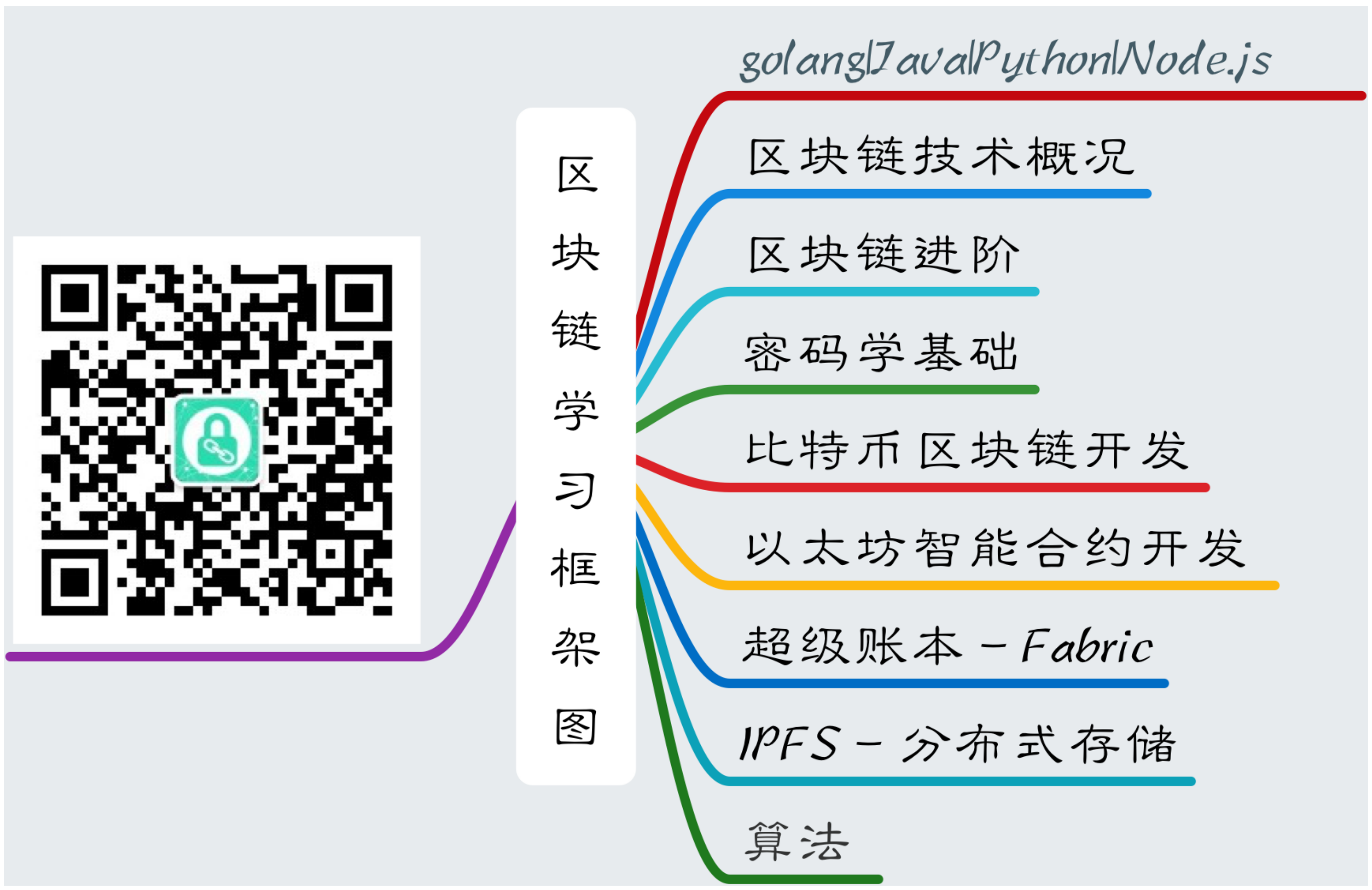
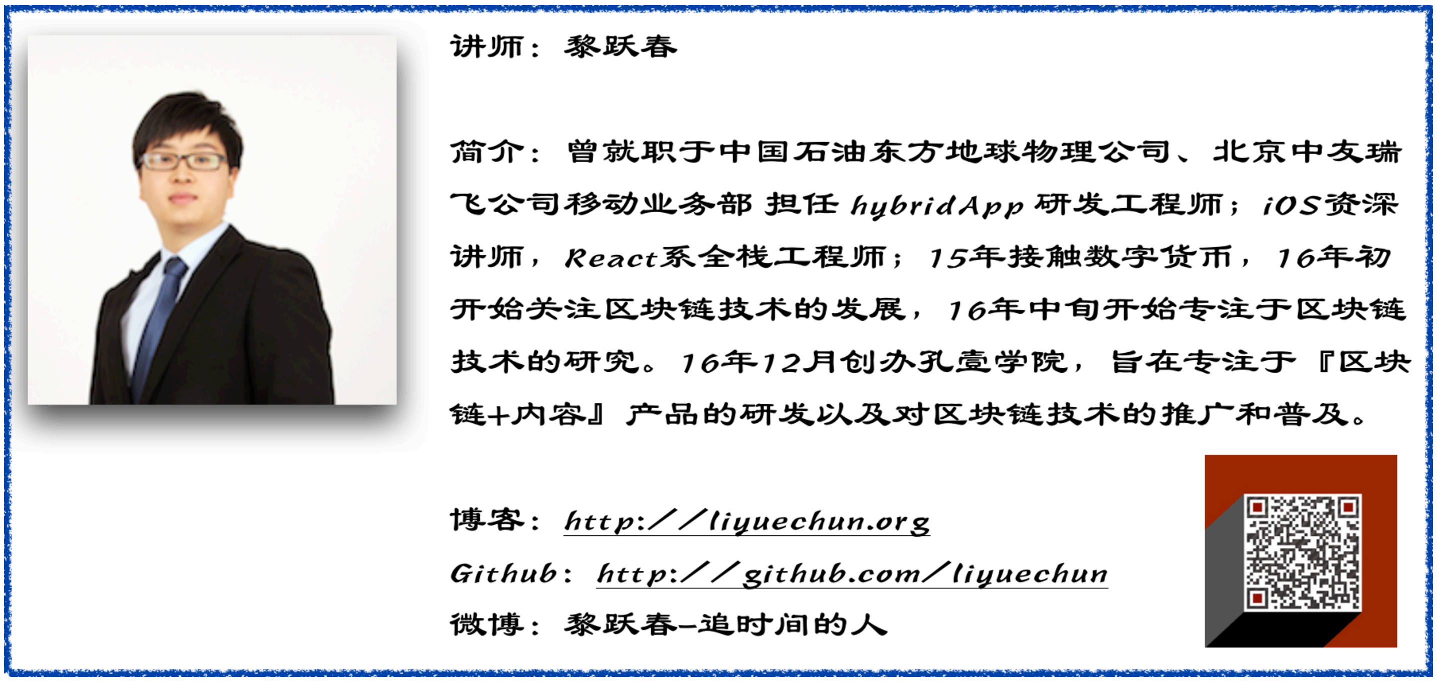


如何编写智能合约(Smart Contract)?(I)



讲师： 黎跃春

简介： 曾就职于中国石油东方地球物理公司、北京中友瑞飞公司移动业务部 担任 hybridApp 研发工程师； iOS资深讲师， React系全栈工程师； 15年接触数字货币， 16年初开始关注区块链技术的发展， 16年中旬开始专注于区块链技术的研究。 16年12月创办孔壹学院， 旨在专注于『区块链+内容』 产品的研发以及对区块链技术的推广和普及。

博客： http://liyuechun.org
Github： http://github.com/liyuechun
微博： 黎跃春-追时间的人

学习目标

1. 了解智能合约
2. 简单环境搭建
3. 能够利用`solidity`编写`Hello World`合约
4. 合约部署
5. 和合约互动

使用solidity语言撰写智能合约

`Ethereum`上的智能合约需要使用`solidity`语言来撰写。虽然还有其他能用来撰写智能合约的语言如`Serpent`（类Python）、`lll`（类Fortran），但目前看到所有公开的智能合约都是使用`solidity`撰写。

宣传上说，`solidity`是一种类似`Javascript`的语言，而且围绕着`solidity`的各种开发工具链，都是使用属于`Javascript`生态系的`npm`来提供的。但我觉得`solidity`还是比较像Java或C#。因为和Javascript不同，solidity与Java或C#同属于强类型（Strong Type，在定义变数时需要指定类型）语言、在定义函式（function）时同样需指定回传的类型（type）、同样也需要先编译才能执行。这些特性都是`Javascript`所不具备的。

