Snappy
Fast On-chain Payments with Practical Collaterals

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Cryptocurrencies based on permissionless blockchains could

- Decentralize the global financial system
- Reduce trust assumptions
- Increase operational transparency
- Improve user privacy

Open Challenges

	Centralized Processors	Permissionless Blockchains
Throughput	Thousands of txs/sec	Tenths of txs/sec
Latency	Confirmation in <3 sec	Minutes to finality
Privacy	Trusted third party needed	[0, full privacy)

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- *Retail Payments*
- *Point-of-Sale Purchases*
- *Time-critical Transactions*

On-chain Improvements

- e.g., Proof-of-Stake, Sharding
- Improve the throughput of the blockchain.
- Improve latency only under a relaxed threat model.

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No improvement in latency under the original threat model.

Layer 2 Protocols

- Move transactions off the chain.
- Use the blockchain only when necessary.
- High-throughput and low-latency.

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Payment channels

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- Pre-deposit their future expenditure.

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Payment networks, **Payment hubs, Side-chains**

- Incompatible with the unilateral nature of retail payments (no rebalancing).
- Additional trust assumptions.

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- Low latency (<2 secs) suitable for retail payments.
- Operates on top of low-throughput and high-latency blockchains.
- Future on top of high-throughput and high/mid-latency blockchains.

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Key Features

- No changes to the underlying consensus protocol. ✔
- No additional trust assumptions. ✔
- No additional operational requirements. ✔

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Key Features

- No changes to the underlying consensus protocol. ✓
- No additional trust assumptions. ✓
- No additional operational requirements. ✓
- Small opportunity cost.
- Requires smartcontract language.

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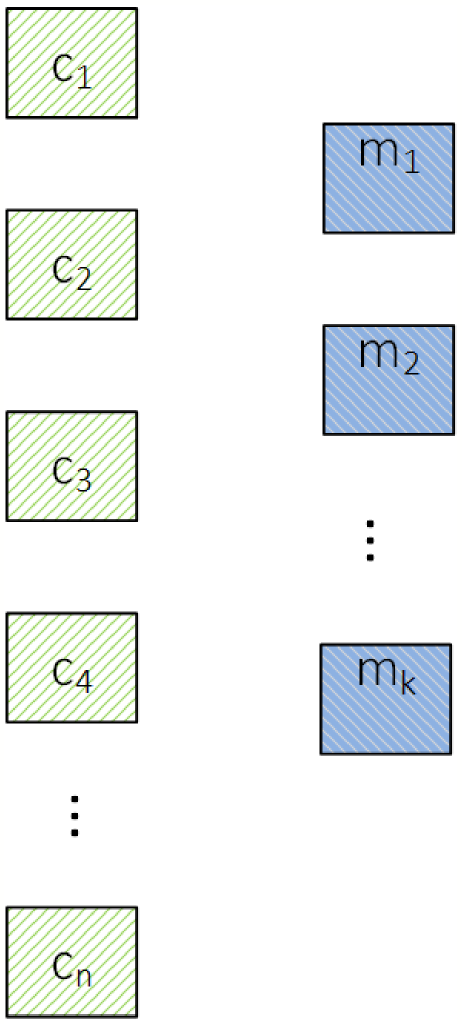
Application scenarios

- ❖ A large number of users (e.g., 1,000,000 customers).
- ❖ A moderate set of recipients (e.g., 100 merchants).



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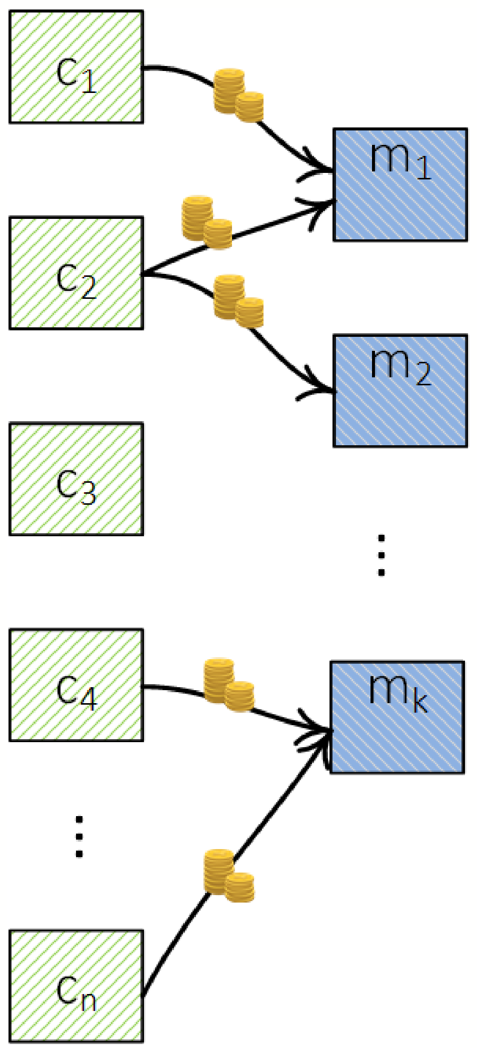

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- ❖ Users pay the recipients.
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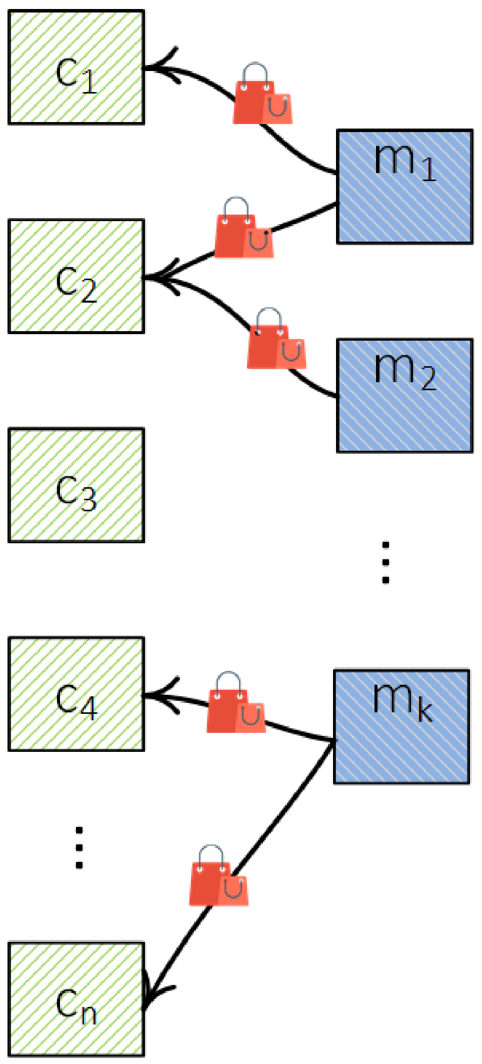
- ❖ The recipients give the products, once they receive the funds.



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- Block interval (e.g., ~13 seconds for Ethereum)
- Probabilistic finality (>1 confirmations)
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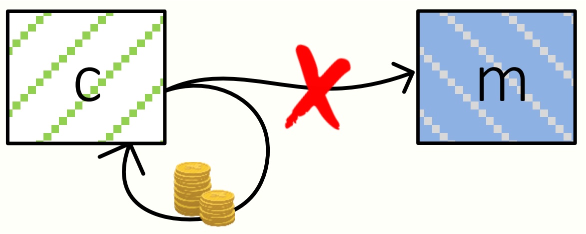

Trivial Solutions

- Convince your supermarket to trust you?
- Pre-deposit funds to your local supermarket?
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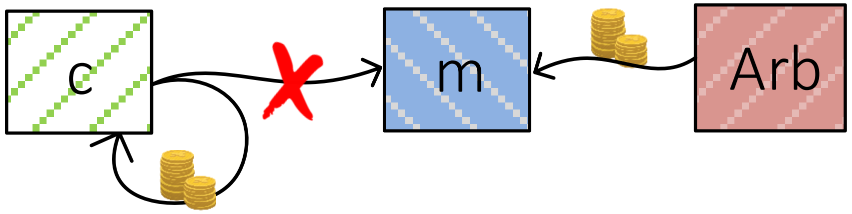
Can we do better?

- Customers keep their money in their wallet.
- Merchants guaranteed to get their money.
- No trust to/reliance on third parties.

Idea: Collaterals

1. Customer places collateral (e.g., $100) on a smartcontract.
2. Victim merchants can claim funds if the customer cheats.



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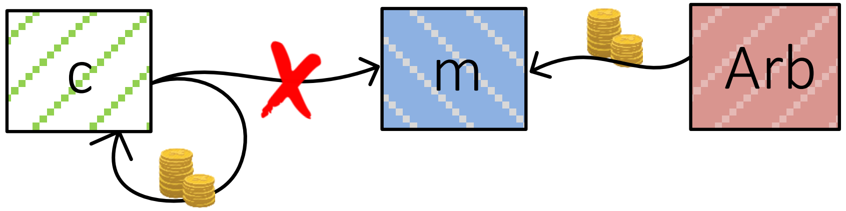
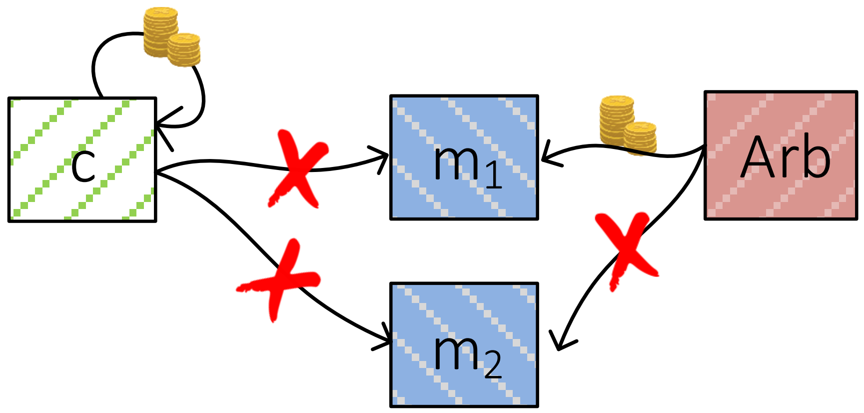


A settlement "claim" requires

- The payment transaction (given to the merchant by the customer).
- Its conflicting transaction (from the blockchain).
- In Ethereum, conflicting transactions share the same *nonce*.

