FINAL EXAM (April 30, 2002)

COP 6617 Distributed System Design

Open books and notes

Name ————————————————- SSN ————————————————-

1. (5 pts, **one** out of two)
   (a) Give **two major challenges** in designing routing protocols in ad hoc wireless networks.
   (b) What **PVM** and **MPI** stand for?

2. (5 pts, **one** out of two)

   (a) Implement a **barrier synchronization** between two processes using two semaphores (and initialize both semaphores).

   (b) Using **Petri nets** to model a three-stage pipeline representing an assemble process. The Petri nets is defined in such a that it will never dies, and during the execution, at most one token may appear in each place.

3. (15 pts)

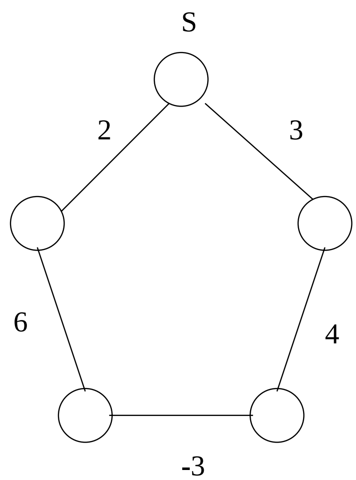
   (a) Express the following DCDL expression $[S_1; [S_2 \| S_3]] \| [S_4 \| S_5]$ in a precedence graph.

   (b) Express the expression using fork/join.

4. (25 pts)

(a) In the Dijkstra's algorithm, it is required that all edges are **non-negative**. Apply the Dijkstra's algorithm to the graph given below with S being the source. What kind of problem will appear?

(b) Suppose the negative edges are allowed, but there exists no negative cycle. Provide a **sufficient condition** related to network topology and/or costs of edges such that the Dijkstra's algorithm works correctly. (The weakness of the sufficient condition is not a concern here.)



5. (25 pts) Maria proposes a new turn model called **credit-based turn model**. A credit-based negative-positive model means that only negative to positive turn is allowed. One credit is recorded after such a turn and is associated with the routing packet (the initial credit is assumed to be zero). Any other turn is allowed only when the credit associated with the packet is non-zero (and credit will be reduced by one after the turn). Note that a turn here means a 90-degree turn.

   (a) List all possible turns.

   (b) Will credit-based turn model cause deadlock?

   (c) Can a message from a give source reach any location, and why?

6. (25 pts) In **Byzantine agreement protocol** $k+1$ rounds of message exchanges are needed to tolerant k faults. The number of processes n is at least $3k+1$. Assume P_1 and P_2 are faulty in a system of $n = 7$ processes.

   (a) Show the messages P_3 receives in first, second, and third round.

   (b) Demonstrate the correctness of the protocol by showing the final result vector (after a majority voting) for P_3.

   (c) Briefly show that result vectors for other non-faulty processes are the same.

Bonus Problem (10 additonal pts)

To support fault-tolerant routing in 2-D meshes, D. J. Wang (1999) proposed the following new model of faulty block: Suppose the destination is in the first quadrant of the source. Initially, label all faulty nodes as *faulty* and all non-faulty nodes as *fault-free*. If node u is fault-free, but its north neighbor and east neighbor are faulty or useless, u is labeled *useless*. If node u is fault-free, but its south neighbor and west neighbor are faulty or can't-reach, u is labeled *can't-reach*. The nodes are recursively labeled until there are no new useless or can't-reach nodes.

(a) Give an intuitive explanation of useless and can't-reach.

(b) Re-write the definition when the destination is in the second quadrant of the source.