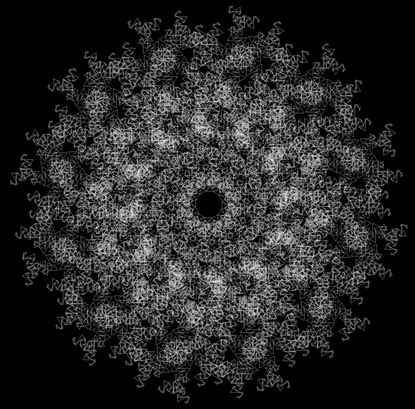
Isaac Sheff

Heliax .dev

TYPHON

Naqib Zarin



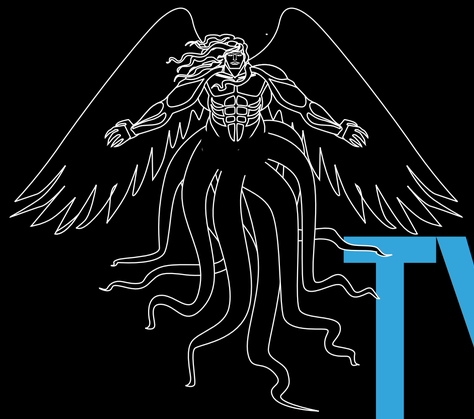
TG x Thoth

anoma

Aleksandr Karbyshev

Heliax.dev

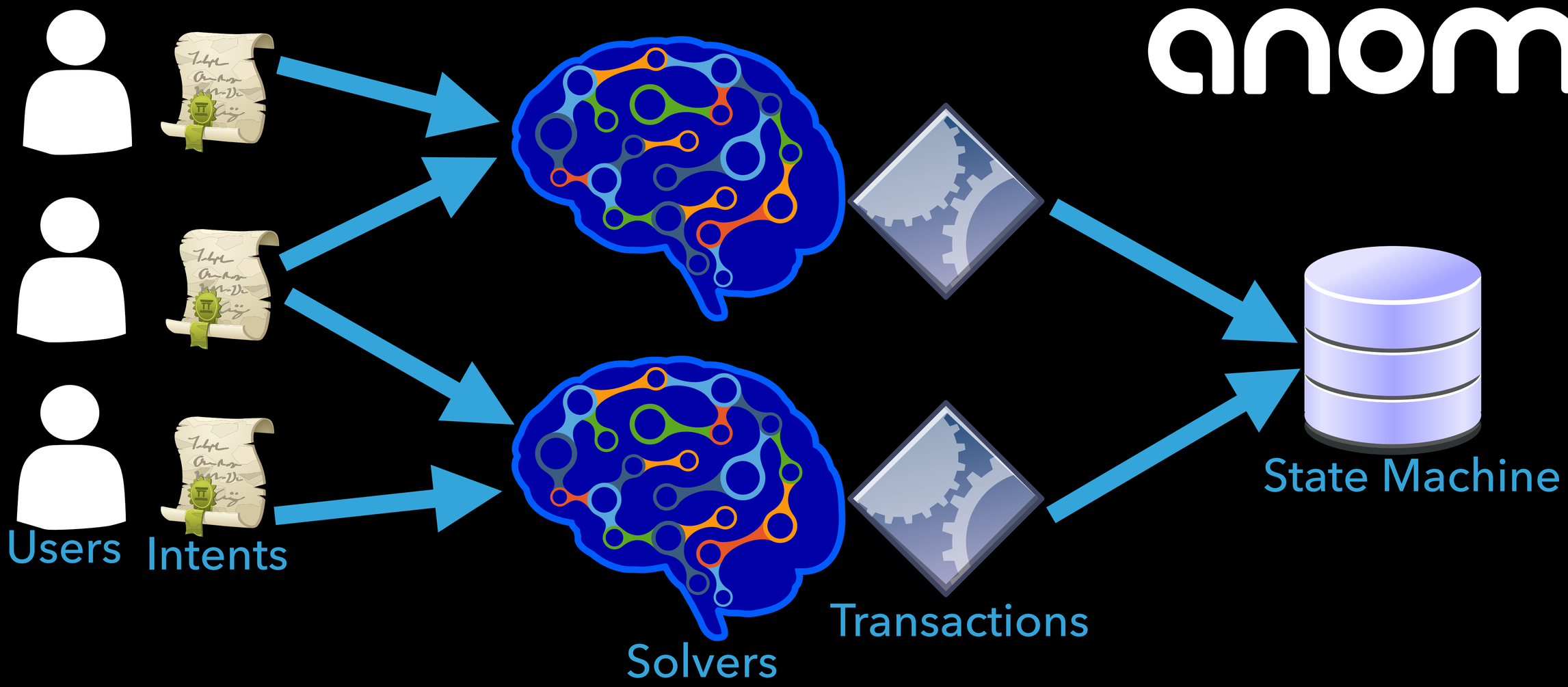
Tobias Heindel



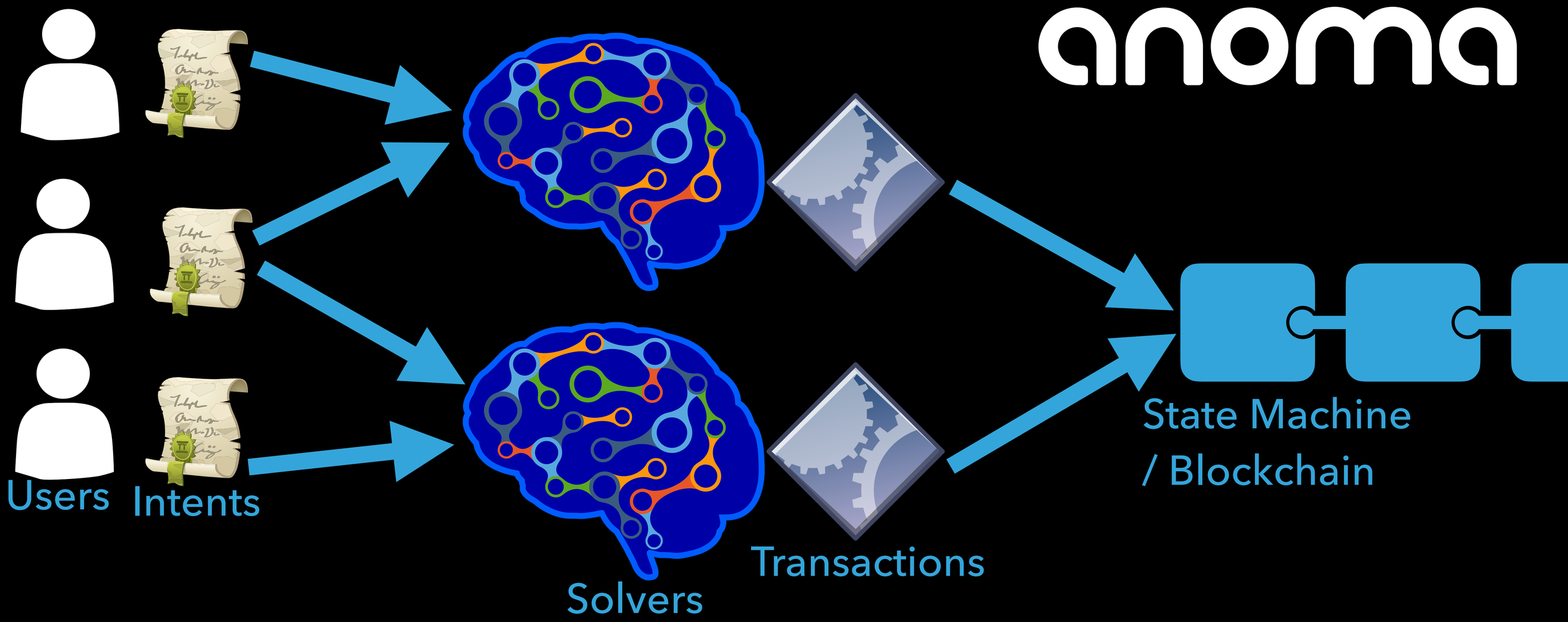
TYPHON

Isaac Sheff

anoma



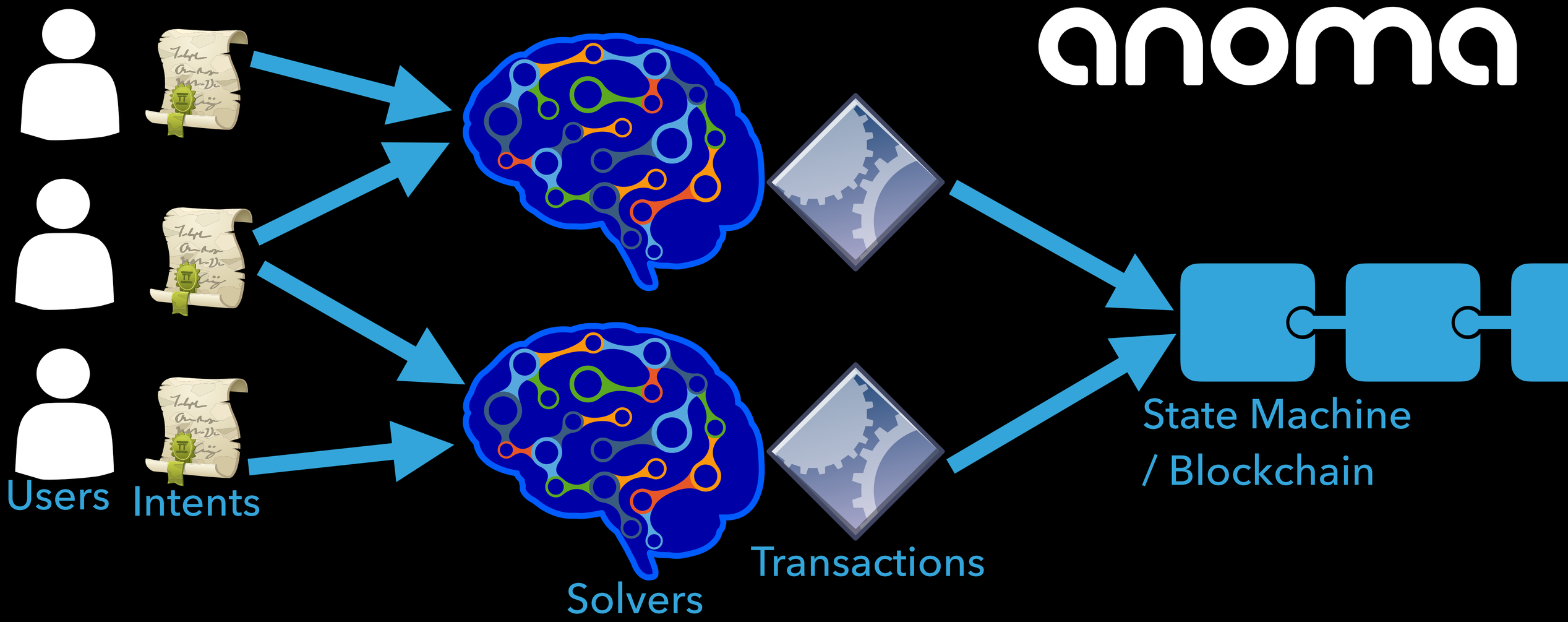
anoma


Users
Intents
Solvers
Transactions
State Machine
/ Blockchain

3 POINTS

- Shared P2P Layer

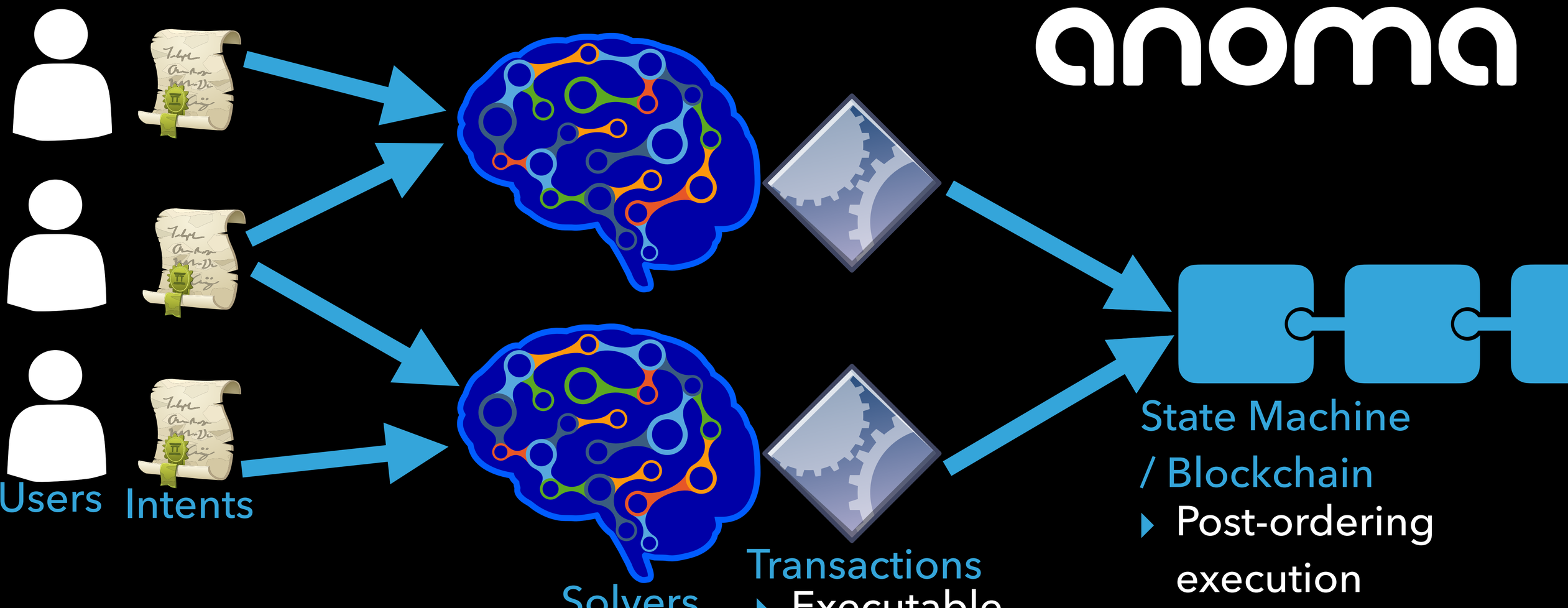
anoma



3 POINTS

- Shared P2P Layer
- Post-ordering execution

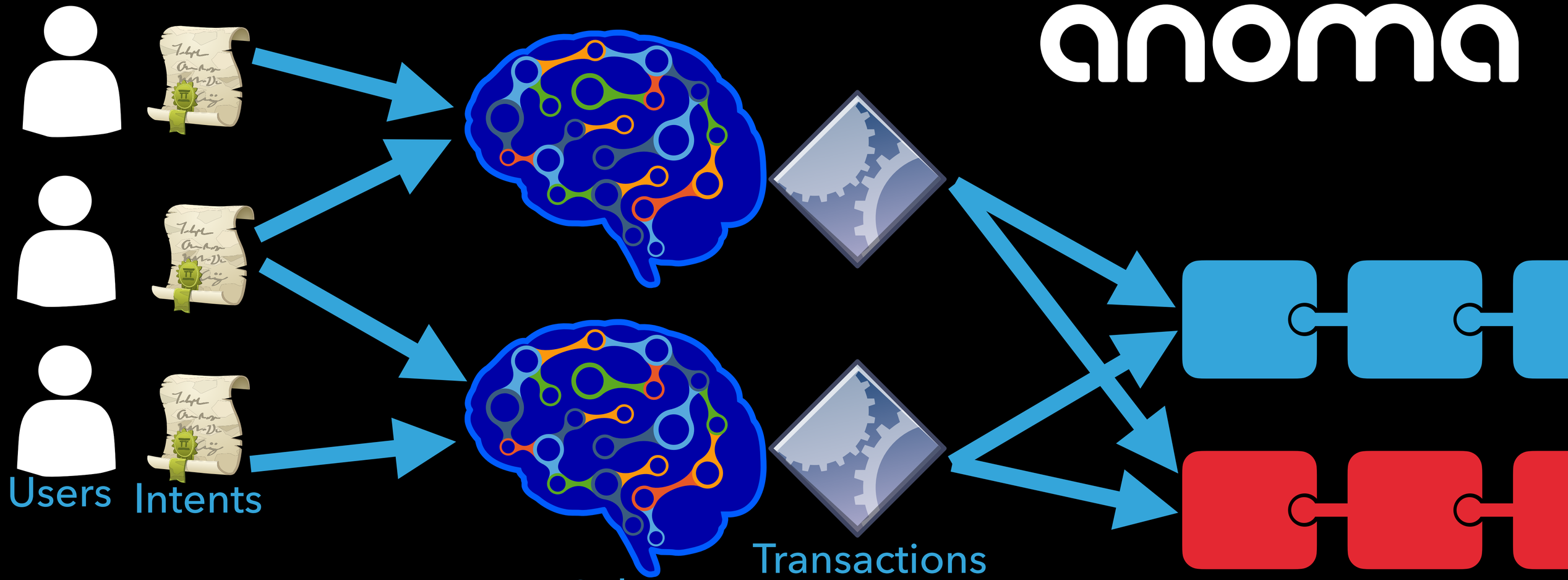
anoma

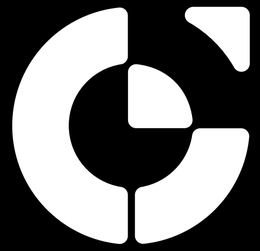


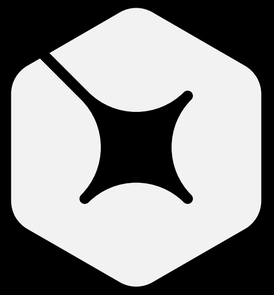
3 POINTS

- Shared P2P Layer
- Post-ordering execution
- Multi-chain transactions

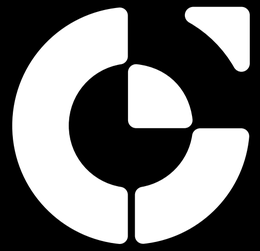
anoma

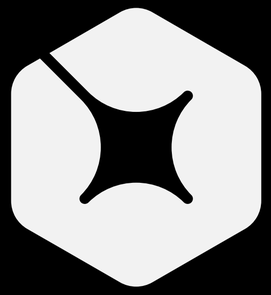






anoma uses CometBFT





anoma uses CometBFT

anoma will use TYPHON, which supports CHIMERA CHAINS

CometBFT

HETEROGENEOUS TRUST

- Many Instances
- Shared Validators
  - Software for multiple instances
  - Add chains on demand
  - Reduce redundancy

COMPONENTS

Shared P2P Layer

P2P

- Communication / Multicast
- P2P Overlay Domains with Sovereignty (PODS)

P2P OVERLAY DOMAINS WITH SOVEREIGNTY (PODS)

- https://arxiv.org/abs/2306.16153

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P2P OVERLAY DOMAINS WITH SOVEREIGNTY (PODS)

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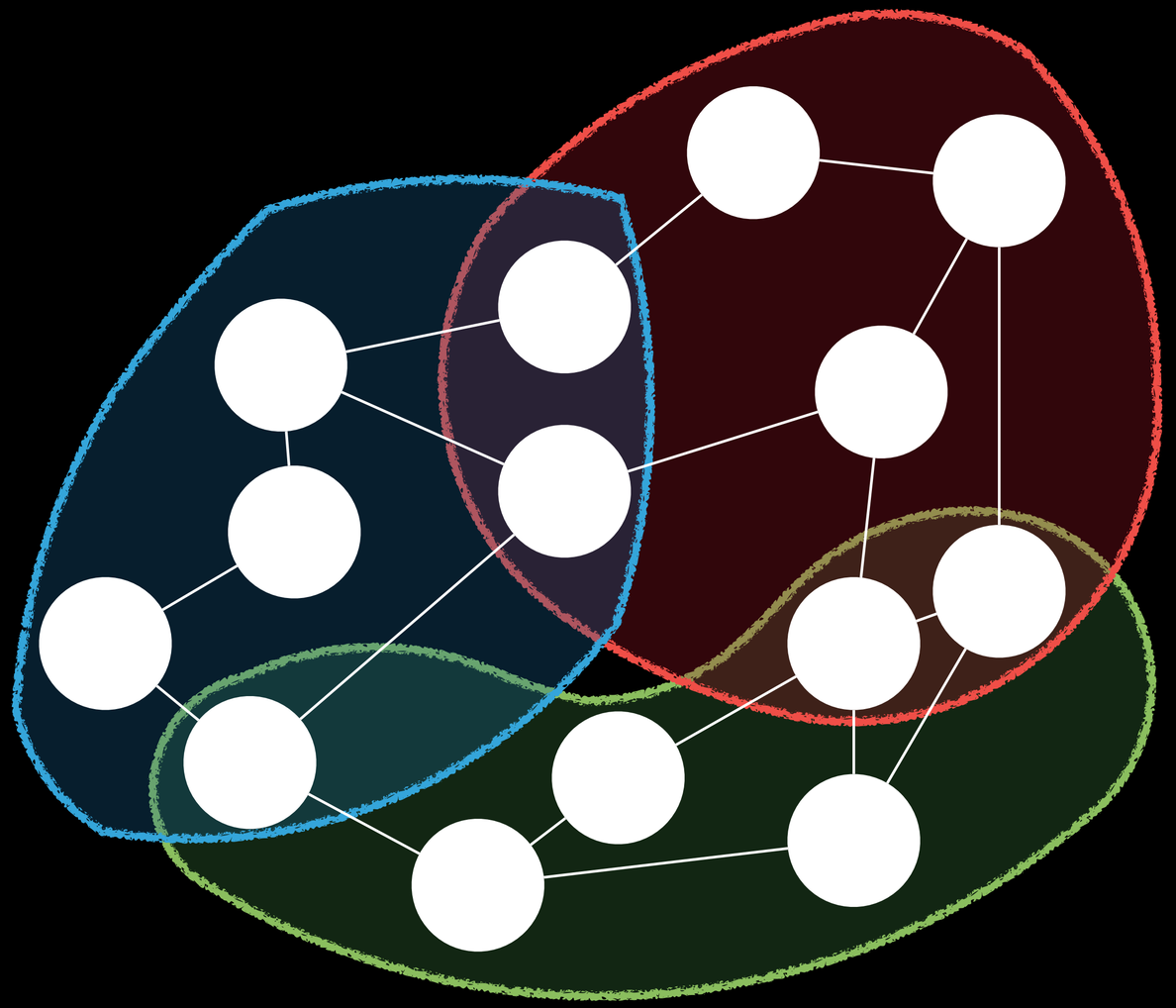

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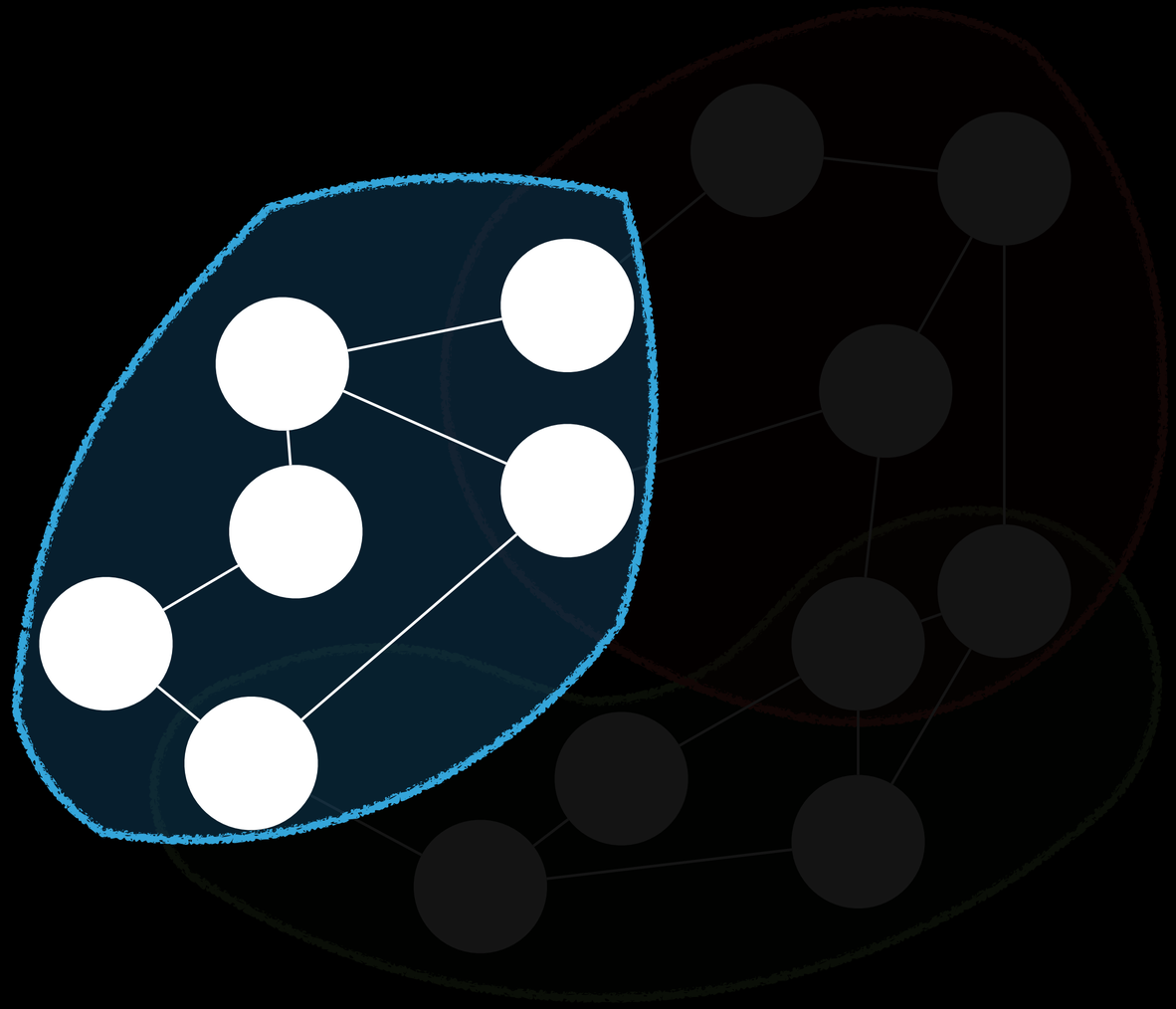

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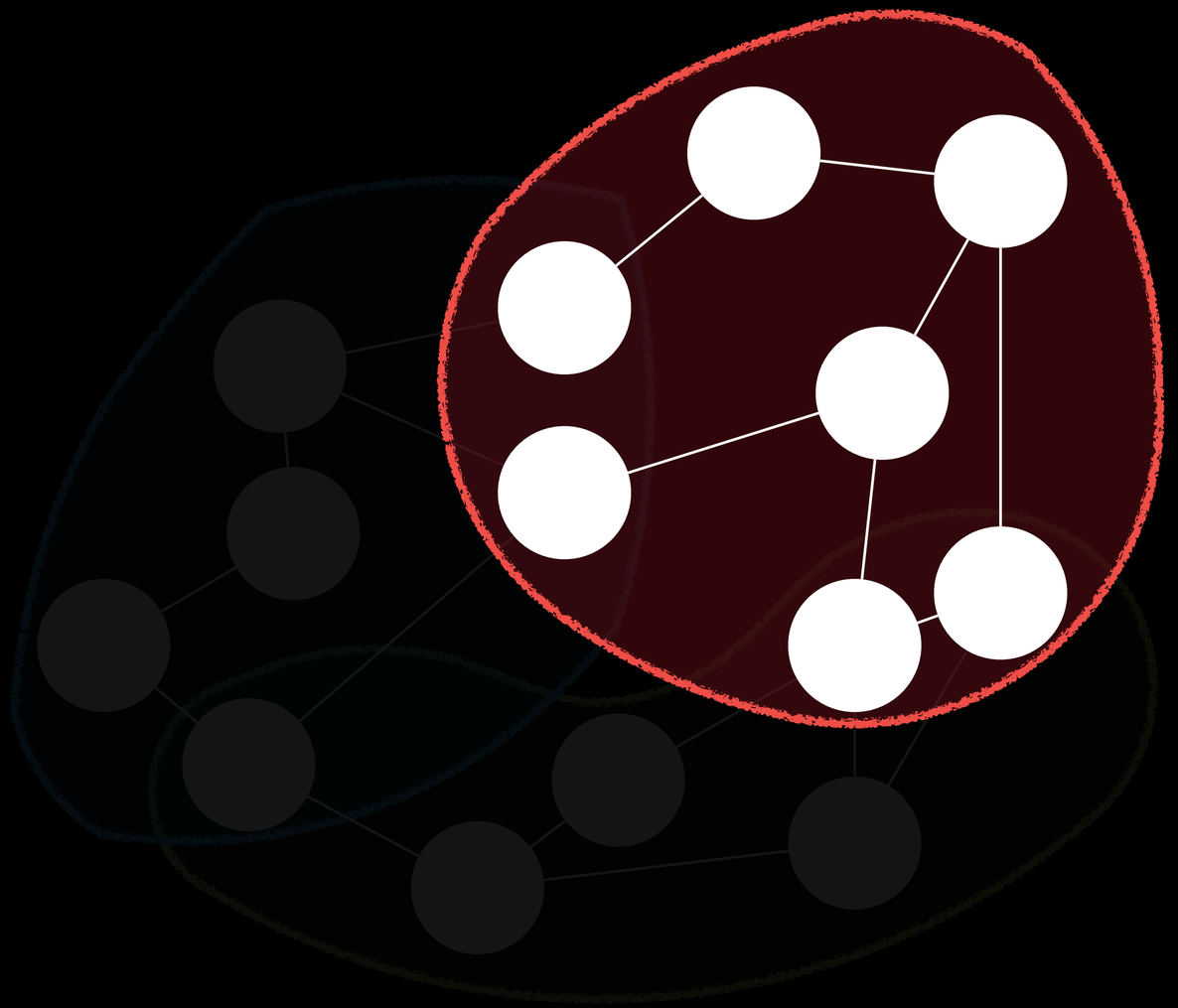

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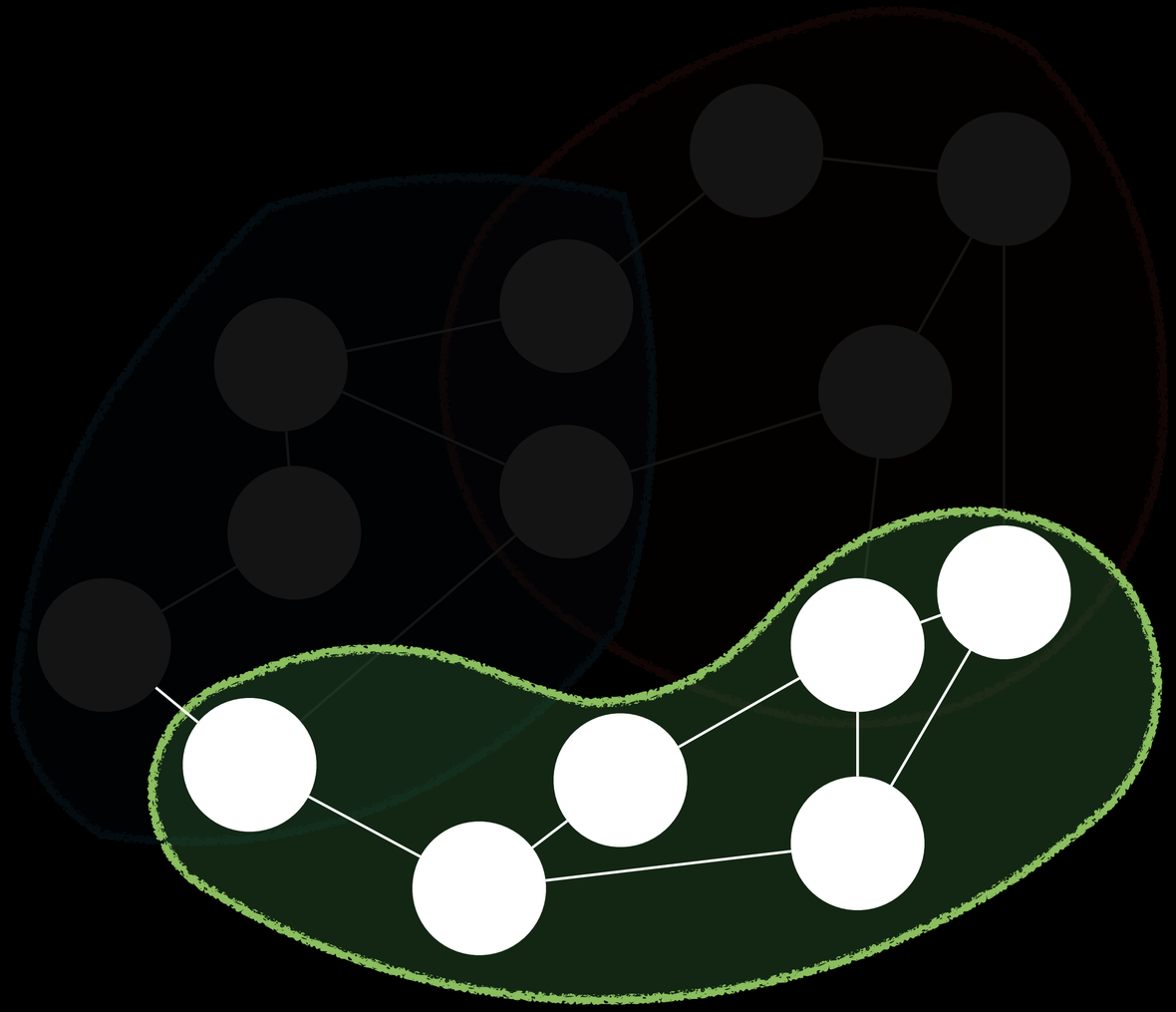

P2P OVERLAY DOMAINS WITH SOVEREIGNTY (PODS)

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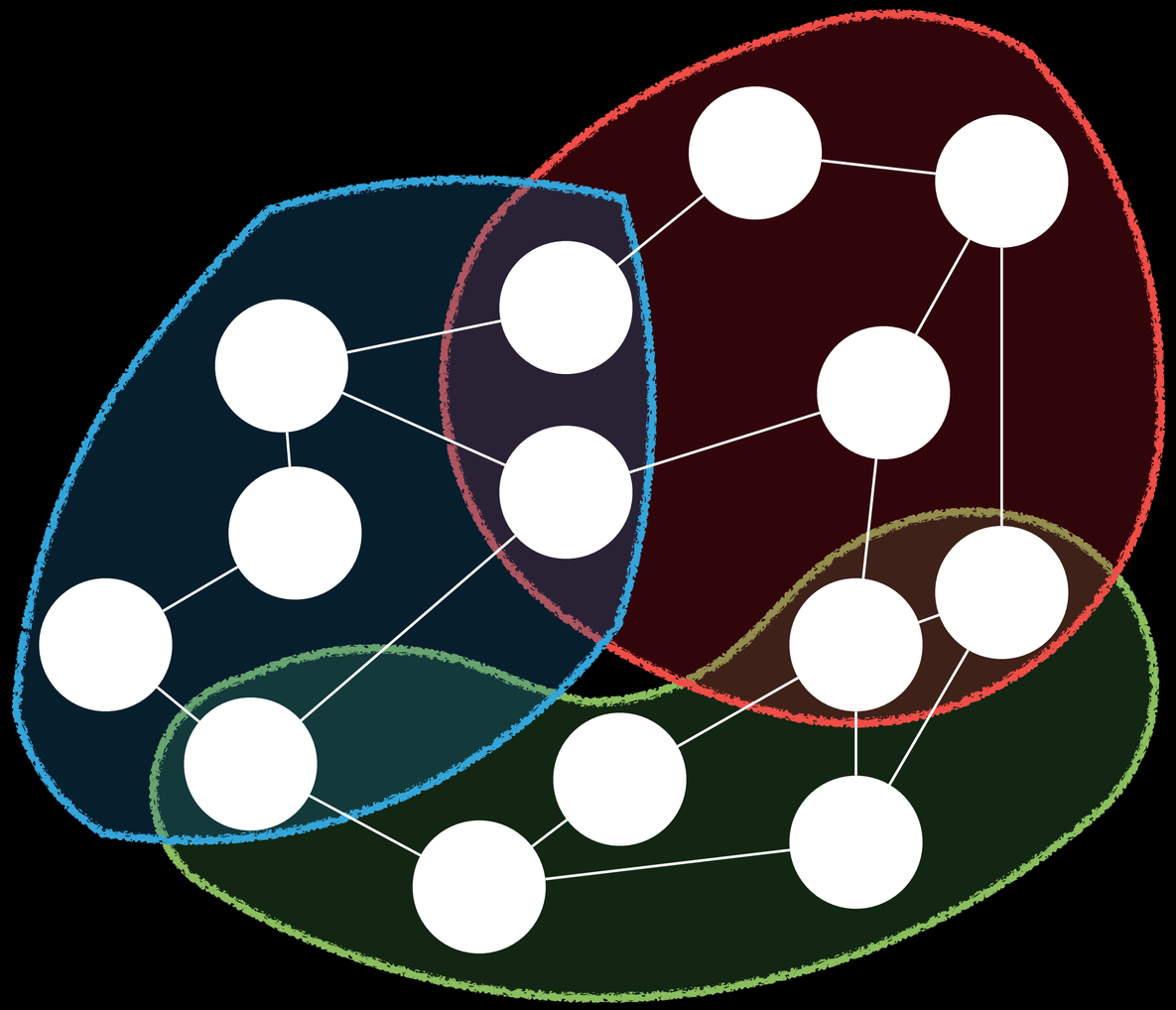
- Multiple Independent Overlay Networks (Domains)
  - Performance of a small overlay



P2P OVERLAY DOMAINS WITH SOVEREIGNTY (PODS)

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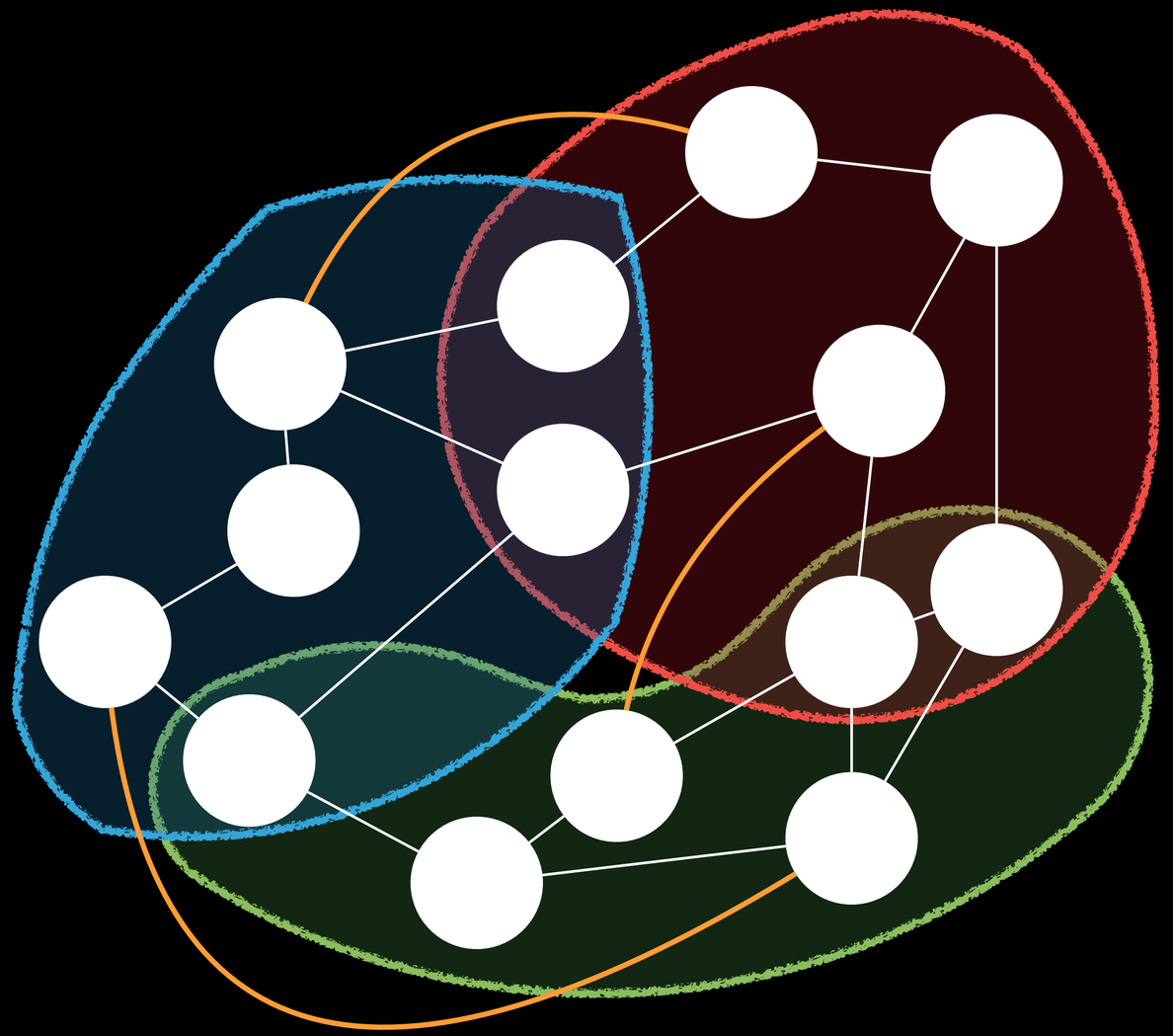
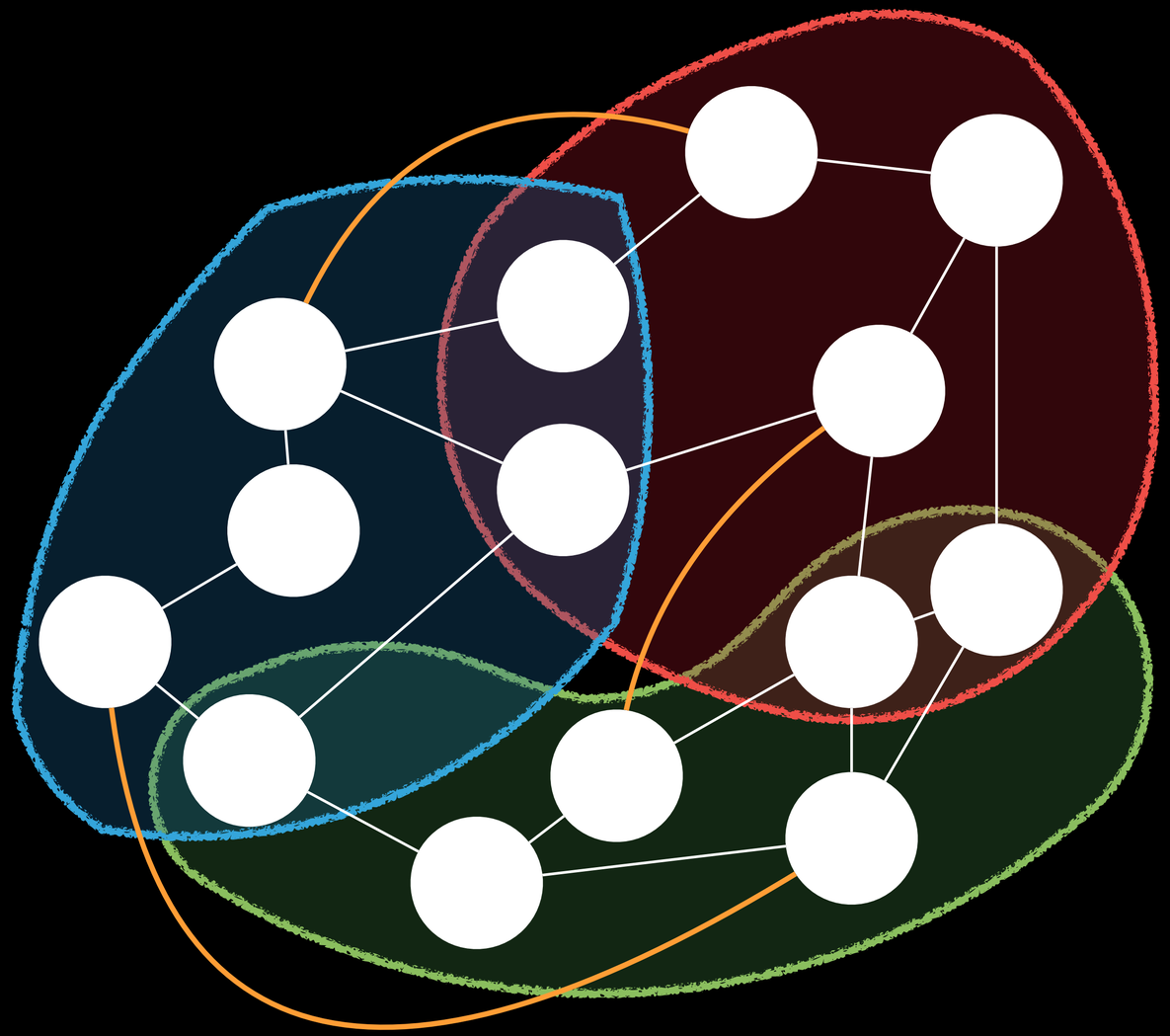
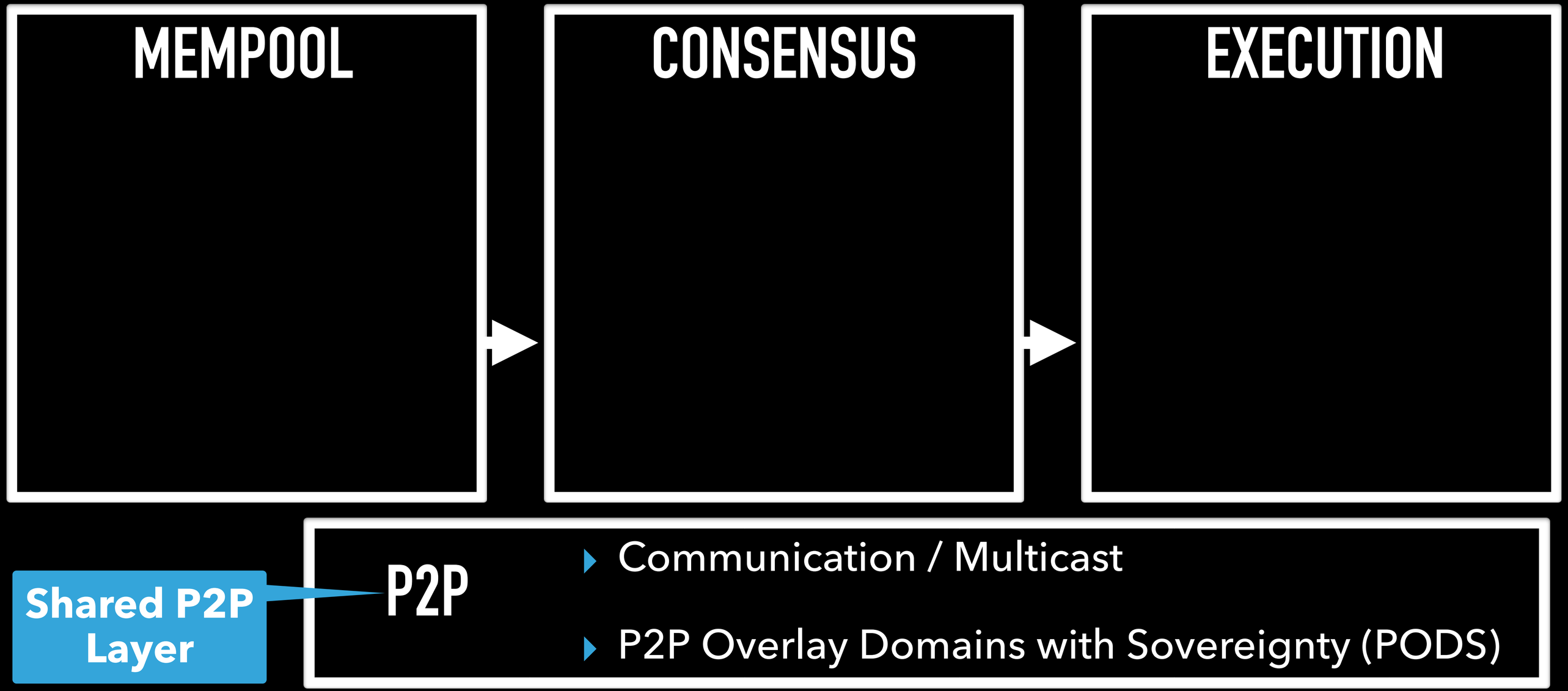


P2P OVERLAY DOMAINS WITH SOVEREIGNTY (PODS)

- https://arxiv.org/abs/2306.16153
- Multiple Independent Overlay Networks (Domains)
  - Performance of a small overlay
- Inter-Domain Routing
- Cross-domain attack response
  - Security of a large overlay



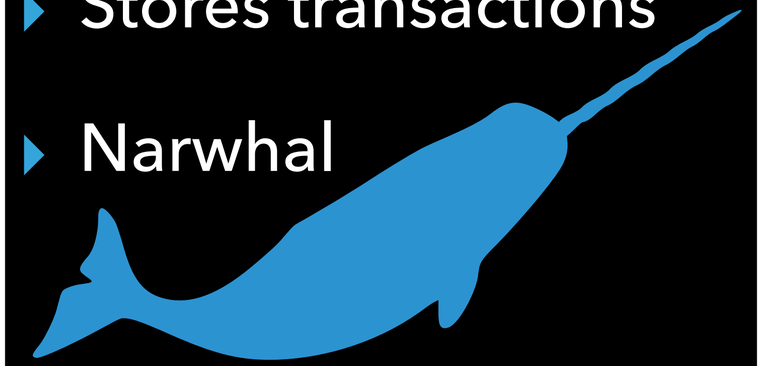
COMPONENTS


MEMPOOL
CONSENSUS
EXECUTION
Shared P2P Layer
P2P
Communication / Multicast
P2P Overlay Domains with Sovereignty (PODS)

COMPONENTS

MEMPOOL

- Receives from clients / solvers
- Stores transactions
- Narwhal



CONSENSUS

EXECUTION

Shared P2P Layer

P2P

- Communication / Multicast
- P2P Overlay Domains with Sovereignty (PODS)

Cross-chain transactions

COMPONENTS

MEMPOOL

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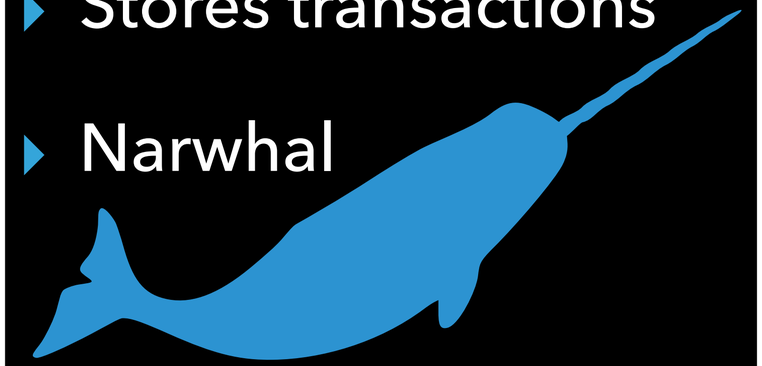
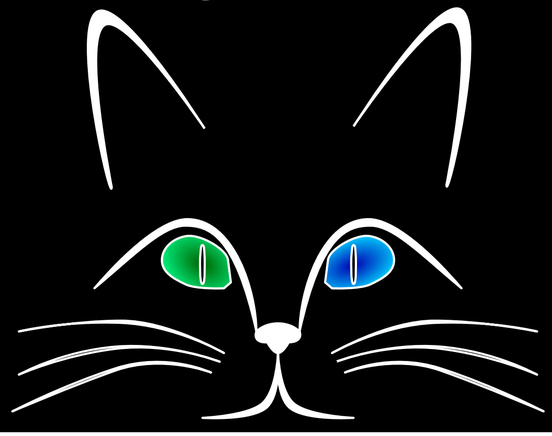


CONSENSUS

- Orders transactions
- Heterogeneous Paxos



EXECUTION

Shared P2P Layer

P2P

- Communication / Multicast
- P2P Overlay Domains with Sovereignty (PODS)

COMPONENTS

Cross-chain transactions

Post-ordering execution

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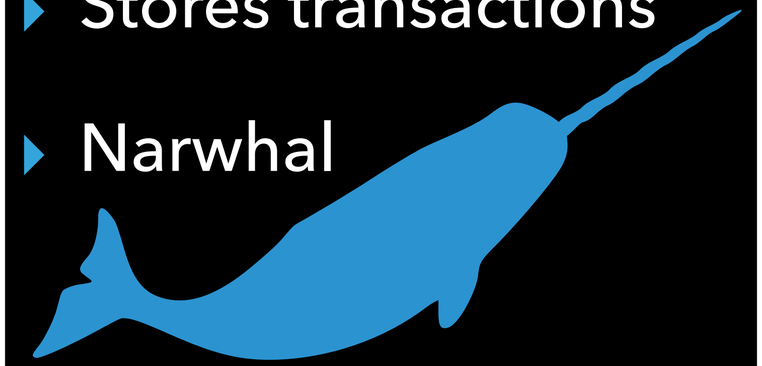

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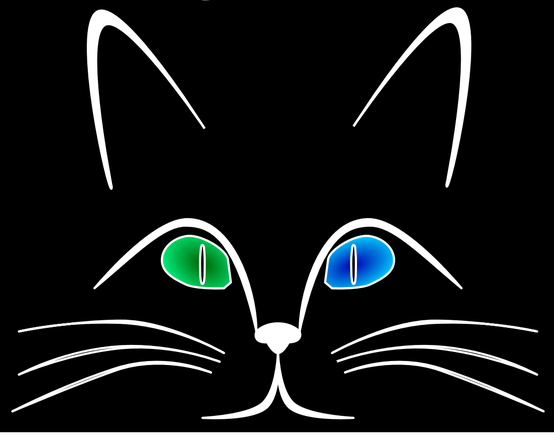
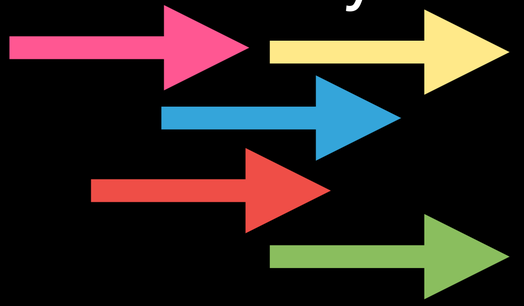


EXECUTION

- State machine
- Client reads
- Concurrency



Shared P2P Layer

P2P

- Communication / Multicast
- P2P Overlay Domains with Sovereignty (PODS)

COMPONENTS

Cross-chain transactions

Post-ordering execution

MEMPOOL

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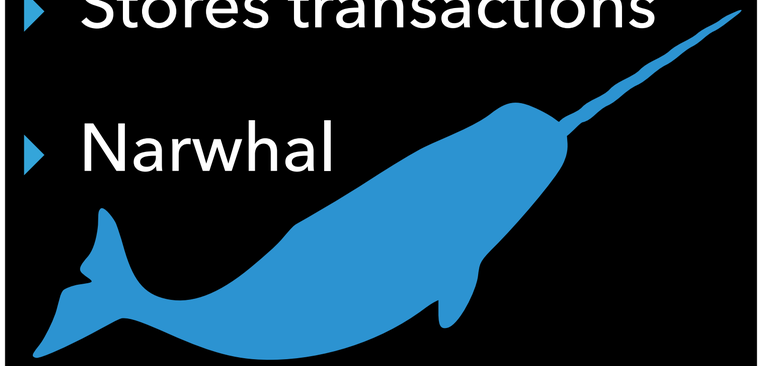

CONSENSUS

- Orders transactions
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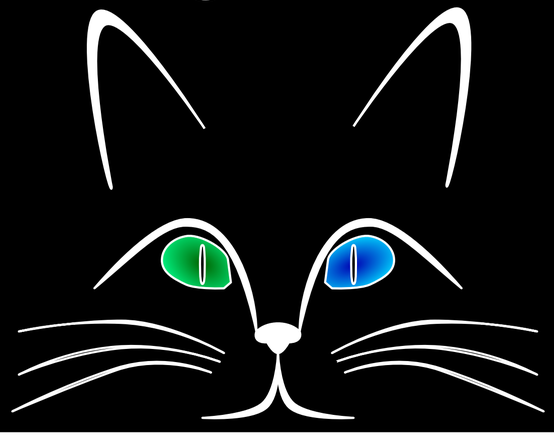

EXECUTION

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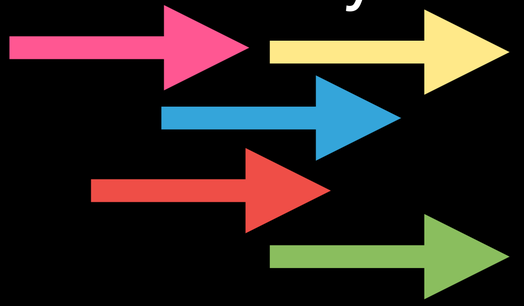


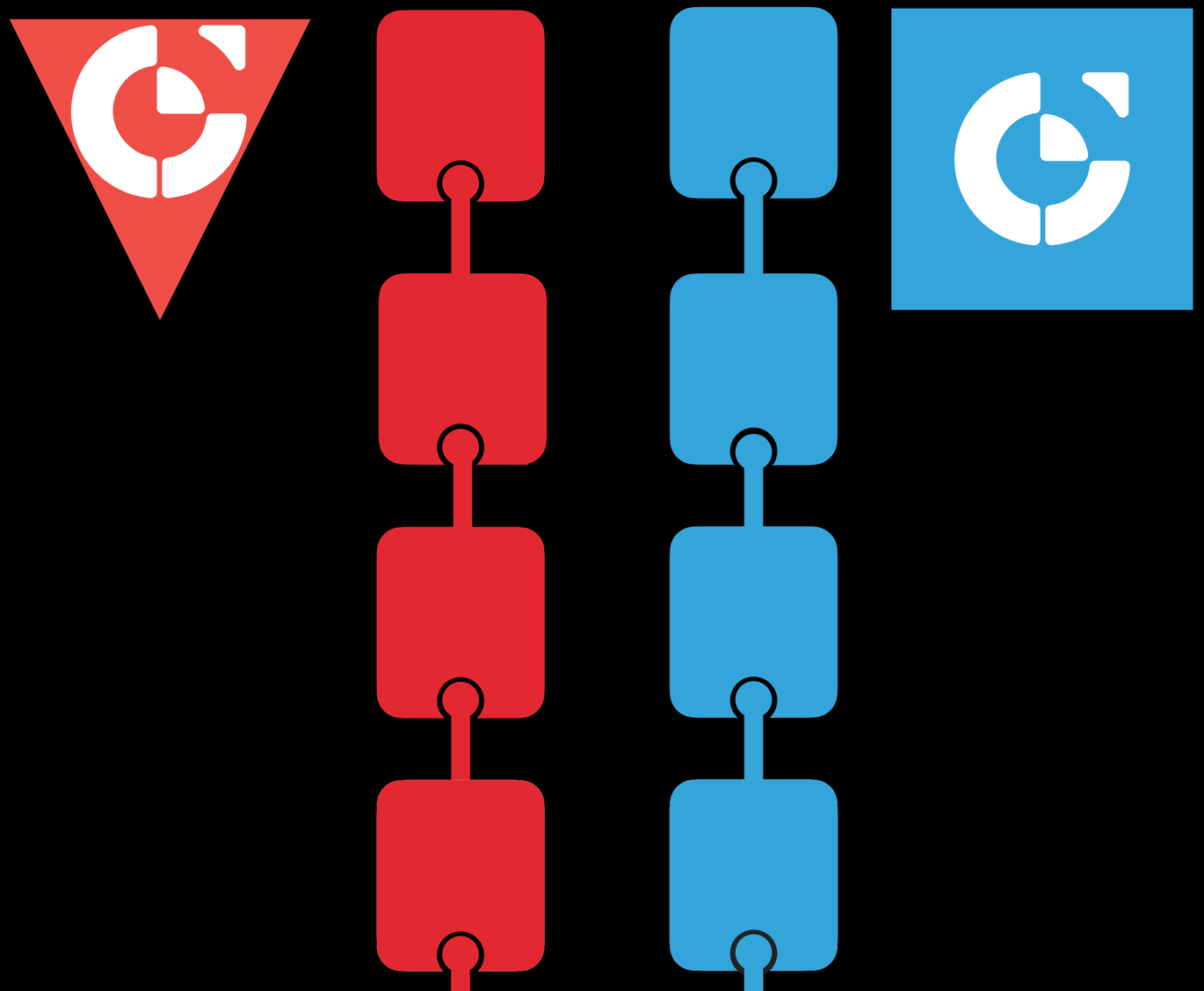
Shared P2P Layer

P2P

- Communication / Multicast
- P2P Overlay Domains with Sovereignty (PODS)

