https://gitter.im/web3j/jaxlondon

https://github.com/blk-io/jaxlondon

Building Ethereum ĐApps in Java with web3j

Conor Svensson
conor@blk.io

Content

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

blk.io

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

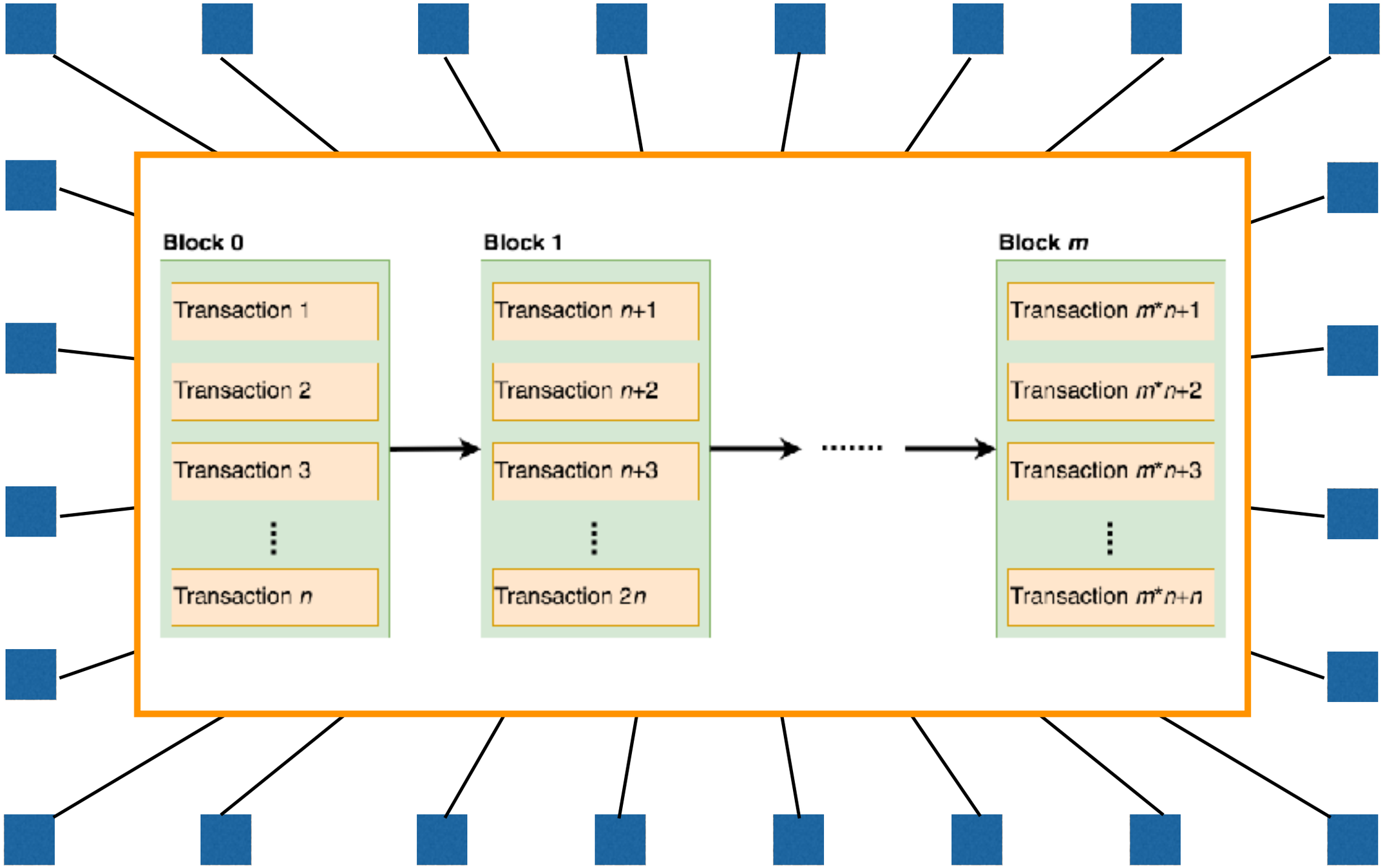
- Developed trading/risk/regulatory platforms on the JVM
- Co-founded a couple of fintech startups in Australia
- web3j author
- Founded blk.io this year
- Enterprise Ethereum Alliance member
    - EEA London organiser
    - Co-chair of integration and tools working group
    - Co-chair of Quorum working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

