# A hands-on tutorial: Working with Smart Contracts in Ethereum

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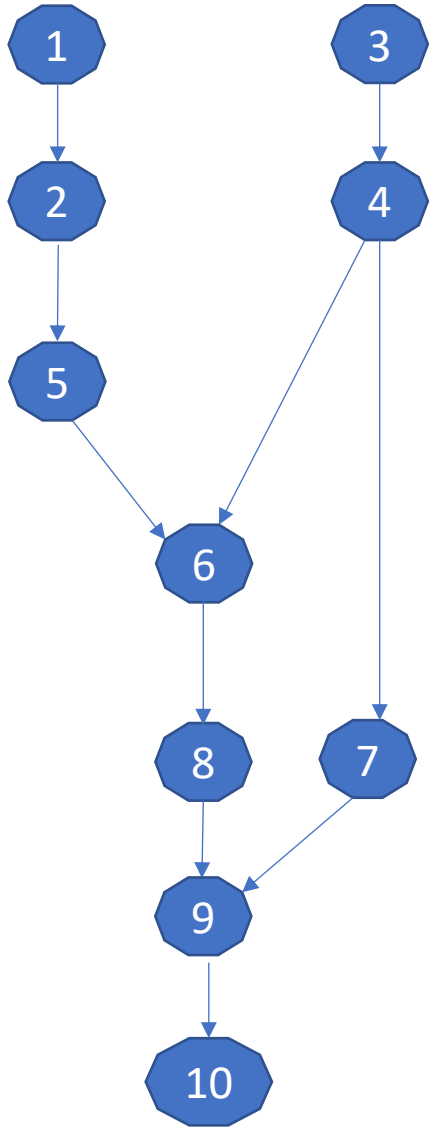
# Different tools provide different functionality

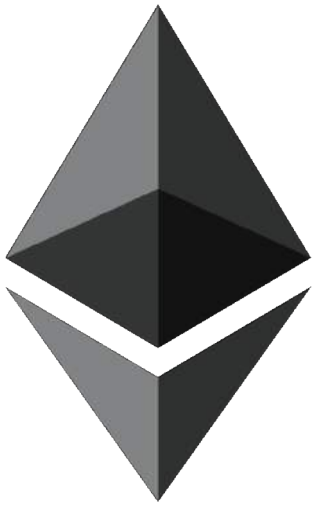
| | Tools / Activities | Remix | Ganache | MyEtherWallet | Geth |
|---|---|---|---|---|---|
| 1 | Configure the Blockchain | - | - | - | + |
| 2 | Deploy the Blockchain | Not Persistent | + | - | + |
| 3 | Develop the contract | + | - | - | + |
| 4 | Compile the contract | + | - | - | + |
| 5 | Create user account | + | + | + | + |
| 6 | Deploy the contract | + | - | + | + |
| 7 | Create the UI for interacting | + | - | + | + |
| 8 | Run the client | + | - | + | + |
| 9 | Interact with the contract & have fun | + | - | + | + |
| 10 | Monitor the execution | - | + | - | + |




https://remix.ethereum.org/
http://truffleframework.com/ganache/
https://github.com/kvhnuke/etherwallet/releases/tag/v3.21.06

# Use which tool for what purpose? (1/2)

- Use Geth for everything?
  - Powerful but command-line only



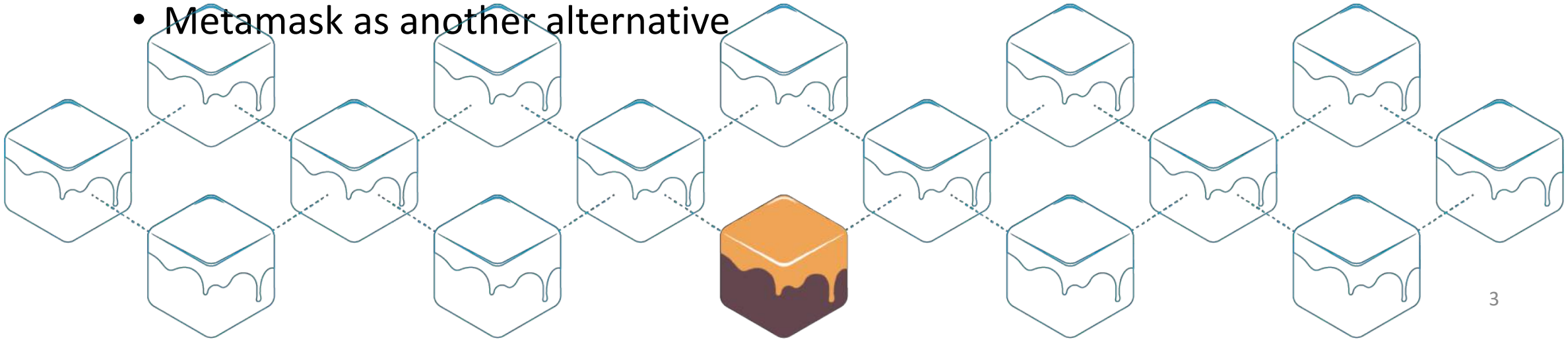
- What should I use?
  - As a starting point for developing contracts – mostly Remix

- What cannot Remix do?
  - Configure the blockchain
  - Create real (non-test) user accounts and transfer funds between user accounts
  - Monitor the execution
  - Other advanced operations

# Use which tool for what purpose? (2/2)

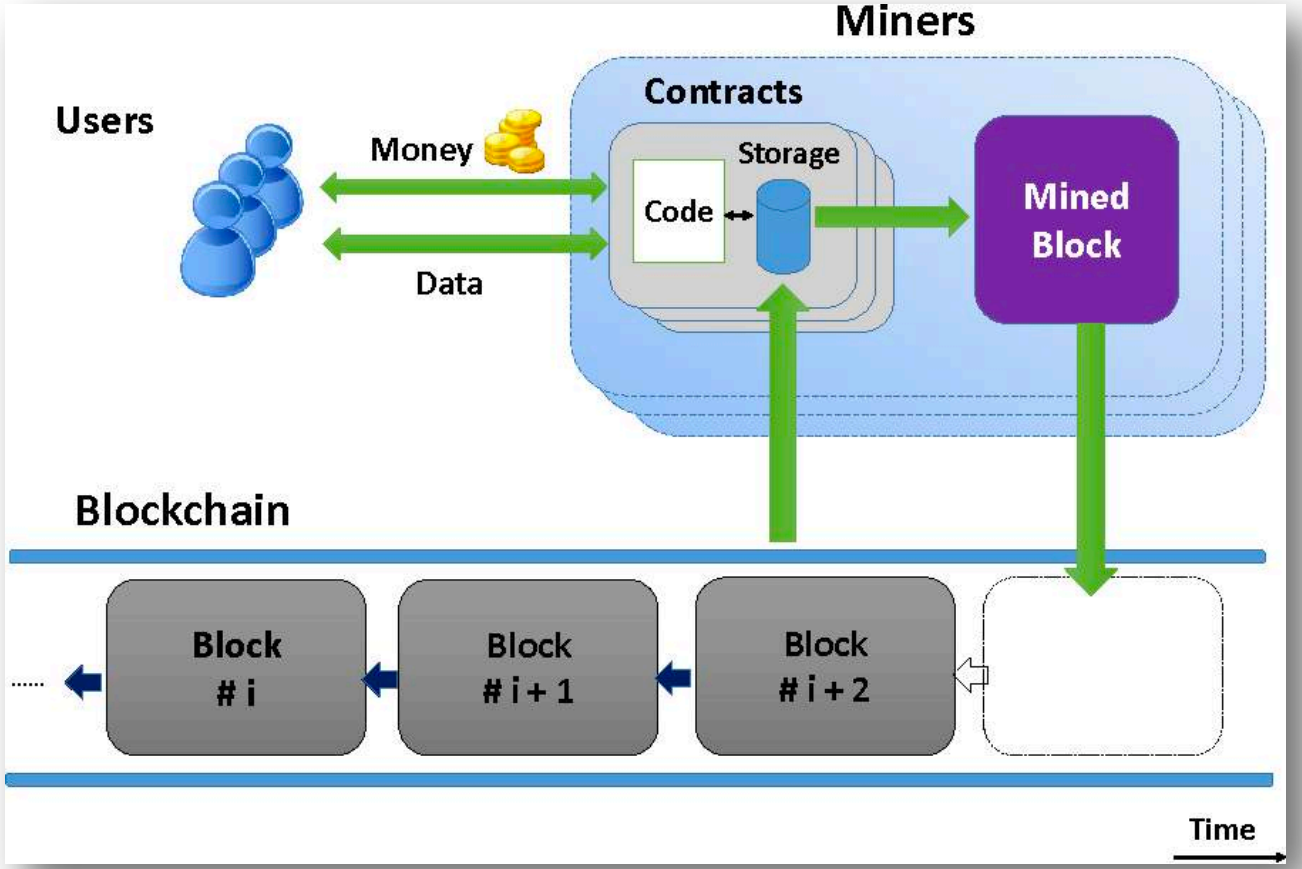
- Why use Ganache?
  - To inspect and monitor the execution
  - To visualize certain elements in a better way

- Why use MyEtherWallet?
  - To create a personal wallet (real user account), transfer funds between user accounts, and interact with contracts
  - Metamask as another alternative



# Smart Contracts

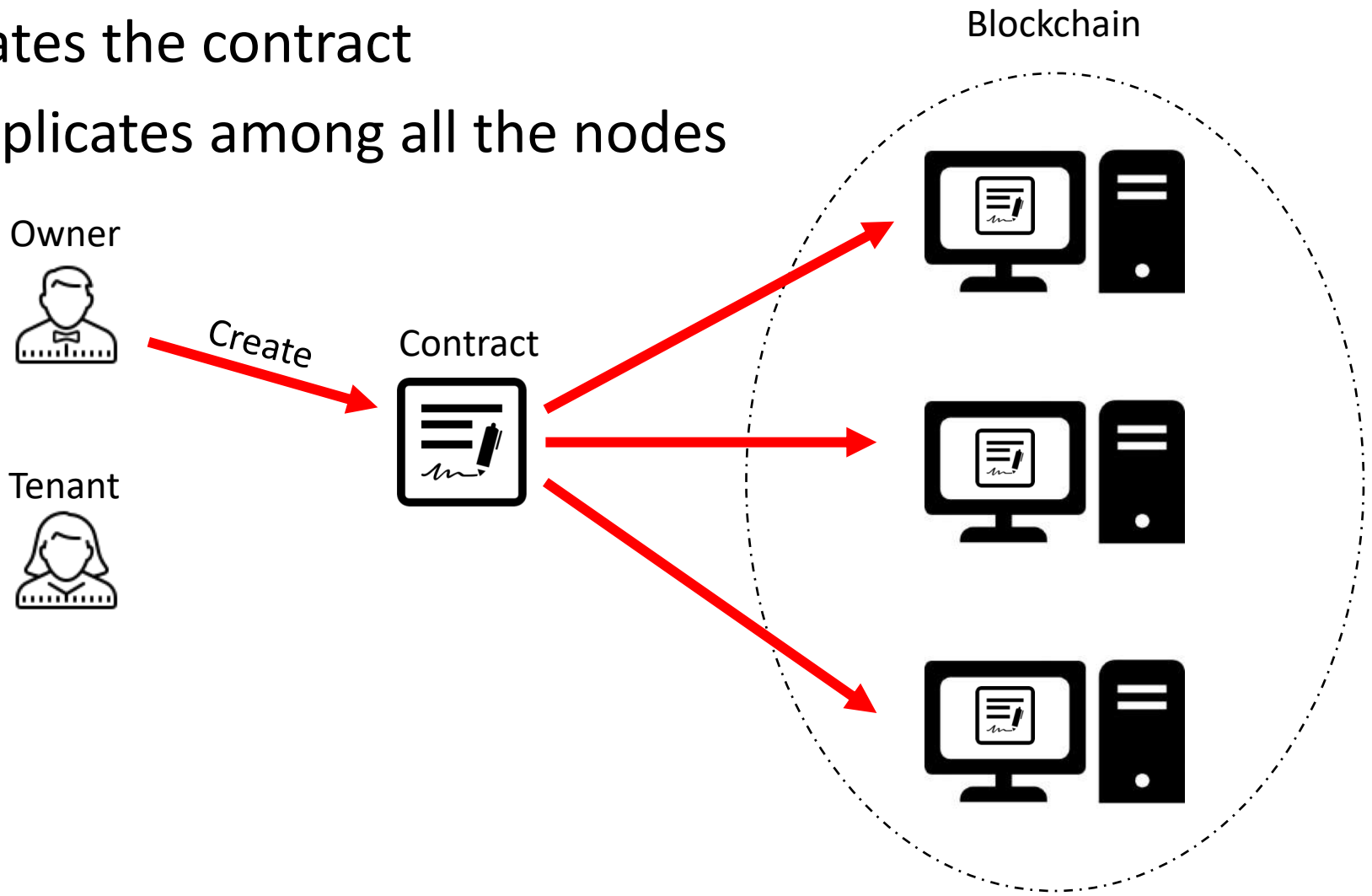
- In the form of code
- Stored on a blockchain
- Executes under given conditions




- K. Delmolino, M. Arnett, A. E. Kosba, A. Miller, and E. Shi, "Step by Step Towards Creating a Safe Smart Contract: Lessons and Insights from a Cryptocurrency Lab," *IACR Cryptology ePrint Archive*, vol. 2015, p. 460, 2015.

