Midway Design Review

Stride
December 8, 2017

Advisor : Professor Tessier

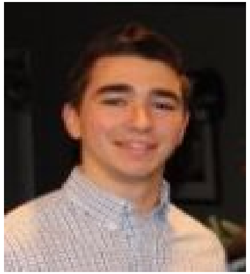
Group Members

Advisor
Prof. Tessier

Richie Hartnett
CSE

Jarred Penney
EE

Joe Menzie
CSE



Jack Higgins
EE

What is the Problem?

- Parkinson's Disease (PD) makes walking challenging
- Physical therapy and other treatments are expensive
- Limited inexpensive methods of monitoring exercises outside of clinical environment

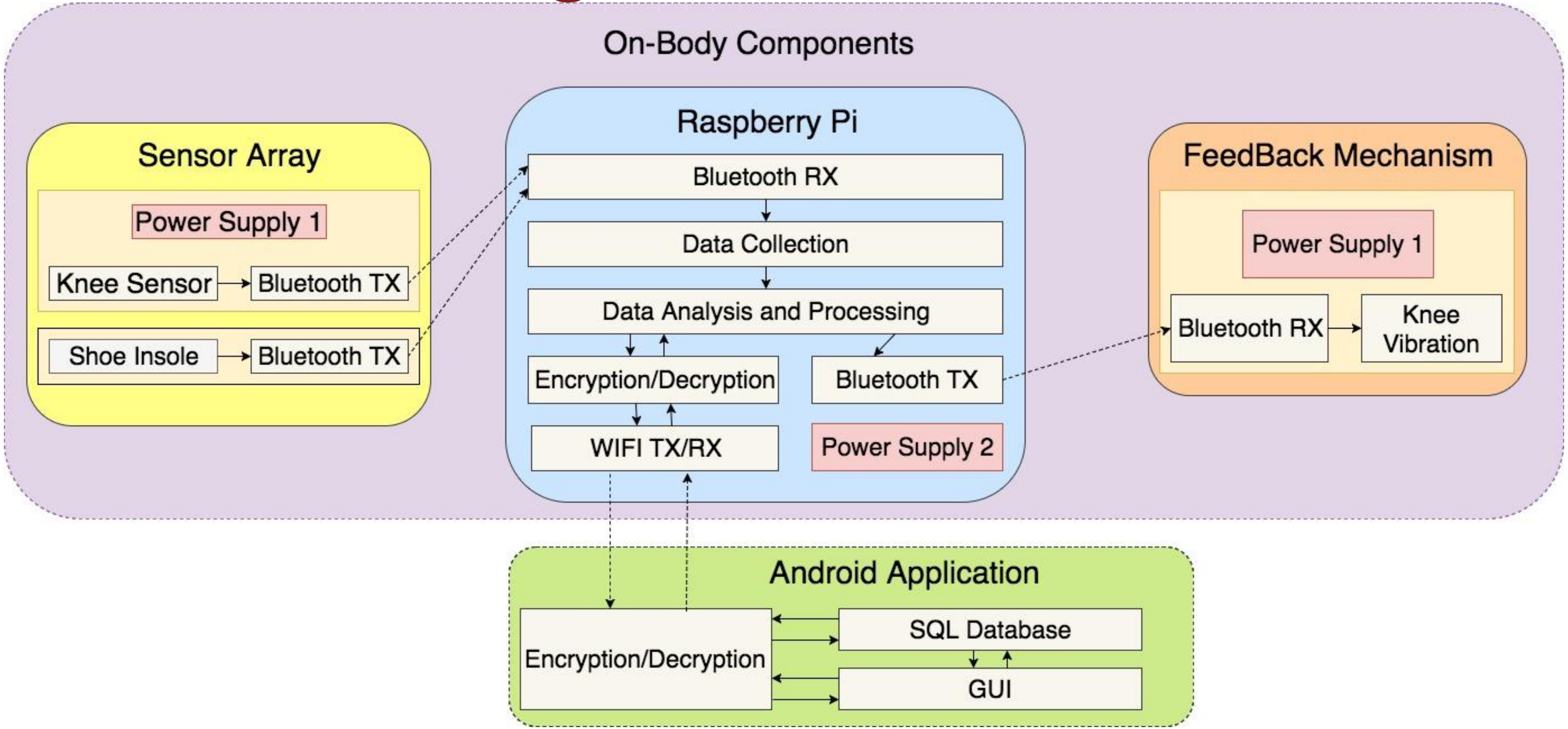
What is Stride?

