P2P Systems and Blockchains

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Lesson 21:
PERMISSIONED BLOCKCHAINS: HYPERLEDGER

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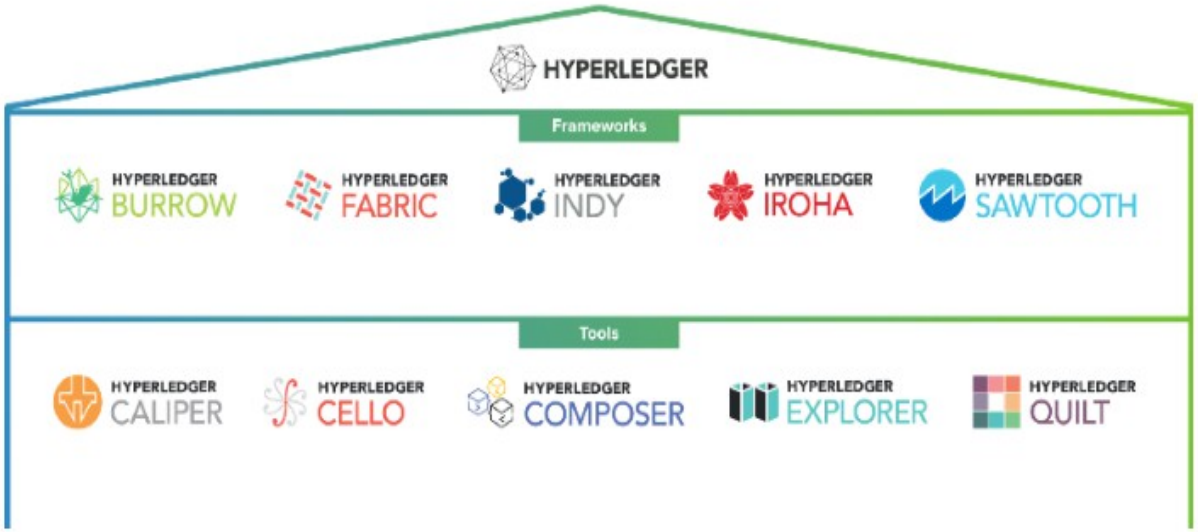
DISTRIBUTED LEDGERS APPLICATIONS

- distributed ledgers: a generalization of the blockchain
- which are the basis of the distributed ledger technology?
  - combine concepts from cryptography and game theory
  - remove the need for trust in a system
  - ensure that users are able to transparently interact with reduced reliance on third party authorities.
- what is distributed ledger technology good for? Essentially, users are able to create database environments where
  - mutually untrusting users can exchange value or append records without a central coordinator.
  - the database cannot be tampered
- a lot of projects raised in the last years, also in fields different from cryptocurrencies many have failed

THE HYPERLEDGER PROJECT

- an open source meta-project under the aegis of the Linux Foundation
  - aims to create interoperable cross-industry blockchain technologies.
- several variations of Hyperledger including Sawtooth and Iroha, each with unique features and functionality.



- another project: the R3 consortium Corda framework:
  - a meta-project, not open source, for the development of business blockchain

A CHOCOLATE PRODUCTION SUPPLY CHAIN

- an example to show Hypeledger functionalities
- participants in the chain are:
  - farmers (growers)
  - importer
  - confectionery company, with a branch in South America
  - forwarder (logistic service between the shipper and the carrier)
  - shipper ()
- assets
  - anything that has value and can be transferred from one participant to another.
  - example of assets:
    - the cocoa beans
    - the expedition (which can embed another asset, the cocoa beans)
    - a contract between the importer and the confectionery company for the purchase and delivery of a batch of cocoa beans

WHAT IS A CONTRACT?

- a "contract" asset: a set of parameters linked to some participants:
  - contract id
  - arrival date
  - penalties for delays
  - reference to the actors involved
    - shipper
    - importer
    - forwarder
    - confectionery company
- other parameters may be present
  - permissible temperature range during transport detected through the sensors during the journey, on ships, on trucks, etc.
  - if the limits are exceeded
    - the shipper will automatically pay a penalty.

