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# IoT-based Low-cost Children Tracker System

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ABSTRACT

Recently, many cases of missing children between the ages of 14 and 17 years have been reported. Parents are always worried about the possibility of their children being kidnapped or lost. This work proposes an Android-based solution to aid parents in tracking their children in real-time. Nowadays, most mobile phones are equipped with internet service capabilities, allowing them to connect with the world. The system's architecture is built on three main components: GPS satellite, IoT technology, and NodeMCU microcontroller board. The most important features of this work are its low cost, lightweight design, and small size. The Blynk app is installed on the mobile phone, and the GPS module is attached to the NodeMCU microcontroller to obtain the child's location. Then, the location information is accessed through the Blynk app with the help of map services.



## 1. Introduction

Global Positioning System (GPS), is a revolutionary technology that enables accurate positioning, navigation, and timing information worldwide. It relies on a network of satellites orbiting the Earth, constantly transmitting signals to GPS receivers. By receiving signals from multiple satellites, these receivers can determine their precise location on the planet. GPS technology has become an integral part of various sectors, including transportation, mapping, surveying, and outdoor activities. It has revolutionized navigation, making it easier for individuals to find their way, explore unfamiliar places, and reach their destinations with confidence. GPS has opened up new possibilities and has become an indispensable tool in our increasingly interconnected world [1], [2].

The working principle of GPS technology is based on a constellation of satellites orbiting the Earth. These satellites continuously emit signals that contain precise timing information and their own location data. A GPS receiver, such as those found in smartphones or dedicated navigation devices, picks up these signals. To determine its own position, the receiver needs signals from at least four satellites. By measuring the time, it takes for the signals to reach the receiver, along with the known locations of the satellites, the receiver can calculate its distance from each satellite. Using trilateration, a mathematical technique, the receiver can then pinpoint its own location by intersecting the spheres or ellipsoids formed by these distances. With precise timing and location data from multiple satellites, GPS receivers can accurately determine latitude, longitude, altitude, and velocity. This information is then used for various applications, such as navigation, tracking, and mapping, making GPS an essential tool in our modern world [3], [4].

GPS technology offers remarkable accuracy in determining location, thanks to its sophisticated design and advanced algorithms. The accuracy of GPS can vary depending on several factors. In open areas with a clear view of the sky, GPS receivers can achieve a positioning accuracy of within a few meters. However, in urban environments or areas with obstructions like tall buildings or dense foliage, the accuracy may be reduced due to signal blockages or reflections. To mitigate these issues, techniques like differential GPS (DGPS) or real-time kinematic (RTK) positioning can be used. DGPS employs reference stations that correct GPS signals for atmospheric and other errors, resulting in improved accuracy. RTK positioning involves a base station and a rover receiver, where the base station provides real-time corrections to enhance the accuracy of the rover's position. Overall, GPS technology has made significant advancements in accuracy and continues to evolve, enabling precise location information for a wide range of applications, from navigation systems and geolocation services to scientific research and surveying [5]-[7].

GPS technology has found a multitude of applications across various sectors, revolutionizing how we navigate, track, and gather location information. In transportation, GPS plays a crucial role in-vehicle navigation systems, providing turn-by-turn directions and real-time traffic updates to help drivers reach their destinations efficiently. It has also become an indispensable tool for logistics and fleet management, enabling companies to track and optimize the movement of goods and vehicles [8]. In the field of mapping and surveying, GPS is used to create accurate maps, survey land boundaries, and monitor changes in the Earth's surface [9]. Outdoor enthusiasts rely on GPS for activities such as hiking, camping, and geocaching, allowing them to navigate unfamiliar terrain and find hidden treasures [10]. Emergency services employ GPS to locate and respond to distress calls promptly [11]. Additionally, GPS technology has found applications in agriculture, wildlife tracking, scientific research, and even in the field of fitness, where it is used to track and analyze performance during workouts. Overall, GPS technology has transformed numerous industries, enhancing efficiency, safety, and convenience in our daily lives [12].

