Blockchain Explored

A Technical Deep-Dive on Hyperledger Fabric V1

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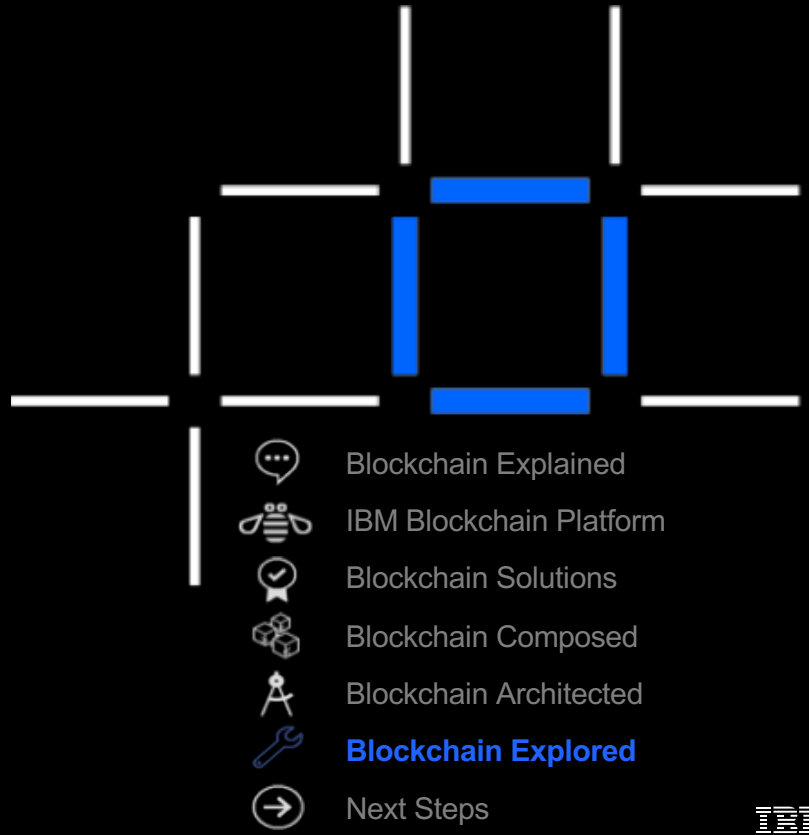
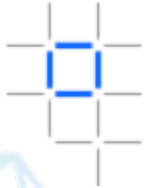


February 2018

IBM **Blockchain**

What is Hyperledger Fabric

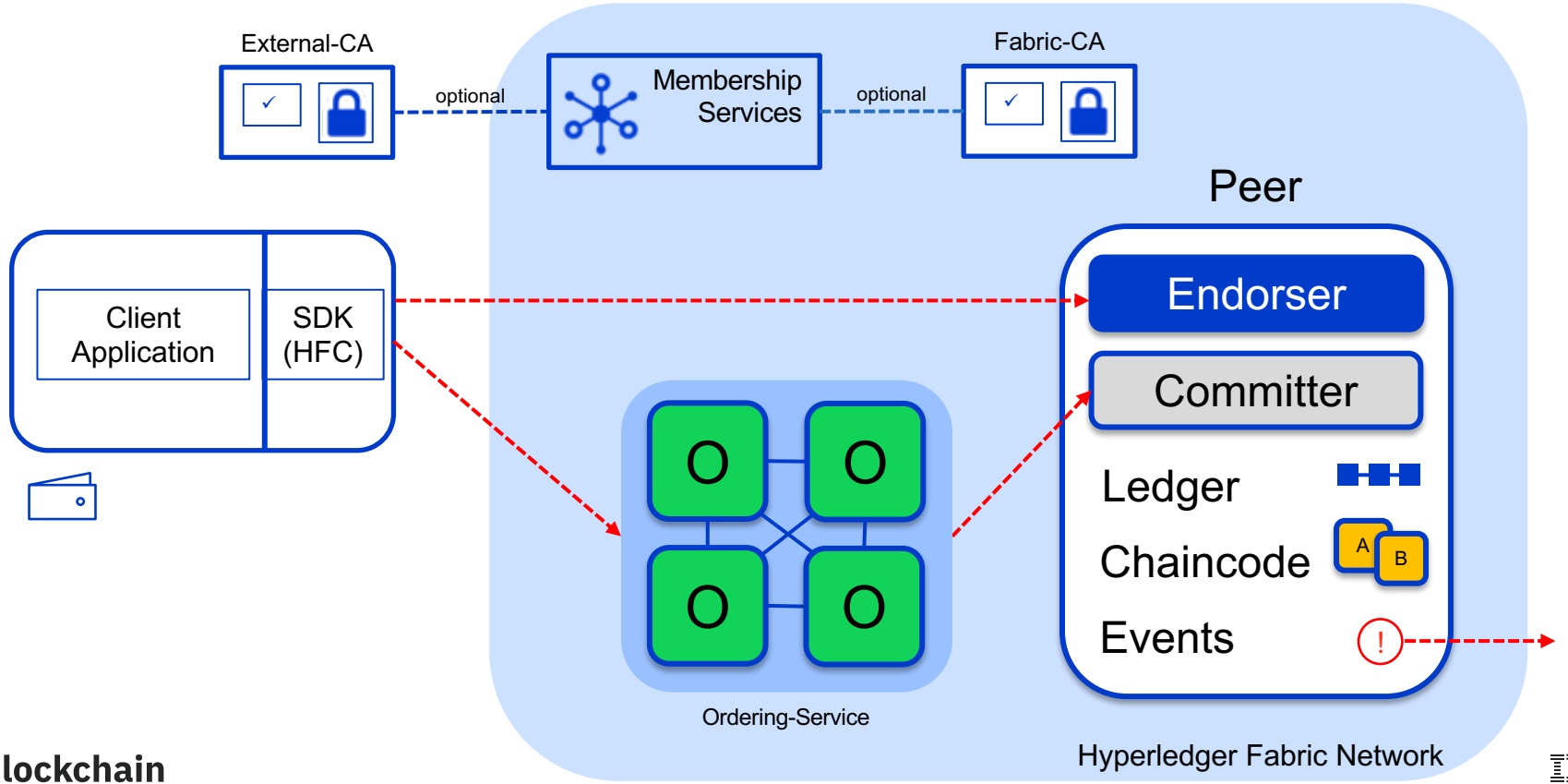


- Linux Foundation Hyperledger
  - A collaborative effort created to advance cross-industry blockchain technologies for business

- Hyperledger Fabric
  - An implementation of blockchain technology that is intended as a foundation for developing blockchain applications
  - Key technical features:
    - A shared ledger and smart contracts implemented as “chaincode”
    - Privacy and permissioning through membership services
    - Modular architecture and flexible hosting options

- V1.0 released July 2017: contributions by 159 engineers from 27 organizations
  - IBM is one of the contributors to Hyperledger Fabric

Hyperledger Fabric V1 Architecture



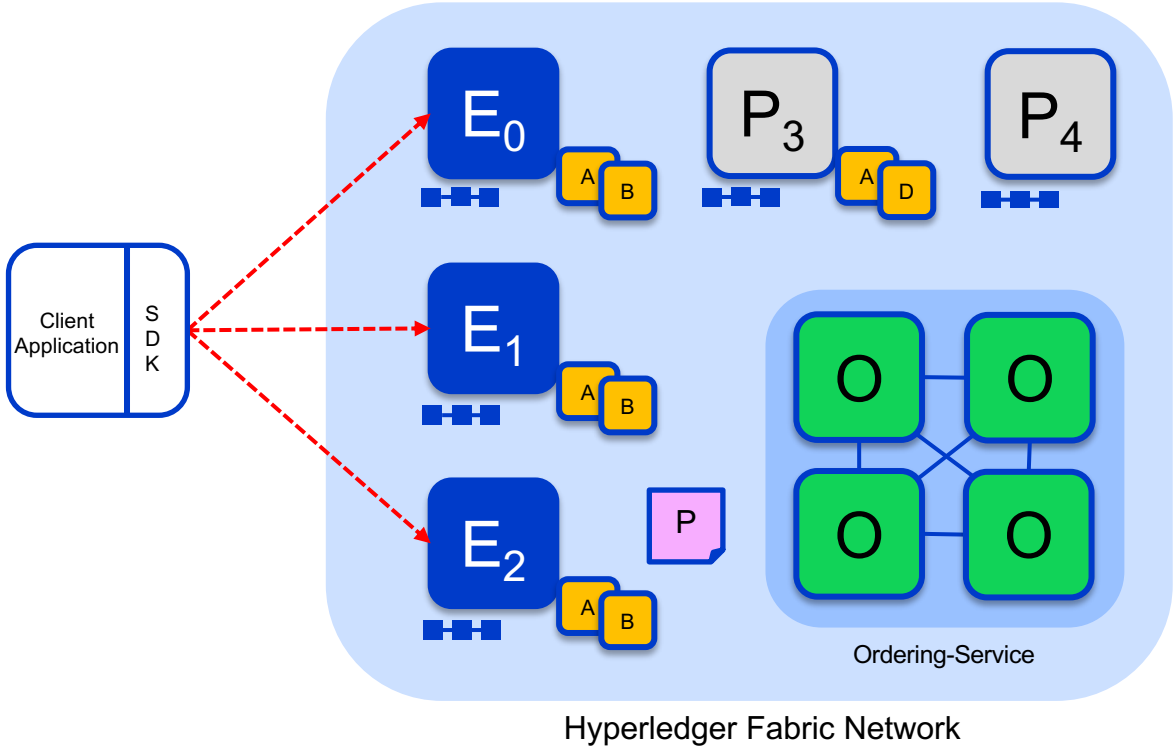
Technical Deep Dive

- [Network Consensus]
- Channels and Ordering Service
- Network setup
- Endorsement Policies
- Permissioned ledger access
- Pluggable world-state

Nodes and roles

	**Committing Peer:** Maintains ledger and state. Commits transactions. May hold smart contract (chaincode).
	**Endorsing Peer:** Specialized committing peer that receives a transaction proposal for endorsement, responds granting or denying endorsement. Must hold smart contract
	**Ordering Node:** Approves the inclusion of transaction blocks into the ledger and communicates with committing and endorsing peer nodes. Does not hold smart contract. Does not hold ledger.

