MedCap Project Proposal

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Motivation

- Everyone who spends long periods of time in the sun is at risk for heat illness, especially those who are extremely active
- Every person has a different tolerance for heat, based on a wide variety of factors
- Estimated 9,000 heat illnesses in high school athletes annually leading to death and disability

Existing Products

- The wearable technology market is rapidly advancing and expanding (Fitbit, Apple Watch, etc.)
- LightBEAM SmartHat: Fitness data only
- No product extracts meaningful data from dynamic PPG processing

Requirements: Shall

- Gather body metrics to determine heat illness
- Transmit sensor data from microcontroller to smartphone app
- Store and process data for immediate and historical trends
- Output a red, yellow, or green to indicate user's stress level
- Graphs shall be displayed to track trends in levels of heat stress

Requirements: Will

- Send a text message/alert to directly alert user and user's followers
- Use machine learning to better estimate blood pressure from PPG data

Indication Algorithm

- Heat illness determined by three measurements
  - Independent
  - Weighted
- Data stored and analyzed
  - Organized for raw and processed
  - Processing framework
- Analysis based on data over time
  - Change in MAP
  - Core temperature
  - Local heat index

$$weights: 0 < w_3 < w_2 < w_1 < 1$$

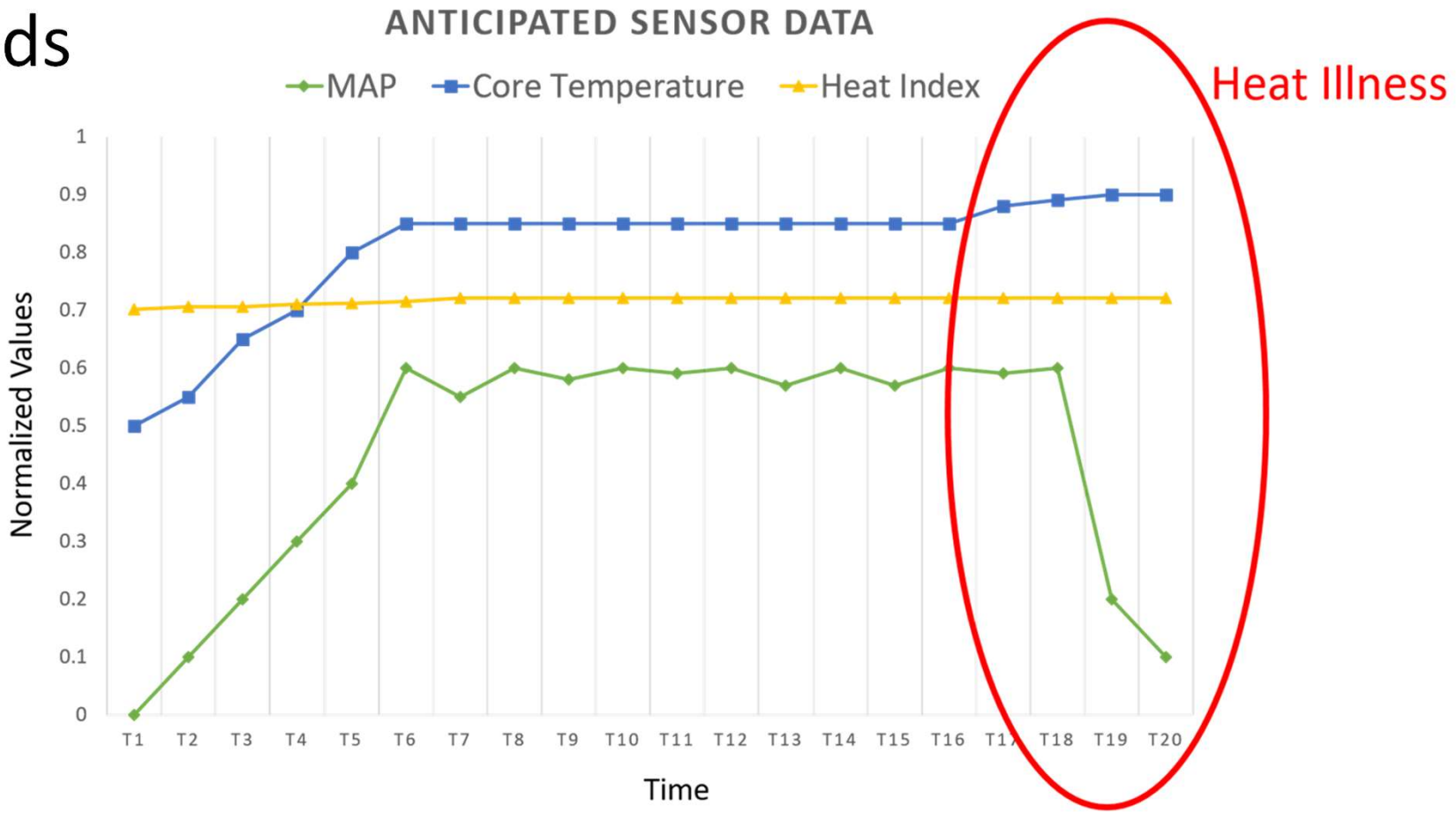
$$m_1: mean\ arterial\ pressure$$

$$m_2: core\ temperature$$

$$m_3: heat\ index$$

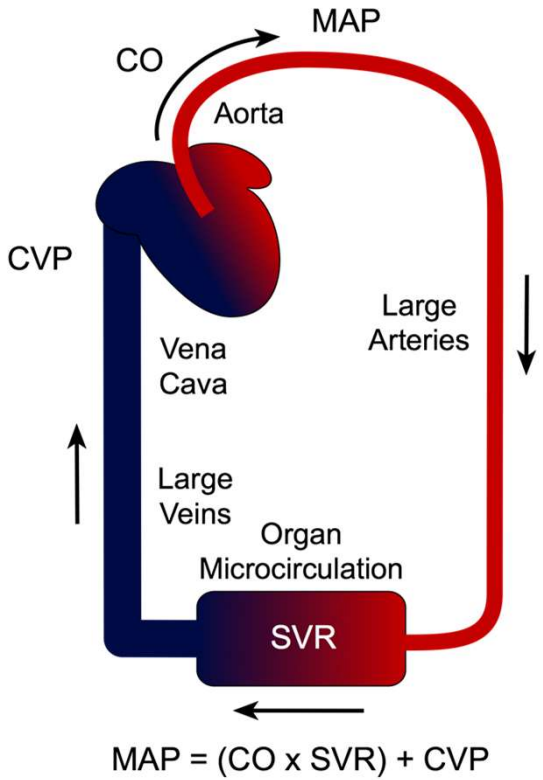
$$\sum_{i=1}^{3} w_i * m_i$$

Trends


ANTICIPATED SENSOR DATA
MAP
Core Temperature
Heat Index
Heat Illness
Normalized Values
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
T13
T14
T15
T16
T17
T18
T19
T20
Time

Design Approach: Medical Research

- Heat Stress -> Body goes through measurable thermoregulatory response
- Clinical Definition of Heat Stroke
  - Core temperature of 40°C+
- Problem: Core Temperature is not sufficient to ***solely*** determine heat illness early

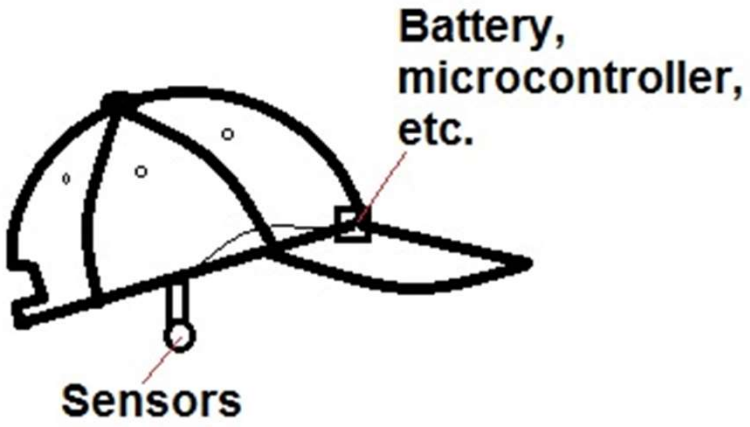


Design Approach: Sensing Data

- Solution: Team has focus on the arterial pressure curve
- Pulse Point: Temporal Artery
- PPG as cardiac output estimator
  - Directly maps arterial pressure curve
- Core Temperature as secondary cardiac output estimator

