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Performance Evaluation of IEEE 802.11 MAC DCF Using Various Schemes Towards: Throughput, Delay and Reliability

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Abstract: Wireless local area networks (WLANs) have become increasingly popular in the computer communications industry in recent years. Performance improvement of IEEE802.11 is a challenging & very popular problem between the researchers. CW (Contention Window) is an important factor, which plays an important role to improve or reduce the performance of IEEE 802.11. We modify the calculating method of CW (Contention Window) size after a Successful & unsuccessful transmission and study the effect of CW size on performance. The proposed modification significantly reduces the probability of collision and provides better quality of service. The complexity of implementing such a modification is low and the related parameter is easily determined. Simulation results show that the proposed modification outperforms DCF in terms of throughput, the probability of collision and average delay.

Keywords: 802.11;DCF(Distributed Coordination Function); MAC(Medium Access Control);BEB(Binary Exponential Backoff);CSMA/CA(Carrier Sense Multiple Access With Collision Avoidance) ;QoS (Quality of Service).

I. INTRODUCTION

To provide an efficient and robust network in a wireless environment for a collection of Stations, the IEEE 802.11 working group have chosen the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) protocol as the standard protocol for wireless local area networks (LANs). The CSMA/CA protocol is a random access protocol that is subjected to collisions. In the case of a collision, each mobile station executes the Binary Exponential Backoff (BEB) retransmission algorithm to resolve the collision and maintain the stability of the CSMA/CA channel. Armed and commercial applications can be greatly benefited by efficiently using WLANs. In a WLAN, Transmission of packets takes place in an unsynchronized fashion. Conflicts are minimizing & the shared channel is properly coordinated if MAC access control (MAC Layer) employs the protocol .There for the need for an effective mac protocol is adamant. In WLAN all connecting nodes are communicating via a shared transmission channel (medium). The MAC layer provides two mechanisms (DCF & PCF) for controlling the access of shared channel, PCF is an option mechanism but DCF is mandatory. Due to the common transmission channel collision of packets is the very common in WLAN. The carrier sensing multiple access/collision avoidance (CSMA/CA) protocol and the binary exponential backoff (BEB) algorithm are two main components of DCF that are used to avoid collisions of packet [1][9].

II. OPERATIONAL MODE OF CONVENTIONAL DCF

In 802.11, DCF can be named as a fundamental access method which is working in order to facilitate asynchronous data transfer on 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). DCF is primarily based upon CSMA/CA. The station is unable to listen to the channel while transmitting, that is the reason why CSMA\CD is not used. In 802.11 CS is performed at Physical Layer also called as Physical Carrier Sensing and MAC layer also termed as Virtual Carrier Sensing. [5] [10]. DCF allows medium sharing between nodes using CSMA/CA protocol. Two channel access mechanisms are used in DCF: Basic Access Mechanism & RTS/CTS Mechanism. In basic access mechanism, on successful transmission, after a receiving of packet, the receiver node transmitted a positive MAC acknowledge (ACK) to sender. It is also known as two way handshaking mechanism. In RTS/CTS, before sending a packet, the sender node tries to reserve the channel. If the channel is

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idle, the sender sends an RTS frame first after receiving the RTS receiver send back CTS frame after the SIFS. After that actual packet is transmitted & ACK response occurs. [1][7]. (For more details about DCF please use following reference [1][2][3][5][7].

III. BINARY EXPONENTIAL BACKOFF ALGORITHM

DCF adopts an exponential backoff scheme. The back-off time for every packet transmission is chosen within the range of 0 , CW-1 and in a uniform fashion. The value "CW" is termed as Contention Window and it drastically depends upon the number of unsuccessful transmission for the chosen packet. For the very first transmission the value of CW is set to CWmin also termed as minimum contention window and after every transmission that becomes unsuccessful the value of "CW" is doubled reaching to a maximum limit of : CWmax = 2m * CWmin. The back off time counter continually gets decremented until the channel is sensed in an "Idle" state. It goes in "Frozen" State when a transmission is detected on the channel and it goes to the reactivated state when the channel is sensed idle again for more than a DFIS. As soon as the back-off time reaches zero the station starts the transmission [1][2][3][7]. Back off time for basic DCF is Random ( ) * (Slot Time) where Random ( ) is given by the following mathematical formula: Random ( ) =2i+k -1. Where i (initially equal to 1) is the transmission attempt number and k depends on the PHY layer type and Slot Time is a function of physical layer parameters. When the value of "i" ranges to the upper limit, the random range (CWmax) remains the same and when a packet is successfully transmitted, the CW is reset to CWmin. Value of CWmin=31 and CW max=1023. With 802.11 standard, the chosen value for CW is CWmin = 31, CWmax =1023 and for k we took the value 4 because the min value of CW is equal to 31 (i.e. 2i+4 for i=1) the value become 31,and i takes values from 1 to 6 (i = {1, 2, 3, 4,5, 6}) (i.e. i=6 gives the CW=1023) , So after each collision the possible CW is {31, 63, 127, 255, 511,1023}.

