Engr 8893/9869 Final Exam

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Instructions: Answer all questions. Write your answers in the space provided. Request a yellow booklet if more space is required. This is an **closed** book test, no textbooks, notes, calculators, PDA's, Turing machines, telephones, time-machines, lamps containing wish granting genies, or oracles are permitted. Dictionaries are permitted.

Total points: 121

Name:

Student #:

Q0 [15]

Assume that an assertion P_c is associated with each condition variable c, M is the monitor invariant, respected by all public operations, and P_c and M do not depend on the "state" of the queues. Let L represent any assertion that only involves variables local to the process.

(a) State axioms for $\mathsf{signal}(c)$ and $\mathsf{wait}(c)$.

(b) Explain in plain English what these axioms mean.

(c) Now suppose that P_c and M may depend on the number of processes $\#c$ waiting on c. Now what are the axioms?

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Q1 [20]

A number of threads need to share N interchangeable nonpreemptable objects numbered from 0 to $N-1$. When a process needs an object it calls

procedure acquire(int &)

acquire returns the number of an object. Threads block in acquire until one of the N resources becomes available. When the thread no longer needs the object, it calls

procedure release(int)

with an argument that is the number of an object it has previously acquired but not released.

Write acquire and release using a monitor.

[Hint. Assume you can use standard operations on finite sets of integers]

Q2 [20]

A network of N servers gives out globally unique transaction numbers to any of M clients. Clients send messages on a channel from

chan[N] requestTN(int clientID) ;

to obtain a unique integer from the corresponding server. The servers reply with a message along a channel from

chan[M] sendTN(int TN) ;

Each server can hold only two blocks of consecutive transaction numbers at a time. When one block is empty, the server sends a message to a master server along a channel

chan masterRequest(int serverID) ;

The master eventually replies with the base and length of another number block along a channel from

chan[N] masterReply(int firstTN; int lengthOfBlock) ;

Servers should continue to dole out numbers while waiting for a new block, until both blocks have run out.

Using the pseudo-code, implement the server and master processes. (Treat int as consisting of all integers, so the master never runs out.)

[Hint: Use the in-ni statement so that servers can accept messages on either of two channels.]

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Q3 [18]

(a) Express the following property using propositional linear temporal logic: If r is ever true for two successive time steps, then at some time thereafter[1] q will become true and remain true forever.

(b) Can the following set of jobs be scheduled by rate monotonic scheduling. Explain

Job	Processing time	Period
J0	8	20
J1	5	50
J2	5	40

(c) What problem does the priority inheritance method solve?

(d) Define *speedup* and *efficiency*.

(e) Which is more powerful monitors or semaphores? Explain.

(f) What problem does Lamport's logical clocks solve?

[1] I.e. in or after the second of the two successive time steps when r is true.

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Q4 [20]
For this question assume the int type consists of all integers.

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int $x := 0$;
int $y := 0$;
boolean $done := false$;

____
co

    ____
    while(! $done$) {
        ____
        ⟨await($x \geq y$) $y := y + 1$;⟩
        ____
    }
    ____

//

    ____
    while(! $done$) {
        ____
        ⟨**await**($y \geq x$) $x := x + 1$;⟩
        ____
    }
    ____

//

    ____
    ⟨**await**($x > 100$) $done := true$;⟩
    ____

oc
____
$\{ y > 99 \wedge x > 100 \}$

(a) Complete the proof outline so that it shows $y > 99 \wedge x > 100$ is true upon termination.

(b) State all Hoare triples that need to be shown in order to demonstrate that the proof outline is interference free.

(c) For each of the following properties, is it a liveness or a safety property.

1. $x \leq y + 1 \wedge y \leq x + 1$ is true throughout the co statement ____________________
2. y is always less than 100____________________
3. If x is ever less than y then subsequently eventually x will be greater than y____________________
4. Termination____________________

(d) For each of the properties in part (c). Indicate whether the property is unconditionally true, false, or true conditional on a fairness assumption. Indicate the required fairness assumption

1. $x \le y + 1 \land y \le x + 1$ is true throughout the co statement ____________________________
2. y is always less than 100____________________________
3. If x is ever less than y then subsequently eventually x will be greater than y______________________
4. Termination____________________________

Q5 [15]

A cellular automaton consists of a undirected graph of *cells*. Each cell can be in any of a number of states. The state of a cell in the next time period is some function its current state and the states of its neighbors. Suppose that the graph is a large toroidal grid.

(a) Describe how a cellular automaton can be implemented on a shared memory machine where the number of cells is less than the number of processors.

(b) How would you modify your solution if the number of cells is much greater than the number of processors.

(c) How would you modify your solution if the processors do not share memory but must use relatively slow communication channels.

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Q6 [5]
(a) True or false

- 2 phase commit is resilient to intermittent failure of participants.____________
- 2 phase commit is resilient to intermittent failure commit manager.____________

(b) What are three strategies for concurrency control in *distributed* transaction processing.

Q7 [10]
(a) Explain the relative merits and demerits of the following three methods of achieving confidence in concurrent programs and algorithms.

- Testing
- Automated state space exploration
- Manual proof using a logic such as PL

Best of luck on your remaining exams and future careers whether within or without the university.