

# Blockchain based Food Supply Chain

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**Abstract** - In the current scenario, food safety has drawn major social and commercial concerns. The poor performance of food supply including inefficient transaction, fraud, adulteration etc has lead to greater trust issues. Traceability is one of the key factors that promote trust which can be achieved by integrating the current system with blockchain. Blockchain is an emerging technology that allows transaction among distributed parties without the need of intermediaries. Being a distributed digital ledger technology, blockchain ensure transparency and security along with traceability. It creates and maintains tamper-proof database that can be accessed by all the entities in the network. The data is collected from sensors that are installed in the food packets which provide real time monitoring. Thus, blockchain keeps record of all the information at every instance.

**Key Words:** Blockchain, Smart contract, Food Supply Chain

## 1. INTRODUCTION

In the present scenario of COVID-19 pandemic, most of the places are under complete lockdown. COVID-19 is deadly infectious disease that can spread very rapidly. Thus limiting the movement of those with known infection exposure will avoid disease spread. As a result the manufacture, trade and transport industries are closed. So people will not have access to their necessary requirements. Food being the main necessity for humans, needs to be rapidly moved from one place to another from where it is being cooked or produced. The actual point of distribution can be somewhere far from where it needs to be distributed to. So it cannot be assured whether the food gets contaminated during travel. The food packet being traversed through each supply node leaves its quality undetected.

There are open kitchens all around the country to provide food for medical staff and for those in need. The food made in a remote place has to be transported to these respective locations. The probability of contamination is very high in this situation due to limited transportation facility and resources to validate quality. To solve this problem, we propose an automatic food monitoring system using blockchain technology. Blockchain makes use of smart contract which assures authentication at each transaction.

The food items produced are packed in separate boxes that are encapsulated with sensors to check various constraints. These sensors can detect gas evolution, temperature change, microbial growth etc. and the respective sensor values are automatically recorded. Food packets are carried from one location to another through various transactions. On each transaction, a data block is created with information about the packets including the nature, quality, location and ownership of the food item. Each transaction must meet the smart contract requirement which is the threshold sensor value to validate the exchange. Once the transaction is verified, the sensor value of the transaction is appended to its pre-existing data blocks thus forming a blockchain. The records are automatically updated whenever a change is made and the information is visible to all the entities in the network.

We will build a food supply chain traceability system for real time food tracing based on blockchain which aims to make sure that the quality of food product is kept steady from the production till the end.

## 2. LITERATURE REVIEW

The main drawbacks of existing food supply chain are lack of food safety, unavailability of Information about the origin, lack of transparency, traceability and controllability etc.

Madumidha, P. S *et al.* proposes a system which mainly focus on the traceability of the agricultural food supply chain in Tamilnadu in [1]. Various technologies like RFID, Blockchain, IoT, etc are used to make the system more reliable, secure and transparent. Smartcontract is used to ensure the quality without the need of a third party. The main advantage of this proposed system is that it increases the economic status of the country, reduces the rate of corruption and there by increases the consumer as well as producer's satisfaction.

Sara Saberi *et al.* discuss about Blockchain technology and its relationships to sustainable supply chain management. [2] proposes a system in which the transactions in the supply chain are verified with a digital contract called smart contract. Before the product is transferred to the next level, it must meet a smart contract requirement to validate the exchange. Once the contract is met, transaction details update the blockchain ledger. The nature, quality, location and ownership are made visible to the entities.

Umesh Bodkheet *al.* put forward a Blockchain-Driven IoT for Food Traceability with an Integrated Consensus Mechanism. The paper [3] evaluates the disadvantages of our existing food supply chain and proposes a system which integrates all the aspects of blockchain, fuzzy logic, and IoT technology. The proposed modular frame work of BIFTS has 3 modules. IoT monitoring module, Blockchain data management module. And fuzzy quality evaluation module. The paper suggests further improvements like extension of PoSCS, Integration of flaws in supply chain etc.

Zhong, R. *et al.* as the awareness about food safety, quality, freshness etc are increasing, discuss how to upgrade the current food supply chain to match with the increasing demand for the future. The current challenges of food supply chain and future perspectives are highlighted in [4]. The paper made the conclusions like advanced technologies like cloud computing, IoT, and Big data analysis can be employed to upgrade the food supply chain to a smart future. Also a data driven approach for decision making for supply chain management could be adopted.

