Initial Public Offering (IPO) on Permissioned Blockchain using Secure Multiparty Computation

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IBM

Outline

- Hyperledger and Fabric
- Fabric Architecture
- Initial Public Offering and Multi-Party Computation

Hyperledger and Fabric

HYPERLEDGER

HYPERLEDGER FABRIC

- **Hyperledger – www.hyperledger.org**
  - Global collaboration hosted by the Linux Foundation
    - Advances blockchain technologies for business, neutral, community-driven
    - Started in 2016: Hyperledger unites industry leaders to advance blockchain technology
    - ca. 230 members in May '18
  - Develops and promotes blockchain technologies for business
  - Hyperledger has 5 frameworks and 5 tools, hundreds of contributors

- **Hyperledger Fabric – github.com/hyperledger/fabric/**
  - A generic blockchain framework, modular, consortium
  - Originally contributed by IBM and DAH
  - Architecture, consensus, and cryptography contributed by IBM Research - Zurich

Hyperledger Overview

Hyperledger Modular Greenhouse Approach

THE LINUX FOUNDATION

Infrastructure

Technical, Legal, Marketing, Organizational

Ecosystems that accelerate open development and commercial adoption

Cloud Foundry | Node.js | HYPERLEDGER | Open Container Initiative

Frameworks

Meaningfully differentiated approaches to business blockchain frameworks developed by a growing community of communities

HYPERLEDGER FABRIC	HYPERLEDGER SAWTOOTH	HYPERLEDGER IROHA	HYPERLEDGER INDY	HYPERLEDGER BURROW
Permissioned with channel support	Permissioned & permissionless support	Mobile application focus	Decentralized identity	Permissionable smart contract machine

Tools

Typically built for one framework, and through common license and community of communities approach, ported to other frameworks

HYPERLEDGER COMPOSER	HYPERLEDGER CELLO	HYPERLEDGER EXPLORER	HYPERLEDGER QUILT	HYPERLEDGER CALIPER
Model and build blockchain networks	As-a-service deployment	View and explore data on the blockchain	Ledger interoperability	Blockchain framework benchmark platform

Fabric Architecture

HYPERLEDGER FABRIC

In a Nutshell

Permissioned

- **Strong identity management**
- Support for **multiple credential** and cryptographic services for identity
- Support for **”bring your own identity”**

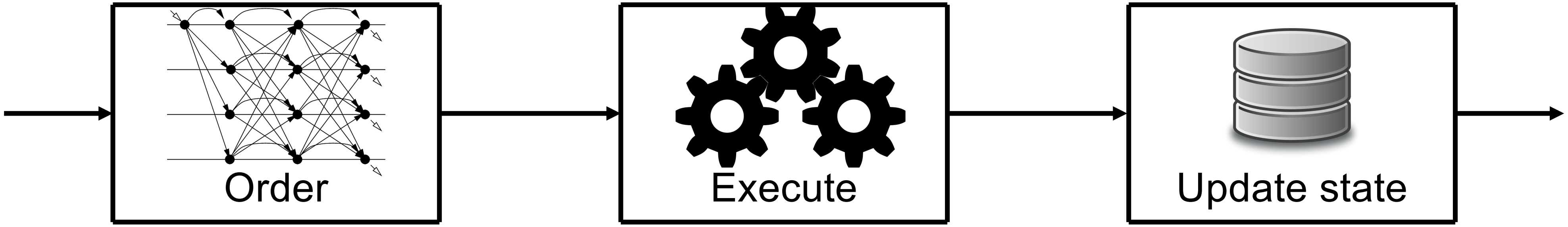
Privacy Friendly

- Support **broader regulatory requirements** for privacy and confidentiality
- **Contract state concealable to unauthorized parties**
- Business Logic is executed only after authorized entity request and only on a subset of the netwrok

Scalable

- **Scale the number of participants and transaction** throughput
- **Eliminate non deterministic transactions**
- **Parallel execution of the business logic**

Traditional design: Replicated State Machine



- Consensus or atomic broadcast
- Deterministic (!) tx execution
- Persist state on all peers

- All prior BFT systems operate like this [S90]
- All prior permissioned blockchains operate like this
  - Including Hyperledger Fabric until V0.6

