EADME.md

imulation of Queuing Networks in OMNeT++

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

X1_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++;
}
```

dditionally, a custom sink module is defined to collect the long-run average time spent in system per customer. Here is the **y_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);
}
```

mnetpp.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)
```

letwork Visualization

ong-Run Average Time Spent in System per Customer

/M/1 Queue

ıeoretical

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

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

here:

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

 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.

ɔr a deterministic service time, the variance is 0.

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

mulation

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

th the following stats:

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

/M/1 Queue

ıeoretical

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

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

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

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

the formula becomes:

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

here:

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

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

mulation

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

ode

ou can access the code at my github repository