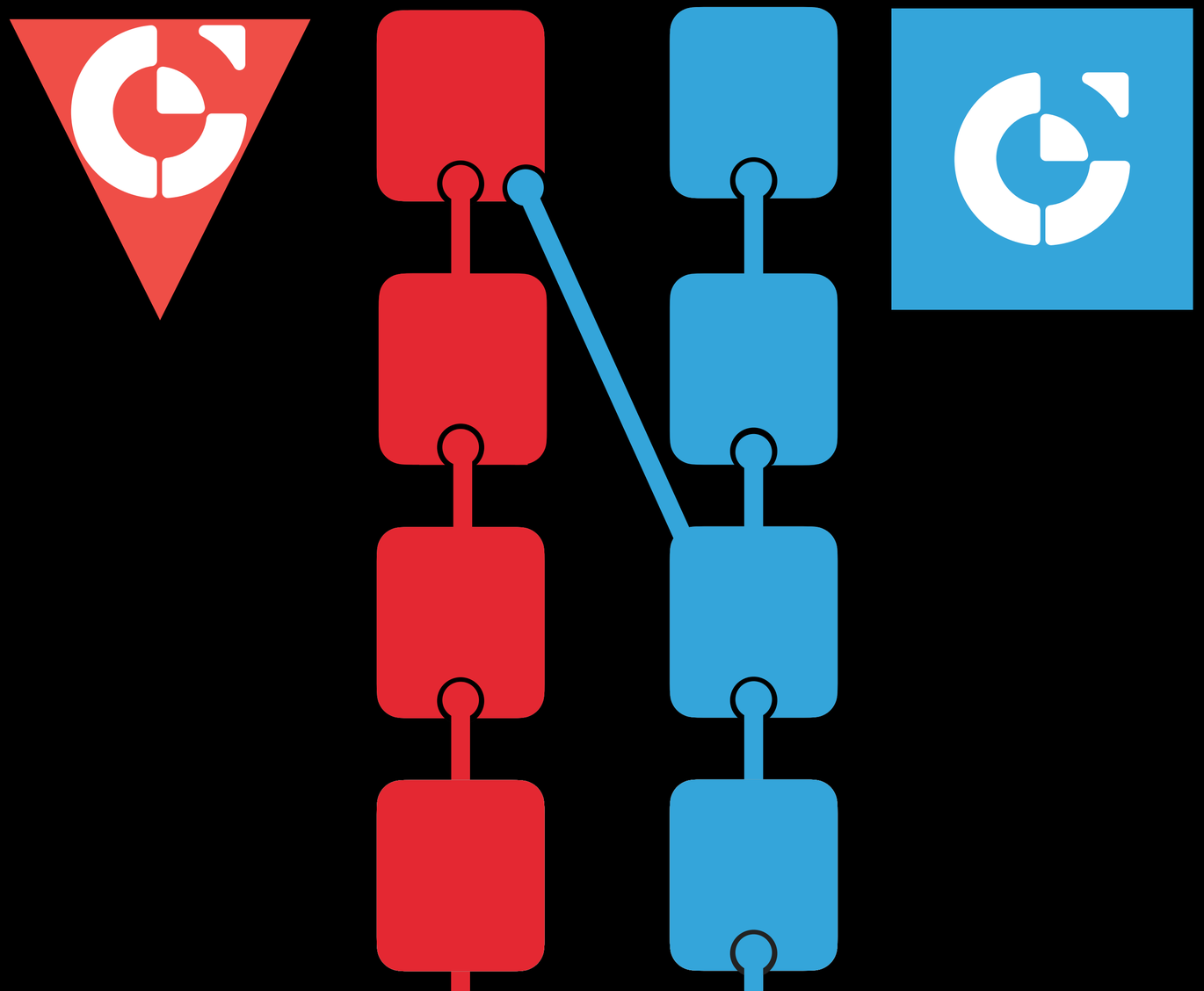
ATOMIC COMMITMENT ACROSS CHAINS

- Multiple chains
- Different validator machines



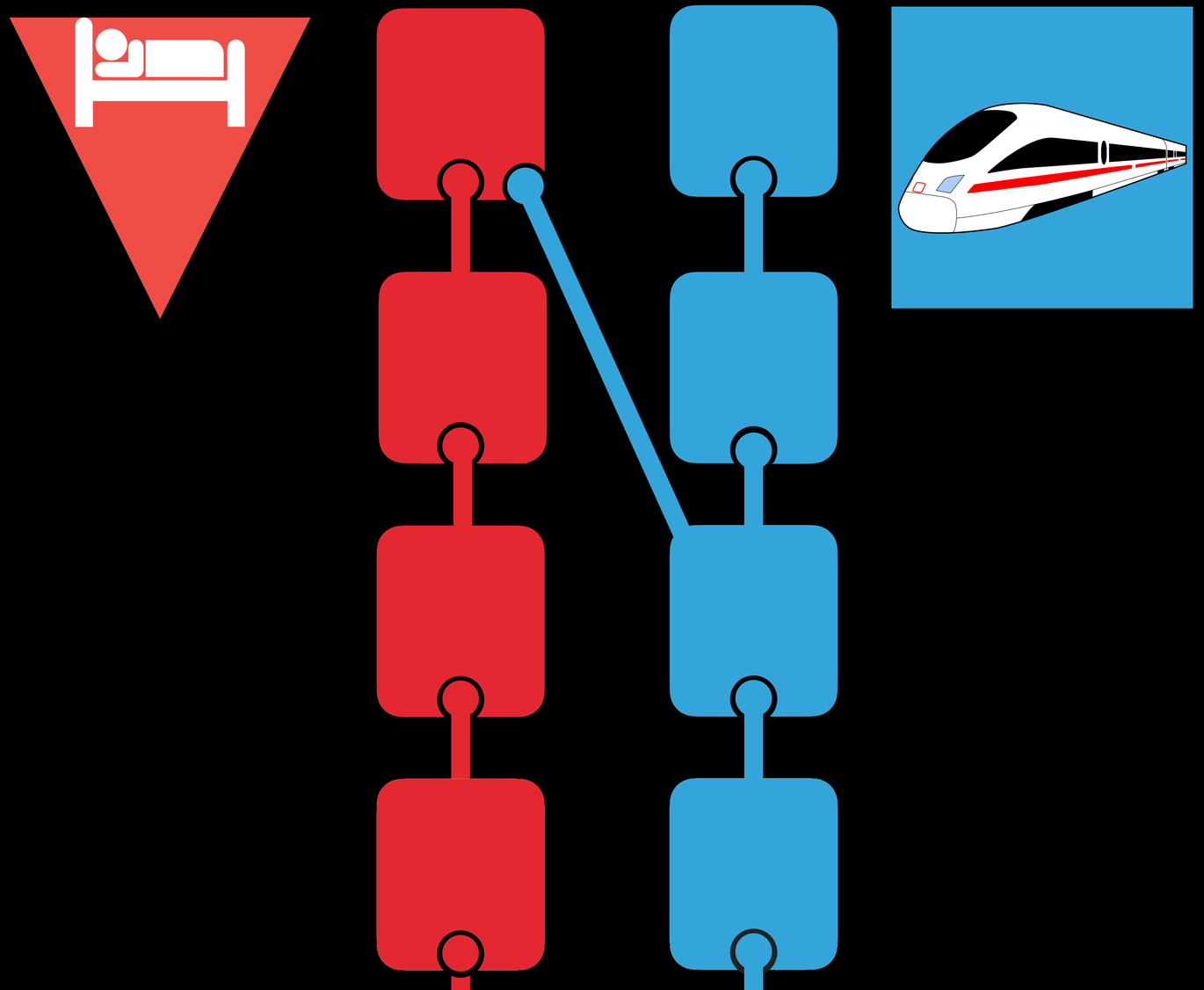
ATOMIC COMMITMENT ACROSS CHAINS

- Multiple chains
- Different validator machines
- IBC (ibcprotocol.org)



TRAIN & HOTEL PROBLEM

- Multiple chains
- Different validator machines
- IBC (ibcprotocol.org)
- Atomic commitment
  - Both or Neither:
    - Hotel Room
    - Train Ticket



TRAIN & HOTEL PROBLEM

- Multiple chains
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  - Both or Neither:
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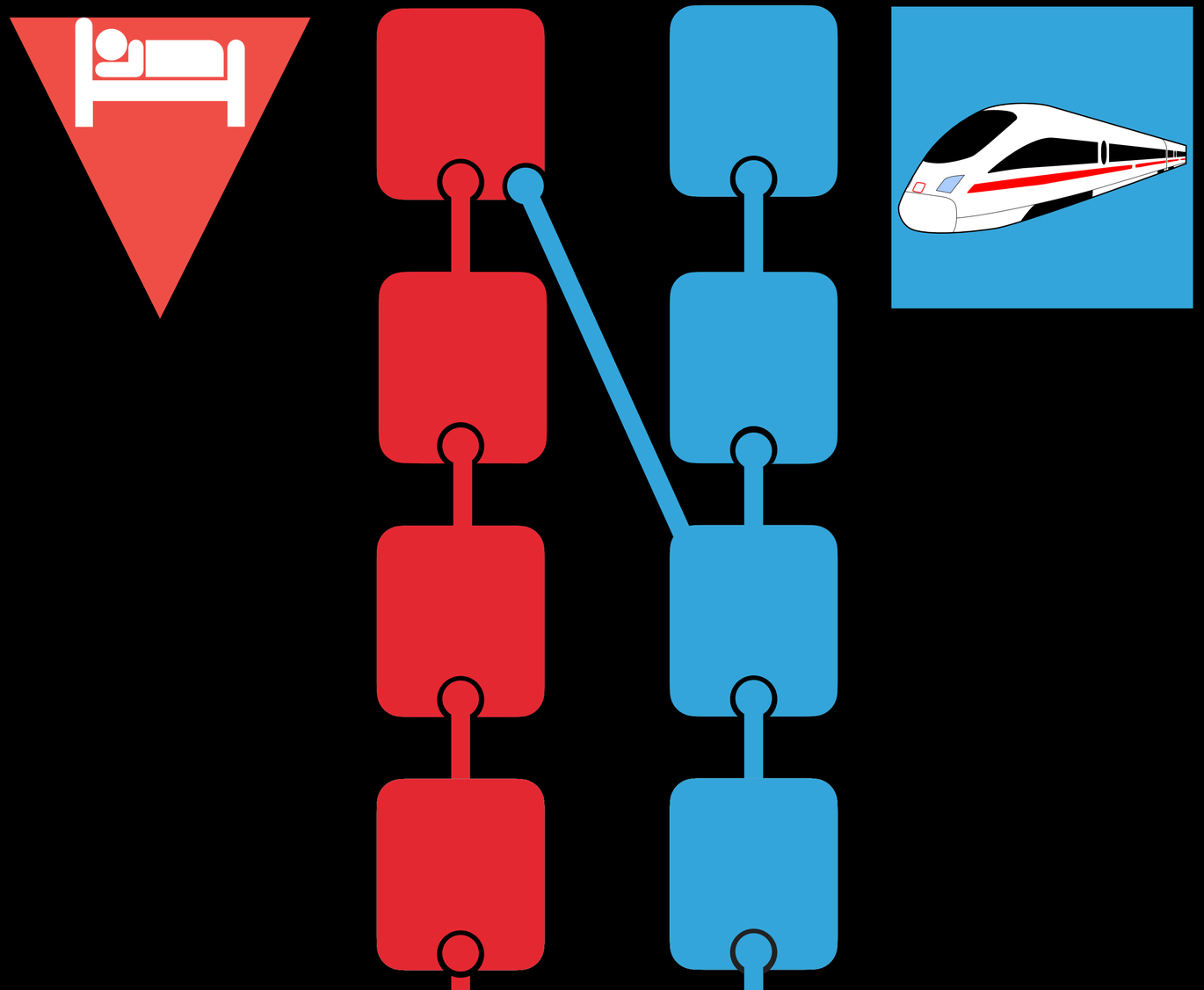
    - Train Ticket
- Shared Sequencers? (Espresso)



TRAIN & HOTEL PROBLEM

- Multiple chains
- Different validator machines
- IBC (ibcprotocol.org)
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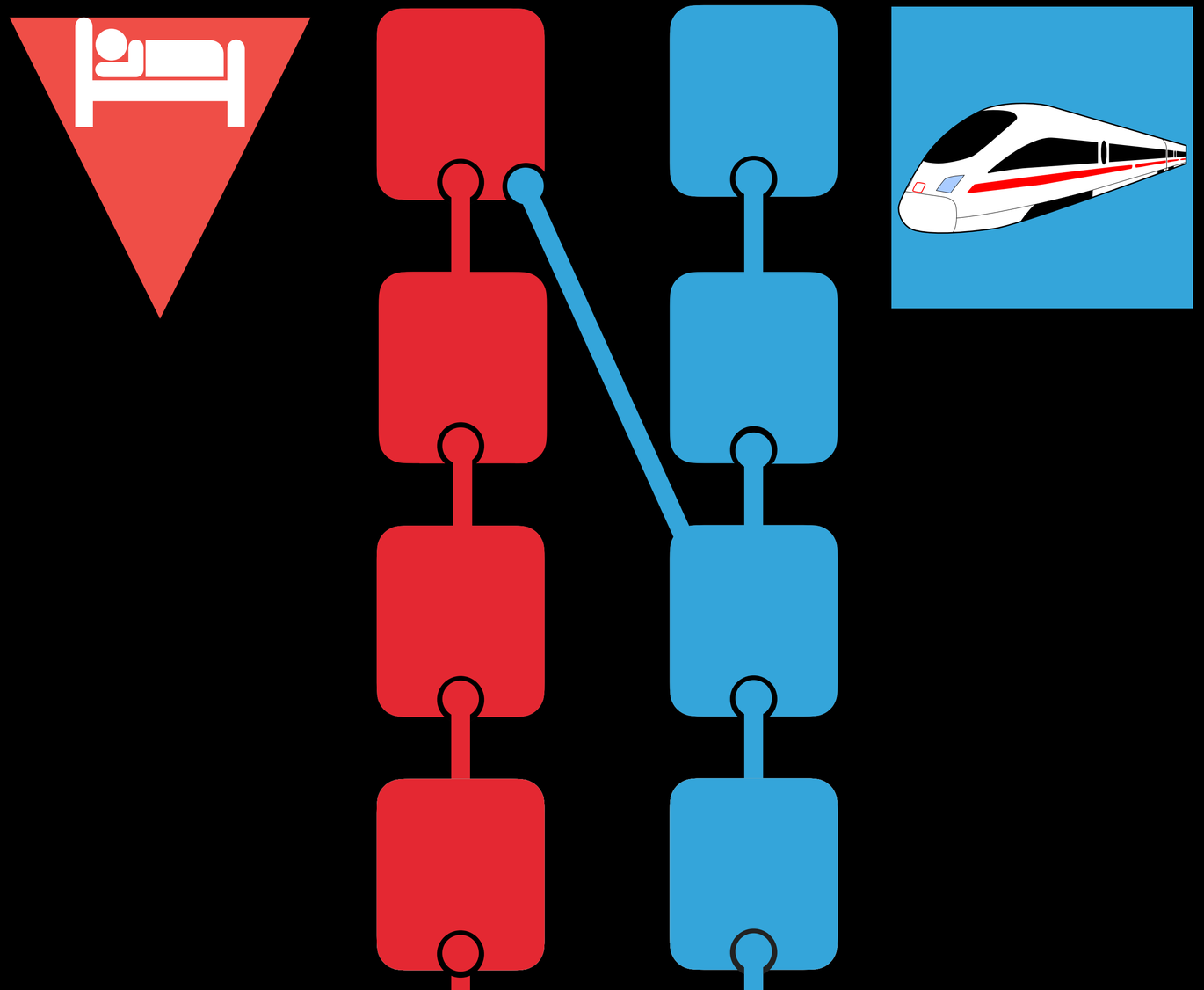
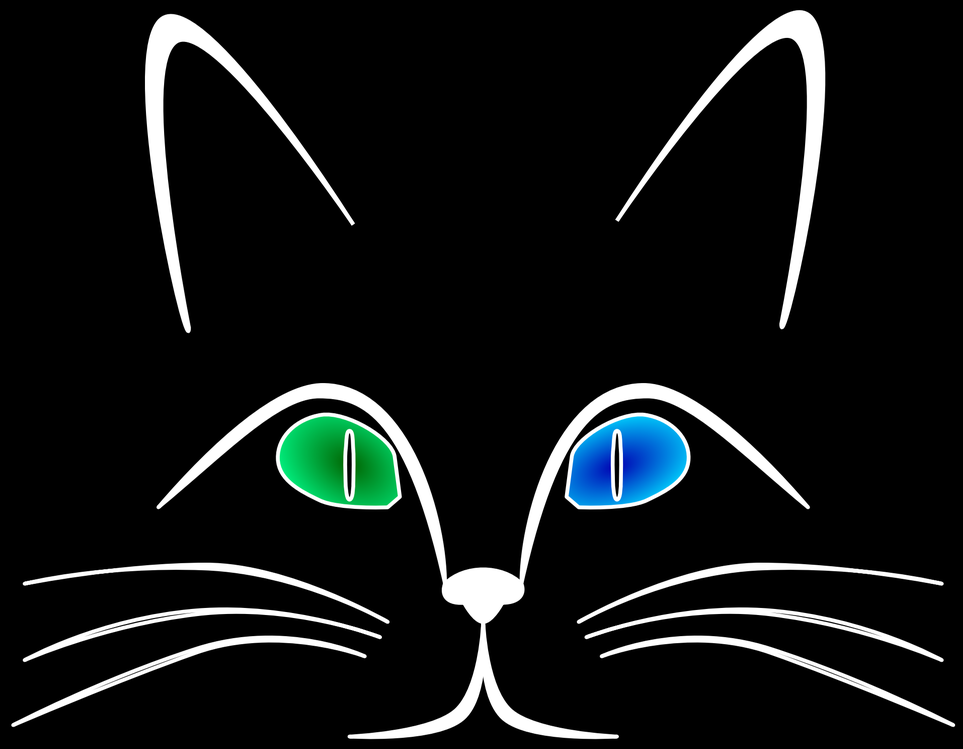
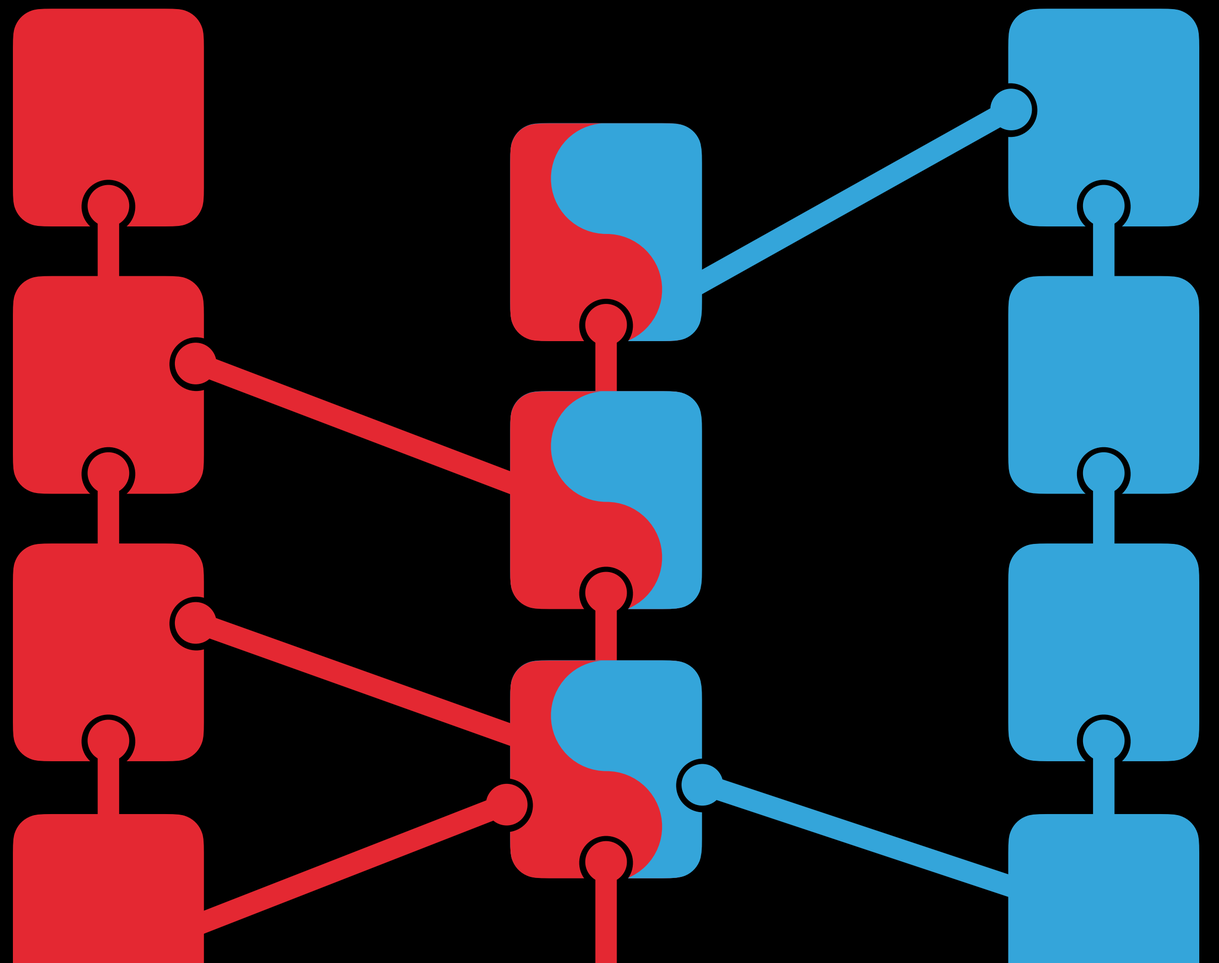
  - Both or Neither:
    - Hotel Room
    - Train Ticket
- Multi-phase commit



MOTIVATION

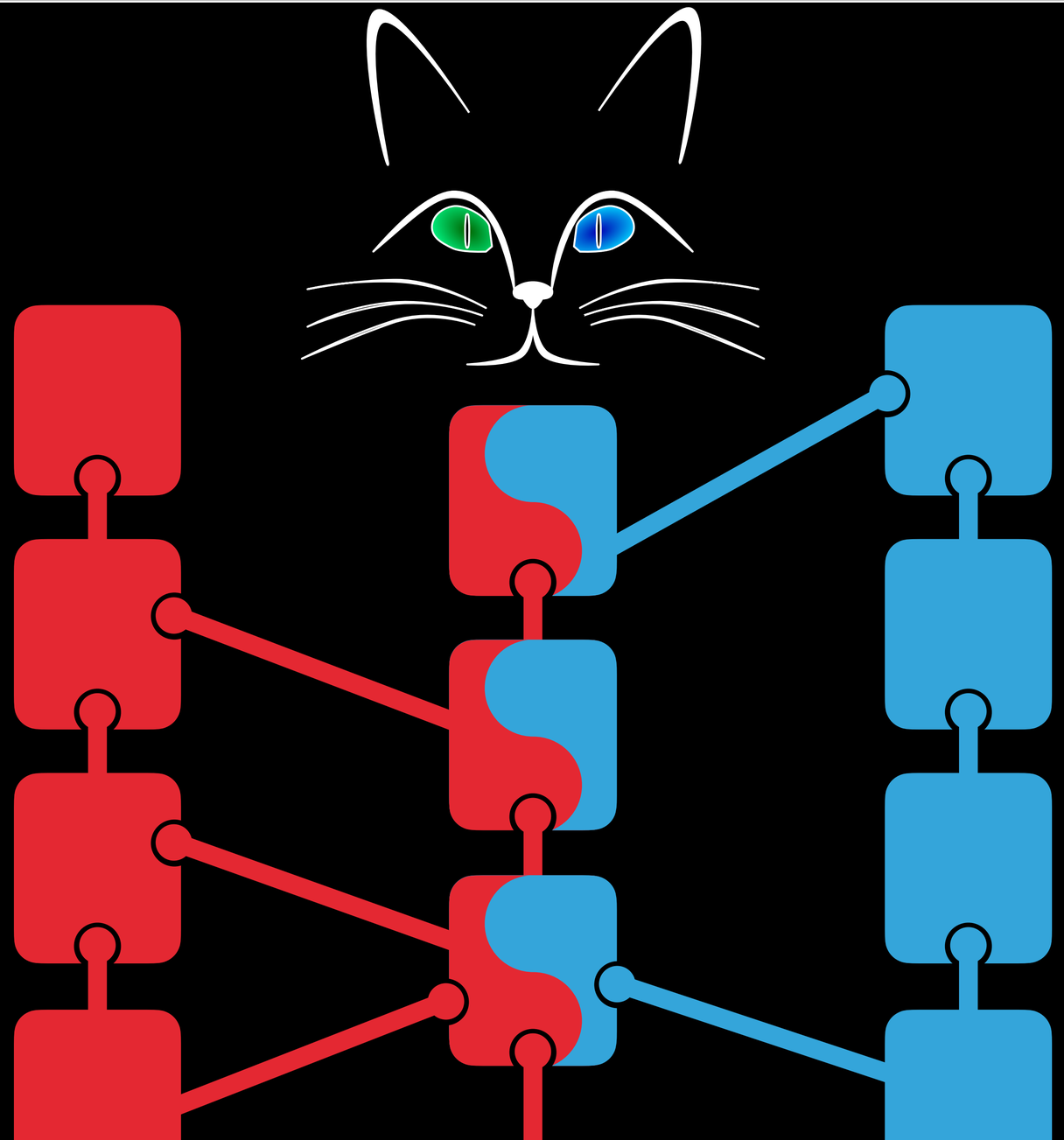


CHIMERA CHAINS



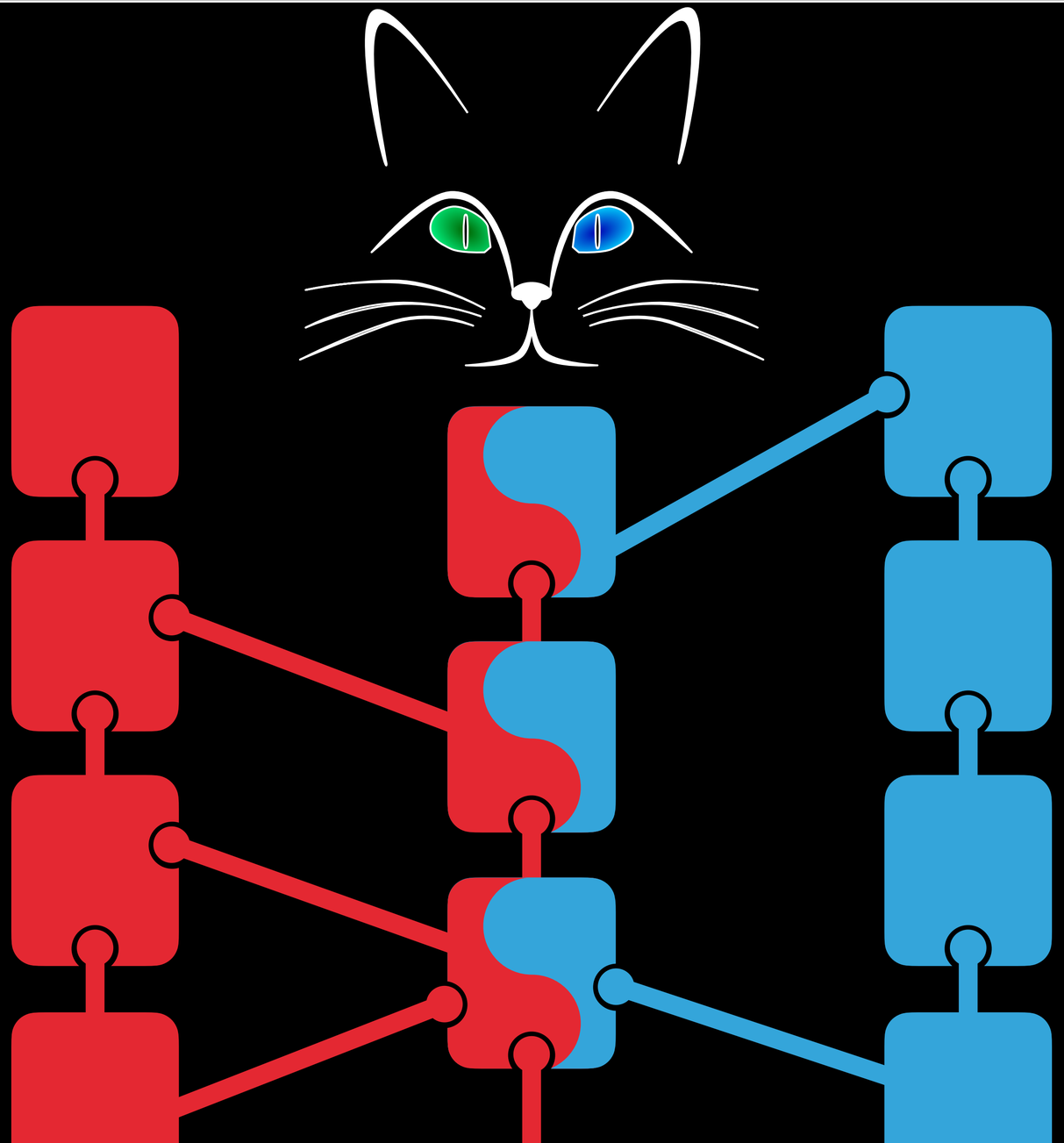
CHIMERA CHAINS

- Each chain liveness / integrity of its own consensus



ATOMIC BATCHES

- Each chain liveness / integrity of its own consensus
- Atomic batches of "multi-chain" transactions that commit atomically (ALL or NONE)



ATOMIC BATCHES

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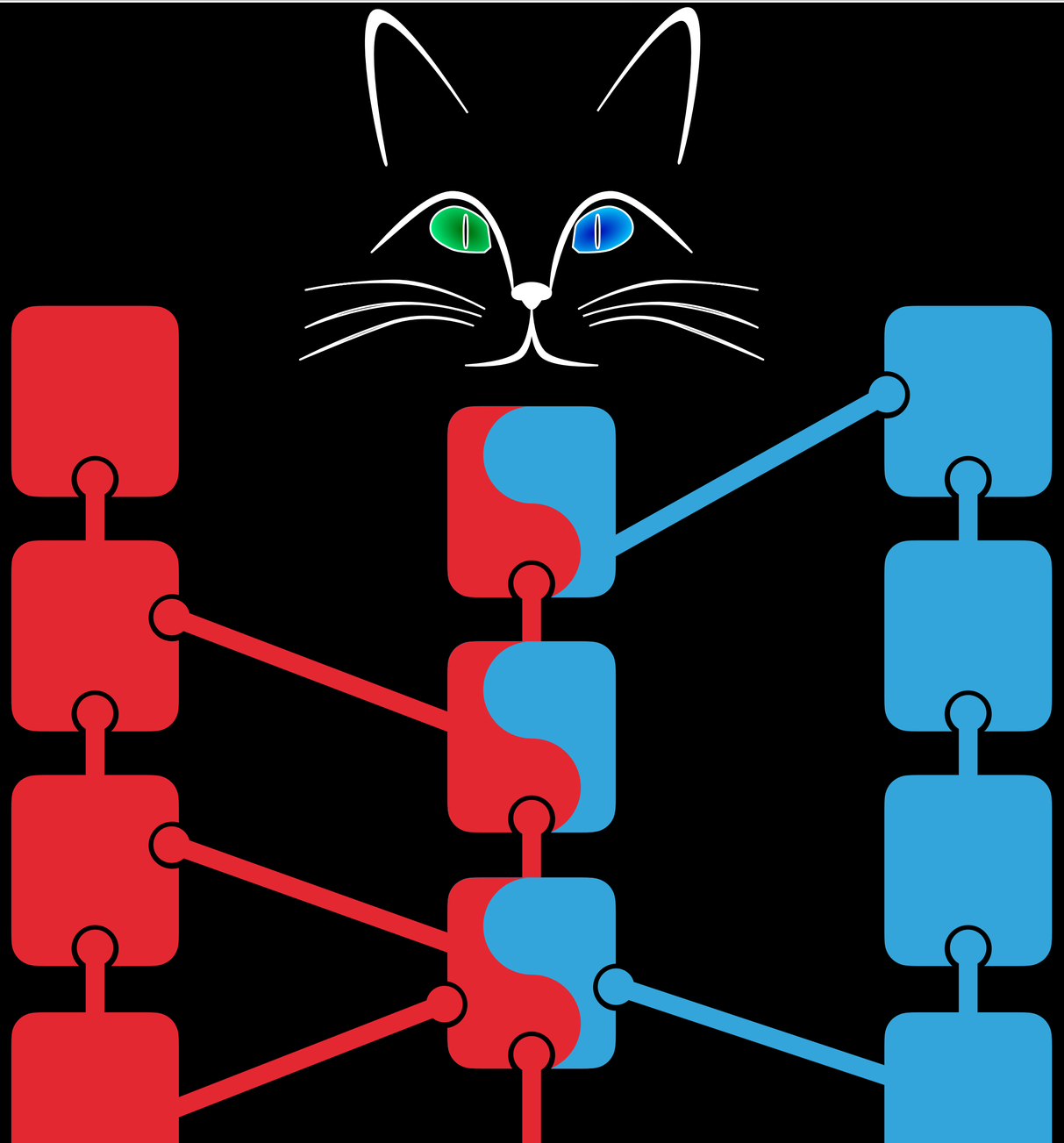
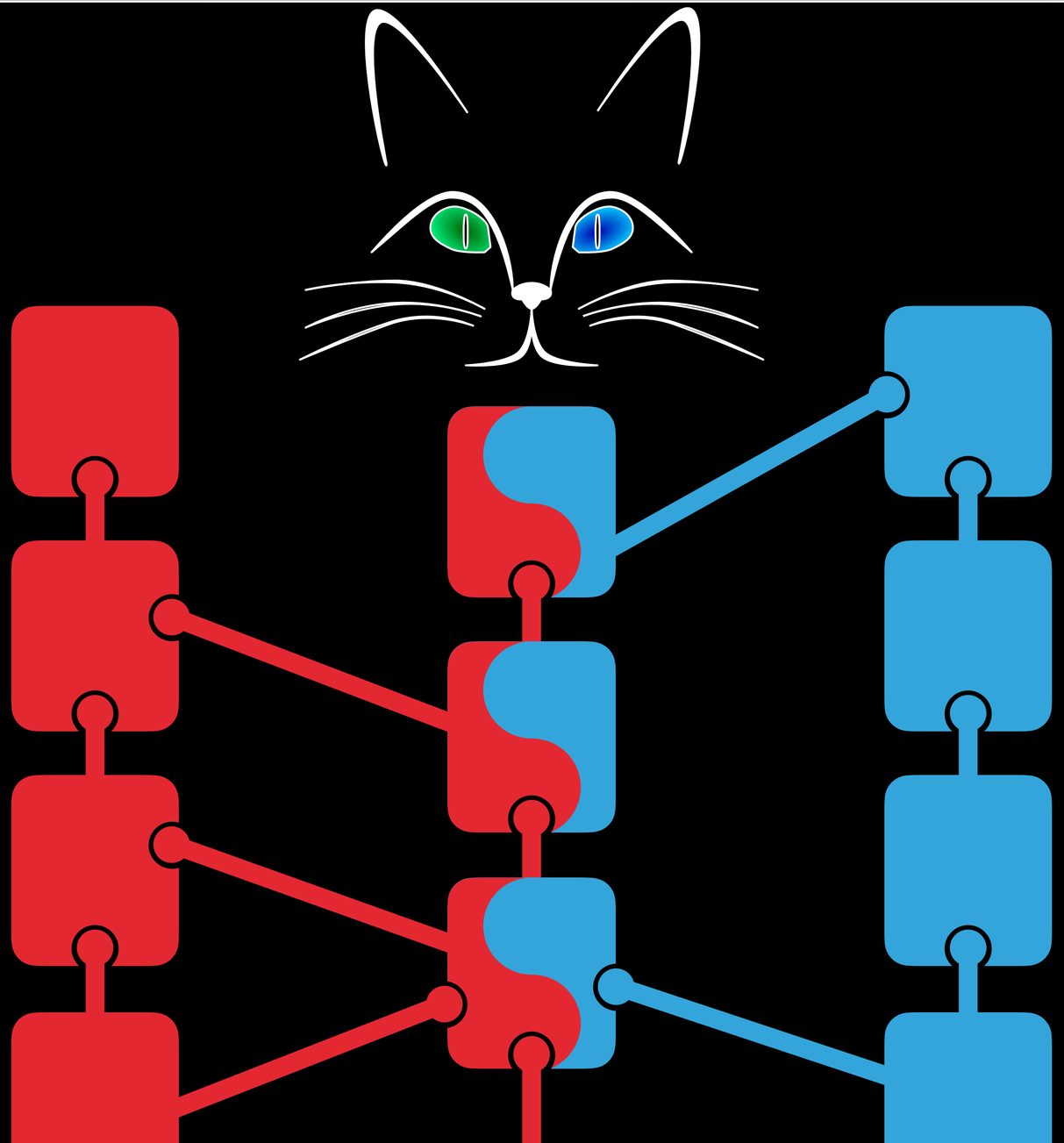
- Heterogeneous Paxos (OPODIS 2020)



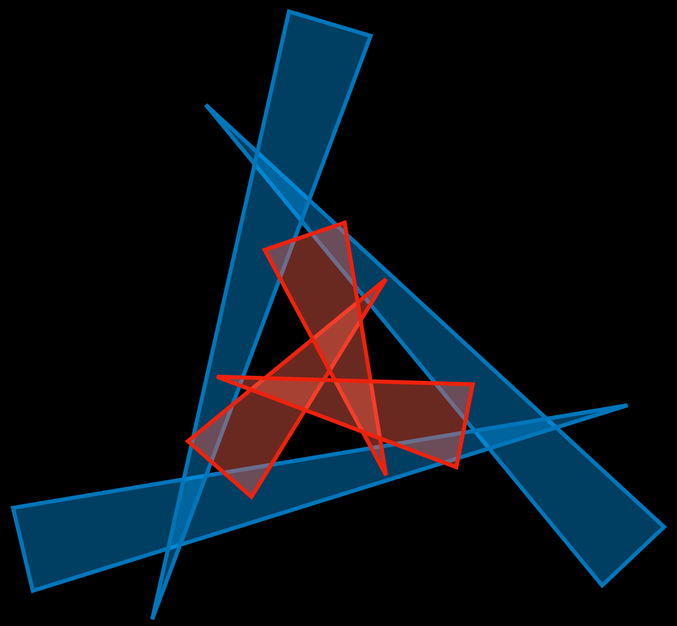
ATOMIC BATCHES

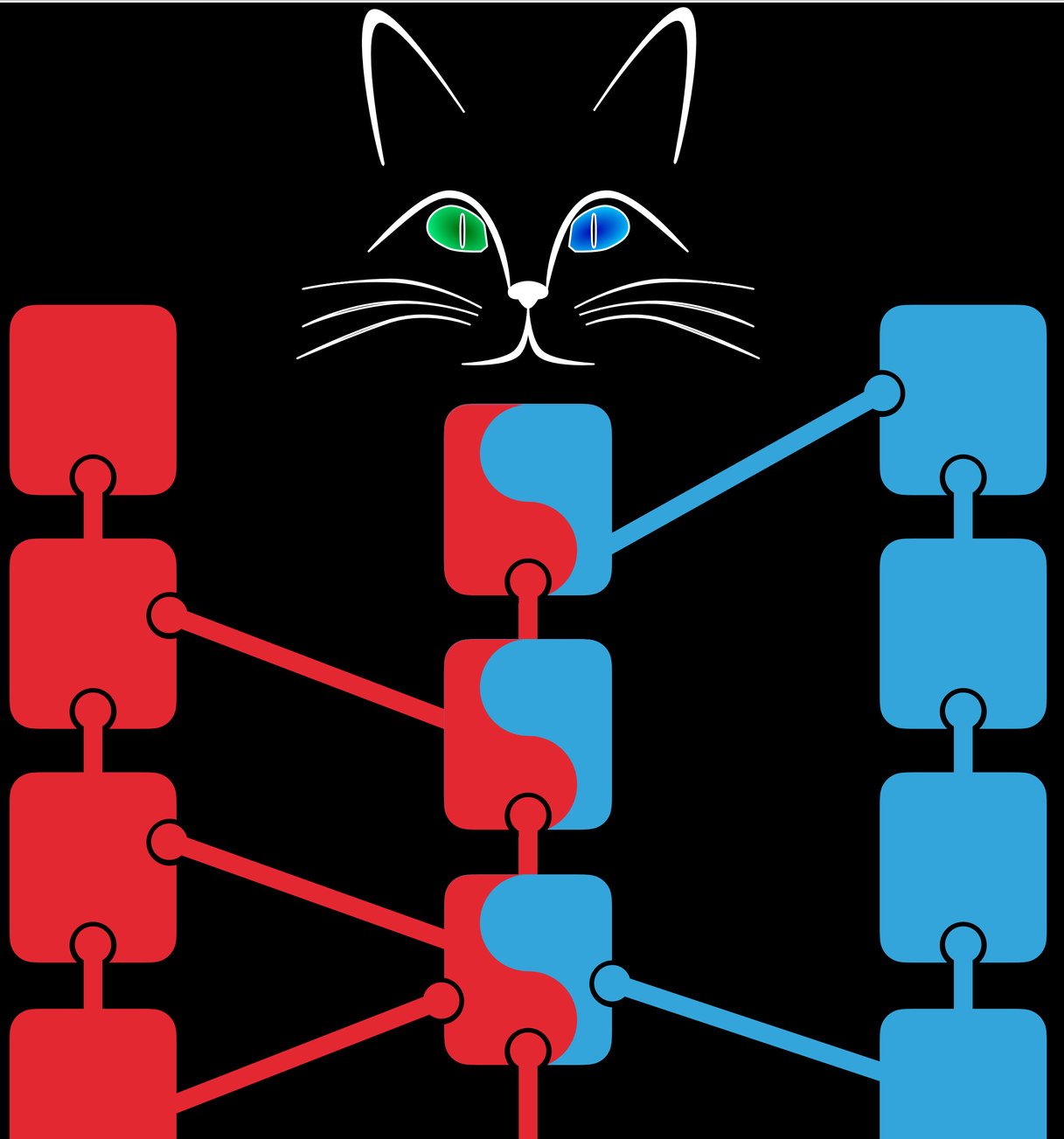
- Each chain liveness / integrity of its own consensus
- Atomic batches of "multi-chain" transactions that commit atomically (ALL or NONE)
- Heterogeneous Paxos (OPODIS 2020)
  - Atomicity guaranteed under certain conditions



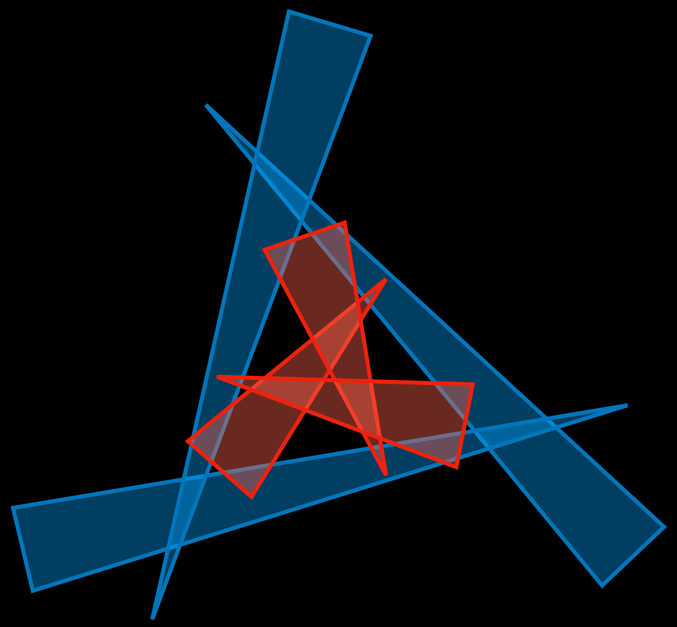
TRUST ASSUMPTIONS

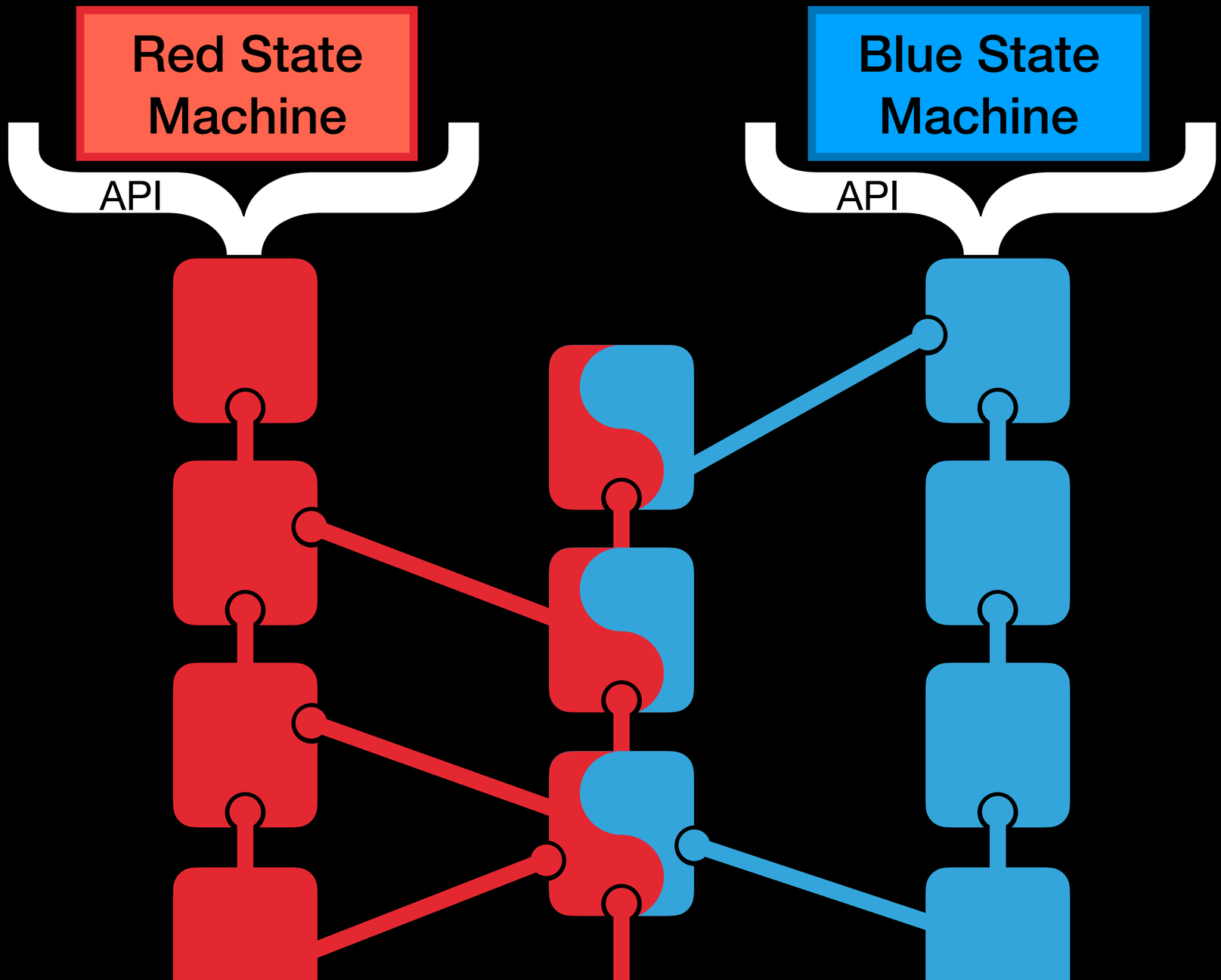
- Safety derives from validators common to multiple chains
- High validator overlap in practice





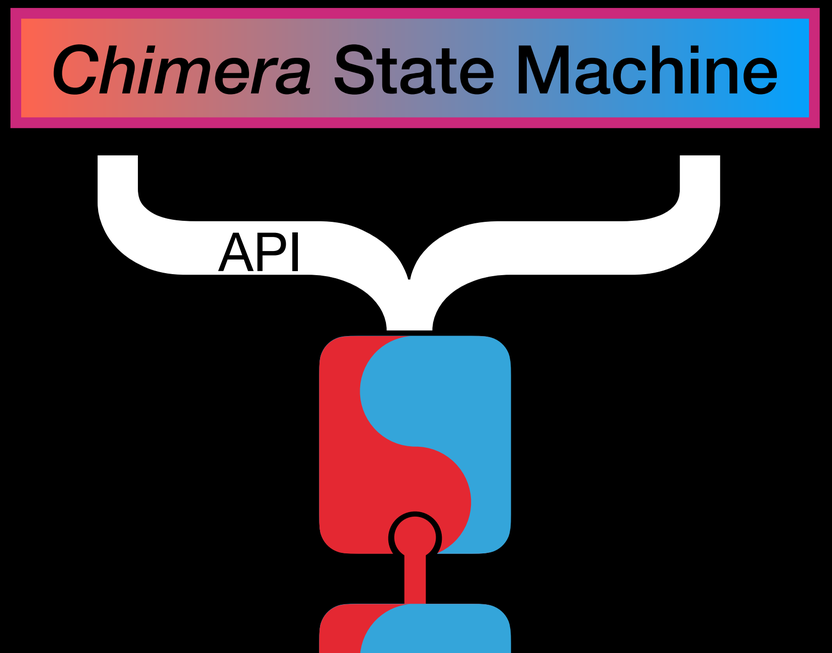
STATE MACHINE





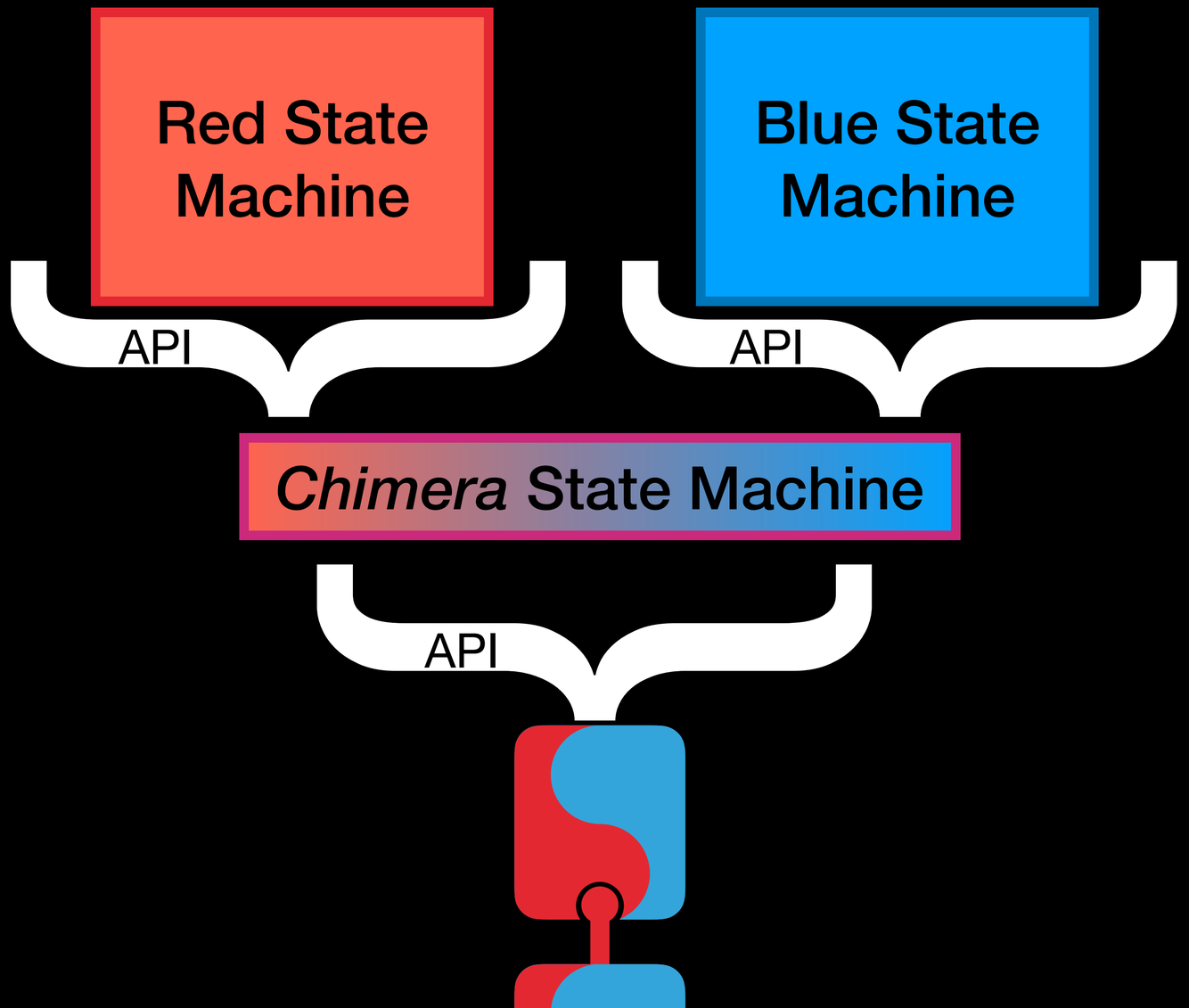
STATE MACHINE

- Over Chimera Chain



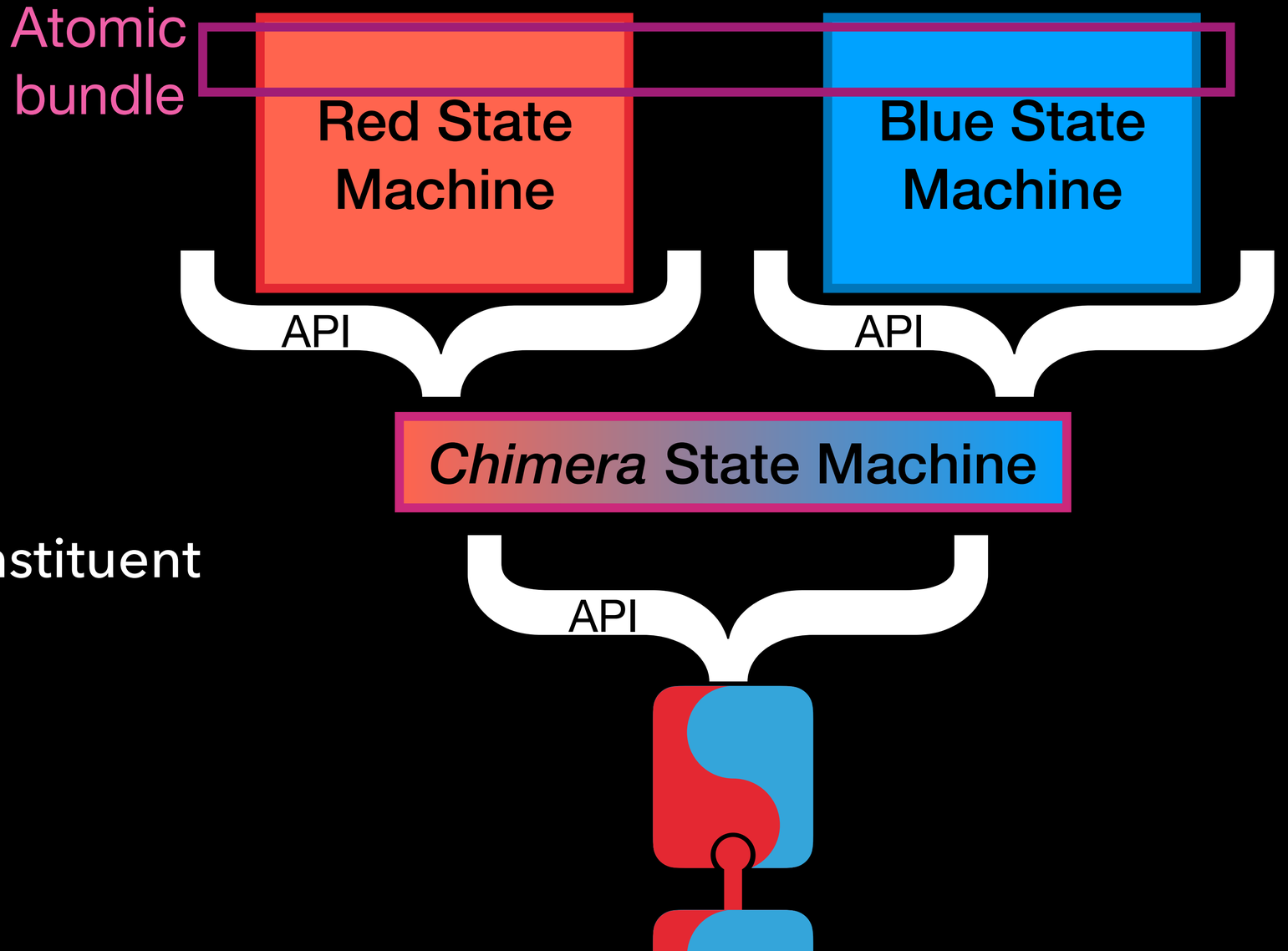
STATE MACHINE

- Over Chimera Chain
- Instances of constituent chain state machines



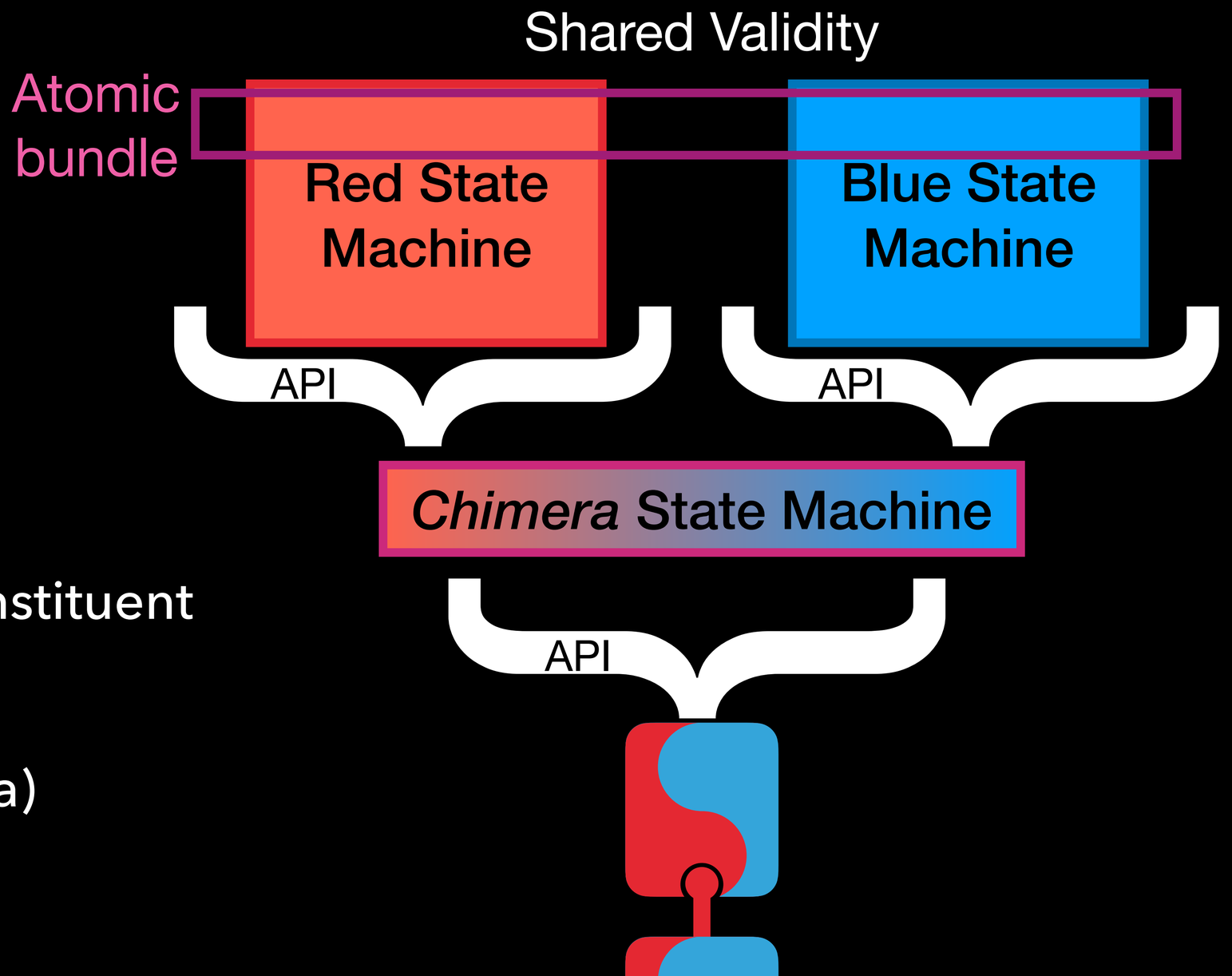
STATE MACHINE

- Over Chimera Chain
- Instances of constituent chain state machines
- Transactions:
  - Atomic bundles of constituent chain transactions



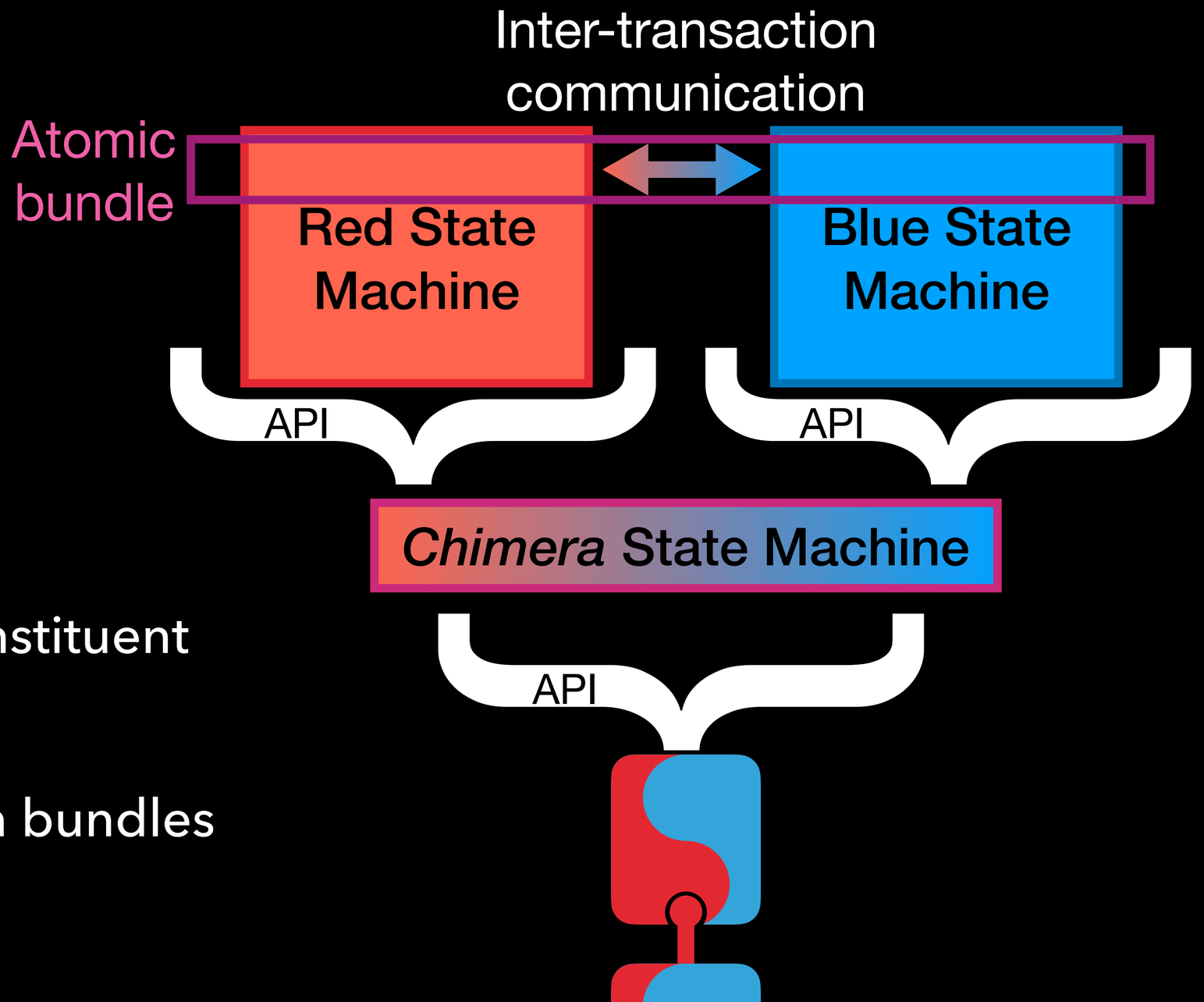
STATE MACHINE

- Over Chimera Chain
- Instances of constituent chain state machines
- Transactions:
  - Atomic bundles of constituent chain transactions
  - Shared Validity (Umbra)



