# Building Ethereum ĐApps in Java with web3j

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blk.io

# Content

- Blockchain fundamentals
- Ethereum
- web3j
- Smart contracts
- RxJava in web3j
- Quorum

# Schedule

- 09:00 - 09:45 Blockchain 101
- 09:45 - 10:30 Getting started with Ethereum
- **10:30 - 11:00 Break**
- 11:00 - 12:30 Ethereum and web3j
- **12:30 - 13:30 Lunch**
- 13:30 - 14:30 Smart contracts
- 14:30 - 15:00 RxJava
- **15:00 - 15:30 Break**
- 15:30 - 16:30 Quorum
- 16:00 - 17:00 Back to web3j & wrap up

# About me

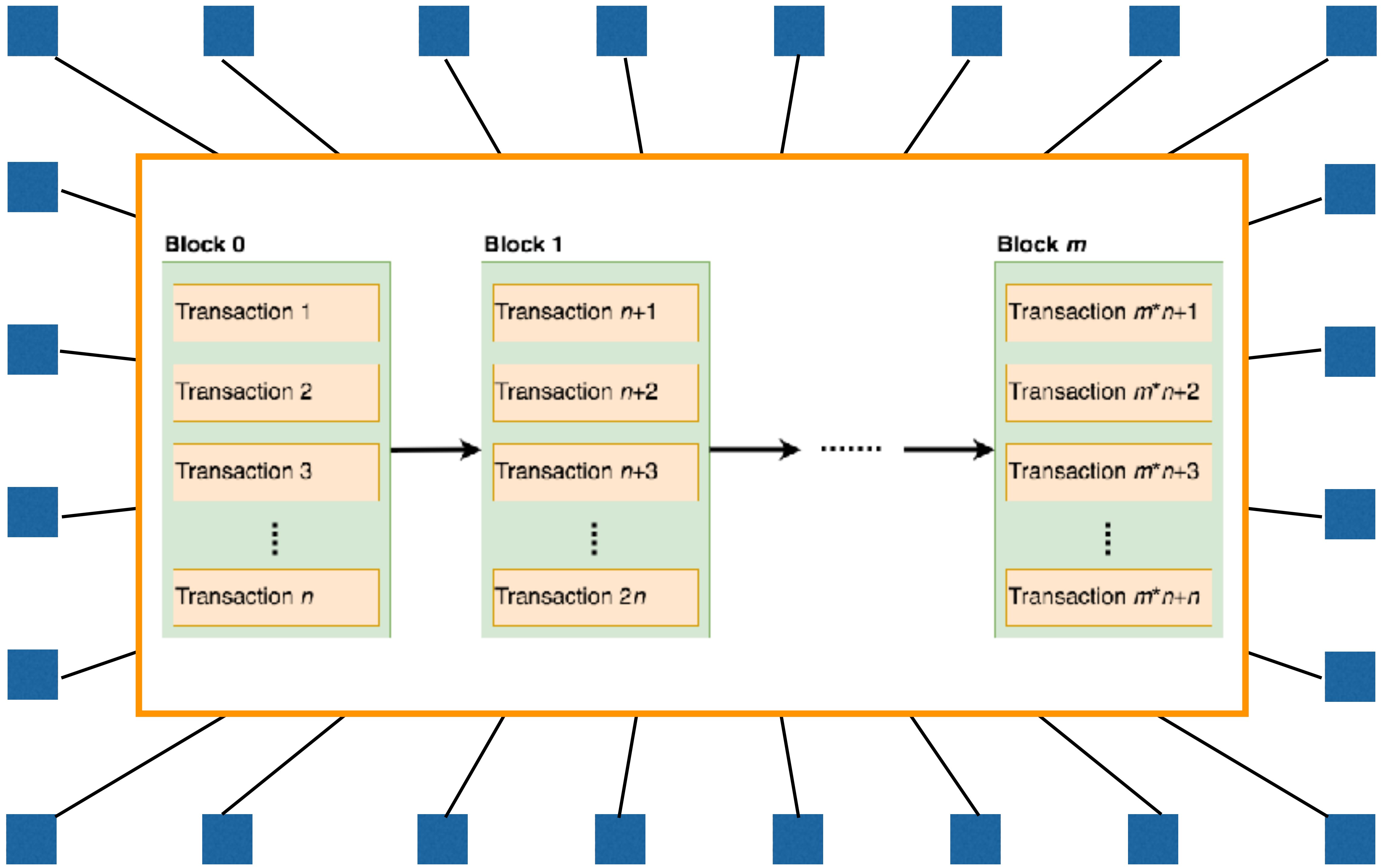
- Developed trading/risk/regulatory platforms on the JVM
- Co-founded a couple of fintech startups in Australia
- web3j author
- Founded blk.io this year
- Enterprise Ethereum Alliance member
  - EEA London organiser
  - Co-chair of integration and tools working group
  - Co-chair of Quorum working group
- Bearish on ICOs…

## About you…

- What do you want to get out of today?

## Blockchain 101

# Decentralised, immutable data store



# Blockchain technologies

bitcoin

2008

2013

ethereum

ripple

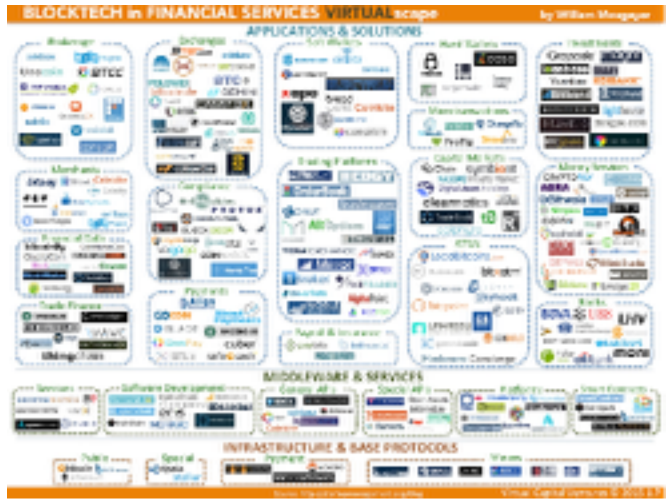
Digital Asset Holdings

Chain

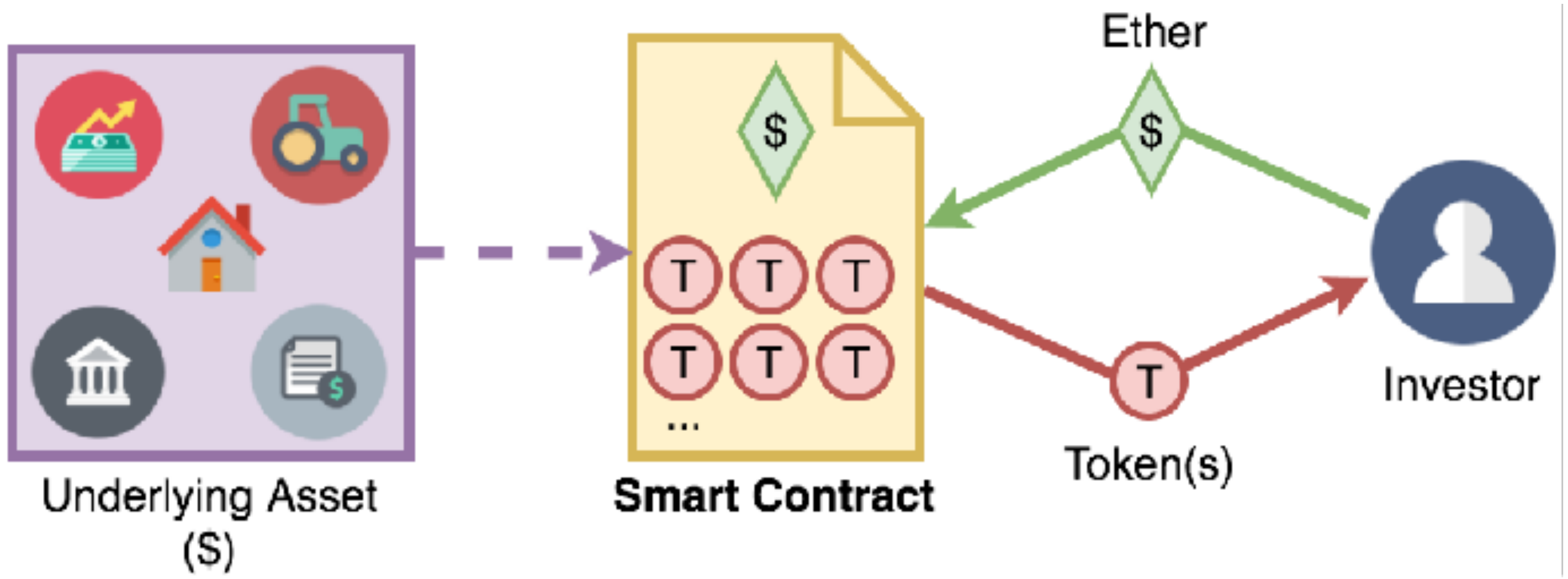
HYPERLEDGER PROJECT

2014

2015+


BLOCKTECH in FINANCIAL SERVICES VIRTUALscape
APPLICATIONS & SOLUTIONS
MIDDLEWARE & SERVICES
INFRASTRUCTURE & BASE PROTOCOLS

# Distributed Ledger Technology



- Smart Contracts

- Public and private

- Consensus mechanisms

# Use cases

- Smart contracts
- Sharing inter-organisational data
- Digital asset registry
- Identity management
- IoT device data

## Considerations

- Public or private?
- Wallet security
- Cross chain interoperability
- Blockchain skills shortage

# Practicalities

- Rapidly changing
- Limited scalability
- Network stability
- Immature tooling
- New architectural paradigms

## Platforms

ethereum

R3 CEV

Chain

J.P.Morgan

HYPERLEDGER PROJECT

Digital Asset Holdings

Microsoft

CONSENSYS

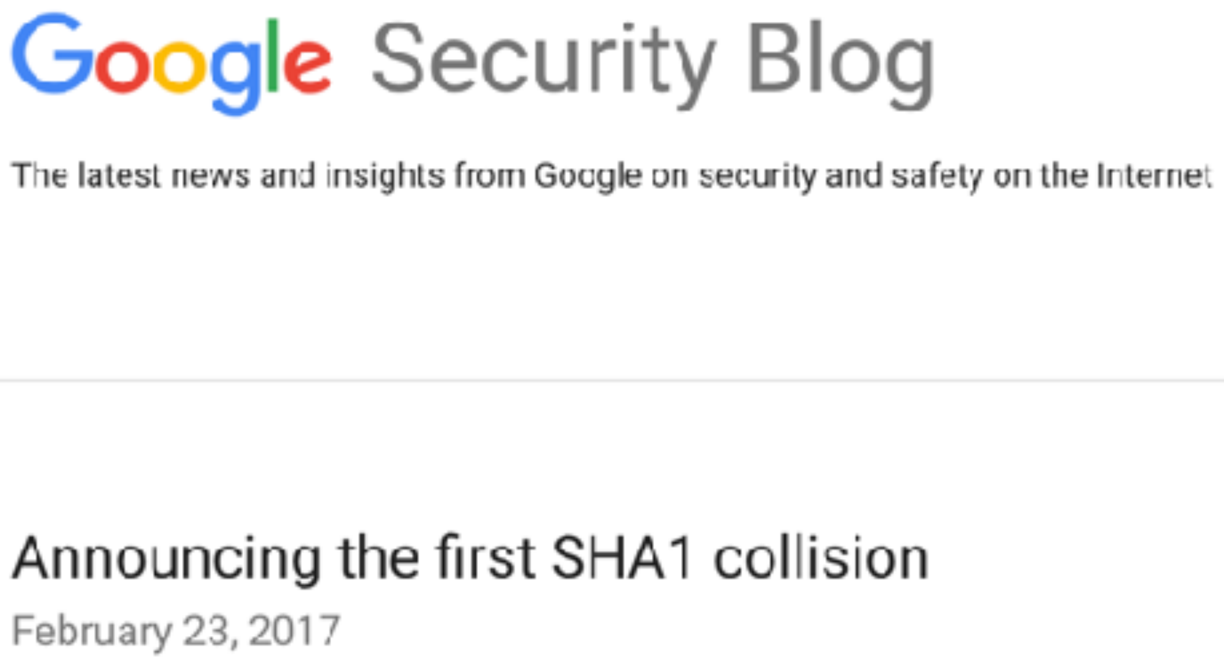
## Some prerequisites

# Key technologies

- Cryptographic Hashing
- Consensus
  - **P**roof **o**f **W**ork
  - **P**roof **o**f **A**uthority
  - **P**roof **o**f **S**take
- Merkle trees
- Public key cryptography (asymmetric cryptography)
- Digital signatures

# Cryptographic Hash

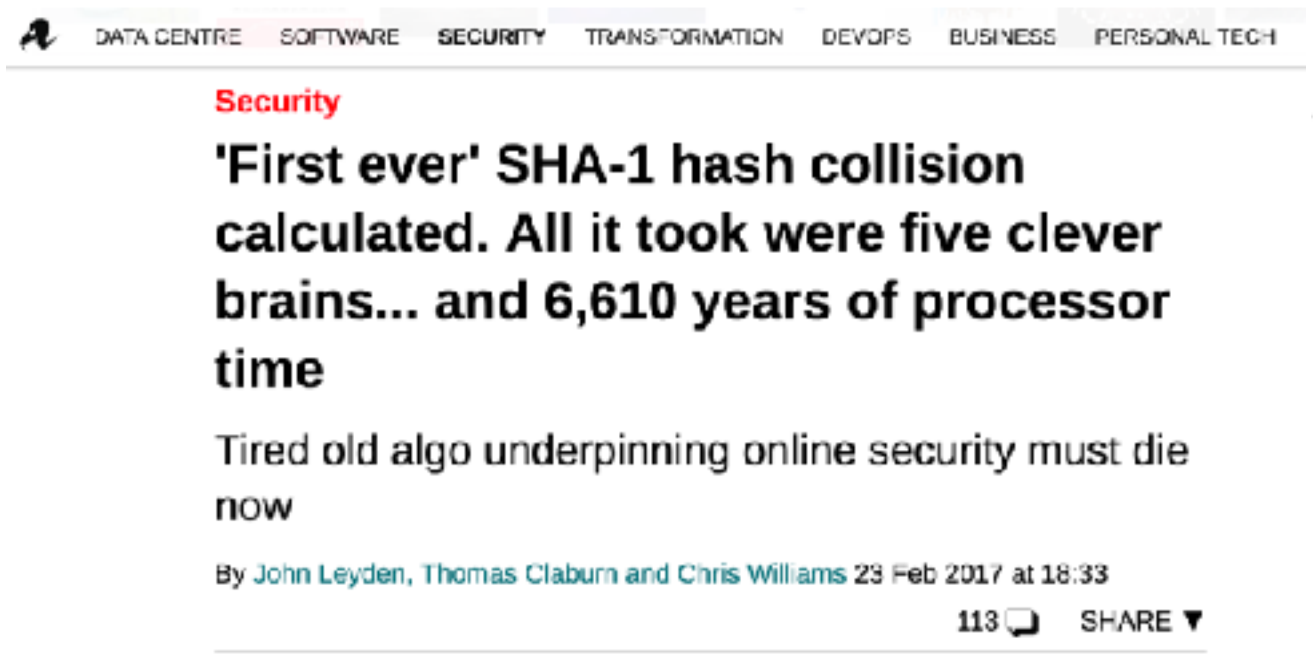
- One way function (cannot decipher input)
- Maps arbitrary input to fixed size output (the message digest)
- Avoid MD5 & SHA1!


