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Random Multiple Access Scheme Protocol

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Abstract: ***This paper considers random access protocol, which is part of multiple access scheme protocol. It focuses on carrying out a background research of the Aloha and CSMA family in terms of performance, throughput and offered load. Furthermore, the paper presents, compares and discusses the measurements result obtained in Aloha's and CSMA's family in terms of throughput and offered load using Matrix Laboratory, C++ and QualNet simulator.***

Index Terms: Aloha, CSMA, MAC, QualNet, Simulation.

I. INTRODUCTION

Random multiple access scheme protocols allow the transmission of different packets or resources for several users. This includes a dynamic sharing of the medium used for the transmission among several users in view to matching a burst data traffic generated. Packet transmission is random among users because access to the medium is based on the contention because there is no priority or scheduled time for transmission [1]. Furthermore, packets involved in collision are discarded or lost; hence, the broadcast channel is wasted during the collision period. The effect of collision is caused by congestion amongst the nodes transmitting at the same time [2].

The classification of the multiple access protocols is shown in Fig. 1.1: In this paper, the focus is on the random access protocol, also known as contention method protocol because all transmitting stations compete with each other to access the medium and no specific time is scheduled for transmission of packets [3]. In the OSI networking model the multiple access scheme protocols reside in the Medium Access Control (MAC) layer, which is between the Data Link Control (DLC) layer and Physical layer [4].

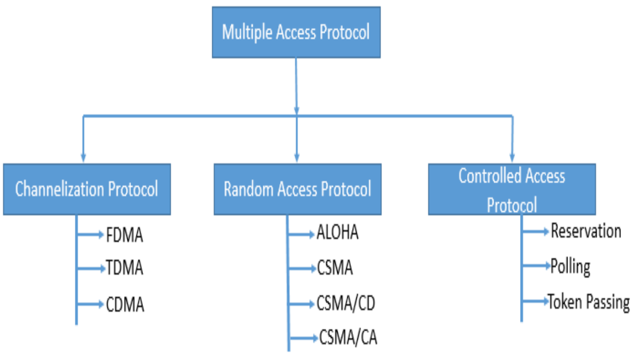

Fig. 1.1: Classifications of multiple access protocols

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II. METHODOLOGY

A. *Aloha Family*

Aloha is the first random multiple access scheme developed. Norm Abramson and his team at the University of Hawaii developed it in 1970. Its implementation is simple and straightforward. It exhibits the characteristics of a contention-based protocol that does not assure the successful transmission of packets in advance [3]. Logical star network topology is used in Aloha with a central hub, receiving all the packets and then transmitting all these packets using different channels. In the process of transmission, if a collision occurs data cannot be received, thus it will be retransmitted until all the packets are delivered correctly to the recipients [5]. Aloha family is divided into Pure and Slotted-Aloha.

Pure Aloha

Pure Aloha is the basic protocol in the Aloha family; it operates as a single hop system. Packets (frames) are sent, whenever a user of a particular transmission channel wants to send as a result, there is a tendency of a collision, if thus occur, it waits for a random period which is called a back-off algorithm time to resend the packets [6].

Mathematically;

$$S_1(g) = g \times e^{-(2\times g)} \quad (1)$$

$\therefore S_1(0.5) = 0.5 \times e^{-(2\times 0.5)}$

$S_1(0.5) = 0.5 \times 0.3679 = 0.1839$

The maximum throughput S_1 is 18.39%, when "g" offered load is 0.5, the Pure Aloha will have a total arrival rate of exactly one packet vulnerable period [1].

Slotted Aloha

Slotted Aloha is a variation of the Pure Aloha because of slotted channel. Packets (frames) are sent using time slot that is generated thus packets transmission can only start at the start of a particular time slot. The throughput of a Slotted Aloha probability is double the throughput of a Pure Aloha [2]. Mathematically;

$$S_2(g) = g \times e^{-(g)} \quad (2)$$

The maximum value of the throughput S_2 is 36.79%, when the offered load "g" is equal to 1.0 making the Slotted Aloha to have a bimodal behaviour similar to the Pure Aloha [1].

