"Modelling of the Anti-Collision Algorithm in RFID system"

Shafinaz Binti Ismail
"Faculty of Electrical Engineering, UniversitiTeknologi MARA"
"40450 Shah Alam, Selangor, Malaysia"
"shafinaz.ismail@gmail.com"

ABSTRACT: **In RFID system, the greatest challenge faced is the tag could not be read due to collisions.This proposal studies on the modeling of the anti-collision algorithm in RFID system. We will focus on analyzing the performance of the Aloha and slotted Aloha algorithms by deriving the performance metrics of throughput. Finally, we will compare this metric with the results from simulation by using OPNET software.**

Keywords: ***RFID, Aloha, Slotted Aloha, Throughput***

I. INTRODUCTION

Nowadays, "Radio Frequency Identification (RFID)" is developing as a major technology enabler for tracking goods and assets around the world. RFID is the wireless non-contact use of radio-frequency electromagnetic field to transfer data, for the purpose of automatically identifying and tracking tags attached to objects [1]. According to Roy Want, "RFID has moved from obscurity into mainstream applications that help to speed up the handling of manufactured goods and materials".

RFID is widely used to identify, track, and manage the tagged animate or inanimate objects automatically using wireless communication technology. For example, barcode is still the dominant player in supply chain industries and departmental stores. However, RFID technology is becoming more important in replacing barcode technology nowadays as several main advantages such as communication without line-of-sight (LOS), robust system, greater data capacity, higher read rate than barcode, and write capability because RFID tags can be rewritten with new data [2].

II. ANTI-COLLISION ALGORITHMS

In general, there are two types anti-collision algorithm widely used in RFID systems. Aloha anti-collision protocol is most widely used in RFID system. There are two types of Aloha anti-collision protocol which are Pure Aloha and Slotted Aloha. Aloha algorithm was selected to evaluate and analyze the RFID performance due to its simple implementation. Tag collision in RFID systems occurs when multiple tags are energized by the tag reader simultaneously. This problem is often seen whenever a large volume of tags must be read together in the same RF field. The reader is unable to differentiate these signals and tag collision confuses the reader. [3]

A. ALOHA

Aloha algorithm is a simple anti-collision method based on TDMA. When the tag reaches the interrogation area of a reader, the tag will transmit the data immediately, and when more than one tag response at the same time, the collision occurs. The drawback of this algorithm is the high probability of collision. [4]

B. Pure Aloha

The pure Aloha protocol is very simple. It states that a newly generated packet is transmitted immediately hoping for no interference by others. Should the transmission beunsuccessful, every colliding user, independently of the others, schedules its retransmission to a random time in the future. This randomness is required to ensure that the same set of packets does not continue to collide indefinitely [5].

Pure Aloha is a single-hop system. Hence, the throughput is the fraction of time the channel carries useful information, namely non-colliding packets. The channel capacity is the highest value of arrival rate, λ for which the rate of throughput is equal to the total arrival rate. [5]

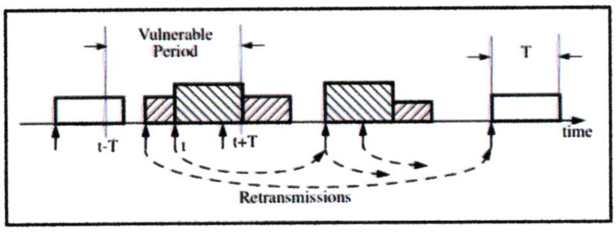

Figure 1: Pure Aloha Packet Timing

Consider a new or old packet scheduled for transmission at some time t (as shown in Figure 1). This packet will be successful if no other packet is scheduled for transmission in the interval t-T,t+T and this period of 2T is called the vulnerable period. The probability of this happening, that is, the probability of success, is that no packet is scheduled in an interval of length 2T and since the scheduling is Poisson distributed, we have the distribution of successful transmission as:

$$P_{suc} = e^{-2gT} \tag{2.1}$$

Now, packets are scheduled at a rate of g per second of which only a fraction of P_{suc} are successful. Thus, the rate of successfully transmitted packets is gP_{suc}. When a packet is successful, the channel carries useful information for a period of T seconds. Using the definition that the throughput is the fraction of time that useful information is carried on the channel we get:

$$S = gTe^{-2gT} \tag{2.2}$$

The equation of (2.2) gives the channel throughput as a function of the offered load. Defining $G \triangleq gT$ to be the normalized offered load to the channel, the rate per packet transmission time packets are transmitted on the channel, we have

$$S = Ge^{-2G} \tag{2.3}$$

The relation between S and G is depicted in Figure 2 which is typical to many Aloha type protocols. At G=0.5, S takes on its maximal value of $0.5e \approx 0.18$. This value is referred to as the capacity of the pure Aloha channel. [5]