STATE MACHINE

- Over Chimera Chain
- Instances of constituent chain state machines
- Transactions:
  - Atomic bundles of constituent chain transactions
  - Communication within bundles



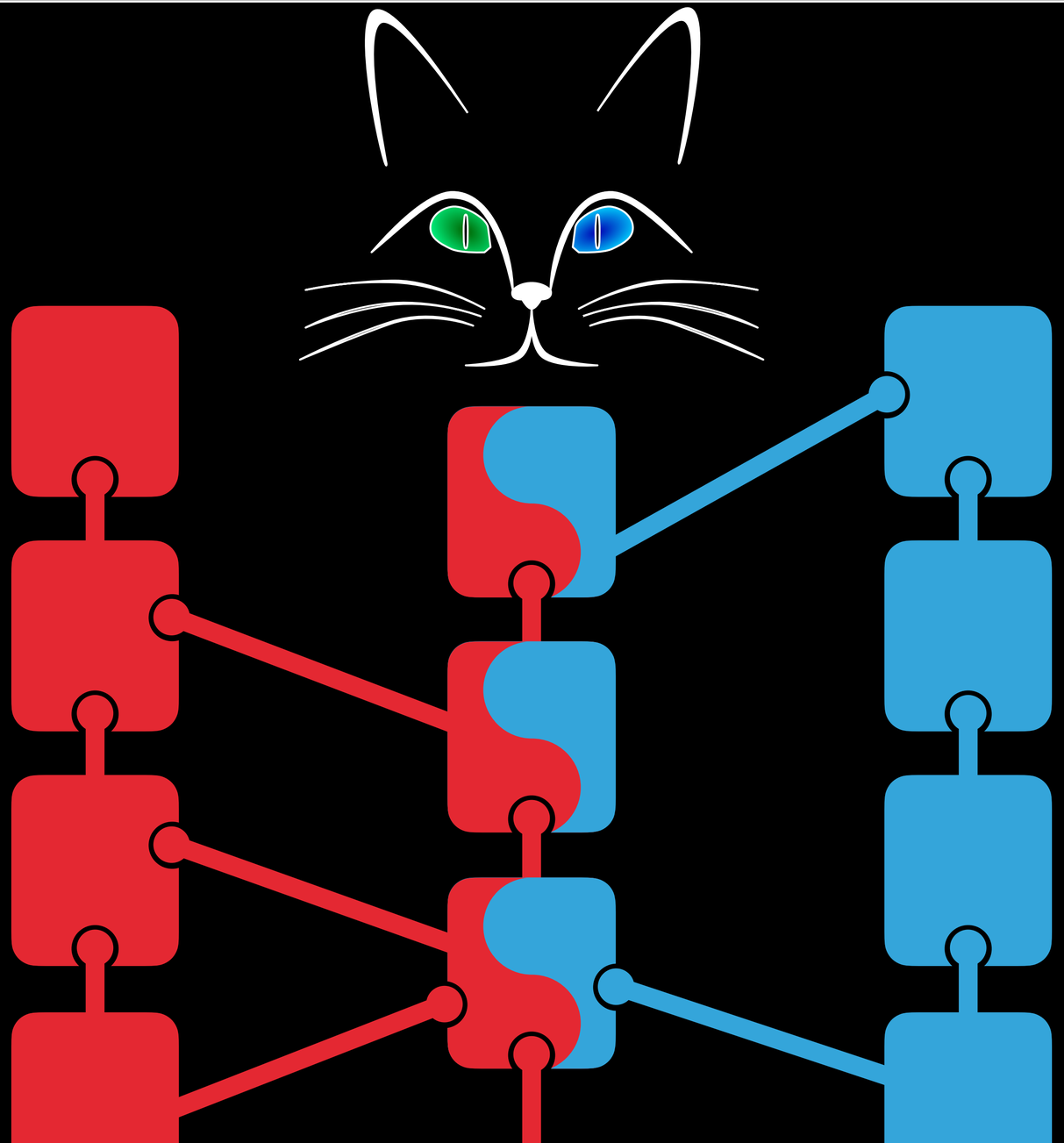
STATE MACHINE

- Over Chimera Chain
- Instances of constituent chain state machines
- Transactions:
  - Atomic bundles of constituent chain transactions
  - Communication within bundles

Inter-transaction communication

CHIMERA CHAINS

- Each chain liveness / integrity of its own consensus
- Atomic batches of "multi-chain" transactions that commit atomically (ALL or NONE)
- Heterogeneous Paxos (OPODIS 2020)
  - Atomicity guaranteed under certain conditions



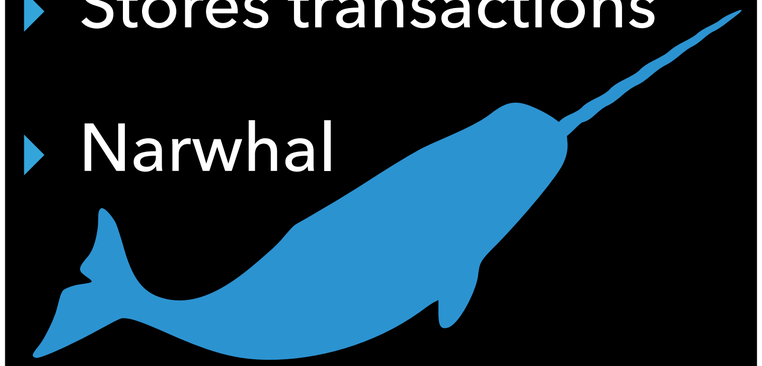
COMPONENTS

Cross-chain transactions

Post-ordering execution

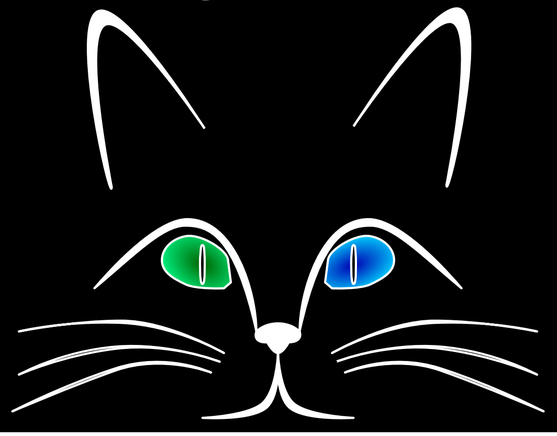
MEMPOOL

- Receives from clients / solvers
- Stores transactions
- Narwhal



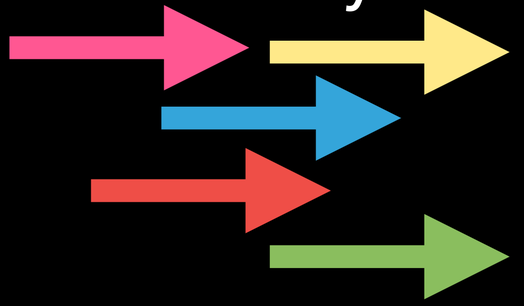
CONSENSUS

- Orders transactions
- Heterogeneous Paxos



EXECUTION

- State machine
- Client reads
- Concurrency



Shared P2P Layer

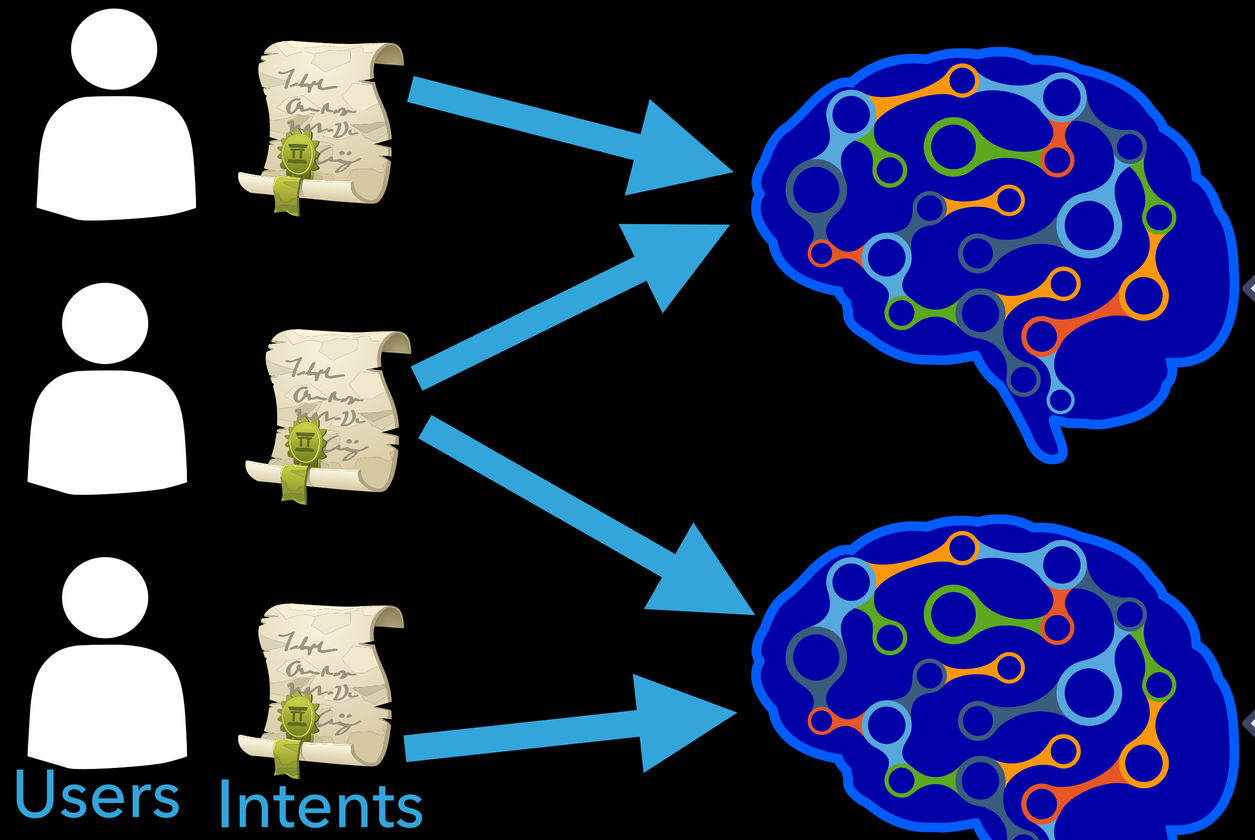
P2P

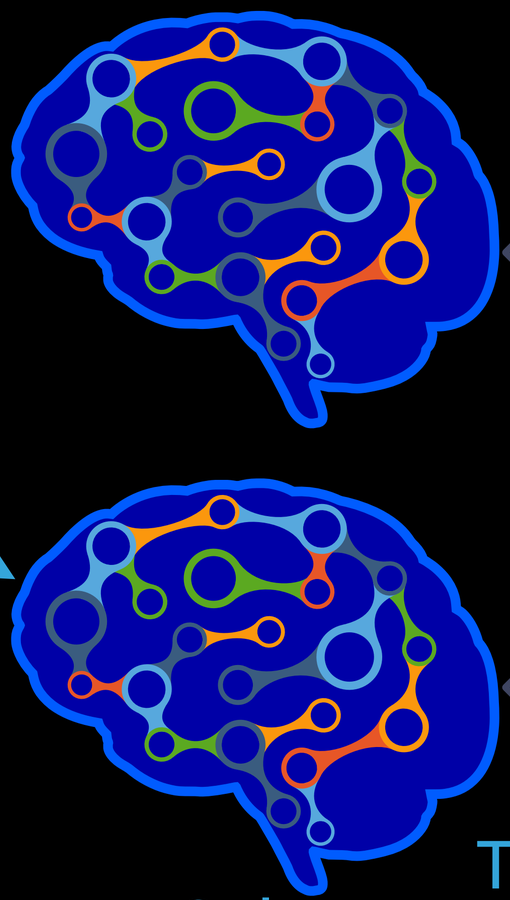
- Communication / Multicast
- P2P Overlay Domains with Sovereignty (PODS)

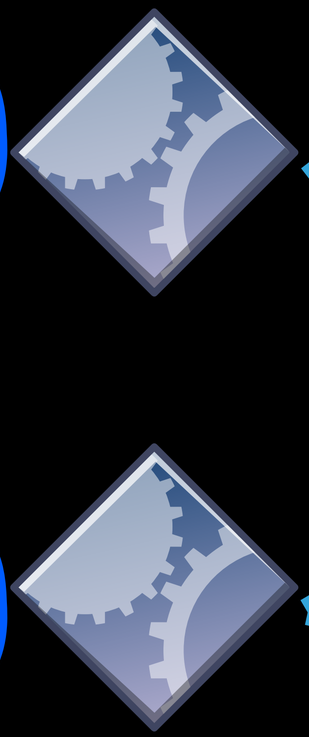
3 POINTS

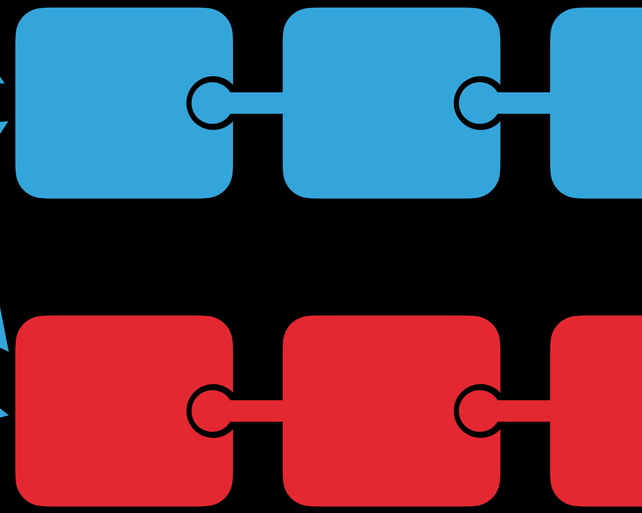
- Shared P2P Layer
- Post-ordering execution
- Multi-chain transactions

anoma









CONCLUSIONS

anoma will use TYPHON, which supports CHIMERA CHAINS

- PODS: https://arxiv.org/abs/2306.16153
- Full spec proposal coming soon!
- github.com/anoma/typhon

anoma will use TYPHON, which supports CHIMERA CHAINS

- PODS: https://arxiv.org/abs/2306.16153
- Full spec proposal coming soon!
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- Formal specification & proofs
  - New heterogeneous protocols
- Communication language within atomic bundles
- Share Components
- Practical problems encountered

TYPHON OVERVIEW

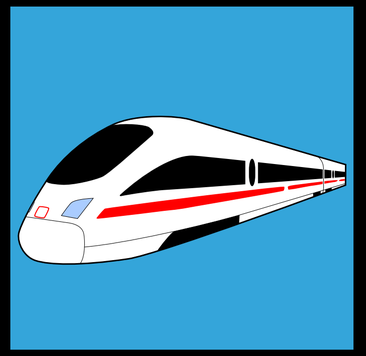
BONUS SLIDES

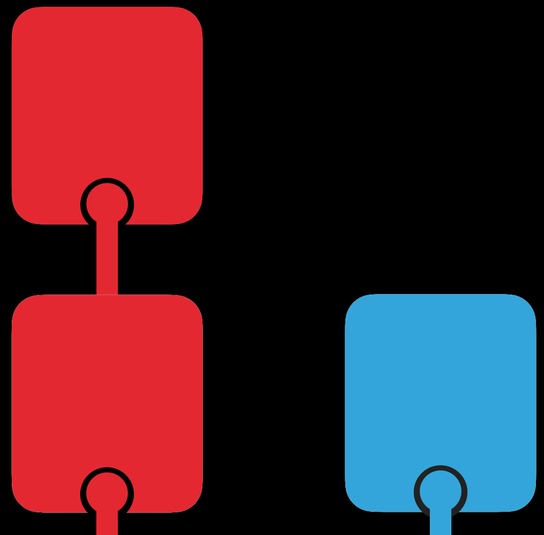
TYPHON OVERVIEW

2 PHASE

ATOMIC COMMITMENT ACROSS CHAINS

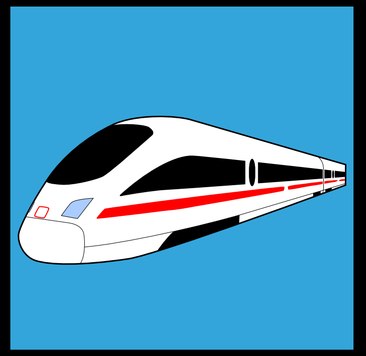
- Atomic commitment
  - Both or Neither: Room & Ticket
- Multi-Phase Commit

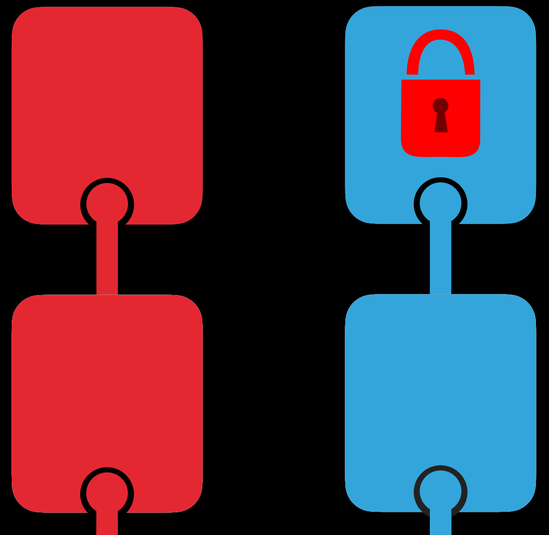




ATOMIC COMMITMENT ACROSS CHAINS

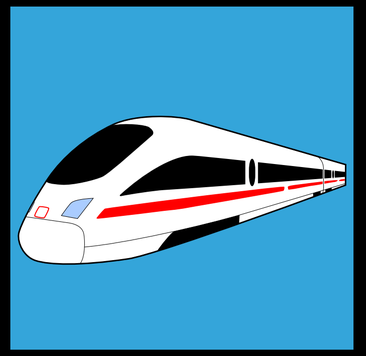
- Atomic commitment
  - Both or Neither: Room & Ticket
- Multi-Phase Commit
  - Each chain locks

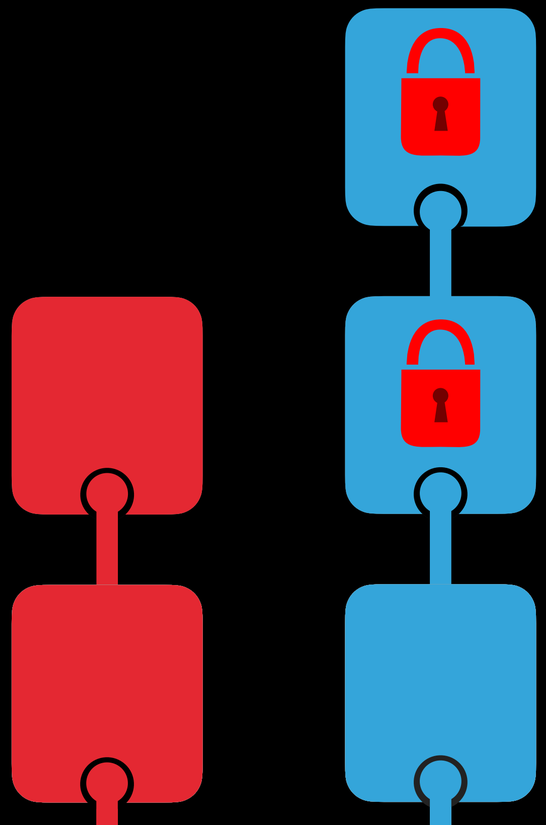




ATOMIC COMMITMENT ACROSS CHAINS

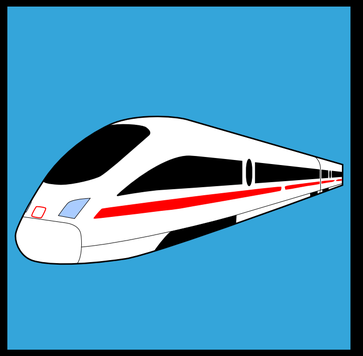
- Atomic commitment
  - Both or Neither: Room & Ticket
- Multi-Phase Commit
  - Each chain locks
    - And stays locked

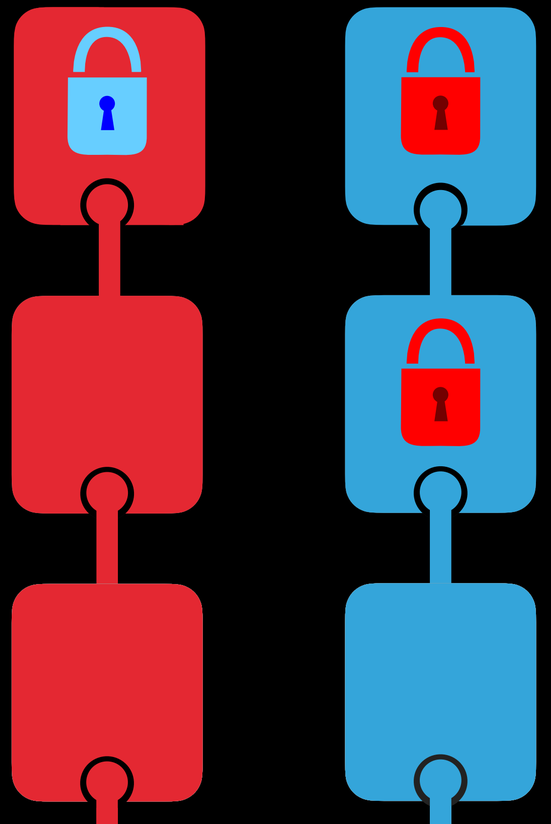




ATOMIC COMMITMENT ACROSS CHAINS

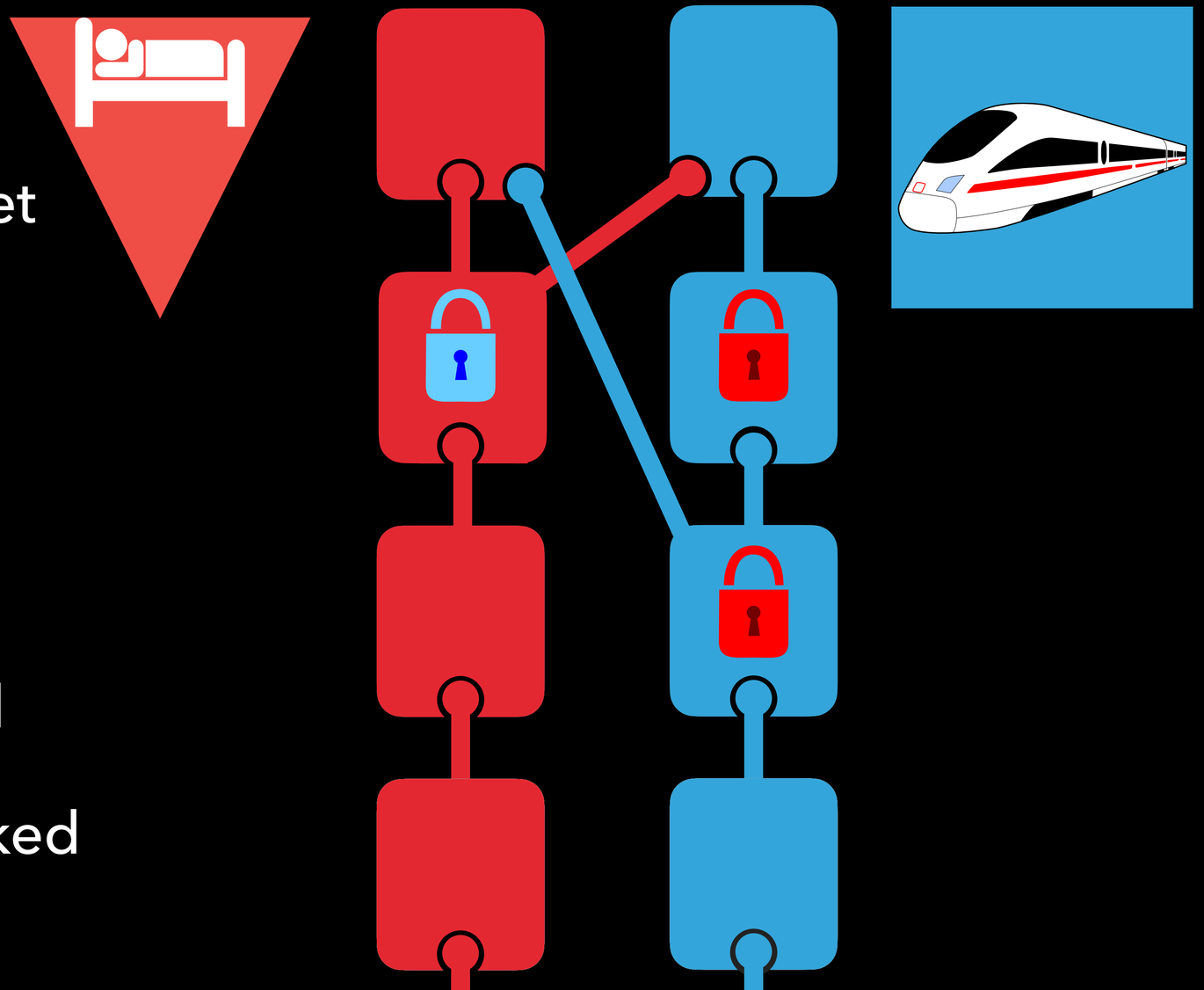
- Atomic commitment
  - Both or Neither: Room & Ticket
- Multi-Phase Commit
  - Each chain locks
    - And stays locked
    - Until both chains are locked





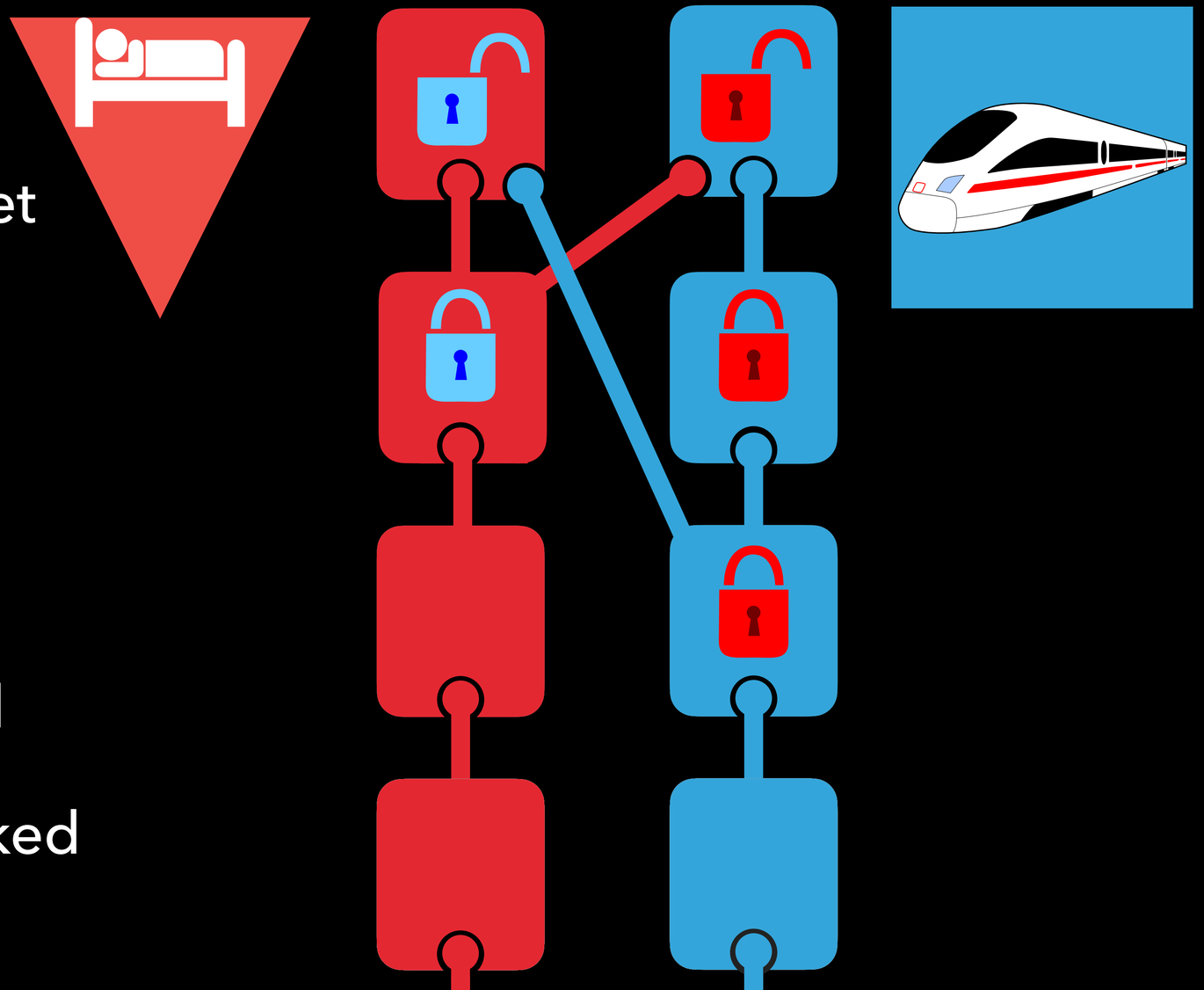
ATOMIC COMMITMENT ACROSS CHAINS

- Atomic commitment
  - Both or Neither: Room & Ticket
- Multi-Phase Commit
  - Each chain locks
    - And stays locked
    - Until both chains are locked
  - Verifies other chains have locked



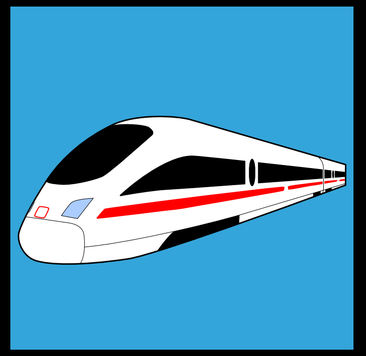
ATOMIC COMMITMENT ACROSS CHAINS

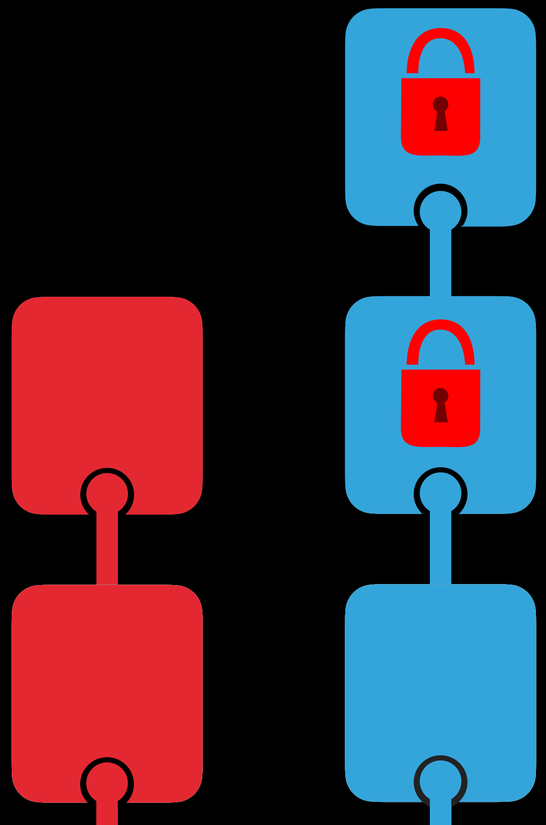
- Atomic commitment
  - Both or Neither: Room & Ticket
- Multi-Phase Commit
  - Each chain locks
    - And stays locked
    - Until both chains are locked
  - Verifies other chains have locked
    - Unlocks



ATOMIC COMMITMENT ACROSS CHAINS

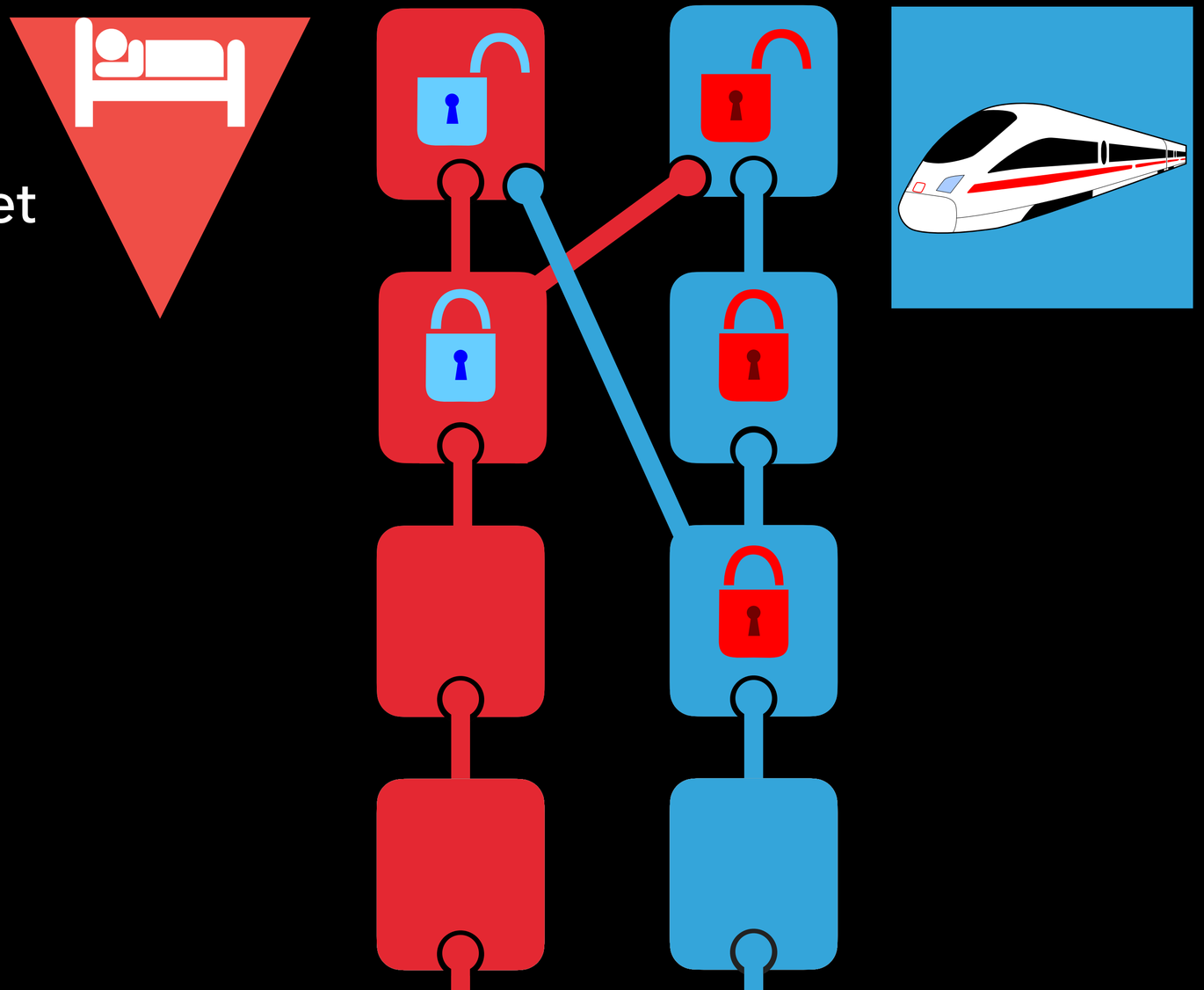
- Atomic commitment
  - Both or Neither: Room & Ticket
- Multi-Phase Commit
  - Liveness





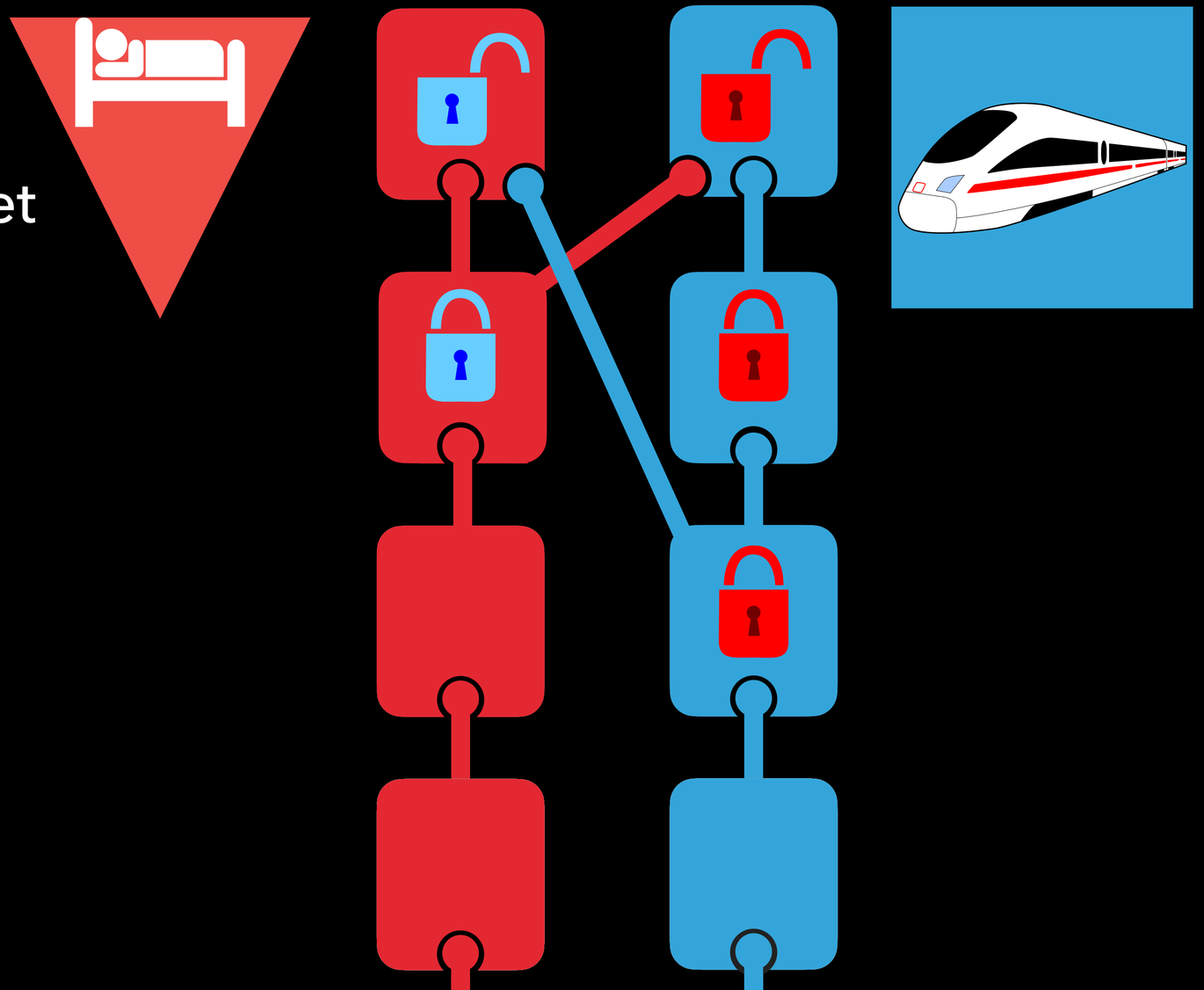
ATOMIC COMMITMENT ACROSS CHAINS

- Atomic commitment
  - Both or Neither: Room & Ticket
- Multi-Phase Commit
  - Liveness
  - Multiple Rounds



ATOMIC COMMITMENT ACROSS CHAINS

- Atomic commitment
  - Both or Neither: Room & Ticket
- Multi-Phase Commit
  - Liveness
  - Multiple Rounds
  - Free Option

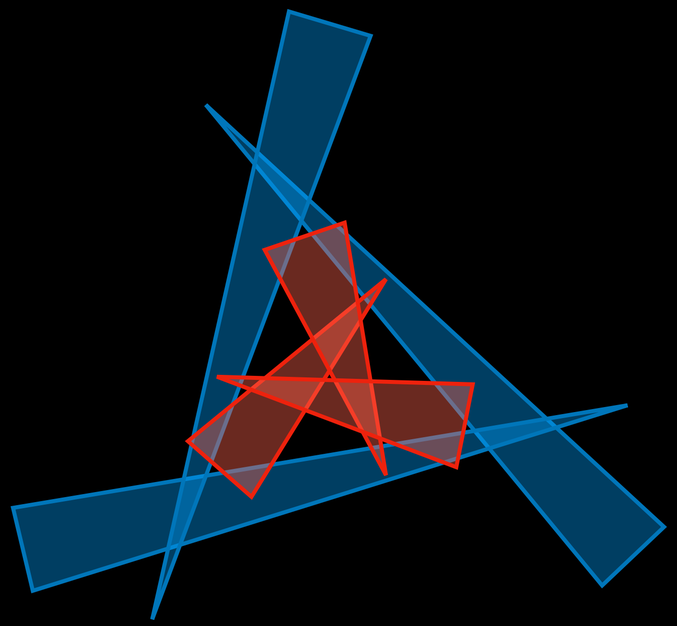


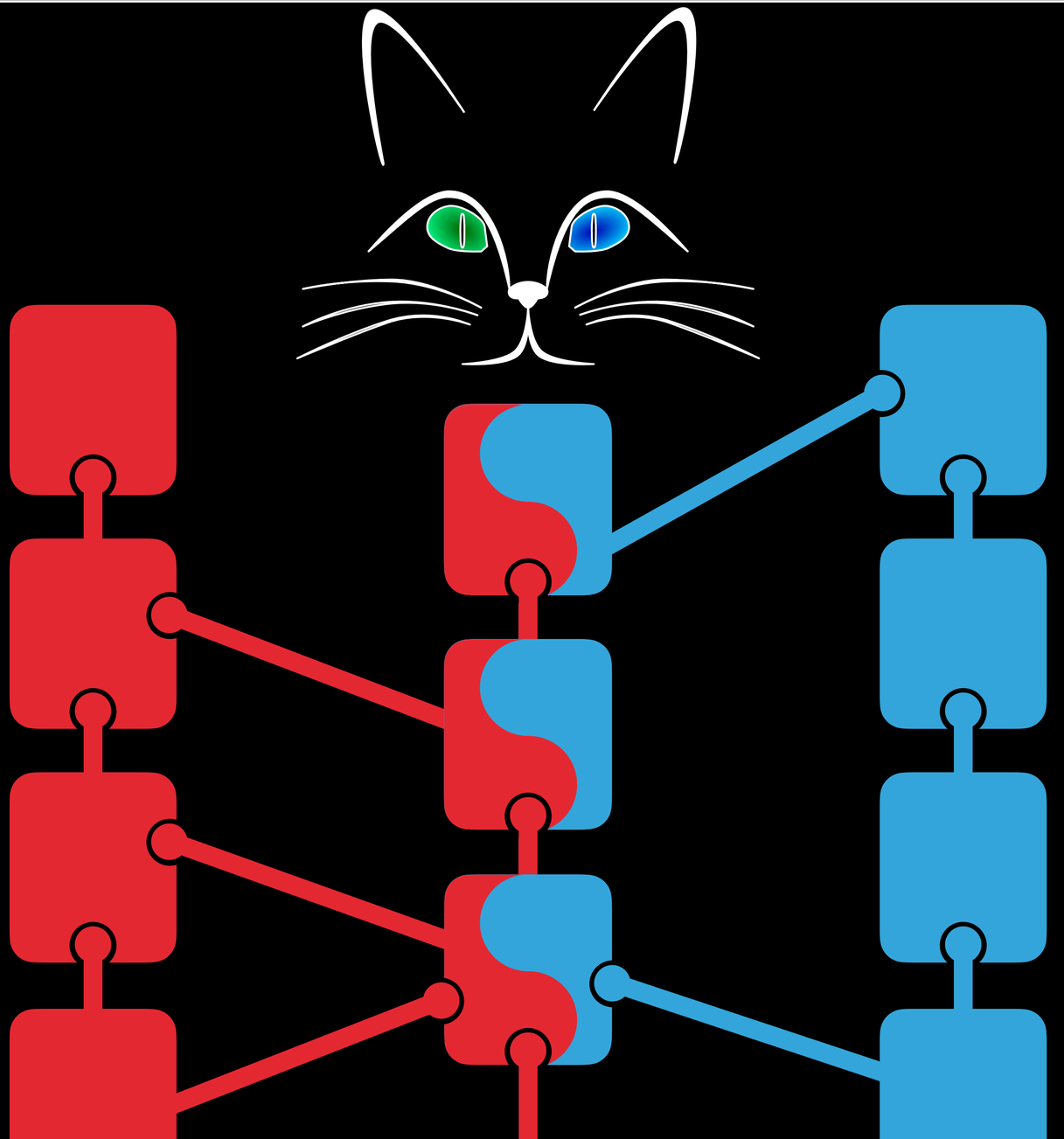
TYPHON OVERVIEW

LOSS OF ATOMICITY

TRUST ASSUMPTIONS

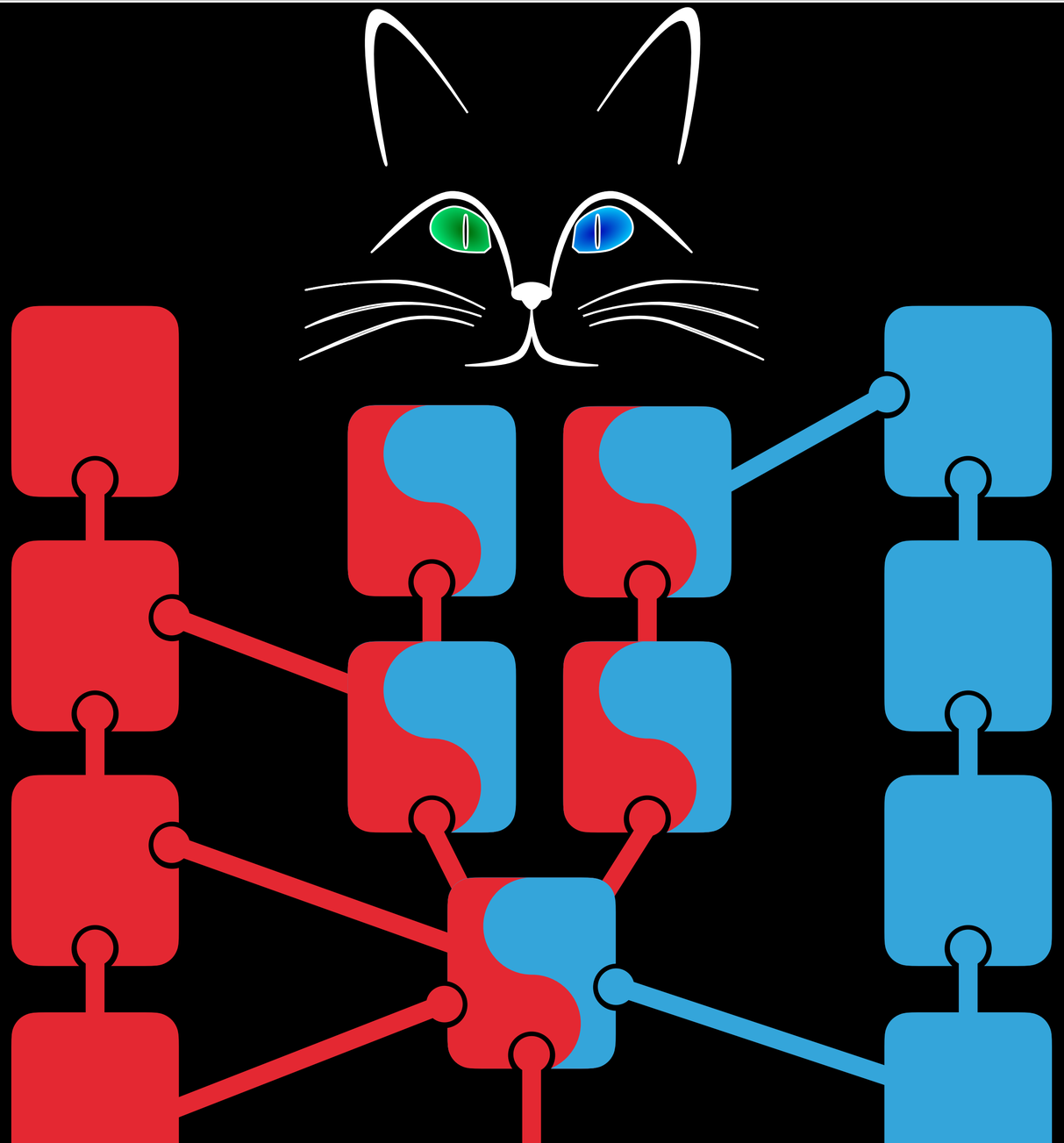
- Safety derives from validators common to multiple chains
- High validator overlap in practice





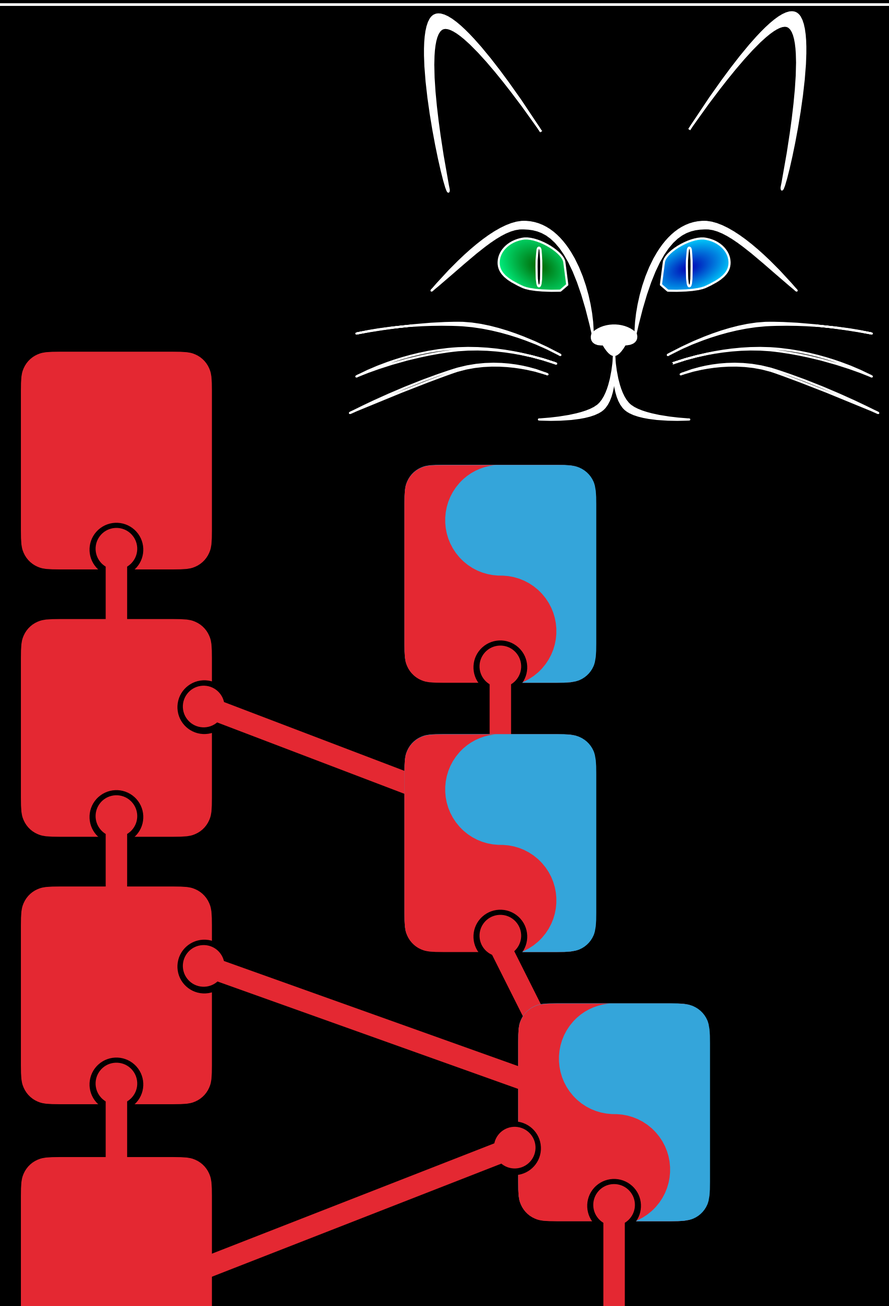
WHEN ATOMICITY FAILS

- Each chain liveness / integrity of its own consensus



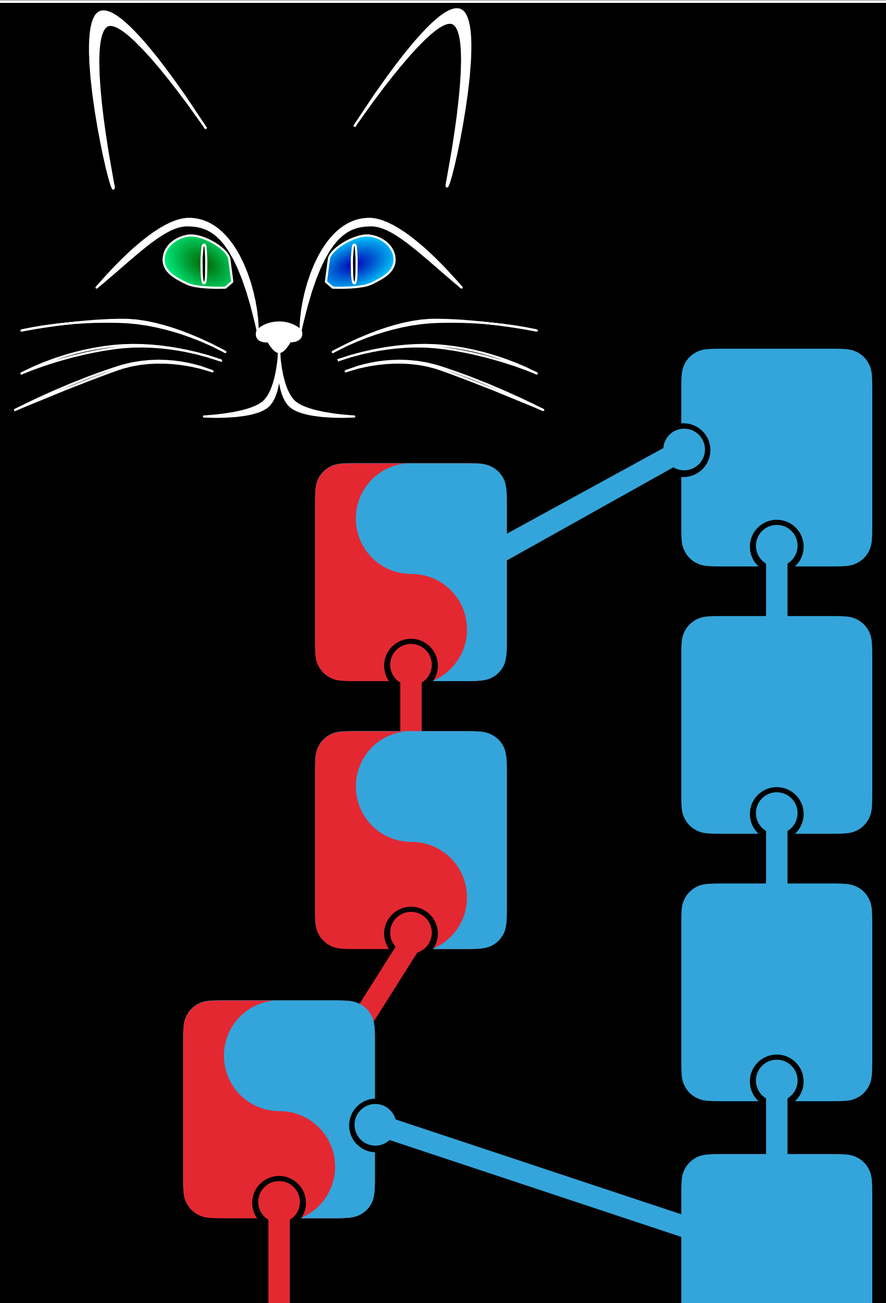
WHEN ATOMICITY FAILS

- Each chain liveness / integrity of its own consensus
- Red Chain remains consistent



WHEN ATOMICITY FAILS

- Each chain liveness / integrity of its own consensus
- Red Chain remains consistent
- Blue Chain remains consistent



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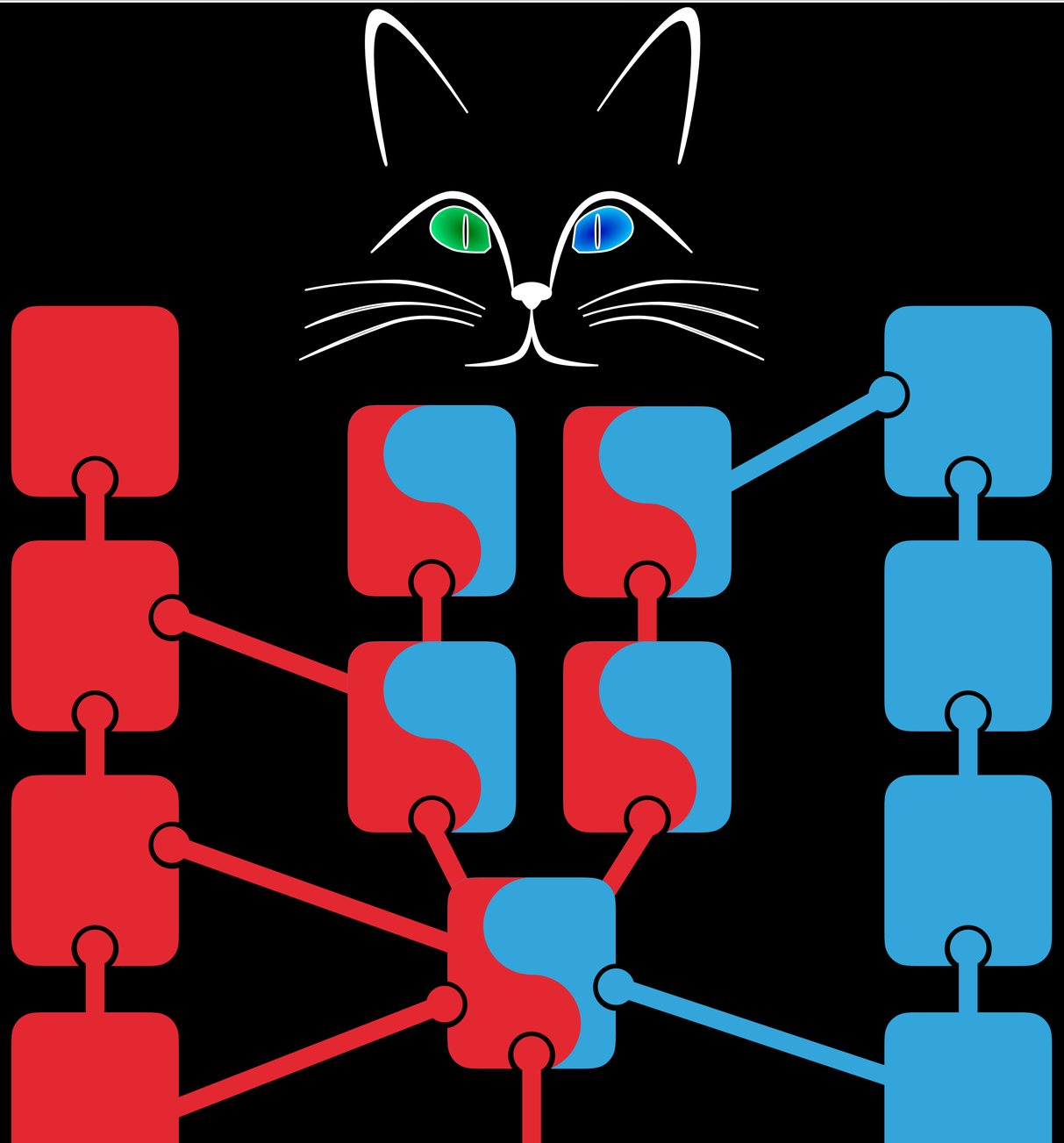

