

Blockchain Enhanced Stock Trading Application

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Abstract: *Stock exchange works and functions in a very inconvenient and hectic way because of post-trade processes which are cost-inefficient, time-consuming and can be prone to numerous risks. This motivates us to experiment with new technologies like blockchain which has immense potential to change the process of post-trading. In this paper, we propose an implementation of a stock trading application built on Hyperledger Fabric, a hybrid blockchain architecture. The network for our application is built using Hyperledger Composer framework. All the transactions done on the client app are recorded and appended to the Fabric with the help of a REST server. Fabric contains various security measures such as Access Control Lists and channels to ensure only authorized users to have access to those transactions. Before the users can perform any transactions, they will be given an identity card containing the certificates and credentials required to access the blockchain network. With our approach, we aim to significantly cut the transaction costs of exchanging shares and bring about a seamlessly efficient platform where participants would confirm trades via a distributed ledger.*

Keywords: Stock Trading, Securities Exchange, Hybrid Blockchain, Distributed Ledger, Hyper ledger Fabric, Hyper ledger Composer

I. INTRODUCTION

Stock market investments are not for light-hearted people is often heard in general. Most of the times we get a negative review from people who have made an investment in the stock market. There is an overall atmosphere in society that one must be very lucky to make a profit in the stock market. The reviews for these losses are so bad that even individuals who have never tried investing in the stock market feel sceptical before actually giving it a try. Although, it is true that stock markets are hard to predict and one has to be updated about current affairs every time but sometimes, even individuals with great knowledge of the market find it arduous to make a profitable transaction. So the question that arises is how such abominable industry even works? How the stock market is such a huge financial attraction? Well, there's no answer to these apparent questions but thinking about it one can say that investing in stock market can make multi-fold profit for individuals and also there goes a common saying that "Practice makes a man perfect".

The stock market is difficult to understand because of the complex procedure of the transaction taking place. The mechanism includes pre-trade, trade, post-trade and custody, and securities servicing along with other small steps. Often these multi-step procedures are time-consuming, cost inefficient, cumbersome, and highly prone to risks [1]. Since these steps are necessary to be followed for a particular share to be exchanged, it frequently takes more than 24 hours for a transaction to complete. Sometimes it takes more than 3 days to complete the transaction. Often traders lose their money because of this time-consuming process. As this process is so exhausting traders usually deal with brokers who take a commission for their services. Because of these circumstances investment in stock market is highly avoided by common people.

Using blockchain to implement a stock exchange may solve these problems [2]. Hence, to overcome these obstacles, we came up with the idea to create a simple blockchain application for performing stock trading. Blockchain has great potential [3] to provide efficiency as there is no need for clearing house, auditor to verify trades and custodian to ensure a fund has the share that trader claims. This process cuts down the involvement of middleman, lowers the transaction cost, provides high security and transparency and high liquidity [4]. Overall, we can achieve a reliable and realistic method of stock exchange.

After analysing the problems faced by people in stock market investment, we can infer that the masses usually avoid for investment in stock market. This negative perception of people about the stock market must change. We can achieve

this by making the process more easy, transparent, quicker and by encouraging people to deal with their stock by themselves rather than depending completely on the broker. By applying blockchain technologies we can improve a lot in the existing system and attract more people to invest in stock exchanges.

II. PROBLEMS IN TRADITIONAL STOCK EXCHANGE

2.1 Overview

The current stock exchange has a very complex structure to follow. The online transaction processes of trading are inclusive of buying and selling of bonds, stocks, and other investments, these all come under online trading. Some basic steps follow pre-trade, post-trade, stock custody, and security servicing. A typical post-trade process is as shown in Figure 1. The problems faced are as follows:

- The traditional stock exchange system has centralized ledger which stores all assets at a single location so if the system fails then entire data might be lost.
- In current stock exchange system intermediaries (brokers) are required to verify and perform transactions like placing an order, execution of the order, settlements etc.
- A traditional system also lacks transparency [5].

