Name……..…ID……..……..Section…….……Seat No……..….

Sirindhorn International Institute of Technology
Thammasat University

Final Examination: Semester 1/2007

Course Title : ITS 323 – Introduction to Data Communications

Instructor : Dr Steven Gordon

Date/Time : Thursday 11 October 2007, 9:00 – 12:00

Instructions:

- This examination paper has __ pages (including this page).
- Condition of Examination
  Closed book (No dictionary, **Non-programmable calculator allowed**)
- Students are not allowed to be out of the exam room during examination. Going to the restroom may result in score deduction.
- Turn off all communication devices (mobile phone etc.) and leave them under your seat.
- Write your name, student ID, section, and seat number clearly on the answer sheet.
- The space on the back of each page can be used if necessary.
- Unless stated in the question, you can assume the speed of transmission is 3×10^8m/s
- Unless stated in the question, give IP addresses in dotted decimal notation.

Part A - Multiple Choice Questions [30 marks]

Select the most accurate answer (only select one answer). Each correct answer is worth 2 marks.

1. Packets in one TCP connection can be distinguished from packets in another TCP connection by:
   a) Source port, destination port, protocol number
   b) Source IP address, destination IP address, protocol number
   c) **Source port, destination port, source IP address, destination IP address**
   d) Source IP address, destination IP address
   e) Source port, destination port
   f) Protocol number

2. The Address Resolution Protocol maps addresses between which layers?
   a) Application layer to Transport layer
   b) Transport layer to Network layer
   c) Network layer to Data link layer
   d) Application layer to Network layer
   e) Transport layer to Data link layer

3. According to the free-space propagation model, increasing the size of the transmit antenna (while maintaining all other parameters at the transmitter) will:
   a) Reduce the gain of the transmit antenna
   b) Reduce the gain of the receive antenna
   c) Reduce the distance that can be transmitted
   d) Increase the received power
   e) Increase the power lost between transmitter and receiver
   f) Increase the frequency used in transmission

4. Which protocol provides flow control, error control and connection management?
   a) IP
   b) HTTP
   c) TCP
   d) DNS
   e) UDP
   f) ARQ

5. A transmission system that provides half-duplex communications between A and B:
   a) Only allows A to send to B
   b) Only allows B to send to A
   c) If A is sending to B, then B cannot send to A at the same time
   d) If A is sending to B, then B can send to A at the same time
   e) Allows both A and B to transmit to each at the same time

6. A web browser, such as Firefox or Internet Explorer, normally implements:
   a) TCP and HTTP
   b) TCP and IP
   c) HTTP
   d) ARP
   e) IP
   f) TCP

7. A switch-based LAN is more efficient than a hub-based LAN because:
   a) A switch can connect two different LANs together
   b) A switch uses contention-based MAC protocols
   c) A switch allows multiple computers to send at the same time
   d) A switch is easier to implement than a hub.
   e) A hub uses reservation-based MAC protocols

8. An implementation of TCP receives a 1000 byte message from an application protocol. TCP sends the data as 5 separate segments. Which of the following is always true?
   a) Each segment will contain the same source port number
   b) Each segment must be the same size
   c) Each segment can be sent immediately after the previous is sent
   d) A separate acknowledgement will be received for each segment
   e) A segment can only be sent after an acknowledgement for the previous segment has been received

9. Computer A uses single-bit odd-parity to transmit 7-bits of data to B – the following bits are received by computer B: 01010110. What does computer B know?
   a) The original data sent was 1010110
   b) The received bits contain an error
   c) The bits sent were 01010110
   d) The bits sent were 11010110
   e) The received data is correct

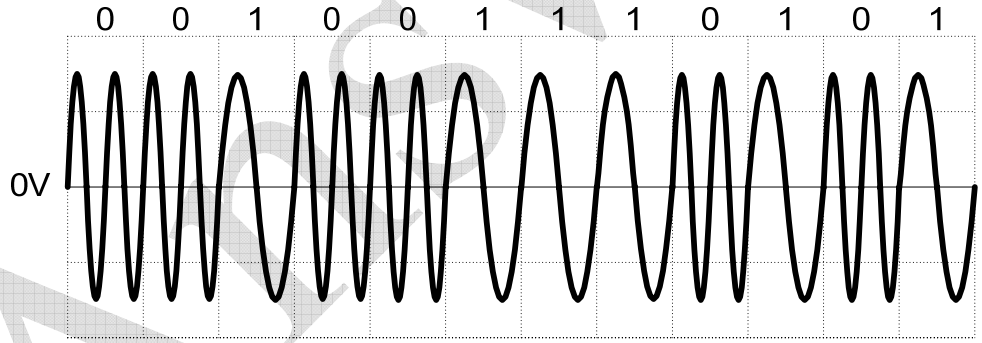
10. Which switching network technology does not require a connection to be setup?
    a) ATM
    b) IP
    c) Frame Relay
    d) X.25
    e) Telephone network

11. If a transmission system uses 16 voltage levels to transmit a digital signal, then how many bits does each signal level represent?
    a) 1
    b) 2
    c) 3
    d) 4
    e) 8
    f) 16

12. An application sends 100 byte messages in order to keep packet delay low. The protocol stack introduces 50 bytes of overhead (e.g. headers) per message. Assume that messages are not broken into smaller segments, and no other overheads are present. What throughput can be achieved on a 100Mb/s Fast Ethernet link?
    a) 100 Mb/s
    b) 10 Mb/s
    c) 50 Mb/s
    d) 75 Mb/s
    e) 150 Mb/s
    f) 66Mb/s
    g) 33 Mb/s

13. What is the bandwidth of a signal that can be decomposed into four sine waves with frequencies at 30, 80, 180, and 280 MHz?
    a) 4 MHz
    b) 30 MHz
    c) 140 MHz
    d) 250 MHz
    e) 280 MHz
    f) 560 MHz

