ResilientDB: Global Scale Resilient Blockchain Fabric.

Rohan Sood, Utkarsh Drolia, Ashwitha Kassetty, Kunlin Tan, Alejandro Armas

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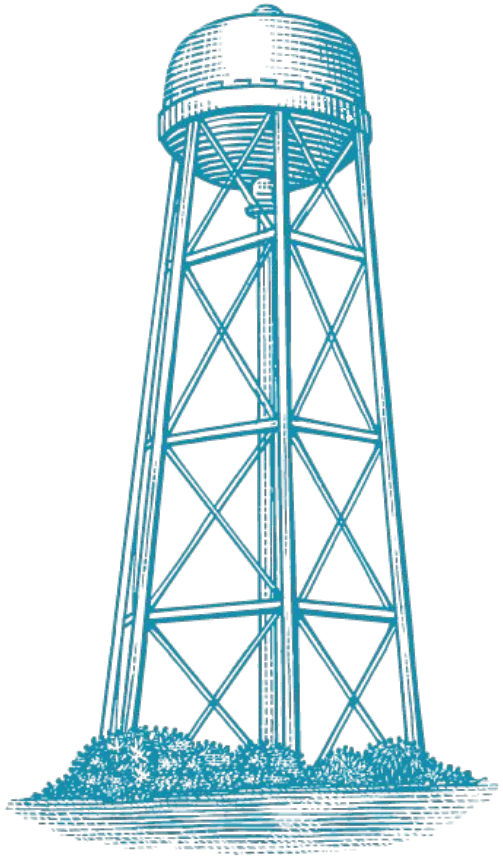

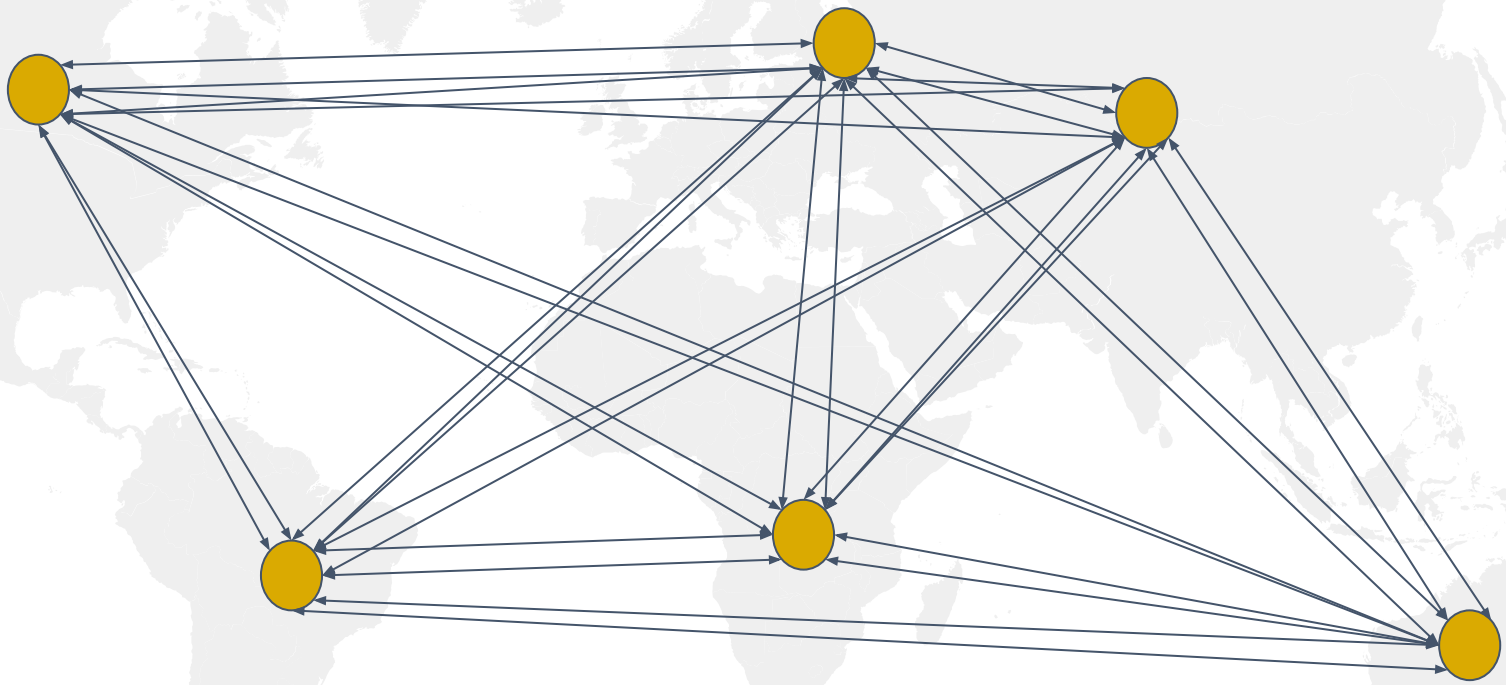

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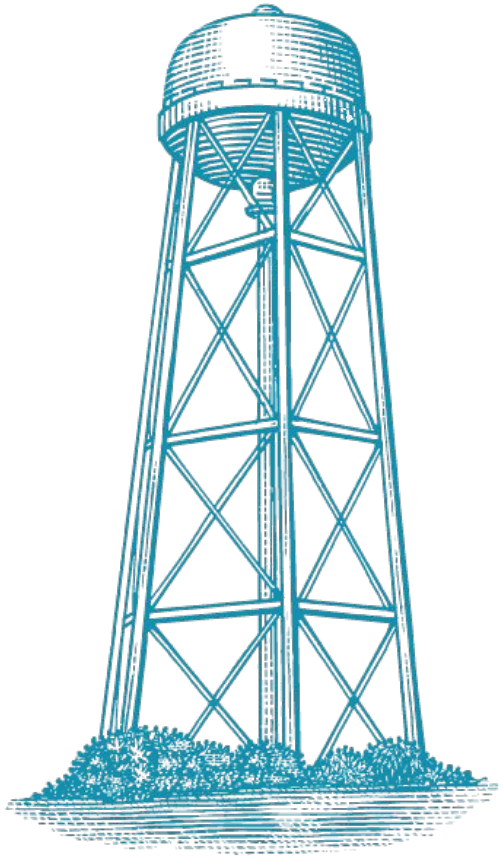

What do you think is going wrong?

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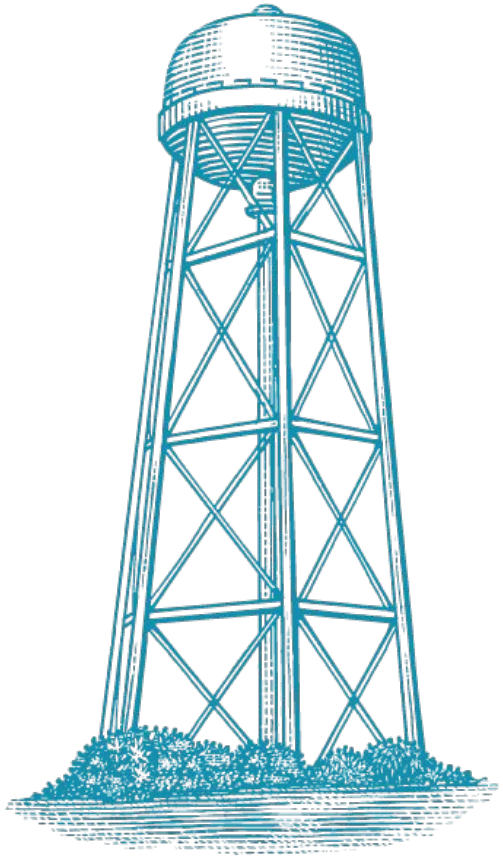
Latency speeds



	Ping round-trip times (ms)						*Bandwidth* (Mbit/s)					
	O	I	M	B	T	S	O	I	M	B	T	S
Oregon (O)	≤ 1	38	65	136	118	161	7998	669	371	194	188	136
Iowa (I)		≤ 1	33	98	153	172		10004	752	243	144	120
Montreal (M)			≤ 1	82	186	202			7977	283	111	102
Belgium (B)				≤ 1	252	270				9728	79	66
Taiwan (T)					≤ 1	137					7998	160
Sydney (S)						≤ 1						7977

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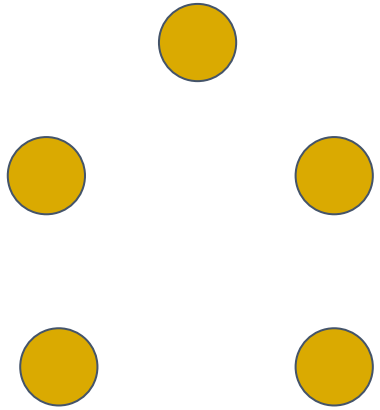
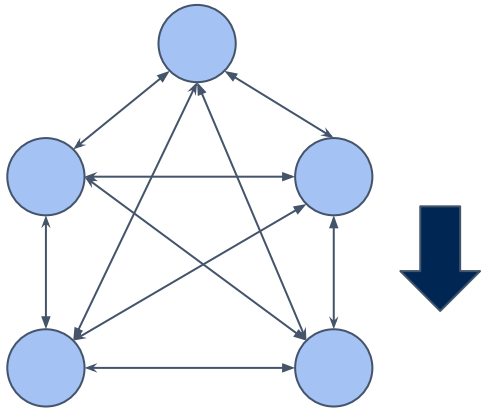
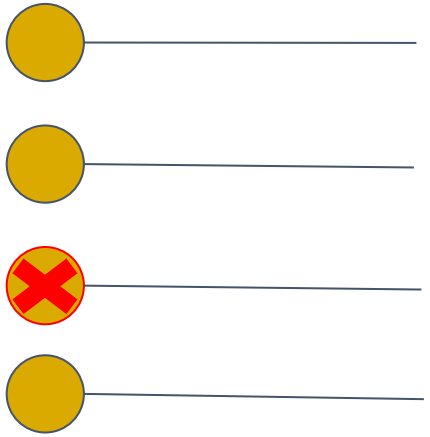
Creating a global scale protocol



Making a topologically aware grouping of replicas ie CLUSTERS



Optimistically reducing global communication between these clusters



Making the protocol live and safe by having novel remote view change that deals with maliciousness and failures

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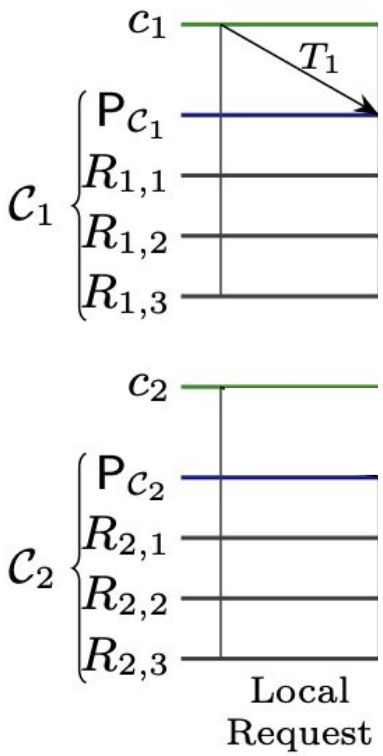
Introducing GeoBFT from a high level



Here we have 2 clusters having 4 nodes, GeoBFT operates in rounds, and in each round every cluster will be proposing a single client request for execution

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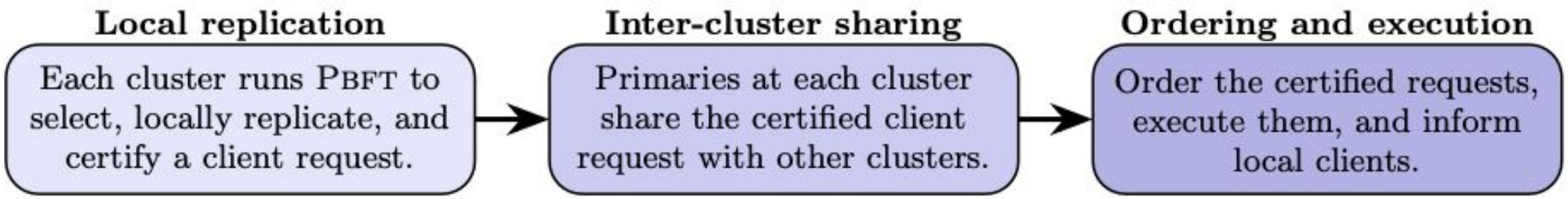
Introducing GeoBFT from a high level



