SIMULATION EXPERIMENT IV

Performance analysis of ALOHA and S-ALOHA medium access control protocols

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Introduction:

This experiment/laboratory was completed to understand the basic concepts of random-access techniques used in communication networks by simulating the ALOHA and S-ALOHA protocols using the OMNeT++ IDE. A simulation of these protocols for different traffic loads was also completed to analyse the performance of ALOHA and S-ALOHA protocols.

Basic Description:

```
[General]
network = elec3500.simulations.ALOHA.Aloha
#debug-on-errors = true
#record-eventlog = true

sim-time-limit = 900seconds
Aloha.numHosts = 12
Aloha.slotTime = 0    # no slots
Aloha.txRate = 19200bps
Aloha.host[*].pkLenBits = 1728b #=119 bytes, so that (with +1 byte guard) slotTime is a nice round number
Aloha.host[*].radioDelay = 0ms
seed-set = 21

[Config PureAloha]
description = "pure Aloha"
Aloha.host[*].iaTime = exponential(X)
Aloha.host[*].pkLenBits = exponential(1728b)

[Config SlottedAloha]
description = "slotted Aloha"
# slotTime = pkLen/txRate = 960/9600 = 0.1s
Aloha.slotTime = 100ms
Aloha.host[*].iaTime = exponential(X)
Aloha.host[*].pkLenBits = 1728b

#10.8
#4.35
#2.7
#1.96363636364
#1.54285714286
#1.27058823529
```

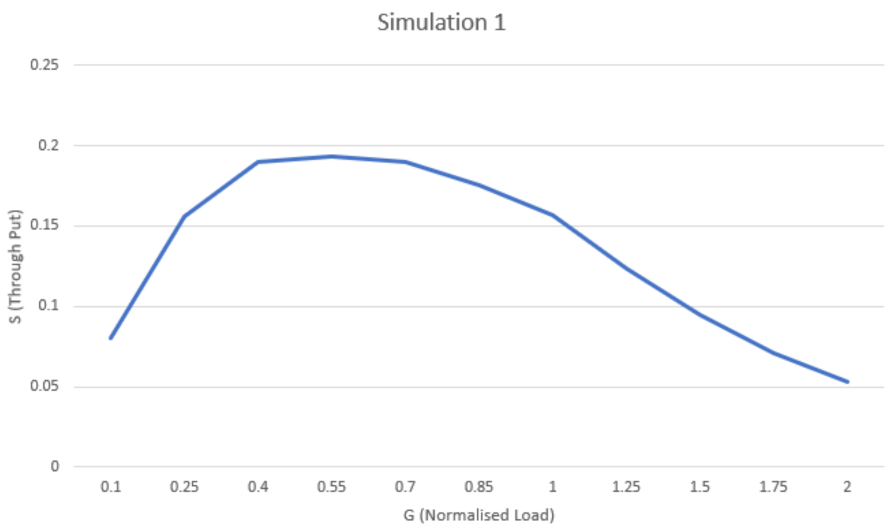
Figure 1 - Simulation Model

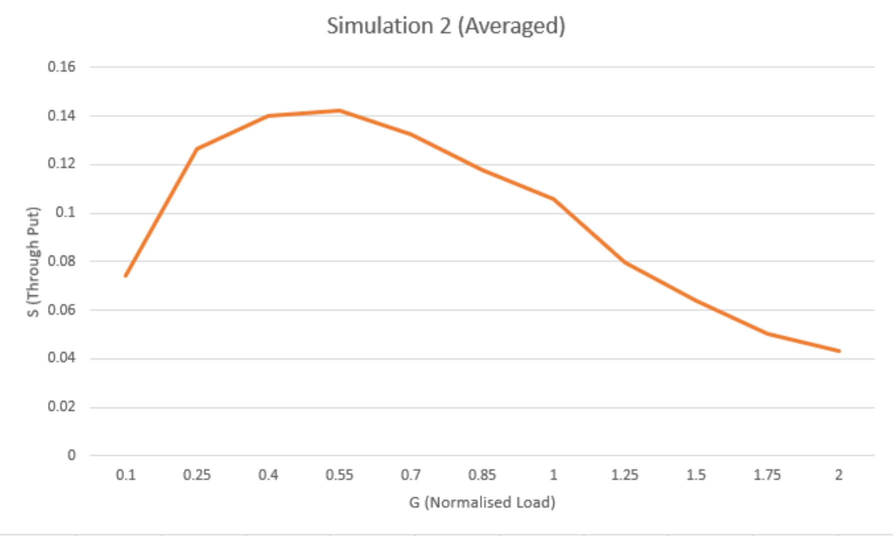
Default Seed Value = 21. The simulation time limit was 900 seconds.

