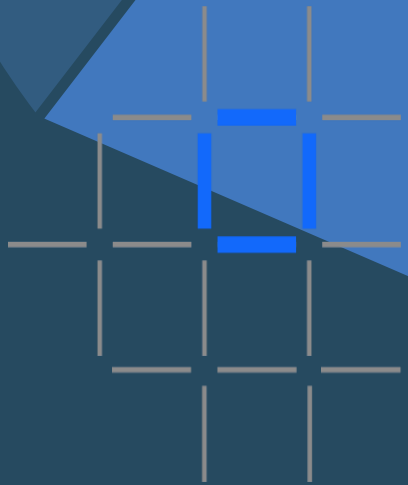


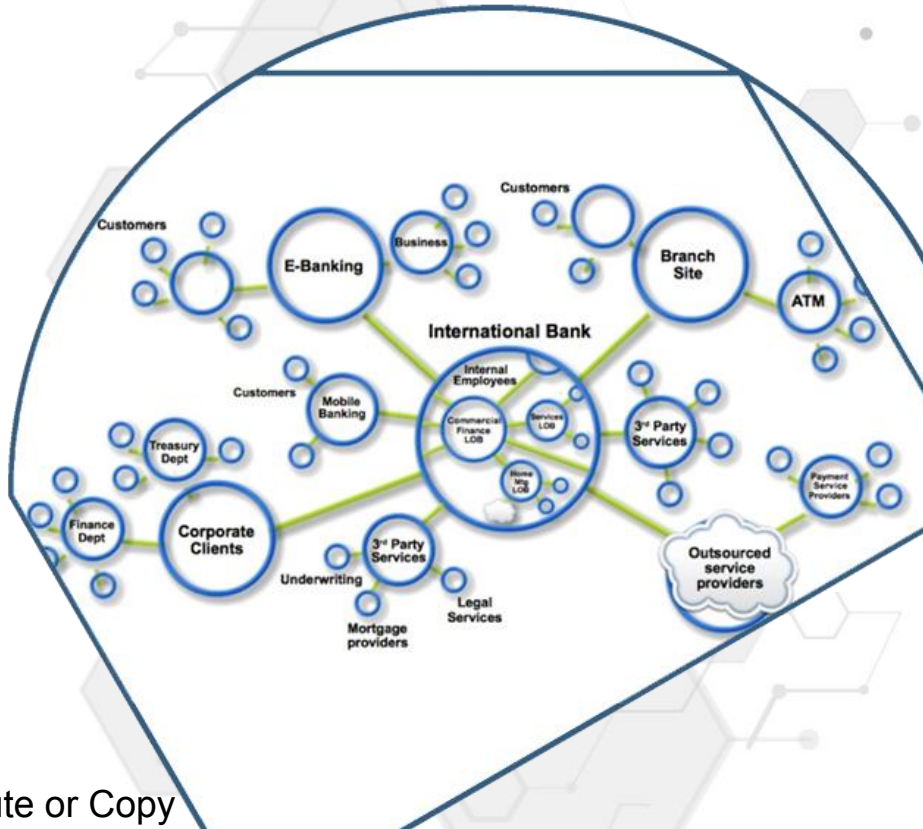
IBM blockchain foundation developer

Video presentation slides

Business Networks, Wealth, and Markets

- **Business Networks**
  - Participants are customers, suppliers, banks, partners
  - Cross geography & regulatory boundary
- **Wealth**

  goods & services across business network in transactions and contracts
- **Markets**
  - Public (fruit market, car auction), or
  - Private (supply chain financing



Transferring Assets, Building Value

Anything that is capable of being owned or controlled to produce value, is an asset

Two fundamental types of asset

- Tangible, e.g. a house
- Intangible, e.g. a mortgage

Intangible assets subdivide

- Financial, e.g. bond
- Intellectual, e.g. patents

Cash is also an asset

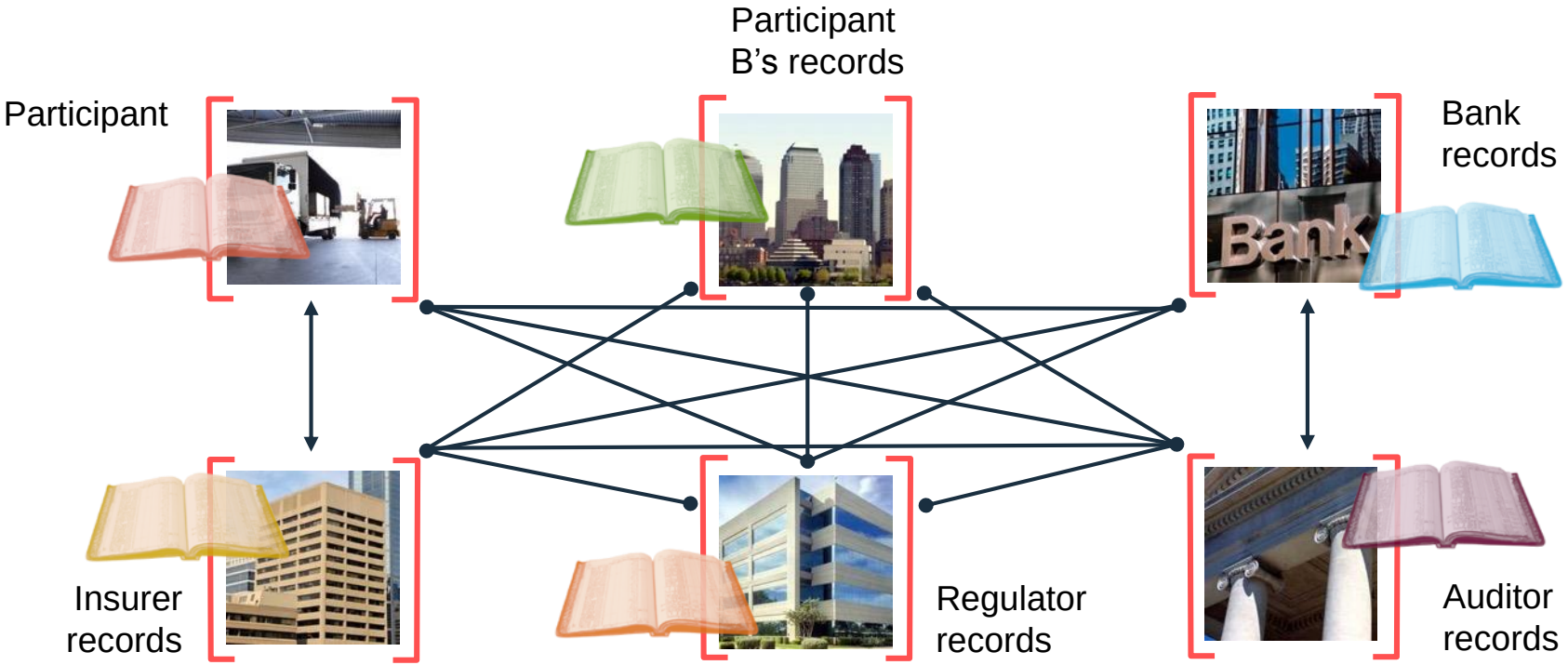
- Has property of anonymity

Introducing Blockchain

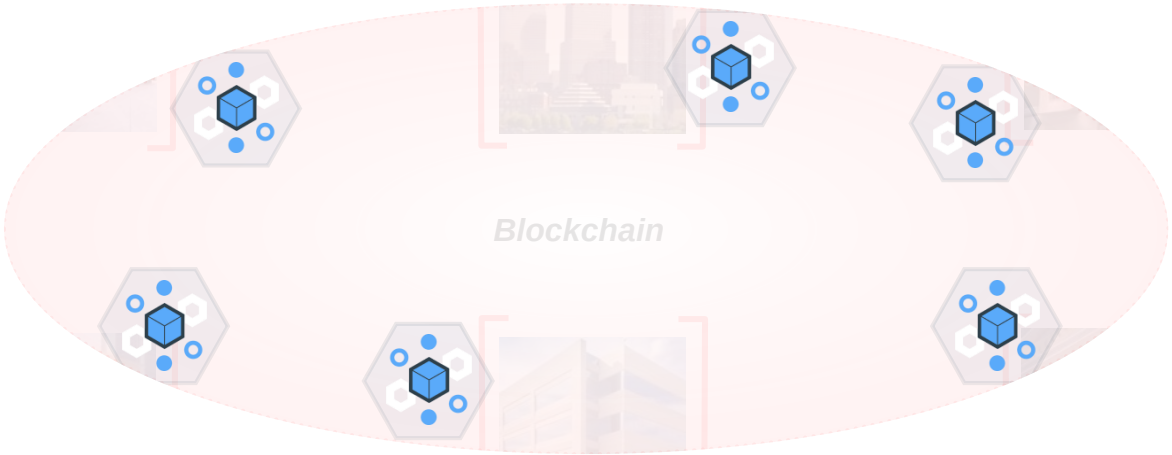
A trusted, distributed ledger

with shared business processes

Problem …



… inefficient, expensive, vulnerable



Blockchain Underpins Bitcoin …

bitcoin

An unregulated shadow-currency

The first blockchain application

Blockchain for business differs in key areas:

Identity over anonymity

Selective endorsement over proof of work

Assets over cryptocurrency

Requirements of Blockchain for Business

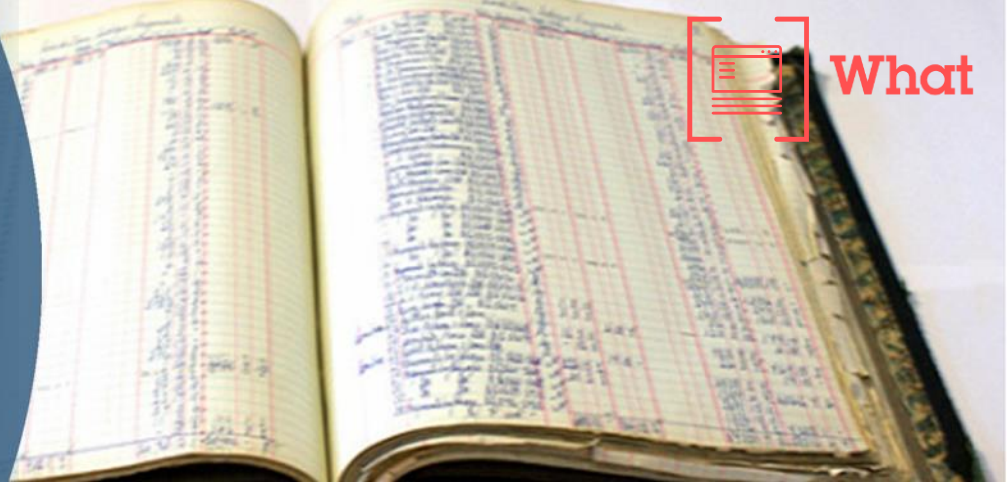
Append-only distributed system of record shared across business network

Business terms embedded in transaction database & executed with transactions

Ensuring appropriate visibility; transactions are secure, authenticated & verifiable

Transactions are endorsed by relevant participants

Shared Ledger



What

Records all transactions across business network

Shared between participants

Participants have own copy through replication

Permissioned, so participants see only appropriate transactions

THE shared system of record

Smart Contract

What

Business rules implied by the contract … embedded in the Blockchain and executed with the transaction

Verifiable, signed

Encoded in programming language

Example:

Defines contractual conditions under which corporate Bond transfer occurs

Privacy

What

The ledger is shared, but participants require privacy

Participants need:

- Appropriate confidentiality between subsets of participants

  Identity not linked to a transaction

Transactions need to be authenticated

Cryptography central to these processes

Trust

What

The ledger is a trusted source of information

- Participants **endorse** transactions
  - Business network decides who will endorse transactions
  - Endorsed transactions are added to the ledger with appropriate confidentiality
- Assets have a verifiable audit trail
  - Transactions cannot be modified, inserted or deleted
- Achieved through consensus, provenance, immutability and finality

Blockchain Benefits

Saves
time

Transaction time from days to near instantaneous

Reduces
cost

Overheads and cost intermediaries

Reduces
risk

Tampering, fraud, & cyber crime

Increases
trust

Through shared processes and recordkeeping

Example: Shared Reference Data

What

- Competitors/collaborators in a business network need to share reference data, e.g. bank routing codes
- Each member maintains their own codes, and forwards changes to a central authority for collection and distribution
- An information subset can be owned by organizations

How

- Each participant maintains their own codes within a Blockchain network
- Blockchain creates single view of entire dataset

Benefits

1. Consolidated, consistent dataset reduces errors
2. Near real-time access to reference data
3. Naturally supports code editing and routing code transfers between participants

Example: Supply Chain

What

- Provenance of each component part in complex system hard to track
- Manufacturer, production date, batch and even the manufacturing machine program

How

- Blockchain holds complete provenance details of each component part
- Accessible by each manufacturer in the production process, the aircraft owners, maintainers and government regulators

Benefits

1. Trust increased, no authority "owns" provenance
2. Improvement in system utilization
3. Recalls "specific" rather than cross fleet

Example: Audit and Compliance

What

- Financial data in a large organization dispersed throughout many divisions and geographies
- Audit and Compliance needs indelible record of all key transactions over reporting period

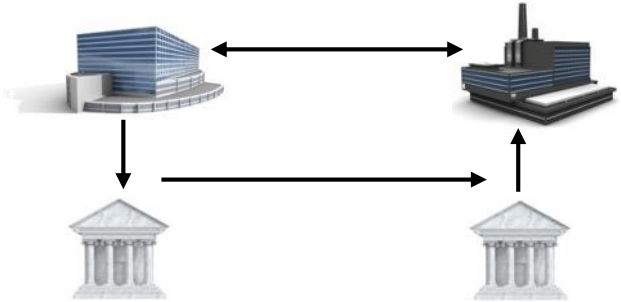
How

- Blockchain collects transaction records from diverse set of financial systems
- Append-only and tamperproof qualities create high confidence financial audit trail
- Privacy features to ensure authorized user access

Benefits

1. Lowers cost of audit and regulatory compliance
2. Provides “seek and find” access to auditors and regulators
3. Changes nature of compliance from passive to active

Example:
Letter of Credit



What

- Bank handling letters of credit (LOC) wants to offer them to a wider range of clients including startups
- Currently constrained by costs & the time to execute

How

- Blockchain provides common ledger for letters of credit
- Allows all counter-parties to have the same validated record of transaction and fulfillment

Benefits

1. Increase speed of execution (less than 1 day)
2. Vastly reduced cost
3. Reduced risk, e.g. currency fluctuations
4. Value added services, e.g. incremental payment

Further Examples by Selected Industry

Potential use cases

Financial	Public Sector	Retail	Insurance	Manufacturing
Trade Finance	Asset Registration	Supply chain	Claims processing	Supply chain
Cross currency payments	Citizen Identity	Loyalty programs	Risk provenance	Product parts
Mortgages	Medical records	Information sharing (supplier – retailer)	Asset usage history	Maintenance tracking
	Medicine supply		Claims file	

Patterns for Customer Adoption

HIGH VALUE MARKET

- Transfer of high value financial assets
- Between many participants in a market
- Regulatory timeframes

ASSET EXCHANGE

- Sharing of assets (voting, dividend notification)
- Assets are information, not financial
- Provenance & finality are key

CONSORTIUM SHARED LEDGER

- Created by a small set of participants
- Share key reference data
- Consolidated, consistent real-time view

COMPLIANCE LEDGER

- Real-time view of compliance, audit & risk data
- Provenance, immutability & finality are key
- Transparent access to auditor & regulator

Key Players for Blockchain Adoption

Regulator

- An organization who enforces the rules of play
- Regulators are keen to support Blockchain-based innovations
- Concern is systemic risk – new technology, distributed data, security

Industry Group

- Often funded by members of a business network
- Provide technical advice on industry trends
- Encourages best practice by making recommendations to members

Market Maker

- In financial markets, takes buy-side and sell-side to provide liquidity
- More generally, the organization who innovates
  - Creates a new good or service, and business process (likely)
  - Creates a new business process for an existing good or service

How IBM Can Help

Technology

Hyperledger Fabric

Hyperledger Composer

Hosting and Support

High Security Business Network

IBM Cloud

Making blockchain real for clients

Garages

Engagement

Hyperledger, a Linux Foundation Project

- A collaborative effort created to advance cross-industry blockchain technologies for business
- Announced December 2015, now over 140 members
- Open source, open standards, open governance
- One active framework (“Fabric”) and seven projects in incubation
- IBM is a premier member of Hyperledger

Brian Behlendorf
Executive Director

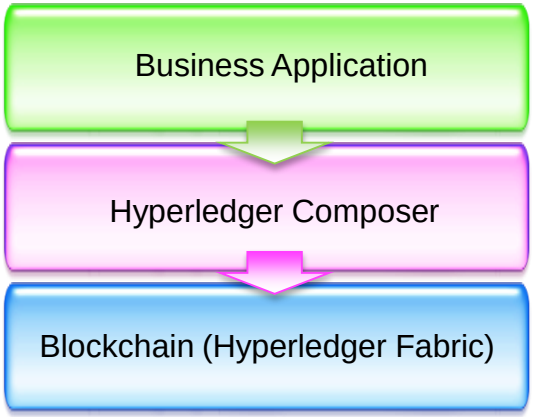
Blythe Masters
Board Chair

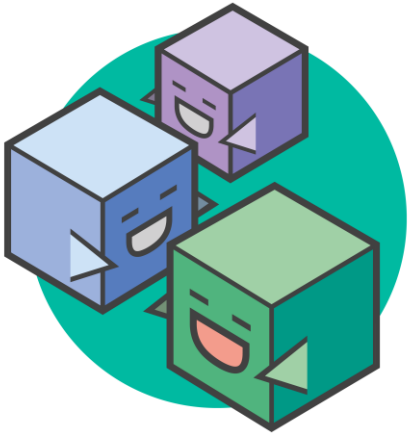
Chris Ferris
TSC Chair

www.hyperledger.org

Hyperledger Composer: Accelerating time to value

- A suite of high level application abstractions for business networks
- Emphasis on business-centric vocabulary for quick solution creation
- Reduce risk, and increase understanding and flexibility





