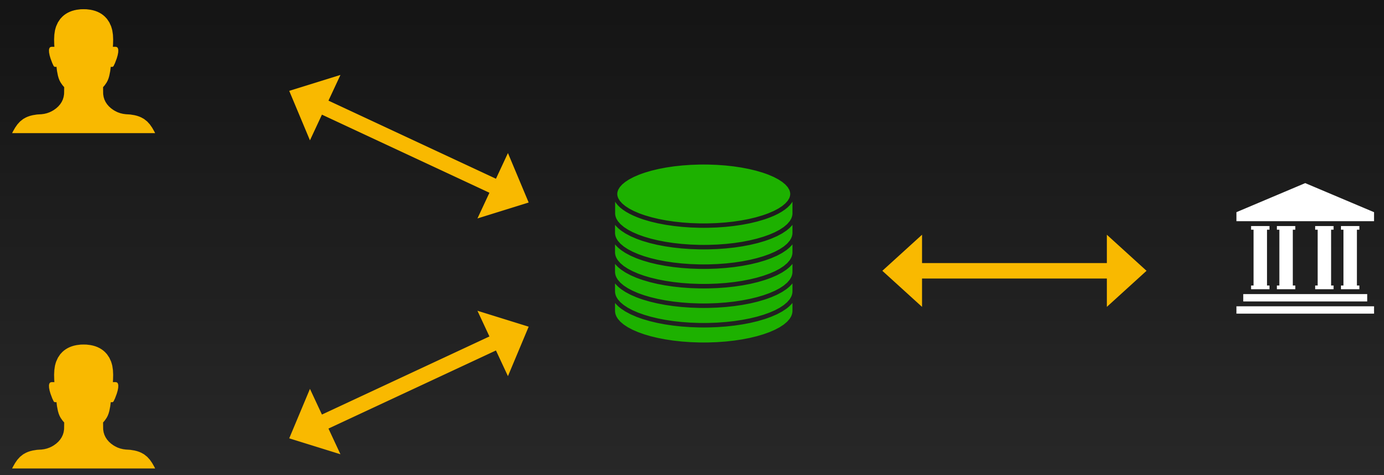
FastPay

High-Performance Byzantine Fault Tolerant Settlement

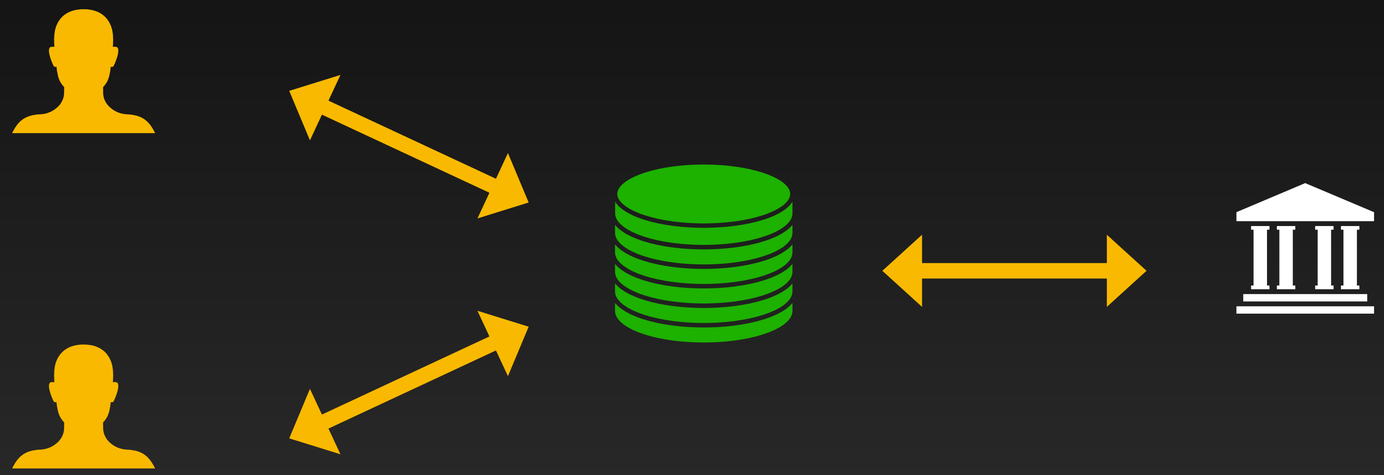
RTGS

A simplified view



RTGS

A simplified view

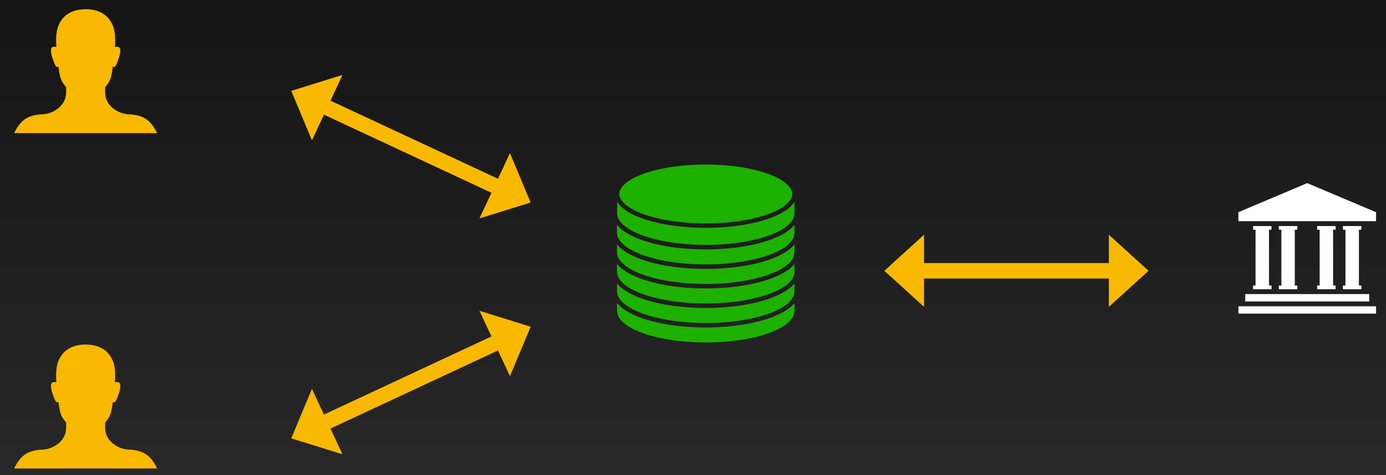


Very centralized

Low capacity (expensive)

RTGS

A simplified view

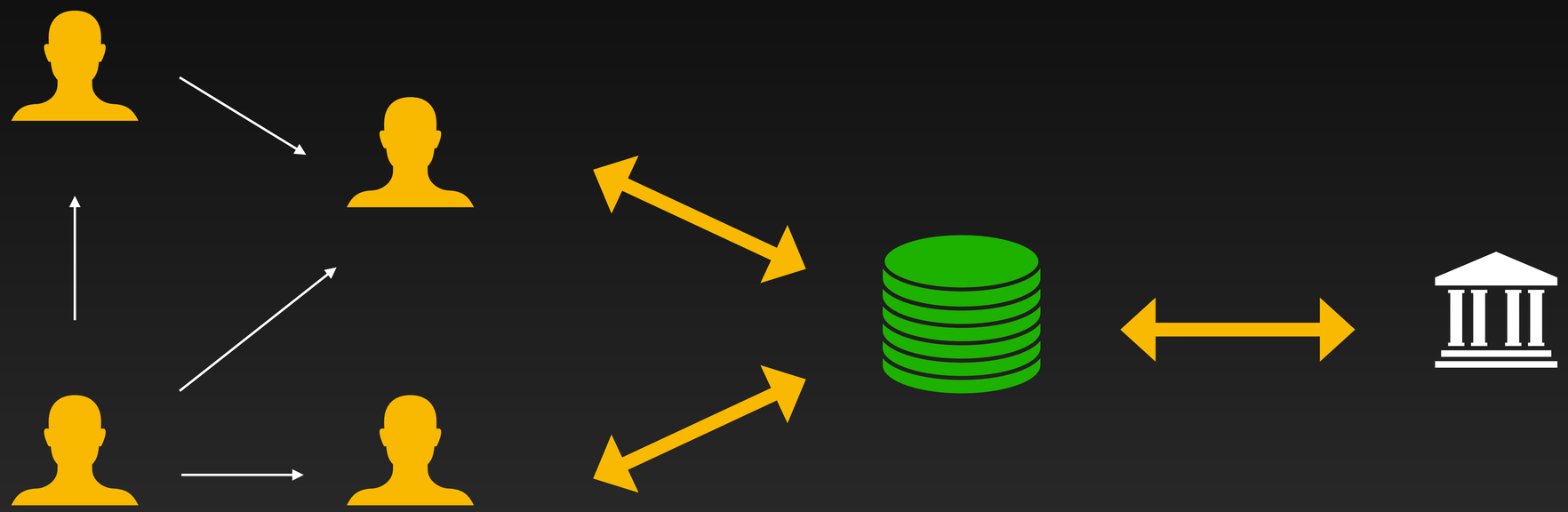


TPS: 500 tx/s

Latency: minutes

RTGS

A simplified view



TPS: 80,000 tx/s

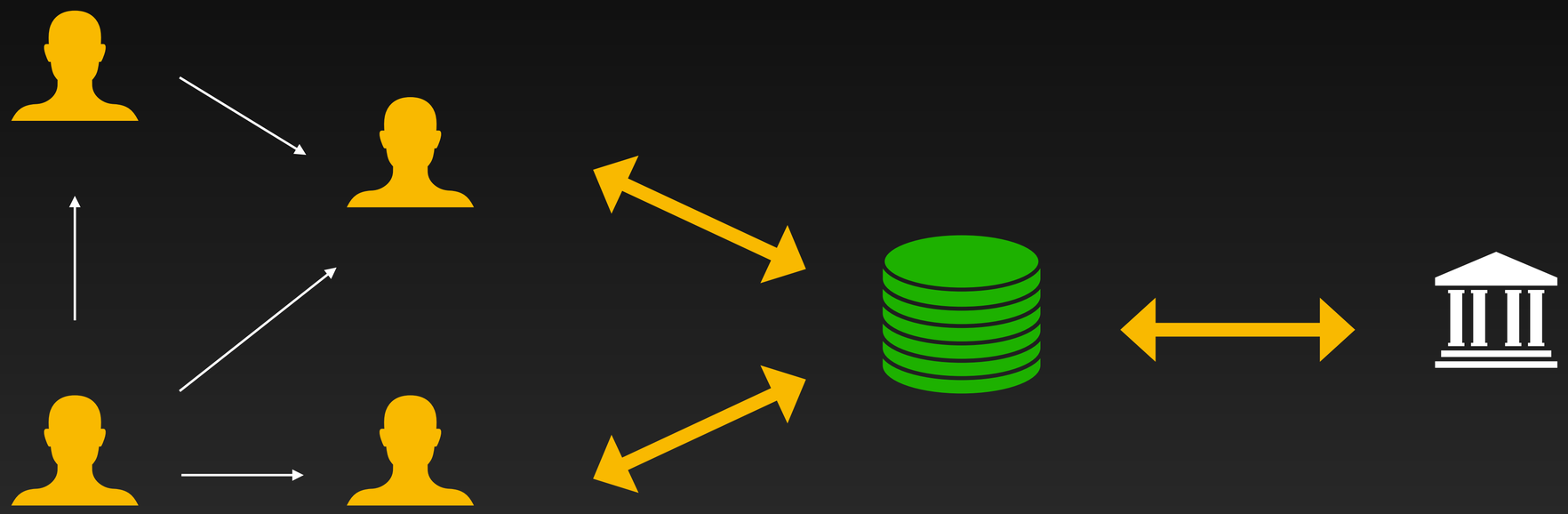
Latency: seconds

TPS: 500 tx/s

Latency: minutes

RTGS

A simplified view

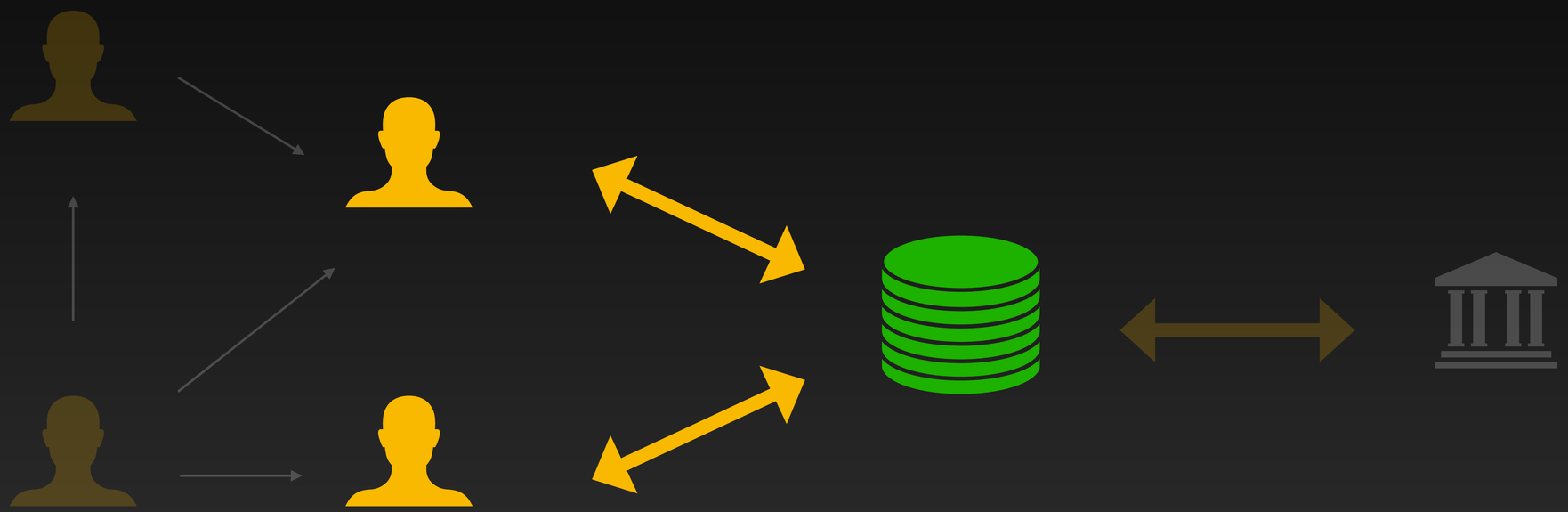


Promises of payment

Settlement

RTGS

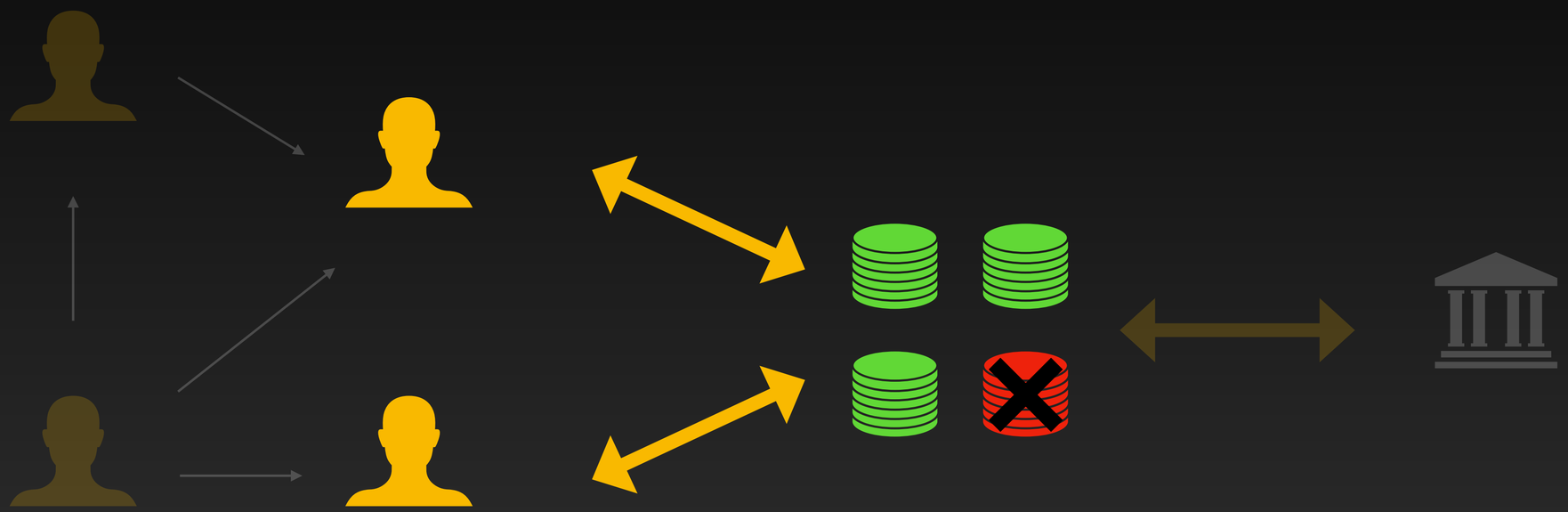
A simplified view



Fast settlement

RTGS

A simplified view



BFT resilience

High capacity (cheap)

Byzantine Fault Tolerance

> 2/3

In summary

What we want

- Low latency
- BFT reliance
- Fast finality
- Hight capacity

Current industry

- Low latency (not settled)
- Centralized
- Slow finality
- Hight capacity (not settled)

