Advance Computer Networks Final Exam

1. (20%) Please answer the following questions regarding Poisson processes.
   (1) Let \( X(t) \) and \( Y(t) \) be two independent Poisson processes. Let \( W(t) = X(t) + Y(t) \). Show that \( W(t) \) is a Poisson process.
   (2) Suppose that each arrival in a Poisson process, independently, is of one of two types: Type 1 with probability \( p \) and Type 2 with probability \( q = 1 - p \) (this is sometimes referred to as splitting a Poisson process). Show that Type 1 arrivals and Type 2 arrivals form separate and independent Poisson processes.

2. (20%) Please explain how to evenly decompose the given delay threshold \( T \) and the given overdue probability \( P \) considered in an end-to-end percentile-type delay requirement to \( k \) hops, so that when the allocated requirement to each hop is satisfied then the end-to-end delay requirement is guaranteed to be satisfied. Please propose as many methods as possible.

3. (20%) Consider a large institute, where the rate of outgoing calls is \( m \) calls per second and the call arrival process is assumed to be Poisson. Assume also that the call holding time can be characterized by an exponentially distributed random variable with mean \( t \) seconds. Please propose a method to calculate the minimum number of outgoing lines (channels) required, denoted by \( n \), so that the call blocking probability (the probability that an outgoing call finds that all the outgoing lines are occupied) should be no greater than \( p\% \).

4. (20%) Please briefly describe the 6 functional modules (and the relations among them) for network planning and capacity management as discussed in the class.

5. (20%) Please explain how admission control and policing (flow enforcement) can be jointly applied in a high-speed network to assure QoS requirements.

6. (20%) Consider Poisson traffic with mean arrival rate \( \lambda \) (packets per second) which is serviced by 2 identical parallel transmission lines with the service rate \( \mu \) (packets per second) each. Assume that each line is of infinite buffer. Let \( \lambda = \mu = 1 \). Please use the Markov chain approach introduced in the class to calculate the average packet delay associated with each line when the following routing policies are adopted, respectively: (i) “random and even splitting” policy (ii) “joining the shorter queue” policy, where the queue length is in terms of the number of packets, and (iii) “alternating” policy (i.e. numbering the Poisson arrivals sequentially and dispatching all even-numbered arrivals to one line while dispatching all odd-numbered arrivals to the other).