- Low cost array of wearable sensors that collects body movement information, designed for those with Parkinson’s Disease
- Provide real-time feedback and track long term performance progress
- Used in home as well as in clinical environment

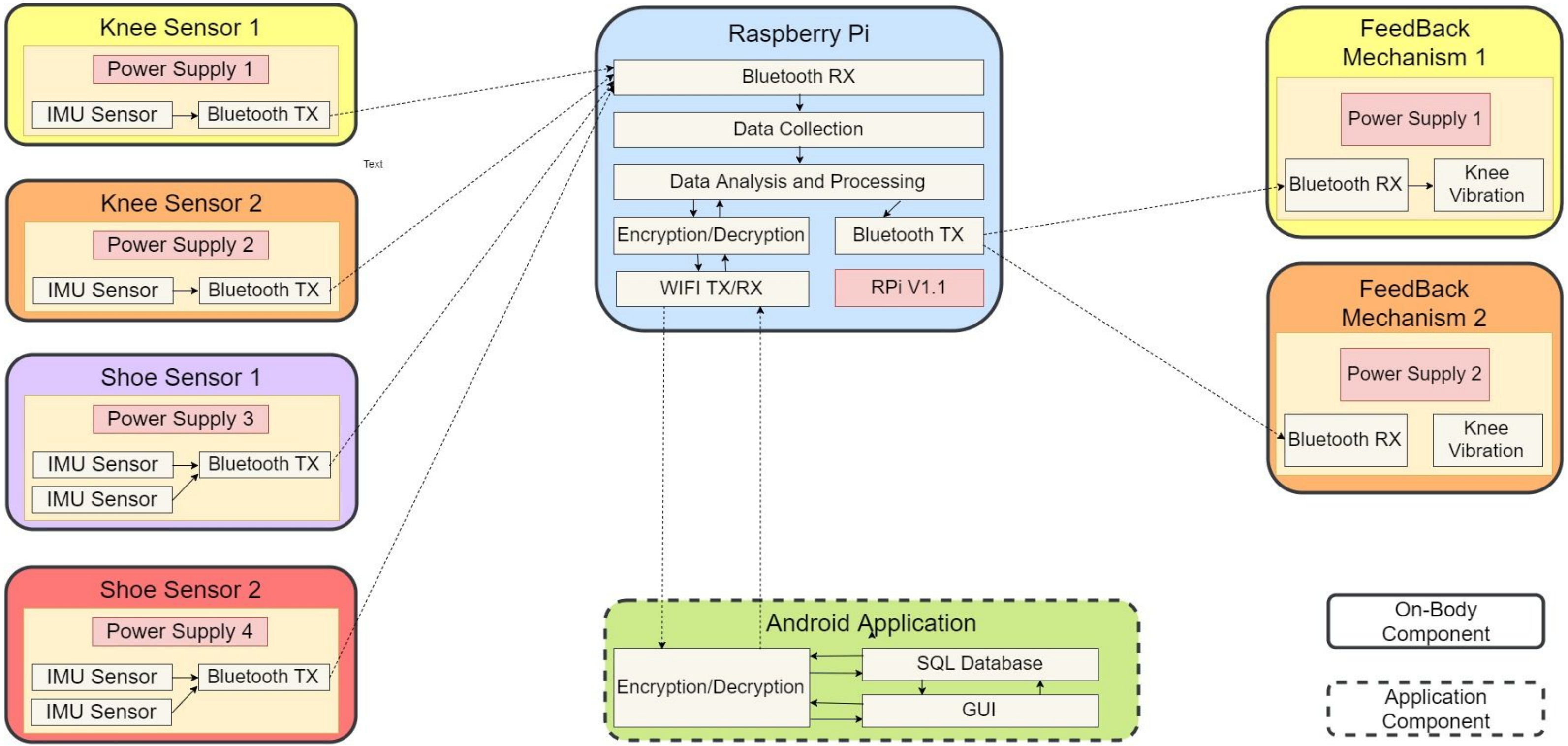
System Requirements

- Accurately collect movement data to appropriately monitor an individual's:
  - Stride length (Within 10% error of Qualisys Oqus Motion Capture System measurements)
  - Cadence
  - Heel-to-toe motion
  - Freezing
- Provide real-time feedback to correct stride length during exercise (less than 100ms)
- Store and display data Android application to track long term patient progress
- Lightweight product that is easy for patient to put on
  - Sensor systems < 1 pound
  - Waist clip (Raspberry Pi + power supply) < 3 pounds
- Sensor systems and Raspberry Pi will have battery life of greater than 2 hours

