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

Sirindhorn International Institute of Technology
Thammasat University

Final Examination: Semester 1, 2010

Course Title: ITS323 Introduction to Data Communications

Instructor: Steven Gordon

Date/Time: Friday 15 October 2010; 9:00–12:00

Instructions:

- This examination paper has 19 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).

Prepared by Steven Gordon on 1 October 2010
ITS323Y10S1E02, Steve/Courses/ITS323/Assessment/Final-Exam.tex, r1440

Multiple Choice Questions [28 marks]

Write your answers in the table at the end of the multiple choice questions. Choose only one answer (there is only one correct answer for each question). 2 marks for a correct answer. 0 marks for an incorrect or no answer.

1. A disadvantage of circuit switching (versus datagram packet switching) is:
   (a) It is difficult to guarantee performance for delivery of data
   (b) **As new connections are requested they may be blocked**
   (c) Data is likely to be dropped at switches
   (d) Switches are complex because they must process every piece of data
   (e) A larger delay (than datagram packet switching) will always occur when transferring the same amount of data

2. Normally UDP would be implemented as:
   (a) Part of a user application, such as web browser, email client or audio/video streaming application.
   (b) An application installed by users that want to use UDP
   (c) Hardware on the LAN/WAN interface cards
   (d) **Software in the operating system**
   (e) Device drivers that control the LAN/WAN interface cards

3. The type of switching used in IP networks is:
   (a) **Datagram packet switching**
   (b) Virtual circuit packet switching
   (c) Circuit switching
   (d) Ethernet switching
   (e) None of the above

4. With some adaptive routing protocols information about the network (e.g. topology, link costs) comes from all nodes and is updated on a periodic basis. For normal flooding, where does the information come from and how is it updated?
   (a) All nodes, periodic updates
   (b) All nodes, continuous updates
   (c) All nodes, no updates
   (d) No nodes, periodic updates
   (e) No nodes, continuous updates
   (f) **No nodes, no updates**
   (g) Neighbour nodes, periodic updates
   (h) Neighbour nodes, continuous updates

5. Select the correct set of features provided by IP:

   (a) Addressing, error control, security

   (b) Connection-oriented, multiplexing, flow control

   (c) **Connection-less, addressing, multiplexing**

   (d) Addressing, flow control, quality of service

   (e) Addressing, error control, connection-less

   (f) Flow control, addressing, multiplexing

6. Which protocol provides flow control, error control and connection management:

   (a) ARP

   (b) DNS

   (c) ICMP

   (d) HTTP

   (e) **TCP**

   (f) UDP

7. Consider virtual circuit packet switching. A has 3 packets to send to B, via 2 switches. The transmission time of a packet is 10ms and the link propagation delay is 2ms. A connect request packet has as transmission time of 1ms, as does a connect response. All links are identical. Assuming no queuing or processing delay, if A has data to send at time 0, at what time is the data fully received at B?

   (a) 30 ms

   (b) 36 ms

   (c) 54 ms

   (d) 56 ms

   (e) **74 ms**

   (f) 80 ms

8. In IP:

   (a) Fragmentation may occur at the source host only, with re-assembly at the routers and destination host

   (b) Fragmentation may occur at the source host and routers, with re-assembly at the routers and destination host

   (c) Fragmentation may occur at the source host only, with re-assembly at the destination host only

   (d) **Fragmentation may occur at the source host and routers, with re-assembly at the destination host only**

   (e) Fragmentation and re-assembly is not implemented.

