15 Plot the characteristic curve of throughput versus offered traffic for a Pure and Slotted ALOHA system

NOTE: ***NetSim Academic supports a maximum of 100 nodes and hence this experiment can only be done partially with NetSim Academic. NetSim Standard/Pro would be required to simulate all the configurations.***

15.1 Theory

ALOHA provides a wireless data network. It is a multiple access protocol (this protocol is for allocating a multiple access channel). There are two main versions of ALOHA: pure and slotted. They differ with respect to whether or not time is divided up into discrete slots into which all frames must fit.

15.1.1 Pure ALOHA

In pure Aloha, time is continuous. In Pure ALOHA, users transmit whenever they have data to be sent. There will be collisions and the colliding frames will be damaged. Senders need some way to find out if this is the case. If the frame was destroyed, the sender just waits a random amount of time and sends it again. The waiting time must be random or the same frames will collide over and over, in lockstep. Systems in which multiple users share a common channel in a way that can lead to conflicts are known as contention systems.

The probability of no other traffic being initiated during the entire vulnerable period is given by e^{-2G} which leads to S= $G * e^{-2G}$ where, S (frames per frame time) is the mean of the Poisson distribution with which frames are being generated. For reasonable throughput S should lie between 0 and 0.5.

G is the mean of the Poisson distribution followed by the transmission attempts per frame time, old and new combined. Old frames mean those frames that have previously suffered collisions.

The maximum throughput occurs at G = 0.5, with S = 1/2e, which is about 0.184. In other words, the best we can hope for is a channel utilization of18%. This result is not very encouraging, but with everyone transmitting at will, we could hardly have expected a 100% success rate.

15.1.2 Slotted ALOHA

In slotted Aloha, time is divided up into discrete intervals, each interval corresponding to one frame. In Slotted ALOHA, a computer is required to wait for the beginning of the next slot in order to send the next packet. The probability of no other traffic being initiated during the entire vulnerable period is given by e^{-G} which leads to S = $G * e^{-G}$ where, S (frames per frame time) is the mean of the Poisson distribution with which frames are being generated. For reasonable throughput S should lie between 0 and 1.

G is the mean of the Poisson distribution followed by the transmission attempts per frame time, old and new combined. Old frames mean those frames that have previously suffered collisions.

It is easy to note that Slotted ALOHA peaks at G = 1, with a throughput of $s = \frac{1}{e}$ or about 0.368.

15.2 Calculations used in NetSim to obtain the plot between S and G

Using NetSim, the attempts per packet time (G) can be calculated as follows;

$$G = \frac{Number\ of\ packet\ transmitted * Slot\ length(s)}{ST}$$

Where,	G	=	Attempts per packet time
	ST	=	Simulation time (in second)

The throughput (in Mbps) per packet time can be obtained as follows:

$$S = \frac{Number\ of\ packet\ success * Slot\ length(s)}{ST}$$

Where,	S	=	Throughput per packet time
	ST	=	Simulation time (in second)

In the following experiment, we have taken packet size=1460 (Data Size) + 28 (Overheads) = 1488 bytes.

Bandwidth is 10 Mbps and hence, packet time comes as 1.2 milliseconds.

(Reference:** A good reference for this topic is Section 4.2.1: ALOHA, of the book, Computer Networking, 5th Edition by Tanenbaum and Wetherall**)

15.3 Network Set Up

Part-1

Open NetSim and click **Examples > Experiments > Throughput-versus-load-for-Pure-and-Slotted-Aloha** as shown below **Figure 15-1**.