Sample transaction: Step 1/7 – Propose transaction

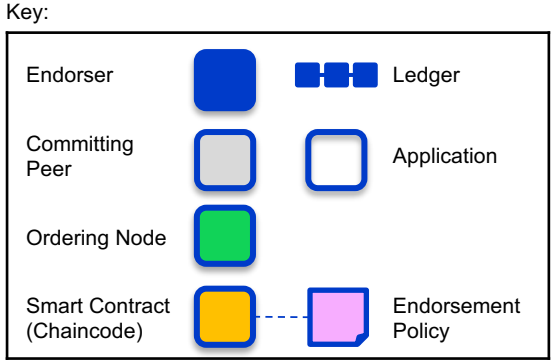


Hyperledger Fabric Network

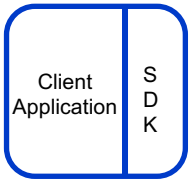
Application proposes transaction

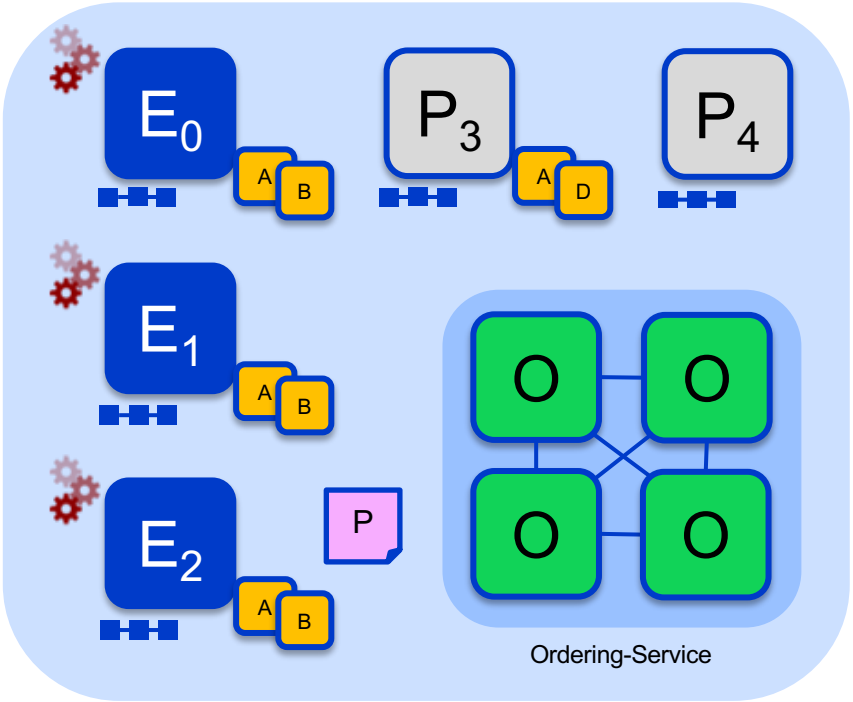
Endorsement policy:
- "E_0, E_1 and E_2 must sign"
- (P_3, P_4 are not part of the policy)

Client application submits a transaction proposal for Smart Contract A. It must target the required peers {E_0, E_1, E_2}



Sample transaction: Step 2/7 – Execute proposal





Hyperledger Fabric Network

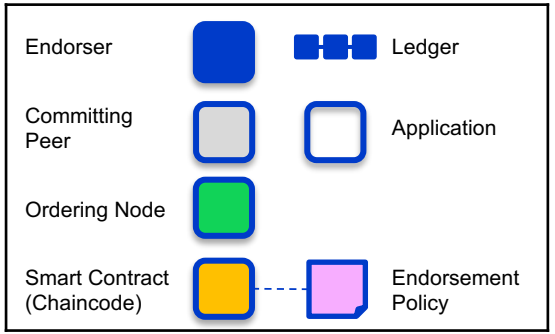
Endorsers Execute Proposals

E_0, E_1 & E_2 will each execute the proposed transaction. None of these executions will update the ledger

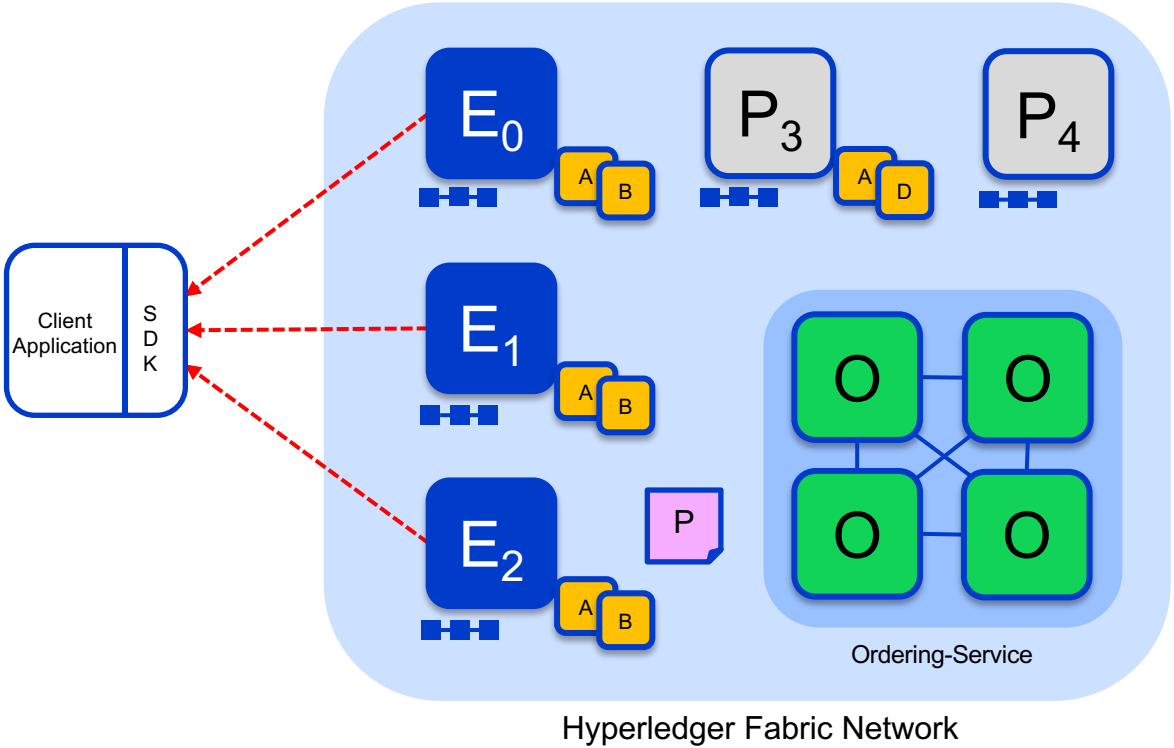
Each execution will capture the set of Read and Written data, called RW sets, which will now flow in the fabric.

Transactions can be signed & encrypted

Key:



Sample transaction: Step 3/7 – Proposal Response



Hyperledger Fabric Network

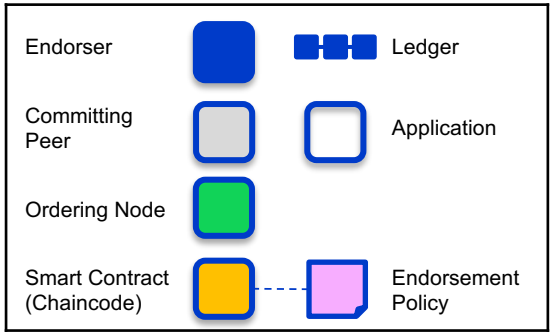
Application receives responses

RW sets are asynchronously returned to application

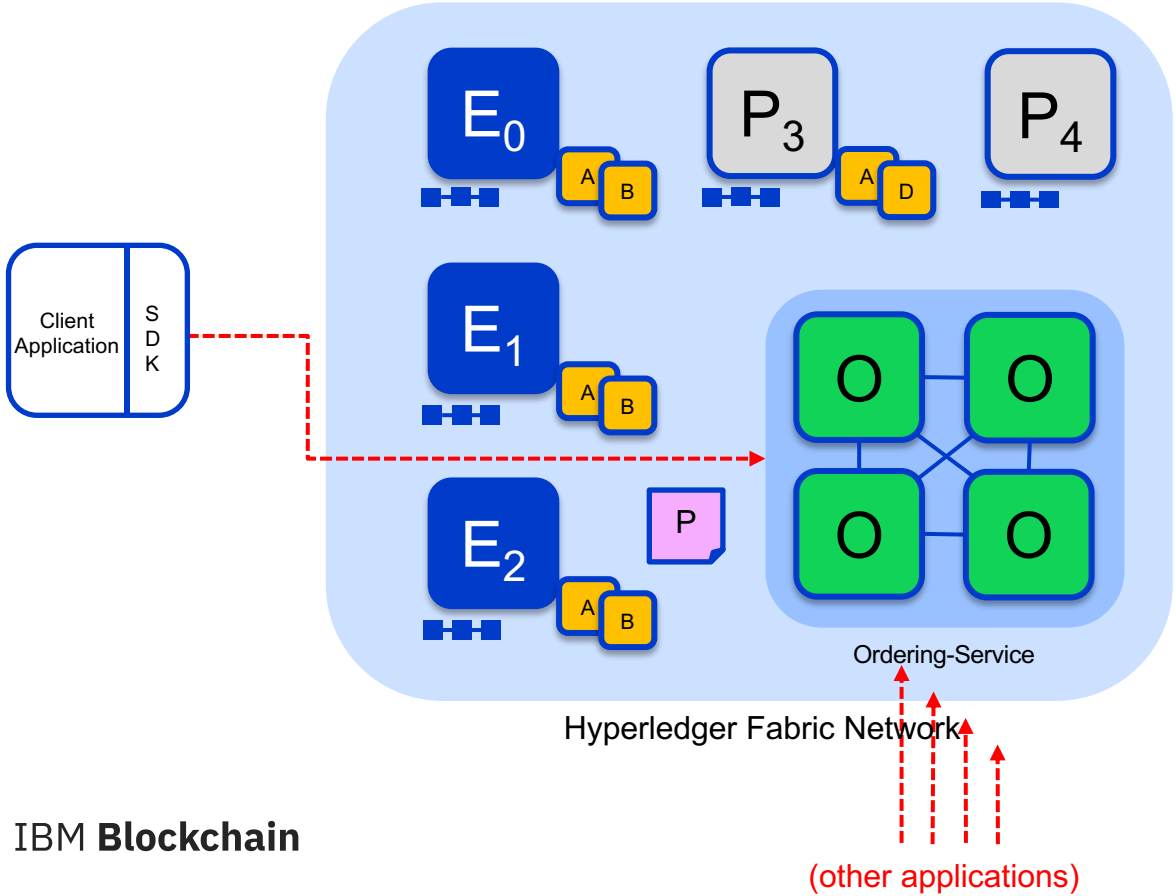
The RW sets are signed by each endorser, and also includes each record version number

(This information will be checked much later in the consensus process)

Key:



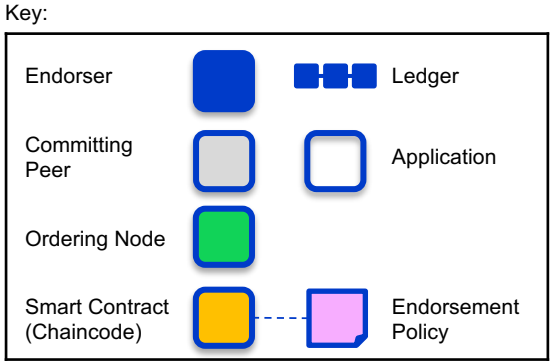
Sample transaction: Step 4/7 – Order Transaction



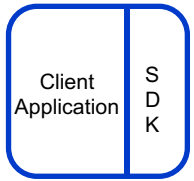
Responses submitted for ordering

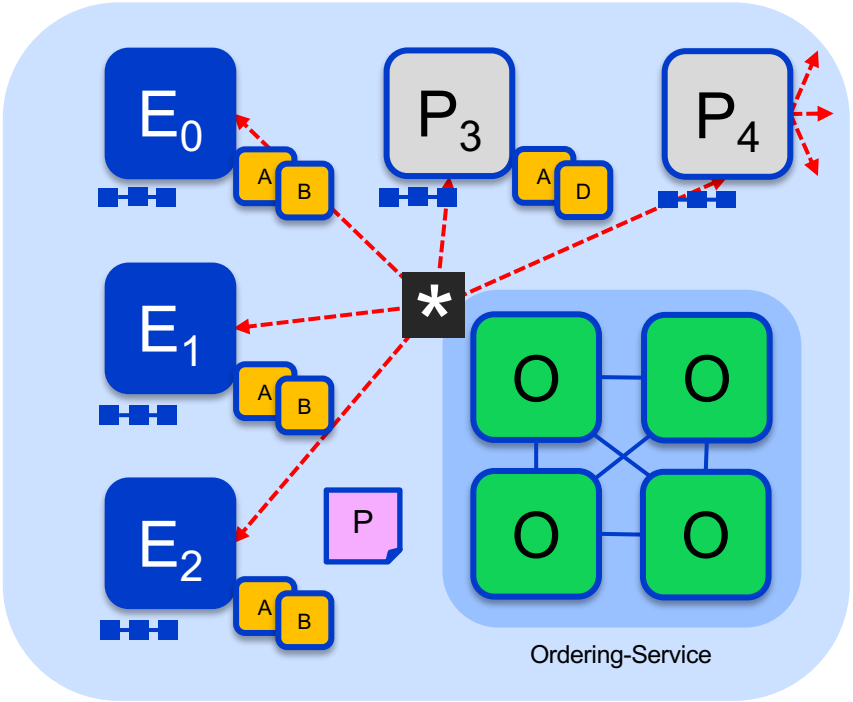
Application submits responses as a transaction to be ordered.

Ordering happens across the fabric in parallel with transactions submitted by other applications



Sample transaction: Step 5/7 – Deliver Transaction





Hyperledger Fabric Network

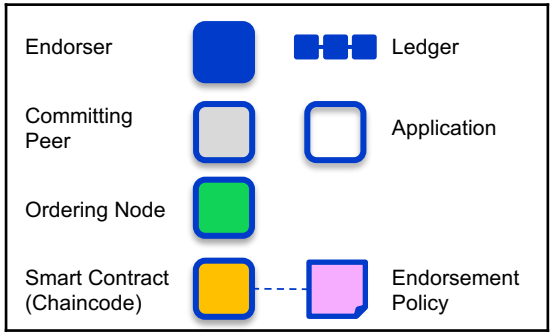
Orderer delivers to committing peers

Ordering service collects transactions into proposed blocks for distribution to committing peers. Peers can deliver to other peers in a hierarchy (not shown)

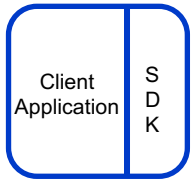
Different ordering algorithms available:

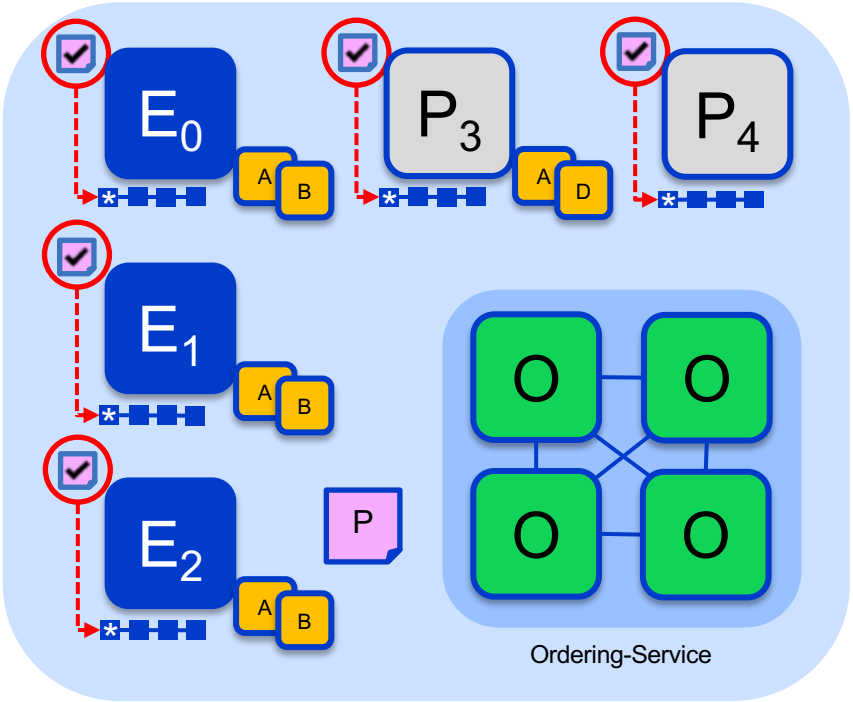
- SOLO (Single node, development)
- Kafka (Crash fault tolerance)

Key:



Sample transaction: Step 6/7 – Validate Transaction





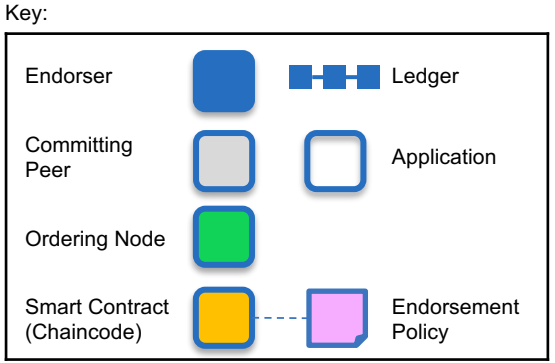
Hyperledger Fabric Network

Committing peers validate transactions

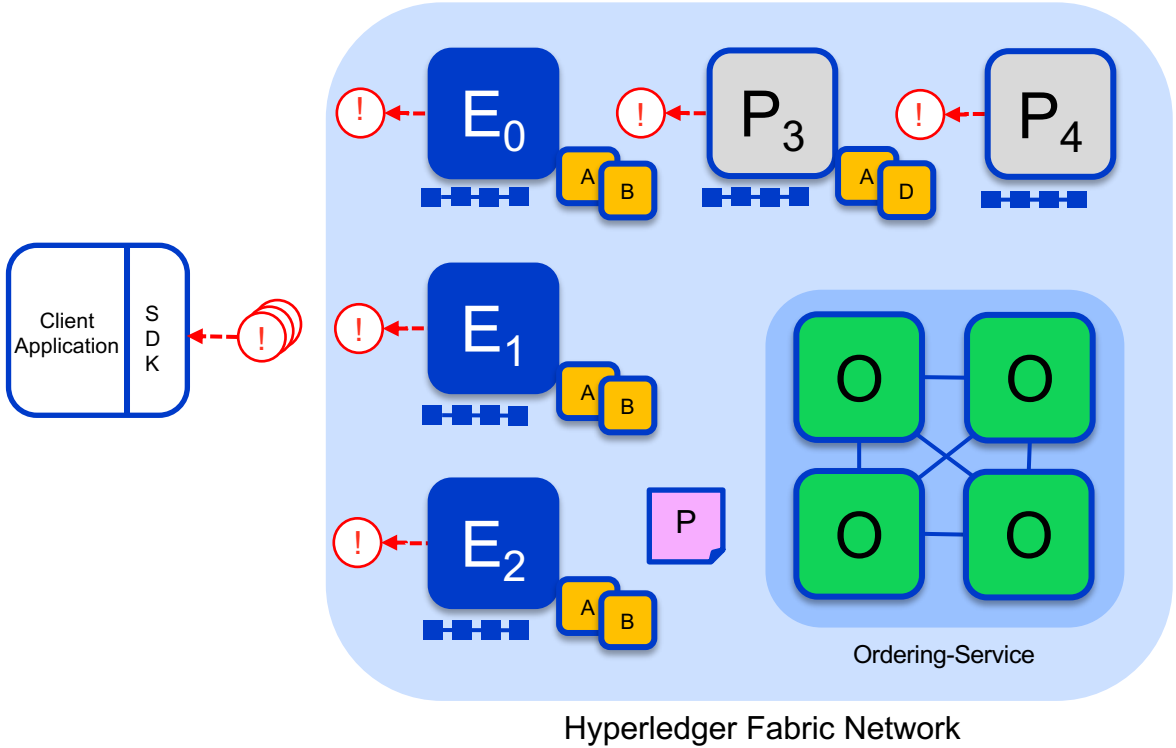
Every committing peer validates against the endorsement policy. Also check RW sets are still valid for current world state

Validated transactions are applied to the world state and retained on the ledger

Invalid transactions are also retained on the ledger but do not update world state



Sample transaction: Step 7/7 – Notify Transaction

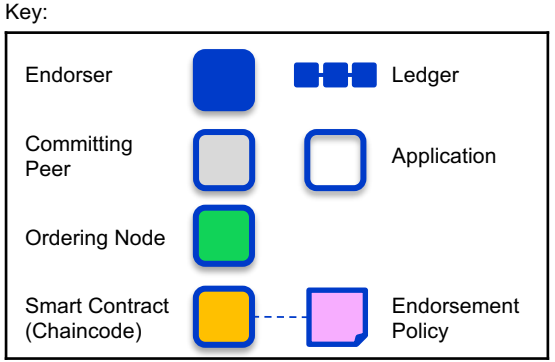


Hyperledger Fabric Network

Committing peers notify applications

Applications can register to be notified when transactions succeed or fail, and when blocks are added to the ledger

Applications will be notified by each peer to which they are connected

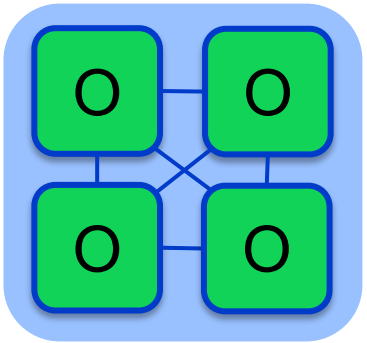


Technical Deep Dive

- Network Consensus
- [Channels and Ordering Service]
- Network setup
- Endorsement Policies
- Permissioned ledger access
- Pluggable world-state

Ordering Service

The ordering service packages transactions into blocks to be delivered to peers. Communication with the service is via channels.

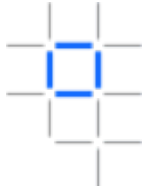


Ordering-Service

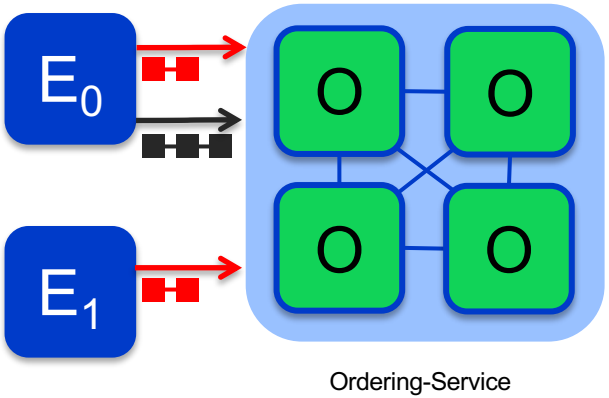
Different configuration options for the ordering service include:

- SOLO
  - Single node for development
- Kafka : Crash fault tolerant consensus
  - minimum recommended config for Kafka:
    - 3 Orderer nodes
    - 4 Kafka brokers
    - 3 Zookeeper nodes
    - ISR=2, RF=3

Channels

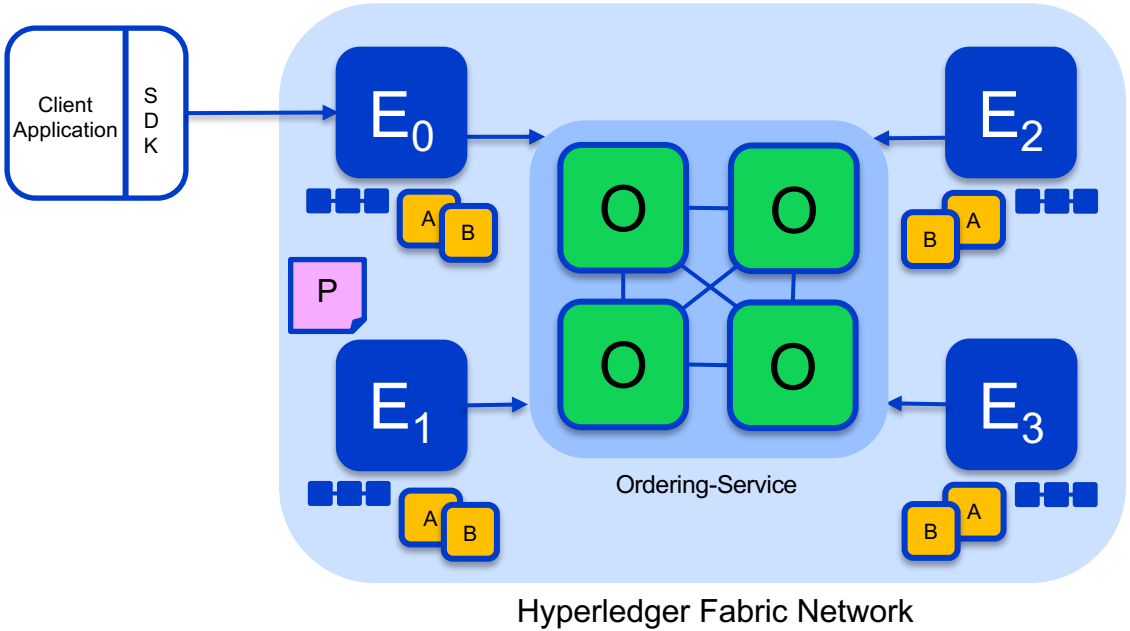


Channels provide privacy between different ledgers



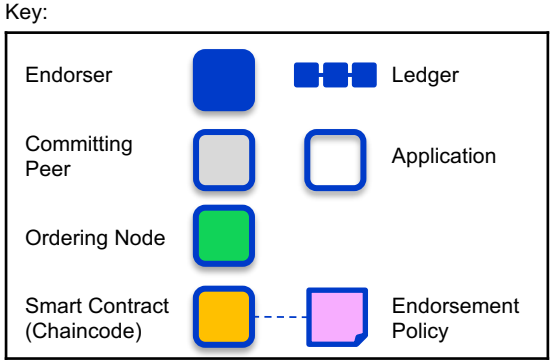
- Ledgers exist in the scope of a channel
  - Channels can be shared across an entire network of peers
  - Channels can be permissioned for a specific set of participants
- Chaincode is installed on peers to access the worldstate
- Chaincode is instantiated on specific channel
- Peers can participate in multiple channels
- Concurrent execution for performance and scalability

