BLOXY: Providing Transparent and Generic BFT-Based Ordering Services for Blockchains

Symposium on Reliable Distributed Systems, October 4, 2019

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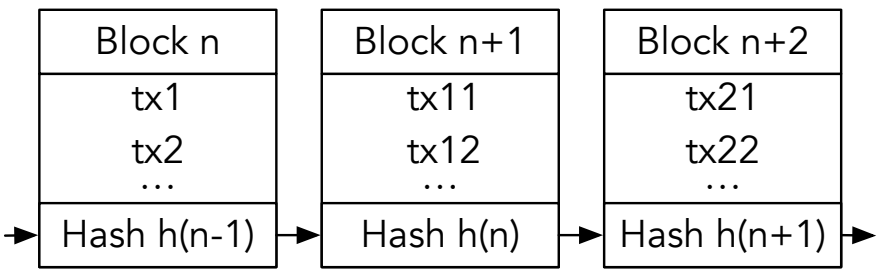
Funded by DFG

Blockchain Technology for Industry Usage

- Transactions are stored decentralised and tamper-proof
- **Permissioned** blockchains:
  - Number of users and access to data regulated
  - Interesting for companies and organisations
  - Several use cases: supply chain management, distributed storage, ...



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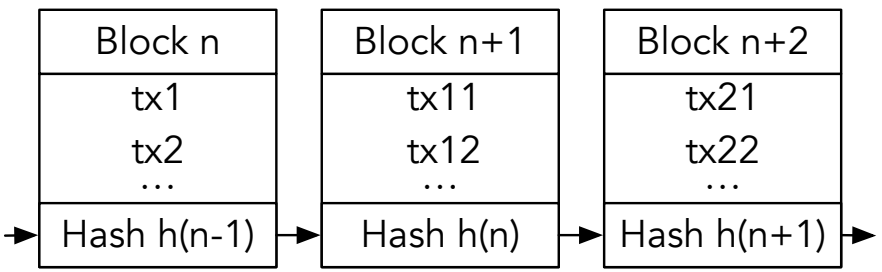

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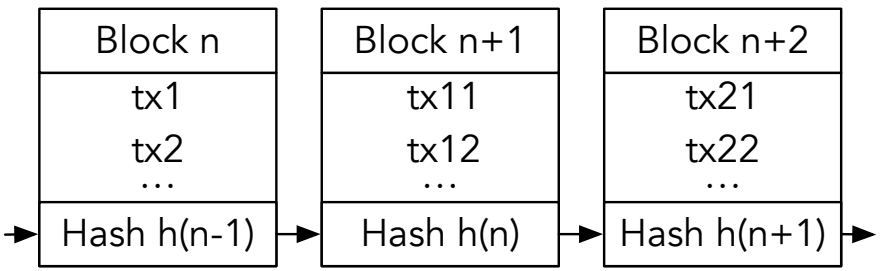
↳ Different use cases lead to different **requirements** for consensus!



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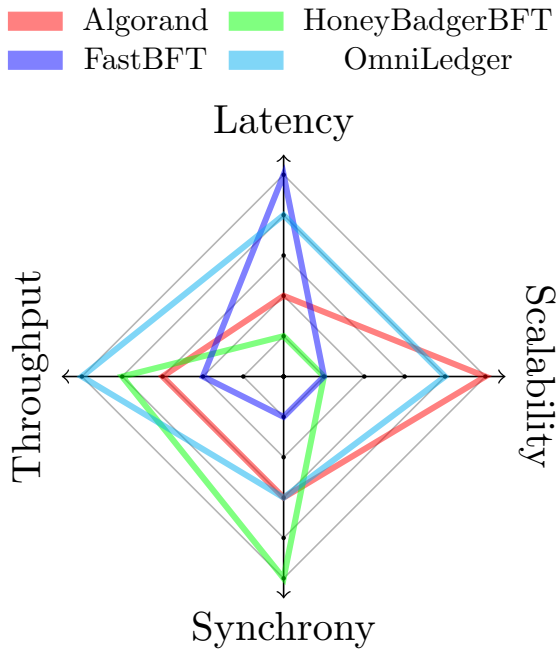

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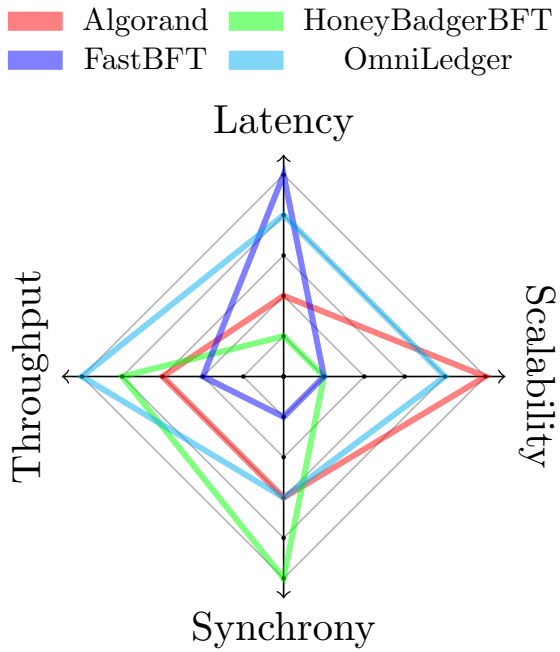

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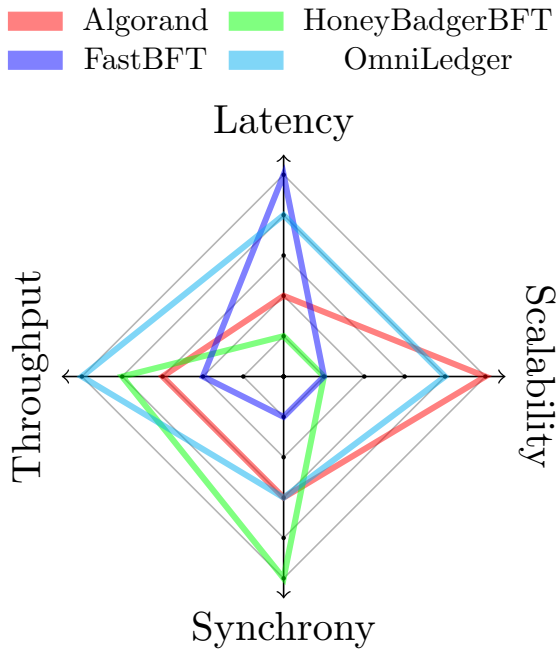

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↳ Allow operators to **choose protocol fitting to use case!**

Hyperledger Fabric

- Permissioned blockchain platform [Androulaki et al., EuroSys'18]
- Modular design with **pluggable consensus**

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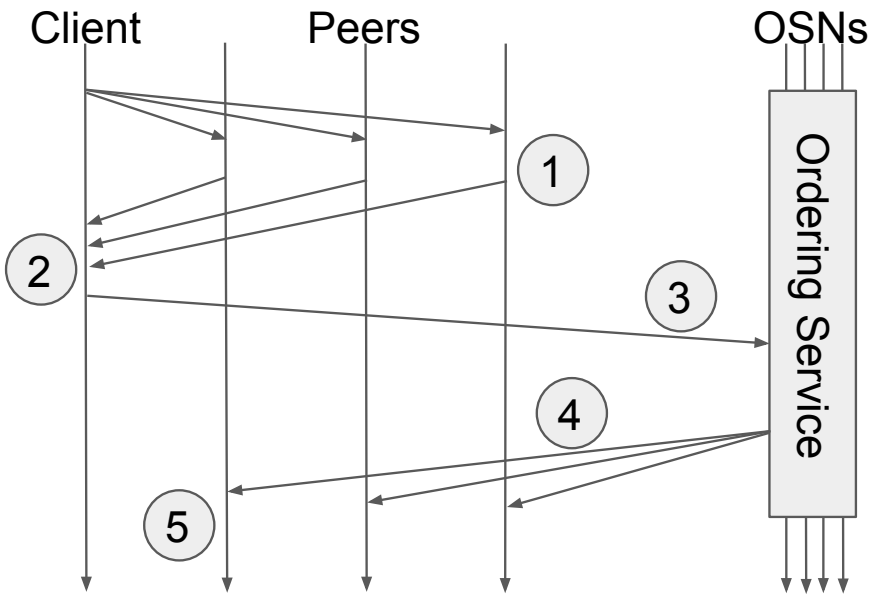
HYPERLEDGER FABRIC

