

Blockchain: Role of Blockchain in Covid-19 Vaccine Supply Chain Management

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ABSTRACT

Manufacturers all around the world raced to create and release a vaccine to counteract the threat of COVID-19. Once a vaccine has been licensed for use, it will be necessary to deal with all other issues with transportation, storage, and distribution logistics, such as the need for frozen storage temperatures. Due to the number of intermediaries involved in the launch of any new medication or vaccine, it is challenging to implement a rollout of any new drug or vaccination successfully. COVID-19 vaccines have more significant problems since they employ two separate vaccines, each with different storage needs. To be effective, some chemicals must be kept at a constant temperature. To meet the quality standards outlined in the specifications, the temperature must be maintained from the time of manufacturing, through the distribution centers, throughout transportation, and in the healthcare facilities and vaccination centers. In the pharmaceutical and logistics industries, blockchain provides a route ahead, mainly when disruption occurs at an unprecedented scale.

Keywords: Covid, Blockchain, Vaccine, Supply chain management

Introduction

COVID-19 vaccination campaign provides insight on the impact of supply networks, such as pharmaceutical supply chains, on safe, dependable, and efficient supply. A system that might assist in the tracking, monitoring, and resolving of difficulties in pharmaceutical supply chains has the potential to provide value concerning blockchain. The content of this paper covers what blockchain is, how it may be used to enhance pharmaceutical supply chains, and how we see it in use in the COVID-19 [1] vaccine supply chain.

What is blockchain?

Distributed ledger technology (DLT) is commonly referred to as the blockchain. Distributed ledgers often employ replication, sharing, and synchronization across many locations, institutions, and nations under a consensus process. Changes occur immediately and instantly with every modification.

New information is stored on the blockchain as a "block." A hash function is used to link this block to the previous block in the chain. Without this, the blockchain would have no guarantee of long-term durability. In hash-based cryptography, reverse engineering is effectively impossible. To remove or alter a piece of data once it has been placed on the chain is impossible. This is because one modification will force all other blocks to need to be edited as well. Distributed ledger technology is so. Every node will share this blockchain in the network. To create a falsified record, someone would have to control 51% of all nodes simultaneously. This enhances

security above and beyond a single ledger kept by a trusted authority.

It is possible to create a blockchain network in several different methods. A "permissionless" blockchain is one where everyone is allowed to use the blockchain without requesting permission. Every piece of data is duplicated on every node, and all nodes are treated equally. In addition to public permission blockchains, which allow certain parties to transact on the blockchain, there are private permissioned blockchains. Only a particular set of individuals can engage in a specific transaction on the blockchain. Once the data has been distributed, the nodes utilize the protocol to determine who is receiving the data.

Role of Blockchain in supply chain management

Multifaceted supply chains pose a risk to businesses' capacity to detect problems and errors and, in extreme cases, can lead to critical data loss. Early COVID-19 vaccines require modest temperatures to ensure their efficacy when administered, therefore resolving visibility concerns is essential to preserving their integrity. When designing a consistent, dependable, and transparent delivery system, creating a successful experience might be tricky. The lack of a mechanism to detect process flaws makes it exceedingly difficult to identify areas of improvement. This means changes in any one area might occur without knowing those improvements in other areas. Additionally, an unstable supply chain allows hackers to use stolen data and manufacture fake medications, increasing the risk to patients.

In light of the present climate, pharmaceutical firms have done a lot to rethink how they make and distribute their products. Continuity of business, providing safe working conditions for employees, and streamlining the process of generating effective COVID-19 vaccinations have all been maintained as a result of these initiatives. To ensure the continuing transparency and effectiveness of their supply networks, they must maintain a well-maintained supply chain. The delivery of the vaccines will essentially be in the hands of logistical firms. All necessary information regarding the vaccinations' integrity must be intact and dependable while ensuring that vaccines arrive safely. Vaccines must be kept at a consistent temperature throughout their transportation process. Is the packing undamaged? All safety procedures were followed while the drug was in the manufacturer's control, enabling patients to have complete trust in the type of vaccination they're receiving.

