CSIS0234B Computer and Communication Networks (Class B)
Assignment 2
From Physical connections to Data link control

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This is a written, individual assignment. Put your completed assignment to the assignment box, or send your electronic version to the course web page through the web hand-in system.

1. (10%, Level: Easy) Suppose the SNR of a channel at distances of 10m and 20m are 100dB and 90dB respectively. The noise level is constant for all distance.

   a. Suppose the channel is directional, point-to-point. Predict the SNR at 1m and 40m. At what distance the noise and the signal are at the same level?

   b. Repeat the last step assuming an omni-directional, broadcast channel.

2. (15%, Level: Medium) In one possible configuration of 100Mbps Ethernet, 4 pairs of category 3 cables are used, and 8B6T is used for data encoding. The communication is "simplex": at any time, only one party should be sending data, in 3 of the 4 available pairs of wires. The 4-th pair is not used for sending data (instead it is used for collision detection).

   a. Derive the baud rate of the scheme, and the bandwidth required for the scheme, from the above descriptions. Show all your workings. (Hint: category-3 cables are only certified to communicate at frequency of up to 16MHz.)

   b. Use Shannon's capacity to compute what is the minimum SNR needed for such rate to be used. (Note that Ethernet actually requires much better SNR than what you calculated: it is not designed to be very noise tolerant.)

   c. In the frequency you calculated above, a category-3 cable can easily achieve SNR of 80dB. What is the Shannon's capacity in the 3 data wires in total? Explain why the standard uses "only" 100Mbps of the available capacity.

3. (20%, Level: Medium to hard) Read section 3.7.1–3.7.2 of the textbook about phase modulation and QAM, and answer the following question.

   a. A channel uses QAM for communication. Suppose it is currently used to send a signal at a particular point of the signal constellation, when a reflecting obstacle causes the path length to increase. The net effect is that the propagation time is lengthened slightly, by Δt. Show that the effect is to rotate the point in the signal constellation by an angle θ, and compute the value of θ.

   b. Unluckily, two senders somehow send data at the same time. They are sending $a_1 + b_1 i$ and $a_2 + b_2 i$ respectively in the complex coordinate (the A_k axis is the real coordinate, the B_k axis is the imaginary coordinate). Assuming the magnitude received from the two senders are the same. Show that the eventually, the receiver would instead receive $(a_1 + a_2) + (b_1 + b_2)i$. (Note: this "linearity" property is crucial for many spreading and multiple access schemes, like CCK used in 802.11b Wireless LAN and CDMA used in many mobile phones.)

4. (15%, Level: Medium) Many datalinks use the CRC scheme to detect errors.

   a. Suggest why CRC in data link layer is usually put at the trailer rather than the header

of the frame.

b. Since many devices migrate hardware functionalities to software, sometimes there needs to be a software implementation. In order to do so, one can naively shift the packet data bit-by-bit into a register and compute XOR with the generator. With the use of a 256-word table (each word having the same length of the CRC), suggest a way to speed up the process so that individual bits need not be extracted from packets. Show how your scheme would compute 16-bit CRC of the short message containing the sequence of four bytes [15, 25, 25, 15] (in decimal), using a generator of 1 0010 1000 0000 0001 (spacing is added to ease reading).

5. (15%, Level: Medium) This problem is about the Selective Repeat protocol.

   a. In a channel, Selective Repeat is used without Negative Acknowledgement. The channel is uni-directional, so piggy-backing is not used. The transmission delay is 50ms, the sender timeout is set to 500ms, the frame time for data and acknowledgement are 3ms and 1ms respectively, and the processing delay is negligible. The sender and receiver windows are both set to 10. Find the number of frames that are resent when one data frame is dropped due to error.

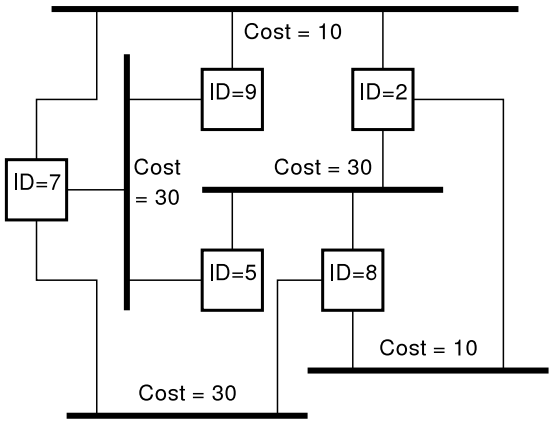
   b. Suppose negative acknowledgement is added. The aim is that when only 1 data frame is in error, only that frame should be resent, while the channel should still be completely utilized. What is the minimum sender timeout and window size?

6. (15%, Level: Medium) When two computers communicate over an Ethernet network connected using a hub, it is usually the case that stop-and-wait performs better than go-back-n and even selective repeat. Explain why. Will the same hold when using a switch?

   Test your assertion by employing the computers in our lab in CP-LG104: the bigger 12-port network connecting devices in the lab is a hub, the smaller, 5-port device is a switch. To test, slightly modify the solution for tutorial 3, so that the sender will continue sending until the number of acknowledgements received is less than the number of data messages sent by, say, 5. Report the transfer speed when communicating a 1MiB file in the four possible combinations of environments (using switch and using hub, using stop-and-wait and using go-back-5). (You don't need to submit your program.)

7. (10%, Level: Easy) All Ethernet switches communicate configuration BPDU (cBPDU) to each other to compute spanning trees.

   a. Consider the following network. In the figure, we assume that the switches agree on the cost of each network.



At the steady state, which of the ports will become a root port and which will become a destinated port? Which will be deactivated?

b. By using Ethereal in our lab, determine how often are cBPDU sent in each switch.

c. Suggest a way to deal with the problem of the routing loop during the period of time before the spanning tree is built correctly.