Digital Asset Holdings

Chain

HYPERLEDGER PROJECT

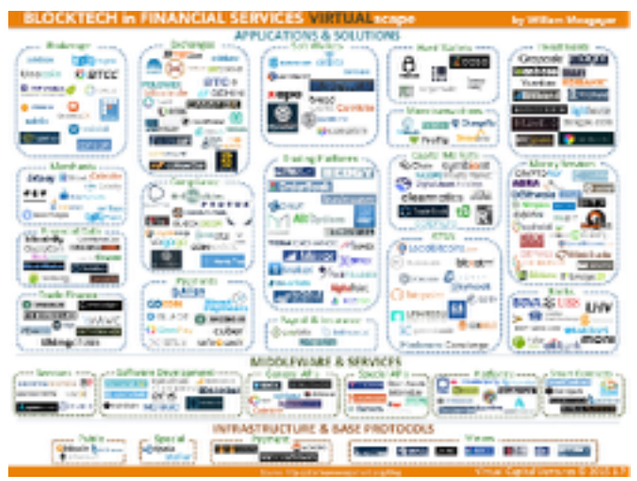
2013

2015+

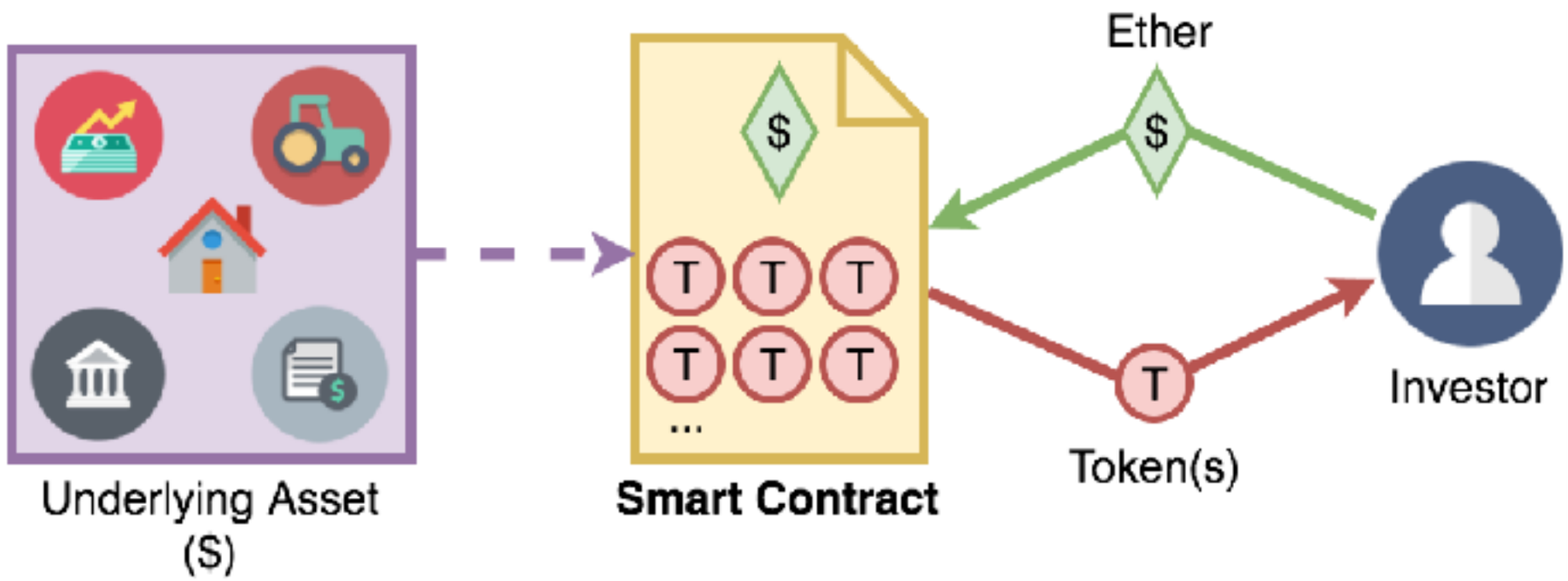
ethereum

ripple

2014



Distributed Ledger Technology



- Smart Contracts
- Public and private
- Consensus mechanisms

blk.io

Use cases

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

blk.io

Considerations

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

blk.io

Practicalities

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

blk.io

Platforms

ethereum

R3 CEV

Chain

J.P.Morgan

HYPERLEDGER PROJECT

Digital Asset Holdings

Microsoft

CONSENSYS

Some prerequisites

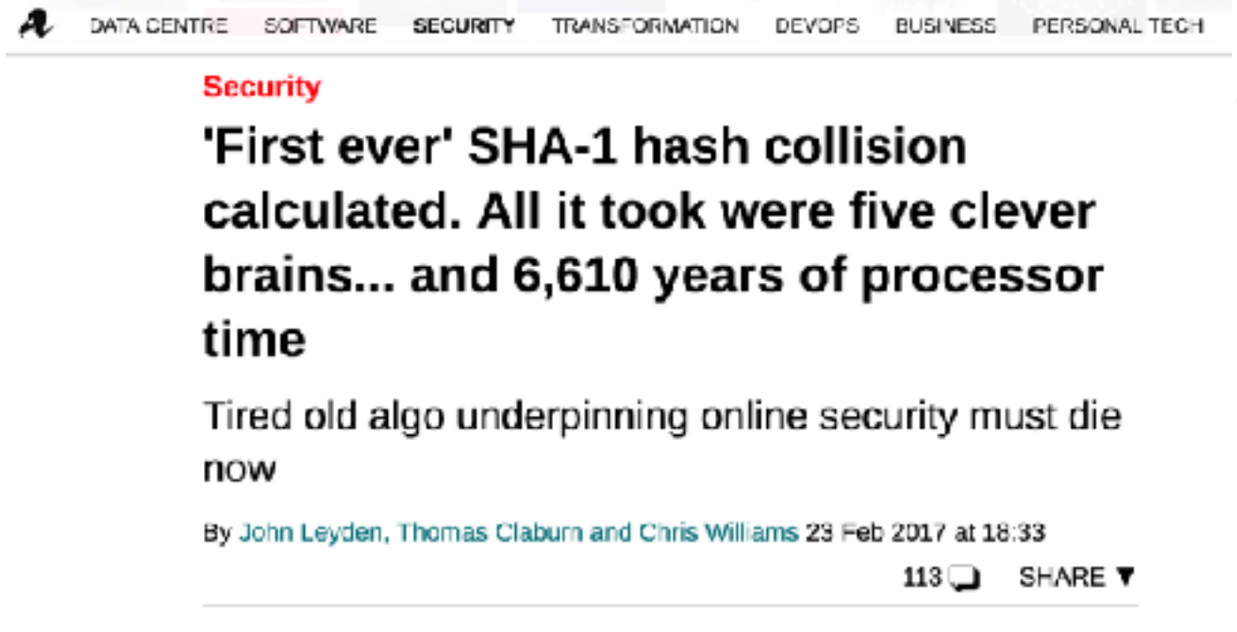
Key technologies

- 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

blk.io

Cryptographic Hash

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


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


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

blk.io

Hashing in Ethereum

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

```
@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

blk.io

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:

```
nonce = random int

while hashimoto(block, nonce) * difficulty > threshold

   increment nonce

return nonce
```

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

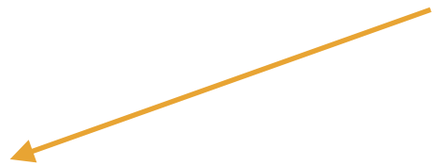
Solution

blk.io

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



blk.io

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?

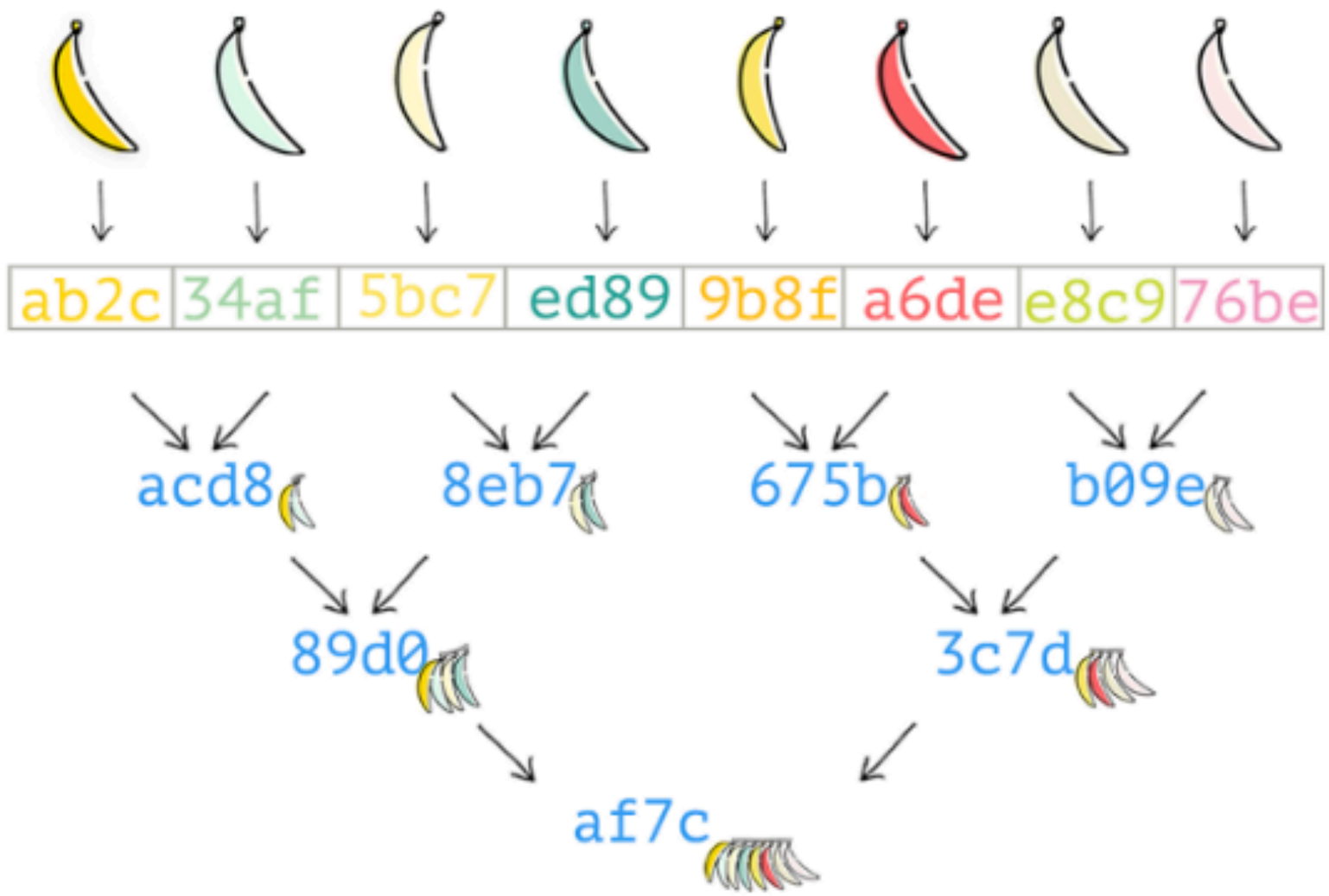
Proof of Authority

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

blk.io

Merkle Trees

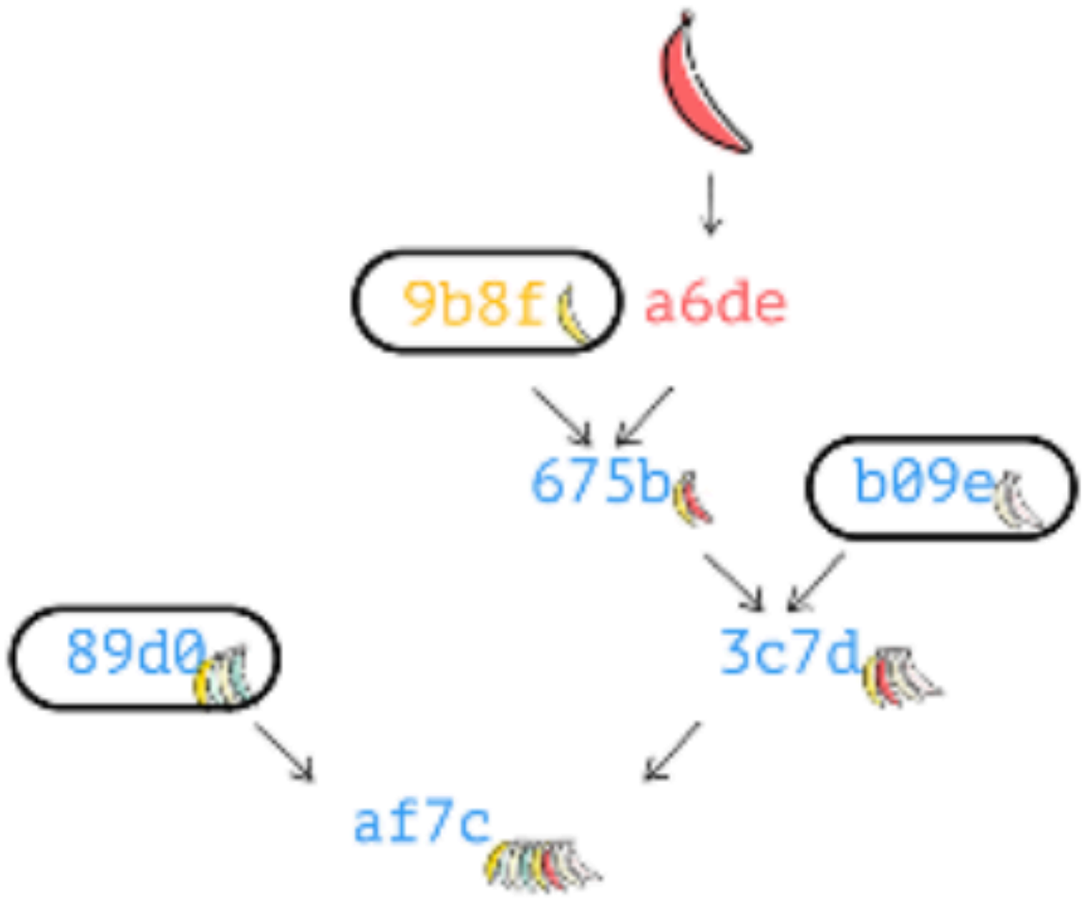
How to encode 8 bananas ?



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

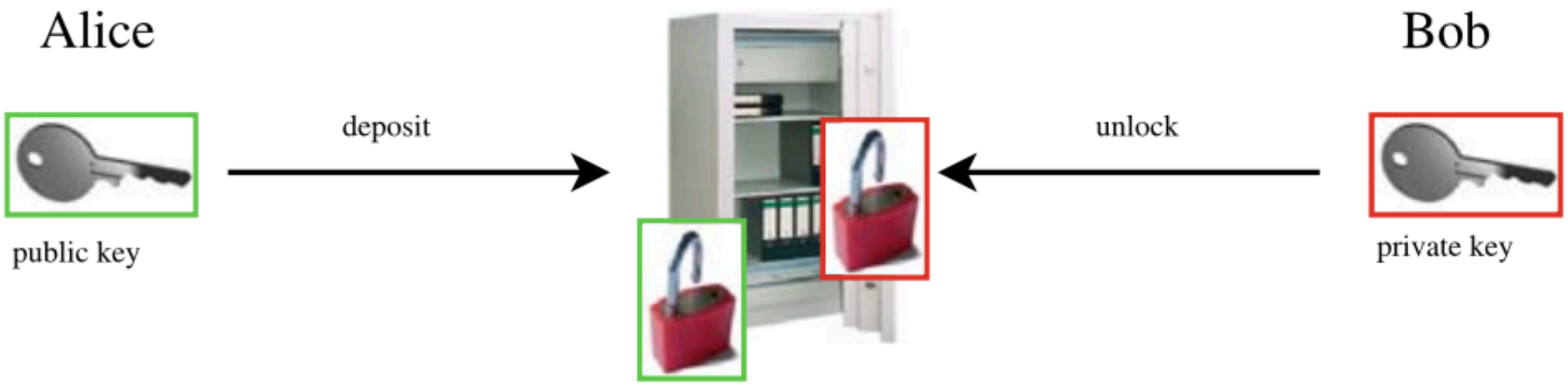
blk.io

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 $k_{pr,B}$, $k_{pub,B}$
	$\xleftarrow{k_{pub,B}}$	publish public key