Single Channel Network

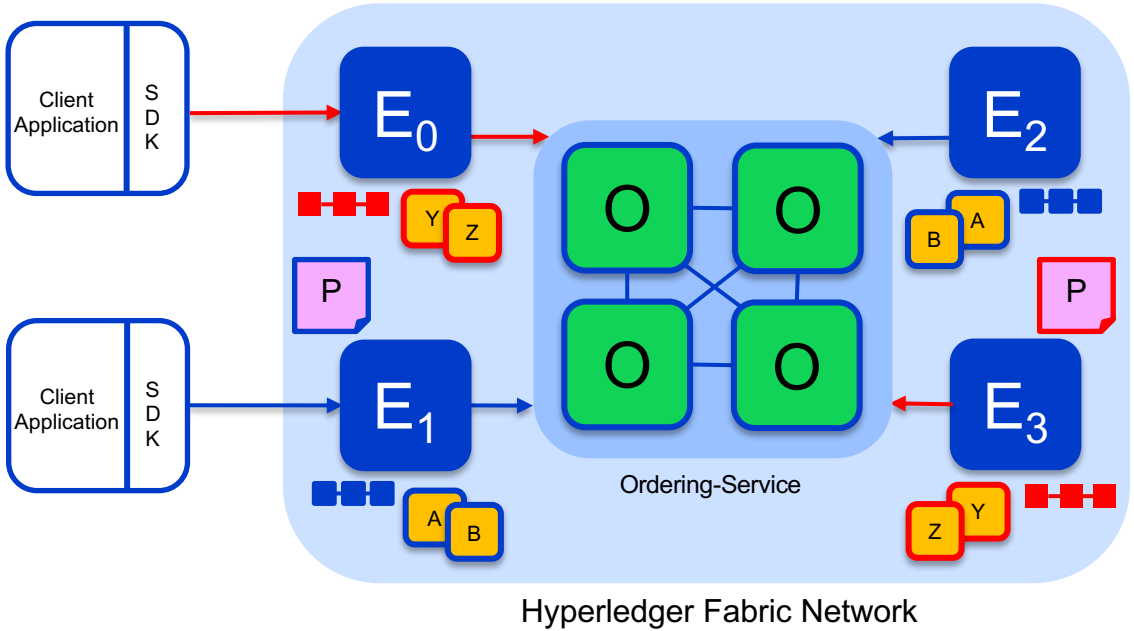


Hyperledger Fabric Network

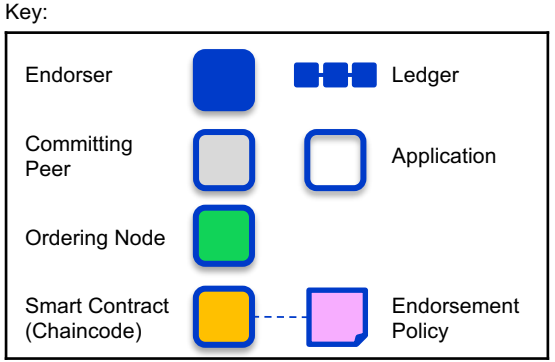
- Similar to v0.6 PBFT model
- All peers connect to the same system channel (blue).
- All peers have the same chaincode and maintain the same ledger
- Endorsement by peers E_0, E_1, E_2 and E_3



Multi Channel Network



- Peers E_0 and E_3 connect to the red channel for chaincodes Y and Z
- Peers E_1 and E_2 connect to the blue channel for chaincodes A and B



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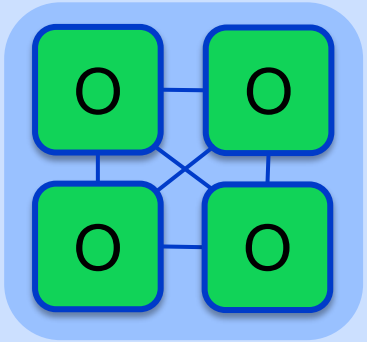
Bootstrap Network (1/6) - Configure & Start Ordering Service



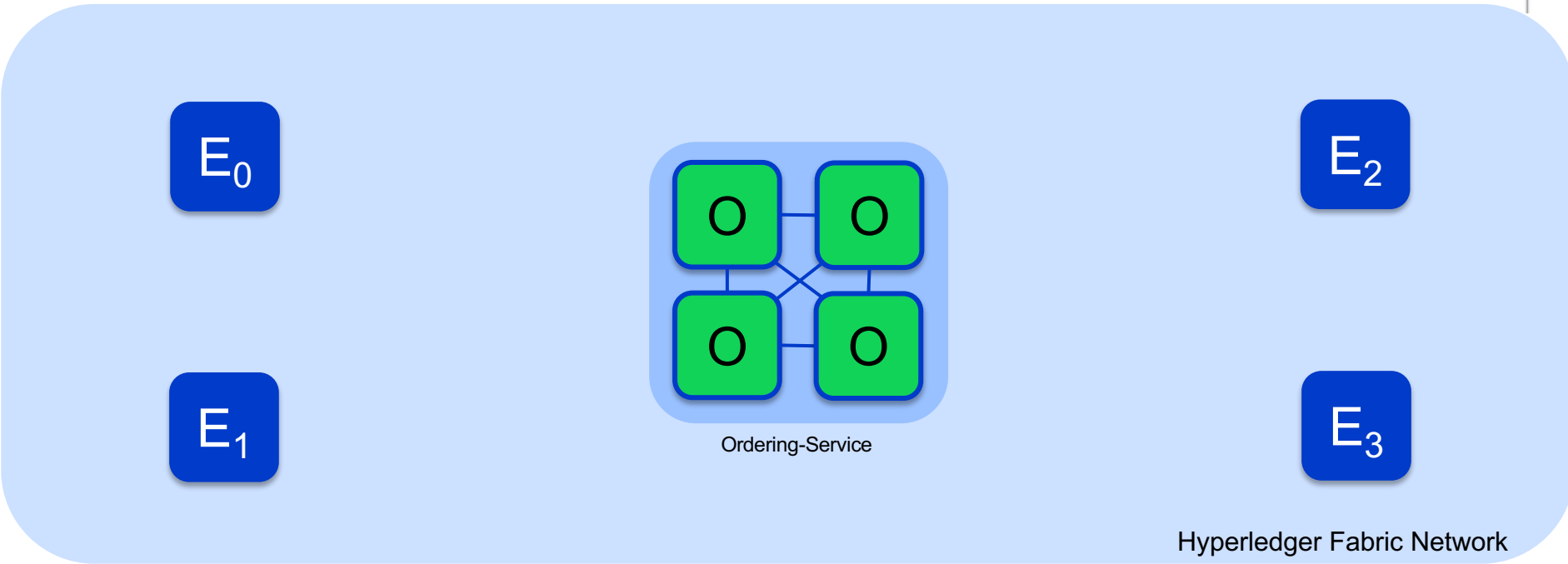
Ordering-Service

Hyperledger Fabric Network

An Ordering Service is configured and started for the network:

$ docker-compose [-f orderer.yml] ...

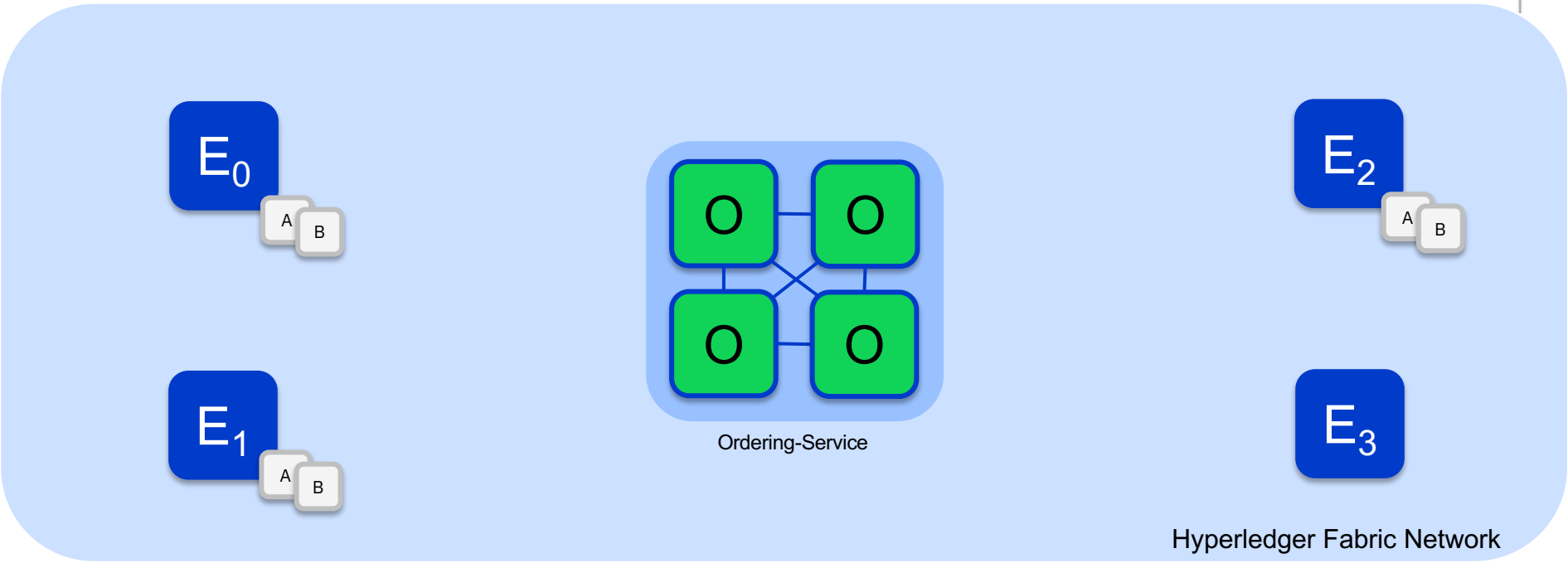
Bootstrap Network (2/6) - Configure and Start Peer Nodes



A peer is configured and started for each Endorser or Committer in the network:

$ peer node start ...

