

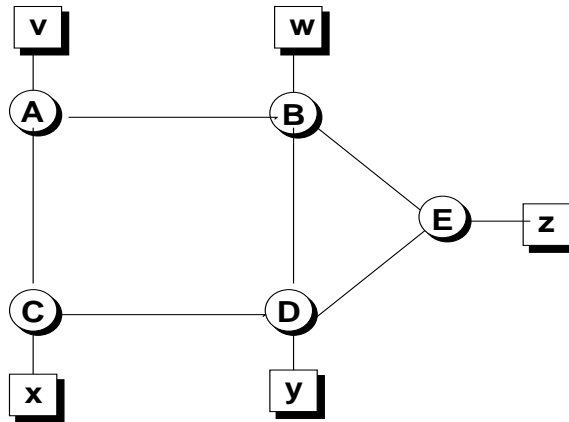
CS 352 Final
Version A
Spring 2000

Name:
Student ID:
Section:
Login Name:

- Do not open this exam until you are told to begin.
- You have 3 hours.
- Once you start the exam, you may not leave the room.
- Make sure your exam has 10 pages including the cover page.
- The exam is closed book.
- Calculators are allowed.
- No Palmpilots or other hand held computers are allowed.
- Write your name and student ID number on every page.

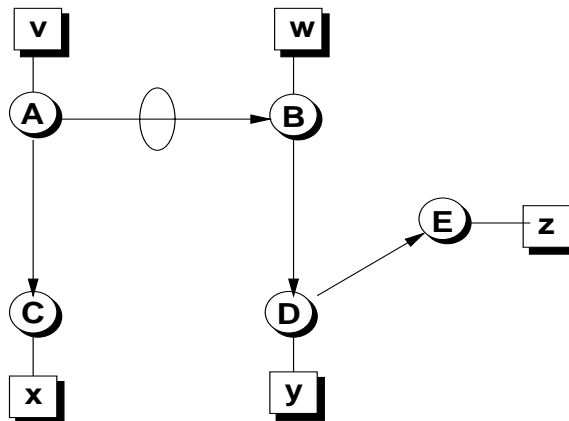
1 Multicast (15 points)

Consider the following multicast network, where the routers are labeled **A** through **E** and the hosts are labeled **v** through **z**. Hosts **v,x,y** and **z** form multicast group **G**. The routers use distance-vector routing for unicast routes and reverse path multicast for multicast routing.



Destination Network	Routing Table for A		Routing Table for B		Routing Table for C		Routing Table for D		Routing Table for E	
	Next hop	Distance	Next hop	Distance	Next hop	Distance	Next hop	Distance	Next hop	Distance
A	A	0	A	3	A	4	B	4	D	6
B	B	3	B	0	D	3	B	1	D	3
C	C	4	D	3	C	0	C	2	D	4
D	B	4	D	1	D	2	D	0	D	2
E	B	6	D	3	D	4	E	2	E	0

A. Assume all prune and graft messages have been sent. Draw the resulting multicast spanning tree from source **v**:



B. If host **v** had used unicast to reach all members of **G**, how many packets would cross the link **A** → **B**?
 2 packets.

2 Token Ring (15 points)

In the token ring MAC protocol, a host wanting to transmit data needs to grab the token before sending the data. Each token/frame has an Access Control Field which has 3 priority bits(PPP), 1 monitor bit(M), 1 token bit(T) and 3 reservation bits(RRR).

We have a Token Ring network consisting of 5 hosts A,B,C,D,E and the token circulates in that order. **D is the designated "monitor" station.**

Consider the following table. The token/frame has just arrived at host mentioned in "Host" field, with the AC field values set in "Incoming AC Field". Indicate the values of various bits of AC Field of the token/frame leaving the host("Outgoing AC Field") when the "Event" has occurred at "Host".

Assume that the Host receiving a frame in each part is neither the source nor the destination of the frame that arrived.

Treat each event as a different, unrelated part of the question. That is, treat the cases individually.

Host	Incoming AC Field								Event at Host	Outgoing AC Field							
	P	P	P	T	M	R	R	R		P	P	P	T	M	R	R	R
A	*	*	*	*	*	*	*	*	A generates the token	0	0	0	0	0	0	0	0
C	0	0	1	1	0	0	0	0	C has a frame to transmit to D with priority 3.								
D	0	1	0	1	0	0	1	0	D has a frame of priority 1 to send to C.								
B	0	1	0	0	0	0	0	0	B has a frame of priority 2 to send to E.								
E	0	1	1	0	0	0	0	0	E has a frame of priority 5 to send to C.								
D	1	0	0	1	0	0	1	0	D has a frame of priority 4 to send to A.								

