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Perishable Food RFID Traceability System with IoT Sensors

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Abstract: The food industry is usually rated by the quality of the goods and products served by the company. Thus, maintaining quality plays a crucial role. In recent years, consumers are starting to take care of their food quality intake for greater health. This project paper will describe "Perishable Food RFID Traceability System with IoT Sensors" designed by using RFID and IoT devices to precisely identify the surrounding condition and location of the perishable food to maintain the safety and quality of perishable food during transportation and storage. Tracking real-time location and the ambiance temperature could ensure the logistics can achieve the objectives and also ensure the reliability of the system to maintain food quality.

Keywords: RFID, IoT Sensors, Logistic

1. Introduction

Perishable food is a product that its quality is easily becoming worst due to the inconsistent surrounding conditions over time especially throughout the transportation of the product from the supplier to the consumers. To keep the perishable good, an excellent quality logistic system that gives constant supervision is needed. There is a supplier that still uses outdated logistic systems which they maintained to use the traditional paper to track their logistic processes that could cause an error and delay in sharing information. Sometimes customers did not have a choice in choosing a great quality of their food due to the lack of fresh products at the market which worries the consumers because those products might already be contaminated foods and could affect their health. The supply chain should be improvising its performance by tracking and tracing the logistic process with the technology of RFID traceability. A better quality IoT monitoring system could help in measuring the surrounding condition of the perishable food during transportation to give caution to the supplier and consumer about the product.

The main objectives for this project is to design a prototype of Perishable Food RFID Traceability System with IoT Sensors circuit that maintaining the quality and safety of the perishable food, to simulate the Perishable Food RFID Traceability System with IoT Sensors device for the implementation

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for the food industry, and to evaluate the performance of the Perishable Food RFID Traceability System with IoT Sensors device in tracking and tracing the perishable food's surrounding condition and location.

The perishable food used for this project is carton milk. This prototype is designed and simulated using Proteus 8 Professional before the prototype is created. The RFID reader will be installed at the supplier's and the market's gate. The RFID tag and IoT sensors are embedded with the product's container. The data collected will be shared with the supplier and consumer through the Blynk Application. The size of the prototype is 30 cm x 41 cm x 15 cm. This project could benefit suppliers where they could always provide fresh perishable. Consumers also could keep a healthy life when they are consuming fresh food.

Blockchain framework were chosen to implement in this perishable food traceability system because this blockchain has a lot advantage such as it could improve the real time information and transparency in the food supply chain as stated in the study [7]. Besides, RFID technology and IoT-based sensor allows several supply chain partners generate product information during transporting the product such as the condition and location of the product, according to the [9]. The RFID reader also much easier to develop which it can be used straight away compared to the customized RFID tag which have to modify it with an ionic liquid before use, referring to [10]. The concept used in [13] can be used to develop the traceability system which it consists of sensor layer, network layer and the application layer.

2. Materials and Methods

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study.

2.1 Electrical Components

The table below is a list of electrical components that need to be prepared to develop the Perishable Food RFID Traceability System with IoT Sensors prototype project.

Table 1: List of electrical components

No	Description	Quantity
1	Arduino NodeMCU V3 ESP8266 WIFI Controller Board	3
2	Arduino RFID RC522 Card Reader Module	2
3	Arduino DHT11 Temperature and Humidity Module	1
4	Light Sensor Module LDR Photo Resistor Module	1
5	Breadboard	3
6	Resistor 1k	1
7	Connecting Wires	1 meter

2.2 Methods

Figure 1 below shows the steps of developing the Perishable Food RFID Traceability System with IoT Sensors.

