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Locating Indoors with Wifi: An Analysis of Positioning System

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ABSTRACT: An indoor positioning system with a WIFI IP address is a technology that locates users within buildings using WIFI signals. The user's device connects to several WIFI access points across the facility, and this system analyses the device's specific IP address as it does so. The technology can precisely pinpoint the user's location by triangulating their position and comparing the signal strength of their smartphone at each access point. Indoor navigation, asset tracking, and location-based marketing are just a few of the many possible uses for this technology. A system that uses WIFI signals to pinpoint a user's location within a building is known as an indoor positioning system employing WIFI IP address. This system works by analysing the unique IP address of the user's device as it connects to different WIFI access points within the building. By comparing the signal strength of the device at each access point, the system can triangulate the user's position and provide accurate location information. This technology has a wide range of potential applications, including indoor navigation, asset tracking, and location-based marketing. A WiFi positioning system's ability to operate indoors and in places where GPS signals may be hindered or poor, such as within buildings or in urban canyons, is one of its advantages. Another benefit is that since it doesn't need to be installed, it can be a more affordable alternative to conventional GPS-based systems. The system has several drawbacks as well. For instance, the density and signal strength of the accessible access points affect how accurate the location data is. Also, the system could not function well in locations with a lot of interference or in places with poor WiFi signals. All things considered, a WiFi positioning system utilising WiFi IP addresses has the potential to offer a number of advantages in a variety of fields and use cases. The system is probably going to keep getting more accurate and useful as long as technology and data analysis methods evolve.

KEYWORDS: Position, WIFI, IP address, Indoor positioning system (IPS)

I. INTRODUCTION

When GPS or other technologies are unable to offer an exact location for an object or person, IPS are employed. Recent years have seen a substantial increase in interest in indoor positioning systems (IPS) as a result of this need for location-based services in indoor spaces. The most extensively used and well-liked tool for determining a person's location is a GPS. It is utilised almost everywhere. Due to the utilisation of satellite signals, it makes object tracking simple. When GPS signals are weak or non-existent inside buildings, IPS can offer precise location data. Using WIFI IP addresses, which makes use of the already-existing WIFI infrastructure, is one method for indoor positioning. Due to its low cost, simple setup, and the broad availability of WIFI networks, this technology has grown in popularity. The fundamental principle of WIFI IPS is to locate a device by using the specific IP address that is issued to it as it connects to various WIFI access points throughout a building. This is accomplished by triangulating the position of the device by examining the WIFI signal's strength and quality at each access point.

Numerous possible uses for WIFI-based IPS exist, including asset tracking, location-based marketing, indoor security, and indoor navigation. To offer a more precise and complete locating solution, the technology can be linked with other location technologies, such as Bluetooth beacons or RFID tags.

In this regard, this technology has developed quickly, with constant research and development aimed at enhancing its precision, dependability, and scalability. In this study, the state-of-the-art in WIFI-based IPS will be reviewed, along with its guiding principles, difficulties, and prospective uses.

Due to the rising need for location-based services in interior spaces, the use of WIFI-based IPS has extended more widely in recent years. This is especially true in expansive and intricate structures like retail malls, hospitals, airports, and conference facilities where it can be difficult to navigate and find specific places of interest.

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IPS powered by WIFI has a number of benefits over conventional indoor positioning technologies. For instance, it may use the current WIFI infrastructure and does not need any additional hardware, such beacons or RFID tags, making it inexpensive and simple to deploy. Additionally, it can deliver precise positional data even in locations with poor or non-existent GPS signals.

WIFI-based IPS, however, also faces a number of issues that must be resolved. The possibility of errors resulting from signal interference, multipath propagation, and changes in the building's environment is one of the main difficulties. This may result in mistakes being made when triangulating the device's position, which may reduce the system's overall accuracy.

Researchers have created a number of signal processing algorithms and machine learning techniques to solve these issues and enhance the precision and dependability of WIFI-based IPS. To handle signal fluctuations and noise as well as to increase the accuracy and scalability of the system, methods like fingerprinting and machine learning-based approaches, for example, have been proposed.

