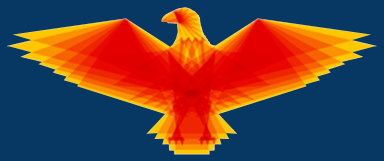
Eagleye: Personnel Tracking in an Augmented Reality Environment



Team: sdmay18-34
Client: Optical Operations LLC
Faculty Advisor: Dr. Daji Qiao
Team Members: Chandler Chockalingam, Victor Da Silva, Josua Gonzales-Neal, Logan Highland, Jason Ramirez, Christopher Stapler

Problem Statement

- No way for construction General Contractors (GCs) to view workers in real time
- Personnel and safety issues
- Lost time and money on megaprojects
  - 9 out of 10 go over budget by 50% (McKinsey & Co.)
  - $3.3 million a day lost
- Current systems do not deliver quantity or quality of data needed for decision making
- Leading indicators of safety issues should be more clear to supervisors
  - Construction: 1 in 5 worker deaths in 2015

Source:https://powerhousehub.com/files/image/Wide_hero_images/Construction-Worker-Safety-wide-hero.jpg

What is Eagleye?

- System to track personnel
- Viewable in real time from HoloLens
- Efficient project management tool
- Displays vital data for daily operations

Functional Requirements of System

- **Worker shall wear token on toolbelt**
- System uses site wifi
- Token uses signal strength (RSSI)
- Admin website
- Data storage for future playback

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- **Shall be accurate within 6 meters**
- Battery life = 1 work day (10 hours)
- Real-time, outdoor tracking
- Maintainability - Must be maintainable to allow for future development

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Deliverables

- **A real-time tracking system capable of locating users**
- HoloLens Application that retrieves information from our services and displays a 3D map with personnel tracking
- A modular solution that can be easily modified or upgraded
- Project demo ready for client to show investors

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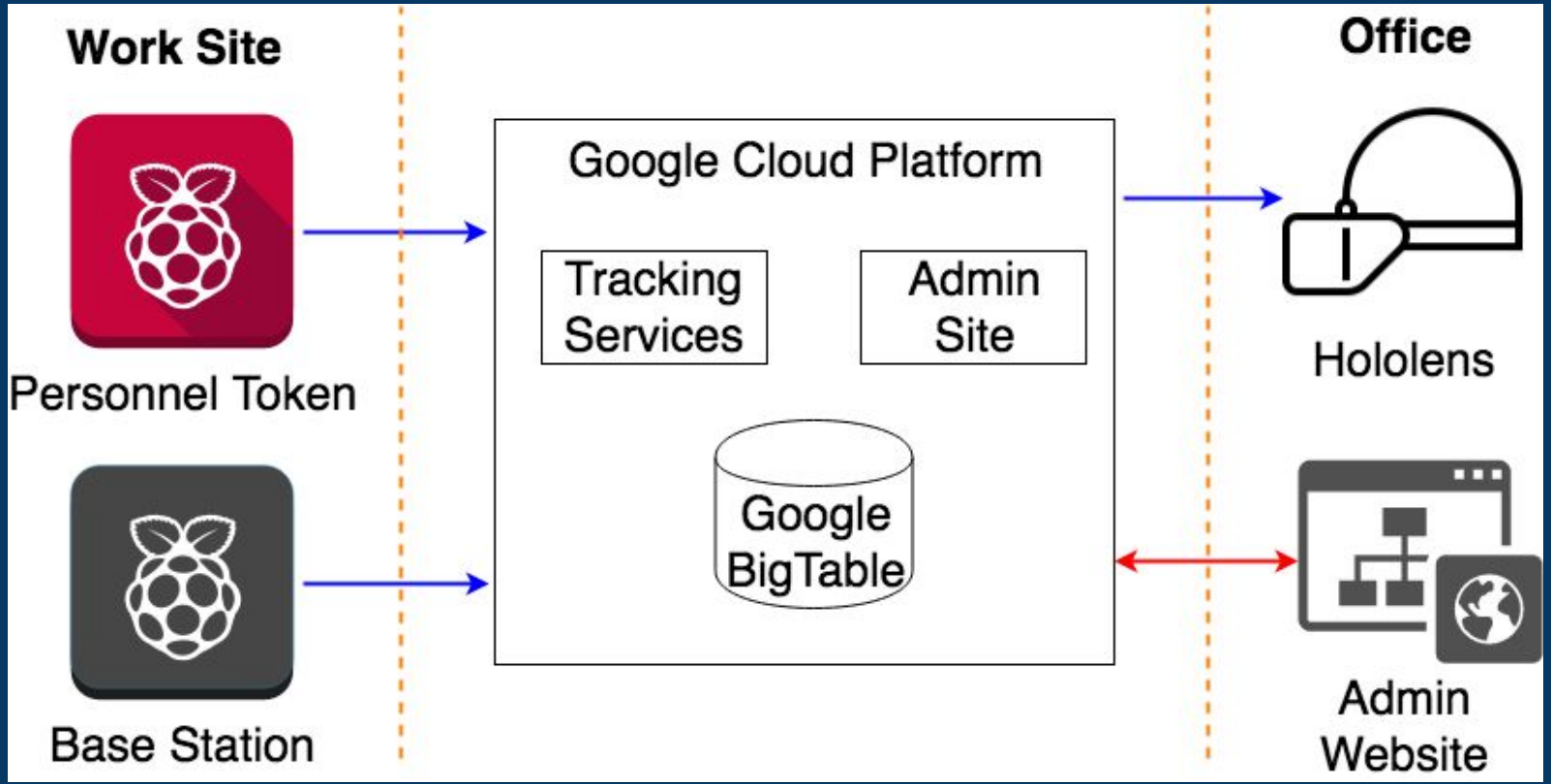
Site Overview