- Features
  - Model your business networks, test and expose via APIs
  - Applications invoke APIs transactions to interact with business network
  - Integrate existing systems of record using loopback/REST
- **Fully open** and one of eight Hyperledger projects
- Try a demo now! - http://composer-playground.mybluemix.net/

IBM engagement model overview

1. Discuss Blockchain technology
2. Explore customer business model
3. Show Blockchain Application demo

Remote

1. Understand Blockchain concepts & elements
2. Hands on with Blockchain on Bluemix
3. Standard demo customization

Digital

1. Design Thinking workshop to define business challenge
2. Agile iterations incrementally build project functionality
3. Enterprise integration

Face to face

1. Scale up pilot or Scale out to new projects
2. Business Process Re-engineering
3. Systems Integration

Face to face

Hyperledger Composer

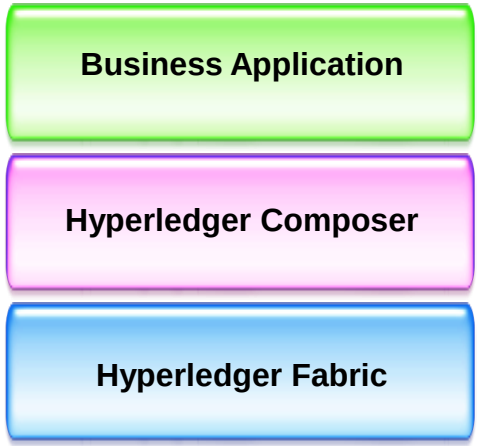
What is Hyperledger Composer?

- **Blockchains provide a low-level interface for business applications**
  - Smart contract code run on a distributed processing system
  - Inputs go into an immutable ledger; outputs to a data store
  - Applications are built on top of a low level of abstraction

- **Hyperledger Composer**
  - A suite of high level application abstractions for business networks
  - Emphasis on business-centric vocabulary for quick solution creation

- **Features**
  - Model your business network, test and deploy
  - Applications use APIs to interact with a business network
  - Integrate existing systems of record using loopback/REST

- **Open Tools, APIs and libraries to support these activities**
  - Exploits Hyperledger Fabric blockchain technology
  - Fully open and part of Linux Foundation Hyperledger



https://hyperledger.github.io/composer/

Benefits of Hyperledger Composer

Increases understanding

Bridges simply from business concepts to blockchain

Saves time

Develop blockchain applications more quickly and cheaply

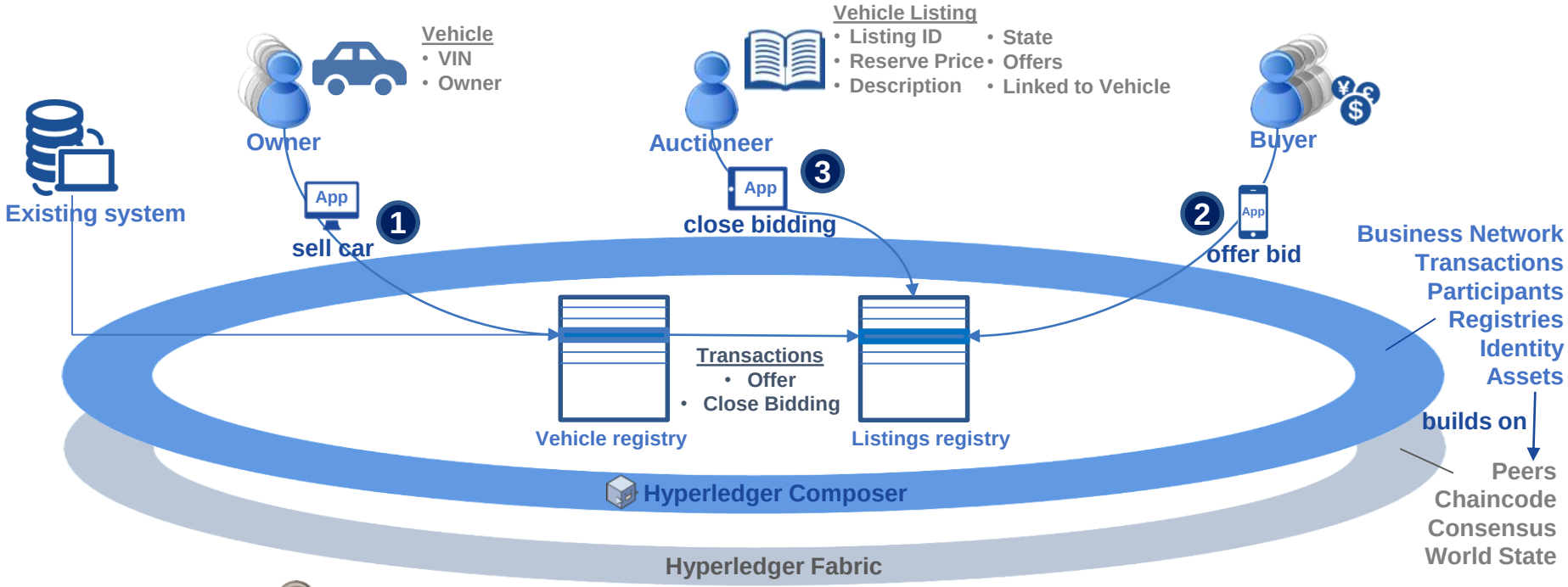
Reduces risk

Well tested, efficient design conforms to best practice

Increases flexibility

Higher level abstraction makes it easier to iterate

An Example Business Network – Car Auction Market

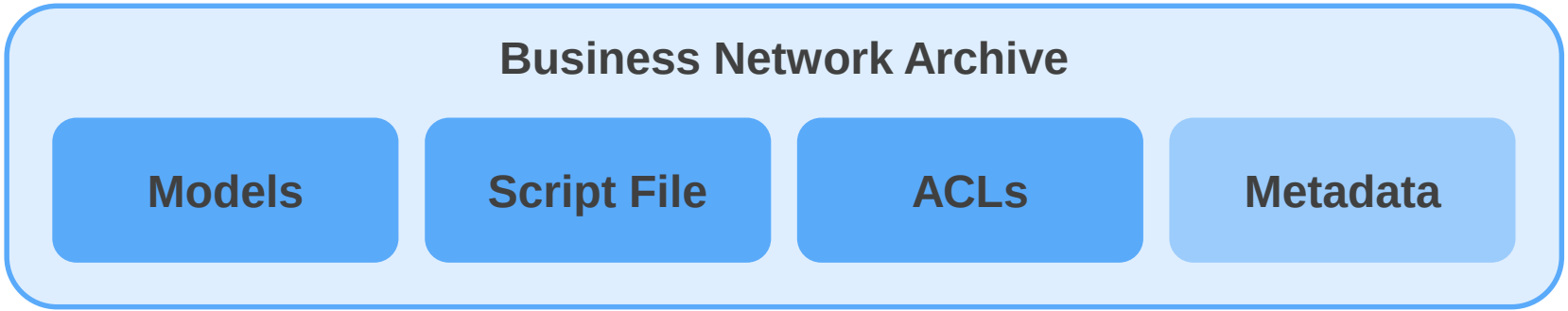


Conceptual Components and Structure of Composer

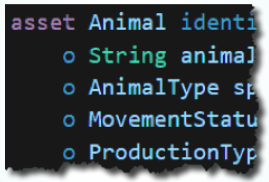
Business Network is defined by **Models, Script Files, ACLs and Metadata and packaged in a Business Network Archive**

Solution Developer models the business network, implements the script files that define transaction behaviour and packages into a business network archive

