SECTION A - ATTEMPT ALL QUESTIONS

1. What are some of the possible services that a data link-layer protocol can offer to the network layer? [2 marks]
2. Why would the token-ring protocol be inefficient if a LAN had a very large perimeter? [3 marks]
3. Explain why an ARP query is sent within a broadcast frame and an ARP response is sent within a frame with a specific destination MAC address? [4 marks]
4. Given the macroscopic description of TCP throughput, in the period of time from when the connection's rate varies from $\frac{W}{(2.RTT)}$ to $\frac{W}{RTT}$, only one packet is lost (at the very end of the period), *where W is the window size and RTT is the Round trip time*. Show that the loss rate (fraction of packets lost) is equal to

$$L = \text{loss rate} = \frac{1}{\frac{3}{8}W^2 + \frac{3}{4}W}$$

[5 marks]

5. List three nonproprietary Internet applications and the application-layer protocols that they use. [6 marks]
6. Give any two applications of terrestrial microwave. [2 marks]
7. In developing any network, the designer must take into account a number of considerations when selecting the type of medium to use. Give any three of these considerations. [3 marks]
8. What is the 32-bit binary equivalent of the IP address 223.1.3.27? [4 marks]
9. Compare and contrast the IPv4 and the IPv6 header fields. Do they have any fields in common? [3 marks]
10. It has been said that when IPv6 tunnels through IPv4 routers, IPv6 treats the IPv4 tunnels as link-layer protocols. Do you agree with this statement? Why or why not? [2 marks]
11. Compare and contrast link-state and distance-vector routing algorithms. [3 marks]
12. Discuss how a hierarchical organization of the Internet has made it possible to scale to millions of users. [3 marks]

SECTION B - ATTEMPT ANY THREE QUESTIONS

Question One

a. List down any three common types of firewalls. [3 marks]
b. As a network administrator for your company, give two reasons why you would consider it preferable to invest company resources in a firewall. [2 marks]
c. Using RSA, choose $p = 3$ and $q = 11$, and encode the word "dog" by encrypting each letter separately. Apply the decryption algorithm to the encrypted version to recover the original plaintext message. [6 marks]
d. Considering RSA with $p = 5$ and $q = 11$.
   i. Compute the values of n and z you would obtain. [2 marks]
   ii. Let e be 3. Why is this an acceptable choice for e? [1 mark]
   iii. Find d such that $de = 1 \pmod{z}$ and $d < 160$. [2 marks]
   iv. If c denotes the corresponding cipher-text, by showing the steps necessary, encrypt the message $m = 8$ using the key (n, e). [4 marks]

$\frac{cd-1}{40} = 3$ whereas

2, 3, 5, 7, 11,

→ a b c d e f g h i j k l m n o p q r s t u v w x y z.

$ed - 1 = 80$

$ed = 81$

$d = \frac{81}{2}$

Question Two

Consider Figure 1 below showing TCP window size as a function of time. Assuming TCP Reno is the protocol experiencing the behavior shown in Figure 1, answer the following questions. In all cases, you should provide a short discussion justifying your answer.

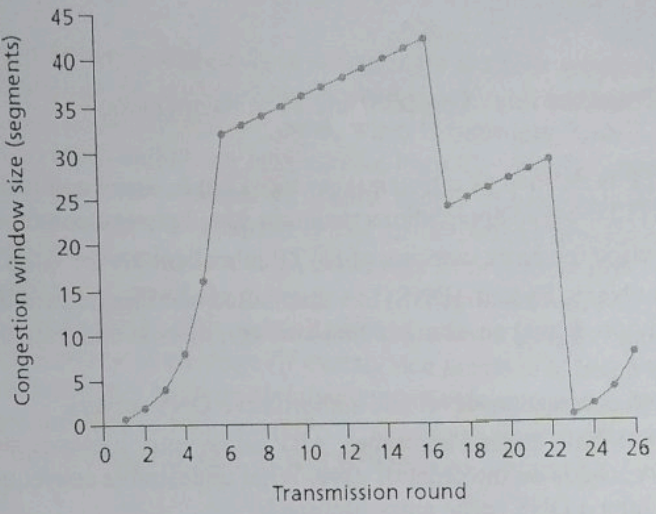

Figure 1: TCP window size as a function of time

a. Identify the intervals of time when TCP slow start is operating. [2 marks]
b. Identify the intervals of time when TCP congestion avoidance is operating. [2 marks]
c. After the 16th transmission round, is segment loss detected by a triple duplicate ACK or by a timeout? [2 marks]
d. What is the initial value of ssthresh at the first transmission round? [2 marks]
e. During what transmission round is the 70th segment sent? [2 marks]
f. Assuming a packet loss is detected after the 26th round by the receipt of a triple duplicate ACK, what will be the values of the congestion window size and of ssthresh? [3 marks]
g. Suppose TCP Tahoe is used (instead of TCP Reno), and assume that triple duplicate ACKs are received at the 16th round. What are the ssthresh and the congestion window size at the 19th round? [4 marks]
h. Again, suppose TCP Tahoe is used, and there is a timeout event at 22nd round. How many packets have been sent out from 17th round till 22nd round, inclusive? [3 marks]

