CSE446: Blockchain & Cryptocurrencies

Lecture – 18: Ethereum – 6 & HF - 1

Inspiring Excellence

Agenda

- Ethereum consensus
- Hyperledger Fabric

Bitcoin consensus

- The PoW algorithm utilised in Bitcoin is called a Compute-bound consensus algorithm
- A Compute-bound PoW, also known as CPU-bound PoW, employs a CPU-intensive function
  - that carries out the required computational task by leveraging the capabilities of the processing units (e.g., CPU/GPU)
  - and it does not rely on the main memory of the system
- These particular characteristics can be massively optimised for faster calculation by using Application-specific Integrated Circuit (ASIC) rigs

Bitcoin consensus

- This is not an ideal scenario as now general people with their general purpose computer cannot participate in the mining process
- The mining process is mostly centralised among a group of mining nodes
- Many crypto-currency enthusiasts suggest that this is not a democratic process and facilitates the “rich getting richer” scenario

Memory-bound consensus algorithm

- To counteract this issue of Bitcoin's CPU-bound PoW algorithm, memory-bound PoWs have been proposed
- A memory-bound PoW requires the algorithm to access the main memory several times
- This ultimately binds the performance of the algorithm within the limit of access latency and/or bandwidth as well as the size of memory
    - The higher the memory the faster the performance

Memory-bound consensus algorithm

- This restricts ASIC rigs based miners not to have manifold performance advantage over CPU/GPU-based mining rigs
- The reason is even though thousands of ASICs could be combined they would have a performance threshold based on the size/bw/latency of the memory
    - Remember that you can’t install unlimited memory within a PC
- This approach also limits the profit margin of the miners who have a mammoth ASIC-based mining rig
- Another motivation of this approach is to de-monopolise the mining concentrations around some central mining nodes

Ethereum consensus algorithm

- Ethash (DAGGER-HASHIMOTO)/DAGGER is the consensus algorithm designed for Ethereum
- Ethash is a memory-bound PoW algorithm with the goal to be ASIC-resistant for a long period of time
- Dagger is one of the earliest proposed memory-bound PoW algorithms which utilises a Directed Acyclic Graph (DAG)
    - a directed acyclic graph (DAG) is a directed graph with no directed cycles
- However it was found be vulnerable
- Ethereum combined Dagger and Hashimoto algorithms to be more secure

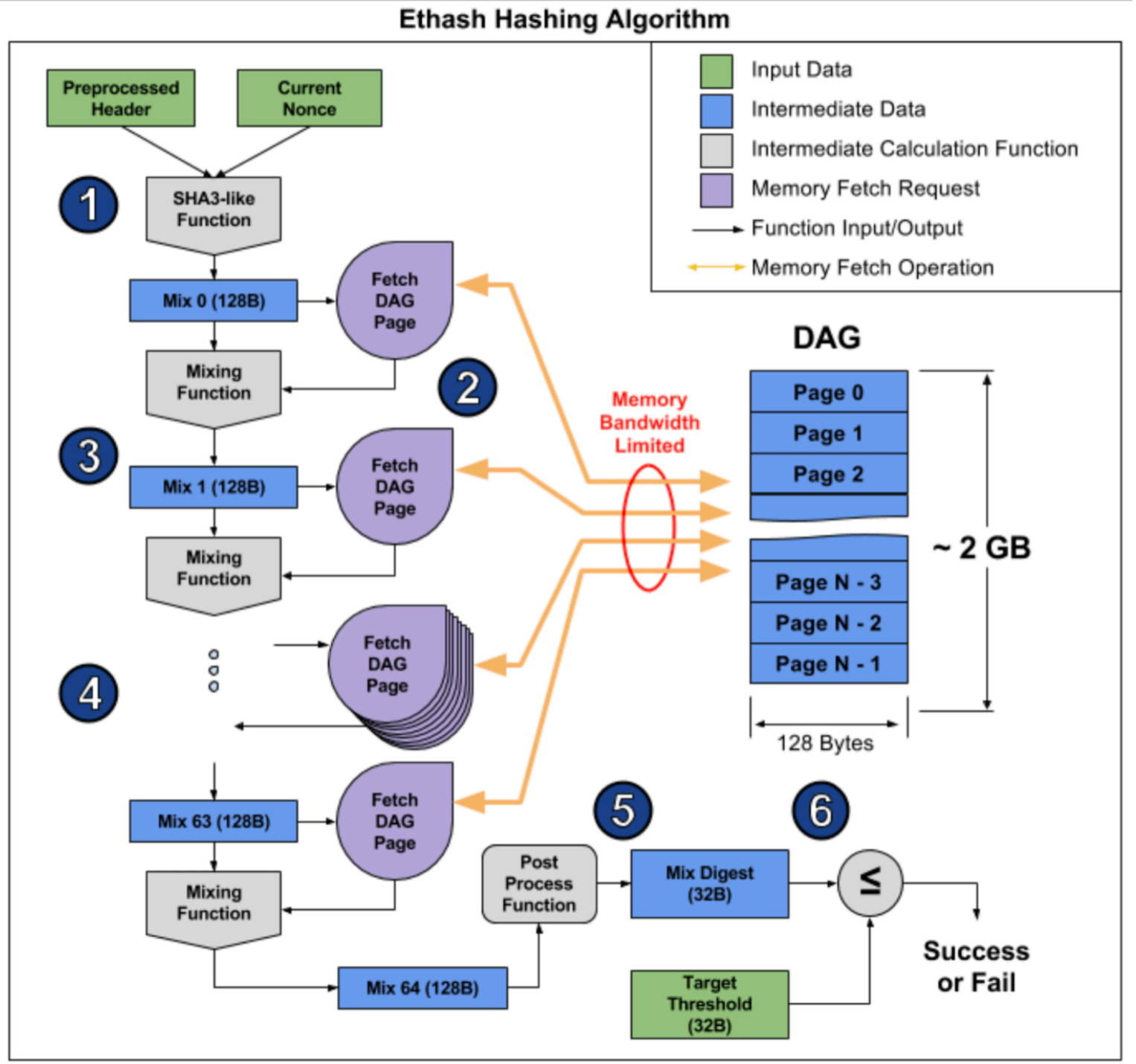
Ethash algorithm

- Ethash depends on a large pseudo-random dataset (the DAG), which is recomputed during each epoch
- Each epoch is determined by the time it takes to generate 30,000 blocks which is approximately five days
- During the DAG generation process, a seed is generated at first, which relies on the length of the chain
- The seed is then used to compute a 16 MB pseudo-random cache
- Then, each item of the DAG is generated by utilising a certain number of items from the pseudo-random cache

Ethash algorithm

- Then, the latest block header and the current candidate nonce are hashed using Keccak (SHA-3) hash function
- The resultant hash is mixed and hashed several times with data from the DAG, the mixHash data field
- The final hashed digest is compared to the difficulty target and accepted or discarded accordingly

Ethash algorithm



From Lecture Slides of Blockchains & Cryptocurrencies Course at Johns Hopkins University