2.2 The Need for Blockchain

The participants must spend more time as well as money for stock investment process. It is so often that participants (brokers or traders) must wait for more than three days for a transaction to complete. This is because multi-layered steps involve intermediaries such as operational trade clearance and regulatory processes. These multi-layered steps are time-consuming, cost-inefficient, cumbersome, and highly prone to risk [6].

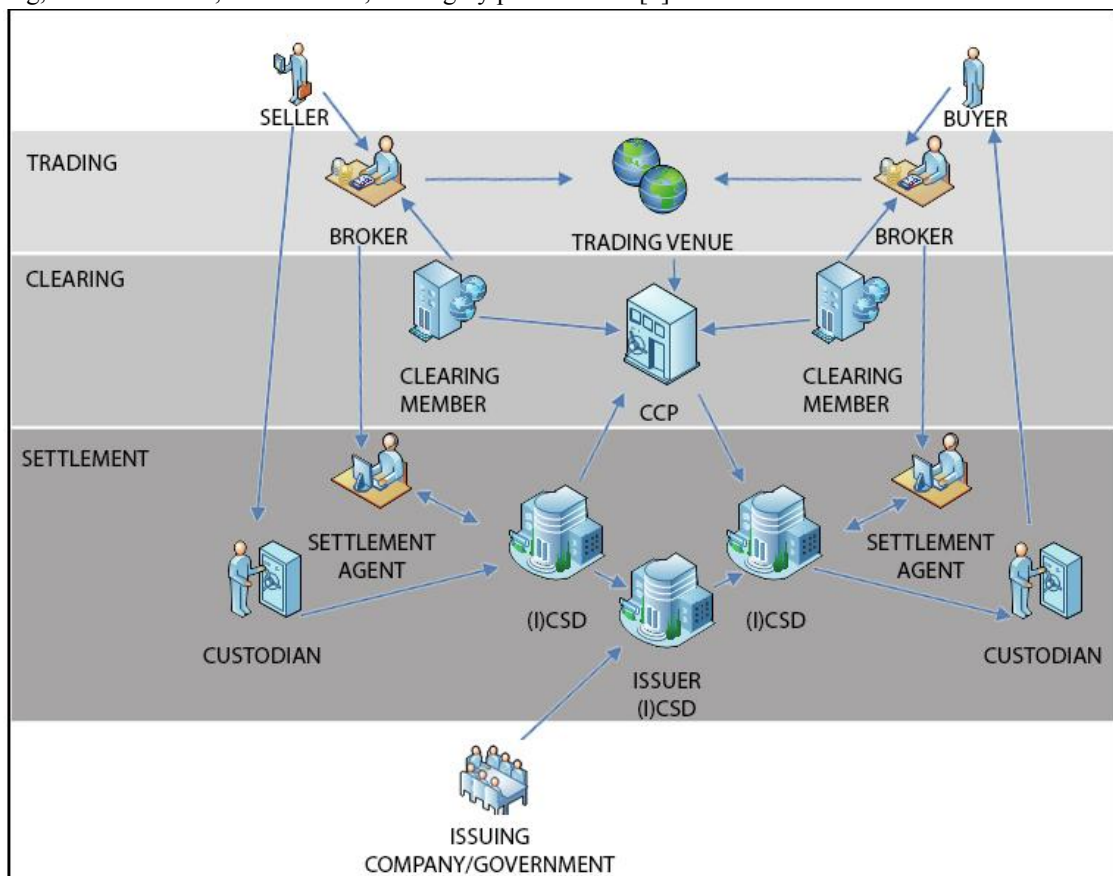


Fig. 1 Post-trading in traditional systems [7]



From a report by global financial risk consultancy Oliver Wyman [8] it is inferred that IT and operations in capital markets cost banks \$100-150 billion per year. The post-trade and securities servicing fee is an extra \$100 billion. To summarize we all can agree to conclude that existing method causes delay and inefficiency in the market in operations to incur significant capital and liquidity loss. To overcome these obstacles, we can perform a stock exchange with blockchain. Blockchain can be used in various fields [9], [10], but it is important to understand the use-case before applying it. We want to develop a transaction platform for stock exchange using decentralized networks which perform transactions efficiently with high security and low cost. Using decentralized network investors, stockbrokers, clearinghouse, settlement banks, transfer agent and other participants will be directly affected. Blockchain will eliminate the middleman, delay in the transaction, and provide high transparency and security. Our application must cut down transaction time from 3 days to a few minutes. Thus, the stock transaction should happen instantaneously with a minimum cost of processing. The system must be more beneficial for traders and investors than the traditional method of stock exchange by using decentralized applications.

