Blockchain and Its Applications in Healthcare/ Supply Chain Logistics

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1. Introduction

Blockchain technology grabbed the public attention when its cryptocurrency shocks the financial industry services. Defining blockchain is extremely important and equally difficult. It is a technology that can be defined as a distributed ledger database for recording transactions between parties permanently as it is a trustless protocol which combines transparency, immutability to enable secure transactions. Nevertheless, in past years, the attention of researchers moved to the applications of blockchain, now we hear the technology expanding to fields like healthcare, supply chain logistics, energy, and telecommunications because of its capability of ensuring data immutability and public accessibility of data streams. Blockchain can increase the efficiency, reliability, and transparency of the entire supply chain and maximize the inbound process. Blockchain is anonymous and free to join, meaning that the communication parties have free access (Perboli, Musso and Rosano,2018) where submitted data cannot be altered and, in particular, the integrity guarantees are not provided by any centralized party, but rather the consensus of the entire network; and published data cannot be removed, meaning that no authority can apply censorship to already published data (Perboli, Musso and Rosano,2018).

Risk for global supply chains are fed by numerous external and internal factors. Global trends such as globalization and global connectivity, are increasing the complexity of global supply chains along to reduce the operating costs, just in time inventory, reduced product lifecycles and outsourcing are just part of the business models that brought both significant improvement and challenges to the supply management. Supply Chain and Logistics are the topics paying more attention to the Blockchain where the efficiency of the supply chain relies on trust between the different stakeholders. Companies are struggling for procurement and information flows within theirs, having no other option than to trust their stakeholders both internal and external (Hinckeldeyn & Kreutzfeldt,2018). Companies are trying to find a new way to have reliable track over the entire supply chain operations and limiting the dependence on outsourced stakeholders. The most visible example of traceability frauds or breaches can be found in the food or car manufacturing industries where due to recalls or slow sales can impact their finances by more than $100 million a year. Now Preventing scandals and fines, making supply chain information more reliable is becoming a key challenge for the industry. This technology enables us to record every transaction within a supply chain distributed ledger and the information is always encrypted for example RFID technology (Madumidha et el. ,2019) can be used for tracking and tracing the goods with high traceability and with enhanced tracking system.

Another important use of blockchain is implemented in the field of healthcare and applications around this field. The healthcare industry has been adopting innovative technologies that allow the digitalization of health records and the automation of clinical processes. The need for interoperability across different departments in healthcare requires a seamless data exchange inside the system. Blockchain technology has the potential to transform healthcare, placing the patient at the center of the healthcare ecosystem and increasing the security, privacy, and interoperability of health data. With the evolution of the Internet of Things (IoT) (Tijan et el.,2019) along with many health devices and health apps, a huge amount of data is recorded and transferred every day which needs to manage regarding privacy, security, and availability. During the patient's treatment process doctors and hospitals need to access their medical records while ensuring the security and privacy of sensitive information as they share such data with hospitals. Blockchain

technology has started a revolution in the field of healthcare as using this technology data can be secured and shared between multiple hospitals but this also assures the privacy of each patient's data by giving their medical ownership to the patients themselves. Blockchain-based contracts can assist healthcare organizations in monitoring supply-demand cycles through its entire lifecycle- how is the transaction taking place, whether the contract is successful, or if there are any delays. Blockchain works on a validation-based exchange, the claims can be automatically verified where the network agrees upon the way a contract is executed (Pervez and Haq,2019), since there is no central authority which would be result in fewer errors or frauds. Blockchain has taken healthcare and Supply Chain logistic industries by storm over the past year, and there are significant investments for blockchain. With such wide-ranging possibilities, it is no surprise blockchain seems poised to one of the key pillars in the digital world.

This paper focuses on the use and expansion of blockchain technology in healthcare and supply chain logistics fields. The history and origin of Blockchain technology will be presented in Chapter 2, technical details of types of Blockchain systems will be presented in Chapter 3. Risks, limitations, and strategies of Blockchain systems will be discussed in Chapter 4, implications for society and industry in Chapter 5 and Chapter 6 will portray the suggested course of action for developing more blockchain solutions for healthcare and supply chain logistics. In Chapter 7, conclusions will be presented, and Chapter 8 will discuss about different Annotated bibliography.

2. Literature Review

This chapter presents the history and origin of blockchain technology and its implementations in different fields. It describes how Blockchain technology originated and developed over time to be what is it right now. This chapter will examine methodically and in detail the scope of blockchain technology in healthcare and supply chain logistics. Blockchain technology must be one of the biggest innovations of the 21stcentury given the ripple effect it is having on various sectors, from financial to manufacturing as well as education. Unknown to many, is that Blockchain history dates back to the back to 1992, when W. Scott Stornetta published their work on a cryptographically secured chain of blocks (Tijan et el. ,2019) and in the year 1992, they incorporated Merkle trees into the design allowing several documents to be collected into a block. Satoshi Nakamoto conceptualized the first blockchain(Kassab et el.,2019) in 2008 from where the technology has evolved and found its way into many applications beyond cryptocurrencies as mentioned in the first whitepaper about the technology in 2009 where he provided details of how the technology was well equipped to enhance digital trust given the decentralization aspect that meant nobody would ever be in control of anything. Ever since Satoshi Nakamoto exited the scene and handed over Bitcoin development to other core developers, the digital ledger technology has evolved resulting in new applications that make up the blockchain History. While there are several reviews regarding blockchain technology (Christ et el. ,2019) the authors argue that the state-of-the-art of blockchain-enabled applications has received limited attention.

