

Blockchain Technology Integration: Revolutionizing Supply-Chain Management

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EXECUTIVE SUMMARY

Introduction

Blockchain technology has received large attention in recent years with the growing popularity of crypto currencies and financial applications, however, the potential the technology can bring to other leading industries of the world has not been fully realized. One industry that could take advantage of this innovative technology is that of supply chain management, the process of transporting products from their origin as raw materials to their final destination with consumers as manufactured goods. This report will analyze the current problems within the supply chain management industry and use professional research and data collection methods to discover the benefits of blockchain integration into supply chain information systems.

Research Methodology

The driving research questions for this report were as follows:

- (i) What are the current problems faced within the supply chain management industry today?
- (ii) What components of blockchain technology prove an edge over traditional information management systems?
- (iii) Which organizations are currently using or planning to integrate blockchain networks for supply chain management frameworks?

A systematic literature review is conducted within the report using research from formal articles, case studies, and various news outlets. Additionally, limitations to the research methodology are mentioned to address desired approaches to data collection.

Data Collection

IBM Food Trust was the field site used for data collection in this report, which is designed around IBM's Blockchain network. This case study will explore how IBM consumer needs drove the design of this innovative information system and the revolutionary new systems transforms the concepts of traceability, efficiency, and security to a level never before seen in the supply chain industry. Additionally a demo of the information system will be entailed and what users of the network will see in real time.

Analysis

The data collected within the research methodology will be viewed through the lens of an organization as an organism and present how blockchain integration benefits both the organization and its members. Blockchain networks have the capability to solve the major problems that the supply chain industry faces and provide multiple approaches to security that were previously unseen in similar systems.

Findings

This report has found that organizations should begin implementing blockchain based networks to improve the organization as an organism. Providing the best experience for all users of the information system as well as improving the performance of the organization as a whole. It is recommended that organizations purchase networks from established networks such as IBM rather than developing their own in-house networks for more reliable service and compatibility with intermediate parties. Additionally, organizations should begin integration with a more localized system to improve understanding of the network's features and blockchain technology frameworks. Research should continuously be conducted by organizations to extend the scope of blockchain use within all operations.

Abstract

Over recent years, blockchain technology has entered the spotlight with the boom of cryptocurrency, non-fungible tokens, and the development of Web 3.0. However, it is important to recognize the capabilities of an information system such as this and what it could bring to some of the leading industries of the world. This report will detail the advantages of implementing blockchain networks for improvements in supply chain management frameworks. An introduction to blockchain technology will provide the general framework of blockchain networks and the unique self-security that the network establishes with its usage. Various network types will be discussed and what makes each unique to the others. Additionally, the pillars that make this technology a state-of-the-art innovation will be addressed as the later case study and analysis will center on the concepts of each pillar. Further information about current supply chain management management and integration problems will be visited as well as the solutions to provide a basis for the purpose of integration of blockchain networks into the supply chain industry.

The findings of this report entail there are several critical problems within the supply chain management industry of which the integration of blockchain systems can address. Organizations should begin implementing blockchain based networks to improve the organization as an organism. Integrating while keeping this approach in mind will provide the best experience for all users of the information system as well as improve the performance of the organization as a whole.

1. Introduction to Blockchain Technology

1.1. Blockchain 101

A blockchain is a digitally public ledger system that monitors the process of recording transactions and locating assets. Originally designed in 1991, the system was intended to timestamp digital documents, preventing them from being mutated or backdated. This system concept did not see much use until the creation of Bitcoin in 2009 and since has seen continuous implementation in cryptocurrencies. It has not been until recent years that the technology's potential is now receiving recognition for its potential in multiple industries of the world [1,11, 12, 13]. Some of the core principles of blockchain technology are decentralization, consensus, and transparency. These principles are what make some of the characteristics of most current blockchains possible. These systems can provide transparent information to anyone who is a part of the network at any time.

The framework of a blockchain is simple in design and powerful in practice, making usability ideal for anyone who seeks interest in information management. Each transaction that occurs when using a blockchain system is recorded as a block of information, this information can range from anything that applies to the needs of the user or organization. Anything from medical

records, quality reports, employee personal information, and financial transactions can be stored within a block. This block is added to the chain of existing blocks which are stored in chronological order enabling the verification of the time and sequence of each transaction [16].

