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CSC/ECE 570 – Computer Networks
OpNet Lab #2
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## Summary

Addressed topic- The original tutorial that OpNet Lab #2 is based on guides the user on how to create a Node Model and deploy it from the Object Pallet. We learn about the components that go into the Node Model including the Processors, Queues, Sinks, and packet streams.

Objectives:

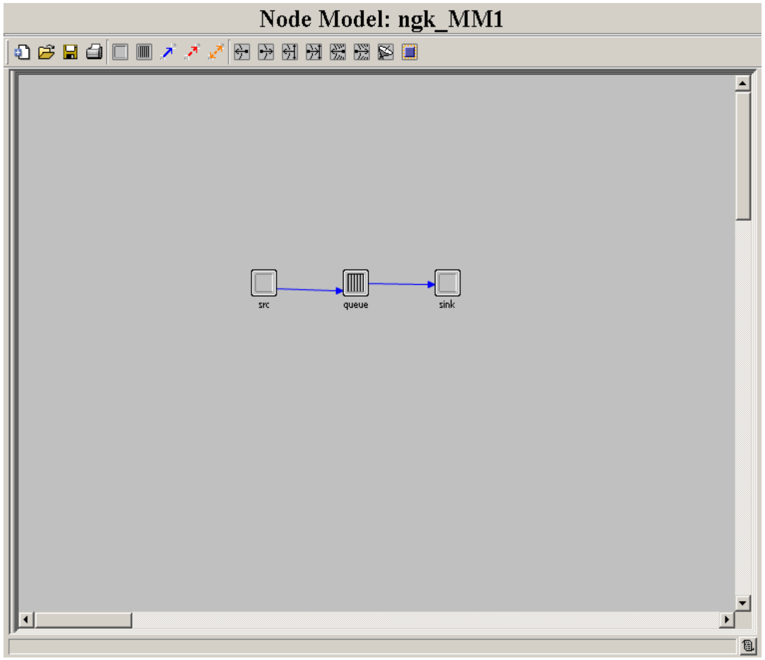
- One objective of the OpNet MM1 queue Tutorial is to develop familiarity with the Node editor of OpNet Simulation software as well as running simulations of the Node Model created.

- Once familiarity is developed, the next objective is to understand the different parameters of the queuing models.

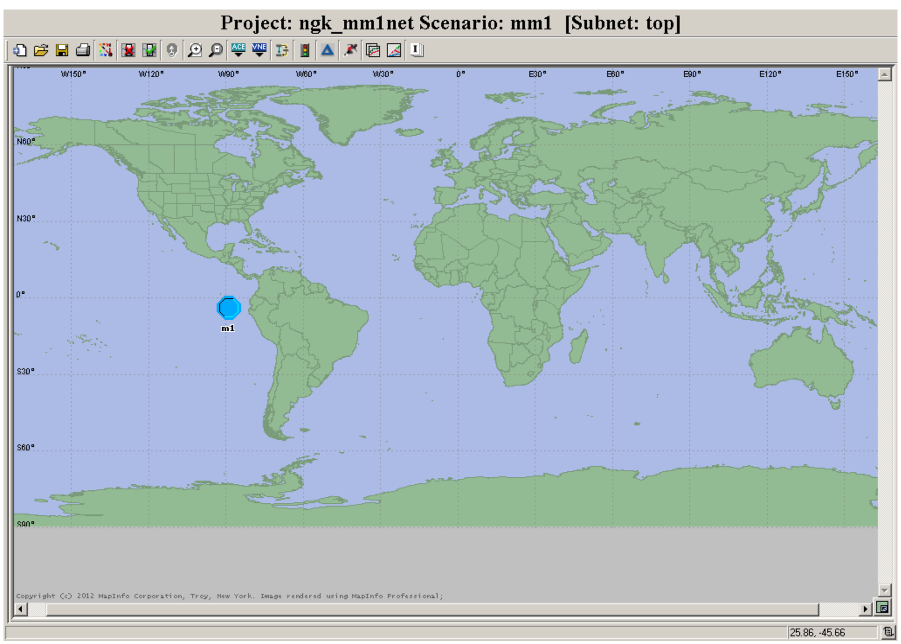
- The next objective is to understand how to create new node models while understanding, deriving, and adjusting the node parameters.

## Implementation

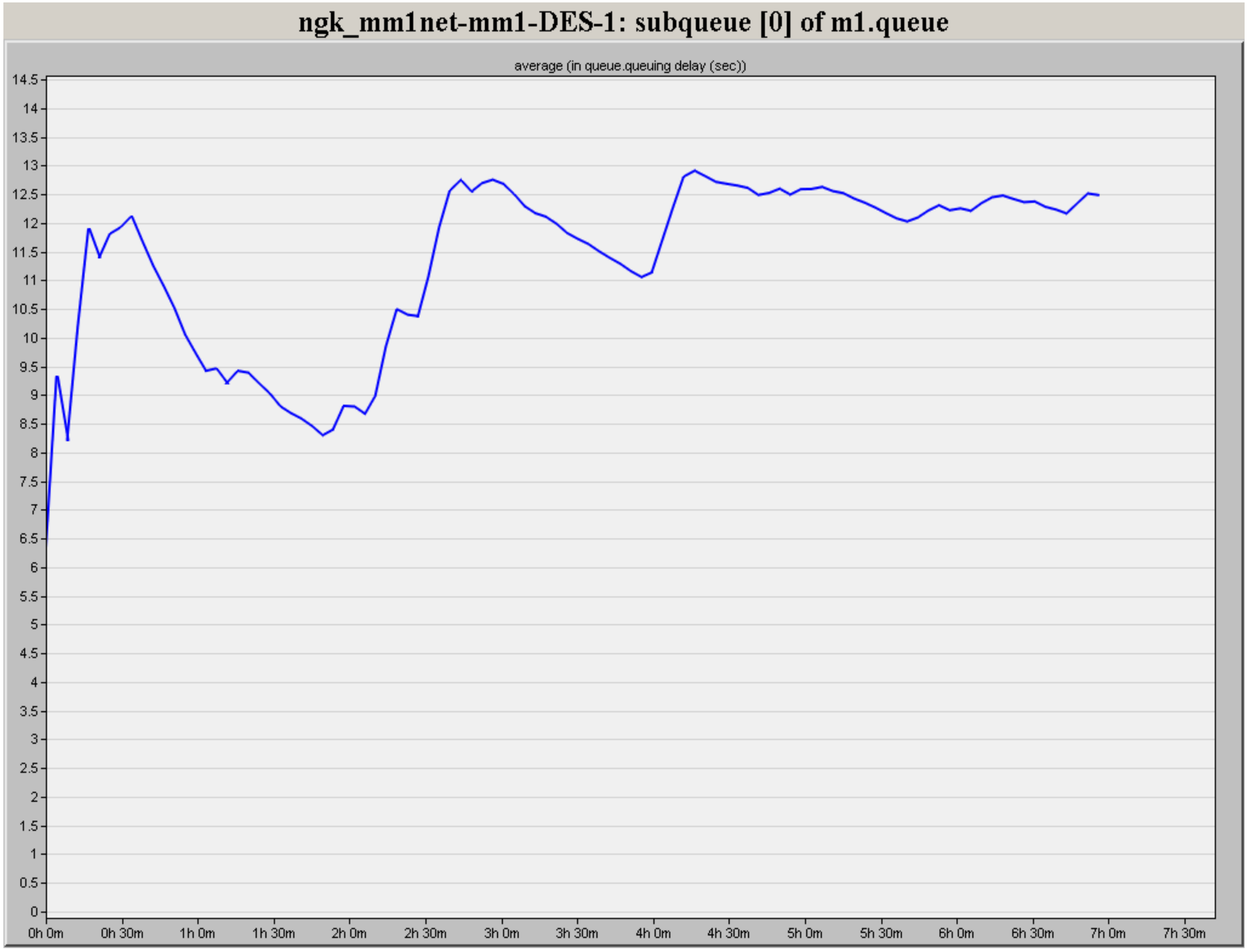
<u>Tutorial</u>
We start by editing the Node Model. We create a Processor, Queue, and Sink. The series of packets is guided by the blue 'packet streams.'

