

ByzzBench

A Benchmark Framework for BFT Testing Algorithms

João Miguel Louro Neto & Burcu Kulahcioglu Ozkan

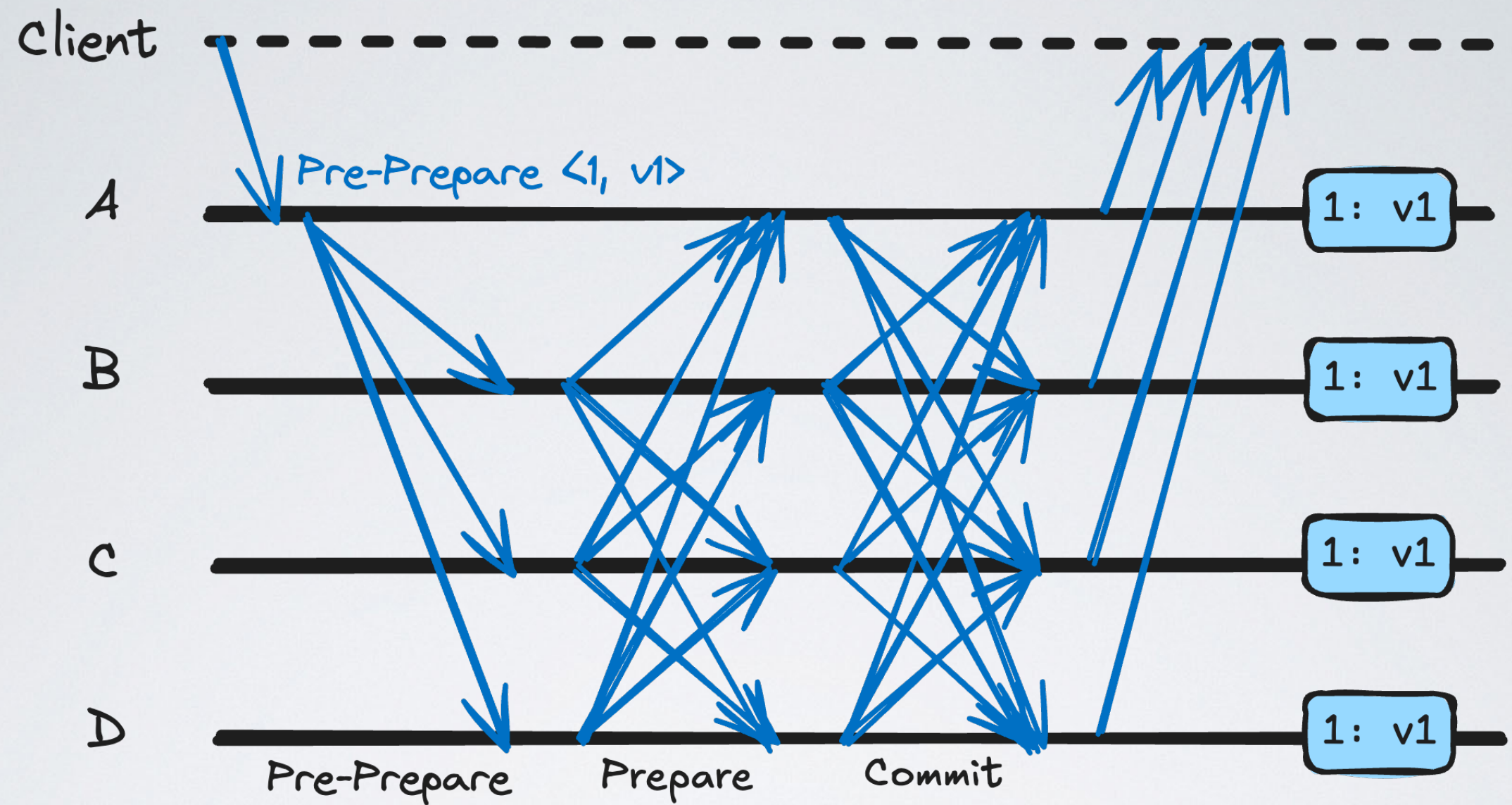
FMBC'25 — May 4th, 2025 
6th International Workshop on Formal Methods for Blockchains



BFT protocols are central to
all sorts of critical applications
including Blockchains

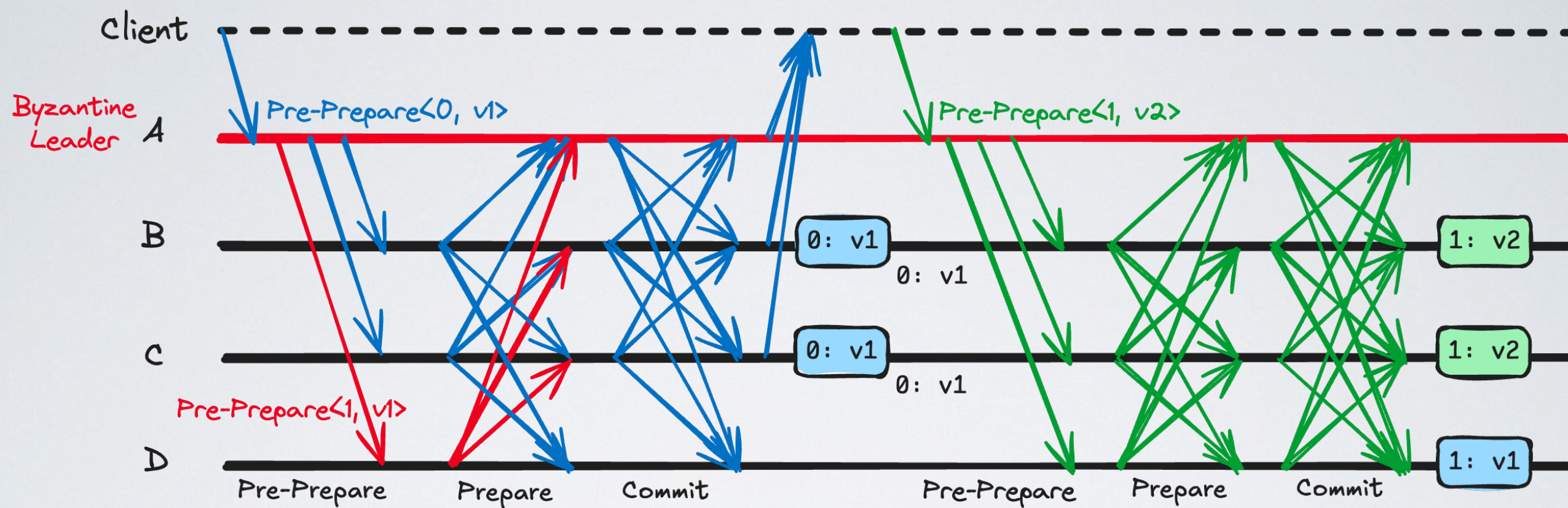
BFT PROTOCOLS ARE PRONE TO BUGS

- Bugs in these protocols can lead to **severe security and reliability risks.**
- Despite 40+ years of research and formal proofs, new bugs are still being discovered in real-world BFT systems