III. PROPOSED SOLUTION

3.1 Overview

Basically, stock exchange hosts a market for traders to buy or sell stocks, bonds, options, communities, and futures are traded during the specific business hour in the working day. All these procedures can be done 24*7 using blockchain technology. This particular transaction can be secured and can be tracked at any time without any dependency on others. Thus, this will cut off the possibilities of double spending and make transaction happen in seconds.

3.2 Selecting the Right Blockchain

There are 3 types of blockchain which are used for building applications. These are public, private and hybrid. In public blockchain, every user has the same access rights. The private blockchain is not transparent in nature. Thus, a combination of these two types gives us a hybrid blockchain. This makes it ideal for our use case [2] as we need to have some privacy and transparency features.

We can improve the existing workflow of stock markets which is very time consuming and non-transparent to quick and real-time. By using blockchain technology we can make transaction secure and track able. A website for performing share trading can be built by using Node.js. We can use a hybrid type of blockchain to build our application. The proposed method for post-trade given in Figure 3 can be quite useful for designing a blockchain based solution.

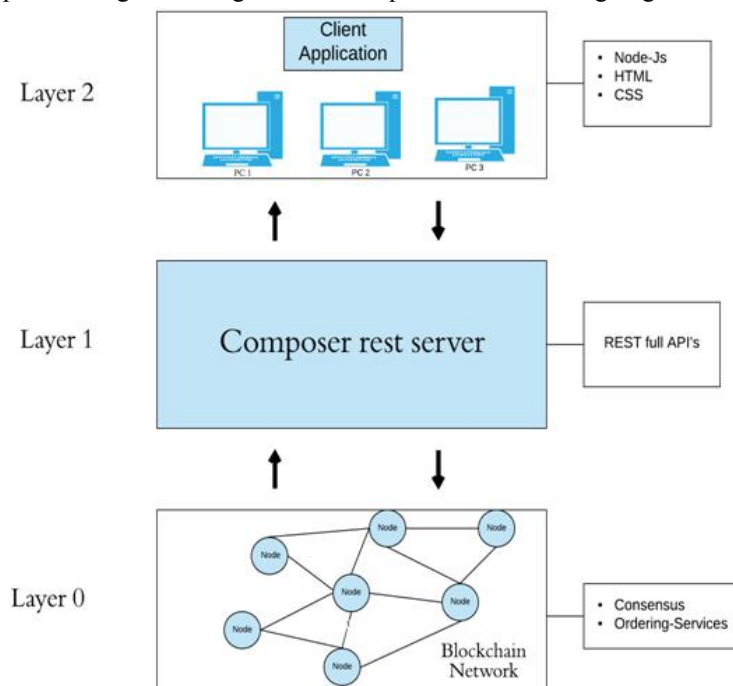


Fig. 2 3-Layer System Architecture

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3.3 Tools for Solving the Problems

We are using Hyperledger’s [11], Fabric and Composer for building our decentralized applications. The platform is designed for scalability [12], so it is a good choice for an application such as ours. All events which occur while performing transaction are managed on the server side which is built using Node.js. Front-end can be built using HTML and we can make it appealing using CSS and Bootstrap. Authentication is done by verifying national identity issued by the government of respective individual users.

A reliable and uninterrupted server is needed to host our website. For building server-side application we have used Node.js [13]. As Node.js supports cross-platform it makes us ideal for us. Events like buying shares, selling shares, bonds, equities, etc. are all performed on the server side and displayed on the front end which is built using frameworks such as Bootstrap [14], HTML, Cascading Style Sheets (CSS) and JavaScript(JS).

