ASSET TRACKING AND MONITORING SYSTEM

A PROJECT REPORT

submitted by

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to
the APJ Abdul Kalam Technological University
in partial fulfillment of the requirements for the award of the Degree
of
Bachelor of Technology
in
Electronics & Communication Engineering

Department of Electronics & Communication Engineering
Government Engineering College Idukki
685603

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DECLARATION

We undersigned hereby declare that the project report **ASSET TRACKING AND MONITORING SYSTEM** submitted for partial fulfillment of the requirements for the award of degree of Bachelor of Technology of the APJ Abdul Kalam Technological University, Kerala, is a bonafide work done by us under supervision of Prof. Josemartin M J. This submission represents our ideas in our own words and where ideas or words of others have been included, we have adequately and accurately cited and referenced the original sources. We also declare that we have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in our submission. We understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

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CERTIFICATE

This is to certify that the report entitled **ASSET TRACKING AND MONITORING SYSTEM** submitted by **AMEGHA R , ARDRA M, FASNA C, HARIKRISHNAN V R** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Electronics & Communication Engineering is a bonafide record of the project work carried out by him/her under my/our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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ABSTRACT

In today's fast-paced world, efficient asset tracking and monitoring have become crucial for various industries, including logistics, agriculture, and manufacturing. This project aims to develop a comprehensive and cost-effective IoT-based Asset Tracking and Monitoring System using GPS and LoRa (Long-Range) technology. This system will address the need for real-time location tracking and motion detection of assets to improve overall asset management and security. The system leverages GPS's (Global Positioning System) power for accurate and real time location tracking. GPS modules will be embedded within the assets, allowing precise positioning information to be transmitted regularly. This information will be transmitted over a LoRa (Long-Range) wireless network, ensuring long-distance and low-power communication between the assets and the central monitoring station. LoRa technology is well-suited for asset tracking due to its long-range capabilities, making it ideal for monitoring assets spread across vast areas, such as agricultural fields or large warehouses.

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Chapter 1

INTRODUCTION

Asset tracking and monitoring systems have become integral in various industries, enhancing efficiency and security. One such technology that has gained prominence is the use of Long Range (LoRa) communication. LoRa, a low-power, wide-area network (LPWAN) technology, provides an ideal platform for real-time tracking and monitoring of assets over extended distances. The foundation of LoRa-based asset tracking lies in its ability to transmit data over long ranges while consuming minimal power. This makes it suitable for applications where assets are spread across vast areas, such as logistics, agriculture, and supply chain management. The extended range of LoRa enables seamless communication between devices, allowing for continuous monitoring even in remote or challenging environments. In a LoRa-based asset tracking system, each asset is equipped with a LoRa-enabled device, typically a tracker or sensor. These devices utilize low-power, ensuring prolonged battery life and reducing the need for frequent replacements. The trackers transmit relevant data, such as location, temperature, and status, to a central LoRa gateway. The gateway acts as a bridge between the devices and the back end server, facilitating data aggregation and analysis. One of the key advantages of LoRa technology is its ability to penetrate obstacles, making it suitable for both indoor and outdoor asset tracking scenarios. This versatility ensures that assets can be monitored effectively in warehouses, manufacturing plants, or during transportation, regardless of the surrounding environment. The implementation of LoRa-based asset tracking systems brings several benefits to organizations.

Asset tracking and monitoring have become indispensable in industries ranging from logistics and supply chain management to agriculture and industrial operations. Traditionally, these systems relied on centralized architectures, often facing challenges of high data transmission costs and dependency on continuous connectivity. The advent of TinyML and LoRa addresses these issues by introducing local intelligence and long-range communication capabilities, respectively.

The motivation behind implementing asset tracking and monitoring systems using TinyML and LoRa lies in the quest for enhanced efficiency, security, and sustainability. By leveraging the power of local machine learning processing and long-range, low-power communication, organizations can revolutionize how they manage and monitor their assets, paving the way for a more connected and intelligent future.

Chapter 2

LITERATURE SURVEY

In paper[1], the authors present an IoT-based rental asset tracking and monitoring system to develop innovative and flexible IoT devices for better management of asset infrastructure. We study different wireless technologies for monitoring the physical location of rental items. These technologies include WiFi, Bluetooth, GSM cellular, and LoRa.