IV. PROBLEMS WITH EXISTING ARCHITECTURE

DCF is used in order to resolve collision through Contention Window and backoff time. As stated in the original standard [1], "after each successful transmission, the backoff stage will resume to the initial stage 0, and the contention window will be set to CWmin regardless of network conditions such as the number of competing nodes". This method, referred to as 'heavy decrease' tends to work well when the number of competing nodes is less. Substantial performance deprivation occurs when the number of competing nodes rises & causes a new coalition between the nodes.

The operation of the existing DCF protocol can be summarized from the following figure –

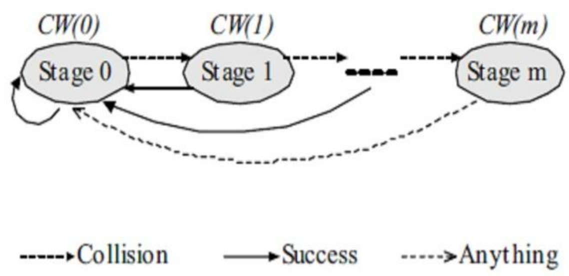

Fig. 1.Operation of 802.11 DCF with BEB Algorithm

For example, let us assume that the current backoff stage is 'i' with contention window CW(i) = 2i * CWmin , and after a successful transmission, the next backoff stage will be stage 0 with contention window CW(0) = 31 according to the specification. But if the number of competing nodes is large enough (>>31), the new collision will likely occur at the backoff stage 0. The main argument is that since the current backoff stage is 'i' some collision must have occurred recently at the previous stage. Now if the number of current competing nodes is larger than or close to CW(i), and if the backoff stage is set to 0, there is a high probability that new collisions will happen. So resetting the contention window after every successful transmission is an inefficient approach if the number of nodes is large. The working of BEB algorithm can be summarized as follows:

CW = min [2*CW, CWmax], upon collision (1)
CW = CWmin, upon success (2)

We also observe that fast build-up is caused when the waiting times uniformly spreads the backlog traffic subsequently over a larger time frame but in case of MANET this rapid build-up of the waiting time along with an increasing number of various occurrences of collisions cannot be termed appropriate, wherein the contending nodes ultimately succumb to the geographic location of the contention and are displaced due to their mobility. Therefore the node must not be made to wait for the durations as the waiting times vary exponentially with a binary base [1][7][9].

V. MODIFICATION IN BEB

The IEEE 802.11 DCF is based on CSMA/CA (carrier sense multiple access with collision avoidance) technique and adopts a slotted BEB (binary exponential backoff) as a stability strategy to share the medium. But its contention window resetting mechanism degrades the performance of a

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network. (Already described in section IV). In this section, we propose four schemes to modify the CW size after a transmission & Collision to investigate the performance of the IEEE 802.11 DCF. On collision we use the shift schemes (i.e. left shift and right shift) to increase the CW size & on successful transmission we modify the default resetting scheme of 802.11 to according to the code shown below.We explore our simulation using following schemes.

Scheme 1 Description: Our first Scheme is based on adding 3 to two bits left shift of the variable CW, where the number 3 replaces the two bits equal to zero after shift operation. So for this scheme Random ( ) becomes

Random ( ) =2(2i+3) -1.

By using this scheme the number of retransmissions attempts decreases from six to four as compared to BEB. Number of retransmission after each calculation is {i=1, 2,3,4}.When i becomes 1 the value of CW will 31(i.e. the min value of CW),and when i becomes greater than 3,CW will reset to 1023(i.e CW max).So after each collision ,possible CW values are {31,127,511,1023).

