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Food Safety Solution Using Block Chain Technology

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FOOD SAFETY SOLUTION USING BLOCK CHAIN TECHNOLOGY

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ABSTRACT

Block chain technology is a modern technology that is digital based and has a provision for storage of information of products that cannot later be hacked neither manipulated. Block chain technology is a technology that looks forward to bringing transformational features that will impact food industries. From the year 2009 when block chain technology was founded, its applications have had a wide range of applications including the food industry. It is clear from its description that this technology will impact and transform the entire food sector by enhancing safety. The ability of block chain technology to hold and provide information on food products will enable consumer protection from harmful food products that may result in foodborne illnesses. There have been increased cases of food insecurity as a result of a lack of awareness of information about the food being consumed. This paper will consider using block chain technology as a tool for food safety. This can be effectively achieved with the help of a quick response code. Implementation of QR code on block chain technology will make it possible to track information about food products throughout their life, thereby, providing relevant and necessary information on food products before they are consumed. This will make it highly effective in using block chain technology to improve food safety levels globally.

Key words: Block chain technology, Food safety, Food Technology, QR code.

1.0.Introduction

Food safety is the condition of processing, managing and storing food in hygienic ways, in order to prevent illnesses from occurring to human population. Food safety and quality assurance have become increasingly difficult in times of growing global flows of goods. Food safety is the act of handling and properly preparing food to prevent its contamination which will result in food poisoning. Food safety is guided by principles that aim at reducing the level of sickness by individuals from foodborne illnesses. From the past and present cases of food poisoning foodborne illnesses, there is a need for the implementation of block chain technology in providing food safety solutions. Block chain technology provides a virtual space for providing and sharing information to its users across their network.

Block chain technology has paved the way for its adoption in the food and beverage industry to enhance traceability. Traceability is the ability to determine the history of data and related food product movement before consumption.

Block chain technology makes the food industry more transparent, thus making a difference for the consumers. This technology has been reviewed by many food industry organizations such as Starbucks and by 2023; it will be fully adopted by global food industries. Through this technology, consumers will be able to get all the information they may need on the food before consumption. Blue chain technology will be able to avail of a lot of data related to tracking food illnesses to the consumers. Through this technology, the consumers will have information like date of vaccinations and use of antibiotics of the animals they are consuming their products. The data on food recorded and stored with the implementation of block chain technology cannot be altered and modified and thereby will be a perfect way of providing food safety to multiple consumers.

