Emerging Technologies for the Circular Economy

Lecture 10: Ethereum and Smart Contracts Part 2

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- Updated versions of these slides will be available in our Github repository.

NEWS/UPDATES

Course Evaluation – QR Code and Link

- Link: Click Me

Invited Lectures

- 06.07.2022 → Invited Lecture (Dr. Ulrich Gallersdörfer)
- 13.07.2022 → Invited Lecture (Prof. Dr. Steffen Herbold)

Disclaimer and Further Resources

- The lecture slides (Figures are often copied directly) are based on the course Blockchain-based Systems Engineering from TU Munich, which is distributed under a CC-BY-SA 4.0 license
- All their slides, exercises and further information are available online: https://github.com/sebischair/bbse

ETHEREUM DECENTRALIZED APPLICATIONS

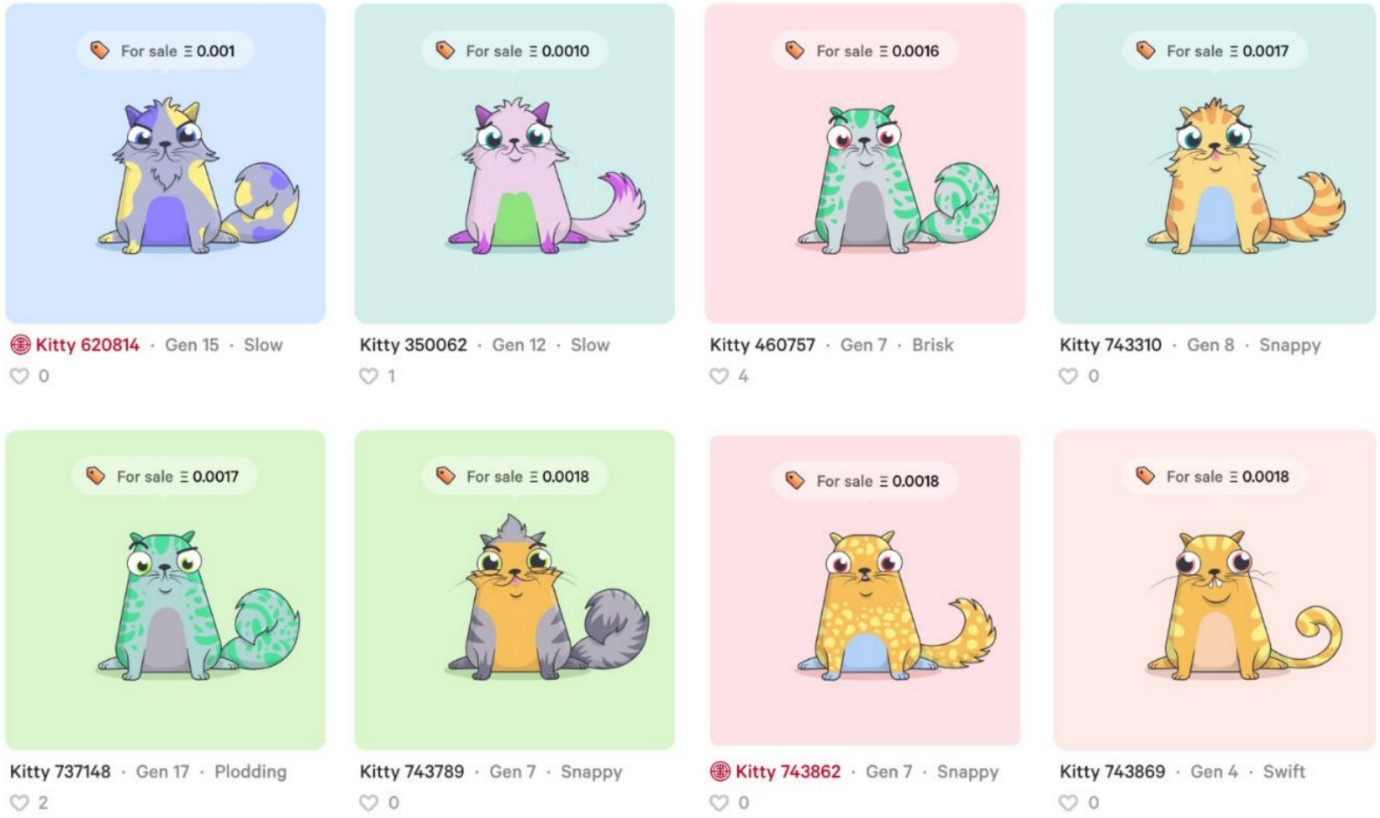
Motivation

- Direct interaction with smart contracts is complicated
- Smart contracts do not provide a graphical user interface on their own
- Programming knowledge or special tools are required to make function calls

U. Gallersdörfer, P. Holl, and F. Matthes, “Blockchain-based Systems Engineering – Lecture Slides,” Oct 2019. [Online]. Available: https://github.com/sebischair/bbse

Motivation

- Building UIs on top of smart contracts to make them accessible to average users
- The UI abstracts the complicated function calls and allows a user to interact with them just like with a regular (web) application



U. Gallersdörfer, P. Holl, and F. Matthes, “Blockchain-based Systems Engineering – Lecture Slides,” Oct 2019. [Online]. Available: https://github.com/sebischair/bbse

Definition

- In the community, multiple definitions for dApps exist
- In general, a dApp is not necessarily based on a Blockchain, e.g., BitTorrent is a decentralized P2P application without any blockchain involved
- In this lecture, we consider a dApp as a decentralized application (in the terms of blockchain) based on one or more smart contracts and accessible via a dedicated user interface
- In particular, the following properties must hold:
  - The core data records of the application must be stored on the blockchain
  - The functions that change the core data records must be executed on the blockchain, i.e. via a smart contract

Benefits

The meaningfulness of implementing a distributed application is dependent on the concrete use case and / or the problem that is being solved.

Some general properties of Ethereum-based dApps:

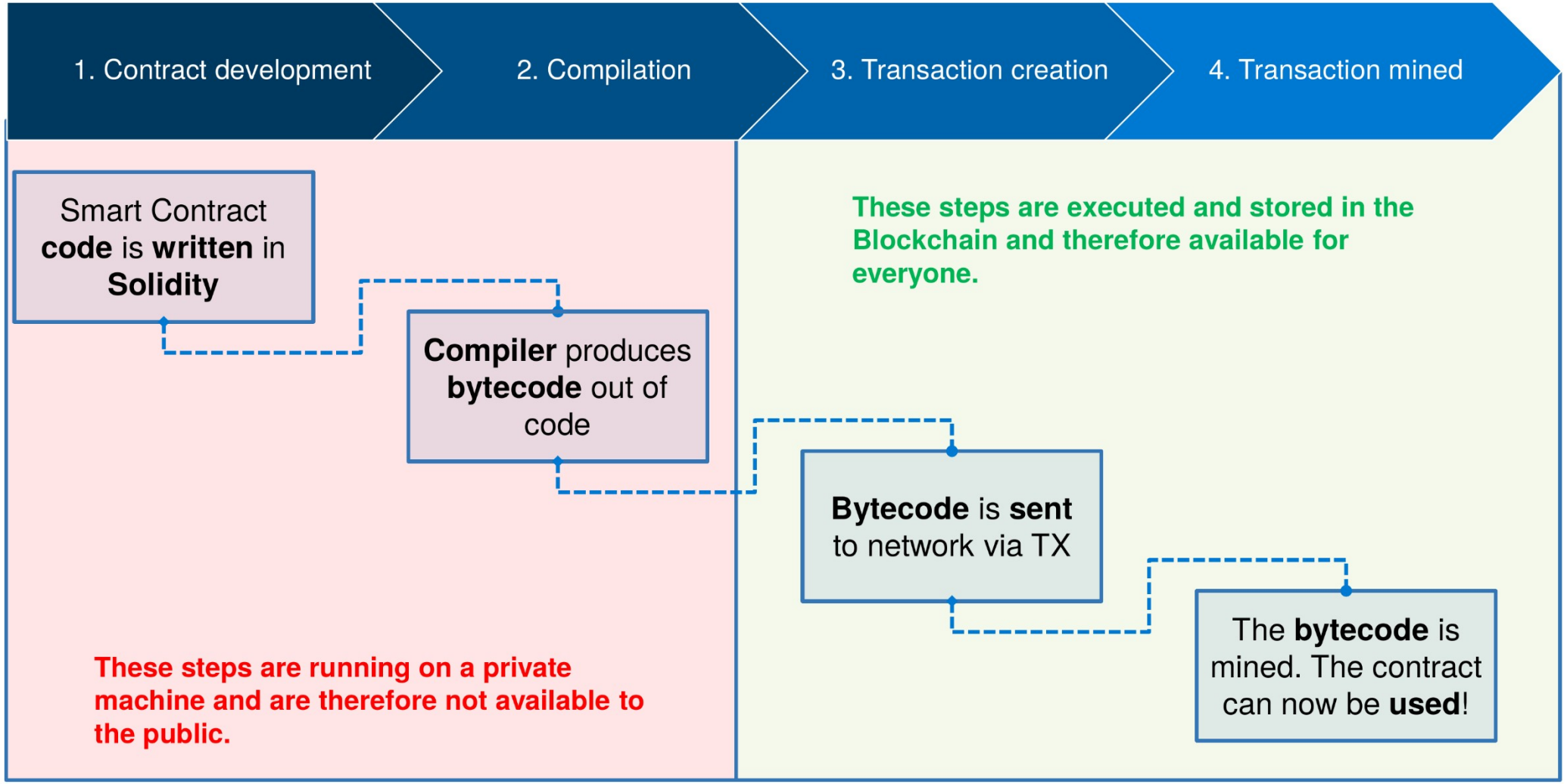
- **Trust**
  - The source code of any verified smart contract can be checked by anyone.
- **Payment**
  - Payment is implemented by default since anyone can send / receive Ether.
- **Accounts**
  - dApps can be build on top of Ethereum’s account system, so there is no need to implement an additional user account management system.
- **Storage**
  - dApps can leverage the Blockchain as common (expensive) data storage.

Drawbacks

Decentralized applications have also some intrinsic disadvantages:

- **Costs**
  - Any state change and computation costs money. For that reason, only mission-critical data and functionality should leverage the blockchain.
- **Time**
  - The current block time of Ethereum is around 14 seconds, i.e., it takes at least 14 seconds from the function call to the definite result of it.
- **Availability**
  - In theory, availability is one of the key advantages of dApps. However, in high transaction scenarios (e.g. the release of crypto kitties) it is possible that the network throttles and is not able to process function calls anymore.
- **Transparency**
  - Without third party services, it is impossible to access and verify a Smart Contract source code.

Recap – Deploy Smart Contract on Chain



U. Gallersdörfer, P. Holl, and F. Matthes, “Blockchain-based Systems Engineering – Lecture Slides,” Oct 2019. [Online]. Available: https://github.com/sebischair/bbse

TU Clausthal

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Bytecode Source Code on Chain

Switch To Opcodes View | Find Similiar Contracts

0x6080604052600436106100995760003575c0100000000000000000000000000000000000000000000000000000000900463ffffffff16806306fdde031461009e578063095ea7b31461012e57806318160ddd1461019357806323b87
2dd146101be578063313ce567146102435780637
0a0823114610274578063
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65b6001805460018160011615610100020316600290048060
1f0160208091040260200160405190810160405280929190

U. Gallersdörfer, P. Holl, and F. Matthes, “Blockchain-based Systems Engineering – Lecture Slides,” Oct 2019. [Online]. Available: https://github.com/sebischair/bbse

Publicly Available Source Code

Etherscan.io is a service which also verifies source codes and the respective byte code.

Contract Source Code Verified (Exact Match)

Contract Name:	SparkleCrowdsale	Optimization Enabled:	No
Compiler Text:	v0.4.25+commit.59dbf8f1	Runs (Optimiser):	200

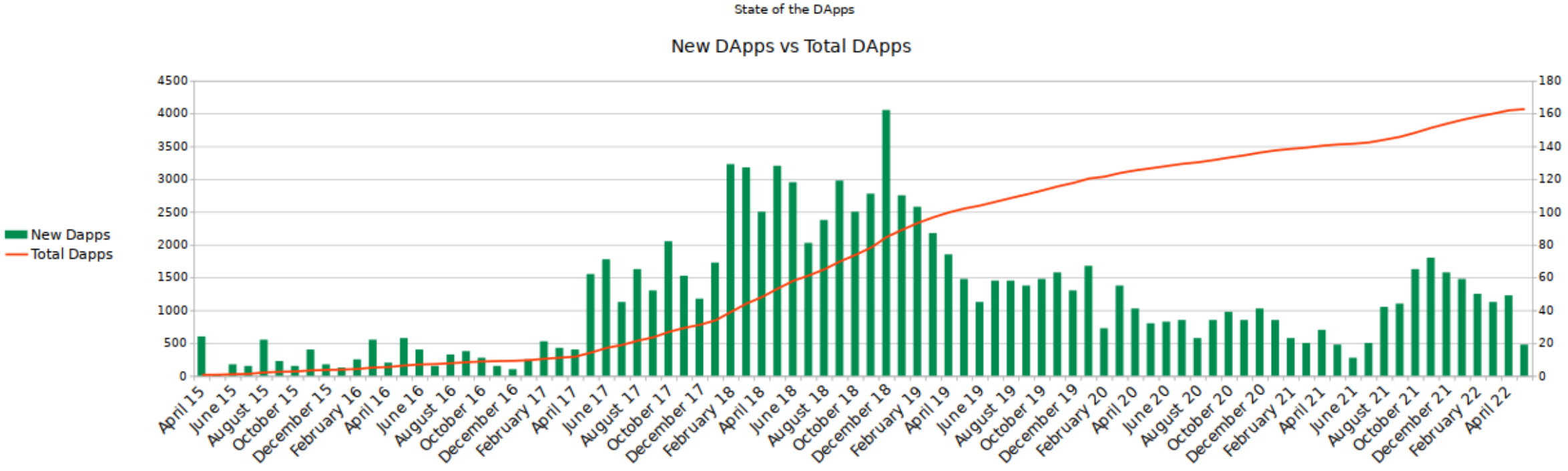
Contract Source Code </> Copy Find Similiar Contracts

```
1  pragma solidity 0.4.25;
2
3  // File: openzeppelin-solidity/contracts/ownership/Ownable.sol
4
5  /**
6   * @title Ownable
7   * @dev The Ownable contract has an owner address, and provides basic authorization control
8   * functions, this simplifies the implementation of "user permissions".
9   */
10 contract Ownable {
11   address private _owner;
12
13   event OwnershipTransferred(
14     address indexed previousOwner,
15     address indexed newOwner
16   );
17
18   /**
19    * @dev The Ownable constructor sets the original `owner` of the contract to the sender
20    * account.
21    */
22   constructor() internal {
23     _owner = msg.sender;
24     emit OwnershipTransferred(address(0), _owner);
25   }
```

