Integration of Personnel Tracking in an Augmented Reality Environment

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Client: Optical Operations LLC
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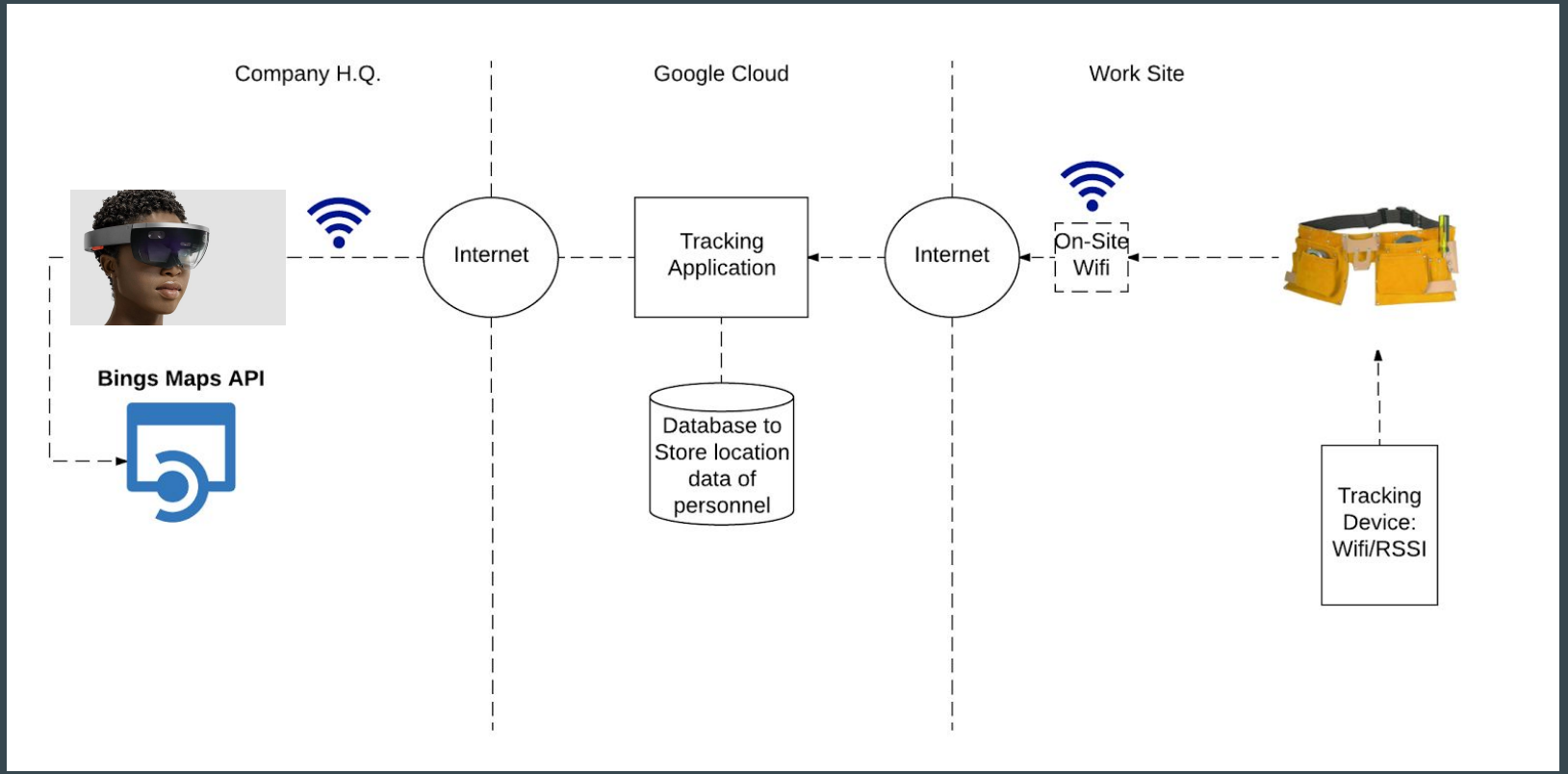
Problem Statement