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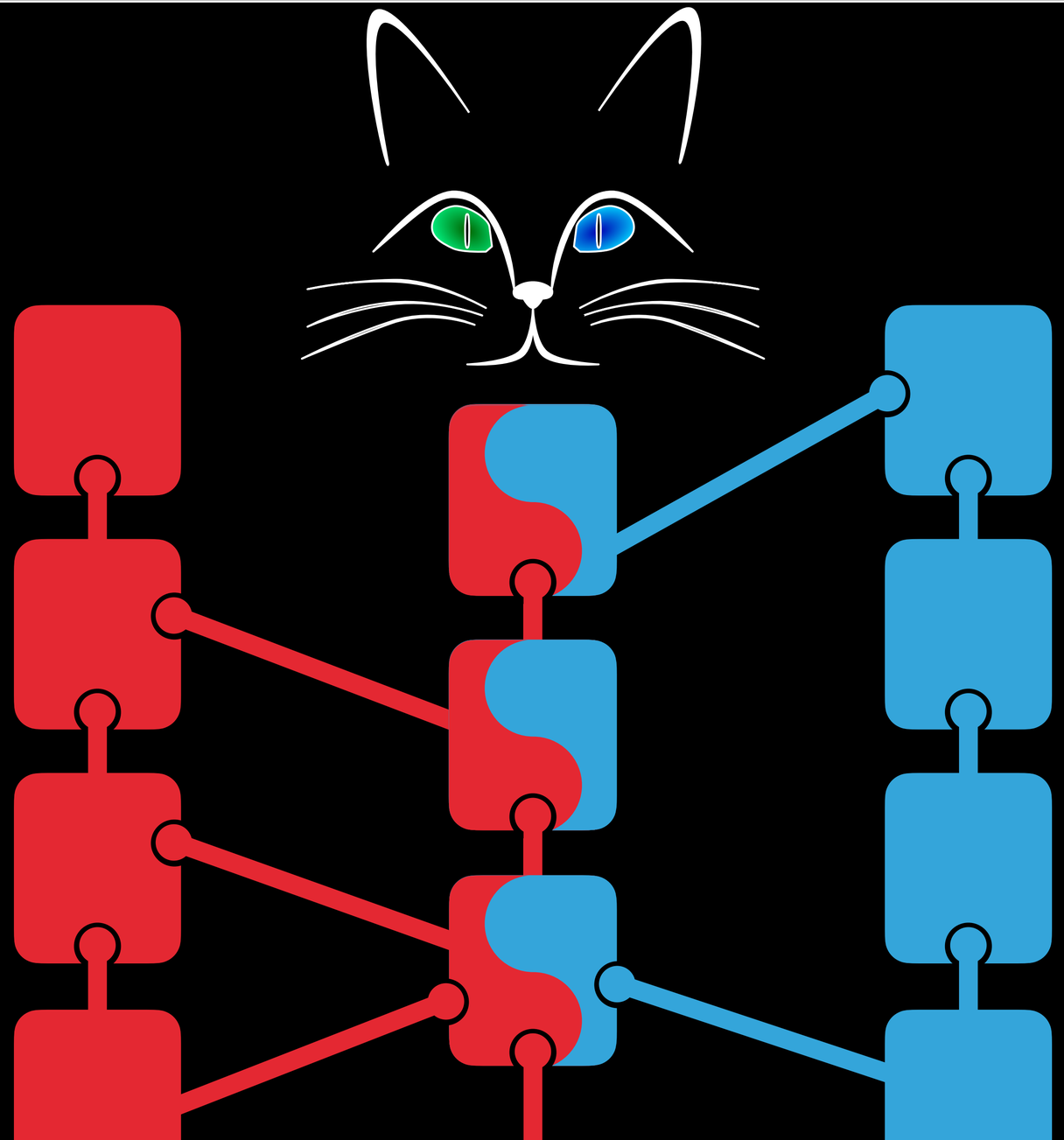
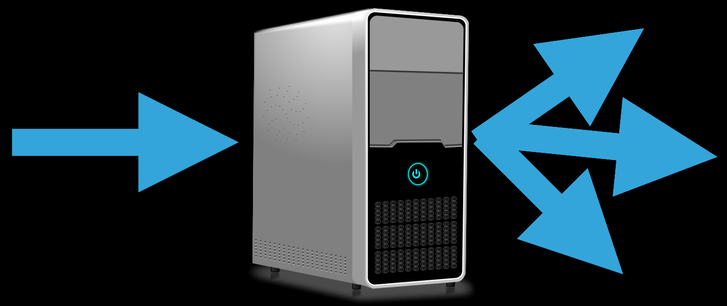


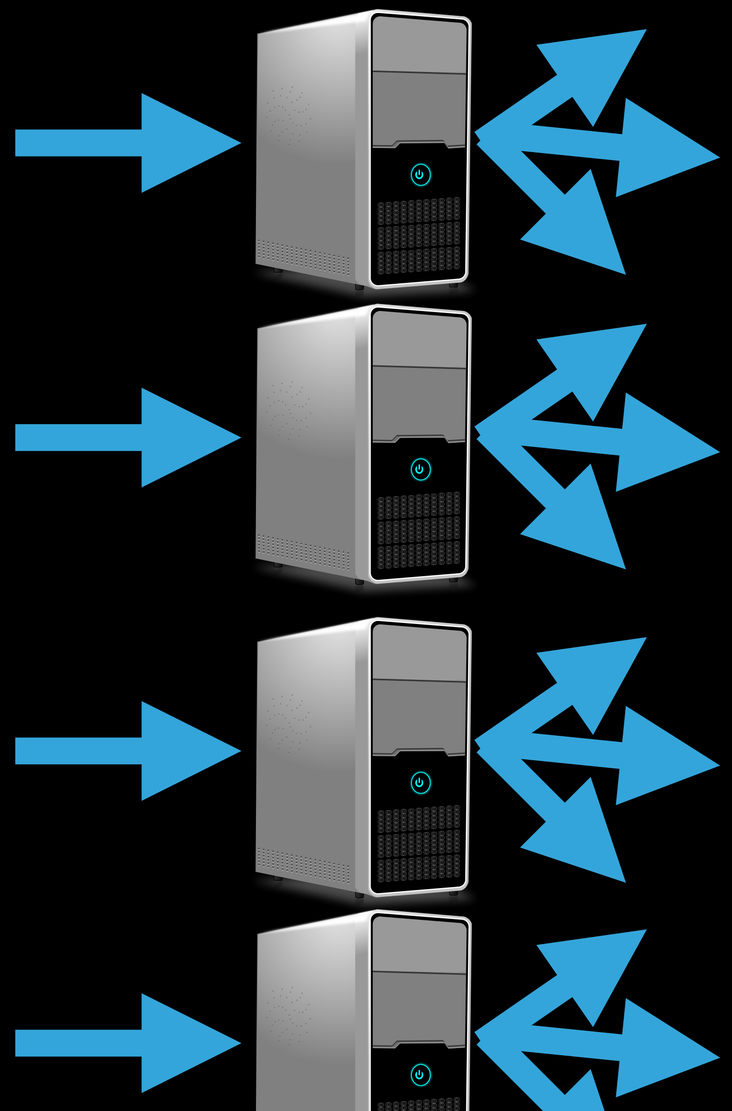
NARWHAL MEMPOOL [DANZENIS ET. AL., EUROSYS 2022]

- Validators
  - Receive transactions from clients
  - Replicate and store



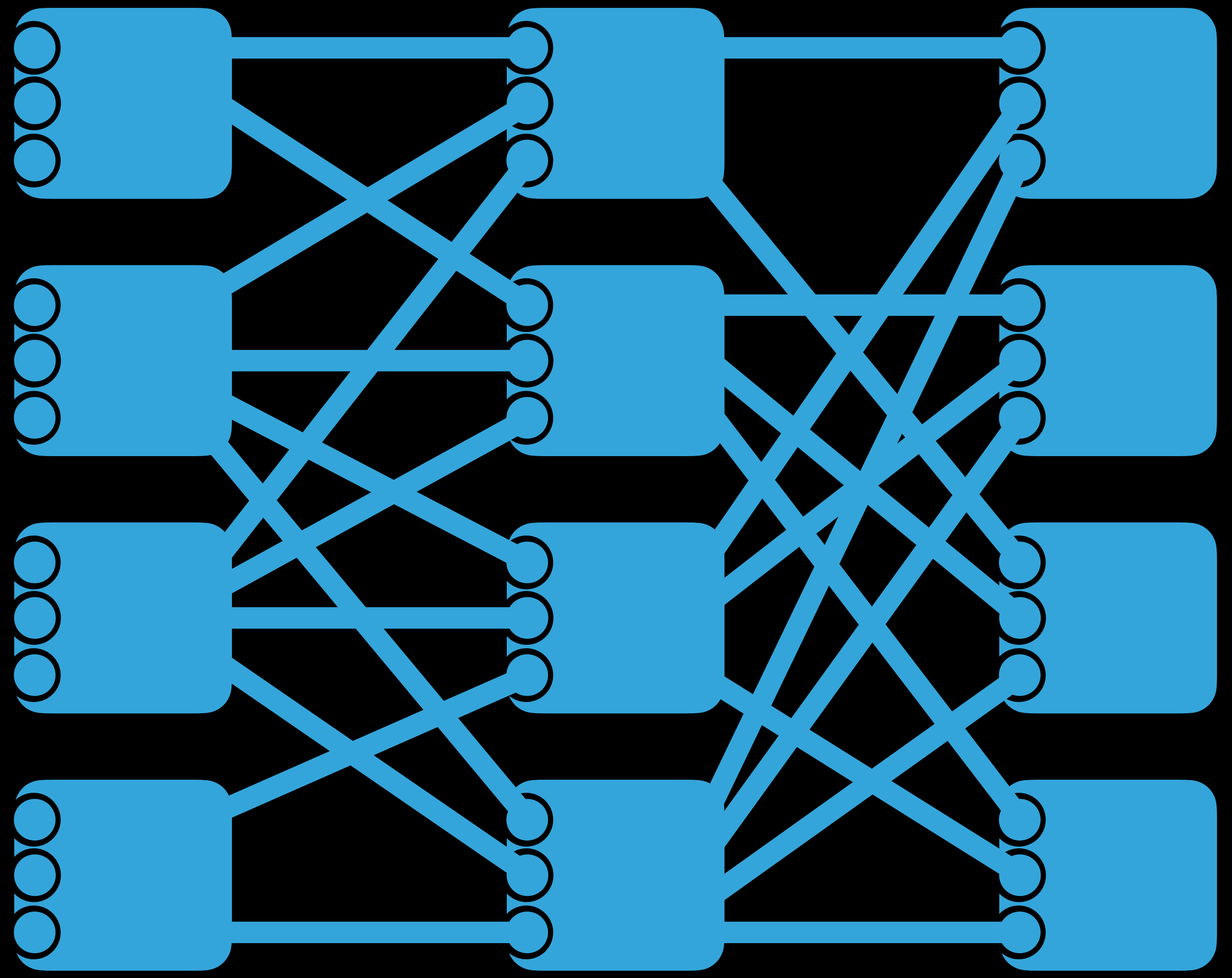
NARWHAL MEMPOOL [DANZENIS ET. AL., EUROSYS 2022]

- Validators
  - Receive transactions from clients
  - Replicate and store
- Many workers per validator



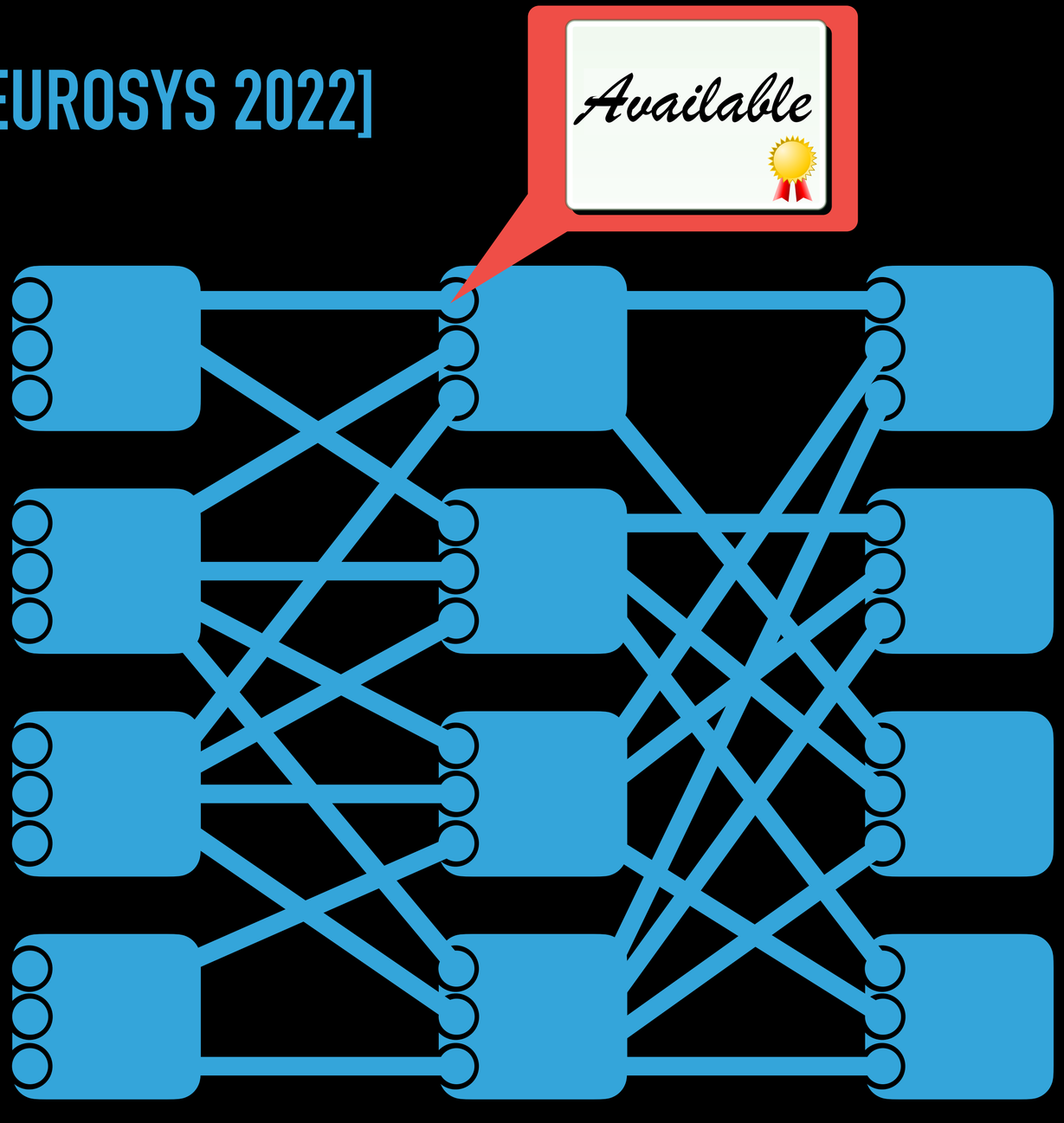
NARWHAL MEMPOOL [DANZENIS ET. AL., EUROSYS 2022]

- Validators
  - Receive transactions from clients
  - Replicate and store
- Many workers per validator
- DAG of Mempool blocks



NARWHAL MEMPOOL [DANZENIS ET. AL., EUROSYS 2022]

- Validators
  - Receive transactions from clients
  - Replicate and store
- Many workers per validator
- DAG of Mempool blocks
  - Certificates of Availability
  - Consensus chooses total order



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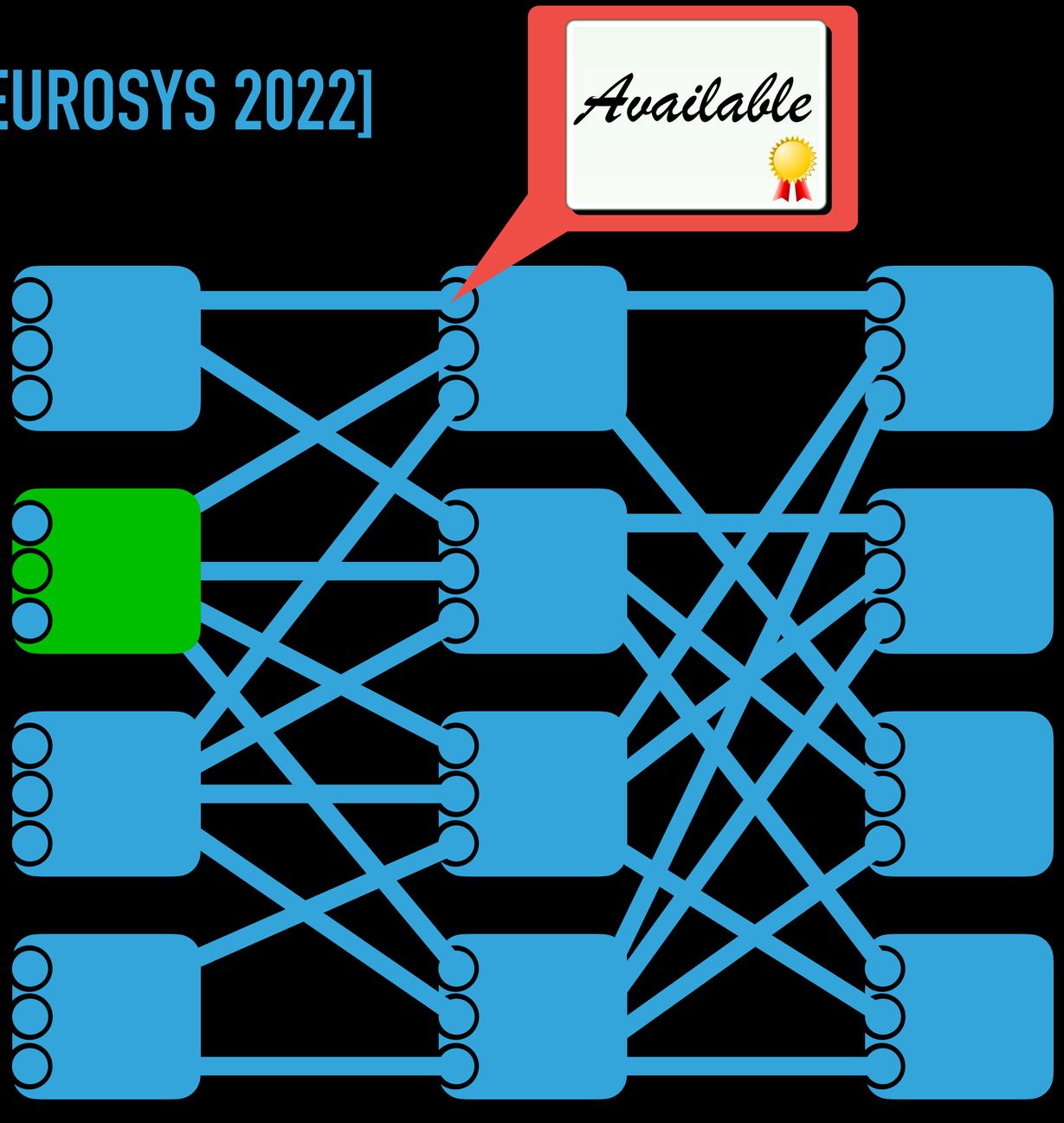

NARWHAL MEMPOOL [DANZENIS ET. AL., EUROSYS 2022]

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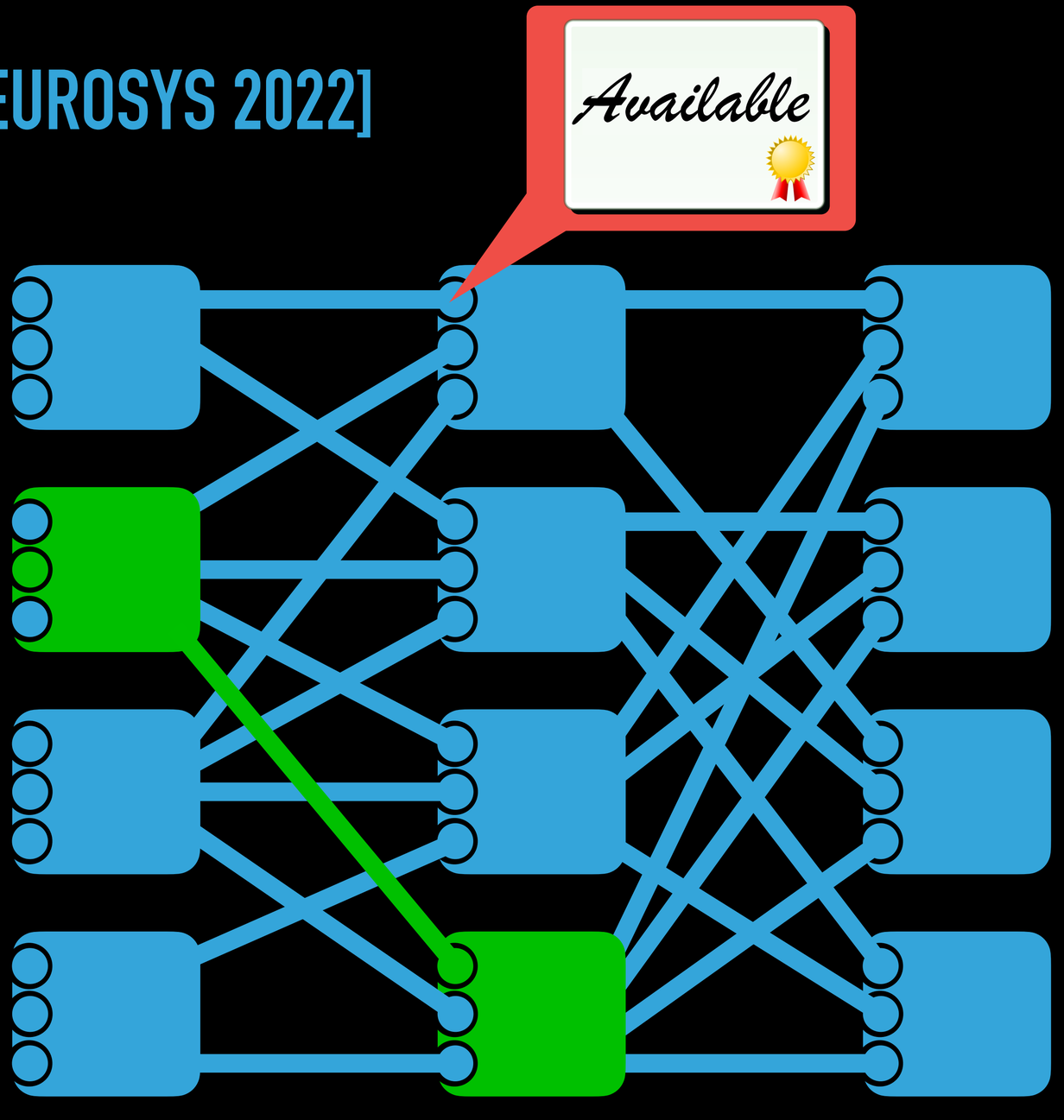

NARWHAL MEMPOOL [DANZENIS ET. AL., EUROSYS 2022]

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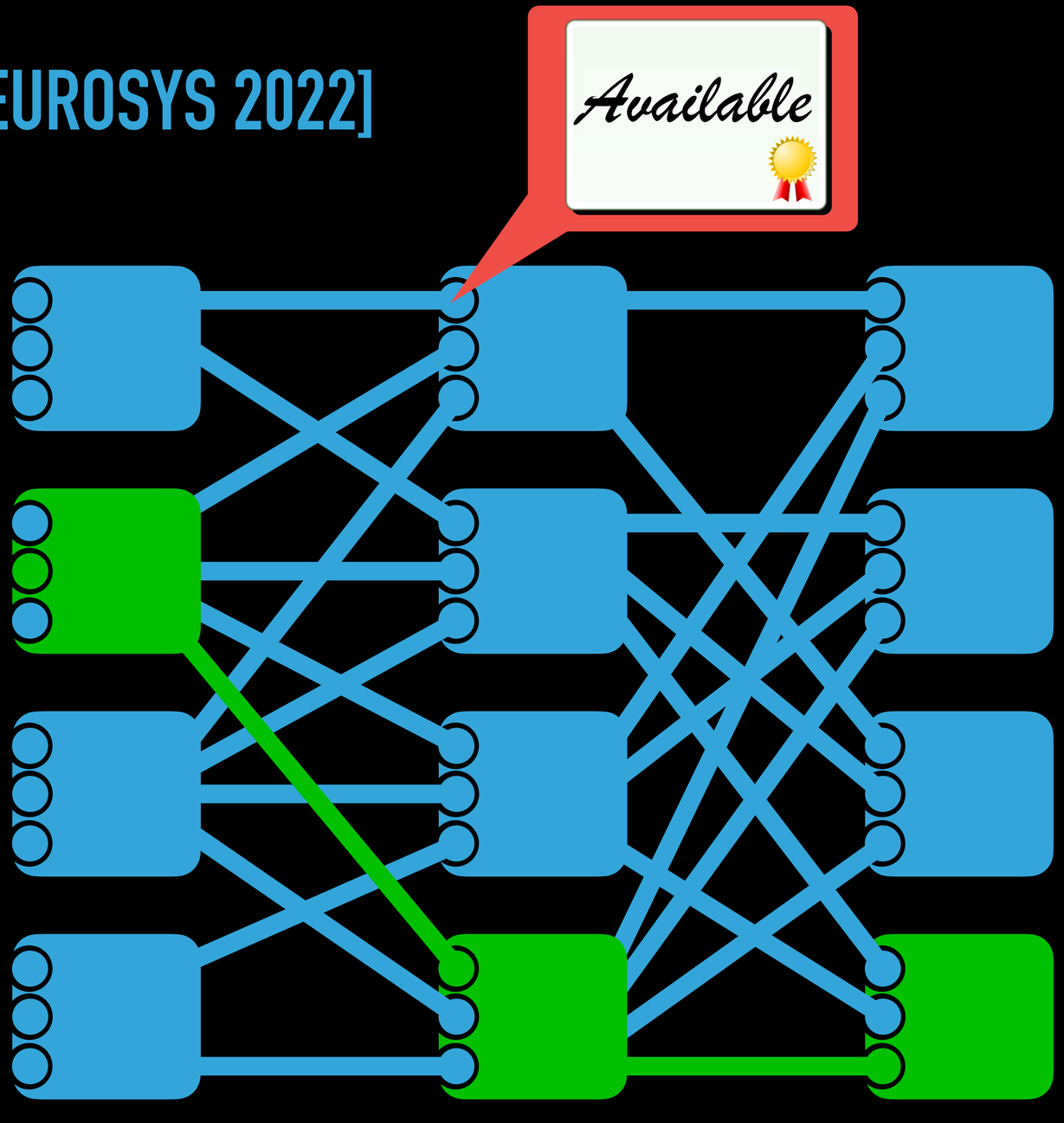

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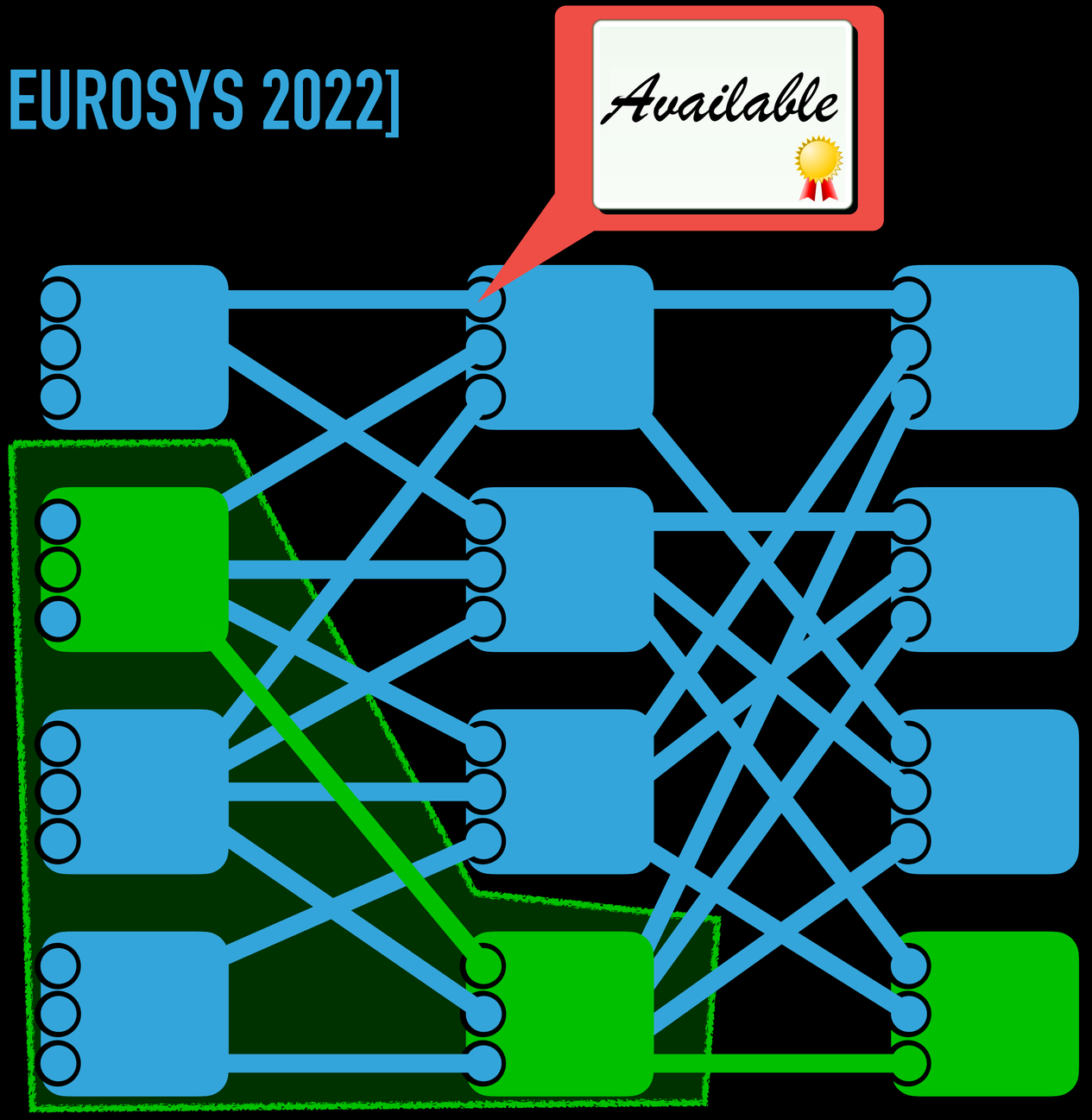

NARWHAL MEMPOOL [DANZENIS ET. AL., EUROSYS 2022]

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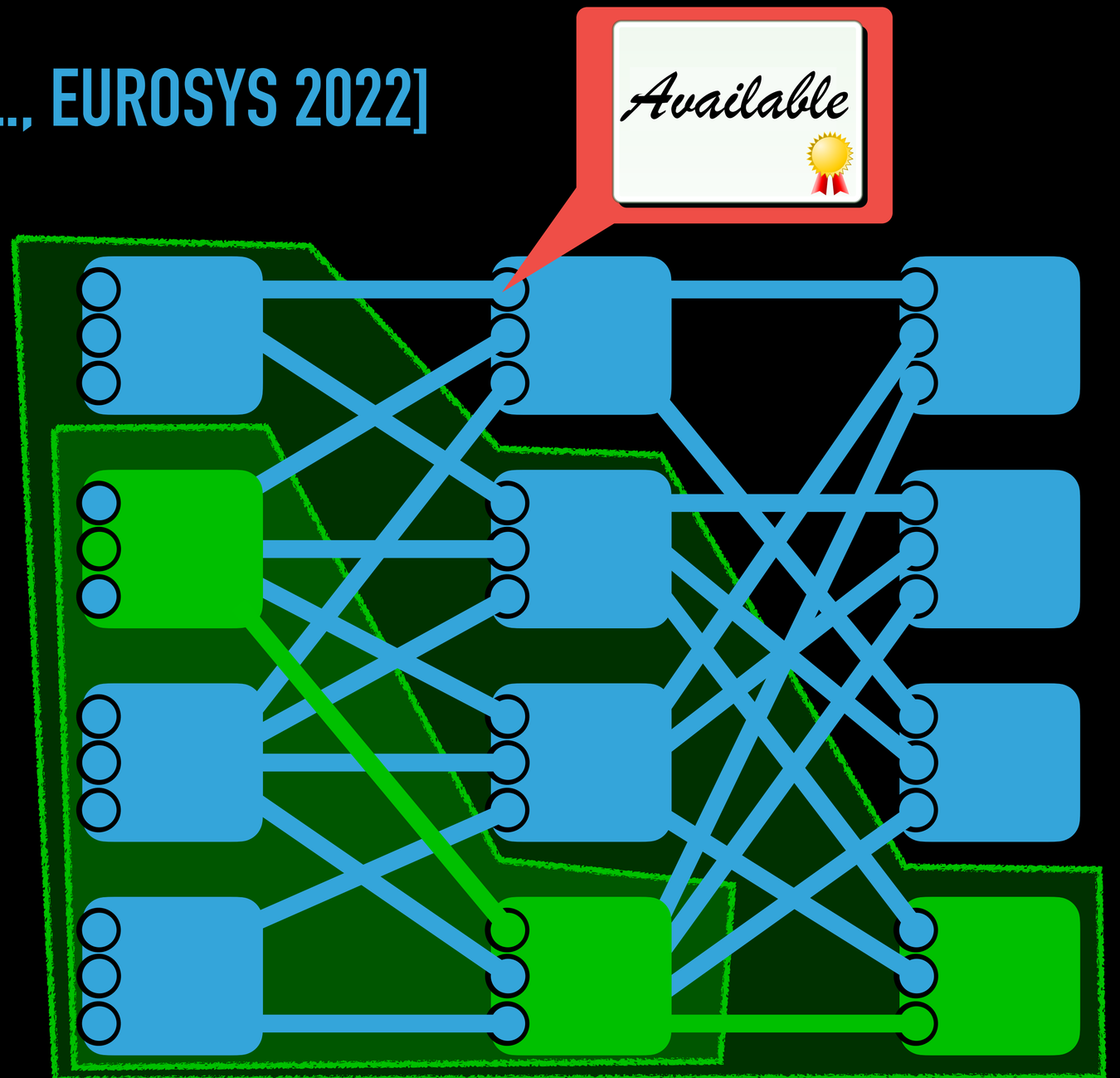
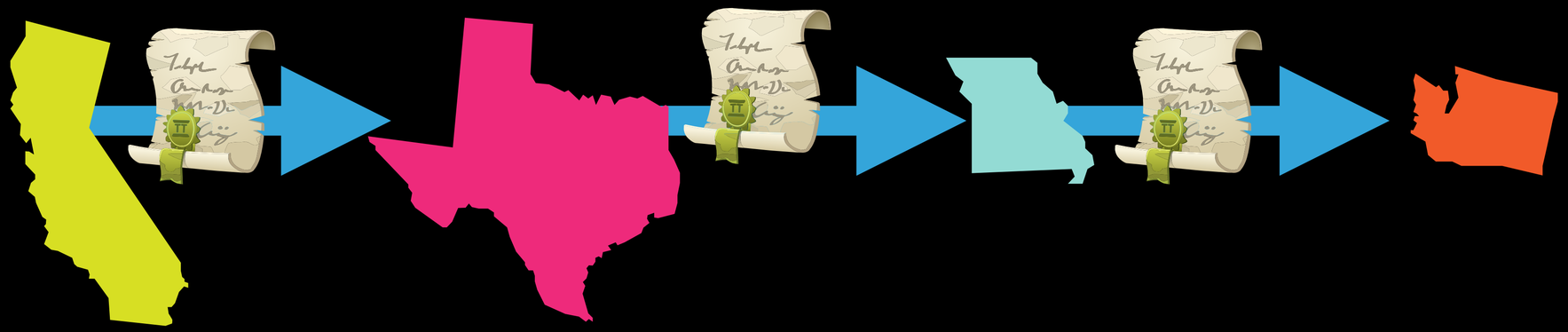


COMET

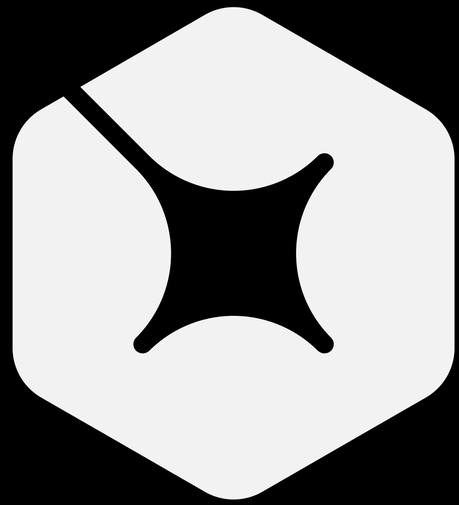


- State Machine
  - Sub-state with well-defined permissions
- High availability
- ~~High Throughput~~
- High Integrity
  - "Everyone" agrees

Serialized execution

Block proposal bottleneck

Cross-chain transactions



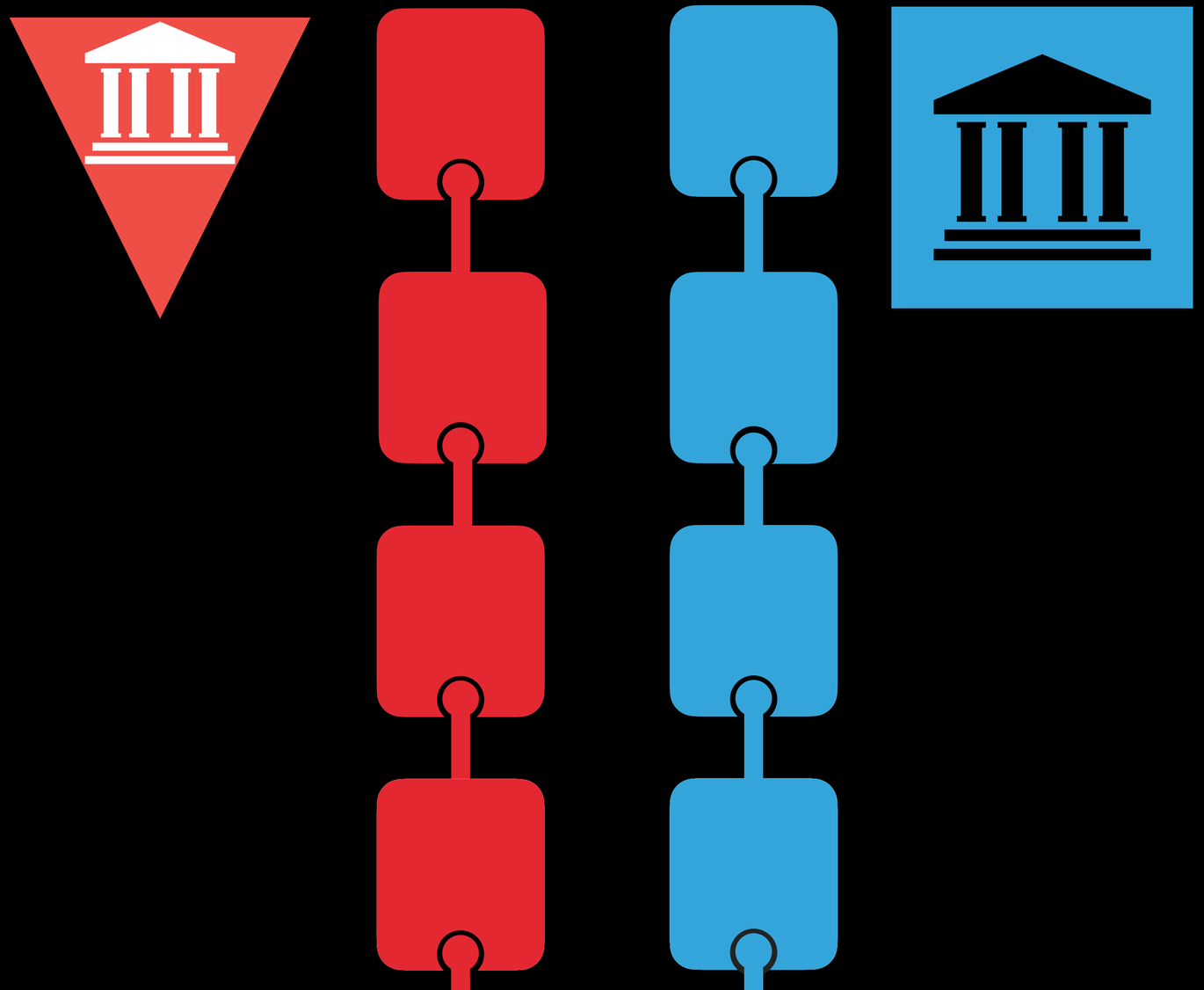
IEVS

VOCABULARY

State Machine Replication	Blockchain
BFT Replicated State Machine System	Chain
State Machine	State Machine
State Transition / Transaction	Transaction
Log	Ledger
Object	Smart Contract
Batch of Transactions	Block
Replica / Learner	Full Node
Acceptor	Validator / Voter / Miner
Slot / Instance of Consensus	Height

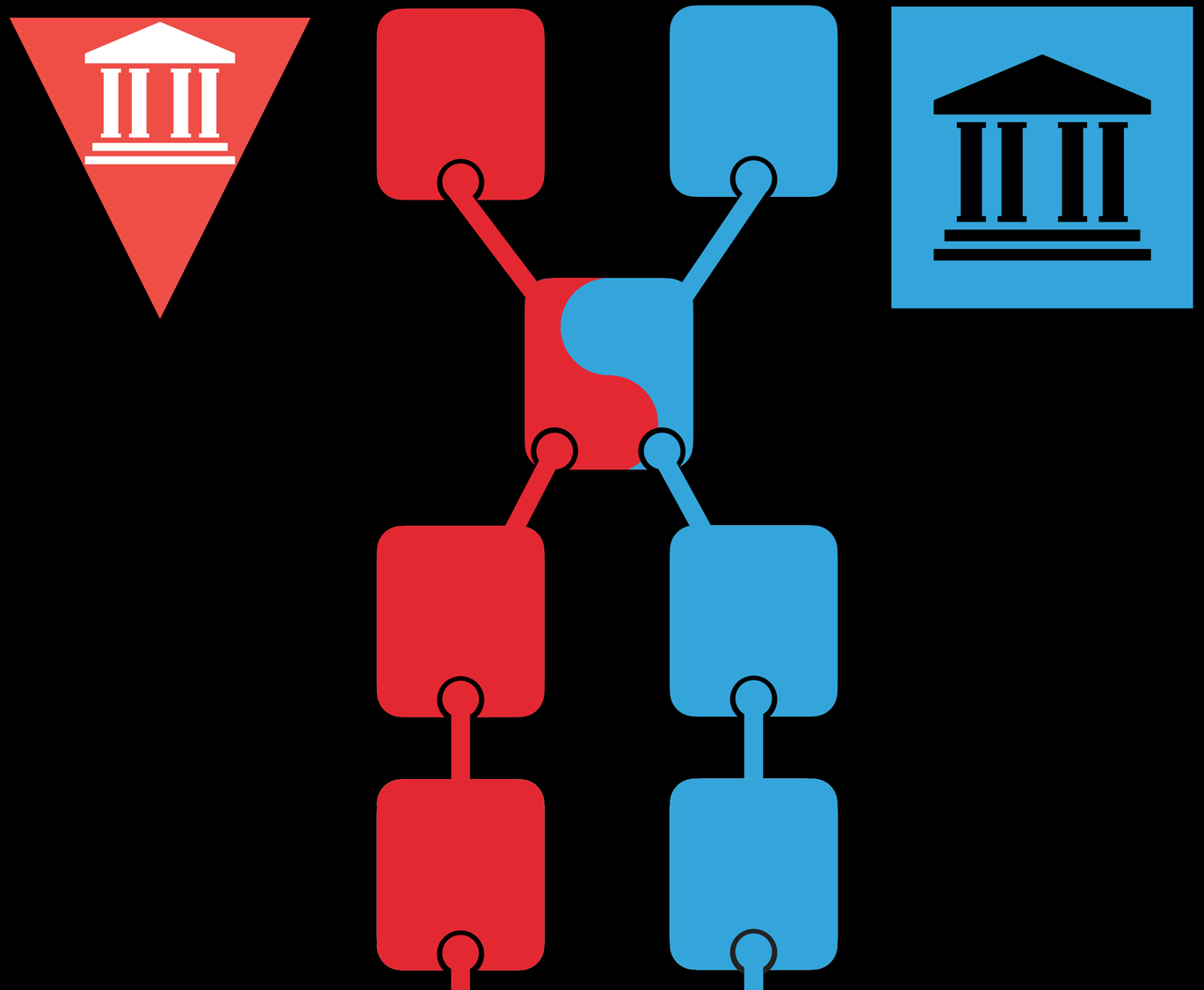
ATOMIC COMMITMENT ACROSS CHAINS

- 2 chains (with finality)
  - Different maintainers

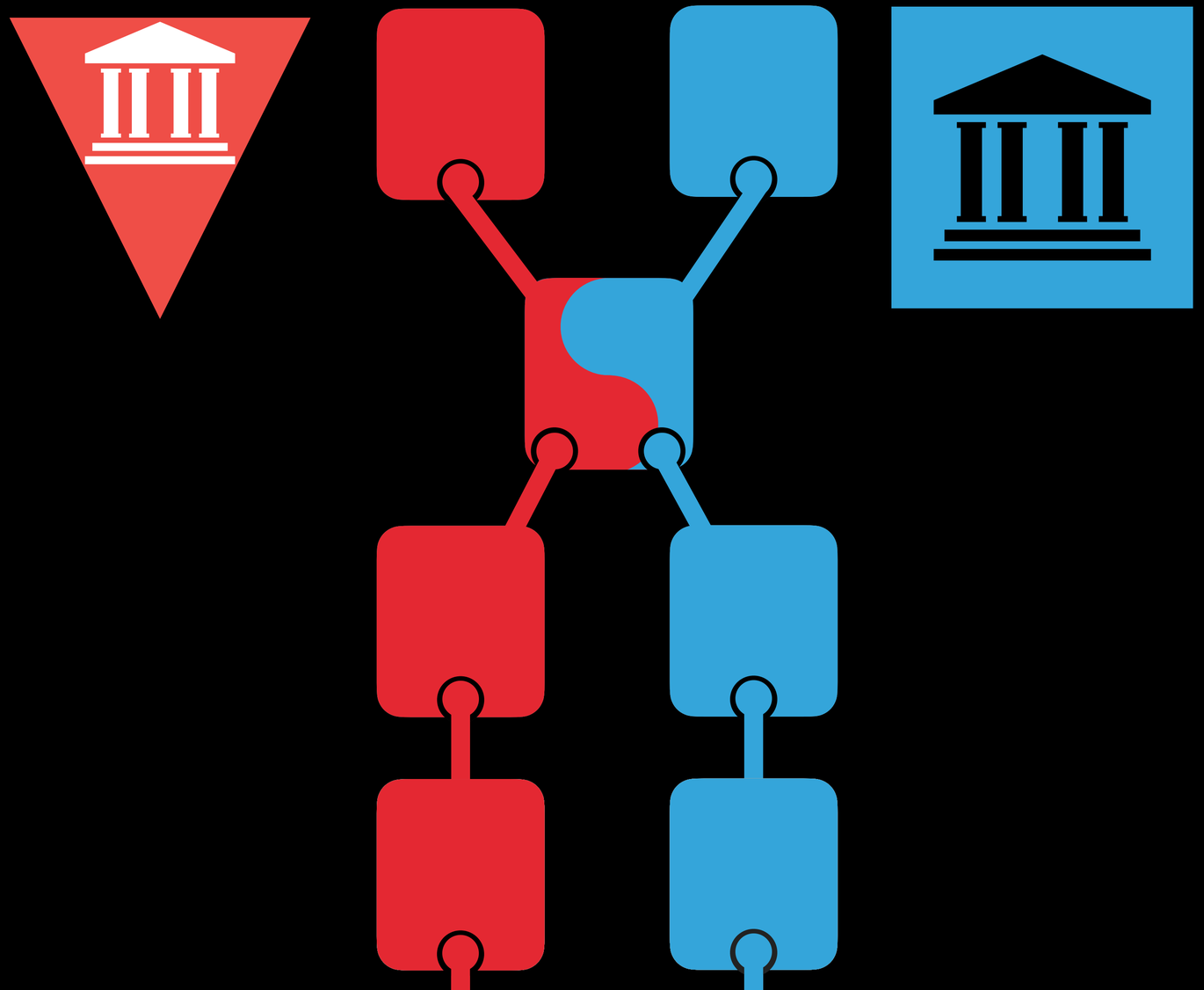


ATOMIC COMMITMENT ACROSS CHAINS

- 2 chains (with finality)
  - Different maintainers
- One block for both chains



HETEROGENEOUS PAXOS



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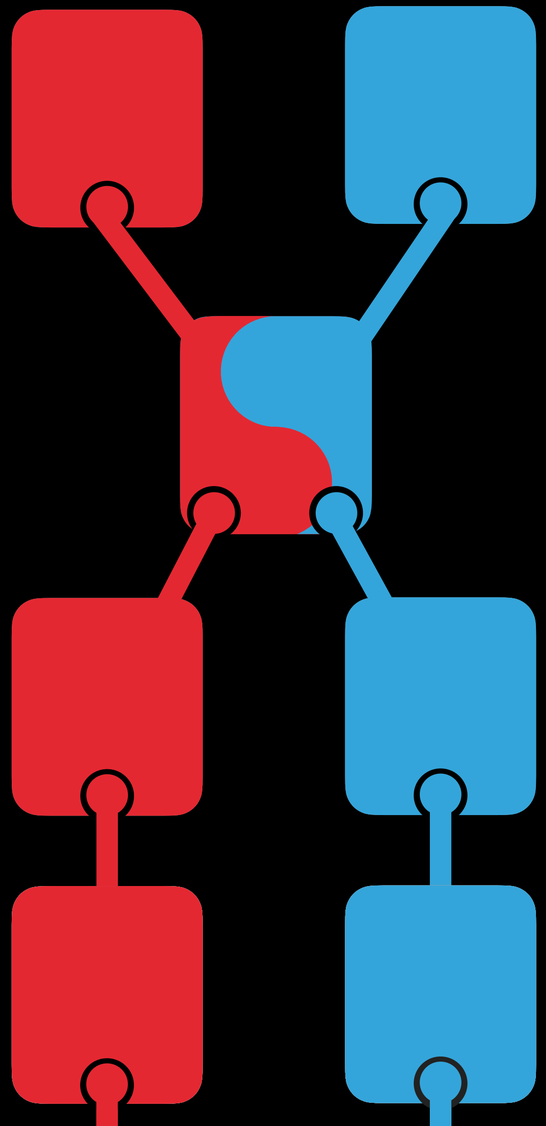

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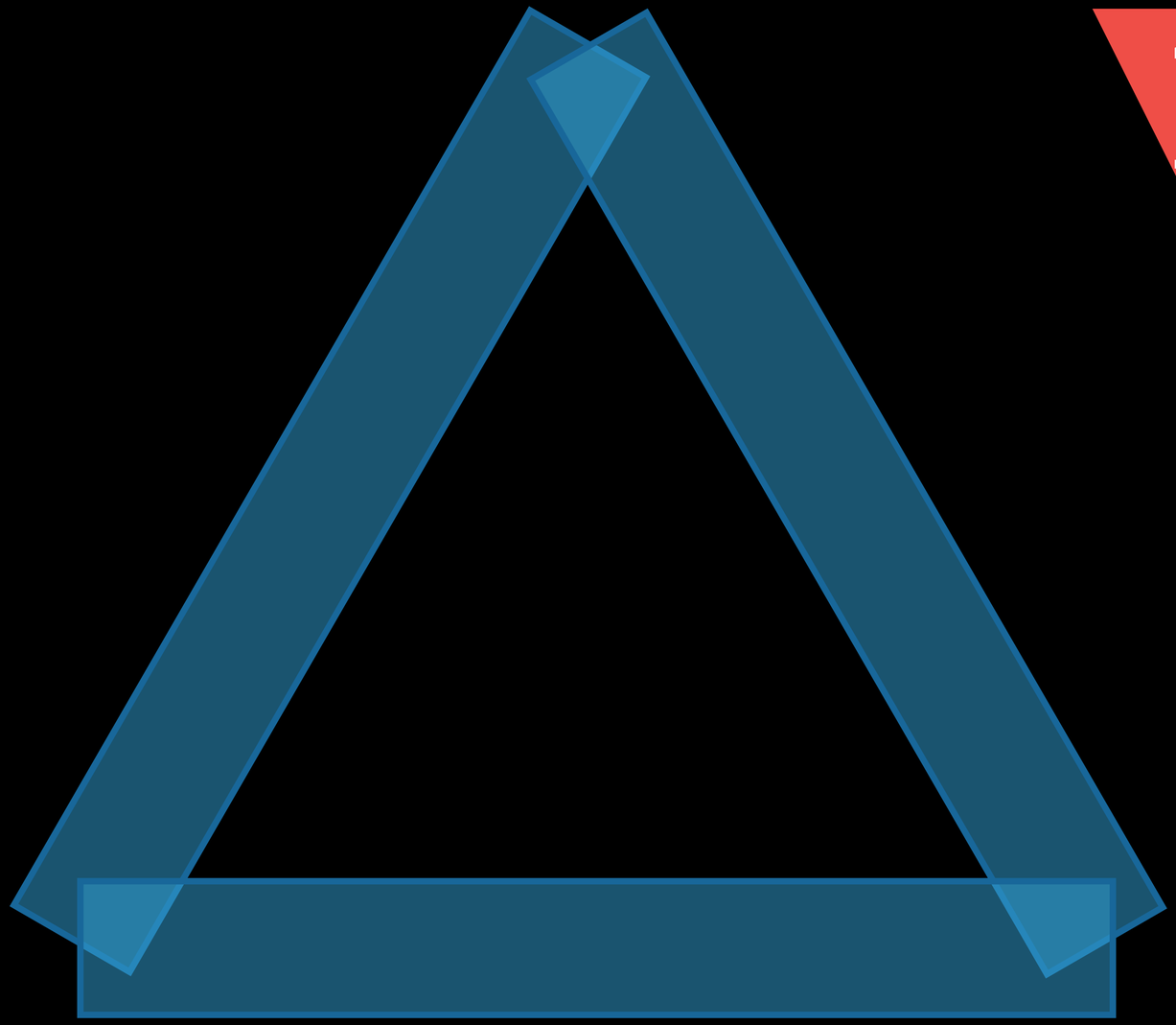

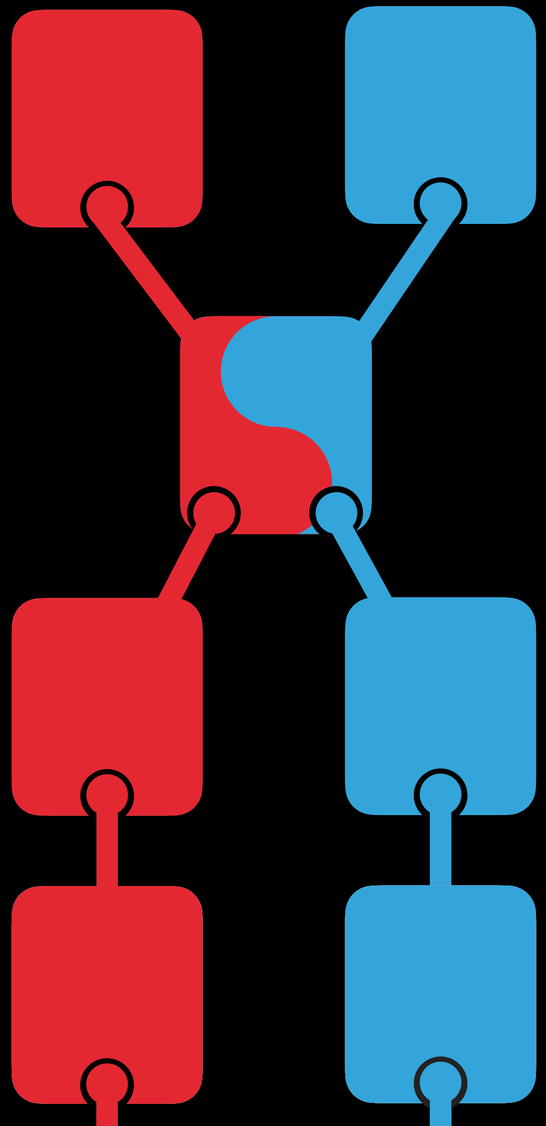

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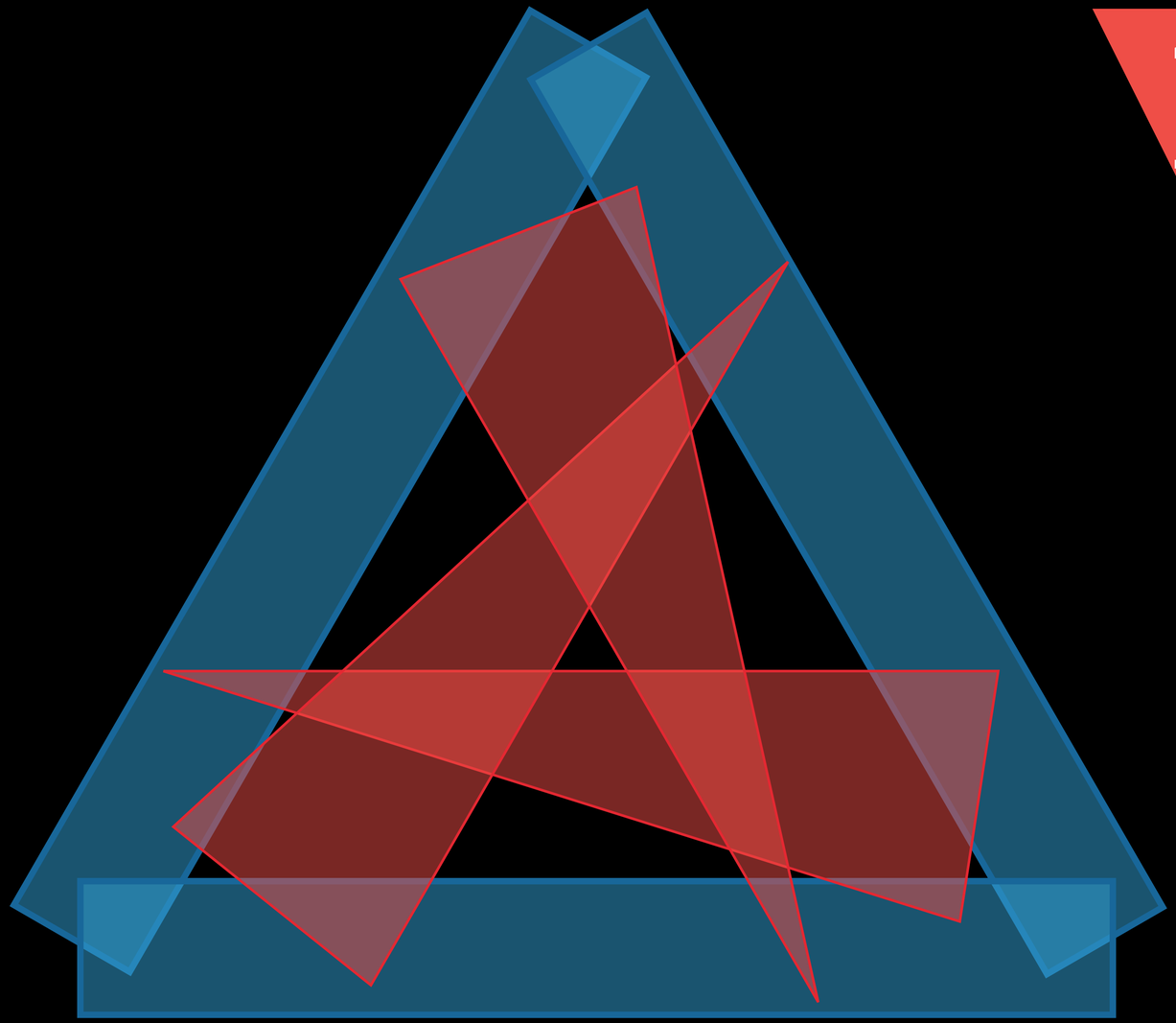

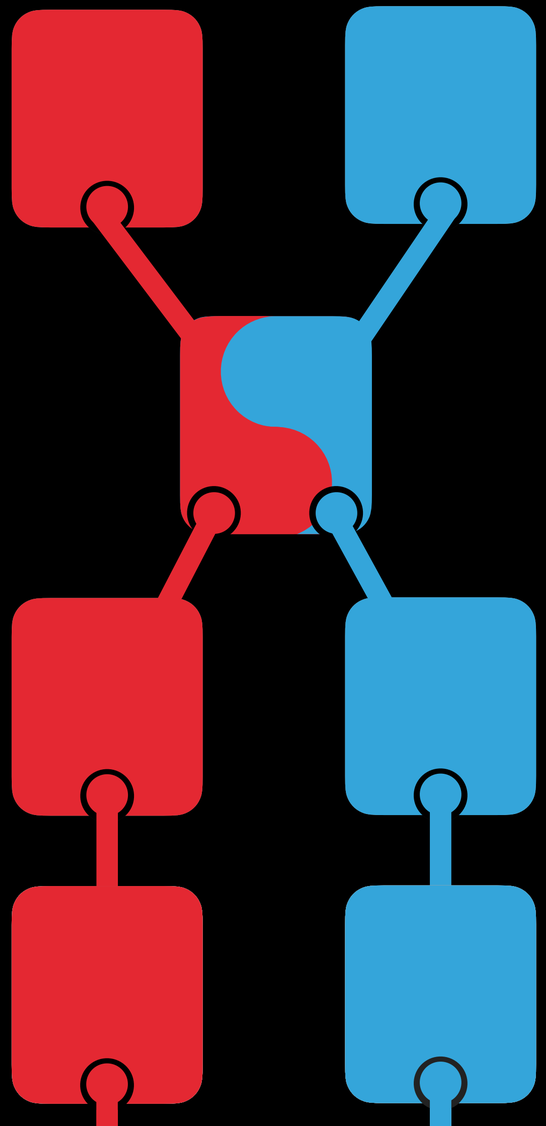

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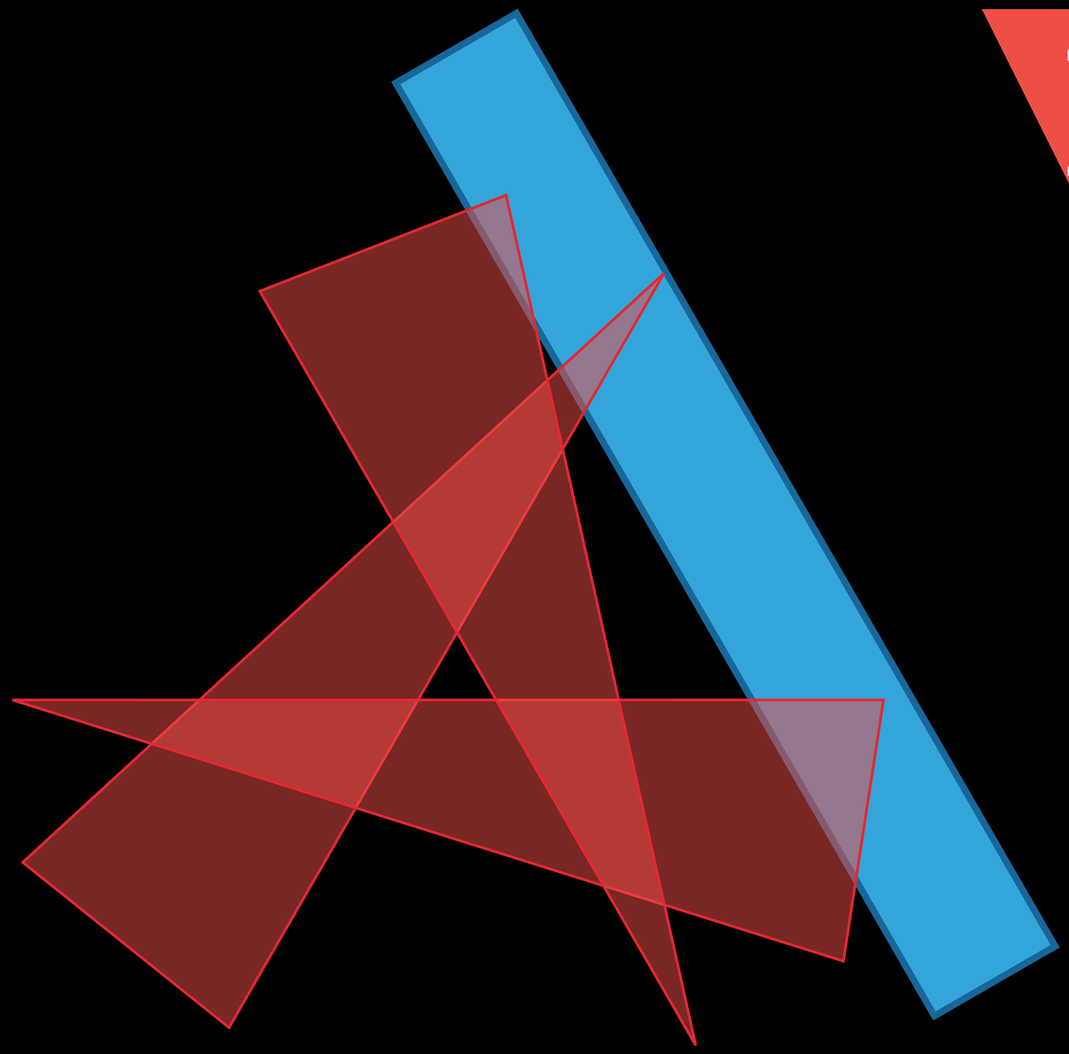