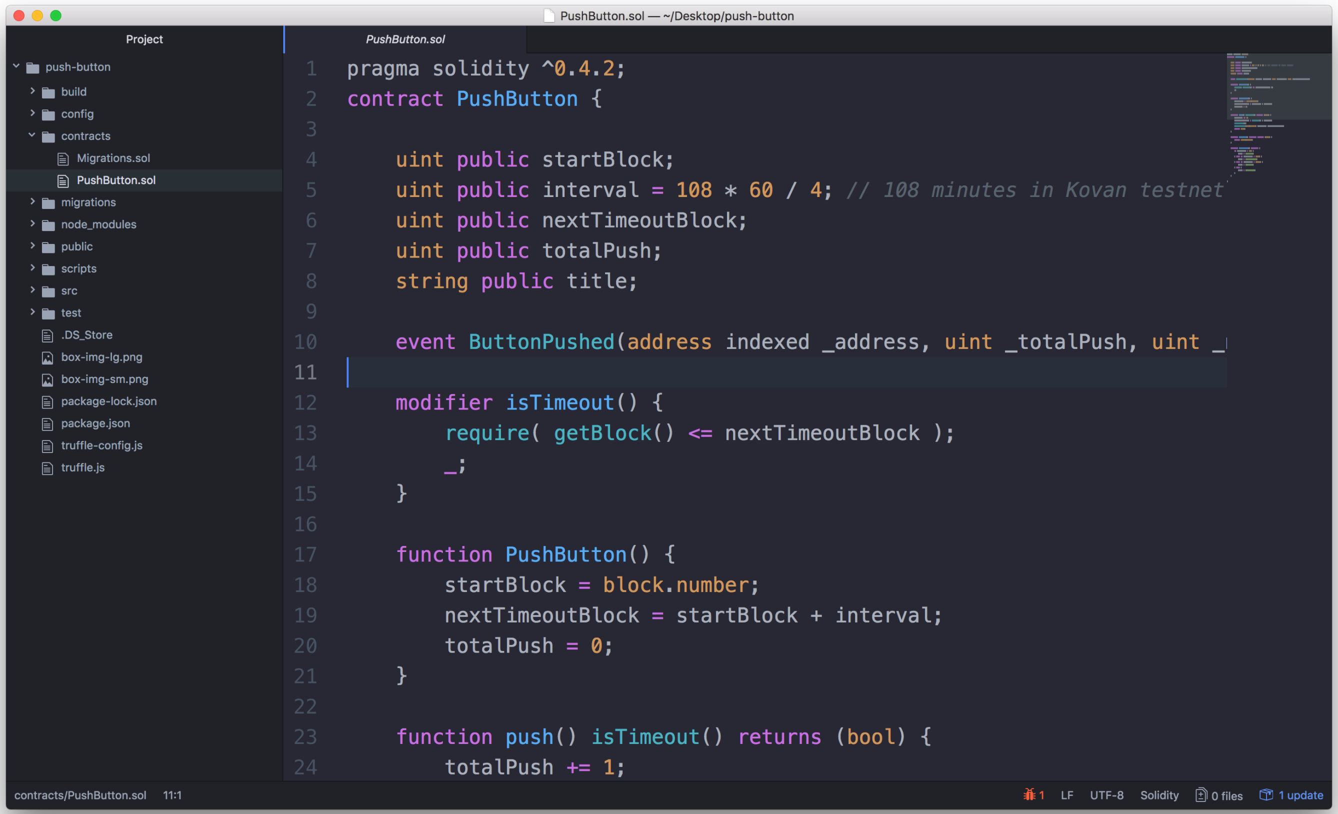
开发前的准备

本文将使用当前最活跃的智能合约开发框架`truffle`为基础来开发。`ENS（Ethereum Name Service）`也是采用`truffle`框架。其他选择还有`embark`等。

就像一般网站或App开发一样，在提供公开服务之前，开发者会在自己用于写程序的电脑（又称作本机）或透过测试网络来测试程序执行的效果，测试完成后，才会部署到公开的网络上提供服务。开发区块链智能合约（程序）的过程也是如此。特别是公开链上所有写入或读取计算结果的操作都需要真金白银（虚拟代币），而且根据网络状况，每个公开链上的操作都需要要一小段反应时间（15秒~数分钟），这些等待颇浪费宝贵的开发时间⏳。因此在开发的过程中，我们将使用`testrpc`工具在电脑上模拟智能合约所需的以太坊内存块链测试环境。

`testrpc`中也包含了`Javascript`版本的`Ethereum`虚拟机（Ethereum Virtual Machine），因此可以完整地执行智能合约。

此外，开发前还需准备一个合手的编辑器。我目前是使用`Atom`搭配`solidity`插件来开发。`solidity`插件除了支持语法高亮之外，也会透过`Solium`检查并提示基本的语法错误，相当方便。其他编辑器应该也有类似的插件可选择。



PushButton.sol — ~/Desktop/push-button

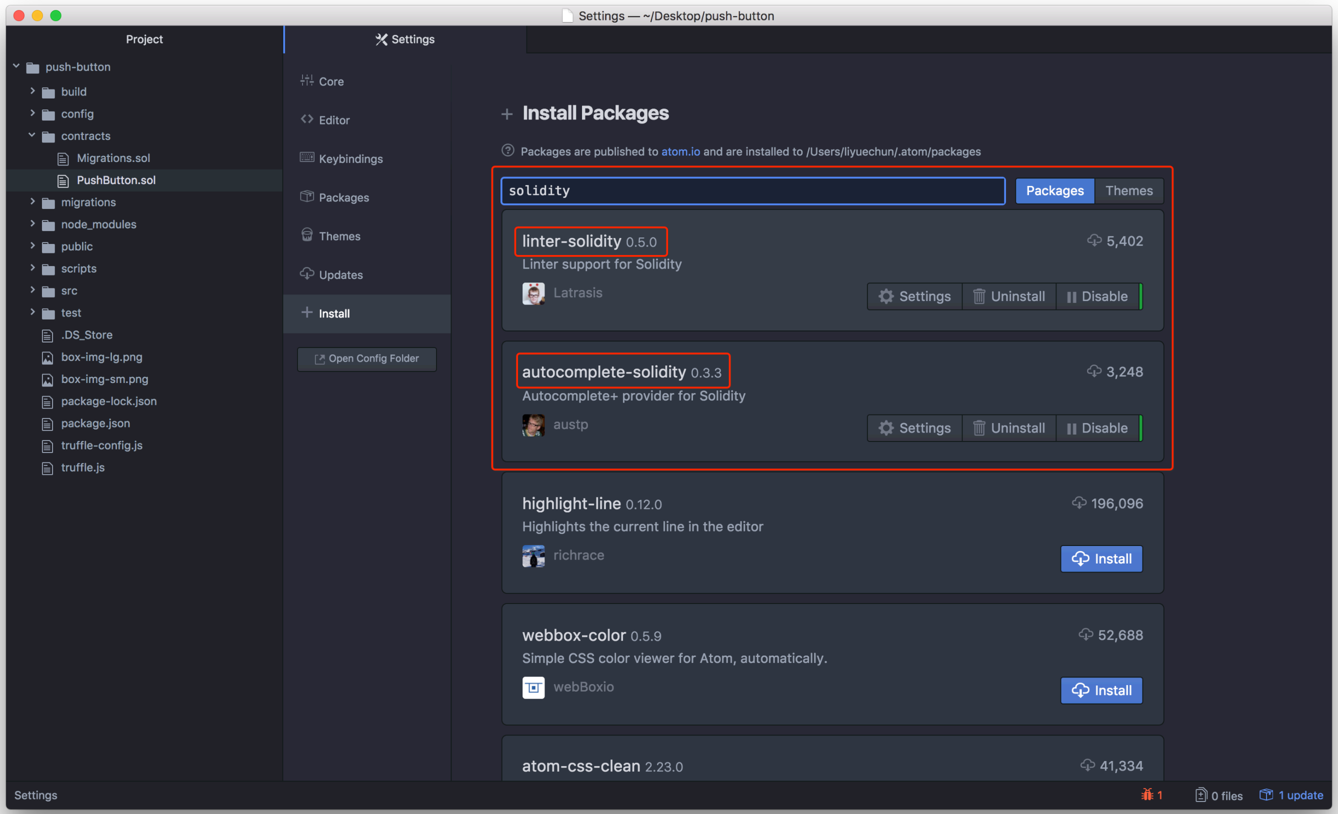
Project

- push-button
  - build
  - config
  - contracts
    - Migrations.sol
    - PushButton.sol
  - migrations
  - node_modules
  - public
  - scripts
  - src
  - test
  - .DS_Store
  - box-img-lg.png
  - box-img-sm.png
  - package-lock.json
  - package.json
  - truffle-config.js
  - truffle.js

