Chapter 10

Communications, Networking, and the Internet

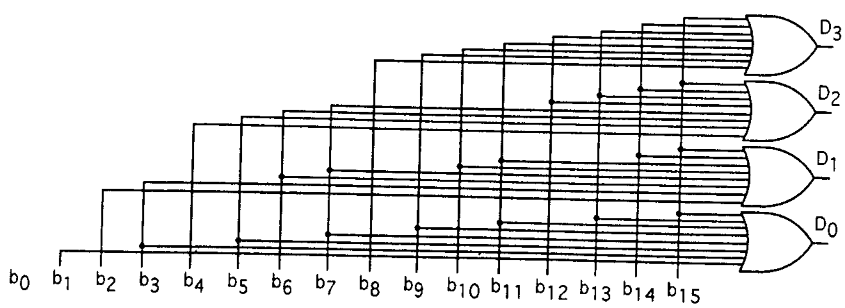
10.1 A packet-switched network has a bit-error rate of 10^{-12}. Assume that each 1 K packet will contain either a 4-byte CRC field or a 16-byte ECC field. If you were designing the error detection and correction strategy, which approach would you choose to maximize throughput if each erroneous packet must be retransmitted? Show your calculations, and state any assumptions you make. (§10.1)

Solution: One packet has 1 KB, or 8000 bits, and the bit-error rate is 10^{-12}. So one packet has a probability of $(1 - 10^{-12})^{8000} \approx 1 - 8\times10^{-9}$ of being transmitted correctly. The strategy of using a CRC will force retransmission of one out of $1/(8\times10^{-9}) = 125$ M packets. This gives a negligible reduction in throughput. The throughput reduction comes entirely from the 4 byte overhead, and is $1024/(1024 + 4) = 0.996$.

Assume the ECC has the ability to detect and correct all errors so no retransmission is necessary. The reduction in throughput is then $\frac{1024}{1024 + 16} = 0.985$, which is lower than for the CRC field. This problem shows that a very low bit-error rate transmission medium favors error detection and retransmission over error correction.

10.3 Design the 2^n-to-n encoder that a modem might use to convert the 2^n different possible signals detected by a modem during one baud time into the n bits that are part of the received message. (§10.2)

Solution: The following 2^4-to-4 encoder produces all 0s for input signal b_0.



10.5 Write a C program fragment to convert a string of text to uppercase. (§10.2)

Solution:

```
#include <stdio.h>
/*function uppercase(ch): convert the input character to uppercase;
input argument:            char ch;
return the uppercase of this character. */
char uppercase(ch)
char ch;          /*the input character*/
{          if ('a' <= ch && ch <= 'z')/*if a lower case char.*/
                return ch - 32;      /*flip bit 5 from 1 to 0*/
           else            return ch;
}
/*function upperstring(str): convert the input character string to uppercase;
input argument:      char *str. */
void upperstring(str)
char *str;
{          char ch;
           while (ch=*str)/*while not end of string*/
                *str++ = uppercase(ch);
}
```

10.7 Both RG-8 and RG-58 coaxial cables have a velocity factor of 0.66.

a. What is the worst-case time interval between when a thicknet Ethernet station begins transmitting and when it detects a collision?

b. What is the physical length of a bit in the 10BASE-5 Ethernet?

c. How many bits may be on the cable simultaneously in thicknet Ethernet?

d. Suggest an average back-off time for this net after a collision. Justify your answer with a brief discussion. (§10.3)

Solution: a. The worst-case time is the time required for a signal to propagate from one end to the other and back again in the longest possible distance. For RG-8 (thicknet), this worst-case time is $\frac{2 \times 500}{3.0\times 10^8 \times 0.66} = 5.05\ \mu s$. For RG-58 (thinnet), the worst-case time is $\frac{2 \times 185}{3.0\times 10^8 \times 0.66} = 1.87\ \mu s$.

b. The rate of 10BASE-5 is 10 Mbps, that is $0.1\ \mu s$ per bit. The length of a bit propagating on the wire will be $1\times 10^{-7} \times 3.0\times 10^8 \times 0.66 = 19.8\ m$.

c. At most 500/19.8 = 25 bits may be on the cable simultaneously.

d. The average back-off time for thick net could be 2 times the worst-case collision detection time. That is $10.1\ \mu s$. This is the worst-case time for detecting a collision and transmitting the jamming signal.

10.9 a. What is the raw data rate of a digital video signal with 512 × 512 1-bit pixels at 30 frames per second?

b. How many packets per second would be required to transmit the signal over a 10BASE-5 Ethernet link?

c. What percentage of the total bandwidth of the Ethernet LAN is consumed by this transmission, assuming no collisions, use of the entire data field, and a connectionless protocol? (§10.3)

Solution: a. $512 \times 512 \times 1 \times 30 = 7.862\times 10^6$ bits per second

b. Number of packets $= \left\lceil \frac{7.862\times 10^6}{1500 \times 8} \right\rceil = 655$ packets

c. % of the total bandwidth = $7.862\times 10^6 / 9.83\times 10^6 \times 100\% = 80\%$

10.11 How many networks can the current class A, B, and C 32-bit IP addresses support? (§10.4)

Solution: As stated in Section 10.4.3 of the textbook, class A can support 126 networks, class B 16,384 networks, and class C 2,097,150 networks.

10.13 Suppose that network 204.123.216.0 is subnetted using a 4-bit subnet mask.

a. How many host IDs can each subnet support?

b. How many subnets can it support?

c. What is the subnet address of machine 204.123.216.23?

d. What is its host ID?

e. What is its subnet mask? (§10.4)

Solution: a. This class C network has one octet available for host ID, and with a 4-bit subnet mask, this leaves 4 bits for identifying host IDs on each subnet. But all 0s and all 1s are reserved and cannot be used as host IDs, so there are 14 host IDs possible on each subnet.

b. The same holds for the number of subnets, 16 – 2 = 14 subnets.

c. The final octet of machine 204.123.216.23 is 23, which is 00010111. With a 4-bit subnet mask, the machine's subnet address is 0001, or 1.

d. The host ID is 0111, or 7.

e. The subnet mask for this machine, and the entire network, is 255.255.255.(1111 0000b), which is 255.255.255.240.