Vu, Senior Member[16] MAC Access Delay of IEEE 802.11 DCF IEEE TRANSACTIONS ON WIRELESS COMMUNICATION VOL 6 NO. 5 MAY 2007	we have developed a model of the access delay of the IEEE 802.11 MAC for saturated stations. we have developed a model of the access delay of the IEEE 802.11 MAC for saturated stations. We have shown how numerical transform inversion can be used to compute distributional values from the generating function.this asymptotic analysis of the theoretical unlimited retransmission case provides insights for practical DCF systems. we have shown that the heavy-tail induced by BEB in the theoretical system translates to a truncated power law tail induced by truncated BEB in DCF. This result implies a relatively high probability of long packet delays in DCF and raises doubts about the efficacy of using DCF for delay- sensitive applications.
9	Yu Zheng, Kejie Lu, Member, IEEE, Dapeng Wu, Senior Member, IEEE, and Yuguang Fang, Senior Member, IEEE [17] "Performance Analysis of IEEE 802.11 DCF in Imperfect Channels" 2006	In this paper, we provide an accurate analytical model to evaluate the performance of DCF, which is the fundamental MAC scheme in IEEE 802.11, The main contribution of our study is that we consider the impact of different realistic factors together including binary exponential backoff, various incoming traffic load queueing system at the MAC layer, and imperfect wireless channels, which has never been addressing in a comprehensive manner before. Extensive simulation and analysis results show that our analytical model can accurately predict the delay and throughput performance of IEEE 802.11 DCF under different channel and traffic conditions.
10	Inderjeet Kaur, Manju Bala , Harpreet Bajaj [11] "Performance Evaluation of Wlan by Varying Pcf, Dcf and Enhanced Dcf Slots To Improve Quality of Service 2012	". The performance of wireless Network using PCF, DCF & EDCF co-ordination functions for different parameters like Channel Reservation, Data Traffic Received, Data Traffic Sent, Dropped Data Packet, Retransmission Attempts, and Load has been checked. Investigations have revealed that Network having EDCF co-ordination functions is useful to improve the Quality of Service. Channel reservation with EDCF varies from 33ms to 34.7ms, with DCF and PCF it is 10ms. It has been noticed that the traffic sent for PCF varies from 659 kb/sec to 677 kb/sec, DCF 662 kb/sec to 675 kb/sec and EDCF 613 kb/sec to 685 kb/sec. It has been noticed that the Traffic Received for PCF varies from 27 kb/sec to 10 kb/Sec, DCF 139 kb/sec to 149 kb/sec and EDCF 269 kb/sec to 279 kb/sec. It has been noticed that

		the Data Dropped for PCF varies from 0 bits/Sec to 2761 bits/Sec, DCF 0bits/Sec to 625bits/Sec and with EDCF varies from 0bits to 397bits and then to149bits. It has been noticed that the Retransmission Attempts for PCF is 20Packets/Sec, DCF is 17 Packets/Sec and of EDCF is 30 Packets/Sec. It has been noticed that the scenario where PCF is used can handle load of the order of 1125kb/Sec. That's the scenario where DCF is used can also handle the load of the order of 1125kb/Sec. But with EDCF, It can handle Load up to 1319kb/Sec. Hence Wireless Network having EDCF co-ordination functions is very useful to improve the Quality of Service.ssss

V. CONCLUSION

In this survey paper it has evaluated that there are various problems and limitations with the existing architecture (i.e. BEB) of IEEE 802.11 DCF the shortcomings that have been evaluated are unfair channel access among several stations, repeated retransmissions, frequent collisions and inability of network performance under bandwidth utilization. The above shortcomings highly affect the QoS parameters like throughput, delay and reliability in Binary Exponential Backoff mechanism. Another major problem observed is that of Contention Window size (CW).A small sized CW results in increased probability of collision in back off interval where as a large CW results in decreased network performance. The basic objective of the work is to enhance QoS parameters is by extending DCF with the new calculation method to increase contention window (CW) size so that each station can access the medium after a small number of attempts, and can overcome the shortcomings of existing architecture (BEB) by increasing the efficiency of the transmission.

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