Spring 2022 Exam 4

You have 70 minutes. The exam tallies up to 100 points. Please be concise: avoid verbose answers. **Good luck!**

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The Code educates all members of the Georgia Tech Community about the Institute's expectations and Students' rights and creates a standard by which Students are expected to conduct themselves for the purpose of establishing an environment conducive to academic excellence. Georgia Tech Students, Registered Student Organizations, and Groups are responsible for their own behavior, and the Institute has the authority to establish an internal structure for the enforcement of its policies and procedures, the terms of which students have agreed to accept by their enrollment.

<u>Question 1:</u>

We reserve the right to modify numbers for this question on the final exam.

a) We have a disk with the following design specifications:

- Total # of cylinders = 250 (numbered 0-249). Assume that 0 = outermost cylinder and 249 = innermost cylinder.
- Current head position = cylinder 47 and the head is currently moving outwards, towards the disk's cylinder 0.
- Suppose that the latency of moving the head position is M per cylinder, and the latency of transferring a track is C.
- Assume there are currently 7 pending requests. Assume that each request transfers an entire track, and that after locating the target track, the disk head can immediately start transferring the track (i.e., there is no rotational latency incurred).

Request id:	R1	R2	R3	R4	R5	R6	R7
Cylinder id:	14	17	91	168	56	48	8

Give your answers to questions (i) and (ii) as a function of M and C.
(i) What is the expected response time for R5 (request 5) if the disk scheduling algorithm used is SCAN? Explain your answer. (3 points)

(ii) What is the expected response time for R5 (request 5) if the disk scheduling algorithm used is LOOK? Explain your answer. (3 points)

b) This question is not related to the previous part (a). Assume the following disk drive specifications:

- Average seek time: 18 ns
- Rotational speed: 7500 RPM
- Platters: 3
- Surfaces: 2
- Tracks per surface: 8000
- Sectors per track: 1024
- Recording density: 256 bytes per sector

This disk has received a request to read 7 random sectors, how much total time (expressed in ns) will that request take to complete? Explain your answer. (5 points)

Question 2:

Students in CS 2200 are tasked with writing two functions, `foo()` and `bar()`, that operate on a shared variable, `curr`. Both functions are part of a multi-threaded program, thus multiple threads may be calling them concurrently.

The specifications are as follows:

- `foo()` must set `curr` to an integer value and call `bar()`, and
- `bar()` must increment the value of `curr`.

a) Student A looks at these specifications and writes the following code:

```
int curr = 0;

int foo(int val) {
   int y;
   curr = val;
   y = bar();
   return y;
}
```

```
int bar() {
   int x;
   x = curr + 1;
   return x;
}
```

What can go wrong with this code? What is this error called? (2 points)

b) Using the same specifications, student B implements the following code:

```
int curr = 0;
pthread_mutex_t curr_mutex;

int foo(int val) {
   int y;
   pthread_mutex_lock(&curr_mutex);
   curr = val;
   y = bar();
   pthread_mutex_unlock(&curr_mutex);
   return y;
}
```

```
int bar() {
   int x;
   pthread_mutex_lock(&curr_mutex);
   x = curr + 1;
   pthread_mutex_unlock(&curr_mutex);
   return x;
}
```

What can go wrong with Student B's code? What is this error called? (2 points)

c) Suggest how to modify Student B’s code to ensure that it produces the desired result? (3 points)

Question 3:

a) Based on Unix commands, determine, for each command, whether a new i-node is created and its reference count. Assume that these commands are executed in the displayed order and that initially none of the files f1, f2, f3, f4 exist in the file system. (6 points)

Command	New i-node? (yes/no)	Old ref count	New ref count
`touch f1`			
`touch f2`			
`ln -s f1 f3`			
`cat f3`			
`cp f2 f4`			
`rm f2`			

b) What is the difference between `ln -s f1 f2` and `ln f1 f2`? Give one reason you would opt to use the latter instead of the former. (2 points)

c) Considera file system that uses the hybrid storage allocation strategy. The file system has the following parameters:

i) Size of index block = 256 bytes

ii) Size of pointer = 16 bytes

iii) Size of data block = 2048 bytes

iv) Each i-node consists of:

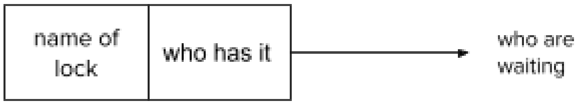
1) 1 direct data block pointer
2) 1 single indirect pointer
3) 1 double indirect pointer

What is the size in bytes of the biggest file that can be created with this file system? (5 points)

Note: The numbers for this problem may change in the actual exam you will be taking.