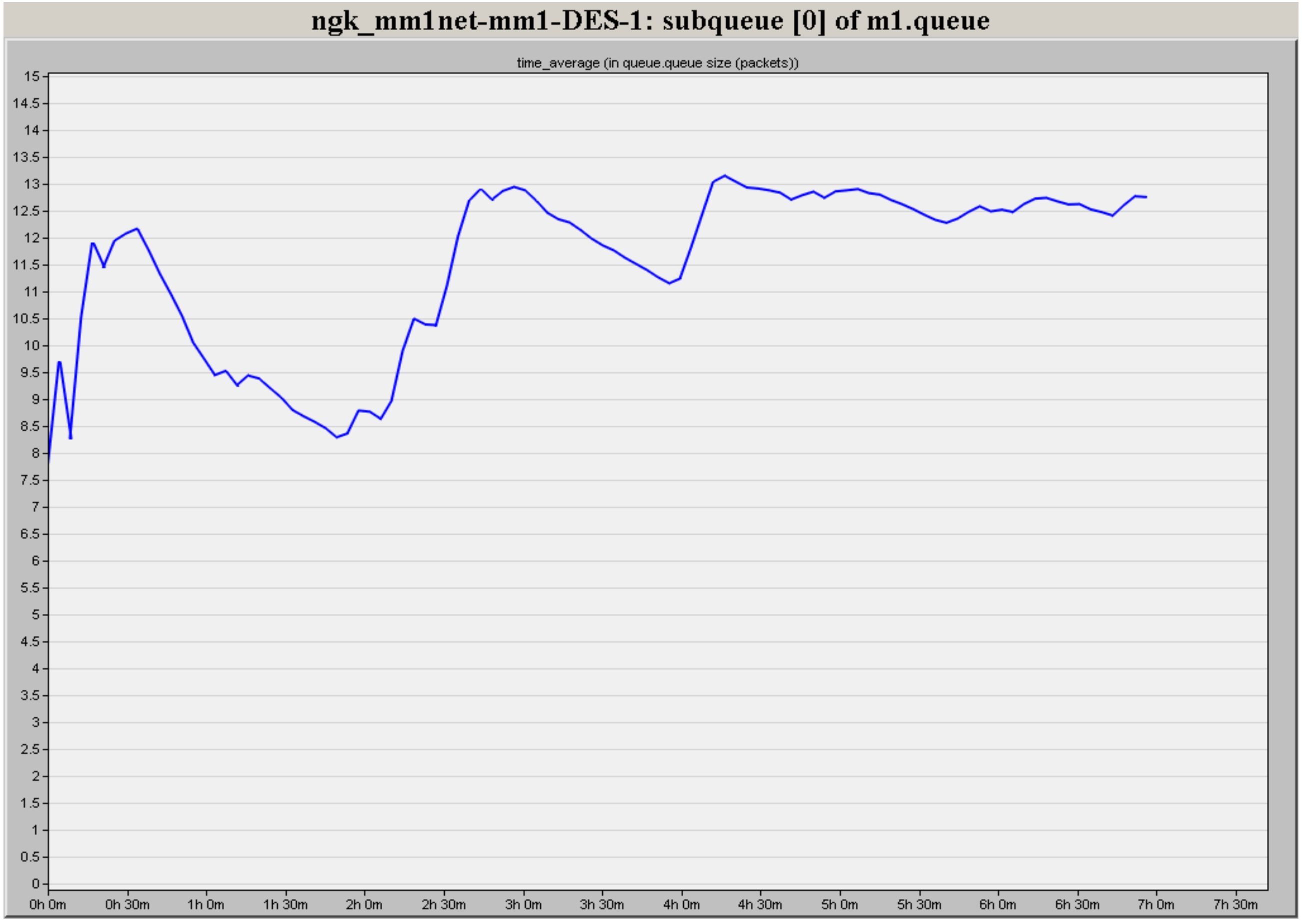



The M/M/1 (Markov input, Markov output with c= 1 server) node is then selected from the palette and placed in the workspace.

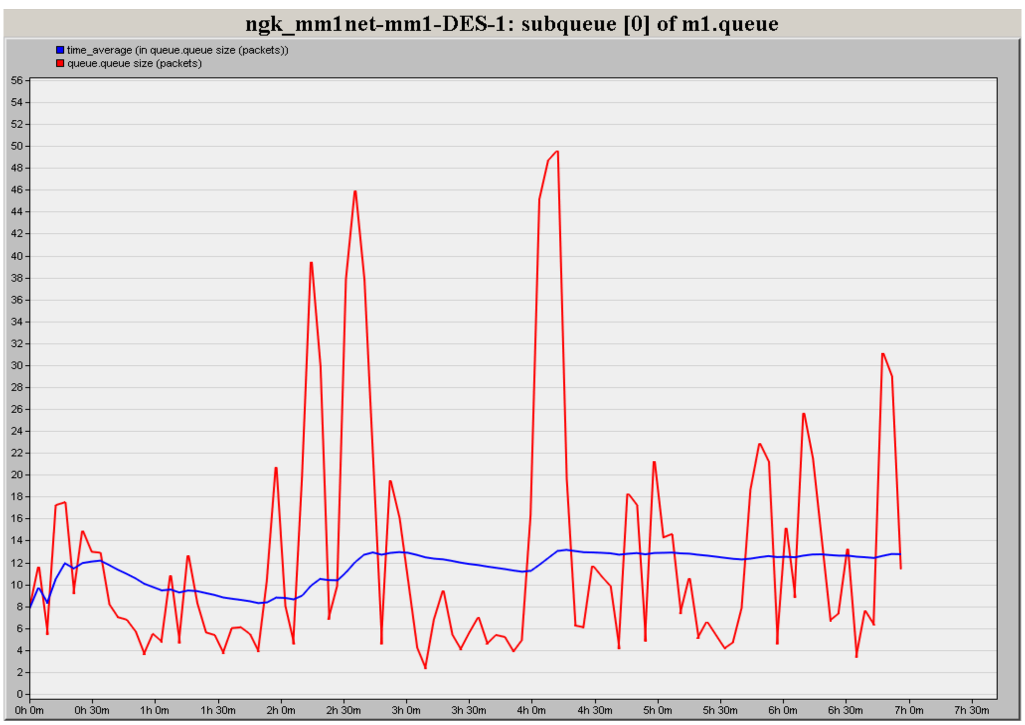


Queue Delay and Queue Size statistics are collected during a 7 hour simulation.