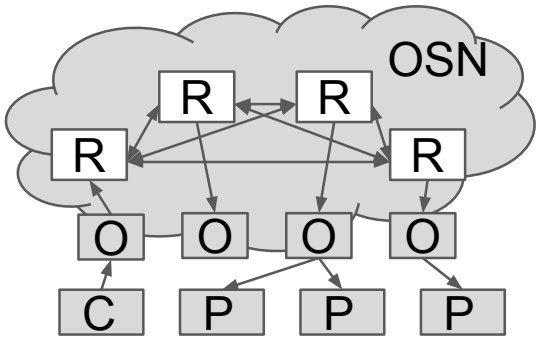
- **Transaction flow:**

1. Peers execute transaction
2. Client collects endorsements
3. Client sends transaction to be ordered
4. Ordering Service Nodes (OSNs) distribute blocks
5. Peers validate transactions



Ordering Services in Fabric

- No fault tolerance: Solo
- Crash-fault tolerance: Apache Kafka
- Byzantine fault tolerance: BFT-SMaRt
  [Sousa et al., DSN'18]



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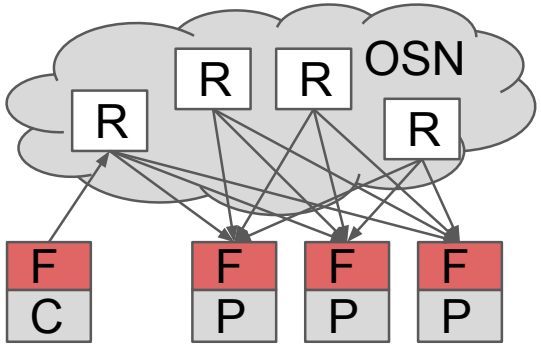

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  - Client tasks compromise pluggability
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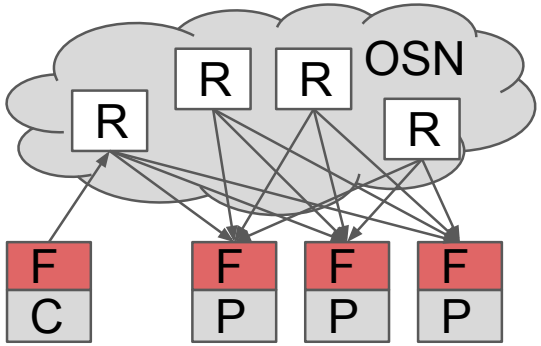

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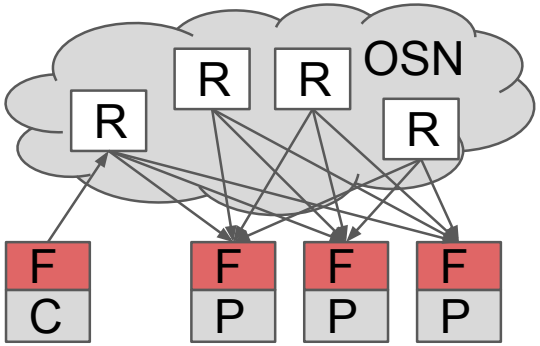

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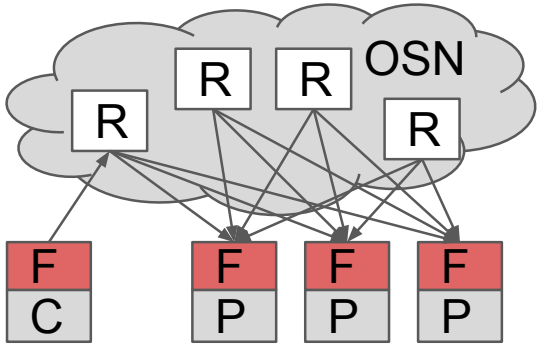

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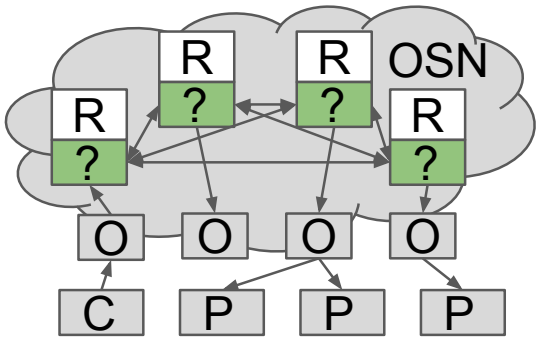

↳ **Goal**: Shift **BFT client** functionality to **replica nodes** to maintain modularity!

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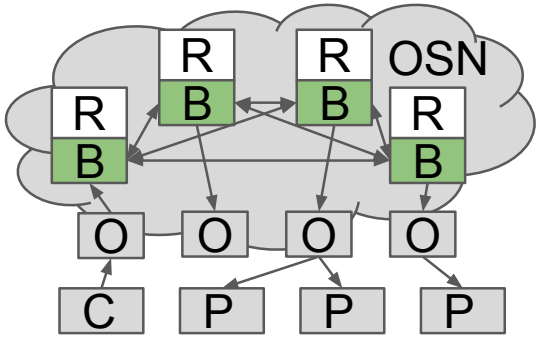
Bloxy: Blockchain-Aware Trusted Proxy

- **Consensus proxy** for Hyperledger Fabric
- Encapsulates BFT client functionality
- **Transparent** access to a **generic** ordering service



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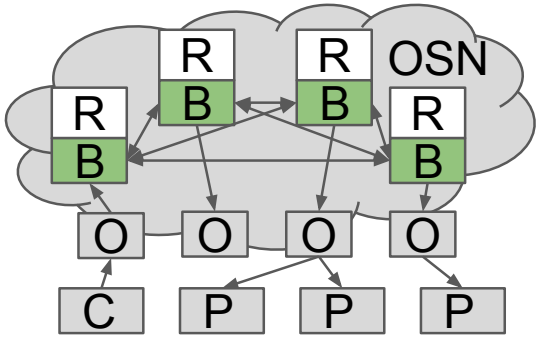

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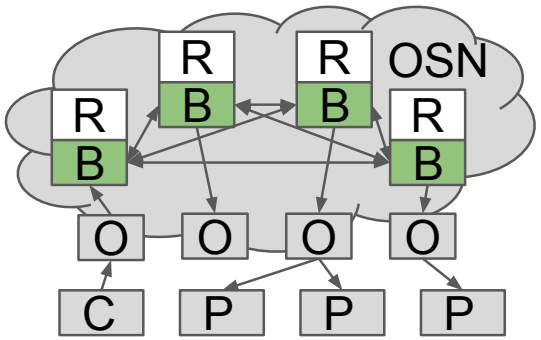

