IoT enabled hospital asset tracking using advanced interdisciplinary approaches

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Abstract. As the healthcare landscape embraces the revolutionary power of digitalization, improving inventory systems has become a top priority. Hospital asset tracking primarily focuses on monitoring various assets within a healthcare facility. These assets encompass human resources, medical equipment, vehicles, and other essential resources crucial for seamless hospital operations. Tracking assets in a hospital setting can range from monitoring individual medical devices to overseeing entire fleets of equipment and staff resources. The central objective is to maintain real-time records of asset status, and location to optimize productivity while minimizing costs. This project tracks the assets within the hospital using RFID sensors and outside the hospital using GPS. Radio frequency identification system (RFID) is an automatic technology and is used to identify objects, and record data through radio waves. Hospital asset management and tracking has become one of the main priorities in healthcare as it saves hospitals both money and time. Hospitals are under constant pressure to persistently track their medical equipment and supplies to make sure that they are properly utilized. This enhances financial performance and ensures the delivery of high-quality patient care. These are the advanced approaches to improve hospital asset management through real-time tracking and data analysis.

1. Introduction

In the bustling world of a hospital, countless vital assets constantly shift and flow. Lost or misplaced items not only waste precious time and resources but can even compromise patient care. This is where the dynamic duo of RFID and GPS enters the scene, transforming hospital asset tracking into a game-changer. Imagine tiny RFID tags, like invisible guardians, attached to your valuable assets. These tags emit unique radio signals that are picked up by strategically placed readers throughout the hospital. Think of it as a constant roll call,

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instantly identifying any asset within range, regardless of whether it's tucked away in a drawer or whizzing down a corridor. When assets venture beyond the building, GPS takes over, using its satellite network to pinpoint their location with remarkable accuracy. Think of it as a watchful eye in the sky, tracking ambulances, mobile medical units, or even loaned equipment on their journeys. The benefits of this dynamic duo are manifold. Ultimately, hospital asset tracking with RFID and GPS is more than just a technological marvel. The seamless integration with existing workflows, training programs for staff and ethical considerations of data privacy and security. Leveraging advanced interdisciplinary approaches, IoT-enabled asset tracking systems offer unprecedented efficiency and accuracy in managing vital medical equipment and resources.

2. Existing methods

Jeon [1] investigates the feasibility of using BLE (Bluetooth Low Energy) beacons for indoor navigation within hospitals, focusing on positioning accuracy and user experience. The proposed system leverages fingerprint-based localization, where pre-recorded signal strength (RSSI) maps from beacons at known locations are used to estimate the position of a mobile device with an unknown location. Khan [2] comprehensively reviews the application of Ultra-Wideband (UWB) technology for indoor localization within healthcare settings, exploring its potential to revolutionize patient care, asset management, and safety. The paper paints a promising picture of UWB's potential to transform healthcare through precise, real-time location tracking in complex environments. Although cost and standardization remain challenges, ongoing development and collaboration suggest a bright future for UWB in healthcare, driving improvements in patient care, resource management, and overall safety.
A. P. Aguiar [3] proposes a system that combines geofencing technology with IoT sensors to improve medication management and patient safety in hospitals. The system aims to prevent medication errors and enhance medication adherence by monitoring both medication access and patient location. The paper highlights the promising potential of combining geofencing and IoT sensors to significantly improve medication management and patient safety in hospitals. While addressing privacy concerns and ensuring smooth integration is crucial, the benefits of reduced errors, enhanced adherence, and data-driven insights make this technology a valuable tool for advancing healthcare efficiency and patient well-being.