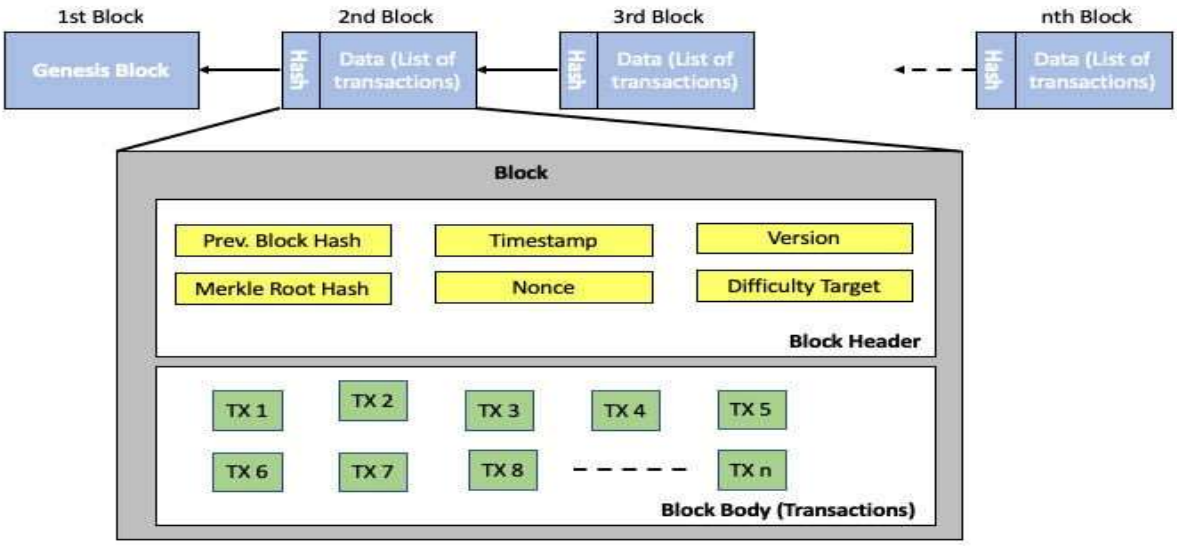


Figure 1: Example of a blockchain containing n blocks, in which each successive block contains the hash of the previous block, a timestamp, the transaction information, the nonce number for the mining process and other details needed for the protocol to work.

Implementation of block chain technology enables food industries to save lives from foodborne illnesses since the technology can provide information that consumer wants in seconds. For a case of outbreak of diseases relating to consumption of certain food products, for example, beef, block chain technology can be used as a lifesaver. The record in block chain management is kept permanently and can be over and over again to enhance high levels of food safety among the consumers. With time, there are emerging tools for food traceability which are block chain based that can be used to track information on most consumable food products such as milk and butter. The full implementation of this technology by global and national food industries will have a significant role in reducing the cases of food illnesses.