Though it may not address every problem, blockchain technology has already been demonstrated to aid. Practically applicable success stories for using blockchain to preserve data from IoT sensors that may monitor pharmaceutical temperature throughout the shipping process include utilizing blockchain to secure crucial data from these sensors. The benefits of blockchain in shipping are not only limited to shipping, though.

The advantages of blockchain

Several pharmaceutical and logistics sectors will benefit from blockchain's unique features. Blockchain's distributed, decentralized ledger system offers an unalterable record of data modification as it is passed from one person to the next. This vital characteristic has numerous benefits.

Ensuring greater security: One of blockchain's greatest strengths is its security. No alterations are allowed to any transactions in the supply chain. A chain of data that cannot be changed is crucial to ensuring the production of legitimate pharmaceuticals since it pinpoints the distribution

of counterfeit or tampered merchandise.

Maintaining cold-chain requirements: Distribution requirements need proper temperature and humidity to guarantee drugs are delivered suitable for use. Blockchain is crucial for keeping vital information intact and ensuring vital handling procedures are followed, thereby avoiding the financial loss associated with cold-chain regulations not being fulfilled.

Enabling greater efficiencies: The streamlined and efficient supply chain powered by unified data is an advantage over one that depends on stakeholders to maintain up-to-date data. Because the blockchain keeps track of every handoff, and the entry of erroneous data, such as duplicate assets, causes shipment delays, shipping delays are prevented. At the same time, reducing delivery times while maintaining data integrity is possible.

Creating a single source of truth: When appropriately implemented, blockchain provides the level of transparency needed to provide a complete, unified picture of all the data. A data gap may negatively impact the quality of the supply chain by leaving room for errors to occur and remain undetected. By removing any data gaps, the whole supply chain becomes an open book with comprehensive visibility into each stage, allowing firms to monitor the process and assure quality. Using the blockchain, companies may handle data more effectively and guarantee that all relevant stakeholders can access the data safely.

Developing resiliency now and into the future: Technology is used more frequently because of the rise in health and safety regulations. The application of blockchain technologies can increase teamwork, regardless of location, by delivering safe and transparent data.

Building consumer confidence: Successful supply chains provide high-quality products while simultaneously cultivating trust and inspiring confidence in healthcare professionals and patients alike. Businesses need to be able to identify and fix mistakes as they arise, as well as to maintain consistent standards throughout their product lines, thereby helping them compete more effectively and leading to long-term success.

How blockchain benefits vaccine supply-chain management

Connecting all players through a secure supply chain is crucial to producing high-quality products, including pharmaceuticals. Using blockchain to improve supply-chain operations in the pharmaceutical sector might benefit this industry [2].

Also, if numerous parties and chains of custody are implicated, the logistics business might profit. Blockchain distributes ledgers to increase openness across various touchpoints, vastly improving transparency for all parties involved. Additional benefits include enhancing the delivery process by having unimpeachable proof of cargo location and integrity, accelerating document transfers, and reducing operating expenses.

Every link in the chain from producer to consumer should use innovative blockchain healthcare techniques. It's time for every party in the supply chain to come on board. If it's executed correctly, blockchain's influence on vaccinations currently being created and disseminated will be even more significant for medications being developed and distributed in the future [5].

Vaccines and medicines may be tracked and monitored through the supply chain on the blockchain. To apply a digital identity to physical products such as pharmaceuticals or vaccinations, many problems arise. This may be done via identifiers, for example, barcodes, which could be applied to the goods. These must be tamper-proof and identifiable so that counterfeit medication can't be mixed in with the marked

package. To do this, the manufacturer or the regulator may scan a barcode and obtain all of the necessary information. Alternatively, barcode scanners might be used by hospitals and pharmacies with minimal infrastructure to check the validity of a medication. The bokode is a much smaller, more specific, and more information-dense visual data tag presently in use. For typical digital cameras, including mobile phone cameras, may be viewed up to several meters away.

It is possible to search back through all previous entries, all points of interaction, locations, and timestamps to locate the source of the product, manufacturer, and even the particular batch it originated from using blockchain. The blockchain helps track items along the supply chain, making it possible to discover and correct faults quickly. This would, in turn, help to remove counterfeit, defective, and expired items from circulation sooner and more efficiently. Other built-in safeguards include the blockchain. Since barcodes may be easily copied, the blockchain will detect any suspicious behavior instantly and immutably. No matter how much you try to change the data in the chain, all authorized users will know about it. This significantly improves manual databases, which are easier to meddle with. Information can be modified or deleted, and procedures for confirming that the organization that has handled the goods has met regulatory standards can be made available.