M. C. Lee [4] proposes a novel system for hospital asset tracking, combining the strengths of LoRaWAN (Long Range Wide Area Network) technology with RFID (Radio Frequency Identification) tags. The system aims to improve inventory management, reduce asset loss, and streamline equipment allocation within hospitals. The study demonstrates the effectiveness of combining LoRaWAN and RFID for hospital asset tracking, leading to significant improvements in inventory management, asset utilization, and operational efficiency. Z. Wang [5] proposes a system combining Wi-Fi and BLE (Bluetooth Low Energy) beacons for comprehensive real-time patient monitoring and asset tracking within hospitals. The paper demonstrates the potential of combining Wi-Fi and BLE beacons for a comprehensive and real-time healthcare monitoring and asset tracking system. While addressing infrastructure costs, privacy concerns, security risks, and battery dependence is crucial, the potential benefits for patient care, operational efficiency, and data-driven decision-making make this technology a promising tool for the future of hospital operations.
J. Zhang [6] leverages GPS data from ambulances to optimize ambulance dispatch and resource allocation within a city, aiming to improve response times and ultimately, patient outcomes. This study demonstrates the potential of using GPS data and predictive modelling to significantly improve ambulance dispatch efficiency and patient care.

A. A. Al-Ghamdi [7] proposes a solution for the predictive maintenance of medical equipment using data collected from IoT sensors and analysed through big data analytics.

The objective is to prevent unexpected equipment failures, minimize downtime, and ultimately reduce repair costs within healthcare settings. The paper demonstrates the effectiveness of using IoT sensors and big data analytics for the predictive maintenance of medical equipment. Y. Liu [8] investigates the potential of BLE (Bluetooth Low Energy) beacons to revolutionize hospital pharmacy inventory management. By attaching beacons to individual medication packages, the system enables real-time tracking and monitoring of pharmaceutical supplies, aiming to enhance inventory control and prevent medication shortages. The paper showcases the promising potential of BLE beacons for transforming hospital pharmacy inventory management. A. Al-Nuaimi [9] explores the potential of combining UWB (Ultra-Wideband) technology with sensor data from wearable devices for accurate indoor positioning and activity recognition within smart hospitals. This paper showcases the immense potential of combining UWB and sensor fusion for revolutionizing indoor positioning and activity recognition in smart hospitals. X. Wu [10] explores how merging geofencing and blockchain technology can optimize hospital supply chain management and resource allocation. By combining these innovative tools, it aims to ensure secure, transparent, and efficient tracking of medical supplies within hospitals.

3 Proposed method

3.1 Problem statement

The efficient management of hospital assets is a critical challenge for healthcare institutions, impacting patient care, finances, and operational effectiveness. A lack of a reliable hospital asset tracking system results in difficulties locating, monitoring, and maintaining vital medical equipment. This leads to increased downtime, reduced staff productivity, and potential delays in patient treatment. The challenge lies in effectively monitoring a diverse range of assets within a hospital setting, from individual medical devices to entire fleets of equipment and staff resources. The central objective is to maintain real-time records of asset location. While this is essential for optimizing productivity and minimizing costs, the current methodologies may fall short of providing the required level of precision and efficiency. RFID, as an automatic identification technology, is chosen for its ability to identify objects and record data through radio waves. However, the integration of RFID and GPS systems for comprehensive asset tracking poses implementation challenges, and the project aims to address these challenges to establish a seamless and accurate asset management system. Therefore, seeks to bridge the existing gaps in hospital asset management, providing a solution that not only saves time and resources but also contributes to the overall efficiency and effectiveness of healthcare delivery.

3.2 Objectives

- Provide real-time visibility into the location of critical hospital assets to reduce search time and improve asset utilization.
- Decrease operational costs by preventing loss, theft, or misplacement of expensive medical equipment through asset tracking and monitoring.
- Minimize excess inventory by accurately tracking asset usage patterns, ensuring that equipment is available when needed, and reducing unnecessary purchases.

3.3 Architecture diagram

We have a relay here because the micro-controller can handle only 2 modules at a time but we have 3 modules over here. LCD gives the current coordinates using the GPS module. When the hospital asset equipped with RFID is scanned by the EM-18 Reader Module, the current location is updated to the server using the Neo-6 GPS module. When an invalid RFID is scanned the buzzer goes on and 'invalid' is displayed on the LCD as shown in Figure 1.