14. The bit sequence below is encoded with the analog signal. This is an example of:



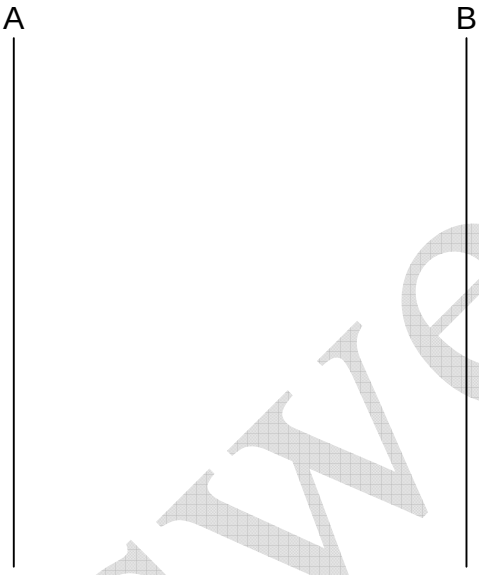
    a) ASK
    b) FSK
    c) PSK
    d) FM
    e) NRZ-I
    f) FEC

15. SMTP is most commonly used for:
    a) Managing devices (such as routers and switches) on a network
    b) Sending emails from an email client to an email server
    c) Retrieving emails from an email server to an email client
    d) Mapping IP addresses to hardware addresses
    e) None of the above

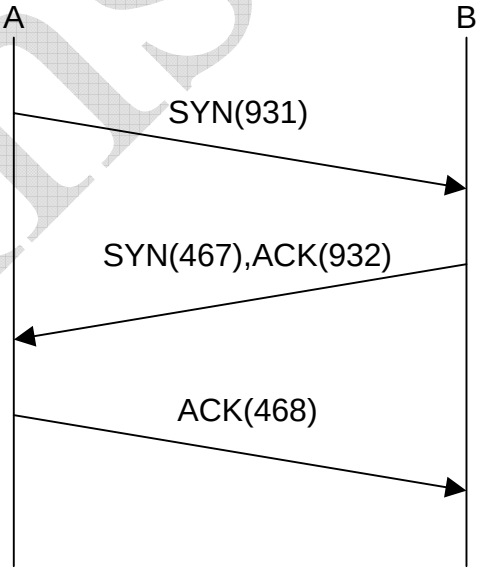
Part B – Short Questions [19 marks]

Question 1 [3 marks]

a) Draw a diagram to illustrate the TCP connection setup process between A and B. You must include the segment types as well as any other important information carried in the segments. Assume A chooses an initial sequence number of 931, and B chooses 467. [2 marks]



Answer



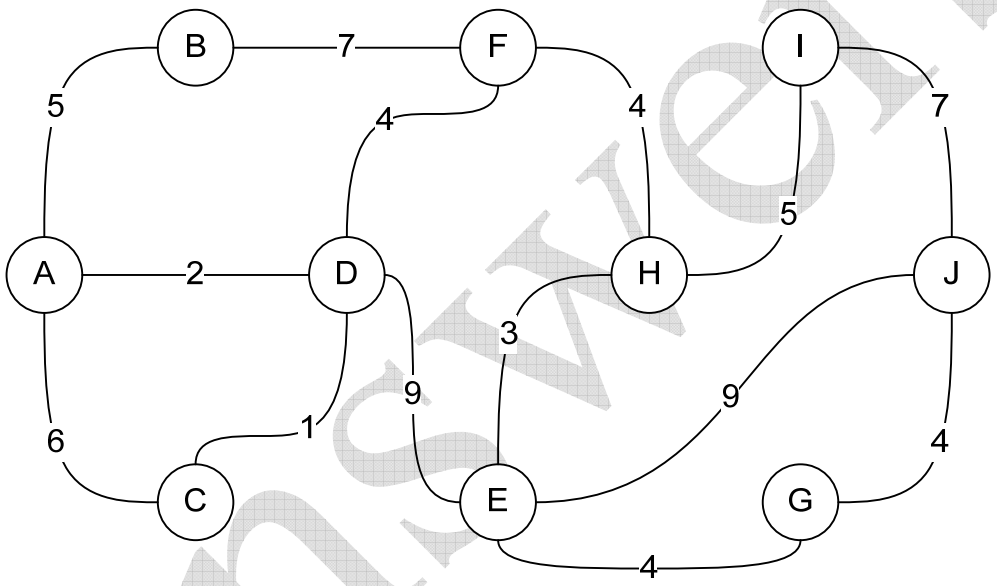
b) After the connection is setup, if the first data sent from B to A is a segment containing 1500 bytes of data, then what is the acknowledgement number sent from A to B in response? [1 mark]

Answer

1968. The sequence number for the first byte of data is 468, and hence the last byte is 1967. The ACK contains the next byte expected.

Question 2 [3 marks]

Consider the network below. For each link, the delay, in milliseconds, is shown. Assume the links are bi-directional, and the costs are identical in both directions.



a) What is the least cost path from A to J if the metric is number of hops? [0.5 mark]

Path: _____

b) What is the least cost path from A to J if the metric is delay? [0.5 mark]

Path: _____

c) If flooding is used (instead of least-cost routing), and node A sends a packet to J, and that packet has an initial TTL = 2, then explain what happens. [2 marks]

Answer

a. From A to J, the minimum number of hops is 3: path A – D – E - J
b. The minimum delay is 19millisends, A – D – E – G – J
c. A sends to its neighbours (B, D and C) which decrement the TTL to 1 and send to their neighbours (F, E, D). They decrement the TTL to 0 and determine the packet cannot be forwarded (TTL=0) and the packet is dropped. The packet does not reach the destination, J.

Question 3 [4 marks]

a) Explain the difference between FDM and TDM [2 marks]

Answer

Frequency Division Multiplexing allocates each user a separate frequency, and all transmit at the same time.

Time Division Multiplexing allocates each user a time slot, and all users transmit on the same frequency, but at different times.

b) Explain the difference between Synchronous TDM and Asynchronous (or Statistical) TDM. [2 marks]

Answer

Synchronous TDM allocates time slots to users in an ordered manner, independent of whether a user currently has data to transmit.

Statistical TDM allocates time slots to users on demand, meaning if a user has nothing to transmit, a time slot can be given to another user (who has data to transmit).

Question 4 [3 marks]

Complete Table 1 for classful IP addresses.