Question 4:

The internal representation for a lock in the thread library is shown below:

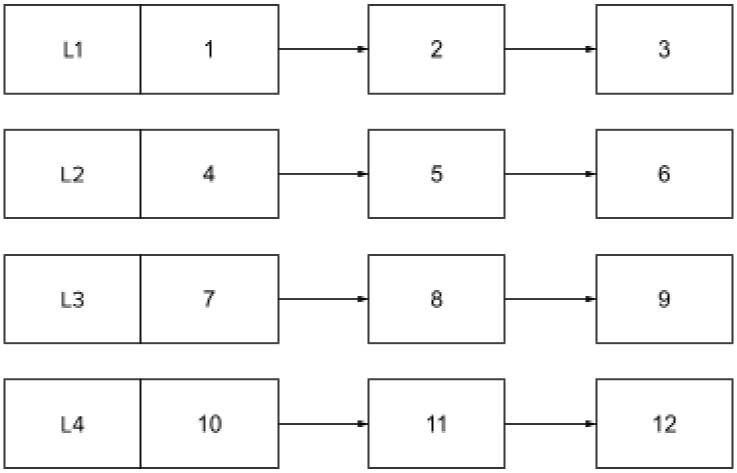


Assume that we have a program with 8 threads, T1 to T8, and the following sequence of events happens:

a) T1 executes thread_mutex_lock(L1);
b) T2 executes thread_mutex_lock(L3);
c) T3 executes thread_mutex_lock(L1);
d) T4 executes thread_mutex_lock(L2);
e) T5 executes thread_mutex_lock(L1);
f) T6 executes thread_mutex_lock(L4);
g) T1 executes thread_mutex_unlock(L1);
h) T7 executes thread_mutex_lock(L2);
i) T2 executes thread_mutex_lock(L4);
j) T8 executes thread_mutex_lock(L3);

Assume that before the start of the sequence, all locks (L1 to L4) were free.

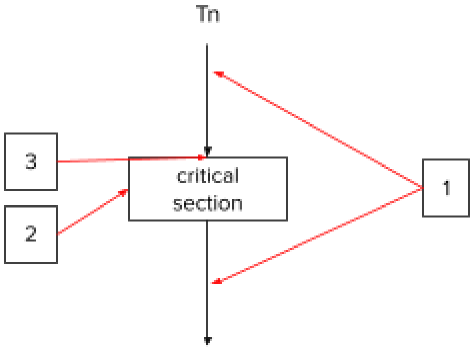
a) Show the thread library's lock bookkeeping state after the aforementioned 8 steps. For each number in the figure (1 to 12), enter the corresponding thread id (T1 to T8). If a number does not have a corresponding thread id, enter N/A. (8 points)
Note: You should put at most ONE thread-id corresponding to each number.



- 1:
- 2:
- 3:
- 4:
- 5:

- 6:
- 7:
- 8:
- 9:
- 10:
- 11:
- 12:

b) Shown in the figure below are possible points of execution for each of the eight threads (T1 to T8). For each thread, select the number that best corresponds to its current point of execution based on your answer to part (a). (4 points)



Note: the execution point numbered “1” corresponds to a thread being before or after the critical section in its execution.

a. T1:
b. T2:
c. T3:
d. T4:
e. T5:
f. T6:
g. T7:
h. T8:

Question 5:

The following timelines show the execution history of two threads, each running on a different core of a multicore processor that is endowed with hardware cache coherence for shared memory. x and y are shared memory locations the two threads are operating on, while R1 and R2 are general-purpose registers in each core. For each sequence, determine the final value of x and y.