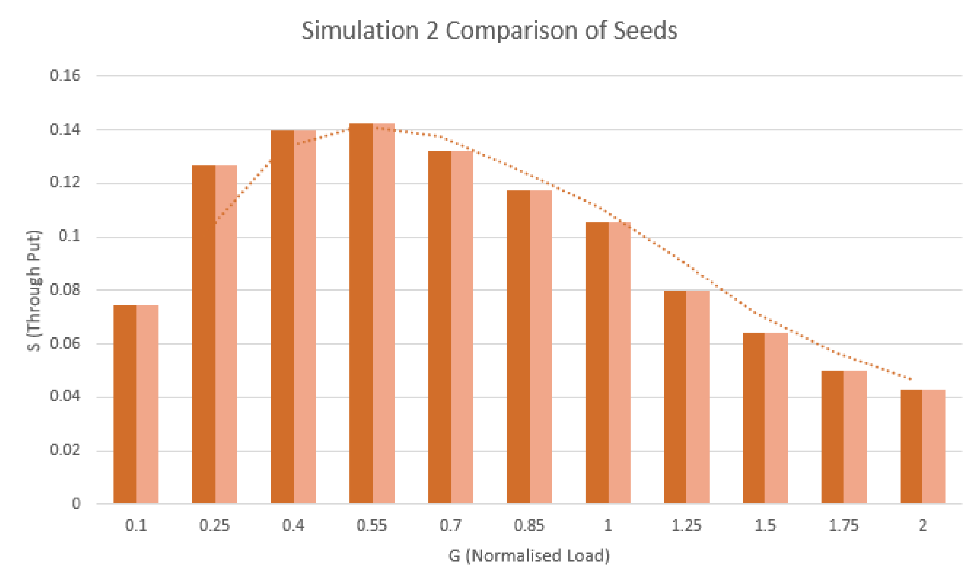
Figure 1 is the simulation model used in the experiment. It contained 9 default variables with three of them being changed for each different simulation. One of the variables being changed is the exponential vs constant on the packet length bits variable in the ALOHA simulation. Another variable being changed was the interarrival time in the ALOHA and S-ALOHA simulations. The interarrival time was selected by completing a series of calculations where the only differing numerical value was the normalised load. The final variable which was changed was the seed value. The seed value only differed for Simulation 2 as the simulation needed to be repeated with the default seed value and a different seed value (which was 50).

The commented-out numbers below the S-ALOHA config include some of numbers used for the inter-arrival time.

Results:







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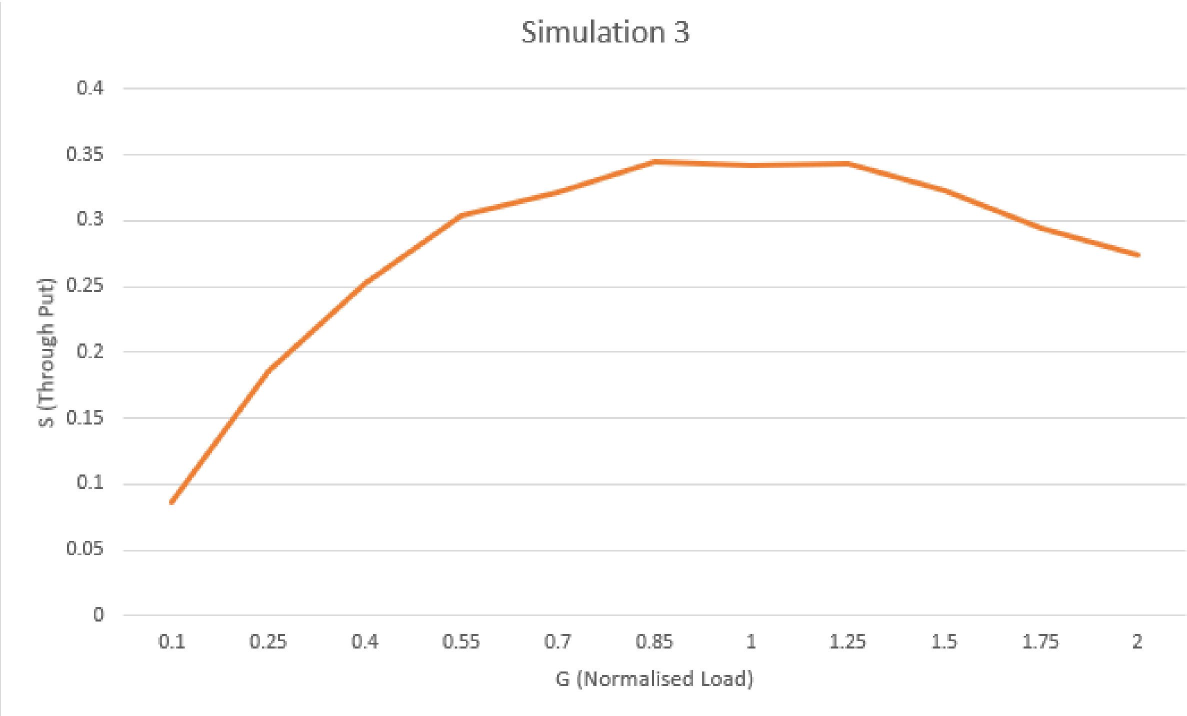
Results Cont.:

