Exam #2 for Computer Networks (CIS 6930)

Fall 2003

>>> SOLUTIONS <<<

Welcome to Exam #2 in Computer Networks (CIS 6930). You have 75 minutes. Read each problem carefully. There are eight required problems (each worth 12.5 points) and one extra credit problem worth 5 points. You may have with you a calculator, pencils, eraser, blank paper, and one 8.5 x 11 inch "formula sheet". On this formula sheet you may have anything you want (definitions, formulas, etc.) *handwritten by you*. You may use both sides. Computer generated text, photocopies, and scans are not allowed on this sheet. Please submit your formula sheet with your exam. No sharing of calculators. Start each numbered problem on a new sheet of paper and do not write on the back of the sheets. Submit everything in problem order. Good luck and be sure to show your work.

Problem #1

a) Compare checksums and CRCs as a means of detecting errors. Discuss the tradeoffs between checksums and CRCs.

Checksums have a greater probability of undetected errors than do CRCs. That is, CRCs are better at detecting errors and will result in less undetected errors than checksums. CRCs are easily be computed in hardware, but not very easily in software. Checksums can be computed in software much faster than can CRCs.

b) Compute the CRC for a given message (*M*) and a generator polynomial (*P*). *M* is 0111101 and *P* is 1011.

We divide *M* by *P* and the remainder is the CRC. We use modulo-2 math with no borrows or carries. The quotient of the division is 110110 and the remainder is 10. Thus, the CRC is 010.

c) Describe an error that cannot be detected with a checksum.

Consider a message of at least two *N*-bit words. For a *N*-bit check sum if an odd numbered work has a value *M* added to it that an even numbered word has subtracted from it, then the checksum will be the same as the for the original message.

d) An Ethernet frame has 8 bytes of 10101010b in the preamble. What is the purpose of this preamble?

This preamble serves to delimit the frame for the receiving adapter. Specifically, the purpose of the preamble is to synchronize the receiver's clock with the sender's clock for the receipt of the frame.

Problem #2

a) What is a Local Area Network (LAN)? Be precise.

Very precisely, a LAN is a data network optimized for a medium-sized area with 10's to 100's of stations and 100's to 1000's of meter span. A LAN is owned, operated, and used by a single organization.

b) What are the types of media used in LANs?

The types of media are coax, unshielded twisted pair (two categories – voice grade (3) and data grade (5)), fiber, and wireless. There was also shielded twisted pair (from IBM). Coax comes in two flavors – thick and thin.

c) What is the key disadvantage of a physically direct-wired LAN? Explain how a star-wired LAN remedies this disadvantage.

Fault detection and isolation are very difficult in a large (large span and large number of stations) direct-wired LAN. To find and isolate a fault one must literally "walk the wire". In a star wired LAN faults can be detected and isolated in a central location – the wiring closet. To detect and isolate a fault in a wiring closet, individual lobes of the LAN can be unplugged until the LAN returns to operation. This can be automated.

d) Compute the minimum possible frame size for a CSMA/CD protocol given the following parameters. Maximum medium span is 5000 meters (signal propagation is 5 nanoseconds per meter) and the data rate is 100-Mbps.

The minimum frame size is $t_{fr} = 2 \cdot t_{pr}$ where t_{fr} is the frame size in bits divided by the data rate in bits per second and t_{pr} is the medium span in meters multiplied by the signal propagation in seconds per meter. We solve for frame size, *x*, in $x/(100 \cdot 10^6) = 5000 \cdot 5 \cdot 10^{-9}$ and the result is 312.5 bytes.

e) Compute the utilization (U) for a token ring LAN where all stations have frames queued to send given the following parameters. The ring length is 5000 meters (signal propagation is 5 nanoseconds per meter), number of stations is 25, mean frame length is 100 bytes, and the data rate is 100-Mbps. Would early token release increase the utilization? If yes, by how much?

We first compute $t_{fr} = (100 \cdot 8)/(100 \cdot 10^6)$ which is 8 microseconds and $t_{pr} = 5000 \cdot 5 \cdot 10^{-9}$ which is 25 microseconds. Here we have $t_{fr} < t_{pr}$ so $U = t_{fr}/(t_{pr} + (t_{pr}/N))$ which is 30.8%. for this case, early token release would improve performance to $U = t_{fr}/(t_{fr} + (t_{pr}/N))$ which is 88.9%. this is an almost 3 times improvement.

Problem #3

a) Give the forwarding and learning algorithm for transparent bridging (TB). How are entries removed from tables?

The TB forwarding and learning algorithm is executed for each received frame at each port:

1) **Receive a frame**
2) **If (DA is in table) and (DA is local) then not forward the frame, else forward the frame**
3) **If (SA is in table) then check and update the direction in the table**
4) **If (SA is not in the table) then add SA to the table**

A time-out policy is used to remove unused addresses in a bridge table (i.e., addresses not checked and updated within a set period of time – typically 5 minutes).

b) Compare and contrast transparent bridging and source routing.

