Ethereum

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Part IV. Ethereum Accounts

Ethereum Accounts & Addresses

In previous lecture, we have discussed that Ethereum accounts can be categorized into:

- **Externally Owned Accounts (EOAs)**: Controlled by private keys. These accounts do not contain code but can send transactions.
- **Contract Accounts**: Controlled by smart contracts. These accounts contain code (i.e., the smart contract) that is executed when interacted with.

An **address** in Ethereum is a **unique identifier** that represents the location of an account on the blockchain.

Ethereum Account Structure

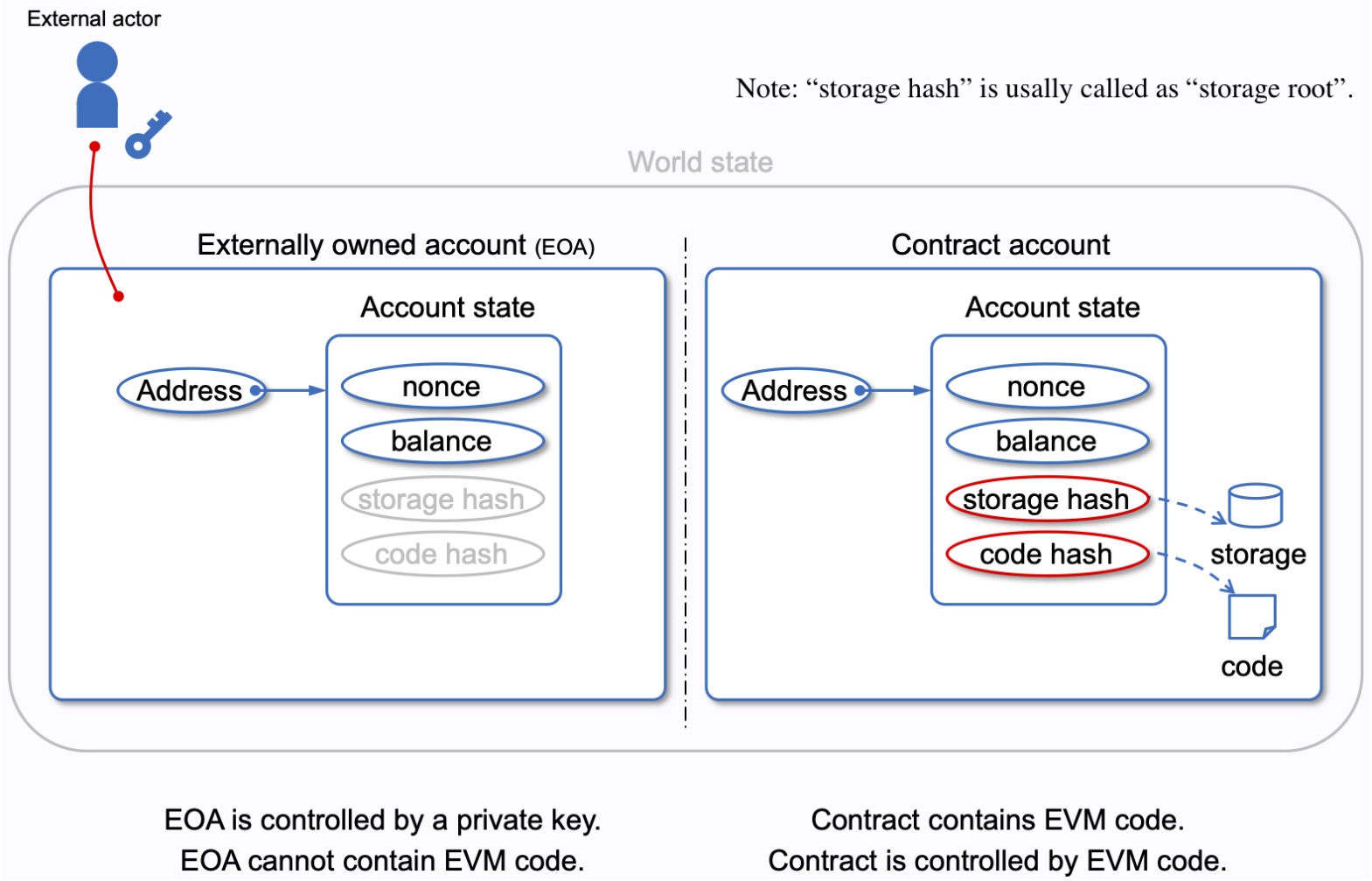


Figure 1: Ethereum Account Structure

Source: Ethereum EVM illustrated

Account Components

Both EOAs and contract accounts share the following components:

1. **Nonce**: a counter that tracks the number of transactions sent from the account.
2. **Balance**: the amount of Ether held by the account.
3. **Address**: a unique 160-bit identifier for the account, derived differently for EOAs and contract accounts.
   - EOA address is the last 20 bytes of the Keccak-256 hash of the public key.
   - Contract accounts address is derived from the sender EOA's address and its nonce at the time of deployment.

