RESEARCH ARTICLE OPEN ACCESS

Tracking the Remote Location using LoRa

Prof. B. Gopinathan [1], Saida. A[2], Kasthuri Priya. R[3]
Asst. Professor [1], Student [2] & [3]
Department of Computer Science and Engineering
Adhiyamaan College of Engineering, Hosur
Tamil Nadu - India

ABSTRACT

In the contemporary past, there have been many incidents that make individuals feel dreadful, especially for women when they travel and there have been many cases where taxi drivers or auto-rickshaw drivers have molested or tried to kidnap the women passengers, at the worst case this situation has been increasing through the years passed. The problem is that although we try to reach the person who may be far away, it is no way useful unless the known person is nearer. The proposed system depicts the notion of **offline tracking** of the sufferer which counts the truancy of the network coverage and internet connection. This is obtained through the usage of **GPS module** and **LoRa technology.**

Keywords :— Internet of Things (IoT), Long Range, LoRa, LR-WAN.

I. INTRODUCTION

As decades being passing, technology is emerging in a significant way and at the same pace, technocrats also give their vital amount of contribution in all technical fields. Each technological development has spoken a lot in terms of urban development and technical insights

In the present era, we all got tuned into the digital world. This change over speaks everywhere and showcasing rapid growth among all sectors.

At a point in time, the change of wired to wireless has being spoken a lot, Author [3] thought this idea could be used to deal with the safeness of individuals particularly women who pay their high contribution, nationwide through their job. It is not recommended to use the Arduino platform for critical applications, as described by Arduino Community However, it is sufficient for prototyping. In this paper, we try to build a cheap and portable prototype that may be a greater aid when it comes to the emergency need.

This gave an idea of proposing a prototype/device, which will secure them from harassment and kidnaps while they travel a long way for their work.

The rest of the paper is methodical in the following way. Section 2 describes detailed study that covers the LoRa technology. Section 3 covers background issues in previously designed models for navigation purposes. Section 4 covers the background of the Lora Technology. Section 5 give a comparative study of all LoRa technologies. Further Section 6 covers the methodology. Section 7 tells about the system design completely. Section 8 depicts the diagrammatical representation of the expected prototype. Section 9 deals with the deployment ideology of the result obtained in real-time. Section 10 covers the experimental results acquired. Section 11 concludes the paper.

II. LITERATURE SURVEY

Reference [1] gives the solution regarding health issues when old age people are alone in home and analysis of LoRa at affordable prize and analysis of person monitoring areas. It specifies details of the frequency and bandwidth of various other countries. It depicts that LoRa is flexible in the functioning and to be used with terms and conditions applied.

Reference [2] says that it finds effort of environmental pollution and determine that humidity level be the key factor to conclude that effect. It details about sensors and data transmitted through IoT devices and the Raspberry pi controller to collect the data and, it uses GPS to identify the particular area. It specifies the conceptual description of LoRa.

Reference [3] deals with the usage of LoRa technology as a wide area network (WAN) for weather monitoring in agriculture fields. The paper conveys its major motive as to check the feasibility of LoRa based LPWAN technology and give a flexible solution for agriculture fields in the future. It tells that LoRa operates in a non-licensed band below 1 GHz (433,868,915) for long-range wireless connection.

Reference [4] deals with LPWAN – precisely speaking about LoRa in comparisons. It illustrates the implementations of LoRa based localization and, thereby the process is done by a phase-based approach.

Reference [5] papers deal with building Air pollution system or wireless sensor network for data transmission. The study in this paper tells us that examination results cover 900m i.e. 9 km of distance typically. It mainly covers the concept of cost and energy consumption of Lora. It mainly focuses on the measure of pollution in the indoor and outdoor

area by a sensor at a maximum distance coverage of LoRa and data transmission between nodes and gateway.

Reference [6] depicts the novel scheme for overcoming the bandwidth limitations of LoRa. It tells about few metrics taken into concern as measurements for achieving the same.

Reference [7] explores the relationship between LoRa transmission parameters – algorithm to determine optimal settings for power, coverage, and non-line of sight environment.

