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Indoor Positioning System

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Introduction

The current demand for localization extends beyond what GPS can provide as it is limited to outdoor settings. Radio signals used in the Global Positioning System offer global coverage but are unable to penetrate obstacles and buildings. Our system is designed to solve this problem by implementing an Indoor Localization System using ultra-wideband RF-based localization based on the recent 802.15.4a standard. At a high level, the system is modeled after the architecture of the Global Positioning System by utilizing anchors as the satellites and tags as the receivers. With the use of cloud technology, an end-to-end system is created that achieves security as well as usability. The hardware packaging is encapsulated within a miniature PCB design at a low cost, aimed as a plug-and-play integration within other systems in need of indoor detection. Applications of our IPS design include domains such as navigation (room-to-room integration within other systems in need of indoor detection. Applications of our IPS design include domains such as navigation (room-to-room), asset tracking in warehouses, and robotics (autonomous vehicles, drone detection). We demonstrate that all of the specific products on shelf, asset tracking in warehouses, and robotics (autonomous vehicles, drone detection). We demonstrate that all of the components mentioned are essential to effectively carry out successful indoor positioning with a focus on user flexibility and efficiency in response.

Method

1. Leveraging the user interface from our mobile application, the user selects Anchor locations (minimum 4 for 3D positioning) on a selected map and building schematic
2. All information is pushed to a cloud broker through Amazon Web Services into associated MQTT topics for M2M communication
3. Tag module remains “subscribed” to topics and receives information as they arrive. Everything received is stored into memory in the firmware.
4. Using the geometric method of Trilateration, the position of the Tag is calculated from coordinate and distance metrics from Anchors.
5. Calculated Tag coordinate is pushed onto AWS for the mobile app to continuously display Tag location via a marker
6. Via UART on the firmware, NMEA sentences are reported for plug-in-play integration with other systems dependent on GPS modules
7. Longevity of module life cycle is maintained near 90% efficiency through custom PCB design and low-dropout regulator integration

Results

Hardware

For any project, the hardware is the foundation that makes the magic possible. For our concerns, it has been necessary to create a pcb design that encapsulates all hardware components in our system into a sleek and miniature design for the purposes of easy deployment into the user’s environment as necessary. What has been achieved includes interfacing with the ESP8266 microcontroller chip and the DWM1000 frequency module chip in addition to integrating a 8-pin Tag-Connect programmer. Low-Dropout regulator for stable power and efficiency, and a switching transistor for auto-programming ability via RTS and DTR signals given from common serial communication bridges.

Software

The top layer of the project is a mobile application developed on React-Native that supports both Android and iOS platforms. Focusing on more of the application of our system, the mobile app enables users to set anchor positions on a given map and building schematic through the “consumer mode”. Unlike prior implementations of the system that involved creating a coordinate plane relevant to our system only, by leveraging Google Maps, we are now able to consistently work with GPS coordinates for our project involved. The goal of this is to serve as a visual guide for the user to set up all necessary anchors within their environment of interest. Once the system is set up by initializing at least 4 anchor positions, users (Tags) can access their real time location within the building via a marker. In addition to the consumer aspect, the app also serves as a tool to aid in development and debugging for involved developers. By accessing the developer mode, metrics such as module “heartbeat” and “life-cycle” may be viewed to ensure quick deployments and troubleshooting. The developer may also access this page to enable Over-The-Air programming for any firmware updates needed to be pushed.

Drone Demonstration

One application of the indoor positioning system is realizing swarm programming of drones indoors which is not possible without the system as drones do not have enough location information indoors due to the lack of GPS information to be aware of their current location. The system enables collision avoidance through a central controller which coordinates each drone in the swarm. Each drone would carry one tag to transmit current location. By entering destinations for each drone through our GUI, paths would be calculated and command would be pushed to each drone to execute.

Conclusions

Indoor Positioning has been a relevant topic for decades as researchers and scientists have been working on a method to extend the usage of the Global Positioning System into an indoor setting. The proposed solution has been verified to work in both the 2D and 3D plane with the required extension of a single anchor in the system as well as with a focus on information security on the cloud. To further the design in the future, we aim to improve the hardware with more power efficient options such as BLE (Bluetooth Low Energy). On the firmware side, we are working on methods for dynamic cellular-handoff of the tag to different sets of anchors to enable easy movement. On the app side, more features are looking to be added such as user registration. Further implementation may include a “recommendations” feature that will remove the need for user-defined anchor placement during the initialization process.