Scheme 1: Adding 3 to two bits left shift

```
 Void inc_cw ( )
{
CW = (CW << 2) +3
If (CW > CW max
        CW = CW min;
        } On a Collision……
```

Scheme 2 Description: our second scheme is based on adding 3 to 2 bits right shifts of the variable CW, where the number 3 is used to replace the 2 bits equal to one after shift operation. The rest of the procedure is similar as described in scheme 1.

Scheme 2: Adding 3 to two bits Right shift

```
Void inc_cw ( )
{
CW = (CW >>2) +3
If (CW > CW max
CW = CW min;
}   On a Collision……
```

Scheme 3 Description: In our third Scheme we have added 7 to three bits left shift of the variable CW, where the number 7 is used to replace the three bits equal to zero after shift operation and Random( ) becomes .

Random ( ) =2 (3i+5) -1.

The number of retransmissions attempts after each calculation decreases by this scheme. Number of retransmission is (03) (i= {0, 1, 2}), and when i become greater than 1, CW is reset to 1023. So after each collision, possible CW values are: {31, 255, 1023}.

Scheme 3: Adding 7 to three bits Left Shift

```
Void inc_cw ( )
{
CW = (CW << 3) +7
If (CW > CW max)
CW = CW min;
}   On a Collision…
```

Scheme 4 Description: our fourth scheme is based on adding 7 to 3 bits right shift of the variable CW, where the number 7 is used to replace the 3 bits after shift operation. The rest of the procedure is similar as described in scheme 3.

Scheme 4: Adding 7 to three bits Right Shift

```
Void inc_cw ( )
{
CW = (CW >> 3) +7
If (CW > CW max)
CW = CW min;
}   On a Collision…
```

Code for Resetting CW since the transmission was successful:This code will remain same for all Schemes from Scheme 1 to 4.

```
Void Dec_cw( )
{
If (CW>CW max)
CW=CW/2;
} On Success...
```

Where CW=Current Contention Window. CW min= Minimum Size of contention window. CW max=Maximum size of contention window.

VI. SIMULATION

Using Global Mobile Information System Simulator (GloMoSim) design and implementation of schemes has been carried out successfully. Glomosim is a scalable simulation environment for large wireless and wired communication networks. The simulation under the study was a network that comprised of nodes that were placed in the 800 x 800 m2 area. The data rate is 11 Mbps and random waypoint mobility (RWMM) is applied to study the node movement. In RWMM, the nodes travel at a uniform and evenly distributed speed [MIN SPEED, MAX SPEED]. The simulation of every node is initiated by its movement towards a randomly chosen destination also known as a waypoint. After the node reaches the waypoint it is made to rest for a PAUSE time. It then again selects a new waypoint and starts its movement towards it. This selection of new

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waypoint and movement towards it by the node is repeated until the simulation time is completed. In the simulation in this paper the pause time is set to 0 which means that the movement of the modes is continuous throughout the entire simulation. This is done in order to gain a proper insight about the worst case scenario regarding the impact of the node mobility.

Table I
Simulation Parameters

Parameter	**Value**
Mobility Model	Random Waypoint
Speed of Mobile Node	Uniformly distributed Between [0,10] M/sec
Propagation model	Two Ray
Area (in m2)	800 x 800
Channel Frequency	2.4 GHz
Data Rate	11 Mbps
MAC protocol	802.11 DCF with Proposed backoff Schemes on Collision.

VII. RESULTS OBTAINED

On the basis of simulation results we found that the evaluation criteria for high density and low density network in conventional DCF for QoS(Quality of service)parameters such as Delay, Throughput and Packet received varies. We have evaluated the comparative study between our schemes with the existing architecture BEB Algorithm (Original Scheme). The following graphs were plotted from the obtained output –

A. *Comparative study of scheme 1 and scheme 2 against original scheme with QoS parameters*: Figures 2, 3, 4 show QoS parameters in high density network. In the average End to end delay Scheme 2 gives better result (up to 120 nodes) as compared to BEB and scheme 1. When the number of nodes increases scheme 1 gives better result than the conventional DCF.

In case of throughput when the number of nodes is less (number of nodes 30) scheme 2 gives optimum results as compare to BEB and scheme 1. And when the number of nodes increases scheme 1 gives better result as shown in the fig 3 and the same comparison result we get in total number of packets received as we get in throughput shown in fig 4.