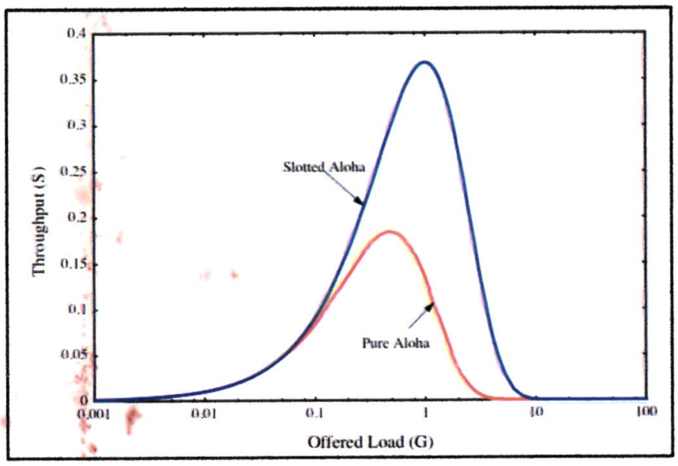

Figure 2: Throughput-Load of Pure and Slotted Aloha

C. *Slotted Aloha*

In slotted Aloha algorithm, the time is divided into several slots, and the tag must transmit data in one slot which it selects. So this method will decrease the probability of collision than Aloha algorithm, but the reader and tag must communicate synchronously. When there is only one tag in one slot, reader can interrogate with tag and require the information of tag correctly. Due to the limitation of the number of slots, this algorithm used in the case that there are a few tags in the area. [5]

A more efficient version of Aloha is the slotted Aloha protocol. In slotted Aloha time is divided into small time slots. Transmissions can only be initiated at the start of a time slot. Although slotted Aloha offers improved channel capacity over Aloha, neither protocol performs well under heavy traffic conditions. As the traffic load increases, transmissions keep colliding and infinite time delays are possible. [5]

The slotted Aloha variation of the Aloha protocol is simply that of pure Aloha with a slotted channel. The slot size equals T the duration of packet transmission. Users are restricted to start transmission of packets only at slot boundaries. Thus, the vulnerable period is reduced to a single slot. In other words, a slot will be successful if and only if exactly one packet was scheduled for transmission sometime during the previous slot. The throughput is therefore the fraction of slots or probability in which a single packet is scheduled for transmission. Because the process is composed of newly generated packets and the retransmitted packets is Poisson distributed so the throughput can be expressed as:

$$S = gTe^{-gT} \tag{2.4}$$

or using the definition of the normalized offered load G = gT

$$S = Ge^{-G} \tag{2.5}$$

The channel capacity is $\frac{1}{e} \approx 0.36$ and is achieved at G=1.

III. RESULT AND ANALYSIS

A. *Theoretical Analysis of Pure Aloha*

The performance of anti-collision protocol influences the overall success of the RFID system. Therefore, it is important to design a suitable anti-collision protocol to increase the system performance. In the Aloha based protocols, the overall performance is good when the number of tags in the interrogation zone is low.

In aloha, the RFID tag transmits its ID or data whenever it is in the read range of the reader irrespective of whether other tags are in transmission state. The analysis of throughput of the pure aloha in RFID is carried out in this section.

Theoretical analysis of Pure Aloha is based on the assumption that the frame arrival rate, the new generated frames and the retransmitted frames is following a Poisson process with a mean of Lambda (λ). Therefore, in order to verify the theoretical results, we use the same probability distribution.