Account Components

Both EOAs and contract accounts share the following components:

4. **Storage Root**: a hash of the root node of a Merkle Patricia trie that stores the account's data.
   - For EOAs, this is typically empty since they don't have associated storage.
   - For contract accounts, this is used to store the state variables of the smart contract.
5. **Code Hash**: a hash of the contract's bytecode.
   - For EOAs, this is the hash of the empty string because they do not have associated code.
   - For contract accounts, this hash points to the bytecode stored on the blockchain.

Account as A Conceptual Framework

We can also think the concept of "account" as a conceptual framework and it comprises components that are distributed between the user's **device** and the Ethereum **blockchain**.

1. **On-Device Components**:
   - **Private Key**: Enables signing transactions and proving the ownership of EOAs.
   - **Public Key**: Derived from the private key, used to generate the EOA's address.
2. **On-Chain Components**:
   - Address
   - Nonce
   - Balance
   - Code Hash
   - Storage Root

Account State

The **account state** contains all the dynamic and mutable information related to an account, such as nonce, balance, storage root, and code hash.

Component	Data Stored On-Chain	Original Data (Not Fully Stored On-Chain)
Storage Root	Hash of the root of the Merkle Patricia Trie for contract storage	The complete key-value storage data for a contract account
Code Hash	Keccak-256 hash of the contract bytecode	The full contract bytecode, stored in Ethereum code storage