Design Approach: Cap Design

- Soft cap
- One-size-fits-all
- 3D-printed earpiece



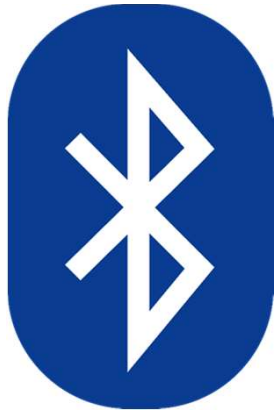
Design Approach: Power Considerations

- Max amperage pull
  - PPG sensor: 4.5mA
  - Accelerometer: 11uA
  - Microprocessor: 10mA
  - Thermometer: 27mA
  - Total: 41.5mA
- 2 AAA battery shield for microprocessor outputs 100mA
- ON/OFF switch on RFduino battery shield
- 25mm x 77mm x 22.86mm footprint
- 540-1200mAh depending on AAA battery type
- Safe estimate: 9.1 hr
- Fancy batteries est: 20.24 hr

Design Approach: Communication Protocol

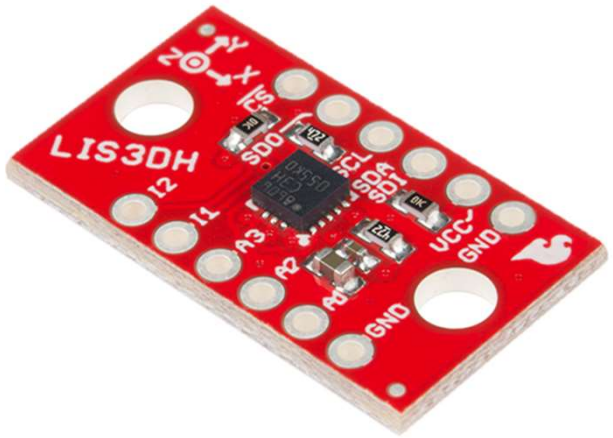
- Major Tradeoff: Bluetooth vs Zigbee

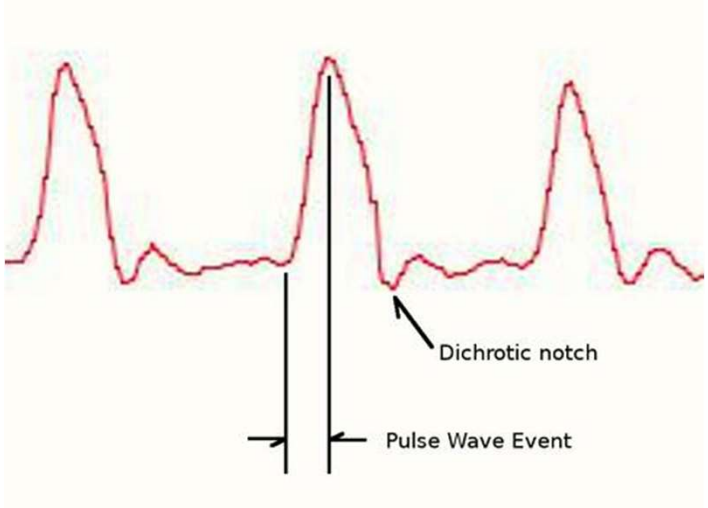
	Bluetooth	Zigbee
Transmission Distance	~100m	~300m
Occupies WiFi Signal	NO	YES
Occupies Bluetooth Signal	YES	NO
Hardware Available on Smartphones	YES	YES



Design Approach: Data Transfer

- Program microcontroller to transmit data over Bluetooth
- Reduce noisy signal:
    - Transmission interval determined by accelerometer
    - Active filter within pulse sensor