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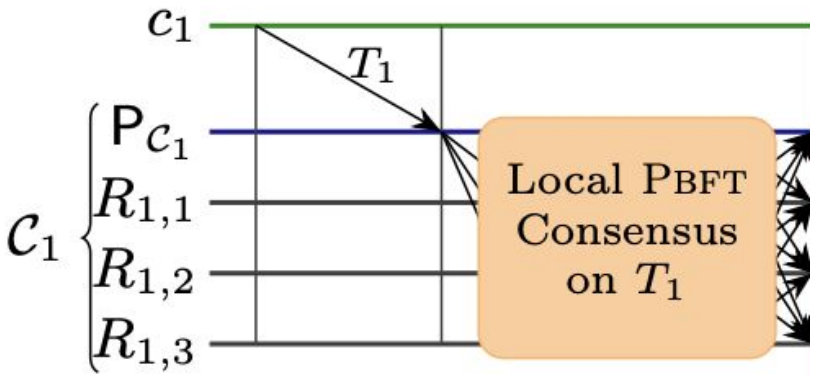
Introducing GeoBFT from a high level



The local client sends the transaction to the primary and performs PBFT in its local cluster

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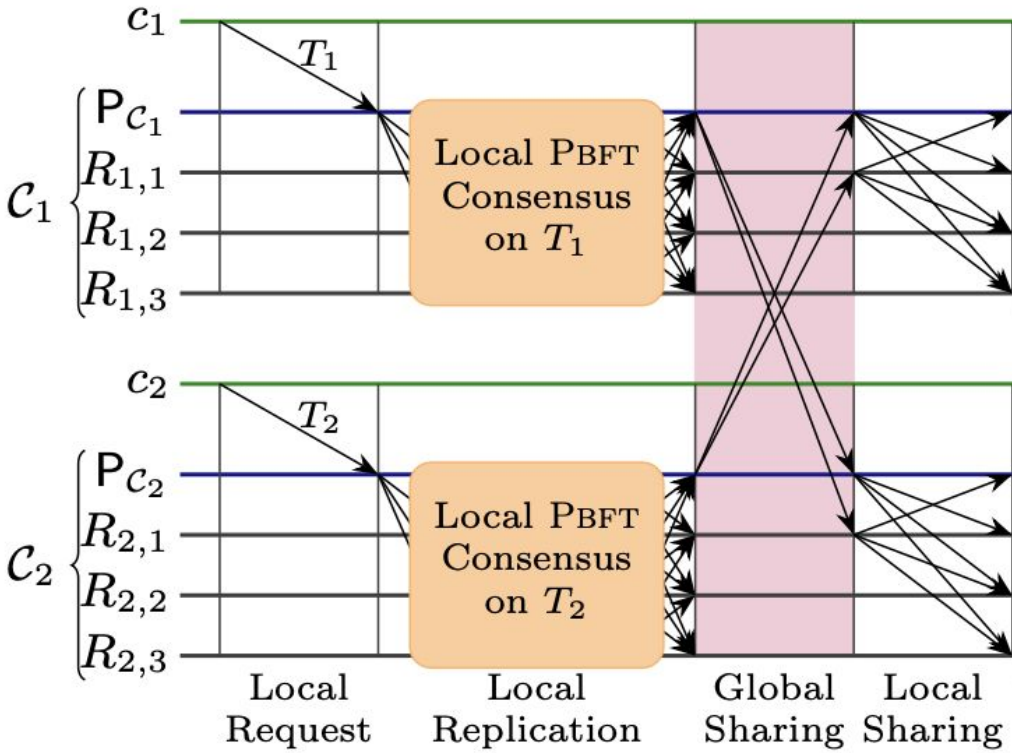
Introducing GeoBFT from a high level



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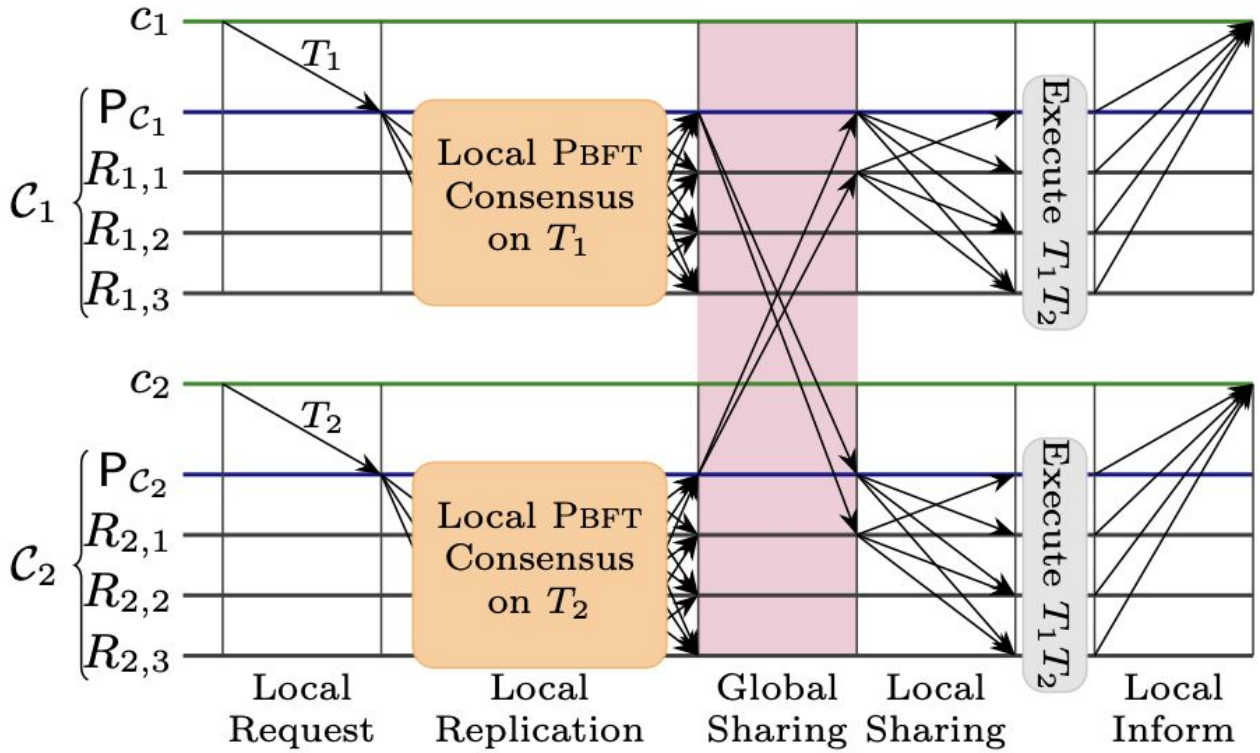
Introducing GeoBFT from a high level



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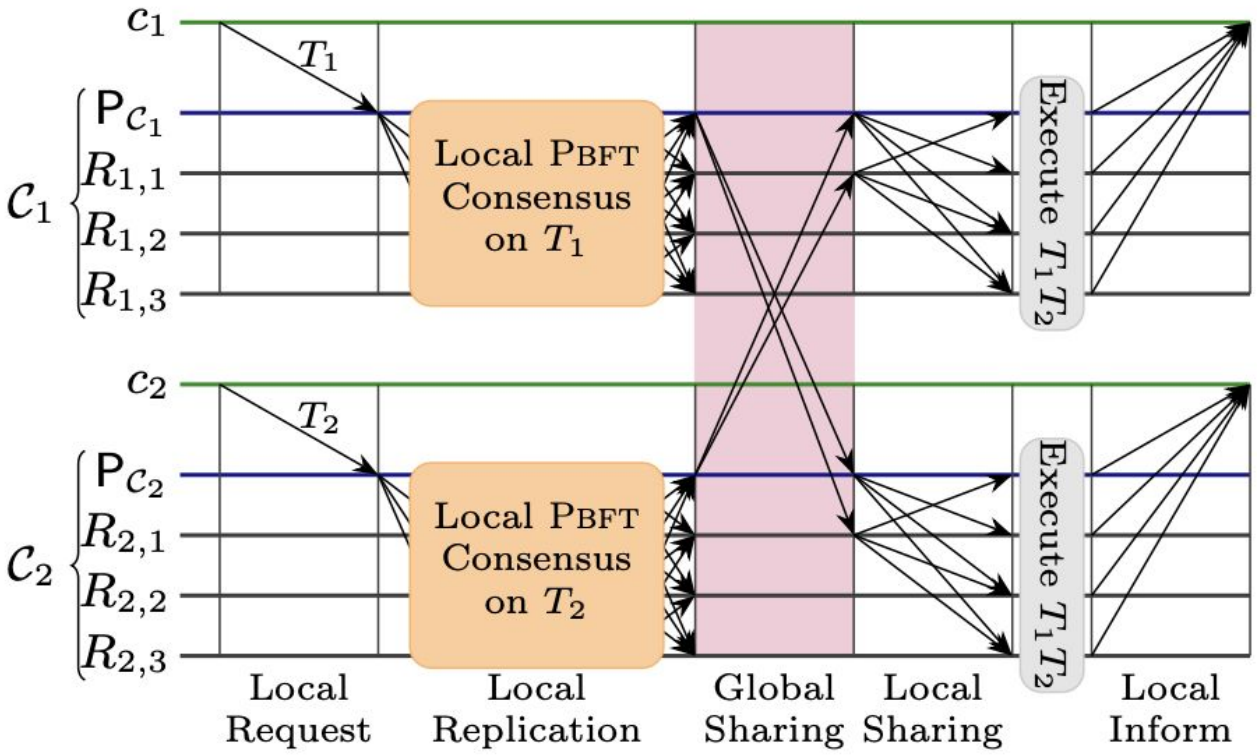
Introducing GeoBFT from a high level



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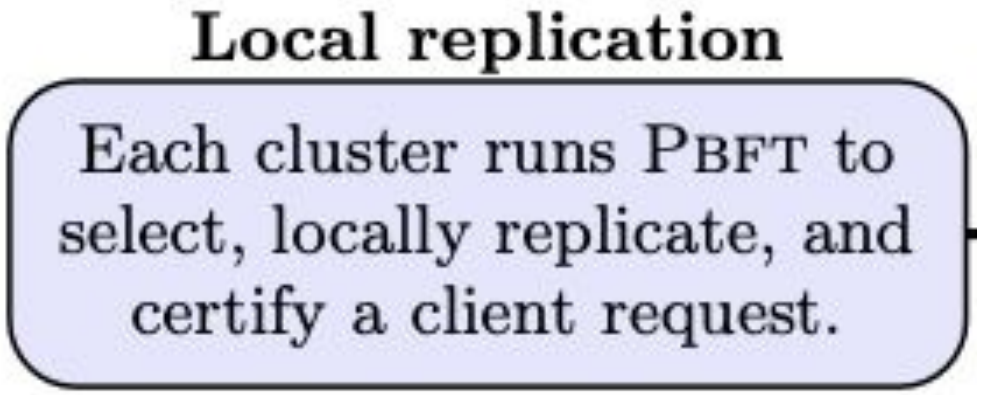
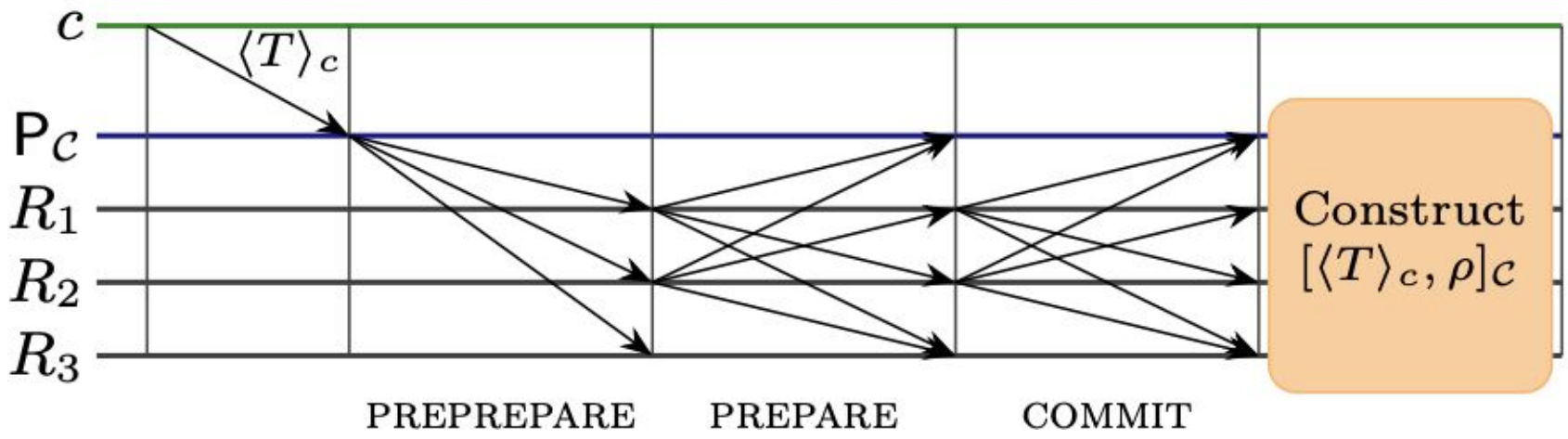
Local Replication (PBFT)



Local Replication (PBFT)

Local replication

Each cluster runs PBFT to select, locally replicate, and certify a client request.