PushButton.sol

```
pragma solidity ^0.4.2;
contract PushButton {

    uint public startBlock;
    uint public interval = 108 * 60 / 4; // 108 minutes in Kovan testnet
    uint public nextTimeoutBlock;
    uint public totalPush;
    string public title;

    event ButtonPushed(address indexed _address, uint _totalPush, uint _

    modifier isTimeout() {
        require( getBlock() <= nextTimeoutBlock );
        _;
    }

    function PushButton() {
        startBlock = block.number;
        nextTimeoutBlock = startBlock + interval;
        totalPush = 0;
    }

    function push() isTimeout() returns (bool) {
        totalPush += 1;
```

contracts/PushButton.sol 11:1 1 LF UTF-8 Solidity 0 files 1 update



Settings — ~/Desktop/push-button

Project

- push-button
  - build
  - config
  - contracts
    - Migrations.sol
    - PushButton.sol
  - migrations
  - node_modules
  - public
  - scripts
  - src
  - test
  - .DS_Store
  - box-img-lg.png
  - box-img-sm.png
  - package-lock.json
  - package.json
  - truffle-config.js
  - truffle.js

Settings

Install Packages

Packages are published to atom.io and are installed to /Users/liyuechun/.atom/packages

solidity — Packages | Themes

linter-solidity 0.5.0 — 5,402
Linter support for Solidity
Latrasis — Settings | Uninstall | Disable

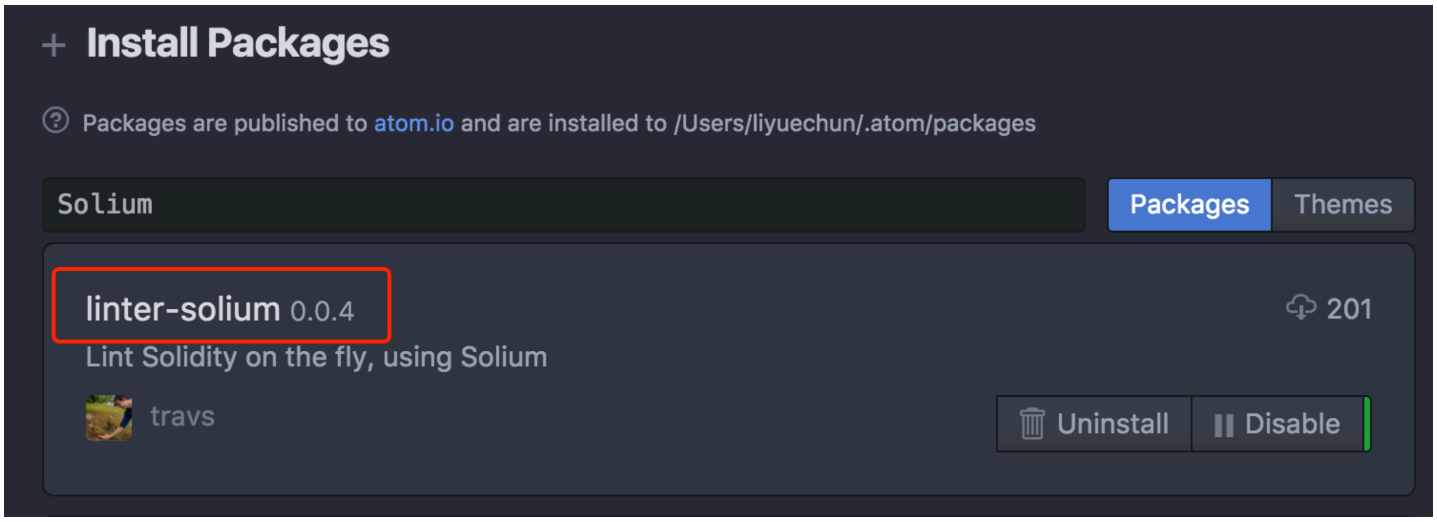
autocomplete-solidity 0.3.3 — 3,248
Autocomplete+ provider for Solidity
austp — Settings | Uninstall | Disable

highlight-line 0.12.0 — 196,096
Highlights the current line in the editor
richrace — Install

webbox-color 0.5.9 — 52,688
Simple CSS color viewer for Atom, automatically.
webBoxio — Install

atom-css-clean 2.23.0 — 41,334

Settings 1 0 files 1 update


+ Install Packages
Packages are published to atom.io and are installed to /Users/liyuechun/.atom/packages
Solium
Packages
Themes
linter-solium 0.0.4
201
Lint Solidity on the fly, using Solium
travs
Uninstall
Disable

安装所需工具

首先开发机上必须装好Node.js，再使用以下命令安装所需的工具：

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

```
liyuechun:~ yuechunli$ npm install -g ethereumjs-testrpc truffle
/usr/local/bin/testrpc -> /usr/local/lib/node_modules/ethereumjs-testrpc/build/cli
.node.js
/usr/local/bin/truffle -> /usr/local/lib/node_modules/truffle/build/cli.bundled.js
+ truffle@3.4.9
+ ethereumjs-testrpc@4.1.3
added 1 package and updated 7 packages in 76.132s
liyuechun:~ yuechunli$
```

启动Testrpc

安装好后随时可以使用`testrpc`命令来启动以太坊测试环境。

```
liyuechun:~ yuechunli$ testrpc
EthereumJS TestRPC v4.1.3 (ganache-core: 1.1.3)

Available Accounts
==================
(0) 0xbbd414b340f2255dab9d923428c97f0b65d9df81
(1) 0xe9869e3cf29b6fca81762c314df229c7c4fea25e
(2) 0xc79e72362a4511b9e499d186654332c4d6f569be
(3) 0x9a6f0651907c149d4173c03927144dbbba1473d4
```

```
(4) 0x5b13a5d6788752b26dd4e338aae2e01058ee145e
(5) 0xfc7f56d942ad5260be23ecee92a344aba1b7e7d8
(6) 0xc48dc22c6bacd6ade4421ab54f25bc45c1c51142
(7) 0x3fe2b7d4141dd0a456661f77086d055cbaf3b78f
(8) 0x567979fed26ca85e9d1b4ac919c840e3fc9857e2
(9) 0xb2eafe245f098eef1c2c1f466d9a8dcd58764c62

Private Keys
==================
(0) 947ab78e91133103612ca099d60e6c38cac5bb769f7f097c82d003cf058500bd
(1) 8ffe0ba8dc53e16944a17dddd3378b5fba0379cd84df4e5237b8b46d05b8762f
(2) ffe2e04e43e4106b247407656f5233bcc3e0c49730972d0df9c1d1093375e2ef
(3) a20e453dc44c76aaca6a22efdbb605c2ed9eea64c11317e683461e11bd105ea7
(4) 4748268ff1b828868dc56d07a1b121b427e1bdede5dbb3c14ef1254d9d26b1a5
(5) f9957e68c6d20d38b81604a0509e6c4591478bc754f87d5682564073705fbb46
(6) 34e648b23c0ace6b2b0893651d87f70be8496f97ecf6b7b4607b2acc4e05c9bd
(7) d2477cedec217e3fb19a5981dafbc125ef66ccc9dc7df29301d08a24da843cf5
(8) d319f85ccd80e55b2e707e05f09662632564c297248f8b96f82ea5eeaeef0851
(9) 88c33ac9f1062b82f9e82f86a0ce307e3bd8fcf683b9751232c2f193f5bdc668

HD Wallet
==================
Mnemonic:      hire custom clinic expect fury fantasy try dress source spy viable
flag
Base HD Path:  m/44'/60'/0'/0/{account_index}

Listening on localhost:8545
```

可以看到`testrpc`启动后自动建立了`10`个帐号（Accounts），与每个帐号对应的私钥（Private Key）。每个帐号中都有`100`个测试用的以太币（Ether）。要注意`testrpc`仅运行在內存中，因此每次重开时都会回到全新的状态。