IP address	171.18.32.4	200.171.16.228
Class		
Network address		
Broadcast address		
Number of Hosts		
Number of Networks		

Table 1

Answers

IP address	171.18.32.4	200.171.16.228
Class	B	C
Network address	171.18.0.0	200.171.16.0
Broadcast address	171.18.255.255	200.171.16.255
Number of Hosts	65534	254
Number of Networks	16384	2097152

Question 5 [4.5 marks]

Complete Table 2 for classless IP addresses.

IP address	101.86.32.32	101.86.32.32	200.171.16.228
Subnet mask (dotted decimal)		252.0.0.0	
Subnet mask (short "/" notation)	/15		
Network address			
Broadcast address			
Number of Hosts			126

Table 2

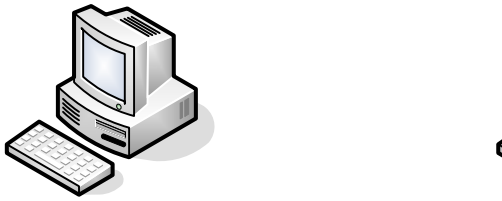
Answers

IP address	101.86.32.32	101.86.32.32	200.171.16.228
Subnet mask (dotted decimal)	255.254.0.0	252.0.0.0	255.255.255.128
Subnet mask (short "/" notation)	/15	/6	/25
Network address	101.86.0.0	100.0.0.0	200.171.16.128
Broadcast address	101.87.255.255	103.255.255.255	200.171.16.255
Number of Hosts	131070	67108862	126

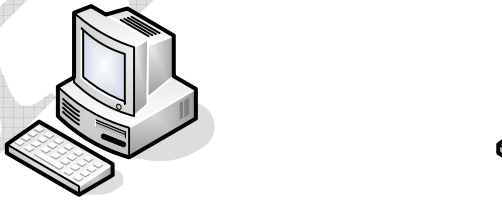
Question 6 [1.5 marks]

Draw the following three LAN topologies to connect the four computers.

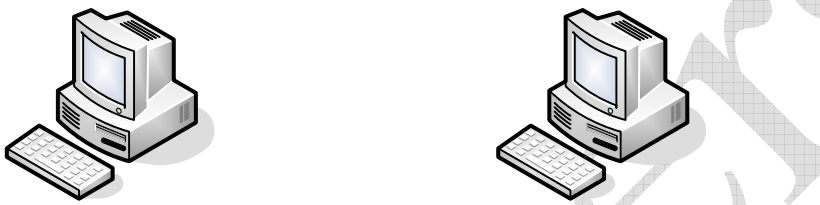
a) Ring [0.5 mark]



b) Hub [0.5 mark]

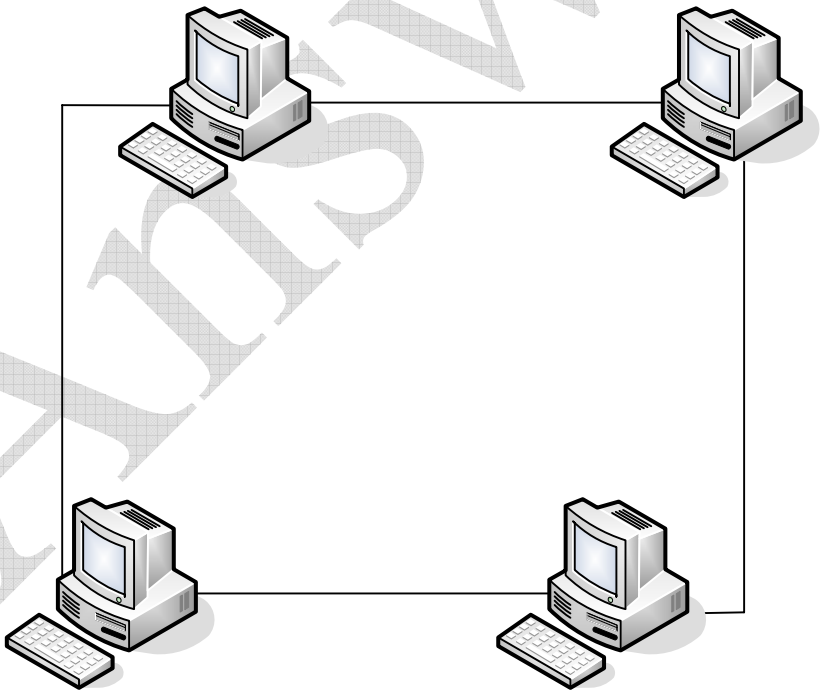


c) Bus [0.5 mark]