Host	outgoing AC field							
	P	P	P	T	M	R	R	R
-	0	0	0	0	0	0	0	0
C	0	0	1	1	0	0	1	1
D	0	1	0	1	1	0	1	0
B	0	1	0	1	0	0	0	0
E	0	1	1	1	0	0	0	0
D	1	0	0	1	1	1	0	0

3 Ethernet (15 points)

Two hosts, A and B, are connected to an Ethernet Network along with some other hosts. Host A wishes to send frame a and host B wants to send frame b to some other hosts on the Ethernet.

Suppose that host A has had 3 collisions while trying to send frame a (with some hosts other than host B) and host B has had 2 collisions while trying to send frame b (with some hosts other than host A). At time T, only hosts A and B are the ones that are ready to transmit some data. All other hosts remain idle.

- A. What is the maximum slot number that A can decide to transmit packet a in?

Slot 8.

- B. What is the probability that A and B will collide in the next transmission as well?

*The probability = 0.125 (1/8). Compute this taking the probably A and B send in the same slot, $S = 0.25 * 0.125$, and adding together all the probabilities of them picking the same slot (4 total).*

- C. Suppose that A generates random number 0.2 and B generates random number 0.4. What are the slots that A and B will transmit their packets in?

Recall that each host picks a number between [0:1] and then picks a slot based on dividing the range [0:1] by the number of slots. Since A has 8 slots, each spanning a range of 0.125, and B has 4 slots, spanning a range of 0.25 each, A will pick slot 2 and B will pick slot 2.

4 Protocol Layering (10 points)

- A. Assume you have a large network which implements reliability at the transport layer. Is it necessary to have reliability at the link layer as well? Answer yes or no, and give a reason (no more than one line, please).

No. Packets still can be delivered correctly from one host to another because the transport layer can recover from lost of missing data-link layer packets.

- B. True or False:

_T___ Sliding windows type protocols might be used by several layers at the same time, in the same network, for a particular session.

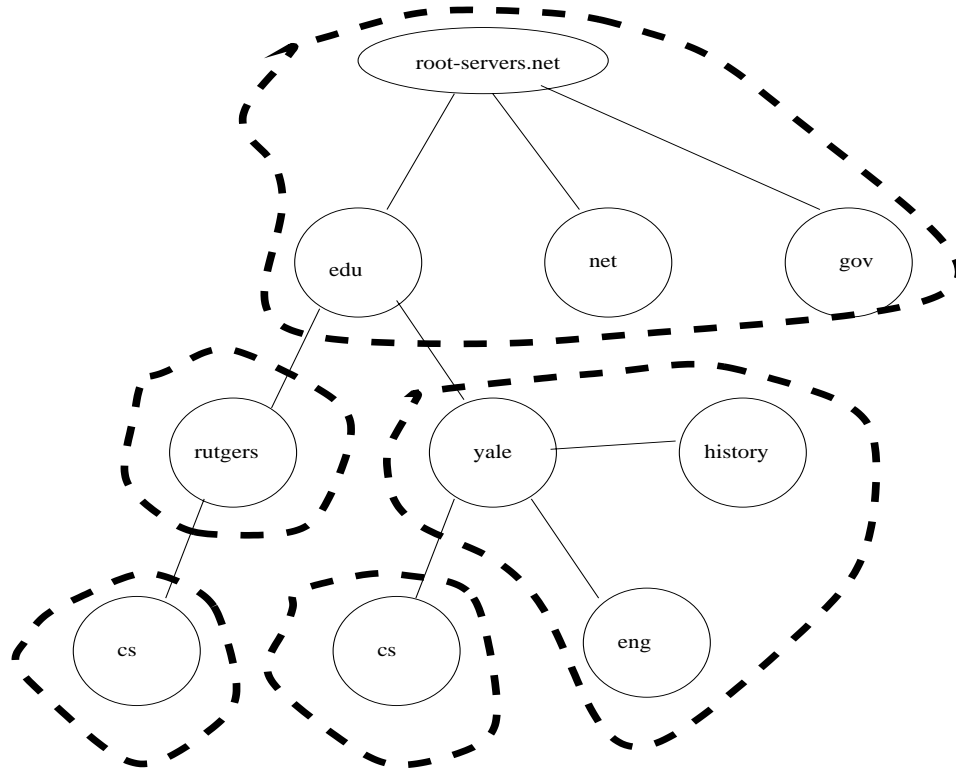
_T___ Medium Access Sublayer is a part of Data Link Layer.