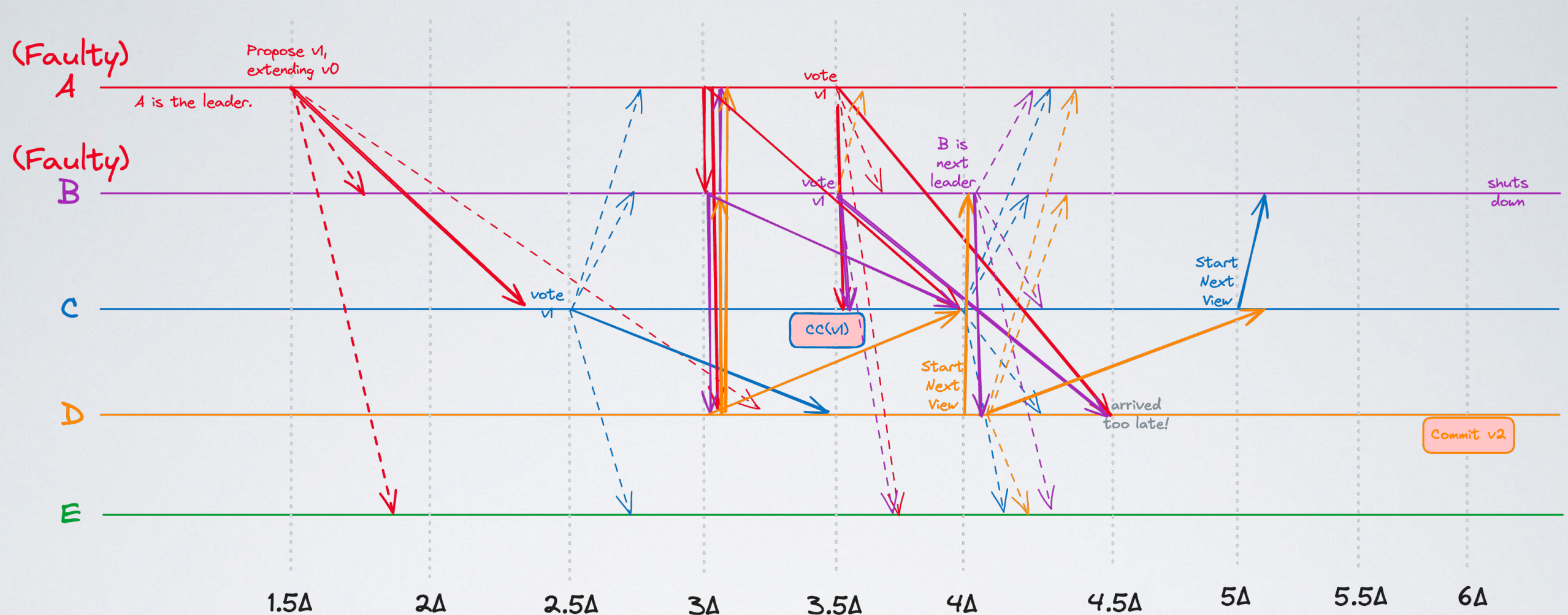
PBFT

[Miguel Castro, Barbara Liskov, 1999]



BUGS?

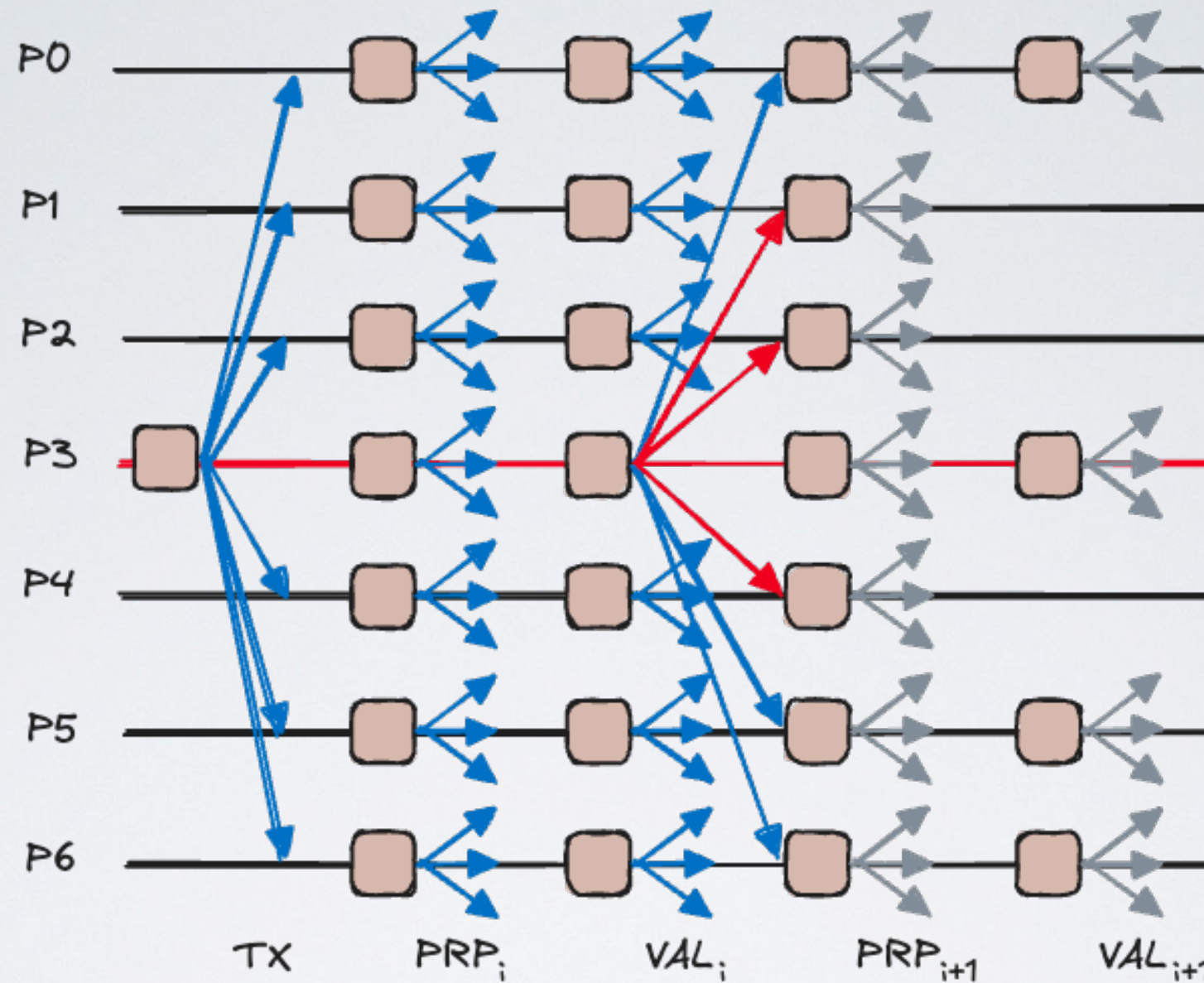
PBFT-Java
 [L. Winter et al., 2023]



BUGS?

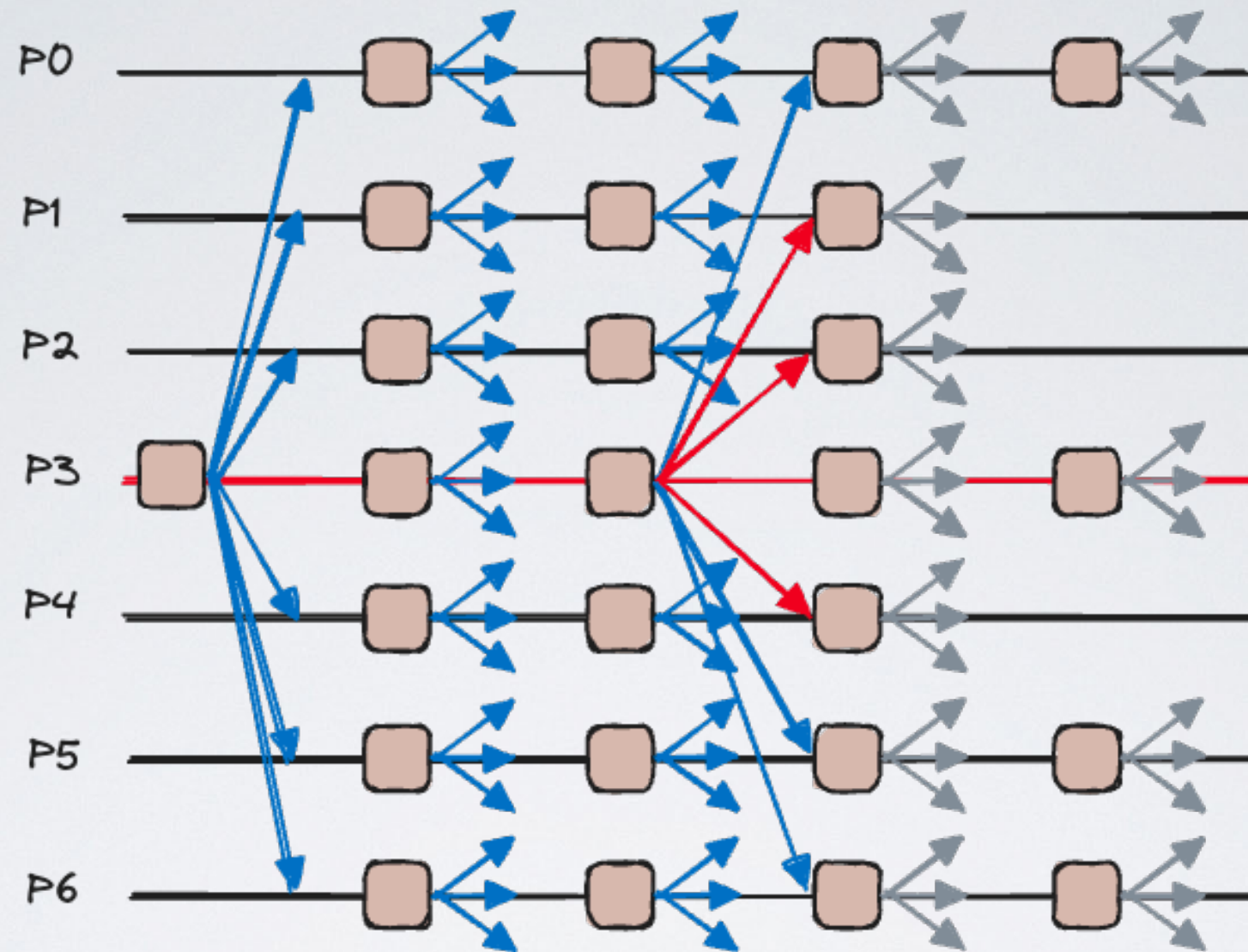
Sync HotStuff

[Atsuki Momose and Jason Paul Cruz 2020]



