

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

# Sirindhorn International Institute of Technology Thammasat University

**Final Exam: Semester 1, 2011**

**Course Title:** ITS323 Introduction to Data Communications

**Instructor:** Steven Gordon

**Date/Time:** Thursday 13 October 2011; 9:00–12:00

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## **Instructions:**

- This examination paper has 21 pages (including this page).
- Conditions of Examination: Closed book; No dictionary; Non-programmable calculator is allowed
- Students are not allowed to be out of the exam room during examination. Going to the restroom may result in score deduction.
- Students are not allowed to have communication devices (e.g. mobile phone) in their possession.
- Write your name, student ID, section, and seat number clearly on the front page of the exam, and on any separate sheets (if they exist).
- Assume bits are ordered from left to right. For example, for the data 00001111, the first (1st) bit is 0 and the last (8th) bit is 1.
- Assume the speed of transmission is  $3 \times 10^8$  m/s
- Reference material included at the end of the exam may be used.

**Question 1** [10 marks]

Consider datagram packet switching being used to send  $n$  packets across a single path with  $h$  hops, where  $n \gg h$ . Each packet has a length of  $l$  bits. Each link has a data rate of  $b$  bits per second. Each link has a propagation delay of  $p$  seconds. Although there is processing delay and queuing delay at each node, they are both so small that you can assume they are both 0.

- (a) Write an equation that gives the total time,  $T_{datagram}$ , it takes from when the source host initiates the data transfer until the destination host has received all of the data. [6 marks]

- (b) If all the conditions above are the same except virtual circuit packet switching was used instead of datagram packet switching, then would the total time,  $T_{virtualcircuit}$ , be greater than  $T_{datagram}$ , less than  $T_{datagram}$ , equal to  $T_{datagram}$  or there is insufficient information to know. Explain your answer. [2 marks]
- (c) Explain an advantage of virtual circuit packet switching compared to datagram packet switching. [2 marks]

**Question 2** [7 marks]

- (a) Draw a diagram to illustrate the TCP connection setup process between client A and server B. For each segment you must indicate appropriate flags and sequence/ack numbers. Assume A chooses an initial sequence number of 399, and B chooses 1034. [3 marks]

- (b) Assume that after the TCP connection setup between A and B above, that A sends 1500 bytes of data in a single segment to B. Then B sends 3000 bytes of data in a single segment to A using piggybacking. Finally A responds with an acknowledgement. Draw a new diagram showing the data transfer, indicating flags and numbers for each segment. (You don't have to draw the connection setup again) [4 marks]

### Question 3 [13 marks]

Consider the network in Figure 1.

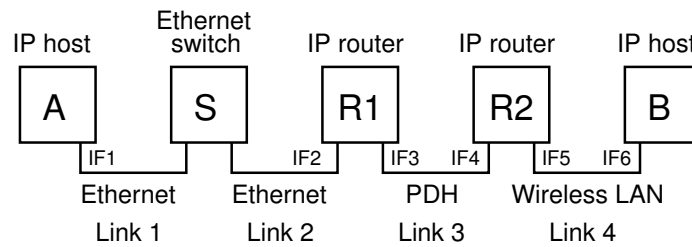


Figure 1: An internet

The addresses on each interface,  $IF$ , are given in Table 1. All subnet masks are  $/24$ .

Table 1: Interface Addresses

<i>Interface</i>	<i>MAC Address</i>	<i>IP Address</i>
$IF_1$	01:23:45:67:89:AB	10.10.10.1
$IF_2$	AA:BB:CC:DD:EE:FF	10.10.10.2
$IF_3$	22:44:66:88:AA:CC	20.20.20.3
$IF_4$	11:33:55:77:99:BB	20.20.20.4
$IF_5$	FE:DC:BA:98:76:54	30.30.30.5
$IF_6$	00:00:11:11:22:22	30.30.30.6

Host A is running a web browser and a voice-over-IP (VoIP) application, while host B is running a web server, a web browser and a VoIP application. The user on host A has clicked on the URL `http://www.example.com/courses/index.html`. Assume DNS has already been used and that host A has already established a connection to host B (host A chose initial sequence number 1234, host B chose 89). Also, host A and B have already started a voice call using their VoIP applications. The VoIP application sends UDP packets containing PCM encoded voice.

Assume all HTTP requests are 100 Bytes in length, all HTTP responses are 1,000 Bytes, and all VoIP packets are 50 Bytes. The transport layer protocols can send the application layer data in a single segment. All requested URLs exist and are accessible on the server.

Assume you can intercept any packet on any link in the internet and see the entire contents of the packet. For the following packets and locations, complete the corresponding tables giving the value of the header fields.