Li, Dong & Wang *et al.* propose a Sustainable food supply chain management. The authors focus on challenges and opportunities in sustainable food supply chain management [5] and recent developments in research on SFSM. The challenges include incentives, Governance and cooperation, technological innovation, packaging and containment for sustainability, food quality and safety, Implementation strategies etc. Through this research presented various challenges in sustainable food supply chain management is targeted and also future challenges are discussed.

Yong He *et al.* bring in to the operations management research on food safety and quality in [6]. The operations management focuses on using optimization models to view the effect of various operational variables like pricing, inventory etc. It classifies the literature to different categories and identify challenges for further research within each category.

W. Ritha *et al.* put forward a Food Supply Chain Management System, Enhancing Sustainable Development and Minimizing Operating Cost [7]. Author presented a food supply chain management system for enhancing sustainable development and reducing the operational cost. The production and distribution are the main challenges in this competitive world. The paper discuss about supply chain management today, problems and solutions for food supply chain management, and recent development in researches etc. From this paper various types of challenges have been seen to reduce the operating cost and increase the sails. But the solution made in the food supply chain management is not fixed due to uncertain. So the present and future challenges in the food supply chain management have been discussed.

Sidra Maliket *al.* share his views on a system which assisted by a centralized data collection [8]. IoT based mechanism can reduce the wastage of food, and improve efficiency of

distribution and transportation. It also supports a very quick removal of spoiled product from the supply chain. It utilizes quality sensing technologies, communication infrastructure for online tracking etc. In this technology each box will contain an S&C module; it sends the food quality data to the local hub. It also presents some disadvantages like faulty modules or patchy cellular communications etc.

Mondal, K. P *et al.* bring a blockchain inspired RFID-based information architecture for food supply chain [9]. It uses a conventional blockchain which is decentralized to ensure the security and transparency. Smart contract permits the transportation of the food packet by checking its quality constraints. RFID which is integrated with sensors is used to extract the information from a food packet. The security features can be further improved in this technology by strengthening the hardware security of the readers and sensors ID's.

Toshendra Kumar Sharma in his article [10] put forward his some views on blockchain technology and how it can be utilized to handle this present pathetic situation due to Covid-19. Drug and donation supply chains, food supply chains, managing medical data all these areas can utilize this technology for secure and transparent support. Author also discuss about tracking Infectious Disease Outbreaks, securing medical supply chains, donation tracking etc. as a conclusion author says that blockchain is an efficient and transparent healthcare business model with higher degree of trust and accuracy. Thus, the use of blockchain-enabled platforms can help prevent these kind of situations now we face as a part of covid-19.

Daniel Macriniciet *al.* highlights some features of smart contract in block chain [11]. He conducted a systematic study on blockchain based on smart contract. It identified about 16 blockchain based smart contract problems. He also discussed the solution to the identified problems. Zhanguo Zhu *et al.* discuss about the recent t advances and also the opportunities in sustainable food supply chain [12]. He tells about our existing system and their contributions. Major environmental research problems, social research problems, etc are discussed and Different models are presented on the article. Finally he opened the window to future opportunities which stands for farmer's welfare, Non-profit supply chain to alleviate food insecurity, Traceability-driven food supply chain, Sustainable farming etc. category.

Guojun Jiet *al.* develops a model which takes big data as input to make very informed production decision in food supply chain. This paper [13] introduce a Bayesian network method, and integrates data samples and finds a cause and effect between the data to predict the market demand. The paper ended up with the conclusion that an analytical frame work has a vast capacity to to support the decision making by extracting information from big data.

Samuel J. Stratton explains that COVID-19 is not just a medical issue but a global issue that can affect the economic and social balance and it has threatened the government as well. It is an infectious disease and containment of the outbreak requires the best of public health actions and skills. This has led to the shutdown of global trades and lockdown to restricted communal interaction. The paper [14] underlines that COVID-19 has the potential to become a global pandemic.