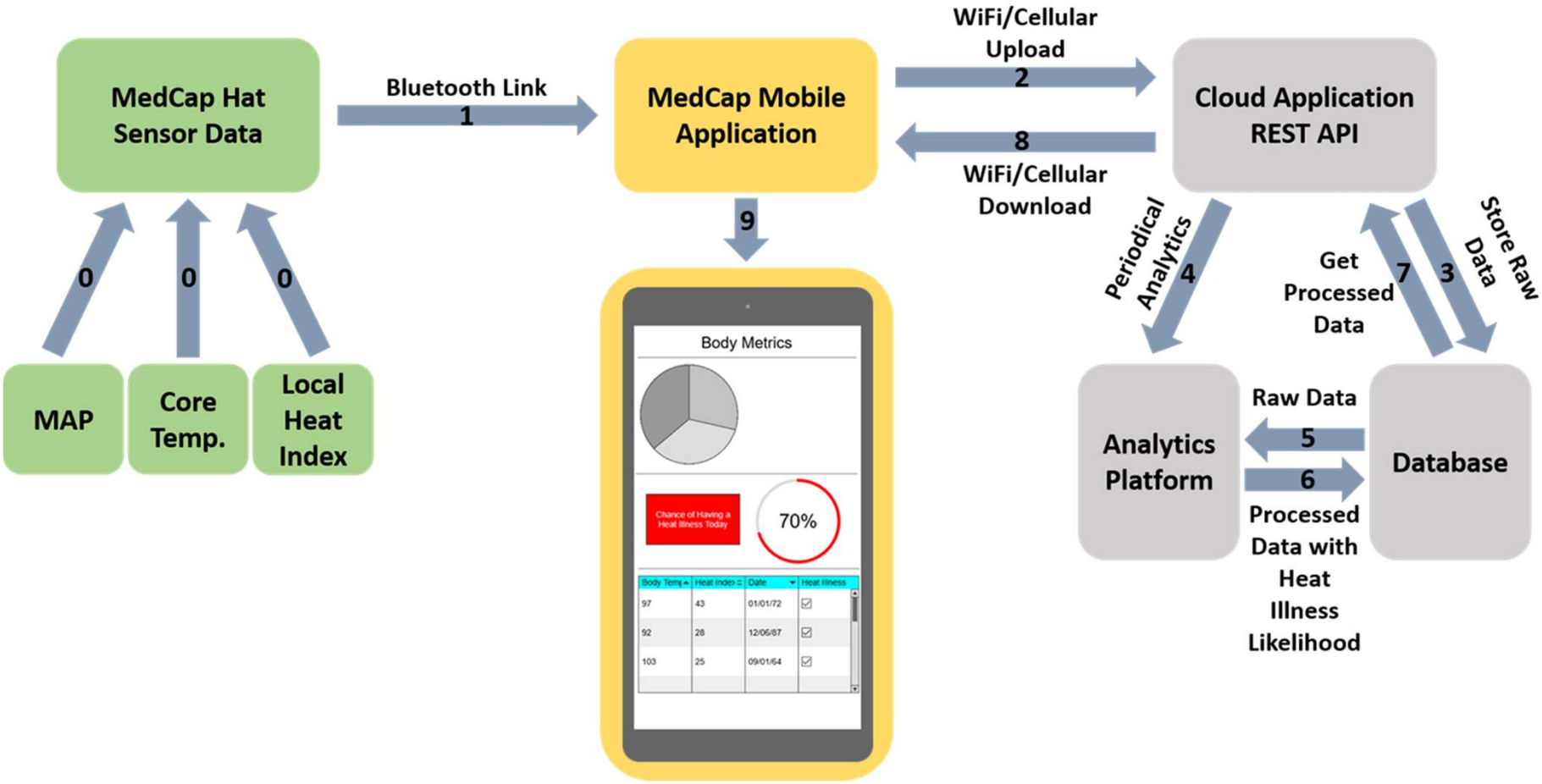




Design Approach: Data Processing

- Raw data points received by MedCap Mobile Application
  - REST API
- Input into unprocessed database table
- Analytics framework pulls from unprocessed table
  - Poll from the last *n* seconds
  - Scan for differences and values
- Gather processed data and consolidate time intervals
- Input into processed database table
- Processed data available to MedCap Mobile Application