In paper[2], the authors described LoRa technology. It is very useful for the long-range communication with the high receiving sensitivity ability and it actively works for noise floor without any interference. One of advantage of LoRa is that it uses low power sensors and low power means it increases battery life and affect overall system cost. The span of communication has become the critical part on most of the IoT system, especially in Wi- Fi and Bluetooth based IoT system. Internet of Things (IoT) expansion led the market to find alternative communication technologies since existing protocols are insufficient in terms of coverage, energy consumption to fit IoT needs. LoRa gateway devices are employed to take care of number of end devices and nodes.

Chapter 3

OBJECTIVES

To solve issues existing in supply chain, we have come up with idea of asset tracking and monitoring system using tiny machine learning whose main objective is LoRa's low-power characteristics enabling extended battery life for the tracking devices, minimizing the need for frequent battery replacements. To enhance asset monitoring, the project will incorporate motion detection capabilities. The central monitoring station will include a user-friendly interface that provides real-time asset location data, motion alerts and historical tracking information. Users can access this information through a web-based dashboard or a mobile application, ensuring accessibility from anywhere at any time.

Chapter 4

BLOCK LEVEL DESIGN

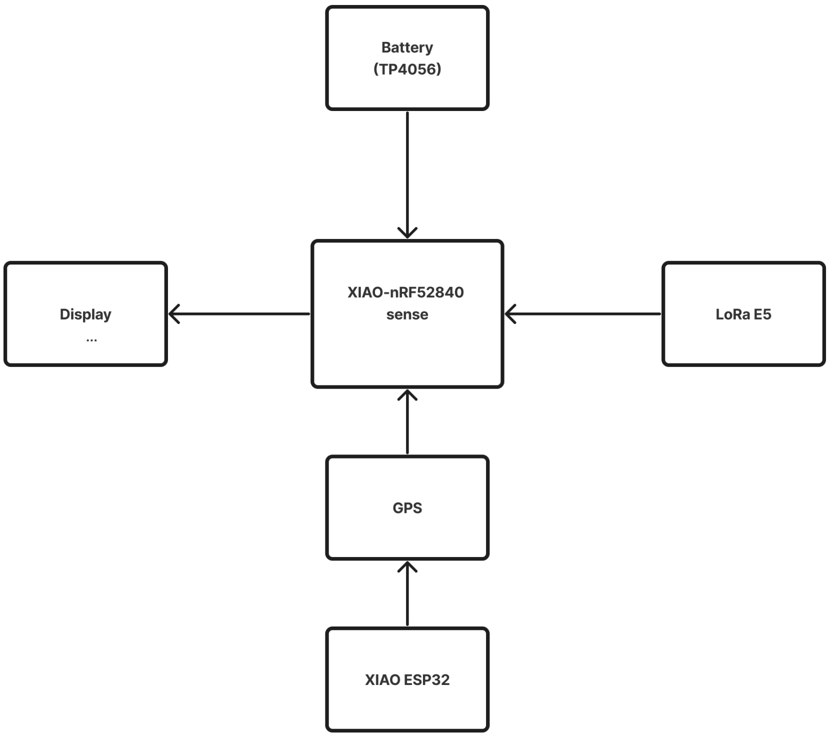

Figure 4.1: Block level design

The block-level design of an asset tracking and monitoring system using TinyML and LoRa involves a seamless integration of sensors, TinyML models, edge devices, LoRa communication, gateways, and cloud-based analytics. This holistic approach ensures a robust and scalable solution capable of efficiently tracking and monitoring assets while leveraging the advantages of both TinyML and LoRa technologies.

