iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** XI **Month of publication:** November 2023

DOI: https://doi.org/10.22214/ijraset.2023.57118

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue XI Nov 2023- Available at www.ijraset.com

Smart Shopping Cart Using RFID

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Abstract: ***Optimizing the shopping experience is essential for both customers and businesses in the dynamic world of retail. This research study offers a revolutionary solution called the "Smart Shopping Cart," which uses Radio-Frequency Identification (RFID) technology to speed up the shopping experience. This ground-breaking solution promises to boost shopping cart functionality, enhance inventory control, and provide customers with a smooth purchasing experience. The Smart Shopping Cart makes use of an integrated RFID reader system and RFID tags that are attached to each product. It enables automatic item tracking, doing away with the requirement for human checkout scanning. This technologically advanced method cuts down on consumers' wait times at the register and minimizes pricing and item recognition mistakes, enhancing their entire shopping experience. Moreover, the system incorporates real-time inventory management features, enabling retailers to monitor product stock levels efficiently. This results in reduced out-of-stock occurrences and optimized supply chain operations, benefiting both retailers and consumers. Additionally, the Smart Shopping Cart can provide personalized shopping recommendations and promotions, enhancing customer engagement and loyalty. This research paper examines the Smart Shopping Cart's technical implementation, RFID integration, data processing, and security. It analyzes potential benefits, environmental impact, and ethical concerns, focusing on efficiency, reduced operational costs, and customer satisfaction. In conclusion, the Smart Shopping Cart, which makes use of RFID technology, presents a solution that has the potential to change the way people shop currently, to the advantage of both customers and businesses. This innovation offers a tremendous chance for shops looking to stay competitive in the digital age to increase productivity, cut costs, and provide a better shopping experience. This study gives helpful advice for the effective implementation of RFID-based Smart Shopping Carts in the retail sector as well as insights into their potential.***

Keywords: ***Smart Shopping cart, Retail Efficiency, RFID technology, RFID tag, LCD, RFID reader, Barcode reader, Retail efficiency.***

I. INTRODUCTION

The retail sector is not immune to change in this era of technological innovation. Through the use of cutting-edge technologies, the traditional shopping experience, which was traditionally characterized by manual product selection and checkout procedures, is currently going through a significant transition. Among these, Radio-Frequency Identification (RFID) stands out as a paradigm-shifting innovation that has fundamentally altered how customers interact with retailers, goods, and their entire shopping experience. This study examines the intriguing field of RFID technology and how it has been incorporated into the field of retail through the development of smart shopping carts. Smart Shopping Carts utilize RFID technology to enhance efficiency and convenience in the retail sector.

These carts, equipped with RFID readers and sensors, enable real-time tracking of items added to the cart, reducing wait times and enhancing the overall shopping experience. RFID technology also provides personalized recommendations, in-depth product information, and navigation assistance. This study explores the wide-ranging effects that RFID-enabled smart shopping carts have on the retail industry. We'll look at the fundamental ideas behind RFID technology, how it has developed, and how it has been incorporated into the retail industry.

Additionally, we will look into the benefits and drawbacks of this technology from the standpoints of consumers and retailers. To further highlight the usefulness of Smart Shopping Carts with RFID integration, we will examine real-world case studies and deployments. As we begin this exploration, it quickly becomes clear that the fusion of RFID technology and Smart Shopping Carts has the ability to fundamentally alter how we buy, making it more entertaining, efficient, and easy. This research paper explores the transformative power of technology in retail, its implications for the future, and its potential to inspire innovation and research, benefiting retailers and consumers.