Ethereum PoS algorithm

- Ethereum moved to a PoS consensus algorithm in 2022
- Like any PoS algorithm there are a number of validators
- To be a validator, one has to deposit 32 eth to an escrow contract
- On depositing their ETH, the user joins an activation queue that limits the rate of new validators joining the network
- Once activated, validators receive new blocks from peers on the Ethereum network
- The transactions delivered in the block are re-executed, and the block is verified
- The validator then sends a vote (called an attestation) in favour of that block across the network

https://ethereum.org/en/developers/docs/consensus-mechanisms/pos/

Ethereum PoS algorithm

- Under Ethash algorithm, the timing of blocks is determined by the mining difficulty
- In proof-of-stake, the block generation time is fixed
- Time in proof-of-stake Ethereum is divided into slots (12 seconds) and epochs (32 slots)
- One validator is randomly selected to be a block proposer in every slot
- This validator is responsible for creating a new block and sending it out to other nodes on the network

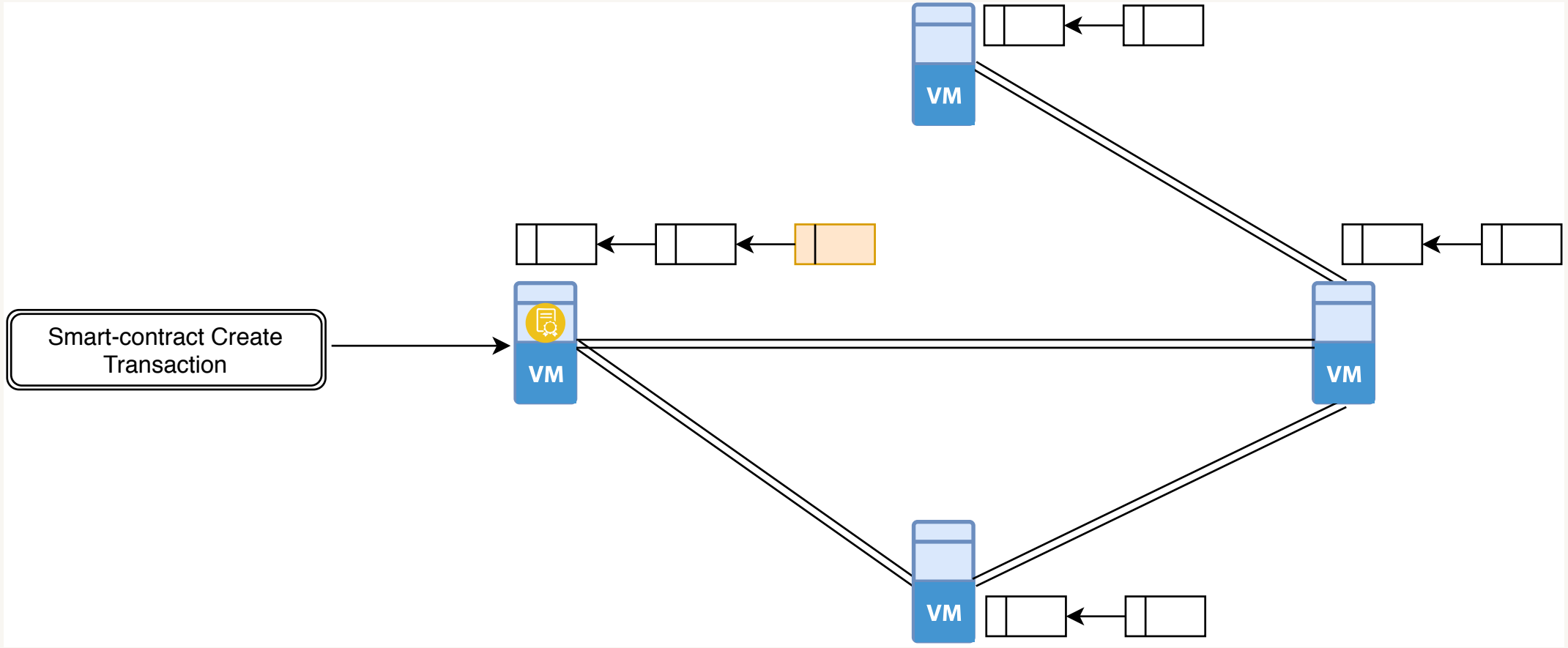
https://ethereum.org/en/developers/docs/consensus-mechanisms/pos/

Ethereum PoS algorithm

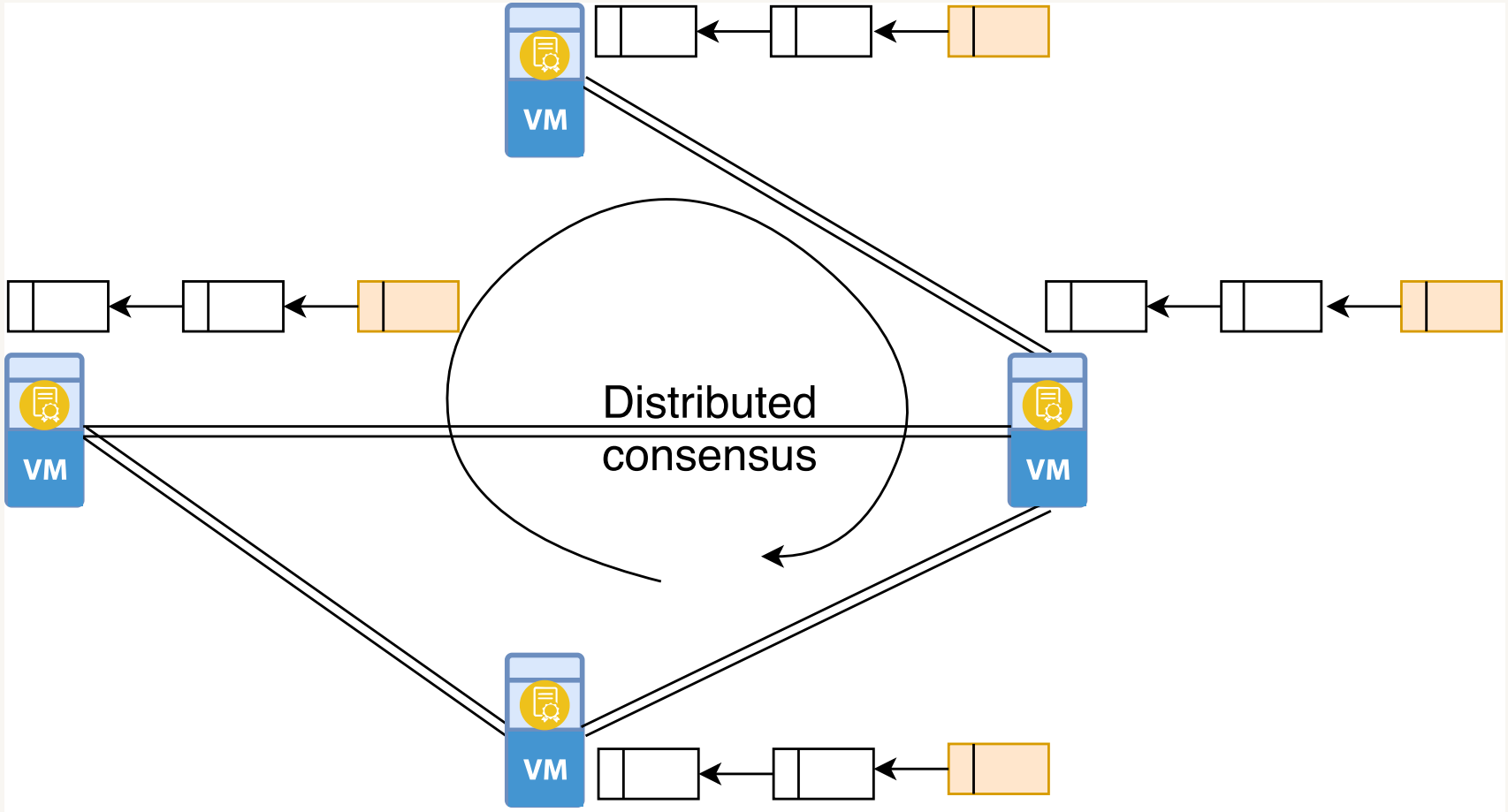
- Also in every slot, a committee of validators is randomly chosen, whose votes are used to determine the validity of the block being proposed
- If a validator is chosen to attest the next block, they are rewarded in ETH as a percentage of their stake
- Conversely, validators who do not perform their duties--if they are offline, for example--receive penalties, or slashes, in the form of small amounts of ETH subtracted from their stakes