一切准备就绪，我们可以开始建立第一份智能合约项目了。

建立项目

开启另一个终端窗口，输入以下命令以建立项目：

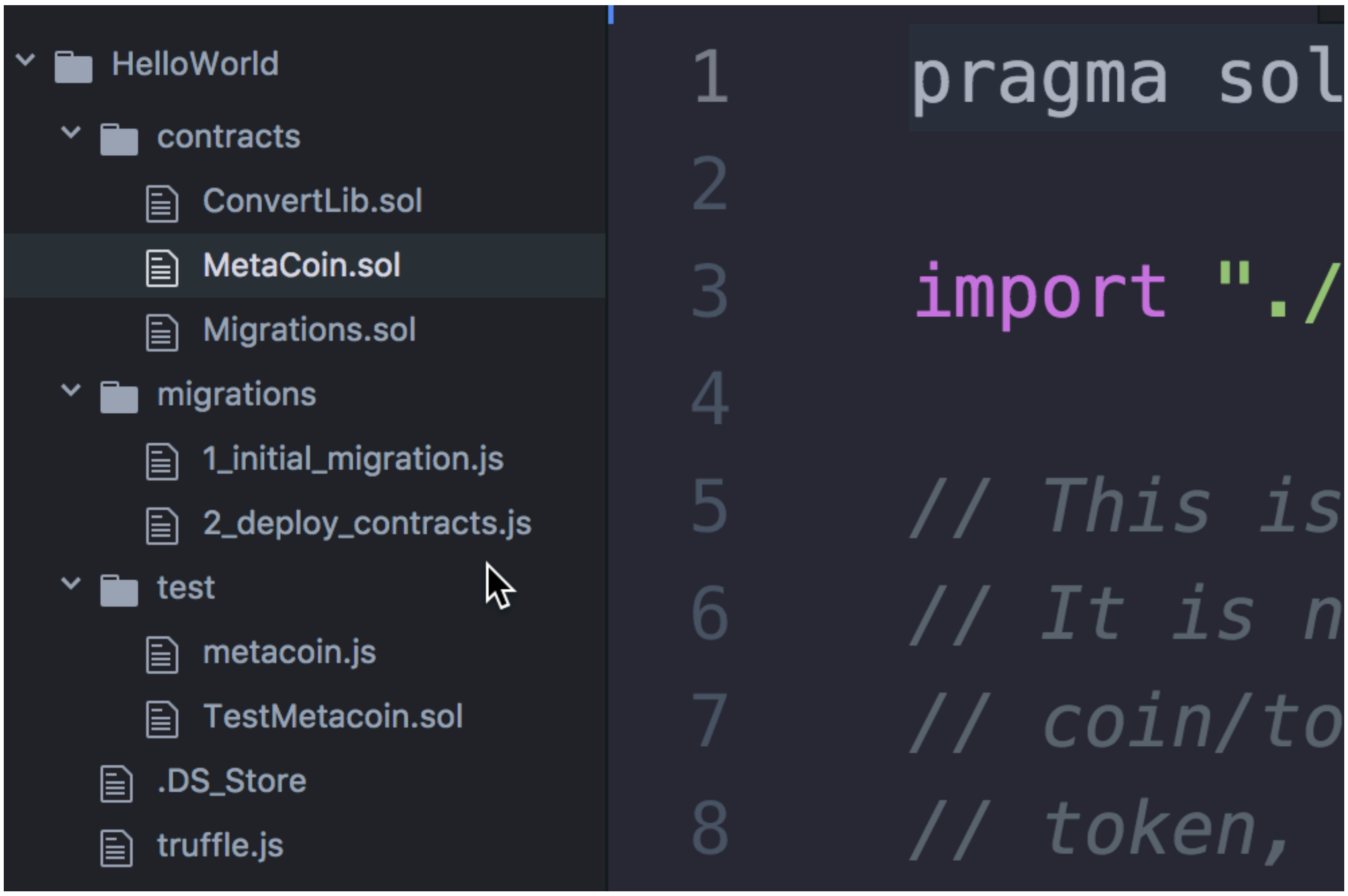
```
liyuechun:Desktop yuechunli$ mkdir SmartContractDemo
liyuechun:Desktop yuechunli$ cd SmartContractDemo/
liyuechun:SmartContractDemo yuechunli$ mkdir HelloWorld
liyuechun:SmartContractDemo yuechunli$ cd HelloWorld/
liyuechun:HelloWorld yuechunli$ truffle init

Downloading project...
Project initialized.

  Documentation: http://truffleframework.com/docs
```

```
Commands:

  Compile: truffle compile
  Migrate: truffle migrate
  Test:    truffle test

liyuechun:HelloWorld yuechunli$ ls
contracts   migrations  test        truffle.js
```

目录结构:

`/contracts:`存放智能合约原始代码的地方，可以看到里面已经有三个`sol`文件，我们开发的`HelloWorld.sol`文件就存放在这里。

`/migrations:`这是 `Truffle`用来部署智能合约的功能，待会儿我们会修改`2_deploy_contracts.js`来部署 `HelloWorld.sol`。
`/test:`测试智能合约的代码放在这里，支持`js` 与 `sol` 测试。
`truffle.js:` `Truffle` 的设置文档。

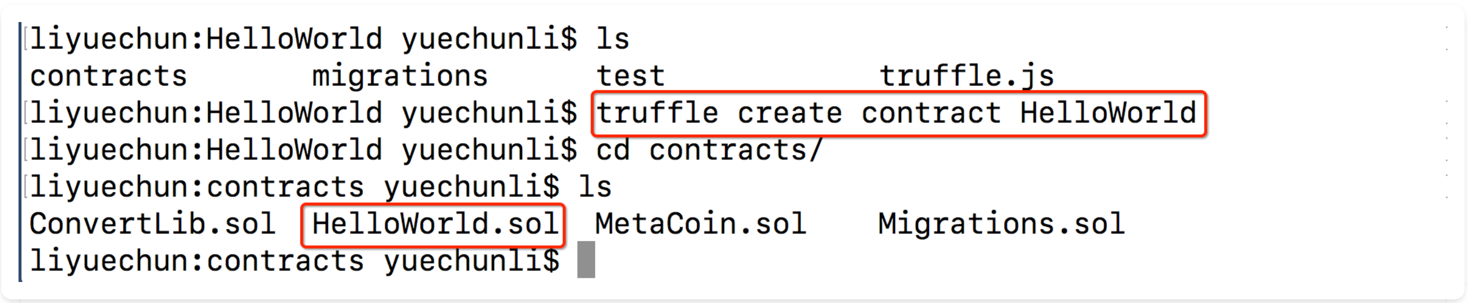


```
HelloWorld
  contracts
    ConvertLib.sol
    MetaCoin.sol
    Migrations.sol
  migrations
    1_initial_migration.js
    2_deploy_contracts.js
  test
    metacoin.js
    TestMetacoin.sol
  .DS_Store
  truffle.js
```

```
pragma sol

import "./

// This is
// It is n
// coin/to
// token,
```

新建HelloWorld合约

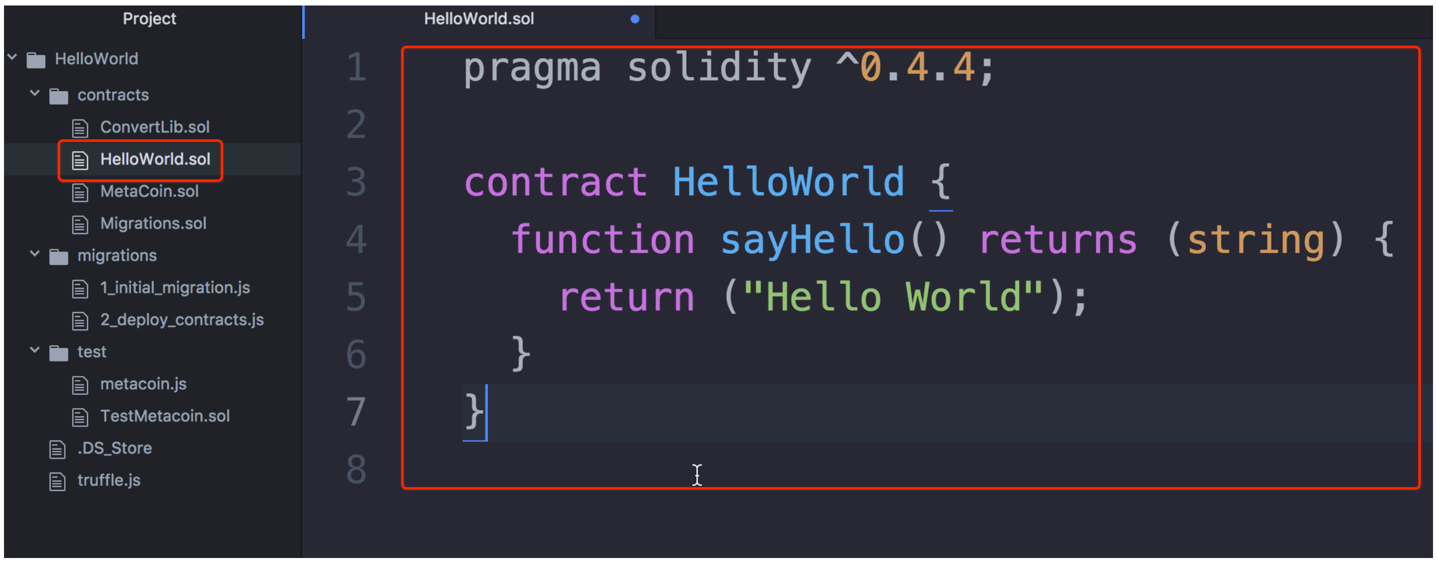
在`contracts`文件夹下新建`HelloWorld.sol`文件，当然也可以直接在`HelloWorld`路径下面直接执行`truffle create contract HelloWorld`命令来创建`HelloWorld.sol`。



```
liyuechun:HelloWorld yuechunli$ ls
contracts       migrations      test            truffle.js
liyuechun:HelloWorld yuechunli$ truffle create contract HelloWorld
liyuechun:HelloWorld yuechunli$ cd contracts/
liyuechun:contracts yuechunli$ ls
ConvertLib.sol  HelloWorld.sol  MetaCoin.sol    Migrations.sol
liyuechun:contracts yuechunli$ 
```