4.1 MOTION DETECTION

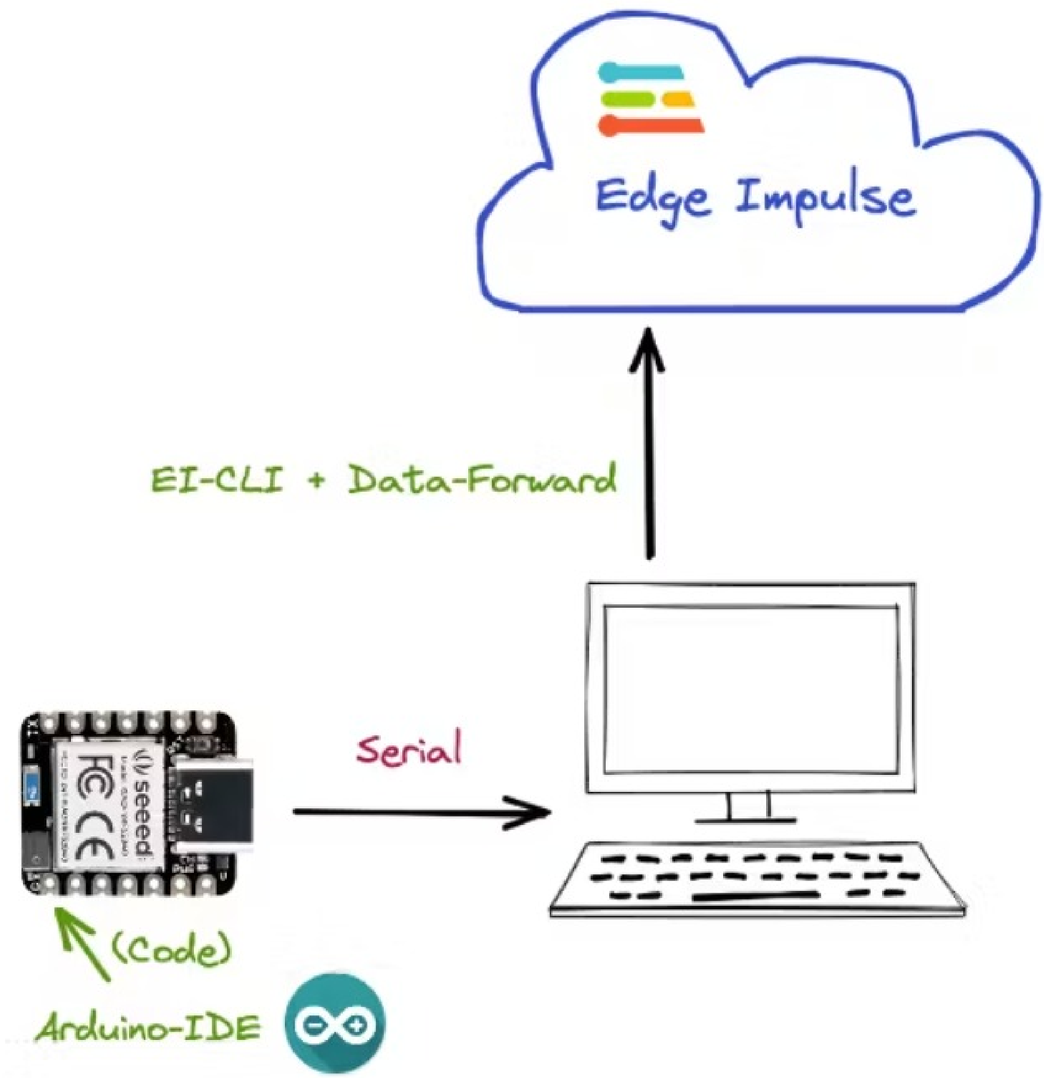

Figure 4.2: Diagram showing how the microcontroller is trained by TinyML

4.2 LOCATION TRACKING

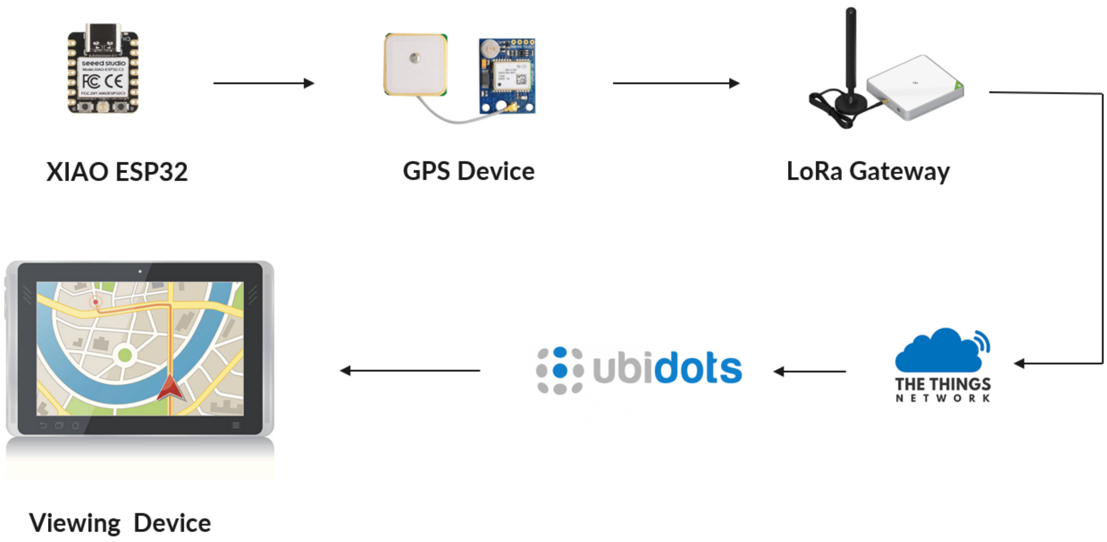

Figure 4.3: Location Tracking

Chapter 5

DESIGN AND METHODOLOGY

This system will address the need for real-time location tracking and motion detection of assets to improve overall asset management and security. The system leverages GPS's (Global Positioning System) power for accurate and real time location tracking. GPS modules will be embedded within the assets, allowing precise positioning information to be transmitted regularly. This information will be transmitted over a LoRa (Long-Range) wireless network, ensuring long-distance and low-power communication between the assets and the central monitoring station. To enhance asset monitoring, the project will incorporate motion detection capabilities. The micro controller Xiao nRF52840 sense will be selected to handle motion detection algorithms and ESP32 is used to location tracking. This micro controller will use accelerometer and gyroscope sensors to detect changes in asset motion. When motion is detected, the system will trigger a notification to the central monitoring station, allowing for immediate response in case of unauthorized asset movement or tampering. The central monitoring station will include a user-friendly interface that provides real-time asset location data, motion alerts, and historical tracking information. Users can access this information through a web-based dashboard or a mobile application, ensuring accessibility from anywhere at any time.

5.1 MICROCONTROLLER

In this project we use 2 microcontrollers. One is for motion detection and another is for location tracking.

Figure 5.1: XIAO nRF52840

Specific motion-related sensors on the XIAO nRF52840 Sense include an accelerometer and a gyroscope. These sensors can be used to detect motion and changes in orientation. However, the exact capabilities of motion detection depend on the software and firmware implemented on the board.

Figure 5.2: XIAO ESP32

The XIAO ESP32 can be used with GPS modules to enable location tracking and navigation functionalities in your projects. You can connect a GPS module to the ESP32 via UART or I2C communication protocols. Then, you can use libraries like TinyGPS++ or Adafruit GPS library to parse the GPS data and extract useful information such as latitude, longitude, altitude, and time. This allows you to create projects ranging from simple GPS trackers to advanced navigation systems.