	Received Frames		
Normalised Traffic Load	**Sim 1**	**Sim 2**	**Sim 3**
0	-	-	-
0.1	803	802	866
0.25	1555	1572	1848
0.4	1902	1941	2520
0.55	1931	2158	3035
0.7	1896	2136	3211
0.85	1756	2103	3451
1	1568	1970	3426
1.25	1234	1693	3433
1.5	949	1512	3231
1.75	710	1332	2937
2	531	1155	2740



Analysis:

In the results above we are able to see the effect that the Random access, ALOHA & S-ALOHA Protocols have on the performance of medium access control.

When we look at the results of simulation 1, when compared to simulation 2, we see the result that the ALOHA Protocol produces a higher Utilisation when the packet size distribution is of a linear/constant value, compared to the exponential values produced in simulation 2. Furthermore, in simulation 2, we noticed that the utilisation was similar for each of the seeds that were given to the random function. This would indicate that the packet length being exponential is more important than what range of starting values it has, in terms of effect on utilisation.

Figure 5 highlights S-Aloha's performance curve, with a peak just below that of 0.35. This measures a full 0.15 above ALOHA at its peak during linear packet lengths. This shows the practical implications of Slotted Aloha's greater maximum efficiency, as well as why *Tt < 2x Tt* Vulnerable time and reduced collisions lead to a greater utilisation.

Questions:

1:

Theoretical Values:

ALOHA:

$$S = Ge^{-2G} \qquad (1)$$

S = 0.25e^-2x0.25 = 0.151633...

S = 0.55e^-2x0.55 = 0.183079...

S = 0.85e^-2x0.85 = 0.155281...

S = e^-2 = 0.135335...

S = 1.25e^-2x1.25 = 0.102606...

S-ALOHA:

$$S = Ge^{-G} \qquad (2)$$

S = 0.25e^-0.25 = 0.194700...

S = 0.55e^-0.55 = 0.317322...

S = 0.85e^-0.85 = 0.363303...

S = e^-1 = 0.367879...

S = 1.25e^-1.25 = 0.358131

2:

Simulation values:

VALUES	ALOHA	S-ALOHA
0.25	0.155606309	0.184904779
0.55	0.193156037	0.303503372
0.85	0.175687418	0.345103834
1	0.156924672	0.342603807
1.25	0.123466494	0.343341964

For ALOHA, the results are very similar between simulated and theoretical values. The only real significant difference between the two is that the theoretical values at 0.55 are smaller than the simulated results and that the dip in throughput dips slowly than suddenly to that of the simulated results.

For S-ALOHA, the simulated results show a similar correlation line with the theoretical results but are off by about 0.01-0.02. The difference between the two is the theoretical results rise sharply and then begin to decrease slowly by an increment of about 0.01, whereas the simulated results do the same thing except the decrease after the sharp rise is much smaller, by about 0.001-0.005.

These results differ overall because of the seeding used in the simulation. It adds an extra layer of randomness that the theoretical values do not take in account for.

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Questions cont.:

3.

Given the comparison between the results of ALOHA 1 and ALOHA 2, there exists a trend that would suggest that the smaller, more linear packet sizes being sent in ALOHA 1 are able to be handled more resourcefully than the exponentials used in ALOHA 2. When comparing figure 1 and figure 2 directly, we are able to see the magnitude that this impacts the system. As the traffic load increases, ALOHA 2 seemed more resilient to the change before dropping to a lower utilisation/throughput, as seen in table 1. This is despite ALOHA 1 having the higher overall utilisation when comparing the two.

4.

ALOHA and S-ALOHA share many of the same similarities, but when we directly compare the protocols, we are able to break down why S-ALOHA offers a higher throughput. One of the big factors is the probability of a successful transmission. In ALOHA, this is calculated as $G \times e^{-2G}$, whereas for S-Aloha, it is $G \times e^{-G}$. Another factor contributing to the higher throughput is collision avoidance. ALOHA does not reduce the number of collisions whereas S-ALOHA can reduce the number of collisions by half, which doubles the efficiency.

5.

The other advantage of S-ALOHA when protocol comparing load vs channel utilisation plots is efficiency and time. In Pure Aloha, time is continuous and is not globally synchronized.
In Slotted Aloha, time is discrete and is globally synchronized. S-ALOHA is also 2 times as efficient when compared to the ALOHA protocol. The exact number to show this efficiency difference is 18.4% for ALOHA and 36.8% for S-ALOHA.

6.

The peak throughput of the S-ALOHA network in bits/sec is:

$1728 \times 0.34510383448704 = 596.33942599360512$ bit/sec