Previous Block Diagram

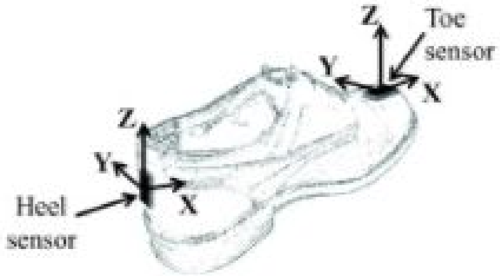


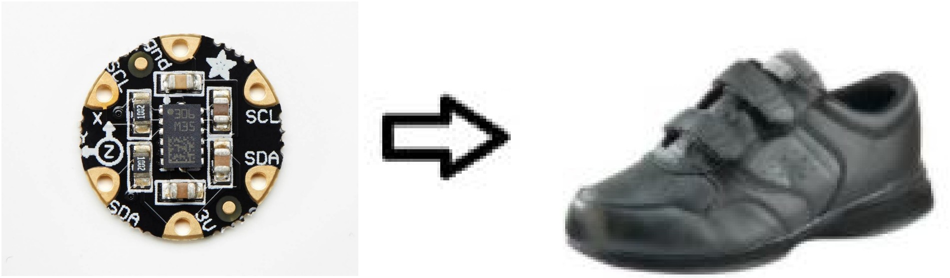
Redesigned Block Diagram



Mechanical Design- Shoe Sensor

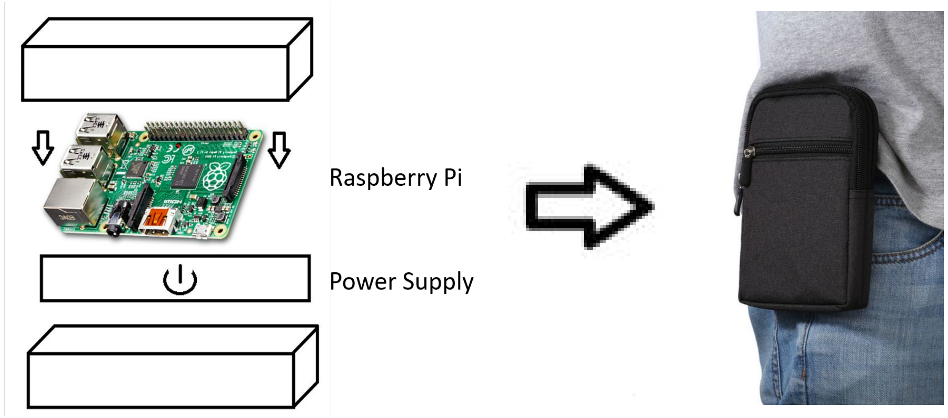
- Easy to put on velcro shoe
- A sensor will be secured on front and rear of each shoe
- Wired to smaller PCB secured on outside of shoe





Mechanical Design- Knee and Belt

- Knee Sleeve
  - Sensor will be on front
  - Wired to small pcb in pocket on back
  - Velcro Strapped for ease of putting on
  - Feedback vibrator on inside of knee



- Waist Clip Box containing:
  - Raspberry Pi
  - Power Supply

PCB Design

- PCB
  - Atmega32u4
    - Processor inside Adafruit Feather
  - nRF51822
    - Bluetooth Module inside Adafruit feather
  - Button Cell Batteries
    - 3V Button Cell batteries
    - 100mAh each
  - Feedback Vibrator

PCB	Shoe	Knee Sleeve
Processor	Atmega32u4	Atmega32u4
Bluetooth	nRF51822	nRF51822
Battery	3V Button Cell	3V Button Cell
Vibration	none	Mini Vibration Motor
IMU	Yes, 2	Yes, 1