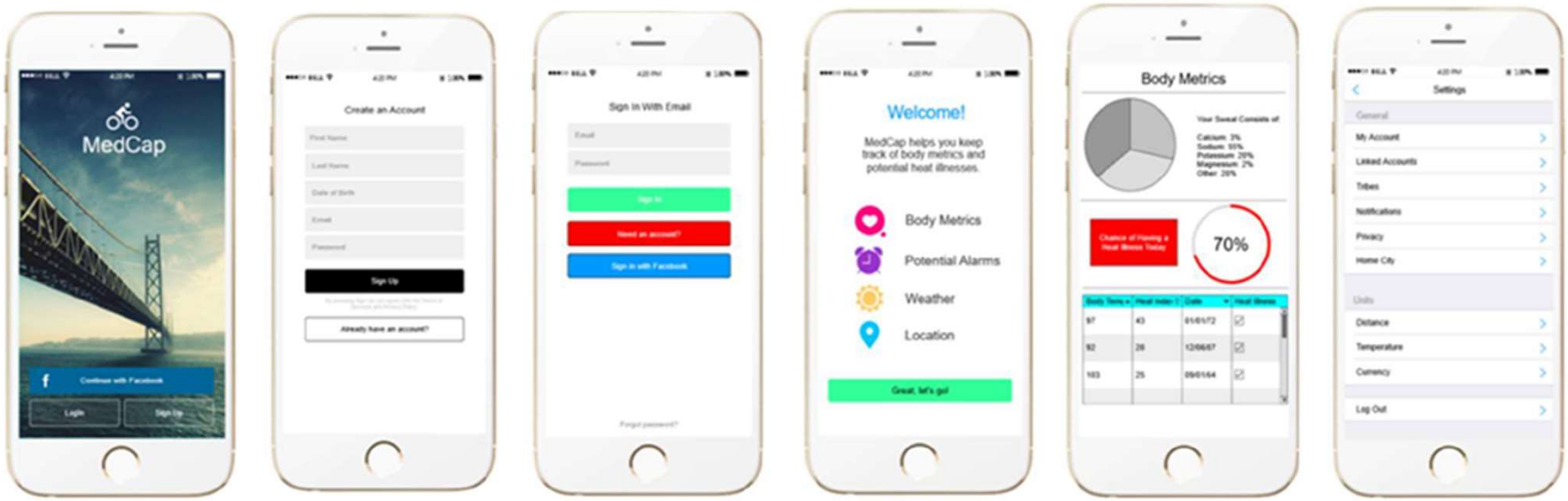
Data Flow and Cloud Architecture



Design Approach: User Interface

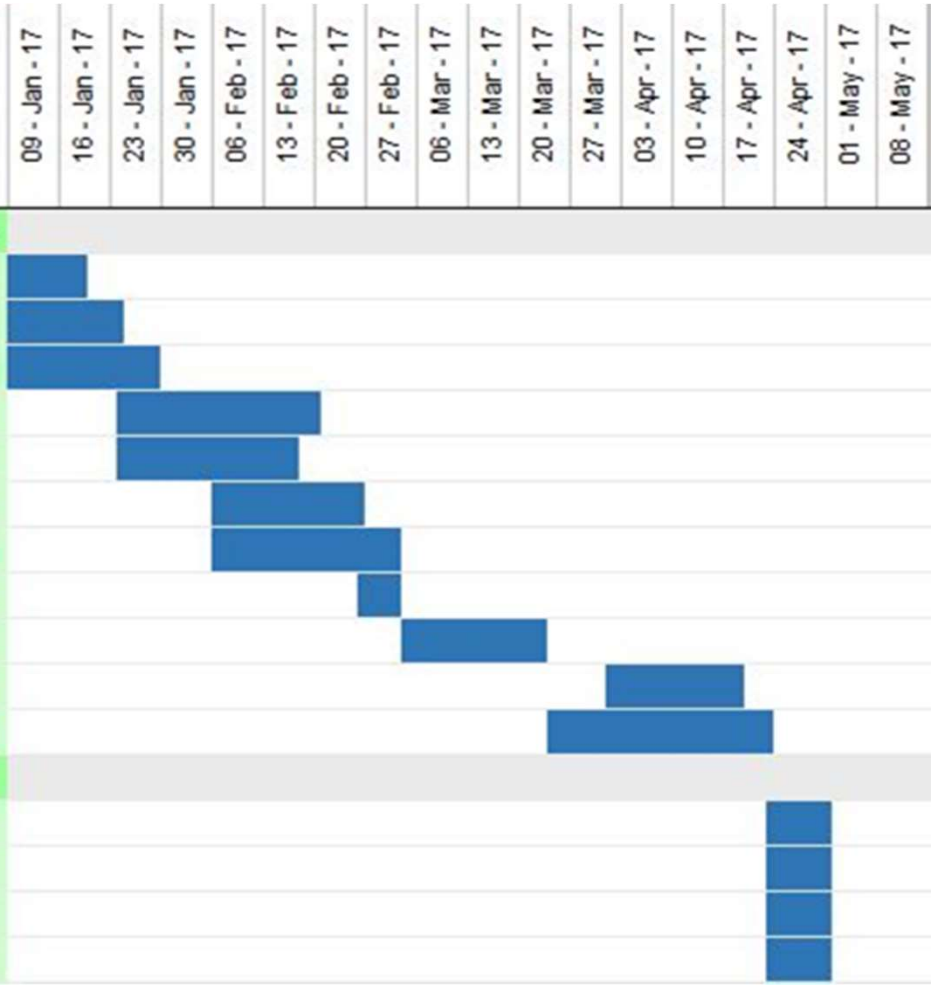
- React Native
  - Reusable components
- Open-Sourced Bluetooth Integration Modules
- UI/UX will be derived from Fitbit's mobile application
  - Graphs, Tables, and Interactive Flowcharts
  - Minimalistic
- User Profile
  - Facebook and Email Login
  - Handle multiple users

