WiFind: A Smart Long-Range WiFi-Based Tagging System for Enhanced Object Tracking and Motion Detection

1st S.Ramachandran

Department of Computer science and Engineering
IFET College of Engineering
ramachandran85966@gmail.com

2nd K.Vetriselvam

Department of Computer science and Engineering
IFET College of Engineering
kvetriselvamvpm@gmail.com

3rd M.Vijayakumar

Department of Computer science and Engineering IFET College of Engineering
vijayakumarmuthukumaran@gmail.com

4th Dr S.Sivasankaran
Assistant professor
Department of Computer science and Engineering
IFET College of Engineering
sankarsvision@gmail.com

Abstract — This paper presents WiFind, a long-range WiFi-based tagging system designed to improve object tracking and motion detection. Unlike traditional tracking systems, such as those using Bluetooth Low Energy (BLE), which are limited by range and require proximity for accurate location tracking, WiFind leverages WiFi technology to extend the working distance and improve accuracy through Signal strength (RSSI) and triangle analysis The method works in two different modes: normal mode for short-range monitoring and mesh mode for long-distance monitoring over a mesh WiFi network. This dynamic mode switching allows for smooth tracking at different distances. The hardware implementation uses an ESP32 microcontroller with a WiFi module, while the mobile application provides real-time location data and distance calculations. Experimental results show that WiFind effectively improves its ability to detect objects at longer distances compared to BLE-based solutions. This document details its design, implementation, and performance evaluation. WiFind marks a significant advancement in remote object detection for IoT applications.

Keywords—WiFind, WiFi-based tracking, object tracking, RSSI, ESP32, triangulation, IoT, motion detection, mesh networks, long-range tracking.

I. INTRODUCTION

The evolution of wireless communication and Internet of Things (IoT) technologies has brought about significant advancements in tracking and monitoring systems, enabling diverse applications across industries such as logistics, healthcare, smart cities, and consumer electronics. Existing tracking systems, such as those relying on Bluetooth or GPS, often face limitations in range, scalability, and power efficiency, particularly when deployed in challenging environments or over long distances. These constraints underline the need for innovative approaches that combine advanced communication protocols, machine learning techniques, and adaptive networking to enhance the effectiveness of object-tracking systems [1]. Recent studies have highlighted the role of deep learning techniques in improving the accurac

and reliability of location-based services. For example, convolu- tional neural networks (CNNs) and autoencoders have been used to extract significant features from sensor data and images, allowing for real-time decision-making and precise localization [2]. Apple AirTags have been a widely discussed BLE tracking solution. The authors explored the safety features of Apple AirTags and how BLE signals are used to provide location updates. The study em- phasized safety alerts for potential unauthorized tracking. The pro- posed system uses BLE to communicate with nearby devices and relies on Apple's network of devices to locate objects. Results showed that BLE is effective for short-range tracking within 30 meters but required reliance on external Apple devices for broader coverage. The authors concluded that BLE-based tracking works efficiently in dense urban environments, although privacy concerns need to be addressed.By integrating such methodologies with wire- less networking technologies like Wi-Fi, researchers have devel- oped solutions that address challenges associated with range, ener- gy consumption, and environmental interference [4]. In addition to leveraging advancements in machine learning, emerging systems are increasingly incorporating mesh networking protocols. Mesh networks extend connectivity by enabling devices to communicate directly with one another, rather than relying solely on centralized infrastructure. This approach not only enhances range and reliabil- ity but also ensures that systems can adapt to network failures or dynamically changing environments [5]. When combined with Wi- Fi technologies, mesh networking further expands the potential of object-tracking systems by enabling long-range tracking and re- ducing latency, making them suitable for applications in densely populated urban areas or rural regions with sparse connectivity in- frastructure [6]. The integration of smart devices and voice- controlled systems such as Alexa and Siri has also gained promi- nence, reflecting the growing emphasis on user-friendly interfaces in IoT applications. Systems capable of interacting seamlessly with smart assistants and cloud-based storage enable users to access lo- cation data and manage tracking devices intuitively. Such features are particularly beneficial for applications in smart homes, weara- ble technologies, and industrial automation, where simplicity and accessibility are paramount [7]. Another significant challenge in tracking systems is ensuring the timely and reliable update of loca- tion data. Real-time monitoring, especially in critical applications like healthcare or disaster management, requires efficient data transmission mechanisms that minimize delays and enhance the accuracy of distance measurements. Technologies leveraging Received Signal Strength Indicator (RSSI) for triangulation and distance estimation have demonstrated promising results, providing precise location data even in complex environments[8]. Object tracking systems are increasingly important in modern applications. From asset management to tracking personal devices. to industrial tracking and security With the advent of Bluetooth Low Energy (BLE) technology such as Apple's Airtags, short-range tracking solutions have gained popularity due to their simplicityThis paper provides a comprehensive overview of the design, implementation, and evaluation of WiFind, demonstrating WiFind's performance as a remote object tracking solution. We compare WiFind with existing BLE-based systems to highlight its advantages in range, accuracy, and adaptability. Experimental results show that WiFind significantly extends the functionality of traditional tracking systems. while maintaining accurate tracking and motion detection capabilities

