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Performance Evaluation of ALOHA-CS MAC Protocol

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PERFORMANCEEVALUATIONOFALOHA-CSMACPROTOCOL

Strictly as per the compliance and regulations of:

Performance Evaluation of ALOHA-CS MAC Protocol

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I. Introduction

Medium Access Control (MAC) protocols are collection of algorithms for solving the problem of sharing a single channel by multiple transmitting nodes. The problems can be solved by partitioning the channel, or by allowing random access of the transmitting nodes or by hybrid algorithms [2]. The performance of any algorithm or protocol is evaluated on the basis of some factors: average time of a packet spent in the transmission queue, throughput- fraction of channel capacity for useful data transmission, fairness to the transmitting nodes, stability and robustness against channel fading, power consumption, support for multimedia etc. Pure ALOHA is a random access protocol for solving the problem for sharing a single channel by multiple transmitting. In this paper, the performance of carrier sense Pure ALOHA protocol is analyzed on the basis throughput and the average number of retransmission of the packets. The paper is organized as follows: Random access technique for sharing a single access point is introduced is section II. In section III, the mathematical formulation of Pure ALOHA technique is show. In Section IV, the system model is introduced, simulation techniques are discussed and the results are analyzed.

II. Random Access Technique

In Random access technique, no portion of the channel is kept fixed for any transmitting node, rather the channel is allocated to the transmitting nodes on a random basis. When a packet comes to the transmitting nodes it checks whether the channel is free. If it is free, the node sends the packet through the packet. In case of the channel being occupied, the packet is retransmitted after a random interval according to some algorithms for retransmission. It specifies how to detect collision and how to recover from collisions.

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III. The Pure Aloha Technique

For analyzing Aloha in communication, let all packets have same length L and required T seconds for transmission. This can be visualized in Fig .1. The figure 1 shows three stations A, B and C that have sent packets. At first packet A send a time t_o, If packet B send any time between time $t_o - T$ and t_o, then end of packet collides with beginning of packet A . If packet C sends any time between time t_o and $t_o + T$, starts of packet C collides with end of packet A.

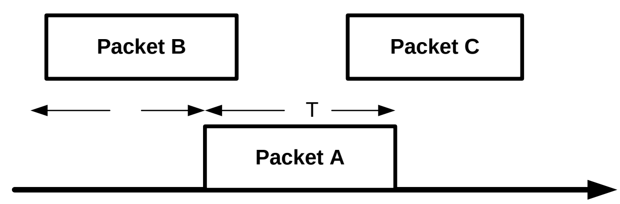

Fig. 1 : Pure Aloha

Collisions occur if packet transmissions overlap by any amount of time. Since all the packet overlap with part of another, no transmission was successful.

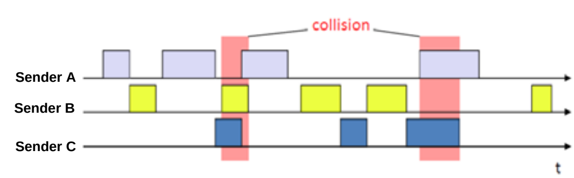

Fig. 2 : Aloha collisions

The transmission of a packet is successful if the packet does not collide with other packets at the destination.

In Pure ALOHA the vulnerable period- the time interval during which the packets are susceptible to collisions with transmissions from other users is considered to be twice the transmission length of each packet. For the study of pure ALOHA it is assumed that all the packets have same packet length, channel data rate is fixed and the users generate new packet at random time interval.

The number of packet generated per unit time follows Poisson's distribution:

$$\Pr[k] = \frac{\lambda^k e^{-\lambda}}{k!} \qquad (1)$$

Where, k is number of packet generated per unit time, λ is the only parameter of the Poisson's distribution i.e. the average number of packet generated per unit time [3].

The performance of the system is characterized by throughput S of the system.

$$S = \begin{bmatrix} \textit{Average number of Packet} \\ \textit{generated within} \\ \textit{packet transmission time}, T_p \end{bmatrix} \begin{bmatrix} \textit{Probability of} \\ \textit{no collision} \end{bmatrix}$$

Here,

$$\begin{matrix} \textit{Probability of} \\ \textit{no collision} \end{matrix} = \begin{matrix} \textit{Probability of} \\ \textit{generating no packet} \\ \textit{within vulnerable time}, 2T_p \end{matrix}$$

$$= \Pr[0] = \frac{(2\lambda T_p)^0 e^{-2\lambda T_p}}{0!} = e^{-2\lambda T_p}$$

$$S = (\lambda T_p) e^{-2\lambda T_p} = G e^{-2G} \qquad (2)$$

Here, G is the offered load. When offered load is 0.5, the throughput is maximum and maximum throughput for pure ALOHA is 18.7%. But here we uses Carrier Sense (CS) ALOHA, which senses whether the channel is free before transmission so the throughput is greater than throughput for normal (without carrier sensing) pure ALOHA.

IV. Protocal Discption and Model

Carrier sense ALOHA is different from others ALOHA. It extends the carrier sensing function to include all packets regardless of whether the sensing device is the recipient or not. Aloha is predecessor to carrier sense multiple excess systems used in many broadcast system. Thus ALOHA depends on the ability of a node to detect or learn that a collision has occurred [4]. Here the evaluation is considered a wireless local area network having *N* nodes and a single access point which is shown in Fig .1. The four nodes are competing to gain the access of AP for transmitting their data packets. The MAC protocol used for sharing the AP is ALOHA with carrier sense (ALOHA-CS). Therefore, a node with a new data packet immediately senses the carrier. If the carrier is idle, the node transmits the packet immediately. If the carrier is busy, transmission of the packet is delayed by an integer number of packet duration. After retransmission try by the maximum allowed times, a packet will be dropped.