The collateral is used only when doublespending!

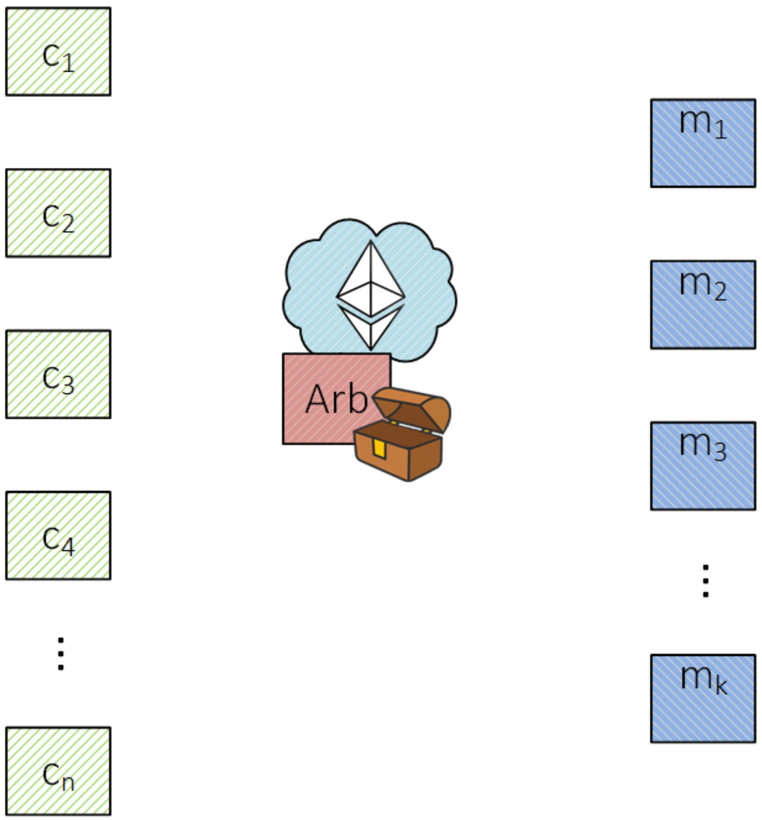
Triple-spending Attack



Scaling collaterals to multiple merchants

- Need to keep track of “pending” transactions.
- Merchants accept payment, if the collateral suffices for everyone.

Proposal #1: Trusted Merchants



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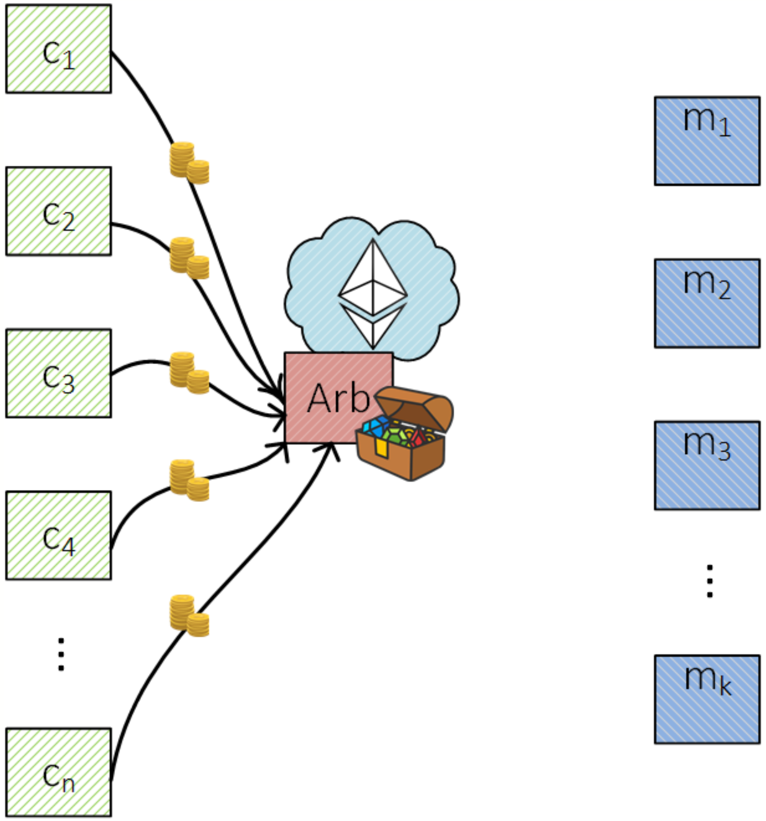

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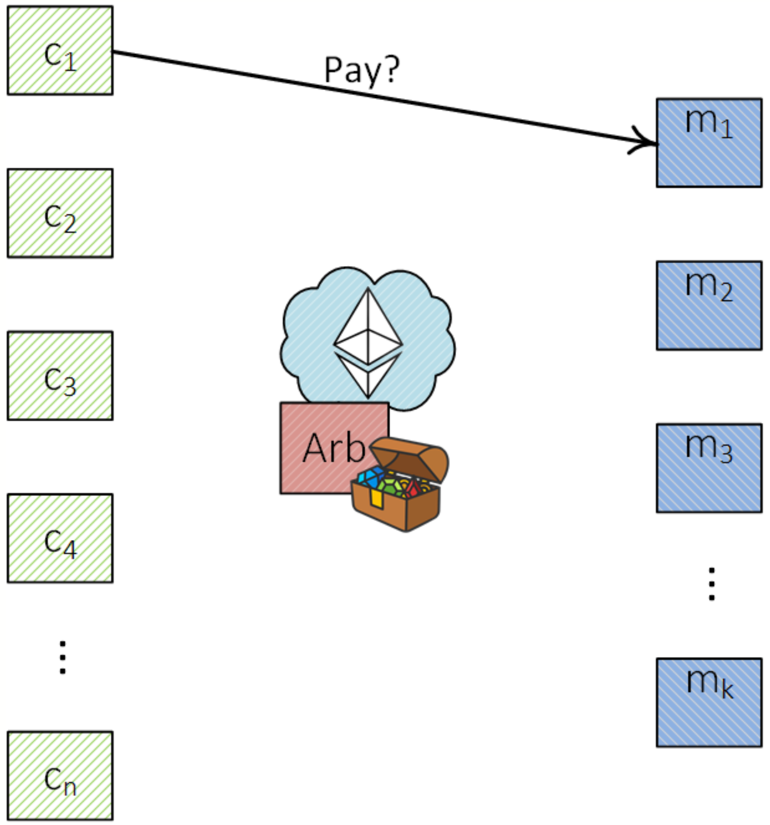

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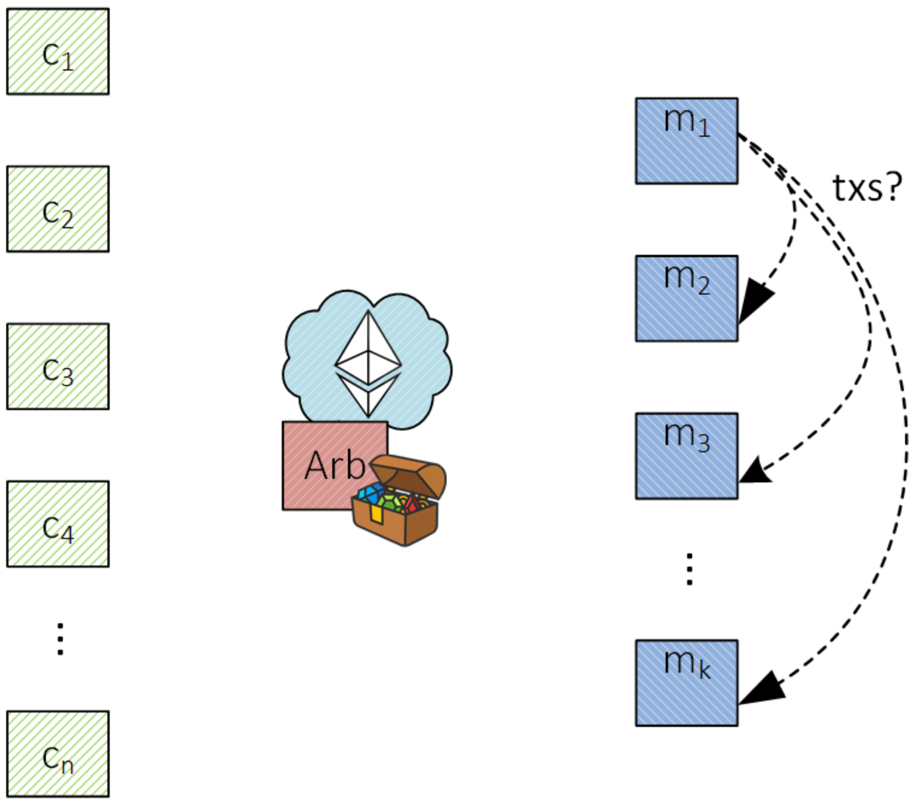