https://ethereum.org/en/developers/docs/consensus-mechanisms/pos/

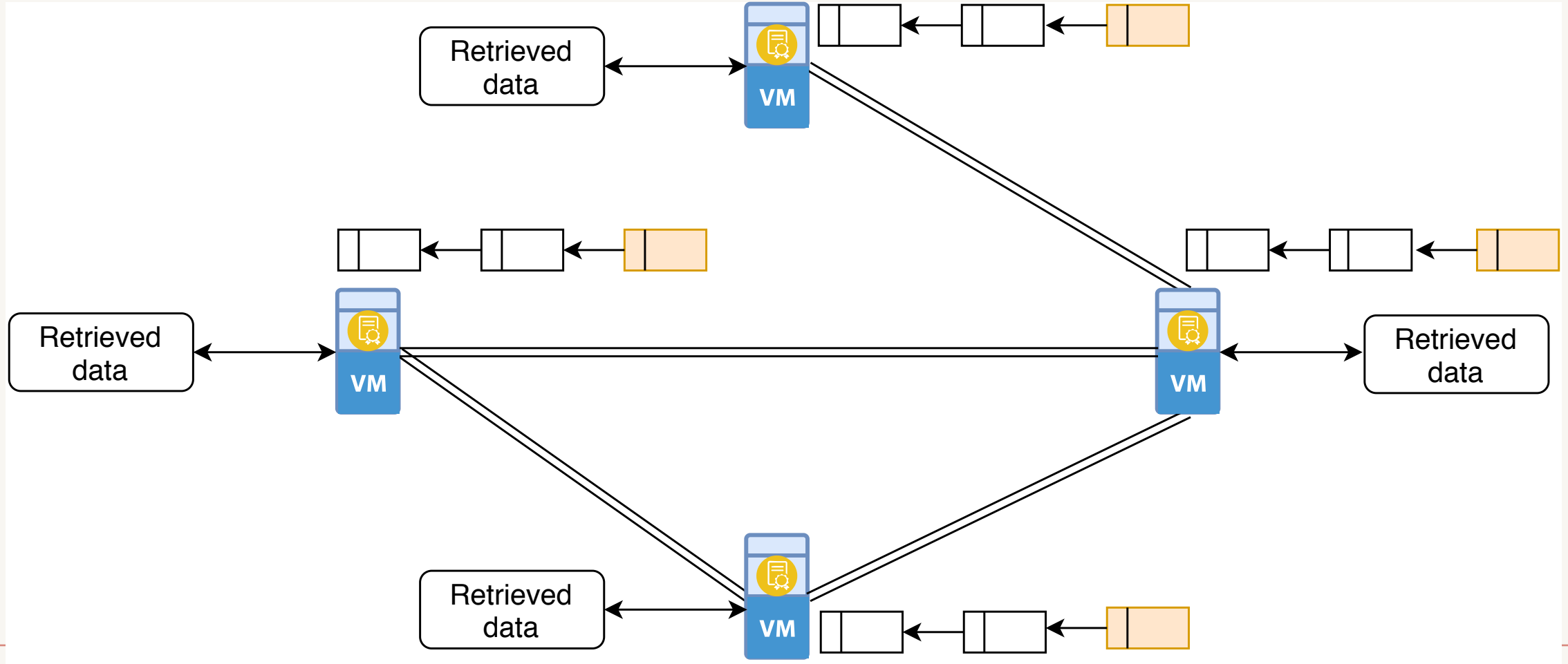
Ethereum illustration



Ethereum illustration

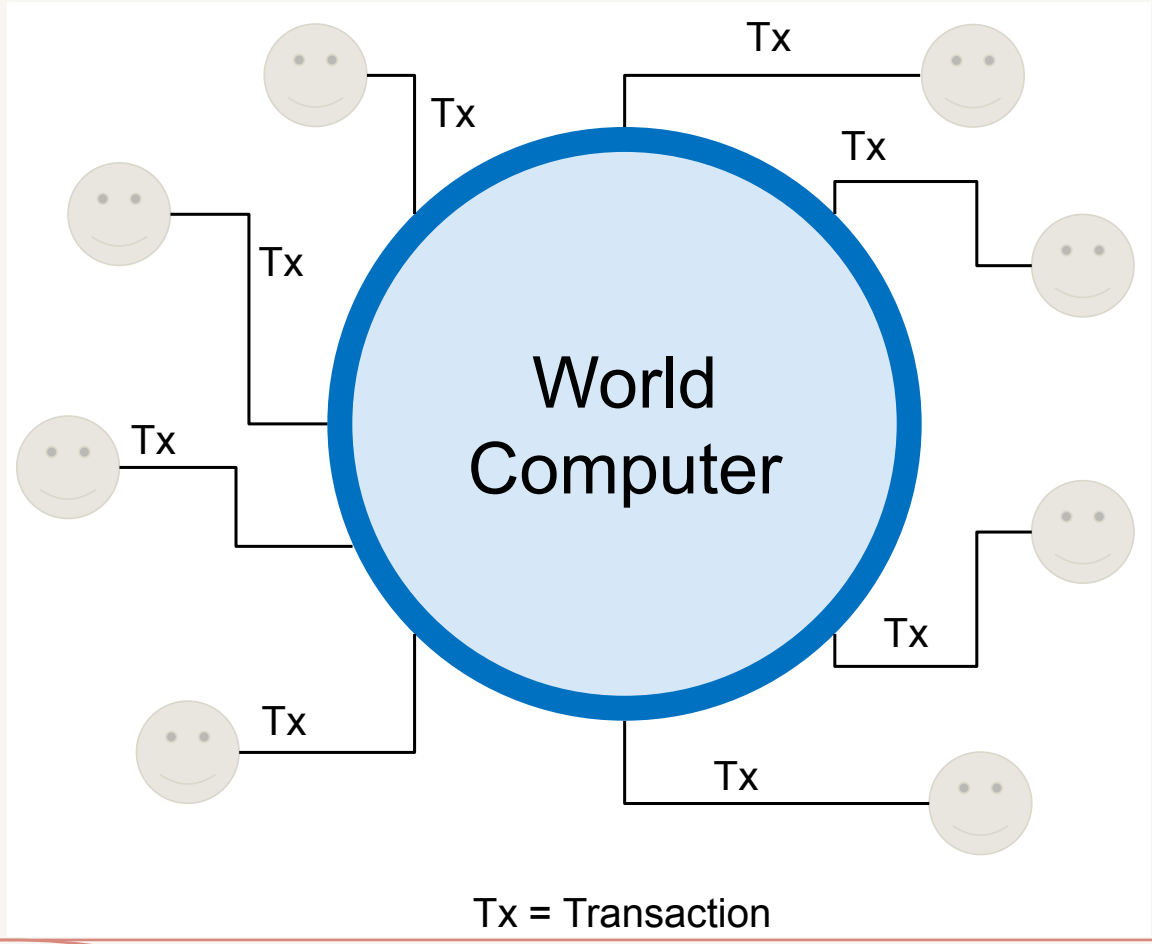


Ethereum illustration



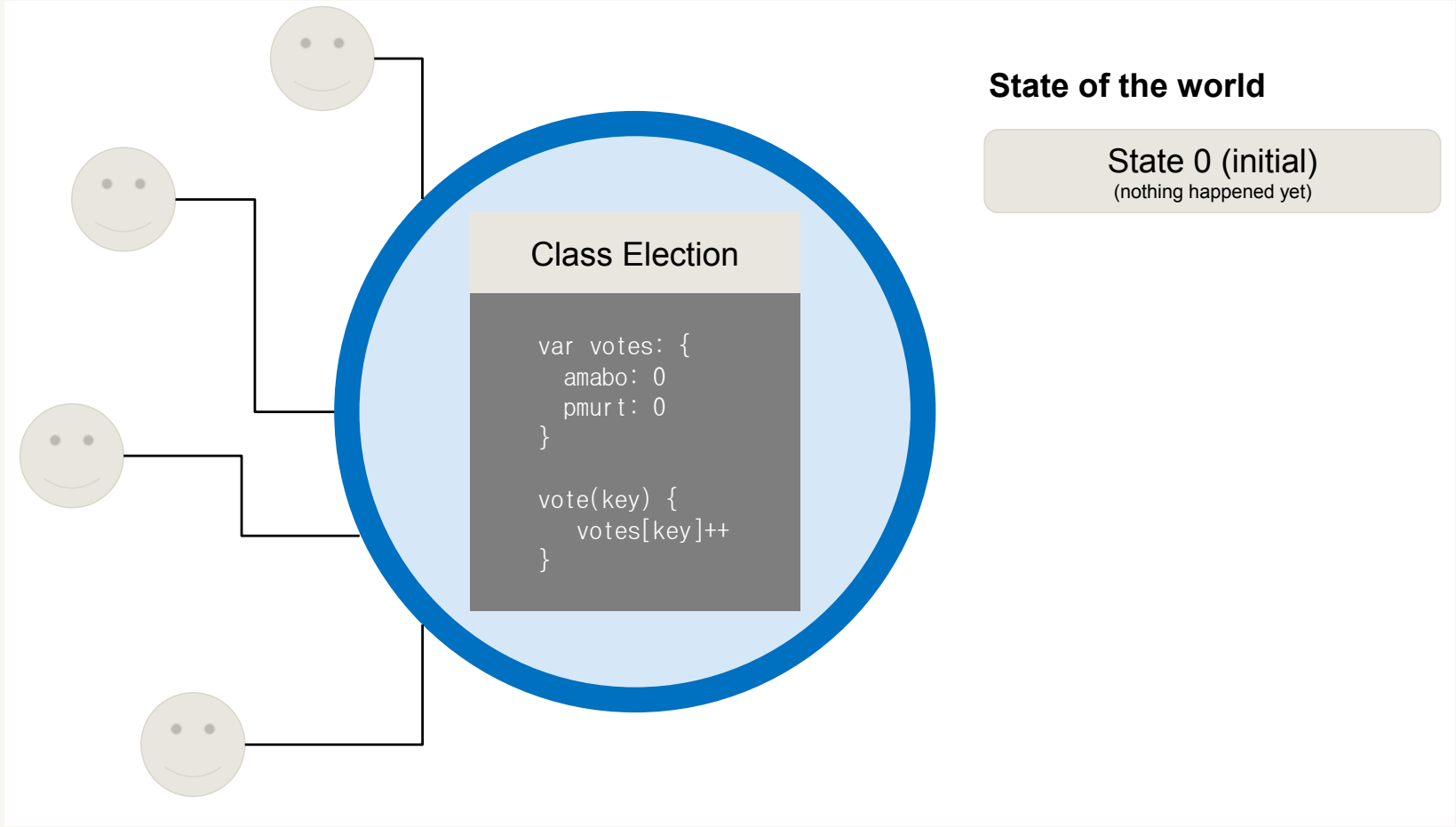
Ethereum visualisation

- All participants are using the “same” computer
- Users issue transactions to call programs on the computer
- Everyone shares the same resources and storage
- The computer has no explicit, single owner
- Using the computer’s resources costs money (eth)