U. Gallersdörfer, P. Holl, and F. Matthes, “Blockchain-based Systems Engineering – Lecture Slides,” Oct 2019. [Online]. Available: https://github.com/sebischair/bbse

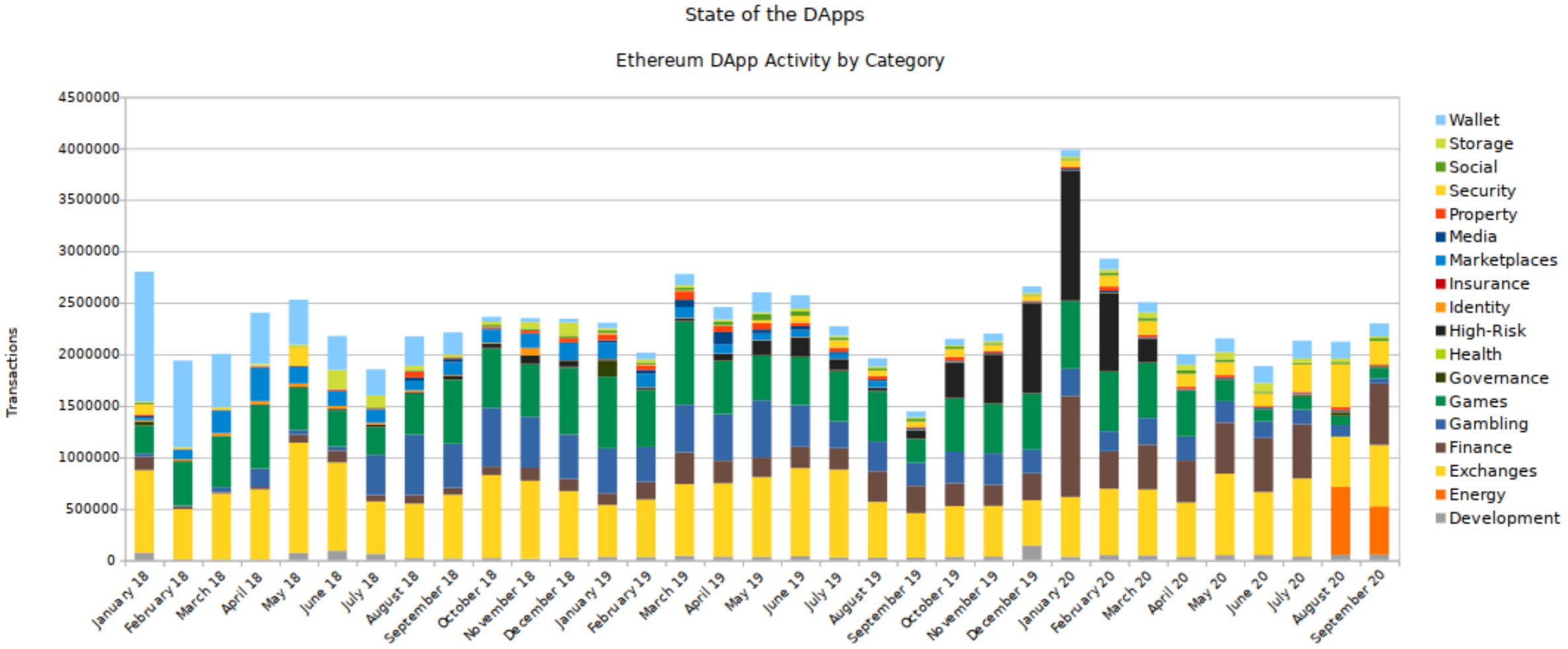
Web-based Ethereum dApps

- State of the Dapps (Link) is a curated and community-driven directory of decentralized applications.
- As of May 2022, the directory lists 4073 DApps (2970 Ethereum DApps).



Graph recreated based on data from https://www.stateofthedapps.com/stats

dApps Statistics – Transactions per dApp



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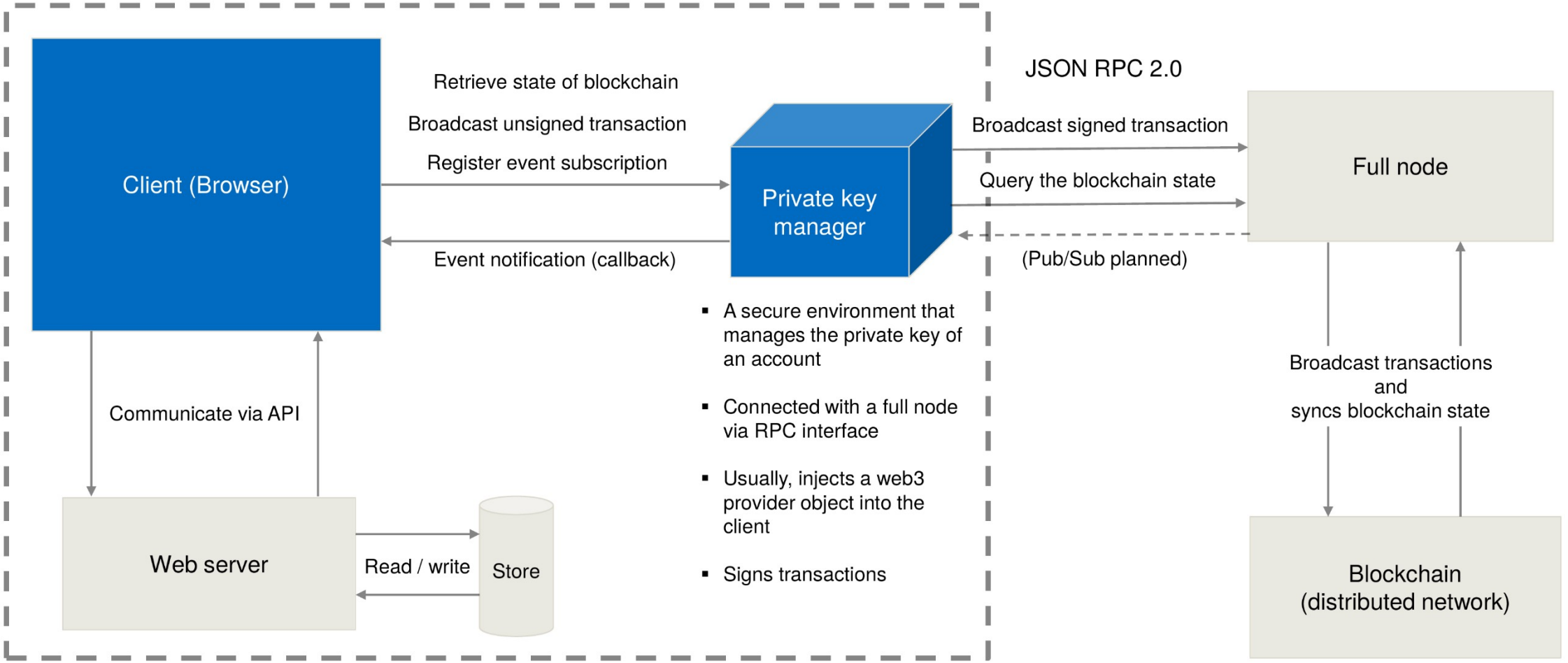
Architecture of Web-based dApps