Solution Administrator provision the target environment and may manage deploy



Extensive, Familiar, Open Development Tool set



Data modelling

JavaScript business logic

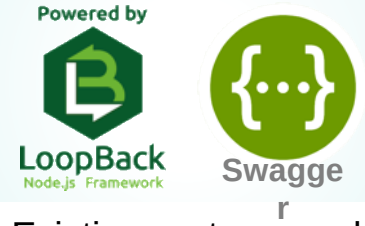
Web playground

Client libraries

Editor support

CLI utilities

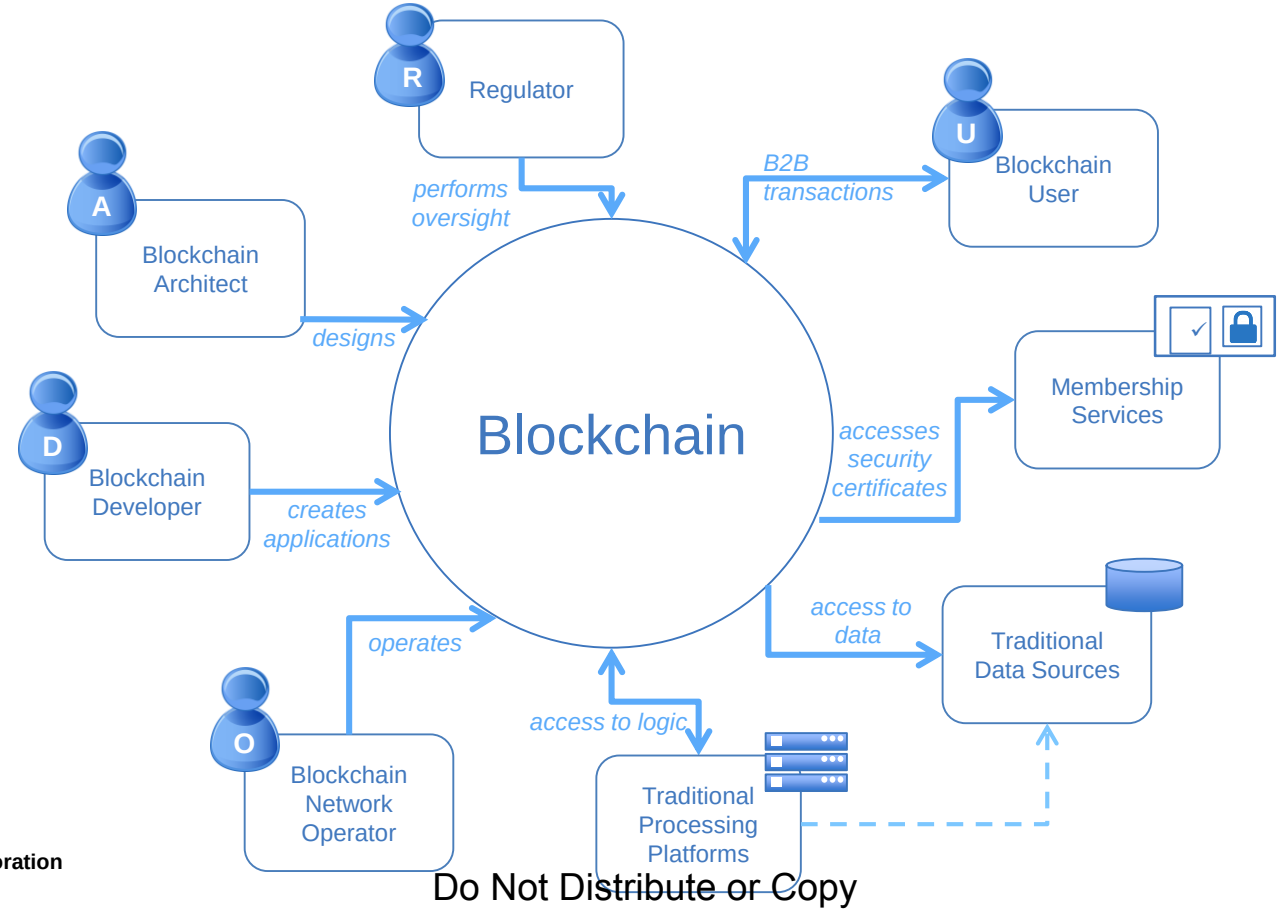
Code generation



Existing systems and data

Blockchain Fabric Development

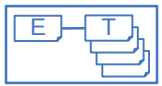
Actors in a Blockchain Solution



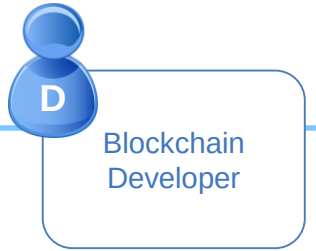
Actors in a Blockchain Solution

Blockchain Architect		Responsible for the architecture and design of the blockchain solution
Blockchain User		The business user, operating in a business network. This role interacts with the Blockchain using an application. They are not aware of the Blockchain.
Blockchain Regulator		The overall authority in a business network. Specifically, regulators may require broad access to the ledger's contents.
Blockchain Developer		The developer of applications and smart contracts that interact with the Blockchain and are used by Blockchain users.
Blockchain Operator		Manages and monitors the Blockchain network. Each business in the network has a Blockchain Network operator.
Membership Services		Manages the different types of certificates required to run a permissioned Blockchain.
Traditional Processing Platform		An existing computer system which may be used by the Blockchain to augment processing. This system may also need to initiate requests into the Blockchain.
Traditional Data Source		An existing data system which may provide data to influence the behavior of smart contracts.

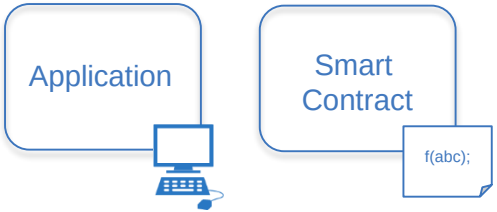
Components in a Blockchain Solution

Ledger		A ledger is a channel's chain and current state data which is maintained by each peer on the channel.
Smart Contract		Software running on a ledger, to encode assets and the transaction instructions (business logic) for modifying the assets.
Peer Network		A broader term overarching the entire transactional flow, which serves to generate an agreement on the order and to confirm the correctness of the set of transactions constituting a block.
Membership		Membership Services authenticates, authorizes, and manages identities on a permissioned blockchain network.
Events		Creates notifications of significant operations on the blockchain (e.g. a new block), as well as notifications related to smart contracts.
Systems Management		Provides the ability to create, change and monitor blockchain components
Wallet		Securely manages a user's security credentials
Systems Integration		Responsible for integrating Blockchain bi-directionally with external systems. Not part of blockchain, but used with it.

The Blockchain Developer

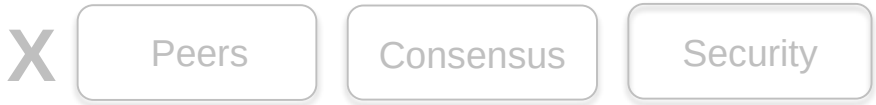


Blockchain developers' primary interests are…



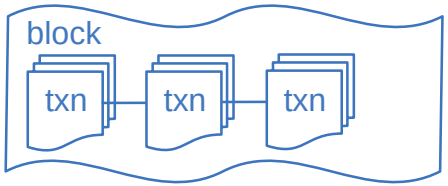
…and how they interact with the ledger and other systems of record:

They should NOT have to care about operational concerns, such as:

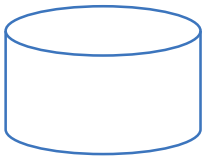


How the Developer Interacts with the Ledger

A ledger often consists of two data structures



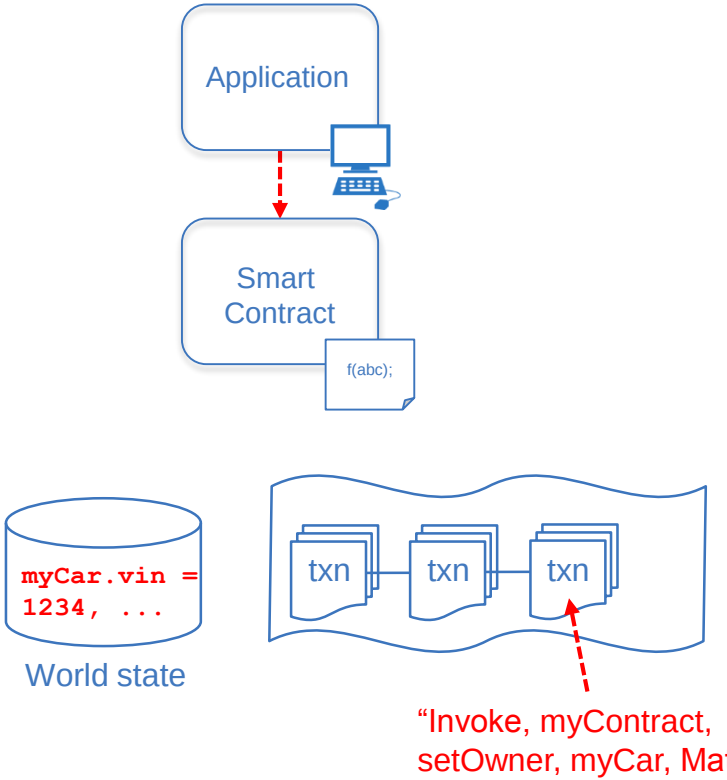
Blockchain


World state

- Blockchain
  - A linked list of blocks
  - Each block describes a set of transactions (e.g. the inputs to a smart contract invocation)
  - Immutable – blocks cannot be tampered

- World State
  - An ordinary database (e.g. key/value store)
  - Stores the combined outputs of all transactions
  - Not usually immutable

Working with the Ledger: Example of a Change of Ownership Transaction (change car1 owner to Matt)



Transaction input - sent from application

```
invoke(myContract, setOwner,
        myCar, Matt)
...
```

