Proof-of-Stake Sidechains

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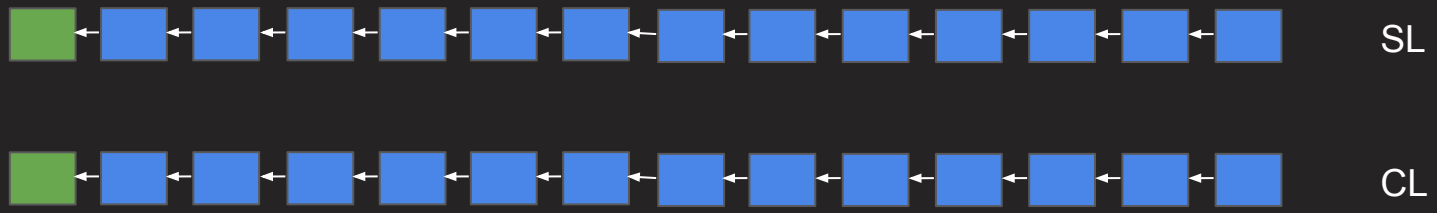
Motivation

- Imagine a **stake blockchain** where you want both the safety of Bitcoin and the features of Ethereum
- We start with one chain, the “Settlement layer”

- The SL is a safe, limited-feature blockchain
- We want to create a *network* of blockchains

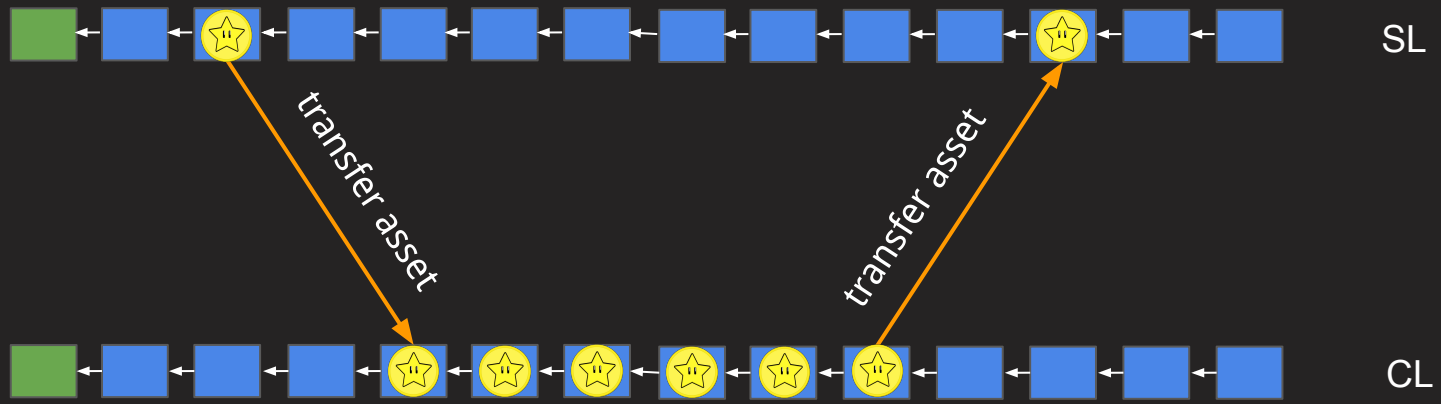
Motivation

- We introduce the “Computation Layer”, a different blockchain
- CL will be a feature-rich smart contract chain



We need to move money between SL/CL

1. move 1 coin from SL to CL

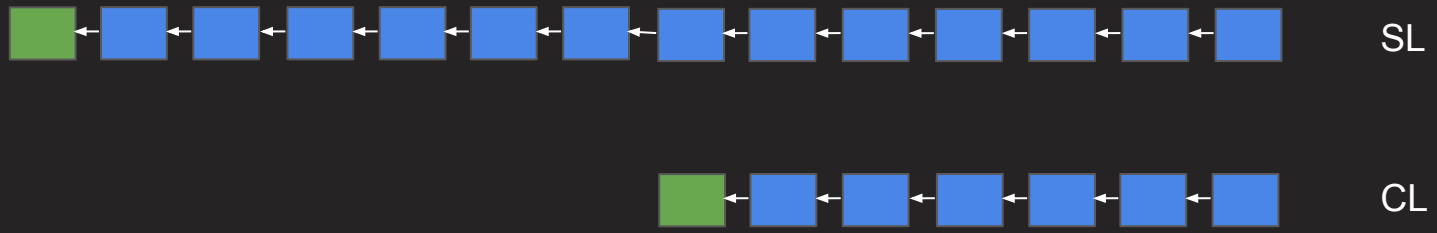


2. move 1 coin around within CL
   enjoy smart contract functionality

3. move 1 coin from CL **back** to SL

We need to move money between SL/CL

- CL will begin with its own Genesis block when it’s ready



Two types of nodes

- Full nodes will come in two flavours:
  - “SL nodes”: Only monitor SL blockchain
  - “SCL nodes”: Monitor both SL and CL blockchains

