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Review on Effect of IoT in Inventory Management System

Pooja G[1], Nehashree Saravanan S[2], Nivetha S R[3], Abirami S[4], Priyadharshini H[5], Dr. S. Ramani[6]
Department of Food Processing and Preservation Technology, Avinashilingam Institute for Home Science and Higher Education for Women

Abstract: ***Inventory management plays a crucial role in every business organization that works on production. Appropriate control mechanism of inventory is essential to ensure stock levels of all the raw materials that are required for production of good. With the application of emerging technologies like IoT and sensors, the management of the stock levels has become more efficient in both industrial and domestic level. This has not only reduced the man power that is required for supervision of inventory, but also made the lifestyle of people more comfortable and easier.***
Keywords: Inventory management, IoT, Sensors, Microcontroller, User interface.

I. INTRODUCTION

Supply chain acts as a very important methodology in business management by playing an important role in business processes. This largely deals with turning all of the raw resources into completed goods and services, as well as distributing them to the eventual customer. Thus it acts as a vital link between producers and the consumer market. One of the key dimensions of supply chain management is Logistics management. Logistics is about the processes of planning, executing the forward flow and warehousing of the raw materials and finished goods with relevant information and records between the point of origin and landing point. This therefore involves Inventory management. [39] Inventory Management is the management of stock levels of particular good at particular point of time and at particular place. It plays a crucial role in running and maintaining a business organization that mainly functions in the production line.

A. Purpose

The primary goal of this article is to research and provide in the form of a review how inventory management is crucial in organizations, how it has evolved over a period of time at both industrial and domestic level and how the invention and expansion of IoT can impact the management of inventory.

B. Significance of Inventory Management

In any business organization that works as a production unit, there is a space where the raw materials go in and get stored. Similarly, the finished products are also taken back this stock area at times, before distribution. Inventory management makes extensive use of data to keep track of the batch numbers, price, and quantity of the items as well as the information collected during the process. In general, inventory management receives 60% of the budget. It holds a very significant place as it co-ordinates and schedules operation flow. [40]

Models for inventory management are used in almost all businesses. The literature's scope encompasses a variety of subject areas, including engineering, engineering technology, agriculture, energy, environmental science, and medical according to Science Direct’s search for publications on Inventory management.

When considering both open access publications and journals to which only subscribers have access, it was found that the most commonly discussed topics in inventory management are engineering, energy, and environmental science. Due to the expanding consequences of climate change, environmental science has made re-engineering necessary, which has increased the need for stock management. [3]

C. Timeline of Inventory management

Inventory management concepts have existed since the dawn of time. With the development of new tools and technology over the past century, inventory practice has become more contemporary and has undergone evolution. For instance, traders in the past counted and totaled the goods sold each day.

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Prior to the development of more precise inventory record management and accounting systems by the Egyptians and Greeks, handwritten notes and hunches were used in an inefficient and imprecise manner. Inventory management practices have improved over the years. These advancements have resulted in further cost savings and increased customer satisfaction.
One of the major advancement seen in Inventory management is the intervention of IoT. It has enabled to manage stock levels by providing real time data at all point of time along with giving accessibility to the data related to inventory from anywhere.

II. IOT EVOLUTION

In this modern era, nourishing the standard of innovation in daily life act as a catalyst that changes the way we live our lives. Innovation starts with an idea or invention followed by bringing them under general usage. For example: If Fryer is an invention, development of smart sensors that can maintain pre-defined oil temperature and notifying the users helps in optimizing the process which is ultimately known as innovation. These operations are sustainable with the execution of IoT (Internet of Things) in a far-reaching manner. IoT is an adjunct of internet that unites the physical world with sensors and other communication networks.

A. Pre Internet

There was a time when there is no internet and had only human to human interaction. This period is known as Pre-Internet era which follows a hierarchical and standardized structure in various industrial activities. The rational strategy followed in Pre-Internet economy was an energy intensive period that made communication difficult between customers and suppliers. The challenges faced during the pre-internet era lead to the enrichment of communication and business by virtue of internet.