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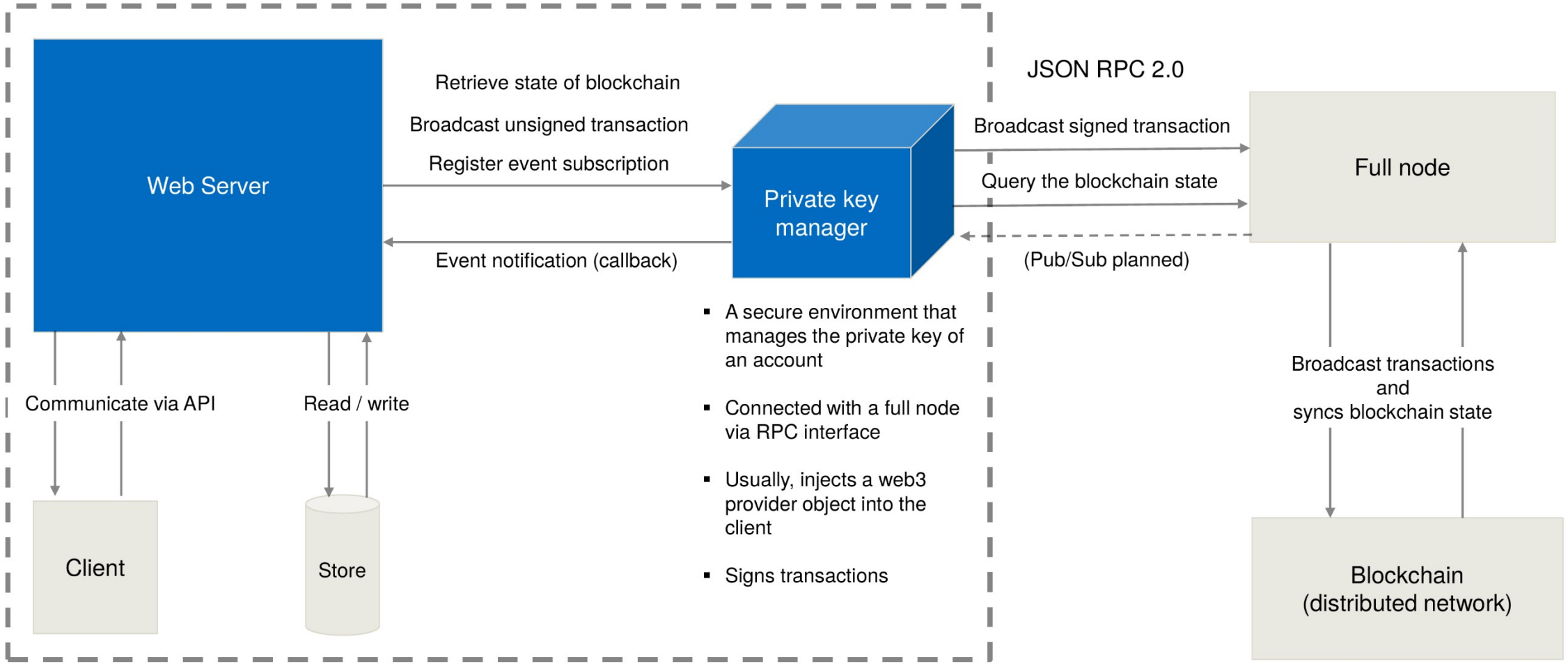
Architecture of Web-based dApps



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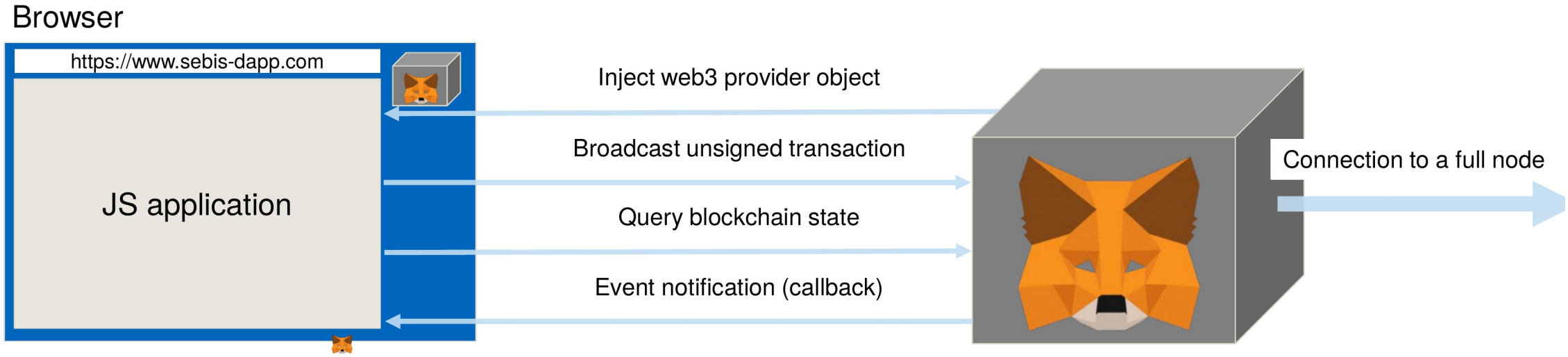
Metamask



