

# Enhancing Supply Chain Management Using Blockchain Technology

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**Abstract:** Blockchain technology is emerging in every field. Blockchain is a constantly growing ledger that keeps a permanent record of all the transactions that have taken place in a distributed, decentralized and immutable way. Supply Chain Management is a broad range of activities that involve the management of the flow of goods and services, from the point of inception to the point of consumption. Blockchain technology can i) assure provenance tracking and traceability across the supply chain management ii) improves the quantity, quality and access to information at every step of the way across the chain iii) provides a more transparent way to provide data or information at a given instance of time. Blockchain technology can also be adapted in the supply chain management to overcome its disadvantages. The paper shows different case studies where the benefits of applying blockchain technology in supply chain management are appealing that has shown many benefits. It highlights the cases that have reduced fraud and errors; mitigate risks and provide data transparency and privacy, etc. The paper shows the creation of a general blockchain network and the information passing mechanism which is used to pass the information among the participants across the supply chain. With information passing mechanism we can provide data transparency to the consumers across the supply chain.

**Keywords:** Blockchain, IoT devices, Network effects, Scalability, Supply Chain, Transparency.

## I. INTRODUCTION

Blockchain is a constantly growing list of records called blocks, which are linked and secured using cryptography [1]. It is a distributed database of records or public ledger of all transactions that have taken place in the network [2]. Blockchain technology with decentralization, distributed and immutability properties provide promising results in supply chain management.

One of the core benefits that we get using blockchain is data interoperability, which is used for sharing information with suppliers, customers, and vendors. Transparency makes to avoid any illicit product distribution. If any, we can easily find them. Due to its distributed (shared public ledger) network property, which makes every participant of the network access the information from any part of the chain.

With the immutable property of the blockchain, no one is able to change the product information so that data breach can be avoided. The combination of transparency and immutability of the data is used to maintain the integrity of the supply chain and helps to reduce any fraud in the system. Using blockchain technology in the supply chain offers the potential to connect different ledgers and data points while maintaining the data integrity among multiple participants of the network. Other than these, a few other benefits of adapting blockchain technology in the supply chain industry [3] are listed below.

- a. It reduces fraud and errors
- b. Improve inventory management
- c. Increases transparency and traceability
- d. Reduces tedious work of record-keeping about products.
- e. Increases supplier and consumer trust.
- f. Increases Sustainability.

## How blockchain helps in enhancing supply chain management?

An effective supply chain management depends on several parameters of the chain like transparency and privacy at any instant of time which includes where goods are at any given time, and the origin of all the parts of the chain. By using blockchain technology-based records, we can store and share that information for every component by using shared public ledger, so that we can track the flow, how it was created and where it is at any moment. With the integration of IoT and Blockchain in Supply chain management we can maintain information security between the IoT devices across the chain, In addition to that, Blockchain provides immutability property with which no one can manipulate or tamper data between devices. Consider a scenario: Provenance is a digital platform where it provides transparency to the consumer by gathering and presenting information about the products, With the use of blockchain technology as a platform to make it more trustworthy[4], so that the shoppers know about the products they buy with use of provenance tracking, traceability and they can discover that the product is verified. Reliability, provided to the consumers by providing authentic products with transparency creates more trustworthiness which is a major concern for any consumer driven business. Benefits: By Integrating IoT devices with blockchain, we can efficiently improve traceability and transparency, and a consumer can access information about the product from its initial stage until it reaches the consumer through the supply chain. Measurement of supply chain management performance is often described in terms of objectives such as quality, speed, dependability, cost, and flexibility.

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## II. MOTIVATION

We visit supermarkets very frequently for daily needs. The fruit section mentioned berries from the U.S.; intrigued by those, raised a question-how one can trust whether are they really from the US?

A constant zeal to know the fact behind this made me explore, which paved the path to Blockchain technology where research is going at a rapid pace to provide trustworthy, transparency as some of its objectives in supply chain management.