BUGS IN PRODUCTION BLOCKCHAINS

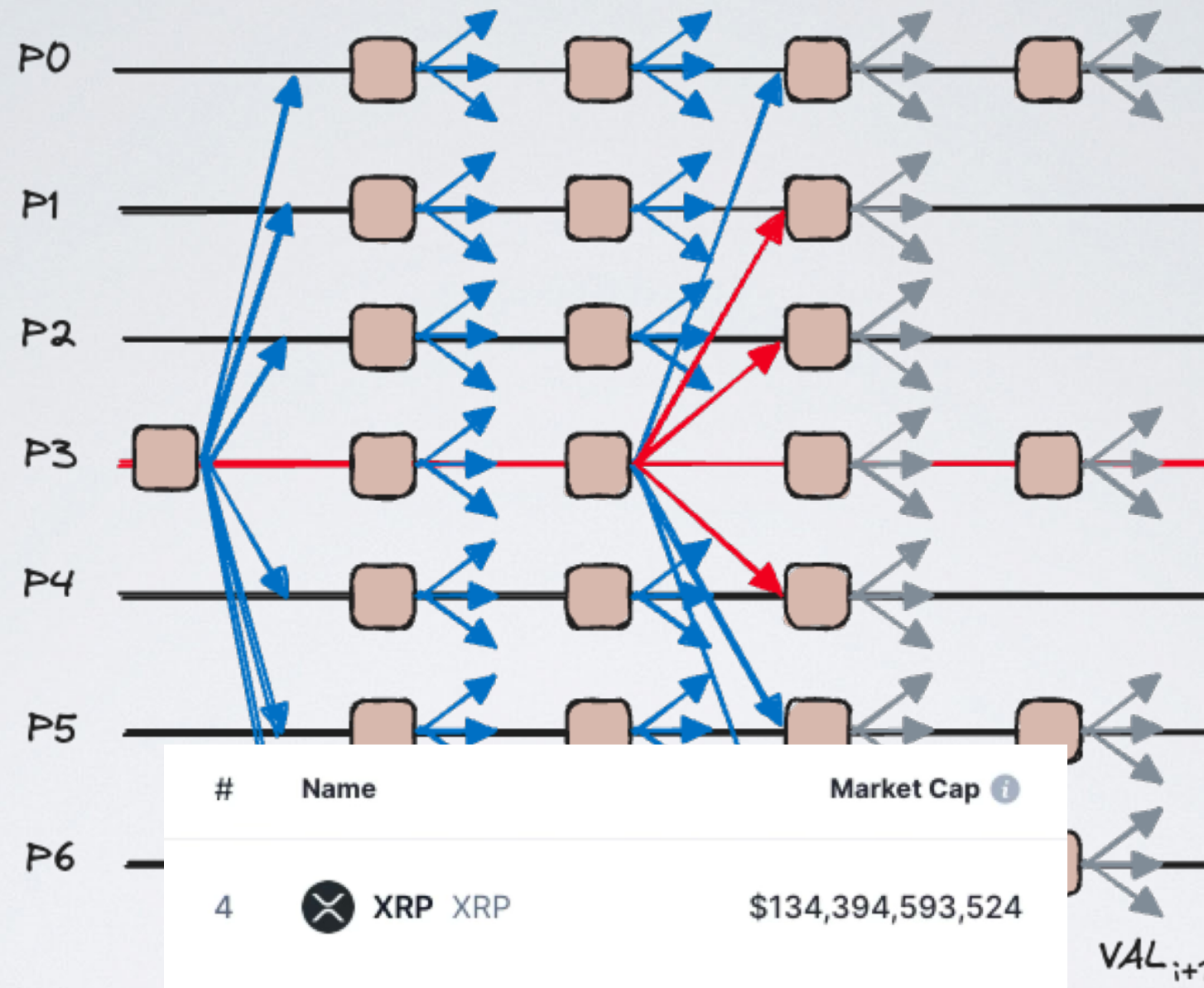
XRPL CP Liveness Violation
[L. Winter et al., 2023]



How was this bug found?

BUGS IN PRODUCTION BLOCKCHAINS

XRPL CP Liveness Violation
[L. Winter et al., 2023]



Levin Winter and Florena Buse win Ripple Bug Bounty Award

NEWS - 25 APRIL 2023 - [COMMUNICATION EWU](#)

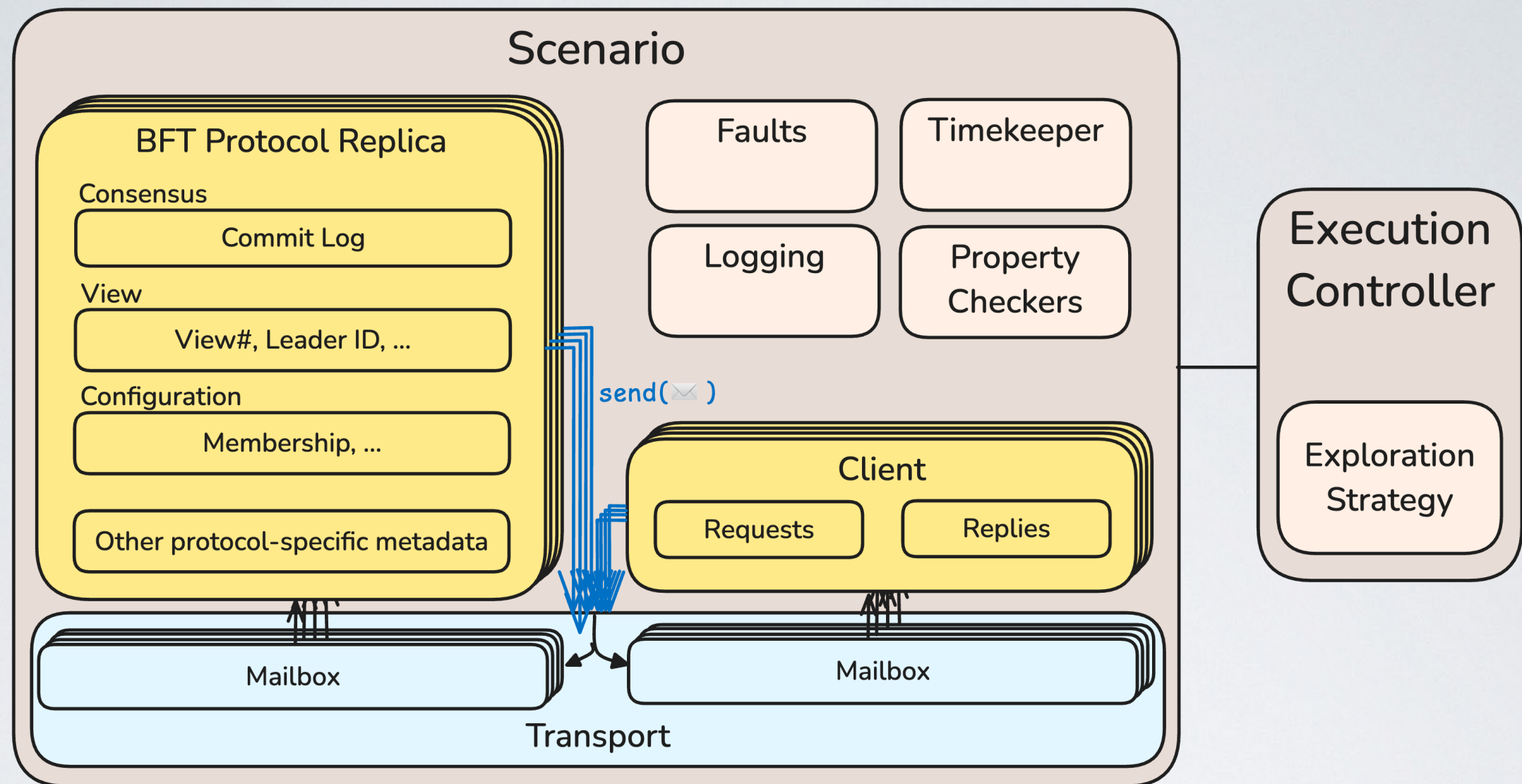
Burcu Özkan's Honours Programme students, Levin Winter and Florena Buse, have been awarded by [Ripple's Bug Bounty Program](#) for the new bug they discovered in the XRP Ledger using the programme's new testing method. Read more about their work in "[Randomized Testing of Byzantine Fault Tolerant Algorithms](#)" in OOPSLA 2023.