In conclusion, a variety of possible applications exist for WIFI-based IPS, and continuing research aims to increase the technology's precision, dependability, and scalability. WIFI-based IPS is positioned to play a significant role in the development of indoor positioning in the future thanks to the growing adoption of IoT devices, the development of more sophisticated algorithms, and machine learning approaches.

II. LITERATURE REVIEW

The integration of Radio-Frequency Identification (RFID) technology in large manufacturing organizations has gained significant attention in recent years, particularly in the realm of human tracking. This literature review aims to explore and analyse existing research on the use of RFID for tracking humans in large manufacturing environments. The review will focus on key themes such as technological advancements, privacy concerns, efficiency improvements, and the impact on overall organizational performance.

1. L Batistic, M Tomic (2018)- We need to stay up to date with emerging trends and technology since the area is always changing. Because of its increased precision, IPS is now widely used in business settings for tracking people and assets. In terms of regular personal usage applications, it hasn't yet gained traction. Herein, we offer a synopsis of the most pertinent IPS technologies together with a methodology. The cost, accuracy, performance, and complexity of the technologies are the comparison criteria. Additionally, being looked at are hybrid techniques as a potential solution to IPS technology shortcomings. For personal applications utilising pocket-sized devices (such as smartphones), the study primarily focuses on IPS technology.
2. F Liu, J Liu, Y Yin, W Wang, D Hu, P Chen (2020) - Numerous indoor location-based services (ILBSs) have found their way into everyday life as a result of the wireless communication technology's quick growth. In wireless transmission, WiFi-based positioning strategies with a wide variety of infrastructure have drawn attention, despite the fact that many different approaches have been proposed to be used to ILBS in the last 10 years. The authors of this survey separate WiFi-based indoor locating methods into two categories: active and passive, depending on whether the target is carrying specific gadgets. Following a thorough examination of several outstanding publications within the relevant subject, the authors provide an in-depth overview of these two categories of positioning strategies. In the present technical context, they also assess the difficulties and potential development trends.
3. F Qin, T Zuo, X Wang (2021) - Due to its many benefits, including a high transmission range and simplicity of usage indoors, WiFi is frequently utilised for indoor positioning. In order to enhance the precision and resilience of indoor WiFi fingerprint localization technology, this study suggests a positioning system called CCPos (CADE-CNN Positioning). This system is built on a convolutional neural network (CNN) and a convolutional denoising autoencoder (CDAE). This method uses the K-means algorithm to separate the validation set from the entire training set during the offline phase. During the online phase, the CDAE first denoises the RSSI and then extracts important characteristics. Next, CNN outputs the location estimation. The Alcala Tutorial 2017 dataset and UJIIndoorLoc are used in this work to validate the CCpos system's functionality.
4. Han Zou; Ming Jin; Hao Jiang; Lihua Xie; Costas J. Spanos (2017)- The most promising method for indoor localization is the WiFi fingerprinting-based IPS. Two significant issues, nevertheless, prevent its widespread application. The first step is to conduct an offline, labor-and time-intensive site survey approach. Second, environmental dynamics can affect the RSS fingerprint database that was constructed offline. In order to fully address these problems, we present in this work WinIPS, a WiFi-based non-intrusive IPS that aims to provide calibration-free indoor localization by enabling automated online radio map creation and adaption. In a non-intrusive way, WinIPS can extract the MAC and RSS addresses of WiFi access points (APs) and mobile

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devices from data packets broadcast in the flow of current WiFi traffic. When creating radio maps, APs can serve as online reference points. The non-uniform RSS distribution of an interior environment is estimated using a brand-new Gaussian process regression model.