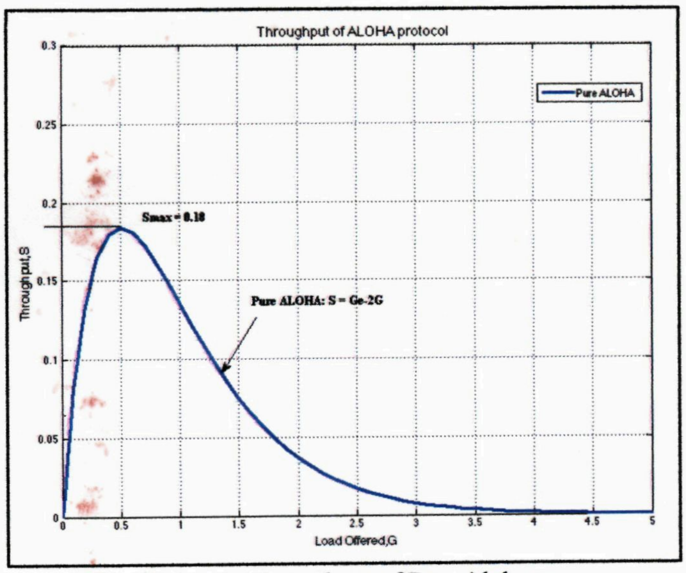

Figure 3: Throughput of Pure Aloha

Figure 3 shows the throughput for the pure Aloha. The efficiency reaches its maximum when the value of Lambda (λ) is 0.5. Pure Aloha normalised throughput is calculated by $S = Ge^{-2G}$. The maximum throughput occurs when G = 0.5 and S=0.18 which is the highest maximum throughput which is equal to 18%.

G	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
S	0.0	0.082	0.134	0.165	0.180	0.184	0.181	0.173

Table 1 : Throughput of Pure Aloha.

Table 1 shows the throughput value when S is calculated for selected G values by using the formula $S = Ge^{-2G}$.

B. *Theoretical Analysis of Slotted Aloha*

The theoretical analysis of Slotted Aloha is based on the assumption that the frame arrival rate, the new generated frames and the retransmitted frames follows a Poisson process with a mean of Lambda. Therefore, in order to verify the theoretical results, we use the same probability distribution.

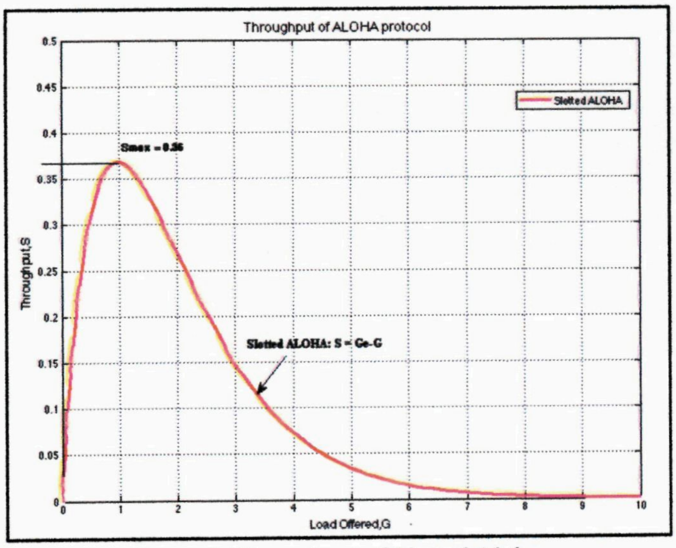

Figure 4: Throughput of Slotted Aloha

Figure 4 shows the throughput for the slotted Aloha. The efficiency reaches its maximum when the value of Lambda (λ) is 1. The Slotted Aloha normalised throughput is calculated by $S = Ge^{-G}$.The maximum of throughput occurs when G = 1 and S=0.368 which is the highest maximum throughput and equal to 36.8%. If G<1, too many idle slots are generated. If G>1, too many collisions are generated. The study of results by theoretical says that the performance of slotted Aloha protocol is becoming worst as the load increases.

G	0.0	0.2	0.4	0.6	0.8	1.0
S	0.00	0.164	0.268	0.329	0.359	0.368

Table 2 : Throughput of Slotted Aloha.

Table 2 shows the throughput value when S is calculated for selected G values by using the formula $S = Ge^{-G}$.

C. *Comparison Between the Theoretical Throughput of Pure Aloha and Slotted Aloha*

Figure 5 shows the comparison between theoretical throughput of Pure Aloha and Slotted Aloha. Analysis of pure Aloha shows that the maximum throughput is limited to be at most 1/(2e). The analysis result of slotted aloha is twice the maximum throughput of pure Aloha. The main disadvantage of Pure Aloha is its low channel utilization. This is expected due to the feature that all users transmit whenever they want. In Slotted Aloha, a request cannot send anytime, instead it is required to wait for the beginning of the time slot. The big advantage of slotted Aloha is the increase in channel utilization. Slotted Aloha reduces vulnerability to collision, but also adds a waiting period for transmission if contention is low, it will prevent very few collisions and delay of a few packets that are sent.

