Project

The purpose of this project is to verify through simulations, the queuing and scheduling dynamics in stochastic networks. You are free to use any software platform (i.e., Python, Matlab) to carry out these simulations.

PART 1: The Geo/Geo/1 Queue. [30 points]

Given a Geo/Geo/1 queue, consider the following scenarios:

i) An arrival rate of 0.2 and a service rate of 0.5
ii) An arrival rate of 0.45 and a service rate of 0.5
iii) An arrival rate of 0.6 and a service rate of 0.5

For each of the scenarios above:

A) Find and plot the empirical occupancy rate over 1000 time slots (from $k = 0,\ldots,9999$). On the same plot show the theoretical occupancy rate (if it exists).
B) Plot the empirical average of the queue length, $\frac{1}{k}\sum_{i=0}^{k} q[i]$ over 1000 time slots (from $k = 0,\ldots,9999$). On the same plot show the theoretical average queue length (if it exists).

Describe your strategy for simulation. Compare scenarios (i)-(iii) and and why your plots make sense.

PART 2: The G/G/1 Queue. [30 points]

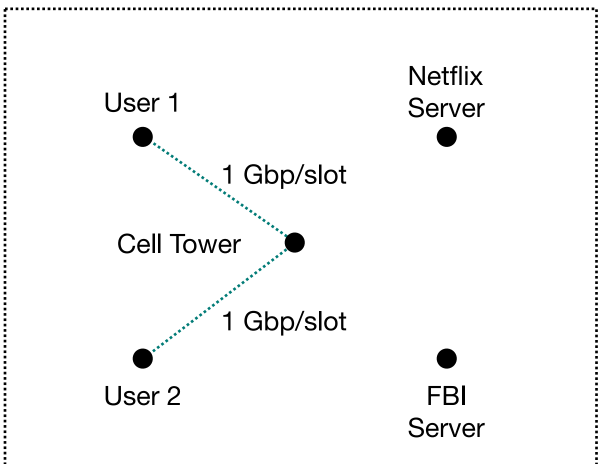
The service process $s(k)$ of a G/G/1 queue has the following distribution: $P(s(k) = n) = \frac{1}{100}$ for $n = 0,\ldots,99$ and $P(s(k) = n) = 0$ for $n \geq 100$. Consider the following scenarios:

i) The arrival process $a(k)$ has the following distribution: $P(a(k) = n) = \frac{1}{45}$ for $n = 0,\ldots,44$
ii) The arrival process $a(k)$ has the following distribution: $P(a(k) = n) = \frac{1}{95}$ for $n = 0,\ldots,94$

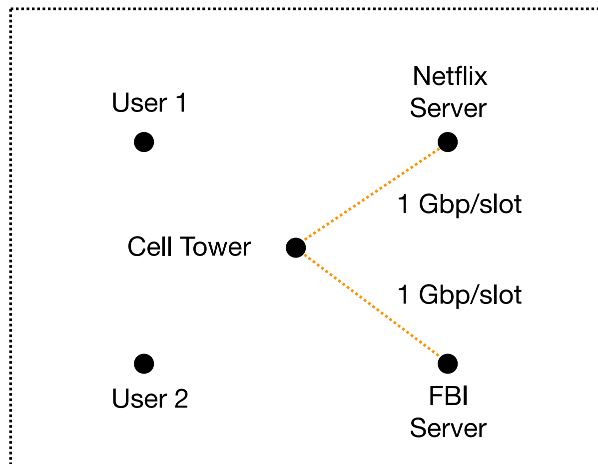
For each of the scenarios above, plot the empirical average of the queue length, $\frac{1}{k}\sum_{i=0}^{k} q[i]$ over 1000 time slots (from $k = 0,\ldots,9999$). On the same plot, show the upper-bound on the average queue length of a G/G/1 queue. Describe your strategy for simulation. Compare scenarios (i)-(ii) and explain why your plots make sense.

PART 3: MaxWeight/Back-pressure routing. [40 points]

Two users communicate with two servers through a wireless cell tower as depicted below. Only one link can be activated at any given instant. The topology of the network is time-varying. During even time-slots users communicate with the cell tower and during odd time slots the cell tower communicates with the servers. The arrival processes of all commodity flows are Bernoulli and i.i.d. Packets are generated by the users in **BOTH** types of time slots (even and odd-valued)**.** A centralized controller uses maxweight/backpressure routing to schedule transmissions.



Topology for even time slots



Topology for odd time slots

Consider the the following scenarios:

(i) Data packets destined for the Netflix server are generated by User 1 at rate of 0.24 Gbp/slot
Data packets destined for the FBI server are generated by User 1 at a rate of 0.24 Gbp/slot
Data packets destined for the Netflix server are generated by User 2 at a rate of 0.24 Gbp/slot
Data packets destined for the FBI server are generated by User 2 at a rate of of 0.24 Gbp/slot

(ii) Data packets destined for the Netflix server are generated by User 1 at rate of 0.10 Gbp/slot
Data packets destined for the FBI server are generated by User 1 at a rate of 0.38 Gbp/slot
Data packets destined for the Netflix server are generated by User 2 at a rate of 0.38 Gbp/slot
Data packets destined for the FBI server are generated by User 2 at a rate of of 0.10 Gbp/slot

(iii) Data packets destined for the Netflix server are generated by User 1 at rate of 0.10 Gbp/slot
Data packets destined for the FBI server are generated by User 1 at a rate of 0.38 Gbp/slot
Data packets destined for the Netflix server are generated by User 2 at a rate of 0.10 Gbp/slot
Data packets destined for the FBI server are generated by User 2 at a rate of of 0.38 Gbp/slot

For each of the scenarios above plot the empirical average of the queue lengths, $\frac{1}{k}\sum_{i=0}^{k} q_j^c[i]$, over 1000 time slots (from $k = 0,\ldots,9999$), where $j \in \{\text{User 1}, \text{User 2}, \text{Cell Tower}\}$ and $c \in \{\text{Netflix Server}, \text{FBI Server}\}$. There are a total of six queues so each scenario should have six plots. Describe your strategy for simulation. Compare scenarios (i)-(ii) and explain why your plots make sense.