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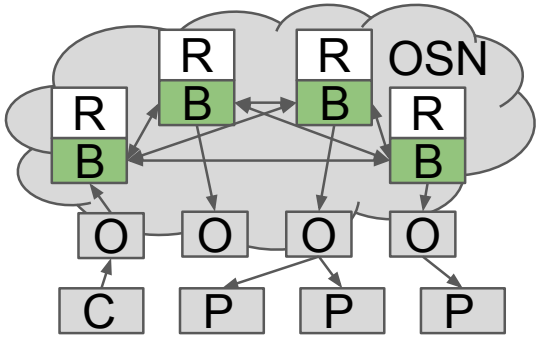
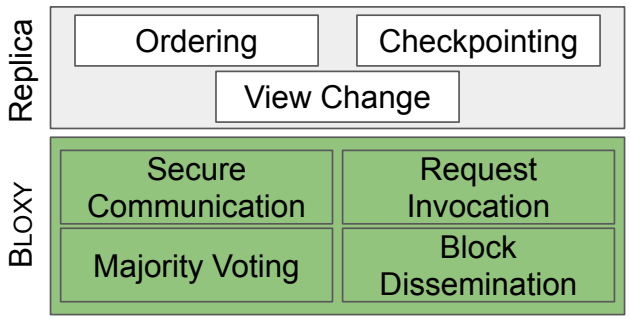
- Functionality:
  1. Establishing secure connections
  2. Forwarding transactions as BFT requests
  3. Majority voting on replies
  4. Block dissemination





Trusted Execution: Intel SGX in a Nutshell

- x86 **instruction set extension** introduced with Skylake architecture
- Creation of TEEs $\rightarrow$ **enclaves**
- Execution and data inside enclaves **protected from privileged software**
- Hardware-based **memory integrity protection** and **encryption**
- Remote attestation of enclaves
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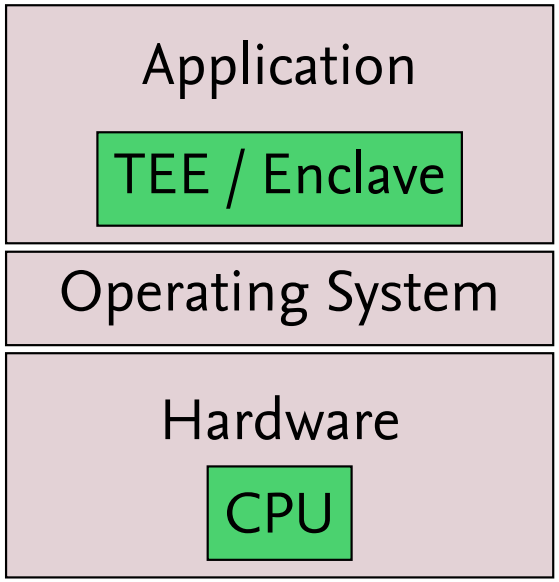

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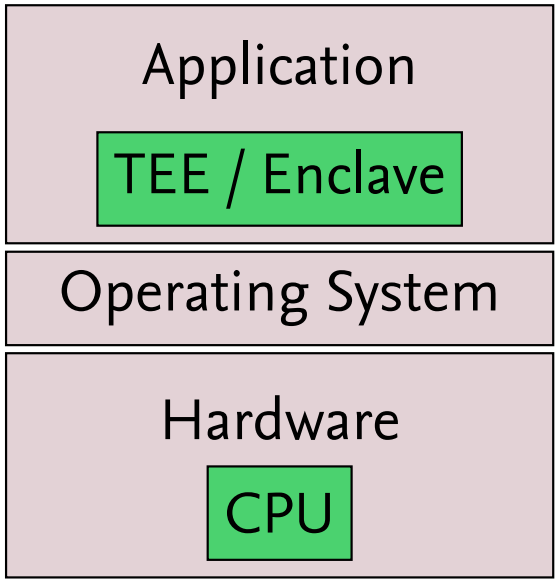

↳ **Intel SGX** allows the creation of **enclaves**, trusted execution environments (TEEs) protected by hardware.

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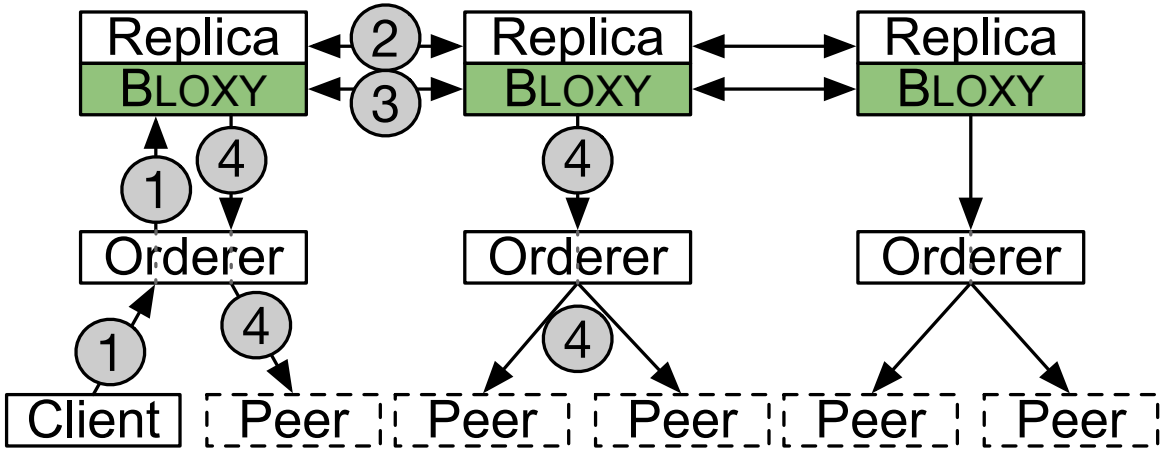

① Transaction forwarded to Bloxy via orderer

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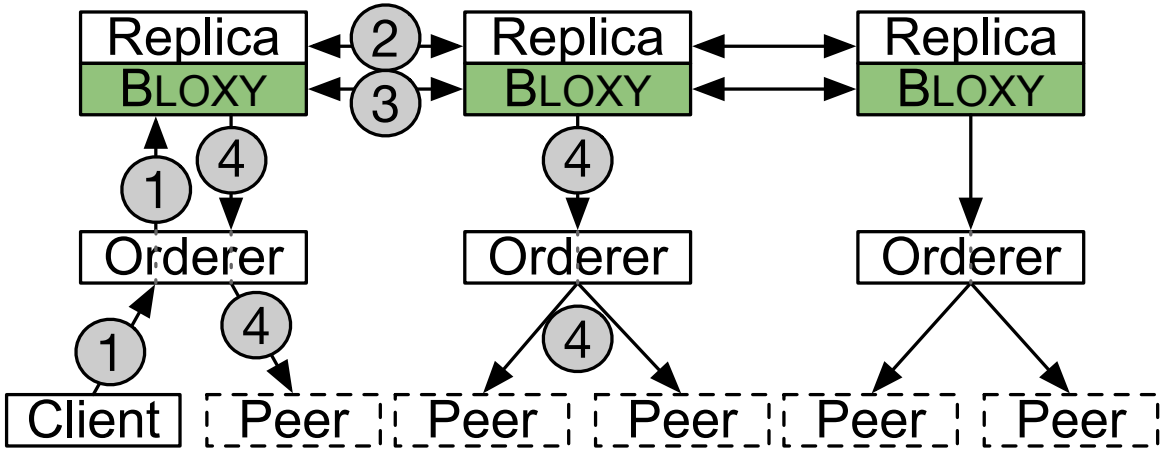

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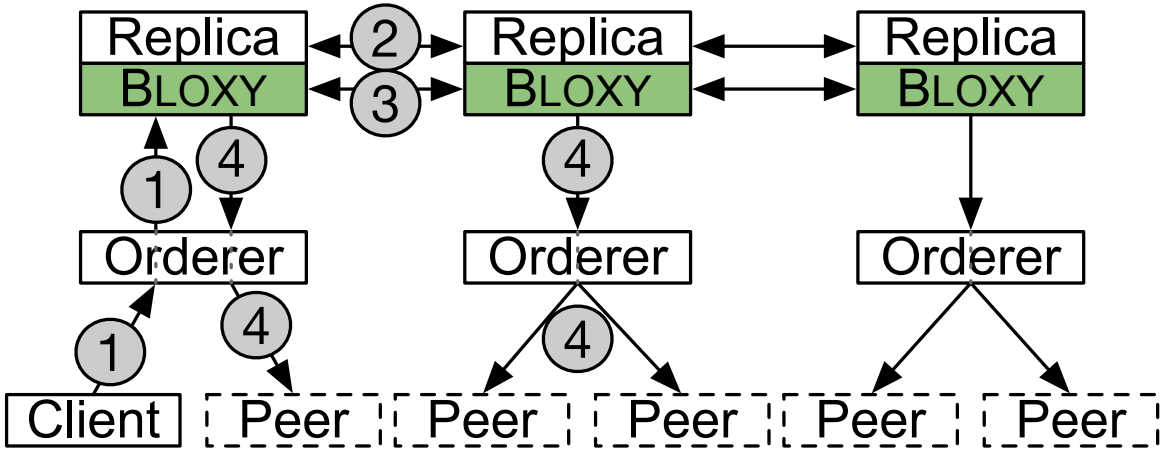

① Transaction forwarded to BLOXY via orderer

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③ BLOXIES get block, exchange hashes, perform majority voting

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↳ Lower overhead due to **less** and **shorter** messages!

