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Performance Analysis of Slotted ALOHA with Rayleigh Fading

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Abstract-ALOHA is a wireless packet data transfer network protocol whereas Slotted ALOHA is a modification of pure ALOHA. The time frame is divided into several segments, in which length of each packet transmission time will be equal to each segment. Random packet transfer may cause collision. The performance of slotted ALOHA is better compared to pure ALOHA as per the consideration of throughput in each case. But various environmental effects and fading may occur which creates instability in their performance. In this paper, the performance of slotted ALOHA for 20,000 slots is analyzed through which 50 nodes are transmitting packets. It is observed that, throughput reaches near zero for higher arrival rate. Again the performance of this Slotted ALOHA network considering path loss and Rayleigh fading is analyzed.

Keywords- *Slotted ALOHA, Packet Transmission, Path Loss, Rayleigh Fading*

I. INTRODUCTION

The goal of this work is to obtain insight into the performance attributes of media access control (MAC) protocols in wireless networks. In this simulation, the performances of the ALOHA protocols are analyzed in spatially distributed wireless networks. Users/packets arrive randomly in space and time according to a Poisson point process. For wireless environment multipath fading and path loss introduced by channel has been considered. An SINR-based model is considered, and a packet transmission is encountered as successful if the received SINR is above a predetermined threshold value for the entire duration of the packet. The final comparison results show that Slotted ALOHA performs better when path loss and multipath fading is considered. Here a random probability distribution function has been considered to decide whether a user is allowed to transmit or not. The result also shows how Slotted ALOHA performs in different probability threshold.

II. BACKGROUND AND RELATED WORKS

The performance of unslotted ALOHA was studied in [1]. It showed the distribution of packet length in wireless environment. [2] introduced mathematical expression for successful transmission of packets in ALOHA channel. The Slotted ALOHA protocol was studied and system throughput was analyzed for various conditions in [3, 4]. The performance of Slotted ALOHA was also analyzed in [5] which showed different behavior of single and multi-packet transmission depending on traffic size. Again in [6], authors proposed retransmission slot reservation scheme with respect to offered load to improve the throughput performance over ALOHA and Slotted ALOHA. In [7], authors developed a model of transmitting packets and analyzed capacity of Slotted ALOHA in Rayleigh Fading channels.

III. RESEARCH APPROACH AND MODEL

A. *Throughput Analysis*

In Slotted ALOHA, in case of conflicts, packets are overlapped completely not partially. For rate of traffic of channel offered (G), according to [8] the equation of troughput becomes

S=Ge^(-G)

A random discrete variable X is known to have a Poisson distribution with parameter λ > 0, if, for k = 0, 1, 2, ..., the probability function of X is given by:

f(k,λ) = Pr (X = k) = (λ^k e^(-λ))/k!

Where, e is Euler's number (e = 2.71828...)

k! is the factorial of k.

A model used commonly for random and mutually independent message arrivals is the Poisson process. So for this simulation 'poissrnd' has been used to get a probabilistic packet arrival data.

B. *Path Loss Model*

The signal which is received in receiver terminal becomes weaker due to the changing propagation attenuation with the distance. Let L(d) denote the log-distance path loss, which is a function of the distance d between the transmitter and the receiver. Then according to [9, 10] path loss becomes

$L(d) = L(d_0) + 10k \log (d/d_0)$ dB, $d >= d_0$

Where k is the path loss exponent and d_0 is the close-in reference distance. According to [9, 10] typical values of path loss exponent for various environments are shown in following table:

TABLE I. VARIATION OF PATH LOSS EXPONENT AT DIFFERENT ENVIRONMENTAL CONDITION

Path loss exponent, k	Environmental Condition
2	Free space
2.7 to 3.5	Urban cellular radio
3 to 5	Shadowed urban cellular radio
1.6 to 1.8	In building with line of sight
4 to 6	Obstructed in building
2 to 3	Obstructed in factories

In this work the following considerations have been made:

Path loss exponent = 3, for urban cellular radio
d_0 = 100 meter, for outdoor microcell

C. Multipath Fading

In wireless communications, multipath interference may cause either in constructive or in destructive mode. Destructive interference is the cause of fading which creates signal distortion or phase shifting. Magnitudes of the signals distribution due to Rayleigh distribution is known as Rayleigh fading [11].

In this simulation, 4 paths have been considered for the radio signal. Their delay and gain vector are as followed:

Delay Vector = 1.0e-004 * [0 0.0400 0.0800 0.1200];

% Discrete delays of four path channels

Gain Vector = [0 -3 -6 -9]; % Average path gains (dB)

16 QAM is considered as a modulation technique with addition of Additive white Gaussian noise. Then average received power level is calculated. Based on the distance of the node an average path loss is taken into account and total power received at the antenna is measured.

In this paper, distributed users are assumed in a circular area with angle distribution uniformly over 2*pi. Users are distributed in the circular area with the distribution which follows the probability density function (pdf) f(x)= 2r.

The signal gets affected by path loss or fading and noise has been introduced. Considering this strength of signal and noise, signal to noise ratio (SINR) has been calculated. A threshold SINR level is considered when multiple users try to transmit their packet through same slot. This threshold value for SINR is set 10 dB. When a single user has SINR greater than this threshold value i.e. 10 dB it is considered as a successful transmission of the packet.

The activeness of the user has also been considered by setting a probability for individual. Two probability 1/20 and 1/30 are set to determine whether the user become active or not.

IV. EXPERIMENTAL OUTCOME

A. Simulation of Slotted ALOHA

In this simulation, 20,000 slots and total number of 50 nodes are considered for this simulation. A node tries to transmit with a probability. Total number of packet arrival and packets being transmitted for packet arrival rate range from 0 to 2 has been calculated. Performance of Slotted ALOHA channel for different probability has been plotted in Fig 1.