5.2 LORA

Figure 5.3: LoRa E5

The LoRa E5 is a wireless communication module designed for Low Power Wide Area Network (LPWAN) applications. It operates on the Long Range (LoRa) modulation technology, providing long-range connectivity with low power consumption. This module is commonly used in IoT (Internet of Things) devices, enabling them to transmit data over extended distances while conserving battery life. The LoRa E5's features include support for various frequency bands, making it adaptable to different regions globally. Its efficiency in facilitating reliable, long-range communication makes it a popular choice for diverse IoT applications, such as smart agriculture, smart cities, and industrial monitoring.

5.3 LORA GATEWAY

Figure 5.4: LoRa Gateway

A LoRa gateway serves as a crucial bridge between end-devices and network servers in LoRaWAN (Long Range Wide Area Network) deployments. Essentially, it receives messages from sensors or devices within its coverage area and forwards them to the network server for processing. Conversely, it also relays messages from the server back to the devices. This bidirectional communication enables a wide range of applications, from smart agriculture to smart cities.A LoRa gateway consists of a few key components: a LoRa concentrator, which handles the modulation and demodulation of radio signals, antennas for transmitting and receiving signals, and a microcontroller or computer for processing data. These gateways are typically installed on high vantage points, such as rooftops or tall structures, to maximize coverage and range.

5.4 GPS

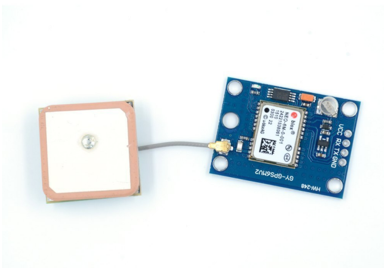

Figure 5.5: NEO-6M GPS Module

GPS chips are often embedded in devices like trackers or tags that can be attached to vehicles, equipment, or other valuable items. The tracking system provides real-time location updates, helping businesses monitor and manage their assets efficiently. The NEO-6M GPS module is a popular GPS receiver module known for its compact size and reliability. It's commonly used in various applications like drones, navigation systems, and IoT devices due to its high performance and low power consumption. It has become a ubiquitous component in the realm of GPS technology, offering an array of capabilities and functionalities that cater to a wide range of applications. This essay delves into the key features, applications, and advantages of the NEO-6M GPS module.