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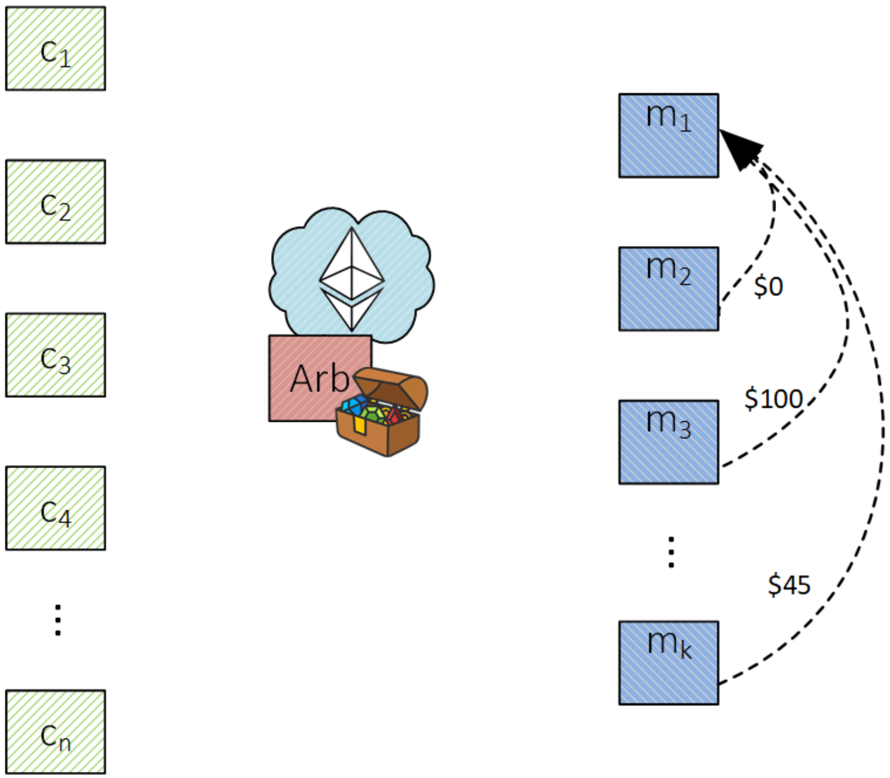

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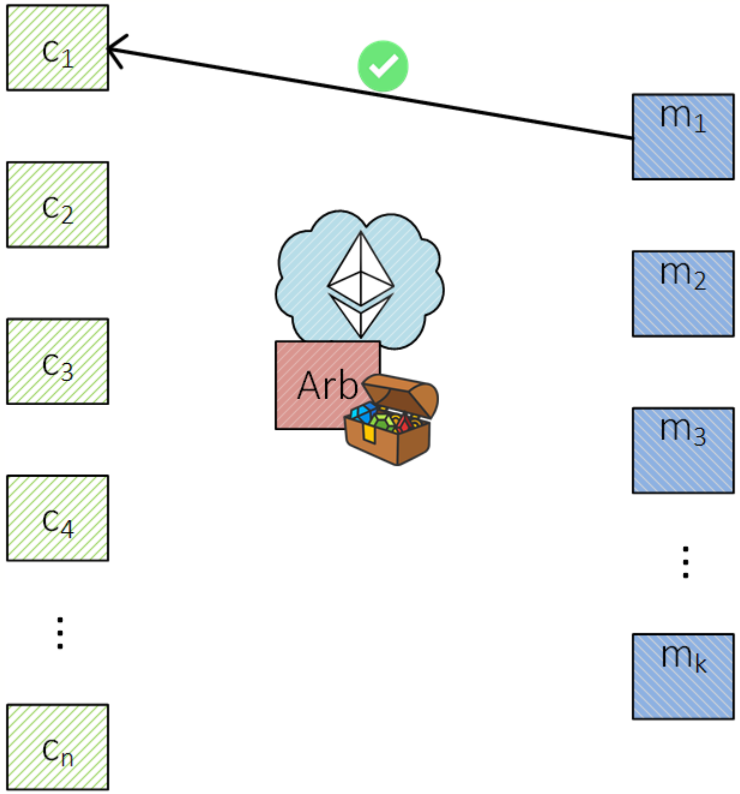

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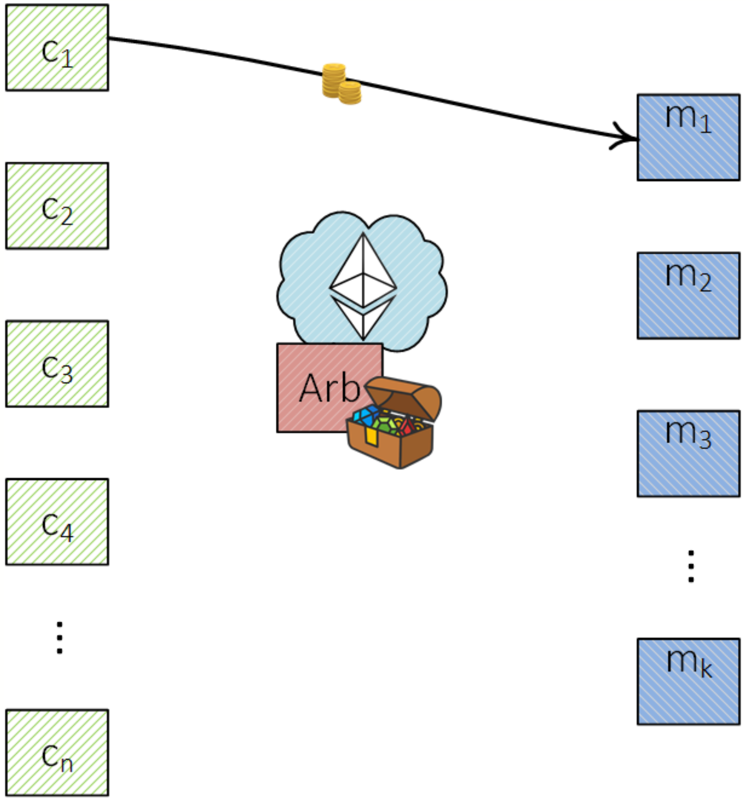


Proposal #1: Trusted Merchants

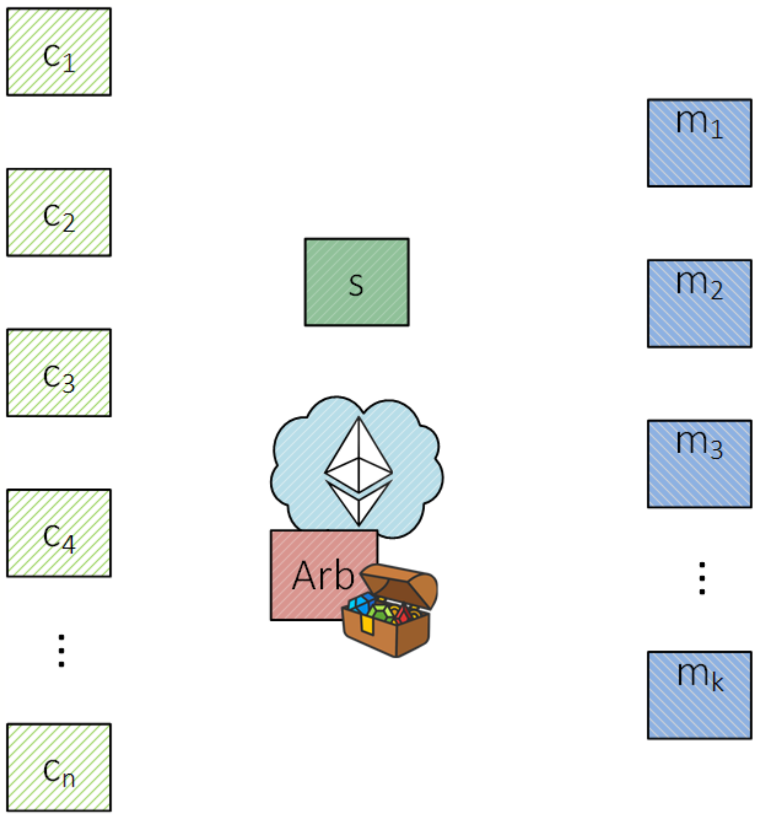
Drawbacks

- ❖ Assumes all merchants are trustworthy.
- ❖ Requires 100% availability of all merchants.