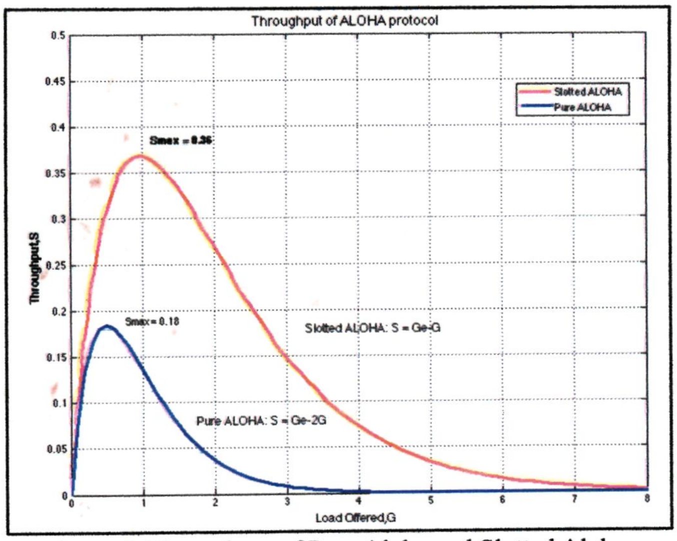

Figure 5: Throughput of Pure Aloha and Slotted Aloha

D. Simulation and Analysis of Pure Aloha Using Opnet

The aloha channel performance can be measured according to the number of successful received packets as a function of the packets submitted, regardless of whether the packets are original or retransmitted. For this network, channel throughput is a typical measurement of network performance.

The result of the simulation are stored as scalar values in the output scalar file which allows the user to view the network's performance as a function of an input parameter rather than a function of time. The channel throughput as a function of channel traffic across all of the simulations can be viewed in the Analysis Configuration Editor in OPNET.

Theoretical analysis have shown that a pure aloha system has a channel throughput S as a function of channel traffic G given by $S=Ge^{-2G}$. This relationship gives a maximum channel throughput of Smax=0.18. At low traffic levels, collision seldom occur. At high traffic levels, the channel is overwhelmed and excessive collision prevent packets from being successfully received. This behavior is demonstrated by the simulation graph in Figure 6. It is observed that the maximum throughput is achieved near G=0.5 and is close to the expected value of 0.18.

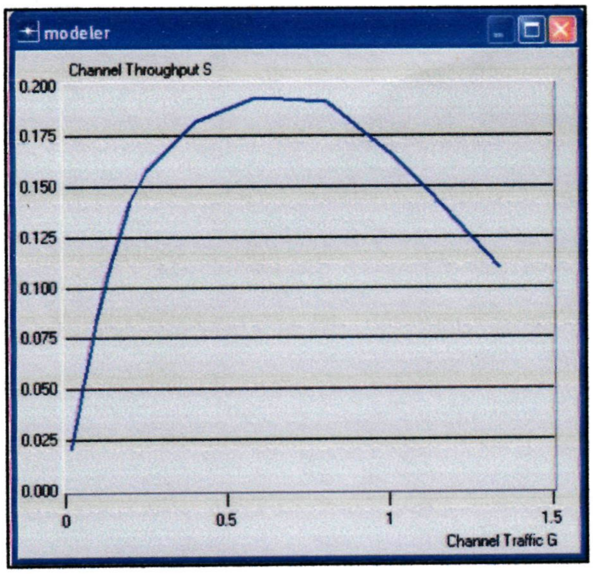

Figure 6: Throughput of Pure Aloha using OPNET

E. Simulation and Analysis of Slotted Aloha Using Opnet

Theoretical analysis has shown that a slotted aloha system has a channel throughput, S as a function of channel traffic G given by $S = Ge^{-G}$ This relationship gives a maximum channel throughput of Smax=1.4. This behavior is demonstrated by the simulation graph in Figure 7. It is observed that the maximum throughput is achieved when G=1.0 and is close to the expected value of 0.55

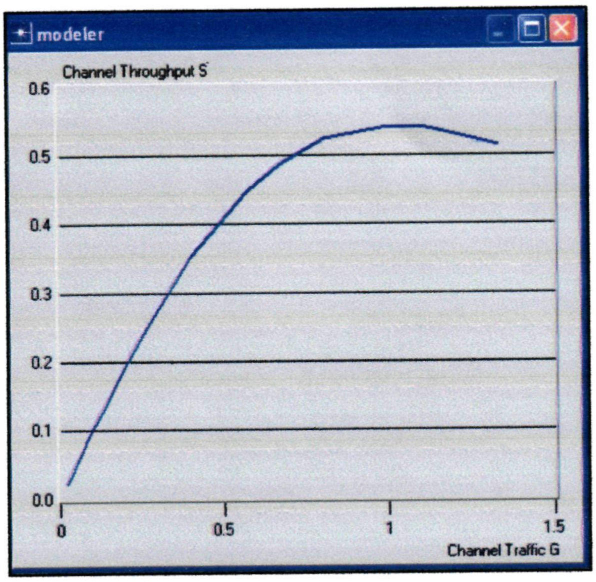

Figure 7 : Throughput of Slotted Aloha using OPNET

Comparison between the results of Simulation of Throughput of Pure Aloha and Slotted Aloha