Question Three

a. Discuss the four main services offered by the data link layer. [4 marks]
b. Considering Voice-over-IP applications, one of the drawbacks of a small packet size is that a large fraction of link bandwidth is consumed by overhead bytes. To this end, suppose that the packet consists of P bytes and 5 bytes of header.
    i. Consider sending a digitally encoded voice source directly. Suppose the source is encoded at a constant rate of 128 kbps. Assume each packet is entirely filled before the source sends the packet into the network. The time required to fill a packet is the **packetization delay**. In terms of L, determine the packetization delay in milliseconds. [5 marks]

ii. Packetization delays greater than 20 msec can cause a noticeable and unpleasant ec... Determine the packetization delay for L = 1,500 bytes (roughly corresponding to ... maximum-sized Ethernet packet) and for L = 50 (corresponding to an ATM packet). [4 marks]

iii. Calculate the store-and-forward delay at a single switch for a link rate of R = 622 Mbps for L = 1,500 bytes, and for L = 50 bytes. [4 marks]

iv. Give the advantages of using a small packet size. [3 marks]

Question Four

a) What is FTP and the role of ports 20 and 21 in its operation? [3 Marks]

b)

i. HTTP is defined as a *stateless* protocol but in some applications, state is important. How do HTTP-based applications maintain state between communication entities? [2 Marks]

ii. Describe the basic working of HTTP in a client-server setup. [4 Marks]

c) The Domain Name System (DNS) is a distributed and hierarchical database system for domain name resolution. Using an example ***(mak.ac.ug)***, discuss and state the relevance of such a structure. [5 Marks]

d) Compare and contrast top-level and authoritative DNS servers. [4 Marks]

e) ARP and DNS both depend on caches; ARP cache entry lifetimes are typically 10 minutes, while DNS cache is on the order of days. What undesirable consequences might there be in having too long a DNS cache entry lifetime? [2 Marks]

Question Five

a) Give two important functions of the network layer. [2 Marks]

b) The Makerere University Library is in the process of redesigning its network to accommodate more users and also to achieve traffic segmentation for the different offices and users. The user projections below are for the next 3 years:

- ✓ Students – 250
- ✓ Staff – 50
- ✓ Wireless - 500

The University ICT Services, mandated with provision of University ICT needs, has assigned the CIDR address space 10.10.0.0/22 for use with a prefix of /24 as the least for subnets to be created in the new design. The Library has also been tasked with address space utilization with minimum wastage possible.

i. What is CIDR as applied to the use case above? [2 Marks]

ii. Advise the University Library on the segmentation of the network above for the different users clearly showing the following: [10 Marks]

- o Address space
- o Start and end usable IP addresses
- o Maximum number of users supported

iii. State the relevance of NAT in such a setup. [1 Mark]

iv. Describe the two configuration types that may be required by the Library router to ensure communication between the networks above and the University core network. [4 Marks]

c) List two routing protocols that support equal load balancing. [1 Mark]

Question Six

Consider the scenario shown in Figure 2, in which there are four wireless nodes, A, B, C, and D. The radio coverage of the four nodes is shown via the shaded ovals; all nodes share the same frequency. When A transmits, it can only be heard/received by B; when B transmits, both A and C can hear/receive from B; when C transmits, both B and D can hear/receive from C; when D transmits, only C can hear/receive from D. Suppose now that each node has an infinite supply of messages that it wants to send to each of the other nodes. If a message's destination is not an immediate neighbor, then the message must be relayed. For example, if A wants to send to D, a message from A must first be sent to B, which then sends the message to C, which then sends the message to D. Time is slotted, with a message transmission time taking exactly one-time slot, e.g., as in slotted Aloha. During a slot, a node can do one of the following: (*i*) send a message; (*ii*) receive a message (if exactly one message is being sent to it), (*iii*) remain silent. As always, if a node hears two or more simultaneous transmissions, a collision occurs and none of the transmitted messages are received successfully. You can assume here that there are no bit-level errors, and thus if exactly one message is sent, it will be received correctly by those within the transmission radius of the sender.

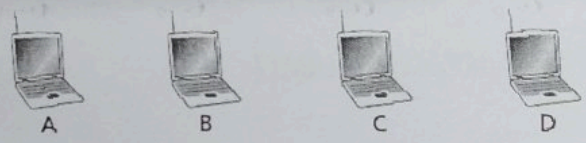

Figure 2. Network scenario for question 6

a. Suppose an omniscient controller (i.e., a controller that knows the state of every node in the network) can command each node to do whatever it (the omniscient controller) wishes, i.e., to send a message, to receive a message, or to remain silent. Given this omniscient controller, what is the maximum rate at which a data message can be transferred from C to A, given that there are no other messages between any other source/destination pairs? [5 marks]
b. Assume now A sends messages to B, and D sends messages to C. What is the combined maximum rate at which data messages can flow from A to B and from D to C? [5 marks]
c. If instead A sends messages to B, and C sends messages to D. What is the combined maximum rate at which data messages can flow from A to B and from C to D? [5 marks]
d. Suppose now that the wireless links are replaced by wired links, what is the maximum rate at which a data message can be transferred from C to A in this wired scenario. [5 marks]

HAPPY NEW YEAR TO YOU