

City University of Hong Kong

Course code & title: EE3009 Data Communications and Networking

Session: Semester A 2020/21

Time allowed: Two hours and 15 minutes
(inclusive of 15 minutes for uploading)

This paper has 7 pages (including this cover page).

1. This paper consists of 4 questions.
 2. Answer **ALL** questions.
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Instructions :

Please make sure you follow all instructions from the University, ARRO, and EE. Please note the following:

1. This paper consists of **4** questions. The questions are ALL compulsory. Make sure that you attempt all of them. The total score is 100.
2. This is an **open-book exam**. Students can read the lecture notes and/or other materials available online.
3. You are responsible for receiving the questions on Canvas, hand-write all answers on blank answer sheets, compile the answers into a single PDF file, and **upload the file before the deadline** of the exam.
4. **Stay on Zoom after the deadline** until the examiner allows you to leave.

Answering this exam paper implies your acknowledgment of the Pledge for following the Rules on Academic Honesty:

“I pledge that the answers in this examination are my own and that I will not seek or obtain an unfair advantage in producing these answers. Specifically,

1. I will not plagiarize (copy without citation) from any source;
2. I will not communicate or attempt to communicate with any other person during the examination; neither will I give or attempt to give assistance to another student taking the examination; and
3. I will use only approved devices (e.g., calculators) and/or approved device models.
4. I understand that any act of academic dishonesty can lead to disciplinary action.”

On the first page of your answer sheets, copy the following sentence and sign it: *I pledge to follow the Rules on Academic Honesty and understand that violations may lead to severe penalties.* (Signature) _____ (Date) _____

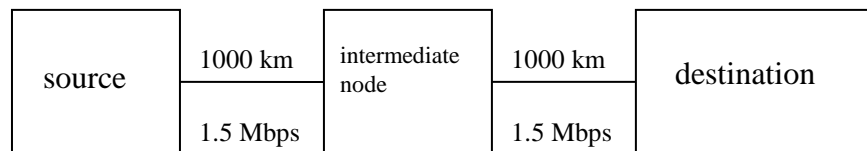
Contact Information

- Should you have any technical problem during the exam, contact your course leader or invigilator via Zoom private chat, email: eeschan@cityu.edu.hk or by phone call at 3442 7781.
- If you are not able to contact course leader/invigilator, you can reach the department via:
 - (a) Departmental hotline at (+852) 3442-7740
 - (b) Department Whatsapp phone: 9269-4066
 - (c) Department WeChat ID: wxid_lly7yf5fzozj722 or scan the following QR Code



Question 1. (25 marks)

- a. Besides communication links, provide two other components of Internet? [2 marks]
- b. Name two technologies used for residential access networks? [2 marks]
- c. A link has capacity 50 Mbps, and is shared by eight users under packet switching mode. Each user requires a bandwidth of 10 Mbps, and only transmits 40% of the time. What is the probability that the total bandwidth required by users does not exceed the link capacity? [3 marks]
- d. A 64-kilobyte message is to be transmitted from the source to the destination as shown below. Each link limits packets to a maximum size of 2-kilobytes, and each packet has a 32-byte header. How long does it take to transmit the message from the source to the destination? Assume that the signal propagates at a speed of 2×10^5 km/s, and t_{ack} and t_{proc} are both negligible.



- [6 marks]
- e. Consider the information sequence 1111000000000000, and the generator polynomial $g(x) = x^8 + x^2 + x + 1$.
- Find the corresponding CRC codeword of this information sequence. [9 marks]
 - Can this code detect single-bit errors? Explain your answer. [1 mark]
 - Draw the shift register division circuit for this generator polynomial. [2 marks]

Question 2. (25 marks)

- a. A file of length 10^6 bytes is to be transmitted over a 1 Mbps communication line that has a bit error rate of $p = 10^{-6}$. Assume that bit errors occur independently.
- i) What is the probability that the entire file is transmitted without errors? (Note for large n and very small p , $(1-p)^n \approx e^{-np}$.)

[2 marks]

- ii) The file is broken up into N equal-sized blocks that are transmitted separately. Write down an expression for the probability that all the blocks arrive without error.

[2 marks]

Stop-and-Wait ARQ is used to transmit the entire file without dividing into blocks.

- iii) Let P_f be the probability of frame transmission error, write down an expression in terms of P_f for the probability of taking i transmissions to deliver a frame successfully.

[2 marks]

- iv) Suppose the propagation delay, processing delay and transmission time of ACK are all negligible, what is the total time required for a successful frame delivery if i transmissions are required?

[2 marks]

- v) On average, how long does it take to deliver the file?

[6 marks]

- b. Describe the operation of the Go-Back-N protocol with window size W s frames, with respect to the transmitter and receiver side.

[5 marks]

- c. Figure 1 corresponds to an HDLC ABM frame exchange with no errors. Complete the diagram by completing the labeling of the frame exchanges, and write the sequence of state variables at the two stations as each event takes place.

