UNIVERSITY OF COLOMBO, SRI LANKA

UCSC **UNIVERSITY OF COLOMBO SCHOOL OF COMPUTING**
(Successor to the Institute of Computer Technology (ICT), University of Colombo)

BIT

DEGREE OF BACHELOR OF INFORMATION TECHNOLOGY (EXTERNAL)

Academic Year 2002/03 – 2ⁿᵈ Year Examination – Semester 4

IT4101: Data Communications and Networks
Part 2 - Structured Question Paper
24ᵗʰ July, 2004
(ONE AND A HALF HOURS)

To be completed by the candidate

BIT Examination Index No: _____

Important Instructions:

- The duration of the paper is **1 ½ (One and a half) hours**.

- The medium of instruction and questions is English.

- This paper has **4 questions** and **15 pages**.

- **Answer question 1 (**40 marks**) and any 2 of the other questions (**30 marks each**) only**.

- **Write your answers** in English using the space provided **in this question paper**.

- Do not tear off any part of this answer book.

- Under no circumstances may this book, used or unused, be removed from the Examination Hall by a candidate.

- Note that questions appear on both sides of the paper.
  If a page is not printed, please inform the supervisor immediately.

**Questions Answered**
Indicate by a cross (×), (e.g. ☒) the numbers of the questions answered.

To be completed by the candidate by marking a cross (×).	1	2	3	4	
To be completed by the examiners:					

1)   (a) Identify the digital encoding method used to encode the information of the signal shown in the answer box and then complete the timing diagram for the rest of the signal.

(15 marks)

ANSWER IN THIS BOX

| 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 |
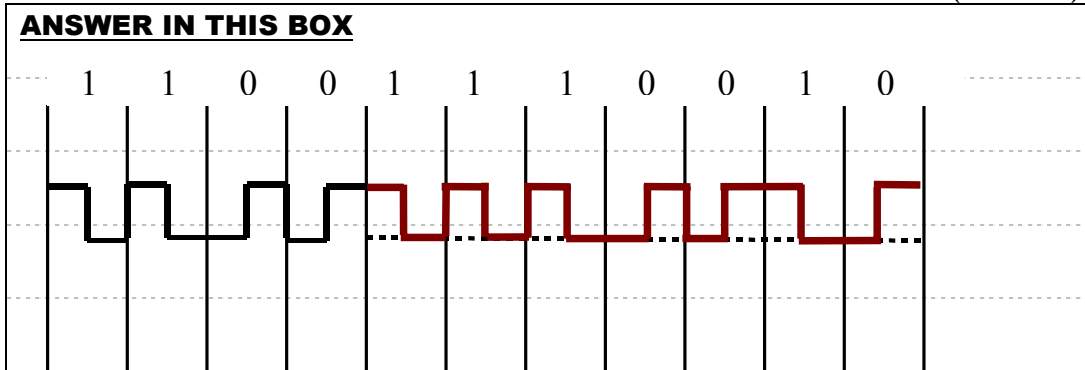
(b) With respect to data communications, state whether the following statements in the answer box are true or false.

(10 marks)

ANSWER IN THIS BOX

	STATEMENTS	TRUE	FALSE
(i)	The term "baud rate" is used to specify the rate at which the number of frequency components change in a digital signal.		√
(ii)	A digital signal can be regenerated into its exact original shape by summing up all the Fourier components of that signal.	√	
(iii)	The exact step-wise shape of a digital signal is essential to be maintained at the receiver in order to decode it correctly since the information about the shape of the digital signal is encoded in the signal.		√
(iv)	When the bit rate of a fixed baud rate digital signal is increased, the signal occupies a wider bandwidth.		√
(v)	Using the Nyquist theorem, it can be proved that a noise free 3000Hz channel cannot transmit binary signals above the rate of 6000 bps.	√	
(vi)	Quadratic Amplitude Modulation (QAM) can be used to generate a 9600 bps signal from a 1200 baud signal.		√
(vii)	In its typical usage, an Unshielded Twisted Pair (UTP) cable can carry a digital signal over a maximum distance of 200 meters.		√
(viii)	The skin effect due to current propagation on a metal wire increases the bandwidth of the wire since it reduces the effective cross section area of the wire.		√
(ix)	In fibre optic cables, the material used for the core and the cladding have different refractive indices.	√	
(x)	Electromagnetic interference can produce only a minimal effect on the signals transmitted via fibre optic cables.	√	

(c) The minimum and the maximum frequency limits of a voice grade telephone line are 300Hz and 3300Hz respectively. The Signal-to-Noise ratio of the line is 35dB. Clearly indicating all the steps, calculate the theoretically highest bit rate possible on this telephone line.