THERE ARE TESTING METHODS BUT...

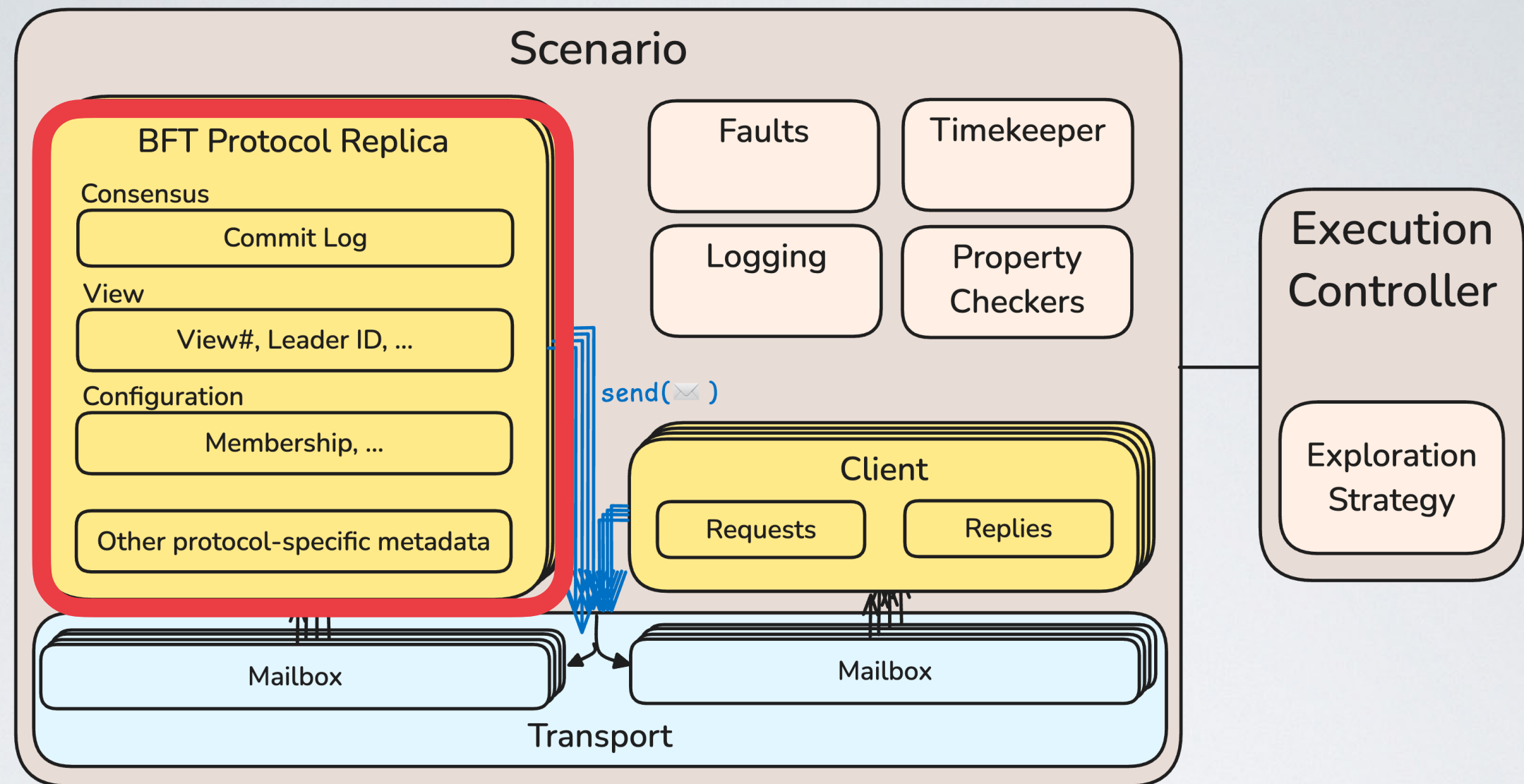
- Existing BFT testing methods are:
 - **System-specific** (e.g. ByzzFuzz for XRPL, Twins for DiemBFT)
 - **Not comparable** (how do they compare?!)
 - **Hard to use** (non-unified interfaces for SUTs; fault injection; non-determinism)

We need a Benchmark Suite for Evaluating BFT Testing Algorithms

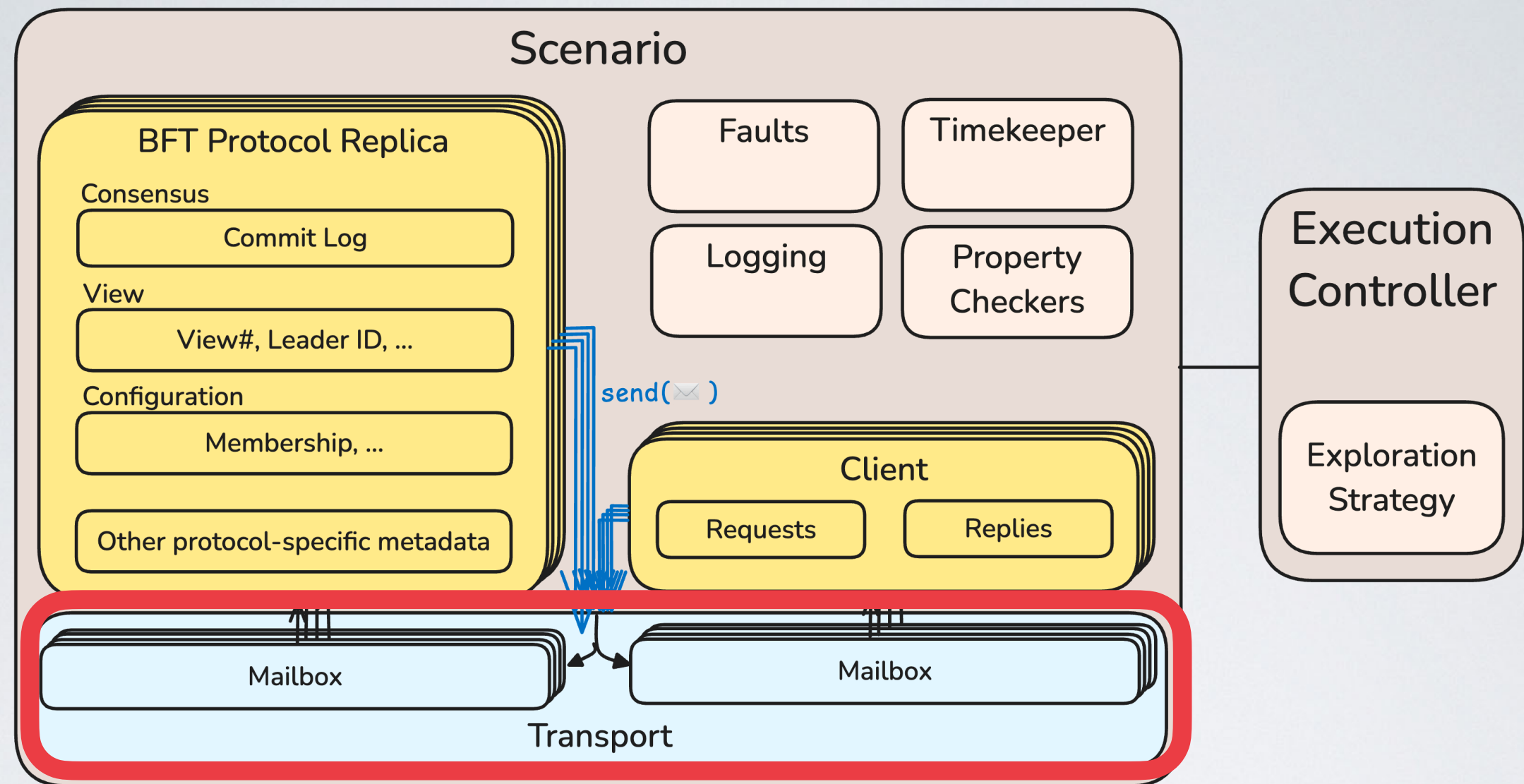
We need a Benchmarking Framework for BFT Testing Algorithms