9. Which is the most common data rate used today in IEEE 802.3 Ethernet LANs?

   (a) 1 Mb/s
   (b) 10 Mb/s
   (c) 11 Mb/s
   (d) 54 Mb/s
   (e) **100 Mb/s**
   (f) 200 Mb/s

10. When using link state routing, the most important information in a link state packet created by router A is:

    (a) Number of links that router A has to other nodes
    (b) Number of hops from router A to every other router in the network
    (c) **Addresses of routers that are directly linked to router A**
    (d) Addresses of all other routers in the network
    (e) Number of hops that the packet should be forwarded
    (f) Current cost of all links in the network

11. Which technology is best described as being designed for short-range, low data rate, long battery lifetime:

    (a) Wireless LAN
    (b) Ethernet
    (c) Round Robin
    (d) Token Ring
    (e) **ZigBee**
    (f) WiMax

12. Wireless LAN, Bluetooth, WiMax and ZigBee include standards:

    (a) Developed by IETF, for the physical and data link layers
    (b) Developed by IETF, for the network layer
    (c) Developed by IEEE, for the physical layer only
    (d) **Developed by IEEE, for the physical and data link layers**
    (e) Developed by ITU, for the network layer
    (f) Devleoped by ITU, for the physical layer only

13. Which of the following statements about internetworking is true?

    (a) A host can have only one network interface

    (b) **A host may send a packet with a router as destination**

    (c) A router always has two network interfaces

    (d) A router cannot be a source of IP datagrams

    (e) A host may forward IP datagrams

    (f) A subnet has only one router attached

    (g) None of the above

14. Consider a stop-and-wait ARQ protocol used over a 1Mb/s link. What is the maximum throughput that can be achieved if data frames contain a maximum of 1000 Bytes of data and the link propagation delay is 21ms (ignore the size of ACKs and headers; answer is rounded to nearest Kb/s):

    (a) 20 Kb/s

    (b) 23 Kb/s

    (c) **160 Kb/s**

    (d) 186 Kb/s

    (e) 381 Kb/s

    (f) 1 Mb/s

Question	*Answer*
1	*b*
2	*d*
3	*a*
4	*f*
5	*c*
6	*e*
7	*e*

Question	*Answer*
8	*d*
9	*e*
10	*c*
11	*e*
12	*d*
13	*b*
14	*c*

Question 1 [11 marks]

A TCP connection is established using a three-way handshake, as illustrated in Figure 1.

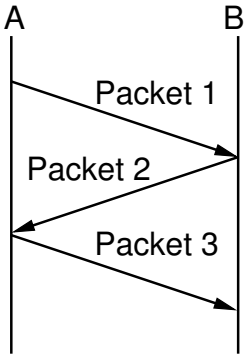


Figure 1: TCP Three-Way Handshake

A web browser, assigned port number 50123 by the operating system on computer A, initiates a connection to a web server on computer B. The IP address of A is 1.2.3.4 and the IP address of B is 5.6.7.8. The web browser has 200 Bytes of data to send to B. Assume to reduce the number of packets sent, the first data sent by A is *piggybacked* on the last three-way handshake packet. Assume the initial sequence number chosen by A is 1111, and chosen by B is 2222. Assume no optional fields are used in IP or TCP headers.

(a) For each of the packets in the three-way handshake, give the values of the selected header fields by completing the tables below (for Flags, give the abbreviation of the flag(s) that is set to 1): [9 marks]

i. Packet 1:

Protocol	*Field*	*Value*
IP	Total Length	*40*
IP	Source Address	*1.2.3.4*
IP	Destination address	*5.6.7.8*
TCP	Source Port	*51023*
TCP	Destination Port	*80*
TCP	Sequence Number	*1111*
TCP	Flags	*SYN*

ii. Packet 2:

Protocol	*Field*	*Value*
IP	Source Address	*5.6.7.8*
IP	Destination address	*1.2.3.4*
TCP	Source Port	*80*
TCP	Destination Port	*50123*
TCP	Sequence Number	*2222*
TCP	Acknowledgement Number	*1112*
TCP	Flags	*SYN, ACK*

iii. Packet 3:

Protocol	*Field*	*Value*
IP	Total Length	*240*
TCP	Sequence Number	*1112*
TCP	Acknowledgement Number	*2223*
TCP	Flags	*ACK*

(b) Comparing TCP to UDP, explain a disadvantage of using TCP as a transport protocol when an application only has a small amount of data to send across an internet that has a large end-to-end delay. [2 marks]

Answer. *Before the data is delivered, TCP must first establish a connection. That is, at least three packets must be sent sequentially to deliver the data. With UDP, only a single packet has to be sent because there is no connection setup.*

Question 2 [13 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 183.79.14.203 with subnet mask 255.255.0.0: [3 marks]

i. What is the network address?

ii. What is the directed broadcast address?

iii. If classful addressing was used, what class would this IP address belong to?