III. PROBLEM STATEMENT

As organizations increasingly embrace technological advancements to enhance operational efficiency and security, the deployment of IPS technology for tracking humans within their premises has gained momentum. While this technology offers potential benefits such as improved personnel management, enhanced safety, and streamlined processes, there is a pressing need to critically examine the ethical implications and privacy concerns associated with its implementation.
The use of IPS technology to track individuals raises questions about the balance between organizational objectives and the fundamental right to privacy. As it become more commonplace in identification badges and access cards, employees may find themselves subject to constant surveillance, giving rise to concerns related to autonomy, dignity, and the potential for abuse of personal information. Moreover, the seamless nature of IPS tracking poses challenges in establishing clear boundaries on when and how employee data is collected, stored, and utilized, leading to uncertainties about the extent of individual autonomy within the workplace.
This article aims to delve into the multifaceted issues surrounding the use of IPS technology for human tracking in organizational settings. Key areas of exploration will include the impact on employee morale and trust, the potential for unauthorized access and data breaches, and the need for robust policies and regulations to safeguard individual privacy. By addressing these concerns, the article seeks to contribute to the ongoing discourse on the responsible and ethical use of technology within organizational contexts, promoting a balanced approach that prioritizes both operational efficiency and the protection of individual rights.

IV. OBJECTIVES

The objective of this article is to comprehensively examine the utilization of IPS technology for human tracking within organizational environments. Through a detailed exploration of its applications, advantages, and potential challenges, the article aims to provide a nuanced understanding of the implications associated with personnel tracking systems. Additionally, the article seeks to shed light on the ethical considerations and privacy concerns arising from the implementation of this technology in organizational settings. By fostering a balanced perspective, the objective is to contribute insights that can inform organizational decision-making, guide the development of effective policies, and promote responsible and ethical use of RFID technology for human tracking within the workplace.

V. DESIGN AND METTHODOLOGY

The design and methodology of the Multi-Floor Wi-Fi Access System are critical componentsthat underpin the project's success. This section provides an in-depth exploration of the system's architectural design, the principles governing its algorithms, the methodology of its implementation, and the strategies for achieving seamless Wi-Fi access across multi-story buildings.

ARCHITECTURAL DESIGN

The architectural design of the Multi-Floor Wi-Fi Access System is driven by the need to overcome the challenges posed by multi-story buildings, where signal propagation and networkcongestion often disrupt user experience. The system's primary components are as follows:

- Multi-Router Setup: The cornerstone of the design is the deployment of multiple routers, each located on different floors. This spatial distribution is crucial for enhancing signal strength and reducing dead zones. Users are intelligently directed to the closest access point, ensuring they receive optimal signal quality.
- Admin Panel: The admin panel is a central component for network management and monitoring. It provides administrators with a user-friendly interface to oversee the network's performance, monitor user connections, and optimize network settings.
- Intelligent Algorithms: The system employs a set of intelligent algorithms for user connection management and Quality of Service (QoS). These algorithms consider factors like signal strength, network load, and user traffic patterns to ensure efficient allocation of resources.