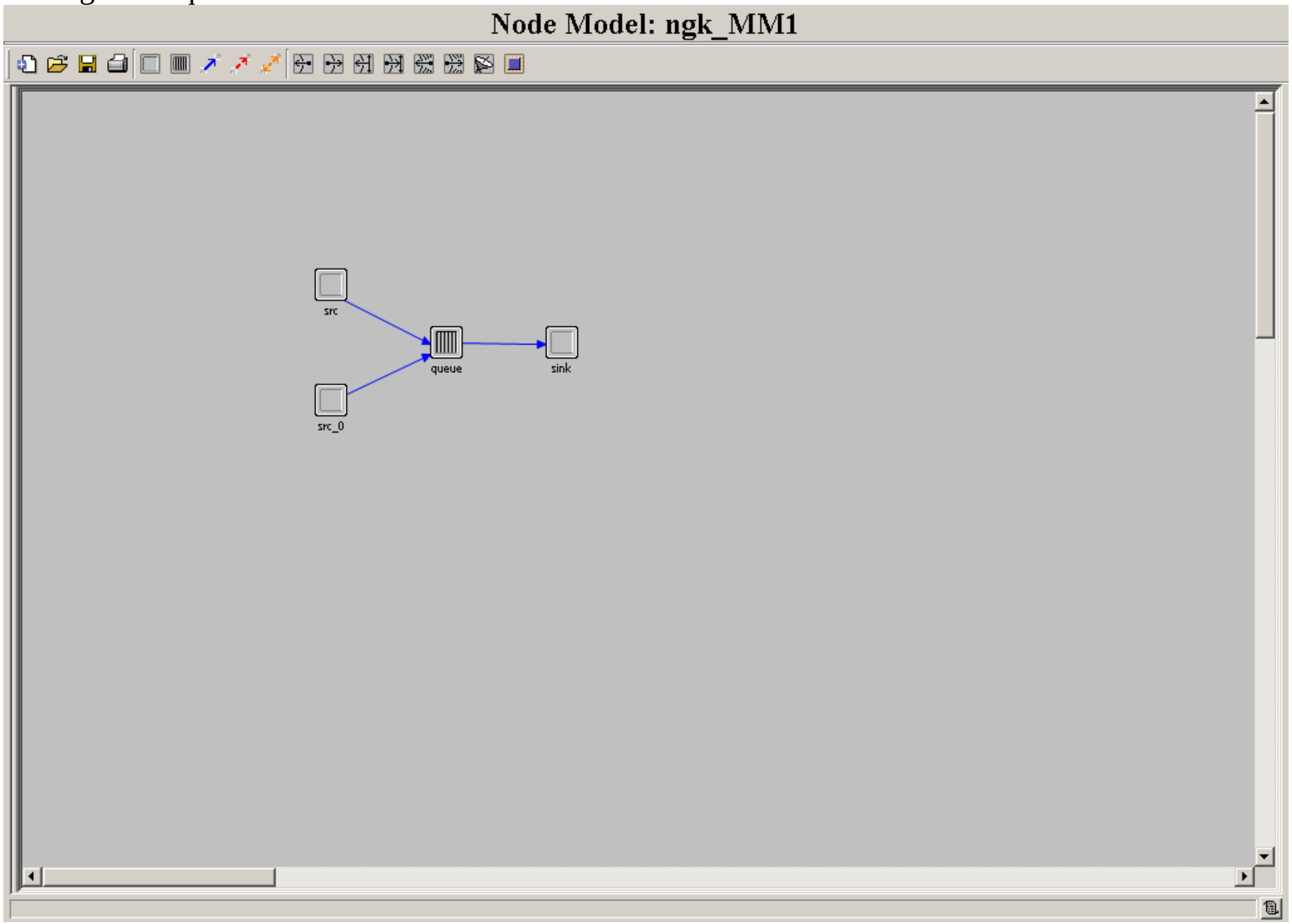



The queue size and the time-average of the queue size are compared on the same graph.