(b) For a host with IP address 43.64.209.17/10: [4 marks]

i. What is the network address?

ii. What is the directed broadcast address?

iii. What is the subnet mask (in dotted decimal notation)?

iv. What is the maximum number of hosts that can attach to this subnet?

(c) A host does not yet have an IP address configured, nor does it know its network address. [3 marks]

i. Give an IP address that the host can send to in order to send to itself.

ii. Give an IP address that the host can send to in order to deliver an IP datagram to all nodes on its subnet.

iii. For the case of part (ii), give the source address of the IP datagram.

(d) For a router with IP address 10111110000011111000000000000100 and host *on a different subnet to the router* with IP address 190.15.244.12: [3 marks]

i. What is the IP address of the router (in dotted decimal notation)?

ii. 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?

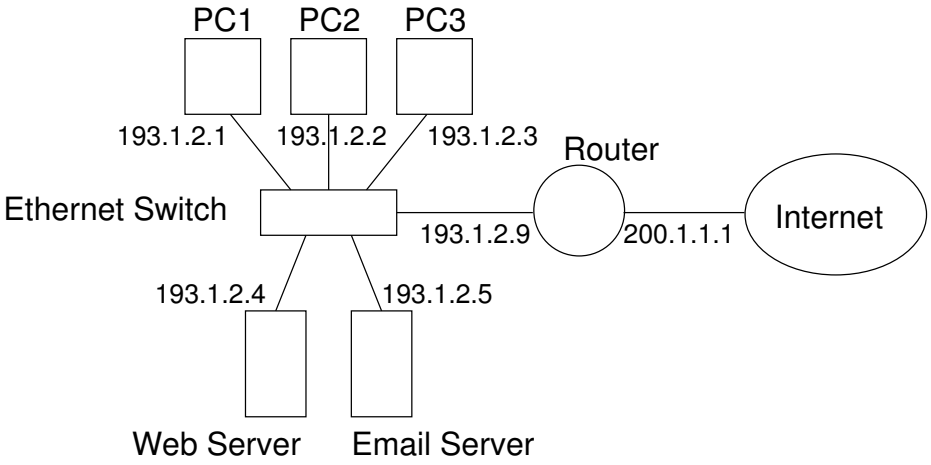
Question	*Answer*
(a) i.	*183.79.0.0/16*
(a) ii.	*183.79.255.255/16*
(a) iii.	*B*
(b) i.	*43.64.0.0/10*
(b) ii.	*43.127.255.255/10*
(b) iii.	*255.192.0.0*
(b) iv.	$2^{22} - 2 = 4194302$
(c) i.	*127.0.0.1*
(c) ii.	*255.255.255.255*
(c) iii.	*0.0.0.0*
(d) i.	*190.15.128.4*
(d) ii.	*/18 or 255.255.192.0*

Question 3 [13 marks]

Consider a small switched Fast Ethernet local area network with six stations: three PCs, one web server, one email server and one router. The router provides a connection to the Internet via a WiMax (IEEE 802.16) link.