Make it practical for retail payment at physical points of sale

This requires extremely low latency

FastPay

Acknowledgments

Mathieu Baudet

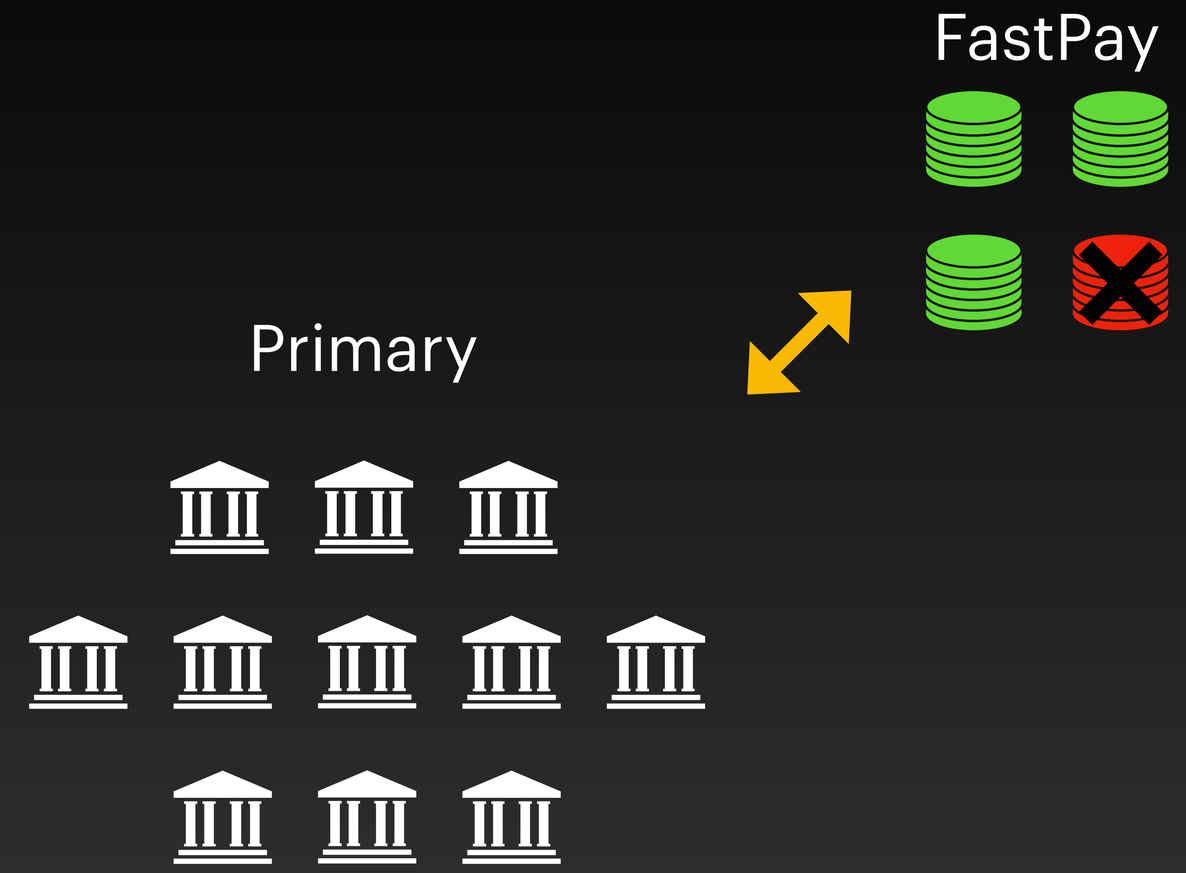
George Danezis

Alberto Sonnino

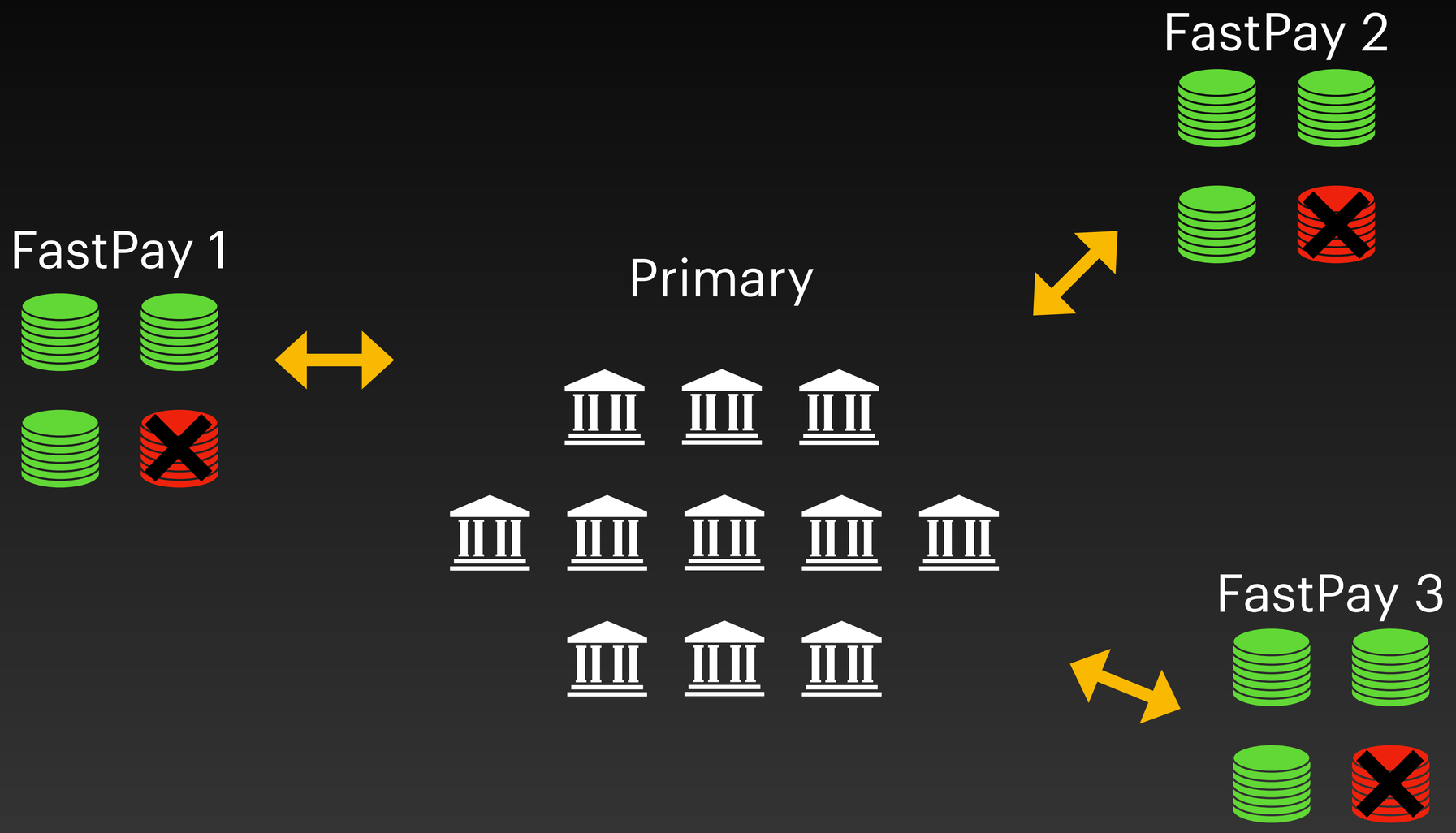
Facebook Novi

Overview

Overview

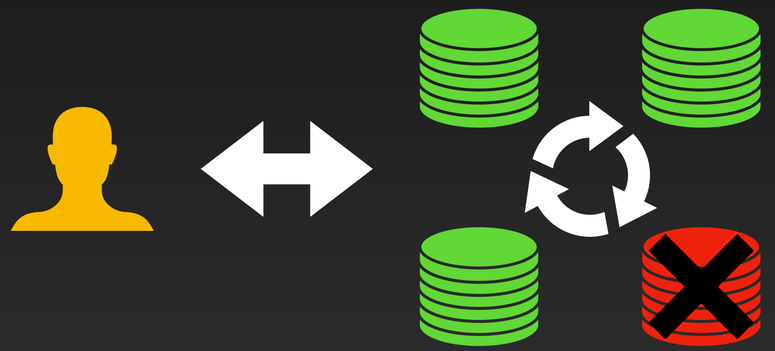


Overview



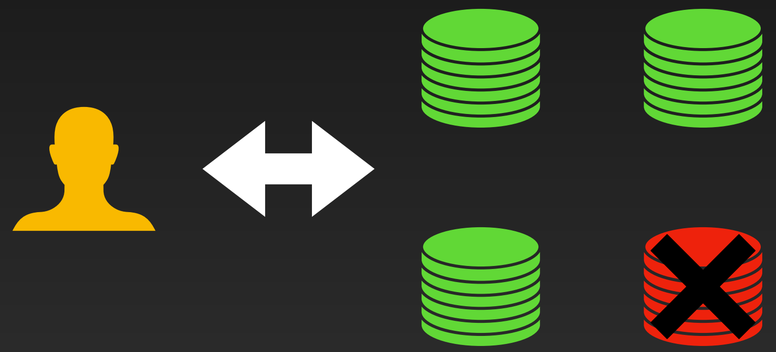
Difference with blockchains

Blockchains



Byzantine Consensus

FastPay



Byzantine Consistent Broadcast

FastPay

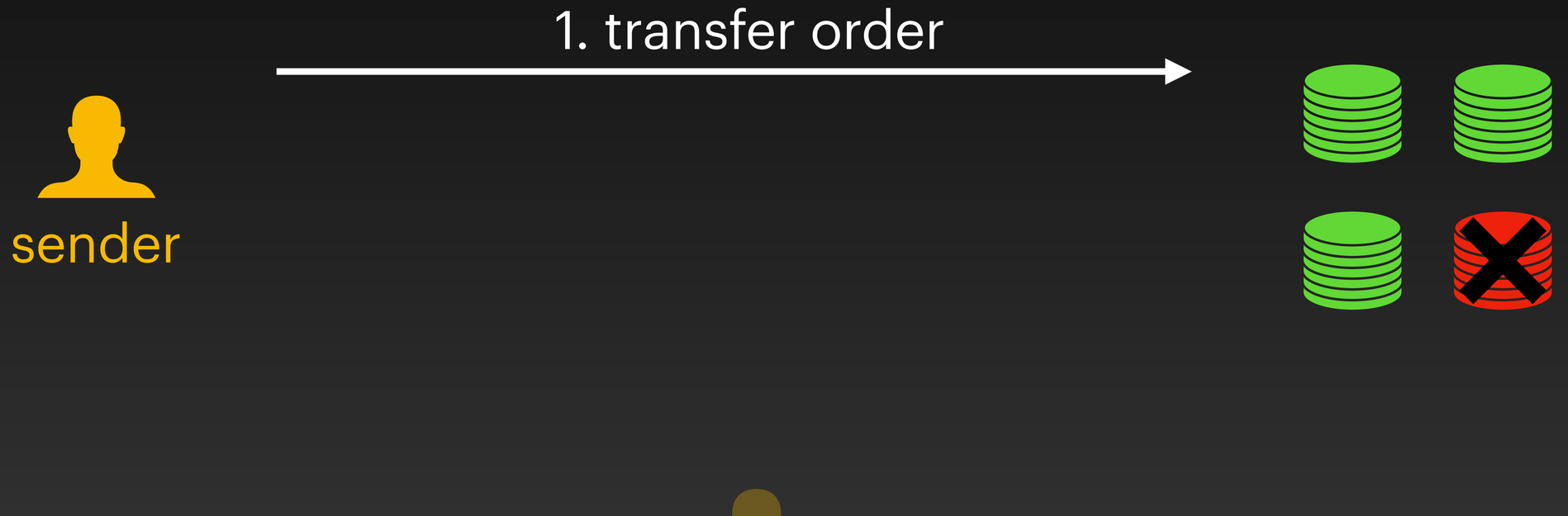
How does it work?

sender

recipient

FastPay

How does it work?



FastPay

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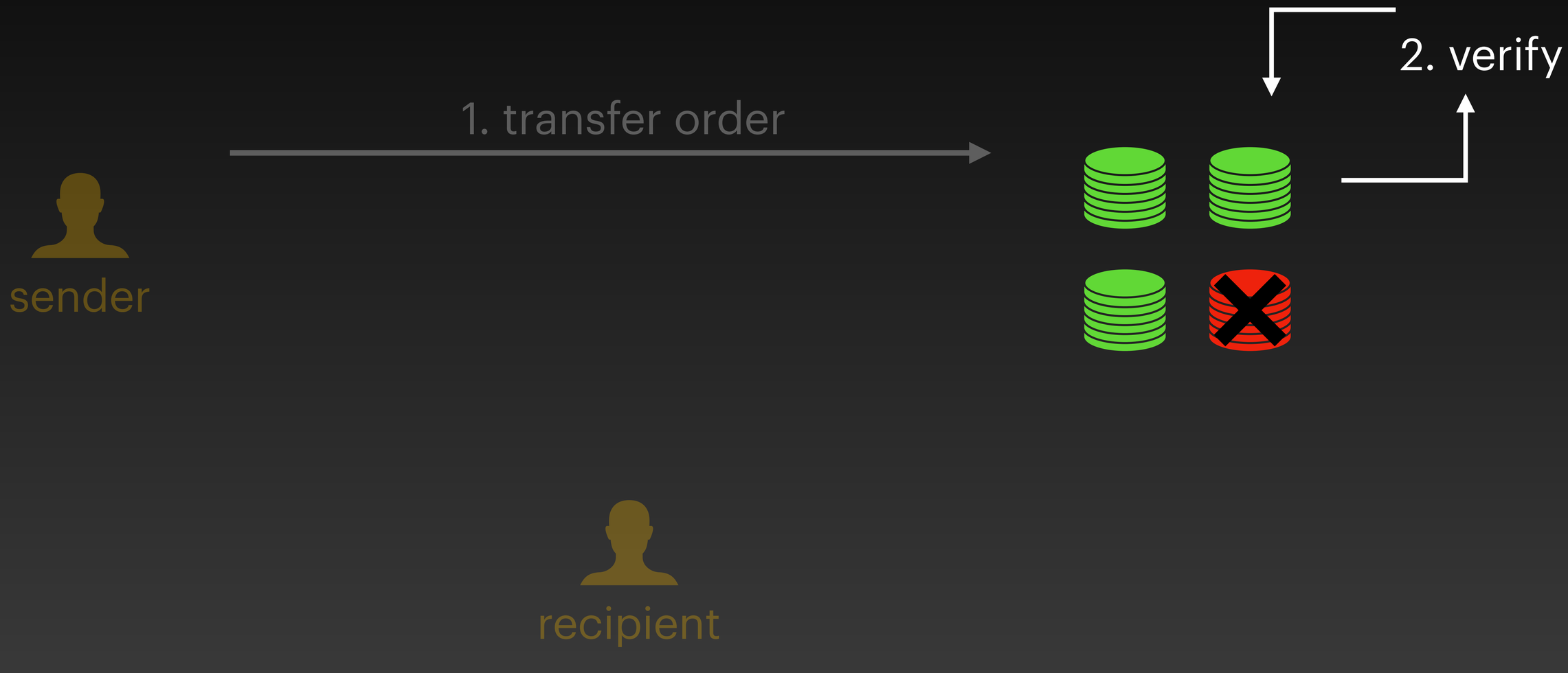
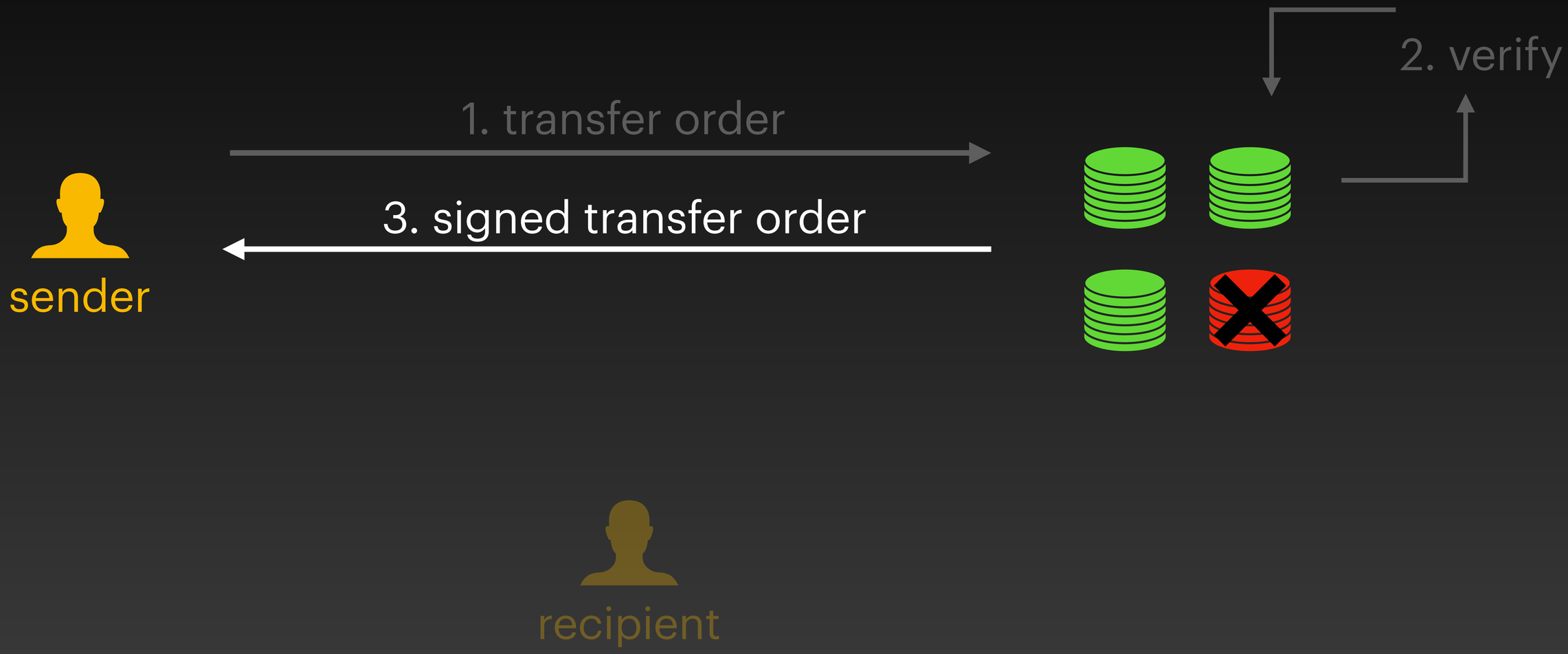


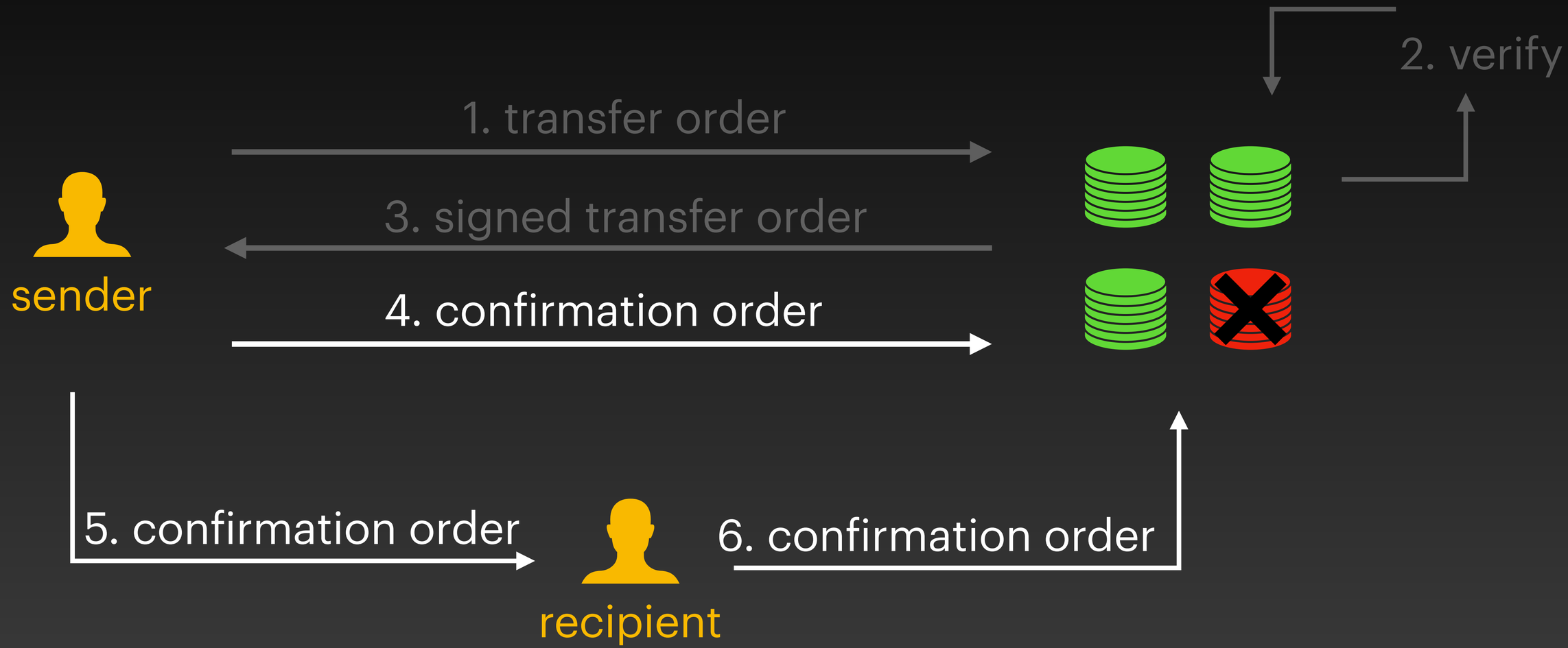
FastPay

How does it work?