Cross-chain transactions [out]

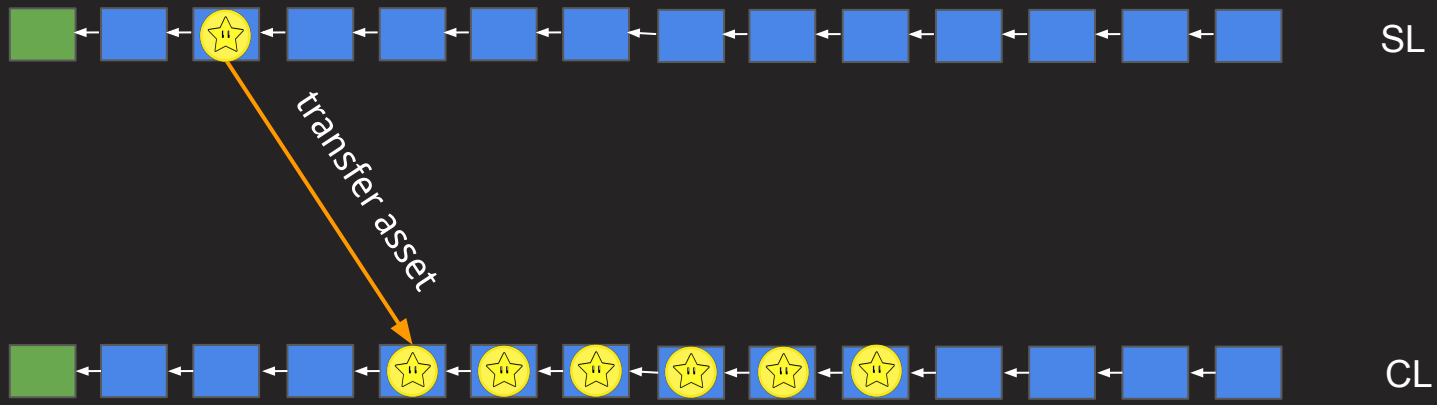
1. Money moves around in regular transactions in SL
2. A special transaction “destroys” money on the SL
3. A follow-up transaction “creates” new (corresponding) money on the CL

Cross-chain transactions [in]

1. Money moves around in regular transactions in CL
2. A special transaction “destroys” money on CL
3. A follow-up transaction “creates” new (corresponding) money on the SL

Direct observation

- SCL nodes can *see* outgoing transactions from SL



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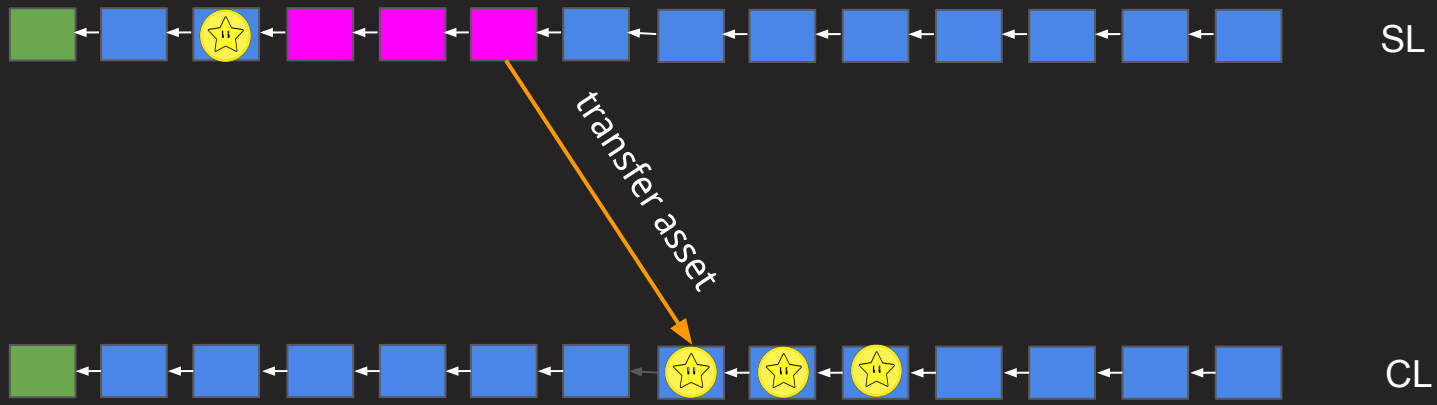
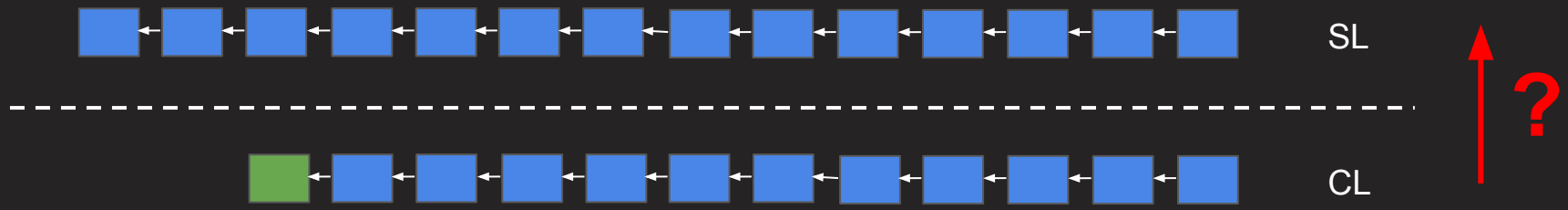


