DESIGN AND ANALYSIS OF AN IOT-ENABLED ASSET TRACKING AND MANAGEMENT SYSTEM FOR LOGISTICS

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ANALYSIS OF AN IOT-ENABLED ASSET TRACKING AND MANAGEMENT SYSTEM FOR LOGISTICS

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

This thesis is dedicated to my family, especially my beloved parents, whose constant support has been the cornerstone of my journey. To my father and mother, who instilled in me the value of hard work and perseverance and to my siblings, whose unwavering belief in me has always been a source of strength .

I also extend my heartfelt gratitude to my fellow friends and colleagues, who have stood by me through both joyful and challenging times through this study , offering their encouragement and assistance. Lastly, I dedicate this work to my supervisor and mentor, whose wisdom and guidance have been instrumental in shaping my academic path. Your dedication and influence are deeply reflected in this thesis.

ABSTRACT

Asset management in engineering, especially when combined with modern communication technologies and the Internet of Things (IoT), will greatly improve how to manage and maintain physical assets. The main goal of this combination project is to make improvement in assets management by using real-time monitoring to do predictive maintenance and data-based decisions. With IoT, sensors and modules are placed in assets to gather and send data of their condition, performance, and surroundings. This information is then sent through advanced networks to IoT software, where it can be analysed using smart cloud algorithms and monitoring systems. The results from these analyses will help organisations to predict problems, use resources more wisely, and reduce downtime and costs. The methods used typically include the development of low-cost hardware for tracking devices consisting of sensors, transmitters, and receivers of LoRa attached to a small microcontroller Arduino , setting up secure communication networks and using IoT database or edge computing to store data. Data analytics tools for Arduino serials provide useful insights into how assets are performing. The key finding from integrating asset management with IoT and modern communication is that it will significantly boost operational efficiency and operational quality. This approach will help to detect issues early, extend the life of assets, support better planning in operation, and improve overall productivity. In conclusion, combining asset management with IoT and modern communication is a major advancement in engineering, offering a complete solution for managing complex systems.

ABSTRAK

Pengurusan aset dalam bidang kejuruteraan, terutama apabila digabungkan dengan teknologi komunikasi moden dan Internet of Things (IoT), dapat menaik taraf pengurusan aset fizikal. Matlamat utama projek adalah untuk memastikan aset dapat beroperasi dengan lebih baik melalui pemantauan masa secara nyata, ramalan untuk penyelenggaraan, dan penilaian berasaskan data simpanan. Dengan IoT, sensor dipasang pada aset untuk mengumpul maklumat dan menghantar data mengenai keadaan terkini sistem, prestasi, dan persekitarannya. Data ini kemudian dihantar melalui rangkaian ke sistem pusat untuk dianalisis dengan menggunakan algoritma cloud dan sistem pemantauan. Analisis ini membantu organisasi meramalkan masalah, merancang penyelenggaraan dengan lebih awal, serta dapat menjimatkan masa serta kos. Pendekatan ini melibatkan pembangunan peranti pengesan kos rendah yang terdiri daripada modul sensor, pemancar, dan penerima LoRa yang dipasang pada mikropengawal Arduino, menyediakan rangkaian komunikasi selamat, dan menggunakan pengkomputeran database Cloud untuk memproses serta menyimpan data. Alat analisis data serial Arduino memberikan maklumat penting tentang prestasi aset. Kesimpulannya, integrasi pengurusan aset IoT dengan komunikasi moden meningkatkan kecekapan operasi dan memperbaiki kualiti operasi dengan ketara, membantu mengesan isu lebih awal, memanjangkan hayat aset, dan membuat keputusan yang lebih baik untuk, meningkatkan produktiviti keseluruhan .

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In the Name of Allah, the Most Gracious, the Most Merciful. First, I would like to thank my parents , my supervisor, TS. SHAHRIL IZUAN MOHD ZIN , for their valuable guidance and continuous support throughout this project. Their knowledge and encouragement have been essential for the completion of this thesis.

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LIST OF SYMBOLS AND ABBREVIATIONS

IoT	:	Internet of Things
LoRaWAN	:	Long Range Wide Area Network
GPS	:	Global Positioning System
RFID	:	Radio-Frequency Identification
GSM	:	Global System for Mobile Communications
MQTT	:	Message Queuing Telemetry Transport
RF	:	Radio Frequency
ESP32	:	Microcontroller with integrated Wi-Fi and dual-mode Bluetooth
AWS	:	Amazon Web Services
QR	:	Quick Response
GPIO	:	General Purpose Input/Output
ID	:	Identification
IDE	:	Integrated Development Environment
IIOT	:	Industrial Internet of Things
Wi-Fi	:	Wireless Fidelity
UWB	:	Ultra-Wideband

IMU	:	Inertial Measurement Unit
cm	:	centimeter
m	:	meter

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Asset management is the process of monitoring and optimising resources such as component inventory, machinery and stocks **[1]** . The project aims to design and analysis an IoT-enabled asset tracking and management system for logistics operations. By implementing the power of Internet of Things (IoT) technology, the system provides real-time monitoring and control over assets throughout the logistics supply chain, including warehouse activities. The system will use a combination of multiple sensors in warehouse operation , GPS modules for outdoor tracking , Raspberry Pi central devices for indoor tracking and wireless communication technologies LoRa to gather data from the logistic section and transmit it to a database and cloud server. The project will involve hardware design, firmware development, database and server integration . Hence, this project aims to develop a low-cost assets management system using an embedded microcontroller to track all collected data, such as real-time location , record storage activities and delivery status and process data using IoT . In the end of this, this project seeks to optimise asset utilisation, minimise loss and improve overall operational efficiency from hardware performance analysis.

1.2 Problem Statement

Owners need to track and maintain their rental assets and end-users seek high- quality services of logistic management. Traditional asset management relies on manual processes and systems to track and manage physical assets. This method typically involves the use of spreadsheets, paper records, or basic computer systems to store and update asset information. Data is often entered manually, which increases the risk of errors and inaccuracies. This demands the use of information and communication technology (ICT) and Internet of Thing (IoT) to improve the performance of existing asset tracking systems. Shortage and delays may occur from sloppy asset management **[2] .** The challenge addressed in this project is to develop and evaluate an efficient IoT-based system for tracking and managing assets in logistics operations by using low-cost components **.** Based on insights from existing research on low-cost IoT solutions, the goal of this project is to design a system that integrates various sensors and wireless communication modules to provide real-time monitoring of assets locations and conditions. By drawing on the hardware and software components utilized in previous studies , such as Arduino microcontrollers and Wi-Fi transceivers, the project aims to create a scalable and cost-effective solution for asset tracking. The proposed system will enable users to improve their inventory management processes by accurately tracking the movement and status of assets, to enhance operational efficiency and reduce costs. Through analysis and testing, the project seeks to validate the effectiveness and reliability of the IoT-enabled asset tracking system for its implementation in real-world logistics environments.

1.3 Objective

The main objectives for this project are specified as shown below :

a) Design and develop an IoT-based asset tracking device for a logistics management system, utilising Raspberry Pi as a communication tool.
b) To analyse the functionality of the logistic management system using the data from real-time monitoring to optimise asset tracking utilisation.

1.4 Scopes of Works

The scope of this project involves designing and implementing an IoT-enabled asset tracking and management system for the logistics industry environment. The project consists of two main parts , first part to design the low-cost tracking system for assets management and second part collecting data information and transmitting the data to the user through IoT for analysis. This project consists of several key tasks including hardware design, software development and deployment and testing the system . The project will include selecting appropriate hardware components , such as main controller , transmitter and receiver modules , communication modules , and designing the physical infrastructure of the prototype for logistics warehouse environments. Software development will focus on creating systems for data processing and storage monitoring , as well as front-end interfaces for user interaction using IoT software such as using Xampp MySQL database and Blynk IoT. A prototype system will be tested repeatedly to ensure its functionality and performance based on the analysis . Hence, the testing will involve implementing the system in a situational logistics environment to provide information to users. The project aims to enhance existing asset tracking and management efficiency within the logistics industry while considering factors like accuracy, response time, and reliability of the system and how to improve the existing past management system based on the data obtained.

CHAPTER 2

BACKGROUND STUDY

2.1 Literature Review

Asset management is the process of monitoring and optimizing resources like stock, machinery and vehicles **[1].** By investigating previous research in relevant fields and examining how Internet-connected devices have been used to monitor assets like packages or vehicles in real-time. Past researchers also focused on technologies like RFID tags , Qr Tracking and GPS trackers that are commonly employed for asset tracking, alongside methodologies for optimizing logistics operations, including route planning and inventory management system as shown on Figure 1 . This includes the development of an upgraded system to enhance asset tracking and management efficiency within the logistics industry. Hence, various IoT platforms, such as Xampp MySQL Database , Google Clouds Console and Blynk IoT are explored for their function in connecting and managing these tracking devices.

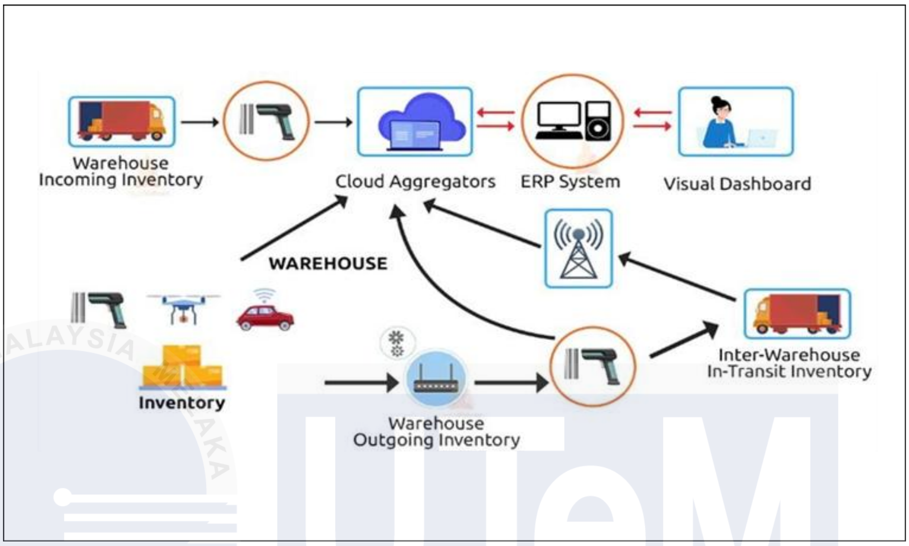


Figure 1 : Assets management operation

The Raspberry Pi 4 Model B as shown in Figure 2 is the main part component for implementing IoT-enabled asset tracking and management systems, especially in logistics tracking operation , due to its versatile features and strong performance compared to another controller. Studies show that the Raspberry Pi 4, with its powerful quad-core processor, can handle the complex data tasks needed for managing logistics. Its wireless LAN, Bluetooth and Gigabit Ethernet provide reliable connectivity in different settings.

The GPIO pins allow for easy connections with sensors and GPS modules for accurate tracking. The USB 3.0 ports enable fast data transfers, important for large amounts of data common in logistics. Its small size and low power use make it perfect for mobile and distributed applications. This minicomputer has been widely chosen, and many studies use the Raspberry Pi 4 in IoT projects, showing it reliable that can easily connect with cloud services for data analysis and monitoring, improving efficiency in logistics project. Overall, this highlights the Raspberry Pi 4 Model B as a cost-effective and powerful option for developing advanced IoT systems.

Figure 2 : Raspberry Pi 4 Model B

The Raspberry Pi Camera Module shown in Figure 3, combined with a Raspberry Pi 4 Model B , is crucial in developing IoT-based asset tracking and management systems for logistics. This camera captures high-quality images and videos, making it suitable for QR code scanning on packages. It connects seamlessly to the Raspberry Pi, which employs software like OpenCV and Pyzbar libraries to interpret these QR code's function . This combination enables precise real-time asset tracking for assets identification replacing RFID. The compact size and low power consumption of both the Raspberry Pi and its camera make them ideal for mobile tracking applications.

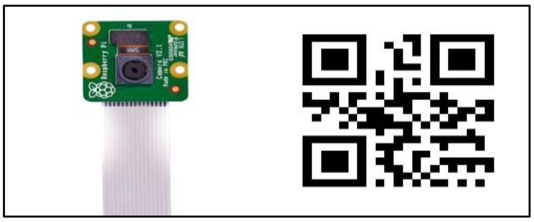


Figure 3 : Raspberry Pi Camera module for QR code scanner

In designing an IoT-enabled asset tracking device for logistics, the integration of LoRa WAN modules, which include a transmitter and receiver, is essential. LoRa technology, known for its long-range and low-power capabilities, provides a reliable communication backbone for tracking assets over extensive areas. The LoRa module SX1278, shown in Figure 4, is a suitable choice due to its robust performance and ease of integration with microcontrollers like the Raspberry Pi. These modules can send and receive data over distances up to 10 kilometers, making them ideal for logistics applications where assets may be spread over large areas.

The transmitter unit, attached to the asset, sends location and status data to the receiver unit, which then processes this information and updates the tracking system in real time. Study indicates that using LoRa technology in logistics improves tracking accuracy and operational efficiency by enabling real-time monitoring of assets and being able to send data without an internet connection. Its low power consumption extends the battery life of tracking devices, reducing maintenance costs of the device.

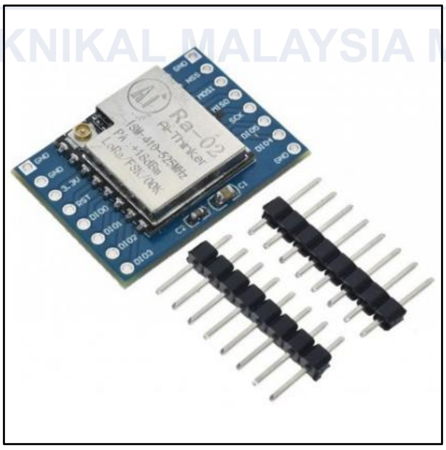


Figure 4 : LoRa modules SX1278

Integrating a GPS module with LoRa technology is important for obtaining precise location data. The GPS module shown in Figure 5, typically based on the u- blox NEO-6M chip, is known for its high sensitivity and accurate positioning capabilities which are suitable to obtain direct satellite location. When paired with LoRaWAN modules like the Reyax RYLR896 or SX1278 , this setup enables real-time location tracking of assets over long distances.