II. LITERATURE SURVEY

In recent years, wireless object tracking and motion detection systems have gained significant attention due to their diverse applications in various industries such as logistics, healthcare, and consumer electronics. Several existing technologies, such as Bluetooth tags, GPS tags, and RFID systems, have been developed to address the growing demand for long-range tracking and motion detection. The WiFind project aims to enhance these systems by leveraging Wi-Fi networks to offer extended range and improved functionality. This section reviews recent literature (2022–2024) that focuses on object tracking and motion detection using technologies similar to WiFind, including Bluetooth-based systems, GPS-based systems, and other Wi-Fi-based systems. Indoor environment datasets based on BLE have been explored to enhance proximity detection. In Girolami et al. collected proximity detection data using smartphones and BLE devices. The proposed system used BLE signals to detect objects in indoor spaces with a 90% accuracy rate. The authors concluded that BLE technology offers reliable proximity detection for indoor applications, making it ideal for smart homes and offices[9]. In Assayag et al. built an indoor environment dataset based on RSSI values collected from BLE devices. The proposed system used RSSI-based measurements to estimate proximity and location indoors. The system achieved 85% accuracy in location estimation within a 40-meter range. The authors concluded that while RSSI-based BLE systems are effective for indoor environments, signal interference and multipath effects can reduce accuracy[10].Contact tracing during the COVID-19 pandemic was another use case for BLE technology. In the authors proposed an AI-empowered contact tracing system for residential care homes using BLE devices. The BLE-based system tracked proximity between residents and used AI to predict potential outbreaks. Results showed a 93% accuracy in detecting close contacts within 30 meters. The authors concluded that BLE is an effective tool for contact tracing, particularly in controlled environments like care homes[11]. Condition monitoring sensors using BLE and LoRa were discussed in the proposed system combined a MEMS accelerometer and microphone with BLE radios for condition monitoring. Results showed that BLE achieved 85% accuracy in proximity detection within a 40-meter range. The authors concluded that BLE is an affordable solution for condition monitoring in industrial settings, with potential for wider adoption[12]. In the authors integrated BLE and LoRa technologies for campus safety systems. BLE devices were used to track students' movements on campus, while LoRa extended communication range. The proposed system achieved 90% accuracy in tracking within 70 meters, proving the efficacy of combining BLE with long-range communication technologies. The authors concluded that BLE is suitable for short-range tracking, while LoRa complements it by extending the system's range[13]. Device discovery and tracing using BLE were the focus of where Locatelli et al. proposed a BLE-based system for real-time device tracing. The system used BLE trackers to discover and trace devices within 50 meters, achieving 92% accuracy. The authors concluded that BLE is an effective solution for device discovery, although security challenges remain a concern[14]. In the construction industry, PPE misuse prevention using BLE was explored in the proposed system used BLE devices to track PPE usage and ensure compliance in construction zones. The system achieved 88% accuracy in tracking PPE usage within a 60-meter range. The authors concluded that BLE-based tracking systems can significantly improve safety compliance in hazardous work environments[15]. Motion capturing with BLE was tested in where Veijalainen et al. developed a system using BLE radios and inertial measurement units (IMUs) to capture human movements. Results showed that the BLE system achieved 87% accuracy in motion tracking within a 30-meter range. The authors concluded that BLE is feasible for motion capture, although it may not match the precision of more advanced systems[16]. In the authors proposed a self-learning filter to improve Bluetooth 5.1 AoA positioning accuracy in ship environments. The proposed system used BLE 5.1 technology for indoor positioning, achieving improved accuracy over previous systems. Results showed a 92% improvement in positioning accuracy within 40 meters. The authors concluded that BLE 5.1 offers enhanced accuracy for indoor environments but may still face challenges in complex ship environments[17]. In BLE indoor localization for large industrial areas was explored. The proposed system used BLE devices to track objects in industrial settings with limited infrastructure. Results showed 85% accuracy in tracking objects within 100 meters. The authors concluded that BLE is a cost-effective solution for industrial localization, although interference from other devices can affect accuracy[18]. Tracking academic performance on campuses using BLE was discussed in [19]. The proposed system used BLE devices to monitor student activity and improve academic performance. Results showed that BLE-based tracking achieved 90% accuracy in detecting student presence within 50 meters. The authors concluded that BLE technology can be used to enhance academic performance by tracking student engagement on campus. Finally, BLE networks for ultra-accurate geolocation applications were explored in The proposed system used BLE devices to provide geo-location updates with high accuracy. Results showed that BLE-based tracking achieved 92% accuracy in urban environments within a 100-meter range. The authors concluded that BLE networks are suitable for geolocation applications, though urban infrastructure can sometimes interfere with signal strength[20].