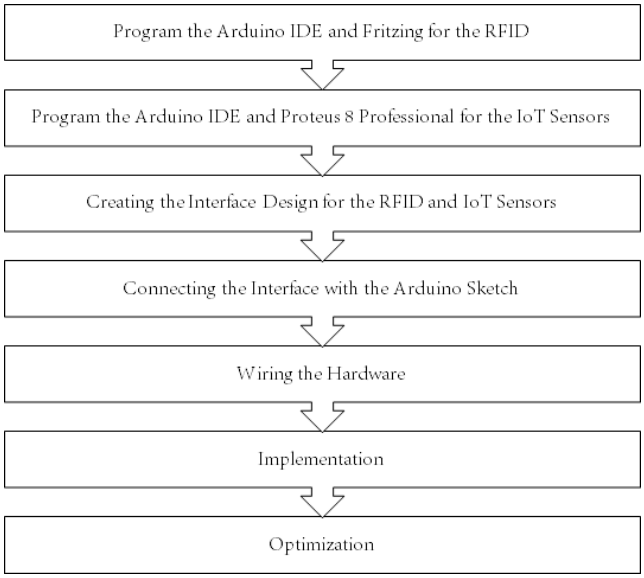


Figure 1: Flowchart of Steps to Develop the Prototype

2.3 System Design

This section is divided into two parts which are electrical design and interface design. The electrical design will show the electrical components connected for the device. While the interface design is to enable a user to communicate with a computer or system. Figure below illustrates the concept of the system design.

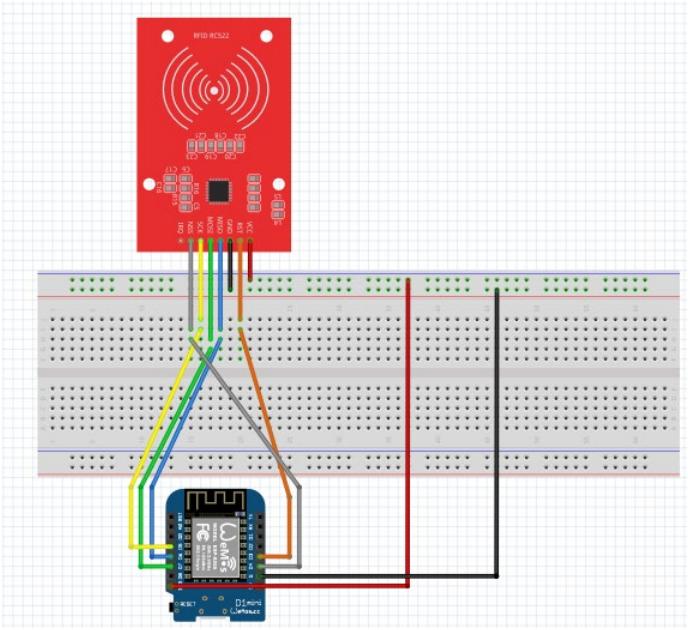


Figure 2: Electrical Circuit Design of the RFID Traceability System

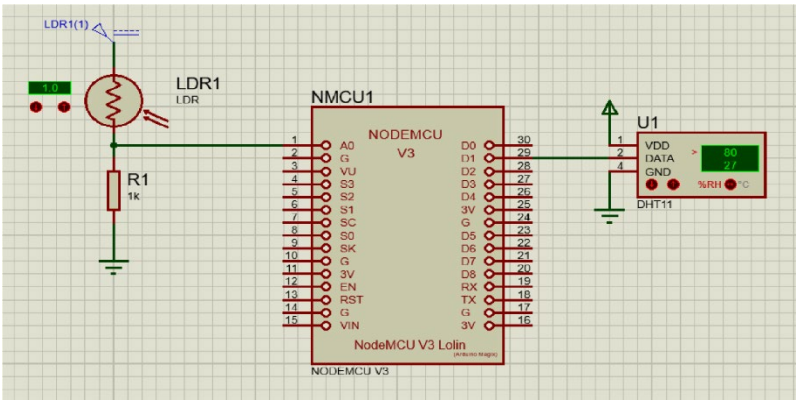


Figure 3: Electrical Circuit Design of the IoT Monitoring System

Figure 2 shows the RFID traceability system's electrical circuit design which designed using the Fritzing software. The distance read range for the RC522 is 5 cm. While Figure 3 shows the electrical design of the IoT sensors that are controlled by the ESP8266. This design is constructed using the Proteus 8 Professional Software.

