Indoor Positioning System using Esp32 IOT, Bluetooth Low Energy and Nano-Framework

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Abstract. A navigation system is a computing system that aids in navigation and is considered as an important functionality these days. A **navigation system** is a device that has the capability of knowing your current position, and allows you to determine your destination. Intra campus navigation system is an IOT application that fabricates a customized navigation scheme and technology for navigation inside campuses. As a new comer or outsider, it is difficult to get to a desired location, classroom, labs, offices inside a huge campus. However, intra campus navigation overcomes this short coming as it provides a system consisting of a BLE device and GPS. Here, the proposed work demonstrates the implementation of ESP 32 on trending Nano frame work technology. The application will also provide shortest route from any source to destination inside the campus. Hence, we conclude that such intra –campus application will be highly useful and can be tweaked to transform into a whole new other system as well.

1 Introduction

Nowadays, navigation has been an essential part of our life as it helps us to travel, navigate or identify directions to get to our desired location, without facing any difficulty and being lost. This papers motive is to provide an efficient and sustainable IOT application which would cater the needs of newly admitted individuals into the campus. Maps have been used for centuries to transit users from one place to another. In the last decade, navigation devices have used digital maps to locate the position of the user and assist in providing navigational directions. It is very difficult to search for a particular location inside the campus such as labs, administrative offices, classrooms for various department. The problem to this solution was a miracle of engineering. when our team dissected into the problem, we tried to design a solution which was customizable, convenient and cost efficient. After sufficient research and analysis, we designed a product with trending nano framework technology and used IoT systems to create a petite yet accurate ecosystem of devices to help people navigate through huge campuses, institutes, etc. and also providing an upper hand with its subsidiary functionalities such and security and tracking..

The ESP32 IoT platform is a potent microcontroller that supports WiFi and Bluetooth as well as other protocols and offers dependable wireless connectivity. The IPS can communicate location information effectively thanks to the integration of Bluetooth Low Energy technology, enabling the tracking of people and assets in real time. An open-source software platform called the Nano-Framework offers effective resource management, which speeds up the development and deployment of applications.

The IPS can precisely locate people and assets inside utilising ESP32 IoT, Bluetooth Low Energy, and Nano-Framework. With the help of this system, organisations can track their assets and streamline their operations thanks to real-time location data. In order to offer complete security measures, the IPS can also be connected with other systems, such as security systems.

The IPS is a low-cost option for indoor location and tracking that uses ESP32 IoT, Bluetooth Low Energy, and Nano-Framework. Businesses may take advantage of their existing infrastructure thanks to this system's scalability and ease of integration with other systems. Additionally, this system needs very little hardware, which makes it the perfect choice for small businesses.

In conclusion, the IPS system that combines Bluetooth Low Energy, ESP32 IoT, and Nano-Framework is a strong and effective tool that provides location data with great accuracy. Numerous applications, such as asset tracking, indoor navigation, and location-based services, are ideal for this system. The system has dependable wireless connectivity, effective data transfer, and resource management thanks to the ESP32 IoT platform, Bluetooth Low Energy, and Nano-Framework. The IPS is a perfect option for organisations of all sizes because it is also affordable, adaptable, and simple to integrate with existing systems.

1.1 Project Contribution

1.1.1 The creation of a robust and approach for indoor positioning system using the latest nano-framework and IoT.

1.1.2 We provided a small and updated system to fill in the gaps of indoor navigation tracking and many more functions which were not available using the existing applications like Global Positioning system.

1.1.3 In this project we provide a hybrid system which is multifunctional and can be used for navigation as well as tracking.

1.1.4 Many more features such as security, identification, information storing and timestamps are provided to give a multifunctional application to the client.

2 Literature Survey for Problem Identification and Specification

2.1 IEEE Xplore:25 June 2018, A novel campus navigation App with augmented reality and deep learning [1]

Augmented reality has been widely used in many applications because it offers an amazing way to overlay computer-generated images over the user's real-world view, creating a composite view rooted in real and virtual worlds. Augmented Reality is a realistic, direct or indirect view of the physical reality environment whose elements are “enhanced” through computer-generated or sensory input such as sound, video, graphics, tactile, or GPS data. In this paper, we present a novel campus navigation APP that uses augmented reality to provide users with a new and interesting way to meet our campus. With advanced augmented reality technologies such as computer vision and object recognition, the information about the campus environment and its objects is overlaid in the real world and becomes interactive. In order to improve the APP efficiency, this paper presents a virtual terrain modeling interface with deep learning to improve the object recognition ability.

Due to the emergence of powerful mobile devices and bandwidth-improved broadband wireless networks, multimedia mobile applications (such as streaming or check-in places anywhere) can be executed anywhere. Among multimedia mobile applications, augmented reality (AR) attracts a lot of attention because it offers an amazing way to overlay computer-generated images over the user’s real-world view, creating a composite view rooted in real and virtual worlds. AR provides a realistic, direct, or indirect view of the physical reality environment whose elements are ”enhanced” through computer-generated or sensory input such as sound, video, graphics, tactile, or GPS data. Since augmented reality technology allows people to interact with the world around them, AR has become another new aspect embedded in modern life. In this paper, we propose a campus tour APP with AR technology. The campus tour APP allows users to learn about the campus by quickly taking photographs of campus attractions. In order to identify a large number of tourist attractions on campus, the proposed APP combines positioning techniques to reduce search delays. In addition, we adopt machine learning to improve image recognition.