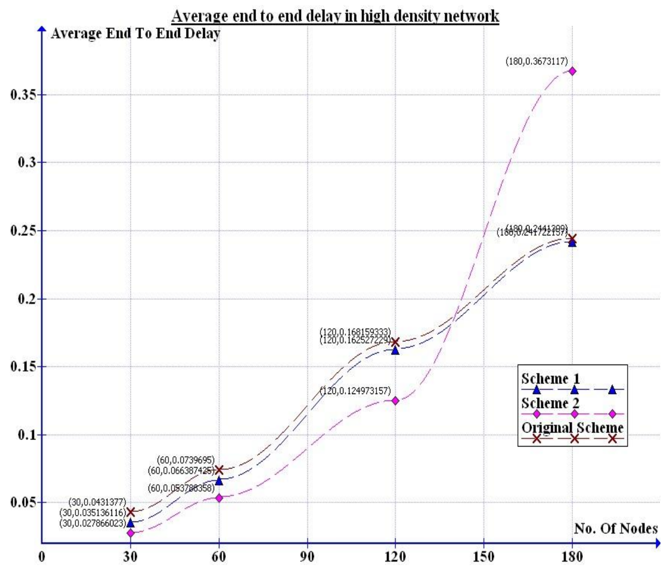

Fig. 1. Average end to end delay vs. Number of nodes

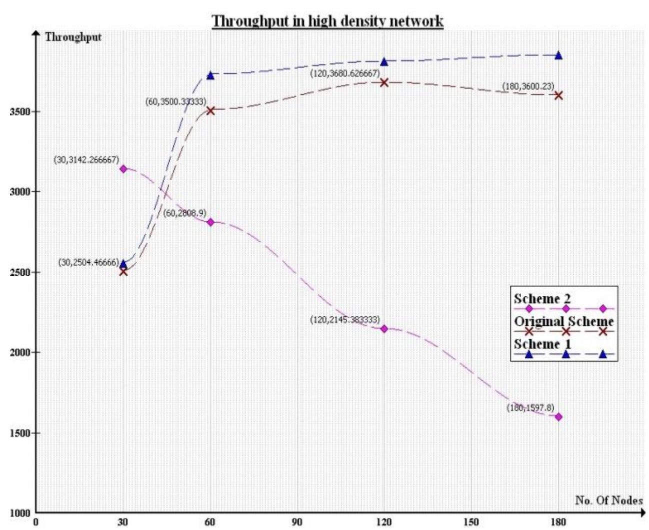

Fig. 3. Throughput vs. Number of nodes

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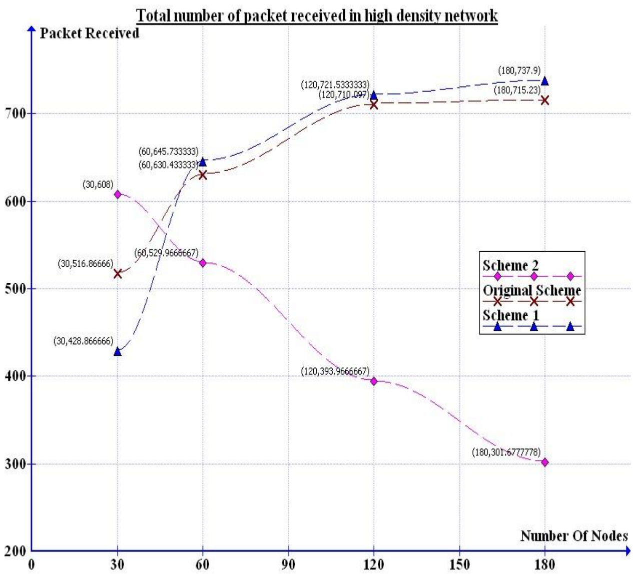

Fig. 4. Total number of packet received vs. Number of nodes

B. Comparative study of scheme 3 and scheme 4 against original scheme with QoS parameters: Figures 5, 6, 7 shows QoS parameters in high density network. Scheme 3 gives a consistently unsurpassed result in an average end to end delay and throughput as compare to BEB and scheme 4 shown in fig 5 and 6 respectively. The total number of packets received does not differ much from the different values of back off factor. When the number of nodes in the network is less (Less than or equal to 60) scheme 3 and 4 gives better result as compared to BEB. However, in the high density network (more than 60 nodes) the total number of packets received decreases in scheme 3 & 4 as compared to BEB (original scheme).