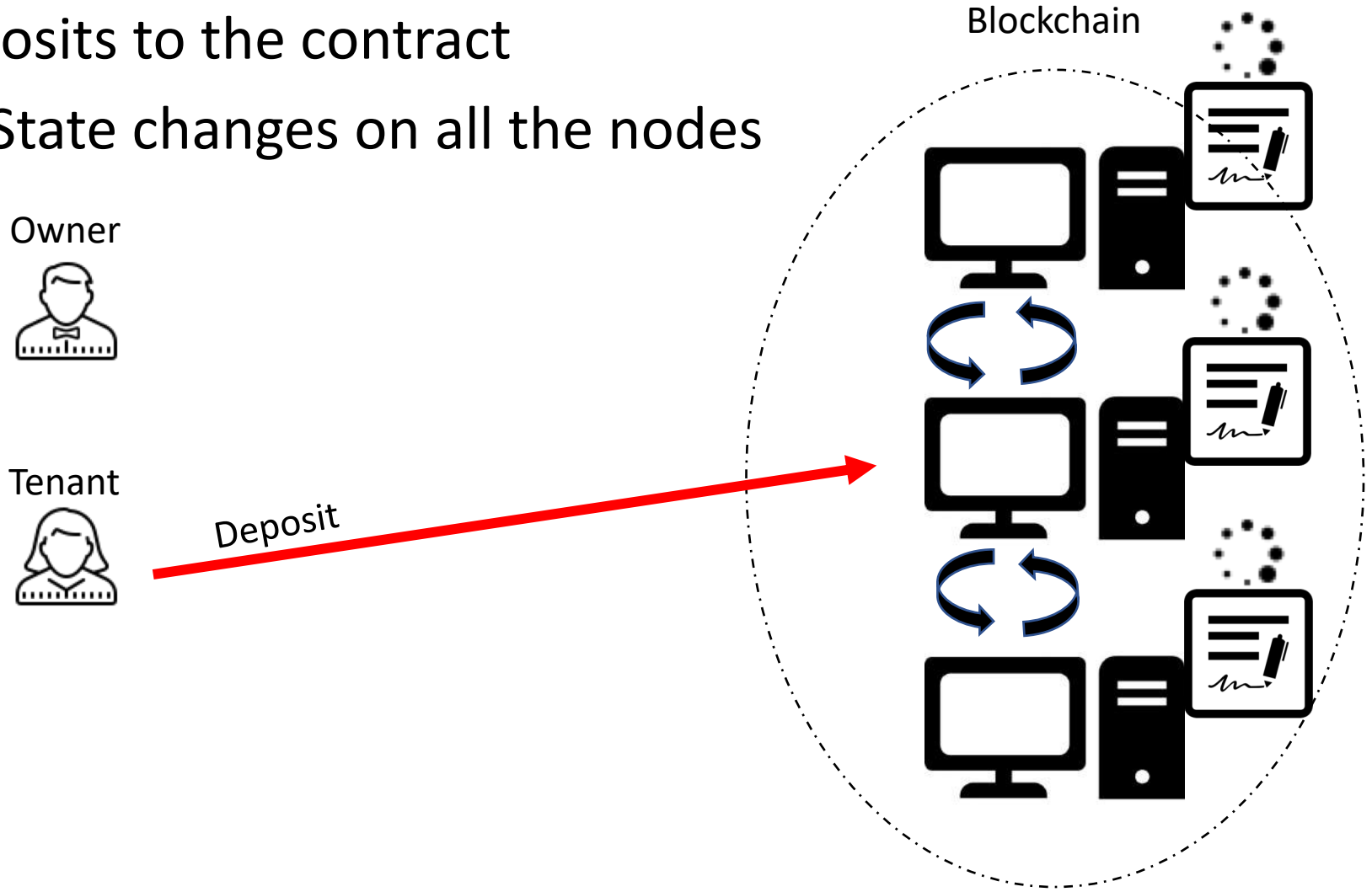
# Smart Contracts Example (1/3)

- Owner creates the contract
- Contract replicates among all the nodes



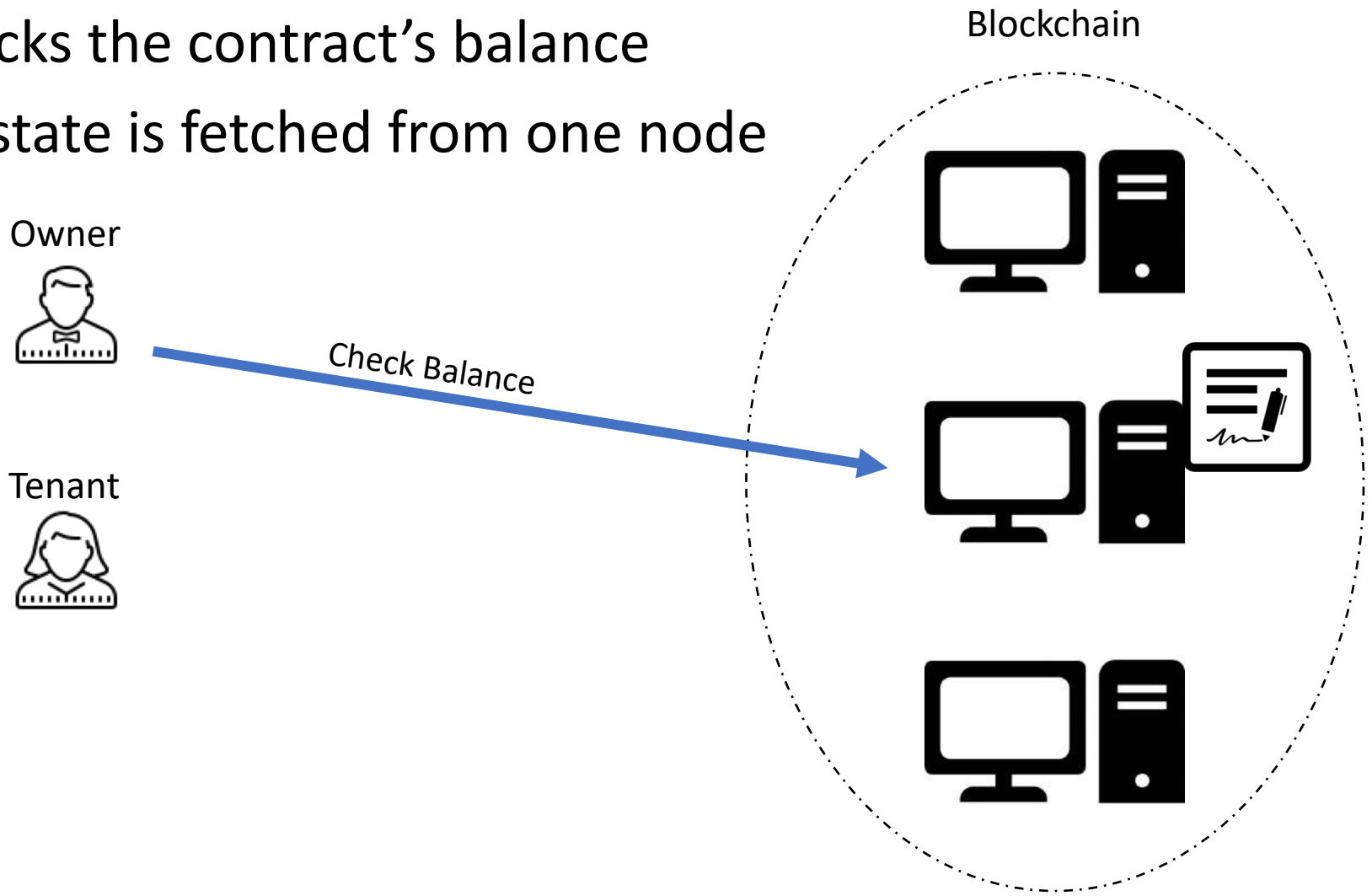
# Smart Contracts Example (2/3)

- Tenant deposits to the contract
- Contract's State changes on all the nodes



# Smart Contracts Example (3/3)

- Owner checks the contract's balance
- Contract's state is fetched from one node

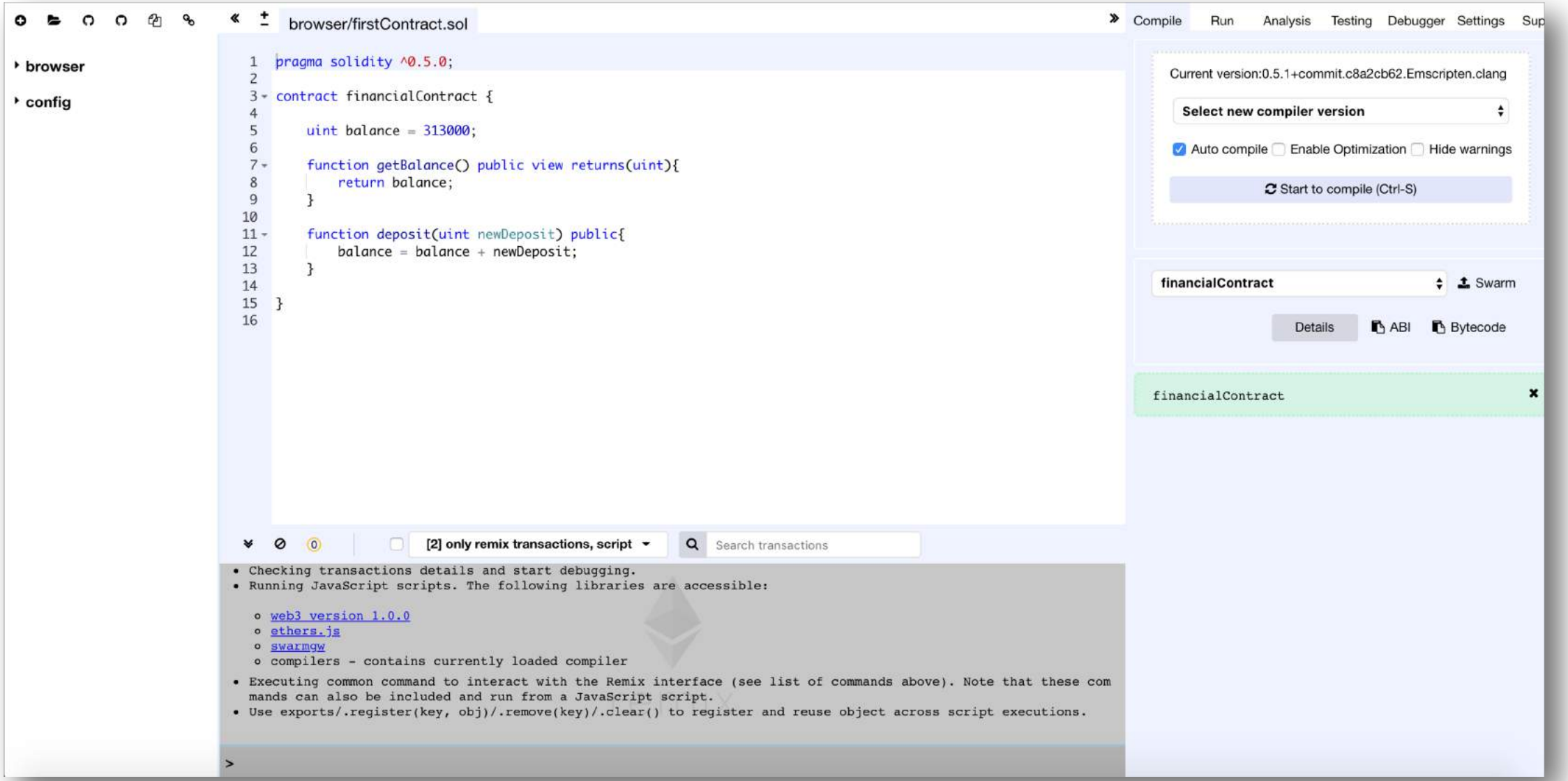


# Smart Contracts

1. Developing a simple contract
2. Compiling the contract
3. Deploying the contract
4. Interacting with the contract
5. Adding more functions to our code to make it more practical

# Open Remix : remix.ethereum.org

- An open source tool for writing, compiling and testing Solidity contracts



# Solidity

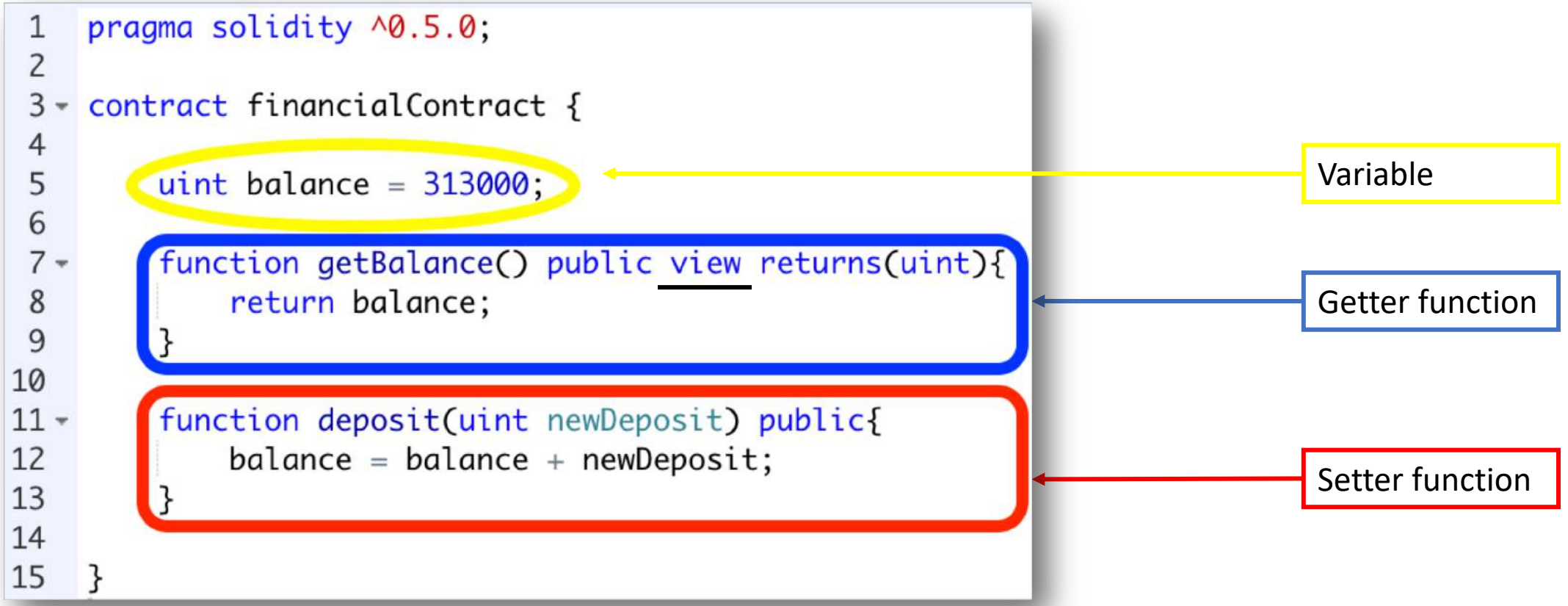
- Object-oriented
- Contract-oriented
- High-level language
- Influenced by C++, Python, and JavaScript
- Target Ethereum Virtual Machine (EVM)

## Serpent as an Alternative?

- Low-level language
- Complex compiler

# Start Coding

- Setter and Getter: Set and get the information.