2.2 IEEE Xplore: 20 April 2015, an event driven university campus navigation system on android platform [2]

A university campus may be very large or it may have many campuses. Every year lots of new students get admitted in the university. Many new buildings are built, new courses are started and some departments may be relocated inside the campus. There are no facilities to find places like administrative building, departments, library, canteen, etc. in the campus and how to find those places from current location. It creates problem to the new comer to reach easily and timely in the desired location. The new faculty member, staff and visitors also face same problem inside campuses. Moreover, there does not exist an efficient system to inform about any event which will happen just few minutes or few hours later in the university campus with its proper location and shortest path from current location. Nowadays, most of the students, faculty members and staff use android phone for personal purpose. A Global Positioning System (GPS) based map application will be most helpful to locate desired place and shortest path from current location and to get updates of events on map with its location. Thus, it will reduce frustration and confusion of anybody inside the campus. This paper presents the architecture and design of a Google Map based application on Android Platform. The application has been implemented using Android SDK and has been tested for two campuses of Jadavpur University (Main campus and Salt Lake campus).

2.3 IEEE Xplore: 14 January 2015, An improved algorithm applicable for Campus Navigation System [3]

With an increasing number of College Admissions activities, education and scientific researches organized by universities, it is of prominent importance for newcomers to get help from campus navigation. And smart phones being more popular, it is possible to solve the above problem. During the process of setting up one kind of campus navigation system, the thesis improved the basic A algorithm: using bidirectional search in the basic implementation of an algorithm and adding a path cache function and an anticipation mechanism. Path cache made full use of the paths which had been calculated by an algorithm to decrease the delay of figuring out the path.

This paper mainly focuses on the development of accurate navigation in the campus with a small scale and the study of network navigation research to facilitate the broad masses of teachers and students to quickly target location and generate a few suggestion paths to choose. We use the recognized A* algorithm as the based algorithm to route in 2015 International Conference on Network and Information Systems for Computers map navigation. In response to the situation in which a large number of students use the campus navigation terminals online at the same time, leading to a comparatively heavy load on the server, this paper tries to use a multi-layer network to adapt to different precision of

path search and matches caching mechanism and path anticipation mechanism to speed up in path solving when there are a large number of client requests. In addition, we use some optimization techniques to further improve the response speed of the program so as to make the improved A* algorithm have a larger throughput.

2.4 IEEE Xplore: 17 December 2021, Wi-Fi Based Indoor Navigation System for Campus Directions [4]

Car navigation systems have made place everywhere around the globe. Outdoor navigation systems can be widely located in almost every geographical location that has access to the internet. However, indoor navigation system is very important for the pedestrians to find out their ways in complicated indoor areas such as shopping malls, subways, universities, exhibitions, underground areas, and tunnels etc. The recent rapid expansion of Wi-Fi zones and the increase of Wi-Fi equipped smartphones have enabled transformation of this idea to the reality. This work presents university indoor navigation system designed to help students, staff, and visitors to find their desired location. The work shows promising results when using distance measuring algorithm, the Trilateration, and the ITU-R P.1238 model together using the Network Simulator 2 "NS2" for the indoor navigation

Indoor navigation is becoming increasingly popular as location-based services are necessary in numerous dimensions of living style. The applications of indoor navigation include e-commerce, vehicle tracking, discovering the nearest shops, medical clinics or food options Moreover, the modern living styles have restricted outdoor life to an extent that according to the recent researches, around 70% of people spend their time indoors. Thus, it is imperative that the demand for indoor navigation has risen to a great extent . Indoor navigation systems have gained plenty of attention in this context Wireless Fidelity (Wi-Fi) positioning is seen as one of most viable support to provide indoor navigation. The reasons that make Wi-Fi one of the most suitable candidates is that it is a cost-effective solution and is used by millions of consumers. Moreover, indoor navigation with Wi-Fi access points does not require extra deployments as that are already installed in the infrastructures of indoor environments including office buildings, universities, buildings, hospitals, and shopping centers . This paper presents a Wi-Fi based indoor navigation system for university campus which is designed using simulation on Network Simulator 2 "NS2". The prototype developed and mapped to the academic block 23 of Universiti Teknologi PETRONAS (UTP). The UTP is growing rapidly and is expanding its area with rapid progress. It is difficult for the new ones to find their paths inside the UTP. Some of the factors that necessitate the design of the indoor navigation system for UTP include new students exploring the campus for the classes/instructor offices, construction of new blocks, visitors, new faculty and discovering the food options on campus. The proposed model will work with the help of a hybrid localization technique using proximity technique and the distance calculation using RSSI. This model will contribute in developing a hybrid technique that will help us determining the indoor location of the user moreaccurately depict the campus indoor WiFi infrastructure and campus map.