Reference [8] tells about LoRa for marine time communication and for lightweight boats.

III. PROBLEM CONSIDERATIONS

There have being Existing cases that need to be considered in certain criteria to know the problems attached with it in-depth for our further analysis.

In [9] we can find certain scenarios regarding the vehicle safety communication systems and the recent trends in it. The research paper explains about the issues in inter vehicle communications and the technology and deployment trouble that is present. It details about the period where the inter vehicle communication was boom in Europe, US, Japan in 1980's and 1990's. But the major problem was protocol and communication media. The paper spoke about the concept of deployment with multiple services and low penetration rate communication which we tried to achieve by our proposal. When it comes to safety we also need to speak about the AVCSS (Advanced Vehicle Control and Safety Systems). It provides the vast transformation detail of inter vehicle communications to Intelligent Transport Systems (ITS).

Another concept that merely matches the concept of our proposal is said in [10]. It describes the emerging autonomous vehicles (AV) technologies. It deals with mobility issues and cost of transportation which is the key factor we deal with. It is the mere concept of connected vehicles and transportation structure with cars. It completely speaks about the hurdles, opportunities, traffic circulations, and mean while its future reflections on vehicle transportations which is taken into consideration here as conceptual review.

[10] Says that these technologies have given rise to the prospect of autonomous vehicle (AV) technology which aims to reduce crashes, energy consumption, pollution, and congestion but, at the same time increasing transport accessibility. Adding to that, we get to know the complete functioning of the AV's and also its pros and cons in real-time. From [11] we could understand that smartphone navigation plays a precise role in driving behaviour based on real-time driving as well as stimulated driving considering the real-time experiments performed. The vehicle data obtained on driving and the eye movement of the concerned person are considered to be the key data for the evaluation, Having obtained the data of certain parameters we have the conclusion that the distraction occurring on noticing the smartphone navigation device placed gives a significant change in driving behaviour compared to the normal driving behaviour of the driver. Technically speaking, these issues are to be considered when imposing a new navigation technology with the help of other devices. Practical experiments with 20 real-time drivers have been conducted to obtain the results concluding that smartphone devices play a major change and review that smartphone could only be a secondary option when it comes to navigation.

IV. BACKGROUND

In [12] we get to know certain information about the LoRa like its invention, deployment, advantages, disadvantages, ranges, technical details, extended information about the LoRa and LoRa WAN and its comparative study. We also get to know some alternatives for LoRa in technical terms.

In [13] the important specifications of LoRa such as range (2-5Km Urban (1.24-3.1 mi), 15Km suburban (9.3 mi), frequency (ISM 868/915 MHz), standard (IEEE 802.15.4g), modulation (Spread spectrum modulation type based on FM pulses which vary), capacity (One LoRa gateway takes thousands of nodes), battery (Long battery life), and LoRa physical layer (Long battery life) are discussed. Further, we could find the extended module. It also tells that hat LoRa wireless technology is going to play a big role in the IoT market. Interconnecting devices to create smart cities, industrial and commercial solutions, whilst reducing the limitations from other wireless technologies such as power and other overheads.

It details about the difference between LoRa and Lora WAN. And have the view that "IS LORAWAN THE BEST WIRELESS TECHNOLOGY FOR YOUR IOT DEVICE? USE THIS FREE WHITE PAPER TO COMPARE THE BENEFITS AND DRAWBACKS OF SEVERAL OPTIONS BEFORE YOU COMMIT". It tells that because all the gateways in a network are tied back to the same server, it's the server's job to decide which gateway should respond to a transmission. In a large network, any given transmission is typically heard by multiple receivers; the server then tells one gateway to respond and the others to ignore the transmission. This process helps avoid downlink and uplink collisions, because a single gateway is transmitting, and the gateways that are overlapping can simply listen for other transmissions. [14].