5.5 LI-ION BATTERY

Figure 5.6: Li-Ion battery

Lithium-ion batteries are a type of rechargeable battery commonly used in portable electronics, electric vehicles, and other applications. They are known for their high energy density, which allows them to store a lot of energy in a relatively small and lightweight package.he unique properties of Li-ion batteries have revolutionized numerous industries and everyday technologies. In consumer electronics, they power smartphones, laptops, and wearable devices, offering longer runtimes and faster charging capabilities. In transportation, electric vehicles (EVs) equipped with Li-ion batteries have emerged as viable alternatives to traditional internal combustion engine vehicles, reducing greenhouse gas emissions and dependence on fossil fuels. Additionally, Li-ion batteries play a crucial role in renewable energy storage systems, enabling the integration of solar and wind power into the electrical grid.

Chapter 6

CIRCUIT DESIGN

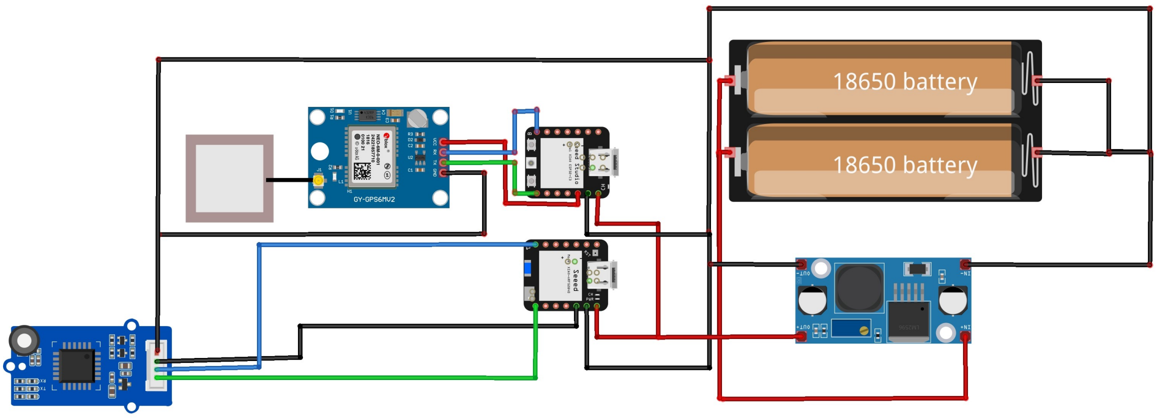

Figure 6.1: Circuit diagram

Chapter 7

SOFTWARE

7.1 ARDUINO IDE

Figure 7.1: Arduino IDE

The Arduino IDE (Integrated Development Environment) is a software platform used for programming Arduino microcontrollers. It provides a user-friendly interface for writing, compiling, and uploading code to Arduino boards. It's a great tool for beginners and experienced users alike to create projects ranging from simple blinking LED lights to complex robotics and IoT applications.It provides a comprehensive development environment for creating projects with Arduino boards, whether you're a beginner or an experienced developer. It abstracts away much of the complexity of embedded programming, allowing you to focus on your project's functionality and creativity.

7.2 THE THINGS NETWORK

Figure 7.2: The Things Network

The Things Network (TTN) is a global, open, and community-driven Internet of Things (IoT) network. It provides infrastructure and tools for building and deploying low-power, long-range wireless networks for IoT devices. It democratizes IoT connectivity by providing an open, community-driven platform for building and deploying LoRaWAN-based IoT solutions. It empowers developers and organizations to create innovative applications that leverage the benefits of long-range, low-power wireless communication.

7.3 UBIDOTS

Figure 7.3: Ubidots

Ubidots is a cloud-based Internet of Things (IoT) platform that provides tools and services for collecting, storing, visualizing, and analyzing sensor data in real-time. It provides a comprehensive and user-friendly platform for building, deploying, and managing IoT applications. It simplifies the process of collecting, analyzing, and acting on sensor data, enabling organizations to derive valuable insights and drive innovation in their IoT projects.

