XJTLU

DataToken Developer Diary

Solidity Smart Contract

P2P Cellular Data Sharing

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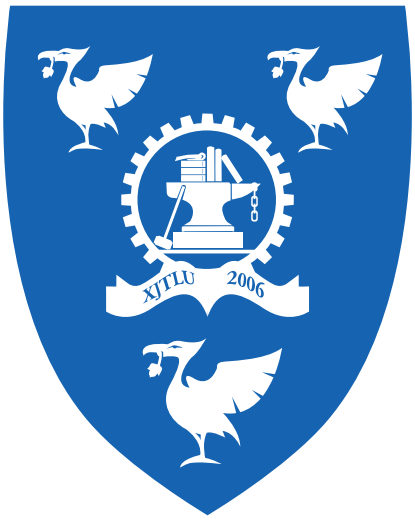

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Abstract

This project aims to implement a blockchain oriented cellular data sharing software on Ethereum platform. The first part of this Final Year Project focuses on software layer implementation, and the second half will consider some potential implementations in real life.

1 Introduction

DataToken is the name of the smart contract to be developed as my Final Year Project (FYP) in XJTLU. All DataToken projects will be named with postfix"alpha" since the propotype development is far from finished yet. Versions are depicted in *.* format e.g. 0.0; increment on the number before the dot means new functions or features are added, increment on the number after the dot means minor changes are added to source code.

2 DataToken Alpha 0.0

version alpha 0.0 initially designed functions createAccount, askforSharing

3 DataToken Alpha 0.1 20171014 Fri

The contract should be an ether pool (etherbase) thus it should allow user charge their account by putting ether in to the contranct. the first method to put ether in is the provide value when creating a user account. A second way is to call topUp function to send ether to this contract and get some token. By design, the token distributed by the contract should be at a constant exchange rate to ether. currently, the rate is set to be 1 token = 1 wei which is the smallest ether unit.

A withdraw function is created corresponding to topUp function. This function should allow user account to exchange their token back to ether in their ether address. But the chellange is, when sending ether from the contract, the gas fee is to be paid by the sender, if the sender here is the message sender i.e. the user, the user will pay for the gas, however, if the sender is considered as the contract itself, there will be a problem. If the contract is charged gas for each transaction (the contract will loss at least 0.001 ether for each transaction according to current gas price), the contract etherbase will fail due to too many withdraw transactions. The contract itself is not making any profit but will have to pay some fee due to users' transaction, that's not fair. Then an experiment should be held to examine how the ethereum network perform such a transaction from the contract with msg.sender a user to be the caller of the function. 0.001 ether = 10^15 wei which is a large amount of loss in terms of wei. experiment design: create the contract with external address A; create user account with external address B, charge 0.01 ether for token; expecting: the contract has 0.01 ether and address B pay 0.01 ether plus gas fee; address B call withdraw function to withdraw 0.01 ether; expecting: the contract send 0.01 ether to B and B pay the gas, resulting B receive 0.01 minus gas fee. An easy way to examine the behavior of the function (actually the contract convention) is to set a getter for the contract. top-up the contract first, suppose the contract possesses _amountA wei check the contract balance; withdraw _amountB wei by calling function withdraw as external address (user) check the contract balance; if the balance == _amountA - _amountB the transaction fee was paid by the msg.sender i.e. the user account. else the fee was paid by the contract

The contract shouldn't be paying that fee for transfering back.

3.1 Diary 20171016 Mon

Mapping a host address to a guest address will make the link unique, thereby the sevice can only be recorded one on one which is no good for practical use. I'm now searching for a datastructurea like array which can be marked as related to one host address so that all guests of the same host address can be stored in it. In the documentation of solidity $\hat{0}.4.18$, mapping types expression

$$mapping(KeyType => ValueType)$$

allows KeyType to be almost any type except for mapping type; ValueType to any type including mapping type. This mapping feature can merge mappings from guest to pay-

ment status. And here is a solution for linking host to guest.The following code is a good demonstration from stackexchange.

```
pragma solidity ^0.4.11;

contract AuthorizationManager{
    struct User{
      string userId;
      uint roleId;
    }

    mapping (string => User[]) companyUserMap;

    function addUser(string _key,string _userId, uint _roleId){
        companyUserMap[_key].push(User(_userId,_roleId));
    }

    function removeSingleUser(string _key){
        companyUserMap[_key].length--;
    }
}
```

3.2 Diary 20171017 Tue

What should a ledger be like? An individual ledger or a public ledger to record everyone?