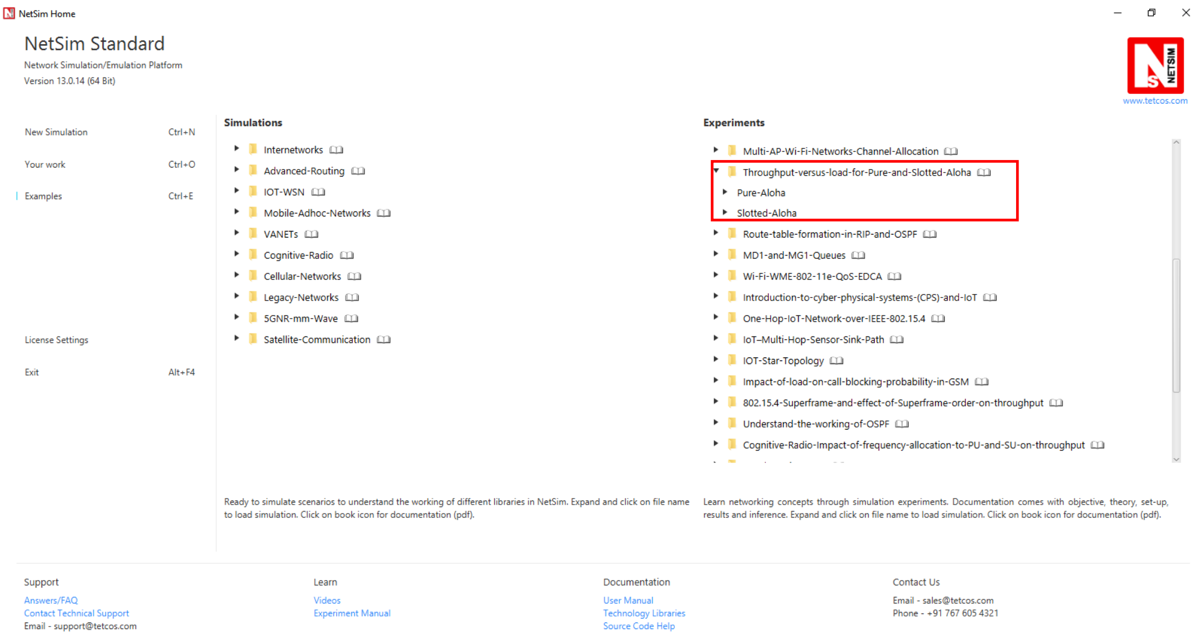

Figure 15-1: Experiments List

NetSim UI displays the configuration file corresponding to this experiment as shown below **Figure 15-2**.