With the use of internet of things (IoT) technology, it is possible to utilize blockchain for tracking the implementation of the COVID-19 vaccination deployment. The Covid-19 vaccine delivery chain has to monitor temperature and storage duration, as the vaccines have varied storage requirements. If blockchain technology is in place during the transit and storage of vaccination batches, it may monitor temperature and other vital information. Using IoT sensors to gather and store information about containers, then transferring that information to the blockchain, may implement the system. This increases the ability of other authorized parties to ensure the vaccinations have been carried and kept appropriately, assuring that the vaccines are safe and effective.

Many more possible benefits may be available in the context of pharmaceutical supply chains using blockchain, including promptly and efficiently finding problems, hold-ups, and bottlenecks and eliminating the danger of double counting. Blockchain can effectively detect problematic items and help remove them from the supply chain, as described above.

Pharmaceutical supply chains

The supply chain industry might be significantly improved by blockchain. While blockchain cannot handle every eventuality, it dramatically reduces the likelihood of mistakes in the chain. As a result, pharmaceutical supply chains contain numerous stakeholders and processes that are carried out in stages — starting with the provider of the API, such as a company that manufactures pharmaceuticals, then following the manufacturer, which employs the drug, after which are found the packaging and distribution companies, and at last, patients. For one thing, the introduction of more intermediaries causes additional complexity, which makes it more challenging to track and guarantee the validity of pharmaceuticals. Due to the unique characteristics of blockchain, it might prove that the items came from their origin and be more secure [6].

The COVID-19 vaccine rollout

Covid-19 vaccine deployment is getting a lot of attention because of its central role in supply

chain management. COVID-19 is rolling out in the UK, and over 18 million individuals have now got their second injection. According to a news statement by the UK government dated February 13, 2021, vaccinations are currently being given at 267 hospitals, 1,034 local vaccination locations, 90 vaccination clinics, and 194 community pharmacies. It is entirely unusual for a rollout of this magnitude and speed to occur. Therefore, much more emphasis must be placed on assuring that the rollout is managed correctly, accurately, and safely [7].

The COVID-19 vaccines have an additional burden since they contain vaccines with differing storage needs. Those have to be stored at the correct temperatures to be effective. This temperature must be maintained from the moment it's manufactured till it's distributed to customers, during the delivery process, and when it's used at healthcare facilities and vaccination clinics. Also, the vaccinations are not interchangeable, so the following doses must be the same as the patient's first. To guarantee that the COVID-19 vaccine deployment is safe, reliable, traceable, and mistakes are avoided, it is essential to have a healthy supply chain.

How Blockchain Could Advance the COVID-19 Vaccine Rollout

As pharmaceutical firms outsource COVID-19 vaccines to contract manufacturers, they are confronted with additional difficulties in ensuring product safety and efficacy. Vaccine makers may contract out manufacturing and distribution while guaranteeing that the product reaches the community safely. Blockchain is well-suited for improving the COVID-19 vaccine manufacturing and time-sensitive delivery projects because [8].

Lower Costs, Fewer Recalls

The materials that COVID-19 vaccines are sourced from, the critical qualities of the raw materials, and the parameters included in the manufacturing process are defined all at the same time as they are being procured. This is followed by the vaccines being manufactured, stored, and shipped from suppliers, contract manufacturers, and distributors. The management of the environment is essential throughout the whole chain of custody. The quality, effectiveness, and safety of the vaccine can be compromised if there is an excursion outside of these parameters at any stage in the value chain [9]. The excursion can delay or possibly result in the loss of millions of dollars worth of time-sensitive shipments. If this progresses, it might lead to supply disruptions and put patient safety at risk. There are limited quantities of COVID-19 vaccinations. Therefore the health hazards posed by restricted supply must be avoided.