Local Replication (PBFT) - commit certificate

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Inter-Cluster Sharing

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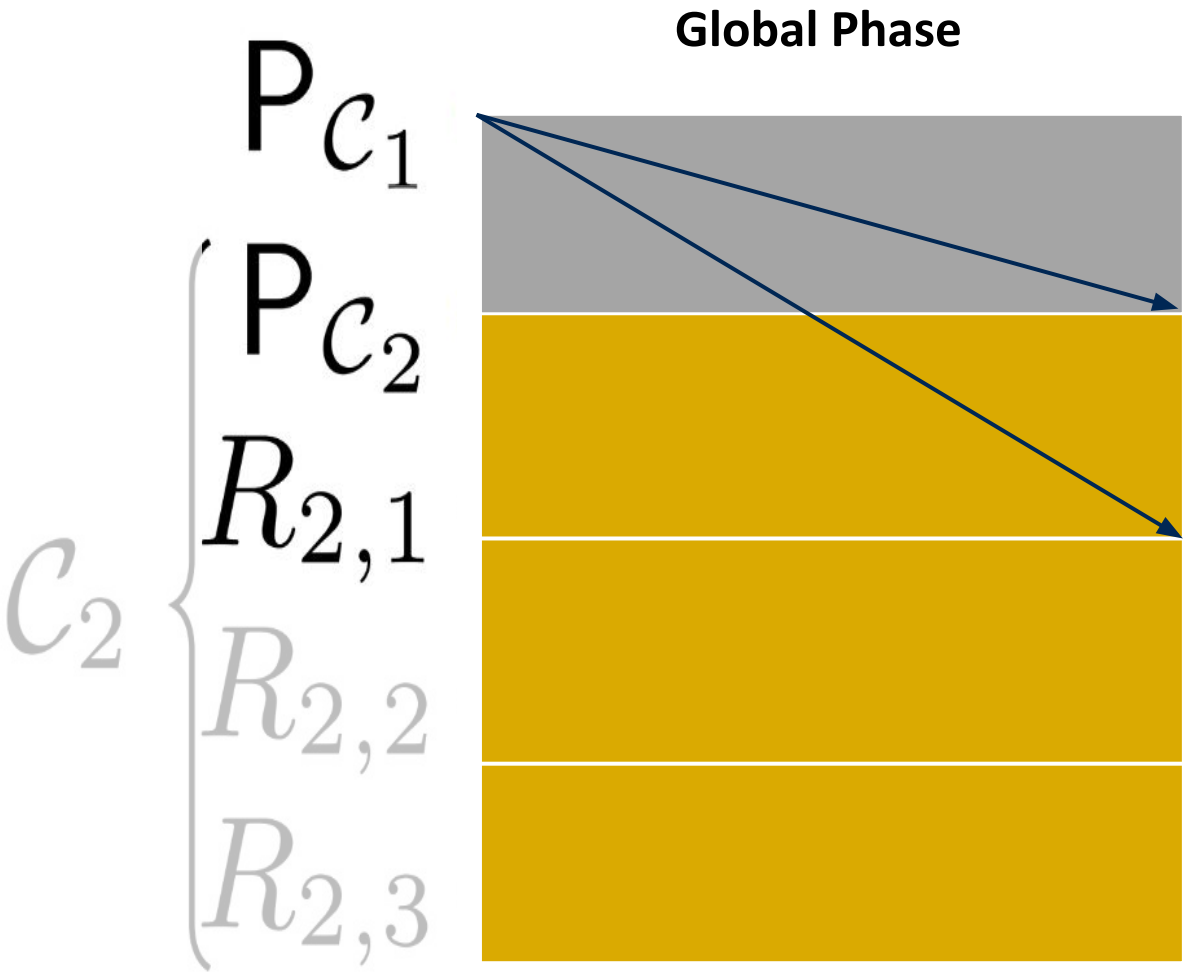
Message Forwarded (m)

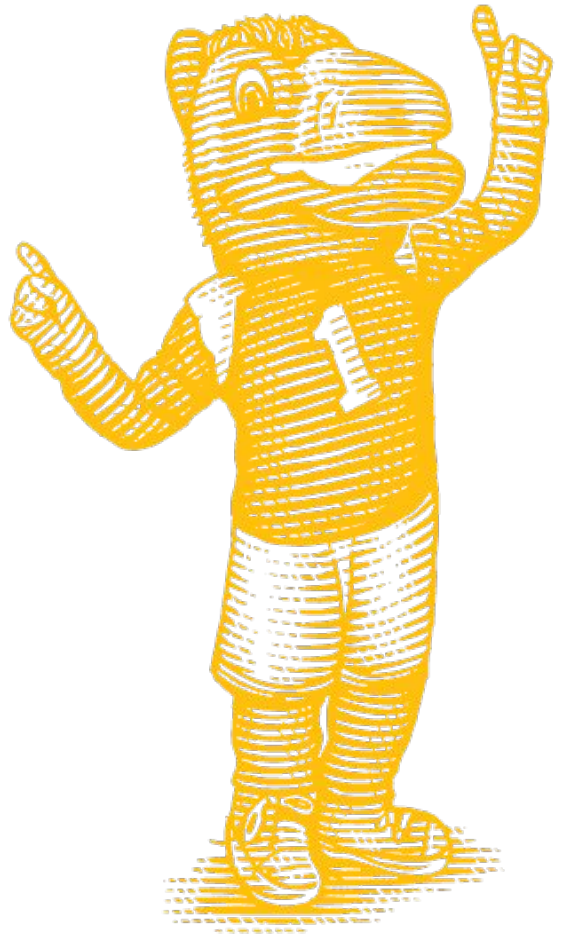
$$m = (\langle T \rangle_c, [\langle T \rangle_c, \rho] c_1)$$

$\langle T \rangle_c$ - Client Request of the cluster forwarding the message

$[\langle T \rangle_c, \rho] c_1$ - Commit Certificate of Cluster 1

Optimistic Inter-cluster Sharing (ICS)





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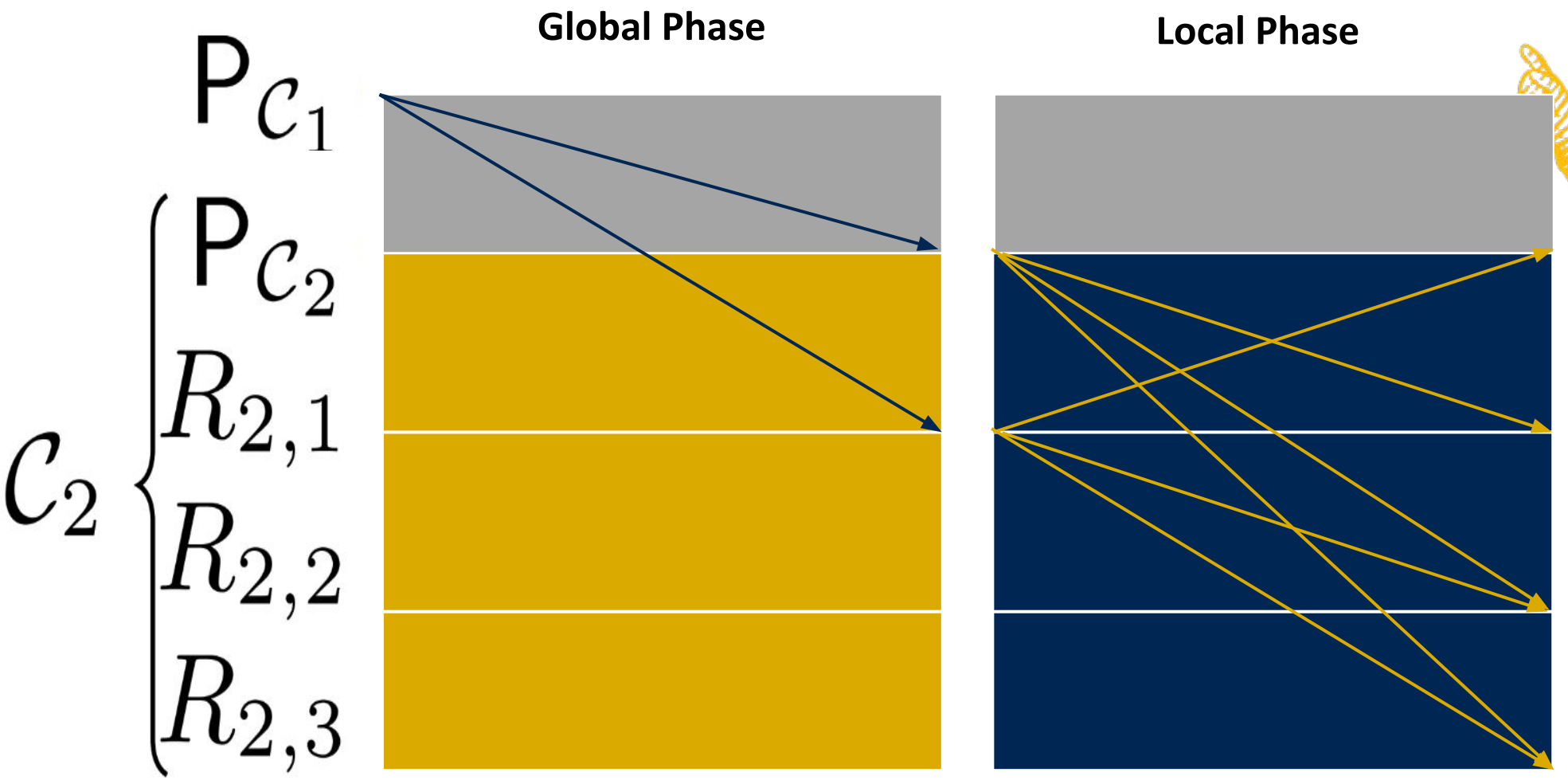
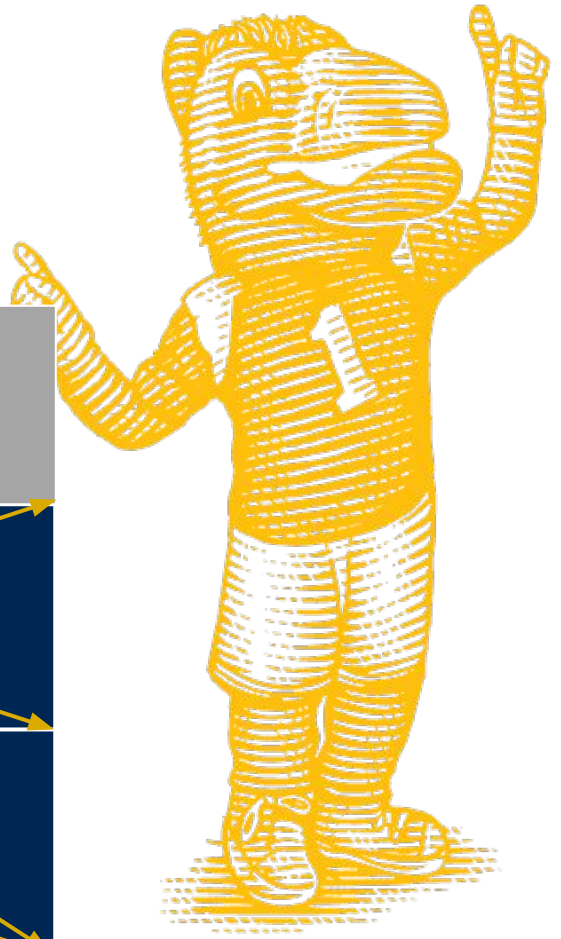
Optimistic Inter-cluster Sharing (ICS)





Forward m = ($\langle T \cdot \rangle_c$, $[\langle T \cdot \rangle_c, \varrho]_{C1}$)

