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Viability and Analysis of Blockchain Platform for E - Voting

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ABSTRACT: As of late, with high level of polarisation and distrust, several citizens have grown to distrust government agencies. More and more countries now face a battle to keep the spirits of democracies alive. To avoid further increase in tension and risk further deterioration of trust in the election process. We plan to deploy and check the viability of an e-voting system using blockchain, which is a type of database, and its protocols are such that it ensures decentralisation of power, thus making it more secured and transparent. The main focus of this paper is to check the viability of evoting using blockchain based network and to identify which blockchain platform is more suited for the deployment of e-voting system. To truly understand and decide which platform would be best for the required scenario. Research and analysis of varied number of transactions must be done on the different blockchain platforms, for the different performance metrics of a blockchain network i.e., Local Transactions per second which is the required time to update the state database, Latency which is an indicator of the duration for the packets to reach the given destination. Throughput which is the number of packets that are treated within a given frame of time. This study will help identify the viability of e-voting as a whole and the performance comparison of the different platforms for the specific case.

KEYWORDS: Blockchain,E-voting, Decentralisation.

I. INTRODUCTION

Growing list of records is called Blockchain. They are linked together using cryptography [1]. Contents of the block are cryptographic hash of previous block, timestamp, transaction data. Transaction data is being proved by transaction data. Hash of previous block is stored in Blocks. Therefore, blockchain cannot be modified. Data cannot be altered. It is a peer-to-peer network. Nodes are responsible for communication and validation of new blocks. They are considered secure because of their design [5]. It serves as a public transaction ledger of cryptocurrency bitcoin. Bitcoin is the first digital currency that can be used because of blockchain. You do not need a trusted authority or centralized server [3]. In Businesses, private blockchain is used with set of rules and regulations. Permissioned blockchain can be more secure and decentralized than permissionless in the future [4]. Participating parties are called peer's nodes in which transaction is carried without third party. Consensus algorithm like Proof of Stake and Proof of Work are used to validate transaction depending on the agreement [9]. Block is a single recent transaction that is to blockchain after verified with hash code. Transaction is stored in blocks usinghash key, which links the previous node and next node. Hash key will change if the data is changed or altered. Because of these two reasons the blockchain is immutable. Changes made in one node or block will be synchronized with all nodes in the network which makes data hampering impossible.It is a distributed software network that works as digital ledger and enables transfer of asset. It is a shared public ledger that no one can control only inspect. E-Voting takes care of casting and counting the no of votes. It is kind of a tool to increase the efficiency of electoral process and increasing trust in its management. It can ensure security. Four basic step of election process with e-voting are that voters makes choices, voters submit their ballot, system records the submitted ballots, votes are counted. If implemented the e-voting system can eliminate threats like fraud, early results, reduce cost. It can be seen as the tool for advancing democracy and trust in system to add credibility and efficiency. Strengths of e-voting are faster vote count, more accurate result, prevention of fraud, cost savings, efficient handling. Weakness of e-voting are lack of transparency, increased cost, increased infrastructure and environmental requirements, increased security requirements, reduced level of control. Types of e-voting systems Direct Recording Electronic (DRE), OMR Systems, Electronic Ballot Printer (EBP), Internet Voting Systems. The result after implementation shows that it is secure. One of the major problems of voting that is forgery of votes can be solved with e voting. E-voting can improve data handling by reducing transactions which also reduce the corruption. It is the most promising for implementation of Blockchain technology. Some issues that require solutions are public's ability to understand the whole process, individual should be able to verify their votes, confirmation of result by third party, way to verify user, accessibility of blockchain. It can be implemented with the use of information and communication technology. It can be a solution to number of political problems. It can increase the transparency, responsiveness and accountability of the government. It provides improved participation and information to citizens.