By use of blockchain, which offers real-time monitoring of a company's cold chain, it is possible to reduce these risks while at the same time safeguarding it from fraud [10]. To track the provenance of raw ingredients and finished goods from manufacture to patient delivery, blockchains are suitable. They are not held by any single organization and cannot be altered. As a defective batch can be quickly detected and eliminated, this eventually decreases recalls and cuts costs.

Lifecycle Visibility

The integrity of the whole lifespan of a product from start to finish may be maintained with blockchain technology [11]. A process that allows suppliers to track demand and medical

institutions to track when shipments are arriving or delayed makes tracing each stage of the product lifecycle possible. Such a distribution strategy may be established based on incoming supply and demand restrictions. When received, medical facilities could verify that the vaccinations are legitimate and certify that they were correctly stored along the supply chain since there is an immutable chain of custody evidence from the time they left the production facility until the vaccines were received. An adverse occurrence should be informed to distribution companies and healthcare practitioners so that measures may be taken to remove implicated vaccinations. The distribution of vaccines would be streamlined, ensuring effectiveness, quality, safety, and efficacy for patients. Also, each stage in the process would be validated using blockchain.

Tamper-Proof Trail

With a blockchain, environmental data can be made 100% real-time and is sure to meet product design, quality criteria, and regulatory compliance requirements. Manufacturers keep track of their inventory using these available components, outgoing parts, and arriving parts, which are recorded on the blockchain, so nothing is wasted.

To assist with this, blockchain might track the transportation and warehousing of vaccinations and when they are delivered, picked up, and transferred to assure that the correct procedure is always followed. All parties can guarantee that vaccinations were kept and managed appropriately and data was not changed along the route because blockchain is immutable and cannot be tampered with.

Trust and Transparency

Trusting partners may verify vaccine progress in real-time when all parties are aware of the whereabouts of the vaccinations throughout the development, procurement, manufacturing, storage, and delivery chain. Blockchain offers a comprehensive immutable database where suppliers, manufacturers, distributors, and medical staff may exchange consistent, correct information without any interference, accountability, or evidence of authenticity throughout the chain of custody [12].

Ensuring a degree of accountability and accuracy while tracking raw materials and vaccinations helps to avoid the potential of counterfeit substances and vaccines getting into the value chain.

Amid their complicated and expensive production process, while simultaneously attempting to preserve the provenance, efficacy, quality, and safety of vaccines, vaccine manufacturers must also guarantee that all doses arrive safely. Batches or overproduction that lead to all or partial shipments being disposed of or counterfeit vaccines entering the supply chain can occur if doses are not tracked consistently across the supply chain. As a result, fewer individuals will be vaccinated, and efforts to stop the epidemic would be delayed.

To monitor the COVID-19 vaccine supply chain, blockchain is leveraged to create an audit trail of all points in the supply chain, including the origins of the vaccine, manufacturing,

transportation, and storage. This ensures a more accurate record of where vaccines come from, who makes them, where they are, and how they are stored.

Architecture for Vaccine Pharma to Patient Arm

Blockchain technology is a valuable tool for keeping vaccination delivery accurate and transparent. Fig 1 illustrates the vaccine distribution route between Pharma and the patient [13].

Blockchain Distributed Ledger Technology (DLT) has a transparent, shared system of record built on immutable data and is available to all members of the supply chain. IoT sensors monitor the temperature of the vaccine supply from when it leaves the facility to the time it arrives at the hospital. Sensors connected to the Internet of Things (IoT) transmit information about IoT-related events, such as when a vaccination supply arrives at a pharmacy, to the blockchain ledger [14].

Vaccine storage temperature can fall below an acceptable level. In this case, the smart contracts notify suppliers to be rescued and relocated to a more appropriate cold storage location. Distribution, logistical bottlenecks, and predicting undesirable side effects may all be supported by AI-based analytics combined with a reliable blockchain data source.