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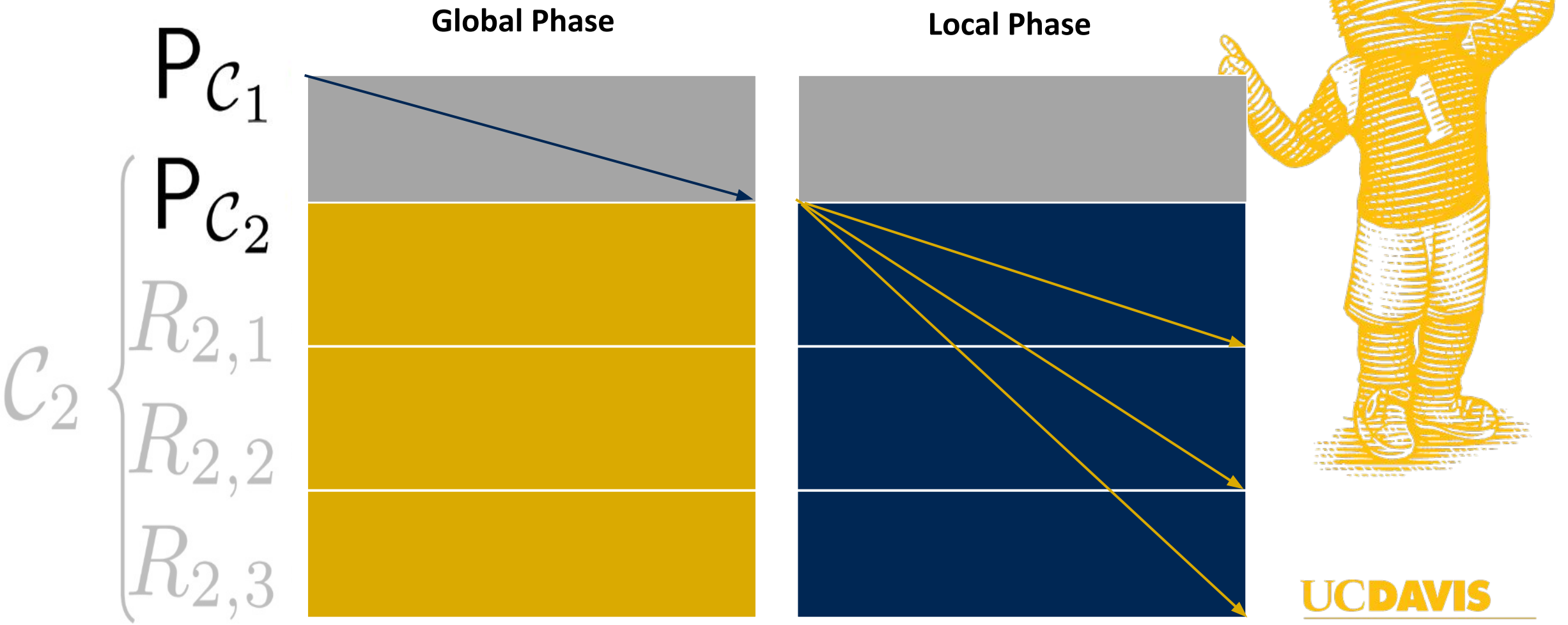
Can we reduce communication?



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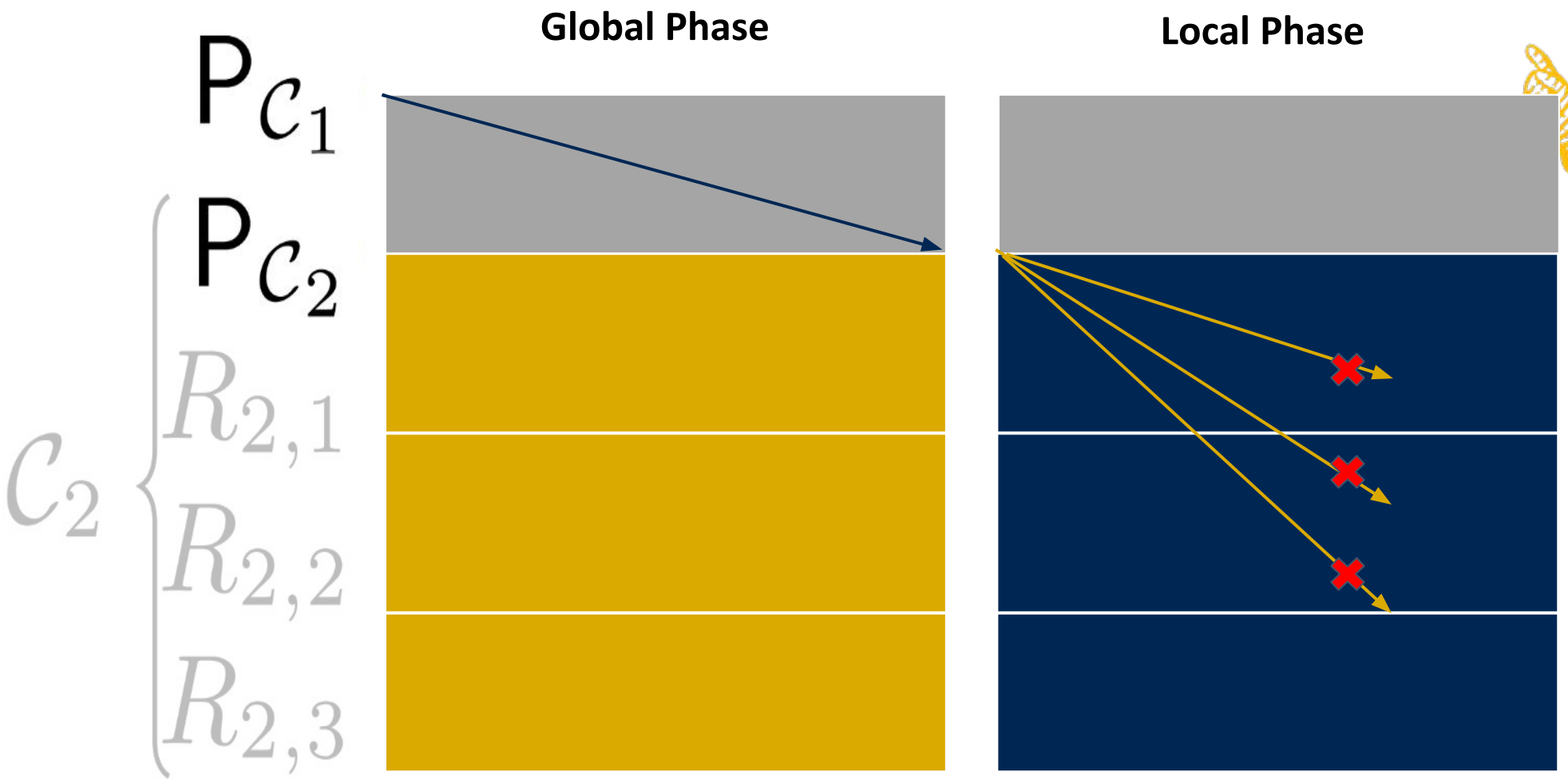
Inter-cluster Sharing (Scenario 1)



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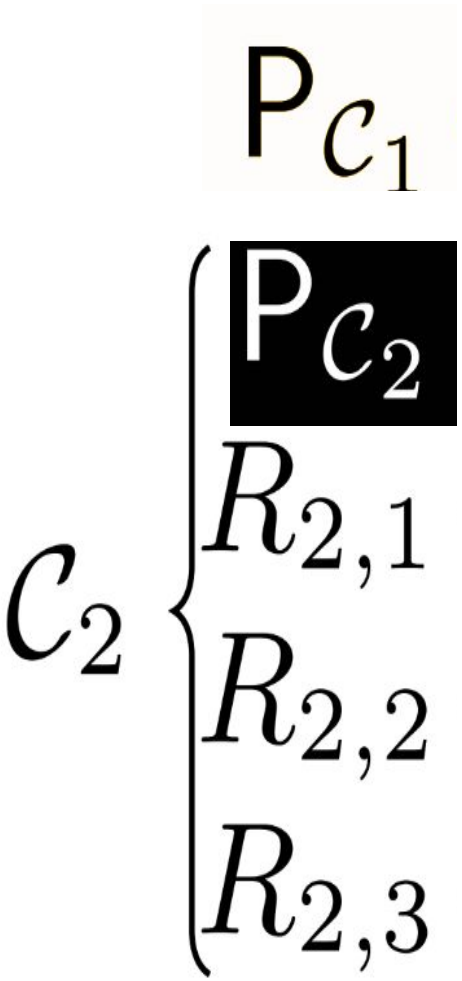
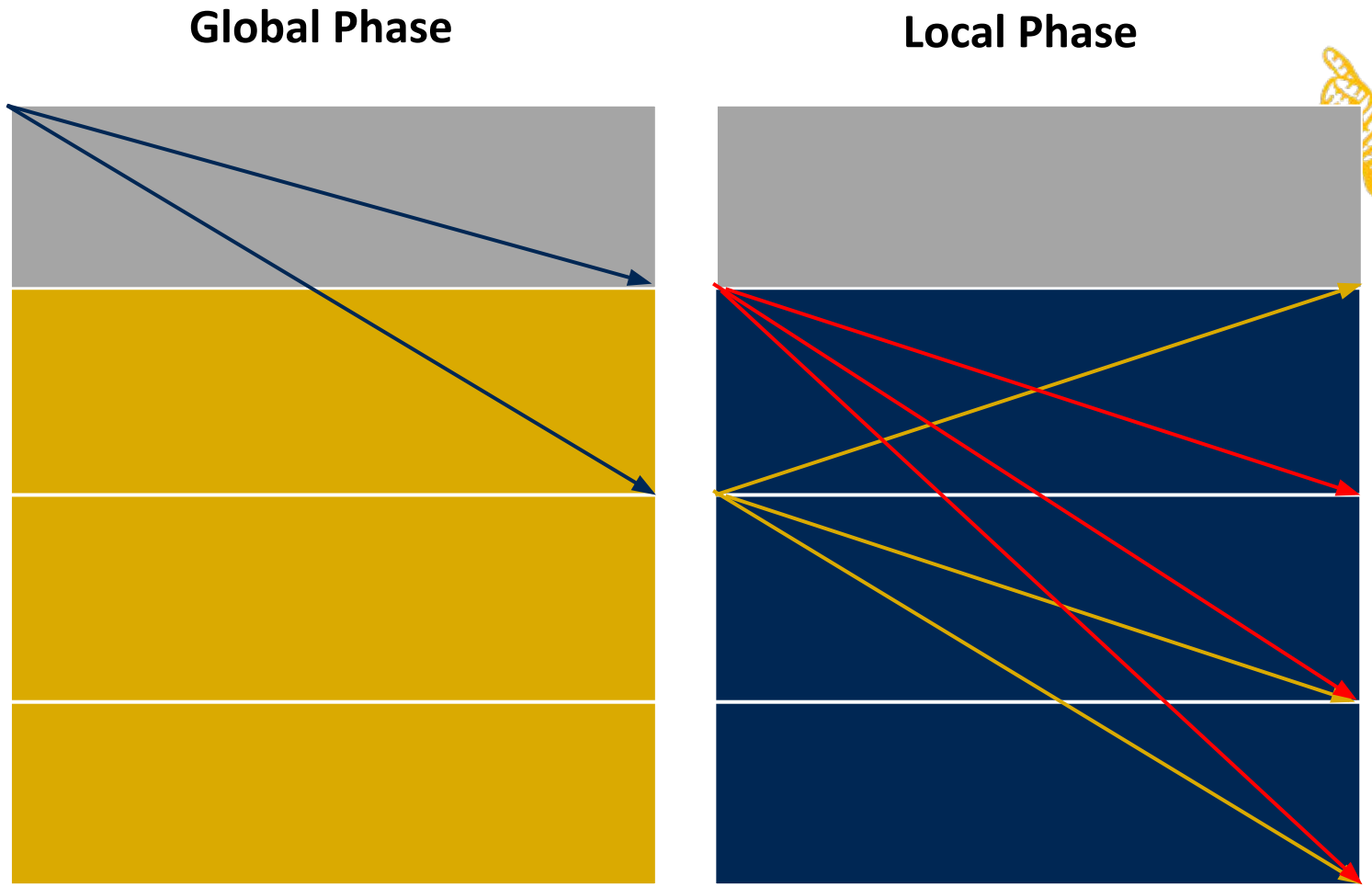
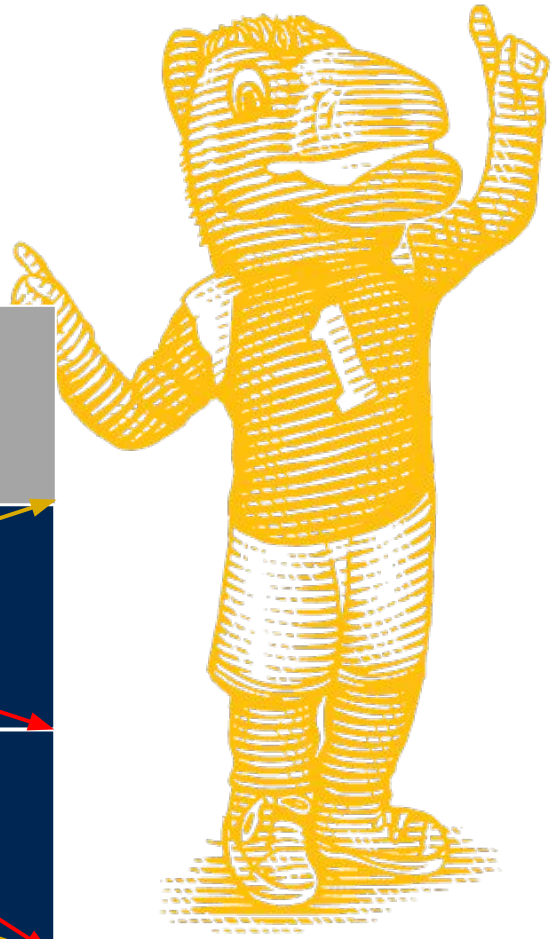
How Optimistic ICS Resolves This