## III. RELATED WORK

A prominent objective of supply chain management is also to reduce risks. Among the various risks that different organizations face include relational risks such as a business partner's engagement in opportunistic behavior (e.g., cheating, distorting information) [5]. In this section let's look to different case studies where the blockchain technology was made in use under broad application sectors to reduce risks.

### Application 1: Food Safety

Food safety is one of the prominent areas where the research is going rapidly. Approximately, for one percent reduction in foodborne disease in the United States, it saves the US economy about \$700 million.

### CASE 1: Food Supply Chain

One of the most important fields in which the supply chain is being implemented is in the Food Industry. The food supply chain enhances the integrity, transparency, and traceability among the global supply chain platform. Due to an increase in the intricacy involved in the food supply chain, it is becoming an onerous job for the food producers, suppliers (distributors) and retailers to ensure the provenance tracking of the products through the supply chain [3]. There are many food safety issues, that are to be addressed which include cross-contamination, and the use of detrimental ingredients for the production of the food, identifying and the spread of foodborne illness, is made even worse due to lack of data, transparency, and traceability. The source of contamination and finding its root cause can take from days to month which is explained briefly in the "Spinach outbreak" case. According to the report from the WHO, one-out-of-ten people fall ill, and around 420,000[3] die due to eating contaminated food.

**By using Blockchain:** Blockchain resolves above-discussed issues by providing neutrality in the supply chain. Since there are no third parties involved in the transaction authorization i.e. which is decentralized and everything works based on a consensus, both, the users and the operators of the system had to follow a set of rules to keep the system working efficiently. Wal-Mart in collaboration with IBM developed blockchain technology to monitor the consumer products using RFID (Radio Frequency Identification) sensor tags [6]. Blockchain provides numerous advantages for all the participants in the food supply chain. Food producers should ensure that the originality and quality of their supplies of the food must be maintained by tracking. If any attempts are made for the tampering of the food item through the supply chain, it can be caught using transparency. If there is any identification of the fraud, then the notification must be sent directly to the retailer even before the food item reaches its destination. With

blockchain, consumers can assure food supplies that they consume came from the legitimate source with transparency. With traceability and transparency, consumers can identify and consume high-quality food.

We are in dire need of reducing food waste because one-third of all food that's produced on the planet goes to waste.

### Benefits of Blockchain in Food Safety:

- Enhanced food safety.
- Less food waste.
- Detect food fraud.

### CASE 2: Seafood Verification

The seafood supply chain has got many disadvantages due to the lack of transparency. The present seafood supply chain has tedious processes like manual record keeping that makes it more prone to errors. Moreover, other issues that result in making the seafood supply chain inefficient are the improper food storage conditions, mislabeling frauds, and the prevalence of unregulated practices [3]. Due to these issues, the quality and security of the food that reaches to the end-customer is compromised, which threatens the industry's economic security.

**By using Blockchain:** Blockchain technology can prove to be a panacea to the seafood verification problems as it can track fish and seafood right from the production to its distribution. The project named Hyperledger Sawtooth is revolutionizing the supply chain by bringing traceability and accountability through its blockchain platform. Sawtooth allows the seafood to be detected in the supply chain through sensors with the use of IoT technology that transmit the location and time of the products to the blockchain. This allows the buyer to access a comprehensive record of the product.

### CASE 3: Spinach Outbreak (2006) North America

In September 2006, there was an outbreak of food-borne illness caused by Escherichia coli (E. coli) bacteria found in uncooked spinach [7] in 26 U.S. states.

On October 6, 2006, 199 people had been infected, including three people who died and 31 who suffered a type of kidney failure called hemolytic uremic syndrome after eating spinach contaminated with the E. coli O157: H7, a potentially deadly bacterium that causes bloody diarrhea and dehydration. This strain is more potent than in any other food poisoning scares. Federal health officials said half of those reported sick have been hospitalized compared to 25 to 30 percent in past outbreaks. The U.S. Food and Drug Administration (FDA) called for bagged fresh spinach to be removed from shelves and warned people not to eat any kind of fresh spinach or fresh spinach-containing products. It took two weeks to trace back the source of that spinach to the original farm. During those two weeks, there is no spinach in the market.