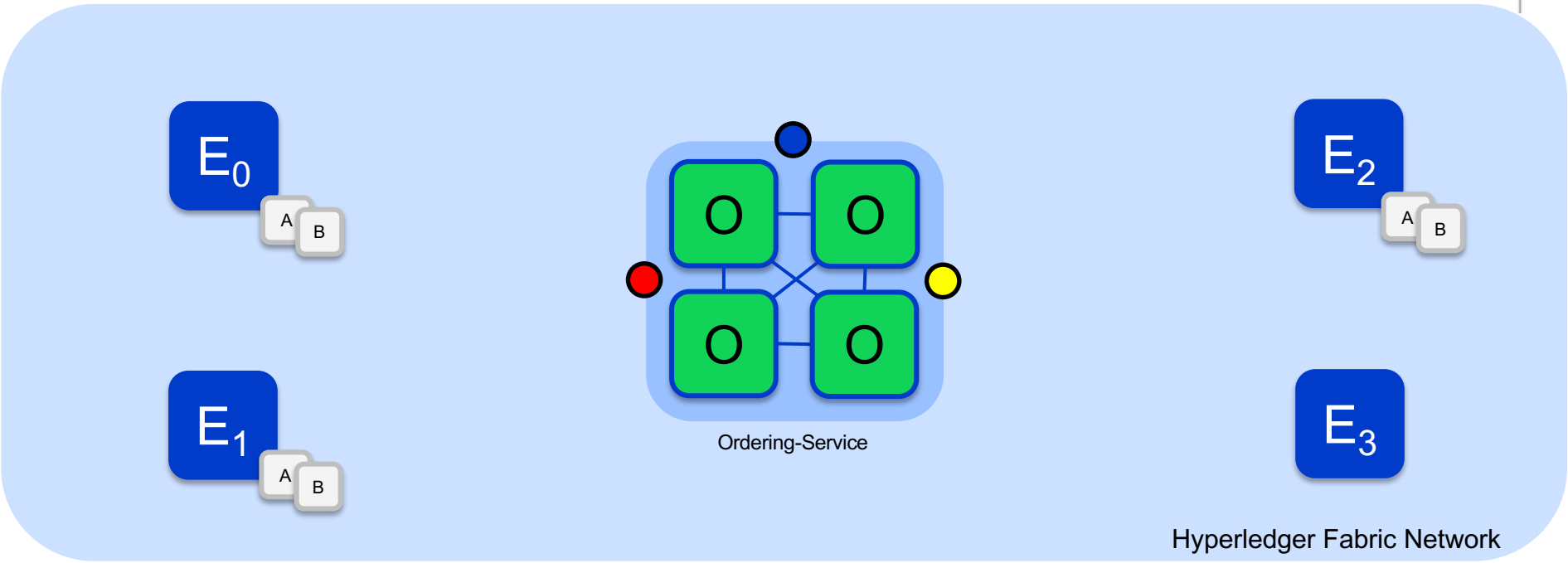
Bootstrap Network (3/6) - Install Chaincode



Chaincode is installed onto each Endorsing Peer that needs to execute it:

$ peer chaincode install ...

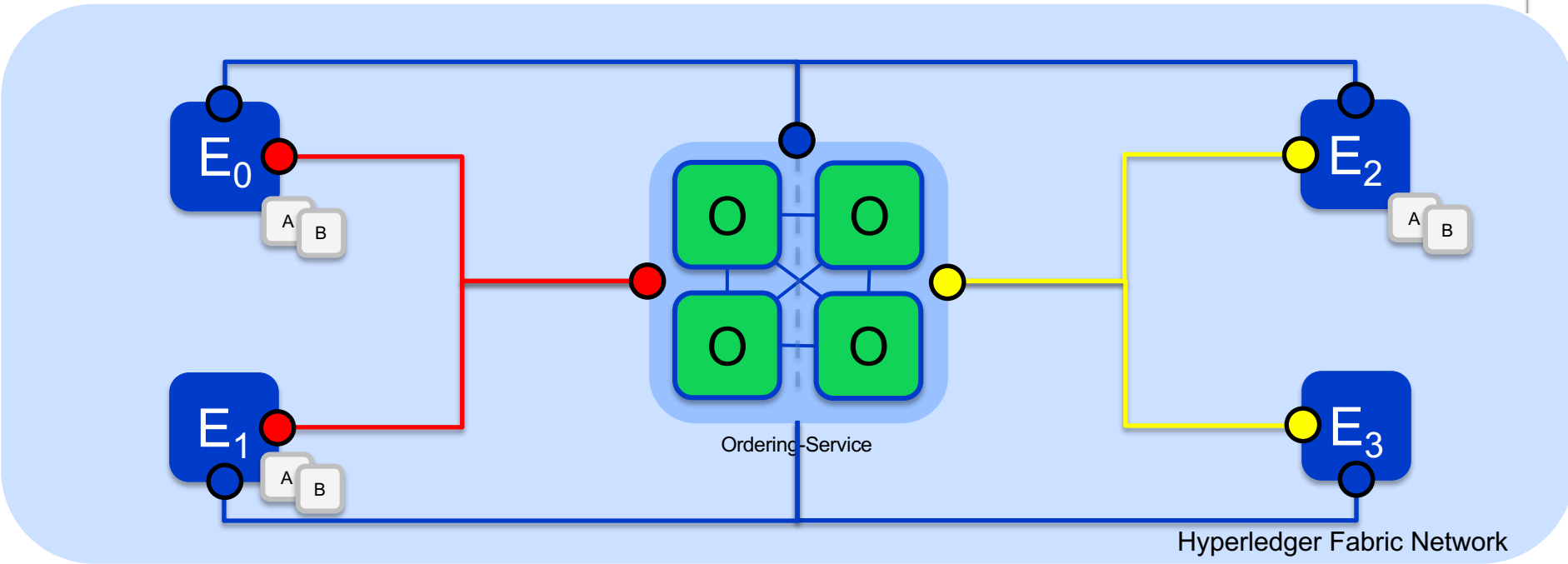
Bootstrap Network (4/6) – Create Channels



Channels are created on the ordering service:

$ peer channel create –o [orderer] ...

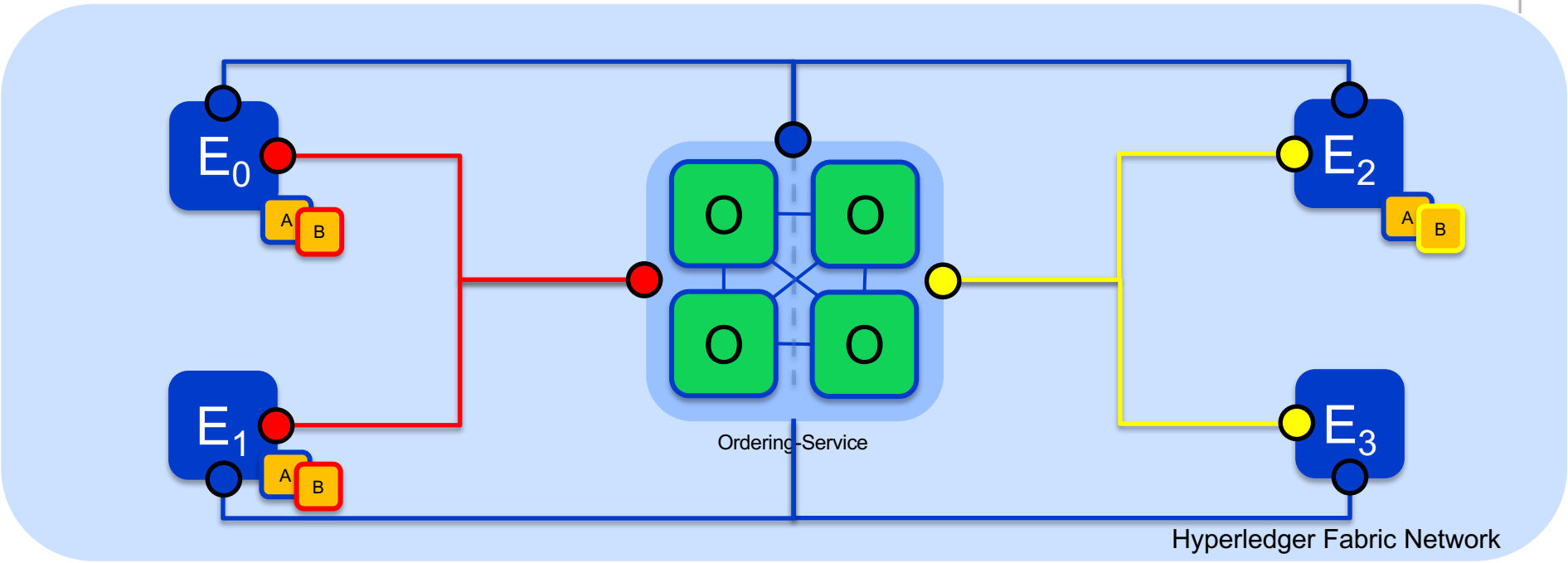
Bootstrap Network (5/6) – Join Channels



Peers that are permissioned can then join the channels they want to transact on:

$ peer channel join ...

Bootstrap Network (6/6) – Instantiate Chaincode



Peers finally instantiate the Chaincode on the channels they want to transact on:

$ peer chaincode instantiate ... –P ‘policy’

An Endorsement Policy is specified and once instantiated chaincode can process transactions.