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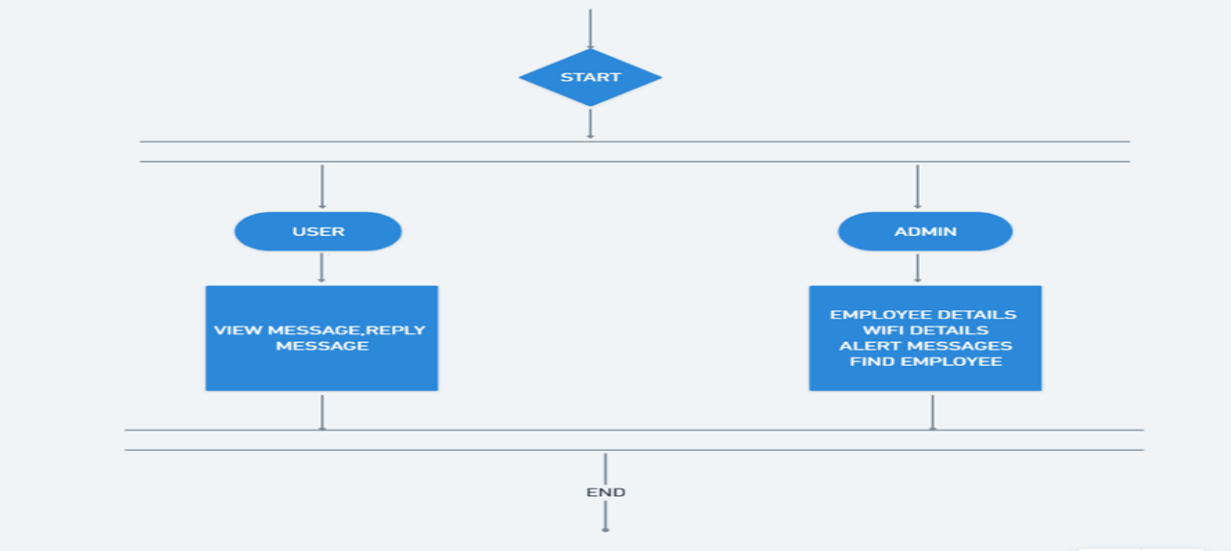
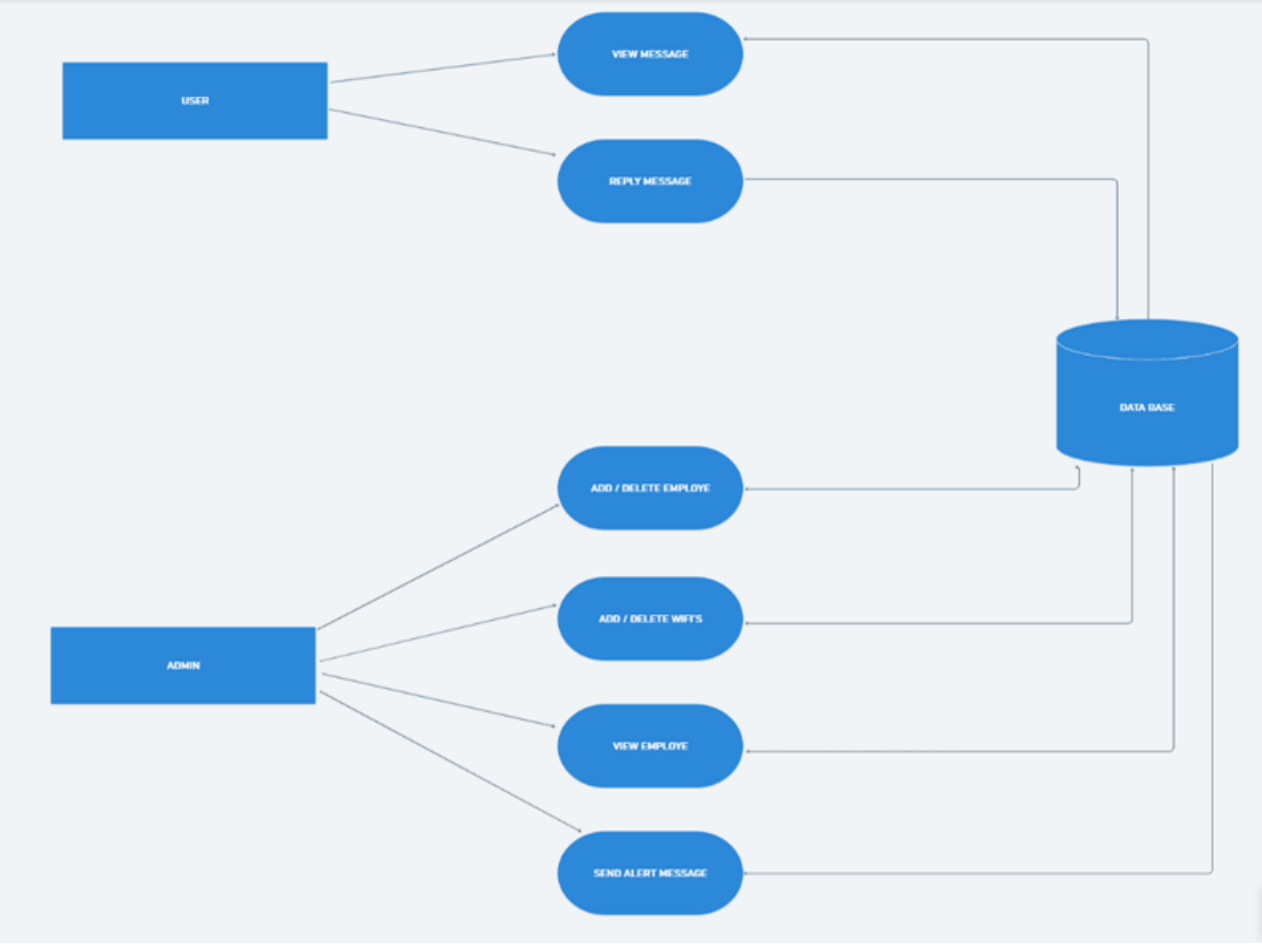
DATA FLOW DIAGRAM (DFD)