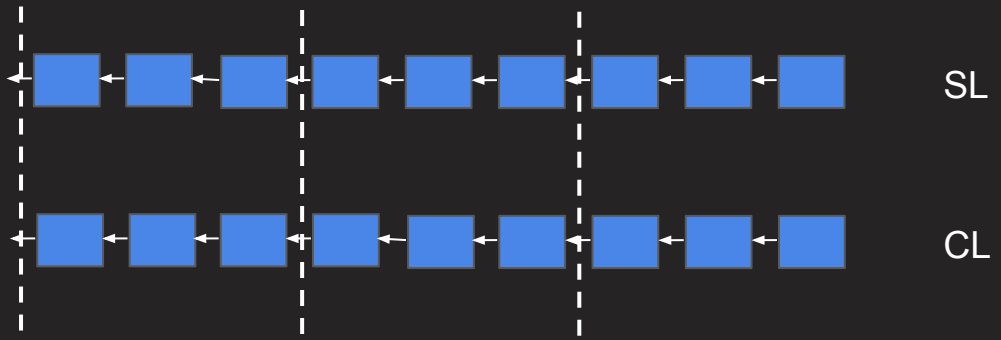
The isolation problem

- SL nodes do not download CL blocks
- How can they learn about CL transactions?
- This is necessary so that SL can unlock the money in SL