		sign message: $s = \text{sig}_{k_{pr}}(x)$
	$\xleftarrow{(x,s)}$	send message + signature

verify signature:
$\text{ver}_{k_{pr,B}}(x, s) = \text{true/false}$

Source: Understanding Cryptography (Springer 2010)

blk.io

Ethereum

Ethereum

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

blk.io

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

blk.io

1 Ether = $300 USD

$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

blk.io

Smart Contracts

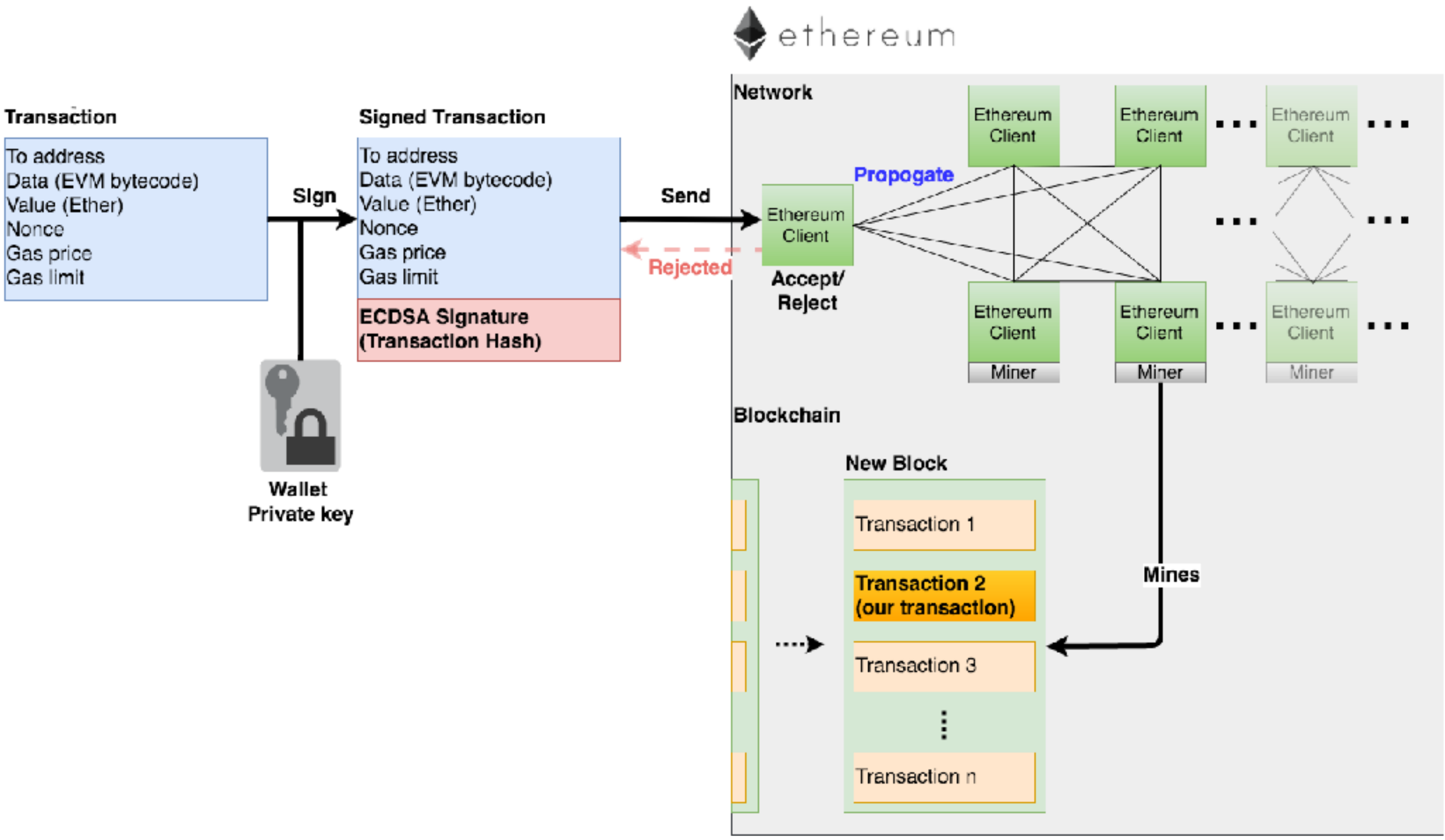
- *Computerised contract*
- Code + data that lives on the blockchain at an address
- Transactions call functions => state transition

blk.io

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):

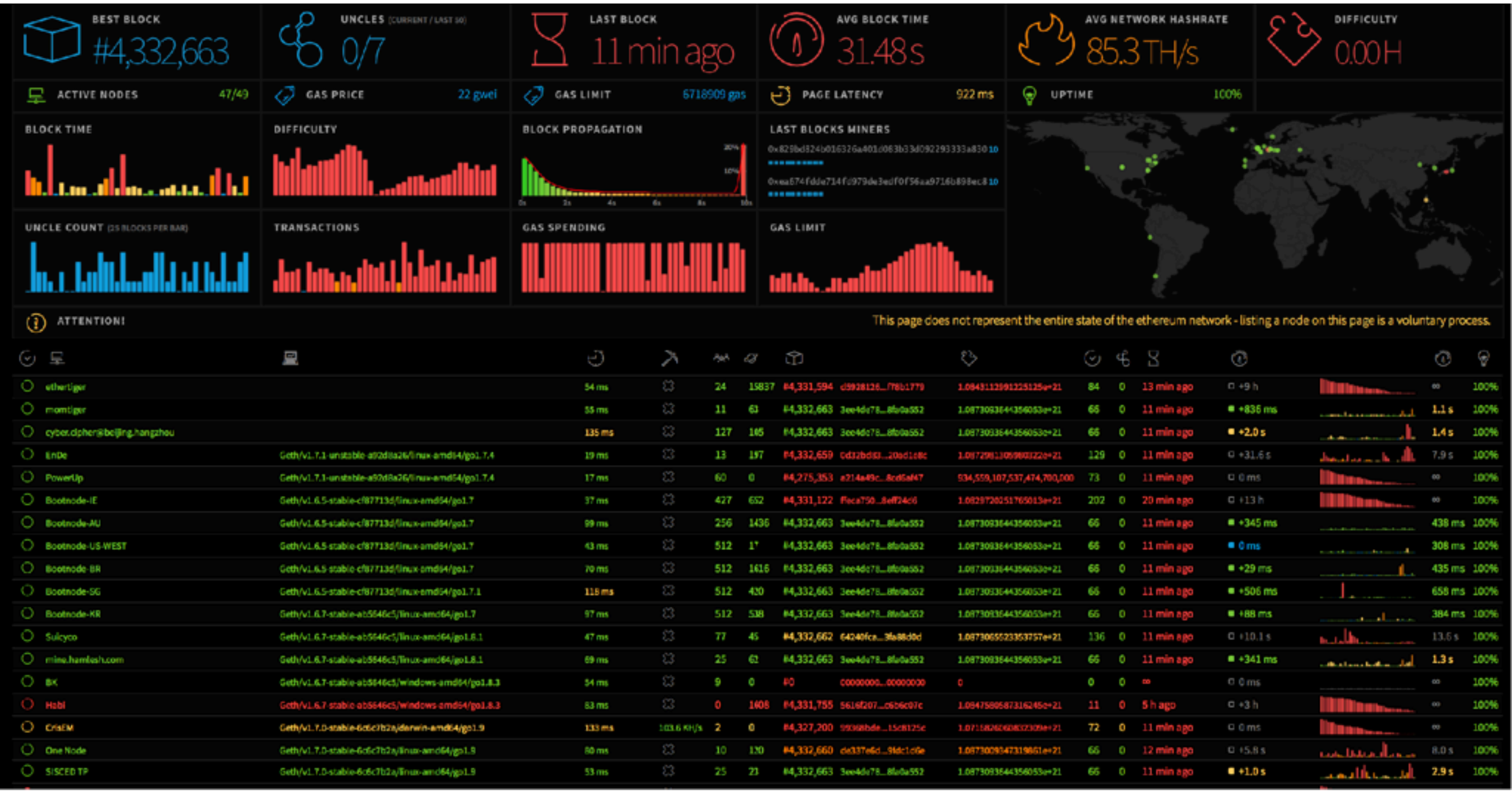
```
$ geth --rpcapi personal,db,eth,net,web3 --
rpc —rinkeby