Google Security Blog

The latest news and insights from Google on security and safety on the Internet

Announcing the first SHA1 collision

February 23, 2017


DATA CENTRE SOFTWARE SECURITY TRANSFORMATION DEVOPS BUSINESS PERSONAL TECH

Security

'First ever' SHA-1 hash collision calculated. All it took were five clever brains... and 6,610 years of processor time

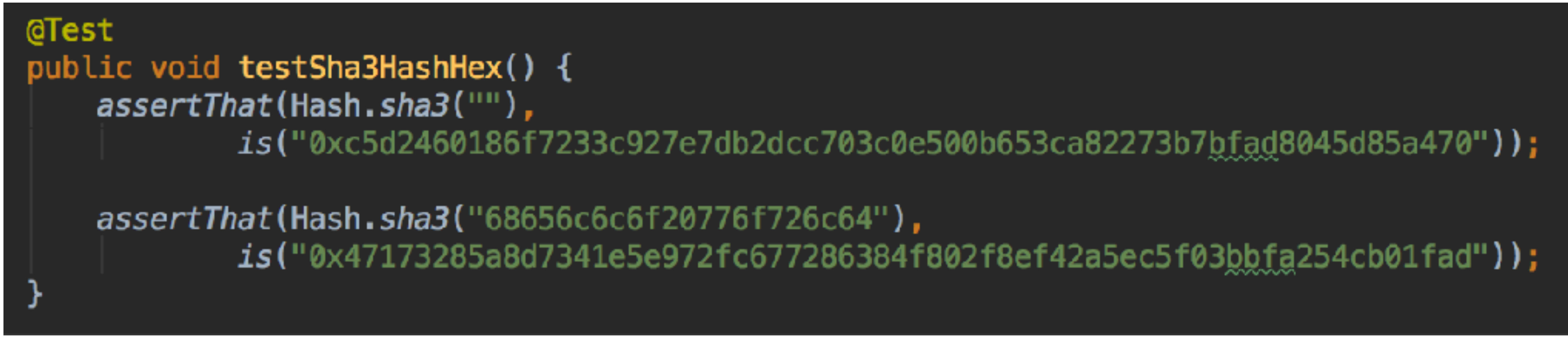
Tired old algo underpinning online security must die now

By John Leyden, Thomas Claburn and Chris Williams 23 Feb 2017 at 18:33

113 SHARE ▼

# Hashing in Ethereum

- KECCAK-256 used in Ethereum (modified SHA3)
  - 32 byte hash
  - See org.web3j.crypto.HashTest



```java
@Test
public void testSha3HashHex() {
    assertThat(Hash.sha3(""),
            is("0xc5d2460186f7233c927e7db2dcc703c0e500b653ca82273b7bfad8045d85a470"));

    assertThat(Hash.sha3("68656c6c6f20776f726c64"),
            is("0x47173285a8d7341e5e972fc677286384f802f8ef42a5ec5f03bbfa254cb01fad"));
}
```

# Proof of Work

- Miners continually trying to verify blocks for the blockchain
  - 5 ether reward for each solution
- Based on Cryptographic hash function

```
hash(<block>) =>
a7ffc6f8bf1ed76651c14756a061d662f580ff4de43b49fa82d80a
4b80f8434a
```

- Miners applying hash function millions (mega) of times/sec = MH/s
- Single GPU generates 5-30 MH/s
- CPU ~ 0.25 MH/s

## Ethash Algorithm

- Ethash Proof of Work algorithm (formerly Dagger Hashimoto)
  - SHA3-256 variant hashing function
  - Memory-hard computation
  - Memory-easy validation
  - Can't use ASICs (Application Specific Integrated Circuits)
  - Uses 4GB directed acyclic graph file (DAG) regenerated every 30000 blocks by miner

# Proof of Work Difficulty

- Hashing blocks
  - Difficulty - dynamically adjusts parameter defined originally in genesis block (one block produced every 12s)
    - Started at 0x400000000 (0.017 TH)
    - Now at 0x3205AF767000 (55 TH)
- Simplified example:

**Fetches bytes from DAG + combine with block Returns SHA3-256 hash**

```
nonce = random int

while hashimoto(block, nonce) * difficulty > threshold

   increment nonce

return nonce
```

**Solution**

# Genesis Block

```
{
    "nonce": "0x0000000000000042",
    "timestamp": "0x0",
    "parentHash": "0x0000000000000000000000000000000000000000000000000000000000000000",
    "extraData": "0x0",
    "gasLimit": "0x8000000",
    "difficulty": "0x400000000",
    "mixhash": "0x0000000000000000000000000000000000000000000000000000000000000000",
    "coinbase": "0x3333333333333333333333333333333333333333",
    "alloc": {
    }
}
```

Set to a low value in test networks

# Proof of Stake

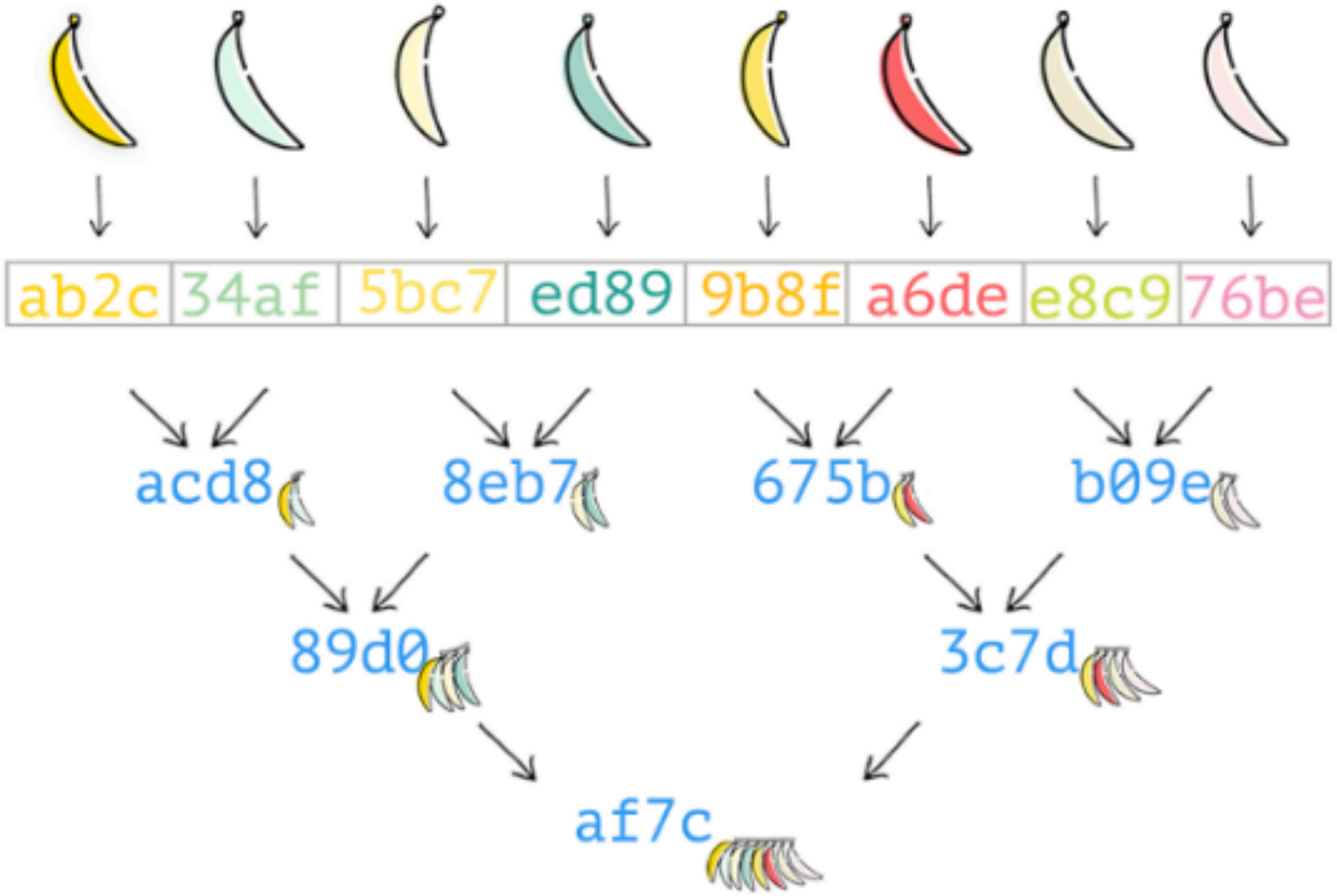
- Validators commit money to the network (their stake)
- Loose their stake if they don’t abide by the rules
- Ethereum implementation - Casper
- Go-live 2018?

## Proof of Authority

- Only authorities allowed to create new blocks
- Suitable for private chains
- Less computationally expensive
- Used by Kovan (Parity) and Rinkeby (Geth) testnets

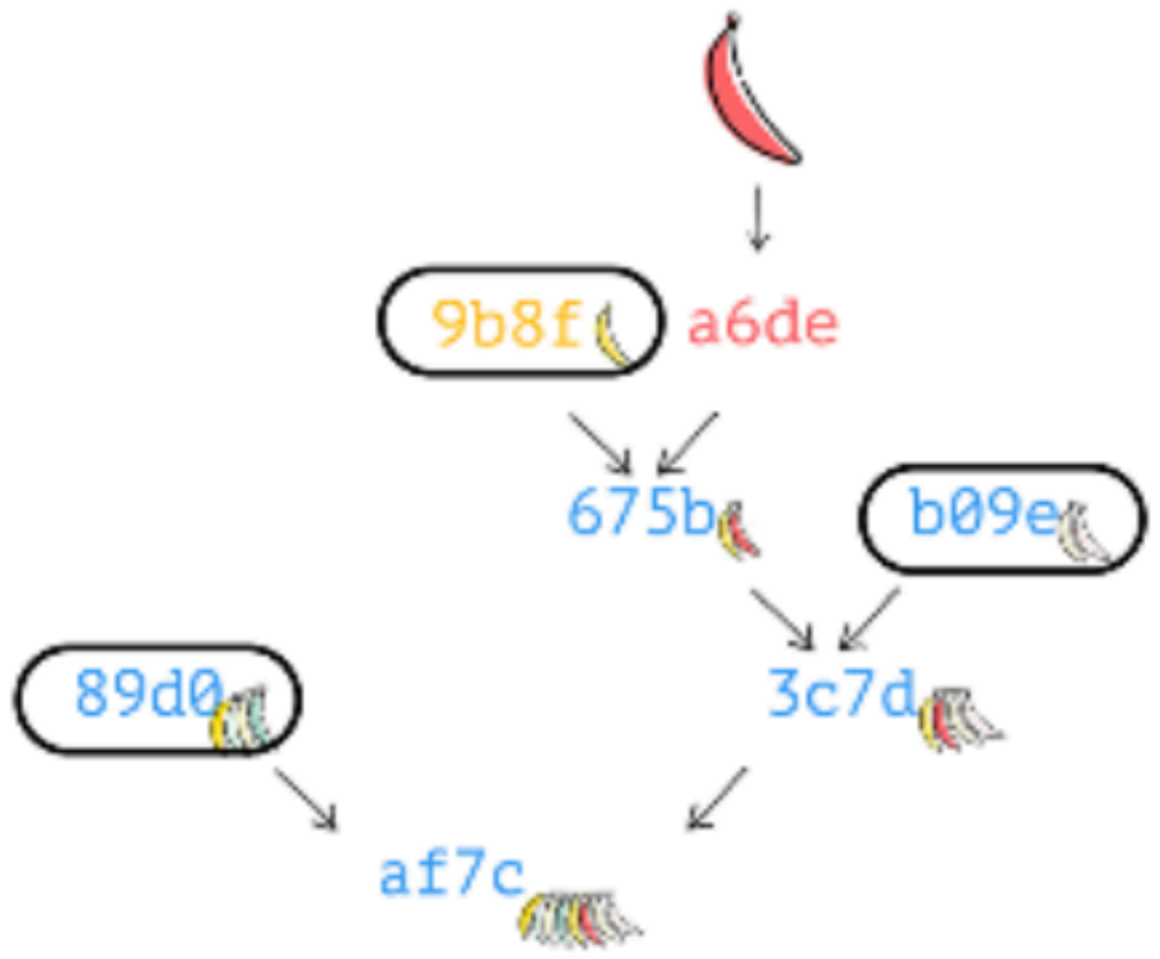
# Merkle Trees

How to encode 8 bananas ?



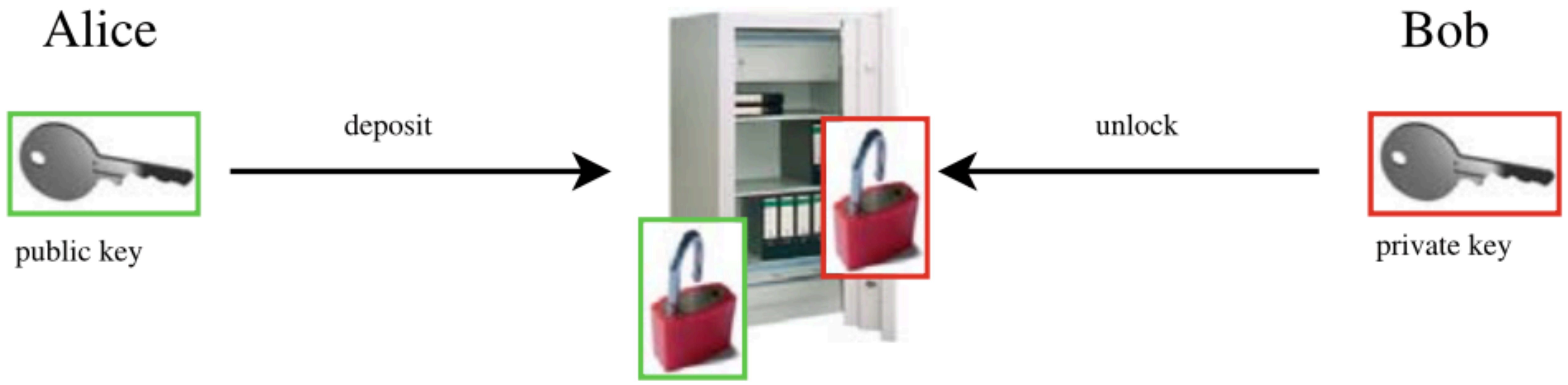
Source: http://bit.ly/2g5lmOM

# Merkle Tree (Banana) Verification

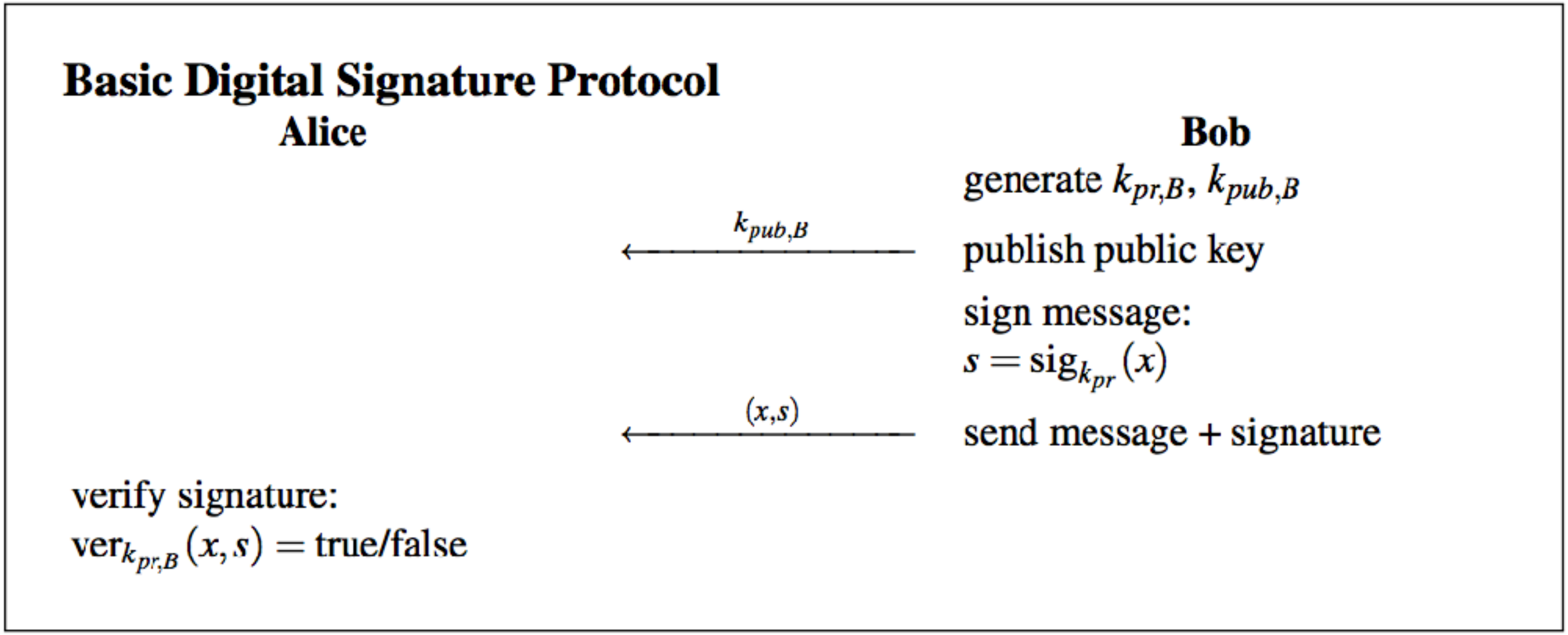


## Public Key Cryptography

- Asymmetric cryptography (2 keys)
  - Bob publishes public key
  - Alice encrypts with public key
- Only Bob can decrypt via private key



