Logistics, traceability in food supply chain management

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Abstract The food sector is crucial in providing the basic needs to sustain a range of human behaviors and activities. Supply chain is one of the important IoT application areas. IoT solutions support the monitoring, analysis, and management of the food sector in real-time. Through the application of IoT, the routing process of food products is greatly improved. The system is composed of a set of connected nodes that form a network of sensor nodes with the integration of RFID and IoT technology. The RFID tags associated with the food products enable the detection of the location, temperature and other parameters of the food products. The IoT platform provides real-time tracking and monitoring of the food products from the source to the destination. The task of the Food supply chain is to promote efficiency, transparency so that suppliers, clients, and partners may receive crucial information about the travel history movement along with quality of their products. Traceability plays a critical component for ensuring food safety, protecting public health, and providing assurance that food is free from contamination. By tracking the movement of food through the supply chain, businesses can ensure that food is sourced from approved suppliers.

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1 Introduction

Supply chain management (SCM) is a critical area of research and practice that has gained significant attention in recent years. With the globalization of businesses and the increasing complexity of the market, companies are seeking to optimize their supply chain operations to remain competitive. Supply chain management encompasses the planning, coordination, and execution of activities involved in the movement of goods and services from suppliers to end consumers. It includes all the processes and activities that take place from the acquisition of raw materials to the delivery of finished goods to customers. The main objective of SCM is to increase the efficiency and effectiveness of the supply chain. It is to reduce costs, improve customer satisfaction, and enhance company profitability. Effective

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supply chain management requires a holistic approach that considers the entire supply chain, including suppliers, manufacturers, distributors, retailers, and customers [1]. SCM is a multidisciplinary field that draws on disciplines such as operations management, logistics, marketing, finance, and information technology. Advances in technology, such as the Internet of Things (IoT), artificial intelligence (AI), and block chain, have significantly impacted supply chain management, providing new opportunities for optimizing processes and improving the overall performance of the supply chain [1]. Supply chain management is significant, and both academics and professionals are aware of this; a lot of study is being done in this field. A complex system that includes all steps in food production, processing, distribution, and consumption is known as the food supply chain. Everything from the farm to the fork is included. This covers the raising of cattle and crops, as well as the transportation, sale, and consumption of food products. There are several stages in the food supply chain, and they each have their own actors and activities. The production of raw resources, such as crops and livestock, and their transportation to processing facilities make up the first stage of the food supply chain. Raw materials are converted into finished food products during the processing stage. The process of processing involves turning raw materials into finished foods that are then packed, labelled, and delivered to stores or distribution centres. Food goods are transported from the processing facility to the place of sale during the distribution stage. Stores, dining establishments, and other food service providers may fall under this category. Consumers buy food at the point of sale, and then eat it [2].

The food supply chain is subject to a range of challenges, including climate change, food safety, and food waste. Climate change can impact crop yields, while food safety issues can arise at any stage of the supply chain. This includes pesticide use on farms to food processing. Food waste is also a significant issue, with up to one-third of all food waste [3]. A well-organized food supply chain management is essential for ensuring food production and distribution in a safe, sustainable, and cost-effective manner. Advances in technology, such as the block chain and the Internet of Things, are increasingly used to improve food supply chain management. This provides enhanced transparency and traceability of food products. The Internet of Things (IoT) has emerged as a powerful technology that can be utilized to improve the efficiency and safety of the food supply chain. IoT sensors can be used to track the location, temperature, humidity, and other environmental conditions of food products as they move through the supply chain. This is from farm to fork. In this way, IoT sensors can provide real-time visibility and control over the food supply chain, enabling better decision-making and reducing spoilage and contamination risk. IoT sensors can be used to monitor food products' temperature during transportation and storage. This is critical for ensuring food safety and quality [5].

Temperature sensors can be embedded in packaging or attached to food products to monitor temperature continuously. This information can be transmitted wirelessly to a central monitoring system, which triggers alerts if the temperature falls outside a specified range. This can help prevent spoilage and reduce foodborne illness risk. In addition to temperature monitoring , IoT sensors can also be used to track food products' location as they move through the supply chain. Location sensors can be embedded in packaging or attached to food products to track real-time. This can help to improve the supply chain's efficiency, enabling better scheduling and coordination of transportation and delivery [5]. IoT sensors can also be employed to monitor food products' humidity and other environmental conditions. This is particularly crucial for products such as fresh produce and seafood, which are highly sensitive to humidity changes and can quickly spoil if not stored properly.