_F___ ICMP packets operate at the transport layer.

_F___ If one OSI layer is modified, all the layers above it will have to be changed accordingly.

_F___ Network, Transport and Application layers all depend on DNS to work properly.

5 Domain Name System (20 points)



Consider the internet in the figure above, in which zones are indicated with a dashed line. There is only one DNS server per zone and it happens to have the same name as the highest node in each zone: `yale.edu`, `cs.yale.edu`, `rutgers.edu`, `cs.rutgers.edu` and `root-servers.net`. The only servers supporting recursive querying are `cs.yale.edu` and `cs.rutgers.edu`.

For each of the queries below, list in order all the DNS servers contacted by the resolver (located in the OS of the machine running the query). Assume there is no caching performed at any level of the hierarchy.

- A. `napoleon.history.yale.edu` is a machine installed in the history dept at yale, and a user on `eden.rutgers.edu` launches these query: `"host1 napoleon.history.yale.edu"` .

rutgers.edu
root-servers.net
yale.edu

- B. At the prompt of `paul.cs.rutgers.edu` somebody launches this query: `"host napoleon.history.yale.edu"`.

cs.rutgers.edu

- C. Later, `napoleon.history.yale.edu` is assigned a new IP (but keeping the complete name) and is physically moved in the engineering building on to a local Ethernet with other machines such as `electron.eng.yale.edu` and `theorem.eng.yale.edu`. At the prompt of `eden.rutgers.edu` a user launches this query: `"host napoleon.history.yale.edu"`.

rutgers.edu
root-servers.net
yale.edu

¹Note: The `host` program is a less featured version of the command `nslookup`.

Name:

SID:

6

D. In engineering building, on `napoleon.history.yale.edu`, somebody queries: `"host paul.cs.rutgers.edu"`.

yale.edu
root-servers.net
rutgers.edu
cs.rutgers.edu

E. Follow the same scenario as in B, but this time indicating in order, all the queries involved in the process. Use this notation to represent a query: `rutgers.edu → rootservers.net` to indicate that `rutgers.edu` is generating/forwarding a query to `rootservers.net`.

paul.cs.rutgers.edu → cs.rutgers.edu
cs.rutgers.edu → rutgers.edu
cs.rutgers.edu → root-servers.net
cs.rutgers.edu → yale.edu

Name:

SID:

8

```
-----  
1000  
1001  
-----  
0011  
0000  
-----  
0110  
0000  
-----  
1100  
1001  
-----  
1011  
1001  
-----  
010 = R
```

Answer is C, 010.

7 Hamming code (15 points)

You have the following 4-bit message that is to be transmitted using the Hamming code with even parity:

1011

A. What is the bit string to be transmitted? Circle the letter code for the answer to part A:

[a] 0010011 [b] 0011011 [c] 0110011 [d] 0111011

[e] 1010011 [f] 1011011 [g] 1110011 [h] 1111011

Answer is C, 0110011.

B. The following Hamming encoded message has been received. It may or may not contain a single-bit error. Is there an error, and if so, what bit is in error?

0011011

Circle the letter code for the answer to part B, (Note that X marks the location of the bit in error, and the b's are ordinary bit locations.):

[a] No error [b] Xbbbbbb [c] bXbbbbbb [d] bbXbbbb

[e] bbbXbbb [f] bbbbXbb [g] bbbbbXb [h] bbbbbbX

Bit 6 is in error, so the answer is bbbbXb.

8 Transmission Control Protocol (15 points)

Suppose that you are using TCP over a 10^9 (1 Gbits/s) link with 1-way latency of 100 ms to transfer a 2×10^6 (2 MB) byte file and the TCP receive window size is always 10^6 (1 MB) bytes. If TCP sends 10^3 (1 KB) packets: (ignore packet transmission time and assume no packet loss).

RTT	Window	Time	Data Received
	(segments)	(ms)	(Kbytes)
1-start	1	0	0
1-end	2	200	1
2-start	2	200	1
2-end	4	400	3
3-start	4	400	3
3-end	8	600	7
4-start	8	600	7
4-end	16	800	15
...
10-start	512	1800	511
10-end	1024	2000	1023
11-start	1024	2000	1023
11-end	2048	2200	2047

- A. How many RTTs does it take until slow start opens the send window to 1 MB?

