Blockchain Global Voting System

Group TBD.

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Introduction

From the US presidential election to student association resolution, voting is a common but indispensable activity in our daily life. However, the traditional voting systems, either on-site or online, always have some disadvantages because of their natural form and restrictions using traditional technologies. In this project, we designed the smart contract and implemented a voting system using blockchain technology. By applying the two most important features, cryptography and decentralization, the security and reliability of the voting process is guaranteed.

Disadvantages of traditional on-site voting

- People need to go to the voting polls in person and wait in a long line (Persidential Election)
- Impossible to alter vote before the deadline if the voters change their mind
- Hackers can apply malicious attack the back-end server/database and manipulate the results

Advantages of online voting through blockchain

- The voting results are public and immutable
- The decentralized network can help prevent malicious attack
- People can vote anywhere where the Internet is accessible
- People have the authority to alter their vote before the deadline in case that they change their mind
- Real-time voting results are always visible to everyone

Objectives

The functionalities of our voting system are divided into 3 parts, from basic to advanced based on the importance of these functions to the system. Some of the advanced functionalies may not be able to finish before the deadline but we guarantee that all the basic and itermediate functions will be implemented.

Basic Functions

Vote

There are two kinds of voting - straight and cumulative. In the straight voting, each voter can have one vote per share for each nominator. In other words, voters only need to select the candidates they intend to vote for, the votes for each candidate are fixed. In cumulative voting, each voter can vote candidates they want to vote with different votes number. There are several constraints on voting. For example, the voter should always vote before the deadline and should have never voted before. Besides, the candidates should be valid as well.

Inquire

Under Inquire, firstly, voters can check their account share details which includes: Total share, Total Votes, Votes Used, Available Votes, Number of voted Candidates , Remaining Times to Modify My Vote(MAX 3 times); Secondly, voter can see their current votes record; Thirdly, voter can change their previous votes based on their votes record, however, the maximum time of change votes is 3. Also, only the voter has the authority to change the votes, others do not have right to modify record. The security and authority is guaranteed by the blockchain.

Results

Results show the real-time vote results of each candidate in the form of a histogram.

Intermediate Functions

Candidate Creation

A candidate can be created by candidate name, personal photo url and personal information.

Share Allocation

Only deployer can allocate specific shares to each vote through their account address which can not exceed the total share.

Advanced Functions

Voting Deadline

A voting deadline is a reference to indicate that all the voters made after the deadline will be declined. However, time setting is always a tough part in solidity. Therefore, we put voting dealine setting function in the advanced part.

Multi Voting Choices

Multi votings with different purposes can be set and stored in the blockchain which can be switched between each other in the front-end.

Application Wireframe

At the beginning, we can see our application wireframe level below based on our functions needs:

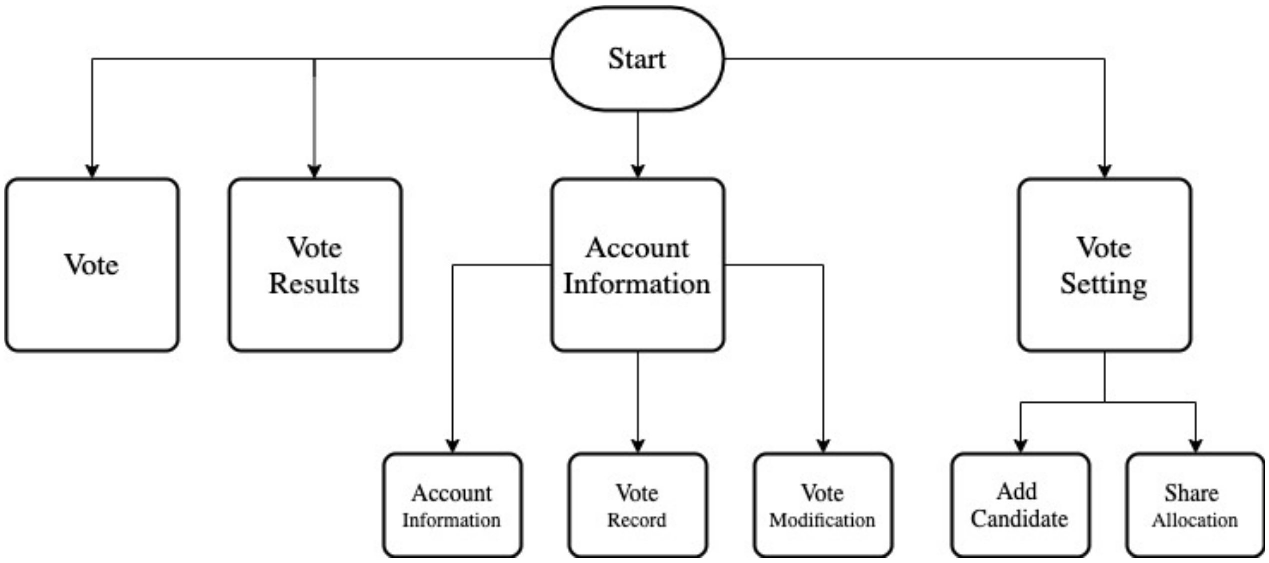
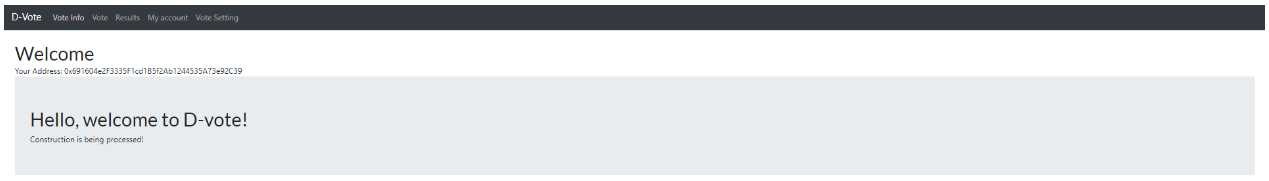