Concerned by limitations around Bitcoin's , developers started working on developing a blockchain solution that can perform various functions in addition to be a peer-to-peer network and Ethereum (Tijan, et el. ,2019) was born out as a new public blockchain in 2013 with added functionalities compared to Bitcoin, a development that has turned out to be a pivotal moment in

Blockchain history where Ethereum differentiated from bitcoin blockchain by enabling a function that allows people to record other assets such as contracts. This feature expanded Ethereum functionalities from being a cryptocurrency to be a platform for developing decentralized applications as well. Officially launched in 2015, Ethereum blockchain has evolved to become one of the biggest applications of blockchain technology given its ability to support smart contracts used to perform various functions. Ethereum blockchain platform has also succeeded in gathering an active developer community that has seen it establish a true ecosystem. Blockchain 1.0 (Pervez and Haq,2019) which includes applications enabling digital cryptocurrency transactions whereas blockchain 2.0 which includes Smart contracts-based set of applications extending beyond cryptocurrency transactions; and blockchain 3.0 which includes applications in areas beyond the previous two versions, such as government, health, science and IoT. There are indeed some reviews focused on the particular role of blockchain including the development of decentralized and data-intensive applications for the IoT (Madumidha et el. ,2019), and managing big data in a decentralized fashion

Nowadays health services oversee the challenges of medical and healthcare providers insufficiency and their uneven distribution, the health problems are also increasing in difficulty, resulting in the need for better and diverse healthcare system. The trend of IT in healthcare can be explained as: electronic medical records, biomedical databases, and public healthcare records that have been improved instead of availability, traceability; but also, on the availability of data. In healthcare sector the need for security and interoperability in always needed and can be overcome by using blockchain, now with the evolution of IoT and abundance of health devices and mobile healthcare applications, a considerable amount of medical data are recorded and transferred every day(Pervez and Haq,2019). Other reviews focus on Blockchain-based solutions combining with various IoT systems on supply chains to increase accountability in fields of pharmacy and the proposed solution speeds up logistics and minimizes discrepancies (Vora et al.,2019). Researchers and developers are already aware of the capabilities of the blockchain technology which is secure by design that provides the capability to achieve decentralized consensus and consistency, and resilience to intentional and/or unintentional attack (Esposito et el. ,2018). Particularly considering healthcare domain, blockchain has the potential to support the entire lifecycle of medicines, medical equipment, health supplies, besides reinforcing the value of health records and potentializing the ownership of the medical history to the patients through unified registers. In many healthcare implementations, blockchain technology redefines data processing and governance. This is to its adaptability and unprecedented segmentation, secure and sharing of medical data and services. In the healthcare industry, blockchain technology is at the forefront of many current developments.

Supply chain logistics sector issues involve several trust and performance issues. Blockchain can be used to disrupt supply chain logistics operations for process automation, distributed governance and better performance RFID (Madumidha et el., 2019) which a sensor used to detect the materials using radiofrequency can be used with the purpose the tracking; and tracing the goods. From the perspective of the cross-border supply chain structure (Lai,2019), the participants in the supply chain are more dispersed and diversified, and the storage and logistics system are more complex. Logistics and supply chain management are regarded as domains where blockchains are good fits for a series of reasons because during the lifecycle of the product it flows

down the value chain (from production to consumption) the data generated in every step can be documented as a transaction, thus creating a permanent history of the product (Tijan et el. ,2019).

After reviewing the history and origin of blockchain technology, its development in supply chain & healthcare; and the following chapter 3 will go through the technical details of the types of blockchain systems.

3. Technical Details

Every technology is important and plays an important role in the overall development of the industry. There always was a fascination in terms of Blockchain and its related fields but since the past few years, promises have been delivered. In this chapter, current Blockchain developments in Healthcare and supply chain logistics fields will be evaluated.

3.1 Blockchain Technology

Blockchain is defined as follows: blockchain is a distributed database, which is shared among and agreed upon a peer-to-peer network. It consists of a linked sequence of blocks, holding time-stamped transactions that are secured by public-key cryptography and verified by the network community. Once an element is appended to the blockchain, it cannot be altered, turning a blockchain into an immutable record of past activity. Using this technology system work in a way that a copy of the database is distributed to each party and such party may then make changes to the database subject to collectively accepted rules. The changes made by the various parties are collected and stored in the database at regular intervals as a bundled packet called ‘blocks’ (Tijan et el., 2019). Since the blockchain is immutable, the alteration of the covert messages is virtually impossible, and the embedding of covert information is free to be fragile.

Once the block is full, nodes simultaneously perform Proof-of-Work—mathematical operations that are difficult to solve but whose correct solution is easy to verify. The first node that succeeds in solving a Proof-of-Work problem broadcasts the solution, along with the block of transactions, to all other nodes. Nodes can quickly and cheaply verify the accuracy of the transactions and solutions, and when 51% of the processing power of the network votes to approve a block, nodes begin recording new transactions to a new block, amending them to all previous blocks. Blockchain technology solves the double-spend problem with the help of public-key cryptography, whereby each user is assigned a private key, and a public key is shared with all other users (Tijan et el. ,2019). The main idea of the blockchain is a distributed database comprising records of transactions that are shared among participating parties. Every transaction is verified by the consensus of most of the participants in the system, making fraudulent transactions unable to pass collective verification. Once a record is created and accepted by the blockchain, it can never be altered. This allows for the creation of a jointly generated electronic time stamp that all participants can trust, even if they do not trust one another. In this manner, it is easy to verify the origin and accuracy of the information whatever its source as external intermediary (such as a centralized server) trusted by all the parties is required to validate the data (Liang, Li, and Li,2019).

3.2 Blockchain in Supply Chain Logistics

The supply chain is one of the fields that may benefit most from blockchain technology. This technology is expected to increase transparency and accountability to enable more flexible

value chains in the supply chain. In the context of globalization, the diversity and complexity of supply chain composition, a great amount of uncertainty in the external environment and the shorter life cycle of new product development make supply chain management critical to the profitability or even the survival of a company as blockchain can be used to facilitate the origin tracking, logistics and decreasing paper load processing. Delivery (Hinckeldeyn and Jochen,2019) is the very last step to pass the promised goods or services to the customers. Any incident or failure that occurs during delivery could certainly result in regretful customer satisfaction and even possibly lead to a negative impact on the future operation of the organization. When blockchain comes to transport, smart trucks and containers are opening for new approaches to monitoring. Sensors and the Internet of Things (IoT) are enabling goods container store port when a value limit has been exceeded, e.g., temperature, tilt or incoming light intensity, like the freight being forwarded remains in clear view across the entire supply chain it can improve smart transportation systems and finally it can offer new decentralized manufacturing architectures(Liang, Li, and Li,2019).

