OPEN ACCESS
Saudi Journal of Engineering and Technology
Abbreviated Key Title: Saudi J Eng Technol
ISSN 2415-6272 (Print) |ISSN 2415-6264 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article

Block chain-Logistics and Proposed Layer Flow Model

Muhammad Jawad Hamid Mughal[1*], M. Nawaz Brohi[2]
[1]Department of Computing and Engineering Sciences, SZABIST, UAE
[2]Faculty of Computer Science, Bath SPA University, UAE

DOI: 10.36348/sjet.2020.v05i12.005 | **Received:** 11.12.2020 | **Accepted:** 21.12.2020 | **Published:** 24.12.2020

***Corresponding author:** Muhammad Jawad Hamid Mughal

Abstract

Data protection and transparency are highly recommended modern approaches for any transaction domain. The proposed layer model will provide an improved and secure approach for transporting of goods using crypto currencies and excluding intermediate parties. Paper gives temporarily overview of crypto currency, logistics movement channels, block chain evaluation, challenges, types, applications and layer model that shows movements of good from scratch (source) to delivery (client destination) through secured transactions medium, excluding intermediate parties (banks etc.) storing signatures in distributed ledger.

Keywords: Block chain, smart contracts, digital payments, bit coin, crypto currencies and signature.

INTRODUCTION

Crypto currencies idea is shifting away the traditional financial infrastructure. Cryptographic algorithms and peer to peer network solutions of information systems are allowing security, transparency and decentralization; old cash systems were centralized and non-transparent. In 2008, a paper was published by Satoshi Nakamoto referring electronic cash (peer to peer) system [2]. Idea was of online payment transaction from sender to receiver without involvement on any third party (financial sector). Bit coin was first to appreciate the concept of e-cash system and now all digital currencies are satisfied to use this secure technology against other centralized systems. Figure-1 shows the time period of bit coin from domain registration till firstly deployed. From August 2008 till November 2008 bit coin domain was registered, design paper was published and SourceForge.net project was registered. In January 2009, genesis block was established, version 0.1 of bit coin was released and first bit coin transaction was made from Satoshi to Hal Finney (Figure-1). It is an independent online currency that includes some existing online payment features. Cash transaction requires detailed identification of payer and payee, while bit coin does not requires any identification. Recent break of current financial system causes economic crisis which advantage new class of currencies and gain community attention.

BACKGROUND

Block chain idea was first come to famous in 2009 with BTC crypto currency. It is basically an open ledger that keeps all the record in parallel to database from the time of its creation. Complex mathematical block equations are managed through multiple computers connected in a network and are allowed to verify changed made in public ledger. Computers are connected in decentralized network, where bit coin software is installed, running and maintaining blocks through computers. To join network of computers that run bit coin utilities and maintaining block chin does not required any permission or authorization to join as it is public, permission less, anyone can join. This differentiates the technology from current financial companies system [3]. In 2013 several companies were promoting the concept of block chain without the bit coin ideas. At that time few preapproved participants were allowed to manage or allow making changes to block chain. Ledger is a set or collection of all financial records/transactions which is shared among all members in a network.

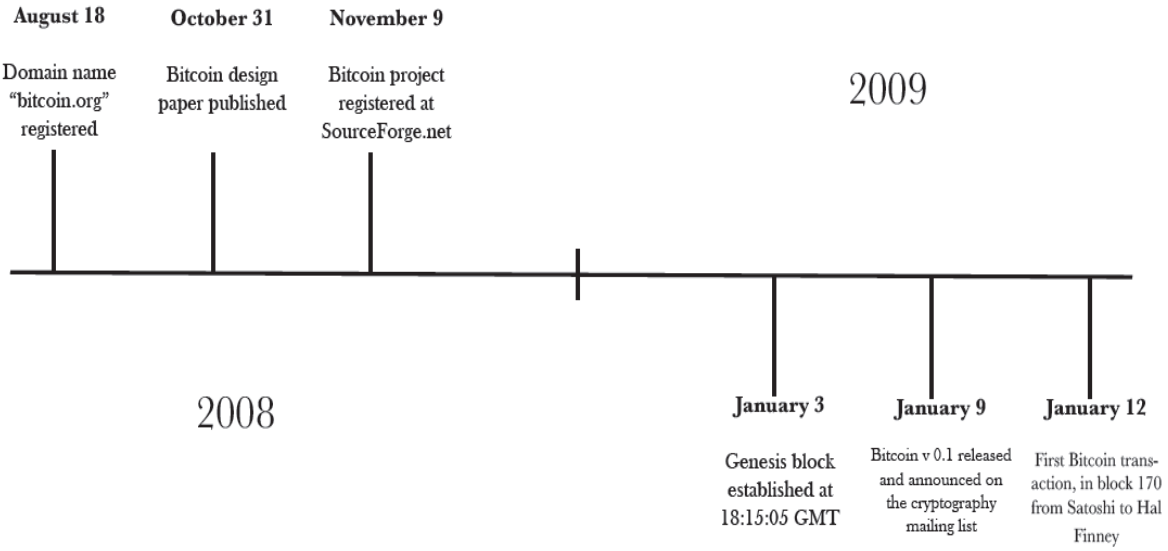

Fig-1: Bit coin History [2]

Academic work on block chain is less but its growing. SSRN listed 37 papers in Mar 19, 2016 using block chain terminology, in July 2017 number increased to 222 papers which describes technology and legal concerns. Overview on block chain delivered by Harvey in 2015, Cong and et al in 2017 studied the action of smart contracts associative to block chains and decentralized agreements on improved contractibility and enforceability made possible by smart contracts, point raised by Catalini and Gans in 2016 that due to distributed financial records lower the verification and networking cost which can help in deployment of this new idea (process), in 2017 Khapko and Zoican focuses on the importance of quick settlement feature of block chain and how it can time efficiency can affect market strategies. Brummer (2015) outline the effects of technological confusion on financial market regulation and Yermack in 2016 described possible suggestion of block chain structure on corporate governance [4].

MATERIAL AND METHODS

Block Chain

Block chain is designed for storing financial transaction records (ledger), it can be extended to new states for implementing decentralized resources. Each resource in decentralized peer to peer network can process transactions to other states in secured manner. Generating new state machine in block chain, all nodes are updated in a network and define it as a valid state [5]. In financial area block chain gain great famous because people start realizing that this technology has potential to bring improvement in financial industry. Internet provides users a platform to buy or sell goods without giving profit to retailers (third parties, agents etc.). Block chain idea is to provide people a secure transaction, transferring sensitive information and financial claims without intermediaries involvement, that also act as keeping users information. Michael Casey (from Media Lab) described during AFA 2016 meeting that after Medici (15th century) block chain is the first technology which brought change in financial sectors [4]. Internet (WWW) is a frictionless technology of exchanging information and the block chain is technology of transferring values frictionless. All financial transactions are recorded publically and accessible network not in private databases. Transactions made in a decentralized network are verified by exchange parties known as public keys. Proof of work protocols are used for transactions verifications and different participants compete for fee (to verify). As per economic perspective there are great chances of adapting this technological transformation in future.

How Block Chain Works

Block chain is a chain of many blocks that are having decentralized structure and data in block is shared between all the members included in a network. Block chain is a house of logs where many records are grouped by time stamped blocks. Every block has its unique hash number which identifies the block. Each block refers to the previous block (block = n+1 will refer to hash of block = n, block = n will refer to hash of block = n-1, block = n+2 will refer to hash of block = n+1 and so on) that creates link between each block and give a shape of chain to blocks. Every block has the information of each transaction made in a network and nodes that are ordered in a chain by back linked blocks can crack the data state being transferred in network. To understand work of block chain in a better way, we needs to know how network of block chain runs. Nodes (clients) work on similar block chain. Node is an entry point for multiple block chain users in a network. Assume users transacts through own nodes in peer to peer network. User interacts through public and private keys with block chain. To sign own transactions private key is used whereas public key is used for addressable throughout the network. Those transactions are broadcast to nearest peers by user's node that is signed. Incoming transactions are validated before any further

action as it will supply to whole network and invalid are rejected [6]. After that validated transactions by above process are packaged into sequence of information (time stamped) block and this process is called mining. At the end node verifies either suggested block hold transaction which is valid and it is referring to hash of pervious block in a block chain is correct. If all the material is verified and correct so block is added to chain. If this is not the case so suggested block is discard. That process is repeating. What initiates the transactions validation? Block chain shared database without any trusted middleman or authority. To prevent distributed environment of block chain from any break down and to help protected glob view of block chain; certain rules should be follow on which all the database transaction should make their satisfaction. Rules are programmed for chain clients and are used to decide whether incoming transactions are valid and save to broadcast them on network. If steps mentioned above are followed by any node, the block chain that is operated by specific node becomes authenticated for network activities.

Block Chain in Transportation

Block chain integration with transportation will be beneficial for industry (mostly import/export) and will provide ease for distributers and clients. Intermediate parties will be removed and data transfer will more secure. Block chain can advantage transportation with crew information, weather statistics, accident alert and records, vehicle mileage etc. Participants of block chain can have access on previous records, maintenance, and will have equal rights depends upon restriction level. Organizations involved in supplying materials can have a secure access for update shared descriptions, digital bills etc. and are able to verify transactions. Block chain is accessible and viewable (under assigned permission level) for parties included in transaction like manufacture, third parties, government sectors etc. this way parties can monitor the quality of ordered products and can argue if the product is fake or copy [15].

Block Chain Forms

Block chain mainly consists of three different type i.e. public, private and hybrid. Each type is explained one by one. These types appear after bit coin introduced block chain technology to the world.

A) Public Block Chain

Public block chain also known as not permissioned, is a type in which everyone can participate either by reading or by making transactions. It is a decentralized ledger network. Transparency is one of the key features in this type but some industries like banking sector only transact with few peers (trusted) [7]. Public type nature is that it is free for everyone for internet users. For validation decentralized chain of blocks relays on consensus algorithm (proof of work mechanism is used). In bit coin case the chain having maximum proof of work measured as valid ledger [8].

B) Private Block Chain

Private and hybrid types are also known as permissioned, centralized and usually use in close group. Permissioned is preferable feature that participants should have within an organization. Private is used in single organization (like Government Sector) where users / participants are pre-defined. Transaction validators in private block chain are part of the ledger and can read valuable data. To avoid arbitrary behavior for transaction validation byzantine algorithm is used. In such type a centralized entity acts as controller for other entities to make them as reader / writer [7]. In private ledger, permissions (write) are organized by central position (decision maker) and only read permission can be public or limited.

C) Hybrid Block Chain

Hybrid is a grouping of different nodes (organizations) with pre-defined users and permissions. It has pre-defined miners (software installed on server) same as private block chain that can do transactions validation [7]. Hybrid lays between low trust (public) and highly trusted (private) entity model. It is also known as consortium block chains due to partially decentralized manner [8].

Table-1: Block Chain Types [7]

Consensus	Type	Governance	Trust	Scalability	Use
Decentralized, based on proof	Public, not permissioned	Anonymous nodes	Low	Limited	e.g. Virtual currency
Hybrid, based on validation	Consortium, private, permissioned	Pre-selected set of nodes	Medium	Unlimited	e.g. Banking system
Centralized, based on validation	Private permissioned	Single organization	High	Unlimited	e.g. Government notary

Applications of Block Chain Technology

Block chain technology was basically developed for improving financial sectors but it as time passes and technology was getting famous in the market. Organizations came to know that block chain is not only for financial domain but can be beneficial and be utilized for other domains. There are many applications implemented and some are still under development under block chain techniques. In this section few block chain applications are describe.

Smart Contracts

Key idea is to store term, information and material in a contract and execute automatically when terms and conditions are agreed. Block chain make contracts more secure between entities which does not depend or do not need third party confirmation. No one is allowed to disclose agreement information in smart contracts [18]. Smart contracts are very important and famous component of block chain technology. Smart contracts are generally having to complex infrastructure. They are deployed and executable in block chain network. They are used by block chain components to enter agreements and solve problems with least trust. Platforms are provided to user so they can build and execute contracts by them self on bit coin (block chain) network. Contracts can be updated even if they were submitted and also before spreading them into network. Smart contracts are simple due to scripting language and because complex flow control is not supported. In market there are many block chain platforms that can be used for smart contracts, Ethereum is one of them. It consists of its own block chain with built-in scripting language (Turnin-complete) for contract writing [10]. Main purpose of smart contract is programmable transaction; all transactions will be through digital currencies and m2m communication also known as IOT. E.g. ADEPT (IBM project). Currently, in courts contracts are enrolled by lawyers and court does the judgment. Ehtereum make its easy by encoding contracts in block chain and allow self-executing. So far DAO is the first and sophisticate app for smart contracts in a block chain; other apps exist only in prototype [17].

A) How Smart Contract Work

The concept of smart contract was introduced by Nick Szabo in 1994. That is a computerized transaction executes as contract. He proposed to translate contractual paragraph into lines of code and insert them into property (hardware / software) – to minimize intermediate parties need between sender and receiver and accidental exceptions. Smart contracts are scripts that are stored on block chain framework. As they exists on chain, smart contract are assigned with unique addresses. Smart contracts can active by addressing signature (transaction) to it. They are executed independently and are arranged automatically on to the nodes in decentralized network. This indicates that nodes in smart contracts facilitated in block chain are running VM and networks performing as distributed VM [6]. Let's take an example that includes three participants Alice, Bob, Carol and X, Y as digital currencies being traded. Bob as a participant deploy smart contract on network that defines three functions; i) deposit function that allows him deposit parts of X in contract, ii) trade function send 1 unit of X back (from contract's credit) on receiving 5 units of Y, iii) withdraw function allowing Bob for withdraw assets that contract holds. Deposit and withdraw functions are mentioned for Bob that only he can call these functions using his key. Bob made a transaction to that contract's address knowing as deposit function, move three X units to contract and this transaction is recorded in block chain. Alice own twelve Y units, made transaction of send ten Y units to contract's knowing trade function and receive two X units. It is also store in block chain. After that signed transaction is send by Bob to contact's known as withdraw function. Signature is checked by contract for ensuring that withdrawal was initiated by contract's owner and then transfer of its deposit back to Bob. Block chain that links to transaction style of bit coin can enables or qualify resources / money transfers between those country parties that have less or no trust relationship. Block chain that contains smart contracts and allows multi step interaction process between non trusted counties party. Smart contract run as independent actors and its behaviour is predictable. Noting that DAOs concept was raised due to smart contracts, objects on block chain may modifies their behaviour, if processes are following programed in contracts are followed. In simple words contract (smart) that can calls (by address) another contract to achieve its main task.

B) Digital Payments

Currently a centralized payment ledger are using for payment clearance in business for keeping transactions records and maintaining balance. Flow of payment method is, transaction is made from transacting parties to intermediate (third party or banks) after that validity is checked and then both accounts of senders, receivers are adjusted accordingly. As block chain is consist of decentralized network, each transaction made is broadcasted to all nodes of the network, which also includes; processing power, more transaction and time. Signatures also become block chain part and copied to each member computer. This is way it is considered slower and expensive as compared to centralized clearance. MasterCard and Visa can clear two thousands of transactions per second whereas bit coin can clear only seven. Block chain technology is used by bit coin not only for cheaper and quick transactions but also because for removal of third parties that acts as middleware. Transaction clearance is performed by nodes and competes to verify [17]. Maintaining central transaction records for any currency controlled is very difficult and resourceful. Eliminating third parties as middle line will provide strong advantage or distributed ledger will be more effective, this could be answer only over coming years (if market accept digital currencies).

C) Smart Home

Smart homes are basically collections of many IOT devices, immutable ledger IL, storage connected and communication to each other as shown in Figure-2. Every smart home consists of local and private IL that is same as block chain but is centralized and managed by SHM. Process includes incoming, outgoing both transactions where shared key is used for

communicating with IOT devices and storage (local). IL job is to maintain policy header that is defined by home owner for received transactions authorization. Inside the smart home local devices made transactions to share or store data. In every smart home there is a secure storage which is managed by SHM. Share key is distributed between all IOT devices and storage and this key is used by smart home devices from stored transaction generation [9]. Core component for smart home includes home miner, local BC, transactions and local storage.

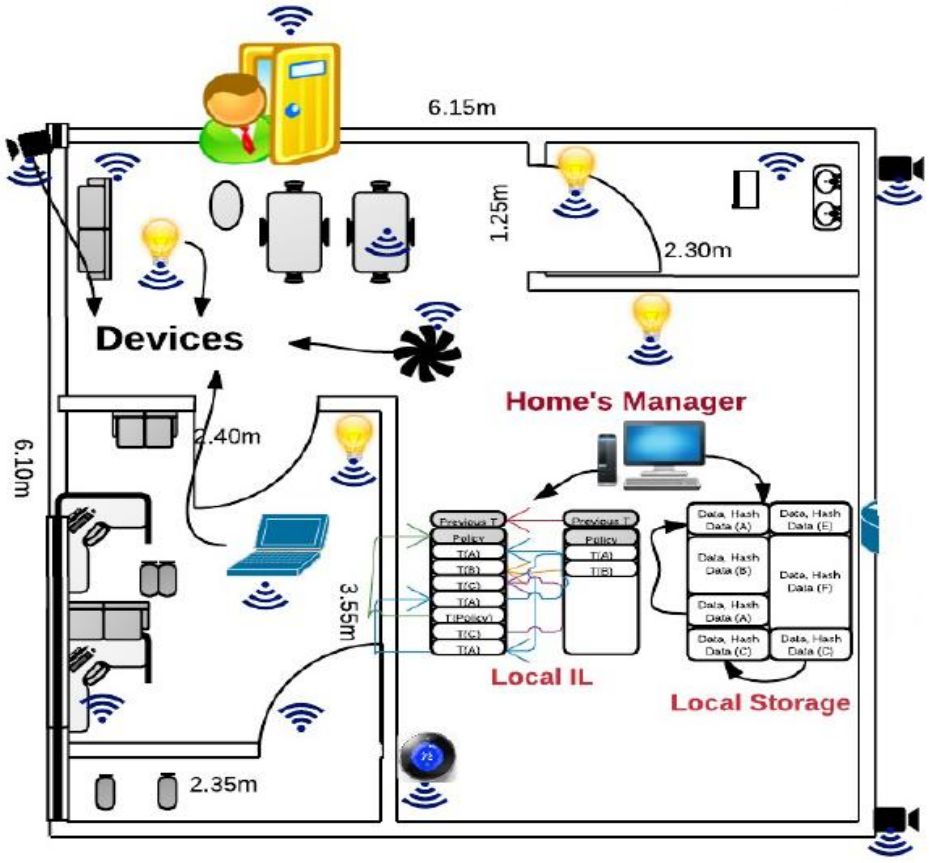

Fig-2: Block Chain Based Smart Home Layout [9]

Cloud Storage

User's data is grouped, stored in identical blocks and given a unique number to block. For authentication SHM uses block number and hash of data. If storage is able to trace block number which was received and hash from SHM, then it means that the specific user is authenticated. Data from user is received in the form of packets and stored in FIFO manner in blocks besides hash. Suppose Alice is a user who created account in cloud storage and assign permissions to components for data upload to cloud facility. While bootstrap process in cloud storage; cloud initiates the pointer to first block data. Data is send to SHM at the time data to be stored by thermostat in cloud. After sending data to SHM permissions are checked, block and hash numbers are extracted from local IL. Then random ID is generated and attached to data to be sent to storage. Two nodes cannot have the same ID at the same time. First, transaction validity is checked; also space availability is calculated and confirmed in cloud storage. Hash of data packets received is compared with hash received in transactions. If two hashes are matched then packets are store in cloud storage and new block no. with SHM private key is encrypted [9].

Block Chain Challenges

Block chain is an evolving technology that faces multiple challenges. Major challenge related to block chain is the lack of awareness, especially areas other than financial (banking) domain and lack of technology understanding (how it works). Distributed ledger technique is one of the great innovations in recent time but it may take significant amount of time to adopt widely. Following are few typical challenges with block chain described.

A) Scalability

Block chain size is becoming huge due to daily massive amount of transaction. Every node in a block chain has to store all the transactions to verify if the source of transaction is valid or not. There are millions of transactions in block chain per second but block chain has a restriction of approximate seven transactions per second, which cannot fulfill the processing of millions transaction that can delay the

small transactions because block chain (miners) gives priority to higher transaction over small once. Block chain scalability problem can be classified into two types:

- Storage optimization, which means that for a node in a block chain, it is difficult to operate full ledger copy. For this Bruce suggested a new crypto currency scheme, in which previous records (transaction) are removed by network [1].
- Redesigning, Bit coin NG (Next Generation) idea was proposed to redesign block chain. Idea was to divide standard block in to two i.e. key block first part for leader election and micro block for transaction storage [12].

B) Irreversibility

One major but least noted challenge of a block chain is irreversibility. Transaction with the involvement on three parties can lead to human or software errors but can easily be reversed by engaging with intermediate parties. Block chain is more complex and reversing things are more complicated. When blocks are confirmed and new blocks are attached to previous block chain becoming a chain member, it is difficult but possible to reverse any transaction made [17]. Fork problem is a problem that is related to decentralized node version and occurred when software updates. Consensus rules are changed for nodes when new block chain software version is updated. Nodes can be split in to two half i.e. old nodes and new nodes. Following four situations can be appearing: new nodes will agree with transaction of block sending by old nodes. New nodes will not agree with transactions of blocks by old nodes. Old nodes will agree with transaction of block sending by new nodes. Old nodes will not agree with transaction of block sending by new nodes. Due to these four cases fork problem is created and according to these cases problem can be divide in Hard Fork and Soft Fork [13].

C) Privacy Leakage

Certain amount of privacy can be maintained by block chain itself through public and private keys. Without any identity surety users share their public and private key for data transaction. Transactional privacy is not fully guaranteed by block chain as transaction values and balances for public key can be seen publically [19]. Bit coin transaction can reveal user information. A technique was presented by Biryukoc et al that can link user pseudonyms with IP address and can work if user is on the other side of firewall or NAT. Clients connected to set of nodes can be identify uniquely [14].

RESULTS AND DISCUSSION

Block chain Logistics

In logistics, moving of assets from one location to another requires many steps that consist of information of goods as well as financial records. As shown in Figure 3, the international logistics consist of many individual steps on both sides i.e.; export and import. For every shipment made in response of request from client side requires flow of phases that includes manual entry of data, storing transactions records, documentations, approvals etc. International shipment is actually divided into to two parts, one is exporter's domain and other one is importer's domain. When request is initialized at exporter's end, all the required assets are getting ready for shipment. Local as well as in international logistics depends on various departments that perform their tasks and forward the shipment to next phase (same happens on importer's end). Firstly, exporter arranges the material for shipment and prepares required documentation. Documents then send to export customs for verification and standard amount being paid by exporter's bank. After customs clearance documents are rechecked by logistics department and materials along with documents are forwards for export through drivers. On the importers end, first carriers receive the martial and forward it to import house / port. Other phase is custom clearance, if items send are valid and cleared by import custom then items are forwarded to importer else request is cancel and martials are send back. This traditional process is complex, non-transparent and time consuming.

Table-2: Comparison of logistics workflow with and without Block Chain Technology [1]

Characteristics	Without Block Chain	With Block Chain
Documentation	More	Less
Transparency	No / Limited View	Yes
Security	No or very less	Highly Secure
Traceability	Yes but too difficult	Easy and Accurate
Delivery Confirmation	No or too late	On Time
Invalid Transaction	Can be happen	Hash # changes
Off days Approval	Wait for working day	Works even on off days
Physical Currency	Yes	Digital Payment (Bit Coin)
Exchange Rate	Every time	Standard for Bit Coin
Agents	Yes	No
Integrated Planning	Less	Highly
Information Flow	Delay per organization	On Time, accurate
Toll Payment	Manual	Digital / Bit Coins

Manual entry, documentations, record storage, financial records and clearance, human availability etc. can be the factors in delaying of delivery that can cost business / organizations. Implementing this process using block chain techniques may reduce various logistics problems i.e. cost saving, less documentation (save papers / ink) automated and error free process. Additional advantages of have data transparency, predictability of logistics operations, speed the delivery of goods and valid transactions. Block chain can overcome the logistics problems and provide and efficient process, that can build trust between different companies / stakeholders. Further stockholders can share the information by natural security block chain mechanism.

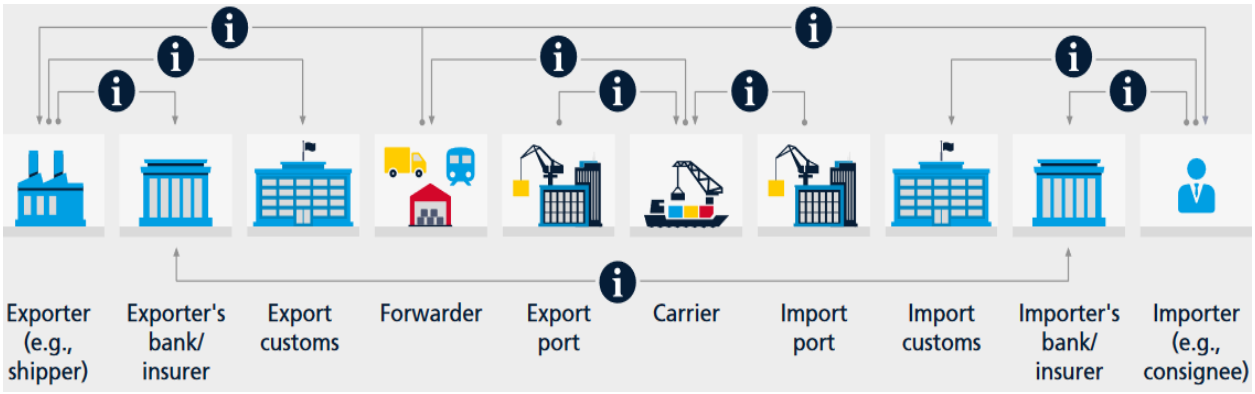

Fig-3: Information Flow in International Logistics [11]

Logistics Planning and Procedure: International Shipment

Shipment of goods upon client request is an important part for any organization. There are many methods used for international shipment i.e. by road, by air, by sea. Some organization uses their own logistics for delivery of material (these are big companies), some get in contact with third party logistics for the delivery (those are small companies and cannot afford logistics department). For international shipment some standard rules are followed with in the organization and out of the organization for validation and clearance of assets from on geographical location to another. Each organization has its own process flow for international shipments. Figure 4 shows logistics planning flow for international shipment of a particular organization. Flow diagram describes the flow materials, that how the request is made and how it is processed by different departments. At first instance requestor makes a request for any item needed. The request is received by inventory department and stock availability is checked. If the requested items are available then request is forwarded to hire desk for making of commercial invoice. Each department has their own hire desk team which keeps the information of in-house inventory and updates the customers online. Once commercial invoice is ready with all the requirements entered and signed by authorized persons (supervisor, manager, managing director etc.) for approval, the invoice is then submitted to logistics department for further action. Logistic team double checks the information and ready the documentations like country of origin, export etc. Then transportation is arranged for delivery and materials are dispatched from the yard.

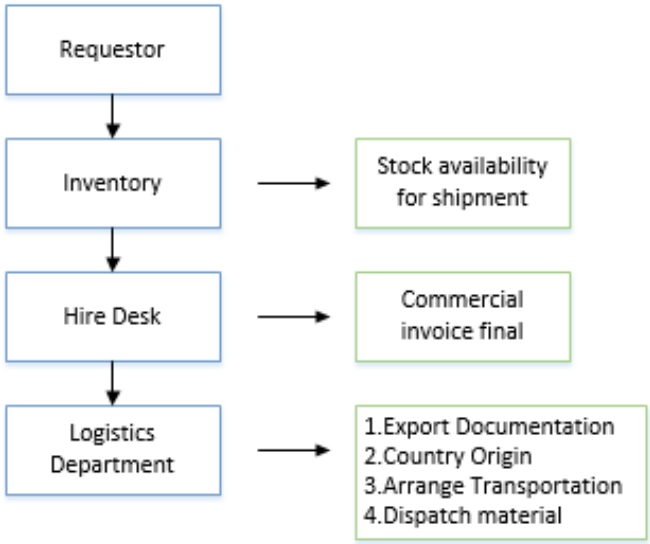

Fig-4: International Shipment Logistics Planning

The logistics team receives the commercial invoice/ packing list from the hire desk. They print out the packing list and hand it over to the warehouse coordinator for cross checking. The store keeper or the warehouse coordinator ensures that all details on the list are correct. If any changes have to be made, the warehouse coordinator informs the hire desk and the packing list is revised and sent again to the logistics team. This is followed by the export document process and applying for custom duty. Simultaneously, the logistics team arranges for the preparation of the plates for fleeted items (if required) as per the details provided by the workshop (such as serial number, frequency, etc.)

Once the export document process and custom duty process is complete, logistics arranges for transport from a 3PL (third party logistics). The modes of international shipments include land, air (<100kg) and sea. Logistics receives quotes from three 3PL companies and chooses the appropriate one from it. The PO is created and approved by the MD. The selected 3PL company regularly updates the logistics team regarding status of the shipment. After delivery by 3PL, the confirmation, invoice and other related documents are submitted to organization.

Layered Model

Layered model mainly consists of various horizontal layers that are segregated due to their roles and performance. Every layer has own responsibilities to perform. Proposed model entail of presentation, business logic, network / security and data layer.

Request originated from presentation layer shall move to next close layer i.e. business logic layer and then move till network layer. Model shows the operations performed by conceptual implementation in layered approach, from creating invoice till delivery and data storage in data layer. In data layer all transactions record are stored and two ways arrow shows communication between interfaces, data extraction from database at runtime.

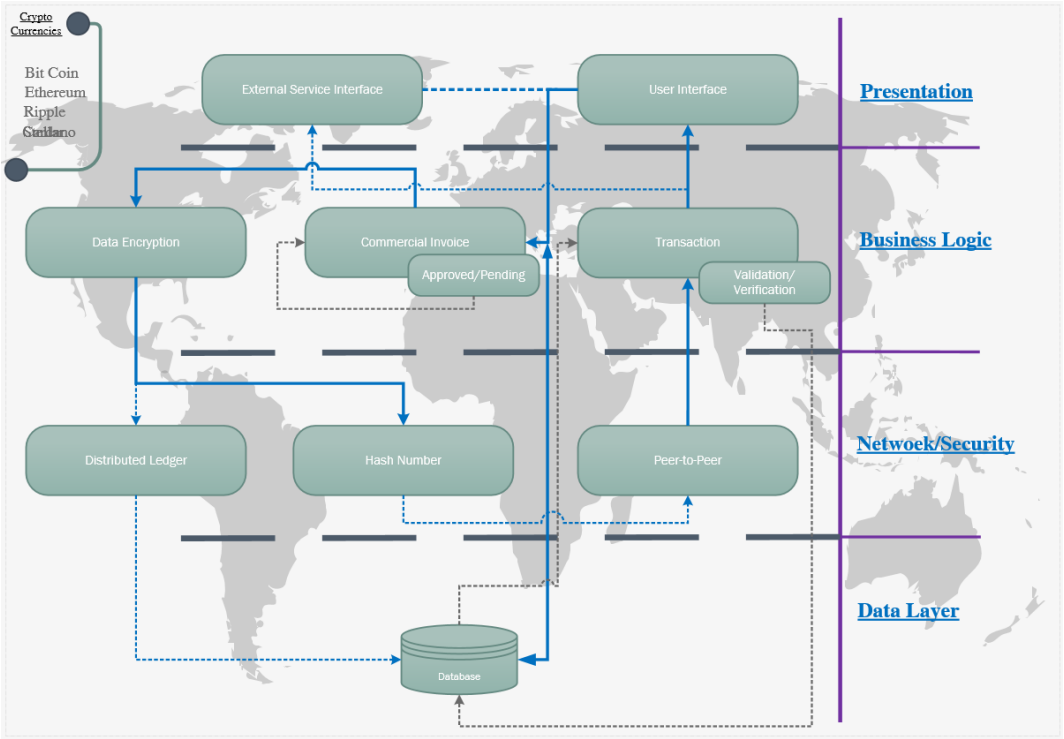

Fig-5: Proposed Layered Model

User interface and external service interface are the attributes of first layer. User get the request and starts initiating process using app interface. All required information must be provided to reduce further delays. Dotted lines in Figure 5 shows inter communicational and connected channels which links to other layers.

Invoices generated in first layer will get approved by authorized management and transactions are validated or verified in business logic layer. Most important different complex mathematical equations are used to encrypt the data. SHA 256 is mostly known algorithm used for data encryption in block chain technology. All approved signature are moved to database to be accessible throughout the chain.

In network layer nodes are loosely connected to each other that forms p2p network with no fixed topology. Each node have its own unique ID that helps secure transactions in block chain. Hashing technique is used encrypt data in block. Every block has a hash number which is linked to previous block hash number.

Slightly change, fraud or any kind of interruption will change the whole values in block chain [1].

Database stores all the information alone with transactional records and security breach.

CONCLUSION

In this paper, we are proposing a layer model for logistics automation using block chain technology. The model will help to eliminate extra work, unnecessary activities/involvements of third parties. Breaking down the complex process into multiple layers which will distribute the work and complete it phase by phase. Segmentation will provide more data security and ease in traceability. Due to block chain and crypto currencies the model deliver secure transaction from initializing request till delivery.

REFERENCES

1. Mughal, M. J. H., & Brohi, M. N. (2019). Proposed Workflow and Conceptual Implementation for Logistics Automation Using Block Chain Technology. Journal of Mechanics of Continua and Mathematical Sciences, 14(4):406-418.
2. Crosby, M., Pattanayak, P., Verma, S., & Kalyanaraman, V. (2016). Blockchain technology: Beyond bitcoin. Applied Innovation, 2(6-10), 71.
3. Walch, A. (2015). The bitcoin blockchain as financial market infrastructure: A consideration of operational risk. NYUJ Legis. & Pub. Pol'y, 18, 837-839.
4. Katya, M., & Andreas, P. (2017). Market Design with Blockchain Technology. Social Science Research Network.
5. Azaria, A., Ekblaw, A., Vieira, T., & Lippman, A. (2016, August). Medrec: Using blockchain for medical data access and permission management. In 2016 2nd International Conference on Open and Big Data (OBD) (pp. 25-30). IEEE.
6. Christidis, K., & Devetsikiotis, M. (2016). Blockchains and smart contracts for the internet of things. Ieee Access, 4, 2292-2303.
7. De Kruijff, J., & Weigand, H. (2017, June). Understanding the blockchain using enterprise ontology. In International Conference on Advanced Information Systems Engineering (pp. 29-43). Springer, Cham.
8. Pilkington, M. (2016). Blockchain technology: principles and applications. In Research handbook on digital transformations. Edward Elgar Publishing.
9. Dorri, A., Kanhere, S. S., & Jurdak, R. (2017, April). Towards an optimized blockchain for IoT. In 2017 IEEE/ACM Second International Conference on Internet-of-Things Design and Implementation (IoTDI) (pp. 173-178). IEEE.
10. Xu, X., Pautasso, C., Zhu, L., Gramoli, V., Ponomarev, A., Tran, A. B., & Chen, S. (2016, April). The blockchain as a software connector. In 2016 13th Working IEEE/IFIP Conference on Software Architecture (WICSA) (pp. 182-191). IEEE.
11. Matthias, H. (2018). BlockChain in Logistics. DHL Customer Solutions & Innovation, Germany.
12. Eyal, I., Gencer, A. E., Sirer, E. G., & Van Renesse, R. (2016). Bitcoin-ng: A scalable blockchain protocol. In 13th {USENIX} symposium on networked systems design and implementation ({NSDI} 16) (pp. 45-59).
13. Lin, I. C., & Liao, T. C. (2017). A survey of blockchain security issues and challenges. IJ Network Security, 19(5), 653-659.
14. Biryukov, A., Khovratovich, D., & Pustogarov, I. (2014, November). Deanonymisation of clients in Bitcoin P2P network. In Proceedings of the 2014 ACM SIGSAC Conference on Computer and Communications Security (pp. 15-29).
15. Clark, M. (2018). What Blockchains Could Mean for Government and Transportation Operations. U.S, Tech Report January 2018.
16. Zheng, Z., Xie, S., Dai, H., Chen, X., & Wang, H. (2017, June). An overview of blockchain technology: Architecture, consensus, and future trends. In 2017 IEEE international congress on big data (BigData congress) (pp. 557-564). IEEE.
17. Saifedean, A. (2017). Blockchain Technology: What is it good for?. Social Science Research Network.
18. Laura, J. (2017). The blockchain technology and its applications in the financial sector. Aalto University, Bachelor Thesis.
19. Meiklejohn, S., Pomarole, M., Jordan, G., Levchenko, K., McCoy, D., Voelker, G. M., & Savage, S. (2013, October). A fistful of bitcoins: characterizing payments among men with no names. In Proceedings of the 2013 conference on Internet measurement conference (pp. 127-140).