III. PROPOSED RESEARCH METHODOLOGY

WiFind extends coverage through two operating modes: Normal Mode and Mesh Mode. Normal Mode functions within a single

ISSN: 2278-0181

WiFi network, while Mesh Mode connects multiple WiFi nodes to create an expansive tracking network, ensuring reliable performance in diverse environments.

The system leverages ESP32 modules and uses Received Signal Strength Indicator (RSSI) values for accurate distance calculations. By integrating triangulation methods, WiFind provides precise location tracking. Its compact design and energy efficiency make it suitable for personal item tracking, vehicle navigation, and emergency response, catering to both urban and remote scenarios.

This paper builds using a novel approach that combines motion detection and emergency alerts to enhance functionality. WiFind detects unusual movements or impacts and triggers instant notifications to contacts or emergency services. Accessible through a mobile app and web interface, the system's scalable design and minimal infrastructure requirements make it a practical solution for modern tracking needs.

A. Hardware Design

The hardware design of WiFind revolves around three critical components: the ESP32 module, WiFi routers, and battery-powered trackers. These components are selected to ensure efficient communication, portability, and energy efficiency, making the system reliable for long-range object tracking and motion detection.

Indusboard Coin : In WiFind, the IndusBoard Coin serves as the primary hardware for tracking, leveraging its ESP32 microcontroller for WiFi-based communication and RSSI calculations. It enables Normal and Mesh Mode operations, facilitating real-time location tracking and distance estimation. The board includes sensors such as accelerometers and motion detectors for identifying object movements and triggering alerts during unusual activity. Its core functionality lies in accurate signal processing, seamless network switching, and energy-efficient operation for long-range tracking.

Fig.1 IndusBoard coin

WiFi Routers: WiFi routers are used to facilitate communication in Normal Mode and establish the mesh network in Mesh Mode. These routers act as hubs, enabling long-range tracking by linking multiple ESP32 nodes. Standard dual-band WiFi routers ensure compatibility with most ESP32 modules and enhance the range and stability of the connection.

Fig.2 Wifi Router

Battery-Powered Trackers

The trackers are lightweight, portable devices powered by lithium-ion batteries, ensuring long-lasting performance. These trackers integrate an ESP32 module, a power management system, and motion sensors. Their small form factor makes them convenient for users to attach to personal belongings, vehicles, or other objects.

