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Evaluation of Blockchain in Capital Market Use-Cases

Sinsu Anna Mathew, VIT University, Chennai, India
Abdul Quadir Md, VIT University, Chennai, India

ABSTRACT

This article describes the "Blockchain" which is an upcoming technology in the current leading world and which serves as a capital market use-cases for many of the global Fintech industries across the world, is a distributed ledger of economic transactions which not only used for recording financial transactions but mostly everything of value in this world. In the current world, mostly all the transactions are done through online which mainly includes the bank as a "middle man," which could be untrustworthy at times. Blockchain comes into the picture which eliminates the need of a middle man or third party between the users who are involved in the transactions. Represents a financial ledger entry of data structure which consists of record of transactions which is digitally signed and cannot be tampered as authenticity is ensured in which the ledger is considered to be of high integrity. One of the leading and highly valued platform of blockchain is "Hyperledger Fabric" which is meant for securing transactions and serves a powerful container technology for smart contract development in the global capital firms. The potential of Blockchain and DLT in capital markets in this upcoming world could remove many of the inefficiencies and costs inherent in the global capital markets across the world and could be considered as a viable technology which enable to settlement.

KEYWORDS

Blockchain, Hyperledger Fabric, Ledger, Smart Contract

1. INTRODUCTION

The global markets across the world are increasing day by day and all are looking for a technology where transactions could be done without the need of a centralized authority between the dealer and the buyer. Since capital is a very critical component which is used for generating the economic outputs, Capital markets includes primary markets and secondary markets, where primary markets consist of stocks and bonds which are issued and sold to investors and secondary markets consists of the trade existing securities. Capital firms are markets mainly meant for buying and selling equity and debt instruments which are securities in the global world or in other words which facilitates the buying and selling of financial instruments. Capital markets involve issuing of stocks known as equity securities and issuing bonds known as debt securities for medium-term and long-term durations (Condos, Sorrell, & Donegan, 2016). It includes various participants as the individual investors, municipalities, governments, companies, organizations, banks and financial institutions. As the blockchain acts as a catalyst for the evolution of various new applications and is a next-step from computing architectural concepts needs to take care of five key concepts – blockchain, decentralized consensus, trusted computing, smart contracts and proof of work or stake. Built-in-robustness is one of the major advantage of Blockchain technology as it helps in storing blocks of information that are same across its network. Another advantage of the distributed ledger is that it cannot be controlled by

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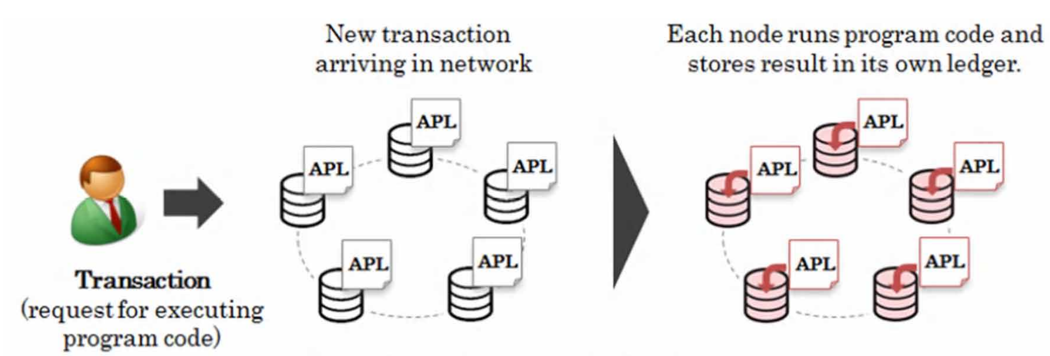
any single entity and has no single point of failure. The blockchain network also results in transparency as the information is embedded within the network and it is public. It cannot be corrupted at any cost as alteration of any data on the blockchain would result in the usage of a huge amount of computing power to override the entire process. The blockchain makes up a network of computing nodes which solves the problem of manipulation. The global network of nodes use the blockchain network as helps in solving the problem of transactions of stocks or bonds among the capital firms, where it verifies, validates and authenticates each and every user with their own credentials and records transactions in the ledger which is distributed among all the participants in the trade (Buehler et al., 2015).

DLT or the distributed ledger technology has become has attracted a lot of people from various industries which has explored a lot of applications in which the centralized consensus process is replaced by DLT. Application of DLT to capital markets is one of the areas attracting people's attention. Global exchanges, CCPs, CSDs, banks, dealers, and market facility providers have productively explored DLT applications through PoC (proof of concept), and venture in technology income producer or participating consortiums. Cost reduction is one of the inherent advantages of exploiting DLT for capital market framework. DLT enables network partners to validate the transference of rights between each other and share those records in an changeless manner by applying cryptographic technology (Swanson, 2015). DLT consists of five technological features such as database to report ledger, cryptographic hash function to abstract data, public key cryptography, P2P network, and consensus algorithm. A 'smart contract' function facilitate users to generate business applications that can be deployed and accomplished on distributed nodes only to devoted parties or a sole entity. Due to the difference in openness policies, appropriate consensus algorithms differ. Since anyone can produce new blocks in public DLTs, assignments like proof of work (PoW) are recurrently built into the consensus algorithm to avoid venomous participants overwriting past facts (see Figure 1).

Consortium or private DLTs can confine block creation to designated shareholders. It is also possible to restrict tenancy of multiple nodes to a single individual or entity. These access control deliberation enables use of a swift consensus algorithm where a chief node nominated by a simple rule bring about a new block, and then the block is approved by a predefined proportion of nodes (Underwood, 2016).

This paper proposes about the potential of bringing up the blockchain technology and how it can lead a great impact on the FinTech industries and how it is designed to solve the problems of doble spending, issue of trust, Consensus on the latest correct version of the transaction history and not allowing anyone to make changes upon an agreed chain of transactions (Paech, 2016). Global capital market are financial markets which are equity securities known as stocks and debt securities which are known as bonds. In other words, they are meant for buying and selling stock and bond financial instruments. Capital market firms consists of issuing equity securities and debt securities for long-term and short-term durations as in the contract of one year or more depending on the

Figure 1. Working of DLT among the peer nodes (Source: Swanson, 2015)



agreement between the parties (Mainelli & Milne, 2016). Capital markets are generally strenuous in financial centers across the world. Age portion of the trade happening inside the capital businesses occur through electronic trading systems out of which are open towards people in general and few are tightly monitored. Other than stock and bond equities, the capital markets also include other two classifications such as "primary markets" and "secondary markets". Primary markets allow various industries to raise stock without or before holding the first sale of a stock which helps in making a great profit for the company. It helps in company's development which brings to "liquidity" where a security or an asset can be bought or sold at stable prices. The most considered standard liquid asset is the "Cash" since it could be easily converted to another asset. If the company faces the problem of liquidity, they sell their assets to few other investment banks or some other global capital firms.

Therefore, the leading "Blockchain technology" helps the leaders of the global financial firms to understand the importance of Blockchain and how it enables both the parties to have a transaction of their own in a secured world without the involvement of a "middle man" which may sometimes lead to untrustworthiness among themselves. Blockchain is a distributed database or a distributed ledger technology which is constraining and a very good and efficient way of organizing the financial transactions of various data among the trusted parties. Blockchain technology besets a range of novelty that build upon each other, and the potential benefits of how it could be achieved in the underlying systems and technologies (Hull et al., 2016).

Discovering the importance of how the new leading technology could be applied in the global financial markets which leads to a huge range of innovations and the impact on different parts of value chain and participants. It also leads to discovering the major risks in implementing the Blockchain for various use cases in terms of technology, industry coordination, standards and governance, laws, regulation and policy. Potential uses and the steps needed for its adoption are also looked into which makes the industries to move into a blockchain-based system since the technology at a larger scale. Blockchains which was at first meant for the "Bitcoin protocol" is a ledger of transactions where the cryptographically signed data of blocks are added to one another in the form of a chain which is known as "immutable records". The distributed ledger is mainly an architecture which consists of a peer to peer nodes where they collaborate to reach a consensus on the correct state of a shared data resource (Peters & Panayi, 2016). It ultimately leads to a series of modernization in organizing and sharing the data. Blockchain helps in the development of industries which helps in the fast settlement of transactions and the building up and automatic execution of smart contracts which includes business logic which is encoded into the ledger.

To evaluate the growing approach of blockchain technology in capital markets and how it offers an outlook to data management and sharing. Blockchain is establishing as a potentially unruly force capable of transforming the financial services industry by making transactions agile, cheaper, more protected and transparent. Blockchain, also known as a distributed ledger technology was basically created as a capturing database for Bitcoin transactions and was developed to enable individuals and management to process transactions without the need for a central bank or other mediator, using complex algorithms and consensus to check transactions where many of the capital markets are betting on blockchain to provide a reliable backup to systems that depend on mediators and third-party validation of transactions. Their goal is to grease blockchain's distributed ledger approach to design a system that distribute trust — a radical evacuation from existing transaction processing methods — to significantly sever all types of transaction fees and scale down processing times (Peters & Panayi, 2016).

A crucial variation, however, is that while the Internet facilitate the exchange of data, blockchain could enable the change of value; that is, it could facilitate users to bring out trade and commerce beyond the globe without the obligation for payment processors, custodians and resolution and reconciliation individuals. Their goal is to brutalize processes, minimize data storage costs, reduce data duplication and strengthen data security. The attraction of blockchain was its method of authenticating and tracking transactions. Rather of a trusted third-party or a central bank, it depends on consensus among a peer-to-peer network of nodes based on complicated algorithms. Instead of being stored in a single database, blocks of time-stamped transactions are gathered on all nodes across a value chain (Hull et al., 2016).

2. PROBLEM STATEMENT

Estimation of how transactions can be done on a global scale which helps in finding out a solution to many of the inefficiencies afflicting the industries across the globe. The next decade is most likely to be changed in case of social web, big data, cloud, robotics and even the artificial intelligence and the technology blockchain behind the digital currencies like bitcoin. The blockchain technology which is mainly a distributed ledger of economic transactions runs on millions of devices and is open to anyone, which consists of not just information but mainly everything of value which can be stored securely and privately. The trust in blockchain is established through collaboration and clever code by a group of programmers, which in turn ensures integrity and trust between strangers. This technology is mainly the first native digital medium for value, which has a big implication for business and corporation.

The potential of the blockchain is to reduce the cost and complexity of financial transactions which improves the transparency and regulations. The blockchain technology experts provides a strong evidence that the distributed ledger platform could transform business, government and society in a more realistic way which increases the trust between the dealers and Investors by eliminating the middle man in the group.

3. LITERATURE SURVEY

3.1. What is Blockchain?

Blockchain is an emerging upcoming technology that has a wide-range of implications that may transform not only the financial industries but also many of the capital firms and financial businesses (Zhang, Cecchetti, Croman, Juels, & Shi, 2016). The term "Blockchain" means it's a distributed ledger of economic transactions where the data once entered is immutable or unchangeable. It consist of a lists of ordered records called "blocks". Each block has a timestamp of its own and is linked to its previous state. It's also called as an "innovative crypto technology" that enables many of the systems and industries to move forward based on their standards and also acts as an immediate beneficiary for many of the financial industries across the world. In financial industries, there's always a way to correct an attack but according to the concept of Blockchain, there is no mechanism to correct it rather than to accept it. It optimizes the global infrastructure and helps in dealing with global issues in this much confined space. This new technology in the FinTech industry has energized the financial services industry globally (Fairfield, 2014).

Technology innovations of blockchain consist of:

1. Encryption: New methods purposes encryption technologies which may enable the safety and anonymity of quite touchy information within a shared access environment. They allow users to reveal information selectively in conformity with others as required.
2. Mutual Consensus Verification: Mutual consensus approval protocol allow a network agree updates to the database collectively, together with a sure bet so the average dataset remains correct at whole times besides the need for a central living authority. There are a range of different methods in conformity with union protocols and safeguard against the malicious manipulations and guarantees that no single point of failure exists.
3. Smart Contracts: They are programmable codes build for generating instructions if a certain condition is met such as payment instruction or moving collateral. They become immutable once accepted to the ledger.

Blockchain which is the distributed ledger of economic transactions is also for all bitcoin transactions which have ever been executed. The current part of the blockchain is known as the block, which records all the current and recent transactions. Once the transactions are recorded, it goes into the blockchain which acts as a permanent database. After the completion of a block, a new block gets generated. Blocks are connected to each other in a linear, chronological order in which every block contains a hash of the previous block. In other words, the blockchain is like the history of transactions related to the bank. Every bitcoin transactions are entered in a chronological order in the blockchain like the way bank transactions are done in which blocks are like individual bank statements. The blockchain consists of records of every bitcoin transactions ever executed. Therefore, it can provide any information like how much value belonged to a particular address at a certain point of time in the past. In today's world, the information is shared through a decentralized online platform such as the internet. But in the case of transferring value such as money, people depend on the centralized financial establishments as the banks. Even most of the online payments are done through credit card or debit cards which also links through the bank. Thus, blockchain eliminates the possibility of a third party by maintaining the major roles as recording transactions, establishing identity and establishing contracts which is mainly carried out by the global financial capital firms. Across the world, the financial service marketing is the biggest sector of industry by market capitalization. It can make the transactions to be done in fraction of second by enabling peer to peer transactions and in fact has the capability to create huge efficiencies (Zhang, Cecchetti, Croman, Juels, & Shi, 2016).

Ways in which blockchain can transform the financial industry:

1. ***Asset Management:*** The blockchain's ability of distributed ledgers to replace the role of "middle man" had a really great impact on the buy-side firms which has the potential to cut cots, reduce delays, provide more timely and exact data and enhance reporting accuracy. Blockchain can have a reasonable impact on the agreement of securities transactions and can afford a great opportunity to reduce the costs of asset managers leading to reduced charges for shareholders. Each party in the trade consists of either broker dealers, intermediaries, custodians, clearing and settlement teams who keeps within themselves the record of all the transactions. Blockchain technology provides an automated trade lifecycle where the transaction are accessible to all the parties involved in the trade. It ultimately leads to cost saving, effective data management and transparency.
2. ***Insurance:*** Smart contracts can be created as policies o the blockchain which is an ideal use case for blockchain. It gives complete control, transparency and traceability for every requirement and may led to automatic pay-outs.
3. ***Supply Chain:*** Smart contracts are executed automatically on the blockchain to transfer titles of goods and money and creates a trusted network of assured authenticity and the origin of products which are being supplied.
4. ***Payments:*** One of the use case for payment is international payments in which certain banks like Santander enabled customers to make international payments within 24 hours a day and clearing the next day through the application of blockchain.
5. ***Fund Valuations:*** It enhances the rigor and timeliness of record keeping. It consists of a timeline supply regarding pricing data. It provides opportunity to piece frequent argue over information with service vendors.

4. PUBLIC BLOCKCHAINS

A public blockchain enables anyone in the world to read the transactions or to send the transactions or enables anyone to see if they are included in the chain and if the transactions are valid allows anyone in the world to participate in the consensus process. Consensus process determines what blocks get added to the chain and what the current state of the block. Cryptoeconomics which is a combination of economic incentives and cryptographic verifications using mechanisms proof of work or proof of stake are used for securing blockchains. Public blockchains are known to be "fully decentralized". Also known as "Unpermissioned ledgers" as they have no owners and cannot be owned. The main purpose is to allow anyone to contribute information to the ledger and to have identical copies in everyone's possession. No actor can deny any transaction from being added to the ledger. Integrity of the ledger is maintained by the participants by reaching a consensus about its state. Public ledgers cannot be edited and is used as a global record of transactions in the case of assigning property ownership (Fairfield, 2014).

5. PRIVATE BLOCKCHAINS

Also termed as "Permissioned ledgers", can have one or many owners. When a new block is added to the chain, the integrity of the ledger by the consensus process, which is mainly a trusted group of partners or actors as the government department or banks, which maintains a shared record and is simpler than the consensus process used in public blockchain. Highly-verified datasets are provided by the permissioned blockchain as the consensus creates a digital signature, which can be viewed by all the parties in the private blockchain. It is faster than un-permissioned ledger and is opted by most of the FinTech industries. Here the write permissions are kept centralized to one organization (Fairfield, 2014).

6. CONSORTIUM BLOCKCHAINS

It's a blockchain which consists of a pre-selected set of nodes as like a consortium of 15 financial institutions, where each operates on a particular node out of which 10 should sign every block, for the block to be valid. The consensus process is controlled by that 15 financial institutions taking part in the ledger. It could be public, which gives the right to read the blockchain and is considered as "partially decentralized".

The major difference between the "Consortium blockchains" and the "Private blockchains" is that the Consortium provides a low trust as like the public blockchains and the single highly trusted entity property of a private blockchain. Public blockchains is mainly a traditional centralized system with an attachment of cryptographic auditability.

The consortium or company running a permissioned blockchain can easily change the rules of a blockchain, revert transactions and modify balances etc. Transactions are cheaper since the verifications are only done by few nodes and not by many. Trustworthiness among each node increases and errors can be fixed as fast as possible by allowing the use of consensus algorithm which allows perfections after a shorter block times. As the read permissions are restricted, permissioned blockchains provide a greater level of well privacy (Vukolić, 2015).

7. DISTRIBUTED LEDGERS

Distributed ledgers are distributed databases that are spread across multiple sites, countries and is public to all. It's a continuous ledger where records are stored one after the other, rather than sorting in blocks. Trust is the major fact which should be maintained among the operators or validators in distributed ledgers. It also consists of digital signatures among the various parties (Wyman, 2016).

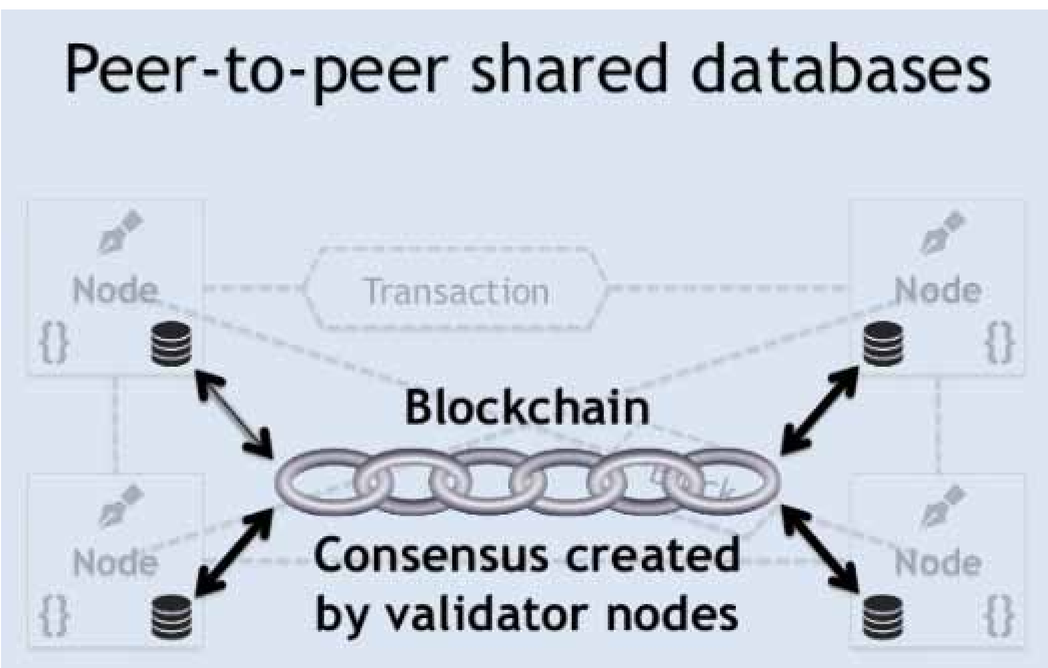
Blockchain's primary elements include:

1. **Decentralization:** Instead of one central authority governing everything within an environment, blockchain distributes regulate among all nodes in the transaction chain, designing a shared framework.

2. **Digital Signature:** Blockchain permits an exchange of transactional value using exclusive digital signatures that confide on public keys and private keys to design proof of ownership.
3. **Mining:** A distributed consensus system compensate miners for confirmation and authentication of transactions and cache them in blocks using stern cryptographic rules.
4. **Data Integrity:** The use of complicated algorithms and consensus among users assures that transaction data, once settled upon, cannot be altered. Data cache on blockchain thus acts as a single adaptation of truth for all parties convoluted, reducing the risk of fraud.

When a transaction or an edit is to be made in the network, the majority of the peer nodes in the blockchain have to execute some consensus within the network and should evaluate and verify the entire history of the blockchain block which is proposed and make sure that the history and the signature is valid. After the validation is approved by all the nodes in the network, the new transaction is accepted into the ledger where a new block is added to the chain of transactions which is known as the "Blockchain". If the majority of the nodes in the network do not agree with the transaction, then the new transaction is not added to the ledger. The distributed consensus model provides an advantage of running blockchain without the need of some central authority. Blockchain uses various mechanisms which achieves consensus on transactions where only known participants can be included in the chain and exclude everyone else. Most important blockchain use-case is the Bitcoin blockchain, which is a public ledger in which everyone can participates. Permissioned blockchains are also in use by many of the organizations across the world, where only authorized participants are allowed in the network. Each block in the network maintains a hash of the previous block which is connected and in the chain of blocks. The blockchain consists of chaincode or smart contracts which serves as a major backbone for blockchain network. Each node in the network that performs the task of validating and relaying transactions gets a copy of the blockchain which is downloaded automatically while joining the blockchain network and creates a powerful network among themselves. Each node in the network are

Figure 2. Peer-to-Peer shared database (Source: Fairfield, 2014)



known to be the administrator and mining bitcoins. It supports protocols and cryptographic operations which are developed to permit individuals to exchange bitcoins in real time. Enables peer-to-peer decentralized transaction record-keeping, where all participants broadcast their transactions to a shared public ledger called a blockchain. Verification of the legitimacy of transactions is performed by volunteers called 'miners'. Miners are required to complete a proof of work in order for a block to be verified and accepted (see Figure 2).

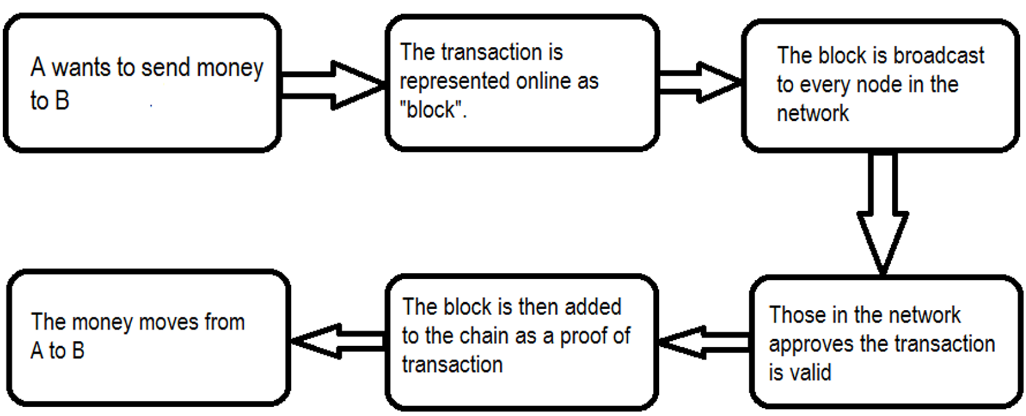
7.1. Workflow of Bitcoin Mining

- The first miner who finds the solution, announces it to others on the network and the other miners then validate the solution.
- If the approval is granted by all, the block is cryptographically added to the ledger and the miners move on to the next set of transactions.
- The blocks are added to the blockchain a linear, chronological order.
- Each node gets a copy of a blockchain, which gets downloaded automatically.
- Blockchain has complete information about the addresses and the balances of each transactions.
- Once a block of data is recorded on the blockchain ledger, its extremely difficult to change or remove (see Figure 3).

8. SMART CONTRACTS IN BLOCKCHAIN

Smart contracts which is also known as self-executing contracts, blockchain contracts or digital contracts is used for digitalized ledger which can be converted to computer code which is stored, replicated and supervised by the network of nodes that run the blockchain. In a smart contract approach, an asset or currency is relocated into a program "and the program runs this code and at some point, it automatically validates a condition and it naturally determines whether the asset should go to one person or back to the other person, or whether it should be instantly refunded to the person who sent it and the decentralized ledger also stores and replicates the document which gives it a certain security and immutability. Exchange of money, property shares are all done through smart contracts in a conflict-free way. Smart contracts give us an assurance of autonomy, trust, backup, safety, speed, savings, accuracy and meets the road for business and distributed ledger technology. It assures not even any forms of confusion and never any need for litigation which of course guarantees a very

Figure 3. Workflow of blockchain mining



specific set of outcomes. Smart contracts are the pillars of the blockchain technology which have the capability within them to implement various operations and multiple tasks (Morabito, 2017).

Smart contracts are agreements where the terms mentioned in the agreement can be preprogrammed which gives the ability to self-execute and self-enforce it. The main goal of a smart contract is to allow the dealer and the buyer to do trade and business among themselves without the need of a third party. They are using programming code languages such as C++, Go, Python.

8.1. How do Smart Contracts Work?

1. Coding which represents what goes into the smart contract and they code exactly the way what the parties want them to do. It is done by inputting the appropriate logic in the smart contract while developing the smart contract.
2. Distributed ledgers which represents how the smart contract is sent out. The code is encrypted and sent out to the nodes through a distributed network of ledgers.
3. Execution represents how it is processed in the network. One of the node among the network receives the code and comes to an individual agreement on the results of the code execution (Morabito, 2017).

9. PROPOSED WORK

Hyperledger fabric is one of the upcoming blockchain platform which is also a social innovation which helps many of the global industries across the world to transform and immensely reduce the cost of working together across organizations. State-machine replication model is the best way in which blockchain could be understood where a service maintains some state and clients invoke the operations that convert the state and generate outputs. Since it is based on the distributed protocol, run by nodes connected over the internet, "Blockchain" is known as a "trusted" computing service. An asset is created or represented by the service, in which all the nodes have some stake. Services are shared among all the nodes but they do not trust each other. Blockchain in the "permissioned ledger" monitors who participates in the validation and in the protocol as all the nodes have established identities and they form a *consortium* (Kosba, Miller, Shi, Wen, & Papamanthou, 2016).

The project is a collaborative effort taken by all the nodes participating in the network to form an enterprise-grade, open-source distributed ledger infrastructure. It identifies and realizes cross-industry open standard platform for distributed ledgers, which can change the way business transactions are conducted globally.

9.1. Fabric

The network of networks is known as "fabric". One or more networks can be used by an application which manages the different assets, agreements and transactions between different sets of member nodes. Foundation of each network is the Ordering Service which is selected by the network and passes a config file with rules called as policies, that govern it. The rules include deciding which members can join the network, how members can be added to the network or removed and determining the configuration details like block size. These rules may also include the policies which may sometimes lead to changing the rules, as a matter of consensus between the members of the network (Christidis, & Devetsikiotis, 2016).

Distributed ledger platform is implemented by the Hyperledger fabric for running smart contracts, leveraging the new technologies with a creative architecture that allows pluggable implementations of various functions. The group of nodes runs the distributed ledger protocol of fabric. Transactions in the fabric, known as the ledger of digital events is shared among the different participants where each one is having a stake in the system. The consensus of the participants can only update the ledger and once the information is recorded, it cannot be altered. Every transaction which are entered in the ledger is cryptographically verifiable with proof of agreement from the nodes taking part in the transaction where all the transactions are secured, private and confidential. In order to gain access to the system, each participant registers with proof of identity to the network membership services. Transactions along with the derived certificates are issued which is un-linkable to each node and offers a complete anonymity on the network. Sophisticated key derivative functions are used for encrypting the transaction content which ensures that only authorized participants may view the content, protecting the confidentiality of the business transaction.

Bitcoin is the simple application of the fabric which is an implementation of blockchain, which is a modular architecture whereby allowing the components to be plug and play by implementing this protocol specification. Any main stream language can be hosted for smart contract development which is its powerful container technology and the major motto of fabric architecture.

9.1.1. Major Terminologies related to Hyperledger Fabric

1. Transaction – For executing a function on the blockchain, a request has to be passed on to the blockchain and this function is implemented by a blockchain.
2. Transactor is the individual who issues transactions like client application.
3. Ledger is a chain of cryptographically connected blocks, which contains transactions and the current world state.
4. World State is the group of variables which contains the results of executed transactions.
5. Chaincode which is also known as the "smart contract" is an application-level code, stored on the ledger as a part of a transaction and runs transactions that may modify the world state.
6. Validating Peer is a computer node on the network authorized for running consensus, validating the transactions, and maintaining the ledger.
7. Non-validating Peer is a computer node on the network which acts as a proxy connecting transactors to the nearby validating peers. A non-validating peer will never execute transactions but verifies them and also hosts the event stream server and the REST service.
8. Permissioned Ledger is a network in the blockchain where each individual or node is required to be a member of the network. Unidentified or unauthorized nodes are not allowed to connect or view the ledger.
9. Privacy is a must requirement among the chain transactors to camouflage their identities in the network and the transactions should be linked to the transactor without special priviledge when members of the network examine the transactions.
10. Confidentiality is the ability to distribute the transaction content which is not accessible to anyone other than the stakeholders of the transaction.
11. Auditability is required in the blockchain, as business usage of blockchain needs to adhere to with regulations to make it easy for regulators to examine transaction records.

10. ARCHITECTURE OF THE PROPOSED WORK

The Hyperledger fabric architecture is made up of with the core components and is aligned in three categories (Christidis, & Devetsikiotis, 2016) (see Figure 4).

1. Membership Services
2. Blockchain Services
3. Chaincode Services

10.1. Membership Services

Managing the identity, privacy, confidentiality and auditability on the network are the services provided by the membership services. In an un-permissioned ledger, all the nodes can participate in the transaction and could be added on to the block, in a way, there are no distinction of roles. Elements of Public Key Infrastructure (PKI) and decentralization/consensus are combined together by the membership services inorder to transform a non-permissioned blockchain into a permissioned blockchain. Every member participating in the network, has to register in order to obtain a long-term credential such as the "Enrollment Certificate". With the help of Transaction Certificate Authority (TCA), the users could be granted permission to issue pseudonymous credentials and is also used to authorize transactions that are submitted and are persisted on the blockchain.

10.2. Blockchain Services

Distributed ledger is managed by the blockchain services through a peer-to-peer protocol, built on HTTP/2. Most efficient hash algorithm are provided by the highly optimized data structures for maintaining the world state replication. Various consensus such as PBFT, Raft, PoW and PoS could be plugged in and configured per deployment.

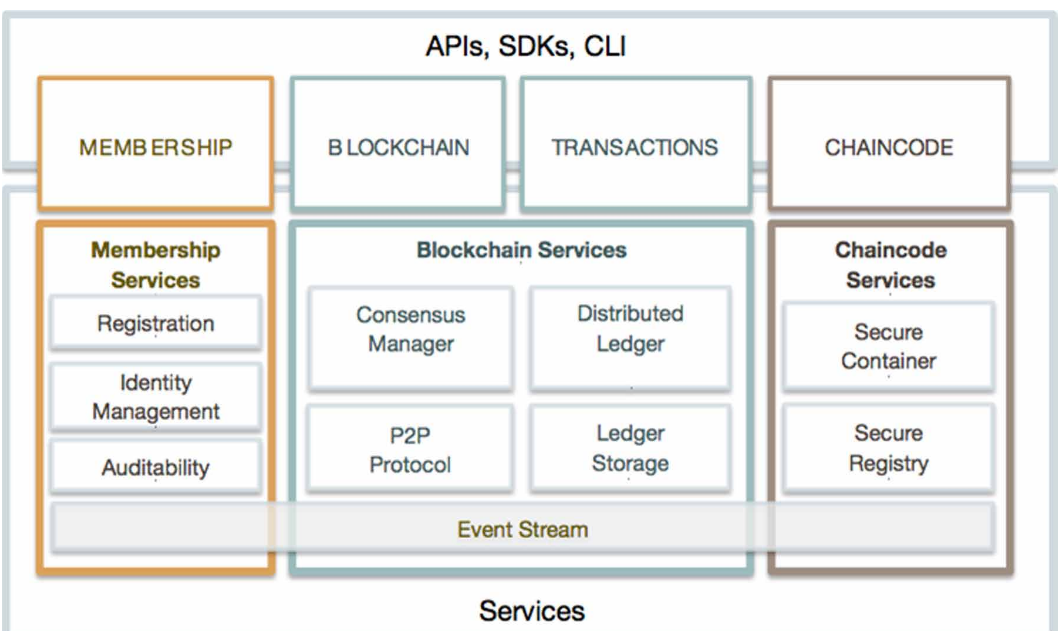
10.3. Chaincode Services

It provides a secured and lightweight path to uplift the chaincode execution on the validating nodes. It consists of a set of signed base images containing secure OS and chaincode language, runtime and SDK layers for Go, Java, and Node.js.

10.4. Protocol of the Chaincode

Peer-to-peer communication of the fabric is built on gRPC, where a bi-directional stream-based messaging is allowed. Protocol buffers which are language-neutral, platform-neutral and is an extensible-mechanism which is used to serialize the data structures for data transfer between peers.

Figure 4. Architecture of Hyperledger fabric (Source: Christidis, & Devetsikiotis, 2016)



Messages are encapsulated which are passed between the nodes by Message proto structure, which consists of four types: Discovery, Transaction, Synchronization and Consensus. Payload is an opaque byte array which contain objects as Transaction or Response depending on the type of the message, for example, if CHAIN_TRANSACTION is the type, then the payload is a Transaction object (Delmolino, Arnett, Kosba, Miller, & Shi, 2016) (see Figure 5).

10.5. Transaction Messages

Three types of transactions are involved such as Deploy, Invoke and Query. Specified chaincode on the chain is installed by a deploy transaction, while in a query and invoke transaction, a function is called of a deployed transaction. When a deployed transaction is instantiated on the chain and is addressable, it is known as the Create transaction. BFT Consensus protocol are run by the validating peers for executing a replicated state machine that accepts all the transactions as Deploy, Invoke and Query. During the transaction of a message, certain fields are required as chaincodeID, payloadHash, metadata, uuid, timestamp, confidentialityLevel, nounce, cert, signature, TransactionPayload.payload. A transaction consists of a chaincode specification which defines the chaincode and the execution environment which consists of the language and the security context. The chaincode are implemented in a language called GoLang (see Figure 6).

CHAINCODE_DEPLOY is the transaction type of a deploy transaction and payload contains an object of ChaincodeDeploymentSpec. Verification of the hash of the codePackage is done by the

Figure 5. Protocol of the transaction messages. *Source: Delmolino, Arnett, Kosba, Miller, & Shi, 2016)

```
message Message {
    enum Type {
         UNDEFINED = 0;

         DISC_HELLO = 1;
         DISC_DISCONNECT = 2;
         DISC_GET_PEERS = 3;
         DISC_PEERS = 4;
         DISC_NEWMSG = 5;

         CHAIN_STATUS = 6;
         CHAIN_TRANSACTION = 7;
         CHAIN_GET_TRANSACTIONS = 8;
         CHAIN_QUERY = 9;

         SYNC_GET_BLOCKS = 11;
         SYNC_BLOCKS = 12;
         SYNC_BLOCK_ADDED = 13;

         SYNC_STATE_GET_SNAPSHOT = 14;
         SYNC_STATE_SNAPSHOT = 15;
         SYNC_STATE_GET_DELTAS = 16;
         SYNC_STATE_DELTAS = 17;

         RESPONSE = 20;
         CONSENSUS = 21;
    }
    Type type = 1;
    bytes payload = 2;
    google.protobuf.Timestamp timestamp = 3;
}
```

validating peers when theu deploythe chaincode which make sure that the package has not been tampered with since the deploy transaction entered the network. CHAINCODE_INVOKE is the transaction type of an invoke transaction and the payload contains an object of the ChaincodeInvocationSpec. The message type of a query transaction is CHAINCODE_QUERY and is similar to invoke transaction.

11. DEVELOPMENT OF THE CHAINCODE

Chaincode also known as "Smart contract" is the business logic that governs how the different participants in a blockchain network interact or transact with each other. The business network transaction in the code is encapsulated by the chaincode. When the chaincode is invoked, it gets the world state of the ledger. Chaincode is mainly written in a language called Go or Java, which runs inside a docker container. A way is provided for the chaincode developers to test and debug their code and whenever any of the participants wants to invoke the chaincode, the chaincode has to be deployed first using the CLI, REST, API or SDK. When the request is received immediatel, the docker container spins up with the relevant chaincode. Three choices are made available, among which needed to be selected for the development of the chaincode (Croman et al., 2016).

1. Development of Vagrant environment which is used for developing the fabric.
2. Development of Docker container environment for Mac or windows.
3. Development of Docker toolbox.
4. Getting the latest master Hyperledger fabric v0.6 from the github.com.

Figure 6. Transaction messages (Source: Delmolino, Arnett, Kosba, Miller, & Shi, 2016)

```
message ChaincodeSpec {
    enum Type {
        UNDEFINED = 0;
        GOLANG = 1;
        NODE = 2;
    }
    Type type = 1;
    ChaincodeID chaincodeID = 2;
    ChaincodeInput ctorMsg = 3;
    int32 timeout = 4;
    string secureContext = 5;
    ConfidentialityLevel confidentialityLevel = 6;
    bytes metadata = 7;
}

message ChaincodeID {
    string path = 1;
    string name = 2;
}

message ChaincodeInput {
    string function = 1;
    repeated string args  = 2;
}
```

If using the docker environment, we need to pull and run the fabric-peer and fabric-membersrvc images from the DockerHub. Membersrvc consists of all the certificates issued for a particular user or in other words the user's credentials. Multiple terminal windows may be needed, essentially for all components. One terminal runs the membersrvc and the other runs the peer.

11.1. Setting up a Vagrant Development Environment

1. When downloaded the Master source code of Hyperledger fabric v0.6, get into the devenv subdirectory which resides in the fabric workspace environment and ssh into the vagrant.

```
cd $GOPATH/src/github.com/hyperledger/fabric/devenv
vagrant ssh
```

2. Soon after the development of the vagrant environment, build and run the Certificate authority (CA) server.

```
cd $GOPATH/src/github.com/hyperledger/fabric
make membersrvc && membersrvc
```

The Certificate Authority (CA) is a default setup which is in the membersrvc.yaml configuration file, which consist of multiple users who are already registered within the CA. Each user is provided with an enrollment ID enrollment PW pairs. In the configuration file, the role of the users is mentioned in the form of an integer as 1 = client, 2 = non-validating peer, 4 = validating peer, 8 = auditor.

3. For running a validating-peer, ssh into the vagrant fronm the devenv subdirectory of your fabric workspace environment and build and run the peer process.

```
cd $GOPATH/src/github.com/hyperledger/fabric
make peer
peer node start --peer-chaincodedev
```

11.2. Chaincode Structure

The chaincode which is written in Go language, consists of a shim package API that let chaincode interact with the blockchain network to access the state variables, transaction context, caller certificates and attributes and to invoke other chaincodes. The chaincode consists of main() function which is used for bootstarpping/starting the chaincode. When the peer invokes the deploy function of the chaincode, the chaincode gets executed. Chaincode interface consists of three methods, that is, Init, Query and Invoke.

11.2.1 Init method()

When the chaincode is first deployed on to the blockchain network, the init method is called which will be executed by each peer that deploys its own instance of the chaincode, which can be used for any tasks related to initialization, bootstrapping or setup (see Figure 7).

11.2.2 Query method()

Whenever any read/get/query operations need to be performed on the blockchain state, the Query method is invoked. The query method does not change the blockchain state and won't run within a transactional context. And if anyone attempts to modify the state of the blockchain context, an error might pop out about the transactional context. The query method is only for reading the state of the blockchain and enhancements are not recorded on the blockchain (see Figure 8).

Figure 7. Init method of the chaincode

```go
func (t *SimpleChaincode) Init(stub shim.ChaincodeStubInterface, function string, args []string) ([]byte, error) {
    if len(args) != 1 {
        return nil, errors.New("Incorrect number of arguments. Expecting 1")
    }

    err := stub.PutState("hello_world", []byte(args[0]))
    if err != nil {
        return nil, err
    }

    return nil, nil
}
```

Figure 8. Query method of the chaincode

```go
func (t *SimpleChaincode) Query(stub shim.ChaincodeStubInterface, function string, args []string) ([]byte, error) {
    fmt.Println("query is running " + function)

    // Handle different functions
    if function == "read" {                            //read a variable
        return t.read(stub, args)
    }
    fmt.Println("query did not find func: " + function)

    return nil, errors.New("Received unknown function query: " + function)
}
```

11.2.3 Invoke method()

Whenever a state of the blockchain ID is to be modified, the invoke method is called. Create, update and delete operations should be encapsulated within the invoke method. When invoke method is called, it will modify the state of the blockchain and the blockchain fabric code will automatically create a transaction context, which may execute the method. Whatever invocations are made, are recorded on the blockchain as transactions, which will ultimately is linked up with the blocks (see Figure 9).

12. HYPERLEDGER FABRIC SDK FOR NODE JS

As Hyperledger fabric is the operating system of the blockchain network which is permissioned provides a powerful API which interact with the fabric v0.6 blockchain, which is the hyperledger fabric SDK for Node.js. Node js javascript runtime is used to design the SDK. It is through the node SDK, that the User Interface communicates with blockchain. It's like a middleware where all the functions of the chaincode are called as such the deploy, invoke and query. When the particular functions are invoked, it is linked with the chaincode and the chaincode is executed according to the invoked function. The function first executed when a user interacts with the SDK is the registering and enrolling of the user, which checks with the membersrvc.yaml and core.yaml, where the enrollment certificates and the transfer certificates are generated and the user is given the access to those functions in the

Figure 9. Invoke method of the chaincode

```go
func (t *SimpleChaincode) Invoke(stub shim.ChaincodeStubInterface, function string, args []string) ([]byte, error) {
    fmt.Println("invoke is running " + function)

    // Handle different functions
    if function == "init" {
        return t.Init(stub, "init", args)
    } else if function == "write" {
        return t.write(stub, args)
    }
    fmt.Println("invoke did not find func: " + function)

    return nil, errors.New("Received unknown function invocation: " + function)
}
```

chaincode. Thus, it acts like an entrance to the blockchain ledger. Node js provides an hfc module for installing the fabric SDK (Zhang, Cecchetti, Croman, Juels, & Shi, 2016).

An identity is must for transacting on the Hyperledger blockchain which should be both registered and enrolled with Membership Services. Registration is mainly where a user invitation is issued to join a blockchain, which may consist of adding a new user enrollment ID to the membership services configuration, which could be done programmatically with the member.register method or could be added directly to the membersrvc.yaml file. Accepting a user invitation to join the blockchain network is the enrollment, which is done by the entity that transacts on the blockchain and could be done programmatically through the member.enroll method.

12.1. HFC Objects

1. ***Chain:*** This is the main higher-level class which is the client's representation of the chain. Interaction with multiple chains is allowed with the help of HFC and also shares a single keyValStore and MemberServices object with multiple chains.
2. ***keyValStore:*** Stores and retrieves all the persistent data and is the very simple interface used by the HFC and the storage includes the private key which needs to be so secure.
3. ***MemberServices:*** It's an interface which represents the Membership services and is implemented by the MemberServicesImpl class, and provides identity features such as privacy, unlinkability and confidentiality. This implementation issues ECerts for enrollment identity and TCerts for transactions.
4. ***Member or User:*** It represents the users who transacts on the chain and also the peers who are also the members who does the checks on the transactions. Registering and enrolling of the users can be done which interacts with the MemberServices object. Deploy, Query and Invoke functions can also be called, which interacts with the peer.
5. ***TransactionContext:*** Deploy, Invoke and Query is implemented in the TransactionContext, which interacts with the membership services to get a TCert to perform these operations. One-to-one relationship is maintained between the TCert and TransactionContext.

13. ADVANTAGES OF DISTRIBUTED LEDGERS

- It creates a cryptographic transaction network without mediators.
- Consensus is based on the veracity of transactions.
- Transaction penance and immutability
- Avoidance of "double spend"
- Prevention of failure of single node to bring down the entire system.
- Brings up a permanent time and date stamp.
- Scalable to many participants, account holders and account entries.
- Applicable to financial assets in capital markets.
- Provides faster clearing and settlement.
- Authorized parties are allocated to access and verify ownership records with information and processes embedded in chaincodes.
- Ledger consolidation

14. PERFORMANCE EVALUATION

Bilateral Repo deal contract which is a Hyperledger project, is mainly a deal between the clients through an agreement. The Dealer and the Investor captures the Inventory Management, where the chaincode gets invoked and a notification is sent to both the custodians (Clearing bank and Investor custodians). After approving the noti_cation by both the custodians, their deal can be enquired by only their custodians and editions are also done in the enquiry part. After the Inventory capture, Admin captures the Repo deal capture, which is invoked by the chaincode, and noti_cations are sent to both the users (dealer and investor). After approving the notifications, they can query their deal with their respective Reference ID. Deploy, Invoke and Query is done by the chaincode according to the business logic. The Query can be done only if both the users accept the notifications as it confirms a proof of deal between the clients. Whatever deal is done between the clients, is stored in the ledger as a proof of transaction. During the enquiry of a query, the contract is settled and invokes the settlement function in the chaincode, and the notifications goes to both the custodians, who views and approves the settlement deal. Collateral Substitution is a provision in a contract which allows the buyer to obtain a release of the real collateral by replacing it with another form to the seller. The chaincode invokes the collateral substitution function and notifications are sent to both the custodians. After the approval from the custodians they can enquire it, as of what changes have happened between the dealer and the investor. All the transactions which are happening, can be seen on the dashboard as live, where the blocks are getting incremented as per the logic on the smart contract.

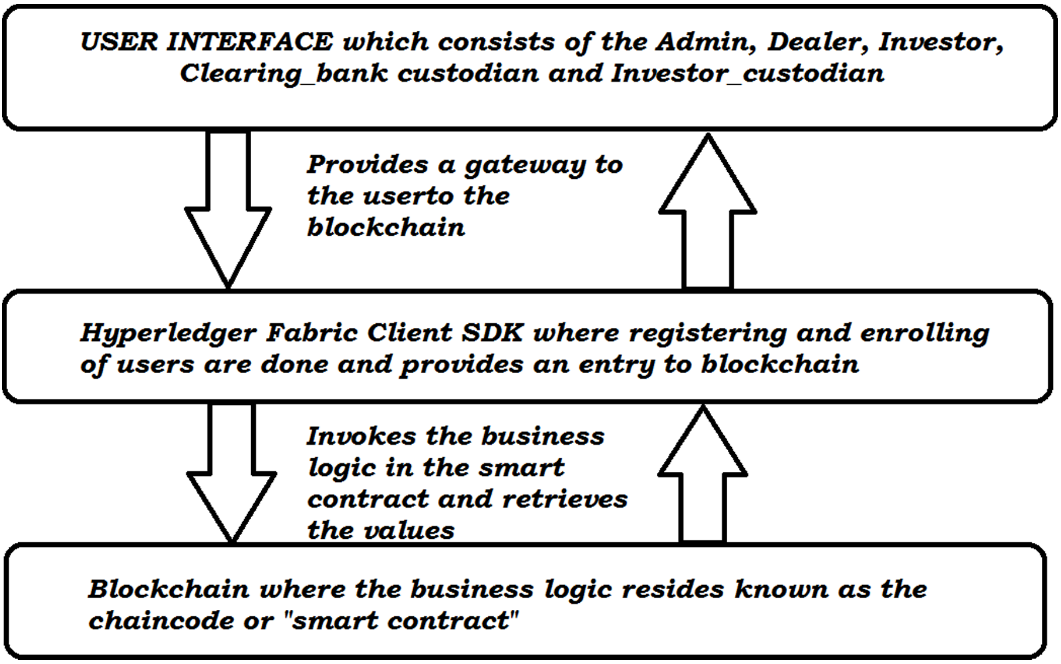
14.1. Workflow of Repo Deal Contract

See Figure 10 for the workflow of Repo Deal Contract.

15. RESULTS OF BILATERAL REPO

- The results of Bilateral Repo, which is an Hyperledger fabric project proved a tremendous use case to the financial industries.
- The console are used by the Dealer and the Investor or The Seller and the buyer.
- The use case is made in such a way, that the Dealer and the Investor logs in to the console in which either of the parties have to make an agreement for the stock or trade they are going to buy and sell.
- There are various modules such as the Inventory Management, Repo deal capture, Agreement templates, Notifications and the Collateral Substitution.
- Each of the screens consists of their own respective chaincodes with functions and the data which is stored in the JSON format.
- Each of the Dealer/Seller and Investor/Buyer have their own custodians in which, if and deal happens can only be viewed by the user and their respective custodians.
- Clearing Bank custodian is the custodian for the Dealer and Investor_cust custodian is the Investor.
- When the user logs in to the console, the first step is it deals with the membership services to retrieve the TCerts and ECerts for the users and validates their authentication and authorization.
- Either of the Dealer or the Investor has to log in with Inventory Management and captures the inventory.
- When the Inventory Management is captured, it deals with the chaincode of Inventory Management and invokes the JSON.
- As soon as both of them invokes the chaincode successfully, notifications are sent to both the custodians who on accepting it can enquire them at the Inventory Report screen.
- After the Inventory Management capture, the Admin logs in to the Repo deal screen to capture the deal between the dealer and the Investor.
- The Admin is validated and authenticated through the membership services, and submits the Repo Deal.
- After capturing the deal, it interacts with the chaincode and invokes it successfully.
- After invoking from the chaincode, notifications are sent to both the Dealer and the Investor.
- The Dealer and the Investor have to either approve or reject the notification.

Figure 10. Workflow of Repo Deal Contract



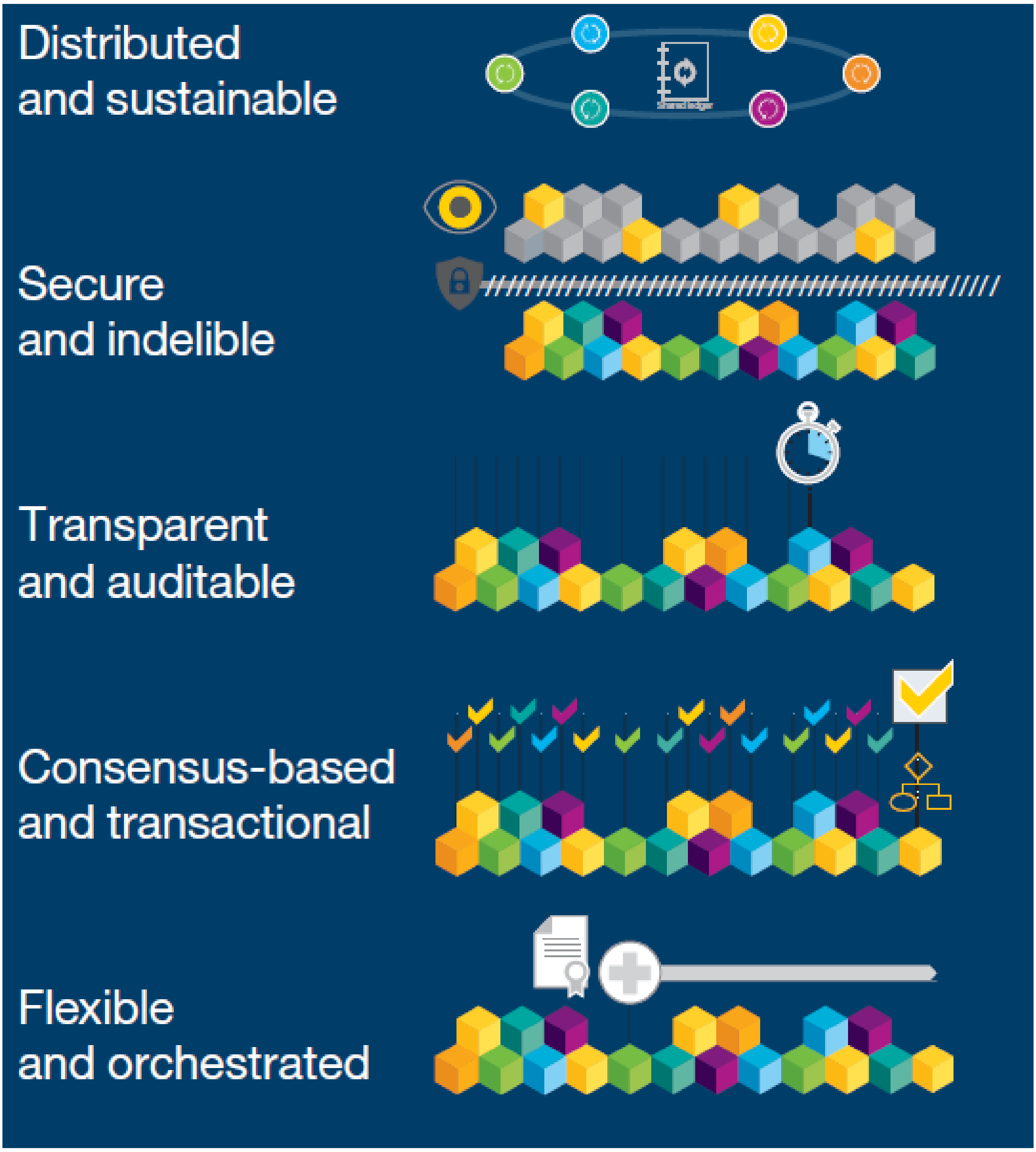
- After approval of the notifications, the admin, dealer and the Investor can either enquire it through the Deal enquiry screen.
- The Enquiry screen consists of all the details happened between the Dealer and the Investor.
- The Enquiry screen consists of an edit, save, settle and close button where the editing can be done if required and is saved.
- After saving the settlement is done between both of the users by clicking on to the settle button and again close button enables all the buttons to be unseen from the screen after editing.
- When the settlement is done, notifications are gone to both the custodians who on approving it can enquire it in the Inventory Report screen.
- Again, Collateral Substitution screen is there, where multiple collateral fields could be added if needed and the deal is submitted which invokes the collateral substitution function and notifications are gone to both the custodians.
- After approving the notifications, the custodians can enquire it in the Inventory Report.
- Some in built calculations are also built which on doing some calculations automatically calculates the amount (see Figure 11).

The issues that can be faced while transferring of an asset is Inefficiency, Expense and Vulnerability. The Hyperledger model helps these vulnerabilities and inefficiencies by providing the Membership services and the contract confidentiality mechanisms (see Figures 12, 13, and 14).

16. RESEARCH POTENTIALITIES IN FUTURE CONTEXT

Utilizing blockchain innovation along these lines could interestingly empower customers to purchase and offer computerized duplicates second hand, give them away or give them to philanthropy shops, loan them to companions incidentally or abandon them as a component of a legacy – similarly as

Figure 11. Attributes of the blockchain platform



they used to with vinyl and books – while guaranteeing that they are not proliferating different unlicensed duplicates. For blockchain to prevail with regards to supporting a technique for overseeing computerized rights where such a large number of others have fizzled, it would need to adjust the privileges of venders, purchasers, system of performing artists that involve the first proprietor of the substance and an enormous scope of different middle people, including those that create and keep up the blockchain itself. With such complex systems of interests in question, it would be hopeful to expect a brisk and uncontroversial answer for rise, albeit some recommend that inside a timescale of 10 to 15 years blockchain innovation can be relied upon to have had a genuine effect on the music business, with quicker open doors for early movers.

Figure 12. Hyperledger fabric model

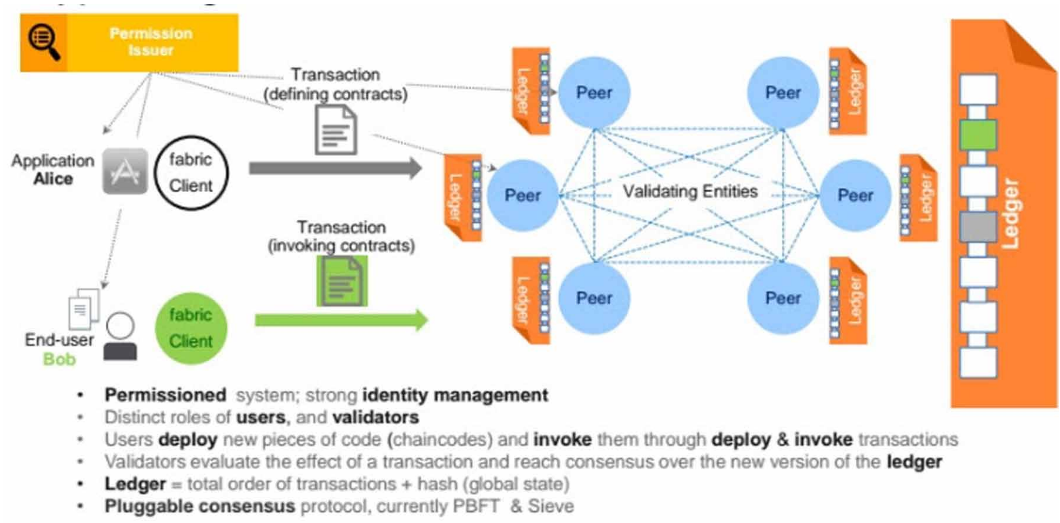
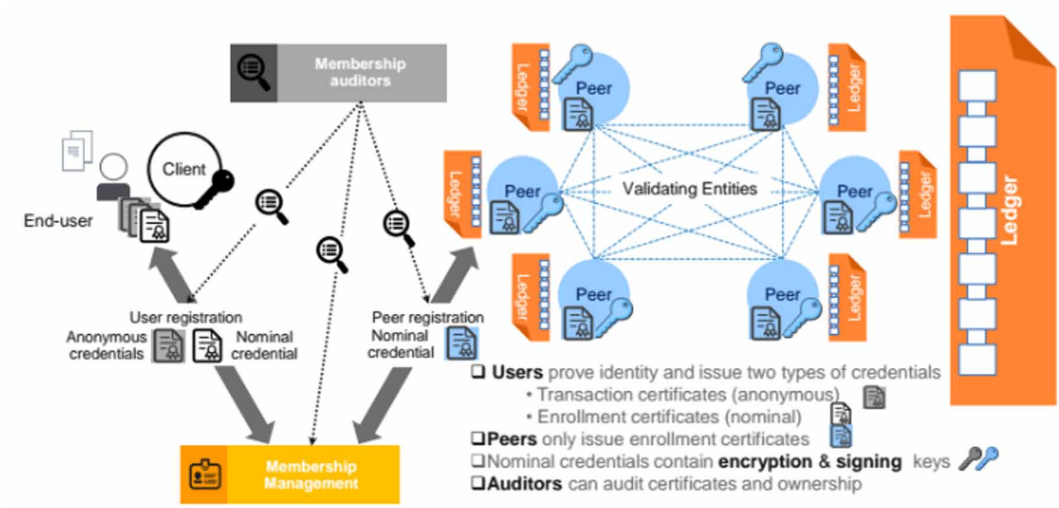
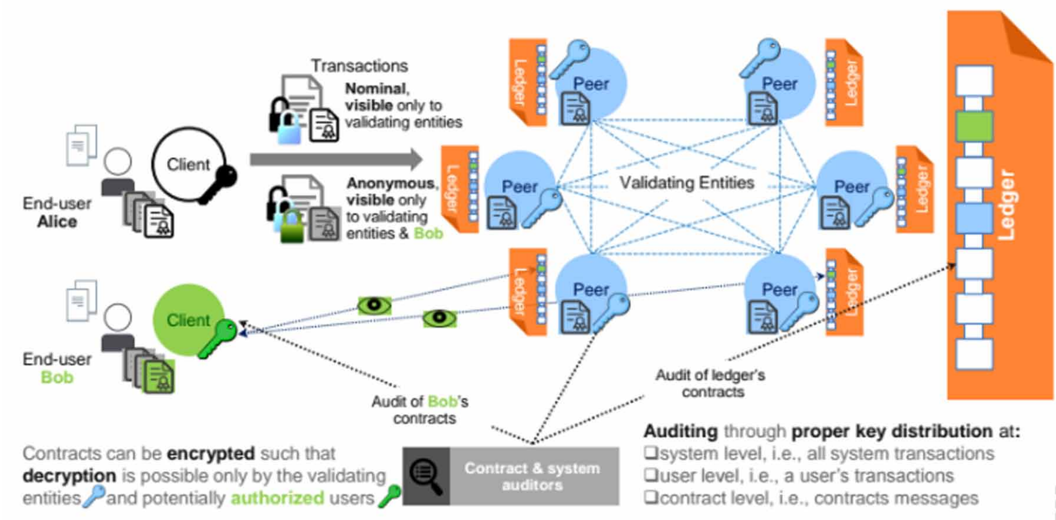


Figure 13. Working of membership services



Efficient mapping study was chosen as the examination technique for this investigation. The objective of a precise mapping study is to give a review of an examination range, to set up if look into prove exists, and evaluate the measure of proof. We picked the deliberate mapping process as our examination strategy on the grounds that our objective was to investigate the current investigations identified with Blockchain innovation. The consequences of the mapping study would help us to distinguish and outline ranges identified with Blockchain innovation and conceivable research crevices.

Figure 14. Smart contract confidentiality



17. CONCLUSION

"Blockchain in capital firms" plays a major role in the life of the dealers and the Investors which enabled them to do transactions in a secure way without the use of a "middle man". Blockchain which is also known as the distributed database of economic transactions where each and every users are registered and enrolled based on the membership services. Smart contracts are built based on the business logic, which on deploying, invoking and querying the chaincode is done by the programmatic code. Smart contracts which acts as a major backbone of the blockchain network can be accessed only through the HFC SDK. Thus, it helps many of the Fintech industries in bringing up their trust on the customers and increasing their efficiencies and stabilities across the global world.

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Abdul Quadir Md is a PhD student and currently an Assistant Professor in the School of Computing Sciences and Engineering at VIT University, Chennai. His research focuses on Trust Management in Multi-Cloud Environment. He has taught a number of courses on computers over the years.