# Digital Signatures


**Basic Digital Signature Protocol**
**Alice**
**Bob**
generate $k_{pr,B}$, $k_{pub,B}$
$k_{pub,B}$
publish public key
sign message:
$s = \mathrm{sig}_{k_{pr}}(x)$
$(x,s)$
send message + signature
verify signature:
$\mathrm{ver}_{k_{pr,B}}(x,s) = \mathrm{true/false}$

**Source: Understanding Cryptography (Springer 2010)**

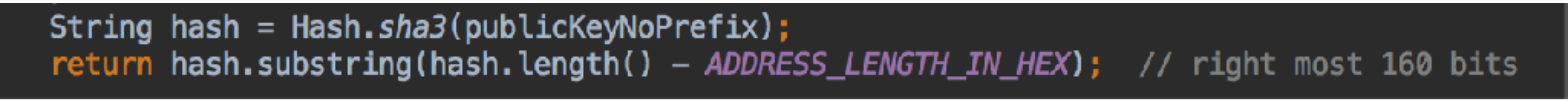
Ethereum

# Ethereum

- *The world computer*
- Turing-complete virtual machine
- Public blockchain (mainnet & testnets)

# Ether

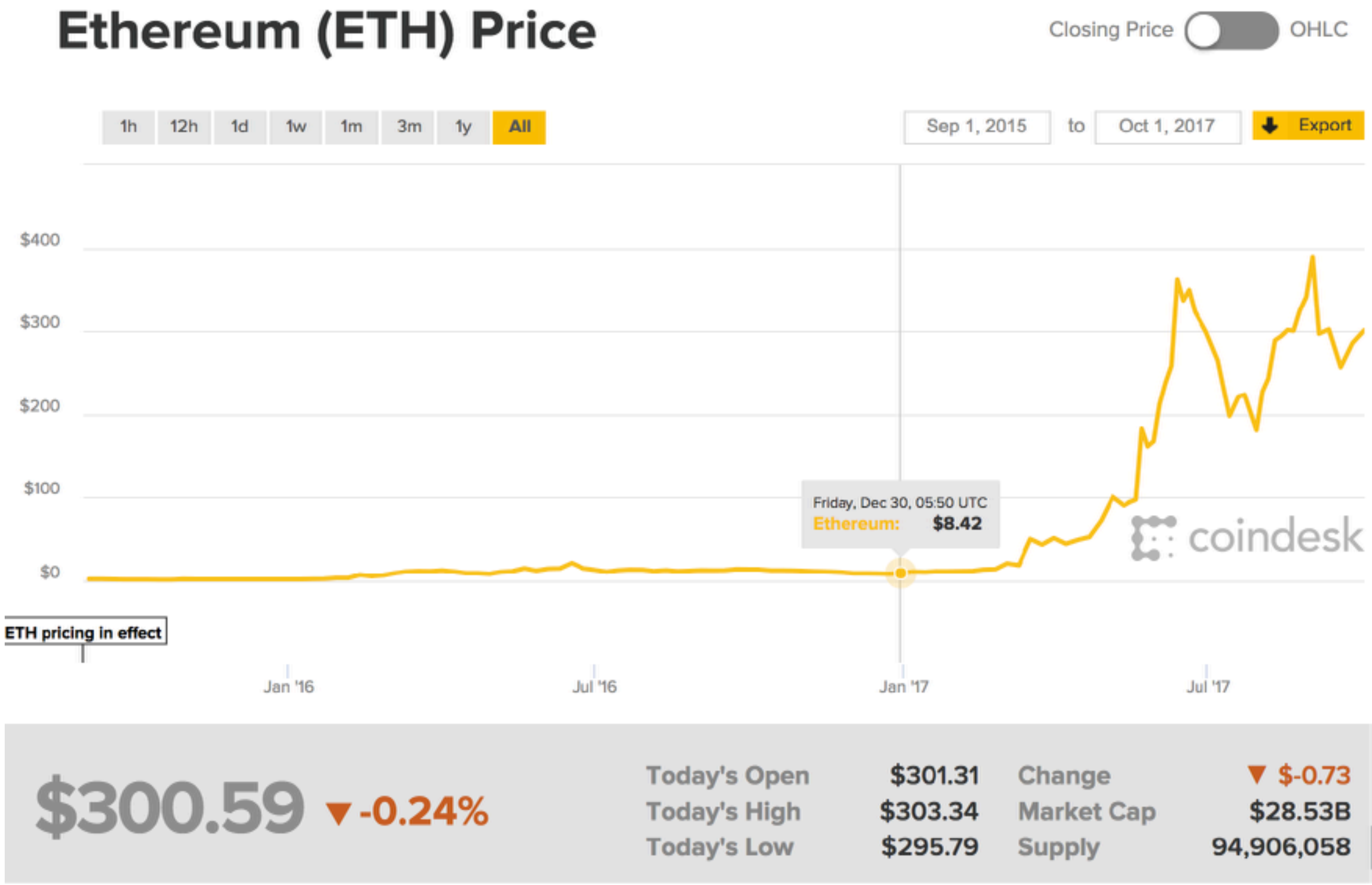
- The fuel of the Ethereum blockchain
- Pay miners to process transactions
- Market capitalisation ~$38bn USD (Bitcoin ~$71bn)
- Associated with an address + wallet file
  0x19e03255f667bdfd50a32722df860b1eeaf4d635



```
String hash = Hash.sha3(publicKeyNoPrefix);
return hash.substring(hash.length() - ADDRESS_LENGTH_IN_HEX);  // right most 160 bits
```

- See org.web3j.crypto.Keys

# 1 Ether = $300 USD


Ethereum (ETH) Price

$300.59 ▼ -0.24%

| | | | |
|---|---|---|---|
| Today's Open | $301.31 | Change | ▼ $-0.73 |
| Today's High | $303.34 | Market Cap | $28.53B |
| Today's Low | $295.79 | Supply | 94,906,058 |

# Obtaining Ether

- **Buy it**
  - Find someone
  - Coinbase
  - BTC Markets
- **Mine it**
  - mainnet => requires dedicated GPUs
  - testnet => quick using your CPU, via a faucet

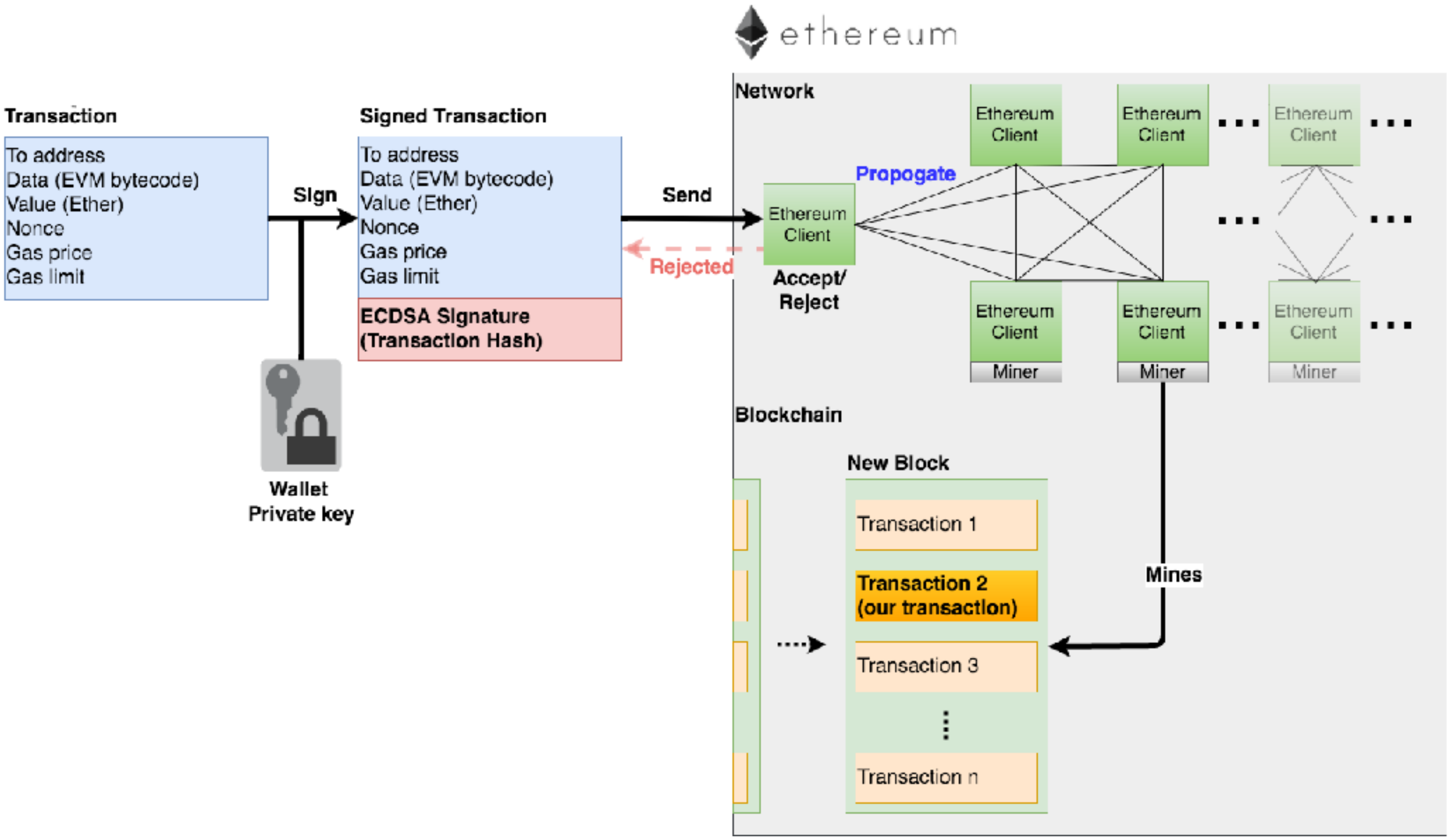
## Smart Contracts

- *Computerised contract*
- Code + data that lives on the blockchain at an address
- Transactions call functions => state transition

# Transactions

- Transfer Ether
- Deploy a smart contract
- Call a smart contract

# Transactions



# Getting started with Ethereum

Free cloud clients @ https://infura.io/

Run a local client (to generate Ether):

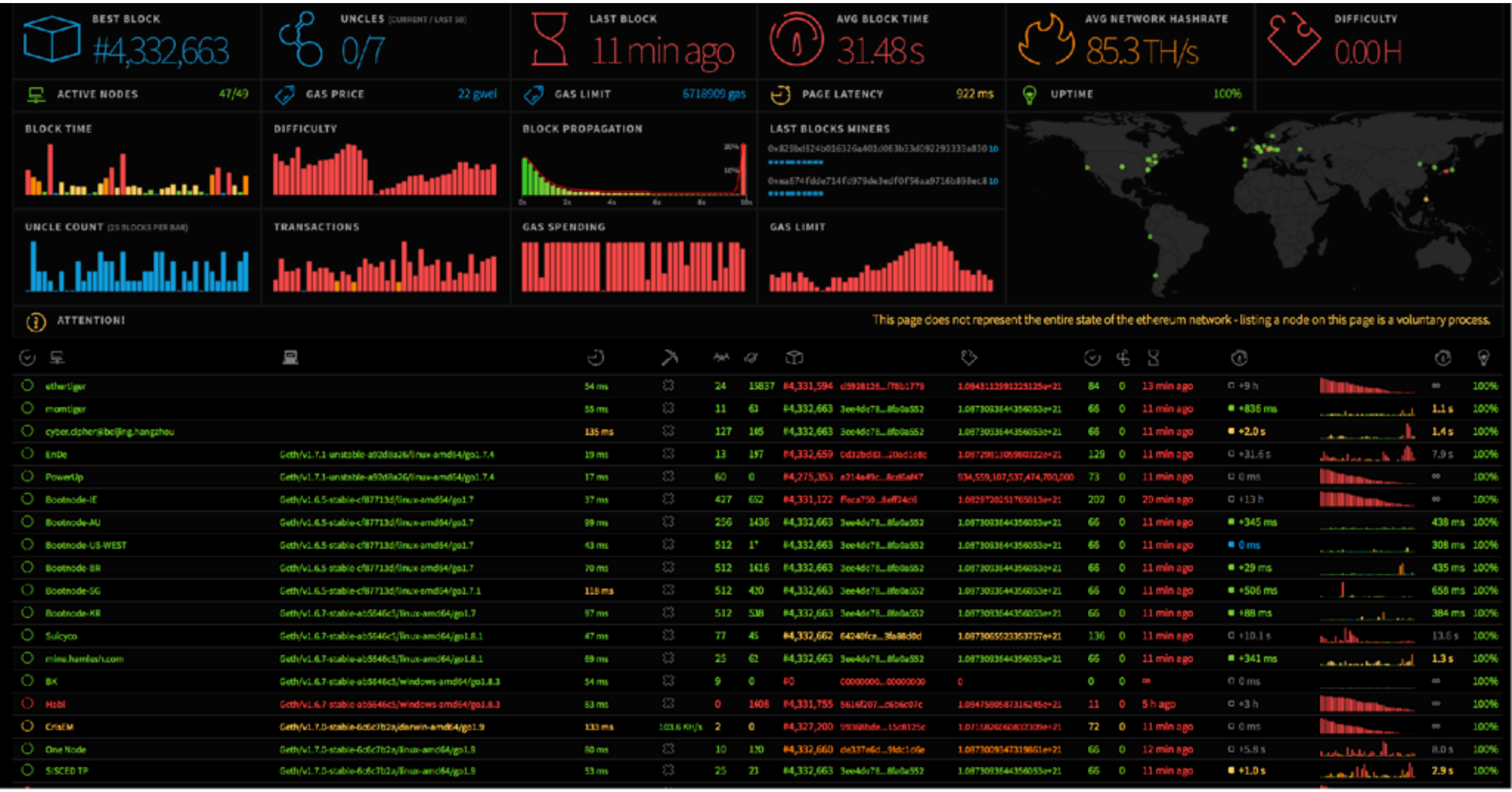
```
$ geth --rpcapi personal,db,eth,net,web3 --
rpc —rinkeby console

$ parity --chain testnet
```

Development client

```
$ testrpc --account="0x<address>,
1000000000000000000000000000" —account="…"
```

# ethstats.net



BEST BLOCK #4,332,663

UNCLES (CURRENT / LAST 50) 0/7

LAST BLOCK 11 min ago

AVG BLOCK TIME 31.48 s

AVG NETWORK HASHRATE 85.3 TH/s

DIFFICULTY 0.00 H

ACTIVE NODES 47/49

GAS PRICE 22 gwei

GAS LIMIT 6718909 gas

PAGE LATENCY 922 ms

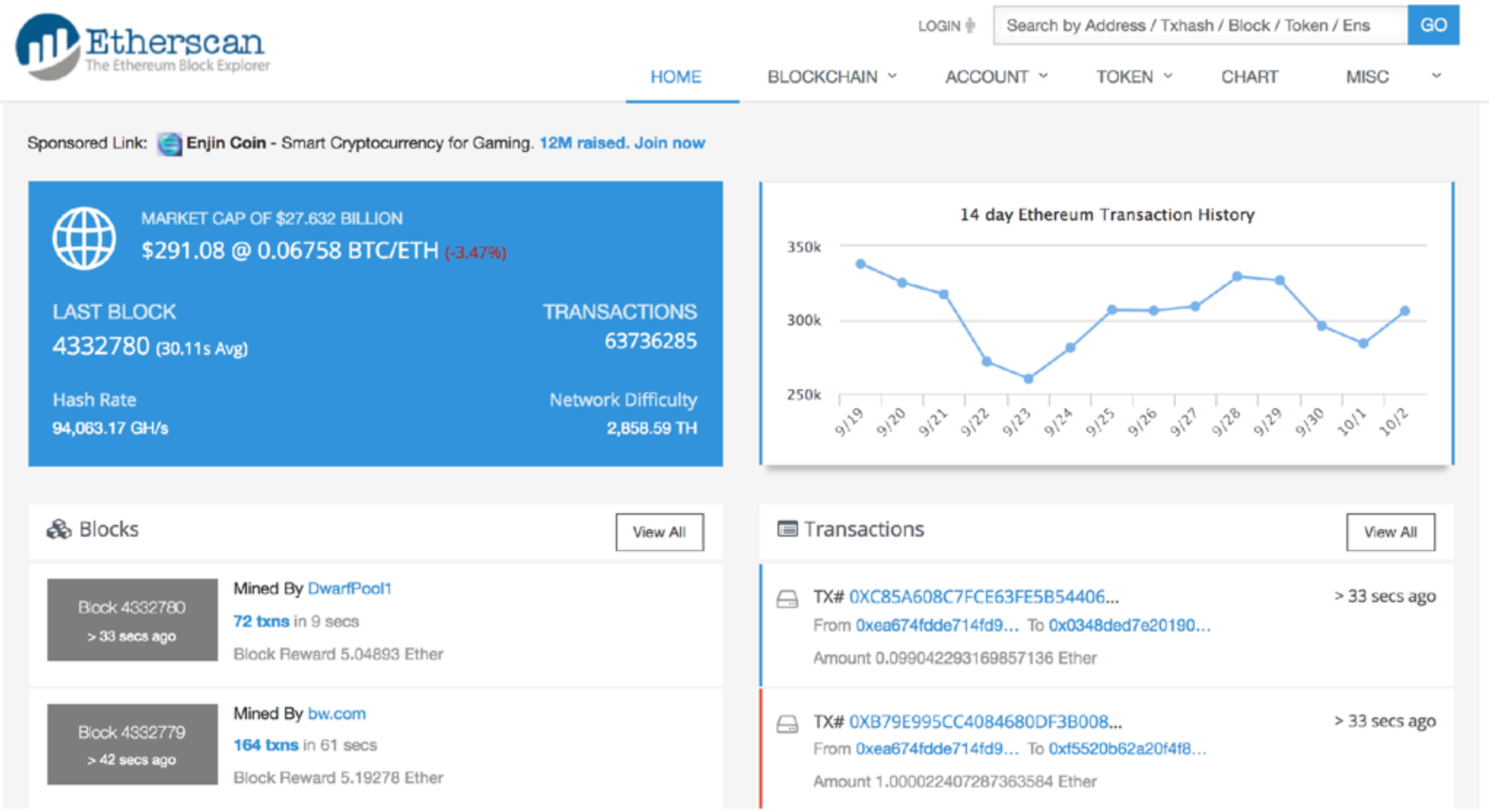
UPTIME 100%

ATTENTION!