2.5 IEEE Xplore: 12 February 2008, GPS and UWB Integration for indoor positioning [5]

The Global Positioning System (GPS) is an accurate positioning system. However, in the presence of obstructions or under indoor environment, the low availability of the GPS makes positioning impossible at times. The UWB positioning system, dubbed as the natural way for multipath mitigation, could perform well for indoor positioning. However, as range measurements are never perfect, the accuracy of the UWB positioning also relies heavily on the geometry of the transmitters placed in the building. The proposed GPS-UWB positioning could provide better positioning accuracy under such circumstances as compared to the UWB system. In addition, the convergence on the position estimation is less sensitive to the initial guess of the user position.

2.6 IEEE Xplore: 29 November 2010, Indoor positioning using low cost GPS receivers: Tests and statistical analyses [6]

In recent years, GPS chipset technologies have been changed completely in order to allow for positioning under extreme conditions, such as in indoor environments. The necessity of always having a positioning capability is rising, but what accuracy level can be reached? Some specific tests have been carried out to estimate the limits for indoor positioning. It has also been evaluated whether this technique can be used for GIS applications. A low cost receiver tailored to indoor positioning, has been used in several tests in a test field, in both kinematic and static mode. The results show that the obtained performance in indoor positioning is encouraging, but still needs to be improved using additional sensors (i.e. INS, RF).

2.7 IEEE Xplore: 06 December 2018, Integration of UWB and IMU for precise and continuous indoor positioning [7]

The application of Ultra-Wide-Band (UWB) for indoor positioning is booming owing mainly to its much higher precision than other common sensors. However, its positioning precision, stability and particularly continuity are still largely restricted by non-line-of-sight (NLOS) errors caused by the complicated motion behavior and infrastructure in indoor environments. In this paper, we study the integration of low-cost inertial measurement unit (IMU) with UWB in order to provide reliable and continuous positioning solutions especially in the situation of NLOS and insufficient or unavailable UWB signals. The algorithms of integrated IMU and UWB positioning are investigated and the relevant demo platform is developed. The kinematic experiment is carried out. The results reveal that compared to UWB-only positioning, incorporating IMU with UWB can significantly improve the positioning continuity as well as the positioning accuracy to a certain extent.

2.8 IEEE Xplore: 06 December 2018, Design and Implementation of UWB/MIMU Tightly-coupled System for Indoor Positioning [8]

UWB (Ultra-wideband) technology is a very promising indoor positioning method because of the advantages of anti-multipath and high precision. For UWB positioning, at least three distance measurements between the base station and a mobile station are required. In practical applications, the signal loss of base stations often occurs due to occlusion and other factors, then resulting in the failure of positioning. To solve this problem, a tightly-coupled method which combines UWB range and measurements of MIMU (Micro Inertial Measurement Unit) is proposed in this paper. The integration positioning system can work continuously during the loss of UWB signals with advantages of INS (Inertial Navigation System) technology's autonomy and high precision in a short time. A tightly-coupled filter based on EKF (Extended Kalman Filter) is designed, and the integration system is implemented. The simulation based on Matlab and experiments in the indoor testing scene based on the Optitrack system are carried out respectively. The results show that the UWB/MIMU tightly-coupled system can solve the problem of positioning discontinuity caused by signal loss of UWB base stations, and the precision of dynamic positioning is better than 0.3 meters in complex indoor environments.

3 Proposed Methodology

3.1 In the presented paper, the use of Bluetooth low energy (transmitters), Esp32 devices and web applications is done widely to cater the needs of indoor positioning. In the proposed methodology, the Bluetooth low energy transmitter is integrated with the Esp.32 IoT to make the system which will contain the algorithms to identify and calculate the location of the user. Figure 1 shows the architecture of the system. In this system there are multiple levels of information transfer through which the final results will be provided. There is a centralized cloud which will be the connecting bridge between the user, Bluetooth low energy transmitters and the Esp.32 devices.

3.2 In relation to the presented *figure 1* the Bluetooth low energy BLE transmitters are the unit level of the system. Unique ID's will be registered and assigned to the user in the form of Bluetooth low energy transmitters. These ID's will contain a unique number will be the differentiator of every user, these ID's will be broadcasted by the transmitter which will be received by the Esp32 devices setup all over the campus. The System architecture of the project is as follows.

3.3 When a location request will be generated to the system, the request consisting the unique number will be pushed to the cloud. When the cloud gets the request, it sends the unique ID to all the IoT modules and commands the modules to return the location coordinates attested to them if the provided unique Bluetooth Low Energy ID is been currently broadcasted in their field of coverage.

3.4 When any module/modules receive the broadcasting of the Unique ID requested to them, they return back their location coordinates with timestamps to the cloud. The cloud has internal program which calculates the data and information provided to it by the IoT devices and calculates the location of the client requesting the location. When the calculations are completed a Graphical Map of the area is presented to the client with its location coordinates marked. Once this process is stimulated, the device auto re-fresh's the protocol and provides the user with their location on a map.

