Smart Luggage Security With IoT Based Security

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ABSTRACT: A Smart Luggage System is designed to offer a smart and secure solution for passengers with the help of IoT Technology. Passengers frequently experience challenges in tracking and protecting their luggage during transportation. The system aims to provide real-time monitoring, theft detection, and location tracking through the ESP32 microcontroller. The primary aim of our project is to offer smart, connected support for luggage security. Current travel security systems tend to be limited to simple locking features without intelligent aspects. This device is intended to provide greater security and remote tracking, providing travelers with confidence and control like sophisticated tracking systems. A small-scale study was conducted to learn about different issues associated with luggage safety, such as theft, loss, and unauthorized movement. Our project primarily deals with people who require dependable, technology-based solutions to track their luggage. The system combines RFID identification, GPS for tracking, and a vibration sensor to detect anomalies. The response is through SMS notifications. The system seeks to provide an inexpensive, efficient, and easy-to-use smart luggage system with real-time reporting and improved security while traveling.

KEYWORDS: Smart Luggage, IoT, ESP32, travel security, GPS tracking, RFID, vibration sensor, theft detection, real-time monitoring, SMS alert, remote alerts, luggage security, intelligent systems, microcontroller, smart travel, anomaly detection, location tracking, wireless communication, low-cost solution, portable security, personal belongings, passenger security, smart devices, transportation security, embedded systems, connected luggage, IoT-based tracking, mobile alert system, smart tourism, secure travel, sensor integration, travel tech.

I. INTRODUCTION

As we enter the era of smart technology and increased travel around the world, the issue of keeping personal items safe while in-transit has become increasingly important. Tampering, theft and loss situations crop up frequently and are often tied the busy transport networks used at airports, railway and bus stations and more. Traditional security does not often support user expectations for safety and trackability of bags. To tackle these issues we propose a Smart Luggage System based on IoT-based Security – a strong, effective, and real-time solution for stock control that combines advanced electronics and smart software technologies. The system is largely based on the capabilities of an ESP32 microcontroller which acts as the brains of the device, receiving information from a variety of connected modules and sensors to gather and develop the finalized product. In order to ensure that unauthorized access is abated, the system performs an RFID-based

authentication method which grants access to only the authenticated user. There is also a physical vibration sensor, as mentioned before, to detect physical movement and unauthorized handling of the bag. In situations where suspicious behavior is detected, a local buzzer sounds to notify someone, while simultaneously a real time SMS is sent to the registered user, leveraging Twilio SMS API for rapid notifications. As previously hinted, beyond local alerts, tracking of location is an essential aspect of this configuration. A GPS NEO6M module has been integrated into luggage to acquire the current geographic location of the luggage which is critical in case of loss, or theft.

The coordinates and other sensor data is sent to the cloud using the MQTT communication protocol, which allowed for quick, lightweight, and secure data transmission over the internet. The system also uses a Node-RED dashboard for monitoring and user interface, which is a simple interface for showing real-time data including GPS coordinates, vibration status, and RFID scans along with system notifications. This way, the user can monitor the status of their luggage from anywhere at any time. The entire system was built with the Arduino IDE, which makes it easy to program, debug, and will allow for new upgrades in the future. It is scalable, and can be extended upon, with potential add-ons like geofencing, temperature detection, battery life monitoring, and mobile app integration.

II. LITERATURE SURVEY

Chitra Haigune et al. [1] discuss the prevention of luggage theft using embedded sensors and communication modules. They offer a solution using vibration sensors, accelerometers, and communication to detect unauthorized movement and convey alerts. This work inspired the inclusion of embedded sensor technology in the smart luggage system to support early detection of theft or tampering and provide more protection to the traveler in transit. They focus on producing a low-cost consumer-ready product for mass consumer consumption, as this is also a principle of the design of intelligent luggage systems. Espressif Systems [2] describes the technical characteristics of the ESP32 Microcontroller and the wide-ranging capabilities, such as dual core processing, Wi-Fi, and Bluetooth. These capabilities provide the ESP32 excellent versatility for IoT-based solutions, as they can connect and communicate with most sensors, like GPS, RFID, and vibration sensors, in real-time. The guide outlines important steps to set up the device for low-power use, which is also important; since the goal is for the smart luggage system to be able to function for extensive use before depleting the battery. Additionally, the option to connect the ESP32 to cloud services for connected luggage, will allow for remote monitoring of the luggage. This will give the user a constant informational feed for their luggage.