It describes the complete building of the LoRa and Lora WAN from the 1980s to 2016. We could find the full round information about LPWAN (Low Power Wide Area Network) from the past to the future and features covered with it. The modern LPWAN movement began with Sigfox, and then LoRa came onto the scene. Now the cellular carriers are offering their own IoT device connectivity options via LTE

Cat-M and IoT. Concluding that While LTE-M may end up capturing a large portion of high-end data contracts, wide area, and sensor-based networks will be able to ride on the backs of Lora WAN and SIGFOX and cater to billions of medium to low-end contracts. These opportunities could have a huge impact on our world—from helping to feed the global population, to reduce the amount of water consumed, to cutting back on energy consumption, and so much more. LPWANs empower very real applications because they allow companies to get data back from sensor networks and make more efficient decisions about how to utilize resources [15].

V. LORA – COMPARISON BETWEEN TECHNOLOGIES

A. Sigfox Vs LoRa

All that said, the focus in IoT connectivity seems to have shifted. Are Sigfox and LoRa still competitors? Yes. But people aren't as focused on network technology these days—they're focused on use cases and applications. These technologies have been relegated to their proper place—they're tools, nothing more. Sigfox is a narrowband (or ultra-narrowband) technology. It uses a standard radio transmission method called binary phase-shift keying (BPSK), and it takes very narrow chunks of spectrum and changes the phase of the carrier radio wave to encode the data. To be much simple LoRa (is associated with physical layer) and LORAWAN (is associated with MAC-layer) of the OSI layers. Unlike SigFox, both the endpoint and the base station are relatively inexpensive with LoRa-enabled devices. This is primarily because you can use the same radio for a receiver on the base station and at the endpoint. While the Lora WAN base station tends to be more expensive than the endpoint, it's inexpensive in comparison to a SigFox base station. Other than these minor differences, Sigfox and LoRa serve similar markets. It's worth noting that both technologies were originally designed for the European regulated bands between 865 and 868 MHz, and they've both faced challenges in coming over to the regulatory markets in the U.S. Progress is being made, and both technologies are working toward optimization for FCC use [16].

B. Why LoRa?

Unlike other disruptive technologies that can be slow to gain global adoption, Semtech's LoRa Technology is not a promise of future potential but is available today all around the globe. With over several hundred known use cases (and growing), and more than 100 million devices deployed on every inhabited continent, Semtech's LoRa devices and the Lora WAN® protocol are creating a Smart Planet. Industry analyst IHS Market projects that 43% of all LPWAN connections will be based on LoRa by 2023. LoRa Technology is realizing the potential of the Internet of Things (IoT). Lora fills the technological gap between the previously existing technologies, complementing the Wi-Fi Bluetooth and cellular technology, having rapidly scaling ecosystem (a comprehensive collection of network operators, hardware manufacturers, software designers, service providers, universities, and industry associations that play a key role in creating and enabling devices, networks, and applications.), it answers us as to why need to use the LoRa technology [17].

C. What is Lora?

After several attempts and tests, considering the drawbacks in existing systems, LoRa came into existence. LoRa (short for long range) is a spread spectrum modulation technique derived from chirp spread spectrum (CSS) technology. Semtech's LoRa devices and wireless radio frequency technology is a long-range, low power wireless platform that has become the de-facto technology for Internet of Things (IoT) networks worldwide. LoRa devices and the open Lora WAN® protocol enable smart IoT applications that solve some of the biggest challenges facing our planet: energy management, natural resource reduction, pollution control, infrastructure efficiency, disaster prevention, and more. LoRa Wireless RF Technology and simply stating, LoRa connects devices (or all things) to the Cloud [18].

VI. METHODOLOGY

The complete process of the prototype will represent a rescuer locating the victim via the aid of booming wireless technology. Concerning the existing systems like Wi-Fi, Bluetooth, Cellular network concepts, a high-end concept emerged as the so-called LoRa Technology which is the acronym of long-range. We try to provide a solution to existing problem i.e. overcoming the shortcomings of GSM concepts in navigation and communication disadvantages when it comes to mobility. We overcame the dependency situation i.e. navigation with GSM via an Internet connection in the existing systems to a greater extent from our proposed idea. The prototype is designed in testing purpose requirement as single person prototype meanwhile overcoming the issues occurred in the complete process. The proposed idea covers modules like Transceiver, Receiver, NEO6M GPS module (for gaining satellite data), HC-05 Bluetooth module for performing communication at the receiver end and, the deployment setup in an overall concept.