Food products can be monitored for moisture content using humidity sensors, which can trigger alerts when humidity levels fall outside a certain range.

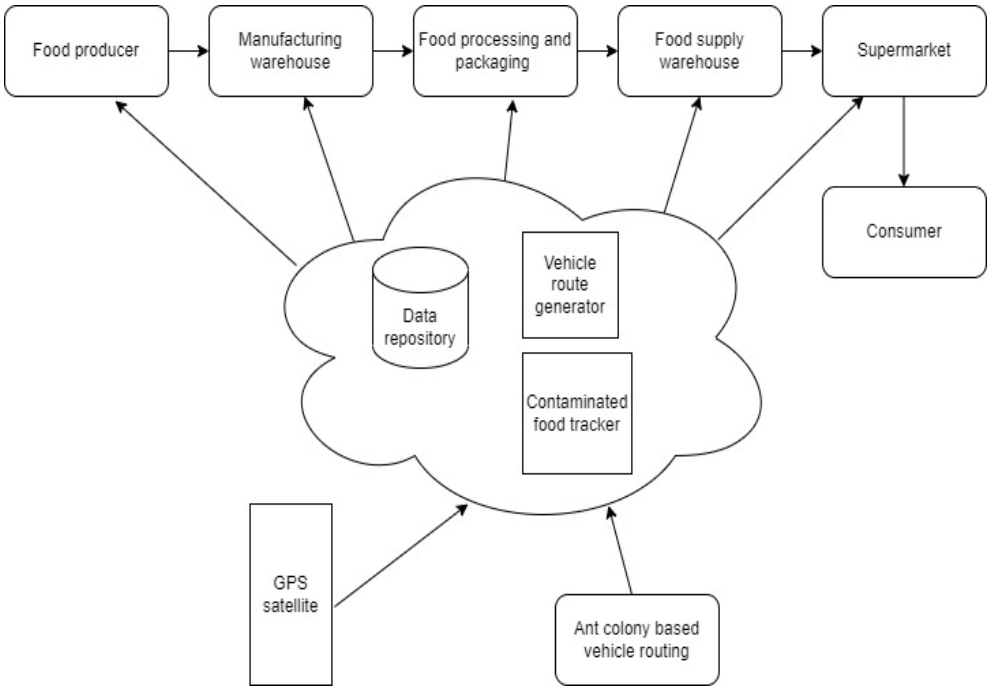

Fig.1 IoT based food supply chain

The fig.1 explains about the architecture of a food supply chain typically involves several components and stages that work together to ensure the timely and efficient delivery of food products from farm to table. Here's a breakdown of a typical food supply chain architecture:

1. Primary production: This stage involves the production of raw materials, such as crops and livestock, by farmers and other producers.
2. Processing: Once raw materials are harvested, they are typically transported to processing facilities where they are transformed into finished products, such as packaged food items, frozen foods, or beverages.
3. Distribution: Finished products are then transported to warehouses and distribution centers before being delivered to retailers, restaurants, and other end-users.
4. Retail: Retailers, such as grocery stores, sell finished products to consumers who purchase and consume them.
5. Waste management: This stage involves the management and disposal of food waste generated throughout the supply chain, including at the production, processing, distribution, and retail stages.

In addition to these stages, the architecture of a food supply chain also involves various stakeholders, such as farmers, suppliers, manufacturers, distributors, retailers, and consumers. These stakeholders work together to ensure that food products are delivered safely and efficiently to end-users, while minimizing waste and maintaining food quality and safety. To optimize the efficiency and transparency of the food supply chain, many companies are implementing advanced technologies, such as IoT-based sensors, block chain, and data analytics, to monitor and track food products throughout the supply chain. These technologies can help identify and address issues quickly, improve traceability and accountability, and ensure food safety and quality.

2 Related work

In this article, the authors present a conceptual framework for green and smart IoT-based supply chain management. The framework integrates the concepts of green supply chain management, smart supply chain management, and the internet of things (IoT) to create a comprehensive approach to managing supply chains with a focus on environmental sustainability [1].The authors begin by discussing the importance of sustainable supply chain management in reducing environmental impact and increasing efficiency. They then introduce the concept of smart supply chain management, which utilizes real-time data and advanced analytics to optimize supply chain operations. The authors also highlight the potential of IoT to collect and analyze data from various sources in the supply chain [1].