Issues with the traditional replication design

Sequential execution

- Increased latency – or – complex schemes for parallelism

Operations must be deterministic

- Difficult to enforce with generic programming language (difficult per se!)
- Modular filtering of non-deterministic operations is costly [CSV16]

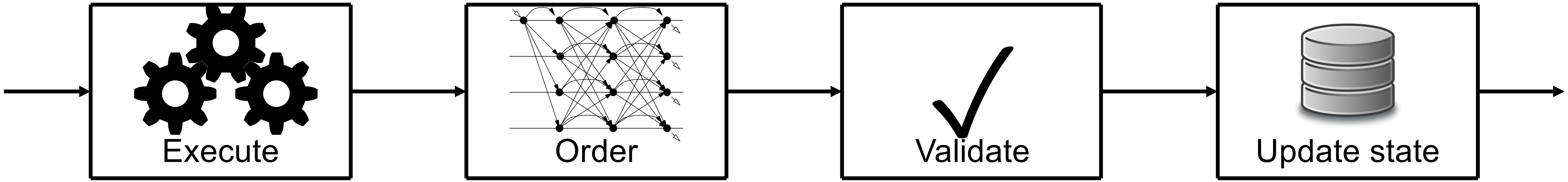
Trust model is fixed for all applications (smart contracts)

- Typically some (F+1) validator nodes must agree to result (at least one correct)
- Fixed to be the same as in consensus protocol

Privacy is difficult, as data spreads to all nodes

- All nodes execute all applications

Fabric Unique Architecture Scales



- Simulate tx and endorse
- Create rw-set
- Collect endorse-ments

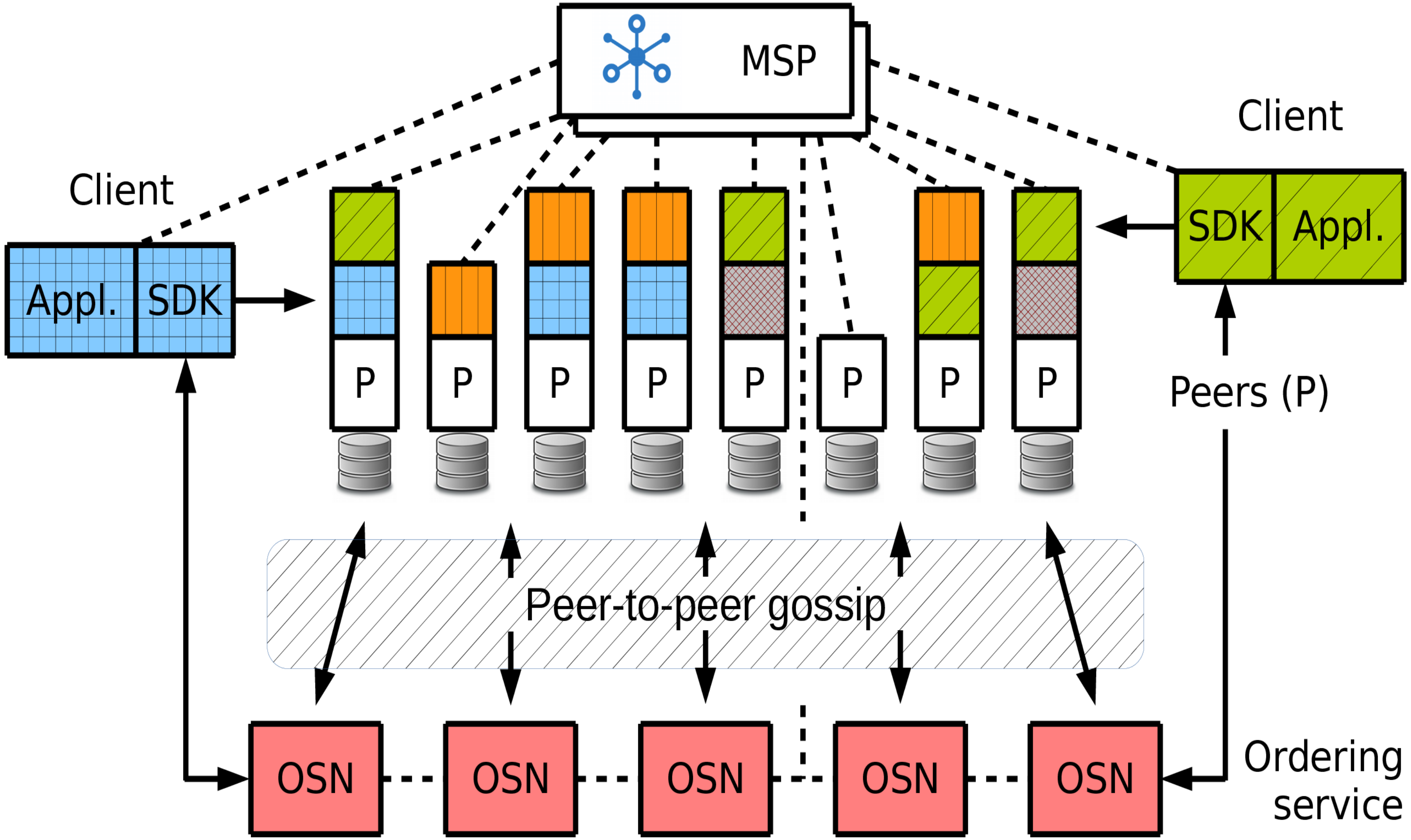
- Order rw-sets
- Atomic broadcast (consensus)
- Stateless ordering service

