ELEC3500/ELEC6500/SENG6400 - Telecommunications Networks

Assignment 1

This is an **individual assignment**.

Weight: **7.5%** of the course final mark.

Submission due date: **11.59pm Friday 27 August 2021 (Week 6)**.

Submit your assignment via the course Blackboard (using the Assessment tab). Any late submission will be penalised as per the Course Outline.

Total Mark: 75

Instructions: Unless specified otherwise, use the free space propagation speed of light $3x10^8$ m/s to calculate the propagation delay. For numerical calculations, the results must show the appropriate unit. Show a complete solution for each problem in your submission.

1. (10 marks) Consider a client-server system with the following parameters and requirements. The client transmits $10x10^6$ bits of data every minute to the data server connected directly to it. The transmission link speed is $20x10^6$ bps. Each packet is 2,000 bytes long which includes a 20-byte packet header.
   a. Calculate the number of packets generated per second for data transmission at the client node.
   b. The system requires every packet must be delivered within 4 ms of generating a data packet. Calculate the maximum link distance between the client and the server that still can meet this requirement. Ignore processing and queuing delays.
   c. Calculate the number of overhead bits transmitted per second from the client to the server.

2. (10 marks) Two client terminals A and B are connected to a server via a router, as shown in Fig. 1. Terminal A generates 200,000 bytes of data every second, while Terminal B generates 145,000 bytes of data every second. Links 1 and 2 each support a maximum packet size of 1,600 bytes which includes a 40-byte header. Every second, the router combines all the payloads received from A and B, and generates a new packet which includes a 40-byte header. Link 3 supports a maximum packet size of 4,000 bytes. Calculate the following values:
   a. The minimum required transmission rates of Links 1 and 2 to accommodate the traffic from Terminals A and B, respectively. Assume that the terminals use the maximum packet size.
   b. The number of packets generated by the router every second to send its payload to the server.
   c. Minimum transmission rate of Link 3 for the server to receive the router's packet within one second. Ignore any processing and propagation delays.

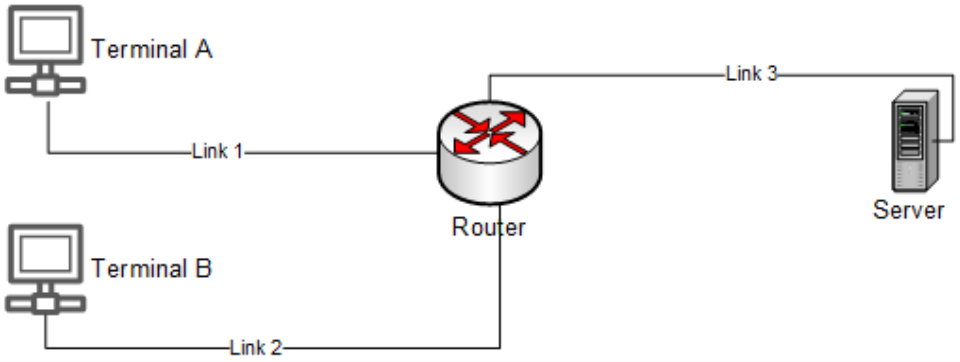

Fig. 1 (for Question 2)

3. (10 marks) Suppose network users share a 4 Mbps link. Also, suppose each user requires 200 kbps when transmitting, but each user transmits only 15% of time.
   a. When circuit switching is used, how many users can be supported?
   b. Suppose packet switching is now used and that there are 20 users. Find the probability that any given time, at most 4 users are transmitting simultaneously.

4. (10 marks) Consider a digital multimedia transmission system. Separate audio and video coders are used to encode these signals. Audio and video bits are packed in packets together and transmitted over a transmission link. Each packet is 2,000 bytes long, which includes a 48-byte header. The system generates one packet after every 40 ms. Calculate the following values:
   a. Minimum data transmission rate required to support the above system.
   b. The minimum signal-to-noise ratio (SNR) in dB required to transmit the above audio and video information. Assume a 400-kHz transmission channel bandwidth is used.
   c. The end-to-end packet delay over a 50-km link, using answer in Part a).

5. (13 marks) A digital audio broadcast service is used to transmit digital music. Stereo audio signals are to be transmitted using a digital modem over a data link. An audio signal is sampled at a rate of 44 kilo samples/second and quantised using a 24-bit quantiser. The data link has a transmission bandwidth of 0.5 MHz. Note that a stereo signal uses two channels. Assume a 46-byte overhead is added to each packet before transmission.
   a. What is the total bit rate produced by a stereo audio signal?
   b. What is the minimum SNR value (in dB) required for the above data link?
   c. Assume that the broadcast service uses the UDP/IP/Ethernet protocol to transmit digital audio, using a packet switched network. The maximum packet size is limited to 800 bytes, which includes the combined packet header: UDP header (8 bytes), IP header (20 bytes), and Ethernet header (18 bytes). Calculate the number of packets required to transmit a 500 ms digital audio segment.
   d. Assume that pipeline packet transmission technique is used, and the transmitter-receiver distance is 100 km. Calculate the end-to-end delay of transmitting and receiving an audio segment in Question 5c.

6. (10 marks) A string of 10011100 arrives at the line encoder of a link adapter. Draw the output wave form for the following line codes.
   a. Polar NRZ
   b. Bipolar
   c. Manchester
   d. Differential Manchester

7. (12 marks) An access multiplexer (AM) installed in the roadside box of the NBN (National Broadband Network). Assume that 200 homes are connected to the AM. The average packet interarrival arrival time at the AM is 200 μs. The average packet length is 2,500 bytes where the packet length is exponentially distributed.
   a. Calculate the number of packets arriving at the AM every hour.
   b. Calculate the incoming traffic rate (in bits/sec) at the input of the AM.
   c. Assume that the output of the AM is connected to the NBN core network via a 2-Gbps link. Calculate the total normalised load ρ at the AM.
   d. Assume that the packet arrival process is exponentially distributed. Calculate the average queuing delay introduced by the AM.