DirectMe:
Indoor Navigation System for Visually Impaired People

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Overall Project Goals and Specific Aims

Overall goal

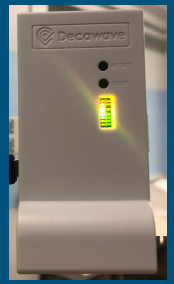
- Provide a voice command system to help blind people navigate in indoor locations

Specific aims

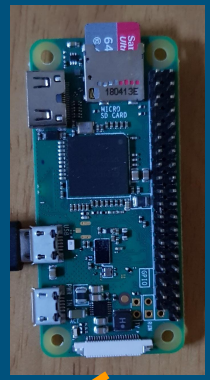
- Implementation of an Ultra-wideband (UWB) real time localization system
- Calculation of shortest path from user’s location to destination
- Android app with speech recognition and text to speech synthesis
- Usage of bluetooth beacons to improve upon accuracy of the system
- Integration of the three subsystems via communication protocols

Technical Approach
System Overview

UWB anchors



MQTT broker



MQTT Protocol

Bluetooth beacon

Android smartphone

- Speech recognizer
- Text to speech
- Beacon interface

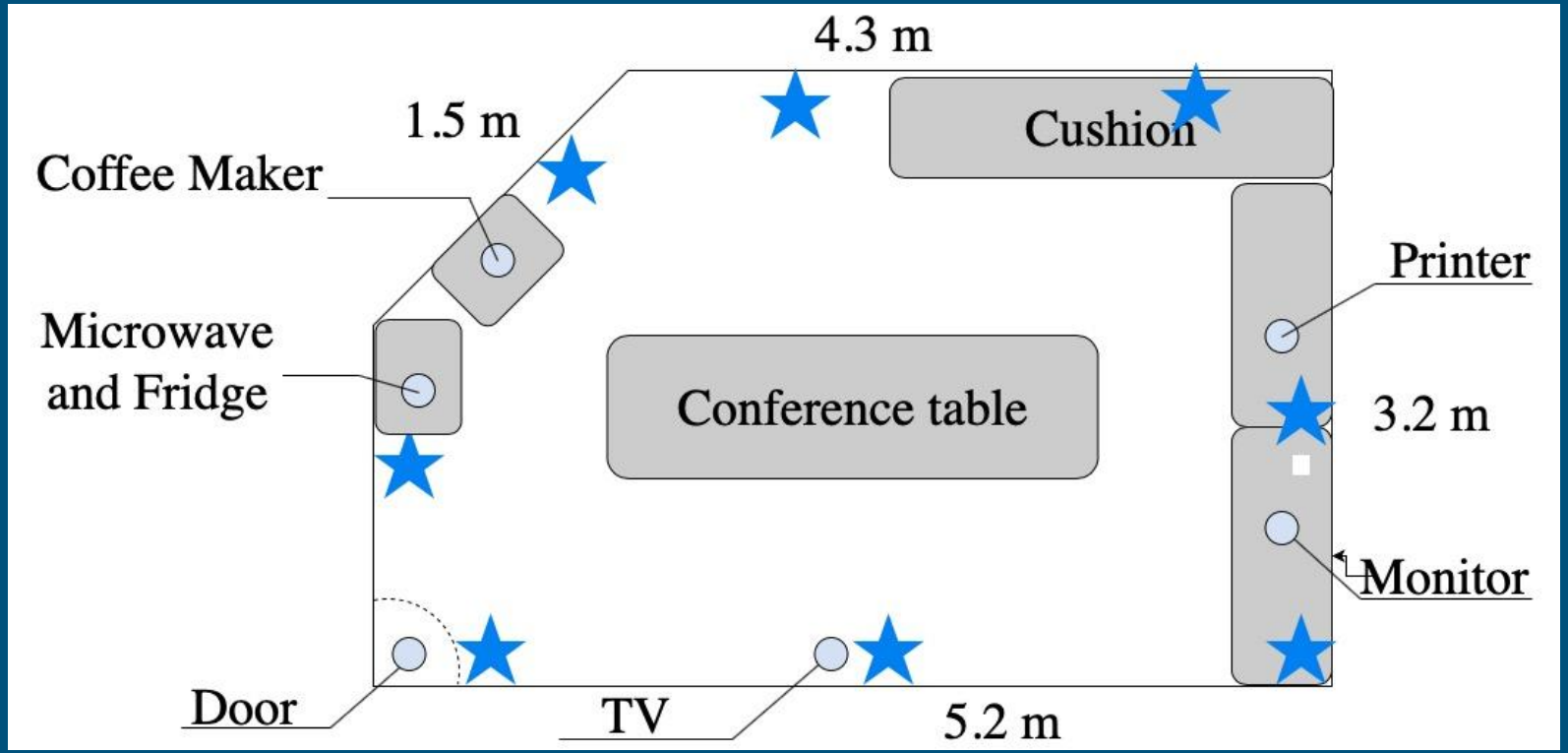
HTTP

Server

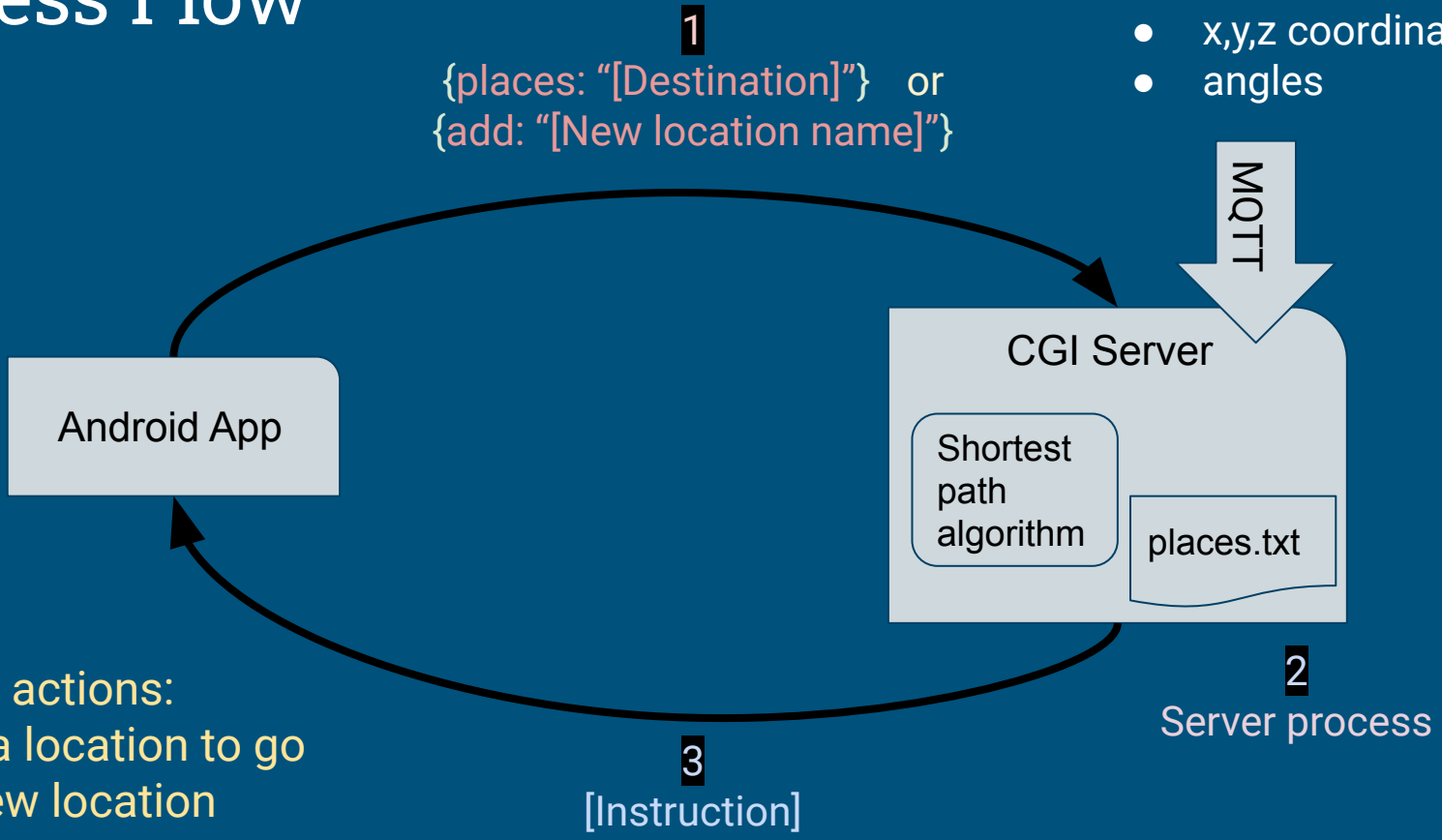
- Shortest path calculation (A*)