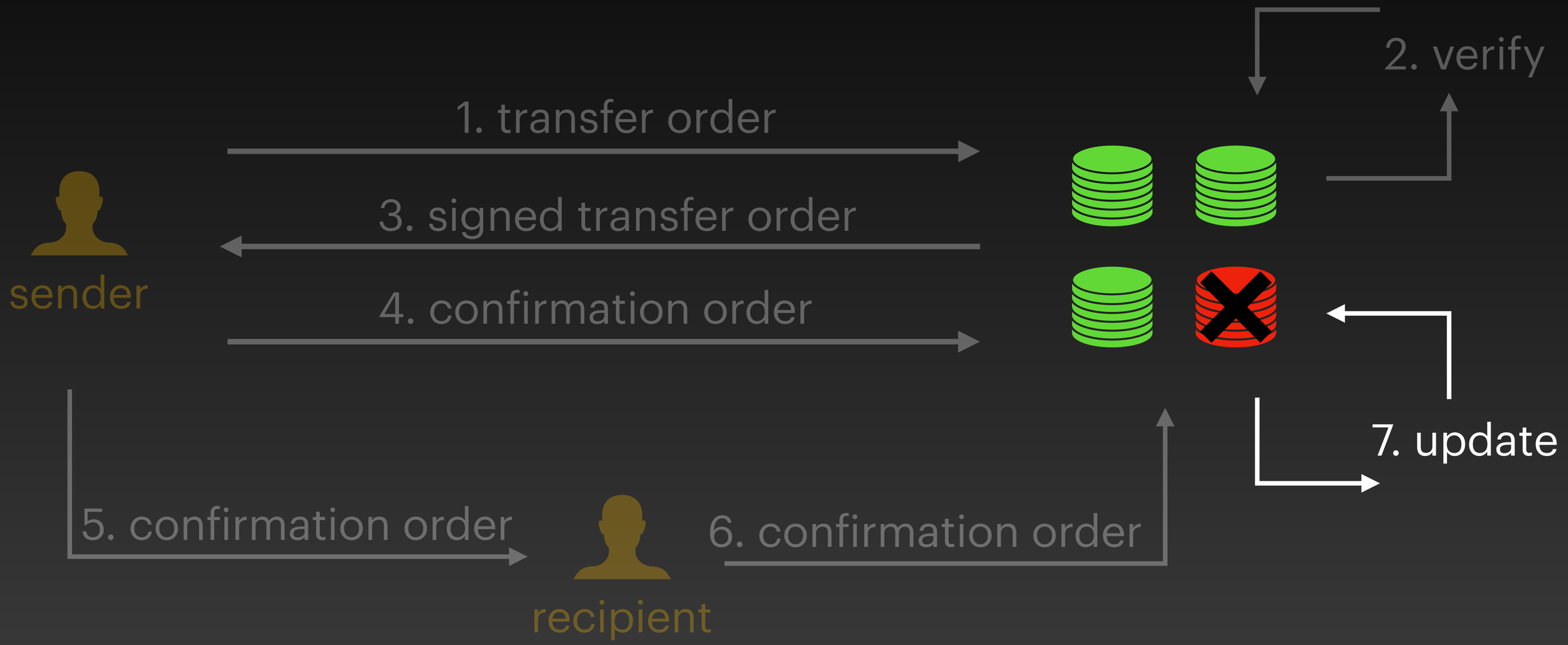
FastPay

How does it work?



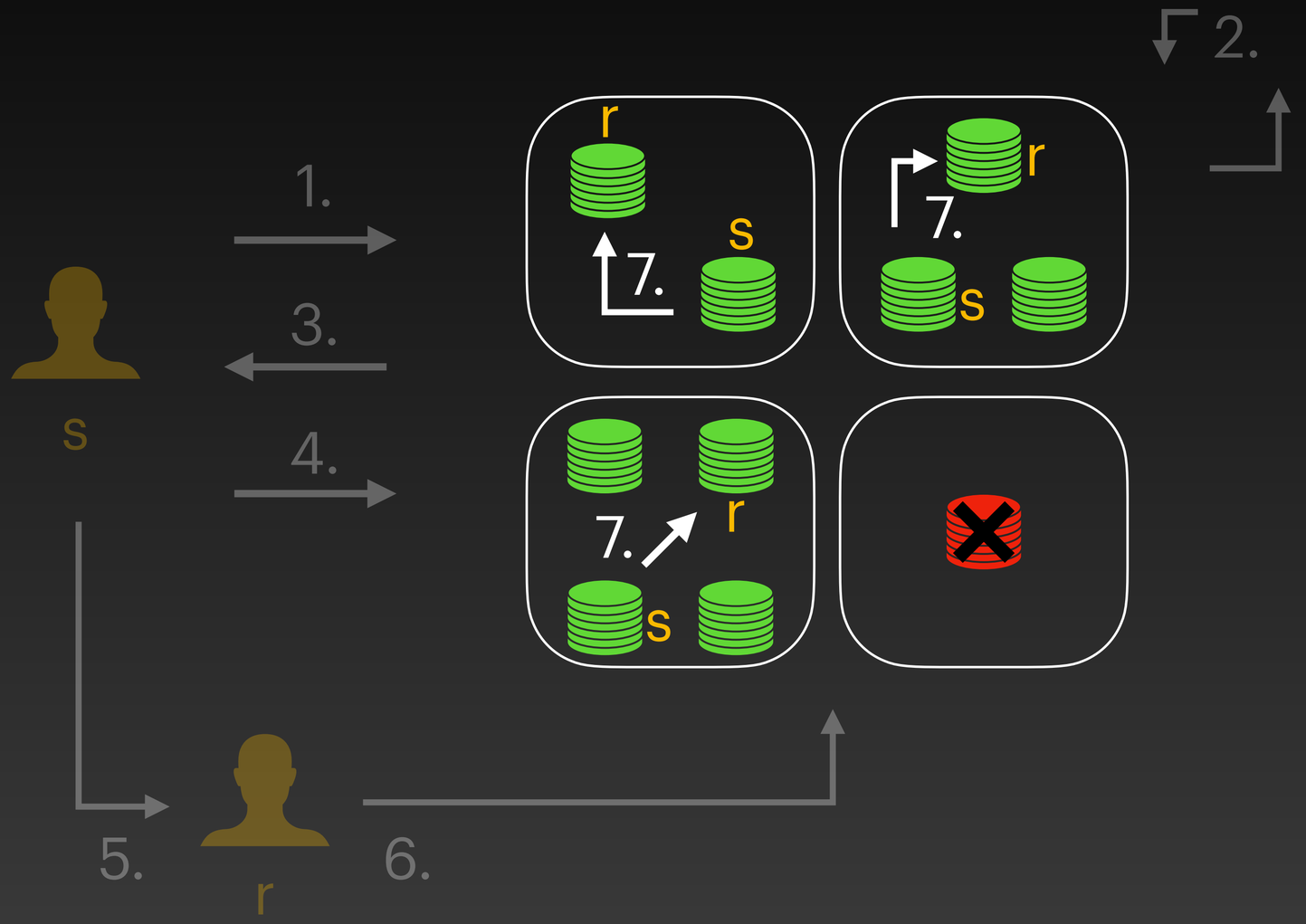
FastPay

How does it work?



FastPay

Increasing capacity



Byzantine Consistent Broadcast

Validity

No duplication

Integrity

Consistency

FastPay
Authorities' state

Authorities

- Authority name and keys
- Committee information
- Accounts information
- Last primary tx index 

Each account

- Verification key
- Balance
- Sequence number
- Last transfer order
- List of certificates and synchronization orders

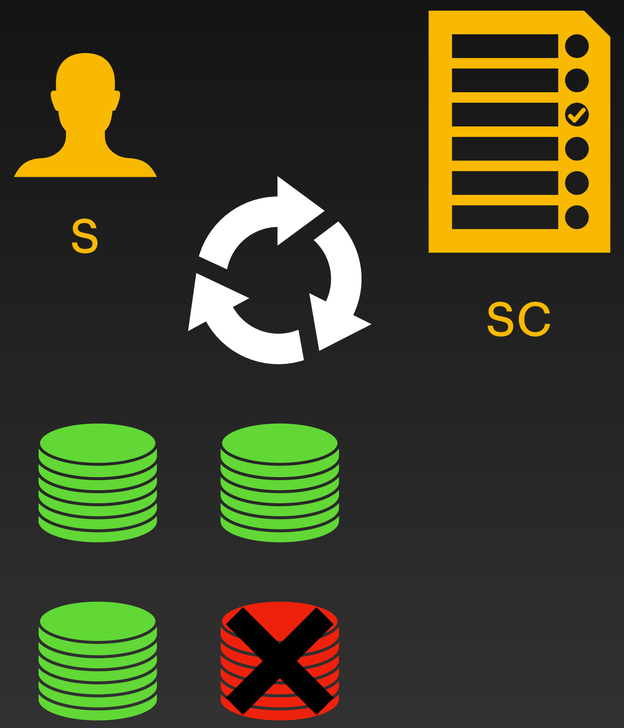
FastPay

Clients' state

- Their account's address
- Their secret key
- Committee information
- Last sequence number
- Last signed transfer order

FastPay

Interface it with a primary infrastructure



Smart Contract's state

- The committee information
- Total funds in the contract
- Last primary tx index
- "Redeem log"

FastPay
Authorities' state

Authorities

- Authority name and keys
- The committee information
- Committee information
- Accounts information
- Last primary tx index 

Each account

- Verification key
- Balance
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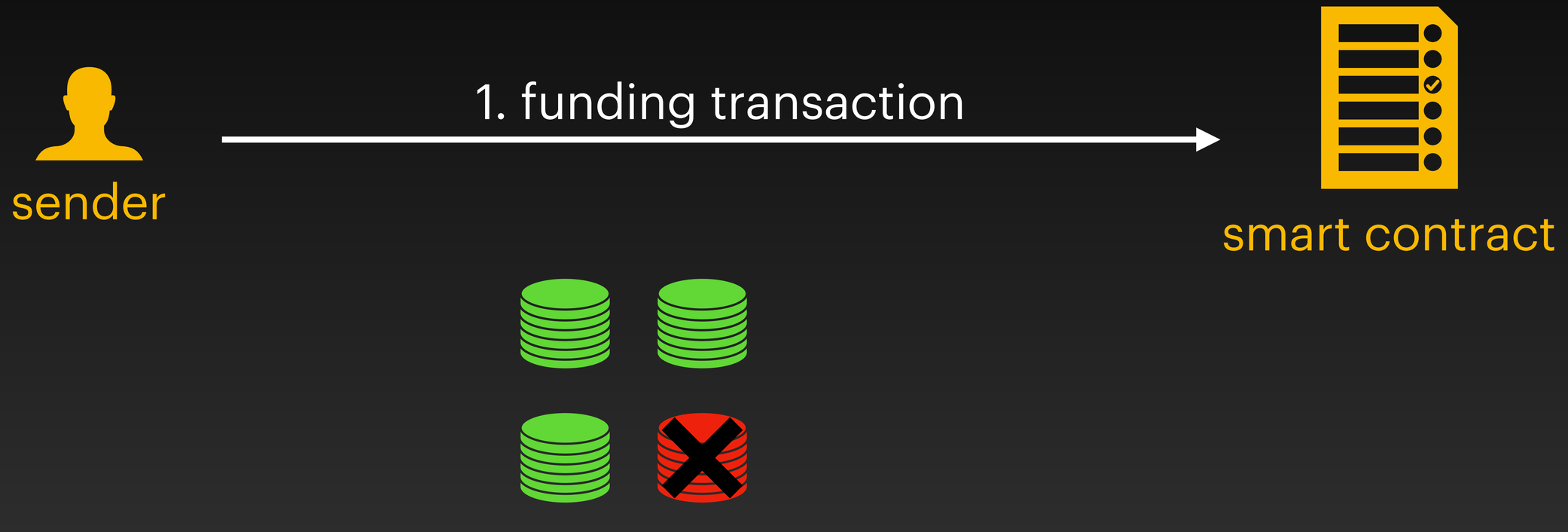
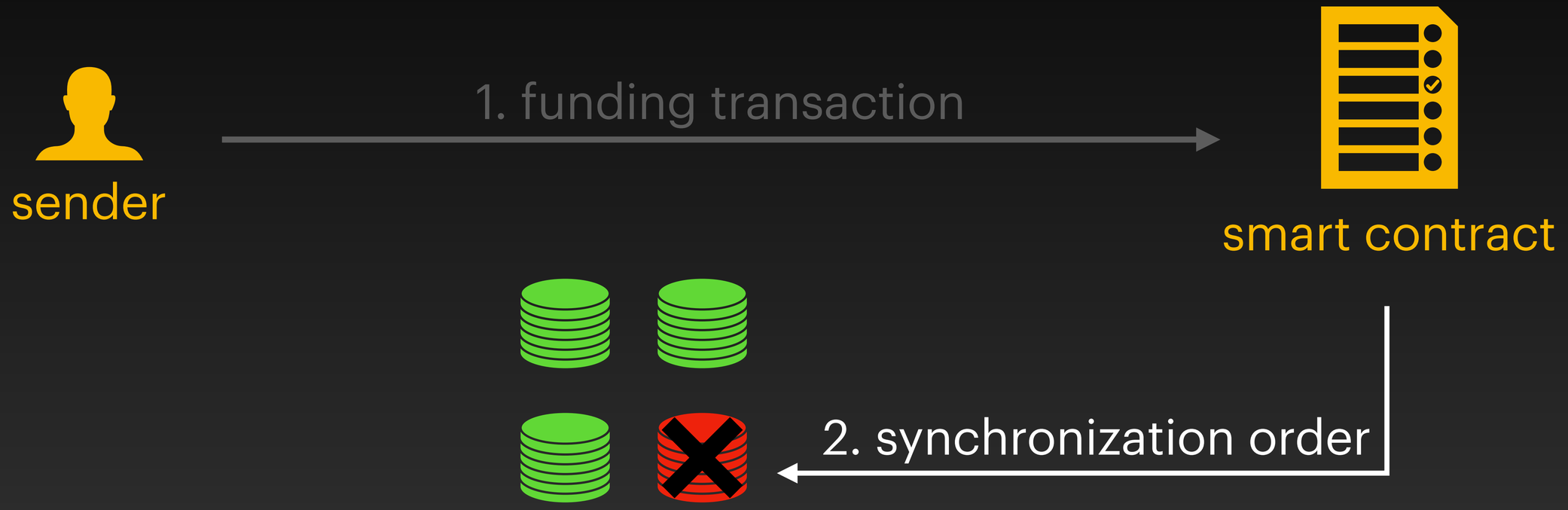
FastPay