u-blox AG [3] provides the complete datasheet of the NEO-6M GPS module that was used in the smart luggage system for tracking purposes in real-time.The data sheet allows the viewer to understand the precision of location, how often to expect updates, and which connectivity interfaces were used with the GPS module.The NEO-6M includes high sensitivity which allows it to pinpoint its location accurately in tough situations like indoors or when the view of the satellites is poor. This is very important to supply the smart luggage system accurate location information so the overall device performance in tracking lost or missing luggage, can improve..

Arduino [4] establishes the Arduino IDE; an open-source environment perfectly suited for microcontroller programming such as the ESP32. The environment incorporates a variety of libraries to make development easier by providing support for sensor integration, communication chips, and alarm systems. In addition, the IDE's interface is user-friendly, has built-in debugging capabilities, and allows the user to confirm that their smart luggage system is functioning properly. It is important to note that Arduino IDE is compatible with a variety of microcontroller boards allowing experimentation and code refinement to properly gauge the accuracy and efficiency of system functions such as motion sensing and alarming.

Node-RED [5] is described as a low-code development environment for developing and

managing IoT applications. In the intelligent luggage system, Node-RED provides the ability to quickly assemble interactive dashboards and to process real-time data while offering simple and efficient monitoring of luggage status. Additionally, Node-RED easily integrates with multiple components; it has a ready-made interface for external sensor inputs, cloud provider APIs, and messaging systems. Node-RED employs a flow-based development environment, which allows for the creation of complex flows without the extended efforts of writing code for a system design. This simplifies overall development and allows for quick implementation to adapt to user perceptions, like adding new features or optimizing data handling.

III PROPOSED ARCHITECTURE

Smart Luggage System with IoT-Based Security is an upcoming innovation that aims to enhance passenger safety, convenience, and control of personal items while in transit. With the rapid pace of life in the modern world and an increase in the theft, loss, and tampering of luggage on public transit systems and in busy transportation terminals, there is a growing need for a safe, smarter, more responsive, and technology-based solution. The Smart Luggage System with IoT-Based Security will address all of these issues associated with luggage safety and security by using the Internet of Things (IoT) to assist and improve real-time tracking, monitoring, and alerts for security breaches.

This system is specialized in a synergy of the hardware and software technology to increase and improve luggage security. Key hardware devices used in this system include an ESP32 microcontroller (for limited processing power), a GPS NEO-6M module (for location tracking), RFID (radio frequency identification) (to gain access to the luggage system), vibration sensors (used to detect anomalies), and a buzzer (in audio format to issue notifications). All of these hardware devices come fully programmed and wired together with compatible software technologies such as Node-RED (for the creation of an interactive, dynamic dashboard), MQTT (Message Queuing Telemetry Transport - allows secure messaging), Twilio (for the sending of SMS alerts), and XAMPP-MySQL (for the local (on PC or RPI) storage and management of the data logs of location histories and access occurrenceswithRFID).