This page does not represent the entire state of the ethereum network - listing a node on this page is a voluntary process.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ethertiger | | 54 ms | | 24 | 15837 | #4,331,594 | d3928126...f78b1779 | 1.0843112991225125e+21 | 84 | 0 | 13 min ago | +9 h | | ∞ | 100% |
| momtiger | | 55 ms | | 11 | 63 | #4,332,663 | 3ee4de78...8fa0a552 | 1.0873093644356053e+21 | 66 | 0 | 11 min ago | +836 ms | | 1.1 s | 100% |
| cyber.cipher@beijing.hangzhou | | 135 ms | | 127 | 105 | #4,332,663 | 3ee4de78...8fa0a552 | 1.0873093644356053e+21 | 66 | 0 | 11 min ago | +2.0 s | | 1.4 s | 100% |
| EnDe | Geth/v1.7.1-unstable-a92d8a26/linux-amd64/go1.7.4 | 19 ms | | 13 | 197 | #4,332,659 | cd32bd83...20ad1e8c | 1.0872981305980322e+21 | 129 | 0 | 11 min ago | +31.6 s | | 7.9 s | 100% |
| PowerUp | Geth/v1.7.1-unstable-a92d8a26/linux-amd64/go1.7.4 | 17 ms | | 60 | 0 | #4,275,353 | a214a49c...8cd6af47 | 934,559,107,537,474,700,000 | 73 | 0 | 11 min ago | 0 ms | | ∞ | 100% |
| Bootnode-IE | Geth/v1.6.5-stable-cf87713d/linux-amd64/go1.7 | 37 ms | | 427 | 652 | #4,331,122 | ffeca750...8eff24d6 | 1.0829720051765013e+21 | 202 | 0 | 20 min ago | +13 h | | ∞ | 100% |
| Bootnode-AU | Geth/v1.6.5-stable-cf87713d/linux-amd64/go1.7 | 99 ms | | 256 | 1436 | #4,332,663 | 3ee4de78...8fa0a552 | 1.0873093644356053e+21 | 66 | 0 | 11 min ago | +345 ms | | 438 ms | 100% |
| Bootnode-US-WEST | Geth/v1.6.5-stable-cf87713d/linux-amd64/go1.7 | 43 ms | | 512 | 17 | #4,332,663 | 3ee4de78...8fa0a552 | 1.0873093644356053e+21 | 66 | 0 | 11 min ago | 0 ms | | 308 ms | 100% |
| Bootnode-BR | Geth/v1.6.5-stable-cf87713d/linux-amd64/go1.7 | 70 ms | | 512 | 1616 | #4,332,663 | 3ee4de78...8fa0a552 | 1.0873093644356053e+21 | 66 | 0 | 11 min ago | +29 ms | | 435 ms | 100% |
| Bootnode-SG | Geth/v1.6.5-stable-cf87713d/linux-amd64/go1.7.1 | 118 ms | | 512 | 420 | #4,332,663 | 3ee4de78...8fa0a552 | 1.0873093644356053e+21 | 66 | 0 | 11 min ago | +506 ms | | 658 ms | 100% |
| Bootnode-KR | Geth/v1.6.7-stable-ab5646c5/linux-amd64/go1.7 | 97 ms | | 512 | 538 | #4,332,663 | 3ee4de78...8fa0a552 | 1.0873093644356053e+21 | 66 | 0 | 11 min ago | +88 ms | | 384 ms | 100% |
| Suicyco | Geth/v1.6.7-stable-ab5646c5/linux-amd64/go1.8.1 | 47 ms | | 77 | 45 | #4,332,662 | 64240fca...3fa88d0d | 1.0873065523353757e+21 | 136 | 0 | 11 min ago | +10.1 s | | 13.6 s | 100% |
| mine.hamlesh.com | Geth/v1.6.7-stable-ab5646c5/linux-amd64/go1.8.1 | 69 ms | | 25 | 62 | #4,332,663 | 3ee4de78...8fa0a552 | 1.0873093644356053e+21 | 66 | 0 | 11 min ago | +341 ms | | 1.3 s | 100% |
| BK | Geth/v1.6.7-stable-ab5646c5/windows-amd64/go1.8.3 | 54 ms | | 9 | 0 | #0 | 00000000...00000000 | 0 | 0 | 0 | ∞ | 0 ms | | ∞ | 100% |
| Habl | Geth/v1.6.7-stable-ab5646c5/windows-amd64/go1.8.3 | 83 ms | | 0 | 1608 | #4,331,755 | 5616f207...c6b6c07c | 1.0847580587316245e+21 | 11 | 0 | 5 h ago | +3 h | | ∞ | 100% |
| CrisEM | Geth/v1.7.0-stable-6c6c7b2a/darwin-amd64/go1.9 | 133 ms | 103.6 KH/s | 2 | 0 | #4,327,200 | 9938bde...15c8125e | 1.0711826260832309e+21 | 72 | 0 | 11 min ago | 0 ms | | ∞ | 100% |
| One Node | Geth/v1.7.0-stable-6c6c7b2a/linux-amd64/go1.9 | 80 ms | | 10 | 120 | #4,332,660 | de337e6d...9idc1d6e | 1.0873009347319861e+21 | 66 | 0 | 12 min ago | +5.8 s | | 8.0 s | 100% |
| SISCED TP | Geth/v1.7.0-stable-6c6c7b2a/linux-amd64/go1.9 | 53 ms | | 25 | 23 | #4,332,663 | 3ee4de78...8fa0a552 | 1.0873093644356053e+21 | 66 | 0 | 11 min ago | +1.0 s | | 2.9 s | 100% |

# etherscan.io



Etherscan
The Ethereum Block Explorer
LOGIN
Search by Address / Txhash / Block / Token / Ens
GO
HOME
BLOCKCHAIN
ACCOUNT
TOKEN
CHART
MISC

Sponsored Link: **Enjin Coin** - Smart Cryptocurrency for Gaming. **12M raised. Join now**

MARKET CAP OF $27.632 BILLION
$291.08 @ 0.06758 BTC/ETH (-3.47%)

LAST BLOCK
4332780 (30.11s Avg)

TRANSACTIONS
63736285

Hash Rate
94,063.17 GH/s

Network Difficulty
2,858.59 TH

14 day Ethereum Transaction History

Blocks — View All

Block 4332780
> 33 secs ago
Mined By DwarfPool1
72 txns in 9 secs
Block Reward 5.04893 Ether

Block 4332779
> 42 secs ago
Mined By bw.com
164 txns in 61 secs
Block Reward 5.19278 Ether

Transactions — View All

TX# 0XC85A608C7FCE63FE5B54406... > 33 secs ago
From 0xea674fdde714fd9... To 0x0348ded7e20190...
Amount 0.099042293169857136 Ether

TX# 0XB79E995CC4084680DF3B008... > 33 secs ago
From 0xea674fdde714fd9... To 0xf5520b62a20f4f8...
Amount 1.000022407287363584 Ether

# Testnet Monitoring

**Kovan**

- http://kovan-stats.parity.io/
- https://kovan.etherscan.io

**Rinkeby**

- http://rinkeby.io
- https://rinkeby.etherscan.io

**Ropsten**

- https://ropsten.etherscan.io

# Exercise

- Sign up to Infura
- Start running a node locally (note the console argument)

```
$ geth --rpcapi personal,db,eth,net,web3
--rpc —rinkeby console
```

- Check status of syncing at geth console with command:

```
eth.syncing
```

web3j

WEB3J.IO FEATURES OVERVIEW PROJECTS COMMUNITY

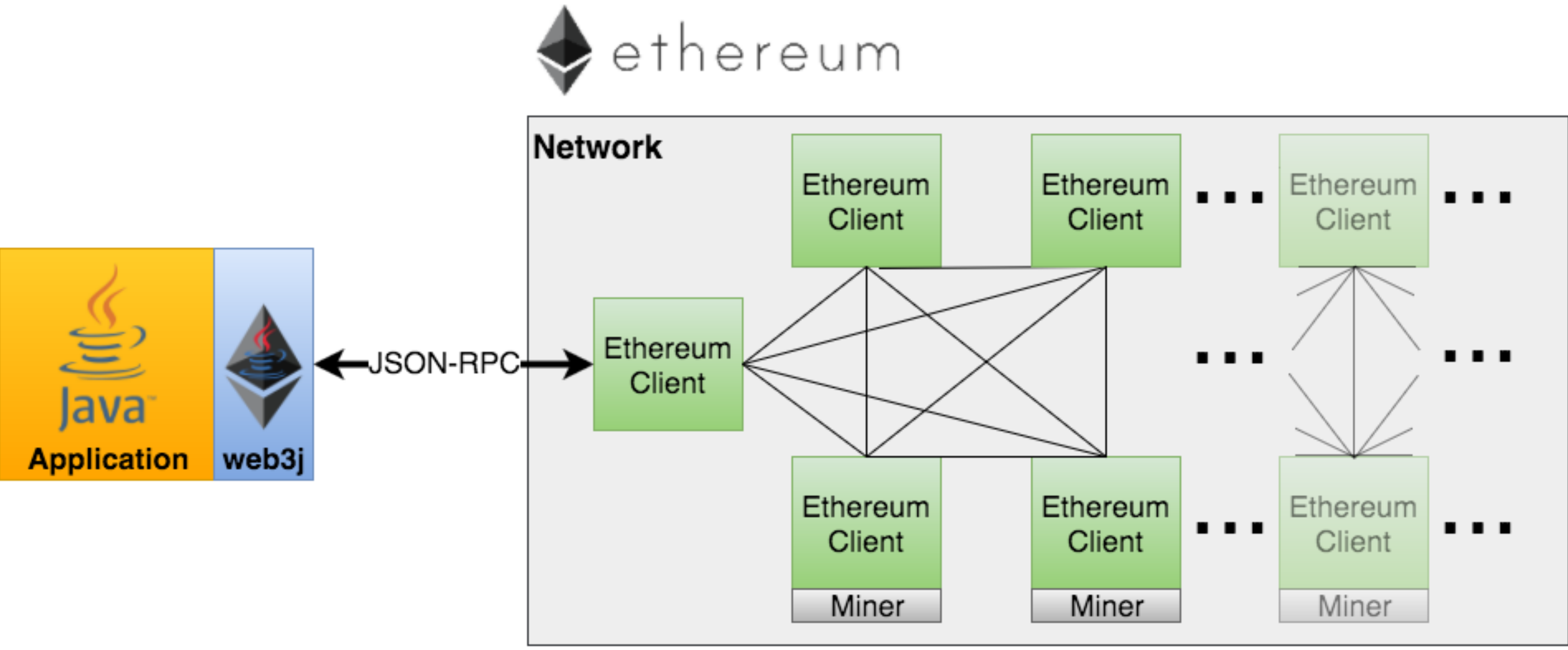
ANDROID

Java™

spring by Pivotal™

Maven™

# Integration with Ethereum



## Integration challenges

- Smart contract application binary interface encoders/ decoders
- 256 bit numeric types
- Multiple transaction types
- Wallet management
- …

## web3j

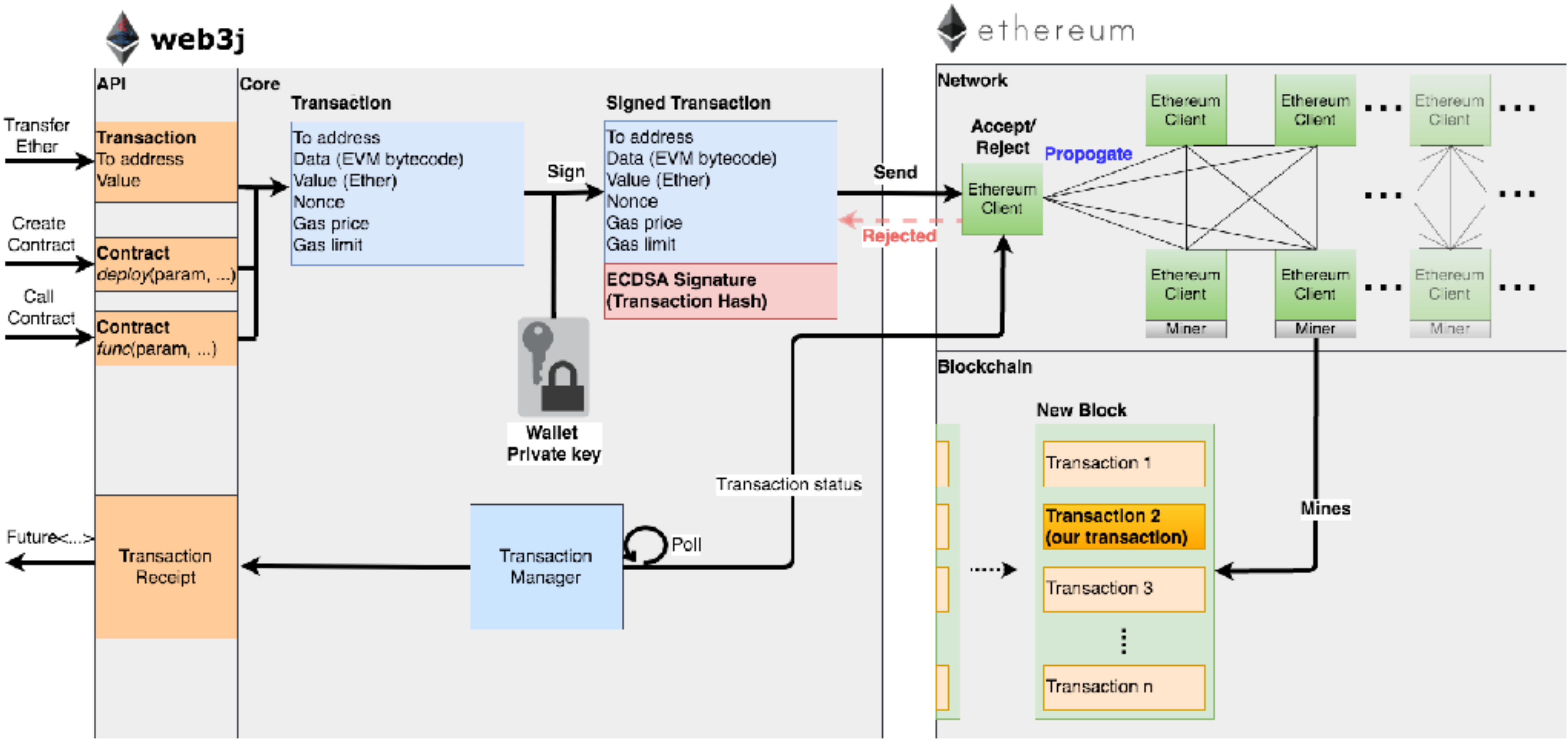
- Complete Ethereum JSON-RPC implementation
- Sync/async & RX Observable API
- Ethereum wallet support
- Smart contract wrappers
- Command line tools
- Android compatible

blk.io

# web3j artefacts

- Maven’s Nexus & Bintray's JFrog repositories
  - Java 8: org.web3j:core
  - Android: org.web3j:core-android
- web3j releases page:
  - Command line tools: web3j-<version>.zip
- Homebrew:
  - `brew tap web3j/web3j && brew install web3j`