Once added to the blockchain, the block is immutable due to each of the blocks containing the hash, or fingerprint, of themselves as well as the hash of the previous block. This prevents the ability to change the information stored on the block. If there is an attempt to mutate the block, the hash of that block would change, making all succeeding blocks invalid. In addition to this, blockchains operate on a process known as “proof of work.” As computers and other computational systems are able to produce hashes at extraordinary rates, typical blockchain networks, such as Bitcoin, use this mechanism to slow the creation of an individual block to approximately ten minutes [10]. Again, if there is an attempt to change the information of a block, all blocks that succeed would have to execute the proof of work process in order to become valid once again. This process, as you could imagine, could take an infinite amount of time depending on the size of a blockchain network, effectively making the information more secure the larger the blockchain gets. Blockchains are known as peer-to-peer networks where everyone who is a part of the network has access to the entire blockchain and receives updates to the blockchain once each entity verifies new blocks, thus reaching a consensus on data accuracy.

1.2. Types of Blockchains

Similar to other information management systems and web-based networks, blockchain technology possesses the capabilities of privacy and limitations to members. Despite early security issues during the birth of popular blockchains that question the true protection of information stored on these networks, there are various methods that can regulate the accessibility of the information stored on these information systems [9].

Public

Public blockchains are open and visible to the entire public however, no single entity holds ownership to any of the ledgers within the system. Security is maintained with the consensus method of approving blocks that wish to be added to the blockchain via internet-connected computers that validate incoming transactions (proof of work/cryptocurrency mining) [18]. These networks allow for any participant to keep their identity anonymous to maintain privacy amongst the large user body. Challenges that public blockchains face are the need for large computational resources to maintain the network at such large scales and high user traffic [16, 19].

Private

Private blockchains run on a permissioned, peer-to-peer network and are only accessible by approved members and maintain privileges that can only be accessed by select

members which can be performed with smart contracts (see 1.3.) [18] . Private networks use a unique process known as “selective endorsement” to achieve consensus in which certified users can verify transaction requests [16]. This task may be performed by an individual or team of individuals since the organization may not experience such high user traffic as public networks. As imagined, in order for users to have this capability the network will require more user information and less anonymity. Businesses that intend to utilize this type of network would need to send invitations to participants and could assign them privileges depending on the intricacy of the network. This allows for stronger trust within the system and could thus improve work efficiency and confidence among team members [18].

Permissioned

Permissioned blockchains operate similar to private networks however, do not need to be fully private as public networks are also able to use the features that come with permissioned blockchain networks. Permissioned networks are set up by providing users with certificates that assign privileges and access restraints [18]. They do not use consensus among the users to approve transactions, rather an agreement protocol is used to maintain a shared network of truth [10]. Restrictions can be placed on who has access to the networks and the privileges they have for managing the information stored on the network.

Consortium

Consortium blockchain networks operate similar to a permissioned network by allowing select organizations to be a part of the network. Managers of the network can set responsibilities amongst larger groups, making it ideal for businesses that depend on the information management systems of other organizations [16].

1.3. Smart Contracts

Smart contracts are customized programs that are executed when specified preconditions are met [4, 15]. These conditions can be created by the organization as a form of added security to the preexisting blockchain network to verify a variety of conditions. This excludes the need for any intermediate bodies to check qualifications for any user requesting access to features of a blockchain network, thus speeding up the process for transactions.

1.4. Pillars of Blockchain Technology

The framework of blockchain technology differs from all current forms of information management systems. Whether creating applications, decentralized ledgers, or peer-to-peer

networks, there is a common set of pillars that can be observed. These pillars are traceability, trust, and efficiency.

Traceability

One of the most important elements of supply chain management is the ability to accurately track products from their origin to their final destination with the customer. Blockchain technology has the ability to share real-time information about products including location and the status of the product between all the locations and organizations the product reaches along the way [3]. Whether it be the shipping of groceries across the country or international spices being transported to a local business, the ability to digitally stamp all transactions allows for the best visibility and traceability within the supply chain industry [10].

Efficiency

When comparing the efficiency of all current information management systems, none can compete with the level of efficiency that blockchain networks hold. With the level of traceability, blockchain technology eliminates the need for physical documents to be signed or transferred at the various stages of the supply chain process and instead replaces it with digital smart contracts. This enables automated transactions that will update all relevant parties in order to reach an agreement [8]. In addition, there will be less information prone to human input error and most importantly, loss of information. Overall, fewer parties are needed to verify the transactions between others and there is no longer a need to reconcile with multiple ledgers [2].

