Simulation of Queuing Networks in OMNeT++

This program has the ability to simulate both MM1 and MD1 Queues depending on which configuration is selected.

MX1_Network.ned

```
import org.omnetpp.queueing.PassiveQueue;
import org.omnetpp.queueing.Server;
import org.omnetpp.queueing.Sink;
import org.omnetpp.queueing.Source;

network MX1_Network
{
    submodules:
        server: Server {
            @display("p=213,148");
        }
        sink: My_Sink_ext {
            @display("p=316,148");
        }
        passiveQueue: PassiveQueue {
            @display("p=128,148");
        }
        source: Source {
            @display("p=54,148");
        }
    connections:
        passiveQueue.out++ --> server.in++;
        server.out --> sink.in++;
        source.out --> passiveQueue.in++;
}
```

Additionally, a custom sink module is defined to collect the long-run average time spent in system per customer. Here is the **my_Sink_ext.cc** file:

```
#include "my_Sink_ext.h"

Define_Module(My_Sink_ext);

void My_Sink_ext::initialize()
{
    Sink::initialize();
    histogram.setName("Histogram");
}

void My_Sink_ext::handleMessage(cMessage *msg)
{
    Sink::handleMessage(msg);
    simtime_t delay = simTime() - msg->getCreationTime();
```

```
    histogram.collect(delay);
}
```

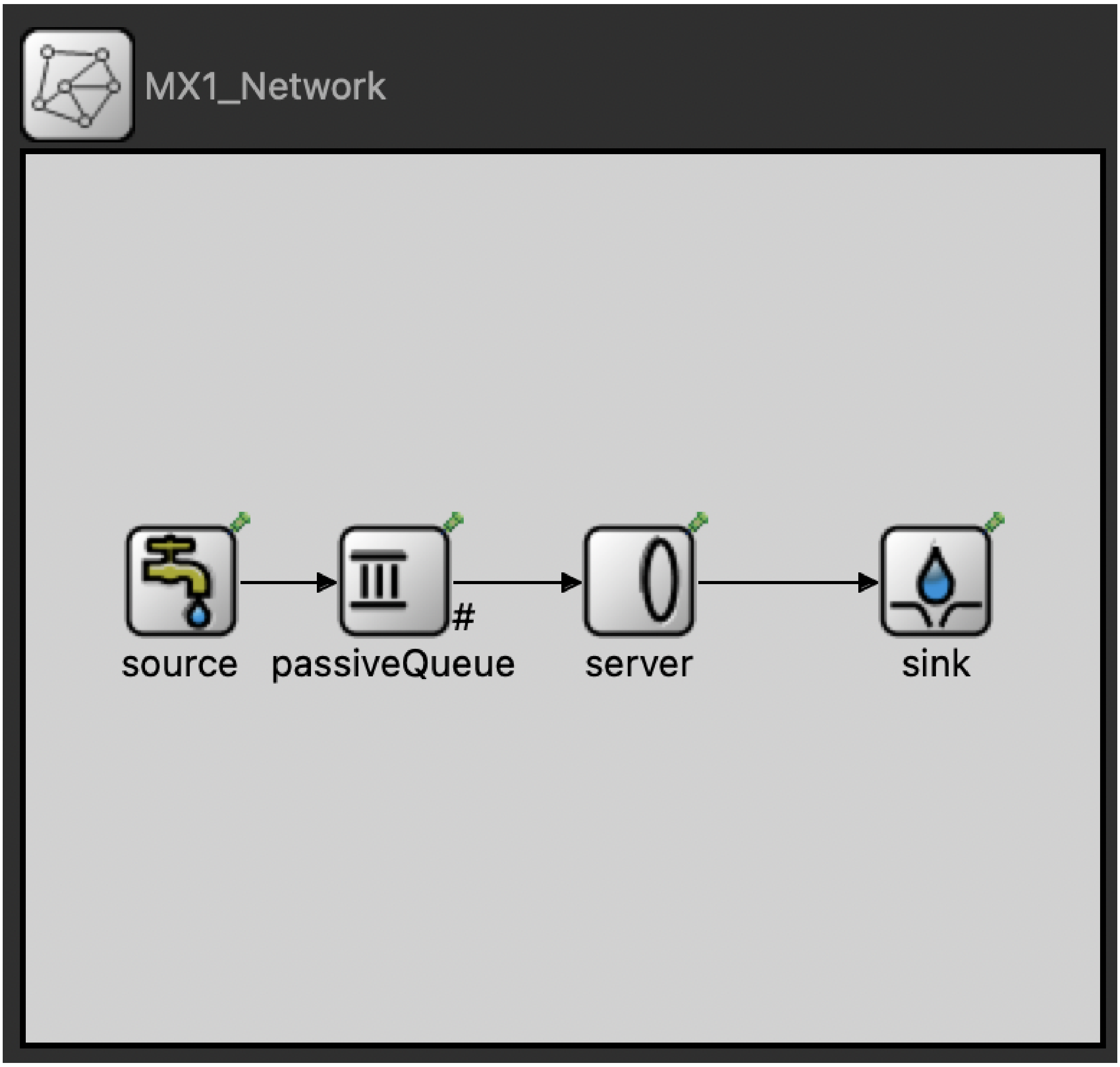
omnetpp.ini

```
[General]
network = MX1_Network
**.source.interArrivalTime = exponential(1.0s)
**.source.numJobs = 100000

[MD1]
network = MX1_Network
\*\*.server.serviceTime = 0.75s

[MM1]
network = MX1_Network
\*\*.server.serviceTime = exponential(0.75s)
```