B. Internet of Content

The emergence of Internet dates back to 1950's. The first phase of Internet (1989) concentrates on connecting information with hardly any interaction between server and user. It started with the evolution of www (World Wide Web) that enables people and machine communicate easily. Dornberger et al (2018) had given a model on how the development of enumerative technology leads to changes in human to computer interaction. Greater number of users of Web 1.0 is consumers of content, focusing on reading. [52]

C. Internet of Services

Web 1.0 technology allows only one way communication between creator and user with no interaction from users on other side. This marked the escalation of Social web (Web 2.0) that enables users to create, read and write on web. Aggregate of Web 1.0 and Web 2.0 forms the Smart IT platforms and services. Web 2.0 technology is widely applied in Supply chain management (e-business) that relies on internet for front end and back end process involving inventory management, financial tasks etc. In their study of web technologies in supply chain management, Cagliano et al. (2003) divided them into three main categories: e-commerce, e-procurement, and e-operations. [53]Supply chain management is an essential process in industries that has an ultimate aim to establish a synergy among the various supply chain partners and also the employees.

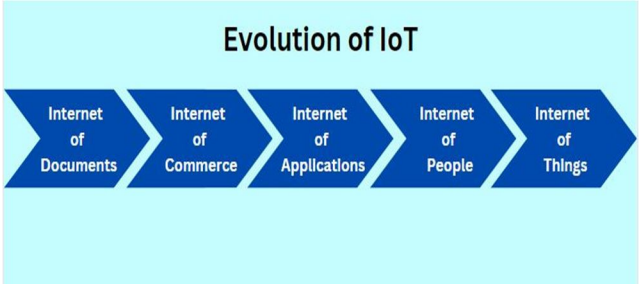


Fig. 1 Evolution of IoT

D. Internet of People

The third stage of evolution of internet is the decentralized version of web2.0 (Web 3.0) that focuses on detailed insights and data analysis that helps in development of semantic web, artificial intelligence etc. The web technologies are been improved to generate, connect and share the content through findings and analysis. This revolutionary step is made through development of Block chain technology that helps to access information from any electronic device. The key features of web3.0 like Block chain, Crypto currency, NFT, Decentralized apps captures the web and become closer to the users like us.

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Web 3.0 technologies enables digital identity for various supply chain partners like farmers, growers with data privacy and also helps in real time payments using smart contracts, which lowers the transaction costs. Tools of web 3.0 like NFT creates unique tokens or digital asset attached to field, orchard or particular crops for efficient traceability.

E. Internet of Things

Development of intelligence in machines and devices marks a radical growth among industries and domestic areas. This collective network of devices with embedded sensors and built-in software impacts our lives in various ways. Inventory management plays a keen role in food industry that allows business to thrive, if properly maintained. This was made easier by virtue of IOT that minimizes overstocking and shortages and creates streamlined supply chain. Smart containers embedded with ultrasonic sensor and other modules communicate the inventory status of products to the user through web application. [21] This overcomes the tedious process of manual inspection. Deployment of wireless sensor networks, IoT and cloud computing enables real time tracking and monitoring of products and parameters like shelf life, sales, responses from customers. [27] The system is set up to make an order as soon as the grocery level drops below the essential threshold thanks to the use of cameras that scan the data stored within the cabinet. [54]

III.IOT IN INVENTORY MANAGEMENT

The process of making orders for, keeping, using, and reselling a company's inventory is known as goods management. This encompasses raw material, component, and completed goods management, as well as storage and processing. In a variety of businesses, including manufacturing and the pharmaceutical industry, inventory management is crucial. Similar to that, it plays a significant role in our daily activities, particularly in the kitchen. Kitchen inventory control is crucial for maintaining control over the supplies of food and goods in our kitchen.

Initially, managing the kitchen inventory was done manually, which takes up a lot of our time. People today are extremely busy and look for alternatives to such time-consuming chores to improve and simplify their lives. The use of IoT to manage the inventory is the most widespread and effective invention that has made human lives easier and better. IoT is a vision that enables people and objects to interact in an ideal world via any channel or service.[42] The Internet has evolved into the world's fastest and biggest data exchange network, connecting billions of devices. The notion of the Internet of Things arose as a result of network evolution and the pervasive presence of the internet. Fundamentally, the objects referred to by the phrase Internet of Things are self-contained sensors capable of gathering and sending real-time data via the Internet, making them smarter. [43] IoT in kitchen inventory management typically includes the use of sensors, microcontrollers, and development of a website or application to display the real times values of the groceries. This aids in the proper management of kitchen inventory by keeping track of groceries, generating notification alerts for replenishment expiry, and alerting for recipe recommendations contained in the database.[45], [46] Some advances have been achieved utilizing IoT, including not just measuring the quantity of goods and alerting users, but also automatically placing orders.[3] This is particularly relevant at big scale levels, such as warehouses, where finding any product can be quite challenging because a user must manually do a thorough search in every stockroom present.