4 System Architecture Explanation:

Starting with the BLE, every BLE has its own unique id. The functionality of BLE is to transmit its ID without pairing it with other devices. The infrastructure where this project will be implemented will have ESP 32 IoT modules implanted into them at various locations strategically identified and mathematically calculated. All these ESP will be connected to the server via internet and LAN Cables.

As soon as any BLE transmitting its ID comes in the range of the ESP 32 module; the ESP 32 module will capture its ID. Once it has captured its ID it will attest the id with time stamp and location coordinates and push it to the server using internet.

Now when the server has the information (location and timestamp) of a specific BLE device it will register it into the database records at the cloud server.

The cloud server access will be modified and provided to people in the UI Format in the following way:

1. Admin: Admin gets the rights of adding, modifying, altering , deleting the details of ESP 32 devices implanted into the campus, the BLE devices, the users, the visitors and also the tracking of each and every BLE device active in the campus.

2. Supervisor: Supervisor has the rights to monitor and track all the BLE devices which are active in the campus. Supervisor has no rights to alter or add any details of any devices, ESP 32 or BLE.

3. Visitor: Visitor has the rights to only view the locations of themselves (their own BLE device). They have no rights to alter or add any other devices and BLE in the campus. They also don't have any rights to view other active BLE devices present into the campus.

Now as the data is present in the server any of the above can view the BLE location by entering their unique ID provided to them using the UI Panels. UI panels will convert the location coordinates into the maps and present it to the end user. This is how this system works and above presented is the system architecture of the project indoor positioning system.

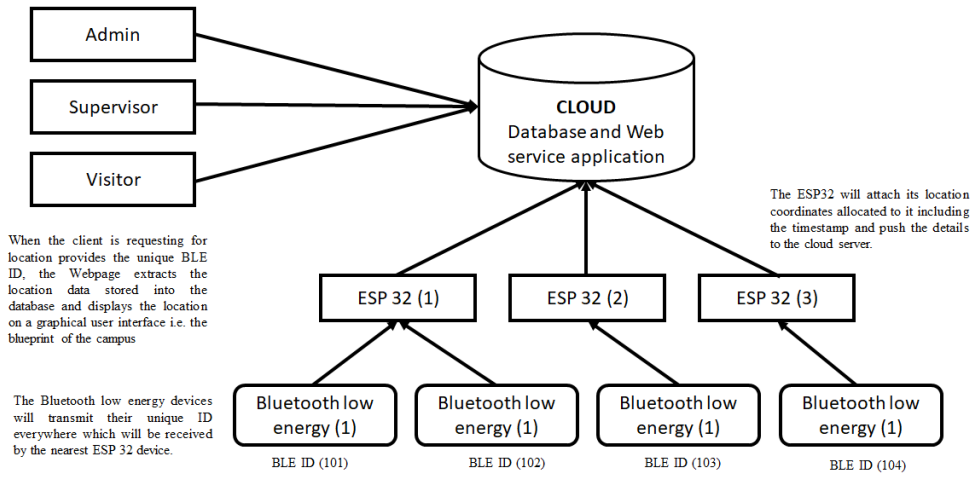
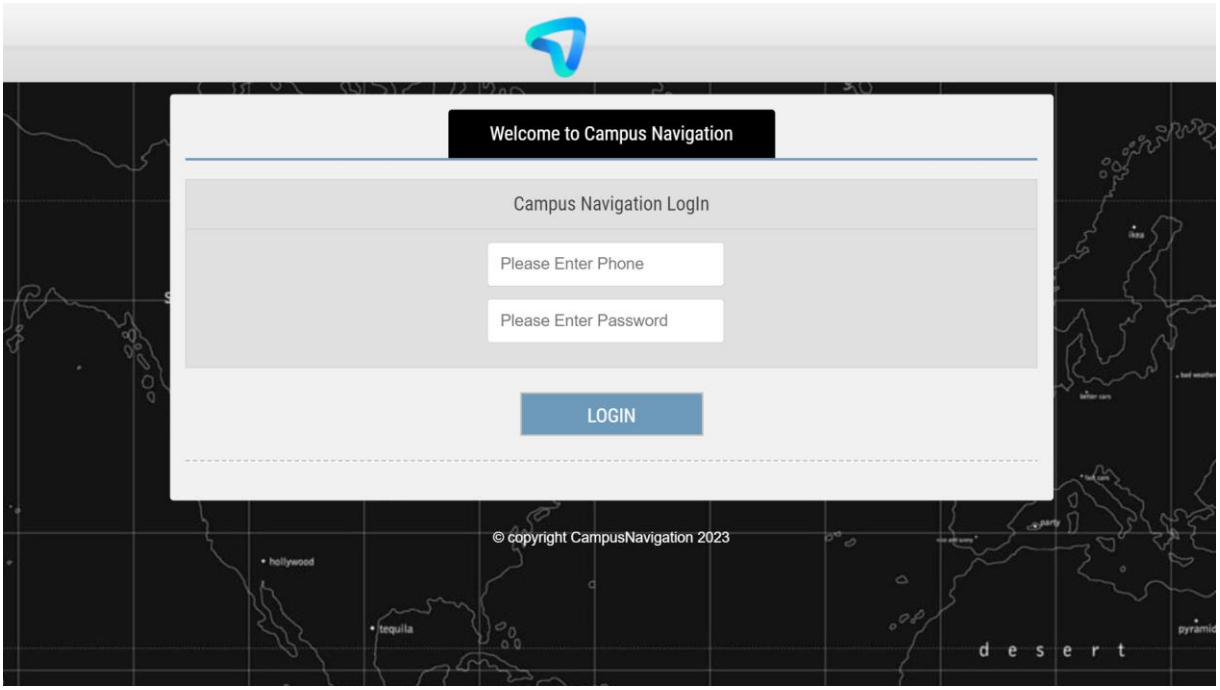