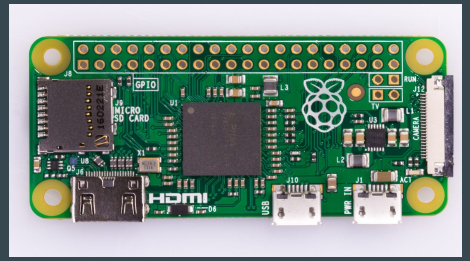
- No way for construction General Contractors (GC's) to view the workers on their sites in real time
- Lost time and money on megaprojects
  - 9 out of 10 go over budget (McKinsey & Co.)
  - $3.3 million a day lost
- Current systems do not deliver quantity or quality of data needed for strategic decisions
- Leading indicator of safety issues should be more clear to supervisors

Concept Sketch of Proposed Solution



Description of Proposed System (Frontend)

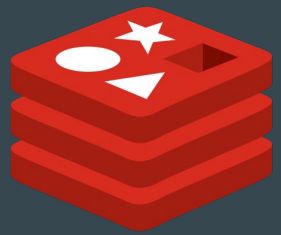
- Tracking Device
  - Obtains Wireless Tracking Data (WTD): [(Mac Address, RSSI Value)], Time, UserID, WorkSiteID
- Work Site Setup Interface
  - Sets up a work site with users and AP settings
- Hololens Application
  - Uses Augmented Reality to virtually place GC's teams in a virtual work site



Description of Proposed System (Backend)

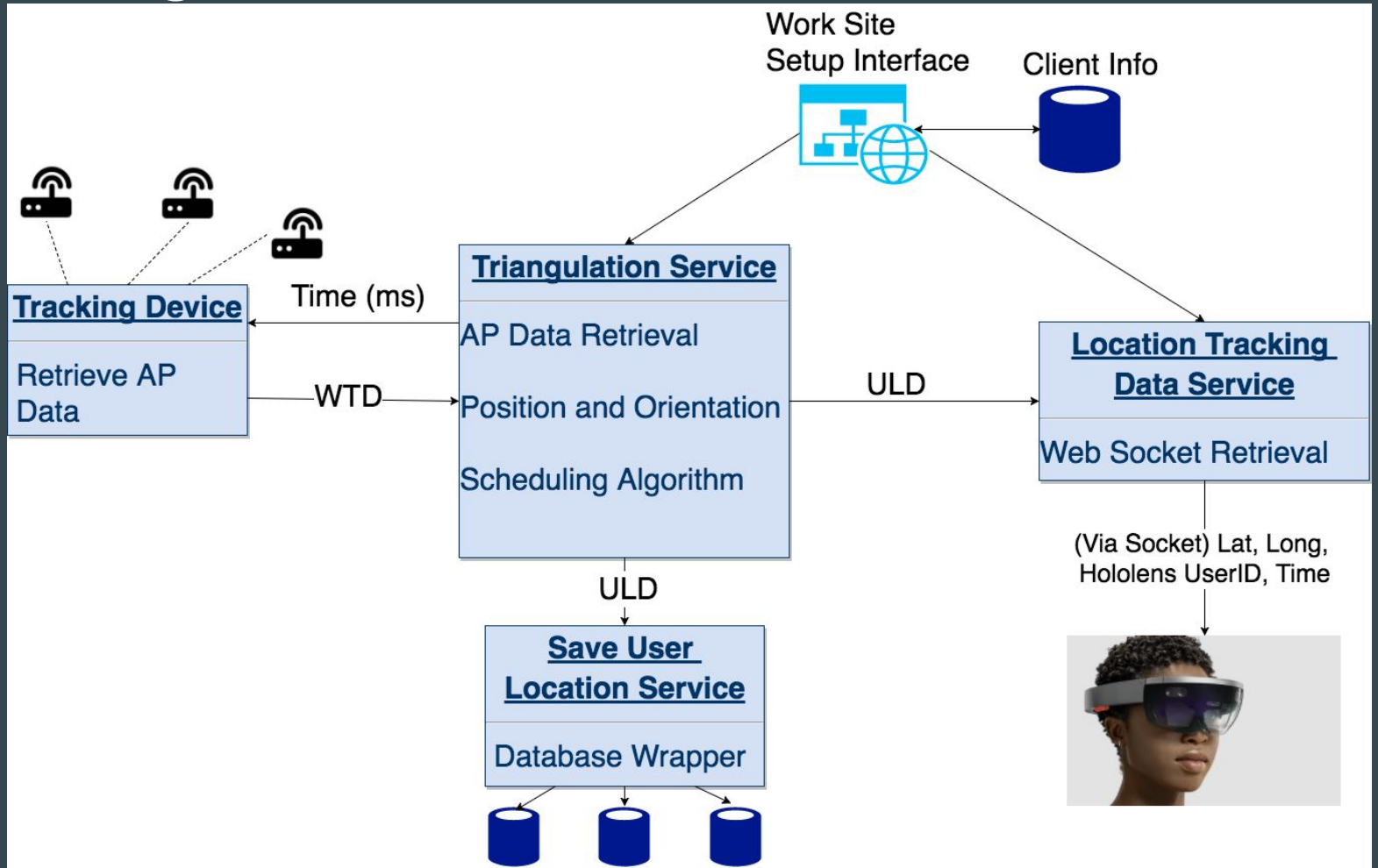
- Triangulation Service
  - Runs triangulation algorithm to create User Location Data (ULD) from WTD
  - ULD: latitude, longitude, Time, UserID, WorkSiteID
- Location Tracking Data Service
  - Sends ULD updates to the general contractor's view of the work site in real time
- Save User Location Data Service
  - Saves ULD in Databases