**By using Blockchain:** With blockchain in supply chain management, we can trace it within minutes, possibly within seconds.

**Application 2: Disaster Response (Flooding)**

In case of a disaster like flooding, especially in flash floods we have to get the real-time data to know location of the people who are affected by disaster and amount of food, medical facilities that are required for the affected people, so in collaboration with GIS (geographic information system), and supply chain management we can easily track the location of the people [8].

For Example, you are one of the members of the major disaster response effort; you have to collaborate with the geographically dispersed team from different organizations at different locations; you need to guide people through a collaborative process of designing and operating the supply chains needed to respond effectively to this flooding disaster. A single organization can't operate the entire supply chain on its own, so a way must be found for collaborative decision making and working together which is a key when a disaster occurs. Effective disaster response depends on supply chains to deliver supplies and equipment where and when needed. First responders at disaster sites cannot do their jobs without responsive supply chains to support their work. Due to the transparency property of the blockchain, all parties in these online sessions can see how well different disaster response plans are working and can enhance the response plans. They can see where the problems are and collaborate on ways to best respond to these problems as earlier as possible. They can see the vehicles and routes available to deliver those supplies with the help of information visibility. This transparency of data, along with the common goal shared by all parties of delivering effective disaster response services, has the effect of bringing about a consensus concerning the actions to be taken by all participants. This drives the coordination between different organizations involved in delivering and using disaster supplies at specific locations.

**IV. IMPLEMENTATION**

**Building Blockchain Network:**

A general blockchain network was implemented with the use of a postman framework. Postman, an HTTP client is a user-friendly interface, which is used to interact with the blockchain. Flask - a web framework, is used to develop a web application that encompasses blockchain technology. The file named transactions.json file, which stores the sender, receiver address and the information to send. The methods used in creating the blockchain network are:

Get\_chain: This request invokes the get\_chain method to get the entire chain of blocks that we have mined till now.

Mine\_block: This request invokes the mine\_chain method to mine the block i.e. to add new blocks to the chain by solving the valid hash with the use of proof of work mechanism. The first block in the chain is called "Genesis Block".

Firstly, a block was created that has to be mined where proof of work mechanism operates in which miners across the blockchain network participates to find the valid hash for the above created block. If a miner solves the cryptographic puzzle (valid hash) then, all the other miners in the network have to validate it. If the block is valid, it is added to the blockchain network which is shown in Fig 1.

Further, if we mine blocks then a new block is added in connection with the old block with the prev\_hash field which makes it as a chain of blocks. If anyone wants to manipulate

the data, then he has to mine the entire chain of blocks from the manipulated block to the present block, which requires huge computational efforts.