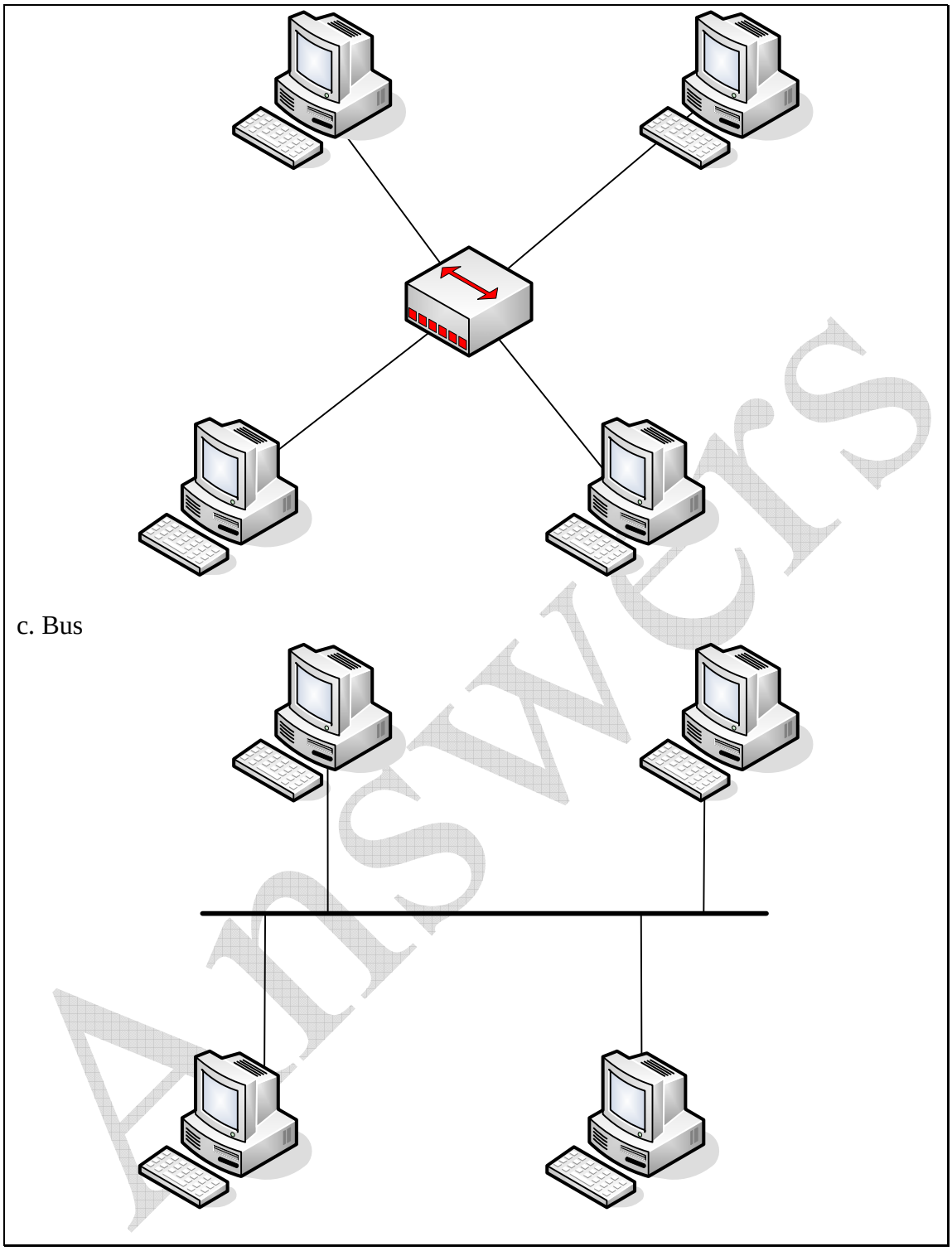


Answers

a. Ring



b. Hub



c. Bus

Part C – General Questions [53 marks]

Question 7 [24 marks]

Consider the internet in Figure 1. It shows a number of computers, servers and routers connected to networks.

The number inside the network shows the number of milliseconds delay for communicating between one node on that network to another node on that network. For example, it takes 1ms for Router A to send a packet to the SIIT Web Server. Ignore all other delays (such as processing times).

The current cache at each DNS server is shown. Assume the other nodes (such as Host A) have no DNS cache. Also shown below the DNS cache is the IP address of other DNS servers that this server knows about.

The list of files on the SIIT Web Server are shown.

A user on Host A types the following URL into their web browser:
http://www.siit.tu.ac.th/graduate.html