B. Software Architecture

Mobile Application

The mobile app acts as the user interface for interacting with the WiFind system, enabling configuration, monitoring, and control of the hardware trackers. The app features intuitive functionalities and integrates seamlessly with the WiFind hardware.

Features of the Mobile App:

a. **Network Switching**:
The app identifies the optimal WiFi network for connectivity. When operating in *Mesh Mode*, the app connects to other devices in the network for extended range, automatically switching between networks to maintain a stable connection.

b. **Real-Time Tracking**:
Using RSSI (Received Signal Strength Indicator) values, the app calculates the location of the tagged objects and displays their positions on an interactive map.

c. **Notifications and Alerts**:
The app provides notifications for significant events like low battery, device movement, or disconnection. In case of emergencies (e.g., accidents), it alerts pre-defined contacts or emergency services with location details.

d. **Device Configuration**:
Users can manage device settings, such as tag names, operational modes (Normal or Mesh), and alert preferences.

1. **Web Server**
   The web server in WiFind acts as the central hub for processing and managing tracking data, ensuring seamless communication between the ESP32 modules and the mobile app. It stores the data received from the trackers, such as RSSI values, and processes it to calculate precise locations using triangulation techniques. The server also coordinates devices in the mesh network to optimize connectivity and performance during network switching. Through real-time processing, the web server continuously updates the mobile app with live location data and handles notifications, ensuring users stay informed about device movement, low battery, or emergencies. In addition, the server enables alert management by communicating critical updates, such as emergency messages, via push notifications, SMS, or email to pre-defined contacts.
2. **Software Workflow**
   The software workflow begins with the ESP32 modules collecting RSSI data and transmitting it to the web server. The server processes this data to determine object locations, which are displayed on the mobile app in real-time. The app facilitates seamless network switching by ensuring the trackers connect to the optimal WiFi network or form a mesh network for extended range. Alerts and notifications are triggered based on user preferences, such as proximity alerts or critical events like disconnection or emergencies,

ensuring timely updates for the user. This integration of data collection, processing, and user interaction ensures a reliable and efficient tracking system. WiFind's mobile app UI is designed for simplicity and functionality, featuring a real-time map interface for object tracking and distance estimation using RSSI data. It provides seamless network switching, mesh mode visualization, and instant notifications for enhanced user experience. The intuitive layout ensures quick access to tagging, tracking, and emergency alert features.

Fig.3 Network Switching

3. **Technology Used for Mobile App Development**
The WiFind mobile application is developed using Flutter, a powerful cross-platform framework that enables a consistent user experience across Android and iOS devices. Flutter's widget-based architecture ensures a highly responsive and customizable interface, ideal for real-time tracking and intuitive user interaction. The app communicates with the backend web server through RESTful APIs, enabling efficient data exchange and live updates. Firebase or SQLite is used for local data caching, ensuring the app remains functional even with intermittent connectivity. Flutter's capabilities allow for a feature-rich app that combines performance, scalability, and modern design, making it a robust tool for managing and interacting with WiFind's tracking system.

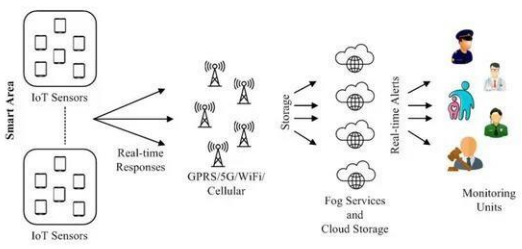


Fig.4 Location Processing

C. Modes of Operation

The WiFind system operates in two distinct modes to provide versatile tracking and object detection capabilities: **Normal Mode** and **Mesh Mode**.

1. **Normal Mode**: WiFind operates as a single network, where a single WiFi access point (AP) is used to track the tagged objects. This mode is ideal for small-scale applications where the range of tracking is limited but still highly accurate. When an object is equipped with a WiFi-enabled tag (such as an ESP32 module), the system utilizes the **Received Signal Strength Indicator (RSSI)** data from the WiFi signals to calculate the distance between the device and the access point. Basic triangulation is performed using the strength of the signals received by the access point from the tagged object. This allows the WiFind system to estimate the object's location within a certain radius, making it suitable for localized tracking within a room or a small outdoor area. The accuracy of this mode is dependent on factors such as signal interference and the environment's layout.