The structure of the GPS technology in general manner, the GPS system consists of three parts or segments that can be broken down into the space segment, the ground segment, and the user segment. The explanation of each segment is interpreted as follows [13], [14]:

- Space Segment: The space segment is the part of the system that is made up of the GPS satellites that are in geosynchronous orbit around the earth.
- Ground Segment: The ground segment is the part of the system that has the master control station operated by the Air Force, and both ground antennas and monitoring stations. The master control station is where the Air Force manages the satellite system. The ground antennas collect telemetry information from the satellites and also send commands and data up to the satellites for accuracy corrections.
- User Segment: The user segment consists of the devices that actually receive and use the data provided by the GPS satellites to perform navigation, such as handheld, marine, aviation, and automotive units. Fig. 1 shows the GPS system and its various segments.

Many years ago, numerous cases of missing children between the ages of 14 and 17 were reported. Parents have always been concerned about the possibility of their children being kidnapped or getting lost. With the advancements in technology, the introduction of microcontrollers, and the emergence of smart navigation and tracking systems like Google Maps, there has arisen a need to address this issue. In this work, we will design a small and affordable device that can be attached to a child's neck or bag, enabling their tracking via Google Maps. Furthermore, this device can also be used to track pets or placed in vehicles and bikes for location monitoring, providing information about their whereabouts [15].

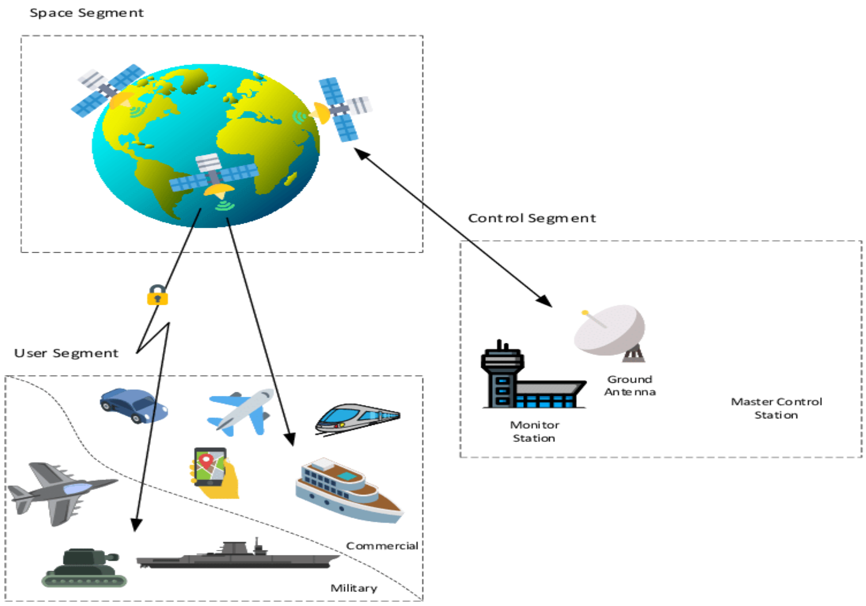


**Fig. 1.** Three segments of GPS system

## 2. Utilised Hardware and Software

This section of the paper presents the hardware components utilized to develop this work, such as the NodeMCU, GPS module, and Blynk platform.

### 2.1. NodeMCU Microcontroller

The NodeMCU microcontroller kit is an open-source module essentially utilized for constructing IoT applications. This kit incorporates firmware that can operate on the ESP8266 Wi-Fi SoC from Espressif Systems, which comes as a built-in chip in this kit. The hardware is based on the ESP-12 kit. Similar to Arduino microcontroller kits, it can read both analogue and digital signals from the physical world. It can be utilized in various traditional projects such as smart homes, smart irrigation systems, and robots. The NodeMCU kit includes 10 digital pins (D1-D10) that can be used for reading digital input or providing digital output. Additionally, some of these pins support analogue output using the PWM technique, except for pin D0, which does not provide PWM. PWM is employed to offer analogue output by varying the pulse width of the signal. Furthermore, this kit contains a single pin (A0) used for reading analogue input signals. The NodeMCU microcontroller board is presented in Fig. 2 [16]-[17].

