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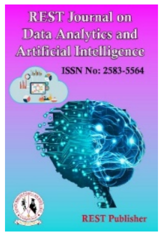

Advance Realtime Monitoring of Food in Refrigerator Based on IoT

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Abstract: *Real-time monitoring of food in refrigerators is one of the many facets of our everyday life that the development of Internet of Things (IoT) technology has revolutionized. People can now easily monitor temperature, humidity, and other key characteristics thanks to IoT-enabled sensors and connection, assuring ideal preservation circumstances and reducing waste. This article examines the advantages and features of sophisticated IoT-based real-time monitoring systems for freezers.there are important ramifications for food hygiene, long-term viability and ease from this study on sophisticated real-time monitoring of food in refrigerators based on IoT. Potential rotting may be avoided by meticulously monitoring and analyzing variations in humidity, which also helps to promote better diets by lowering waste from food. It also makes it possible for automated and prompt alarms, increasing efficiency and guaranteeing the general safety of people and their households. There are numerous crucial elements in the process for developing a smart parking system in an IoT context. First, sensors are placed in parking places to gather up-to-the-minute occupancy information. Then, using wireless communication protocols, this data is sent to a central server or cloud computing platform. After that, a data processing and analysis module interprets the gathered data using algorithms and machine learning techniques and presents parking availability information to users via a mobile application or other user interfaces. For effective management and monitoring of parking spaces, the system also includes automated payment methods and interacts with existing infrastructure. ESR1, ESR2, ESR3, ESR4, ESR5 performance, capacity, features, Security risk, Cost.*

Keywords: *Block chain technology, communication protocols, automation, refrigerator, food.*

1. INTRODUCTION

Indeed, ensuring food safety in the cold-chain process is crucial, and monitoring the temperature, humidity, door status, and location of refrigerator trucks in real-time plays a significant role in maintaining the quality and safety of perishable goods like fruits, dairy products, and meat. To achieve this, several technological solutions can be employed Temperature and Humidity Sensors: Refrigerator trucks should be equipped with temperature and humidity sensors placed strategically within the vehicle. These sensors continuously monitor and transmit the temperature and humidity data to a centralized system.

IoT (Internet of Things) Connectivity: The sensors inside the refrigerator trucks can be connected to an IoT platform, enabling real-time data transmission. This connectivity allows for remote monitoring and control from a centralized location.

Telematics and GPS Tracking: Integrating telematics technology and GPS tracking systems enables the monitoring of the location and movement of the refrigerator trucks. This information provides insights into the transportation process, allowing for better management and coordination..

Remote Monitoring System: A dedicated remote monitoring system can receive and analyze the data from the sensors in real-time. It can issue alerts or notifications if the temperature or humidity deviates from the desired range, allowing for prompt corrective actions.

Data Logging and Reporting: The system should also record the temperature and humidity data over time. This historical data can be used for analysis, quality control, and compliance purposes. Detailed reports and analytics can be generated to identify patterns, detect anomalies, and optimize the cold-chain process.