Figure 1. System Architecture Model

5 Result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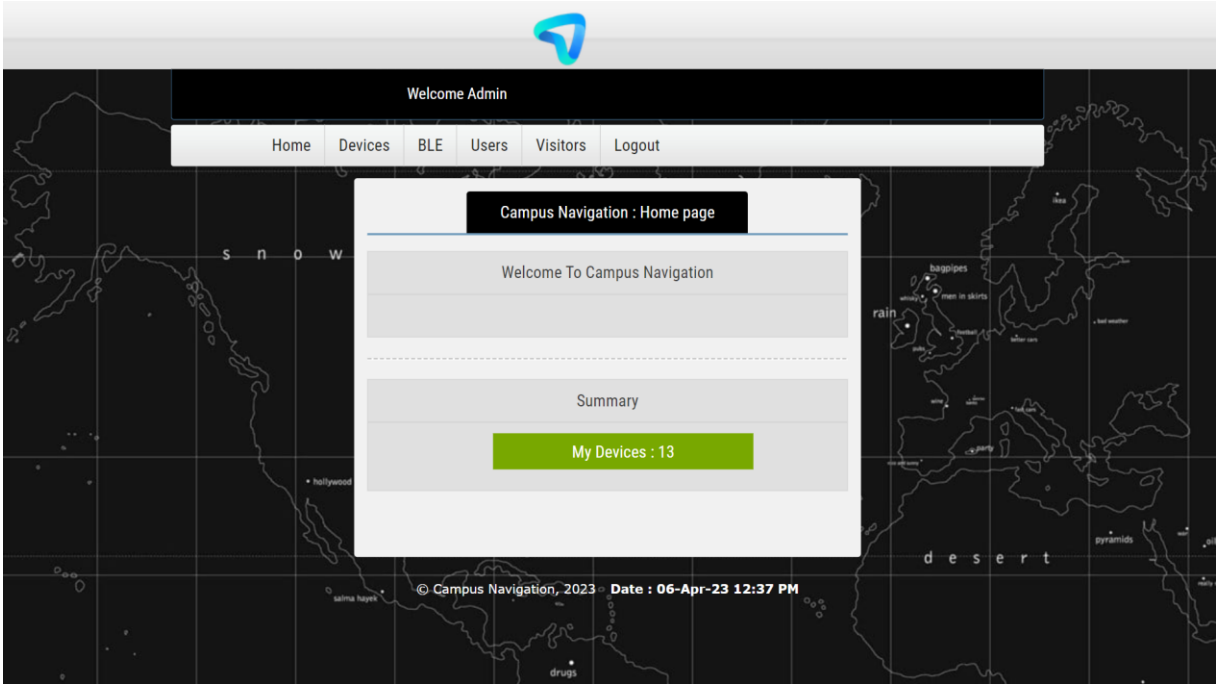
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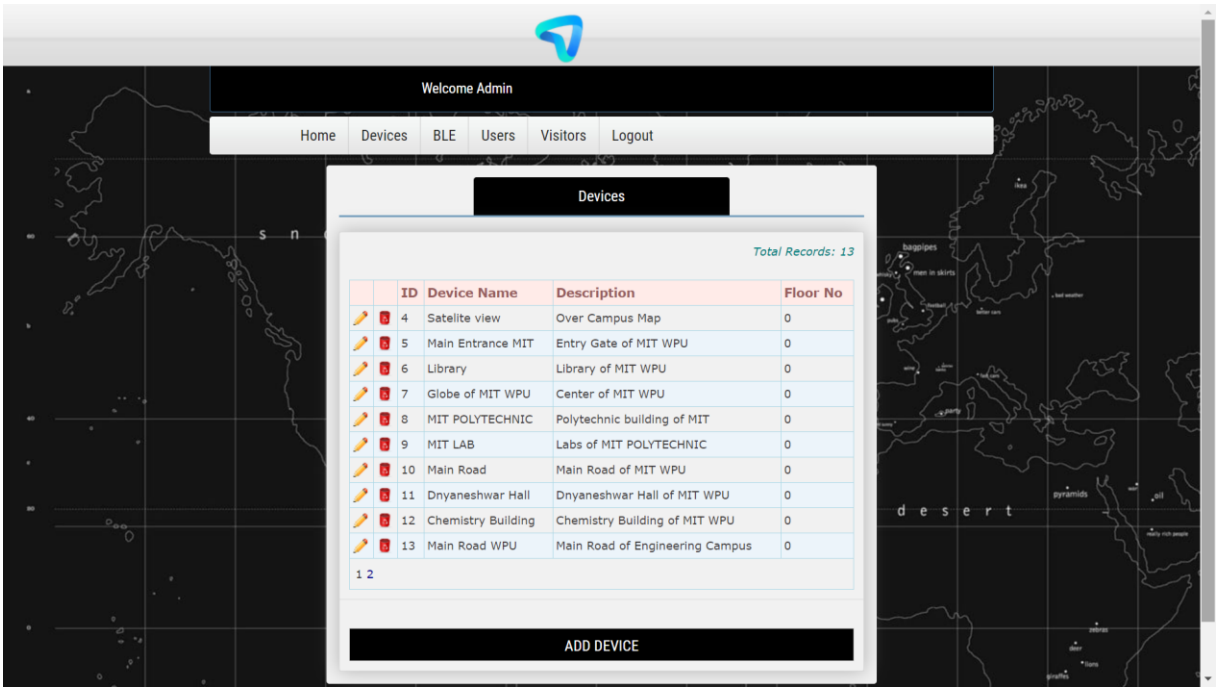