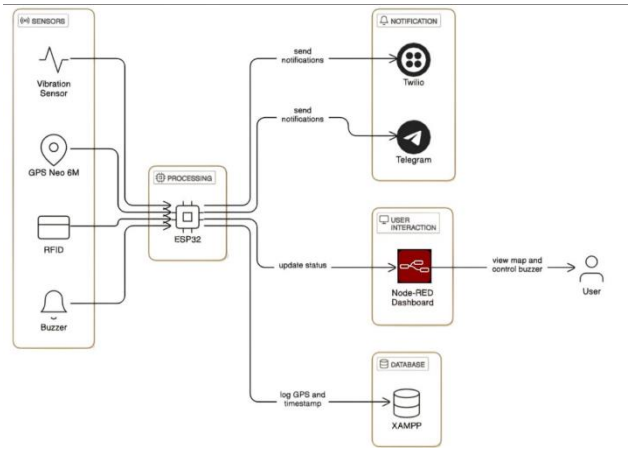

Fig. 1 Architecture Diagram

The system uses a strategy of constant surveillance of the luggage states from sensors. The RFID module only allows recognized people into the bag, while a vibration sensor will warn on forceful or ehisterical handling which may reflect tampering or theft. The GPS module maintains a "live" location of the luggage in the ecosystem, which is beneficial with luggage transport, as it gives travelers an idea to the location of their things in a map interface.

All of the sensor data is then transferred to the ESP32 microcontroller, which is the brain of the system. The ESP32 receives the inputs from the sensors and will perform the necessary action that corresponds with everything—whether it has read an RFID tag that is not the original owner's or has experienced some kind of unusual vibration when if the bag does not move, the ESP32 activates the buzzer as an alert to other people and initiates a notification to the user. To help with data transfer and communication, our system uses MQTT protocol to securely send data packets to the Node-RED dashboard using the Mosquitto MQTT broker. Node-RED is an advanced, but low-code platform that allows very elegant visualizations of data from lock/unlock status, vibration alarms, and GPS tracking. The dashboard allows users to view and monitor the current condition of the system in real-time from anywhere; this provides

convenience and flexibility to the solution. In addition to being able to monitor visually, The system also applies Twilio's cloud communication service messaging API to send real-time SMS alerts to the mobile device of the user. For example, should there be suspicious activity, the system will automatically alert the owner and prompt him or her to act as quickly as possible. It is even possible to get alerts about the security status of baggage without any continuous manual supervision. All information such as GPS locations, RFID scan attempts, and vibration detection sensor actions are stored into a MySQL database running within XAMPP. The database will have a full history of all activities which may prove useful in a security audit, to request user feedback, or for report writing in relationships with conflict.

The architecture has been designed to be scalable and modular, which allows for the addition of features in future versions, such as camera modules, fingerprint recognition, or Bluetooth tracking. The three layers for sensing, processing and communicating give the whole system reliability, accuracy and speed. The Smart Luggage System really, isn't just a theft fighting device. It's a complete, end-to-end solution for smart luggage. Better safety for luggage, built from hardware sensor technology, smart microcontrollers, real-time message protocols, and user access to dashboards, gives it the ability to solve multiple systems in luggage user cases. confidence, transparency, and control for travelers. At the airport, at hotels, or in a mode of transport, users can be confident that their luggage is both secure and can be precisely tracked.

The architecture required to allow for seamless deployment of IoT and cloud technologies represents an example of modern digital technologies being applied to real-world issues to make travel not only safer, but smarter and more efficient.

IV.TECHNOLOGY USED

The Smart Luggage System with IoT based Security is created through integrated hardware and software solutions for real-time tracking, enhanced safety, and easier access for travelers. The center of the system is at the microcontroller, which is the ESP32, the brain of the entire system. The ESP32 has onboard Wi-Fi and Bluetooth capabilities for mobile applications that require trouble-free wireless communication to support an IoT-based service. The ESP32 will read the sensor data, process the data and send data to cloud services or a dashboard interface.

In order to provide secured access control, the system incorporates an RFID module (RC522) that only allows access for authorized persons to unlock or open the luggage by scanning pre-registered RFID tags. For real time location tracking, the system utilizes the NEO-6M GPS module, which consistently acquires geolocation data in latitude and longitude to enable the user to track the luggage through a visualized interface. There also incorporates a vibration sensor (SW-420) as a deterrent to ensure the contents of the bag do not get intruded and to monitor normal unusual motions, like bumping while not moving. It uses detection, to recall anytime it senses unusual vibration or movement like shaking or bumping while not moving, the system then identifies the event as suspicious.

