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Performance Analysis of IEEE 802.11 Ad Hoc Network with varying CWmin

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ABSTRACT
Several MAC protocols proposed for IEEE 802.11 wireless local area network. In that research, authors used the same backoff scheme proposed in the IEEE 802.11 i.e. the minimum contention window size is 32. However we can vary the minimum contention window size as per the network requirement. It the network size is big we can take big contention window and when the network size is small we can take small window size. This way we can increase the performance of network and decrease the average delay. In this paper we analyze the performance of IEEE 802.11 wireless ad hoc network, in terms of varying the minimum contention window and simulate to validate our numerical result in OPNET 14.5.

Keyword
WLAN, Ad-hoc network, minimum contension window

1. INTRODUCTION
The Distributed Coordination Function (DCF) and Point Coordination Function (PCF) provided by the IEEE 802.11to access the MAC layer [1]. The Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) scheme is used in the DCF access mode to determine channel status. If a node has packet to send, it sense the channel, if it found the channel is idle it can continue its transmission. If the channel found busy, it postpones transmitting the packet to the Binary Exponential Backoff (BEB) algorithm [2], [3]. The BEB algorithm needed because of two reasons, first, when the network load increases gradually; all the nodes sharing the same radio medium come to saturated, so the collision ratio increases. Therefore, BEB algorithm doubles their contention window size to reduce the probability of collisions in the network [4]. Second, when the contention window size is very big, it will increase the packet delivery delay in the small network because of idle slot time. In this paper we analyze the performance and average delay of wireless ad hoc network and show the effect on performance results with varying minimum contention window size on small and big network. To validate our result, we simulate it on OPTNET 14.5 [5].

The rest of this paper is organized as follows: Section 2 analyzes the throughput and delay. Section 3 discusses the simulation setup. Section 4 evaluates the analysis and simulation results and Section 5 concludes our work.

2. NUMERICAL ANALYSIS
In this section we estimate the saturation throughput and average delay for small and big network. For analysis we follow the same random scheme in [6]. The transmission probability τ can be given by -

$$\tau(\mathrm{p}) = \frac{2}{1 + \mathrm{W} + \mathrm{pW}\sum_{i=0}^{m-1}(2\mathrm{p})^{i}}. \quad (1)$$

The τ is depends upon collision probability p. To find the value of p it is necessary that a transmitted packet encounters a collision. In a time slot, at least one of the n-1 remaining stations transmits. These yields -

$$\mathrm{p} = 1 - (1 - \tau)^{n-1}. \quad (2)$$

2.1 Throughput
Suppose S be the normalized system throughput, defined as the fraction of time the channel is used to successfully transmit payload bits. To compute, let us analyze what can happen in a randomly chosen slot time. Suppose Ptr is the probability that there is at least one transmission in a slot time. Since stations contend on the channel, and each transmits with probability τ.

$$\mathrm{Ptr} = 1 - (1 - \tau)^{n}. \quad (3)$$

The successful probability Ps that a transmission occurring on the channel is successful is given by the probability that only one station transmits i.e.

$$\mathrm{Ps} = \frac{\mathrm{n}\tau(1 - \tau)^{\mathrm{n}-1}}{\mathrm{Ptr}}. \quad (4)$$

Now we are able to express S-

$$S = \frac{PsPtrE[P]}{(1 - Ptr)\sigma + PtrPsTs + Ptr(1 - Ps)Tc}. \quad (5)$$

Here, Ts is the average time of success full transmission, Tc is the average collision time and σ is the duration when the channel is idle.

2.2 Average Delay

In this section we calculate the average delay E[D] for a successfully transmitted packet. For calculating the delay we flow the equations derived in [7].

The E[D] is given by –

$$E[D] = E[X].E[slot]. \quad (6)$$

Where E[X] is the average number of time slots for a successful packet transmission and the E[slot] is the average length of slot time.

E[X] and E[slot] given as –

$$E[X] = \frac{(1 - 2p)(W + 1) + pW(1 - (2p)^m)}{2(1 - 2p)(1 - p)}. \quad (7)$$

$$E[slot] = (1 - Ptr)\sigma + PtrPsTs + Ptr(1 - Ps)Tc. \quad (8)$$

Now we can calculate the average delay by putting the value of equation (7) and (8) into equation (6).

3. SIMULATION SETUP

In this section we discuss about our simulation setup. For simulation we use OPNET 14.5 [5]. OPNET provides virtual environment of network scenario. It provides several editors such as antenna pattern editor, node editor, process editor, and packet format editor etc. to give real scenario of the network. We design a simulation scenario for 5, 10, 20 and 50 nodes, randomly distributed in 500 × 500 m^2 area. For simulation we create an empty scenario logical scenario which modeled wireless lan model for small and big network. The setup wizard review depicts in Figure 1.

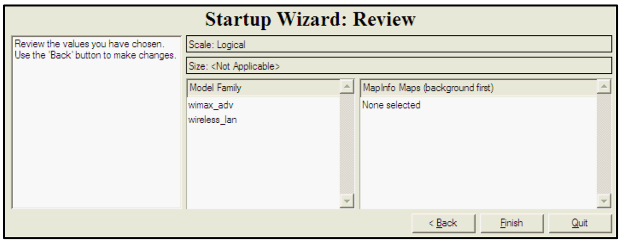

Figure 1: Setup wizard for the simulation

The scenario of the network depicts in Figure 2 for five nodes, similarly we design the scenario for 10, 20 and 50 nodes.