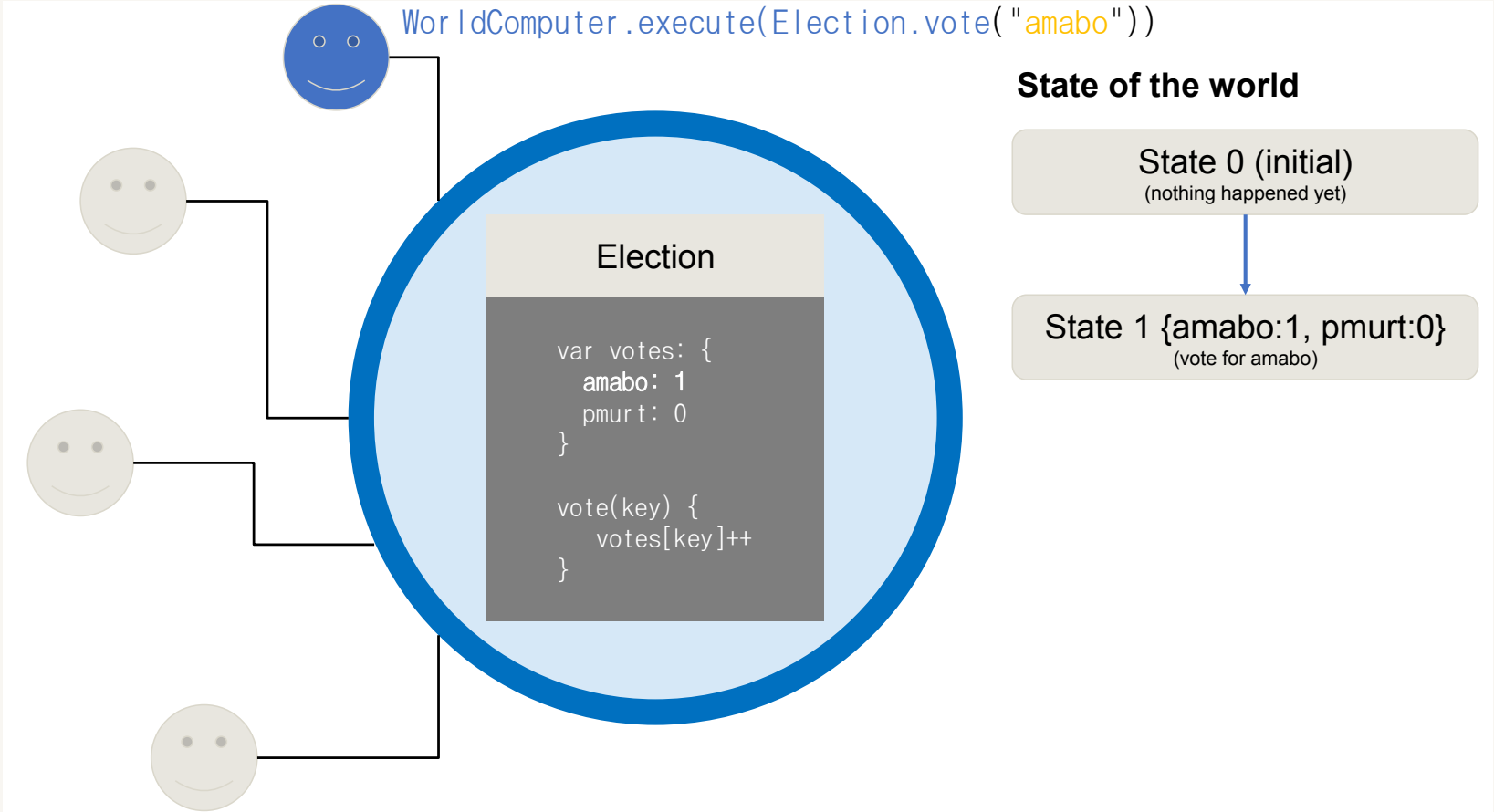


07 Ethereum Basics - Gallersdörfer, U., Holl, P., & Matthes, F. (2020). "Blockchain-based Systems Engineering". Lecture Slides. TU Munich.

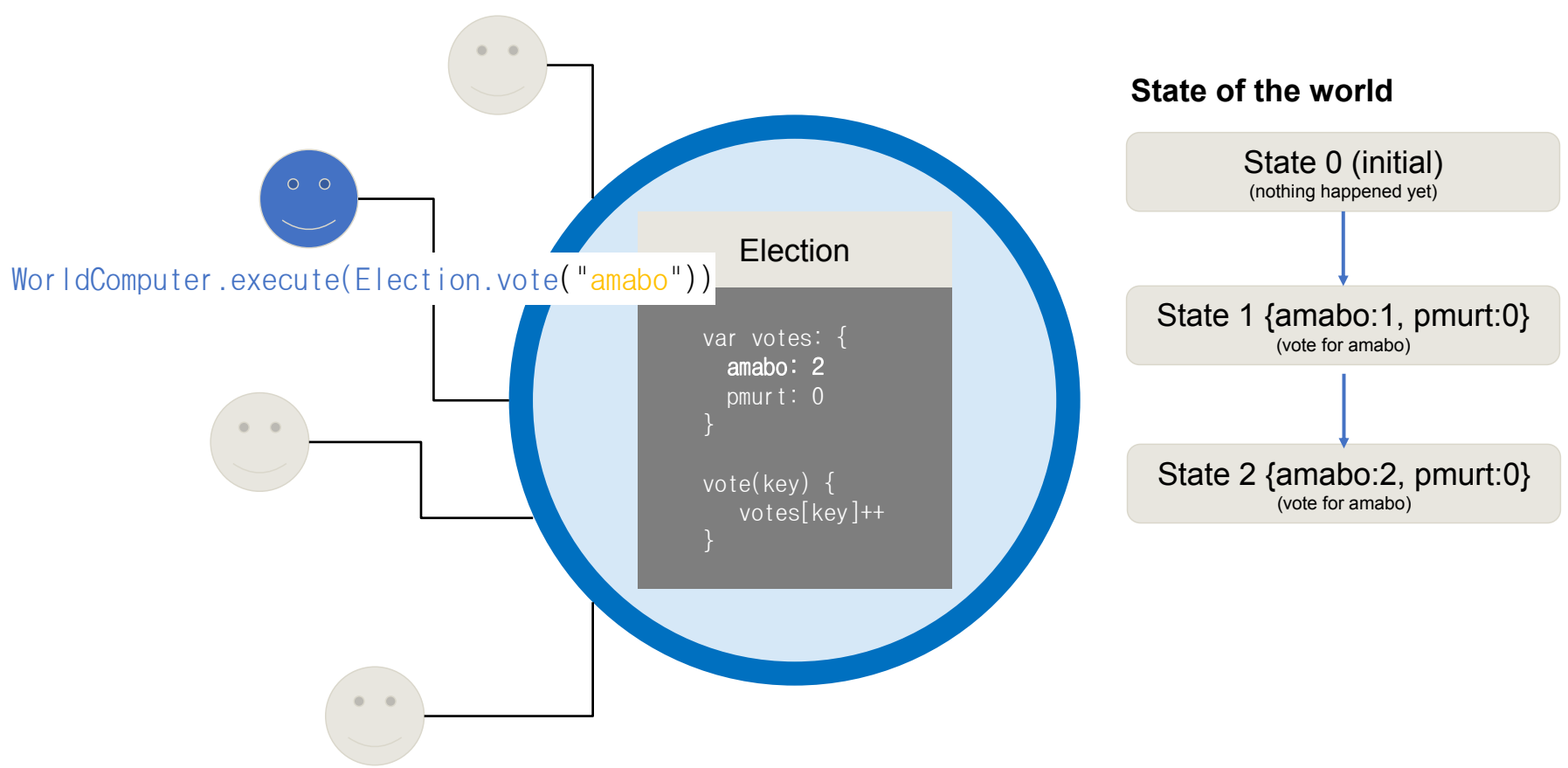
Ethereum visualisation: election example