# web3j transactions



## Using web3j

- Create client

```
Web3j web3 = Web3j.build(new HttpService());
    // defaults to http://localhost:8545/
```

- Call method

```
web3.<method name>([param1, …, paramN).
[send()|sendAsync()|observable()]
```

## Display client version

```
Web3j web3 = Web3j.build(new HttpService());

Web3ClientVersion clientVersion =
    web3.web3ClientVersion()
      .send();

System.out.println("Client version: " +
    clientVersion.getWeb3ClientVersion());
```

```
Client version: Geth/v1.7.1-stable-05101641/
darwin-amd64/go1.9.1
```

## Exercise

- You can refer to https://docs.web3j.io
- Create a simple Java application to display the network version being used by web3j
- Create a new Java project and add the web3j 2.3.1 project dependency or clone https://github.com/blk-io/jaxlondon
- Connect to:
    - Your local node
    - Or, an Infura node
- Bonus - see if you can figure out what the network version means and interpret the result

# Create a wallet

```
$ web3j wallet create

              _      _____ _     _
             | |    |____ (_)   (_)
__      _____| |__      / /_     _  ___
\ \ /\ / / _ \ '_ \     \ \ |   | |/ _ \
 \ V  V /  __/ |_) |.___/ / | _ | | (_) |
  \_/\_/ \___|_.__/ \____/| |(_)|_|\___/
                         _/ |
                        |__/

Please enter a wallet file password:
Please re-enter the password:
Please enter a destination directory location [/Users/Conor/
Library/Ethereum/testnet/keystore]: ~/testnet-keystore
Wallet file UTC--2016-11-10T22-52-35.722000000Z--
a929d0fe936c719c4e4d1194ae64e415c7e9e8fe.json successfully
created in: /Users/Conor/testnet-keystore
```

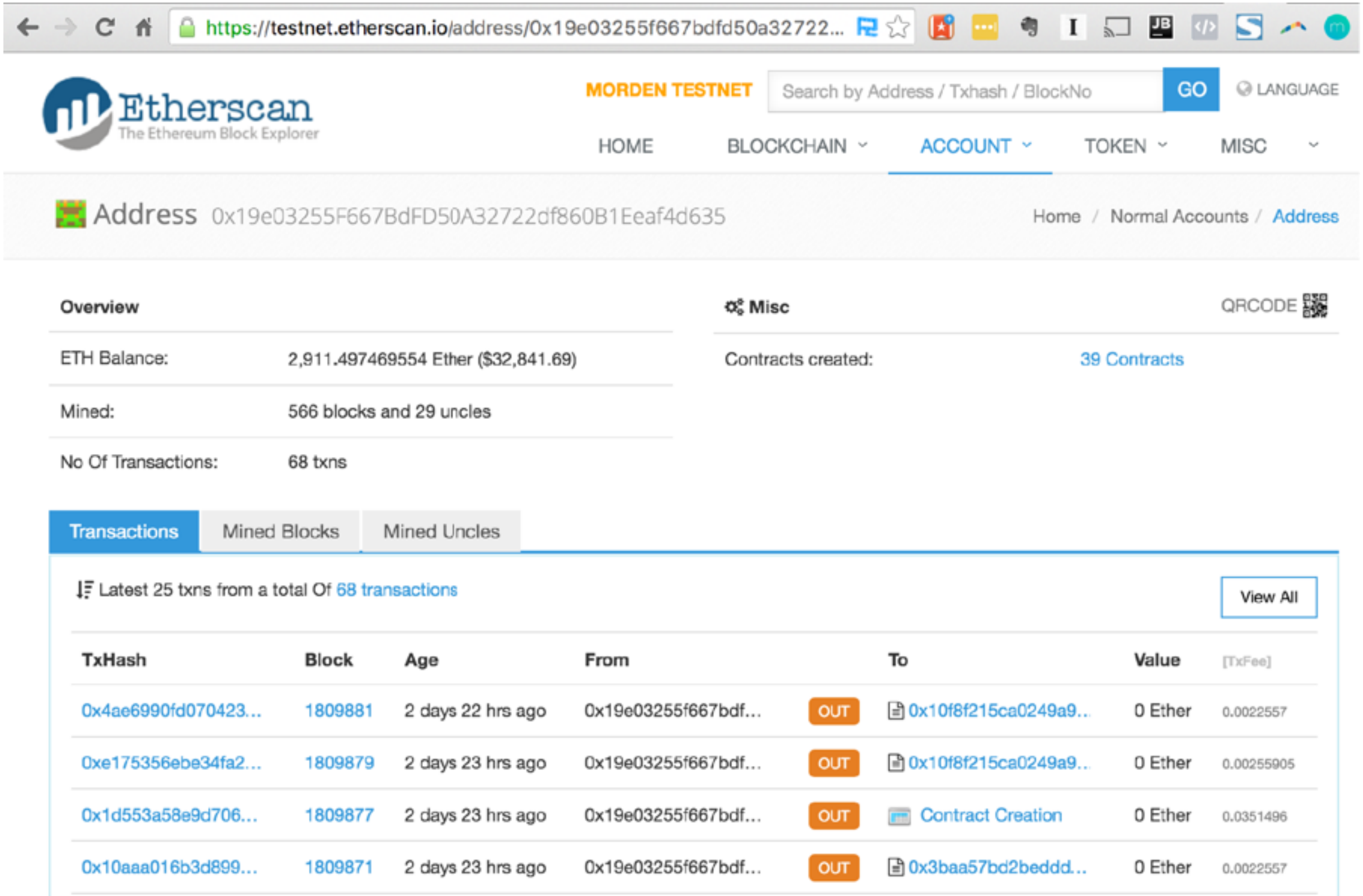
# Wallet file

```
{
   "address":"a929d0fe936c719c4e4d1194ae64e415c7e9e8fe",
   "id":"c2fbffdd-f588-43a8-9b0c-facb6fd84dfe",
   "version":3,
   "crypto":{
      "cipher":"aes-128-ctr",

"ciphertext":"27be0c93939fc8262977c4454a6b7c261c931dfd8c030b2d3e60ef76f99bfdc6"
      "cipherparams":{
         "iv":"5aa4fdc64eef6bd82621c6036a323c41"
      },
      "kdf":"scrypt",
      "kdfparams":{
         "dklen":32,
         "n":262144,
         "p":1,
         "r":8,

"salt":"6ebc76f30ee21c9a05f907a1ad1df7cca06dd594cf6c537c5e6c79fa88c9b9d1"
      },
      "mac":"178eace46da9acbf259e94141fbcb7d3d43041e2ec546cd4fe24958e55a49446"
   }
}
```

# View transactions


https://testnet.etherscan.io/address/0x19e03255f667bdfd50a32722...
Etherscan
The Ethereum Block Explorer
MORDEN TESTNET
Search by Address / Txhash / BlockNo
GO
LANGUAGE
HOME
BLOCKCHAIN
ACCOUNT
TOKEN
MISC
Home / Normal Accounts / Address
QRCODE
Transactions
Mined Blocks
Mined Uncles
View All

Address 0x19e03255F667BdFD50A32722df860B1Eeaf4d635

| Overview | |
|---|---|
| ETH Balance: | 2,911.497469554 Ether ($32,841.69) |
| Mined: | 566 blocks and 29 uncles |
| No Of Transactions: | 68 txns |

| Misc | |
|---|---|
| Contracts created: | 39 Contracts |

Latest 25 txns from a total Of 68 transactions

| TxHash | Block | Age | From | | To | Value | [TxFee] |
|---|---|---|---|---|---|---|---|
| 0x4ae6990fd070423... | 1809881 | 2 days 22 hrs ago | 0x19e03255f667bdf... | OUT | 0x10f8f215ca0249a9... | 0 Ether | 0.0022557 |
| 0xe175356ebe34fa2... | 1809879 | 2 days 23 hrs ago | 0x19e03255f667bdf... | OUT | 0x10f8f215ca0249a9... | 0 Ether | 0.00255905 |
| 0x1d553a58e9d706... | 1809877 | 2 days 23 hrs ago | 0x19e03255f667bdf... | OUT | Contract Creation | 0 Ether | 0.0351496 |
| 0x10aaa016b3d899... | 1809871 | 2 days 23 hrs ago | 0x19e03255f667bdf... | OUT | 0x3baa57bd2beddd... | 0 Ether | 0.0022557 |

# Sending Ether

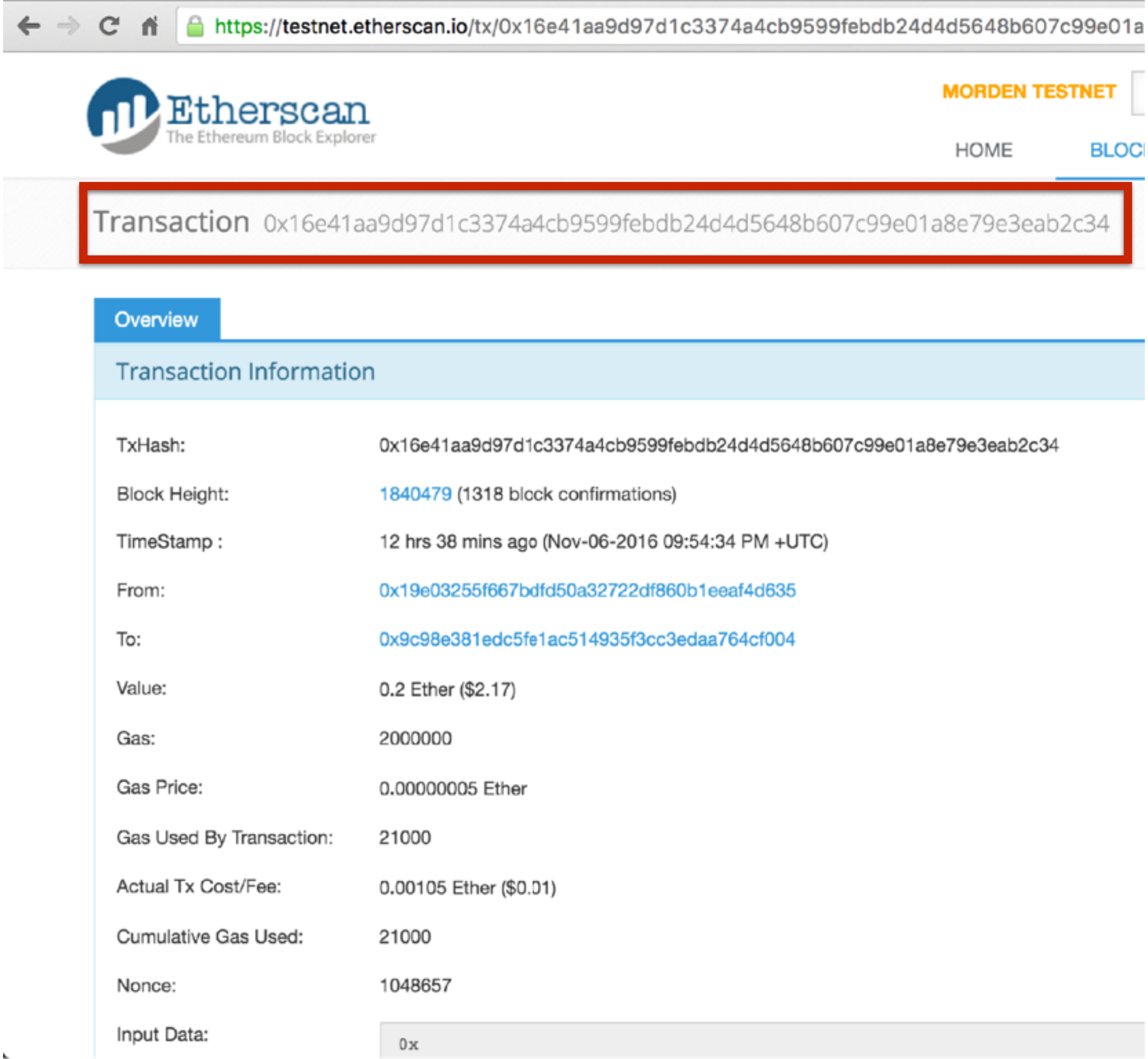
```
Web3j web3 = Web3j.build(new HttpService());

Credentials credentials = WalletUtils.loadCredentials(
    "password", "/path/to/walletfile");

TransactionReceipt transactionReceipt =
    Transfer.sendFundsAsync(
        web3,
        credentials, “0x<to address>",
        BigDecimal.valueOf(0.2),
        Convert.Unit.ETHER).get();

System.out.println(“Funds transfer completed…” + …);
```

```
Funds transfer completed, transaction hash:
0x16e41aa9d97d1c3374a4cb9599febdb24d4d5648b607c99e01a8
e79e3eab2c34, block number: 1840479
```



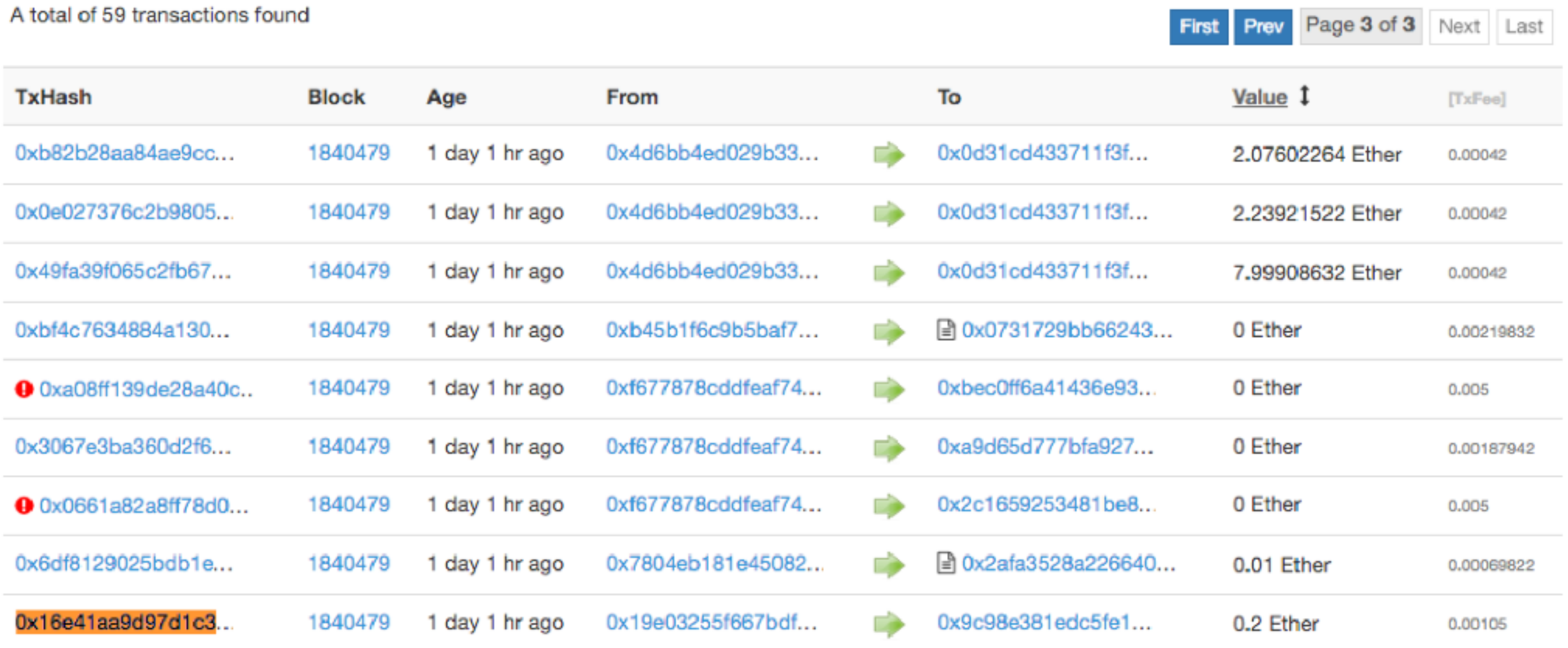
https://testnet.etherscan.io/tx/0x16e41aa9d97d1c3374a4cb9599febdb24d4d5648b607c99e01a