Network Visualization



Long-Run Average Time Spent in System per Customer

M/M/1 Queue

Theoretical

For a M/G/1 Queue we can use the following formula to calculate the long-run average time spent in system per customer

$$w \approx \frac{1}{\mu} + \frac{\lambda\left(\frac{1}{\mu^2} + \sigma^2\right)}{2\left(1-\rho\right)}$$

Where:

- μ is the service rate
- λ is the arrival rate
- ρ is the utilization
- σ^2 is the variance of the service time

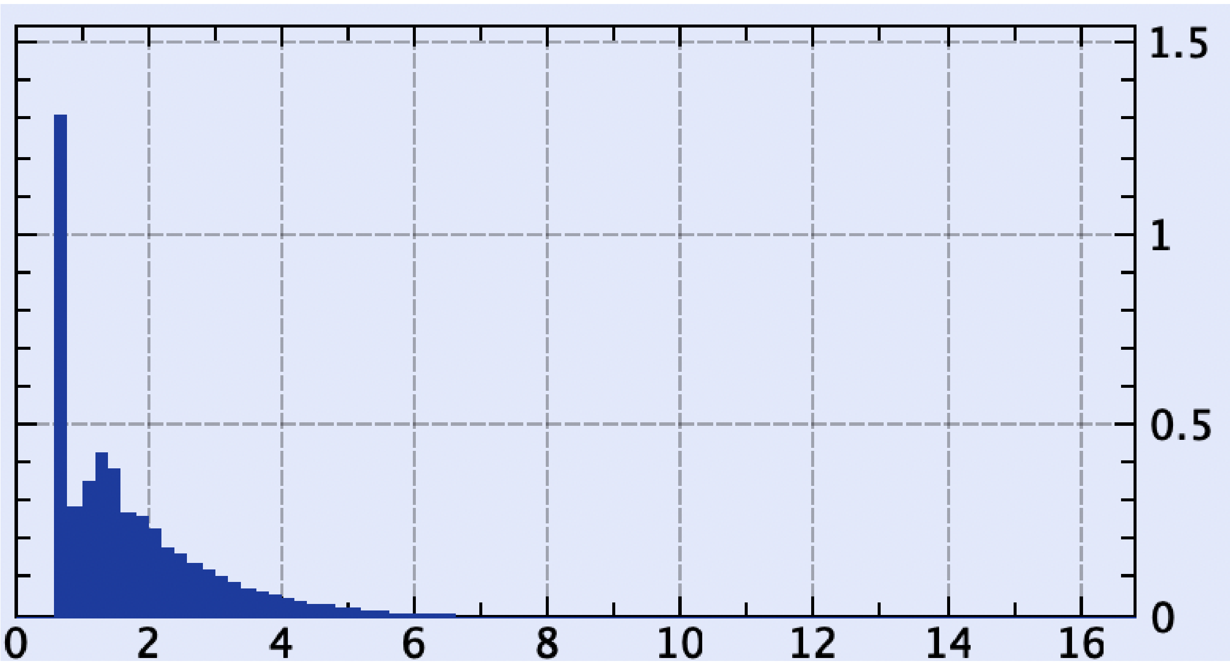
In this case, our service rate is 1/0.75 = 1.3333, our arrival rate is 1, and our utilization is 1/1.3333 = 0.75.

For a deterministic service time, the variance is 0.

$$w \approx \frac{1}{1.3333} + \frac{1\left(\frac{1}{1.3333^2} + 0\right)}{2\left(1-0.75\right)} \approx 1.87500001$$

Simulation

The long run average time spent in system per customer is collected using the **cHistogram** module. The following is the output of the simulation:



with the following stats:

Histogram (cHistogram) count=1000000 mean=1.87939 stddev=1.3643 min=0.75 max=16.6148

The mean, **1.87939** is very close to the theoretical value of **1.87500001**.

