A Wearable Real-Time Location System (RTLS) Device for Emergency Response and Personal Protection

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Abstract - **Some Universities in developing countries often face challenges in ensuring safety and security on their campuses due to the evolving nature of threats and the need for quick, effective responses. In these settings, traditional security measures often fall short in providing real-time insights into the location of individuals during emergencies or suspicious incidents. This is due to the uncharted nature of some campuses and outright lack of infrastructure. To address this gap, this paper proposes the implementation of a Real-Time Location System (RTLS) tailored specifically for university environments. The RTLS utilizes a combination of technologies such as GPS and Wi-Fi, to accurately track the real-time location of students and across the campus. By integrating these technologies into a unified platform, the system provides continuous monitoring and instant alerts to security personnel in the event of emergencies, enabling them to respond promptly and effectively.**

Keywords: Wearable Real-Time Location System, RTLS, Emergency Response, Personal Protection.

I. Introduction

Educational institutions have long faced security challenges, ranging from unauthorized access to more serious concerns including violence and criminal activity. Traditional security solutions, while necessary, can prove insufficient in providing a proactive response to the dynamic nature of these problems [1]. Campuses are often big and have a lot of pedestrian traffic even at night. These conditions could encourage crime and dangerous activities by some individuals making students feel unsafe. Recognizing the limitations of current techniques, this study proposes integrating a Real-Time Location System (RTLS) as a revolutionary measure to improve security procedures on educational campuses.

Real-Time Location Systems (RTLS) are advanced technologies that track and monitor the real-time location of objects, assets, or people inside a given area. RTLS uses a range of technologies, including radio frequency identification (RFID), global positioning system (GPS), Wi-Fi, Bluetooth, and Ultra-Wideband (UWB), to correctly locate and report the exact location of tracked things. These systems have numerous uses in areas such as healthcare, manufacturing, logistics, retail, transportation, and safety. In healthcare settings, RTLS is used for asset management, patient tracking, staff workflow efficiency, and infection prevention. RTLS enables hospitals to improve patient care, reduce equipment downtime, and boost employee productivity [2]. In manufacturing and logistics, RTLS allows for real-time tracking of inventory, resources, and vehicles in warehouses, distribution centers, and production facilities. By giving visibility into the movement of goods and assets, RTLS improves inventory management, lowers stock outs, and streamlines order fulfillment [3]. Overall, RTLS technologies enable enterprises to monitor and manage assets, workers, individuals, and processes in real time, resulting in greater efficiency, productivity, and safety across multiple industries. As technology advances, RTLS is projected to play a critical role in transforming asset monitoring, supply chain management, and operational efficiency.

II. Related Works

RTLS have been used for the purposes of safety and tracking of personnel and items in different scenarios. The researchers in [4] address the implementation of a Real-Time Location System (RTLS) to improve safety and operational efficiency within warehouse environments. The study underscores the critical role of RTLS in mitigating safety risks, optimizing workflows, and enhancing overall warehouse performance. [5] Delves into the implementation of a Real-Time Location System (RTLS) in hospital Emergency Departments (EDs) to enhance operational efficiency and alleviate challenges associated with locating medical equipment.

There are different technologies employed in implementing an RTLS, all with their peculiar advantages and disadvantages. An interesting one is the Ultra-Wide Band. It is used to provide sufficient localization accuracy [6]. It is easily chosen because of its scalability and easy synchronization. However, UWB technology still encounters difficulties in consistently producing stable results. For this reason, the system's capabilities are further bolstered through the integration of sensor fusion to achieve more efficient real-time localization of multiple targets and often optical technologies

can also be used with RTLS [7]. It has also seen great usage along with Radio Frequency Identification (RFID) in contactless tracking which has reasonable coverage and as such employed in big firms and companies [8]. Despite its relative high cost in implementation, RFID is a go to in providing enhanced safety and security measures.

Another well-known technology is Bluetooth [9] which has great versatility indoors as minimal range is always a bottleneck in using this technology to implement RTLS. Present research investigates how the IoT (Internet of Things) location system based on Bluetooth can be implemented for this solution. The location based on Bluetooth is hard to predict. Radio wave interference in this frequency is affected by other devices, steel, vessels containing water, and more. However, proper data processing and signal stabilization can increase the accuracy of the location.