# Compile the Contract

- Compile tab: Start to compile button

# Set Deployment Parameters (1/2)

- Run tab: Environment = JavaScript VM

# Set Deployment Parameters (2/2)

- JavaScript VM: All the transactions will be executed in a sandbox blockchain in the browser. Nothing will be persisted and a page reload will restart a new blockchain from scratch, the old one will not be saved.
- Injected Provider: Remix will connect to an injected web3 provider. Mist and Metamask are example of providers that inject web3, thus they can be used with this option.
- Web3 Provider: Remix will connect to a remote node. You will need to provide the URL address to the selected provider: geth, parity or any Ethereum client.

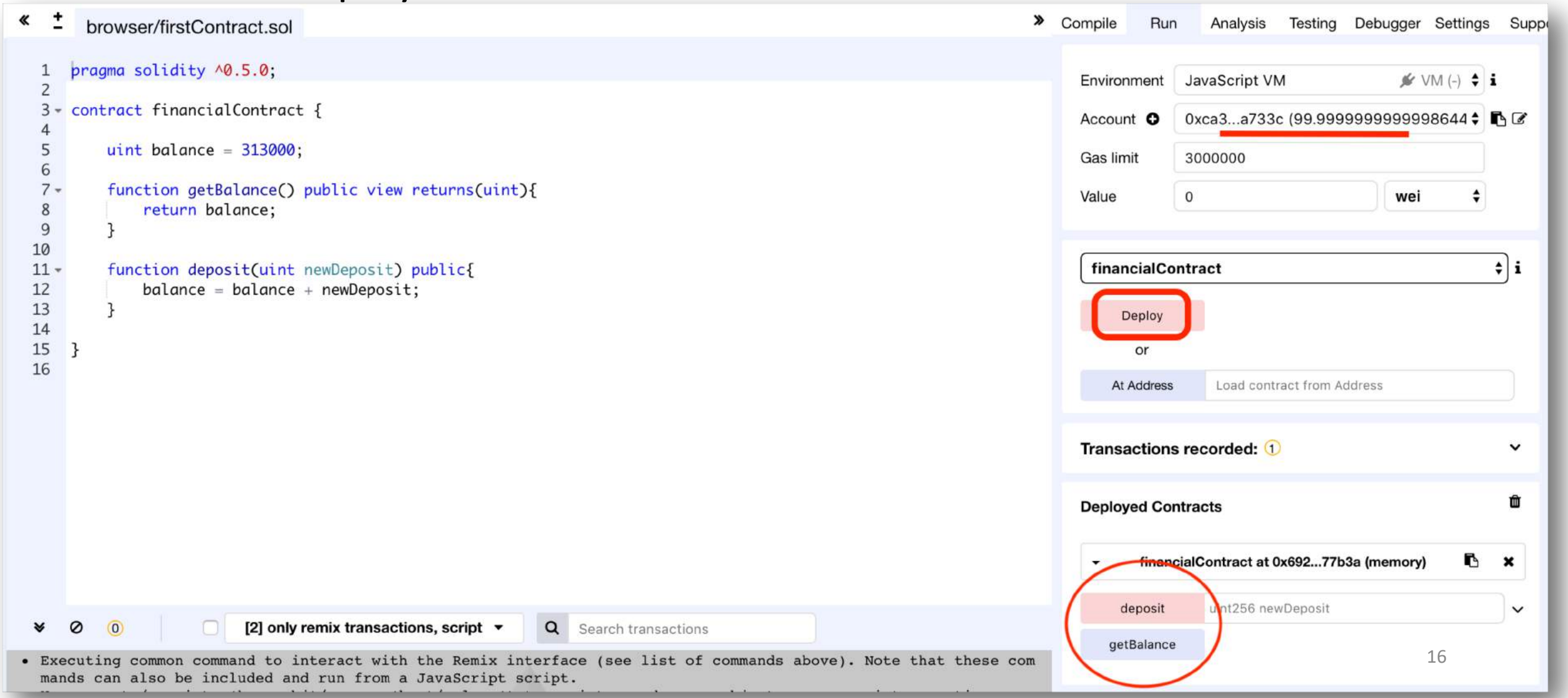
- Gas Limit: The maximum amount of gas that can be set for all the instructions of a contract.
- Value: Input some ether with the next created transaction (wei = $10^{-18}$ of ether).

# Types of Blockchain Deployment

- Private: e.g., Ganache sets a personal Ethereum blockchain for running tests, executing commands, and inspecting the state while controlling how the chain operates.
- Public Test (Testnet): Like Ropsten, Kovan and Rinkeby which are existing public blockchains used for testing and which do not use real funds. Use faucet for receiving initial virtual funds.
- Public Real (Mainnet): Like Bitcoin and Ethereum which are used for real and which available for everybody to join.

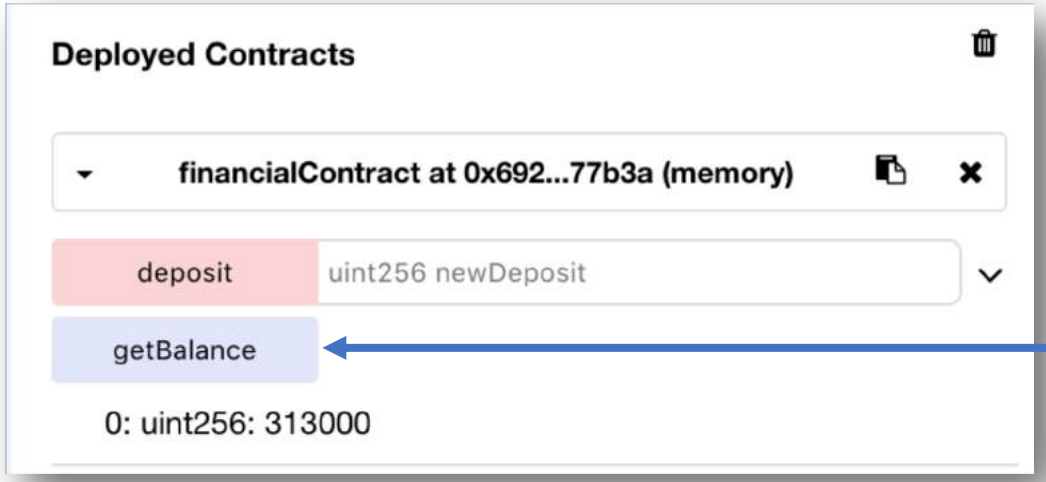
# Deploy the Contract on the Private Blockchain of Remix

- Run tab: Deploy button

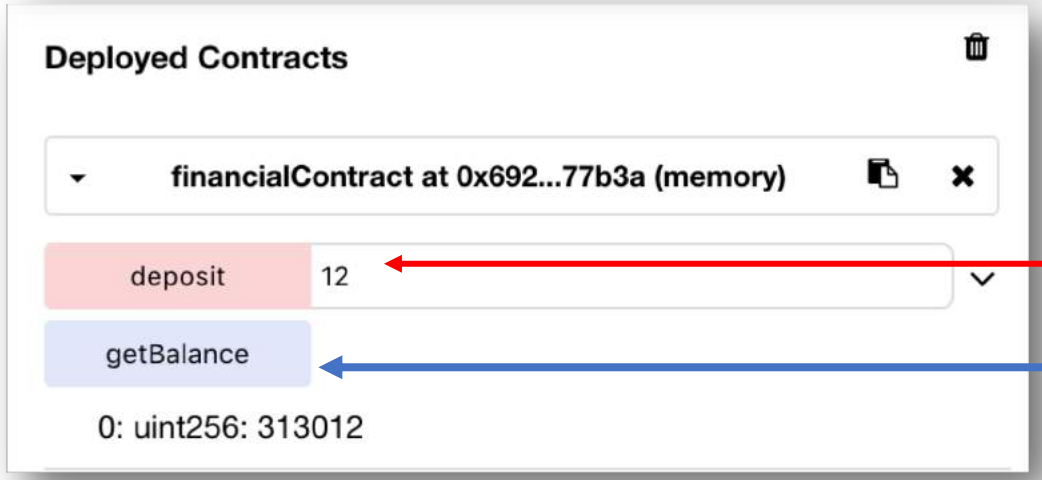


# Interact with the Contract

- Setter = Red Button: Creates transaction
- Getter= Blue Button: Just gives information




Press getBalance to see the initial amount 1




Input a value and press deposit button to create and confirm the transaction 2

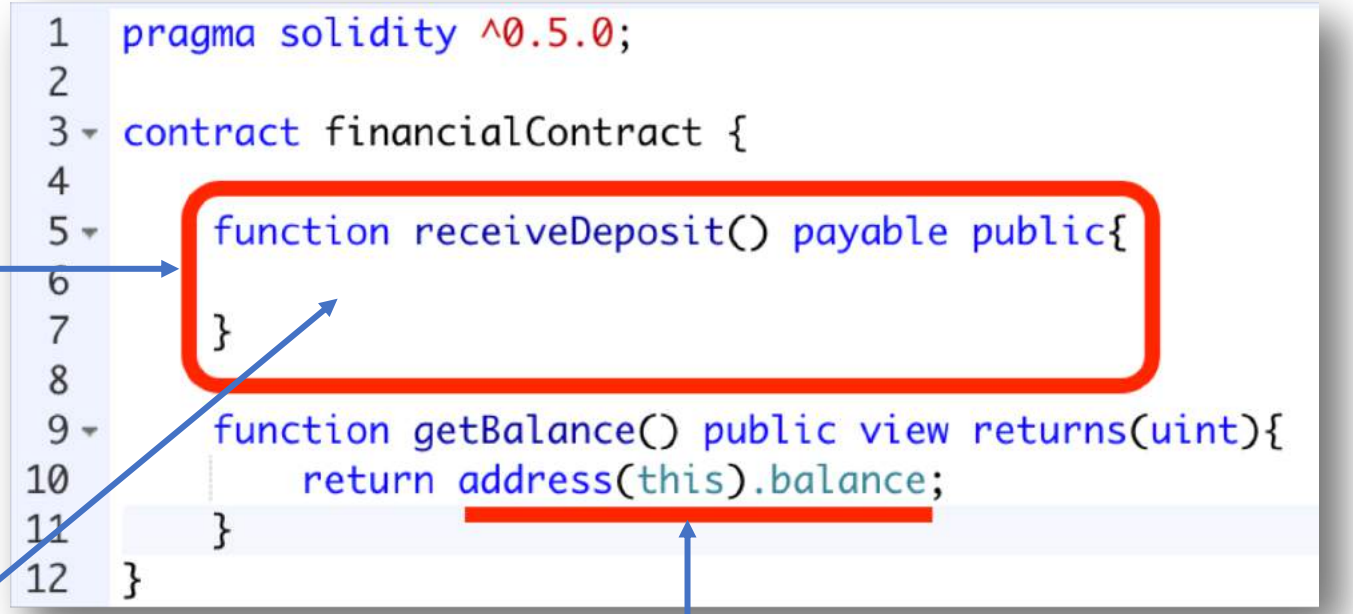
Press getBalance again to see the result 3

# Additional features

- Transferring funds from an account to the contract
- Saving the address of the contract creator
- Limiting the users' access to functions
- Withdrawing funds from the contract to an account

# Receive ether (1/2)

- Transfer money to the contract



```
1  pragma solidity ^0.5.0;
2
3  contract financialContract {
4
5      function receiveDeposit() payable public{
6
7      }
8
9      function getBalance() public view returns(uint){
10         return address(this).balance;
11     }
12 }
```

Payable keyword allows receiving ether

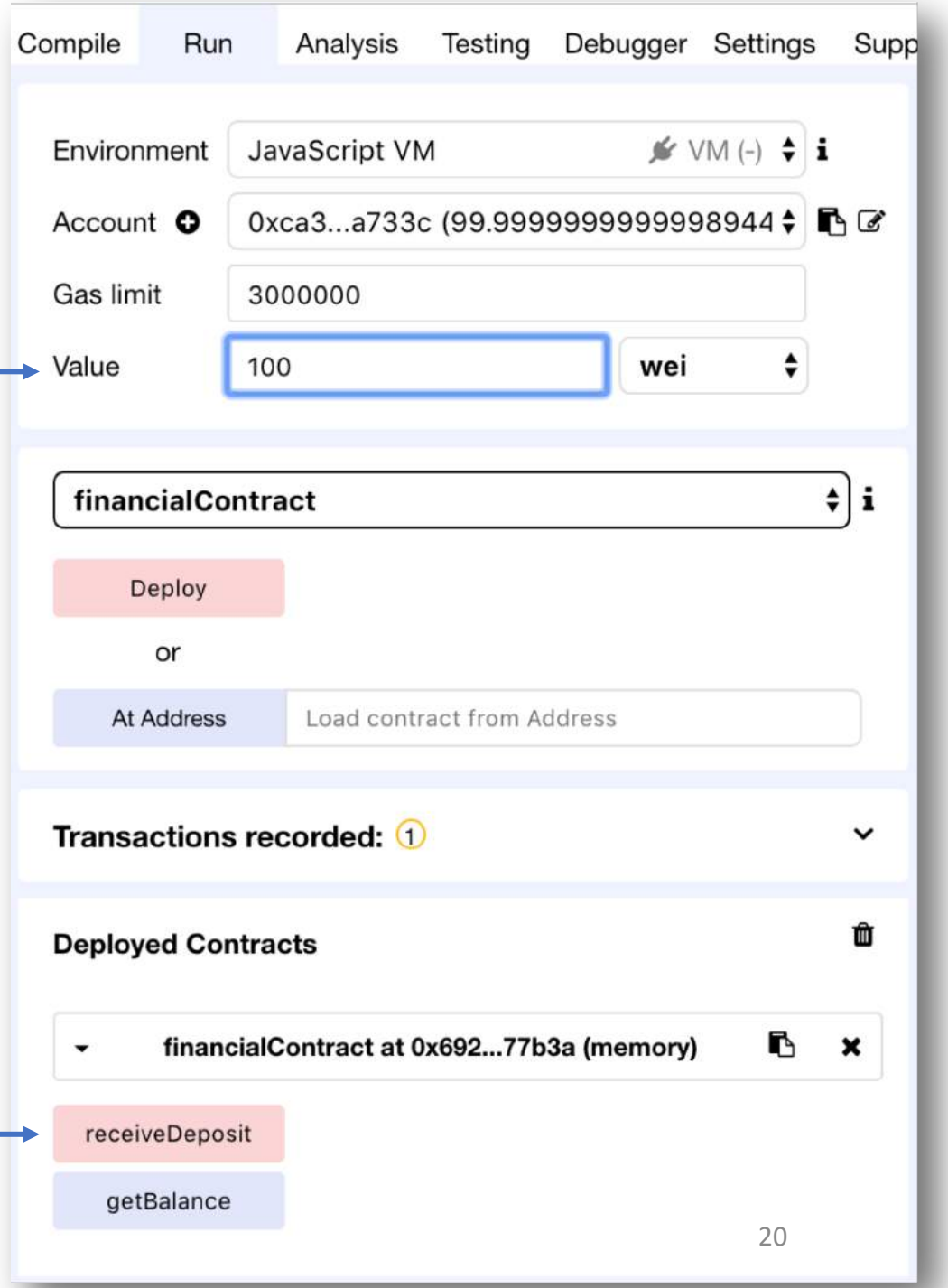
Hidden Code:
*Address(this).balance += msg.value;*