From primary infrastructure to FastPay



FastPay

From primary infrastructure to FastPay



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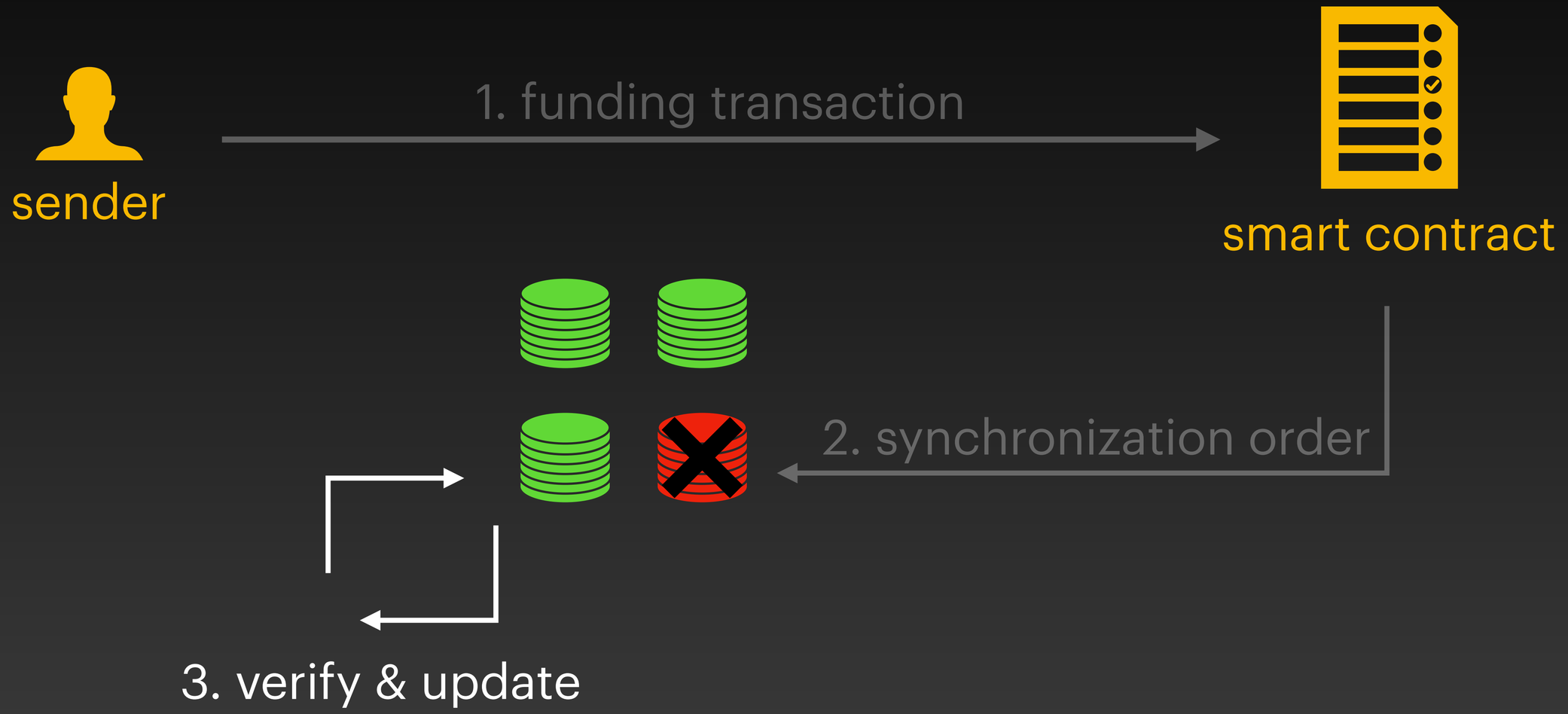
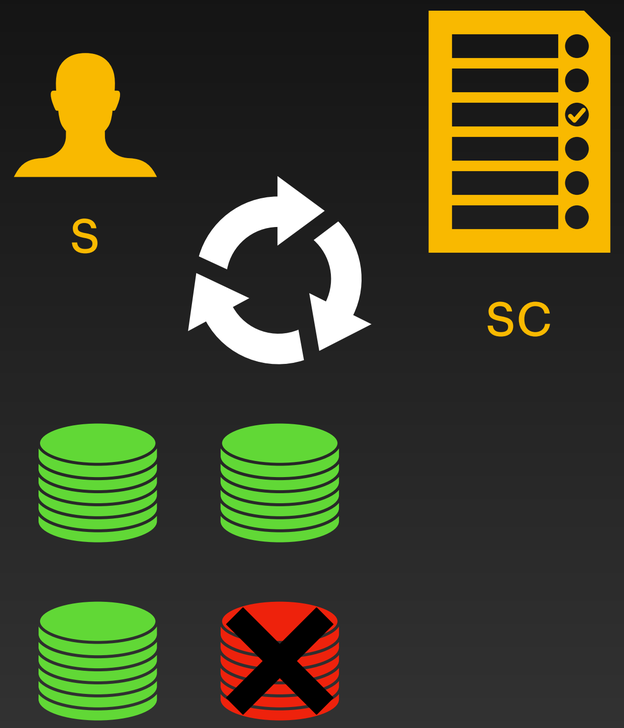
From primary infrastructure to FastPay



FastPay

Interface it with a primary infrastructure

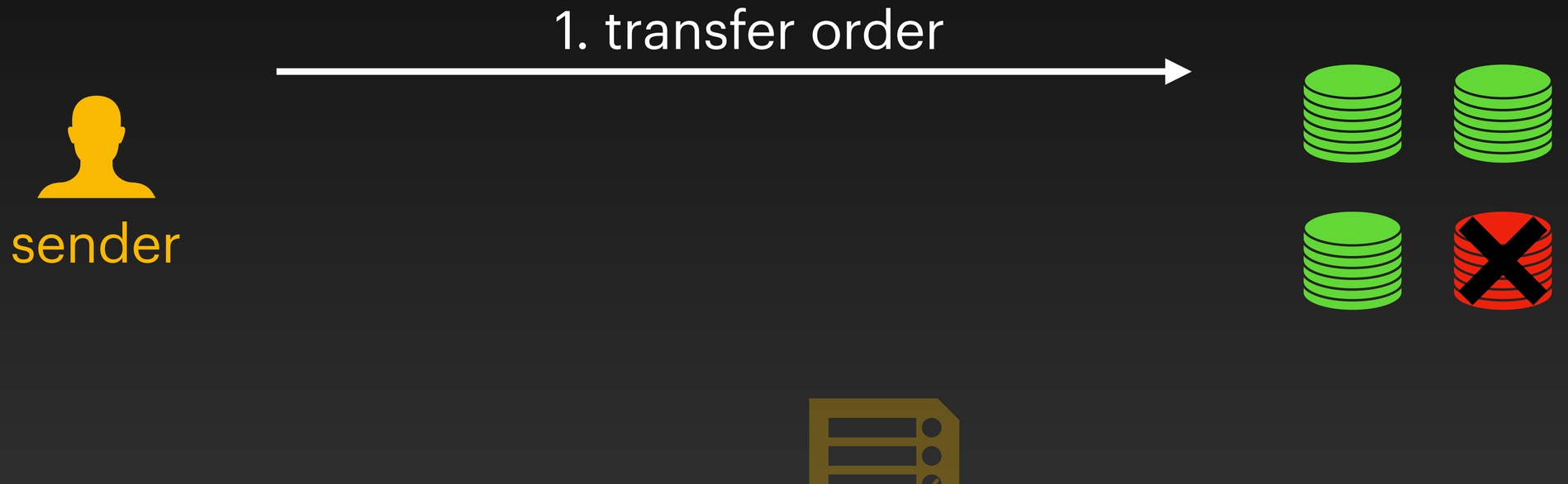


Smart Contract's state

- The committee information
- Total funds in the contract
- Last primary tx index
- "Redeem log"

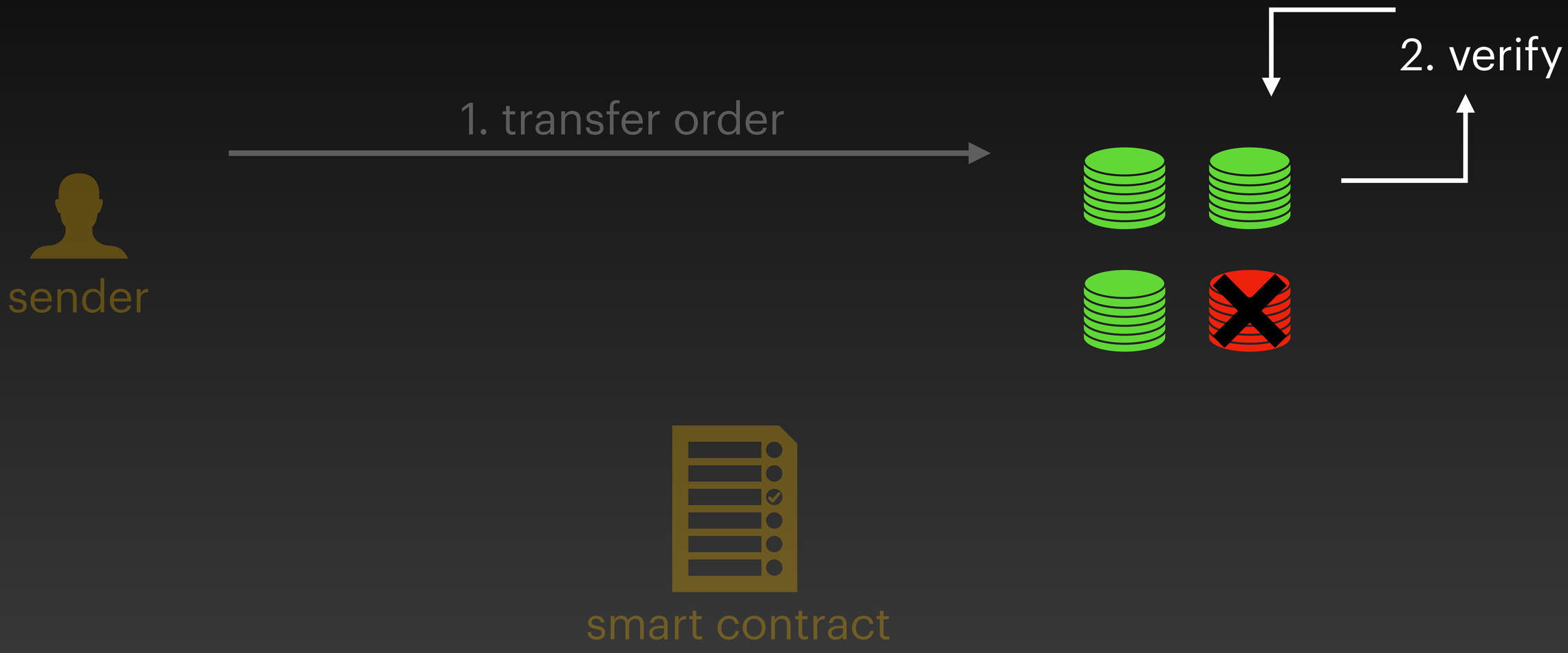
FastPay

From the primary infrastructure to FastPay



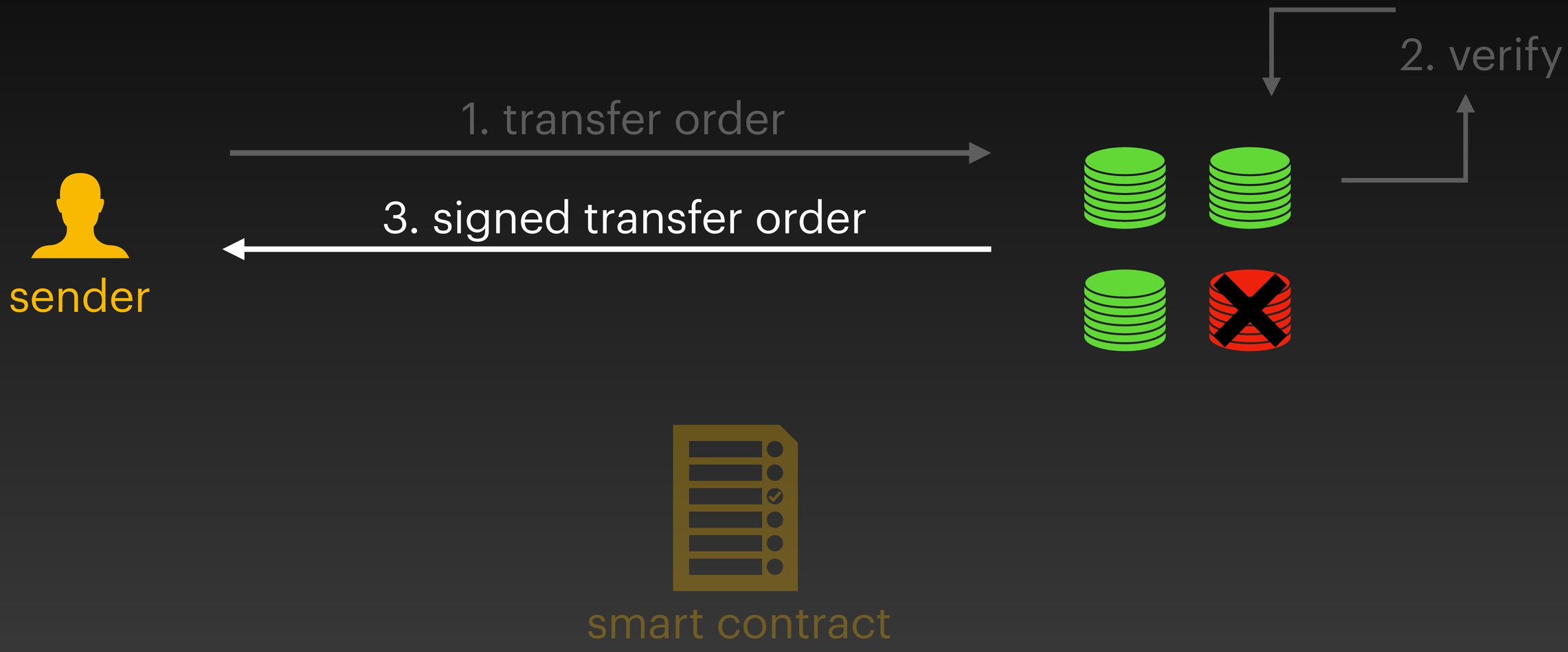
FastPay

From the primary infrastructure to FastPay



FastPay

From the primary infrastructure to FastPay



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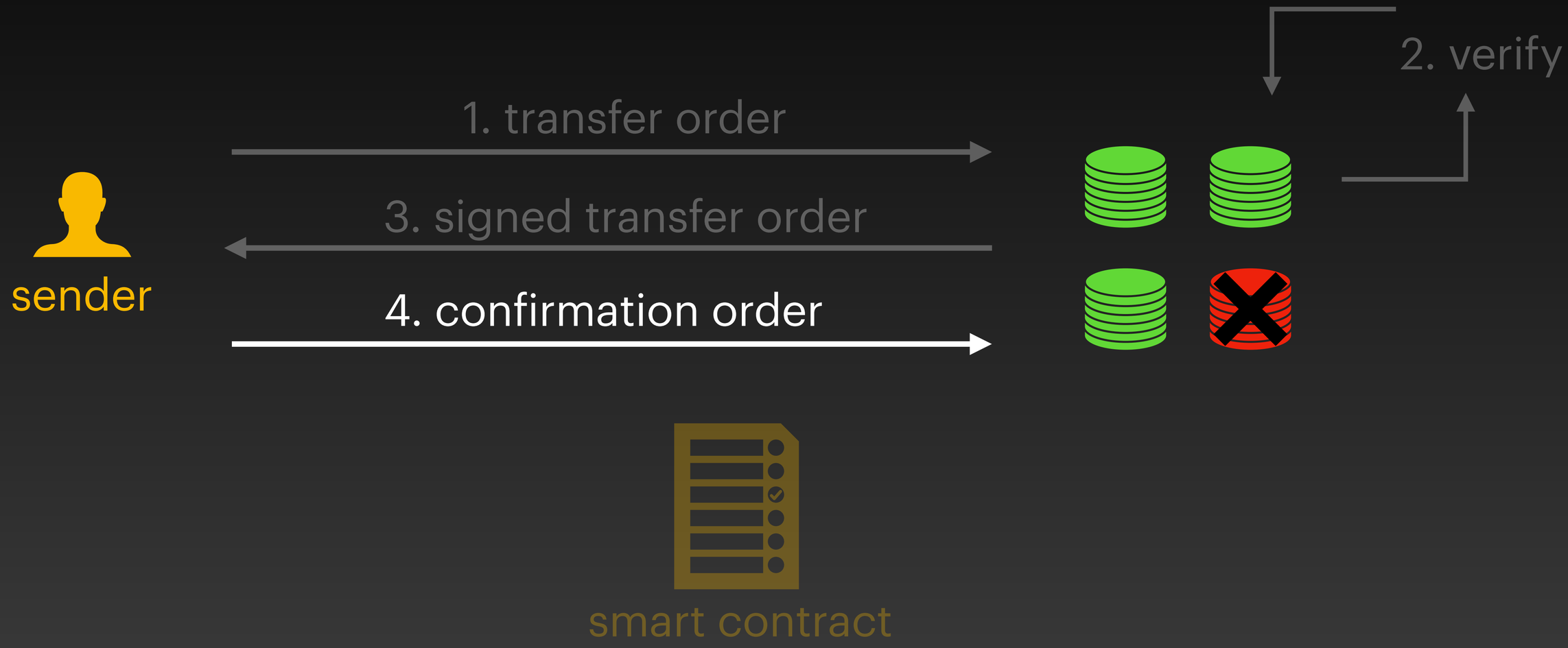

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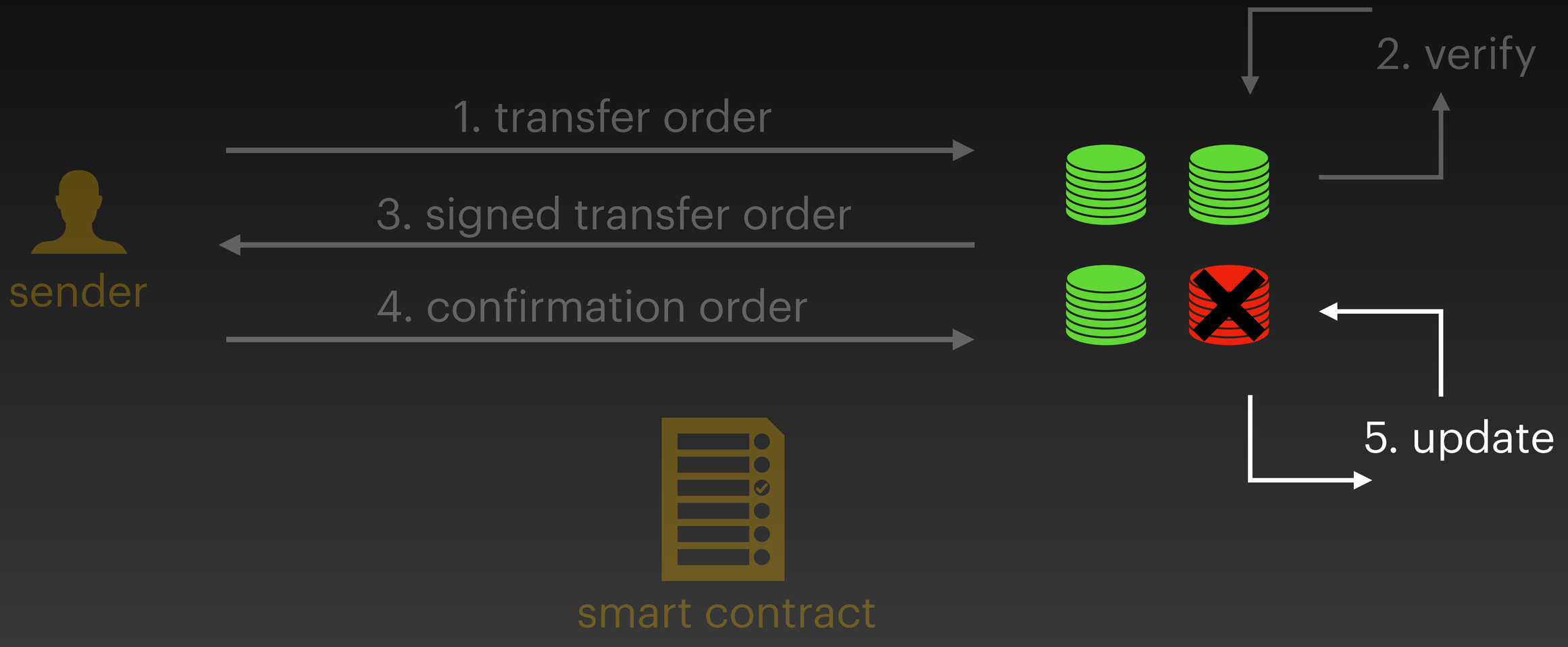