3.3 Blockchain in Healthcare

Blockchain technology gives numerous advantages to clinical specialists, medicinal services suppliers, and people, as it would create a single storage location for all health data, set data access permissions at the lowest level and track personalized data in real-time. Healthcare researchers need complete data sets to advance understanding of disease, fasten biomedical discovery, track the development of medicines/drugs rapidly, and design individual treatment plans based on genetics, lifecycle, and environment (Kassab et el. ,2019). By including patients of various ethnic and financial foundations and from various geographic territories, the mutual information arrangement of blockchain would give a wide scope of data. It provides perfect information for studies because blockchain collects health data over the lifetime of an individual and health care blockchain will extend the collection of health data to include data from groups of people currently under-served by the medical community. The mutual information condition of blockchain makes it simpler for difficult-to-reach crowds to be interested and for the overall population to deliver more reflective results. A health care blockchain will likely encourage the development of a new breed of smart health care provider apps that would find a way around the latest medical research and develop customized treatment pathways. The health care provider and the patient would have access to the same information (Zhang et el. ,2017).

4. Risks, limitations, and strategies/solutions

Every technology system which exists in this world has some amount of risk and limitations attached to it. Humans are responsible to know the limitations of a system, analyze the risks and find out strategies to tackle the risks and limitations. The following are the risks, limitations, and strategies of Blockchain technology-powered systems for supply chain logistics and healthcare.

4.1 Risks

The Risks related to blockchain technologies in healthcare and supply chain logistics are as follows:

4.1.1 Security and Privacy issues

Concerning the security and privacy of blockchain-based healthcare applications, there is a concern that despite the encryption techniques are used, it may be still possible to reveal the identity of a patient in a public blockchain by connecting sufficient information that are related to that patient. There is also the potential risk of security breaches that could emerge from intentional malicious attacks to the healthcare blockchain by criminal organizations or even government agencies that could compromise the privacy of the patients. Blockchain networks that power different cryptocurrencies have been attacked previously as the private keys which are utilized for data encryption and decryption in blockchain are also prone to potential compromise which could bring about unapproved access to the stored health data (Perboli, Musso and Rosano, 2018). The transaction data stored in blockchain ledger is transparent, everyone can access the transaction data that exists on the node, thus causing all transaction data to be spread out open to all. This will present a significant security risk for the blockchain users. It was reported that even the identity of all blockchain users is encrypted, over 60% of user's real identities have been identified resulting from big data analysis (Shae and Tsai,2017) across other data from the Internet. Transparency and privacy are two contradict requirements.

Blockchain technology is a revolutionary way to manage supply chains and many other functions. However, with such opportunity and promise come exposures to physical property, business reputation and a variety of financial and nonfinancial third-party damages. A system needs to be designed in such a manner that the data is not visible to anyone outside the organization as privacy and confidentiality are hard to establish on a public blockchain, because any member of the public can obtain a full copy of the whole transaction history and use it without restriction.

4.1.2 Interoperability

The interoperability challenge originates from the way that there isn't yet a current standard for creating blockchain-based healthcare and supply chain logistics applications; in this way, applications developed by various merchants or on various platforms will most likely be unable to interoperate. Consider, for example, the two remote patient monitoring applications, in which one is developed on the Ethereum platform while the other is developed on the Hyperledger Fabric platform, it would be difficult to exchange information from one platform to the other (Shae and Tsai,2017). The biggest challenges faced so far when it comes to public health management are data protection and interoperability. A huge challenge in logistics is to coordinate information exchange across the many kinds of goods, modes of transport, and information systems.

4.1.3 Premature Network

Blockchain is a network composed of hundreds of thousands of nodes working together to function correctly. Therefore, if any system which is in the early stages of its development and growth with a small number of nodes can be more vulnerable to corruption and an attack. Blockchain can grow very large over the course of time outstripping the storage(Azaria, Ekblaw, Vieira et el., 2016) capacity of hard drives as once data has been added to the block chain, it is very difficult to modify it and changes in blockchain code or data is very much required which often requires change in the existing protocol which can be incompatible with the previous versions that means when nodes do not update to the new version won't be able to process the

transactions or push new blocks to the blockchain . The network risks losing nodes if the chain containing the data becomes too large to be downloaded and store.

4.1.4 Human Error

Few organizations can decide to build their blockchain system which can be difficult and can be risky as one mistake can end up compromising the entire system. Security risk arises most with the poorly managed blockchain systems as blockchain technology can be difficult to understand, therefore any employee responsible for working with the system should be trained to understand its functionality as well as the associated risks. Users need to be aware of multi-factor authentication and of how the technology works in order to prevent phishing attempts. Simultaneously, developers must be educated to provide secure platforms and minimize bugs.

4.1.5 Verification Delay and Access Permissions

In a public blockchain scenario, it takes about 10 minutes for the process to verify the transactions which are known as consensus (Vora et al,2018) and in most cases, transactions may take about one to two hours to be fully verified. This kind of time delay can pose a security threat and can increase the vulnerability of the system, as data might not always hold the same status but there is a designated operator who controls and chooses the nodes responsible for verification in private blockchain. These nodes communicate all new and verified transactions to the entire network. A single operator is responsible for choosing and securing access to these nodes, which can become a single point of exploitation.

4.1.6 Regulatory Clash

Blockchain’s decentralized characteristic is problematic for most industry regulators. For healthcare organizations specifically, blockchain creates massive hurdles when complying with government regulations such as HIPAA. Since blockchain is still emerging into commercial use, there is regulatory uncertainty which could cause severe noncompliant damages (Kassab et el., 2019). Also, shared distributed ledgers have no specific locations in terms of jurisdiction and applicable law which constitutes to a problem, as each network node me be subject to different legal (Tijan et el., 2019) requirements and these is no central authorized administrator responsible for each block of chain. This creates a problem where there may be no party in the end responsible for functioning of distributed ledgers and the data contained in it. A legal framework is required to use blockchain as unique and trusted source of identity. Standard rules are necessary for authentication of legal person allowed in that blockchain with different authorities and for data protection.

