



Asset Tracking Using Low Power Bluetooth

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Abstract: Asset Tracking is important for data management in organizations. The high value assets of individual/organization may get stolen. Companies and individuals can take advantage of asset tracking to protect their investments. These devices can let them know how often an asset is being used, when it's being used, if it has left a predetermined area and help to locate it if it's stolen. The System comprised of software integrated with hardware for preventing internal pilfering of assets. The system consists of i). nRF52 Beacon ii). ESP12E WiFi Module/Node MCU iii) central server. nRF Beacon will send BLE data serially to the receiver equipped with ESP12E WiFi Module and Bluebee Board to establish WiFi Connection at the Receiver and thus connected to the Central Server. This system helps tracking and monitoring of assets in real time and personal/organizational database is updated by the information stored in the Central server.

Keywords: Asset Tracking, Bluetooth Low Energy, Bluebee Board

I. INTRODUCTION

Asset is a resource own by an individual/organization that has an economic value. Both companies and individuals can take advantage of asset tracking to protect their investments.. In RFID journal Ashton wrote that." If all objects in existence were equipped with identifiers and wireless property, these objects can be communicating with one another and be managed by computers". There are two types of assets:

- Tangible Assets
- Intangible Assets

Tangible assets are assets that have a physical form. This includes both fixed assets, such as machinery, buildings, land, and current assets, such as inventory whereas intangible assets are not physical in nature. If company is not investing money there is lose in time and money. The ultimate goal of asset tracking is to save time and money. Tracking company plus provides priceless info regarding asset usage (who is mistreatment what, where and when), maintenance and calibration schedules, and need for new equipment. Asset Tracking is a method of tracking physical assets either by scanning labels attached to assets or by using tags like GPS, BLE, Barcode, NFC or RFID which broadcasts tag location without manual tracking. Asset tracking mainly performs 3 functions:

- (i) Documenting asset attributes
- (ii) Location identification
- (iii) Tracking movement

In my system, Asset Tracking is done possible using Near Field communication (BLE Low Energy is used) to avoid distant transmission interferences.

II. LITERATURE SURVEY

According to research commissioned by Cisco, there will be 50 billion devices connected to the internet by 2020. The problem of asset localization and tracking is not new. A large number of research works faced it in different scenarios and under various constraints: Some of related approaches are given below.

A. On Device Mapping of WiFi Hotspots via Direct Connection of WiFi Enabled and GPS Enabled Mobile Devices

This paper [1] uses a WiFi enabled and GPS enabled user devices. It executes a hotspot location utility, which enables the device to detect WiFi hotspots and update a locally stored hotspot location database (LHLD) containing geographically mapped hotspots. When a hotspot is detected, the device accesses the hotspot, retrieves identification information and usage terms from the hotspot, and measures performance metrics of the hotspot. The utility stores the identified hotspot with the current GPS coordinate as an entry within the LHLD. When a user later desires to locate hotspots within a particular geographic location, the user enters the physical address of the location, and hotspots with matching (or proximate) GPS coordinates of the entered address are presented to the user. The user may specify



certain preferences for usage terms, performance metrics, and location criteria, and the utility filters all geographic hits and returns only hotspots in the geographic location that also satisfy these preferences.

B. Asset Tracking Architecture with Bluetooth Low Energy Tags and Adhoc Smartphone Applications

This paper [2] aimed at tracking assets within construction sites or similar contexts. The main components are: (i) RFID tags, (ii) Bluetooth Low Energy (BLE) Tags and (iii) Android smartphones. The core functions of the architecture are performed by two Android applications: the Asset Proximity Locator (APL) and the Wandering Objects Location Finder (WOLF). The key feature of the asset tracking function is the ability to maximize smartphone battery lifetime by switching on and off the GPS unit, thus guaranteeing that the smartphone can be used for an entire working shift. An asset tracking architecture has been presented that jointly exploits the traditional asset tracking techniques and the facilities offered by modern Android smartphones.

C. A Time of Arrival Based Location Algorithm Reducing the Errors due to Non-Line Of Sight Propagation

In the presence of NLOS propagation, a location algorithm is proposed to reduce the induced errors. In the proposed algorithm, mathematical programming is used to find the ML estimate of the source position in the restricted domain defined by the inequalities due to propagation. The proposed algorithm [3] has higher accuracy than the LOS algorithm because more restricted conditions are applied based on the results of the LOS algorithm. An effective location algorithm, which considers non line of sight (NLOS) propagation, is presented. By using a new variable to replace the square term, the problem becomes a mathematical programming problem, and then the NLOS propagation's effect can be evaluated. Compared with other methods, the proposed algorithm has high accuracy.

