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Research Article

VaultVote: A Ray of Hope for Transforming the Voting System of India

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Abstract

Purpose:

This paper aims to propose Block-chain based Online Voting System over traditional voting systems for fair and transparent elections. Unlike traditional voting systems, under the proposed one there is no central tallying authority. Voting is done on a proof-based mechanism and each vote is stored as a permanent, unalterable block in the block-chain encrypted by cryptographic hash.

Design/methodology/approach:

The proposed system VaultVote uses Ethereum blockchain as a network, a smart contract in solidity as backend and HTML and JavaScript as frontend. As the eth-voting is implemented on Ethereum blockchain so the information is immutable, no one can change any data including casted votes. It works on a decentralized server, as a result no single person or organization can own it. Ganache has been used across the entire development cycle; enabling to develop, deploy, and test dApps in a safe and deterministic environment.

Findings: In Our study we had deployed a comprehensive system, VaultVote which is a block-chain based voting system using Ethereum network. The proposed system is cost efficient with transparent handling, offering voter's privacy and auditability. Our proposed

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system VaultVote is tested on Ganache local network with five participants as contesting candidates and 100 voters for casting the votes. The system is comprehensive one and satisfies all the requirements of a secret, trustworthy and completely online voting system.

Originality:

There are several solutions for voting involving differing degree of benefits and drawbacks. Institutions conducting elections are always in search of a solution which may resolve the significant issues like lack of transparency and auditability. Block-chain technology may surely emerge as the most sought after solution to such teething problems which are faced by election commissions/agencies across the globe.

Keywords: *Vaultvote, Block-Chain Technology, Electoral Reforms, Voting Process, VVPAT, EVMs*

Introduction

Election is a process through which people elect their representative(s) from a list of candidates. It is regarded as the most popular process of finding peoples' pronouncement. Despite the emergence of digital era and swift proliferation of Information and Communication Technology (ICT), many countries are still using a traditional paper-based voting system which is considered as an obstruction to the conduct of a fair election. The traditional voting system has faced several issues viz; booth capturing, ballot paper stealing, Unfair counting any many more. In order to resolve the significant issues and drawbacks of existing paper-based voting, technology came a step ahead and offered a machine for the voting popularly known as Electronic Voting Machine (EVM).

If we take example of Indian Scenario, the EVM which is the replacement of the erstwhile ballot box is now mainstay in the Indian electoral process. As an idea it was Conceived in 1977 for the first time in the Election Commission and the Electronics Corporation of India Ltd. (ECIL), Hyderabad was entrusted with the responsibility of designing and developing it. In 1979 a proto-type was developed and demonstrated by the Election Commission before the representatives of political parties on 6th August, 1980. After achieving the consensus on this idea, The Bharat Electronic Ltd. (BEL), Bangalore, another public-sector undertaking, was also co-opted along with ECIL to manufacture EVMs.

In order to create a provision for the use of EVMs in the elections, in the year 1989, the Indian Parliament cleared the amendment into the Representation of the People Act, 1951. Eventually, a general consensus on introduction of EVM could only be reached in 1998 following which EVMs were used in 25 Legislative Assembly constituencies spread across three states of Madhya Pradesh, Rajasthan and Delhi.

An Electronic Voting Machine (EVM) facilitates of each vote to be recorded and counted with legibility and impartially, but these machines are subjected to security, distrust, and inquiry through worldwide. The use of EVMs has undoubtedly revolutionized the Electoral System but transparency had always been an issue of debate among political parties. The introduction of Voter Verifiable Paper Audit Trail (VVPAT) system in 2013 following the government notification amending the Conduct of Elections Rules, 1961, has somehow attempted to provide increased transparency and verifiability to the entire poll process in the country. (Election Commission of India, 2018).

Despite the sincere efforts of Indian electoral bodies to ensure the conduct of unbiased and transparent elections in India, opposition parties at times raise their concern about the reliability of EVMs. Although the present system of using EVM is tested and trusted one but the possibility of improvement in it cannot be ruled out.