(a) Draw the LAN, showing the devices and links. You can draw "the Internet" as a circle or cloud. *Give each interface a class C IP address.* [6 marks]

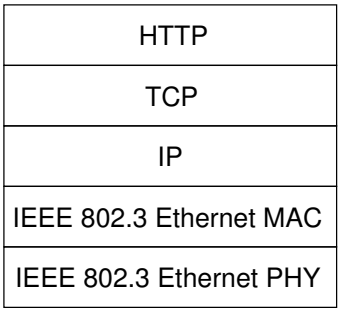
Answer. *In the topology below I used the Class C network address 193.1.2.0 for nodes on the LAN, and the Class C network address 200.1.1.0 for the router interface attached to the Internet. You could use other Class C addresses so long as they meet the requirements: all hosts (and router interface) attached to the switch use the same network address but have unique host portion of the address; the network address used by the external router interface is different from the network address for the LAN.*



(b) What is the name of the topology used in the LAN? [1 mark]

Answer. *Star topology*

(c) Draw the protocol stack of the web server, labelling each layer with the protocol/standard used (you may use acronyms). [3 marks]



Answer. *In the stack for the web server (and router in next question) I have only shown the IEEE MAC as the data link layer. In fact, the data link layer is separated into two sub-layers in the IEEE 802 architecture: a MAC as well as a common Logical Link Control (LLC) sub-layer.*

(d) Draw the protocol stack of the router, labelling each layer with the protocol/standard used (you may use acronyms). [3 marks]

Answer. *Same comment about the MAC/DLL apply as the question above.*

<table>
<tr><td colspan="2">IP</td></tr>
<tr><td>IEEE 802.3 Ether. MAC</td><td>IEEE 802.16 WiMax MAC</td></tr>
<tr><td>IEEE 802.3 Ether. PHY</td><td>IEEE 802.16 WiMax PHY</td></tr>
</table>

Question 4 [8 marks]

Consider the following set of DNS servers in the Internet. Each server has a *number*, the *domain* that it manages, its *IP address*, and the current domains in its *cache*. Make the following assumptions:

- Each DNS server knows the IP address of its parent and children DNS servers in a simple DNS hierarchy.
- The Root DNS server manages the top level domains (instead of having separate servers for `.com` and `.th`).
- Each DNS server knows the IP address of web servers (www) and FTP servers (ftp) within the domain.
- Hosts do not have a DNS cache.

No.	*Domain*	*IP Address*	*Cache*
1	`.siit.tu.ac.th`	`203.131.209.70`	`www.google.com`: `64.233.181.147` `ftp.chula.ac.th`: `161.200.192.249`
2	`.cs.tu.ac.th`	`203.131.208.2`	`www.tu.ac.th`: `203.131.222.38`
3	`.tu.ac.th`	`203.131.222.11`	`www.yahoo.com`: `98.137.149.56` `www.chula.ac.th`: `161.200.192.248`
4	`.chula.ac.th`	`161.200.192.4`	-
5	`.ac.th`	`122.155.12.37`	`www.chula.ac.th`: `161.200.192.248`
7	`.google.com`	`216.239.32.10`	`www.siit.tu.ac.th`: `115.178.61.153` `ftp.yahoo.com`: `98.137.132.15`
8	`.yahoo.com`	`98.137.132.14`	`www.google.com`: `64.233.181.147`
9	root	`198.41.0.4`	-

(a) If a host computer in SIIT's network (which knows the IP address of the SIIT DNS server, that is `203.131.209.70`) requests the following domain, indicate the order of DNS servers in which the request goes via. Give your answer as a sequence of DNS server numbers, e.g. *1→2→3*. [6 marks]

i. `www.tu.ac.th`: *1→3*

ii. `ftp.yahoo.com`: *1→3→5→9→8*

iii. `www.chula.ac.th`: *1→3*

(b) Assume the responses from the above three requests were cached by the host computer in SIIT. If an application on the host subsequently requests `www.tu.ac.th` then is a DNS request sent to a DNS server? Explain your answer. [2 marks] *No. Since the requested domain is in the hosts cache, then an immediate response is returned with the corresponeding IP address. A request is not sent to a DNS server*

Question 5 [10 marks]

Consider the network in Figure 2. Each router has multiple numbered interfaces (e.g. Router A has interface A1 and A2). There are three LANs shown, with each LAN containing multiple hosts. Router E connects, via interface E2, to another router which then may connect to many more routers and LANs (in other words, assume more LANs can be reached via router E).