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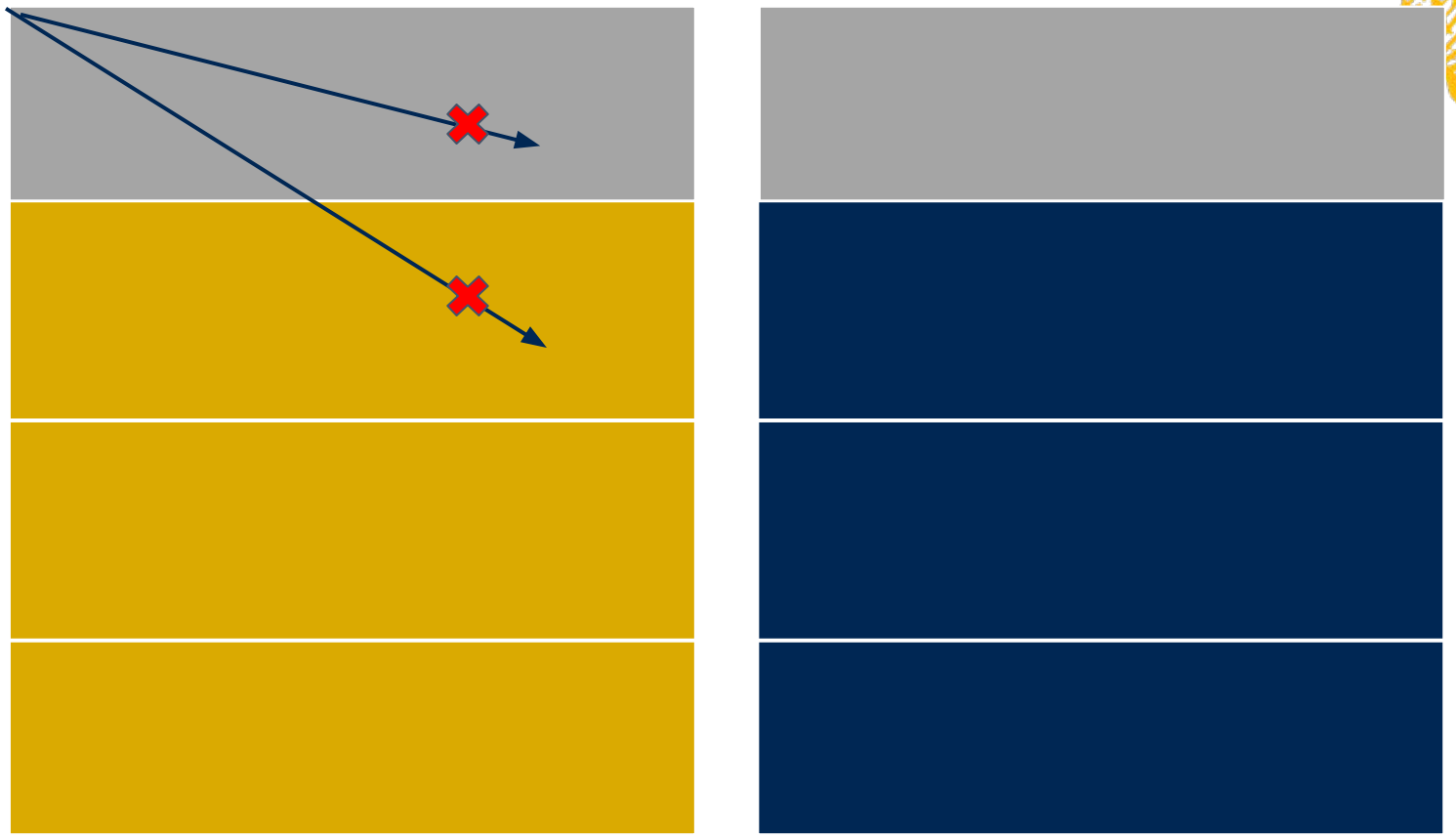
ICS (Scenario: Byzantine P_{C1})

P_{C_1}

C_2 { P_{C_2}, $R_{2,1}$, $R_{2,2}$, $R_{2,3}$



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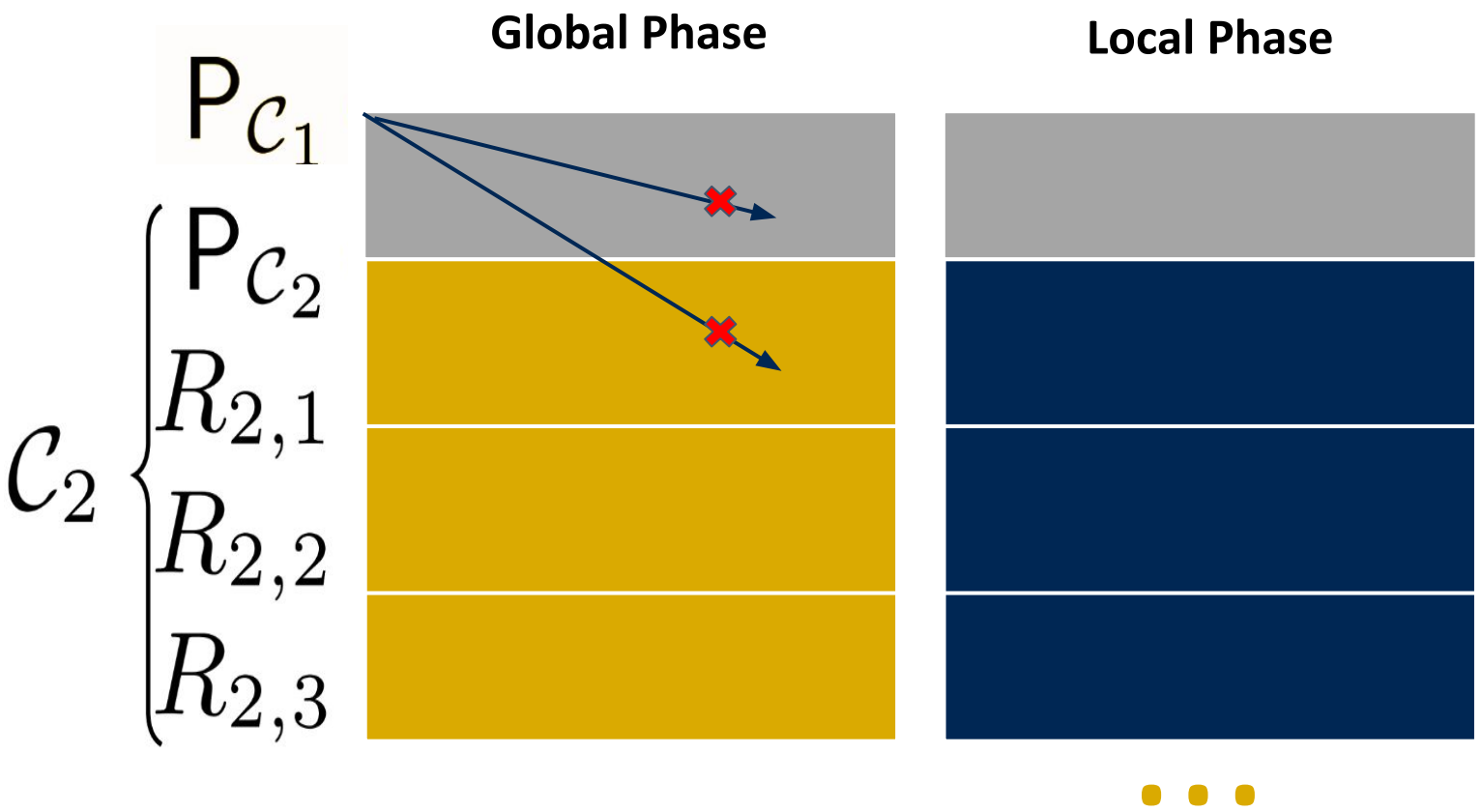
Proposition 2.5. *Let $\mathfrak{S}$ be a system, let $\mathcal{C}_1, \mathcal{C}_2 \in \mathfrak{S}$ be two clusters, and let $m = (\langle T \rangle_c, [\langle T \rangle_c, \rho]_{\mathcal{C}_1})$ be the message $\mathcal{C}_1$ sends to $\mathcal{C}_2$ using the normal-case global sharing protocol of Figure 5. We have the following:*

Receipt *If the primary $\mathsf{P}_{\mathcal{C}_1}$ is non-faulty and communication is reliable, then every replica in $\mathcal{C}_2$ will eventually receive m.*

Agreement *Replicas in $\mathcal{C}_2$ will only accept client request $\langle T \rangle_c$ from $\mathcal{C}_1$ in round ρ.*

Remote View Change



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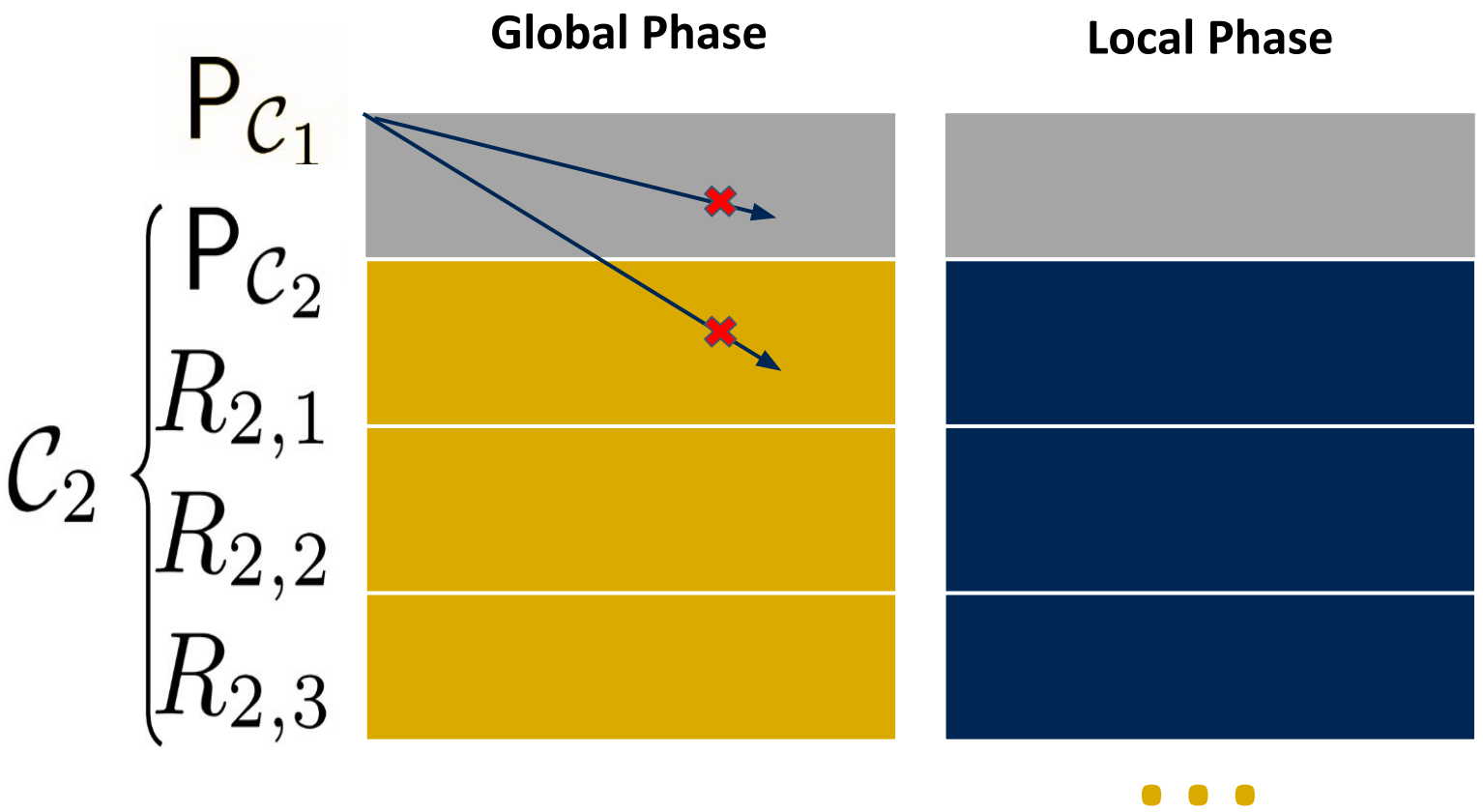
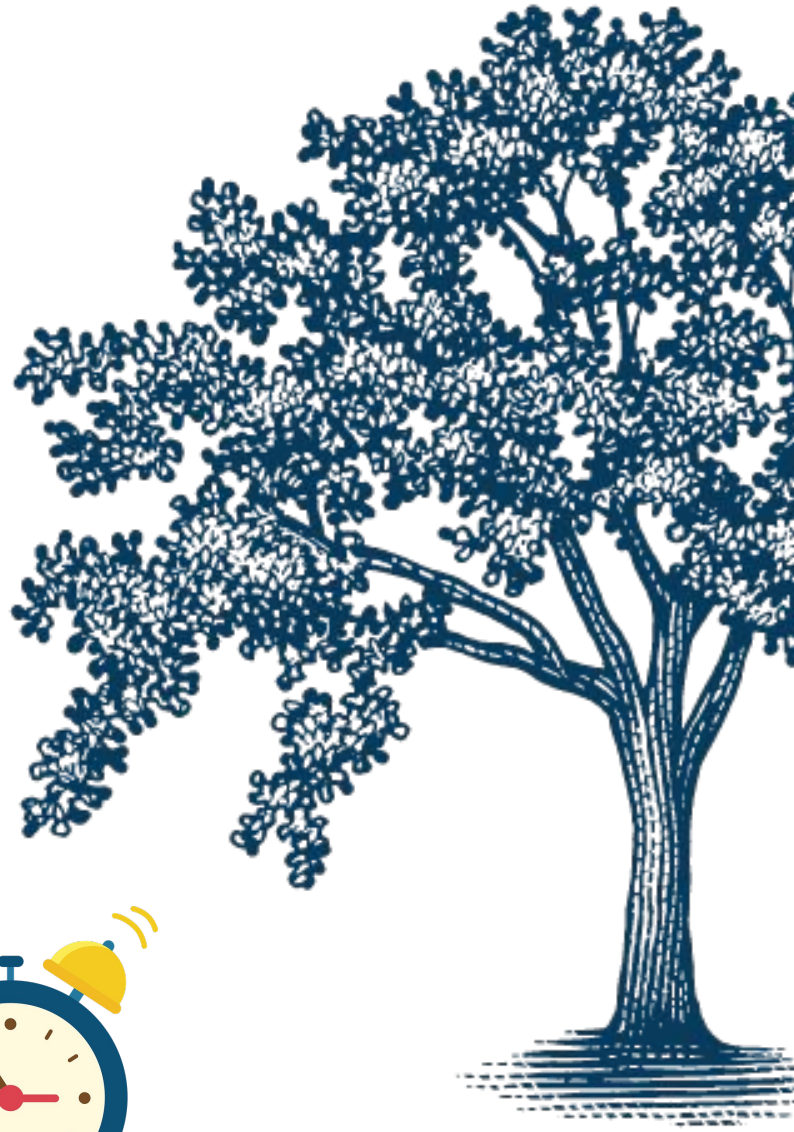
Remote View Change