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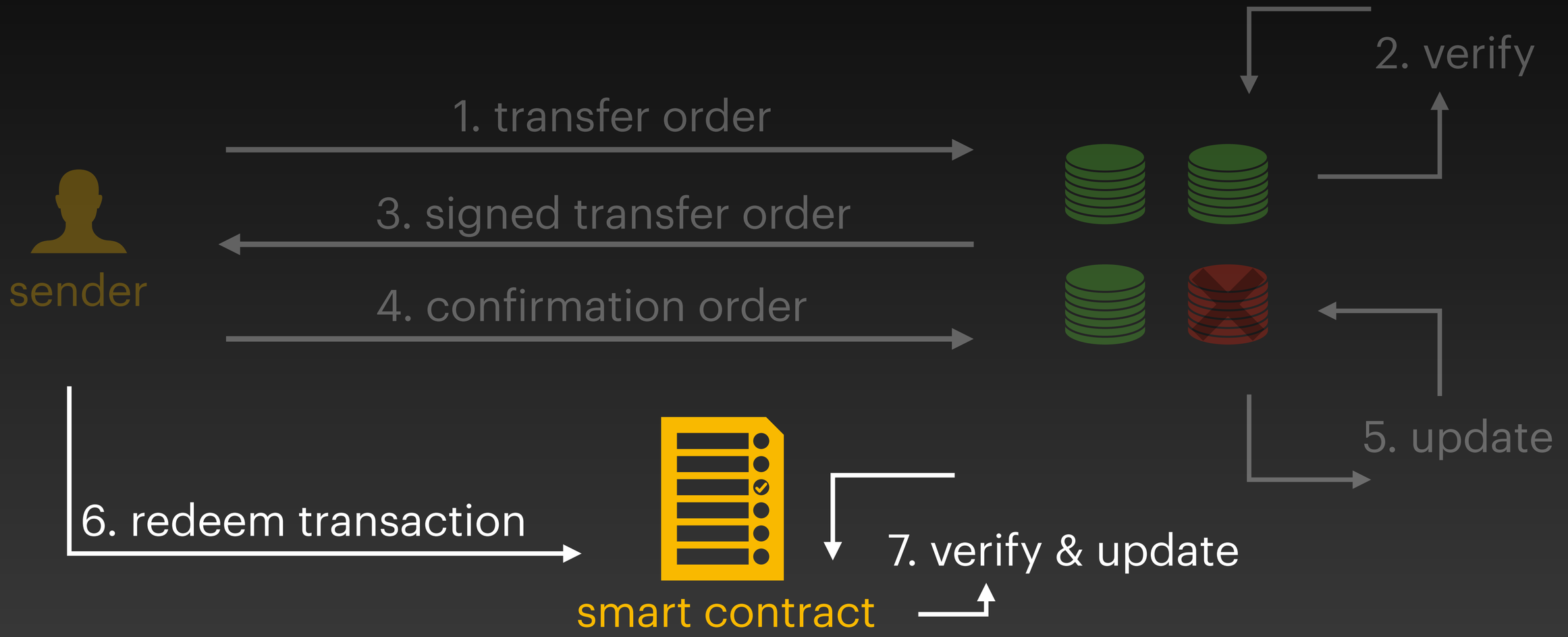
From the primary infrastructure to FastPay