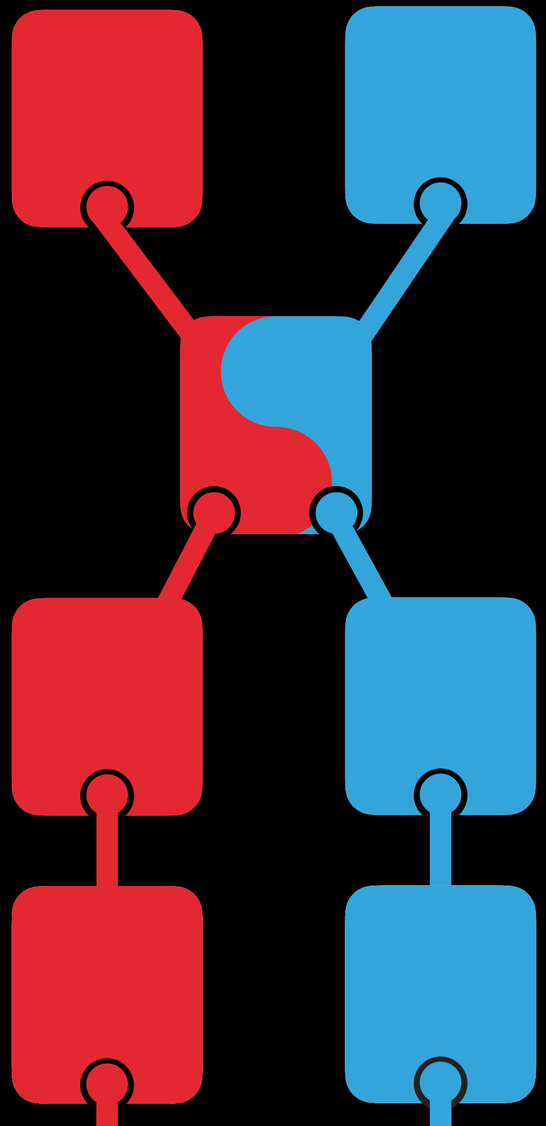

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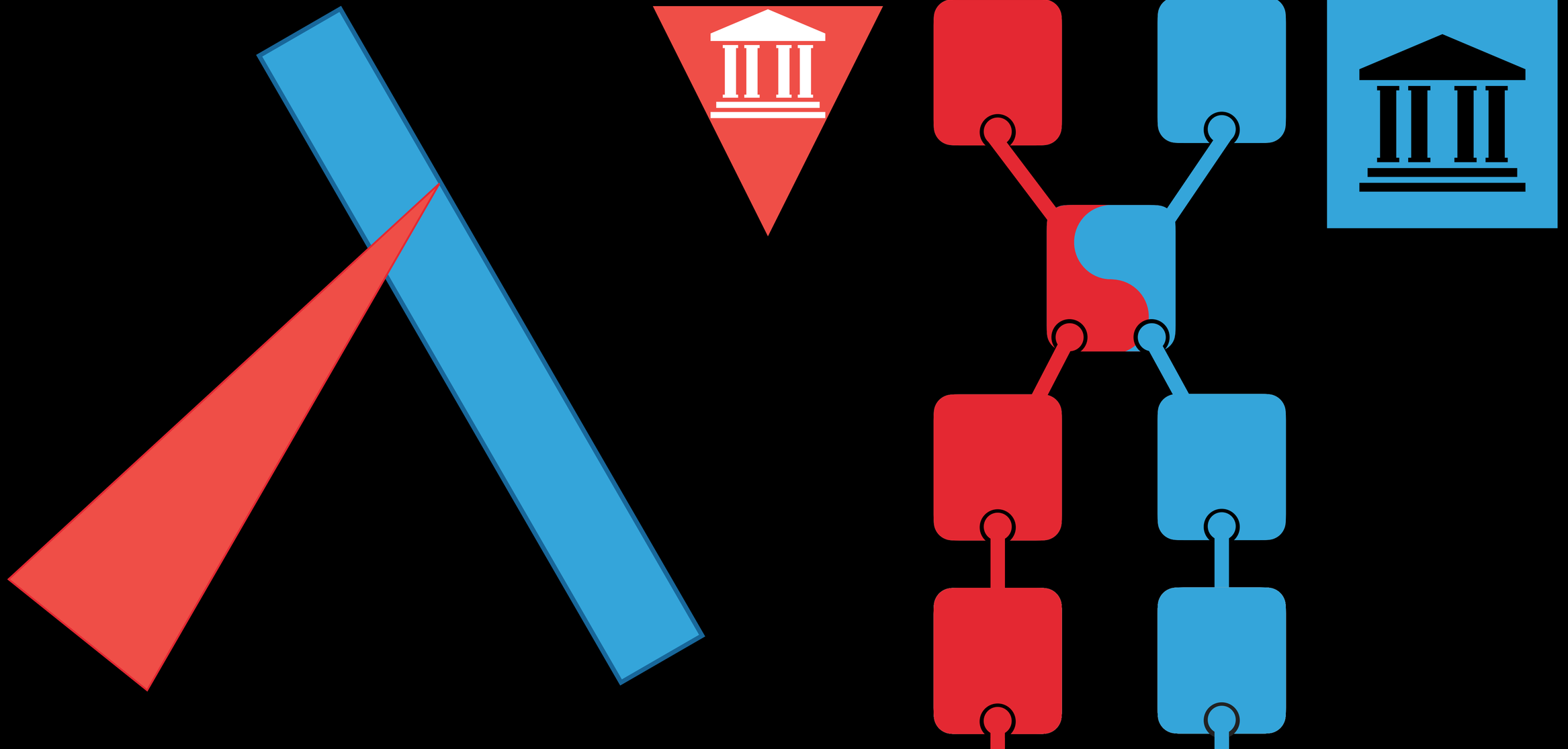

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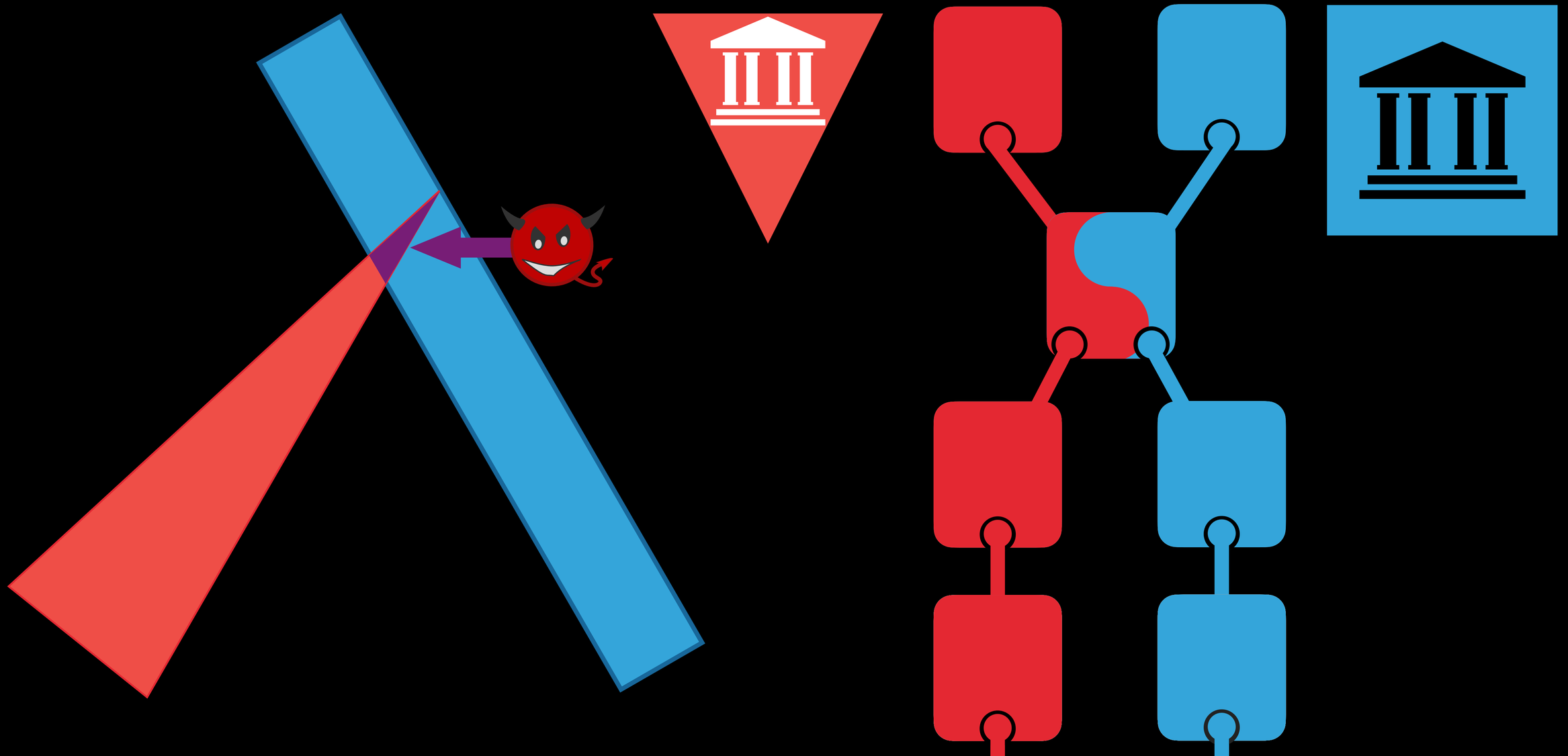

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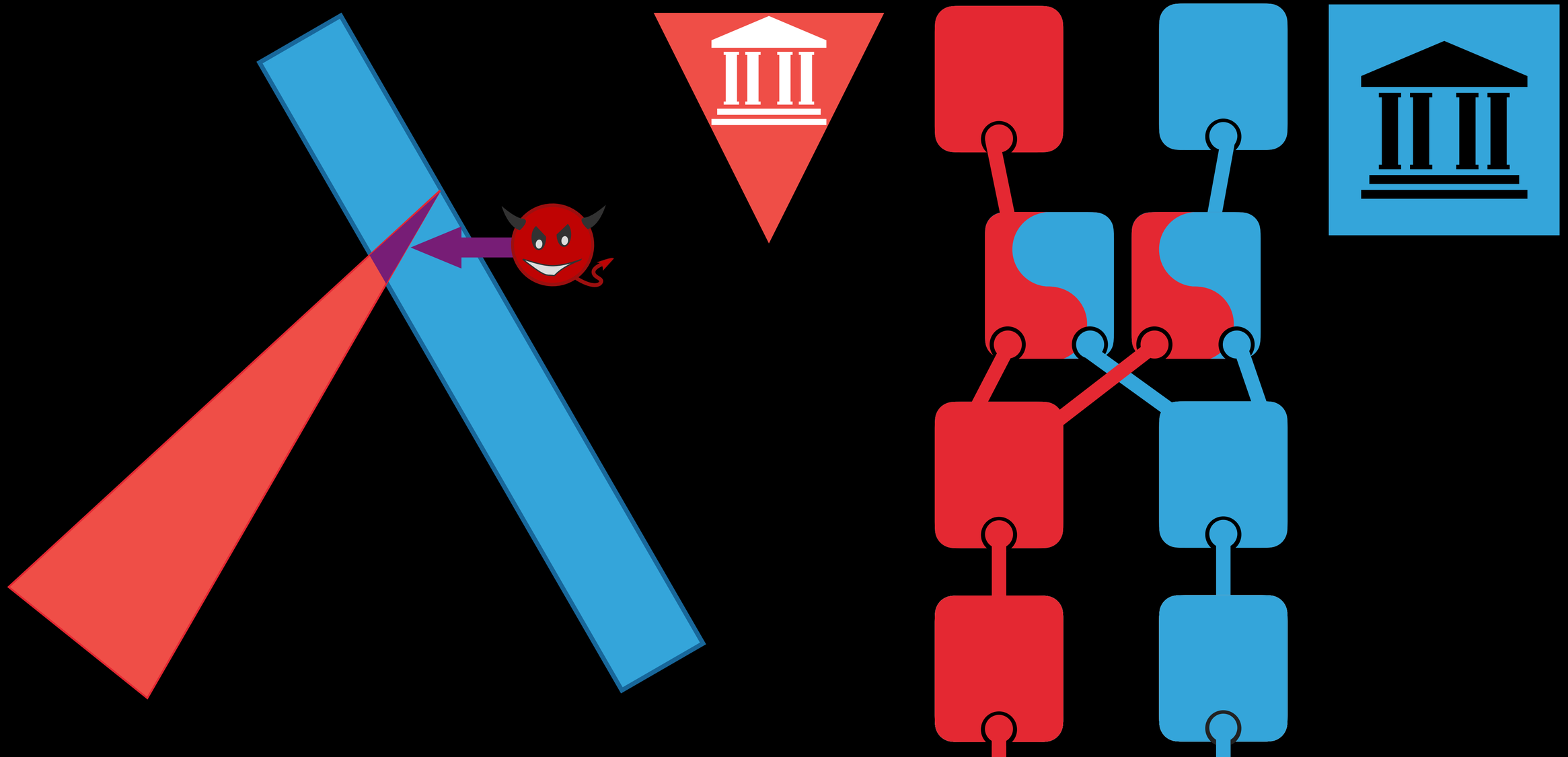

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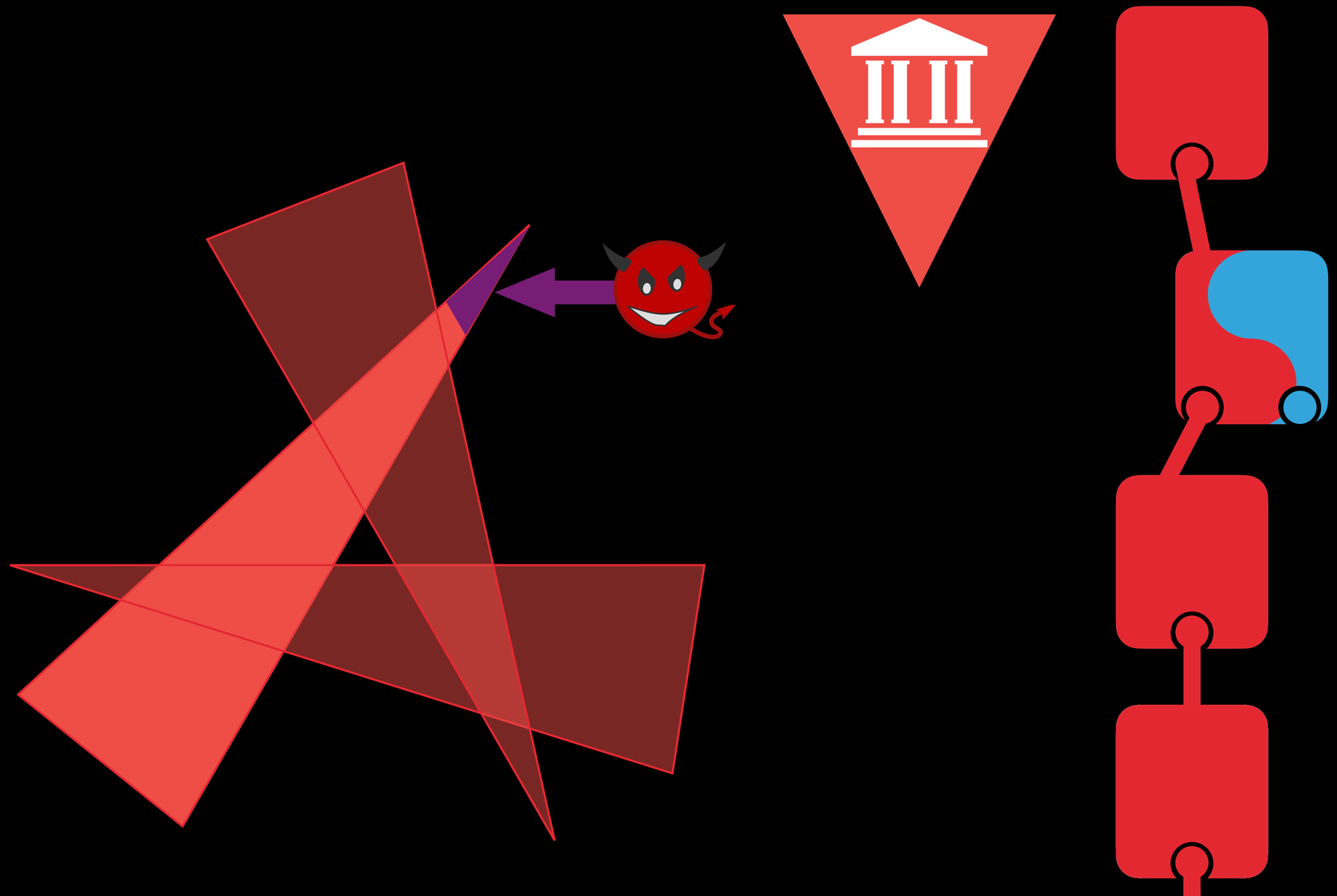

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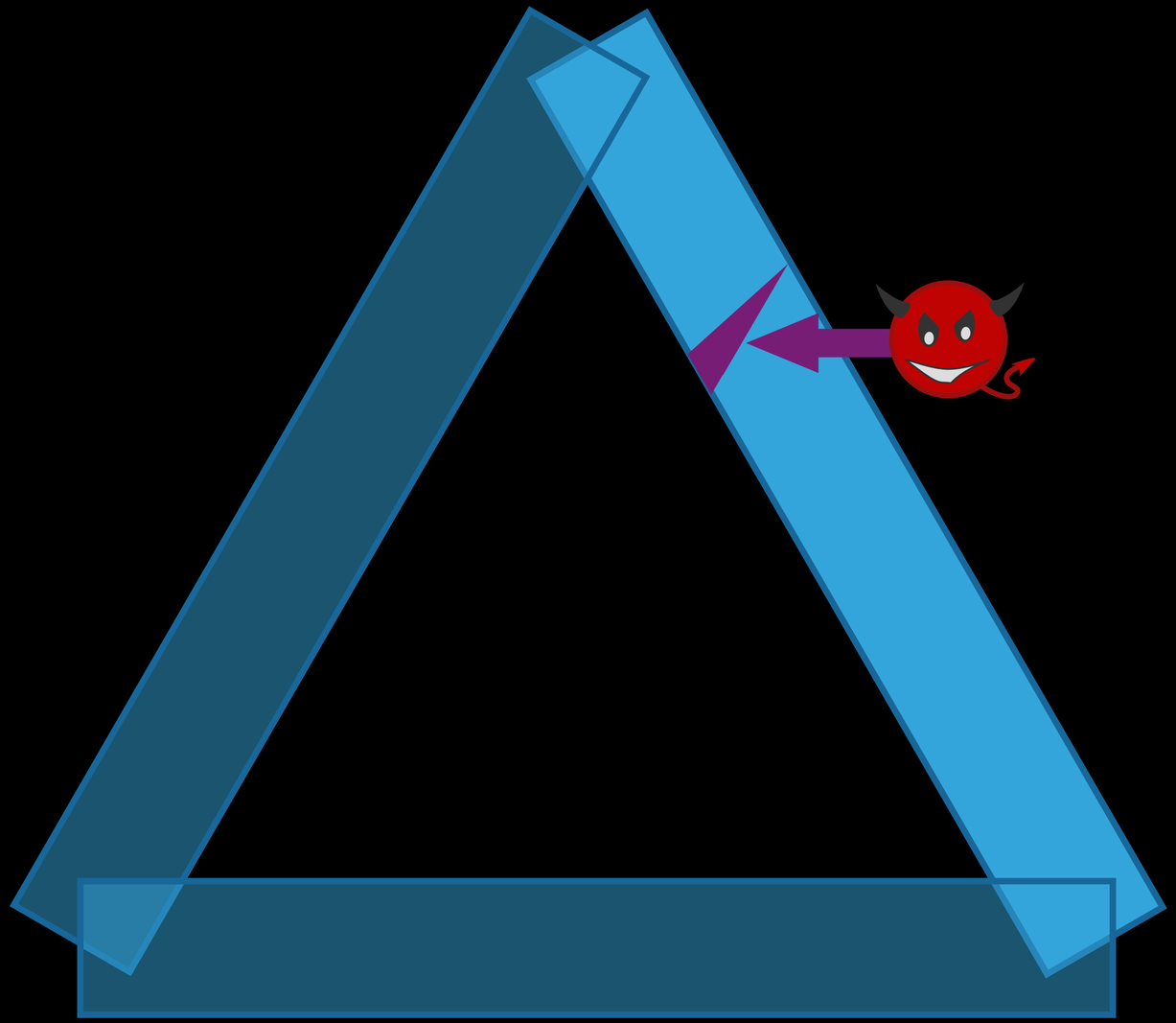

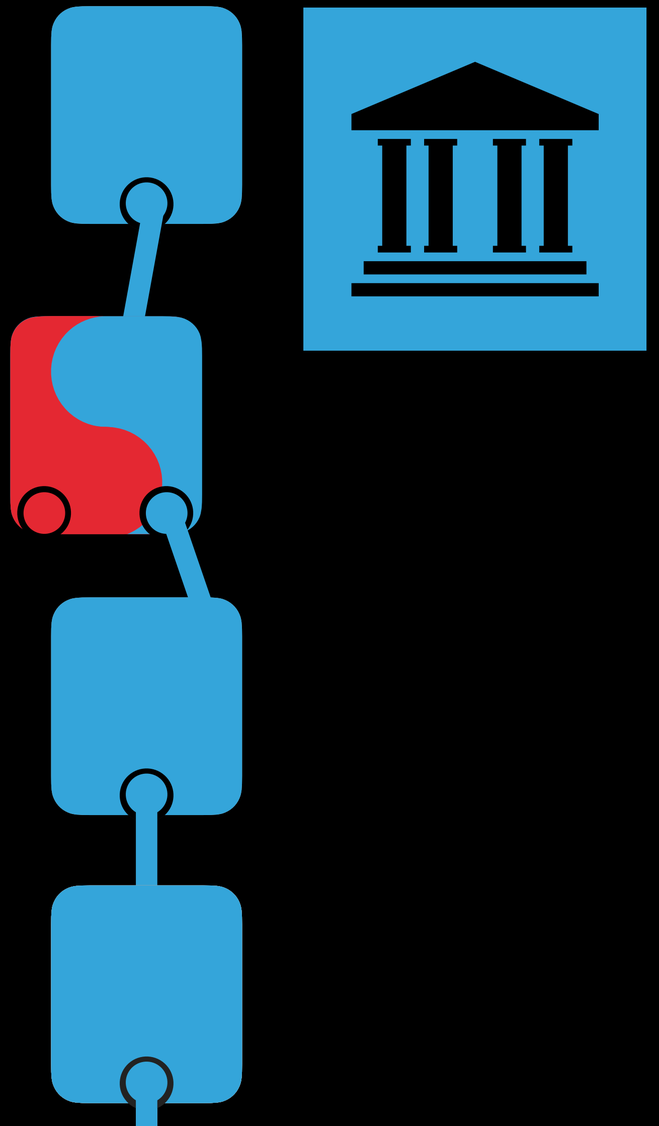

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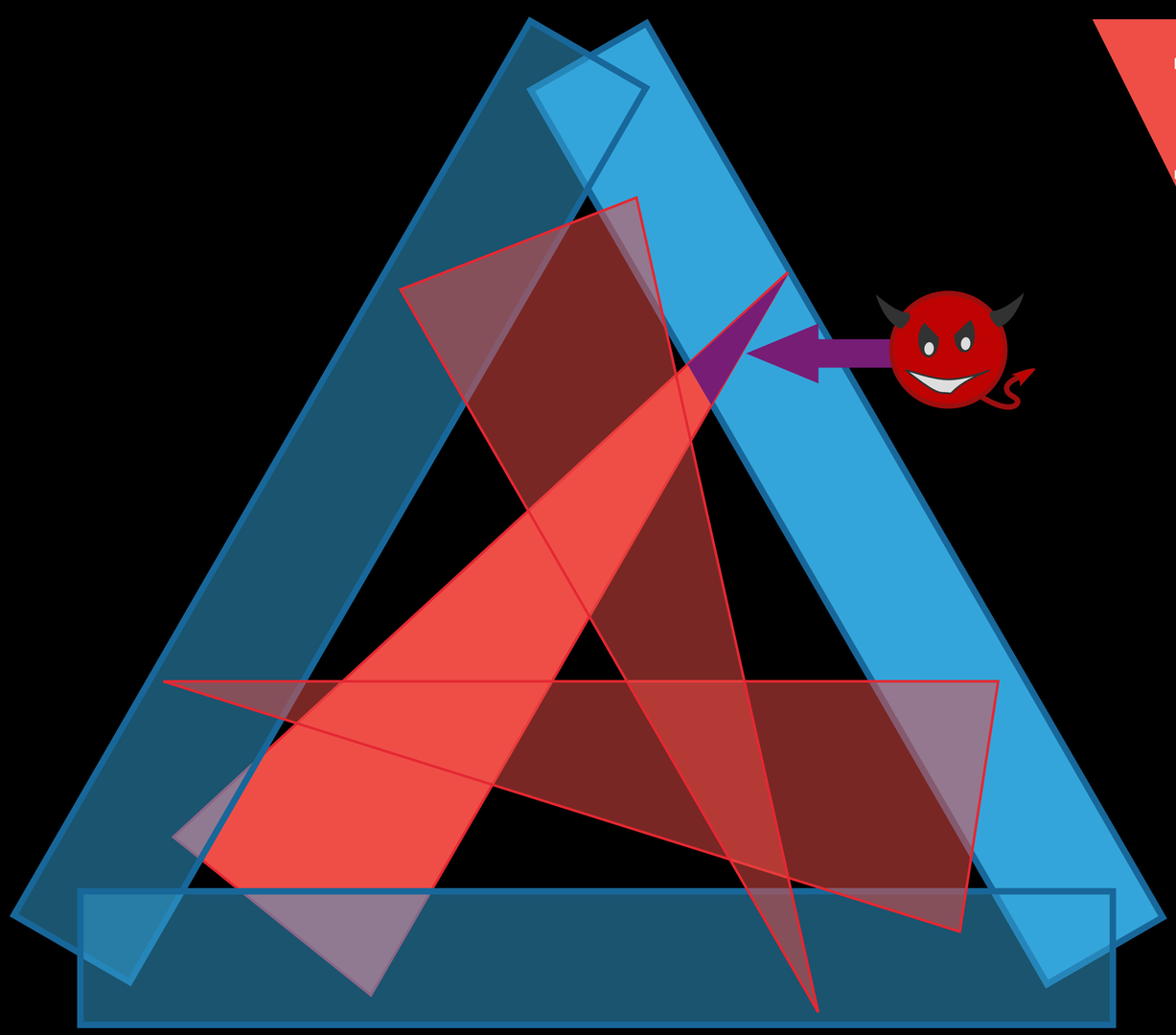

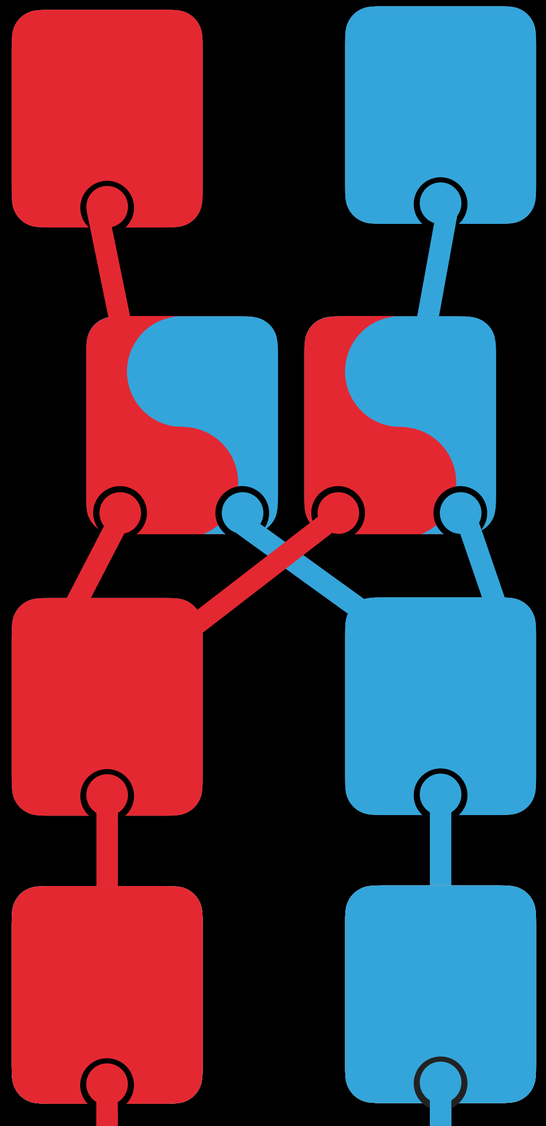

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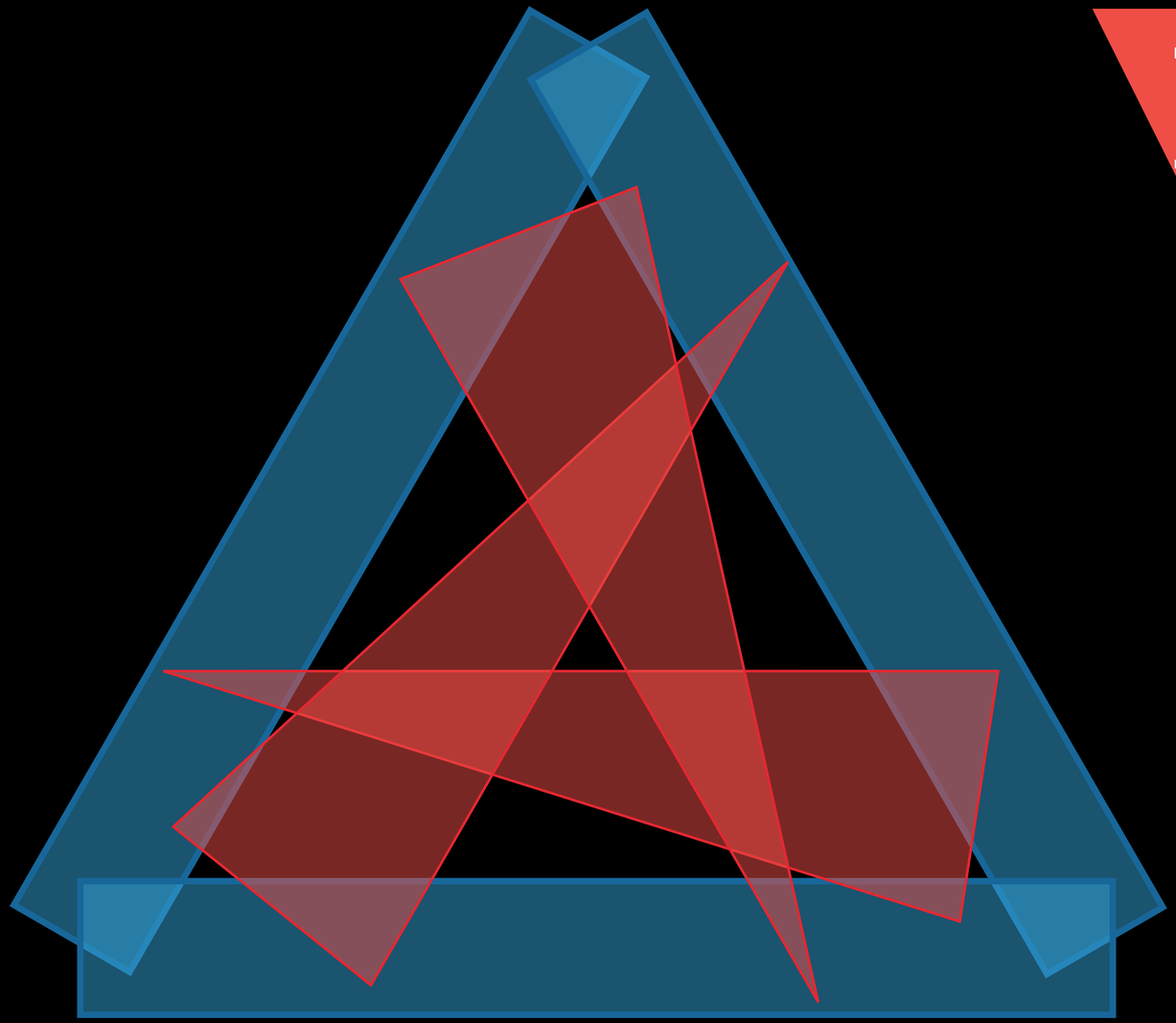
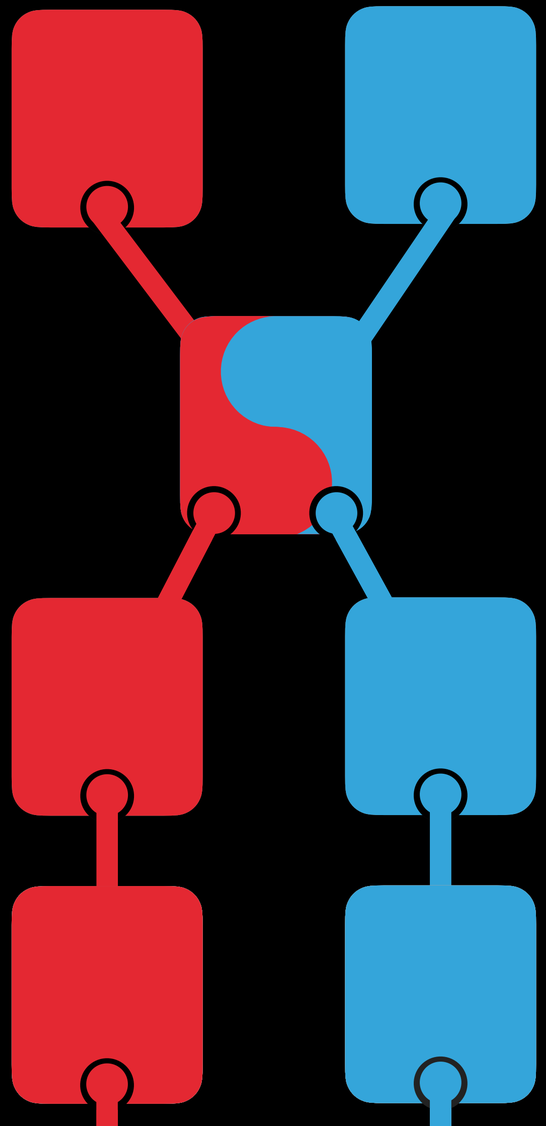
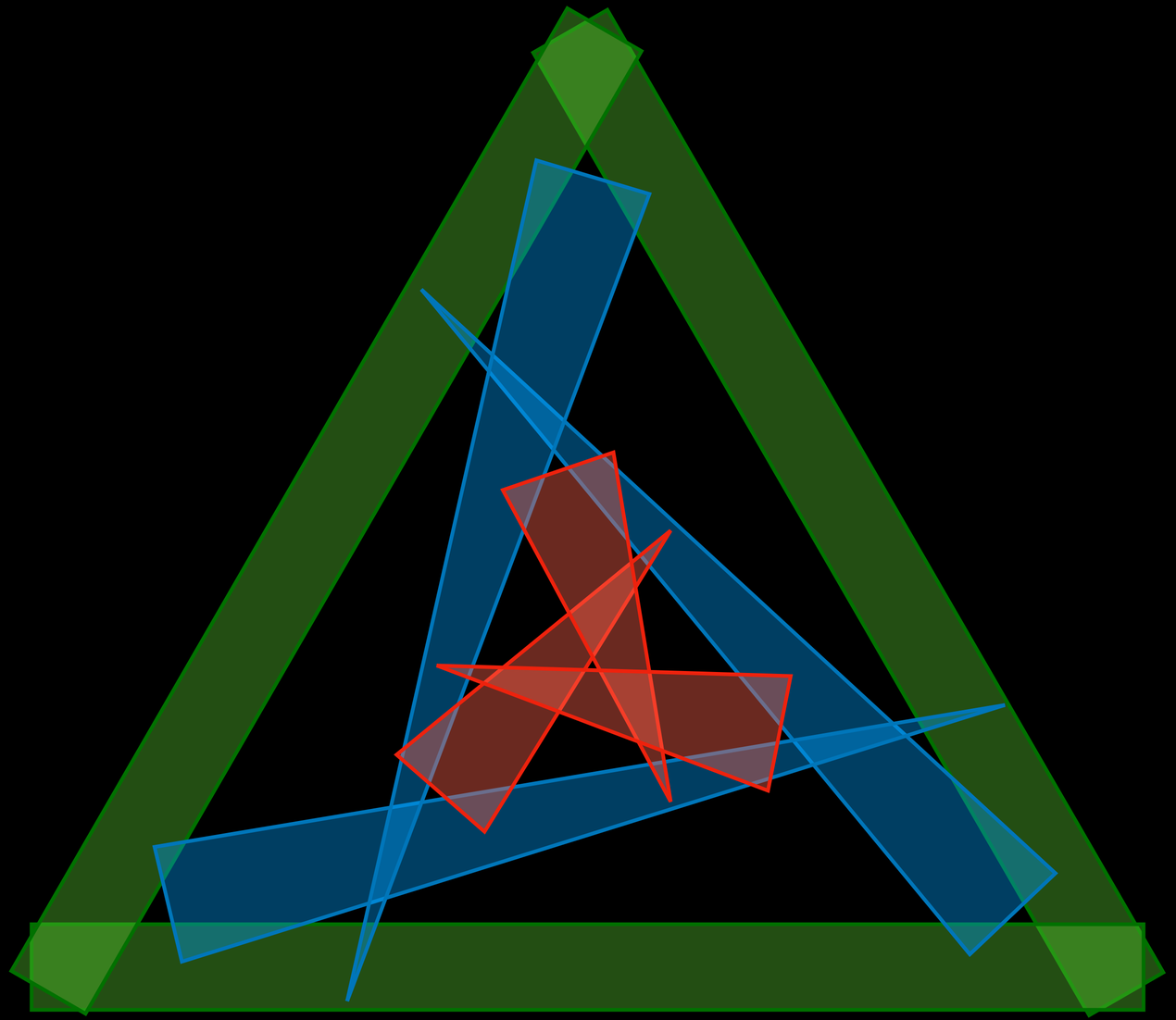
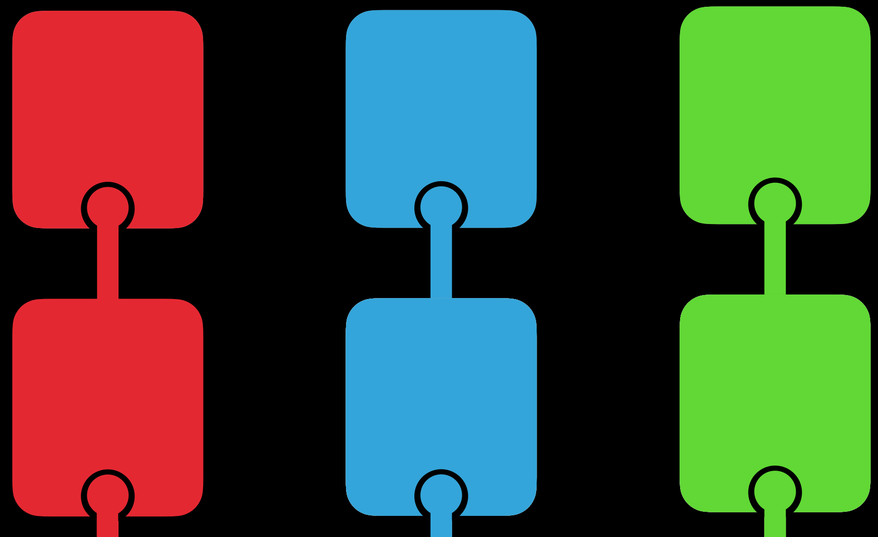




WHICH CONSENSUS WHEN?





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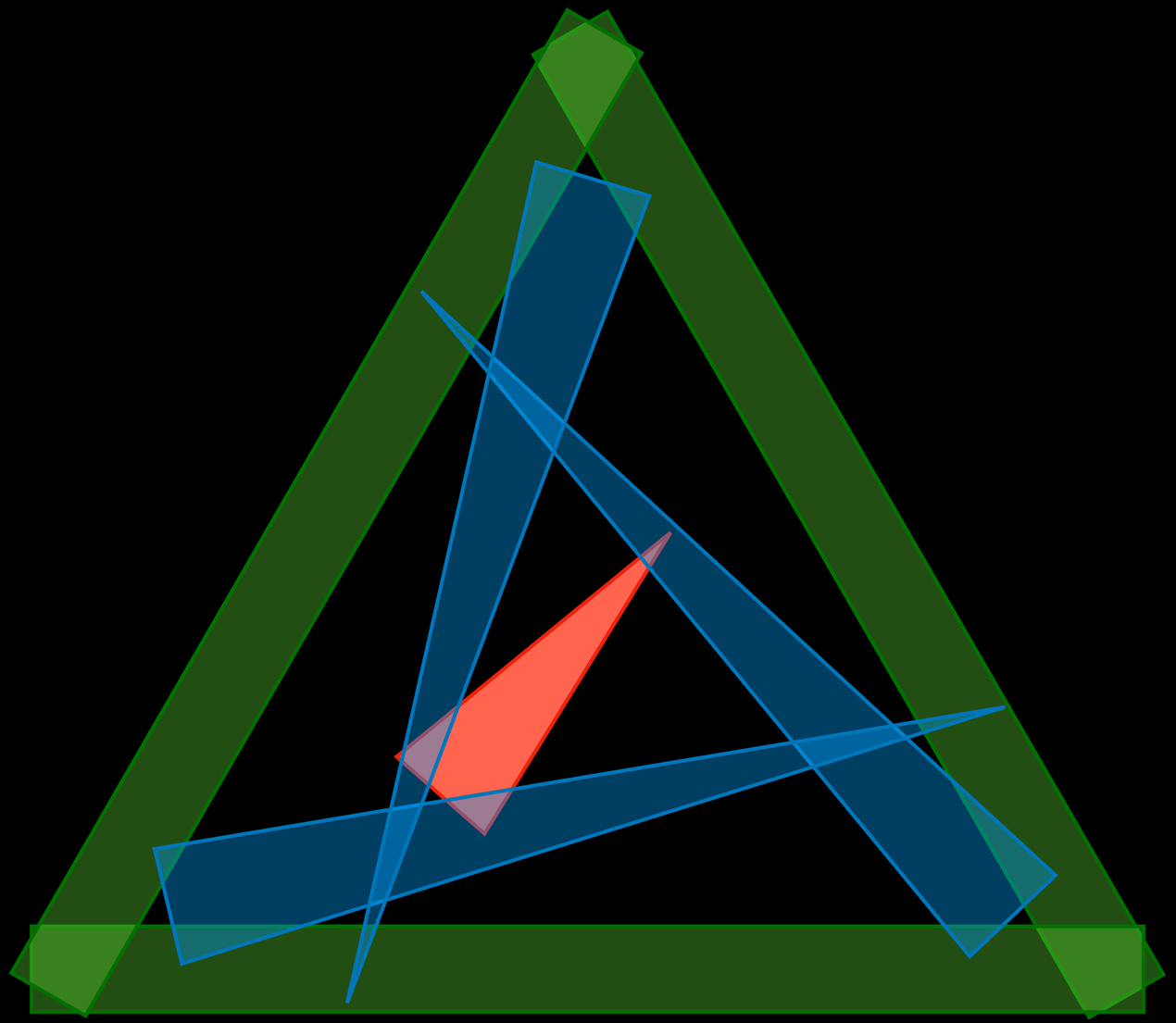

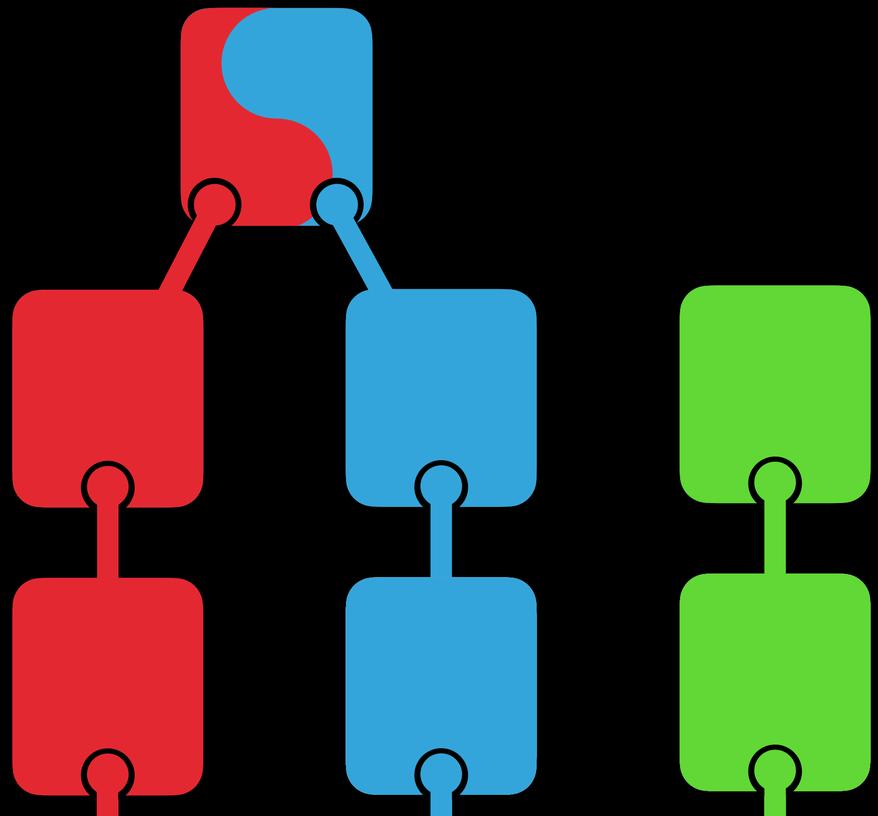

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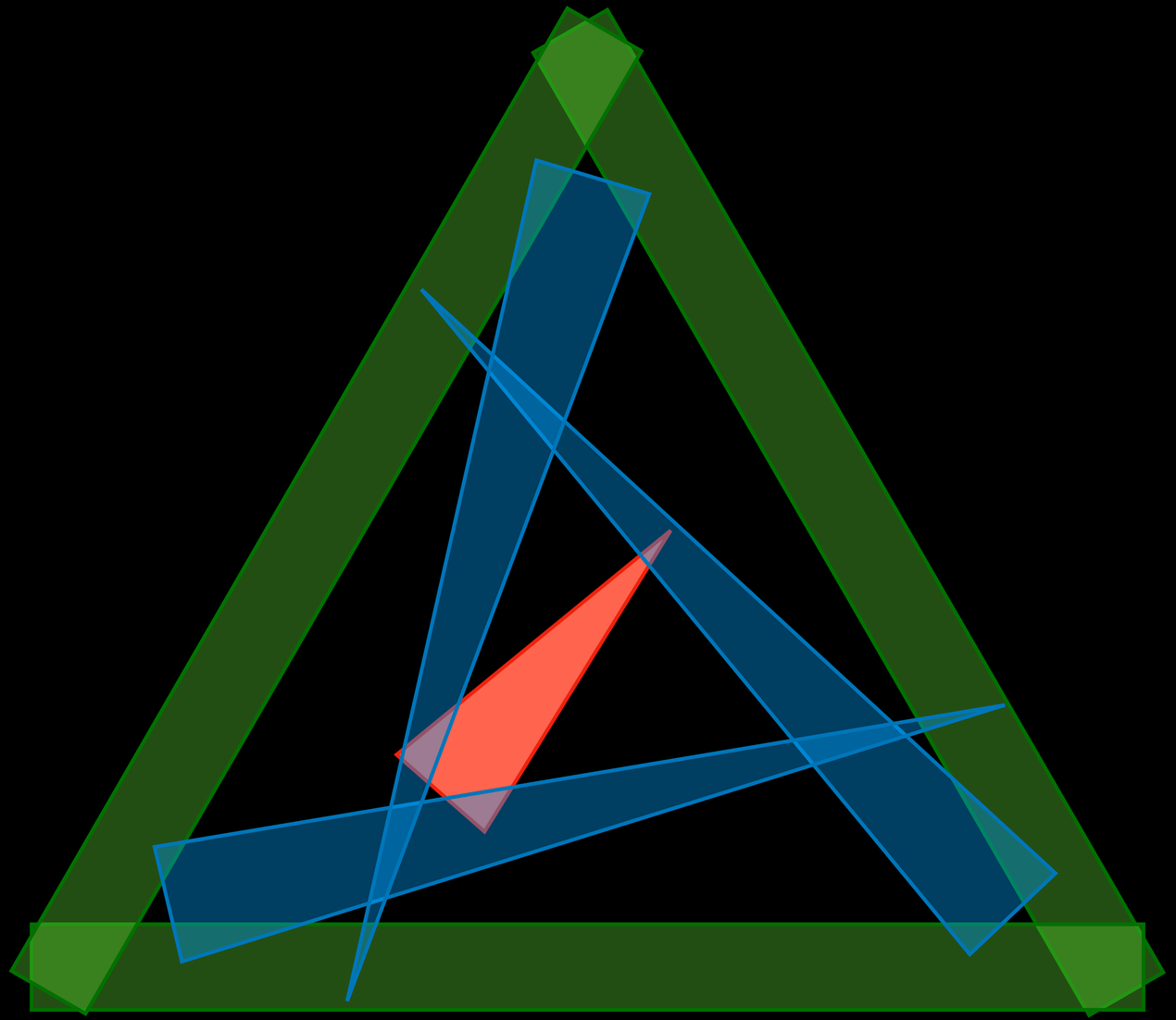

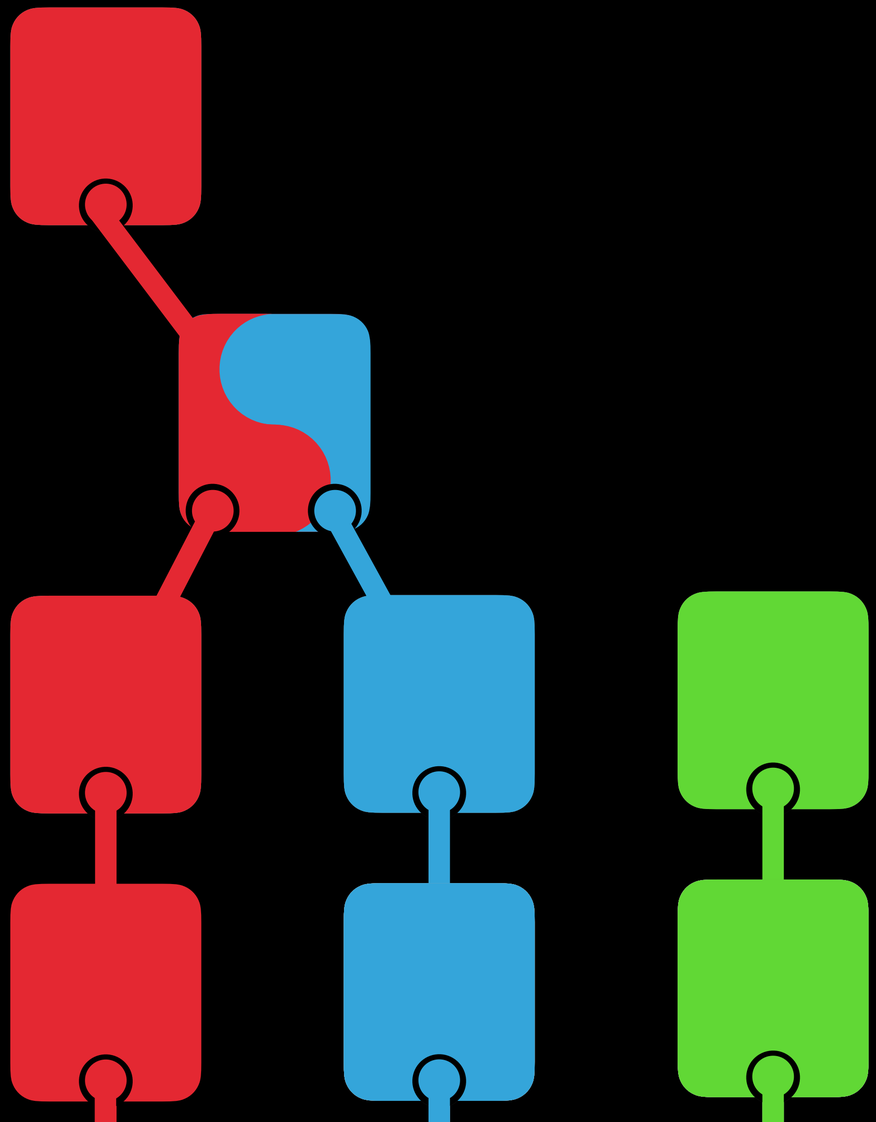

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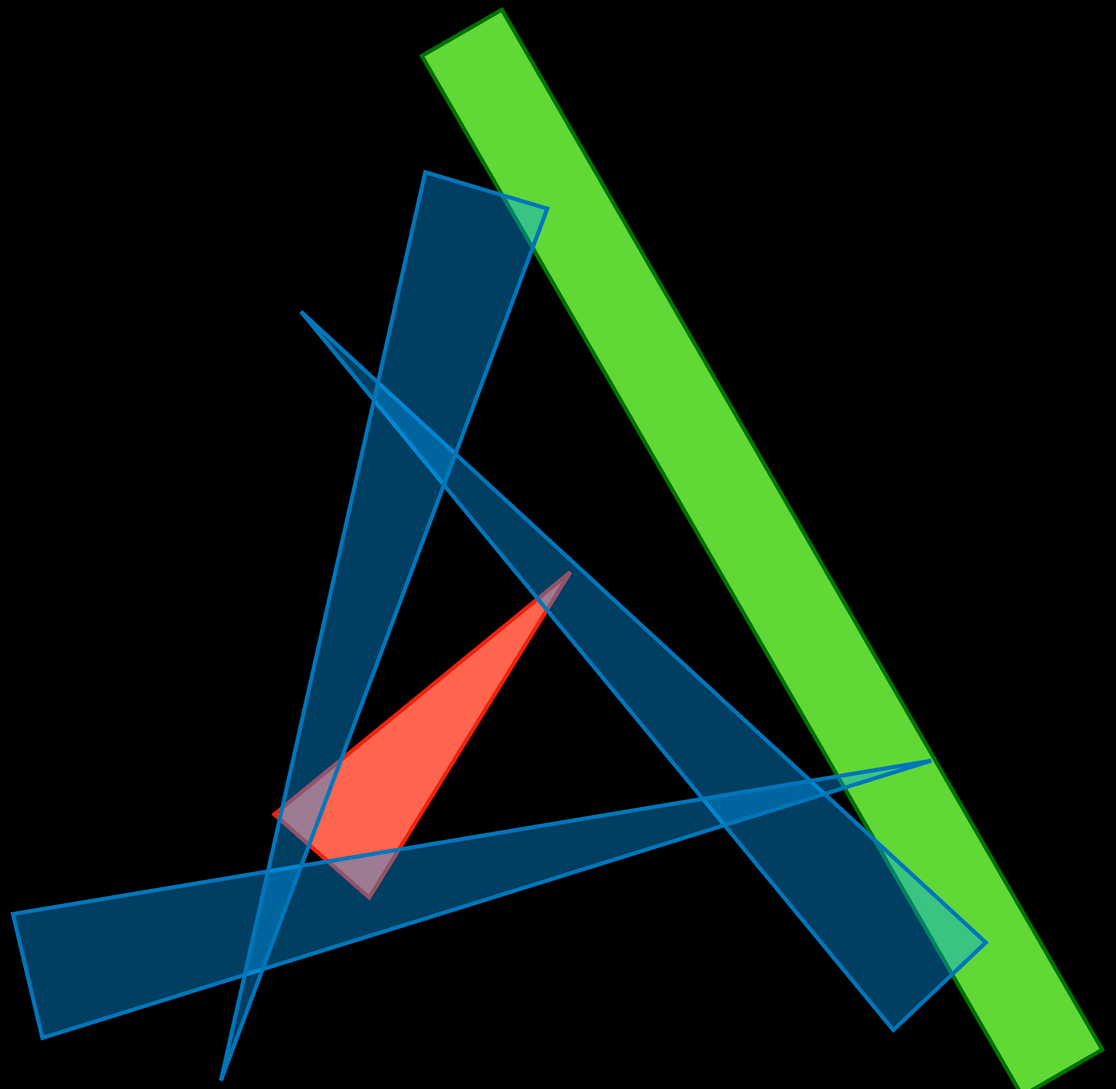