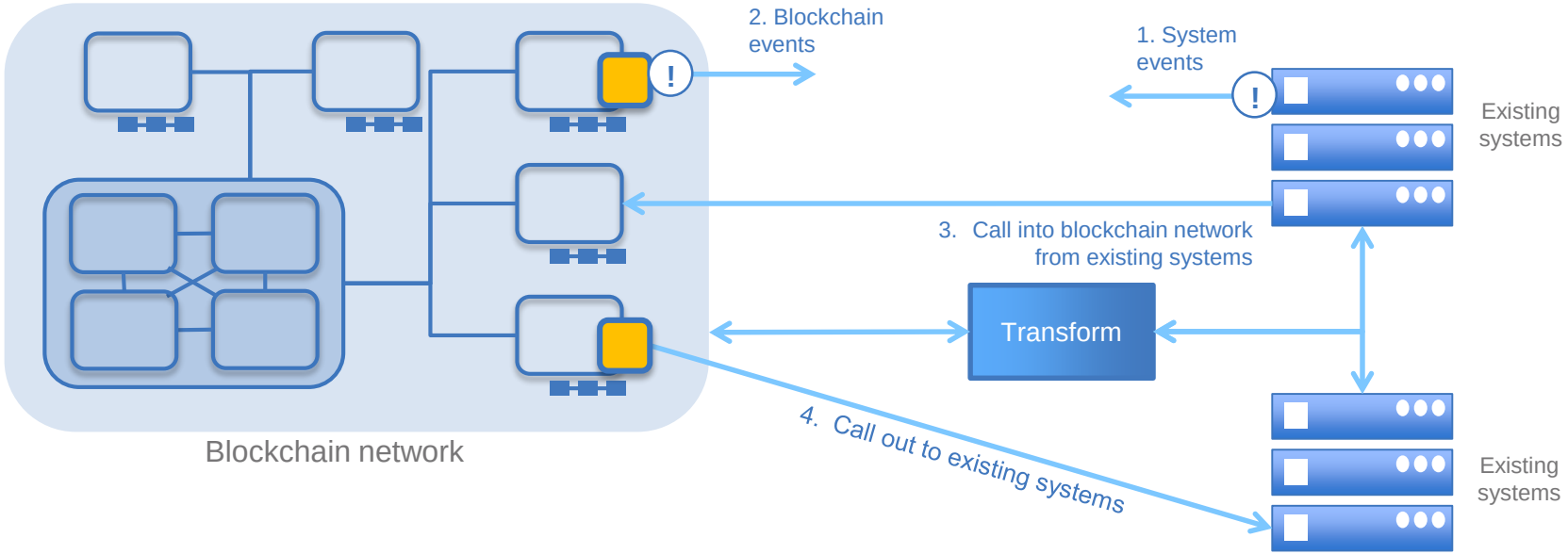
Smart contract implementation

```
setOwner(Car, newOwner) {
   set Car.owner = newOwner
}
```

World state: new contents

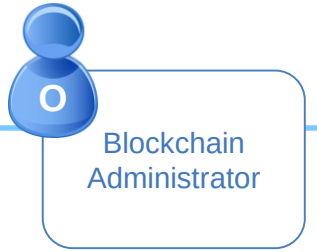
```
myCar.vin = 1234
myCar.owner = Matt
myCar.make = Audi
...
```

Integrating with Existing Systems

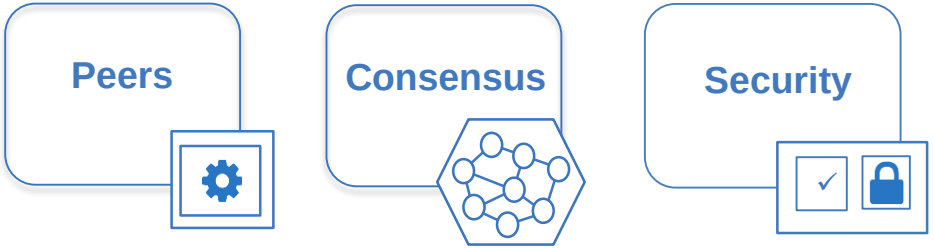


Blockchain Architecture

The Blockchain Administrator (Operator)



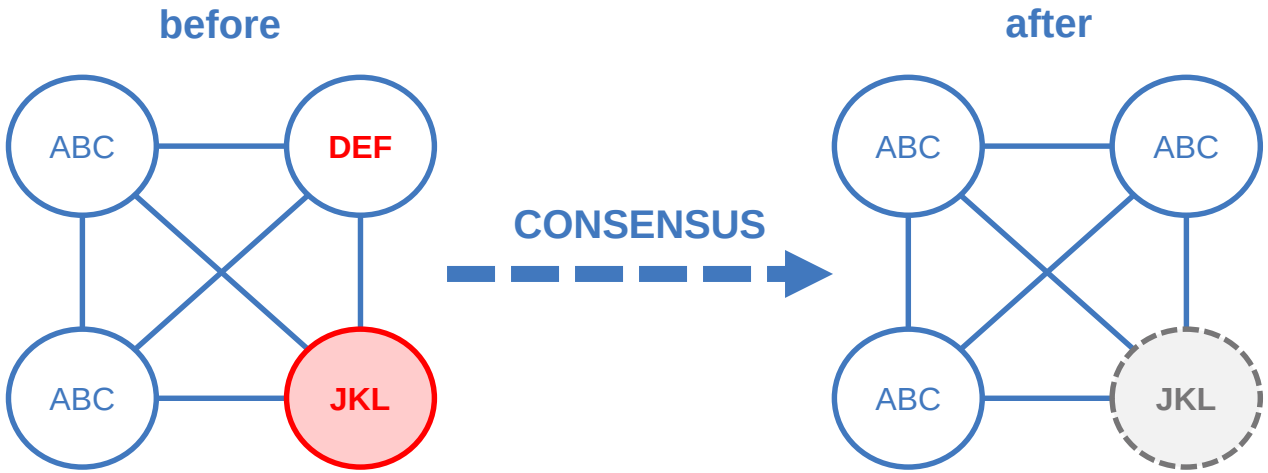
Blockchain administrators' primary interests are in the deployment and operation of part of the blockchain:



They should NOT have to care about development concerns, such as:

X Application code | Smart contract code | Events and integration

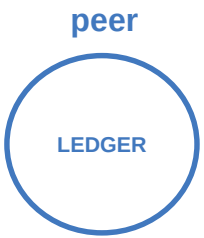
Consensus: The Process of Maintaining a Consistent Ledger



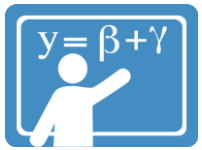
Keep all peers up to date.

Fix any peers in error.

Ignore all malicious nodes.



Some Examples of Consensus Algorithms



Proof of work

Proof of stake

Solo

Kafka/ Zookeeper

Proof of Elapsed Time

PBFT-based

Consensus Algorithms have Different Strengths and Weaknesses

Proof of work

Require validators to solve difficult cryptographic puzzles
PROs: Works in untrusted networks
CONS: Relies on energy use; slow to confirm transactions
Example usage: Bitcoin, Ethereum

Proof of stake

Require validators to hold currency in escrow
PROs: Works in untrusted networks
CONS: Requires intrinsic (crypto)currency, ”Nothing at stake” problem
Example usage: Nxt

Proof of Elapsed Time

Wait time in a trusted execution environment randomizes block generation
PROs: Efficient
CONS: Currently tailored towards one vendor
Example usage: Sawtooth-Lake

Consensus Algorithms have Different Strengths and Weaknesses

Solo

Validators apply received transactions without consensus
PROs: Very quick; suited to development
CONS: No consensus; can lead to divergent chains
Example usage: Hyperledger Fabric V1

PBFT-based

Practical Byzantine Fault Tolerance implementations
PROs: Reasonably efficient and tolerant against malicious peers
CONS: Validators are known and totally connected
Example usage: Hyperledger Fabric V0.6

Kafka/
Zookeeper

Ordering service distributes blocks to peers
PROs: Efficient and fault tolerant
CONS: Does not guard against malicious activity
Example usage: Hyperledger Fabric V1

Security: Public vs. Private Blockchains

Public blockchains

- For example, Bitcoin
- Transactions are viewable by anyone
- Participant identity is more difficult to control