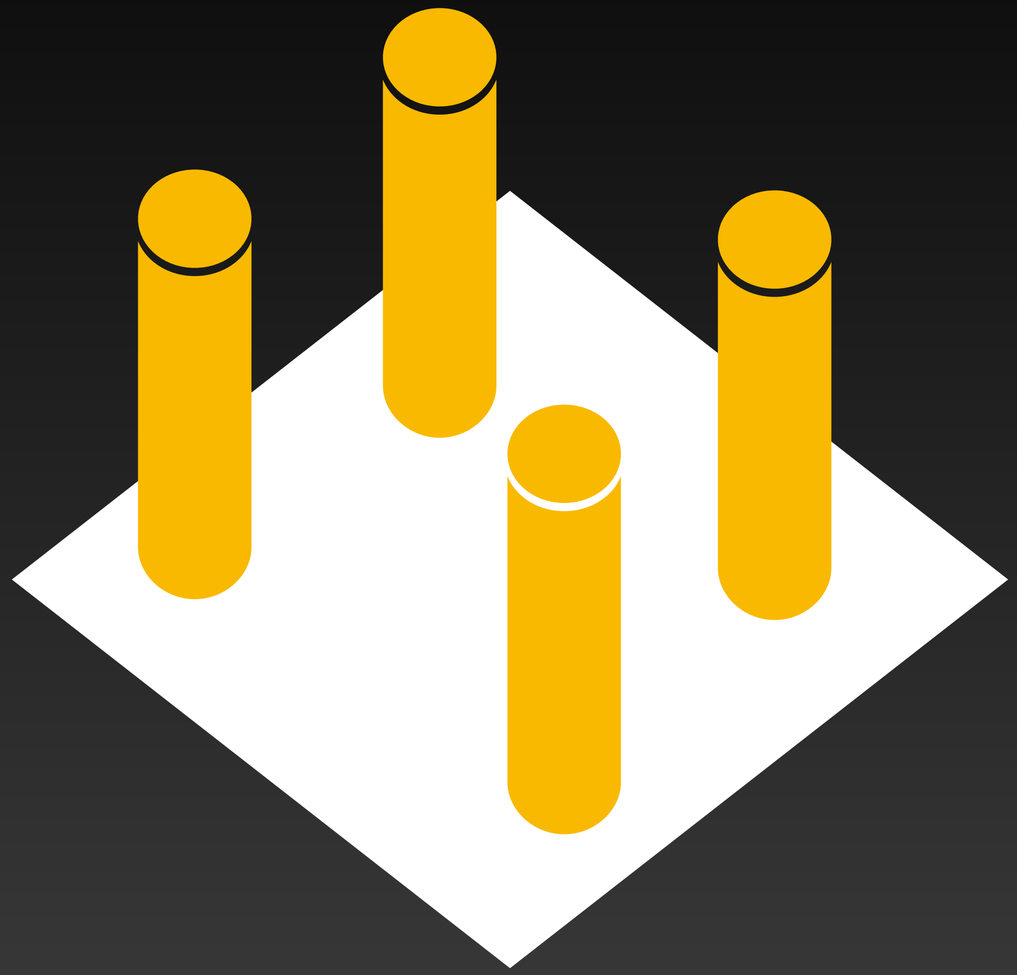
FastPay
Implementation

- Written in Rust
- Networking: Tokio & UDP
- Cryptography: ed25519-dalek

https://github.com/novifinancial/fastpay

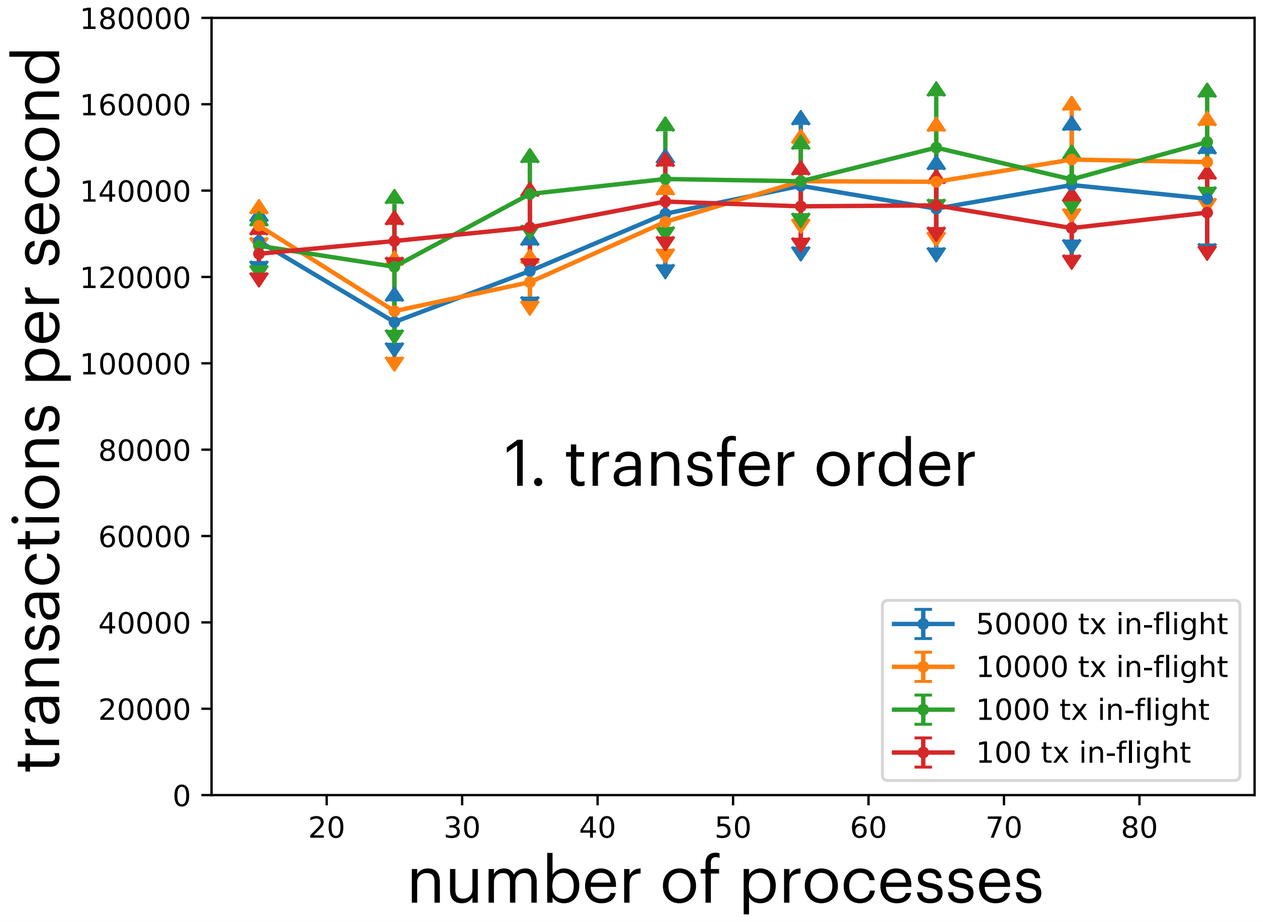
FastPay

Throughput Evaluation



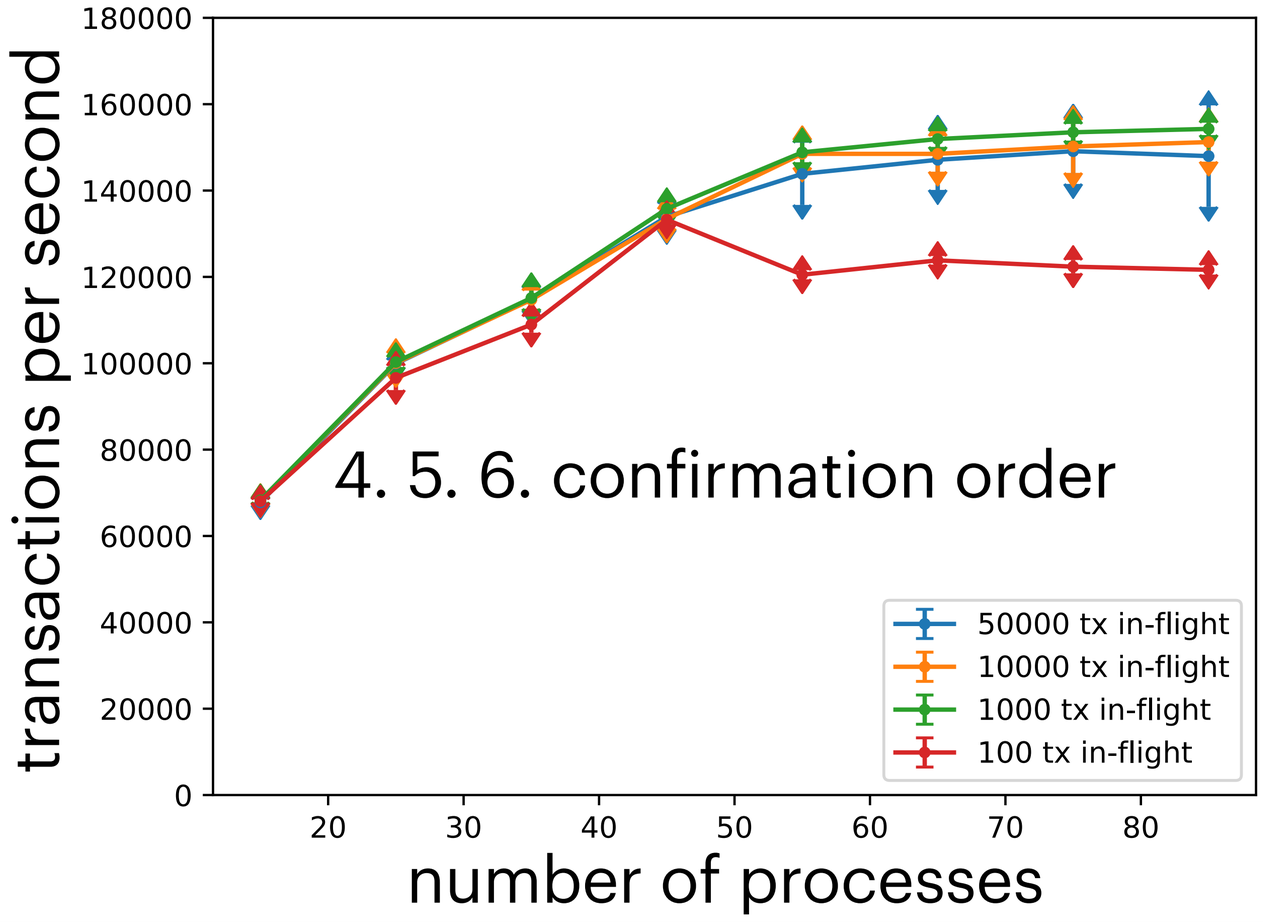
FastPay

High concurrency

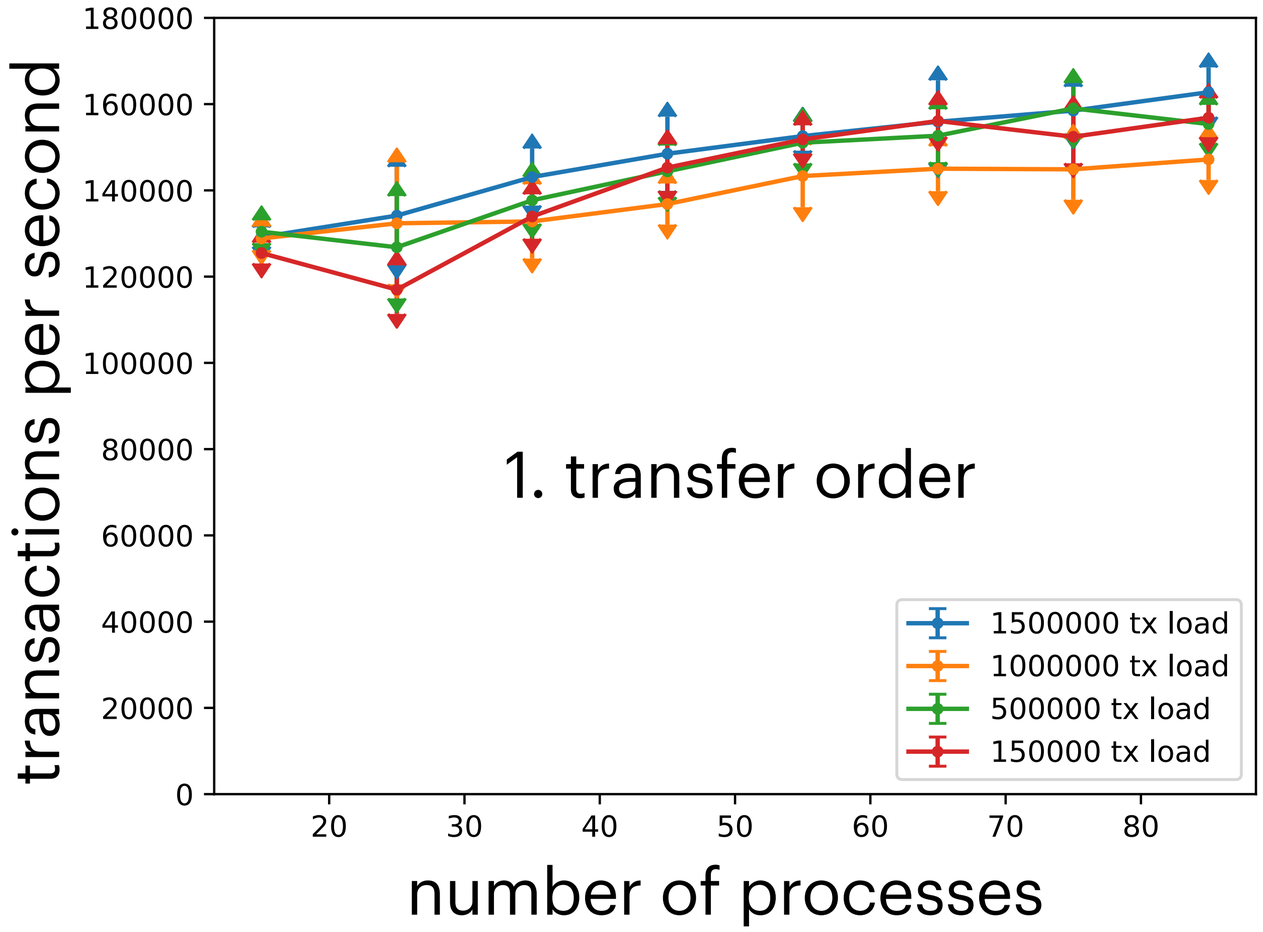


FastPay

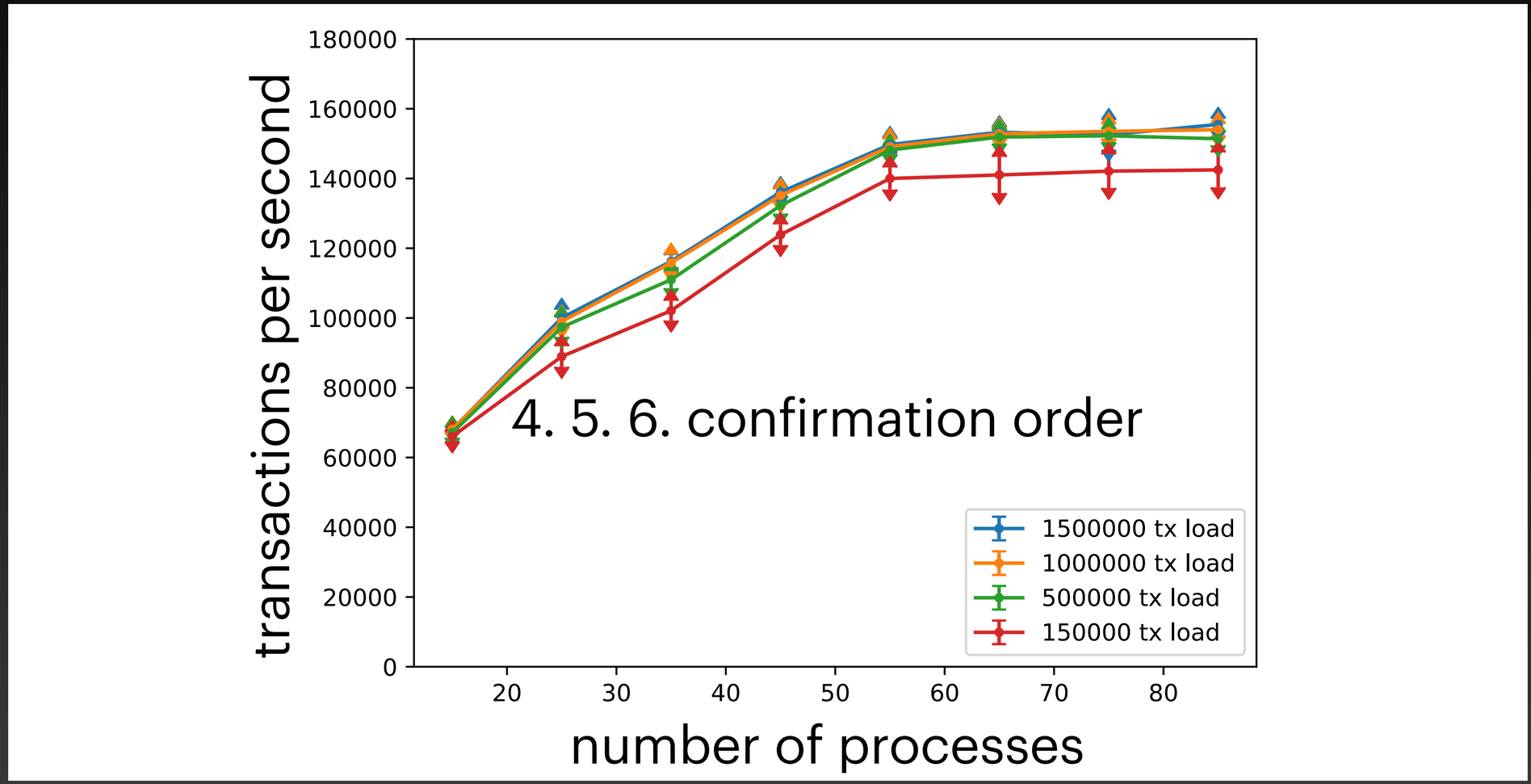
High concurrency



FastPay
Robustness

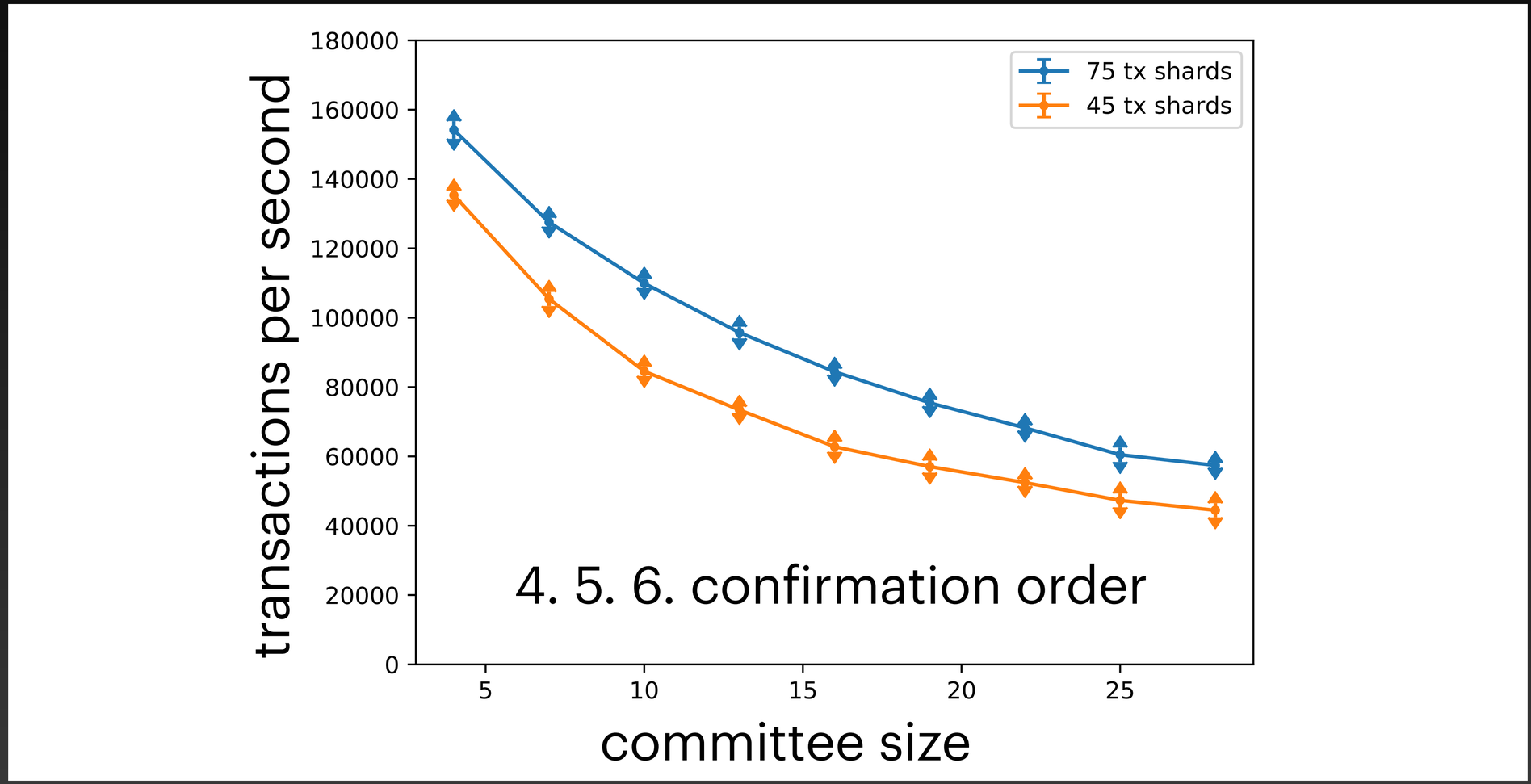


FastPay
Robustness



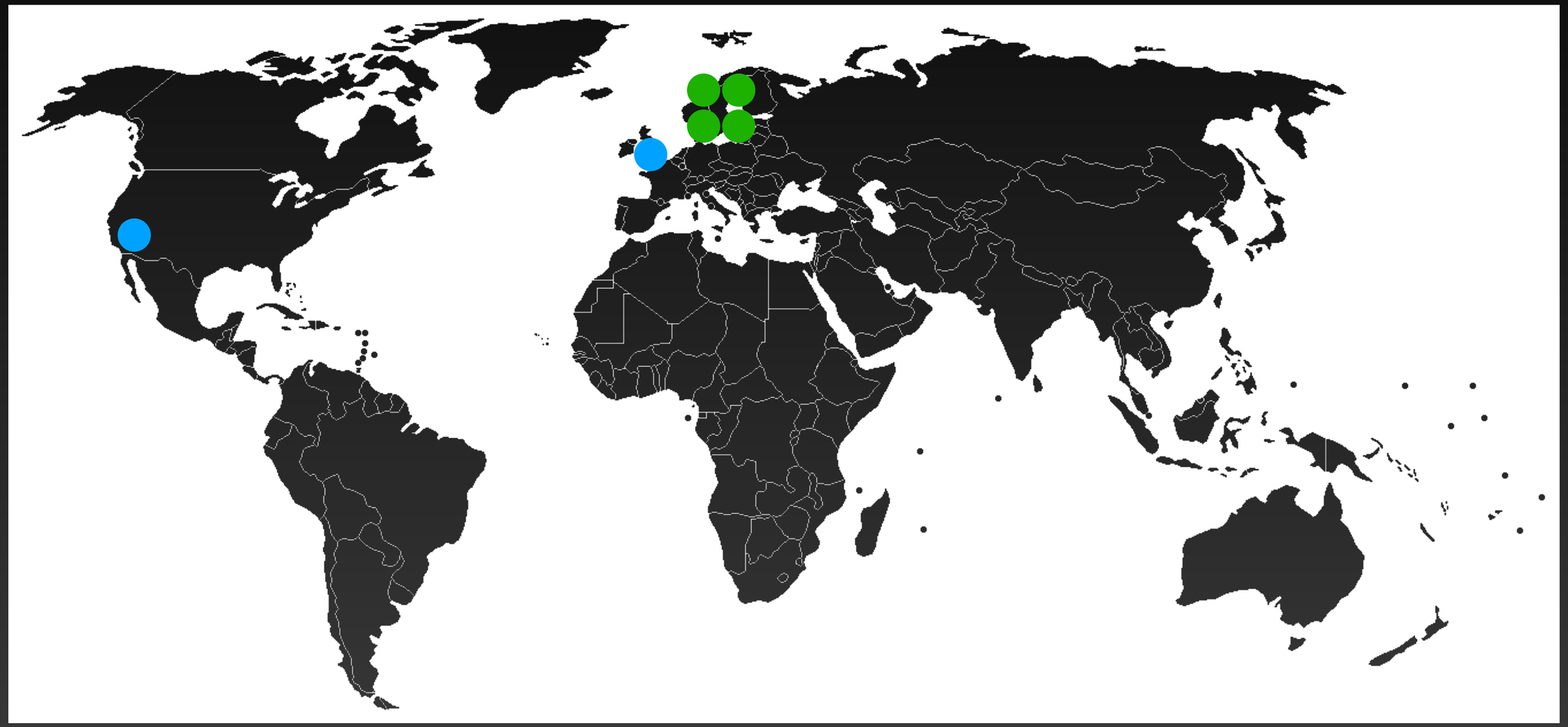
FastPay

Influence of the number of authorities

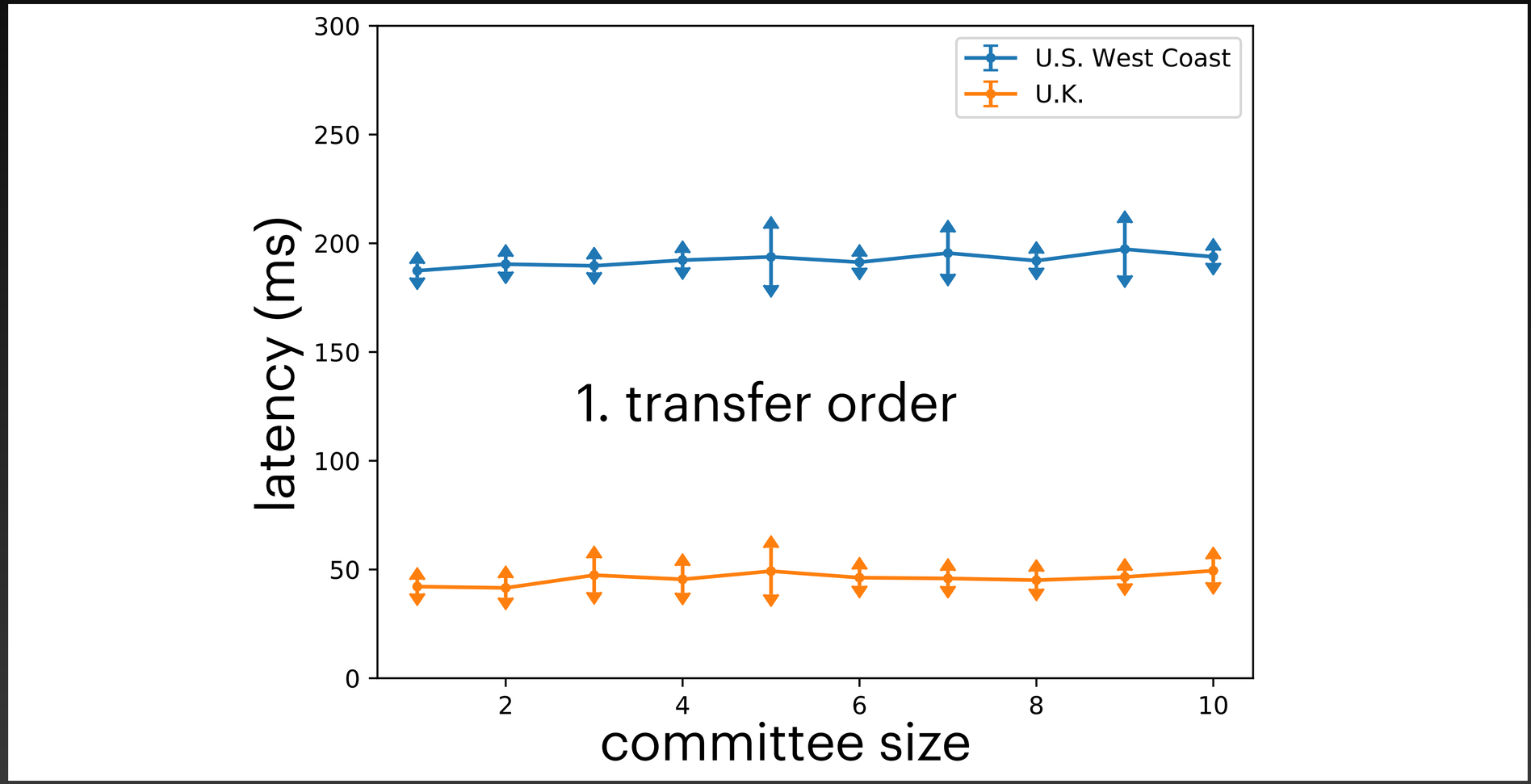


FastPay

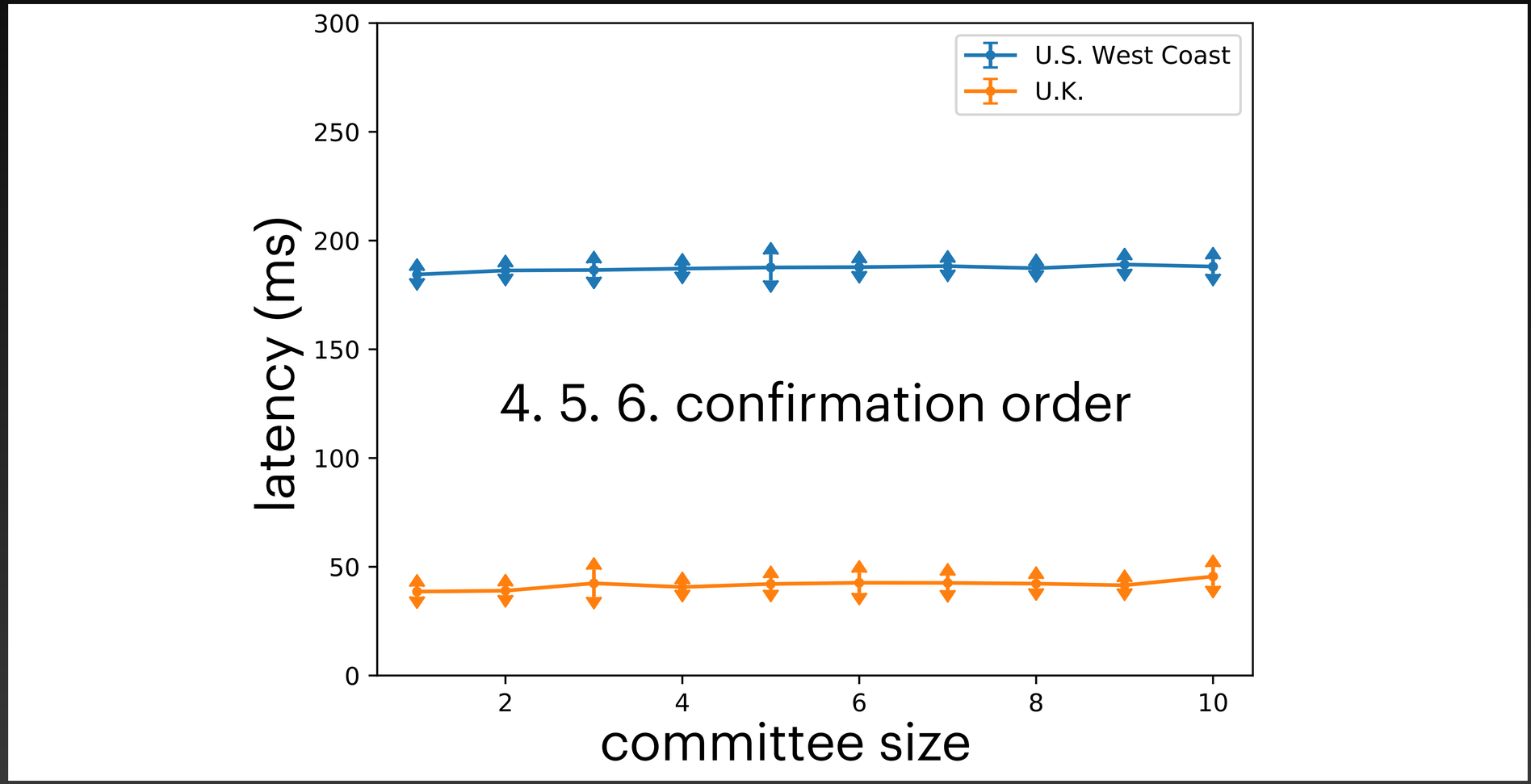
Latency setup



FastPay
Latency

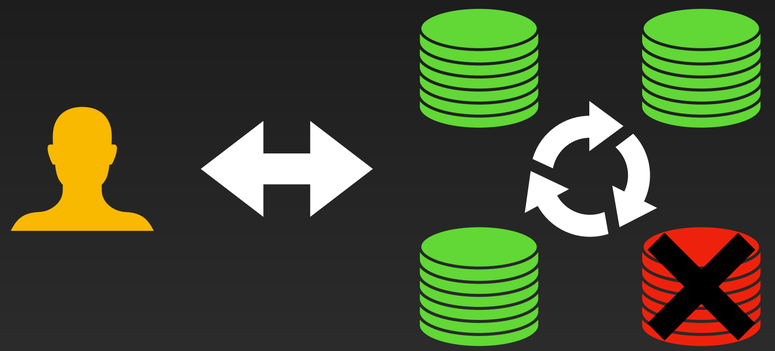


FastPay
Latency



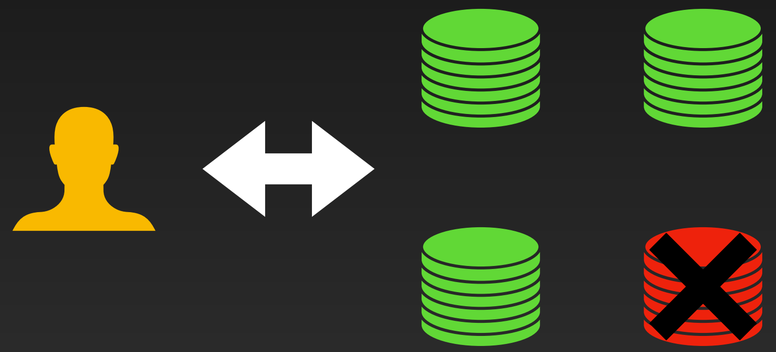
Worst-case efficiency

Blockchains



Bad leader can slow down the protocol

FastPay



No leader, nothing changes

FastPay

The cost of simplicity

- Less than 4,000 LOC
- Over 1,500 Git commits
- Took 2.5 months to 3 engineers

FastPay

Deployment costs

- AWS m5d.8xlarge instance
- ~ 5 USD / hour

Conclusion

FastPay

- Based on Byzantine Consistent Broadcast
- Simple design, low latency, high capacity, very robust

- **Paper:** https://arxiv.org/abs/2003.11506