- (a) The packet containing the HTTP request sent by A, intercepted on link 1. [6 marks]

<i>Layer</i>	<i>Field</i>	<i>Value</i>
Data Link	Source Address	
Data Link	Destination Address	
Network	Protocol	
Network	Total Length	
Transport	Destination Port	
Transport	Sequence Number	

- (b) The packet containing the HTTP response sent by B, intercepted on link 3. [4 marks]

<i>Layer</i>	<i>Field</i>	<i>Value</i>
Network	Source Address	
Network	Destination Address	
Network	Total Length	
Transport	Sequence Number	

- (c) A packet containing VoIP data sent by A, intercepted on link 4. [3 marks]

<i>Layer</i>	<i>Field</i>	<i>Value</i>
Network	Source Address	
Network	Destination Address	
Transport	Total Length	

## Question 4 [14 marks]

Consider a network with two links: A—B—C.

First consider the link from A to B with the following characteristics:

- DATA frame consists of 100 bits of header plus 900 bits of data (total size 1,000 bits)
- ACK frame consists only of 100 bits of header
- Link data rate is 10Mb/s
- Link distance is 240km

The Sliding Window flow control protocol is used on this link. The receiver (B) sends an ACK frame immediately after receiving a DATA frame (there is no processing delay). A 4-bit sequence number is used within the header of the DATA frame (and ACK frame). The maximum window size is 15.

- (a) What is the maximum number of DATA frames node A can send before having to wait for an ACK? [1 mark]
- (b) Assuming node A always has data ready to send, and it starts transmission of its 1st DATA frame at time 0s, at what time can node A start transmitting the 2nd DATA frame? [2 marks]

(c) At what time can node A start transmitting the 16th DATA frame? [4 marks]

(d) What is the maximum throughput that can be achieved across the link from A to B? [3 marks]



Now consider the link from B to C with the following characteristics:

- DATA frame consists of 100 bits of header plus 900 bits of data (total size 1,000 bits)
- ACK frame consists only of 100 bits of header
- Link distance is 2.1km

The Stop and Wait flow control protocol is used in this link.

- (e) What is the minimum data rate necessary for Link B to C such that the throughput from A to C is the same as calculated in part (d)? [4 marks]

## Question 5 [15 marks]

Assuming classless IP addressing is used, answer the following questions by writing your answers in the table on the next page. Unless otherwise stated, give all IP addresses in dotted decimal notation.

- (a) For a host with IP address 207.89.34.56/8: [3 marks]
- What is the network address?
  - What is the directed broadcast address?
- (b) For a host with IP address 73.193.16.4 and subnet mask 255.224.0.0: [4.5 marks]
- What is the network address?
  - What is the directed broadcast address?
  - What is the maximum number of IP devices that can attach to this subnet?
- (c) A host does not yet have an IP address configured, nor does it know its network address. [4.5 marks]
- Give an IP address that the host can send to in order to send to itself.
  - Give an IP address that the host can send to in order to deliver an IP datagram to all nodes on its subnet.
  - For the case of part (ii), give the source address of the IP datagram.
- (d) For a router with IP address 01101111010011101110000100000011 and host *on a different subnet to the router* with IP address 111.78.25.3: [3 marks]
- What is the IP address of the router (in dotted decimal notation)?
  - What is the subnet mask of the router (in slash or dotted decimal notation) that allows the most hosts to attach to the routers subnet?

<i>Question</i>	<i>Answer</i>
(a) i.	
(a) ii.	
(b) i.	
(b) ii.	
(b) iii.	
(c) i.	
(c) ii.	
(c) iii.	
(d) i.	
(d) ii.	

**Question 6** [8 marks]

Consider LAN A with 5 computers (stations).

(a) Draw a diagram illustrating LAN A if using a bus topology. [2 marks]

(b) Draw a diagram illustrating LAN A if using a ring topology. [2 marks]

Consider another three LANs, LAN B, LAN C and LAN D, each with 5 computers. (That is, there are four LANs, and a total of 20 computers). Each of the four LANs use a star topology. The four LANs are then connected together by using a mesh topology amongst the switches.

- (c) Draw a diagram illustrating the single larger LAN showing all 20 computers. [4 marks]

## Question 7 [6 marks]

Consider the network shown in Figure 2. The delay (measured in milliseconds) and data rate (measured in Mb/s) for each link are shown in the format: (data rate, delay).