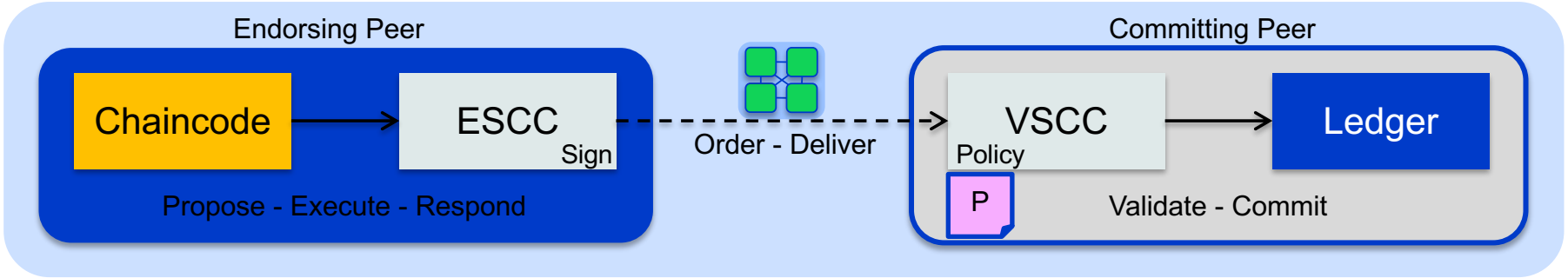
Technical Deep Dive

- Network Consensus
- Channels and Ordering Service
- Network setup
- [Endorsement Policies]
- Permissioned ledger access
- Pluggable world-state

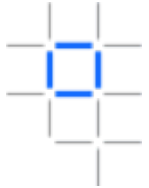
Endorsement Policies

An endorsement policy describes the conditions by which a transaction can be endorsed. A transaction can only be considered valid if it has been endorsed according to its policy.

- Each chaincode is deployed with an Endorsement Policy
- **ESCC** (Endorsement System ChainCode) signs the proposal response on the endorsing peer
- **VSCC** (Validation System ChainCode) validates the endorsements



Endorsement Policy Syntax



```
$ peer chaincode instantiate
-C mychannel
-n mycc
-v 1.0
-p chaincode_example02
-c '{"Args":["init","a", "100", "b","200"]}'
-P "AND('Org1MSP.member')"
```

Instantiate the chaincode mycc on channel mychannel with the policy AND('Org1MSP.member')

Policy Syntax: EXPR(E[, E...])

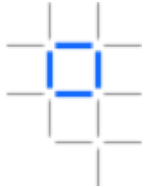
Where EXPR is either AND or OR and E is either a principal or nested EXPR

Principal Syntax: MSP.ROLE

Supported roles are: member and admin

Where MSP is the MSP ID, and ROLE is either “member” or “admin”

Endorsement Policy Examples



Examples of policies:

- Request 1 signature from all three principals
  - AND('Org1.member', 'Org2.member', 'Org3.member')
- Request 1 signature from either one of the two principals
  - OR('Org1.member', 'Org2.member')
- Request either one signature from a member of the Org1 MSP or (1 signature from a member of the Org2 MSP and 1 signature from a member of the Org3 MSP)
  - OR('Org1.member', AND('Org2.member', 'Org3.member'))

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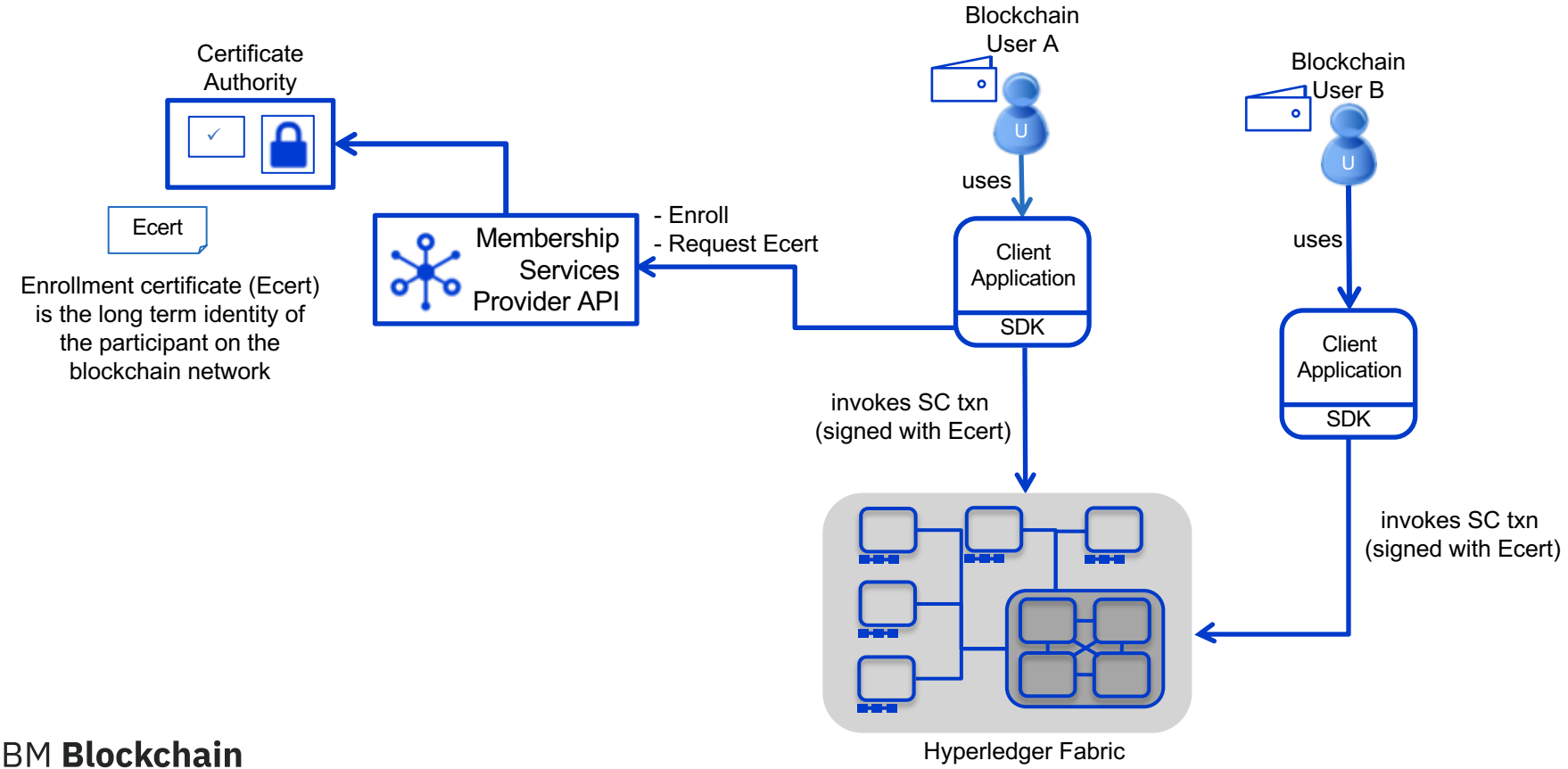
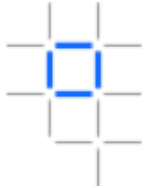
Membership Services Overview

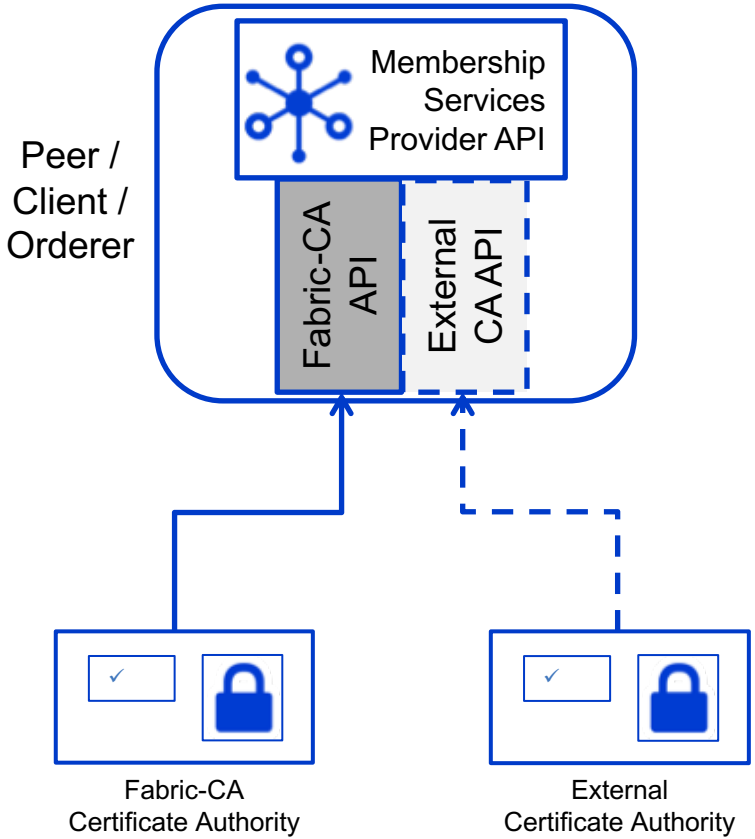


Transactions and Identity



- Enrollment Certificates (Ecerts)
  - Long term identity
  - Can be obtained offline, bring-your-own-identity
- Permissioned Interactions
  - Users sign with their Ecert
- Membership Services
  - Abstract layer to credential providers