Limitation: when a group of miners comes together to form a pool (memory pools) there is a chance of 51% attack. So, proof of the stake mechanism is used but it also has some limitations like one who has more stake for the transaction in the network gets the next block to be mined which in turn leads to the rich get richer. Further, the Casper mechanism is developed which is a combination of proof of work and proof of stake mechanisms.

```

{
  "chain": [
    {
      "index": 1,
      "previous_hash": "0",
      "proof": 1,
      "timestamp": "2019-07-04 10:24:38.578075"
    },
    {
      "index": 2,
      "previous_hash": "ce31607d9e2c311403f6a00ef567a082f09afda4d574aef668468970c1e5878",
      "proof": 533,
      "timestamp": "2019-07-04 10:26:46.638431"
    },
    {
      "index": 3,
      "previous_hash": "c712d0ea735cf06a9ac4c05cd71a67d49cabb62ae2f5f09f79c144386eccf380",
      "proof": 45293,
      "timestamp": "2019-07-04 10:26:48.152708"
    },
    {
      "index": 4,
      "previous_hash": "21c2520f78204928c9c853a7b3a36f64819d1db84d7900f10ef94d1c1ab1fb2b",
      "proof": 21391,
      "timestamp": "2019-07-04 10:26:49.226433"
    },
    {
      "index": 5,
      "previous_hash": "9d0a70f3b7c54daee465135ff8f795aae09ac9ac072eff22815aae376590743",
      "proof": 8018,
      "timestamp": "2019-07-04 10:26:50.083312"
    },
    {
      "index": 6,
      "previous_hash": "069ac8273597862b2ccfe7c001bc6bfda2ba67bc8b81fe6c6e68ce203fa37efb",
      "proof": 48191,
      "timestamp": "2019-07-04 11:25:01.932953"
    },
    {
      "index": 7.
    }
  ]
}

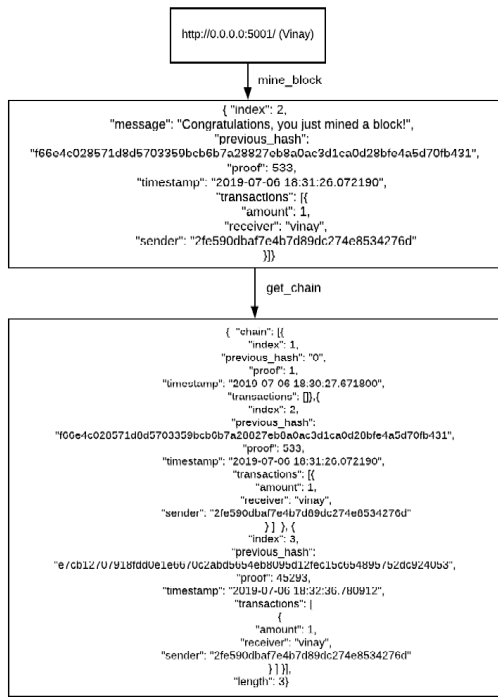
```

**Fig 1(General blockchain network).**

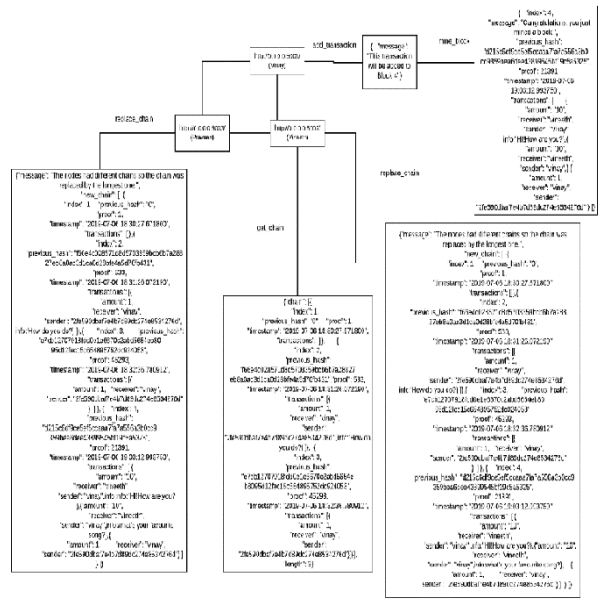
Fig 1 shows the creation of block chain network with index indicating the number of the blocks in the network with field's proof, timestamp etc.

In Fig 2, Vinay with address (http://0.0.0.0:5001/ ) using mine\_block method mined a block which gives output as "congratulations, you have just mined a block" with other fields like timestamp, proof etc. Proof field can be found by solving the cryptographic puzzle.





**Fig 2(Node “Vinay” mined a block).**



**Fig 3(Information Passing Mechanism) (if the figure is not clear please contact me).**

### Information Passing Mechanism:

One of the important traits that Blockchain provides in supply chain management is data transparency. In the experiment results carried out, we have created 3 nodes which are similar as if there were 3 computers; which were named as Vinay, with the address “http://0.0.0.0:5001”; “http://0.0.0.0:5002” as Vineeth and “http://0.0.0.0:5003” as Praveen in a nodes.json file. We implemented the Connect\_node method, with which every node in the network is connected to all other nodes across the chain which makes it a complete graph of nodes in the network.