Ethereum visualization: election example



Ethereum visualization: election example



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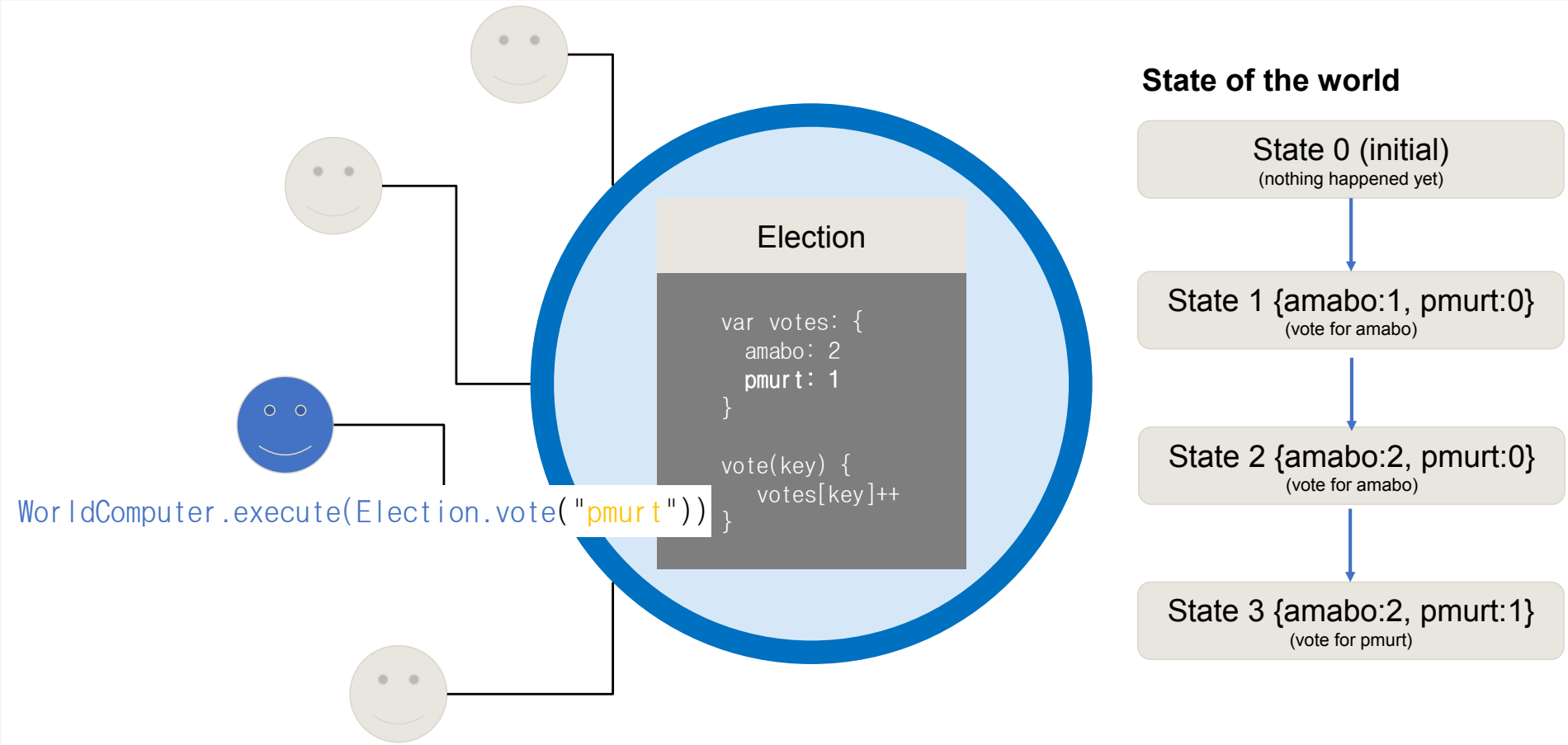

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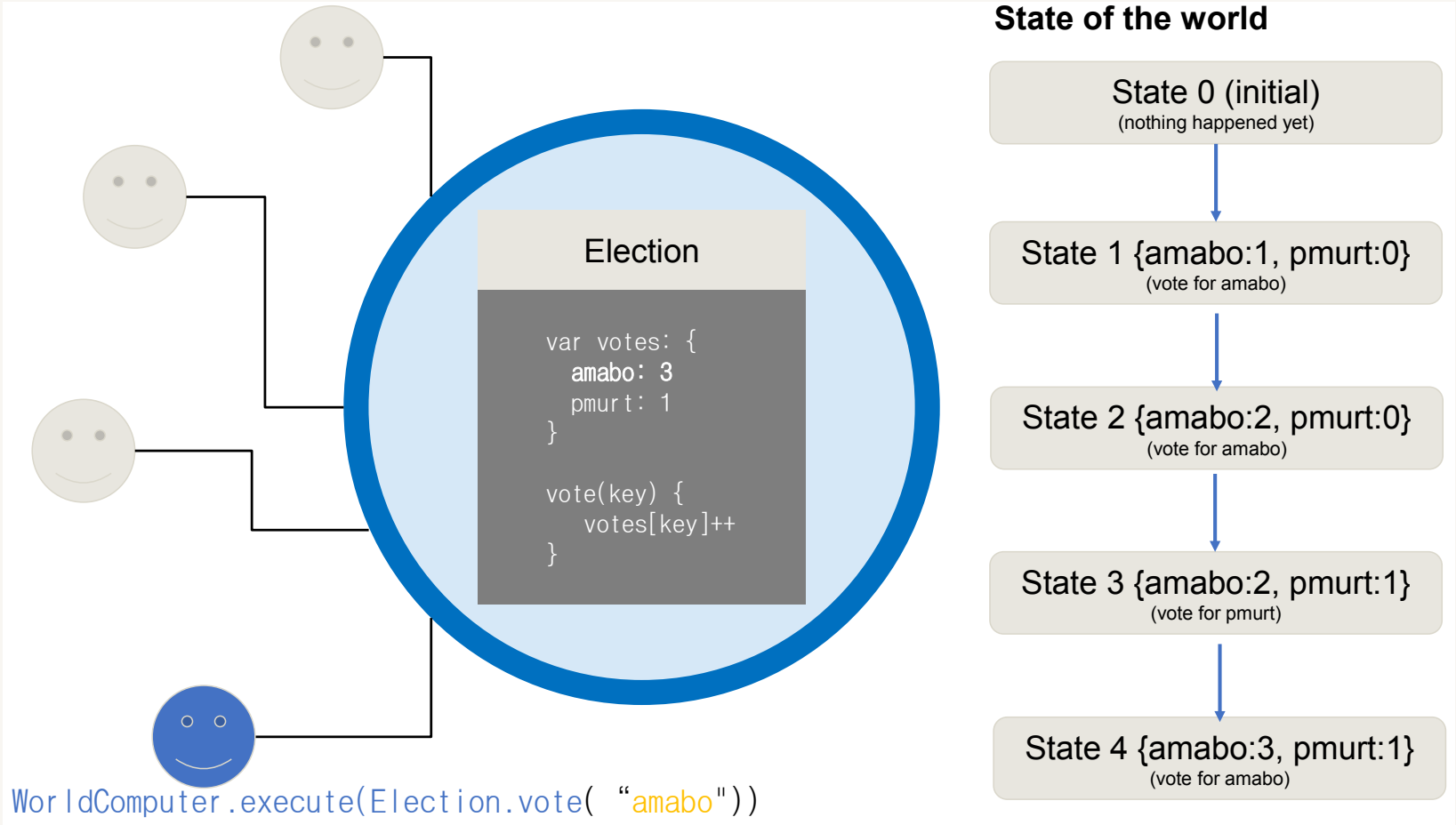
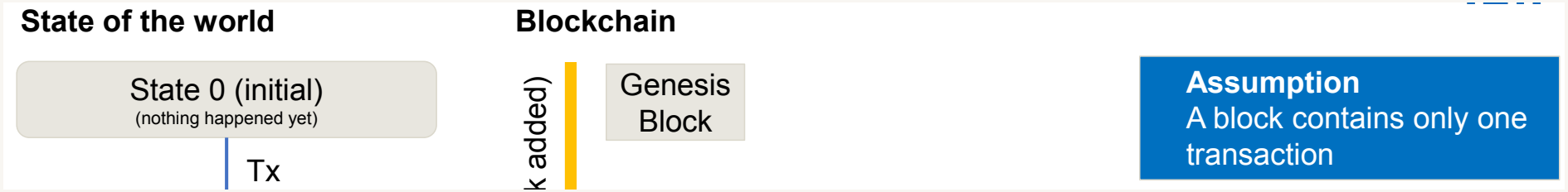
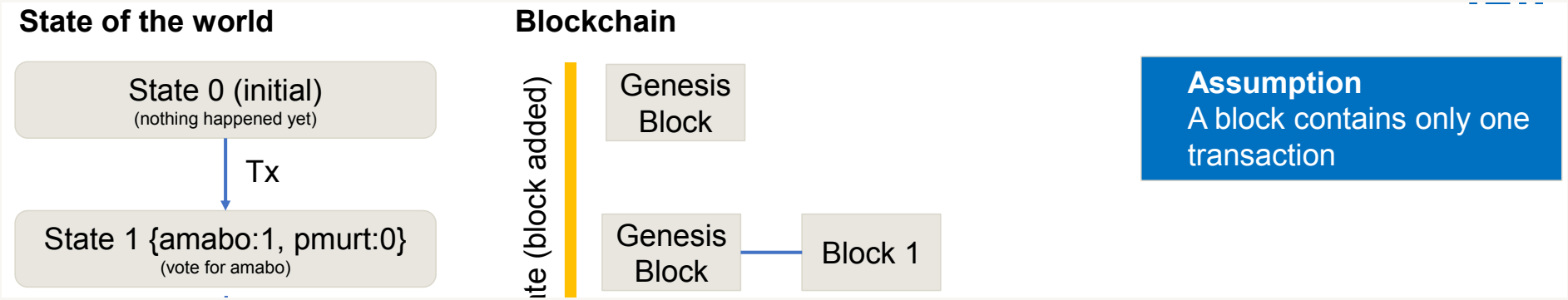