Mobile Applications: Mobile apps can be developed to provide access to real-time data, alerts, and reports to stakeholders involved in the cold-chain process, such as drivers, logistics managers, and quality control personnel. By implementing these technologies and systems, stakeholders can ensure that the temperature and humidity conditions within refrigerator trucks are continuously monitored, the door status is tracked, and the location of the trucks is known in real-time[1]. This comprehensive monitoring and control enhance food safety, reduce the risk of spoilage, and facilitate timely interventions in case of any deviations or issues. Fruits, vegetables, meat, and frozen desserts are examples of perishable items, and the cold chain is crucial to maintaining their freshness. About 360 million tonnes of perishable goods are wasted each year owing to inadequate refrigeration, according to a research published by the International Institute of Refrigeration[2]. Since it was realised how important cold chain management is, there has been a growing amount of interest in studying ways to keep the right climatic conditions to regulate the quality of perishable foods using cutting-edge technologies. Time temperature integrator (TTI) labels and information on temperatures recorders are examples of traditional techniques . The development of electronic devices in the field of home automation makes an intelligent home application unstoppable. Many smart gadgets are utilised on a daily basis for various purposes.The suggested solution will be aimed for application in the most inevitable appliance, the refrigerator, as IoT develops. The refrigerator is a highly significant component of daily life, thus it should be given additional consideration for modifications to increase its effectiveness and utilisation . A new technology that can help automate duties inside the refrigerator to make people's lives easier and more pleasant has to be presented as well, in light of the rise in automation [5]. Currently, anytime we discuss the Internet of Things or Cloud of Things, smart kitchen immediately comes to mind. The cooking area is the home's biggest garbage generator and second-largest energy consumer, so that explains it.As a result, producers are always looking for methods to create smart kitchen goods that consume less energy and waste while increasing comfort.For instance, a Samsung Smart house promotes a "total household solution" with the tagline "Enrich Your Life" with the intention of reestablishing balance in your life.It offers a means to handle housework remotely while also enhancing activities done at home[6]. The focus of your cumulative dissertation is on establishing a decentralized information system for food supply chain management using block chain technology. Additionally, you demonstrate how this information system can be applied in the context of food safety from a supply chain management perspective .To begin, you establish a safety control system for the food supply chain by integrating your new information system with the Hazard Analysis and Critical Control Points (HACCP) method, which is a widely recognized approach for identifying and controlling food safety hazards. By connecting all the potential hazard points along the food supply chain, your control system enables information collection, transfer, storage, checking, and sharing among supply chain members. The primary objective of this integrated system is to enhance the quality and safety of food products. By leveraging block chain technology, which offers decentralized and immutable data storage and verification, you can establish trust and transparency within the supply chain. This technology ensures that information is securely collected, recorded, and shared among the relevant stakeholders, reducing the risk of fraud, tampering, or data manipulation. By implementing this decentralized information system, supply chain members can have real-time visibility into the various stages of the food supply chain, including production, processing, distribution, and retail. This allows for effective traceability and accountability, making it easier to identify and resolve any issues that may arise. It also enables prompt and efficient recall processes if needed, ensuring consumer safety and minimizing the impact of potential food borne outbreaks. Overall, your research aims to leverage block chain technology to establish a decentralized information system that enhances the safety and quality control of food products throughout the supply chain. By integrating this system with established risk management methods like HACCP, you provide a comprehensive approach to address food safety concerns and improve supply chain management in the food industry[7]. Currently, monitoring calls for a distinct chain of locations where the product is actively scanned (using a serial number, a quick response code, sophisticated label, or data recorder), frequently only giving past information gathered at the time of scanning. This is insufficient in the agri-food industry, where maintaining certain parameters (such as temperature, humidity, etc.) to stop product deterioration is necessary to ensure business continuity and lower supply chain risks.[8]. An article was put out with the goal of improving user diet through the usage of intelligent refrigerators[9]. The aforementioned technologies are frequently employed in fields such as smart fire suppression, intelligent transit, protecting the planet, and safety for everyone, among many others, with the basic goals of increasing mechanisation and social intelligence. In particular, IOT implementation in trucks with refrigerators can improve the effectiveness of the transportation operation. This article is based on the idea of a network of things, the use of RFID, GPRS/GPS, wireless communications, and an Internet-based intelligent monitoring system created for automobiles with refrigerators[10].