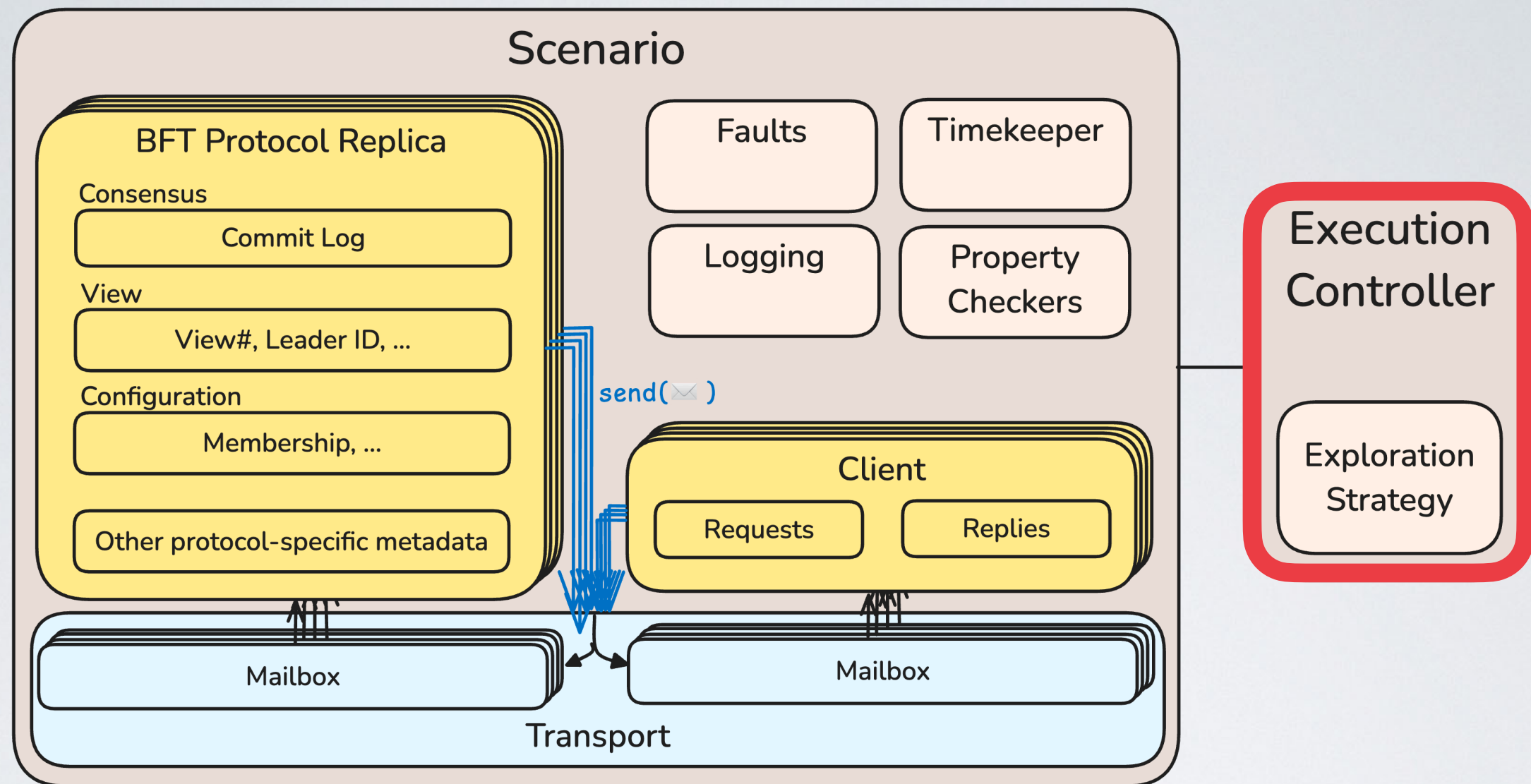
BYZZBENCH ARCHITECTURE



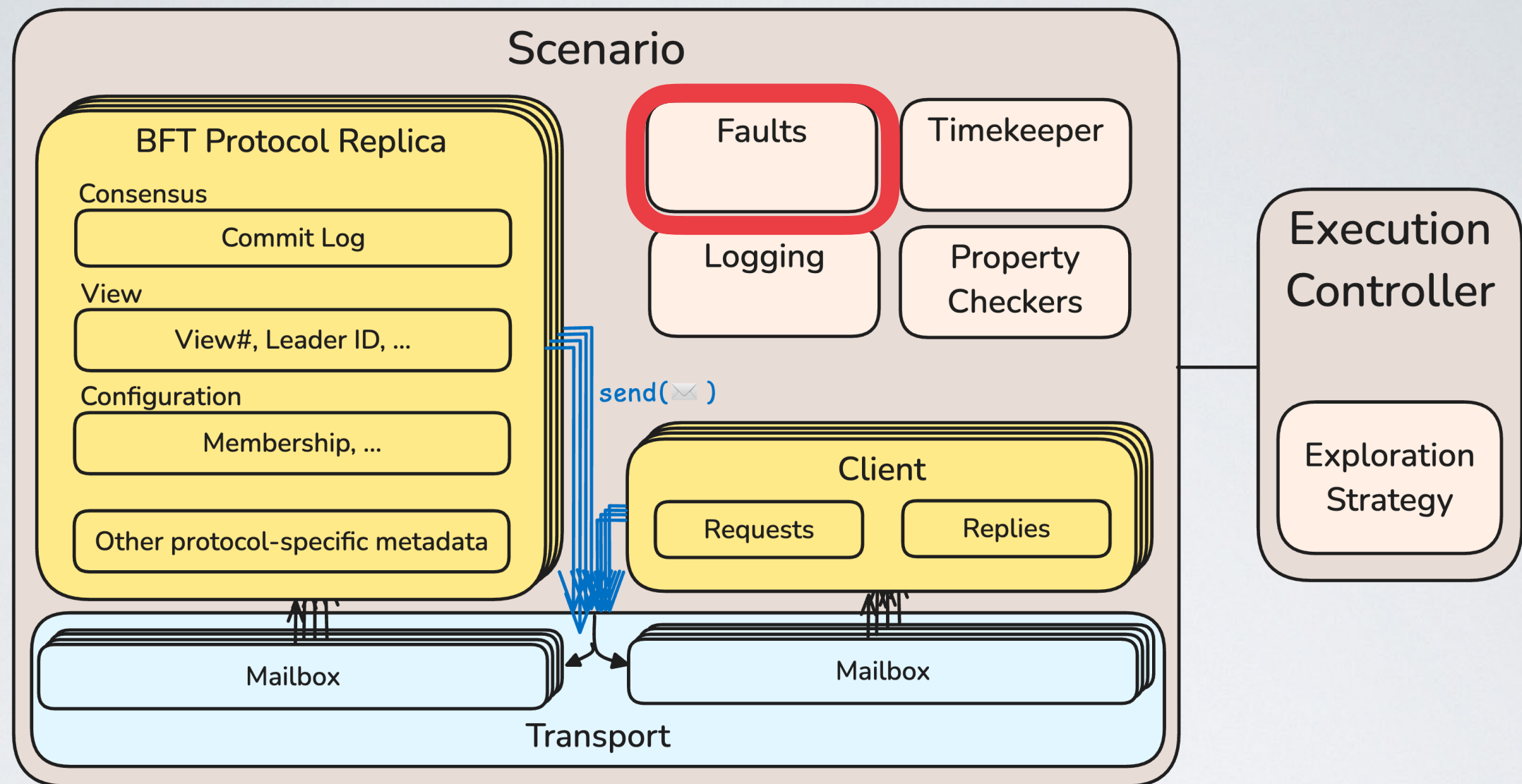
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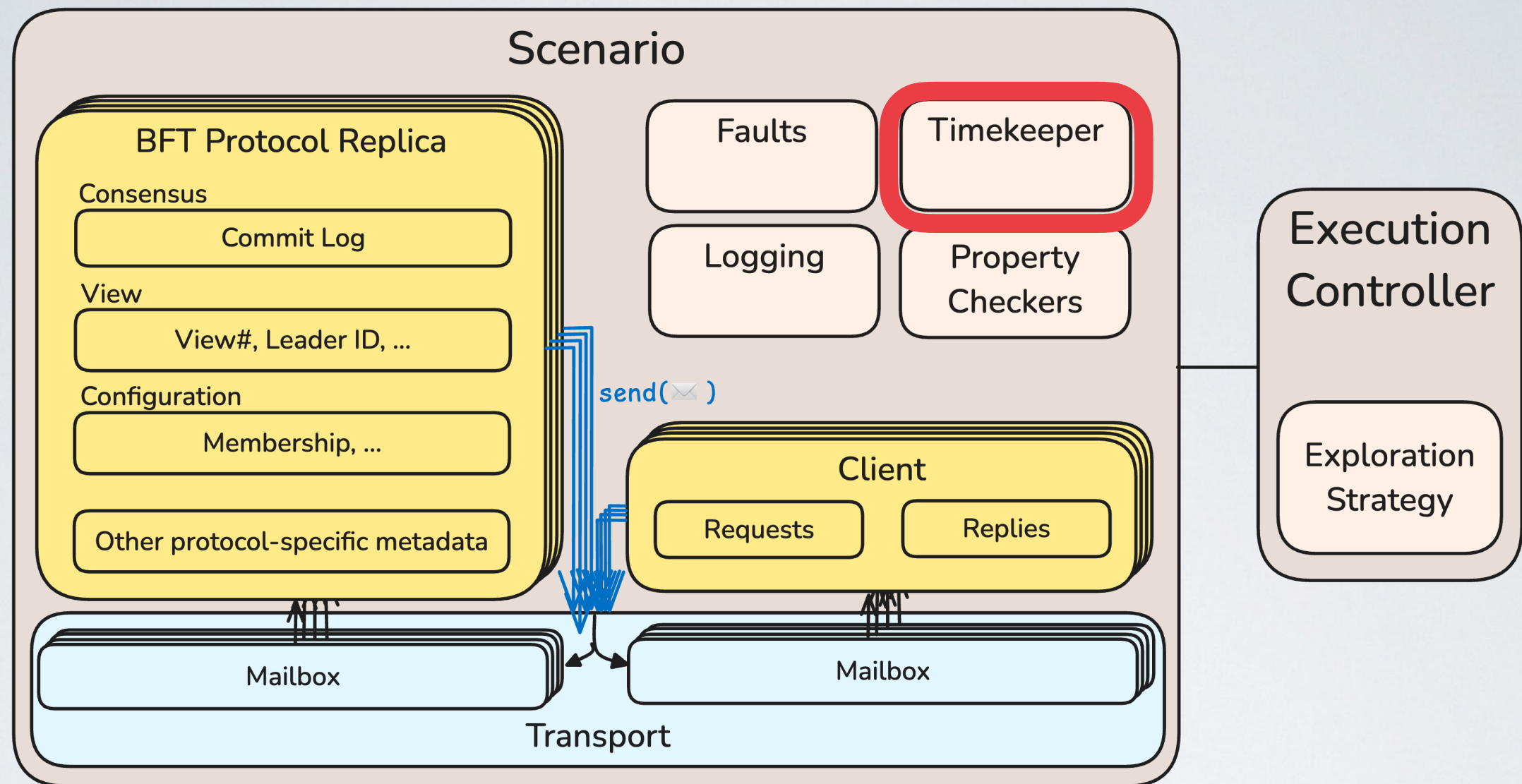