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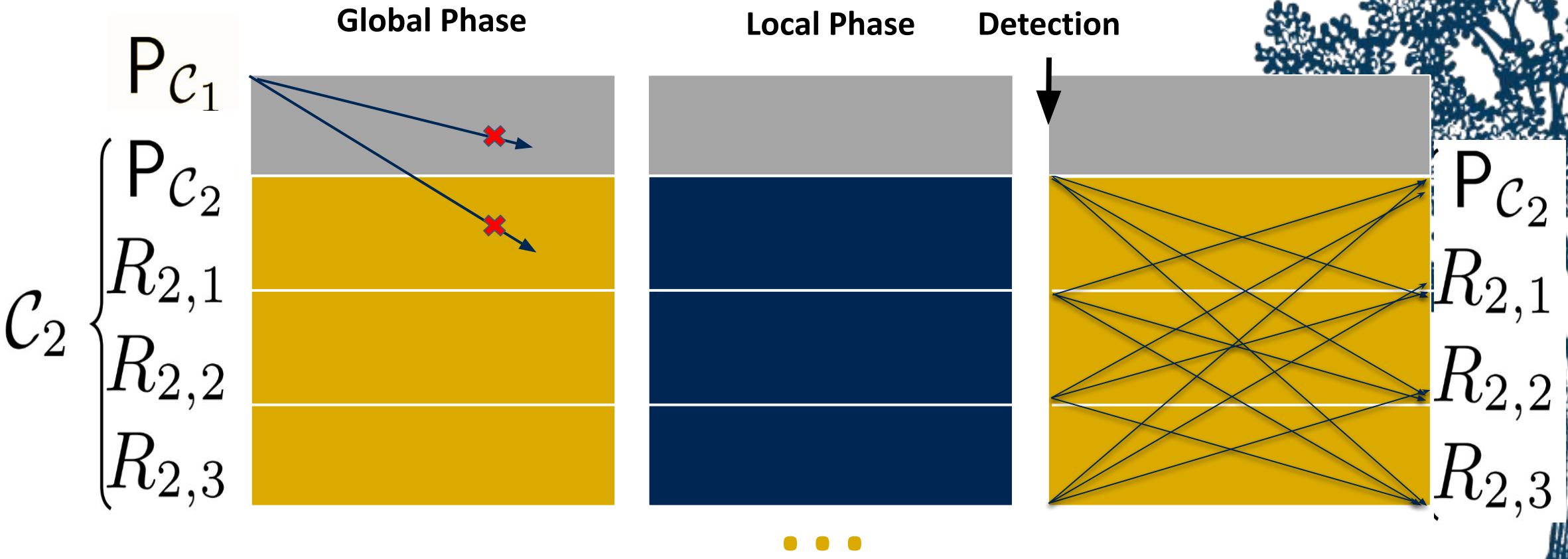
Remote View Change (Phase 1 of 4)



$R_{2,2}$ detects the failure of C_1

$R_{2,2}$ Broadcast $DR_{VC}(C_1, \varrho, v_1)$ to all replicas in C_2

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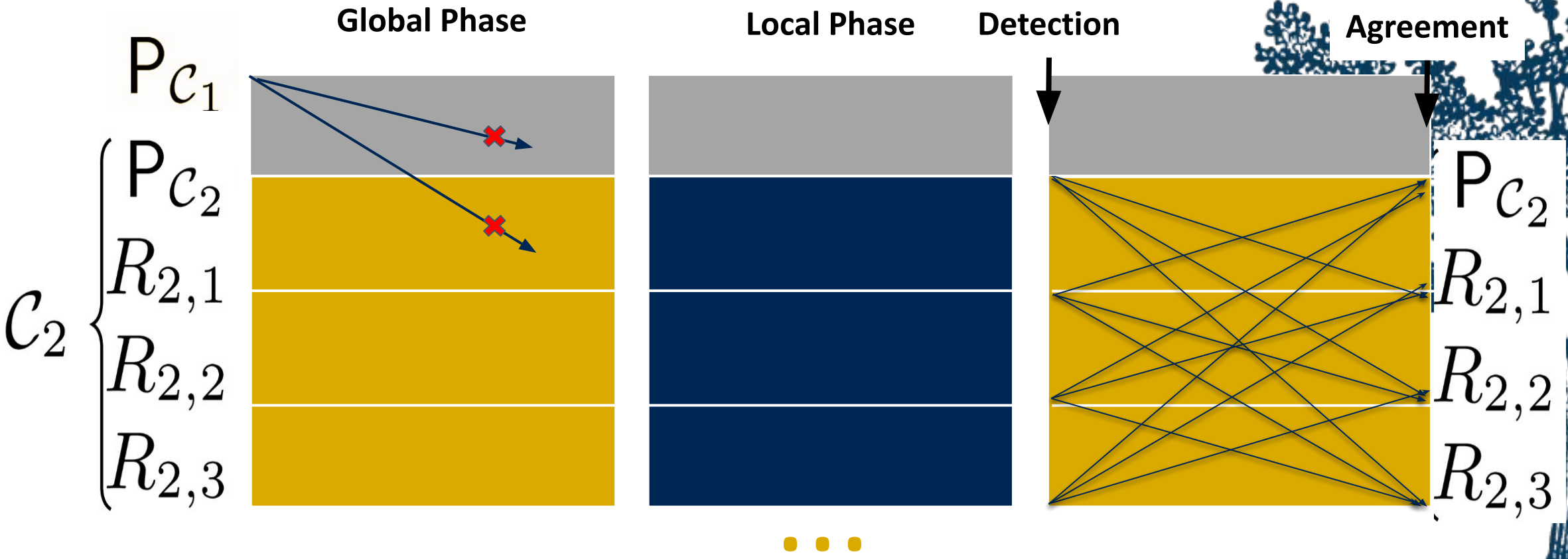
Remote View Change (Phase 2 of 4)



$R_{2,2}$ waits for n-f identical $DR_{VC}(C_1, \varrho, v_1)$

Non-fault replicates in C_2 initiate the agreement

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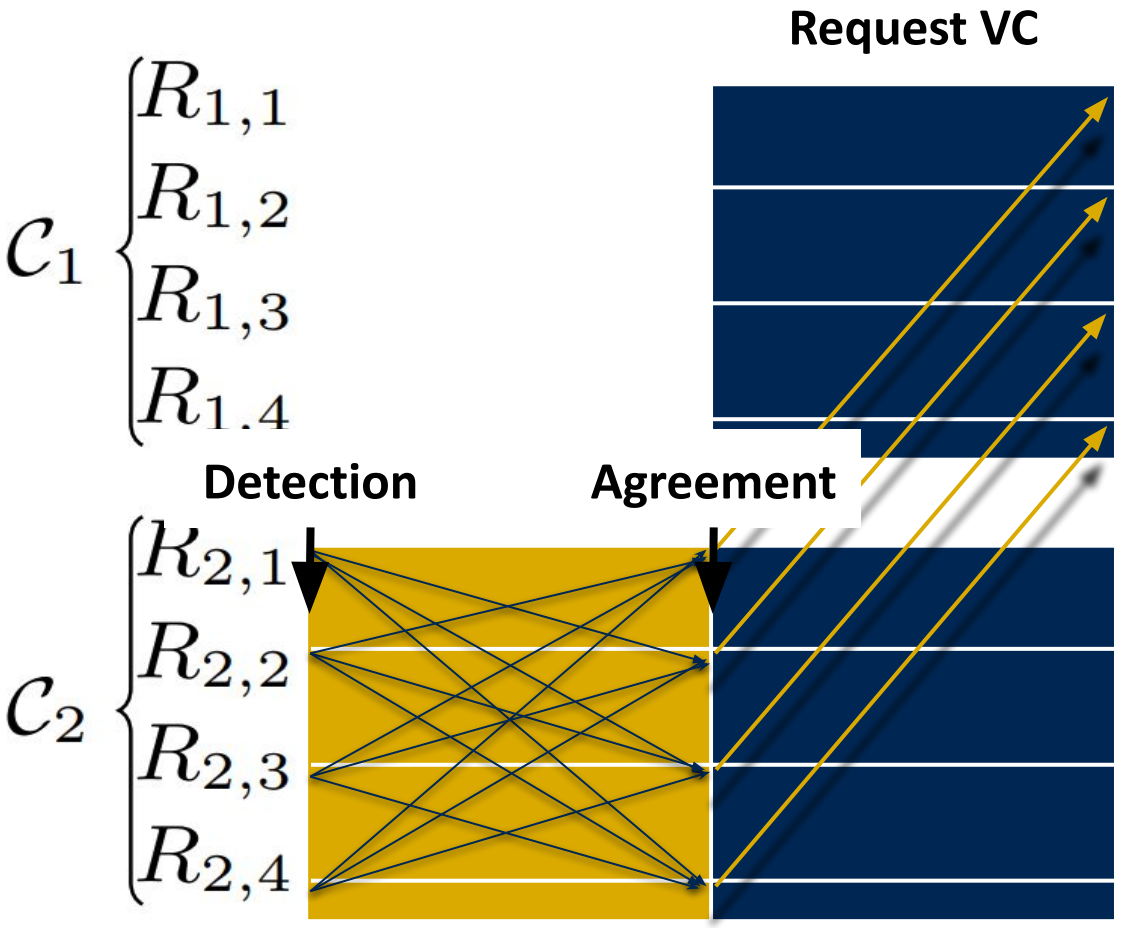
Remote View Change (Phase 3 of 4)