D. An Overview of Wireless Indoor Geolocation Techniques and Systems

Wireless indoor networks are finding their way into the home and office environments. Also, exploiting location information becomes very popular for both wireless service providers and consumers applications. However, the indoor radio channel causes challenges in extracting accurate location information in indoor environment so that traditional GPS and cellular location systems cannot work properly in indoor areas. This paper provides an overview of

the indoor geolocation techniques. After introducing an overall architecture for indoor geolocation systems, technical overview of two indoor geolocation systems are presented. To demonstrate the predicted performance of such systems some simulation results obtained from an indoor geo location demonstrator are presented.

E. Reducing Power Consumption by Offloading Applications

Methods of reducing power consumption in a computing device are described in which file sharing applications which are running in the background are offloaded onto a lower power subsystem and the rest of the computing device can be put into a low power state. The lower power subsystem runs application stubs which autonomously execute a subset of the operations performed by a file sharing application which was previously running on the computing device. Before the rest of the computing device goes into the low power state, application state information is passed to the lower power subsystem for use by the application stubs. In an example, the application stub may continue to download files whilst the rest of the computing device is in standby or is shutdown and the application state information may include details of the files that are to be downloaded.

III. METHODOLOGY

In this project, we use two assets (transmitters) and two receiver using Bluetooth Low Energy (BLE) and Node MCU. Asset 1 and Asset 2 will be configured as transmitters, transmitting beacons [unique ID]. The receiver is consist of a nRF52 board and Node MCU board. When asset 1 or asset 2 comes in the range of receiver, it will collect beacons [unique ID of assets]. Since there is no wifi module in the nRF52 module, it will send the collected unique ID to the Node MCU via serial protocol. The Node MCU receives data from nRF52 module serially and data send to the server by calling a php page. The central server will process & display information. If beacon 1 is detected by receiver 1, PC shows asset 1 is in range of receiver 1. If beacon 2 is detected by receiver 2, PC shows asset 2 is in range of receiver 2. If beacon 1 and 2 is detected, PC shows asset 1 and asset 2 is in range. If beacon 1 and 2 is not detected, PC shows no asset is in range. In the project two Node MCU units (at the receiver sections) and two Beacon/Bluetooth boards is used at the transmitter section which are the beacon/Bluetooth boards. Asset 1 and Asset 2 (Transmitter Beacons/Boards) will sent unique beacon ID's to the receivers (Node MCU's). Asset 1(Transmitter 1) has a unique beacon ID collected by



receiver 1 and Asset 2 (Transmitter 2) has a unique beacon ID collected by receiver 2. NODE MCU (ESP8266) is the microcontroller board unit used in the receiver section for establishing secure communication between each assets and also to identify each beacon ID's. The collected beacons are sent to the central server where assets can be tracked and monitored individually. The block diagram of the system can be seen in fig 1. The system mainly consists of:

- NRF Beacon
- Node MCU
- Central Server

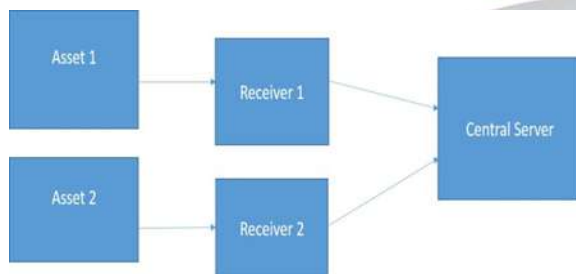


Fig 1: Block Diagram

A. Hardware Used

i) Node MCU

The Node MCU is an open source firmware and development kit that helps one to prototype IoT products. It has a firmware which runs on the ESP8266 WiFi SoC only one analog pin and hardware which is used is the ESP-12E module/Node MCU ADC and programmed with Arduino IDE. It is great for connecting cloud and Arduino is great at talking with different sensors. This project uses NodeMCU ADC with Arduino IDE Development kit. Fig. 2 shows the layout of NodeMCU Board.