Fig.1. FRID Smart Cart

II. LITERATURE REVIEW

We have studied some of the papers before starting a project and would mention some of the key information about those papers. So, the first paper titled “Data Transmission using RFID system on Shopping carts or checkout process efficiency in Supermarket at Indonesia” strives to conduct a survey comparing the barcode scanning procedure with the RFID technology in retail industry at Indonesia. This paper regarding development of Smart Shopping System using Smart Shopping Carts shows that it is able to reduce queue time by eliminating the barcode scanning process during the checkout process as the process of scanning items to be shopped has been independently done in the shopping process by the customer. RFID shows a high capability, durability, and efficiency. [1] The second paper implies that the super market shopping system will feature RFID tags on products, carts with RFID readers and ZigBee Trans receivers, online payment procedures, and anti-theft measures. This will simplify the shopping experience, provide an anti-theft system, enable online transactions, and offer suggestions for product purchases. However, proper functioning of RFID tags and ZigBee is required.[2] The third presents a prototype of intelligent Smart Shopping Cart Learning Agents, combining machine learning techniques, beacon-based navigation, hologram-based navigation, Picture Exchange Communication System integration, language understanding, speech synthesis capabilities, drag-and- drop techniques, and keyboard button combinations. The system is partially observable, cooperative, and multi-agent, with deterministic shopping environments and episodic tasks.[3] The work is done with the help of RFID technology with the help of an EM-18 reader, an RFID card and Node MCU. The main aim of this smart trolley is to reduce the time wasted at the time of billing of the product so that the customers get more benefit. It can be implemented where a huge amount of the rush in the mall by replacing the normal trolley with the smart trolley, which takes less time in this world of automation.[4] This study examines the impact of a smart cart system on work performance and convenience from a human factors perspective. Key findings include tilting the cart handle to 45°, using a pick-to-light system for better performance, and positioning the touch screen at 250mm from the handle for eye, arm, and wrist comfort. The smart cart is expected to enhance workers' task choices and improve overall work performance.[5] Since the commercial introduction of barcodes in the early 1970s, automated identification (auto-ID) has been extensively employed in daily life. RFID (Radio Frequency Identification) use has gained widespread acceptance more recently, roughly after 2003. While the simplicity, efficacy, and efficiency of these automated identification technologies are all improved, the related risks must be carefully weighed against the benefits. Automated identification has the ability to expose its subject to security and privacy problems by its very nature. In order to define related attack scenarios and explore countermeasures, we take into account unique vulnerabilities related to barcode and RFID.[6] The remainder of the seventh [7] paper is structured as follows: In Section 1, we learn about the history of RFID. Additionally, the theoretical foundation and hypothesis development are explained in this part. The study technique is presented in Section 2 along with a description of the data. Data analysis is explained in Section 3. The findings and management ramifications are covered in Section 4. With limits and potential directions for further research, the result is summarized in the final section.

The brief of the eighth paper is as follows. The Internet of Things (IoT) is advancing through sensor, RFID, and embedded system technologies, which can improve food logistics management, quality, safety, and packaging. RFID technology offers benefits like accuracy, speed, and larger store capacity compared to barcodes. However, it still faces challenges in overcoming obstacles and is still widely used in modern life.[8]

In order to increase read range, this research proposes three array topologies of chipless RFID tags. It is suggested to use an RFID tag without a chip that has eleven stacked octagonal resonators. The suggested single element tag has a read range of 1.20 meters, 10 bits of encoding capacity, and spectral and spatial efficiency of 1.821 bits/GHz and 2.066 bits/cm2, respectively. Array arrangement is used to increase the tag read range even more. The 2x2, 3x3, and 4x4 arrays attain read ranges of 2.20 m, 3.20 m, and 4.20 m, respectively. The suggested chipless RFID tag is built on a 0.15 mm ultrathin substrate, allowing it to conform to the tag. The simulated and measured findings show a fair degree of consistency.[9]RFID technology is a new sensing paradigm due to its cost-effectiveness, wireless power transfer capabilities, and versatility. It has been successful in industries like logistics, apparel, agriculture, food, and manufacturing. This review explores RFID's working principles, evolution, and applications, comparing it to wired and Wireless Sensor Networks. Principal RFID applications include agriculture, aviation, structural health monitoring, biomedicine, food processing, and more. A generalized methodology for intelligent condition monitoring using RFID and Machine Learning is suggested.[10]

III. METHODOLOGY

A smart shopping cart using RFID technology requires defining requirements, researching technology, identifying system components, tagging products, and integrating sensors, displays, and wireless connectivity. Tagging products involves attaching RFID tags to individual items or grouping them into containers or packages, and connecting RFID readers, antennas, and other components to the cart. Software development involves creating a user interface, implementing RFID data processing algorithms, and integrating with backend systems. Data processing and tracking extract information from RFID data, while User Experience Design is crucial. Testing and evaluation ensure proper installation and integration with existing infrastructure.

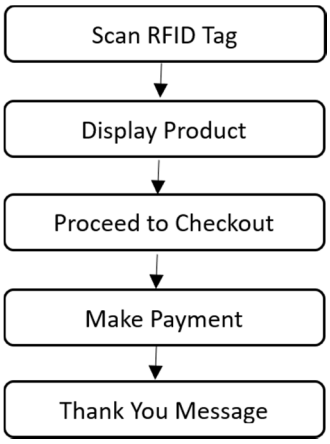

Fig.2, Working Flowchart

The above flowchart gives a view of how the proposed is meant to work. Here we present a brief explanation of each step in the flowchart

1) *Scan RFID Tag:* The RFID scanner detects RFID tags placed on products when they are placed in the cart. Checks if an RFID tag is detected. If a tag is detected, the system retrieves information about the product associated with the RFID tag.
2) *Display Product Information:* The product information is displayed to the shopper, which may include the product name, price, and any other relevant details. Add Product to Cart: The shopper can choose to add the product to their cart
3) *Proceed to Checkout:* The shopper either goes to the checkout counter if the cart is full or continues shopping. At the checkout counter, the shopper reviews the contents of their cart.
4) *Make Payment:* The shopper makes a payment for the items in the cart. Checks if the payment is successful. If the payment is successful, a receipt is printed for the shopper.
5) *Thank You Message:* The system displays a thank you message to the shopper. The process is complete.