$ parity --chain testnet
```

Development client

```
$ testrpc --account="0x<address>,
1000000000000000000000000" —account="…"
```

ethstats.net



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

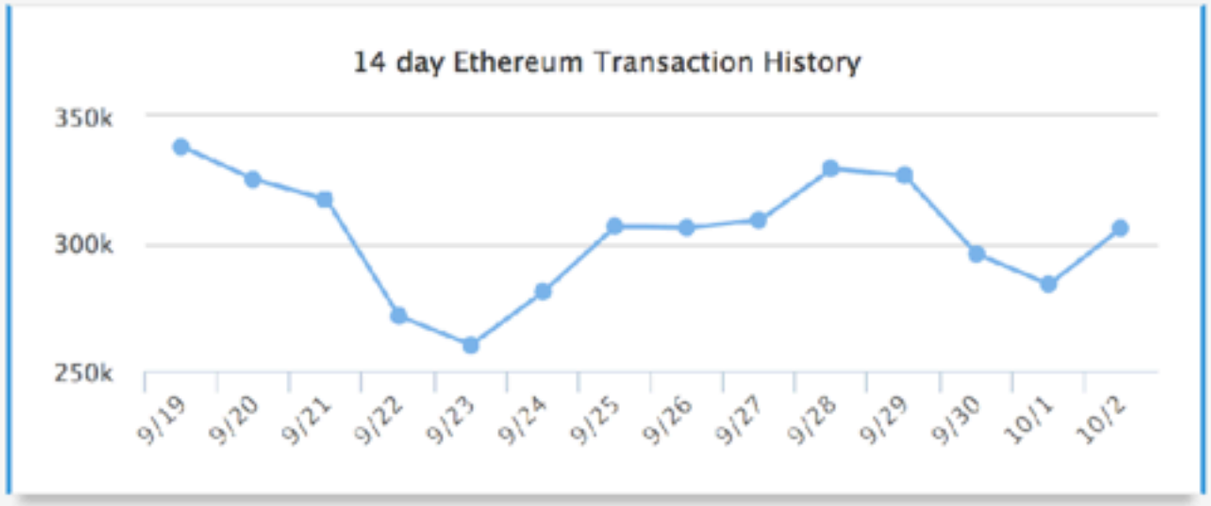
$291.08 @ 0.06758 BTC/ETH (-3.47%)

LAST BLOCK
4332780 (30.11s Avg)

TRANSACTIONS
63736285

Hash Rate
94,063.17 GH/s

Network Difficulty
2,858.59 TH



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

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

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

blk.io

Exercise

- Sign up to Infura

- Start running a node locally

web3j

android

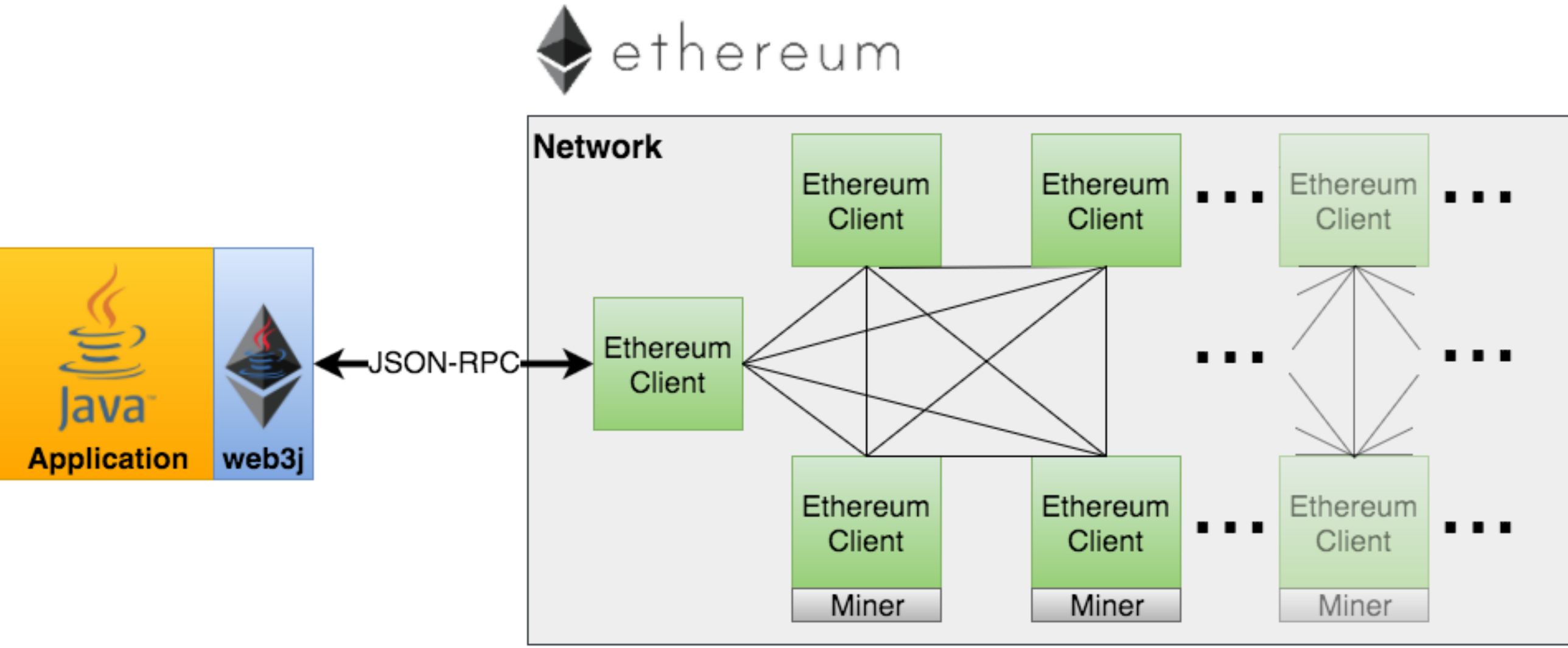
Java™

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
- …

blk.io

web3j

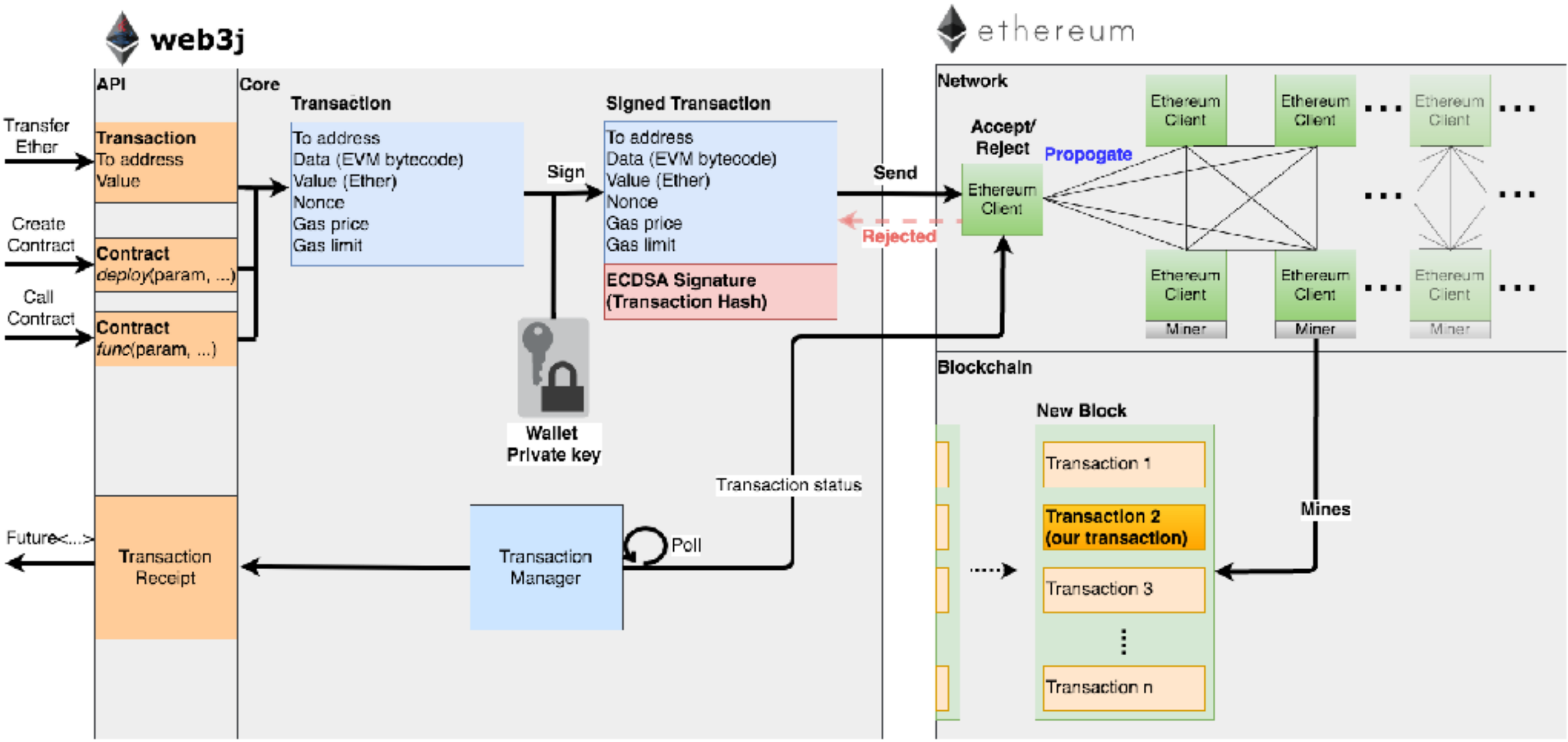
- Complete Ethereum JSON-RPC implementation
- Sync/async & RX Observable API
- Ethereum wallet support
- Smart contract wrappers
- Command line tools
- Android compatible

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());
```

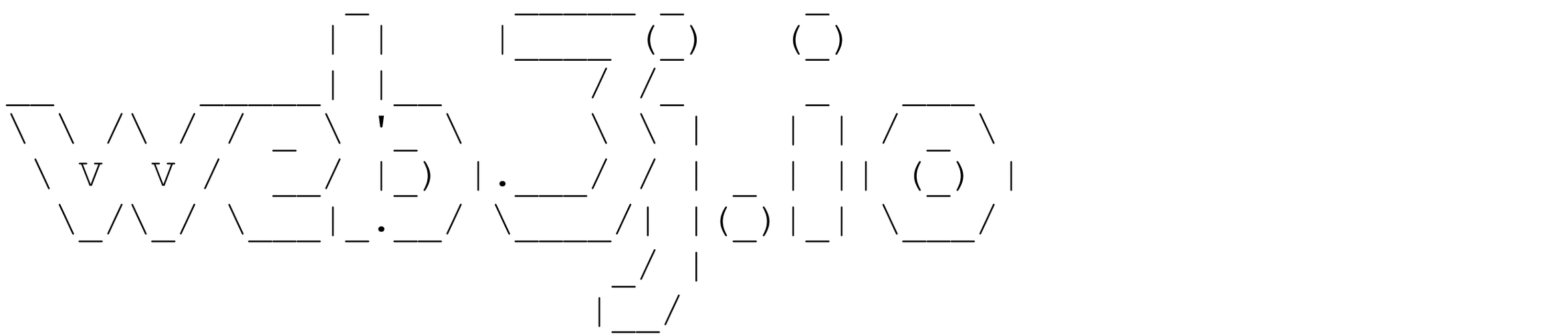
Client version: Geth/v1.7.1-stable-05101641/darwin-amd64/go1.9.1