Power Source- Raspberry Pi

Raspberry Pi:

- RPi PowerPack V1.1
    - Rechargeable
    - 3.7V
    - 3800mAh
    - Designed specifically for Raspberry Pi 3 Model B
    - “Last about 9 hours”

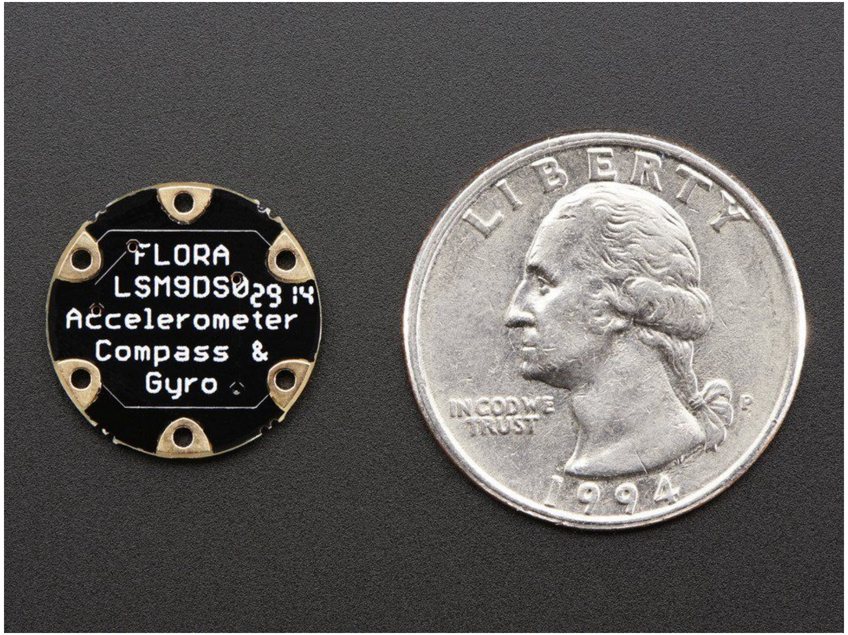
FLORA 9-DOF

- VDD range (2.4-3.6 V)

- 9 DOF IMU
  - 3D Accelerometer
  - 3D Gyroscope
  - 3D Magnetometer

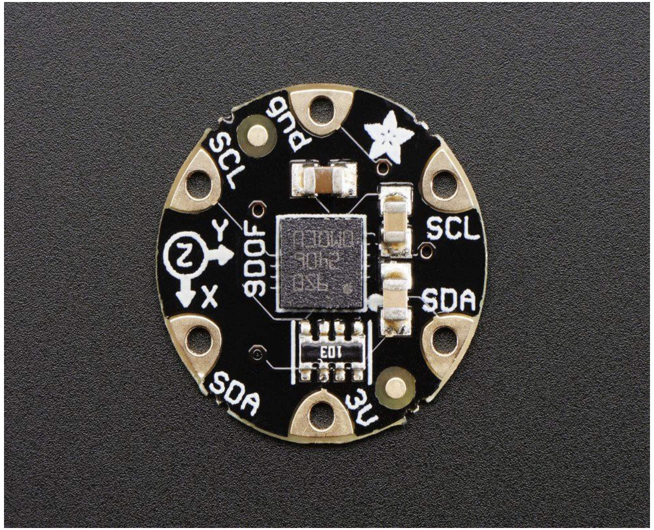
- Small size and weight
  - 16 mm diameter
  - .8 mm thickness

- Easily mounted



FLORA 9-DOF Programming

- Setting individual sensors
  - Enable/Disable degrees of freedom
  - Data rate: 100 Hz
  - Sensitivity levels: +/- 16 g's, 2000 dps
- Reading raw values
  - Read from output registers
  - 2 bytes for each reading (i.e. acceleration in x direction)
- Data Analysis
  - Convert raw values to meaningful data (m/s^2, degrees/sec)
  - More complex operations