To accompany these sensors, a buzzer module is provided to transmit an audible warning in the event of unauthorized attempts of any type, or movement deemed suspicious, as used in public areas, such as train stations and airports, where it would act as a deterrent. All of the hardware is therefore powered by a rechargeable battery pack for both portable, as well as continued use while traveling.

From a software perspective, the Arduino IDE is used to write and upload code into the ESP32 microcontroller. The IDE supports functionalities for embedded C/C++ programming as well as supporting functionality for making the ESP32 able to communicate with outside modules and sensors for a development sense. As the means to

graphically show data in real time, Node-RED is the tool used, using flow-based programming and creating specific dashboards based on specified sets of requirements. The Node-RED interface is used to display data such as lock status, motion detection and GPS position using an interactive map.

We will be utilizing the MQTT protocol for communication between the ESP32 device and the Node-RED dashboard with the Mosquitto MQTT broker. MQTT is a low bandwidth messaging protocol for IoT devices that includes a level of reliability. This guarantees that the information that was collected by the luggage system is efficiently, securely and effectively sent in real-time. To better the communication for the user, the Twilio API will be used so that the system can send SMS notifications to the user's mobile when the system identifies a threat. This way, the owner can receive real-time notifications for swift action when needed.

XAMPP will act as a local server environment and MySQL will be used as the database backend for data analysis/storage on the system. All essential data (vibration logs, RFID scan attempts, and GPS points) will be securely stored in the MySQL database and later analyzed for future use. In addition, the Google Maps API can be added to the dashboard to allow a visual representation of the luggage real-time location which will contribute to a better overall experience of the user.

In sum, this intelligent luggage solution integrates a broad deep stack of technologies, including embedded systems, internet of things protocols, web-based dashboards and cloud integrations to produce an end to end, intelligent and secure travel experience for today's user.

V.RESULTS AND DISCUSSION

The Smart Luggage System with IoT-Based Security takes advantage of high-end hardware and the latest software to deliver an intelligent and secure travel experience. The principal technologies used for the project were the ESP32 microcontroller, the RFID module, GPS NEO-6M, vibration sensor, buzzer, and communication tools like Node-RED, MQTT, Twilio, and XAMPP-MySQL. The ESP32 allowed the system to gather information through the sensors of the piece of luggage and control actions based on real-time input into the application. The RFID module gives secure access to luggage by checking the authorized tag, the GPS module allows tracking the luggage location in real-time, the vibration sensor captures abnormal moving or mishandling of the luggage, and the buzzer functioned as audible warning system in the event of a potential threat.

The system also uses the MQTT protocol and Node-RED dashboard for data visualization and communication. In addition to user remote luggage status, the system incorporates the Twilio API to send sms alerts to the user's phone when the luggage has suspicious activities. Each event, such as llocation logs, vibration alerts, and access attempts, is logged to a MySQL database hosted on XAMPP for tracking and historical data analysis. In summary, the easy integration of technologies gives users the ability to monitor in real-time, be immediately notified, and intelligently control their luggage simply by using a dashboard or app.

The overall outcomes using this system are very good. In testing conditions, the system was able to successfully identify unwanted access through the RFID module and activate both the buzzer alarm and SMS notifications almost instantly. The vibration sensor seems to be very sensitive to unwanted movement in real time, and all the information was passed and sent to the ESP32. The GPS module was continuously transmitting accurate readings regarding location that would allow users to track their suitcases completely unobstructed, and the information was passed and sent over Wi-Fi with the MQTT protocol. The Node-RED dashboard was able to display all of the information in an easy to interpret way and well organized manner. Also, for accountability, the backend database retained all of the logs for all interactions, meaning there were records of all of the systems activity adding to the overall confidence in having a stable and reliable system.

Overall, the Smart Luggage System functioned effectively and met its intended goal of improving luggage security with intelligent monitoring and

alerting capabilities. The instantaneous response ability of the system following a suspicious event, effectiveness of real-time tracking, and significant amounts of data storage make it useful for passengers, particularly in busy transport situations or heightened risk areas. The application of IoT technologies demonstrate the usefulness of smart security systems practically and helps advance safer, smarter travel solutions.

