Mid-term examination of Introduction to Networking

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1. Consider the queuing delay in a router buffer. Suppose all the packets are L bits long, the transmission rate is R bit/sec and that N packets arrive simultaneously at the buffer every LN/R seconds.

   Question. Find the **average** queuing delay of a packet.

   Hint. The queuing delay for the first packet is 0; for the second packet it is L/R; for the third packet it is $2L/R$ etc. The last packet (number N) has already been transmitted when the second batch (i.e., group) of packets arrives.

2. **Questions.** Consider the queuing delay in a router buffer. Let I denote the traffic intensity, that is: $I = aL/R$. Suppose that the queuing delay takes the form $IL/R(1-I)$ for $I < 1$.

   (a) Provide a formula for the total delay, that is, the queuing delay plus the transmission delay.

   (b) Express the total delay as a function d of L/R, that is to say, define $d(x) = \ldots$

3. We consider sending voice from host A to host B over a packet-switched network (for example, Internet phone). Host A converts analog voice to a digital **64 Kbps** bit stream on the fly. Host A then groups the bits into a **48-byte** packets. There is one link between host A and B; its transmission rate is **1 Mbps** and its propagation delay is **2 msec**.

   As soon as host A gathers a packet, it sends it to host B. As soon as host B receives an *entire* packet, it converts the packet's bits into an analog signal.

   Question. How much time elapses from the time a bit is created (from the original analog signal at host A) until the bit is decoded (as part of the analog signal at host B)?