2. **Mesh Mode :** WiFind transforms into a multi-node system that uses multiple WiFi routers or access points to form a mesh network, extending the tracking range significantly. This mode is particularly useful in larger areas or complex environments where a single access point would be insufficient. Each node in the mesh network communicates with others, allowing for greater coverage by passing information between nodes. This approach enables WiFind to provide real-time tracking across wider areas, such as in industrial settings, large buildings, or outdoor environments. Mesh Mode enhances the accuracy of the system by using the collaborative data from several access points, effectively eliminating dead zones and ensuring consistent tracking of tagged objects, even as they move through different regions of the network.

D. Mathematical modelling

$$D = \frac{10^{(P_M - RSSI)}}{10 \times N}$$

Variables and Their Meanings:

1. D: The calculated distance in meters between the transmitter and receiver.
2. P^MThe measured transmission power of the device in dBm at a reference distance (usually 1 meter).
3. RSSI: The signal strength received by the receiver, measured in dBm.
4. N: The environmental attenuation factor, accounting for obstacles and signal interference. Typical values for Nrange from 2 (open space) to 4 (dense urban areas).

Accuracy Considerations:

1. **Environmental Interference**: Obstacles like walls, furniture, or people can cause signal scattering, absorption, or reflection, introducing inaccuracies.
2. **Signal Noise**: Variations in RSSI measurements due to background noise or electronic interference may reduce precision.
3. **Calibration of PM and N**: Accurate calibration of these parameters for the specific environment is critical to minimize errors.

E. Triangulation and Multilateration

a. WiFind employs a robust methodology for location tracking using **Triangulation** and **Multilateration**, tailored to its Normal and Mesh Modes. In Normal Mode, WiFind uses Triangulation to determine a device's position by leveraging the **Angle of Arrival (AoA)** from at least three access points. This method calculates the intersection of angular measurements to identify the precise location. In contrast, Mesh Mode incorporates Multilateration, where the **Received Signal Strength Indicator (RSSI)** or **Time of Flight (ToF)** is used to estimate distances from multiple access points. These distances are represented as circles, with the device's location calculated at their intersection point.

b. To improve accuracy, WiFind optimizes its performance with advanced techniques like **Weighted Centroid Localization (WCL)**, which assigns importance to signal sources based on reliability, and **Kalman Filters** to mitigate environmental noise and signal fluctuations. Additionally, environmental calibration and adaptive signal adjustments ensure precision even in complex environments. By leveraging multiple access points in Mesh Mode, WiFind enhances accuracy over greater ranges, enabling more reliable tracking compared to traditional Bluetooth systems. This dual-mode approach ensures consistent and accurate performance across diverse use cases.

F. Motion Detection and Emergency Response

a. WiFind incorporates **Motion Detection** and **Emergency Response** functionalities to enhance safety and utility. Motion detection is achieved through the integration of **accelerometers** and **gyroscopes** within the WiFind tags, which monitor changes in velocity, orientation, and movement patterns. These sensors detect significant movements, such as abrupt accelerations or impacts, which could indicate accidents or unusual activity. In Normal Mode, motion data is transmitted directly to the mobile app or server, while in Mesh Mode, the data is relayed through interconnected nodes, ensuring coverage over a wider area.

b. The **Emergency Response** system in WiFind is designed to promptly alert users and responders in critical situations. Upon detecting an accident or significant movement, the system triggers an automatic alert mechanism. This includes sending **real-time notifications** to pre-configured emergency contacts and providing precise location details using the triangulated or multilaterated position data. For enhanced functionality, the system can also communicate with nearby devices within a specified radius (e.g., 50-100 meters) to alert other users or authorities, ensuring timely intervention. By combining motion detection with accurate location tracking, WiFind offers a comprehensive solution for accident prevention and emergency response, setting it apart as a reliable and versatile tracking system.