4.2 Limitations

Like every other technology implementing blockchain in health care and supply chain logistics has its very own limitations which are as follows:

4.2.1 Lack of scalability

Blockchain technology can be somewhat disruptive and requires a radical rethink and significant investment in the entire ecosystem, for replacement of existing systems and redesigning of existing business processes. Decentralization limits the number of transactions the blockchain

can process to the limitations of a single fully participating node in the network, the more people or nodes join the network, the chances of slowing down is more. Therefore, before taking the plunge, healthcare providers particularly publicly funded providers will need to undertake a cost-benefit analysis to understand the return on investment and any potential implications. For example, the same record can reside in multiple nodes of the network, located in different countries with different privacy and data protection requirements (Esposito et el., 2018).

4.2.2 Rarity of technical talent

The lack of technical talent is also a significant hindrance to the development of the technology. There's no shortage of activity around blockchains and distributed ledger technology and technical talent is scarce and expensive. Blockchain application developers are rare and expensive and the cost of training professionals with such skills is very high because of long-term training needs. Also, it requires consent and collaboration of all participants to reach agreements to build a new common system that provides value for all of them.

4.2.3 Lack of standards

There is currently a lack of standards concerning blockchain technology and its development for applications around the supply chain industry and healthcare industry (Zhang et el., 2017). Therefore, organizations are reviewing whether a smart contract is a confirmation of a contract - an informal agreement with regards to the sharing of data among involved participants. Organizations who are dealing in the supply chain are still using outdated systems to record information, using Blockchain-powered systems build on sensors and IoT's to collect different type of data might create a problem for blockchain to handle a lot of data also wrong data when entered the chain will result in inaccurate data assumptions in subsequent chains.

4.3 Strategies

Risks and limitations of blockchain technology can be handled by setting up standard rules with regards to its development and implementation in real-world applications. The standard rules will behave as guidelines which need to be followed while developing any application for healthcare or supply logistics based on blockchain technology. Organizations that plan to introduce, implement and develop their existing or new software solutions using the blockchain platform should be ready to trainee their employees with the latest technology so that more people and organizations get involved in the development of such applications, Also cost of research, operations and maintenance could be brought down. Managers need to be dynamic and should always motivate their employees to keep learning and updating their knowledge to remain competitive. New models can be built to scale up security issues revolving around information sharing using blocks and Some standards can be set up while setting up smart contracts between two organizations which can behave as legal (Tijan et el., 2019) documents between parties involved. Organizations must take step to develop blockchain applications on the same platform instead of independent platforms as this can help them to be more compatible with other applications

Now we have discussed the risk and limitations in this chapter and the next chapter, we will discuss about benefits and implications of blockchain for the society and industry.

5. Implications for society and industry

Every technology when introduced or implemented in any industry had a different implication for society and industries. Blockchain technology also have their different implications for society when implemented in healthcare and supply chain logistics industries. This part will introduce the normal changes in society from each viewpoint.

5.1 Potential uses of Blockchain in supply chain Logistics

Blockchain uses smart contracts that can behave as legal contracts to hold vendors and suppliers accountable, maintaining constancy to duties and responsibilities as mentioned within service level agreements. Blockchain helps to integrate payment solutions thus ensuring the timely movement of products as it reduces the time between ordering and payment processing. Payment processing has significant repercussions for avoiding violations of international and domestic trade agreements, preventing unlawful installments from nations and entities that are authorized from working with different pieces of the world. Capacity to make open and private blockchains (Tijan et el. ,2019) securing exclusive, if not private, data from unapproved parties and recording all exercises throughout the store network which will grow more important as new technologies, including unmanned, independent trucks and drones. Better client service levels and extensive adaptability, resulting from the ability to provide more information regarding a product's manufacturer, origin, transfer, and use (Tijan et el, 2019). In the store network, an agreement between inventory network pioneers and accomplices and arrangement of business objectives all through the business must emerge. With time, the expenses of taking care of transparency-related procedures, like manual signatures on order invoices, will diminish as the procedure moves into the computerized domain.

5.2 Potential uses of Blockchain in Healthcare

The healthcare part incorporates the utilization of blockchain to follow medical devices, prescriptions, and even close to patients' records. Since numerous medical devices and products might be made for an individual and highly customized, the capacity to track the process of assembling, delivery, payment, and continued service. Blockchain innovation is expected to improve medical record management and the insurance claim process, accelerate medical and biomedical research, and advance biomedical and healthcare data information record. With blockchain technology, patients can connect to other hospitals and gather their medical data automatically (Christ et el., 2019). The Blockchain innovation considers reporting the transactions in a decentralized record which improves exactness and brings transparency while simultaneously sparing the crucial assets like time, expenses and efforts. Blockchain technology brings integrated healthcare information data as well as keeps up traceable records of distributed data and work. Also, the public/private key access strongly shields the general security by wiping out the chances of data leakage (Azaria, Ekblaw, Vieira and Lippman, 2016). Blockchain technology additionally encourages following the movement of drug from maker to the patient, aside from guaranteeing timely inventory supply it additionally takes out the chances of forging and by automating the repetitive processes, the Blockchain technology helps the healthcare industry to extract the maximum potential of manpower during various stages and procedures. Subsequently, it enhances human productivity and increased productivity means better yield in a shorter range of time. By empowering cutting the procedures into various stages the Blockchain technology also helps to

keep the budget under control, brings down organization costs and allows better, purpose-specific utilization of allocated funds.

5.3 Protection of crucial data

One of the significant difficulties during the innovative work forms is leakage of crucial patient data that can be utilized for malicious purposes or personal interests. Another challenge is to find out that just the verified and most refreshed form of patient data/diagnosis data accessible to different parties during various stages. Furnished with the most recent cryptographic features the blockchain technology not just encourages checking the data authenticity with the assistance of digital signature yet, in addition, it helps in offering a full proof security (Liang, Li and Li, 2019) to the data. In this manner, it offers the exact answer to the twin issues of trust and security. It ensures the data related to payments, tracking of goods and crucial information related to logistics is shared between different parties involved in this process based on smart contracts which would be developed after the specific service level agreement is established and data sharing is done based on permission-based blockchains(Wu et al,2019).