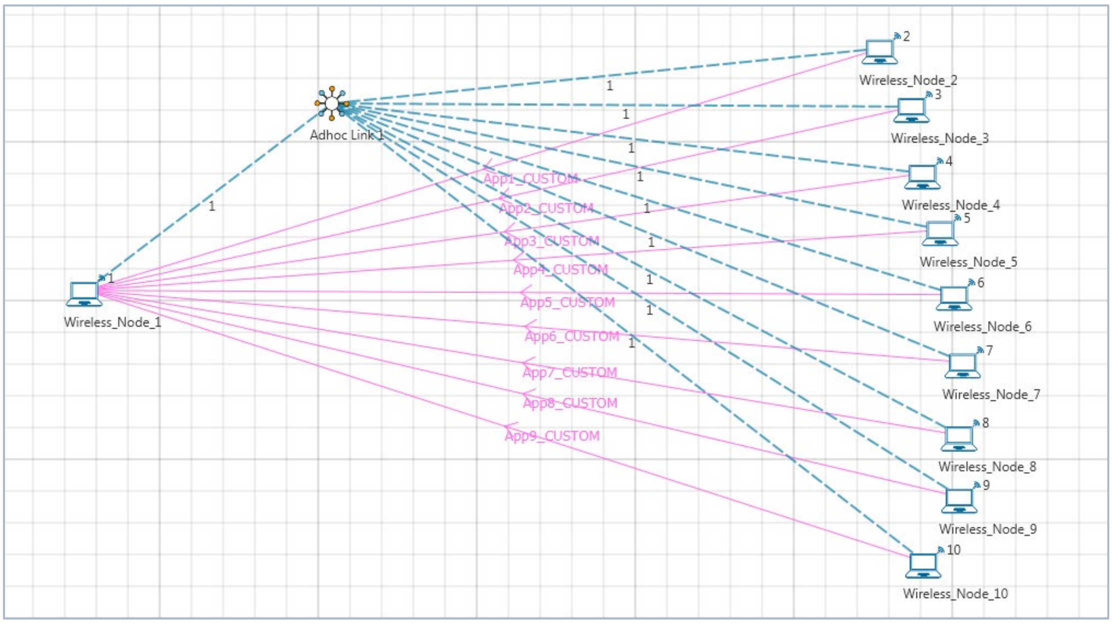

Figure 15-2: Network topology for Pure aloha experiment

Sample Inputs

Input for Sample 1:

Step 1: Drop 10 nodes (i.e. 9 Nodes are generating traffic.)

Node 2, 3, 4, 5, 6, 7, 8, 9, and 10 generates traffic. The properties of Nodes 2, 3, 4, 5, 6, 7, 8, 9, and 10 which transmits data to Node 1 are given in the below table.

Step 2: Wireless Node Properties

Wireless Node Properties	
Interface1_Wireless (PHYSICAL_LAYER)	
Data Rate (Mbps)	**10**
Interface1_Wireless (DATALINK_LAYER)	
Retry_Limit	**0**
MAC_Buffer	**FALSE**
Slot Length(µs)	**1200**

Table 15-1: Wireless Node Properties

(Note: *Slot Length(µs) parameter present only in Slotted Aloha → Wireless Node Properties → Interface_1 (Wireless))*

Step 3: In Adhoc Link Properties, channel characteristics is set as **No Path Loss**.

Step 4: Application Properties

- Right click on the Application Flow "App1 CUSTOM" and select Properties or click on the Application icon present in the top ribbon/toolbar. The properties are set according to the values given in the below **Table 15-2**.

Application_1 Properties		
Application Method	Unicast	
Application Type	Custom	
Source_Id	2	
Destination_Id	1	
Transport Protocol	UDP	
Packet Size	Distribution	Constant
	Value (Bytes)	1460
Inter Arrival Time	Distribution	Exponential
	Packet Inter Arrival Time (µs)	200000

Table 15-2: For Application_1 Properties

- Similarly create 8 more application, i.e. Source_Id as 3, 4, 5, 6, 7, 8, 9 and Destination_Id as 1, set Packet Size and Inter Arrival Time as shown in above table.

Step 5: Plots are enabled in NetSim GUI.

Step 6: Simulation Time- 10 Seconds

Note: *Obtain the values of Total Number of Packets Transmitted and Collided from the results window of NetSim.*

Input for Sample2:

Step 1: Drop 20 nodes (i.e. 19 Nodes are generating traffic.)

Nodes 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20 transmit data to Node 1.

Continue the experiment by increasing the number of nodes generating traffic as 29, 39, 49, 59, 69, 79, 89, 99, 109, 119, 129, 139, 149, 159, 169, 179, 189 and 199 nodes.

Part-2 - Slotted ALOHA

Input for Sample1:

Step 1: Drop 20 nodes (i.e. 19 Nodes are generating traffic.)

Nodes 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20 transmit data to Node 1 and set properties for nodes and application as mentioned above.

Continue the experiment by increasing the number of nodes generating traffic as 39, 59, 79, 99, 119, 139, 159, 179, 199, 219, 239, 259, 279, 299, 319, 339, 359, 379, and 399 nodes.

15.4 Output

Comparison Table: The values of Total Number of Packets Transmitted and Collided obtained from the network statistics after running NetSim simulation are provided in the table below along with Throughput per packet time& Number of Packets Transmitted per packet time.