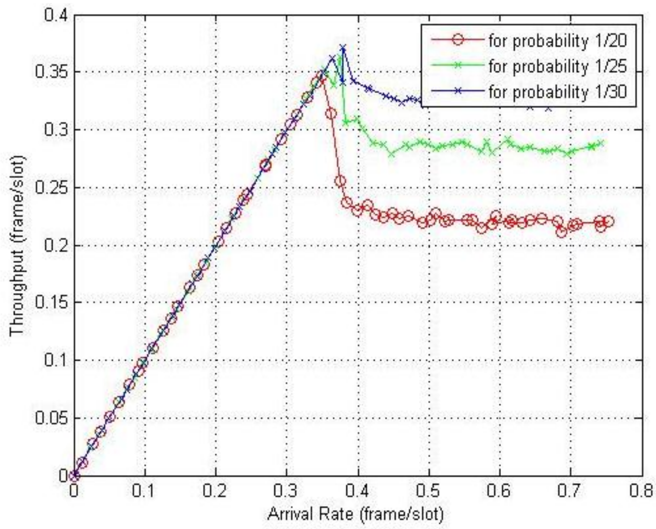

Figure 1. Performance of Slotted ALOHA channel for lower probability

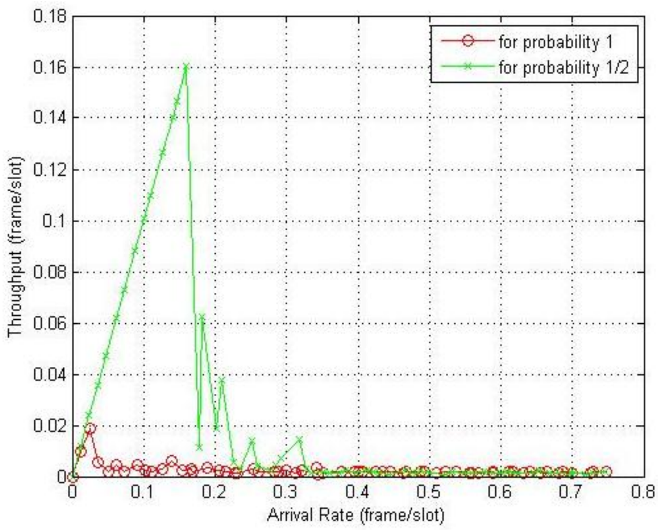

Figure 2. Performance of Slotted ALOHA channel for higher probability

From the Fig 1 and Fig 2, it has been noticed when each node tries to transmit with a higher probability, for small arrival rate the graph is linear which indicates all arrived packets are being transmitted. As arrival rate increases more collision occurs resulting decrease of throughput drastically. As each node tries to transmit with a certain probability for higher arrival rate it reaches near saturation. Throughput reaches near zero for higher arrival rate as collision occurs in the slots.

B. *Simulation of Slotted ALOHA with Rayleigh Fading*

When a user transmits the signal, it gets affected by path loss, multipath fading and noise. Average received power of individual nodes with considering this path loss, noise and multipath fading is calculated. A 10 dB threshold of SINR level is set. So when there is a collision in the slotted ALOHA simulation the SINR value of individual node is calculated with the consideration that received power of other nodes as interference. A successful transmission of packets is assumed to occur on a slot when the level of SINR of a single user becomes greater than the threshold value.

With this scenario the channel has been again simulated for 20,000 slots and 50 nodes. A node tries to transmit with a certain probability and here it is 0.05. Channel performance is again analyzed by calculating the rate of packet arrival and packets that are being transmitted for the considered range of arrival. The performance of the slotted ALOHA channel with Rayleigh fading has been shown in Fig 3.

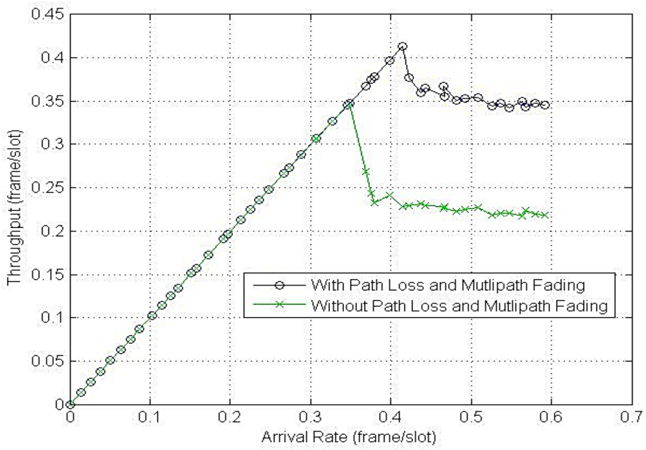

Figure 3. Performance of slotted ALOHA channel with and without multipath fading and path loss

From the two graphs shown in Fig 3, it is observed that the slotted ALOHA simulation with considering multipath fading and path loss has a throughout greater than the situation where multipath fading and path loss haven't been considered. So simulation concludes that Fading channels improve the capacity of slotted ALOHA networks.

V. CONCLUSION

All results in this simulation are very near to analytical result. It is noticed for low traffic rate that all scenarios have linear throughput. But when the frame arrival rate increases different scenario behaves differently. For lower probability threshold throughput reach higher value compared to higher probability threshold, as with low probability tends to have fewer collisions. Rayleigh Fading and path loss diminish mutual packet interference which reduces blocking probability. As a result there is increase in throughput of Slotted ALOHA network.

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