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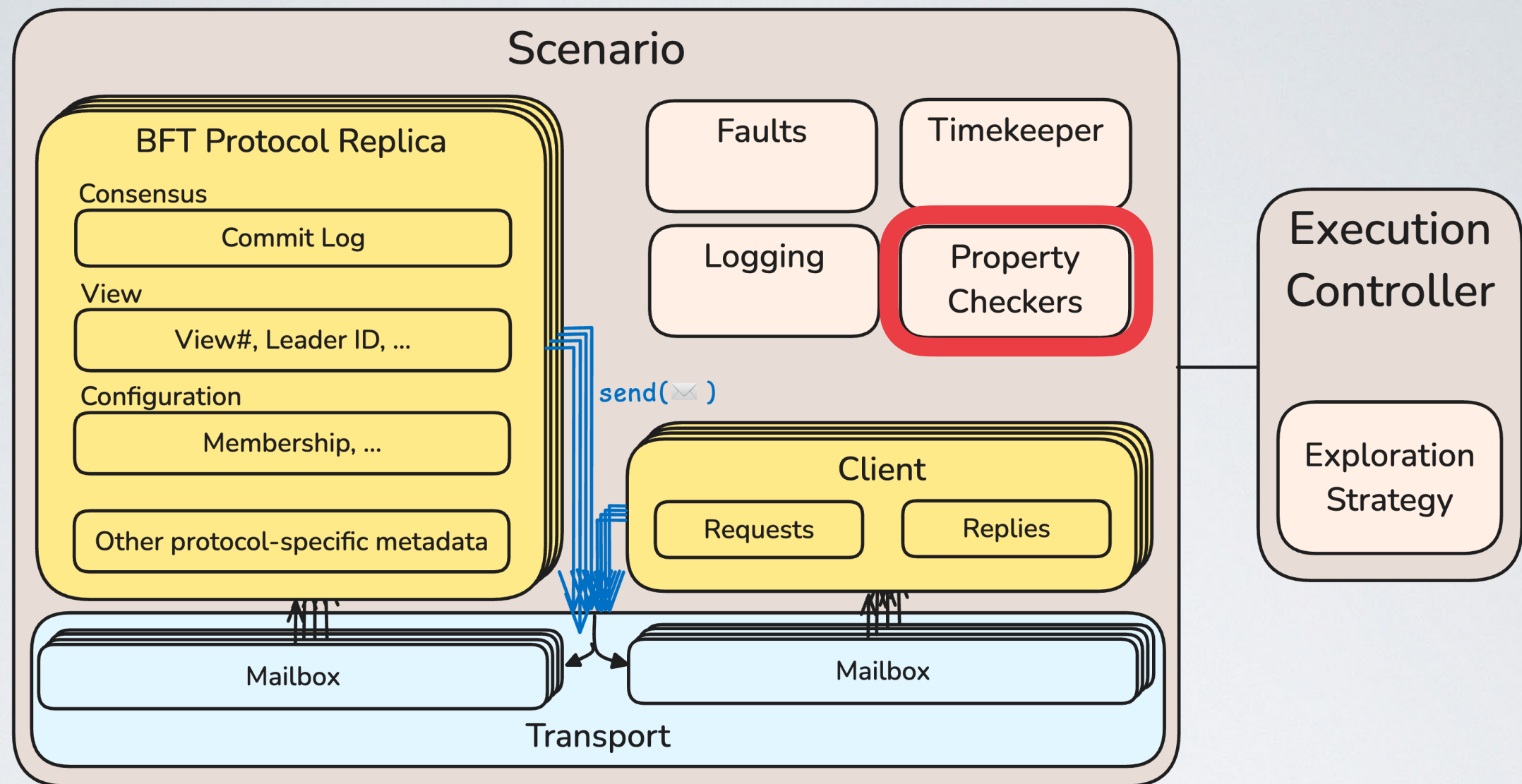
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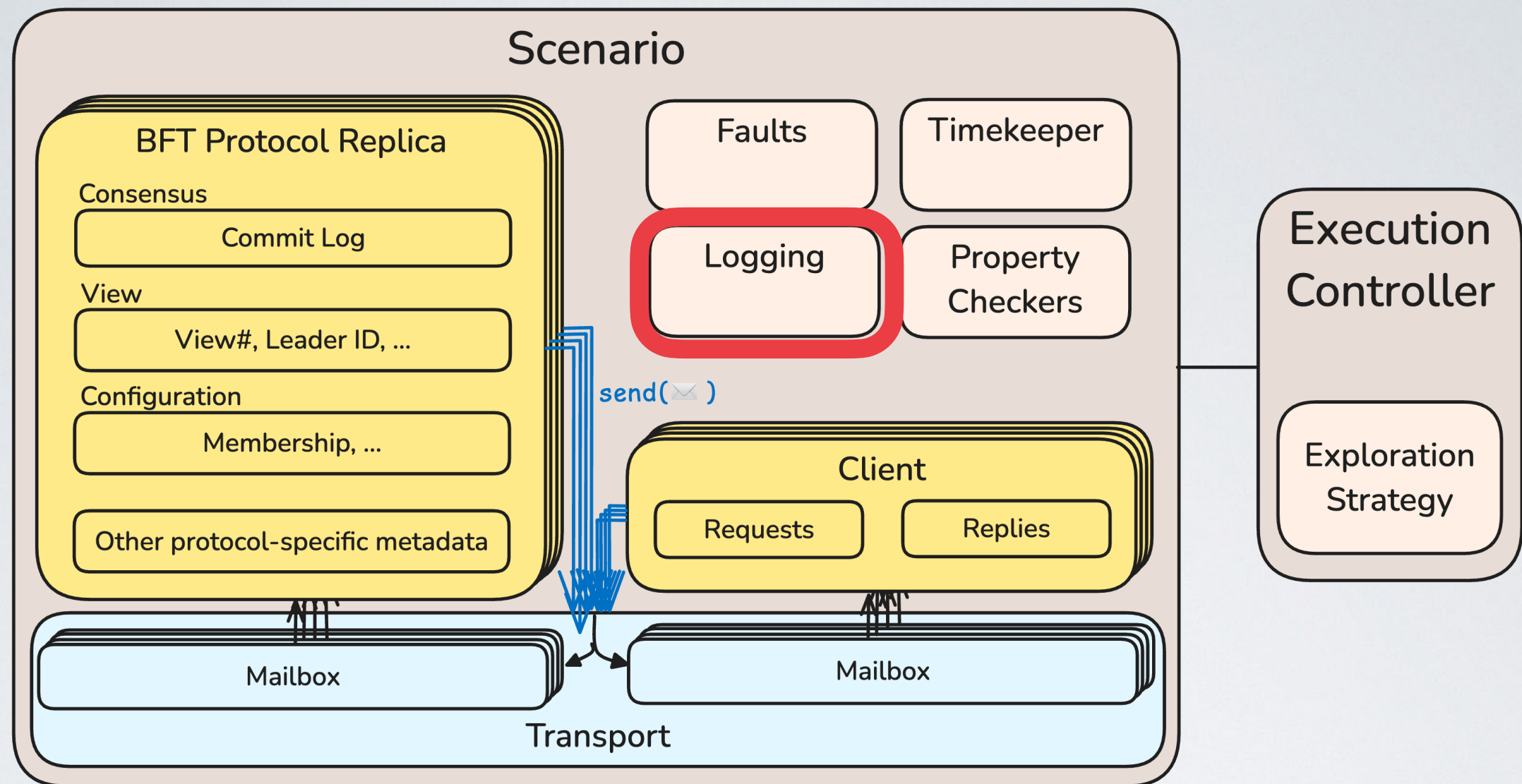