Figure 1. Wireframe level

Voting application main page



Welcome

Your Address: 0x691604e2F3335F1cd1B5f2Ab1244535A73e92C39

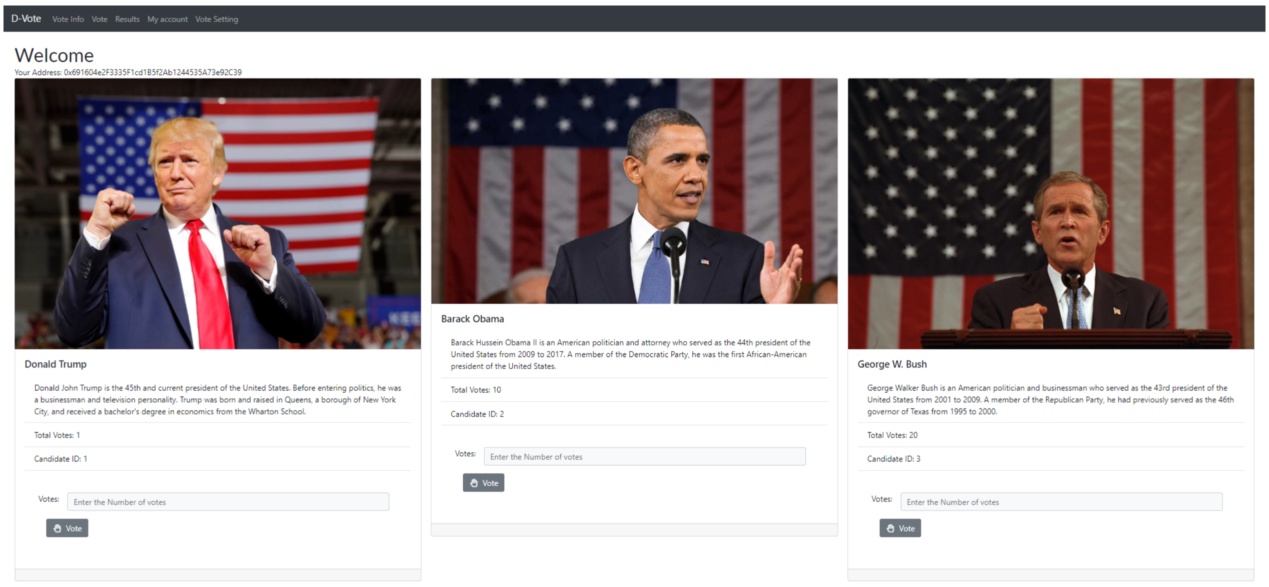
Hello, welcome to D-vote!

Construction is being processed!

Figure 2. Main Interface

The main interface page contains greeting information, also your current account address, the account address information will consistent within other pages.

Vote page



Welcome

Your Address: 0x691604e2F3335F1cd1B5f2Ab1244535A73e92C39

Donald Trump

Donald John Trump is the 45th and current president of the United States. Before entering politics, he was a businessman and television personality. Trump was born and raised in Queens, a borough of New York City, and received a bachelor's degree in economics from the Wharton School.

Total Votes: 1

Candidate ID: 1

Votes: Enter the Number of votes

Barack Obama

Barack Hussein Obama II is an American politician and attorney who served as the 44th president of the United States from 2009 to 2017. A member of the Democratic Party, he was the first African-American president of the United States.

Total Votes: 10

Candidate ID: 2

Votes: Enter the Number of votes

George W. Bush

George Walker Bush is an American politician and businessman who served as the 43rd president of the United States from 2001 to 2009. A member of the Republican Party, he had previously served as the 46th governor of Texas from 1995 to 2000.