At the emergency period when the victim needs the aid, he/she calls for the help via the transceiver (the prototype which he/she carries) and when the communication flow to the receiver end the rescuer get to know it via the signal (buzzer sound) at the deployment setup which in turn help to locate the victim.

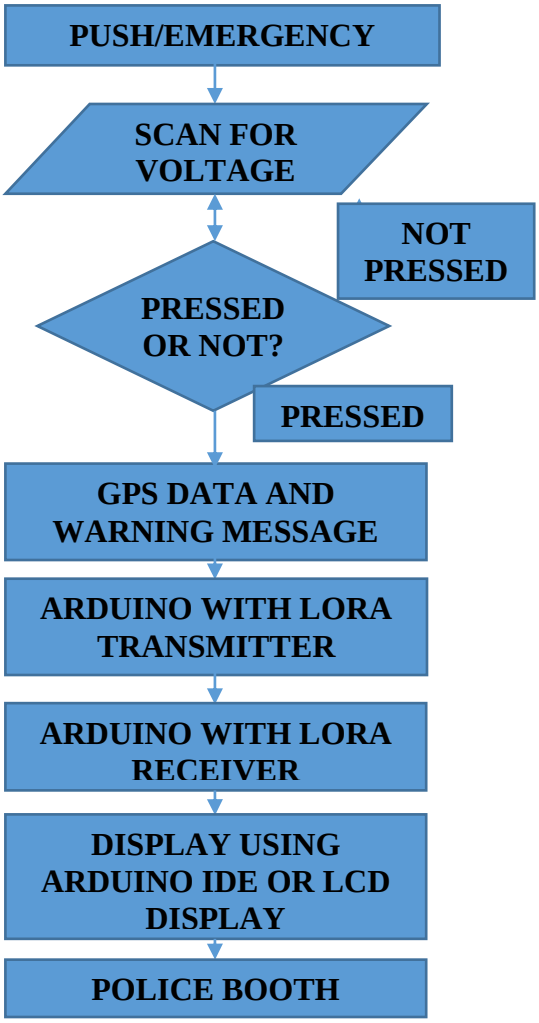

Fig 1. Flow diagram of working process

The device works like when the button pressed for help (i.e. push button) next process would be scanning device voltage detecting the pressing and sending signal to the receiver end where the data is received in signal (buzzer sound and location display in LCD) which be as notification to the rescuer to rescue the victim . The proposed idea be different from other real-time prototypes in terms of providing the output and overcoming the shortcomings, i.e. usage of internet and GSM technology, which represent in various existing systems.

VII. SYSTEM DESIGN

The panacea implementation process is done with – hardware & software.

A. Ublox NEO6M GPS Module

The u-blox NEO-6M GPS engine on these modules is quite a good one, and it also has a high sensitivity for indoor applications. Furthermore, there's one MS621FE-compatible rechargeable battery for backup and EEPROM for storing configuration settings. The module works well with a DC input in the 3.3- to a 5-V range (thanks to its built-in voltage regulator). As indicated, the GPS modules are based on the u-blox NEO-6M GPS engine. The type number of the NEO-6M is NEO-6M-0-001, and its ROM/FLASH version is ROM 7.0.3 (PCN reference UBX-TN-11047-1). The NEO-6M module includes one configurable UART interface for serial communication, but the default UART (TTL) baud rate here is 9,600. Because the GPS signal is right-hand circular-polarized (RHCP), the style of the GPS antenna will be different from the common whip antennas used for linear polarized signals. The most popular antenna type is the patch antenna. Patch antennas are flat, generally have a ceramic and metal body, and are mounted on a metal base plate. They are often cast in a housing. Remember, the position of the antenna mounting is very crucial for the optimal performance of the GPS receiver. When using the patch antenna, it should be oriented parallel to the geographic horizon. The antenna must have a full view of the sky, ensuring a direct line of sight with as many visible satellites as possible.

GPS receivers work by figuring out how far they are from several satellites. They are pre-programmed to know where the GPS satellites are at any given time.