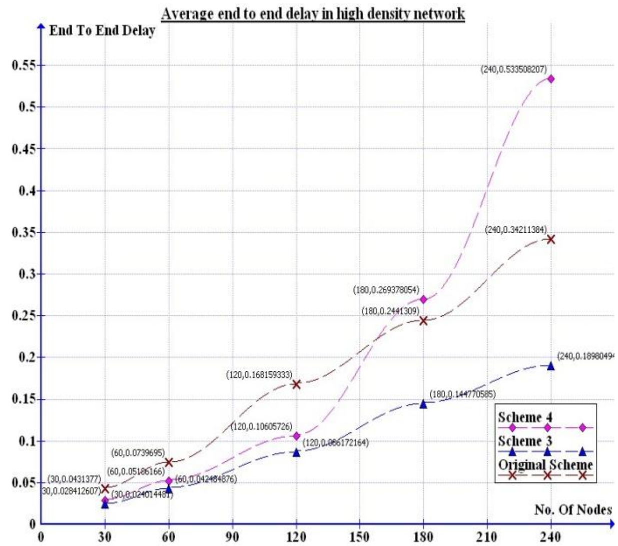

Fig. 5. Average end to end delay vs. Number of nodes

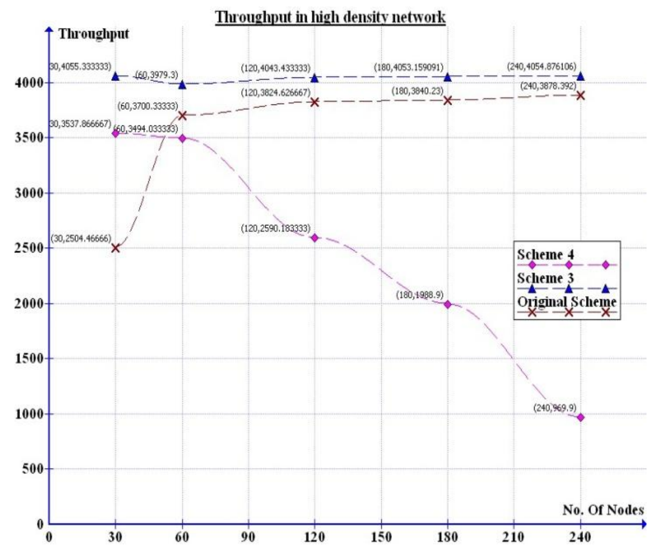

Fig. 6. Throughput vs. Number of nodes

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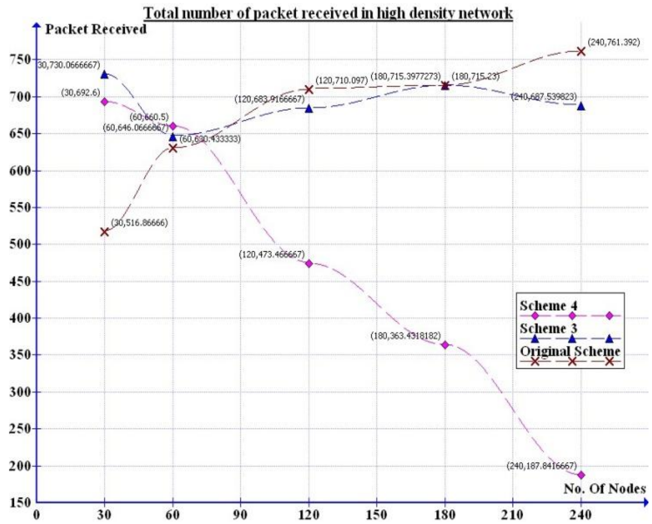

Fig. 7. Total number of packet received vs. Number of nodes

C. Comparison Of scheme 1 and scheme 3 against original scheme with all parameters: Figures 8, 9, 10 show QoS parameters in high density network. Scheme 3 gives constantly incomparable result in an average end to end delay and throughput as compare to BEB and scheme 1 shown in fig 8 and 9 respectively. In total number of packets received When the number of nodes in the network is less (Less than or equal to 30) scheme 3 gives better result as compare to conventional DCF and scheme 1. However, in the high density network (more than 60 nodes), the total number of packets received increases in scheme 1 as compared to BEB and scheme 3.