Side-chain variant

- ❖ Additional trust assumptions
- ❖ e.g., BFT -> 1/3 malicious merchants

Proposal #2: Trusted Third Party



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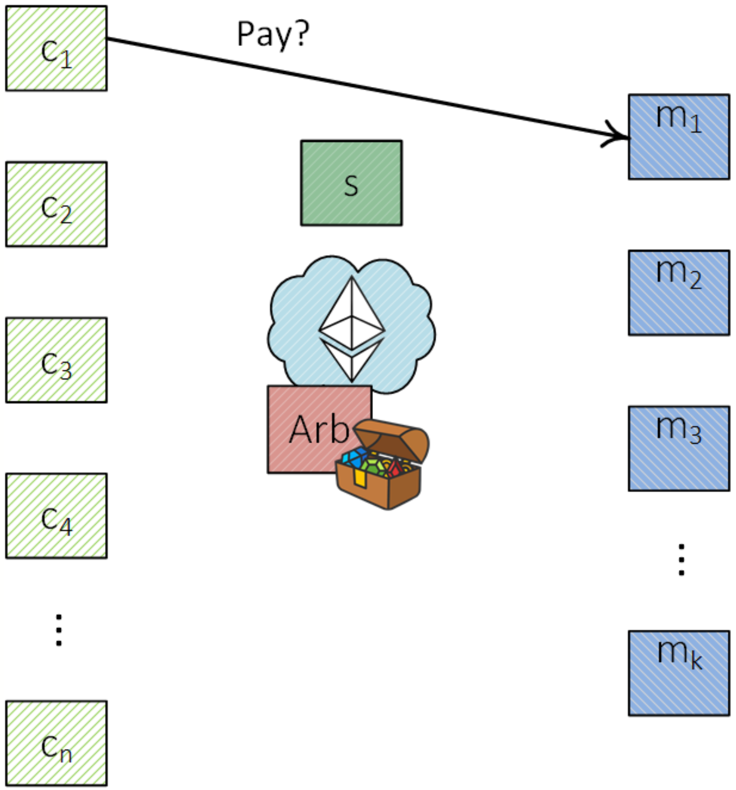

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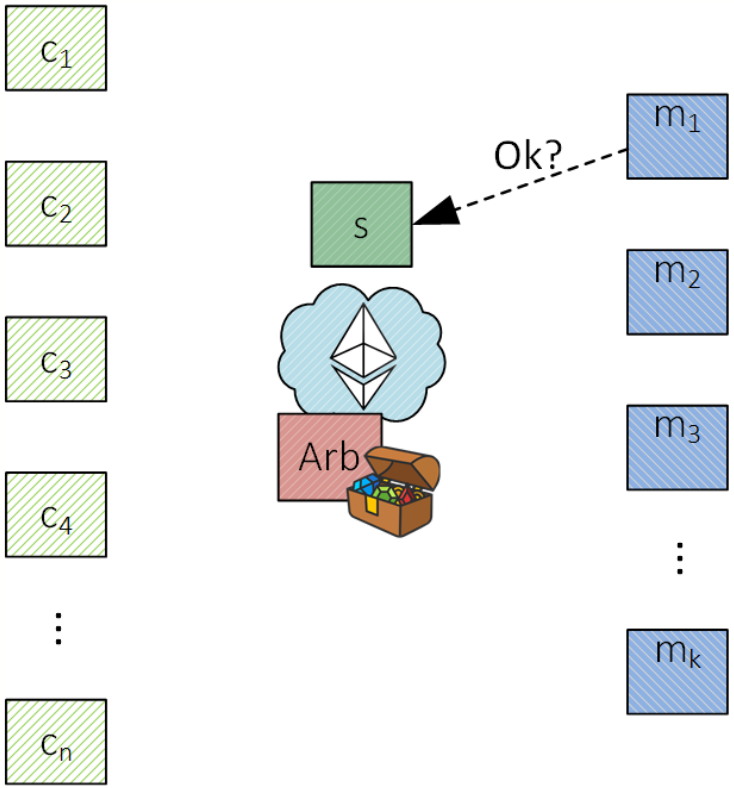

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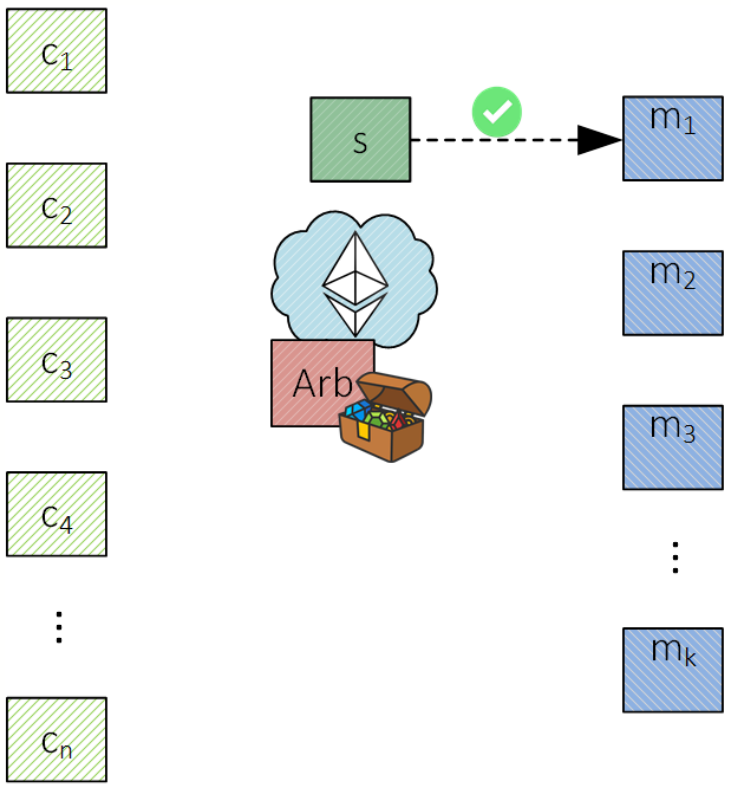

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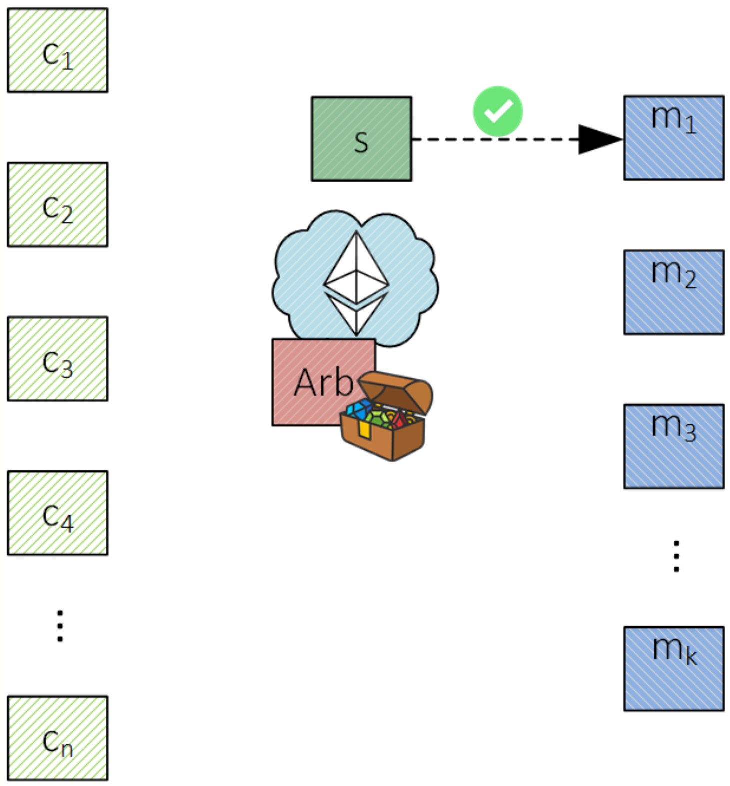
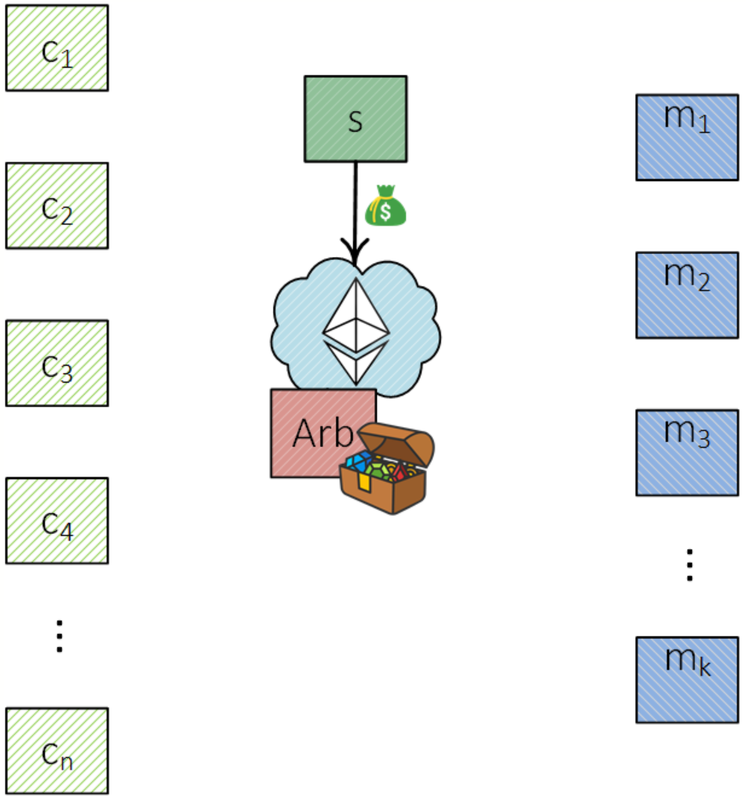


Drawbacks

- What if the statekeeper equivocates?
- What if the statekeeper colludes with customers?

Proposal #3: Untrusted Third Party

- Almost the same as before
- Statekeeper places collateral per merchant.
- If the customer's collateral get depleted, the statekeeper's collateral is used.