(10 marks)

ANSWER IN THIS BOX

$$C = B \log_2 (1 + S/N)$$

where **C is the highest bit rate in bps,**

B is the bandwidth of the channel and

S/N is the Signal-to-Noise ratio.

Thus, $10 \log_{10}(S/N) = 35$ **dB.**

i.e. $\log_{10}(S/N) = 3.5$

i.e. $(S/N) = 10^{3.5}$

Therefore **S/N = 3162**

Therefore $C = 3000 \log_2 (3163)$

i.e. **C = 3000 x 11.62 = 34860 bps**

(d) The table in the answer box is meant to summarize the characteristics of some widely used transmission media.

Fill the table in the most appropriate manner as provided below in respect of each of the columns 2 to 6.
- Column 2 (Cost) with Low, Moderate or High
- Column 3 (Data Rate) with 1-100Mbps, 1 Mbps – 1 Gbps, 10Mbps – 2 Gbps, or 1 Mbps – 10 Gbps
- Column 4 (Attenuation) with High, moderate, Low, or Variable
- Column 5 (Electro Magnetic Interference) with High , Moderate or Low
- Column 6 (Security) with Low, Moderate or High

(05 marks)

ANSWER IN THIS BOX

(1) Medium	(2) Cost	(3) Data Rate	(4) Attenuation	(5) Electro Magnetic Interference	(6) Security
UTP cable	Low	1-100 Mbps	High	High	Low
Microwave link	High	1 Mbps – 10Gbps	Variable	High	Moderate
Optical Fibre cable	High	10Mbps – 2Gbps	Low	Low	High
Coaxial cable	Moderate	1Mbps – 1 Gbps	Moderate	Moderate	Low

2)   (a) Although TCP is a stream-oriented protocol, it is sometimes important for the host program at
           one end of a connection to send data "out of band" without waiting for the host program at the
           other end of the connection to consume octets already in the stream.

      (i) State a network application where such "out of band" signalling needs to be used.

      (03 marks)

ANSWER IN THIS BOX
When TCP is used for a remote login session, the user may decide to send a keyboard sequence that interrupts or aborts the program at the other end. Out of band signals are most often needed when a program on the remote machine fails to operate correctly.

      (ii) Explain in detail, how TCP accommodates "out of band" signalling.

      (04 marks)

ANSWER IN THIS BOX
To accommodate out of band signaling, TCP allows the sender to specify data as "urgent". The mechanism used to mark urgent data when transmitting it in a segment consists of the "URG" code bit and the "URGENT POINTER" field. When the URG bit is set, the URGENT POINTER specifies the position in the window where urgent data ends.

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(b)   A simple Stop-and-Wait acknowledgement protocol wastes a substantial amount of network bandwidth because it must delay sending a new packet until it receives an acknowledgement for the previous packet.

(i) Explain how the "sliding window protocol" can be used to enhance the network bandwidth as a solution to the above problem.

(04 marks)

ANSWER IN THIS BOX

Sliding window protocols use network bandwidth better because they allow the sender to transmit multiple packets before waiting for an acknowledgement. The protocol places a small window on the sequence and transmits all packets which lie inside the window. Once the sender receives an acknowledgement for a packet inside the window, it slides the window along and sends the next packet. The window continues to slide as long as acknowledgements are received.

(ii) What are the factors on which the performance of a "sliding window protocol" depends?

(02 marks)

ANSWER IN THIS BOX

The performance of a sliding window protocol depends on the window size and the speed at which the network accepts packets.

(c) Assume that a full block of IP addresses (from 192.168.100.0 to 192.168.100.255) is given to a computer network administrator. The network administrator needs to subnet the above IP block into three (3) subnets with Subnet-1 having 50 hosts, Subnet-2 having 30 hosts and Subnet-3 having 20 hosts.

(i) What is the subnet mask that can be used by the network administrator?

(03 marks)

> **ANSWER IN THIS BOX**
>
> **Here we have to assume that all zero and all one subnets can be used as well.**
>
> **Then the subnet mask is 255.255.255.192**

(ii) What is the maximum number of hosts supported by each such subnet?

(03 marks)

> **ANSWER IN THIS BOX**
>
> **Each subnet can have maximum of 62 hosts.**

(d) There are a number of static routing algorithms of which "shortest path routing" is an example. Here it builds a graph of the subnet, with each node of the graph representing a router and each arc of the graph representing a communication link.

(i) State five (5) metrics on which the weight of the arcs can be computed for the "shortest path routing" algorithm.

(05 marks)

> **ANSWER IN THIS BOX**
>
> **The labels on the arcs could be computed as a function of the distance, bandwidth, average traffic, communication cost, mean queue length and measured delay.**

(ii) State two (2) more examples of static routing algorithms other than the one stated in (d).