Past studies show that the GPS module continuously collects location data, which is then transmitted via the LoRa network to a central server or cloud platform. This transmission is facilitated by the low-power, long-range communication features of LoRaWAN , operation making it suitable for wide-area coverage in logistics applications. The combined system ensures that the exact location of each asset can be displayed on maps, providing significant advantages in terms of monitoring and management.

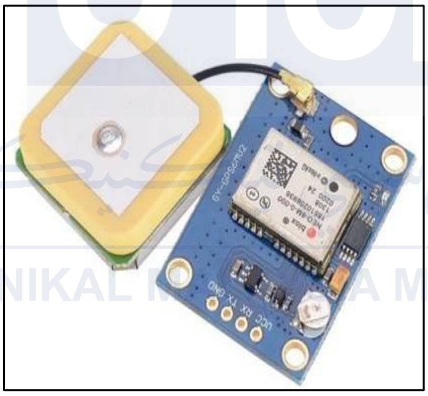


Figure 5 : GPS module NEO-6M chip

The Arduino Nano shown in Figure 6 serves as the central processing unit, managing data from the GPS module and sending it to the LoRa transmitter. The wiring connections in the diagram demonstrate how power is supplied from a battery, and how data is exchanged between the GPS module, Arduino Nano, and LoRa module. The resistors shown ensure that signal levels are appropriate for each component. The low power consumption of the LoRa module ensures that the system can operate for extended periods without frequent battery replacements. This combination of components results in a reliable, cost-effective solution for tracking and managing assets, improving operational efficiency and transparency in logistics operations.

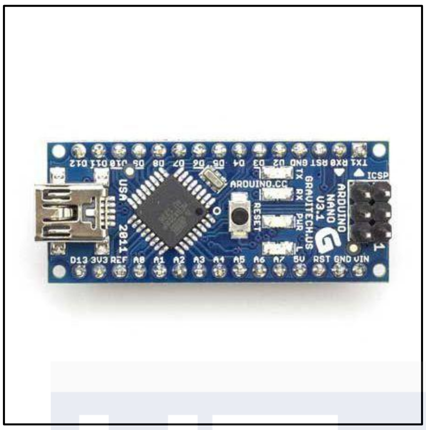


Figure 6 : Arduino Nano Microcontroller

The NodeMCU ESP8266 in Figure 7 is a small and affordable microcontroller board with built-in Wi-Fi, making it perfect for connecting devices to the internet. It uses the ESP8266 chip, which can send and receive data over Wi-Fi. The board works like a minicomputer, running simple programs code that control devices like LEDs, sensors, or motors. You can program it using Arduino IDE or Lua scripting, and it connects to your computer via USB. When powered, it connects to a Wi-Fi network and can send or receive data from online servers, mobile apps, or other devices. This makes it great for creating smart home projects or Internet of Things (IoT) devices. NodeMCU is a good choice for Internet of Things (IoT) projects because it's built around the ESP8266, which contains a CPU, RAM, networking (Wi-Fi), and an operating system.

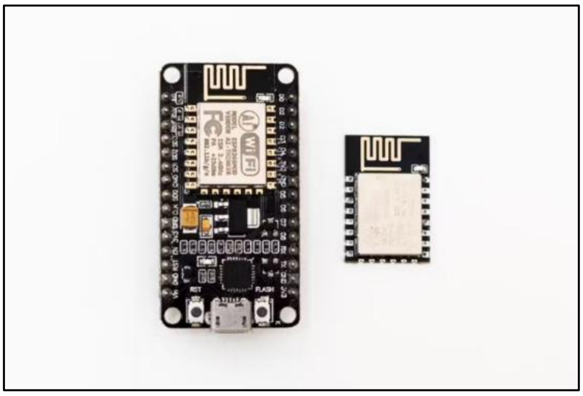


Figure 7 : NodeMCU ESP8266 microcontroller

The software implementation of the project is achieved with the help of Arduino IDE, an open-source, cross-platform integrated development environment that consists of code editor with syntax highlighting, a built-in serial monitors for debugging and library manager for installation and organising libraries **[4]**. Both GPS and LoRa modules can be used to generate location data to be uploaded periodically to a server. This server then sends the data notification to a mobile application via the internet.

Additionally, Python is used for programming the Raspberry Pi. Python is ideal for handling various tasks such as interfacing with hardware components and processing data. Libraries like Picamera are used for controlling the camera module, while OpenCV and pyzbar are used for QR code scanning and decoding. Python scripts on the Raspberry Pi can manage data collection, process GPS coordinates, and transmit this information via the LoRa module to ensure seamless integration with the overall asset tracking system. This combination of Arduino IDE for microcontroller programming and Python for Raspberry Pi scripting provides a robust and flexible software foundation for the IoT-enabled asset tracking and management system.

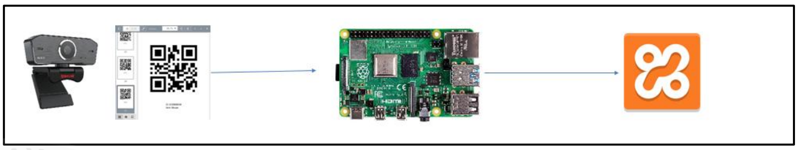


Figure 8 : Raspberry Pi Application.

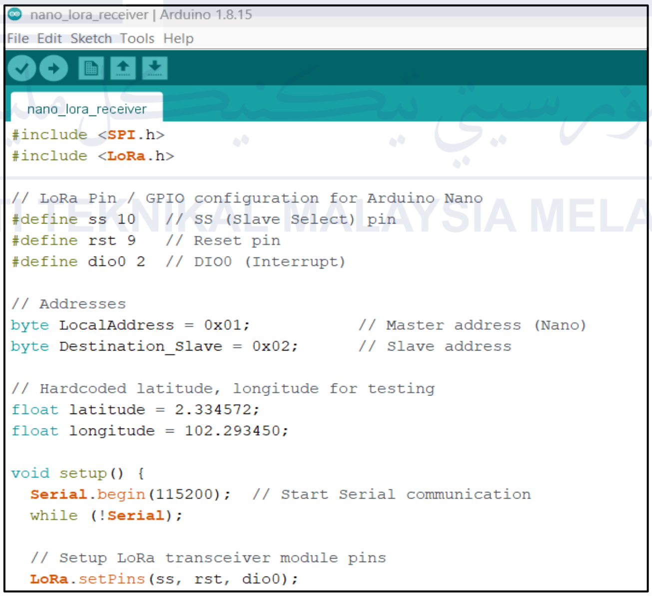


Figure 9 : Arduino IDE for Microcontroller Programming

2.2 Previous Research Paper Comparison

Table 1 : Comparison of Previous Research Paper

	Author	Sources	Description/Finding
1.	A.B. Gurulakshmi, Sanjeev Sharma, Rajesh G, Ananyaa Sundar, A. Bharath Kumar, Darshan D, Chakravarthi K, Dhyan Reddy **[4]**	Title: Design and Implementation of an Easy-to Use Tracking Device for Logistic Applications University: New Horizon College of Engineering, Bangalore, India 4th International Conference on Intelligent Engineering and Management (ICIEM 2023)	The paper discusses the development of a plug-n-play vehicle tracking device using GPS and GSM technology for cost-efficient tracking. Additionally, the study explores various hardware and technologies used, such as GPS, GSM, ESP32 microcontroller, and Arduino IDE for software implementation. Furthermore, the research presents two methods of implementation for tracking: active and passive tracking, each with its advantages and limitations.
2.	Aishwarya Raj Laxmi , Ayaskanta Mishra **[2]**	Title: RFID based Logistic Management System using Internet of Things (IoT) KIIT Deemed University Bhubaneswar, Odisha, India. 2nd International conference on Electronics, Communication and Aerospace Technology (ICECA 2018)	The paper discusses the importance of shipment tracking and visibility for logistic and financial interests, highlighting RFID's role in automatically identifying and tracking objects. It discusses the integration of Raspberry Pi with RFID modules and the utilization of MQTT protocol for real-time data transmission to a CloudMQTT broker. This protocol is used for publishing real-time passive RFID tag data to CloudMQTT broker from Raspberry Pi.
3.	Reda Khalid and Waleed Ejaz **[5]**	Title: Internet of Things-based On-demand Rental Asset Tracking and Monitoring System Department of Electrical Engineering Lakehead University, Ontario, Canada 5th International Conference on Information and	The paper findings include the identification of communication technologies such as LoRa and LoRaWAN as viable options for low-power, long-range connectivity, along with the use of GPS for accurate location tracking. The review highlights the importance of efficient energy management strategies, such as incorporating motion sensors for auto on/off functionality and periodic location tracking to conserve

		Computer Technologies (ICICT)	battery life. Development of an RF Wireless Power Transfer system for powering battery-free devices for asset tracking.
4.	V. Selvakumar , Siji Sivanandan , A Subbarayudu , V. Saillaj **[1]**	Title: Smart Asset Management: Tracking and Optimizing Assets with IoT Sensors 2nd International Conference on Edge Computing and Applications (ICECAA 2023)	The paper discusses how implementing IoT sensors can revolutionize asset monitoring, utilization, and maintenance processes. By deploying proximity, temperature, and GPS sensors in a manufacturing facility, the research demonstrates real-time tracking of assets, monitoring of perishable commodities, and optimization of production line equipment. Through data analysis, patterns and trends in asset utilization are identified, leading to the development of optimization strategies such as modifying production line structures, implementing just-in-time inventory systems, and adjusting equipment maintenance schedules.
5.	Attila Frankó , Gergely Vida , Pal Varga **[6]**	Title: Reliable Identification Schemes for Asset and Production Tracking in Industry 4.0 Department of Telecommunications and Media Informatics, Budapest University of Technology and Economics, 2, Magyar Tudósok krt., 1117 Budapest, Hungary.	The paper discusses the use of ultra-wideband (UWB) technology, RFID systems, Bluetooth, and other wireless protocols for asset tracking, with a focus on indoor localization systems and technologies. The review highlights research on hybrid systems combining different technologies like UWB and IMU for improved accuracy in indoor positioning. Moreover, it examines the integration of blockchain technology and permissioned blockchain models like ManuChain for ensuring security and traceability in supply chains

Table 2 : Comparison Application

No.	Application	Suitable environment	Power Consumption	Range	Cost	Compatibility with microcontroller/microcomputer	Advantage	Disadvantage
1.	LoRa Module	Rural areas, large-scale outdoor monitoring	Low to moderate	Several kilometers	Moderate	Compatible with Lora WAN gateway	-Long-range -low power consumption	-Limited bandwidth -Require gateways
2.	Active RFID	Asset tracking, warehouse management	Moderate to high	Up to hundreds of meters	High	Compatible	-Real-time tracking, -longer range	-Higher cost -larger size
3.	Passive RFID	Access control, inventory management	Very low	Up to a few meters	Low	Compatible with RFID reader	-Lower cost -smaller size	-Shorter range -Requires nearby reader
4.	GSM	Urban areas, remote monitoring	Moderate to high	Dependent on cellular	Moderate	Compatible	-Wide coverage -Real-time communication	-Costly -Limited in remoted areas
5.	GPS	Fleet management, outdoor asset tracking	Moderate to high (when active)	Global	High	Compatible with GPS modules	-Accurate location tracking -Longer range	-Limited indoors
6.	Multi- sensors module	Environmental monitoring, smart agriculture	Variable, depending on sensors	Up to hundreds of meters	Variable	Compatible	-Diverse data collection capabilities	-Complex -Higher power usage

CHAPTER 3

METHODOLOGY

3.1 Project Methodology

This section describes the steps involved in designing the hardware for tracking devices, creating an IoT monitoring system, and testing them, as illustrated in Figure 10 flowchart diagram . This devices design is based on several research paper studies that address the major elements of the asset tracking device design as well as the logistic management monitoring system.