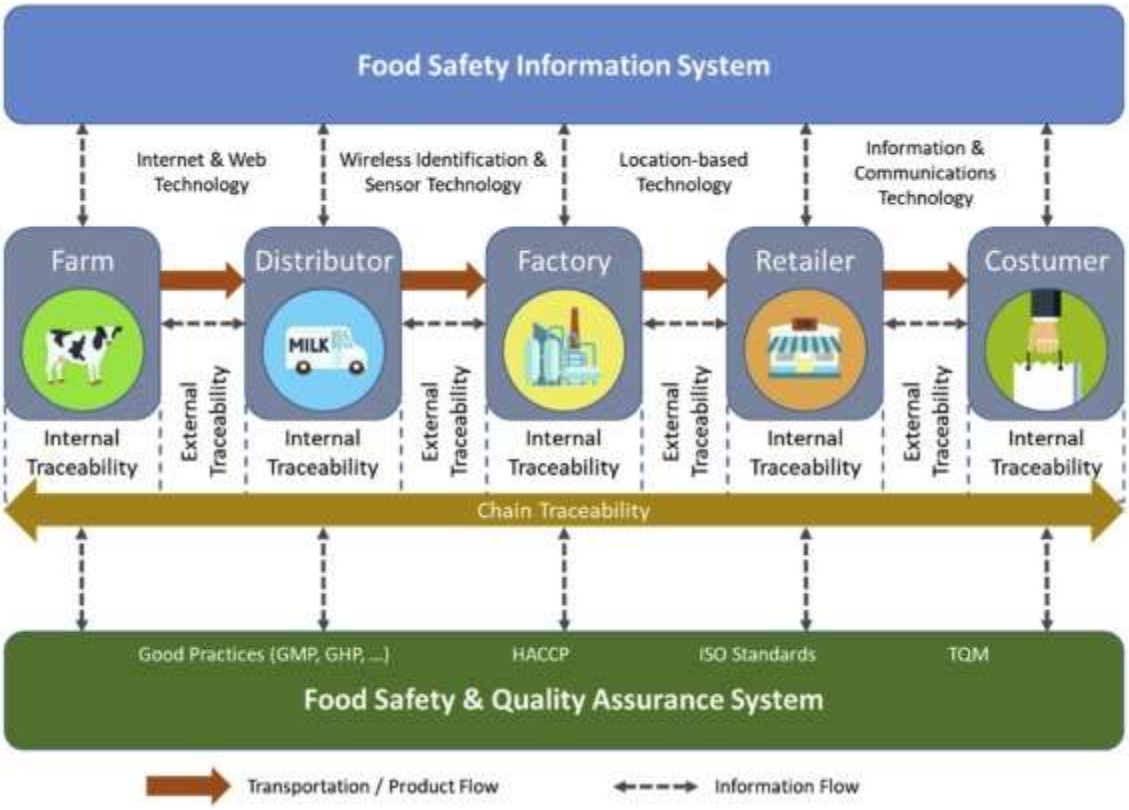


Figure 1: ***A diagram illustrating how block chain technology can be used to as a food safety information system.***

Block chain technology has been successfully implemented in agricultural, banking and health sectors in improving efficiency levels and transparency (Monrov, 2018). The other important field which need to have a significant benefit from this technology is food industry. Consumption of food is a day to day basis activity and therefore food safety is vital (Anna, 2015). Block chain technology when implemented in all the food industries will eradicate cases of foodborne diseases.

Block chain technology can be implemented in Agricultural and food supply chain process to capture all the necessary information based on the food. The information needed will keep the final consumers on the state of food products before consumption. Figure above indicates food information traceability with the help of block chain technology. There is a flow of relevant

information from different parties including distributor, factory, retailers and the final consumers. Block chain technology has the capability of informing the final consumers on the relevant information on food to keep them safe (Monica, 2019).

Figure above justifies the roles of different parties in improving food safety using block chain technology. Internal and external traceability is important in improving levels of foods safety. Block chain technology allows manufacturers to digitally connect and link up between the information described and the consumers. These details could include farm details, shipping details, processing duration and temperatures for storage.

2.0.Problem Statement

Block chain technology has been implemented in various fields such as Agriculture, Health, Banking and Education (Singh, 2018).

Block chain technology can as well be implemented in food industry as a tool for food safety. With the advanced levels of technology, it is important for various food industries to find ways of ensuring safety in the food products they are offering to consumers. Angela (2019), describes block chain technology to be a tool of improved operations across all the fields. Just like other sectors, block chain technology will bring huge impact in protecting the consumers against ill practices surrounding food.

Food poison cases have been in existence for the many years with the consumers having limited information about the food products they are consuming. A case of investigation done by the Pharmacy and Poisons Board (PPB) in Kenya in 2016 found out that many individuals suffer and even die from the foodborne illnesses. The PPB reported that 5% of the Mathare residents die from food poison in every six months. Diseases such as cholera and typhoid have become common both

in children and adults. These diseases are caused by consumption of ill food stuffs. It is therefore important to determine possible ways of eradicating and protecting the consumers. Implementation of block chain technology will be a solution to eradicate foodborne illnesses globally. Through this technology, consumers will be able to get all the information on the products before consumption. This paper will look forward to describe how block chain technology to provide food safety solution.

3.0.Objectives

The following objectives can be used to guide the study on the use of block chain technology as a tool for food safety

3.1 General objectives

Determination of food safety solution using block chain technology

3.2 Specific Objectives

The following specific objectives will be used to guide the study

i. To determine the extent to which use of QR code can be improve the efficiency of block chain technology in providing food safety solution.
ii. To investigate the significance of proprietary clustering algorithm in lock chain technology as a tool for food safety

4.0.Related work

Block chain technology is a revolutionized technology bringing impacts on different industries in terms of securing data from any form of copyright (Mohamedin, 2017). It is a data structure that retains data record for a long period as well as ensuring security, decentralization, and transparency of data and information. (Tschorsch and Scheuermann 2016). Block chain technology has been used by institutions of different sectors such as banking, health, and agriculture to secure and protect their data against redundancy (S. and Rosano, M., 2018). A case of China courts, block chain technology has been implemented to fight duplication of data for online writers as reported by Chinese news outlets.

