March 6, 2009
Midterm Exam
EE 6340: Introduction to Telecommunications Networks

NOTE: Please, complete the following table and keep record of your assignment number.

<table>
<thead>
<tr>
<th>First Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Last Name</td>
<td></td>
</tr>
<tr>
<td>Student ID</td>
<td></td>
</tr>
<tr>
<td>Assignment #</td>
<td>0</td>
</tr>
</tbody>
</table>

**Exercise 1.** Consider a single serve system and two types of job arrivals. Type 1 job arrivals form a Poisson process with rate $\lambda_1$. Type 2 job arrivals form a Poisson process with rate $\lambda_2$. Service time for type 1 job is exponentially distributed with average $1/\mu_1$. Service time for type 2 job is exponentially distributed with average $1/\mu_2$. Type 1 job can preempt type 2 job. When preempted, type 2 job is put on hold, i.e., it will return to service once type 1 job is done. There is no room in the system for a job to wait, i.e., upon arrival either a job can begin service, or it is discarded. [Note that this problem cannot be solved using conventional priority queue models, which are designed to model an infinite waiting queue.]

A) Determine the stability condition of the queue and build the Markov chain of the system [pt. 20].

B) Using the Markov chain in A), compute the steady state distribution $\pi_{i,j}$, defined as the probability of having $i$ jobs of type 1 and $j$ jobs of type 2 in the system [pt. 20].

C) Compute $P_s^{(1)}$, defined as the probability that upon arrival, a type 1 job is discarded [pt. 10].

D) Compute $P_s^{(2)}$, defined as the probability that upon arrival, a type 2 job is discarded [pt. 10].

E) Compute the percentage of type 2 jobs that upon beginning service are preempted at least once [pt. 10].

**Exercise 2.** Consider the M/G/1/1 queue with the following special behavior. Two arrival streams are considered, each forming a Poisson process. Type 1 jobs arrive with rate $\lambda_1$, and they require a service time which is modeled as $X_1$, a generic random variable. Type 2 jobs arrive with rate $\lambda_2$, and they require a service time which is modeled as $X_2$, an exponentially distributed random variable. A job arriving when the server is busy is always dropped, unless the arriving job is of type 1, and the job in service is of type 2, in which case the type 2 job is preempted from service and discarded (i.e., the preempted job will never resume service).

A) Determine the stability condition of the queue [pt. 5].

B) Compute $P_1$, defined as the probability that a type 1 job is dropped upon arrival [pt. 10].

C) Compute $P_2$, defined as the probability that a type 2 job is dropped upon arrival [pt. 10].

D) Compute $P_2^*$, defined as the probability that a type 2 job is preempted while being in service [pt. 10].

E) Compute $d_1$ and $d_2$, defined as the departure rate (counting only the jobs that successfully complete service) of type 1 jobs and type 2 jobs, respectively [pt. 10].

F) Compute $T$, defined as the average time spent in the system by the jobs that finish their service successfully [pt. 10].