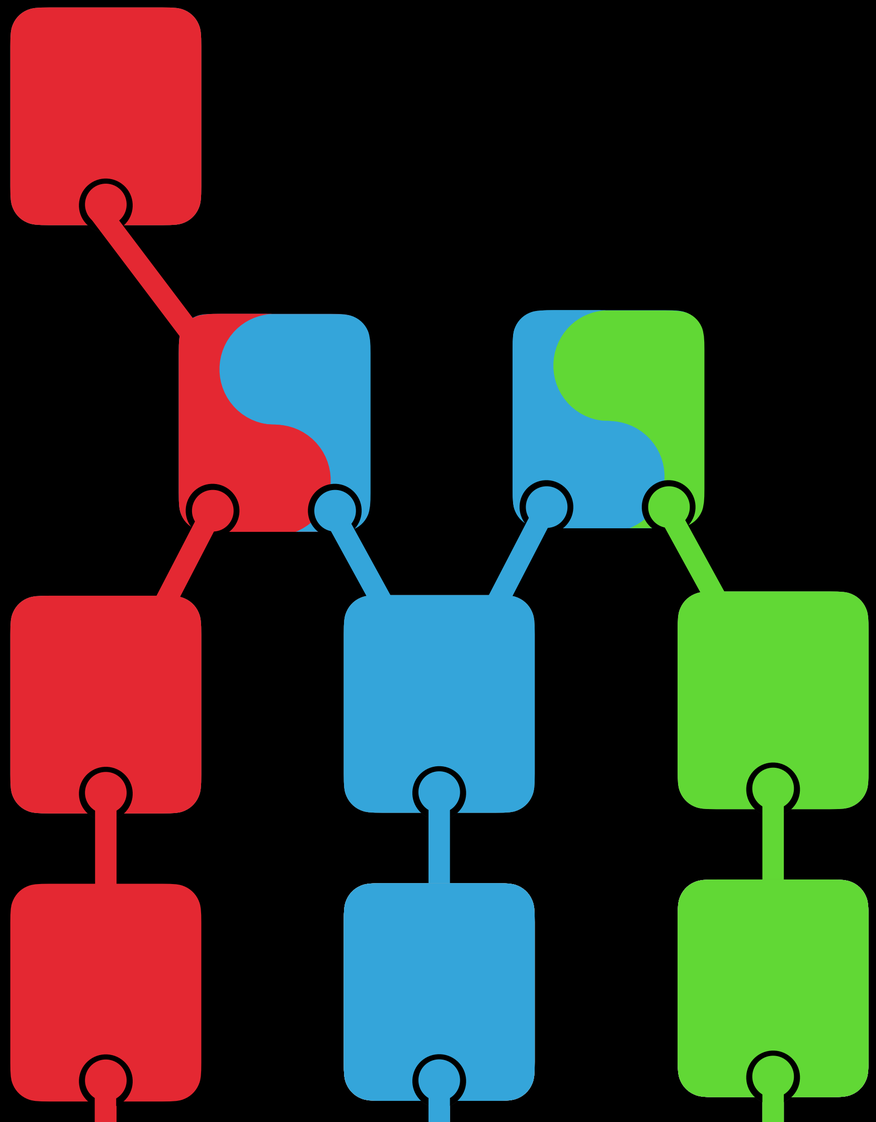

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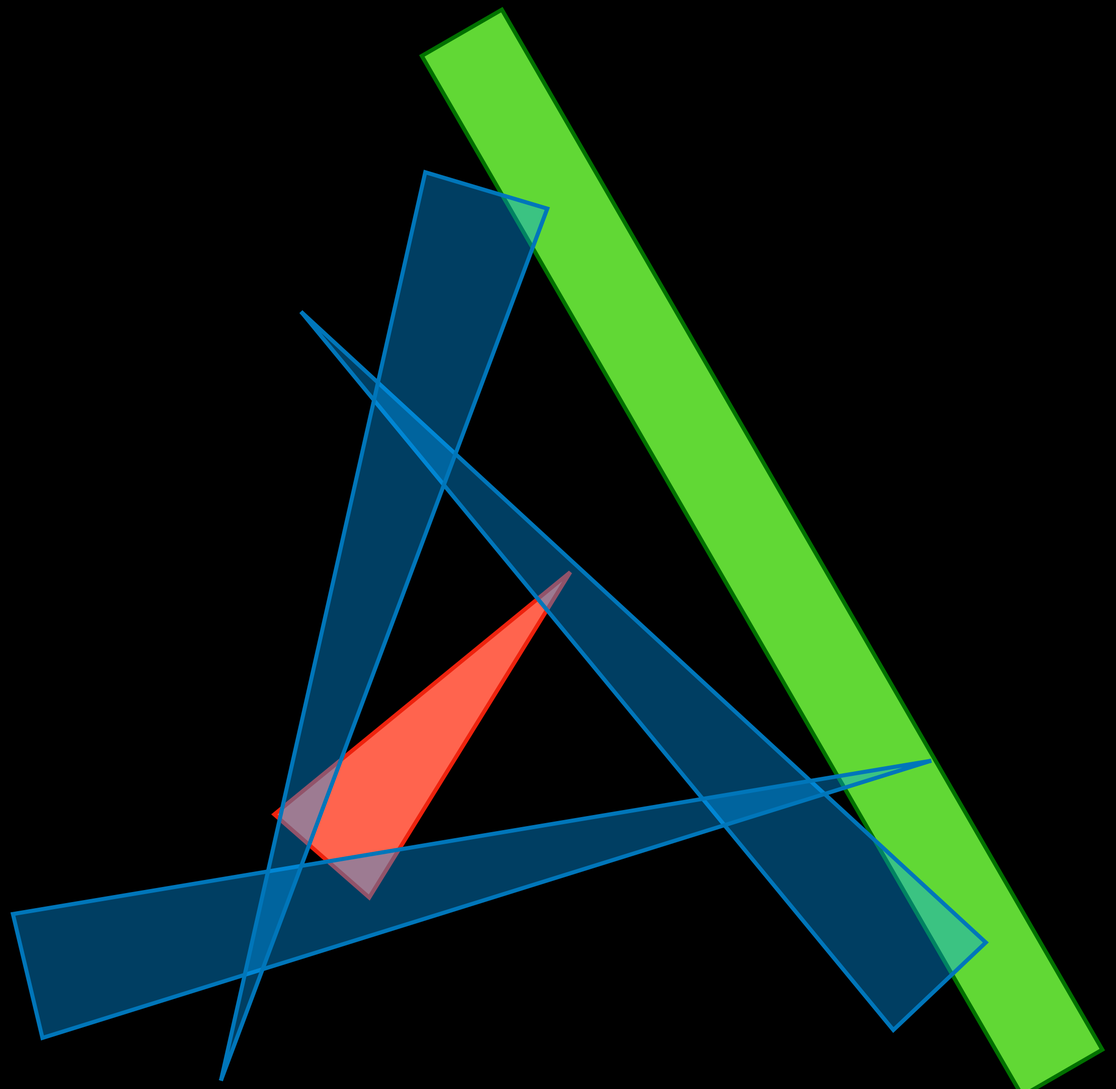
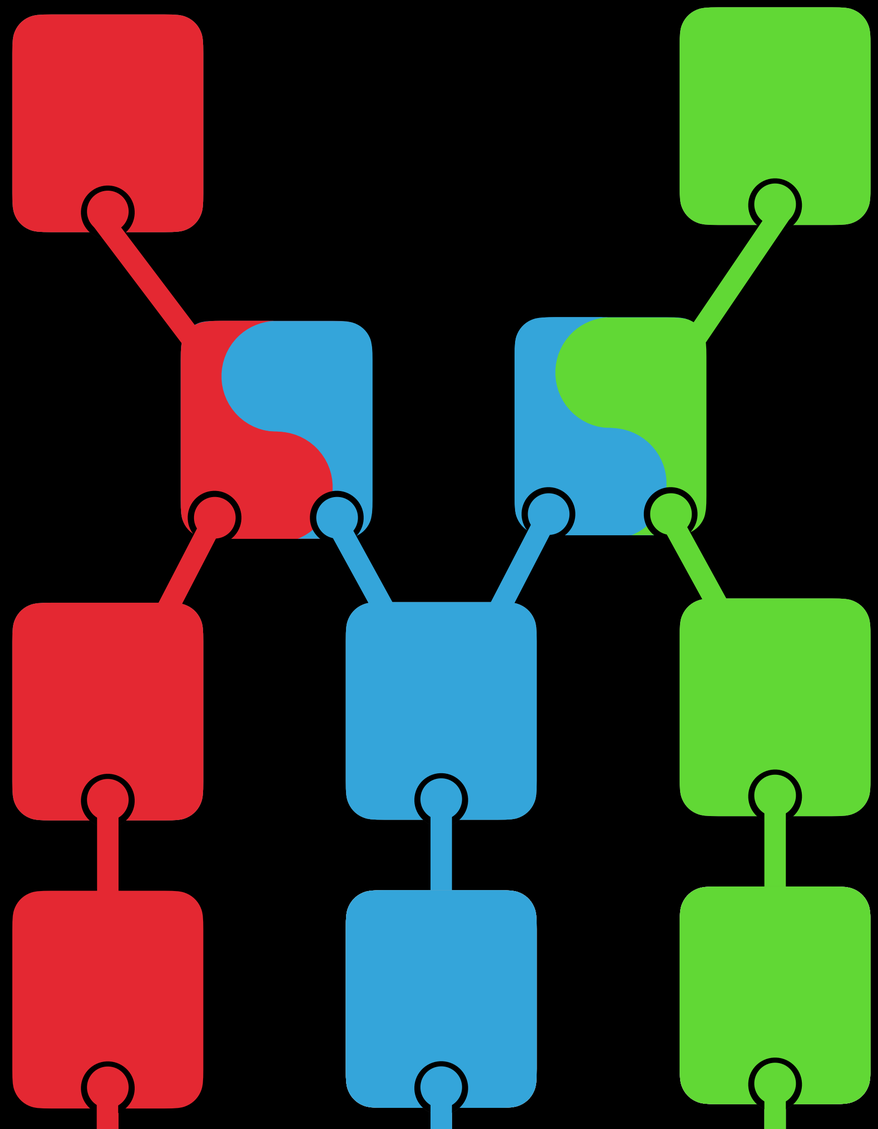
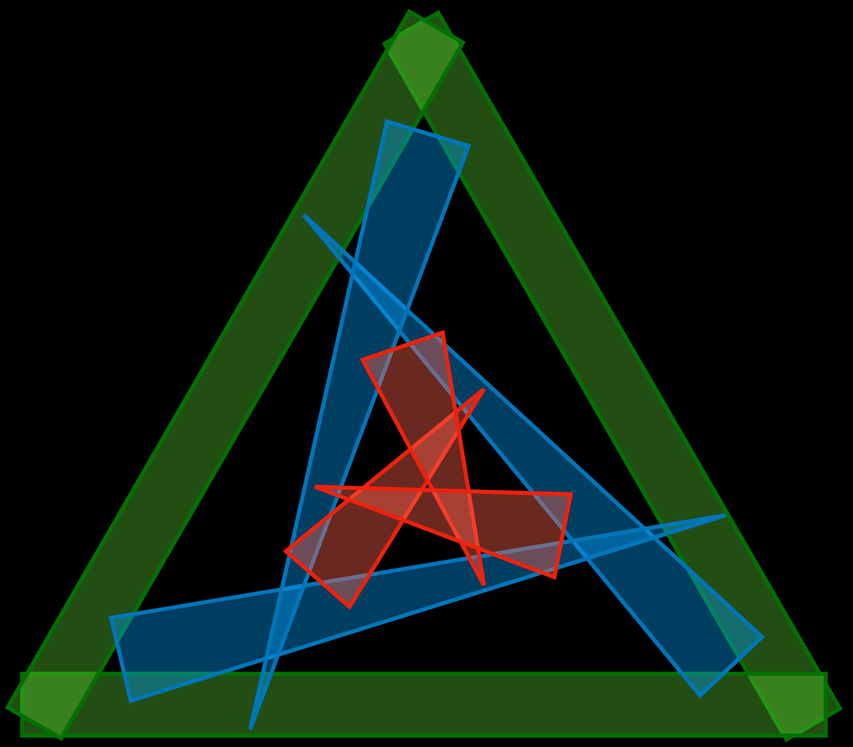
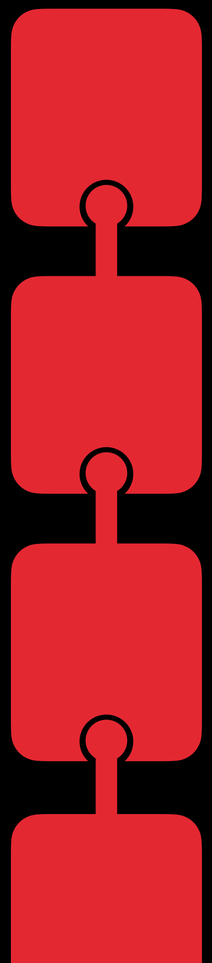
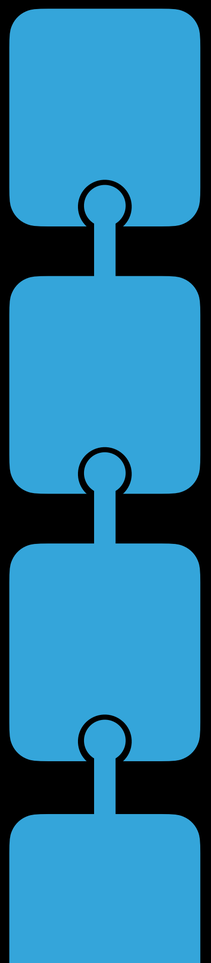


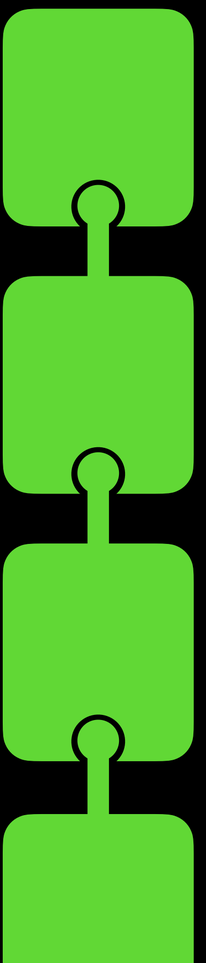


CHIMERA CHAINS



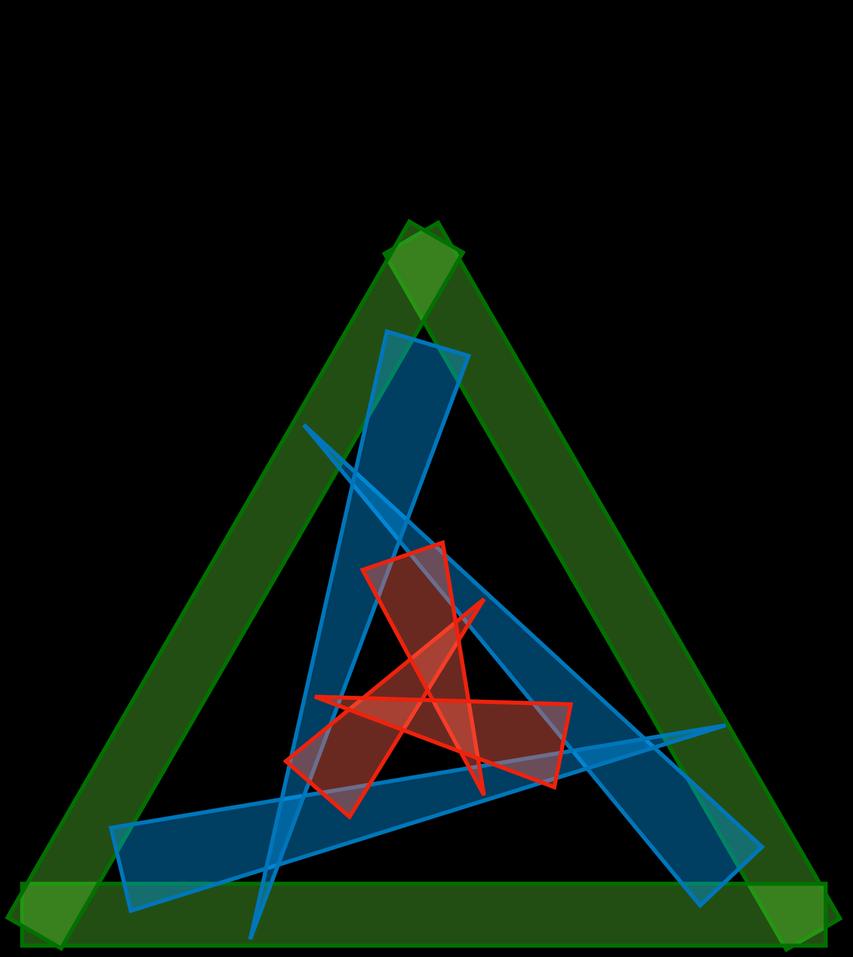


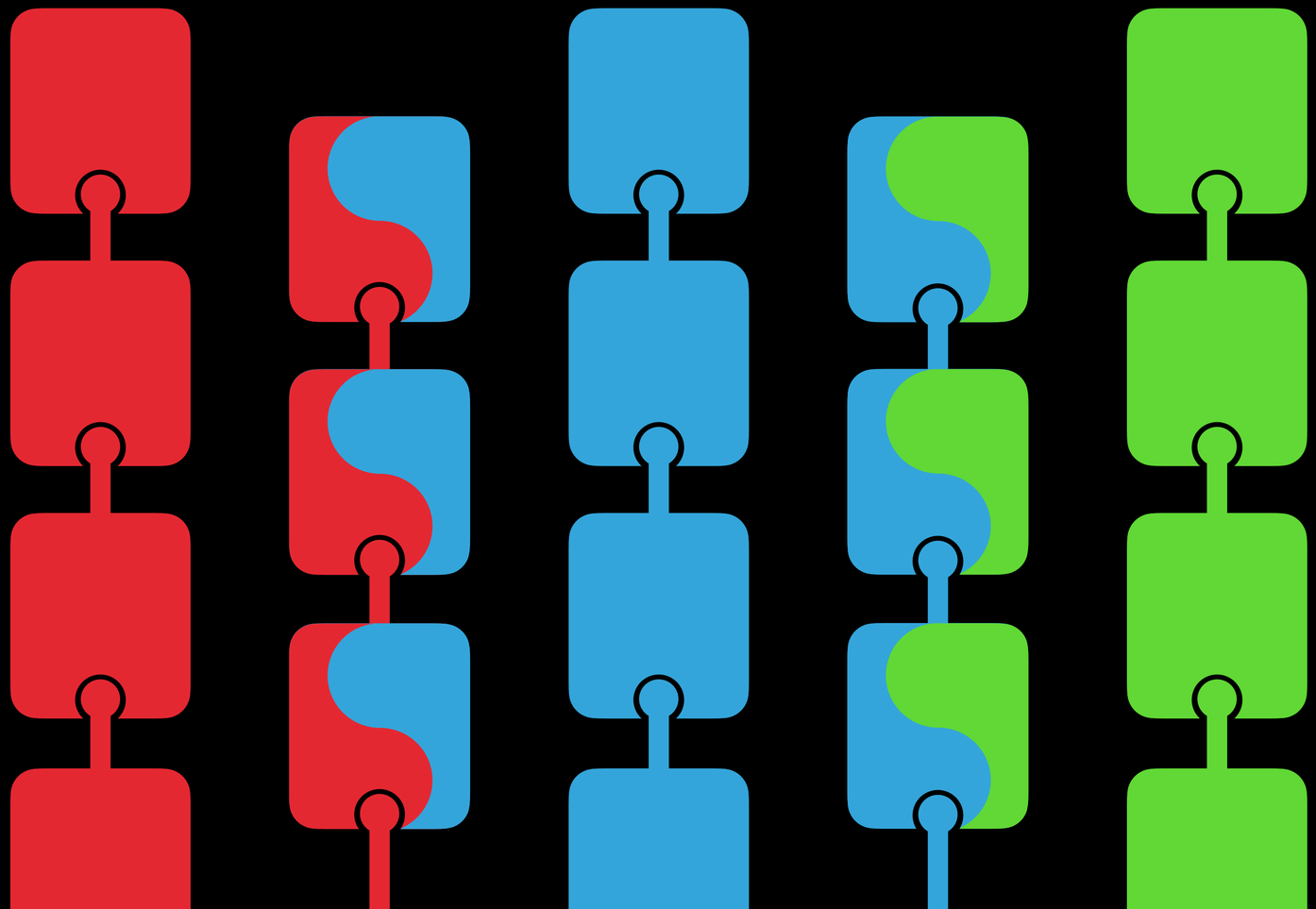




CHIMERA CHAINS

- A chain for each possible consensus





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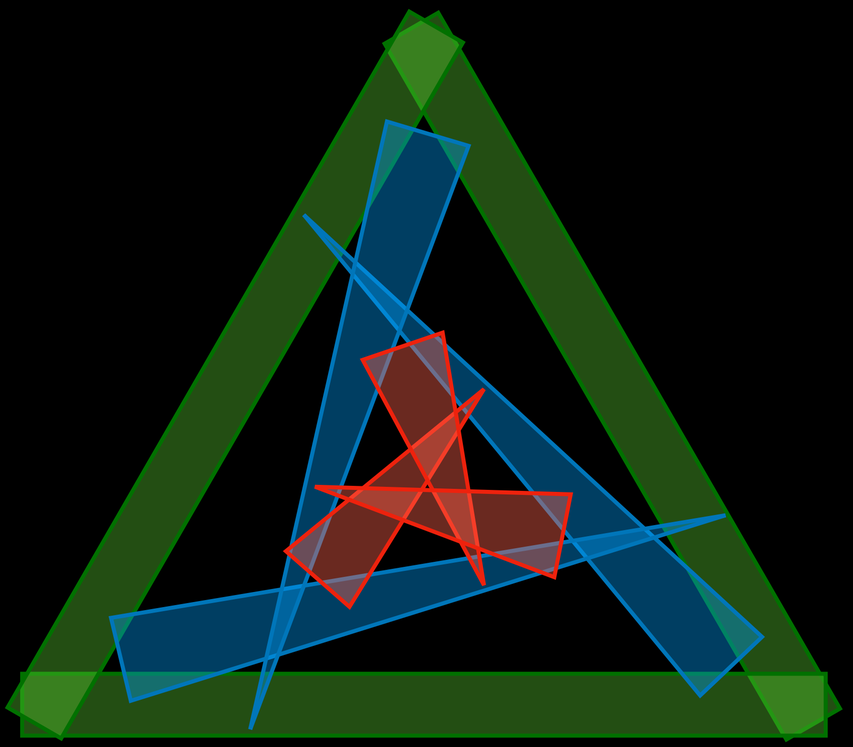

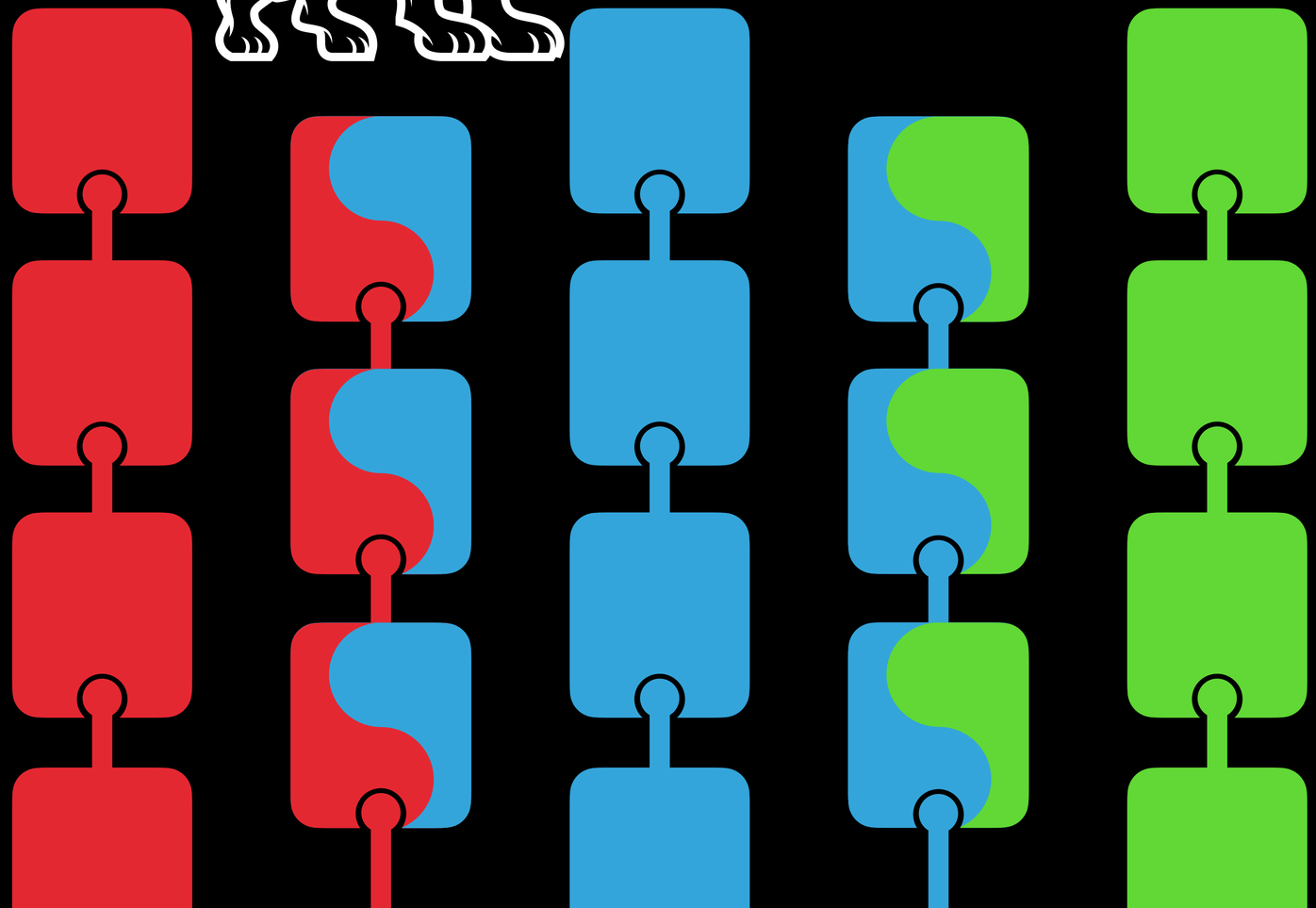

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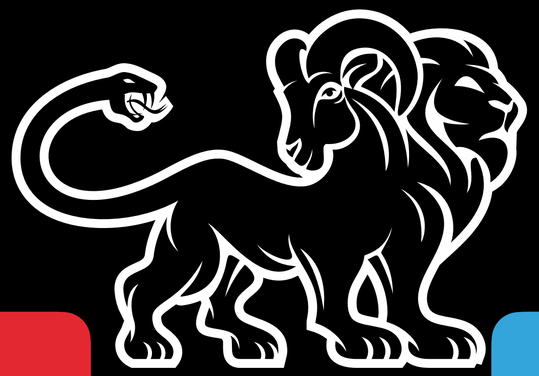

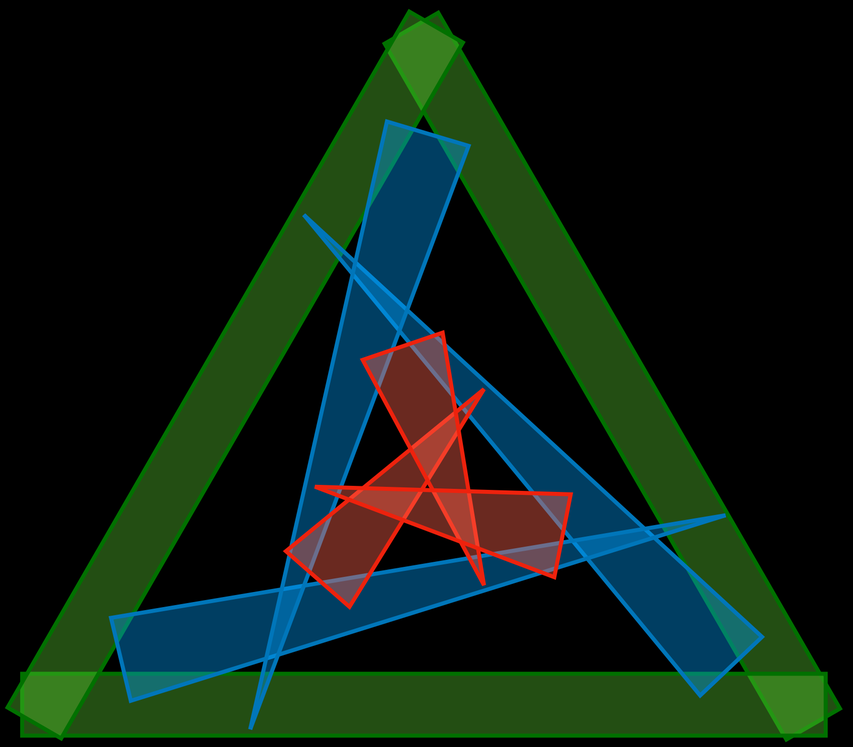

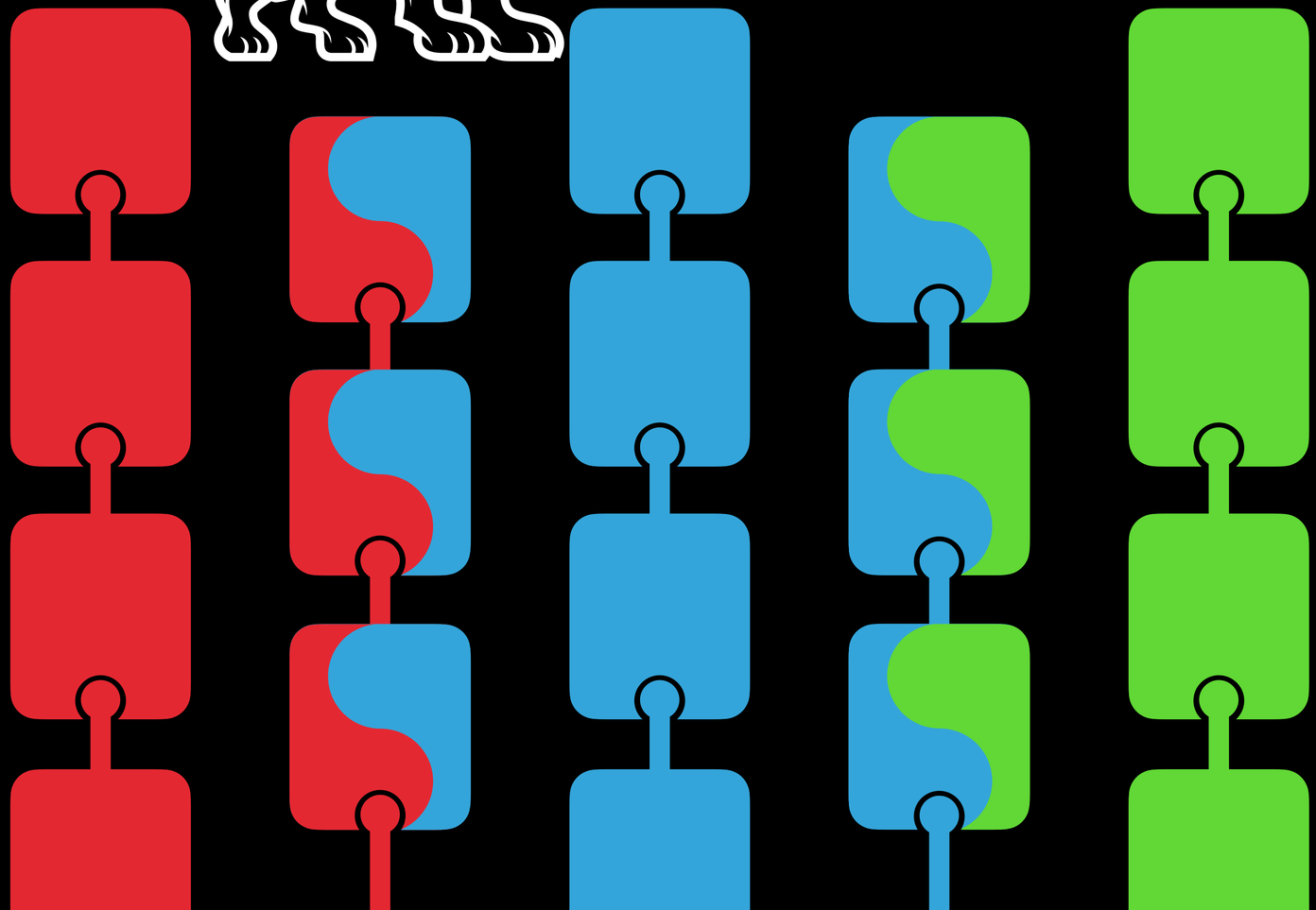

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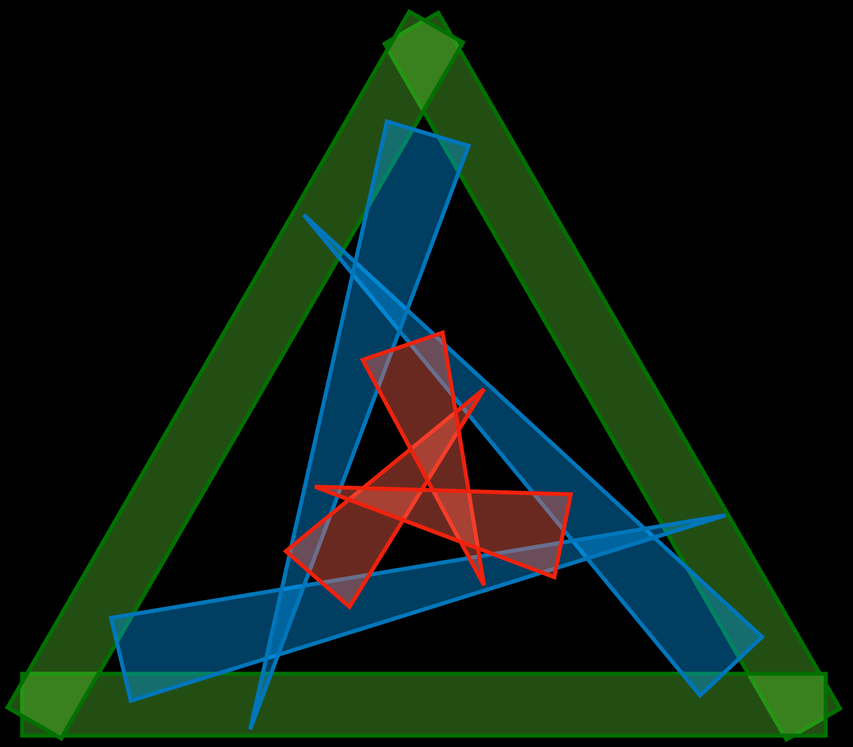
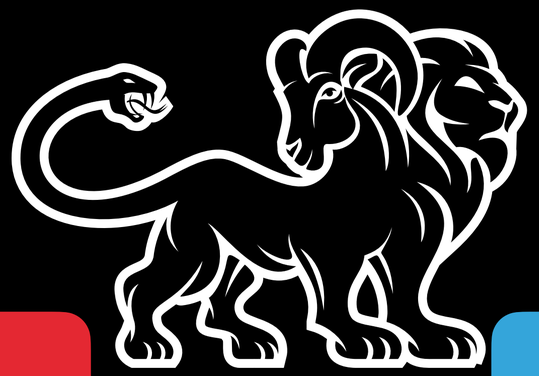
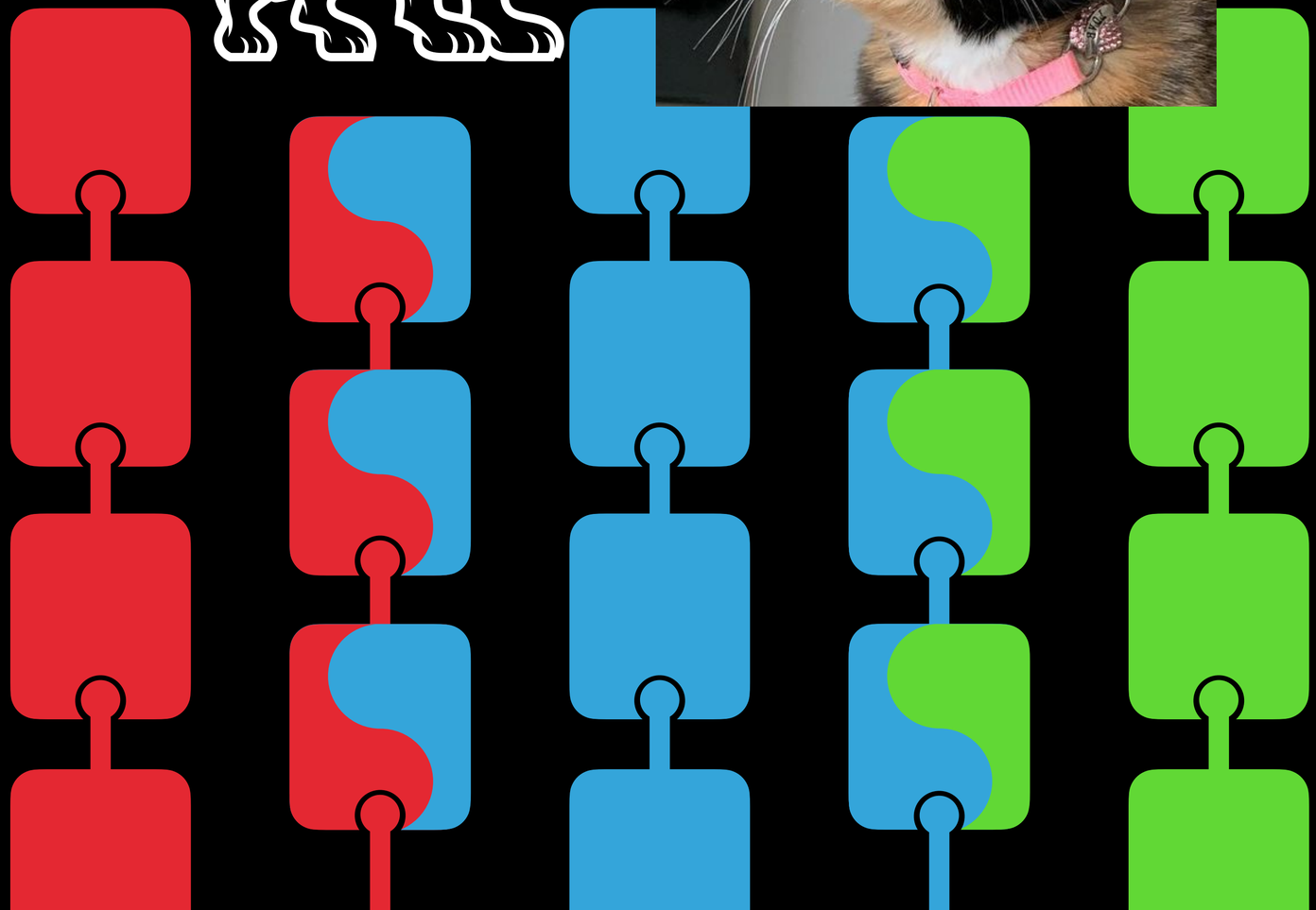
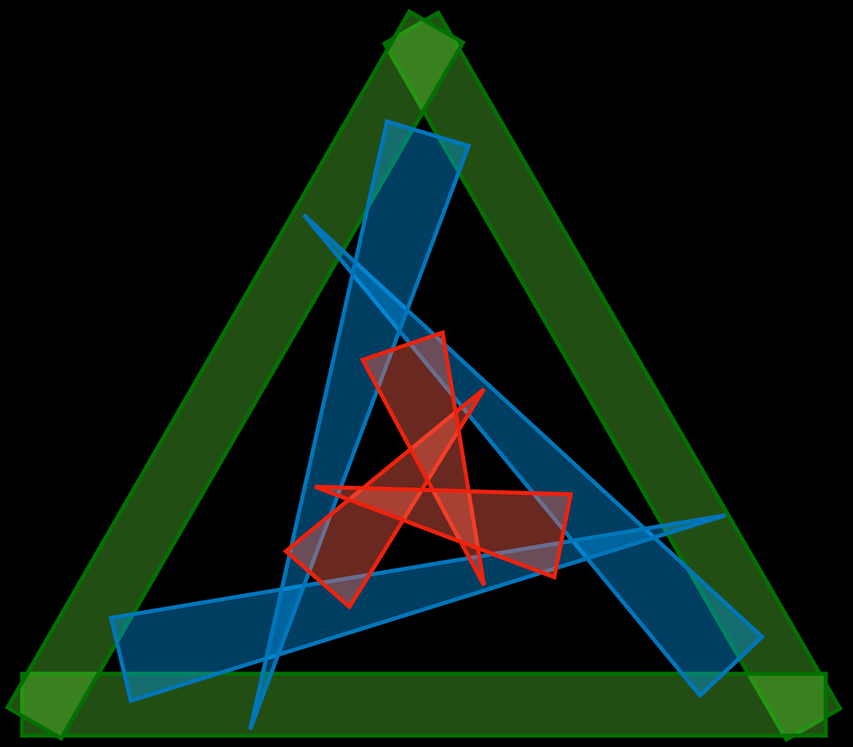


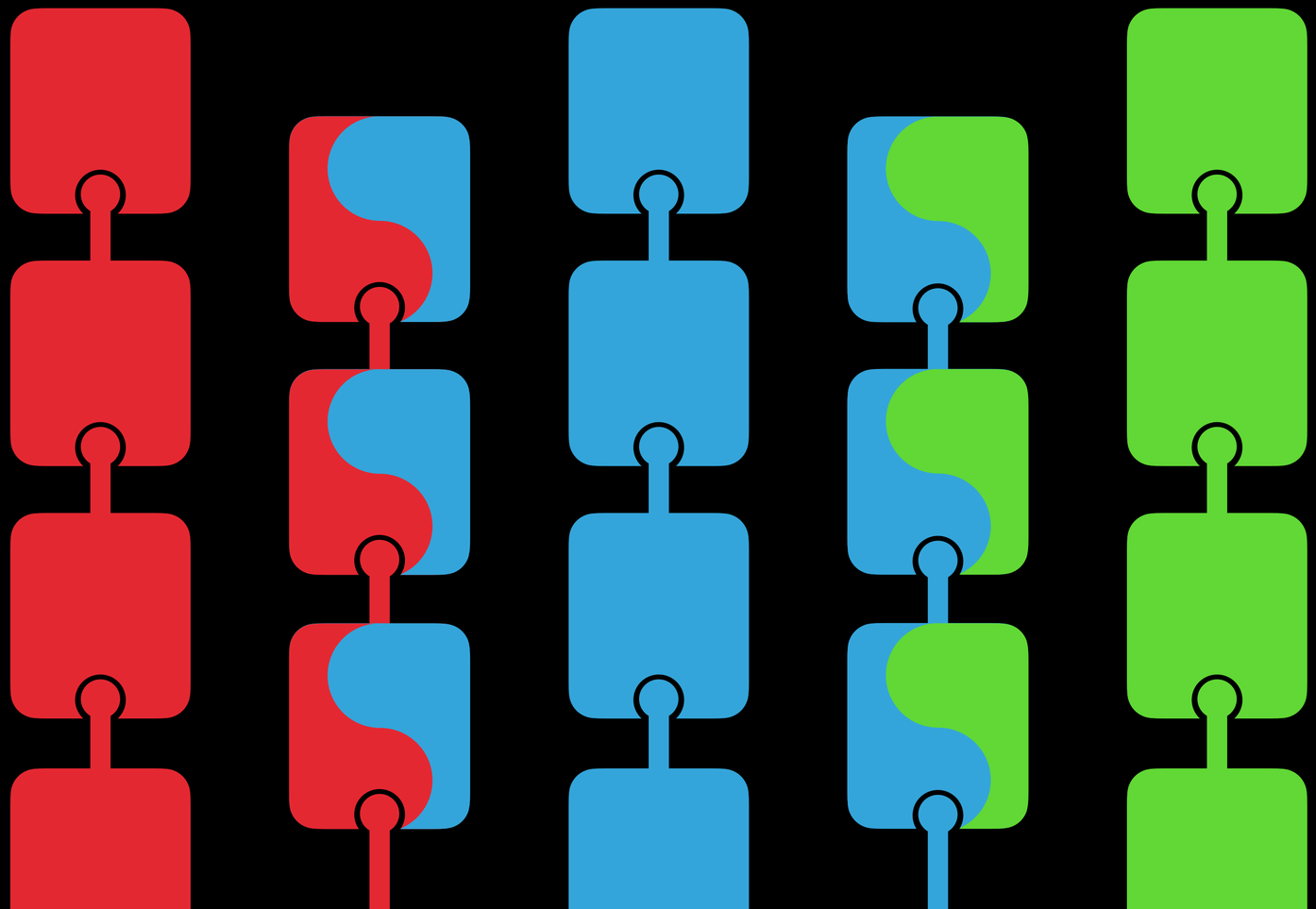




CHIMERA CHAINS

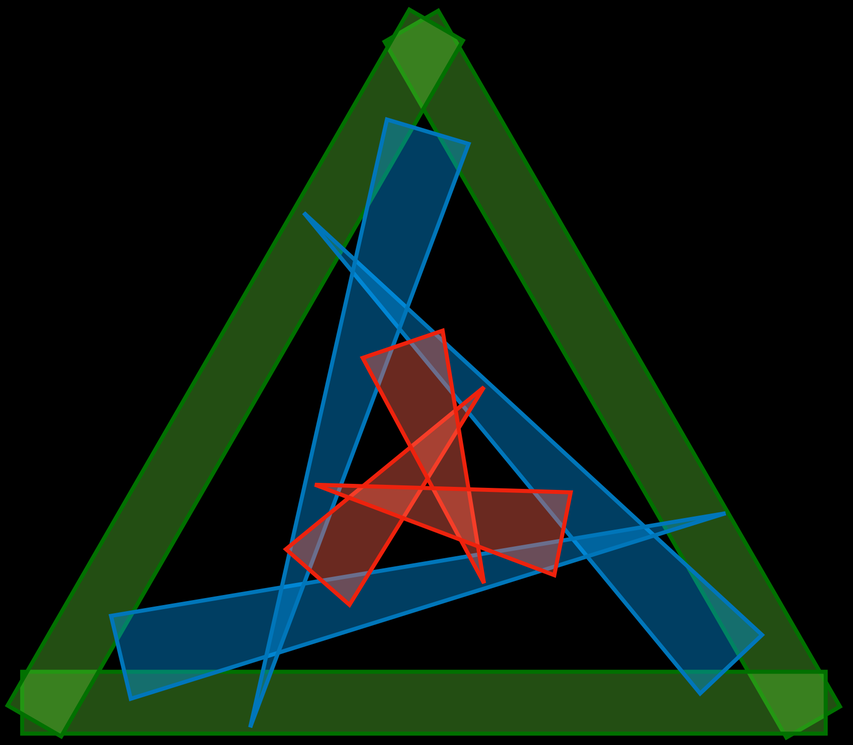
- A chain for each possible consensus
  - On-demand

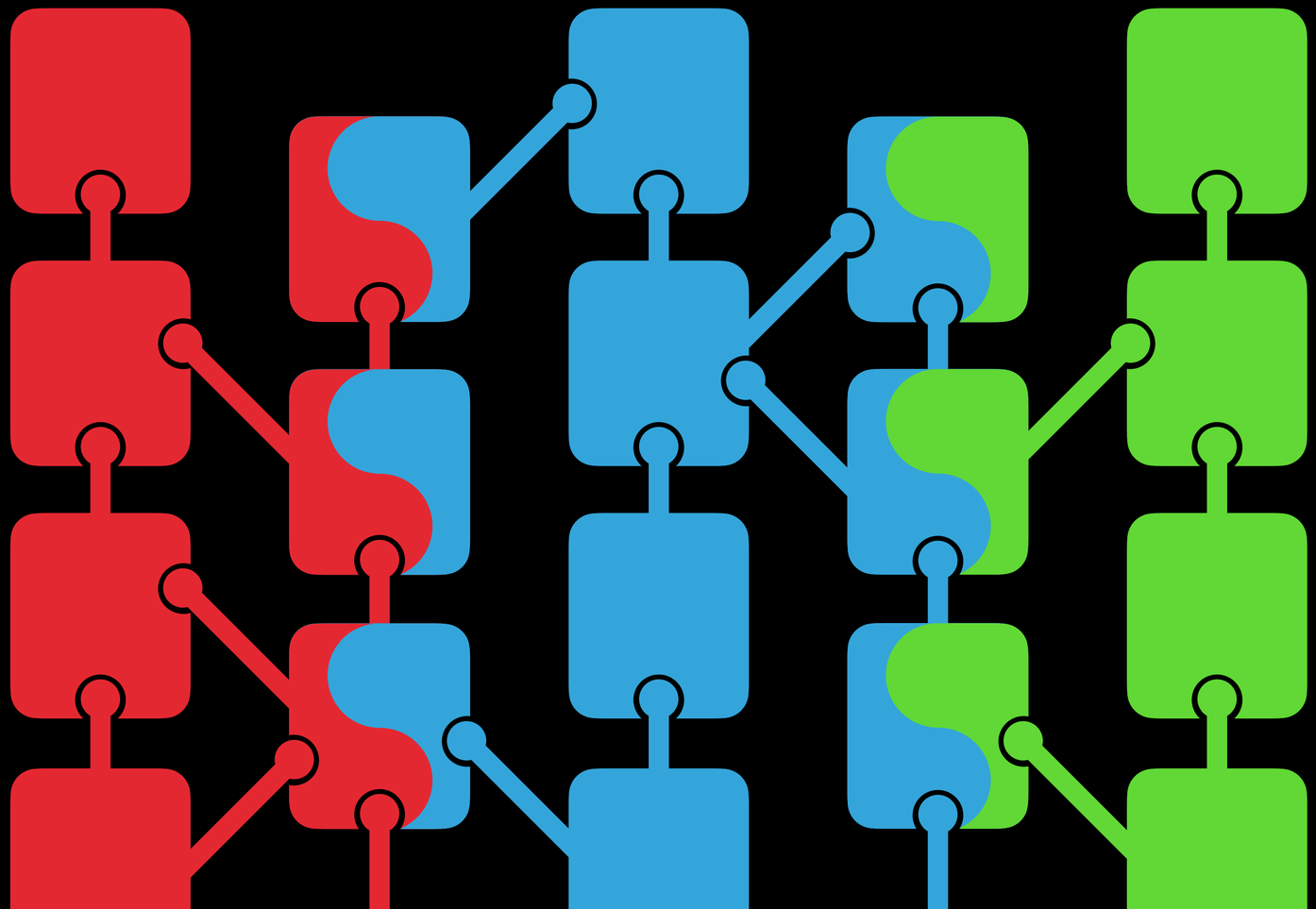




CHIMERA CHAINS

- A chain for each possible consensus
  - On-demand
- Inter-Chain Communication





CHIMERA CHAINS

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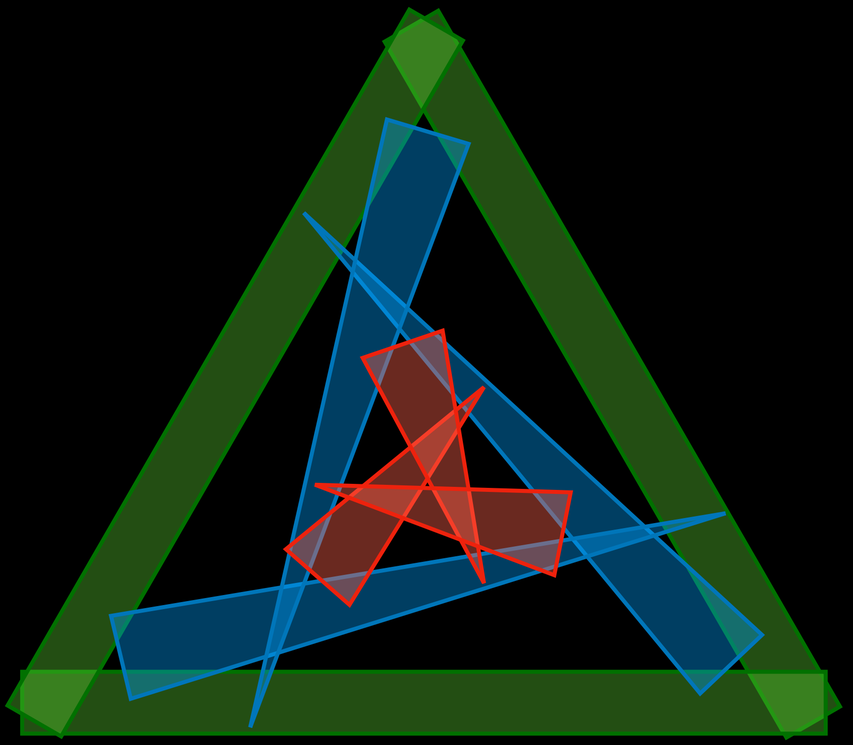
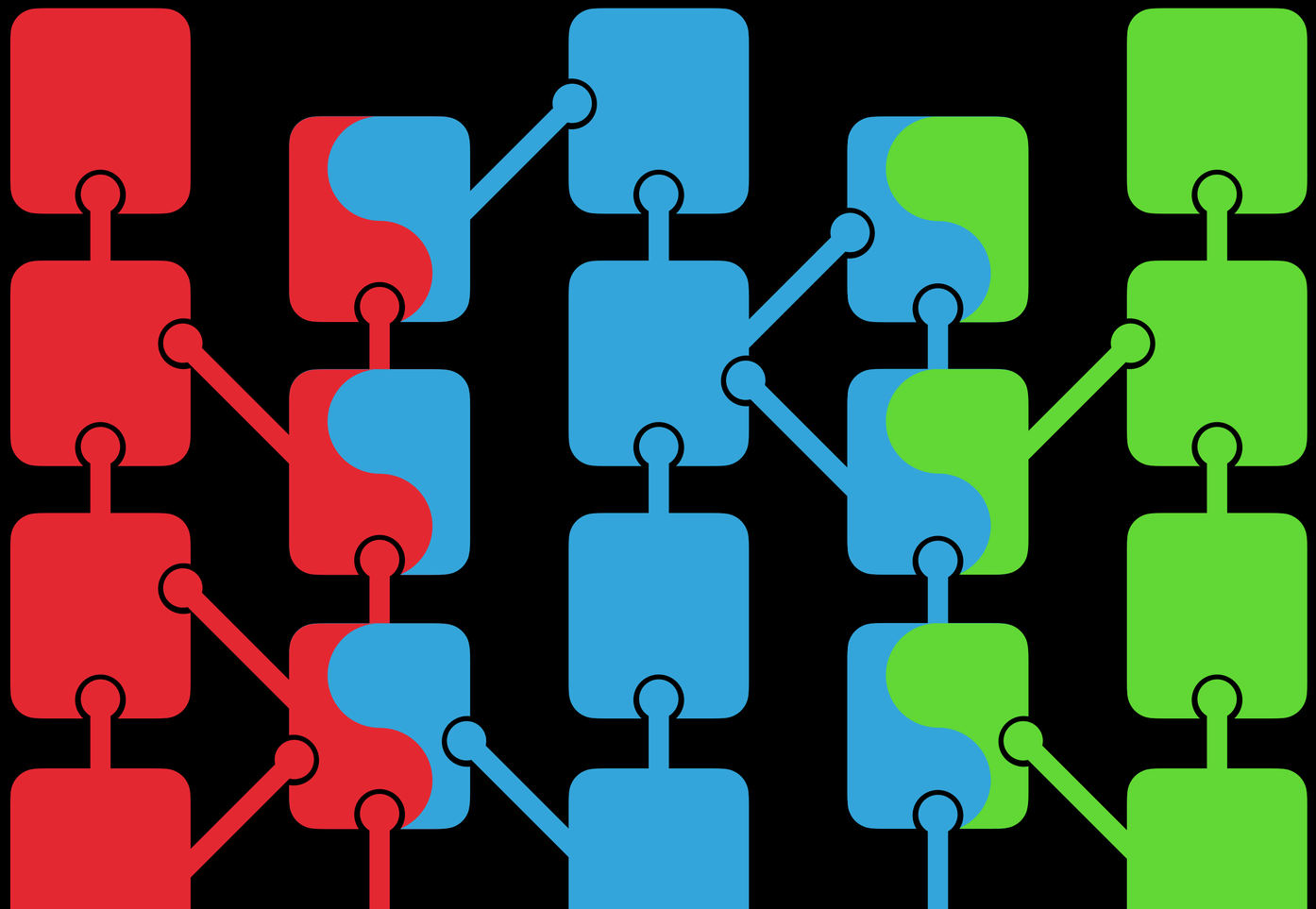
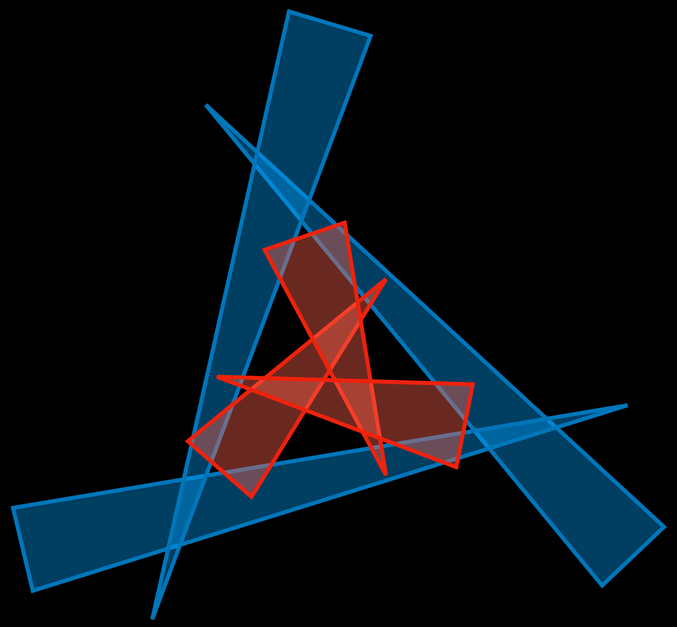
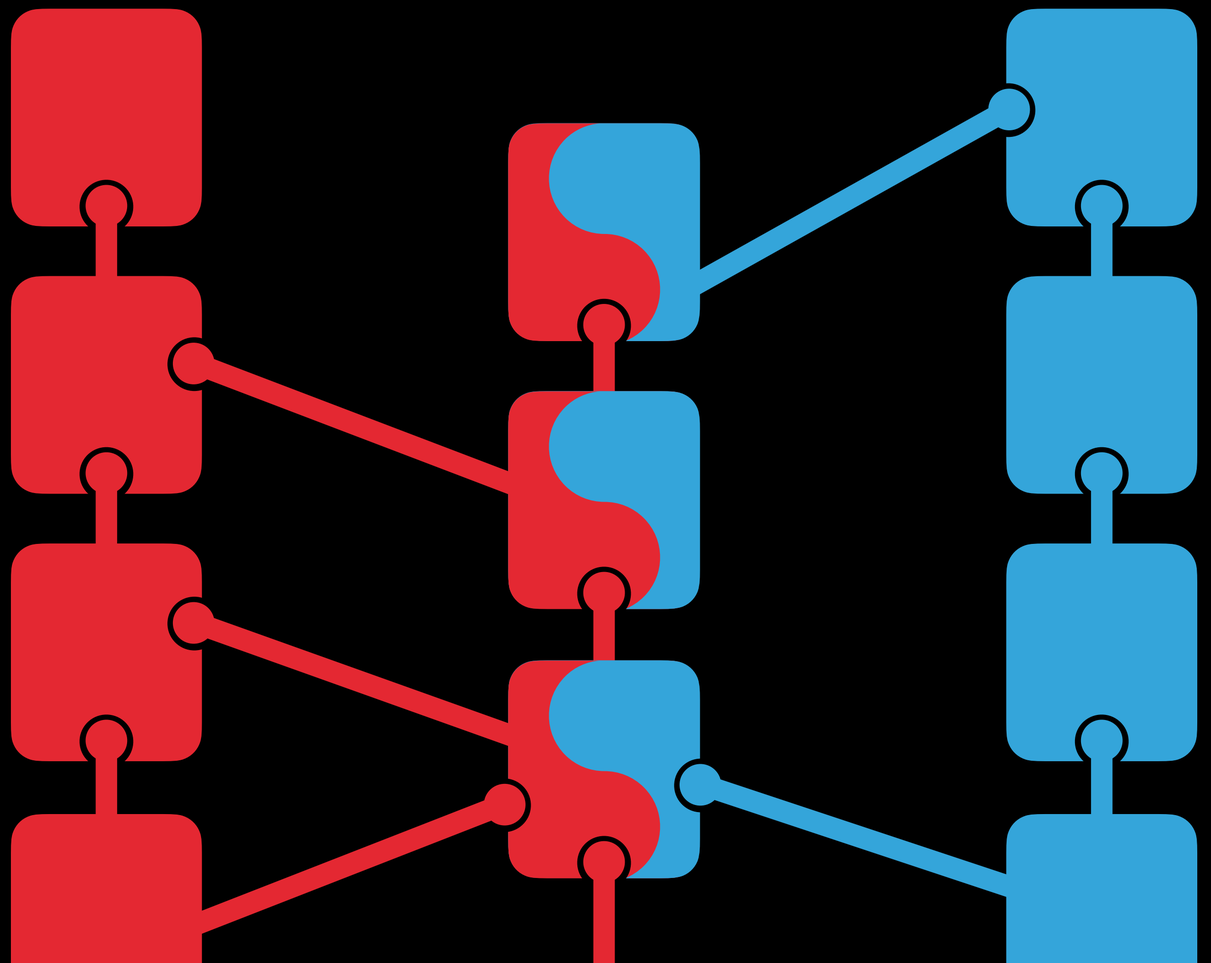




CHIMERA CHAINS

- Each chain liveness / integrity of its own quorums
- Inter-chain transaction atomicity when quorum intersections all contain a safe node





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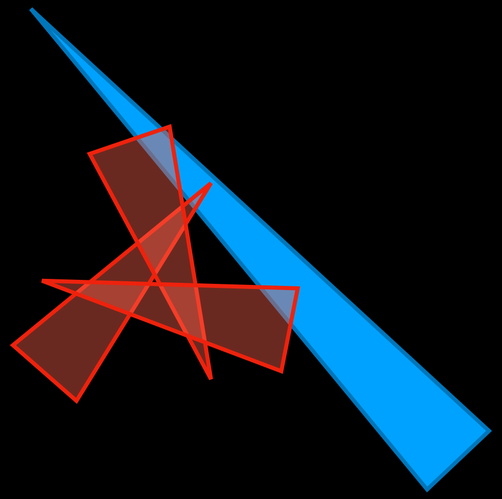

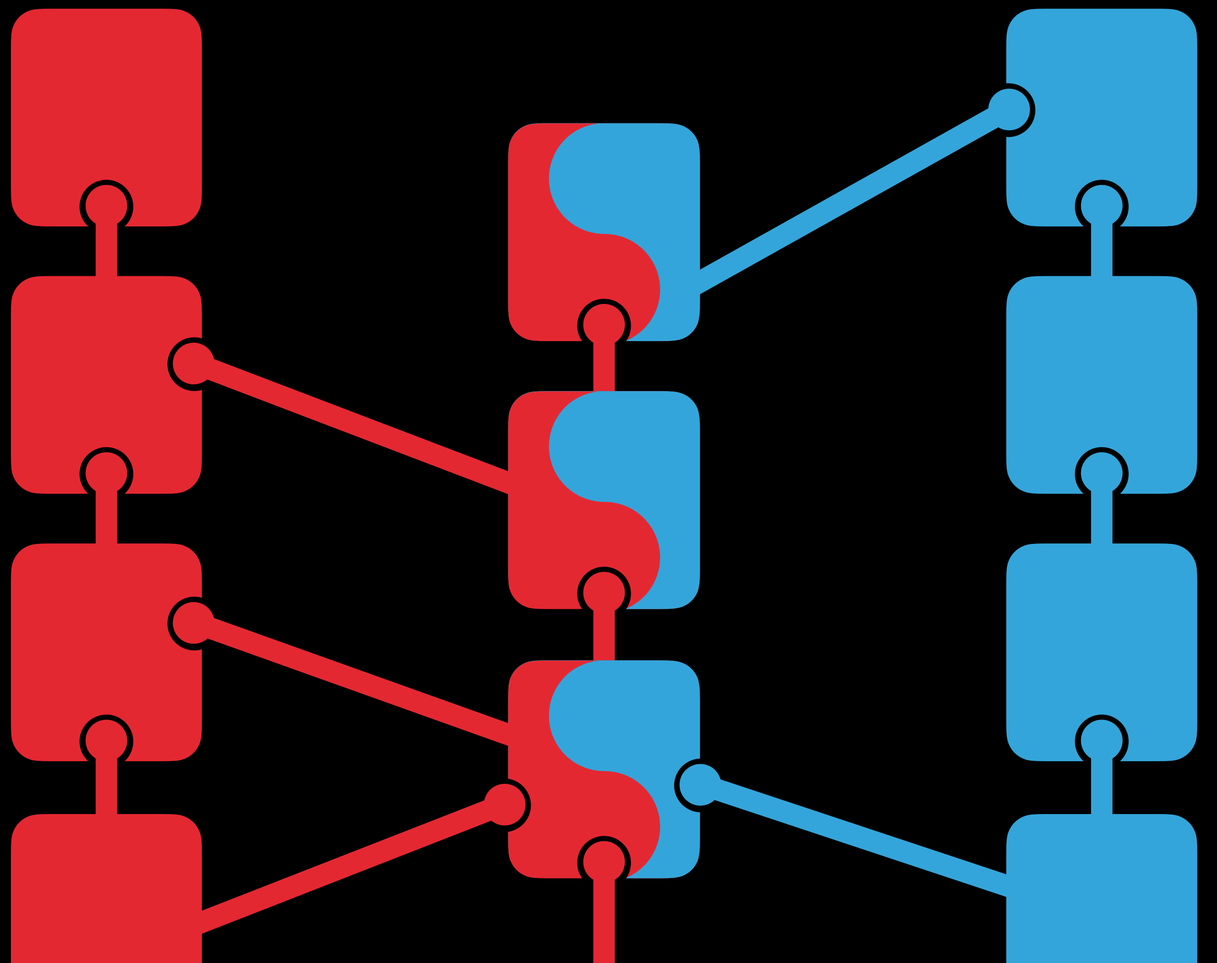

CHIMERA CHAINS

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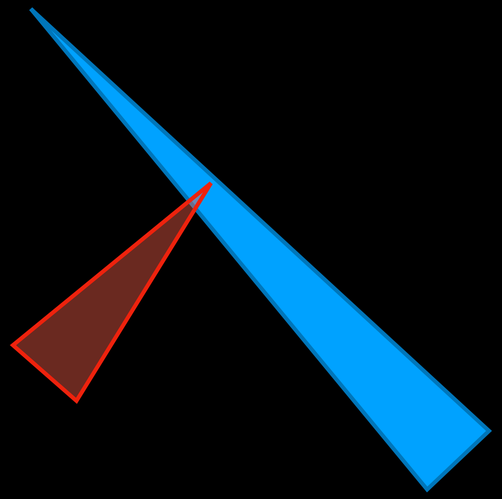