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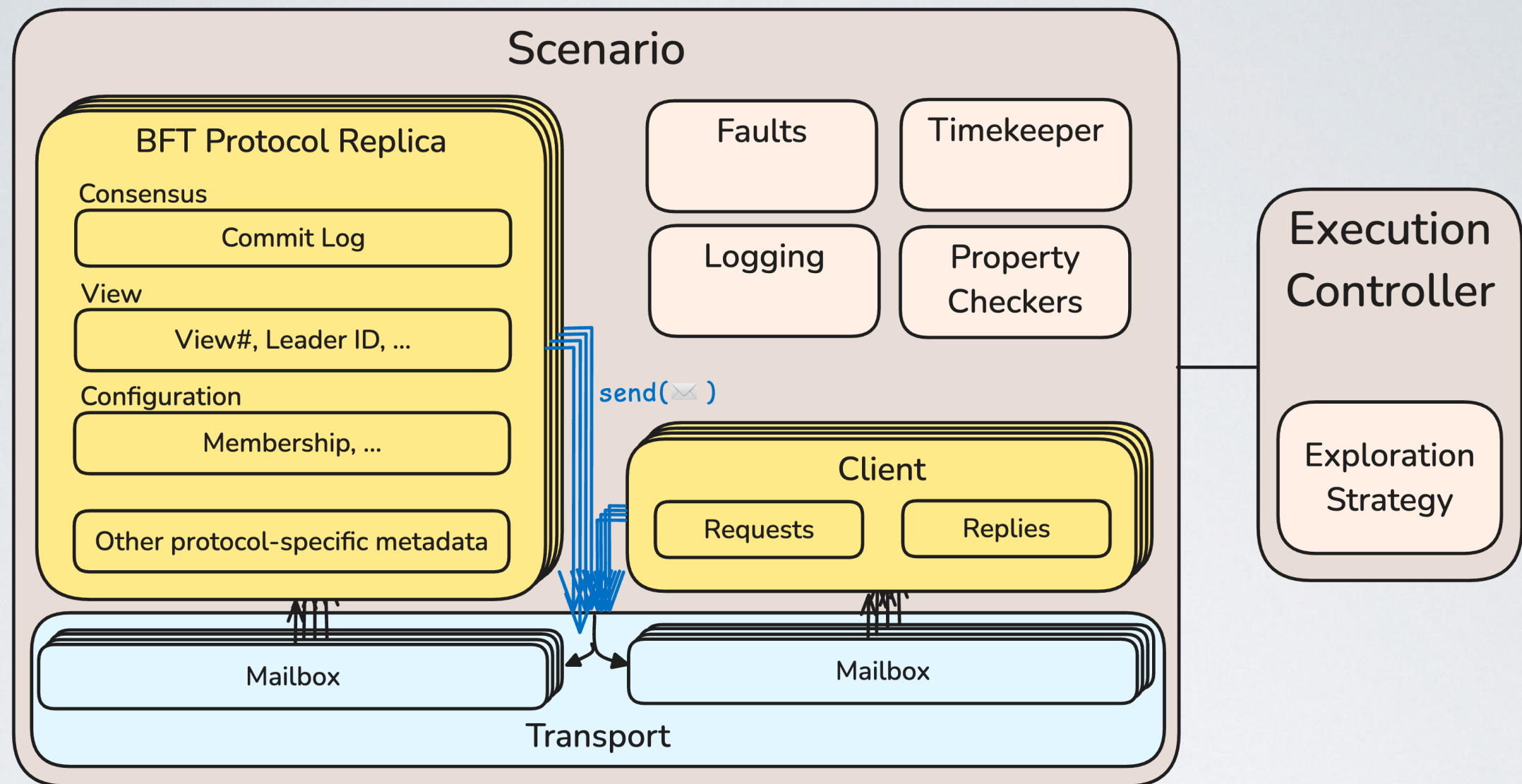
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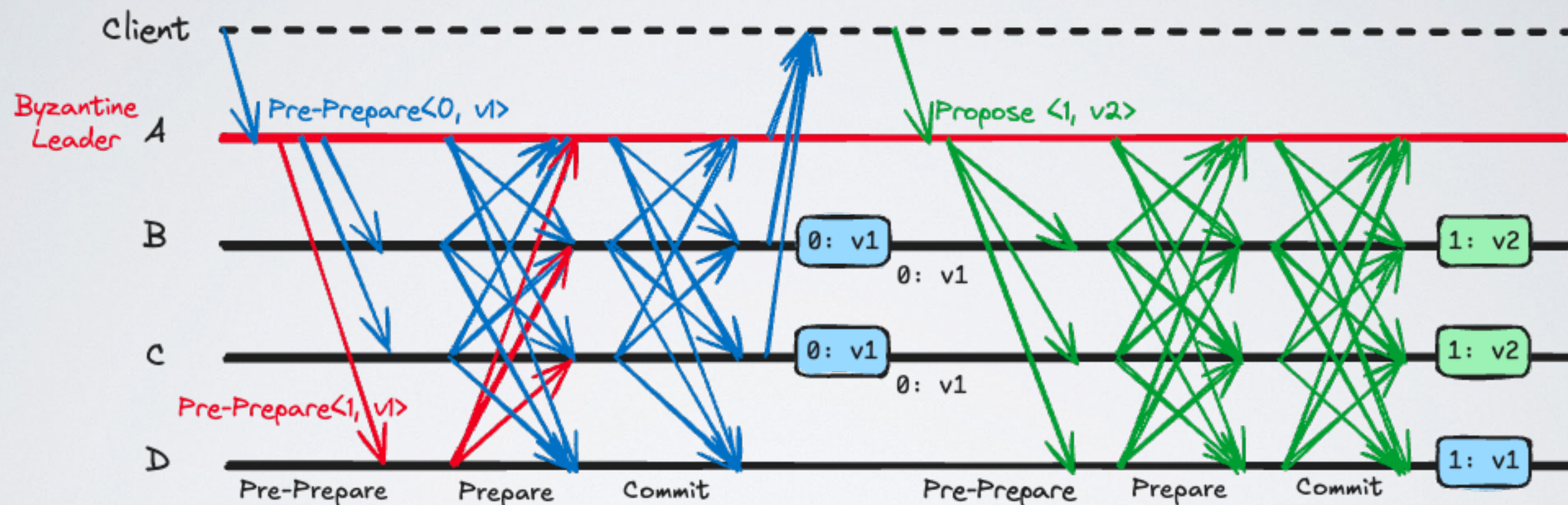