PERMISSIONED BLOCKCHAINS

- all the steps of the supply chain may be managed automatically by the blockchain in a single "environment" common to all the parties involved.
  - only the parties involeved can partecipate to the blockchain
  - they must be authenticated by a certification authority
- the blockchain may be integrated by IoT tools or anyway devices able to talk to each other through
  - mobile, wi-fi
  - NFC
  - Bluetooth
- why a permissioned blockchain?
  - not all participants have access to any information.
    - transporters can not access transaction data between importers and growers.
    - forwarder are not authorized to view transaction data between importer and shippers.

WHY A PERMISSIONED BLOCKCHAIN?

- other participants may belong to the supply chain with supervisory or control functions.
- a supervisor may be authorized to view asset-contracts and transactions between growers and importer to check that there is adequate payment.
- a government agency could read the blockchain in the context of monitoring imports from particular countries.
- a quality consortium would verify the origin area of cocoa beans and transport conditions.
- all these participants could be blockchain nodes, possibly with different roles.
- an environment suitable for this scenario: Hyperledger Fabric

HYPERLEDGER FABRIC: GENERAL CHARACTERISTICS

- support smart contracts: chaincodes
- a simple API allowing external applications can, through API to perform two operations:
  - read blockchain data through queries similar to the queries of a database
  - update the blockchain update, submitting a transaction request
- three types of nodes:
  - clients
  - peers (endorsers)
  - orderers

HYPERLEDGER FABRIC: CLIENTS AND PEERS

- clients
  - send the proposals for transactions to be approved, by endorsers
  - do not own a copy of the blockchain, must connect to a peer
    - the grower starting the procedure by a smartphone
- peers
  - maintain copy of the blockchain and have chaincodes
  - receive ordered state updates in the form of blocks from the ordering service and maintain the state and the ledger.
  - may be endorsers
- orderers
  - send the proposals for transactions to be approved, by endorsers.
  - do not own a copy of the blockchain.
  - a grower who starts, from his/her smartphone, the payment procedure (transaction) may be a client

HYPERLEDGER FABRIC: ENDORSERS

- endorsement, what is it? support or approve something.
  - signing a cheque to transfer money: approving the transfer of money
  - insurance company can endorse (approve) changes to a policy document, withouth rewriting it
- trust is an important aspect of endorsement
  - the more you trust the endorser, the more you trust her/his endorsement.
  - endorsements is basis of agreements and trust between people and organisations.
- endorsement even more important when transactions cross organisational boundaries.
- this concept is the first step of the hyperledger consensus process