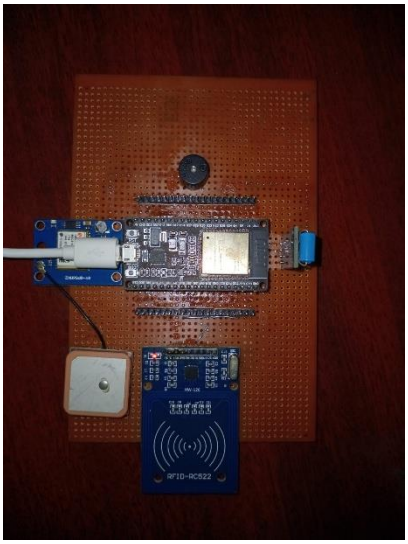

Fig:2 Output image

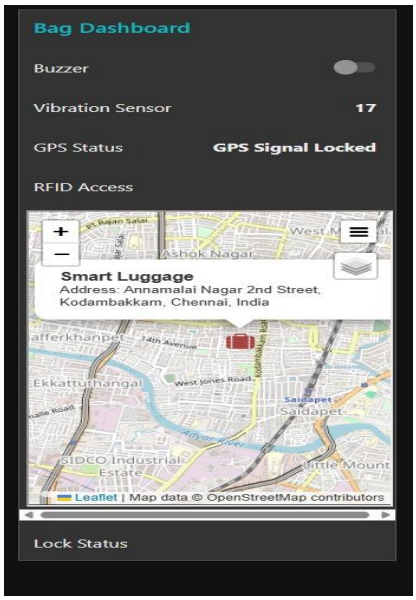

Fig. 3 Dashboard image

VI.CONCLUSION

Smart Luggage System with IoT Security is a prime example of the latest technology to solve safety challenges in travel. The solution consists of hardware such as ESP32, RFID, GPS, and vibration sensors mounted on the bag, and software platforms such as Node-RED, MQTT, Twilio and MySQL. This solution provides a higher level of safety, better monitoring, and a more aggressive alert scheme to inform the user. This is a timely solution for everyday problems that causes exclusion, mishandled bags, and lost bags, and it offers a degree of comfort to the users and better bag management for transport operators.

The architecture and design of the system were found to be efficient and reliable during testing, with effective threat detection, accurate GPS tracking, and smooth communication between the hardware and the cloud interface. The simplicity of the dashboard and real-time notifications through SMS make it extremely user-friendly and convenient for daily use.

In summary, this project demonstrates the capabilities of IoT-based solutions in the area of smart travel security. Not only does it improve the security of personal items, but it also helps in the development of intelligent transport systems. With increased enhancements and scalability, such solutions can become the norm in future smart cities and digital travel infrastructures.

VII.FUTURE ENHANCEMENTS

While the current implementation of the Smart Luggage System does offer real-time monitoring and security supervision features, there remains significant opportunity for the system's expansion and improvement to make it even smarter, more cost effective, and easier to use. One specific option is to incorporate a mobile app to give the user intuitive oversight of their bags - including geofencing alerts if the bag travels a distance out of observable zone.

Another possible enhancement could be the addition of biometric security features that include fingerprint and face scanning features to ensure that only the legal owner of the luggage can open it. In addition, camera modules could be added to take pictures if attempted to access trip with permission which could serve as evidence in the event of theft or misappropriation.

Battery optimization and solar panels can be used to improve the power efficiency of the system, particularly for extended journeys. To improve global connectivity, GSM modules or eSIM support can be incorporated so that location tracking and communication are maintained even without Wi-Fi.

In addition, integrating AI algorithms can assist in detecting irregular patterns of movement and anticipating potential threats from user travel behavior. Integration with airport and airline databases might automate baggage check-in/check-out procedures, enhancing passenger convenience.

Overall, these future updates aim to advance the smart luggage system into an even more independent, intelligent, and secure travel companion for modern travelers.

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