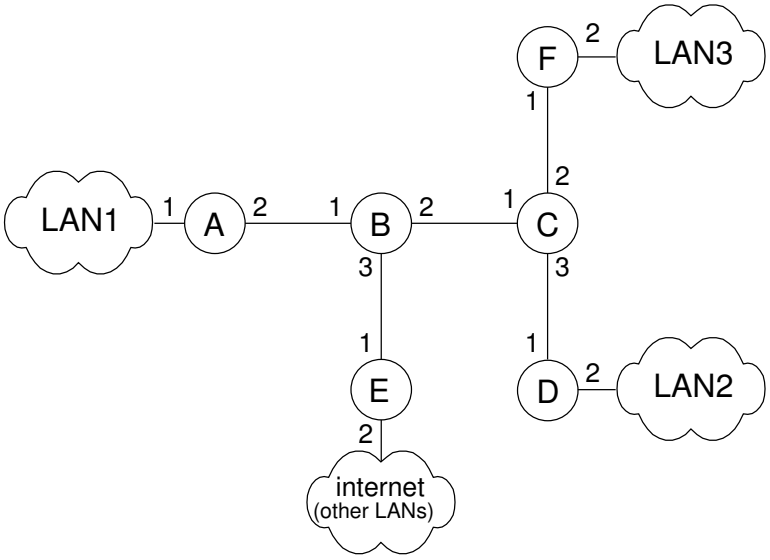


Figure 2: Routed Network

Assuming the destinations may be in any of the three LANs or in any LANs beyond router E, 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 A

Dest	*Next*

Router B

Dest	*Next*

Router C

Dest	*Next*

LAN2 Host

Dest	*Next*

Answer. *Variations of the following answer are possible (e.g. not relying on* direct*).*

Router A

Dest	*Next*
LAN1	direct
*	B1

Router B

Dest	*Next*
LAN1	A2
LAN2	C1
LAN3	C1
*	E1

Router C

Dest	*Next*
LAN2	D1
LAN3	F1
*	B2

LAN2 Host

Dest	*Next*
LAN2	direct
*	D2

Question 6 [8 marks]

Assume a web browser is running with port 54321 on a host with IP address `1.2.3.4`. A web server is running on a host with IP address `5.6.7.8`. The contents of the directory the web server makes publicly available is:

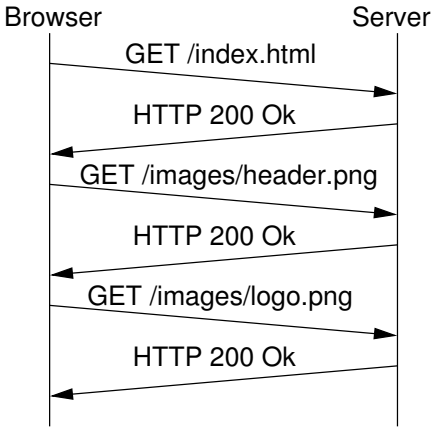
```
/index.html                350 Bytes
/contact.html              500 Bytes
/images/header.png      10,000 Bytes
/images/logo.png         2,000 Bytes
/images/steve.png        5,000 Bytes
```

The page `index.html` has the images `header.png` and `logo.png` embedded (using HTML code such as `<img src="file" />`), as well a link to `contact.html` (e.g. using `<a href="contact.html">contact</a>`). The page `contact.html` has all three images embedded, as well as links to `index.html` and `tobecompleted.html`.

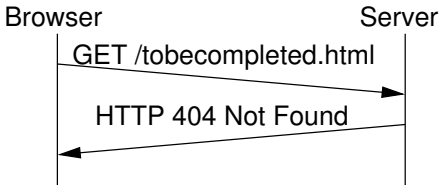
Assume at time 0 seconds the user of the web browser clicks on a link with the URL `http://1.2.3.4/index.html`. [**SG: ERROR IN EXAM: address should be http://5.6.7.8/index.html**]

(a) Complete the 1st diagram on the next page that shows the exchange of HTTP messages between the two computers until the entire page (including images) are displayed in the web browser. For requests you must clearly indicate the file requested. For responses you must indicate the HTTP status code. [6 marks]