Chapter 8

PROJECT FUNDING

SI NO	COMPONENTS	RATE
1	Xiao-nRF52840	2820
2	Xiao-ESP32C3	569
3	Lithium Battery	259
4	LoRa E5	1699
5	LoRa E5 Gateway	12198
6	GPS	526
7	3D printing and PCB	500

Total estimated cost=18,571/-

Chapter 9

PROTOTYPE

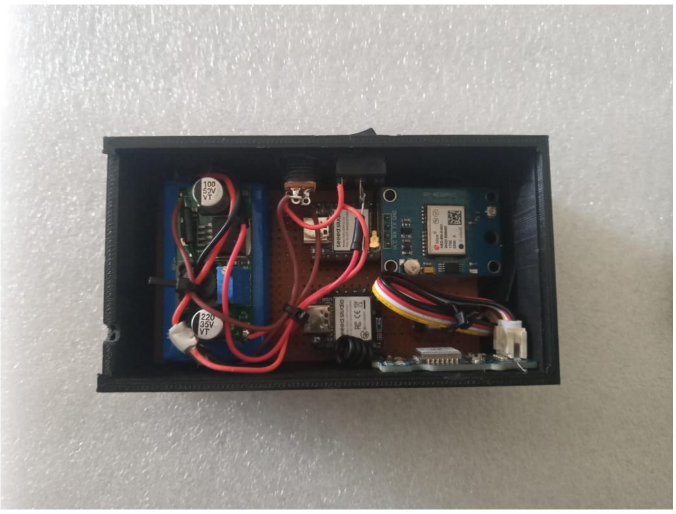

Figure 9.1: Prototype

Figure 9.2: Prototype

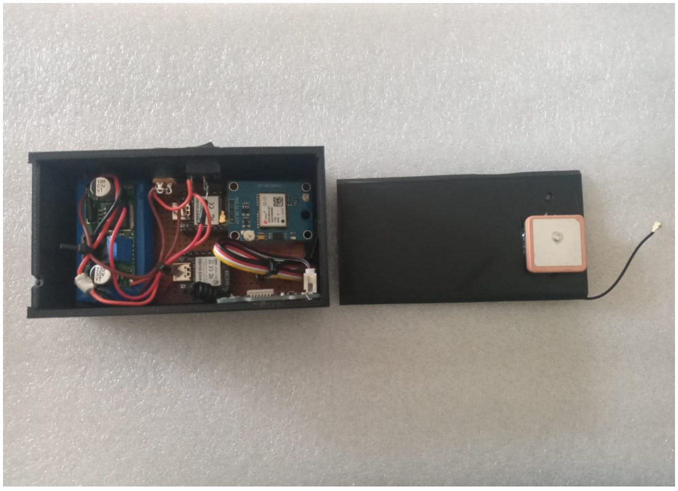

Figure 9.3: Prototype

Chapter 10

PRELIMINARY ANALYSIS

The Aset Tracking and Monitoring System is a cutting-edge project that leverages Tiny ML and LoRa technology to enhance asset security. Utilizing the Edge Impulse platform, we developed a motion detection algorithm and constructed a robust machine learning model. This model was seamlessly integrated into an Arduino application, enabling real-time monitoring of asset movement. The system is capable of detecting various conditions such as idle state, left or right movements, and sudden jerks, significantly reducing the risk of asset theft. This innovative combination of Tiny ML and LoRa ensures efficient and reliable tracking, providing a proactive approach to asset security in diverse environments.