In the paper [15] James J says that large outbreaks have occurred and the medical facilities are surrounded with suffering and death. With increase in concern the government has taken various measures which include quarantines, isolation, and travel restrictions in an effort to prevent introduction of disease causing virus. The health care systems are at major risk. So in order to support their effort the society must strongly encourage social distancing and the good hygiene measures.

By acquiring knowledge and considering limitations from all these papers we ended up with a blockchain based food supply chain, which overcomes the limitations like lack of security, transparency etc. It also ensures the quality and there by permits the transportation by making use of a smart contract. All these make the system more reliable and efficient. In the present situation of Lock-Down as the people are restricted to go out for work and all, this food supply chain will be really helpful because it works based on the major principle of block chain. Which makes the supply chain more reliable and decentralized. And also the smart contract enables the transportation of the food packet without the physical presence of people for checking the item manually. As the sensors and all hardware components embedded inside the packet, the physical contact and there by the virus spreading through food transportation can be reduced to a limit.

### 3. PROPOSED SYSTEM

#### 3.1 System Design

A typical food based supply chain is shown in Fig.1. Each packaged food product with an embedded sensor system travels through various stages of transactions starting from packaging through transportation, storage and finally to a consumer for purchase. A data block is created containing the information about the package at each transaction. Once the transaction is verified, the data is converted into a block of information and appended to its pre-existing data blocks thus forming a chain of information blocks.

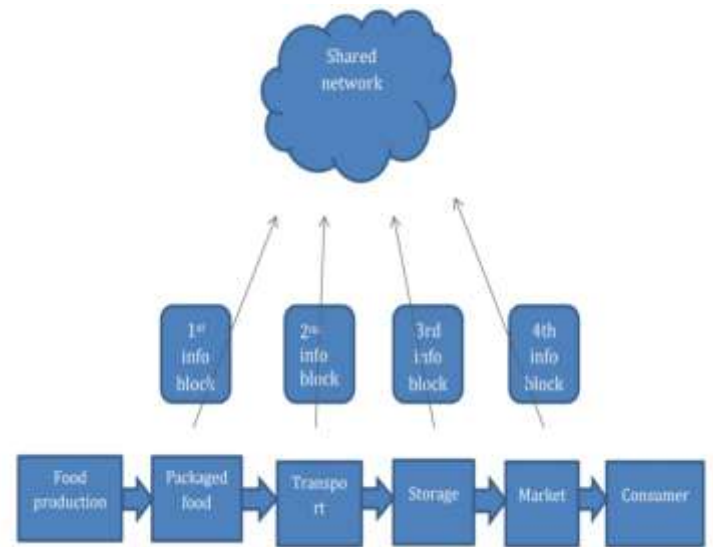


Fig -1: Proposed system

#### 3.2 Process

The food packet to be transported is equipped with an embedded sensor system. Each packet will be boxed along with its own sensor circuit which comprises an arduino board, sensor, beeper, potentiometer with the LCD display projecting outward as depicted in fig.2. The LCD is made visible to acquire the sensor reading that provide the methane value of respective food product.

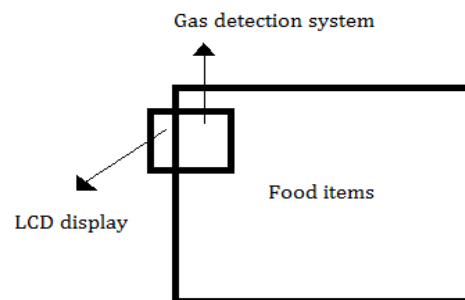


Fig -2: Food packet

During the initial stage of the supply chain which is packaging, a genesis block is created which is the first block of the blockchain. The genesis block will contain the sensor readings of fresh food along with other information including item, hash, details of owner etc. The food packet is then delivered to next stage of supply chain. Here, the sensor reading at that instance is taken and added to the data block. Each food product will have a threshold methane value which when exceeded marks its spoilage. The data obtained at the current instance is verified using smart contract, of which one of the main parameter is the threshold methane

value. Once the condition is met, the packet sensor value of the transaction is appended to its pre-existing data blocks thus forming a blockchain and this packet can be taken to the next level. If the condition is not met, that particular food packet will be dropped and it will not enter to next block as well as destination.