Inventory management is an important aspect of customer service and cost reduction in any production setting. Inventory becomes a concern when firms become worldwide, with thousands of components and hundreds of warehouses, and a lot of effort is spent managing inventory and assuring proper distribution. [9] As a result, the warehouse inventory management system is very helpful in preventing this problem since it maintains track of the details of the individual products and informs us of the stockroom in which the product is stored. [42] There are different methods to track the inventory such as the use of load sensor to detect the weight of the products using a load cell [3], [44], [45] or using RFID technology i.e., RFID tags to locate a particular product. [9], [42], [46], [47] Among the Internet of Things (IoT) technologies that concentrate on identifying and tracking are RFID (Radio Frequency Identifying), bar codes, and smart sensors. Because of its identifying and tracking abilities, RFID in particular is often used. Additionally, RFID provides the benefit of optimizing corporate processes, reducing labor costs, improving the precision of inventory movement and placement, and consistently raising business productivity. [43] RFID is the wireless communication technology that is most appropriate for warehouse inventory control systems. The transmitter component transmits the tag data to the open source hardware through a wireless link that may access the internet. The Internet of Things architecture is used in the design of the warehouse inventory management system to track the products connected to the tags with product information and time stamps for additional verification. [42]

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Quick access to current value of goods via a website or application is one of the most important advantages of integrating IoT in inventory management. Because most individuals now have smart phones that can connect to the internet, real-time values are collected from the product or container and sent to a website or application via a wifi module. This allows the user to view the inventory at any time and from any location. Both the values recorded by the sensors and the signals produced by the RFID tags are transferred via a wifi module and saved in the cloud, where they may be accessed through a website or application created specifically for the purpose.[9]

Table I given is constructed after studying several papers that talk in detail about warehouse maintenance using sensors and integrating IoT. Inventory can be managed in different methods. These methods are based on the types of sensors used for measuring the levels of stocks, types of microcontrollers used, the user interface that is in action and the integrated circuit that is handled in each case.

A. RIFD system

For many years, supply chain management, the food business, the retail sector, and the livestock management sector have all employed RFID technology. It has lately emerged as a brand-new and fascinating field of study and is getting much of attention. The big push began when the large retailer Wal-Mart declared in 2005 that all of its vendors had to provide shipments with RFID capabilities. Real-time product replenishment is made possible by RFID technology in the retail sector without the assistance of a person or line of sight. [47] Radio-frequency identification, also known as RFID, collects and stores data from a tag that is attached to an object using radio waves. If the tag isn't in the reader's immediate line of sight, it can be read from many feet away. [9] A microprocessor included within the RFID tag itself allows the reader to read data from it as well as write data to it to perform in-place real-time updating. Every tag is encased in plastic or paper for safety, and it may be affixed to a variety of places for tracking. A great deal of RFID tags used for tracking inventory is passive, meaning they are energised by the reader's radio waves rather than a battery. Active tags are used for distant tracking of vehicles like trucks and railway wagons; they are powered, more costly, and more sophisticated. Containers with RFID tags assist increase internal control, improve event management, such as the replacement of cold storage areas, and minimise the preparation of items for expiration. [46]

B. Sensors

IOT's primary building blocks include sensors, user interfaces, networking, and data processing systems. The benefits associated with wireless sensor and actuator networks (WSAN) and information-centric sensor networks (ICSN) are incorporated into the Internet of Things (IoT). When smart sensors were used with the IOT, it became smarter and more intelligent. One of the technology standards for IOT established by researchers is the use of sensors. So sensors play an important role in an IOT based device. Management of supply chains, retail, irrigation, aeroplanes, and autos are just a few industries where sensors are used. Wireless sensor networks (WSN) and single sensor technologies enable intelligent parking, illumination, traffic control, smart irrigation and farming, structural wellness, the armed forces, smart structures, and transit systems, among other things.[48]

Sensors also known as detectors are devices that are used to detect a physical or chemical change as a signal from the surrounding environment and sends the data to other electronic device which converts it into an understandable form to the electronic device from which the data can be analysed. The input signal can be either heat, light, gas, moisture, pressure and other environmental phenomenon. Sensors are used in various applications starting from a simple water detection system to more advanced applications like in aerospace. They play a significant part in our everyday life and make it easier and better because they are utilised everywhere. The electrical properties of sensors often change in response to changing physical conditions. As a result, most artificial sensors collect, analyse, and send environmental data using electronic devices. The capacity to manage the movement of electrical power is crucial since these electronic devices work on the same concepts as electrical circuits. A sensor, in the simplest terms, transforms environmental inputs such as light, sound, heat, and mobility into electrical impulses. Before being sent to the computer for processing, these signals are routed via a device that converts them to a binary code.