Total Votes: 20

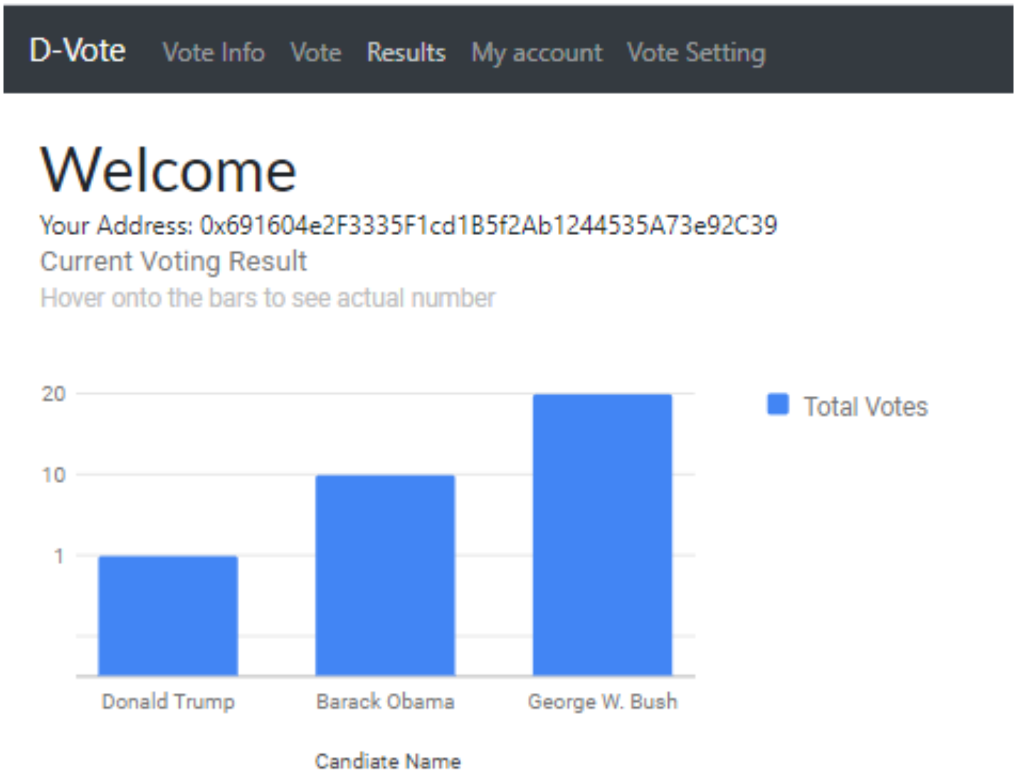
Candidate ID: 3

Votes: Enter the Number of votes

Figure 3. Vote Page

Candidate related information like: name, personal photo and introduction and current votes number. Voter can vote for candididate by inputing the number of votes and clicking vote button.

Result Page



Welcome

Your Address: 0x691604e2F3335F1cd1B5f2Ab1244535A73e92C39

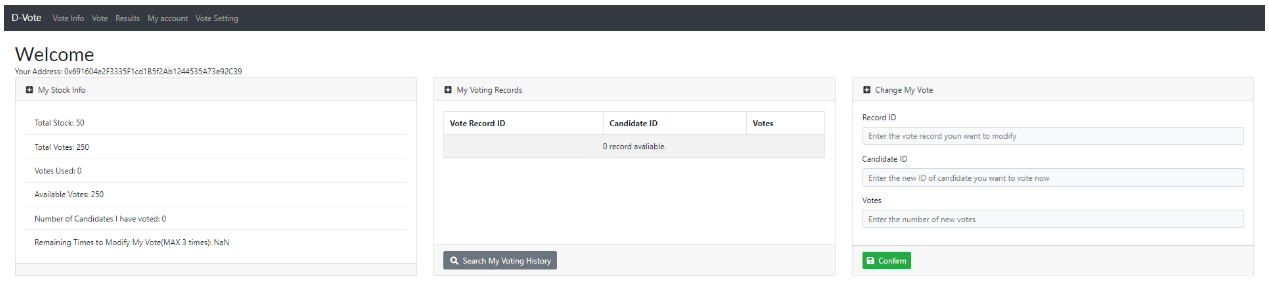
Current Voting Result

Hover onto the bars to see actual number

Figure 4. Results Page

Voter can see the current votes results any time they want to see. The results shown in a histogram.

Account page



Welcome

Your Address: 0x691604e2F3335F1cd1B5f2Ab1244535A73e92C39

My Stock Info

Total Stock: 50

Total Votes: 250

Votes Used: 0

Available Votes: 250

Number of Candidates I have voted: 0

Remaining Times to Modify My Vote(MAX 3 times): NaN

My Voting Records

Vote Record ID	Candidate ID	Votes
0 record avaliable.		

Change My Vote

Record ID: Enter the vote record youn want to modify

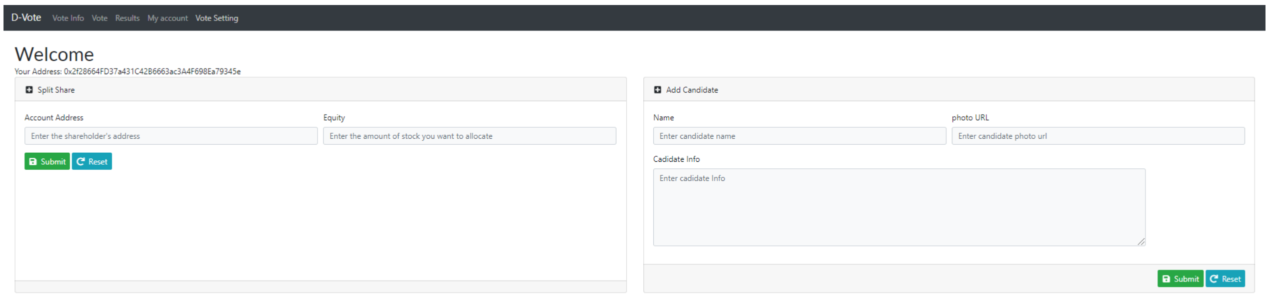
Candidate ID: Enter the new ID of candidate you want to vote now

Votes: Enter the number of new votes

Figure 5. Account Page

We have 3 sections under this page which are: account details, voter's current vote record and change vote.

