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

Fabrice Benhamouda, Angelo De Caro, Shai Halevi, Tzipora Halevi, Charanjit Jutla, Yacov Manevich, and Qi Zhang

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Outline

• Hyperledger and Fabric

• Fabric Architecture

• Initial Public Offering and Multi-Party Computation
Hyperledger and 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 Modular Greenhouse Approach

### 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

<table>
<thead>
<tr>
<th>Framework</th>
<th>Features</th>
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<tbody>
<tr>
<td>Hyperledger Fabric</td>
<td>Permissioned with channel support</td>
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<tr>
<td>Hyperledger Sawtooth</td>
<td>Permissioned &amp; permissionless support</td>
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<tr>
<td>Hyperledger Iroha</td>
<td>Mobile application focus</td>
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<tr>
<td>Hyperledger Indy</td>
<td>Decentralized identity</td>
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<tr>
<td>Hyperledger Burrow</td>
<td>Permissionable smart contract machine</td>
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</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Tool</th>
<th>Description</th>
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<tr>
<td>Hyperledger Composer</td>
<td>Model and build blockchain networks</td>
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<tr>
<td>Hyperledger Cello</td>
<td>A-as-a-service deployment</td>
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<td>Hyperledger Explorer</td>
<td>View and explore data on the blockchain</td>
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<td>Hyperledger Quilt</td>
<td>Ledger interoperability</td>
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<tr>
<td>Hyperledger Caliper</td>
<td>Blockchain framework benchmark platform</td>
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</table>
Fabric Architecture
**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 network

**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

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

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

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

- Validate endorsements & rw-sets
- Eliminate invalid and conflicting tx

- Persist state on all peers

Diagram:

1. **Execute**
   - Simulate tx and endorse
   - Create rw-set
   - Collect endorsements

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

3. **Validate**
   - Validate endorsements & rw-sets
   - Eliminate invalid and conflicting tx

4. **Update state**
   - Persist state on all peers
Fabric Architecture

Client

Appl. SDK

MSP

SDK Appl.

Peers (P)

Ordering service

Peer-to-peer gossip
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 own provider” membership architecture**.

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- **Privacy / Access Control**
  - Contract state concealable to unauthorized parties.
  - Logic is executed only after authorized entity request.

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- **Authorized Execution**
  - Access Control Enforcement Framework.

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- **Privacy / Access Control**
  - User activity & contract logic concealable to unauthorized entities.

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- **Secure Chaincode Availability Framework**
  - Application Libraries for Privacy.

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- **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)*
Secure Multi Party Computation (MPC)

• Cryptographic protocol for emulating a trusted party
  • In a system with no trusted parties

• $P_1, P_2, ..., P_n$ are mutually suspicious
  • Each with its own secret input $x_1, x_2, ..., x_n$
  • Want to compute a joint function $y = f(x_1, x_2, ..., x_n)$

Goal:

Correctness: Everyone computes $y = f(x_1, ..., x_n)$

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