Bloxy Short-Term Block Storage

- Fulfil Fabric's **requirements** for ordering services
- **No Skipping**: **all** peers need **all** blocks
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↳ Bloxy can guarantee **all requirements** for ordering services!

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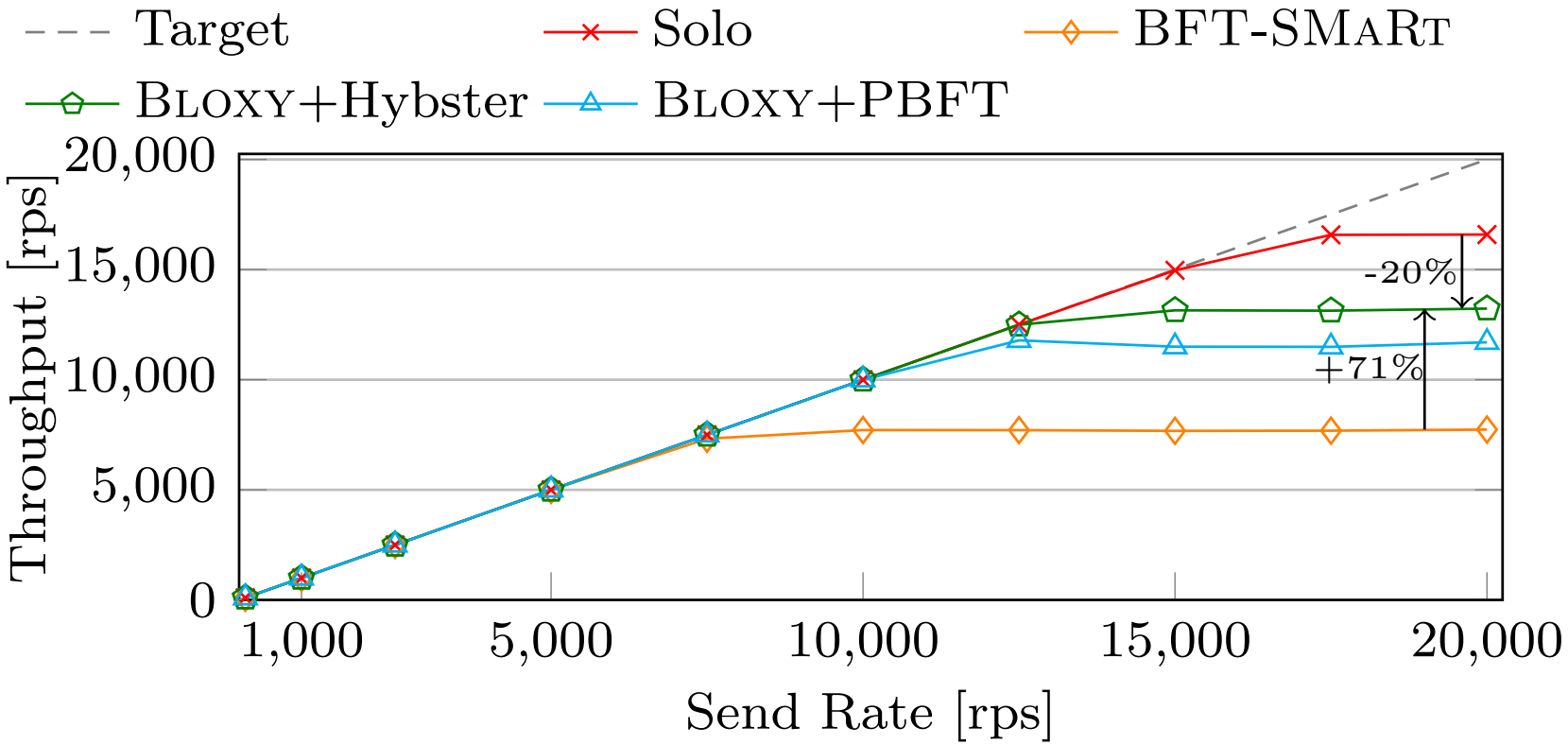
↳ BLOXY allows easy integration of **arbitrary BFT protocols**!

Evaluation of BLOXY

- 4 machines for **ordering service**
  - SGX-capable 4-core Xeon v5 CPUs, 32GB RAM
- 5 machines as **peer and orderer** nodes
  - non-SGX 4-core Xeon v2 CPUs, 16GB RAM
- **10 Gbps** interconnection (switched network)
- **Ordering Service Component:**
  - What is BLOXY's **impact on latency**?
  - What **throughput** can BLOXY achieve?
- **Complete Fabric network:**
  - Does BLOXY affect the performance of **Fabric**?

Throughput Evaluation of Ordering Services



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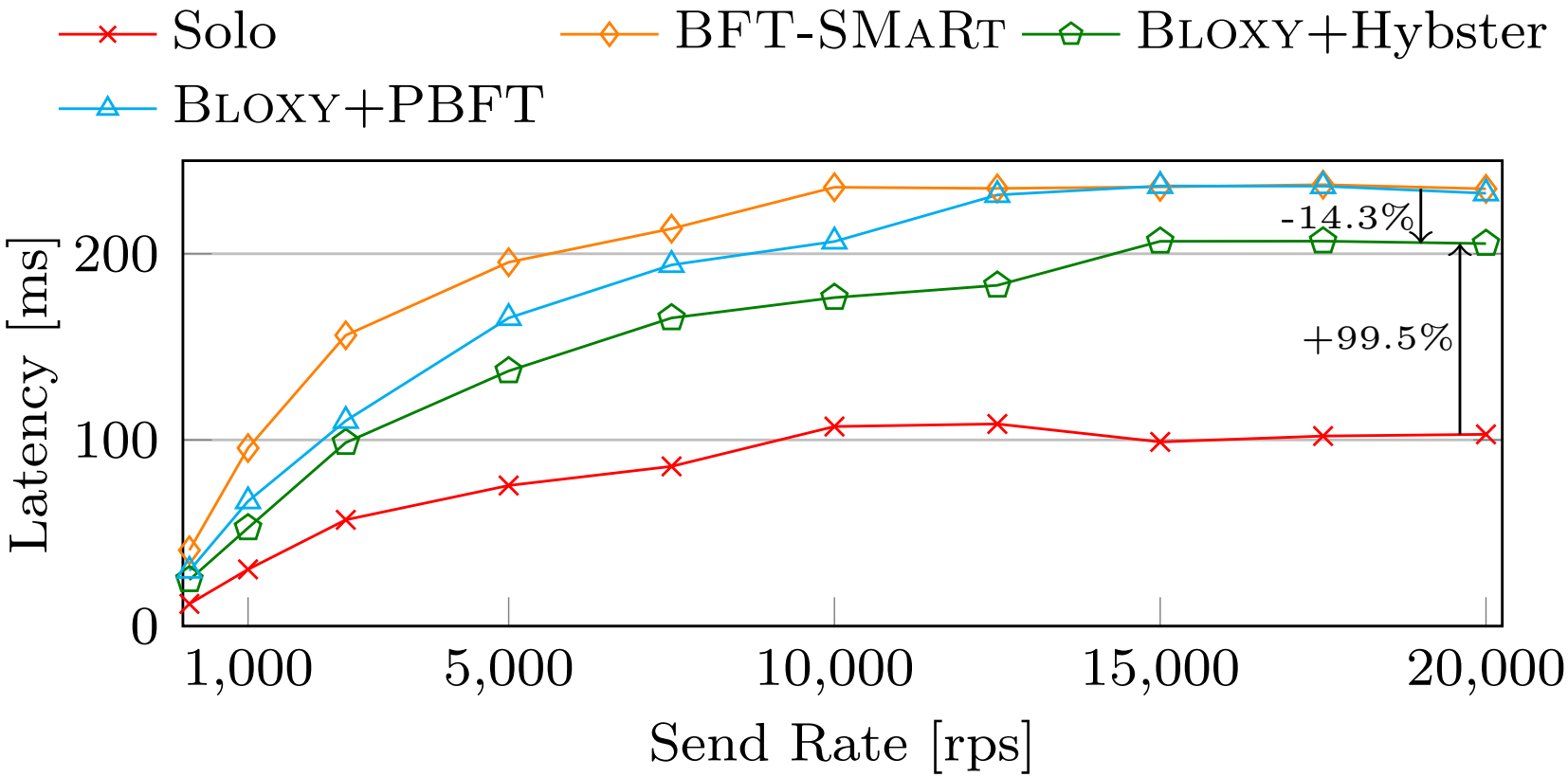