- **Code:** https://github.com/novifinancial/fastpay

asonnino@fb.com

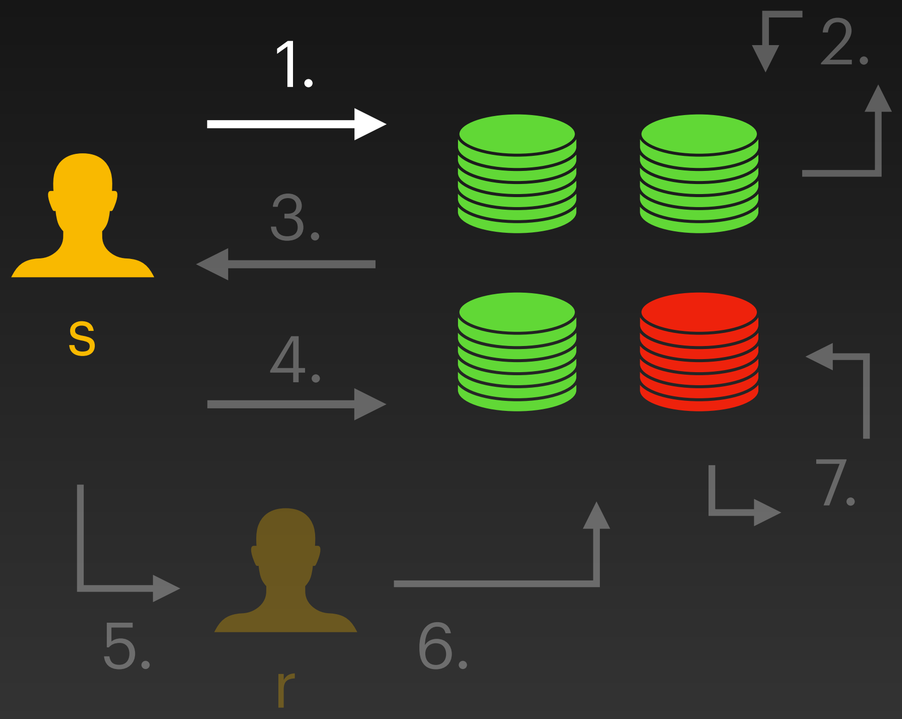
Alberto Sonnino

EXTRA

Protocol Details

From FastPay to FastPay

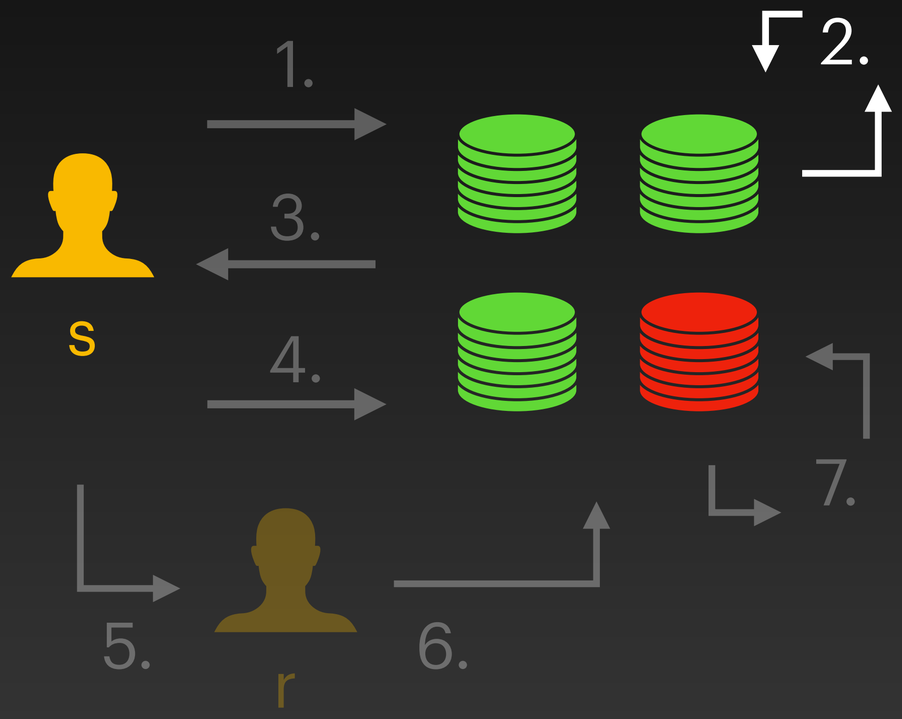
FastPay
Protocol details



1. transfer order

- Sender address
- Recipient address
- Amount
- Sequence number
- Sender's signature

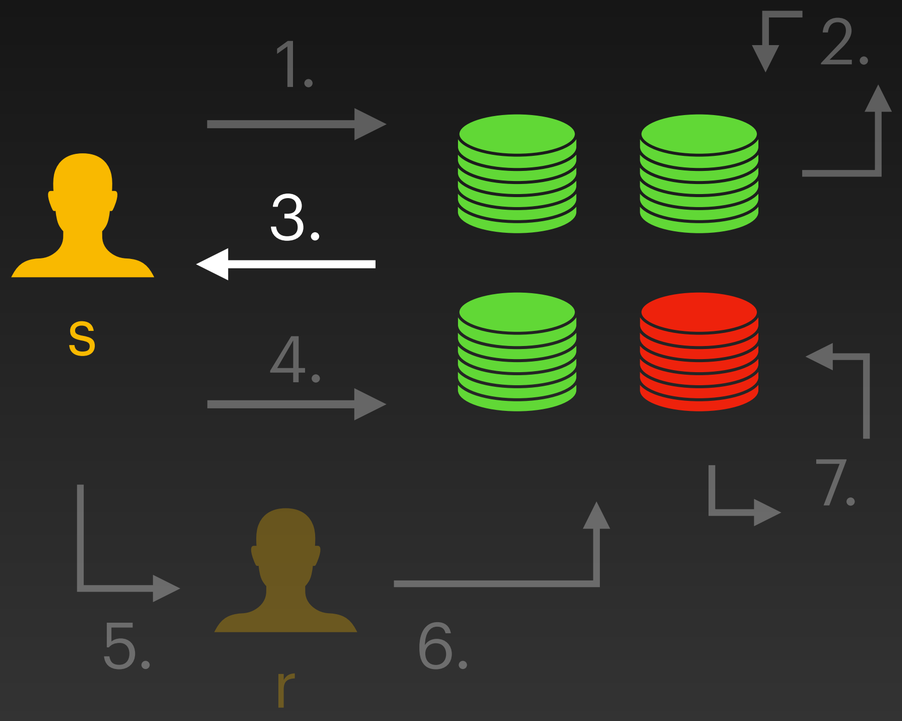
FastPay
Protocol details



2. verify

- The sender's signature
- No previous tx is pending
- The amount is positive
- Sequence number is as expected
- Balance is sufficient

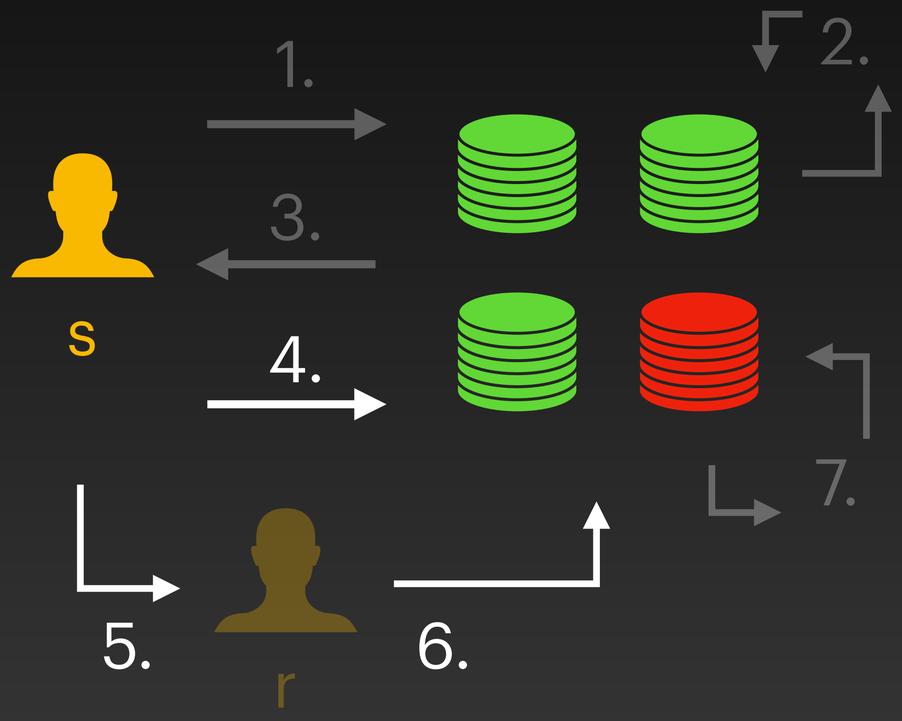
FastPay
Protocol details



3. signed transfer order

- Each authority signed the transfer order received in step 1.

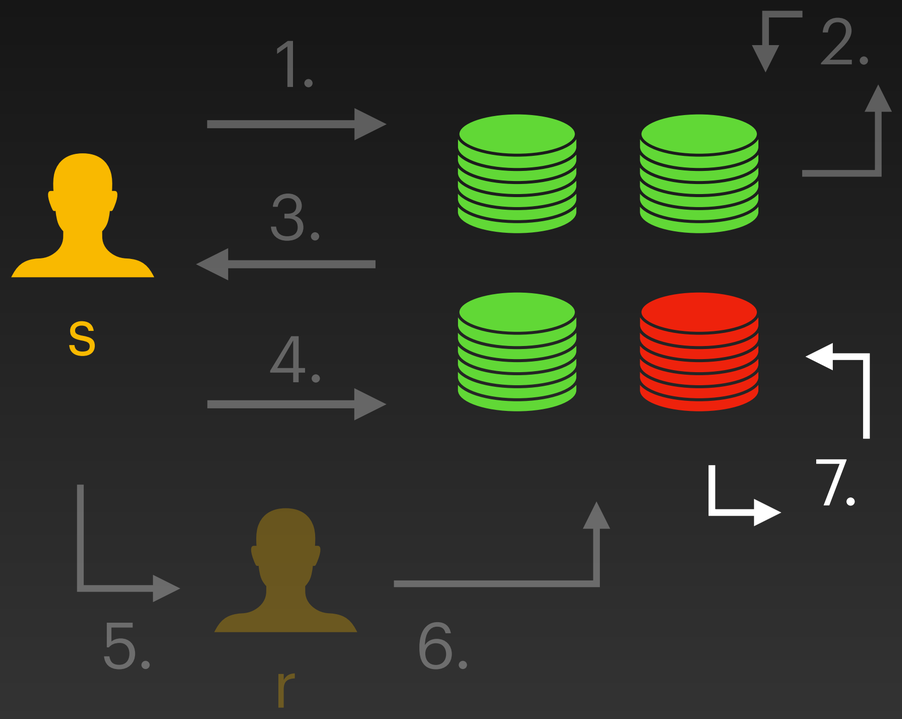
FastPay
Protocol details



4. 5. 6. confirmation order

- Collect enough signed transfer orders from step 2.

FastPay
Protocol details



7. update

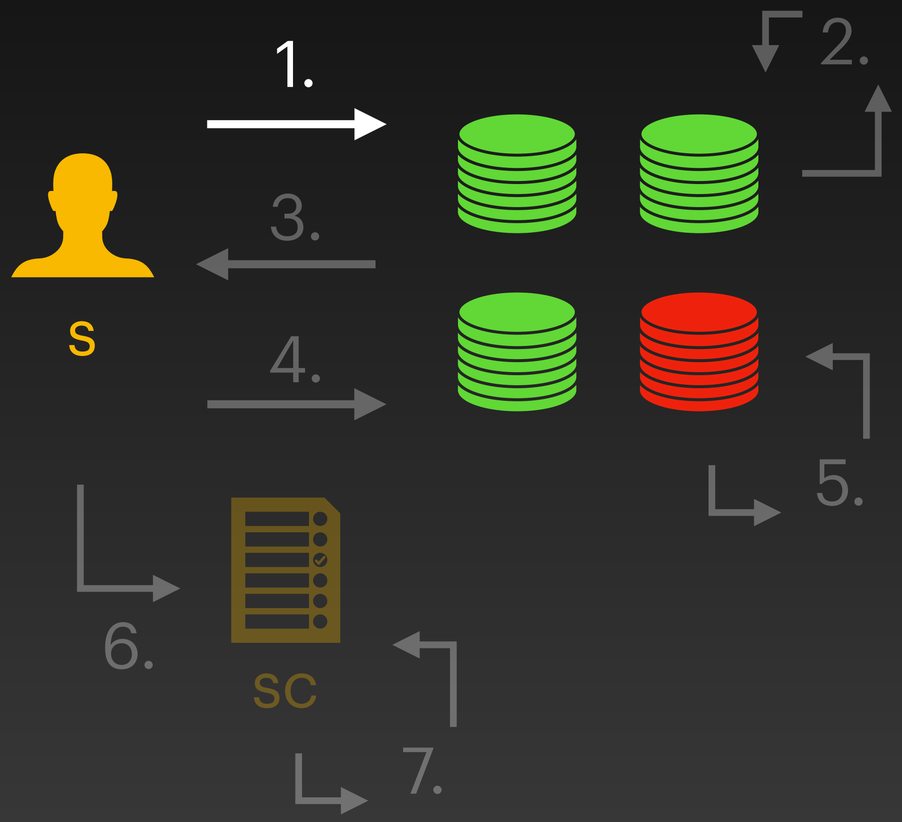
- Check there are enough signatures
- Decrease the senders' balance
- Increase the sequence number
- Set the pending order to None
- Increase the recipient's balance

Protocol Details

From FastPay to primary infrastructure

FastPay

From FastPay to primary infrastructure



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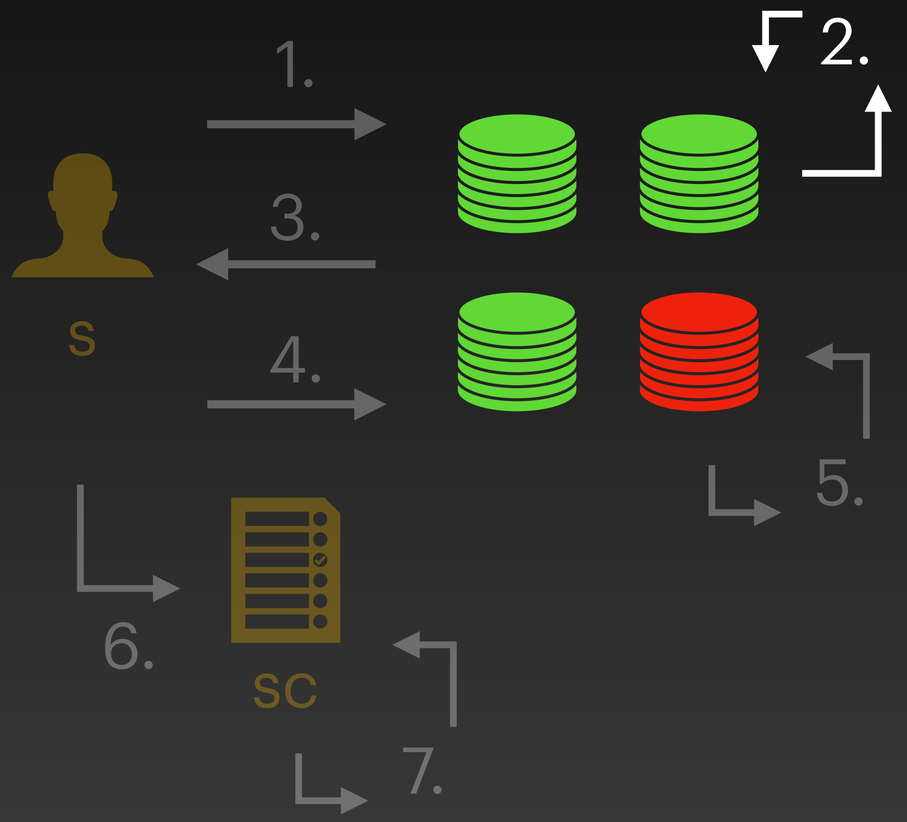
FastPay