2. MATERIALS AND METHODS

2.1 Weighted product method:

By Bridgeman (1922), the Weighted Product Method had been developed. Although the approach has not been extensively used, Yoon and Hwang (1995) claim that it has solid logic and is operationally simple.[1] WPM are frequently used to describe scoring techniques. The Bridgeman-proposed weighted averaged sum product assessment (WASPAS) is a member of the more recent generation of MCDM techniques. With this technique, well-known weighted sum model (WSM) and weighted product model (WPM) methodologies are combined in a novel way.[3] In instances with dynamic environments, it enables excellent ranking correctness. Since it might be difficult for consumers to describe their degree of happiness or discontent with the cloud service providers with regard to the qualities, there is generally confusion in the sharp data.[4]. The approach was used in actual hackers, especially the widespread assaults on Latvia and the Islamic Republic, and the outcomes of the evaluation of the online assaults were given.[5] WPM normalises the performance values of alternatives using equations. It uses many formulae to determine the scores of the choices. The options are ranked by WPM in decreasing order of overall score [10]. In this model, the attribute values are the CSP performance in each measure that is recorded in the history log, while the weights are the QoS preferences supplied by the requesting user.[11] One benefit of WPM is its applicability in both single- and multi-faceted MADMs. The drawback is that there is no solution with an equal weight of the choice vectors instead of real values[12]. The AHP approach is used to determine the relative weights of the various criteria. As a result, the WPM approach is used to rank the potential networks. This technique uses a combination of nets of neurons and utility functions to choose a network. The suggested approach takes use of a fuzzy neural network to gather network-, user-, and terminal-related input criteria and assess each access network's performance [14]. T Multiple Criteria Decision Making (MCDM) models and fuzzy synthesised choices are the foundation of several service choosing methodologies. [21]he findings we have acquired to assess our choice of services offered by the cloud indicated that our model outperforms previous MDMC approaches like TOPSIS, WPM, and the original AHP[17], captures the BDTP extremely well, guarantees Big Data QoS, and scales with the growing number of cloud providers. Through a variety of cloud services from several CSPs, WPM, the SAW, and imposed QoS requirements of Big Data workflows were used[16]. Similar to WSM is the Weighted Product Method (WPM). The primary distinction is that multiplication is required in WPM rather than addition. The score for total performance is calculated as [18].WPM should be used to promote strict cyber security regulations, according to further research.[13] When choosing a cloud-based cyber security solution, organisations may make educated selections by adhering to the Weighted Product Methodology. The methodical assessment of various criteria and the weights given to them aids in the prioritisation of needs and the choice of a solution that best fits the organization's cyber security goals[25].

2.2 Parameters

E-SMART REFRIGERATOR:

An e-smart refrigerator, also known as a smart refrigerator or connected refrigerator, is a modern appliance that incorporates advanced technology and internet connectivity to provide additional features and functionality compared to traditional refrigerators.

Performance:

Performance is crucial when evaluating an e-smart refrigerator. Factors like cooling efficiency, connectivity, app integration, user interface, energy efficiency, build quality, and noise level contribute to an optimal user experience and long-term satisfaction with the appliance.

Capacity:

Capacity is an important consideration when choosing an e-smart refrigerator. It determines how much food and beverages the appliance can store. Consider your household's needs and look for a model with ample storage space to accommodate your groceries and other items.

Features:

E-smart refrigerators offer a wide range of advanced features. These include internet connectivity, touch screen displays, food management systems, energy efficiency, voice control, notifications, entertainment options, and more. Choose a model that suits your needs and enhances your kitchen experience.

Security risk:

While e-smart refrigerators bring convenience, they can also pose security risks. With internet connectivity, vulnerabilities may exist, potentially leading to unauthorized access, data breaches, or even cyber attacks. Regularly update firmware, use strong passwords, and follow security best practices to mitigate risks.

Cost :

The cost of e-smart refrigerators varies depending on factors like brand, size, features, and overall quality. While they may have a higher upfront cost compared to traditional refrigerators, the added functionality and convenience can provide long-term value and energy savings.

3. RESULT AND DISCUSSION

TABLE 1. Advance Realtime Monitoring of Food in Refrigerator Based on IoT

	performance	**capacity**	**Features**	**Security risk**	**Cost**
ESR1	0.6452	0.9625	0.1138	0.0575	0.6965
ESR2	0.6581	0.8128	0.7988	0.2739	0.9746
ESR3	0.7416	0.8052	0.0594	0.3617	0.3837
ESR4	0.3283	0.3651	0.6030	0.7036	0.1278
ESR5	0.1861	0.7980	0.8450	0.4997	0.5179

Table 1 shows us the data sets which have alternative parameters: ESR1, ESR2, ESR3, ESR4, ESR5 and evaluation parameters : performance, capacity, features, Security risk, Cost. Which bear some values.