Figure 8 shows the comparison between the result of simulation of throughput of Pure Aloha and Slotted Aloha. Analysis of pure Aloha shows that the maximum throughput is limited to be at most 1/(2e). The result of slotted aloha is twice the maximum throughput of pure Aloha.

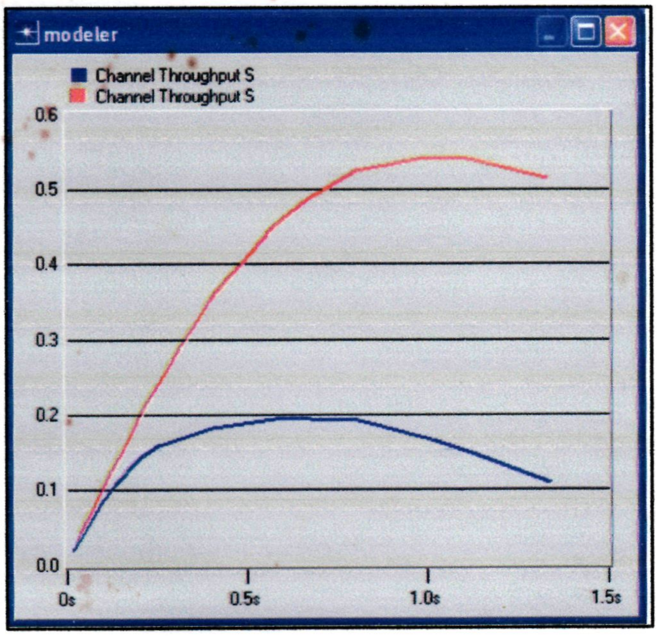

Figure 8: Throughput of Pure Aloha and Slotted Aloha

IV. CONCLUSION

The theoretical analysis on the throughput of pure Aloha has shown that the maximum throughput of 18% can be achieved at the offered load of 0.5 and the Slotted Aloha has shown that the maximum throughput of 36% can be achieved at the offered load of 1.0. The main drawback of Aloha is its low channel utilization. This is expected due to the feature that all users transmit whenever they want. In slotted Aloha, a user cannot send anytime, instead it is required to wait for the beginning of the time slot. The advantage of the slotted Aloha is the increase in channel utilization. Slotted Aloha reduces vulnerability to collision, but also adds a waiting period for transmission if contention is low. The theoretical analysis of Aloha and slotted Aloha and the simulation results obtained using OPNET has shown similar throughput values.

V. REFERENCE

[1] http://en.wikipedia.org/wiki/Radio frequency_identification

[2] Vinod Namboodiri, Maheesha DeSilva, Kavindya Deegala, Suresh Ramamoorthy, "An Extensive Study of Slotted Aloha-Based RFID Anti-Collision Protocols" Volume 35 Issue 16, September, 2012, Pages 1955-1966

[3] Lee, S. Joo, C. Lee, "An Enhanced Dynamic Framed Slotted ALOHA Algorithm for RFID Tag Identification," in the Proc. of International Conference on Mobile and Ubiquitous Systems: Networking and Services (MOBIQUITOUS), pp. 166-174, 2005.

[4] Tao Cheng and Li Jin "Analysis and Simulation of RFID Anti-collision Algorithms" School of Electronics and Information Engineering, Beijing Jiaotong University, Pages 697 – 701, Feb 2007

[5] Raphael Rom, Moshe Sidi and Haifa, Israel "Multiple Access Protocols, Performance and analysis" Springer-Verlag , June 1989

[6] Tommy Svensson Alex Popescu, "Development of laboratory exercises based on OPNET Modeler" Blekinge Institute of Technology, June 2003

[7] Nemai Chandra Karmakar, "Handbook Of Smart Antennas For Rfid Systems", *Wiley & Sons Ltd.* 2010.

[8] R. Want, An introduction to RFID technology, IEEE Pervasive Computing 5 (1) (2006) 25–33.

[9] K. Finkenzeller, "RFID Handbook: Radio-Frequency Identification Fundamentals and Applications, Second Edition," *Wiley & Sons Ltd.*, Apr. 2003.