This review will not be complete without talking about the Global Positioning System (GPS). Its integration is considered the simplest as it can be implemented with just the retrieval and display of geographical coordinates (latitude, longitude) [10]. However, a major drawback is the numerous third-party services usually involved in retrieving and displaying the information on a software map. It is often used with a GSM module as one of the easiest ways of getting access to maps display. Due to this, technical skills in electronics and/or software programming is most times required.

III. System Design and Implementation

The following are the major components of this system:

- Arduino Uno
- Esp 8266
- GPS module
- LM317T
- Blynk Cloud System

The Arduino Uno [11] is a popular microcontroller board that serves as a foundation for many electronics projects, particularly in the realm of hobbyist and educational programming. It's based on the ATmega328P microcontroller and comes with a set of digital and analog input/output pins, which can be programmed to interact with various components such as sensors, motors, LEDs, and more.

The ESP8266 [12] is a highly popular and versatile Wi-Fi module that has gained widespread adoption in the world of IoT (Internet of Things) and DIY electronics projects. Initially released by Espressif Systems in 2014, the ESP8266 quickly became a favourite among hobbyists, makers, and

professionals due to its low cost, small form factor, and powerful capabilities.

A GPS (Global Positioning System) module is a device that receives signals from satellites orbiting the Earth to determine its own geographic position accurately. It is able to calculate its exact latitude, longitude, and altitude coordinates by triangulating signals from multiple satellites.

The LM317T is a versatile voltage regulator integrated circuit (IC) manufactured by Texas Instruments [13]. Finally, the Blynk system [14]is a low-code IoT which can be used to prototype, deploy and remotely manage remotely connected devices from small to large scale.
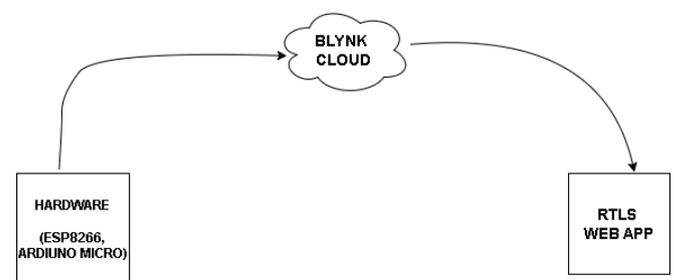
A block diagram of the system is shown in Figure 1.

Figure 1: System Block Diagram

The Arduino microcontroller and ESP8266 module are commonly used in conjunction to implement Real-Time Location Systems (RTLS) due to their versatility, low cost, and ease of integration with sensors and communication modules. The Arduino microcontroller serves as the brains of the system, managing data processing, sensor interfacing, and overall control logic. Meanwhile, the ESP8266 module provides Wi-Fi connectivity, enabling the RTLS to transmit location data to external services such as the Blynk cloud platform.

To implement an RTLS using Arduino and ESP8266, you would typically connect a GPS module to the Arduino to obtain latitude and longitude values. These values are then transmitted to the Blynk cloud platform via the ESP8266 module over Wi-Fi.

Prototyping was done using a breadboard before final implementation with the Veroboard. The ESP8266 having 8 pins (VCC, GND, EN, RST, GP100, GP101, TX, RX). The TX of the Arduino was connected to the RX of ESP8266, and the RX of the Arduino was connected to the TX of the ESP8266. It is important to note that in our case, digital pins 4 and 5 of the Arduino was used to as TX and RX respectively.

For the GPS module, the TX and RX were connected to digital pins 2 and 3 of the Arduino Uno serving as RX and TX

respectively. The VCC of the GPS module was connected to a 4V charging board and all components (Arduino, GPS module, ESP8266) were all grounded commonly on the breadboard.

IV. WEB App Implementation

Implementing a Real-Time Location System (RTLS) web app using Next.js[15], TypeScript[16], and React.js [17]offers a powerful combination of performance, scalability, and developer productivity.