E-voting Systems :

In many democratic countries, conducting 'unbiased and transparent' elections had been a challenging task for authorities. This is mainly due to lack of proper infrastructure and institutional manipulations. In the early 1990s, some countries adopted EVM based systems

over Ballot based elections. But these EVM based systems faced many challenges and are not highly appreciated due to possibility of data manipulation and hacking of machines.

In 2005 Estonia ( ) introduced an Online Voting System and conducted local elections successfully. This system uses the internet as the means of casting a vote. This technology has brought some transparency in elections but these systems rely on centralized architectures, which make them vulnerable to cyber-attacks and data manipulations. Block-chain offers an ultimate solution to many problems discovered in these maiden attempts of online voting. A block-chain-based voting application does not concern itself with the security of its internet connection.

Block-chain technology, runs on a decentralized system.Block-chain is a system of storing data in a way that makes it difficult or impossible to change, hack, or cheat the system. It is based on Distributed Ledger Technology (DLT), which makes the history of any digital information unalterable and transparent through the utilization of decentralization and cryptographic hashing. The information is stored in blocks and each block is connected to other blocks of similar information to form a chain. Each block contains a cryptographic hash of the previous block, a timestamp, and the transaction data. (Please Refer to figure I)

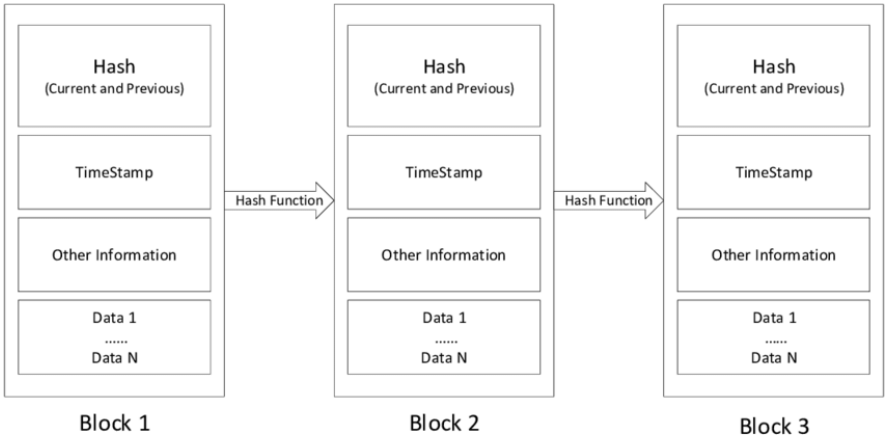

Figure 1: Structure of block-chain

There are many real-world applications of Block-chain technology few of them to note are Crypto-currency Exchange, Supply Chains Monitoring, Advertising insights etc. But in recent years, people have used block-chain to revolutionize industries far and wide including cloud storage, crowd funding and even healthcare. However, one of the biggest challenges that block-chain technology can solve is voter fraud. This decentralized type of infrastructure is extremely useful for voting because a vote is a small piece of high-value data.

In block-chain if any instance occurs where the info is tampered with, the block-chain breaks. Making changes in both disconnected and live block-chain advancements is an extremely cumbersome task unlike the traditional database systems in which info is often manipulated or deleted easily. Storing public information with a system of proof-of-work helps the block-chain maintain integrity and creates trust among users. Essentially, block-chains are often thought of because of the scalability of trust via technology. Block-chain's primary value lies in its ability to improve old systems.