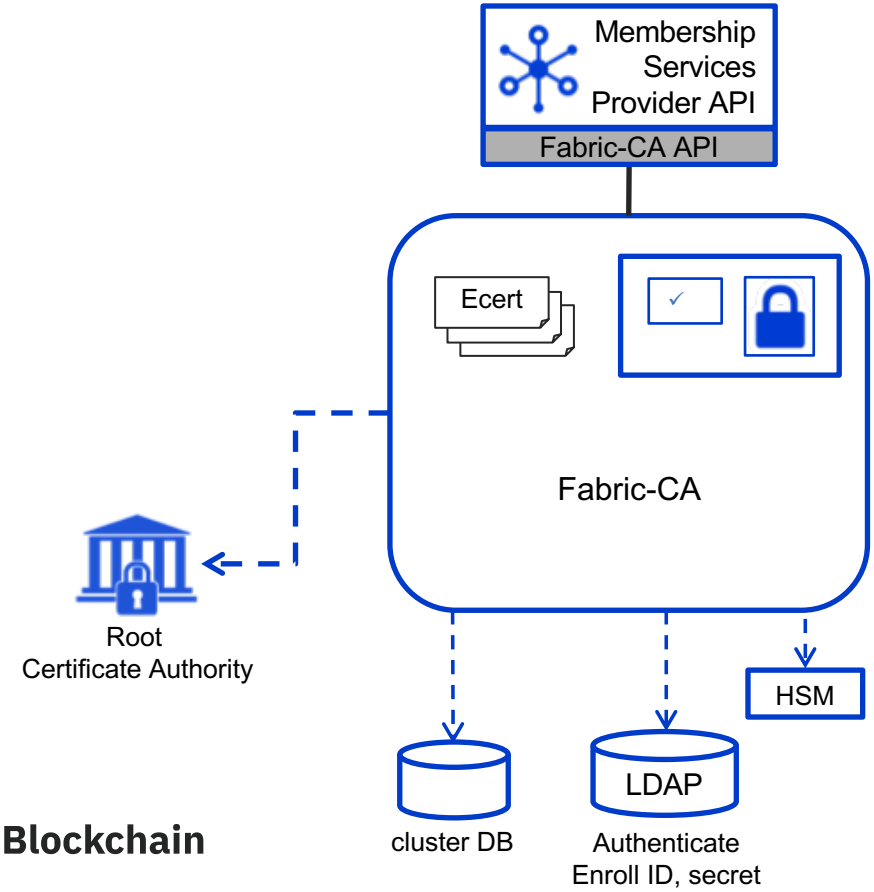
Membership Services Provider API



Membership Services Provider API

- Pluggable interface supporting a range of credential architectures
- Default implementation calls Fabric-CA.
- Governs identity for Peers and Users.
- Provides:
  - User authentication
  - User credential validation
  - Signature generation and verification
  - Optional credential issuance
- Additional offline enrollment options possible (eg File System).

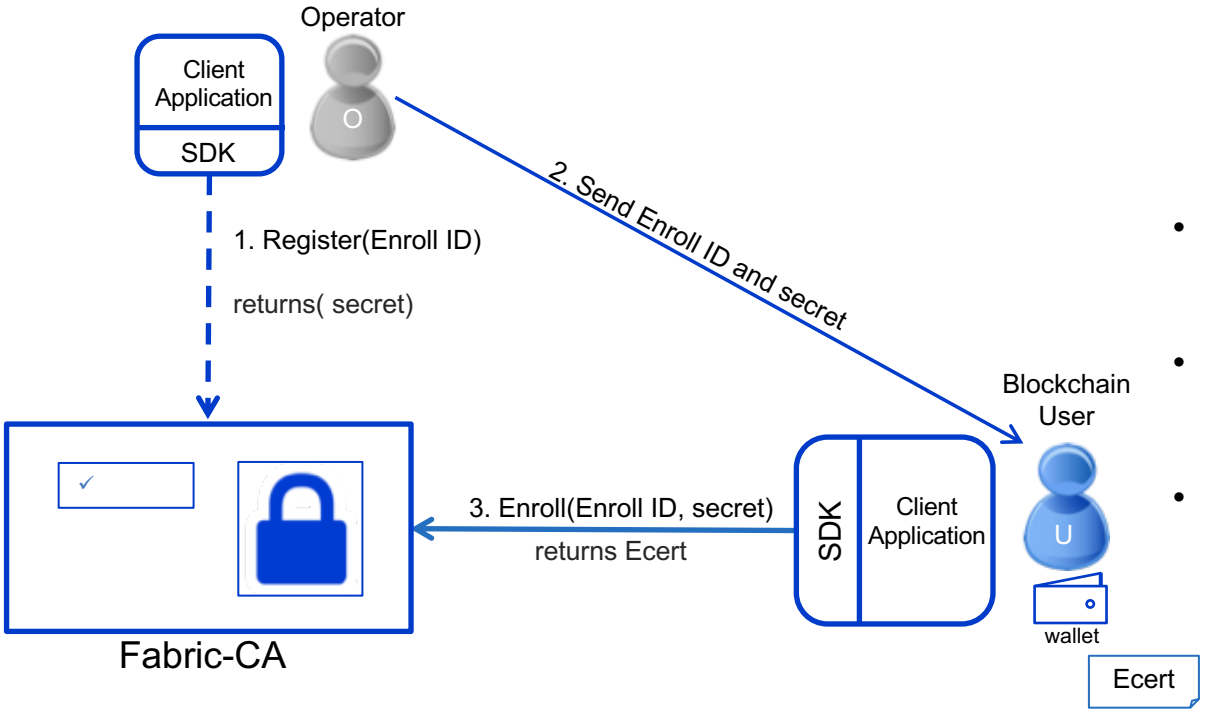
Fabric-CA Details



Fabric-CA

- Default implementation of the Membership Services Provider Interface.
- Issues Ecerts (long-term identity)
- Supports clustering for HA characteristics
- Supports LDAP for user authentication
- Supports HSM

New User Registration and Enrollment



Registration and Enrollment

- Admin registers new user with Enroll ID
- User enrolls and receives credentials
- Additional offline registration and enrollment options available

Technical Deep Dive

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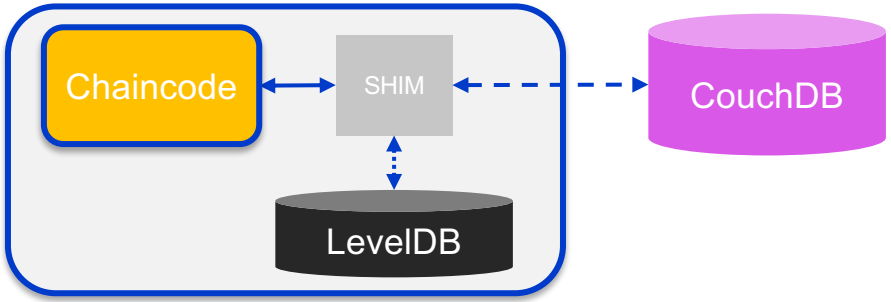
- [Pluggable world-state]

World State Database

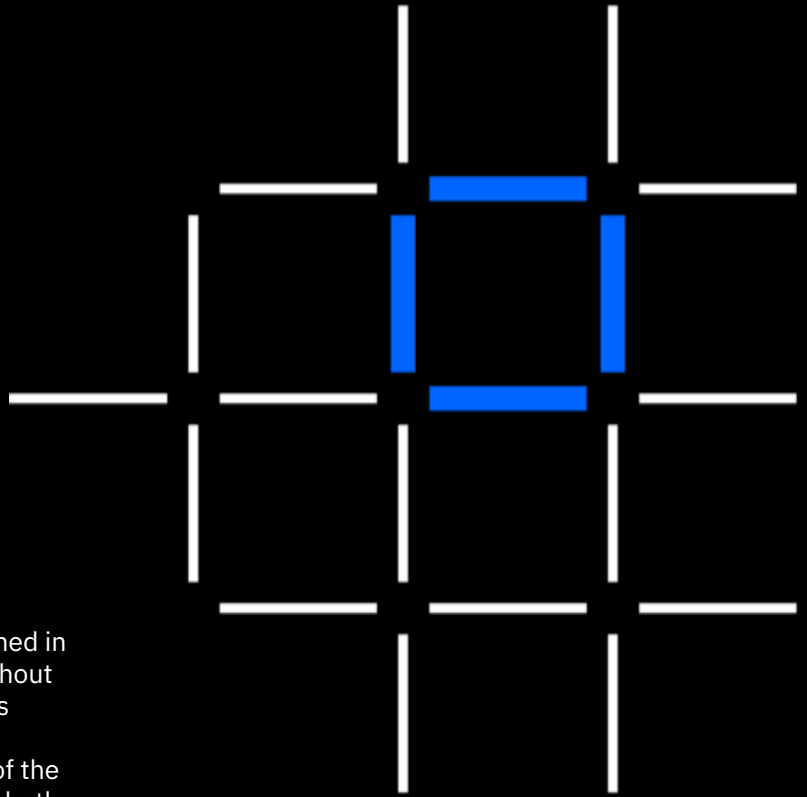
- Pluggable world state database
- Default embedded key/value implementation using LevelDB
  - Support for keyed queries, but cannot query on value
- Support for Apache CouchDB
  - Full query support on key and value (JSON documents)
  - Meets a large range of chaincode, auditing, and reporting requirements
  - Will support reporting and analytics via data replication to an analytics engine such as Spark (future)
  - Id/document data model compatible with existing chaincode key/value programming model



Thank you

Barry Silliman

IBM **Blockchain**



www.ibm.com/blockchain

developer.ibm.com/blockchain

www.hyperledger.org

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