The article first describes the current challenges faced by supply chains, such as waste, inefficiency, and lack of transparency. It explains how a circular economy can address these challenges. The authors then introduce their proposed framework for circular supply chain management, which consists of four layers: data acquisition, data analysis, decision-making, and implementation [2]. The data acquisition layer involves collecting data from various sources such as sensors, social media, and internal systems. The data analysis layer uses AI and machine learning algorithms to process the data and generate insights. The decision-making layer utilizes these insights to make informed decisions about the supply chain, while the implementation layer uses block chain technology to ensure transparency and traceability throughout the supply chain. This article also includes a case study of a real-world implementation of this framework in the food industry. The case study demonstrates how the proposed framework can improve supply chain efficiency, reduce waste, and promote sustainability [2].

The authors explain that block chain can be used to create a secure and transparent supply chain. This is where all stakeholders can track products from the point of origin to the final destination. By recording transactions on a shared, decentralized ledger, block chain technology can help to prevent fraud, reduce errors, and increase efficiency in the supply chain[3]. The authors highlight several applications of block chain in supply chain management, including product traceability, provenance tracking, and smart contracts. They argue that block chain technology can be particularly useful in industries where product safety and authenticity are critical, such as the food and pharmaceutical industries. The use of block chain in these industries can help to ensure authentic and safe products for consumers, while also reducing the risk of fraud and counterfeiting [3].

The authors identify various challenges in supply chain management, such as data security, data privacy, trust among supply chain partners, and lack of transparency. They propose

that block chain technology can help address these challenges by providing a secure, transparent, and immutable ledger that can be shared among all parties involved in the supply chain [6]. The article also presents a case study that demonstrates the use of block chain technology in supply chain management. The case study involves a food safety monitoring system that uses block chain to track food products' movement from farm to table. The authors discuss how block chain technology can improve food safety by enabling the tracking of each step in the supply chain. This is from the farm where the food was grown to the store where it is sold [6].

The authors discuss the importance of traceability in the food industry and the benefits it can bring to the supply chain. These benefits include improving food safety, reducing food fraud risk, and enhancing consumer confidence in food products. They propose a general framework for traceability that includes four main components: identification, tracking, monitoring, and information management [7].The article also presents experimental evidence for the implementation of a traceability system using a case study of a meat processing plant. The authors describe the use of a barcode system for identifying and tracking meat products through the supply chain, from the farm to the final consumer. They also discuss the use of a database system for monitoring and managing the information related to the meat products, such as production and transportation data [7].

The authors first provide an overview of the challenges faced by the food industry in terms of traceability, such as the need to track products through multiple stages of the supply chain and the need to respond quickly to food safety incidents. They then propose RFID technology as a solution to these challenges [8]. The article describes the benefits of RFID technology, such as its ability to provide real-time visibility into the supply chain and its potential to improve traceability accuracy and efficiency. The authors also discuss the potential barriers to the adoption of RFID technology, such as the cost of implementing the technology and concerns about data privacy [8].

3 Proposed work

In order to address the issues related to network operations' high energy consumption and lag time, block chain technology has emerged as a possible solution. A more effective and long-lasting method of managing data can be achieved by utilising block chain technology at the network edge. Additionally, block chain is the perfect tool for tracing and tracking food products in the supply chain because it provides a tamper-proof and immutable record of transactions. A complete and accurate history of the origin, movement, and environmental exposure of a food item can be obtained via block chain. As a result, the supply chain is more visible and transparent and costly and manual operations are no longer necessary. IoT gadgets are helpful for keeping an eye on the physical state of food products, but they are not currently coupled with block chain technology. As a result, it is still difficult to track a food item from farm to table throughout its full journey. Overall, by enhancing trust, collaboration, and sustainability in the food supply chain, the integration of block chain technology and IoT devices has the potential to change how the food supply chain is managed.