5.4 Extracting the best benefits

While there are different purposes of carefully collecting the healthcare data or supply chain logistics data, it is much increasingly critical to extract the best advantages out of this healthcare data or supply chain logistics without complicating the procedures. For that reason, the convenience of data and uniform similarity while working across differing frameworks (Jayaraman, Hammadi and Simsekler,2018) is significant because of its sharp focus on streamlined stream, uniform convenience, and multi-faceted protection systems across various stages. The blockchain technology perfectly handles diverse difficulties where considering all things; it helps in separating the maximum output from the data collected on diverse levels and to ensure impacts of blockchain to be positive on society with the increase in involvement of more organizations and individuals involving in development and research around blockchain technology for healthcare and supply chain logistics. Therefore, slowly and steadily the benefits of blockchain can be more visible and available for society over time.

The next chapter discusses the suggested course of action to adapt to new development revolving around blockchain for healthcare and logistics.

6. Suggested course of action

World is changing every day; existing technologies are getting outdated which are getting replaced by the new and much more advanced technologies. This has become a trend from last few decades, and with changes in the technologies there is an impact on society and industry. This section will present the course of action for the use of blockchain in our society and industry.

6.1 Positive Approach

Organizations or group of organizations which would like to apply blockchain technology to their supply chain and healthcare solutions should follow a hard approach were before implementing a blockchain solution they understand the weakness and risk of their industry. Organizations once after identifying risks should access how blockchain can help in resolving

these risks. Organizations should start small, where they should select one risk point that would not be complex and would not be costly in the project. Thus, the solution which would be created should be applied only in small scale example in case of supply chain only to some of the suppliers. When different organizations try to develop a solution based on one blockchain-powered platform, the pace of development (Hinckeldeyn and Jochen,2018) will fasten where organizations can team with startups, researchers, and customers who can have an external view about the solution which would be developed. After each failure, when solution nears to perfection organizations should try to implement it on a larger scale.

6.2 Reskilling of Employees

Organizations should motivate their employees to reskill themselves in these technologies around blockchain and should also provide training to their employees. More the number of employees, when trained with such technology, is, more the number of people will be available to work on such technology. Hence reducing the scarcity of skilled workers. These skilled workers can bring up innovations in blockchain and can help in resolving existing issues around blockchain or can help in the development of new solutions using different blockchain technologies available.

6.3 Governing body

Different organizations from different technology-related fields should come up together for setting up a governing body responsible for research and development of applications or solutions powered by blockchain (Zhang et el., 2017). This governing body should be responsible to set up guidelines around the development of blockchain technology and should be responsible for the patent or authentication of the development. Different organizations can team up together to develop one solution which can be beneficial for the society and industry both.

7. Conclusion

With the ever-increasing popularity of blockchain technology, different organizations from healthcare and supply chain industry have started researching and developing of blockchain-powered applications. Blockchain technology is an innovative platform for decentralized and transparent transaction mechanism in industry and business. Blockchain technology can easily provide secure business operation in supply chain logistics as the platform on which applications or solutions would be developed is based on decentralized systems and this creates a permanent record that can be shared and is publicly accessible. This technology can facilitate logistics tasks: it can be used to track purchase orders, order changes, and freight documents, and it can help in information sharing about manufacturing process and delivery. IoT's and RFID technologies can be integrated with blockchain for data collection, tracking, and delivery of goods (Madumidha et el., 2019). The blockchain technology has huge potential for development and application in the logistics sector and supply chain, presenting challenges for further research.

Using blockchain technology, privacy, security, availability and fine-grained control of access to electronic health record data can be ensured. The goal of using blockchain is to improve healthcare processes and thus patient outcomes. Blockchain can help in many ways; reducing transaction costs by using smart contracts which are embedded general-purpose protocols (Hinckeldeyn and Jochen, 2018) to simplify procedures, reduce administrative burdens and

remove intermediaries. Other blockchain efforts are aimed at improving the collection, use, and sharing of health data from patients, researchers, and sub-processors of data. Blockchain technology helps to create a healthcare ecosystem that is iterative, scalable, secure, accessible and decentralized. This would allow patients to exchange their medical records freely and safely with doctors, hospitals, research organizations, and other stakeholders-all while maintaining full control over the privacy of their medical data. However, data impact of blockchain technologies was implemented minimum in healthcare and supply chain domain but with many people and organizations showing interest in the development of this field and new blockchain platforms being developed which can support the development of creating decentralized applications for these domains. Future work can be done to develop less complex and more user-friendly blockchain-powered solutions in healthcare and supply chain domain, so that more and more organizations can be involved in the overall development purpose.

8. Annotated Bibliography

Vora J. et al., BHEEM A Blockchain-Based Framework for Securing Electronic Health Records, *2018 IEEE Globecom Workshops (GC Wkshps),* Abu Dhabi, United Arab Emirates, 2018, pp. 1-6.

Authors mention using current technologies to maintain electronic health records has resulted in keeping information commonly out of reach to patients. Authors mention blockchain technology to settle many issues since it shares the information in a decentralized and value-based design that can be utilized in the to keep up the balance among security and availability of electronic health records. Authors propose a blockchain-based structure for efficient capacity and support of electronic health records which gives the protected; and efficient access to clinical information by patients, suppliers, and outsiders, while saving the patient private data. The article recommends developing a model to introduce ‘block pharma’ a blockchain-based solution to store and transfer data related to electronic health records.

This article is useful in analyzing how the purposed blockchain-based solution will fulfill the need of patient providers and third parties. This article is useful to justify the role of vital functions which make the use of blockchain effective like using a different type of blockchain contracts impacting patients, care providers, third parties et.el and using different types of algorithms which can be used to complete whole blockchain transaction.

C. Esposito, A. De Santis, G. Tortora, H. Chang, and K. R. Choo, Blockchain A Panacea for Healthcare Cloud-Based Data Security and Privacy, in *IEEE Cloud Computing*, vol. 5, no. 1, pp. 31-37, Jan.Feb. 2018.