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
```



```
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
```

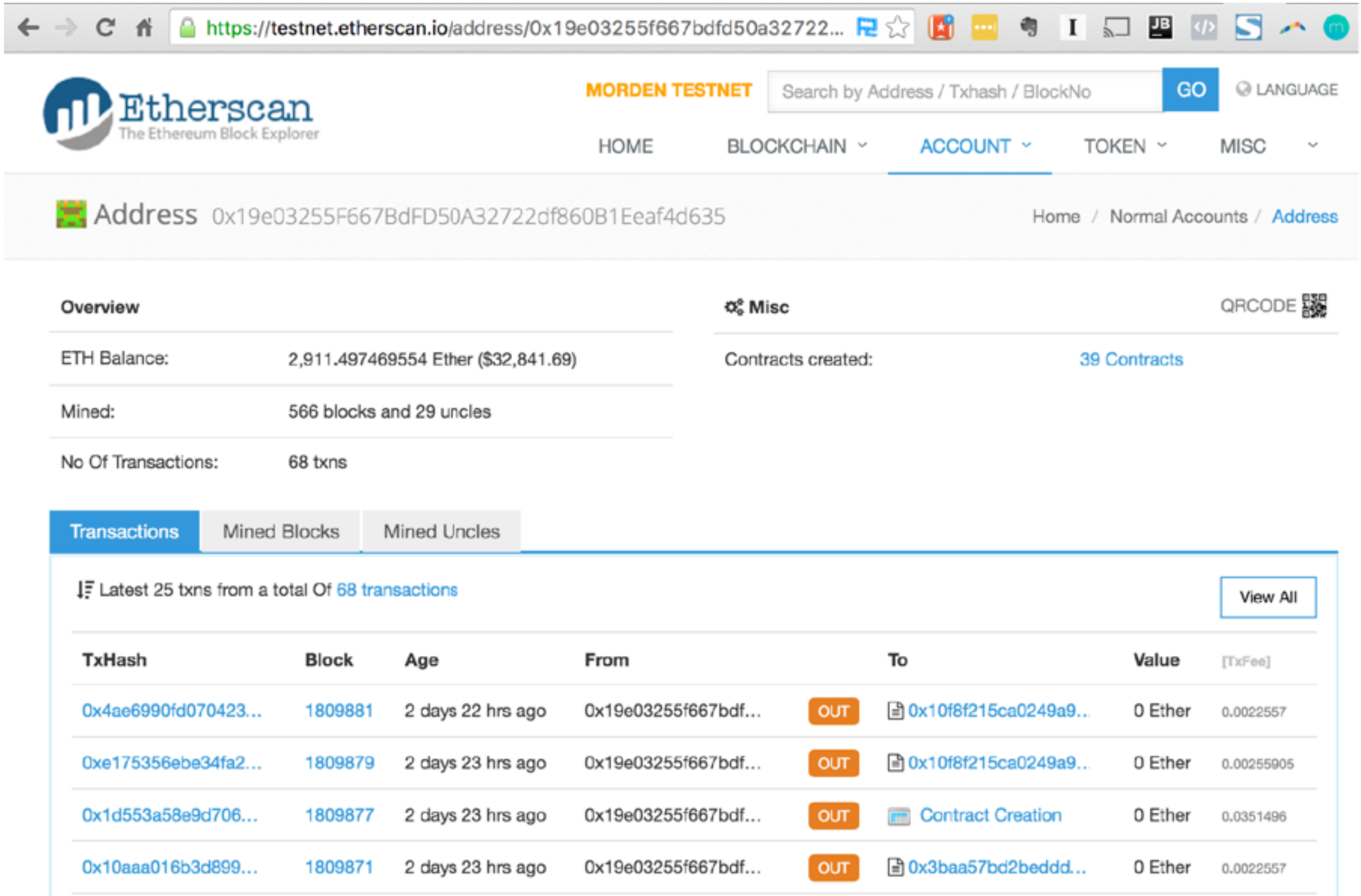
Wallet file


```
{
   "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



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:
0x16e41aa9d97d1c3374a4cb9599febdb24d4d5648b607c99e01a8e79e3eab2c34, block number: 1840479

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

Etherscan
The Ethereum Block Explorer

MORDEN TESTNET

HOME BLOC

Transaction 0x16e41aa9d97d1c3374a4cb9599febdb24d4d5648b607c99e01a8e79e3eab2c34

Overview

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

blk.io

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
80546001600160a060020a031916336001600160a060020a03161790555b8051610053906001906020840
19061005b565b505b506100fb565b828054600181600116156101000203166002900490600052
6020600209060 1f016020900481019282601f1061009c57805160ff1916838001178555610 0c95
65b8280016001018555821561 00c9579182015b828111156100c95782518255916020019190600
0101906100ae565b5b506100d69291506100da565b5090565b6100f891905b808211156100d6
576000815560010161 00e0565b5090565b90565b6101e68061010a6000396000f300606060405
263ffffffff60e060020a6000350416634c0e1b5811461002c578063cfae32171461003e575bfe5b3
4156100345 7fe5b61003c6100ce565b005b341561004657fe5b61004e610110565b6040805160
208082528351818301528351919283929083019185019080838215610094575b805182526020
0831115610094576 01f199092019160209182019101610074565b5050509050909081019060 1f168
0156100c05780820380516001836020036101000a0319168152602001915 05b509250505060405
5180910390f35b600543373ffffffffffffffffffffffffffffffffffffffff90811691161415610 10d576000547fffffffff
ffffffffffffffffffffffff16ff5b5b565b6101186101a8565b60018054604080516020600284861615610
100026000190190941693090304601f810184900484028201840190925281815292918301828
2801561019d5780601f106101725761010080835404028352916020019161019d565b820191906
000526020600020905b81548152906001019060200180831161018057829003601f168201915b
5050505050905 05b90565b6040805160208101909152600815290560 0a165627a7a72305820 1
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, BigInteger.ZERO,
    new Utf8String("Hello blockchain world!"))
    .get();

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

Hello blockchain world!

blk.io

testrpc

- Local development Ethereum client
- Installation via:

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

- Run:

```
$ testrpc --account="0x<address>,
1000000000000000000000000" —account="…"
```

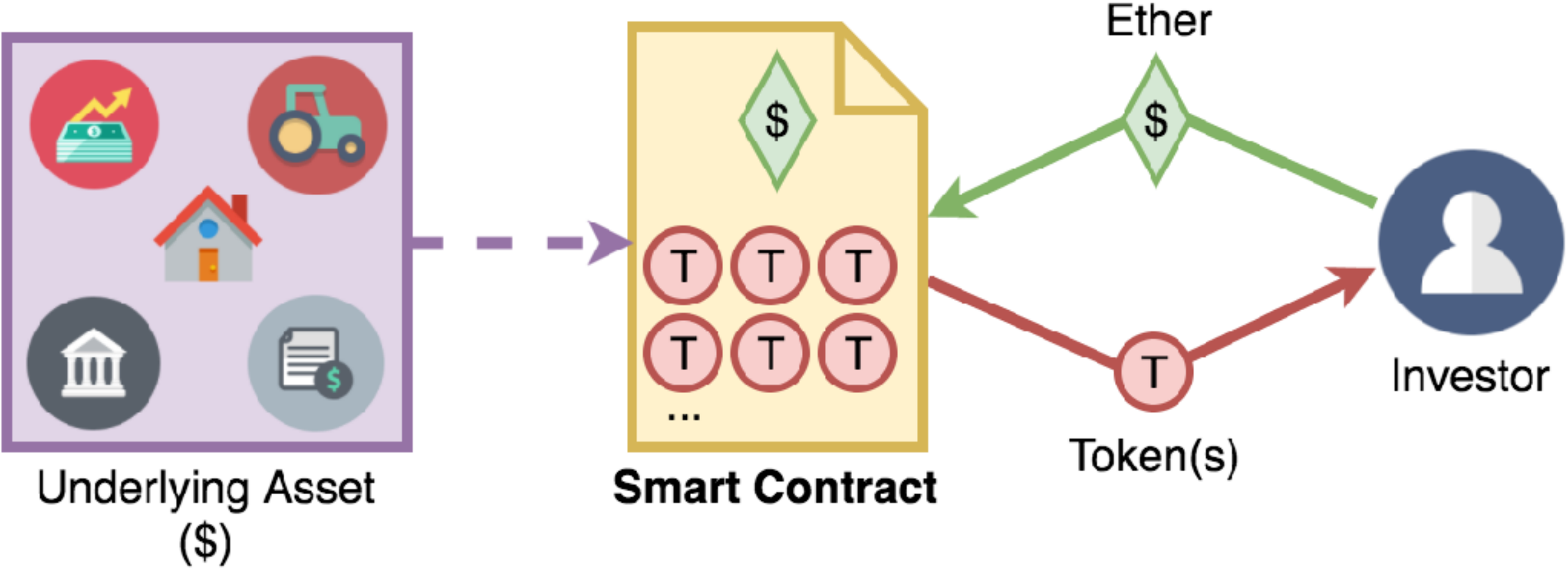
- Doesn’t support filters
- More information at https://github.com/ethereumjs/testrpc

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!

