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Exercise 1
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Virtamo/Penttinen

1. a) How much information is in transit ("on wire") on a 1000 km long transmission cable if the transmission speed is a) 10 Mb/s b) 155 Mb/s? Use 2 * 10^8 m/s as the propagation speed of the transmitted signal.
   b) How long is the transmission time of one ATM cell on a transmission line operating at 155 Mb/s ?
   c) How long does it take to fill the payload of one ATM cell from a source with transmission speed of 64 kbit/s ?

2. Information is transferred in fixed size (N bit) packets either as datagrams or using virtual connections. In the first case one needs n_d bits for the address. In the latter case the length of the VCI field is n_c ($< n_d$) bits. In addition the set up of the connection takes a time equal to that of transmitting D bits. When is the transmission of an M bit long message faster using a virtual connection than using a datagram?

3. a) Error frequency is related to the size of the ATM cell. Assuming that the bit error rate (BER) is p, each cell has N bits and that the errors in consecutive bits are statistically independent, show that the cell error rate (CER) is $\mathrm{CER} = 1 - (1-p)^N \approx Np$.
   b) Assume that retransmission is done each time when there is an error in the cell. In this case, for each correctly received cell one has to send $(1 - \mathrm{CER})^{-1}$ cells on the average. Assuming that each cell has n bits overhead independent of the cell size, show that the average number of bits sent per one correctly received bit is $(N + n)/(N(1 - p)^{N+n})$. What is the minimizing optimal cell size of the given expression if n = 40 (5 bytes) and a) $p = 10^{-9}$ or b) $p = 10^{-3}$?

4. In a part of an ATM network there are four successive nodes A, B, C, D. The following permanent virtual paths (VPC connections) have been set up: A-B-C-D, A-B-C, B-C-D. Route A-B-C-D has eight virtual channel connections (VCC): two of them do not use any of the virtual paths above (i.e. they consist of separate node-per-node VPC connections); on the other hand there are two VCC connections in each permanent VPC. Give a possible set of VPI/VCI identifiers on each link for each VPC and VCC connection (change the identifiers whenever it is possible).