Transparent bridging (TB) does not require changes to the end nodes (e.g., to applications), source routing (SR) does. In SR end nodes must initiate route discovery and store routes. TB does not allow for parallel forwarding bridges (i.e., cycles in a network of LANs), SR does allow this. TB may be less speed scalable since it involves table look-up and updating in a bridge whereas SR requires much less processing (essentially only a matching of ring and bridge number in a RIF) in a bridge. For frequently changing topologies, SR is a mechanism of quickly determining (likely) new paths. The TB table learning and (especially) ST algorithm require considerable time to adjust to a new topology

Problem #4

a) What are the attributes of a perfect transport?

The perfect transport is 1) suitable for LAN and WAN, 2) suitable for carrying real-time traffic (low delay), 3) speed scalable, and 4) easy to switch.

b) Sketch the B-ISDN protocol model and describe the purpose of the ATM and AAL layers.

This is a 3-D cube with three layers (PHY, ATM, AAL, and higher layers top to bottom) and two planes with one plane divided. The undivided rear plane is management and the divided front plane is control and user. The ATM layer is the transport layer for video, voice, and data. The AAL layer "adapts" the ATM layer to fit the requirements of the class of traffic. For example, voice and video needs timing information and data needs segmentation and reassembly (from/to packets/cells).

c) Sketch the ATM cell format and describe the purpose of the VPI and VCI fields. Describe also the two purposes of the HEC field.

An ATM cell has a five-byte header and 48-bytes of payload. The header contains GFC, VPI, VCI, PT/CP, and HEC fields. The VPI and VCI fields are the virtual circuit label. This label is partitioned into two parts so that different levels of switches can be implemented (i.e., VC only, VP only, or both VP and VC). A VP corresponds to a physical cable and a VC is a virtual connection within a physical connection. The two purposes of the HEC field are to 1) error check the header and 2) serve as a synchronization or delimiting mechanism for delimiting ATM cells (i.e., in a bit stream when a correct 5-byte field CRC is generated, then it can be assumed that an ATM cell has been found).

Problem #5

Parallel Iterated Matching (PIM) is used to schedule the switch matrix of a VOQ IQ switch with crossbar switch fabric. Give the PIM algorithm and discuss its trade-offs.

In iterations or cycles do the following between input and output ports:

1) **Each unmatched input sends a request to every output for which it has a queued cell**
2) **If an unmatched output receives a request(s), it randomly selects a request and grants it.**
3) **If an input receives a grant, it randomly accepts one**

After several iteration in which a maximal match is achieved, the switch matrix is scheduled based on the accepted grants (and all grants and accepts are cleared). Tradeoffs… PIM is fair (in the long run) and does require state information (thus, it is simple to implement). However, randomness is difficult to implement at high-speed.

Problem #6

a) What are the key parameters for guided media?

Key parameters are noise immunity, low radiation, physical strength, physical size, and cost.

b) If a signal is attenuated by a factor of 10, what is the loss in dB?

$N_{db} = 10\log\left(\frac{1}{10}\right) = -10$ **or 10 dB attenuation**

c) What are two advantages of Manchester encoding over a simple NRZ coding? What is one disadvantage (of Manchester encoding)?

The two advantages are 1) the senders clocks can be derived or pulled-out and 2) there is little DC component. The key disadvantage is that the signal rate is twice the data rate.

d) What is the purpose of RS-232 and what is a null modem?

RS-232 is an interface to connect DTE to DCE (classically, a terminal to a modem). A null modem is a cross-over cable to connect two DTEs together. Most importantly, the TX and RX wires are crossed-over.

Problem #7

a) What are the four components of security (i.e., what is "network security")?

The four components are confidentiality, authentication, message integrity, and access/availability.

b) Describe how Public Key Cryptosystems work. You need not go into the mathematics of the RSA algorithm.

In a PKC each person has a public (K+) and private (K-) key. The public key is made public and is used by senders to encrypt a message *m* (i.e., K+(*m*)). Given K+(*m*) it is impossible to recover *m* without know the secret K- (secret to the receiver). The receiver does *m* = K-(K+(*m*)). One can also do K-(*m*) and recover *m* with K+(K-(m)). This is used to sign a message so that only the sender could have sent it (i.e., only the sender knows K-).

c) Describe how SNMP works (i.e., describe the main components and their interaction).

Simple Network Management Protocol (SNMP) consists of a manager, agents, and MIBs (Management Information Base). Agents and their MIBS are located in remote devices. MIBS contain counters and other management objects. The agent software and hardware updates these objects and communicates with the manager. A manager can GET or SET an object in a MIB. An agent can also generate a TRAP message if a counter in a MIB crosses a prespecified threshold.

Problem #8

b) What is jitter?

Jitter is delay variability.

b) What are two key application-level techniques for supporting multimedia on best-effort networks.

Two key application-level techniques are jitter buffering to remove packet-level delay jitter and Forward Error Correction (FEC) to reduce the effects of packet loss.

c) What are the key pillars (i.e., main tenets or principles) for building a QoS multimedia network?

The four pillars are 1) packet classification, 2) isolation (scheduling and policing), 3) high resource utilization, and 4) call admission.

Extra Credit

Why is digital transmission better than analog transmission over a long distance where repeaters are needed in any case?

In digital transmission the noise component in the signal is removed at each repeater when the digital signal is regenerated at a higher amplitude. For analog transmission, the noise component is simply amplified at each repeater and is thus additive between repeaters for the length of the transmission link.