(02 marks)

> **ANSWER IN THIS BOX**
>
> **Another two static routing algorithms are "flooding" and "flow-based" routing.**

(e) State two (2) advantages of ADSL over PSTN as approaches for local access.

(04 marks)

> **ANSWER IN THIS BOX**
>
> **(Any two of the following)**
>
> **ADSL has two different data rates, one for incoming and another for outgoing connections.**
>
> **ADSL allows the use of Megabit speed data rates unlike the standard PSTN links.**
>
> **ADSL does not need any special cabling infrastructure. The same domestic PSTN connection can be shared for normal telephony as well as for an ADSL connection.**

3)   (a) Use the most suitable words from the following list and fill in the blanks in the paragraph below.

(a) Transport	(g) electrical and mechanical	(m) Application
(b) IP	(h) error detection and correction	(n) TCP
(c) File Transfer	(i) open systems	(o) Presentation
(d) IEEE	(j) Session layer	(p) upper
(e) lower	(k) point-to-point	(q) Data Link
(f) ISO	(l) end-to-end	(r) Network

Through the OSI model, __(i)__ introduced layered architecture into network design. It is known as the OSI reference model because it deals with the interconnection of __(ii)__ . This model has seven layers to which the different functions of the network architecture have been assigned. The __(iii)__ specifications of the communication links are defined in the Physical Layer of the model. It is up to the __(iv)__ layer to ensure an error free connection to the __(v)__ layers. The establishment of an __(vi)__ connection is handled by the __(vii)__ layer. The mechanism needed to rout the data packets is implemented according to the definitions in the __(viii)__ layer. The well known two protocols in the Internet, __(ix)__ and __(x)__ are the protocols corresponding to the __(xi)__ layer and the __(xii)__ layer respectively of the OSI model. The job of managing the abstract data structures and converting from the representation used inside the computer to the network standard representation is handled by the __(xiii)__ layer. One of the examples for an __(xiv)__ layer function is the __(xv)__ protocol.

(07 ½ marks)

ANSWER IN THIS BOX					
(i)	**f**	(ii)	**i**	(iii)	**g**
(iv)	**q**	(v)	**p**	(vi)	**l**
(vii)	**a**	(viii)	**r**	(ix)	**n**
(x)	**b**	(xi)	**a**	(xii)	**r**
(xiii)	**o**	(xiv)	**m**	(xv)	**c**

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(b) Consider the three columns in the answer box. In respect of each item in column 1, select the appropriate item from column 3 and write down in column 2 the corresponding Roman numeral.

(05 marks)

ANSWER IN THIS BOX

Column 1	Column 2	Column 3
1. 10Base T	v	i) Manageable Switch
2. CSMA/CD	vi	ii) Ethernet frame
3. IEEE 802.5	viii	iii) Layer 3 Switch
4. Coaxial cable	ix	iv) Hub
5. VLAN	iii	v) UTP cables
6. WLAN	x	vi) Ethernet
7. ICMP	i	vii) Physical address mapping
8. Source Address	ii	viii) Token Ring
9. Star Topology	iv	ix) BNC Connector
10. ARP	vii	x) IEEE 802.11

(c) CSMA/CD is the media access control mechanism used in Ethernet. With respect to CSMA/CD, give a brief description on each of the following.

(06 marks)

ANSWER IN THIS BOX

(i) Carrier Sense	**Before an Ethernet device sends a frame on the Ethernet cable, it listens to find if another device is already transmitting a frame.**

Continued…

(ii) Multiple Access	Once a device finds that other devices are not transmitting any frame, it starts transmitting the frame. If two devices detect that the Ethernet cable is free at the same time, then both will start transmitting the frames. This will result in a collision.
(iii) Collision Detect	The Ethernet devices while transmitting the frames, also listen for the collision.

(d) If a collision is detected, what are the steps taken by each Ethernet access controller?

(02 ½ marks)

ANSWER IN THIS BOX

If an Ethernet access controller detects a collision, both the devices stop sending the frame (back off).

Then they retry the transmission after a random time-out period. This process is repeated till the frame is transmitted successfully, for a maximum of 16 times. The frame is discarded after the 16th retry.

(e) Given the minimum size of an Ethernet frame as 72 bytes and the speed of electromagnetic propagation in thick coaxial cable as 60 percent of the speed of light (3×10^8 meters/sec), calculate the maximum cable length for the 10mbps Ethernet collision domain.

(06 marks)

ANSWER IN THIS BOX

The minimum size of the Ethernet frame is 72 bytes.

To send 576 bits in 10Base 5, it takes (576 bits / 10Mbps) = 57.6 microseconds.

