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Smartsense Trolley System: A Case Study on Econsave Plaza Pandan Malim Among Employees and Customers

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Abstract

Introduction/Main Objectives: This study examines the development and evaluation of the Smart Sense Trolley System, an Internet of Things (IoT)-based solution designed to address trolley loss, misplacement, and operational inefficiencies in retail environments.

Background Problems: Retail environments face persistent issues such as trolley theft, improper customer usage, substantial replacement costs, and labor inefficiencies in managing trolley assets.
Novelty: The novelty lies in the integration of an ESP32 microcontroller, GPS module, geofencing alerts, and Telegram-based notifications into a single IoT-enabled system for real-time trolley monitoring and perimeter control.

Research Methods: A mixed-method approach was employed. Quantitative data were collected from 52 respondents to assess acceptance and perceived effectiveness. Qualitative insights were gathered through interviews with supermarket managers.

Finding/Results: Quantitative findings showed high acceptance, with mean scores ranging from 4.29 to 4.48 across dimensions of usability, convenience, system quality, and operational impact. Qualitative findings confirmed persistent issues of theft, improper usage, and high replacement costs. Respondents affirmed the system's potential to reduce labor needs, enhance asset management, and improve the shopping experience. The system was deemed a practical and cost-efficient innovation aligned with national digitalization and sustainability goals.

Conclusion: The Smart Sense Trolley System significantly contributes to improving operational efficiency, supporting responsible resource management, and strengthening smart retail practices.

Keywords: Trolley, Smart sense, Efficiency

Introduction

Supermarkets rely heavily on trolleys to provide convenience and comfort to their customers. However, one of the persistent problems faced by many retail establishments is the loss and mismanagement of shopping trolleys. (Ward & Kahn, 2013) Noted that the absence of monitoring systems in shopping carts contributes to inefficient allocation and higher rates of loss in retail environments. Customers often take trolleys outside the supermarket premises and sometimes leaving them in parking lots, nearby housing areas or public roads. This leads to high replacement costs, reduced trolley availability and inefficiency in operations. Over time, these tosses can cause financial strain to supermarket and inconvenience to customers who are unable to find available trolleys when needed.

Traditional method used to manage trolley movement like manual monitoring by staff are time-consuming, expensive and ineffective. (The Straits Times, 2022), A FairPrice spokesman said: "Onaverage, the costs of repairing, replacing and retrieving unreturned trolleys is about $150,000 a year." As a result, supermarket is unable to respond immediately to potential trolley loss or theft and leading to further operational challenges.

Observations and interviews conducted as part of this study reveal that supermarkets face persistent challenges in managing their shopping trolleys, particularly with regard to trolley loss, damage, and misplacement. For example, Miss Zuzana, the Manager on Duty at Econsave Plaza Pandan Malim (November 31, 2025), stated that *“older customers mostly like to bring our trolleys back to their home due to they don’t have enough strength to carry the items they bought themselves.”* Additionally, Store Manager Mr. Chandran (November 31, 2025) reported that *“there are also customers who take our trolleys and sell them to scrap centers.”* These findings align with previous research showing that customers frequently remove trolleys from store premises, either unintentionally or deliberately, leading to high replacement costs and operational inefficiencies (Nordin & Sulaiman, 2020).

To overcome and address this issue Smart Sense Trolley System is developed by applying Internet of Things (IoT) technology for a real-time monitoring and tracking. This system uses an ESP32 microcontroller as the main unit control that connected to GY-GPS6MV2 module to detect the exact location of the trolley. When trolley moves beyond 100-meter radius from the supermarket area, the system will trigger a buzzer alarm to warn and alert the users and sends a Telegram notification to supermarket management. This dual-alert mechanism ensures immediate awareness and quick response to prevent trolley loss and misplacement from both employees and customers.

Overall, Smart Sense Trolley System serves as an innovative approach to improving supermarket management and customer service. It not only reduces losses but also contributes to the advancement of smart technology in everyday applications. Through this final year project, the potential of IoT in creating smarter, safer and more efficient retail environments is clearly demonstrated, paving the way for further development and large-scale implementation in the future. This have been supported by Khan, A., & Lee, J (2022) which explained that implementation of IoT and GPS tracking will have improved efficiency, reduced losses and the feasibility of large-scale smart retail. In addition, this system also demonstrates how smart embedded systems can be used to solve real-world problems in retail industry.

Research Methods

This study employed a mixed-methods research design integrating both quantitative and qualitative approaches to evaluate the effectiveness and practicality of the Smart Sense Trolley System. The methodology consisted of three main components: prototype development, quantitative survey analysis, and qualitative interviews.

