FINAL EXAM (May 8, 2023)
CIS 5644 Distributed
Computing Open books and notes

Name_____

1. (20%) Give a **Yes/No** answer to each question below and then provide a **brief explanation:**

   - Multicasting is usually more difficult to implement than broadcasting in a distributed system.

   - Two virtual channels are sufficient to avoid deadlock in a k-way train station. We assume that a train can enter from direction i and exit to direction j, where i, j is from {1, 2, …, k}.

   - In a system with one fail-stop node and one Byzantine faulty node, at least 7 nodes are needed for non-faulty nodes to reach a consensus.

   - When all nodes are present, an n-node ($n = 2^k$) structured P2P CHORD resembles a hypercube.

   - Write-invalidation is easier to implement compared to write-through in a system with multiple copies of a data item.

2. (20%) Provide an example of two transactions T_1 and T_2 that involve three data objects A, B, and C. T_1 and T_2 have at least one common object to access. Your example shows that the two-phase locking runs faster than a serial schedule, if lock/unlock time is negligible.

3. (20%) Suppose 25 nodes are organized in a two-level clustering, with 5 nodes in each cluster 5 nodes.

    a. Enumerate all possible two-level read and write quorum assignments. Note that the quorum assignments at different levels are not necessarily the same, but they are the same within each level. For example, (r, w) is (3, 3) at the upper-level while (r, w) is (2, 4) at the lower-level.

    b. Find a two-level quorum assignment that has the minimum effective read and write quorums.

4. (20%) Apply the Johnson's rule to schedule four map-shuttle tasks (m, s): (2, 5), (6, 3), (5, 4), (5, 6) that achieve the minimum total execution time, assuming map and shuttle cannot be overlapped. Provide a simple intuitive explanation of the Johnson's rule. For example, why minimum of the first stage should be at the front, while why minimum of the second stage should be at the end.

5. (20 %) In an extended safety level model with faulty links. Two end nodes of a faulty link are treated as faulty (i.e., with safety level being zero). Find safety levels for a 3-cube with one faculty link (100, 101) (a link connecting two end nodes 100 and 101) and one faulty node 011. Show how an optimal broadcasting from 100 using the safety level is completed. Discuss any other possible extensions.