# Indoor Positioning System (IPS) with Bluetooth Beacons

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## Goal

Develop a low-cost Bluetooth indoor positioning system to track a user's location indoors. To supplement the location and tracking functionality of GPS to enable a more immersive indoor experience.

## Motivations and Objectives

- **Motivations**
  - To allow indoor location services since GPS fails to do so
  - To enhance the experience of museums, malls, and corporations, through the use of interactive directories and venue maps
  - To enable indoor tracking of employees such as security personnel

- **Existing Solutions**
  - Apple's indoor tracking requires use of Wi-Fi and motion data from the phone
  - Trilateration measures distance from a device using RSSI and Link Quality signal parameters
  - Dead Reckoning uses triangulation with the accelerometer and compass between signal strength updates
  - Fingerprinting uses RF signals to find a unique location map offline and uses location estimation online

- **Objectives**
  - A scalable passive system (requires an IOS application)
  - Portable & low energy (regulated battery power)
  - Incorporation of the magnetometer for physical phone's direction and error checking

## Research Challenges

- UUID identification of Bluetooth beacons
- Location estimation algorithm
  - Nearest neighbor implementation
  - Use of onboard phone sensors for error checking

## Implementation

- **Hardware**
  - Purchase Bluetooth modules
  - Voltage-Regulator Circuit for modules
  - Build circuit packaging to hang
  - Mount asymmetrically on floor plan
  - Grid the floor for sample taking

- **Software**
  - RSSI [dBm] sampling app
  - Online RF sample database
  - Device model, heading, name of user, UUID & 5 RSSI, timestamp
  - Location estimation algorithm

- **Cost breakdown** – 5 Beacons
  - Cost per device: $40.10
  - Total cost of system: $200.50

## Results

- Theoretical tracking should produce a maximum error 0.57 meters (1.9 feet)
- Experimental tracking produces an error of 1.5 meters (4.9 feet)
- 20+ Hours of battery life for beacons

## Future Works

- Business analytics (track many user’s locations, property, and statistics of traffic flow -> possible areas of higher revenue stream & energy efficiency of building)
- 3D printed enclosures for better portability, simpler installation, and a sleeker form factor
- Geo-fenced push notification to phone if near a beacon
- Estimation Algorithm: supplement with a Naive Bayes adaptive decision method

## References


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