Network Simulation

2019/20

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Photonics Integrated Circuits, Sensors & Netoworks
(PIXNET 2019-21)

Final Network Simulation Project Modelling a degree two node where packets can be also added and dropped from a client

25 Jan 2020

1 Question

Model a degree two node where packets can also be added and dropped from a client. Both input and output port capacity is 100Mb/s.
Where,

- Packets have got an average length of 1500 bytes following a negative exponential distribution
- Both port A and client packets are queued in a single queue
- The switch queue is assumed to be infinite and client packet interarrival time fixed to 1 ms (Port A traffic varies with negative exponential distribution).

Plot,

1. Average switch Throughput as a function of the arrival rate from the other input (port A) and from the client
2. Average Delay in the system as a function of the arrival rate from the other input (port A) and from the client

2 Task Abstract

The project is about to implement the switch model in such a way that packets can be added by port A & client, however it can be dropped by Client only. The switch throughput and average packet delay are analyzed by the C-code. The strategy to implement this assignment is to model two queues and one server, making two arrivals and one departure, three events in all, to make this event driven simulation.

3 Project Objectives

As asked in the question, in this project, we design a network node with two input ports (Port A and Client) where an average length packets are queued in a single buffer and an output port (Port B) as shown in the Fig. 1 below. The inter-arrival time of packets from Port A is randomized with a negative exponential distribution while for client it is fixed to 1 ms.

To evaluate the performance of the degree two node, we will plot the

- Average delay spent by a packet in the system as a function of the arrival rate of Port A and client
- Average switch throughput as a function of the arrival rate of Port A and client

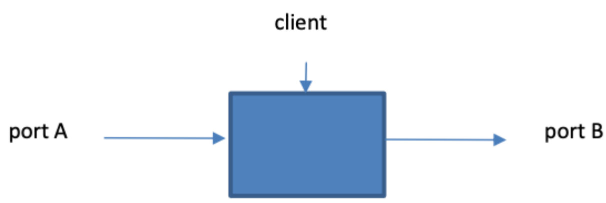


Figura 1: Network node implementation

To achieve the very first objective, the average delay spent by a packet in the system can be computed by adding the average delay spent by a packet (either from client or port A) in the queue and the service time (S) as shown in the formula

$$Estimated\ Delay\ in\ the\ system\ = \sum_{n=1}^{n}(D_i + S_i) \quad (1)$$

Since the size of the average packet size is 1500 bytes, the average service time can achieved using the formula

$$\eta_S = \frac{AveragePacket\ Size}{Service\ Rate} = 120\mu s \tag{2}$$

With a computed η_S of $120\mu s$, the expected average delay spent by a packet in the system should be $\geq \eta_S$. The second objective is to plot the average throughput as a function of the arrival rate of Port A and client. The average switch throughput can be achieved by using the formula

$$Throughput = \frac{Outcoming\ bits\ per\ second}{Outcoming\ Capacity\ per\ second} \tag{3}$$

The throughput is computed with increasing values of arrival rates of Port A and client while the service rate is fixed at 100Mb/s. The 95% confidence interval is also computed to measure the degree of certainty/uncertainty for the given case.

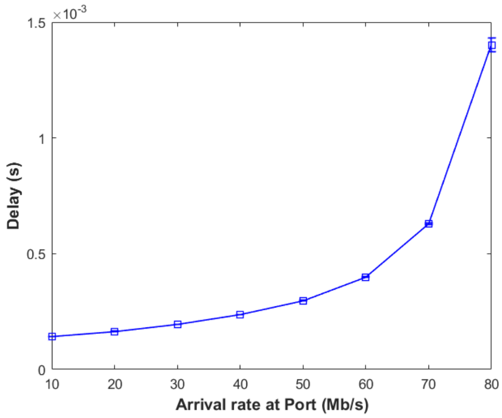
To achieve this, we assigned a different seed values from the array of values on the lcgrand code for port A . Then we increment the seed values in every iteration to produce different values for the average delay spent by a packet in the system and different values for the average switch throughput.

With a given service rate of 100 Mb/s, the arrival rate of the port is varied from 10Mb/s to 80 Mb/s, while the arrival rate of the client is fixed to 1Mb/s.
To compute for the values of the mean inter-arrival time, we can use the given packet size (1500 bytes) and the arrival rate of the client or port A.

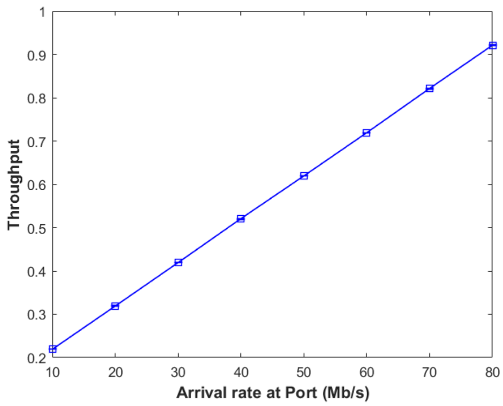
$$Mean\ Interarrival\ Time = \frac{Packet\ Size}{Arrival\ Rate(Client\ or\ Port\ A)} \tag{4}$$

To generate an exponential random variable with a given mean of , the inverse-transform algorithm was derived to perform: Generate $U \simeq U(0,1)$ from the lcgrand.c code.
Return $x = -\beta \ln U$.

