undetected? What is the probability when using a parity bit? Which method detects more errors?

11. An 8-bit byte with binary value 10101111 is to be encoded using an even-parity Hamming code. What is the binary value after encoding?

12. An 8-bit byte with binary value 1001 1010 is to be encoded using an *odd*-parity Hamming code. What is the binary value after encoding?

13. A 12-bit *odd*-parity Hamming code whose hexadecimal value is 0xB4D arrives at a receiver. What was the original value in hexadecimal? Assume that not more than 1 bit is in error.

14. Hamming codes have a distance of three and can be used to correct a single error or detect a double error. Can they be used to do both at the same time? Explain why or why not. In general, if the Hamming distance is n, how many errors can be corrected? How many errors can be detected?

15. Consider a protocol that for every 16 bytes of message data adds 1 byte of redundant data. Can this protocol use a Hamming code to correct single errors?

16. One way of detecting errors is to transmit data as a block of n rows of k bits per row and add parity bits to each row and each column. The bit in the lower-right corner is a parity bit that checks its row and its column. Will this scheme detect all single errors? Double errors? Triple errors? Show that this scheme cannot detect some four-bit errors.

17. In the previous problem, how many errors can be detected and corrected?

18. Give a formula for the lower limit on the number of redundant bits r, that need to be added to a message m, to correct all single *and double* errors.

19. Given the answer to the previous question, explain the popularity of complex probabilisitic error-correction mechanisms, such as convolutional codes and the Low-Density Parity Check, discussed in this chapter.

20. Suppose that data are transmitted in blocks of 1000 bits. What is the maximum error rate under which error detection and retransmission mechanism (1 parity bit per block) is better than using Hamming code? Assume that bit errors are independent of one another and no bit error occurs during retransmission.

21. A block of bits with n rows and k columns uses horizontal and vertical parity bits for error detection. Suppose that exactly 4 bits are inverted due to transmission errors. Derive an expression for the probability that the error will be undetected.

22. Suppose that a message 1001 1100 1010 0011 is transmitted using the Internet Checksum (4-bit word). What is the value of the checksum?

23. What is the remainder obtained by dividing $x^7 + x^5 + 1$ by the generator polynomial $x^3 + 1$?

24. A bit stream 10011101 is transmitted using the standard CRC method described in the text. The generator polynomial is $x^3 + 1$. Show the actual bit string transmitted. Suppose that the third bit from the left is inverted during transmission. Show that this error