Transaction 0x16e41aa9d97d1c3374a4cb9599febdb24d4d5648b607c99e01a8e79e3eab2c34

Transaction Information

| | |
|---|---|
| TxHash: | 0x16e41aa9d97d1c3374a4cb9599febdb24d4d5648b607c99e01a8e79e3eab2c34 |
| Block Height: | 1840479 (1318 block confirmations) |
| TimeStamp : | 12 hrs 38 mins ago (Nov-06-2016 09:54:34 PM +UTC) |
| From: | 0x19e03255f667bdfd50a32722df860b1eeaf4d635 |
| To: | 0x9c98e381edc5fe1ac514935f3cc3edaa764cf004 |
| Value: | 0.2 Ether ($2.17) |
| Gas: | 2000000 |
| Gas Price: | 0.00000005 Ether |
| Gas Used By Transaction: | 21000 |
| Actual Tx Cost/Fee: | 0.00105 Ether ($0.01) |
| Cumulative Gas Used: | 21000 |
| Nonce: | 1048657 |
| Input Data: | 0x |

# Block #1840479



A total of 59 transactions found

First Prev Page 3 of 3 Next Last

| TxHash | Block | Age | From | | To | Value ↕ | [TxFee] |
|---|---|---|---|---|---|---|---|
| 0xb82b28aa84ae9cc... | 1840479 | 1 day 1 hr ago | 0x4d6bb4ed029b33... | ➡ | 0x0d31cd433711f3f... | 2.07602264 Ether | 0.00042 |
| 0x0e027376c2b9805... | 1840479 | 1 day 1 hr ago | 0x4d6bb4ed029b33... | ➡ | 0x0d31cd433711f3f... | 2.23921522 Ether | 0.00042 |
| 0x49fa39f065c2fb67... | 1840479 | 1 day 1 hr ago | 0x4d6bb4ed029b33... | ➡ | 0x0d31cd433711f3f... | 7.99908632 Ether | 0.00042 |
| 0xbf4c7634884a130... | 1840479 | 1 day 1 hr ago | 0xb45b1f6c9b5baf7... | ➡ | 📄 0x0731729bb66243... | 0 Ether | 0.00219832 |
| ❗ 0xa08ff139de28a40c... | 1840479 | 1 day 1 hr ago | 0xf677878cddfeaf74... | ➡ | 0xbec0ff6a41436e93... | 0 Ether | 0.005 |
| 0x3067e3ba360d2f6... | 1840479 | 1 day 1 hr ago | 0xf677878cddfeaf74... | ➡ | 0xa9d65d777bfa927... | 0 Ether | 0.00187942 |
| ❗ 0x0661a82a8ff78d0... | 1840479 | 1 day 1 hr ago | 0xf677878cddfeaf74... | ➡ | 0x2c1659253481be8... | 0 Ether | 0.005 |
| 0x6df8129025bdb1e... | 1840479 | 1 day 1 hr ago | 0x7804eb181e45082... | ➡ | 📄 0x2afa3528a226640... | 0.01 Ether | 0.00069822 |
| 0x16e41aa9d97d1c3... | 1840479 | 1 day 1 hr ago | 0x19e03255f667bdf... | ➡ | 0x9c98e381edc5fe1... | 0.2 Ether | 0.00105 |

# Sending via the command line

```
$ web3j wallet send ~/.ethereum/keystore/<walletfile> 0x<destination address>

              _      _____ _     _
             | |    |____ (_)   (_)
__      _____| |__      / /_     _   ___
\ \ /\ / / _ \ '_ \     \ \ |   | | / _ \
 \ V  V /  __/ |_) |.___/ / | _ | || (_) |
  \_/\_/ \___|_.__/ \____/| |(_)|_| \___/
                         _/ |
                        |__/

Please enter your existing wallet file password:
Wallet for address 0x<source address> loaded
Please confirm address of running Ethereum client you wish to send the transfer request to [http://
localhost:8545/]: https://mainnet.infura.io/<infura token>
Connected successfully to client: Parity//v1.4.4-beta-a68d52c-20161118/x86_64-linux-gnu/rustc1.13.0
What amound would you like to transfer (please enter a numeric value): 10
Please specify the unit (ether, wei, ...) [ether]: ether
Please confim that you wish to transfer 10 ether (10000000000000000000 wei) to address 0x<destination
address>
Please type 'yes' to proceed: yes
Commencing transfer (this may take a few
minutes) ................................................................................................
............................$

Funds have been successfully transferred from 0x<source address> to 0x<destination address>
Transaction hash: 0x<tx hash>
Mined block number: 2673468
```

# Faucets

- Request free Ether for testnets
- Geth (Rinkeby)
    - Crypto Faucet at https://www.rinkeby.io/
    - Provide Gist with wallet address
- Parity (Kovan)
    - https://gitter.im/kovan-testnet/faucet
    - State wallet address

## Exercise

- Install web3j command line tools

```
brew tap web3j/web3j

brew install web3j
```

- Generate a wallet file

```
web3j wallet create
```

- Request some ether from a Rinkeby or Kovan faucet
- https://rinkeby.io
- Transfer some ether to the person sitting next to you

```
web3j wallet send
```

## Smart Contracts

# Ethereum Smart Contracts

- Usually written in Solidity
- Statically typed high level language
- Compiled to Ethereum Virtual Machine (EVM) byte code
- Create Java wrappers with web3j

# Smart Contract Compilation

- Compile

```
$ solc Greeter.sol --bin --abi --
optimize -o build/
```

- Generates
  - Application Binary Interface (ABI) file
  - EVM bytecode (binary) file

## Greeter.sol

```
contract mortal {
    address owner;

    function mortal() { owner = msg.sender; }

    function kill() { if (msg.sender == owner) suicide(owner); }
}

contract greeter is mortal {
    string greeting;

    // constructor
    function greeter(string _greeting) public {
        greeting = _greeting;
    }

    // getter
    function greet() constant returns (string) {
        return greeting;
    }
}
```

# Greeter.abi

```
[
  {
    "constant": true,
    "inputs": [

    ],
    "name": "greet",
    "outputs": [
      {
        "name": "",
        "type": "string"
      }
    ],
    "payable": false,
    "type": "function"
  },
  {
    "inputs": [
      {
        "name": "_greeting",
        "type": "string"
      }
    ],
    "type": "constructor"
  },
  ...
]
```

# Greeter.bin

```
6060604052341561000c57fe5b6040516102f03803806102f0833981016040528051015b5b6000
8054600160a060020a031916633600160a060020a03161790555b80516100539060019060208401
9061005b565b505b506100fb565b828054600181600116156101000203166002900490600052
602060002090601f016020900481019282601f1061009c57805160ff1916838001178555610 0c95
65b82800160010185558215610 0c9579182015b82811115610 0c957825182559160200191906 0
0101906100ae565b5b506100d69291506100da565b5090565b6100f891905b808211156100d6
576000815560010161 00e0565b5090565b90565b6101e68061010a6000396000f300606060405
263ffffffff60e060020a6000350416634 1c0e1b5811461002c578063cfae3217146100 3e575bfe5b3
41561003457fe5b61003c6100ce565b005b341561004657fe5b61004e610110565b6040805160
20808252835181830152835191928392908301918501908083838215610094575b80518252602
083111561009457601f1990920191602091820191016100745 65b505050905090810190601f168
0156100c05780820380516001836020036101000a031916815260200191505b50925050506040
5180910390f35b6000543373ffffffffffffffffffffffffffffffffffffffff9081169116141561010d5760005473ffffffffff
ffffffffffffffffffffffffffffff16ff5b5b565b6101186101a8565b6001805460408051602060028486161561 0
100026000190190941693909304601f81018490048402820184019092528181529291830182 82
801561019d5780601f106101725761010080835404028352916020019161019d565b820191906
0005260206000209 05b8154815290600101906020018083116101805782900360 1f168201915b
505050505090505b90565b60408051602081019091526000815290 5600a165627a7a723058201
41d86fec5655546a8ea51f05c2df449092e6e94a88e09d4214fdf5836d7b56e0029
```

# Smart Contract Wrappers

- Generate wrappers

```
$ web3j solidity generate build/greeter.bin build/greeter.abi -p org.web3j.example.generated -o src/main/java/
```

# Greeter.java

```
public final class Greeter extends Contract {
    private static final String BINARY = “6060604052604....";
    ...

    public Future<Utf8String> greet() {
        Function function = new Function<Utf8String>("greet",
                Arrays.<Type>asList(),
                Arrays.<TypeReference<Utf8String>>asList(new
TypeReference<Utf8String>() {}));
        return executeCallSingleValueReturnAsync(function);
    }

    public static Future<Greeter> deploy(Web3j web3j, Credentials
credentials, BigInteger gasPrice, BigInteger gasLimit, BigInteger
initialValue, Utf8String _greeting) {
        String encodedConstructor =
FunctionEncoder.encodeConstructor(Arrays.<Type>asList(_greeting));
        return deployAsync(Greeter.class, web3j, credentials,
gasPrice, gasLimit, BINARY, encodedConstructor, initialValue);
    }
    ...
```

# Hello Blockchain World!

```
Web3j web3 = Web3j.build(new HttpService());

Credentials credentials =
    WalletUtils.loadCredentials(
        "my password",
        "/path/to/walletfile");

Greeter contract = Greeter.deploy(
    web3, credentials,
    ManagedTransaction.GAS_PRICE, Contract.GAS_LIMIT,
    BigInteger.ZERO,
    new Utf8String("Hello blockchain world!"))
    .get();

Utf8String greeting = contract.greet().get();
System.out.println(greeting.getValue());
```

```
Hello blockchain world!
```

blk.io

# testrpc

- Local development Ethereum client
- Installation via:

```
$ npm install -g ethereumjs-testrpc
```

- Run:

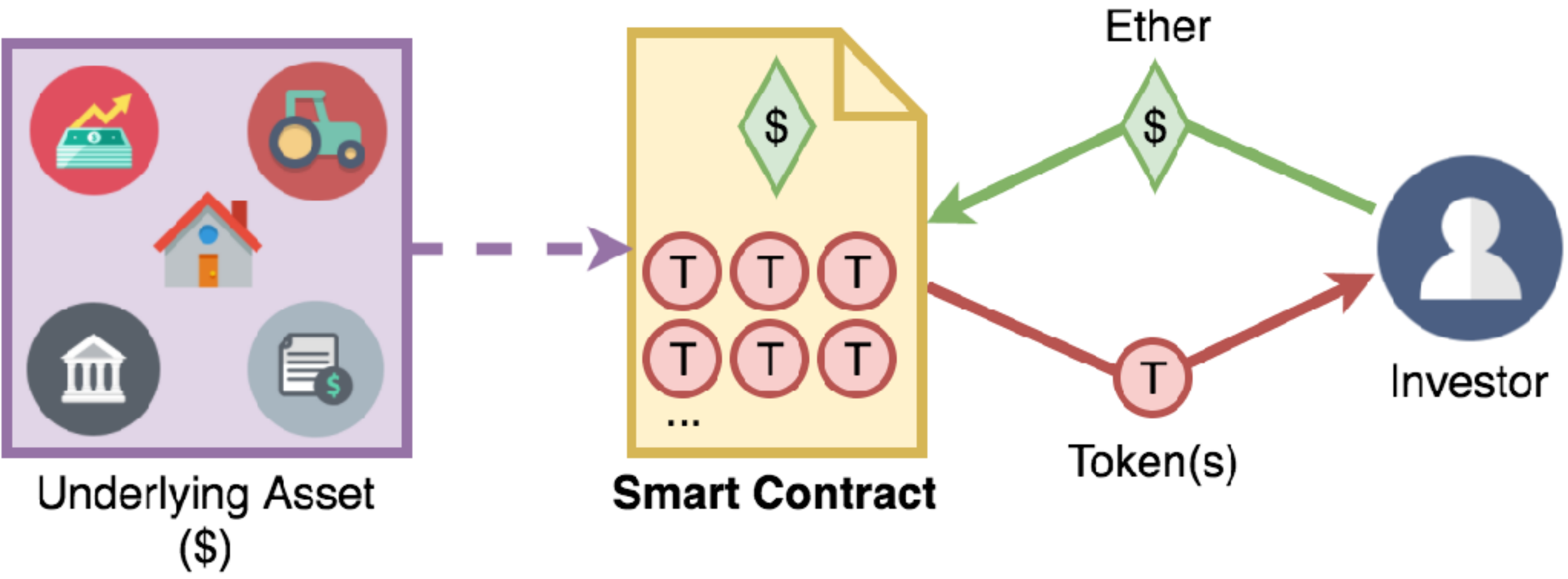
```
$ testrpc --account="0x<address>,
1000000000000000000000000000" —account=“…"
```

- Doesn’t support filters
- More information at https://github.com/ethereumjs/testrpc

# Exercise

- Install Solidity
- Add the Greeter Solidity source code to your project
    - https://github.com/web3j/web3j/blob/master/codegen/src/test/resources/solidity/greeter/Greeter.sol
- Modify the Greeter to add a setter method
- Deploy & run the Greeter contract!

# Smarter Contracts



blk.io

## Smarter Contracts

- Asset tokenisation
- Hold Ether
- EIP-20 smart contract token standard
- See web3j examples

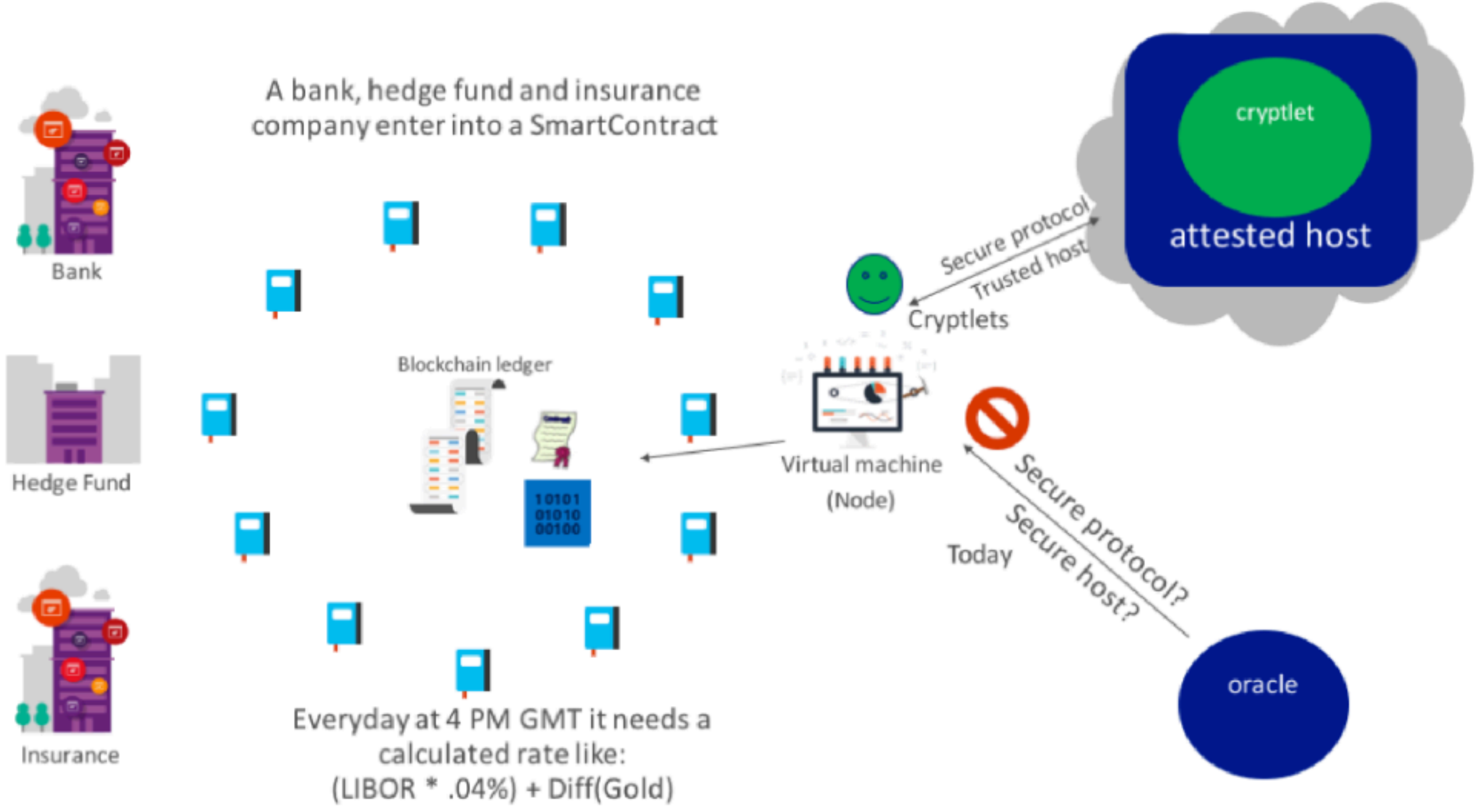
# Events

- Also known as logs
- Write data to the Ethereum blockchain as part of a transaction
- Defined in Solidity as:

```
event Name(paramType param1, …, )
```