In this article, the authors envision blockchain as the remedy for healthcare cloud-based security and privacy and concentrate on the benefits of blockchain and cloud technologies in managing patients’ electronic health records. Authors identify the potential use of blockchain technology to protect healthcare data hosted without the cloud and discuss the practical challenges of such a proposition. Authors state that such type of data can be secured and protected using blockchain as this technology

works on cryptographic primitives using public keys, infrastructure, and public clouds to ensure privacy. Authors state that using blockchain an open and distributed database can be build which consists of a list of data structures linked with each other and distributed among multiple nodes.

This article is helpful as it suggests using blockchain agreement can be reached without the involvement of trusted mediator, thus avoiding performance bottleneck and a single point of failure. It will be helpful to understand information related to medical history as blockchain data is complete, consistent, timely, accurate and easily distributed and if any changes made to the blockchain, they can be easily visible to all the members of the patient network and any unauthorized modifications can be detected.

Azaria, A., Ekblaw, A., Vieira, T. and Lippman, A., "MedRec Using Blockchain for Medical Data Access and Permission Management," *2016 2nd International Conference on Open and Big Data (OBD)*, Vienna, 2016, pp. 25-30.

The authors state that years of heavy control and red tape have hindered progress in electronic medical records (EMRs), as the patients are now more interested to check their overall health records and to regain control over their medical data. Authors propose MedRec in this paper: a new, decentralized record management method for managing electronic medical records, which utilize blockchain technologies network which provides patients with comprehensive, unchanging monitoring and quick access to their medical records through facilities and treatment sites. Authors mention that taking advantage of specific blockchain technologies, MedRec manages authentication, confidentiality, transparency and data sharing crucial recommendations, considerations when managing sensitive data and information. This article is useful in understanding how MedRec helps data economies to grow and deliver large data to motivate researchers.

This article develops a blockchain structure applied to the electronic medical record, by building a distributed ledger protocol that uses public-key cryptography and proof of work algorithm is used to secure the model or data and will help in understand the idea better.

Kassab, M. H., DeFranco, J., Malas, T., Laplante, P., Destefanis, g. and Graciano Neto, V. V., "Exploring Research in Blockchain for Healthcare and a Roadmap for the Future," *in IEEE Transactions on Emerging Topics in Computing*.

In this report, the authors describe the importance of healthcare sector and how blockchain can be fruitful in saving billions of dollars if introduced in this sector as healthcare is a data-intensive area, with an impressive volume of data, which is available daily to monitor patients, overseeing clinical research, creating clinical records, and preparing clinical protection claims. Authors suggest the uses of blockchain along with the need to construct distributed records including virtual tokens, the force of this developing innovation has now stretched out to the clinical space. Authors mention to orchestrate the examinations on the advantageous interaction of blockchain in healthcare services; condense and categorize existing

benefits/challenges on joining blockchain in healthcare services domain; give a structure that will encourage new research exercises.

This article presents research to develop an understanding of the scenarios that involve deploying blockchain in healthcare, benefits that arise from this incorporation and challenges in such context. This article helps to highlight key benefits of blockchain features like how blockchain improves availability, improves security, improves performance, improves transparency.

Zhang, P., Walker, M. A., White, J., Schmidt, D. C. and Lenz, G., "Metrics for assessing blockchain-based healthcare decentralized apps," *2017 IEEE 19th International Conference on e-Health Networking, Applications and Services (Healthcom)*, Dalian, 2017, pp. 1-4.

The authors suggest measurements to survey blockchain-based DApps in terms of their achievability, expected capacity, and consistency in the healthcare services area where the written public blockchain must be encrypted and securely managed by parties interacting with this app. The authors explore Smart contracts that are worked on a blockchain to help on-chain storage and empower Decentralized Apps (DApps) to communicate with the blockchain programmatically as programmable blockchains have created interest in the healthcare services area as a potential solution to determine key difficulties. Authors claim that DApp should support user identifiability and authentication while providing strategies to mitigate lost personally identifiable information.

This article provides information about blockchain, how this technology can improve healthcare interpretability. It will be useful in understanding set of evaluation metrics, from both the technical and domain perspectives, to assess healthcare DApps using this technology and serve as an initial guide for creating future apps in this domain.

Wang S. et al., Blockchain-Powered Parallel Healthcare Systems Based on the ACP Approach, *in IEEE Transactions on Computational Social Systems*, vol. 5, no. 4, pp. 942-950, Dec. 2018.

Authors proposed a framework of parallel healthcare system which is based on an artificial system, computational experiments and parallel execution approach which helps to improve the precision of analysis and the adequacy of treatment as it utilizes artificial healthcare services frameworks to show and model patients' conditions, analysis, and treatment process. Authors talk about developing blockchain-powered parallel healthcare system, through building a consortium blockchain linking patients, clinics, healthcare agencies networks for extensive human services information sharing and clinical records survey. The authors mention a model named parallel gout diagnosis and treatment framework which should be developed and deployed to check and exhibit the effectiveness and efficiency of the blockchain-powered Public healthcare System structure.

This article explores the idea of building a blockchain-powered framework which will be using a parallel healthcare system based on artificial system modeling to

simulate and represent the actual healthcare scenarios. It will be useful to understand how building a consortium blockchain that contains patients, hospitals, can help with the purpose of enabling the parallel healthcare system with integrity, scalability, and security.

Shae, Z. and Tsai, J. J. P., "On the Design of a Blockchain Platform for Clinical Trial and Precision Medicine," *2017 IEEE 37th International Conference on Distributed Computing Systems (ICDCS)*, Atlanta, GA, 2017, pp. 1972-1980.

The authors propose a blockchain platform for clinical trials and precision in the medical domain. Authors describe the scope, challenges, approaches and system design concepts of a blockchain platform for clinical trial and precision along with technology requirements and various design ideas to develop this platform. Authors talk about 4 new frameworks based on existing blockchain and talk about their technology challenges like a new blockchain-based general distributed and parallel computing model to study parallel computing methodology for big data analytics, blockchain application data management component for data integrity, big data integration, and incorporating the uniqueness of clinically related information, verifiable anonymous identity management component for identity privacy for both person and Internet of Things (IoT) devices, and secure information access to make possible of the patient-driven medication, and trust data-sharing management component to enable a trust medical data ecosystem for collaborative research.

