Assignment-II Solutions: Distributed Systems (Week-2)

Q. 1 Consider the following statement:

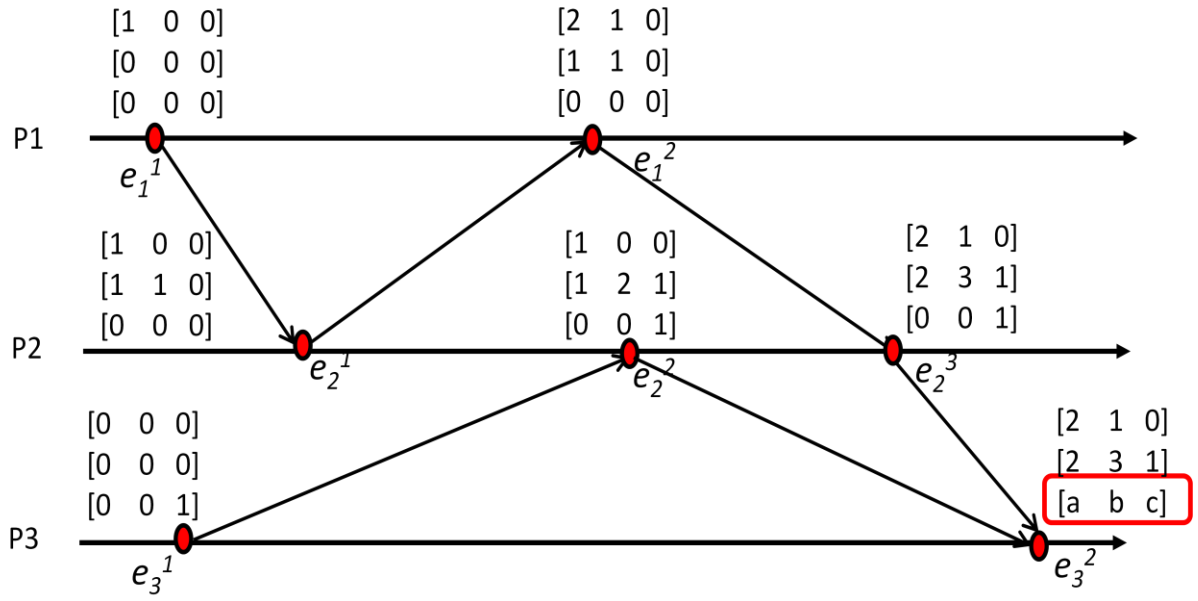
The Chandy-Lamport global snapshot algorithm works correctly for non-FIFO channels.

A. True
B. False

Ans: B. False

Explanation: Chandy-Lamport global snapshot algorithm requires FIFO channels

Q. 2 Find out the correct matrix clock values of a, b, c at P3 process as highlighted in the given figure:

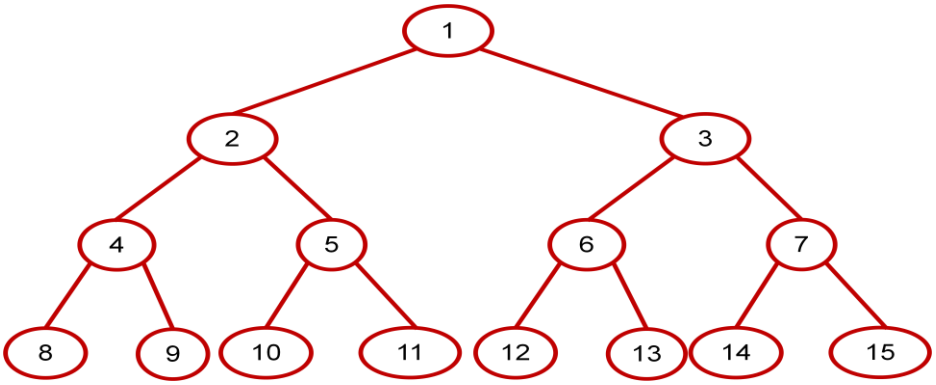


A. [0 0 2]
B. [2 3 1]
C. [2 3 2]
D. [0 0 1]

Ans: C. [2 3 2]

Explanation: Solved by the property of Matrix Clocks

Q. 3 Consider a tree structured quorum with 15 sites as shown in below figure:



when node 2 fails, the possible quorums can be formed as:

A. {1-2-4-8}, {1-2-4-9}, {1-2-5-10}, {1-2-5-11},{1-3-6-12}, {1-3-6-13}, {1-3-7-14} and {1-3-7-15}
B. {1-4-8-5-10}, {1-4-8-5-11}, {1-4-9-5-10}, {1-4-9-5-11}, {1-3-6-12}, {1-3-6-13}, {1-3-7-14} and {1-3-7-15}
C. {1-3-6-12}, {1-3-6-13}, {1-3-7-14} and {1-3-7-15}
D. {1-4-8-5-10}, {1-4-8-5-11}, {1-4-9-5-10}, {1-4-9-5-11}

