SEMESTER 1 FINAL ASSESSMENT 2020/21

EMBEDDED NETWORKED SYSTEMS

Duration 4 hours

The School Office and the Exams Officer will produce the front matter and rubric. Please leave the rubric area blank except for:

1. Special instructions
2. Inclusion of extra sheets of information which cannot be placed in this single document
3. If you are producing multiple versions of this assessment by varying questions, please indicate what the combination of questions is for each version

Question 1

(a) You know that some links in your network (shown in Figure 1) are unreliable, but that your nodes will generate their own packets at a relatively low rate.

You decide to use flooding to get packets to their destination as quickly and reliably as possible. After considering your network topology, you configure your nodes to send packets with a hop limit of 2. No other intelligence is built into the algorithm.

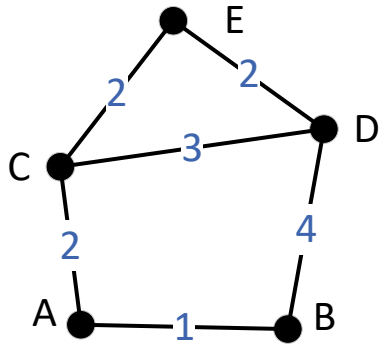

Figure 1 – Network Topology for Question 1a

You send an unacknowledged packet from node A to node E.

(i) **Determine** what transmissions are made by each node on the network while delivering this packet. You should also state how many transmissions are made in total.

(ii) **Discuss** the suitability of this routing scheme, and its configuration, to this application (considering effectiveness, efficiency and robustness).

[10 marks]

(b) The traffic on the network described in part (a) increases. You decide to modify it to use a different routing scheme, either Link State Routing or Distance Vector Routing. The other properties of this network remain unchanged.

(i) **Explain** which alternative routing scheme would be most appropriate, clearly justifying your answer.

(ii) **Explain** what information would be held by each node for your preferred scheme, for this network. **Describe** what computation would need to be done by each node in order to calculate the best route (but you do not need to carry out this computation).

[7 marks]

Question continues on following page

(c) Simple TCP may operate a ‘cumulative’ acknowledgment scheme. Alternatively, a ‘selective acknowledgment’ scheme may be used.

In an example transmission, with a small congestion window, packets 0-2 are received correctly, packets 3 and 4 are lost, but packets 5-7 are received.

List the acknowledgments sent by both schemes, for the sender’s first attempts to transmit these packets.

Discuss the impact of the two schemes on data transfer performance.

[7 marks]

(d) You are using a one-time pad to encrypt plaintext. You should allocate sequential codes to letters, where A=1, B=2, C=3, etc.

(i) **Show** the steps in encrypting plaintext “CAT” with the pad “DOG”. **State** the resultant ciphertext.

(ii) **Explain** the main advantage and drawback of this form of encryption.

[6 marks]

(e) Alice wants to share a program file with Bob.

The file is not secret. In fact, Alice would be very happy for anyone to use it! However, Alice wants Bob (or anyone else who receives it) to have confidence that the file has arrived without being corrupted or tampered with.

Discuss whether a conventional checksum would be suitable for this purpose. If not, you should **describe** a suitable alternative scheme.

[3 marks]

Question 2

(a) A receiver (with link-layer address 01110111_2) uses a link-layer protocol with the frame structure shown in Figure 2. The CRC-8 uses a generator polynomial of $G(x) = x^8 + x^7 + x^5 + x^2 + x + 1$, and is calculated over the data in the Length and Payload fields. Byte stuffing is used for framing, with a flag byte of 0x55 and an escape byte of 0x99. The Length field is an unsigned integer specifying the total number of bytes in the Payload field.

Header (1-byte: 0x55)	**Destination_Addr** (1-byte)	**Length** (1-byte)	**Payload** (variable)	**CRC-8** (1-byte)	**Footer** (1-byte: 0x55)

Figure 2 – Frame Structure for Question 2a

Determine the data passed to the NET on receiving each of the following frames. Show all your working.

(i) 01010101 10011001 01010101 00000001 10100011 00010110 01010101
[5 marks]

(ii) 01010101 01110111 00000010 01101111 10100011 11111001 01010101
[10 marks]

(b) A manufacturer is designing a wireless temperature sensor (the '*device*') for use inside domestic homes. The *devices* are battery-powered, and transmit a single frame of data whenever the temperature changes by 1°C. Data are transmitted to a mains-powered *gateway*, which receives 10-byte frames from the *devices* and provides connectivity to the Internet. The *gateway* does not need to transmit data frames to a *device*. The system is designed to accommodate up to 8 *devices* per *gateway*, and 1 *gateway* per home. The system uses a part of the radio spectrum that is unused by anything else, and the wireless channel has a typical BER (Bit Error Rate) of $1x10^{-5}$. The manufacturer contacts you for advice on the design of its networking protocol.

(i) **Explain** which MAC protocol you would choose for the system, clearly justifying your answer.
[6 marks]

(ii) **Explain** which flow-control protocol you would choose for the system, clearly justifying your answer.
[6 marks]

(iii) **Explain** which error-control method you would choose for the system, clearly justifying your answer.
[6 marks]

Question 3

(a) The manufacturer of the system in Question 2b has now chosen which radio hardware they are going to use for the *device*. The radio consumes 50mW, 45mW, and 0mW in transmit, receive/listen, and sleep states respectively. It takes 10ms for a frame to be transmitted or received. You can ignore the power consumption of the microcontroller and sensors etc. Based on the scenario in Question 2b, and the protocols that you chose in your answer(s)*:

(i) **Derive** an expression to approximate the average energy consumption of the *device*. **Justify** any assumptions that you make.

[11 marks]

(ii) **Estimate** how long you might expect a *device* to last for, when powered from a 150mAh 1.5V coin cell. **Justify** any assumptions that you make. **Explain** whether you think your answer is realistic.

[5 marks]

**if you did not answer Question 2b, choose a MAC and flow-control protocol of your choice*.

(b) When the level of traffic approaches a network's capacity, congestion control strategies can help to avoid 'congestion collapse'.

(i) **Explain** why congestion control is the responsibility of *both* the transport layer and the network layer. You should briefly describe the congestion control functionality of each layer.

[6 marks]

(ii) You are using TCP Reno, which includes "fast recovery". Your congestion window is set to 24 kB when three duplicate ACKs are received.

State the congestion window size for the next three RTTs (assuming subsequent transmissions are successful). **Discuss** how this scheme performs compared with "slow start".

[6 marks]

(iii) You are investigating an issue with network congestion, and notice that a very large number of small TCP packets are being transmitted. Many of them have a very small WIN value.

Explain the likely cause of the issue, and suggest a solution to it.

[5 marks]

END OF PAPER