1. Prototype Development

The Smart Sense Trolley prototype was developed using an ESP32 microcontroller, GY-GPS6MV2 module, active buzzer, and a customized enclosure box. Jumper wires were used to connect all hardware components. The system was programmed to track real-time trolley

movement and activate alerts when the trolley exceeded a 100-meter predefined geofence radius. The development process included circuit design,
component integration, coding of GPS data acquisition, and Telegram API configuration for automated notifications. The finalized prototype was tested within a controlled environment to ensure accuracy, stability, and consistency of alerts.

Figure 1: The flow to set the product
Source: Author Data, 2025

2. Quantitative Data Collection

A structured questionnaire consisting of 10 five-point Likert-scale items was administered to supermarket customers and employees at Econsave Plaza Pandan Malim. A total of 52 valid responses were collected. The questionnaire measured respondents' perceptions of system quality, usability, effectiveness, convenience, and impact on work efficiency. Descriptive statistics, mean scores, were used to evaluate user acceptance and satisfaction. Mean score interpretation was applied to determine the overall perception level.

3. Qualitative Data Collection

Semi-structured interviews were conducted with key management personnel, including the Store Manager and Manager on Duty, to gather in-depth insights into operational challenges and existing trolley management issues. This approach is suitable for exploratory studies because it allows researchers to probe participants' experiences while maintaining flexibility during the interview process (Kallio et al., 2016). The interviews also examined management perceptions of the Smart Sense Trolley System and its potential role in improving operational efficiency.

Qualitative data obtained from the interviews were analysed using thematic analysis, which is a widely accepted method for identifying, organizing, and interpreting recurring patterns within

qualitative datasets (Braun & Clarke, 2006). Through this process, several themes emerged, including trolley loss patterns, monitoring inefficiencies, cost implications, and perceived benefits associated with system implementation. Thematic analysis was selected due to its suitability for extracting meaningful insights from managerial experiences and understanding behavioural issues within organizational settings

Result

The analysis focuses on evaluating the system's effectiveness, usability, design quality, and impact on supermarket operations. Responses from customers and employees were examined to identify key patterns, levels of satisfaction, and areas for improvement.

1. Quantitative Analysis

The findings provide valuable insights into how the Smart Sense Trolley System can enhance shopping experiences, reduce trolley losses, and improve overall management efficiency.

Table 1: Mean for questionnaire given to the customers

BIL	QUESTION	MEAN
1	How effective is the Smart Sense Trolley System in improving the overall shopping experience for both customers and employees?	4.48
2	How do customers perceive the *usability and design quality* of the Smart Sense Trolley System?	4.31
3	How does the system's quality (such as accuracy and responsiveness)? affect employees' work efficiency?	4.46
4	Does the Smart Sense Trolley System enhance the *quality of employee performance* by reducing manual tasks or human error?	4.42
5	How does the Smart Sense Trolley System affect employees? workload and productivity?	4.29
6	Does the Smart Sense Trolley System make your shopping experience faster and more convenient?	4.46
7	Is the Smart Sense Trolley System easy for you to use and understand?	4.35
8	Does using the Smart Sense Trolley System make your shopping experience more enjoyable?	4.44
9	Would you like to continue shopping at stores that provide the Smart Sense Trolley System?	4.38
10	Does the system improve your interaction and service quality with customers?	4.44

Source: Sarma, M., & Ahmed, S. (2020)

From the data we gathered using google form, our survey provides a comprehensive understanding of the respondent's perceptions toward the Smart Sense Trolley System. Overall, the results demonstrate that the system has received highly positive feedback from both customers and employees. With mean scores ranging from 4.29 to 4.48, it is evident that most respondents strongly agree (Nunnally & Bernstein, 1994) that the system is effective, user-friendly, and beneficial in enhancing the shopping experience and work efficiency

Research shows that the integration of smart technologies such as IoT-based tracking systems reduces operational delays**,** improves staff productivity, and enhances the overall customer experience. When repetitive manual tasks are minimized, employees can focus on service quality, while customers enjoy smoother and faster shopping activities (Sarma, M., & Ahmed, S. 2020) On behalf of workers they can improve their productivity from lacking and wasting

time searching for trolley. But on behalf of customer, by providing a little touch of technology and innovation can increasing their level of excitement.

2. Qualitative Analysis

Semi-structured interviews were conducted with two key management personnel at Econsave Plaza Pandan Malim—the Store Manager and the Manager on Duty—to obtain deeper insights into existing trolley management challenges and to assess the perceived feasibility of implementing the SmartSense Trolley System. The qualitative data were analyzed using thematic analysis, enabling the identification of recurring issues, operational gaps, and managerial expectations regarding the proposed system.

Theme 1: High Incidence of Trolley Loss and Damage

Both managers reported frequent trolley losses, estimating an average of up to 10 missing trolleys monthly. Elderly customers were noted as a primary group who tend to take trolleys home due to physical limitations, while some customers deliberately remove trolleys and sell them to scrap centres. These behaviours result in continuous financial strain, as each trolley costs approximately RM500 to replace.