Proposal #3: Untrusted Third Party

- Almost the same as before
- Statekeeper places collateral <u>per merchant.</u>
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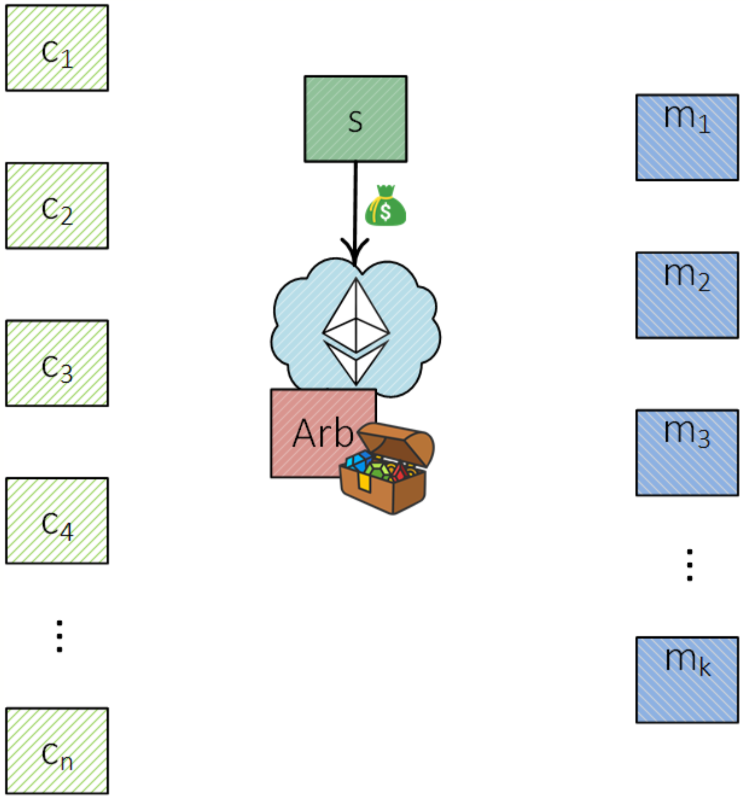
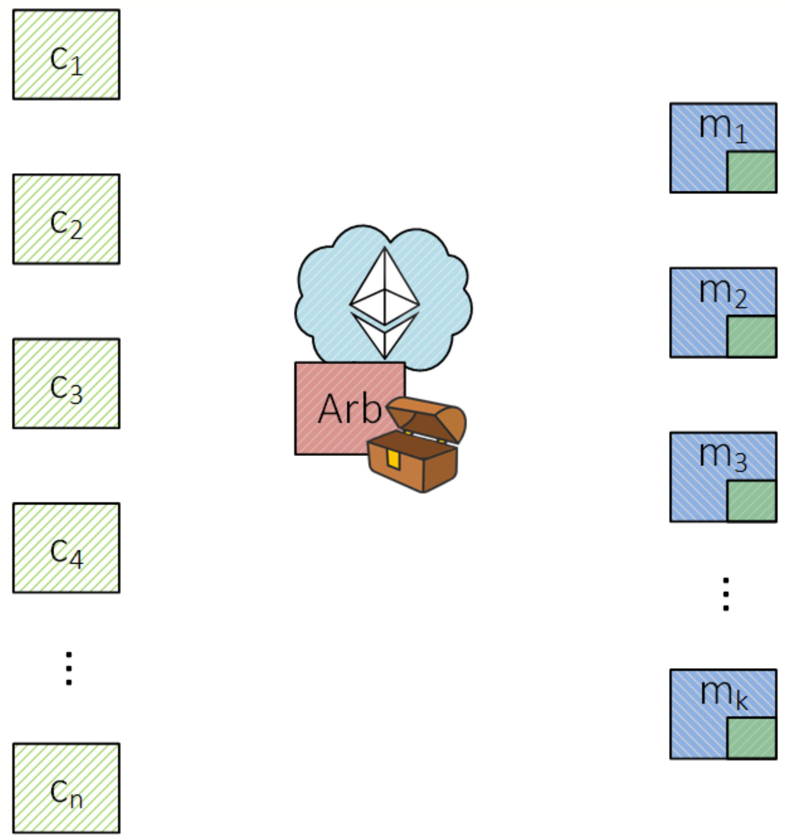


Drawbacks

- We still rely on a third party.

Snappy: Statekeeping Merchants



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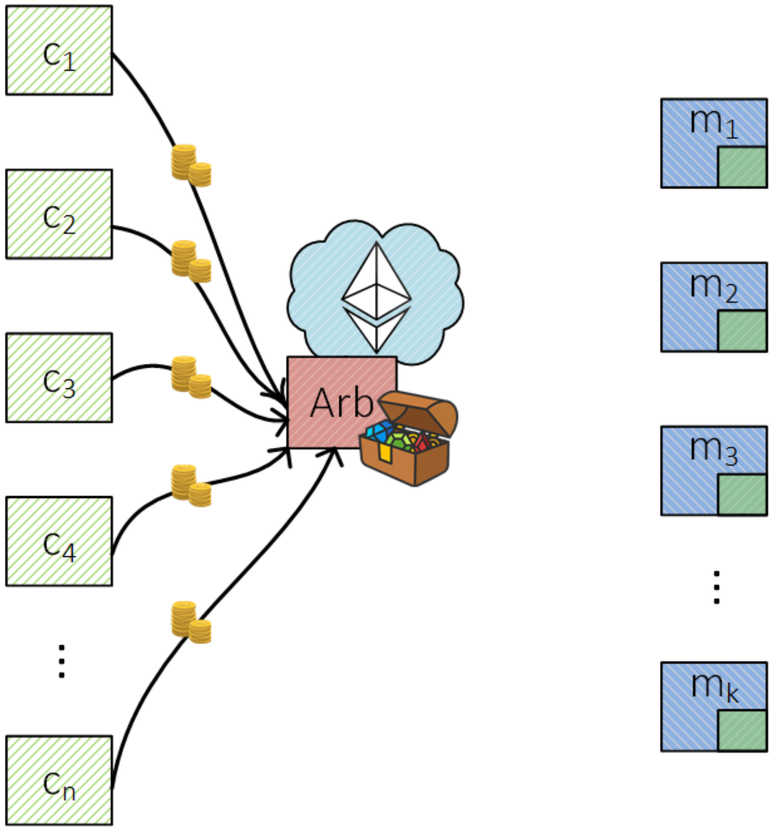

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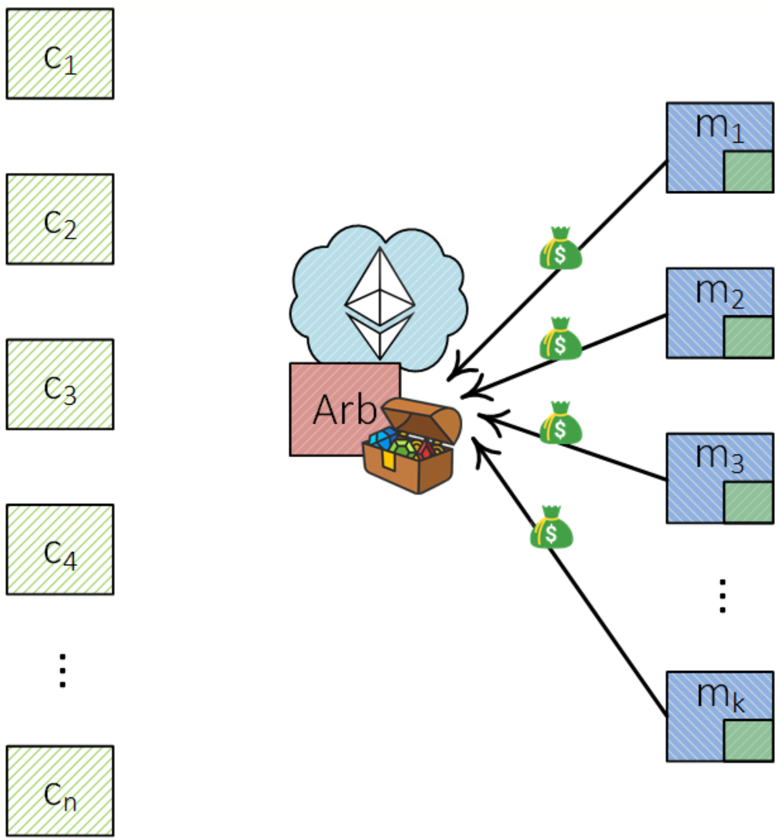

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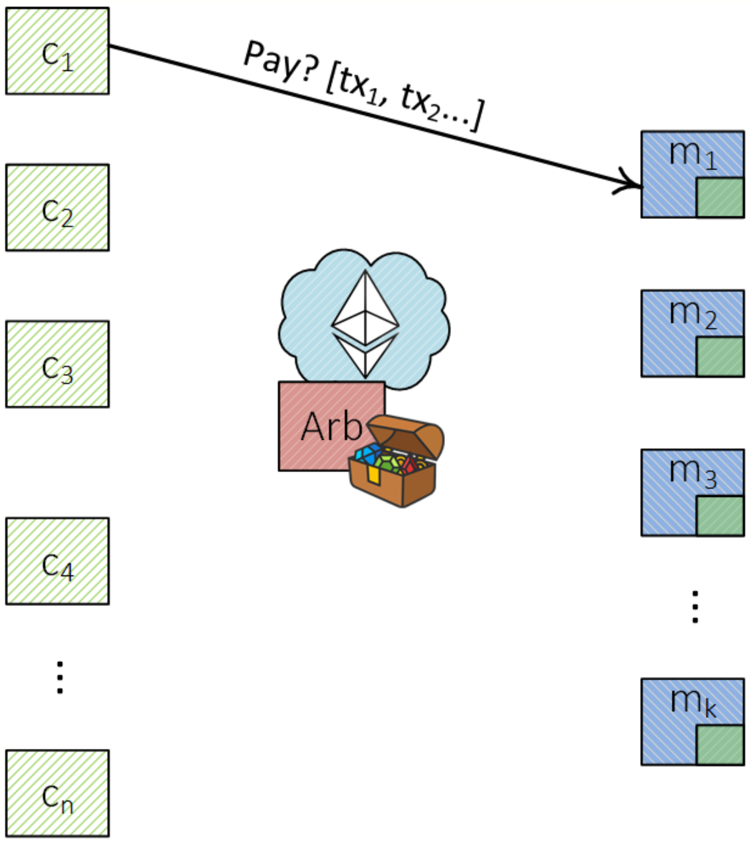