Review of Literature:

Voting forms the basis of any democracy because it ensures representation of people at large. Notwithstanding multifaceted safety measures, it is not devoid of frauds (Zhao, Fan & Yan,2016, Karame& Audroulaki,2016,Risius& Spohrer,2017, Faveri et.al.,2016, Lehoucq,2003)

Voting systems of modern age are still lagging in terms of time taken by them to complete the election process. They are labeled as 'slow' because results can only be declared once the ballots are collected from different locations and eventually counted at a central place. Furthermore, these results cannot be verified. Voters had no way left for getting assured that their votes are included in the results or whether their votes were tampered with (Qi et.al.,2017)

This problem of lack of transparency and non-verifiability flickered interest in electronic voting as an alternative. This alternate triggered the creation of several e-voting solutions (Mpekoa and Greunen,2017, Willemson,2018)

E-voting resolves many of the well stated problems like delay in declaration of results etc having direct effect on voting processes. Though, the electronic voting systems operational today are not the ideal one and still function with different limitations like privacy, authentication and data integrity etc.(Binder et.al.,2014, Xu et.al.,2017)

Electronic voting may be described as deployment of electronic means or information technologies to organize the voting procedures (Binder et.al.,2014, Willemson,2018).

Generally, each e-voting system comprises of registration, authentication, and authorization, casting of vote, verification and eventually counting of votes (Naidu et.al.,2016) E-voting is a comprehensive term which consists of a variety of systems, solutions and most importantly implementations (Binder et.al.,2014). Benefits derived from E-voting systems may be listed as follows (Wolf et.al.,2011):

- It helps in preventing fraudulent acts by reduced human involvement, and accelerates the processing of results,
- With better presentation and auto validation of ballots it reduces the number of spoilt ballots.
- Owing to reduced voting overhead it results into cost reduction as well

Introduction of an e-voting system in any existing system gives rise to several technical, procedural and legislative challenges. If we count the drawbacks of an e-voting system, followings are the most significant one (Wolf et.al.,2011)::

(i) Dearth of transparency and understanding of the system results into lack of trust in the given solution;

(ii) Absence of generally accepted standards for e-voting system;

(iii) Threat of fraud and manipulation by hackers and at times privileged insiders;

Amidst all these drawbacks and limitations of e-voting system, Block chain technology may surely be used to tackle some of the aforementioned problems. One of the traits of block chain is its ability to create a platform for a public verification of data stored inside. By using it, block chain technology may offer development of an e-voting system which can surely be audited by common voters as well. Recognizing the potential of it, globally some countries had not only initiated research on it but had successfully implemented block-chain-based systems for e-voting (Ojo and Adebayo, 2017).

Estonia, as a country is a very popular name in this field, in 2012 introduced block-chain technology in national health, judicial, legislative, security and commercial code systems and is now working on integration of block-chain into voting procedure [Enterprise Estonia,2012, State Electoral Office of Estonia,2017, Heiberg and Willemson,2014).

South Korea is next in line to apply block-chain and is known for successfully conducting election for local government in the year 2017.

Haibo Yi (2019)proposed a block-chain based e-voting system. Firstly, they design a synchronized model of voting records based on distributed Ledger Technology (DLT) to avoid forgery of votes. Secondly, they created a user credential model based on elliptic curve cryptography (ECC) to provide authentication and non-repudiation. Lastly, they implemented a withdrawal model that allows voters to change their vote before a present deadline.

Bosri, R. et al. (2019) proposed a system in which the election commission creates the Ethereum account for the voters and their details will be stored in aEthereum network. The system also provides voting centers, as every person in a developing country can't afford a smartphone so they can also cast their vote from a designated voting center. In case they opt for voting at the voting center, they will be allowed only after the biometric authentication process. Every voter will get a chance to change their vote before the final submission if they made any mistake. Moreover, the system comprises two steps of verification before the vote is added into the blockchain, first step by the voter and second step by the consensus observers by the election candidates. If any uncertain situation arises such as booth capturing, the observers may decline the vote confirmation request and no vote will be added into the block-chain.

Olawande Daramola and Darren Thebus (2020)proposed a blockchain-based architecture for national e-voting system (BANES). In this system, before the election voters will get a smart card which consists of a public key for identification which will be combined with a personal identification number (PIN) for voter authentication. This will ensure only valid voters can vote. Casting of votes will take place only at the designated polling units. The whole voting procedure will be as follows. The voter inserts the card into the voting node and then enters the password. It is followed by authentication and authorization. If the authentication and authorization is successful, then the digital ballot will be generated, which consist of candidate public key and unique ballot id. Voter submits a vote, then the transaction is authenticated by using the digital signature of the private key. The transaction is sent to all nodes and stored on the block-chain.