Theme 2: Ineffectiveness of Current Monitoring Methods

The supermarket currently uses a serial-number identification system; however, missing trolleys still require manual searching, making the method inefficient. Staff assigned to retrieve trolleys often take excessive time or divert from their tasks, which contributes to operational inefficiencies. The managers confirmed that the absence of real-time tracking makes it difficult to identify the location of missing trolleys promptly.

Theme 3: Labour Burden and Operational Inefficiency

The interview highlighted that trolley collection is labour-intensive and time-consuming. With limited manpower and high daily customer volume, employees struggle to retrieve abandoned trolleys, particularly from external areas such as parking lots and nearby residential zones. Management indicated that an automated monitoring system would significantly reduce staff workload and improve daily operational flow.

Theme 4: Financial Impact on the Organization

The recurring cost of trolley replacement was identified as a major operational burden. The managers emphasized that losses accumulate monthly, and additional manpower required for trolley retrieval further increases operating expenses. The SmartSense Trolley System was viewed as a potential cost-saving measure by minimizing both trolley loss and labour requirements.

Theme 5: Perceived Benefits of the SmartSense Trolley System

Both interviewees expressed strong support for the implementation of the SmartSense Trolley System. They believed that GPS tracking, geofencing alerts, and real-time notifications would allow faster response to trolley misuse, reduce theft, and improve overall asset management. The managers also noted that the system would likely increase customer responsibility and awareness, as audible alerts help deter improper use.

Theme 6: Contribution to Customer Experience and Store Efficiency

The implementation of the system was perceived to enhance customer convenience by ensuring consistent trolley availability. Efficient trolley management would reduce clutter around the premises, improve store organization, and contribute to a more seamless shopping

experience. From a managerial perspective, improved system visibility would support better planning, monitoring, and decision-making.

Discussion

The findings of this study demonstrate that the Smart Sense Trolley System provides clear and measurable benefits across several key operational domains, particularly customer satisfaction, employee performance, and overall store efficiency. The consistently high mean scores from respondents indicate strong acceptance of the system, suggesting that smart technologies are increasingly viewed as essential components of modern retail operations.

The qualitative data further support this view. Interviews with supermarket management revealed that trolley loss, theft, and misplacement are long-standing challenges that impose substantial financial burdens. With each trolley costing approximately RM500 to replace and an estimated five units lost monthly, the financial impact is significant. Current manual monitoring methods were described as inefficient, labour-intensive, and unreliable, often requiring staff to undertake time-consuming collection routines or searches.

In contrast, managers indicated strong confidence that an automated system equipped with GPS tracking, geofencing, and real-time notifications would address these shortcomings effectively. They highlighted that such technology would not only reduce trolley loss but also lessen staff workload, allowing employees to focus on customer service and other essential tasks. This is consistent with research showing that IoT-based automation in retail environments improves operational efficiency, reduces manual labour requirements, and enhances staff productivity (Al-Turjman, 2020). These findings also support the quantitative results of this study, which indicated positive perceptions of the system's convenience, effectiveness, and contribution to operational improvement—an effect similarly observed in smart retail technology implementations (Khan & Lee, 2022).

From an operational perspective, the system enables better asset management by providing real-time visibility of trolley locations and usage patterns. These data can be used to optimize maintenance schedules, redistribute trolleys according to customer demand, and reduce unnecessary labour expenses. This aligns with the broader retail industry trend toward adopting smart infrastructure to improve productivity, streamline processes, and strengthen competitive advantage (Retail Asia, 2025).

While the system requires ongoing maintenance and technological upkeep, this investment is justified by the long-term gains in efficiency, cost reduction, and enhanced customer experience. By integrating smart technologies, supermarkets can position themselves as forward-thinking, customer-centered, and operationally resilient retail environments.

Conclusion

Overall, the Smart Sense Trolley System represents a practical, affordable, and effective innovation that addresses a real and persistent problem in the retail sector. Its implementation supports the transition toward smarter, more sustainable, and technology-driven retail management.

Moving forward, the Smart Sense Trolley can be further developed with several advanced features to increase its functionality and sustainability. One major improvement would be the addition of solar-powered charging systems, allowing the trolley's sensors and GPS modules to operate continuously without dependence on electrical recharging, (Mohamed, R., & Ismail, N. 2021). This approach aligns with global efforts to promote green energy solutions and

reduce carbon emissions. Another suggestion is to design a mobile or web-based monitoring application that allows store managers to oversee the status and location of all trolleys remotely. Real-time notifications and data analytics could help management identify usage patterns, predict maintenance needs, and improve customer service. Additionally, the integration of RFID (Radio Frequency Identification) or NFC (Near Field Communication) tags can enhance the accuracy of location tracking, particularly in indoor environments where GPS signals may be weak.

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