The simulation has been performed on a MATLAB based Monte-Carlo simulation platform. Here, a wireless local area network (LAN) with a single access point (AP) and four nodes competing to gain the access of AP for transmitting their data packets is considered which is illustrated in Fig. 3.

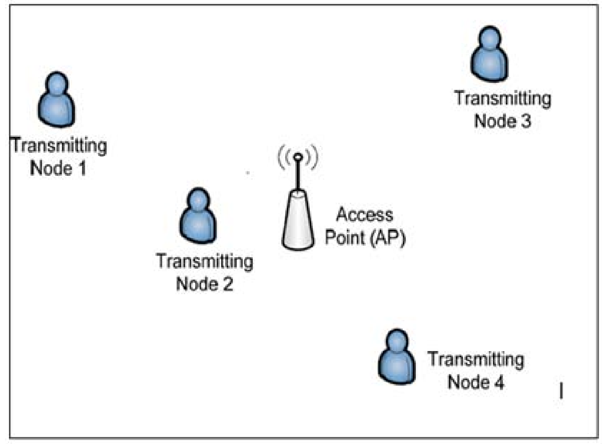

Fig. 3 : Access Point and Trasnmitting Nodes inside LAN

V. Simulation and Result

a) Random Packet generation

Packet from each transmitting node is generating according to Poisson's distribution, so the time interval between each packet is an exponential distribution with mean $1\,/\,\textit{no of packet generation in unit time}$. Exponentially distributed random numbers are generated in MATLAB for representing packet access in the access point. All the packets are equally probable to come from any of the transmitting nodes; so they are distributed among the transmitting nodes using uniforms integer random number generator from 1 to 4. A packet in access point can be retransmitted packet or a fresh packet, where a packet can be retransmitted not more than 8 times.

b) Throughput Analysis

Throughput is defined as the ratio of the successfully transmitted packet per sec to the number of packet generated per sec. In pure ALOHA a node can start transmission at any time. In slotted ALOHA, all nodes have synchronized clocks marking frame boundary times (the clock period is the time for one frame transmission) and a node wishing to transmit does so at the start of the next frame slot. In both cases, a node transmits without checking the state of the channel [5].

The throughput which is defined as the portion of channel bandwidth for successful transmission i.e. percentage of successful transmission of total transmission is calculated and plotted for three different packet lengths: 2000, 4000 and 10000 bits in Fig.4.

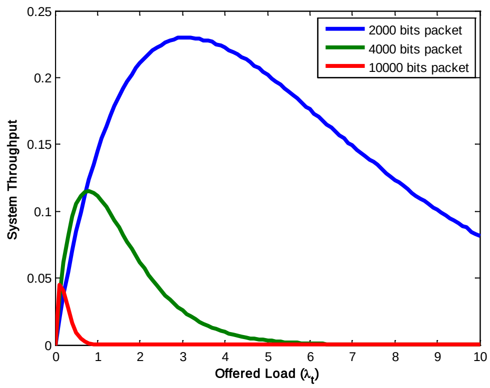

Fig. 4 : System Throughput Vs. Offered Load (λ_t)

Fig.4 indicates that throughput of packet length 4000 is higher than packet length 10000 and throughput of packet length 2000 is higher than packet length 4000.

c) Average No. of Retransmission

The Average number of retransmission is also calculated for the three packet lengths which increases with offered load as expected.

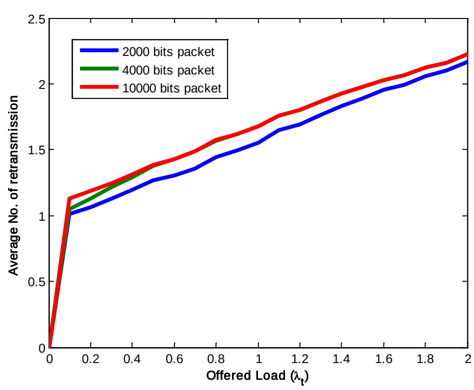

Fig. 5 : Average No. of Retransmission Vs. Offered Load (λ_t)

For a given critical limit of the new packet generation rate, the number of transmission control is not needed for a stable operation. The reason is that if the new packet generation rate is below a certain limit, the probability of success is very high because of the lower aggregate traffic generation rate [6]. The probability of retransmission is very low in that situation. Therefore, the aggregate traffic generation is lower even with the higher maximum allowable number of transmissions. The aggregate traffic generation rate increases with the multiplication of the retransmission probability and number of transmissions, for a given new packet generation rate[7]. If the retransmission probability becomes very low because of higher success probability, the multiplication of retransmission probability and the number of transmissions also become very low. Hence, the aggregate traffic generation rate becomes almost the same as the new packet generation rate. Thus, the throughput also remains almost constant regardless of the augmentation of number of transmissions. This lower aggregate traffic generation rate is not sufficient to make the system unstable. This critical limit of the new packet generation rate depends on the number of users and the type of capture.Fig.5 shows that the number of retransmission vs offered load. The average number of retransmission increases as the offered load increases.

VI. Conclusion

Aloha-CS is simpler and more scalable, as it only needs a small amount of memory, and does not rely on additional control messages. Aloha-CS, on the other hand, requires the use of additional packets, which serve as advance notification to neighboring nodes, so that they can avoid transmitting packets that could result in collisions. The Aloha-CS needs to collect and store more information, therefore it requires more resources. Due to the need to select a suitable lag time for a given network setting, the scheme is less scalable as it needs to check if its lag time is still appropriate whenever there are any significant topology changes. However, the extra cost allows the Aloha-CS to achieve much better throughput and collision avoidance. Throughput maximizes for a definite offered load and average number of retransmission increases with offered load as expected.

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