# Distributed Mutual Exclusion Algorithms II

Different Approaches


1

## Outline


- Ricart-Agrawala algorithm
- Token based algorithm for Ring topology
- Raymond's algorithm
- Limitations of Raymond's algorithm
- Quorum based algorithm

30 May 2024

2

## Latency and Raymond's Algorithm

- The process of decision making takes place in multiple number of nodes.
  - There could be a high latency involved in the process.
  - The amount of latency depends on number of concurrent requests and height of the tree.
  - It may be worth keeping in mind that the inverted tree structure does not assume that it's a height-balanced tree.

3

## Deadlock and Raymond's Algorithm

- Deadlock may occur if and only if one or more of the following conditions are true:
  1. Token cannot be transferred to a node because no node holds the privilege.
  2. $P_{hold}$ is unaware that there are other nodes requiring the token.
  3. The token does not reach the requesting node.

4

## Deadlock and Raymond's Algorithm

1. Token cannot be transferred to a node because no node holds the token.
   - This scenario can not occur for Raymond's algorithm because we have assumed that the network is reliable, and messages are not lost.

5

## Deadlock and Raymond's Algorithm

2. $P_{hold}$ is unaware that there are other nodes requiring the token.
   - The algorithm ensures that a node that needs the token sends a REQUEST message either to $P_{hold}$ directly or to a node that has a path to $P_{hold}$.
   - Thus condition 2 can never occur.

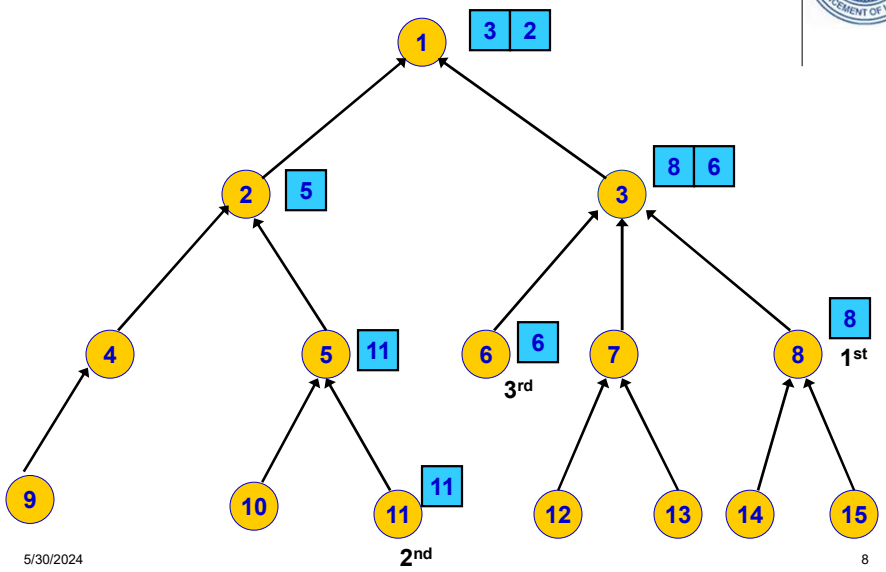
6

## Deadlock and Raymond's Algorithm

3. The token does not reach the requesting node.
   - The series of REQUEST messages are saved in the local Qs in various nodes such that the REQUEST Qs of those nodes collectively provide a logical path for the transfer of the token from $P_{hold}$ to the requesting nodes.
   - Thus, scenario 3 too can never occur.