Data Analysis

- Handling gyroscope "drift" and noisy accelerometer

Solution 1:
Fuse measurements to compensate

Filtering: Complementary, Kalman

Solution 2:
Reset each gait cycle

Filtering: Low Pass

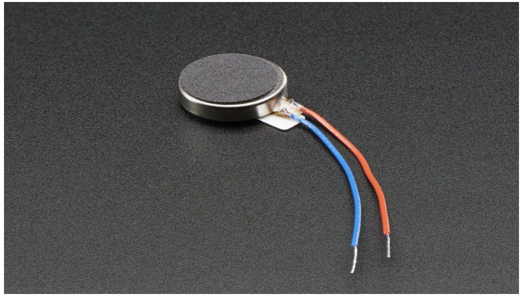
Data Analysis (Cont'd)

- Calculating Parkinsonian performance metrics
- Displacement Method
- Joint Angle Method

Table 1: IMU Measurements and Metrics

	Measurements	Metrics
Knee IMU	Displacement, Joint angle, Segment inclination	Stride length, Cadence
Shoe IMU	Heel strike, Toe strike, Heel-off, Toe-off	Heel-to-toe weight distribution, freezing

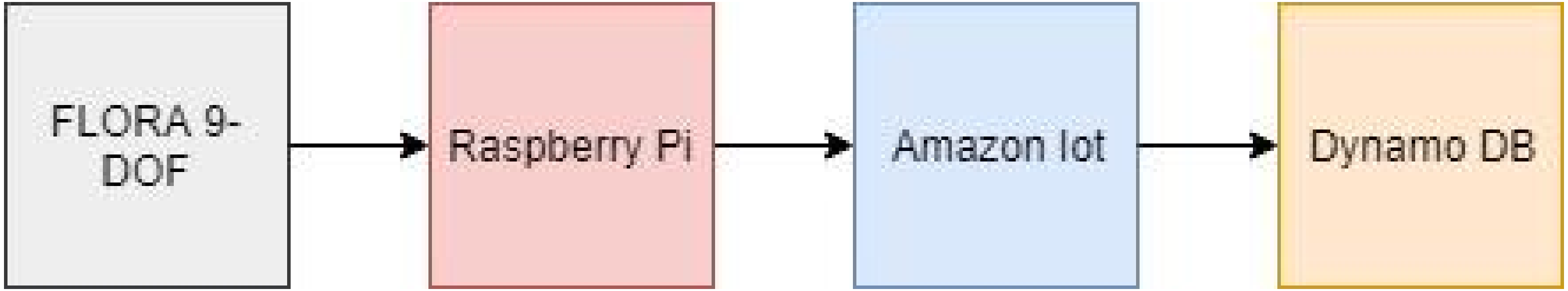
Neuro Training



- Vibrations on knee to indicate stride length error
  - Patient-specific stride length threshold
  - Two levels of vibrations depending on severity of error (both benign)

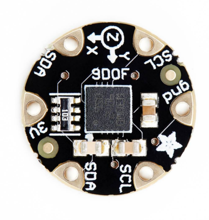
- Auditory Cueing
  - Rhythms played via app to stimulate proper cadence
  - Recommended by a Neurological PT

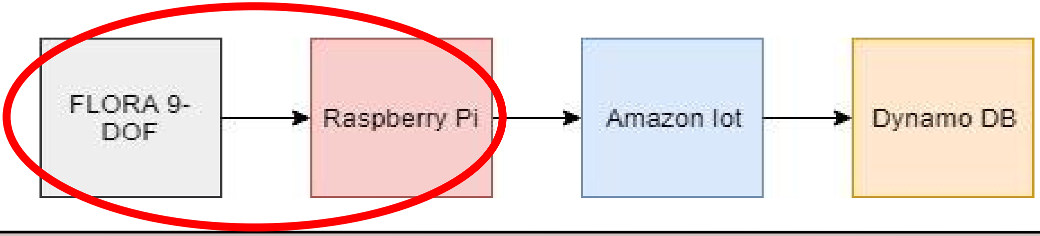
Data Movement Diagram



Data Movement: Sensor to Raspberry Pi

- Python programming
- Continuously writes to file using I2C bus
- Will be done with Bluetooth moving forward





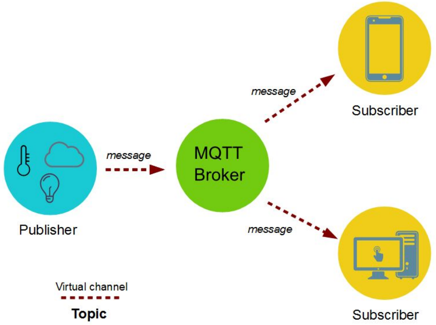
Data Movement: Raspberry Pi to Amazon Iot

