University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER II EXAMINATIONS - 2011/2012

School of Electrical, Electronic and Communications Engineering

EEEN 20060

Communication Systems

External Examiner: Professor S. McLaughlin

Head of School: Professor T. Brazil

Module Coordinator: Brian Mulkeen*

Time Allowed: 2 Hours

Instructions for Candidates

Answer any **three** questions. You may consult one textbook and one folder of notes during the examination.

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.

All rough work should be entered in your answer books.

Instructions for Invigilators

This is an **open-book** examination – candidates are allowed to consult one textbook and one folder of notes during the examination. If possible, please provide additional working space for candidates, to facilitate this.

Calculators are permitted, but no rough-work paper is to be provided for candidates.

Question 1

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

a) A TV news gathering van transmits a signal at 14.8 GHz to a geostationary satellite for onward transmission to the TV studio. Its maximum transmit power is 20 W. The van is required to operate throughout Europe, where distance to the satellite varies between 38 000 km and 41 000 km.

The satellite needs a minimum receive power of 2.6 pW. The receive antenna on the satellite, at 14.8 GHz, has gain of 40 dB in the centre of the beam (near Luxembourg). In more distant parts of Europe, the gain can fall by up to 5 dB.

What is the minimum gain required of the transmit antenna on the van? Give your answer in dB, as an integer. What assumptions did you make in arriving at this answer?

b) Figure 1 shows a small network that uses simple distance-vector routing. The number beside each link indicates the distance or cost associated with that link, which is fixed. Write down the first distance vector that node F would send to its neighbours. Draw up the routing table that you would expect to find at node F when the network has been operating for some time.

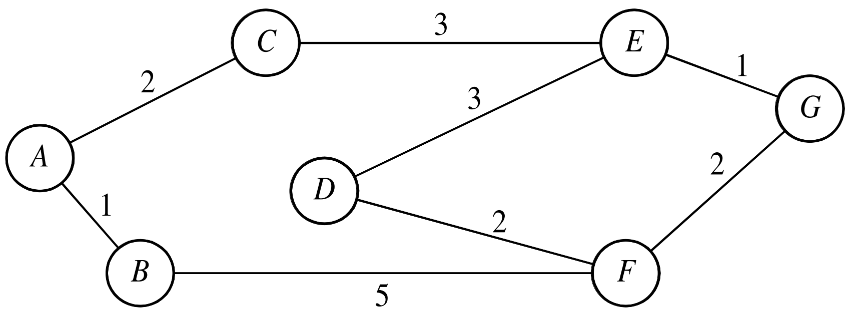

Figure 1: Network Diagram

c) A cordless telephone system is designed to have a range of up to 300 m, and supports up to 5 handsets on one radio channel using TDMA with 10 time slots in a 15 ms TDMA frame. The base unit uses the first 5 time slots to transmit data to each handset in turn, and then each handset transmits in turn to the base unit. Each handset transmits a fixed time after it receives its data from the base unit.

Explain how the system can avoid collisions if handset 2 is used at maximum range while handset 3 is close to the base unit. Draw a diagram of one TDMA frame, and propose a suitable duration for each transmission.

d) Some communication systems first establish a connection between the devices that want to communicate; then transfer information over this connection; and then close the connection when finished. Outline some advantages of this method. Explain why other communication systems do not use connections.

e) An error detection code adds 4 check bits to a group of 20 data bits, using an interleaved parity check with odd parity. The check bits are transmitted last. Show how to calculate the check bits, using the data bits below as an example (leftmost bit transmitted first). Explain why this code might be preferred to a simpler code, which added one check bit to each group of 5 data bits.

1 0 0 1 1 0 1 1 1 0 0 0 0 0 1 0 1 1 1 0

Question 2

A building management system controls and monitors all the electrical and mechanical systems in a large building. This includes the heating, ventilation, lighting, fire alarm, burglar alarm, etc. There are many sensors (sensing temperature, smoke, movement, light-level, etc.) and many control devices (controlling heating equipment, lights, alarms, etc.) distributed around the building. All of these devices are connected to a central computer, which gathers information from all the sensors, makes all the decisions, and sends instructions to the control devices.

The connections use twisted pairs of wires, with the computer at one end and up to 30 devices connected in parallel along each pair of wires. Each connection operates at 100 kbit/s, and the maximum length of each pair of wires is 600 m. The messages exchanged are never more than 80 bits long. You may make reasonable assumptions about the other details of this system, but you must state these assumptions clearly in your answer.

a) Discuss some of the options that could be considered in the design of the medium-access control protocol for this system. Consider the advantages and disadvantages of each, in the context of this system. (50%)

b) Choose a suitable medium-access control protocol, and give reasons for your choice. Specify the details of your proposed system, and estimate the throughput that it could provide, in terms of messages per second, on each pair of wires. (50%)

Question 3

A physical-layer protocol uses ternary (3-level) signals to send binary data along a cable, which has attenuation 1.6 dB/km at the important frequencies. The transmitter collects a group of four data bits, and transmits a sequence of three ternary signals to represent each group of four data bits. Each ternary signal is represented by a fixed voltage, which is transmitted for 1 µs. The next ternary signal follows immediately.

a) What voltage would you use to represent each of the ternary signals? Give reasons for your proposal. Sketch an example of the transmitted signal, showing the scale on each axis. (30%)

b) What considerations would you take into account in designing the mapping from groups of bits to sequences of ternary signals? There are 27 possible sequences of three ternary signals, and only 16 of these will be used. Give examples of sequences that you would avoid, with reasons. (30%)

c) Explain how and why the signal might be changed on the channel. Sketch an example of the eye diagram that you might see at the receiving end of the system, at a distance of 25 km. Show the scale on each axis. Explain how the receiver should make decisions. (40%)

Question 4

You are to design a link-layer protocol to provide reliable transmission of arbitrary binary data over a link with propagation delay 8 ms. The physical layer allows transmission in both directions at the same time, and delivers 5 Mbit/s, with each bit having probability of error 10^{-5}. There are several devices at each end of this link, so data frames, and any acknowledgements, must include the address of the source and destination devices, each 6 bits long.

a) Decide how your protocol will operate. Specify what information you will include in the frame header, and in the trailer, and the number of bits you will allocate to each item. Similarly, specify the form of any acknowledgements that you use. Give reasons for your design decisions. In this part of the question, you may assume that the frame will be between 2000 and 4000 bits in length – you may need this information to decide how many bits are needed to represent sequence numbers and/or frame size information. (50%)

b) Calculate the optimum number of data bits in your frame. (If you cannot do this, make a reasonable assumption, so that you can continue.) Calculate the throughput that your protocol can deliver, assuming that there is always data waiting to be transmitted. Show how you arrive at your answers, and explain any other assumptions that you make. (50%)

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