This followed after the launch of the first internet court to address internet-related cases in Hangzhou, China (Kamath, R. 2018). According to Mathews (2018), block chain technology is regarded as one of the greatest opportunities for innovation and a perfect means of storing safeguarding data against loss and duplication. This technology has been used to protect government data against theft and duplication in different government ministries (Okech, 2015).

4.1 Background Study

During last year's SAP Innovation Day, held in Nairobi, I garnered lessons on how we can utilize technology to extricate our country from industrial muddle. From business intelligence powered by Big Data analytics to the use of augmented Artificial Intelligence (AI) algorithms that predict the future of business processes, the event quenched the thirst for knowledge of the participants. On expert, Mr. Timo Elliot, drew my attention when he accentuated how blockchain technology has been used in San Diego, California, to trace fish and yellowfin tuna from the time they are caught in the sea to the moment they hit store shelves. It then crossed my mind how this technology

can be used to cushion Kenyans against consuming meat laced with Sodium Metabisulfite (commonly sulphites), a chemical that makes it appear fresh for longer — as shown in an NTV exposé of industrial malpractice in the country. (Daily Nation Kenya, Wednesday October 2 2019)

The Ministry of Health has since directed all county public health departments to heighten surveillance in supermarkets, butcheries, meat processors and other food businesses. But more questions than solutions regarding the quality of safety controls within the country's food chain have arisen. The debate continues and no solution has been propounded. As the preconditions for the take-off of the Fourth Industrial Revolution stream into Africa, there has never been a better reason to use the data we have to create a better continent.

Beef, pork, goat, chicken, mutton, venison, fish and seafood must be fit for human consumption at any sales point, and the ugly claws of capitalism must be cut off from wiping out meat-loving populations. Meat is perishable, opening the industry to vulnerabilities of making gaffes that would, ultimately, affect human lives. When foodborne diseases threaten public health, the first step to root-cause analysis is to track down the source of contamination and there is no tolerance for uncertainty.

Food Supply Chain

The food chain worldwide is highly multi-actor based and distributed, with numerous different actors involved, such as farmers, shipping companies, wholesalers and retailers, distributors, and groceries.

The main phases characterizing a generic agri-food supply chain are described below:

1. *Production*: The production phase represents all agricultural activities implemented within the farm. The farmer uses raw and organic material (fertilizers, seeds, animal breeds and feeds) to grow crops and livestock. Throughout the year, depending on the cultivations and/or animal production cycle, we can have one or more harvest/yield.
2. *Processing*: This phase concerns the transformation, total or partial, of a primary product into one or more other secondary products. Subsequently a packaging phase is expected, where each package might be uniquely identified through a production batch code containing information such as the production day and the list of raw materials used.
3. *Distribution*: Once packaged and labeled, the product is released for the distribution phase. Depending on the product, delivery time might be set within a certain range and there might be a product storage step (Storage).
4. *Retailing*: At the end of the distribution, the products are delivered to retailers who perform the sale of the product (Retailers). The end-user of the chain will be the customer, who will purchase the product (Customer).
5. *Consumption*: The consumer is the end user of the chain, he/she buys the product and demands traceable information on quality standards, country origin, production methods, etc.