For a fair Election, present paper proposes use of VaultVote which is a block-chain based voting system using Ethereum network. Ethereum is an open block-chain platform that permits anyone to build and use decentralized applications.

The proposed system provides security by protecting the votes from unauthorized access and manipulation. In the system, votes are stored in Block-chain. Due to the attribute of the immutability of Block-chain; it is quite impossible to manipulate the information (votes) which are recorded on Block-chain. If anyone changes a transaction, he will have to re-mine all the blocks' information from that block till the current block. Every block contains a unique hash using a hash function and the hash of the previous block.

Rationale of the Study

Elections in countries like India involve lot of resources as well as time and are also very costly. Setting up EVM in many different places and then on the day of polling huge number of workforce is employed for the smooth conduct of voting. Voters are also supposed to go to their designated polling booths and stand in queues for hours to cast their vote. Sometimes voters are notpresent at their native places for casting a vote either they have to travel to their native place or they forego their right to vote. This process wastes the time of voters, scarce resources and most significantly human resources.

Conducting elections during pandemics like COVID-19 situation is very difficult, as people cannot simply go to polling booths and cast their votes, these results in postponement of elections causing a huge loss to the election authorities and government.

Further, the proposed system will open a convenient way for the people with disabilities and for others because it's a less time consuming process. So it will definitely increase the voter turnout percentage. Being a transparent mechanism it will strengthen the trust of voter. Also carbon footprint generated by this system is very less because of no logistic involvements of ballots.

Traditional EVM (or ballot-based voting systems) used centralized databases for keeping a record of voters and votes. These centralized databases are prone to hacking and data manipulations, which don't ensure accomplishment of fair elections. Further, in case of online voting systems, the internet is used as a medium to vote, so there are obvious security related issues like cyber-attack on servers.

This led to a need for a secure election system. The proposed online voting system is based on decentralized architecture using blockchain technology and overcomes most of the challenges faced by existing voting systems.

Ethereum block-chain and Smart contracts:

In this research Ethereum block-chain is used for the purpose of implementation of an online voting system. Ethereum is an open source block-chain based software, which consists of its own cryptocurrency Ether. It enables smart contracts and Dapps (Decentralized application) to be developed and run without any interference of third parties.

Ether (ETH) is Ethereum's cryptocurrency which is used to pay the transaction fees and fees for the computational resources for any transaction executed on Ethereum network. Ether is peer-to-peer currency like bitcoin. Ether is also used to buy gas, which is used to pay for the computation of any transaction made on the Ethereum network. Gas is the execution fee paid by a user for running a transaction in Ethereum.

Smart contracts are the simple programs stored on blockchain executed whenever the predefined conditions are met. Smart contracts are used to automate the execution of transactions and agreements without the need of involvement of third party and time loss. Important feature of the smart contract is that once it is executed it cannot be altered, any transaction done in a smart contract is registered permanently, it's immutable. So even if the smart contract will modify the transaction with the original smart contract, it will not modify, the transaction will not be editable.

A decentralized application (Dapp) is an application which runs on the distributed computing system. It is not hosted on a centralized server, but instead on a peer-to-peer decentralized network. A distributed computer system consists of multiple software components that are on multiple computers, but run as a single system.

Problem Definition

Current online voting systems are based on centralized databases. All the election related data and votes are stored on a central server and managed by a single organization or authority. This makes the system prone to data leaks, institutional manipulations and cyber-attacks as the internet is used as a medium to cast vote.

The objective of the proposed work is to create a voting system which is transparent, unbiased and no alteration can be possible at the time of election and after the election. To add, it should be well affordable in terms of cost as well as comfortable for the voters too. Also, as a performance measure there should be accuracy in the number of votes and counting of votes

In the proposed solution voters can cast their vote through the smartphones, laptops and other gadgets in which they can use a web browser. This will save the time of the voters and the resources of the governments. System is more efficient in terms of speed, in other words it saves the time to go to the center and stands in a queue for the verification and casting votes.