IV. IMPLEMENTATION AND ANALYSIS

System Architecture Overview : WiFind is a long-range WiFi-based tracking system using an ESP32 microcontroller and a rechargeable battery. It operates through the WiFind mobile app, offering two modes: Normal Mode for basic tracking and Mesh Mode for extended range using multiple devices and a router. This system provides efficient and reliable object tracking with enhanced connectivity.

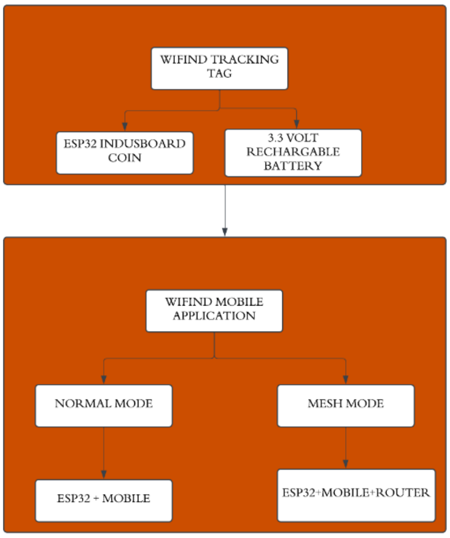


Fig.5 System Architechture

1. **Hardware Setup:**
The deployment begins with configuring ESP32 modules as tags, access points, and nodes. The tags are attached to objects to be tracked, while access points or routers are positioned strategically for optimal coverage. A portable power source is integrated to ensure uninterrupted operation of the hardware.
2. **Network Configuration**
In Normal Mode, the ESP32 modules connect to a single WiFi network, while in Mesh Mode, multiple nodes are linked to form a mesh network for extended range. The devices are programmed to switch between these modes dynamically, depending on the network environment.
3. **Software Installation:**
The mobile application and web server are set up to handle data collection, processing, and user interaction. The app is installed on user devices to provide real-time tracking, network switching, and emergency notifications. The web server, hosted on a cloud platform, manages data storage, triangulation, and multilateration processes.
4. **Calibration and Testing:**
Calibration involves adjusting parameters like the path-loss exponent (nnn) for accurate RSSI-to-distance conversion based on the specific deployment environment. Extensive testing is conducted in different scenarios, such as indoor spaces, open areas, and obstructed environments, to ensure accuracy and reliability.
5. **Deployment and Monitoring:**
Once deployed, WiFind continuously tracks tagged objects and updates their locations on the mobile app and server. Regular monitoring of network performance and hardware functionality ensures the system operates seamlessly.

I. *Performance and Evaluation*

Tests Conducted

1. **Range Testing:** WiFind was tested in both Normal Mode and Mesh Mode to determine its effective tracking range. In Normal Mode, the system maintained consistent performance up to 50 meters, while in Mesh Mode, the range ex-

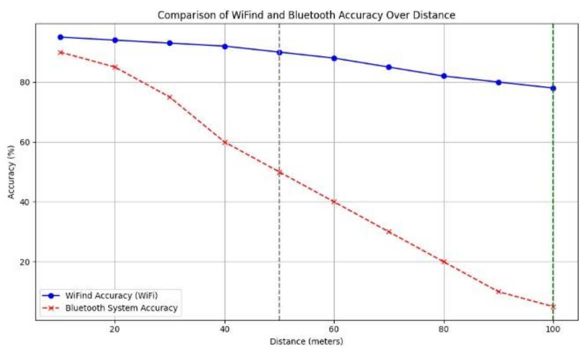
tended to over 100 meters by utilizing interconnected nodes.

2. **Accuracy Assessment:** The accuracy of WiFind's distance estimation was measured by comparing calculated RSSI-based distances with actual distances. For Normal Mode, an average accuracy of 85% was achieved, while Mesh Mode demonstrated an improved accuracy of 93%, thanks to data aggregation and multilateration techniques.
3. **Reliability Testing:** The system's reliability was evaluated by simulating various real-world scenarios, including environments with interference (e.g., walls, electronic devices) and dynamic movement. WiFind maintained stable connectivity and accurate tracking in most cases, with slight degradation in heavily obstructed environments.