This flowchart represents a simplified version of the process. In a real-world scenario, there may be additional steps and decision points, such as handling discounts, promotions, and dealing with missing or damaged RFID tags. The actual implementation may vary depending on the specific requirements and technology used in the smart shopping cart system.

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Volume 11 Issue XI Nov 2023- Available at www.ijraset.com

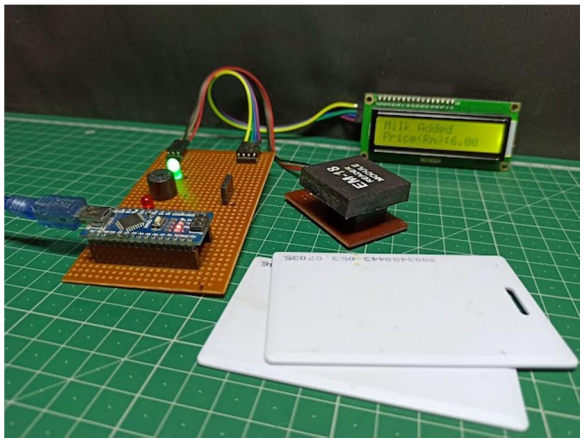

Fig 3: Working Smart Cart Circuit.

IV. RESULTS

So, the results we found out that the RFID technology used in smart cart is been seen more time efficient rather than barcode scanner. We have compared the total time for shopping using both the system and this is what we found out. So, for carrying out comparison we would assume 20 consumers in a queue who are at boiling counter for checking out.[1]

Here, we have some of product conditions for the barcode and RFID system. Products are classified into 3 sub-categories assuming that there are no products without barcode. The category, time and quantity of these products is given in the following table.

A	Barcode easy to Scan	60%	5 secs
B	Barcode hard to find	25%	8 secs
C	Wet barcodes	15%	7 secs

We, assume the packing time (P) for each product as 4 seconds. And an average payment time (R) is 400 seconds. We formulated total time by the

$$(6A \times 5) + (3B \times 8) + (2C \times 7) = \text{Scanning Time}$$

$$P * 4 \text{ seconds} = S \text{ Time}$$

formula w.r.t. paper [1].

a) Scanning Process:

b) Packaging Processes

c) Payment time is 400 secs.

d) Total time for checking out:

$$\text{Total time} = \text{Scanning time} + \text{Packing time} + \text{Payment time}$$

No	Total Items	Scanning Time (seconds)	Packaging Time (seconds)	Payment Time (seconds)	Total Time in seconds
1	10	68	40	400	508
2	20	136	80	400	616
3	30	204	120	400	724
4	40	272	160	400	832
5	50	340	200	400	940
6	60	408	240	400	1048
7	70	476	280	400	1156
8	80	544	320	400	1264
9	90	612	360	400	1372
10	100	680	400	400	1480

So here are some observations varying the no of products for barcode scanning procedure.

In RFID system, the scanning is done automatically so time for scanning becomes zero and here are the results.

No	Total Items	Scanning Time (seconds)	Packaging Time (seconds)	Payment Time (seconds)	Total Time in seconds
1	10	0	40	400	440
2	20	0	80	400	480
3	30	0	120	400	520
4	40	0	160	400	560
5	50	0	200	400	600
6	60	0	240	400	640
7	70	0	280	400	680
8	80	0	320	400	720
9	90	0	360	400	760
10	100	0	400	400	800

From the above comparison we found out that overall 16 % time is reduced when we use RFID system which in short saves 1.13 mins for 10 products which is tolerable but for 100 products it saves over 10 mins and this in return saves a lot of time for a large number of customers.

V. LEARNING OUTCOMES

After creating a smart shopping cart using RFID (Radio Frequency Identification) technology, you likely gained several valuable insights and experiences. Here are some of the things you may have learned:

1) *RFID Technology:* You have acquired a deep understanding of RFID technology and its applications in the context of a smart shopping cart
2) *Hardware and Software Integration:* Developing a smart shopping cart would have involved integrating hardware components such as RFID readers, antennas, and display screens with software systems.
3) *System Design and Architecture:* You have likely designed and implemented the architecture of your smart shopping cart system
4) *Customer Experience Enhancement:* A smart shopping cart can provide a unique and improved shopping experience for customers.
5) *Data Analytics:* You may have learned how to analyze this data to gain insights into customer behavior, optimize product placement, improve marketing strategies, and enhance overall business operations.
6) *Operational Efficiency:* By implementing this technology, you may have gained insights into how it can reduce waiting times, eliminate manual processes, and improve overall operational efficiency in retail environments.
7) *Challenges and Problem Solving:* Throughout the development of your smart shopping cart, you may have encountered various challenges such as integration issues, data synchronization problems, or optimizing the performance of the system.