3.1.1 Project Flowchart

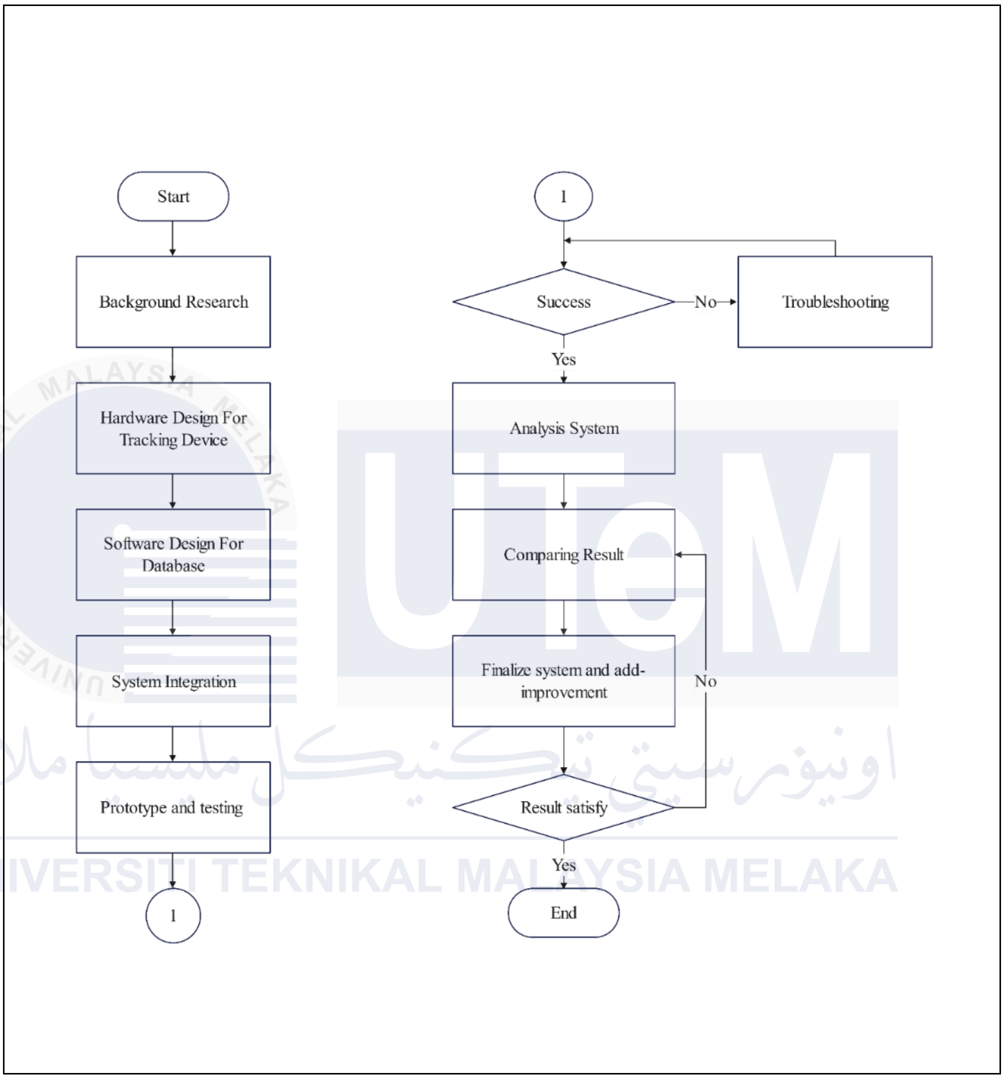


Figure 10 : The Project Flowchart

The flowchart outlines the systematic approach for developing a low-cost asset management system, emphasizing key stages from research to finalisation. It begins with Background Research part , where existing technologies and methods are analysed to understand current solutions and pinpoint areas for improvement. After research, the focus shifts to Hardware Design for the Tracking Device, which involves selecting suitable components like sensors, communication modules (e.g., LoRa and ESP8266), and microcontrollers such as Arduino Nano to build the physical tracking device.

Simultaneously, Software Design for the local database takes place, which involves developing the necessary database schema, backend scripts, and web interfaces to manage and display data collected from the tracking devices. Once both hardware and software are ready, they come together in the System Integration phase, ensuring seamless operation of all components.

After integration, a prototype of the system is created for the Prototype and Testing phase, where it undergoes real-world testing to detect and rectify any issues of the hardware. The system's success is then evaluated through a Success Check. If it fails to meet the desired standards, it goes through Troubleshooting to address problems. If the initial tests are successful, the project advances to the Analysis System stage, where performance is analysed in greater detail. Following this, results are evaluated and compared in the Comparing Result part to ensure they align with the project's expectations. If any discrepancies are found, necessary enhancements are made in the Finalize System phase. The system is then retested to verify improvements.

Finally, the Result Satisfy stage confirms if the project's requirements are fully met, leading to project completion. If the results are unsatisfactory, the process loops back to refine and the system need to optimize further. This flowchart provides a clear, iterative roadmap for building a reliable, low-cost asset management system, ensuring every component and function is meticulously tested and improved until the final product meets all the necessary criteria.

3.1.2 Hardware and Software Requirements

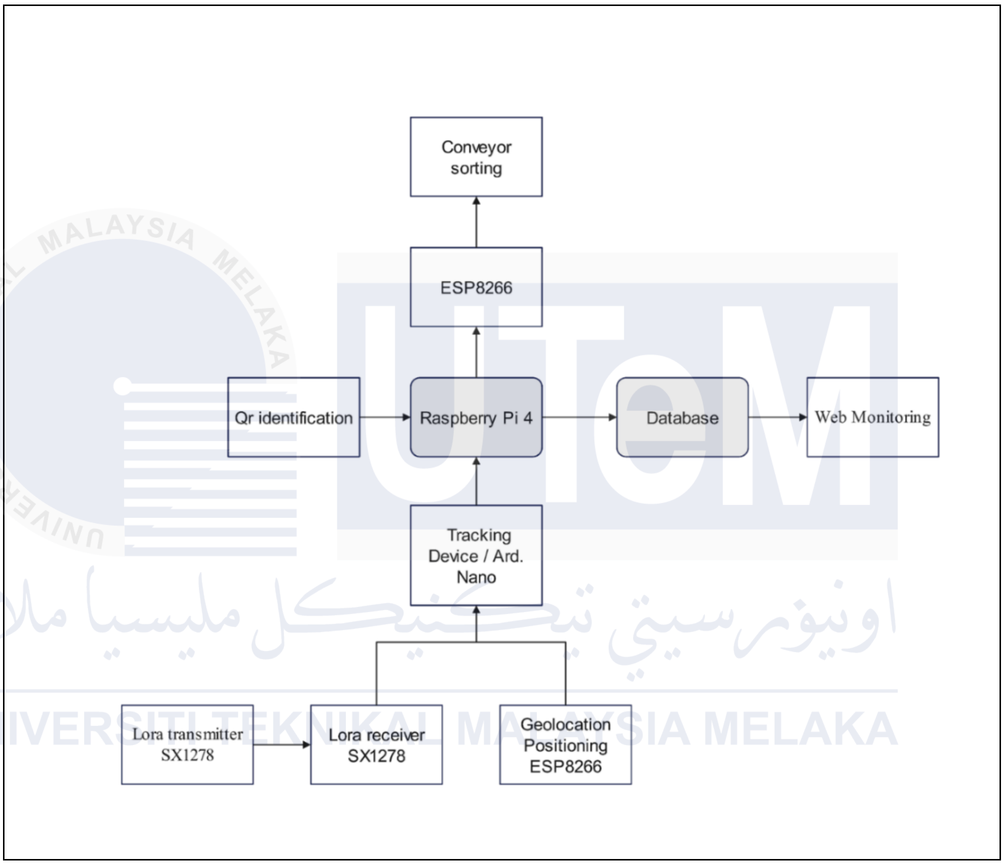


Figure 11 : Implementation of Tracking System

This block diagram outlines a low-cost asset management system that using affordable technologies to track and monitor assets efficiently. At the core of this system is the QR identification using camera , a simple and cost-effective method for tagging assets. QR codes are inexpensive to generate and easy to scan using standard cameras, reducing the need for more expensive tagging methods like RFID. The Raspberry Pi 4 serves as the central processing unit, collecting and managing data from different sources. It is a low-cost, versatile mini-computer capable of running multiple tasks simultaneously, making it an excellent choice for small operation.

The system also includes a tracking device based on Arduino Nano, an affordable microcontroller that processes and transmits data. This device uses LoRa technology with the SX1278 module , which is a cost-efficient solution for long-range, low-power wireless communication, eliminating the need for cellular networks and keeping operational costs low.

For geolocation, the system incorporates the ESP8266 module, a low-cost Wi-Fi microchip that can provide location data without the need for expensive GPS modules. The ESP8266 is also utilised in conveyor sorting systems, automating the sorting process and communicating the status to the Raspberry Pi, further reducing manual labour and associated costs. The data collected by the Raspberry Pi is stored in a database, which can be set up using open-source software, saving on the costs associated with proprietary solutions. This database is essential for organizing and accessing asset data through monitoring.

For monitoring purposes, a web-based interface is implemented, allowing users to track and manage assets in real-time through any internet-enabled device. This web monitoring system eliminates the need for expensive dedicated monitoring stations and provides a user-friendly platform for overseeing the asset management process.

Overall, the system design focuses on cost-effectiveness by using widely available and inexpensive components.

Each element of the system, from QR codes to the Raspberry Pi, Arduino Nano, LoRa modules, ESP8266 and open-source software, contributes to an affordable solution for asset management. This approach is ideal for small to medium-sized businesses looking for a dependable, scalable, and low-cost way to manage their assets without significant capital investment. The system's modular nature also ensures flexibility and adaptability to different operational needs, making it a sustainable choice for businesses aiming to optimize asset tracking and monitoring on a budget.

3.1.3 Programming Raspberry Pi OS using python IDE

This project has significantly objective to achieve which is to design and develop the asset tracking device for logistic management system by using IoT. Below are a few objectives that need to be achieved before proceeding to final hardware.

1. **Software Functionality** : Raspberry OS , Arduino IDE and Python scripts are to be effectively able used to program and control hardware components.
2. **Successful Integration of Hardware Components** : The Raspberry Pi effectively interfaces with the IR sensor and GPIO pins. The system reliably can detect asset movement using the IR sensor and camera .

3. **QR Code Detection** : Using OpenCV and Pyzbar, the system accurately scans and decodes QR codes. QR code data is successfully processed and utilized for asset identification.

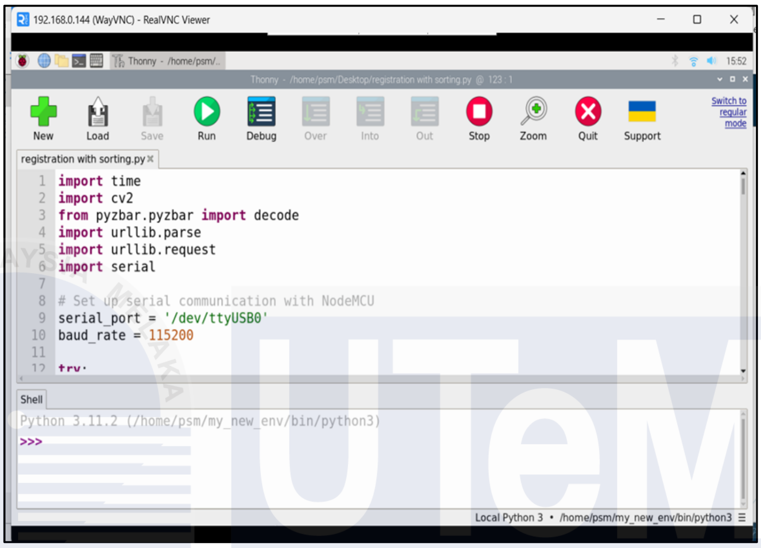


Figure 12 : Run Programming Code on Raspberry Pi OS

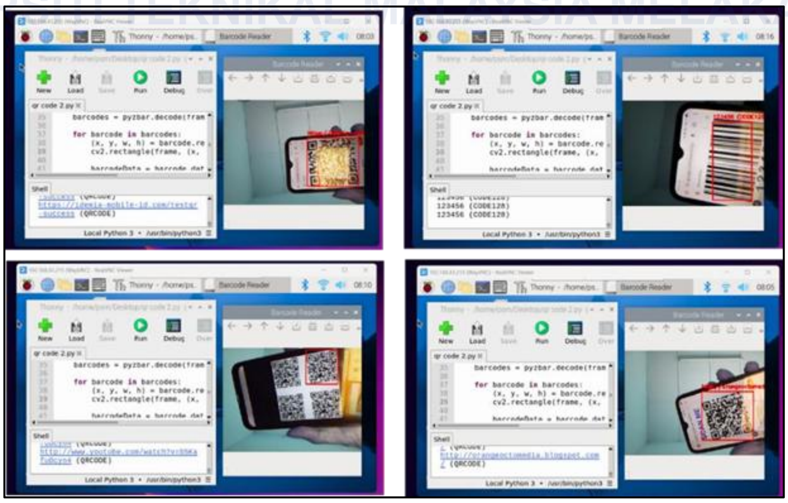


Figure 13 : QR code detection using Raspberry Pi Thorny Python

3.1.4 Theory and Calculation for Conveyor Management

This section explains of Indoor tracking operation consist of two part of tracking method being used in this system . This includes system operation , theory and calculation.

3.1.4.1 Specification

$$Conveyor\ Length\ (L):\ 27\ cm\ (0.27\ m$$

$$Conveyor\ Width\ (W):\ 7.5\ cm\ (0.075\ m)$$

$$Conveyor\ Height\ (H):\ 8\ cm\ (0.08\ m)$$

$$Roller\ Diameter\ (d):\ 2\ cm\ (0.02\ m)$$

$$Roller\ Circumference(c) : C = \pi \times 0.02\ m\ =\ 0.0628\ m$$

$$Motor\ RPM:\ 125\ RPM$$

$$\mathrm{V} = 125 \times 600.0628\ \mathrm{m/s} \approx 0.131\ \mathrm{m/s}$$

$$Belt\ Weight:\ 0.1\ kg - 0.5\ kg$$

$$Item\ Weight\ (Wi):\ 2\ kg$$

$$Total\ Load\ (W): W\ = 0.5\ kg + 2\ kg = 2.5\ kg$$

$$Power\ requirement = \frac{0.131\ m}{s} \times 0.25\ kg = 0.03275$$

$$time\ to\ sorting = t = \frac{0.27\ m/s}{0.131\ m/s} \approx 2.06\ seconds$$

The conveyor process is a key part of warehouse operations, used to move goods efficiently within the facility. The setting for delay time is determined by calculating the movement of item from start point to sorting point. Based on the calculation the time for sorting is estimated to be 2.06 second or more. This is important to set the initial delay for the mini-conveyor system. Below is the operation of the conveyor in the project.

3.1.4.2 Conver sorting operation

1. Loading:

- Items are placed on the conveyor belt at the starting point.
- This can be done manually or using robotic systems, depending on the setup.

2. Transportation:

- The conveyor belt moves the items through different sections of the warehouse.
- It is powered by motors and designed to handle various item sizes and weights.

3. Sorting:

- At designated points, items are automatically or manually sorted based on specific criteria like destination, size, or type.
- Sensors, cameras, or QR code scanners can identify items and direct them to the correct path.

4. Storage or Dispatch:

- Items are either directed to storage areas or prepared for dispatch.
- For storage, items are organized on shelves or bins. For dispatch, they are packed and labeled for delivery.

5. Control and Monitoring:

- The conveyor system can be managed by using software that monitors its performance and ensures smooth operation through Blynk app.
- Add-on sensors detect jams or malfunctions, triggering alerts for quick action.