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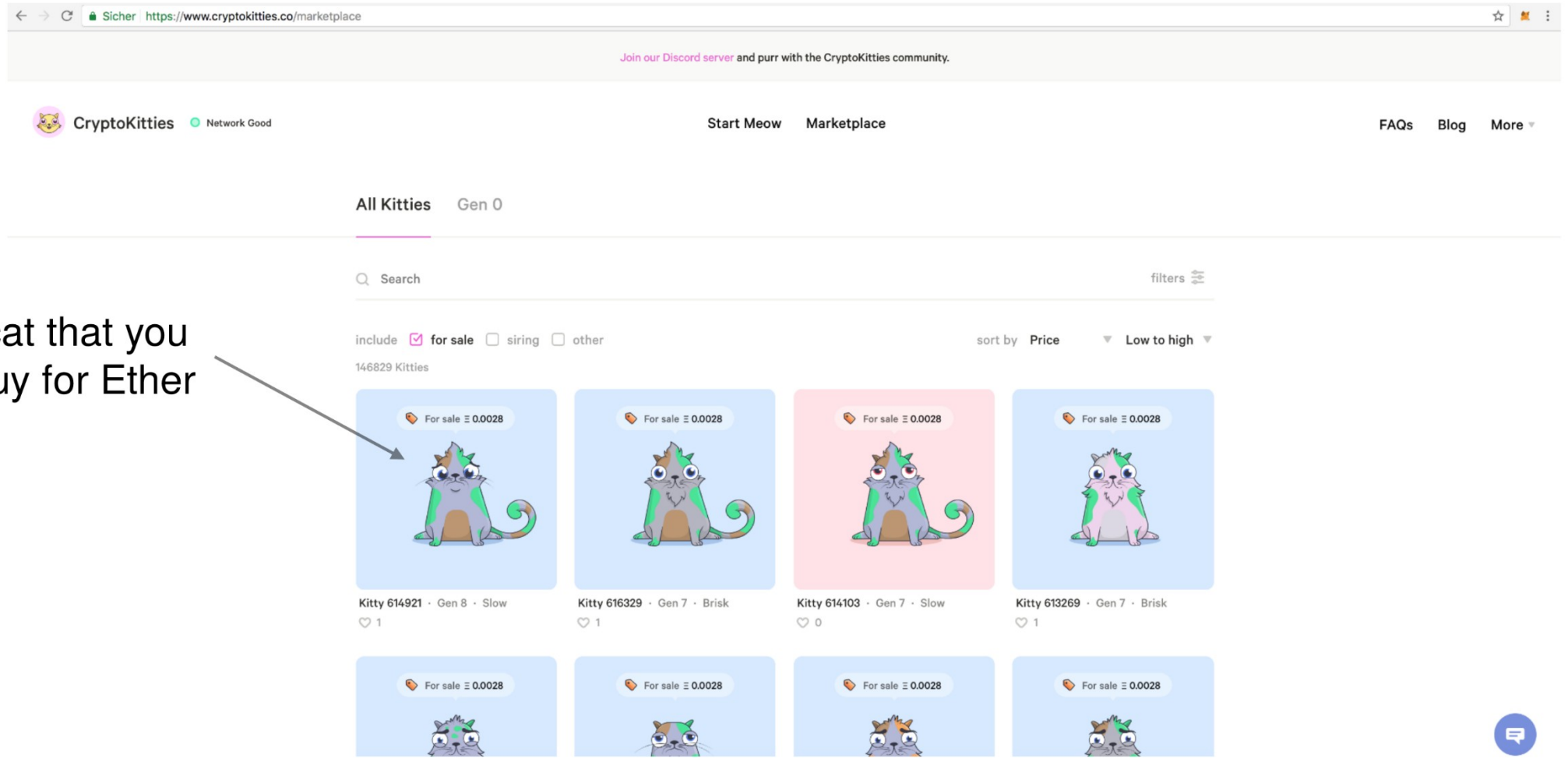
Example: CryptoKitties



Select a cat that you want to buy for Ether

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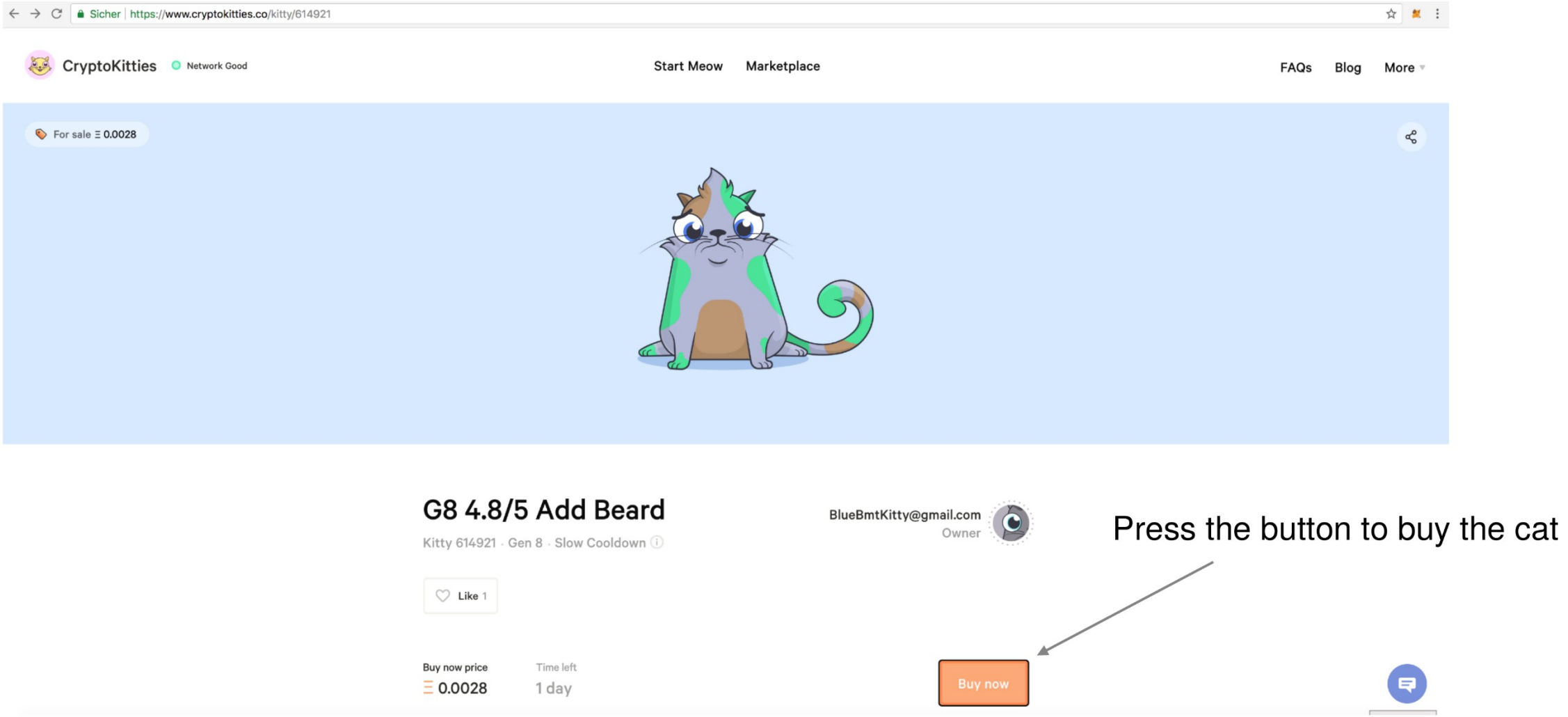
Example: CryptoKitties