Different sorts of sensors may be used to track inventory, such as detecting the weight of the container or measuring the quantity of product in a container using ultrasonic waves. In general, a load cell is used to assess whether the goods are adequate by measuring the weight of the container. In this type of inventory system, each change in the item weight is precisely calculated by computer software, and logical inferences are drawn as to if the inventory needs more stock or not. In this method, "Load Cells," which are merely metallic spring parts composed up of "Strain gauges," are employed. It should be noted that when a load or weight is put to a "Strain gauge," the resistance changes. The Wheatstone bridge technique, which determines the null voltage difference across two potential dividers connected in parallel, can be used to identify this resistance shift. [49]

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The load cell provides us with analogue data. Digital load cell output is produced using a load cell connected to the HX711 load cell amplifier with a 24-bit ADC. Anywhere in the world may access the internet and view the weight of a retail container as measured by the load cell via a computer, tablet, or smart phone. A notification is sent to the phone or laptop when the load cell weighs the shopping container and determines if the weight is below the threshold value. [45] The load cell must be installed between two flat surfaces using the two threaded holes on each side to provide the required strain for estimating the container's weight. Once fixed, the flat surface may be used as a scale to weigh a storage container on our mobile app and track food consumption. [46]

Another type of sensor used in inventory management is the ultrasonic sensor. Ultrasonic sensors measure distance using ultrasonic pulses. It sends out an ultrasonic pulse and receives the reflected wave from the target. This technology-based inventory system is especially well-suited for products held in liquid form. Using this technique, it is possible to estimate the liquid content of storage containers with accuracy. Every change in the volume of fluid in its container of storage may be precisely calculated and recorded by computer software within fraction of a second. The main advantage of using an ultrasonic detector in such an inventory system is the fact that the liquid being kept is not physically harmed by it. Only ultrasonic sound waves are used by the sensor to communicate with the liquid. It should be underlined that the sensing parts of this inventory system become modular since the sensor does not physically come into touch with the liquid. [49] These can be used to manage both liquid and solid stocks without any modifications. The transducer calculates the amount of time it takes for a pulse to go from the container's top to its whole surface and back. The space between the highest point of the box and the surface of the inventory is calculated using this time. By using two assumptions: maximum and thresholds, the maximum is the distance from the lowest permissible inventory and threshold is the distance from the maximum acceptable inventory. It's obvious that a maximum threshold exists since the separation increases when stock prices fall. A threshold amount should be chosen so that the market can function up until the arrival of the new products. Similarly a LDR (light detecting resistor) can be used to manage the inventory. LDR is a high resistance semiconductor that serves as a photo resistor. An LDR, or light-detecting resister, loses resistance as the amount of light striking its surface increases. LDR operates on the basis of photo conductivity; when light strikes its surface, the electrons in the semiconductor's valence band are stimulated to the conduction band and can conduct electricity as a result. This idea may be applied to create an intelligent inventory system in conjunction with output analysis computer software. [3], [49]

Different sensors may be employed to preserve the security of the items in the warehouse or in a kitchen in addition to calculating the amount of the goods. These sensors include moisture and gas sensors. Gas sensors are used to find gas leaks in warehouses, while moisture sensors are used to monitor a product's moisture content and alert the user by linking to a website or mobile application over wifi. We may learn more about the condition of the product within the container by collecting the moisture content readings. Gas sensors are also highly helpful in securing a warehouse since they can detect gas leaks. [47], [51]

C. Microcontrollers

With the advancement of modern technology, standalone systems are now able to do all required operations without the help of extra hardware like microcontrollers. These feature a large number of integrated circuits on board, allowing them to carry out a variety of tasks independently. They are used in a variety of settings, from sturdy industrial equipment to simple home gadgets. [55] In IoT base systems, many microcontrollers are employed.