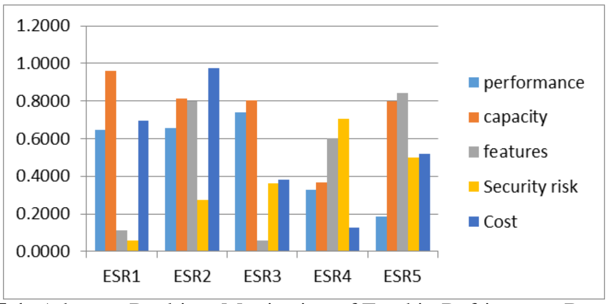

FIGURE 1. Advance Realtime Monitoring of Food in Refrigerator Based on IoT

Figure 1 shows us the graphical representation of the table 1 which have alternative parameters "ESR1, ESR2, ESR3, ESR4, ESR5" and evaluation parameters :" performance, capacity, features, Security risk, Cost". Which bear some values.

TABLE 2. Performance value

	performance	**capacity**	**features**	**Security risk**	**Cost**
ESR1	0.87002	1.00000	0.13467	0.08167	0.18349
ESR2	0.88736	0.84453	0.94539	0.38932	0.13114
ESR3	1.00000	0.83660	0.07028	0.51400	0.33308
ESR4	0.44275	0.37935	0.71362	1.00000	1.00000
ESR5	0.25096	0.82915	1.00000	0.71019	0.24678

Table 2 shows us the normalized values of the given data by using WPM method.

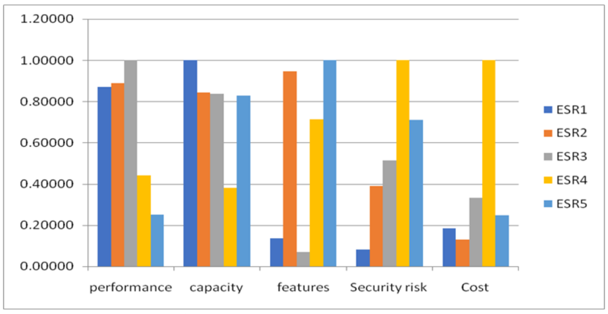

FIGURE 2. Performance value

Figure 2 shows us the ESR4 have maintained a good outcome in every aspect followed by ESR5 and ESR1 stays at the least with least score in almost of the aspects except in performance and capacity.

TABLE 3. Weights Distributed

	performance	capacity	features	Security risk	Cost
ESR1	0.20	0.20	0.20	0.20	0.20
ESR2	0.20	0.20	0.20	0.20	0.20
ESR3	0.20	0.20	0.20	0.20	0.20
ESR4	0.20	0.20	0.20	0.20	0.20
ESR5	0.20	0.20	0.20	0.20	0.20

Table 3 shows the weights of ESRs which are taken equally.

TABLE 4. Weighted normalized decision matrix

	performance	**capacity**	**features**	**Security risk**	**Cost**
ESR1	0.97254	1.00000	0.66966	0.60592	0.71240
ESR2	0.97638	0.96677	0.98883	0.82806	0.66611
ESR3	1.00000	0.96495	0.58799	0.87537	0.80262
ESR4	0.84963	0.82377	0.93474	1.00000	1.00000
ESR5	0.75844	0.96322	1.00000	0.93385	0.75590

Table 4 shows the weighted normalized decision matrix of the ESRs where ESR4 has the highest values in all the aspects followed by ESR5 and ESR1 have the least values in features and security risk which makes the ESR1 to stay at the last position.

