

Solution to HW1

1. Tracert (10 pts)

Traceroute works by increasing the "[time-to-live](#)" value of each successive batch of packets sent. The first three packets sent have a time-to-live (TTL) value of one (implying that they are not forwarded by the next router and make only a single hop). The next three packets have a TTL value of 2, and so on. When a packet passes through a host, normally the host decrements the TTL value by one, and forwards the packet to the next host. When a packet with a TTL of one reaches a host, the host discards the packet and sends an [ICMP time exceeded](#) (type 11) packet to the sender. The traceroute utility uses these returning packets to produce a list of hosts that the packets have traversed en route to the destination.

Usage: `tracert [-d] [-h maximum_hops] [-j host-list] [-w timeout] target_name`

Options:

- d Do not resolve addresses to hostnames.
- h maximum_hops Maximum number of hops to search for target.
- j host-list Loose source route along host-list.
- w timeout Wait timeout milliseconds for each reply.

Output of a tracert example is ignored here.

2.5 (10 pts)

A case could be made either way. **First**, look at the functions performed at the network layer to deal with the communications network (hiding the details from the upper layers). The network layer is responsible for routing data through the network, but with a broadcast network, routing is not needed. Other functions, such as sequencing, flow control, error control between end systems, can be accomplished at layer 2, because the link layer will be a protocol directly between the two end systems, with no intervening switches. So it would seem that a network layer is not needed. **Second**, consider the network layer from the point of view of the upper layer using it. The upper layer sees itself attached to an access point into a network supporting communication with multiple devices. The layer for assuring that data sent across a network is delivered to one of a number of other end systems is the network layer. This argues for inclusion of a network layer.

In fact, the OSI layer 2 is split into two sublayers. The lower sublayer is concerned with medium access control (MAC), assuring that only one end system at a time transmits; the MAC sublayer is also responsible for addressing other end systems across the LAN. The upper sublayer is called Logical Link Control (LLC). LLC performs traditional link control functions. With the MAC/LLC combination, no network layer is needed (but an internet layer may be needed).

2.6 (8 pts)

a. No. This would violate the principle of separation of layers. To layer (N - 1),

the N-level PDU is simply data. The (N – 1) entity does not know about the internal format of the N-level PDU. It breaks that PDU into fragments and reassembles them in the proper order.

b. Each N-level PDU must retain its own header, for the same reason given in (a).

2.7 (8 pts)

Data plus transport header plus internet header equals 1820 bits. This data is delivered in a sequence of packets, each of which contains 24 bits of network header and up to 776 bits of higher-layer headers and/or data. Three network packets are needed. Total bits delivered = 1820 + 3x24 = 1892 bits.

2.13 (10 pts)

The "netascii" transfer mode implies the file data are transmitted as lines text terminated by the character sequence {CR, LF}, and that both systems convert between this format and the one they use to store the text files locally. This means that when the "netascii" transfer mode is employed, the file sizes local and the remote file may differ, without any implication of errors in transfer. For example, UNIX systems terminate lines by means of a single character, while other systems, such as Microsoft Windows, terminate lines means of the character sequence {CR, LF}. This means that a given text file usually occupy more space in a Windows host than in a UNIX system.

3.6 (12 pts)

$(1 + 0.1 \cos 5t) \cos 100t = \cos 100t + 0.1 \cos 5t \cos 100t$. From the trigonometric identity $\cos a \cos b = (1/2)(\cos(a + b) + \cos(a - b))$, this equation can be rewritten as the linear combination of three sinusoids:

$$\begin{aligned} &\cos 100t + 0.05 \cos 105t + 0.05 \cos 95t \\ &= \sin(\pi/2 + 100t) + 0.05 \sin(\pi/2 + 105t) + 0.05 \sin(\pi/2 + 95t) \\ &= \sin(2\pi(100t/2\pi) + \pi/2) + 0.05 \sin(2\pi(105t/2\pi) + \pi/2) + 0.05 \sin(2\pi(95t/2\pi) + \pi/2) \end{aligned}$$

	amplitude	frequency	phase
The first component:	1	$100/2\pi$	$\pi/2$
The second component:	0.05	$105/2\pi$	$\pi/2$
The third component:	0.05	$95/2\pi$	$\pi/2$

3.8 (10 pts)

If $f_1(t)$ is periodic with period X, then $f_1(t) = f_1(t + X) = f_1(t + nX)$ where n is an integer and X is the smallest value such that $f_1(t) = f_1(t + X)$. Similarly, $f_2(t) = f_2(t + Y) = f_2(t + mY)$. We have $f(t) = f_1(t) + f_2(t)$. If f(t) is periodic with period Z, then $f(t) = f(t + Z)$. Therefore, $f_1(t) + f_2(t) = f_1(t + Z) + f_2(t + Z)$. This last equation is satisfied if $f_1(t) = f_1(t + Z)$ and $f_2(t) = f_2(t + Z)$. This leads to the condition $Z = nX = mY$ for some integers n and m. We can rewrite this last as $(n/m) = (Y/X)$. We can therefore conclude that if the ratio (Y/X) is a rational number, then f(t) is periodic.

3.13 (15 pts)

a. $(30 \text{ pictures/s}) (480 \times 500 \text{ pixels/picture}) = 7.2 \times 10^6 \text{ pixels/s}$
 Each pixel can take on one of 32 values and can therefore be represented by 5

bits:

$$R = 7.2 \times 10^6 \text{ pixels/s} \times 5 \text{ bits/pixel} = 36 \text{ Mbps}$$

b. We use the formula: $C = B \log_2(1 + \text{SNR})$

$B = 4.5 \times 10^6 \text{ MHz} = \text{bandwidth}$, and

$\text{SNR}_{\text{dB}} = 35 = 10 \log_{10}(\text{SNR})$, hence

$\text{SNR} = 10^{35/10} = 10^{3.5}$, and therefore

$$C = 4.5 \times 10^6 \log_2(1 + 10^{3.5}) = 4.5 \times 10^6 \times \log_2(3163)$$

$$C = (4.5 \times 10^6 \times 11.63) = 52.335 \times 10^6 \text{ bps}$$

c. Allow each pixel to have one of ten intensity levels and let each pixel be one of three colors (red, blue, green) for a total of $10 \times 3 = 30$ levels for each pixel element.

3.20 (10 pts)

a. Using Shannon's formula: $C = 3100 \log_2(1+400000) = 57690\text{bps}$

b. Due to the fact there is a distortion level (as well as other potentially detrimental impacts to the rated capacity, the actual maximum will be somewhat degraded from the theoretical maximum. A discussion of these relevant impacts should be included and a qualitative value discussed.

3.21 (8 pts)

$$C = B \log_2(1 + \text{SNR})$$

$$20 \times 10^6 = 3 \times 10^6 \times \log_2(1 + \text{SNR})$$

$$\log_2(1 + \text{SNR}) = 6.67$$

$$1 + \text{SNR} = 102$$

$$\text{SNR} = 101$$

3.23 (7 pts)

$$(E_b/N_0) = -151 \text{ dBW} - 10 \log 2400 - 10 \log 1500 + 228.6 \text{ dBW} = 12 \text{ dBW}$$