Smart contract is key feature of blockchain which allows performance of credible transactions without third parties. These transactions are traceable, irreversible, immutable and provide security.

### 3.3 Structure of a Block

Hash of block
Manufactures
Address
Item id
Item
Sensor type
Sensor value
Time stamp
Previous hash

Fig -3: Structure of a block

The transaction records are permanently stored in blocks. In the proposed system each block contains the hash of the block, hash of previous block, detail of manufacturers, address, item id, item, sensor type and sensor value. A hash is developed based on the information present in the block header. Manufacture field provide the agency that produce the food, address field provide theirs address. The item\_id is a unique id to distinct the food item and item field is the food product. Sensor type specifies the kind of sensor used which can be for gas detection, climatic change or microbial growth. Sensor value is the respective sensor reading obtained at that instance. Timestamp specifies when an event occurs based on date and time of day. The structure of the block is given in fig.3.

### 4. GAS DETECTION SYSTEM

The below figure shows circuit diagram in order to automatically detect the emission of methane gas which is produced from rotten fruits and vegetables. This particular diagram contains various components. These components

are Arduino UNO, MQ2 gas sensor, 16\*2 LCD display, 10K potentiometer, 330-ohm resistor, buzzer, some jumper wires. blockchain based applications.

The hardware provides real time sensor readings. When the gas is produced the system detects its presence and alerts.

Arduino is open source electronics platform which can be easily programmed, erased and reprogrammed at any instant of time. It consists of mainly 2 elements. These are hardware and software. It uses hardware Arduino development board which is a microcontroller based on the ATmega328 and software for developing the code known as the Arduino IDE (Integrated Development Environment) which is a cross-platform application written in Java. The Arduino Uno board can be programmed with Arduino software. A USB connector is used to connect Arduino IDE in the system with Arduino UNO. The Arduino software. A USB connector is used to connect Arduino IDE in the system with Arduino UNO. This cable helps to load program which is written in C or C++ programming language from the computer. It is very easy to manage power inside it and there is feature of built-in voltage regulation. This can also be powered directly off a USB port without any external power. It can sense the environment by receiving input from MQ2 gas sensors and can affect its surroundings.

The MQ-2 smoke sensor is used to detect the following gases: LPG, Butane, Propane, Methane, Alcohol, Hydrogen. Here this sensor uses to detect the emission of methane gas which is produced from rotten fruits and vegetables within the food packet. It contains a sensing material whose resistance changes when it comes in contact with the gas. This change in the value of resistance is used for the detection of gas. It consists of a potentiometer which adjusts the sensitivity of sensor according to how accurate you want to detect gas. The voltage that the sensor outputs changes accordingly to the methane gas level that exists in the food packet. The sensor outputs a voltage is proportional to the concentration of methane gas. In other words, the relationship between voltage and gas concentration is the following: the greater the gas concentration, the greater the output voltage and the lower the gas concentration, the lower the output voltage. applications.

10K potentiometer is manually adjustable variable with 3 terminals. It connects with LCD display. Applications.

LCDs are used to display text/characters only. There is liquid crystals to produce a visible image. There is an LED backlight and it can display 32 ASCII characters in two rows with 16 characters on each row. 16\*2 LCD display shows the value of methane gas each at every instance. This value of each Transportation stores in each block. The alert is given by buzzing the buzzer attached to the circuit.