Security

The security of Blockchain technology is quite different from traditional information management systems. As mentioned, consensus on information accuracy is required from all of the network members in order for a new block to be added to the chain. For added security, not even system administrators have the ability to change information that is stored on the blockchain as all transactions are immutable, permanently preserving the information stored on the network [18]. This record-keeping system of blockchain networks will thus help reduce counterfeited products from entering transportation at the various stops of the material flow [8]. Consumers will in turn have greater trust with the network, their products, as well as the various intermediary bodies each business will encounter.

2. Critical Problems With Modern Supply Chain Management Frameworks

2.1. Supply Chain Management

Supply chain management can be described as the process of storing, transporting, and delivering products from their origin as raw materials to their final destination of consumers after being manufactured [8]. The Council of Supply Chain Management Professionals also extends supply chain management to the coordination of multiple businesses simultaneously with corresponding business processes [3]. This can be achieved by following three basic flows as described by Sadiq Aliyu, et al. ‘material flow’, ‘information flow’, and ‘money flow’ [17]. Material flow describes the process of creating and transporting products for the business and information flow involves the communication between all points of contact throughout the material flow. This information could include the verification of products arriving at a certain location, the verification documents for orders, or meetings that occur to plan future management ventures.

The goal of supply chain management as described by Kabossa A.B. Msimangira is for members within an organization to work together and build a partnership with each other to increase the competitive advantage of the supply chain as a whole [7]. It is vital that collaboration and communication are encouraged throughout the management style of the business in order to maintain proper trust and efficiency. This is a vital role within all organizations and is one that has continuous studies for improvements in efficiency and accuracy.

2.2. Problems

Ironically, one of the main issues with the majority of supply chain information systems used today is poor end-to-end transparency, leading to sub-par efficiencies for businesses [3]. This can be further divided into several issues which range from human input errors, processing delays, delayed updates to shared data due to poorly maintained information management systems, security trust with intermediary parties, inaccuracy with product tracking and tracing, and transportation speeds [17]. Essentially, all areas that compose supply chain management systems struggle to meet the desired operating standards. This area of business is one that should be a priority and growing concern as the demand for products has increased with the recent popularity of delivery and other contactless services. In addition, with the tremendous increase of e-commerce models over the COVID-19 pandemic, businesses are forced to change their supply chain networks to better handle the growing user traffic, all of which need a new dynamic approach to supply chain models [7]. Similar to the information management models of other industries, there is no center-cut way to operate within the supply chain industry, however, it is crucial to mitigate problems that could arise in all areas to ensure efficiency within each business.

A recent study by Kabbossa A.B. Msimangira and Sitalakshmi Venkatraman titled “Supply Chain Management Integration: Critical Problems and Solutions,” explores the general practices of supply chain management integration and the various problems that industry professionals address within New Zealand [7]. The study consisted of fourteen subjects that were full-time employees within the supply chain management industry and additionally studied supply chain management in a graduate program at the Open Polytechnic of New Zealand. Out of all the responses, the research team found four critical problems that these subjects have encountered while working in the industry [7]. Out of these four, three relate to the current discussion of blockchain technology and supply chain management integration and were listed as follows:

- (i) **Communication Breakdown:**
Subjects within the study reported a large issue with communication from all members of their organization. This ranged from lack of reporting and visibility on the flow of products, quality reports, training on the current information system used for supply chain management, and management decisions from higher authority figures.
- (ii) **Lack of Efficiency:**
The majority of supply chain management systems do not provide fast and accurate information to persons during the material flow of goods. Often, parties have difficulty managing incoming orders and current inventory as the supply chain network does not reflect the current status of products accurately, leading to input errors on logistics and miscommunication between involved organizations.
- (iii) **Lack of Trust:**
Current supply chain networks do not have frameworks that support visibility among all involved parties. Critical information is often withheld from individuals within supply chain management teams and leads to poor communication with intermediary parties. In addition to this, trust is diminished throughout the management hierarchy which is reflected in the work ethic of team members.

A full table of problems within supply chain management integration was made by this research team with additional problems related to supply chain management and blockchain technology integration (Table 1).

2.3. Solutions

In order to improve the communication breakdown, lack of efficiency, and lack of trust identified by Msimangira and Venkatraman, three critical solutions were found by the team based on their studies, two of which relate to the capabilities of blockchain integration with supply chain information systems [7].

(i) Communication Improvements:

There is a prevalent need for more communication throughout the supply chain information system in order for all parties involved in the material flow of goods to provide accurate information on their end. In addition to this, all members of the organization should be properly trained with the systems used for information management and turn towards a more universal network that works best for collaboration among organizations.