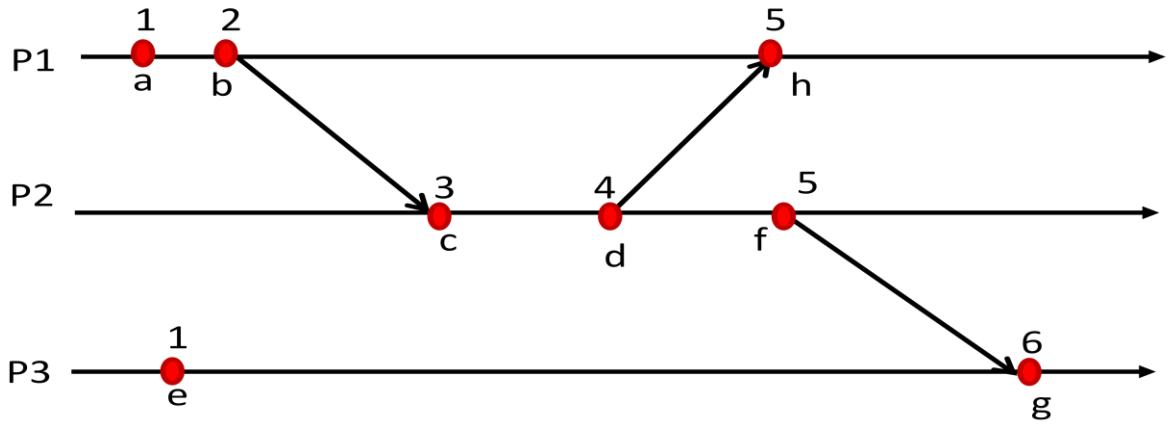
Ans: B. {1-4-8-5-10}, {1-4-8-5-11}, {1-4-9-5-10}, {1-4-9-5-11}, {1-3-6-12}, {1-3-6-13}, {1-3-7-14} and {1-3-7-15}

Explanation: If any site fails, the algorithm substitutes for that site two possible paths starting from the site's two children and ending in leaf nodes.

For example, when node 2 fails, we consider possible paths starting from children 4 and 5 and ending at leaf nodes. The possible paths starting from child 4 are 4-8 and 4-9, and from child 5 are 5-10 and 5-11. So, when node 2 fails, the following eight quorums can be formed:

{1-4-8-5-10}, {1-4-8-5-11}, {1-4-9-5-10}, {1-4-9-5-11}, {1-3-6-12}, {1-3-6-13}, {1-3-7-14} and {1-3-7-15}

Q. 4 Consider the following figure:



Specify how many possible consistent cuts are there that contain the event h.

A. 2
B. 3
C. 4
D. 5

Ans: D. 5

Explanation: There are total five possible consistent cuts that contain the event h.

Q. 5. For each critical section (CS) execution, Ricart-Agrawala algorithm requires _____ messages per CS execution and the Synchronization delay in the algorithm is _____.

A. 3(N − 1), T
B. 2(N − 1), T
C. (N − 1), 2T
D. (N − 1), T

Ans: B. 2(N − 1), T

Explanation: For each CS execution, Ricart-Agrawala algorithm requires (N − 1) REQUEST messages and (N − 1) REPLY messages. Thus, it requires 2(N − 1) messages per CS execution. Synchronization delay in the algorithm is T.

Q. 6 The properties hold for quorums in a coterie are:

A. Total ordered set and Minimality property
B. Partial ordered set and Intersection property
C. Minimality property and Intersection property
D. Graceful degradation and Relinquish property

Ans: C. Minimality property and Intersection property

Explanation:

A **coterie *C*** is defined as a set of sets, where each set g ∈ C is called a **quorum.** The following properties hold for quorums in a coterie:

Intersection property: For every quorum g, h ∈ C, g ∩ h ≠ ∅.
For example, sets {1,2,3}, {2,5,7} and {5,7,9} cannot be quorums in a coterie because the first and third sets **do not have a common element**.
Minimality property: There should be no quorums g, h in **coterie C** such that **g** ⊇ **h**.
For example, sets {1,2,3} and {1,3} cannot be quorums in a coterie because the first set is a superset of the second.

Q. 7 The Network Time Protocol (NTP) which is widely used for clock synchronization on the Internet uses the _____method. The design of NTP involves a _____of time servers

A. Differential delay, Binary tree
B. Offset Delay Estimation, Hierarchical tree
C. NTP timestamps, Quorum
D. Roundtrip delay, Hierarchical tree

Ans: B. Offset Delay Estimation, Hierarchical tree

Explanation:

The Network Time Protocol (NTP) which is widely used for clock synchronization on the Internet uses the Offset Delay Estimation method.