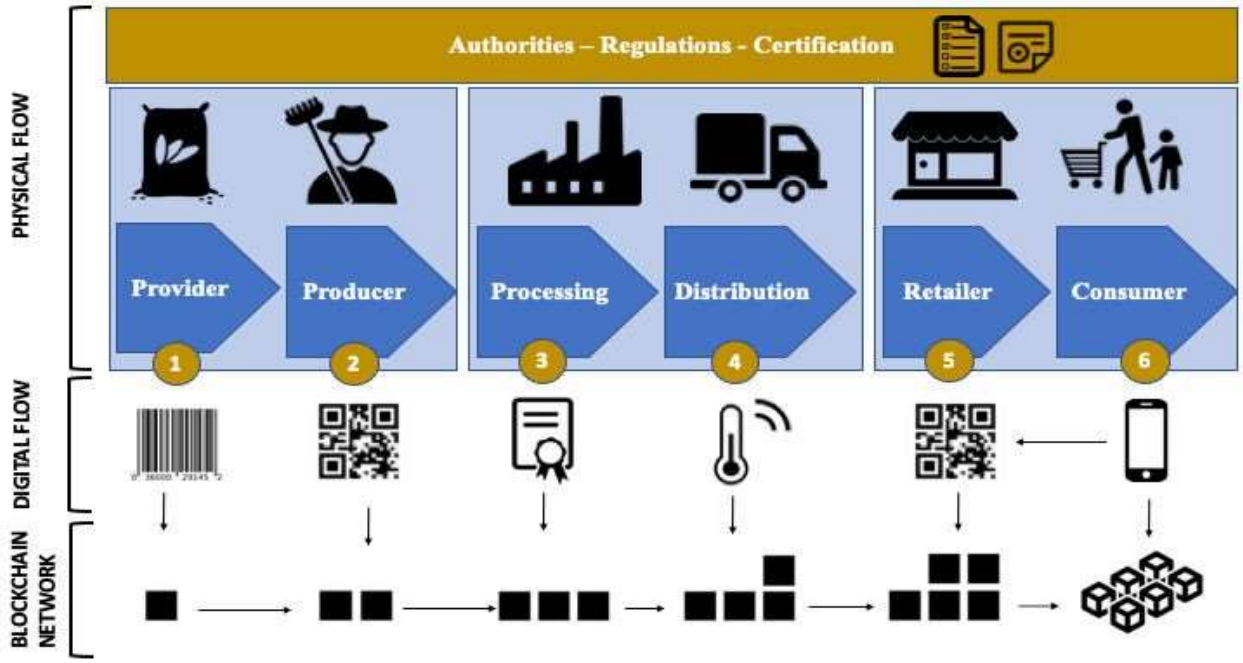


Figure 2 (top section, physical flow) illustrates a simplified version of the food supply system and its main phases and actors.

This current system is till date inefficient and unreliable (Tripoli and Schmidhuber 2018). Exchange of good are based on complex and paper-heavy settlement processes while these processes are not much transparent, with high risks between buyers and sellers during exchange of value. As transactions are vulnerable to fraud, intermediaries get involved, increasing the overall costs of the transfers (Lierow, Herzog and Oest 2017). It is estimated that the cost of operating supply chains makes up two thirds of the final cost of goods. Thus, there is much space for optimization of the supply chains, by effectively reducing the operating costs. Finally, when people buy products locally, they are not aware of the origins of these goods, or the environmental footprint of production.

4.2.2. Block-chain Technology in The Agricultural Sector

When compared to other technological applications, block chain technology is at its infancy stage and this hasn't hindered it from bringing impact to agricultural sector. Block chain technology has been considered highly relevant in addressing data and records transparency as well as food integrity (Thompson, 2018). Many different technologies have been applied in the agricultural sector to improve the levels of output. Block chain technology has been able to form part of the technological advancements that are channeled to improve the agricultural sectors. The use of block chain technology in the U.S and U.K in agricultural sectors has made it possible to assign and immutable and unique digital identifiers to food products and transactions making them easily traceable. This has made it possible for individuals to comply with food production and safety standards as well as environmental standards.

Block chain technology is a growing technology and is perceived to be of importance when it comes to processing claim systems in agricultural sectors. Block chain technology is a digital aspect that is increasingly used to easily facilitate management of firm records at national levels to minimize cases of data redundancy. Management of a large number of farms requires block chain technology to facilitate the sharing of on-farm data to enhance data driven technologies and generation of smart farms. Block chain technology has not only become relevant in agriculture alone but also food supply chain management (Green, 2016). A lot of information about providers of the crops, machinery, fertilizers, pesticides, etc. are often recorded to the block chain for easy facilitation of agricultural processes.