- Up to 3 indexed events (for searching)
- 32 byte size limit per parameter
- Arrays (including string & bytes) only hash is available

# Oracles & Cryplets

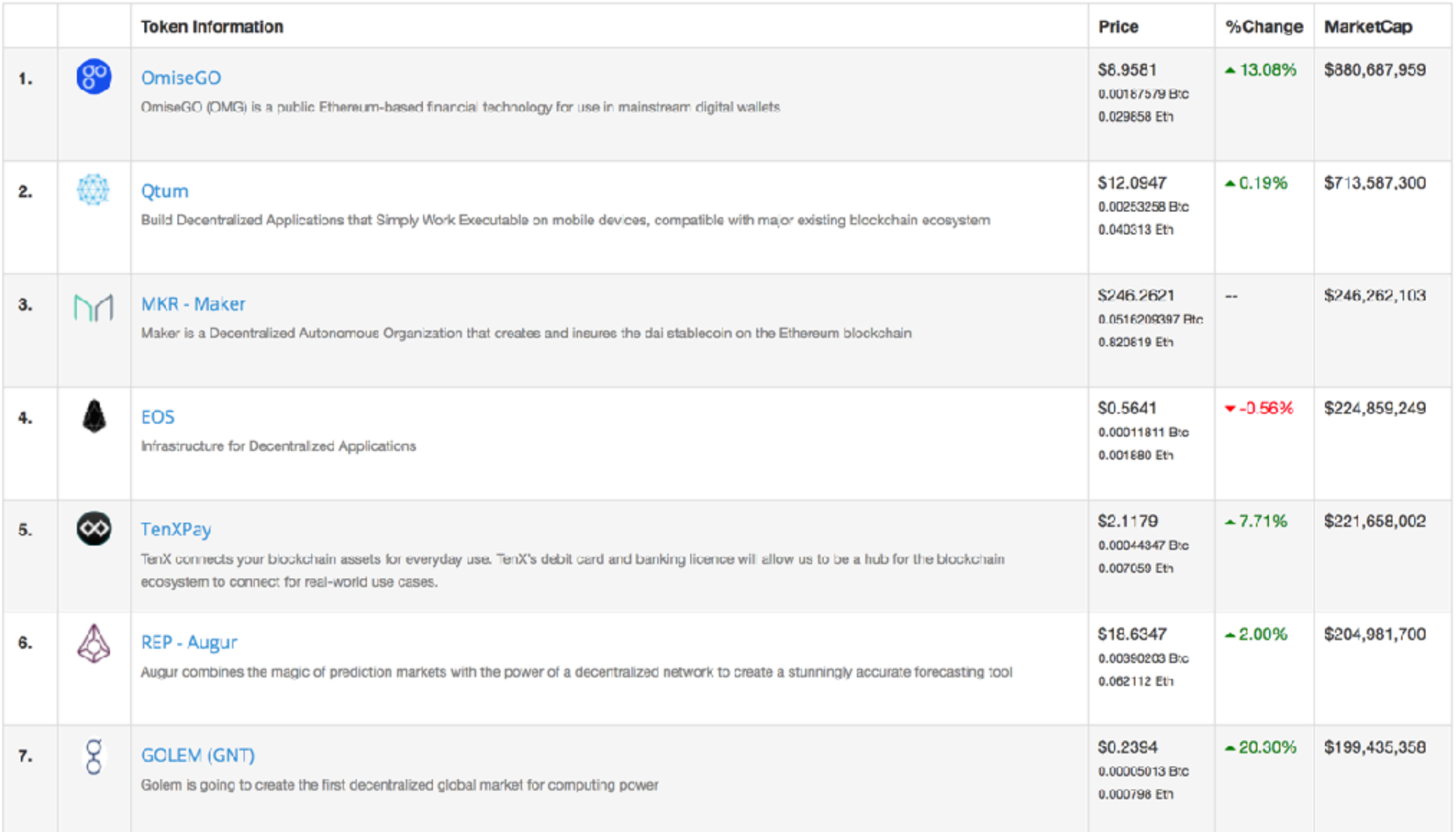


**Source:** **https://github.com/Azure/azure-blockchain-projects/blob/master/bletchley/bletchley-whitepaper.md**

## State Channels

- Interactions that take place off the blockchain
- Result of interactions is stored on the blockchain
- Facilitates negotiating between actors without blockchain throughput constraints

# Initial Coin Offerings



| | | Token Information | Price | %Change | MarketCap |
|---|---|---|---|---|---|
| 1. | | OmiseGO<br>OmiseGO (OMG) is a public Ethereum-based financial technology for use in mainstream digital wallets | $8.9581<br>0.00187579 Btc<br>0.029858 Eth | ▲ 13.08% | $880,687,959 |
| 2. | | Qtum<br>Build Decentralized Applications that Simply Work Executable on mobile devices, compatible with major existing blockchain ecosystem | $12.0947<br>0.00253258 Btc<br>0.040313 Eth | ▲ 0.19% | $713,587,300 |
| 3. | | MKR - Maker<br>Maker is a Decentralized Autonomous Organization that creates and insures the dai stablecoin on the Ethereum blockchain | $246.2621<br>0.0516209397 Btc<br>0.820819 Eth | -- | $246,262,103 |
| 4. | | EOS<br>Infrastructure for Decentralized Applications | $0.5641<br>0.00011811 Btc<br>0.001880 Eth | ▼ -0.56% | $224,859,249 |
| 5. | | TenXPay<br>TenX connects your blockchain assets for everyday use. TenX's debit card and banking licence will allow us to be a hub for the blockchain ecosystem to connect for real-world use cases. | $2.1179<br>0.00044347 Btc<br>0.007059 Eth | ▲ 7.71% | $221,658,002 |
| 6. | | REP - Augur<br>Augur combines the magic of prediction markets with the power of a decentralized network to create a stunningly accurate forecasting tool | $18.6347<br>0.00390203 Btc<br>0.062112 Eth | ▲ 2.00% | $204,981,700 |
| 7. | | GOLEM (GNT)<br>Golem is going to create the first decentralized global market for computing power | $0.2394<br>0.00005013 Btc<br>0.000798 Eth | ▲ 20.30% | $199,435,358 |

## ERC20 Token Standard

- The standard that is driving ICOs (Initial Coin Offerings)
- ERC20 is the Ethereum standard for working with tokens (coins) in smart contracts

## ERC20 Functions

**Define token**

- Name, Symbol
- Total supply

**Manage**

- transfer - by owner or on behalf of
- approve - delegated transfer on behalf of

**Observe**

- get transfer allowance
- get balance

# ERC20 interface

```
contract ERC20 is ERC20Basic {

  function allowance(
    address owner, address spender) public constant returns
(uint256);

  function transferFrom(
    address from, address to, uint256 value) public returns (bool);

  function approve(
    address spender, uint256 value) public returns (bool);

  event Approval(
    address indexed owner, address indexed spender, uint256 value);

}
```

**Source: Open Zepplin http://bit.ly/2nindNI**

# Open Zepplin

- Smart contract frameworks
- Industry best practices
  - Security patterns
  - Modular
- Auditors of ICO contracts (~$1.5bn of crypto)

# Contract libraries

- Available from https://github.com/OpenZeppelin/zeppelin-solidity/tree/master/contracts
- Maths libraries
- Crowdsales
- Tokens
- Payments

# ERC20 in web3j

- web3j provides ERC20 integration test

  https://github.com/web3j/web3j/blob/master/integration-tests/src/test/java/org/web3j/protocol/scenarios/HumanStandardTokenGeneratedIT.java

- Based on ConsenSys ERC20 implementation

  https://github.com/ConsenSys/Tokens

# Exercise

- Create an ERC20 smart contract wrapper
- Reference implementations to use:
  - ConsenSys
    - https://github.com/ConsenSys/Tokens/tree/master/contracts
  - Open Zepplin
    - https://github.com/OpenZeppelin/zeppelin-solidity/tree/master/contracts/token

## RxJava in web3j

## web3j + RxJava

- Reactive-functional API
- Observables for all Ethereum client methods

```
Web3j web3 = Web3j.build(new HttpService());  //
defaults to http://localhost:8545/

web3j.web3ClientVersion().observable().subscribe(
x -> {

    System.out.println(x.getWeb3ClientVersion());

});
```

# Processing all new blocks

```
Web3j web3 = Web3j.build(new HttpService());

Subscription subscription =
    web3j.blockObservable(false)
        .subscribe(block -> {
            System.out.println(
                "Sweet, block number " +
                block.getBlock().getNumber() +
                " has just been created");
        }, Throwable::printStackTrace);

TimeUnit.MINUTES.sleep(2);
subscription.unsubscribe();
```

# Replay transactions

```
Subscription subscription =
web3j.replayTransactionsObservable(
        <startBlockNo>, <endBlockNo>)
        .subscribe(tx -> {
                ...
});
```

## Replay all + future

```
Subscription subscription =
web3j.catchUpToLatestAndSubscribeToNewBlocks
Observable(
        <startBlockNo>, <fullTxObjects>)
        .subscribe(blk -> {
                ...
});
```

## Replay Performance

941667 blocks on Ropsten (14th June 2017):

- Blocks excluding transactions in 7m22s.
- Blocks including transactions in 41m16s

*(2013 Macbook Pro)*

# Event callbacks

- Process events in smart contracts

```
HumanStandardToken contract = deploy(web3j, ALICE,
                GAS_PRICE, GAS_LIMIT,
                BigInteger.ZERO,
                new Uint256(aliceQty), new Utf8String("web3j tokens"),
                new Uint8(BigInteger.TEN), new Utf8String(“w3j$")).get();

contract.transferEventObservable(
        <startBlock>, <endBlock>)
                .subscribe(event -> {
                        ...
});
```

## Exercise

- Checkout the tx project available at https://github.com/web3j/examples
- Run some of the examples to see blocks and transactions being created on the blockchain
- Remember to hook into your own local client

Quorum

## Quorum

- JP Morgan’s fork of Ethereum
- Made public November 2016
- Private blockchain technology
- Adds transaction privacy
- RAFT consensus (thousands tx/sec)
- Reference client for Enterprise Ethereum Alliance

# Integration with Quorum

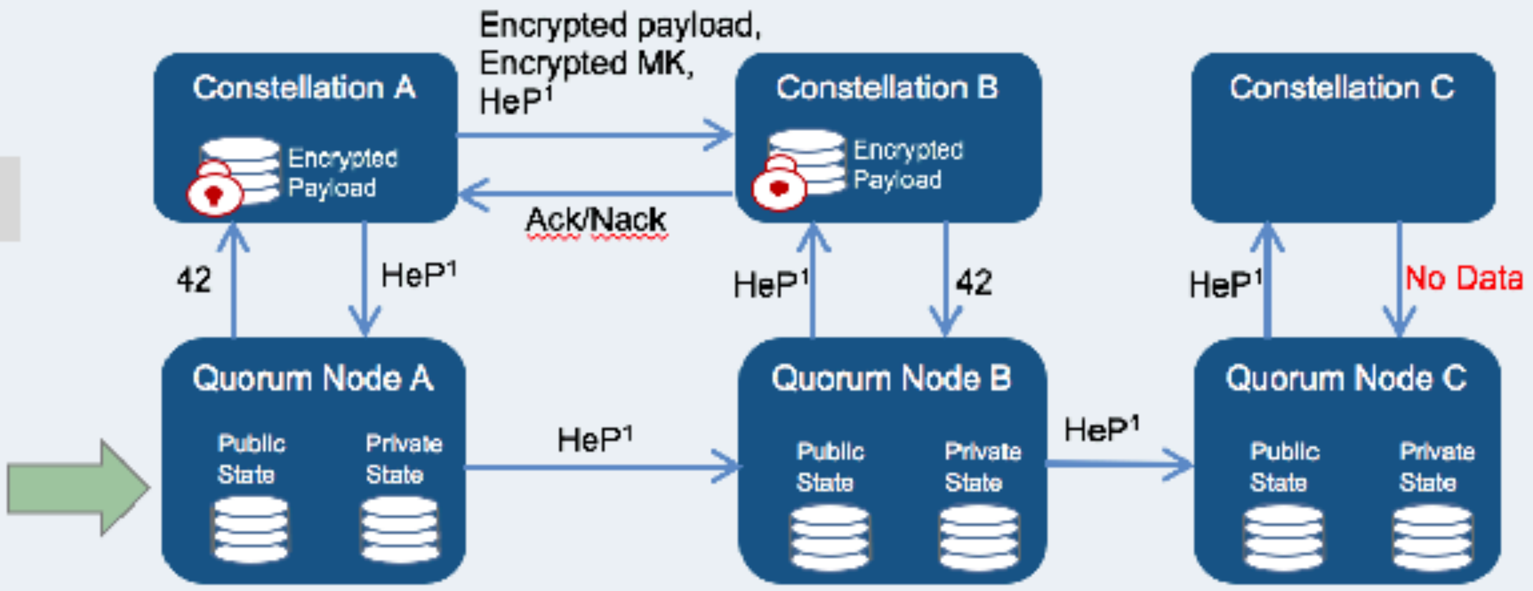
- Simple to use, same familiar Ethereum Transaction:

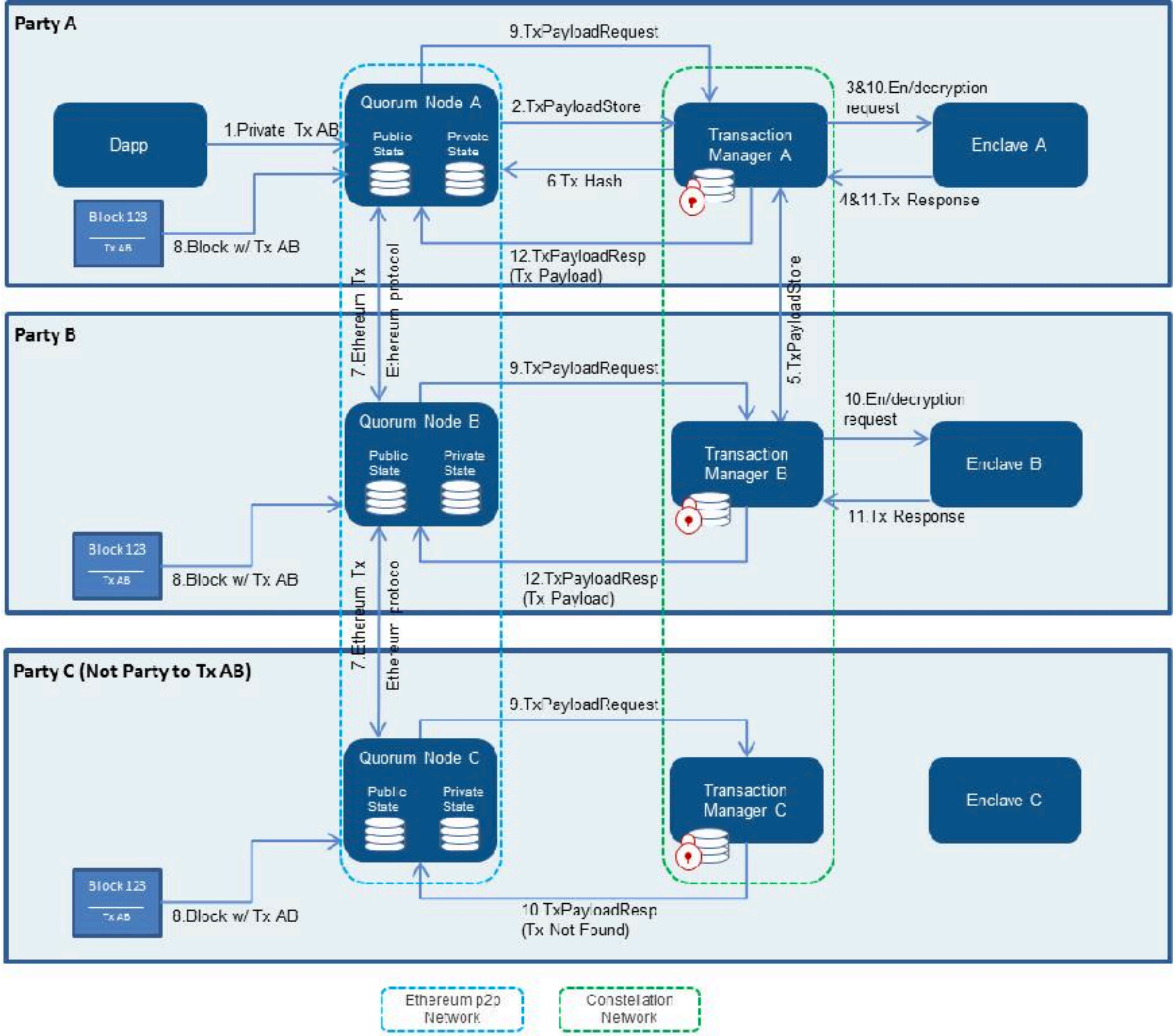
**Public Transaction (no change from geth):**