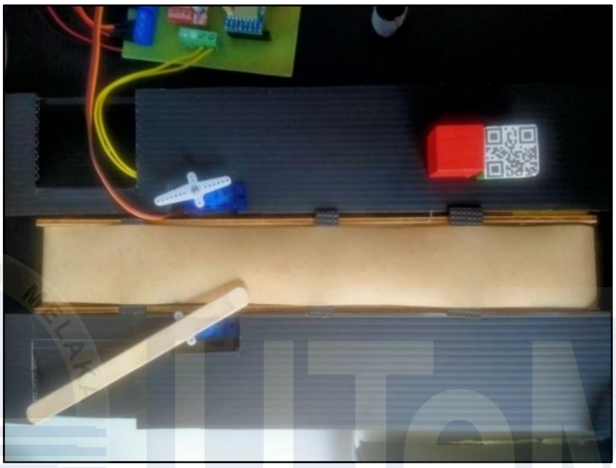


Figure 14 : Conveyor management design

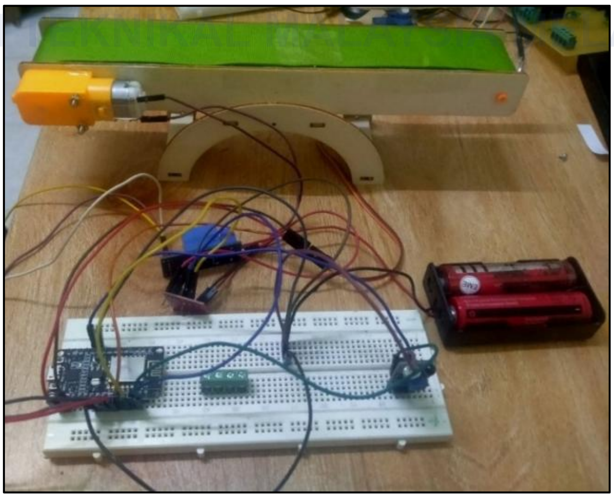


Figure 15 : Conveyor setup and Testing

3.1.5 Tracking Device Operation

1. QR Code Scanning:

- Items are tagged with QR codes that contain information about their assign device.
- Scanners or mobile devices are used to scan these tags, updating their position in the system.

2. GPS Tracking:

- Useful for large warehouses or outdoor facilities.
- GPS devices attached to vehicles or equipment provide real-time location updates.

3. LORA Technology:

- The LoRa SX series, particularly the SX1276, SX1277, SX1278, and SX1279, are transceiver modules designed for LoRa (Long Range) communication. This module could transmit data over long distances with low power consumption.

4. Wi-Fi Positioning:

- These systems provide precise indoor tracking by using small devices that communicate with fixed receivers using API from Google Clouds Console ,
- Ideal for locating assets in real time within specific zon

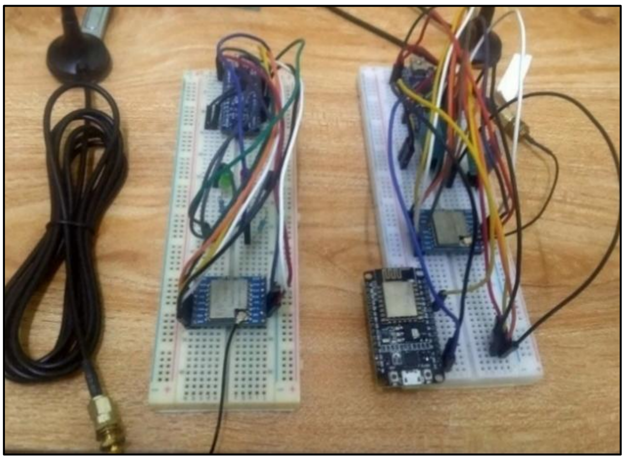


Figure 16 : Proteus PCB Design for Indoor Tracking

3.1.6 Hardware Schematic Design and Fabrication

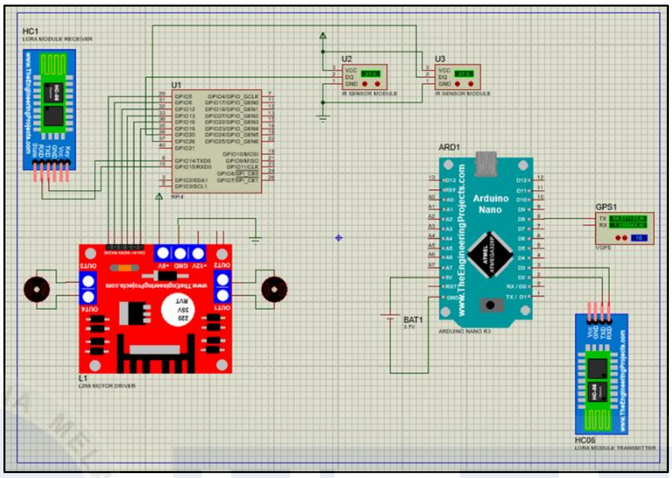


Figure 17 : Proteus Schematic Circuit Design for Tracking Device

The circuit is shown as Figure 17 shows the schematic design of tracking devices. By combining a GPS module with LoRa SX1278 receiver and transmitter with a microcontroller like the Arduino Nano, as illustrated in the wiring diagram, forms an effective communication suitable for long-range serial data transfer without internet connection. The GPS module, based on the NEO-6M chip, provides accurate location data by continuously receiving signals from satellites. This location data is then transmitted via the Lora WAN module, such as the SX1278 , which supports long-range, low-power communication. After schematic , circuit then be converted to PCB design process to achieve the physical hardware design.

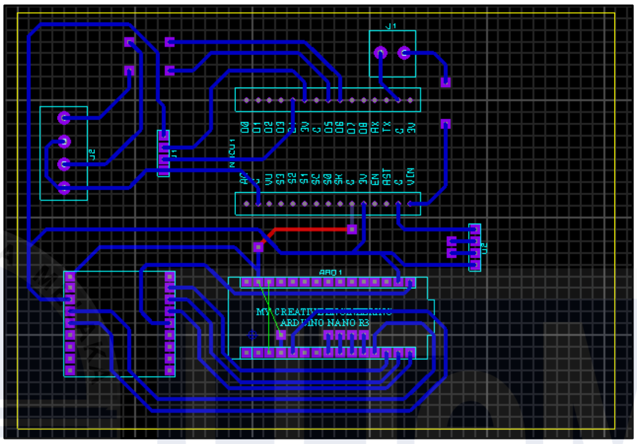


Figure 18 : Proteus PCB Design for Outdoor Tracking

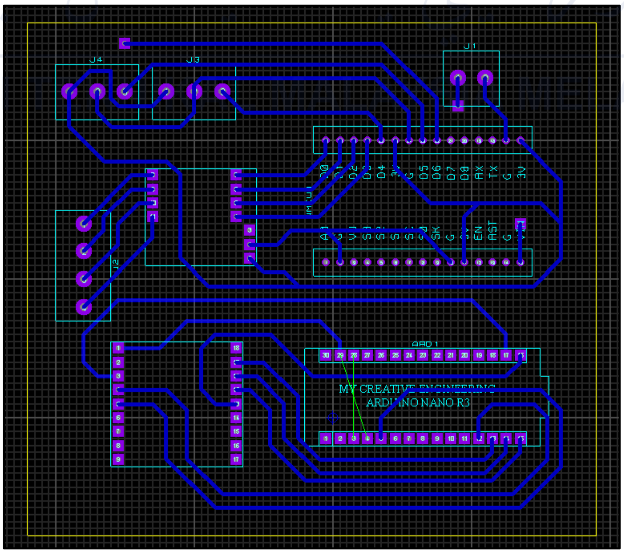


Figure 19 : Proteus PCB Design for Indoor Tracking

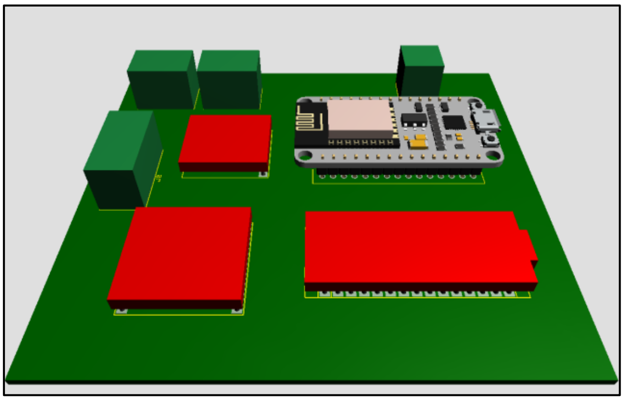


Figure 20 : Proteus PCB Circuit Design for Indoor (3D Viewer)

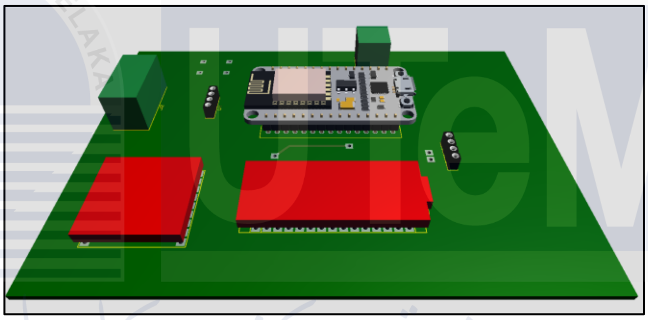


Figure 21 : Proteus PCB Circuit Design for Outdoor Tracking (3D Viewer)

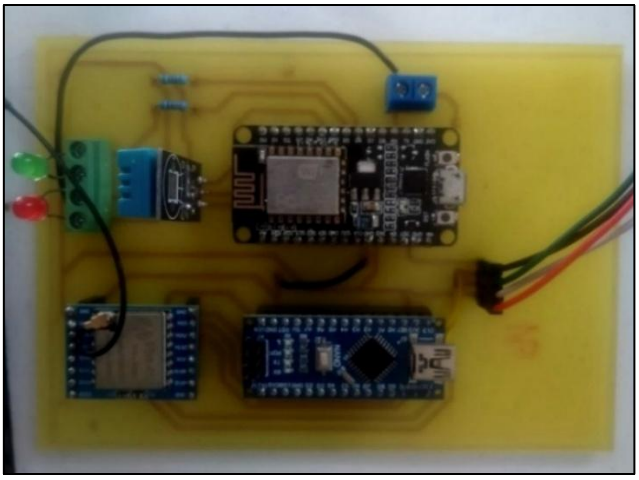


Figure 22 : Soldering components on PCB for Outdoor Device

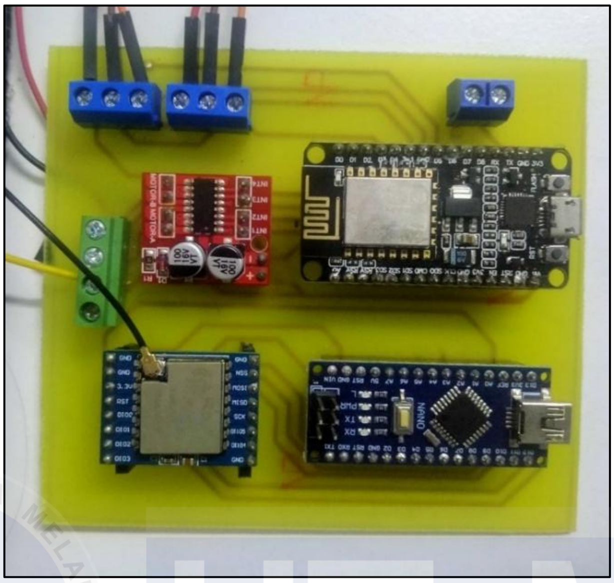


Figure 23 : Soldering components on PCB for Indoor Device

This section involved assembling the hardware components according to the design specifications and integrating them with the software modules. This will design a complete mini scale prototype to test fabricates devices and implement it to IoT software. Figure 22 and Figure 23 show the final component assembly on PCB board. Throughout this phase, attention was focused on addressing technical challenges and optimising the system for real-world deployment in logistics settings. The system went for simulated and real-world logistic scenarios to evaluate its accuracy in asset tracking, responsiveness to user inputs, and overall reliability. Testing results were used to refine the system and ensure its readiness for deployment.

3.1.7 Software Design for Web Interfaces

Software development included designing the backend system for data processing, storage, and communication with IoT devices, as well as developing frontend interfaces for user interaction and visualisation of asset information. Software modules were also implemented for functionalities such as inventory management and asset monitoring.

From a literature review, several software packages can be used as monitoring systems, such as localhost webpage , Google Cloud and Blynk IoT cloud. The data display on webpage in Figure 24 is fetch from record data store in Xampp database , then be displayed on webpage as IoT monitoring interfaces. This configuration can be accessed by browsing the localhost default IP address which is http://192.168.0.119/ESP8266_MySQL_database/Psm/index.php . Logging into this modem will allow the user to do monitoring and view item activities.