Figure 4: Interface Design

Figure 4 is showing the interface designs for the communication between the human and devices of the Perishable Food RFID Traceability System with IoT Sensor. This interface design is constructed using the Blynk Application. Supplier can monitor their product while the consumer officer or the consumer themself can monitor the product's surrounding condition history throughout the journey from the supplier to the market.

2.3 Architecture of the System

Figure 5 below shows the architecture of the system and the working principles. It represents the traceability system throughout the movement of the product from the supplier to the market.

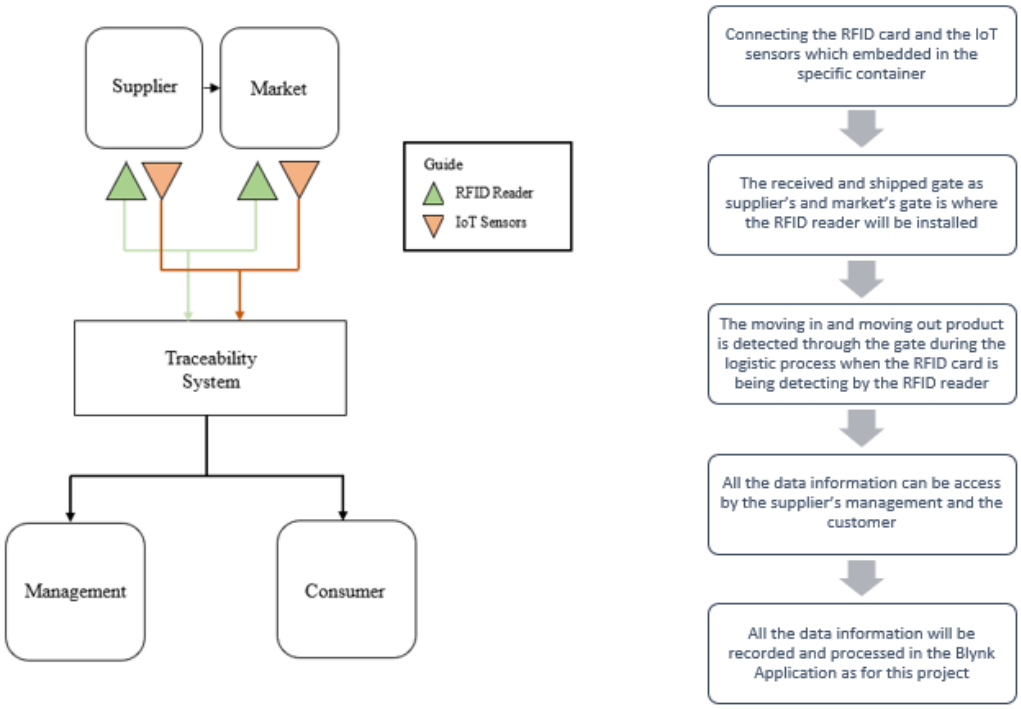
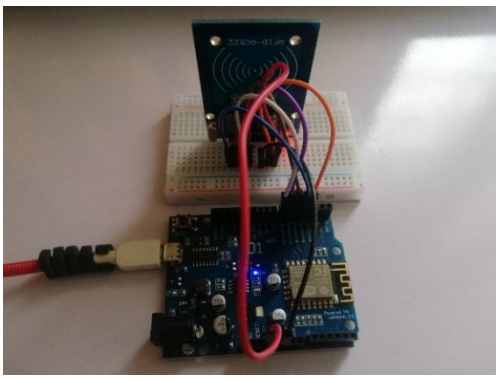