We can get the balance of the contract

# Receive ether (2/2)

1. Input the value as wei ($10^{-18}$ of ether)

2. Click the receiveDeposit button to transfer the money to the contract



# Constructor

- Will be called at the creation of the instance of the contract

```
1  pragma solidity ^0.5.0;
2
3  contract financialContract {
4
5      address owner;
6
7      constructor() public{
8          owner = msg.sender;
9      }
10
11     function receiveDeposit() payable public{
12
13     }
14
15     function getBalance() public view returns(uint){
16         return address(this).balance;
17     }
18 }
```

We want to save the address of the contract creator

# Withdraw funds

- Modifier: Conditions you want to test in other functions
- First the modifier will execute, then the invoked function

```
1  pragma solidity ^0.5.0;
2
3  contract financialContract {
4
5      address owner;
6
7      constructor() public{
8          owner = msg.sender;
9      }
10
11     modifier ifOwner(){
12         if(owner != msg.sender){
13             revert();
14         }else{
15             _;
16         }
17     }
18
19
20     function receiveDeposit() payable public{
21
22     }
23
24     function getBalance() public view returns(uint){
25         return address(this).balance;
26     }
27
28     function withdraw(uint funds) public ifOwner{
29         msg.sender.transfer(funds);
30     }
31 }
```

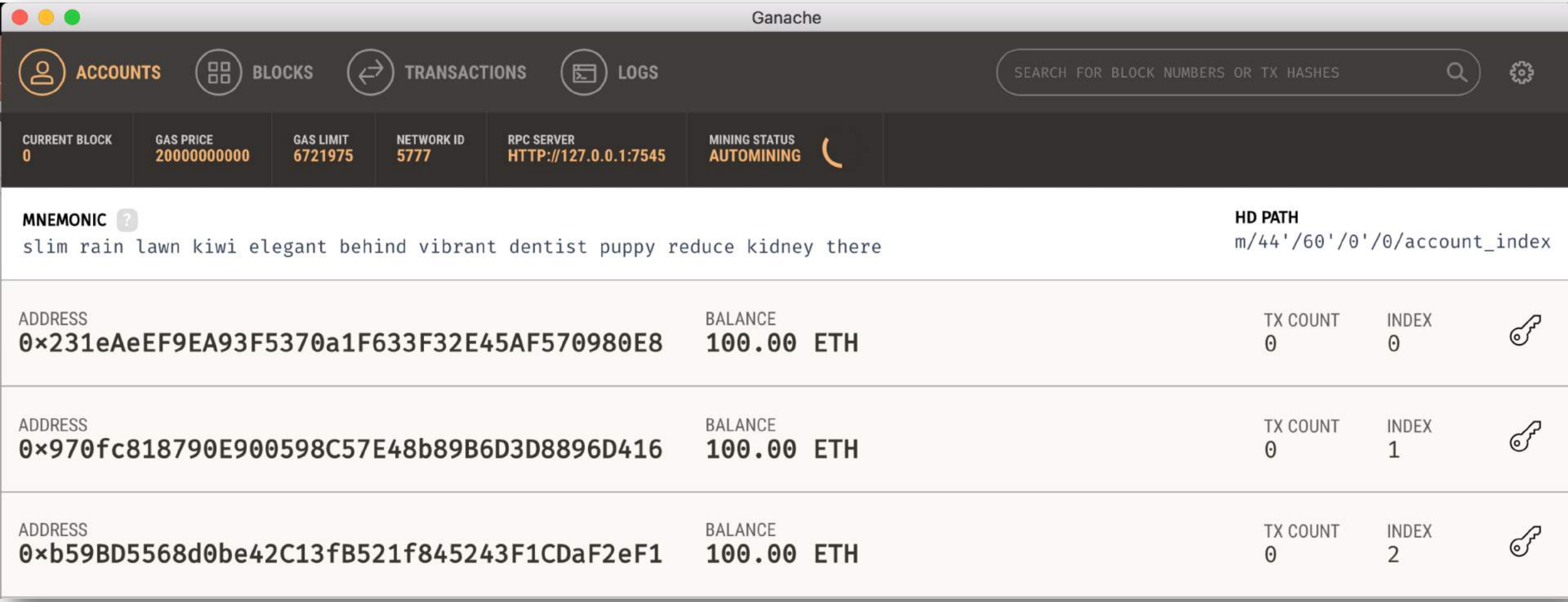
Only the contract's creator is permitted to withdraw

Transfer some money from the contract's balance to the owner

# Now deploying a smart contract on an external blockchain

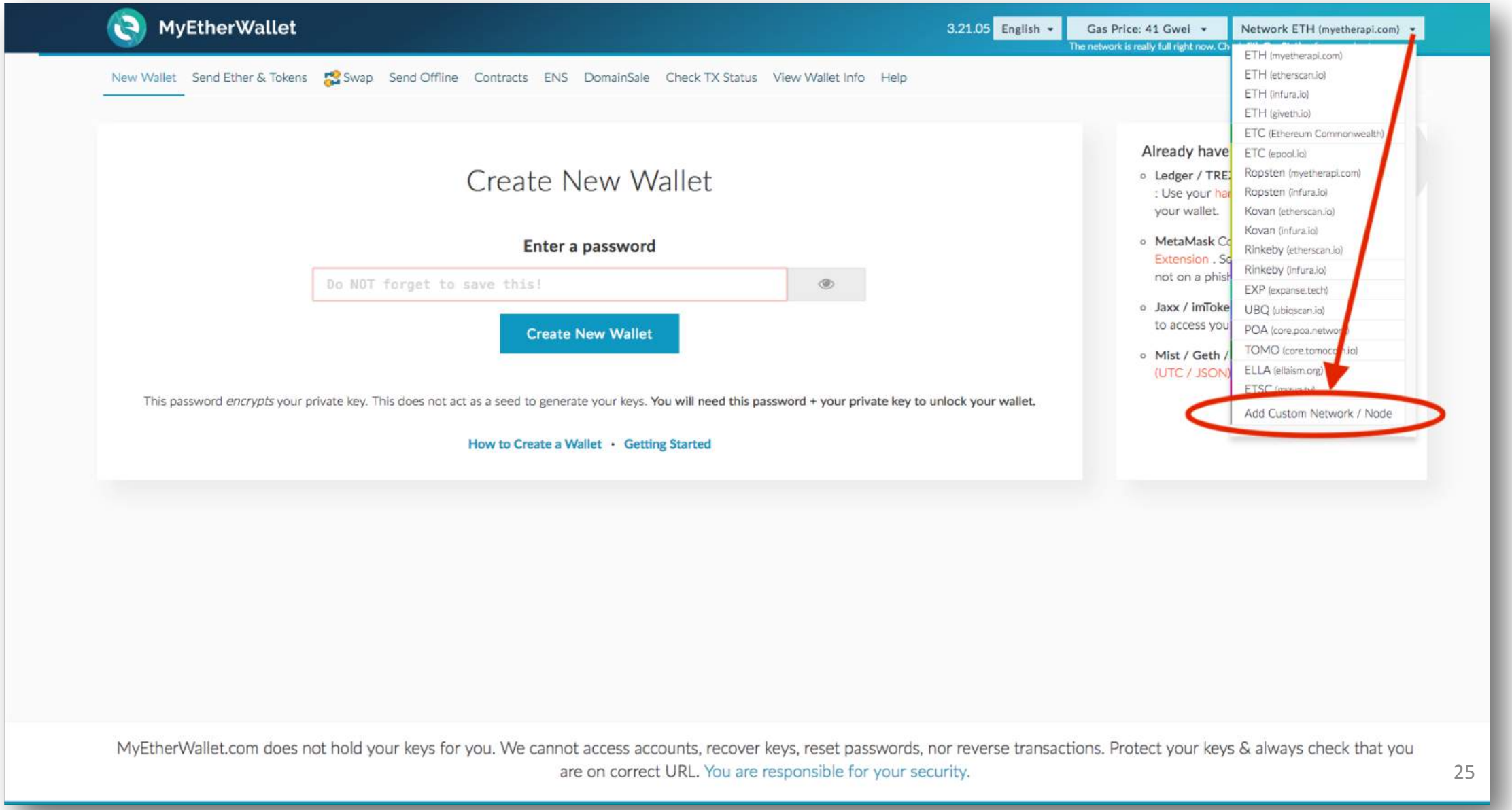
| | Tools / Activities | Remix | Ganache | MyEtherWallet | Geth |
|---|---|---|---|---|---|
| 1 | Configuring the Blockchain | - | - | - | + |
| 2 | Deploying the Blockchain | Not Persistent | + | - | + |
| 3 | Developing the contract | + | - | - | + |
| 4 | Compiling the contract | + | - | - | + |
| 5 | Creating user account | + | + | + | + |
| 6 | Deploying the contract | + | - | + | + |
| 7 | Creating the UI for interacting | + | - | + | + |
| 8 | Run the client | + | - | + | + |
| 9 | Interact with the contract & have fun | + | - | + | + |
| 10 | Monitoring the execution | - | + | - | + |

# Run Ganache

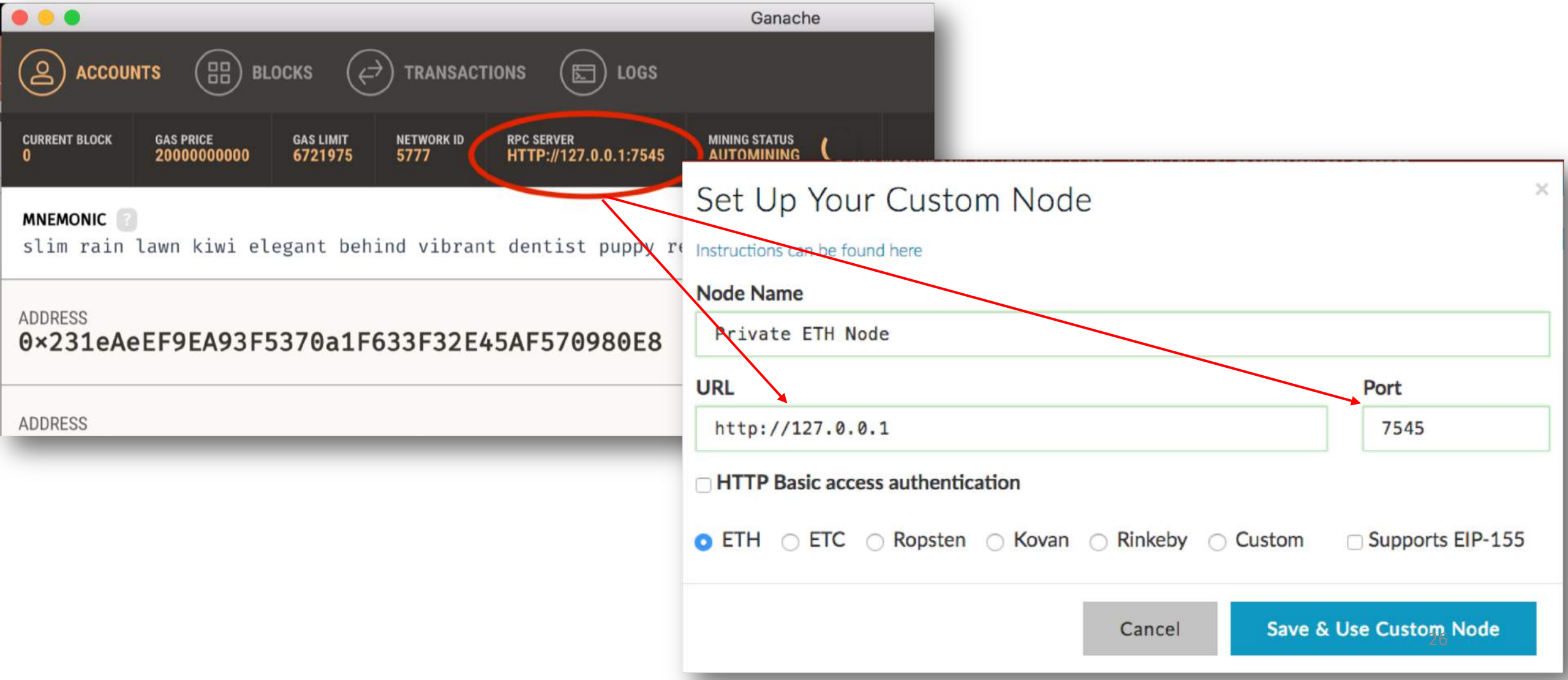

Ganache
ACCOUNTS
BLOCKS
TRANSACTIONS
LOGS
SEARCH FOR BLOCK NUMBERS OR TX HASHES
CURRENT BLOCK
0
GAS PRICE
20000000000
GAS LIMIT
6721975
NETWORK ID
5777
RPC SERVER
HTTP://127.0.0.1:7545
MINING STATUS
AUTOMINING
MNEMONIC
slim rain lawn kiwi elegant behind vibrant dentist puppy reduce kidney there
HD PATH
m/44'/60'/0'/0/account_index
ADDRESS
0×231eAeEF9EA93F5370a1F633F32E45AF570980E8
BALANCE
100.00 ETH
TX COUNT
0
INDEX
0
ADDRESS
0×970fc818790E900598C57E48b89B6D3D8896D416
BALANCE
100.00 ETH
TX COUNT
0
INDEX
1
ADDRESS
0×b59BD5568d0be42C13fB521f845243F1CDaF2eF1
BALANCE
100.00 ETH
TX COUNT
0
INDEX
2