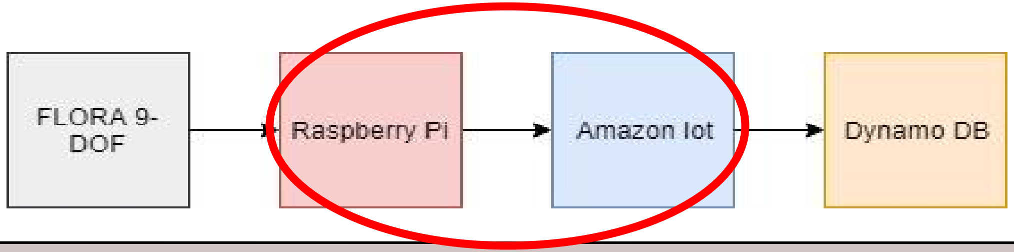
- MQTT
- JSON
- Amazon IoT

AWS IoT

dataTopic Dec 8, 2017 10:41:44 AM -0500 Export Hide

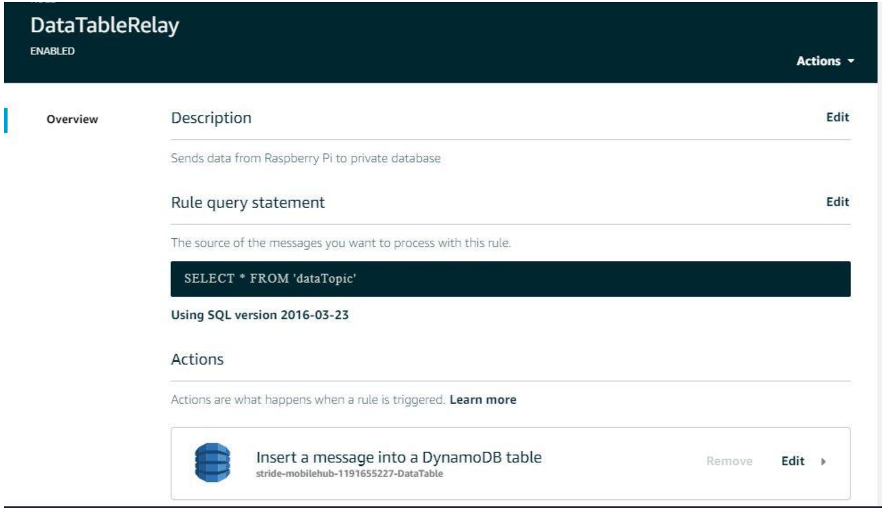

```
{
  "sessionID": "1_49",
  "magnetometerz": "0.66",
  "accelerometer x": "-3.18",
  "user": "rhartnett",
  "accelerometer z": "8.61",
  "magnetometer x": "0.26",
  "magnetometer y": "1.03",
  "gyroscope x": "-0.42",
  "gyroscope y": "2.03",
  "gyroscope z": "-7.84",
  "accelerometer y": "-2.02"
}
```