HYPERLEDGER FABRIC (HLF): ENDORSERS

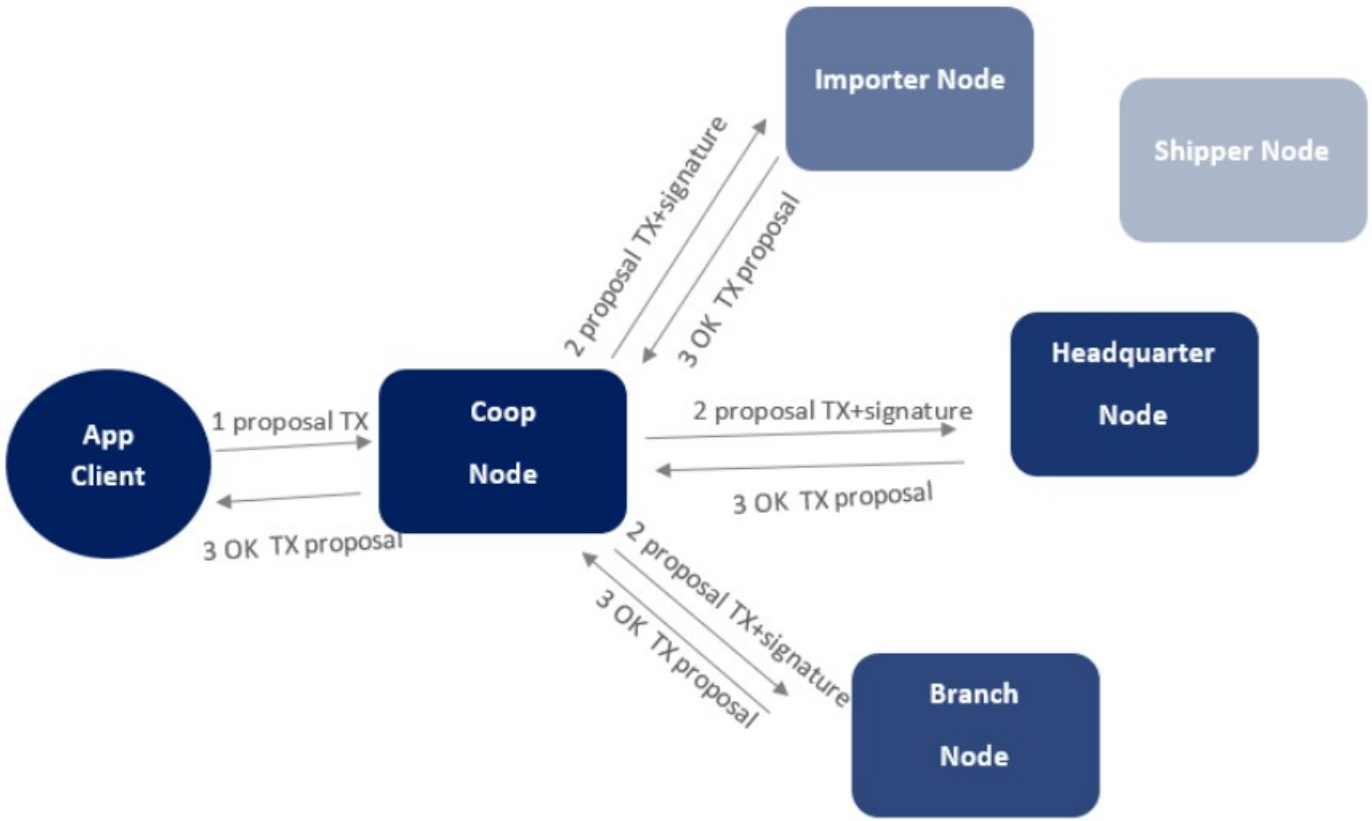
- endorsement in HLF:
  - execution of a smart contract by a set of organizations
  - an endorcement policy must state which organisation(s) must endorse the transaction.
- the client submits a endorsement proposal
  - it is wrapped in a transaction including input data
  - the whole transaction is cryptographically signed by the client
  - the transaction is sent to one or multiple endorsers
- the endorser
  - receives the transaction
  - verifies the signature to ensure the transaction hasn't been modified.
  - simulates the execution of the transaction by executing the smart contract and returns what is called the endorsement response.
  - cryptographically signs the response

ENDORSEMENT FOR CHOCOLATE PRODUCTION

A farmer wants to sell a batch of cocoa beans:

- sends the transaction request to the network via smartphone
- connects to a reference peer, farmers' cooperative node which “digitally” signs the request
- the request is passed to a set of endorsers, for instance the importer node, the node of the headquarter of the company, and so on.
- the endorser guarantees
  - the request is well formed
  - the client is authorized to carry out the transaction
  - the digital signature is authentic and it has not already been presented, etc.
- the endorsers send their response to the request through the network.