One approach is to figure out the how much data is sent in each round trip. Given we know the 1-way latency of each RTT is 200 ms. If we can compute the data sent as a function of the RTT, and we know the time per RTT, we can compute the throughput, i.e. bytes/time.

The TCP slow-start algorithm doubles the window, measured in segments, each RTT (until we reach linear mode, which we can ignore in this question).

The send window exceeds 10^6 at the end of the 10th RTT.

- B. How many RTTs does it take to send the 2 MB file?

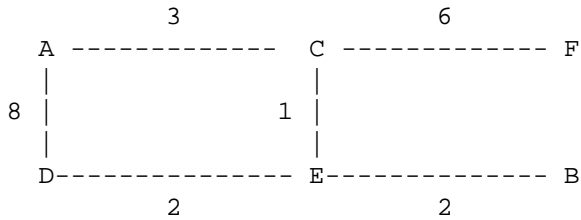
The volume of data thus also doubles each RTT. The data received at the end of each RTT is thus $2^{RTT} - 1$. It takes 11 RTTs to send the file.

- C. What is the effective throughput for the 2 MB file transfer?

Throughput = $\frac{\text{bytes}}{\text{time}}$. We sent 2 million bytes in 2.2 seconds, so the effective throughput is 0.9 MB/s

9 Distance Vector Routing (10 points)

The diagram below shows 6 routers and the measured link costs between them.



A. For the network given above, what vectors will the router E get after the distance vector routing protocol stabilizes? Fill in the columns of the following table. Note, not all columns may be needed.

	A	B	C	D	E	F
		A/6	A/3	A/6		
		C/3	B/3	B/4		
		D/4	D/3	C/3		
		E/2	E/1	E/2		
		F/9	F/6	F/9		

B. Using the above vectors, construct router E's routing table.

E destination	outgoing link
A	C
B	B
C	C
D	D
E	C

10 Link State Routing (20 points)

A router, R, is connected to routers A and B. R receives the following link-state packets:

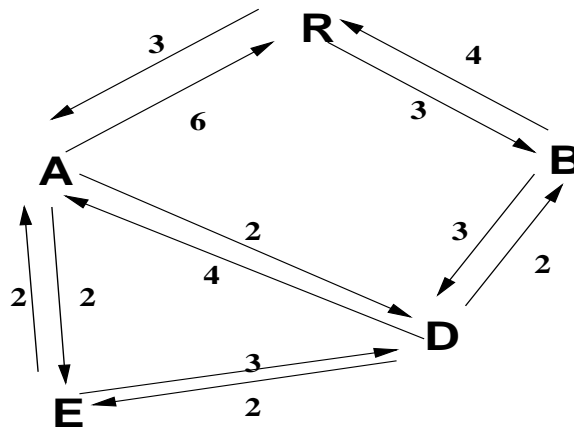
Time Received (sec)	Source Router	Incomming Link	Sequence #	Time To Live	Neighbor/Link Cost		
1	D	B	10	5	A/4	B/2	E/3
2	B	B	200	2	R/4	D/3	
3	D	A	5	5	A/3	B/2	E/3
4	A	A	50	1	R/6	D/2	E/2
7	D	B	12	1	A/4	B/2	E/2
8	E	A	50	2	A/2	D/3	

A. For each packet above, show to which routers the LSP's are forwarded. Outgoing LSP's are delayed by 1 ms after the corresponding incomming LSP is received. Show all fields of the packet. Note: not all rows of the table may be required.

Time sent (sec)	Source Router	Outgoing Link	Sequence #	Time To Live	Neighbor/Link Cost		
1.001	D	A	10	4	A/4	B/2	E/3
2.001	B	A	200	1	R/4	D/3	
8.001	E	B	50	1	A/2	D/3	

B. Router R also sends the following packets. Show router R's representation of the network as a **directed** graph at time 10 seconds:

Time sent (sec)	Source Router	Outgoing Link	Sequence #	Time To Live	Neighbor/Link Cost		
5	B	A	10	7	A/1	B/1	
6	B	B	11	7	A/2	B/2	
9	B	A	12	7	A/3	B/3	



11 Token Bucket (15 points)

You have constructed a token bucket class in Java using a queue of length 4, a thread and a timer. The token bucket class operates on packets, and replenishes tokens at the rate of 1 token/ms. The maximum token count is 3. If possible, the class replenishes tokens **before** any other operations.