Before the last bit is sent, the first bit must have reached the last node and if there is a collision, it must be sensed by the sender during this time. That means, the round trip time is 57.6 micro seconds.

The speed of propagation = 3×10^8 x (60 / 100) meters/sec

$$= 180 \times 10^6 \text{ meters/sec}$$

Therefore the maximum cable length

$$= (57.6/2) \times 10^{-6} \times 180 \times 10^6 \text{ meters}$$

$$= 180 \times 57.6 / 2 \text{ meters}$$

$$= 5184 \text{ meters}$$

(f) Suppose there is heavy traffic on a CSMA/CD LAN as well as on a Token Ring LAN. A station on which of these systems is more likely to wait longer to send a frame? Why?

(03 marks)

ANSWER IN THIS BOX

A station on CSMA/CD LAN may have to wait longer to send a frame because, in the CSMA/CD LAN, the stations compete with each other causing collisions resulting in longer retransmissions and delays. Token passing is a collision avoidance method and every station gets an equal opportunity in gaining access.

4) (a) State three (3) major design goals of the synchronous optical network (SONET) technology?

(03 marks)

ANSWER IN THIS BOX

Three major design goals of SONET technology are:

To make it possible for different carriers to work together

To provide a way to connect multiple digital channels together

To provide support for operations, administration and maintenance.

(b) The authenticity of many legal, financial and other documents is determined by the presence or absence of an official handwritten signature. For computerized message systems, an alternative solution must be found to implement authenticity.

(i) Explain how digital signatures can be used as a solution to this problem.

(05 marks)

ANSWER IN THIS BOX

Let us assume the following:

D(.) – Decrypt key (Private key)

E(.) – Encrypt Key (Public key)

P – Plain text

E(D(P))=D(E(P))=P

Mr. A can send a signed plain text message P, to Ms. B by transmitting

$E_B(D_A(P))$**. Note that Mr. A knows his own private key D_A, as well as**

Ms. B's public key, E_B.

When Ms. B receives the encrypted message, she transforms it using

her private key yielding $D_A(P)$. She then decrypts it using the public key

of Mr. A, E_A, to get the original plain text.

(ii) Although using public-key cryptography for digital signatures is an elegant solution, there may be problems which are related to this scheme. State such problems.

(03 marks)

ANSWER IN THIS BOX

- **Problems might arise when one party discloses his secret keys or if one party decides to change keys.**

(c) In an SNMP enabled environment, each node must be capable of running an SNMP management process, called an SNMP agent. When an agent notices that a significant event has occurred, it immediately reports the event to all management stations in its configuration list. This report is called a "SNMP trap". What is meant by "trap directed polling" under this environment?

(05 marks)

ANSWER IN THIS BOX

Because communication from managed nodes to the management station is not reliable, it is wise for the management station to poll each managed node occasionally to check for unusual events. The model of polling at long intervals with acceleration on receipt of a trap is called "trap directed polling".

(d) Network administrators prefer to group users on Ethernet LANs to reflect the organizational structure rather than the physical layout of the building for a variety of reasons. The resulting concept is called "Virtual LANs" (VLANs) and has been standardized by the IEEE 802 committee.

(i) State three (3) advantages which can be achieved by employing VLANs.

(03 marks)

ANSWER IN THIS BOX

(Any three of the following)

- **User groups can be defined and isolated, hence security enabled.**
- **Each VLAN is a broadcast domain similar to a sub-network and hence, efficiency increases.**
- **Some user LANs are more heavily used than others and it may be desirable to separate them and hence, load can be balanced.**
- **When users move, a logical re-configuration will help.**

(ii) In a VLAN enabled environment, how does an Ethernet switch know from what VLAN an incoming frame is originating?

(05 marks)

ANSWER IN THIS BOX

For this, three methods can be used.

- Each port on the switch/bridge is labeled with a VLAN identification.

- The switch/bridge has a table mapping of the MAC address of each machine connected to it along with the VLAN identification.

- By examining the payload of the frame, the switch can assign a VLAN identification.

(e) What is a "Virtual Private Network" (VPN)? Explain how a VPN can be implemented over the Internet.

(06 marks)

ANSWER IN THIS BOX

A network built up from organizational computers and leased lines is called a private network. However, when we overlay such a network on top of a public network (such as the Internet) with most of the properties of a private network, it is called a virtual private network. Here, they are called "virtual" because it creates a virtual circuit and not a real circuit.

A common design is to equip each end station with a firewall and create tunnels through the Internet between the two ends. For tunnelling, we can employ IPSec to aggregate all traffic between the two ends. IPSec will provide the security aspects of the channel between the two ends.

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