blk.io

Smarter Contracts



blk.io

Smarter Contracts

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

blk.io

Events

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

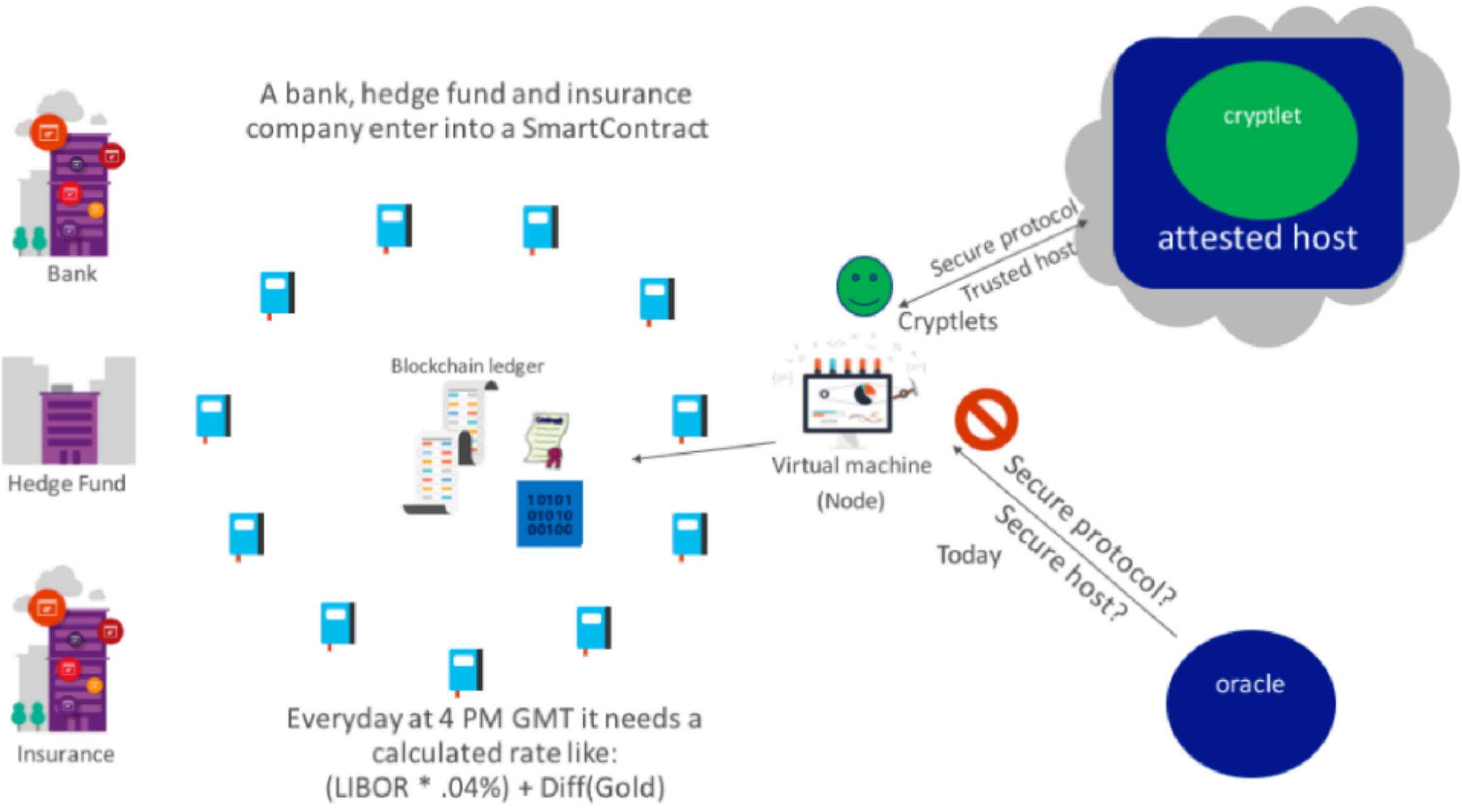
```
event Name(paramType param1, …, )
```

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

Initial Coin Offerings

		Token Information	Price	%Change	MarketCap
1.		OmiseGO OmiseGO (OMG) is a public Ethereum-based financial technology for use in mainstream digital wallets	$8.9581 0.0018759 Btc 0.029658 Eth	▲ 13.08%	$880,687,959
2.		Qtum Build Decentralized Applications that Simply Work Executable on mobile devices, compatible with major existing blockchain ecosystem	$12.0947 0.00253258 Btc 0.040313 Eth	▲ 0.19%	$713,587,300
3.		MKR - Maker Maker is a Decentralized Autonomous Organization that creates and insures the dai stablecoin on the Ethereum blockchain	$246.2621 0.0516209397 Btc 0.820619 Eth	--	$246,262,103
4.		EOS Infrastructure for Decentralized Applications	$0.5641 0.00011811 Btc 0.001880 Eth	▼ -0.56%	$224,859,249
5.		TenXPay 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 0.00044347 Btc 0.007059 Eth	▲ 7.71%	$221,658,002
6.		REP - Augur Augur combines the magic of prediction markets with the power of a decentralized network to create a stunningly accurate forecasting tool	$18.6347 0.00390203 Btc 0.062112 Eth	▲ 2.00%	$204,981,700
7.		GOLEM (GNT) Golem is going to create the first decentralized global market for computing power	$0.2394 0.00005013 Btc 0.000798 Eth	▲ 20.30%	$199,435,358

Oracles & Cryplets



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

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

blk.io

Open Zepplin

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

blk.io

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
  - Open Zepplin

blk.io

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)