Google Cloud Platform



redis

Block Diagram

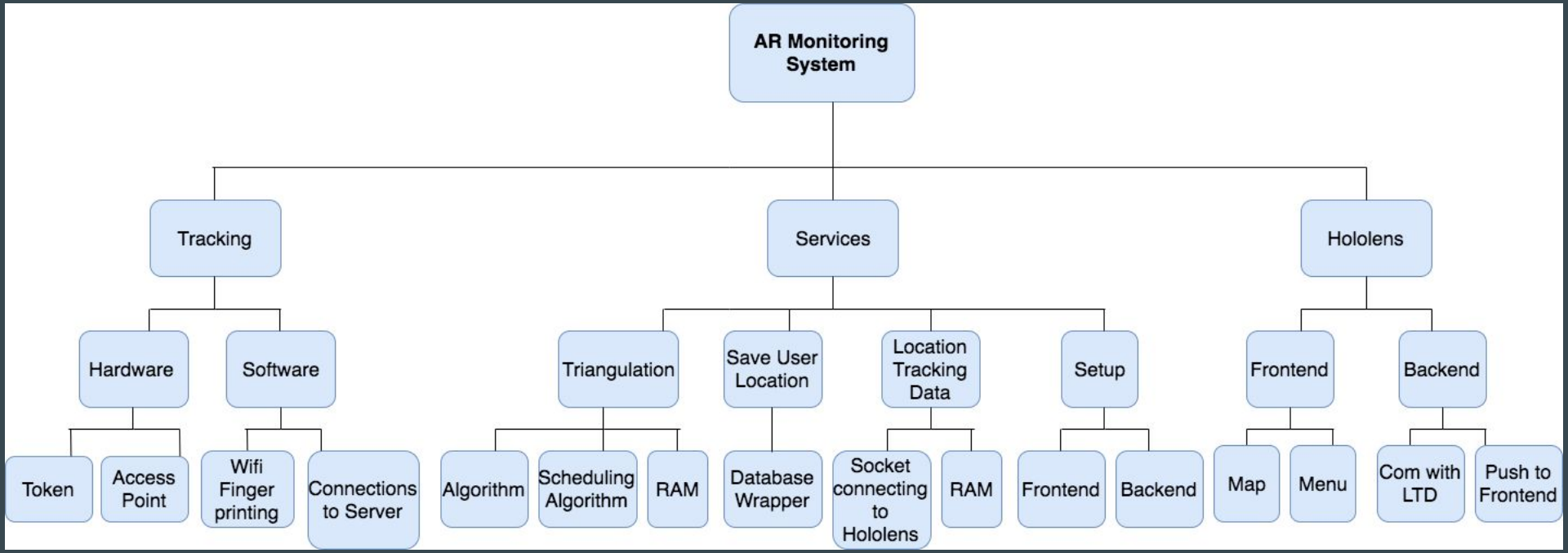


User Interface Description

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

(Minecraft Hololens Demo)

Functional Decomposition of Proposed System



Analysis of Proposed System

- Areas to Improve
  - System component dependency
    - Modularize our Triangulation Service -> more services
  - Setup may be long and error-prone
    - Create website in accordance with proper setup process
- Areas of Strength
  - Data obtainable with a closed wifi network
  - Scaleable for several worksites
  - Platform to be added on to in the future
  - Hololens over HTC Vive or Oculus Rift