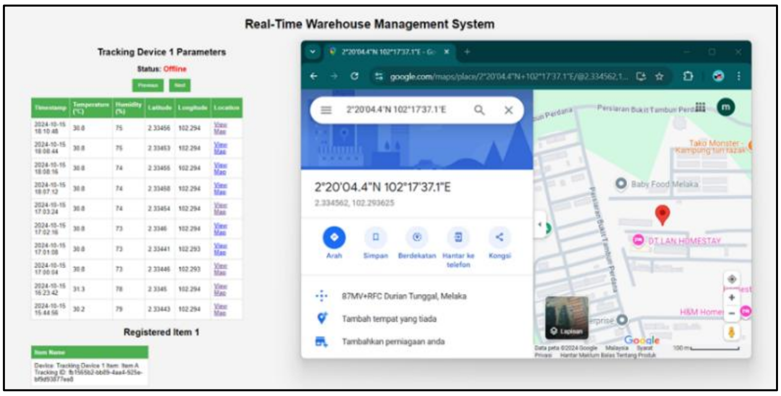


Figure 24 : Web monitoring setup for Monitoring using

Figure 25 : Web monitoring on mobile using IP address

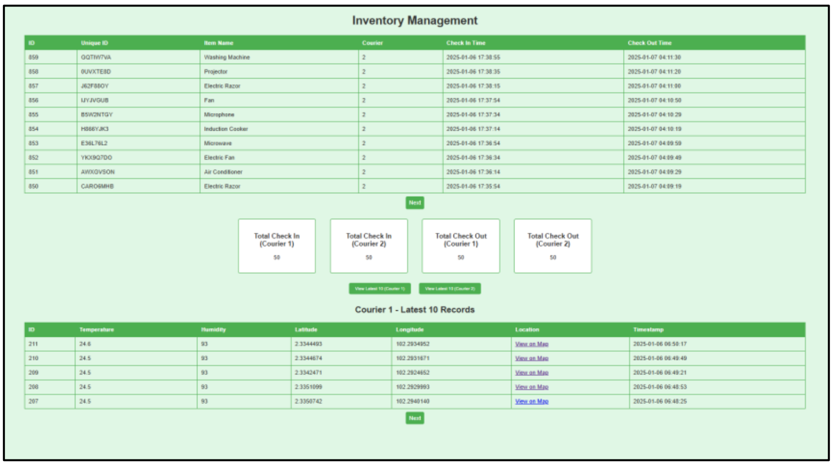


Figure 26 : Monitoring Interface for Management System in Window OS

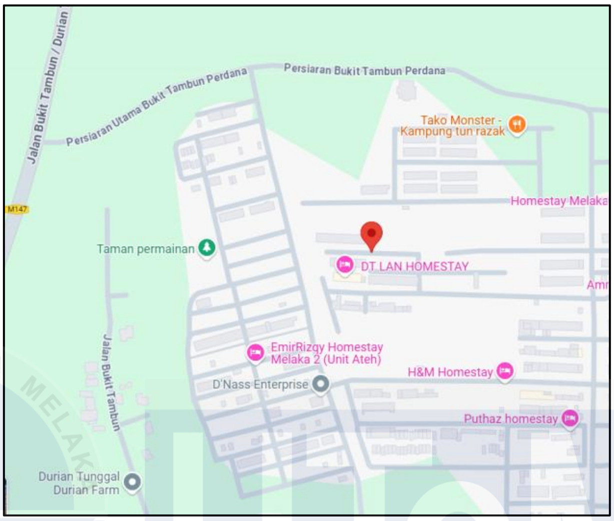


Figure 27 : Location Tracking on Google Maps

3.1.8 System Implementation and Prototype

The system implementation and prototype phase involve translating the theoretical design of the project into a working model. This phase is crucial for validating the functionality, performance, and reliability of the system components before the final deployment. The prototype serves as a demonstration of how the individual modules of the system interact and perform in real-world scenarios. By assembling hardware components, integrating software, and conducting tests, the prototype provides valuable insights into potential issues and improvements. Figure 28 , Figure 29 and Figure 30 shows the final prototype design.

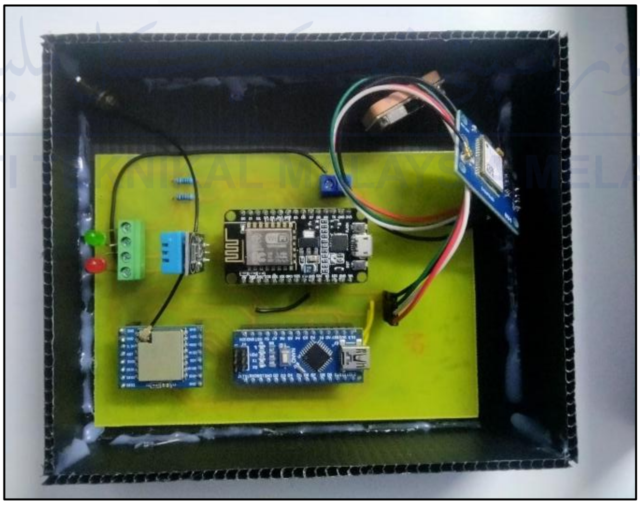


Figure 28 : Outdoor Tracking Device

Figure 29 : Indoor Tracking Device and Sorting System (Front view)

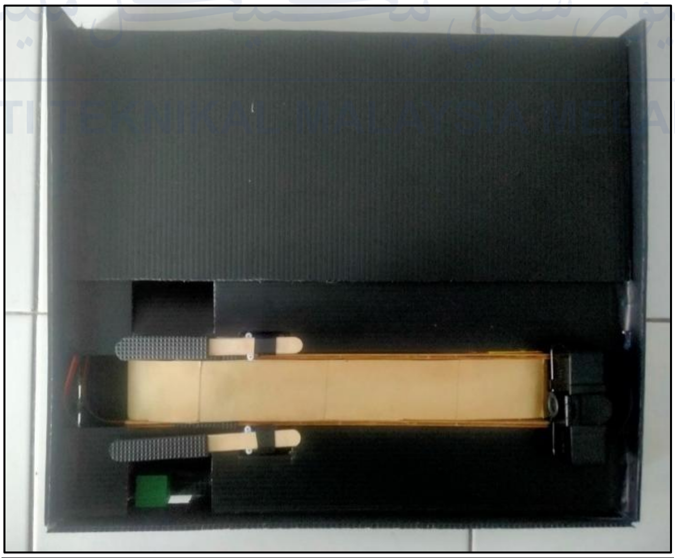


Figure 30 : Indoor Tracking Device and Sorting System (Top view)

3.1.9 Performance and Data Analysis

After testing and troubleshoot , the performance of the developed system was analysed to assess its effectiveness in meeting the project objectives and requirements. Key performance metrics and parameters such as accuracy of asset tracking, response time, scalability and efficiency were evaluated using monitoring software . Performance analysis also involved comparing the system's performance against traditional methods and industry standards. Insights gained from performance analysis were used to further optimize the system and provide recommendations for future enhancements. Several data for analysis are obtained through Python serial and Arduino IDE serial monitor . This data the be either recorded directly on a local database or converted to an Excel file. Figure 31 shows the data collection using Arduino IDE serial monitor.

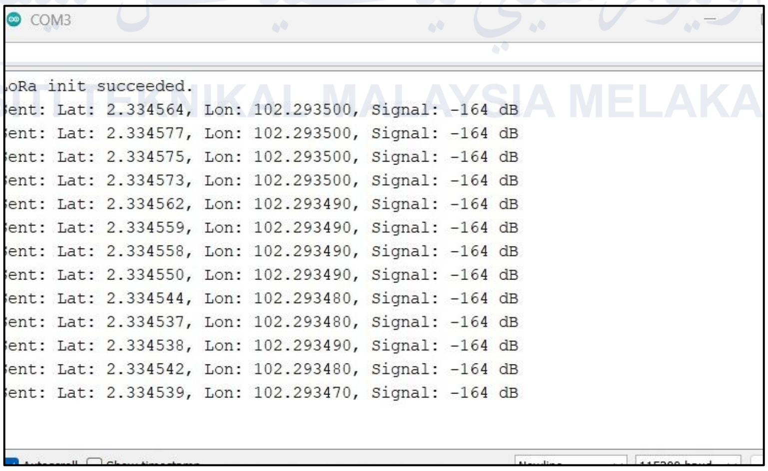
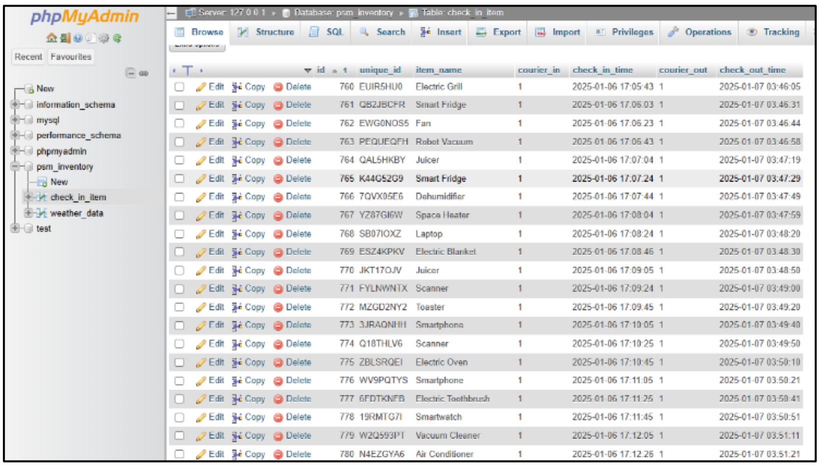


Figure 31 : Data collection using Arduino serial monitor for location



id	unique_id	item_name	courier_in	check_in_time	courier_out	check_out_time
760	EUIR5HU0	Electric Grill	1	2025-01-06 17:05:43	1	2025-01-07 03:46:05
761	QB2JBCFR	Smart Fridge	1	2025-01-06 17:06:03	1	2025-01-07 03:46:31
762	EWG0NOS5	Fan	1	2025-01-06 17:06:23	1	2025-01-07 03:46:44
763	PEQUEQFH	Robot Vacuum	1	2025-01-06 17:06:43	1	2025-01-07 03:46:58
764	QAL5HKBY	Juicer	1	2025-01-06 17:07:04	1	2025-01-07 03:47:19
765	K44G52G9	Smart Fridge	1	2025-01-06 17:07:24	1	2025-01-07 03:47:29
766	7QVX05E6	Dehumidifier	1	2025-01-06 17:07:44	1	2025-01-07 03:47:49
767	YZ87GI6W	Space Heater	1	2025-01-06 17:08:04	1	2025-01-07 03:47:59
768	SB07IOXZ	Laptop	1	2025-01-06 17:08:24	1	2025-01-07 03:48:20
769	ESZ4KPKV	Electric Blanket	1	2025-01-06 17:08:46	1	2025-01-07 03:48:30
770	JKT17OJV	Juicer	1	2025-01-06 17:09:05	1	2025-01-07 03:48:50
771	FYLNWNTX	Scanner	1	2025-01-06 17:09:24	1	2025-01-07 03:49:00
772	MZGD2NY2	Toaster	1	2025-01-06 17:09:45	1	2025-01-07 03:49:20
773	3JRAQNHH	Smartphone	1	2025-01-06 17:10:05	1	2025-01-07 03:49:40
774	Q18THLV6	Scanner	1	2025-01-06 17:10:25	1	2025-01-07 03:49:50
775	ZBLSRQEI	Electric Oven	1	2025-01-06 17:10:45	1	2025-01-07 03:50:10
776	WV9PQTYS	Smartphone	1	2025-01-06 17:11:05	1	2025-01-07 03:50:21
777	6FDTKNFB	Electric Toothbrush	1	2025-01-06 17:11:25	1	2025-01-07 03:50:41
778	19RMTG7I	Smartwatch	1	2025-01-06 17:11:45	1	2025-01-07 03:50:51
779	W2Q593PT	Vacuum Cleaner	1	2025-01-06 17:12:05	1	2025-01-07 03:51:11
780	N4EZGYA6	Air Conditioner	1	2025-01-06 17:12:26	1	2025-01-07 03:51:21

Figure 32 : MySQL Xampp Database for data storage

3.2 Project Planning

This part discusses the project planning and implementation cost of the hardware design and software design.

3.2.1 Gantt Chart of the Project

Figure 10 shows the project planning for the final year project in 2 semesters . The activities consist of major planning that needs to be achieved based on flowchart and objectives.

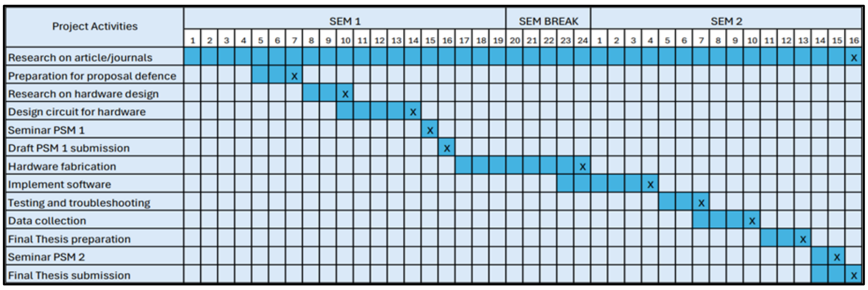


Figure 33 : : Project Gantt Chart

3.2.2 Project Cost

This part explains the financial cost for all components shown in table 3. A microcontroller or single-board computer, such as Raspberry Pi, acts as the central processing unit. Cloud infrastructure is implemented for data storage, enabling real-time monitoring and control over assets throughout the logistics supply chain. The system includes a user interface for monitoring and control, allowing users to optimize asset utilization and improve overall operational efficiency

Table 3 : Total Cost Component

No	Components	Price (RM)
1	5MP Camera Board Raspberry Pi Camera	33.59
2	Mini L298N DC Motor Driver Dual H Bridge PWM Control	
3	Lora SX1278 RF 433 Wireless Transceiver Module	47.78
4	RF Antenna (433Mhz) w/ SMA Male Interface LoRa 433 SX1278	22.96
5	IPEX to SMA [Female] Connector Cable	
6	Conveyor Belt DIY	15.41
7	PP Corrugated Board	25.80
8	Raspberry Pi 4	
9	NodeMCU ESP8266	
10	Arduino Nano	
	Total	145.54

3.3 Is The Project Relevant to Sustainability And Is It Environmentally Friendly?

The project is highly relevant to sustainability and supports efforts to protect the environment while enhancing operational efficiency in logistics. It uses advanced technology like IoT, GPS, and QR code scanning to streamline processes and minimize waste, directly aligning with Sustainable Development Goals (SDGs). Specifically, it contributes to Goal 9 by promoting innovation in logistics using modern technologies that reduce inefficiencies and optimize resource utilization, making logistics infrastructure smarter and more efficient. It also aligns with Goal 12 by ensuring better inventory management, reducing waste, and minimizing the environmental impact of transportation through optimized routes and real-time GPS tracking. Furthermore, it supports Goal 8 by automating warehouse operations, which reduces manual labor, minimizes workplace injuries, and creates a safer and more efficient work environment.