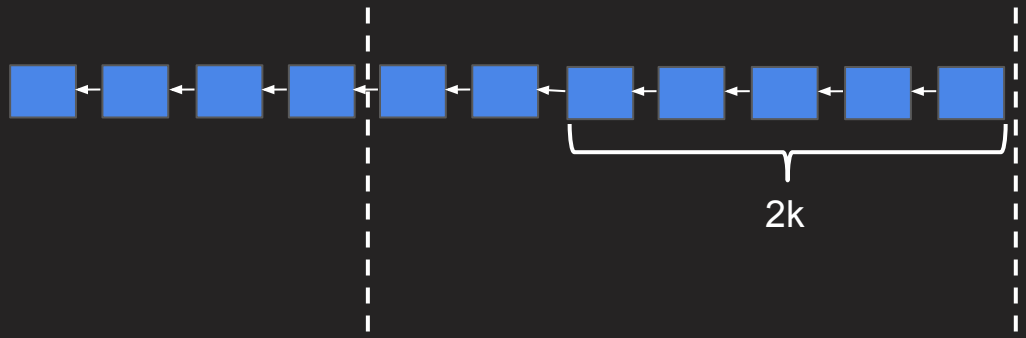
Epoch synchronization

- We synchronize the epochs between SL / CL



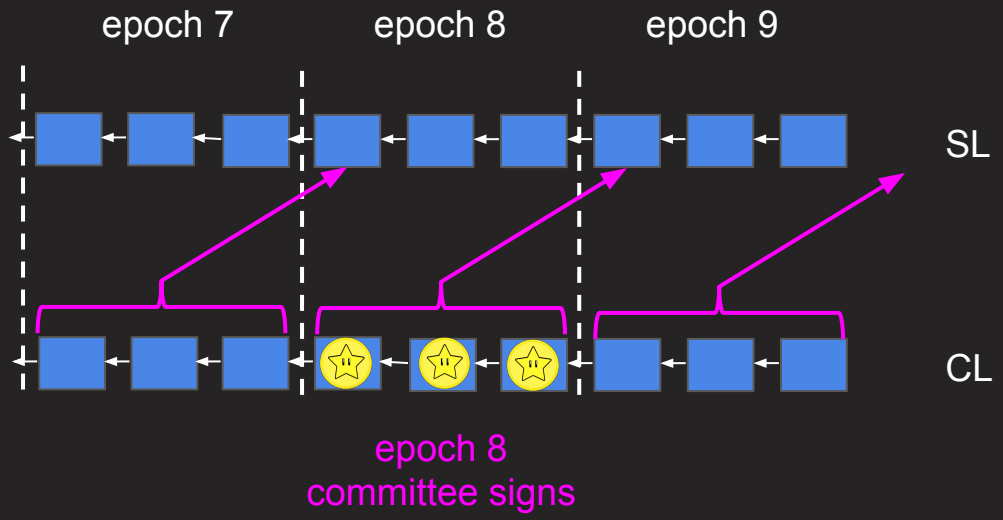
The epoch committee

- **Basic idea**: Each epoch elects a small CL committee
  which represents the epoch
- The committee is probabilistic and representative of the stake
  It's more probable you will be in the committee if you have large stake
- How to elect?
  - Sample the last *2k* slots of epoch
  - Those *2k* slot leaders constitute the committee
- "Honest majority" of stake translates to "honest majority" in the committee
- Committee is temporary -- changes once per epoch


2k

Certificate-based cross-chain communication

- CL epoch committee *signs off* transactions destroying money in CL
- These signatures are submitted to the SL
- The signature is transmitted across chains once per epoch



Transfer of control

How do the SL nodes verify incoming transactions?

- SL nodes know what the CL committee is for each epoch
- SL nodes know the CL committee at CL Genesis
- In addition to the transactions,
  the old committee *signs off* the new committee at every epoch
- This passes control from the old committee to the new committee

The firewall property

- If the CL has a catastrophic failure, incoming money is limited to the outgoing amount
- The SL nodes keep count of how much money has left SL
- No more money can come back
- This ensures the *macroeconomic* properties of SL are maintained even if CL fails

References

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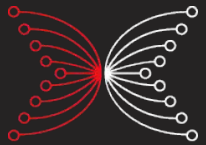
  Compact Superblock Storage for NIPoPoW Applications, MARBLE 2019

45DC 00AE FDDF 5D5C B988 EC86 2DA4 50F3 AFB0 46C7

Thanks! Questions?



INPUT | OUTPUT

CARDANO

National and Kapodistrian
University of Athens

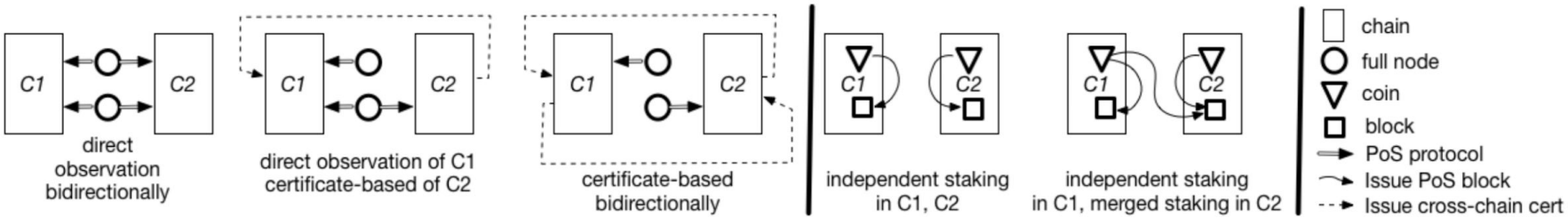


Fig. 1: Deployment options for PoS Sidechains.

Definition 8 (Pegging security). *A system-of-ledgers protocol Π for $\{\mathbf{L}_i\}_{i\in[n]}$ is* pegging-secure *with liveness parameter $u \in \mathbb{N}$ with respect to:*

- *a set of assumptions $\mathbb{A}_i$ for ledgers $\{\mathbf{L}_i\}_{i\in[n]}$,*
- *a merge mapping $\mathsf{merge}(\cdot)$,*
- *validity languages $\mathbb{V}_{\mathsf{A}}$ for each $\mathsf{A} \in \bigcup_{i\in[n]} \mathsf{Assets}(\mathbf{L}_i)$,*

if for all PPT adversaries, all slots t and for $\mathcal{S}_t \triangleq \{i : \mathbb{A}_i[t] \text{ holds}\}$ we have that except with negligible probability in the security parameter:

Ledger persistence: *For each $i \in \mathcal{S}_t$, $\mathbf{L}_i$ satisfies the persistence property.*
Ledger liveness: *For each $i \in \mathcal{S}_t$, $\mathbf{L}_i$ satisfies the liveness property parametrized by u.*
Firewall: *For all $\mathsf{A} \in \bigcup_{i\in\mathcal{S}_t} \mathsf{Assets}(\mathbf{L}_i)$,*

$$\pi_{\mathsf{A}}\left(\mathsf{merge}\left(\{\mathbf{L}_i^{\cup}[t] \ : \ i \in \mathcal{S}_t\}\right)\right) \in \pi_{\mathcal{S}_t}(\mathbb{V}_{\mathsf{A}}) \ .$$