This paper portrayed quickly the scope, approach, difficulties, and system design plan idea of a blockchain stage for clinical trial and precision medication. It is useful to understand 4 new framework segments to investigate new blockchain-based distributed parallel computing paradigm for big data analytics and to investigate data integrity.

Christ, M. J., Nikolaus Permana Tri, R., Chandra, W. and Gunawan, W., "Exploring Blockchain in Healthcare Industry," *2019 International Conference on ICT for Smart Society (ICISS)*, Bandung, Indonesia, 2019, pp. 1-4.

The Authors states blockchain is quite a popular technology that has a great opportunity in the Healthcare industry as it contains sensitive data of human health condition history because of which security and protection of such data are the primary concern. Authors say in the current time of the internet the most promising technology which emerged is blockchain because of its powerful features like security, transparency, and traceability. Authors look at the utilization of blockchain to see how this innovation can be executed in the healthcare system and to settle Electronic Medical Record (EMR) issues like security, protection, and interoperability.

This article provides measures and strategies to fabricate a model for incorporating EMR by utilizing a third party. It will be useful to utilize blockchain as the privacy concern is solved because of the decentralized model of blockchain, where there is no third party to control the data and anyone who needs to access the data will be

notified to the owner. This article also helps to understand the use of smart contracts that facilitate the verification, performance, and enforcement of digital transactions so that it can remove the third party.

Perboli, G., Musso, S. and Rosano, M., "Blockchain in Logistics and Supply Chain: A Lean Approach for Designing Real-World Use Cases," *in IEEE Access*, vol. 6, pp. 62018-62028, 2018.

The article presents Blockchain innovation as a distributed record database for recording exchanges between parties. The authors mention the capacity of ensuring data immutability and accessibility of information streams, Blockchain can build the efficiency, reliability, and transparency of the general supply chain, and improve the inbound procedures. Authors state concerns of Blockchain in non-financial applications that are centered around the innovative part and the Business Process Modeling are inadequate for designing a strategy to develop; and validate the overall Blockchain solution; and integrate it in the Business Strategy. The authors also discuss how the Blockchain will help in reducing the logistics costs and in optimizing the activities and the research challenges.

This article is helpful to understand the basic issues in the implementation of Blockchain in the supply. It will be useful to share the data along the whole Blockchain which helps in adopting the solution. This article states, a correct implementation of the Blockchain innovation in the inventory network must begin from an examination of the requirements, to plan of action fit for financial profits and customers.

Meng, M. H. and Qian, Y., "A Blockchain Aided Metric for Predictive Delivery Performance in Supply Chain Management," *2018 IEEE International Conference on Service Operations and Logistics, and Informatics (SOLI),* Singapore, 2018, pp. 285-290.

This article mentions blockchain technology as a game-changer for supply chain management industry especially after the introduction of smart contracts which enable a user to apply blockchain technology into larger extent as it supports more type of operations and offer a programmatic solution to process the data to the ledger. Authors state supply chain as the field which is to be most benefitted from blockchain technology. The authors briefly explain the ongoing projects of blockchain in the business industry, and then propose their assessment model and blockchain framework to seek an enhanced metric for delivery performance with real-time feature and higher accuracy. Authors explain about blockchain framework called Delivchain which is designed for industrial supply chain management. They discuss the benefits of their purposed framework.

The article develops a model based on blockchain called DelivChain which can be used for enhanced assessment models for real-time predictive delivery performance in supply chain management. It helps to identify the benefits of DelivChain could bring to these days industrial supply chain from alternate points of view.

Hinckeldeyn, J. and Jochen, K., "(Short Paper) Developing a Smart Storage Container for a Blockchain-Based Supply Chain Application," *2018 Crypto Valley Conference on Blockchain Technology (CVCBT)*, Zug, 2018, pp. 97-100.

The article revolves around blockchain and the internet of things which should have an enormous effect on logistics. The authors present a prototypical smart contract utilizing smart storage containers to research the potential and the development of Blockchain and the Internet of Things for logistics procedures. Authors suggest creating a smart storage container is created and associated with an Ethereum-based smart contract. According to authors smart contract depends on a multi-signature wallet of three parties to process the payments and arbitrate differences. The authors highlight the need to create new communication protocols for IoT devices to communicate based on blockchain technology. This article helps us understand the role of intermediates for Blockchain-based supply chain applications which need to be redefined.

This article explores the prototypical implementation of a Blockchain-based supply chain application. This prototype is useful as it shows both how smart storage containers and smart contracts could be coupled and which developments are needed to make it a use case, which is interesting for logistical companies.

Pervez, H. and Haq, I. U., "Blockchain and IoT Based Disruption in Logistics," *2019 2nd International Conference on Communication, Computing and Digital Systems (C-CODE)*, Islamabad, Pakistan, 2019, pp. 276-281.

The author presents blockchain technology alongside the Internet of Things (IoT) and Cloud Computing is relied upon to cause interruption in the current business forms at an extraordinary scale. The research paper mentions blockchain as it allows users to have a peer-to-peer network, where participants can collaborate anonymously without involving 3rd party. This research paper suggests smart contracts are programs or algorithms which are stored in blockchain which allow automating organizational business models. Authors presents smart contracts in blockchain architecture to represent business logic as smart contracts are self-executing program which can be triggered on events generated by IoT sensors. Authors in this paper present a comprehensive analysis of the disruptive innovation happening in the logistics processes due to blockchain and smart contracts.

This article points in the role of blockchain in the digital disruption of logistics and supply chain, it also lists the most important key performance indicators (KPI) needed to be redefined for logistics in context with the blockchain-powered distribution. It highlights the baseline implementation of blockchain-based smart contract management systems in Hyperledger and suggests the characteristics that blockchain technologies must have to positively disrupt the supply chain logistics process.

Jayaraman, R., AL Hammadi, F. and Simsekler, M. C. E., "Managing Product Recalls in Healthcare Supply Chain," *2018 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, Bangkok, 2018, pp. 293-297.