Proposed Solution

The proposed solution of the given problem is VaultVote. VaultVote uses Ethereum blockchain as a network, a smart contract in solidity as backend and HTML and JavaScript as frontend. Information of voters will be uploaded by the election commission into the database so that no user can register more than one time. The information of election candidates should also be uploaded by the election-commissioner after verifying their documents so only eligible persons can contest. As the eth-voting is implemented on Ethereum blockchain so the information is immutable, no one can change any data including casted votes. It works on a decentralized server, as a result no single person or organization can own it.

After the election, results will be displayed on the same portal. Here the counting of votes will be done by smart contract ensuring accuracy in the number of votes. Transactions done using a smart contract require some amount of cryptocurrency ether. Therefore, users will be provided with a digital crypto wallet at the time of registration. A digital wallet is an application which allows users to store and transact in cryptocurrency. Wallets provided to the users will contain the required amount of ether needed to cast a vote. They will use this wallet to cast a vote. As each user's wallet will only contain the amount of ether required to cast a vote, they will be able to cast their vote once. This prevents double-voting.

Methodology

The overall architecture and functioning of the proposed system are described below. The system is consisting of two major roles; (1). Administrator and (2).Voters. Administrator is the controlling authority having the access of voter's data as well as of the candidate data. Voters are the ultimate users of the system who will cast their vote. Responsibilities of administrator and voters are shown below using fig 2

Election roles and process

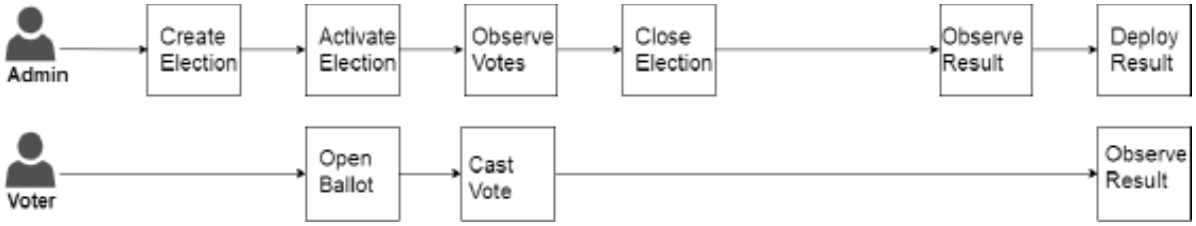

Figure 2:Election Roles and Process

As illustrated in figure 2, the detailed processes for both the roles are as follows,

Election roles:

a) Administrators: The administrator of this portal will be the Election commission. The administrator i.e., Election commission will be responsible for conducting the election. The admin will create the election, register candidates and voters.

b) Voters: Voters will have to register themselves on the portal in order to become eligible to cast a vote. On successful registration, they will receive login credentials, using which they can cast a vote on the day of election.

Election processes:

The proposed system election process is represented by a set of smart contracts, which are instantiated on the blockchain by the election administrators.

Following are the main processes in the system:

a) Voter registration: In order to be eligible to cast a vote, users will have to register themselves with the election authorities before elections. Admin will facilitate the registration process. To register voters, the admin will authenticate the voters using some government identity proof. After successful registration a corresponding wallet will be generated for each

eligible voter. The eligible voters will receive their login credentials to vote. The credentials will be the wallet's id and password.

b) Election creation: Administrators create Election ballots using a decentralized app. This app interacts with an election smart contract, in which the admin declares the list of candidates. This smart contract creates a set of ballots and deploys them onto the block-chain, with a list of candidates.

c) Vote transaction: When a voter casts their vote on the portal, the voter interacts with a smart contract which is present in the backend, through the program. This contract further interacts with the block-chain and vote is stored as a transaction or block on the block-chain. Each block holds information about who was being voted. When a voter casts his vote, the weight of their wallet will be decreased by 1, not enabling them to vote again.

d) Results: When the voting period is over, the voting process will be disabled for the voters. After that results of a particular election will be updated on the portal. Date and time of results will be pre-decided by the election authorities. As this system is based on blockchain, tallying of votes is an instantaneous process. Count of votes will be automatically retrieved from the blockchain and will be displayed on the portal after the voting period is over.