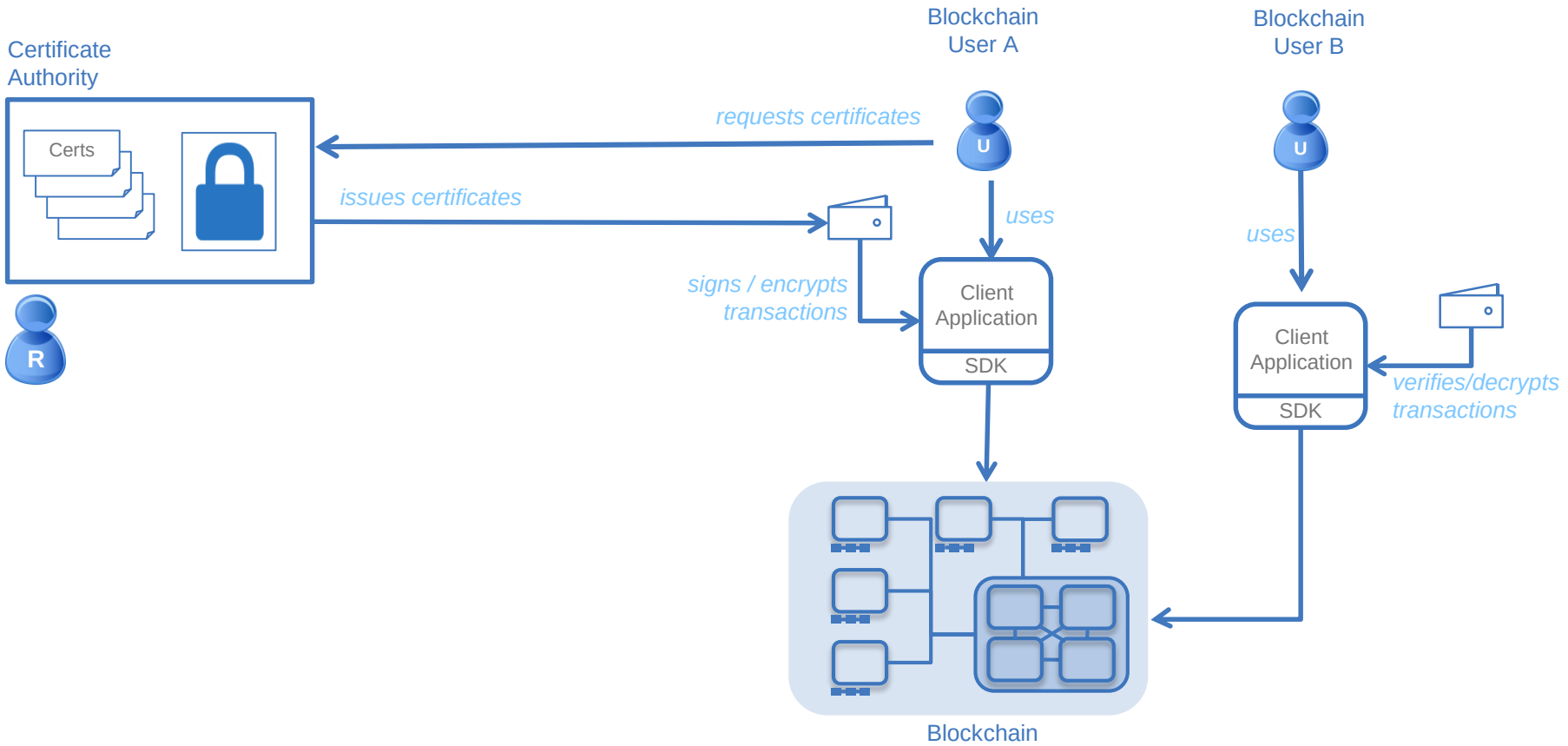
Private blockchains

- For example, Hyperledger Fabric
- Network members are known but transactions are secret

- Some use cases require anonymity, others require privacy
  - Some may require a mixture of the two, depending on the characteristics of each participant

- **Most business use cases require private, permissioned blockchains**
  - Network members know who they're dealing with (required for KYC, AML, etc.)
  - Transactions are (usually) confidential between the participants concerned
  - Membership is controlled

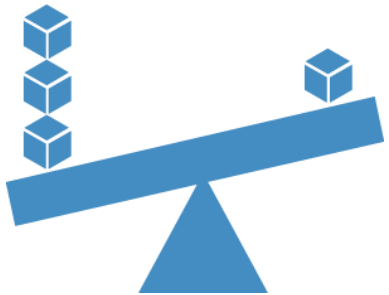
Certificate Authorities and Blockchain



Other Nonfunctional Requirements

- Performance
  - The amount of data being shared
  - Number and location of peers
  - Latency and throughput
  - Batching characteristics
- Security
  - Type of data being shared, and with whom
  - How is identity achieved
  - Confidentiality of transaction queries
  - Who verifies (endorses) transactions
- Resiliency
  - Resource failure
  - Malicious activity
  - Non-determinism

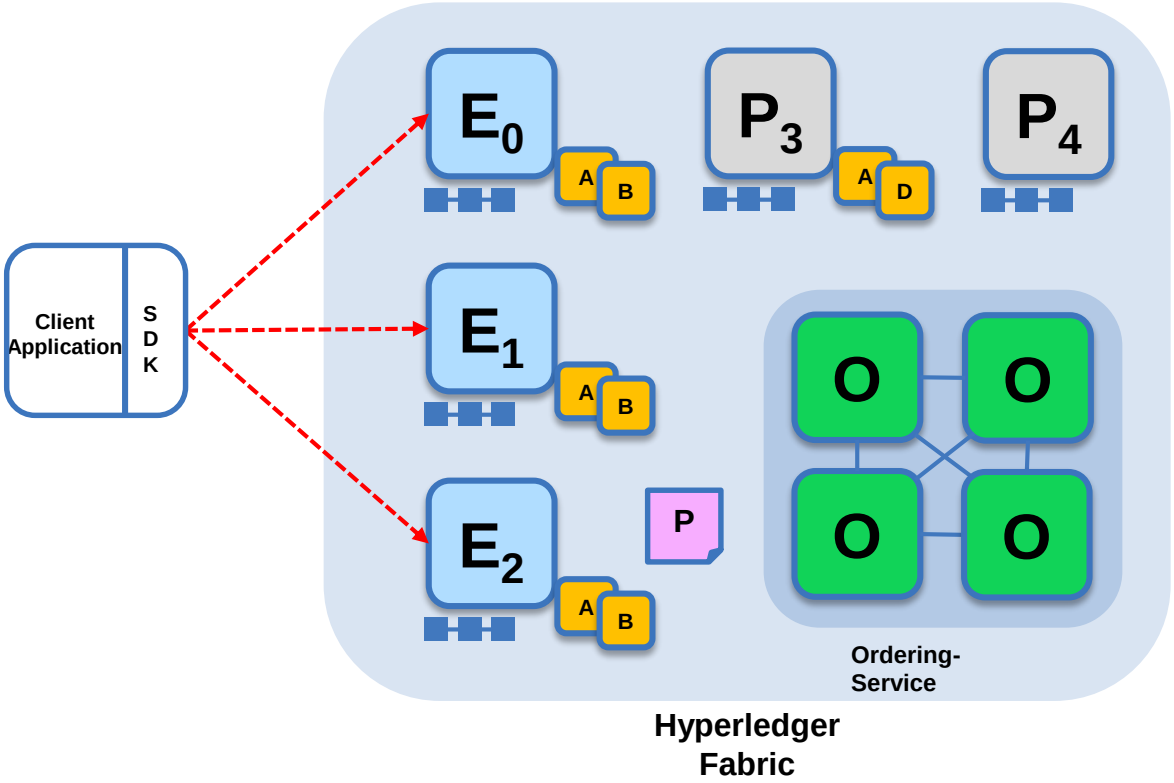
Consider the trade-offs between performance, security, and resiliency!



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 Nodes (service)**: 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

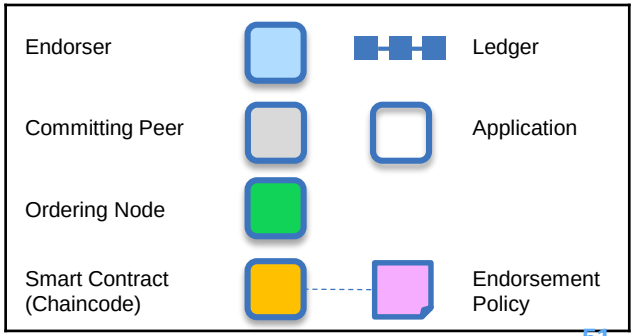


Application proposes transaction

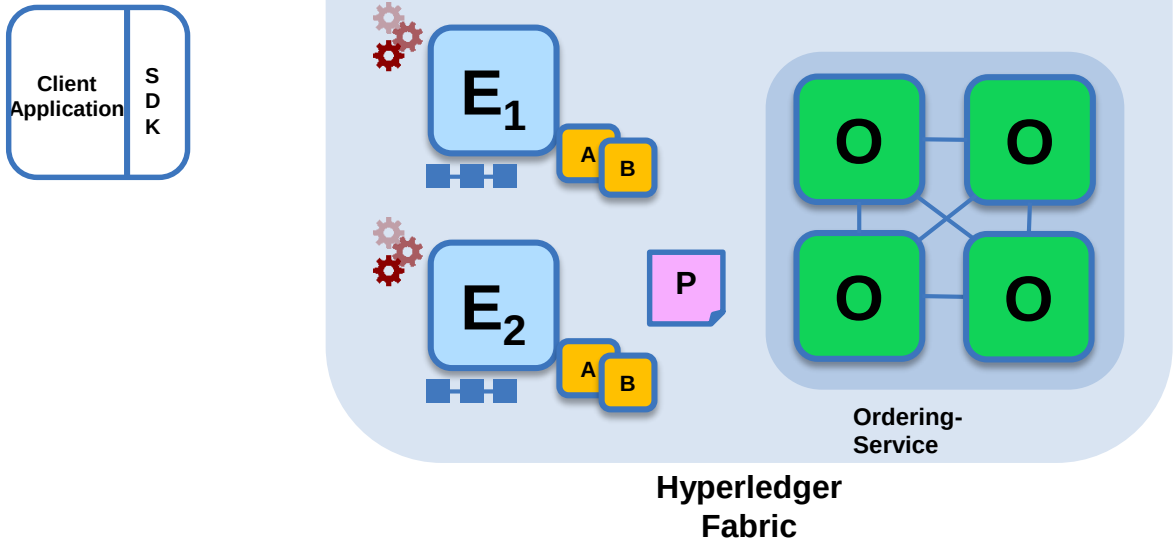
Endorsement policy:
- **"E_0, E_1 and E_2 must sign"**
- **(P_3, P_4 are not part of the policy)**