(ii) Visibility & Honesty:

Organizations need to provide more visibility within the hierarchy of roles, allowing complete visibility of information within the information management system. Trust must be present in both the information system and amongst team members in order to maximize work efficiency.

Organizations should be taking the necessary risks and choosing to innovate before being overtaken by other competitors in the industry. There should be constant research and analytics for supply chain management teams in an attempt to balance all problems unique to each organization. This includes researching emerging supply chain management software and hardware as well as conducting cost/benefit analysis for a possible change in management methods [7]. A detailed table for solutions to the current problems created by Msimangira and Venkatraman was also made that includes additional solutions that share relevance to the topic of blockchain technology and information management systems (Table 2).

3. Systematic Literature Review

3.1. Research Methodology & Data Collection

This study explores the current state of supply chain management and how the innovations of blockchain technology can have a profound impact on supply chain management integrations. Some of the main research questions were as follows:

Research Questions

- (i) What are the current problems faced within the supply chain management industry?
- (ii) What components of blockchain technology provide an edge over traditional information management systems?
- (iii) Which organizations are currently using or planning to integrate blockchain networks for supply chain management frameworks?

When conducting research for this report I first began collecting articles from news outlets and formal case studies. I then would read and annotate each article to note information and data that

would best support my report. The only search engines that I considered for data retrieval were Google and Google Scholar. Keywords that were used during my research were “blockchain technology”, “supply chain management”, “blockchain integration with supply chain management”, and “IBM Blockchain.” The references of other research reports tended to have very specific articles that also related to my research topics, therefore I explored these articles and reports in order to obtain very specific information for the different sections of my report. When filtering through my search results, I only considered reports from 2016 and beyond in an attempt to provide current blockchain technology data as the industry is a rapidly growing one with innovations and popularity occurring at a similar pace. My research accumulated a total of 22 references ranging from scholarly articles, news outlets, and a collection of IBM Blockchain documentation. Several reports detail the components of blockchain technology and its features as well as the current status of supply chain information systems.

3.2. Limitations

During the initial research period, I did not foresee any possible limitations to gathering information for my report and presumed this to be the same throughout the duration of my research. I encountered my first limitation shortly after this when meeting with an originally proposed case study. I am a member of Blockchain at UCI, an on campus club that hosts events, workshops, and guest speakers with leading industry professionals to grasp a larger understanding of blockchain technology and Web 3.0. One event that was scheduled was a guest presentation by the CEO of RIOT Blockchain, Jason Les. I conducted research on Jason Les and the organization prior to the event and later attended the event with research questions that were designed for a case study on his company. About half way through this event I realized that the information Jason proved through the event pertained more to the hardware the company used and how the company came to be where it is today. This worried me as I started to believe this organization may not be one that provides relevant information to my research. After the event I was able to speak with Jason and asked some of my questions which centered around the industries that blockchain technology could benefit from the most. The majority of his responses were in fact not as beneficial as I had envisioned with most of his responses beginning with “I haven’t been looking too much at...” and “I’ve been meaning to catch up on that area...”. After the event I realized I would indeed need to scratch this company as a possible case study and began looking towards other organizations.

Another limitation came while attempting to reach out with a member from The Home Depot for my originally planned second case study. After finding success with IBM Blockchain as a case study and their recently successful Food Trust, I noticed articles that talked about other companies that used their blockchain network for their supply chain systems as well, one of which was The Home Depot. This stood out to me because they had a featured article published on IBM which positively reviewed their experience with IBM Blockchain and its integration

with their supply chain practices [20]. The article, however, was rather short, coming in at only a five minute read. I decided to reach out to the Senior Director of Financial Operations at The Home Depot, Dave Richa. Dave was the representative that IBM used for the majority of the article therefore I decided to write a relatively short list of questions to obtain more information and data on how specifically IBM's Blockchain network helped The Home Depot. I messaged Dave via LinkedIn but unfortunately never received a response. With little informational articles published on The Home Depot's integration with IBM Blockchain I decided that I would also have to scratch this company as a possible case study and instead place all of my focus on IBM Food Trust.

Overall, reaching out to organizations seemed to be the largest limitation to the research process of my report. I am interested in how I could have more success with producing my own research and developing better strategies for contacting representatives of well established organizations.