Pure Aloha:

Number of nodes generatin g traffic	Total number of Packets Transmitted	Total number of Packets Collided	Total number of Packets Success (Packets Transmitted -Packets Collided)	Throughput per packet time(G)	Number of Packets Transmitted per packet time(S)	Packets per packet time theoretical (S = $G * e^{-2G}$)
9	494	60	434	0.05928	0.05208	0.05265
19	978	187	791	0.11736	0.09492	0.09281
29	1482	415	1067	0.17784	0.12804	0.12461

39	1991	700	1291	0.23892	0.15492	0.14816
49	2443	1056	1387	0.29316	0.16644	0.16311
59	2907	1429	1478	0.34884	0.17736	0.17363
69	3434	1874	1560	0.4122	0.19212	0.18075
79	3964	2377	1587	0.47568	0.19044	0.18371
89	4468	2909	1559	0.53616	0.18792	0.18348
99	4998	3468	1530	0.59976	0.1836	0.18073
109	5538	4073	1465	0.66456	0.1758	0.17592
119	6023	4574	1449	0.72276	0.17388	0.1703
129	6503	5102	1401	0.78036	0.16812	0.16386
139	6992	5650	1342	0.83904	0.16104	0.15668
149	7481	6208	1273	0.89772	0.15276	0.14907
159	7998	6787	1211	0.95976	0.14532	0.14078
169	8507	7341	1166	1.02084	0.13992	0.13252
179	9008	7924	1084	1.08096	0.13008	0.12442
189	9486	8483	1003	1.13832	0.12036	0.11682
199	10025	9093	932	1.203	0.11184	0.10848

Table 15-3: Total No. of Packets Transmitted and Collided obtained from the network, Throughput per packet time& Number of Packets Transmitted per packet time etc for Pure Aloha

Slotted Aloha

Number of nodes generating traffic	Total number of Packets Transmitted	Total number of Packets Collided	Total number of Packets Success (Packets Transmitted -Packets Collided)	Throughput per packet time(G)	Number of Packets Transmitted per packet time(S)	Packets per packet time theoretical ($S = G * e^{-G}$)
19	974	111	863	0.11688	0.10356	0.10399
39	1981	407	1574	0.23772	0.18888	0.18742
59	2893	891	2002	0.34716	0.24024	0.24534
79	3946	1504	2442	0.47352	0.29304	0.29491
99	4976	2286	2690	0.59712	0.3228	0.32865
119	5996	3144	2852	0.71952	0.34224	0.3504
139	6961	3999	2962	0.83532	0.35544	0.36231
159	7967	4974	2993	0.95652	0.35904	0.36752

179	8969	5994	2975	1.07628	0.357	0.36686
199	9983	7042	2941	1.19796	0.35292	0.36156
219	10926	8011	2915	1.31112	0.3498	0.35337
239	11928	9073	2855	1.43136	0.3426	0.34207
259	12969	10224	2745	1.55628	0.3294	0.32825
279	13916	11266	2650	1.66992	0.318	0.31438
299	14945	12430	2515	1.7934	0.3018	0.29841
319	15967	13592	2375	1.91604	0.285	0.28202
339	17011	14765	2246	2.04132	0.26952	0.26508
359	17977	15895	2082	2.15724	0.24984	0.24947
379	18983	17010	1973	2.27796	0.23676	0.23348
399	19987	18146	1841	2.39844	0.22092	0.21792

Table 15-4: Total No. of Packets Transmitted and Collided obtained from the network, Throughput per packet time& Number of Packets Transmitted per packet time etc for Slotted Aloha

Thus, the following characteristic plot for the Pure ALOHA and Slotted ALOHA is obtained, which matches the theoretical result.