$\therefore S_2(1.0) = 1.0 \times e^{-(1.0)}$

$S_2(1.0) = 1.0 \times 0.3679 = 0.3679$

B. *CSMA Family*

This scheme sense the medium before transmitting, thus the possibility of a collision is reduced of a packet from another transmitter. However, due to the propagation delay there are

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still chances of collision amongst the carrier signals.
It makes use of a back-off algorithm in repeating the transmission of packets in the medium. They are grouped into Persistent, Non-Persistent and Slotted Non-Persistence CSMA [6].

Persistent CSMA

Persistent CSMA is a multiple access scheme protocol where the user senses or listens to the transmission medium; when the medium is silenced or idle, it thus transmit packets with a probability of one. It is known to have a comparatively high collision rate [6]. Mathematically;

$$S_3(g) = \frac{g\times(1+a-e^{-a\times g})\times e^{-g\times(1+a)}}{(1+a)\times(1-e^{-a\times g})+a\times e^{-g\times(1+a)}} \quad (3)$$

The maximum throughput S_3 is given when the offered load "*g*" and interval time "*a*" is 1.0 and 0.01 respectively, these values are chosen based on optimization.

$$S_3(1.0) = \frac{0.0073}{0.0137}$$
$$\therefore S_3(1.0) = 0.5307$$

Non-Persistent CSMA

Non-Persistent CSMA operates such that when the transmission medium is busy it delays for a random period (using the back off-algorithm) before listening to the medium again and make decisions if to send or not, it is comparatively not greedy in transmission [6]. Mathematically;

$$S_4(g) = \frac{g\times e^{-(a\times g)}}{g+(1+2\times a)+e^{-(a\times g)}} \quad (4)$$

Non - Persistent CSMA S_4 has a maximum throughput of 81.48% when the offered load and interval time are 10.0 and 0.01 respectively.

$$\therefore S_4(10.0) = \frac{9.0448}{11.1048}$$
$$S_4(10.0) = 0.8148$$

Slotted Non-Persistent CSMA

Slotted Non-Persistent CSMA is a multiple access scheme protocol that when the transmission medium is free all through a current slot, makes decisions if to transmit or not. Therefore if the probability of transmitting is *P*, then, to defer is 1 − *P* [6].

Mathematically;

$$S_5(g) = \frac{a\times g\times e^{-(a\times g)}}{1-e^{-(a\times g)}+a} \quad (5)$$

$$\therefore S_5(13.5) = \frac{0.1180}{0.1363} \quad \therefore S_5(13.5) = 0.8655$$

The maximum throughput for Slotted Non - Persistent CSMA, S_5 is 86.55% when the offered load "*g*" is approximately 13.5 and the interval time remain constant [1].

III. RESULTS AND DISCUSSION

In the research and development of random access protocol, in addition to its implementation, simulation results are essential for analysis and testing. This session presents and analyses the simulation results obtained from the different simulations. In this paper, the simulations were performed using QualNet, Matlab and C++. In each simulation, the throughput and offered load performance results were analyzed, the throughput is in bits per second while the offered load is the number of packets.

A. Matlab Result

In the Matlab implementation as seen in Fig. 3.1, each of the different random access protocol results has presented the perfect performance just like the theoretical result. Each random access protocol throughput is equivalent to the theoretical calculation. The throughput shows the number of packets transmitted successfully to the end station for each random access protocol.

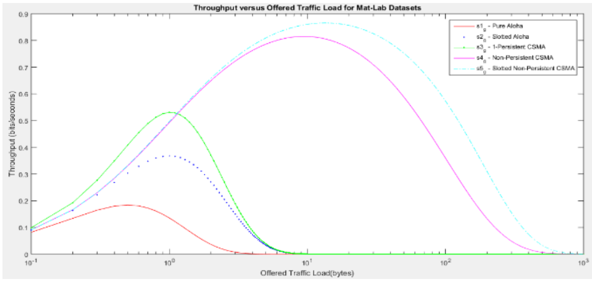

Fig. 3.1: Mat-Lab Simulation results of all the different random access protocols

B. Object Oriented Programming in C++ Result

Fig. 3.2 represents C++ implementation result, an Object Oriented Programming approach is used where throughput values of all the different random access protocol results are written into a text file. The throughput results are the same with the one obtained in Matlab and theoretical approach.