4. Case Study

4.1. IBM Food Trust

With IBM first beginning research and development on a blockchain network of their own in 2014, IBM Food Trust blockchain cloud service successfully saw its introduction into the supply chain industry in August of 2017 with the aim of providing better tracking and tracing of food supply chain data [22]. Some of the main areas of improvement with the integration of this supply chain system described by IBM are supply chain efficiency, brand trust, food safety, sustainability, food freshness, food fraud, and food waste [21]. They addressed that consumers are becoming more concerned with the products they purchase, especially when it comes to food. A growing interest in product origin, production sustainability, and labor practices have motivated the IBM Blockchain business team to provide this transparency to their consumers, retailers, manufacturers, and suppliers [21]. In turn, greater brand trust is earned from the consumers providing a competitive advantage against other market competitors.

Further motivation to improve the supply chain practices for the IBM Blockchain business team includes growing regulations for advanced practices and technological innovations for ensuring food safety as expenditures on product damage and waste management have increased due to the outdated forms of food tracing in the current industry. It is estimated that a third of fresh food is thrown away globally due to consumers being uncertain about the quality of their food products [21]. The IBM Blockchain business team believes technology, such as theirs could help reduce this problem and in turn cut down food loss by a whopping \$120 billion each year [21]. Having full transparency with the blockchain network will allow all contributors of the production process to report and eliminate food that does not meet industry standards. This means fewer consumer worries and safety concerns.

Having this information in their possession, IBM Food Trust strives to provide better protection from both natural expirations of food products and potential fraud that occurs within the industry. Fresh food and other quality concerns have always been at the forefront of supplier concerns but with the recent COVID-19 pandemic, shelf life maintenance has grown substantially as more than half of current consumers have expressed their worries about the freshness of food within physical grocery stores [21]. Current methods of supply chain management are responsible for fresh produce spending half of its time in transportation to the location of the retailer [21]. IBM Food Trust aims to reduce the confusion and invisibility that arises during this process with digital stamp tracking, environment monitoring, and instantaneous transactional recording. Thus maximizing the shelf life of all products and eliminating the large quantities of wasted food each year.

4.1.1. Food Trust Demo

I was able to access a demo of the Food Trust and view sample orders that display both the destinations of all the ingredients that are involved in the production of a single good as well as relevant documents that were obtained throughout the material flow of goods. The dashboard overall has the capability to receive all product information as well as monitor any real-time human input errors.

One feature found to be very impressive was the location and ingredients timeline. From the dashboard, users have the ability to search for products within their supply chain with filter fields such as a 14 digit GS-1 Global Trade Item Number (GTIN), a 12 digit or 8 digit Universal Product Code (UPC), or a custom IBM Food Trust product ID. Further search fields include lot, serial, or pallet numbers. Upon finding a product, users are able to view how long each ingredient remained at certain locations throughout the manufacturing process (Figure 1). The level of traceability with this state-of-the-art system is immensely in-depth as a simple whole-grain margherita pizza has ingredient information traced from its origin in farms on October 5, 2021, until it reached the shelves of its final retailer on November 13, 2021. All ingredients can be traced to their origin with accurate dates. Pure olive oil from a farm in Greece, tomato purée from a distributor located in Spain, and organic mozzarella cheese from a distribution center in Italy that used organic whole milk from a local farm that can be confirmed at that location from October 5, 2021, to October 16, 2021.

Documentation also takes advantage of the blockchain network and allows documents of a wide variety to be digitally saved on the document library (Figure 2). Food Trust provides users with multiple input fields to accurately label documents and ensures that each document cannot be tampered with. Notable fields that can provide greater visibility to the supply chain include sharing permissions that allow users to select organizations they feel can have access to the documents. Implementing the characteristics of consortium networks, relevant organizations

have the authorization to view product information and provide their facilities with the necessary documentation, ensuring everyone is on the same page at the same time. Similar to the dashboard of the location and ingredient timeline, the documents library allows users to search for anything within the ledger with filters such as document category, type, and which organizations have access to it. Once found, users have several options to manage these records such as report documents with expired certification or that conflict with other operations as well as share documentation with other organizations or the end consumers of the product, providing the best visibility experience.

Features that are also included in the IBM Food Trust system but were not available to view through the demo were the consumer application which provides similar functionality of the location and ingredient timeline as well as insights into the current inventory and how to maximize product life. The IBM Food Trust blockchain supply chain management system appears to be far ahead of its time and certainly provides the necessary features to revolutionize the supply chain industry. It certainly does its part to solve some of the major problems found within supply chain management integration and appears to have full support in continuing to reach more industries.

