B1. Networks (25 points)

a) (6 points) Describe four components that make up communication delay.

b) (6 points) Consider the following simple 3 node network

and the following assumptions

Bandwidth from A to B, 1.5 Mbps (Megabits per second)

Bandwidth from B to C, 1.5 Mbps

Distance from A to B, 1000 km

Distance from B to C, 1000 km

Propagation speed, $2 * 10^8$ meters/s

A, B, C process packets in negligible time

How long will it take a single 1024 byte packet to be completely transmitted from A to C assuming:

i. B acts as a cut-through switch with buffering capability

ii. B acts as a store and forwarding router

c) (7 points) For case "ii.", sketch an approximate graph showing communication delay from A to C as a function of packet size. What do the slope and vertical intercept of the graph represent?

d) (6 points) Assume now that nodes A, B, C do not process data infinitely fast, but need to run a CRC algorithm for error detection. If the amortized cost of doing this is 5 microseconds for every 32 bits of data at A, and an equal cost at nodes B and C, how long does it now take for a 1024-byte packet to successfully reach C, counting all the delays encountered in the transmission? (Assume B is a store and forward router.)

B2. Networks (25 points)

a) (3 points) Explain the difference between a protocol and a service.

b) (8 points) TCP and UDP, respectively, provide a large number of services to their user. Describe as many as you can. Be careful NOT to describe protocol mechanisms.

c) (4 points) "For some common Internet applications today, UDP services alone are insufficient while TCP services are more than necessary." Describe one such application and how it justifies the above statement.

d) (10 points) In many ways, transport and data link protocols that provide reliable data transfer are similar (e.g., TCP, HDLC). However, significant differences exist due to major dissimilarities between the environments in which the two operate. Discuss 3 important differences.

B3. Networks (25 points)

The Internet has grown from connecting 4 hosts in 1969 to millions of hosts of different kinds in 2001.

a) (4 points) Describe what model is used to support heterogeneity.

b) (3 points) Describe what addressing scheme is used to support heterogeneity.

c) (3 points) Describe what protocols are used to support heterogeneity.

d) (4 points) Describe what model is used to support scalability.

e) (4 points) Describe what addressing scheme is used to support scalability.

f) (7 points) Describe what routing scheme and protocols are used to support scalability.

B4. Networks (25 points)

a) (5 points) Consider the use of 1000-bit frames on a 1-Mbps satellite channel with a 270-ms delay. What is the maximum link utilization possible for a

i. Stop-and-Wait protocol

ii. Selective-Repeat protocol

iii. Go-Back-N protocol

b) (5 points) Consider an ARQ algorithm running over a 20-km point-to-point fiber link. Assume the speed of light is $2 * 10^8$ m per second in the fiber. Suggest a suitable time out value for the ARQ algorithm to use.

c) (7 points) Suppose you are designing a sliding window protocol for a 1-Mbps point-to-point link to the moon, which has a one-way latency of 1.25 seconds. Assume that each frame carries 1 KByte of data. Assuming a full pipeline, what is the minimum number of bits needed for the sequence number for i. Selective-Repeat and ii. Go-Back-N, respectively?

d) (4 points) A WWW server is usually set up to receive relatively small messages from its clients, but to transmit potentially very large messages back to them. Explain which type of ARQ protocol (Selective-Repeat, Go-Back-N) would provide less of a burden to a particular popular WWW server.

e) (4 points) In the sliding window protocol, why doesn't it make sense to have a receiving window size greater than the sending window size?