The project also offers significant environmental benefits by addressing common inefficiencies in logistics. It helps reduce resource wastage through accurate inventory tracking, ensuring goods are utilized before they expire or become obsolete, particularly for perishable items. Additionally, the system uses energy-efficient components, such as the Raspberry Pi and LoRa modules, which consume low power while transmitting data over long distances. By optimizing warehouse processes and delivery routes, the project reduces energy consumption and lowers carbon emissions. For example, real-time GPS tracking allows businesses to plan delivery routes efficiently, cutting down on fuel use and contributing to a smaller carbon footprint. Moreover, the hardware components selected for the project, including Arduino Nano and other energy-efficient technologies, demonstrate a commitment to eco-friendly practices.

Despite its many benefits, there are challenges that need to be addressed to enhance the project's sustainability. One challenge is the environmental impact of manufacturing electronic components, as their production involves energy-intensive processes and the extraction of raw materials. Additionally, the disposal of outdated or malfunctioning hardware could lead to electronic waste (e-waste) if not properly managed. Establishing recycling protocols and encouraging the use of recycled materials in hardware components could help mitigate this issue. Another challenge is the reliance on stable internet connectivity for real-time operations, which can vary in its environmental friendliness depending on the energy sources used to power the network infrastructure.

Figure 34 : Sustainable Development Goals (SDG-17)

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Comparison between traditional method and IoT System

Traditional asset management and IoT asset management differ significantly in terms of efficiency, accuracy, and scalability. Traditional methods, with their reliance on manual data entry, are more prone to human error and delays. In contrast, IoT systems automate data collection, providing more accurate and timely information. The maintenance approach also differs; traditional systems are reactive, often addressing issues after they have occurred, whereas IoT systems enable predictive maintenance, identifying potential problems before they cause major disruptions. This proactive approach helps reduce both downtime and maintenance costs.

The cost implications of these two methods are also notable. While traditional systems may seem less expensive initially due to lower technology investment, they often incur higher ongoing costs due to the manual processes involved. On the other hand, IoT systems require an upfront investment in technology and infrastructure but offer long-term savings through enhanced efficiency and reduced operational costs.

Scalability is another critical difference. Traditional asset management can be challenging to scale, especially for large organizations managing numerous assets. IoT systems, however, are designed to scale easily, allowing businesses to track many assets across various locations without a significant increase in manual effort.

Real-time data availability in IoT systems also supports better decision-making. Traditional systems provide limited, often outdated information, which can impede effective decision-making. IoT systems, by contrast, offer continuous updates and comprehensive data analytics, empowering organizations to make informed decisions swiftly.

Lastly, environmental monitoring is another area where IoT systems excel. They can monitor various environmental factors affecting assets, such as temperature and humidity, ensuring that assets remain in optimal conditions. Traditional systems lack this capability, making them less effective in environments where asset conditions must be closely monitored.

id	unique_id	item_name	courier_in	check_in_time	check_out_time	courier_out
785	9EGNECFG	Electric Oven	1	1/6/2025 17:14	1/7/2025 3:52	1
786	DYKFU4ND	Air Purifier	1	1/6/2025 17:14	1/7/2025 3:52	1
787	SLYKTQCI	Space Heater	1	1/6/2025 17:14	1/7/2025 3:53	1
788	6RS7KVAD	Smartwatch	1	1/6/2025 17:15	1/7/2025 3:53	NULL
789	ZXRXKJEL	Vacuum Cleaner	1	1/6/2025 17:15	1/7/2025 3:53	1
790	ZRSTGQIT	Speaker	1	1/6/2025 17:15	1/7/2025 3:54	NULL
791	P388PB86	Keyboard	1	1/6/2025 17:16	1/7/2025 3:54	1
792	U7WY2TYV	Keyboard	1	1/6/2025 17:16	1/7/2025 3:54	NULL
793	ZO3C7SF3	Smartwatch	1	1/6/2025 17:16	1/7/2025 3:54	1
794	X62W0SJK	Electric Grill	1	1/6/2025 17:17	1/7/2025 3:55	NULL
795	25DA4IHY	ectric Pressure Cook	1	1/6/2025 17:17	1/7/2025 3:55	1
796	UXTI98A2	Space Heater	1	1/6/2025 17:17	1/7/2025 3:55	NULL
797	9HU5T47A	Webcam	1	1/6/2025 17:18	1/7/2025 3:55	1
798	DARRBY5E	Refrigerator	1	1/6/2025 17:18	1/7/2025 3:56	NULL
799	O1WDNZHZ	Smartwatch	1	1/6/2025 17:18	1/7/2025 3:56	1
800	2HHURRNY	ectric Pressure Cook	1	1/6/2025 17:19	1/7/2025 3:56	NULL
801	YCYFMJPW	Dehumidifier	1	1/6/2025 17:19	1/7/2025 3:56	1
802	KUTTFUUL	Air Purifier	1	1/6/2025 17:19	1/7/2025 3:57	NULL
803	8XXWW6HK	Microwave	1	1/6/2025 17:20	1/7/2025 3:57	1
804	405Q27BH	TV	1	1/6/2025 17:20	1/7/2025 3:57	1
805	OUPNHHMZ	Oven	1	1/6/2025 17:20	1/7/2025 3:57	1
806	095S50LQ	Hair Dryer	1	1/6/2025 17:21	1/7/2025 3:58	NULL
807	NCOAD2OF	Electric Blanket	1	1/6/2025 17:21	1/7/2025 3:58	1
808	TSD8FT3D	Toaster	1	1/6/2025 17:21	1/7/2025 3:58	NULL
809	ULVE5KN9	Refrigerator	1	1/6/2025 17:22	1/7/2025 3:58	1
810	V2X1HAVZ	Smart Thermostat	2	1/6/2025 17:22	1/7/2025 3:59	2
811	2QG68WN9	Tablet	2	1/6/2025 17:22	1/7/2025 3:59	2
812	XCAU8PFN	Toaster	2	1/6/2025 17:23	1/7/2025 3:59	2
813	RZ1PZRTN	Food Processor	2	1/6/2025 17:23	1/7/2025 3:59	NULL
814	ROP9K0RU	Fan	2	1/6/2025 17:23	1/7/2025 4:00	2
815	XZK12PTQ	Cordless Vacuum	2	1/6/2025 17:24	1/7/2025 4:00	2
816	MEOJ8WS7	Electric Grill	2	1/6/2025 17:24	1/7/2025 4:00	2
817	EQVN7KSD	Cordless Vacuum	2	1/6/2025 17:24	1/7/2025 4:00	NULL
818	U1ZYKG56	Speaker	2	1/6/2025 17:25	1/7/2025 4:01	2
819	9T5CG5L7	Space Heater	2	1/6/2025 17:25	1/7/2025 4:01	NULL
820	TL6CC6Q2	Headphones	2	1/6/2025 17:25	1/7/2025 4:01	2
821	OMQZ2I3J	Webcam	2	1/6/2025 17:26	1/7/2025 4:01	NULL
822	N6ZS9MBE	Laptop	2	1/6/2025 17:26	1/7/2025 4:02	2
823	D679QH79	Coffee Maker	2	1/6/2025 17:26	1/7/2025 4:02	NULL
824	S02HYXB0	Vacuum Cleaner	2	1/6/2025 17:27	1/7/2025 4:02	2
825	673EVTH9	Printer	2	1/6/2025 17:27	1/7/2025 4:02	2
826	Q3QIF1JZ	Dehumidifier	2	1/6/2025 17:27	1/7/2025 4:03	2
827	YPCU8PRR	Rice Cooker	2	1/6/2025 17:28	1/7/2025 4:03	NULL
828	GHWNEV3E	Webcam	2	1/6/2025 17:28	1/7/2025 4:03	2
829	0J71Z741	Water Heater	2	1/6/2025 17:28	1/7/2025 4:03	NULL
830	V9QF1X7A	Electric Oven	2	1/6/2025 17:29	1/7/2025 4:04	2
831	IZY9PNH6	Refrigerator	2	1/6/2025 17:29	1/7/2025 4:04	NULL
832	UTN1LWPN	Mouse	2	1/6/2025 17:29	1/7/2025 4:04	2
833	QUEZKXZY	Washing Machine	2	1/6/2025 17:30	1/7/2025 4:04	NULL
834	LZ95R0SZ	Oven	2	1/6/2025 17:30	1/7/2025 4:05	2

Figure 35 : Indoor Inventory Data Collection

id	temperature	humidity	latitude	longitude	location	timestamp
225	28.9	85	2.3343868	102.2934723	ww.google.com/maps?q=2.334387,102	1/7/2025 8:15
226	28.9	85	2.3343201	102.2934875	ww.google.com/maps?q=2.334320,102	1/7/2025 8:15
227	28.9	85	2.3339679	102.2936401	ww.google.com/maps?q=2.333968,102	1/7/2025 8:15
228	28.9	85	2.3341074	102.2940063	ww.google.com/maps?q=2.334107,102	1/7/2025 8:15
229	28.9	85	2.3341424	102.2944031	ww.google.com/maps?q=2.334142,102	1/7/2025 8:16
230	28.9	84	2.3339381	102.2956009	ww.google.com/maps?q=2.333938,102	1/7/2025 8:16
231	28.9	84	2.3335166	102.2955475	ww.google.com/maps?q=2.333517,102	1/7/2025 8:16
232	28.9	84	2.3330526	102.2955246	ww.google.com/maps?q=2.333053,102	1/7/2025 8:16
233	28.9	84	2.332715	102.2953033	ww.google.com/maps?q=2.332715,102	1/7/2025 8:16
234	28.9	84	2.3323343	102.2951965	ww.google.com/maps?q=2.332334,102	1/7/2025 8:16
235	28.9	84	2.331574	102.295433	ww.google.com/maps?q=2.331574,102	1/7/2025 8:17
236	28.9	84	2.3306854	102.2955704	ww.google.com/maps?q=2.330685,102	1/7/2025 8:17
237	28.9	84	2.3301871	102.2954483	ww.google.com/maps?q=2.330187,102	1/7/2025 8:17
238	29	84	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:17
239	29.3	84	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:17
240	29.3	84	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:17
241	29.3	84	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:18
242	29.3	84	2.3283088	102.2939453	ww.google.com/maps?q=2.328309,102	1/7/2025 8:18
243	29.3	83	2.3279812	102.2939606	ww.google.com/maps?q=2.327981,102	1/7/2025 8:18
244	29.3	83	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:18
245	29.3	83	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:18
246	29.3	83	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:18
247	29.3	82	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:19
248	29.3	82	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:19
249	29.3	82	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:19

Figure 36 : Humidity , Temperature and Location Data Collection

Inventory in Figure 35 is used to keep track of assets or packages in a logistics system, helping to monitor their movement in and out of a warehouse or similar environment. This data is recorded through database . Each row in the table represents one item being tracked, with several pieces of important information recorded. The id column gives each record a unique number, ensuring every entry is different. The unique_id is likely a special code, like a QR code or barcode, that identifies each asset or package. The item_name describes what the item is. The courier_in column shows who brought the item into the warehouse, while the check_in_time records the exact time it arrived. When the item is sent out, the check_out_time logs the time it leaves, and the courier_out shows who took it out. This table helps to manage and track assets efficiently by providing a clear record of their entry and exit, which can be used to prevent loss and improve the overall management of items.

Null in a database table refers to a field that has no value assigned to it. It represents the absence of data. For example, if an item has been checked into the warehouse but not yet checked out, the check_out_time and courier_out fields might be null because those actions have not occurred yet.

Figure 36 recorded monitoring environmental conditions and tracking locations. Each row in the table represents a specific reading or data point. The id column uniquely identifies each record. The temperature and humidity columns store environmental readings, which are crucial for managing environments sensitive to temperature and moisture, such as warehouses storing perishable goods or delicate equipment. The latitude and longitude columns record the geographic location of the reading, allowing for the tracking of items or assets in different locations. The location column could store a descriptive name or identifier for the specific place corresponding to the latitude and longitude. The timestamp column logs the exact time when the data was recorded, enabling a time-based analysis of environmental conditions and location changes.

In terms of impact on the management system, this table helps in real-time monitoring and managing the conditions within warehouses or during the transportation of goods. It can provide valuable insights for predictive maintenance by analysing trends in temperature and humidity over time, identifying patterns that might lead to equipment failure or spoilage of goods. By predicting these issues before they occur, the system can prevent losses and maintain operational efficiency.

4.2 Performance analysis for Camera Tracking and Sorting system

4.2.1 Optimizing Time Intervals for Enhanced Sorting Accuracy in Conveyor Systems.

Time Interval (s)	Sorting Accuracy (%)	Total Items Sorted (out of 30)
2	60	18
4	70	21
6	75	23
8	80	24
10	85	26
12	88	26
14	90	27
15	100	30
16	100	30
18	100	30
20	100	30

Figure 37 : Time vs Total Item for Conveyor

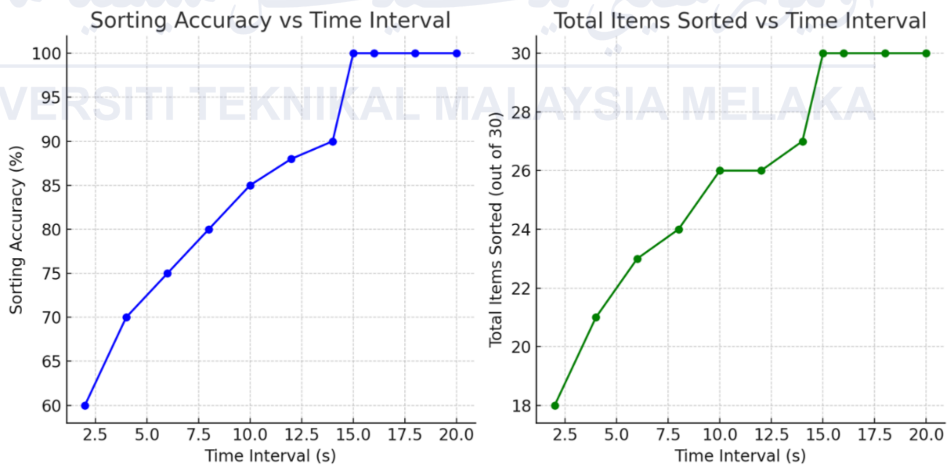


Figure 38 : Graph comparison for conveyor sorting

The figure 38 , shows data on sorting accuracy and the total number of items sorted over various time intervals. As the time interval increases from 2 to 20 seconds, both sorting accuracy and the total items sorted show a noticeable improvement. At a 2 second interval, the sorting accuracy starts at 60%, with 18 out of 30 items sorted correctly. As the interval increases, sorting accuracy improves steadily, reaching 100% accuracy at 15 seconds and beyond, where all 30 items are sorted correctly.