1) *Arduino Uno:* It is known as an open-source programming board because you can upload programmes onto it and utilize them to communicate with real-world objects. Based on the Atmega328 microprocessor, it is a microcontroller board. It can communicate with electromagnets, sensors, and motors.
2) *Raspberry Pi:* It is a collection of small single-board computers that is maybe the most inventive computer of the market today. Python, C, C++, BASIC, Perl, and Ruby are just a few of the programming languages that the Raspberry Pi can run. [56] By integrating relays, sensors, and lights with smart phones or computers, home automation systems can readily host some of the applications for home automation. The system may be remotely controlled with ease by the operator.
3) *Beagle Bones:* Beagle Bones Texas Instruments has developed a family of single-board Linux computers (SBCs) called Beagle Bones. Beagle Bone Black is an inexpensive, society-supported development platform for developers. This small single board computer would be ideal for a complex robot project.
4) *ESP8266:* Espressif Systems produced the WiFi SOC (system on a chip) in question. It is a closely integrated semiconductor designed to provide full internet connectivity in a small package. By connecting the ESP8266 to any microcontroller through the serial UART and running the conventional AT Command set Firmware, the ESP8266 may be utilized as an exterior Wi-Fi module. Alternatively, it can operate directly as a microcontroller that supports Wi-Fi by building updated firmware with the available SDK.

D. Wireless Communication Protocol

IoT Communication Protocol is anticipated to revolutionize the way information is transmitted from people to people, people to things, and things to things. Connected, information-transferring, and decision-making capabilities exist in smart devices. [57] Now that there are millions of IoT devices linked to the internet, we can use the suite of protocols known as TCP/IP to interact over networks. [58] The productivity of many smart domains (smart homes, smart cities, etc.) is increased through wireless sensor network connections, however some hazards are also added. For a better understanding of how protocols are implemented in smart environments, it is imperative to first grasp the relationship between the traditional OSI or TCP/IP model and the IoT protocol stack. [59]

IoT protocols for communication are typically described as LPWAN and network short.

1) *Low Power Wide Area Network (LPWAN):* A reduced-power wide-area network, often called a low-power network or LPWAN, is a type of wireless broad-area networking used for wireless communications that permits long-distance communication at a low bit rate among devices like sensors which are powered by batteries.
2) *Short Range Network:* Although short-range wireless communication is not specifically categorized, it generally refers to communication distances on par with WPAN and WLAN. Wide-area wireless networks using multi-hop technologies, such FAN (Field Area Network), have gained popularity recently.

- *6LoWPAN:* The first and most popular IoT connectivity standard, 6loWPAN is an IP-based protocol for Internetworking. It can be directly connected to another IP network gateway or proxy without using any intermediary entities for translation.
- *ZigBee:* Based on IEEE802.15.4 low power wireless networks, the ZigBee Alliance was created. ZigBee is a standard for high-level suites of inexpensive protocols for the creation of personal areas, low power digital radios, and small-sized networks for data transmission over greater distances.
- *Bluetooth Low Energy (BLE):* BLE is also known as a smart Bluetooth Essential IoT programme protocol. It is intended to be enhanced for fast, low bandwidth, and low latency IoT applications.
- *Near-Field-Communication (NFC):* NFC is a wireless contact technology that transmits data between devices over a very short distance.
- *Message Queue Telemetry Transport (MQTT):* The MQTT protocol is the actual norm for IoT communications. The MQTT publish/subscribe protocol, which is an OASIS and ISO standard, provides a scalable and reliable way to link devices over the Internet.
- *Wi-Fi:* Wi-Fi is a wireless internet technology that transfers networks via electromagnetic waves. Wi-Fi integration and interoperability will enable IoT solutions to securely interact with one another and with billions of user-centric devices in order to extract the most value from IoT applications and settings.

E. User Interface

User interaction is vital in a wide spectrum of software and systems. This is also applicable to Internet of Things (IoT) technologies. However, IoT has grown well beyond the installation of commercial plants: IoT is already (and will stay) an aspect of everyday life for customers. As a result, interfaces for users in the Internet of Things (IoT) system are going to have an increasingly essential role in consumer acceptance, much as they do in other domains like the internet, mobile, and wearables. [60]

1) *Mobile Application:* The creation of internet-of-things apps for mobile apps allows for the administration of smart devices such as smart watches, detectors, medical equipment, and other gadgets. With less hazards and expenses for the workforce, to offer a simple and comfortable user experience, a single application combines device-specific programmes on a single dashboard.
2) *Websites:* Websites are the most often utilized user interfaces for IoT based solutions. It is an easy-to-use online software solution that simplifies Stock, Client Data, Sales Leads, Customer Orders, and other inventory management systems.