The following steps are taken to implement RTLS web app using these technologies:

- Initialize a new Next.js project with TypeScript support using the Next.js CLI.
- Install necessary dependencies, such as axios for making HTTP requests to the cloud server and a mapping library like React Leaflet or Google Maps React for displaying the map component.
- Write a function to fetch longitude and latitude data from the cloud server using the fetch API or axios.
- Handle asynchronous data fetching using React's use Effect hook and manage state using use State hook.
- Create a map component using React.js and integrate it into your Next.js app.
- Pass the longitude and latitude data fetched from the server as props to the map component.
- Use the mapping library's API to render a map with markers representing the real-time location data.
- Apply styles and CSS to improve the visual appearance and usability of the web app.
- Implement user interface enhancements such as zoom controls, map layers, and tooltips to enhance the user experience.
- Test the web app locally to ensure functionality and responsiveness across different devices and screen sizes.
- Deploy the Next.js app to a hosting platform such as Vercel or Netlify for production use.

By leveraging Next.js, TypeScript, and React.js, a robust and scalable RTLS web app that efficiently fetches and displays real-time location data from a cloud server can be created. This approach combines the benefits of server-side rendering, type safety, and component-based architecture to deliver a seamless and user-friendly experience for tracking and visualizing location data in real time.

V. System Test and Results

The initial test was conducted at the Faculty of Education, University of Nigeria, Nsukka. Upon activation,

there was a noticeable delay (30 seconds) in establishing connectivity between the ESP8266 module and the Blynk cloud, attributed to the poor internet connection. However, one connection was successfully established and access to the Blynk application achieved, the device's status transitioned in real-time from offline to online almost instantaneously (less than 5 seconds). The latitude of 6.860215827255177 and longitude of 7.407921994731345 were promptly displayed. Utilizing the customized web application, the real-time location was accurately depicted. A screenshot of the system is shown in figure 2.

Upon activation, the location coordinates were sent immediately from the module to the monitoring system with little time lag. The location was also updated in real time as the user moved around. This was tested in various locations with same results except in locations with poor network coverage which introduces some delay but this was not enough to affect the system functionality.
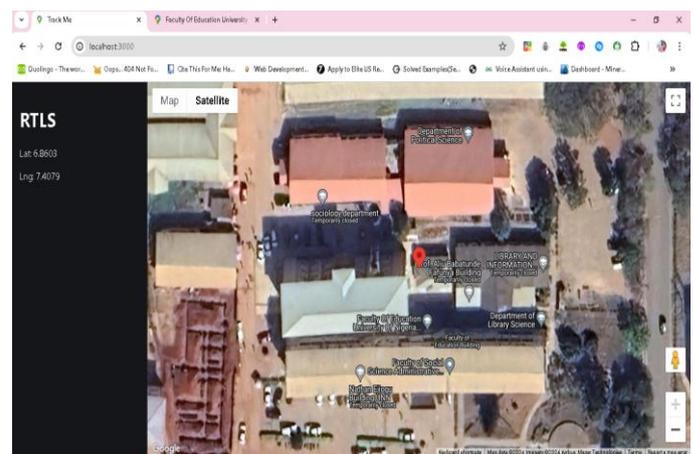

Figure 2: System Overview

The analysis of the Real-Time Location Tracker System revealed several key findings regarding its functionality, performance, and usability. One notable strength of the system lies in its ability to provide continuous and reliable tracking of students' locations, enhancing campus security and safety measures. The utilization of ESP8266 and Blynk IoT ensured seamless connectivity and data exchange, facilitating real-time monitoring and management of student movements.

However, despite its effectiveness, the system also exhibited certain limitations and areas for improvement. One such limitation is the dependency on Wi-Fi connectivity for the ESP8266 module, which may pose challenges in areas with limited or unstable internet access. Additionally, while the accuracy of location tracking was generally satisfactory, occasional discrepancies or inaccuracies were observed, particularly in indoor environments or areas with obstructed GPS signals.

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VI. Conclusion

In conclusion, the Real-Time Location Tracker System represents a promising solution for enhancing security and monitoring capabilities on campus. By leveraging ESP8266, GPS module, Blynk IoT, and web application integration with Google Maps, the system enables efficient and reliable tracking of students' locations in real-time. While the system has shown considerable effectiveness and functionality, further refinement and optimization may be required to address existing limitations and enhance overall performance.