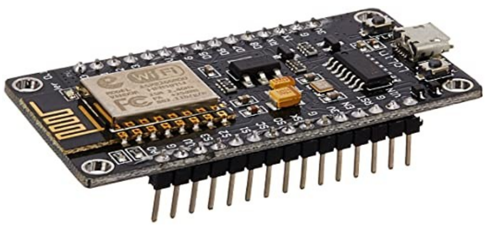

**Fig. 2.** NodeMCU microcontroller kit

### 2.2. GPS Module

In fact, GPS devices operate by determining their distance from a number of satellites. These devices are pre-programmed to locate the GPS satellites. The satellites transmit information in the form of radio waves, including their position and current time, across the Earth. By receiving and interpreting these waves, the receiver can identify the satellites. One commonly used module for GPS applications is the NEO-6M GPS chip, distributed by U-Blox. This chip is characterized by its small size, smaller than a postage stamp, yet it packs numerous features into its compact design. The module can track up to approximately 22 satellites on different 50 channels and boasts a high sensitivity level of up to (-161 dB) for tracking while consuming only 45 mA of power from the source (e.g., battery or power supply). Unlike other GPS modules, it can refresh its location up to 5 times per second, with a horizontal location accuracy of up to 2.5 m. The U-Blox 6 positioning engine has a time-to-first-fix smaller than one second. One notable feature of this module is its power-saving mode, which allows selective switching of receiver segments ON/OFF to minimize power consumption. This dramatically reduces the module's power consumption to just 11mA, making it suitable for power-sensitive applications such as GPS watches. The basic data pins of the NEO-6M GPS chip are separated out into 0.1" pitch headers, facilitating UART communication with microcontroller kits. The module supports baud rates ranging from 4800bps to 230400bps, with 9600bps being the default. Fig. 3 illustrates the GPS module [18][19].

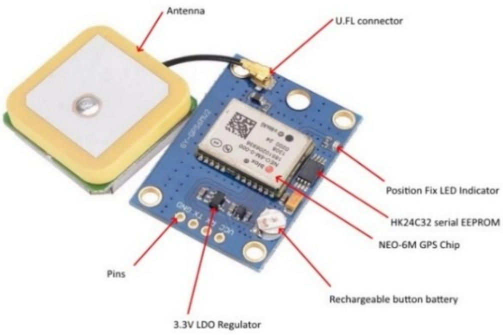


**Fig. 3.** The GPS module

## 2.3. Blynk Platform

Blynk is the most popular IoT platform for connecting devices to the cloud, designing apps to remotely control and monitor them, and managing thousands of deployed products. Blynk provides iOS and Android apps for controlling Arduino, Raspberry Pi, and similar devices over the Internet. It offers a digital dashboard where you can easily build a graphical interface for your project by dragging and dropping widgets. Setting up everything is straightforward, and you can start experimenting in less than 5 minutes. Blynk is not limited to a specific board or shield but instead supports the hardware of your choice. Whether your Arduino, Raspberry Pi, or ESP8266 chip is connected to the Internet via Wi-Fi, Ethernet, or another method, Blynk will help you get online and ready for the Internet of Your Things. The Blynk platform consists of three main parts [20]-[22]:

- Apps: permits the users to create different interfaces for their project requirements by utilizing several of the widgets that are provided by the platform.
- Server: it is accountable for the all of the communications among the smart mobile phone and the hardware appliances, where the users are able to utilize the Blynk cloud. Which is open-source, could simply treat a lot of the appliances and can even be originated on the Raspberry Pi kits.
- Libraries: which contains within it a set of instructions and programs that enable users to use the platform on their various boards.

Every time the user presses the Button in its own programmed Blynk app, the message transferred toward the Blynk Cloud, Fig. 4 illustrates the communication process between the smart mobile phone, the Blynk server, and the hardware.

