

# Politecnico di Milano

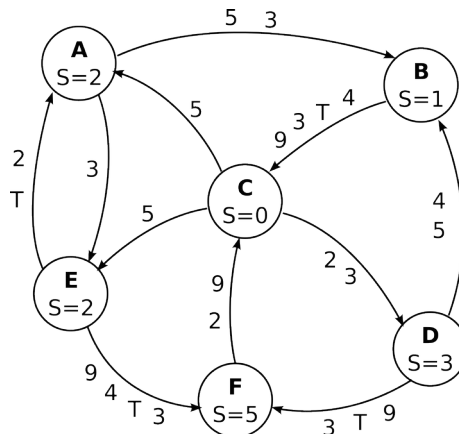
## 090950 – Distributed Systems

Prof. G. Cugola – November 18<sup>th</sup>, 2023

Rules:

- You are not allowed to use books, notes, or other material.
- You can answer in Italian or English.
- Total time for the test: 2 hours.

1. You want to implement your own streaming library for a video service on the Internet. Describe the specific requirements of a similar service that do not fit the characteristics of the IP protocol and the mechanisms that you could put in place to address those limitations.
2. Describe how scalar clocks can be used to implement a totally ordered multicast communication (clarify the assumptions for the protocol to work). Compare this solution with a solution based on a centralized server in charge of receiving messages via point-to-point links and dispatching them (via point-to-point links) to every group member. Focus your comparison on the traffic generated by the two solutions and the assumptions for the two protocols to operate correctly.
3. Consider the system in figure, which is running a distributed snapshot. Suppose that every process works by adding the value held by the received messages to its internal state  $S$ . Process A started the snapshot, recording state 2 and sending the tokens to processes B and E, which already processed them and sent out their own tokens. Show the state captured by every node at the end of the snapshot (local state and messages recorded for each link). Clarify the assumptions you made to come to the result. *NOTE: There is a “spurious” message in the figure: which one? Identify and remove it before running the snapshot.*



4. Describe pessimistic timestamp ordering: which problem does this protocol address? How does it work? In a system, with few requests to manage per second and a large dataset to access, would you use pessimistic or optimistic timestamp ordering and why?
5. Consider the following schedule of read and write operations on a replicated data store. Is the schedule consistent with the FIFO, causal, and sequential consistency models? By looking at this schedule, what can we infer about the consistency model of the data store? Motivate your answers.

|    |        |        |        |        |        |
|----|--------|--------|--------|--------|--------|
| P0 | W(x) 2 | W(x) 5 | R(x) 4 | W(y) 3 |        |
| P1 | W(y) 1 | W(x) 4 | R(y) 1 | R(y) 3 | R(x) 4 |
| P2 | R(y) 1 | R(x) 4 | R(x) 5 | R(y) 3 |        |

6. Three peers (IDs = 2, 9, 12) participate in a circular DHT with finger table using the CHORD protocol. Assume that the DHT uses 4-bits to represent the node IDs and the Keys. (a) Show the routing tables of the three peers. (b) Peer 2 wants to retrieve the value of an object having key 10. Show the exchange of messages required to search the desired value.
7. Consider the Raft consensus protocol. Which problem does it solve? Under which assumptions? Does the protocol guarantee safety (it is always correct) and liveness (it always makes progress)? Motivate your answers