FIRST LEVEL DFD



SECOND LEVEL DFD



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VI. METHODOLOGY

The methodology employed in the development of the Multi-Floor Wi-Fi Access System follows a systematic approach to ensure the system's functionality, reliability, and security.

- Requirements Analysis: The project initiated with a comprehensive requirements analysis to understand the specific challenges presented by multi-story buildings. This analysis identified the need for multi-router placement, user connectionmanagement, and robust security.
- Design Phase: The architectural design was crafted to address the identified challenges. It incorporated the placement of routers on different floors, the developmentof the admin panel, and the creation of intelligent algorithms for user connection management and QoS.
- Development and Implementation: The system was developed according tothe design specifications. This involved creating and configuring the routers, building the admin panel, and implementing the intelligent algorithms. Security measures, including user authentication and data encryption, were meticulously integrated.
- Testing and Optimization: Rigorous testing was conducted to evaluate the system's performance. Unit tests, integration tests, and user testing were performed to identify and rectify any issues. Optimization efforts were aimed at ensuring efficient resource allocation and minimal network congestion.
- User Documentation: A user manual was produced to provide clear and conciseinstructions for users to connect to the Wi-Fi system, access the admin panel, and troubleshoot common issues.
- Security Measures: To safeguard user data and network integrity, the system was equipped with encryption protocols, access controls, and other security features. Privacy and data protection were paramount throughout the design and implementation.

VII. POTENTIAL BENEFITS TO THE ORGANISATION

1. Enhanced Security: IPS can be used for access control, ensuring that only authorized personnel can enter specific areas within the manufacturing facility.
2. Workforce Management: IPS tracking can assist in monitoring employee attendance, working hours, and break times, leading to better workforce management.
3. Efficiency and Productivity: Tracking devices provide real-time data on the progress of production processes. Managers can identify bottlenecks, optimize workflows, and make informed decisions to enhance overall production efficiency.
4. Safety Monitoring: IPS can be employed to monitor employees' locations in hazardous areas, enabling quick response in case of emergencies. IPS can be utilized to ensure that employees are wearing appropriate safety gear in designated areas, promoting a safer work environment.
5. Asset Tracking: Large manufacturing facilities often have a significant number of assets, such as machinery, tools, and equipment. IPS enable organizations to monitor the location, status, and usage of these assets, helping prevent loss, theft, or unauthorized use.
6. Process Optimization and supply chain visibility: Tracking devices provide visibility into the entire supply chain, allowing organizations to track the movement of goods from suppliers to manufacturers and, ultimately, to customers. This visibility helps in better demand forecasting, logistics planning, and order fulfillment. Tracking employee movements can provide valuable data for analyzing and optimizing manufacturing processes, leading to improved efficiency.
7. Quality Control: IPS help in monitoring and tracing the production history of individual products. In case of quality issues, organizations can quickly identify the source of the problem, recall affected products, and implement corrective measures. It can be used to monitor and trace products through the manufacturing process, aiding in quality control and compliance with production standards.
8. Inventory Management: Tracking devices help monitor the movement of raw materials, work-in-progress items, and finished goods throughout the manufacturing process. Real-time data on inventory levels and locations can prevent stockouts, reduce excess inventory, and streamline the supply chain.
9. Automation Integration: IPS technology can be integrated into automated systems, enabling seamless communication between humans and machines in a manufacturing environment. The data collected from tracking devices can be analyzed to identify trends, inefficiencies, and areas for improvement. Continuous monitoring and analysis contribute to data-driven decision-making and process optimization.