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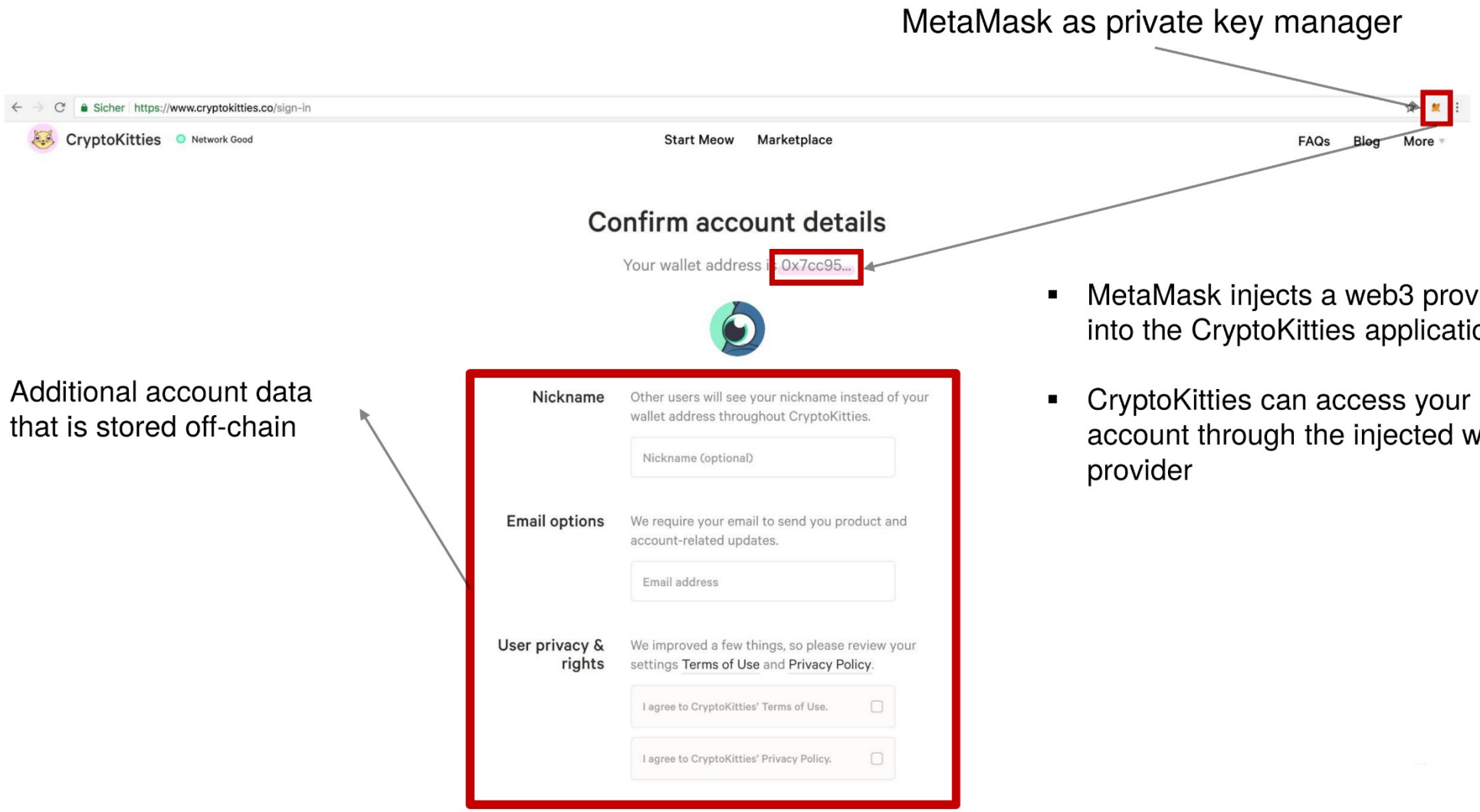
Example: CryptoKitties



- Additional account data that is stored off-chain

- MetaMask injects a web3 provider into the CryptoKitties application
- CryptoKitties can access your account through the injected web3 provider

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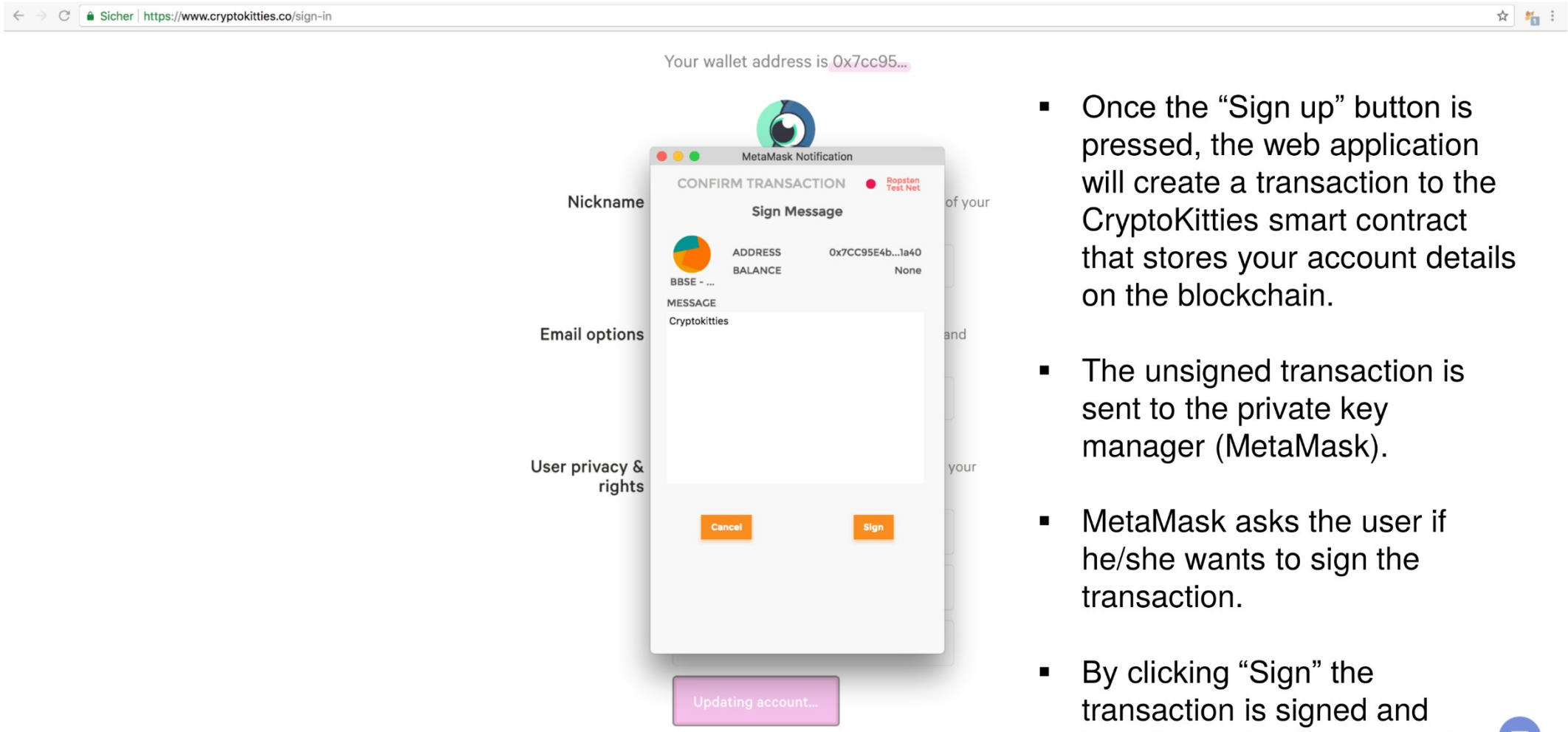
Example: CryptoKitties