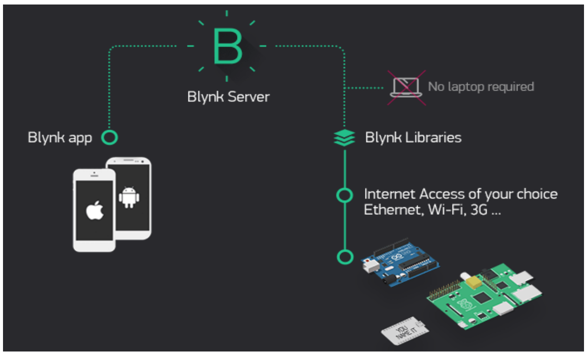


**Fig. 4.** Communication process between mobile app and the hardware

## 3. System Design and Implementation

This subsection of the chapter presents the necessary steps for the designing and implementing of the real-time child tracking system based on the NodeMCU microcontroller, GPS module, and Blynk app. We propose a solution to solve the problem based mainly on GPS and IoT technologies. It takes advantage of the two main rich features that are offered in advanced smart mobile platforms nowadays. The working used hardware and software components to implement the project are:

- NodeMCU microcontroller board
- GPS module
- Blynk app
- dArduino IDE

### 3.1. Real-Time Tracking System

This part of the chapter presents the proposed system (i.e., device) that is responsible for child tracking. This device is based on the IoT technology supported by the NodeMCU microcontroller. The GPS module is used for real-time tracking purposes. In addition, a special android app is programmed based on the Blynk platform to track the car position via the Google map, as shown in Fig. 5.

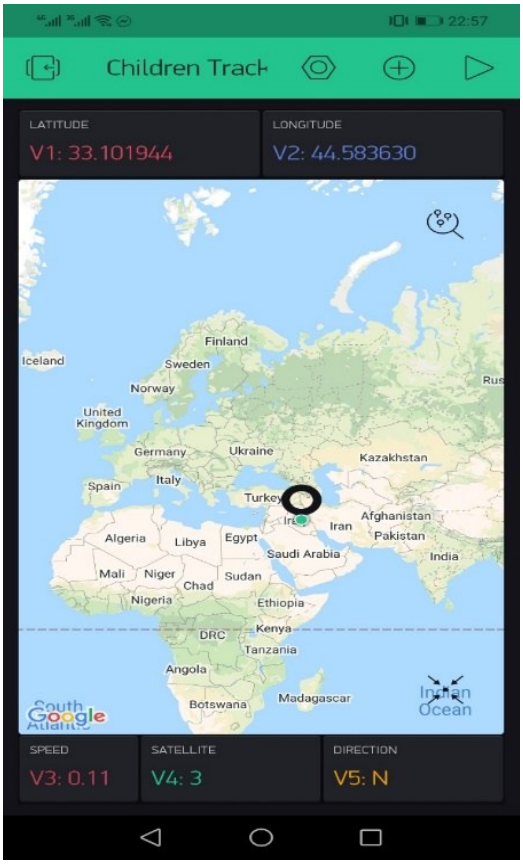


**Fig. 5.** Programmed app for the real-time child tracking

The application displays the child speed and direction, as well as the longitude and latitude of the location where the child comes to a stop, which it receives from the GPS module. The application also displays the child real-time location on a Google map. Fig. 6 and Fig. 7, respectively, illustrates the block diagram of the real-time child tracking subsystem and the implemented circuit of the proposed device.