C_2 send request m_{RCV} for remote view-change in C_1

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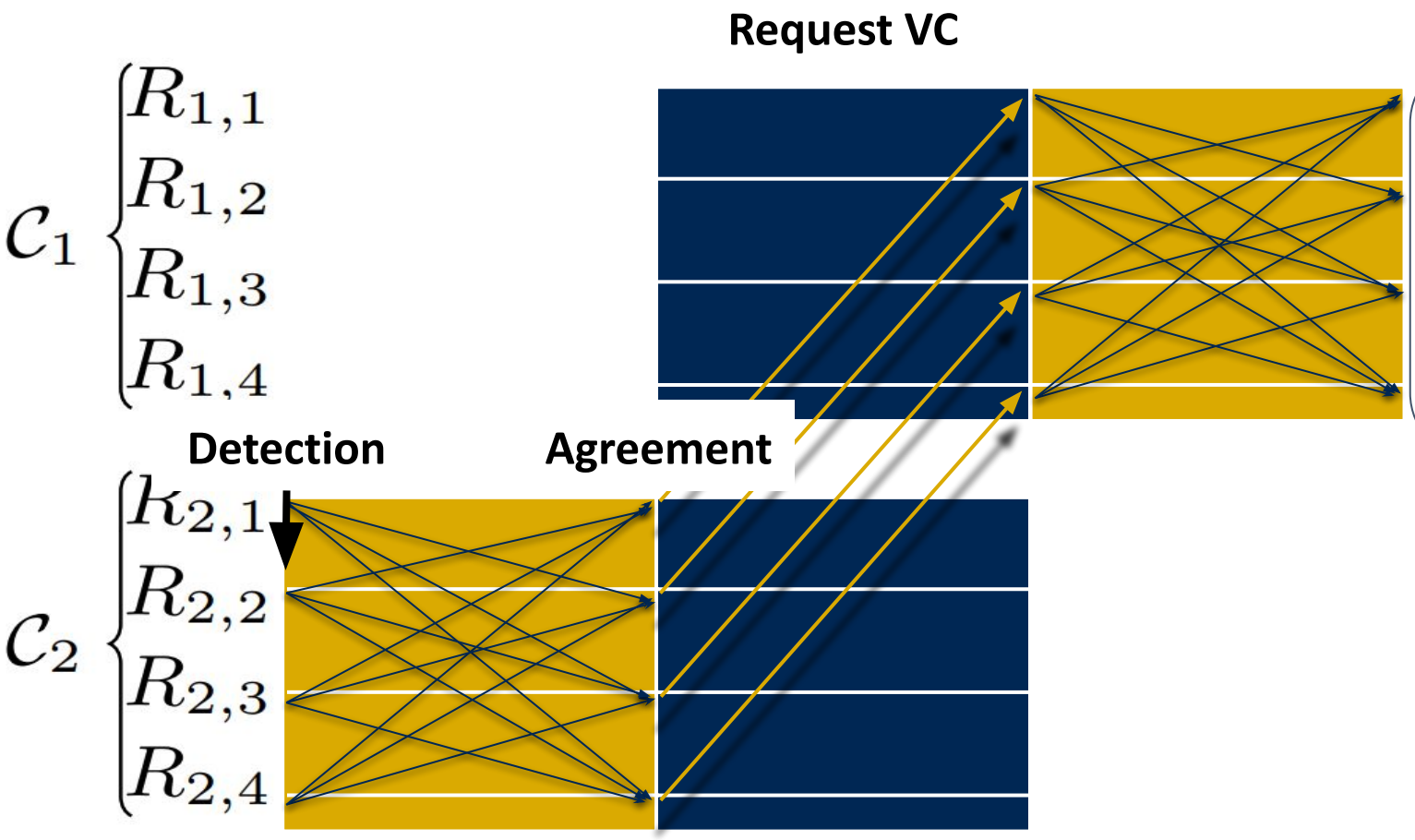
Remote View Change (Phase 4 of 4)



Induced view-change in C_1 (PBFT)

C_1 forward the request to all replicas in C_1

Waits for f+1 identical $R_{VC}(C, \varrho, v)$

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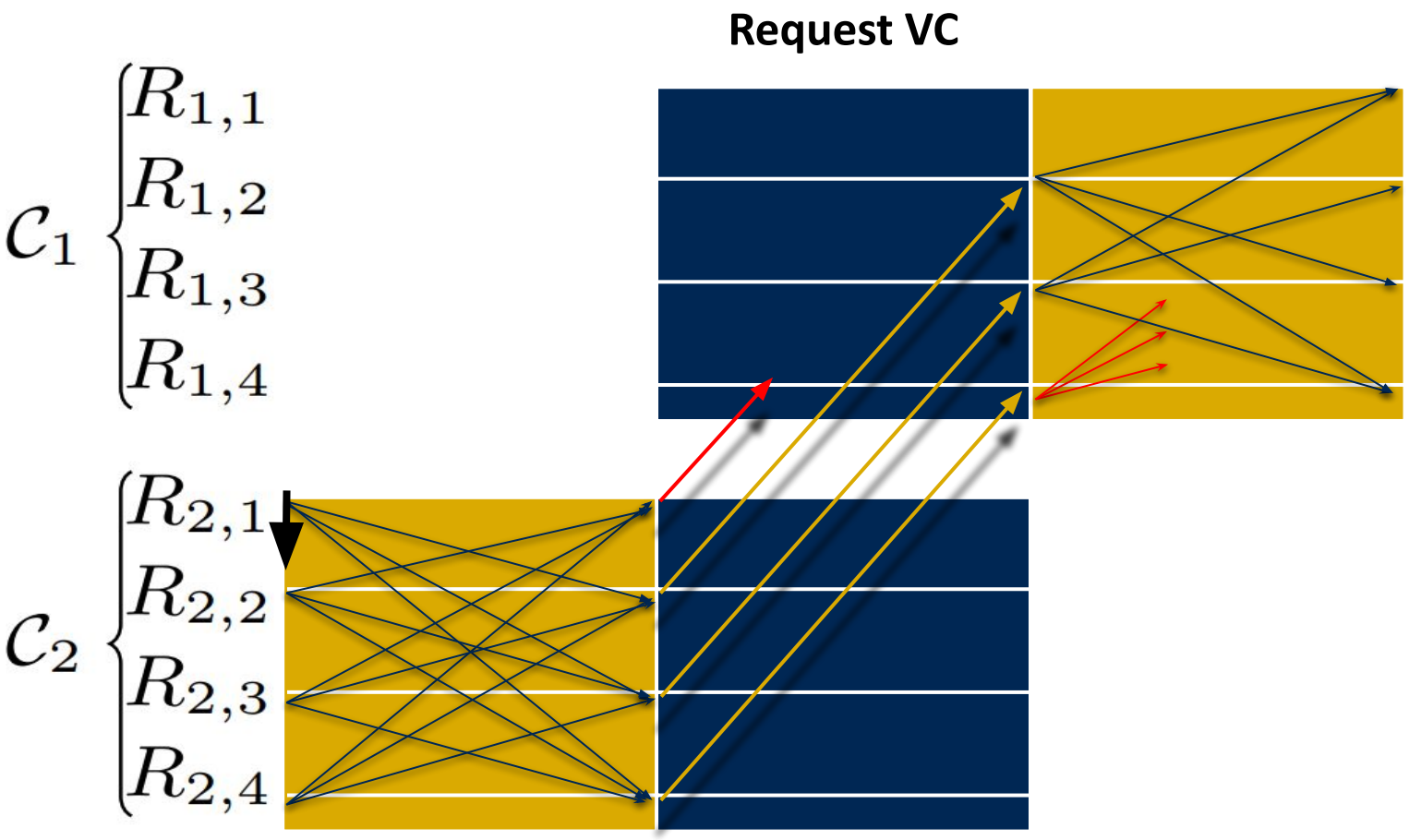
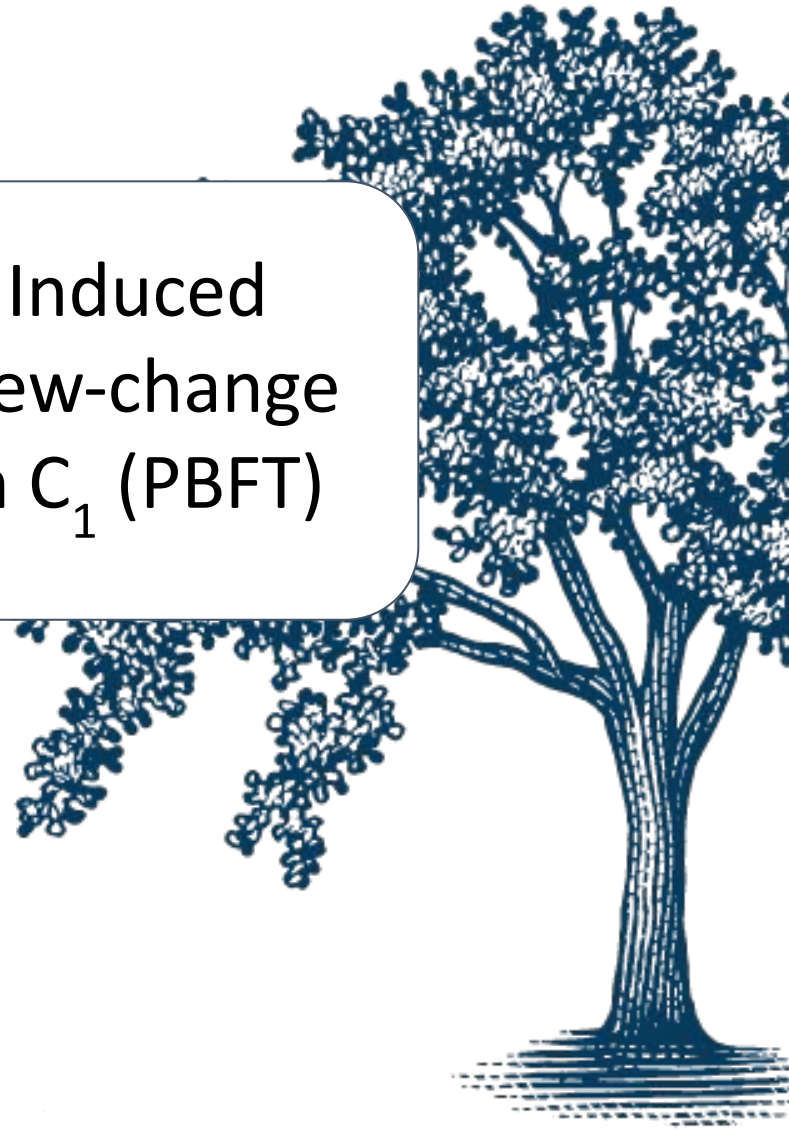
Remote View Change (Scenario 1)



Induced view-change in C_1 (PBFT)



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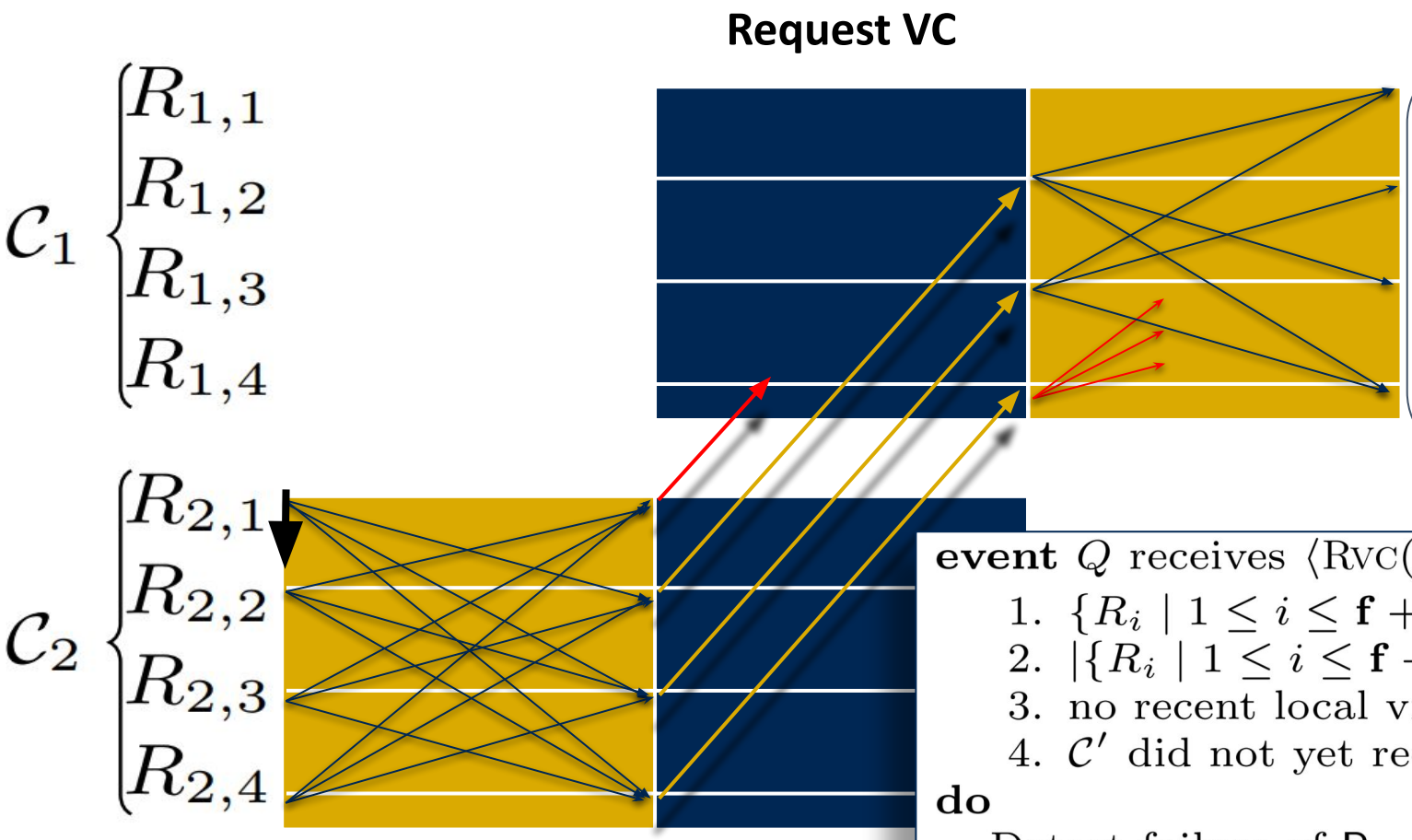
Remote View Change (Scenario 1)