The focus of this paper is to check the viability of e-voting using blockchain based network and to identify which blockchain platform is more suited for the deployment of e-voting system. There are multiple external as well as internal issues of the blockchain platforms should be kept in mind while deciding the right platform for the e-voting system. It could be the scalability and the throughput of blockchain platform. The availability of required supporting documents and the quality of structure and integrity the platform provides, but the most important aspect could be the performance of the platform for the required scenario. To truly understand and decide which platform would be best for the required scenario. Research and analysis of varied number of transactions must be done on the different blockchain platforms, for the different performance metrics of a blockchain network i.e., Local Transactions per second which is the required time to update the state database, Latency which is an indicator of the duration for the packets to reach the given destination. Throughput which is the number of packets that are treated within a given frame of time. This study will help identify the viability of e-voting as a whole and the performance comparison of the different platforms for the specific case.This will also help identify the inherent limitations in the decentralized networks. Thus, helping us identify the perfect scenarios for the adoption of e-voting. For the analysis almost identical contracts were developed on solidity and on Go for the Ethereum and Hyperledger network respectively. Then, performance analysis was done to identify the performance of the network on the basis of the required performance metrics by varying the size of the transactions. After observing the comparison of the different platforms, we discussed their implications.

II. PRIVATE & PUBLIC BLOCKCHAIN

2.1) Private Blockchain

It is a permissioned blockchain. Access is only validated to those who have consent to join the network. It is managed by network administrator. This network relies on third party to control the network. Only the participating nodes have knowledge about the transactions.[10] Some features are it focus on privacy concerns, Private Blockchain are more centralized, locally distributed nodes result in high efficiency, performance is faster when less nodes are participating, being able to add nodes and services on demand can provide a great advantage to the enterprise [10].In this type of network only a single organization has authority over the network. Private blockchain can be used by internally connected organization or organization having interconnected network or having a private server. Private Blockchain uses less energy than public blockchain. Private Blockchain are more trusted and are better in terms of scalability issues. The chance of minor collision happening is less to none in private blockchain. Some of the consensus algorithms that can be used in private blockchain are Proof of Elapsed Time (PoET), Raft and Istanbul BFT. Private Blockchain have more transaction per second. Private Blockchain are preferred by those companies which are more focused on security and privacy. But it requires less energy and an outside entity to operate. Resources required in setting up a private blockchain is not accessible by many organizations that is getting in the way for companies to switch to blockchain based systems. This is one of the major drawbacks of private blockchain that it offers security and privacy but at a very high cost.

2.2) Public Blockchain

Anyone can participate since it is an open network. It is permissionless. Operations can be done by any participating in the network. It is decentralized. Data is secure as it is immutable and block are verified with hash code [10]. Some features are that security is high cause it is immutable, anyone can participate in the network, anonymity is maintained, nodes does not have to follow any rules and regulations, ledger is fully transparent. Can access the ledger anytime you want, ledger is fully decentralized and nodes has the responsibility to maintain the network, data cannot be changed and altered, database is not centralized [10]. Public Blockchain is lighter therefore magnitude is less and provides throughout for transactions. Public Blockchain have less transaction per second. In terms of scalability issues charts are high in public blockchain. Public Blockchain are decentralized therefore more secure as it has high number of nodes and therefore it uses more energy for validation and processing. Chances of collision in Public Blockchain are high and because there are high number of participants and therefore risk is high. Public Blockchain are decentralized and therefore there is absolutely no trust between nodes. Public Blockchain is decentralized that is why it is more secure but it requires high energy to operate and record of data are not stored in a single place whichmakes it inaccessible.

III. BLOCKCHAIN PLATFORM

3.1) Ethereum

Ethereum is a public network with the functionality of smart contracts, that enables user to automate real world, complex problems [30]. Thereby, eliminating thirdparty. It also offers native cryptocurrency which is one of the largest in terms of market capitalization. Its wide use case and world-wide acceptance and strong structure and quality of documentations, enables it to be one of the better platforms for the e-voting system. The blockchain platform is permissionless and is based on consensus. It also provides a virtual machine for the smart contract deployment. Ethereum uses gas to compute the transaction fee. As the gas price is increased the more likely it is for the transaction to be completed. Ethereum is the most widely used public blockchain network, used due to its ability to create intelligent smart contracts. Ethereum could specially be used to solve complex problems that require an intermediary or a third party, thereby making it automatic and removing the need of third party by building a system of trust, security and integrity.