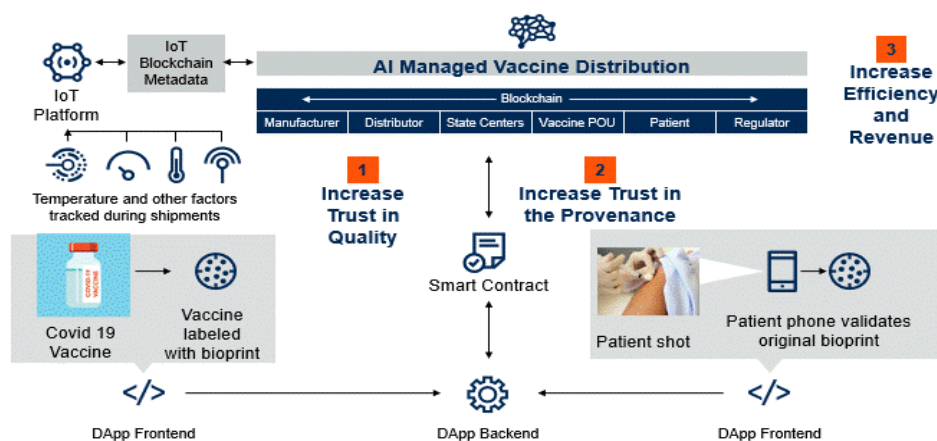


Figure 1. The integrated architecture of Blockchain, IoT, and AI

Without a doubt, any network member (i.e., node) can verify the unchanging blockchain data, which makes arguments about the current status and placement of the vaccination unnecessary. Appropriate and ready vaccination supplies are no longer a secret, allowing decision-makers to base their choices on adequate and up-to-date information. The image on the left demonstrates how blockchain and the Internet of Things (IoT) may be technically integrated [13].

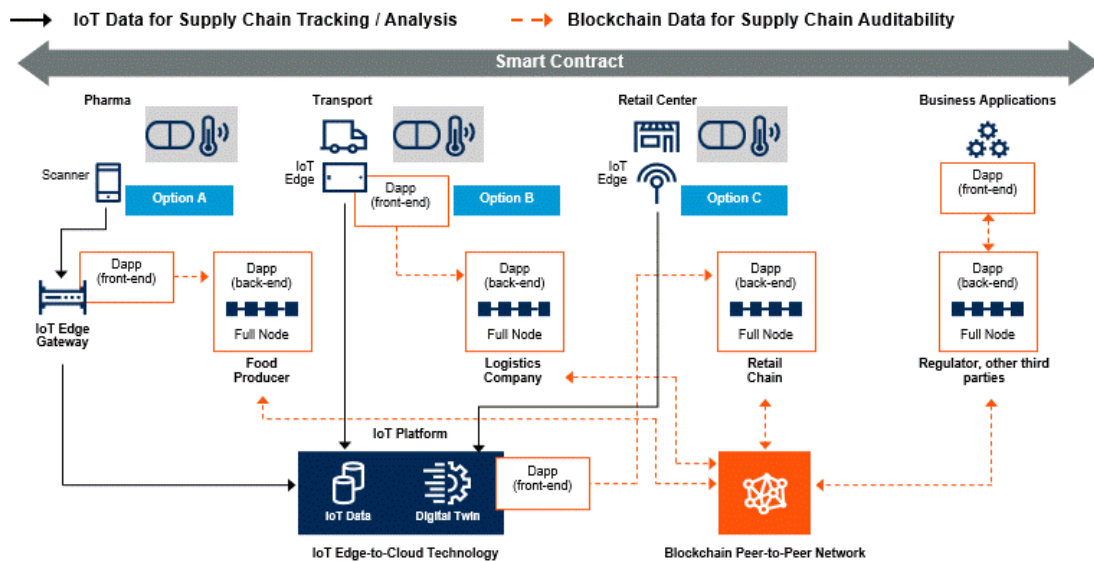


Figure 2. IoT and Blockchain Conceptual Integration Architecture

Conclusion

This study proposed a blockchain-based system for transparent tracing of COVID-19 vaccine registration, storage, and administration. It also included reporting adverse effects and a system for transparency on where, when, and how often the vaccination is administered. With blockchain, vaccine-vendor registration data is provided with immutable, transparent, and correct identification information for vaccination. This alleviates fraud, impersonation, and identity theft. Vaccine delivery is tracked and monitored via decentralized smart contracts. Additional advantages of a blockchain-based system include immutable records for the administration of vaccines, transparency and tamper-proof self-reporting of adverse effects, identification of patients, and the relationship between vaccines and disease.

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