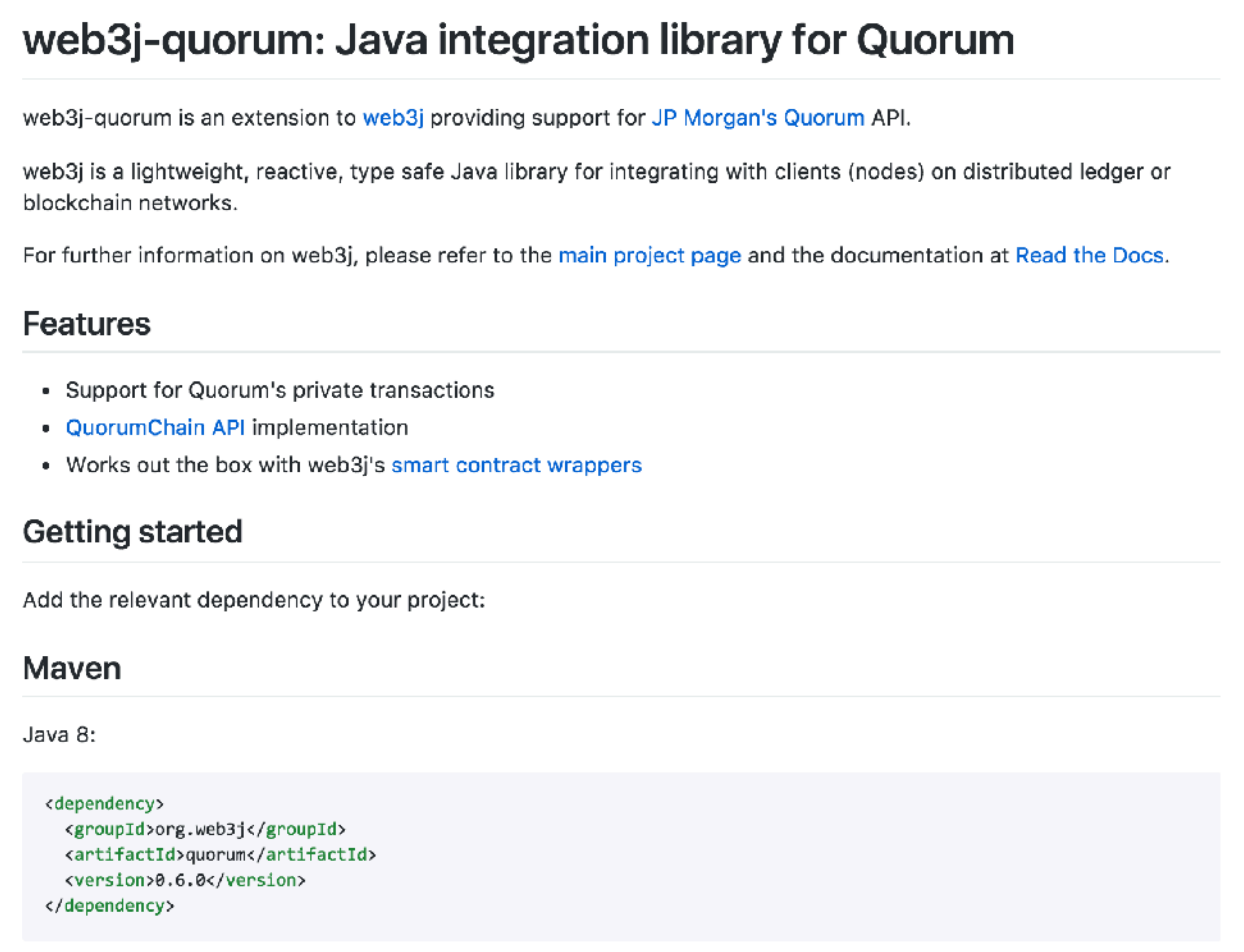
```
myContract.new(42, {from:$PartyA, data:$CODE})
```

**Private Transaction (from Party A):**

```
myContract.new(42, {from:$PartyA, data:$CODE,
                privateFor:[$PartyB]})
```




Party A
Dapp
1.Private Tx AB
Block 123
Tx AB
8.Block w/ Tx AB
Quorum Node A
Public State
Private State
9.TxPayloadRequest
2.TxPayloadStore
6.Tx Hash
12.TxPayloadResp (Tx Payload)
Transaction Manager A
3&10.En/decryption request
Enclave A
4&11.Tx Response
5.TxPayloadStore
7.Ethereum Tx
Ethereum protocol
Party B
Block 123
Tx AB
8.Block w/ Tx AB
Quorum Node B
Public State
Private State
9.TxPayloadRequest
Transaction Manager B
10.En/decryption request
Enclave B
11.Tx Response
12.TxPayloadResp (Tx Payload)
Party C (Not Party to Tx AB)
Block 123
Tx AB
8.Block w/ Tx AB
Quorum Node C
Public State
Private State
9.TxPayloadRequest
Transaction Manager C
Enclave C
10.TxPayloadResp (Tx Not Found)
Ethereum p2p Network
Constellation Network



# web3j-quorum: Java integration library for Quorum

web3j-quorum is an extension to web3j providing support for JP Morgan's Quorum API.

web3j is a lightweight, reactive, type safe Java library for integrating with clients (nodes) on distributed ledger or blockchain networks.

For further information on web3j, please refer to the main project page and the documentation at Read the Docs.

## Features

- Support for Quorum's private transactions
- QuorumChain API implementation
- Works out the box with web3j's smart contract wrappers

## Getting started

Add the relevant dependency to your project:

## Maven

Java 8:

```
<dependency>
  <groupId>org.web3j</groupId>
  <artifactId>quorum</artifactId>
  <version>0.6.0</version>
</dependency>
```

# Hello Quorum World!

```
String fromAddress = “0x<from-address>";
List<String> privateFor = Arrays.asList(“<enclave-key>”, ..);
Quorum quorum = Quorum.build(
        new HttpService(“http://localhost:22001”));

ClientTransactionManager transactionManager =
        new ClientTransactionManager(
                quorum, fromAddress, privateFor);
Greeter contract = Greeter.deploy(
        quorum, transactionManager,
        BigInteger.ZERO, BigInteger.ZERO, BigInteger.ZERO,
        new Utf8String(“Hello Quorum world!")).get();

Utf8String greeting = contract.greet().get();
System.out.println(greeting.getTypeAsString());
```

```
Hello Quorum world!
```

# Exercises

- Run up the Quorum 7 node VM example
- Setup

```
git clone https://github.com/jpmorganchase/quorum-examples.git

cd quorum-examples

vagrant up

vagrant ssh
```

- Run

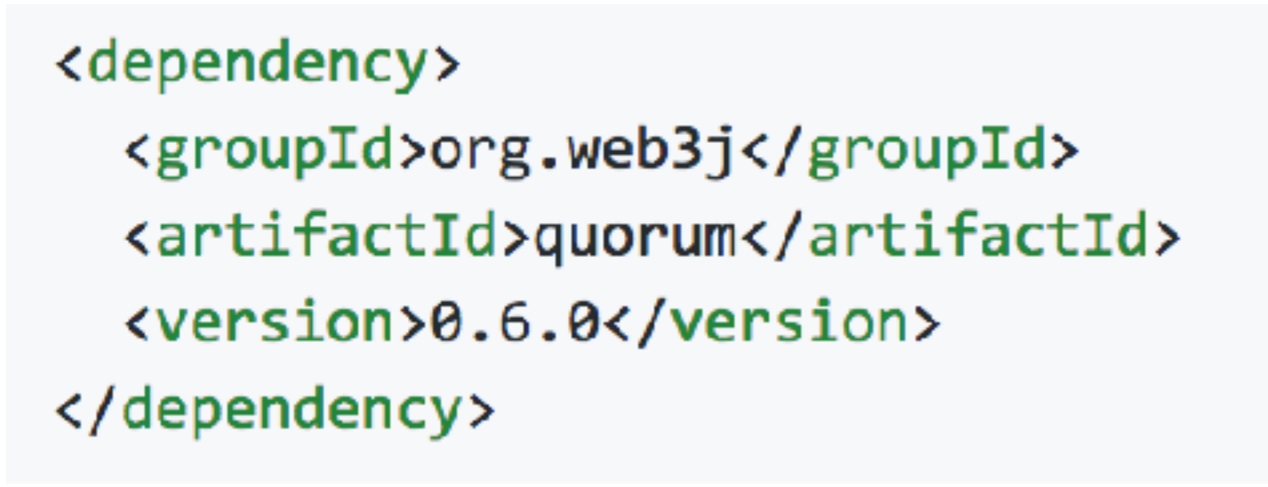
```
cd examples/7nodes/

./raft-init.sh

./raft-start.sh
```

# Exercises ctd.

- Adapt Greeter example to use transaction privacy with Quorum
- Use web3j-quorum 0.6.0
- Use privateFor value of key 7
  - keys/tm7.pub:

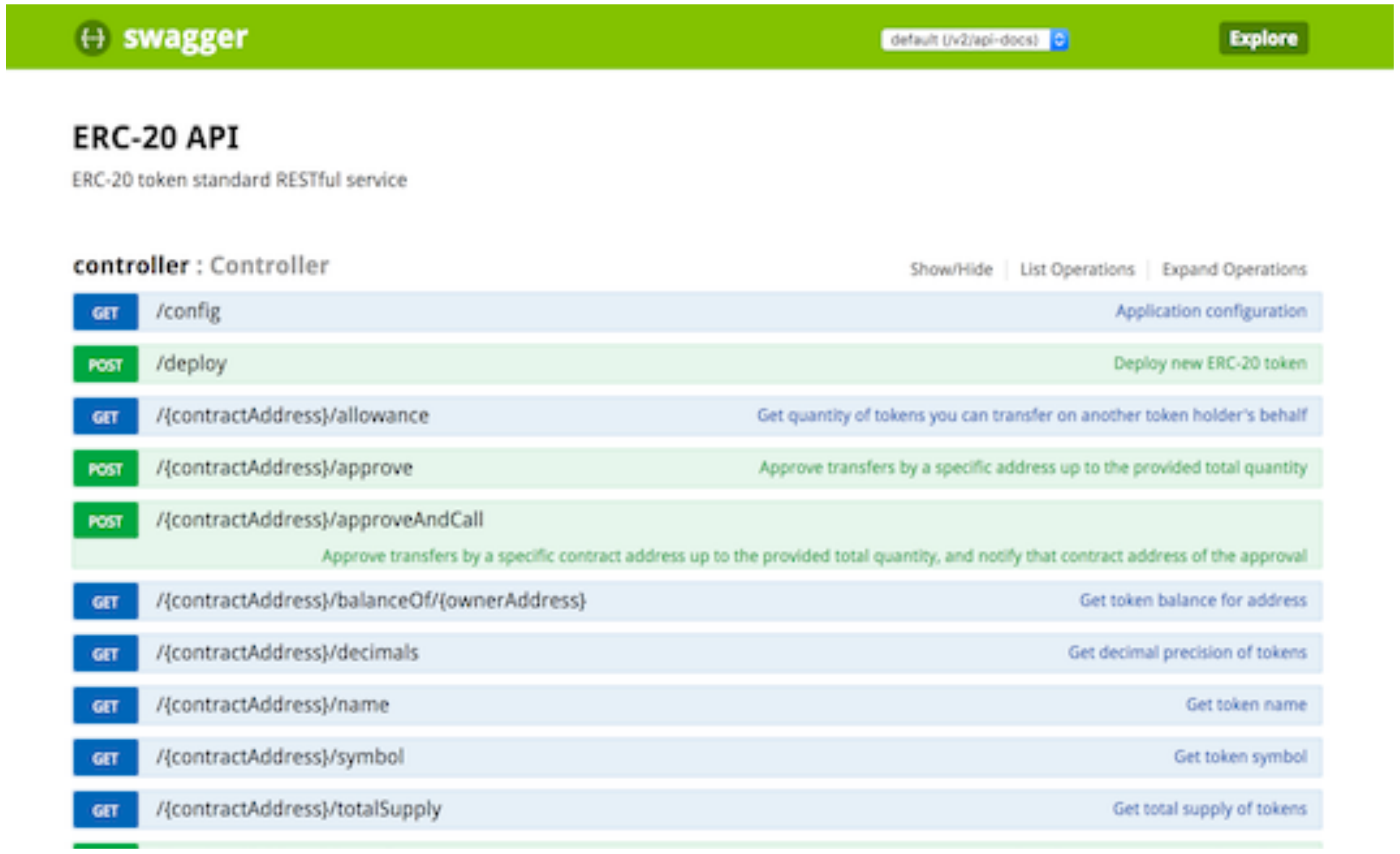


```
<dependency>
  <groupId>org.web3j</groupId>
  <artifactId>quorum</artifactId>
  <version>0.6.0</version>
</dependency>
```

```
ROAZBWtSacxXQrOe3FGAqJDyJjFePR5ce4TSIzmJ0Bc=
```

# Building RESTful services

- Simple Spring Boot application running on Quorum
- Provides RESTful API for managing ERC tokens



**ERC-20 API**

ERC-20 token standard RESTful service

**controller** : Controller

| | | |
|---|---|---|
| GET | /config | Application configuration |
| POST | /deploy | Deploy new ERC-20 token |
| GET | /{contractAddress}/allowance | Get quantity of tokens you can transfer on another token holder's behalf |
| POST | /{contractAddress}/approve | Approve transfers by a specific address up to the provided total quantity |
| POST | /{contractAddress}/approveAndCall | Approve transfers by a specific contract address up to the provided total quantity, and notify that contract address of the approval |
| GET | /{contractAddress}/balanceOf/{ownerAddress} | Get token balance for address |
| GET | /{contractAddress}/decimals | Get decimal precision of tokens |
| GET | /{contractAddress}/name | Get token name |
| GET | /{contractAddress}/symbol | Get token symbol |
| GET | /{contractAddress}/totalSupply | Get total supply of tokens |

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# Exercise

- Clone https://github.com/blk-io/erc20-rest-service.git
- Run a few service instances to demonstrate transaction privacy
- Docker images are available

# web3j

# Hacking on web3j

- git clone https://github.com/web3j/web3j.git
- Run integration tests
    - HumanStandardTokenIT
- Newbie issues labelled with *help wanted*
    - Increment field ids on JSON-RPC requests
    - Cache network id in RawTransactionManager
- Contribute to documentation

## Closing thoughts

- What did you get out of today?

# Where to go from here

- Reddit
  - https://www.reddit.com/r/ethereum/
- Ethereum blog
  - https://blog.ethereum.org/
- Ethereum Improvement Proposals
  - https://github.com/ethereum/EIPs
- Enterprise Ethereum Alliance
  - https://entethalliance.org/