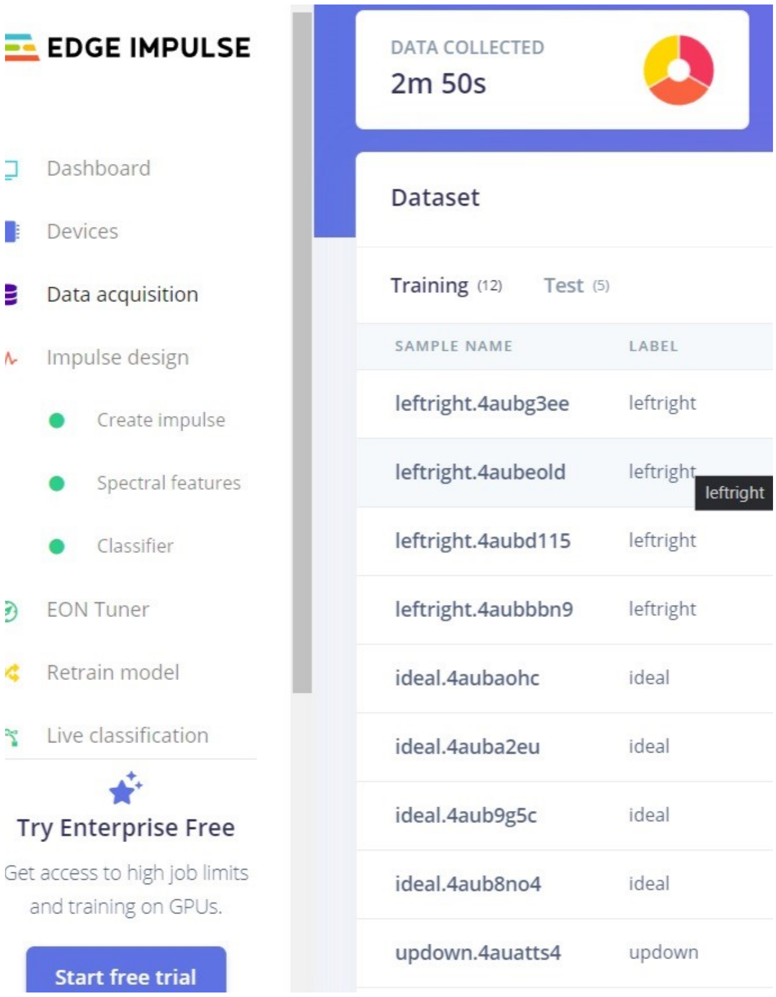

Figure 10.1: ML Model

Figure 10.2: ML Model

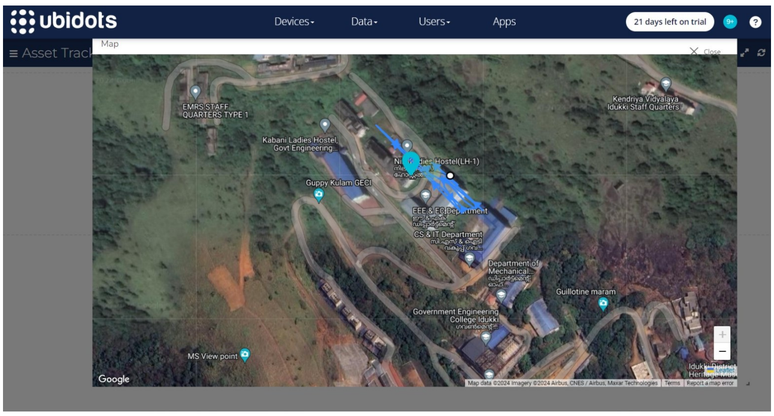

Figure 10.3: Location

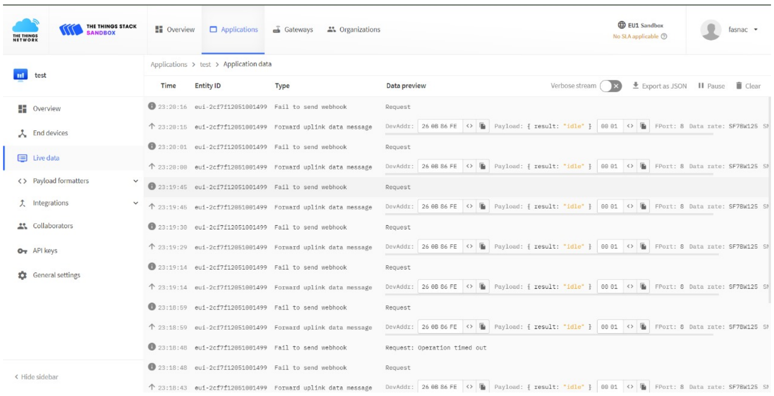

Figure 10.4: Location

Chapter 11

CONCLUSION

A LoRa-based asset tracking and monitoring system offers an efficient and cost-effective solution for real-time location and condition monitoring of assets. With its long-range capabilities and low-power consumption, LoRa enables seamless communication, making it ideal for tracking assets in diverse environments. The system enhances operational efficiency, reduces losses, and provides valuable insights for better decision-making in various industries. However, successful implementation requires careful consideration of factors such as coverage, battery life, and integration with existing infrastructure.

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