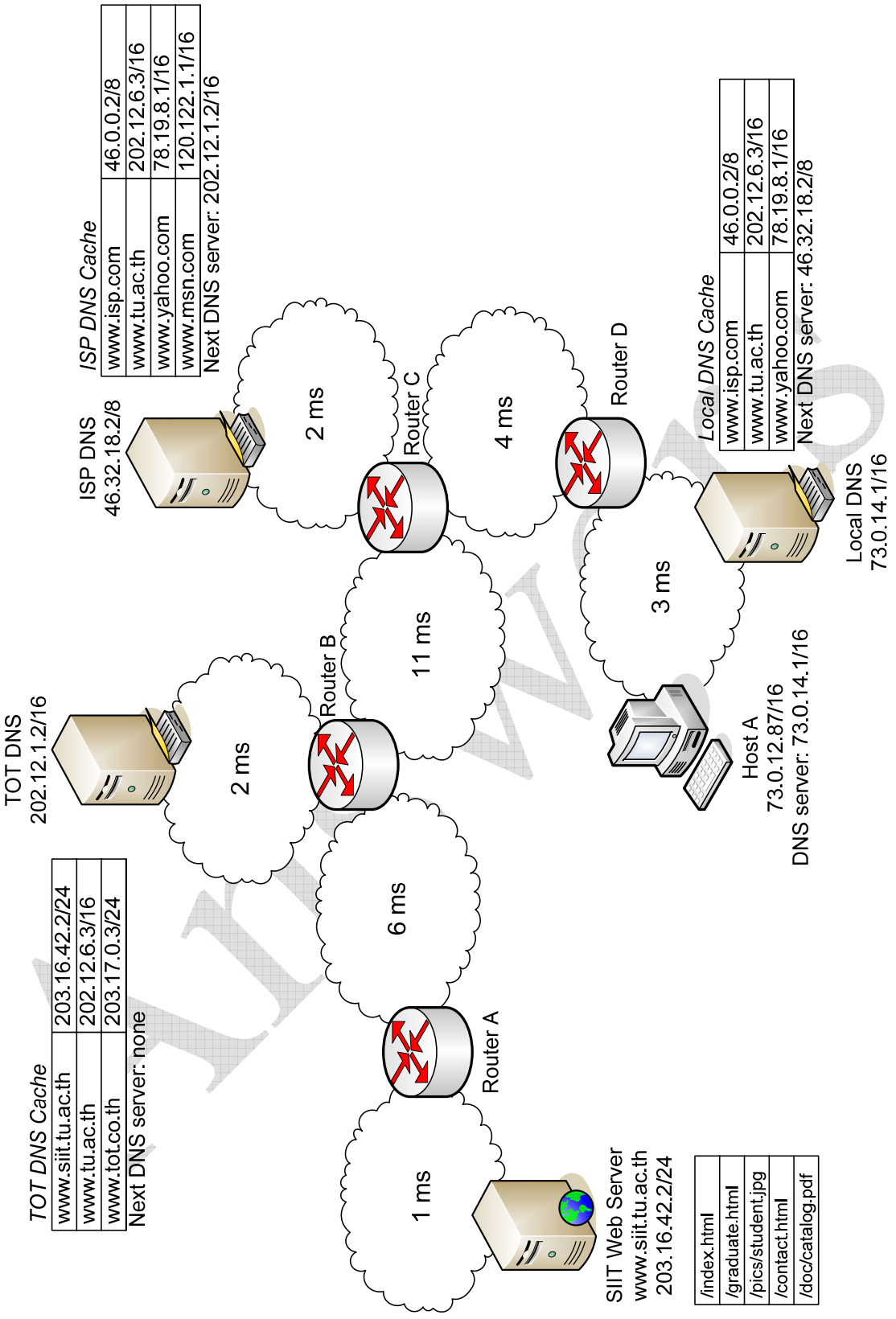

TOT DNS
202.12.1.2/16
TOT DNS Cache
www.siit.tu.ac.th 203.16.42.2/24
www.tu.ac.th 202.12.6.3/16
www.tot.co.th 203.17.0.3/24
Next DNS server: none
ISP DNS
46.32.18.2/8
ISP DNS Cache
www.isp.com 46.0.0.2/8
www.tu.ac.th 202.12.6.3/16
www.yahoo.com 78.19.8.1/16
www.msn.com 120.122.1.1/16
Next DNS server: 202.12.1.2/16
Router A
Router B
Router C
Router D
1 ms
2 ms
6 ms
2 ms
11 ms
4 ms
3 ms
SIIT Web Server
www.siit.tu.ac.th
203.16.42.2/24
/index.html
/graduate.html
/pics/student.jpg
/contact.html
/doc/catalog.pdf
Host A
73.0.12.87/16
DNS server: 73.0.14.1/16
Local DNS
73.0.14.1/16
Local DNS Cache
www.isp.com 46.0.0.2/8
www.tu.ac.th 202.12.6.3/16
www.yahoo.com 78.19.8.1/16
Next DNS server: 46.32.18.2/8

Figure 1

a) Show how Host A uses DNS to discover the IP address of the SIIT Web Server by drawing on Figure 1 where the DNS messages are sent. Your drawing should consist of arrows, and numbers next to each arrow to indicate the ordering of messages. You *do not* have to describe the content of the messages – just draw and label the arrows. [3 marks]

Answer
Arrows should go from:
- Host A to Local DNS
- Local DNS to ISP DNS
- ISP DNS to TOT DNS
- TOT DNS to ISP DNS
- ISP DNS to Local DNS
- Local DNS to Host A

b) For the ISP DNS server, list the DNS messages that it receives, explain the meaning of the content of each message, and explain what ISP DNS does in response to each message. Refer to the numbered arrows from part (a). [6 marks]

Answer

The ISP DNS receives a DNS query from Local DNS. This message means "what is the IP address for domain www.siit.tu.ac.th?". After receiving it, ISP DNS checks in its cache for the domain, realizes it does not know the corresponding IP address, and so forwards the query to its next DNS server, TOT DNS.

The ISP DNS receives DNS response from TOT DNS. This message means "the IP address for domain www.siit.tu.ac.th is 203.16.42.2". After receiving it, ISP DNS adds this information to its DNS cache and sends the response to Local DNS (where it received the original query from).

c) From when the user on Host A enters the URL, how long does it take for Host A to know the IP address of the SIIT Web Server? [3 marks]

Answer

Time from:
- Host A to Local DNS: 3ms
- Local DNS to ISP DNS: 9ms
- ISP DNS to TOT DNS: 15ms
- TOT DNS to ISP DNS: 15ms
- ISP DNS to Local DNS: 9ms
- Local DNS to Host A: 3ms

TOTAL TIME: 54ms

After DNS was used, Host A now has the IP address of the web server.

d) What application protocol is used to retrieve the requested web page? Give the full name (not just the acronym) [1 mark]

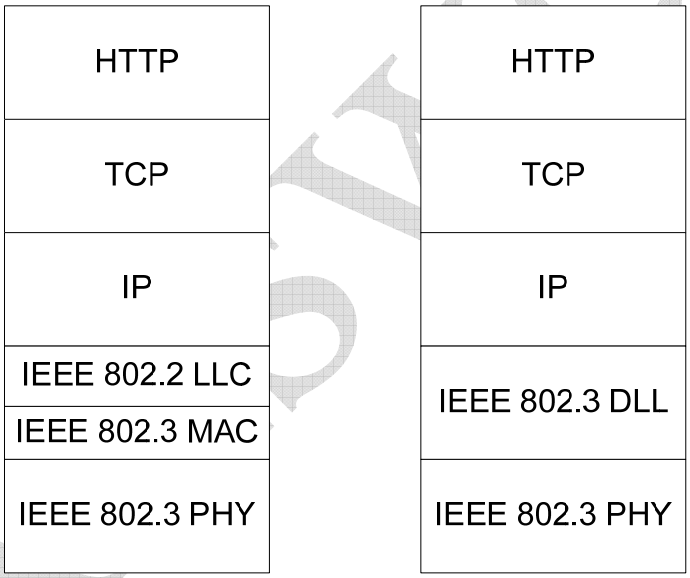
Answer

HTTP – HyperText Transfer Protocol

e) Draw a protocol stack for the SIIT Web Server, assuming IEEE 802.3 Ethernet is used on the LAN that the server is connected to. You must indicate the protocols used at each layer (protocol acronyms are acceptable). Hint: Ethernet covers more than one layer – you must clearly show and name these different layers. [3 marks]

Answer

Although the first stack below is the best, the other is also acceptable.



f) Draw a protocol stack for Router A, assuming Ethernet is also used on the network connecting Router A to Router B. [3 marks]

Answer

As with the previous part, it is acceptable to show DLL instead of both LLC and MAC.

IP	
IEEE 802.2 LLC	IEEE 802.2 LLC
IEEE 802.3 MAC	IEEE 802.3 MAC
IEEE 802.3 PHY	IEEE 802.3 PHY

g) From when the user on Host A enters the URL, how long does it take for the requested web page to be displayed on the web browser? Hint: include the time for DNS, as well as the web page transfer. [2 marks]

Answer

Time for DNS (from part c.): 54ms

Time from:
- Host A to Router D: 3ms
- Router D to Router C: 4ms
- Router C to Router B: 11ms
- Router B to Router A: 6ms
- Router A to Web Server: 1ms

Request: 25ms
Response: 25ms

Total: 104ms

h) If, while browsing the page http://www.siit.tu.ac.th/graduate.html, the user on Host A clicks on a link to http://www.siit.tu.ac.th/contact.html, how long does it take for the requested web page to be displayed on the web browser? Explain your answer [3 marks]

Answer

The HTTP request/response will take the same time as previously calculated: 50ms. However DNS will be different. Two reasonable explanations (and answers) are

1. Host A does not have a DNS cache (this was an initial assumption in the question). The Local DNS will update its cache from the previous request and hence the DNS software on Host A will send a request to Local DNS, which will immediately send a response. The DNS phase takes 6ms. Total time: 56ms

2. Host A does have a DNS cache (this is a reasonable assumption). Hence there is no time to obtain the IP address. Total time: 50ms.