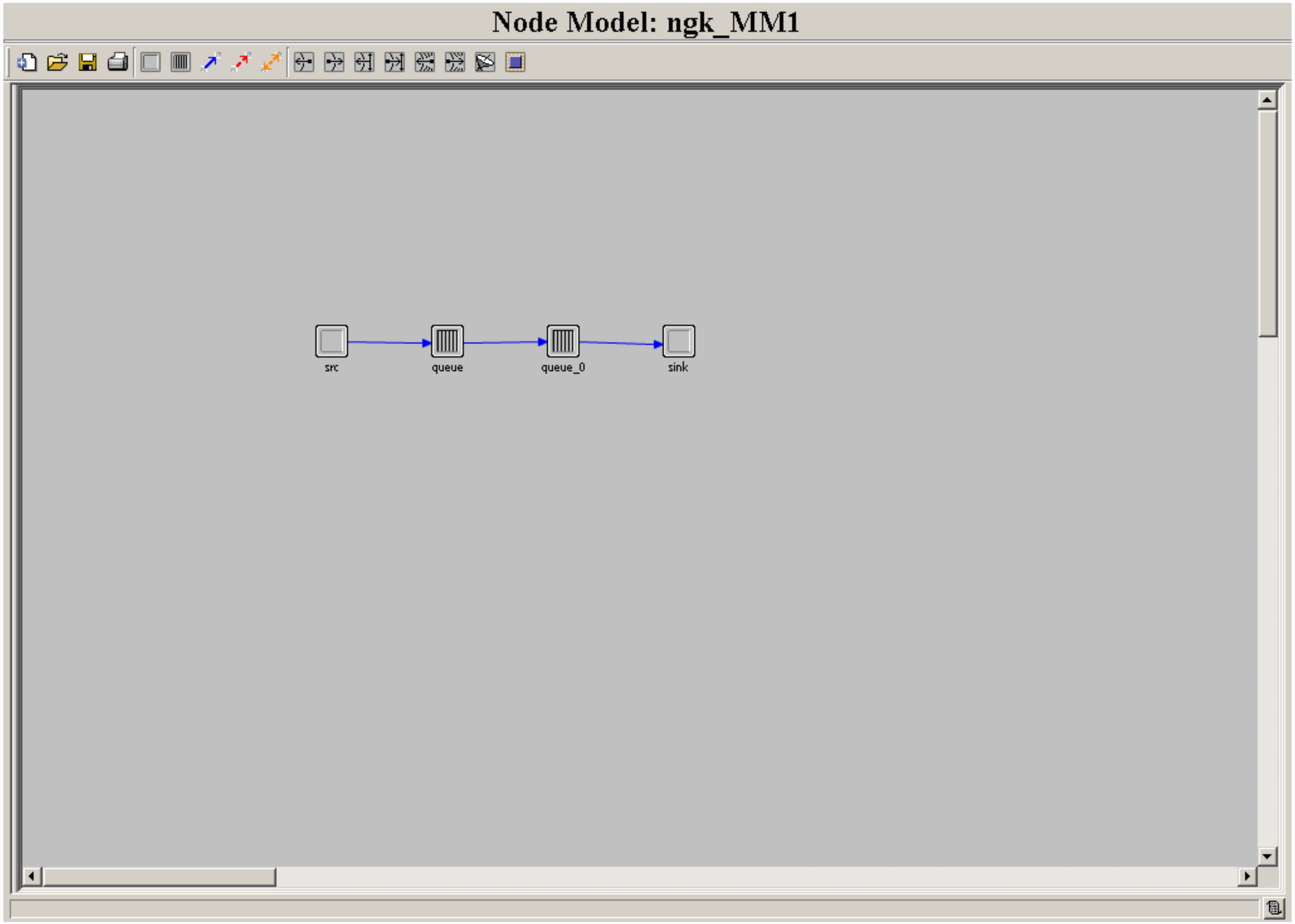


For the implementation of Question 1:a modified version of the Node Model from the Tutorial is used. Parameters are simply adjusted after calculations are made to satisfy the requirements.

As seen below Question 2 requires that the Node Model be adjusted so there are now two processors leading to the queue.



As seen below Question 3 requires the use of two queues in place of the original one queue leading to the single sink.

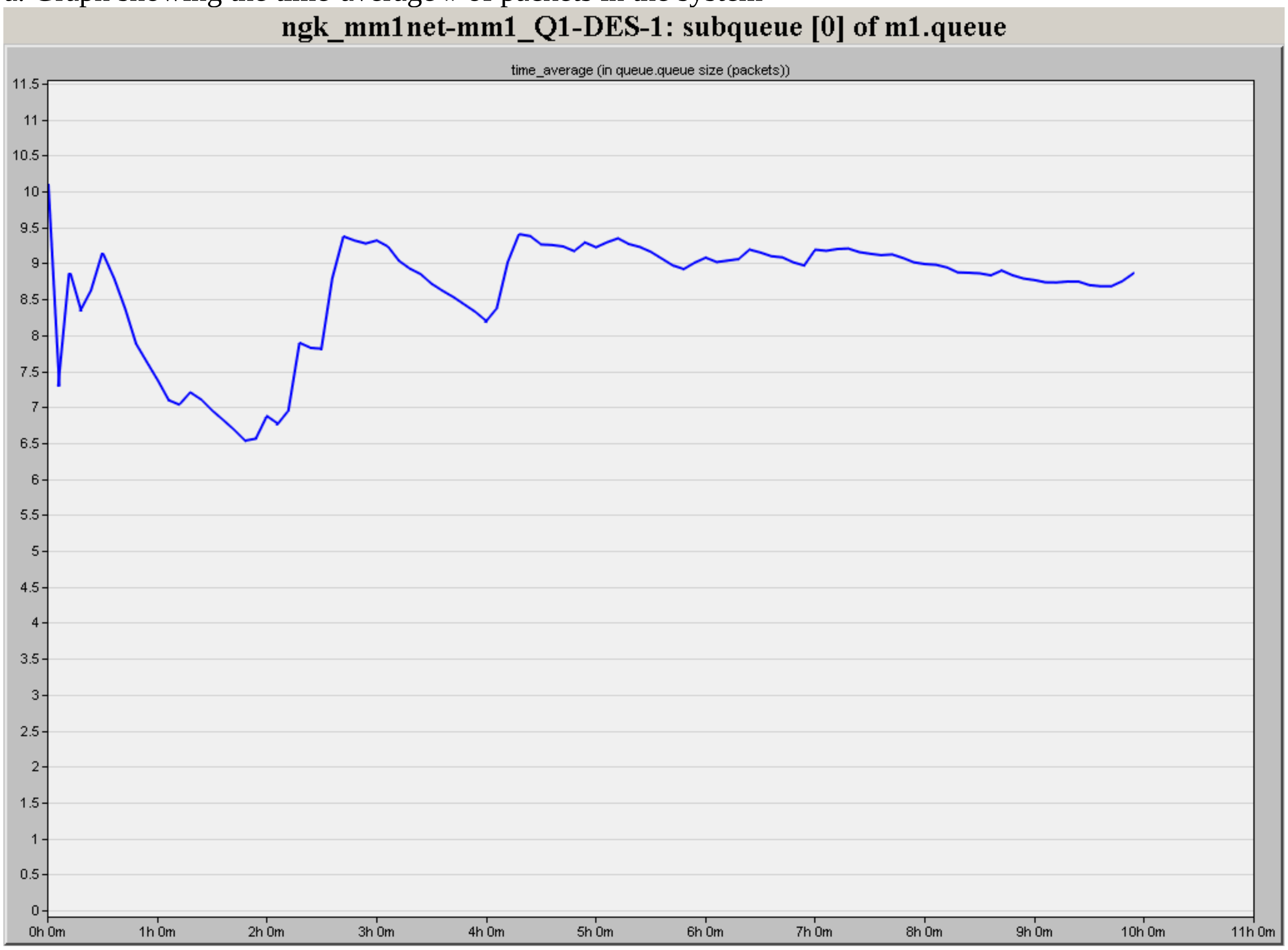


**Results**
The results obtained from the Tutorial are published above. The results from addition queuing exercises are published below under the answers section. The results obtained are similar to what one would expect, although there is some ambiguity in how two sources are handled.