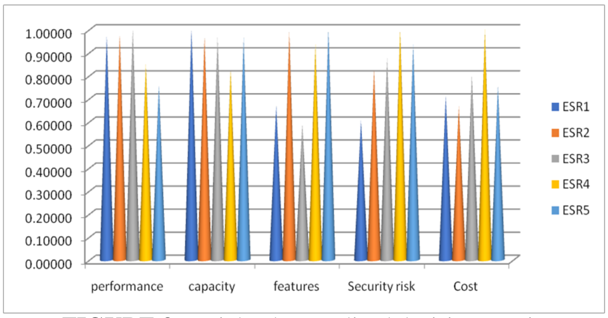

FIGURE 3. Weighted normalized decision matrix

Figure 3 represents the graph of the above table where ESR1 has the least graphs and ESR4 stays on top by having a good average in all the features mentioned.

TABLE 5. Preference Score

Alternatives	Preference Score
ESR1	0.28112
ESR2	0.51484
ESR3	0.39864
ESR4	0.65423
ESR5	0.51569

Table 5 the above table shows the preference score of the 5 ESRs among them ESR4stands on the top with a score of 0.65423 and least is of ESR1 with a score of 0.28112 and this is obtained by using the WPM method.

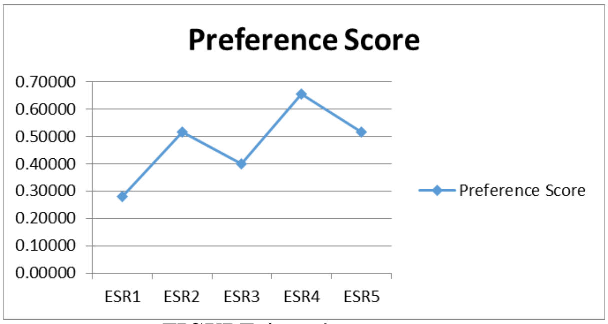

FIGURE 4. Preference score

Figure 4 shows the graphical representation of the above table. We can clearly see that near ESR4 there is a high spike at the ESR4 and least spike at ESR1 which decide their position in ranking and this is analyzed by using WSM method.

TABLE 6. Rank

Alternatives	Rank
ESR1	**5**
ESR2	**3**
ESR3	**4**
ESR4	**1**
ESR5	**2**

Table 6 shows the rankings of the ESRs where ESR4 stands at the first place followed by ESR5 and ESR2 and ESR3 and ESR1 stands at 4th and 5th place . this is analysed by using WSM method.

4. CONCLUSION

In conclusion, the advent of advance real-time monitoring of food in refrigerators based on the Internet of Things (IoT) brings numerous benefits and advancements to the realm of food storage and management. By leveraging IoT technology, refrigerators can now provide seamless and intelligent monitoring of food items, ensuring optimal freshness and reducing food waste. The real-time monitoring capabilities of IoT-enabled refrigerators allow users to remotely access information about the contents of their fridge. Internal cameras capture images of the items stored inside, while sensors track temperature, humidity, and expiration dates. This information can be accessed through a companion app or a web portal, providing users with a comprehensive overview of the food inventory and its condition. This level of connectivity and monitoring empowers users to make informed decisions about their groceries. They can check the status of items while grocery shopping, minimizing the risk of purchasing duplicates or forgetting necessary ingredients. Moreover, the ability to receive alerts and notifications about expiring items or unusual temperature fluctuations enables proactive management, preventing food spoilage and promoting healthier eating habits.The IoT-based monitoring also enhances food safety. The ability to track temperature variations in real-time ensures that the fridge maintains an optimal and safe storage environment. This is particularly crucial for perishable items such as meats, dairy products, and certain fruits and vegetables that require specific temperature conditions to remain fresh and safe for consumption. While the advance real-time monitoring of food in refrigerators based on IoT brings significant benefits, it is important to consider the security aspect. Manufacturers and users must prioritize cyber security measures to protect sensitive data and ensure the privacy of individuals. Overall, the integration of IoT technology into refrigerators revolutionizes the way we manage our food. It enhances convenience, reduces waste, improves food safety, and promotes more efficient and informed grocery shopping habits. The future holds even more possibilities as IoT technology continues to evolve, further refining the monitoring capabilities and creating a smarter, more sustainable kitchen ecosystem.

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