INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR Department: Computer Science and Engineering
Spring Semester: 13
Full Marks: 75
Sub. No: CS60002 Sub. Name: Distributed Systems

Answer as much as you can

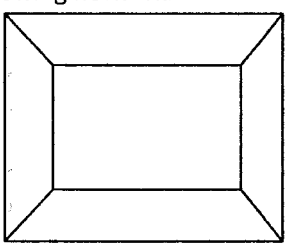
1. (i)In distributed balanced sliding window protocol two processes p and q are exchanging packets between themselves. discuss scenarios when following conditions are true [S_p is the index of next expected packet from process Q in process P, a_p is the index of lowest number word for which process P has not received any acknowledgement (implicit) yet from process Q, l_p and l_q are non negative constant where $l_p+l_q>1$]

   a. $S_p - l_q = a_p$
   b. $a_p = s_q$
   c. $s_q = a_p + l_p$

   (ii) Answer following questions regarding mutual exclusion
   a. Provide an example to show that Maekawa's mutual exclusion algorithm is not a deadlock free mutual exclusion algorithm.
   b. Build a valid request set for Maekawa's algorithm of 7 processes.

2+2 + 2+ 2+3=11

2. Answer the following questions from deadlock free packet switching
   a. If an acyclic orientation cover for P of size B exists, then there exists a Deadlock Free Controller with only B buffers at each node.
   b. Find acyclic covers for the following network.



3+3=6

3. Consider the following CHORD ring and answer the following questions
   a) Assume that hash key of a file is mapped to 7. Also assume that a search for the same file is inititated from node 1. During the search of the file a number of nodes and few entries of finger tables of those nodes will be examined. Populate a table in sequence of visit with format given below.

Visit id	Node id	Finger table index	Comments
1			
2			
...	...	...	...

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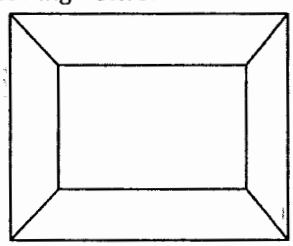

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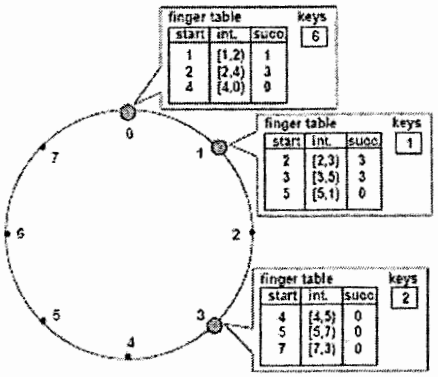
b) Assume a new node is being inserted with hash value 6 and bootstrapping node is node 1. Write down actions taken by existing node and new joinee node. Draw current ring with updated finger tables.

4+6=10



4. Answer following questions from self stabilization

a) Let us assume a system of n clocks in a chain ticking at the same rate. Each clock is 3-valued, i,e it ticks as 0, 1, 2, 0, 1, 2... A configuration is valid when all clocks are in same phase. A failure may arbitrarily alter the clock phases. The clocks phases need to be stabilized, i.e. they need to return to the same phase. Design a set of rules for this.

b) Show changes of clock value till stabilization with a system with 5 clocks with initial configuration {0 2 1 0 1}.

4+3=7

5. Answer following questions from leader election algorithms

a) Is leader election possible in a ring in which all but one processor has the same identifier? Give Proof Propose the algorithm or disprove.

b) Modify the LeLann & Chang-Robert's algorithm for leader election to elect 2 leaders in a unidirectional ring (two processes with the highest IDs, use minimum buffers).

c) Write a code-snippet to explain extinction of waves in echo algorithm (only needed part).

d) Prove that, leader election problem and minimum spanning tree problem are of same order of magnitude in terms of complexity.

2 + 3 + 3 +4 = 12

6. In the GHS algorithm, let's say there are two fragments F1 and F2 with level L1 and L2. Let P be a node belonging to fragment F1 issues a connect request to node Q belonging to fragment F2. Please answer the following questions for L1<L2.

a) Is the connection request from P to Q always accepted immediately? If not what are the conditions?

b) Q issues an initiate message if the connection request is accepted. What are the parameters of the initiate message?

c) Let's assume PQ is the minimum outgoing edge from fragment F2. What would be the value of state parameter sent along initiate message? Justify your answer.

d) If PQ is not minimum outgoing edge for fragment F2 then what would be the value of state parameter sent from Q to P? Justify your answer.

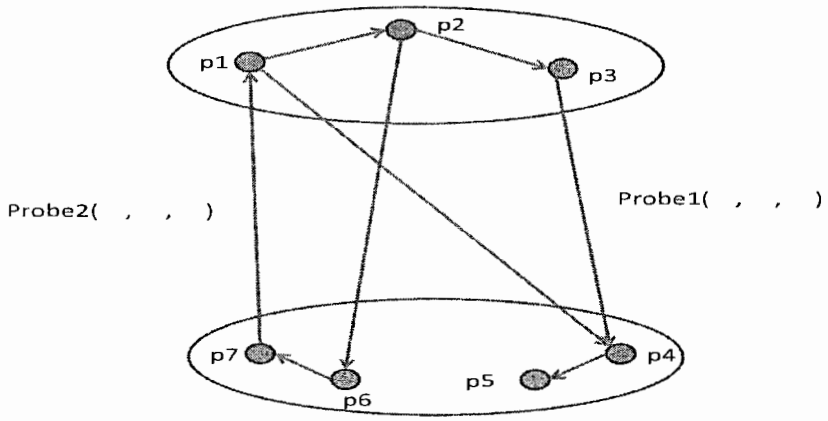
1+1+2+2 = 6

7. Consider the following algorithm for failure detection among n processes. Each process picks k other processes at random and sends heartbeat messages to each of those processes. If a process P_i receives a heartbeat message from process P_j, it will expect further heartbeats to arrive from P_j at regular intervals. If they stop, after some timeout, P_i declares P_j as failed process and broadcasts this to all of the other processes. Suppose m random processes fail at once. What is the probability that not all failures will be detected? You have to clearly state the scenario when detection would not be possible.

5

8. Answer following questions

a. Assume Probe1 and Probe2 both are initiated by process p1. Fill in the probe messages that are passed, in the Chandy-Misra-Haas Algorithm.



b. Given Path pushing and Edge chasing algorithms - how is one better than the other in terms of message size?

c. Derive the upper bound on number of messages exchanged in Chandy-Misra-Haas algorithm (AND model)(Edge chasing) for m processes and n sites. What is the delay in detecting a deadlock?

2 + 2 + 3 (2+1) =7

9. Answer following questions from agreement protocol

a. Prove with an example that in Byzantine General's Problem with m faulty generals, no solution is possible if total number of generals n < 3m+1(Show with n = 3,m=1)

b. In Phase king algorithm,

(i) Prove that if king of phase k is non-faulty then at the end of phase k, all non faulty processors have same preference.

(ii) How many rounds are required to come into consensus if there are at most f faulty processors?

(iii) What is the message complexity? Justify.

(iv) Prove that if they reach consensus once, they will stick to the consensus arrived.

3 + 3 + 1 + 2 + 2 =11