Design and Implementation

Figure 3 illustrates the overall workflow and design of the proposed voting system. As mentioned in section 5, the system uses a smart contract as a backend mechanism. Functions or methods in this contract controls the dataflow of the system.

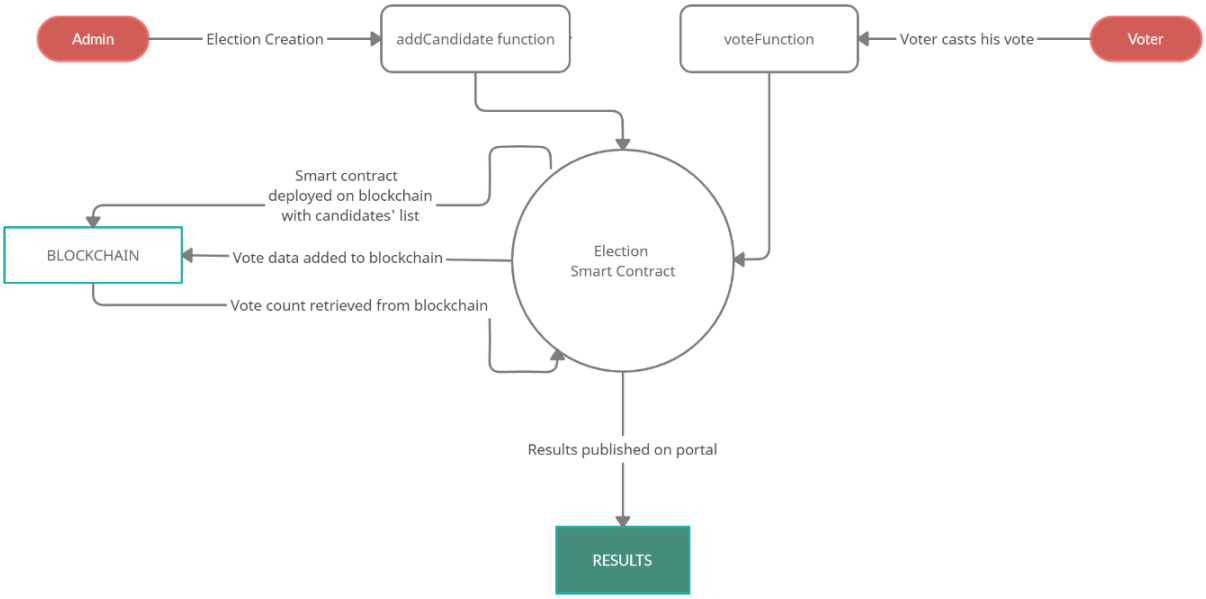

Figure 3:Work-flow Diagram

Functionalities in Smart contract :

The proposed system uses a smart contract written in Solidity. Smart contract which consists of some methods to store the candidates' detail, allowing voters to cast a vote and other tasks. The detailed structure of Election smart contract along with their functions are explained below.

The smart contract which is named as Election consists of the following: A structure Candidate having following variables (Fig 4)

- unit id: - This variable stores the id number of candidates
- string name: - This variable contains the name of the candidate
- uint voteCount: - This variable contains the count of the votes casted in the favour of the candidate.

```
pragma solidity ^0.5.16;

contract Election {
    // Model a Candidate
    struct Candidate {
        uint id;
        string name;
        uint voteCount;
    }
```

Figure 4: Candidate Structure

Add Candidate Function

AddCandidate function takes candidate name as parameter and adds candidates' names to a list in the memory, by using an instance of structure candidate. (Fig 5)

```
    function addCandidate (string memory _name) private {
        candidatesCount ++;
        candidates[candidatesCount] = Candidate(candidatesCount, _name, 0);
    }
```