3.2) Hyperledger Fabric

Hyperledger Fabric [27] is a private network hosted by the Linux Foundation. It offers an enterprise level solution for blockchain. The main advantage of this blockchain is the ability to connect and work with other Hyperledger based blockchains. Thus, enabling cross-industry, cross platform association. There surely are many challenges when processing large number of transactions in decentralised database. It is a permissioned network, although it does not offer any native cryptocurrency. It encapsulated many open-sourced blockchains and tools. Hyperledger Iroha, Sawtooth, Besu to name a few. It also offers the ability to build real world, complex systems through the use of chaincode. Hyperledger is a private blockchain mainly build for enterprise level blockchain solution. The main advantage of this blockchain is the ability to connect and work with other Hyperledger based blockchains. Thus, enabling cross-industry, cross platform association. Table 1) shows the comparison of Ethereum and Hyperledger.

Characteristics	Ethereum	Hyperledger Fabric	R3 codra	
Programming Language	Solidity	Go, java	Kotlin	
Governance	Distributed among all participants	Linux foundation	R3 and organizations involved	
Consensus Algorithm	Pow. Casper Implementation Pos.	PBFT	Notary nodes can run several consensus algorithms	
Scalability	scalability Issue	Easily scalable	Not prevalent	
Privacy	Privacy issue prevalent Due to network permissionless	Offers primarily Through permissioned network	Not prevalent	
Currency	Ether	None	None	

Table 1 - Comparison of Hyperledger and Ethereum

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IV. IMPLEMENTATION

In this section we describe the implementation, infrastructure as well as the setup we used to check the viability of the system and the comparative analysis of the two blockchain networks.

4.1) Setup of infrastructure

For the comparative analysis of the two blockchain platforms namely Hyperledger and Ethereum. The device used for the experimentation has the following specifications: Acer Predator Helios 300 with the Intel(R) Core (TM) i7-7700HQ CPU @ 2.80GHz-2.81 GHz, 16GB RAM, 256GB SSD hard drive with ubuntu 18.04 OS, the software and versions of blockchain platforms are Ethereum's get 1.10.3 [8] and Hyperledger Fabric 2.0 [9].

4.2) System architecture for Ethereum private network

The system architecture of Ethereum consists of Remix, Web.js, EVM and truffle. Every node communicates with its own instance of application. Ethereum Virtual Machine is a blockchain software platform. It is used by develops to build and develop Dapp application. Moreover, it provides sandbox security. Ensuring the smooth running of the smart contracts and making it platform independent. Remix IDE is an online IDE used to develop and debug smart contracts build on solidity. It also provides an interactive environment for the same. Web.js allows to interacts with Ethereum node using HTTP. **Figure 1)** show the system model for Ethereum.