4.2.3. Block Chain Technology in Food Safety

Food industries are looking forward to implementing block chain technology in their operations just like other business sectors (Mayor, 2018). Because of the advanced levels of technology, there is a need to adjust to the operations within the food industry. Enforcing food safety by various food industries is a significant factor in terms of caring for consumers. Several technologies might have been implemented to help in the determination of food safety but block chain technology stand out to be the best (Lolu, 2018). The use of block chain technology has progressively been implemented in the U.S and Canada in food industries to raise safety standards (Hyla, 2018). Properties of block chain technology such as provision for the reading of a QR code make it easy for access to all the information concerning the food products to be acquired by the consumers (Sharples, 2016). From the information obtained on the food animals, consumers can be satisfied that the food is indeed safe for consumption (S. and Rosano, M., 2018) Block chain does not only keep records of the food products lifetime but also displays all the information about the foodstuffs that products may need to purchase.

Block chain is the most preferred and reliable method of food safety since it can store a large amount of data based on the food products without any form of manipulations (Mike, 2016). Block chain technology can be used to enhance food safety by involving all the participants such as farmers, vendors, and consumers in getting access to the information on food. Multinational food industries such as Unilever, Carrefour, and Dole food have attempted to implement block chain technology to improve the safety levels of foods distributed to consumers. An example of implementation of block chain technology can be done to monitor seafood and the supply chain to the final consumers (Blommaert, 2013). The consumers can gather relevant information concerning the safety of seafood's before consumption. Block chain technology is most important

in exchanging information on the food value chain between food manufacturers and consumers right before consumption (Singh, 2019).

5.0.Proposed Methods

Implementation of block chain technology in the food industry to enhance food safety requires a quick response to consumers in terms of giving information. Considering a food industry that has a large number of consumers, the block chain technology must, therefore, be in a position to provide a quick response rate to the information being sought for. The use of quick response code will help in paving way for quick adoption of block chain technology in food safety. The use of quick response codes in block chain will enhance consumers' engagement and increase their value in terms of having the right information concerning the safety of food to be consumed. Future use of QR code in block chain technology will lead to improved levels of accessibility of detailed information such as date of vaccination of the animals, weight and breed types of the animals before they are consumed. Implementation of QR code on block chain technology will make it possible to track information on food products throughout their life, thereby, providing relevant and necessary information on food products before they are consumers. This will make it highly effective in using block chain technology to improve food safety levels globally.

5.1. Algorithm to be adopted

5.1.1. Proprietary Clustering algorithm

This paper will consider adopting proprietary clustering algorithm in determination of how block chain technology can be used as a tool for food safety. This algorithm enhances crypto intelligence that brings together vast arrays of all the indicators using proprietary clustering techniques. This algorithm also adopts advanced methods on statistics and all sorts of cyber crime threat models to

enable end users trace all the transactions with a lot of ease. Proprietary clustering algorithm will enable easy access of the required information on food safety by the consumers since it is very simple to use. All the information can be easily traced in the block chain technology since this algorithm has the capability of uncovering all the relationships and attributes of data. Block chain technology to be implemented in the food industry can easily implement proprietary clustering algorithm to enable users get informed on the food stuffs they are yet to consume.

Provided a set of observations of value of x ranging from X1., X2, X3……...Xn where each and every dimensional vector is an observation.