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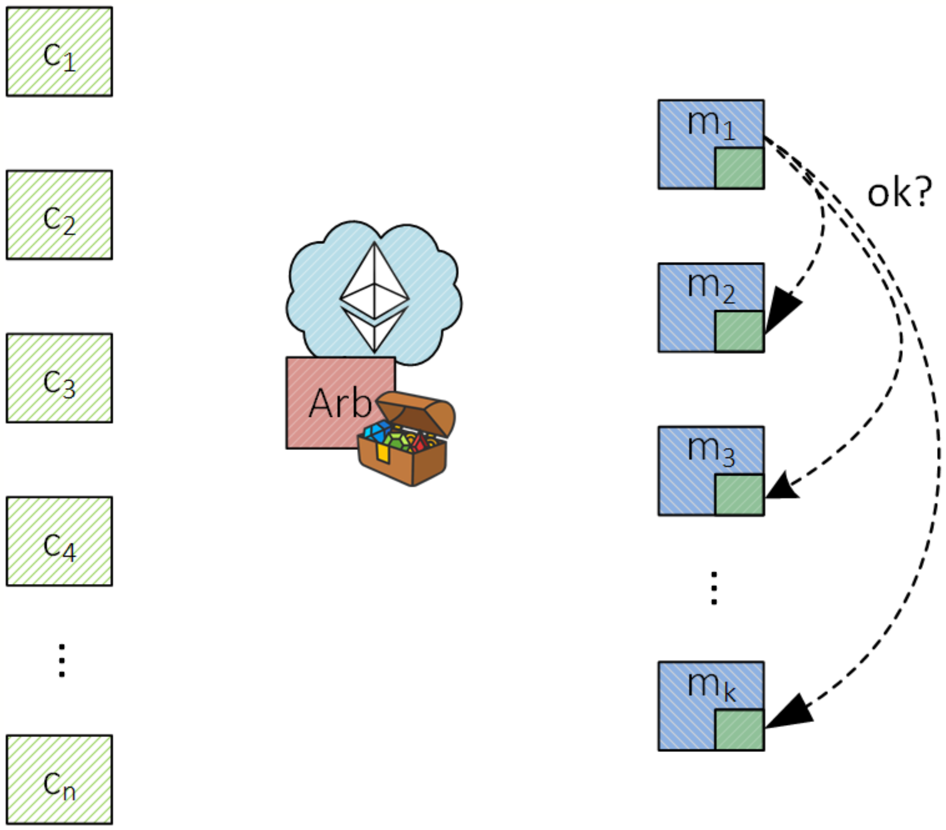

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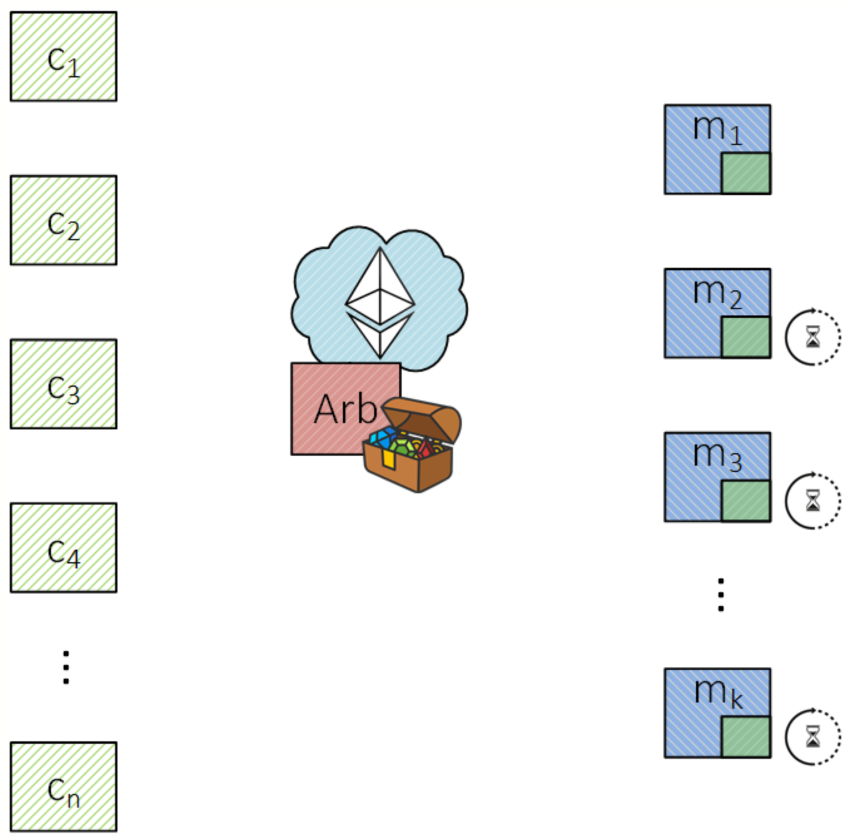

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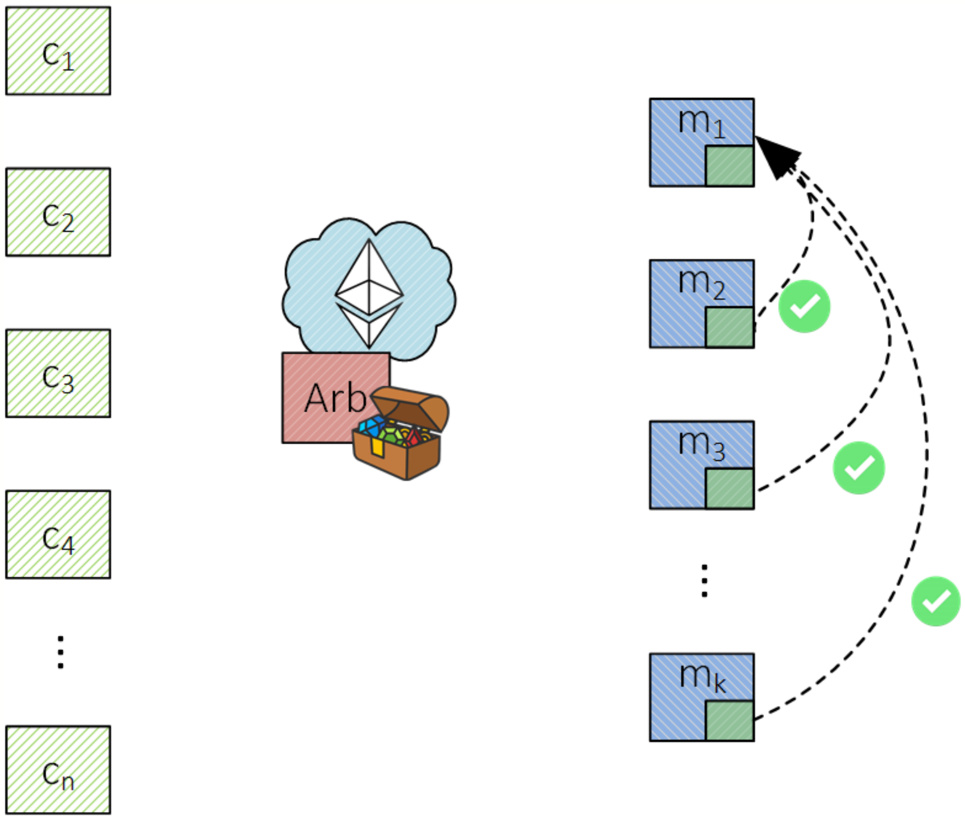