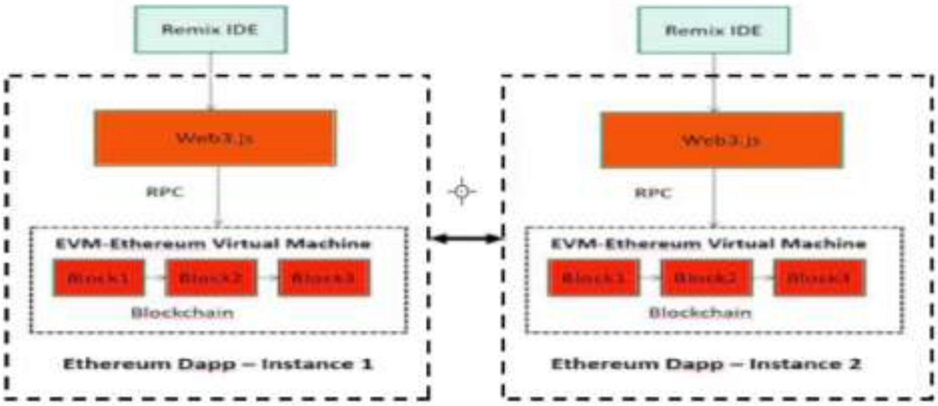

Figure1 - Ethereum system model

4.3) Proposed system architecture for Hyperledger fabric private network

Hyperledger uses a modular architecture. Unlike in Ethereum all nodes do not have the same hierarchy, and hence different nodes perform different function. For e.g., when a voter casts a vote through fabric SDK, the bid is sent to endorser nodes. These endorser nodes check and verifies the transaction and if most endorser nodes, endorses the transaction then the transaction is executed. After this orderer nodes checks all the transaction and then arrange them in order to form a block. This in turn is sent to committer nodes which once verifies the transaction adds a new block in their copy of ledger. **Figure 2)** show the system model for Hyperledger.

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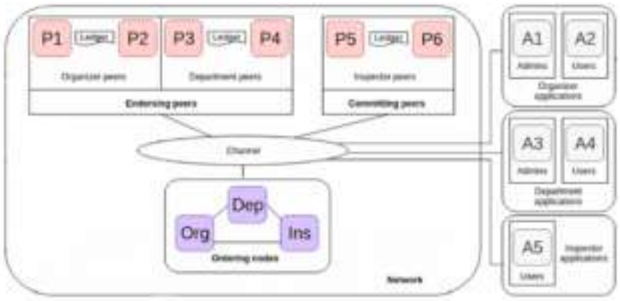

Figure 2- Hyperledger System Model

4.4) Transactions and vote functions on blockchain platform

For this experiment we are going to use CastVote function as a basis for the transactions. The transactions will be asynchronous and thus will not wait for the previous transaction to complete. We will observe the performance while varying the number of transaction and for each specific numberof transactions we repeat it multiple time and take an average of that, for more precise result. These transactions will be done on both networks i.e.,

Ethereum and Hyperledger. The transaction type can be RegisterAccount and CastVote. Figure 3) shows the vote function for Ethereum. **Figure 4)** shows the CastVote function for Hyperledger.

```
function vote (uint _candidateId) public {
    // require that they haven't voted before
    require(!voters[msg.sender]);

    // require a valid candidate
    require(_candidateId > 0 && _candidateId <= candida

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

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

    // trigger voted event
    votedEvent(_candidateId);
}
```

Figure 3 - Vote function on Ethereum smart contract

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```
...
  //only allow vote if the election has started
  if (parsedCurrentTime >= electionStart && parsedCurrentTime < electionEnd) {

    let votableExists = await this.myAssetExists(ctx, votableId);
    if (!votableExists) {
      let response = {};
      response.error = 'VotableId does not exist!';
      return response;
    }

    //get the votable object from the state - with the votableId the user picked
    let votableAsBytes = await ctx.stub.getState(votableId);
    let votable = await JSON.parse(votableAsBytes);

    //increase the vote of the political party that was picked by the voter
    await votable.count++;

    //update the state with the new vote count
    let result = await ctx.stub.putState(votableId, Buffer.from(JSON.stringify(votable)));
    console.log(result);