`HelloWorld.sol`文件内容如下：

```
pragma solidity ^0.4.4;

contract HelloWorld {
  function sayHello() returns (string) {
    return ("Hello World");
  }
}
```



```
pragma solidity ^0.4.4;

contract HelloWorld {
  function sayHello() returns (string) {
    return ("Hello World");
  }
}
```

讲解

```
pragma solidity ^0.4.4;
```

第一行指名目前使用的`solidity`版本，不同版本的`solidity`可能会编译出不同的`bytecode`。`^`代表兼容`solidity` `0.4.4 ~ 0.4.9`的版本。

```
contract HelloWorld {
    ...
}
```

`contract`关键字类似于其他语言中较常见的`class`。因为`solidity`是专为智能合约（Contact）设计的语言，声明`contract`后即内置了开发智能合约所需的功能。也可以把这句理解为`class HelloWorld extends Contract`。

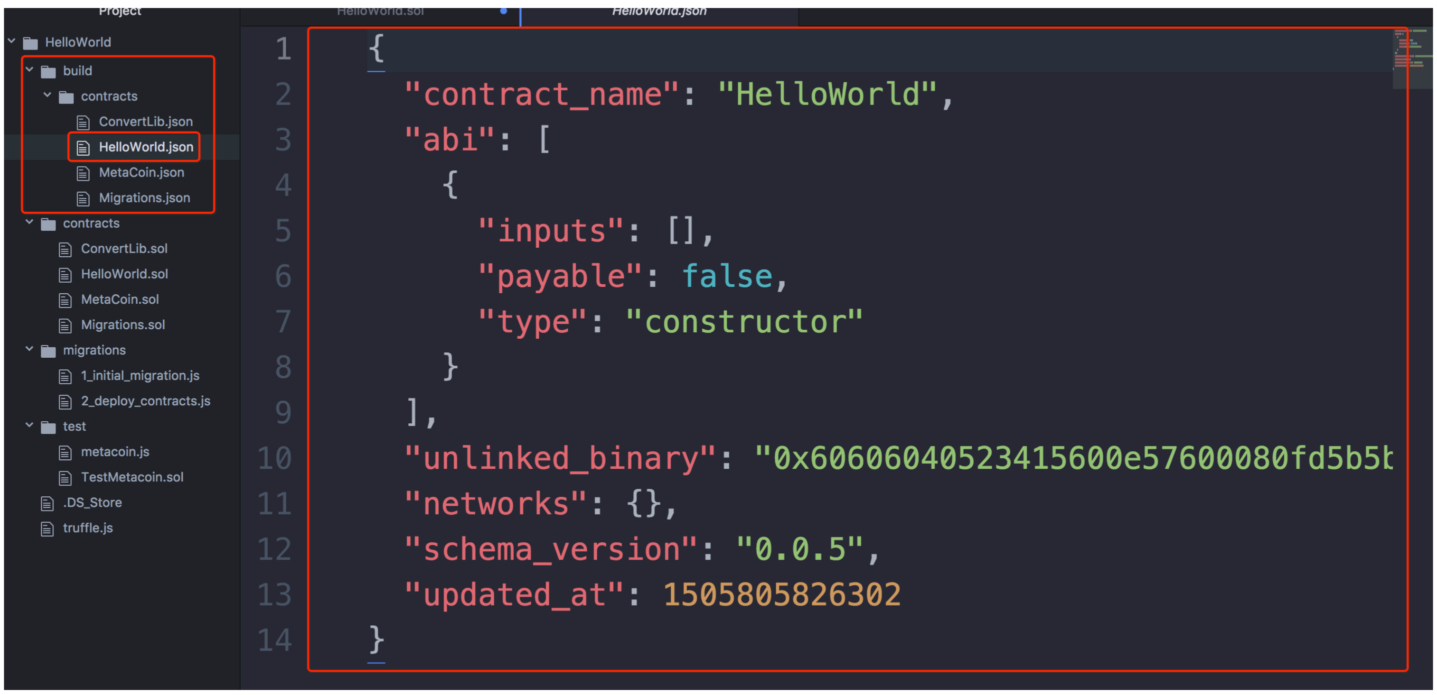
```
function sayHello() returns (string) {
    return ("Hello World");
}
```

函数的结构与其他程序类似，但如果有传入的参数或回传值，需要指定参数或回传值的类型（type）。

编译

现在执行`truffle compile`命令，我们可以将`HelloWorld.sol`原始码编译成`Ethereum bytecode`。

```
liyuechun:HelloWorld yuechunli$ ls
contracts   migrations  test        truffle.js
liyuechun:HelloWorld yuechunli$ truffle compile
Compiling ./contracts/ConvertLib.sol...
Compiling ./contracts/HelloWorld.sol...
Compiling ./contracts/MetaCoin.sol...
Compiling ./contracts/Migrations.sol...
Writing artifacts to ./build/contracts

liyuechun:HelloWorld yuechunli$ ls
build       contracts   migrations  test        truffle.js
liyuechun:HelloWorld yuechunli$ cd build/
liyuechun:build yuechunli$ ls
contracts
liyuechun:build yuechunli$ cd contracts/
liyuechun:contracts yuechunli$ ls
ConvertLib.json HelloWorld.json MetaCoin.json   Migrations.json
liyuechun:contracts yuechunli$ cat HelloWorld.json
{
  "contract_name": "HelloWorld",
  "abi": [
    {
      "inputs": [],
      "payable": false,
      "type": "constructor"
    }
  ],
  "unlinked_binary": "0x6060604052341560 0e57600080fd5b5b5b5b603680601e6000396000f3
0060606040525b600080fd00a165627a7a723058203ee98a767948e9bc08094df4a46ab0361f068b2a
559032cf968df5bbf63e91430029",
  "networks": {},
  "schema_version": "0.0.5",
  "updated_at": 1505805826302
}
liyuechun:contracts yuechunli$
```