blk.io

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 -> {
                        ...
});
```

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

blk.io

Integration with Quorum

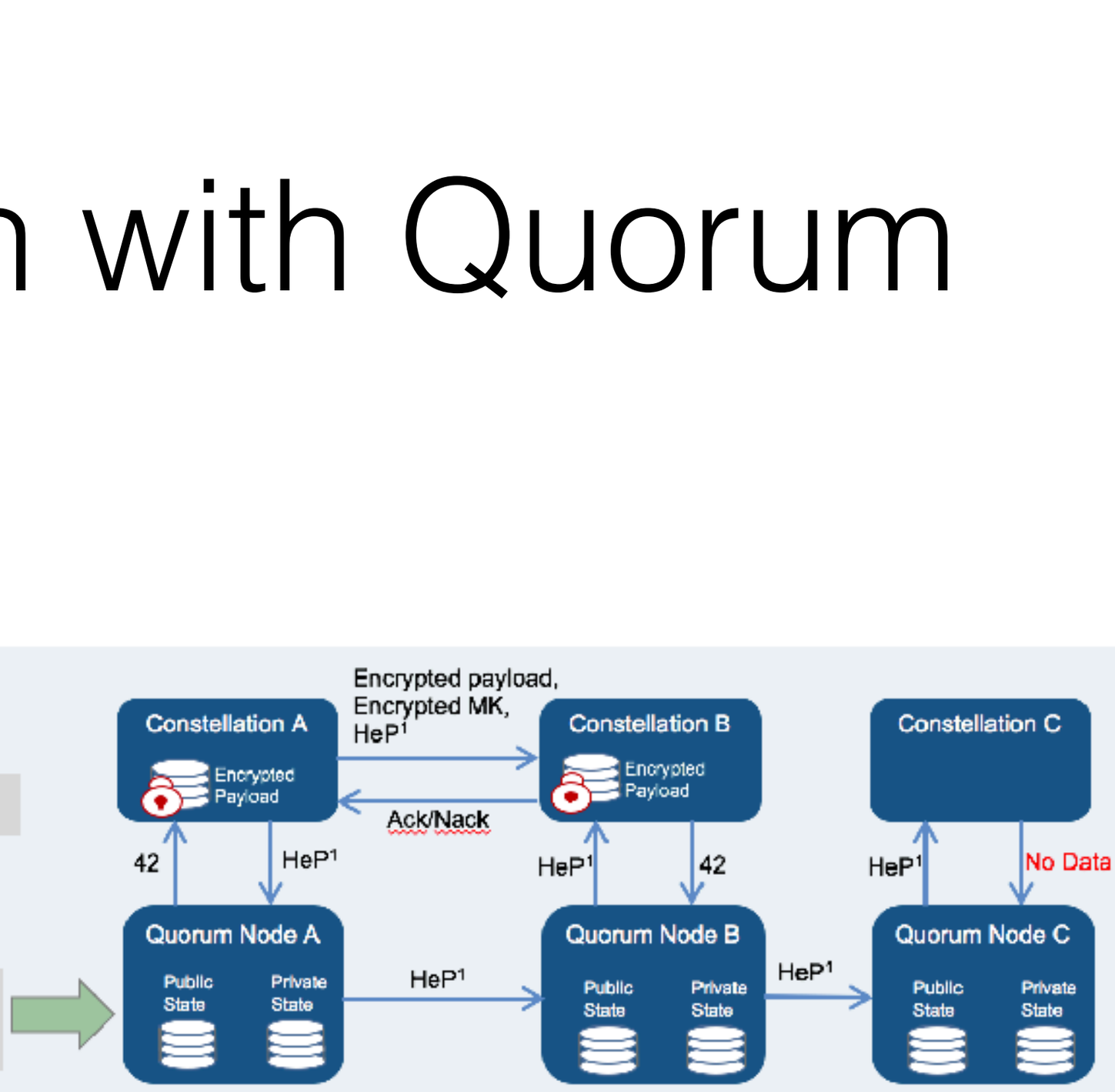
- Simple to use, same familiar Ethereum Transaction:

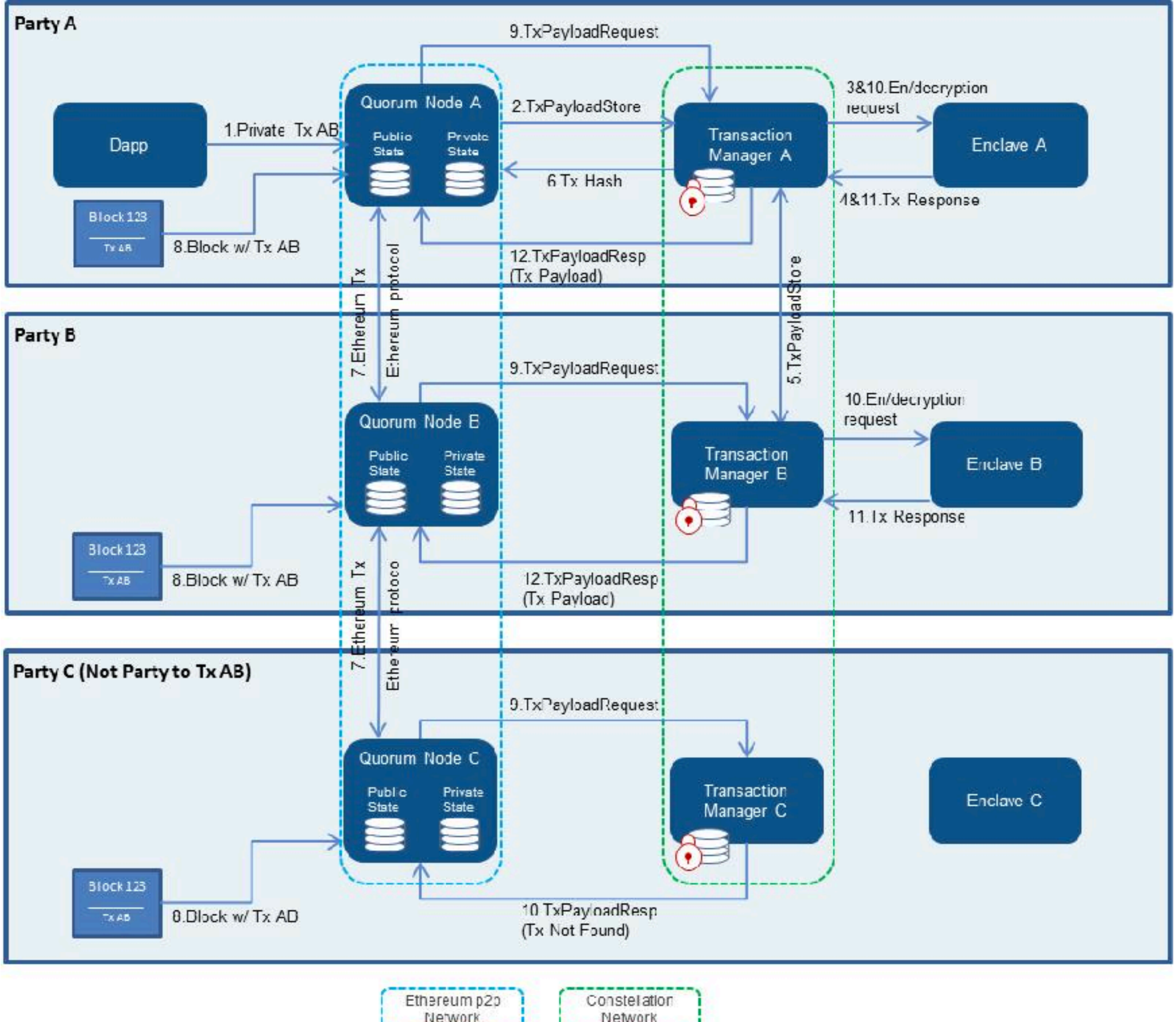
Public Transaction (no change from geth):

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

Private Transaction (from Party A):

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




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

blk.io

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

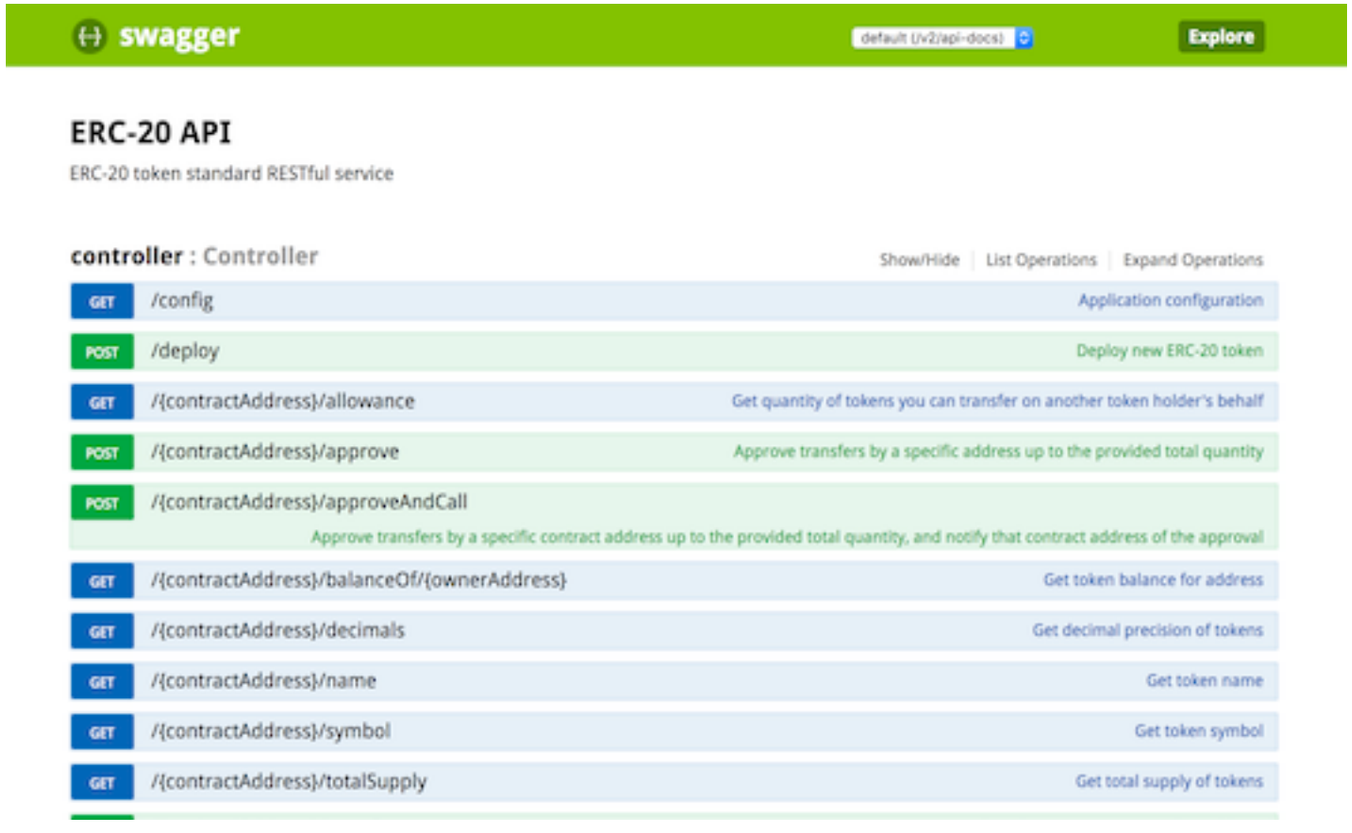
```
<dependency>
  <groupId>org.web3j</groupId>
  <artifactId>quorum</artifactId>
  <version>0.6.0</version>
</dependency>
```

- Use privateFor value of key 7
  - keys/tm7.pub:

```
ROAZBWtSacxXQrOe3FGAqJDyJjFePR5ce4TSIzmJ0Bc=
```

Building RESTful services

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



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

blk.io

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/