University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER II EXAMINATIONS - 2013-2014

School of Electrical, Electronic and Communications Engineering

EEEN 20060

Communication Systems

External Examiner: Professor T. Green

Head of School: Professor T. Brazil

Module Coordinator: Brian Mulkeen*

Time Allowed: 2 Hours

Instructions for Candidates

Answer any **three** questions. All questions carry equal marks.
The percentages in the right margin give an approximate indication of the relative importance of each part of the question.

You may consult one textbook and one folder of notes during the examination.
You must keep these items on or under your desk during the examination, and you must use them quietly, without causing inconvenience to others.

All rough work should be entered in your answer books.

Instructions for Invigilators

This is an **open-book** examination – candidates are allowed to bring one textbook and one folder of notes to the examination, and to consult these during the examination.

Non-programmable calculators are permitted.

Question 1

Answer any **four** parts of this question. All parts carry equal marks.

a) Figure 1 shows a segment of a Manchester coded signal. The tick marks on the time axis are at 1 μs intervals. State the bit rate and identify the bits shown. Explain briefly how you arrive at your answers.

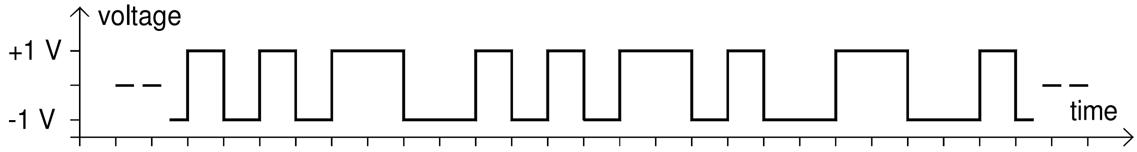

Figure 1: Received Signal

b) A link-layer protocol uses short frames with a cyclic redundancy check on the frame content for error detection. The divisor is 1001. Calculate the check bits that should be appended to the frame below, where the leftmost bit is transmitted first. Explain briefly how the received frame will be checked for errors.

1 0 0 0 1 1 0 1 1 0

c) A physical layer protocol delivers 1024 kbit/s. It uses an advanced modulation scheme, which tends to produce errors in bursts of up to 20 bit errors. The occurrence of these bursts can be modelled as a Poisson random process, with an average rate of 6.3 burst/s. The link layer protocol transmits frames containing 3000 data bits, with another 72 bits in the header and trailer. What is the probability of a frame being received without errors? What type of error detecting code would be needed?

d) In the context of a packet-switched network, outline the advantages and disadvantages of a connection-based service. Also explain how such a service could be provided by the network.

e) Figure 2 shows a small network that uses link-state routing. The number beside each link indicates the cost of using that link. Explain briefly how this operates. Show an example of the routing message that might be sent by node G. Consider a situation where the network has been operating for some time, and the link between node A and node D fails. How would node G find out about this? What effect would this have on the routing decisions at node G? Also consider the effect of adding a new link, with cost 2, between node B and node J. What effect would this have on the routing decisions at node G?

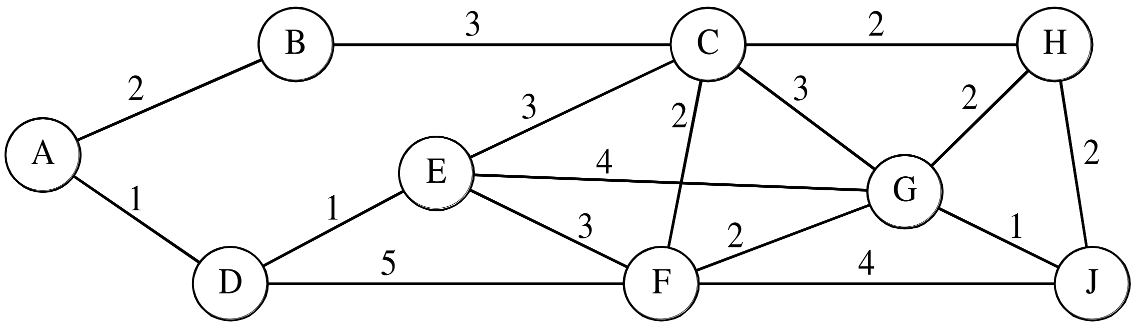

Figure 2: Network Diagram

Question 2

Design a link-layer protocol to provide reliable continuous transmission of images on a point-to-point link from a satellite observatory (telescope) in geostationary orbit to a laboratory in Dublin, at a distance from the satellite of 38,700 km. You may assume that the speed of light is 3×10^8 m/s.

The physical layer provides a full-duplex path at 8 Mbit/s, using a separate frequency for uplink and downlink. Each bit has probability of error 5×10^{-6}.

a) Give details of your design. In particular, specify:
- how the start and end of a frame will be recognised reliably;
- header and trailer contents, including the number of bits allocated to each item;
- what responses the receiver will send;
- what the sender will do while waiting for a response;
- what the sender will do if it receives a negative response;
- what the sender will do if it receives no response.

Also estimate the size of the sending and receiving windows (if any), assuming a frame size of about 3000 bits. Give reasons for your design decisions. (50%)

b) Calculate the optimum number of data bits in a frame (to maximise throughput). (If you cannot do this, assume a sensible number, so that you can continue.) Calculate the throughput that your protocol could deliver using data blocks of the optimum size. Show clearly how you arrive at your answers, and explain any additional assumptions that you make. (50%)

Question 3

Binary signals are transmitted on an optical fibre by turning the light source on or off for the entire duration of each bit interval. When the light source is on, it outputs its maximum power of 50 mW. At the optical frequency used, the fibre has attenuation 0.4 dB/km. At the receiver, a photo-diode converts the light to an electrical signal, giving an output voltage proportional to the power of the incoming light (500 V/W), plus noise with Gaussian probability density function. At a distance of 100 km, the probability of error in the receiver is barely acceptable.

a) Sketch the eye diagram that you would expect to see at the photo-diode output at a distance of 100 km. Give two reasons why this is not just a scaled version of what might be seen at the transmitter. Calculate the voltages that you would expect at the photo-diode output (in the absence of noise) when a 1 or a 0 is transmitted continuously, and mark these on the eye diagram. Explain how the receiver should make decisions. (40%)

b) Propose a method of transmitting data over a distance of thousands of km, using the same technology as in part a. Give details of your proposal. (20%)

c) You want to double the bit rate of the system in part a, without increasing the bandwidth, by using a larger set of signals. Explain how this could be done. Propose suitable values for the output power of the light source, keeping to the maximum of 50 mW. Calculate the distance at which the probability of error would be the same as that achieved in the original design (at 100 km, as in part a). (40%)

Question 4

Thirty devices are connected in parallel on one cable, so that all devices receive all transmissions. The physical-layer bit rate is 200 kbit/s and the total cable length is 1 km. The link-layer protocol uses frames that vary in length from 100 to 4000 bit (including header and trailer), with average payload 2800 bit. On average, all devices produce approximately equal traffic. Each device typically communicates with many other devices in the network.

a) The system currently uses slotted Aloha as the medium access control protocol. Explain how this would work, and propose a suitable duration for the time slot. Calculate the maximum throughput that this system could deliver (in bit/s), stating clearly any assumptions that you make. (50%)

b) Describe two alternative medium-access control protocols that could provide a higher throughput in this system, including at least one without contention. In each case, explain why you think the protocol that you are describing would allow a higher throughput, and whether a master device would be required. Choose one of the two protocols that you have described and estimate the throughput that it could provide under ideal conditions. State clearly any assumptions that you make. (50%)

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