M/M/1 Queue

Theoretical

The same formula can be used to calculate the long-run average time spent in system per customer for a M/M/1 Queue.

$$w \approx \frac{1}{\mu} + \frac{\lambda\left(\frac{1}{\mu^2} + \sigma^2\right)}{2(1-\rho)}$$

Except in this case, the service time is exponentially distributed, the variance is equal to one over the square of the mean.

$$\sigma^2 = \frac{1}{\mu^2}$$

So the formula becomes:

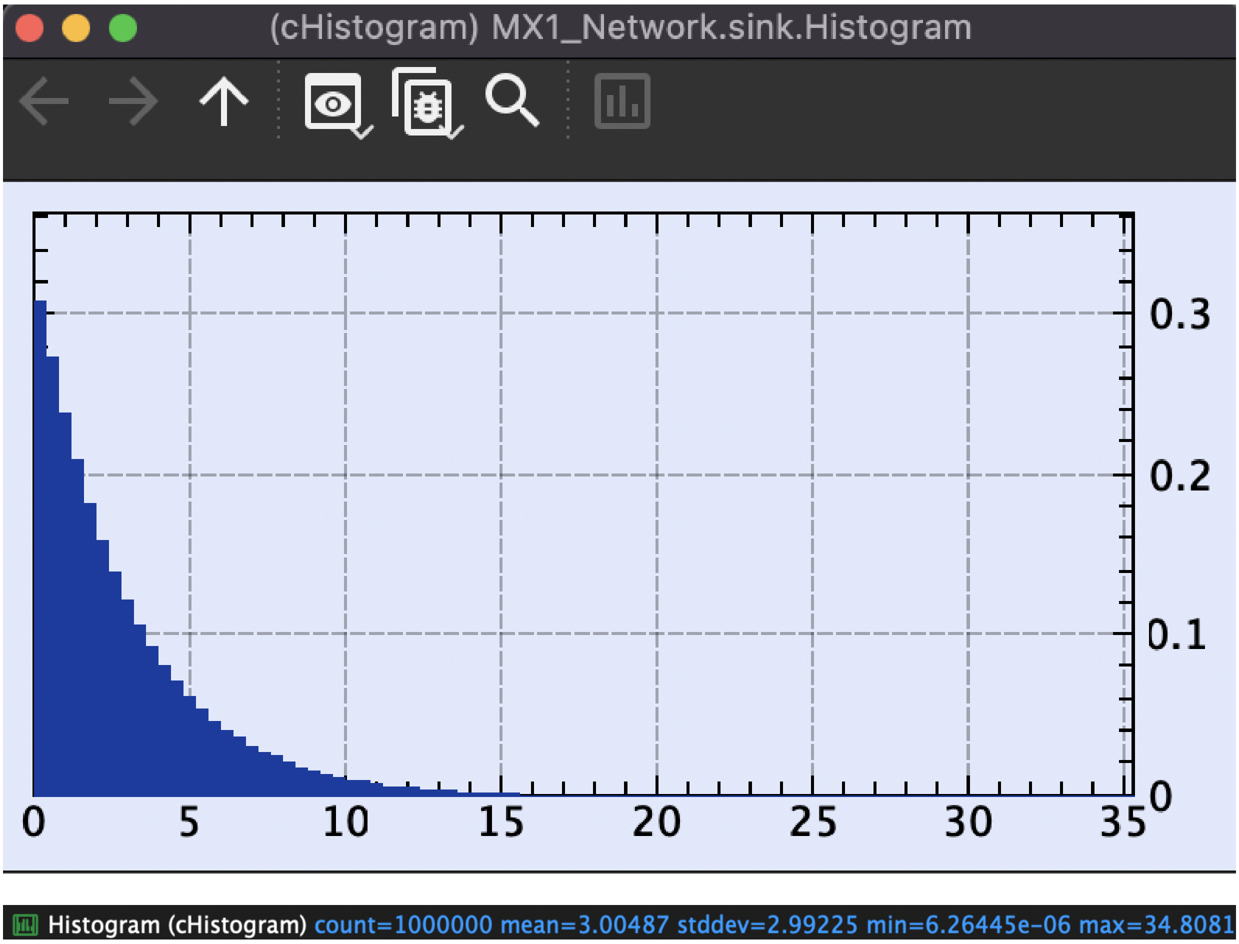
$$w \approx \frac{1}{\mu} + \frac{\lambda\left(\frac{1}{\mu^2} + \frac{1}{\mu^2}\right)}{2(1-\rho)} = \frac{1}{\mu} + \frac{\lambda\left(\frac{2}{\mu^2}\right)}{2(1-\rho)} = \frac{1}{\mu} + \frac{\lambda}{\mu^2(1-\rho)}$$

Where:

- $\mu = \frac{1}{0.75} = 1.3333$
- $\lambda = 1$
- $\rho = \frac{\lambda}{\mu} = \frac{1}{1.3333} = 0.75$

$$w \approx \frac{1}{1.3333} + \frac{1}{1.3333^2(1-0.75)} \approx 3.00000057$$

Simulation



The mean, **3.00487** is very close to the theoretical value of **3.00000057**, so I consider this simulation a success.

Code

You can access the code at my github repository