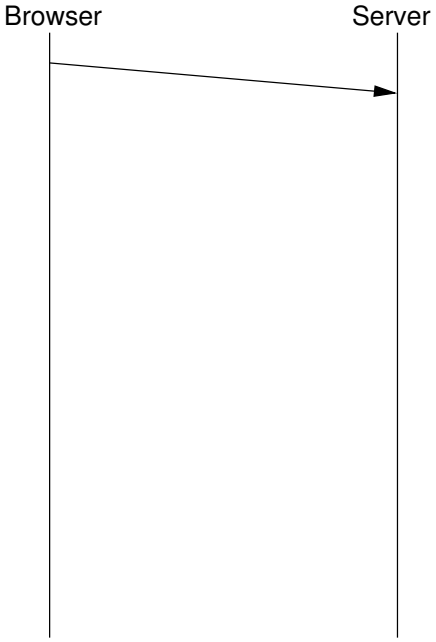
Answer. *Note that the browser automatically requests the images after receiving the HTML. Alternatively, the requests for images could occur immediately after each other.*

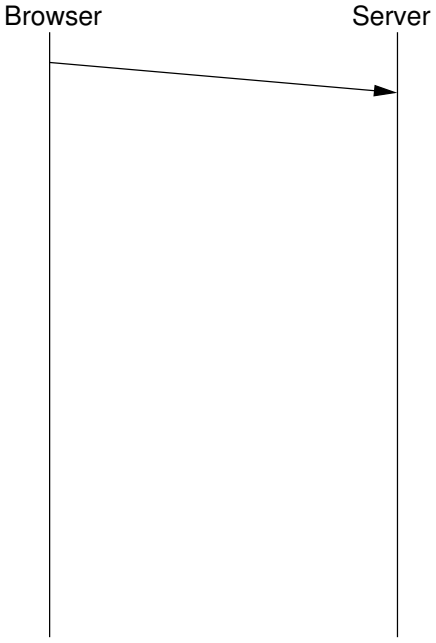


(b) If the user of the web browser then clicks on the link to `tobecompleted.html`, complete the 2nd diagram on the next page showing the exchange of HTTP messages (same format as above). [2 marks] [**SG: ERROR IN EXAM: the index.html page, which the user visited in part (a) doesn't contain a link to tobecompleted.html; contact.html does**]



Answer. *The file does not exist on the web server and hence a Not Found response is sent.*


Browser
Server


Browser
Server

Question 7 [9 marks]

Consider the operation of TCP in Figure 3. Assuming a connection had already been established and A had 10,000 Bytes of data to send to B, the figure shows A transmitting the data in 5 segments (each with 2,000 Bytes of data), the 2nd segment being lost, and acknowledgements being sent by B. The transmission time of a segment with data is 10ms, the propagation time from A to B is 10ms (and same in the opposite direction) and the transmission time of an ACK is 2ms. The sequence number inside the TCP header of the first segment is 1. Note that "ACK" means a TCP segment with no data and the ACK flag set to 1. Assume that after transmitting each data segment, A starts a timer with a timeout period of 70ms (that is, the timer for the 1st segment will expire at time 80ms). In parts (a) to (e) assume only the basic retransmission scheme is used in TCP (*not* Fast Retransmit).