5. Blockchain Integration With Supply Chain Management

5.1. Analysis

The analysis for this report will primarily view the data collected through the lens of an organization as an organism as the benefits of blockchain integration seek the best interest of all needs of the organization.

One of the primary needs of any organization is that individuals operate most effectively only when their needs are satisfied [5]. Two critical problems found within current supply chain practices as mentioned earlier in the report were a communication breakdown amongst members of the organization as well as a lack of trust due to poor visibility in systems. Furthermore, current supply chain management softwares struggle to meet operating standards that are needed to thrive in the supply chain industry. Poor communication, end to end visibility, system efficiencies, and trust amongst parties call for change and the need to innovate to systems that will provide higher satisfaction for organizations and consumers. It is possible to achieve both personal growth among employees as well as maintain organizational aims and objectives if their jobs and interpersonal relationships are redesigned [5]. The solutions discussed within the report can do just that. Organizations within this industry should be providing more visibility in their information systems to all users, especially to better fix hierarchy problems that are prevalent in the industry. Trust amongst all employees and intermediary parties will be achieved through a network that centers its design on traceability and visibility. Providing all users with more

visibility of required products in transport or inventory allows them to feel more useful to the organization and incentivizes them to get more involved with their work.

Blockchain networks have the capability to solve the major problems that the supply chain industry faces and provide multiple approaches to security that were previously unseen in similar systems. Companies have the flexibility to choose their structure of network to fit the needs and interest of their employees whether public, private, permissioned, or consortium. These networks should be acknowledged as open-systems that allow for maximum visibility to all members and the entirety of its environment. Its homeostatic approach to self-security should also be recognized as a key factor that makes this type of information system so revolutionary to the industry. Companies that integrate blockchain technology into their supply chain management practices could divert former security expenditures to other areas of the organization that are in need of maintenance or attention. Blockchain based networks provide a higher level of ownership of products with the insights provided from the revolutionized ability to see and track all stages and locations of products instead of awaiting the arrival of the product to obtain this status. Great beneficial change lies ahead for the majority of organizations that adopt similar networks discussed within the IBM case study. With the enhancements provided through the networks, ecommerce models can excel tremendously and share the benefits of the network with its consumers for better order tracking, customer service, and usability of software.

Attention needs to be focused on the employees of these organizations and making them feel more useful with the integration of this technology. Providing better visibility, efficiency, and trust with the organization will make employees feel more useful and important to the company, thus improving their own efficiency. Blockchain based supply chain systems do indeed have the power to provide employee-centered design by choosing the appropriate network as described earlier. In addition, with collaboration being so much more practical with these types of distributed systems, a dual focus can be achieved and allow the network to be recognized as a “sociotechnical system” [5]. Further alignments can be made between intermediary suppliers and the universal design can lead to more innovation amongst parties to systems that reach far further than the ones described in this report. Alignments have already been made and can be observed within the supply chain industry with numerous organizations adopting the blockchain network established by IBM, more notable ones being Walmart, Sam's Club, and The Home Depot [6, 20].

5.2. Findings

It is important to see that companies need not to develop their own blockchain networks in house but rather can consult larger organizations such as IBM for blockchains run on their network. This universal design can further help companies collaborate with more suppliers and maintain communication with representatives and visibility with their products. Equally, organizations that

seek to implement this technology must consider its early stage of implementation and provide the best transition experience for employees and collaborators. Blockchain technology is one that is still in its infancy and may raise doubt to the majority of organizations within the industry which is why single use independent applications should serve as recommended introduction to the system where there are no intermediate parties or software systems involved. This will provide organization members with the opportunity to recognize value within themselves as well as establish a stronger relationship between themselves and their work environment. Acceptance is key with this technology integration and the right approach can provide monumental approval from industry leaders. With proper integration strategies conducted successfully, organization leaders could begin moving toward more envionsion implementations of supply chain management systems. They can then motivate their employees through higher level needs pertaining to the system, creating involvement increase and job commitment without the need of increasing pay or providing other financial incentives.

More interesting than the integration of these systems into the current supply chain industry is the possibility of blockchain based information management systems leading to entirely separate and innovative systems throughout the future. Technology such as this holds strong potential in system evolution as blockchain integration is continually finding new ventures for integration [14]. The environment that the supply chain management operates in is one of the most diverse of any industry. Product supply management spans all areas of physical goods as well as digital assets. Supply chain management systems constructed with blockchain networks possess the best design for new opportunities posed by the environment and thus provide for extravagant innovation. Expenditure of the already unique data ownership that blockchain networks provide could be the center of new information structures and provide benefits to the consumer side more than the organizational side discussed in this report. Of course, endeavors such as this would require extensive research to ensure the pillars discussed in this report are maintained and further improved. It is vital that approaches to this innovation consider the recognized benefits and how to balance the success factors with the challenges brought aboard.