[6 marks]

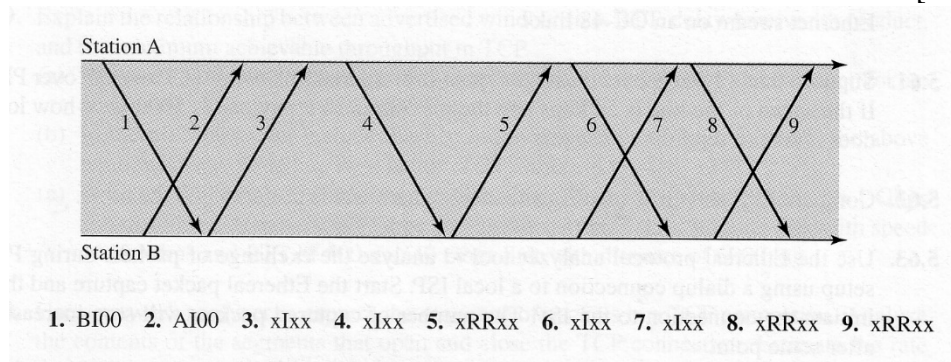


Figure 1.

Question 3.

- a. Starting from the following relationship,
 $G = S + \text{the average number of retransmissions,}$
derive the throughput equation of pure ALOHA.
[6 marks]
- b. Describe the operation of the p -persistent CSMA protocol.
[3 marks]
- c. Describe an enhancement that has been made to the CSMA protocol to improve its performance.
[1 mark]
- d. Referring to Figure 2 below, M terminals are attached by a dedicated pair of lines to a hub in a star topology. The distance from each terminal to the hub is 25 meters, the speed of the transmission lines is 10 Mbps, all frames are of length 12,500 bytes, and the signal propagation on the line at a speed of 2.5×10^8 meters/second. Calculate the maximum network throughput achievable when the hub is implementing CSMA-CD.

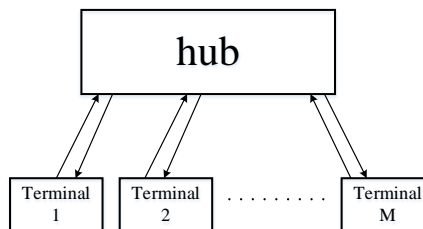


Figure 2.

- e. Consider a token ring network with 25 stations and transmission speed of 25 Mbps. Let τ be the total propagation delay around the ring, and b be the delay in an interface in terms of number of bits. With $\tau = 2.5 \times 10^{-5}$ s, $b = 2$, and frame length equal to 1250 bytes, calculate the maximum throughput when the network operates in the single-frame operation.

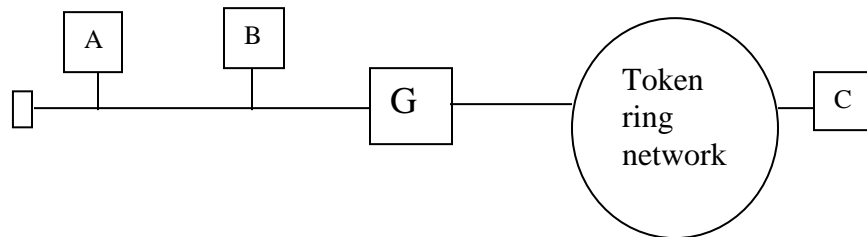
[5 marks]

f.

- i) How many bits does an IPv6 address have?
[1 mark]
- ii) In IPv4 addressing scheme, what is the maximum number of class A networks that can be supported? And how many hosts can be supported in each class A network?
[2 marks]
- iii) A small ISP owns the following networks: 128.56.24.0/24, 128.56.25.0/24, 128.56.26.0/24, 128.56.27.0/24. Perform CIDR aggregation of these networks.
[2 marks]

Question 4.

- a. Referring to the following internetwork, when host A is connected to an Ethernet and wishes to send an IP packet to host C, it first forwards the packet to router G.



- i) A knows the IP address of G, what else does it need to know in order to forward the IP packet to G?
[1 mark]
 - ii) If A does not know the information in the above sub-question (4b. i) , what protocol can it use to find the information? Describe how the protocol operates.
[3 marks]
- b. A high quality speech signal has a bandwidth of 8 kHz. Suppose that the speech signal is to be quantized and then transmitted over a 28.8 kbps modem. What is the SNR of the received speech signal.
[2 marks]

- c. Suppose that a signal has amplitude uniformly distributed between $-V$ and V . Let M be the number of quantization levels.
- i) What is the SNR for a uniform quantizer that is designed specifically for this signal?
[3 marks]
 - ii) Suppose that the quantizer design underestimates the dynamic range by a factor of 2; that is the actual dynamic range is $-2V$ to $2V$. Plot the quantization error versus signal amplitude for this case. What is the SNR of the quantizer?
[10 marks]
- d. Suppose that a low-pass communications system has a 1 MHz bandwidth.
- i) What bit rate is attainable using 8-level pulses?
[2 marks]
 - ii) What is the Shannon capacity of this channel if the SNR is 20dB?
[2 marks]
- e. The nonreturn-to-zero (NRZ) signaling method transmits a 0 with a voltage of $+1\text{v}$ for a duration T , and a 1 with a voltage of -1v for duration T . Plot the signal for the sequence of 4 consecutive 1s followed by 4 consecutive 0s. Explain why this code has a synchronization problem.
[2 marks]

-END-