Ethereum

Introduction

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Ethereum

Overview

Ethereum is a Proof of Work blockchain that uses several of the improvements discussed previously.

- Ethereum uses 12 sec block delay.
- Different P2P network.
- Ethereum uses a different Proof of Work function to protect agains ASICs.
- Ethereum uses uncles.
- Ethereum uses the GHOST rule, instead of longest chain rule.

Similar to Bitcoin, Ethereum uses *hashes of a public key as address*, and signatures for authentication.

Ethereum has a cryptocurrency, Ether.

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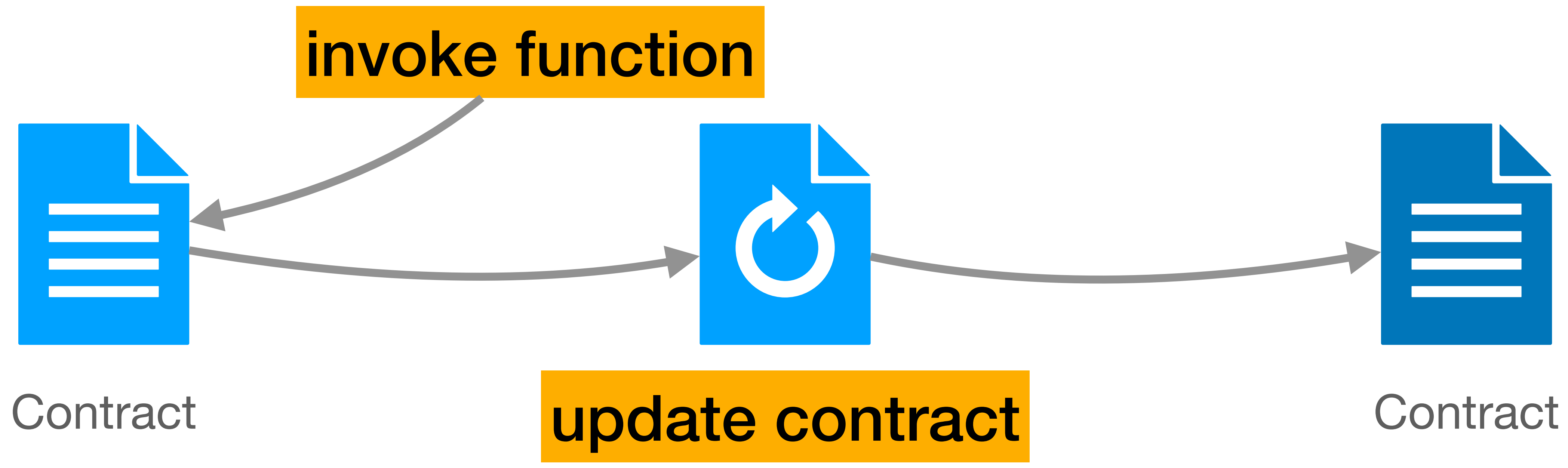
Smart Contract code

A contract is like a object from OOP, with fields and methods

- variables containing state (stored in account, mutable)
- functions



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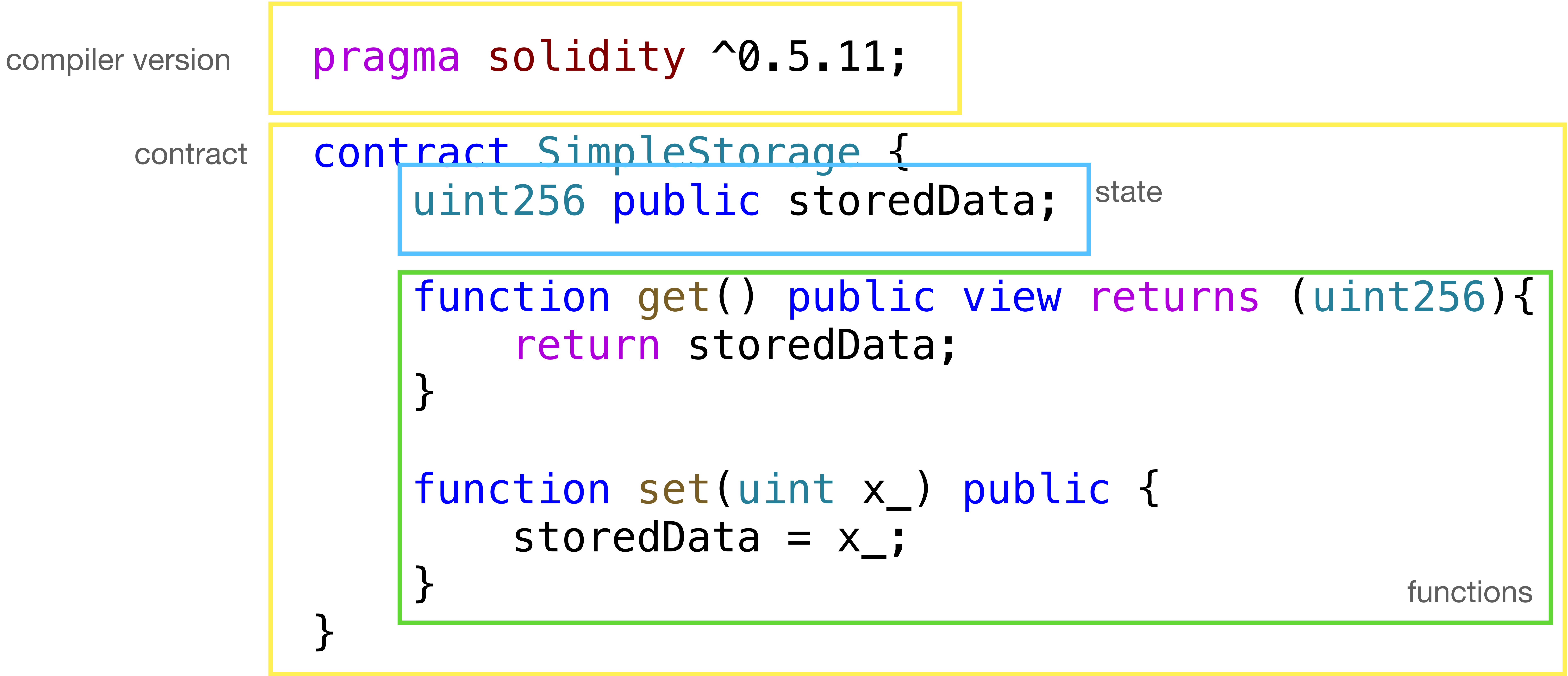
Example: Simple Storage



```
pragma solidity ^0.5.11;

contract SimpleStorage {
    uint256 public storedData;

    function get() public view returns (uint256){
        return storedData;
    }

    function set(uint x_) public {
        storedData = x_;
    }
}
```