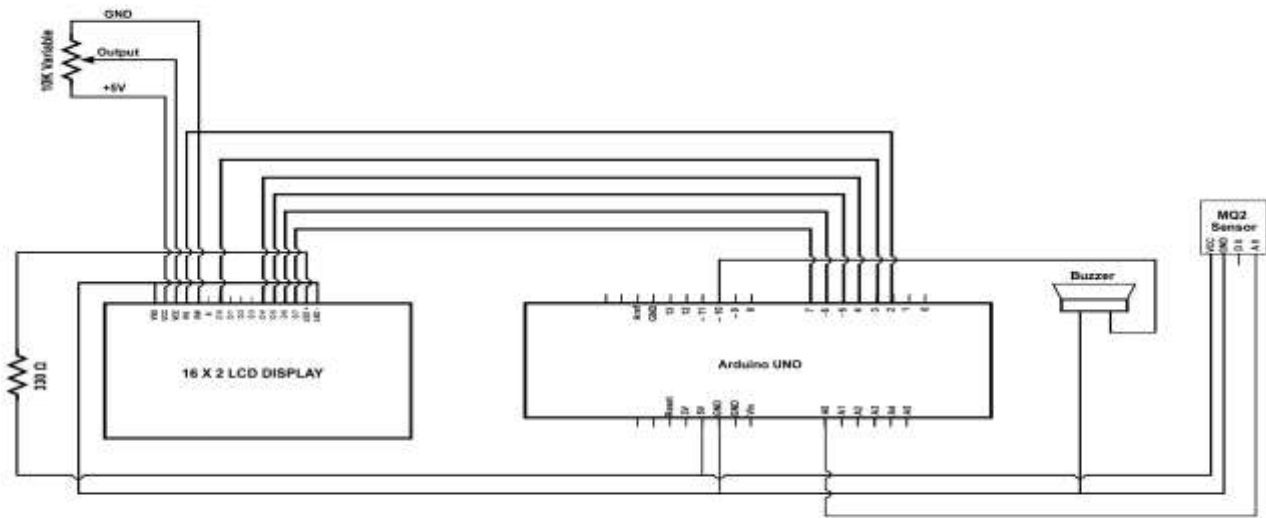


Fig - 4 : Circuit diagram of gas detection system

## 5. IMPLEMENTATION

Blockchain is the key technology used to create security in food transportation chain. The main feature is that they are immutable. So it is not possible to alter the details of food transportation without permission of other members of blockchain. The details of each transaction add into each block. Each block is connected to the previous block with hashing. Each block contains the details of each transactions like item name, manufacturing details, sensor value etc and previous hash. A hash is a function that converts an input of letters and numbers into an encrypted output of a fixed length.

Smart contract allows the performance of transaction without third parties. This transactions are trackable, irreversible, immutable. It provides security. Here the smart contract is that, If there is any change in the sensor values as compared to the original values which is stored in the initial block the packet will be dropped and it will not enter to next block as well as destination. Otherwise it is accepted and move to next destination.

Hyperledger Fabric is a project of hyperledger which is a blockchain framework that is a foundation for developing blockchain-based products, solutions, and applications. Traditional blockchain networks don't support private transactions and confidential contracts. Hyperledger was introduced as solution to this issue. Go language is an open source programming language which is used to create blocks for blockchain based applications.

The hardware provides real time sensor readings. The MQ2 gas sensor, buzzer and LCD display are connected with arduino board to get the required output, which is the sensor readings. When the gas is produced the system detects its presence and alerts. It consists of arduino board that has a variety of microprocessor and controller and contains a set of input/output pin and other circuits. A USB connector is used to load program which is written in C or C++ programming language from the computer.

MQ2 sensor uses to detect the emission of methane gas which is produced from rotten fruits and vegetables within the food packet. It contains a sensing material mainly aluminium oxide based ceramic coated with Tin dioxide, enclosed in a stainless steel mesh whose resistance changes when it comes in contact with the gas. This change in the value of resistance is used for the detection of gas. 16\*2 LCD Display shows the methane gas value from MQ2 sensor at Every instance.

## 6. RESULT

Blockchain inspired Food supply chain platform is used to ensure the quality of food products which is inside a package by periodically testing it with the help of various sensors. For that, blockchain technology, Mq2 gas sensor etc are used. The experiment shows that the data from sensor is accessed in a timely manner and this value is checked against the smart contract to ensure the quality. Here we uses a pack of banana for testing with the help of Mq2 gas sensor which detects the measure of methane produced there by ensure the quality. We obtained the result with the accuracy of

above 85%.The blockchain technology helped to make the supply chain transparent and secure.

## 7. CONCLUSIONS

Using blockchain secure transparent food supply chain has been implemented. Go programming language is used to create blocks with various informations like packet id, timestamp, location details, sensor values etc. Food packages are scanned at different stages within the supply chain. The smart contract provides security.

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