3.4 Simulating a Stock Trading Application Using Blockchain

In this section, we present an experimental implementation of a stock trading application powered by blockchain. There have been a few attempts in decentralizing the stock exchange [15], [16] each having their own pros and cons. We propose a different approach by using the tools that are easier to use and suitable for this use-case. Our system comprises of a three-layer architecture as described in Figure 2. At the top layer, the client application is responsible for interacting with the user performing all the transactions involved in stock trading. The middle layer and the lower layer consist of REST (Representational State Transfer) based API(Application Programming Interface) servers for interfacing with blockchain and Hyperledger Fabric as the blockchain network respectively. The architecture is explained with more detail in the later part.

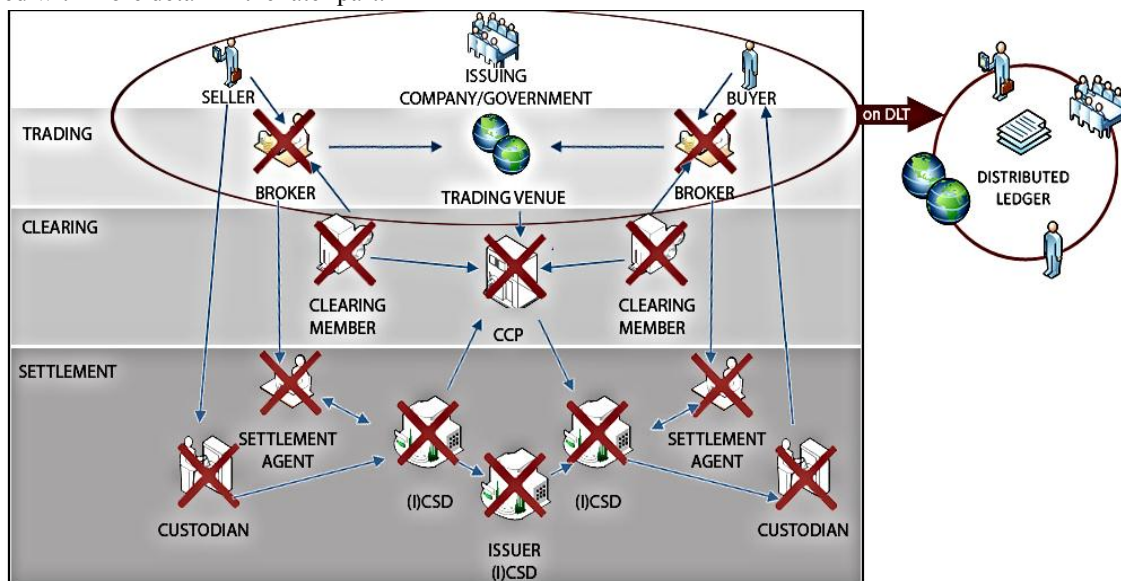


Fig. 3 DLT(Distributed Ledger Technology) based post-trading[7]

3.5 System Design

The most suitable type of blockchain for an application like stock exchange is hybrid blockchain and Hyperledger has such a type of network called Fabric. To work with this network there are many tools available and we as part of our prototype have used Hyperledger Composer. For building our blockchain network we must define our business network and all its dependencies that are part of the Composer tool. Once the network is built, we can use a REST server for interacting with our network using RESTful APIs or we can use it as an intermediary between the client application and the blockchain network. In our system, we have used composer-rest-server provided in the Hyperledger Composer as the intermediary and for the client application, we have used Bootstrap as the front-end framework and Node.js as the back end