Functional Requirements of Proposed System

- Must track >6 people in a playground-sized environment (20 x 20 m)
- Must be accurate within 5 meters
- Battery life = 1 work day (10 hours)
- Sensor communication range: >10 m

Nonfunctional Requirements of Proposed Solution

- Scalability - Create a system that is scalable for use in megaprojects (projects greater than 1 billion dollars)
- Security - Tracking data and other systems should be inaccessible to unauthorized users
- Maintainability - Must be maintainable to allow for future development

System Specifications

- User Interface Specification:
  - Hololens application displays map with personnel scattered across the map in their respective locations
- Hardware Specification:
  - Hololens, Raspberry Pi Zero, and Cisco wireless routers
- Software Specification:
  - Python for the Raspberry Pi and C# for the Hololens

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.

Deliverables

- A real-time tracking system capable of locating at least 6 different 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

Testing and Evaluation Plan

1. Software Testing
    a. Unit tests for each software module
    b. Integration testing covering all requirements
2. Hardware Testing
    a. Connectivity testing between tracking nodes and access points
    b. Functionality testing in with multiple conditions
3. Final Evaluation
    a. Full-system tests on a controlled site

Results of Experimentation and Implementation

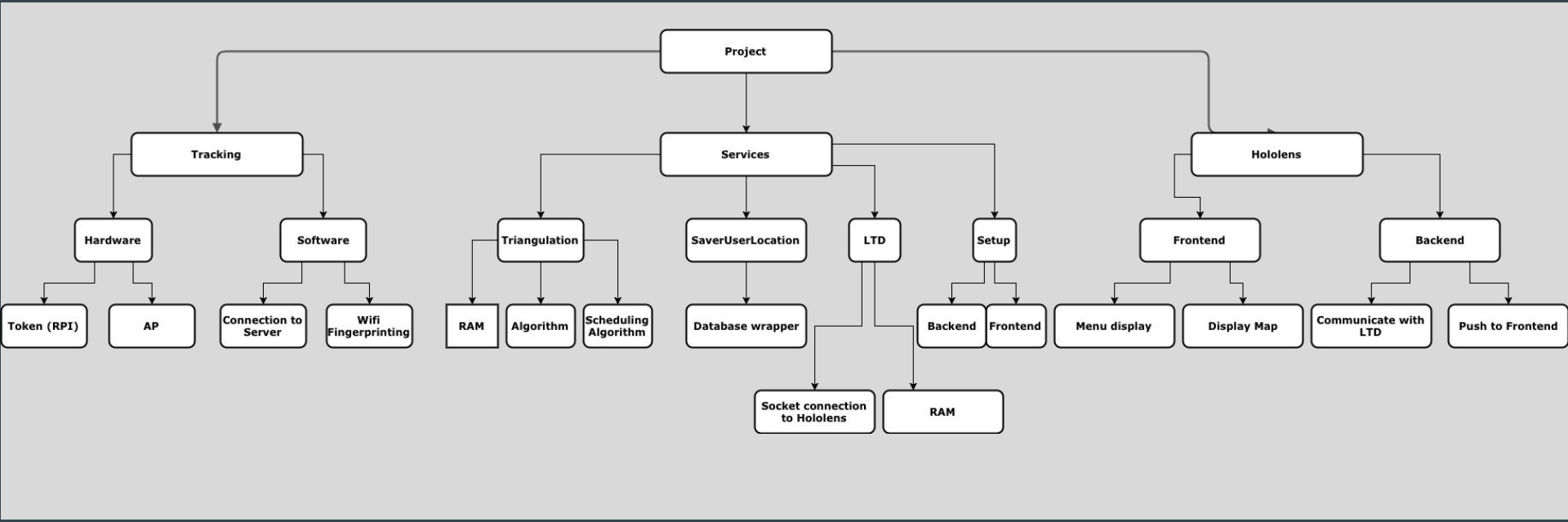
Issues that we ran into experimenting with Channel State Information (CSI):

- Configuration issues
- Only can receive CSI from unencrypted networks
- Determining what CSI belongs with what device
- Limited time to get solution working