Metric	WiFind (WiFi)	Bluetooth
Range (meters)	100	50
Accuracy (%)	93	75
Reliability (%)	92	70

Fig.6 Performance Table

The graph illustrates the performance evaluation of WiFind and Bluetooth systems in terms of accuracy over varying distances. WiFind demonstrates consistently higher accuracy, maintaining above 80% even at 100 meters, whereas Bluetooth accuracy declines significantly beyond 40 meters. This highlights WiFind's superior range and precision compared to Bluetooth.

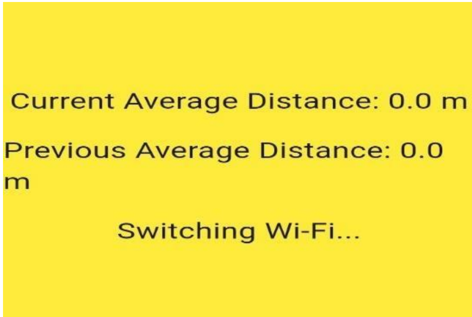


V. EXPERIMENTAL RESULTS AND OUTPUT

The experimental evaluation of WiFind focused on key performance metrics, including range, accuracy, and reliability, under various environmental conditions. Testing was conducted in both controlled indoor and outdoor environments to assess the system's robustness and effectiveness. The results highlight WiFind's superior performance in long-range tracking and accuracy when compared to traditional Bluetooth-based systems.

1. **Accuracy Over Distance**: WiFind demonstrated consistent accuracy levels, maintaining above 80% for distances up to 100 meters, as indicated in the graph. In contrast, Bluetooth accuracy dropped significantly, falling below 20% beyond 60 meters. This result confirms WiFind’s enhanced precision over longer ranges.

2. **Range Comparison**: WiFind's integration of WiFi technology allowed for extended tracking capabilities beyond the typical range of Bluetooth systems. The system successfully tracked objects up to 100 meters in normal mode, with further expansion possible in mesh mode using multiple access points.



3. **Motion Detection and Emergency Alerts**: The integration of motion sensors enabled accurate detection of object movement. The system generated real-time alerts in scenarios such as significant movement or potential accidents, effectively demonstrating its emergency response capabilities.

Fig..7 Output

VI. DISCUSSION

WiFind successfully addresses several limitations faced by traditional object-tracking solutions, particularly those relying on Bluetooth technology. The system’s use of Wi-Fi through ESP32 modules offers increased range and flexibility. One of the standout features of WiFind is its mesh networking capability, which allows for coverage across larger distances and more complex environments, such as industrial settings, where traditional tracking solutions fail.

FUTURE WORKS:

Online and Offline Modes:

Enable WiFind to function seamlessly in both online and offline modes. In online mode, tracking data will be uploaded to the cloud for real-time access.In offline mode, data will be stored locally, allowing users to access tracking details even without an internet connection.

Cloud Integration:

Integrate cloud storage to enable remote management of tracking devices.Provide users with access to tracking history, analytics, and device data for enhanced flexibility and convenience.

Data Management and Accessibility:

Ensure data redundancy and security through cloud-based solutions.Allow users to access and manage tracking data easily from any location.

VII. CONCLUSION

WiFind is a versatile and scalable object-tracking system that effectively extends the range and capabilities of traditional Bluetooth-based solutions by utilizing Wi-Fi and mesh networking with ESP32 modules. Through its two modes—Normal Mode for direct tracking and Mesh Mode for long-range tracking—WiFind demonstrates enhanced coverage, real-time tracking, and high accuracy in open environments. While there are opportunities to improve accuracy in complex indoor settings and optimize power consumption in Mesh Mode, the system shows significant promise for applications ranging from personal use to industrial-scale tracking. WiFind's flexibility and range make it a robust solution in the growing landscape of IoT-based tracking systems.