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PRELIMINARY EVALUATION



Random	BF(0,1)	BF(0,2)	BF(1,0)	BF(1,1)	BF(1,2)	BF(2,0)	BF(2,1)	BF(2,2)
0.0%	0.0%	0.0%	7.1%	5.4%	5.0%	11.6%	9.2%	9.5%

% scenarios with bugs

ONGOING WORK

- Extend the framework to a comprehensive benchmark suite of BFT protocols with known bugs

Year	Protocol	Violation	Bug Source	Execution Parameters				
				#processes	#views (or blocks)	#process faults	#network faults	
2017	FaB	liveness	protocol	4	2	1	2	✓
2017	Zyzzzyva	safety	protocol	4	3	1	4	
2019	hBFT	safety	protocol	4	2	2	2	✓
2020	Sync HotStuff	safety	protocol	5	3	2	7	
2020	XRPL	liveness	trust config	7	2	1	0	
2020	XRPL	safety	trust config	7	2	2	0	
2021	PBFT	liveness	protocol	4	1	2	0	
2022	Fast-HotStuff	safety	protocol	4	11	0	3	
2023	PBFT	safety	pbft-java	4	2	1	0	✓
2023	XRPL	liveness	rippled v1.7.2	7	3	1	0	

ByzzBench

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Import Schedule

Saved Schedules

Invariants: AGREEMENT LIVENESS

Clients

C0

>

Nodes

A

commitLog

length1

log

0

disgruntled

leaderIdB

nodeIdA

timeout1000

tolerance1

viewNumber1

6D PREPARE

56C PREPARE

59C COMMIT

66D COMMIT

72B PRE-PREPARE

78C COMMIT

81D COMMIT

B

commitLog

length2

log

0

disgruntled

leaderIdB

nodeIdB

timeout1000

tolerance1

viewNumber1

45D PREPARE

50A COMMIT

60C COMMIT

79C COMMIT

82D COMMIT

C

commitLog

length2

log

0

disgruntled

leaderIdB

nodeIdC

timeout1000

tolerance1

viewNumber1

48A PREPARE

68D COMMIT

70A COMMIT

73B PRE-PREPARE

76B COMMIT

83D COMMIT

D

commitLog

length2

log

0

disgruntled

leaderIdB

nodeIdD

timeout1000

tolerance1

viewNumber1

49A PREPARE

58C PREPARE

61C COMMIT

71A COMMIT

74B PRE-PREPARE

80C COMMIT

Schedule

<12>

1: Client Request from C0 to A

2: Deliver REQUEST from A to B

5: Deliver PRE-PREPARE from B to D

7: Deliver PREPARE from D to B

4: Deliver PRE-PREPARE from B to C

10: Deliver PREPARE from C to B

12: Deliver COMMIT from B to A

3: Deliver PRE-PREPARE from B to A

14: Deliver COMMIT from B to D

8: Deliver PREPARE from D to C

16: Deliver COMMIT from C to A

Trigger Faults

Isolate A

Isolate B

Isolate C

Isolate D

Discarded Events

BYZZBENCH UI

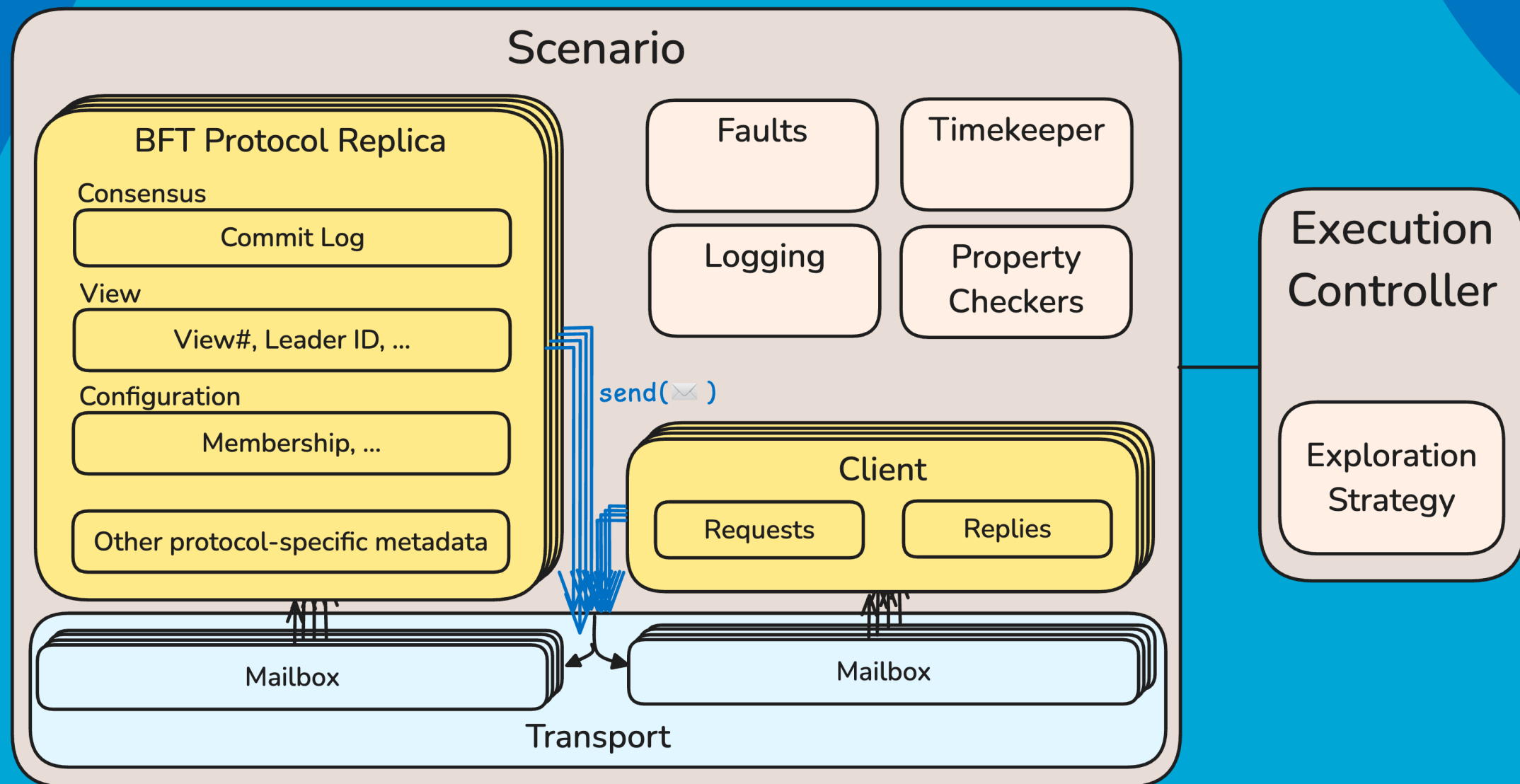
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BYZZBENCH SUMMARY

- A framework to implement BFT protocols and plug-and-play testing strategies.
- Built-in **controlled fault injection** and **property checkers**
- Allows for the **evaluation of different testing algorithms** for BFT protocols
- **First step** towards a **benchmark suite of BFT protocol bugs.**

ByzzBench

A Benchmark Framework for BFT Testing Algorithms



github.com/joaomlneto/byzzbench