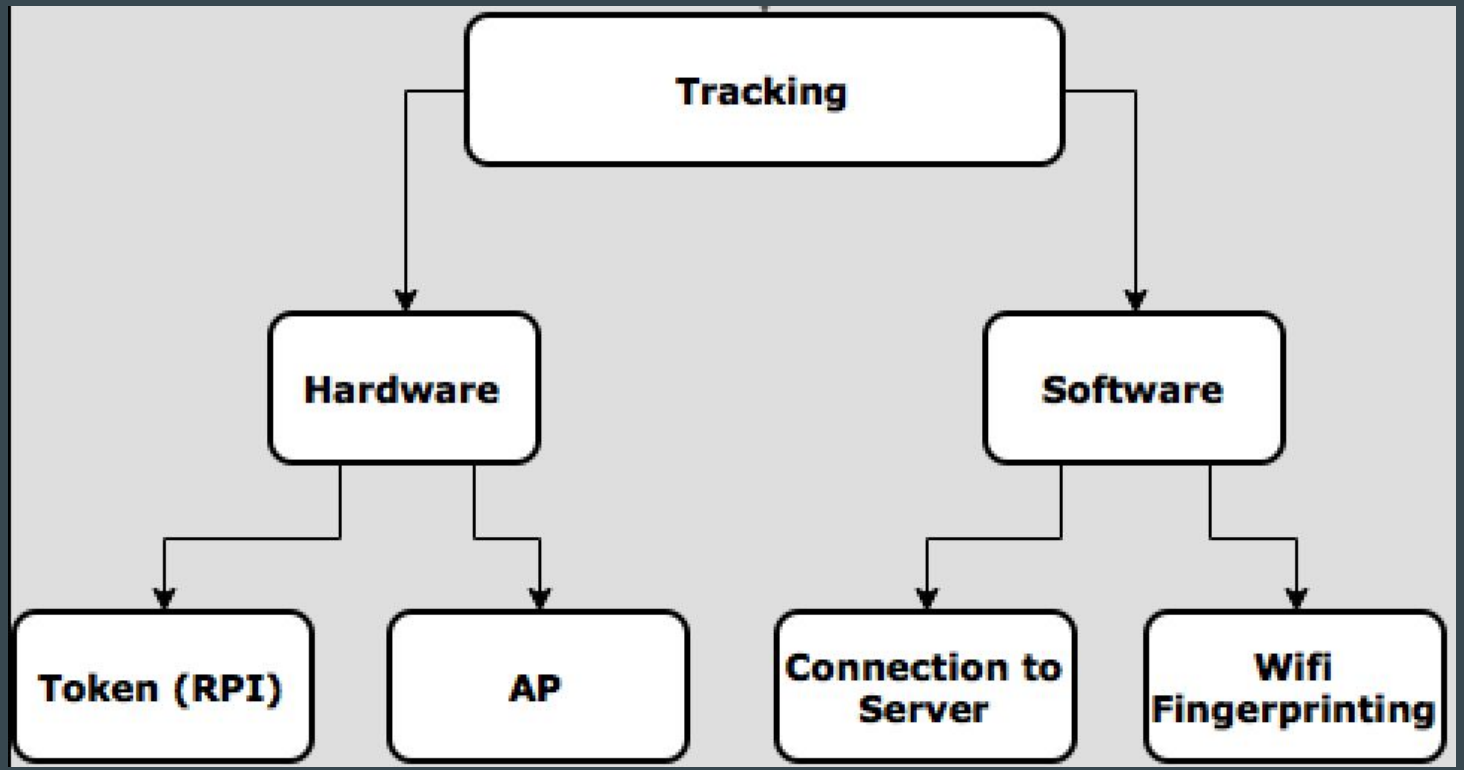
Resource Requirements

- Microsoft Hololens
- Raspberry Pis
  - With wireless chipset
  - With a dedicated battery
- 1 Server
- Access Points
  - Provided by outside service (Cisco and Verizon)
- Internet Access
  - Provided by external resource