When we request Connect\_node on address http://0.0.0.0:5002/ address it gives the output as.

```
{ "message": "All the nodes are now connected. The Blockchain now contains the following nodes:", "total_nodes": [ "127.0.0.1:5003","127.0.0.1:5001"]}
```

In Fig 3 all the nodes are connected and it elucidates the information passing mechanism using blockchain, I successfully demonstrated a transaction between Vinay and Vineeth, Due to transparency property of the blockchain, when Praveen makes replace\_chain request then he will get the entire chain, which includes transaction(information) between Vinay and Vineeth

### V. LIMITATIONS OF USING BLOCKCHAIN

BiTA (Blockchain in Transport Alliance) founded in August 2017, is the largest commercial blockchain alliance in the world. It is a member-driven organization, which includes nearly 500 members in 25 countries [9]. The primary aim of BiTA’s is to adopt emerging technologies that would provide solutions for many problems in the industry sector. This can be accomplished by educating members and encouraging them to use technologies like blockchain and distributed ledger which would provide better industry standards in the global supply chains etc. The BiTA in collaboration with industry leaders such as FedEx, BNSF (Burlington Northern Santa Fe Railway), UPS (United Parcel Service), and JD Logistics together, they discussed the challenges that they would face because of integrating blockchain technology to the supply chain industry [9]. These include network effects, the current lack of blockchain standards in the industry, the issues concerning blockchain and scalability, and the scarcity of technical talent.

Blockchain provides numerous applications in the present generation problems, but it has to overcome the challenges it faces which are mentioned [10] below:

- a) The global supply chain operates in a convoluted environment where different parties have to abide by diverse rules and regulations throughout the supply chain. So to provide consensus among the countries of the supply chain is a complex job to accomplish. For effective implementation of the supply chain, every country needs to make collaborative decisions.
- b) To implement blockchain, it requires a high degree of computerization. Due to different economies for different countries, complete participation can’t be reached; we can’t have the full potential of blockchain in the global supply chain.



c) Lack of standards: Lack of standards is one of the important issues that have to be addressed in blockchain technology and the global supply chain. So, to provide basic standards the BiTA has been hosting events, encouraging active participation of the public by which they can get different opinions that have to be discussed. Some of the topics of discussion include collecting payments, transparency, freight payment, etc. We have to define the jargon in the field of blockchain effectively. For example, defining a 'smart contract' as a forward contract, a confirmation sheet or informal agreement between the parties for the buy and sell off assets at future date.

d) Lack of scalability: Scalability is one of the most important factors for the slow pace of blockchain technology in the world. In a Conventional Banking system, the number of transactions that are processed in second is around 5000. But when it comes to Blockchain used cryptocurrency would be much low (around 3 to 9) when compared with traditional bank transactions. Due to its decentralized mechanism, all the nodes in the chain have to validate the transaction which takes more time. So, here Security comes at the cost of scalability. Scalability across the global supply chain has to be diligently planned so that many countries that are having small supply chains can collaborate.

e) Network effects build a supply chain: For an effective blockchain-based supply chain to be built, it needs to scale and should have a large no of active users. To build a global supply chain we have to make connections all around the world, wherein small chain partners join the network which eventually becomes a chain of a large number of small partners. The disruption caused due to change from a cloud-based platform to a blockchain is one of the reasons for scalability and the network effects that are implicit for this change.

## VI. CONCLUSION

The supply chain ecosystem is one of the best exemplars of how Blockchain and IoT can transform the way we do business and improve the quantity, quality, and access information at every step of the way. With the use of Blockchain technology, we ensure transparency, traceability and data security in supply chain management. There is a huge scope in further research in this field that has to address different issues and we have to embrace the use of blockchain technology circumventing its difficulties like Management of the information (data) about the product to be added to blockchain must be by a legitimate company trustee. One has to be careful before the addition of data as the data once added is immutable. Storing huge information about products in a provenance tracking and efficient retrieval mechanisms must be adopted. As we have discussed the proof of work and proof of stake mechanisms which are used to generate a valid hash has some limitations, so an efficient mechanism must be developed. Reduce the energy cost which is incurred by the use of Blockchain technology due to its computational purposes.

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