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8 MIT POLYTECHNIC Polytechnic building of MIT 0
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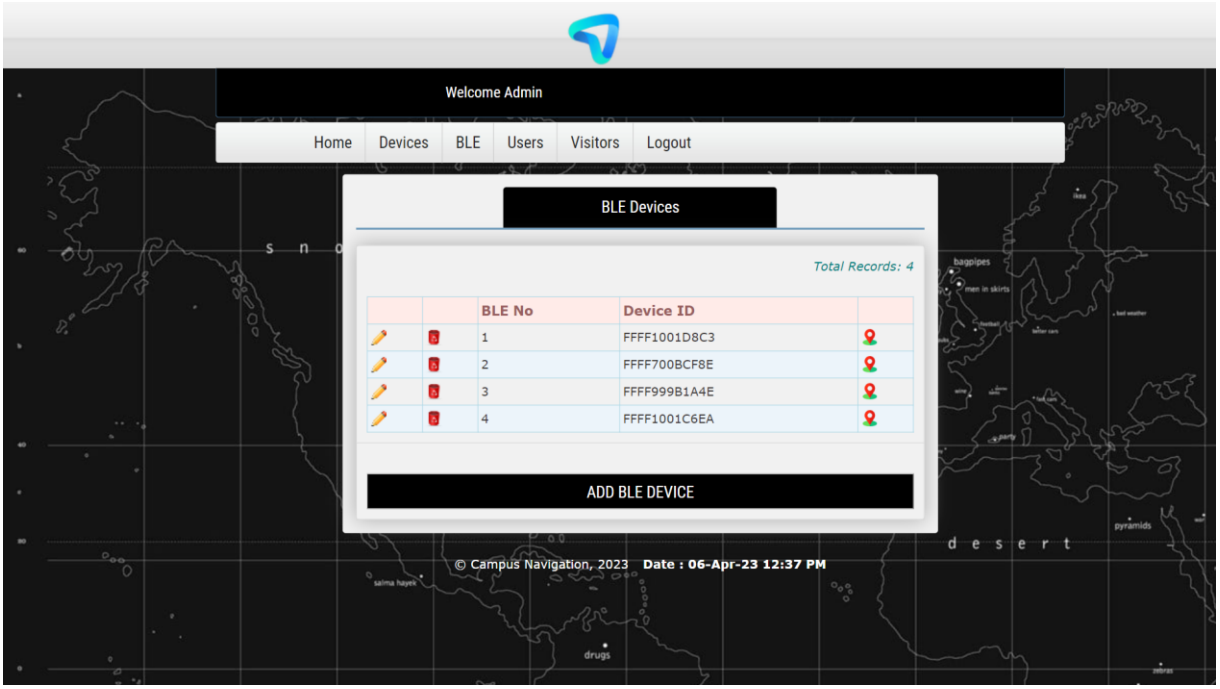
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