ENDORSEMENT FOR CHOCOLATE PRODUCTION



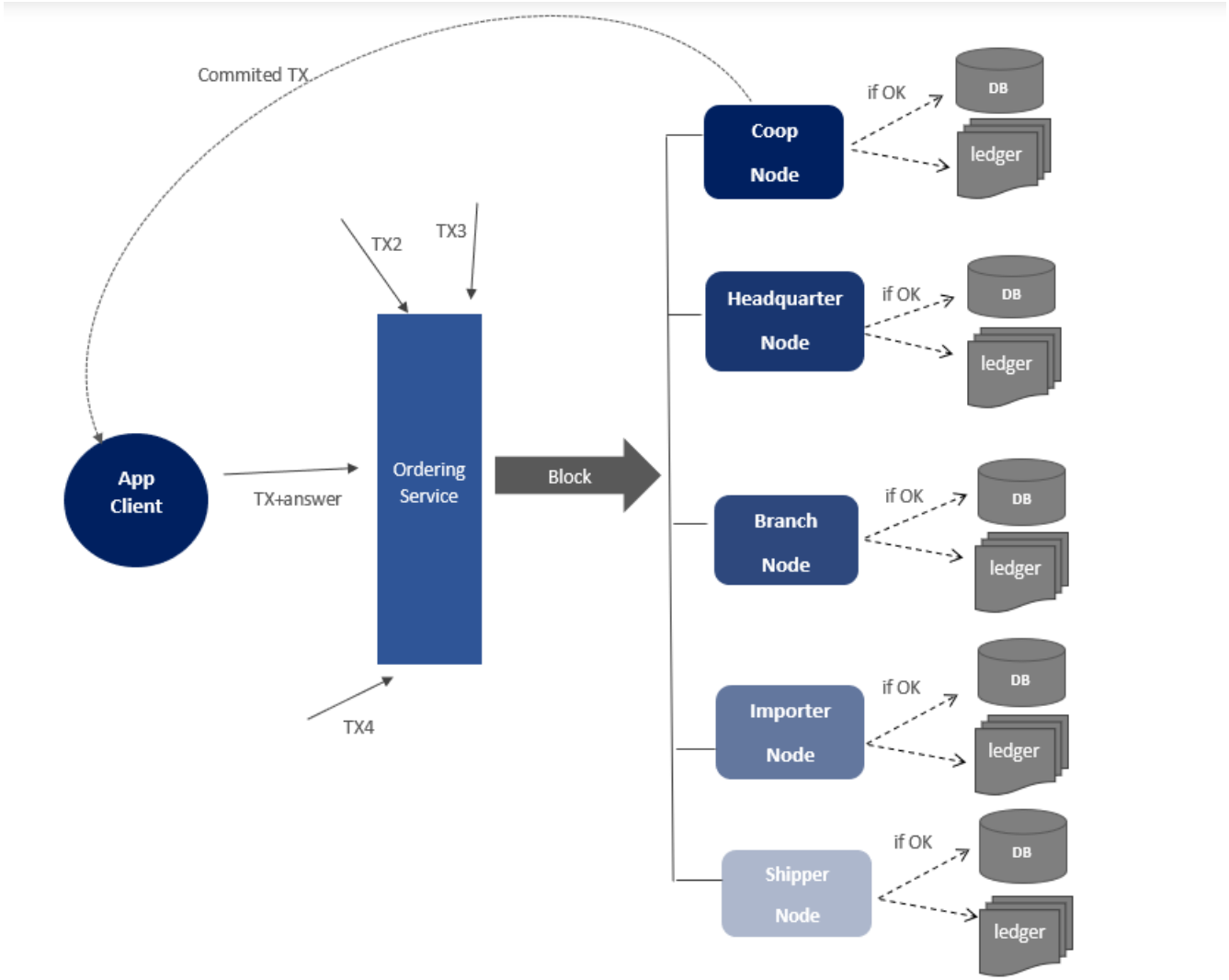
ENDORSEMENT FOR CHOCOLATE PRODUCTION

- the client application collects the endorcement answers
- it checks that the endorcement policy is met
  - the headquarter node OR the branch node has approved the transaction
  - if an endorser does not approve the request or the client does not receive all the necessary endorcements, the transaction is discarded
    - nothing is altered in the blockchain
  - otherwise, the customer sends transactions and approvals associated with the Ordering Service.
    - this service sorts and groups transactions into blocks and sends them to all peers in the network.

HYPERLEDGER FABRIC: ORDERERS

- implement consensus
- establish the total order of all transactions by reaching a consensus among all peer nodes.
- disseminate block to all the peer nodes via peer-to-peer gossip
- are entirely unaware of the application state,
- do not participate in the execution nor in the validation of transactions.
- the customer sends transactions and approvals associated with to the ordering Service.
  - this service sorts and groups transactions into blocks and sends them to all peers in the network.
- the peers control the block ofthe transactions and the associated answers and "tag" as valid or invalid; only at this point the peers add the block to their copy of the blockchain and update the database on the new "world state".