# MyEtherWallet

- add your custom network that you want to test your contracts on

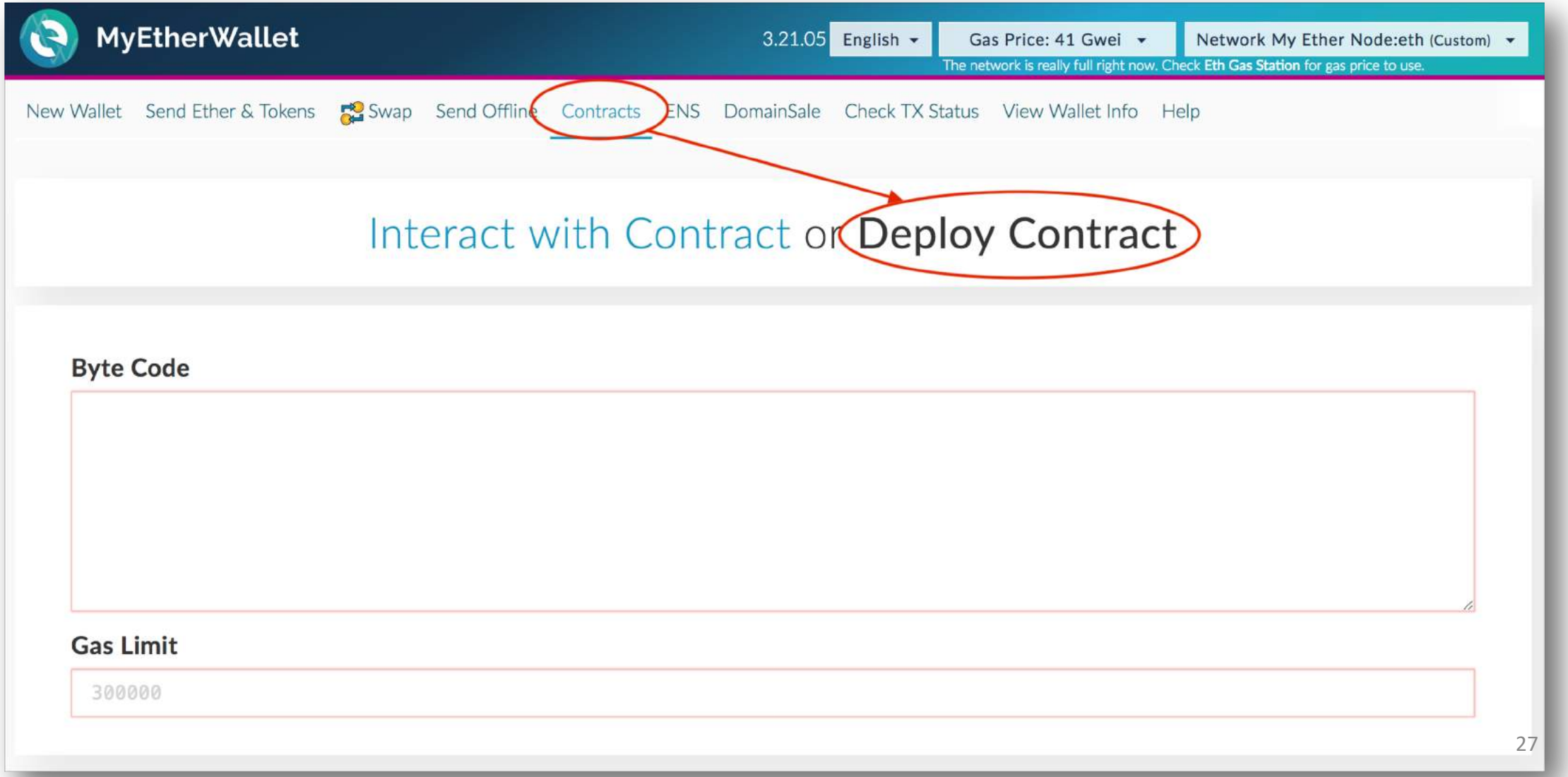


# Import your RPC server address and the port number from Ganache to MyEtherWallet



# MyEtherWallet

- Contracts tab: Deploy Contract

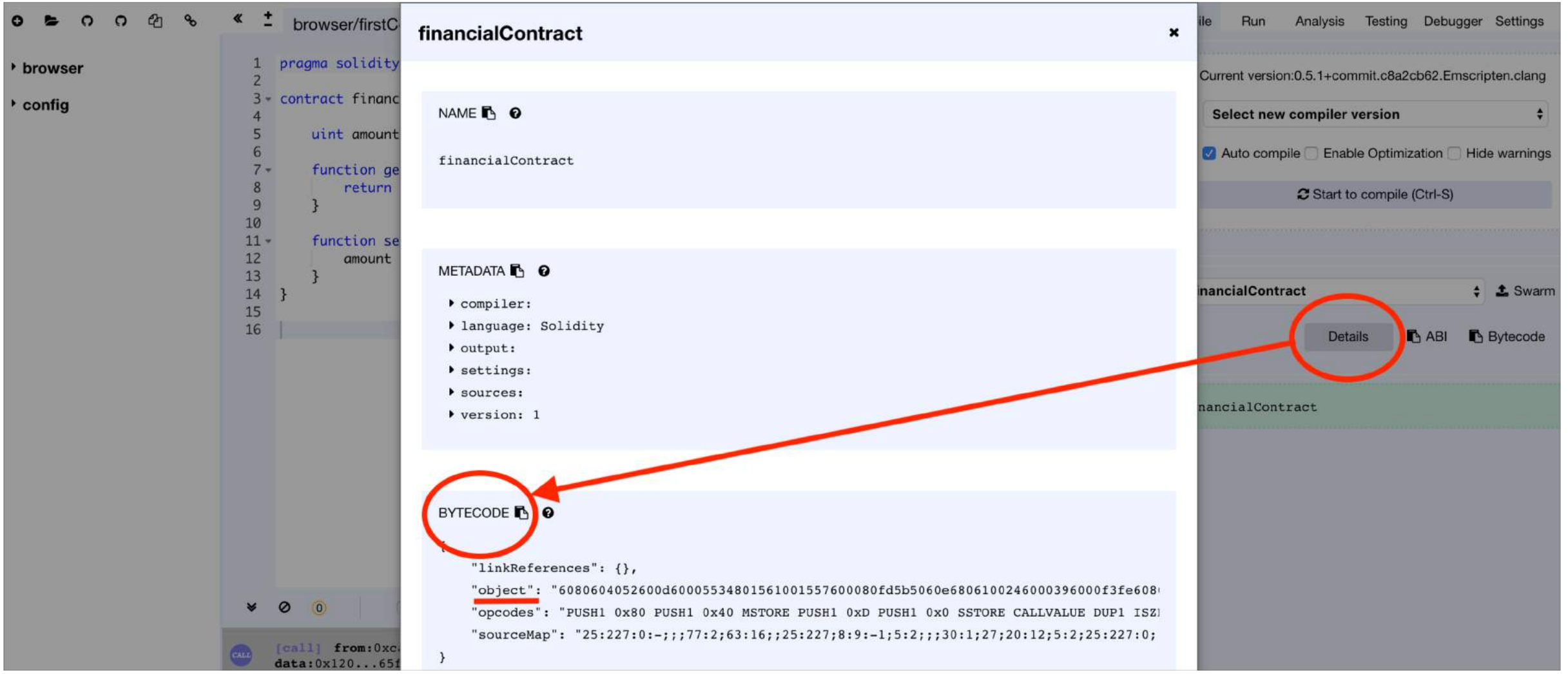


# Remix

- Type your contract and compile it

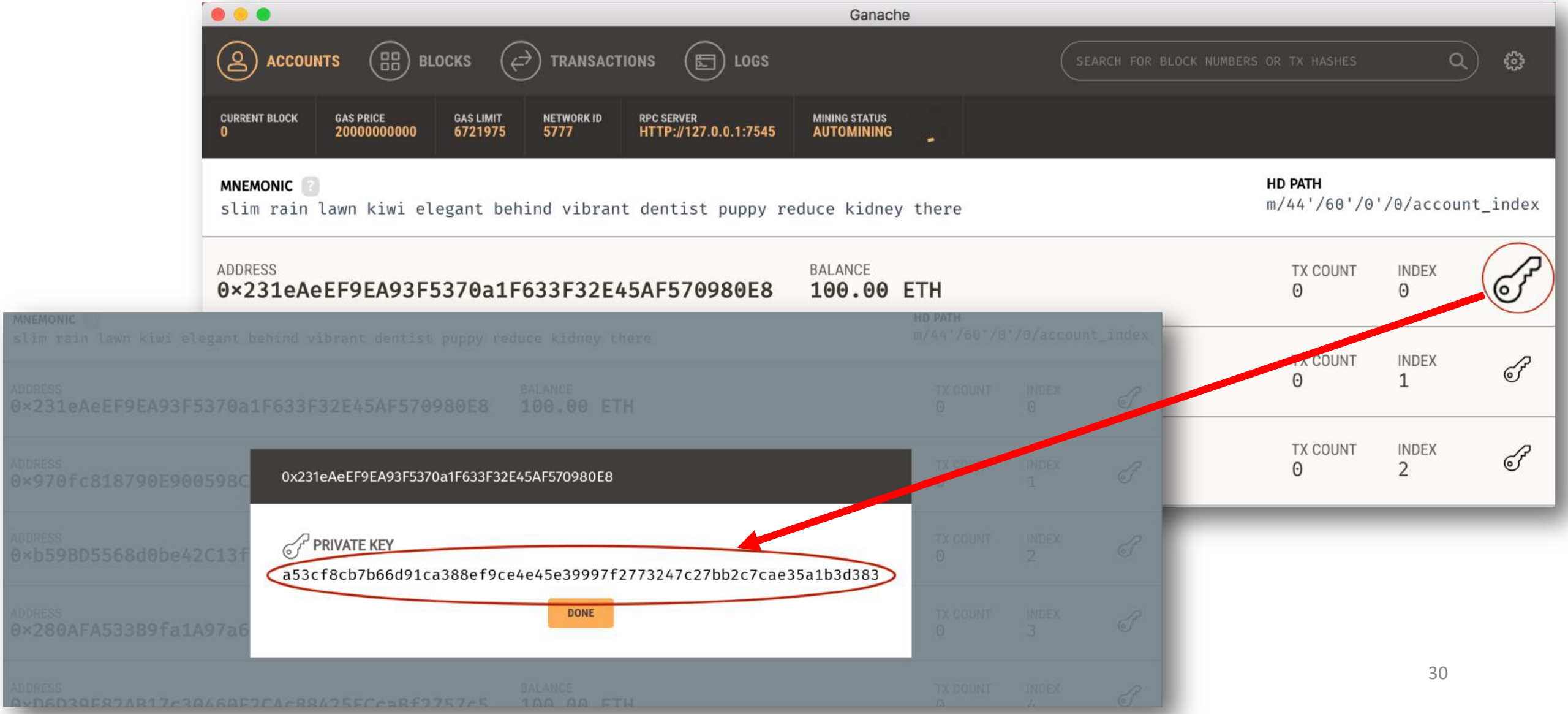
# Remix

## Click on Details Button: access ByteCode to import it to MyEtherWallet



# Ganache

Access your private key for signing your contract in MyEtherWallet.



# MyEtherWallet

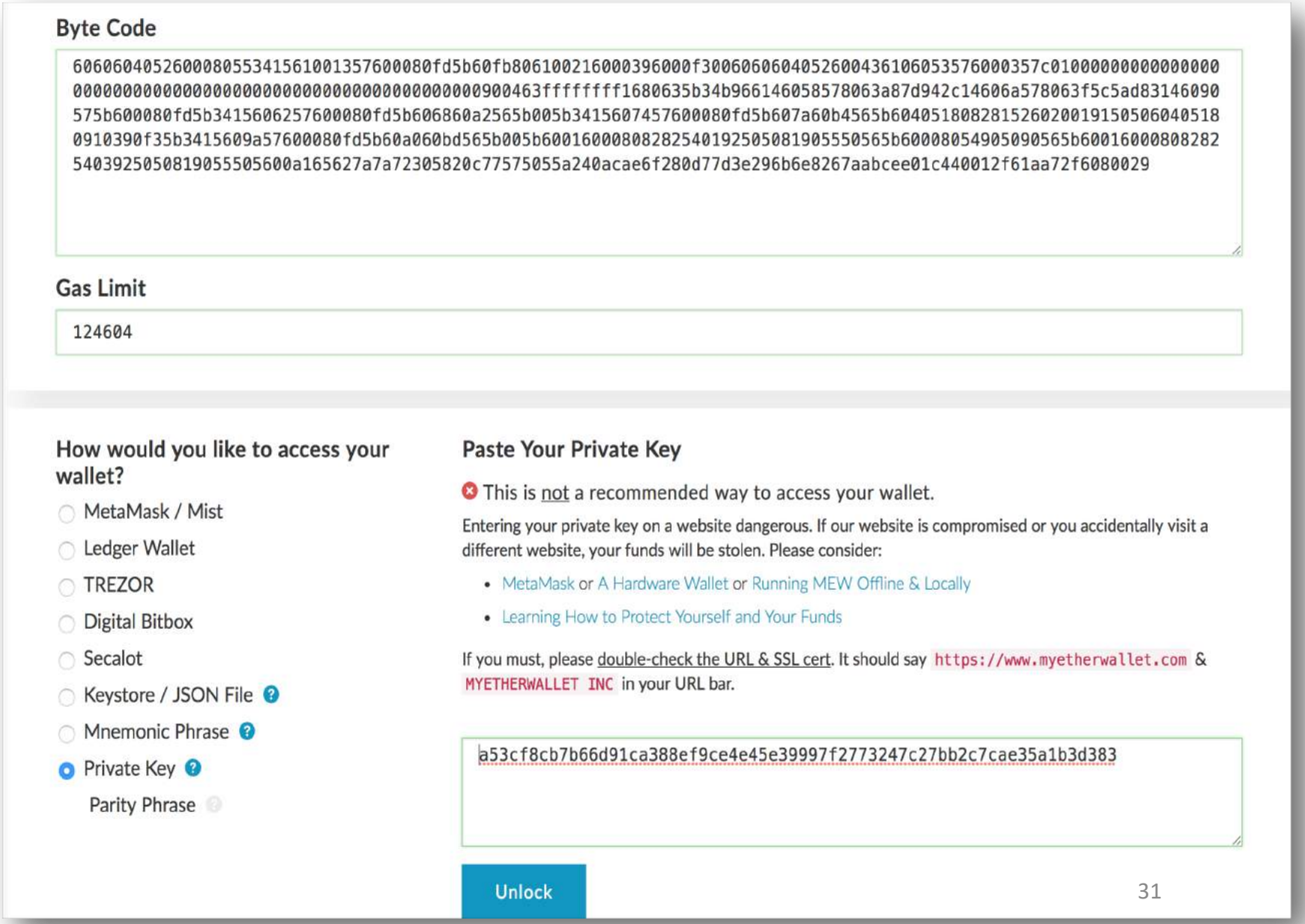
1. Paste the contract's ByteCode from Remix