- Validate endorse-ments & rw-sets
- Eliminate invalid and conflicting tx

- Persist state on all peers

- Includes techniques from databases
- Extends a middleware-replicated database [KJP10] to BFT model

Fabric Architecture



Security First!

Strong identity management

Selective participation to authorized users

Accountability Non-repudiation

Entities are accounted for the transactions they create, cannot forge others' transactions

Modular, easily extensible, "bring your on provider" membership architecture

Privacy / Access Control

Contract state concealable to unauthorized parties

Authorized Execution

Logic is executed only after authorized entity request

Access Control Enforcement Framework

Privacy / Access Control

User activity & contract logic concealable to unauthorized entities

Secure Chaincode Availability Framework Application Libraries for Privacy

Pluggable Components

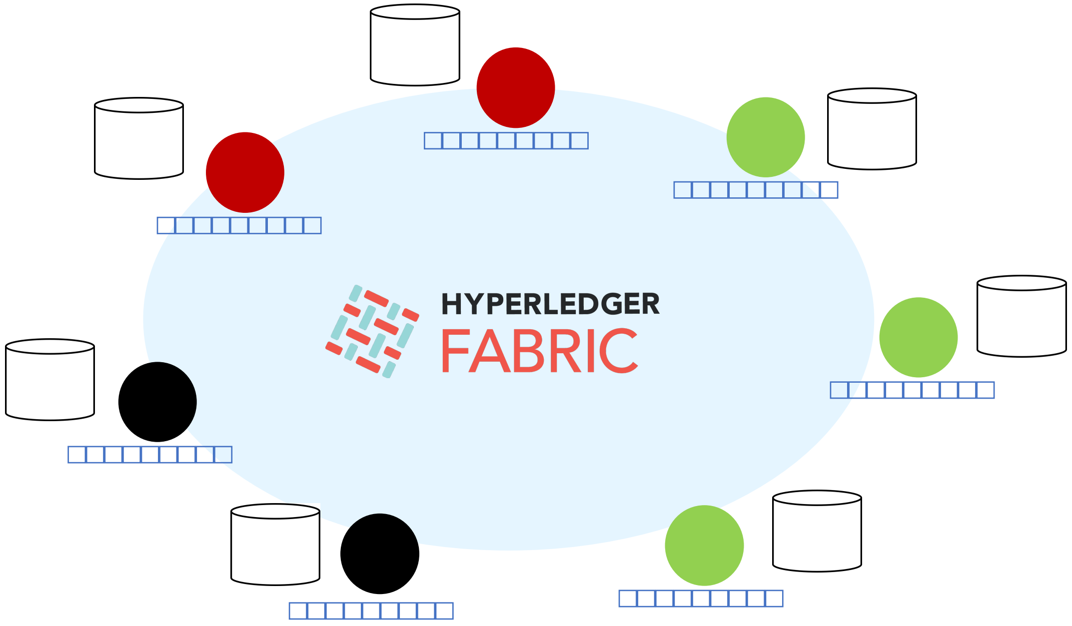
Compatibility with standards

Initial Public Offering (IPO) and Multi-Party Computation

Blockchain Can Revamp Initial Public Offering

- **IPO Trading** is an example of a ***clearing price auction***, where a single seller sells multiple shares at the same price to many buyers.
  - A bank lists it publicly on the ledger, specifying a unique ID.
  - Then, brokerage houses can record IPO orders on the ledger on behalf of investors.
  - Later the listing bank invokes the sell-IPO process, and the peers engage in a protocol to determine the clearing price of this IPO, as well as the share allocation