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Example: Simple Storage

Simple online IDE: https://remix.ethereum.org/

Fun tutorial: https://cryptozombies.io/

- Constructors
- Basic types and collections
- Visibility (private, public)
- Inheritance
- Modifiers (view, pure)

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Example: Simple Storage

Who can invoke functions?

- any user

Who can view values?

- anyone

Who can change the code?

- noone

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Smart Contract code

Smart contract code is immutable and public

- Anyone can trust smart contract (if it is not too complex)
  - No need to trust the creator of the contract
- No one can fix bugs in the contract
- Anyone can find and exploit bugs in the contract

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Smart Contract code

- Assembly for Ethereum Virtual machine (EVM)
- Compiled from higher level language (Solidity)
- Stored in account (codeHash)

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Accounts

Ethereum uses accounts instead of UTXO.
Thus the state of Ethereum contains for every account:

- **address:** e.g. pub-key hash
- **balance**: amount of Ether the address owns
- **nonce**: sequence number of last transaction sent from this account
- **storage root**: *only for non-user accounts (contract account)*
- **code hash:** *only for non-user accounts (contract account)*

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Accounts

Smart Contracts are also represented as accounts.
A contract account has:

- **address:** *e.g. hash from creator address & creation trancation nonce*
- **balance**: amount of Ether the address owns
- **nonce**: number of other contract created by this contract
- **storageRoot**: hash of data stored in this contract
- **codeHash:** hash of the code of this contract

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Accounts

In a contract written in Solidity, you can access:

- The address of the current contract:

```
address contractaddress = address(this);
```

- The balance of the contract:

```
uint balance = contractaddress.balance;
```

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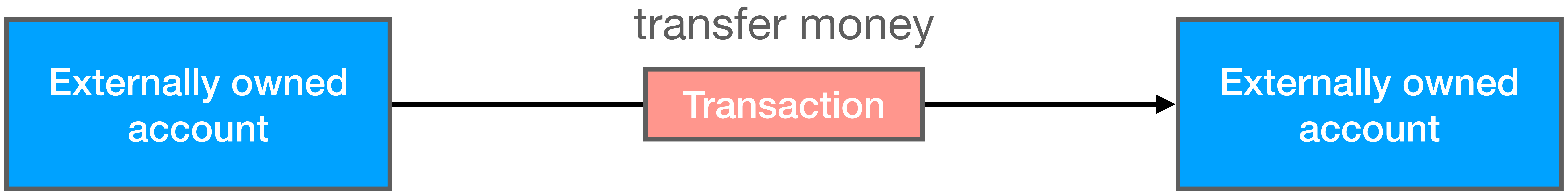
Transactions and authenticaion

Transactions are used to transfer ether, invoke functions, and deploy new contracts.