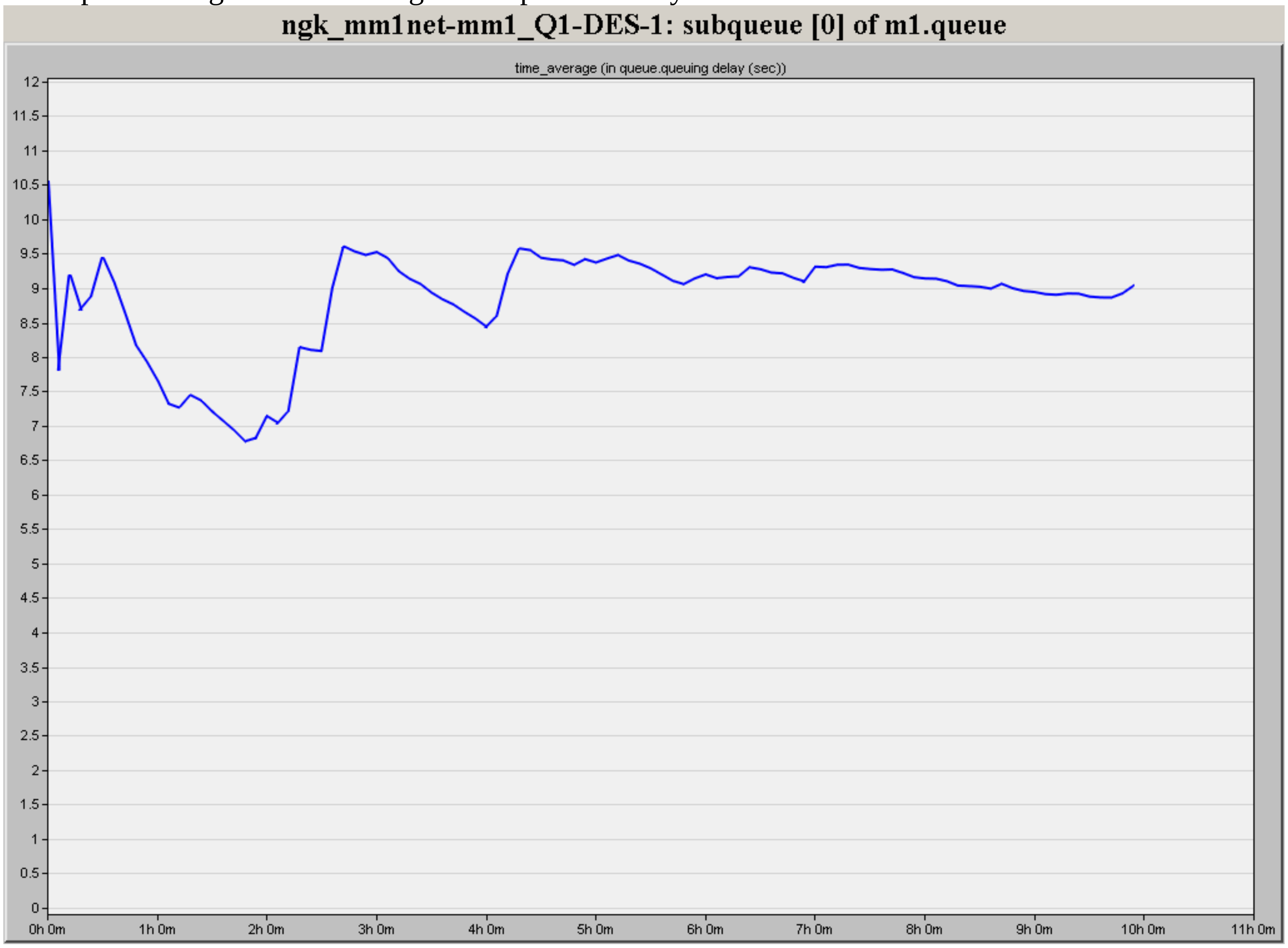
**Answers**

Question 1: One source processor

a. Graph showing the time-average # of packets in the system



b. Graph showing the time-average time spent in the system




c. Queuing Calculation:

L = Long-run time-average number of customers in system
$= 10 = \lambda/(\mu - \lambda)$
$= \lambda/((9600/9000) - \lambda)$

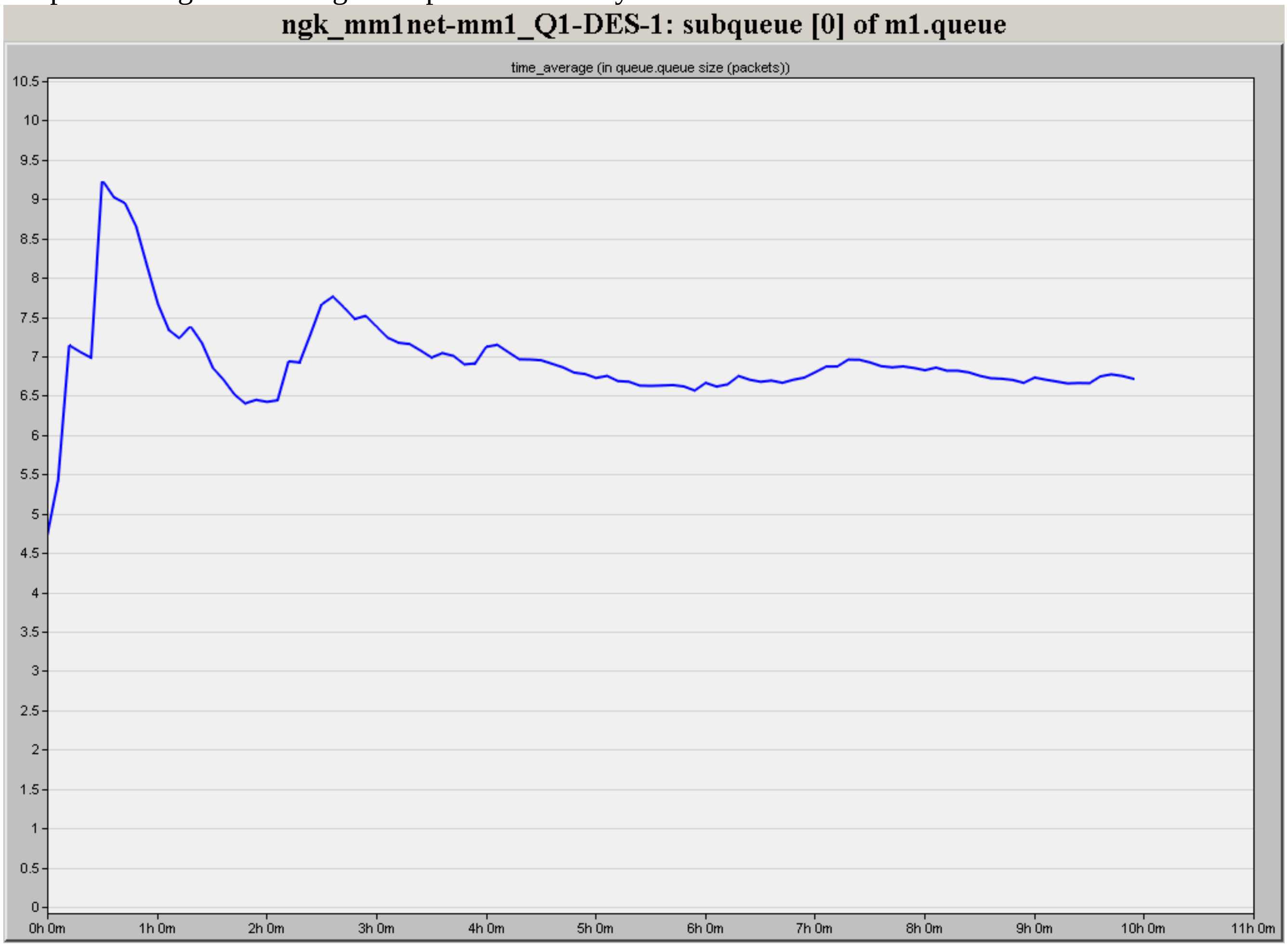
$\mu = 9600/9000 = 1.067$ packets/second

Solve for $\lambda$:
$\lambda = 0.97$
$1/\lambda = 1.03093 \leftarrow$ Inter-arrival time