4 DataToken Alpha 0.2 20171110

Contract vatiable list:

- uint256 public userIndex //index of userInfo array Info
- mapping (address=>bool) public isNotNew //used or not mark
- mapping (address=>uint256) public index //to query in array Info
- (struct) userInfo
  - address etherAdd //Ether private address of this user;
  - bool userRole; //is this user a provider(true) or a receiver(false)
  - uint256 tokenBalance; //

With the structure described in version 0.1, the dataToken v0.2 is designed as objective oriented and mapping feature of solidity language is used to distinguish different state of users. This time, each private ethereum address is treated as a usable user account, user name and user Id. The contract will create an array of users but rather a map array of users, although a ethereum address is marked as used by a map.
The first feature of this contract is to hold user information. Then the contract need to have functions to add new user and delete user as a ethereum user's wish.

4.1 Diary 20171111 Sat

Behavior test of version 0.2: addUser() expecting when calling this function with an ethereum address, the function:

1. initializes a userInfo element in a userInfo array.
2. mark the message sender as used address by mapping the address to bool value true (used), which by default is false (unused).
3. index increment is needed since the function add userInfo to the same userInfo array each time and the index should be different.
4. store the index of current userInfo by mapping the address to a uint256 value.

Method addUser() is described by the following code:

```
function addUser() isNew public {

    Info.push(userInfo(msg.sender,false,0));
    isNotNew[msg.sender]=true;
    index[msg.sender]=userIndx;
    userIndx+=1;
}
```

Bug:

1. **Default target value (uint256) in a map is 0**
   An used address will have the userIndex mapping value 0, which will be interpreted as position [0] if Info[0] does hold information of a user.
   Trail Fix 1: Initialize userIndex with none zero value, say 1. Position [0] in Info array is initialized with the contract address and other default values.

Limitations:

1. Information of users is stored by an array but the array may be size limited.
   Answer: array is capable to store a very big number of indices like 2^{256}; it maybe not a problem for the scope of a small application on Ethereum. This user information system cound be altered by some more flexible methods in solidity language.

2. A method inside dataToken contract named removeUser() will remove message sender from user list and redeem Ethers according to token balance. Once a user (address) is removed from Info[] array, the position (index) of it will be empty, however, current addUser function won't be able to reuse the released indices.
   Answer: For this version of implementation (alpha V0.2), the removed positions will be left empty and not be used by the contract.

4.2 Diary 20171114 Tue

Design of removeUser() method. The very first question is what have been created by a call of addUser(). As the definition of addUser() in Diary 20171111 Sat, once addUser() is called:

- Info[] will have a new userInfo cascated at the end of it.
- A corresponding position in map **index** is created to hold the index of that userInfo.
- A nother map **isNotNew** will hold the state of whether an addresss is used or not. Being True means this address is not a new user.

Once call of removeUser() will remove the created information above.

- Mark the isNotNew mapping of the address as false. The information of this address won't be removed from **Info**. The corresponding index will be reserved.
- Once this address is marking itself as a user again, addUser() could check whether it's **index** mapping is non-zero, then the old position of this address can be marked as user by just changing the value of **isNotNew** mapping.

Limitations

1. This will also cause another problem that a user must be aware that the token won't be redeemed if withdraw function is not called.

Behavior of this function is as expected so far.

4.3 Diary 20171115

Topup and withdraw function are implented.

- topUp()
  is a payable function which is able to send ether to the contract from the message sender. Global variable msg.value is the value designated to send to dataToken contract by the user. If the message sender is a user, certain amount of Ether will be sent to the contract and then the function will offer the user account an equivalent amount of token obeying an 1 wei = 1 token exchange rate.

- withdraw()
  If a user call this function, it will redeem all token of current user back to Ether in the user's address.