Vote setting page



Welcome

Your Address: 0x2f28664FD37a431C42B6663ac3A4F698Ea79345e

Split Share

Account Address: Enter the shareholder's address

Equity: Enter the amount of stock you want to allocate

Add Candidate

Name: Enter candidate name

photo URL: Enter candidate photo url

Cadidate Info: Enter cadidate Info

Figure 6. Vote setting page

We have 2 sections under this page which are: share allocation and candidates adding.

Smart Contract

```
pragma solidity >=0.4.21 <0.7.0;

contract Vote {
    string public voteName;
    uint256 public addCandidateStartDate;
    uint256 public addCandidateEndDate;
    uint256 public voteStartDate;
    uint256 public voteEndDate;
    address public voteDeployer;
    uint public totalCandidateNumber = 0;
    uint public maxNominatedNum;
    uint public voteType = 1;
    uint public totalShareNum;
    uint public maxShareNum;
    uint public currentTotalShareNum = 0;
    bool comfirm = false;
    mapping(uint => Candidate) public candidates;
    mapping(address => Voter) public voters;
    struct Candidate {
        uint candidateId;
        string candidateName;
        string candidatePhoto;
        string candidateInfo;
        uint candidateTotalVote;
    }

    struct OneVote {
        uint candidateId;
        uint voteNum;
    }

    struct Voter{
        uint voteChangeNum;
        uint stock;
        uint totalVoteNum;
        uint voteUsed;
        uint numOfPeopleNominated;
        mapping (uint => OneVote) myVote;
        bool hasVoted;
    }
    event allocateShareEvent(
        address voter,
        uint stock
    );
    event newVoteRecord(
        uint candidateId,
        uint voteNum
    );
    event changeVoteRecord(
        uint candidateId,
        uint voteNum
    );
    event lookForInfo(
        uint candidateId,
        uint inputId
    );
    event addCandidate(
        uint candidateId,
        string candidateName,
        string candidatePhoto,
        string candidateInfo,
        uint candidateTotalVote
    );
    event vote(
        uint voteName,
        uint voteTime,
        bool hasVoted
    );
    event lookUpMyVote(
        address myAddr,
        uint[] recordID,
        uint[] candidateID,
        uint[] voteNum
        );
    constructor(uint256 _addStartDate, uint256 _addEndDate,
                uint256 _startDate, uint256 _endDate,
                uint256 _maxNominatedNum, uint256 _totalShareNum,
                uint256 _maxShareNum, uint _voteType) public {
        voteName = "block chain vote app";
        addCandidateStartDate = _addStartDate;
        addCandidateEndDate = _addEndDate;
        voteStartDate = _startDate;
        voteEndDate = _endDate;
        voteType = _voteType;
        maxNominatedNum = _maxNominatedNum;
        voteDeployer = msg.sender;
        totalShareNum = _totalShareNum;
        maxShareNum = _maxShareNum;
    }
    function createNewCandidate(string memory _cadidateName, string
memory _candidatePhoto,
                                string memory _cadidateInfo, uint256
_currentDate) public {
        require(msg.sender == voteDeployer,
        "You can't create new cadidate. Only deployer can do this.");
        require(_currentDate > addCandidateStartDate && _currentDate <
addCandidateEndDate,
                "The stage for adding new candiddate is not valid, no
candidate can be added");
        require(bytes(_cadidateName).length > 0, "candidate name is
required");
        require(bytes(_cadidateInfo).length > 0, "candidate info is
required");
        totalCandidateNumber++;
        string memory photo =
"https://en.wikipedia.org/wiki/Anonymous_(group)#/media/File:Anonymous_e
mblem.svg";
        if(bytes(_candidatePhoto).length > 0){photo = _candidatePhoto;}
        candidates[totalCandidateNumber] =
Candidate(totalCandidateNumber,_cadidateName,photo,_cadidateInfo,0);
```

```
        emit
addCandidate(totalCandidateNumber,_cadidateName,photo,_cadidateInfo,0);
    }
    function allocateShare(address _voterAddr, uint _shareNum) public {
        require(msg.sender == voteDeployer,
        "You can't deploy stock. Only deployer can do this.");
        require(_shareNum <= maxShareNum,
        "You can't deploy this stock number for this voter.");
        require((currentTotalShareNum + _shareNum) <= totalShareNum,
        "You can't deploy more stock, current stock are greater than
total stock.");
        currentTotalShareNum = currentTotalShareNum + _shareNum;
        Voter memory _voter = voters[_voterAddr];
        _voter.stock = _shareNum;
        _voter.totalVoteNum = _shareNum * maxNominatedNum;
        voters[_voterAddr] = _voter;
        emit allocateShareEvent(_voterAddr, _shareNum);
    }
    function voteForCandidate(uint _candidateId, uint _voteNum, uint256
_currentDate) public{
        require(_currentDate > voteStartDate && _currentDate <
voteEndDate,
        "The stage for voting is not valid, no vote can be created");
        require(_candidateId > 0 && _candidateId <=
totalCandidateNumber, "Invalid Candidate Id");
        require(voters[msg.sender].hasVoted == false ||
voters[msg.sender].voteChangeNum < 3,
        'You have access your max voting modifying times(3 times)');
        require(voters[msg.sender].stock > 0,