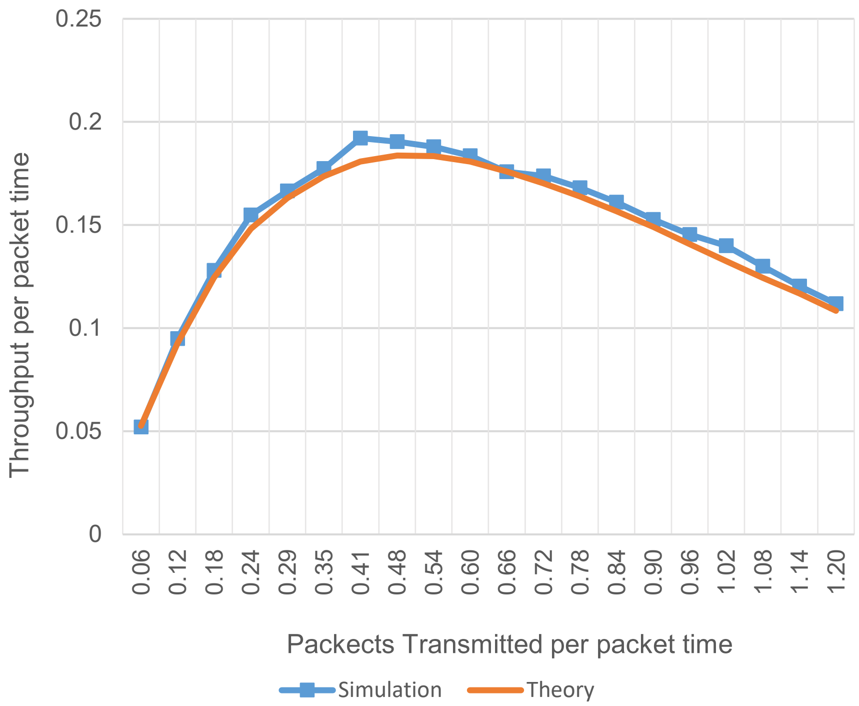

Figure 15-3: Throughput per packet time vs. Packet Transmitted per packet time

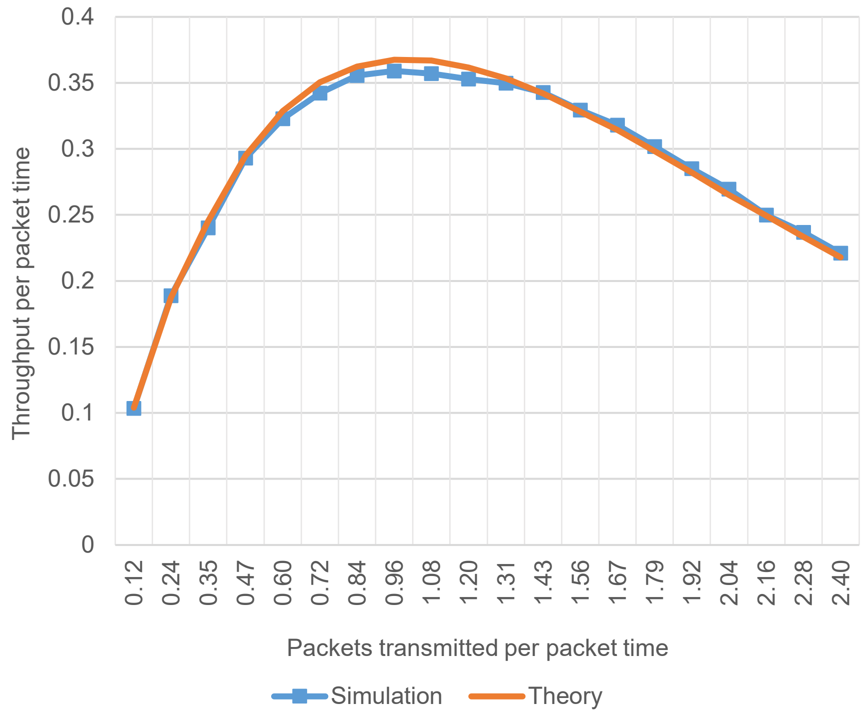

Figure 15-4: Throughput per packet time vs Packet Transmitted per packet time