BLiPS
Winter Review
The Team

Matthew Speck - Project Lead, Parts selection, PCB/Schematic

Amber Du - Data Collection, Signal analyst

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What is BLIPS

- BLIPS stands for Bluetooth Low energy indoor positioning system. Our goal is to track the movement of doctors and nurses and equipment in an operating room using Bluetooth Low Energy devices that are placed in the employee’s ID cards.
How does BLIPS work?

- 3 - 6 Bluetooth beacons will be placed on the ceilings of the operating room to triangulate the employee's position using RSSI values. An IMU is used to keep our processor in a low power state until it is needed (Eg. when the wearer is moving).
Overview

- Location tracking of people in a room using Bluetooth Low Energy signals
  - IMU interrupt-driven
- Sending data real time to a server, which will display data via web application, via WiFi
Parts

Microprocessor: ESP32 BLE and WiFi module

- Xtensa 32 bit microprocessor
- Dual core
- 160 MHz
- 448 Kb of ROM, 520 Kb SRAM
- 2x I2C & I2S
- 3 UART
- Ultra low power co-processor for sleep @ 8Mhz
- 150 mA max current draw
Parts

IMU: LSM9DS1

- IMU chip, contains gyroscope, accelerometer, magnetometer
- Connects through I2C
- 9 Degrees of freedom
- Used to wake CPU from low power state
- 15 mA max current draw
Schematic
Software Development (Badge side)

- Badges will operate on an interrupt driven software structure
  - High energy mode is costly, so we only transmit/collect on a change in position

- This is accomplished via the inertial measurement unit (IMU) on our board
  - Using accelerometer/gyroscope, we can tell when a badge has shifted its location drastically
Interrupt Handling

- Interrupt handling is done through RTOS (real time operating system)

- Once an interrupt is triggered on LSM9DS1, we set a pin high, which the ESP32 can tell means to collect beacon data
Client - Server Communication

- ESP32 (badge) CPU has a built in WiFi module
  - Once data is calculated we send it off to be dealt with on the server side
  - Again, high energy state should be minimized

- Client - Side code will compartmentalize and clean up data as much as possible
  - Can handle readings from up to 10 beacons

- We will be using TCP to transmit data from client to server

- Why TCP?
  - Reliability
  - Ensured data is retrieved in proper order
  - Maintained connection b/w client and host

- Each TCP packet should include data for every beacon it can see (less transmissions)
Software Development (Server Side)

- Where we are now
  - Beacons at a preset location
  - Each beacon has a value applied to it that matches its Minor value
  - By transmitting minor to map to a specific beacon, we can map values to locations
Goal: Configurable Room Design
○ Meteor.js web application
  ■ Built in MongoDB database
  ■ Simplified Web Hosting Application
○ Based on readings, we can draw circles with defined radius’ that configure to the distance
  ■ Three intersecting circles will allow us to achieve triangulation
Software Updates

- **Client-Side**
  - IMU interrupts are firing properly and running as expected
  - If need be, IMU data can be read using I2C
  - Using the interrupts, we can transition out of a deep sleep state, and retrieve Bluetooth values

- **Server-Side**
  - Meteor web application is up and running
  - Given proper distance measurements, we can triangulate a position
  - At the moment, multiple badges can be added to the display (up to a certain point)
Current triangulation (Beacon side)
Physical Setup (video)

https://drive.google.com/file/d/1pEZ0uo0Q1vCQDqBf6dcBc92dmsS0L5v/view?usp=sharing

https://drive.google.com/file/d/1CESFb2_STO_vGyXUnlMrQoDnNh3kk/view?usp=sharing
End Goal (Server-Side)

https://drive.google.com/file/d/1JllH-OBxXHRFuqgUaw64KIBBMztwJMdT/view?usp=sharing

*Simulated data
Wi-Fi (Client-Side)

- Each badge will be individually named to differentiate people inside the operating room.
- Badges will only transmit their location and send it to a server, which will be viewed on a computer in a different area.
- Will only transmit data when IMU detects movement, to minimize power loss.
Wi-Fi (Server-Side)

- Receives RSSI values and IMU data from the badges and stores it.
- Configures the data received, and transmit it into blips on a map showing where the badges are.
- Constantly process new data received, continuously updating current location of where the badges are.
The Problem with RSSI

- Wild variations in signal strength
Partial Solution to RSSI Woes

- Kalman Filtering
BLE Emitter

- We are using Nordic NRF52832 to act as our bluetooth beacons
- In order to artificially attenuate the signal strength we are strobing the transmit strength between three power levels
  - Every third signal sent changes power level
  - -8, -12, -16 Db
What we did this quarter

1. **Badge software**
   a. Chip spends majority of time in low power Deep Sleep State
   b. Chip runs the program via interrupt from IMU

2. **Server software**
   a. Basic communications with device (Kevin, Ahmed)
   b. Offloading location calculations from device to server side (Everyone)
   c. Multiple device handling (Kevin, Ahmed)
   d. Software redesign to move from calculations and position finding from onboard to some external host. (Goes with part A of server software) (Kevin, Ahmed)

3. **Positioning calculation improvements**
   a. Filtering out noisy data for better measurements (Amber)
   b. Crude implementation of prioritizing signals from different beacons based on how many signals are seen by the badge

4. **Beacon Software (Matt)**
   a. Strobing between different power levels to get a better idea of where the badge could be
Plans for next quarter

- Get and test PCB
- Make second Revision including:
  - Battery measurement
  - Reduce size
  - Various power saving measures
- Refine Web application
  - Ability to track multiple objects, ability to configure room size
- Improve triangulation algorithm
  - Do calculations server-side rather than in the badge
  - Add more variables into algorithm
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