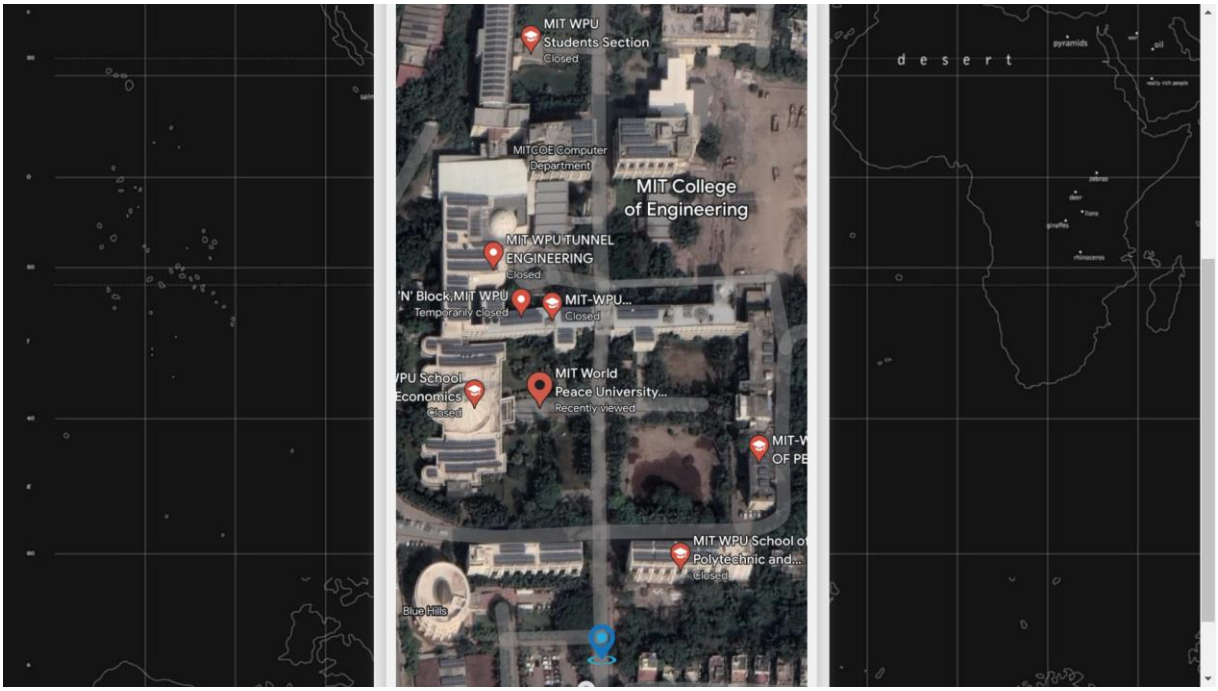
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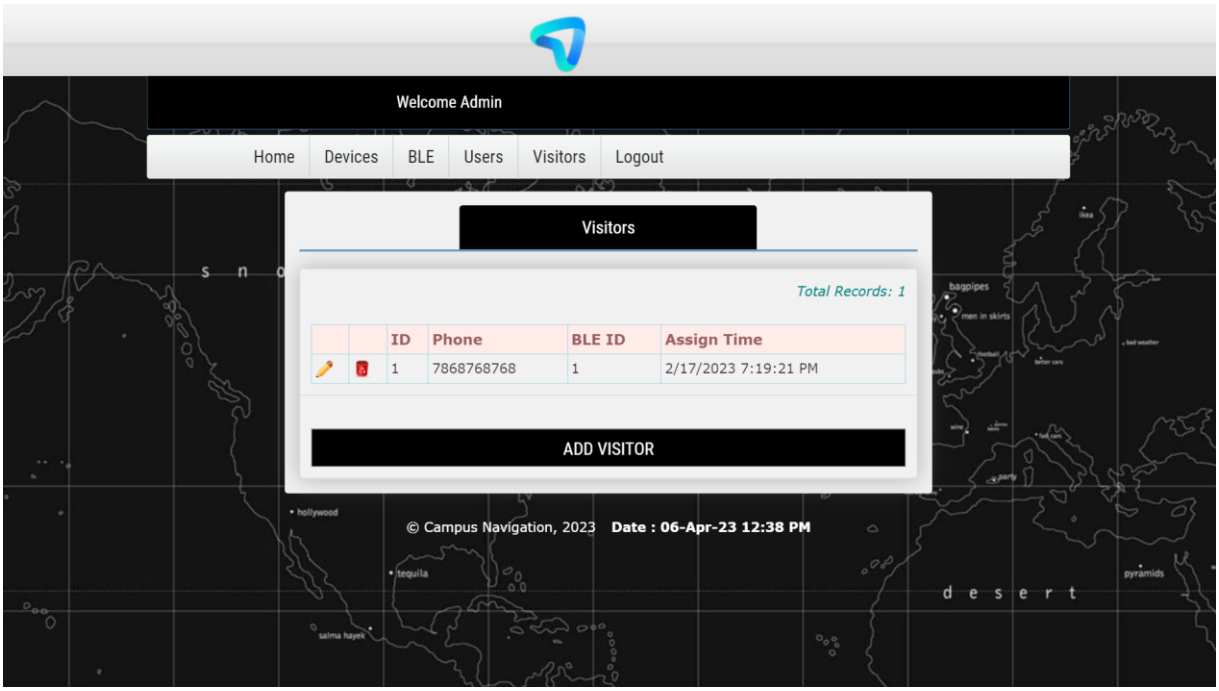
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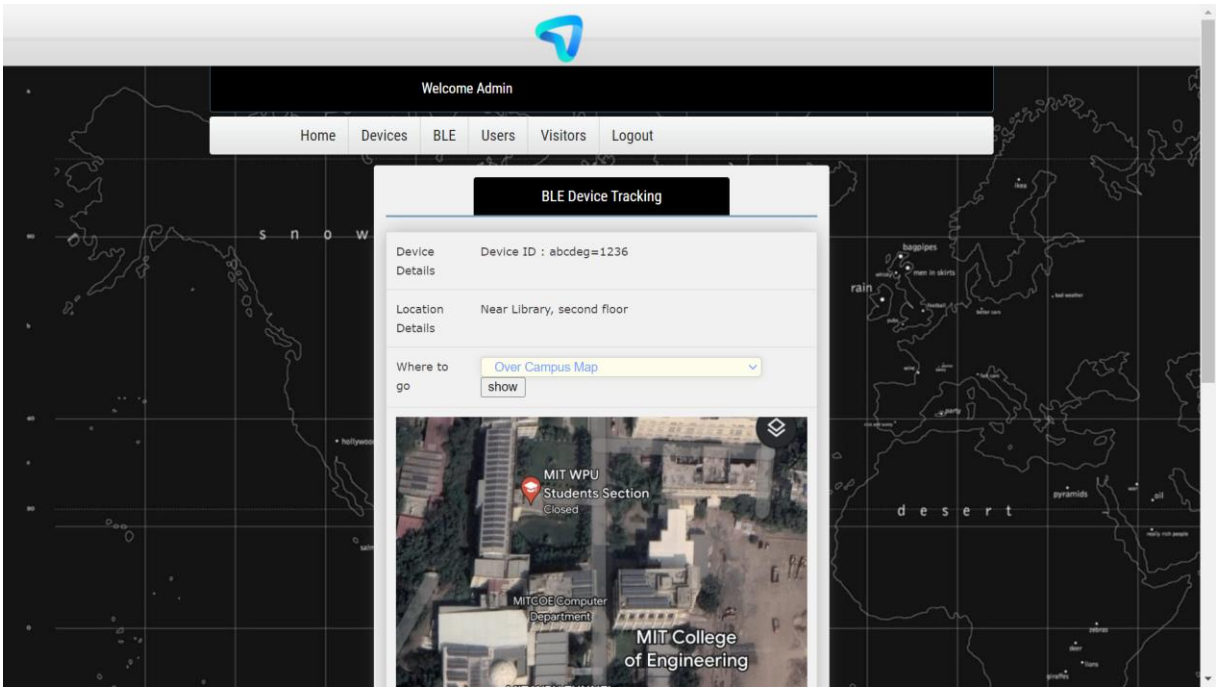