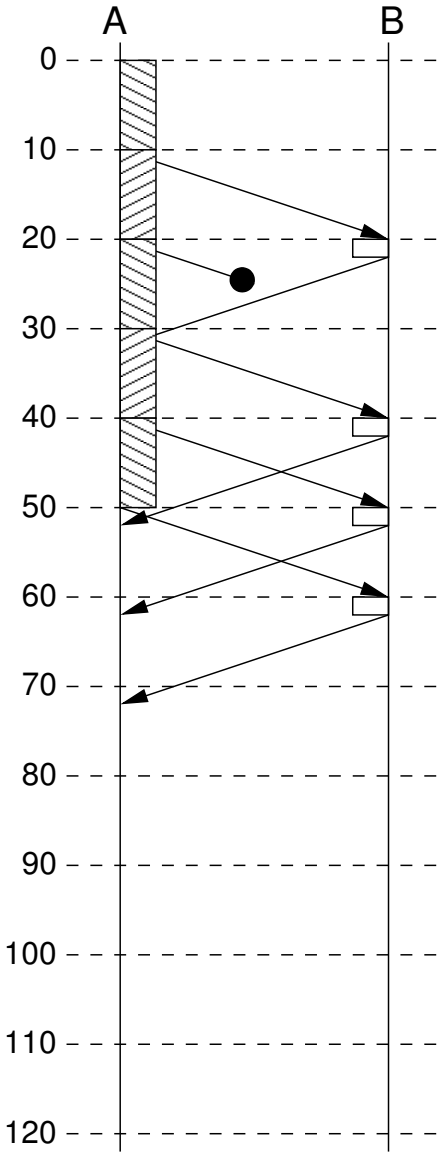


Figure 3: TCP Retransmission

(a) Of the three ARQ mechanisms we studied (stop-and-wait, go-back-N, selective-reject), which does TCP's retransmission scheme most closely resemble? [1 mark]

Answer. *Selective Reject ARQ*

(b) What is the acknowledgement number in the 1st ACK sent by B? [1 mark]

Answer. *2001. Since the first segment has sequence number 1, and 2,000 Bytes, B successfully receives sequence numbers 1 to 2000. Therefore the ACK number indicates the next sequence number expected.*

(c) What is the acknowledgement number in the 4th ACK sent by B? [1 mark]

Answer. *2001. Since the data segment with sequence numbers 2001 to 4000 is lost (2nd segment), B is still expected sequence number 2001*

(d) At what time has B successfully received all 10,000 Bytes of data? [2 marks]

Answer. *110ms. The 2nd segment is lost and the timeout therefore occurs at time 90ms. The transmission takes 10ms and propagation 10ms, therefore all data received at time 110ms*

(e) One method to increase the efficiency in the case that packets are lost would be to decrease the timeout period (that is, A would spend less time waiting to retransmit). If A used a timeout period of 20ms in the above scenario, explain what would happen (e.g. would the efficiency be increased? Why or why not?) [2 marks]

Answer. *No. With a timeout period 20ms for every segment A would timeout and retransmit before the ACK was received,* even if the segment arrives successfully. *The timeout period is too short in this case.*

(f) If Fast Retransmit scheme was used as well, then at what time would B have successfully received all 10,000 Bytes of data? [2 marks]

Answer. *92ms. With Fast Retransmit, A can retransmit after receiving 3 duplicate ACKs, i.e. 4 ACKs with the same ACK number. That is at tim 72ms. Additional 10ms to transmit and 10ms to propagate gives a receive time of 92ms*

Reference Material

Selected well-known ports:

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

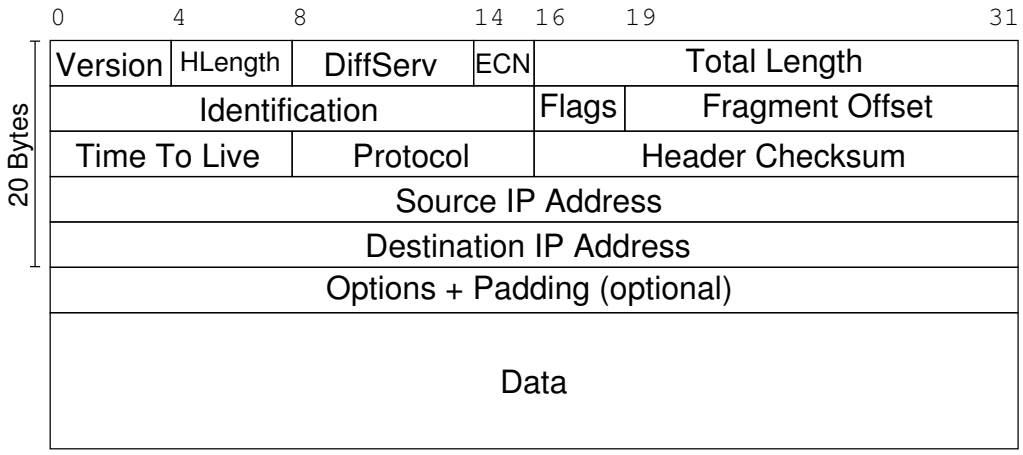


Figure 4: IP Datagram Format. Flags: Reserved, Don't Fragment, More Fragments

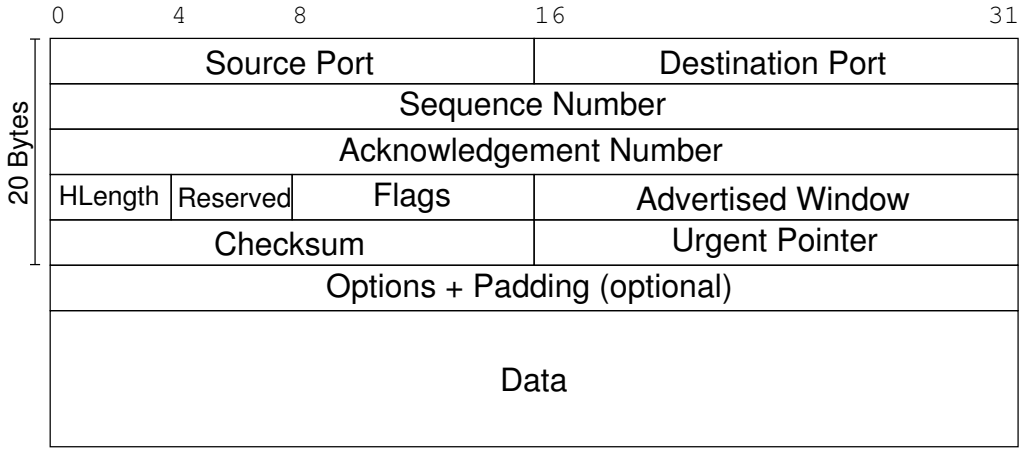


Figure 5: TCP Segment Format. Flags: CWR, ECE, URG, ACK, PSH, RST, SYN, FIN

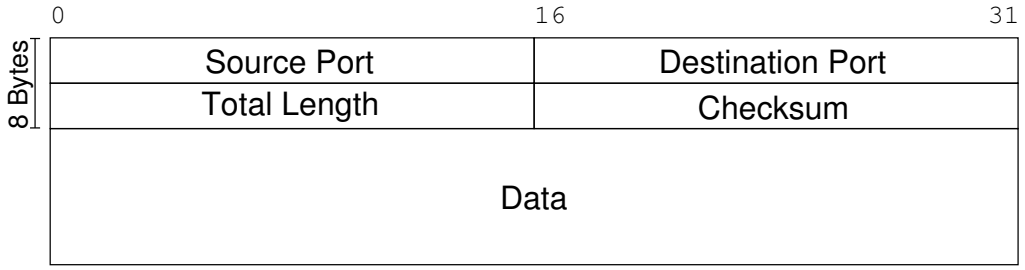


Figure 6: UDP Datagram Format

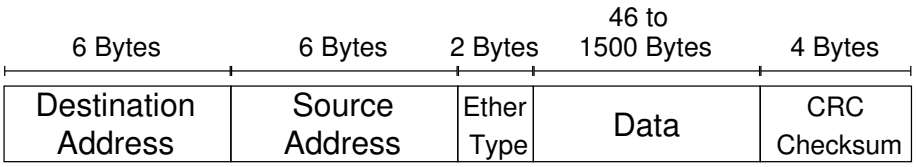


Figure 7: Ethernet Frame Format

Selected HTTP Status Codes:

- 200 Ok
- 304 Not Modified
- 404 Not Found