The satellites transmit information about their position and the current time in the form of radio signals towards the Earth. These signals identify the satellites and tell the receiver where they are located.

The receiver then calculates how far away each satellite is by figuring out how long it took for the signals to arrive. Once it has information on how far away at least three satellites are and where they are in space, it can pinpoint your location on Earth. This process is known as Trilateration.

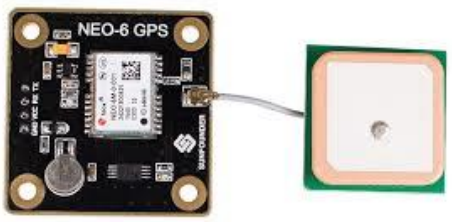

Fig.2 Ublox NEO6M GPS module

B. LORA SX1278

The SX1276/77/78/79 transceivers feature the LoRa® long range modem that provides ultra-long range spread spectrum communication and high interference immunity whilst minimizing current consumption.

The module consists of RFIC SX1278, thin SMD crystal and antenna matching circuit. The antenna port is well matched to standard 50 Ohm impedance. Users don't need to spend time in RF circuit design and choose suitable antennas for different applications. The module operates at 1.8~3.6V with extra low standby current which makes it suitable for battery powered-up applications. Because it is purely hardware module and it adopts ±10ppm crystal which the resolution of it places an important role in calculating spreading factor, bandwidth, etc.

Fig.3 L.oRa SX1278

C. HC-05 Bluetooth Module

HC-05 is a Bluetooth device used for wireless communication. It works on serial communication (UART).It is a 6 pin module. The device can be used in 2 modes; data mode and command mode. The data mode is used for data transfer between devices whereas command mode is used for changing the settings of the Bluetooth module.AT commands are required in command mode. The module works on 5V or 3.3V. It has an on board 5V to 3.3V regulator. As HC-05 Bluetooth module has 3.3 V level for RX/TX and microcontroller can detect 3.3 V level, so, no need to shift transmit level of HC-05 module. But we need to shift the transmit voltage level from microcontroller to RX of HC-05 module.

Fig.4 HC – 05 Bluetooth module

D. Arduino UNO & NANO

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one. Arduino is a single-board microcontroller meant to make the application more accessible which are interactive objects and its surroundings. The hardware features with an open-source hardware board designed around an 8-bit Atmel AVR microcontroller or a 32-bit Atmel ARM. Current models consists a USB interface, 6 analog input pins and 14 digital I/O pins that allows the user to attach various extension boards.

The Arduino Uno board is a microcontroller based on the ATmega328. It has 14 digital input/output pins in which 6 can be used as PWM outputs, a 16 MHz ceramic resonator, an ICSP header, a USB connection, 6 analog inputs, a power jack and a reset button. This contains all the required support needed for microcontroller. In order to get started, they are simply connected to a computer with a USB cable or with an AC-to-DC adapter or battery. Arduino Uno Board varies from all other boards and they will not use the FTDI USB-to-serial driver chip in them. It is featured by the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Fig.5 Arduino UNO Module

E. LoRa TX

Arduino with LoRa transmitter has the NEO6M GPS module and LoRa SX1278 and an emergency button. This device act as the portable tracking device which is used by the victim (especially concerning the working women and the hurdles faced by the daily) at the time of their travel. Fig.6 represents the Lora TX setup. Lora transmitter have a neat design which gives a feel of comfortableness to the user on their travel and assures their safety.GPS module provides the finite details of latitude and longitude of the traveling person which helps the rescuer to safe guard the victim from harassment incidents of the women passengers.

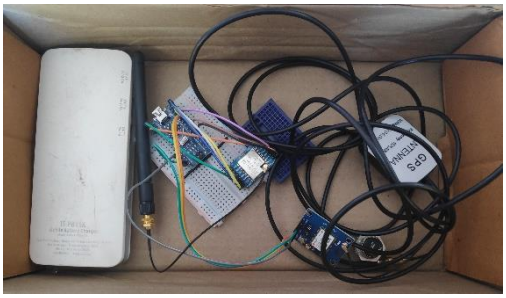

Fig.6 LoRa Transmitter

F. LoRa RX

Arduino with LoRa receiver have the HC – 05 Bluetooth module and antenna. The device receives the signal from transmitter and gives the accurate location of the victim to the rescuer.