Figure 2: Comparison of Data Stored On-Chain vs. Original Data

Ethereum Account Structure

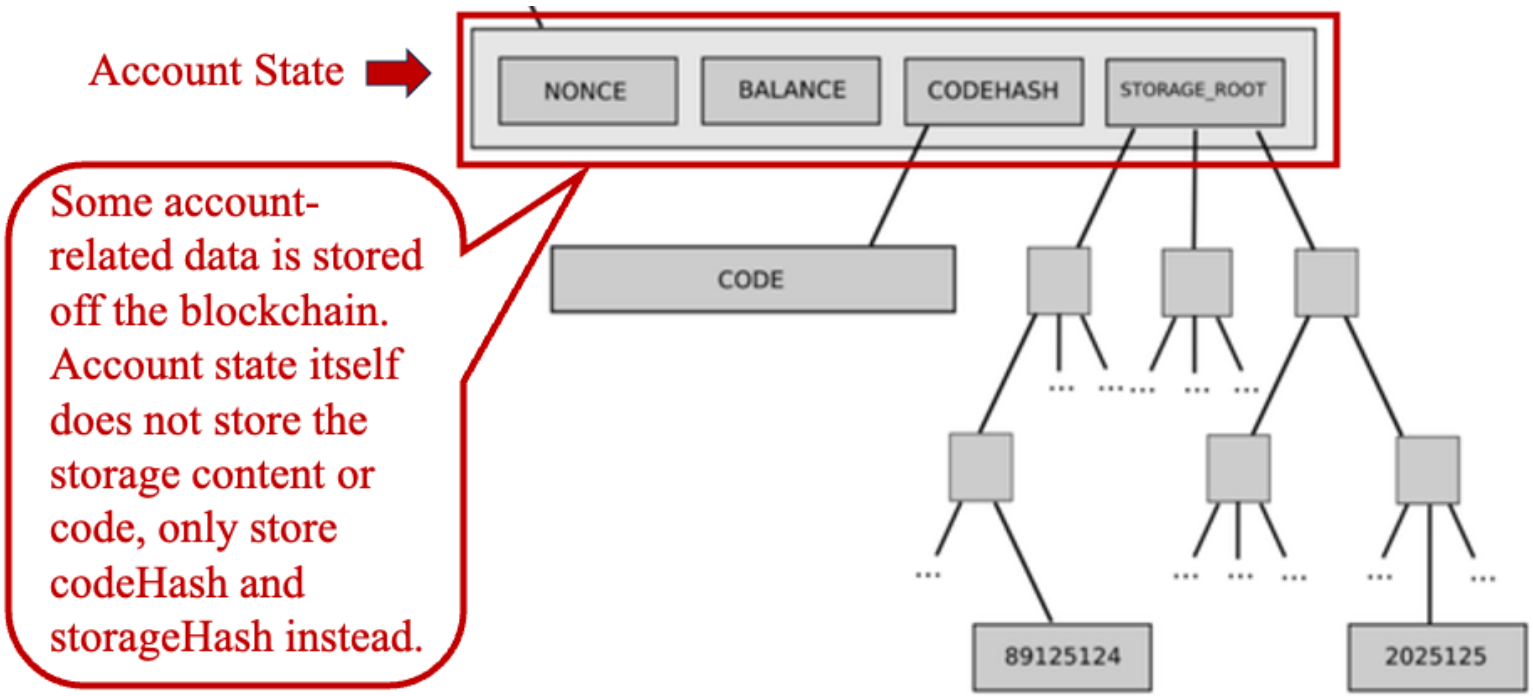


Figure 3: Ethereum Account Structure

Part V. Ethereum Blocks

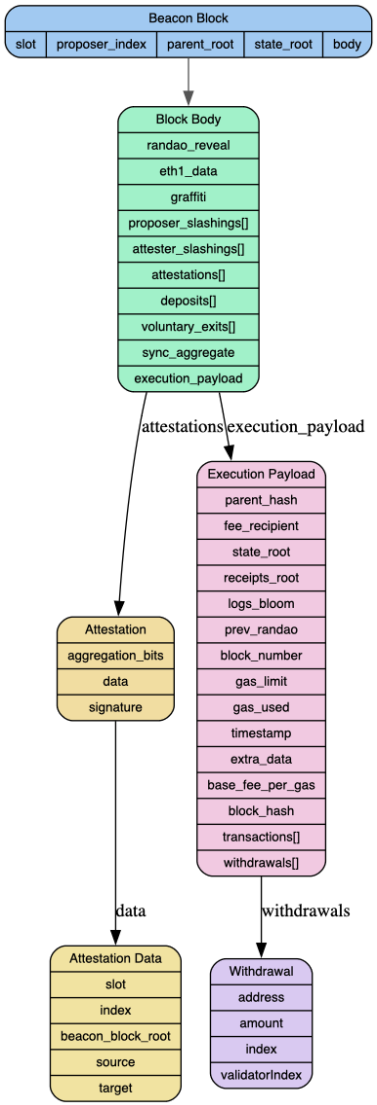
Ethereum Block

Ethereum transitioned from Proof-of-Work (PoW) to Proof-of-Stake (PoS) on September 15, 2022, resulting in a significant change to the block structure.

Most of the available information online about Ethereum's block structure is outdated.
Indicator: if you see terms like *nounce* and *difficulty* in the *block header*, the information refers to the old PoW model and is no longer accurate.

For the latest details on Ethereum's block structure, visit the official website.

A Sketch of the Block Structure



Credit: ChatGPT-o1

Proof-of-Stake (PoS) Consensus

PoS algorithms use several methods to select who will validate the next block:

- **Size of staked tokens**: the more tokens staked, the higher the chance of being chosen to validate.
- **Age of staked tokens**: the longer the tokens have been unspent, the higher the chance of being chosen to validate. Once that stake is used to verify a block, its age is reset to zero.
- **Random Selection**

Proof-of-Stake in Ethereum 2.0

Shard chain: mainly addresses the scalability concern. There are 64 shard chains in the Ethereum network.

Beacon chain: coordinates the information between different shard chains and manages validators.

Validator: the nodes in the Ethereum network who want to confirm transactions. Users need to stake 32 ETH to become validators.