Question 8 [17 marks]

An application on computer A has 4000 bytes of data to send to an application on computer B. The data is sent using TCP. Answer the questions under the following conditions and assumptions:

1. A and B have already established a TCP connection, and they have both selected an Initial Sequence Number = 0.
2. TCP A has a 5000 byte buffer to hold data received from its application.
3. TCP B has a 3000 byte buffer to hold data received from TCP A.(Note that the buffer only needs to hold the data, not the received TCP header).
4. TCP A sends data in blocks of 1000 bytes. That is, each TCP segment contains 1000 bytes of data, plus a 20 byte TCP header.
5. Initially, TCP A knows that TCP's receive buffer is empty and is 3000 bytes in length.
6. The data rate for transmissions between A and B is 100,000 Bytes/sec.
7. The propagation delay between A and B is 10ms. There are no queuing or processing delays.
8. TCP immediately sends an acknowledgement for every DATA segment it receives. ACKs do not carry any data.
9. There are no errors in transmission.

The application on computer A writes 4000 bytes of data to the transmit buffer for TCP A at time 0. The application on computer B reads 2000 bytes of data from the receive buffer for TCP B at time 60ms, and again reads another 2000 bytes at time 100ms.

a) What is the transmission time of a TCP segment carrying data? [1 mark]

Answer

Transmission time = size / rate
DATA segment contains 1000 bytes of data plus a 20 byte header, sent at 100,000 bytes/sec. Transmission time is 10.2ms.

b) What is the transmission time of a TCP ACK segment? [1 mark]

Answer

ACK segment contains only the TCP header (20 bytes). Transmission time is 0.2ms.

c) Complete the diagram in Figure 2 showing:
   - The TCP segments sent between A and B, indicating their approximate transmission time as boxes and propagation time as arrows. As an example, the transmission time and propagation are shown for the first DATA segment.
   - The sequence and acknowledgement numbers carried in each TCP segment

- Any information the TCP segments which is used for flow control (e.g. window size).

Your diagram does not have to be to scale (although for answering subsequent parts of this question it will be easier if it is close to scale). The dotted lines represent 10ms intervals. [8 marks]