- ISU Startup Factory

- 5 Cisco Outdoor Wireless Access Points

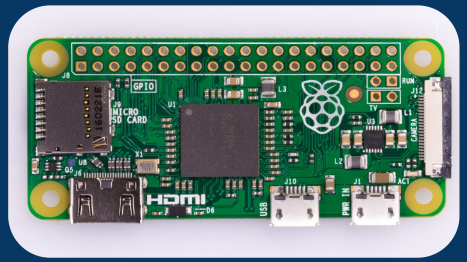
Demo Video

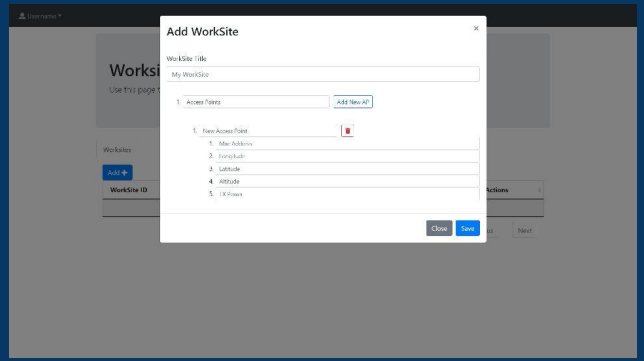
Concept Sketch of Solution



Description of System (Frontend)