- Once the “Sign up” button is pressed, the web application will create a transaction to the CryptoKitties smart contract that stores your account details on the blockchain.
- The unsigned transaction is sent to the private key manager (MetaMask).
- MetaMask asks the user if he/she wants to sign the transaction.
- By clicking “Sign” the transaction is signed and broadcasted to the network

U. Gallersdörfer, P. Holl, and F. Matthes, “Blockchain-based Systems Engineering – Lecture Slides,” Oct 2019. [Online]. Available: https://github.com/sebischair/bbse

Deployment Lifecycle

- Compilation of the Solidity source code
- Generate an **Application Binary Interface** (ABI) in JSON that can be used by other applications to interact with the contract

HelloWorld.sol

```
contract HelloWorld {
        function greet() public returns(bytes32) {
                return "Hello World!";
        }
}
```

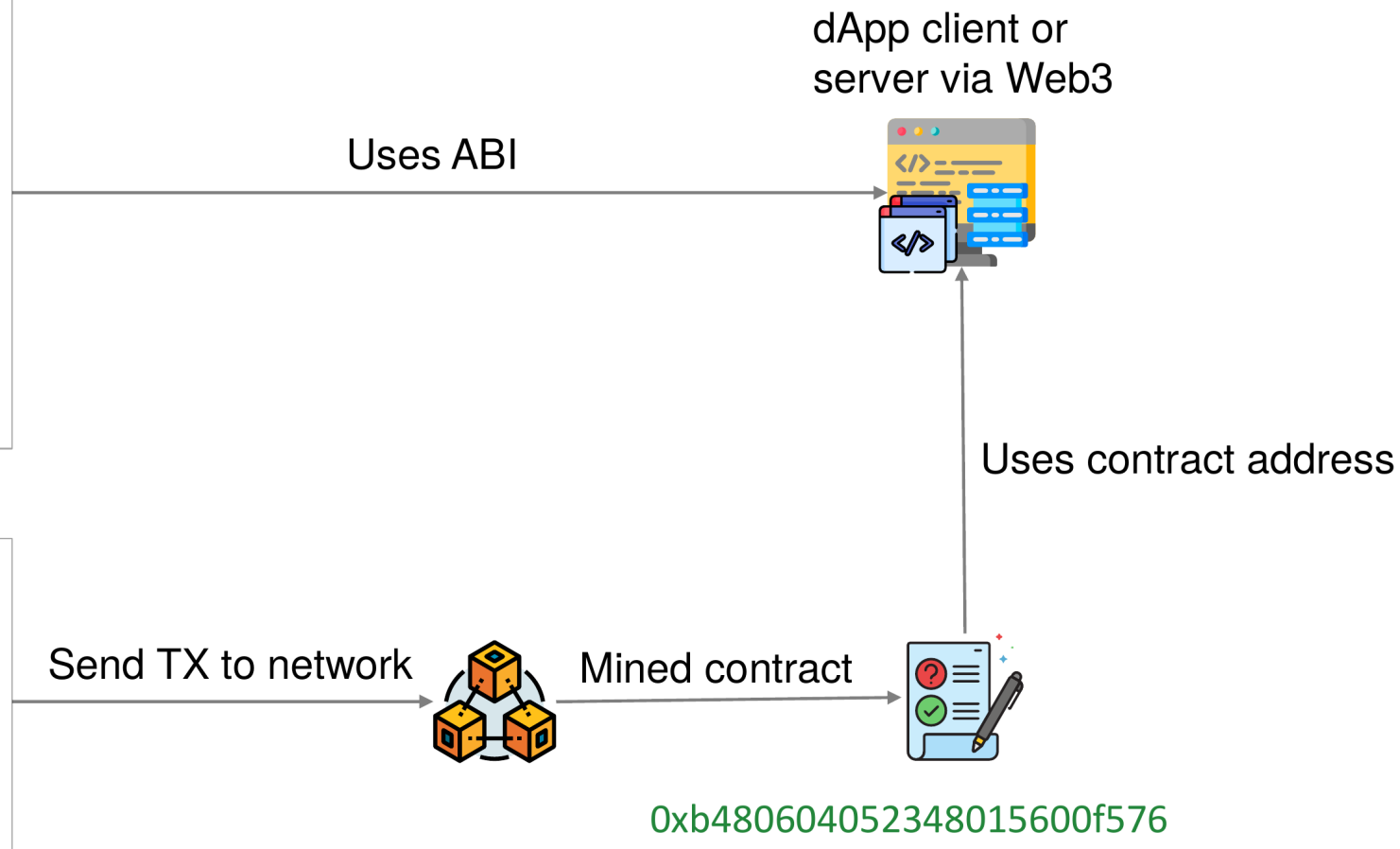
U. Gallersdörfer, P. Holl, and F. Matthes, “Blockchain-based Systems Engineering – Lecture Slides,” Oct 2019. [Online]. Available: https://github.com/sebischair/bbse

Deployment Lifecycle


```
[
  {
    "constant": false,
    "inputs": [],
    "name": "greet",
    "outputs": [
      {
        "name": "",
        "type": "bytes32"
      }
    ],
    "payable": false,
    "stateMutability": "nonpayable",
    "type": "function"
  }
]
```



```
608060405234801560f57600080fd5b5060ba8061001e6000396
000f3fe6080604052600436106039576000357c01000000000000
0000000000000000000000000000000000000000000090048063c
fae321714603e575b600080fd5b3480156049576000 80fd5b50605
06066565b604051808281526020019150506040518091039 0f35b
60007f48656c6c6f20576f726c6421000000000000000000000000
0000000000000000090509056fea165627a7a72305820a4741ad95
e951c73637b4a34111570c749d47ab815d9838dd50c29ed524020
560029
```

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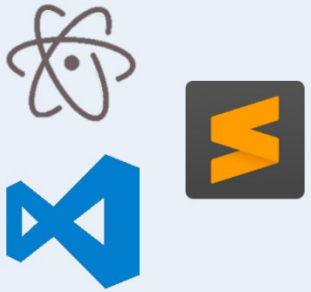
Development Tools