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Appendix

A.1. Data Collection

Table 1 “Major SCM integration problems identified in the Forum” [7]

Nature of problem	Percentage of participant comments on the problem
Insufficient training and competency levels required to maintain existing supply chain (SC) operations and to support implementation of new technologies and increase efficiency	50
Poor communication between SC members, especially primary members	40
Some members in the supply chain are dominant in the business relationship. Lack of trust, communication is limited or formal, and information sharing becomes secretive. This leads to quality problems	40
Lack of internal cost efficiency and speed of delivery in the following areas: ordering, inventory, marketing, and logistics	40
Inadequate distribution channel design and structure i.e., balance of power in contractual relations	30
Lack of a strong organisational culture committed to SCMI	30
SC channel members view themselves as a collection of individual companies, not as a holistic system	20
The supply chain decision makers are usually not near the action i.e. the sales arena. Decisions are based on inaccurate information	20
Supply chain process implementation is often hindered by technology overshadowing the human resource and change management aspect	20
Trade barriers between countries and government policies	20
SC channel members do not share the same business values	20
Company's suppliers serve their competitors and secret information could be revealed to the wrong party	20
The flow of data between businesses is often insufficient or recorded on incompatible databases	10
It is hard to have total control over the third party service provider's actions	10
Poor internal communication of company's objectives cause communication breakdown: lack of effectiveness	10
SC channel members fail to realize their contribution to customer satisfaction	10
Inadequate technology and lack of an integrated logistics System to support infrastructure requirements and inter-channel commitments	10
Under resourced (funding, technology, and personnel)	10

Table 2 “Major SCM integration solutions identified in the Forum” [7]

Nature of solution	Percentage of participant proposing this solution
Two-way communication is needed, and everyone involved in the SCMI must be aware of the structure and processes involved in the SC. Information sharing is important	60
Integrating key members' interactions of the supply chain requires a holistic approach and adoption from top executives to shop floor members for efficient and effective change	40
Form strategic alliances with SC members, and foster an open and honest culture	30
Members in the SC would benefit from integrating SCM software systems, using compatible operating systems and hardware	20
There is a need to have integrated SCM processes, taking into account their impact on the operations of an organisation	20
There is a need to constantly monitor new technologies and software solutions, and conduct the cost/benefit analysis for SC. The cost of change management must be examined	20
There is a need to establish written service level agreements for third party suppliers, and review them on quarterly basis. Also, monthly client surveys must be carried out to monitor their level of professionalism and efficiency	10
Relationship management is required to reinforce written service level agreements and company's strategy	10
Form strategic alliances where all SC parties can reap the benefits	10
Develop standards and responsibilities for each SC member, have regular meetings, discuss problems and opportunities, and encourage two-way communication	10
Define clear lines of responsibility and performance expectations in the SC	10
Emphasise on relationship management, performance measurement, control of processes, and continuous improvement	10
An organisation must be innovative	10