4 Simulation Results



(a) Delay Vs. Arrival Rate



(b) Throughput Vs. Arrival Rate

Figura 2: Objective Plots with 95% confidence interval

Here in this section, we have plotted three graphs. The plot in Fig. 2 represents the variation of the Delay with the Arrival rate (Confidence Interval = 95%). As observed, the given graph shows a position exponential trend that increase with the increment in the arrival rate value.
Similarly, another Fig. 3 represents the trend between the Throughput and the arrival rate.Here unlike the previous one, the variation is simple linear.

Apart from both of these two, we have also try to provide a plot between the Simulation time and the arrival rate, that serve to be a reference plot in drawing various conclusion behind the inference of the trend that we are observing the the above two plots.

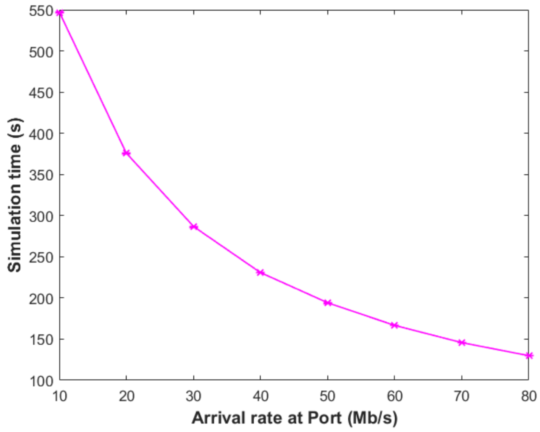


Figura 3: Simulation Time Vs. Arrival Rate

5 Discussion

In this section, we tried to provide an intuitive explanation behind the nature of graphs which we got after performing the simulation for the given problem. Starting from the beginning we would like to show you how we infer the linear increasing trend in the Throughout Vs. Arrival Rate after which we will carry on with our explanation on the Delay Vs. Arrival Rate plot.

5.1 Throughput Vs. Arrival Rate

After taking into consideration the formula given in the question for throughput analysis. We tried to define the throughput in our code which can be expressed as follows

$$Throughput = \frac{Number\ of\ packets\ served\ in\ the\ simulation * Mean\ Packet\ Size}{Simulation\ time * Service\ Rate} \tag{5}$$

Here since its given that it is an infinite queue, so just to deal with this factor we have taken into consideration a large Number of packets that are supposed to served in our given simulation. So, since our main area of focus centered around only around the arrival rate and Throughput I tried to relate everything given on the Right hand Side of the formula (containing the arrival rate dependency via the simulation time), with the Throughput so that it would be easy to draw a direct inference about the trends we got here.

Here, in equation described above , except the Simulation time in the denominator everything we used here is fixed with a constant value. Simulation time is the time since the first packet was served to the time the last packet gets out of the system.

Also from plot 3 shown in Fig.3 you can observe that, with the increase in the arrival rate, the simulation time of the system is decreased. Which ultimately led to the increment of the throughput in equation we put forward through eq. 5. This shows that the plot we obtained for this case is doing exactly the same thing it supposed to do with the formula we described in Equation.
Now in the next subsection, we will try to provide a similar explanation towards the trend we observe in the Delay Vs. Arrival rate plot.

5.2 Delay Vs. Arrival Rate

In this section as well, we tried to provide the explanation to the plot in the same way we have done in the previous subsection. At first, we would like to provide you the formula that we have taken into consideration to infer the trend from the graph we got in Fig.

$$Total\ Delay = \frac{\sum_{n=1}^{n}(Delay_i + S_i) + expon(mean\ service\ time)}{Number\ of\ being\ served\ in\ system} \tag{6}$$

$$Delay = \frac{1}{\mu - \lambda} \tag{7}$$

Here in eq. 7, the quantity in the denominator,the delay is expressed as 1 over the the service rate (μ) minus the arrival rate(λ). Since in our case the service rate is being already fixed to 100 Mbps so if we keep on increasing the arrival rate, the whole term in the denominator will decrease which will ultimately led to the increment of the delay term in equation we have defined through eq. 6 (Number of packets beings served which is defined in the denominator of eq.6 is fixed) .

Now since the increment in delay with this term is also taking into consideration the randomization factor due to the addition of expon(mean service time) factor, we are getting an increasing exponential trend. Thus, this gives an intuitive explanation of the reason behind what we observed from the graph.

6 Conclusion

In this project report, a plot of variation of the delay and throughput of the system was plotted as a function of the arrival rate. For which we have developed an intuitive explanation through the equations we have mentioned earlier in the report for the throughput, and delay.