Figure 5: addCandidate function

vote Function :

On being called, this function checks whether the voter has voted before or not so as to ensure there is no double voting. Then if the voter has not voted then only, he is allowed to vote. When a voter casts the vote, id of the candidate is checked to ensure the candidate is in candidate list residing in the memory. The candidate id is the id of the candidate who is being voted. After this the vote count of the corresponding candidate is increased by 1. (Fig 6)

```
    //voting function
    function vote (uint  _candidateId) public {
        // check if voted before
        require(!voters[msg.sender]);

        // require a valid candidate
        require(_candidateId > 0 && _candidateId <= candidatesCount);

        // record that voter has voted
        voters[msg.sender] = true;

        // update candidate vote Count
        candidates[_candidateId].voteCount ++;
    }
}
```

Figure 6: vote function

Following are the complete steps involved in implementation of the proposed voting system

●At first the voter registers himself in order to be eligible for casting a vote. Eligible voters are assigned a digital wallet to cast their vote.

●On the day of election, the user will login to the voting portal using his device through the wallet's credentials provided to him. If the device is not available with the user, he may go to a dedicated voting center set up by the government to cast his vote.

●After successful authentication of the wallet, the user will be prompted for a ballot. This ballot will contain the list of candidates contesting in election.

●Users will have to select a candidate of choice to vote for from this list.

●When the user has selected candidate and proceeds to the final vote, he will be asked for a final confirmation from his wallet to cast his vote.

●When the user confirms the vote, the vote data will be added to the blockchain via the smart contract.

User will be prompted that he has successfully casted his vote.

Experiments and Evaluations:

The primary goal of evaluation was to assess the performance of the system with respect to e-voting system requirements presented in previous sections and to identify any considerations with regards to its application in a real world scenario. The experimentation consisted of multiple steps i.e. conducting multiple transactions, verification of transactions, mining transactions into blockchain, reflection of the changes made in the public ledger to all the nodes in the network and the usability of the system.

When a voter casts their vote on the portal, the voter interacts with a smart contract which is present in the backend, through the program. This contract further interacts with the block-chain and vote is stored as a transaction or block on the block-chain. Each block holds information about who was being voted. When a voter casts his vote, the weight of their wallet will be decreased by 1, not enabling them to vote again. Transactions done using a smart contract require some amount of cryptocurrency ether. Therefore, users will be provided with a digital crypto wallet at the time of registration. Digital wallets provided to the users will contain the required amount of ether needed to cast a vote. They will use this wallet to cast a vote. As each user’s wallet will only contain the amount of ether required to cast a vote, they will be able to cast their vote once.

For the testing purpose, a test bot has been set up with 5 participants as contesting candidates and 100 voters for casting the votes. Setup was done by Ganache. Ganache is a personal block-chain for rapid Ethereum and Corda distributed application development. It is used for setting up a personal Ethereum Blockchain for testing Solidity contracts. Ganache has been used across the entire development cycle; enabling to develop, deploy, and test dApps in a safe and deterministic environment.This choice is influenced by the ease of availability (free) and therefore it was easily integrated into our proposed system.

Conclusion and Future scope:

To ensure fair election process countries moved from paper ballot systems to electronic voting systems. Many of them lost their trust in the electronic voting system which is widely seen as black boxes that lack transparency and verifiability. In this proposed system VaultVote blockchain technology is used for conducting elections, which ensures the security and privacy of the user as well as the election data. The system is completely decentralized and automated, also does not need to rely on human factors. Any registered voter will have the ability to vote from anywhere using any device connected to the Internet.

Further, for better user interface, integration of Ethereum wallet to the portal can be done, so that users need not to use a plugin to cast a vote. To help with voter verification, API/process will integrate, that will allow checking the validity of all verification IDs used to register into our system. Way forward, testing the system with a greater number of users will be tried, so that scalability of the system can be ensured.

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