- Threads:

Thread 1 (T1)	Thread 2 (T2)

`Time 0: R1 <- 0`
`Time 2: R1 <- R1 + 2`
`Time 4: x <- R2 + R2`
	`Time 1: R2 <- 0`
	`Time 3: R2 <- R1 + R2`
	`Time 5: y <- x + R1`

  a. What is the value of x? (2 points)
    i. 2
    ii. 4
    iii. 6
    iv. None of the above
  b. What is the value of y? (2 points)
    i. 2
    ii. 4
    iii. 6
    iv. None of the above

- Threads:

Thread 1 (T1)	Thread 2 (T2)

`Time 0: R1 <- 0`
`Time 1: R1 <- R1 + 2`
`Time 4: x <- R2 + R2`
	`Time 1: R2 <- 0`
	`Time 2: R2 <- R1 + R2`
	`Time 3: y <- x + R1`

  a. What is the value of x? (2 points)
    i. 2
    ii. 4
    iii. 6
    iv. None of the above
  b. What is the value of y? (2 points)
    i. 2
    ii. 4
    iii. 6
    iv. None of the above

- Threads:

Thread 1 (T1)	Thread 2 (T2)
`Time 0: R1 <- 0`	`Time 1: R2 <- 0`
`Time 2: R1 <- R1 + 2`	`Time 2: R2 <- R1 + R2`
`Time 3: x <- R2 + R2`	`Time 3: y <- x + R1`

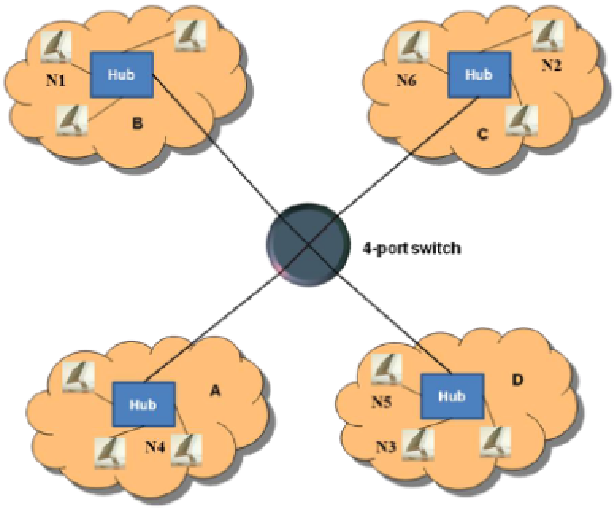
a. What is the value of x? (2 points)
   - i. 2
   - ii. 4
   - iii. 6
   - iv. None of the above

b. What is the value of y? (2 points)
   - i. 2
   - ii. 4
   - iii. 6
   - iv. None of the above

Question 6:

(a) (3 points) The Ethernet protocol is ubiquitously used for the Media Access and Control (MAC) layer that detects collisions and retransmits a packet if there is a collision. Given this mechanism, why do we also need the transport layer to deal with packet retransmissions?

(b) (3 points) In the ethernet network shown in the following figure, assume that nodes N1, N3, N4, and N5 all simultaneously attempt to send packets to N6. Which nodes will experience collision of their packets? Why?

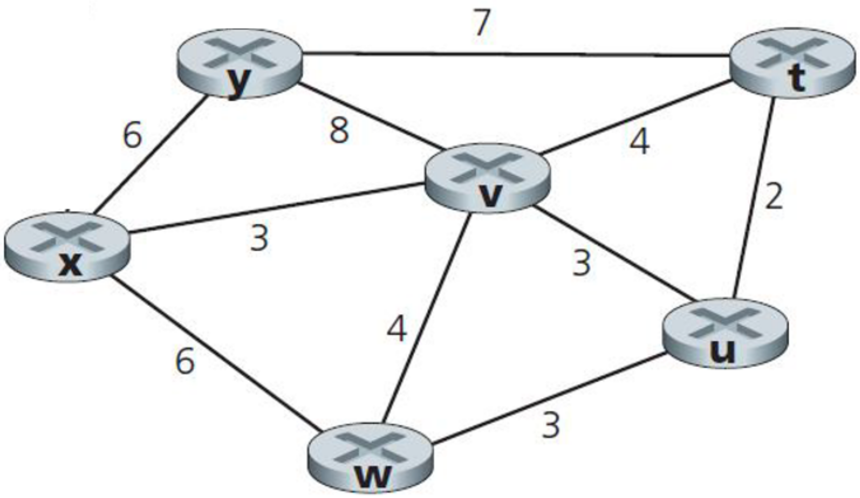


Question 7:

a) (8 points) In the network below, each link is bi-directional and symmetric. With the indicated link costs, use the Distance Vector algorithm to compute the shortest path from network node y to all other network nodes. Show the contents of the DV table for '**Node x**'. One row of the table is pre-populated for you.

Note: The actual exam will ask you to populate the DV table of a different node. The network's link weights may be different.

	Cost through immediate neighbors		
Destination	**v**	**w**	**y**
t			
u	6 (xvu)	9 (xwu)	15 (xytu)
v			
w			
y			



b) (4 points) A transport protocol adds a packet header consisting of the following fields to each packet.
Assume that each of the header fields in the transport layer occupies 4 bytes.

- destination_port
- source_port
- protocol_type
- num_packets
- sequence_number
- packet_size
- check_sum

A network layer protocol adds a datagram header consisting of the following two fields to each packet:

- ipv6 destination_IPaddress
- ipv6 source_IPaddress

A link-layer protocol adds a frame header consisting of the following two fields to each datagram:

- destination_MAC_address
- source_MAC_address

Each IPv6 address is 16 bytes and each MAC address is 6 bytes.

The link-layer operates on a Malav's link layer implementation that can transmit a total of 1590 bytes per frame.

i) Compute the maximum payload that can be sent in each packet on the wire. (2 points)

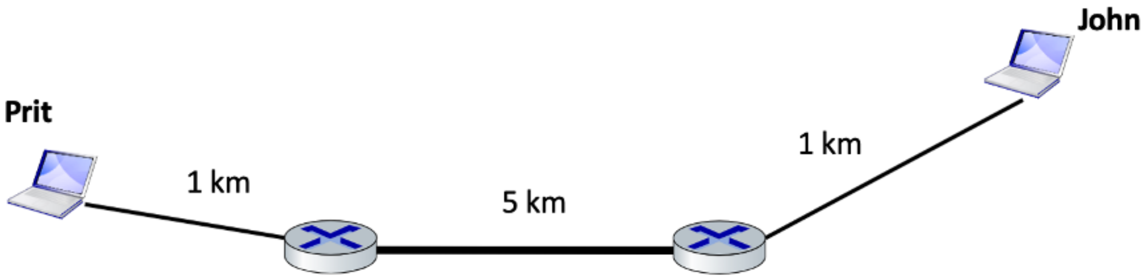
ii) Yesha wants to send a 94.875KB Word document to Andrej via the internet.
Assume that the protocol stack mentioned above minimizes the total number of packets that need to be sent. Assume the network is error free (no collision, no loss of packets, no packet corruption). Compute the number of packets required to send the Word document to Andrej. Show your work for credit. (2 points)

c) (5 points) Assume Prit wants to send a message consisting of 1000 packets to John using Malav's 'Sliding Window' reliable transport layer protocol implementation with a window size of 10 packets.

Assume that the network connecting Prit's and John's computers has the following characteristics:

- Transmission speed on the physical link = 2.5 * 10^8 meters/sec
- Packet loss = 20% (only for data packets; zero loss for ACKs)

- Sender overhead = 1 millisecond
- Receiver overhead = 2 milliseconds
- Assume **each router hop** adds a fixed **cumulative** routing plus queuing latency of 0.1 milliseconds.



Assume that the time to place the data packet and ACK on the wire are negligible compared to the propagation time on the medium.

What's the total elapsed time (in milliseconds) for Prit to be certain that the file has been successfully transmitted to John?

Question 8: (Hidden)
Question 9: (Hidden)