Fig.7 LoRa Receiver

At the receiver end the Bluetooth module (HC-05 Bluetooth module) covers the range of 10 meters with complete 2.4GHz radio transceiver and baseband. It uses **CSR Blue core 04**-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature).

VIII. DIAGRAMMATICAL REPRESENTATION

Below picture gives the structural representation, working flow and connection setup of the LoRa transmitter.

In Fig. 8, the ublox NEO6M GPS module is use for getting the map data via satellite and send it to Arduino via Lora transmitter. We will be using Software Serial Library for this as we are going to print the data from GPS to Serial Monitor (i.e. in the Arduino Serial monitor). If you use the same communication port both the data will clash together and we get invalid data. So assuring the COM port connections is necessary while using two Arduino's. As per the uBlox NEO6M datasheet the voltage level for GPS Module is 3.6V. But we didn't face any heating issue with 5V which assured our testing successful to good range. You can try with 3.3V initially (for TX/RX also) and can shift to 5V if needed. But still it is recommended to use a Level Shifter for long time purpose and assure a perfect result.

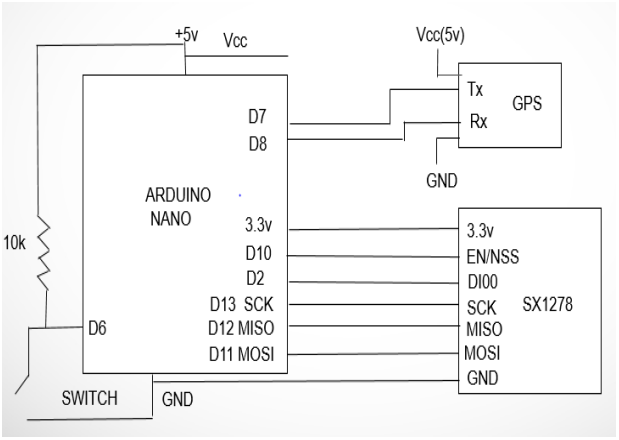

Fig.8 PIN Diagram of LoRa TX

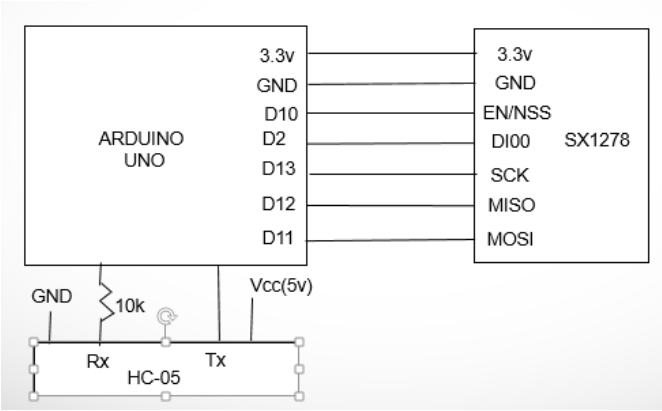

Fig.9 PIN Diagram of LoRa RX

In Fig. 9 we use the HC – 05 Bluetooth module for the communication purpose that receives the current location data of the victim from the LoRa transmitter. The Bluetooth module which we use here covers the range of 10 meters and it works with Enhanced Data Rate and Adaptive Frequency Hopping feature concepts.

The Bluetooth Module has 6pins such as ENABLE, Vcc, GND, TXD, RXD, STATE, and BUTTON SWITCH. When enable is **left open or connected to 3.3V**, the module is enabled i.e. the module **remains on** and **communication also takes place**.

At this **low state**, the **led flashes continuously** which denotes that the module is **not paired** with other device. When this module is **connected to/paired** with any other Bluetooth device, the signal goes **high**. At this **high state**,

the **led blinks with a constant delay** say for example 2s delay which indicates that the module is **paired**.