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VIII. FUTURE OF IPS TECHNOLOGY

The future scope of using IPS for personnel tracking in organizations is promising and likely to witness advancements in various aspects. Here are some potential future developments and areas of growth:

1. Integration with IoT and Sensor Technologies: IPS technology is likely to integrate more seamlessly with Internet of Things (IoT) devices and sensor technologies, allowing for a more comprehensive understanding of personnel movements and activities within the organization.
2. Biometric Integration: Future developments may involve the integration of IPS with biometric technologies, enhancing the accuracy and security of personnel tracking systems through methods such as fingerprint scanning or facial recognition.
3. Advanced Analytics and Predictive Insights: IPS data, when combined with advanced analytics, can offer organizations valuable insights into employee behavior, work patterns, and trends. Predictive analytics may be employed to anticipate personnel movements and optimize resource allocation.
4. Wearable IPS Devices: The development of wearable IP devices, such as smart ID badges or bracelets, may become more prevalent. These devices can enhance convenience, mobility, and user experience in personnel tracking.
5. Real-time Location Services (RTLS): IPS systems may evolve to provide more accurate real-time location services, enabling organizations to monitor personnel movements with higher precision. This can have applications in emergency response, security, and workflow optimization.
6. Blockchain Integration for Data Security: Integrating blockchain technology with IPS can enhance the security and integrity of personnel tracking data. This ensures that the information is tamper-proof, transparent, and secure from unauthorized access.
7. Customization and Scalability: Future systems may offer greater customization options, allowing organizations to tailor personnel tracking solutions based on specific needs and industry requirements. Scalability will be a key consideration to accommodate growing organizations.
8. Improved Energy Efficiency: Advancements in IPS technology may focus on developing more energy-efficient solutions, especially for large-scale deployments. This could involve innovations in IPS tag design and reader technology.
9. Enhanced Privacy Controls: To address privacy concerns, future RFID systems may incorporate advanced privacy controls and encryption methods. This ensures that individuals have more control over their personal data and how it is used within the organization.

IX. CONCLUSION

In conclusion, the adoption of IPS technology for personnel tracking in organizations represents a significant leap forward in enhancing efficiency, security, and overall operational management. The seamless integration of systems enables real-time monitoring of personnel movements, providing invaluable insights for better decision-making. The accuracy and speed of IPS-based tracking contribute to streamlined processes, minimizing errors and optimizing resource allocation.

Furthermore, it fosters a safer and more secure work environment by ensuring that only authorized personnel have access to specific areas. This not only safeguards sensitive information but also mitigates potential security threats. The ability to monitor the location and status of personnel in emergency situations adds an additional layer of safety, allowing for prompt and targeted responses.

Despite the numerous advantages, it is crucial for organizations to address potential concerns related to privacy and data security. Implementing robust privacy policies, securing data transmission, and providing clear communication to employees about the use of this technology will be essential in building trust and maintaining a positive organizational culture.

As technology continues to evolve, IPS systems for personnel tracking will likely witness further enhancements, making them even more integral to organizational operations. The journey towards a more connected and efficient workplace through IPS technology underscores the importance of embracing innovation to stay ahead in the ever-changing landscape of modern business.

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