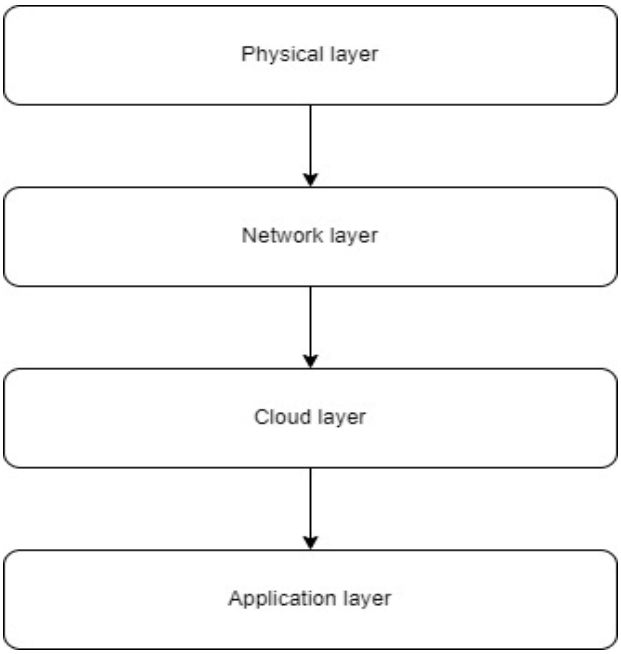

Fig.2 Block diagram of food supply chain

Fig.2 Explains about IoT-based food supply chain diagram typically depicts the system's various parts and tiers. The parts are broken out as follows:

1. Physical layer: This layer contains a range of physical infrastructure, sensors, and gadgets that gather information about the food supply chain. RFID tags, GPS trackers, humidity sensors, and temperature sensors are a few examples of the gadgets employed in this layer.
2. Network layer: The network layer is in charge of sending the information gathered by the physical layer to other central systems or the cloud for processing and analysis. Data transmission reliability and security are made possible by the networking infrastructure found at this layer, which also houses gateways and other communication protocols.
3. Cloud layer: Data collected from the physical layer is processed, stored, and analysed in the cloud layer. This layer contains software programmes that are cloud-based and give stakeholders access to the data so they may learn more about the food supply chain.
4. Application layer: This layer consists of numerous software programmes that offer real-time data to stakeholders about the food supply chain. Dashboards, analytics tools, and mobile apps are a few examples of applications employed at this layer.

The schematic for an IoT-based food supply chain, taken as a whole, demonstrates how several technological tiers interact to give stakeholders real-time data and insights about the food supply chain, empowering them to improve the effectiveness and transparency of the system.

4 Challenges of food supply chain

Several difficulties have been noted when using tracking and tracing technology in supply chain management. First and foremost, data security is a serious issue because hackers or other bad actors may jeopardise sensitive information like customer data, financial information, and intellectual property. Second, managing tracking and tracing technologies has become more difficult due to the growth of the internet of things.

Furthermore, the tracking and tracing technology is not standardised, which makes it challenging to track goods across various businesses and platforms. Effective tracking and tracing also depend on accurate data collection, yet ensuring consistency and quality in data collection procedures can be difficult. A lack of traceability in the food supply chain can also emerge from outdated technologies, traditional paper tracking, and manual inspections, which can slow down communication of information and lead to mistakes.

For enterprises, particularly in the agriculture, food services, and restaurant sectors, rising supplier chain costs can present a serious obstacle. Although getting new technology can be expensive, there may be long-term advantages. Last but not least, maintaining inventory levels demands careful management in order to prevent waste and preserve the satisfaction of clients. To reduce waste while maintaining quality and customer satisfaction, trade-offs might need to be made. In general, eliminating those challenges will involve cooperation from all supply chain participants, including companies, authorities, and tech companies.

5 Conclusion

Traceability, which enables the identification and tracking of food products from the source to the end consumer, is a crucial component of managing the food supply chain. This is crucial for maintaining food quality and safety as well as ensuring that laws and standards are being followed. By allowing for the quick identification and isolation of potentially contaminated products, traceability can aid in the prevention of foodborne diseases and other food-related problems. In the food supply chain, IoT technology can be used to develop a traceability system that is more effective and trustworthy. IoT devices are capable of gathering and storing information about a product, its location, and its temperature. This data can subsequently be used to track food products throughout the supply chain. Relevant stakeholders can access and analyse this data in real time by storing it in a safe, centralised database. IoT can be used to automate processes in the food supply chain, including inventory management and quality control, in addition to tracking food goods. IoT sensors, for instance, can be used to keep tabs on the temperature and humidity in storage facilities, sending warnings if those variables deviate from a predetermined range. This may lessen the risk of spoiling.

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