50%+1 Approvals

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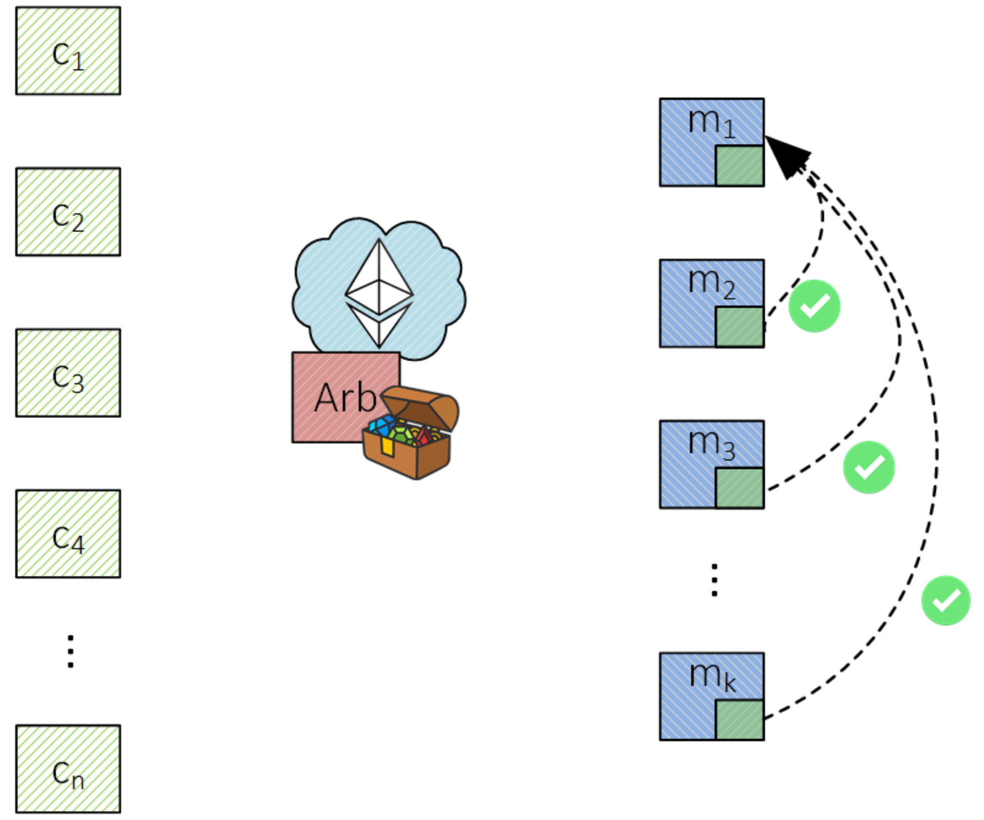
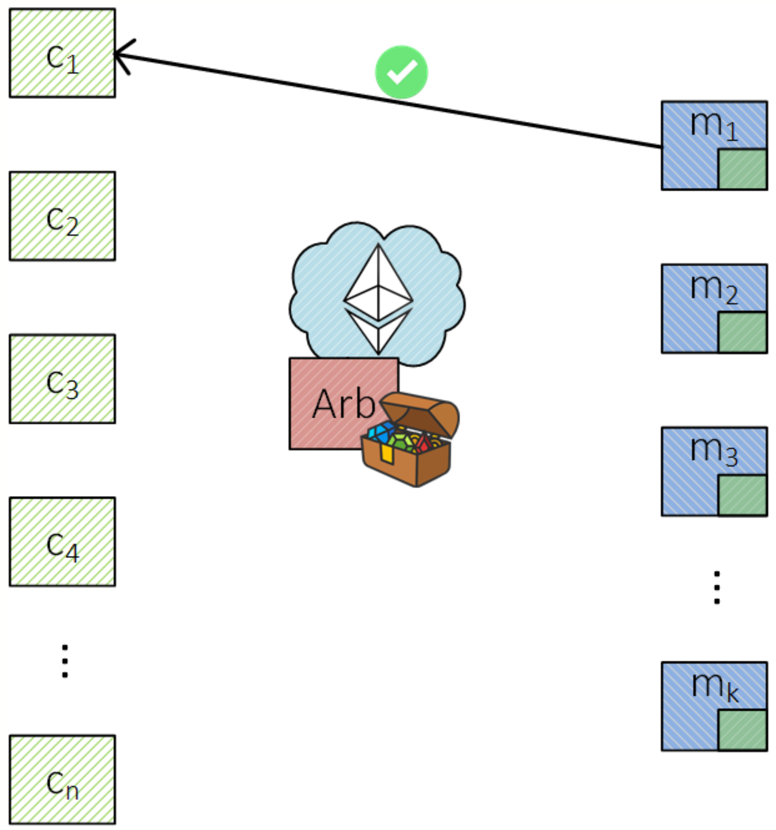


50%+1 Approvals

Approval: “I haven’t approved another transaction from c_1 with the same index number.”

Snappy: Statekeeping Merchants



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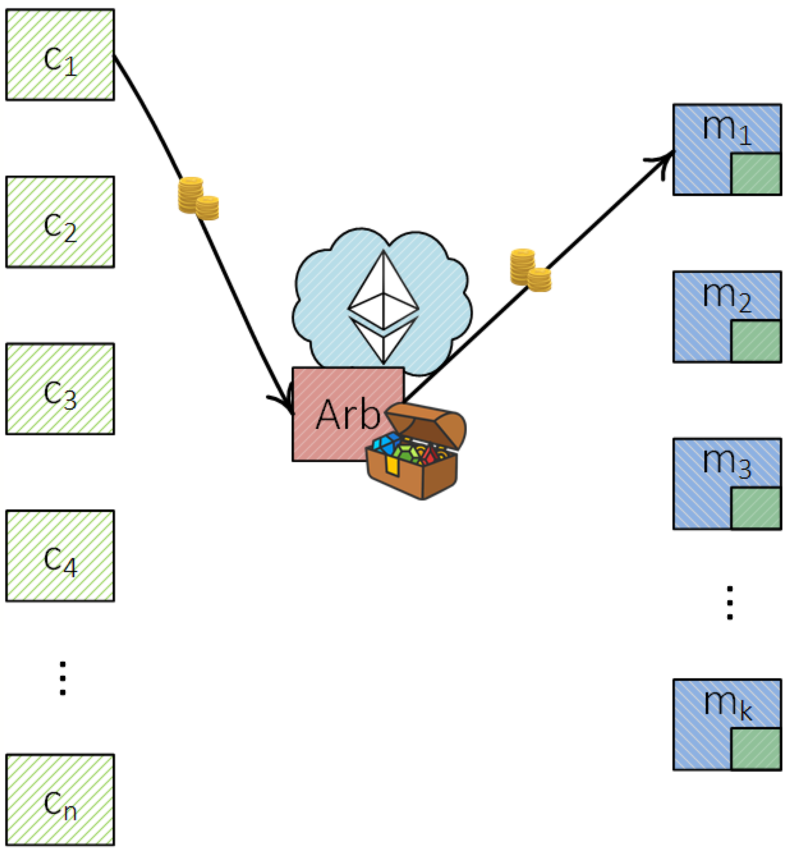
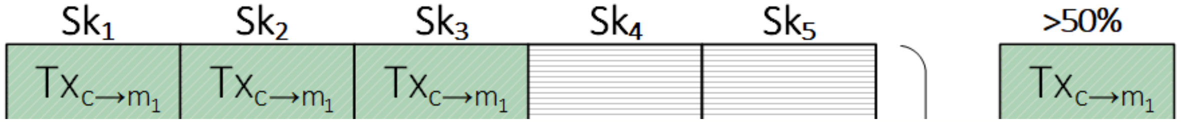


Proof of Merchant Equivocation



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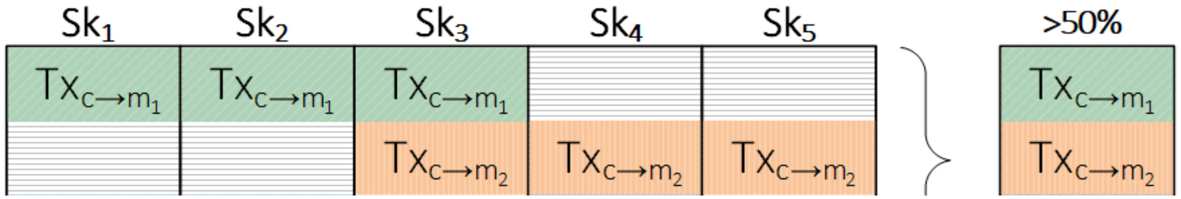

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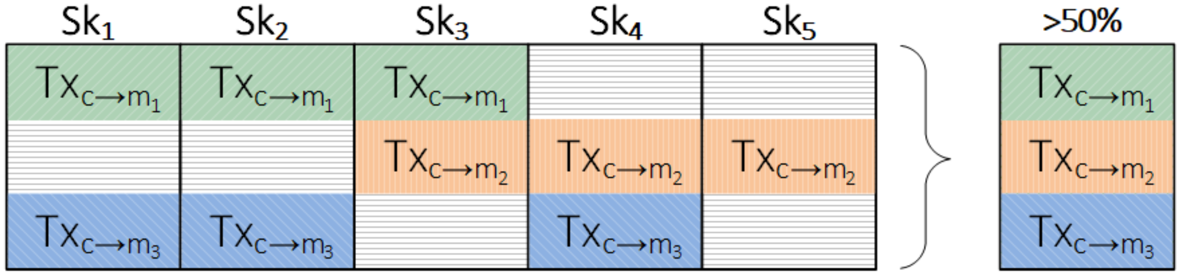
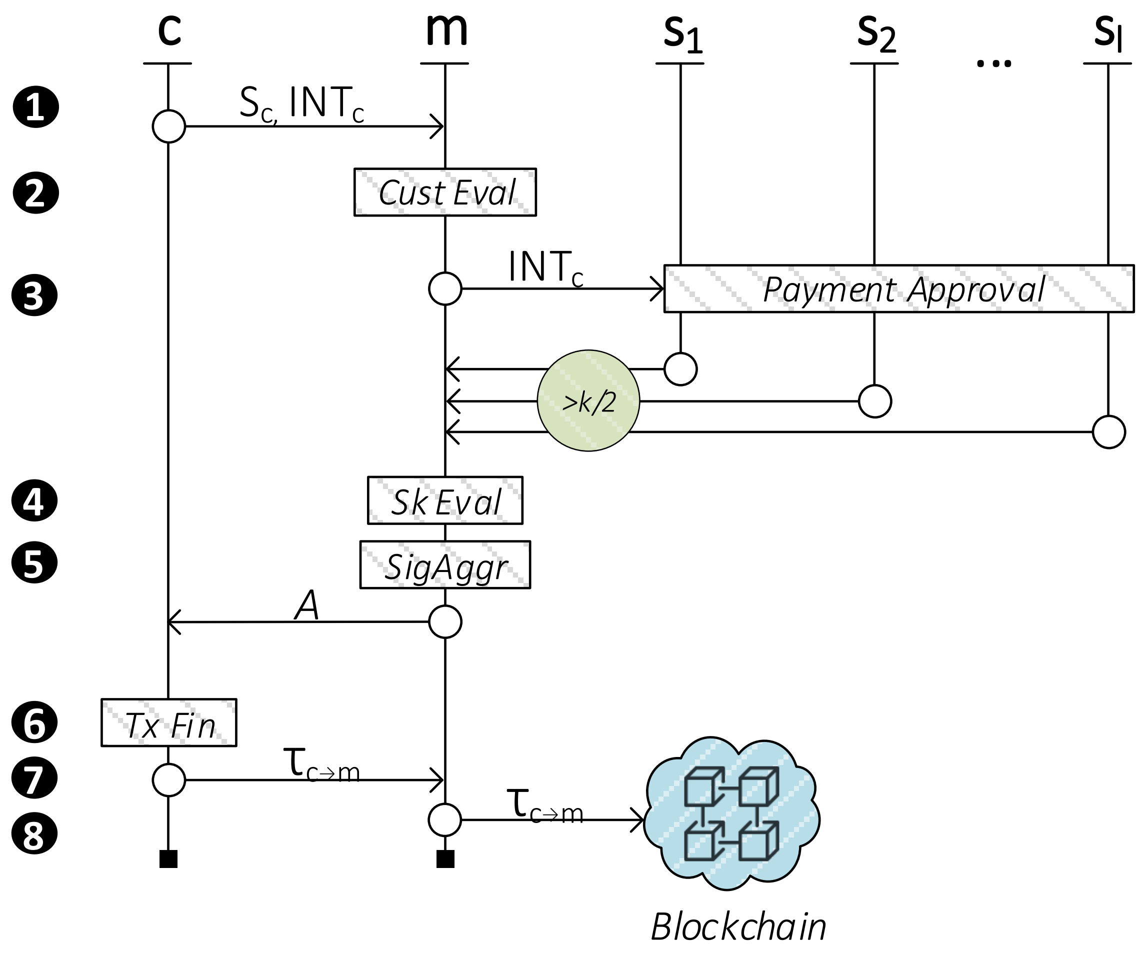