2. Gas Limit will automatically be calculated

3. Paste your private key from Ganache

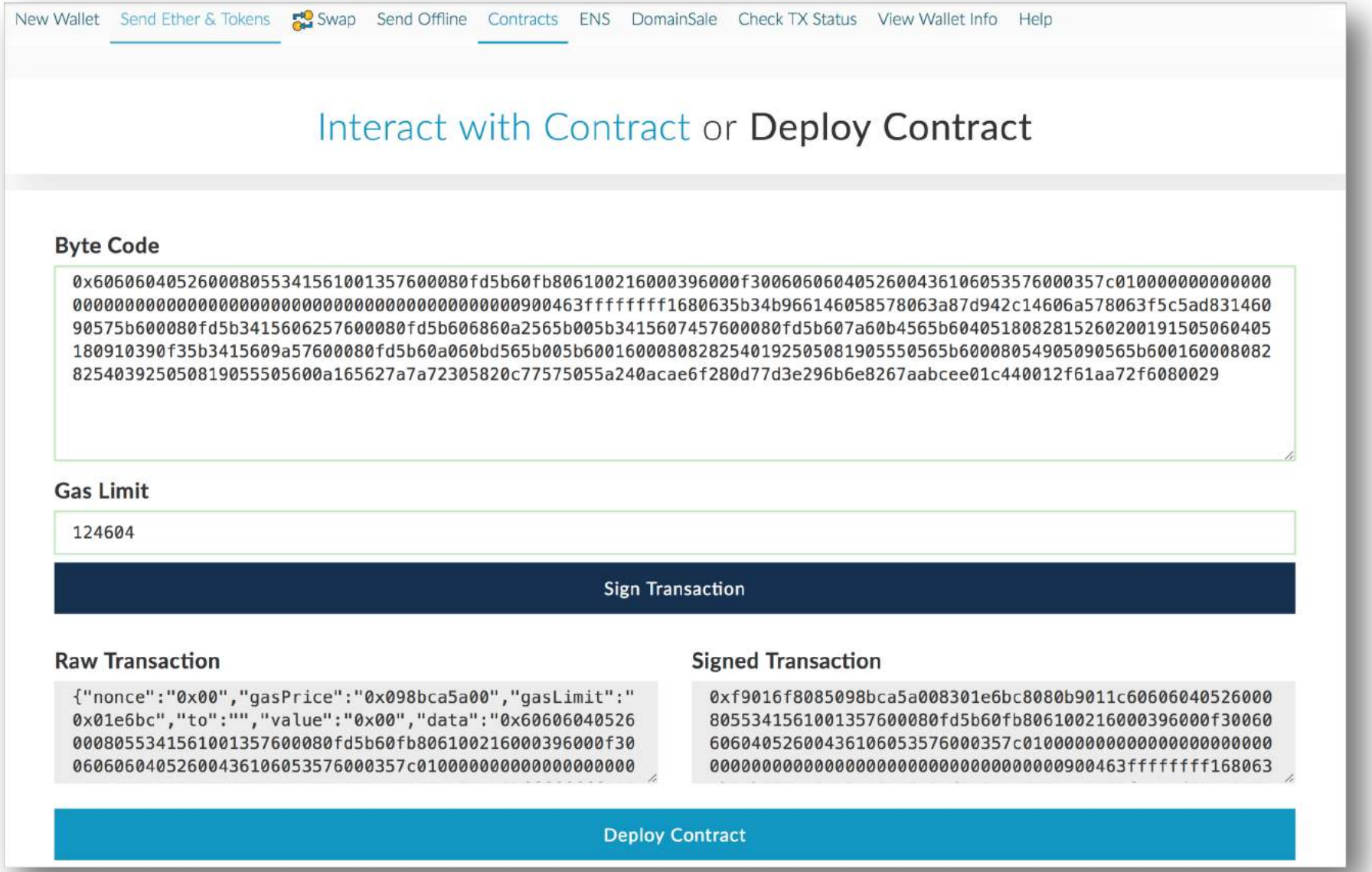
4. Click Unlock

5. Now you have access to your wallet



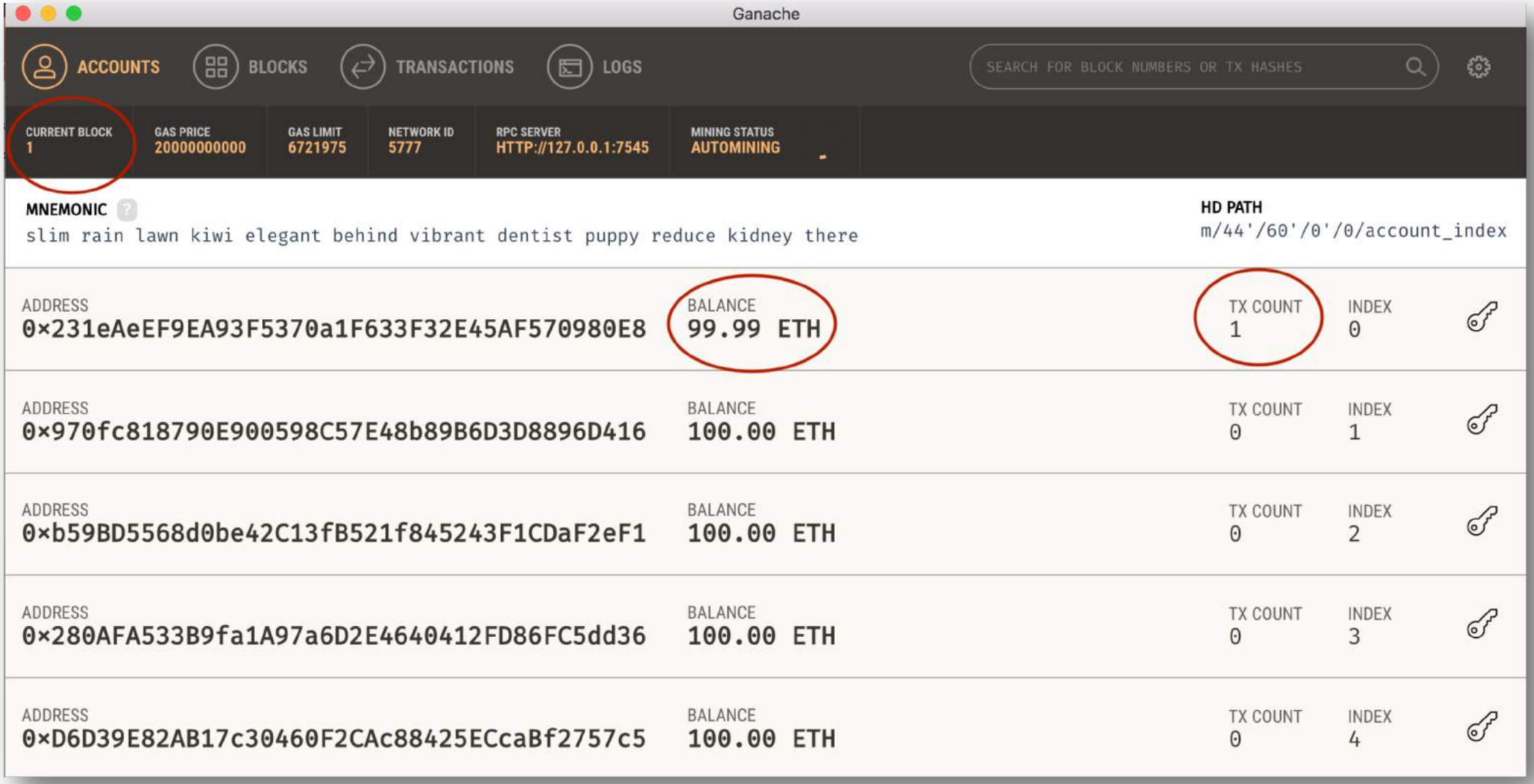
# MyEtherWallet

Click on *Sign Transaction* button to deploy your contract

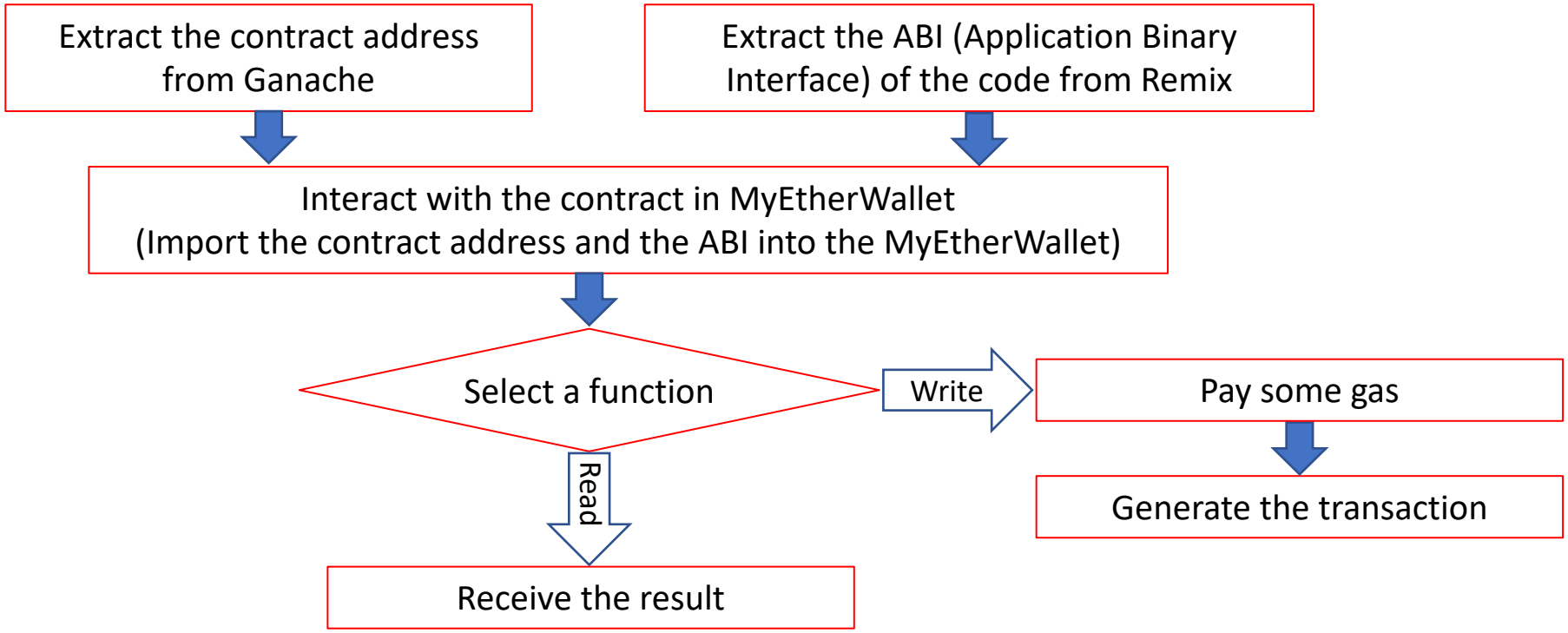


# Ganache

You can see now you have one transaction for your address and your balance has been changed because of the amount of gas you paid for creating the contract.