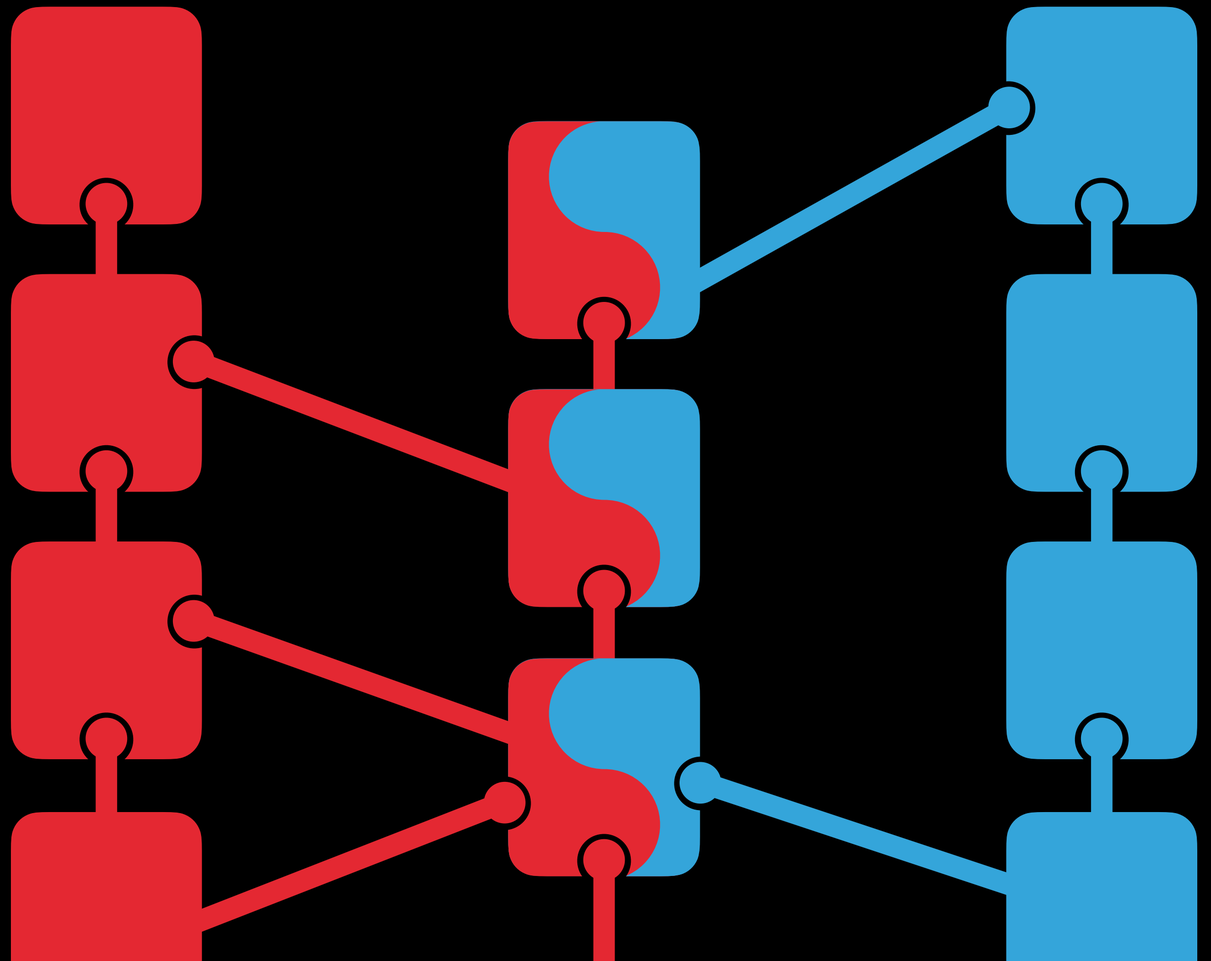

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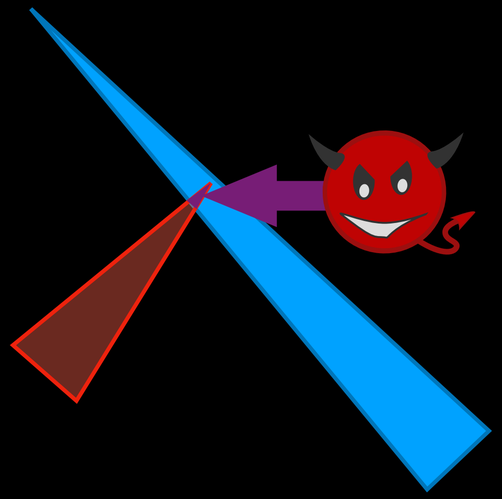

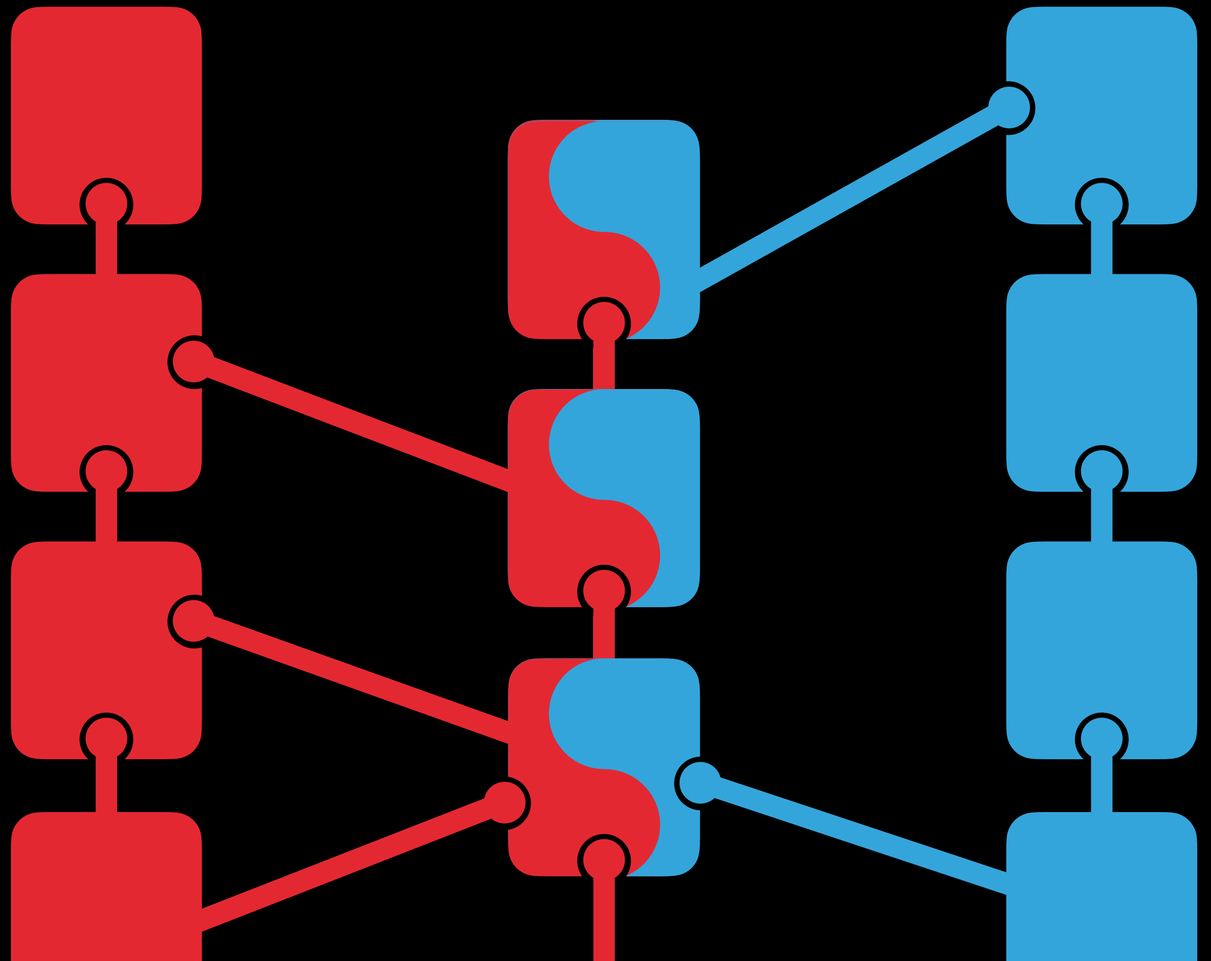

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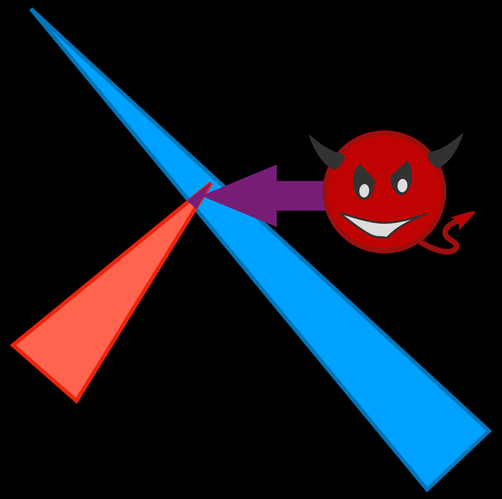

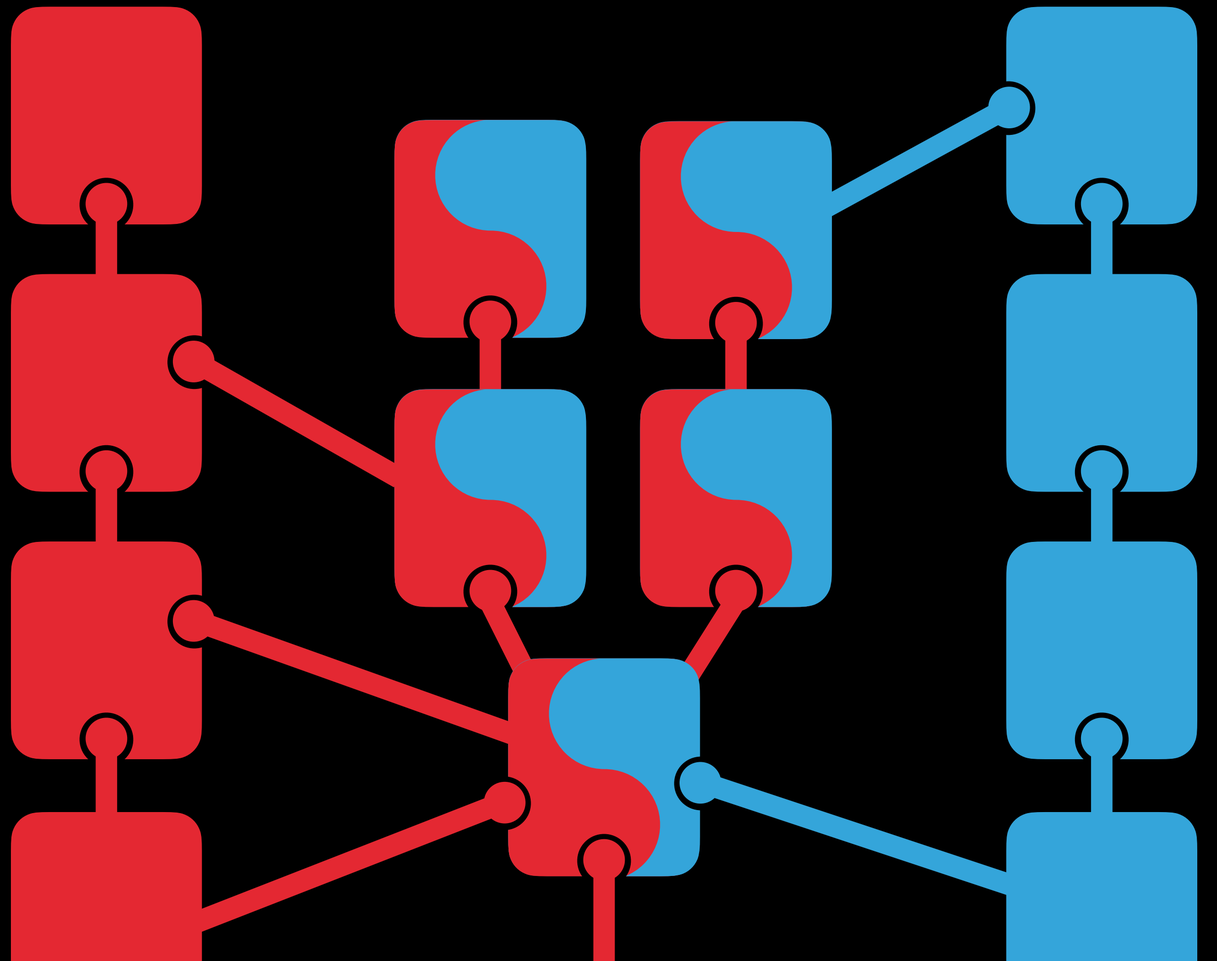

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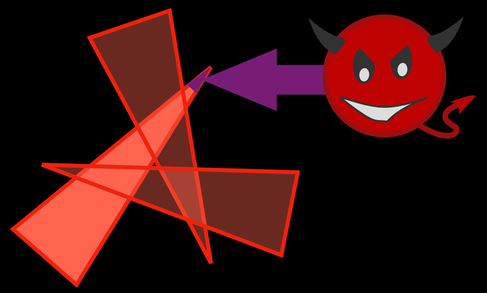

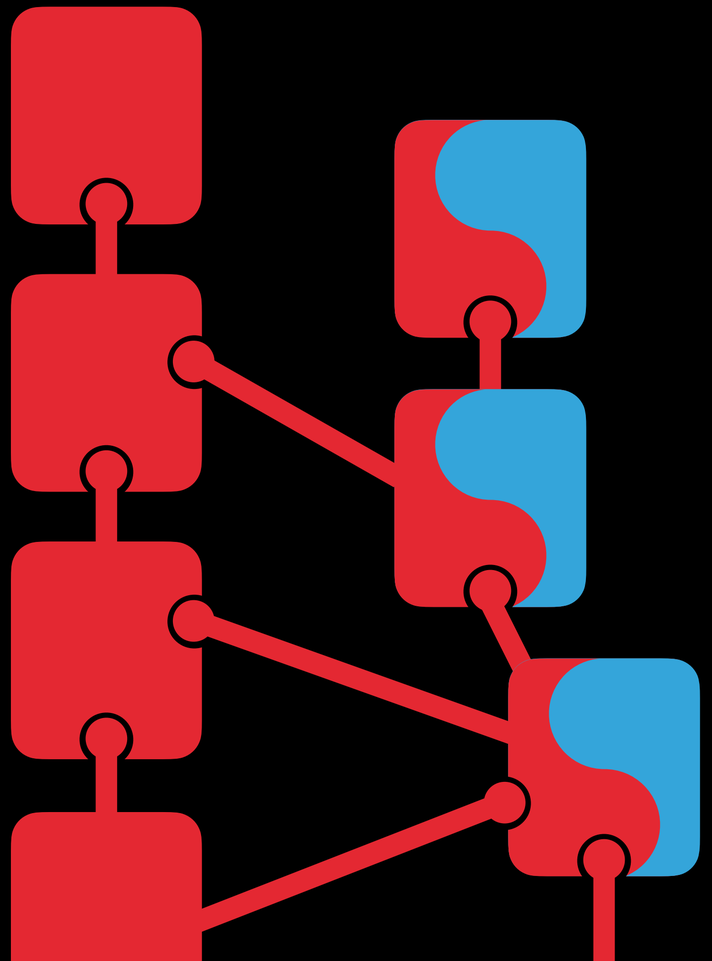

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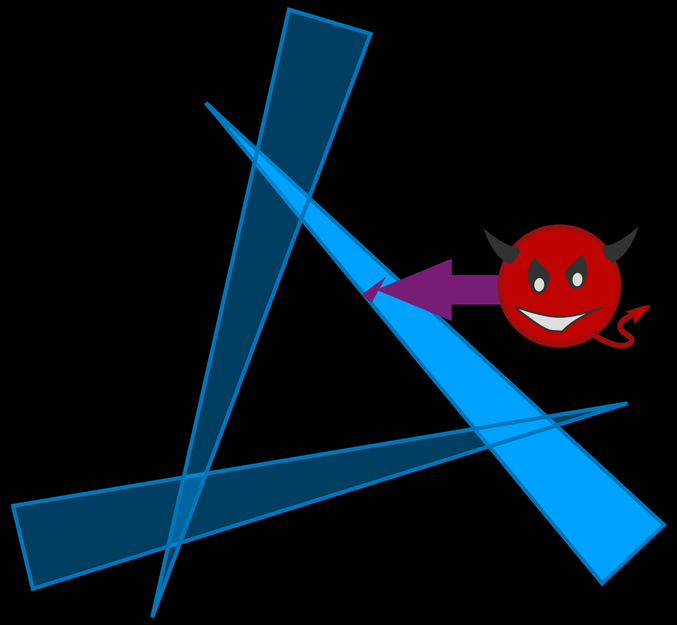

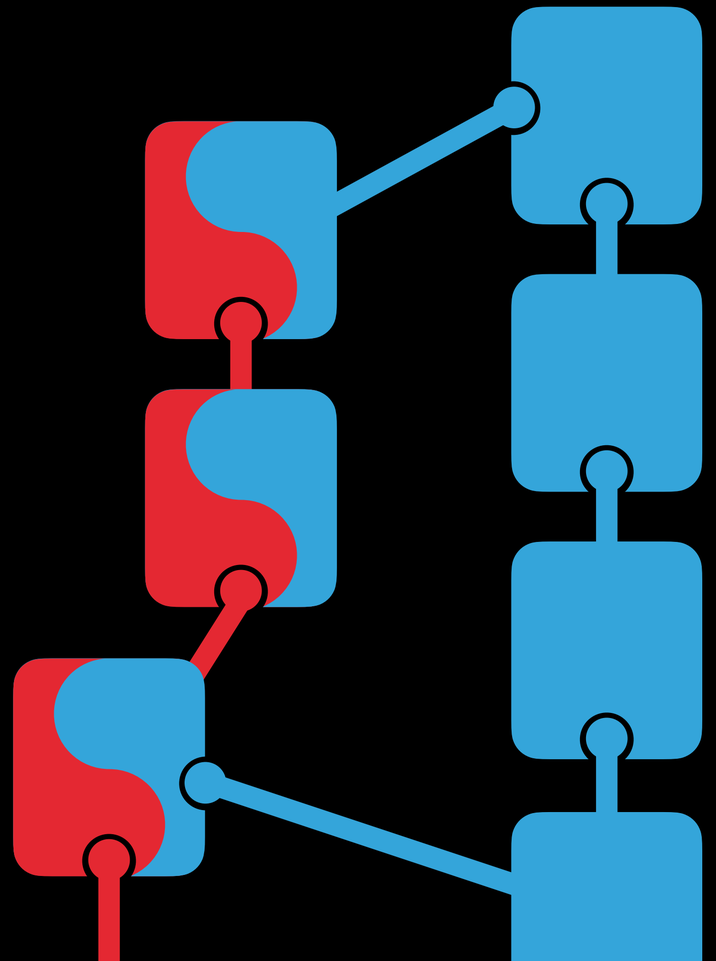

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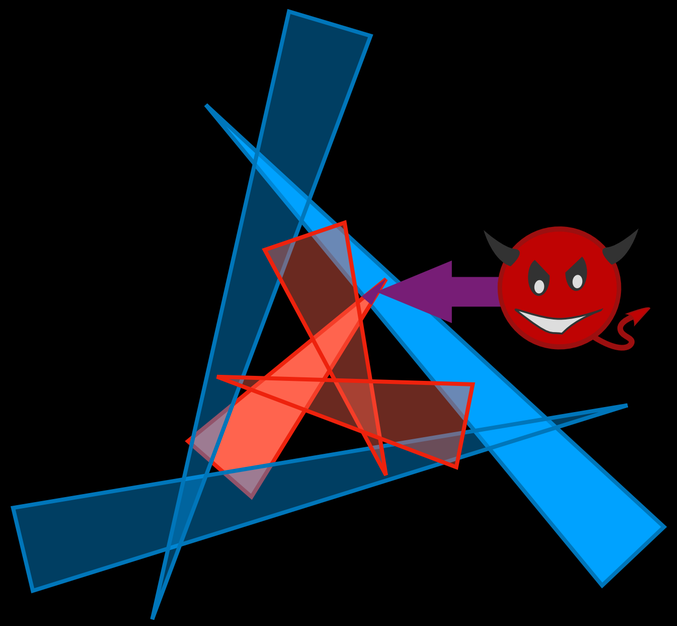

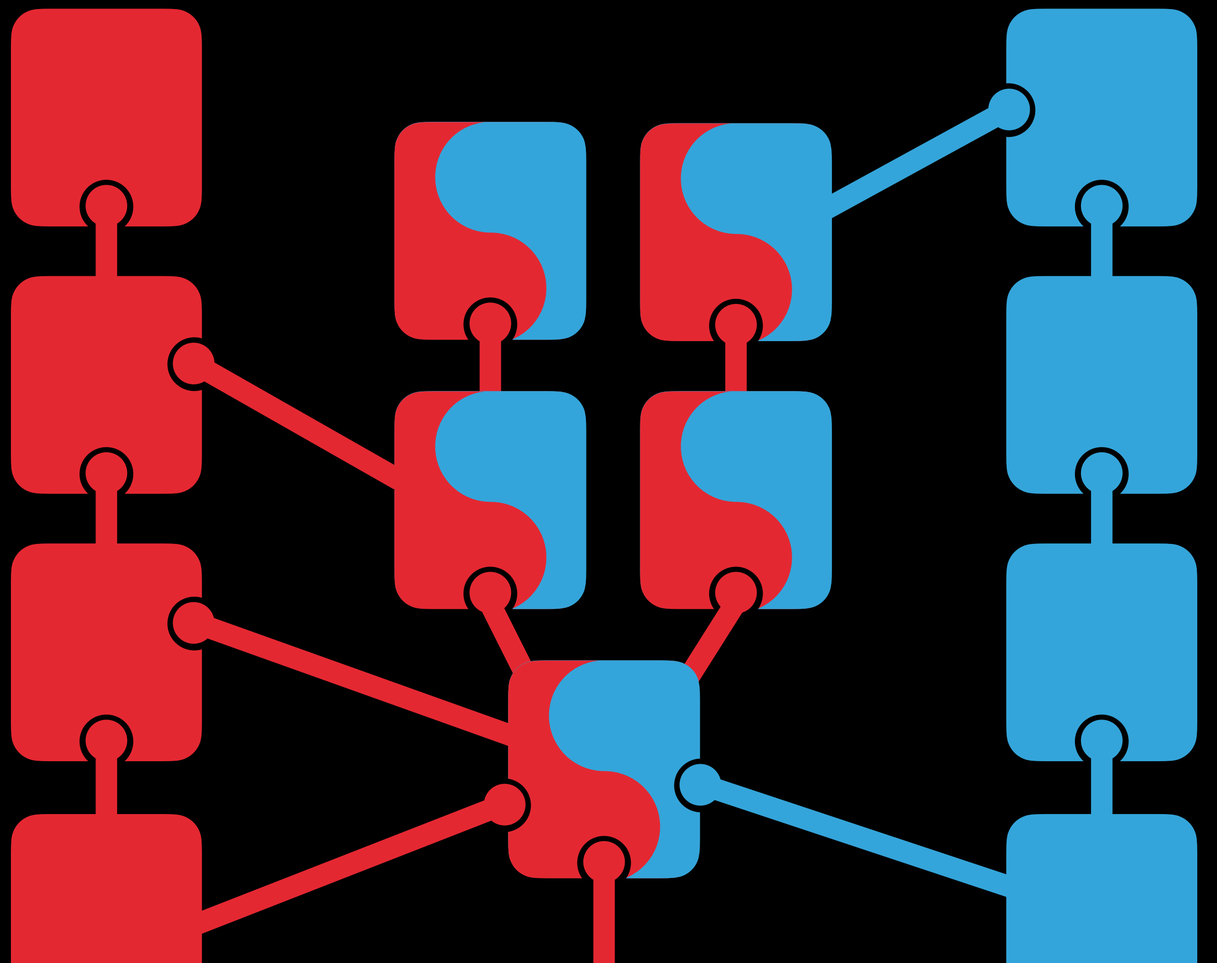

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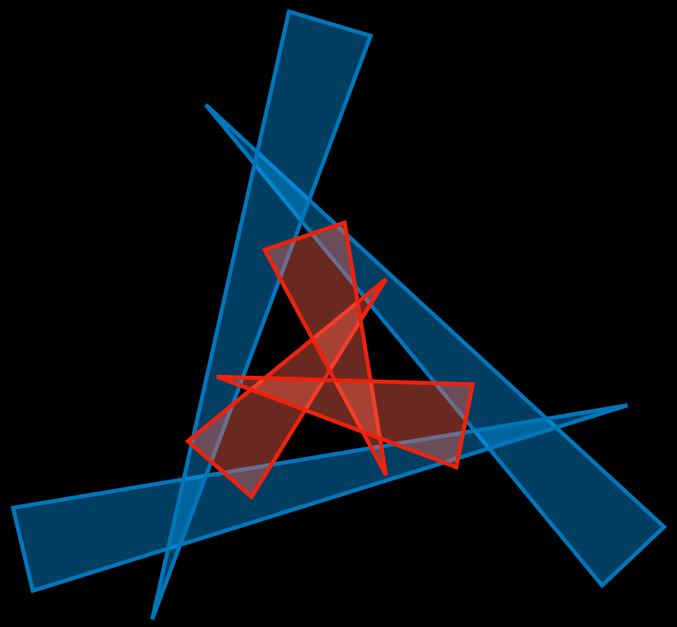

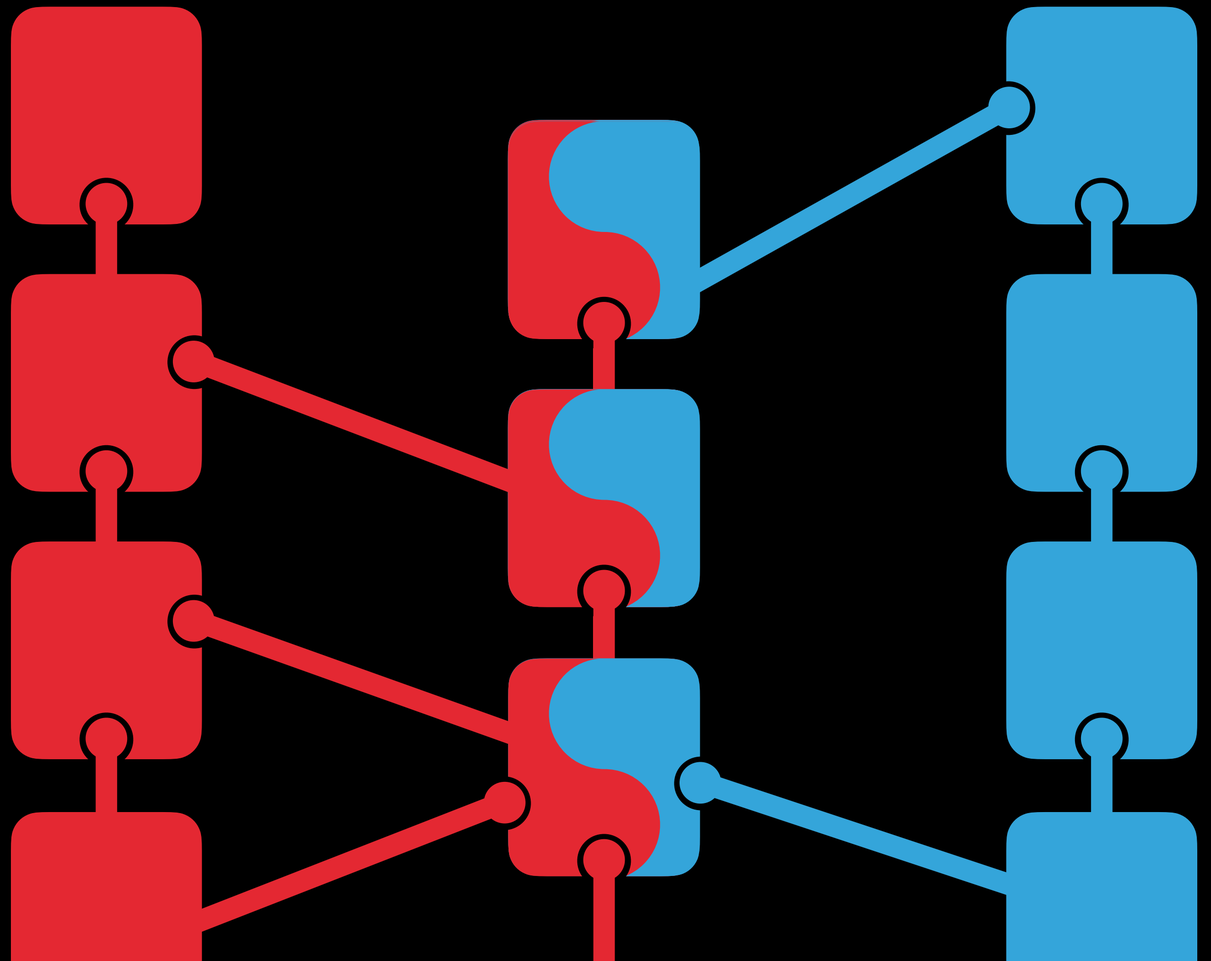

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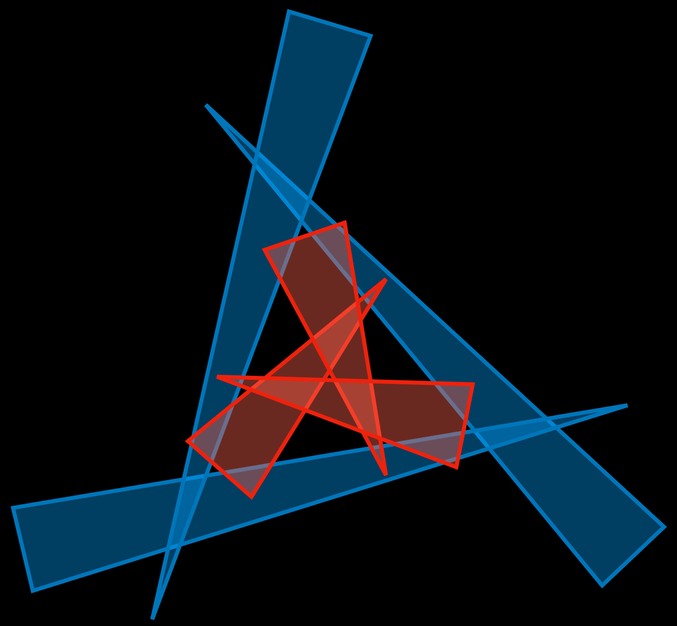
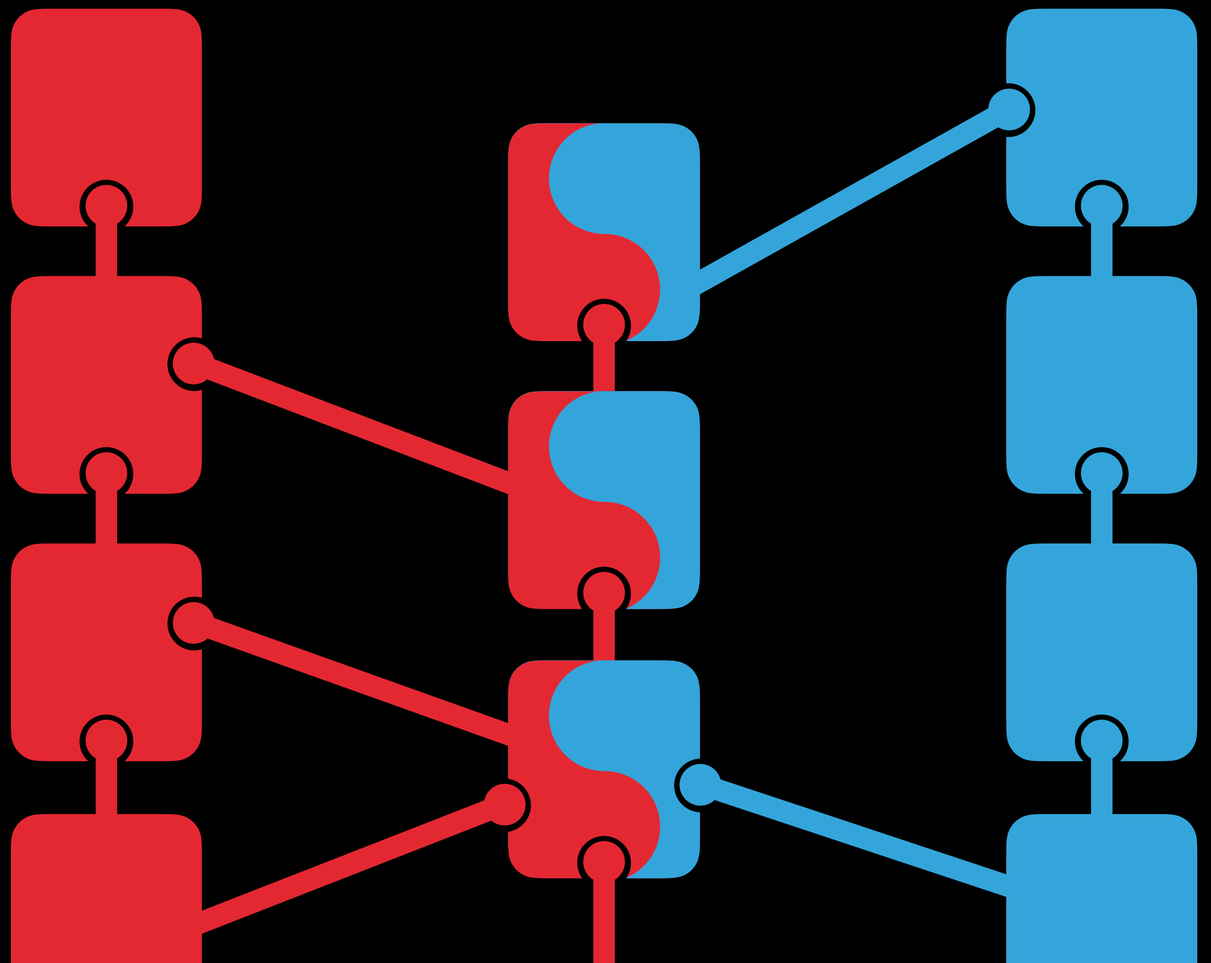
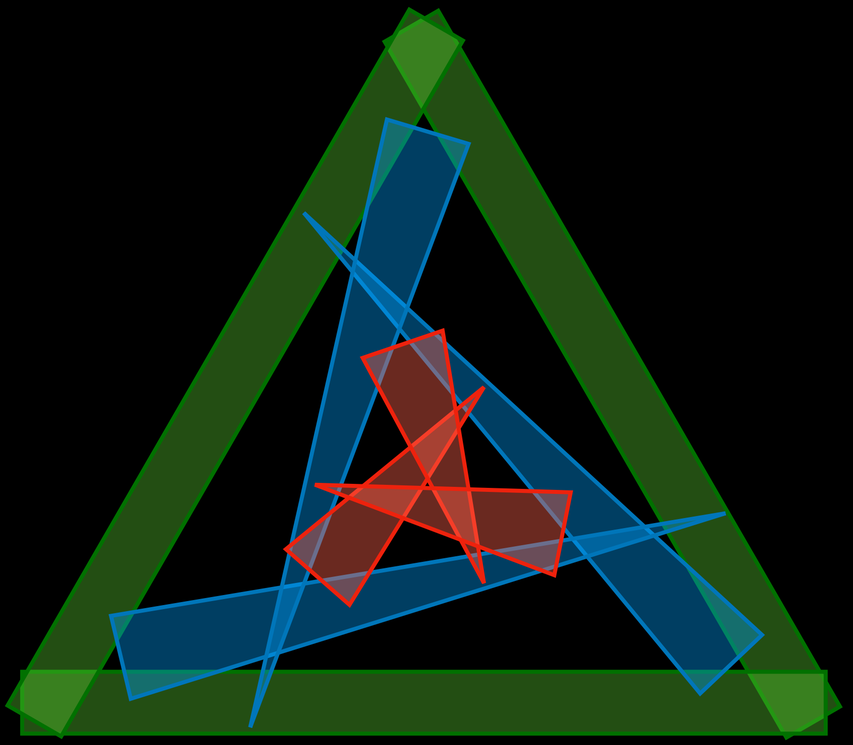
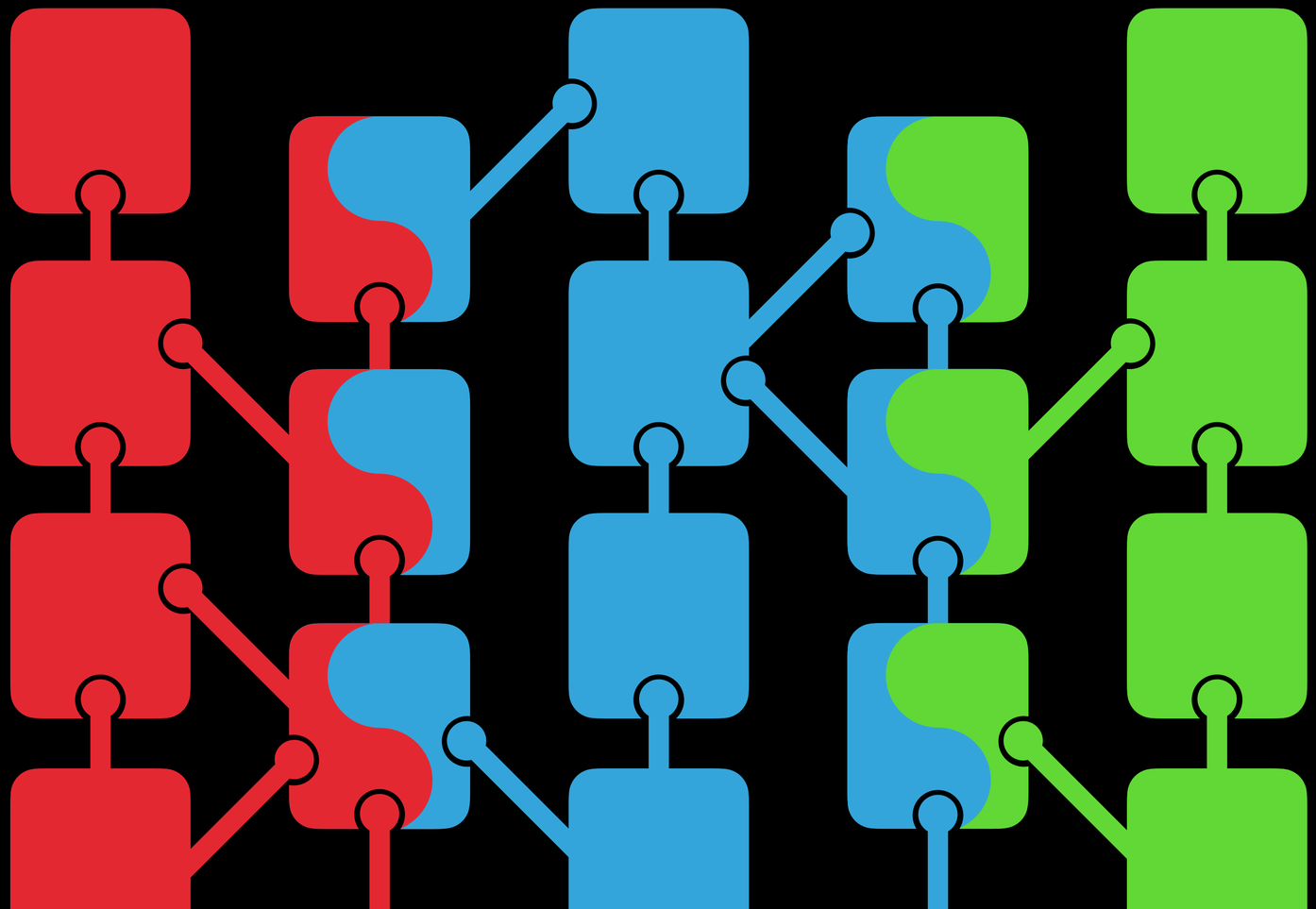




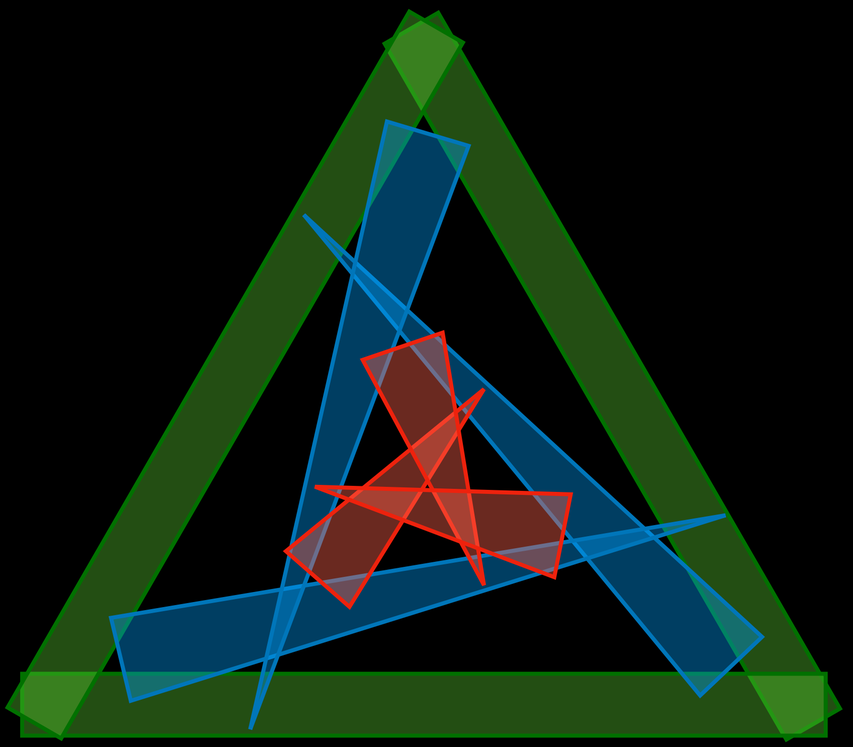
CHIMERA CHAINS

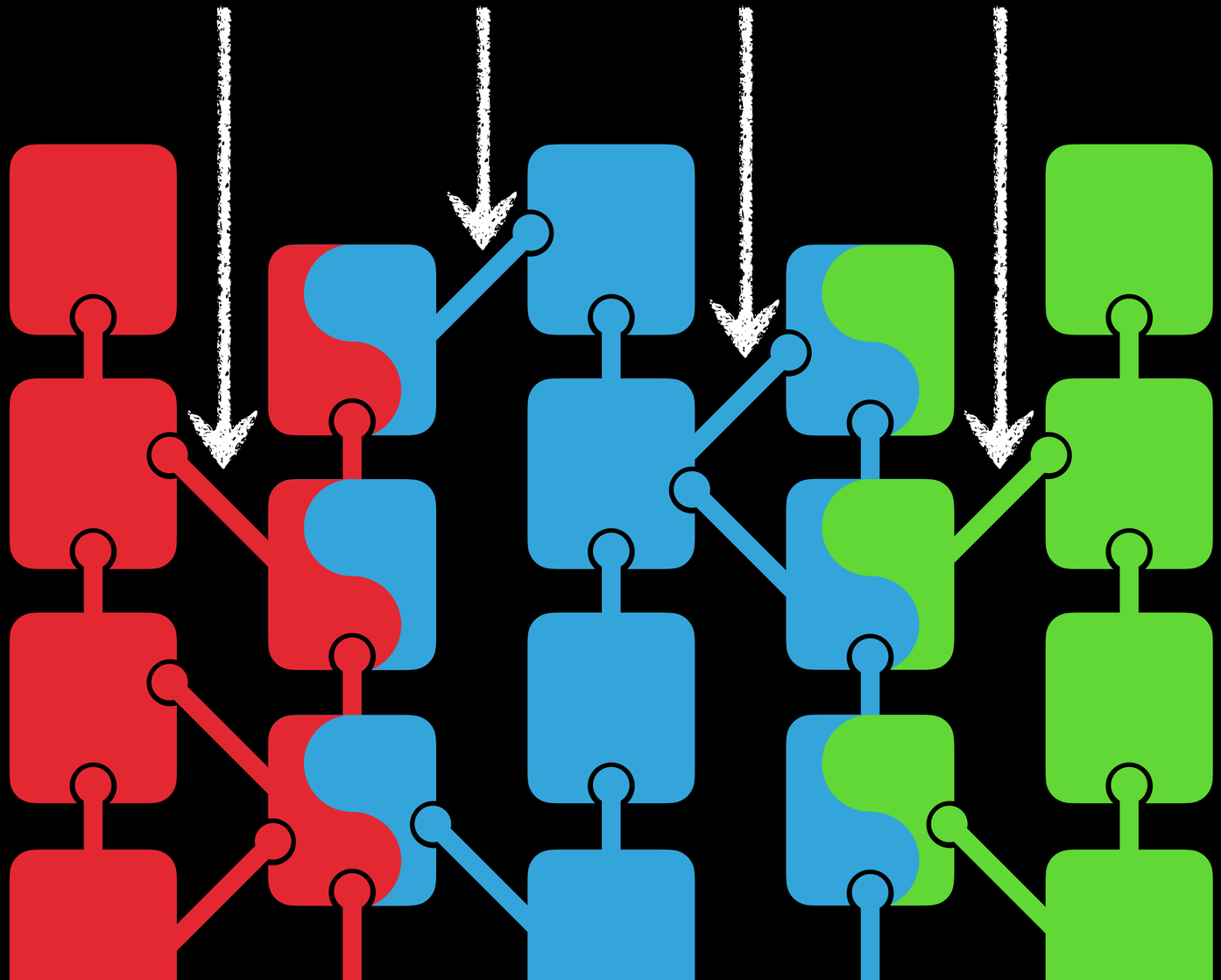
- A chain for each possible consensus
  - On-demand
- Inter-Chain Communication





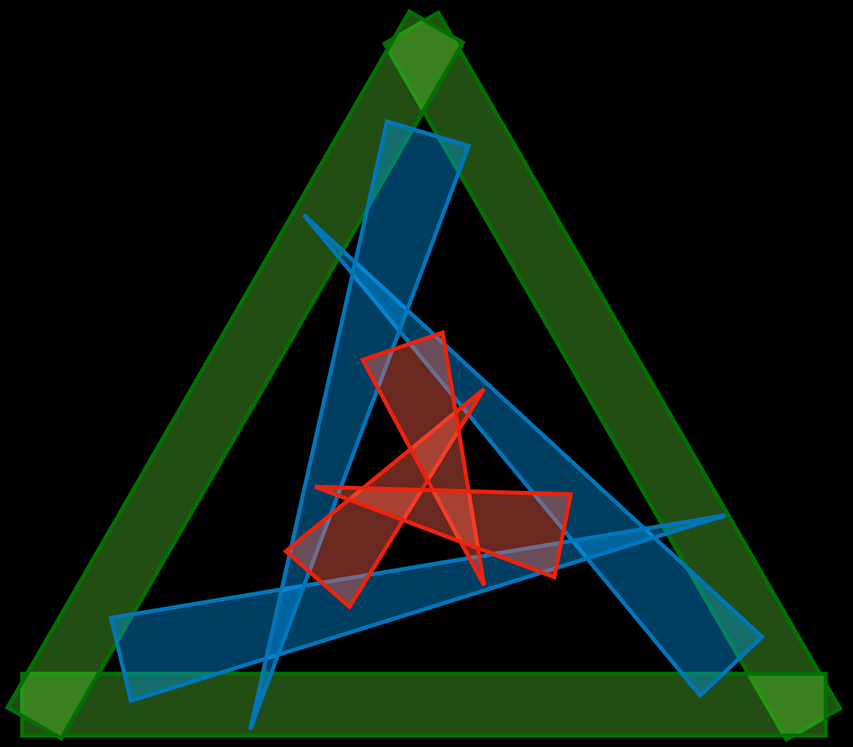
INTER-CHAIN COMMUNICATION

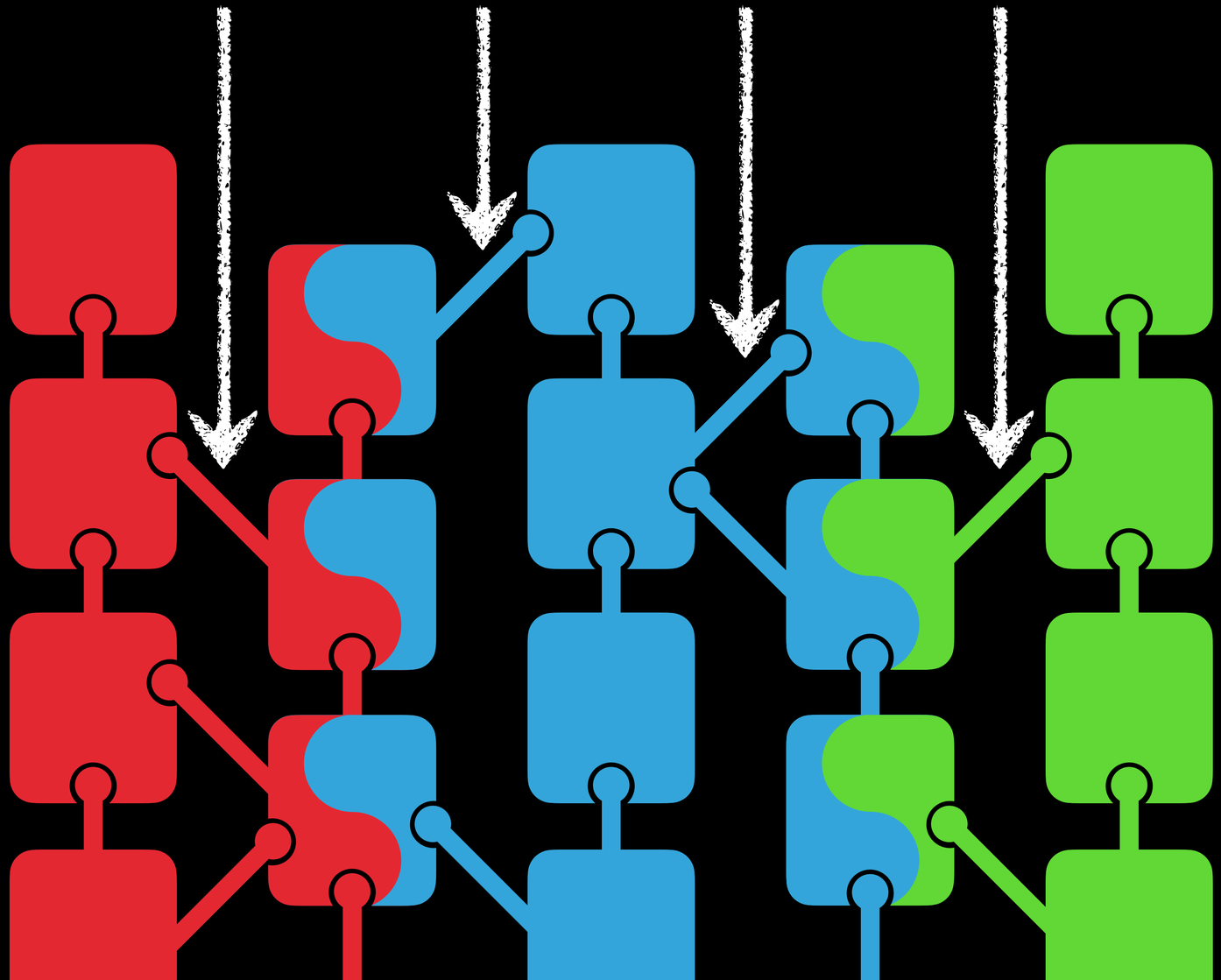




INTER-CHAIN COMMUNICATION

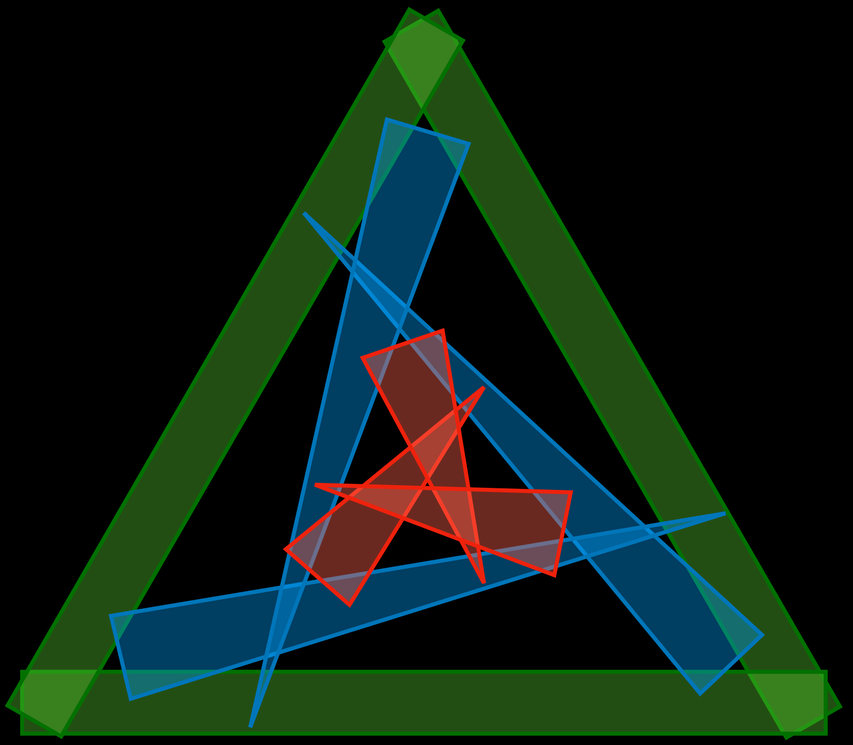
- IBC? [ibcprotocol.org]

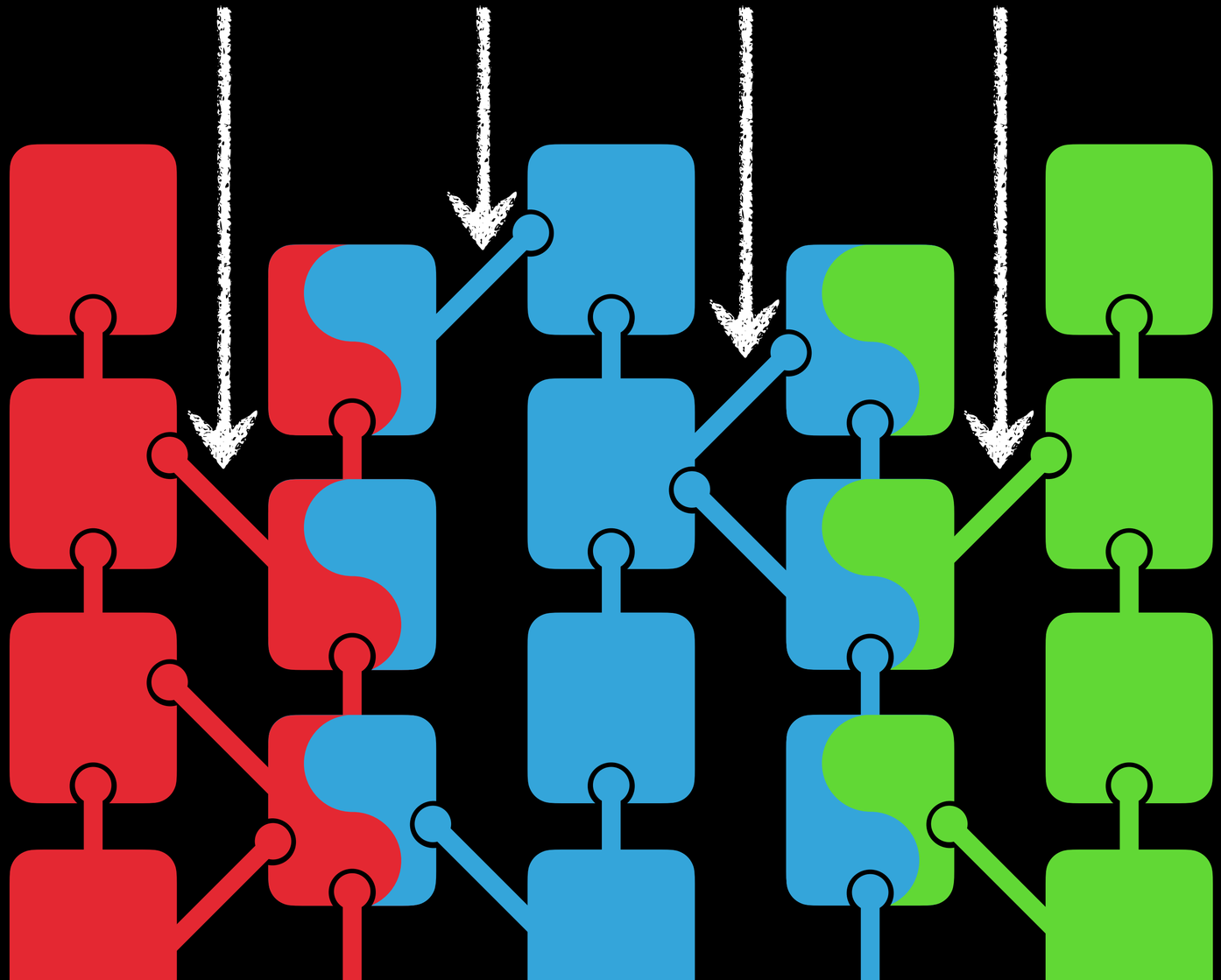




INTER-CHAIN COMMUNICATION

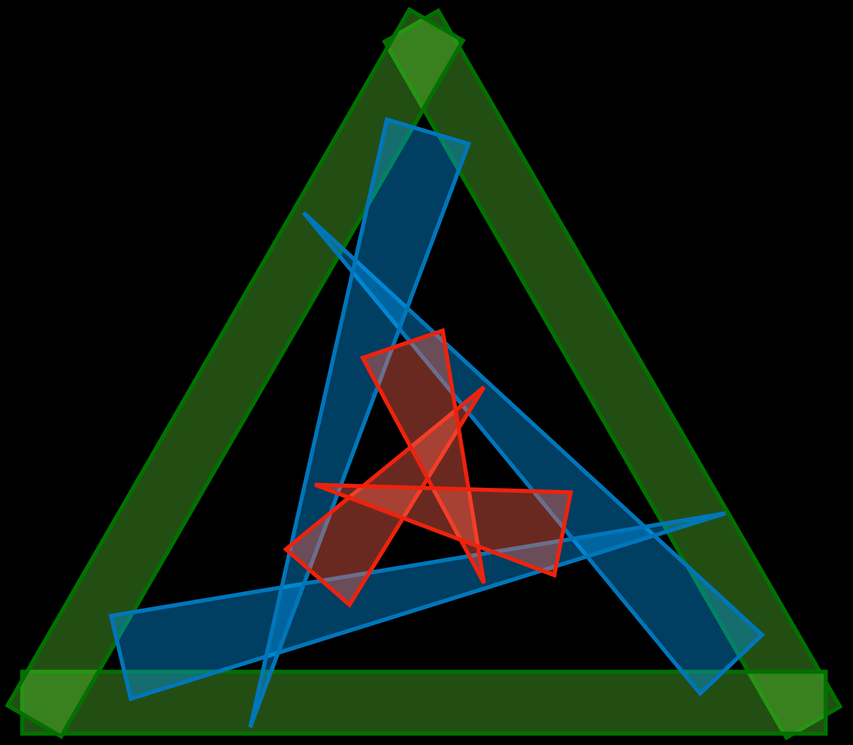
- IBC? [ibcprotocol.org]
- Do we need Proofs?