This data suggests that giving the conveyor more time per interval allows for a more precise sorting process. Initially, shorter intervals result in lower accuracy, due to the system's inability to process items quickly enough. However, as the time interval is extended, the system has enough time to sort each item accurately, achieving perfect sorting with intervals of 15 seconds or more. The analysis clearly demonstrates the importance of balancing speed and accuracy in automated sorting systems. By optimizing the time interval, the system can maximize efficiency without compromising on accuracy, thus providing a framework for fine-tuning conveyor speed to achieve the best performance in practical applications.

4.2.2 Performance analysis to choosing suitable resolution for camera setting.

id	unique_id	item_name	check_in_time	courier_in	check_in_time	courier_out
359	IJYJVGUB	Fan	2025-01-05 14:47:40	2	2025-01-06 05:55:45	2
360	J62F88OY	Electric Razor	2025-01-05 14:48:00	2	2025-01-06 05:56:05	2
361	0UVXTE8D	Projector	2025-01-05 14:48:10	2	2025-01-06 05:56:25	2
362	GQTIW7VA	Washing Machine	2025-01-05 14:48:30	2	2025-01-06 05:56:35	2
100			0:25:15	90	0:40:51	98.88888889
559	U1OZRN1N	Air Conditioner	2025-01-05 17:48:25	2	2025-01-05 16:15:05	2
560	PXSHFRZL	Electric Grill	2025-01-05 17:48:35	2	2025-01-05 16:15:25	2
561	2W2DVT9N	Rice Cooker	2025-01-05 17:48:55	2	2025-01-05 16:15:45	2
562	G3T25106	Electric Blanket	2025-01-05 17:49:05	2	2025-01-05 16:16:05	2
100			0:28:57	98	0:38:22	100
856	IJYJVGUB	Fan	2025-01-06 13:57:26	2	2025-01-06 17:37:54	2
857	J62F88OY	Electric Razor	2025-01-06 13:57:36	2	2025-01-06 17:38:15	2
858	0UVXTE8D	Projector	2025-01-06 13:57:57	2	2025-01-06 17:38:35	2
859	GQTIW7VA	Washing Machine	2025-01-06 13:58:05	2	2025-01-06 17:38:55	2
100			0:26:55	100	0:33:47	100
856	IJYJVGUB	Fan	2025-01-06 13:57:26	2	2025-01-06 17:37:54	2
857	J62F88OY	Electric Razor	2025-01-06 13:57:36	2	2025-01-06 17:38:15	2
858	0UVXTE8D	Projector	2025-01-06 13:57:57	2	2025-01-06 17:38:35	2
859	GQTIW7VA	Washing Machine	2025-01-06 13:58:05	2	2025-01-06 17:38:55	2
100			0:25:22	99	0:33:12	97.97979798
659	IJYJVGUB	Fan	2025-01-05 19:22:25	2	2025-01-07 04:10:50	2
660	J62F88OY	Electric Razor	2025-01-05 19:22:45	2	2025-01-07 04:11:00	2
661	0UVXTE8D	Projector	2025-01-05 19:22:55	2	2025-01-07 04:11:20	2
662	GQTIW7VA	Washing Machine	2025-01-05 19:23:15	2	2025-01-07 04:11:30	2
100			0:25:11	99	0:25:25	77.77777778
237	IJYJVGUB	Fan	2025-01-04 18:36:07	2	2025-01-07 03:35:20	NULL
238	J62F88OY	Electric Razor	2025-01-04 18:36:24	2	2025-01-07 03:35:30	NULL
239	0UVXTE8D	Projector	2025-01-04 18:36:41	2	2025-01-07 03:35:50	NULL
240	GQTIW7VA	Washing Machine	2025-01-04 18:36:58	2	2025-01-07 03:36:01	NULL
100			0:28:03	100	0:25:30	76.28865979

Figure 39 : Data record from database convert to Excel format

Table 4 : Comparison of Delay time vs accuracy for Camera Identification

	Constant Delay Time		Accuracy	
Resolution	Camera accuracy	Time taken(min)	Camera accuracy	Time taken(min)
240p	90	25	100	40
360p	98	28	100	38
480p	100	26	100	33
720p	99	25	100	33
1080p	99	25	100	25
2k	100	28	100	25

Table 5 : Comparison of Delay time vs Accuracy for Sorting

	Constant Delay Time		Accuracy	
Resolution	Camera accuracy	Time taken(min)	Sorting accuracy	Time taken(min)
240p	90	25	98.8	40
360p	98	28	100	38
480p	100	26	100	33
720p	99	25	97.97	33
1080p	99	25	77.72	25
2k	100	28	76.2	25

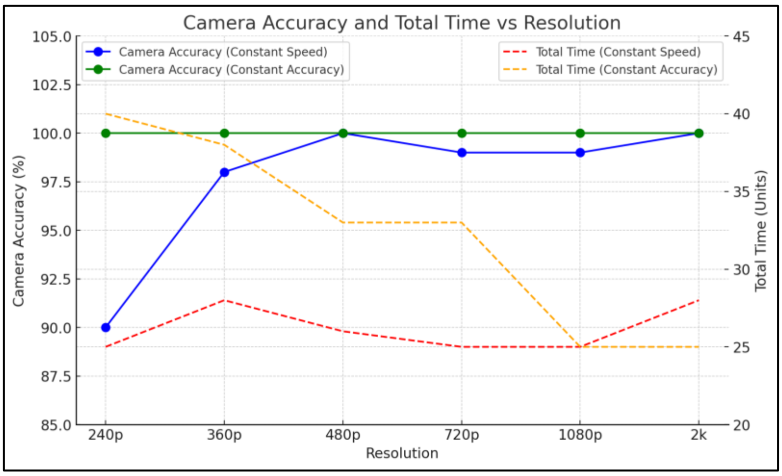


Figure 40 : Camera Accuracy and Total Time

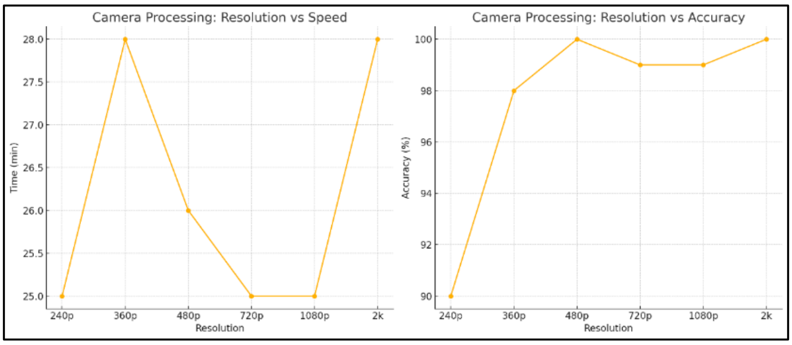


Figure 41 : Camera resolution comparison with Time delay

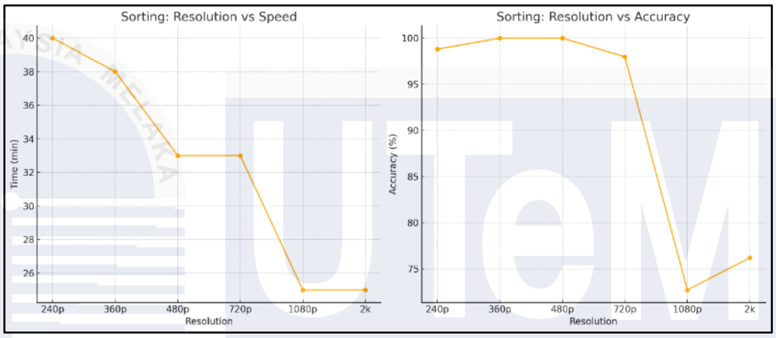


Figure 42 : Camera resolution vs sorting accuracy

Data on camera resolution, accuracy, sorting performance, and the associated total time needed for operations in a warehouse setting are shown in Tables 4 and 5. The project's emphasis on asset management and warehouse logistics with IoT-based solutions is directly related to the outcomes. The data tables demonstrate the effects of camera resolution on accuracy, sorting efficiency, and the overall amount of time required for actual operations. This research has a direct impact on how IoT technologies, such as the ones used in this project, balance accuracy and efficiency to enhance warehouse management.

As the camera resolution increases from 240p to 2k, accuracy improves significantly, reaching 100% at 480p and higher. However, at lower resolutions like 240p, the system compensates for unclear images, which increases processing time. Using higher resolutions like 1080p or 2k gives maximum accuracy and speeds up sorting time, making these ideal for real-time warehouse tasks if the system can handle them efficiently.

At lower resolutions, sorting accuracy is near 100%, but the time taken is longer due to error correction. At higher resolutions, the sorting accuracy drops to around 76-78% because the Raspberry Pi struggles to handle the heavy processing causing the system to freeze . This overload causes errors in communication with the NodeMCU ESP8266 , which performs the sorting, leading to lower performance despite clearer images. The Raspberry Pi acts as the system's main processor but has limited power. At 1080p and 2k resolutions, it cannot manage the large image data effectively, leading to delays and errors. These issues also affect the NodeMCU, which depends on the Raspberry Pi for instructions. This shows the need to optimize hardware and software to balance performance and accuracy.

To improve the system, the user can reduce image resolution to 480p or 720p, where accuracy and speed are balanced. Alternatively, upgrading to a more powerful Raspberry Pi or using external processors for image tasks can help to improve system performance. By addressing these limitations, the system can achieve better sorting accuracy and reliability in warehouse operations.

4.2.3 Comparison of Wi-Fi-positioning and GPS module Neo-6m for Outdoor Tracking

id	temperature	humidity	latitude	longitude	location	timestamp
197	25.8	88	2.3320453	102.2926331	'.google.com/maps?q=2.332045,	1/6/2025 6:43
198	24.8	89	2.3321579	102.2932739	'.google.com/maps?q=2.332158,	1/6/2025 6:44
199	24.8	90	2.3326962	102.2925644	'.google.com/maps?q=2.332696,	1/6/2025 6:44
200	24.5	90	2.3326898	102.2935867	'.google.com/maps?q=2.332690,	1/6/2025 6:45
201	24.5	91	2.3327422	102.2945786	'.google.com/maps?q=2.332742,	1/6/2025 6:45
202	24.5	92	2.3325565	102.2954865	'.google.com/maps?q=2.332556,	1/6/2025 6:46
203	24.5	92	2.3325858	102.2962341	'.google.com/maps?q=2.332586,	1/6/2025 6:46
204	24.5	92	2.3339207	102.2965393	'.google.com/maps?q=2.333921,	1/6/2025 6:47
205	24.5	93	2.3352101	102.2956238	'.google.com/maps?q=2.335210,	1/6/2025 6:47
206	24.5	93	2.3350334	102.2952042	'.google.com/maps?q=2.335033,	1/6/2025 6:47
207	24.5	93	2.3350742	102.294014	'.google.com/maps?q=2.335074,	1/6/2025 6:48
208	24.5	93	2.3351099	102.2929993	'.google.com/maps?q=2.335110,	1/6/2025 6:48

Figure 43 : Database example for Outdoor Tracking Device

Here's a tabulated comparison between the Geolocation API using NodeMCU and the GPS Module NEO-6M:-

Table 6 : Comparison between geolocation and Gps

Feature	Geolocation API using NodeMCU	GPS Module NEO-6M
Technology	Wi-Fi-based geolocation	Satellite-based GPS positioning
Plotting Points	More frequent plotting points	Fewer plotting points
Location Accuracy	General location, less precise	More precise and accurate location data
Suitability	Suitable for urban areas with dense Wi-Fi networks	Suitable for outdoor environments with clear satellite visibility
Performance Limitations	May lack precision due to Wi-Fi triangulation	Performance degrades in areas with limited satellite visibility (indoors, dense urban environments)