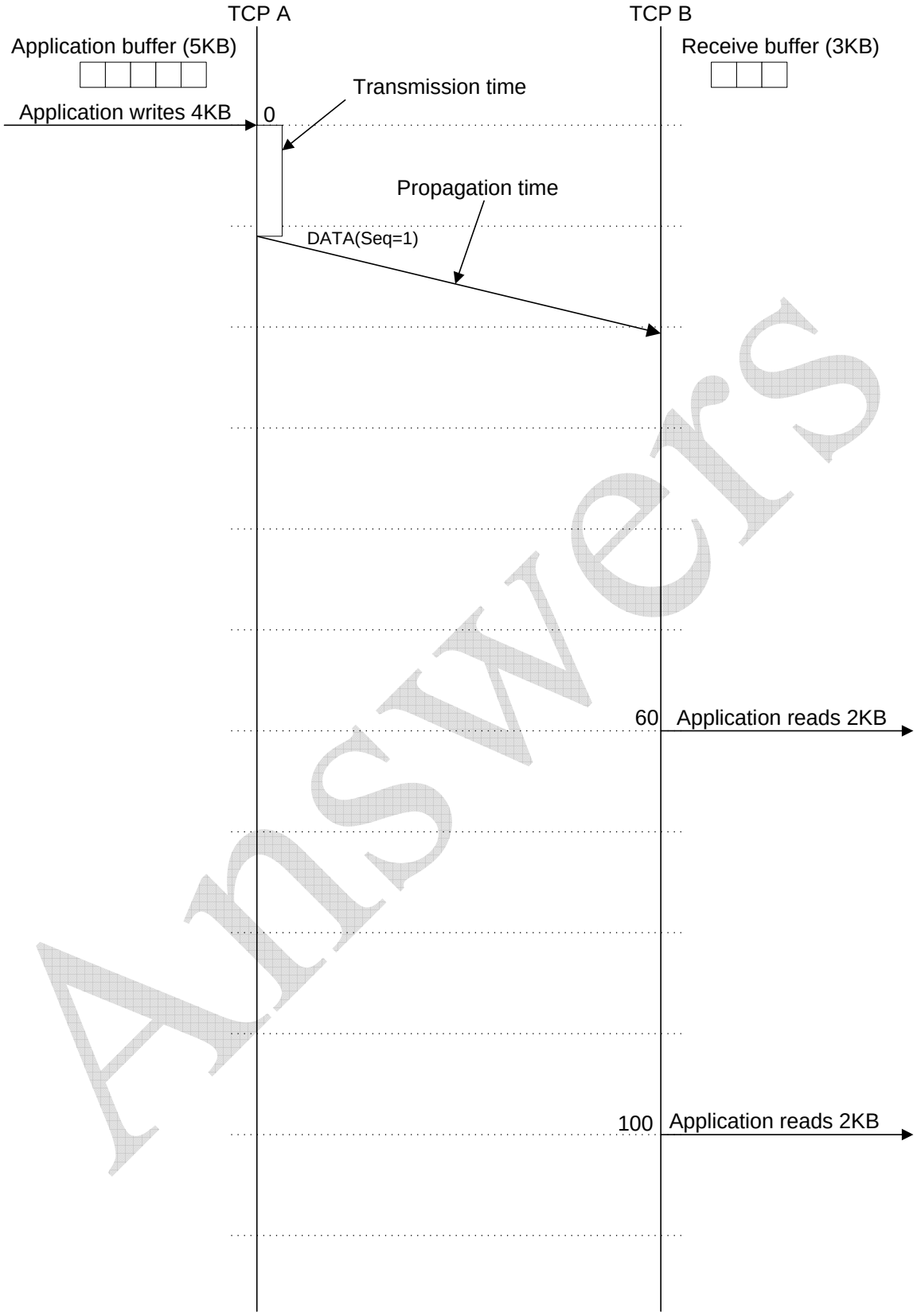
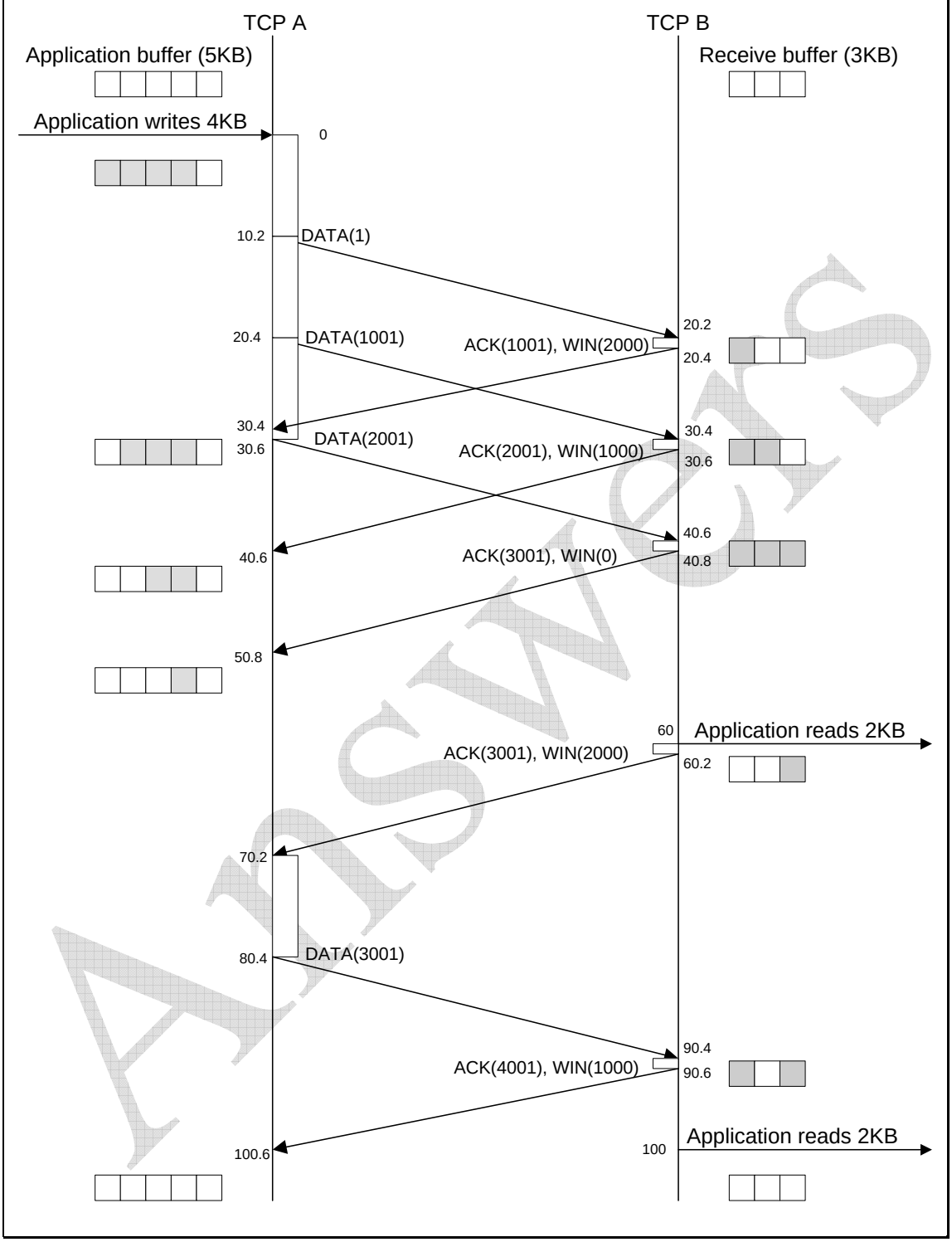


Figure 2

Answer



d) For the third ACK transmitted by TCP B:
   a. What time does the transmission of the ACK start? [0.5 mark]
   b. What acknowledgement number does the ACK carry? [0.5 mark]
   c. What value for flow control does the ACK carry? [0.5 mark]

Answers

a. 40.6ms
b. 3001
c. 0

e) For the ACK transmitted by TCP B in response to the last DATA segment sent by A:
    a. What time does TCP A receive the entire ACK? [0.5 mark]
    b. What value for flow control does the ACK carry? [0.5 mark]
    c. What does the flow control value from part b. above mean to TCP A? [0.5 mark]

Answers

a. 100.6ms
b. 1000
c. TCP A is only allowed to send 1000 bytes.

f) For TCP A:
    a. What is the total time from when the first byte is sent, until the last DATA segment is acknowledged? [1 mark]
    b. What is the throughput? [1 mark]

Answers

a. 100.6ms
b. 4000B / 100.6ms = 40,000 bytes/sec

g) If flow control was not used in this question, explain what would happen, including the actions of TCP A and TCP B. [2 marks]

Answer

If flow control was not used, then TCP A would send all 4000 bytes (as 4 segments). After receiving the first 3 segments, TCP B's buffer would be full, and upon receiving the 4^{th} segment, either one of the buffered segments, or the 4^{th} segment must be discarded because there is no space in memory (buffer) to store all 4000 bytes.