Proof-of-Stake in Ethereum 2.0

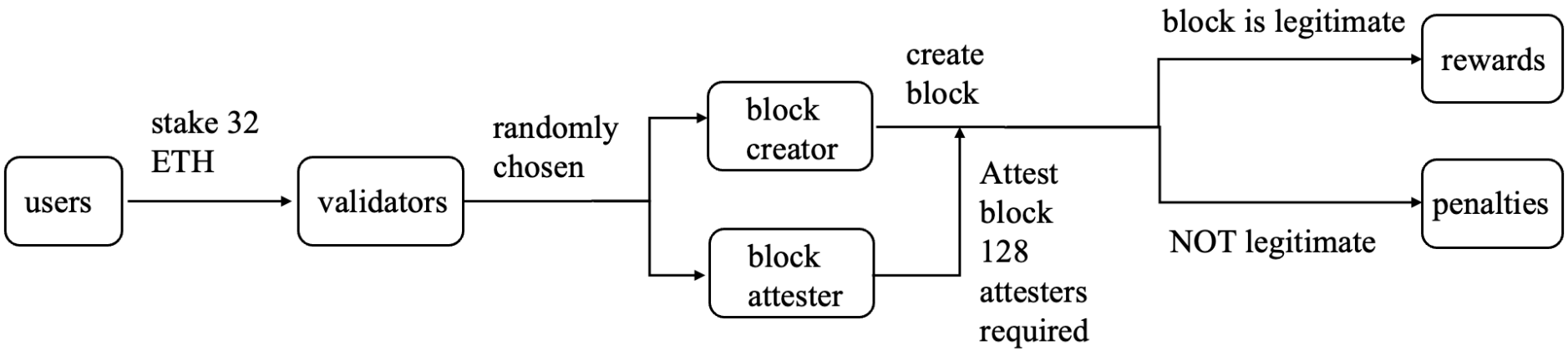


Figure 4: Proof-of-Stake in Ethereum 2.0

Source: Ethereum Foundation: Proof-of-Stake (PoS)

Proof-of-Stake in Ethereum 2.0

- **Pros**:
  - Better energy efficiency
  - Lower barriers to entry (hardware requirement is low)
  - Stronger immunity to centralization
- **Cons**:
  Compared with Proof-of-Work, Proof-of-Stake is more complex and less battle-tested in the real world.

Q: Does 51% attack still exist in proof-of-stake?

Extra: Delegated Proof of Stake

In DPoS, users do not directly become validators, they vote for delegates to become validators.

Users vote on delegates by pooling their tokens into a staking pool and linking those tokens to a particular delegate.

These delegates are usually called as witnesses or block producers.

Extra: Delegated Proof of Stake

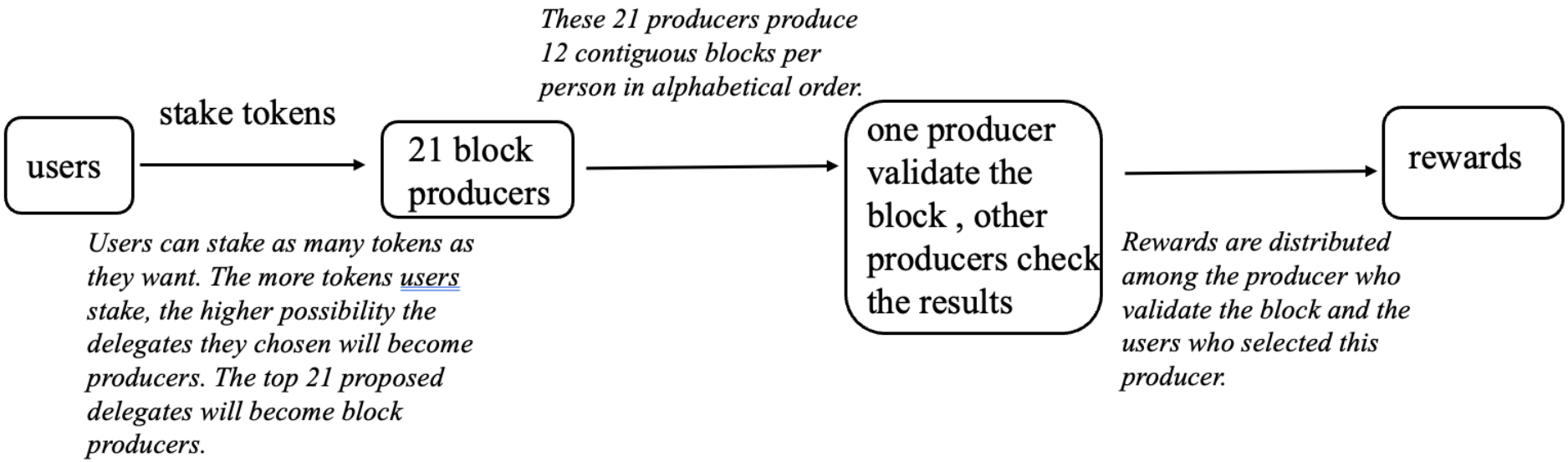


Figure 5: EOS: Delegated Proof of Stake

Source: EOS: Delegated Proof-of-Stake (DPoS)