REFERENCES

[1] E. Uduak, E. Aniefiok, and N. Nse, "Security Challenges in Universities: Implications for Safe School Environment," *Journal of Educational and Social Research*, vol. 10, no. 6, p. 112, Nov. 2020, doi: 10.36941/jesr-2020-0113.

[2] R. Bazo*et al.*, "A Survey About Real-Time Location Systems in Healthcare Environments," *J Med Syst*, vol. 45, no. 3, p. 35, 2021, doi: 10.1007/s10916-021-01710-1.

[3] A. Al-Fuqaha, M. Guizani, M. Mohammadi, M. Aledhari, and M. Ayyash, "Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications," *IEEE Communications Surveys & Tutorials*, vol. 17, no. 4, pp. 2347–2376, 2015, doi: 10.1109/COMST.2015.2444095.

[4] F. Halawa, H. Dauod, I. G. Lee, Y. Li, S. W. Yoon, and S. H. Chung, "Introduction of a real time location system to enhance the warehouse safety and operational efficiency," *Int J Prod Econ*, vol. 224, p. 107541, 2020, doi: https://doi.org/10.1016/j.ijpe.2019.107541.

[5] S. LoGalbo, S. Trojanowski, A. Slusser, L. Iyeke, L. Jordan, and M. Richman, "Speedy and satisfying: Real-time Location System increases Emergency Department efficiency and decreases frustration with finding medical equipment," *medRxiv*, p. 2023.11.20.23298180, Jan. 2023, doi: 10.1101/2023.11.20.23298180.

[6] B. Wijaya, N. Deng, K. Jiang, R. Yan, and D. Yang, "Real-time Adaptive UWB Positioning System Enhanced by Sensor Fusion for Multiple Targets Detection," in *2019 IEEE Intelligent Vehicles Symposium (IV)*, 2019, pp. 1239–1246. doi: 10.1109/IVS.2019.8814038.

[7] P. Sullivan, P. GhafoorpoorYazdi, and S. Thiede, "Real Time Locating Systems (RTLS) – An Enabling Technology to Support Engineering Education within Learning Factories," *SSRN Electronic Journal*, Jan. 2023, doi: 10.2139/ssrn.4470408.

[8] A. Ulku, "The Next Generation In Personnel\/People Tracking: Active RFID Technology Has Allowed for Enhanced Security and Safety," *IEEE Consumer Electronics Magazine*, vol. 6, no. 4, pp. 122–124, 2017, doi: 10.1109/MCE.2017.2714418.

[9] G. Tang *et al.*, "Development of a real-time indoor location system using bluetooth low energy technology and deep learning to facilitate clinical applications," *Med Phys*, vol. 47, no. 8, pp. 3277–3285, Aug. 2020, doi: https://doi.org/10.1002/mp.14198.

[10] M. M. Rahman, J. R. Mou, K. Tara, and M. I. Sarkar, "Real time Google map and Arduino based vehicle tracking system," in *2016 2nd International Conference on Electrical, Computer & Telecommunication Engineering (ICECTE)*, 2016, pp. 1–4. doi: 10.1109/ICECTE.2016.7879577.

[11] "Arduino Uno Rev3 — Arduino Official Store." Accessed: May 21, 2022. [Online]. Available: https://store.arduino.cc/products/arduino-uno-rev3?srsltid=AfmBOopal904kTeLQninuh0oy6uVVuQPgMhgKXc9INPR836NeVOQ1fR-

[12] "ESP8266 Wi-Fi SoC | Espressif Systems." Accessed: May 21, 2022. [Online]. Available: https://www.espressif.com/en/products/socs/esp8266

[13] "LM317-N | Buy TI Parts | TI.com." Accessed: May 26, 2022. [Online]. Available: https://www.ti.com/product/LM317-N/part-details/LM317T/NOPB

[14] "Blynk: a low-code IoT software platform for businesses and developers." Accessed: May 28, 2022. [Online]. Available: https://blynk.io/

[15] "Next.js by Vercel - The React Framework." Accessed: May 28, 2022. [Online]. Available: https://nextjs.org/

[16] "TypeScript: JavaScript With Syntax For Types." Accessed: May 28, 2022. [Online]. Available: https://www.typescriptlang.org/

[17] "React." Accessed: May 29, 2022. [Online]. Available: https://react.dev/

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