Question 9 [12 marks]

Consider the internet shown in Figure 3. The figure shows hosts, Ethernet switches and IP routers. Assume each host has only one IP address, and each router has an IP address for each interface. The router interfaces are labeled (e.g. router A has four interfaces: A1, A2, A3 and A4). There are three networks with hosts in the example internet. Refer to these three networks as:

- Network 1: containing Host 1 and Host 2
- Network 2: containing Host 3 and Host 4
- Network 3: containing Host 5 and Host 6

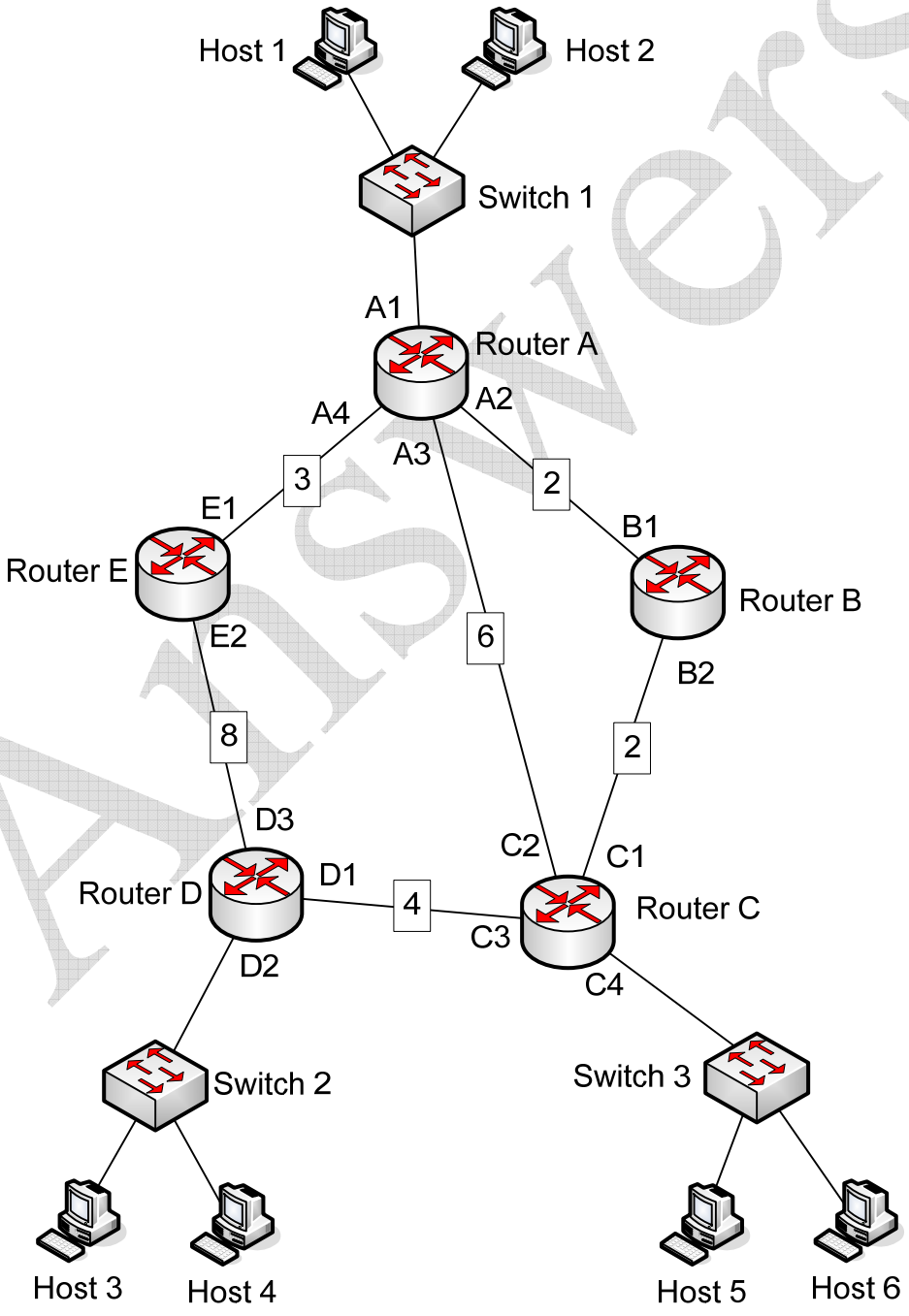


Figure 3

The link costs between routers in the network are shown in boxes on each link.

a) For each router, calculate the least-cost path to each other router. Complete your answer in Table 3, showing the full path and the cost. [5 marks]

	From Router …									
		A		B		C		D		E	
To …	A	-				C-B-A	4				
	B	A-B	2	-							
	C					-					
	D							-			
	E									-	

Table 3

Answer

	From Router …									
		A		B		C		D		E	
To …	A	-		B-A	2	C-B-A	4	D-C-B-A	8	E-A	3
	B	A-B	2	-		C-B	2	D-C-B	6	E-A-B	5
	C	A-B-C	4	B-C	2	-		D-C	4	E-A-B-C	7
	D	A-B-C-D	8	B-C-D	6	C-D	4	-		E-D	8
	E	A-E	3	B-A-E	5	C-B-A-E	7	D-E	8	-	

b) Complete the routing tables for each of the routers. For each of the three destination networks, you must give the interface label (e.g. A1) of the next router in the following tables. Use the word “direct” to indicate a direct connection is available to the destination. [5 marks]

Router A

Destination	Next Router - interface
Network 1	
Network 2	
Network 3	

Router B

Destination	Next Router - interface
Network 1	
Network 2	
Network 3	

Router C

Destination	Next Router - interface
Network 1	
Network 2	
Network 3	

Router D

Destination	Next Router - interface
Network 1	
Network 2	
Network 3	

Router E

Destination	Next Router - interface
Network 1	
Network 2	
Network 3	

Answers

Router A

Destination	Next Router - interface
Network 1	Direct
Network 2	B1
Network 3	B1

Router B

Destination	Next Router - interface
Network 1	A2
Network 2	C1
Network 3	C1

Router C

Destination	Next Router - interface
Network 1	B2
Network 2	D1
Network 3	Direct

Router D

Destination	Next Router - interface
Network 1	C3
Network 2	Direct
Network 3	C3

Router E

Destination	Next Router - interface
Network 1	A4
Network 2	D3
Network 3	A4

c) The above routing tables consider only destination networks that contain hosts. Network management and testing protocols, like SNMP and ICMP, can be used by applications to send IP datagrams to routers (e.g. to configure a router). If a network administrator is using Host 6, and uses SNMP to configure router E, what path do the IP datagrams take? [2 marks]

Answer

From the least-cost paths: Host 6 – Router C – Router B – Router A – Router E. Even though the communication is between host and router, there is no difference in how the routing works compared to host-to-host communication.