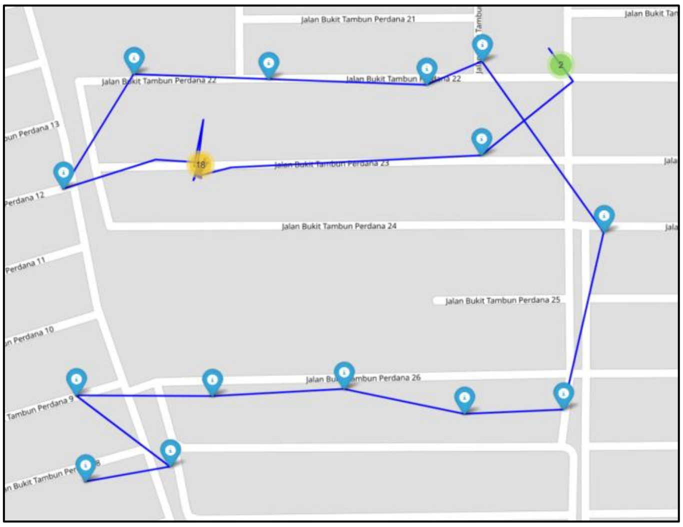


Figure 44 : Geolocation ESP8266 Nodemcu Maps plotting for Location

Figure 45 : GPS module Neo-6m Maps plotting for Location

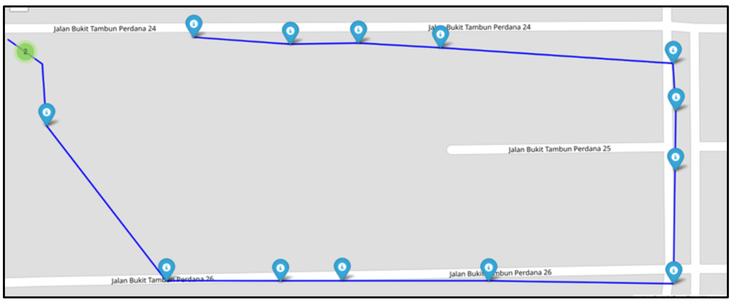


Figure 46 : Gps module Neo-6m Maps plotting for Location

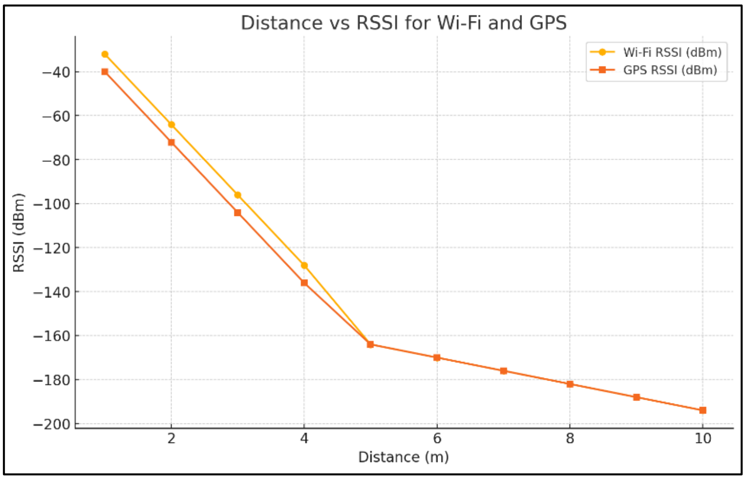


Figure 47 : Relationship between distance and RSSI (in dBm) for both Wi-Fi and GPS

Table 6 illustrate two distinct geolocation methods , Wi-Fi-based geolocation using ESP8266 NodeMCU in Figure 44 and GPS-based tracking using the NEO-6M module Figure 45. In Figure 44 , the NodeMCU employs the Geolocation API, which relies on the triangulation of nearby Wi-Fi networks to estimate the device's position. This approach is beneficial in urban areas where Wi-Fi networks are abundant, allowing for frequent position updates as shown by the dense plotting on the map. However, this method may not be as precise due to the variability in Wi-Fi signal strengths and the general nature of Wi-Fi triangulation.

Figure 46 shows the results of using the GPS module NEO-6M, which relies on satellite signals to determine the exact location. This method offers better accuracy, as indicated by the precise plotting points on the map. However, the GPS module typically provides fewer plotting points because it depends on satellite visibility and the time required to establish a reliable connection. This can result in slower updates, especially in environments where satellite signals are obstructed, such as indoors or in urban canyons.

The differences in plotting density and accuracy between the two figures highlight the trade-offs between Wi-Fi-based and GPS-based geolocation. Wi-Fi-based geolocation offers frequent updates and works well in areas with dense network coverage, but it sacrifices accuracy. On the other hand, GPS-based tracking is more accurate but may have fewer updates due to signal constraints and environmental factors. Choosing the appropriate geolocation method depends on the specific application requirements, including the need for accuracy, update frequency, and the environmental context.

The graph from figure 47 illustrates the relationship between distance and RSSI (Received Signal Strength Indicator) for both Wi-Fi-based geolocation and GPS positioning. As the distance increases from 1 to 10 meters, there is a noticeable decline in RSSI values for both technologies, indicating signal weakening over greater distances. Wi-Fi RSSI drops more sharply, starting at -32 dBm at 1 meter and reaching -194 dBm at 10 meters. GPS RSSI also declines, though less drastically, from -40 dBm at 1 meter to -194 dBm at 10 meters. This trend highlights how Wi-Fi signals degrade faster with distance, whereas GPS provides relatively stable signal strength until around 5 meters, where both technologies show a significant drop. The graph underscores the challenges in maintaining strong and reliable signal strength over longer distances, especially for Wi-Fi-based geolocation. This signal strength and distance comparison analysis is important to record accurate locations for outdoor tracking device . To overcome these limitations of inaccurate location in system , choosing a suitable device module for different environments is very important.

CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 Conclusion

In conclusion, this project successfully implemented a real-time asset management monitoring system that integrates QR code scanning for conveyor sorting, LoRa communication, and GPS tracking. The system allows users to track and manage assets efficiently, with data visualisation and control provided through the Xampp database application and web interfaces. The use of LoRa technology enabled long-range communication, making it suitable for environments where traditional Wi-Fi or cellular networks might not be reliable or available. Result shows that tracking device has potentially has higher percentage of success of detecting item and locating it. However , due to limitation of prototype devices , causing efficiency of devices to drop due then nonoptimize system. Based on the research , this limitation can be overcome for future design by using comparative analysis that been found on this project.

Throughout the course of the project, several challenges have been counter , such as optimising power distribution, ensuring reliable communication between devices, and integrating multiple sensors and modules for data collection. The project demonstrated the feasibility of using a combination of affordable hardware and open-source software to create a robust monitoring system.

Despite its successes, the project also highlighted areas for further improvement, such as enhancing GPS accuracy, improving power management, and securing the communication channels. Future iterations of this system could benefit from incorporating more advanced GPS modules, better power solutions and secure communication protocols. With continued development, this system has the potential to offer a comprehensive solution for various industries, enhancing efficiency, security, and user experience in asset management

This project was undertaken as part of the Bachelor of Electronic Engineering program at Universiti Teknikal Malaysia Melaka. The choice of this project was motivated by the growing need for efficient asset management solutions in various industries. It provided an excellent opportunity to apply theoretical knowledge in practical scenarios, integrating multiple disciplines such as electronics, communication, and software engineering.

In summary, the project is a strong example of how technology can be used to achieve sustainability and environmental goals. By improving efficiency, reducing waste, and using eco-friendly components, the project supports responsible consumption and production while minimizing its impact on the planet. Although there are challenges to address, such as e-waste and manufacturing impacts, adopting renewable energy and recycling measures can further enhance its sustainability. Overall, this IoT-based asset tracking system demonstrates great potential as an environmentally friendly solution for the logistics industry, contributing to a more sustainable future

.

5.2 Recommendation and Future Work

In this project, an asset management monitoring system is successfully developed multiple different systems and integration with the database and monitoring system . Although the system performs well in its current state, there are several areas for improvement and future development. First, it is recommended to enhance the accuracy and efficiency of the GPS tracking system. The current GPS module, NEO-6M, works well in outdoor environments but lacks precision in indoor or dense urban settings. Exploring alternatives such as integrating Wi-Fi-based geolocation or using more advanced GPS modules that support multi-band reception could improve accuracy.

Another area for improvement is power management. During testing, we noticed that the Arduino Nano receiver performance depended on the power supply from the sender device. Future work could focus on optimizing the power distribution across devices to ensure reliable and independent operation. Adding rechargeable batteries or exploring solar-powered options could enhance the system's autonomy.

The software side also has room for enhancement. The system currently relies on the Xampp MySQL and Blynk app for real-time monitoring and control, but expanding its capabilities to include more detailed data analytics and historical tracking could offer additional insights. Implementing machine learning algorithms to predict asset movement patterns and potential issues could make the system more proactive and intelligent.

Security is another crucial aspect that needs attention. As the system involves wireless communication, ensuring data integrity and protecting against unauthorized access is vital. Incorporating encryption methods and secure communication protocols will enhance the security of data transmitted between devices. Upgrade for secure IP server is required for protecting the data.

Lastly, the system's user interface could be made more user-friendly. Although the Web interfaces provide a basic interface, developing a custom mobile or web application could allow for more tailored user experiences, including customizable dashboards, alerts, and reports. Expanding support for multiple users and roles within the app would also make it more suitable for larger organizations.

Future work could also involve scaling the system for more extensive asset management, incorporating additional sensors for environmental monitoring, or integrating with enterprise resource planning (ERP) systems for comprehensive asset tracking. These improvements will make the system more robust, scalable, and versatile, catering to various industries and use cases.

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APPENDICES

Appendix A : Example of Arduino Location Tracking Coding

Nodemcu_databse_test §

```
#include <ESP8266WiFi.h>
#include <DHT.h>
#include <ESP8266HTTPClient.h>
#include <WiFiClientSecure.h>
#include <ArduinoJson.h>

#define DHTPIN D4       // DHT11 data pin
#define DHTTYPE DHT11   // DHT11 type
#define GREEN_LED D5    // Green LED pin
#define RED_LED D6      // Red LED pin

DHT dht(DHTPIN, DHTTYPE);

// Wi-Fi credentials for the two networks
const char* ssid1 = "Zn";
const char* password1 = "nizam12345";
const char* ssid2 = "Vcopperz-2.4G@unifi";
const char* password2 = "DT14008";

const char* serverName = "http:// 192.168.43.113/ESP8266_MySQL_database/Psm/submit.php";
const char* googleApiKey = "AIzaSyA-yIgmBKQ_lCazTVaHUcq2JKi1mONqRPw"; // Replace with your Google API Key

WiFiClientSecure client;

void setup() {
  Serial.begin(115200);
  dht.begin();
  pinMode(GREEN_LED, OUTPUT);
  pinMode(RED_LED, OUTPUT);

  // Try to connect to the first Wi-Fi network
  WiFi.begin(ssid1, password1);
  int retries = 0;
  while (WiFi.status() != WL_CONNECTED && retries < 5) {
```


Appendix B : Arduino Coding for Asset Tracking Conveyor

```
#include <Servo.h>

#include <ESP8266WiFi.h>

#include <WiFiClient.h>

#include <ESP8266HTTPClient.h>



// Pin Definitions

#define SERVO_PIN D4        // Servo motor 1 connected to GPIO2 (D4)

#define SECOND_SERVO_PIN D5   // Servo motor 2 connected to GPIO14 (D5)

#define MOTOR_IN1 D2        // Motor driver IN1 connected to GPIO4 (D2)
```

```
#define MOTOR_IN2 D3        // Motor driver IN2 connected to GPIO0 (D3)


const char* ssid = "";

const char* password = "";


Servo servoMotor1;

Servo servoMotor2;


void setup() {

 pinMode(MOTOR_IN1, OUTPUT);

 pinMode(MOTOR_IN2, OUTPUT);


 servoMotor1.attach(SERVO_PIN);

 servoMotor2.attach(SECOND_SERVO_PIN);


 servoMotor1.write(90); // Set servos to neutral position

 servoMotor2.write(90); // Set servos to neutral position


 Serial.begin(115200);  // Initialize serial communication


 // Connect to Wi-Fi

 WiFi.begin(ssid, password);

 while (WiFi.status() != WL_CONNECTED) {

  delay(1000);

  Serial.println("Connecting to WiFi...");

 }

 Serial.println("Connected to WiFi");


 // Ensure conveyor is off initially

 stopConveyor();

}
```

```
// Function to start the conveyor motor
void startConveyor() {
 digitalWrite(MOTOR_IN1, HIGH);
 digitalWrite(MOTOR_IN2, LOW);
}

// Function to stop the conveyor motor
void stopConveyor() {
 digitalWrite(MOTOR_IN1, LOW);
 digitalWrite(MOTOR_IN2, LOW);
}

// Function to sort items to different devices
void sortToDevice(int device, String unique_id) {
 startConveyor(); // Start conveyor before sorting

 int servoPosition;
 switch (device) {
  case 1:
   servoPosition = 30;  // Position for Device 1
   break;
  case 2:
   servoPosition = 150; // Position for Device 2
   break;
  default:
   servoPosition = 90;  // Neutral position for Device 3 (Error)
   break;
 }

 servoMotor1.write(servoPosition);
```

```
  servoMotor2.write(servoPosition); // Move both servos to the same position

  delay(15000); // Wait for sorting process (15 seconds for longer sorting time)

  stopConveyor(); // Stop conveyor after sorting
  servoMotor1.write(90); // Reset servos to neutral position
  servoMotor2.write(90);

  Serial.println("Sorting complete. Waiting for 10 seconds...");

  // Send courier_out update to the database
  updateCourierOut(unique_id, device);
}

// Function to update courier_out in the database
void updateCourierOut(String unique_id, int courier_out) {
  String serverPath =
"http://192.168.43.113/ESP8266_MySQL_database/Psm/sorting_confirmation.php";
  String url = serverPath + "?unique_id=" + unique_id + "&courier_out=" + courier_out;

  HTTPClient http;
  WiFiClient client;
  http.begin(client, url);  // Use WiFiClient with begin method
  int httpResponseCode = http.GET();

  if (httpResponseCode > 0) {
    String response = http.getString();
    Serial.println("Server Response: " + response);
  } else {
    Serial.println("Error in HTTP request");
  }
```

```
  http.end();
 }

// Main loop to read serial commands and control the sorting process
void loop() {
  if (Serial.available() > 0) {
    String command = Serial.readStringUntil('\n');
    command.trim();

    // Split command and unique_id
    int separatorIndex = command.indexOf(":");
    if (separatorIndex > 0) {
      String action = command.substring(0, separatorIndex); // SORT1, SORT2, etc.
      String unique_id = command.substring(separatorIndex + 1); // Extract the unique_id

      Serial.print("Received command: ");
      Serial.print(action);
      Serial.print(", Unique ID: ");
      Serial.println(unique_id);

      // Based on the action, trigger sorting and update courier_out
      if (action == "SORT1") {
        Serial.println("Sorting to Device 1");
        sortToDevice(1, unique_id);
      }
      else if (action == "SORT2") {
        Serial.println("Sorting to Device 2");
        sortToDevice(2, unique_id);
      }
      else if (action == "SORT3") {
        Serial.println("Sorting to Device 3 (Error)");
```

```
            sortToDevice(3, unique_id);
          }
        }
      }
    }
```