CS-470 Modeling and Simulation Lab 4
Multi-Queue, Multi-Server Networks

Date: Week #6 Lab
Due: Week #8 Lab

The analytical modeling of multi-queue, multi-server networks quickly becomes complex. However, the special case of exponential arrival and service rates for multi-server networks is a notable exception. These heavily studied systems have well-known (and reasonably simple) analytical solutions. M/M/s queuing network models for approximating delay in network communications have been developed by Kleinrock, and are summarized below:

$$d = \frac{1}{\gamma} \sum_{i=1}^{m} \frac{f_i}{c_i - f_i}$$

where:

γ = total demand in the network

m = # of edges in the network

f_i = flow in edge i

c_i = capacity of edge i

For this lab, we wish to simulate the communication delay in a network that links ten Chinese cities. The exact definition of the problem is reported in *IEEE Computer*, August, 1997, and is detailed in the PowerPoint slides that accompany the lecture. The capacitated network, and total demand matrix is included below. Develop a simulation model to measure the percent of packet delay due to queuing in the network. Compare your results to the estimate of Kleinrock, accounting for any discrepancies that you may encounter.

Table 1: Minimum Flow Requirements

Cities	Beijing	Shanghai	Guangzhou	Hong Kong	Wuhan	Chengdu	Xi'an	Kunming	Harbin	Tianjin
Beijing	0	20	20	20	20	10	10	2	5	20
Shanghai	20	0	20	20	20	5	5	2	1	20
Guangzhou	20	20	0	20	10	5	5	5	1	5
Hong Kong	20	20	20	0	10	5	2	2	1	5
Wuhan	20	20	10	10	0	5	5	0	1	5
Chengdu	10	5	5	5	5	0	5	2	0	2
Xi'an	10	5	5	2	5	5	0	0	0	2
Kunming	2	2	5	2	0	2	0	0	0	0
Harbin	5	1	1	1	1	0	0	0	0	5
Tianjin	20	20	5	5	5	2	2	0	5	0

The topology for the Ten Chinese Cities problem follows. The labels on each edge show the capacity first, followed by the actual flow on the edge in parentheses.