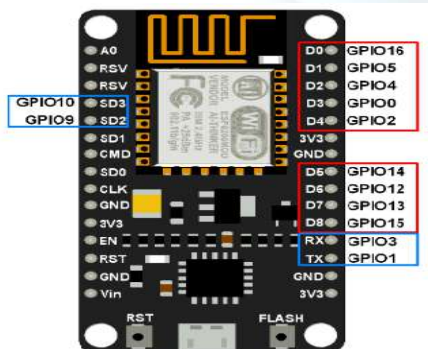


Fig 2:ESP12E NODE MCU

ii) NRF Beacon

Bluebee board is an nRF52 series evaluation board used for wireless communication (RF communication) with Bluetooth enabled devices (like smartphone). It communicates with microcontrollers using serial communication (USART). It is introduced as a part of Bluetooth 4.0 core specification.



Fig 3: Blue Bee Board

It has ultra-low peak, average and idle mode power consumption, low cost, ability to run for years on coin cell battery power, NFC tag interface for OOB(Out of band pairing), which is the additional feature of the board. Bluebee board can be used in a Master or Slave configuration, making it a great solution for wireless communication between asset devices. This Bluetooth module is simply used in our project for serial port replacement to establish connecting PC between Microcontroller and Central server. The module can be configured for baud rates 1200 to 115200 bps. It is mainly used as a serial port replacement to connect MCU and other devices like GPC or PC. The front view of bluebee board is given in fig. 3.

iii) STLink Mini V2 Programmer/Debugger

STLink Utility 2.0 programmer is used for flashing the program written in Keil/Arduino to the Boards. STM32 microcontrollers which uses ARM Cortex M architecture is now becoming popular and are used in many applications because of its feature, cost and performance. Programmed STM32F103C8 using the Keil IDE. The ST LINK V2 is an in circuit debugger and programmer for the STM8 and STM32 microcontroller families. The ST Link V2 and pinout is shown in fig. 4.

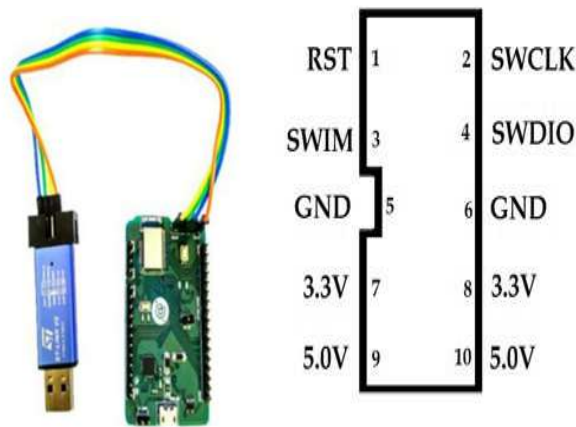


Fig 4: STLINK V2 and its pinout

iv) Central PC Server

In my project Central Server is a Laptop with Windows 10(x64 bit Processor) where we can track asset's status in the XAMPP Live Server. IA-32 (Windows package only) and x64 (macOS and Linux packages only) are used for cross-platform server.

IV. IMPLEMENTATION & RESULTS

A) Hardware Implementation

There are 2 sections in the project: In this section, how beacon id is received to the USART Bluebee beacon and data is made available to the NRF beacon.

1. Beacon Section.
2. Server Section.

ESP8266 WiFi with Arduino IDE used for short distant wireless networking applications (connecting Receiver board 1 and Receiver board 2. It is based on IEEE 802.11 standards. NodeMCU firmware provides Event driven APIs for network applications. NodeMCU WiFi networking can be used to connect, fetch or upload data to internet. This device adds wireless communication protocol to the embedded applications through which it can communicate with any other Assets which has no connection initially. AT commands are used to command the Bluetooth module. Its settings about password, its name, USART communications settings like baud rate, no. of stop bits or parity etc., can be changed. Here we use potentiometer to provide variable voltage from 0-3.3V on ADC pin of DevKit. If the ESP8266 has been configured to use the ADC for sampling the external voltage on pin, this function will always return 65535(max no of ports available).This is a hardware and/or

SDK limitation. Arduino IDE is used in the project for reading ADC channel and print digital value on serial monitor of Arduino Sketch.

B) Software Implementation

In our project Asset Tracking using Low Power Bluetooth ARM Keil and Arduino Software is used. The process flow can be seen in fig. 5.