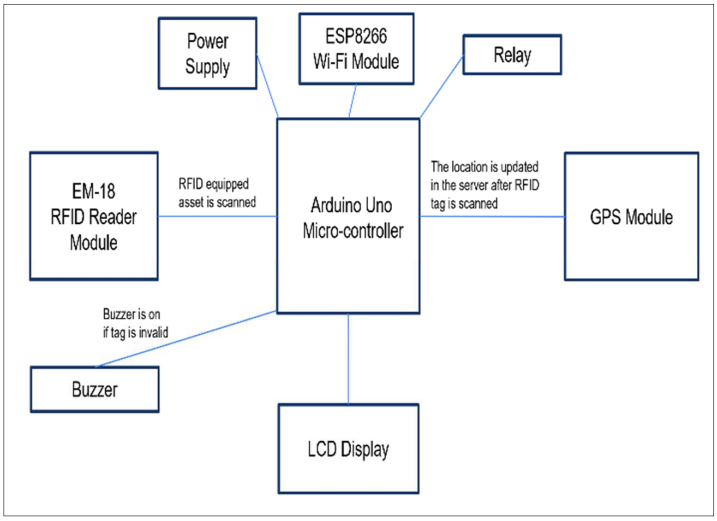

Fig. 1. Architecture Diagram

3.4 Modules and its description

3.4.1 Module 1: System configuration

This module manages the setup and configuration of the entire system: Defining asset types and assigning tags. Setting up a WIFI module to work along with RFID reader network and GPS modules. Setting up a relay for coordination between modules and microcontroller. This module acts as the physical foundation for the tracking system. It provides the essential hardware components, manages their interactions, and data transmission.

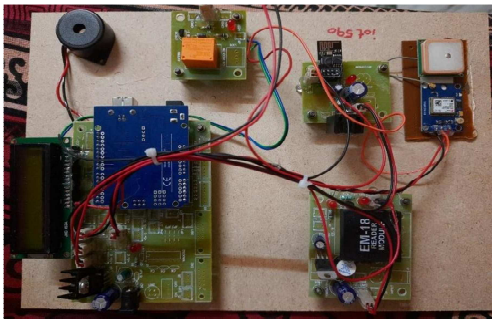

Fig. 2. System Configuration

3.4.2 Module 2: Data Acquisition

RFID Reader Network: A network of RFID readers strategically placed to capture RFID tag data from assets within their read range. Implement redundancy measures for critical areas to ensure continuous data capture.
GPS Module: Embedded along with RFID reader module to capture location data from satellites. Integrate GPS data with RFID readings for comprehensive asset visibility.

3.4.3 Module 3: Data Processing and Integration

Develop a platform to aggregate and process data from both RFID and GPS sources. Standardize data formats and timestamps for accurate and efficient integration. As soon as the RFID tag is scanned the current location of that particular asset is updated to the server.

3.4.4 Module 3: Asset Location Management

The location of a particular asset can be seen in the UI. We can see the latitude and longitude of the location as well. When the RFID tag is invalid, the buzzer goes on.

4 Results and discussions

4.1 Experimental results

The integration of the EM-18 RFID scanner with the system ensures accurate detection of RFID card tags. The system gives us the location of asset based on the location of the reader module and GPS module coordinates. Invalid assets give a buzzer when scanned by the reader module. The LCD displays the coordinates when GPS module is installed and also it displays name of the asset when scanned and sends the location to the server, which can be seen using the user interface.

The following are the steps of the experiment:

Working Setup:
All the components and modules are connected as per the architecture diagram shown previously. This figure shows that all components are working properly with the power supply.

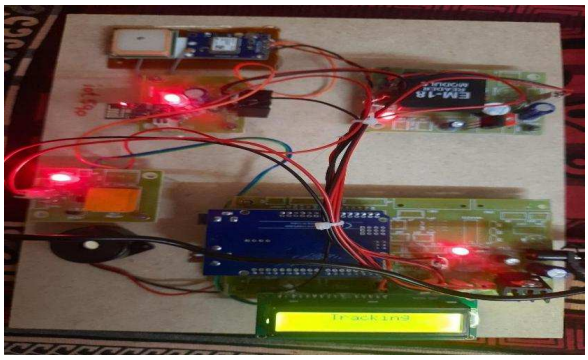

Fig. 3. Working Setup

Initial Display:
When the kit is given a power supply, the LCD shows the following message.