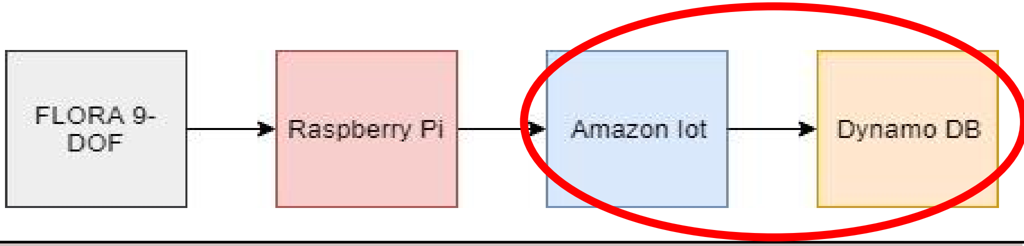





Data Movement: Amazon Iot to DynamoDB

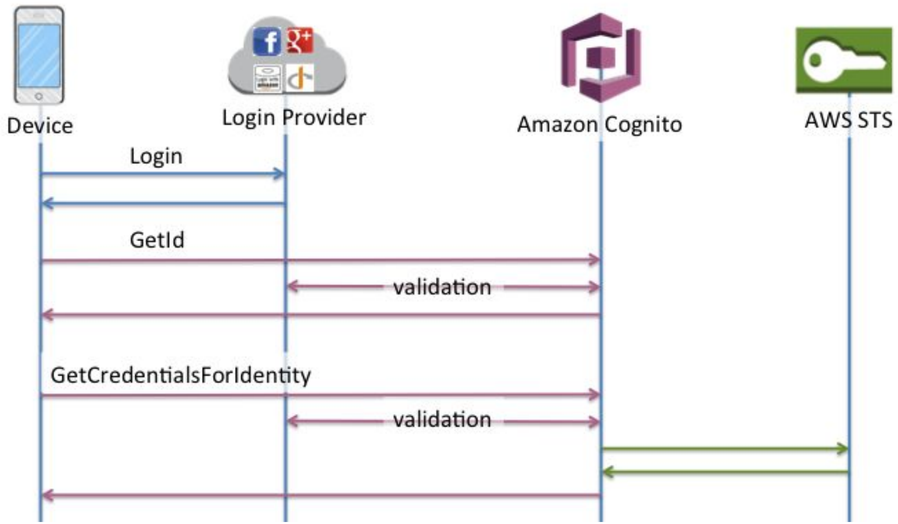
- Rules that react to Topics
- Permissions for Certified Users
- Sort/Range Keys





Application Backend

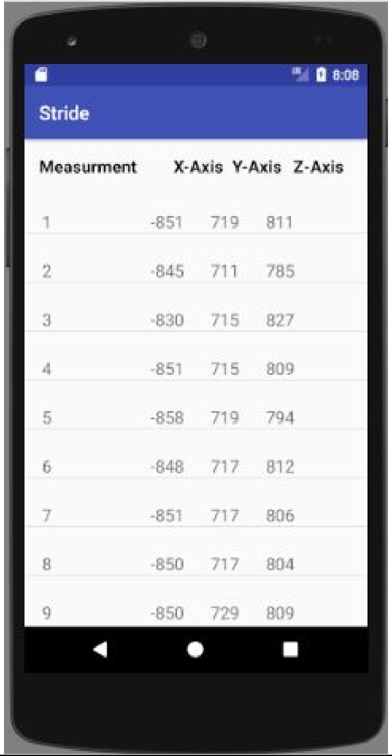
- Used AWS Mobile Hub to integrate backend with Android Application
- Created identity pools using Amazon Cognito to authenticate users
- Credential tokens are given to user to access other AWS services



Application Backend (Cont.)

- Created DynamoDB Table to store session measurements
- DynamoDB is a NoSQL database
- Data table contains:
    - Username
    - Session Number
    - Measurement Number
    - Measurement Data

Application



- Android application designed in Android Studio
- Amazon user authentication
- Retrieves session data from DynamoDB database
- Contains 3 pages
    - Session page
    - Sensor page
    - Data page