Figure 5: Architecture of the System

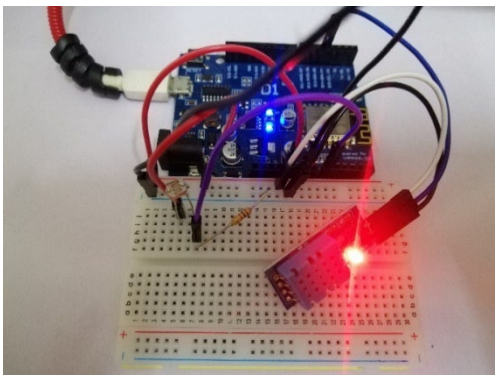
3. Results and Discussion

3.1 Results

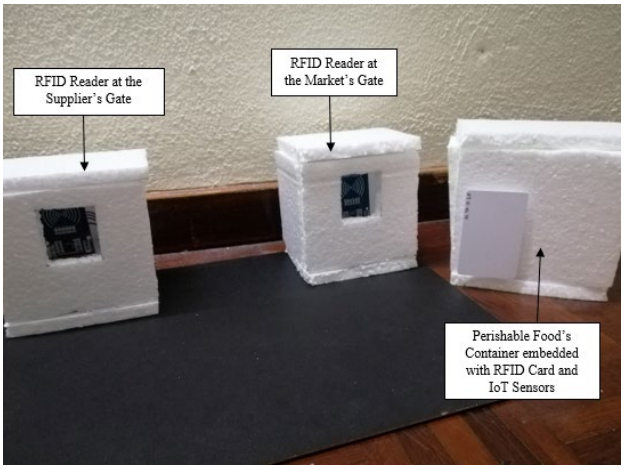
Several studies have been conducted relating the application of RFID and IoT sensors in logistics. Based on the literature review relating to the methodology it is expected that the RFID and IoT sensor can help in sustaining perishable food during logistic.



(a)



(b)



(c)

Figure 6: Prototype of the Perishable Food RFID Traceability System with IoT Sensors

Figure 6 shows the prototype of the Perishable Food RFID Traceability System with IoT Sensors. Figure 6 (a) shows the RFID traceability system prototype to represent as the actual device that will be placed at the supplier's and market's gate. While the Figure 6 (b) shows the perishable food's container embedded with the RFID card at the outside. While the IoT sensors are embedded inside of the container. Figure 6 (c) shows the RFID reader and the perishable food's container

Table 2: IoT sensor value reading

No	Sensor	Limit Setting	Reading Value	
			Good Condition	Bad Condition
1	LDR	<= 200	10	117
2	DHT11 Temperature and Humidity	t = 16°C, h = 81%	t = 16°C, h = 83%	t = 31°C, h = 91%

Table 2 shows the analysis of the IoT sensors' reading value that displayed on the gauges. In order to keep the perishable food in a good quality, set the limit of the IoT sensors. The limit setting for the LDR is below than the value 200. This could help when it gives warning to the user if there is any light exposure to the food during the journey of the food supply chain. While the limit setting for the temperature of the DHT11 sensor is 16°C and for the humidity is 81%.

Figure below shows the simulation results of the Perishable Food RFID Traceability System with IoT Sensors. The data from the whole hardware testing was projected to be used for a 1-hour journey, with 1 minute of testing equaling 10 minutes. The graph plotted during 6 minutes of testing are shown in the figure below.