Induced view-change in C_1 (PBFT)

event Q receives $\langle \text{RVC}(\mathcal{C}_1, \rho, v) \rangle_{R_i}$, $1 \leq i \leq \mathbf{f}+1$, such that:

1. $\{R_i \mid 1 \leq i \leq \mathbf{f}+1\} \subset \mathcal{C}'$, $\mathcal{C}' \in \mathfrak{S}$;
2. $|\{R_i \mid 1 \leq i \leq \mathbf{f}+1\}| = \mathbf{f}+1$;
3. no recent local view-change was triggered; and
4. $\mathcal{C}'$ did not yet request a v-th remote view-change

do

Detect failure of $\text{P}_{\mathcal{C}_1}$ (if not yet done so).

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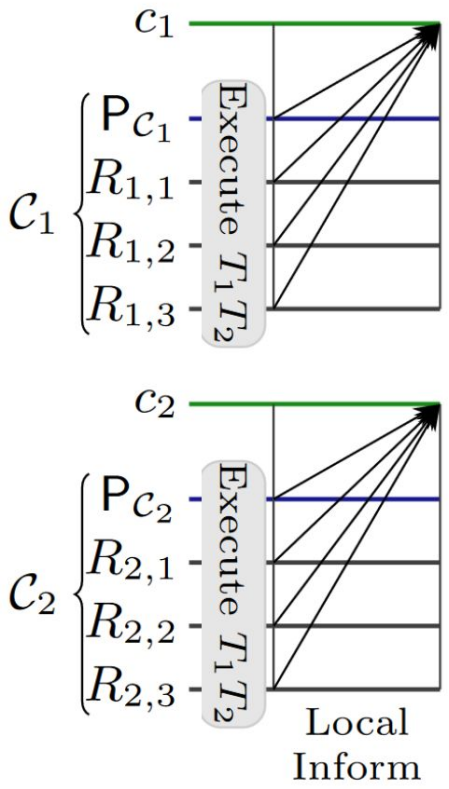
Ordering and Execution

Theorem 2.7. *Let* $\mathfrak{S} = \{\mathcal{C}_1, \ldots, \mathcal{C}_{\mathbf{z}}\}$ *be a system over* $\mathfrak{R}$. *If communication is reliable and has bounded delay, then every replica* $R \in \mathfrak{R}$ *will, in round* ρ, *receive a set* $\{(\langle T_i \rangle_{c_i}, [\langle T_i \rangle_{c_i}, \rho] c_i) \mid (1 \leq i \leq \mathbf{z}) \wedge (c_i \in \text{clients}(\mathcal{C}_i))\}$ *of* $\mathbf{z}$ *messages. These sets all contain identical client requests.*



$$m = (\langle T \rangle_c, [\langle T \rangle_c, \rho] c_1)$$

Evaluation

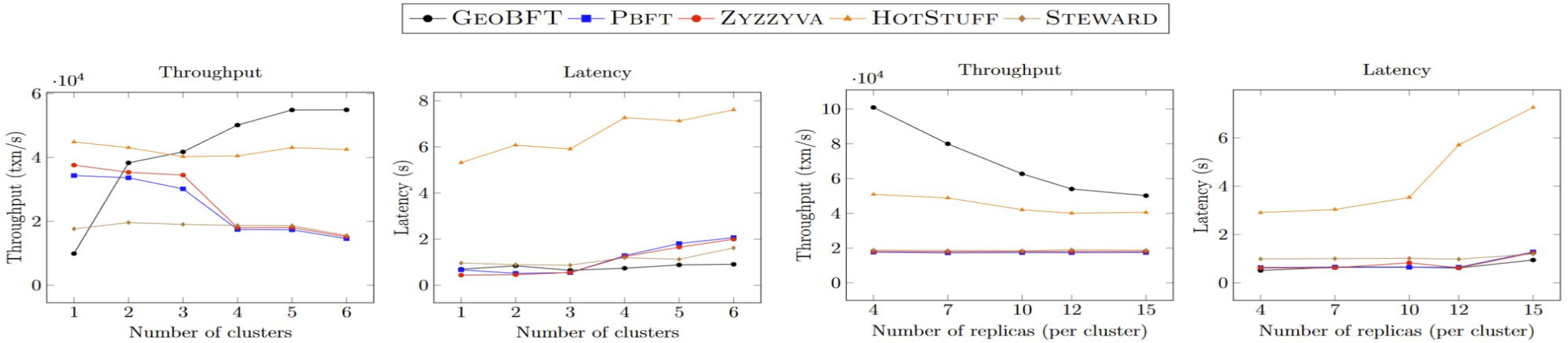


Figure 10: Throughput and latency as a function of the number of clusters; zn = 60 replicas.

Figure 11: Throughput and latency as a function of the number of replicas per cluster; z = 4.

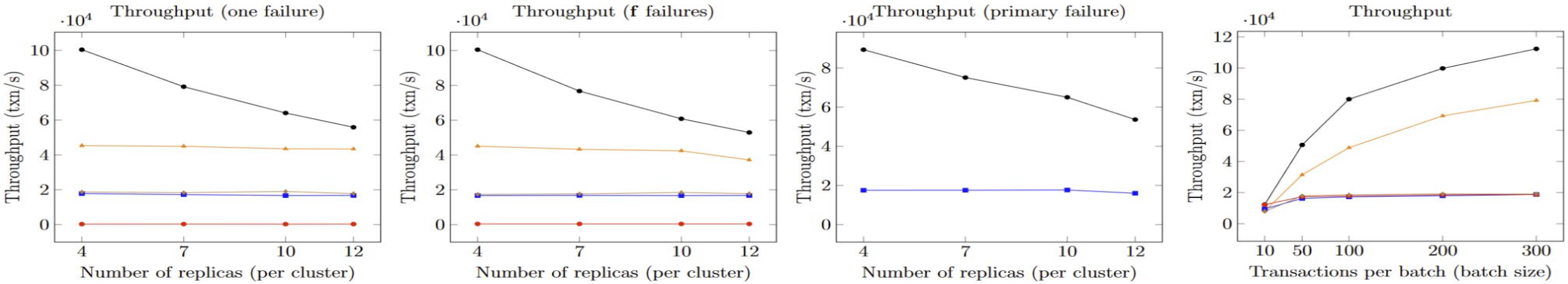
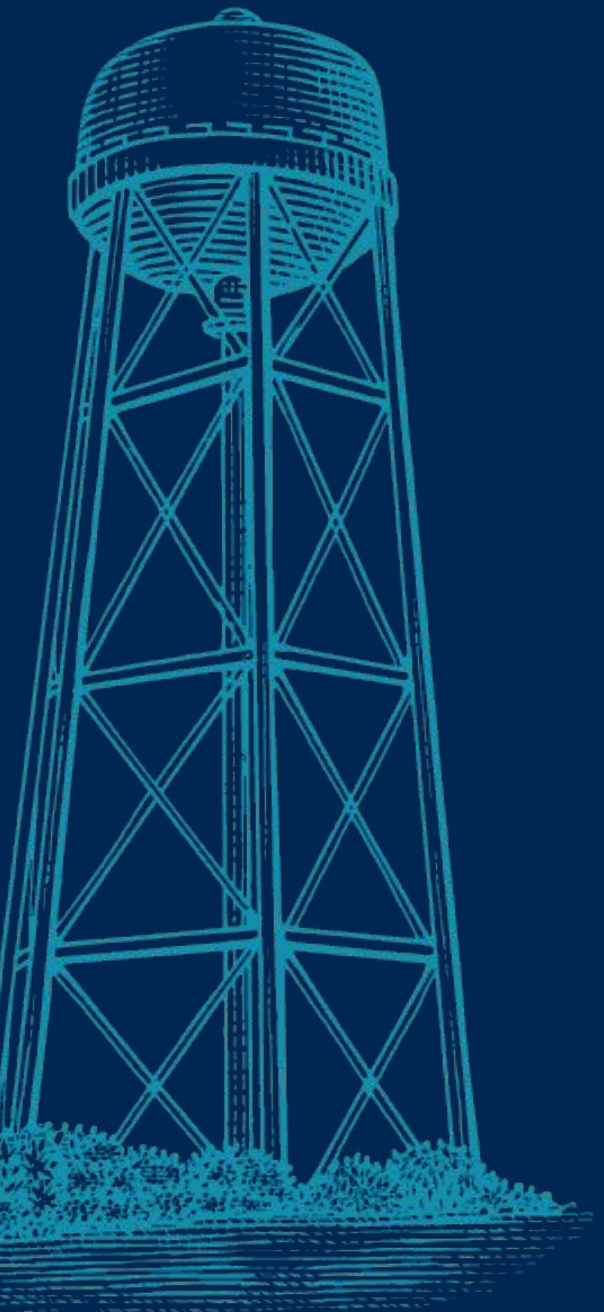


Figure 12: Throughput as a function of the number of replicas per cluster; z = 4. *Left*, throughput with one non-primary failure. *Middle*, throughput with f non-primary failures. *Right*, throughput with a single primary failure.

Figure 13: Throughput as a function of the batch size; z = 4 and n = 7.



Thank you!

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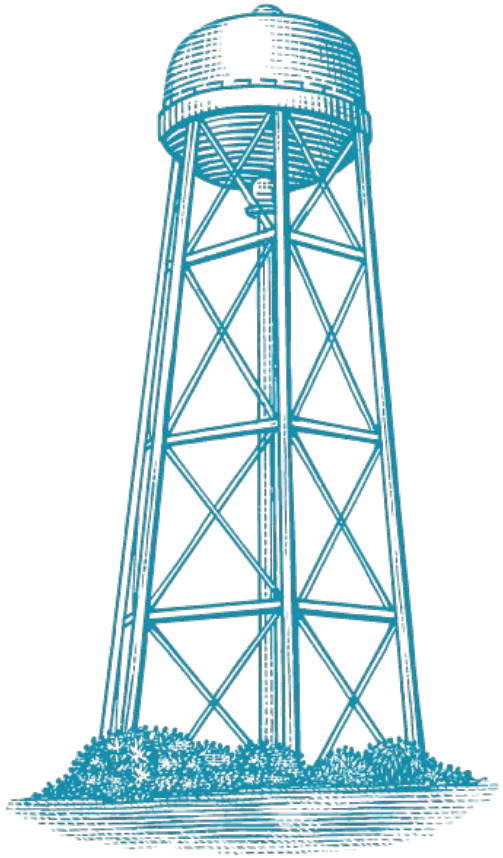
Comparing to other existing protocols



Protocol	Decisions	Communication		Centralized
		(Local)	*(Global)*	
GeoBFT (our paper)	$\mathbf{z}$	$\mathcal{O}(2\mathbf{zn}^2)$	$\mathcal{O}(\mathbf{fz}^2)$	No
↳ *single decision*	1	$\mathcal{O}(4\mathbf{n}^2)$	$\mathcal{O}(\mathbf{fz})$	No
Zyzzyva	1	$\mathcal{O}(\mathbf{zn})$		Yes
Pbft	1	$\mathcal{O}(2(\mathbf{zn})^2)$		Yes
PoE	1	$\mathcal{O}((\mathbf{zn})^2)$		Yes
HotStuff	1	$\mathcal{O}(8(\mathbf{zn}))$		Partly

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