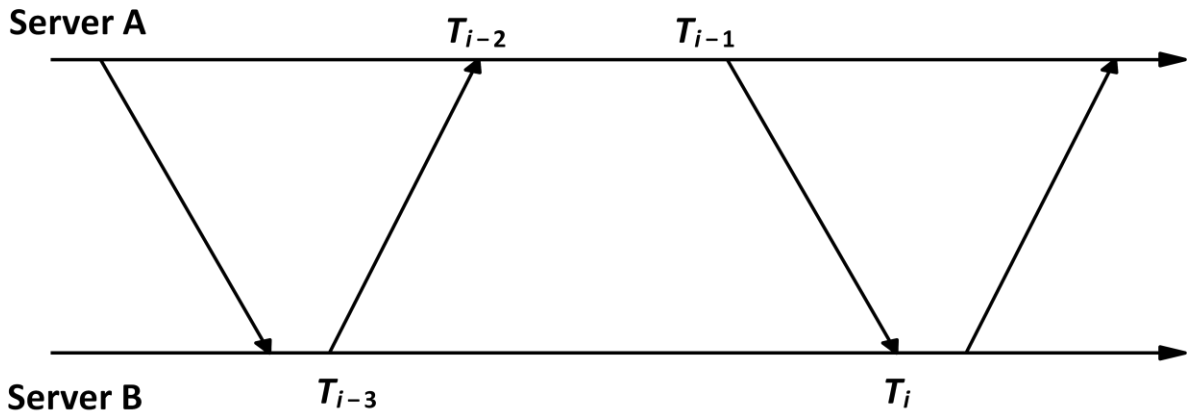
The design of NTP involves a hierarchical tree of time servers:

(i) The primary server at the root synchronizes with the UTC.

(ii) The next level contains secondary servers, which act as a backup to the primary server.

(iii) At the lowest level is the synchronization subnet which has the clients.

Q. 8 Consider the following timing diagram for the two servers:



The **offset O_i** and **round-trip delay D_i** can be estimated as:

A. $O_i = (T_{i-2} - T_{i-3} + T_{i-1} - T_i)/2$ and $D_i = (T_i - T_{i-3}) - (T_{i-1} - T_{i-2})$
B. $O_i = (T_{i-2} - T_i)/2$ and $D_i = (T_i - T_{i-2})$
C. $O_i = (T_{i-2} - T_{i-3} + T_{i-1} - T_i)$ and $D_i = (T_i - T_{i-2})$
D. $O_i = (T_{i-2} - T_{i-3} + T_{i-1} - T_i)$ and $D_i = ((T_i - T_{i-3}) - (T_{i-1} - T_{i-2}))/2$

Ans: $O_i = (T_{i-2} - T_{i-3} + T_{i-1} - T_i)/2$ and $D_i = (T_i - T_{i-3}) - (T_{i-1} - T_{i-2})$

Explanation: Derived from the derivation of Clock offset and delay estimation in the Network Time Protocol (NTP)

Q. 9 At 8:27:340 (hr, min, 1/100 sec.), server B requests time from the time-server A. At 8:27:510, server B receives a reply from timeserver A with the timestamp of 8:27:275.

Find out the drift of B's clock with respect to the time-server A's clock (assume there is no processing time at the time-server for time service).

A. 2 sec
B. 3 sec
C. -1.5 sec
D. -2 sec

Ans: C) -1.5 sec

Explanation: RTT: Reply – Request = 510-340 = 170 1/100sec.

Adjusted local time: Server + RTT/2 = 275 + 85 = 360 1/100sec.

Drift: Adjusted local time – local time = 360 – 510 = -150 1/100sec. = -1.5 sec

Q. 10 The global state recording part of a single instance of the Chandy-Lamport algorithm requires _____ messages and _____ time, where e is the number of edges in the network and d is the diameter of the network.

A. O(loge), O(d)
B. O(e), O(logd)
C. O(e), O(2d)
D. O(e), O(d)

Ans: D. O(e), O(d)

Explanation: The recording part of a single instance of the algorithm requires O(e) messages and O(d) time, where e is the number of edges in the network and d is the diameter of the network.

Q. 11 For each critical section (CS) execution, maekawa's algorithm requires _____ messages per CS execution and the Synchronization delay in the algorithm is _____.

A. $\sqrt{N}$, T
B. $2\sqrt{N}$, T
C. $3\sqrt{N}$, T
D. $3\sqrt{N}$, 2T

Ans: D. $3\sqrt{N}$, 2T

Explanation: Since the size of a request set is $\sqrt{N}$, an execution of the CS requires $\sqrt{N}$REQUEST, $\sqrt{N}$REPLY, and $\sqrt{N}$RELEASE messages, resulting in $3\sqrt{N}$ messages per CS execution.

Synchronization delay in this algorithm is 2T . This is because after a site Si exits the CS, it first releases all the sites in Ri and then one of those sites sends a REPLY message to the next site that executes the CS.

Q. 12 Agarwal-El Abbadi quorum-based algorithm uses _____where All the sites in the system are logically organized into a _____

A. Coteries, Binary Tree
B. Tree-structured quorums, Complete binary tree
C. Grid, List
D. Unrooted Tree Structure, AVL Tree

Ans: B) Tree-structured quorums, Complete binary tree

Explanation: Agarwal-El Abbadi quorum-based algorithm uses '**tree-structured quorums**'. All the sites in the system are logically organized into a **complete binary tree.**

•For a complete binary tree with **level 'k'**, we have **2*k* +1 – 1 sites** with its root at level k and leaves at level 0.