Solutions to Assignment 5

Question 1

(a) A packet with a destination address of 192.168.1.203 matches the second entry in the routing table so it would be sent out over the interface with the IP address 192.168.1.1. The destination MAC address would be the matching entry for 192.168.1.203 which is `12:a4:56:c4:56:07`.

(b) Since none of the arriving packets' destination addresses match any of the interface addresses then the router would attempt to forward the received packets according to the routing table rather than responding with an echo ("ping") response itself.

There is no route for a packet with destination 24.83.17.6 so (i) an ICMP message with (ii) "Destination Unreachable" (type=3) with a code of "net(work) unreachable" (code=3) should be sent to the source address (iii) 10.0.1.1 at MAC address `12:a4:56:10:12:de`. This destination is reachable through subnet 10.0.0.0/8 and so should be sent with a source IP address of (iv) 10.0.1.5 through (v) the interface with that IP address.

There is a route for the address 10.0.0.4 but there is no entry for that device in the ARP table so (i) an ICMP message with (ii) "Destination Unreachable" (type=3) with a code of "host unreachable" (code=1) should be sent to the source address (iii) 192.168.1.200 at MAC address `12:a4:56:78:9f:12`. This destination is reachable through subnet 192.168.1.0/24 and so should be sent with a source IP address of (iv) 192.168.1.1 through (v) the interface with that IP address.

There is a route for the address 192.168.1.203 and an entry in the ARP table but since the TTL value is only 1, it should not be forwarded and an (i) ICMP (ii) "Time Exceeded" (type=11) message with a code of "time to live exceeded in transit" (code=0) should be sent to the source address (iii) 192.168.1.203 at MAC address `12:a4:56:c4:56:07`. This destination is reachable through subnet 192.168.1.0/24 and so should be sent with a source IP address of (iv) 192.168.1.1 through (v) the interface with that IP address.

Question 2

The UDP header has four 16-bit words: source port (`0x4000`), destination port (`0x0010`), length (8(for the header) + 4(for the UDP data) = 12 = `0x0c` and a 16-bit checksum.

The checksum is computed including a pseudo-header that includes: the source and destination IP addresses, the protocol (`0x11`) and the UDP length (`0x0c`). The calculation is as follows:

```
    112  - carries
    4000 - UDP header
    0010
    000c
    0000
    0a00 - IP pseudo-header
    0000
    1400
    0000
    0011
    000c
    f00f - UDP data field
    0ff0
    ----
   15e38 - 32-bit sum

adding MS 16 bits 0001
       LS 16 bits 5e38 =

    5e39
    =
    0101 1110 0011 1001

inverting each bit:

    1010 0001 1100 0110
    =
```

```
a1c6
```

So the UDP header would be:

```
4000 0010
000c a1c6
```

Question 3

A Window value of 2500 indicates that the receiver had 2500 bytes of buffer space available. We can thus send it data with sequence numbers values up to the Acknowledgment field value plus the Window value minus 1[1]. In this case we can send sequence numbers up to $500 + 2500 - 1 = 2999$.

If the most recently transmitted packet had a Sequence value of 1000 and that packet included n bytes (i.e. sequence numbers up to $1000 + n - 1$), then we could send $2999 - (1000 + n - 1) = 2000 - n$ additional bytes.

For example, if the most recent packet had included $n = 1$ data bytes (sequence numbers from 1000 to 1000), then we could send 1999 more bytes (sequence numbers from 1001 to 2999).

The question does not give n so we cannot give a numerical answer.

Question 4

(a) The `ACK` flag is set to 1 and the Acknowledgment field value is set to the received Sequence number plus 1 in a `SYN+ACK` packet sent in response to a `SYN`.

This helps differentiate `SYN+ACK` responses (e.g. two connection attempts to the same web server with the same source host and port values).

(b) A host sets the `FIN` bit to terminate the outgoing side of a TCP connection. If the associated Acknowledgment field has a value of 321 then Sequence numbers up to 320 bytes would have been received since the Sequence number is incremented by one for the `FIN` bit.

[1] There is an error in the lecture notes: the Acknowledgment field is the *next* Sequence number that the receiver expects to see, not the last one received – i.e. it is the received Sequence number plus the TCP payload length.

Unfortunately, the question does not state the initial Sequence number so it's not possible to compute the number of bytes.

However, if we assume the sequence number is the Sequence number relative to the value in the initial SYN packet as displayed by Wireshark, for example, then relative Sequence numbers from 1 to 320 would have been received for a total of 320 bytes.

Question 5

The lowest-cost paths to each of the routers can be computed as:

destination	next hop	cost
A	A	1
C	C	1
D	C	2

Question 6

If only 10 of 1000 (1%) of packets had delays greater than 140 ms we should buffer 140 ms of speech (7 20 ms packets) to get a loss rate of $< 1\,\%$.

However, the minimum delay was 80 ms which represents buffering due to propagation delay and queues in the network. If we output the lowest-delay packets as soon as they arrive, then other packets will arrive with the additional delays of between 0 and 60 ms. Thus buffering $>$ 60 ms of speech (3 packets) at the receiver can ensure the packet loss rate is less than 1%.

Question 7

The use of a speakerphone on the remote end is likely to cause leakage from the remote receiver (speaker) to the remote transmitter (microphone). If the local listener notices an echo this is due to an echo from the remote end since delays from the near end are too short to be distinguished from sidetone.

A far-end echo canceller on the local side will remove the remote echo. A near-end echo canceller on the remote end could also reduce the echo but the question asks about processing on the local side. Thus the correct answer is: (b) far-end echo cancellation.