CS164 — Fall 2002 Midterm

Aids allowed: calculator.

Name: Student Number:

Problem 1. State whether each of the following statements is **true** or **false**.
(**Two points for each correct answer, −1 point for each incorrect answer.**)

a 4B/5B encoding is designed to limit the number of consecutive *one* bits transmitted over the link to reduce power consumption, because it takes more energy to transmit each "one" bit than a "zero" bit.

b A process running some layer-N protocol, $N > 1$, doesn't communicate directly with its peer on another host. Instead, it invokes functions provided by the service interface of a layer-$(N-1)$ protocol.

c *Two dimensional parity codes* are designed for error control in broadcast services, such as digital TV stations, which must be delivered to multiple receivers spread across a wide geographical area, such as the city of Los Angeles.

d The primary purpose of the Spanning Tree Algorithm for bridges is intrusion detection: an outside attacker must first cross at least one edge belonging to the spanning tree before they can reach any of the computers in your network.

e The combination of an $n \times n$ Batcher sorting network followed by an $n \times n$ Banyan interconnection network gives us a *nonblocking* $n \times n$ switch.

f If Alice and Bob are connected by a direct link (rather than some path through a switched network, say), then *all* data sent by Alice's encoder will be received by Bob's decoder, but possibly not in the original order.

g The design of the Internet is based on a *datagram* packet switching model rather than a *virtual circuit* packet switching model.

h If ATM had used a larger cell size, then the minimum network delay for a telephone call would have been larger also.

i In Ethernet, a *broadcast domain* is generally smaller than a *collision domain*, because transmitted signals become weaker as they travel long distances, and a signal too weak to be received without errors could still interfere with other signals.

j When the Stop-and-Wait algorithm is used on a link, then its throughput can never exceed a (finite) maximum value, even if we increase the raw bit rate to infinity.

Problem 2. Framing in Ethernet is based on the following set of rules:

- Each pair of consecutive frames are *separated* by an *inter-frame gap* (which is an idle period that is at least 96 bit times long), followed by a *preamble*, (which is a fixed sequence of exactly 64 bits).
- The *frame length* can be any value (in bytes) between a minimum value of 64 bytes and a maximum value of 1518 bytes.
- The *frame format* consists of a 14-byte header, a payload field whose length is between 46 bytes and 1500 bytes, and a 4-byte checksum.

Answer the following questions, assuming a bit rate of 10^7 bits/sec.

a The Ethernet frame format doesn't include a length field. Briefly explain how it can function properly without one.

b Find the maximum possible number of packets per second that can be carried over a single Ethernet link. Explain which parameter combination gives you this maximum and show your work!

c Find the maximum possible throughput (in bits/sec) that can be achieved by a higher-layer application that uses Ethernet to carry its data.

Problem 3. When an application wants to transfer data over an ATM network,

- the sender gives the outgoing data to the ATM Adaptation Layer (AAL) service interface as a series of large, variable-length packets,
- the sender's AAL divides each packet into a sequence of small, fixed-length cells
- the cells are transported over the ATM network to the destination,
- the destination's AAL reassembles the packets from the arriving cells and passes them to the receiving application.

Two different methods are available for transfering large data packets over an ATM network: AAL 3/4 and AAL 5. In both methods, the packet format includes:

- between 0 and 64 Kbytes of application data
- 8 bytes of header information
- enough "padding" to expand the total length of the packet to an exact multiple of 32 bits (for AAL 3/4) or 48 bytes (for AAL 5).

Note that AAL 3/4 also adds its own 4-byte header inside the ATM cell payload, whereas AAL 5 does not require an extra header inside the ATM cell payload. Thus, AAL 3/4 packets are divided into 44-byte segments for transmission over the ATM network, whereas AAL 5 packets are divided into 48-byte segments.

a For each method, what is the maximum amount of application data that can be carried by a data packet that fits entirely within a single ATM cell?

b Notice that the maximum size of the padding field is much larger for AAL 5 packets than for AAL 3/4 packets. Does this mean that the length of an AAL 5 packet with K bytes of application data is always greater than or equal to the length of an AAL 3/4 packet with K bytes of application data? If so, explain why. If not, give a counterexample.

c Find the worst-case ratio between the number of cells required to carry an AAL 3/4 packet with K bytes of application data, divided by the number of ATM cells required to carry an AAL 5 packet with K bytes of application data.

Problem 4. Suppose Alice, who uses a dialup modem to connect to the Internet through Ivan.net (her ISP), wishes to upload a large file to one of her former classmates from UCR, who now runs a major Internet server called by Bob.com. Assume that Alice's modem connects to Ivan.net at a data rate of exactly 28,000 bits/sec through a 4 kilometer copper line, and that Ivan.net has a direct satellite link to Bob.com. Assume that the satellite link has a data rate of 10 Mbps and that the one-way propagation delay through the satellite link is approximately 250 msec. Also assume that Alice sends 350-byte data packets (including the overhead of all protocol layers), and that Bob.com returns a 70-byte ACK immediately after receiving each data packet.

a Draw and label a *space-time diagram* showing the path from Alice to Bob.com. Make sure your diagram includes both the transmission time and approximate one-way propagation delays for data packets and ACKs travelling across both the modem link and the Internet backbone. (You may assume a velocity of 2×10^8 m/sec. in the phone line.)

b Find the minimum round-trip delay over this path.

c If Alice and Bob use Stop-and-Wait, what would be the throughput (in bits/sec)?

d If Alice and Bob use a sliding window for flow control, find the minimum size for Alice's transmit window that will allow her to transmit continuously, assuming there are no errors.