Final Solutions — Networking

Problem 1:

```
88 41 30 00 64 a5 c3 69   52 4d 38 f9 d3 90 56 5a
64 a5 c3 5e ac 95 80 41   01 00 e7 27 00 20 3f 01
00 00 23 66 09 34 1d af    …
```

The first two bytes (88 41) are frame control and determine how the rest of the header has to be interpreted. In binary, the two bytes are

```
1000 1000   0100 0001.
```

As they are in big-endian, we need to reverse the bytes (not the hex digits, not the field) and obtain

```
0001 0001   1000 0010.
```

The first byte is not of great interest to the solution, but here is what it says:

00: Version 0
01: Type Data Frame
0001: Subtype.

The second byte starts with the DS status. The first bit is the To-DS flag set to 1, the second byte is the From-DS flag set to 0. The rest is "no more fragments", "not a retry", "STA will stay up", "no data buffered", "data is protected", and "not strictly ordered. Thus, this is a packet going from a sender in the BSS via the DS to a sender.

```
88 41 30 00 64 a5 c3 69   52 4d 38 f9 d3 90 56 5a
64 a5 c3 5e ac 95 80 41   01 00 e7 27 00 20 3f 01
00 00 23 66 09 34 1d af    …
```

After the duration field (1100 0000 0000 0000), the next three fields of 6 bytes each give addresses. Which is which depends on the To and From DS fields.

The receiver address is 64:a5:c3:69:52:4d (bytes are not reversed because MAC addresses are big-endian), the transmitter address is 38:f9:d3:90:56:5a, and the source address is 64:a5:c3:5e:ac:95.

Problem 2:

Node B calculates the distance to another node going through Node D and compares this to its current distance. If the first one is smaller, it updates the distance to this value and sets the next-node field to D. This gives:

Node B current	Node B through Node D	New Node B distance vector
A: 2, A	A: ∞, D	A: 2,A
B: 0, -	B: 14, D	B: 0, -
C: 3, C	C: 9, D	C: 3, C
D: 7, D	D: 0, -	D: 7, D
E: 14, A	E: 8, D	E: 8, D

The rightmost column is the new distance vector in Node B.

A package to E would now be routed through Node D, which has a direct link to Node E.

After Node B sends its new distance vector to Node A, the calculation is

Node A current	Node A through Node B	New Node A distance vector
A: 0, -	A: 4,B	A: 0, -
B: 2, B	B: 2, B	B: 2, B
C: 5, B	C: 5, B	C: 5, B
D: ∞, -	D: 9, B	D: 9, B
E: 12, C	E: 10, B	E: 10, B

After Node B sends its new distance vector to Node D, the calculation at Node D is

Node D current	Node D through Node B	New Node D distance vector
A: ∞, -	A: 9, B	A: 9, B
B: 7, B	B: 7,B	B: 7,B
C: 2, C	C: 10, B	C: 2, C
D: 0, -	D: 14, B	D: 0, -

Node D current	Node D through Node B	New Node D distance vector
E: 1, E	E: 15, B	E: 1, E

You might notice that the routes are still not optimal.

Problem 3:

CIDR Address	First Address	Last Address	Number of addresses	Matches 10.14.101.12?
10.14.96.0/20	10.14.96.0	10.14.111.255	4096	yes
10.14.100.0/23	10.14.100.0	10.14.101.255	512	yes
10.14.98.128/25	10.14.98.128	10.14.98.255	128	no
10.14.0.0/16	10.14.0.0	10.14.255.255	65536	yes
10.128.0.0/10	10.128.9.0	10.191.255.255	4194304	no
10.0.0.1	10.0.0.1	10.0.0.1	1	no
default	-	-	<4294967296	yes

Of the three entries that match 10.14.101.12, we choose the one with the longest prefix, which is 10.14.100.0/23. Therefore, we forward the package to Interface m2.

Problem 4:

The TCP header is (at least) 20 B. The IP header is also at least 20 B. Therefore, the package is at least 1500 B long.

The propagation delay consists of processing delay (300 μsec), the queueing delay (assumed to be non-existent), the transmission delay, and the propagation delay. The transmission delay is the time to put the packet on the network, given as packet size in bits over the number of bits per second. This is $\frac{8 \times 1500}{100 \times 10^6} = 0.00012$ sec or 120 μsec. The propagation delay is the length of the connection divided by the speed of light in the medium, or $\frac{400000}{204} = 1960.78$ μsec. This gives a total of (300 + 120 + 1961) μsec = 2381 μsec = 2.381 msec.

If the packet size is 41B, the transmission delay shrinks to $\frac{8 \times 41}{100 \times 10^6} = 3.28 \times 10^6$ sec or 3.28 μsec. This gives a propagation delay of 2264.06 μsec or 2.264 msec.

To obtain 10 MB/sec, we need to send out $\frac{10 \times 10^6}{1460} = 6849.32$ segments per second, or a segment every 146 μsec.

If a segment is lost, we will send out the next segment 146 μsec later. After a delay of 4.645 msec, we will receive an acknowledgment, but only for the segment previous to the one lost. In the meantime, we have send out the next segment and the one after that. Thus, we will receive the third repeated acknowledgment after $3 \times 146 + 4645 = 5083$ μsec after we send out the lost segment. During this time, we will have send $\lfloor \frac{5083}{146} \rfloor = \lfloor 34.8151 \rfloor = 34$ segments, that need to be resend.

Problem 5:

There are bpf $= 1920 \times 1080 \times 24 = 49{,}766{,}400$ bits displayed per frame. The bytes per minute are Bpm $=$ bpf $\times 60 \times 60/8 = 22{,}394{,}880{,}000$ bytes per minute. A DVD has a storage capacity of about $S = 4.7 \times 10^9$ bytes. If there are m minutes worth of uncompressed video on the DVD, then $m \times$ Bpm $< S$, hence $m < S/$Bpm $= 0.209869$ minutes.

After compression, this number is multiplied by 2000 to 419.7 minutes.