Authors highlights product recalls in the healthcare industry as the biggest reason for supply chain disruptions and mentions that to have a product that is secure and reliable can be used for communicating recall information and to recoup or safe removal of the item is extremely challenging. Authors mention medicinal services product recalls are based on the severity of the risk to patient life and such conditions don't assist the supply chain network to evaluate the effect of developing alternative logistics sourcing systems. Authors suggest applications of blockchain technology in the healthcare supply chain can offer a potential solution for enhancing the efficiency of recall management, tracking products and effective information communication across the healthcare supply chain. Authors propose the use of blockchain technology to enable effective product tracking and recall communication. This article helps to develop suitable frameworks, models, and strategies to manage product recalls.

This article states product recalls in healthcare have been increasing for a variety of reasons causing significant supply chain disruptions and healthcare recall management is a complex process that requires information accuracy and efficient notification system. It is useful to identify potential supply chain causes and categorize the relevant factors that contribute to product recalls.

Wu, H., et al., "Data Management in Supply Chain Using Blockchain: Challenges and a Case Study," *2019 28th International Conference on Computer Communication and Networks (ICCCN)*, Valencia, Spain, 2019, pp. 1-8.

Authors mention supply chain management (SCM) crucial for picking up financial, natural and social benefits in the logistics network industry but customary SCM systems ordinarily experience the ill effects of a wide extent of issues, a large number of stakeholders leads to scalability issue of the blockchain network system built upon the Hyperledger fabric for a permission blockchain system. Authors suggest advances in blockchain innovation demonstrate the incredible potential to handle these issues because of its notable highlights including immutability, transparency, and decentralization view of coordination. The authors implement a food tracing system based on permission-based blockchain for the food supply chain scenarios. The authors summarize the pain spots of the existing SCM system and four technical challenges in the design of the blockchain system in practice.

This paper introduces the blockchain technology in supply chain data management with the potential opportunities of adopting blockchain technology and demonstrated the key technical challenges in the design of the blockchain for meeting the demands of the supply chain in practice. This paper addresses the issues and introduces the proposed food safety tracing system.

Lai, J., "Research on Cross-Border E-Commerce Logistics Supply Under Blockchain," *2019 International Conference on Computer Network, Electronic, and Automation (ICCNEA)*, Xi'an, China, 2019, pp. 214-218.

The authors mention the supply chain as the core link of cross-border online trade business. Authors suggest the use of blockchain technology logistics for supply

chain management of cross-border e-commerce. Authors mention three aspects of decentralization of blockchain in logistics, capital flow, and information flow as blockchain technology has good confidentiality and self-repair ability. Authors provide new ideas on how to build an efficient cross-border e-commerce logistics supply chain system, blockchain technology ensures the integrity and fluency of information flow from the cross-border supply chain. This article helps us to understand how to improve China's cross-border e-commerce logistics supply chain management ability.

This paper provides a logistics supply chain framework for e-commerce when the trade is to be done across borders. It is helpful to understand the blockchain technology as it has emerged more efficient, advanced and comprehensive form of organization and describes how supply chain with use of blockchain technology has good data confidentiality, anti-aggression and data self-repair ability.

Liang, S., Li. M., and Li, W., "Research on Traceability Algorithm of Logistics Service Transaction Based on Blockchain," *2019 18th International Symposium on Distributed Computing and Applications for Business Engineering and Science (DCABES)*, Wuhan, China, 2019, pp. 186-189.

Authors proposes a traceability algorithm for logistics services transaction based on blockchain. The article also gives an insight how traceability of the logistics service supply chain is to track the products in all aspects of the supply chain, with logistics services as the core, from the raw material collection, production and processing, product storage, safe transportation, quality inspection, and wholesale distribution. The authors suggest combining the structural characteristics of the blockchain to propose a decentralized new logistics services based on blockchain technology. Authors mention combining asymmetric encryption with the business process of the supply chain to create a new algorithm which is service transition transparent, also integrity and security of data is ensured.

This article provides presents traceability algorithm for logistics service transactions. This paper helps us to understand the multi-dimensional modeling of the traceability data which is based on the proposed models, combined with the business process of the logistics service supply chain which implements bidirectional traceability of the outside mode and the internal model of the entire logistics service supply chain.

Madumidha, S., Ranjani, P. S., Varsinee, S. S. and Sundari, P. S., "Transparency and Traceability: In Food Supply Chain System using Blockchain Technology with the Internet of Things," *2019 3rd International Conference on Trends in Electronics and Informatics (ICOEI)*, Tirunelveli, India, 2019, pp. 983-987.

Authors mention how blockchain technology can improve the Internet of Things (IoT). Authors describe blockchain technology as a technology that provides temper proof data with strong authentication where the information about all the products is encrypted as it is decentralized which can increase the transparency of goods information. Authors explain the supply chain as the network of distributing

raw materials, processing it through intermediate and sold to consumers. The authors propose a system to cover the process of collection of data and managing every node of information which apprehends the tracking and tracing system with the use of IoT devices. This article helps to understand that blockchain technology when united with the Internet of Things, it provides increased transparency and makes the supply chain more efficient.

This article demonstrates the idea of blockchain with IoT devices in the field of supply chain logistics along with mentioning its positives and drawbacks. It is helpful to understand how this technology can be fully automatized so that the maul work in conceptually reduced.

Tijan, Edvard, & Aksentijevic, Sasa & Ivanić, Katarina & Jardas, Mladen. (2019). Blockchain Technology Implementation in Logistics. *Sustainability*. 11. 1185. 10.3390/su11041185.

Authors describe logistics and supply chain management as domains where blockchains are good fits for a series of reasons. Authors provide the idea of how to use blockchain technology in the development of supply chain management. Authors mention major challenges in logistics, such as order delay, damage to goods, errors, and multiple data entry can also be minimized using blockchain technology. Authors mention how blockchain technology can reduce time delays, added cost and human errors in the supply chain logistics industry. This paper helps to understand the current and latest developments of blockchain technology usage in supply chain management.

This article on Blockchain technology offers an innovative platform for a new decentralized and transparent transaction mechanism in industry and business. This paper helps us understand the use of RFID when integrated with IoT and blockchain technology can enable the traceability, eliminate the frauds & errors, minimize costs, reduce wastes, improve inventory management and helps to identify issues faster.