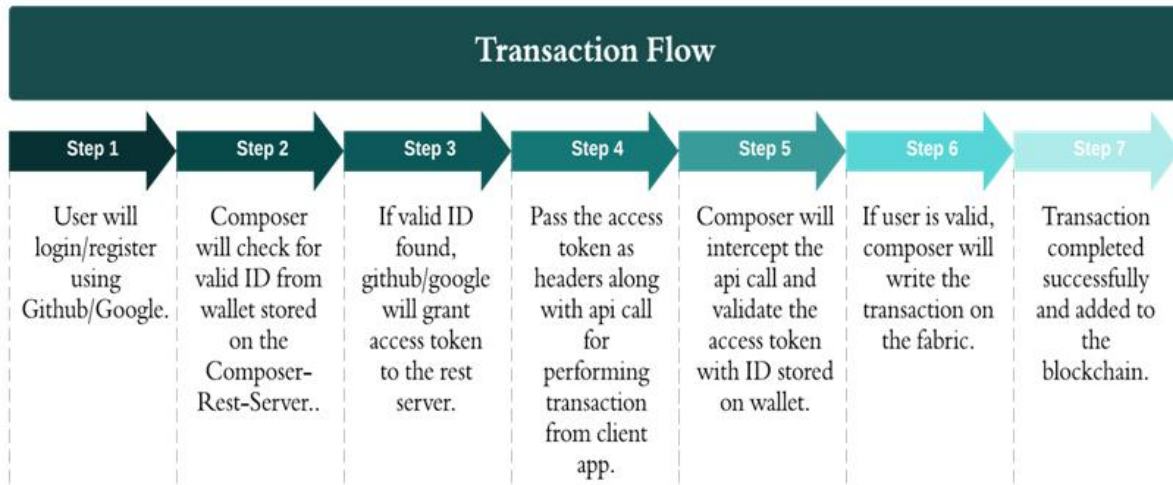


Fig.

4System Transaction Flow

The overall architecture consists of mainly three components: Client app, composer-rest-server, and the blockchain network. Each of the components are outlined below in detail. The client application can be a simple web app built using Node.js for back-end and HTML, CSS, etc. for the front-end GUI. It is a web application comprising of Node.js back-end. The front-end is built using the latest available frameworks such as HTML5 and Bootstrap. The client and the composer-rest-server are secured using TLS encryption and all communication is done using the secure HTTP protocol. We need a combination of two REST servers in our application, one for issuing identities to new users and second for interacting with the blockchain network [18]. This is important for a multi-user client application since a normal user cannot be given administrative rights and admin should also be given only as many rights as required for issuing new identities. The Node.js back-end is configured to use the appropriate REST server as and when any transaction is submitted by the client. The multi-user REST server performs transactions and interacts with the blockchain based on which user is currently registered with it. In the demo system, we have implemented passport-based [19] authentication for authorizing the user. There are many auth-strategies available and can be used depending on the level of security and use-case requirement. The multi-user composer-rest-server contains a wallet with the user credentials that are required for signing the transactions.

```

1 namespace org.yky.stbc
2
3 asset Share identified by shareId {
4     o String shareId
5     o Integer count
6     --> Company company
7     --> Trader holder
8 }
9
10 asset Order identified by OrderId {
11     o String OrderId
12     o OrderType type
13     o Integer count
14     o Double price
15     --> Company company
16     --> Trader trader
17 }
18
19 asset Trade identified by tradeId {
20     o String tradeId
21     o Integer count
22     o Double price
23     --> Trader buyer
24     --> Trader seller
25     --> Company company
26 }
27
28 abstract participant User identified by email {
29     o String email
30     o String name
31 }
32

```

Fig. 5 Assets and Participants defined in Business Network Model



In any blockchain based application, it is very important to select the right blockchain type and the network itself should be suitable for the use-case otherwise the application may not work as intended [20]. Hyperledger Fabric being an open-source hybrid blockchain architecture is the most suitable for using in stock-exchange. Fabric consists of a complex consensus mechanism which helps keep the network secure as well as easily audit-able. There are three phases by which consensus is achieved in Fabric and they are in the sequence as Endorse, Order and Validate. The consensus mechanism can vary depending on the use-case and the number of nodes in the network. As ordering service is plug-able, we can add it as per requirement. Currently, Hyperledger Fabric supports Solo, Kafka and SBFT (Simplified Byzantine Fault Tolerance) consensus [21], [22].