Approval Protocol

1. The customer initializes the payment.
2. Merchant verifies the collateral suffices.
3. Payment approval (50%+1).
4. Statekeeper evaluation.
5. Signature aggregation (e.g., BLS).
6. Customer signs final transaction.
7. Merchant verifies and completes checkout.
8. Transaction logged in blockchain and by the smartcontract.



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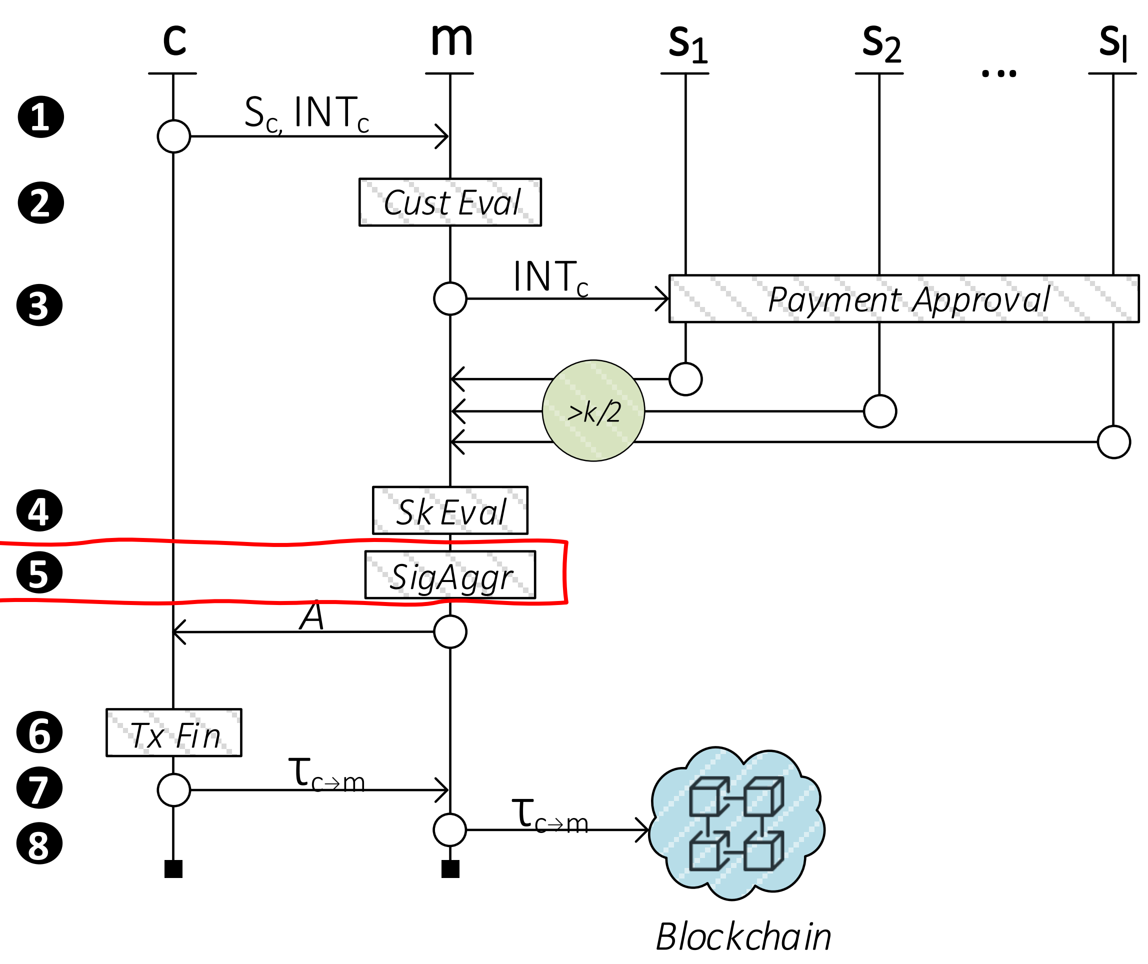
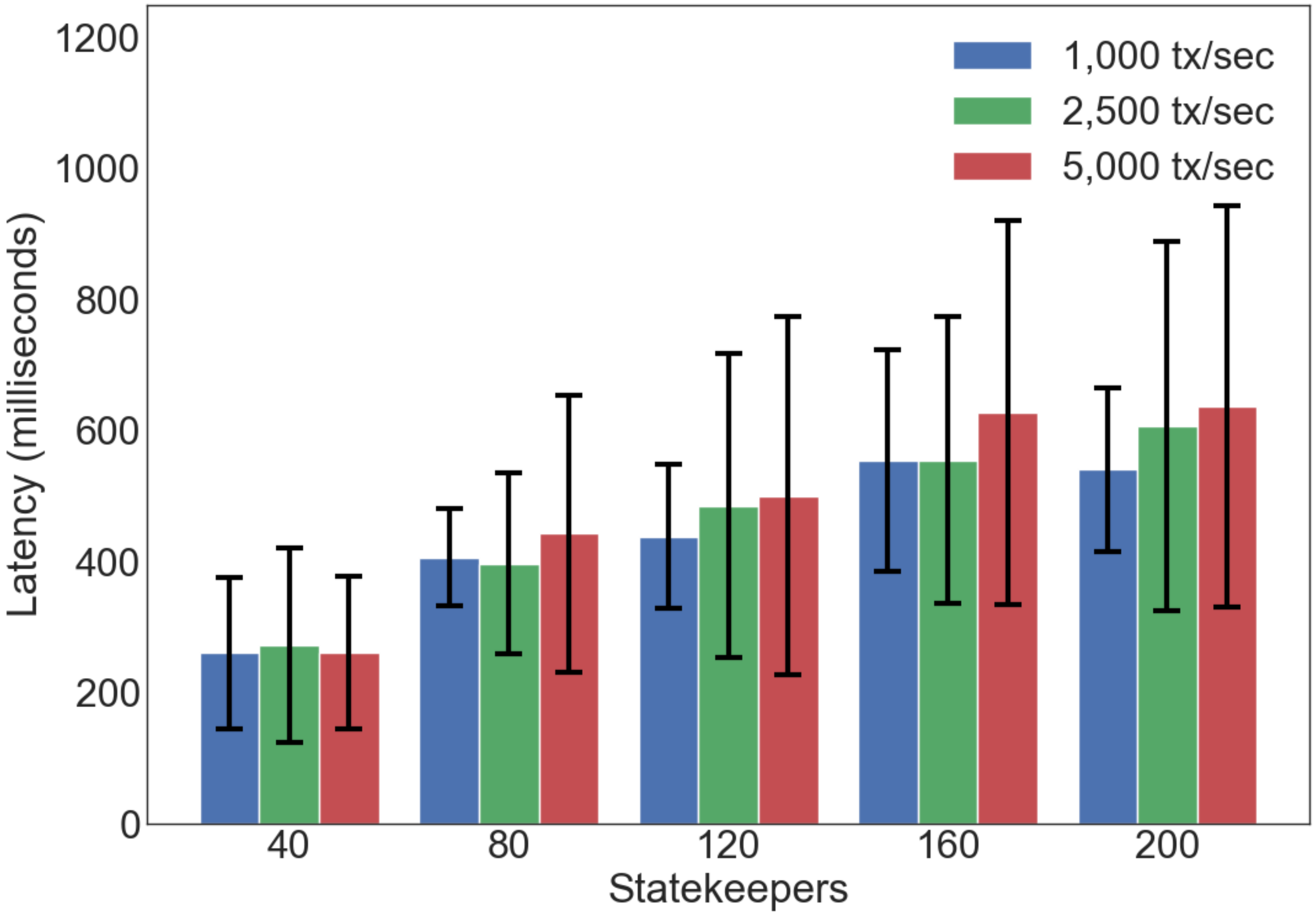


Scalability: Latency



Scalability: Small Collaterals

- Only need to cover the expenditure within the latency period.
- Reusable.
- Flexible.
- Independent of the number of customers.

Takeaways

- ❖ An honest merchant never loses funds.
- ❖ Deployable on top of existing blockchains (e.g.,Ethereum).
- ❖ No additional trust assumptions.
- ❖ Small amount of locked in funds.
- ❖ Very low latency.

Thank you! Questions?

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