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

Key:



Sample Transaction: Step 2/7 – Execute Proposal



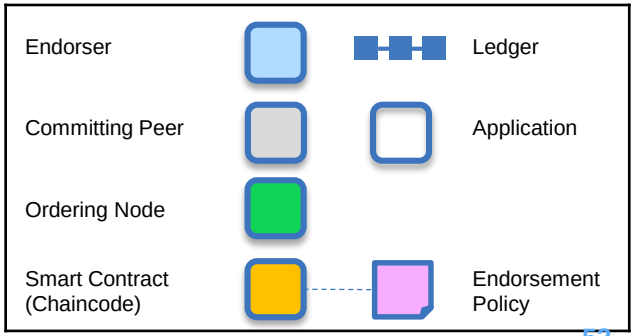
Endorsers Execute Proposals

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

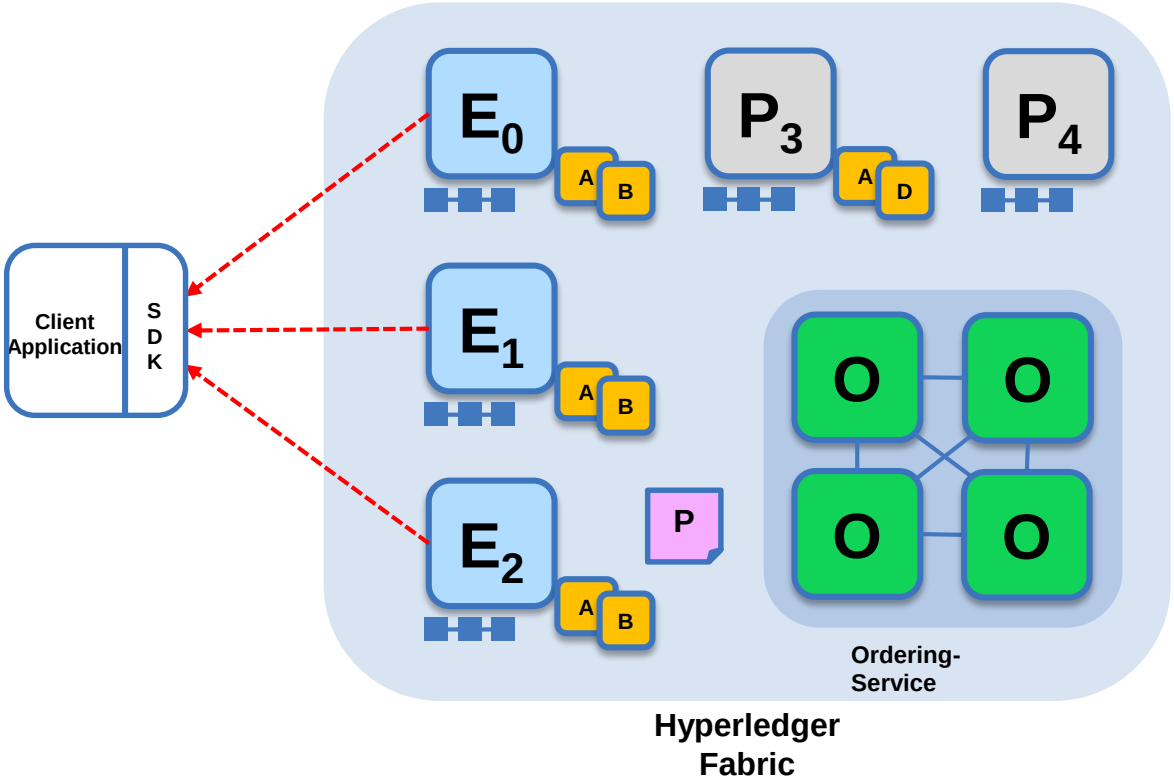
Each execution will capture the set of Read and Written data, called RW sets, which will now flow in the fabric.

Transactions can be signed and encrypted.

Key:



Sample Transaction: Step 3/7 – Proposal Response



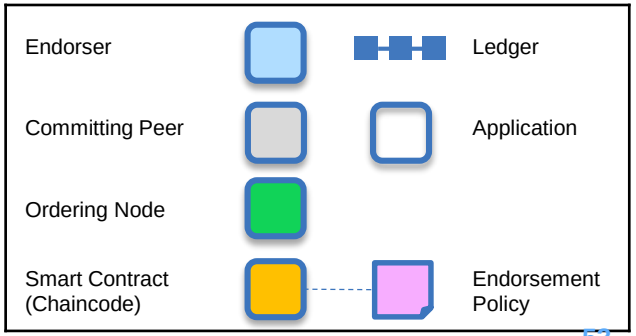
Application receives responses

RW sets are asynchronously returned to application.

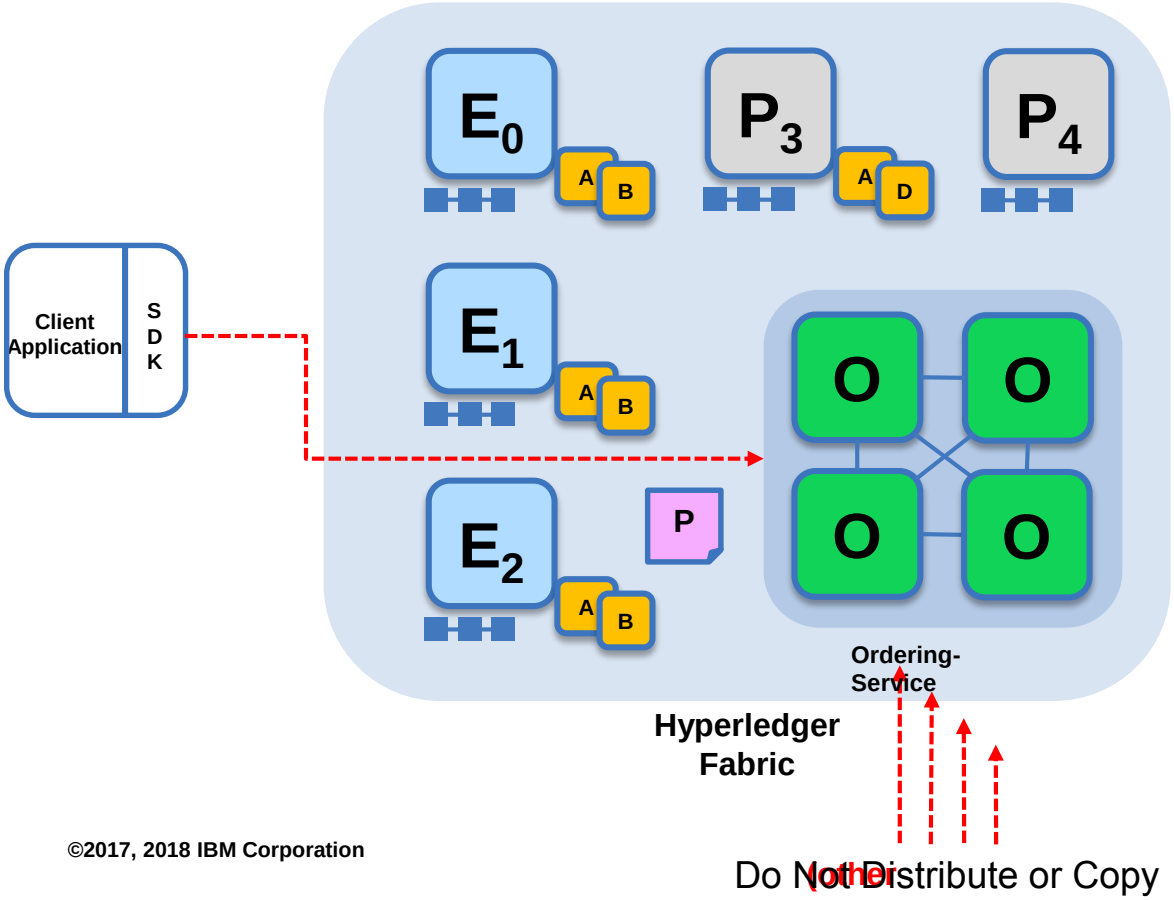
The RW sets are signed by each endorser, and also includes each record version number.

This information will be checked much later in the consensus process.

Key:



Sample Transaction: Step 4/7 – Order Transaction

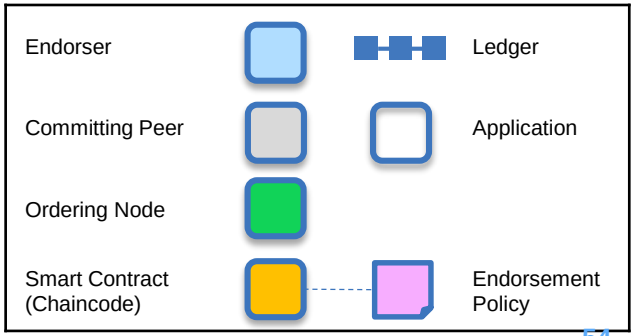


Application submits responses for ordering

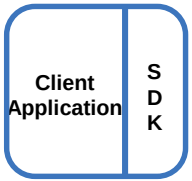
Application submits responses as a transaction to be ordered.