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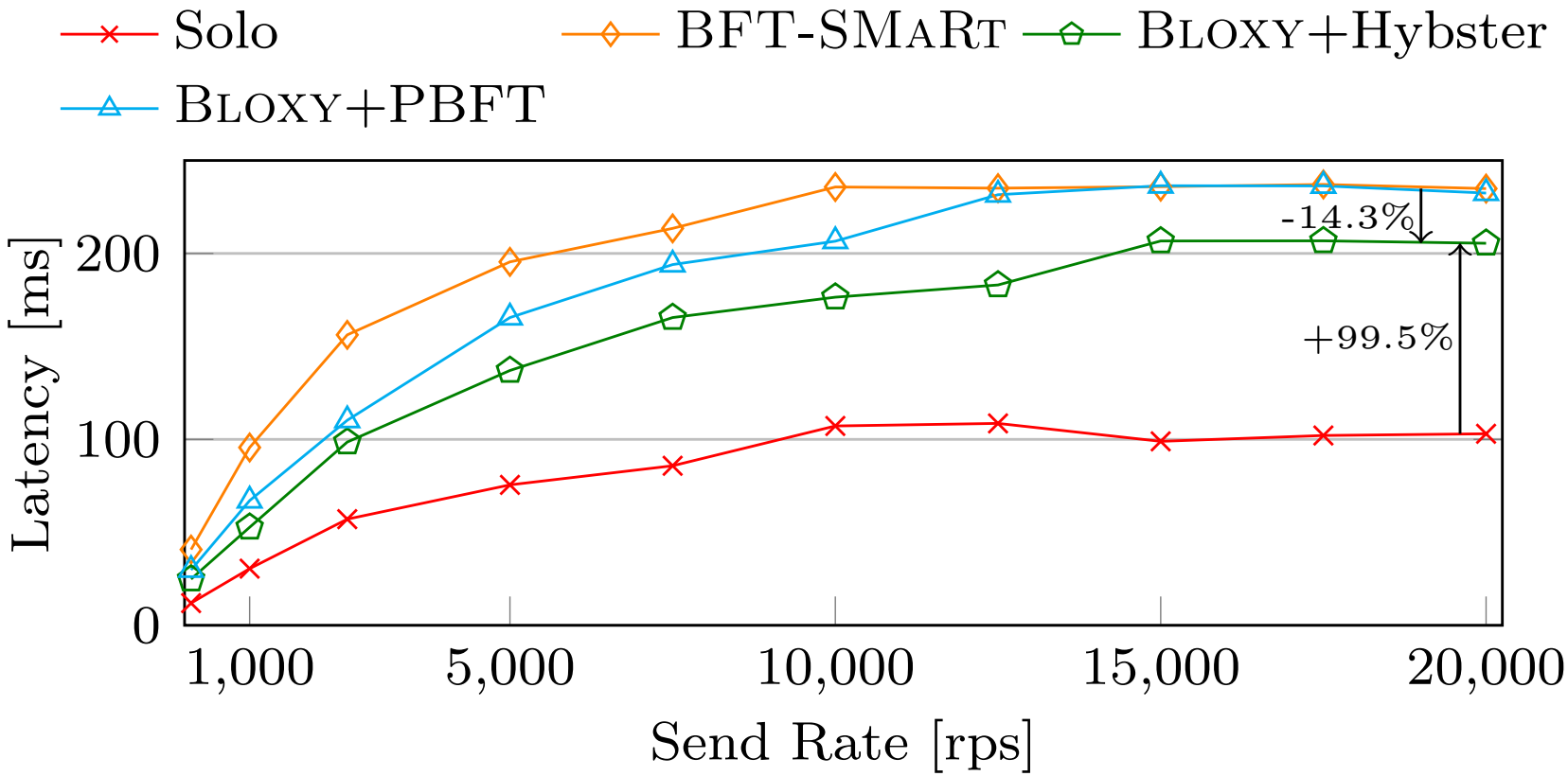
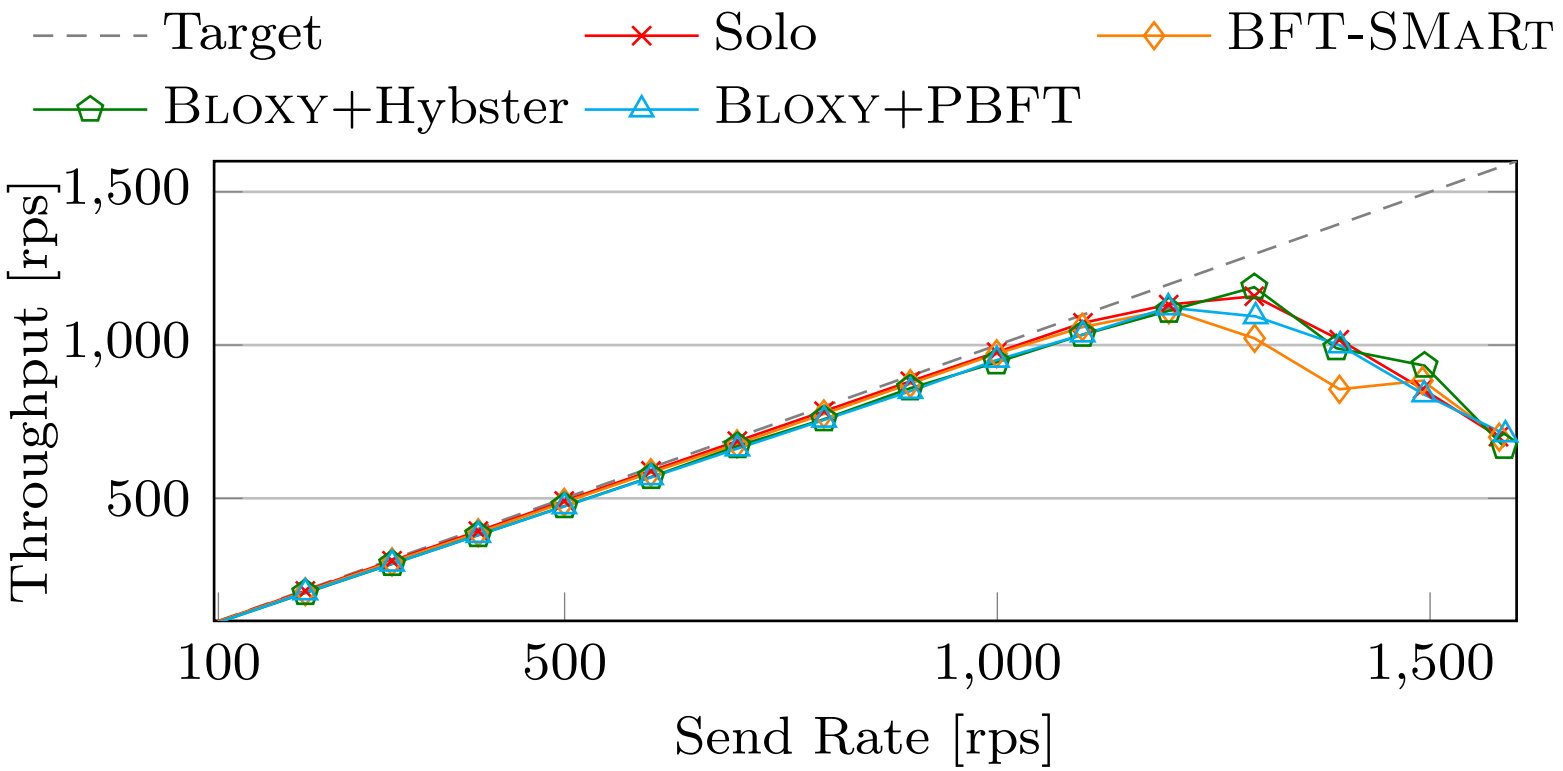