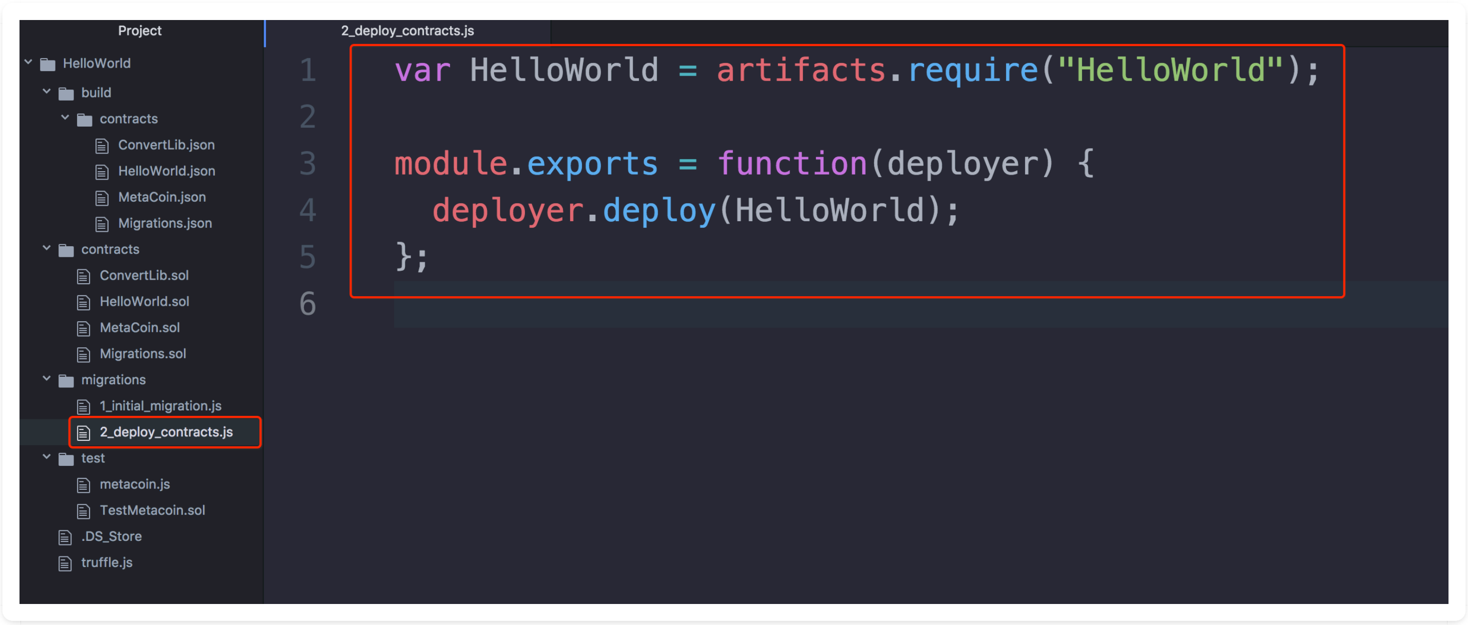
```
{
  "contract_name": "HelloWorld",
  "abi": [
    {
      "inputs": [],
      "payable": false,
      "type": "constructor"
    }
  ],
  "unlinked_binary": "0x6060604052341560 0e57600080fd5b5b
  "networks": {},
  "schema_version": "0.0.5",
  "updated_at": 1505805826302
}
```

编译成功后，会在`HelloWorld`文件夹下面的`build/contracts`文件夹下面看见`HelloWorld.json`文件。

部署

`truffle`框架中提供了方便部署合约的脚本。打开`migrations/2_deploy_contracts.js`文件（脚本使用`Javascript`编写），将内容修改如下：

```
var HelloWorld = artifacts.require("HelloWorld");
module.exports = function(deployer) {
  deployer.deploy(HelloWorld);
};
```



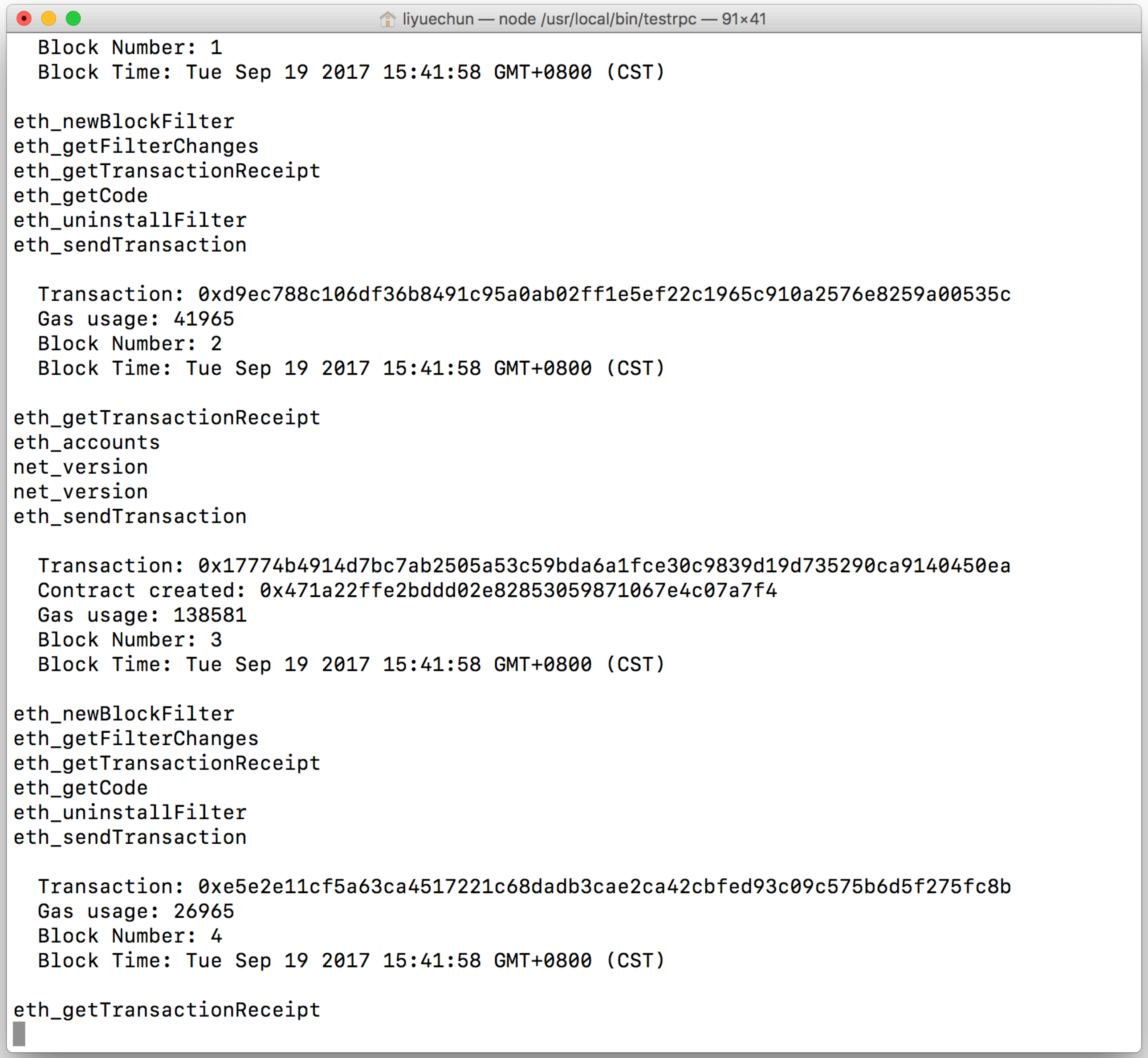
```
var HelloWorld = artifacts.require("HelloWorld");

module.exports = function(deployer) {
  deployer.deploy(HelloWorld);
};
```

使用`artifacts.require`语句来取得准备部署的合约。使用`deployer.deploy`语句将合约部署到区块链上。这边`HelloWorld`是`contract`的名称而不是文件名。因此可以用此语法读入任一`.sol`文件中的任一合约。

现在执行`truffle migrate`命令:

```
liyuechun:HelloWorld yuechunli$ ls
build       contracts   migrations  test        truffle.js
liyuechun:HelloWorld yuechunli$ truffle migrate
Compiling ./contracts/HelloWorld.sol...
Writing artifacts to ./build/contracts

Using network 'development'.

Running migration: 1_initial_migration.js
  Deploying Migrations...
  ... 0x218431f16a5cadc6347449808d981887c90b3872898af7cc9dc9b3280c07c184
  Migrations: 0x64e9673cf962d21642a08635e6654fb7f2ea9bcd
Saving successful migration to network...
  ... 0xd9ec788c106df36b8491c95a0ab02ff1e5ef22c1965c910a2576e8259a00535c
Saving artifacts...
Running migration: 2_deploy_contracts.js
  Deploying HelloWorld...
  ... 0x17774b4914d7bc7ab2505a53c59bda6a1fce30c9839d19d735290ca9140450ea
  HelloWorld: 0x471a22ffe2bddd02e82853059871067e4c07a7f4
Saving successful migration to network...
  ... 0xe5e2e11cf5a63ca4517221c68dadb3cae2ca42cbfed93c09c575b6d5f275fc8b
Saving artifacts...
liyuechun:HelloWorld yuechunli$
```