Proposed MDR Deliverables

MDR Deliverables

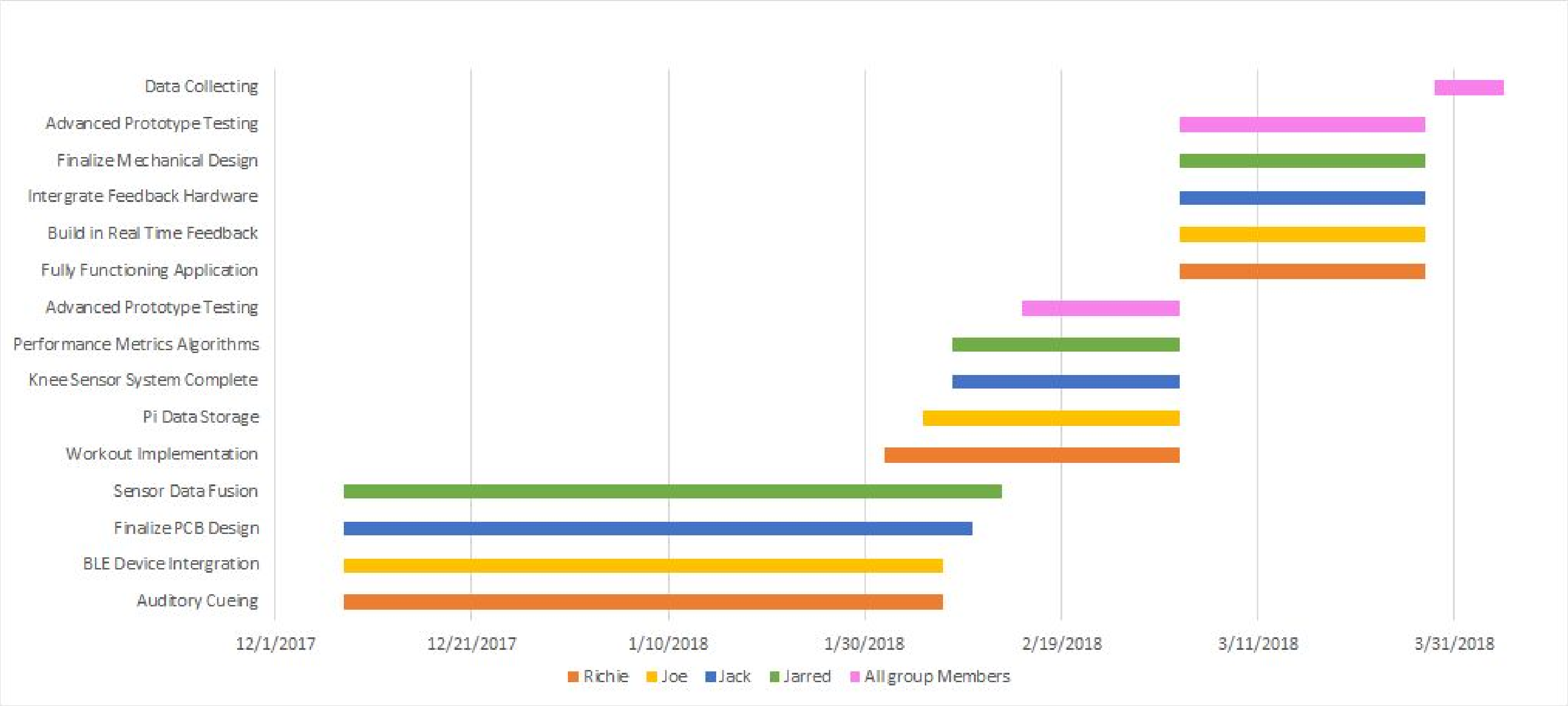
- Have single knee sensor operating and recording data ✓
- Having bluetooth transmitter on a breadboard relaying the information. Raspberry Pi receiving bluetooth transmission.
- Routing the data through the Raspberry Pi and transmit it over WIFI to Amazon cloud server to be store in a NoSQL database ✓
- Android application retrieves data from database and displays it on a basic GUI ✓

In general, have a pipeline throughout our system with which we'll be able to use as foundation to build out the rest of our project.

Proposed CDR Deliverables

- Complete design of knee sleeve with functional IMU and PCB (no feedback)
  - Completed data analysis
- Functioning prototype of shoe with no data analysis
  - Data passed through the pipeline of system
- Simultaneous bluetooth connection between IMU systems and Raspberry Pi
- Implement auditory cueing on Android Application and exercise programming

Gantt Chart


Data Collecting
Advanced Prototype Testing
Finalize Mechanical Design
Intergrate Feedback Hardware
Build in Real Time Feedback
Fully Functioning Application
Advanced Prototype Testing
Performance Metrics Algorithms
Knee Sensor System Complete
Pi Data Storage
Workout Implementation
Sensor Data Fusion
Finalize PCB Design
BLE Device Intergration
Auditory Cueing
12/1/2017
12/21/2017
1/10/2018
1/30/2018
2/19/2018
3/11/2018
3/31/2018
Richie
Joe
Jack
Jarred
All group Members

Individual Roles Moving Forward

- Richie - Team Leader, Android Application, Data Storage
- Joe - Data Transmission, Hardware/Software Interfacing
- Jack - Mechanical Design and PCB Design
- Jarred - Data Processing and Analysis, Sensor Programming

Thank You

Questions?