Assignment 3 Lab Report:
RCO : Causal-Order Broadcast

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1 | Purpose

The purpose of this lab assignment is to implement a causal-order Byzantine broadcast Algorithm that is desgined to work in a complete netwrok with up to f faulty node.

The Report also examines possible Malicisous Action a Byzantine Node can perform and its impact on the whole network.

2 | Expeirmental Setup

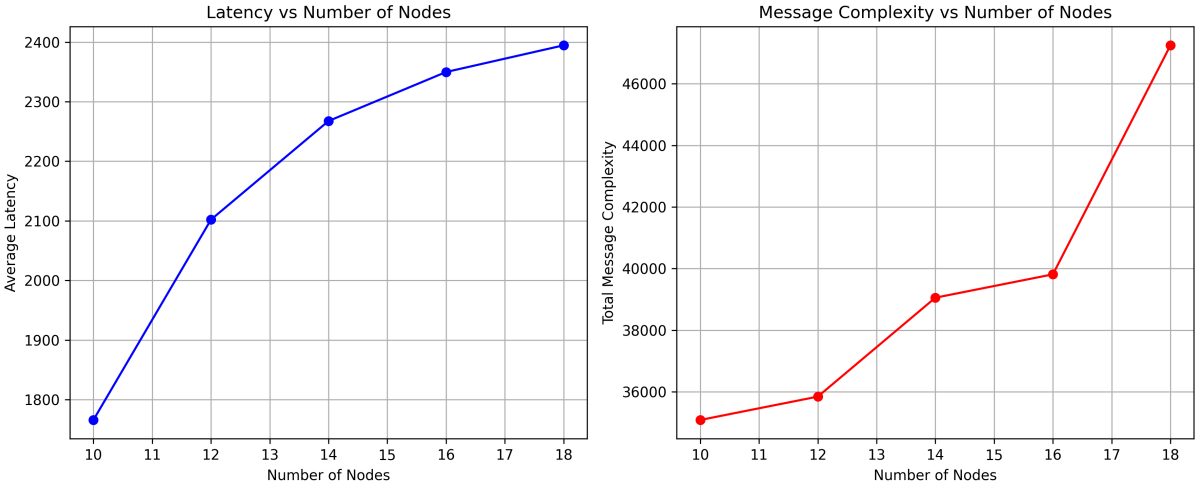
Paramete Name	Values
Number of Nodes	10
Graph Connectivity	6
Number of Failure Nodes	0-2
Number of Broad Casters	3
Number of Distinct Messages	5

In this experiment, the broadcaster will initiates a process by broadcasting a message, which triggers a chain reaction: upon a selected nodes from their predecessors, they will genereate a new message and broadcast it to the Network, simulating a causal-order event chain like $m_1 \rightarrow m_2 .... \rightarrow m_n$

3 Result

3.1 Latency and message complexity for one RCO-Broadcast Operation

In this metric, the experiment was conducted on a 8-connected graph, with 10 to 18 nodes, and 2 distinct messages broadcasting across the network.



3.2 | Byzantine Behaviour and Its Impact

There is several ways that a Byzantine Node can disrupt the RCO Protocols in Several ways, Such as :

1. **Message Dropping**:
   A faulty node can selectively drop a message that is delivered to it
   - Impact :
     - Breaks causal chains, potentially leading to incorrect delivery order at correct processes.
     - Can cause indefinite waiting in correct processes expecting causally related messages.
2. **Manipulate Incorrect Vector Clock (Artificial Boosting Attack)**:
   Byzantine Node p_k Manipulate all values in the vector clock VC[rank(p_j)] $\forall$ correct node p_j.When the Byzantine node send this manipulated vector clock to a correct process, the correct process recieve this false vector clock and propogate it throughout the system.
   - Impact :
     - True Causal Order is disrupted as false dependencies created beween messages
     - True node may faulty deliver a Message even though causal dependencies are not satisfied
     - legitimate message may be never delivered as causal dependencies will never be satisfied
3. **Message Delayed** :
   Byzantine process delivered a message from another process. But instead of immediately forwarding or processing the messsage, it can hold the message for an arbitary amount of time until it is broadcasted to others but much later then expected.
   - Impact:
     - Disruption of Causal Order that may lead to incorrect delivery order at any correct process
     - Increased Latency across all network as Message delivery time is manipulated.
     - A correct node have no way to differentiate bettwen such a Byzantine p_i is delaying the message or a correct p_j that is experiencing very slow communcation

4 | Conclusion

In conclusion, the experiments show that RCO Protocols can be used to achieve causal-order broadcast. With the increase of Node numbers, the latency and message complexity of the RCO Protocols also increase.

Besides, the RCO Protocols can be disrupted by Byzantine Nodes in several ways, such as message dropping, incorrect vector clock manipulation, and message delay. These disruptions can lead to incorrect delivery order at correct processes, and increased latency across the network.