From FastPay to primary infrastructure



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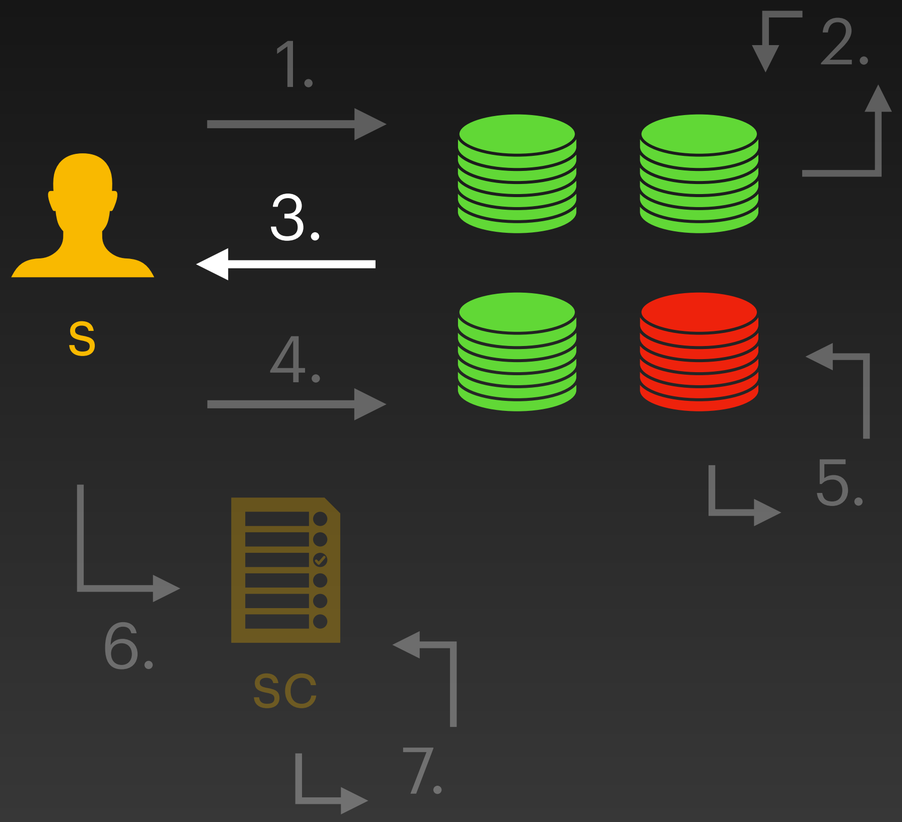
FastPay

From FastPay to primary infrastructure

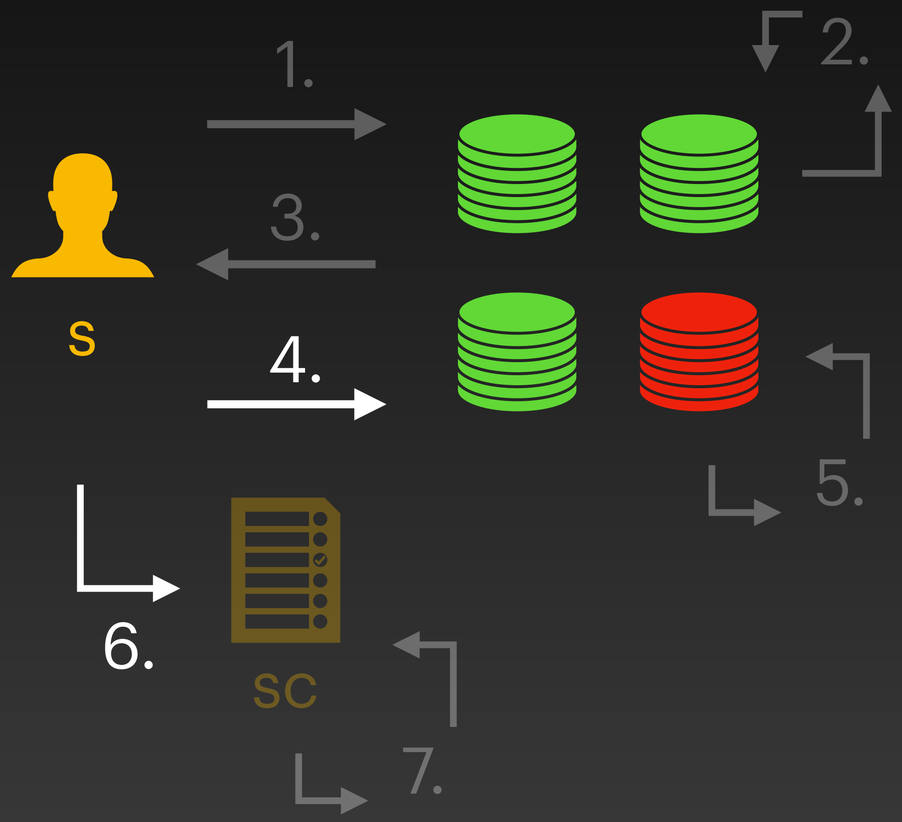


3. signed transfer order

- Each authority signed the transfer order received in step 1.

FastPay

From FastPay to primary infrastructure

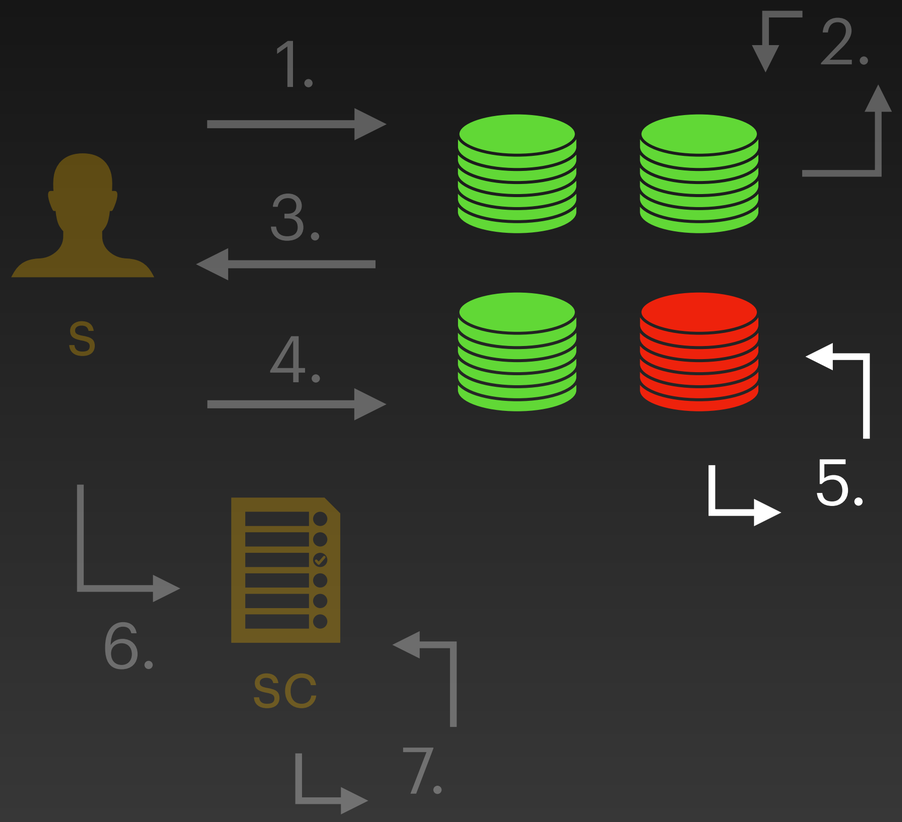


4. 6. confirmation order

- Collect enough signed transfer orders from step 2.

FastPay

From FastPay to primary infrastructure

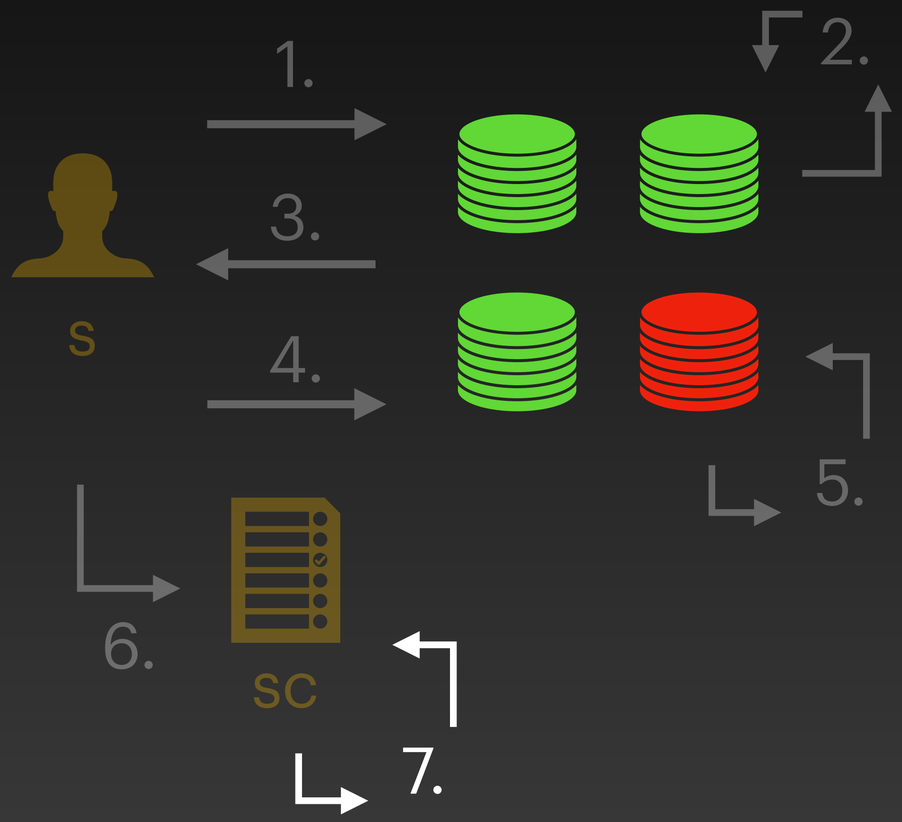


5. update

- Check there are enough signatures
- Decrease the senders' balance
- Increase the sequence number
- Set the pending order to None

FastPay

From FastPay to primary infrastructure



7. verify & update

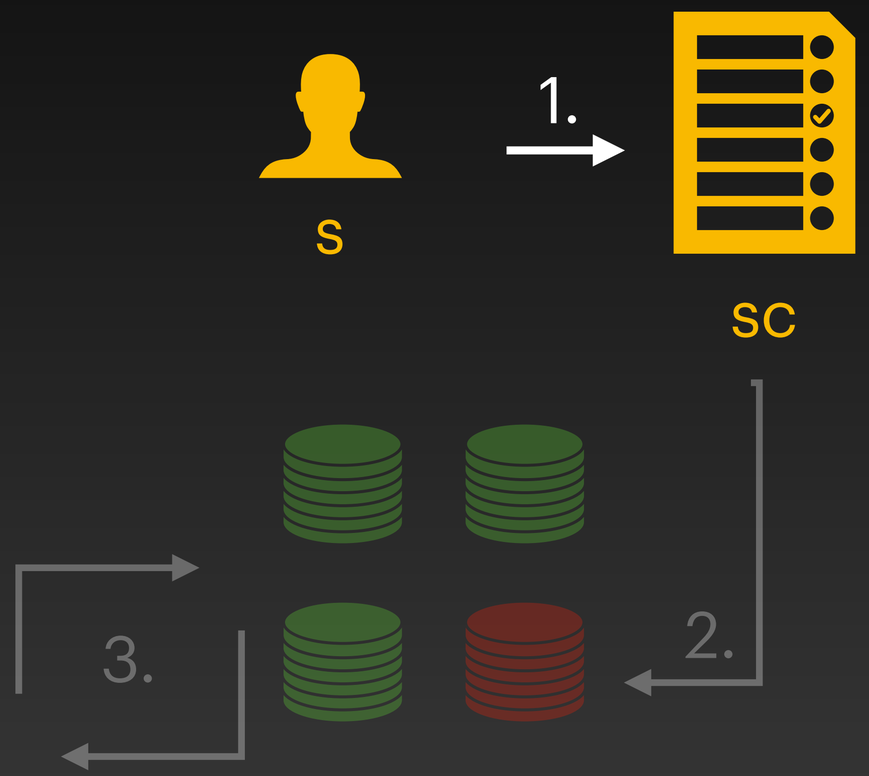
- Check sequence number is not on the redeem log
- Update the redeem log
- Transfer the amount to recipient

Protocol Details

From primary infrastructure to FastPay

FastPay

From primary infrastructure to FastPay

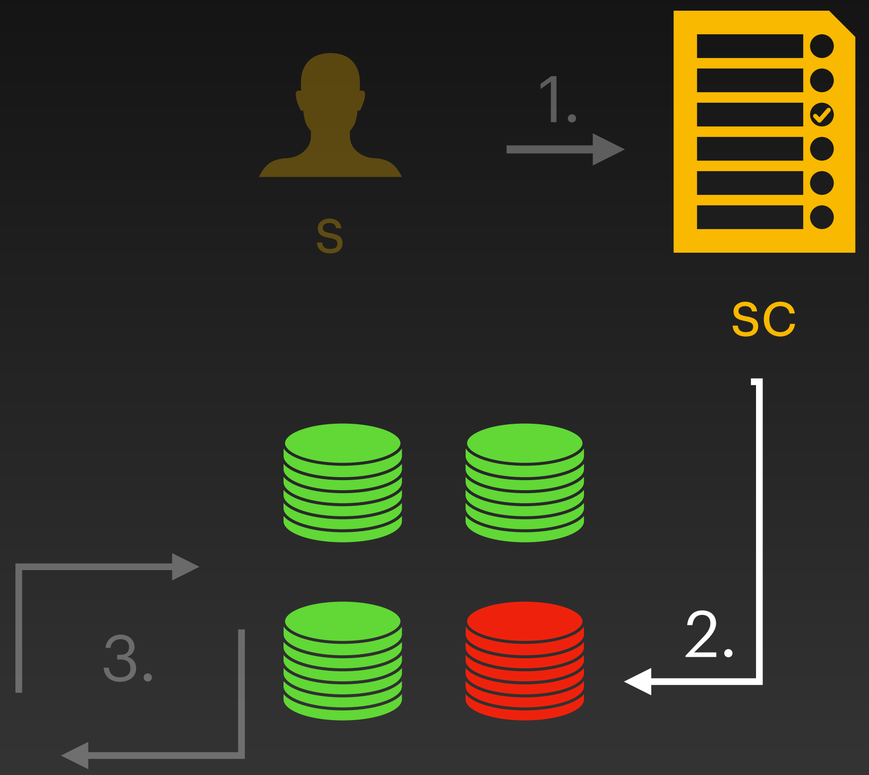


1. funding transaction

- FastPay recipient
- All fields required by the primary infrastructure (and the amount)

FastPay

From primary infrastructure to FastPay

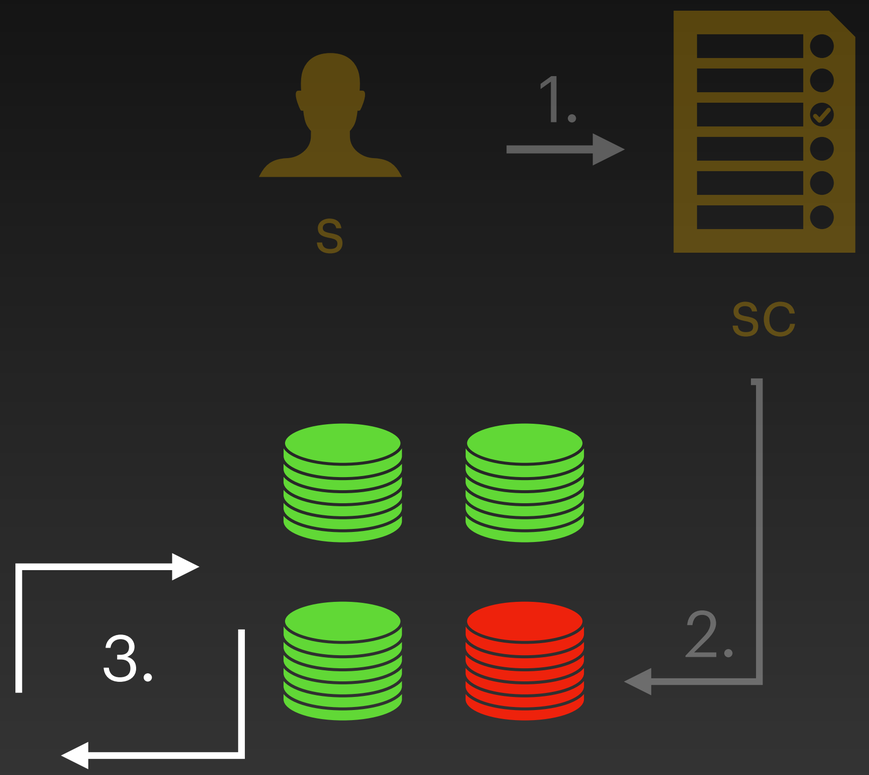


2. synchronization order

- Read the transaction on the primary infrastructure (once it is sequenced)

FastPay

From primary infrastructure to FastPay



3. update & verify

- Check last primary tx index
- Increment last primary tx index
- Create a FastPay account for the recipient (if needed)
- Increase recipient's balance