} else {
  let response = {};
  response.error = 'the election or the voter does not exist!';
  return response;
}
```

Figure 4 -CastVote function on Hyperledger

V. RESULTS

5.1) Assessment of the performance

In this section, we assess the performance of the two blockchain platforms for the required scenario i.e., e-voting system. The performance metrics that we use for the experimentation and analysis are execution time, latency and throughput. First, we take execution time and check execution time of transactions on Ethereum for different size of transactions. We observe as we increase the size of the transaction the execution time increases exponentially. We do the same for Hyperledger as well and observe almost the same pattern. Then we plot a sub-graph to compare the execution time for the two platform, we then observe Hyperledger performs much better in terms of execution time as compare to Ethereum. We perform the same experiment then for latency and throughput. We observe a similar pattern that as the size of transaction increase the performance decrease exponentially. However, Hyperledger performs much better for all the performance metrics and for all the scenarios.

5.2) Concurrency check

When we look at the required use case such as CastVote, platform must be able to handle large concurrent transaction. So, it is imperative we find the maximum concurrent transaction for the two platforms. CastVote transaction are used for this experiment. We start from ten thousand concurrent transaction and then we continuously increase number of concurrent transactions until platform reports failure. After the experiment we observe Ethereum perform much better than Hyperledger in terms of maximum concurrent transactions it can handle. Ethereum is observed to handle over fifty thousand transactions, while Hyperledger is able to handle merely twenty to thirty thousand transaction. Fig. 5: Execution time of the transaction for the following functions: (a) RegisterAccount, (b) CastVote. Logarithmic sub-plots are formed when we vary the number of transactions.

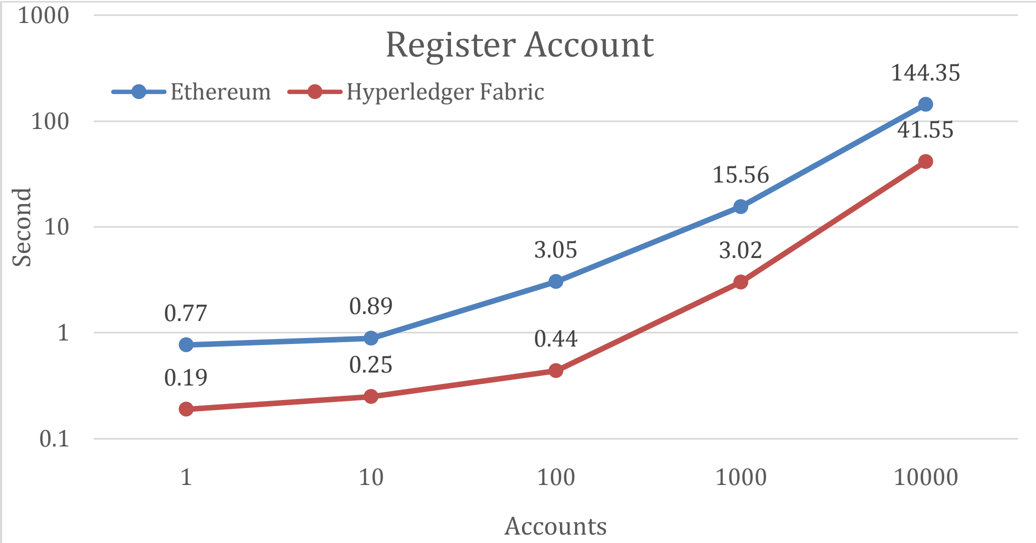

Figure 5(a) - RegisterAccount

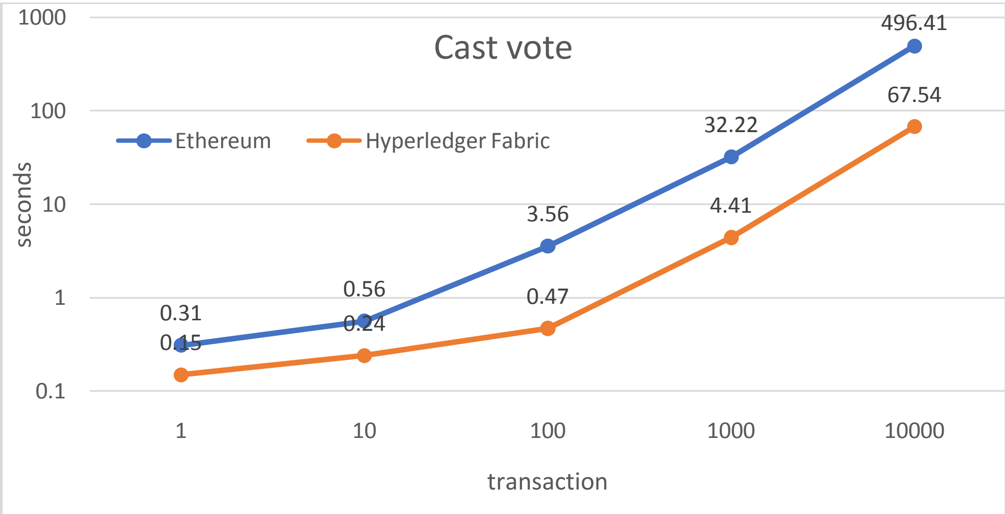

Figure 5(b) - castVote

Fig. 5: Execution time of the transaction for the following functions:
(a) RegisterAccount,
(b) CastVote.
Logarithmic sub-plots are formed when we vary the number of transactions.

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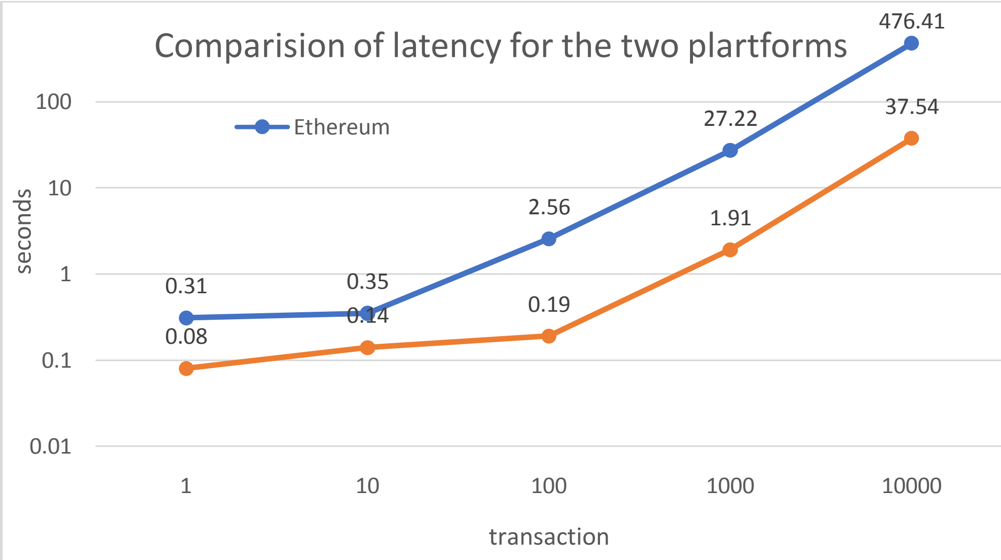