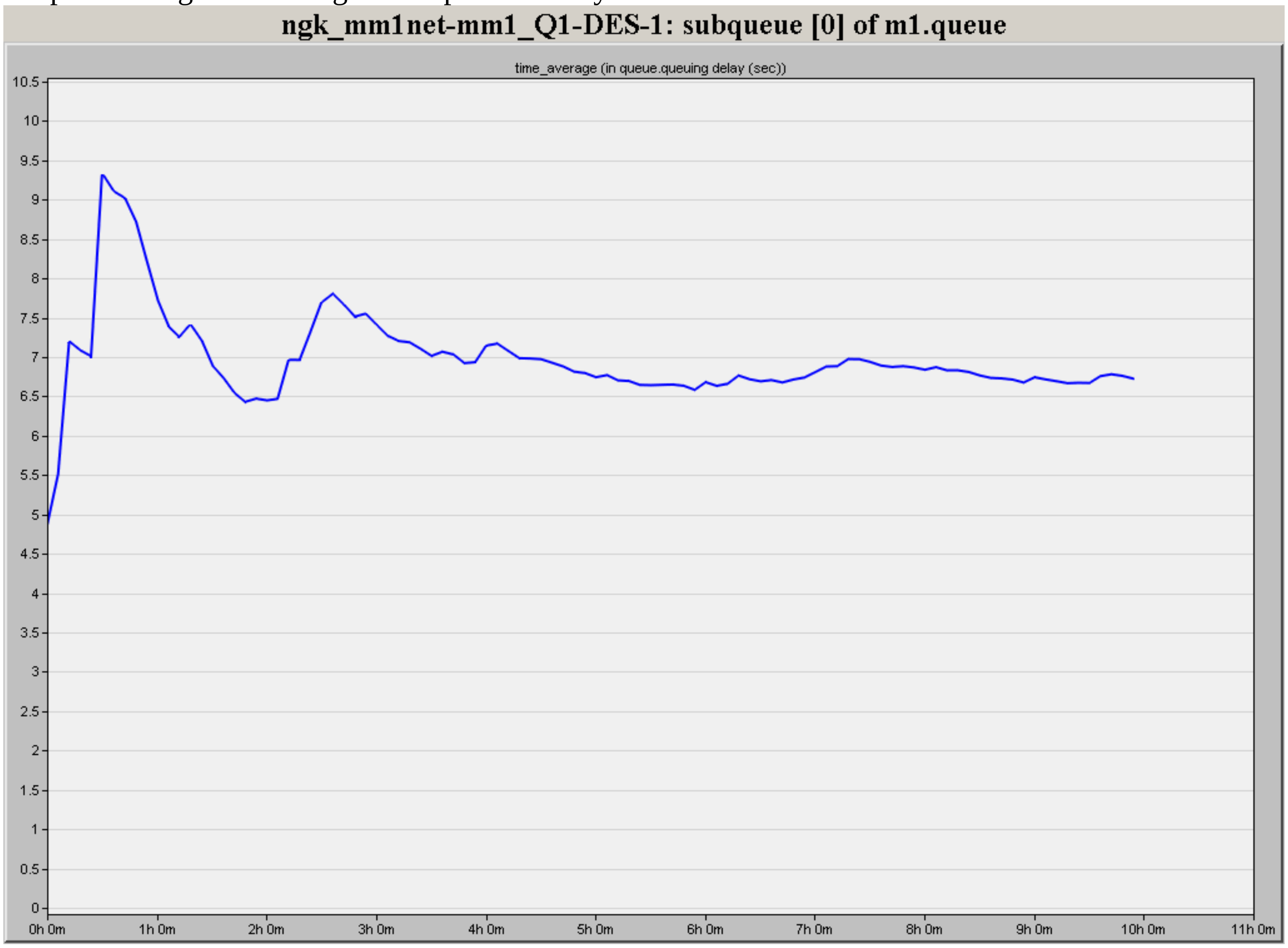
The Long term time-average of the Queue size in the graph of 1a is 9 packets in the queue. Additionally 1 packet will be in processing. This adds up to 10 packets in the system.

d. 1/λ = 1 ← Inter-arrival time

Graph showing time-average # of packets in the system.



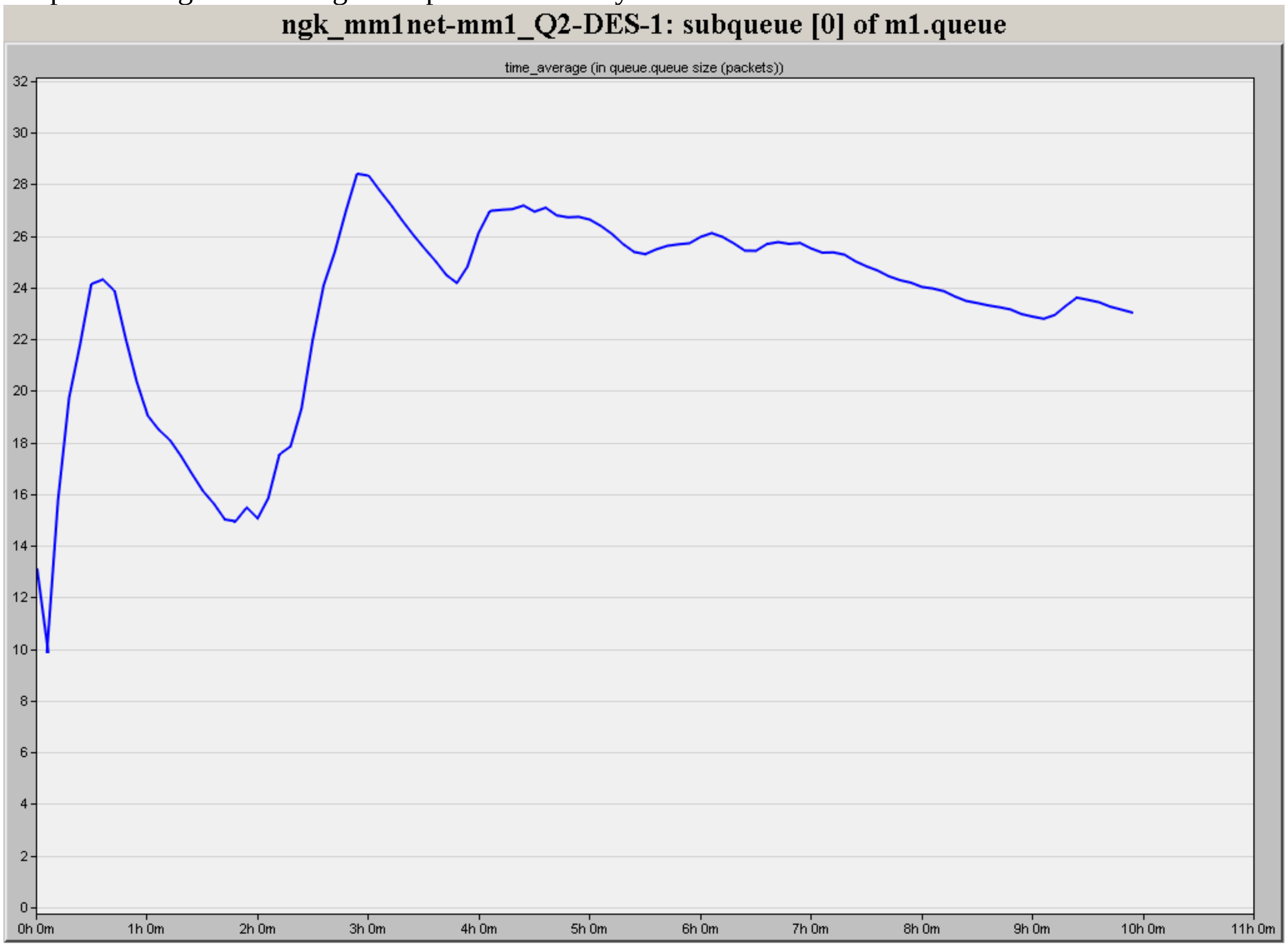
Graph showing time-average time spent in the system.