User Interface Flow



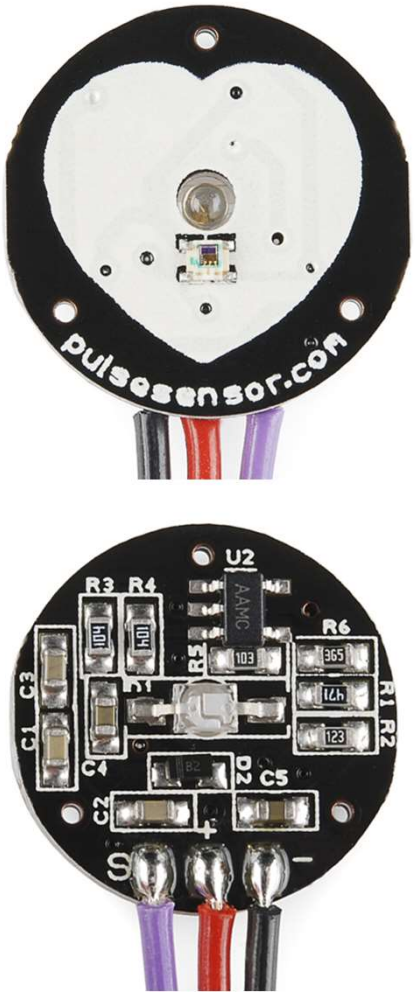
Schedule

WBS	Tasks	Start	End	Duration (Days)
2	**ECE 4012**	1/9/17	4/25/17	107
2.1	Update Proposal and PSF	1/9/17	1/20/17	12
2.2	Proposal Oral Presentation	1/9/17	1/24/17	16
2.3	Website	1/9/17	1/29/17	21
2.4	Order Parts	1/24/17	2/20/17	28
2.4.1	Test Parts	1/24/17	2/17/17	25
2.5	Build Cap Hardware Assembly	2/5/17	2/25/17	21
2.6	Build UI Backend Processing	2/5/17	2/25/17	21
2.7	Integrate Subsystems into Prototype	2/25/17	3/3/17	7
2.8	Test Integrated Prototype	3/3/17	3/23/17	21
2.9	Final Presentation	4/1/17	4/18/17	18
2.10	Capstone	3/23/17	4/25/17	34
3	**ECE 4012-Post Capstone**	4/25/17	5/1/17	7
3.1	Final Project	4/25/17	5/1/17	7
3.1.1	Final Project Demo	4/25/17	5/1/17	7
3.1.2	Final Project Report	4/25/17	5/1/17	7
3.1.3	Final Project Summary	4/25/17	5/1/17	7



Status

- Confirming part choices
- System integration
- PPG signal noise
  - Top of board: sensor
  - Bottom of board: everything else
  - Allows for placement close to skin
  - Noise reducing
  - FFT (backend)
- Device housing
  - Hot Glue
  - Spring



Thank You!

Questions?