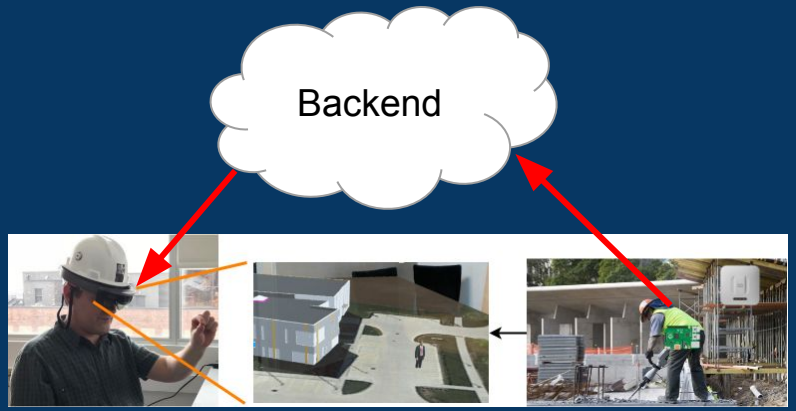
- Work Site Setup Interface
  - Sets up a work site with users and AP settings
- Tracking Device
  - Obtains Wireless Tracking Data (WTD): [(Mac Address, RSSI Value)], Time, UserID, WorkSiteID
- HoloLens Application
  - Uses Augmented Reality to virtually place GC's teams in a virtual work site



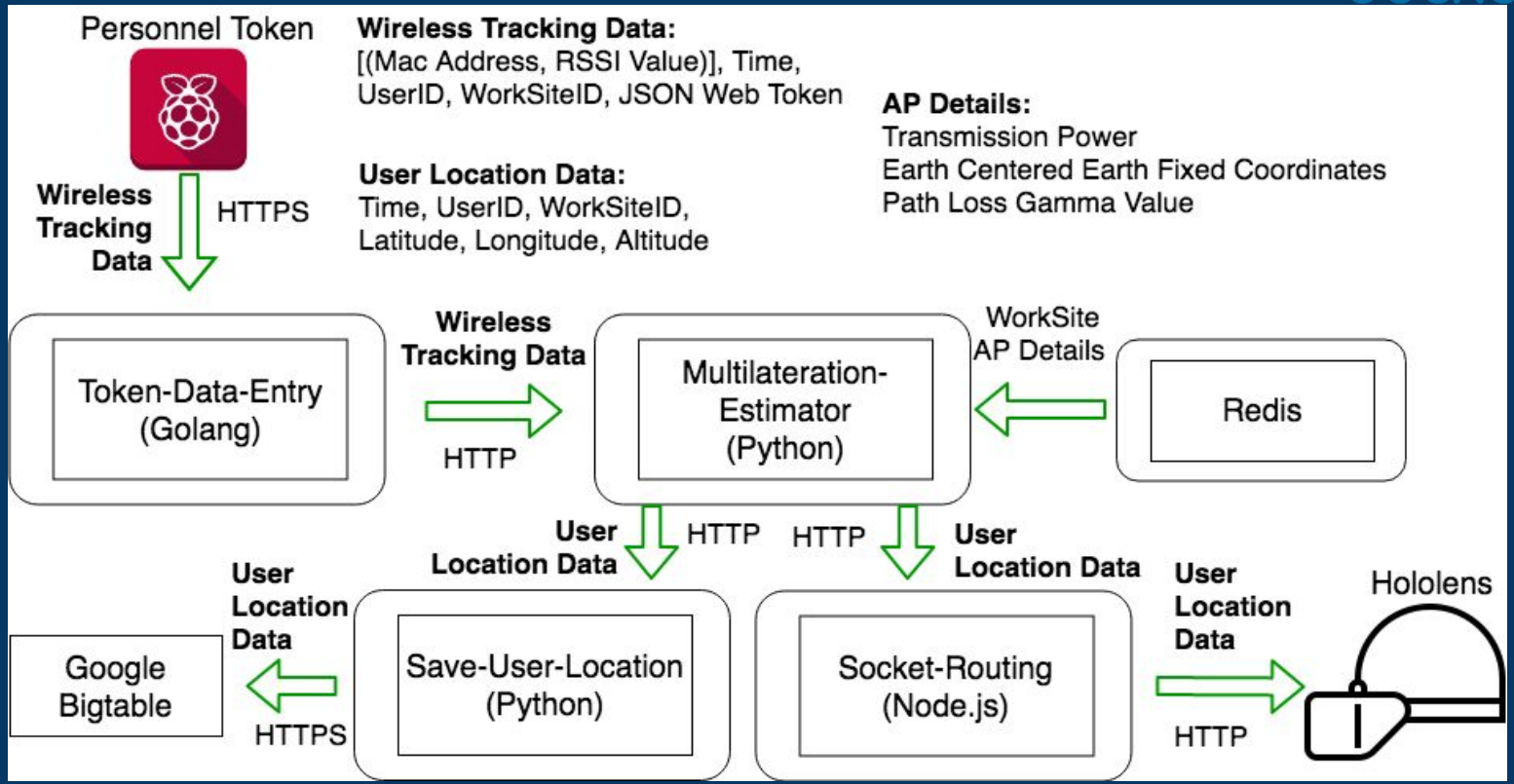


Description of System (Backend)

- Multilateration Service
  - Runs triangulation algorithm to create User Location Data (ULD) from WTD
  - ULD: Latitude, Longitude, Altitude, Time, UserID, WorkSiteID
- Socket Service
  - Sends ULD updates to the general contractor's view of the work site in real time
- Save User Location Data Service
  - Saves ULD in Databases / Google BigTable



Personnel Tracking Dataflow



Tracking

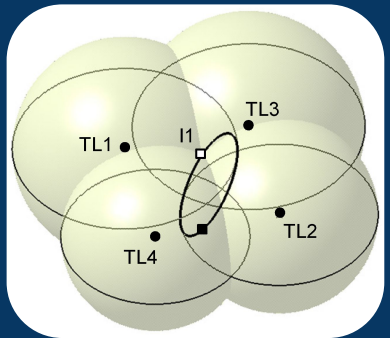
RSSI

- Transform RSSI (Received Signal Strength Indicator) to Distance via path loss function
- d : distance
- n: gamma
- L: RSSI Value
- C: constant

$$L = 10\ n\ \log_{10}(d) + C$$

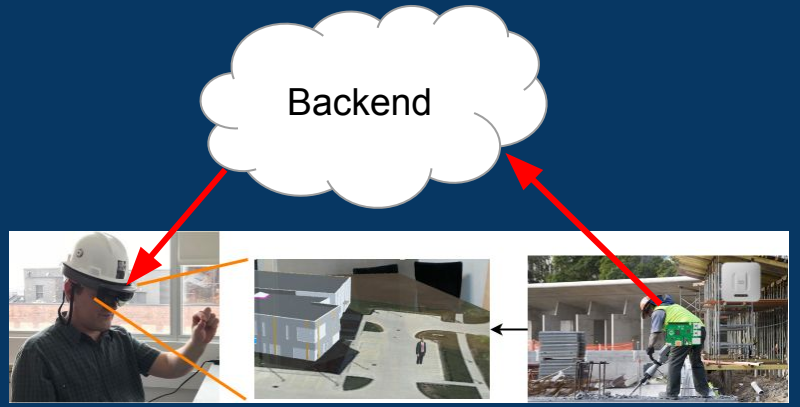
Multilateration

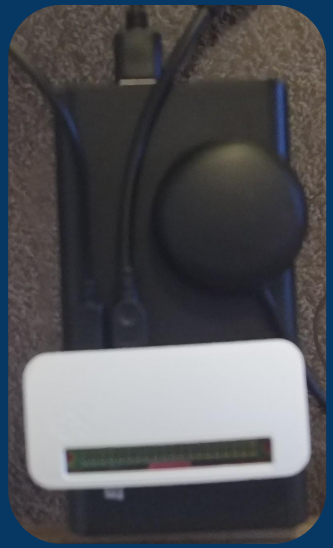
- Since we know where the access point is, and the distance away from each access point, we can run multilateration to get the position



Base Station

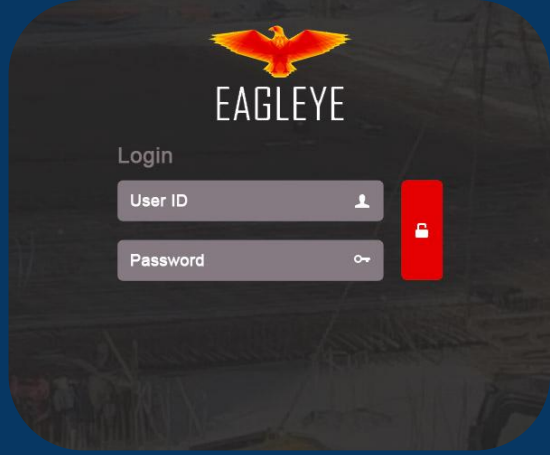
- Takes RSSI readings from multiple different locations
- Knows its location from GPS
- Combines Position and RSSI to get best Path Loss Values from Machine Learning
- Sends updates to Base-Correcting Service

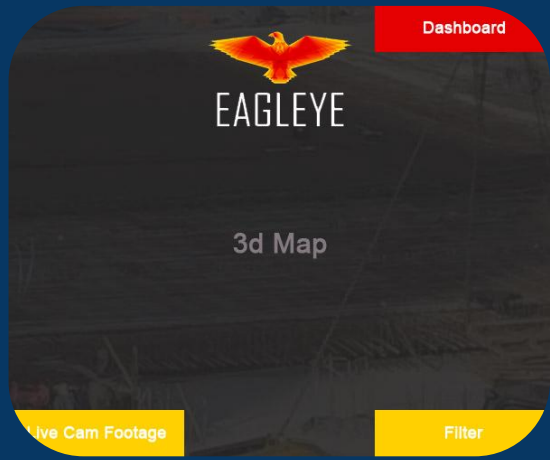




HoloLens Application Overview

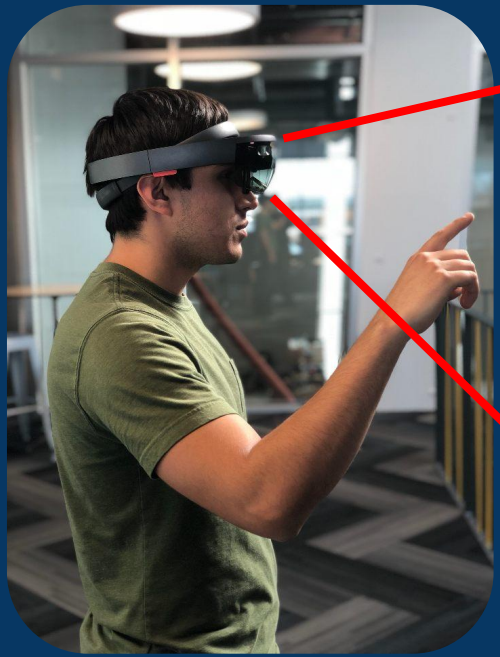
- Login Screen
- Main Application
  - Dashboard Element
    - Filter
    - Dashboard
    - Live Cam Footage
  - Map Element
    - 3D model of ISU Startup Factory
    - 3D Model of a construction worker





Map View

- A bird's eye view of the environment, with personnel moving within that environment