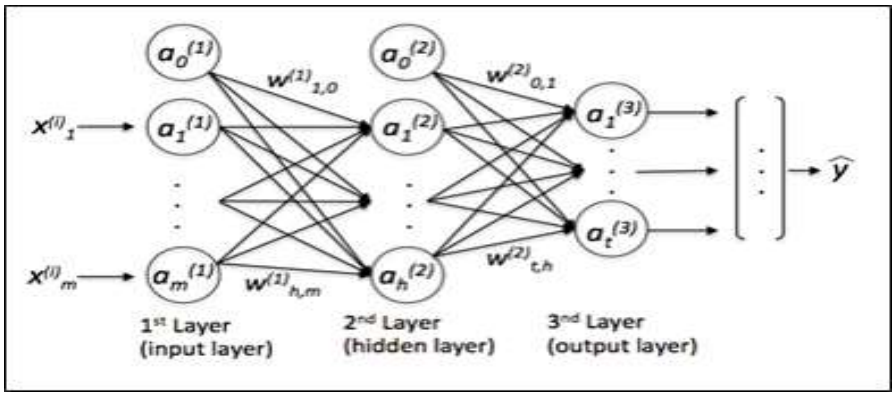
Clustering the observation into sets S= [S1, S2, S3,……..Sn], minimization of the variables within the cluster in this algorithm is described as follows

$\arg\min \sum \sum (X-\mu i)^2 = \arg\min [Si] \text{ Var } Si$

Where i=1 and $X \epsilon Si$.

where µi is the average of points in Si. This formula has an equivalent to the minimization of deviation of lying on the same cluster

All the information can be easily traced in the block chain technology since this algorithm has the capability of uncovering all the relationships and attributes of data. Block chain technology can easily have implemented through a proprietary clustering algorithm to enable users get informed on the real time.



Unlike the binary trees and solving functions of conventional algorithms, Rulex works the way the human brain works, using learned logic to make decisions.

Proprietary clustering algorithm in block chain technology is useful in data exploitation by various parties involved. When dealing with a large number of information on the block chain technology, there is a need for groupings where clustering algorithms can be used in determining natural grouping of information on the block chain. Clustering serves to be one of the best methods of pre-processing data to help in the identification of homogeneous groups within the block chain from which different models can be developed for supervision. Clusters can be computed based on distance or grid. a Distance based method uses distance matrices to end up determining the relationship and similarity on data items. Distance metric helps in the determination of the real and actual distances in prototypical scenarios for the cluster. In Grid based clustering, input space is put into division of hyper rectangular cells which forms clusters with the combination of adjacent high-density cells.

This algorithm is made up of four steps; the first step entails initialization process where each and every cluster is defined. The second stet involves classification where distance for each set of data is calculated where the minimum distance from the centroid gets to be assigned. The third step

entails determination of the centroid cluster which is again recalculated and finally, the convergence conditions are generated as described below.

Generic computation.

Provided a set of observations of value of x ranging from X1., X2, X3 …….Xn where each and every dimensional vector is an observation.

If (meat_type { A, B, C, D } AND data_issue in {1}

AND Number of days between registration course start and date of damages

<=371) THEN fraud=Yes

If (Department _Records in ({Category, H, J, K, J, I,})

THEN FRAUD=YES

IF (Number of days between records and alteration date policy end

<=2) THEN Fraud=Yes

Disclaimer!

Proprietary Clustering algorithm (*using sampled supermaket database*)

For migrating to Rulex and supporting the legacy, the above algorithm is useful for workloads. In department shop, where all records and connecting through a series of nodes. Any transaction or modification are notified to all members across transparency platform. (Singh, A. 2019).

Potential Benefits

Blockchain technology offers many benefits, as it can provide a secure, distributed way to perform transactions among different untrusted parties, (Creydt en Fischer 2019). This is a key element in agriculture and food supply chains, where numerous actors are involved from the raw production to the supermarket shelf (Tripoli and Schmidhuber 2018).

To improve traceability in value chains, a decentralized ledger helps to connect inputs, suppliers, producers, buyers, regulators that are far apart, who are under different programs, different rules (policies) and/or using different applications (Lee, et al. 2017). Via smart contracts, manufacturers can develop scalable and flexible businesses at a lower cost, and the overall effectiveness of manufacturing services can be improved (Li, et al. 2018).

Blockchain has the potential to monitor social and environmental responsibility, improve provenance information, facilitate mobile payments, credits and financing, decrease transaction fees, and facilitate real-time management of supply chain transactions in a secure and trustworthy way (Lee, et al. 2017).