        "You don't have any share. You can't vote");
        require(voters[msg.sender].numOfPeopleNominated <=
maxNominatedNum,
        "You can't vote for any more nominator. You can't vote");
        Voter memory _voter = voters[msg.sender];
        if(voteType == 1){
            require(_voter.voteUsed + voters[msg.sender].stock <=
_voter.totalVoteNum,
            "You don't have so many votes");
        }else{
            require(_voter.voteUsed + _voteNum <= _voter.totalVoteNum,
            "You don't have so many votes");
        }
        bool votedForCandidate = false;
        for(uint i = 0; i <= voters[msg.sender].numOfPeopleNominated;
i++){
            //emit lookForInfo(voters[msg.sender].myVote[i].candidateId,
_candidateId);
```

```
            if(voters[msg.sender].myVote[i].candidateId == _candidateId)
{
                votedForCandidate = true;
             }
        }
        require(!votedForCandidate,
            "You have voted for this candidate, use changeMyVote() to
change your vote");
         // then lets input the new voting info
        voters[msg.sender].numOfPeopleNominated++;
        voters[msg.sender].hasVoted = true;
        uint currentVoteStock;
        if(voteType == 1) {
            currentVoteStock = voters[msg.sender].stock;
        } else {
            currentVoteStock = _voteNum;
        }
        OneVote memory myNewVote = OneVote(_candidateId,
currentVoteStock);
        voters[msg.sender].myVote[_voter.numOfPeopleNominated] =
myNewVote;
        voters[msg.sender].voteUsed += currentVoteStock;

        Candidate memory _cadidate = candidates[_candidateId];
        _cadidate.candidateTotalVote += currentVoteStock;
        candidates[_candidateId] = _cadidate;

        emit newVoteRecord(_candidateId, currentVoteStock);
    }
    // this func can let you look up all the vote records
    function lookUpVoteRecord() public{
        uint num_p = voters[msg.sender].numOfPeopleNominated;
        uint256[] memory recordID = new uint256[](num_p);
        uint256[] memory candidateID = new uint256[](num_p);
        uint256[] memory voteNum = new uint256[](num_p);
        for(uint _recordId = 0;_recordId < num_p;_recordId++){
            recordID[_recordId] = _recordId;
            candidateID[_recordId] =
voters[msg.sender].myVote[_recordId].candidateId;
            voteNum[_recordId] =
voters[msg.sender].myVote[_recordId].voteNum;
        }
        emit lookUpMyVote(msg.sender,recordID,candidateID,voteNum);
     }
    function changeMyVote(uint _candidateId, uint _newVote, uint
_voteInfoNum, uint256 _currentDate) public {
        require(_currentDate > voteStartDate && _currentDate <
voteEndDate,
        "The stage for voting is not valid, no vote can be created");
        require(_candidateId > 0 && _candidateId <=
totalCandidateNumber,
        'Invalid Candidate Id');
        require(voters[msg.sender].hasVoted == true &&
voters[msg.sender].voteChangeNum < 3,
        'You have access your max voting modifying times(3 times)');
        require(voters[msg.sender].myVote[_voteInfoNum - 1].voteNum > 0,
        "voting info ID is wrong, you haven't voted for this person");
        Voter memory _voter = voters[msg.sender];
        OneVote memory _voteToModify =
voters[msg.sender].myVote[_voteInfoNum - 1];
        // emit lookForInfo(_voteToModify.candidateId,
_voteToModify.voteNum);
        // total voteUsed checking
        if(voteType == 2) {
            uint myLastVoteNum = _voteToModify.voteNum;
            require(_voter.voteUsed - myLastVoteNum + _newVote <=
_voter.totalVoteNum,
            "You don't have so many votes");
        } else {
           bool votedForCandidate = false;
           for(uint i = 0; i <= voters[msg.sender].numOfPeopleNominated;
i++){
            //emit
lookForInfo(voters[msg.sender].myVote[i].candidateId,_candidateId);
            if(voters[msg.sender].myVote[i].candidateId == _candidateId
                && voters[msg.sender].myVote[i].voteNum > 0) {
                votedForCandidate = true;
             }
             require(!votedForCandidate, "You have voted for this
candidate.");
            }
        }
        voters[msg.sender].voteChangeNum++;
        Candidate memory _lastVoteCandidate =
candidates[_voteToModify.candidateId];
         if(voteType == 1) {
             _lastVoteCandidate.candidateTotalVote -=
_voteToModify.voteNum;
         } else {
             _lastVoteCandidate.candidateTotalVote -= _newVote;
         }
         candidates[_voteToModify.candidateId] = _lastVoteCandidate;
         voters[msg.sender].voteUsed -= _voteToModify.voteNum;
        uint currentVoteNum;
        if(voteType == 1) {
            currentVoteNum = voters[msg.sender].stock;
        } else {
            currentVoteNum = _newVote;
        }
        OneVote memory myNewVote = OneVote(_candidateId,
currentVoteNum);
        voters[msg.sender].voteUsed += currentVoteNum;
        voters[msg.sender].myVote[_voteInfoNum - 1] = myNewVote;
        Candidate memory _cadidate = candidates[_candidateId];
        _cadidate.candidateTotalVote += currentVoteNum;
        candidates[_candidateId] = _cadidate;
        emit changeVoteRecord(_candidateId, currentVoteNum);
    }
    function changeVoteType(uint _type) public {
        voteType = _type;
    }
}
```