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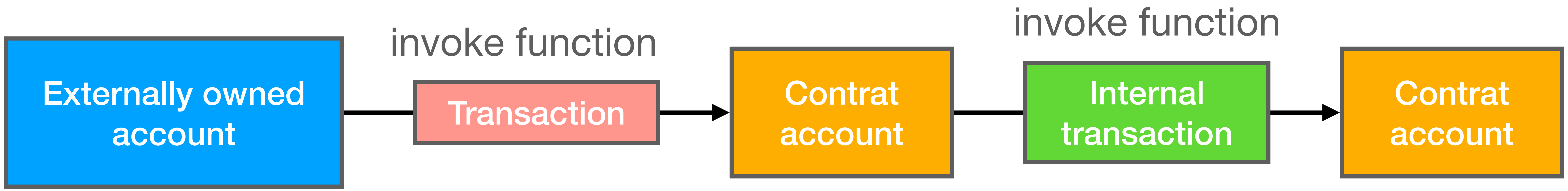

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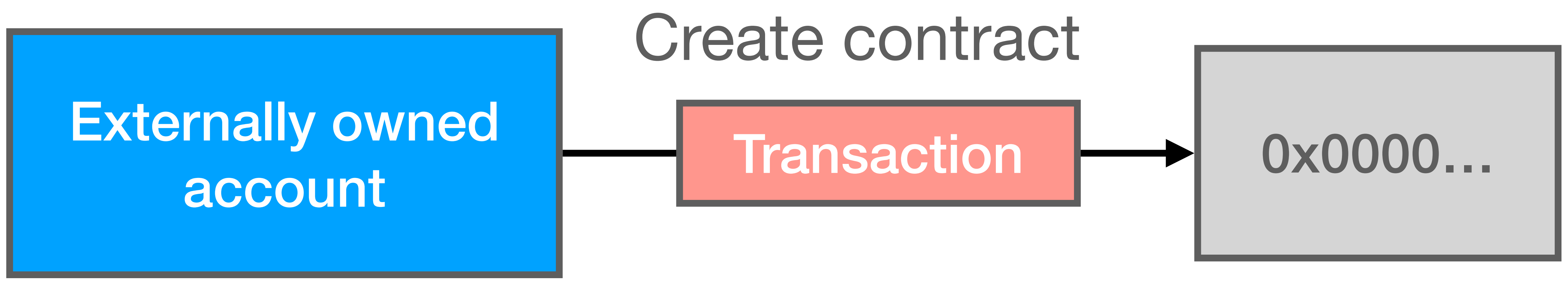

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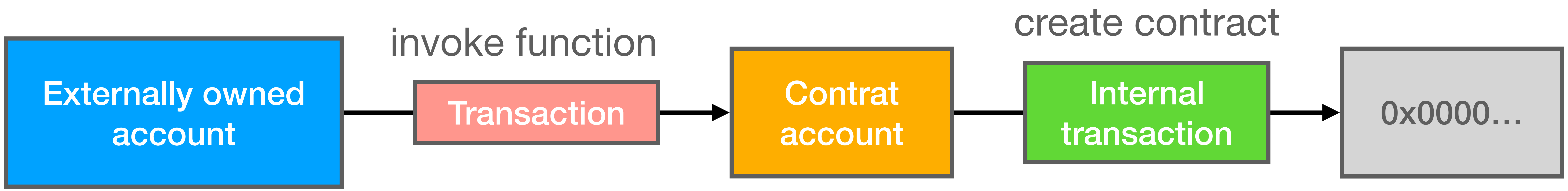

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Transactions and authenticaion

Transactions contain:

- *Nonce:* next sequence number for sender account
- *Gas price:* later
- *max gas:* later
- *Recipient:* destination Ethereum address
- *Value:* Amount of ether send to destination
- *Data:* Payload binay, e.g. function identifier and arguments
- *Signature:* Signature from sender, including his public key

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Transaction validation

Transaction validation includes the following checks

- *Nonce:* is next sequence number for sender account
- Sender has sufficient balance to pay value and fees
- Transaction is correctly signed

When autheticating users in smart contract, we can rely on transaction validation!
Use *msg.sender* to access address invoking transaction.

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Solidity example

```
contract SimpleBank {
    mapping(address => uint) private balances;
    address public owner;

    // function SimpleBank() deprecated syntax for
    constructor() public {
        owner = msg.sender;
    }

    function deposit() public payable returns(uint) {
        balances[msg.sender] += msg.value;
        return balances[msg.sender];
    }

    function withdraw(uint withdrawAmount) public returns (uint remainingBal){
        if (balances[msg.sender] >= withdrawAmount){
            balances[msg.sender] -= withdrawAmount;
            // this throws an error if fails.
            msg.sender.transfer(withdrawAmount);
        }
        return balances[msg.sender];
    }

    function balance() view public returns (uint) {
        return balances[msg.sender];
    }
}
```

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Solidity example

What happens if data is empty?

- Money transfered to account. Default function run.

What is *msg.sender* for internal transactions?

- address of sending contract
    - a contract can have money in our bank!

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Solidity exceptions

If a smart contract throws an exception, or error, state is reverted.

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Gas

How to pay transaction fees in Ethereum?

- all bytecode instructions have a cost specified in Gas
- transaction has fixed cost in Gas
- especially: storing values is expensive

Transactions specify *Gas price* and *Gas limit*

- *Gas price* is ether given per gas
- *Gas limit* is how much the transaction may spend at most

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Gas

Why specific gas per instruction:

- An infinite loop will cost infinitely much gas -> avoid denial of service

What happens if you hit the *Gas limit*?

- Exception is thrown and transaction reverted.
- Gas is still payed!

Which transactions are included?

- Miners will include transactions offering the highest gas price.