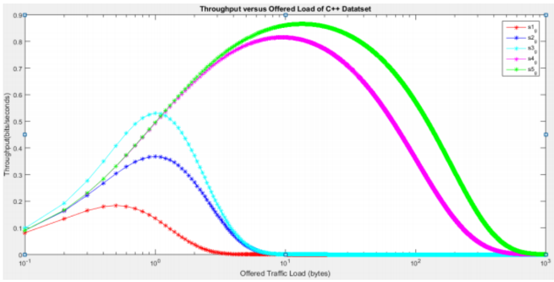

Fig. 3.2: C++ Simulation results of all the different random access protocols

C. QualNet Result

The QualNet implementation considers the values of different values of offered load transmitted in the MAC protocols, a constant packet size of 48bytes is being transmitted, thus for two items transmitted it is expected to deliver 96 bytes (2 * 48 bytes). Table III.I shows the configuration settings for all the MAC protocols.

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Table III.I: Configuration parameters for random access protocols

Configuration Parameters	Values
Simulation tool	QualNet Edu. Version 7.4
Interface	802.11P
Network Simulation Time	100 seconds
Traffic Type	CBR
Interval Time	0.01
CBR Packet Size (bytes)	96, 192, 384, 768, 1008
CBR Packet rate	100 seconds

Based on Table III.I configuration settings, using a bus topology network, the result obtained for the different random access protocols is shown in Fig. 3.3.

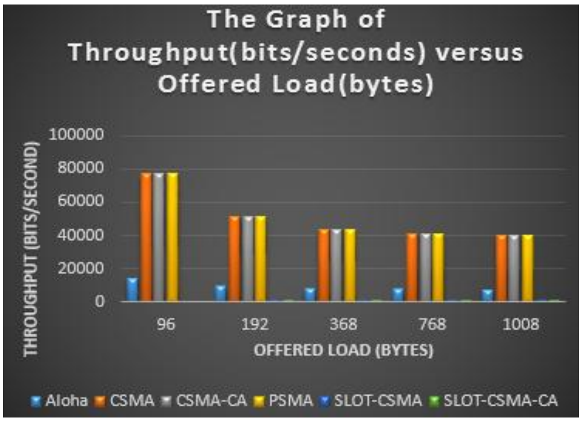

Fig. 3.3: QualNet Simulation results of all the different random access protocols

D. Analysis of the Results

The results obtained from Matlab, C++ and QualNet simulations indicate clearly that Matlab and C++ simulation results are the same with theoretical performance. Mathematically, as the offered load increases, the throughput or the number of packets sent successfully to their various destinations per time will be decreasing tending towards zero. In the QualNet simulator, the result of the Aloha family seems to be realistic, while the CSMA family result is not realistic when compared with the theoretical result because of simulation bugs in the QualNet simulator. Furthermore, in the transport and application layer, there is a very high average delay of unicast and broadcast data of Aloha family compare to CSMAs family, this lead to high delay of transmission, which causes congestion in the medium. In essence, most of the MAC protocol provided in QualNet such as PSMA, CSMA-CA, and Slot CSMA-CA are generic MAC protocol, meaning they behave relative to random access protocols, unlike C++ and Matlab simulations that used the full characteristics of the MAC protocols provided in the multiple access schemes. This shows that the Generic MAC protocol only imitates the basic functionalities of random access protocols, and does not specifically performs the function of MAC protocols.

IV. CONCLUSION

The importance of the random access protocol is not only in a communication system, but both in computing system and storage/server devices of any kind where resources is being shared among many independent users in a network. Thus, it is effective both in wireless and wired local area network. Considering the various research done about random access protocol, there is yet a perfect solution to the problem of congestion, this is evident in the performance of throughput, jitter, total packets received and dropped in the process of transmission.

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