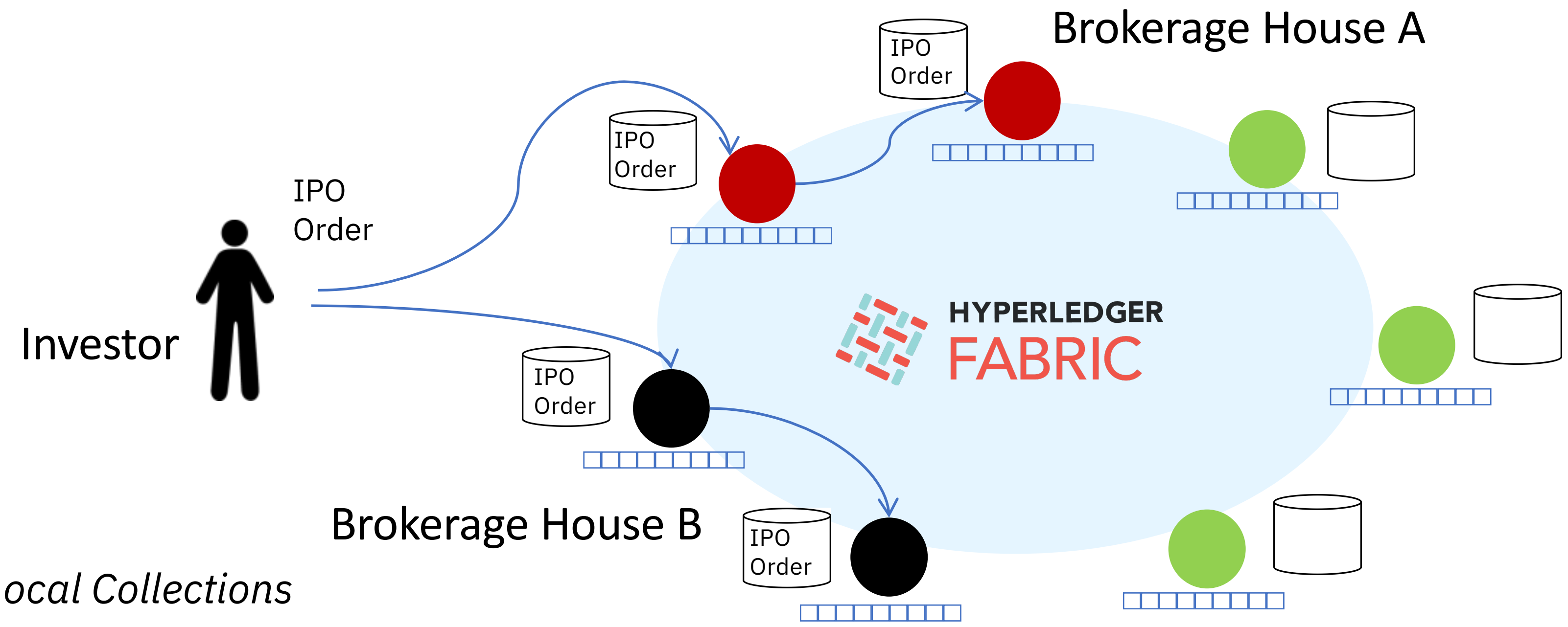
- The use of a **blockchain is highly beneficial**:
  - It provides **strong traceability and auditability**
  - **confidential orders** without having to rely on a trusted party.



IPO – A First Attempt using Fabric

IPO Trading is an example of a *clearing price auction*, where a single seller sells multiple shares at the same price to many buyers.