Testing

```
const Vote = artifacts.require("./Vote.sol");

contract("Vote Test", async accounts => {
    var vote;
    before(async()=>{
        vote = await Vote.deployed();
    });

    describe('initializes the vote contract', async () => {
        it('get vote name', async () => {
            let voteName = await vote.voteName();
            assert.equal(voteName, 'block chain vote app');
        });

        it('get add candidate start and end date', async () => {
            let startDate = await vote.addCandidateStartDate();
            let endDate = await vote.addCandidateEndDate();
            assert.equal(startDate.toNumber(), 100);
            assert.equal(endDate.toNumber(), 200);
        });

        it('get add vote start and end date', async () => {
            let startDate = await vote.voteStartDate();
            let endDate = await vote.voteEndDate();
            assert.equal(startDate.toNumber(), 300);
            assert.equal(endDate.toNumber(), 400);
        });

        it('get vote type, max nominated number and vote deployer',
async () => {
            let voteType = await vote.voteType();
            let maxNominatedNum = await vote.maxNominatedNum();
            let address = await vote.voteDeployer();
            assert.equal(address, accounts[0]);
            assert.equal(maxNominatedNum.toNumber(), 5);
        });

        it('get total share and max share per person', async () => {
            let totalShareNum = await vote.totalShareNum();
            let maxShareNum = await vote.maxShareNum();
            assert.equal(totalShareNum.toNumber(), 100);
            assert.equal(maxShareNum.toNumber(), 50);
        });
    });


    describe('create candidates in contract', async () => {
        it('create a candidate with complete information', async () => {
            let result1 = await vote.createNewCandidate('Kobe Bryant',
'https://KB.jpg', 'Basketball player', 150,{from: accounts[0]});
            let totalCandidateNumber = await
vote.totalCandidateNumber();
            let event1 = result1.logs[0].args;
            assert.equal(event1.candidateId.toNumber(),
totalCandidateNumber.toNumber(), 'Candidate id is correct');
            assert.equal(event1.candidateName, 'Kobe Bryant','Candidate
name is correct');
            assert.equal(event1.candidatePhoto,
'https://KB.jpg','Candidate photo url is correct');
            assert.equal(event1.candidateInfo, 'Basketball
player','Candidate info is correct');
            assert.equal(event1.candidateTotalVote.toNumber(),
0,'Candidate vote number is correct');
        });

        it('create a candidate with incomplete information', async () =>
{
            //invalid candidate name
            try{
                await vote.createNewCandidate('', 'https://KB.jpg',
'Basketball player', 150, {from: accounts[0]});
```