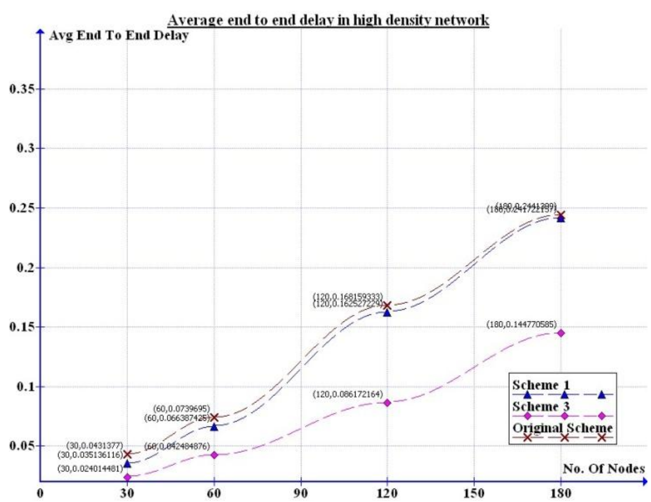

Fig. 8. Average end to end delay vs. Number of nodes

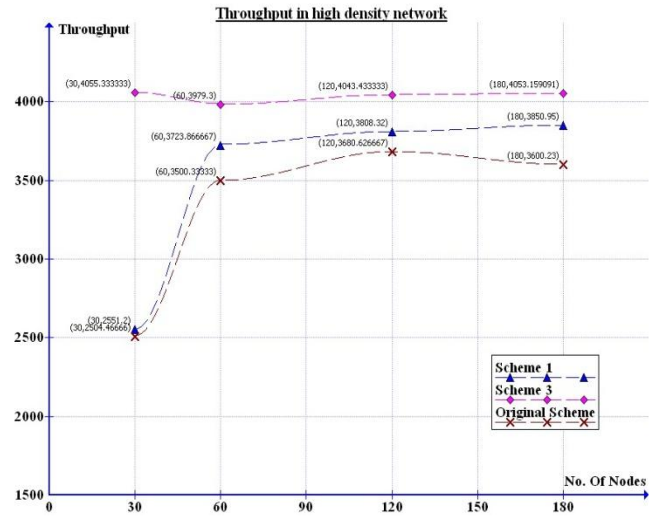

Fig. 9. Throughput vs. Number of nodes

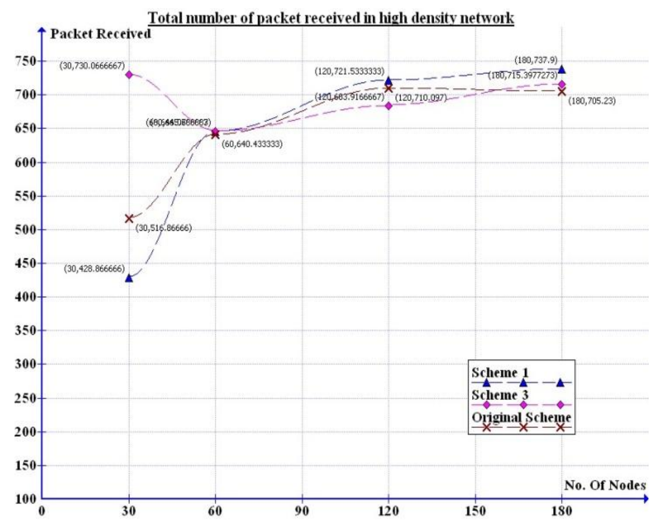

Fig. 10. Total number of packet received vs. Number of nodes

VIII. CONCLUSION & FUTURE WORK

In this paper, we have considered new schemes for DCF protocol by modifications in the Binary Exponential Backoff algorithm. Different values of backoff factors were tested and compared against the conventional IEEE 802.11 DCF protocol. IEEE 802.11 has several disadvantages in that its throughput decreases as the number of nodes in the network increases, average end to end delay is more in high density networks. Simulation for the schemes were carried out using GloMoSim simulator and simulation results shows that – in the first comparison result of scheme 1,2 and Original scheme, scheme 2 gives superior results in an average end to

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end delay when the number of nodes is less than or equal to 120 and scheme 1 gives better results in throughput and packet received as compared to original scheme. Comparison result of scheme 3, 4 with original shows that scheme 3 gives improved results in average delay and throughput as compared to BEB. In our third comparison we examined that scheme 1 and 3 both give improved results as compared to original So, better results can be obtained if we can apply the proposed solution in the real world. Our future work will be to find the number of nodes & switches the schemes automatically according to available active nodes in the network.

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