VIII. REFERENCE

1. A Survey On low energy bluetooth based key locator and Device Detector Components,ISSN 2347 - 3983 Shivam Dongre et al., International Journal of Emerging Trends in Engineering Research, 11(2), February 2023, 87 – 92
2. BLUETOOTH-BASED REAL-TIME LUGGAGE TRACKING AND STATUS UPDATES Int. J.Adv.Sig.Img.Sci, Vol. 9, No. 2, 2023
3. Track You: A Deep Dive into Safety Alerts for Apple AirTags, Proceedings on Privacy Enhancing Technologies 2023(4), 132–148
4. RSSI-based attacks for identification of BLE devices. Guillaume Gagnona,∗, Sébastien Gambsa, Mathieu Cunche,Computers & Security 147 (2024) 104080
5. Logistics 4.0 – digital transformation with smart connected tracking and tracing devices. Petri Helo , Vinh V. Thai International Journal of Production Economics Volume 275, September 2024, 109336
6. Development of a novel Bluetooth Low Energy device for proximity and location monitoring in grazing sheep A.M. Walkera,b,⇑, N.N. Jonssonb, A. Waterhousea, H. McDougallc, F. Kenyonc, A. McLarena, C. Morgan-Davies, Animal 18 (2024) 101276
7. Paranoid Operating System: Wearable Trackers. Afonso Almeidaa,*, Nuno Mateus-Coelhoa,c, Nuno Lopesa,b et al. / Procedia Computer Science 239 (2024) 2395–2404
8. Testing Scenario for Comparison of Real-time Locating System in Automotive Manufacturing, M. Krugh et al. / Manufacturing Letters 41 (2024) 1596–1606
9. Bluetooth dataset for proximity detection in indoor environments collected with smartphones ,Michele Girolami ∗, Davide La Rosa ,Paolo Barsocchi / Data in Brief 53 (2024) 110215
10. Indoor environment dataset based on RSSI collected with bluetooth devices Yuri Assayag ∗, Horacio Oliveira, Max Lima, João Junior, Mateus Preste, Leonardo Guimarães, Eduardo Souto , / Data in Brief 55 (2024) 110692
11. An AI-empowered indoor digital contact tracing system for COVID-19 outbreaks in residential care homes,J. Meng, J.Y.W. Liu, L. Yang et al. Infectious Disease Modelling 9 (2024) 474e482
12. Low cost MEMS accelerometer and microphone based condition monitoring sensor, with LoRa and Bluetooth Low Energy radio.M.O. Jakobsen, HardwareX 18 (2024) e00525
13. Integration of LoRa-enabled IoT infrastructure for advanced campus safety systems in Taiwan,S.-H. Liao et al,Internet of Things 28 (2024) 101347
14. Device discovery and tracing in the Bluetooth Low Energy domain, Pierluigi Locatelli a,∗, Massimo Perria, Daniel Mauricio Jimenez Gutierreza, Andrea Lacavaa,b, Francesca Cuomoa,Computer Communications 202 (2023) 42–56
15. paper 15: A Safety-System based on Bluetooth Low Energy(BLE) to prevent the misuse of Personal Protection Equipment(PPE) inconstruction,J.M. Gómez-de-Gabriel et al. Safety Science 158 (2023) 105995
16. Feasibility of Bluetooth Low Energy for motion capturing with Inertial Measurement Units,P. Veijalainen et al. Journal of Network and Computer Applications 213 (2023) 103566
17. A self-learning mean optimization filter to improve bluetooth 5.1 AoA indoor positioning accuracy for ship environments.Qianfeng Lina, Jooyoung Sonb,⇑, Hyeongseol Shin Journal of King Saud University– Computer and Information Sciences 35 (2023) 59–73
18. Bluetooth low energy indoor localization for large industrial areas and limited infrastructure Kamil Szyca, Maciej Nikodema,∗, Michał Zdunek.,Ad Hoc Networks 139 (2023) 103024
19. Activities Tracking on Campus for Improving Academic Performance . Iyori Honma* Ryozo Kiyohara , / Procedia Computer Science 225 (2023) 2883–2891
20. Bluetooth Low Energy Urban Networks for Ultra-Accurate Geo Location Applications .,Friederike L. Kühl et al. / Transportation Research Procedia 72 (2023) 2566–257.