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Employing Channel Sensing and Equalization Mechanisms for Performance Enhancement in Slotted ALOHA Networks

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***Abstract*— With the advent of IoT and connected networks, the ALOHA protocol has remained an active area of research for adaptive data transmission. Numerous studies have been conducted to enhance system performance regarding throughput.**
This work presents a channel sensing technique for Slotted ALOHA that examines the channel and assesses circumstances of collision or potential collisions.
Equalization has also been incorporated to circumvent the effects of channel noise and disturbance for data packets.
The system's performance has been assessed based on its arrival rate. attenuation and throughput. The results clearly indicate that the throughput of colliding packets is inferior to that of non-colliding packets.

***Keywords*— ALOHA, Slotted ALOHA, Throughput, Arrival Rate, Channel Sensing, Equalization.**

I. INTRODUCTION

The use of slotted ALOHA has remained as one of the most simple to implement yet effective techniques for packet data communication. A technique called channel load sensing protocol CLSP, a hub station senses the channel load, which is the number of ongoing transmissions.
If the channel load is less than a certain threshold, then packet accesses are allowed. Otherwise, packet accesses are rejected until the ongoing transmissions fall below the threshold.
Without the access timing delay, which means the time difference between channel load sensing and timing of packet access, the throughput of a spread unslotted Aloha system with CLSP is satisfactory. When the access timing delay is no longer negligible, a wrong channel load information may be given as the channel load changes moment by moment.
The packet access control based on this wrong information results in degradation of the system performance. Therefore, a spread unslotted Aloha system with CLSP is not practical with the access timing delay. There has been no mention of the effect of the access timing delay in any of the papers.
The object of this paper is to propose a novel spread slotted Aloha system with CLSP and show a significant improvement of the throughput performance even in the presence of access timing delay.
The channel is to be continuously sensed or monitored for the collision or colliding conditions prior to packet data transmission.

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II. CHANNEL SENSING FOR ALOHA

There are several techniques for the sensing purpose of the cognitive channel which are being discussed here. Only the frontlines are being discussed here which show the maximum promise in the accurate spectrum sensing. This technique is used for the energy detection mechanism and senses the energy of the channel at any given point of time. The hypothesis that governs this technique is the following:

$$\boldsymbol{h(t) = k(t); ideal\ no\ packet\ collision} \quad \textbf{(1)}$$

$$\boldsymbol{h(t) = k(t) + j(t);\ collision\ present} \quad \textbf{(2)}$$

The chances for a false alarm occur when there is collision present but the CSI suggest that collision is absent or vice versa. The chances of false alarm increase when there is actual addition of noise in the desired spectrum. It is noteworthy that such noise effects may lead to a false interpretation that there is collision noise being injected in the signal spectrum and it is the act of eavesdropping by the adversary. This however is not true and leads to misleading and inaccurate results. The effect can be summarized as follows:
Let the threshold for collision to be present by 'T'

$$\textbf{If } \boldsymbol{h(t) > T; Collision\ \ presnet} \quad \textbf{(3)}$$

However,

$$\textbf{If } \boldsymbol{h(t) + n(t) > T} \textbf{ holds true;} \quad \textbf{(4)}$$

Then there is a clear chance of false alarm often computed as the probability of false alarm of security threat.

III. MATHEMATICAL MODELLING OF CHANNEL SENSING AND EQUALIZATION

The channel is to be sensed based on the collision activity and can be done using energy sensing. The proposed technique can be explained using the following algorithm:

- Step1. Generate a random serial data set that is to be transmitted in the form of 0s and 1s.
  Let it be given by:
  x(n)=random (n); where n is the number of bits are completely random
- Step2. Design a typical channel response of an ALOHA system.

Let the channel response in time domain h(t) in the frequency domain, let the channel response be H(f)
H(f)=F.T. {h(n)}
F.T. denotes the Fourier Transform

- Step3. Design frequency dependent collision or collision mechanism.
  Let the collision or collision power be:
  Pjam=f(frequency or subcarrier)

Here,
different frequencies are used for different users in the network, which are also called sub-carriers

- Step4. Design and add spectral noise
  Design a time domain noise signal n(t)
  Add it to the signal in the channel to get
  X=S+N
- Step5. Detect low, moderate and high collision action
  The decision is to be based on:

Low Channel Collision Activity: if sub-carrier gain<1.5*Ideal Subcarrier Gain
Moderate Channel Collision Activity: if sub-carrier gain>1.5*Ideal Subcarrier Gain>2*Ideal Subcarrier
High Channel Collision Activity: if sub-carrier gain>2*Ideal Subcarrier Gain

- Step6. Generate signaling points for the system and obtain the scatter plot for:
- No Collision Action
- Low Collision Action
- Moderate Collision Action
- High Collision Action
  The scatter plots can be plotted for
  Re{x(n)}
  Img{x(n)}
- Step7. Compute Throughput for 2 cases:

- Throughput w.r.t. arrival rate
- System throughput w.r.t. SNR

➢ Also compute signal fading with and without colliding packets

Step.8. Apply equalization based on:

$$E(t) = \frac{1}{\sum_{i}^{n} H(t - iT_S)} \qquad (5)$$

Here,

$E(t)$ denotes the time dependent equalizer response.