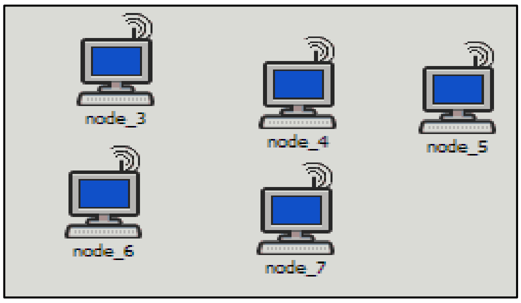

Figure 2: Simulation Scenario

We added an attribute in edit attribute in the nodes as min_CW to give the different value of the minimum contention window size. The Figure 3 shows the attribute fields. Each simulation runs for 600s. The result is the average of 10 runs with random seeds.

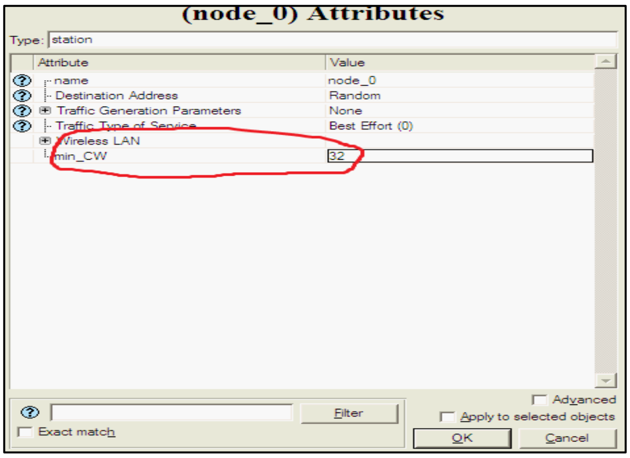

Figure 3: Attributes for varying contention window size

4. PERFORMANCE EVALUATION

In this section we compare the results of the DMAC protocols in the terms of throughput and delay.

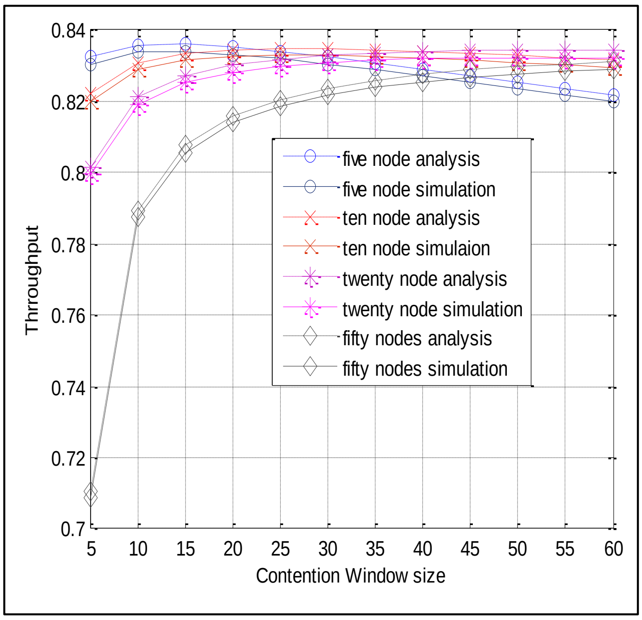

Figure 4: Average Throughput vs. Contention window size

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Figure **4** depicted the throughput vs. contention window size of our analytical and simulation results. In the figure we can see, the small network like five nodes network, there is no need to higher minimum contention window, we can get better result with very small minimum contention window i.e., CWmin = 5. In the other hand in small network if we take big CWmin we degrade he performance of the network because of average slot time is idle. In the figure we can see that the small network like n = 5, 10 and 20 we get better result than n = 50 with lower CWmin. But when the contention window size is increasing the network throughput of n = 50 is gradually increasing and with higher CWmin it get better result than the small network. The reason behind that with big network the lower CWmin gives repeating backoff size caused more collision degrades the network throughput.

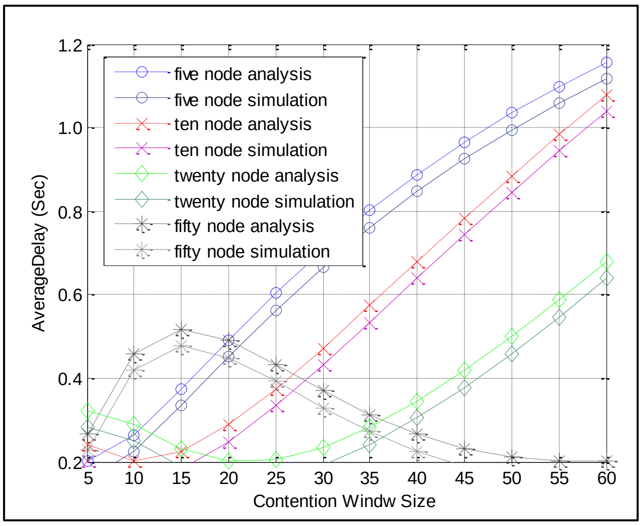

Figure 5: Average Delay vs. Contention window size

Figure 5 shows the curve of average delay vs. contention window size. In the figure we can see that the average delay with small network is lower at the lower CWmin, but when the CWmin is increasing the delay is drastically increasing because of maxium slot time is idle. In the case of n = 5 , 10 and 20 nodes, initially the delay is very low but when the CWmin is going higher it is suddenly increasing. However, in the case of big netwok i.e. n =50, initially the delay is higher but when the CWmin is increasing it going down, because with big network , lower contention window increases collision.

5. CONCLUSION

This paper analyze the network throughput and delay in terms of varying CWmin for small and big network and validate the result by simulation done in OPNET 14.5. The analysis and simulation results shows that with small network no need to take big CWmin, it will degrades the network performance. We should take the CWmin according to the size of the network, would improve the network performance.

6. ACKNOWLEDGEMENTS

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