Ethereum visualization: election example



Ethereum visualization: election example



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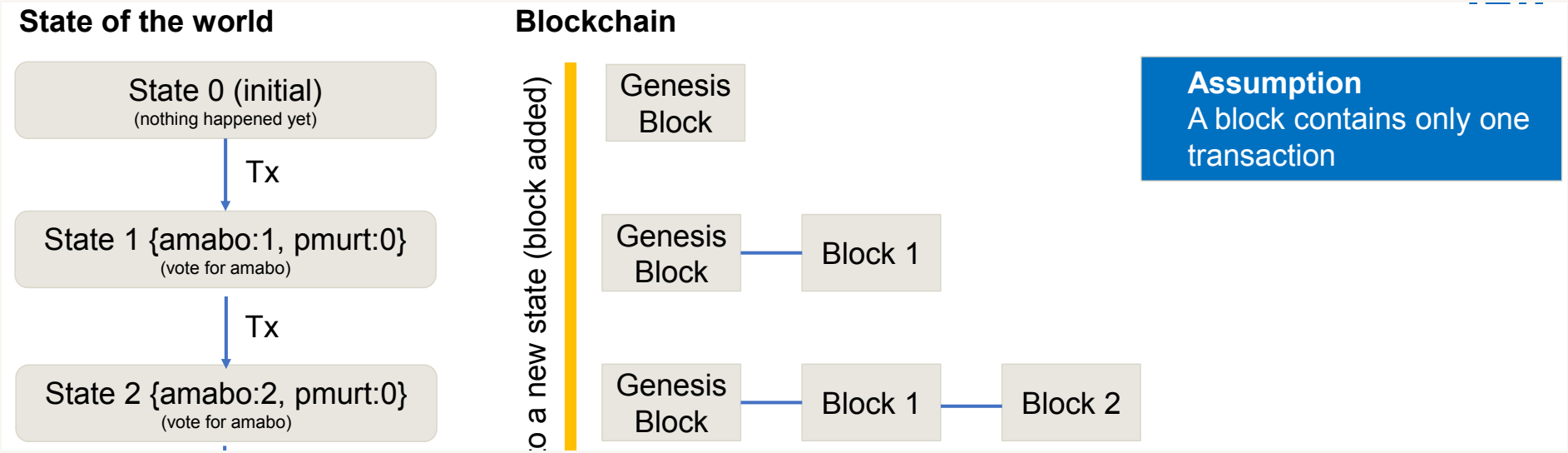

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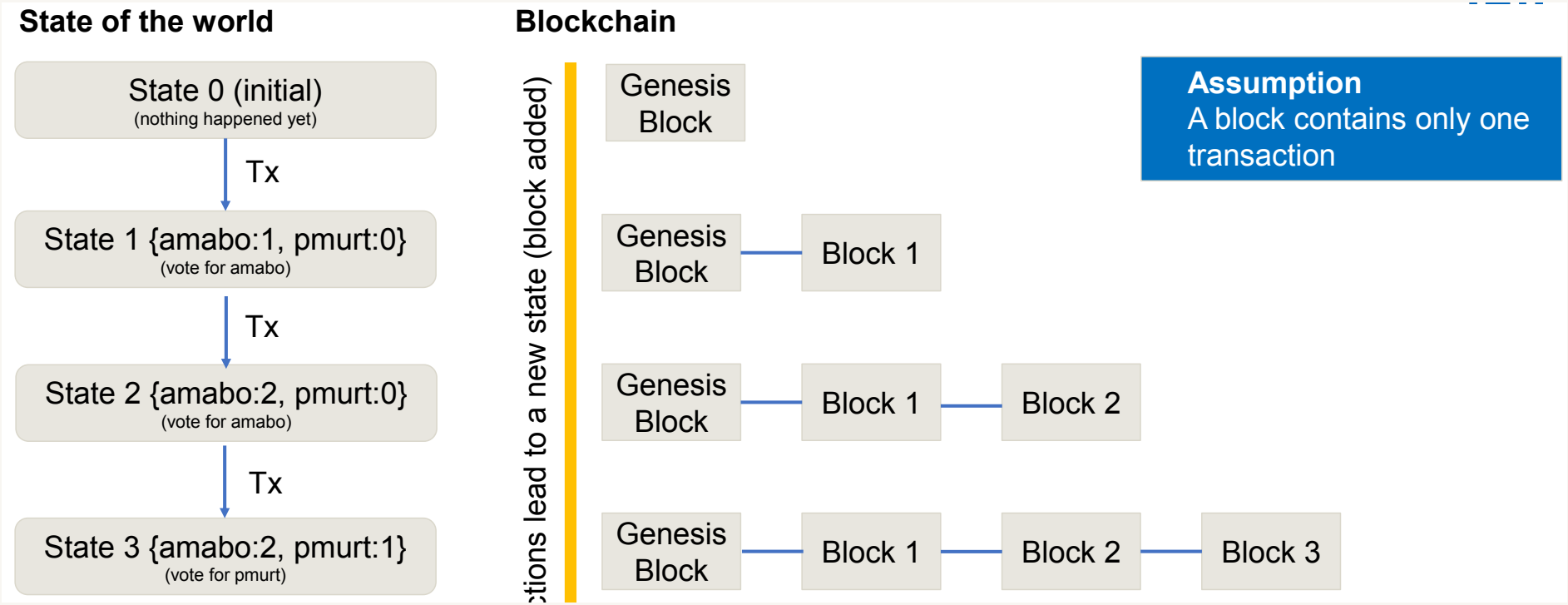