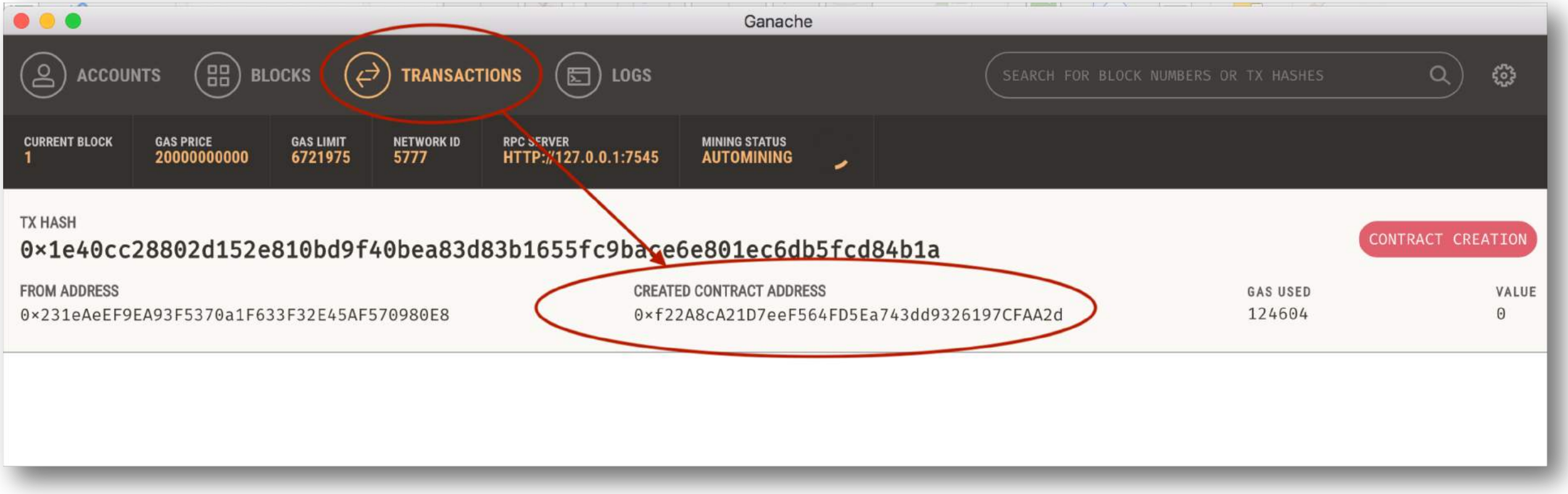


# Interacting with the smart contract



# Ganache

Transactions tab: Copy the created contract address



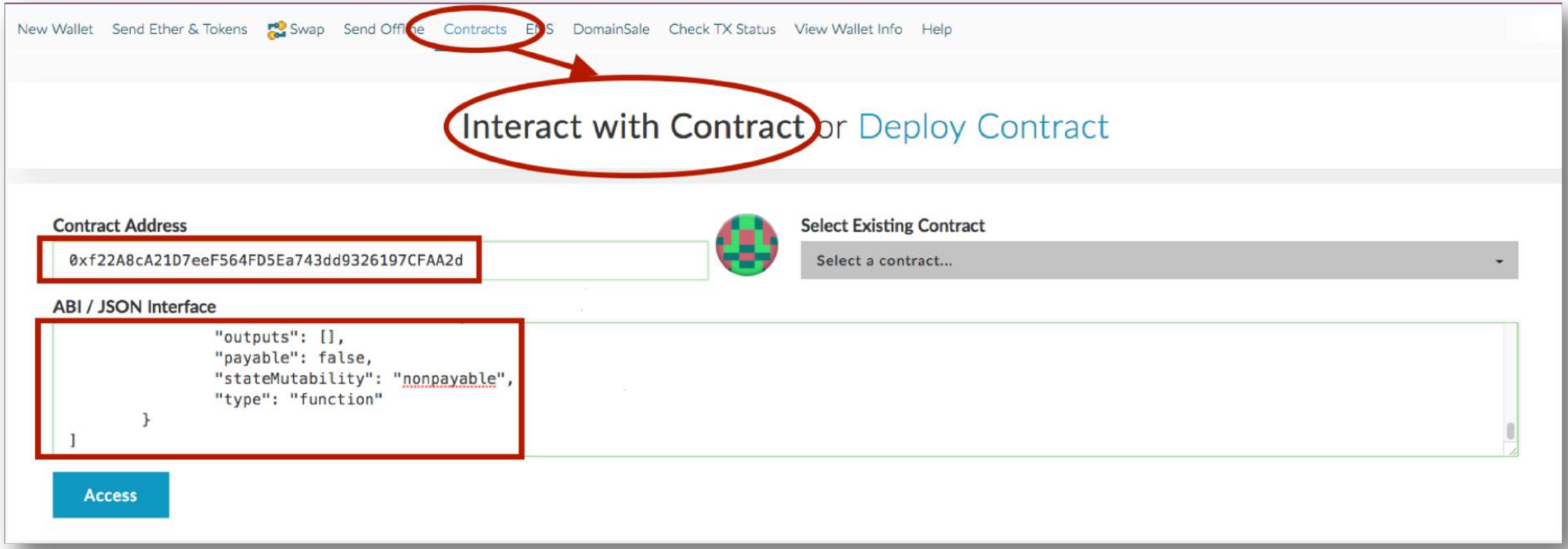
# Remix

Copy the ABI
(ABI is the interface that tells MyEtherWallet how to interact with the contract)

# MyEtherWallet

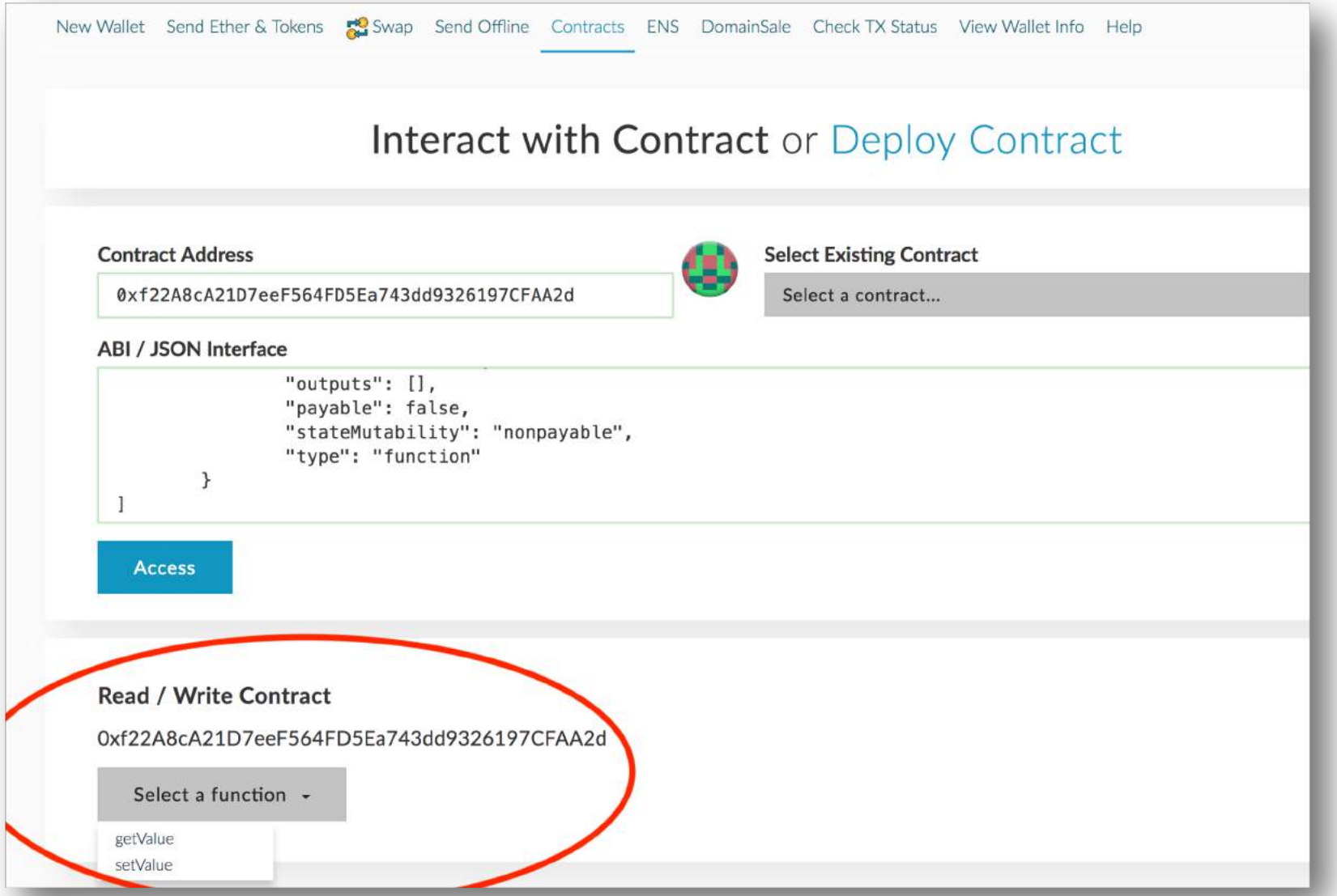
Contracts tab:

Interact with Contract = Paste the contract address from Ganache and the ABI from Remix



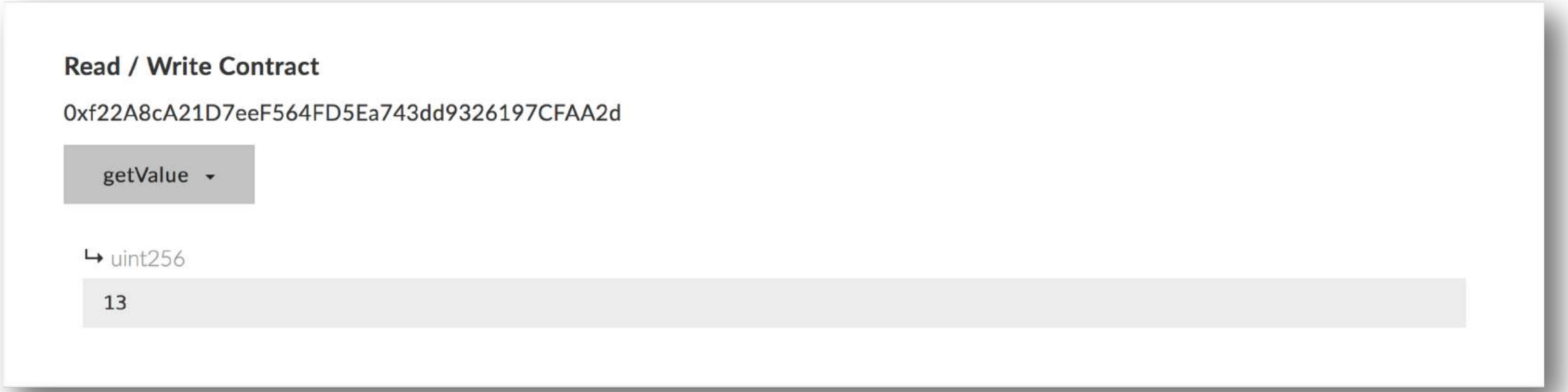
# MyEtherWallet

You now can interact with the contract by selecting a function and invoking it



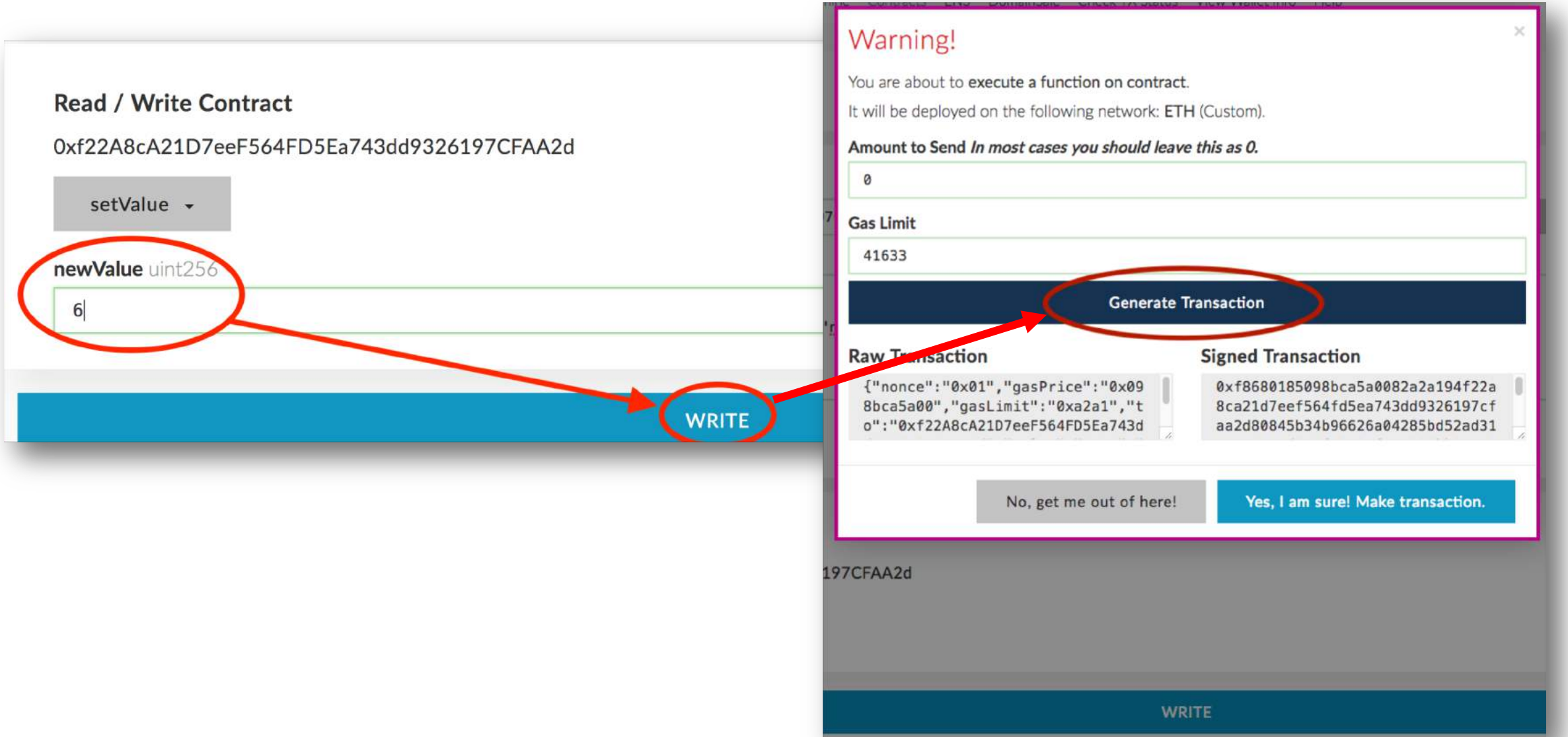
# MyEtherWallet

If you select the getValue function you will receive the value without paying any gas
(There is no operation cost for getting information)



# MyEtherWallet

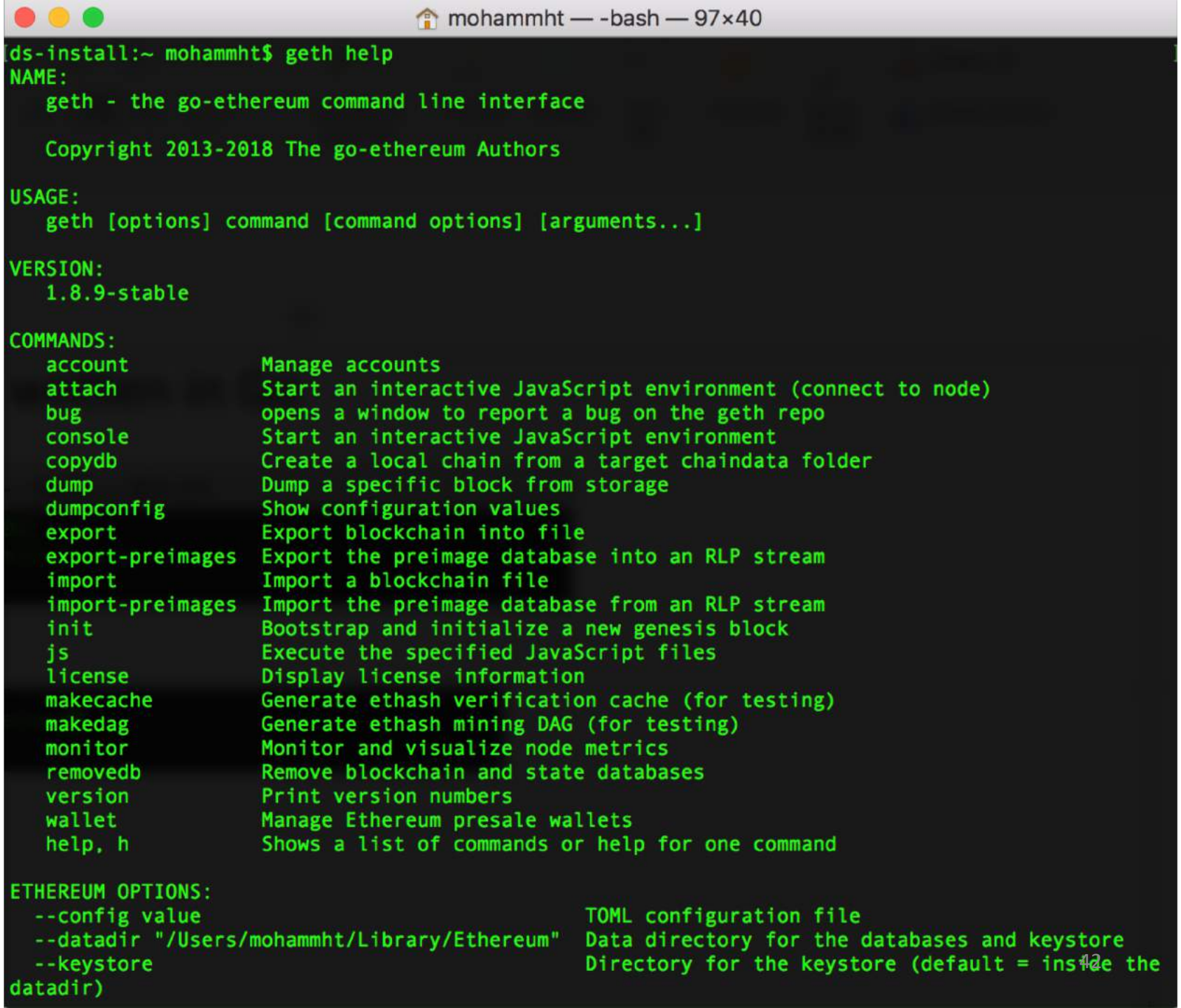
If you choose a function that updates the state of the contract, you will need to pay gas for it in a transaction.