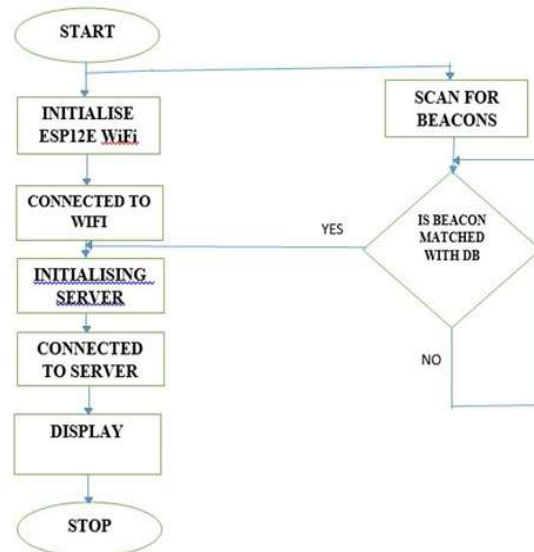


Fig 5: Flowchart

C) Central Server Section (XAMPP)

XAMPP is a free and open source (GNU General Public License) cross platform for solution Stack package developed by Apache Friends consisting mainly of the Apache HTTP Server, MariaDB database, and interpreters for scripts written in the PHP and Perl programming languages. Once XAMPP is installed, it is possible to treat a localhost like a remote host by connecting using an FTP client. It is also possible to connect to local host via FTP with an HTML editor.

XAMPP requires only one zip, tar, 7z, or exe file to be downloaded and run, and little or no configuration of the various components that make up the web server is required. The most obvious characteristic of XAMPP is the ease at which a WAMP webserver stack can be deployed and instantiated. Officially, XAMPP's designers intended it for use only as a development tool, to allow website designers and programmers to test their work on their own computers without any access to the Internet. To make this as easy as



possible, many important security features are disabled by default.

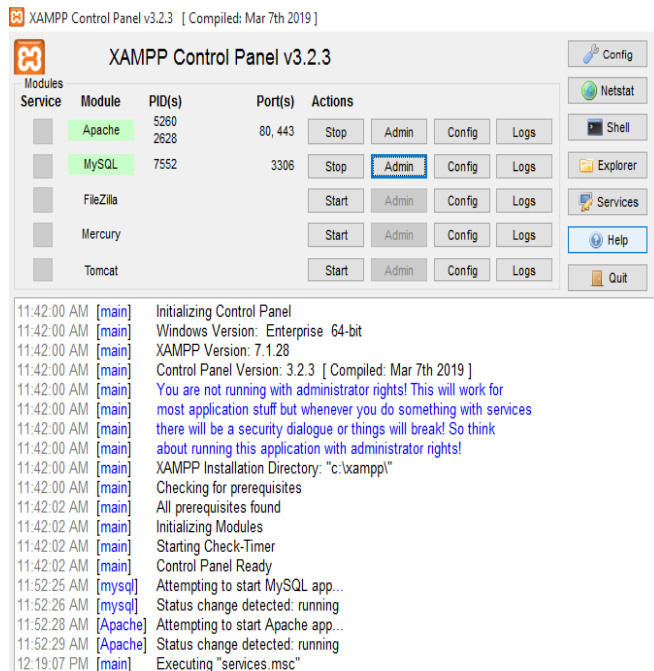


Fig 6: XAMP Control Panel

XAMPP Control Panel V3.2.3 used in my project is shown in fig. 6. The modules used in my project are Apache (for getting into the local http server) and MySQL Database for tracking and monitoring assets which are attached with NodeMCU.

i) PhpMyAdmin

Hypertext Preprocessor (earlier called, Personal Home Page) PHP is an HTML embedded, server side scripting language designed for web development. It is also used as a general purpose programming language. PhpMyAdmin is a free software tool written in PHPA. (As a portable web application) intended to handle the administration of MySQL over the Web (GNU General Public License 2) which is available in 79 languages shown in fig 7.

ii) My SQL Database

MySQL is an open source relational database management system (RDBMS) written in C, C++. MySQL is free and open source software under the terms of the GNU General Public License V2, and is also available under a variety of proprietary licenses. MySQL was owned and sponsored by

the Swedish company MySQL AB, which was bought by Sun Microsystems (now Oracle Corporation). In my project, beacons can be managed by My SQL Database and those beacons from transmitter attached to Node MCU can easily be tracked and monitored by users/administrators at the central servers (Laptop).