BUTTON SWITCH used to switch the module into AT command mode. To enable AT command mode, press the button switch for a second. With the help of AT commands, the user can change the parameters of this module but only when the module is not paired with any other BT device.

The **HC-05** is a very cool module which can add two-way (full-duplex) wireless functionality to your projects. You can use this module to communicate between two microcontrollers like Arduino or communicate with any device with Bluetooth functionality like a Phone or Laptop. There are many android applications that are already available which makes this process a lot easier. The module communicates with the help of USART at 9600 baud rate hence it is easy to interface with any microcontroller that supports USART. We can also configure the default values of the module by using the command mode. So if you looking for a Wireless module that could transfer data from your computer or mobile phone to microcontroller or vice versa then this module might be the right choice for you.

IX. DEPLOYMENT

The idea of the project (as a prototype) is deployed in nearby police station/booth which is available, since the police man are considered to be the rescuer here as for our convenience.

They get to find the location of the victim either by LCD display or Android Application interface. Considering the future needs, the device could be improved as creating an interface at receiver side with the help of NODE-RED programming tool for wiring together hardware devices which will work out when there is a requirement of obtaining the victim location in the standby case.

As a step higher, we have implemented the prototype in terms of offline mode i.e. without internet connection. This can be achieved through setting up a server at the backend (as invisible server, i.e. the Blynk Local Server) which have control over the data transmission, and further we get the output through the application that is a platform with IOS and Android **apps** to control Arduino, Raspberry Pi and the likes over the Internet. It's a digital dashboard where you can build a graphic interface for your project by simply dragging and dropping widgets. This form of our solution is a temporary process of achieving our proposed idea.

As an overcome interest we considered the NODE-RED, explaining that NODE-RED is a flow based development tool for visual programming developed originally by IBM for wiring together hardware devices, API and online services as part of Internet of Things. NODE-RED provides a web browser-based flow editor, which can be used to create JavaScript functions.

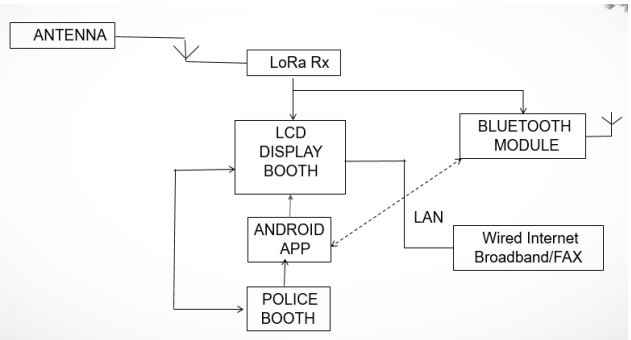

Fig.10 Deployment setup

X. RESULTS AND DISCUSSIONS

Final output of the proposed idea is acquired in android application and in a LCD display which covers our offline concept. Based upon the user convenience (after lot of study conducted) we set the end result to an application output. In our proposed idea we give the deployment setup in nearby police station or booth in case of any emergency aid to the victim. As the future enhancement, we can facilitate the distance coverage in terms of setting up various nodes gateways and collection points where the data is acquired.

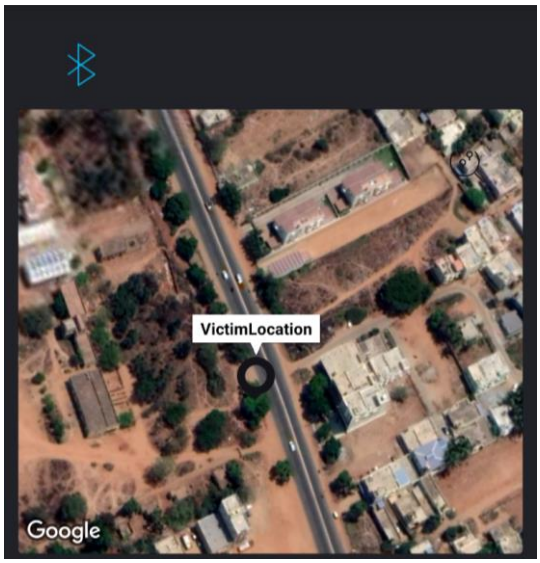

Fig.11 Detected Victim Location

XI. CONCLUSIONS

Our elucidation to the real problems in day-to-day life provides high-level user experience and, assuring a safe journey especially women travellers when they go for work. At the initial stage, we concentrated only on the pre-existing system and, its facilities but later considering its

disadvantages, we arrived in the proposed idea, where there are null occurrences for network unavailability and the ideology of offline navigation without the allowance of GSM technology came into play. We have gone through many testing stages and acquiring their samples, we ensured that the proposed idea no way crosses the rules and, overcome the limitations that are experienced in real-time examples of our concept.