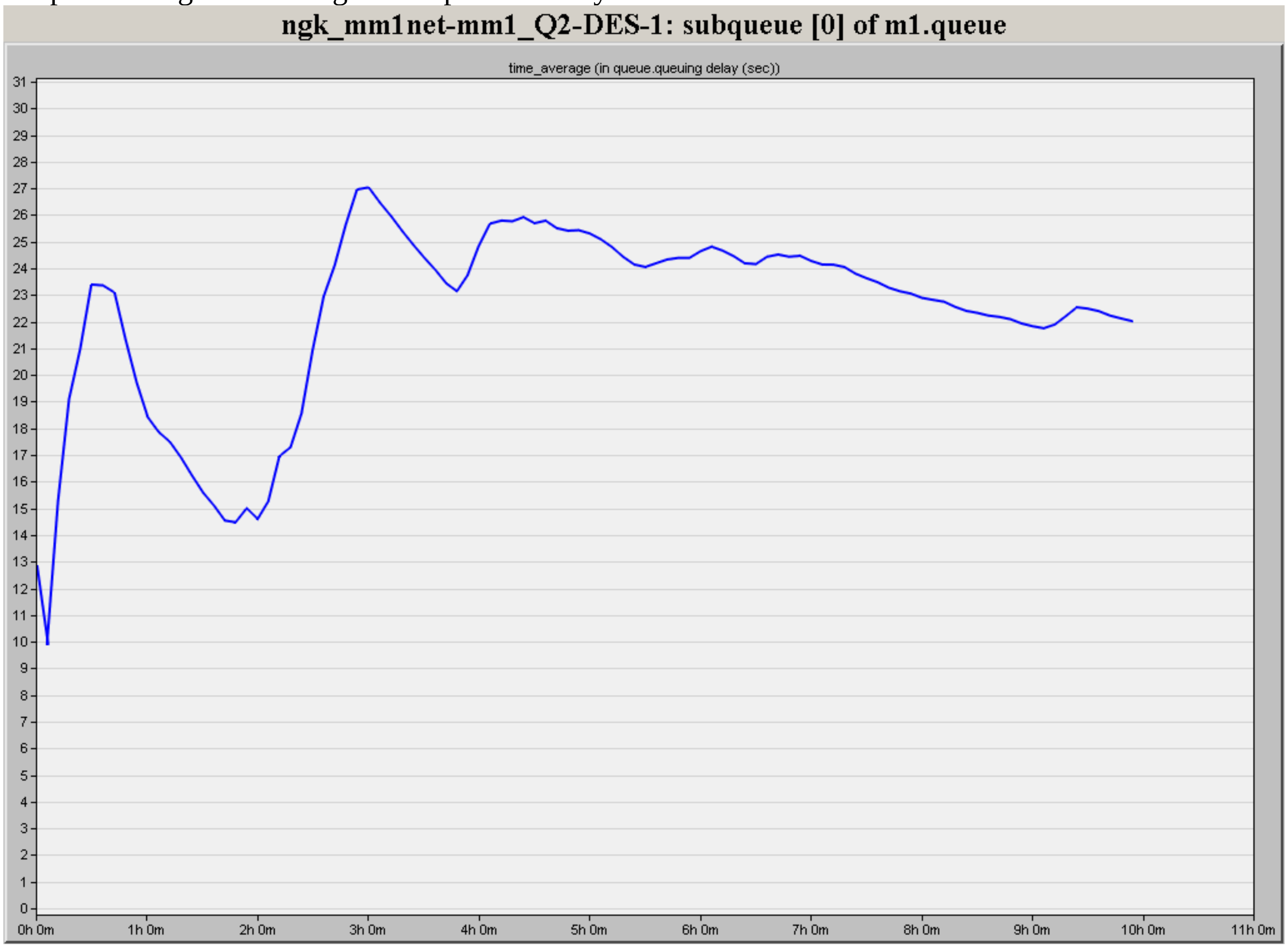
<u>Q2: Two source processors</u>

a.

Graph showing time-average # of packets in the system



b.
Graph showing time-average time spent in the system.




c. Queuing Calculation:

L = Long-run time-average number of customers in system
$= 35.7931 = (\lambda_1 + \lambda_2) / (\mu - (\lambda_1 + \lambda_2))$
$= (\lambda_1 + \lambda_2) / ((9600/9000) - (\lambda_1 + \lambda_2))$

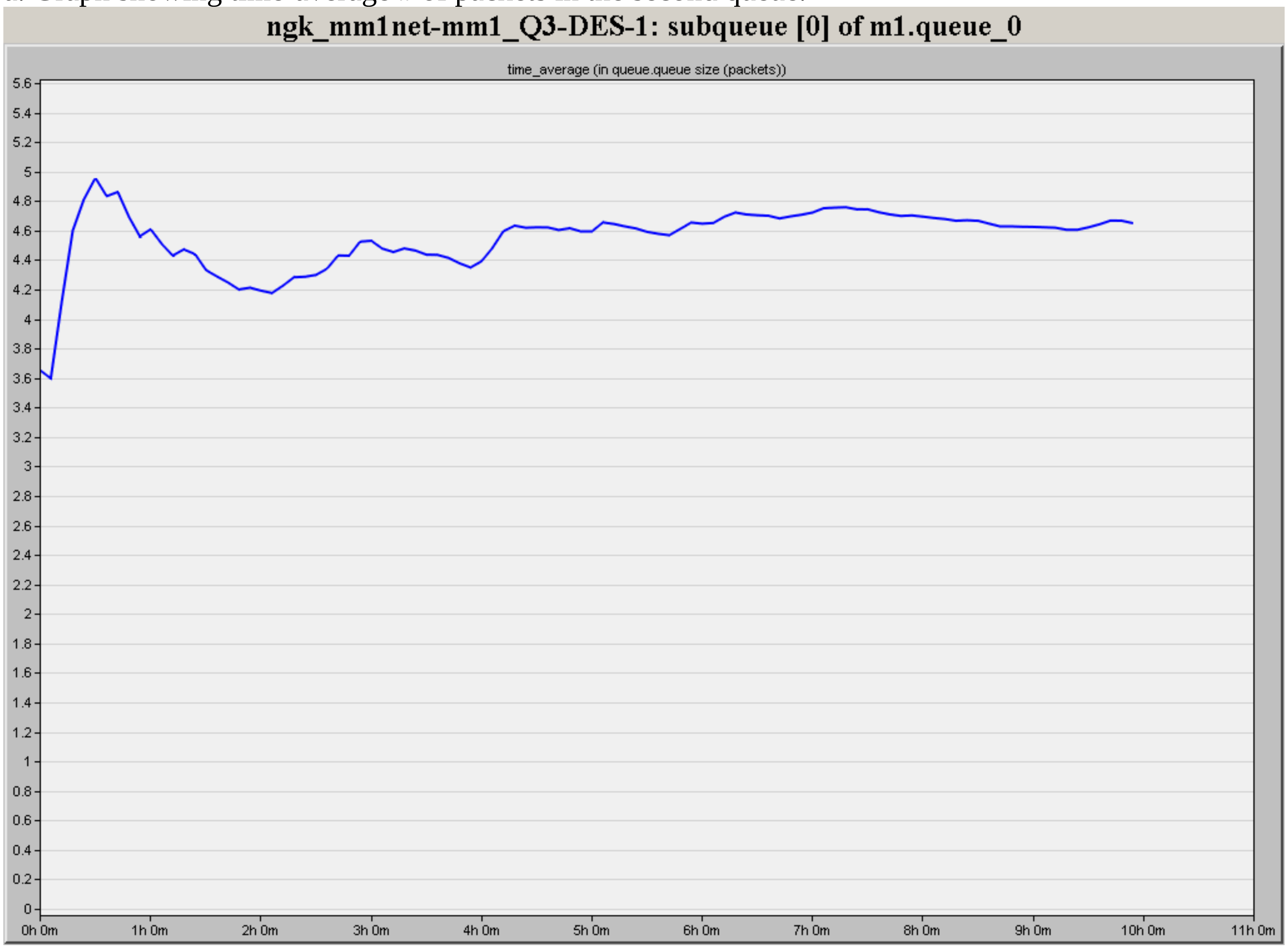
$\mu = 9600/9000 = 1.067$ packets/second