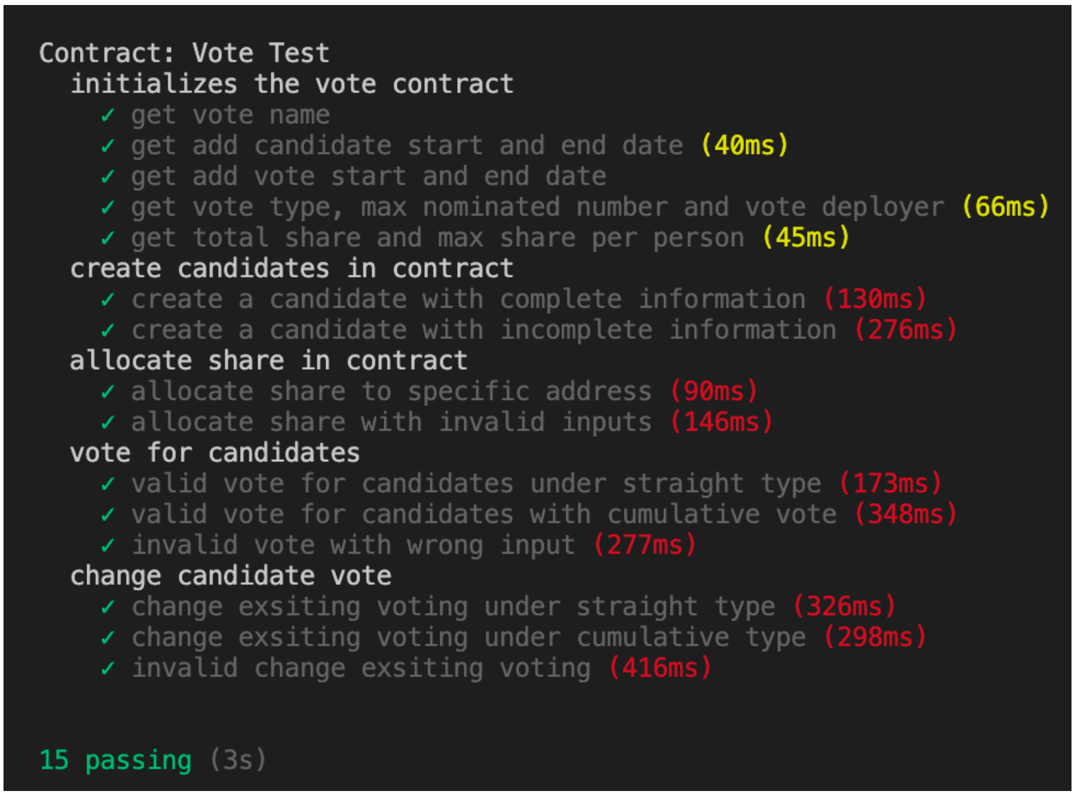
```
            }catch(error){
                assert.equal(error.message.includes('candidate name is 
required'), true);
            }

            //invalid candiate info
            try{
               await vote.createNewCandidate('Kobe Bryant', 
'https://KB.jpg', '', 150, {from: accounts[0]});
            }catch(error){
                assert.equal(error.message.includes('candidate info is 
required'), true);
            }

            //invalid add deployer address
            try{
               await vote.createNewCandidate('Kobe Bryant', 
'https://KB.jpg', '', 150, {from: accounts[1]});
            }catch(error){
                assert.equal(error.message.includes("You can't create 
new cadidate. Only deployer can do this."), true);
            }

            //invalid create time
            try{
               await vote.createNewCandidate('Kobe Bryant', 
'https://KB.jpg', 'Basketball player', 300, {from: accounts[0]});
            }catch(error){
                assert.equal(error.message.includes("The stage for 
adding new candiddate is not valid, no candidate can be added"), true);
            }
        });
    });

    describe('allocate share in contract', async () => {
        it('allocate share to specific address', async () => {
            let result2 = await vote.allocateShare(accounts[1], 10, 
{from: accounts[0]});
            let event2 = result2.logs[0].args;
            let address = event2.voter;
            assert.equal(address, accounts[1]);
            assert.equal(event2.stock.toNumber(), 10);

            let voter = await vote.voters(address);
            let maxNominatedNum = await vote.maxNominatedNum();
            assert.equal(voter.stock.toNumber(), 10);
            assert.equal(voter.totalVoteNum.toNumber(), 10 *
maxNominatedNum.toNumber());
        });

        it('allocate share with invalid inputs', async () => {
            //invalid deployer address
            try{
                await vote.allocateShare(accounts[1], 10, {from:
accounts[1]});
            }catch(error){
                assert.equal(error.message.includes("You can't deploy
stock. Only deployer can do this."), true);
            }

            //invalid deployer address
            try{
                await vote.allocateShare(accounts[1], 50, {from:
accounts[0]});
                await vote.allocateShare(accounts[1], 45, {from:
accounts[0]});
            }catch(error){
                assert.equal(error.message.includes("You can't deploy
more stock, current stock are greater than total stock."), true);
            }
        });
    });

    describe('vote for candidates', async () => {
        it('valid vote for candidates under straight type', async () =>
{
            let result3 = await vote.voteForCandidate(1, 10, 350, {from:
accounts[1]});
            let event3 = result3.logs[0].args;  //[0]: look up event
            let voter = await vote.voters(accounts[1]);
            let candidate = await vote.candidates(1);

            assert.equal(voter.numOfPeopleNominated.toNumber(), 1);
            assert.equal(voter.hasVoted, true);
            assert.equal(voter.voteUsed.toNumber(), 50);
            assert.equal(candidate.candidateTotalVote.toNumber(), 50);

            assert.equal(event3.candidateId.toNumber(), 1);
            assert.equal(event3.voteNum.toNumber(), 50);
        });

        it('valid vote for candidates with cumulative vote', async () =>
{
```

```
            await vote.changeVoteType(2);
            let type = await vote.voteType();
            assert.equal(type.toNumber(), 2);
            let curTotalShare = await vote.currentTotalShareNum();
            assert.equal(curTotalShare.toNumber(), 60);

            await vote.allocateShare(accounts[2], 30, {from:
accounts[0]});
            let result4 = await vote.voteForCandidate(1, 100, 350,
{from: accounts[2]});
            let event4 = result4.logs[0].args;  //[0]: look up event
            let voter = await vote.voters(accounts[1]);
            let candidate = await vote.candidates(1);

            assert.equal(candidate.candidateTotalVote.toNumber(), 150);
            assert.equal(event4.candidateId.toNumber(), 1);
            assert.equal(event4.voteNum.toNumber(), 100);

            await vote.changeVoteType(1);
            type = await vote.voteType();
            assert.equal(type.toNumber(), 1);
        });

        it('invalid vote with wrong input', async () => {
            //invalid vote date
            try{
                await vote.voteForCandidate(1, 100, 450, {from:
accounts[2]});
            }catch(error){
                assert.equal(error.message.includes("The stage for
voting is not valid, no vote can be created"), true);
            }
            //invalid vote candidate id
            try{
                await vote.voteForCandidate(2, 100, 350, {from:
accounts[2]});
            }catch(error){
                assert.equal(error.message.includes("Invalid Candidate
Id"), true);
            }
            //account with no share