MQTT via WebSocket

Technical Approach
UWB Anchors' locations



App - Server Process Flow



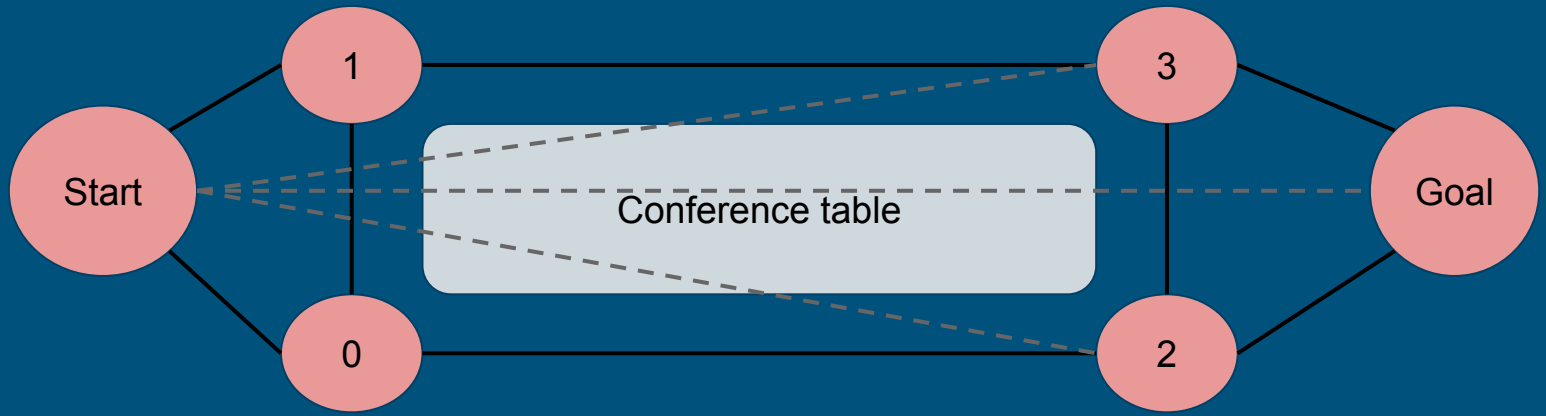
Possible actions:

- Specify a location to go
- Add a new location

Shortest path algorithm

A* with visibility graph

- Nodes correspond to table’s corners
- Only visible connections between nodes are taken into account



Android App - DirectMe

App: “Specify destination or command”

Possible user responses:

1.- “[Destination]”

2.- “Add”

3.- “Pause*”

App: “Walk for *x* meters”
or
App: “Rotate for *y* degrees”

If screen tapped two times:

App: “Specify command”

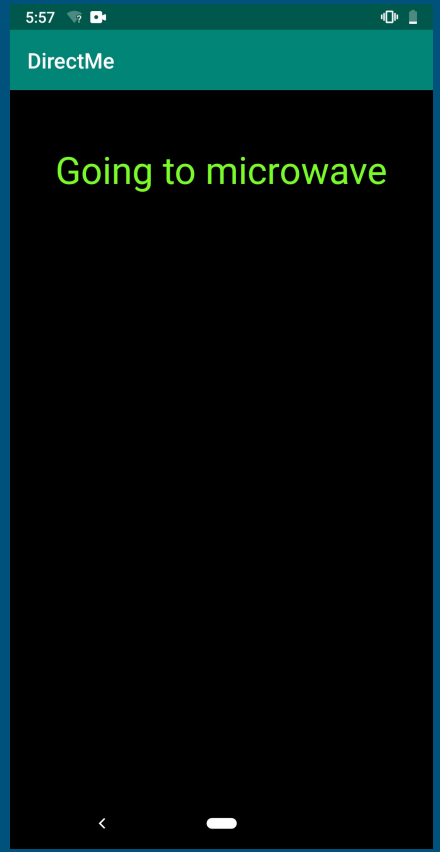
Possible voice responses:

1.- “Add”

2.- “Pause*”

3.- “Return”

4.- “Cancel”



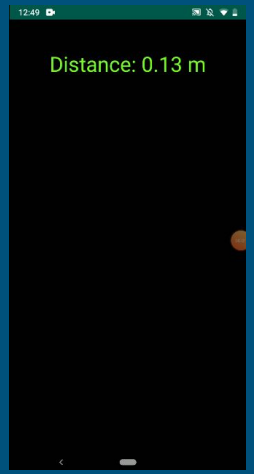
*To resume from Pause :
Double tap the screen

Android App - DirectMe

When user arrives at destination:

App: “You already arrived to your destination”

Bluetooth beacon sensing (used only for the last ~20 cm)



*Tap once to return to main menu

Vibration ~ RSSI

Experimental evaluation

- Measured UWB inaccuracy was reported as 20-30 cm (10 cm in datasheet)
- Inaccuracy due to the UWB anchors placement sometimes makes navigation hard
- Pose estimation factor of ~20 cm in x and y coordinates was calculated and added to properly find the user's body
- Based on testing the wearable on 3 participants, navigation commands were most accurate once the user's arm by his side with BNO055 pointing downward.
- Bluetooth Beacon successfully addressed the inaccuracy due to UWB's error except for the cases where it's placed next to Microwave

Prior work examples and references

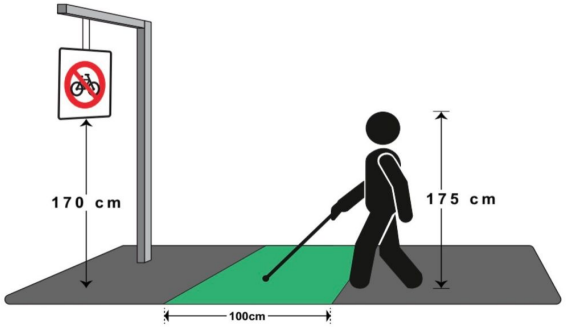
1. Minuet: Multimodal Interaction with an Internet of Things
2. Indoor Positioning for Visually Impaired People Based on Smartphones
3. Analysis of a UWB Indoor Positioning System Based on Received Signal Strength
4. Pozyx: Localization via UWB

Strengths of DirectMe

- The shortest path calculation
- Utilizing Bluetooth beacon to reduce the error rate due to UWB modules
- User friendly App features such as “adding new locations”
- Properly calculating the Pose and taking into account the user’s body median plane.

Limitations and Future Works

- Obstacle avoidance is a must for such system
- Better configuration of UWB anchors
- High dependence on WiFi connection
- More implicit commands → Run user study
- Optimizing the search algorithm → add obstacle avoidance
- Find a better way to increase UWB's accuracy



Detects Obstacles

WeWALK detects obstacles above chest level with an ultrasonic sensor and vibrates when these objects are near.It alerts users if there is low hanging trees, traffic signs, poles and other obstacles.

Project Demonstration

Final Demo

Contribution by each member

1. Amir: Worked on setting up MQTT protocol for receiving data from 9 DOF pose sensor and UWB tag/Anchor system. Wearable hardware development and Overall Github code integration plus building website and video editing.
2. Julian: Worked on the CGI Server for processing data and implemented the A-Star algorithm to find the shortest path. Also helped Riyya with the Android application development.
3. Riyya: Built Android applications like the Text to Speech, Speech to Text converter, sending data to server & beacon and integrated the application to form the final one.

Supplementary