HLF: ORDERING



HYPERLEDGER FABRIC: CHANNELS

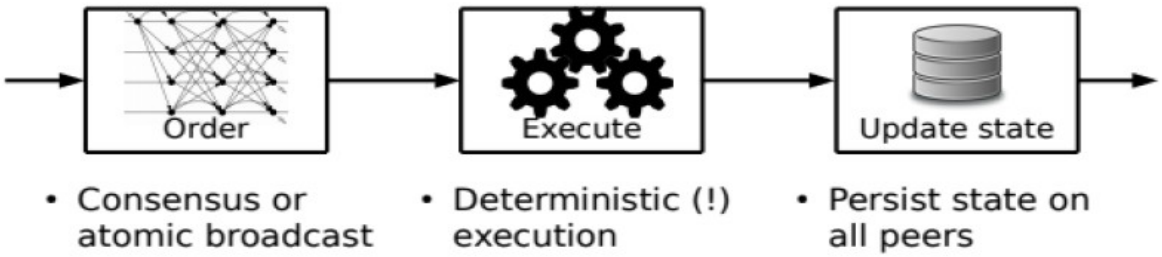
- a company can be part of different business networks
- it is necessary to use secure and independent channels in which information can flow.
- each channel is also the protected space where credentials and authorizations are valid, limited to that business network.
- a participant can also be an endorser in a business network, a client in another, a non-endorser in another.

HYPERLEDGER FABRIC (HLF)

- a Distributed Operating System for Permissioned Blockchains, recently developed in IBM
- comes from the following observation
  - prior blockchains suffer from many limitations due to their order-execute architecture
- HLF address those limitation by offering the execute-order-validate architecture
- these days HLF is used in more than 400 prototypes, proofs-of-concept, and in production distributed ledger systems, across different industries and use cases.

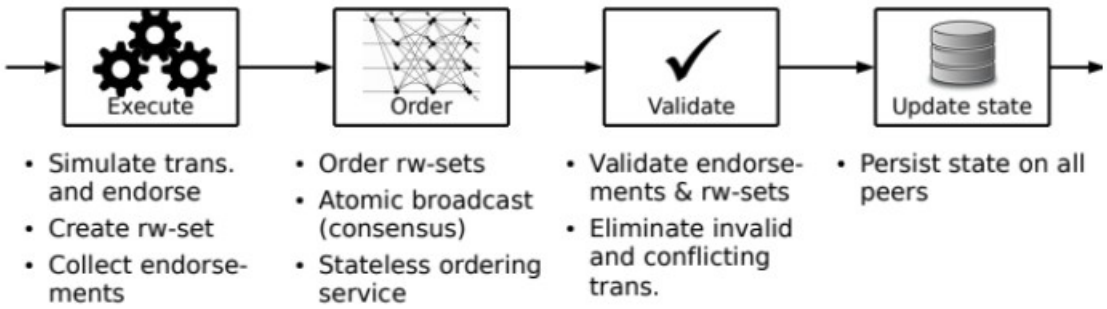
ORDER-EXECUTE MODEL: BITCOIN,ETHEREUM

- In this model, a node in the network typically performs the following:
  - each node assembles a block containing (possibly) valid transactions
  - blocks are ordered through
    - consensus mechanism
    - atomic broadcast mechanisms
  - each node
    - before, collects mined blocks
    - after, executes and validates the transactions sequentially by a pre-defined deterministic order
    - then, the node update the state and persist the transaction in the blockchain



EXECUTE-ORDER-VALIDATE MODEL: HYPERLEDGER

- a new scheme offered by HLF
- each node:
  - first simulates the transaction output according to the current state of its blockchain
  - after, it orders the new state with an ordering service
  - then the node
    - if the state is valid it persist the state in its local blockchain replica, else it is ignored and aborted



HLF: TRANSACTION FLOW

Client:

- submits transaction proposals for execution
- helps orchestrate the execution phase,
- finally, broadcasts transactions for ordering

Endorser:

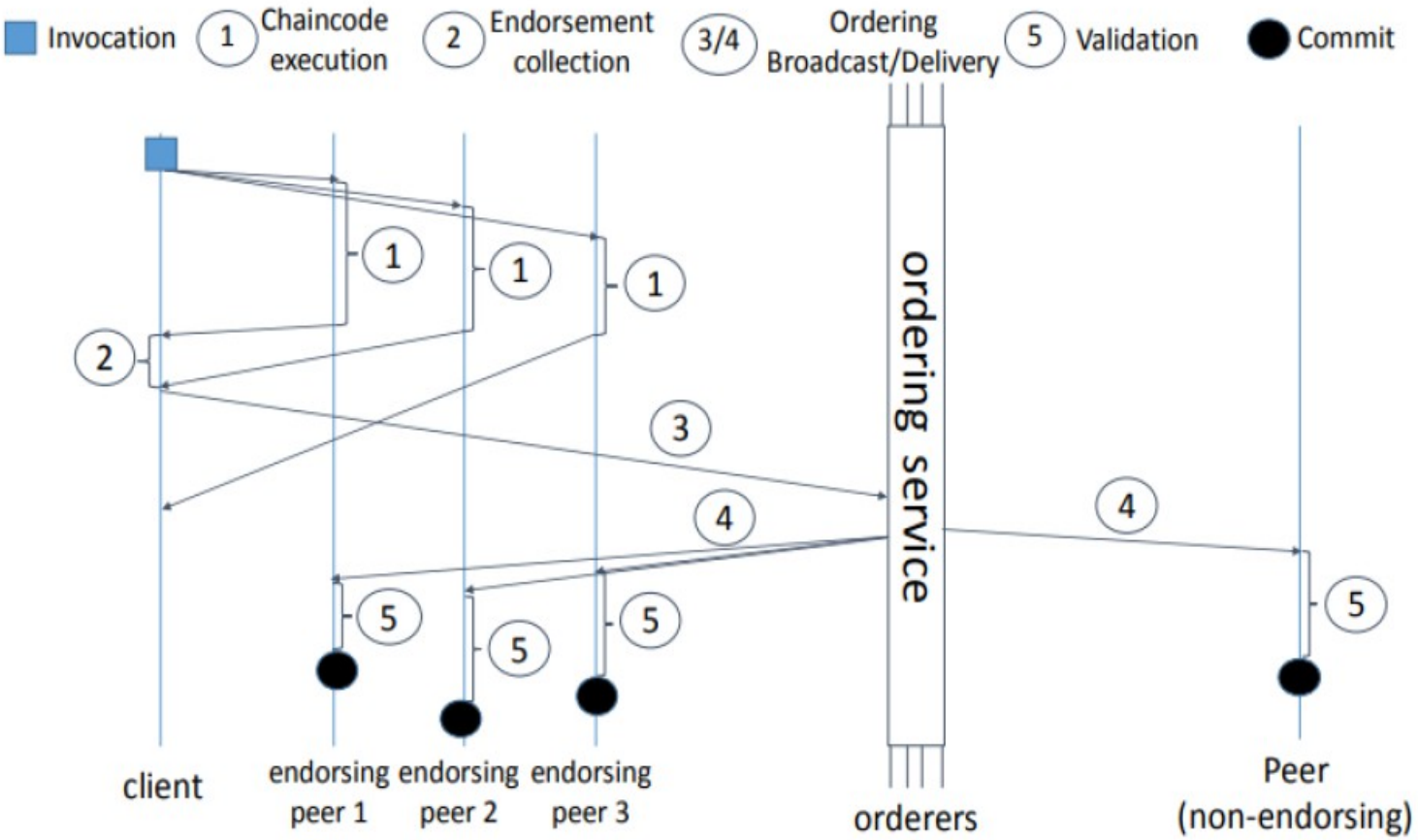
- executes transaction proposals and validate transactions.

  Note that not all peers execute all transaction proposals, only a subset of them called endorsers does

Orderer

- nodes that collectively form the ordering service.
- entirely unaware of the application state,
- do not participate in the execution nor in the validation of transactions

HLF TRANSACTION FLOW



TRANSACTION FLOW: EXECUTION

- clients sign and send the transaction proposal to one or more endorsers for execution according to the application policy

- the endorsers simulate the proposal
  - a proposal is simulated against the endorserser local blockchain state, without synchronization with other peers.
  - endorsers do not persist the results of the simulation to the ledger state

- as a result of the simulation, each endorser produces
  - a value writeset, consisting of the state updates produced by simulation
  - a value readset, representing the version dependencies of the proposal simulation

TRANSACTION FLOW: EXECUTION

- after the simulation, the endorser cryptographically signs a message called endorsement and sends it back to the client

- the client collects endorsements until they satisfy the endorsement policy of the application.
  - this requires all endorsers as determined by the policy to produce the same execution result
  - then, the client proceeds to create the transaction and passes it to the ordering service

TRANSACTION FLOW: ORDERING

- when a client has collected enough endorsements on a proposal, it assembles a transaction and submits this to the ordering service
- the ordering phase establishes a total order on all submitted transactions per application
- to improve performance the ordering service batches multiple transactions into blocks and outputs a hash-chained sequence of blocks containing transactions
- HLF was designed such that its ordering service is highly modular, and can be replaced easily.