TIU Tracking System

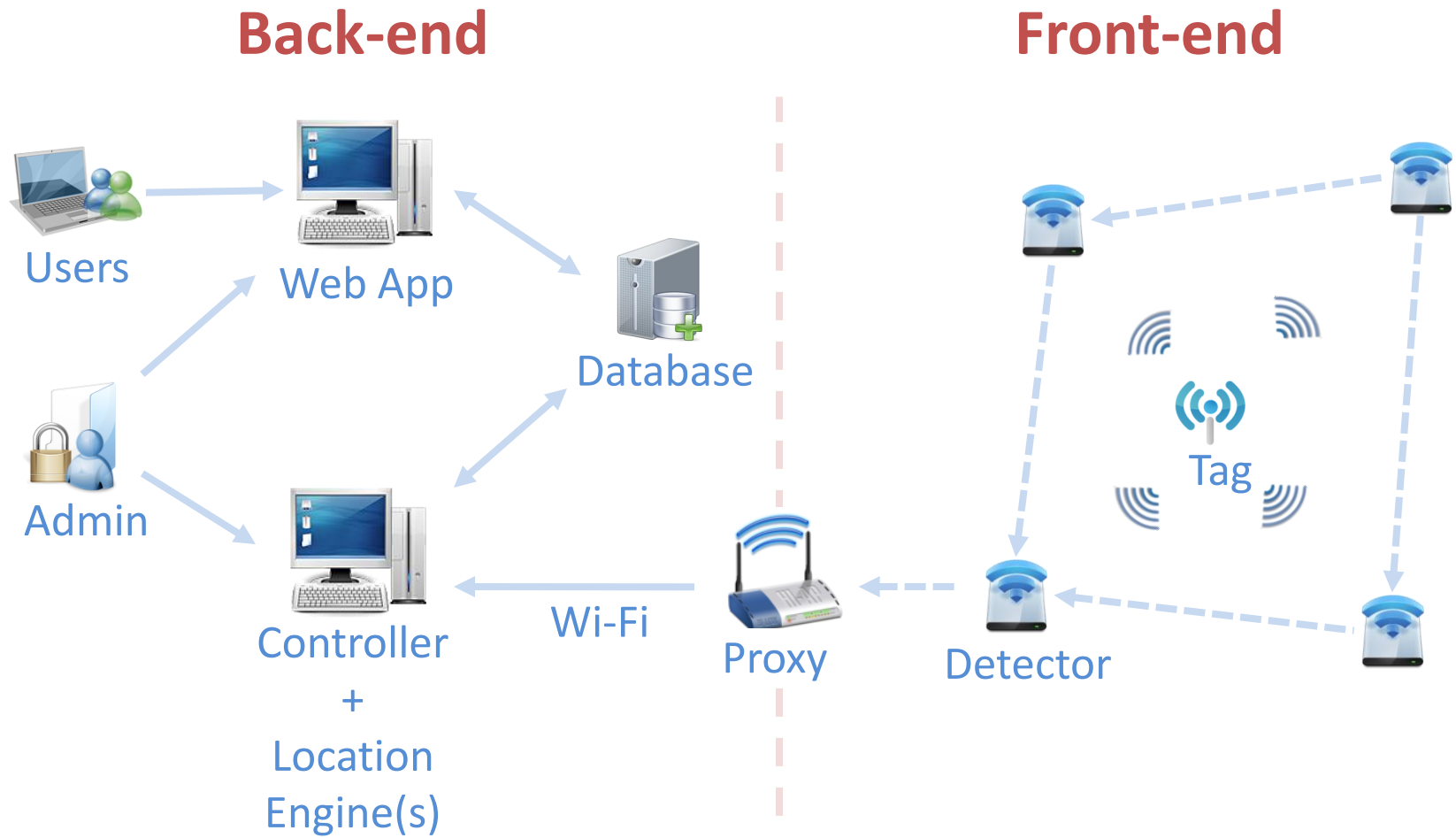|	
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Introduction

- Problem statement

- Key requirements
    - Size
    - Power
    - Accuracy

Agenda

- **System Overview**
- Hardware
- Firmware
- Software
- Deployment
- Results
- Conclusions

System Overview

Back-end

Front-end

Users

Web App

Database

Admin

Controller
+
Location
Engine(s)

Wi-Fi

Proxy

Detector

Tag

Agenda

- System Overview
- **Hardware**
- Firmware
- Software
- Deployment
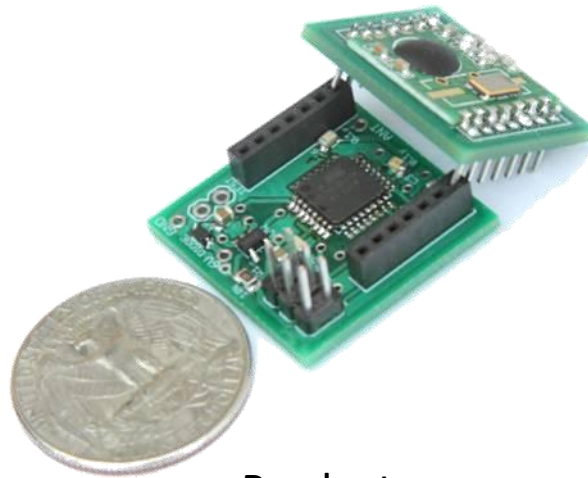- Results
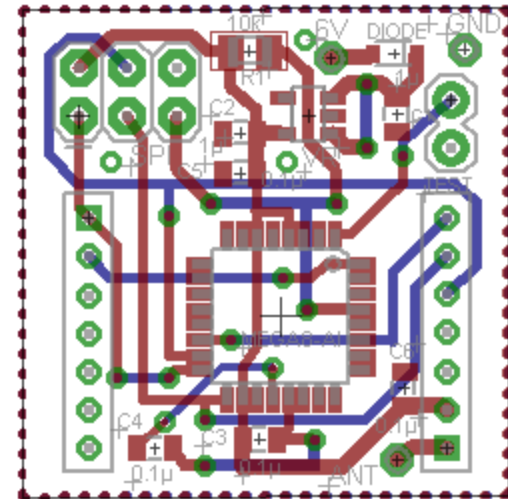- Conclusions

Hardware

- Devices
  - Tag
  - Detector
  - Proxy

- Components
  - RF12 transceiver
  - ATmega328p MCU
  - WiFly 802.11b/g transceiver

- Schematic and layout by Eagle CAD

- PCB by Sunstone Circuits

Hardware

- Tag
  - RF12 transceiver
  - ATmega328p MCU
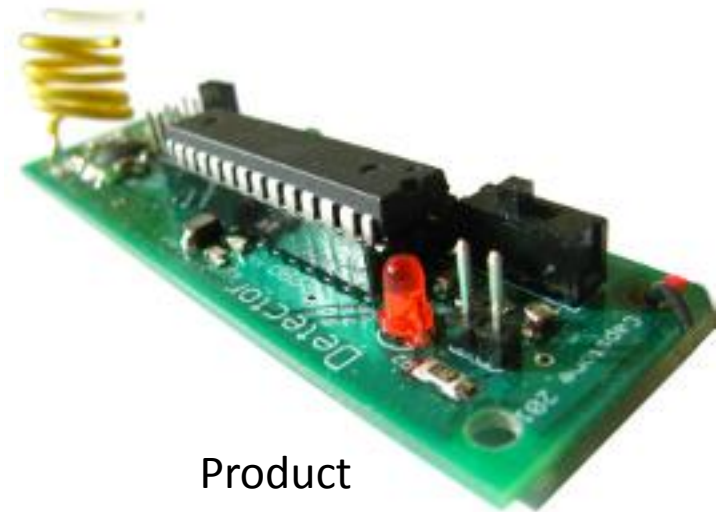 - Size: 1" x 1" x 1"
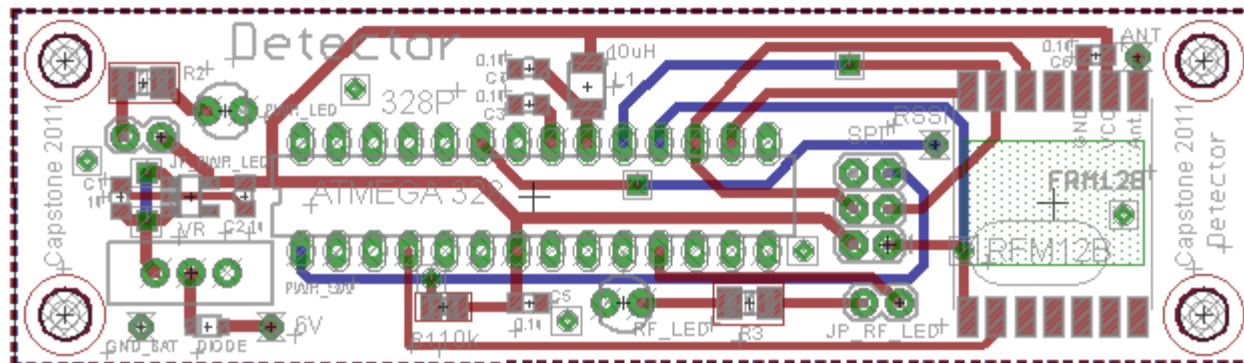 - 240mAh coin cell battery

Layout

Product

Hardware

- Detector
  - RF12 transceiver
  - ATmega328p MCU
  - Status LED
  - Size: 3.5" x 1"
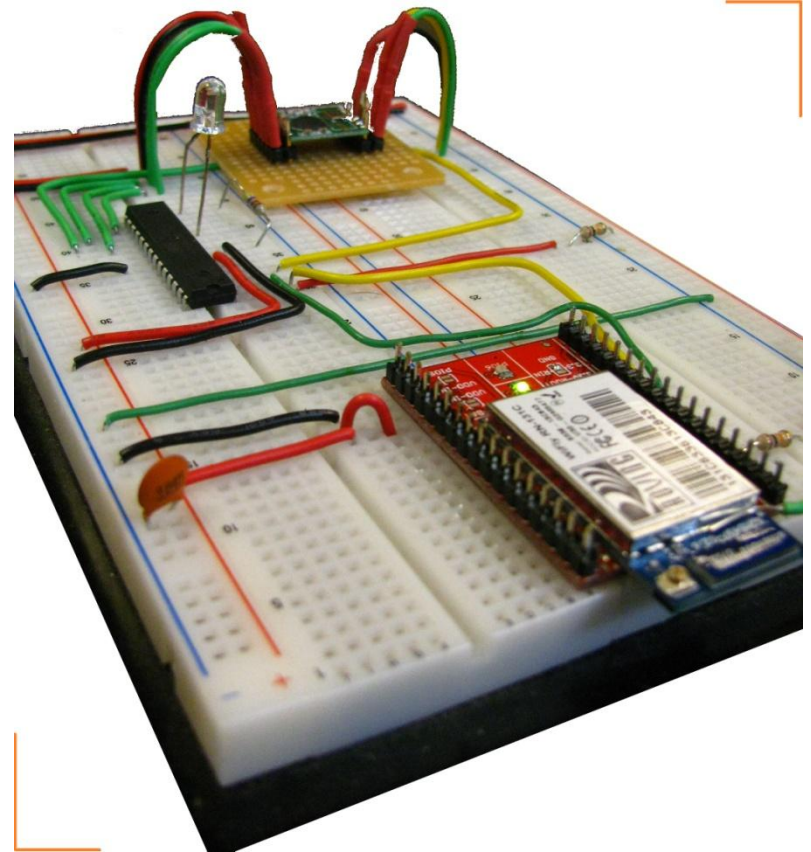

Product

Layout

Hardware

- Proxy
  - RF12 transceiver
  - ATmega328p MCU
  - WiFly 802.11b/g transceiver
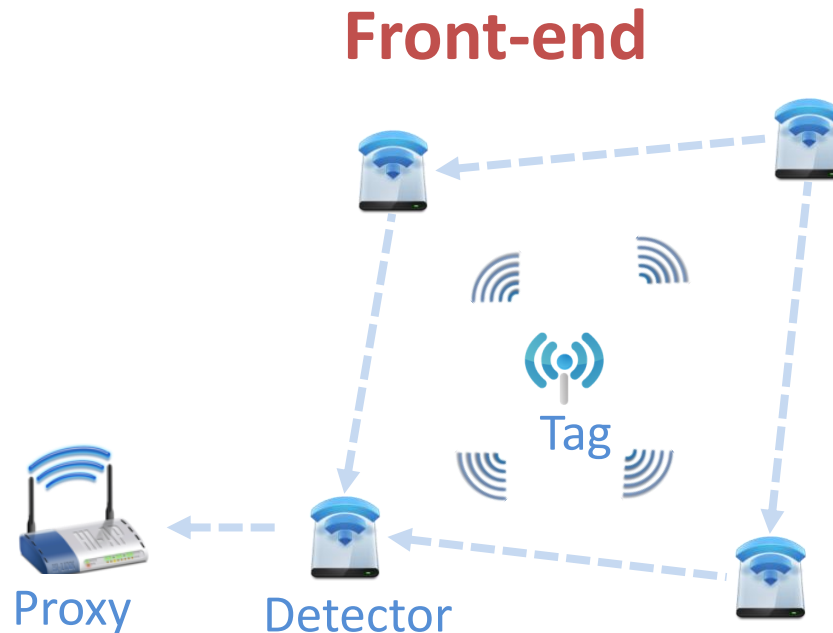 - Breadboard prototype
  - Ceramic antenna

Agenda

- System Overview

- Hardware

- **Firmware**

- Software

- Deployment

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Firmware

- Tag broadcasts
- Detectors relay
- Proxy forwards to Controller

Front-end

Proxy   Detector   Tag

Firmware

- Tag
  - Mostly in low power state
  - Periodically wakes up to broadcast
- Detector
  - Listen for messages from tags and other detectors
  - Controlled flooding
  - Collision avoidance via time division
- Proxy
  - Listens for messages from detectors
  - Forwards messages to Controller
- Generally
  - All speak a common message format which includes
    - Battery Information
    - Infrastructure for a more sophisticated routing protocol
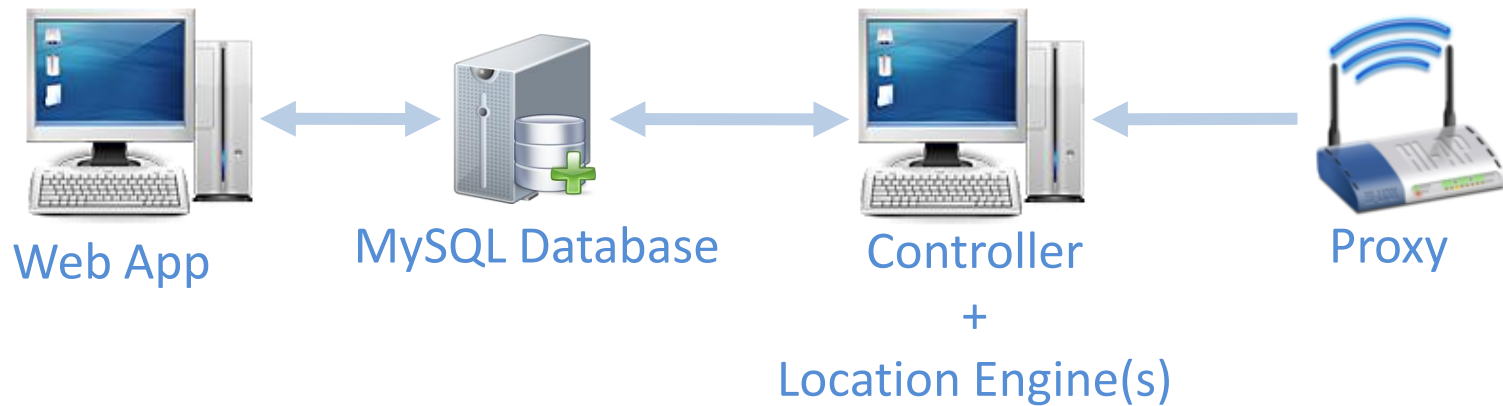   - Fixed length

Agenda

- System Overview
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Software

Back-end

Web App   MySQL Database   Controller
+
Location Engine(s)   Proxy

Software

- Controller
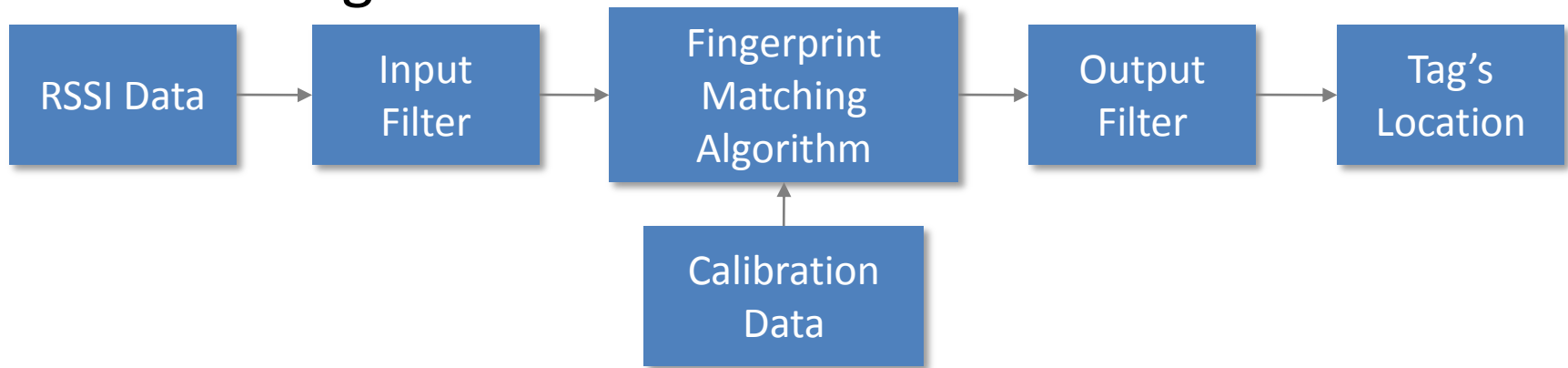 - Collects data from Proxy
  - Feed data to Location Engine
  - Two operating modes
    - Calibrating
      - Collects RF signatures at calibration points
      - Stores calibration data in a local database
    - Locating
      - Passes calibration data to Location Engine
      - Collects and sorts data into packets
      - Feeds the packets to Location Engine
      - Stores results in MySQL Database
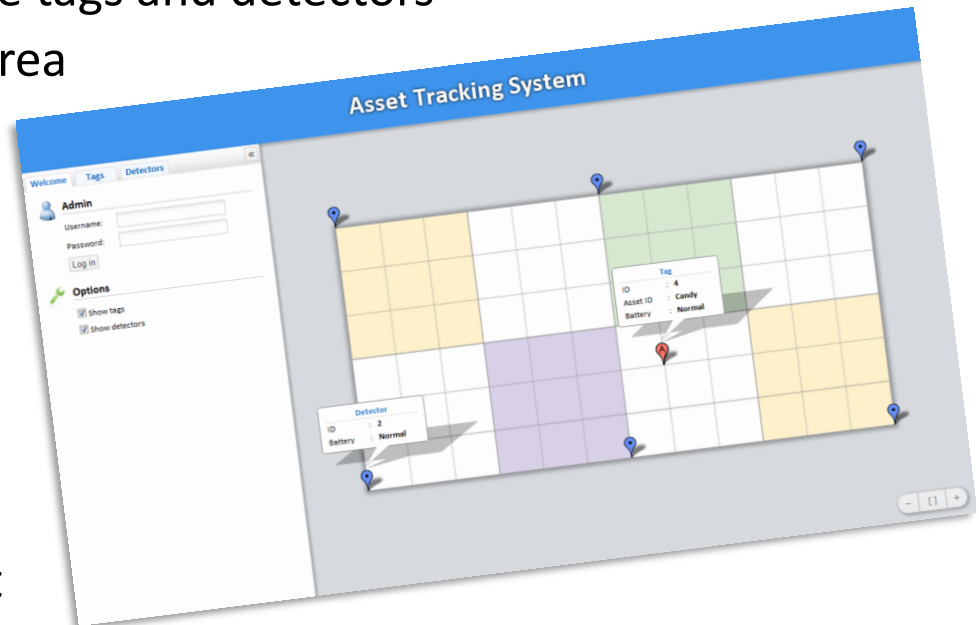
Software

Location Engine

```
┌──────────┐   ┌──────────┐   ┌──────────────┐   ┌──────────┐   ┌──────────┐
│ RSSI Data│──▶│  Input   │──▶│  Fingerprint │──▶│  Output  │──▶│   Tag's  │
│          │   │  Filter  │   │   Matching   │   │  Filter  │   │ Location │
│          │   │          │   │   Algorithm  │   │          │   │          │
└──────────┘   └──────────┘   └──────────────┘   └──────────┘   └──────────┘
                                      ▲
                              ┌──────────────┐
                              │ Calibration  │
                              │     Data     │
                              └──────────────┘
```

- Theory
  - Each location has a unique & consistent RSSI pattern
  - Euclidean distance

$$d = \sqrt{\sum_{i=1}^{N} (RSSI_{li} - RSSI_{ci})^2}$$

- Reduce aliasing by
  - Referencing the nearest detector
  - Interpolating between two closest locations

Software

- **Web App**
  - Functionalities
    - Visualize tags' and detectors' locations
    - Add, modify, and remove tags and detectors
    - Configure the tracking area
  - Design Goals
    - Fast
    - Simple
    - Easy to use
  - Technologies
    - PHP
    - HTML5, CSS3, JavaScript
  - Why Web?

Software

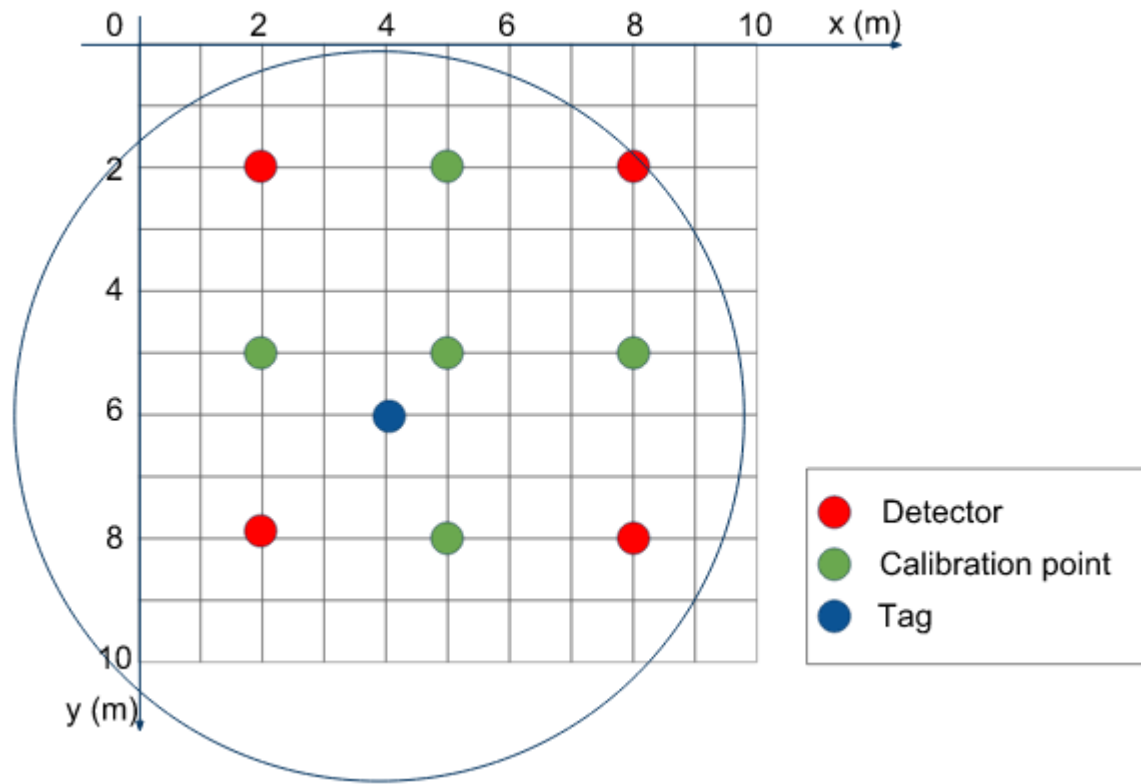- Key points

Agenda

- System Overview

- Hardware

- Firmware

- Software

- **Deployment**

- Results

- Conclusions

Deployment

- Detector placement

- Calibration density

- Each tag has a unique ID with respect to other tags

- Each detector has a unique ID with respect to other detectors

- Proxy possible configurations
  - Proxy must have access to LAN
  - Proxy must create an Ad-Hoc Access point for Controller to connect to
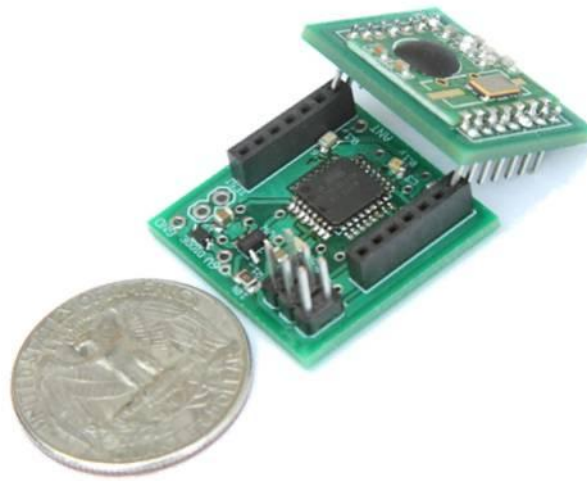
Deployment

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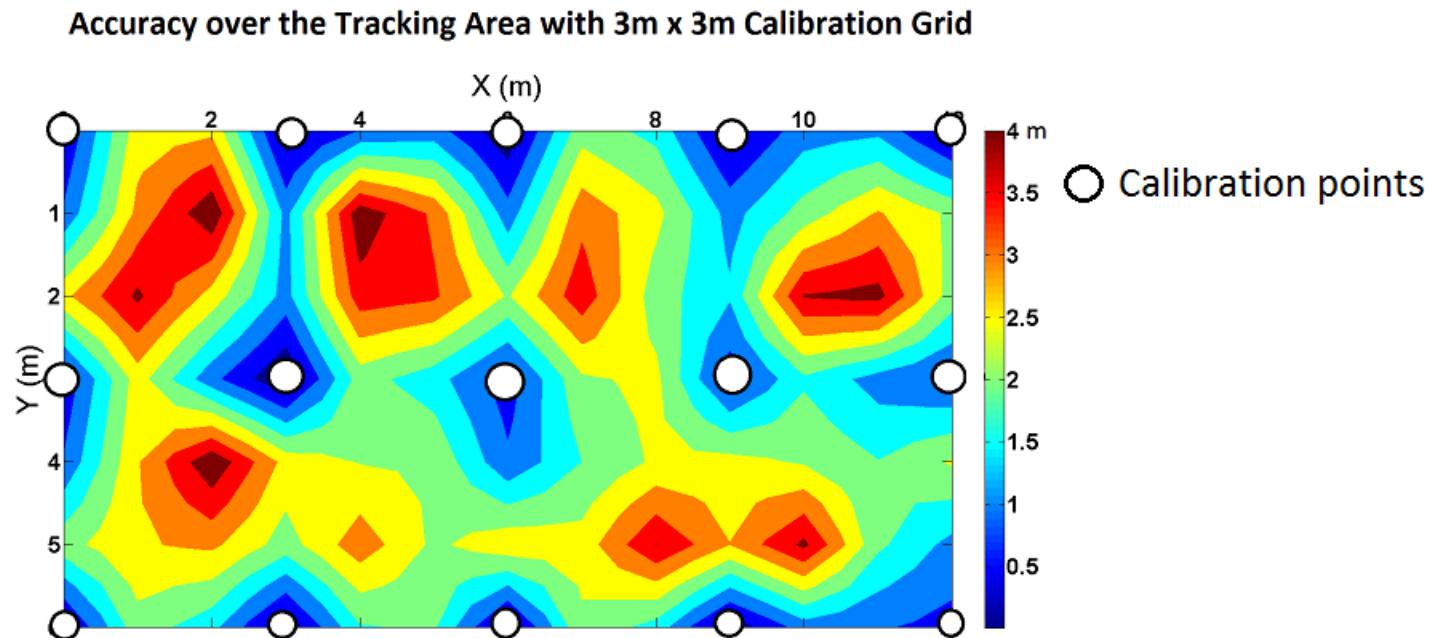
Results

- Size: 1" x 1" x 1"

Results

- Power
  - 240mAh coin cell battery
  - 30mA transmit current
  - 40µA sleep current
  - 1sec broadcast interval
  - 3ms transmit window
  - 0.3% duty cycle

$$Lifetime = \frac{240mAh}{30mA \times 0.3\% + 40\mu A \times 99.7\%}$$
$$= 1,847hr$$
$$= 76 \; days$$

Results

- Accuracy
  - Average 2m
  - Less than 1m at calibration points

Accuracy over the Tracking Area with 3m x 3m Calibration Grid

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- **Conclusions**

Conclusions

- Antenna design
- More testing
  - Calibration density
  - Detector placement
- Improve testability
- Different algorithms
- Environment & signal strength

Acknowledgement

- Professor Robert Daasch
- Alfonso Pereira & Sameer Ruiwale