F. Cloud platform

The "cloud platform" relates to a server's operating system and hardware in a cloud data centre. It enables the coexistence of distant and widespread hardware and software products. Using this paradigm, a cloud computing service which you are able to use via the public web or a specialized personal connection allows you to store data over the internet. The provider secures and maintains its storage servers, facilities and network to ensure that information of any size may be accessed. Wi-Fi modules are used in IoT systems to save data in the cloud. The data may then be obtained and examined via HTTP protocol.

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TABLE I

Ref.	Sensors	IC	Communication Protocol	User Interface	Key features
[1]	Load cell1 for countable and load cell 2 for uncountable groceries	Raspberry Pi Microcontroller	NodeMCUESP8266 (Wireless WiFi module) (MQTT protocol)	Website	A complete, inexpensive, strong, and easy-to-use continuous tracking and kitchen control via remote system.
[2]	Load cell	Raspberry Pi	MQTT protocol	Mobile application	Keeping track of the availability of food in the kitchen. Automatic grocery ordering based on inventory levels.
[3]	Load cell	Arduino Mega	Node MCU ESP8266(TCP and 12 C)	Website	Maintain inventory control. Grocery shopping is done automatically. It is environmentally friendly since it consumes very little electricity and has reusable rechargeable batteries.
[4]	Ultrasonic sensor	Arduino Uno microcontroller	Wi-Fi module(ESP8266)	Mobile application	Places orders once the groceries level found to below.
[6]	DHT-11 Sensor Ch4 Sensor Light Sensor	Arduino Mega	Wi-Fi module(ESP8266)	Mobile application	Temperature and humidity are measured within the containers. When an emergency happens, the user is notified via messages, along with the location of the cargo.
[7]	HC-SR04 Ultrasonic sensor	Raspberry Pi	Wi-Fi module with Realtek 8188 EU chipset	Website	Order placement is automated. Self-sustaining, with no delays caused by insufficient inventory.
[8]	Ultrasound sensor Color sensor Infrared sensor	Raspberry Pi and Arduino module	Wi-Fi/Bluetooth	Mobile application	Automatic inventory management system for remote inventory management and inventory status monitoring. Can be utilized in a small business without the need for a separate terminal.
[9]	Load cell	Arduino Microcontroller	Wi-Fi module MQTT broker	Desktop application Android application	A food stock tracking system built on the Internet of Things guarantees real-time inventory monitoring in the kitchen.

[10]	Load cell	Arduino Mega	Node MCU(ESP8266) Wi-Fi module	Website and App	Manage the inventory's average use of commodities and items.
[11]	HC-SR04™ ultra-sonic sensor	TARANGTMP-20MODULE	Wi-Fi module	Website	Measures the container fill state and sends the notification to the user to update the entire process.
[14]	Load cell with HX711IC Driver LM35IC Temperature sensor	Raspberry Pi 3B+and Arduino module	Wi-Fi module	Mobile application	Reduce the need of human labor, enhancing speed and delivery accuracy, and providing merchants with unprecedented visibility into inventory and supply networks.
[15]	Fork lift UWBIMU Scale RFID tag	Arduino microcontroller	LoRa module WCDMA module Wi-Fi module RFID	Web server	Automated warehouse management
[16]	RFID tag	RaspberryPi3	Node MCU (ESP8266-12e) Wi-Fi module RFID	Web server	Warehouse inventory management system. Very low-cost system and works dynamically.
[17]	RFID tag	Controller	WiFi module RFID	Mobile application	Real-time visibility into the whole logistics process improves inventory operation efficiency by conserving human resources and lowering operational costs.
[18]	Temperature sensor Humidity sensor Illumination sensor	Raspberry Pi 3B+	Wi-Fi module(ESP8266)	Mobile application/ Web application	System for warehouse monitoring and control. Possess more control over commodities, lowering the risk of harm and improving the quality of the warehousing operation.
[19]	MQ2 gas sensor MQ135 sensor LM35 Temperature sensor	Arduino Uno	Node MCU ESP8266	Web server	Simple gas leak detector is its simplicity and its ability to warn its stakeholders about the leakage of the Gas.
[20]	Load cell with HX711 ADC MQ2 smoke sensor MQ5 gas sensor	Microcontroller	SMTP (Simple Mail Transfer Protocol)	Web application	The user is wary about LPG leaks and even of gas. LPG detector tells the user when there is a leak and also when the gas cylinder is nearly empty.