↳ Lower communication overhead of Bloxy protocols, **improved** throughput and latency

Throughput Evaluation of Fabric Network



- Hyperledger Caliper with full Fabric network
  - 12 clients, 2 peers, 3-4 replicas in ordering service
  - Bloxy-backed protocols give comparable performance

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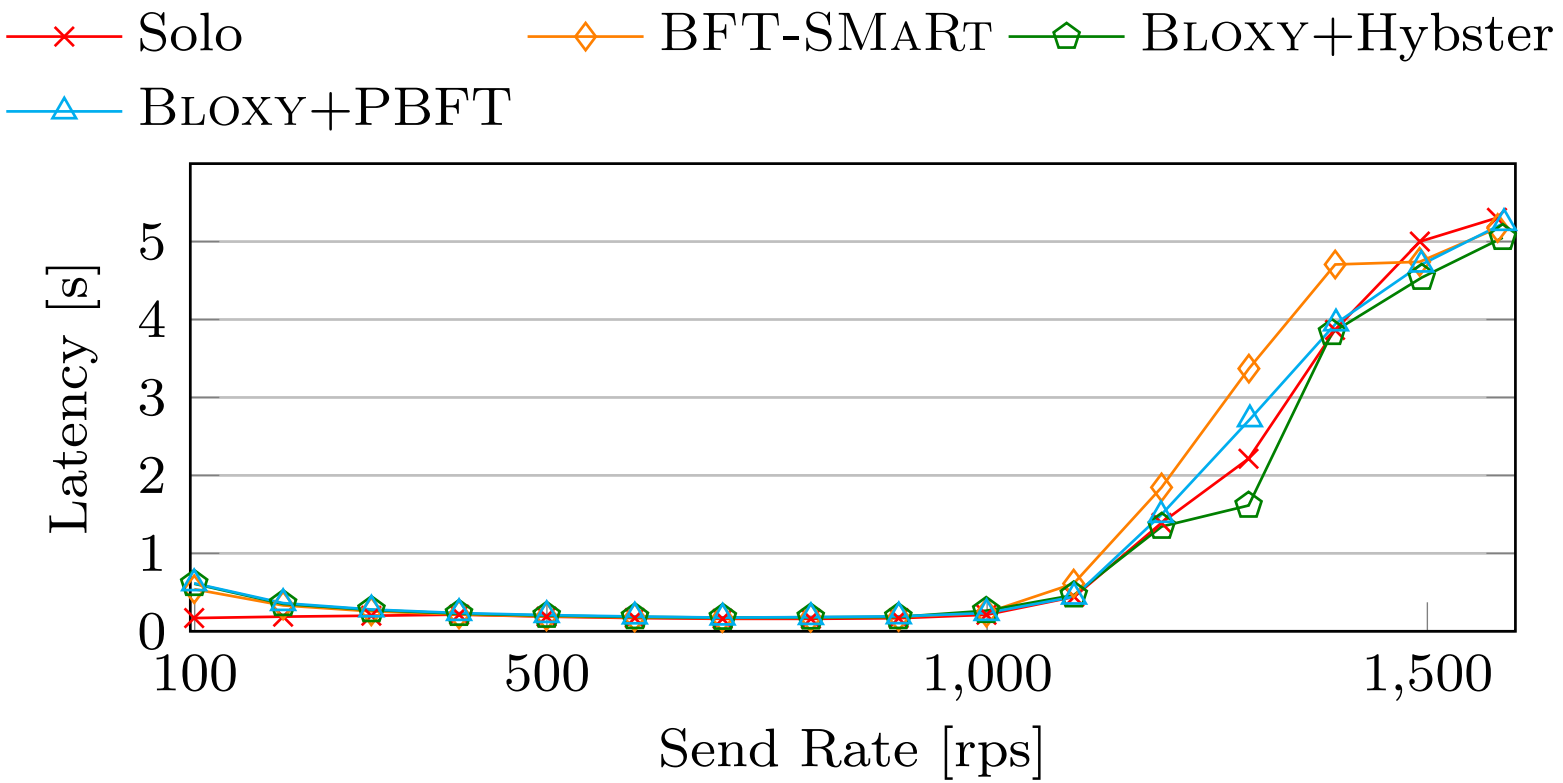

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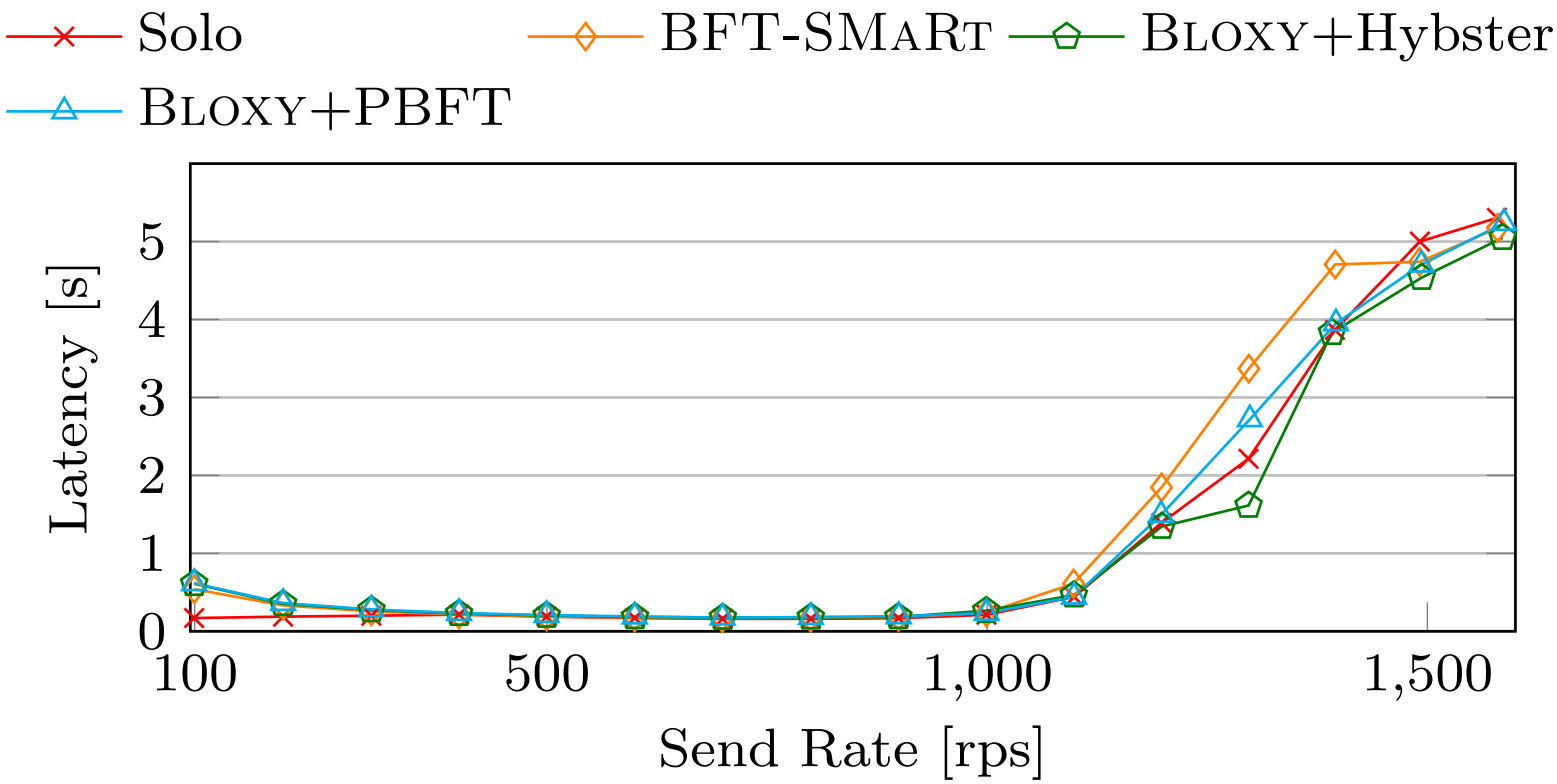