如此一来合约已经部署到`testrpc`中。切换到`testrpc`窗口，可以看到`testrpc`有反应了。



```
  Block Number: 1
  Block Time: Tue Sep 19 2017 15:41:58 GMT+0800 (CST)

eth_newBlockFilter
eth_getFilterChanges
eth_getTransactionReceipt
eth_getCode
eth_uninstallFilter
eth_sendTransaction

  Transaction: 0xd9ec788c106df36b8491c95a0ab02ff1e5ef22c1965c910a2576e8259a00535c
  Gas usage: 41965
  Block Number: 2
  Block Time: Tue Sep 19 2017 15:41:58 GMT+0800 (CST)

eth_getTransactionReceipt
eth_accounts
net_version
net_version
eth_sendTransaction

  Transaction: 0x17774b4914d7bc7ab2505a53c59bda6a1fce30c9839d19d735290ca9140450ea
  Contract created: 0x471a22ffe2bddd02e82853059871067e4c07a7f4
  Gas usage: 138581
  Block Number: 3
  Block Time: Tue Sep 19 2017 15:41:58 GMT+0800 (CST)

eth_newBlockFilter
eth_getFilterChanges
eth_getTransactionReceipt
eth_getCode
eth_uninstallFilter
eth_sendTransaction

  Transaction: 0xe5e2e11cf5a63ca4517221c68dadb3cae2ca42cbfed93c09c575b6d5f275fc8b
  Gas usage: 26965
  Block Number: 4
  Block Time: Tue Sep 19 2017 15:41:58 GMT+0800 (CST)

eth_getTransactionReceipt
```

与合约互动

`truffle`提供命令行工具，执行`truffle console`命令后，可用`Javascript`来和刚刚部署的合约互动。

```
liyuechun:HelloWorld yuechunli$ ls
build       contracts    migrations   test        truffle.js
liyuechun:HelloWorld yuechunli$ truffle console
truffle(development)> HelloWorld.deployed().then(instance => contract = instance)
TruffleContract {
  constructor:
   { [Function: TruffleContract]
     _static_methods:
      { setProvider: [Function: setProvider],
        new: [Function: new],
        at: [Function: at],
        deployed: [Function: deployed],
        defaults: [Function: defaults],
        hasNetwork: [Function: hasNetwork],
        isDeployed: [Function: isDeployed],
        detectNetwork: [Function: detectNetwork],
        setNetwork: [Function: setNetwork],
        resetAddress: [Function: resetAddress],
        link: [Function: link],
        clone: [Function: clone],
        addProp: [Function: addProp],
        toJSON: [Function: toJSON] },
     _properties:
      { contract_name: [Object],
        abi: [Object],
        network: [Function: network],
        networks: [Function: networks],
        address: [Object],
        links: [Function: links],
        events: [Function: events],
        binary: [Function: binary],
        unlinked_binary: [Object],
        schema_version: [Function: schema_version],
        updated_at: [Function: updated_at] },
     _property_values: {},
     _json:
      { contract_name: 'HelloWorld',
        default_network: undefined,
        abi: [Array],
        unlinked_binary: '0x6060604052341561000f57600080fd5b5b6101488061001f600039
6000f300606060405263ffffffff7c0100000000000000000000000000000000000000000000000000
000000600035041663ef5fb05b811461003d575b600080fd5b341561004857600080fd5b6100506100
c8565b60405160208082528190810183818151815260200191508051906020019080838360005b8381
101561008d5780820151818401525b602001610074565b50505050905090810190601f1680156100ba
57808203805160018360200361010000a031916815260200191505b509250505060405180910390f35b
6100d061010a565b60408051908101604052600b81527f48656c6c6f20576f726c640000000000000000
0000000000000000000000000000602082015290505b90565b60206040519081016040526000815290
5600a165627a7a723058202b9d4dd8e7739264271524ea58db573fa09a0b634d1d5b78502e6dd01d76
ba330029',
        networks: [Object],
        schema_version: '0.0.5',
        updated_at: 1505806918535 },
     setProvider: [Function: bound setProvider],
     new: [Function: bound new],
     at: [Function: bound at],
     deployed: [Function: bound deployed],
     defaults: [Function: bound defaults],
     hasNetwork: [Function: bound hasNetwork],
     isDeployed: [Function: bound isDeployed],
     detectNetwork: [Function: bound detectNetwork],
     setNetwork: [Function: bound setNetwork],
     resetAddress: [Function: bound resetAddress],
     link: [Function: bound link],
     clone: [Function: bound clone],
     addProp: [Function: bound addProp],
     toJSON: [Function: bound toJSON],
     web3:
      Web3 {
        _requestManager: [Object],
        currentProvider: [Object],
        eth: [Object],
        db: [Object],
        shh: [Object],
        net: [Object],
        personal: [Object],
        bzz: [Object],
        settings: [Object],
        version: [Object],
        providers: [Object],
        _extend: [Object] },
     class_defaults:
      { from: '0xbbd414b340f2255dab9d923428c97f0b65d9df81',
        gas: 4712388,
        gasPrice: 100000000000 },
     currentProvider:
      HttpProvider {
        host: 'http://localhost:8545',
        timeout: 0,
        send: [Function],
        sendAsync: [Function],
        _alreadyWrapped: true },
     network_id: '1505794143155' },
  abi:
   [ { constant: false,
       inputs: [],
       name: 'sayHello',
       outputs: [Array],
       payable: false,
       type: 'function' } ],
  contract:
   Contract {
     _eth:
      Eth {
        _requestManager: [Object],
        getBalance: [Object],
        getStorageAt: [Object],
        getCode: [Object],
        getBlock: [Object],
        getUncle: [Object],
        getCompilers: [Object],
        getBlockTransactionCount: [Object],
        getBlockUncleCount: [Object],
        getTransaction: [Object],
        getTransactionFromBlock: [Object],
        getTransactionReceipt: [Object],
        getTransactionCount: [Object],
        call: [Object],
        estimateGas: [Object],
        sendRawTransaction: [Object],
        signTransaction: [Object],
        sendTransaction: [Object],
        sign: [Object],
        compile: [Object],
        submitWork: [Object],
        getWork: [Object],
        coinbase: [Getter],
        getCoinbase: [Object],
        mining: [Getter],
        getMining: [Object],
        hashrate: [Getter],
        getHashrate: [Object],
        syncing: [Getter],
        getSyncing: [Object],
        gasPrice: [Getter],
        getGasPrice: [Object],
        accounts: [Getter],
        getAccounts: [Object],
        blockNumber: [Getter],
        getBlockNumber: [Object],
        protocolVersion: [Getter],
        getProtocolVersion: [Object],
        iban: [Object],
        sendIBANTransaction: [Function: bound transfer] },
     transactionHash: null,
     address: '0x471a22ffe2bddd02e82853059871067e4c07a7f4',
     abi: [ [Object] ],
     sayHello:
      { [Function: bound ]
        request: [Function: bound ],
        call: [Function: bound ],
        sendTransaction: [Function: bound ],
        estimateGas: [Function: bound ],
        getData: [Function: bound ],
        '': [Circular] },
     allEvents: [Function: bound ] },
  sayHello:
   { [Function]
     call: [Function],
     sendTransaction: [Function],
     request: [Function: bound ],
     estimateGas: [Function] },
  sendTransaction: [Function],
  send: [Function],
  allEvents: [Function: bound ],
  address: '0x471a22ffe2bddd02e82853059871067e4c07a7f4',
  transactionHash: null }
truffle(development)> contract.sayHello.call()
'Hello World'
truffle(development)>
```

讲解

```
HelloWorld.deployed().then(instance => contract = instance)
```

`truffle console`中预载了`truffle-contract`函数库，以方便操作部署到区块链上的合约。

这边使用`HelloWorld.deployed().then`语句来取得`HelloWorld`合约的`Instance`（实例），并存到`contract`变量中，以方便后续的调用。

上面用的是`Javascript ES6+`的语法，这句也可以写成：

```
HelloWorld.deployed().then(instance => {
    contract = instance
});
```

还可以用ES5的写法：

```
HelloWorld.deployed().then(function(instance) {
  hello = instance;
});
```

```
truffle(development)> contract.sayHello.call()
'Hello World'
```

这里直接呼叫`contract.sayHello()`也会得到一样的结果。`truffle-contract`提供使用`call()`来读取只读（read only）的数据，这样就不需提供`gas`。因此如果遇到的操作需要向区块链写入数据，我们就不能用`call`语句了。

如此一来，我们已写好并部署完成了第一个智能合约，也验证了合约确实可以运作。

加入新方法

我们在`HelloWorld.sol`中再加入一个`echo`方法，`echo`方法接受输入一个参数，并回传传送的参数。

```
function echo(string name) constant returns (string) {
    return name;
}
```

新的`echo`方法中传入了一个`name`参数。我们也为`echo`方法加入一个`constant`声明，表示调用这个方法并不会改变区块链的状态。如此一来，透过`truffle-contract`来调用此方法时，会自动选用`call`来呼叫，也不需要额外提供gas。

