

**Question Fin-1:** (Solution, p 2) What are the five layers of the network stack as studied in this class?

**Question Fin-2:** (Solution, p 2) What is the function of the Transport layer?

**Question Fin-3:** (Solution, p 2) According to Nyquist's theorem, what is the theoretical maximum bit rate that can be achieved using a binary signal, if the maximum analog frequency that can be transmitted is  $H$  hertz?

**Question Fin-4:** (Solution, p 2) Distinguish the terms *error detection* and *error correction*. Which does Ethernet use?

**Question Fin-5:** (Solution, p 2) Describe a simple algorithm for detecting one-bit errors in an  $n$ -bit message, using only one additional bit.

**Question Fin-6:** (Solution, p 2) Suppose we are using CRC error detection (as specified in class) with a polynomial of  $x^2 + 1$ . What additional detection bits would be sent for the 8-bit message 10010010? Show your intermediate work.

**Question Fin-7:** (Solution, p 2) Describe two of the media (i.e., wire types) for which 10 megabit Ethernet defines a standard.

**Question Fin-8:** (Solution, p 2) What are the relative advantages of 10Base-T and 10Base-F?

**Question Fin-9:** (Solution, p 2) Explain how Ethernet handles collisions.

**Question Fin-10:** (Solution, p 3) Why does the IEEE 802 series of standards separate the data link layer into two sublayers (logical link control and media access control)?

**Question Fin-11:** (Solution, p 3) Describe the link state protocol for routing table updates. (This is roughly the protocol used within the Internet today.)

**Question Fin-12:** (Solution, p 3) The IPv4 header contains an 8-bit TTL field. What is the purpose of this field?

**Question Fin-13:** (Solution, p 3) What is Landauer's Principle (which inspires reversible computing)?

**Question Fin-14:** (Solution, p 3) A bit can be represented mathematically with a single number, which is either 0 or 1. How can a qubit be represented mathematically?

**Solution Fin-1:** (Question, p 1) Application, Transport, Network, Data Link, Physical

**Solution Fin-2:** (Question, p 1) The transport layer's job is to simulate end-to-end functionality that is not guaranteed by the network layer, including such functions as directing a packet to the appropriate program on the receiving computer, or assuring that every packet sent is eventually received at the other end, or reordering packets into the order they were sent.

**Solution Fin-3:** (Question, p 1)  $2H$  bits per second.

**Solution Fin-4:** (Question, p 1) With error detection, additional bits are sent to allow the detection of whether a small number of bits are changed; this is what Ethernet uses. Error correction requires the additional bits also to allow inferring exactly which bits were changed during transmission.

**Solution Fin-5:** (Question, p 1) We can add a *parity bit*, which is computed to make the total number of 1 bits in the  $n + 1$ -bit transmission even. When the message is received, if a single bit has flipped, then the number of 1 bits will be odd, and we will know that the transmission was flawed.

**Solution Fin-6:** (Question, p 1) The additional bits sent would be 01.

$$\begin{array}{r} \phantom{101} \overline{) 101111} \\ 101 \overline{) 10010010} \\ \underline{101} \phantom{00} \\ 011 \phantom{00} \\ \underline{000} \phantom{00} \\ 110 \phantom{00} \\ \underline{101} \phantom{00} \\ 110 \phantom{00} \\ \underline{101} \phantom{00} \\ 111 \phantom{00} \\ \underline{101} \phantom{00} \\ 100 \phantom{00} \\ \underline{101} \phantom{00} \\ 01 \end{array}$$

**Solution Fin-7:** (Question, p 1) There are four. 10Base-5 is the original, which was a very thick coaxial wire, to which stations would attach by driving a pin called a vampire tap into the coax cable. This was supplanted by 10Base-2, which is a much thinner coax cable, to which stations would connect by inserting a T-connector between two different coax cables. Today the most popular media are 10Base-T, which uses twisted-pair cables analogous to telephone wires, and 10Base-F, which uses fiber optics.

**Solution Fin-8:** (Question, p 1) 10Base-T is cheaper and easier to manage than 10Base-F. 10Base-F has the advantage that it can transmit signals a much longer distance (2,000m as opposed to 100m), and it is more compatible with faster Ethernet versions.

**Solution Fin-9:** (Question, p 1) When a station wants to send a message, it waits until the wire is apparently idle. Then it begins sending the message. If it detects another station sending a message during this time, it stops immediately, waits for 0 or 1 (chosen at random) "slots" of  $50\mu\text{s}$  each, then it resends if the network appears idle. If a collision again occurs, it then chooses between 0 and 3 slots; then, if a collision again occurs, it chooses between 0 and 7 slots. It continues choosing from larger and larger ranges. If it fails 16 times in a row, the message transmission is aborted.

**Solution Fin–10:** (Question, p 1) They wished to provide a single standard for the more general portions of the data link layer, which they accomplished through the logical link control sublayer. This is then shared among the several media-dependent protocols, each of which defines its own media access control layer.

**Solution Fin–11:** (Question, p 1) Each router periodically checks the status of each of its neighbors and floods the network with this information. Routers receiving this information use it to recalculate the best path to each location on the network, and they use this to determine their routing table.

**Solution Fin–12:** (Question, p 1) Each time a router transfers the IP packet, it decrements this field. When the field reaches 0, the IP packet is discarded, because it appears that the packet may have found a circular loop among the routers' routing tables.

**Solution Fin–13:** (Question, p 1) Any loss of information during a computation expends heat.

**Solution Fin–14:** (Question, p 1) A qubit can be regarded as a vector of two complex numbers, where the sum of the squares of the numbers' magnitude must be 1.