In particular, blockchain seems very suitable to be used in the developing world. Cash transactions lack traceability, which ultimately hinders the ability of small- and medium-sized enterprises in developing countries, to access credit and new markets and to grow.

The blockchain introduces a new method of accounting for value transfers that minimizes uncertainty and disintermediates the exchange of value with a decentralized and shared ledger, functioning as a digital institution of trust, with reduced (if any) transaction costs (Tripoli and Schmidhuber 2018).

Although small farmers produce more than 80% of goods in developing countries, in most cases

they do not have support of services such as finance and insurance (Chinaka 2016).

Blockchain could also be used to fight corruption and the insufficient environmental, social and economic regulatory frameworks in these countries (Rejeb 2018). More examples on how blockchain could help empowering the poor in developing countries are listed in (Thomason, et al. 2018), with focus on tracking climate finance, results tracking, climate adaptation, financial inclusion, and identity.

Concerning the developed world, existing problems such as unfair pricing and the influence of big companies have historically limited the environmental/economic sustainability of smaller farms. Blockchain could help in a fairer pricing through the whole value chain.

Moreover, the potential transparency provided by blockchains could facilitate the development of trading systems that are based on reputation.

Further, there is the potential benefit of increasing consumer awareness and empowerment, considering that the consumer is the market driving force. Consumer increased awareness would put pressure for more transparent, sustainable, safe and fair practices in food production. Since consumers are overwhelmed by the amount and complexity of certification labels, blockchain technology seems to have positive influences on consumers' purchasing decisions (Sander, Semeijn and Mahr 2018).

Challenges and issues facing blockchain.

6.1 Regulation

As cryptocurrencies form the most complete to date global blockchain study case (Yli-Huumo, et al. 2016), the current experience of analyzing these cryptocurrencies indicates that they are vulnerable to speculators and their price has large fluctuations almost daily. The recent decline in

market share and high volatility of the financial value of the most popular cryptocurrencies reduces the overall trust of the public in the underlying blockchain technology of cryptocurrencies, thus having a negative psychological effect on its reputation (Gaurav 2019). Hence, without some form of regulation, cryptocurrencies are not trustful to be used yet in food supply chains as a complete solution. The absence of regulation makes this problem persistent.

A lack of (common) understanding among policy makers and technical experts still exists on how blockchain technology and transactions based on some currency should be used (ICT4Ag 2017).

6.2 Governance and Sustainability

Despite the rather long list of initiatives presented in this review, convincing business cases are still scarce, due to large number of uncertainties involved and the early stages of the technology. Hence, the long-term impact of blockchain on governance, economic sustainability, and on social aspects still needs to be assessed. Some authors have pointed out that an excess of information transparency and the immutability of the data stored in blockchains might bring new challenges for the performance of supply chains (Hald and Kinra 2019). On the one hand, permanent data visibility might compromise privacy issues and could eventually strengthen the surveillance power of centralized entities.

Conclusion

Block chain technology can protect the consumers from suffering food illness related diseases. Block chain technology will therefore be useful in providing all the related information on food products to the consumers before purchase. Block chain technology is accurate and having no provision for altering its data makes it even more accurate as a food safety tool.

There are several cases of food poison and related illnesses which have resulted in deaths both in Kenya and other African countries. It is therefore to determine a technological procedure of increasing food safety procedures.

The use of block chain will provide relevant information to the consumers before the purchase and consumption of food items. National and multinational food industries such as Unilever, Carrefour and Nestle are looking forward to implementing block chain technology as a tool for improving food safety. The use of quick response code will even improve the efficiency of enhancing food safety by block chain technology. It will enhance a provision for a quick search on information related to the type of food products to be consumed. This paper, therefore, highlights on how block chain technology can be used as a tool for food safety in food industries and by consumers as well.

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