3.6 Defining the Blockchain Network

The Business Network Model is defined in the model file using composer modelling language. Components of the model consist of participants, assets, transactions, etc. as shown in Figure 5. Participants of a given business network can perform various transactions that are available and depending upon the requirement of those transactions, they can access and modify the assets defined in the model. Assets and participants once defined can be added, deleted, or modified as needed. Each participant in the network is assigned a business-network card which is required for submitting a transaction. The card comprises of a certificate provided by a Certificate Authority (CA) and a private key of that participant. This ensures that only valid participants can interact with the ledger, thus adding a layer of security. The Access Control Lists (ACL) specify which participants have what level of access to those assets. Along with these two files, there is a query file and logic file which contain all the queries that the client may need to perform on the ledger and definition of transactions respectively. All of these files are combined in a single file called Business Network Archive (BNA) using Composer. This BNA file can be deployed easily on a local/cloud Fabric-runtime as a business network. Whenever the network needs to be updated, we can create another version of the BNA file and deploy it again.

3.7 Developing the Prototype

In the case of stock trading application, the participants in the network will be traders and company owners, since there will be no intermediary between the company owners and the traders or individual traders. In the proposed system whenever new participants register, they will be given a network card and an identity on the blockchain network. Once registered they can carry out trades, issue shares and update them as required in case they are company owners etc. provided they have the proper authorization. The company owner can issue shares in the company's name and traders can buy those issued shares or can even buy it from other traders who wish to sell them directly. The assets include buy-orders, sell-orders, and trades. The users will be able to carry out all the similar transactions that they can do in the current online trading systems. All the transactions will be performed on the client-side using the web-based GUI.

Figure 4 shows a sample transaction. The flow starting from registering on the platform to successfully complete a trade goes through many phases. So, when there is a new user, he/she can register using the provided auth-strategy. After the user has registered on the network identity will be issued and now the user can submit transactions to the blockchain using web-GUI. As shown in the once a transaction is submitted by the user, it will be redirected to the composer-rest-server, which will call the appropriate methods defined in the logic.js file of the business network

3.8 Towards a Production Ready Application

For a simple prototype, we have used the in-built ordering service that uses the Solo consensus, but if and when there is a large-scale implementation such as a complete decentralized stock-exchange then we will have to use better protocols. Our simulation consists of a single physical system called as node in terms of Fabric architecture. The single node comprises of docker containers simulating multiple systems each of them having their own IP address.

To scale the stock trading application into production we can add more nodes in the Fabric and add a better ordering service such as PBFT (Practical Byzantine Fault Tolerance) for achieving the consensus. Now since we have discussed the Fabric network architecture, we can move on to describing the stock trading blockchain network. As stated earlier, the Composer tool is used for defining the various entities of our network. It consists of several files that defines the

Business Network Model, the endorsement policies, authorization, and authentication, etc. Hyperledger composer also provides the REST server required for communication between the client and the Fabric network. Although it is not necessary to use the REST server, it can be quite helpful while implementing a large network that will contain many different transactions.

IV. BLOCKCHAIN INTEGRATION BENEFITS AND FUTURE SCOPE

Blockchain can make stock trades substantially more ideal through computerization and decentralization. It can help lessen enormous expenses collected on clients as far as commission while accelerating the procedure for quick exchange settlements. The innovation can have feasible use in clearing and settlement, while safely automating the post-exchange process, facilitating desk work of exchange and legitimate possession exchange of the security. Blockchain can dispense with the need of outsider controller to an expansive degree [4]. In this section, all the advantages of merging blockchain into stock exchange systems and its future are discussed in greater detail.

4.1 Benefits of Blockchain in Stock Exchange

A. Greater Transparency

Exchange accounts are ending up more straightforward using blockchain innovation. Since blockchain is a sort of conveyed record, all system members share indistinguishable documentation from restricted to singular duplicates. That common rendition must be refreshed through accord, which implies everybody must concur on it. To change a solitary exchange record would require the modification of every single ensuing record and the agreement of the whole system. In this way, information on a blockchain is more exact, predictable, and straightforward than when it is pushed through paper-overwhelming procedures. It is likewise accessible to all members who have permission to access it. To change a solitary exchange record would require the adjustment of every consequent record and the agreement of the whole system [23].