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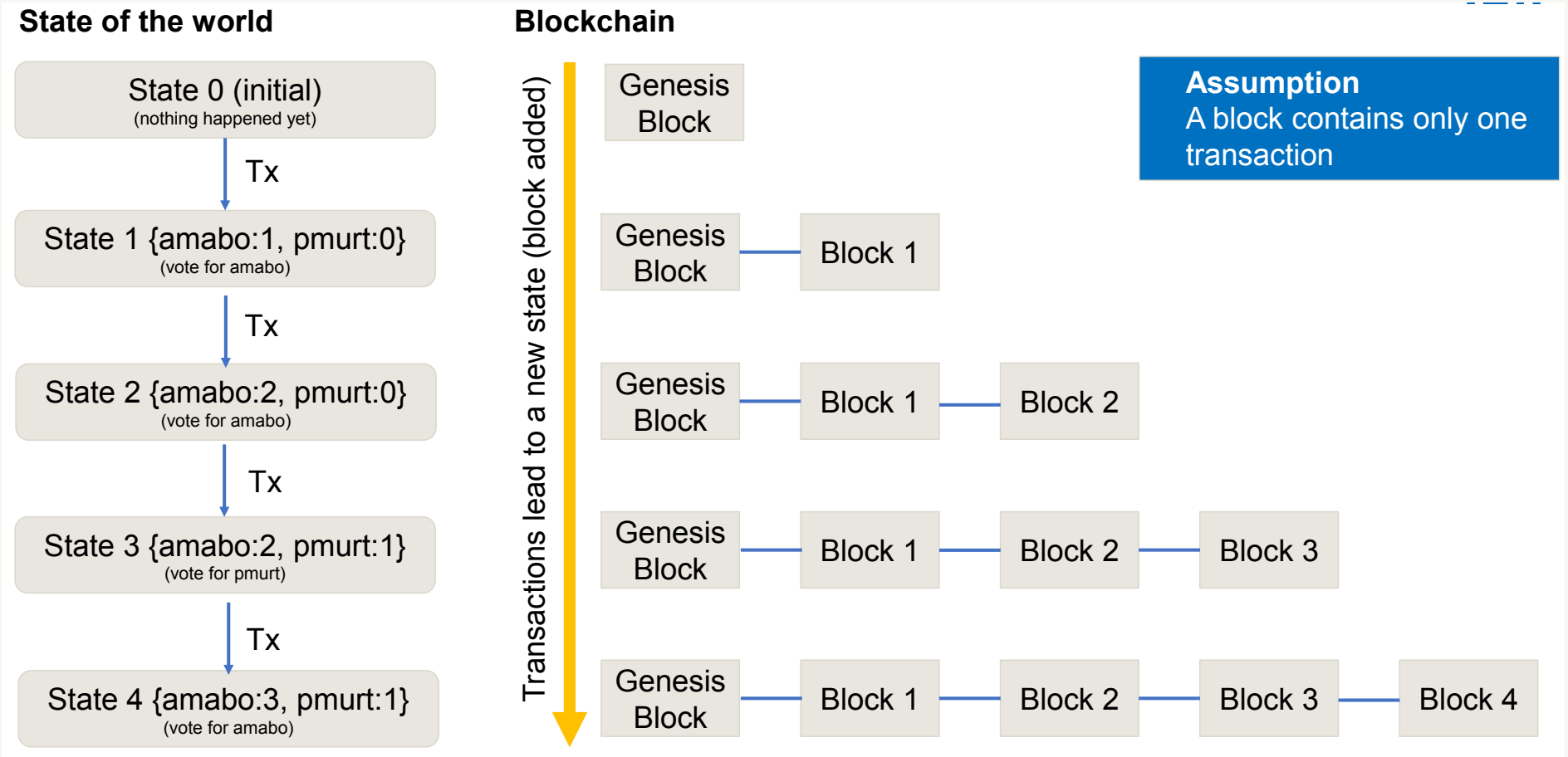

Hyperledger Fabric

- Motivations of private blockchain systems

Motivations for private blockchain systems

- As blockchain tech gaining maturity, interest in applying blockchain technology and distributed application platform to more innovative *enterprise* use cases started to grew
- Particularly they are intersected to disrupt current approach of many application domains
  - Disrupting the existing method brings innovation which leads to new service delivery models
  - CD/LP -> online music -> mp3 -> Napster (Torrents) -> Apple iPod/iTunes
- However, public blockchain systems are unsuitable for many enterprise use cases

Motivations for private blockchain systems

- For enterprise use, we need to consider the following requirements:
  - Participants must be identified/identifiable
    - E.g. financial transactions where Know-Your-Customer (KYC) and Anti-Money Laundering (AML) regulations must be followed
  - Networks need to be *permissioned*
  - High transaction throughput performance
  - Low latency of transaction confirmation
  - Privacy and confidentiality of transactions and data pertaining to business transactions

Hyperledger foundation

- Hyperledger Foundation is an open source collaborative effort created to advance cross-industry blockchain technologies
- It is a global collaboration, hosted by The Linux Foundation
- It includes leaders in finance, banking, Internet of Things, supply chains, manufacturing and Technology
- Joining forces to develop and promote private blockchain systems
- More information: https://www.hyperledger.org/

Hyperledger projects

- Major Hyperledger projects:
  - Fabric – initially developed by IBM which is then open-sourced, released and incubated under the Hyperledger project
  - Sawtooth – developed by Intel which is then released under the Hyperledger project
  - Burrow – a permissioned version of Ethereum released under the Hyperledger project
  - Caliper – a benchmarking platform for Hyperledger projects
  - Composer – a GUI tool to develop complex business networks
- Fabric is the most advanced and matured project under the Hyperledger umbrella projects

Hyperledger Fabric (HF)

- Hyperledger Fabric is an open source enterprise-grade permissioned distributed ledger technology (DLT) platform
- Designed for use in enterprise contexts
- To deliver some key differentiating capabilities over other popular distributed ledger or blockchain platforms
- More information: https://www.hyperledger.org/use/fabric
- Developer documentation: https://hyperledger-fabric.readthedocs.io/en/release-2.5/

Hyperledger Fabric (HF)

- Fabric is highly modular and configurable
- Fabric is the first distributed ledger platform to support smart contracts authored in general-purpose programming languages
  - such as Java, Go and JavaScript, rather than constrained domain-specific languages (DSL)
- Fabric supports pluggable consensus protocols that enable the platform to be more effectively customised to fit particular use cases and trust models
- Fabric does not require a native cryptocurrency

Question?