4.4 Diary 20171116

Design of payment logic:

1. New components of userInfo is added to desicribe a ledger:
   - address provider; //address of the provider, is 0 by default.
   - address receiver; //address of the reveiver, is 0 by default.
   - uint256 volume; //data usage if as a reveiver, is 0 by default.
   - bool paid; //whether the user has paid for the last use of sharing, is true by default.
2. New functions to deal with accounting and payment are needed.
   - pay(address _provider, uint256 _volume)
   - transfer(address _provider, address _receiver, uint256 _amount)
     transfer() will deal with token transfer. It will be called inside function pay(). As to obtain a good level of flexibility, the behavior of transfer token can still be used in somewhere else.
3. In one sharing process, the receiver will have it's provider infromation

4.5 Diary 20171117

An exachange rate mechanism: uint variable v2weiRate and a function chv2weiRate(). To test the function of this contract, an new initializer is defined. The contract will initialize a provider whose address is
0xdd870fa1b7c4700f2bd7f44238821c26f7392148

If it is necessary to change the rate of exchange, call the function. This is not a feature for frequent use but it may be necessary to use during my tests.

A new function link() will match a receiver to a provider when a receiver user call it.

Limitations:

- Each provider may serve serveral receivers at the same time, however, there should be a number limit. What if multiple providers are in the same space with several receivers? (How to match the providers to the receivers?) A typical solution is to maintain receiver number of each provider in the same space at an average level. How to implement this volume balance feature?

4.6 Diary 20171118

Link function will only provide 1 to 1 link now because the struct userInfo allows just one receiver address. The limitation is obvious, the next step is to make this matching more flexible.

5 DataToken Alpha 0.2.2

5.1 Diary 20171128

The concept of contract in Solidity resembles the concept of class in objective oriented languages but "contract" is deployable on Ethereum network.
If a contract (class) called user is defined, can I make an array of instances of user contract in my dataToken contract?
There is problem of gas cost be fore understanding what exactly a contract is in Solidity.

5.2 Diary 20171130

Coding style is changed. Function declaration is like:

```
function getter_this_is_not_new()
constant
public
returns(bool)
```

```
{
    return isNotNew[msg.sender];
}
```

Each function modifier is listed in saperate lines.
A feature of Solidity, enum type is probably used for declaration of flags.
For a private Ethereum address, it's states could be:

- not a user of DataToken contract
- a user of DataToken contract
  - a provider
  - a reveiver
    - have paid the last bill
    - have not paid

5.3 Diary 20171201

Utilizing enum type in Solidity, user identification, user role and payment state can be

- NOTCONTRACTUSER = 0
- ISPROVIDER = 1
- ISRECEIVER = 2
- HAVENOTPAID = 3 i.e. implicitely a provider, but the contract don't allow it do anything but to pay the bill.

userRole(bool) in structure userInfo is changed to be Identification(uint). Values of Identification is from enum state ... as demonstrated above.
Another problem is to match multiple user to the same provider.
OR, the function could return several available providers for user to choose which one to connect to.

Contract variables now are:

- v2weiRate(uint) : token to wei rate. set to 1 in current version.
- providers(addres[ ]) : array of providers i.e. Identification = 1.
- users(userInfo[ ]) : array of user information
  - userInfo(struct) definition
    - Identification(unint) : one value from state(enum)

    - * etherAddress(address) : Ethereum address if this is a user
    - * provider(address) : the provider's address before the next time sharing
    - * dataUsage(uint256) : data usage in MB. Must be integer in current version
    - * receivers(addres[ ]) : each sharing process should allow multiple receiver

- tokenBalance(address=>uint256 mapping) : token balance of a user (address as key)
- providerIndex(address=>uint256 mapping) : if Identification = PROVIDER, note the index in providers(address[ ]) array
- usersIndex(address=>unint256 mapping): if Identification $\neq$ NOTCONTRACTUSER, note the index in users(userInfo[]) array

Fundamental functions in this contract:

- addUser() : mark message sender as a user of this contract
  Identification = ISRECEIVER
- removeUser() : mark message sender as "not a user"
  Identification = NOTCONTRACTUSER
- suProvider() : if Identification = ISRECEIVER, change the message sender's Identification to ISRECEIVER
  Identification = ISPROVIDER
- suReceiver() : if Identification = ISPROVIDER, mark message sender as receiver
  Identification = ISRECEIVER

5.4 Diary 20171202

Bug report:
Cannot add new users. Call of addUser() is always rejected by modifier isNotContractUser() by replying that"This address is a registered contract user."

User Identification(State) is changed to be a mapping called Identification(address=>State), because default mapping value of a unassigned key is 0 which can be used to distinguish new user. Before this change, Identification(State) is a value inside users(userInfo[]) in which unregistered address will have index 0 as default mapping value of userIndex(address=>uint256), that is, all new users will be recognized as users[0] which is the user position for the contract itself.