↳ Ordering service has **no noticeable impact** on Fabric's performance

↳ Generic consensus at **no performance cost**!

→ Full evaluation of all ordering services in paper!

Related Work

- Other uses of Intel SGX as trusted proxy
- **Troxy** [Li et al., DSN'18]
  - Shift BFT client functionality to replica side
  - Aid adoption of BFT protocols e. g. for SMTP and HTTP
  - No changes to common protocols and client implementations necessary
- LibSeal [Aublin et al., EuroSys'18]
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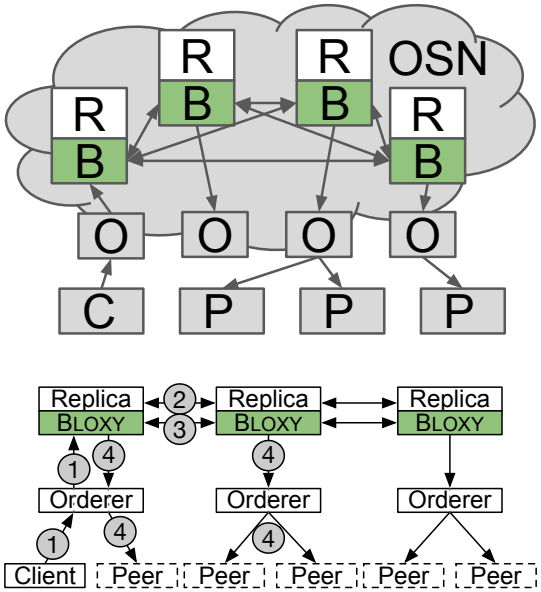
↳ BLOXY tailored for **blockchain** use case and communication, integration into a permissioned blockchain with ordering service

Conclusion

BLOXY's contributions:

- **Consensus proxy** for Hyperledger Fabric
- Encapsulation of **BFT client functionality**



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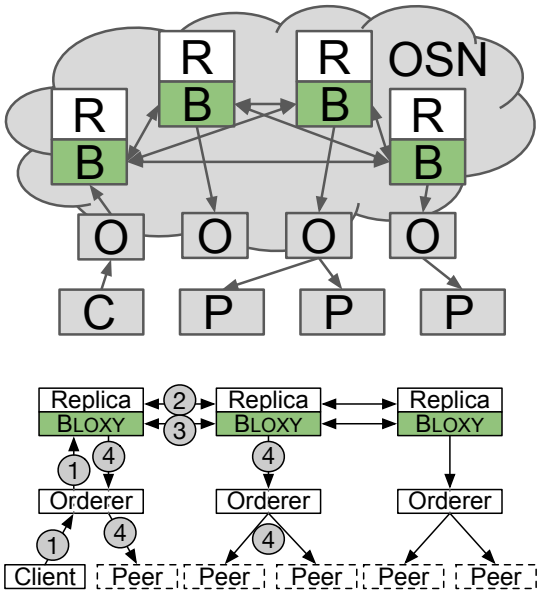
- Enabling **easy integration** of ordering services
- Allowing operators to choose **suitable** protocols



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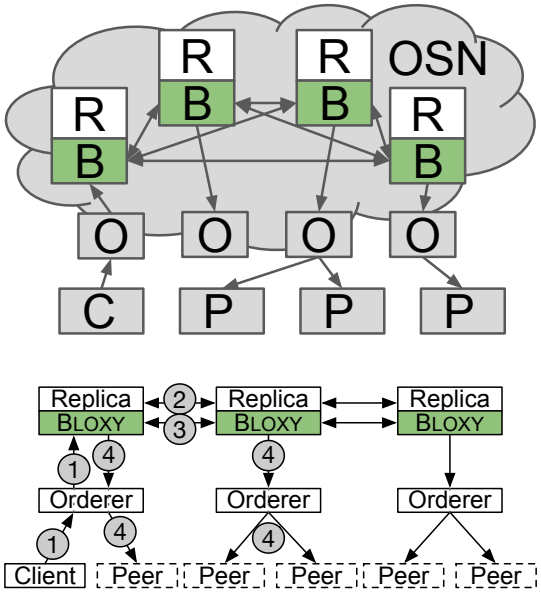
- **Good performance** compared to directly integrated BFT protocols



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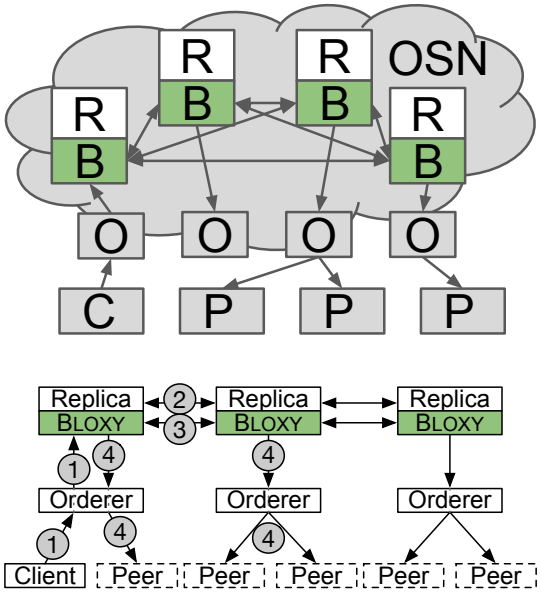

Thank you for your attention! Questions?