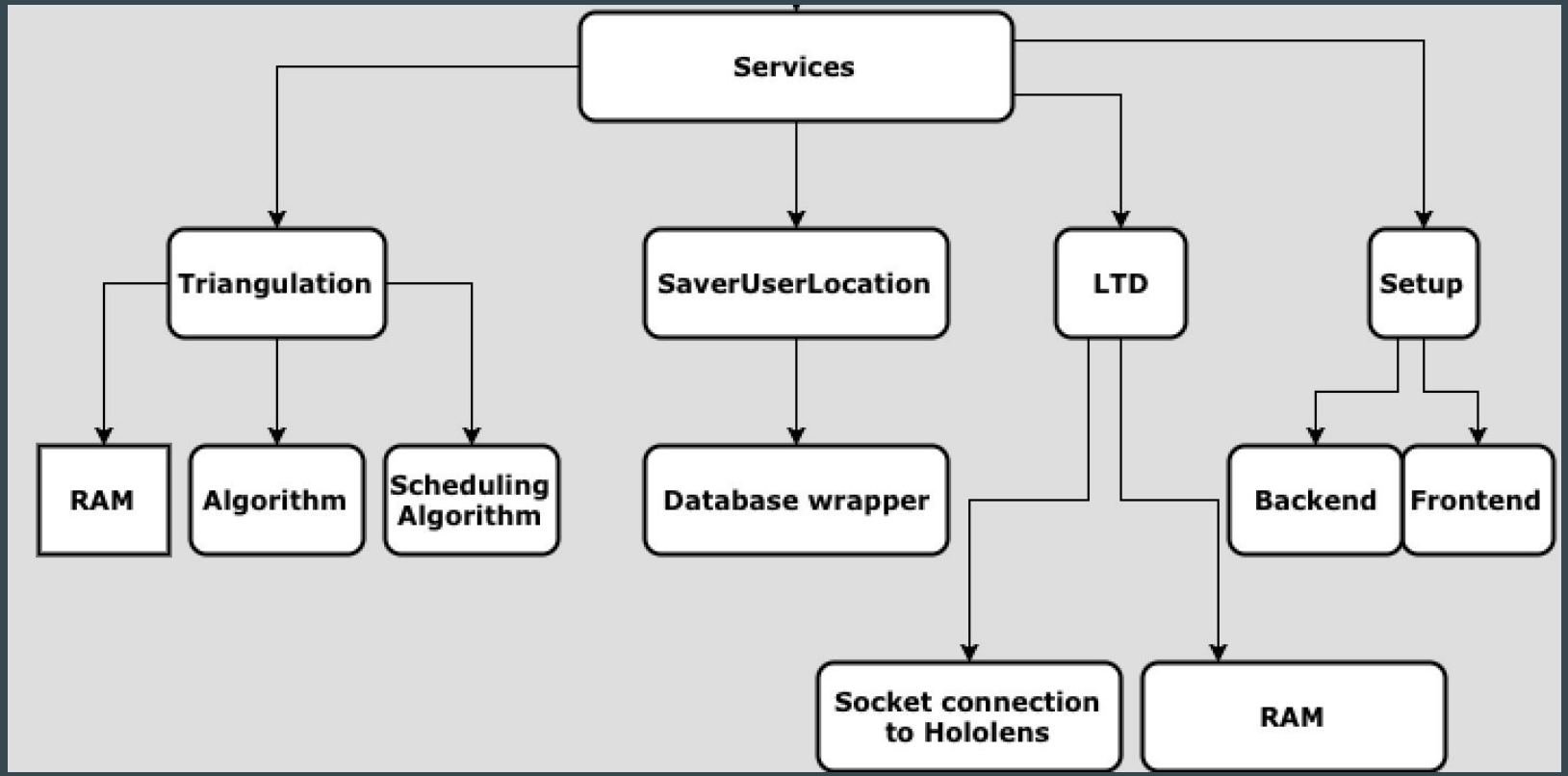
Work Breakdown Structure



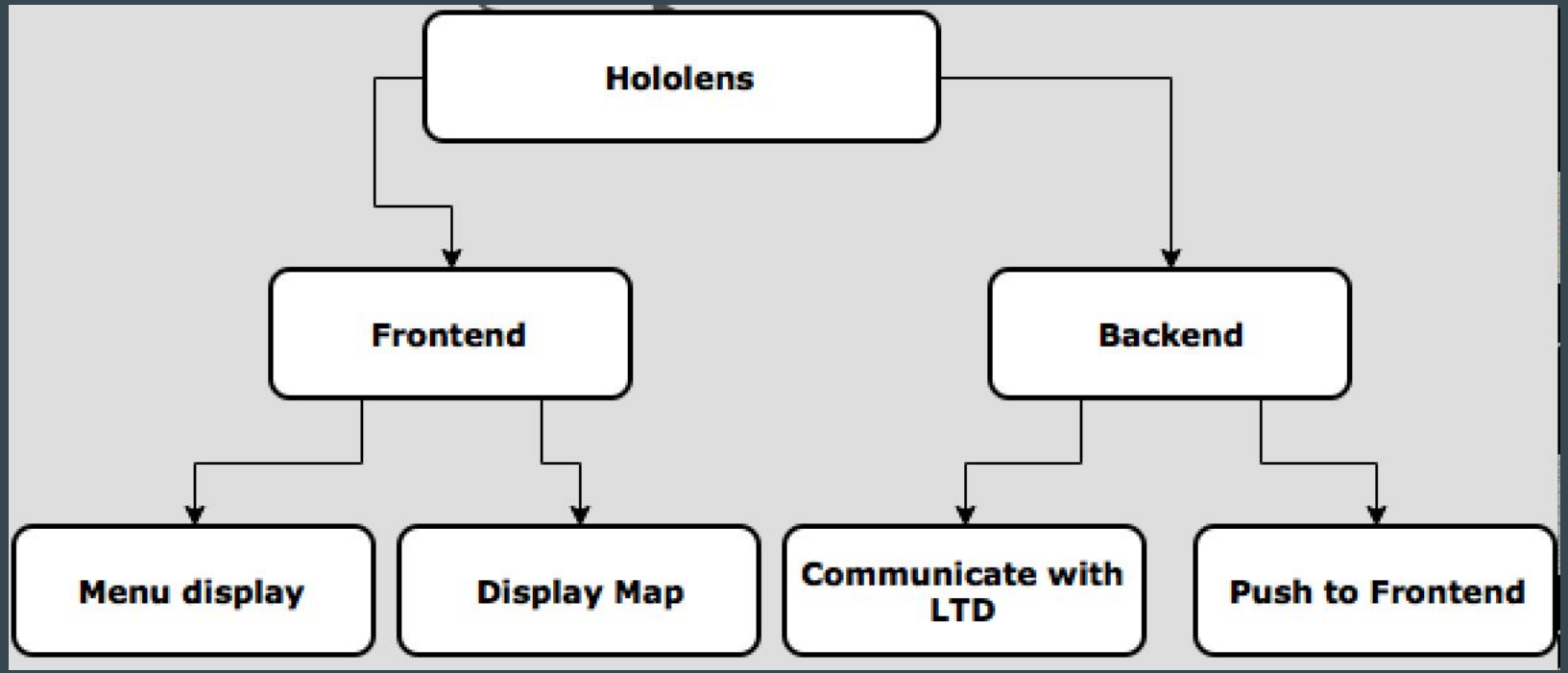
Tracking


Tracking
Hardware
Software
Token (RPI)
AP
Connection to Server
Wifi Fingerprinting

Services


Services
Triangulation
SaverUserLocation
LTD
Setup
RAM
Algorithm
Scheduling Algorithm
Database wrapper
Backend
Frontend
Socket connection to Hololens
RAM

Microsoft Hololens



Project Schedule

- Set up server, configure Raspberry Pis, start Hololens Application- Jan. 19th
- Complete proof of concept Wi-Fi triangulation localization solution - Feb. 9th
- Create Prototypes - Feb. 23rd
- Test and improve tracking system and Hololens application - Mar. 9th
- Integrate tracking system and Hololens application - April 13th
- Prepare for the final demo - April 20th

Risks and Mitigation Strategies

- Going above allotted budget
  - Mitigation: Report to client about current budget and necessary need of additional equipment to continue with the project
- Unable to complete project deliverables
  - Mitigation: Review and communicate with advisor and client to re-evaluate expectations/deliverables, adjust timeline, and move forward with new expectations
- Project members become unavailable
  - Mitigation: Communicate with all members to pick up slack and finish desired tasks
- Inexperience in the software implementation
  - Mitigation: Read, learn, research, and test software that you will encounter. Google it.
- Investing in experimental technologies
  - Mitigation: Communicate with experts in the new technology and get assistance when necessary

Lessons Learned This Semester

- Project timeline and scope is susceptible to untested and new technologies
- Make sure to ask as many questions as possible to advisor and those knowledgeable in the technology
- Communication is key to making sure client, advisor, and members are in unison
- Realizing sunk cost of time and resources and move on

Sources

Nicklas Garemo, Stefan Matzinger, and Robert Palter, “Megaprojects: The good, the bad, and the better,” McKinsey & Company. [Online]. Available: https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/megaprojects-the-good-the-bad-and-the-better. [Accessed: 04-Dec-2017].

Z. Jie, “Research on ranging accuracy based on RSSI of wireless sensor network - IEEE Conference Publication,” IEEE Xplore. [Online]. Available: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5691135. [Accessed: 06-Dec-2017].