Local environment

IDE / Code editor



Artifacts

- Solidity source code files
- Test cases

Build management

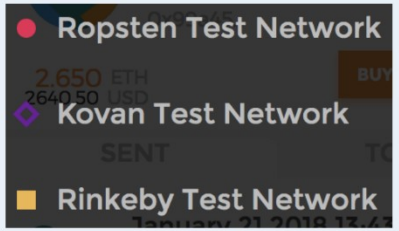
Artifacts

- Compiled .sol files / Bytecode
- Contract ABI / JSON

Network deployment

Local test network

Public test network



Main network

Artifacts

- Transaction for creating the contract
- An address for the contract if the creation was successful

U. Gallersdörfer, P. Holl, and F. Matthes, “Blockchain-based Systems Engineering – Lecture Slides,” Oct 2019. [Online]. Available: https://github.com/sebischair/bbse

Truffle – Development Framework for Smart Contracts

Truffle is a popular framework to facilitate the development of Ethereum smart contracts. It provides tools to compile, test and deploy Solidity contracts.

- Open source – Github
- Built-in network management that allows a developer to deploy a smart contract on various networks, e.g., live and test
- Web-pack like automated re-compilation on code change
- Provides project scaffolding

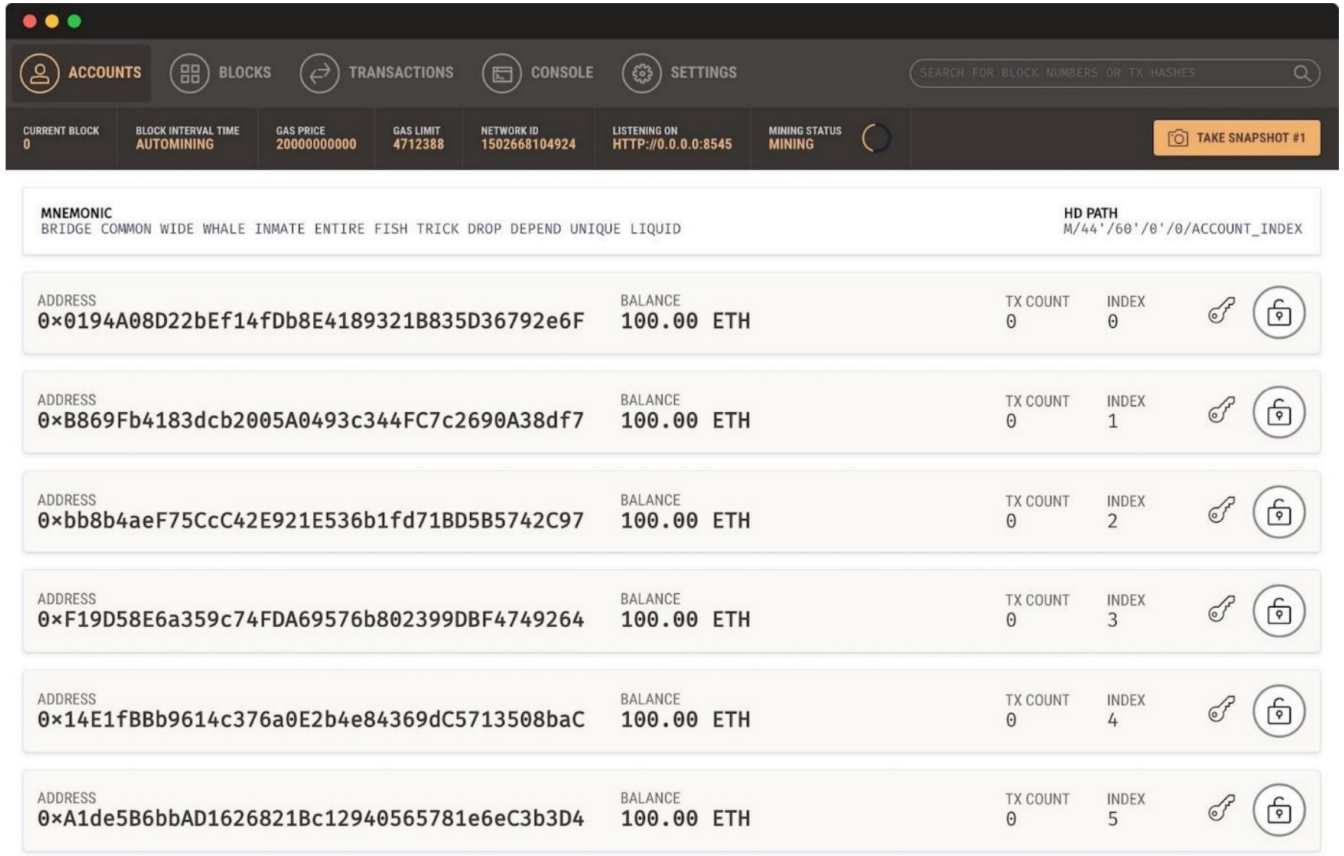
Ganache – Private Ethereum Test Network

Ganache is a local blockchain for Ethereum smart contract development. It can be used to deploy, simulate, and test smart contracts.

- Open source – Github
- Integrates a custom block explorer interface with additional debugging features.
- Uses workspaces to provide multiple Ethereum blockchains with different settings (blocktime etc.)
- Can be linked to Truffle projects to automate tests for smart contracts

Ganache – Private Ethereum Test Network

Ganache ships with a ready-made and developer friendly block explorer:



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Development Tools

Cloud environment

IDE / Code editor + Build management

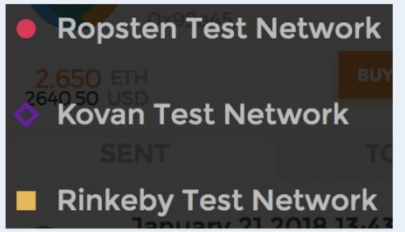
Artifacts

- Solidity source code files
- Compiled contracts bytecode
- Contract ABIs / JSON

Network deployment

Remix emulation

Public test network



Main network

Artifacts

- Transaction for creating the contract
- An address for the contract if the creation was successful

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Remix IDE

- Demo in Excercise Session

Test Networks – Ropsten

- Free to use
- Public
- Block time of ca. 30s
- Proof-of-Work consensus
- Geth and Parity compatibility
- Ether distribution via faucet – Link
- Anonymous

Test Networks – Rinkeby

- Free to use
- Public
- Block time of ca. 15s
- Proof-of-Authority consensus, i.e., one central instance decides what transaction will be mined.
- Geth only
- Ether distribution via faucet – Link
- Twitter or Facebook account required (Spam/DoS protection)

Test Networks – Kovan

- Free to use
- Public
- Block time of ca. 4s
- Proof-of-authority consensus, i.e., one central instance decides what transaction will be mined.
- Parity only
- Ether distribution via faucet – Link
- Github account required (Spam/DoS protection)

NOW WHAT?

Questions?