6 Conclusion

We have proposed indoor positioning system that uses Esp32 module, BLE Mod-ule and Nano-Framework to provide users with a new and fascinating way to meet our campus. The experiment results show that the indoor navigation system that not only navigates the larger patches of the premises, but also the interior of the building making the navigation more precise. In this way, it not only navigates individual to the desired location but also ensures the security of the premises making the system more precautionary

7 Future Scope:

The Future Scope of this project is strategically developed on the foundation of conducting every possible required research and data gathering.

The future scope of this project is developed on the "**FAAQT**" model which was further researched and mapped for the growth and enhancement of this project.

The FAAQT model states the "5 pillar development" of this project which is:

1. **Functionality:** Increasing the functionalities of this project is the first pillar in its future scope. Functionalities when mentioned, it refers to the integration of various tools which are customized or common for the campuses or customers using this product. These functionalities include Hybrid Attendance Systems, Stage 2 Security and surveillance, Enhanced Tracking and navigation, Data Passing, etc.

2. **Accuracy:** Precising the location coordinates for navigation and tracking is one of the major development points in the future. To achieve this, the project architecture would be remodified in the future using the trigonometric algorithms and "3 point data collection" methods so that the location achieved would be accurate and pin pointed.

3. **Affordability:** In the future focusing of affordability of the project would be a necessary and important task to do. The project costings would highly fluctuate its implementation graphs. The costing of the project would be depending on various factors like manufacturing, out sourcing, development, implementation, maintenance and hard/Software costs taking us to out next point of future scope.

4. **Quality:** The quality of the product is a point which cannot be hampered while focusing on cost reduction and also improving the current quality of the product in both means of hardware and software will be one of the most important factors while developing and modifying the product in the future.

5. **Technology:** As the times change, the surroundings including the use cases and the technology changes. For the sustainability of the product in the market the product has to constantly be developed and kept updated with the latest and the most reliable technologies in the market. Updating the technology would help in developing more features into the product, help making the product robust and also compete with the latest products and technologies in the similar sector.

The FAAQT model is the appropriate and adequate future development model for this product as it covers the essential points required for the sustainability and efficiency of this project into the market.

8 References

IEEE Xplore:25 June 2018, A novel campus navigation App with augmented reality and deep learning [1]

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