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[21]	Load cell Gas sensor Temperature And Humidity sensor	ATMega35 Microcontroller	Wi-Fi module/Bluetooth	Web server	Alerts the user of gas leakage. Prevent accidents and hazards. Cost effective and time consuming.
[23]	DHT22 sensor QM-135 gas sensor PIR sensor	Node MCU ESP8266- 12eboard	Wi-Fi module	Web server	Existence of gas leakage, uncontrolled fire, extreme temperature, and in hospitable environment is identified and addressed as soon as possible.
[25]	RFID tag	Arduino Uno with AT Mega328p microcontroller	ESP 8266 Node MCU RFID	Web server	Assist the building industry with inventory management of necessary form work shuttering goods.
[26]	Piezoelectric Loadcell1 Loadcell2	Arduino UNO and Mediatek Linkit ONE.	Wi-Fi module/HM- 10BLEmodule	Mobile application	Allow for automated, real-time updates on inventory availability. Notify the user if food is about to expire. Use past inventory consumption data to improve forecast and planning.
[27]	MQ4 smoke sensor MQ135 gas sensor Load cell	Arduino Uno Microcontroller	Wi-Fi module	Web portal	The daily record of food waste in the computer system contributes to lowering the quantity of food waste at homes and restaurants alike.
[29]	Load cell RFID tag	Arduino Uno	ESP8266 Wi-Fi module RFID	Mobile application	Customers may use the mobile app to look up the availability and details of a product. Retailers may keep track of each product's sales and restock as necessary to prevent situations when the store sells out of a particular item.
[30]	MQ2 gas sensor DHT11 sensor Load cell	Arduino Uno	Node MCU ESP8266	Web application	Notifies the user about the leakage of a gas cylinder and leakage of a gas. Prevent hazards and accidents. Cost efficient and time consuming solution.
[33]	MQ5 gas sensor LM-35sensor	ATMEGA32 Microcontroller	Bluetooth	Mobile application	Detect leakage of the gas. Monitor weight of the gas. Automatically books gas based on availability.

[34]	HC-SR04 Ultrasonic sensor	Raspberry Pi 3+	E-mail	Mobile application	Automatically alert the consumer when a certain commodity is necessary. Places an order for the same with a minimum of human assistance.
[35]	MQ135 gas sensor DHT11sensor Ultrasonic sensor	Microcontroller	ESP32 Module	Web application	Able to control home appliances. Has a scientifically significant effect on electricity usage and cost.
[37]	Load cell	Microcontroller	Node MCU Wi-Fi module	Web server	Identify and teach usage of grocery. Low cost, effective design and easy.
[38]	IR sensor (Fire sensor) MQ2 gas sensor Pressure sensor	Raspberry Pi	GSM module Wi-Fi module	Web server	GSM–extensive coverage of all parameters. Provides a decision making device concept for adaptation to several kitchen scenarios.

The information in the aforementioned table can be summarized as follows. Measuring the quantity of raw materials is the main prerequisite for inventory management. The load cell performs the essential function in this area with the greatest benefits. The implantation of an ultrasonic sensor is another approach to achieve the same result. Utilizing ultrasonic sound waves, it calculates the product's level and distance from the top end of the container. Its main drawback is that it only provides approximations of distances and does not provide measurements in readable units. The type of product in the container affects how the sensor measures and functions (solid or liquid). At an industrial level, gas sensors are used to find gas leaks in warehouses.ESP8266 Wi-Fi Module is the most used communication protocol in line with all the sensors mentioned above. Although the Raspberry Pi is thought to operate more efficiently, the Arduino microcontroller is more practical, more affordable, and used in majority of inventory management devices.