Figure 1 IBM Food Trust Supply chain view: Location and ingredient timeline

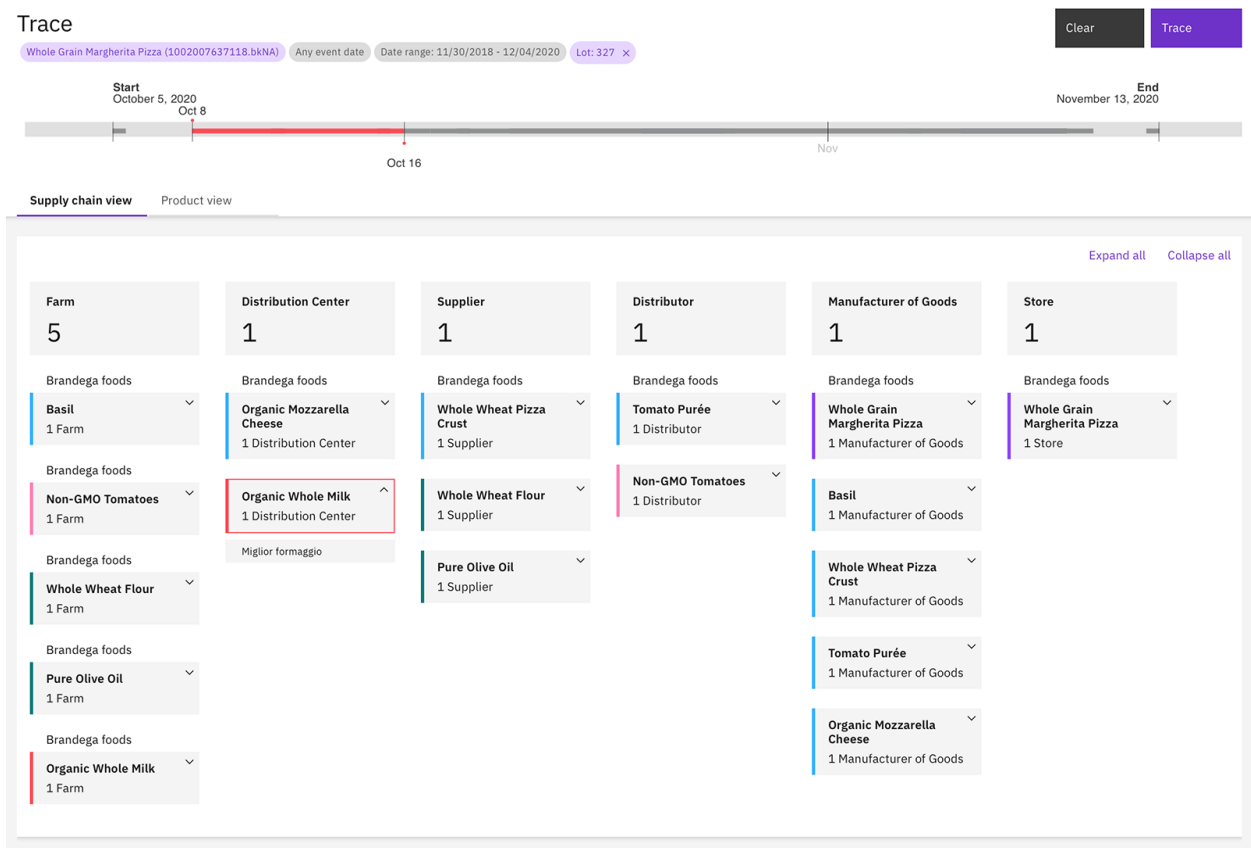


Figure 2 IBM Food Trust Documents library

Document library

Docs: Manage documents

Document category

All

Document type

First select a category

Owning organization

All

Facility

Enter facility name

Expiration from

mm/dd/yyyy

to

mm/dd/yyyy

Product

Enter product name

Lot

First select a product

Clear

Find

Upload a document

Owning organization	Document type	Document title	Focus	Last updated	Expiration date	
Eastside Markets	GLOBALG.A.P. Certificate	Floral Gardens GlobalG.A.P. Integrated Farm Assurance Scheme	ID: 7055812837404.growe0_323e8524	12/02/2020	10/01/2021	:
Eastside Markets	SQF	Westside 1 SQF Level 2 Certificate	ID: 8029177006457.retai2_a9f0a712	12/02/2020	11/05/2021	:
Eastside Markets	BRC Global Standard	Eastside 1 BRC Certificate	ID: 8029177006457.retai2_323e8524	12/02/2020	11/20/2021	:
Eastside Markets	SQF	Westside 1 SQF Level 2 Certificate	ID: 8029177006457.retai2_a9f0a712	12/02/2020	11/04/2020	:
Eastside Markets	BRC Global Standard	Westside 1 BRC Certificate	ID: 8029177006457.retai2_a9f0a712	12/02/2020	05/14/2021	:
Eastside Markets	SQF	Westside 2 SQF Level 2 Certificate	ID: 8029177006457.retai3_a9f0a712	12/02/2020	12/12/2020	:
Eastside Markets	BRC Global Standard	Westside 2 BRC Certificate	ID: 8029177006457.retai3_a9f0a712	12/02/2020	08/17/2020	:
Brandega foods	SQF	Miglior Formaggio SQF Level 2	Miglior formaggio	12/02/2020	09/10/2021	:
Brandega foods	Generic Certificate	Miglior formaggio Organic Certificate	Miglior formaggio	12/02/2020	04/28/2021	:
Brandega foods	SQF	Brandega Food Pizza SQF Level 2	Brandega Food Pizza	12/02/2020	07/08/2021	:

Items per page: 10

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