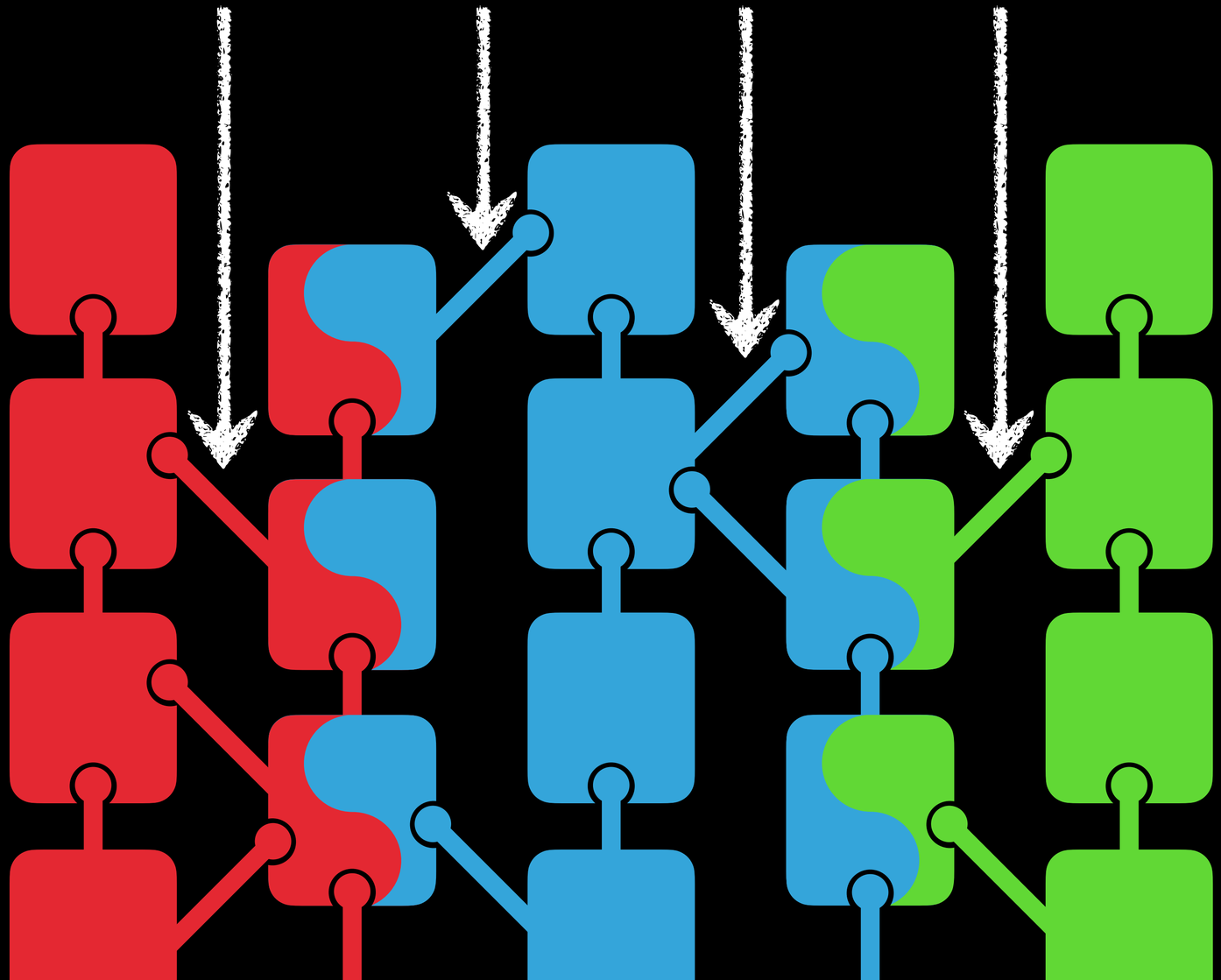




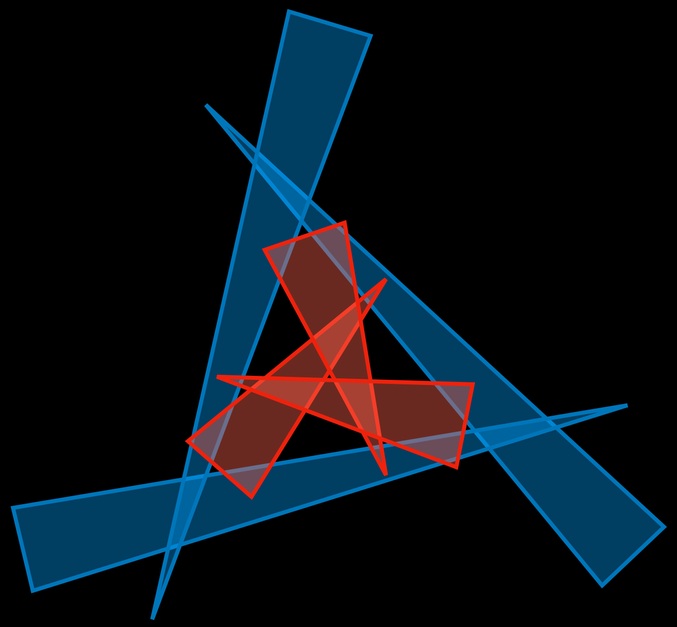
INTER-CHAIN COMMUNICATION

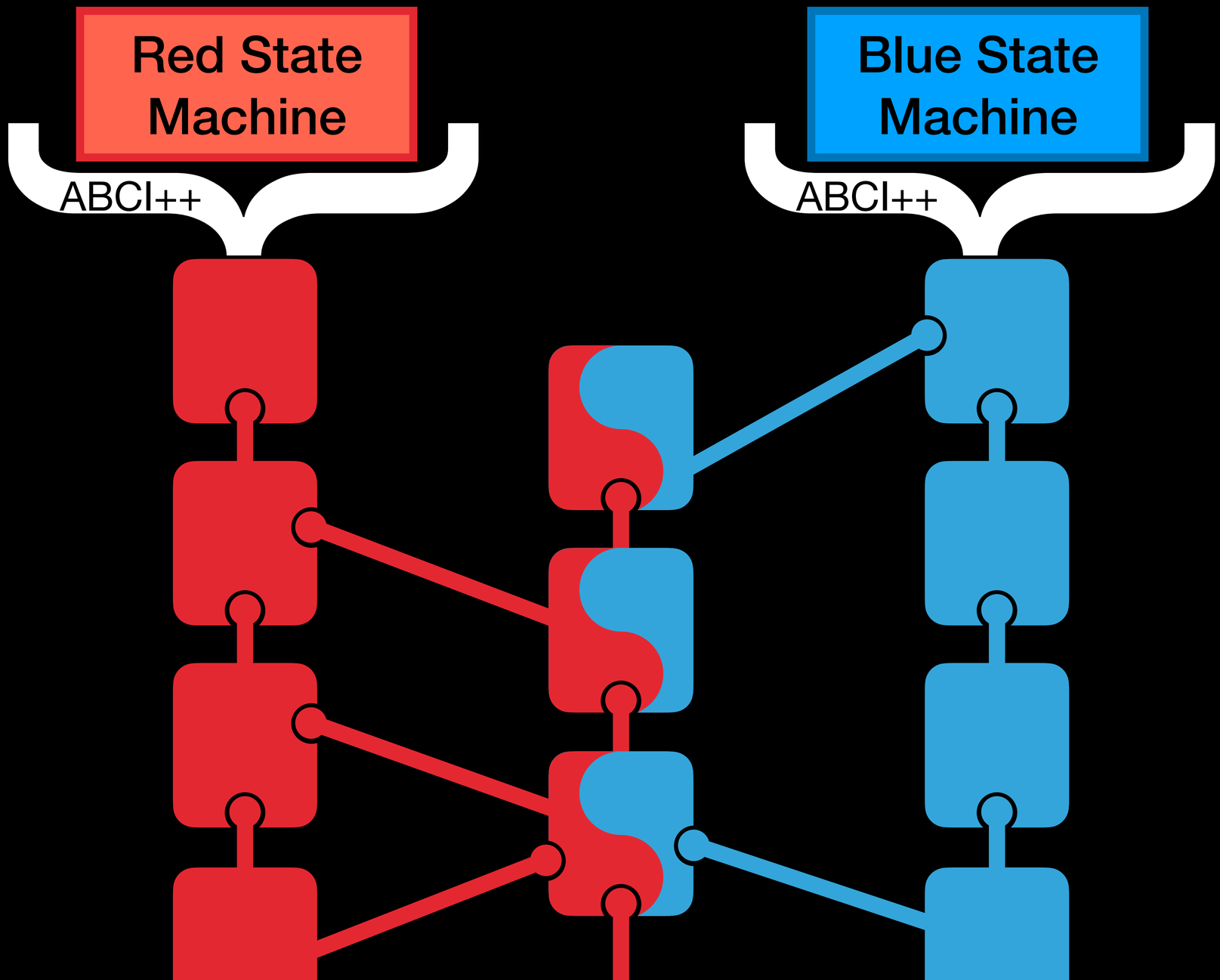
- IBC? [ibcprotocol.org]
- Do we need Proofs?
- Synchrony (in blocks)?





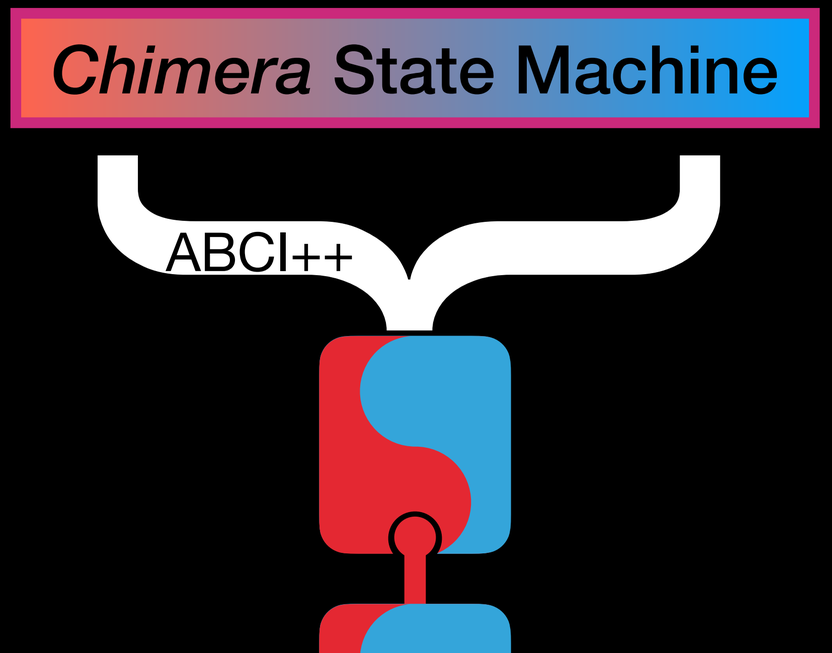
STATE MACHINE





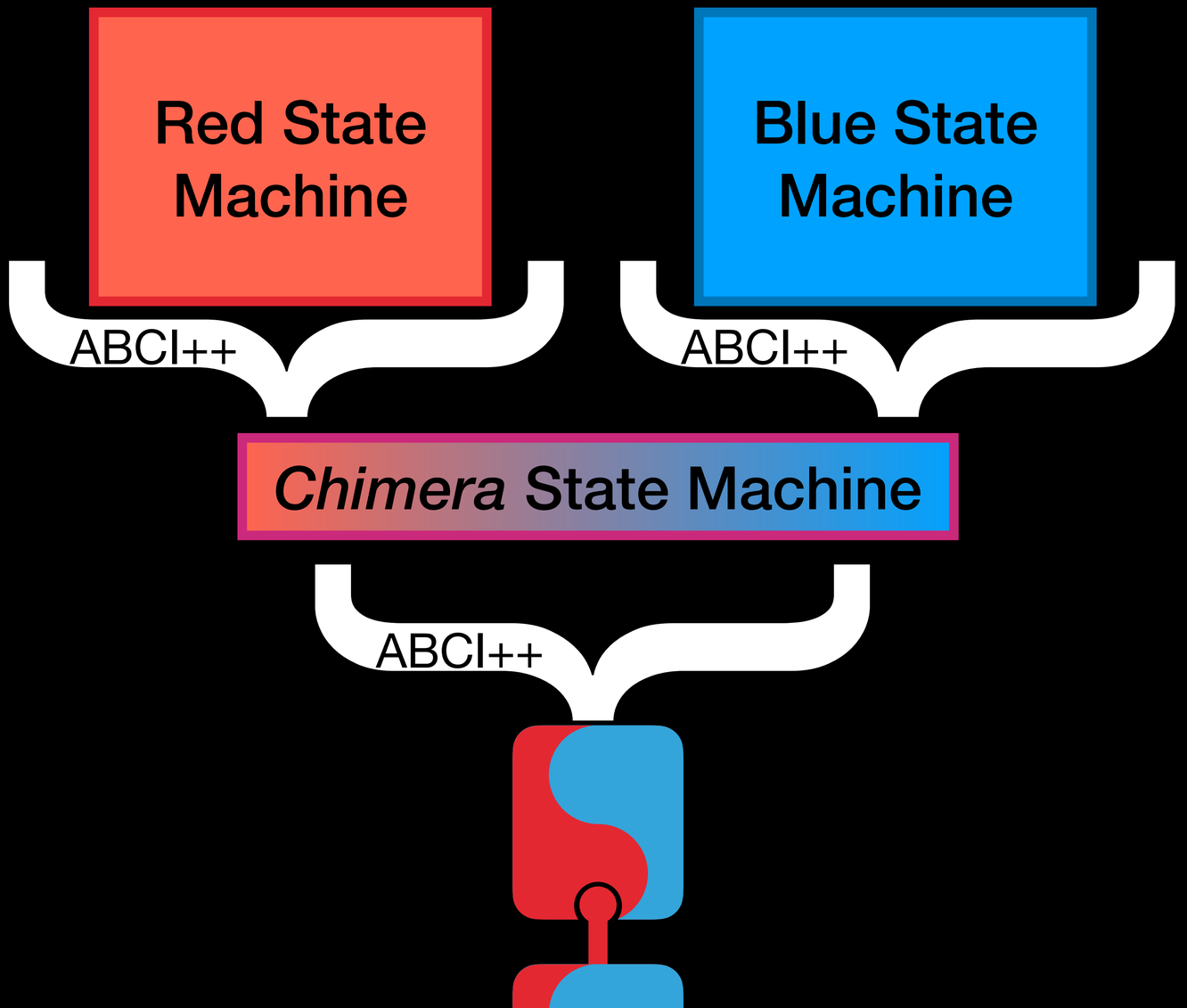
STATE MACHINE

- Over Chimera Chain



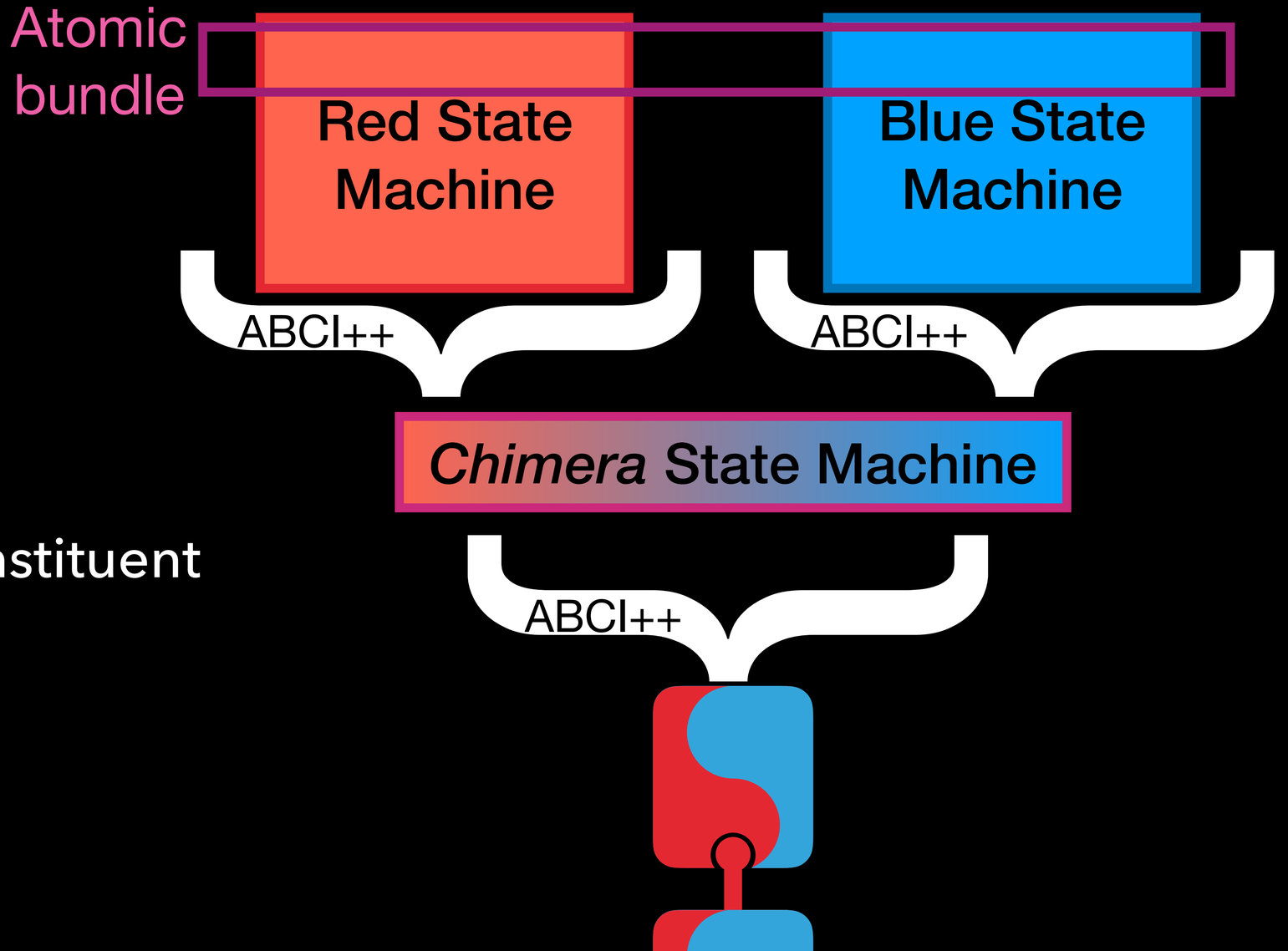
STATE MACHINE

- Over Chimera Chain
- Instances of constituent chain state machines



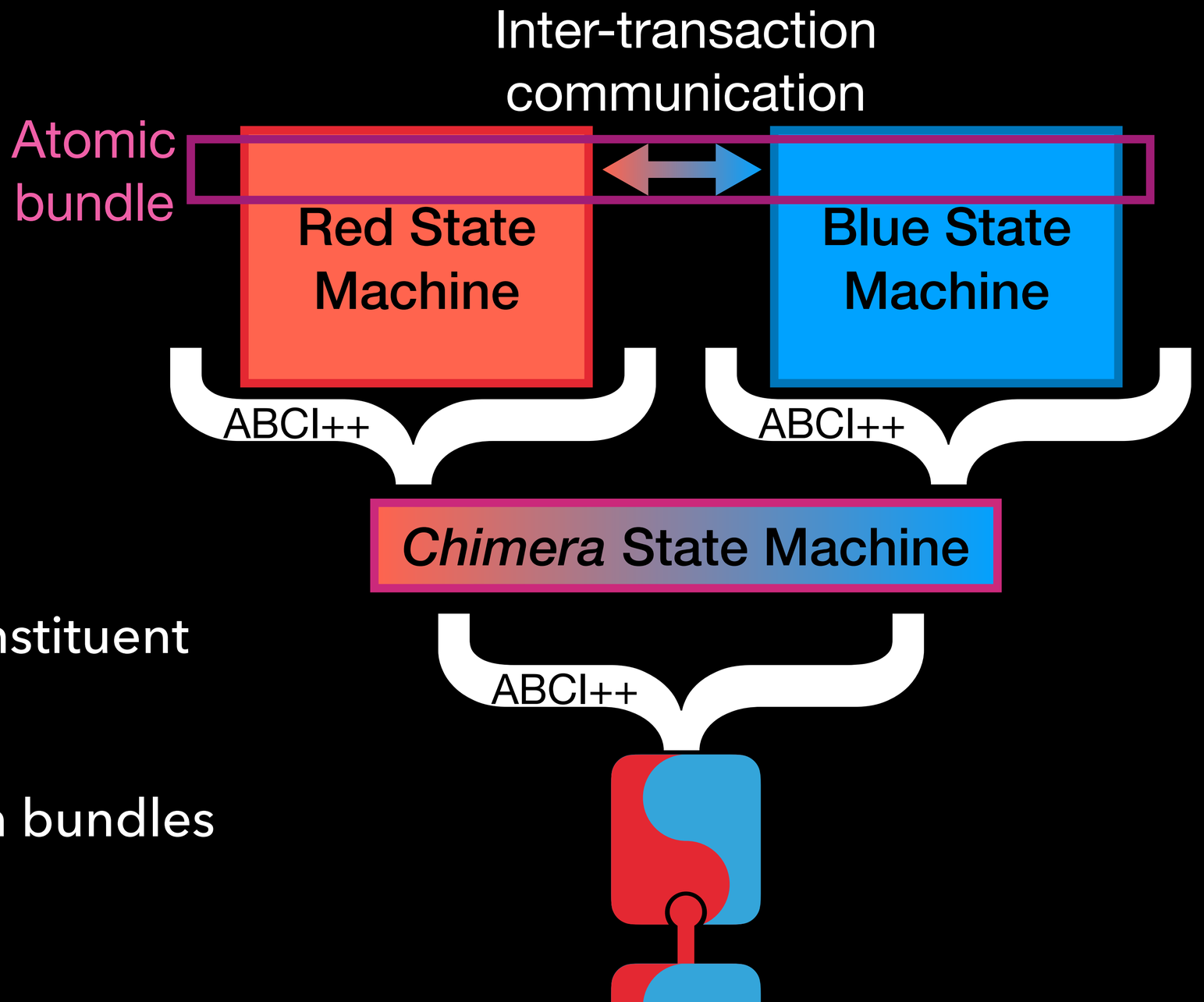
STATE MACHINE

- Over Chimera Chain
- Instances of constituent chain state machines
- Transactions:
  - Atomic bundles of constituent chain transactions



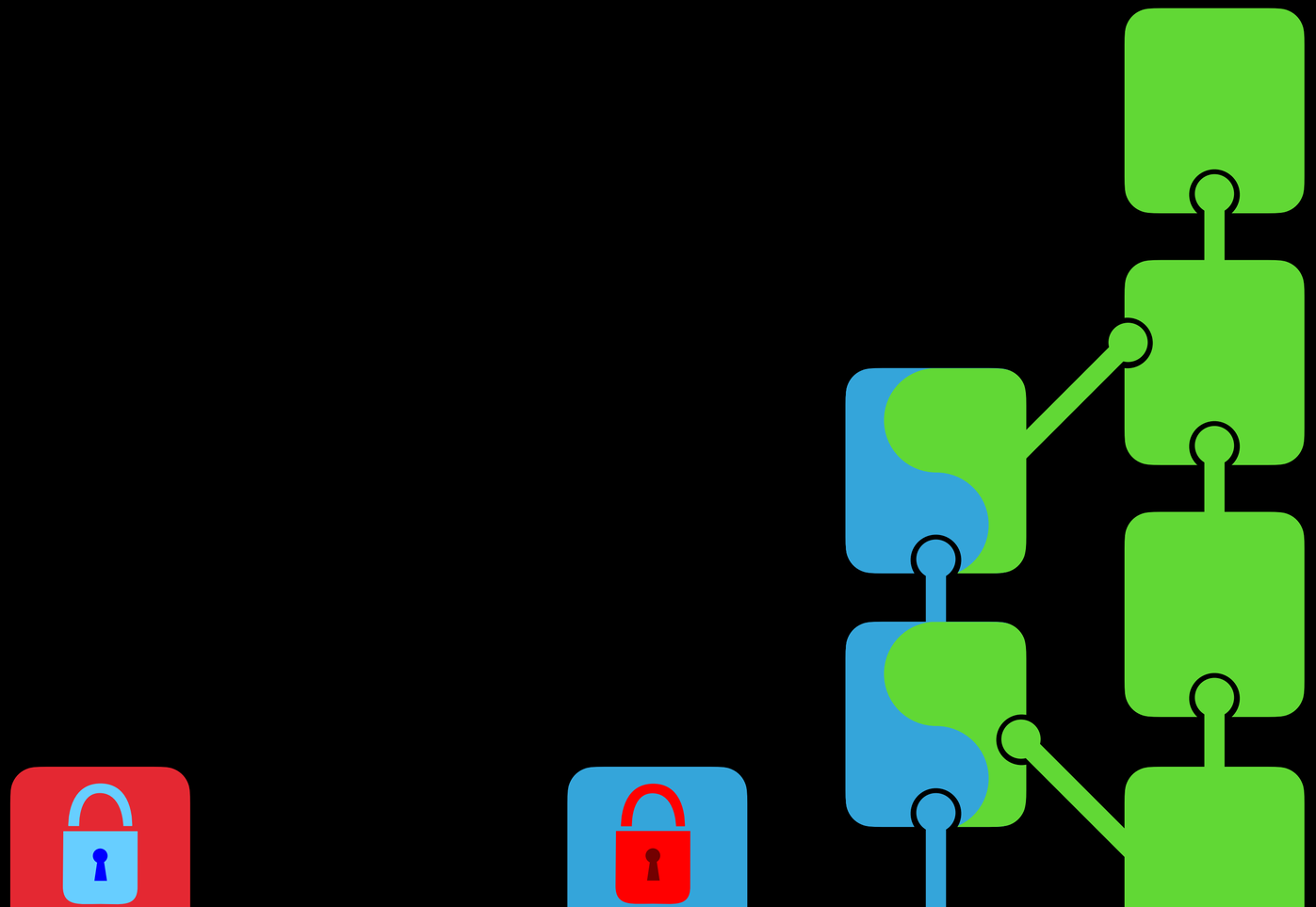
STATE MACHINE

- Over Chimera Chain
- Instances of constituent chain state machines
- Transactions:
  - Atomic bundles of constituent chain transactions
  - Communication within bundles



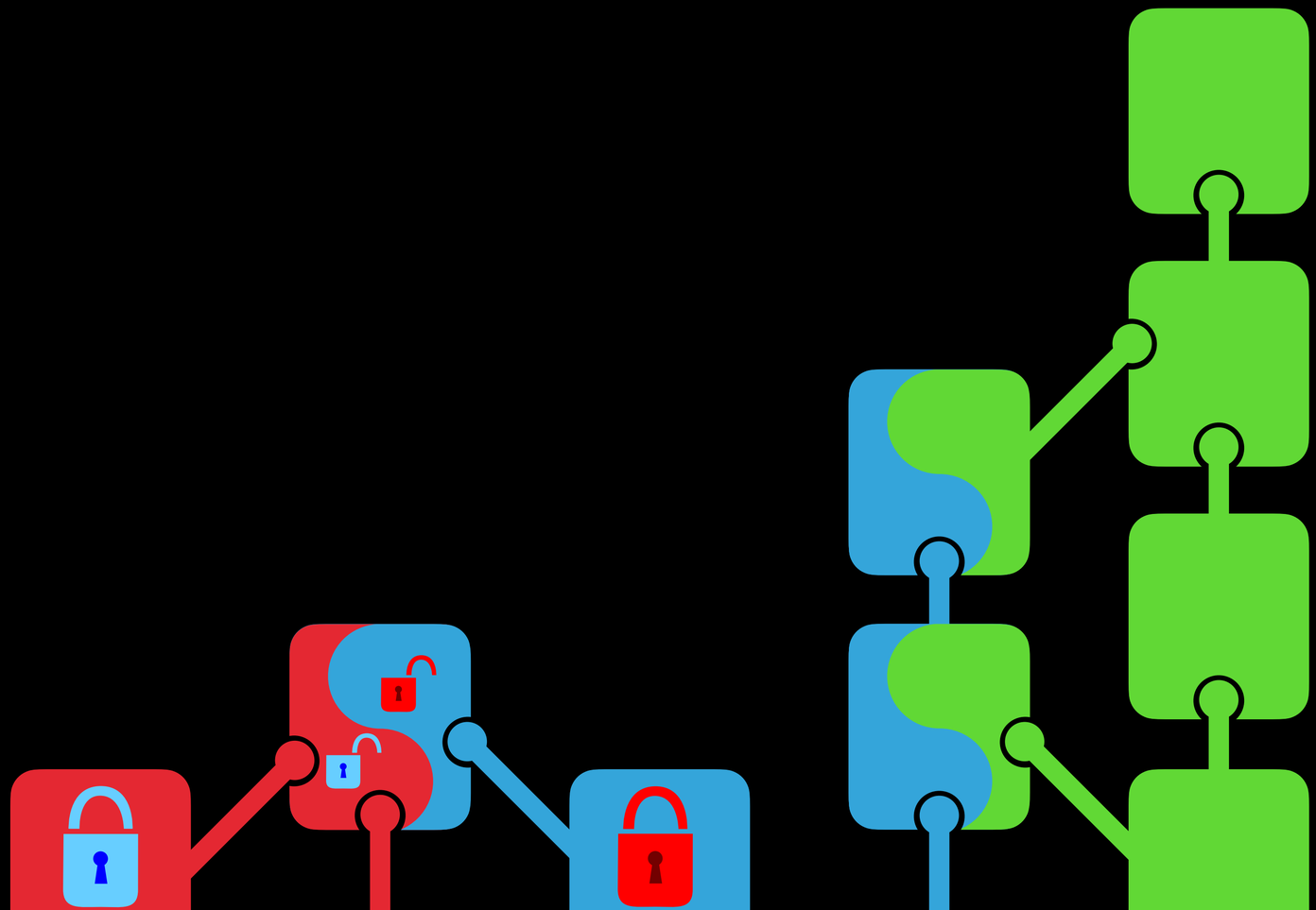
PROGRAMMING MODEL

- Locking State



PROGRAMMING MODEL

- Locking State
  - Locks held by chimera chain



PROGRAMMING MODEL

- Locking State
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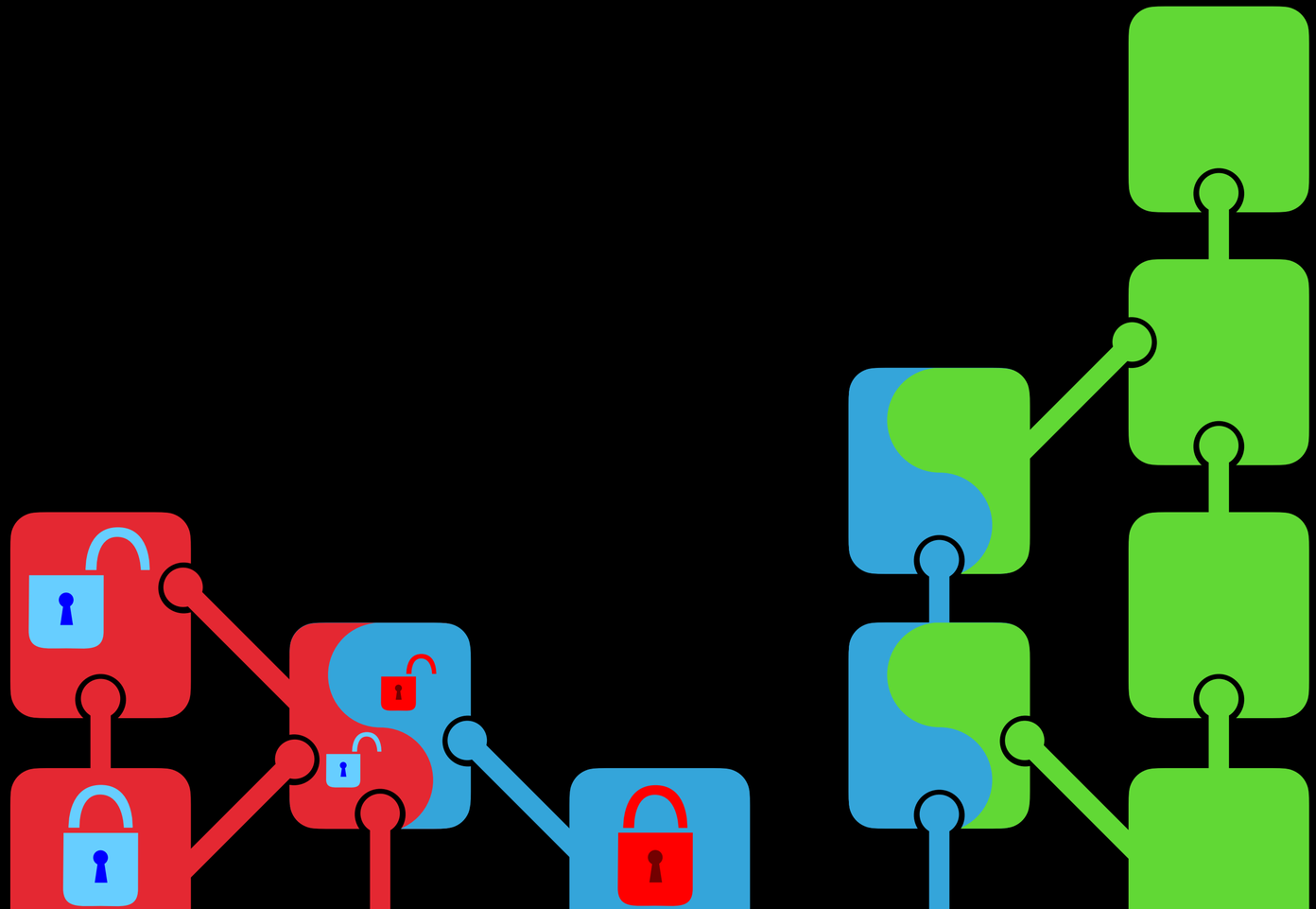
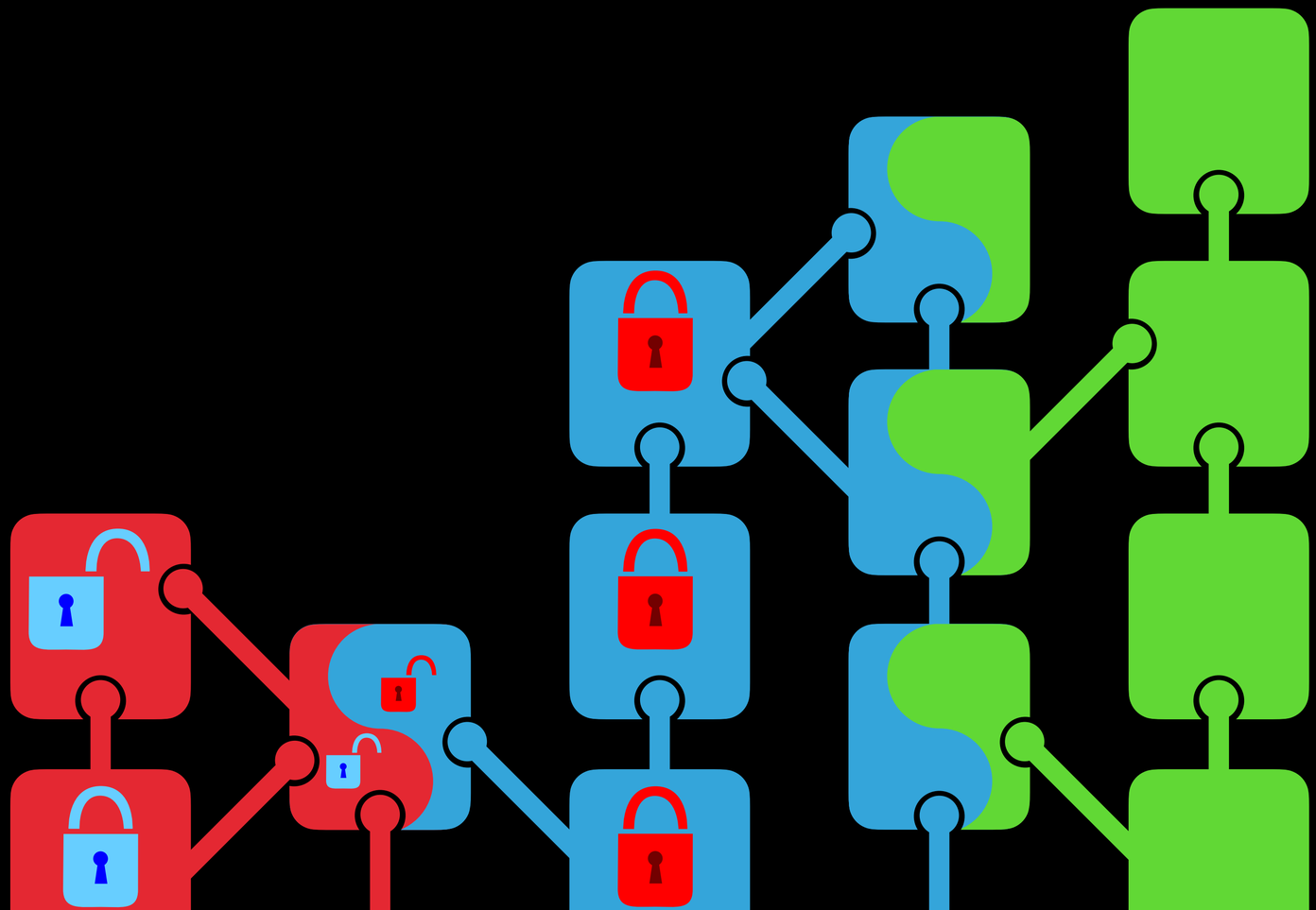


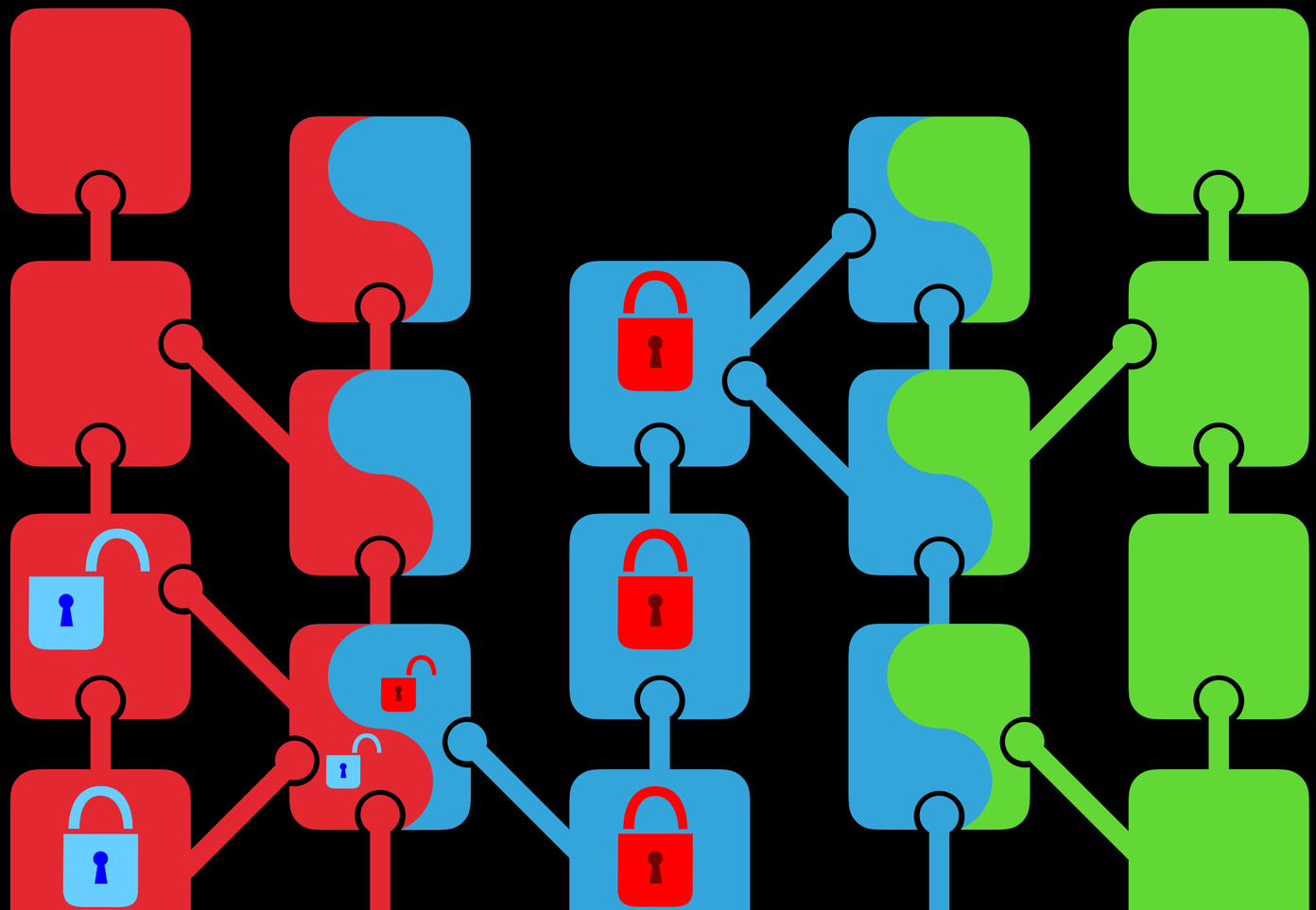
PROGRAMMING MODEL

- Locking State
  - Locks held by chimera chain



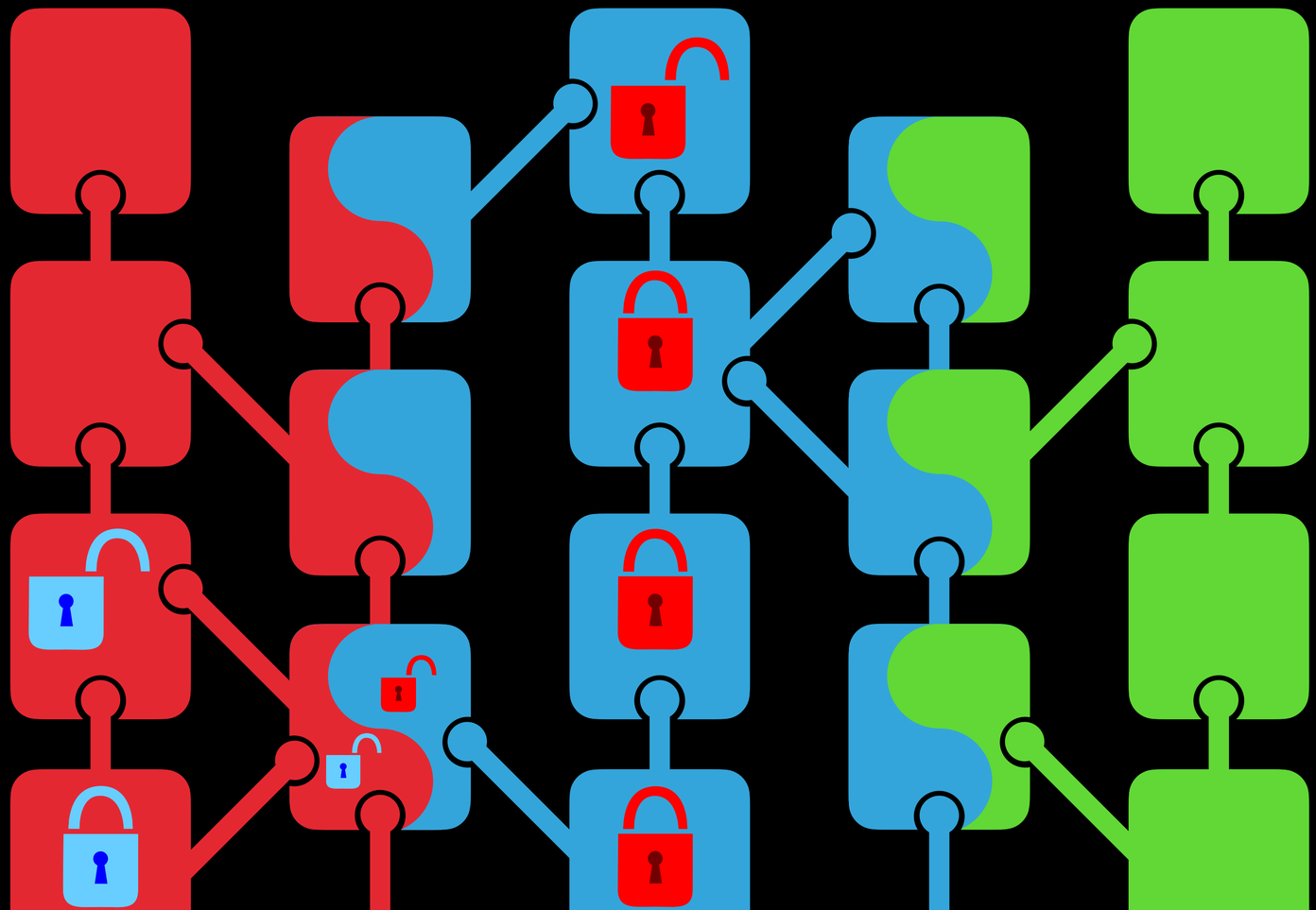
PROGRAMMING MODEL

- Locking State
  - Locks held by chimera chain



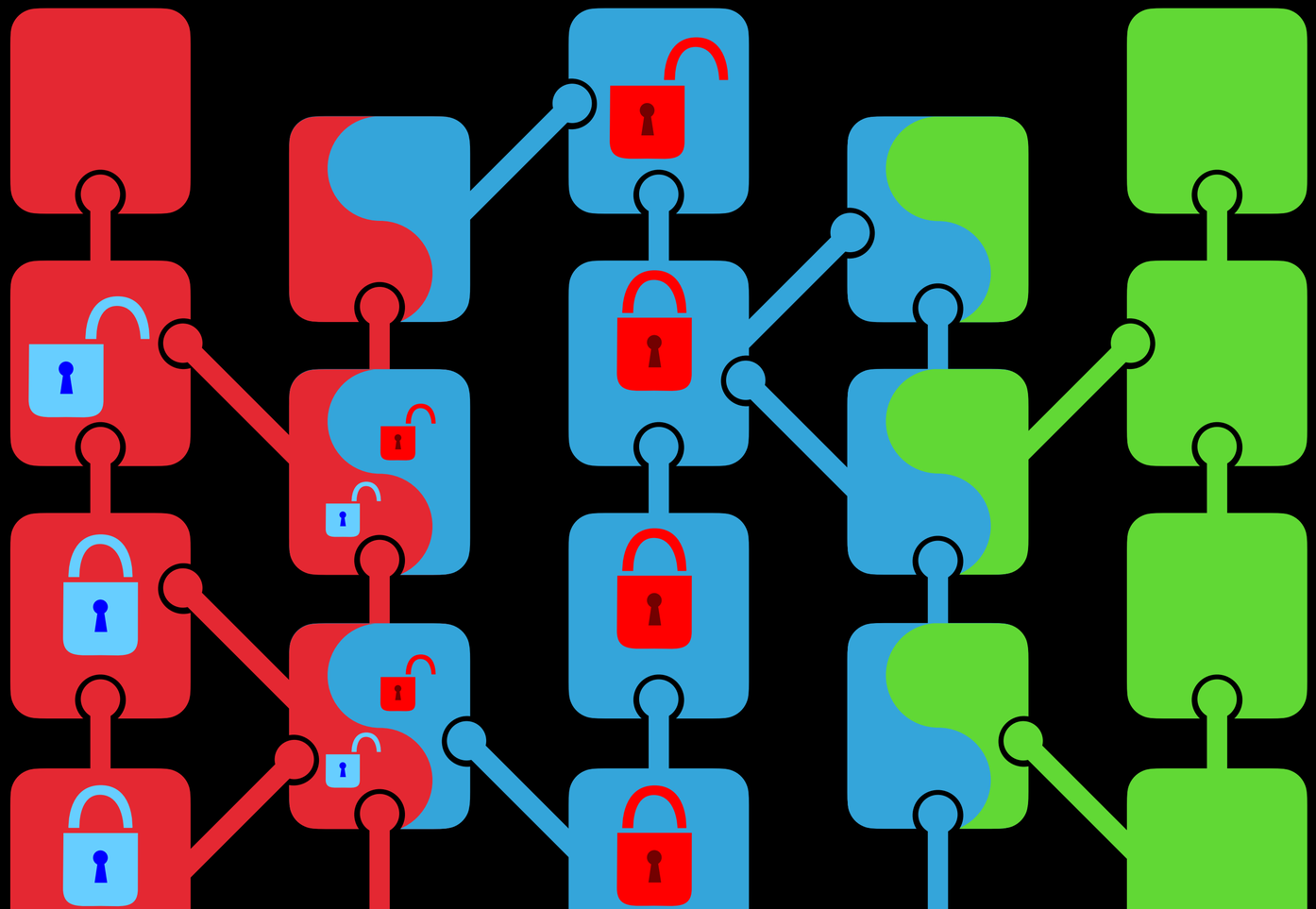
PROGRAMMING MODEL

- Locking State
  - Locks held by chimera chain
  - Maintains liveness



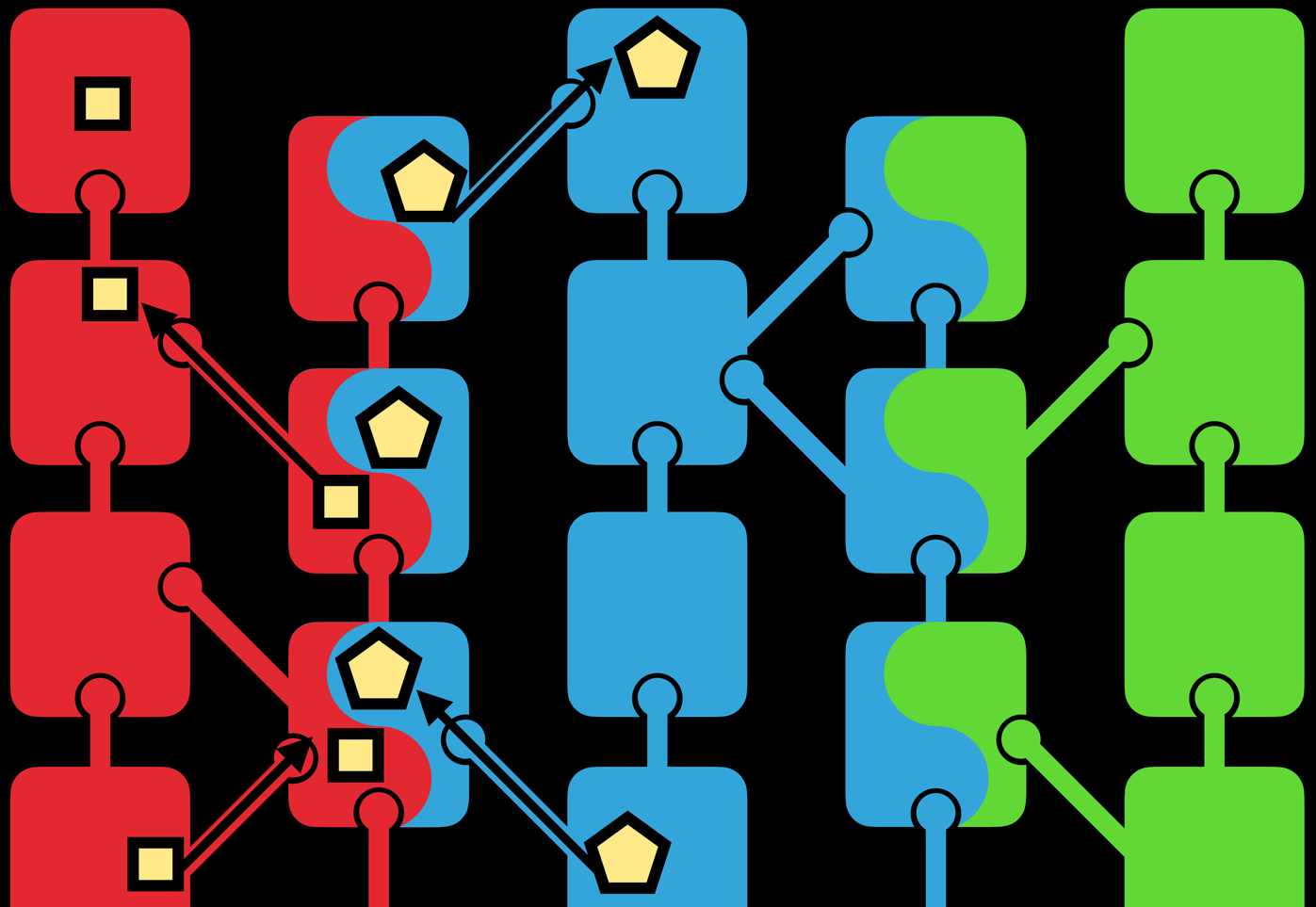
PROGRAMMING MODEL

- Locking State
  - Locks held by chimera chain
  - Maintains liveness
  - Re-usable



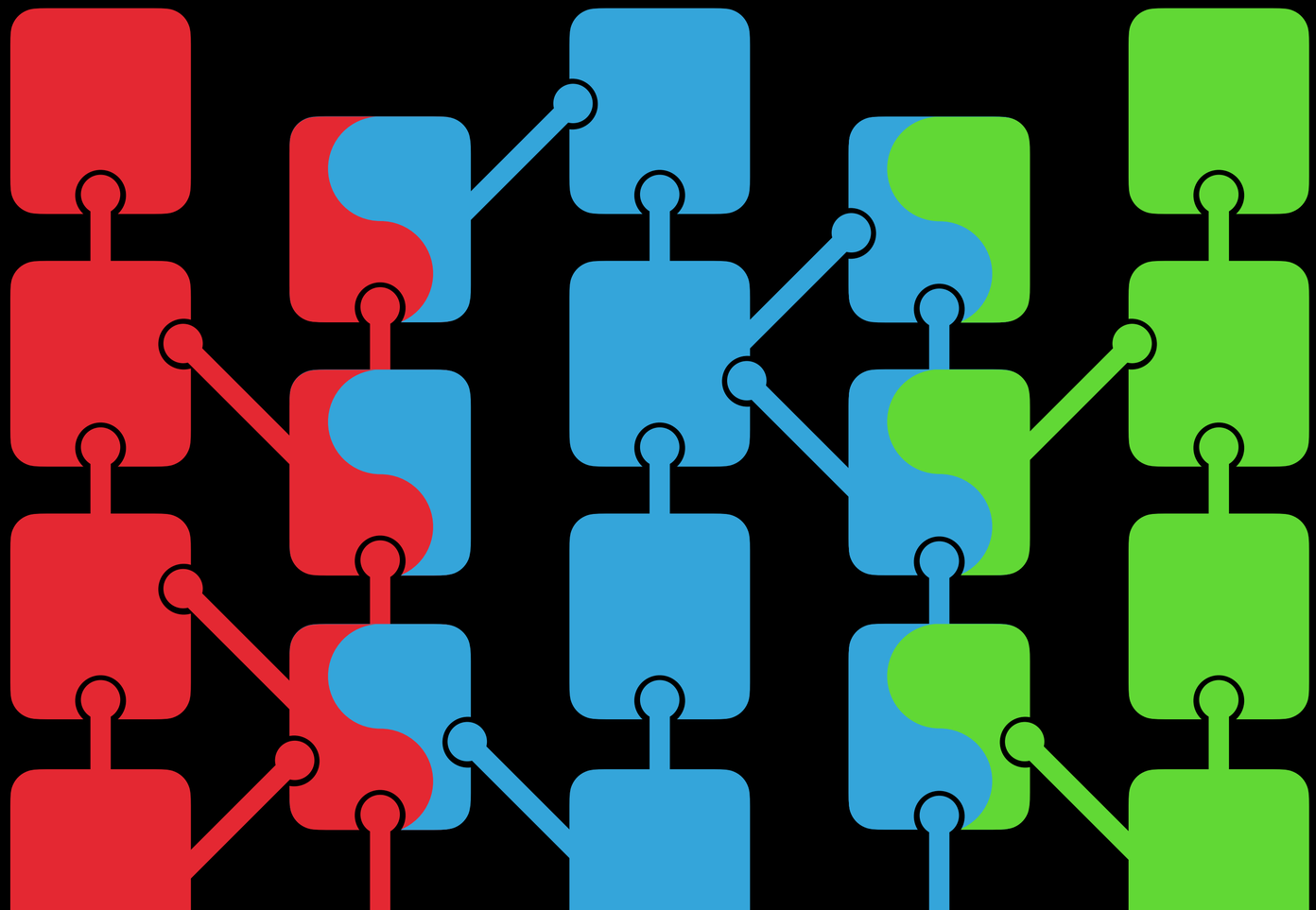
PROGRAMMING MODEL

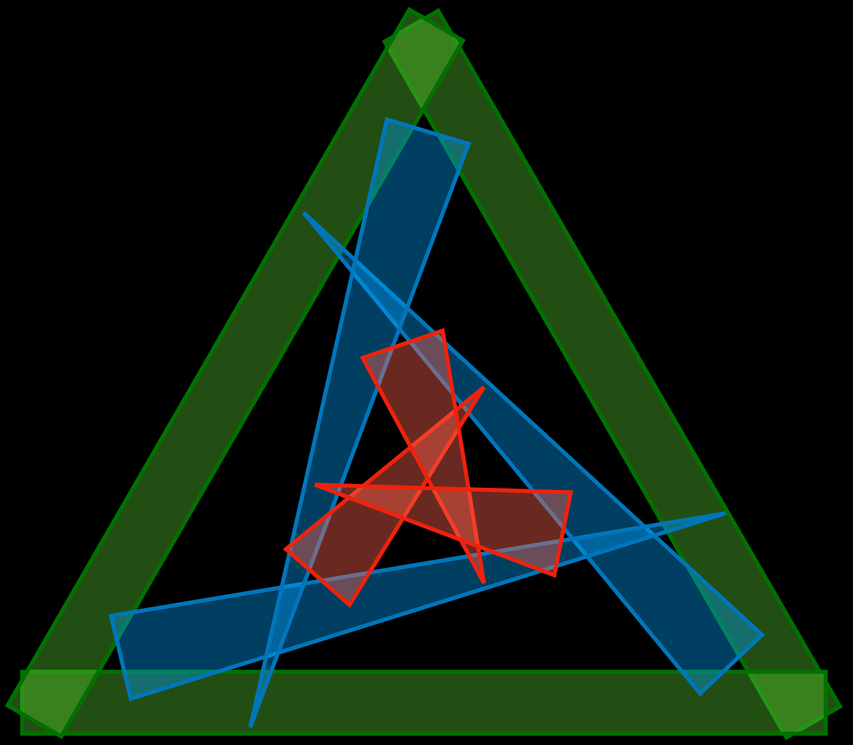
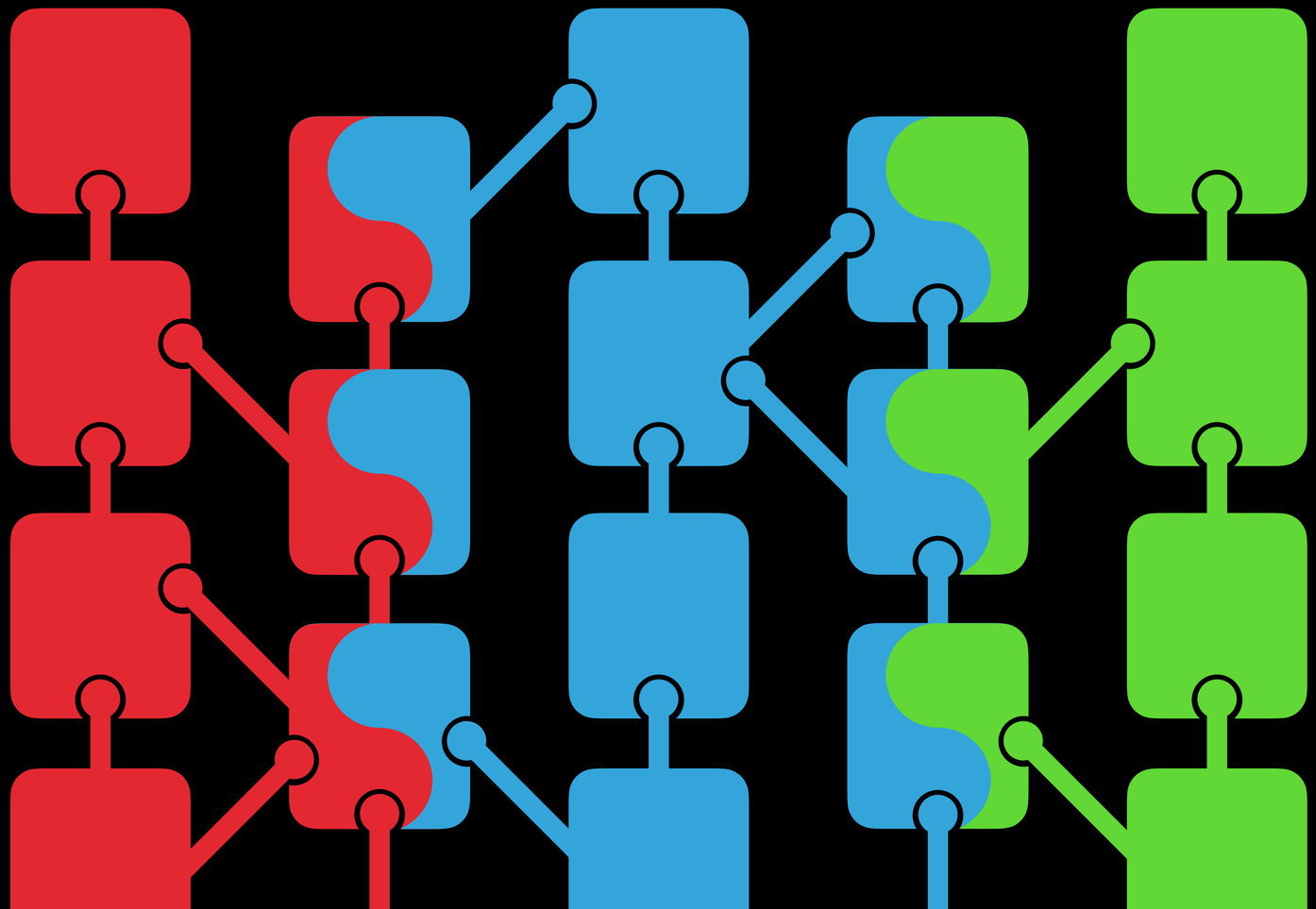
- Locking State
  - Locks held by chimera chain
  - Maintains liveness
  - Re-usable
- Moving Objects
  - Between state machines with same quorums
  - Synchronously (in blocks)



PRACTICAL QUESTIONS

- How to start an on-demand chain?
- Partially synchronous consensus on demand
- Gossiping and assembling atomic transaction bundles



CHIMERA CHAINS: MULTI-BLOCKCHAIN ATOMIC TRANSACTIONS

- No loss of liveness or integrity
- No global ordering
- No global integrity mechanism