$H(t - iT_S)$ denotes the adaptive CSI.

T_S denotes the sampling time.

The simulation results are presented next:

IV. RESULTS

The simulation are presented for a time varying random channel with fading conditions The results are presented subsequently. The parameters evaluated are:

➢ Arrival rate at receiving end w.r.t. throughput

➢ Fading analysis w.r.t. distance considering collision

➢ ALOHA throughput w.r.t. SNR

➢ Channel Scatter.

The channel scatter has been evaluated to validate the channel response through the CSI.

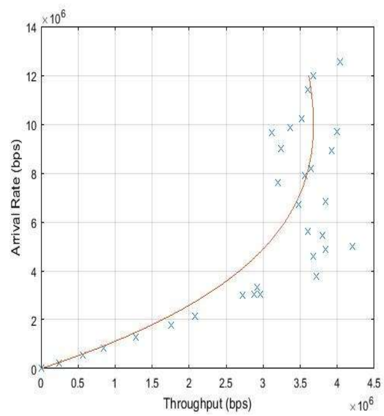

Fig.1 Throughput versus Packet arrival rate at receiving station

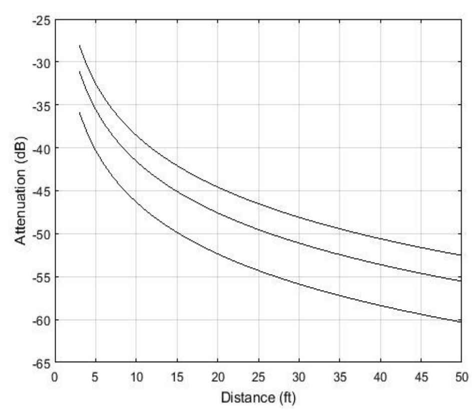

Fig.2 Fading in signal strength with respect to distance without colliding packets

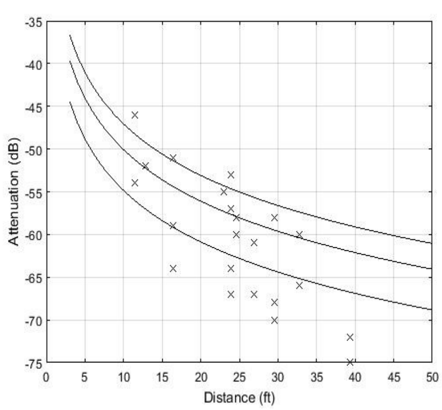

Fig.3 Fading in signal strength with respect to distance with colliding packets

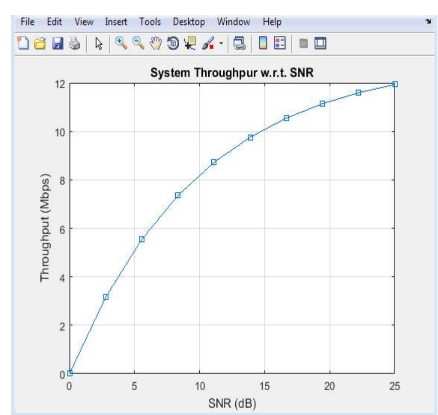

Fig.4 System Throughput w.r.t. SNR

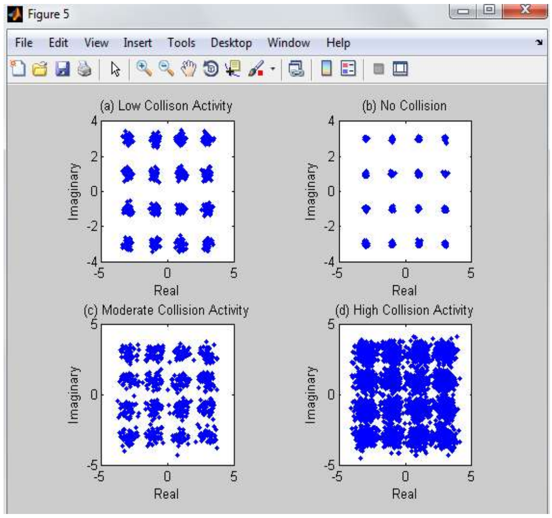

Fig.5 Scatter Plots for Different Collision Conditions

The results depict the following parameters:

- Arrival Rate
- Attenuation
- Throughput
- Channel Scatter

The coherence between the scatter conditions and the throughput can be clearly inferred as when the scatter is less, it results in higher throughput and vide versa.

V. CONCLUSION

Previous discussion indicate that fading and collision conditions may reduce the system throughput for ALOHA systems. The proposed work detects channel activity—high, low, or moderate collision—through energy detection of colliding packets. The estimated CSI is subsequently utilized for data packet transfer. It can be observed that for low collision conditions the channel scatter is less while the scatter increased with high collision validating the CSI based approach of the system. Leveraging the CSI along with equalization allows for high throughput of the system

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