VI. CONCLUSION

In conclusion, the implementation of a smart shopping cart using RFID technology offers numerous advantages. It enables efficient inventory management, streamlines the checkout process, enhances customer experience through personalized recommendations, and reduces theft and product loss. With real-time tracking and data analysis capabilities, retailers can make informed decisions and improve operational efficiency. Overall, RFID- enabled smart shopping carts revolutionize the shopping experience by merging convenience, automation, and data-driven insights.

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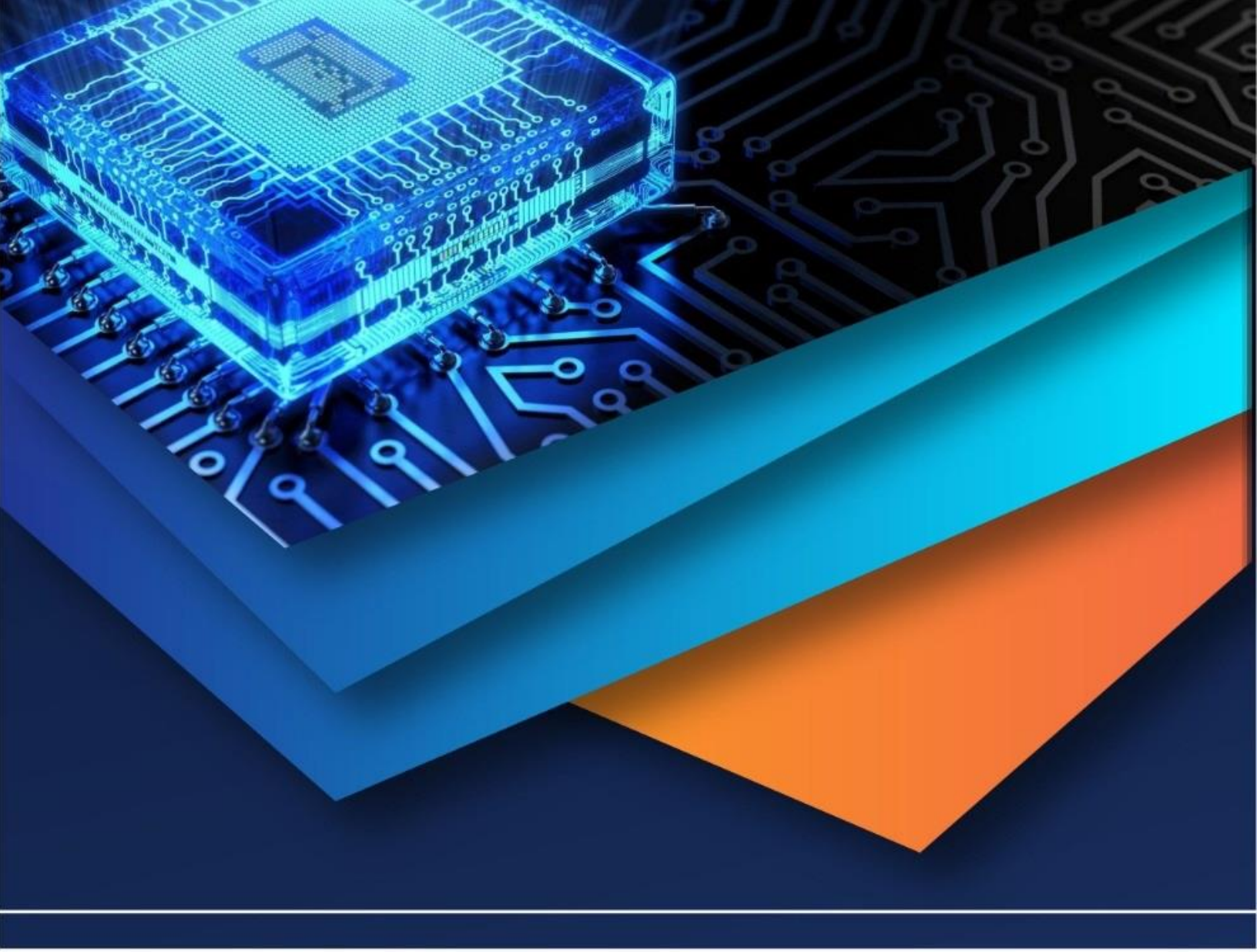

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