## Homework 1 for CSE/EE 461 (Autumn 2002; Wetherall)

Due: Mon, Oct 21 2002, at the beginning of class. (Out: Wed, Oct 9, 2002.)
Note: be sure to show how you derived answers so that you are eligible for partial credit.

## 1. Bandwidth and Latency.

a) How long does it take a packet to travel down a single link? Give an expression for the time to send a packet and have the entire packet received at the other end of the link.
b) Now consider an Internet path composed of N links connected by routers. How long does it take to send a packet over this path? Assume that the packet must be completely received by a router before it is sent down the next link.
c) In the Internet, a fixed size error indication packet is returned from a router to the sender if the TTL reaches zero, rather than the packet being silently discarded. Explain how a source can use the round-trip time of packets to infer the bandwidth and delay of each link along an Internet path. Assume that the rate and delay are the same in both directions along a link and that routing is symmetric. (Hint: Show how this can be done for the first hop and then how it can be done recursively.)
2. Framing. Consider the following two byte-stuffing schemes:

PPP. Here, the byte 0x7E is added at the sender to mark the end of the previous packet and the beginning of the current one. Within the payload, the sender replaces $0 x 7 \mathrm{E}$ with 0x7D, 0x5E. Occurrences of 0x7D must also be escaped; they are replaced with 0x7D, $0 x 5 \mathrm{D}$. At the receiver, $0 x 7 \mathrm{D}$ and the following byte are replaced with one byte that is the XOR of the second byte with $0 \times 20$. Thus $0 \times 7 \mathrm{D}, 0 \times 5 \mathrm{D}$ is replaced with a single $0 \times 7 \mathrm{D}$ and $0 \times 7 \mathrm{D}, 0 \times 5 \mathrm{E}$ with a single $0 \times 7 \mathrm{E}$, reversing the process.

COBS. Here, the byte 0x00 (that is, zero) is added at the sender to mark the end of the previous packet and the beginning of the current packet. Zeros must now be removed from the payload. First, a start byte is added to indicate the number of bytes until a zero is encountered. That zero is replaced with the number of bytes until the next zero, and so forth until the end of the packet. To handle the last zero in the packet, we pretend that there is an extra zero just off the end of the real packet. For example, the packet 0x22, $0 \times 00,0 \times 00,0 \times 55$ becomes $0 \times 00,0 \times 02,0 \times 22,0 \times 01,0 \times 02,0 \times 55$. We must also handle the situation in which there are no zeros in the payload. To do this we use $0 x F F$ to indicate a run of 254 consecutive non-zero bytes without a following zero. After the 254 bytes there is a count of bytes until a zero or another $0 x F F$. At the receiver the reverse process is performed.
d) Draw a picture of the payload $0 \times 010 x 7 \mathrm{E} 0 \mathrm{x} 03$ 0x 000 x 04 framed with both schemes.
e) What is the worst-case expansion of a packet of length $L$ using PPP and COBS? In what scenario do these worst cases occur?
f) What is the best-case expansion of a packet of length $L$ using PPP and COBS? In what scenario do these best cases occur?

## 3. 2D Parity.

a) Peterson, Ch2, Ex 10.
b) What fraction of all the possible four bit errors will be detected?

## 4. CRCs.

a), b) Peterson Ch2, Ex15
c) CRC are typically placed on the wire at the end of the frame (that is, they are the last portion transmitted). Why?
5. Ethernet Collision Detection Give your answers below in terms of physical Ethernet parameters as appropriate, such as distance (D), bit rate (R) and propagation speed (S).
a) Explain how collision detection could fail if it was possible to send packets shorter than the allowed minimum.
b) Suppose station A sees the medium idle and begins transmitting. How long is the interval during which some other station might begin sending and cause a collision? This is also called the time to acquire the medium.
c) Suppose station A sees the medium idle and begins transmitting. How long is the interval during which A might hear of a collision with another station?
d) Give a formula for the minimum frame size required for successful collision detection.
e) Fast Ethernet operates at 100 Mbps , ten times as fast as 10 Mbps , yet both have the same minimum frame size. Explain how this can be the case.
6. Ethernet Capture. Peterson Ch2, Ex37