- A. Given the following packet arrival schedule, fill in the system state: token count, scheduled departures, and queued packets, at each packet arrival time. The class is fast enough such that you can assume packets are sent instantaneously, if possible.

Packet number	Arrival Time (msec)	Departure Time	Token Count	Queued Packets
	0		3	empty
1	1	1	2	empty
2	1.1	1.1	1	empty
3	1.5	1.5	0	empty
4	2	2	0	empty
5	2.7	3	0	5
6	2.9	4	0	5,6
7	3	5	0	6,7
8	3.1	6	0	6,7,8
9	3.2	7	0	6,7,8,9

- B. How would you alter the behavior of the token bucket class to turn it into a leaky bucket with a departure rate of 1 packet/2 ms? Explain.

Remove the token field. Just have the thread wake up every 2 ms and send whatever is at the head of the queue, if anything.

12 Hyper-Text Transfer Protocol (10 points)

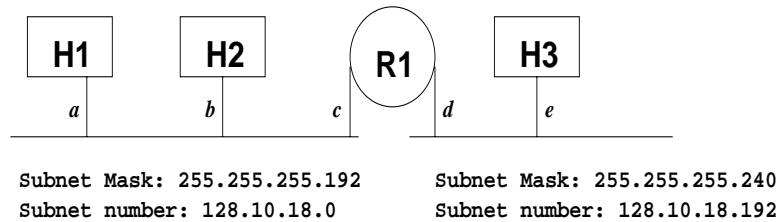
If HTML is entirely replaced by another markup language, such as XML, or any other language that you have designed for the same purpose, will HTTP require modification for functioning? Answer yes or no, and give a reason.

No, HTTP will not require modification. HTTP allows for multiple content types to be sent in an HTTP message using the HTTP header. XML could just be another content type.

13 Subnetting (10 points)

Consider the internetwork of Ethernet LAN's, shown below. Hosts are labeled as H1, H2, H3 and the Router between the two LANs is R1.

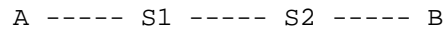
Given each Ethernet's preconfigured subnet numbers and masks, choose appropriate IP addresses for the interfaces *a*, *b*, *c* and *d*. You may select any addresses you like as long they conform to the specified subnet masks and numbers. However, do not assign the first or last addresses as these are reserved for other purposes (e.g. broadcast).



- A. IP address for *a*: 128.10.18.2
- B. IP address for *b*: 128.10.18.3
- C. IP address for *c*: 128.10.18.4
- D. IP address for *d*: 128.10.18.195
- E. IP address for *e*: 128.10.18.196

14 Switching (15 points)

Two hosts, A and B, are connected by two switches S1 and S2 as indicated below. Each link has a bandwidth of 10 Mbps and a delay of 100 ms. Calculate the time taken to transfer 10^6 bits of data from A to B in the following cases :



- A. S1 and S2 do message switching.

Time to send a single message across 1 link = bandwidth time + propagation delay.

Bandwidth time = 0.1 seconds, delay time = 0.1s, total = 0.2s/link. Total time using message switching = time to cross 3 links serially = 0.6 s.

- B. S1 and S2 do packet switching. Assume that there is no header required for the packets, and the packets are p bytes long.

Recall that in packet switching, we are trying to compute a “parallelogram”. In the table below, each packet is shown as P_n .

Time	A	S1	S2	B
0	P_1			
1	P_2	P_1		
2	P_3	P_2	P_1	
3	P_4	P_3	P_2	P_1
...	...			
N	P_N	P_{N-1}	P_{N-2}	P_{N-3}
N+1		P_N	P_{N-1}	P_{N-2}
N+2			P_N	P_{N-1}
N+3				P_N

The number of packets, $N = \frac{10^6}{p}$.

A packet time is the time for one packet to traverse the link: $T_p = \frac{p}{10 \times 10^6} + 0.1s$.

The total time is this: $(N + 3) \times T_p$.

- C. If we have to include a header of length h bits for each packet for routing purposes, and we choose to send packets of size p , how much time will it take to transfer the whole file?

change $T'_p = \frac{(p+h)}{10 \times 10^6} + 0.1s$.

The total time is this: $(N + 3) \times T'_p$.