Solve for $(\lambda_1 + \lambda_2)$:
$(\lambda_1 + \lambda_2) = 1.038$
For sanity keep $\lambda_1$ and $\lambda_2$ the same this way:
$\lambda_1 = \lambda_2 = 0.519001$

$1/\lambda = 1.92678 \leftarrow$ Inter-arrival time of each Source processor

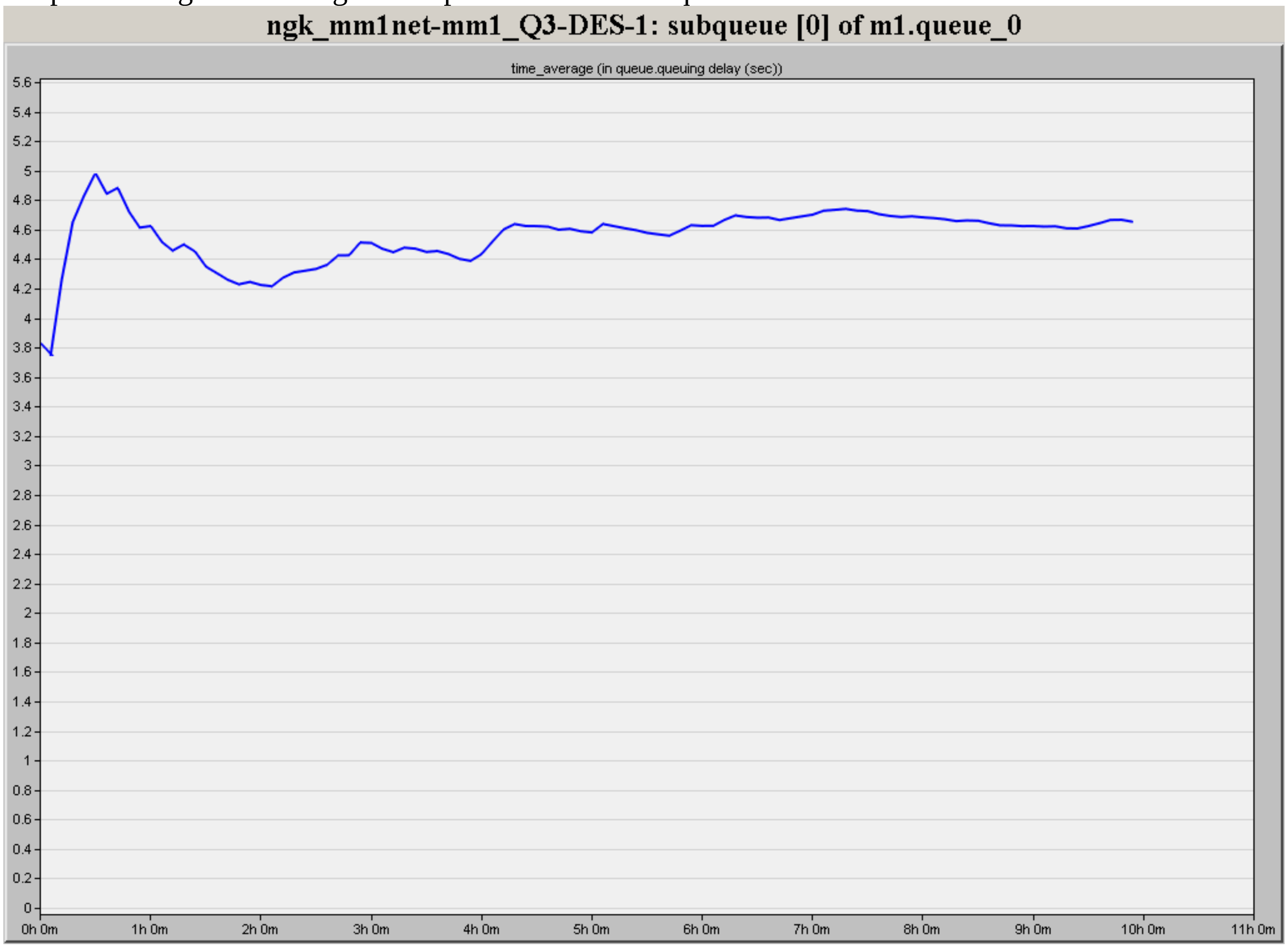
Q3: One source to two queues

a. Graph showing time-average # of packets in the second queue.



b.

Graph showing time-average time spent in the second queue.




c.
Compare graphs of Q3a and Q3b to graphs from the tutorial.
Explanation of significant change in values:

When queue size and delay statistics are gathered from the second queue they are drastically reduced when compared to statistics from the first queue. This is due to the rate at which packets are coming into the second queue. The rate at which packets enter the second queue is same as the service rate at the first queue. The inter-arrival time is reduced from 1 second to 1/1.067 = 0.937207 and the utilization at the second queue is now 1.067/1.067 = 1.

*Note: When statistics were taken from the first queue they were fairly similar to the statistics from the tutorial. Therefore, this question must be in reference to the second queue created.

**Conclusion**

After going through the tutorial the lab was pretty straightforward. The main trouble was in finding the appropriate inter-arrival times. There is a learning curve to finding the sensitivity of the variable and adjusting it. After obtaining results to part C of question 3 it became apparent that the graph is similar to the Tutorial results. Since a “significant change” is expected an assumption was made that these values should be obtained from the second queue.

On a side note: the interesting part of going through the M/M/1 lab is how learning how the (I had the opportunity to take it over summer) CSC/ECE579 course on Performance Modeling fits in with simulation software.