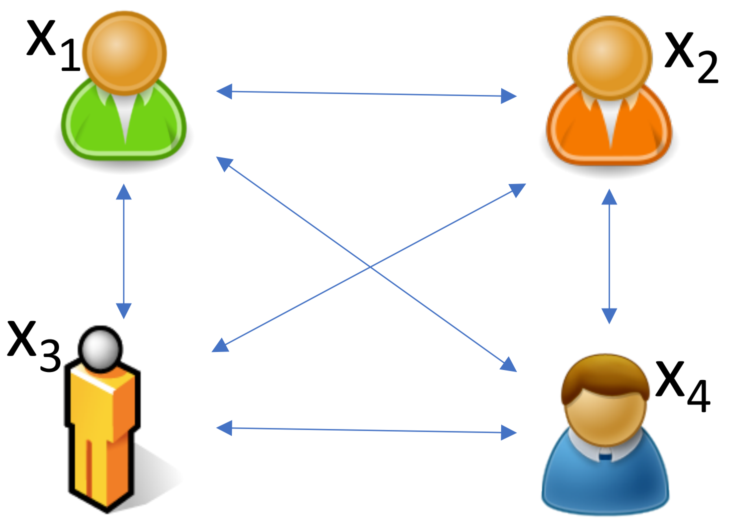
- A bank lists shares publicly.
- Then, brokerage houses records the **IPO orders** on behalf of investors. (**Confidentiality required**)
- Later the listing bank determines the clearing price of this IPO, as well as the share allocation. (**Settlement)**



(Confidentiality) *Local Collections*
(**Settlement**) *Tokens*

Secure Multi Party Computation(MPC)

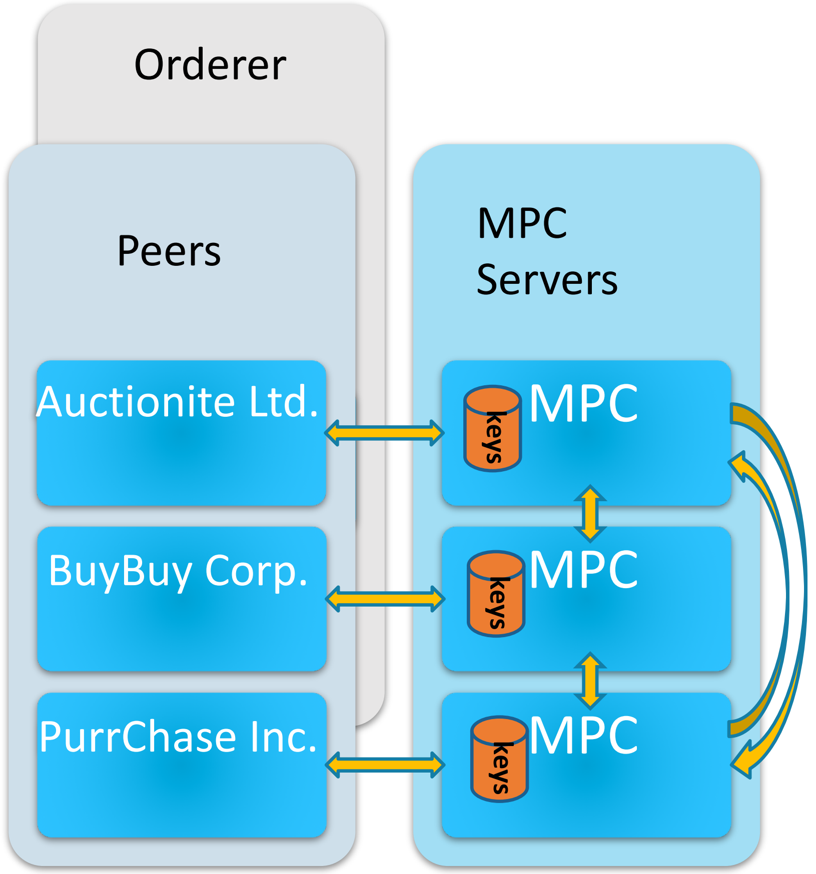
- Cryptographic protocol for emulating a trusted party
  - In a system with no trusted parties
- $P_1, P_2, \ldots, P_n$ are mutually suspicious
  - Each with its own secret input $x_1, x_2, \ldots, x_n$
  - Want to compute a joint function $y=f(x_1, x_2, \ldots, x_n)$