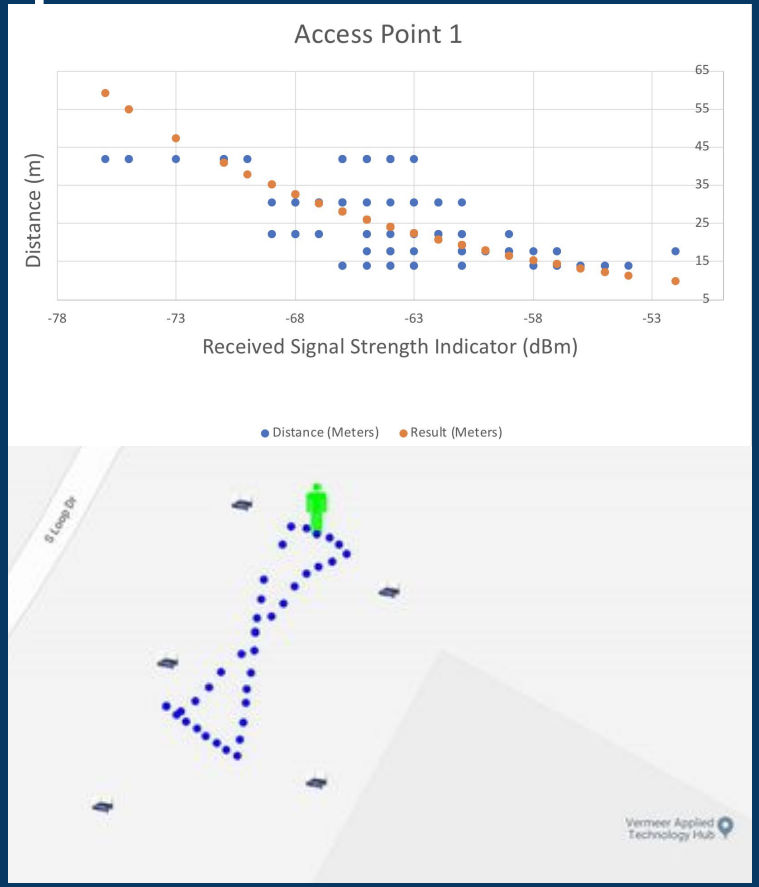


Testing and Evaluation

1. Software Testing
    a. Unit Tests
    b. Wrote software to simulate service usage
2. Hardware Testing
    a. Connectivity testing between Pi, Services, and HoloLens
3. Final Evaluation
    a. Full-system test with all components

Results of Experimentation and Implementation

- RSSI to Distance Tests:
  - Set AP Location, retrieve data
- Simulation Tests:
  - Simulate based on RSSI To Distance Tests
- Full System Test:
  - Setup:
    - 5 Access points
    - 6 Raspberry Pis, 3 each per person tracked
  - Accuracy within 6 - 7 meters



Similar Existing Product Comparison

- GAO RFID Personnel Tracking System
  - An enterprise solution for tracking using solely RFID.
- NAViSEER Precision Personnel Tracking System
  - This system uses GPS, but the precision goes down in GPS-denied areas.
- Accuware - Indoor and GPS located tracking components (https://www.accuware.com)

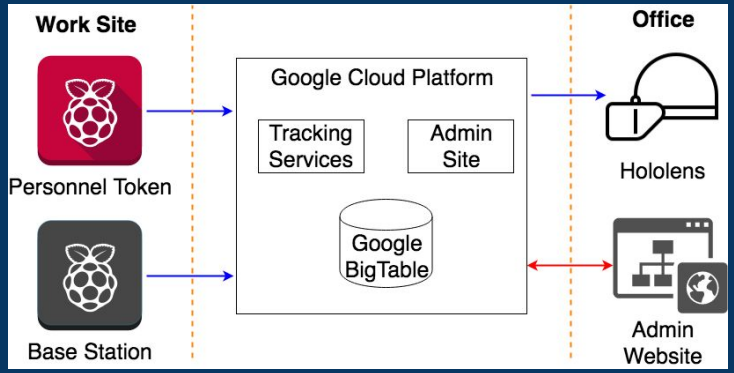
Known Risks Associated with Product

- Privacy concerns and backlash from workers
- Cheaper Alternatives
- Sunken cost on Tracking R&D
- Training general contractors on software

Lessons Learned

- Project timeline and scope can change drastically due to using new technologies (HoloLens)
- Communication is key to making sure client, advisor, and members are in unison
- Realizing sunk cost of time and resources and move forward

Conclusion



- System to track personnel
- Viewable in real time from HoloLens
- Major technologies
  - HoloLens, Raspberry Pi Zero, Cisco wireless access points (APs), GCP