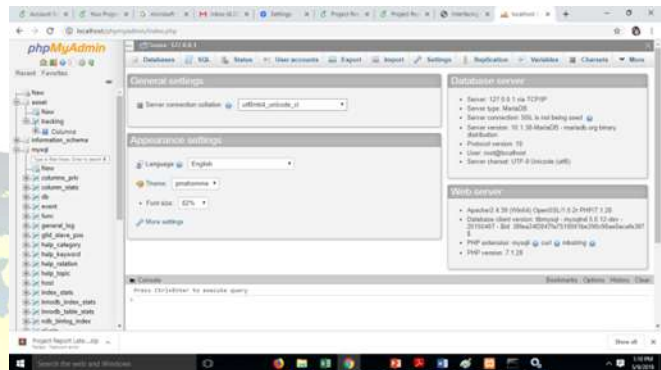


Fig 7: PhpMyAdmin Page

iii) Access to PhpMyAdmin

Step 1 - Log into the control panel.

- Log into the One.com control panel.
- Click PHP and database settings on the advanced settings tile.

Step 2 - Select My SQL database.

- Under PhpMyAdmin in the top right, click Select database and choose the database you want to access (My SQL in my project).

Step 3 - Administer your database.

- A new window opens showing your database in PhpMyAdmin. Check out the guides below to read about the various actions you can perform..

iv) Connection Establishment Terminal

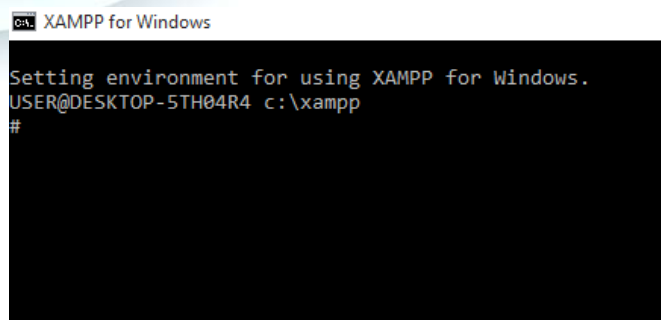


Fig 8: Console Terminal in XAMPP



Connection establishment with the local server can be viewed in the Console Terminal at the Receiver's Laptop. In my project, the attached beacon ID's can be viewed in the terminal and the asset details can be viewed in My SQL DB (NRF ID of Beacons, Power consumed by the beacons etc). Fig. 8 shows the console terminal in XAMPP.

Ping operates by sending Internet Control Message Protocol (ICMP) echo request packets to the target host and waiting for an ICMP echo reply. The program reports errors, packet loss, and a statistical summary of the results, typically including the minimum, the mean round-trip times, and standard deviation of the mean. The command-line options of the ping utility and its output vary between the numerous implementations. Asset owners can easily monitor their assets in the WAMPP Server in XAMPP software. Fig 9 shows the response received when pinging with the target.

```
user@computername:~$ ping 192.168.1.3
PING 192.168.1.3 (192.168.1.3) 56(84) bytes of data.
64 bytes from 192.168.1.3: icmp_seq=1 ttl=128 time=6.38 ms
64 bytes from 192.168.1.3: icmp_seq=2 ttl=128 time=45.2 ms
64 bytes from 192.168.1.3: icmp_seq=3 ttl=128 time=69.1 ms
64 bytes from 192.168.1.3: icmp_seq=4 ttl=128 time=94.0 ms
64 bytes from 192.168.1.3: icmp_seq=5 ttl=128 time=20.5 ms
64 bytes from 192.168.1.3: icmp_seq=6 ttl=128 time=7.37 ms
^C
--- 192.168.1.3 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5003ms
rtt min/avg/max/mdev = 6.384/40.463/94.047/32.588 ms
```

Fig 9: Pinging with the target

The proposed system can be implemented without many difficulties. System efficiently track assets over the internet i.e., assets/beacons attached to the web server shown below. Asset owners can view the tracking sheet. It can be seen in fig. 10.

SlNo	Name of Asset	Date and Time	Location
1	Asset1	13/05/19 11:29:47	Room1
2	Asset2	13/05/19 11:40:47	Room1
3	Asset2	13/05/19 13:06:47	Room2

Fig 10: Tracking of asset in a webpage

V. CONCLUSION

Manual Tracking of assets is difficult for any organization/individual. This system emphasizes the importance of automated system for preventing internal

pilfering of assets. The above designed system is economical and user friendly. This system is capable of WiFi connection with reduced power consumption. For eg: 2 packets are transmitted and 2 packets are correctly received at the receiver's with less energy (Bluetooth). This system can be enhanced with more features like camera, GPS so that assets can be monitored lively and mobile app to get alert messages instantly to the asset owner's phone. If a mobile app is installed in asset owner's phone they can remotely control and track asset's movement without failure. Thus working individuals can go to their work with great safety and happiness.

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