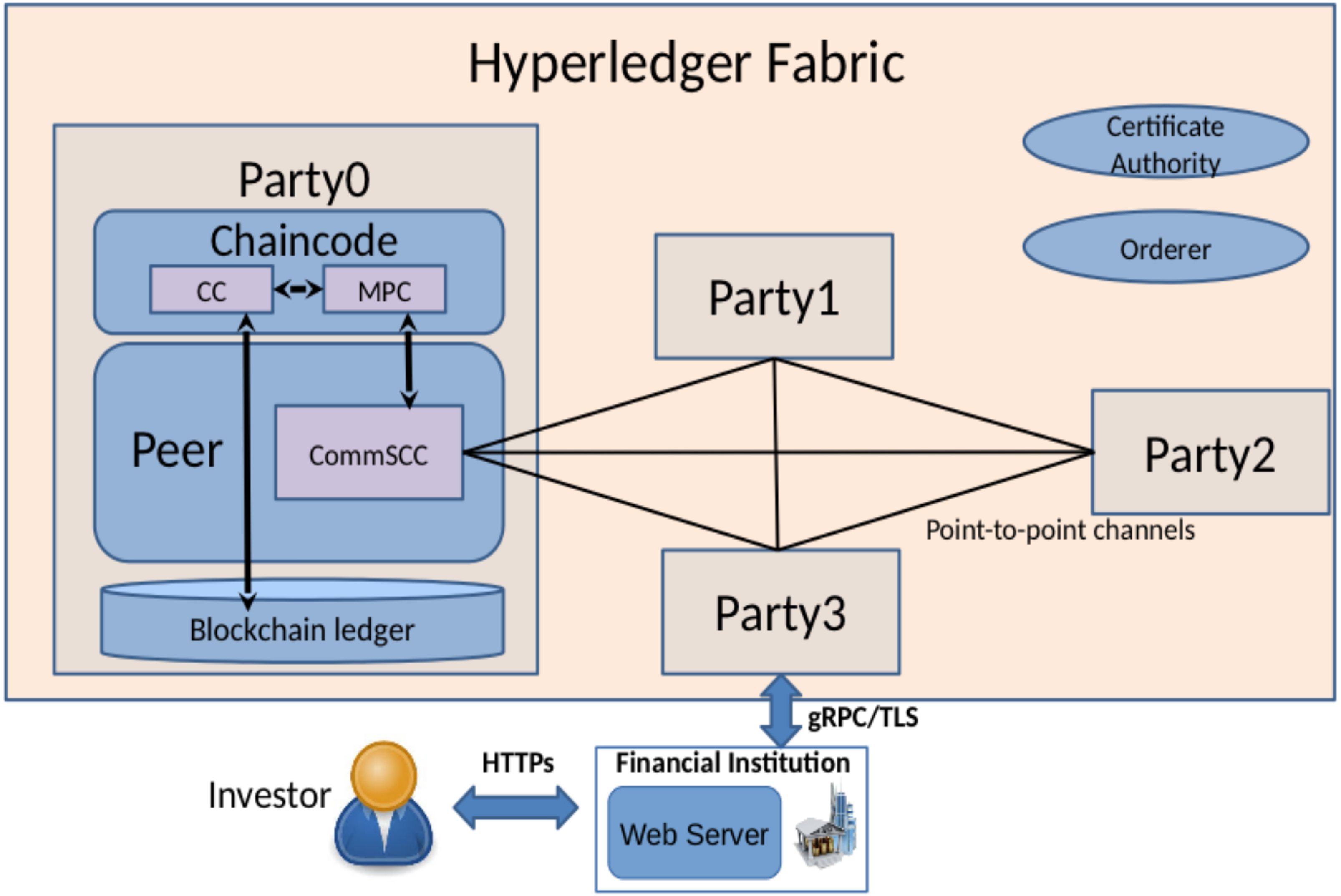
Goal:
Correctness: Everyone computes $y=f(x_1,\ldots,x_n)$
Security: Nothing but the output is revealed