            try{
                await vote.voteForCandidate(1, 100, 350, {from:
accounts[3]});
            }catch(error) {
                assert.equal(error.message.includes("You don't have any
share. You can't vote"), true);
```

```
            }
            //exceed total vote number
            try{
                await vote.changeVoteType(2);
                await vote.voteForCandidate(1, 100, 350, {from:
accounts[2]});
            }catch(error) {
                await vote.changeVoteType(1);
                assert.equal(error.message.includes("You don't have so
many votes"), true);
            }
        });
    });

    describe('change candidate vote', async () => {
        it('change exsiting voting under straight type', async () => {
            let type = await vote.voteType();
            assert.equal(type.toNumber(), 1);

            await vote.createNewCandidate('Michael Jordan',
'https://MJ.jpg', 'NBA Basketball player', 150, {from: accounts[0]});
            let result4 = await vote.changeMyVote(2, 10, 1, 350, {from:
accounts[1]});
            let event4 = result4.logs[0].args;
            let voter = await vote.voters(accounts[1]);
            let candidate1 = await vote.candidates(1);
            let candidate2 = await vote.candidates(2);

            assert.equal(event4.candidateId.toNumber(), 2);
            assert.equal(event4.voteNum.toNumber(), 50);
            assert.equal(candidate1.candidateTotalVote.toNumber(), 100);
            assert.equal(candidate2.candidateTotalVote.toNumber(), 50);
            assert.equal(voter.voteChangeNum.toNumber(), 1);
        });

        it('change exsiting voting under cumulative type', async () => {
            await vote.changeVoteType(2);
            let type = await vote.voteType();
            assert.equal(type.toNumber(), 2);

            let result5 = await vote.changeMyVote(2, 50, 1, 350, {from:
accounts[2]});
            let event5 = result5.logs[0].args;
            let voter = await vote.voters(accounts[2]);
            let candidate1 = await vote.candidates(1);
            let candidate2 = await vote.candidates(2);
            assert.equal(event5.candidateId.toNumber(), 2);
            assert.equal(event5.voteNum.toNumber(), 50);
            assert.equal(candidate1.candidateTotalVote.toNumber(), 50);
            assert.equal(candidate2.candidateTotalVote.toNumber(), 100);
            assert.equal(voter.voteChangeNum.toNumber(), 1);

            await vote.changeVoteType(1);
            type = await vote.voteType();
            assert.equal(type.toNumber(), 1);
        });

        it('invalid change exsiting voting', async () => {
            //invalid vote date
            try{
                await vote.changeMyVote(2, 10, 1, 450, {from:
accounts[1]});
            }catch(error){
                assert.equal(error.message.includes("The stage for
voting is not valid, no vote can be created"), true);
            }
            //invalid candidate Id
            try{
                await vote.changeMyVote(3, 10, 1, 350, {from:
accounts[1]});
            }catch(error){
                assert.equal(error.message.includes("Invalid Candidate
Id"), true);
            }
            //have not voted for this candidate yet
            try{
                await vote.createNewCandidate('Ming Yao',
'https://MY.jpg', 'NBA & CBA Basketball player', 150, {from:
accounts[0]});
                await vote.changeMyVote(3, 10, 1, 350, {from:
accounts[1]});
            }catch(error){
                assert.equal(error.message.includes("voting info ID is
wrong, you haven't voted for this person"), true);
            }
            //have not voted for this candidate yet
            try{
                await vote.changeVoteType(2);
                await vote.changeMyVote(2, 200, 1, 350, {from:
accounts[2]});
            }catch(error){
                await vote.changeVoteType(1);
```

```
                    assert.equal(error.message.includes("You don't have so
many votes"), true);
                }
            });
        });
    });
```

Testing Result



```
Contract: Vote Test
  initializes the vote contract
    ✓ get vote name
    ✓ get add candidate start and end date (40ms)
    ✓ get add vote start and end date
    ✓ get vote type, max nominated number and vote deployer (66ms)
    ✓ get total share and max share per person (45ms)
  create candidates in contract
    ✓ create a candidate with complete information (130ms)
    ✓ create a candidate with incomplete information (276ms)
  allocate share in contract
    ✓ allocate share to specific address (90ms)
    ✓ allocate share with invalid inputs (146ms)
  vote for candidates
    ✓ valid vote for candidates under straight type (173ms)
    ✓ valid vote for candidates with cumulative vote (348ms)
    ✓ invalid vote with wrong input (277ms)
  change candidate vote
    ✓ change exsiting voting under straight type (326ms)
    ✓ change exsiting voting under cumulative type (298ms)
    ✓ invalid change exsiting voting (416ms)


15 passing (3s)
```

Figure 7. Test Results