CONFLICT OF INTEREST

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

[1] Valach and D. Macko, "Exploration of the LoRa Technology Utilization Possibilities in Healthcare Iot devices", 2018, pp. 623-628.

[2] E. Gangadurai, S. Ashvin, J. Subin Rajan, S. Suganthan, "MULTILEVEL MASTER SLAVE ASSISTED LORA COMMUNICATION FOR ENVIRONMENTAL POLLUTION MONITORING SYSTEM", International Journal of Applied Engineering Research ISSN 0973-4562 Volume 14, Number 6, 2019 (Special Issue).

[3] Hakkı Soy, Yusuf Dilay, Sabri Koçer,, "A LoRa-based Low Power Wide Area Network Application for Agricultural Weather Monitoring" , International Journal of Science and Engineering Investigations vol. 6, issue 71, December 2017.

[4] Chaojie Gu Linshan Jiang Rui Tan, "LoRa-Based Localization: Opportunities and Challenges", School of Computer Science and Engineering**,** Nanyang Technological University, Singapore.

[5] Nael Abd Alfatah Husein, Abdul Hadi Abd Rahman, Dahlila Putri Dahnil,, " Evaluation of LoRa-based Air Pollution Monitoring System", (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 10, No. 7, 2019.

[6] Akram H. Jebril , Aduwati Sali , Alyani Ismail and Mohd Fadlee A. Rasid, "Overcoming Limitations of LoRa Physical Layer in Image Transmission" , Received: 17 May 2018; Accepted: 10 August 2018; Published: 27 September 2018. Sensors 2018, 18, 3257; doi:10.3390/s18103257 www.mdpi.com/journal/sensors

[7] JANSEN C. LIANDO, AMALINDA GAMAGE, AGUSTINUS W. TENGOURTIUS, and MO,"Known and Unknown Facts of LoRa: Experiences from a Large Scale Measurement Study", Sensor Netw. Vol. 0, No. 0, Article 19. Publication date: November 2018.

[8] Ramon Sanchez-Iborra, Ignacio G. Liana, Christian Simoes and Elena Couñago and Antonio F. Skarmeta, "Tracking and Monitoring System Based on Lora Technology for Lightweight Boats", Received: 15 November 2018; Accepted: 20 December 2018; Published: 22 December 2018.

[9] https://www.sciencedirect.com/science/article/pii/S0386111214601138

[10] https://link.springer.com/article/10.1007/s40534-016-0117-3/

[11] https://www.hindawi.com/journals/misy/2019/9527890/

[12] https://devopedia.org/lora

[13] https://www.digikey.in/en/maker/blogs/introduction-to-lora-technology

[14] https://www.link-labs.com/blog/what-is-lora

[15] https://www.link-labs.com/blog/past-present-future-lpwan

[16] https://www.link-labs.com/blog/sigfox-vs-lora

[17] https://www.semtech.com/lora/why-lora

[18] https://www.semtech.com/lora/what-is-lora

[19] https://www.electroschematics.com/neo-6m-gps-module/

[20] https://lastminuteengineers.com/neo6m-gps-arduino-tutorial/

[21] https://www.semtech.com/products/wireless-rf/lora-transceivers/sx1278

[22] electronicwings.com/8051/hc-05-bluetooth-module-interfacing-with-8051

[23] https://store.arduino.cc/usa/arduino-nano

[24] https://www.watelectronics.com/arduino-uno-board-tutorial-and-its-applications/

[25] https://components101.com/wireless/hc-05-bluetooth-module