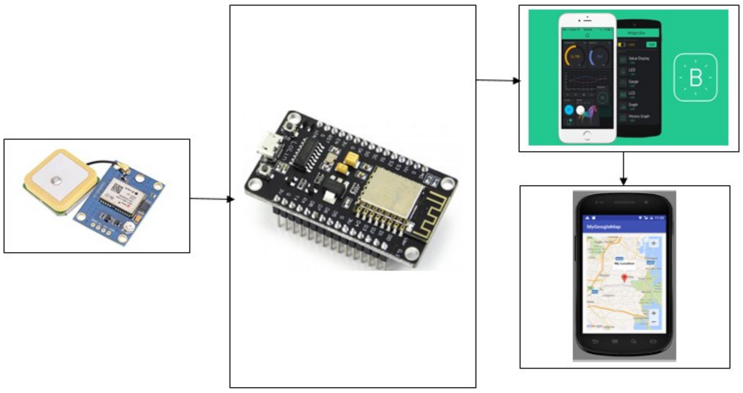

**Fig. 6.** Block diagram of the proposed device for child tracking

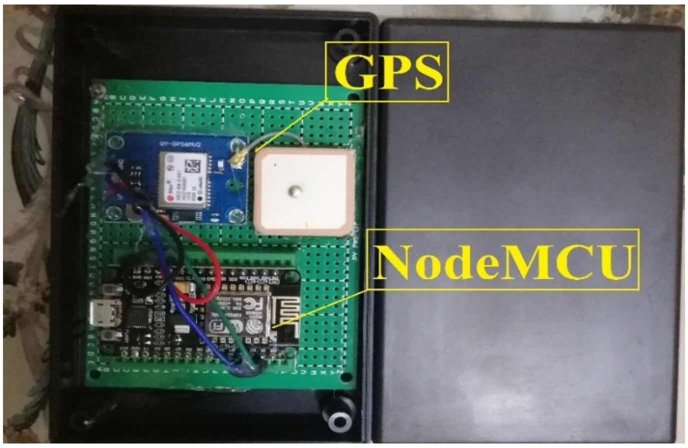


**Fig. 7.** Implemented real-time child tracking device

### 3.2. Results of Real-Time Car Tracking Subsystem

When powered the NodeMCU microcontroller, the GPS is starting to communicate with the satellite to determine the longitude and latitude of the car's location. Then this information is transferred to the NodeMCU microcontroller, which in turn sends it to the Blynk server, which will display it on the programmed application through this platform in the form of longitude and latitude in addition to displaying it in the form of a map utilizing the Google Maps, as illustrated in Fig. 8.

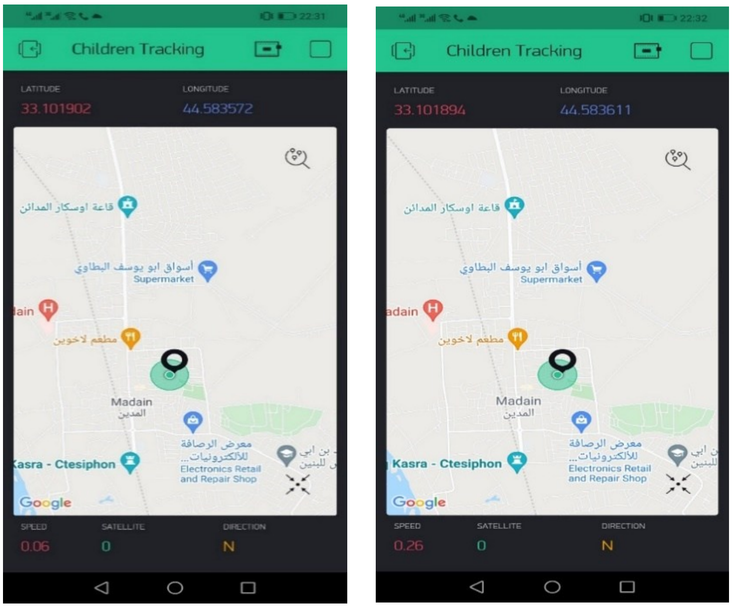


**Fig. 8.** Different device holder positions on the map

To ensure that the proposed system is functioning properly, the location of the smart mobile phone was changed slightly from the system in order to notice the change in longitude and latitude, which is exactly what happened, as a change in the aforementioned lines was observed. The smart phone was connected to Zain-4G-LTE Iraq's Internet service, while the NodeMCU microcontroller was connected to another internet network via the TP-Link router's Wi-Fi network, to ensure the car can be tracked from anywhere in the world.

## 4. Conclusion

In conclusion, this project aims to assist in locating missing or lost children. The proposed solution utilizes the extensive features available in Android and iOS smartphones. The system architecture relies on two key components: GPS satellites and IoT technology. The development of this work was made possible by studying relevant existing works. It is worth noting that some of these works rely on continuous internet connectivity or a server that must remain operational. The prototype implemented in this project utilized the NodeMCU microcontroller board, which supports IoT technology, GPS functionality, and the Blynk server along with its corresponding app. Whereas, the parents can track their child's location by using the Blynk app.

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