Fig. 4. Initial Display

Current Location of RFID Reader:
After the GPS module gets the current location with the help of satellites, it displays on the LCD.

Fig. 5. Current location of RFID reader

WIFI Ready:

After the WIFI module connects with a hotspot, it displays the following message.

Fig. 6. WIFI Ready.

RFID Scan:
After the kit is set with all the modules working, then we can scan the RFID tag/card.

Fig. 7. RFID Scan.

Scanning Asset-1:
Now we scan the RFID tag of asset 1 to get the location.

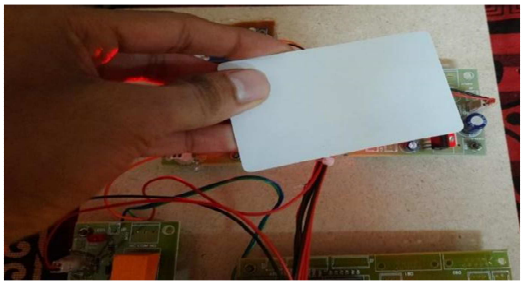

Fig. 8. Scanning Asset-1.

Uploading Asset-1 location:
After scanning the asset, with the help of a GPS module, the location of the asset is uploaded to the server. Similarly, we can do this for various assets.

Fig. 9. Uploading Asset-1 location.

Login to see the location:

To see the location, we log in to the portal or server.

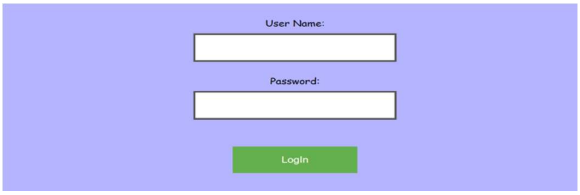

Fig. 10. Login page.

List of Assets location:

After logging in we can see the list of assets and their last scanned location along with the date and time.

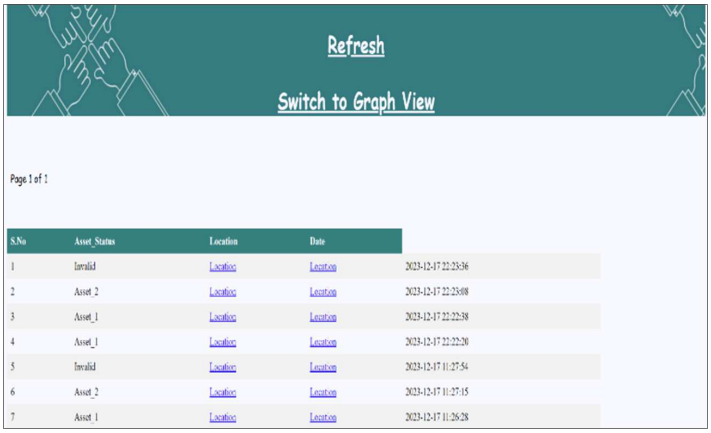

Fig. 11. List of Assets location

Location of asset in Google Maps:

If we click on a particular asset's location, we can see the location on Google Maps.

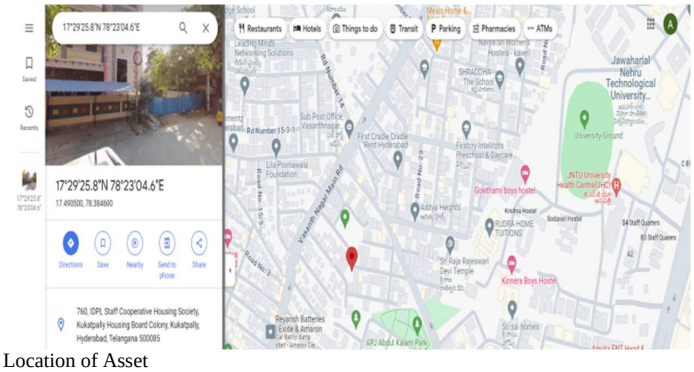

Fig. 12. Location of Asset

Scanning invalid RFID:
Now, we scan an invalid RFID tag to test it. Then we get an invalid message.