# Create Custom Ethereum Blockchain

- Instead of using Ganache with its default properties for private blockchain you can run your own blockchain
- Install Geth: One of the implementations of Ethereum written in Go
- Create the genesis block
- Create storage of the blockchain
- Deploy blockchain nodes
- Connect MyEtherWallet to your blockchain to interact with it

# Geth help


mohammht — -bash — 97×40
ds-install:~ mohammht$ geth help
NAME:
geth - the go-ethereum command line interface
Copyright 2013-2018 The go-ethereum Authors
USAGE:
geth [options] command [command options] [arguments...]
VERSION:
1.8.9-stable
COMMANDS:
account Manage accounts
attach Start an interactive JavaScript environment (connect to node)
bug opens a window to report a bug on the geth repo
console Start an interactive JavaScript environment
copydb Create a local chain from a target chaindata folder
dump Dump a specific block from storage
dumpconfig Show configuration values
export Export blockchain into file
export-preimages Export the preimage database into an RLP stream
import Import a blockchain file
import-preimages Import the preimage database from an RLP stream
init Bootstrap and initialize a new genesis block
js Execute the specified JavaScript files
license Display license information
makecache Generate ethash verification cache (for testing)
makedag Generate ethash mining DAG (for testing)
monitor Monitor and visualize node metrics
removedb Remove blockchain and state databases
version Print version numbers
wallet Manage Ethereum presale wallets
help, h Shows a list of commands or help for one command
ETHEREUM OPTIONS:
--config value TOML configuration file
--datadir "/Users/mohammht/Library/Ethereum" Data directory for the databases and keystore
--keystore Directory for the keystore (default = inside the
datadir)

# Genesis block

- The first block in the chain and a json file that stores the configuration of the chain

genesis.json — Ethereum_Project

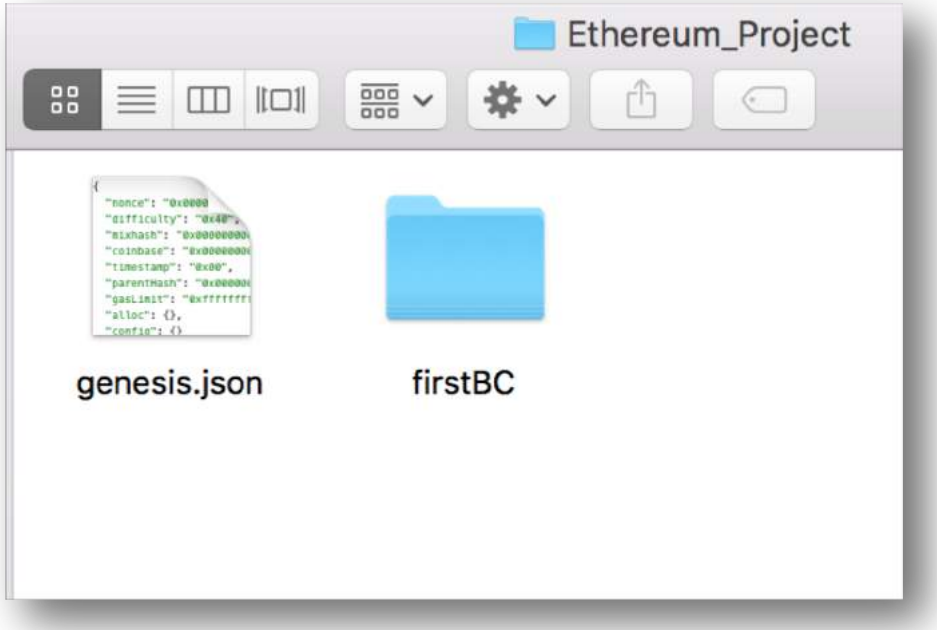
```
{
  "nonce": "0x0000000000000042",
  "difficulty": "0x40",
  "mixhash": "0x0000000000000000000000000000000000000000000000000000000000000000",
  "coinbase": "0x0000000000000000000000000000000000000000",
  "timestamp": "0x00",
  "parentHash": "0x0000000000000000000000000000000000000000000000000000000000000000",
  "gasLimit": "0xffffffffffffff",
  "alloc": {},
  "config": {}
}
```

- Create and store the file as genesis.json

# Create the storage of the blockchain

- Go to the directory of the genesis.json file
- Specify directory of your blockchain
- Create the storage from the genesis block

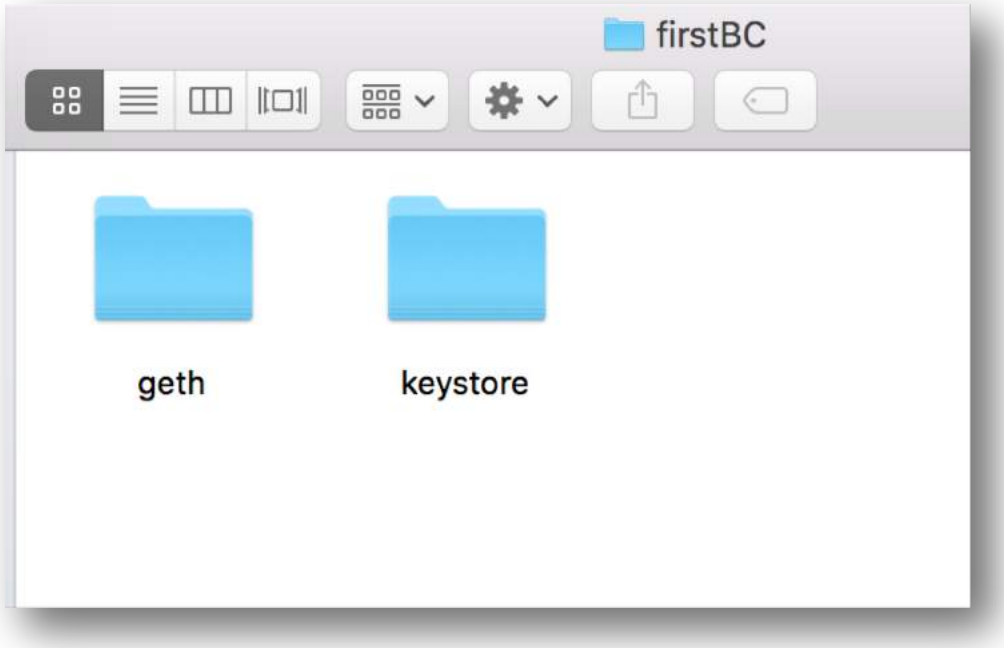
```
[ds-install:Documents mohammht$ cd Ethereum_Project/
ds-install:Ethereum_Project mohammht$ geth --datadir firstBC init genesis.json
```




Folder name of your blockchain

# Inside the Blockchain Folder

- geth folder: Store your database
- keystore: Store your Ethereum accounts



# Start the Ethereum peer node

- Start the blockchain

```
geth --datadir fistBC --networkid 100 console
```

- Networkid provides privacy for your network.
- Other peers joining your network must use the same networkid.

# Blockchain started

- Type *admin.nodeInfo* to get the information about your current node

```
> admin.nodeInfo
{
  enode: "enode://4561ccdd7fdf3f0bdbc903b7bef7d472e136fe2b63012151a1dd3c27e52f49bda2ef66631e67022
b7ca7b9fba06bb0eda8b47210b198f3eeff7e67414d695ed6@[::]:30303",
  id: "4561ccdd7fdf3f0bdbc903b7bef7d472e136fe2b63012151a1dd3c27e52f49bda2ef66631e67022b7ca7b9fba0
6bb0eda8b47210b198f3eeff7e67414d695ed6",
  ip: "::",
  listenAddr: "[::]:30303",
  name: "Geth/v1.8.9-stable/darwin-amd64/go1.10.2",
  ports: {
    discovery: 30303,
    listener: 30303
  },
  protocols: {
    eth: {
      config: {
        byzantiumBlock: 4370000,
        chainId: 1,
        daoForkBlock: 1920000,
        daoForkSupport: true,
        eip150Block: 2463000,
        eip150Hash: "0x2086799aeebeae135c246c65021c82b4e15a2c451340993aacfd2751886514f0",
        eip155Block: 2675000,
        eip158Block: 2675000,
        ethash: {},
        homesteadBlock: 1150000
      },
      difficulty: 17179869184,
      genesis: "0xd4e56740f876aef8c010b86a40d5f56745a118d0906a34e69aec8c0db1cb8fa3",
      head: "0xd4e56740f876aef8c010b86a40d5f56745a118d0906a34e69aec8c0db1cb8fa3",
      network: 100
    }
  }
}
>
```

# Create an account

- Type *personal.newAccount* to create as many accounts as you need

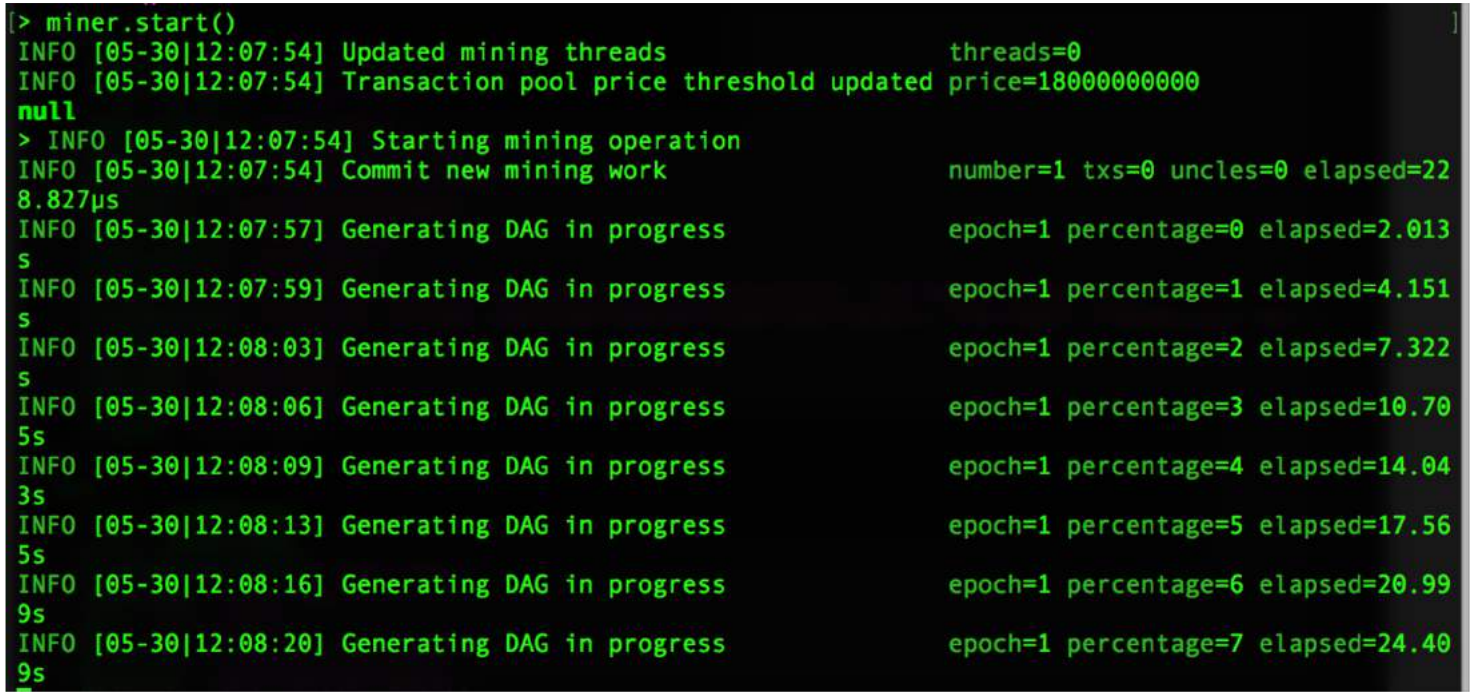
```
> personal.newAccount('Type your password here')
"0xa78eb41a10f096d4d8c4c9ca5196427aaa3fdb33"
>
```

- See the created account(s)

```
> eth.accounts
["0xa78eb41a10f096d4d8c4c9ca5196427aaa3fdb33", "0x354d952e40fc35a47562d479c86e41f6623e5f8c"]
>
```

# Mining

- Type *miner.start()* to start mining




- Type *miner.stop()* to stop mining

# Thank You!

# Any Questions?

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