Midterm Exam

- Due 7:20pm April 7th (hand in hardcopies)
- Open book, open note
- No discussions among peer students.
  - Approach me for whatever problems you may have.
  - Feel free to set appointments with me.
- We will meet briefly on March 31st.

- (20pt) A facility of m identical machines is sharing a single repairperson. The time to repair a failed machine is exponentially distributed with mean $1/\lambda$. A machine, once operational, fails after a time that is exponentially distributed with mean $1/\mu$. All failure and repair times are independent.

  1. Show the state transition diagram of the system, where state i represents the number of operational machines.

  2. What is the (steady-state) probability that there is no operational machine ?

- (20pt) Consider a barbershop run by a master barber and his apprentice. The master's service rate is μ_1 and apprentice μ_2, where $\mu_1 > \mu_2$. Clients always choose the master first but will go for the apprentice when the master is busy. Even clients currently served by the apprentice will switch to the master if he is found idle. Customer interarrival times are exponentially distributed with rate λ. Service times are also exponentially distributed. Draw a station transition diagram for the shop and solve P_i, the probability the shop has i customers.

- (20pt) Device an $O(1)$ algorithm that generates Geometric random variables. Specifically, an invocation produces outcome n with probability $(1-p)^{n-1}p$, where $n=1,2,...$

- (20pt) Devise a packet-interarrival-time generator, that is, each invocation of the generator produces the length of time one has to wait for the next packet. Rather than using a simple distribution function, we wish to produce “bursty traffic,” the trademark characteristic of the Internet traffic.

  1. The traffic can be in two modes, quite and busy.
  2. In a quite period, packets arrives according to a Poisson process with rate λ_1 .
  3. In a busy period, packets arrives according to a Poisson process with rate $\lambda_2 > \lambda_1$.
  4. The length of a quite period is exponentially distributed with mean π_1 .
  5. The length of a busy period is exponentially distributed with mean $\pi_2 < \pi_1$.
  6. Quite and busy periods alternate with each other.

- (10pt) In modern TCP, both RTT and its variances are measured by A TCP source to determine the (initial) timeout interval T_0. Show that the greater the RTT variances of a flow, the worse its throughput.

- (30pt) Devise a Low-Priority TCP (LP-TCP) protocol that uses half of the bandwidth of normal TCP under identical network conditions (that is, identical RTT and packet loss rate p). Argue clearly why your design achieves this goal.

- (10pt) TCP uses the equation RTT=RTT*w + New*(1-w) to estimate round trip times. Assuming initial RTT=R and all the subsequent samples are $2R$, we already showed in a homework that it takes $k=-1/\ln(w)$ samples for RTT to raise to $(1-1/e)R+R$. Derive a $w'=f(w)$ formula so that it takes only half that number of samples to reach the same threshold $(1-1/e)R+R$.

- (20pt) Consider a differentiated service that specify
  – an average traffic rate R (in pkt/sec)
  – an accommodated burst size S (in # of pkt)
  – a burst rate B (in pkt/sec)

  Design a traffic conditioner for the service so that all packets are admitted when inbound traffic rate T < R. When T >R, up to S excessive packets can be admitted at rate B–R; the others are still admitted at rate R, producing the combined rate of B. However once the threshold S is exceeded, excessive packets are dropped.

  Hint: One token bucket is not enough.