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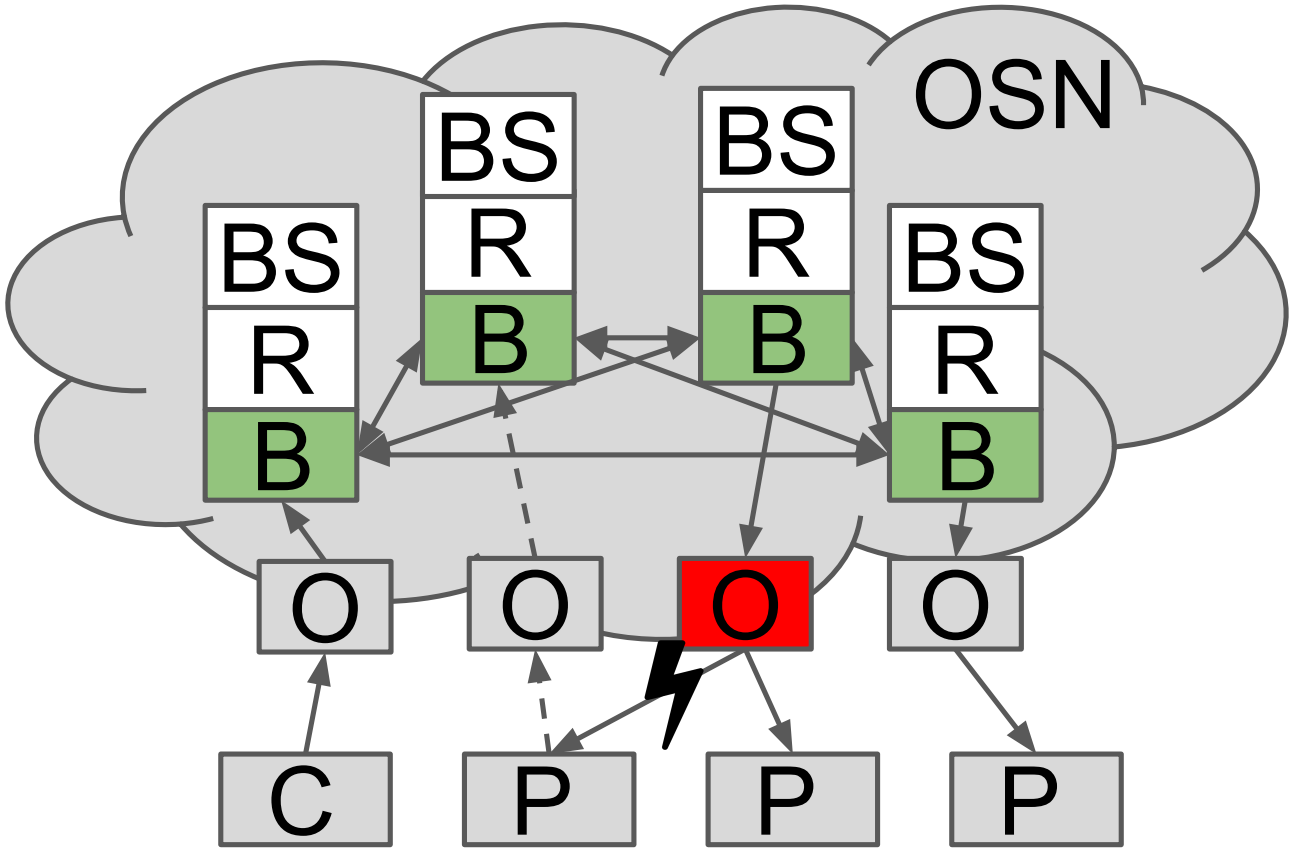
Requirements of Fabric's Ordering Services

- Agreement:
  - Blocks with same sequence number should be identical
  - No support of forks
- Hashchain integrity:
  - Blocks contain hash of predecessor
  - Blocks form non-manipulatable hashchain
- No skipping:
  - No peer can skip a block
  - Has to receive all previous blocks
- No creation of transactions
- Liveness:
  - Transactions submitted to the ordering service will eventually be contained in block

Bloxy Short-Term Block Storage



P: Peers C: Client R: Replica O: Orderer B: Bloxy BS: Block Storage

Bloxy Short-Term Block Storage: Evaluation Results

	Bloxy		(iii) Orderer
	(i) Storage Hit	(ii) Storage Miss	
Duration	21.79 ms	7.19 ms	7.28 ms

(i) Query Short-Term Block Storage

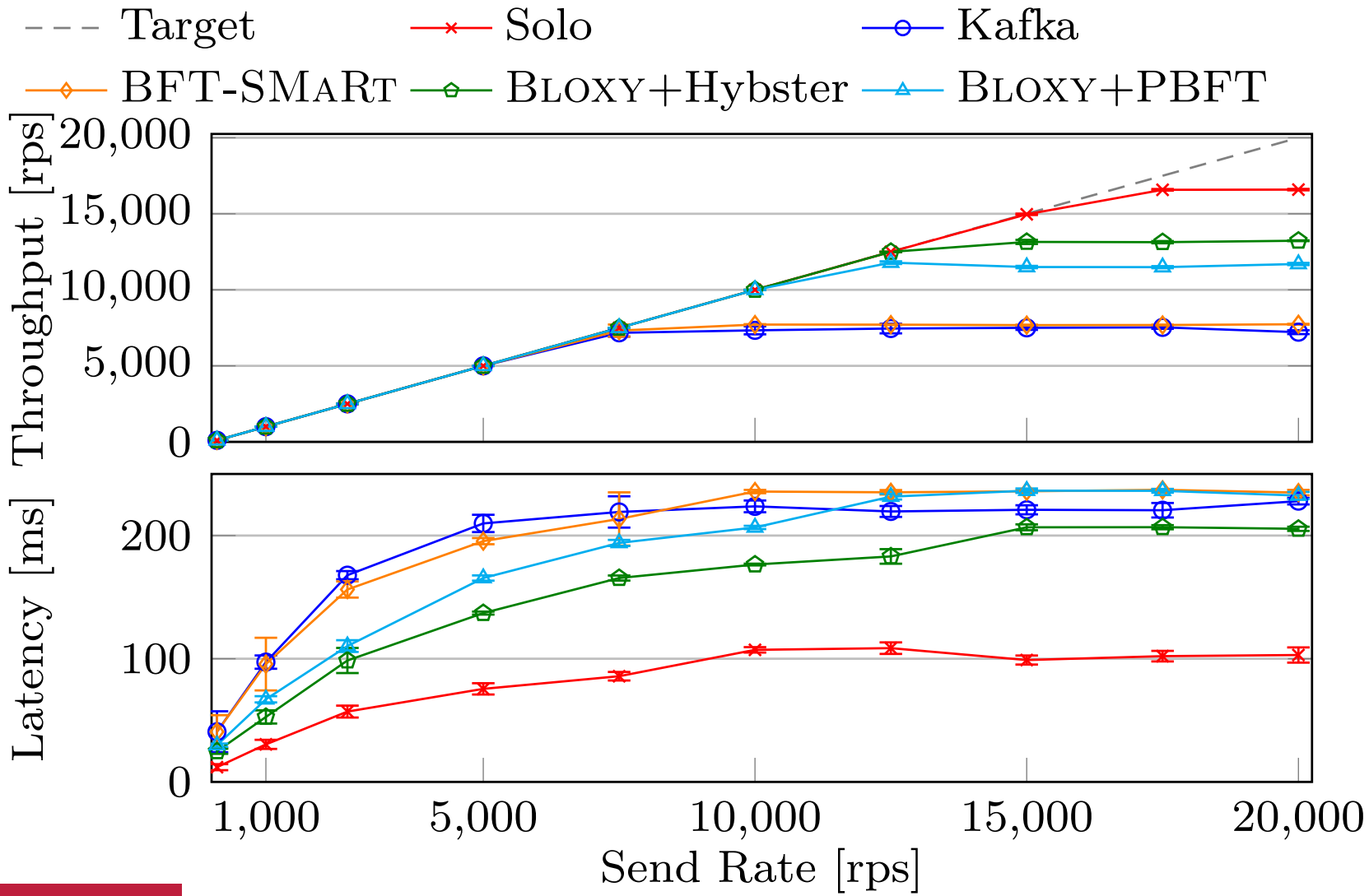
(ii) Query Block Storage, query orderer from acknowledged list

(iii) Randomly query orderers

Public API of Bloxy

- Connection establishment
- Orderer:
  - Submit transaction for ordering
  - Receive voted block
- Replicas:
  - Receive forwarded and translated transaction for ordering
  - Submit block for majority voting

Ordering Service



Ordering Service

- Throughput:
  - 71 % (Hybster) and 51 % (PBFT) higher compared to BFT-SMaRt
  - 20 % (Hybster) and 29.5 % (PBFT) lower compared to Solo
- Latency:
  - 99 % (Hybster) and 125 % (PBFT) higher than Solo
  - 14.3 % (Hybster) lower than BFT-SMaRt

Full Fabric Network