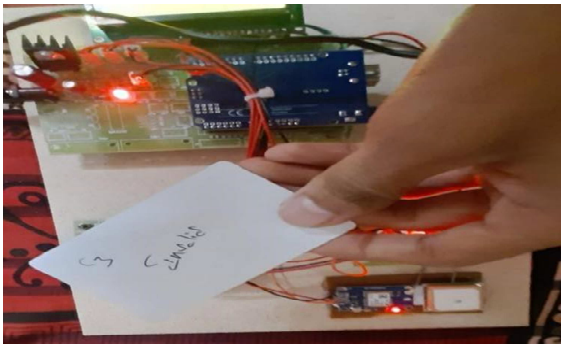

Fig. 13. Scanning Invalid RFID

Fig. 14. Invalid Message

Buzzer:
The buzzer will be on if an Invalid message is displayed

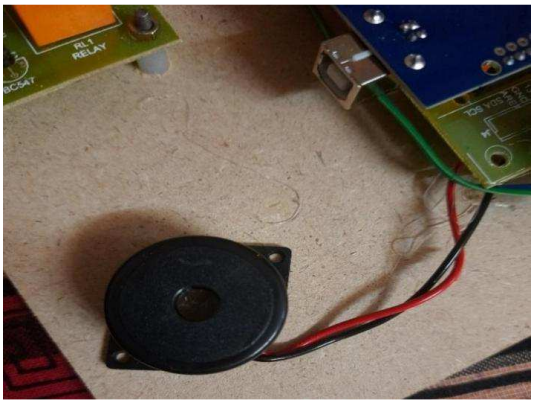

Fig. 15. Buzzer

4.2 Significance of the proposed method

Hospital asset tracking using RFID and GPS holds immense significance in the modern healthcare landscape. It goes beyond just locating equipment and supplies, it has the potential to transform the way hospitals operate, impacting patient care, staff efficiency, and overall cost-effectiveness. You can locate any asset within the hospital in real-time, both indoors and outdoors. No more wasting time searching for misplaced equipment or supplies, improving staff efficiency and patient care. Identifying the equipment availability and assigning tasks based on location, maximizing staff efficiency becomes easier. We can quickly locate equipment for maintenance, minimizing service disruptions and ensure critical equipment is

available for immediate patient care needs. The system can be easily scaled to accommodate a growing number of assets and locations. Overall, the significance of hospital asset tracking using RFID and GPS lies in its ability to improve patient care, staff productivity, and operational efficiency. It represents a powerful tool for transforming healthcare into a more patient-centred, data-driven, and cost-effective system. The full potential of this technology can only be unlocked through its effective implementation and utilization. Careful planning, integration with existing systems, and user training are crucial for maximizing the benefits and ensuring a successful outcome.

5 Conclusion

IoT-enabled hospital asset tracking system using RFID and GPS has the potential to revolutionize healthcare operations. By leveraging the combined power of these technologies, hospitals can achieve enhanced efficiency and productivity, improved patient care, and reduced costs and wastage. In conclusion, the Hospital Asset Tracking project aims to revolutionize the way hospitals manage their resources, ensuring a seamless and efficient healthcare delivery system. Through the integration of RFID and GPS technologies, the project strives to provide hospitals with a robust and scalable solution to address critical challenges in asset tracking and management. The implementation of an IoT-enabled hospital asset tracking system using RFID and GPS is not just a technological upgrade, it's a transformative leap towards a more efficient, productive, and patient-centric healthcare system. The potential benefits are vast, encompassing improved operational efficiency, enhanced patient care, and reduced costs. As the technology matures and adoption grows, we can expect to see even more innovative applications emerge, shaping the future of healthcare delivery. The implementation of IoT-enabled asset tracking systems in hospitals, supported by advanced interdisciplinary approaches, marks a significant step forward in enhancing healthcare efficiency and patient care.

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