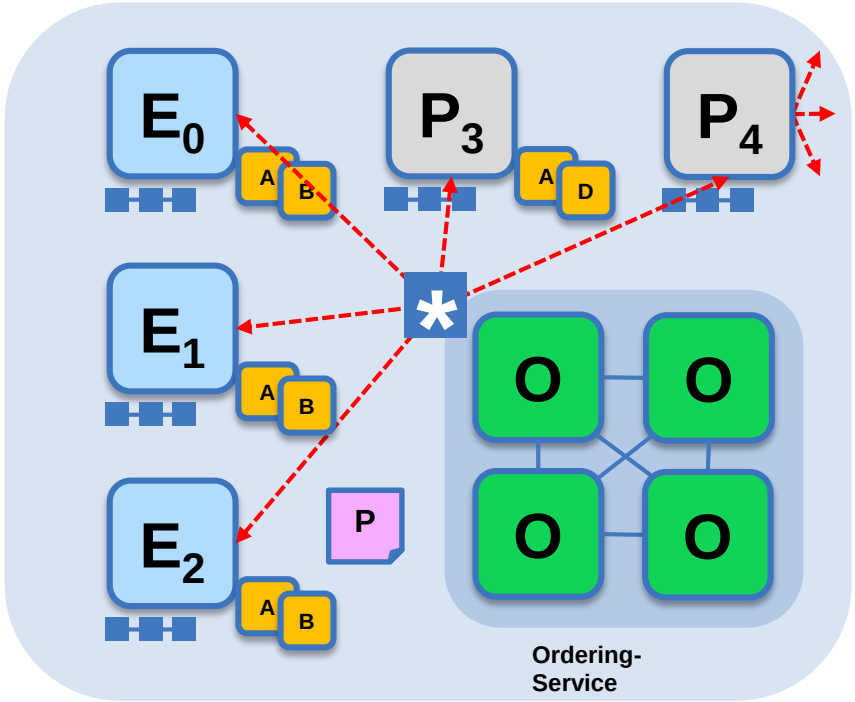
Ordering happens across the fabric in parallel with transactions submitted by other applications.

Key:



Sample Transaction: Step 5/7 – Deliver Transaction





Hyperledger Fabric

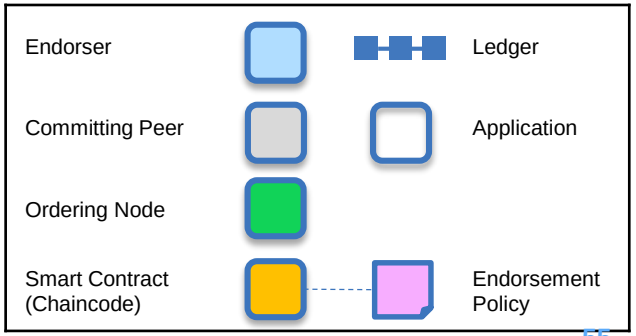
Orderer delivers to all committing peers

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

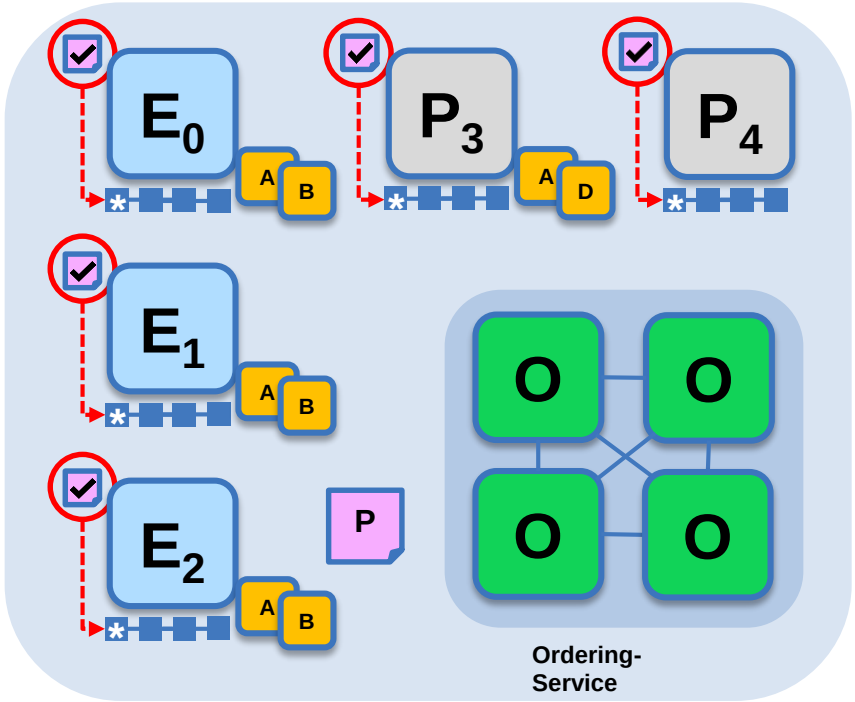
Different ordering algorithms available:

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

Key:



Sample Transaction: Step 6/7 – Validate Transaction



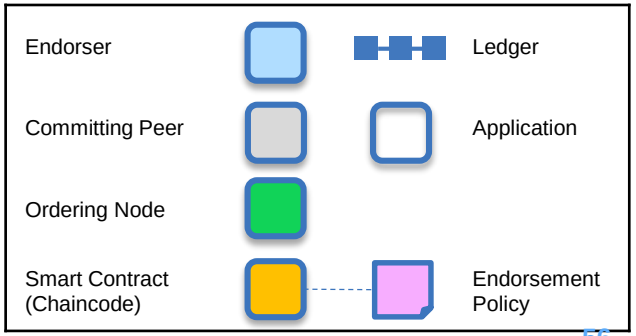
Committing peers validate transactions

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

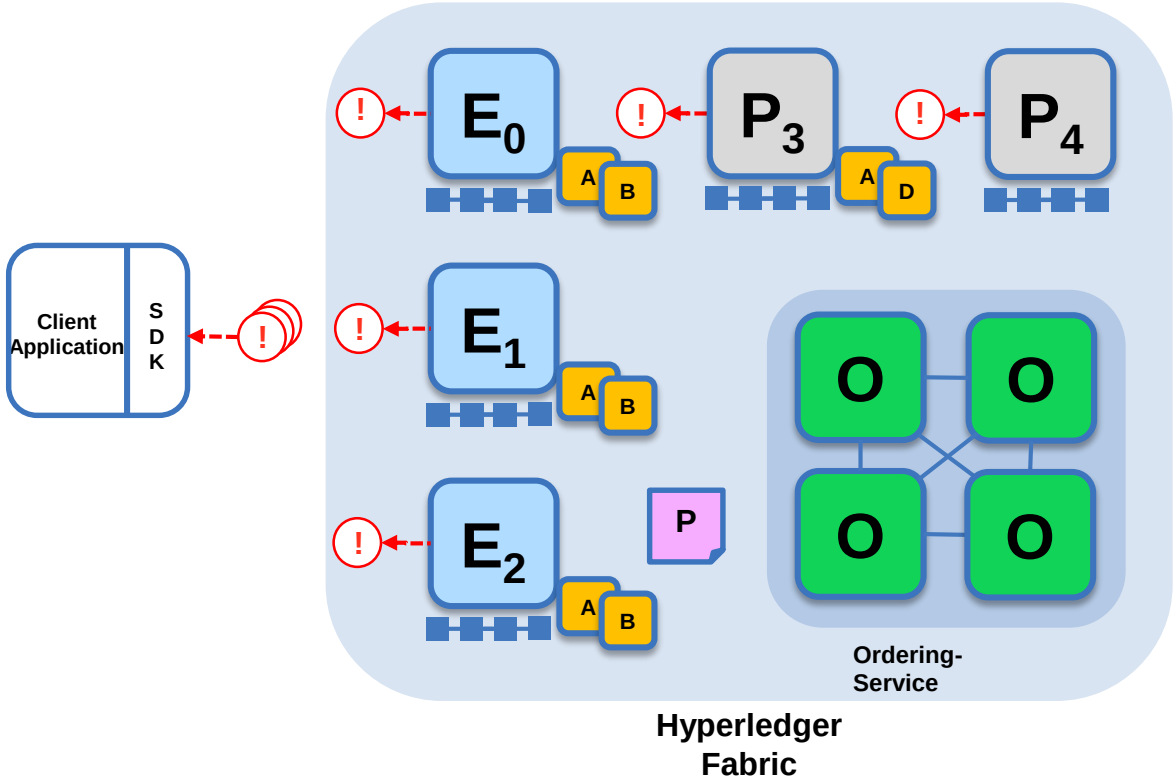
Validated transactions are applied to the world state and retained on the ledger.

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

Key:



Sample Transaction: Step 7/7 – Notify Transaction



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.

Key: