Master's degree thesis

LOG950 Logistics

Implementation of Blockchain Technology in Supply Chain

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Preface

In Starting, I would like to thank my father, mother, sister and my whole family for all financial and emotional support. I fully appreciate all the support I got from my friends, acquaintances and other sources for getting motivated to write thesis.

Next, I would like to give a big thanks to my Supervisor, Bjørn Jæger (Associate Professor in Department of Logistics, Molde University College) who gave an idea and suggested me this topic about Disruptive Technology Blockchain, as when Bjørn suggested me this topic to think about it, I really got fascinated and excited more about Blockchain technology. I immediately decided to write my thesis about it. Though, I had seen couple of videos about Blockchain on TED Talks but I did not know exactly, what was it all about.

I sincerely thank to my dear friend and mentor Agaraoli Aravazhi, who constantly assisted, motivated and always told me good suggestions to work upon the thesis with sources like: good links with articles, sharing whitepapers about new start-ups with Blockchains etc.

I greatly appreciate and thankful for Stephen Nilsson (Blockchain Evangelist, Solution SAP Architect) who gave his valuable time to teach us some Bitcoin Blockchain Programming, which gave us insights about how hash-codes are stored and retrieved onto a Blockchain. He shared a case study model, on which he is working in Skye Consulting AS. Blockchain in Fish Farming Industry using Blockchain as a Universal Source of Truth.

I would to give a big thanks to Nazar Khrupalo (Sales Manager Assistant in Applicature) and Jim Sabogal (Health-Care Leader to use IT systems in T-systems) who gave their precious time for interviewing about the Blockchain and helped to make this study about Blockchain well executed and gave some practical impressions about it.

Finally, I would like to give big Thanks to my Supervisor and Bjørn Jæger to motivate me about Blockchain technology to implement in Supply Chains and write Master thesis about it and organizing a Bitcoin Programming Course to give some practical lessons about it. I really hope I can continue to make much better efforts in future to make this research work inspiration for others.

Shashank Gupta

May 22, 2018

Summary

In the present situation, the modern supply chains are more intricate and chaotic because of so many members and actors have participated in the network. It's difficult to contain all the information of the players like: suppliers, distributors, transporters, storage facilities, and suppliers that contribute in design, production, delivery and sales. Besides, that there are billions of products being manufactured everyday globally, through complex supply chains that reaches to all parts of the world. On the contrary, a clear, transparent and traceable supply chain assists suppliers to minimize fraud and errors. Simultaneously, visibility, monitoring and tracking are vital for the sustainable development of Global Supply chains.
Since, based on the imbalances occurred in a supply chain by asymmetric information and other prevailing problems like Bullwhip Effect, where there is hard to understand the market demand and supply pattern. This study aims to contribute to the research field of logistics and supply chain management by researching the endeavour of Blockchain technology in Supply chains which can bring more visibility and certainty in supply chains.
The Blockchain is a disruptive technology and it is open source in nature. (Nakamoto 2008) which was initially released as a whitepaper as the mixture of existing concepts to merge all of them to make an underlying technology which is world's first decentralized, immutable distributed ledger and it has global consensus by all participants. This means that the content which is stored on the blockchain can neither be changed nor can't be deleted, thus trusted if the writer is trusted.
The main purpose of writing this thesis is to get deep insights about Blockchain technology beyond Bitcoin and how this technology can give benefits in Supply chains to improve the efficiency and endeavour of supply chains. A framework was prepared for such findings according to phases: It analysed the research questions in a segmented manner on the basis of Literature review, Case Studies and Interviews.
The findings of the thesis show that the implication of blockchain in logistics can potentially cover al the loop holes and big concerns which presently the Logistics and Supply chain industry is dealing with. All the pilot studies were being successful, and they are felicitated with features like scalability, sustainability, trust and flexibility. Finally with the case , it is noted that present system can be integrated with Blockchain system and other web services and other enterprise resource planning system.

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1.0 Introduction

The first chapter of this thesis starts with an impression of the research context and problem statement. With Aim and motivation to write the thesis to help audience understand the desire and determination of solving this problem. It also contains some concepts about Supply chain management, their present scenarios and problems they are dealing with.

1.1 AIM: To Implement blockchain technology in Supply Chains

The main Objective of writing this thesis is to research about the insights of Blockchain and to implement Blockchain technology in Supply Chains, to make it more efficient, transparent and trustworthy.

Since, it is a new technology with a lot of sensations, speculations and uncertainties; we first want to find out what's the present status of using blockchain in supply chains.

RQ 1: What's the current status of blockchain in Supply Chains?

1.2 Motivation for Blockchain Technology

1. **Transparency in supply chains:** Transparency is one of the most important and valuable pillars for any supply chain. In 2016 China had used RFID & Blockchain technology to improve Agri-food supply chain by data acquisition, circulation and sharing in production, processing, warehousing and maintaining the distribution and sales link of agri-food supply chain. It leads to provide clear transparency and visibility in Supply Chain. It will store all the product information in blockchain of every phase which brings easy access to all information in Complex Supply Chain systems. (Tian 2016)
2. **Elimination of Third party Entity:** A Blockchain is essentially a distributed database of records of public ledger(record of all transactions visible and accessible to public but all the transactions will be anonymous) of all transactions and other digital events for instance: PoW(Proof of work), Networks, Timestamp servers that have been executed and shared among participating parties (Kalyanaraman 2015a). In traditional approach (Current Paradigm) the database has central authorities who transfer actual value between them and multiple intermediaries are required to facilitate of assets and create trust. Whereas, in Blockchain Paradigm there are distributed nodes that maintain a shared source of information and trust is activated by cryptographic algorithm. So in

such a manner you won't require any central or third party entity to rely on. (Deloitte 2017)

3. **Eradication of Double Spending problem:** The double spending problem is generally spending a single coin more than once to make any payment or transaction is termed as "Double Spending". With reference to the coin here, it shows the digital coin (digital assets) unlike any physical asset. This problem can only occur with digital assets, which are at risks for utilizing more than once for any transaction. In decentralized system Bitcoin fast payments solved this problem by the mechanism of confirmation and maintaining a universal ledger (called "blockchain"). Bitcoin blockchain maintains a chronologically ordered, time stamp transaction ledger from the very start of its operation in 2009. Thus the Blockchain system verifies for the payment confirmation and if it finds that transaction id is already used then it abandon the later transaction, so this how the "Double Spending" problem can be stopped (Kalyanaraman 2015a).
4. **Security:** The blockchain uses SHA-256 Algorithm and other algorithms to encrypt the transactions (Set of Owner's Public key, hash of previous transaction, owner's signature) and records. In Blockchain each transaction is protected through a digital signature. Each transaction is sent to the "public key" of the receiver digitally signed using the "private key" of the sender. In order to spend money, owner (sender) of the cryptocurrency has to prove the "ownership" of the "private-key". The entity receiving the digital currency verifies the digital signature thus ownership of corresponding "private key"—on the transaction and using the "public key" of the sender.(Kalyanaraman 2015a)

   A small example of Digital Signature.

   Digital Signature: A digital signature is generated by Encrypting the text (document, contract, file, media etc.) with the private key of person signing the text. Any person can verify the signature using Public key of person who signed the Decrypt the Digital Signature. (Jæger 2018)

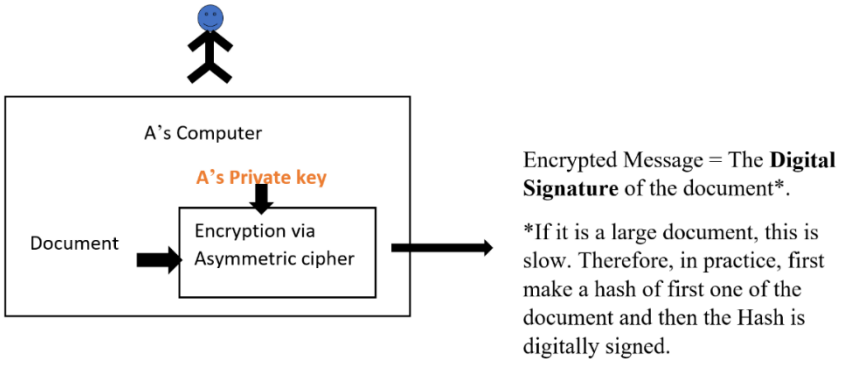


Figure 1: An Example of Digital Signature Using AES Algorithm to send Encrypted Message

Source: (Jæger 2018)

5. **Trust:** Blockchain is a distributed ledger that create permanent and shared record for each transaction associated with an asset which creates an unbroken chain of trust(IBM 2016). Every record is time-stamped and append to the event before it. The extended visibility and shared feature has provided more trust and reliability in supply chain. For offering more trust and protection in Supply chain, blockchain offers different categories of Blockchains for instance: public, permissioned and private.

   IBM Blockchain has potential to develop breakthroughs in three areas:

   - Visibility: Blockchain has provided a great visibility factor with concerns like: has our supplier sent a full order? Did the ship depart port on time? Etc. Blockchain can easily figure it out, where currently an asset is, who owns it or is handling it, what state it's in. So, with that data, organization can predict when goods will arrive and in what condition. Advantages amass up and down the supply chain from just in time planning and inventory management to reduce wastage. Data stored on the blockchain can be accessed by authorized participants, these can be all participants or only those who need a specific share of data depends on the conditions. Data ownership and access can be anonymous and still securely identified between parties who need verification. In short, it can be widely shared and protected at the same time. (IBM 2016)
   - Optimization: The base to the supply chain on the blockchain is being provided today with optimization, the next step after visibility, to minimize disruptions, for instance: Toyota desired to use blockchains to track the thousands of parts that travel through countries, factories and suppliers to manufacture a single car (Nash 2016). Optimizing a supply chain on the blockchain can make new things possible, such as real-time synchronization of decisions with supply chain members. A supply chain with continues real time access of data and situation gives the better idea to analyse the circumstances, that supplier shipment can be partially ordered, the organization can take moves like to reshuffle internal inventory complete it from different supplier or adjust pricing. They can re-route the container to different warehouse. (IBM 2016)
   - Forecasting: Demand forecasting is not a new issue in Supply chains management, with the uncertainty of demand and sales. Since, the data received from the manufacturer is hardly shared with other players in the supply chain. Point of sales data from smaller retail outlets or other points of distribution. As data on the blockchain is widely accessible, demand data like customer purchases could be instantaneously present to every participant in production or distribution

network. Synchronous data fetching could democratize the art of forecasting, which is too often confined to large manufacturers and retailers. (IBM 2016)

Smart Contracts: The concept of Bitcoin Blockchain raised could be in fact using any kind of value transaction or any kind of agreement for instance P2P insurance, P2P energy trading, P2P ride sharing etc. Based on the Bitcoin Blockchain Protocol Colored Coins and Master Coin tried to solve this concern. Since, after this concern the Ethereum project decided to create their own blockchain, and its features and characteristics are quite different from Bitcoin, separating the smart contract layer from the core blockchain protocol, its providing a new way to create online markets and programmable transactions as a piece of code containing terms and conditions known as **"Smart Contracts"**

Smart contracts are computer programs that can automatically execute the terms of contract. When a pre-defined condition in a smart contract among contributing entities is met then the parties involved in a contractual agreement can be automatically make payments as per according to the pre-mentioned conditions in contract in a transparent manner. (Kalyanaraman 2015a) Basically, smart contracts does not rely on third party authorities (Lawyers, legal advisors or other law entities). These legal entities also play a role in Supply chain management, which can be mitigated with the help of smart contracts. All the processes in dealing with such contracts are automated and controlled. The clauses and other terms and conditions of a contract are executed after all the parties have accomplished their duties. Therefore, the function removes all ambiguity pertaining to contract conditions and relevant to the existence of external dependencies. (Krystsina 2017)

6. **Scalability:** The collaboration between IBM and Maersk project in which the case study is taken about delivering the flowers from the Port of Rotterdam (Netherlands) to the Port of Mombasa(Kenya) can be eased with eliminating the complexities of the supply chain and the sheer point to point communication across a loosely coupled web of land transportation providers, freight forwarders, customs brokers government's ports and ocean carriers. Therefore, reducing all those complexities and hurdles will enforce them to deliver orders shipment on time and will reduce other physical documentation of sending courier to other countries, in terms of global supply chains. Therefore, in this manner this could save millions of dollars annually. This could increase worldwide GDP by 5% and total trade volume by 15%. (IBM 2017a)

Since, above mentioned features are one of the most potential and really demanding features that Blockchain technology offers in Supply chain management.

Research Question 2: What are the Supply chain features are likely to be benefitted from Blockchain technology?

1.3 Purpose of Literature Review

The basic purpose of this thesis is to provide a framework for applying the blockchain technology in supply chain to improve the efficiency of the global supply chain and make systems more traceable and transparent. Though in our present system, we are facing many problems in supply chain management. For instance: information gaps that was observed in the case of IBM and Maersk, where because of permissions delays and absence of documentation, it turns into the loss of orders and affects the global trade. Apart from that there is an efficient use of capital for instance: Liquidity delays ("Liquidity assets are the assets that can be readily converted to cash like: Gold, diamond, platinum etc. Currently, there are $4 trillion tied up in a net working capital (Nilsson 2018).

1.4 Research Questions

Q1. Current Status of Blockchains in Supply Chains?
Q2. What kind of supply chain features are likely to be benefitted from blockchain technologies?
Q3. Detailed Case Study of how SAP, Blockchain & RFID technology can be applied in Fish farming industry to make every phase transparent and traceable and more efficient from the consumer perspective?

1.5 What is Supply Chain Management?

Supply chain management is defined as the "systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole." (Zacharia 2001)
According to Lambert (1998) and Zacharia (2001), the definition of supply chain management is *"it's a set of firms that pass material forward. Generally, various self-regulating firms are involved in manufacturing a product and delivering it to the end user*

in the supply chain---raw material and component producers, goods assemblers, wholesalers, retailer merchants and transportation companies are all associates of a supply chain".

1.6 Present Scenario

In current scenario, in Global supply chains with the advancement of time and techniques the business trade and workflow is also changing in supply chain. The complexity of supply chains, with their vast networks of different actors, comprises of concealed entities for both supplier and consumer, which gives rise to the queries about the supply chain multiple layers. These layers can hold socially and ethically questionable activities, for instance the manipulation of natural and human resources, leaving the environmental marks behind. (Benjamin 2015). In most of these cases these factors are masked due to either or both lack of transparency in the supply chains and information irregularity in business agreements. In addition to that, there is a rising interest for information regarding the product origin from scratch to its final product. Commodities and other items are being imported and exported with little information and label of addressing about the manufacturing or product origins; generally known as "Made in X" . (Williams 2015, New 2010). Almost a decade before neither suppliers, vendors and nor customers would not react on the restriction of this information. Moreover, with the expansion of the global market demand for information has increased. Sellers have the advantage of having knowledge, pertaining to the demanded products and services, could contribute to the low-quality services for the high-quality prices in the quest of maximum profit. Subsequently, Buyers can pay the same amount for a high respectively low service quality due to their inability to access the same information (Badzar 2016).

On the Other hand, from a long time a big and basic problem is prevailing in a supply chain is the information distortion in the supply chain. It defines that the information passed in the form of "orders" tends to be distorted and can mislead upstream players in their inventory and production decisions. Specifically, the fluctuation of orders might be larger than that of the sales, and in this commotion, it tends to increase as one moves upstream --- a phenomenon is termed as "Bullwhip Effect". The reason behind this Bullwhip-Effect is the retailer's orders don't coincide with the actual retail sales. It also refers to the phenomenon where orders for making products to suppliers tends to have larger difference than sales to the buyer (i.e.; misbalancing in demand) and this demand distortion propagates upstream in an amplified form (i.e., variance amplification). Here below the figure 2 (based on real data but changed to maintain confidentiality) shows a retail store's sales of a product, alongside

the retailer's orders issued to the manufacturer. The figure simply shows the misbalance in demand information.

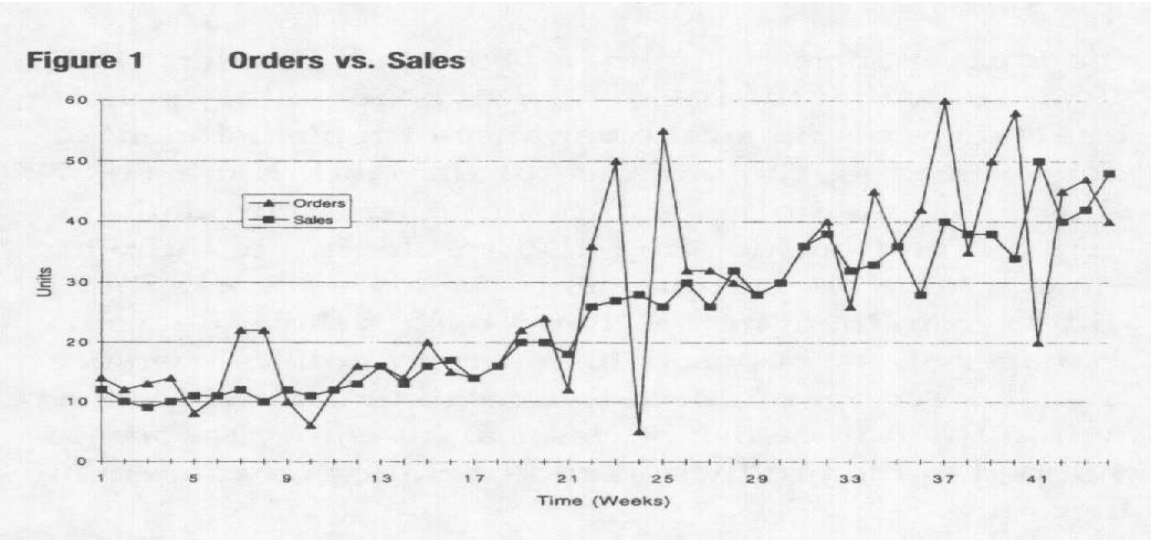


Figure 2: Demand distortion between demand and Supply in Upstream and Downstream part of Supply chain

Source: Whang (1997)

It represents the variance in the sales and orders during the subsequent weeks, which can be either because of communication gap between suppliers and manufacturers. There are some factors which the causes of this Bullwhip Effect are: demand signal processing, the rationing game, order batching and price variations which contributes to occur the effect. Though, because of the confidentiality and other security issues the suppliers, focal firms, wholesalers and other members of the supply chain are reluctant to share their information. Due to these privacy terms and matters the whole supply chain suffer the huge loss of customers, sales, excess of inventory handling costs etc. A good example of Bullwhip Effect is Beer game.

Problems in Supply Chain today

In the Agri-food supply chain traceability System, there is a counteraction by asymmetric information and opaque supply chains, this learning aims to subsidize to the research field of logistics and supply chain management by finding the potential of blockchain technology within logistics. A supply chain comprises of all the connections that are included when producing and distributing goods. Nowadays, a supply chain can potentially involve hundreds of stages and masses of geographical locations. For instance, the supply chain of Apple figuring whose suppliers service more than 1.6 million people in 20 countries (Apple 2016). So, such kind of cases makes it hard to trace events happening in a supply chain and examine incidents. Specifically, in the cases of food supply chain industry, where adulteration in commodities and products is a common thing severely affecting the health of communities. As there are information losses and hurdles in every phase of supply chain,

the further away an incident in the chain is the harder it is to obtain any information on it. (Cecere 2014)

As, nowadays because of land transportation providers, freight forwarders, brokers, government ports, ocean carriers and other active members of the supply chain, the system has become so complex, that it delays the delivery of the freight. There are many other documentation and permissions needs to be taken for approval of the processes. Since, the processes and orders are inter-related to each other, therefore one task depends on another which cause a huge impact on the workflow of business and orders. The delays in deliveries and anti-trust system causes an enormous loss for the whole supply chain which leads to the cost of billions of dollars annually (IBM 2016).

In the food industry supply chain, there are many cases of food adulteration and contamination in groceries items. The horsemeat scandal case in year 2013 in UK was founded, in which owners were selling horsemeat in the packaging and labelling of beef. Since in 2013 this case came into audience attention.

"The consequence of this fraud was that consumers and food processors alike were not only out of pocket financially, because they were being done over, but they were being deceived about what they were eating," the committee of five men and seven women heard during the trial. (Rawlinson 2017).

Similarly, the case of Spinach outbreak in 2006 named Multibreak of E.coli in USA, is one the major cases of infected grocery and the Achilles heel for the supply chain, which caused a heinous disease called " HUS" (Hemolytic-uremic syndrome) which causes a kidney failure.

It infected in 26 states, there were more than 4000 cases under it 3 deaths were involved in which one was elderly woman from Wisconsin and other was a 2-year-old girl and from her stool samples IDAHO confirmed with bacterium E. coli 0157 with a "DNA fingerprint" pattern that matches the outbreak strain. Among the ill people 102 (51%) were hospitalized and 31 (16%) developed a type of kidney failure "HUS". 141 (71%) were female and 22 (11%) were children under 5 years old. One of the surprising news that was shared by Vice President of Walmart in Food safety department Mr. Frank Yiannes he said that after this incident whole spinach stock was pulled out from the country and spinach was totally banned during that time. But to execute this whole activity it took 2 weeks to find the root source of the contagious spinach. Finally FDA (Food and Drug Administration) found that it was one supplier, one farm and one day production and an entire industry killed all farmer's livelihood because of unable to trace and track the item flow in a supply chain is big "Achilles Heel". (Walmart 2017)

Problem: The present electronic networks that handovers the ownership of assets between parties according to business rules are inefficient, expensive and vulnerable. The below figure3 representing the present scenario of banking transaction system.

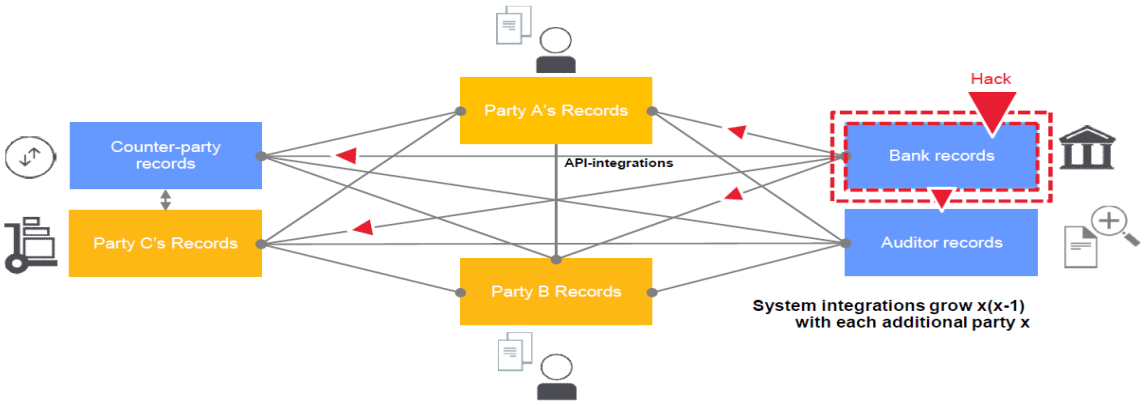


Figure 3: Present Payment system which is Expensive and Vulnerable to hack

Source: Androulaki (2017)

2.0 Literature Review

This chapter describes the traditional way of commerce on Internet using Intermediary as a Authority of trust. Then it defines the ground-breaking **Blockchain technology**, how it works, internal mechanism and types of blockchain exists. Finally, it contains some arguments about which blockchain should be selected in what cases. Last but not least some valuable concepts of Blockchain technology.

2.1 Background

Since, Commerce on the Internet has come to depend almost exclusively on financial institutions helping as trusted third parties to process electronic payments. While, currently the system works well enough in the same manner for all the transactions, it simply shows that we need a trusted party to rely upon, it still suffers from the inherent weakness of the trust-based framework. Here, in figure 4 is the illustration of traditional online financial transactions using third party transfer. Totally non-reversible transactions are not possible, as financial firms can't ignore mediating disputes. Mediation costs increases transaction costs, reducing the minimum practical transaction size and cutting off the possibility for small casual transactions, and there are other broader costs in the loss of ability to make non-reversible payments for non-reversible services. Merchants are cautious for their customers, creating a chaos for more information than they would otherwise need. A certain ratio of fraud is accepted as unavoidable. Therefore, these costs and payments can be ignored in person by using physical currency, albeit no systems available over a communications channel without a trusted authority.

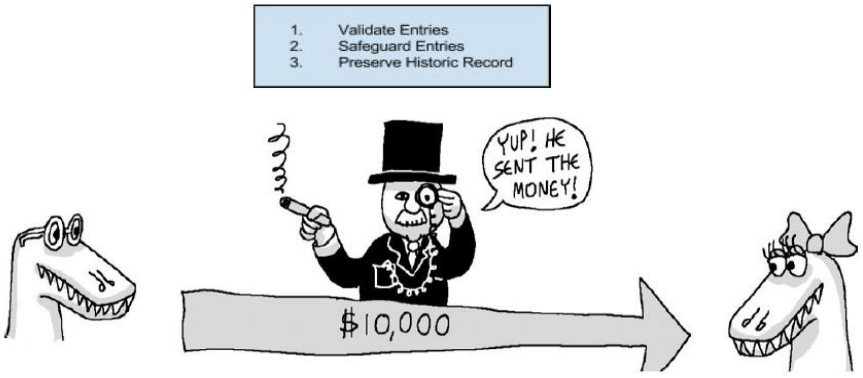


Figure 4: Traditional Online Financial transactions using third trusted party

Source: Wilmer (2014)

2.2 A New Proposed Disruptive Technology "Blockchain"

A Blockchain is coming to be the fifth disruptive computing paradigm after mainframes, PC, the Internet and mobile/social networking. It's essentially a distributed database of records or public ledger of all transactions or it can be said that digital events (Proof of work, Digital signature, Timestamp server) that have been executed and shared among contributing members. Every transaction in the public ledger is verified by consensus of a majority of the participants of the system. And once entered, information can never be erased. In simple terms: Blockchain stores every certain and verifiable record of every single transaction ever made. Using this basic analogy, it's easy to steal a cookie from a cookie jar in an isolated place rather than thieving the cookie from a cookie jar kept in a market place, being watched by thousands of people.

Blockchain is a novel technology generally associated with Bitcoin and is the underlying technology of the most prominent cryptocurrency. Since the founder of the Bitcoin under some pseudonym Satoshi Nakamoto released a paper explaining the cryptocurrency in 2008, apparently Bitcoin was in practices and usage deployed in market since 2009. The working structure in Bitcoin has been examined and concepts have been identified, specifically the blockchain which is not explicitly described in the original paper (Nakamoto 2008). Therefore, Nakamoto perhaps invented this technology for the successful transactions between two or more parties without trusting on the intermediary, though it has many wide applications in other sectors. The most exceptional invention was to handle and transact value among a network of untrusted entities lacking a trusted authority. Moreover, there are various use cases for the technology have emerged and some foretell a paradigm shift in computer science.

A Solution proposed by IBM Hyperledger to the present Payment system is a trusted, distributed, permissioned ledger or otherwise a permissioned blockchain system. A figure below illustrates the proposed solution offered by IBM. The below figure 5 is illustrating the Proposed Model by IBM showing the payment system without the central Intermediary.

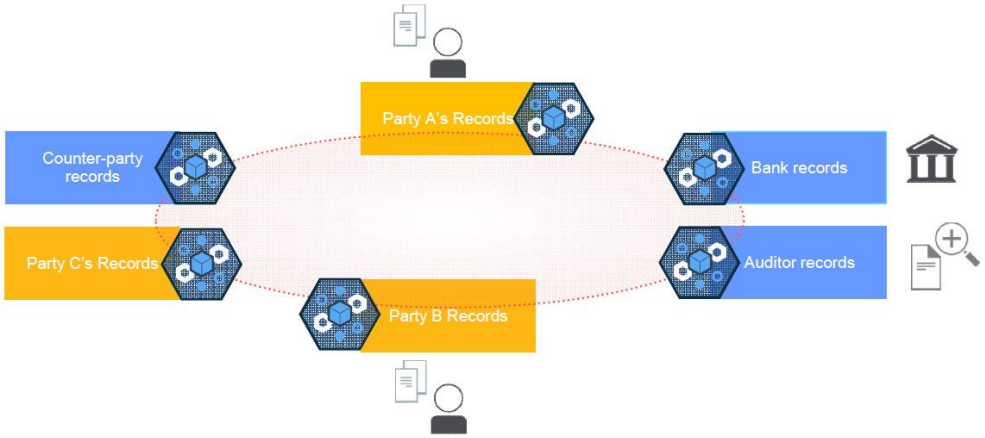


Figure 5: Proposed Model by IBM without Central Authority

Source: Androulaki (2017)

2.2.1 How Blockchain Technology Works ?

The concept of blockchain technology can be explained by describing the working of Bitcoins, since it is intrinsically connected to the Bitcoin. As Bitcoin is an application of Blockchain technology, which works on its principle. Still, the blockchain technology is applied to any digital asset transaction exchanged online. Bitcoin uses a cryptographic proof instead of the trust in the third party for two willing parties to execute an online transaction over the internet. All the transactions are protected through a digital signature. Every transaction is sent to the "public key" of the receiver digitally signed using the "private key" of the sender. Therefore, for spending the money, cryptocurrency owner needs to prove the ownership of the "private-key". The entity receiving the digital currency verifies the digital signature, hence the possession of the corresponding "private-key" –on the transaction using the "public key" of the sender. Below Figure 6 is showing the working of Blockchain technology.

Each transaction is broadcast to every node in the Bitcoin network and is then stored in a public ledger after verification. Each single transaction has to be verified for validity before it is recorded in the public ledger. The node that needs to be verified needs to confirm two things earlier recording and transaction:

1. Spender owns the cryptocurrency --- digital signature verification on the transaction.
2. Spender has ample cryptocurrency in his/her account : checking every transaction against spender's account ("public key") in the ledger to confirm that he/she has sufficient balance in his/her account. (Kalyanaraman 2015b)

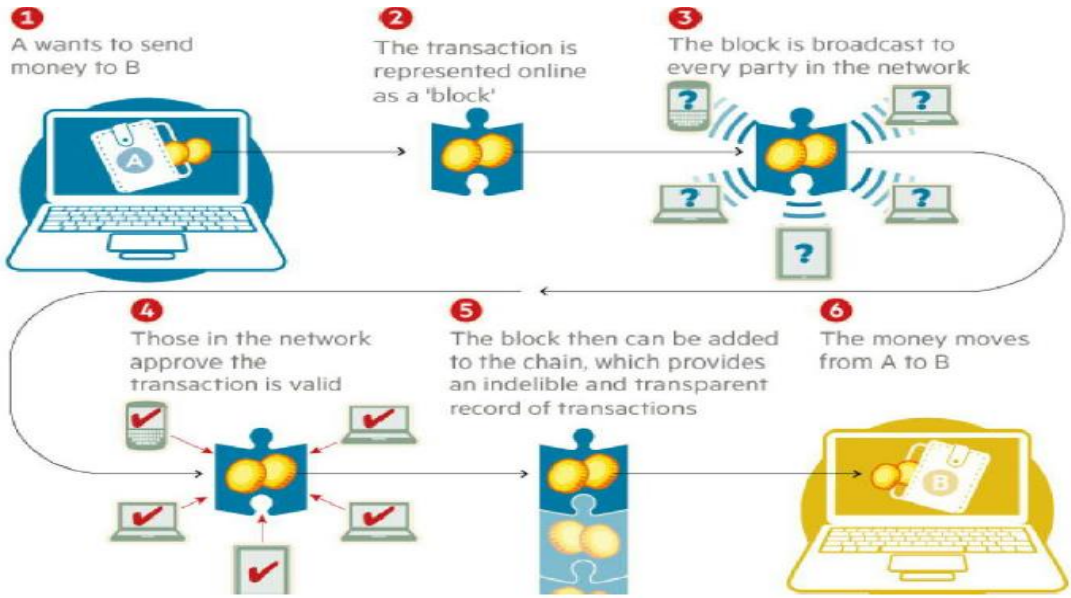


Figure 6: Financial Transactions Using Blockchain Technology

Source: Kalyanaraman (2015a)

2.2.2 Internal Mechanism of the Transactions in Bitcoin Blockchains Technology

Electronic coins are defined as a chain of digital signatures. Each owner transfers the coin to the next by digitally signing the hash of the previous transaction and the public key of the next owner and adding these to the end of the coin. A payee can verify the signatures to verify the chain of ownership.

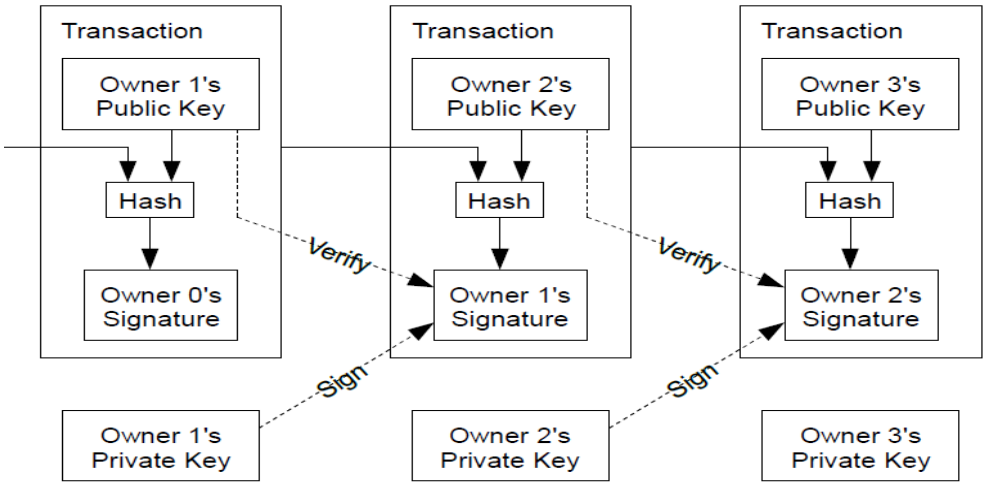


Figure 7: Transaction Structure of a Bitcoin Cryptocurrency Blockchain

Source: Nakamoto (2008)

But, there is a problem that the payee can't verify that one of the owners of the cryptocurrency did not double-spend the coin. A general solution to this problem is the trusted central authority, or mint that checks transaction for double spending. After every

transaction, the coin must come back to the mint to issue a new coin, and only coins issued directly from the mint are trusted not to be able to double spent. The concern with this solution is that the providence of entire money system relies on the company running the mint, with each transaction having to go through them, just like a bank.

The system needs a way for the payee to know that the previous owners didn't sign any earlier transactions. From our perspective and convention, the earliest transaction is the one that counts, so there is nothing to take care about the later attempts to double spend. The only way to confirm the absence of a transaction is to be attentive of all transactions. Above Figure number 7 is representing the internal working of a Bitcoin cryptocurrency Blockchain. So, in this mint-based model, mint was aware of all transactions and decided which arrived first. To achieve this without a trusted party, transactions must be announced publicly. The system is needed for participants to agree upon a single history of the order in which they were received. The payee needs some evidence that at the time of each transaction, the nodes majority agreed it was the first received.

2.3 Types of Blockchains

The concept of Bitcoin Blockchain raised could be in fact using any kind of value transaction or any kind of agreement for instance P2P insurance, P2P energy trading, P2P ride sharing etc. Based on the Bitcoin Blockchain Protocol Colored Coins and Master Coin tried to solve this concern. Since, after this concern the Ethereum project decided to create their own blockchain, and its features and characteristics are quite different from Bitcoin, separating the smart contract layer from the core blockchain protocol, its providing a new way to create online markets and programmable transactions as a piece of code containing terms and conditions known as **"Smart Contracts"**

1. **Public Blockchain**

   As the name itself is representing that these blockchains are open to the public and anybody can participate as a node in a decision-making process. In public blockchains users might or might not be rewarded for their contribution. These ledgers aren't of any individual and are publicly open for everyone to participate in. All the users of Public (Permission-less) ledgers keep a copy of their ledger on their local nodes, using a distributed consensus mechanism to attain the decision about the ultimate state of the ledger. Public blockchains are good for solving efficiency, security and fraud problems within traditional financial institutions(Bashir 2017). State of the art public Blockchain protocols based on Proof of Work(PoW) consensus algorithms are open source and not permissioned : it shows that anyone can participate without any permission. (1) Anybody

can download the code and start using a public node on their local device, validating transactions in the network, thus contributing in the consensus process- it is the process for identifying what blocks get added to the chain and what the current state is. (2) Anybody in world can send the transactions through the network and desired to see them included in the blockchain if they are valid. (3) Everyone can read transaction on the public block explorer. Transactions are clear and transparent but anonymous/pseudonymous.

Examples : Bitcoin, Ethereum, Monero, Dash, Litecoin, Dodgecoin etc.

2. **Federated Blockchains or Consortium Blockchains**

   Federated blockchains works under the governance of a group. On the contrary to the public Blockchains, they don't permit any person with internet access to the Internet to participate in the transactions verifying process. Federated blockchains are relatively faster (highly scalable) and offers more transaction privacy. On the other hand, the Consortium blockchains are often used in the banking sections. In banking systems the consensus mechanism is controlled by a pre-selected group of nodes; for instance one can consider an alliance of 15 financial institutions, each of which operates a node and of which 9 of which must sign every block to agree upon in order for the block to be valid. (Kavchenko 2016)

   Examples: R3 (Banks), EWF(Energy), B3i (Insurance), Corda

   Impact: (1) Decreases the transaction costs and data redundancies and displaces legacy systems and making easy the document handling and getting rid of semi manual compliance structures. (2) From this perspective it can be noticed as an equivalent to SAP systems in 1990's: reduces costs, but not disruptive.

3. **Private Blockchains**

   In private blockchains, write permissions are kept centralized to one organization. Read permissions may be public or restricted based on an arbitrary extent. Examples applications contains database management, auditing etc. which are performed internal to any company, public readability might be in many cases not necessary for all. In some cases, public audit ability can be desired. Private blockchains in a way provides flexibility by setting up groups and participants who can verify transactions internally. It can also put you at the risk of security breaches just like in a centralized system, on the contrary to the public blockchains secured by the game theoretic incentive mechanisms. Eventually, private blockchains have their use case, especially when it's a

matter of scalability and state of compliance of data security and privacy rules and other regulatory issues.

Examples: MONAX, Multichain, IBM Blockchain.

Impact: Provides same flexibilities and facilities like reduction in transaction costs and data redundancies, replacement of legacy systems, abridging document handling and avoidance of semi manual compliance mechanisms

Some would argue that such a system cannot be defined as a blockchain. Also, Blockchain is still in its early stages. It is unclear how the technology will pan out and will be adopted. Many argue that private or federated Blockchains might suffer the fate of Intranets in the 1990's, when private companies built their own private LANs or WANs instead of using the public Internet and all the services but has become obsolete especially with the advent of SAAS (Software as a Service) in the Web2.

Classification Schemes:

Many people gave their views about the classification of blockchains, but there is no consensus on how exactly to differentiate between different types of blockchains. There is a list of different classification schemes. The below table 1 represents the features of Public and Private/Federated blockchains.

	Public	**Private / Federated**
Access	Open read /write	Permissioned read and /or write
Speed	Slower	Faster
Security	Proof of Work Proof of Stake Other Different Consensus Mechanisms	Pre – approved participants
Identity	Anonymous Pseudonymous	Known identities
Asset	Native Asset	Any Asset

Table 1: Public vs Private Blockchains

Source: Skinner (2017)

Classification of Permissioned vs Permission-less Blockchains

Permissioned Blockchains	Permission-less Blockchains
Faster	Slower
Managed upkeep	Public Ownership
Private Membership	Open & Transparent
Trusted	Trust-free
Legal	Illegal

Table 2: Permissioned vs Permission less Blockchains

Source: Wood (2016)

The Bitcoin Blockchain is a disruptive and game changer technology, it is categorized in both public and private. All the stakeholders in the bitcoin network, who don't trust each other, are coordinated through an economical incentive system pre-defined in the protocol and auto enforced by machine consensus of the P2P (peer to peer) network. In permissioned and permission less blockchains, all network contributors validating transactions are known. Bilateral or multilateral legal agreements provides an architecture for trust, not the code.

So further proceeding with the discussions, Pavel Kravchenko the Founder of Distributed Lab. passionate about decentralized technology and its applications. The point of concern here is that while working for the project when we need a blockchain and now it's time to select which blockchain to utilize. The above shown table 2 shows properties of Permissioned and Permission-less blockchains.

2.3.1 Problem of deciding which blockchain is best?

People are arguing about which type of blockchain is suitable for different sorts of projects, i.e.; permissioned or permission less, public or private.

The diversity of blockchain projects and consensus structure increases complexity because each vendor tends to define that their blockchain platform is the best. As there are approximately no publications that assess the pros and cons of every mechanism.

Criteria:

So, in the pursuit of this buzz about "permissioned vs permission less" is distracting us from the deep observation of business problems and solutions which should be the true focus. Thus, community fraternity needs to make a decision about technology --- there is not such concern as "good" or "bad", it's just use cases. That's why I have been thinking about finding criteria to create some kind of theory for blockchains.

Some criteria can be reviewed in my opinion are not relevant but rather can be considered as features of particular blockchain. Figure 8 illustrates an elaborated classification of blockchains by Pavel Kavenchko.

Consensus algorithm itself is not the driver of blockchain selection, but is a result. Different consensus is appropriate for different business cases.

It's been heard that many suggests **immutability** level as a main criterion. It can be reasoned because **immutability** really relies upon the number of people who needs to be agreed in making a change (decentralization of mining power or stakes). If we consider any decentralized system, it is based much more on social harmony than on technological one. Occasionally public, decentralized, anonymous systems can be changed by will of a single person.

On the other hand, **Governance** model itself can't be considered a suitable criterion for discriminating among different types of blockchain. Governance is something that stands on the top of consensus and employs it to change rules.

Anonymity of the user is not a criterion but rather a feature. It is possible to have anonymous users even if validators are known and regulated. Existing banking system shows that it's surely possible.

Trust is an asset in validator is something that abridges a specific user and a validator and can't be considered global.

Therefore, it can be believed that amount of resources required to recreate blockchains is a measure of immutability. Only social consensus matters.

Model

From the above discussion it can be concluded that only 2 criteria matters when it comes to definition of an environment and a blockchain.

Level of anonymity of validators (i.e., do we know their identity?)

Trust level in validators (in the sense of "how unavoidable is punishment for misbehaviour").

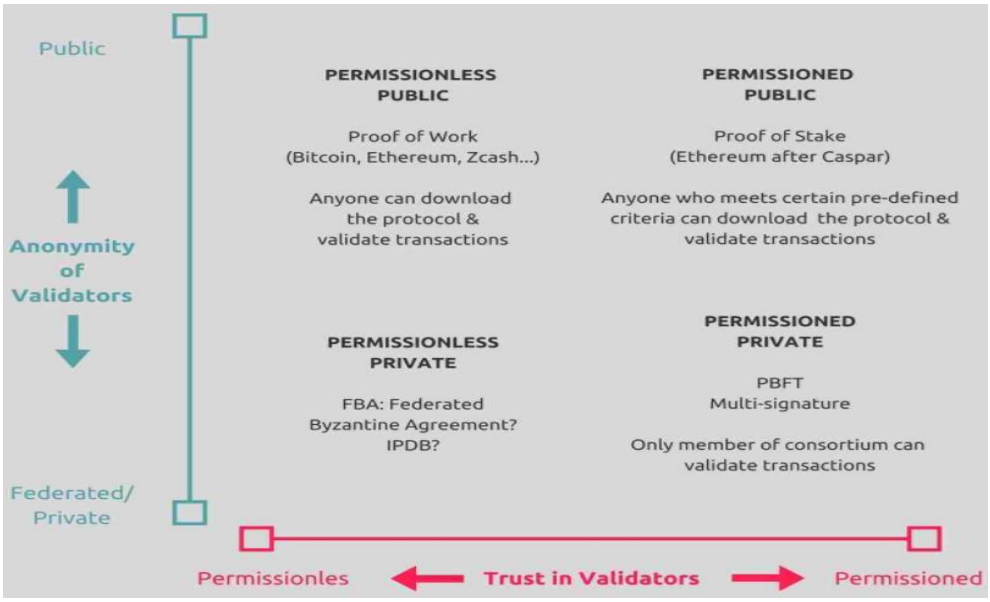


Figure 8: (Kavchenko 2016)

There needs to be analysed the features of each type of blockchain- permissioned vs permission less, public vs private, consensus rules, immutability, user's anonymity and scalability.

Features

The top left quadrant is for permission less and public blockchains. In such blockchains only proof of work, as something external to the system, can be applied here. One need not to be screened in order to participate in the consensus process – it's just a computer to mine. In such cases the trust in a miner is very low, there is no punishment for attacking the system (apart for the fact that mining equipment will not be worthy if attack is successful.) Therefore, such a infrastructure is only suitable for fully anonymous systems, that's totally out of government control. Examples : Bitcoin, Monero. Table 3 is summarizing the features of Permission-less/Public blockchains.

Openness	Consensus	User Anonymity	Immutability	Scalability
Permission less/Public	Proof of Work	High	High	Low

Table 3: Permission-less Public Features of a Blockchain

Source: (Kavchenko 2016)

The Top right quadrant is for permissioned and public blockchains. It is permissioned because somebody must buy coins in order to mine. Coins is an entity that system owns,

unlike mining equipment in bitcoin. Below presenting Table 4 tells us the features of Permissioned/Public blockchain. The level of trust is high in validator as they can lose their security deposit if the network is being attacked with double spending attempt. It is beneficial for community governance, execution of contracts, private money systems. Examples: Bit shares, Ethereum.

Openness	Consensus	User Anonymity	Immutability	Scalability
Permissioned/Public	Proof of Stake	High	Moderate	Moderate

Table 4: Permissioned/Public Blockchain Feature of a Blockchain

Source: (Kavchenko 2016)

The bottom left quadrant is for permission less and public blockchains. Here permission-less simply represents a different concept than in Bitcoin "under specific social agreement anyone who is eligible can become a validator". A good example can be considered of a country where each citizen is qualified to set up a node and participate in consensus. The level of trust is low in a validator, although the identities of entities are known – validators have nothing to give up. Table 5 shows the precise features of Permission-less/Public blockchains. Practice shows that FBA (Federated Byzantine Agreement) consensus is best for this case. First immaturely implemented in Ripple, but then developed and proven in Stellar. Proof of stake is not appropriate as every validator has equal power. Suitable for Consortium or National blockchains.

Openness	Consensus	User Anonymity	Immutability	Scalability
Permission less/Public	FBA (Federated Byzantine Agreement)	Moderate	Moderate	Moderate

Table 5: Permssion-less /Public Blockchain Feature

Source: (Kavchenko 2016)

Bottom right quadrant is for permissioned and private blockchains. Permissioned shows that validator must have some kind of license or be a part of a limited group. This is the only type of a system where blockchain itself is not public. Fast consensus algorithms are

applicable, relied on high trust to a validator—PBFT (Practical Byzantine Fault Tolerance), multi signature. Below, table 6 depicts a clear picture of Permissioned/Private blockchains. High trust twigs from the fact that misbehaviour results in lost license or membership. Immutability is based on agreement between validators. It's valid for banking, fast payment infrastructure, corporate usage etc.

Openness	Consensus	User Anonymity	Immutability	Scalability
Permissioned/Private	PBFT (Practical Byzantine Fault Tolerance) /Multi-signature	Low	Low	High

Table 6: Permissioned/Private Blockchain Features

Source: (Kavchenko 2016)

2.4 Proof of Work

Dwork and Naor's 1992 scheme suggested a central authority that can contain a secret key, but decentralized systems can be far more practical in present era and on today's Internet. The most eminent and widespread known proof-of-work system is back's independently invented "hash-cash" (Adam 2003) it requires the sender to generate a string whose cryptographic hash gets initiated with a certain number of zeroes. Unique property of the hash-cash puzzle (and all proof-of-work puzzles) is that they are extremely costly to solve, but it is comparatively cheap to verify the solution.

To properly align the hash-cash puzzle to specific email, some parts of the string that must be produced are the email recipient address, a timestamp and a nonce. Therefore, these preset values clarifies that a puzzle solution is only valid for a particular destination and verification can be done to ensure that the solution is moderately recently constructed and hasn't been presented to the recipient before. The hash-cash plan is secure to "man-in-the-middle" attacks, on the other hand, an innocent is fooled into computing values for the benefit of another.

Proof-of-work puzzles are not only limited to emails, but also have been proposed for metering visits to websites offering incentives in peer-to-peer systems. (Malkhi 1997) mitigating distributed denial of service attacks and rate limiting TCP connections. Wherever these systems are using proof-of-work as a mode of restricting the abilities of the bad guys.

In fact, the real version called for two hashes with the same initial bit-string – a single hash starting with zeros was a lately improvement.

According to Satoshi Nakamoto paper, that to apply a distributed timestamp server on a peer-to-peer basis, we will need to use a proof-of-work system which is similar to Adam Back's Hash-cash. (Back 2002) instead of newspaper or Usenet posts. The proof-of-work contains scanning if a value that when hashed, such as with SHA-256, the hash starts with a number of zero bits. The average work needed is exponential in the number of zero bits required and can be verified by executing a single hash.

For a timestamp network, the proof-of-work system is implemented by incrementing a nonce in the block until a value is found that returns the block's hash the required zero bits. Once the CPU effort has been used to make it satisfy the proof-of-work, the block can't be changed without redoing the work. As the recent blocks are keeps connected after it, the work to change the block would comprise of redoing all the blocks after it.

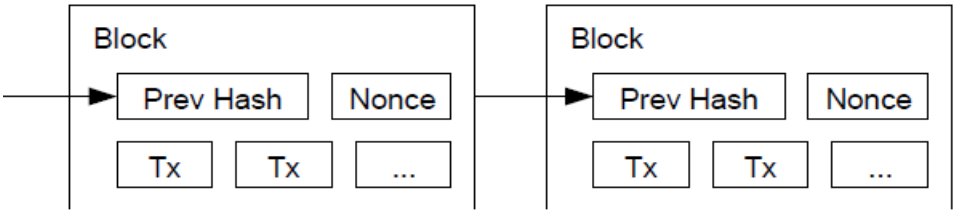


Figure 9: (Nakamoto 2008)

The proof-of-work concept also helps in solving the problem of determining the representation in majority decision making. If the majority were based on one IP-address-one-vote then it could be subverted by anybody and able to allocate many IPs. Proof-of-work is essentially one-CPU-one-vote. As the illustration of Block in PoW is shown above in figure 9. The majority decision is presented by the long chain, which shows the greatest and strongest proof-of-work effort invested in it. If a mainstream of the CPU power is operated by honest nodes, the honest chain will grow the redo proof-of-work of the block and all the rest of blocks are after it and then catch up with and surpass the work of the honest nodes. To compensate for increasing hardware speed and varying interest in running nodes over time, the proof-of-work difficulty is calculated by moving targeting an average number of blocks per hour. It depends on the generation of blocks, if they are generated too fast, that increases the difficulty level. (Nakamoto 2008)

2.5 Proof of Stake

Proof of stake is a concept that defines that a person can mine or validate block transactions, it depends on how many coins he or she holds. It simply represents that the more Bitcoin or altcoin owned by a miner, the more mining power he or she has. The first cryptocurrency to adopt the concept of Proof-of-stake was Peercoin. Nxt, Blackcoin, ShadowCoin soon they will follow the suit. (Investopedia 2012)

Proof-of-stake (PoS) is a consensus system which is based on a proof of ownership that may be put at stake. When there is not a requirement of any heavy computational work then it is referred to as Virtual mining. By using the PoS (Proof-of-stake) the miners mine blocks in proportion to their stake and various algorithms exists. In a roughly way it can be considered equivalent to PoW since rather than suing money to usurp hardware in proportion to the miner's wealth to solve the puzzles, the miners mine blocks in ratio to their wealth in the system directly. A miner may mine the block with the probability in proportion to its stake, with the next miner being chosen similarly. Suppose, the intended miner does not propose a block in time, the next miner is selected likewise. The consensus mechanism relies on the blockchain with the most work behind it, as per according to the conditions of the most stake.

A concept which we know as PoS (Proof-of-stake) was discussed among Bitcoin circles as early as 2011. In a generalized way proof-of-stake means a form of proof of ownership of the currency. Coin age is consumed by a transaction can be considered as a form of proof-of-stake. The proof-of-stake concept was independently discovered and the concept of coin age in October 2011, on the other hand it was realized that proof-of-stake can indeed replace most proof-of-work's functions with careful redesign of Bitcoin's minting and security model. One of the prime reason behind is that the similar to proof-of-work, proof-of-stake can't be easily forged.(Sunny King 2012)

2.6 Proof of Concept :

At Synchronoss, which is the leader of cloud, messaging and other digital products to telecommunications media and technology companies are exploring the proof-of-concept using blockchain technology in many different applications. In the starting of this year the Synchronoss participated to study with the Peer Ledger, a Canadian blockchain company, and SAFE- BioPharma Association, it's the organization who manages the global SAFE-BioPharma digital identity management standard, to figure it out that if robust identity trust can be integrated with blockchain technology. This development has a huge and

considerable impact for the use of distributed electronic ledgers for pharmaceutical, healthcare applications and other sectors.

It is being looked at blockchain to seal our own cryptography and key management systems. The main idea is to offer our customers with a powerful framework to conduct audits, and to fully control their own key transactions. According to new GDPR (General Data Protection Regulation) requirement, it is observed that blockchain can be applied to closure the data processing journal that DPOs (Data Protection Officer) need for sign-off.

Other sectors where blockchain is supreme for are medical records management, voting tracking (no more “hanging chads”) identity management and protection, long term record storage, chain-of-custody for documents for instance : insurance policies or legal documents, IOT usage tracking and for virtually each kind of digital records and transactions. (Doran 2018)

3.0 Research Methodologies

This chapter presents the author's choice of methodologies and approaches for this project. There are couple of research methods framework is designed which is being employed to prove the studies and research analysis. The below figure 10 represents the Research methodologies framework.

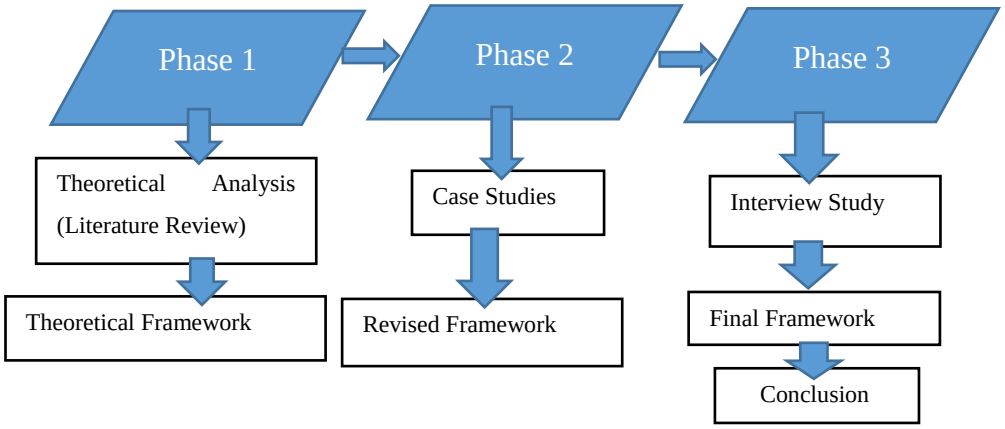


Figure 10: The Three Sequential Phase Diagram in Research Methodologies

The first phase comprises of building the theoretical frame of reference through a literature review/ theoretical study. An analysis of the literature review with the existing study in a condensed form resulted into a theoretical framework. In Second phase, queries regarding the theoretical framework and its influential impact were formulated on the author's analysis. These inquiries were mentioned in an interview study with some experts in the regarding fields, and the answers coming from these interviews formed the pillars for the revised framework. In second phase, we have included and accessed some case studies scenarios where it is being observed that in which kinds of various industries and sectors blockchain can be implemented. So basically, first and second phase are significantly aimed to answer first and second research question: *Q1 What is the current status of Blockchains in Supply Chains?* and *Q2. What type of supply chain scenarios are likely to be benefitted by using blockchain technologies?* The third phase which is about the Interviews done with experts and their opinion and initiatives being taken in this sector and other incubators, IT companies are in a pursuit to find new solutions in Supply chain industry. The third phase tested the revised framework with some case studies with similar business representatives. Since, the framework was implemented to specific business contexts, the third phase also facilitated in answering the research question 2. This phase verified the framework's efficiency and activated minor adjustments in the progress of the final framework. In the 4th phase (Last Phase) which answers the research question Q3: *Detailed Case Study of how*

SAP, Blockchain & RFID technology can be applied in Fish farming industry to make every phase transparent and traceable and more efficient from the consumer perspective? (Provenance & Skye (UNISOT) Case Study) and with the help of some Demonstrator model to show the implication of Blockchain technology in Supply Chains.

3.1 Review Phase 1

The first phase motive was to generate the theoretical foundation for the study.

3.1.1 Literature Review (Theoretical Analysis)

A literature review describes about the current research on the topic (Slack 2004) and also creates an important information relied on an initial stage of the project. (Höst 2006). A prime key concern when writing a literature review is how to look for a relevant literature. (Höst 2006). Therefore, Rowley and Slack in 2004, proposed some strategies for finding a literature. Below Table 7 depicts the strategies for researching of the literature review.

Research Strategy	Description
1. Citation Pearl Growing	Phrases or keywords within research topic are used to recall other sources in new searches
2.Brief Search	Sources are re-accessed quickly and crudely
3.Evaluating books	Exploring relevant to research topic, written by authoritative Author; the biographical details mentioned in the book Summarize the authors experience in the field. Clearly structured and well presented, easy to read.
4. Successive Fraction	Searches are done within a big log of sources to mitigate non-relevant sources.
5. Evaluating Web Resources	Easy to locate through simple searches in standard search engines, provides wide range of information, different tools to assist in the identification and location of documents in each of the categories: library catalogues, search engines, online Databases. Advanced search option offers range of other search devices to help in the formulation of a more precise search.

6. Building Blocks	It looks for the concepts in search statement and extends by using synonyms and related terms. It includes a detailed and lengthy search conducted seeing all of the terms to create comprehensive set of documents.
7. Concept Mapping	Useful way of identifying key concepts in documents collection or a research area. Understand theory, concepts and relationships between them. They can be a sketched map on paper or on a computer. Some structured approaches based on principles such as flowcharts, hierarchies.

Table 7: Six Main Search Strategies

Source: (Slack 2004)

The searches were originally made in this project were based on EBSCOHost for the strings "blockchain in supply chains" and "supply chain traceability". The two searches bring about in near 5,060 results and 806 results respectively. As only one hit contains both strings. To more clearly figure out the relevant sources of information, the citation pearl growing strategy was employed to build new strings in the building blocks strategy. Below illustrated table represents the strings used from this procedure, that were used to perform searches on EBSCOHost and Web of Science. Here Table 8 is showing the research approach for searching the literatures and journal articles like: search term and keywords.

Search Term	**Synonyms or related words**
1. Blockchain	(Distributed or decentralized) AND (ledger OR record) AND (Bitcoin Blockchain)
2. Traceability	Transparency OR ((tracking OR tracing OR genesis OR provenance OR monitoring)) AND (goods OR items))
3. Evaluation	Assessment OR ((adoption OR innovation) AND (model OR Architecture OR Paradigm OR Structure))
4. Definition	Concept OR categorisation OR Description
5. Case Studies	(Implementation OR Use Case) AND Applications.

Table 8: Synonyms or some similar relevant words used in the building blocks search strategy

Source: (Fredrik Jansson 2017)

The screening of articles is based upon the filter or distillation of data. Since all papers in the searchers were not necessarily related to the research questions, they needed to be judged from their real relevance. The screening of relevant papers is inspired by the Dybåand Dingsøyr. (ToreDybå;TorgeirDingsøyr 2008) which passes the paper through some filters and phases to extract the information. It is decided to exclude the following types of papers:(1) papers without full text availability (2) Papers where the main language wasn't English. (3) Papers that had some other meaning than Blockchain used in Computer Science (4). Duplicate papers. (5) Papers that were poster. Thus, when a paper passed all the five-exclusion filter or criteria and after reading the abstract it was considered as focusing on Blockchain, we decided to include it in the next screening stage. Apart from that According to Rowley and Slack (Slack 2004) the articles screening was conducted by four principles. The sources should preferably be *1) pertaining to the research subject. 2)up-to-date, as signalled by the publication date. 3)written by an authoritative author; the biographical information given in the book will summarize the authors experience in the field. 4) Clearly structured and well presented, easy to read.* As searches creates many searches hits, the outcomes were ordered based on number of citations of the article, the article were pre-screened based on abstract. This approach was not applicable in the case of Blockchain technology, as the research subject is new, and the most concerned related articles could be published recently and not have been cited till now.

With the approach described above, six relevant sources for blockchain technology and seven related sources for supply chain traceability passed screening and were ready deeply. Table 9 illustrates an example of some sources in the literature review.

Author(s)	Year	Title	Journal
Feng Tian	2016	An Agri Food Supply Chain Traceability System for China Bases on RFID & Blockchain Technology	Information System and Operations
Satoshi Nakamoto	2008	Bitcoin: A Peer-to-Peer Electronic Cash System	Whitepaper
Kari Kopela Jukka Hallikas Tomi Dahlberg	2017	Digital Supply Chain Transformation toward Blockchain Integration	Supply Chain and Logistics
Loop	2016	Blockchain: the next evolution of supply chains	Materials Handling and Logistics

Nir Kshetri	2017	Blockchain's roles in meeting key supply chain management objectives	Internal Journal of Information Management

Table 9: Examples of sources in the literature review in this Master thesis Project.

Source: (Fredrik Jansson 2017)

3.1.1.1 Theoretical Framework

The second step of the first phase was to filter the literature review to a theoretical framework.

Rival framework designs were discussed by the authors in account of with what Yin, (Yin 2003)

Suggested to develop the validity of the analysis. The result was a justified, still an unrefined architecture for assessing the transparency and traceability of the supply chains through Blockchain technology.

3.2 Review Phase II

As it's been seen that phase one was purely theoretical phase like screening, filtering and condensation of data, phase two is all about the various case studies being observed where blockchain notion can be implemented to enhance the theoretical model.

3.2.1 Selection of Case Studies

The procedure of the study can be elaborated as a theory building from multiple case, which is progressively popular in social science(Eisenhardt 2007, Kshetri 2016b, a). As compared to a single case study, multiple case studies are probably to offer a stronger base for theory building. (Rowley 2002, Yin 1994). Connected with the related literatures, establishment of theoretical gap that occurs in the literature, and explicit statement of research questions to define the gap are the prime features of strong empirical research (Eisenhardt 2007, Yin 1994)

Since, in the qualitative research it is important to make a strong case for the importance of the research questions that have been raised. We have established a theoretical and practical importance of research on the implication of blockchain in supply chain. (Bansal 2012)

There has been a good deal of debate on whether a case research should be based on theory specified a priori or on grounded theory. (Whyte 1984) argues that, to be valuable, research should be guided by "good ideas about how to concentrate the study and observe those data".

On the other hand, (Glaser 1967) recommended that evolution of a theory from the data is the fundamental for the development of grounded theory rather than an imposition of a priori theory.

Clearly, to talk about the selection of cases in a multiple case study research has the same goals as in random sampling. That is, the cases should show the population and there must be a useful variation on the magnitudes of a theoretical interest. (Seawright 2008) . The basic key difference is that in a more case study design, the choice of cases needs to be made more on a significant instead of statistical basis in consideration to adequately show a target population. (Greene 1984)

Firstly, it is essential to make it clear that case selection is also guided by pragmatic, logistical and financial reasons (Seawright 2008). We selected only those cases which could gather and some substantial information from secondary resources. (Eisenhardt 2007) recommended that around five cases are fine for building theory. In this study, we have opted couple of cases, we joined two methods: extreme case method and diverse case method (Seawright 2008). More specifically, the process begins with extreme case method and changed with respect to time, with the implementation of different requirement and recommendations.

In the extreme case method, cases with extreme values on the independent (X) or dependent variable (Y) of interest are selected(Seawright 2008). The cases are chosen in this study are experience in the sense that they are the earliest adopters of blockchain technology in supply chain.

Following this recommendation, we utilize t diverse blockchain case method as a strategy to choose specific cases of firms deploying blockchain in supply chain management. A key aim in this method is to achieve maximum variance along relevant dimensions. This method needs the selection of two or more cases to represent the full range of values characterizing X, Y or some relationship between these variables (Seawright 2008).

As to the factors affecting Y, specifically the incorporation of the emerged transparency and traceability emerged as a key factor to achieve organizational goals. Blockchain and IOT association is powerful and is set to transform many industries.(Kshetri 2017b, a) For instance IOT devices can carry out some automated transactions through smart contracts. (Reports 2016) Connecting it with artificial intelligence (AI) and big data solutions, more significant impacts can be generated.

In Order to attain diversity, we selected cases with different combinations of incorporation of the IOT and deployment of blockchain to validate individuals' and assets' identities. As suggested by (Seawright 2008) for such variables, we opted cases that represent the four

different combinations of incorporation of the IOT and deployment of blockchain to authenticate individuals and assets as shown in table 10.

Degree of incorporation of IOT → Degree of deployment of blockchain to validate identities of individuals and assets ↓	High	Low
High	Maersk	Lockheed Martin Everledger
Low	Walmart Alibaba Intel Solution to track Sea Food Supply Chain Gemalto	Provenance Bext360

Table 10 : The Cases opted and their classification in terms of incorporation of the IOT, visibility, traceability and deployment of blockchain to validate Individuals' and assets identities.

Source: (Kshetri 2017c)

3.2.2 Assessment and development of the Revised Framework

In the assessment of the empirical data. (Yin 2003) suggests that a chain of evidence should be present accompanied with the addressing of rival syntheses, to assure the analysis validity. The assessment was purely qualitative based on the empirical findings from the interviews. The analysis sought similarities in the interviewees' statements, and consistent criticism led to actionable conclusions. Diverse inputs from the interviewees directed in actionable conclusions only when the analysis could encourage that they were not in conflict with the present theory or other criticism.

To ensure that the IInd phase's analysis was done correctly, the authors sent the interviewees the results and observations, enabling them to assess that no other concerns or suggestions have been misinterpreted by the authors. (Fredrik Jansson 2017)

3.3 Review Phase III

After the phase 1 and 2 they are being categorised under purely theoretical. Phase III is based on some observed data based on an interview study to align and enhance the revised framework.

3.3.1 Preparing Queries for the Interview Guide

The third phase commence with deconstructing the theoretical and revised framework and analysing each part of the framework. The analysis of the framework is condensed to several criteria's and several queries on the precision and effectiveness of the framework. The queries were developed on the grounds of the thesis topic, the Research Questions and the analysis of the novel steps taken towards it through an interview study with experts in the relevant fields.

3.3.1.1 Interview Study Approach

The Interviews should be conducted in four steps: Basic Introductory questions, context, main questions and summary. (Höst 2006). The first phase should represent some basic introductory queries about the topic. Secondly it can be interviewed about some specific context of the interview, which should consist of the purpose and why the interviewee has been chosen. After asking some context questions, the main questions should be addressed which are bit controversial because of their volatility or because of their disruptive approach. After the main questions, some quick, neutral questions could be asked to keep the interview flow smooth and polite. Finally, the interview should be summarised to the interviewee, to allow the interviewee appending additional information or clarifying misinterpreted information. (Fredrik Jansson 2017)

3.3.1.2 Interview Study Strategy

Interviews can be organized as: Open-ended, semi-structured and structured. Open ended interviews generally discuss themes rather than specific questions. Such interviews are helpful to get some insights and information for lead researchers outside the preconception of the scope of the interview. Semi-structured interviews are bit tricky with questions, as they are not straight forward to understand and used pre-determined questions with bound answers and open-ended questions with unbound answers. Structured interviews are straight forward with completely determined questions and bound answers. This method is similar to a survey study. (Höst 2006)

The interviews in this third phase of study is aimed to test queries regarding the framework. The interviews with an expert still need to be of explorative in nature, as the framework will be enhanced not only by highlighting the queries, but also by their opinions on their queries. In phase III of the research design consisted of an interview study with representatives from the industry. The motive was to test that the present framework is understandable, relevant and effective as a means of evaluating the applicability of blockchain technology for supply chain transparency. To do this, the case studies from revised framework was used as a case study protocol with the interviewees business situation as the unit of analysis.

3.3.1.3 Final Interview Study

The framework was analysed regarding business case utility. Questions should be in a Structured format to use the revised framework as intended to study the business situation. The evaluation of the framework usability had pre-defined questions that were replicated for distinct interviewees expressed their views and opinions on the current issues and topics openly.

Like in the section Preparing questions for the interview guidelines and Final interview study it contains semi-structured interviews, containing questions with bounded and open-minded answers.

3.3.1.4 Selecting Interviewees

The selection of the interviewees is done based on their experience and their expertise in that technology or the relevant topic on which you are doing your research work. The interviewees can reflect a company or any individual with a start-up or an expert advisor about it. To give good basics of evaluation of the framework, the researchers looked for interviewees that hold extensive knowledge in the profession of supply chain and traceability system.(Fredrik Jansson 2017)

3.3.2 Analysis and Building a Final Framework

The interview study has a great role in understanding the practical usability if the revised framework. This observation is also used the same methodology as the analysis in the phase II of the study. In the section Preparing questions for the interview guidelines, they were given a chance to review the presentation of the results and observations, empowering them to figure out any misinterpretations by the authors. (Fredrik Jansson 2017)

4.0 Findings

This chapter tells us about the findings from different sources like: Literature Review, Case Studies, Analysis of Final Framework, Interviews from Experts. It also includes the answers of the Research Questions, which gives us more deep insights and knowledge about Blockchain technology in Supply Chains.

4.1 Findings from the Literature Review

Literature review provides the root to the topic and the existing work done on that project. Since Blockchain technology is not new if, we talk about the Bitcoin that was introduced by Satoshi Nakamoto in 2008. Since after that there were many companies and other incubators who were influenced by the concept of Blockchain technology and explored that it can be used beyond Bitcoin with their concepts like: Proof of Work (PoW), Proof Of Concept, Transactions, Timestamp Server, Network, Reclaiming Disk Space, Incentives, Simplified Payment Verification with the longest proof-of-work chain, Combining and splitting value. So finally, a combination of these features is evaluated into a new Blockchain technology. There were not many research works done, still some of the Incubators and other companies are experimenting with the Blockchain in different sectors. Most of the search combinations involves blockchain generated some results in Web of Science, Google Scholar and Oria - search which in itself showing many results. It reflects there is a dearth of conducted research within the subject of "Implementation of Blockchain Technology in Global Supply Chains". The single keyword blockchain find results on Web of Science, in the pattern of four academic articles, three in English(Kraft 2015, KIVIAT 2015) and the other one is written in Cyrillic's (Kuznetsov and Yakubov, 2016). The same keywords were used for Oria database and it showed 50 results academic papers, which relates blockchain only in connection with Bitcoin (cryptocurrency), the financial market and payment systems. As Blockchain has many wide applications for instance: Smart contracts is one of the incredible feature, in financial and non-financial areas. It is reflected in the sources of the published articles for instance: IT professional, IEEE technology and Society Magazine. It can also show the signs of lack of research on blockchain and logistics.

Apart from that, being reviewing the literature we found about the differences between traditional way of transactions between parties which is presently we are using and the financial institution as a bank who is a central authority for validating our transactions and other ledgers, records. While blockchain concept is a disruptive technology which is an agglomeration of various existing concepts and united them to bring a new notion :

Cryptography, Timestamp server, PoW (Proof of Work), Network system, Incentives to miners, Reclaiming of disc space, simplified payment verification. In the Blockchain notion two parties are willing to share their information or transfer the money without the need of a central authority.

Each transaction is broadcast to every node in the Bitcoin network and after the consensus of the other members it is being stored on the public blockchain.

Thus, after observing the internal mechanism of how bitcoin blockchain system works, it is a complex system. Because every owner transfer the coin to the next by digitally signing the hash of the previous transaction and the public key of the next owner and adding these to the end of coin.

A very crucial point has been observed in this whole conundrum about blockchain that there bunch of blockchains available in market like: Public blockchain (Permission-less), Federated Blockchains / Consortium Blockchains, Private Blockchains (Permissioned). Since from the study we observed that each blockchain has some specific reason and purpose to use.

Public blockchains itself the name represents are public in nature, anyone can participate and use it. In public blockchains there are cases where user might be or may not get rewarded for their contribution. Public blockchains are really developed to solve efficiently any problems and provide security for fraud problems within traditional financial institutions. Anybody can have access to it, nobody owns it. Everyone can download the code and start using a public node on their local machine, validating the transaction in the network. It is being facilitated with features like anyone in world can send the transactions through the network and expected to see them included in the blockchain if they are valid. Transactions are clear, transparent, visible but anonymous/pseudonymous. (Bashir 2017)

Federated blockchains /Consortium blockchains are the blockchains which works under some authority of a group or governance, like public blockchains they are not supposed to allow any person with internet access to contribute in the transactions verifying process. They are relatively faster, highly scalable and gives more transaction privacy. Banks is the perfect case for the consensus mechanism which is managed by a pre/selected group of nodes; for example, one can take a group of 15 financial institutions, each of which operates a node and of which 9 must sign to each block to agree upon in a sequence for the block to be valid.

Private /Permissioned blockchains are securely private in nature. They give read permissions to public or restricted depends on the case requirement, but the write permissions are always kept centralized to one organization. Example: applications contains

database management, auditing etc. These operations are performed internally within the company, public readability can be probably the cases not necessary for all. Like the Consortium blockchains they offer scalability and state of compliance of privacy and information security and other regulatory issues. It also gives some additional flexibilities like mitigation in transaction costs, replacement in legacy systems, overcoming of the semi manual compliance systems.

Now, in this whole pursuit of discussion, still the main question stands that **which blockchain is better and which should be taken into use for**. As with the literature review we have observed that there is no harmony with this among authors that which blockchain should be opted for. Though the consensus algorithm is present but is not sufficient to satisfy all the use cases.

Different consensus are suitable for different use cases:

It's been noticed that many supported **immutability** level is the main criterion, it simply means that once the data being stored on the blockchain can't be erased or edited.

Trust is another factor that abbreviates a specific user and a validator and can't be taken as a goal. Therefore, it is to be believed that number of resources needed is to recreate blockchains is a measure of immutability, only social consensus matters.

Still the problem prevails that which blockchain is most appropriate, to get the better view and idea, the public and private blockchains are divided into sub categories permission-less public permission-less private and permissioned public & permissioned private.

The **permission-less public blockchains** the proof of work is something external to the system, can be applicable here. In such blockchains it's not mandatory for one to be participated in the consensus process- it's just a computer to mine. In these situations, the trust on a miner is very low, apart from that there is no punishment for attacking the system, there will not be any value of the mining equipment if the attack is successful. Consequently, such an infrastructure is only appropriate for completely autonomous systems, those which are not in government control Examples: Monero, Bitcoin.

So, in simple words it can be said that Permission-less/Public blockchains need Proof of work consensus, user anonymity and immutability is high, whereas scalability is low.

When we talk about **the permissioned public blockchains**, they are permissioned therefore somebody has to buy coins for a process to mine. Coins can be said an entity that system owns, unlike mining equipment in bitcoin. The trust level is high in validator as they can lose their security deposit if the network is being attacked with double spending problem attempt. It is advantage for scenarios like: governance, smart contracts execution, private money systems Examples: Ethereum, Bit-Shares

In this blockchain (Permissioned/Public) the consensus approach is Proof of Stake, user anonymity is high, Immutability and Scalability is moderate.

The next blockchain is **permission-less and public** in nature. Here permission less meaning is something different than in Bitcoin "under particular social agreement, anybody who is qualified can become a validator". The trust level is low in such kind of validators, though characters of entities are known. Practices shows that FBA (Federated Byzantine Agreement) consensus is most appropriate for this case. When implemented in Ripple it was in immature state, but it was successfully applied in Stellar. These type of blockchains are beneficial for Consortium or National blockchains

For (Permission-less/public blockchains) the consensus is FBA (Federated Byzantine Agreement) and User anonymity, immutability and scalability is moderate.

Finally, for permissioned and private blockchains, validator must have some sort of license to be a member of limited group. This is the only kind of a system where blockchain itself is not public. So, bottom line is that these blockchains are suitable for fast payments, infrastructure and corporate usage.

Permissioned/Private blockchains have PBFT (Practical Byzantine Fault Tolerance) consensus, user anonymity and immutability is low but scalability is high.

So, in a nutshell, from a literature review we can say that for different purposes and different sectors there is a usage of Blockchains. It's nothing like a common solution for that.

4.2 Findings from Case Studies

1. **The case study of Maersk** : The Danish Shipping company Maersk is the world's largest container carriers and captures 18% to 20% of the market. (Groenfeldt 2017). Maersk has been a high-profile example of a company that has been successfully tested the implication of blockchain applications in international logistics. Maersk uses the solution to track its shipping containers around the world with features like GPS location, temperature and other conditions. (Johnson 2017).

   The pilot project was organized by Maersk with IBM, the Chairman of IBM Europe, Erich Clementi personally pitched blockchain to the top technology executive at Maersk. For instance, Maersk's storage room at Mombasa office, on the coast of Kenya was to have shelves and shelves of paper records that date back to 2014.(Popper 2017) IBM and Maersk had been working on a version of this software that would have open to everyone involved with every container. To deliver a shipment pf flowers from Port of Mombasa to Port of Rotterdam (Netherlands). Since, when customs authorities signed off on a document, they could suddenly upload a document using digital signature. It

permits to involve everyone including Maersk and government authorities- to see that it was done. (Kshetri 2017c)

In 2014, Maersk tracked a shipment of flowers from Kenya to Netherlands (Port of Rotterdam) in order to understand the physical process and paper work in cross-border trades (Baipai 2017). In most cases, the containers can be loaded on a ship within few minutes. Moreover, there can be help up at port for many days due a missing paperwork. Since study found that handling a single container a simple shipment of refrigerated goods from East Africa to Europe required stamps and approvals from at least 30 people such as customs, tax officials and health authorities. That comprises over 200 different interaction and communications across them.(Groenfeldt 2017)

Since, the flowers are perishable and inside the containers may spoil. It was noted that moving and keeping track of all required paperwork may cost as much as the cost of physically moving the containers. Frauds and forgery are rampant in global supply chain system. For instance, the bill of lading can be tampered with or copied. Criminals also take goods from the containers. They also distribute counterfeit products, which leads into millions and billions of frauds every year.

IBM and Maersk did a proof of concept (POC) in September 2016 which tracked a container of flowers from the Kenyan coast city of Mombasa to Rotterdam in the Netherlands. In the Proof of concept, the shipping cost was $2000, and the paperwork was estimated about $300 (15% of cargo value). So, the POC was seems to be successful. With this pilot project success, Blockchain helps enable unprecedented, secure transparency across the global supply chain. It could also helps in saving time and costs. The worldwide GDP by approximately 5% and total trade volume by 15%. (IBM 2017b)

2. **Case Study of IBM & Walmart**: IBM and Walmart have collaborated in late 2016 for food traceability in the Supply Chain. It was reported that Walmart was trail testing a service it builds with IBM to monitor produce in the U.S and pork in China. The first project was included tracking produce from Latin America to the U.S. The second includes moving pork products from Chinese farms to Chinese stores. Till February 2017, they had completed the two pilots with IBM. Walmart was reported to be confident that a finished version can be ready “within a few years”. (Popper 2017)

   Blockchain activates to track digitally individual pork products in a few minutes compared to many days taken in the past. Details about the farm, factories, batch number, storage, temperature and shipping can be viewed on blockchain. These are the very essential information about any product, with these details it helps to assess the

authenticity of products and the expiry date. In case of food contamination and adulteration, it is possible to pinpoint the products to recall. (Yiannas 2017) (Revention 2006)

While the test was restricted to these two items, it involved multiple stores. If an item is found to be ruined or the source of a product is shown to be compromised, the system acts proactively. The main objective is to improve food safety and tracking of all goods and commodities. The information tracked includes the farm where the vegetable or pig originated and their operating practices. With the help of RFID tags, sensors and barcodes accommodated with the blockchain to enhance the system, which are already widely used across many supply chains, providing the relevant data. (Kharif 2016)

On 31st May 2016, Walmart announced the results of the food safety and traceability protocols test that started in October 2016 in China and U.S Walmart conveyed that blockchain helped to decrease the time in tracking the food origin from days to minutes. (Higgins 2017). Particularly, the tests performed on Chinese pork and US mangoes revealed that tracing the goof origins could be taken care of in couple of seconds, which otherwise used to take many weeks with non-blockchain technologies. (Nation 2017)

One of the most important thing that Blockchain is a boon for life savings because of food adulteration. One of the "Spinach Outbreak" contamination in which people were infected by E. coli(Escherichia Coli) virus in US and 200 people were infected by it. Many patients were hospitalized developed a type of kidney failure called haemolytic-uremic syndrome (HUS). It took almost two weeks to find the infected spinach source. (Revention 2006). In crises including adulterated food products, Walmart would be easily able to track the source and engage in strategic removals of affected products rather than calling the entire product line. This feature really brings more trust that they are having 100% secure and safe food. In this manner, the company can keep buyers' confidence in other products and avoid the danger of consumers ill. (De Jesus 2016)

In May 2017, Walmart filed a patent application with the US Patent and Trademark Office (USPTO) entitled "Unmanned Aerial Delivery to Secure Location". (Coggine 2017). Apart from this blockchain's role in package authentication and tracking, Walmart has announced its plans to empower the technology in authenticating a customer and a courier, measuring the temperatures containers and products and comparing with acceptable thresholds.

Therefore, amalgamation of Blockchain and other technologies like : RFID, Barcodes, NFC tags are boon for Food Supply Chain. (Kshetri 2017c)

3. **Provenance**: In this case study conducted by Provenance, they organized a pilot project in Indonesia to allow the traceability in the fishing industry. By using mobile phones, blockchain and smart tagging, Provenance tracked fish caught by fishermen. The pilot was successfully working in tracking fish in Indonesia for the first six months of 2016. (Kshetri 2017c)

   The sustainable tracking system are majorly relied on papers and reports. Seafood trades source from hundreds of boats, which really makes the full control a challenging job. There is a lack of supervision. Countries in the region such as Indonesia are basically known for their corruption in yellow fin tuna industry. So, this is the trend of the industry characterized by questionable practices. This industry is getting infected by serious problems like: fraud, overfishing, as well as illegal, unreported and unregulated (IUU) fish. There are also the cases of human rights abuses. (Hannam 2017). Blockchain can assist consumers to track the source of their food and address the key challenges mentioned above. Being the world's largest tuna-producing country, Indonesia offers a fertile ground for testing the technology in account to dramatically accrue the transparency and visibility in fishing industry and sea food supply chains. Blockchain-based projects can verify social sustainability claims.

   Blockchains systems encompassing with RFID, NFC tags and other barcodes technology incorporates the sea-food industry and gives a new definition by providing information of fishes from sea to the groceries shelves.

   This system's huge potential stems and motivates to build such kinds of systems and integrate the current ERP systems with Blockchains to empower the industry. It endeavours that stems from the fact that seas in the Asia pacific region offers daily food and income for over 200 million people in Southeast Asia computes for 90% of seafood consumed in the U.S commercial launch of the technology has a potential to stop unethical and illegal practices in the industry like fish contamination cases, slavery etc.

   So, it's the fast tracking system, for seeking all the information about sea-food industry it can be a revolution in this industry to get whole information about sea-food in couple of seconds, this will amasses the new level of trust among consumers and burgeon the sales. (Provenance 2016)

4. **Block MEdX Case Study**: This case study addresses the concern about prescription drug abuse. On 10th August 2017 the opioid epidemic was declared a national emergency. While the problem is multifunctional, one of the primary issues participating to this public health crises is the usage of an antiquated system of prescribing controlled

medications that tends to prescriptions being easily forged and altered in addition to difficulty monitoring patients and prescribers. Block MEdx intends to be a novel e-prescribing platform that will provide secure transmission of prescriptions, a complete universal history of opioid prescriptions for patients, pharmacists and providers, incentives to decrease overprescribing and prescription fraud. Apparently, the target of the MEdX application is to overcome problems with identity verification of medical providers, fake and other altered prescriptions and irregular reporting of controlled substances. BlockMEDX desired to attain these goals by creating a decentralized application using the Ethereum blockchain, using novel prescription information, and creating a real-time, complete record of controlled substances assessed by machine learning algorithms.

Prescription drug abuse, specifically of opioids, is the most significant public health crises of the 21st century. Two million adults over age of twelve were addicted have a substance abuse problem involving prescription pain relievers. (Figures 2016) . The American society of Addiction Medicine reports that drug overdose is the primary cause of accidental death in the United States, with approximately half of those fatalities coming from prescription opioid abuse. Leading figures, facts and projections indicated that up to half a million Americans could die from prescription opioid overdoses within next decade. (forecast 2017) . This crises is similar to the AIDS epidemic of the 1980's in death toll and scope. (Figures 2016). Drug overdose casualties in the US exceeded the figures of the deadliest car collision death toll year on record. (forecast 2017) therefore, that was the time to take some fast and serious step to deal with this huge problem.

In a pursuit, to curb this growing public health crises, the CDC has recently issued new opioid prescribing guidelines. Unfortunately, these guidelines do not merely exist as suggestions for proper prescribing practices. (Prevention) 2017) . The drastic overprescribing of opioid pain medications, pain fraud and a system of documentation and prescription creation which is generally based on the grounds of trust between the patients, prescribers and pharmacies are just a few of the indulging aspects that had led to epidemic. Mostly the prescriptions of the opioids medications are handwritten on paper and can be easily forged. Chemists are compelled to trust on doctor's prescriptions and the ones which are written physically on paper and signed on it. Issues in interpreting handwritten prescriptions also cause medication errors and may turn into prescriptions being filled improperly or incorrectly. However, physicians are unaware of the fact that if the patient has received prescriptions from another doctor for the same medication, therefore doubling the supply of medication. The present system is not trustworthy and,

in most instances, untraceable and unreliable. The roots of the problem run deep and are hollow. Reckless and corrupt providers overprescribe opioids while abusers alter, forge and duplicate paper prescriptions. Responsible doctors and pharmacists often have no way of knowing whether they're giving drugs to a legitimate user or someone with illicit intentions. In light of this, BlockMedX intends to develop a new way to make opioid prescriptions secure. A secure way to make a broken system count. BlockMedX intends to be the first organization to bring blockchain technology to the prescription drug industry.

BlockMedx designed an effective method and system based on Ethereum Blockchain for providers, pharmacists and patients. Blockchain intends to be a cryptographically secure, HIPAA compliant, end to end prescribing platform. Prescriptions will be securely transmitted and recorded on the blockchain accompanied by an MDX token. A token will be paired to each specific prescription, securely verifying the prescription's origin from the point of creation by the physician. Physicians, pharmacies and patients will login to a website using a username and password. This website will have access to the Ethereum blockchain. Physicians and pharmacies will have an Ethereum address generated for them with an on-boarding system. It is essential for them to interact with the smart contract and hold MDX tokens. An MDX token will be a cryptocurrency token that will be needed to issue prescriptions and issue payments in the BlockMedx system.

Findings from the Physicians point of view

Physicians will have the capability to view their own prescribing history and the entire prescription history of the patients that they are authorized to view upon. They have access the BlockMedX distributed application (D-App) in their office to create a new prescription. Physicians will have the skills to issue new prescriptions by filling out the necessary auto-populated fields on an electronic form. Physicians uses non-invasive biometric identity recognition method to sign the prescription which will be paired to their private key on the network. This attribute provides the authenticity that actual physician can only sign and transmit prescriptions. This reflects a total integrated system for that physician's prescribing authority. To issue a new prescription the physician must pay a fee in MDX tokens. They will be able to view the required fee for creating the prescription. Physicians will be able to require to obtain MDX tokens in account to facilitate the secure transmission of their controlled prescriptions using the BlockMEdX D-app.

Physicians can also have a view to a list of their prescription history which will contain the prescription's current status: pending, approved, revoked, declined or accepted. They can easily track if patient attempted to use prescription at more than one pharmacy. If the prescription is in a pending or approved state, the physician may revoke it which could sent it to the revoked state. If a prescription is revoked or declined by a pharmacy, the MDX tokens will be returned to the physicians as tokens to be issued.

Findings for Pharmacies:

Pharmacies will be shown with a queue of approved prescriptions that have not yet been accepted, declined or revoked. The receiving pharmacy will open the BlockMEdX D-App from any of their computers to join the network. For each prescription, pharmacy will be having access to check the prescription history. They will an option to accept or decline. Upon the acceptance the MDX tokens will be transferred to the Pharmacy integrated token wallet issued by the Physician. The Pharmacy will digitally sign a confirmation of the receipt using a non-invasive biometric identity recognition method. They will be able to print the prescription. It includes the QR code from the patient, as printed by the physician which can be utilized to validate the prescription. The QR code will correspond to the transaction ID denoting the fact that the prescription has been sent to a pharmacy, filled by that pharmacy is no longer valid. Furthermore, credit cards may be difficult for certain patient populations to get, thereby the MDX token offers an electronic payment method that has lower barrier to entry. Pharmacies will also be able to look for prior payments from that particular patient as well as request payments via. QR codes and NFC devices.

Findings for Patients:

There is a great advantage for patients because patients will be able to see their prescription history after login. They or anyone else with credentialed access to the system can also scan the QR code on their printed prescription, to crosscheck that prescription has been filled by a specific pharmacy. Patients will receive acknowledgement when a new prescription is created and transmitted for them by a physician. Patients will also be able to control the MDX tokens on their device just like any other crypto-currency wallet. Patients can also pay with MDX tokens by scanning a QR code or tapping their device on the Pharmacy device for NFC functionality.

So, after all findings from these all sources, the Research Questions were answered and summarized.

Q1. Current Status of Blockchain in Supply Chains?

Case Studies	Blockchain's role	Mechanisms Involved	Current Status
1. IBM & Walmart Pilot study of food traceability. (Walmart 2017) 2. Provenance Sea food Farming. (Provenance 2016) 3. Retail Supply Chains. 4. Maersk & IBM Case. (MAERSK 2018) 5. Provenance end to end transparency for fashion.(Martine-Jarlgaard 2017) 6. Alibaba team up case with AusPost, Blackmores and Pwc to explore blockchain to fight the food fraud. (Bindi 2017) 7. Lockhead Martin largest defense contracting firm teamed up with Virginia based Guard Time Federal to leverage Blockchains in Operations. (Higgins 2017) 8. Chronicled a start-up and Life Sciences supply chain consultancy proclaimed to launch a "track & trace" pilot study for pharmaceutical	Trust, all information about a product stored on a blockchain, brings visibility. Blockchain-based digital certification as a means of increasing dependability. Supply chain partners can expect a high level of dependability of measurement for different indicators such as quality and weights. Medicines record can be stored in an Ethereum blockchain. Solidity based smart contract compares data against various regulatory requirements.	Tamper proof systems for digiting trade workflow, tracking shipments end to end used by IBM. RFID tags and NFC (Near Field Communication cards used. Digitally signed documents' secure storage and transmission can confirm the identities of individuals and assets. An asset to enhance integrity and traceability in the food supply chain to combat against low quality and counterfeit products. Auditable data can be provided to satisfy regulators.	Pilot Studies are successful, and other projects are still in development. Many start-ups are working on the demo projects and pilot cases to deeply analyse the technology. Some initiatives have been taken in T-system using blockchain technology for clinical data trials between patients and a drug trial. Sustainability is one of the prime feature of blockchain to track each information on blockchain. It is the one of the most key feature of Blockchain which a consensus algorithm is approved by authors.

industry. (Prnewswire 2017) 9. The Swiss start-up Modum combined with the University of Zurich to design a system to assure the safe delivery of pharmaceutical drugs by reducing labor force and loads of paperwork. (Campbell 2016) 10. Everledger a London based startup uses blockchain-based solutions to verify provenance of products. (Clancy 2017) 11. Gemalto collaborated with insurance company to cover delivery of temperature-sensitive medicines from drug manufactures to hospitals located in hot climate. Blockchain assists in governing the process, providing assurance to the pharmaceutical requirements. (Mathieson 2017) 12. Intel's Solution to track sea food supply chain.(Del Castillo 2017) 13. Bext360's app a Denver based and cloud	Everledger blockchain based system to use tamper-evident RFID tag to track the provenance information. Blockchain helps to govern process and offer assurance that the pharmaceutics required. It also helps to make sure each party in a supply chain oversees its own dataset. Blockchain stores information about fishmonger's store, IOT telemetry and temperature and associated information with the fish. Bext360's API tool enables intermediaries for instance: wholesalers, retailers to embed the technology into websites,	Blockchain can provide higher value when consumers become more conscious about the sources of their foods and beverages. Low Marginal costs to develop a blockchain code if technologies such as IoT have already been used to detect, measure and track key SCM processes. Authorization of the identities of individuals contributing in the supply chain. Digital twins used by Skye consulting to identify the fish-egg batches. Digital	Many countries and big MNC are working on the projects like: UPS (United Parcel Services) to join BiTA (Blockchain in Trucking Alliance), FedX. Many incubators are involved with their pilot studies to work on it and get more insights about Blockchain technology. Modum conducted its first pilot project in June 2016. (Campbell 2016) The UNISOT project is in progress stage which works on the digital twin's representation, all the information about fish will be stored

based software employ Stellar Blockchain to record timestamps and value of transactions on a real-time basis. (Koplin 2007) 14. Public Blockchains, Bitcoin, Skye Consulting Fish Farming case in Supply Chains. (Nelsson 2018)	marketing, point-of-sale.	representation in Blockchain, Secure digital twin data layer in UNISOT. (Universal Source Of Truth)	in a Universal node and the respective node is connected to the Blockchain.

Table 11 : Case Studies benefitted by Blockchain and its mechanisms used in it.

Source: (Kshetri 2017c, Chen 2017)

Here, Table 11 depicts the case studies which are benefitted by Blockchain and the mechanism used in it. The above table is also reflecting the current status of the blockchain in it and some demonstration of the pilot case studies.

Difference between Decentralized Supply chain Database Vs Blockchain based database

	Before	**After**
Technology	Traditional Database/Supply Chain	Permissioned Blockchain
Immutability	Editable	Append-only
Trust	Relies on Authorities Trust	Trust on Technology
Transparency	Low: Obscure in nature, maintain their own ledgers.	High: Ledgers are distributed and shared.
Traceability	Difficult to do backtracking in centralized systems.	Simple to trace due to immutable and decentralized data.
Confidentiality	Encryption persists but legacy issues still enable fraud (e.g. signature)	Strong access control and membership service

		offering with certificate and authenticity.
Interoperability	Different systems, it's difficult to integrate with other system	Easy to integrate with other system with REST API.
Scalability	Harder to scale, expensive	Easier to Scale and cost effective
Security	Strong encryption but legacy issues still enable fraud (e.g. signature)	Strong security system with distributed ledger of transactions, using the concept of PKI (Public Key Infrastructure).
Performance	Normal	Extreme Fast

Table 12: Comparison between Decentralized Supply Chain Databases & Blockchain database used in supply chain

Source: (Chen 2017)

Q2. What kind of supply chain features are likely to be benefitted by blockchain technologies?

Ans: As we all know that blockchain technology has a very broad perspective and wide range of applications in many areas, where it can be implemented, though with regard to the supply chain scenarios we have some use cases, where blockchain perfectly fits into it.

1. **Agri-food supply chain**: For food traceability and getting all information about food products like: Milk, yogurt, vegetables, fruits, sea food like: fish, tuna, meat, beef, chicken etc. Blockchain facilitates to provide complete information about all these products from source to destination within couple of minutes.
2. **Grain Supply Chain**: Blockchain technology can be used to store all information about grain life cycle such as: maize, rice and wheat. It gives the liberty to record all the processing steps of grain.

   Production phase: which contains information about paddy ,soil, water, area, season, quality of seed, growing conditions, planting time, plucking time, fertilizers and pesticides in a digital profile.

   Procurement phase: updates the digital profile of the product by giving related information to warehouse and transportation information of paddy to farmers to respective processing units.

Processing phase : Keeps information of converting paddy into rice can be stored on blockchains like : cleaning, husting, polishing, storing and packing under product digital profile.

Distribution phase :After receiving rice packages from rice processing companies , information about their quality, storages, logistics and distribution is regularly updated on blockchain at certain intervals by distributors, in such a way that it keeps track of all activities of distributors while deliversing rice to retailers. (M. Vinod Kumar 2017)

3. **Shipping perishable items like Flowers from Rotterdam port (Netherlands) to Port of Mombasa (Kenya) in Global Supply Chains (IBM & Maersk collaboration):** The Danish company Maersk is the world's largest container carrier and accounts for 18% to 20% of the market. For a many years, Maersk had been looking for better ways to monitor and track the goods it ships worldwide. For Maersk, the key challenge was the "mountains of paperwork" required with each container. But when Maersk and IBM started working on a version of its software that would be open to everyone linked to the container. After signing of customs authorities off an document, they can immediately upload it's copy with a digital signature. It enables everyone involved-including Maersk and government authorities- to see that it was done. If there were any problems about it later, everyone could track back the record and be assured no one had altered it in the meantime. The cryptography involved would make it difficult for the virtual signatures to be forged. The solution is based on the Linux Foundation's open source Hyperledger Fabric. (Kshetri 2017c) IBM blockchains facilitates with each entity participated in the transaction the growers, export authorities, ports, customs and importers. Shipping from the Port of Rotterdam to the Port of Mombasa requires six different signatures from three different agencies approving the export and documents are (Packing list, commercial invoice, Certificate of origin, Phytosanitary certificate, Export License and Bill of Lading) they define the origin, chemical treatments, quality of the produce and custom duties. Firstly using a PC or mobile device the Kenyan farms submissive packing list that becomes visible to all participants, this action enforces a smart contract rhythm forces and export approval workflow between three agencies, as each agency signs the position for all to see simultaneously information about the flowers inspection, ceiling of refrigerated container, the pick up by the trucker and the approval from customs is communicated to the Mombasa port allowing them to prepare for the container, all the actions

related to the document and the physical goods captures and shared which documents were submitted when and by whom where the flowers are and who is in possession of. So, in this way we can easily track the flowers consignment and every information is stored on the blockchain.

4. **Pharmaceutical Supply Chains:** In pharmaceutical supply chains, blockchain can be implemented to stop forgery of medicines and issues like Opioid crises (overdosage of drugs), reducing waste of paper and ink using Ethereum Blockchains. BlockMEdx application is an decentralized app, can trace the patient record of its prescription history to avoid counterfeit. Blockchain can be expected to see it's used between directly adjacent trading partners as a way of testing, exercising and gaining value from the technology. Blockchain is mainly used for product traceability and DSCSA (Drug Supply Chain Security Act) compliance. Blockchain has got some maturity in clinical trials and loads transportation in sharing electronic medical record data of sharing electronic medical record data among different hospital systems for aggregation and taking care at macro trends and population health issues. Real elements of blockchain (i.e., beyond internal proof-of concept) may be seen in the industry. Still it can be stated that it will take in years for blockchain to implement. Though early pilot projects will take place, an industry-wide agreement will take some time. Also, still lot of areas that need to be tested. Clinical data applications can be strong use case for blockchain technology. In such cases, regulators and study sponsors would believe that data accessed has come from a specific patient and any changes made to the data at the clinical site could be red flagged for further review. Thus, by assigning patients digital ID's, it would become possible to assure that the same patient doesn't enroll in multiple trials concurrently or within a short duration of time. (Shanley 2017b)
5. **Retail Supply Chain used In Tata Consultancy Services Private limited:** It helps retailers to solve customer dilemma and build trust by giving every product a 'Digital ID' that secures all information about product life cycle from origin to retail store. Blockchain technology provides liberties to retailers.
    - It empowers them to adapt easily to regulatory changes to serialization.
    - Block counterfeiting and analyze manufacturing practices.
    - Recollection of a particular batch to produce in face of contamination alert or defects detection.
    - Managing vendor relationships with ease.
    - Accelerate regulatory checks and auditing.

Blockchain mechanism helps in mass collaboration and execution of self-interest, it is a digitally autonomous way of bringing efficiency and reliability to ever-expanding retail supply chain.

Supply Chain Features	Case	Number of Cases
Transparency	All cases	14
Traceability	All Cases	14
Cost	1,2,4,5,6,8,9,11,12,14	10
Risk Reduction	1,2,4,6,7,8,10,12,14	9
Flexibility	All Cases	14
Immutability	1,2,3,4,5,6,8,9,12,14	10
Alleviating delays by removing paperwork and digitalizing the process (Speed)	1,2,3,4,5,6,7,8,9,10,12,14	13
Dependability	10, 11,13	3
Sustainability	1,2,5,6,7,9,10,12,13,14	10
Trust	All Cases	14
Scalability	All cases	14

Table 13: Supply Chain Features that can be benefitted by using Blockchain Technology

So, from Research Question 1, here table 13 is showing the supply chain crucial pillar features which are facilitated and covered by blockchain technology. Here in the above table we have taken 14 cases from the RQ1 table and analysed the respective case studies, that which of the case studies covers and meet the speculations of the supply chain. As we can see that features like transparency, traceability, trust, scalability are the main assets and key points that has been assessed in all case studies. On the other hand features like cost, immutability, sustainability also has a considerable role in Blockchain case studies which covers these dimensions. Therefore, we can conclude that these are the prime Supply chain features that are facilitated in using Supply chain industry using Blockchain technology.

Q3. Detailed Case Study of how SAP, Blockchain & RFID technology can be applied in Fish farming industry to make every phase transparent and traceable and more efficient from the consumer perspective?

Sol : Since, all around the world fish farming is a big industry and complex as well, other than this there are many internal discrepancies and loop holes which can't be tracked down easily like fraud, illegal activities etc. that can be easily monitored and recorded on a blockchain. The processes of getting the fish from fish-eggs that can be tracked and all its information can be stored on a blockchain.

To improve the fish faming industry and making all the departments information monitored and transparent, information about fish from fish pond to plate some incubators are working on it like: Provenance, UK based firm working on the project From shore to plate : Tracking tuna on the Blockchain.

It is the Provenance, pilot blockchain technology for tracing yellowfin and skipjack tuna fish in Indonesia from pond to the store.

In this long case study of 6 months pilot project is conducted by Provenance. They used mobile, blockchain technology and smart tagging were implied to track fish caught by fishermen with verified social sustainability claims. The main objective was to aid robust proof of compliance to standards at origin and along the chain, preventing the "double spend" of certificates and exploring how these new technologies can integrate with the present systems, to form the basis for an open system for traceability powering consumer-facing transparency for food and other products. The pilot was successful in tracking responsibly-caught fish and keep social claims down the chain to export. Provenance ambition is to provide a solution to the grave need for data interoperability : for tracking items and claims securely, end-to-end, in a highly robust, yet accessible format without the need for a centralized data management system. It was found analyzed that blockchains meet these needs and providing an exciting paradigm set for traceability in such vast complex supply chains at the South-East fishing industry.

Blockchain technology can be said as a medium channel that shares the same truth between all stakeholders- fishermen, factories, certifiers, distributors, customer point and consumers, without giving any of them a backdoor to the system. Blockchain gives precisely this opportunity. This project explored new methods for enabling traceability. It is about the secure flow of information enabling the full chain of custody to be accessed, including key social attributes such as fishing method, vessel type and compliance data.

Foundation of a blockchain enables a global p2p network to form: an open platform that can deliver transparency, neutrality, reliability, security, especially in grassroot trade.

- It helps to avoid double-spending of certificates and claims, which is otherwise impossible without a trusted third party.
- Works as a base layer of truth that everyone throughout the chain can refer to in a trusted way.
- It empowers the definition of strong rules called smart contracts that is also a feature of blockchain, it will be enforced by protocol itself.

Existing systems and the technology Opportunity

Provenance interviewers met with the heads of eight fishing organizations, their General Managers and Quality Assurance (QA) officers, are working to revive Indonesia's declining pole and line handling fisheries, snowballing accountability and trustworthy data on social standards at origin. They are all members of AP_2HI, the Indonesian Association of Pole and Line and Handline Fisheries. This interview involved all stakeholders: fishermen, boat captains, engineers, quality assurance experts, suppliers, supply chain auditors of international retailers, factory workers, warehouse workers, freight forwarders, company owners etc. Companies that have been visited by them are : PT Nutrindo Fresfood International, PT Intimas Surya, PT Hatindo Makmur, PT Harta Samudra, PT Aneka Sumber Tata Bahari, PT Sinar Pure Foods.

After collection and analyzing data, we mapped the factories and supply chain of the companies. We compared the data collection methods of three companies, as well as their level of vertical integration, key stakeholders and technology capability. In the below figure 11, it is depicting the methods used across the current traceability systems in Provenace.

Figure 11: Clockwise from top left, Methods used across current traceability systems involves digital labelling, excel lists, can printing and iPad data collection.

Source: (Provenance 2016)

The eight companies to whom the interviewers visited during the Research phase used pen and paper to account for documentation and other material flowing in and out of factories. It simply represents that they follow a manual process with some sort of Excel reporting for government purposes, sent via email once completed. PT Harta Samudra was the only company with some kind of digital accounting for fish products using the ThisFish Tally-O-System by Ecotrust Canada. They were also the first company able to take care of Fair Trade fish. To comply with the fair trade, their supplier uses plastic tags on tuna loins to identify the fisherman that caught the fish, before shipping to the factory.

As now the World is getting digitized, there are many initiatives taken by small and big enterprises (e.g.; mFish, Trace Register, ThisFish) and many more are looking forward to digitize the data capture along the supply chain, though only few have shown a convincing way for making that data truly interoperable without monopoly. Nowadays, every fisherman, supplier and factory worker we met had a mobile phone. 3G and wifi has irregular but accessible at most of the towns and villages are visited.

So, certainly there is a good opportunity to assist in digitize information. It seeks to build on it and use this pilots as a chance to demonstrate how the blockchain can be implemented to make data interoperable along the whole chain, and how to integrate with the present system, between very different actors and systems, linking that data to retailer and consumer experiences for stimulate a change in buyer behavior while reinforcing regulation and voluntary standards.

Besides using the present system, the Provenance application system is designed to work through a simple smartphone interface – either through the Provenance application itself or by connecting Provenance with existing interfaces and systems for data capture along the supply chain. The application connects and maps the features like: identity, location, material attributes, certifications and audit information with a particular item or batch ID. The information stored is an immutable, decentralized, globally-auditable format which protect identities by default, permitting for secure data verification.

Pilot Phase 1: Registration and Collection of data from the "first mile"

Provenance had worked with the local fishermen from two different supply chains to help them to collect catch data and trace it through to suppliers. The corresponding fishermen sent simple SMS messages to make a record of their catch, thus issuing a new asset on the blockchain with each SMS. Mapping it with the permanent, unique ID's, the assets were then delivered from fishermen to supplier along with the catch, in both physical transactions and in the digital register on the blockchain. So, at this stage, the goods are originally owned

by the fishermen becomes linked to the suppliers. The individualities of the fishermen are saved forever in the list of last owners held on the blockchain. Here figure 12 is reflecting the NGO's role in establishing the asset at the fishermen level with certification cascaded across the whole chain.

The conditions of fishermen like social and environmental are observed by the trusted local NGO's, whose audit system validate their compliance to external standard, resulting in their worthiness to contribute in the Provenance- validated chain of custody. Here, figure 13 is showing the reusable tag attached to tuna fish for gathering information.

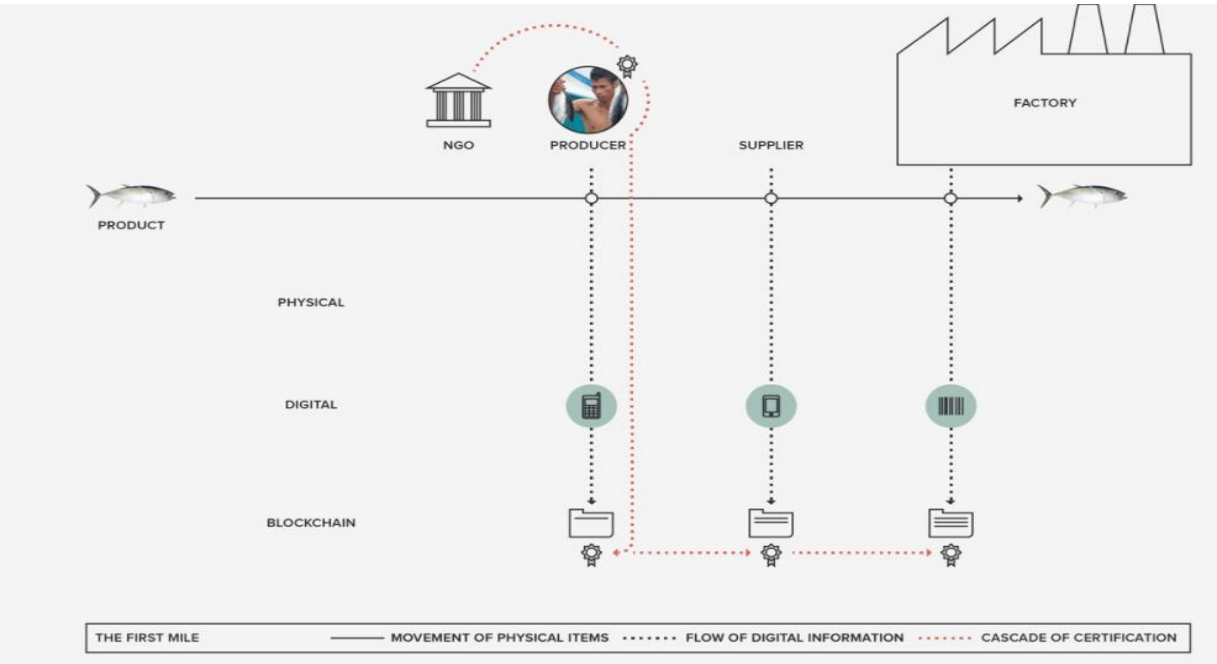


Figure 12: An NGO's role in creating the asset at the fishermen level, with certification cascaded down the chain

Source: (Provenance 2016)

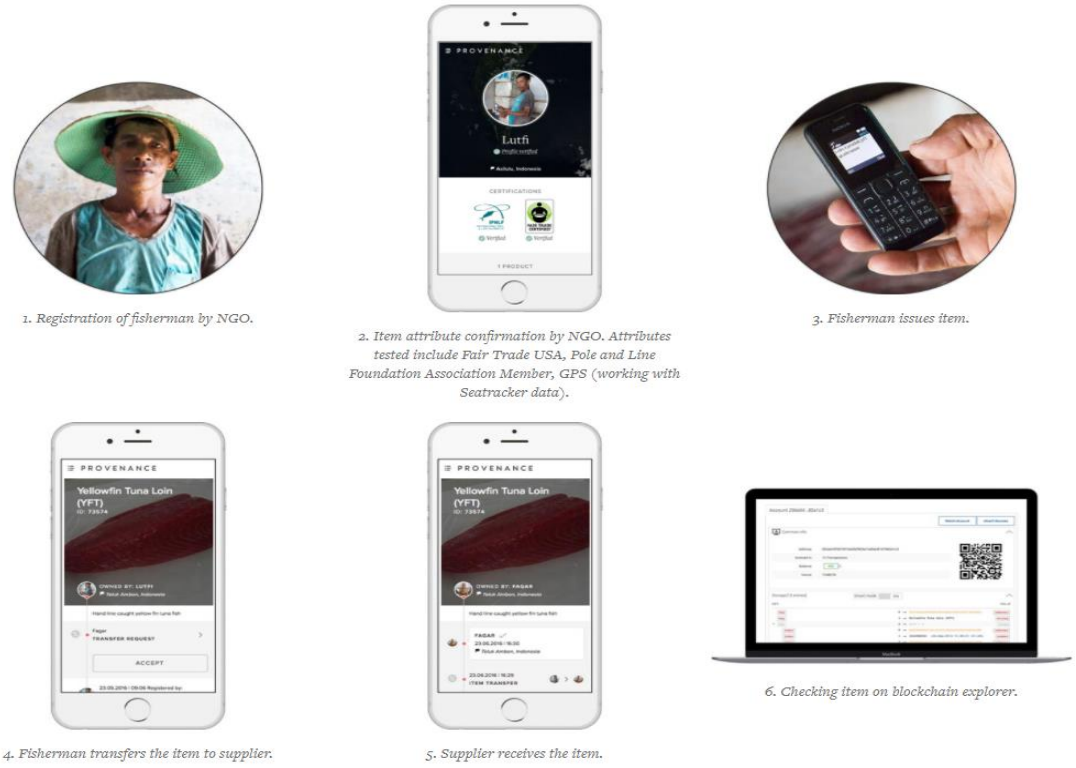
Figure 13: Tuna fish, a reusable tag is attached from which information is automatically uploaded to Blockchain.

Sources: (Candice Visser 2018) (Provenance 2016)

By using the blockchain explorer for instance: morden.ether.camp gives us access to check the raw content of the digital asset that represents the products on the blockchain. It confirms

the history and any other relevant details about the item have been recorded on the blockchain. The architecture we build is thus completely separate and more than building it on the top of Provenance platform. The figure 14 is illustrating a quick cycle and process flow of Yellowfin Tuna fish in Provenance.

Some key steps of Yellowfin tuna:



1. Registration of fisherman by NGO.

2. Item attribute confirmation by NGO. Attributes tested include Fair Trade USA, Pole and Line Foundation Association Member, GPS (working with Seatracker data).

3. Fisherman issues item.

4. Fisherman transfers the item to supplier.

5. Supplier receives the item.

6. Checking item on blockchain explorer.

Figure 14: Key Steps of Yellowfin tuna.

Source: (Provenance 2016)

Pilot Phase 2: Integrating the Blockchain with Existing Systems

Many supply chain mechanisms exist, although they are expensive, large scale Enterprise resource planning (ERP) systems that run on internal hardware or locally internal within the organizations, in private cloud environments. These data silos discourage interoperability and open standards, hardly cover a product's full supply chain, and it's not possible to cover the provenance from the first mile with this system.

There are some exceptions. Among them, Tally-O allows organizations to trace the origin of their fish within processing facilities. The data is then encoded and printed on the label and imported again in the next facility that uses Tally-O. Figure15 is showing the interface between the Provenance Blockchain and other ERP system like : Microsoft Dynamics and SAP.

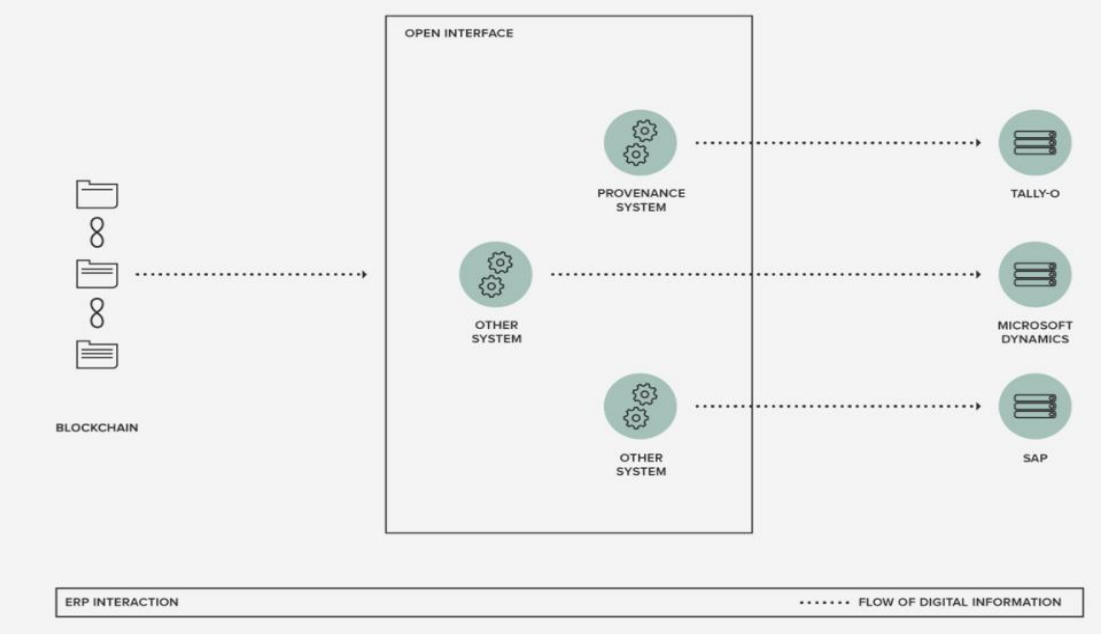


Figure 15: Open Standards permits Provenance and other providers to create a common interfaces for ERP software

Source: (Provenance 2016)

Interoperability :

The standards helps to communicate to unconnected systems using the same intermediary language, structures and identifiers. GS1 for example manages a closed set of global standards for most supply chain concepts such as barcodes and shipping container codes. There are not many standards available for identifying individual instances of products or their history. A unique ID in our system takes a form of an address on the blockchain. Simpler than an identifier is to fetch the data stored at that address on the blockchain allows any entity to access details about the specific item. Thus it is interoperable by default – as long as each entity along the chain commits its transaction to the blockchain in some amount.

Single Source of Truth

To maintain trust in a system, there must a UNISOT/SSOT (Single Source of Truth) for each piece of information. We suggest in this system that, the blockchain should be the single source of truth for verifying the actor's identity, as well as the validity of any certification or feature they entitlement to have. There should be the SSOT for the full ownership of history for each commodity from first mile to end customer. (i.e.; chain of custody) as well as the validity of any certification or any attribute associated with it.

Integration details with the Existing system

1. Accepting items / Ingredients / Materials

   Today, only paper records and accompany the sales and purchase of items such as skipjacktuna. Since, by digitizing the supply chain at the first mile, these products will

be sold along with the digital record. The records will be stored on the blockchain, accessible to anyone with the unique identifier attached to the item as a QRCode, RFID Tags or using any other hardware technology.

2. Allocating new or Transformed products

   In this step, the raw stuffs are being processed and converted into new products, the corresponding assets information is being updated on the blockchain. For instance: whole fish whose catch was registered to the blockchain firstly will leave the factory with many cans, it will be required to have their consequent sale tracked separately. Therefore, provenance implemented the concept of process as contract on the blockchain to manage this. To deal with this malicious processing, open-source pre-requisites will be defined, publicly enforced by the contract.

   Tally-O is implementing mass balancing to compute for the amounts of ingredients used in the transformation. For ex: the calculation for a can of Fair Trade skipjack tune perhaps be 200gm of certified skipjack tuna and 20 ml of olive oil. The information about this computation will be sent to the process contact once the whole execution has been processed, open source conditions will be defined, publicly enforced by the contract.

3. Compliance with Transformed Items

   Similarly, to the inputs were transferred on the blockchain when practically arriving to the factory, now the outputs are shifted to the next actor in the chain when leaving the proximity. Tally-O is in link to scanners that allows shipping management. Scanning labels stores the reference to the digital asset issued at the transformation step activates the transfer of that asset to the next character in the chain.

   In a nutshell, the blockchain provides an audit layer as a base layer for existing ERP systems or other data management systems like Tally-O. It gives the access to data to be shared and mass balancing of certified product to be conducted between two separated factories. Furthermore, it enables to retrieve data from the very first mile in a trustworthy manner- providing a UNISOT (Universal source of truth) end to end record without the need to change existing interfaces for data capture. Figure 16 is demonstrating the integration with the existing systems.

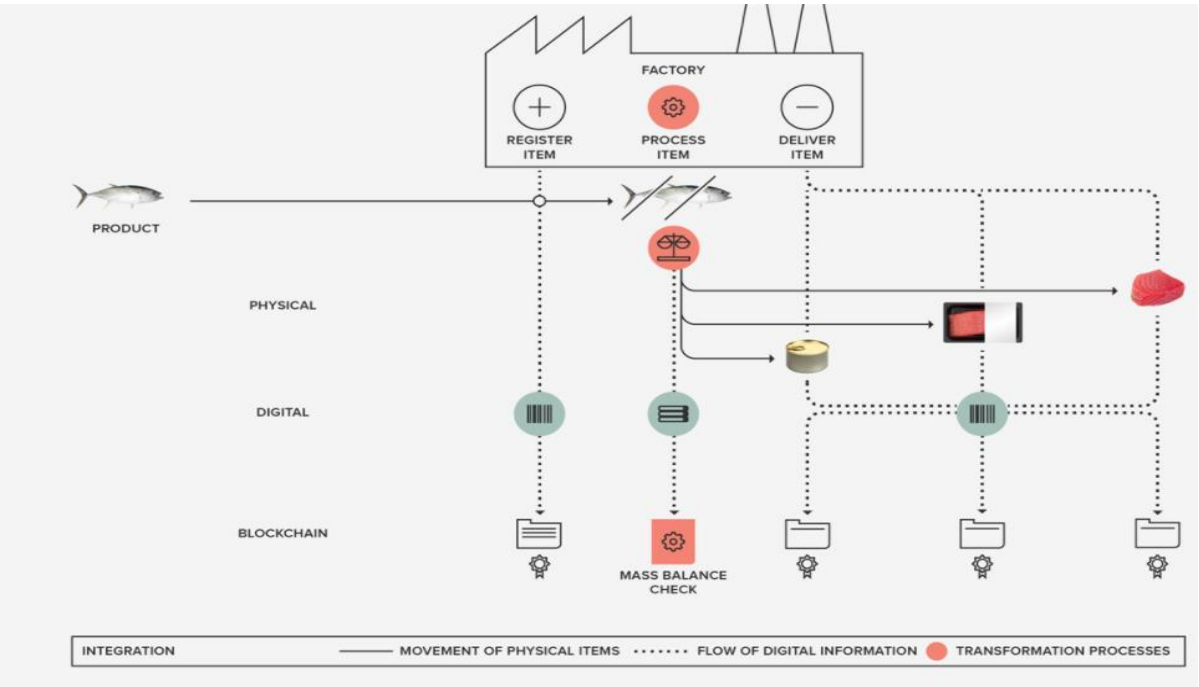


Figure 16: Provenance Integrates with Existing Systems

Source: (Provenance 2016)

Pilot Phase 3: The consumer experience and building an interface for trust.

In the final part of this pilot phase, it's been explored that the information from origin to destination flows in the supply chain can be mediated and trusted by shoppers towards the end of the chain. The reducing number of showing disinterest in local manufacturing has created a 'structural hole' or information gap that can rarely abridged, except by press reports and investigations by NGO's which results into disconnected consumers and highly exploitative market dynamics. As, there are more than 10 million digitally savvy online "ethical shoppers" in the U.K. expected to spend £76 billion by 2016, consumers take buying decisions by the products review or by perceived brand. As a matter of fact, 30% of U.K consumers report that they are very conscious about the environmental and social concerns, but are still striving to bring it into purchases.

To effectively gain more insights and integrate Provenance into physical retail sections, they conducted a workshop and in-store prototyping session with local Brighton supermarket Hisbe Food CIC. The workshop shaded some light on the topics like : consumer behavior, influencing ideas for how Provenance notion could best manifest in super market trade. This strategy motive was to clutter of traditional printed communication with Provenance online and digital stories and journeys, can be approached via in-store tablets, RFID technology, NFC enabled smart stickers, IOT devices. On the tablets shoppers can get

stories about product range, seeing the farms conditions, producers and farming in the pursuit of processing. Through RFID tags and smart stickers consumers can use smart phones to trace all the relevant history about the commodity and getting provenance right on their screens. This system increases and influence more consumers to draw their attention and win their trust, willing to pay more for products with proven origins.

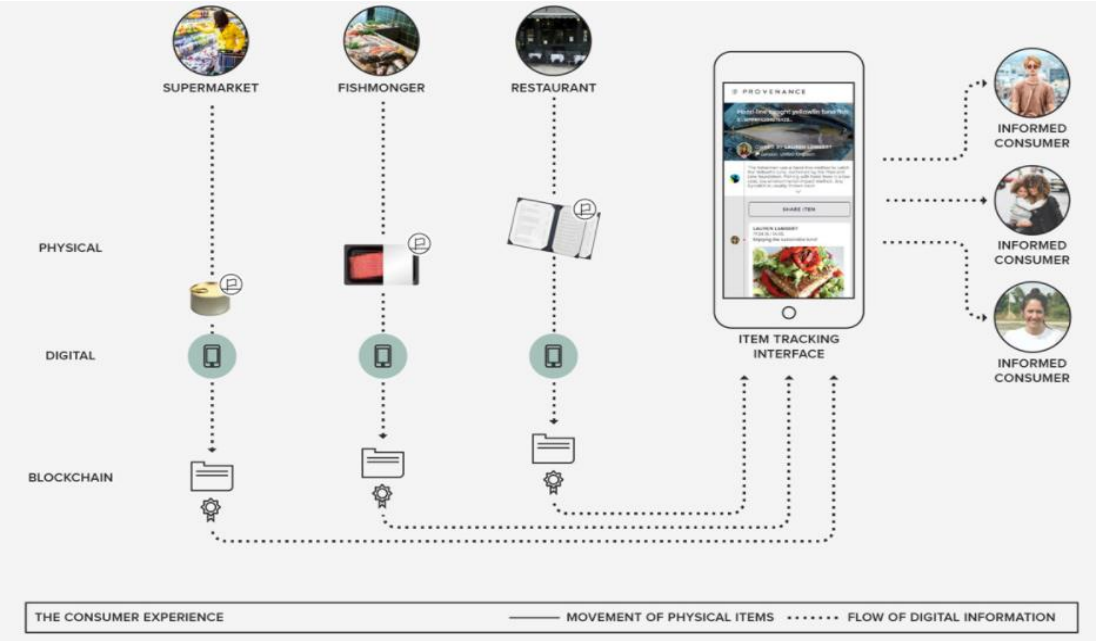


Figure 17: Consumer experience with using Provenance about Products.

Source: (Provenance 2016)

The simplicity provided by Provenance into retail environments provides numerous possibilities for marketing transparency and traceability. Here are some illustrations of few applications to point-of-sale and packaging, as well as implications of Provenance in restaurants. Here, figure 17 is reflecting the customers experiences using Provenance app in different places like : Supermarket, Fishmonger, Restaurants.

Figure 18: NFC Enabled smart stickers carry the Provenance mark along with item or Batch ID

Source: (Provenance 2016)

Figure 19: The stickers attach to Tuna fish Functioning on both dry and chilled sections

Source: (Provenance 2016)

Here Figure 18, 19 and 20 is the illustration of the NFC and other smart tags enabled products which gives the provenance of items or it's batch id and other pertaining information.

Figure 20: Item tracking extends to dining environments showing available information on ingredients.

Source: (Provenance 2016)

For this provenance pilot project, there were products linked to digital devices using QR code, NFC stickers, RFID gadgets, 2D barcodes, IOT (Internet of things) sensors can store the address of the digital product and can store it in the blockchain and can be generated in batches. However, it is easy to copy these tags at any point in the supply chain, it undermines the validity of the physical product associated with the blockchain. NFC tags can be programmed to cryptographically secure data- but they are not currently practical to use for upstream in the supply chain.

Provenance has applied two approaches to avoid duplication

- **High Tech:** It is advanced in NFC technology which securely enables tags to store the information. This makes copying advanced NFC tags increasingly hard and

double spending for the item more expensive. Prooftag uses bubbles to create unique tags that can't be duplicated. Other technologies are also rising for instance : nano spirals are being engineered using electron-beam lithography and it's really hard to clone. So these techniques are well opted for high-value goods for which authenticity is a critical concern. They are expanding these pilot projects with hardware partners to develop the optimum and solutions for high-value food supply chains.

- **Low Tech:** this technique can be used for low-value products, where secure tagging technology does not required. Particularly when the financial incentive to subsidize goods is low or the system makes it hard. If products gets digitally shifted and confirmed as received applying public blockchain would be impossible to sell the digital asset twice for a premium for a certain claim. Moreover, confirming just the right amount of something is in existence, and enrolling when registering that item on the blockchain, needs to be connected with the ERP system and POS systems. To verify further down the chain of ownership, customers would require easy ways to confirm the purchase. This can be completed through Provenance.

Last Phase(Conclusion)

So, the vision of Provenance is to see a future where any material, ingredient or product can have an identity, life and history on the internet in a shared, interoperable pattern. This pilot project brings the light to grave the need for a common backend to accompany the expansion of the digital ecosystem for traceability – all together the multitude of incubators and other technical giants companies are focusing with a shared language and public infrastructure.
It can be said that it works more than an interface, Provenance came along with several great pilot projects in data collection it comprises of vessel tracking, vessel registration, self reporting of catch and effort, independent port sampling concerns, Fair trade capture fish, fish tagging, internal structure for tracing the fish information and other apps for fishermen and suppliers all going in the areas researched in Indonesia. It is obvious to say that data capture was widespread both by software and hardware.

Exchanging information safely and securely between different parties is a hindrance for attaining the level of trusted traceability needed to prove slavery-free fish. Presently, the main solution is being posed if for one of the traceability providers to gain huge monopoly-it is neither secure, just as sustainable. The enormities in the fishing supply chain primarily occur at catch, before the destination of the fish is known. It shows the incentive structure and data system would have to be shared by couple of companies to cover the data capture

required- but there must be a system that assists every fishermen as much as it helps the brands that include their names to the packaging. So provenance has made a system that brought a lone fishermen and the gigantic retailer to work together. So finally, Figure 21 is the representation of whole cycle of tracking tuna fish from the first mile to the Consumer table, providing single source of truth.

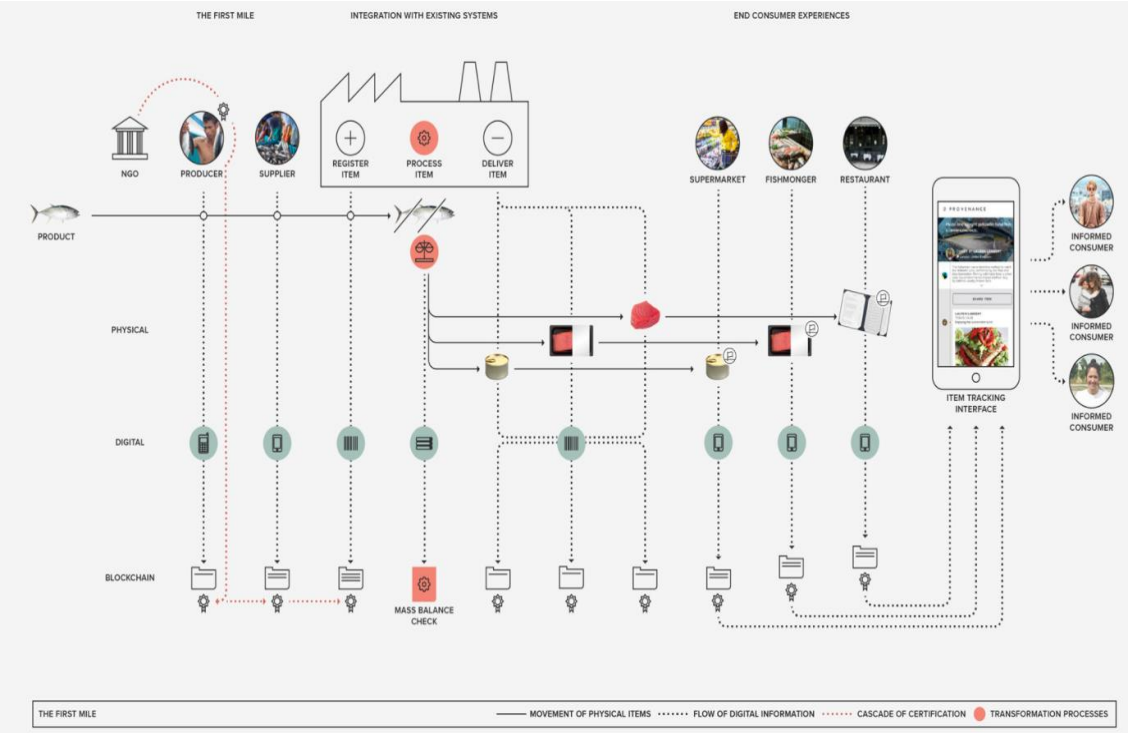


Figure 21: Blockchain Providing the base layer of truth across the Supply Chain

Source: (Provenance 2016)

Case Study to provide a solution to Fish Farming Industry tracking a fish information from very first mile

There is another Case Study about Fish Farming Industry based on Blockchain technology to provide transparency and traceability in Supply Chains implemented by Skye Consulting AS.

In this case study we can follow a product from a fish eggs to refrigerator. This is a generalized case which can be implemented to any Fish farming industry and based on this scenario it can give diversity and a new definition to goods and other food industry supply chain. This example can easily be applied into other industries where you also need to control quality throughout the supply chain by tracking origin, cultivation/manufacturing, processing, transportation, storage, sales and any recycling.

Digital twins in Blockchain

It is a digital representation in Blockchain which secures the digital twins data layer in UNISOT. It also globally track real time digital twins data sharing. A concept of "digital twin" is a digital representation of a physical product which activates the digital tracking and tracking of the item throughout its lifetime, since from creation to recycling. By managing the digital twist in blockchain, The UNISOT (Universal Source of Truth), which is available for all companies in the supply chain, will get a number of new unique opportunities.

We not only have the skill to follow and manage a product and its content as it's physically moved through the supply chain from producer to consumer, but we can also safely trac back origin throughout the supply chain and access information about, for example: origin, ingredients, age, storage times, transport times, temperatures, vibration, CO_2 emissions and more.

A customer, e.g. private customer, professional cook or buyer, by scanning the QR(Quick Response) code and RFID (Radio Frequency Identification) on the packaging, gets all pertinent information about the product straight forward in their mobile phone or into their business system.

It can also be notified (storing timed and unchanging documents) and share all important business documents in the Universal Source of Truth. Blockchain has the flexibility to allow government, customs and inspection organizations to enter licenses, certificates and approvals directly associated to the digital product twin. Figure 22 is a demonstration of a fish farming case study in a supply chain to offer transparency and trackability of whole information about fish batch or slot in every stage.

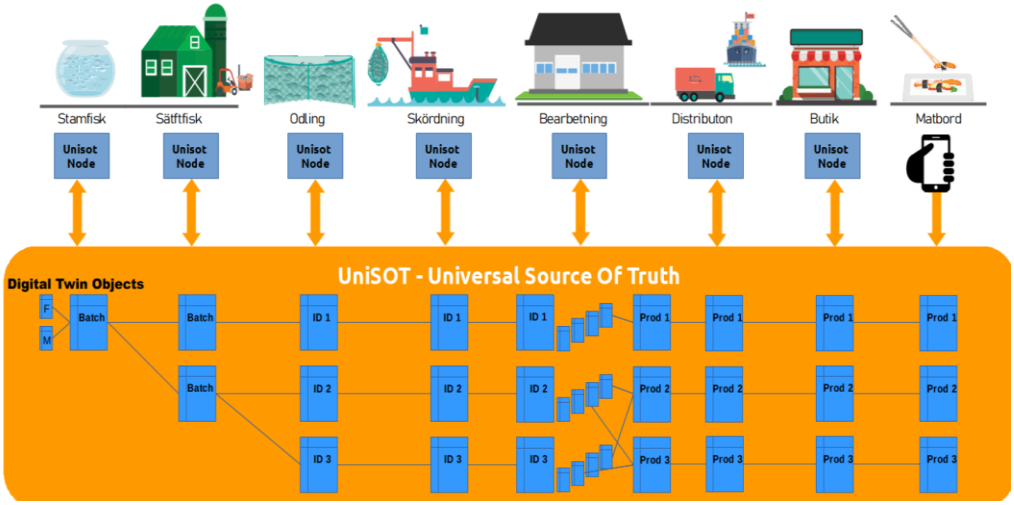


Figure 22: Fish Farming Supply Chain Using Unisot Node.

Source: (Nelson 2018)

So, present existing system ERP SAP integrates using API(Application programming interface) with UN(Universal Node), which is a set of programming logic (Phython, Java, C++), Distributed database node and last the blockchain node they are connected to each other. Finally this Universal node transfers all the data from Existing Enterprise Resource Planning systems like ERP SAP to the blockchain. For a clear view, the illustration is shown below.

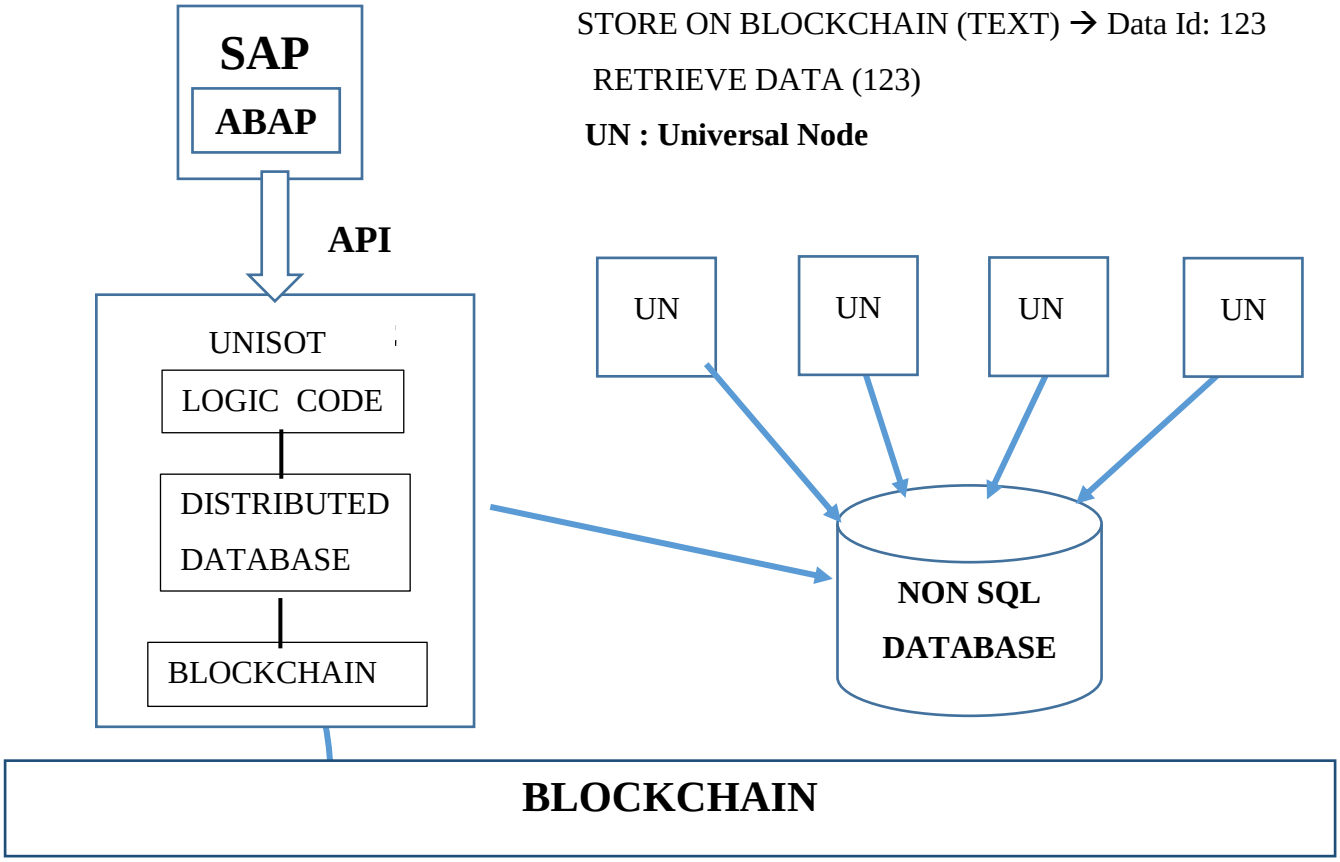


Figure 23: Integration Structure of the Existing system with Blockchain Technology.

Since, from the above case study figure 23 in every department of fish farming industry like fish shore section where with the help of digital twins concept they can get whole information about the fish and then at Satftfisk department it has a Universal node where it collects all relevant information about fish and it stores in the blockchain, similarly in the other different vertical supply chain divisions like : Odling, Skordning, Processing, Storage, distribution, Grocery Stores to dinner table. They all will have the Universal Node as the Universal Source of Truth which helps to store the information on the this Universal node. Finally, this node is storing all the information onto the Blockchain. Customer finally gets all these information by scanning the QR(**Quick-Response**) code, RFID(**Radio Frequency**

Identification) tags or NFC(**Near Field Communication**) stickers like fish is male or female, temperature conditions, Zone location from where it is caught, whole batch information like : fishermen profile, processing process, warehouse information, logistics details etc. As it can be seen from the diagram that documents and other certificates can also be uploaded on the blockchain. It is a pilot project which is presently in his working phase.

Secure Information Transfer

All these vertically integrated members are connected to the Universal Source of Truth, we can also easily establish secure encrypted point-to-point communication without having to build special and expensive integrations to any company that wants to communicate with.

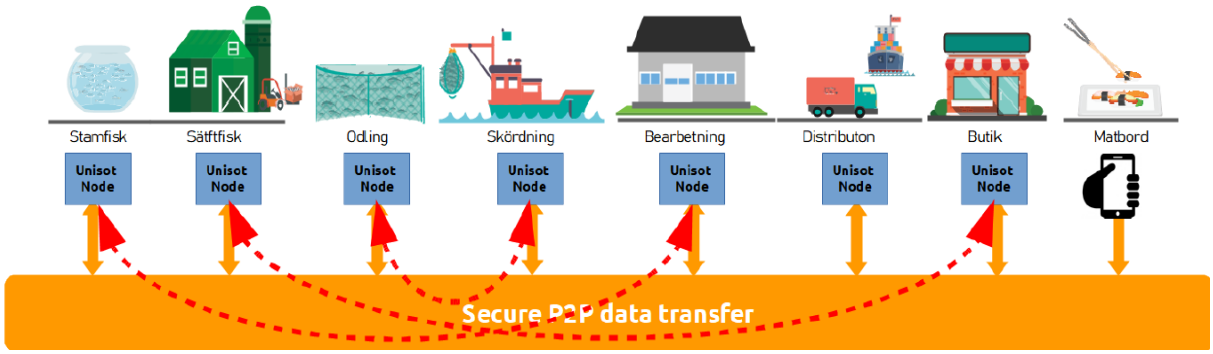


Figure 24: Secure peer to peer data transfer using UNISOT (Universal Source of Truth)

Source: (Nelson 2018)

Here Figure 24, is the illustration of the Universal Node which is available in all the vertical chains or department in the fish farming industry, to record all mandatory information. Then it is showing the secure P2P communication and secure transfer of information in the whole network.

5.0 Discussions

This chapter discusses about the discussions, analysis and observations which we found from the whole thesis and from different sources like: where blockchain technology exactly stands in Supply chain and highlighted other crucial aspects which are important for supply chain perspective. Then it encompasses a Decision Support Model which can help to make decisions in what situation using Blockchains or not and of yes, then which one to opt for.

5.1 Discussion from Literature Review

From the literature review it can be discussed that whether Blockchain term can be a **novel** term, but it's a combination of existing effective concepts which are being facilitated to empower Blockchain technology like : Using SHA-256 Algorithm (Encryption), Consensus Mechanism, Timestamp servers, PoW (Proof of Work), Network System, PoC (Proof of Concept), Incentives to the miners, Simplified payment verification system without running a full network node. So these are the existing traditional concept which are combined by Satoshi Nakamoto to form "Blockchain Technology".

If we talk about the Bitcoin, which is a cryptocurrency based on the concept of Blockchain which follow its principles of transactions between the two parties without the need of an intermediary entity like : bank or any other central authority for approval of trust or a symbol of administrator. As we have shown the working and Internal Mechanism of Blockchain technology in the literature review part, which is a full proof system, without the need of any central authority. It is simply based on the cryptographic concept which is a set of transactions and transaction is a set of (Public key + Hash of Previous Transaction + Private key of Owner). Which provides a great strength to the system. Since the block is a collection of transactions and these blocks are joint on the Blockchain network once they are mined by the miners and verified in a Consensus system by other members in the network. The more blocks are joined to the chain, the more it brings strength to the Blockchain. It's harder to temper or forge it or try to make any fake node.

As, we have mentioned about the different types of blockchain in literature review like: Public blockchain, private blockchain and Federated/Consortium Blockchains which are different in their characteristics, features and to fulfill their purposes. The bitcoin blockchain concept was raised for any kind of transaction like peer to peer insurance, P2P energy trading, P2P ride sharing etc. Following the bitcoin Blockchain protocol, other class methods like Colored coins, master coin a cryptocurrency runs on the concept of Bitcoin. Since, after the Bitcoin blockchain initiation, Ethereum decided to create their own blockchain, its

characteristics, features and working mechanism is totally different from Bitcoin Blockchain.

Ethereum has received a lot of attraction and attention since its announcement at the North American Bitcoin Conference in early 2014 by Vitalik Buterin. On 30th July 2015 it got released, Ethereum blockchain technology is being employed to create applications which are beyond just supporting a digital currency. Such applications are referred to as Crypto 2.0, Blockchain 2.0. Ethereum is the largest and most well-established, open-ended decentralized software platform that allows to write smart contracts and Distributed Applications (DApps) to be built and run without any downtime, fraud, control or any meddling from a third party. Ethereum is not just only a platform but also a programming language (Turing complete) running on blockchain, assisting developers to develop and publish distributed applications.

Ether is generally divided into two categories : it is traded as a digital currency exchange like other cryptocurrencies and is utilized within Ethereum to run applications and even to monetize work. According to Ethereum, it can implemented to "codify, decentralize, secure and trade just about anything." (Bajpai 2018)

5.2 Bitcoin Vs Ethereum

Bitcoin and Ethereum works on the principle of distributed ledges and cryptography, but they are distinct in many technical ways. For example: the programming language on which Ethereum based in Turing complete on the other hand the Bitcoin blockchain is a stack based language. Other differences include block time (Ethereum transaction is confirmed in seconds compared to Bitcoin transactions takes 10 minutes on an average) and their basic working structure is based on (Ethereum uses ethash (Proof of work) algorithm while Bitcoin used secure hash algorithm, SHA-256).

Moreover, from a general perception, Bitcoin and Ethereum are different in their purpose. While bitcoin is created as a digital money as a medium of payment transaction and store its value, Ethereum is build as a wide platform which simplifies peer-to-peer contracts and applications via. its own currency vehicle. As we know Bitcoin and ether are both crypto currencies, the primary purpose of Ether is not only to set up a payment alternative (unlike bitcoin) but to smooth and monetize the working of Ethereum and to empower developers to develop and run distributed applications (DApps).

5.2.1 The Bottom Line

In sum, the bitcoin Blockchain is a public chain, it is not been hacked or any kind of tampering being done with because if its secure architecture and tamper-proof system and using the concept of Digital signatures with the transactions from A to B. On the contrast, when Ethereum blockchain was hacked, on 18th June, members of the Ethereum community observed that funds were being drained from the DAO (Decentralized Autonomous Organization) and the overall balance of the organization went down. During this case a total pf 3.6million Ether (worth approximately $70 million at the time) was drained by the hacker in the first couple of hours. The attackers withdrew Ether from the DAO smart contract multiple times using the same DAO tokens. It was possible through what is called a recursive call exploit. So, there is a loop hole found in the Ethereum blockchains which can't be said 100% full proof. In a nutshell, it can be said that Ethereum is an advancement based on the ideology of blockchain that incorporates bitcoin but with a purpose that doesn't compete with Bitcoin. But Ethereum has much broader and wide applications in future because of concepts like : Smart contracts, Intellectual property etc. and some DApps: IDEX, ForkDelta, PoWH 3D, Etheremon etc. (Madeira 2018)

As we have shared the varieties of blockchains like : Public, private and Federated/Consortium. But which one is the best among these. Since after findings it was finally decided that based on some factors the decision will be made on like: immutability concept is agreed on the consensus basis by the harmony of authors.

To get a more clear idea, the author Pavel Kravchenko divided the blockchain into 4 quadrants: permission-less public which follows PoW (Proof of work) consensus, anonymity and immutability of the user is high and scalability is low and such a structure is appropriate for fully autonomous systems and fully not in government control. So, from the perspective of immutability and hiding the identity of the user, it's perfect to use for such use cases. But can't be preferred for scalability use cases. Examples: Bitcoin, Monero.

Permissioned public blockchains follows proof of stake consensus algorithm in which you must have some coins for a mining process. The trust level is high for validators, for which client always demand but there is a risk factor persists, that if a network is being attacked by a double spending problem. But really beneficial for use cases like: governance projects, smart contracts execution, private money systems Ex: Ethereum, Bit-shares. From the aspect of immutability and scalability it is moderate. So, when it's concern about the privacy and security use cases where date needs to be kept more confidential, in those projects it can be preferred.

The next one is permission-less public blockchains, but here permission-less meaning is something different than it Bitcoin. “Under a particular social agreement, anyone who is qualified and deserving can become a validator”. The level of trust is low in these sort of validators, since the features of entities are known. These kind of blockchains apply FBA (Federated Byzantine Agreement) consensus for use cases. In this consensus, each node doesn’t have to be known and verified ahead of time, membership is open and controlling system is decentralized. Nodes can select whom they trust. These blockchains are specifically opted for Consortium and National Blockchains. Where you don’t want neither all features should be public that can be access by anyone but only by authorized members. For bank services these blockchains can be utilized. (MAZIERES 2016) (Ray 2016)

Finally, last category of the 4th quadrant is Permissioned and private blockchains have PBFT (Practical Byzantine Fault Tolerance) consensus in which validator must have license. These are one blockchains which are not public in nature. PBFA consensus algorithm works on the dependability of a Fault-tolerant computer system, specifically distributed computing systems, where parts might fail and there is imperfect information on either a part is failed.(Wikipedia 2010) In a case of “Byzantine failure”, an entity for instance server can inconsistently seems to be both failed and functioning to failure detection systems, showing distinct symptoms to various observers. Such blockchains are used for fast transactions and infrastructure corporate usage. Here user anonymity and immutability is low that means data stored on blockchain can be edited like in private blockchains but scalability is high from industries angle. (Liskov 1999)

So, from the literature discussion it can be said that for specific use cases and purpose we need the blockchains according to that, and there is no best blockchains phenomenon, it’s all about the use cases and the consensus mechanism. (Liskov 1999)

5.3 Discussion from the Case Studies

1. From the 1st case study about the Maersk and IBM collaboration, we all know that 90% of global trade and freight transport is carried out by a shipping industry. Since in the current supply chain network is complex and there is a turmoil because of intricate supply chain and a sheer volume of point-to-point communication during the loosely coupled load transporters, custom brokers, government ports and ocean carriers. Therefore, IBM and Maersk planned to organize a pilot project which is about shipping the flowers container from Port of Mombasa (Kenya) to Port of Rotterdam (Netherlands) using IBM blockchain which is private in nature, that means only authenticated and authorized members are suppose to have access.

Saving lots of delays and money by reducing all documentation work with securities, custom department, tax officials and other 30 people permissions when it's a trading between two countries. IBM employs tamper proof for digitizing the trade workflow and tracking. Shipping flowers from port of Rotterdam requires signatures from three different agencies approving the export and six documents like: Packing list, Commercial invoice, Export license, Bill of Lading, Phytosanitary certificate) they describes the origin and chemical treatments, service quality. Using PC or mobile phones by the Kenyan farms submissive packing list that creates smart contract and export approval workflow between three agencies, as each agency signs the status is updated for all to see concurrently information about flowers inspection, ceiling of refrigerated container, pick up by trucker and other approvals by customs communicated to the Mombasa port permitting them to prepare for the container. All the actions related to the documents and physical goods captures and shared are stored on the blockchain and shared among members. Since flowers are perishable entities that needs to delivered on time. It also tracks the current position of containers and who is in possession of them. This system can really make Global supply chain efficient, transparent and traceable. As this is a successful pilot project executed by IBM & Maersk.

2. Walmart & IBM have conglomerated to make food supply chain more powerful, with traceability of food information from farms to Grocery store shelves. The reason behind implementing this pilot project is to swiftly trace the whole data about the product in any cases. As in today's market there are huge number of cases of commodities contamination and adulteration like : Horse meat scandal, Spinach outbreak and E.coli HUS virus that infected so many people in US in 2006 . The first pilot project was conducted in the U.S and pork in China. In this operation it required technologies like Blockchain, RFID, NFC, Smart tags, Barcodes etc. to track the information from source to the destination. In May 2017 Walmart filed a patent application with the US Patent and trademark (USPTO) entitled " Unmanned Aerial Delivery to Secure Location". (Coggine 2017). Besides this from this blockchain's role in package authentication and tracking. Walmart has declared his further plans about empowering the technology in authenticating a customer and a courier, gauging temperatures containers and products comparing with acceptable thresholds. Though during the Spinach outbreak in 2006 U.S it took 2 weeks to find out the bone of contention, and before the blockchain technology arrival, still it was the "Achilles

heel" in agri food supply chain. But with the help of blockchain you can trace within a couple of minutes the farm or the location of the Spinach.

So, from this discussion I must say that Blockchain and combination of RFID, NFC (Near field communication) and Smart tags is a new disruptive technology in food supply chain. It also raises the level of trust among customers to have the blockchain trusted food which 100% tested and secure.

3. Provenance is also a similar pilot project start up by UK based company which is based on Indonesia sea food industry to track the sea food Like :tuna fish from sea pond to the shelf store with the help of Blockchain technology and Smart tags, RFID tags. Provenance the name itself shows the origin point of something they are currently on many other case studies like:
    - Pioneering a new standard for trust in food retail, empowering customers all along the supply chain. The Coop uses provenance software to track fresh produce and product claims from origin to supermarket.
    - Tracking proven sustainability claims through global supply chains (International Pole and Line Foundation)
    - Tracking towards a circular future for cotton. (Upcoming project) in which tracking the fabric information from cotton cloth to stitched clothes in stores.

    So, in all these scenarios blockchain is a boon for the industry as a new revolution. As it can be implemented for any product for its traceability and providing visibility in supply chain.

4. Pharmaceutical Supply Chain (Block MedX): From this case study we have seen that how Blockchain technology can solve this big problem of drugs abuse and overdose of drugs opioid, that patients got addicted. It was such a big issue that on 10th August 2017 the opioid epidemic announced a national emergency. The problem is multifunctional, that was not easy to solve at all. Since the usage of antiquated system of prescribing controlled medications that can easily bring to easily forged and altered in addition to difficulty monitoring patients and prescriptions.

In such a conundrum, Block MEdx works as a novel e-prescribing platform that will offer secure transmissions of prescriptions, a complete universal record of opioid prescriptions for patients, pharmacies and providers. BlockMEdX planned to achieve these targets by creating a decentralized application using the Ethereum blockchain, using original

prescription information and creating a real time, complete record of controlled entities assessed by machine learning algorithms.

BlockMEdx designed an effective method and system based on Ethereum blockchain which helps not only patients but also pharmacies and physicians to get rid of this corrupt and forgery system. Blockchain intends to use a cryptographically secure HIPAA compliant, end to end prescribing platform. Prescriptions are securely recorded on the blockchain accompanied by an MDX token. A token will be paired with each particular prescription, securely verifying the prescription's origin from the point of creation by physician.

This Block MEdX D-App is an advantage for physicians because they can easily access the whole records of the patient's prescriptions by login onto this D-App through their mobile or laptop, also having access to create a new prescriptions for the patients. To issue a new prescription the physician must have to pay a MDX token fees, they will be able to see the required fee for creating the prescriptions. Physicians have the privilege to view the list of their prescription history which will tell the prescription's current status: pending, approved, revoked, declined or accepted. They can easily follow if patients is attempting to use prescription at more than one pharmacy.

Similarly, pharmacies can also see the patients records of prescriptions through login on the D-app. They also have an option of accepting or declining the prescription, upon the acceptance of prescription the MDX tokens will be transferred to the Pharmacy integrated token wallet issued by the physician. The pharmacy uses a digital sign as a confirmation of the receipt using a non-invasive biometric identity recognition method. They will then enable to print the prescription, it includes a QR code which can be used to validate the prescription, or they receive equivalent QR code from patient, as printed by the physician in his office. QR code authorizes that's a legal prescription with corresponding transaction ID, sent by the authorized physician to the pharmacy. Furthermore, MDX tokens can be facilitated for electronic payments methods that lowers barrier to entry. Pharmacies will also be looking for prior payments from particular patient as well as request payments via. QR codes and NFC devices.

Patients will also have a great advantage with this Block MEdX D-App to see their prescription history after login. On their behalf anyone else with credentialed access to the system can also scan the QR code on their printed prescription. Patients will be notified when a new prescription is created and sent to them by a physician. Patients have the advantage to pay with MEDx tokens by scanning a QR code or tapping their device with NFC on the pharmacy device for NFC functionality.

5.4 Discussions from the Interviewees

1. For this thesis we interviewed Stephon Nilsson who is Blockchain Evangelist – Solution Architect SAP- UNISOT – Internet of Value – IOT at Skye Consulting AS. He is a Solution Architect specializing in Blockchain Integrations with a devotion for Distributed Systems/technology, Bitcoin, Internet of Value, IoT, Open Source Peer-to-peer.
He has 30 years of professional and international IT experience.
Currently he is working on a Blockchain project in which he is working on "Fish Farming in Supply Chain using Blockchain Technology" to provide full information about sea food: fish from its eggs to fish available in stores shelves and looking forward to integrate current ERP systems with Blockchains to provide Universal source of truth. He was asked couple of questions to answer with.

Q1. What is the present position of Blockchains?
Stephen: pointed out- that blockchain technology is disruptive like Internet in 1990 which brought a new revolution in world, presently it is in testing phase with many pilot projects are working on it, eventually they all are successful, which brings a positive sign to fully implement it. Bitcoin is one of the blockchain application, which created a chaos in the market.

Q2 Why we exactly need Blockchains?
Stephen: pointed out- Blockchain technology provides a valuable features like : transparency, trackability, durability, immutability, process integrity, security. Which are really valuable assets and fundamental pillars for any organization. From the supply chain perspective, there are billions of products available in market and many complex supply chains which include vast network of retailers, distributors, transporters, storage facilities and suppliers that contribute in design, production, delivery and sales. Blockchain facilitates to store each department information and its related product information to make process faster, and digitally accessing all records and documents within the network. It will make system more efficient, because we can save money, time and illegal activities, frauds and child labour crimes from system.

Q. Which blockchains are most preferable in industry according to him?
Stephen: Stephen pointed out that, there should be only public blockchains exists, that can be accessed by anyone. Everyone can participate in the network, see the transactions information and can download all the transactions on his local machine. His own current use

case “Fish Farming in Supply Chain” is also based on Public blockchain which is named as “Universal Source of Truth” in which existing ERP(Enterprise Resource Planning) system integrates with the Blockchain with the help of node created in each section of the Fishing Supply chain to store the information with the help of API in public bitcoin Blockchain.

Q. In what industries blockchain can be employed?
Stephen : Blockchain is something beyond Bitcoin and has wide aspect which can be used in many sectors like : Global Supply chains, Agri Food Traceability, Health care logistics, Pharmaceutical Supply chains (facilitates to reduce paper and ink to write traditional way of prescriptions), Fashion Apparel industry for cotton traceability from sheep to Stores.
And various other questions were asked with Stephen Nilsson about blockchains which can be shared later.
So, the bottom line he shared about the Blockchain technology is that there exist only one blockchain i.e; bitcoin blockchain which is public in nature. This is a new revolution of technology which is inevitable, and it will be implemented in all other various areas. Since there can be the sections where it is viable to use the current ERP systems to keep track of the inventory and other process records like in the internal supply chain of the process.

2. Another interview was done with Nazar Khrupalo, who is the Sales Manager Asistant of Applicature. It is a blockchain development agency working on projects in the blockchain and cryptocurrency industries. They provide a wide range of custom blockchain development services. Nazar was a former Sales Manager in NetLS Software Development in Ukraine.
Since, Nazar Khrupalo is a busy man, but still on request he gave some of his precious time to interview him for and after asking couple of questions we can streamline his views as: - Blockchain is the soon coming future, which will give people new horizon to see things. There will not be any sector which will remain uninfluenced by it.
He mentioned his company builds smart contracts which is a piece of computer code that contains pre-defined agreement conditions for the parties, which will delete the roles of third entities like lawyers, legal advisors and other bodies.

3. Final interview was with Jim Sabogal, who is advising clients to use IT (Information technology) to improve Healthcare & Life Sciences business. He is a health care leader in T-systems. He always updates people on LinkedIn about the latest IT technologies in Medical and HealthCare Industry.

One of the main questions asked to him that:

Q. What do you think as the biggest hindrance to implementation, and how they can be overcome?

Jim: - The biggest hindrance implementing blockchain in the pharmaceutical industry is because of wide range of possible blockchain platforms 17 (Nagpal 2017), as well as different versions of blockchain, including Hyperledger Fabric and Ethereum. Most of these blockchain will work for pharmaceutical organizations, eventually ships thousands of units per day. Many incubators are approaching in market that claim to offer scalability, which would be useful to pharma in life. (Shanley 2017a)

Q. Which blockchain should be opted for pharmaceutical supply chains?

Jim: This is also a concern in pharma supply chain to decide whether to go for a private or a public blockchain. Public clouds can be used that means that the transactions can be viewed on Internet, so private clouds are most likely to meet with the typical pharmaceutical company's data security needs. Which also brings a concern like what will happen about the distributor that offers services across multiple pharma companies? Once the point of scalability is cleared, distributors will take decision about whether they can go for multiple blockchains.

So, finally interviewing with Jim Sabogal, we are also convinced that Blockchain is the upcoming scope for the Pharmaceutical industry. Here Table 14 is the bottom-line of interviewers about Blockchain technology.

Authors	Bottom Line about Blockchain	In favour of Blockchain	In Oppose of Blockchain
1. Stephen Nilsson	Public Blockchains are inevitable and it's an upcoming future.	Blockchain has a broad scope in many wide applications and areas.	Blockchains are not necessarily applicable for internal supply chains.
2. Nazar Khrupalo	Blockchain is a disruptive technology which will change the future. Applicature works on the principle	Smart Contracts gives the facility to remove the third-party entity like: legal bodies, lawyers etc.	Still it is in nascent stage, will take couple of years to come into saturation mode.

	of blockchain and implementation of Smart Contracts.		
3. Jim Sabogal	There are many blockchains which one is to use like : private or public. They have opted for public clouds but when scalability issue will be cleared, distributors will going with multiple blockchains.	Real elements of blockchains (i.e; beyond internal proof of concept) might be seen in the industry in early 2018. It's a big advantage from data security aspect for clinical supply chain management. Blockchain can be used for exchanging clinical data between a patient and a drug trial.	Blockchain is still in early stages, EDC (Electronic data collection) already perform the task for exchanging clinical data between a patient and a drug trial. Use cases are still in development phase.

Table 14: Bottom Line from Interviews about Blockchain from Blockchain Experts.

5.5 Decision Support Model to Select for Blockchain or not and if yes, then which kind of blockchain should be considered

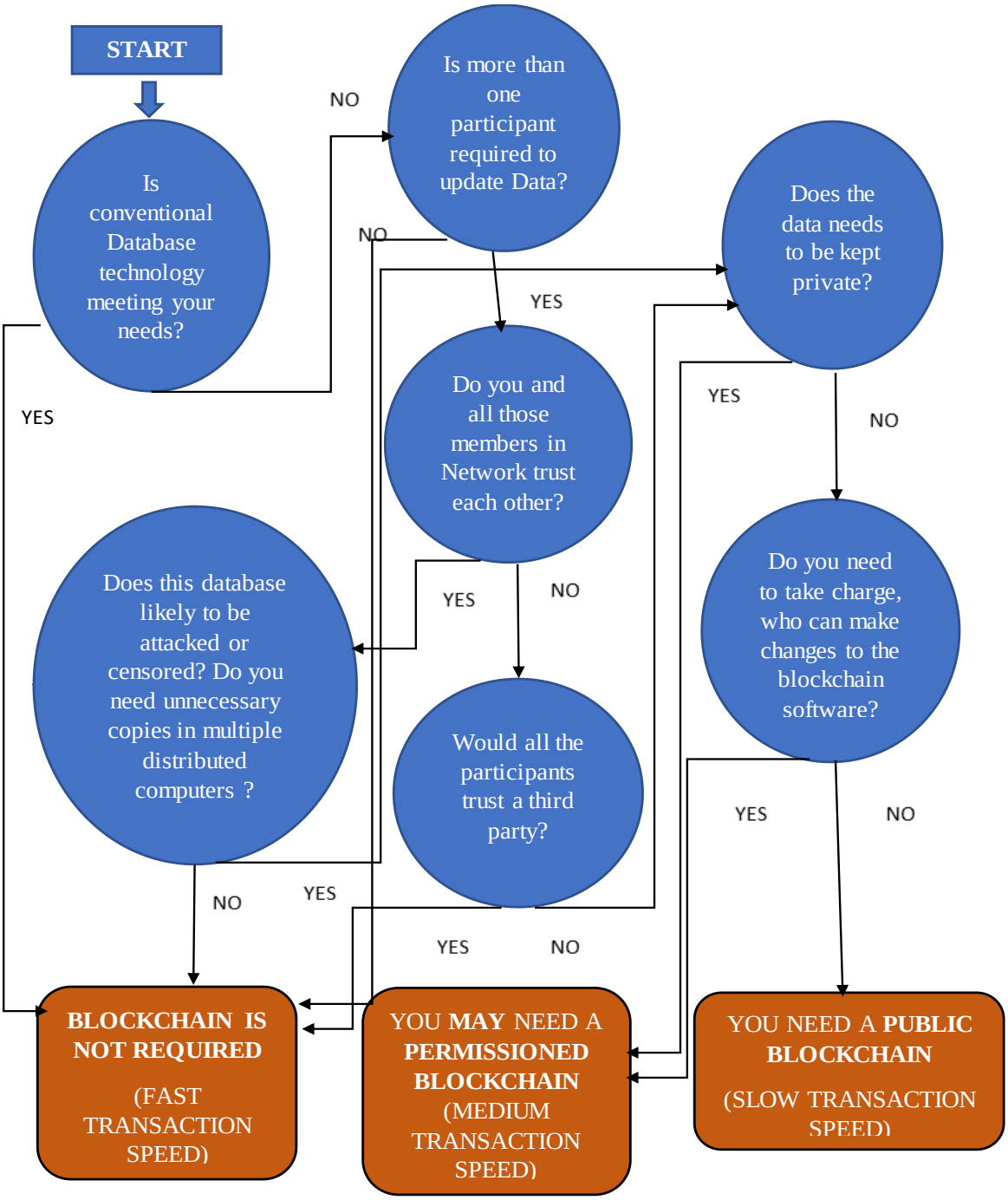


Figure 25: Blockchain Decision Support Model

Source: (Chen 2017)

6.0 Conclusion

This is the final chapter of the thesis that retells the work being done in the thesis and highlight some of the founding's, observed and analysed features which can put some more light on further work. Furthermore, findings and discussions were concluded for the present procedure and discussed. Chapter is complete with the suggestions for future implications work.

6.1 Research Conclusion

This thesis main motive and focus was to provide transparency and traceability for multiple industries in supply chain with blockchain technology.

Firstly, an introduction was started with the Aim, motivation, purpose of the literature review, research questions, what is Supply Chain Management, Present Scenario of Supply Chains, Problems in Supply Chains. In this chapter related to transparency and traceability of modern supply chains is addressed with the motivational features of Blockchain technology as well as corresponding incentive and goal to solve the problem.

The second chapter represents the Literature Review in which addressing what is Blockchain technology, its working manner, internal mechanism of Blockchain how exactly works, Types of blockchain, which blockchain should be opt for which cases. Some key features behind blockchain like : PoW (Proof of Work), PoC(Proof of Concept) ,PoS(Proof of Stake).

In third chapter, the research design methodologies were mentioned to deeply analyse the blockchain technology. It was divided in three phases. In phase 1 we have assessed the literature review and created the theoretical framework. In phase 2, it was a process of selection of case studies used for analysing the blockchain technology in supply chain and then creating a revised framework. In the last phase it was the interviews done with the Blockchain experts and created a final framework.

Fourth chapter is about the findings from all the sources and the phases which me mentioned and answered the respective research questions with some tables, figures and models.

Then, chapter five tells us about the discussion from literature reviews, case studies, interviews and from findings and research questions that how blockchain can assist in different supply chain industries to drive visibility, traceability, scalability, speed, sustainability, risk-reduction factors to improve the efficiency of the supply chains. It also tells us about that still blockchain is in his nascent and development phase.

Finally, chapter six precise the founding and highlight most critical components. As well as comparison is made between traditional database and permissioned blockchain solution.

6.2 Further Research

From the detailed study of this thesis, we have seen that still Blockchain technology is in his nascent/pre-mature stage and the successful execution of the pilot projects in wide range of applications demonstrate that it is upcoming future. Since for the any business there has to be a strong bond of trust among parties which is provided by a blockchain technology. Blockchain technology can offer this required trust with transparent and clear transactions in addition to a record of the product. So that the customer understands the true value product.

Configurations with the Internet of Things and Machine Learning

As, we found many good articles about Blockchain in IoT and the system gives REST API to integrate with other system and web applications. Eventually, the entry of data be relevant to internet of things. As the procedure of how to integrate blockchain with IoT is one of the major concerns. While, IoT data will be the reason for data flood problems, so using machine learning to extract the most valuable information can be great resolution.

Further research would also required to explore and figure out the benefits for the players in the supply chain to employ such a technology. The research would have to show some visible and solid gains and incentives for the characters themselves by having such transparency. But if this can't be found, the explorers would have to go for some alternative solutions, e.g. a forced implication from the government.

There is one more area which also needs to be reckoned that how the technology would be enforced in detail to a specific supply chain, especially the recording. In this thesis we have discussed in the case where with the help of API(Application programming interface) the information about each department is stored on the Universal node, and from there the information hash value is stored onto the blockchain, but in future it can drive some more ways to bring transparency and traceability in supply chain as it is desired.

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8.0 Appendix

Some Case Studies were analysed to give the deeper insights of Blockchain Technology

1. **Shipchain** : It is a system providing a fully integrated system across the entire supply chain from the moment a shipment leaves the factory, to the final delivery on the customer's door. It is allianced with federated in trustless, transparent blockchain contracts. The shipchain platform is on the grounds of simple, yet powerful solution known as "Track and Trace".

Shipchain can offer the Future Logistics Plans:

- End-to-end Track and Trace: Supply chain platform allows for unified tracking across the whole supply chain, between the carriers.
- Incentivized Responsibility: Operators gets bounty in the form of rewards for efficient transport routes, and for delivering goods on time. Reducing theft cases by better tracking system.
- Platform parity: Brokers are no longer needed, but can be used whenever necessary, smaller carriers can operate independently.
- Full visibility: Each step of the supply chain is documented and recorded on either our main blockchain or our sidechain, building full transparency, traceability and ease of communication. (SHIPCHAIN 2017a)

The **Vision** of ShipChain was founded to solve the greatest problems faced by the logistics industries today. The solutions must contain the deep technology and it should be quite simple. Suppose a fully integrated system across the whole supply chain—keep tracks of the product the moment it leaves the factory, field or farm to deliver the finished product to the customer's door or supermarket shelf; alliance in trust less, transparent blockchain contracts.

Tracking & Transparency

For tracking and traceability of shipment across the Ethereum blockchain, implementing ShipChain side-chain to track independent encrypted geographic waypoints in each smart contract.

The meaning of this system is that each waypoint will be encrypted, accessible for interpretation by the contributed parties. It will facilitate the shippers more transparency and visibility during the whole stream of supply chain. It also gives liberty to carriers to

communicate with ease, minimizing the delays and miscommunications. Simple access to information about loads, geo-waypoints and basic compliance information will be stored and publicly validated within the side-chain. Upon delivery and confirmation, the contracts will be executed abd recorded on the main blockchain, releasing any payment escrows. While with the upcoming ELD (Electronic Log Device) compulsory from the United States Department of Transportation, ShipChains will work with most famous ELD developers to integrate directly and march toward our first oriented goals. It encompasses of completion of Track & trace technology. The first step of working with these providers will give permission us to join immediately into the biggest network of US-based trucking freight companies, offering us the platform a full network of fright movement without the arduous requirement of joining to individual freight companies (or even individual Owner-operator trucks) one at a time. In the same manner, there are chances for us to connect with the major US railroads, global ocean freight forwarders and majority of airlines and creating our multimodal blockchain based tracking system. The inner tracking is the initial step in unification, with their internal confirmations being fed to the blockchain. Thus firstly the separate pallets or crates will be tied to the address of the container and with the passage of time the consignment will be tracked as a whole. The business development will help these freight forwarders with the replacement of their base internal tracking with the ShipChain system, permitting a higher scale of perceptibility within all of multimodal shipping partners. The below figure 26 is the illustration of using SideChain and containing all the mandatory information in blockchain and SideChain.

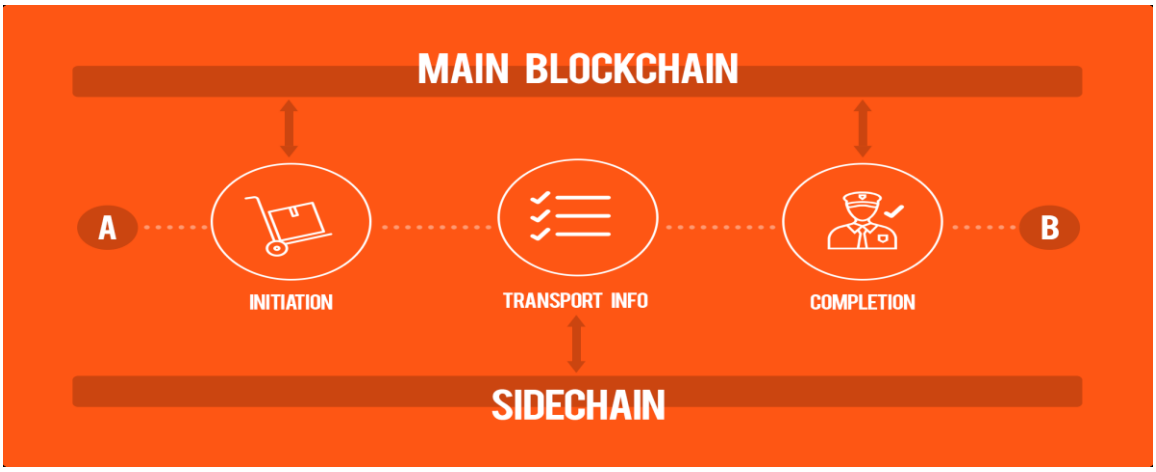

Figure 26: SideChain and Main Blockchain Storing all important information from point A to B.

Source: (ShipChain 2017b)

Decentralized Brokerage

In the present system, freight brokers are available to offer the services like transfer of loads from shippers to carriers; Brokers main job is to find loads, mark them and sell them to carrier, which soars the shipping cost and decreases the profit margins for carriers and other team members. So, here the Ship Chain will cover the need for brokers by permitting carriers the skills to find shipments and smartly route their team members for multimodal and inter freight transportation systems based on factors such as distance, traffic, weather conditions, fuel use and many other features. This load unit will generate a smart contract upon pick-up and hold payments in escrow until conditions are fulfilled for release are met using the main blockchain and SideChain for monitoring, tracking and security monitoring.

Asset Security

Installing blockchain technology into the logistics industry to encode geographic data will improve cargo visibility and result to that suddenly decreases theft. Using technologies like barcodes or hardware RFID integration, products can be automatically cross-checked each time electronic logs are reported, therefore increasing security and privacy, offers peace-of-mind for all parties. So , it can be seen that blockchain comes with the benefits of Per missioning, immutability and encryption are inherent benefits. By bringing accountability to each phase of the process, the blame game between carriers, brokers and shippers is mitigated.

Trustless Incentives

The vision of the ShipChain is disruptive and will bring a new era in the freight industry by this encoding and encrypting waypoint information and relevant data about the loads belongs in a shipment, digital escrows of the whereabouts of goods are eradicated, and finally because of all this individual players can be rewarded for their participation in system that works without just believing about what happened. In the future aspect of the platform, it can be plan to provide driver rewards for obeying speed limits, behaving safely and observing green fuel economy practices.

Technology Used by the ShipChain

1. Contracts & Side-Chains : The ShipChain contracts are based on Ethereum EVM (Ethereum Virtual Machine) smart contracts that can be duplicated and used by anyone to arrange a shipping escrow on the distributed ledger. The overall shipment completion information is stored on the main Ethereum blockchain, and to keep the costs low, separate

tracing of waypoints and load data can be stored and verified in an associated side-chain operating on the ShipChain Protocol (fork of Ethereum software). Big partners will be enabled to operate their own ShipChain Protocol side-chains, with (or without) aid from ShipChain Foundation.

When a shipment order is placed, a role of smart contract is initiated. This contract will include a hash sum signature of the delivery information for the shipment, including beginning address, final delivery point, carriers involved, freight forwaders details, number of shipment items (as granular as preferred with an address for each item being possible), weight, volume, dimensions, quantities, HS codes, intermediary data. Anybody with a legal and valid copy of these values can verify the signature and assert the validity of the contract on the main Ethereum blockchain. As a result, this essentially offers a more detailed Bill of Lading.

The smart contract will be completed on delivery with all validations and conformations of the waypoints recorded to the blockchain. If all the waypoints are affirmed, the contract will be executed (and each contract will be able to specify its own terms for how many concerns will be resolved, including third party arbitration. The below image 27 is a ShipChain first application for cargo booking suppose from Point A to Point B

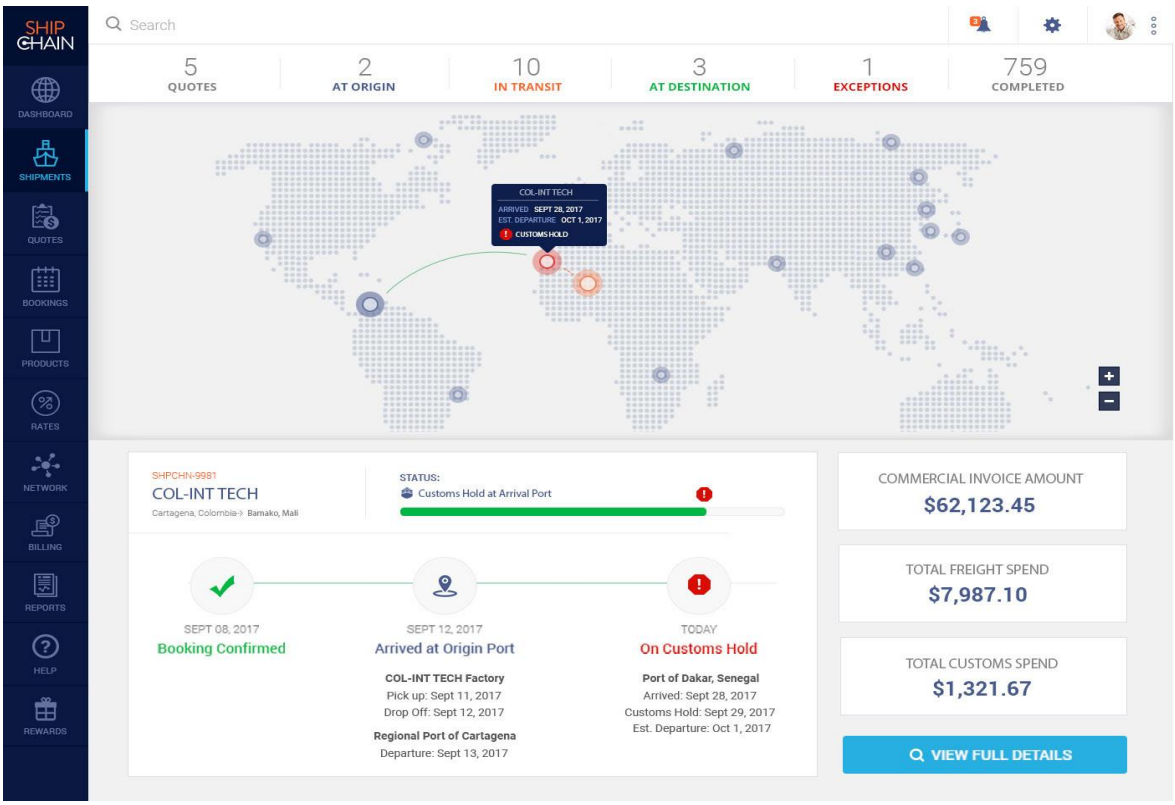

Figure 27: ShipChain app.suggesting routing and shipping methods based on cost, time in transit and contents from "Point A" to "Point B".

Source: (ShipChain 2017b).

ShipChain Web

The decentralized brokerage system will encompass mainly an open marketplace joining shippers and carriers. Shipchain provides a flexibility as an open access to its blockchain marketplace, but also build the first platform of services upon it. ShipChain web platform is a centralized system for booking and looking after the loads delivery and consignments across many carriers and modes of transportation.

For example : the shipper has seven full shipping containers of plastics coming from China to the Europe, the system will identify that a sea carrier, rail carrier and final truck carrier will be the best options for optimization for cost and speed based on the size and type of shipment. The shipper will then observe the measurements on each leg, book their own routes, see their estimated delivery, and having full control over their supply chain without the requirement of a broker. The figure 28 illustrates the ShipChain application interface with Maintenance and continued carrier integrations with the ongoing process for tracking systems.

With the aid of ShipChain web, carriers can post capacity for their shipping vehicles and lanes, dynamically set pricing on the grounds of supply/demand, adjust for estimated fuel cost and having shipment booked to their routes automatically. So, with all this automation system and necessary information held in a smart contract, this process will be faster and easier than ever before. Regulatory compliance may require ShipChain be have license in freight brokerage, freight forwarding and have an internal customs brokerage.

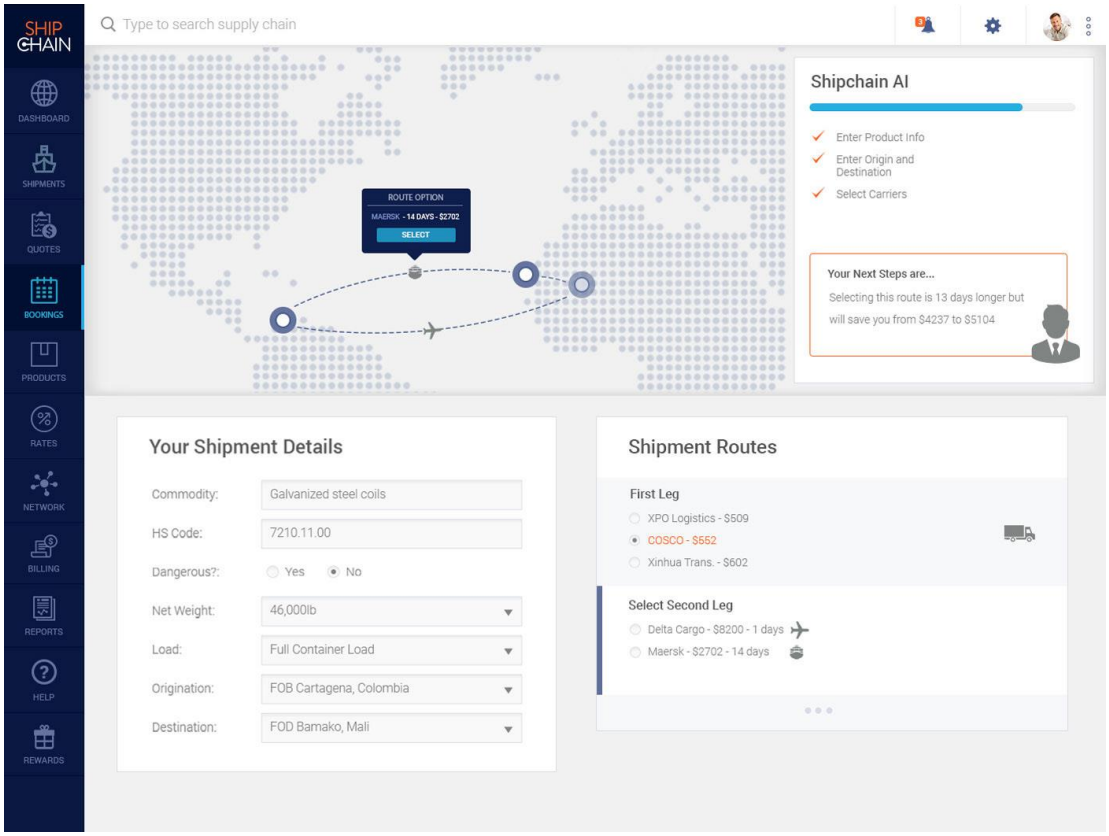

Figure 28: Target rollout date for first version of the ShipChain Web Platform unified tracking system 2018. Maintenance and continued carrier integrations will be an ongoing process for the tracking system.

Source: (ShipChain 2017b)

2. **Cargox (ReShaping the Future of Global Trade with World's First Blockchain Bill of Lading)**

In the logistics industry, it is said that logistics is the backbone of all the global trade. Some 90% of all goods in global trade are controlled by the sea shipping carriers every year, making shipping one of the world's largest industries. CargoX has the power that will transform the global shipping industry by securing "Bill of Lading" documents using blockchain technology, thus gives a flexibility to importers and exporters to exchange those documents digitally, securely and without any counterfeit in an open environment.

The main objective of the CargoX is to build a decentralized and open protocols, tools and utilities for the exchange of shipment ownership (Bill of Lading) in the logistics sector. With Smart B/L it will change today's physical (paper) proof of ownership used for claiming proof of ownership, making it more secure, instantly transferable, simple and easier to archive and massively cheaper than the current (paper) solution.

CargoX can save time and money by bringing producers, importers and freight forwarders and other involved parties together in a well stable ecosystem based on trust and frictionless

communications, offering tools for seeming less interchange of documents, will drive them to high level of security, transparency and traceability.

The Problem with the current system of Bill of Lading Documents:

Bill of Lading (B/L)

A Bill of Lading (sometimes referred as B/L or BoL) is a document issued by a carrier (or his agent) to notify receipt of cargo for shipment. In British English the term shows to sea transport only, and in American English to any method of transportation of goods.

When we transfer the any goods from sea mode it starts with the NVOCC (Non-Vessel operating Common Carrier) issuing a Bill of Lading document that acknowledges the receipt of the cargo.

The Bill of Lading document serves as the purpose of title to the goods in transfer. Anybody in possession of the document can claim the goods at a port, driving it to the important document in the shipping industry.

The below picture 29 depicts the typical scenario of the Bill of Lading Document sycle.

Once the cargo is received and the Bill of Lading is issued by the carrier or NVOCC, that document is sent to the owner (shipper) of the cargo. Once cargo payment has been received, the owner (Shipper) sends the original documents to the buyer of the goods (Consignee or Cnee, or in case of L/C a bank) by express courier services (UPS, DHL, Fedex). At the arrival of vessel at the destination port of the carrier or NVOCC asks the importer (buyer) to show the original Bill of Lading in account to release the shipment to the importer.

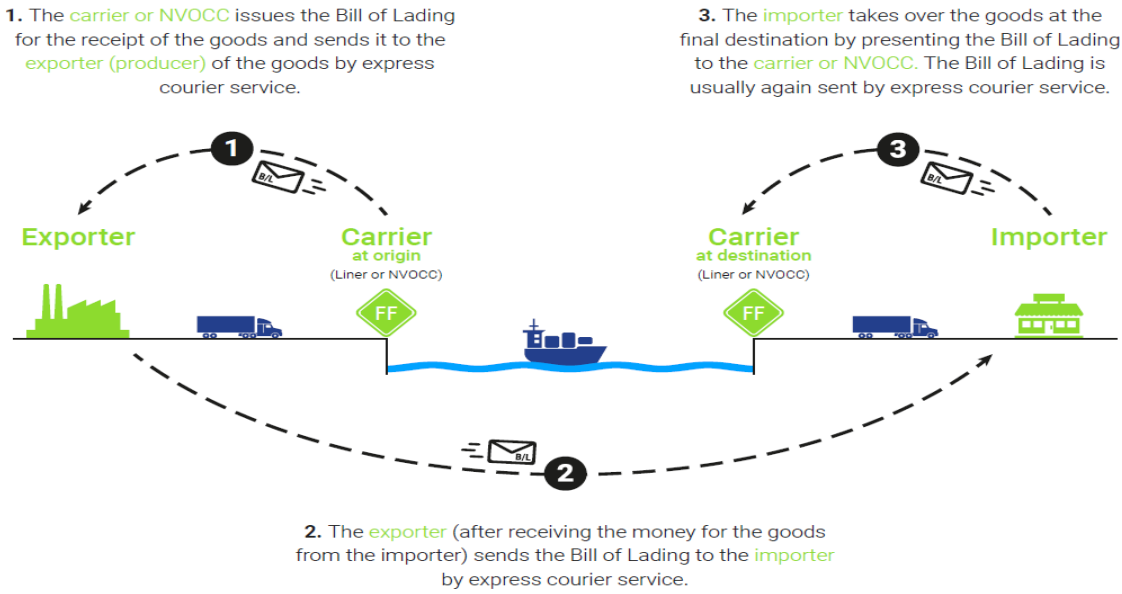

Figure 29: Bill of Lading Cycle

Source: (CargoX 2017)

Achilles Heels:

1. **Cost** : Nowadays each bill of lading has to be printed out on paper. This document is highly important needs to be sent at least 3 times via express parcel delivery companies such as UPS, FedX etc. which is time and money consuming. On an average express courier costs are above USD 100 for each BoL (Bill of Lading).

2. **Lost** : There are chances that BoL can get lost or even stolen. This problem is mostly felt by importers as they need to officially declare the B/L lost, which leads to in weeks of waiting for a new one and due tho which the additional costs incurs along the way arise: for instance demurrage at the port of destination, late arrival of shipment and some cases can be the total factory downtime which can result in a multi-million dollar loss.

3. **Slow** : In the conventional way, it takes ages to receive B/L. The issuer (carrier or NVOCC) sends it to the shipper (1-2 days), the shipper delivers to bank of the importer or the importer (3-5 days), and at the end the importer sends it to destination carrier office for container release (carrier, forwarder, agent) 2-4 days. Totally, each B/L travels with at least 3 courier services and is in transit from 5-10 days, making it more vulnerable to loss or even theft.

CargoX Solution

CargoX will develop an open system based on Ethereum and encrypted permanent decentralised data storage which will allow the creation and exchange of BoL documents. The given figure represents the workflow between different parties in CargoX system.

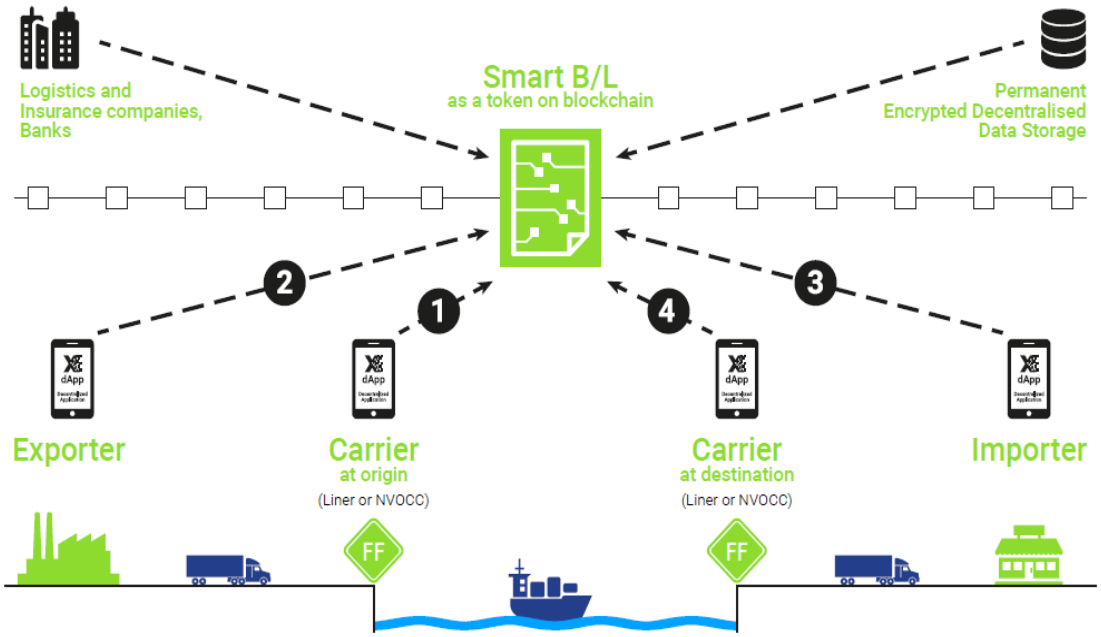

Figure 30: The Blockchain based Smart B/L works in a like manner to tokens. The user can create/ transfer /claim its ownership.

Source: (CargoX 2017).

1. At the Origin the carrier implements our D-App to create a blockchain-assisted Smart B/L with the exporter's address and send a token to the exporter.

2. After receiving the payment for the goods from the importer, the exporter transfers ownership of Smart B/L to the importer by using D-App.

3. The importer can claim ownership of the loads at the destination port by showing the smart BoL token to the carrier or NVOCC at the destination using D-App.

4. At the end point the carrier releases the goods to importer and once importer proved ownership of the smart B/L token.

In whole of this Cargo-X system, all the global trade sensitive critical information will be hidden from public view and only shown to the importer, the exporter and the smart BoL issuer; and special aid and care will be provided to properly secure all information about multiple business conversations between the same peers.
Figure 30 is showing the Blockchain based Smart B/L works in way like tokens.

Usage of CXO (CargoX) Tokens

CXO tokens will be used a core part of a digitalised business model; it will have multiple intrinsic utilities such as: system access, payment for usage fees, gas for running Smart B/L contracts, usage incentives, bountry and reward mechanism, access and payment for advanced features (e.g. document archives, logistics and shipping services) etc.

CXO utility token is carefully designed in such a way as to empower our users, boost interactions with the CargoX system and to facilitate services offered by the partners.

CXO tokens will be needed to obtain access to the system and all core operations on the B/L exchange protocol.

Additional CXO tokens will be needed to allow archiving and other advanced properties of the CargoX system.

CXO tokens will be prioritized payment mechanism for sea freight and other shipments on selected web-logistics portals, offering discounts upto 30%.

CXDApp Workflow

1. The importer creates the transport order

The importer (after getting an offer for sea freight) makes a transport order to a carrier.

2. The carrier creates the digitally signed Bill of Lading document

The carrier collects all the mandatory information from the exporter and creates a draft of the Smart B/L in a Smart Contract app. All the parties involved are added to contribute. Once the B/L draft is confirmed by all parties, the carrier finally seals it with a digital fingerprint. No relevant data can be changed after that. CXD App provides seamless and user friendly interaction with the Smart BoL exchange.

3. The carrier handovers the digitally signed Bill of Lading document to the exporter

After receiving a payment from the importer, the exporter assigns the legal right of ownership to the importer with his digital fingerprint.

4. The importer proves the ownership of the Bill of Lading document

After the cargo's arrival at the destination port, the carrier at end terminal checks the exporter has no reason to hold the release of the shipment. The cargo is handovered to the importer after custom clearance.

To give a clear image of Transfer of Ownership and the Creation of Digitally signed Bill of Lading document. Below figure 31 and 32 are the illustrations of it.

Figure 31: Transfer of Ownership

Source: (CargoX 2017)

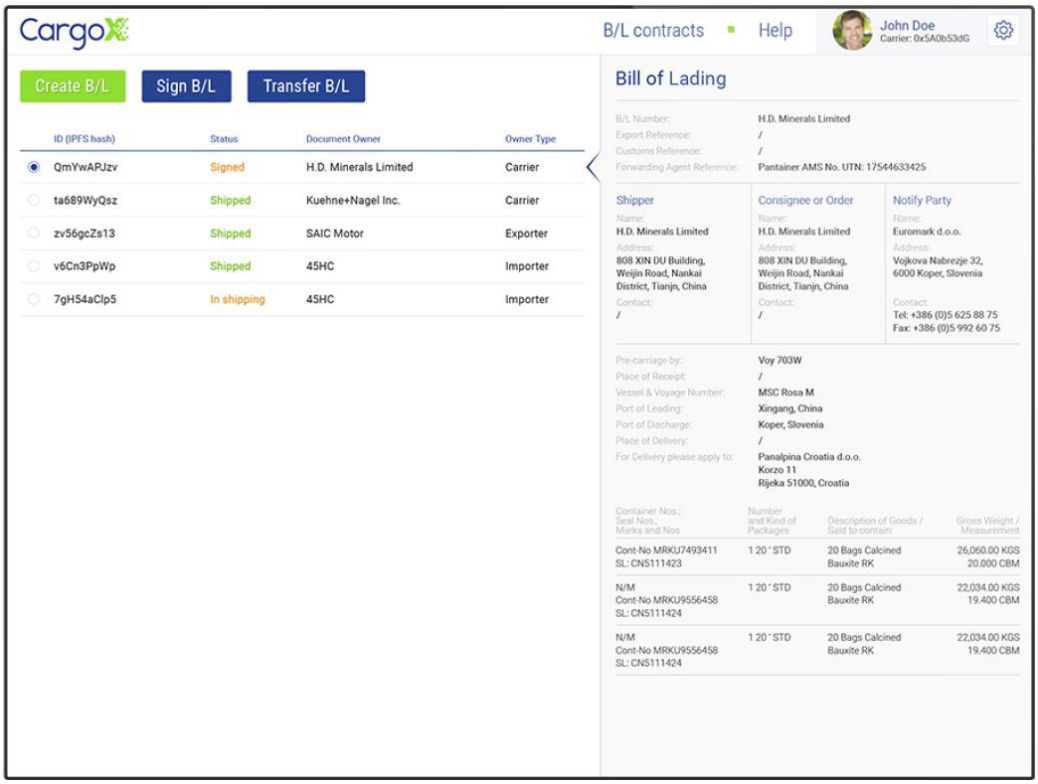

Figure 32: Digitally signed Bill of Lading document

Source: (CargoX 2017)

Developing a blockchain based on proof of concept sample

The Coffee self-service case

This small case is to present the potential of a cryptographic trust-free transaction system based on blockchain. We developed a proof of concept solution for an existing trust-based self-service solution at the coffee shop place operated by some students of University. Importantly, there needs to be an implementation of a digitized version of the currently used punch card procedure for coffee-dispensing, using now smart contracts. The existing system used punch card mechanism, where each coffee drinker has to clip off a piece of a pre-purchased, 10 clips comprising punch card him or herself when having a cup of coffee, can be represented as a trust-based system with inexplicit transaction rules. Basically, coffee could be stolen, or people could just forget to clip off a piece of their punch card. While improving this structure by a blockchain based approach might looks like bit over-engineered, this example encompasses all the essential benefits and challenges of executing such an IT solution for other commercial transactions which would give an advantage from trust-free transaction processes through administering the transaction rules by smart contracts within the blockchain.

In the present situation, the manner the coffee buying works is that one buys a card that values is 10 cups a coffee. Each time one wants a cup, he or she removes a clip using a scissor. Then you can fill a cup from a coffee pot. The punch card shows an artefact that has been provided some weightage in the real world. It can be said that a punch card is a worthless piece of cardboard. It only has a value when used in a transaction in s specific place. This idea is all about you can help yourself without the need for a service man. It is up-to the user of the punch card to withhold the correct number of clips when buying one or more cups of coffee. This way, you can access coffee anytime through self-service. (Malone 2016)

However, there are still some problems using this method, since it works through trusting the users. And for trusting the users, they have to be well-informed about how the system works for instance: what kind of beverages a punch card gains an access to and how long the punch is valid. They have to acknowledge the rules of the "real life contract". In the present system, there is no way of actually enforcing that the users subtract the correct number of clips when they are buying a coffee – or even pay at all, lest there is someone who is enforcing the rule through physical presence, which nevertheless, conflicts the notion of having a self-service or some misconception of how the system works. Employing a blockchain-oriented smart contract solution can help out to overcome these problems.

Implementation of a decentralized trust free transaction system

To have a demonstration of a desired functionality, a smart contract needs to be implemented to dictate the rules of the system. As per according to rules and specifications of a digital punch card based system to drink coffee, all functionalities are required to issue punch card for users to purchase. To allocate this smart property, a function called "**buyClipcard**" is used which permits a particular user to buy a punch card at a certain price. The price can be adjusted by the user of the smart contract to whatever amount of the function called "**setPrice**". While purchasing a punch card, a smart contract ensures that one has sufficient balance of either being able to commit the transaction. To keep the record of the users, transactions and their balances, a map of user addresses on the network and their punch card property, called "**ClipCards**", is implemented. In this manner, it's possible to check if people own a punch card or has sufficient clips. Once those functionalities had been created, it was necessary to formulate the rules of buying a coffee cup, using the punch card token. This part is what we are familiar with the contract is basically a "vending machine" in the context that a product has a fixed price. The feature that abstracts one clip from your punch card is therefore added as useClip. Next, in order for this to be fully automated, a digital lock

on the coffee dispensers is required. So, in our proof of concept approach, we did not implement a hardware solution, as it is the objective of DSR (Design Science Research) approach to explore the blockchain mechanism for generating cryptographic, trust-free transaction systems. Eventually, the existing system can be the suggested one should be implemented, for instance: a commercial coffee vending machine could be connected to the network. A smart contract could then be executed to activate the coffee dispense, as this smart contract would be invoked by the system. Importantly, it could be an IOT application, where a fully developed automated system could be employed with two smart contracts in conjunction with each other. For issuing these smart contracts onto the network you make a transaction with the smart contracts logic, it can be anything for example: the price of fueling such a contract computation is figured out by how many operations it holds. If there are enough ether to fuel the smart contracts is available, the transaction will be submitted to the blockchain and be accessible through the hash-code or the address.

In accordance to access the client of our decentralized application, a browser is desirable to support Ethereum based applications. Presently, there are two clients which are called AlethZero and Mist. We used for our research AlethZero as presented in Figure to showcase an application. Once it is connected to a Ethereum network through a supported browser, the local blockchain will be synchronized. Upon data synchronization, one can steer to the website of the digitalized punch card as shown in figure.

Now that the implementation of the backend functionality has been covered, it is desired to use the smart contracts in an easier way than through command line transactions. It is possible by using the Ethereum JavaScript API to build an HTML client. The job of the client is to simply make the smart contract easier to use, displaying stored information and getting functions accessible through a graphical user interface (GUI) that interrelates with the contract itself. Thus, rather than making specific transactions with data to the smart contract, input fields and buttons have been executed to look after those tasks, as illustrated in figure 33. (Malone 2016)

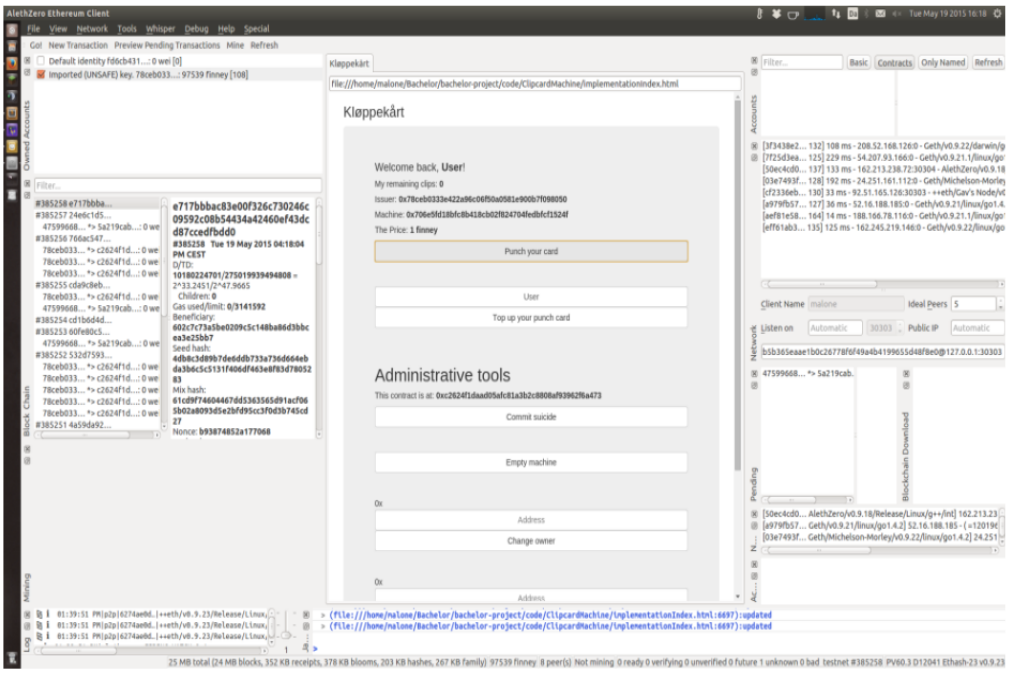

Figure 33: AlethZero Browser View

Source: (Malone 2016)

It can be performed by using JavaScript API that uses web3.js (Ethereum 2014). The web3 object facilitates to communicate with the network because it possesses the users private address information. The API JavaScript provides a lot of features that can be used to communicate with a smart contract and Ethereum blockchain. In a punch card proof of concept, the function is used of storing the data getting out of the contract to display it in our client, besides with calling functions to manipulate this data.

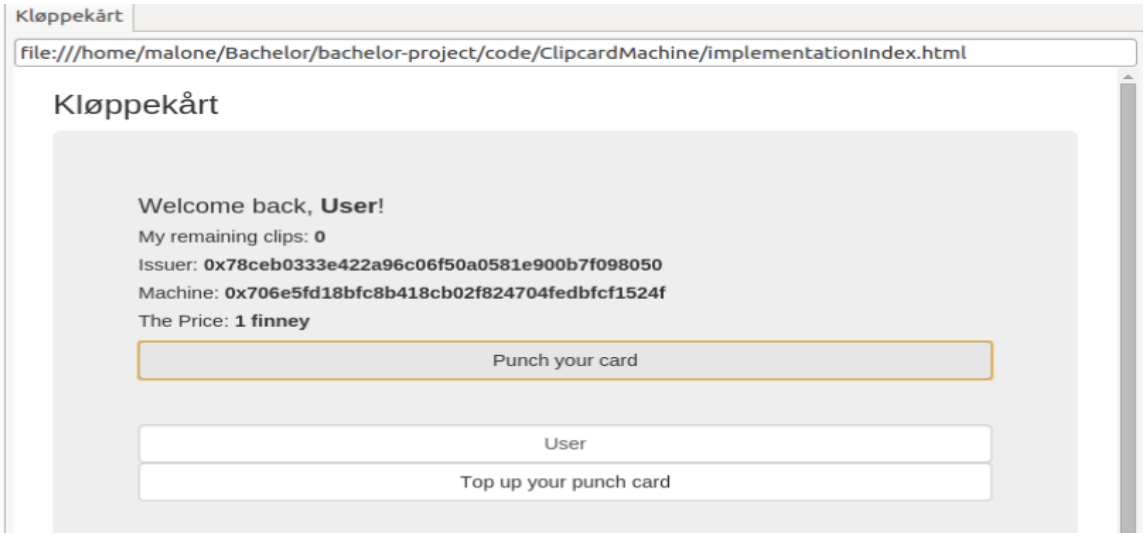

Figure 34: The Graphical User Interface of the HTML/Java Client

Source: (Malone 2016)

All the data that is being showed up in the above figure 34 is taken from the Blockchain, as it is contained in the storage of the smart contract of the implementation. Since the client is connected to the Ethereum network through authenticating with a private key, there is no requirement for an additional logging in, as network already identifies each user individually.

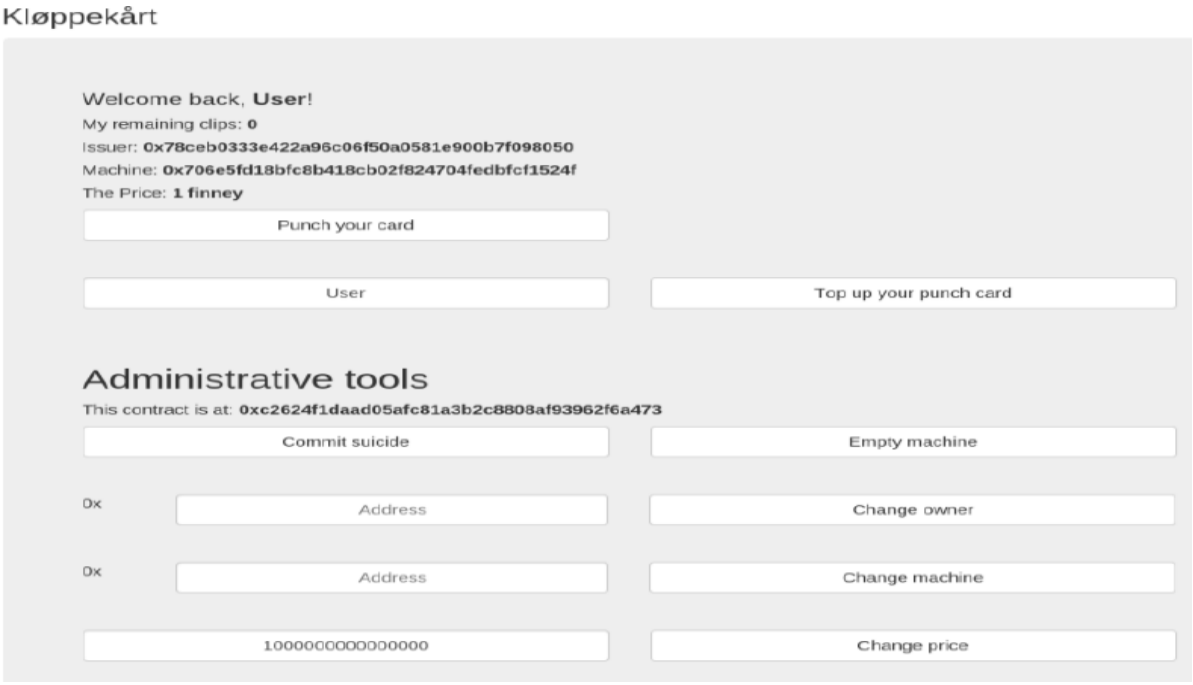

Figure 35: The Administration View of the Client

Source: (Malone 2016)

In the depicted case, the client doesn't know about the user, since it's the first time a person is using the system. Therefore, one is recognized as "User", and has no balance. In addition, the client displays the present price of a punch card, the network address of the issuer of the contract, and the network address of the smart contract that manages the lock on the coffee dispensers. All these values can be rationalized through an admin panel and can be seen in the above figure 35: The administration view of the client. Subsequently, there is no admin login either since the data of user rights too is stored on the blockchain.

So, to purchase a punch card, some amount of ether card is necessary. In the present implementation the price is set to 1 Finney which is 0.001 ether. The price is fixed low for the testing purposes but as stated it can be set as you wish, e.g., to match the price of the physical punch card. Upon the release of Ethereum, ether can be acquired through exchanges or through mining on the network. If anyone owns a sufficient amount of ether you can buy a punch card by typing your name in the name input field and click on the "Top up your punch card" button. This will begin a transaction to the smart contract, giving power to the system, including of the payment of 1 Finney, your name and that you want to invoke the

punch card function on the smart contract. This is all performed through the JavaScript of the client. When using AlethZero, one can see the transaction in the pending machine as seen in below figure.36

Figure 36 : A Pending Transaction

Source: (Malone 2016)

In this way, the transaction is completely clear and transparent and all its data is publicly visible, in the context that computational operations a user wants to be carried out in addition to the data sent with it are listed. Whilst waiting for the transaction to go through, it shows and a loading screen appears. Once a new block has been discovered, the transaction will be submitted to the blockchain. The transaction is thus carried through once it is submitted to the blockchain.

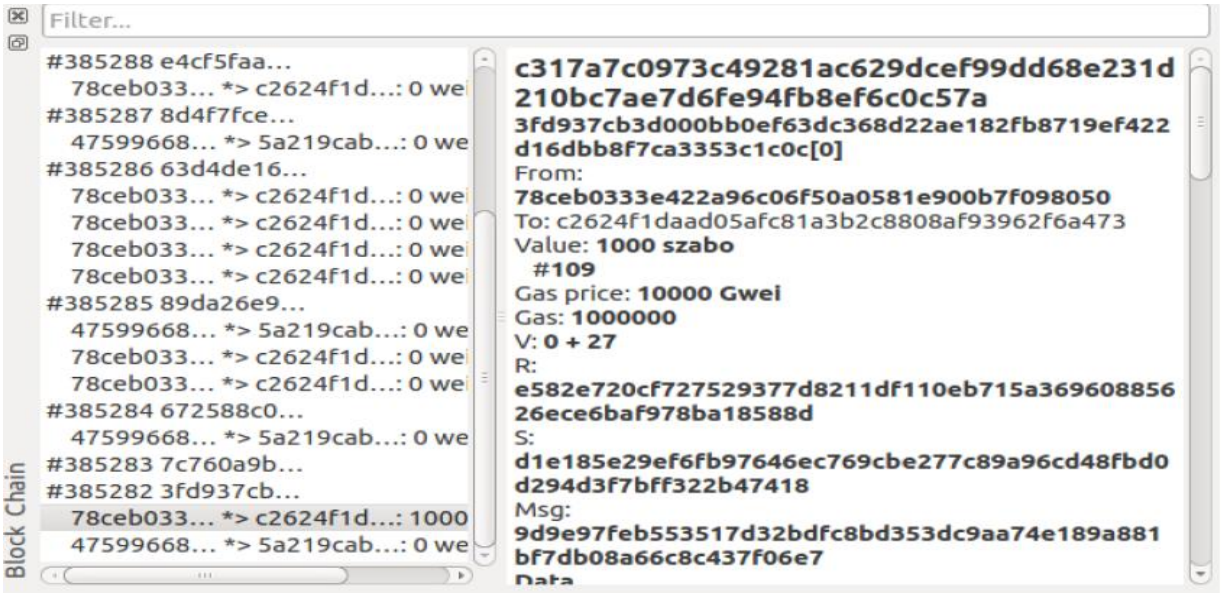

Figure 37: The Transaction is stored on the Blockchain

Source: (Malone 2016)

In the illustrated above figure 37, one can observe that the transaction and its data are now stored publicly visible in a block. The system will now identify the user through his or her address being mapped in the smart contract. Subsequently, your name and a balance of 10 clips will be displayed as shown in figure 38. This transaction is now recorded forever on the blockchain for everyone to see, but unable to be tampered with.

Figure 38: After Buying a cup of coffee, the balance of a punch card has been updated.

Source: (Malone 2016)