IV. SUMMARY

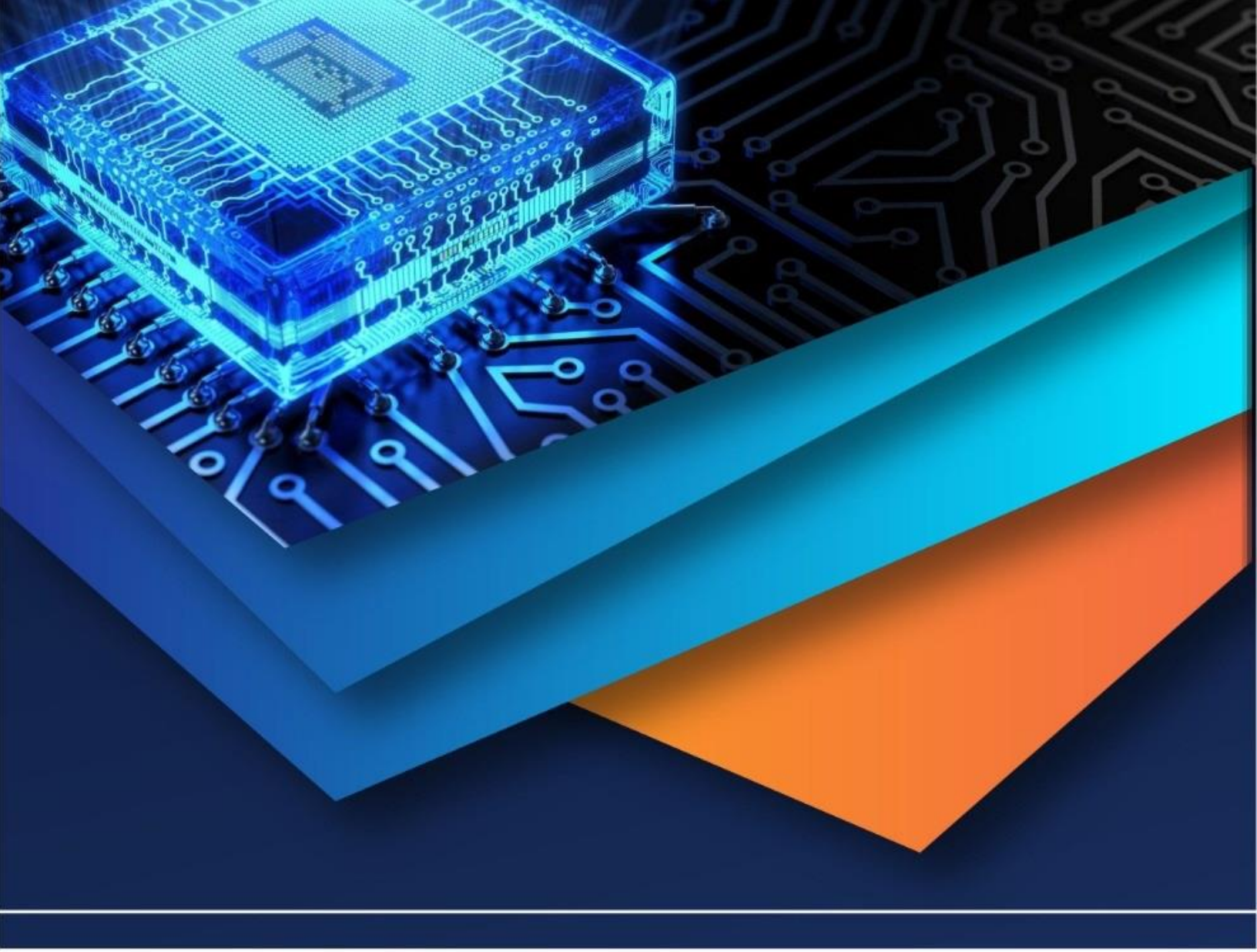
This paper reviewed the literature on the implementation of various technologies that focus on six main areas: food inventory optimization, minimal human intervention, reducing food waste and pilferage, identifying bottlenecks in operations, inventory tracking automation, and constant visibility to inventory quantity, location, and movements. Based on the aforementioned conclusions on inventory management and others, it is clear that the advancement of IOT revolutionised the digital transformation of data and inventory management with less manpower, hence enhancing overall performance efficiency. It was identified that some of the aforementioned papers outlining suggested ideas for inventory management are lacking in some key functionality and are challenging for users who are unaccustomed to using sophisticated technology. In some cases, the user interface might be difficult for users to understand effectively due to its complexity. More study is needed to determine the extent to which these technologies improve efficiency of use.

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