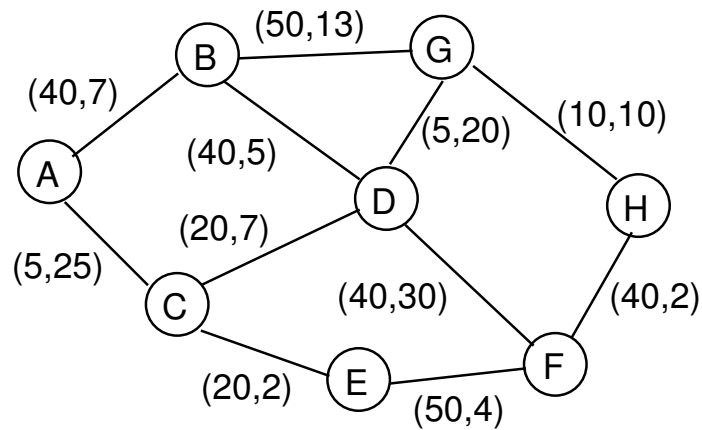


Figure 2: Network

Assuming least-cost routing is used to find a path from A to H, indicate the path and total cost if the cost metric was:

- (a) Number of hops [2 marks]

Path: \_\_\_\_\_ Cost: \_\_\_\_\_

- (b) Link delay [2 marks]

Path: \_\_\_\_\_ Cost: \_\_\_\_\_

- (c)  $\frac{100\text{Mb/s}}{\text{Datarate}}$  [2 marks]

Path: \_\_\_\_\_ Cost: \_\_\_\_\_







## Question 10 [10 marks]

Consider the network in Figure 3. Each router has multiple numbered interfaces (e.g. Router A has interface A1 and A2). There are four LANs shown, with each LAN containing multiple hosts. Router H connects, via interface H1, to another router which then may connect to many more routers and LANs (in other words, assume more LANs can be reached via router H).

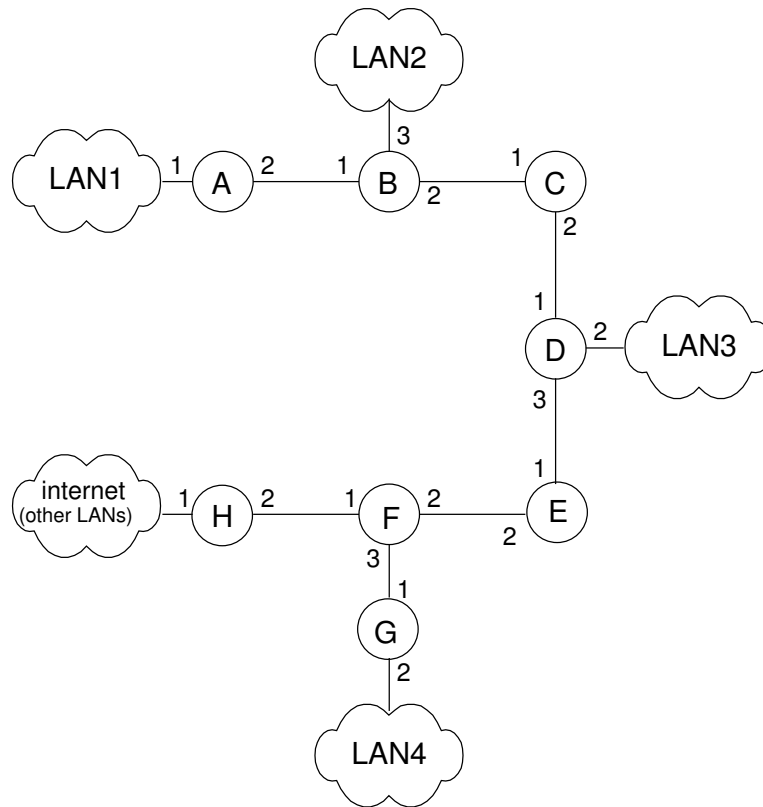


Figure 3: Routed Network

Assuming the destinations may be in any of the four LANs or in any LANs beyond router H, complete the following routing tables. You may use as many rows as necessary. Use \* to indicate a wild card (any value). Use *direct* to indicate direct delivery to the destination. Use the LAN name to refer to a network (e.g. *LAN1*). Use the router name and interface to refer to a next router (e.g. *A1*). Assume rows in the routing table are processed in order (from top to bottom).

Router B		Router F		Router D		LAN1 Host	
<i>Dest</i>	<i>Next</i>	<i>Dest</i>	<i>Next</i>	<i>Dest</i>	<i>Next</i>	<i>Dest</i>	<i>Next</i>

**Question 11** [3 marks]

(a) With respect to point-to-point transmission links, what is multiplexing? [1 mark]

(b) Explain the difference between TDM and FDM. [2 marks]

## Reference Material

Selected well-known ports:

- FTP 20 and 21
- SSH 22
- Telnet 23
- SMTP 25
- DNS 53
- HTTP 80
- HTTPS 443

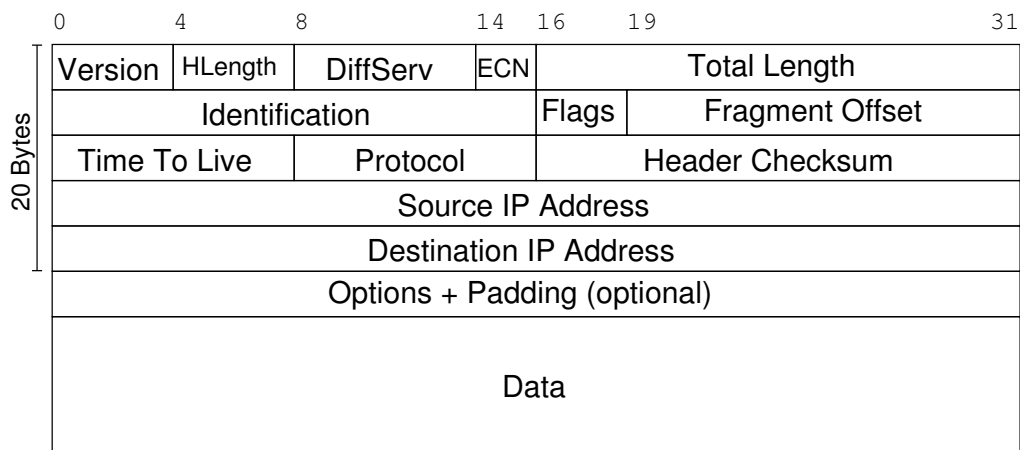


Figure 4: IP Datagram Format. Flags: Reserved, Don't Fragment, More Fragments

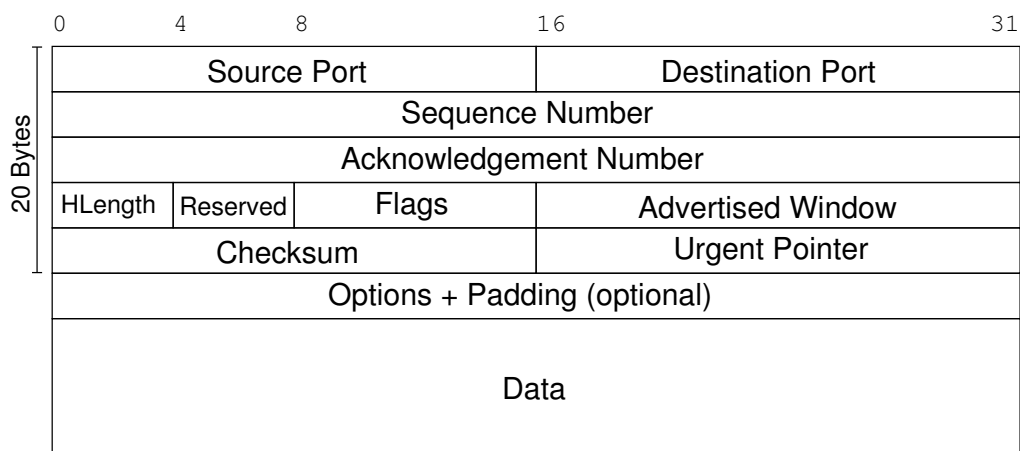


Figure 5: TCP Segment Format. Flags: CWR, ECE, URG, ACK, PSH, RST, SYN, FIN

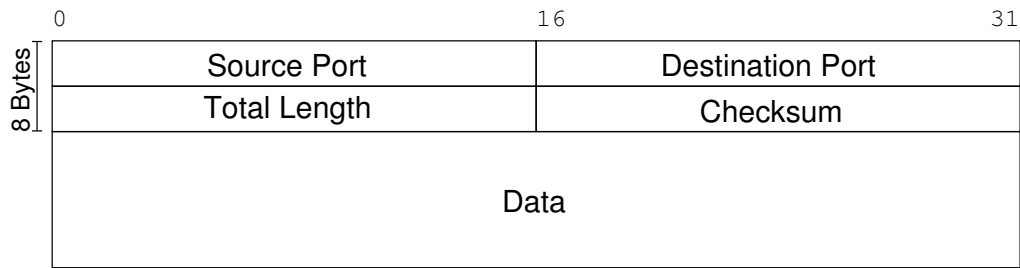


Figure 6: UDP Datagram Format

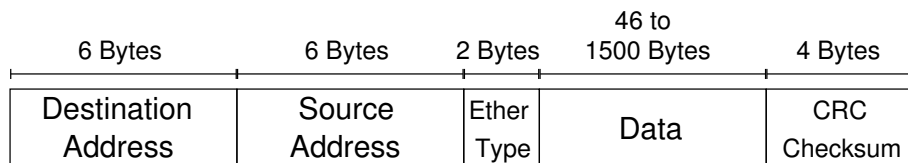


Figure 7: Ethernet Frame Format

Selected Protocol numbers:

- 1 ICMP
- 6 TCP
- 17 UDP

Selected HTTP Status Codes:

- 200 Ok
- 304 Not Modified
- 401 Unauthorized
- 404 Not Found