由于更新了合约内容，我们需要先重新新编译一次，将编译结果部署到`testrpc`上，再透过`truffle console`执行看看结果。

```
liyuechun:HelloWorld yuechunli$ ls
build       contracts   migrations  test        truffle.js
liyuechun:HelloWorld yuechunli$ truffle compile
Compiling ./contracts/HelloWorld.sol...
Writing artifacts to ./build/contracts

liyuechun:HelloWorld yuechunli$ truffle migrate --reset
Using network 'development'.

Running migration: 1_initial_migration.js
  Replacing Migrations...
  ... 0x64cdc42e08a7e3f8070c46d4877ba246d95cbbccbfe1b9abd2450cfc02b48eda
  Migrations: 0x42843f6a470b84e2669f19686a223c1bdefb6f4d
Saving successful migration to network...
  ... 0x57042b767c0f40a4f88ce855e39549010d6d5ae5f880771a45c1f7f36ea0e5b3
Saving artifacts...
Running migration: 2_deploy_contracts.js
  Replacing HelloWorld...
  ... 0x2330e3264aae9d6be3744d8fc71d235fc6dc2934d33ff5159ae209df4cf8f12b
  HelloWorld: 0xbf68789cdd6be1577339e8c739abfa1190c31b6c
Saving successful migration to network...
  ... 0xb4b706d7004654215067ea5954a32f0562b32724d1c646dc43b688b466b10159
Saving artifacts...
liyuechun:HelloWorld yuechunli$ truffle console
truffle(development)> let contract
undefined
truffle(development)> HelloWorld.deployed().then(instance => contract = instance)
TruffleContract {
  constructor:
   { [Function: TruffleContract]
     _static_methods:
      { setProvider: [Function: setProvider],
        new: [Function: new],
        at: [Function: at],
        deployed: [Function: deployed],
        defaults: [Function: defaults],
        hasNetwork: [Function: hasNetwork],
        isDeployed: [Function: isDeployed],
        detectNetwork: [Function: detectNetwork],
        setNetwork: [Function: setNetwork],
        resetAddress: [Function: resetAddress],
        link: [Function: link],
        clone: [Function: clone],
        addProp: [Function: addProp],
        toJSON: [Function: toJSON] },
     _properties:
      { contract_name: [Object],
        abi: [Object],
        network: [Function: network],
        networks: [Function: networks],
        address: [Object],
        links: [Function: links],
        events: [Function: events],
        binary: [Function: binary],
        unlinked_binary: [Object],
        schema_version: [Function: schema_version],
        updated_at: [Function: updated_at] },
     _property_values: {},
     _json:
      { contract_name: 'HelloWorld',
        default_network: undefined,
        abi: [Array],
        unlinked_binary: '0x6060604052341561000f57600080fd5b5b61022c8061001f600039
6000f300606060405263ffffffff7c0100000000000000000000000000000000000000000000000000
000000600035041663ef5fb05b811461004857806363f15da729146100d3575b600080fd5b3415610053
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810190601f1680156100c55780820380516001836020036101000a031916815260200191505b509250
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de955050505050565b60405160208082528190810183818151815260200191508051906020019080
838360005b838110156100985780820151818401525b60200161007f565b50505050905090810190 60
1f1680156100c55780820380516001836020036101000a031916815260200191505b50925050506040
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805b919050565b60206040519081016040526000815290560 0a165627a7a723058208fec8695bd430e
ed53d1591d841c6e80b1a32a91caab996bb270d54425ebd7140029',
        networks: [Object],
        schema_version: '0.0.5',
        updated_at: 1505809278810 },
     setProvider: [Function: bound setProvider],
     new: [Function: bound new],
     at: [Function: bound at],
     deployed: [Function: bound deployed],
     defaults: [Function: bound defaults],
     hasNetwork: [Function: bound hasNetwork],
     isDeployed: [Function: bound isDeployed],
     detectNetwork: [Function: bound detectNetwork],
     setNetwork: [Function: bound setNetwork],
     resetAddress: [Function: bound resetAddress],
     link: [Function: bound link],
     clone: [Function: bound clone],
     addProp: [Function: bound addProp],
     toJSON: [Function: bound toJSON],
     web3:
      Web3 {
        _requestManager: [Object],
        currentProvider: [Object],
        eth: [Object],
        db: [Object],
        shh: [Object],
        net: [Object],
        personal: [Object],
        bzz: [Object],
        settings: [Object],
        version: [Object],
        providers: [Object],
        _extend: [Object] },
     class_defaults:
      { from: '0xbbd414b340f2255dab9d923428c97f0b65d9df81',
        gas: 4712388,
        gasPrice: 100000000000 },
     currentProvider:
      HttpProvider {
        host: 'http://localhost:8545',
        timeout: 0,
        send: [Function],
        sendAsync: [Function],
        _alreadyWrapped: true },
     network_id: '1505794143155' },
  abi:
   [ { constant: false,
       inputs: [],
       name: 'sayHello',
       outputs: [Array],
       payable: false,
       type: 'function' },
     { constant: true,
       inputs: [Array],
       name: 'echo',
       outputs: [Array],
       payable: false,
       type: 'function' } ],
  contract:
   Contract {
     _eth:
      Eth {
        _requestManager: [Object],
        getBalance: [Object],
        getStorageAt: [Object],
        getCode: [Object],
        getBlock: [Object],
        getUncle: [Object],
        getCompilers: [Object],
        getBlockTransactionCount: [Object],
        getBlockUncleCount: [Object],
        getTransaction: [Object],
        getTransactionFromBlock: [Object],
        getTransactionReceipt: [Object],
        getTransactionCount: [Object],
        call: [Object],
        estimateGas: [Object],
        sendRawTransaction: [Object],
        signTransaction: [Object],
        sendTransaction: [Object],
        sign: [Object],
        compile: [Object],
        submitWork: [Object],
        getWork: [Object],
        coinbase: [Getter],
        getCoinbase: [Object],
        mining: [Getter],
        getMining: [Object],
        hashrate: [Getter],
        getHashrate: [Object],
        syncing: [Getter],
        getSyncing: [Object],
        gasPrice: [Getter],
        getGasPrice: [Object],
        accounts: [Getter],
        getAccounts: [Object],
        blockNumber: [Getter],
        getBlockNumber: [Object],
        protocolVersion: [Getter],
        getProtocolVersion: [Object],
        iban: [Object],
        sendIBANTransaction: [Function: bound transfer] },
     transactionHash: null,
     address: '0xbf68789cdd6be1577339e8c739abfa1190c31b6c',
     abi: [ [Object], [Object] ],
     sayHello:
      { [Function: bound ]
        request: [Function: bound ],
        call: [Function: bound ],
        sendTransaction: [Function: bound ],
        estimateGas: [Function: bound ],
        getData: [Function: bound ],
        '': [Circular] },
     echo:
      { [Function: bound ]
        request: [Function: bound ],
        call: [Function: bound ],
        sendTransaction: [Function: bound ],
        estimateGas: [Function: bound ],
        getData: [Function: bound ],
        string: [Circular] },
     allEvents: [Function: bound ] },
  sayHello:
   { [Function]
     call: [Function],
     sendTransaction: [Function],
     request: [Function: bound ],
     estimateGas: [Function] },
  echo:
   { [Function]
     call: [Function],
     sendTransaction: [Function],
     request: [Function: bound ],
     estimateGas: [Function] },
  sendTransaction: [Function],
  send: [Function],
  allEvents: [Function: bound ],
  address: '0xbf68789cdd6be1577339e8c739abfa1190c31b6c',
  transactionHash: null }
truffle(development)> contract.echo("春哥微信:liyc1215")
'春哥微信:liyc1215'
truffle(development)>
```

`echo`方法确实将我们输入的内容回传了。同时因为声明了constant，我们不需要直接调用`call()`方法，`truffle`会自动选用`call`来呼叫。

另一点需要注意的，是这次如果还是用`truffle migrate`命令，我们会得到如下信息：

```
$ truffle migrate
Using network 'development'.
Network up to date.
```

`Truffle`会告诉你现在网络上的合约都已是最新的，但事实上刚刚程序中新增的方法并没有更新到内存块链上。要更新内存块链上已部署的程序，需要改写`migrations`中的脚本，但现在还不到介绍`migration`的时候。还好我们开发用的内存块链是怎么修改都没关系的`testrpc`，可以使用`truffle migrate --reset`命令直接重新在`testrpc`上部署一次。

总结

这篇文章非常简单，通过这篇文章，你将掌握如何配置开发环境、如何创建新项目、如何编译、如何部署合约以及了解整个智能合约开发的流程。

打赏地址

比特币： 1FcbBw62FHBJKTiLGNoguSwkBdVnJQ9NUn
以太坊： 0xF055775eBD516e7419ae486C1d50C682d4170645

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