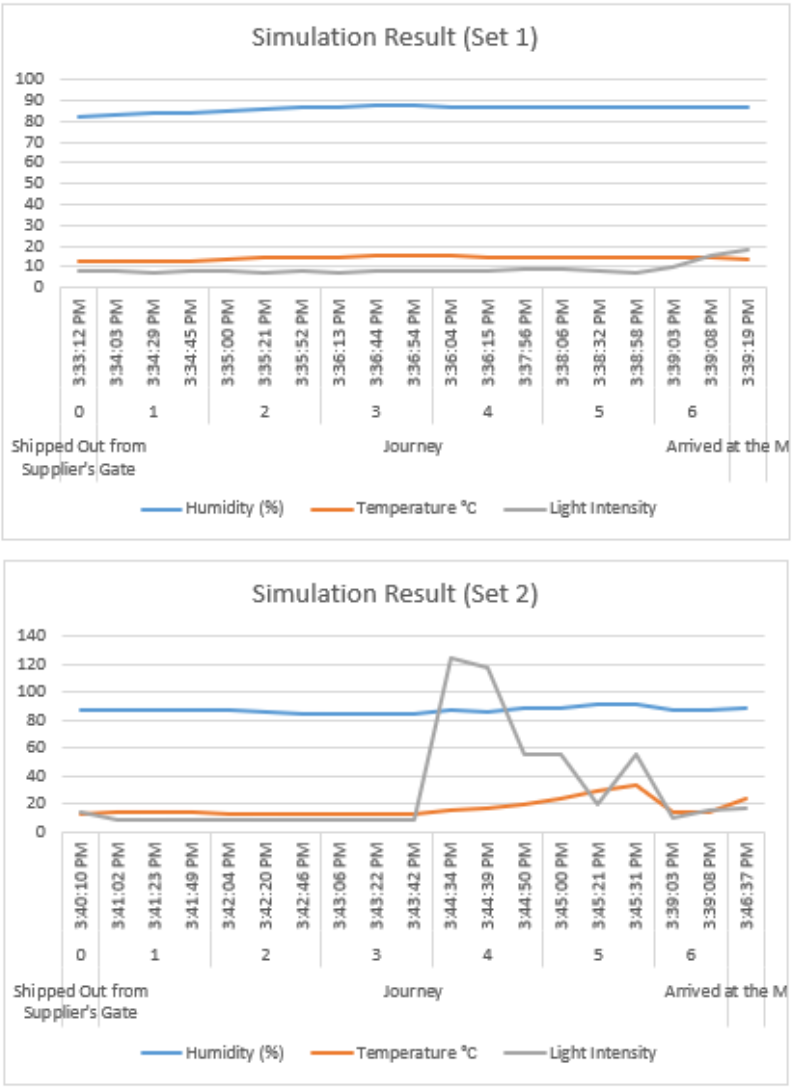


Figure 7: Simulation results of the Perishable Food RFID Traceability System with IoT Sensors

3.2 Discussions

Referring to Set 1 the condition of the perishable food's surrounding throughout the journey from the supplier to market is in an excellent condition. This can be seen where the humidity, temperature and light intensity is constantly in a suitable value for the 1- hour journey. The humidity value observed is not above that 90% and it is constantly in a suitable range value which gives a good sign that the perishable food is still in a good condition and will have a long shelf life. Also, the value of the temperature is not exceeding 20°C and which mean the perishable food is kept in a constant cold temperature. Moreover, there is no increasing value and its not exceeding 80 value of the light intensity which mean the perishable food is not exposure to sunlight that could affect its freshness and quality.

Discussing the Set 2, the condition of the perishable food's surrounding throughout the journey from the supplier to market is not in an excellent condition. This can be seen that there are slightest changing value of the humidity, temperature, and light intensity during the 1- hour journey. The changes value can be observed during the 4th minute which at 3.44pm. The humidity is increasing until it exceeds to 91% which means there a presence of moisture. The presence of moisture can lead to the breakdown of paper packaging [17]. As a result, food contamination or spoilage could occur as a result of package deterioration. Also, the value of the temperature is increasing until 32.8°C which means the perishable food is not kept in a constant cold temperature. This is the proof that the perishable food did

not have a long shelf life due to higher surrounding temperatures may cause vitamins in food to break down, lowering their nutritional value. Moreover, there is increasing value up to 125 of the light intensity which means the perishable food is expose to sunlight.

4. Conclusion

The performance of the food supply chain by using RFID traceability technology could be improve by tracking and tracing the logistic process which can be achieved by implementing the RFID technology at the supplier's and market's gate. The IoT sensors provide the product's surrounding condition during its journey to supplier and consumer to be sure that the product is still good to consume and not harm people's health. This project also can be improvised by implement the GSM module in the RFID traceability system. This could help in providing more accurate information to the supplier and consumer of the product's location.

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