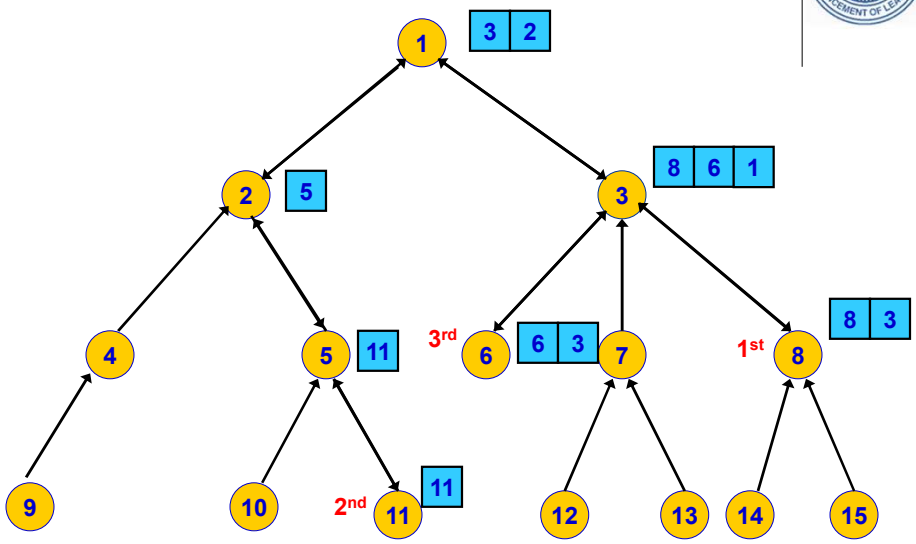
7

## Raymond's Algorithm and Fairness




8

# Raymond's Algorithm and Fairness






9

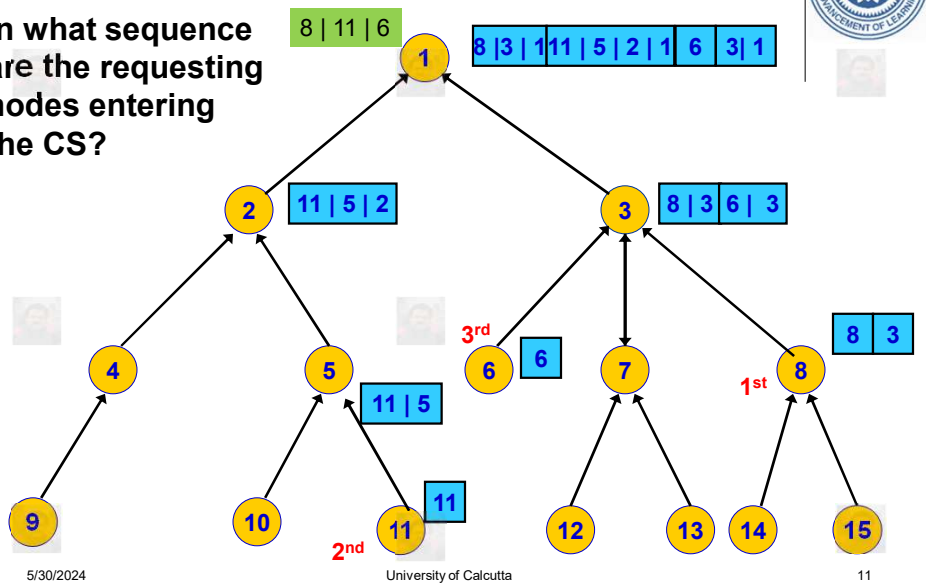
# How do you solve?



10

# Modified Raymond's Algorithm(MRA)

**In what sequence are the requesting nodes entering the CS?**






11

# Starvation and Raymond's Algorithm

- When a node, say A, requests for the token from $P_{hold}$, the identity of A or the ids of intermediate proxy nodes for node A will be present in the REQUEST Qs of various nodes in the path connecting the requesting node to the current $P_{hold}$.
- Thus, depending upon the position of the id of node A in those REQUEST Qs, node A will receive the privilege, sooner or later.

12

## Outline

- Ricart-Agrawala algorithm
- Token based algorithm for Ring topology
- Raymond's algorithm
- Limitations of Raymond's algorithm
- Quorum based algorithm

30 May 2024

13

## Coteries and Quorums

- A Coterie C is defined as a set of sets, where each set g ∈ C is called a Quorum.
- The following two properties hold for Quorums in a Coterie:
  - Intersection Property
  - Minimality Property

30 May 2024

14

## Properties of Quorums

- Intersection Property
  - ∀g ∀h ∈ C, g ∩ h ≠ ϕ.
  - e.g., sets {1,2,3}, {2,5,7} and {5,8,9} cannot be quorums in a coterie as the first and third sets do not have a common element.
- Minimality Property
  - No quorums g, h ∉ C: (g ⊇ h) ∨ (h ⊇ g).
  - e.g., sets {1,2,3} and {1,3} cannot be quorums in a coterie as {1, 2, 3} ⊇ {1, 3}.



15

## Basic Idea for Quorum-based DME

- Let *a* be a site in quorum A.
- If *a* wants to invoke mutual exclusion, it requests permission from all sites in its quorum A.
- Every site does the same to invoke mutual exclusion.



16

## Basic Idea for Quorum-based DME

- As per Intersection property, quorum A contains at least one common site included in a quorum for every other site in the coterie.
- These common sites send permission to only one site at any time.



17

## Basic Idea for Quorum-based DME

- Thus, safety in execution is guaranteed.
- Minimality property ensures efficiency rather than correctness
- While designing for individual Quorum-based algorithms, one has to ensure
  - Liveness
  - Deadlock-free execution



18

## Quorum based DME Algorithms

- Let's assume two lists in every site $S_k$:
  - The first list $R_k$ is called request set.
  - It contains IDs of the sites from which $S_k$ must acquire permission before its CS.
  - The second list $RP_k$ is called response set.
  - It contains IDs of the sites to which $S_k$ must send its permission to execute CS after executing its own CS.

30 May 2024

19

## Quorum based DME Algorithms

- Quorum-based DME algorithms are different in the following two ways:
  - A site does not request permission from all other sites, but only from a subset.
  - The request set of sites are chosen such that $\forall m\ \forall n: 1 \leq m, n \leq N :: R_m \cap R_n \neq \phi$.
  - Consequently, every pair of sites has at least one site that arbitrates between that pair.

30 May 2024

20

## Quorum based DME Algorithms

- A site can send out only one REPLY message at any time.
  - A site can send a REPLY message only after it has received a RELEASE message for the previous REPLY message.





## Thanks for your kind attention

## Questions??