Figure 6: Comparison of latency for the two platforms

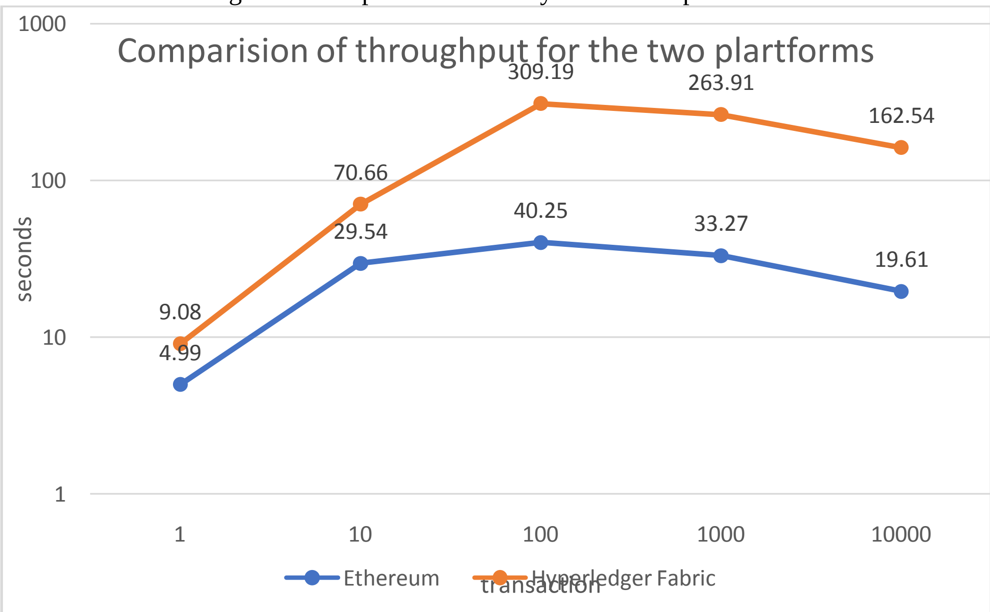

Figure 7: Comparison of throughput for the two platforms

When the size of transactions is increased the latency for both the platforms increased exponentially, which shows the limitations of decentralised network to handle large size of transaction.

VI. ANALYSIS AND IMPLICATIONS

This section explains the metrics considered for performance analysis of blockchain and its viability and the difference/ comparison on these metrics when different size of transactions are used on different patterns. They are the following: Transactions per Secondwhich is the time taken to update the state database. Transaction Datais the data related to the deployment and completion of transaction is called transaction data. Performance Metrics are considered while checking the viability of the e-voting system and comparison of the two different blockchain platforms for the required scenario. They are the following: Time taken for Execution is the total time taken by the network to execute and confirm the transaction.Latency is the time taken for the packet to be executed. It is one of the most important indicators for the performance analysis of a blockchain platform. Throughput is the successful transaction per second for the transaction to complete. Along with latency throughput is considered to be one of the most important metrics for the analysis. The experimentation in the paper shows Hyperledger outperform Ethereum on all the perform metrics namely execution time, throughput and latency. The experiments also observe that the difference in the performance increases even more when the size of the transaction is increased. However, for both the platforms the performance depreciates as the size of the transaction's increases. This reveals the limitation of blockchain while handling large number of transactions. This study helps us understand the limitation of e-voting system based on blockchain. Thus, helping us understand and find the scenarios where this system would be much more suitable such as places where the population is less or distributed sparsely. Moreover, in the modern world as a significant number of populations does not live in their constituency where they are registered. Being able to vote securely and remotely is a great benefit. Finally, even as Hyperledger performs marginally better on all performance metrics. Ethereum is much more effective and efficient in