Multi-Party Computation Enables Decentralization and Privacy

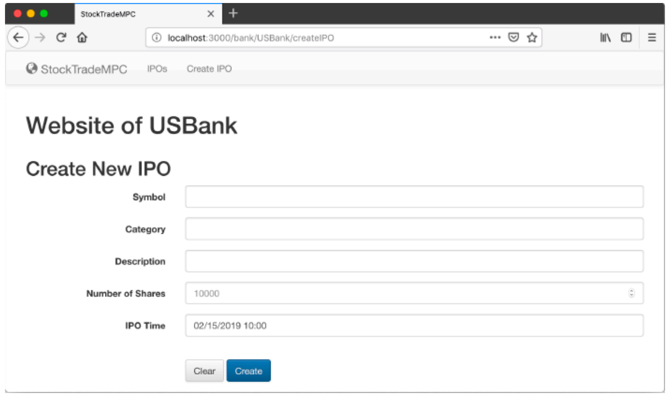
- **Goal**: Enable private data that impacts transactions
  - *In current Fabric, transaction data is seen by everyone*
    - *At least, everyone who needs to endorse the transaction*
  - Private data support opens a whole new level of applications
    - Commerce: Purchase goes through if buyer has enough money
    - Shipping: Bidding on space for containers in a ship
    - Medical: Drug dispensed if client's condition warrants it
    - IoT: Aggregate recorded w/o revealing individual data
    - Audit: Action recorded when departments align their books
      - Without them having to share confidential data (e.g., Chinese wall)
- **Solution**: Use secure Multi-Party Computation (MPC). An interactive protocol with multiple parties, each with private input. Computing the correct output, learning nothing more, audit later when needed.



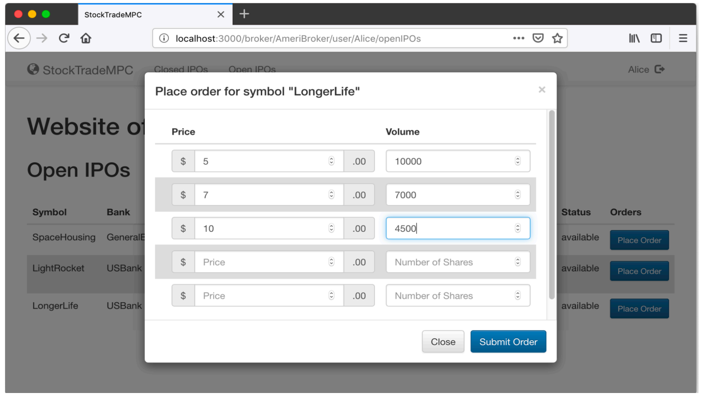
Fabric and MPC deliver **Auditable Privacy**



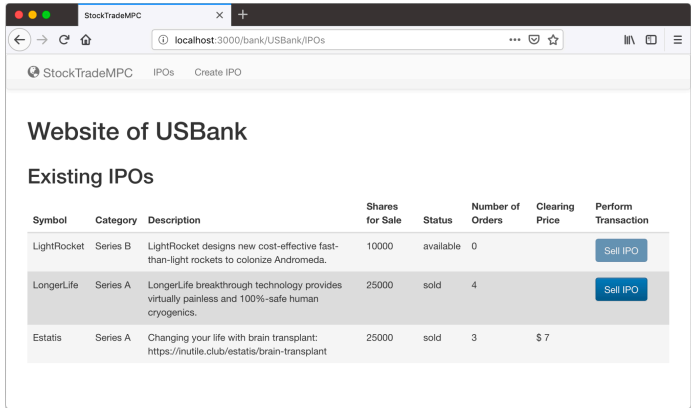
Demo: MPC based IPO on Blockchain



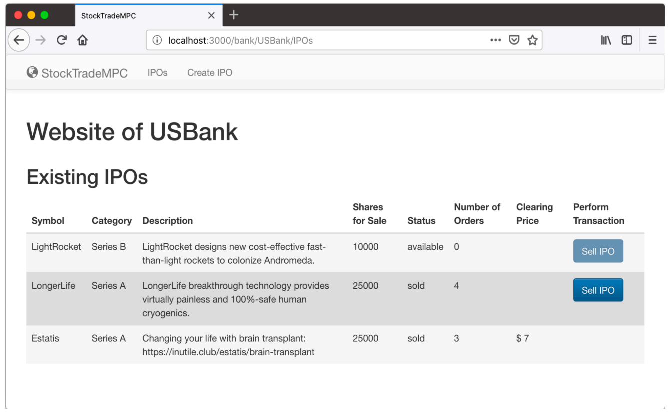
1. Bank create IPO



2. Buyers place orderers



3. Banks sell IPO



4. Bank list the closed IPO