B. Enhanced Security

There are a couple of various ways blockchain is more secure than other record-keeping systems. Trades must be settled upon before they are recorded. After a trade is embraced, it is mixed and associated with the past trade. This, alongside how information is secured over an arrangement of PCs instead of on a singular server, makes it astoundingly troublesome for software engineers to exchange off the trade data. In any industry where, verifying tricky data is noteworthy cash related organizations, government, therapeutic administrations blockchain gets an opportunity to really change how essential information is shared by turning away coercion and unapproved activities [24], [25].

C. Improved Traceability

On the off chance that your organization manages items that are exchanged through an unpredictable inventory network, you're comfortable with how hard it quite may be to follow a thing back to its root. At the point when trades of merchandise are recorded on a blockchain, you wind up with a review trail that shows where an advantage originated from, and each stop it made on its voyage. This recorded exchange information can confirm the legitimacy of benefits and avoid extortion.

D. Increased Efficiency and Speed

When you utilize conventional, paper-overwhelming procedures, exchanging anything is a tedious procedure that is inclined to the human mistake and frequently requires outsider intervention. By streamlining and mechanizing these procedures with blockchain, exchanges can be finished quicker and even more effectively. Since record-keeping is performed utilizing a solitary advanced record that is shared among members, you don't need to accommodate different records and you wind up with less mess. What's more, when everybody approaches a similar data, it winds up less demanding to confide in one another without the requirement for various delegates. Consequently, clearing and settlement can happen substantially faster.

E. Reduced Costs

For most organizations, diminishing expenses is a need. With blockchain, you don't require the same number of outsiders or mediators to make ensures on the grounds that it doesn't make a difference on the off chance that you can confide in your exchanging accomplice. Rather, you simply need to confide in the information on the blockchain. You likewise won't need to survey such a great amount of documentation to finish an exchange on the grounds that everybody will have permission-ed access to a solitary, unchanging rendition.

F. Future work: Implementing it for Production

We have so far discussed the benefits of incorporating blockchain into stock exchange systems. We have created a prototype of stock trading application powered by blockchain technology. Our experimental implementation shows that blockchain can be effectively integrated with stock exchange system. Although blockchain has yet to reach its maturity for implementing an industry level application [26], organizations like The Linux Foundation and others[27] are working towards it. The advantages of using a hybrid blockchain [28] makes it possible to scale it to a larger system where each of the parties participating in the stock exchange such as the company issuing the shares, the regulators and any legal agencies will have their own ordering nodes, peer nodes and client nodes in the Fabric. This will help maintain neutrality in terms of consensus and achieving the goal of decentralizing the stock exchange. A few major stock exchanges seem to be already appraising the technology [29], [30] hinting that a decentralized stock trading experience is in sight.

V. CONCLUSION

In this paper we have investigated the application of blockchain in stock exchange systems. Online stock trading platforms that currently exist face the problem of hackers trying to manipulate outcome of transactions. Also, the clearing and settlement process is very slow and can take up to 3 days to complete. For solving these issues, we propose a blockchain based solution built using Hyperledger. By integrating blockchain with stock exchange a fast and secure system can be obtained.

As a proof of concept, we have implemented a simple simulation using the Hyperledger Fabric blockchain network. Our system consists of a client application for carrying out transactions, REST server and blockchain network. The blockchain network utilizes the Solo consensus mechanism for ordering the transactions. Our solution is implemented on a single node using docker containers simulating multiple peers.

As future implementations we propose a system with multiple nodes representing the various components of stock exchange such as regulators, company issuing the shares, legal entities, etc. Since the Hyperledger framework is designed for high performance and scalability, also the consensus mechanism can be replaced with a better alternative such as Kafka or PBFT depending on the requirement, so the blockchain network can be expanded effectively into production.

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