being able to handle large concurrent transaction. For the required scenario being the e-voting system being able to handle large concurrent transactions is highly important. Thus, Ethereum being much more suitable blockchain platform for the required scenario even as it is not as effective in other performance metrics. Ethereum could be able to handle more concurrent users. Although it may be seen that Hyperledger performs better when compares to transaction individually but when a large concurrent transaction, Ethereum shows more promise. Moreover, blockchain in e-voting shows favourable case. The results are favourable when the cases are following: Areas of low population, urban areas, for non-residential voters blockchain could prove to be a really helpful tool. It is obvious from the finding e-voting using blockchain is the future and maybe even the present too it could be use.

VII. CONCLUSION

This paper demonstrated the viability of e-voting using blockchain based network and identified blockchain platform more suited for the deployment of e-voting system. The experimentation in the paper shows Hyperledger outperform Ethereum on all the perform metrics namely execution time, throughput and latency. The experiments also observe that the difference in the performance increases even more when the size of the transaction is increased. However, for both the platforms the performance depreciates as the size of the transaction's increases. This reveals the limitation of blockchain while handling large number of transactions. This study helps us understand the limitation of e-voting system based on blockchain. Ethereum is much more effective and efficient in being able to handle large concurrent transaction. Although it may be seen that Hyperledger performs better when compares to transaction individually but when a large concurrent transaction, Ethereum shows more promise. Moreover, blockchain in e-voting shows favourable case. The results are favourable when the cases are following: Areas of low population, urban areas, for non-residential voters blockchain could prove to be a really helpful tool. It is obvious from the finding e-voting using blockchain is the future and maybe even the present too it could be use. It's obvious from the finding e-voting using blockchain is that the future and perhaps even the current too can be used. These findings clearly demonstrate the use case of e-voting in the present.

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