Solutions to Assignment 3

Question 1

An OC-12 combines 12 STS-1 signals. Each at STS-1 has a bit rate of 51.84 Mb/s so the aggregate data rate is $12 \times 51.84 = 622.08$ Mb/s.

The frame rate is the same as for other telephony-oriented protocols, the speech sampling rate of 8 kHz.

Each STS-1 has $((3 \times 9) + 9) = 36$ bytes of Section, Line and Path overhead in every $9 \times 90 = 810$ byte frame. Thus each OC-12 frame has $12 \times 36 = 432$ bytes of overhead.

The percentage of overhead is thus $\frac{432}{12 \times 9 \times 90} = 4.44$ %.

Question 2

If the H1-H2 bytes are incrementing once per second the data being carried has data rate that is 8 bits (1 byte) per second faster than the SONET clock rate.

Since the STS-3 rate is 155.52 Mb/s, a difference of 8 b/s represents an error of $\frac{8}{155.52 \times 10^6} = 51 \times 10^{-9} = 0.051$ ppm.

Question 3

An ATM receiver can determine the last ATM frame of a packet transmitted using AAL5 from the third bit of the Payload Type header field.

An AAL5-encapsulated IP packet whose "Total Length" field (bytes 16-31) has the value 512 would have been split up into $\lceil \frac{512+8}{48} \rceil = 11$ ATM frames (the additional 8 bytes are to accomodate the AAL5 trailer). Since this can accomodate $11 \times 48 = 528$ bytes then we must add $528 - 512 - 8 = 8$ bytes of padding.

Question 4

If the VPI/VCI values are not altered at ATM switches then there can be a maximum of $2^{24} \approx 16$ million destinations because the VPI/VCI is a 24-bit value.

If the VPI/VCI are swapped at switches then there is no limit because each switch added to the network allows an additional $2^{24} \approx 16$ million additional end-points.

Question 5

The destination of an ATM frame can only be determined from knowledge of the configuration of all of the switches in the path from the source to the destination. This is because the VPI/VCI at any switch will change the destination.

Question 6

PPP has to escape both flag and escape characters. Thus two of the 256 payload bytes will need to be escaped resulting in 258 bytes[1].

The header will add 5 bytes: one byte each for the flag, address, and control fields and 2 bytes for the protocol field because the LS bit of the first byte of the protocol value (0x00) is 0. At the end of the packet an additional 3 bytes are required (a 2-byte FCS and a one-byte flag). The total length is thus $258 + 5 + 3 = 266$ bytes.

Question 7

The use of a 16-bit vs 32-bit CRC on a PPP connection should be negotiated by the LCP because it is a link-layer control issue (it controls the operation of the PPP protocol) rather than a network-layer (i.e. IP) control issue.

Section 2.1 of RFC-1570, the LCP specification, describes the "FCS-Alternatives" configuration option which has three values:

```
1   Null FCS
2   CCITT 16-bit FCS
4   CCITT 32-bit FCS
```

[1] LCP can configure other values to be escaped but this is not specified in the question.

Question 8

(a) None of the 32-bit IP header words contains TCP SYN flags because the TCP flags are part of the TCP header.

(b) The second nybble of the first byte of an IP packet is the number of 32-bit words in the IP header. If there are no options this value is 5. If this value is 7, there must be two additional 32-bit words or 8 bytes of options.

(c) The minimum value of the TTL field in a received IP packet must be 1 because if the source router or host had decremented the TTL value to zero it should not have send the packet out (it should have "dropped" it and sent an ICMP message to that packet's source address).

(d) Only IP protocols can appear in the protocol field of an IP packet. This includes TCP and ICMP. PPP is a link-layer protocol, HTTP is an application-layer protocol (running over TCP) and NCP is a link-configuration protocol that is part of PPP.

Question 9

The result of looking up the IP network starting at 104.237.160.0 on ARIN.net is:

Network	
Net Range	104.237.160.0 - 104.237.191.255
CIDR	104.237.160.0/19
Name	YOUTUBE
Handle	NET-104-237-160-0-1
Parent	NET104 (NET-104-0-0-0-0)
Net Type	Direct Assignment
Origin AS	AS43515 AS36040 AS36561 AS15169
Organization	YouTube, LLC (YL)

This address space is assigned to YouTube. In CIDR notation this network is written as 104.237.160.0/19. A /19 network has a netmask containing 1's in the leading 19 bits: 255.255.224.0 so the network would be defined as 104.237.160.0 with a netmask of 255.255.260.0.

The first two bytes of the IP address match. The third byte of the IP address in hex is 0xA0 (1010 0000) while the netmask value (260) is 0xE0 (1110 000). If we AND these we get 0xA0 (1010 0000). This is the same as the third byte of the network address so the address 104.237.160.0 is part of the 104.237.160.0/19 network.

Question 10

Identify the type of network that each of the following IP addresses belongs to:

(a) 192.168.192.168 - this is a non-routable private address that should only be used on a LAN that is not directly connected to the Internet

(b) 169.254.250.1 - this is a "link local" IP address that is self-assigned on networks without DHCP servers

(c) 142.232.18.19 - this is a routable IP address that can be used for a host on the public Internet (and happens to be in the BCIT network address range)

(d) 238.11.6.8 - this is a multicast IP address (part of the 224.0.0.0/4 range) that is used to distribute data to multiple destinations simultaneously

Question 11

Given a router that contains the following entries in its routing table:

Destination	Netmask	Metric	Interface
76.9.0.0	255.255.128.0	2	76.9.83.1
76.9.0.0	255.255.128.0	1	76.9.83.16
76.9.134.0	255.255.255.0	1	76.9.83.16
0.0.0.0	0.0.0.0	0	192.168.0.1

Frames with the following destination IP addresses would get routed as follows:

(a) 76.9.0.1 - this matches the first and second entries entries (76.9.0.0/17) but the second entry has a lower metric (cost) so it would be selected and the packet would the sent on the interface that is assigned the IP address 76.09.83.16

(b) 76.9.128.45 - this only matches the last (default) entry so and the packet would the sent on the interface that is assigned the IP address 192.168.0.1

(c) 76.9.134.37 - this matches the third entry and the packet would the sent on the interface that is assigned the IP address 76.09.83.16

Question 12

The format of the DHCP message payload is given in Figure 1 of RFC 2131. Each row has 4 bytes so byte offset 20 is the 5th row which contains the `yiaddr` ("your IP address") field. This is the IP address offered by the server to the client in a DHCPOFFER message.

Question 13

Option 53 (the DHCP message type) must always be included in a DHCP packet to tell the client or server the type of packet[2].

Question 14

A DHCP option with a type value of 11 (decimal) with a value consisting of the string equal to 'Bob' would contain the following bytes:

Value (hex)	Meaning
0B	Type (decimal 11)
03	Length (3 bytes)
42	ASCII (or UTF-8) encoding for 'B'
6F	value of 'o'
62	value of 'b'

Question 15

According to RFC 1533. The DHCP lease time option is encoded as:

```
 Code   Len         Lease Time
+-----+-----+-----+-----+-----+-----+
|  51 |  4  |  t1 |  t2 |  t3 |  t4 |
+-----+-----+-----+-----+-----+-----+
```

The time is a 32-bit unsigned value (in MS bit first order). One hour is $60 \times 60 = 3600$ seconds which is 0x00000E10. The byte values for the TLV-encoded option are:

`0x33 0x04 0x00 0x00 0x0E 0x10`

[2]The DHCP packet format was adapted from an earlier protocol, BOOTP, which used the op field in the first byte to indicate the type of operation.