Team D4 - VitaBand

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Use Case

Problem:

- Outdoor jobs are highly physically demanding
- workers are at risk of heat stroke, overexertion, and falling.

Solution:

- a lightweight wearable device that continuously monitors falling & heat stroke biometrics, and automatically:
  - Alerts the wearers before dangerous thresholds are reached
  - Notifies nearby workers of emergencies

ECE Areas: Circuits, Sensors, Software, Networking

Use Case Requirements

Sampling:

- Heart rate at 1 Hz
- IMU at 50-100 Hz for fall detection
- Temperature at 1 Hz

BLE Range:

- >=10 m under typical outdoor site conditions in case phone is not on wearer

Comfort:

- Armband <300 g
- Flexible, skin-safe materials

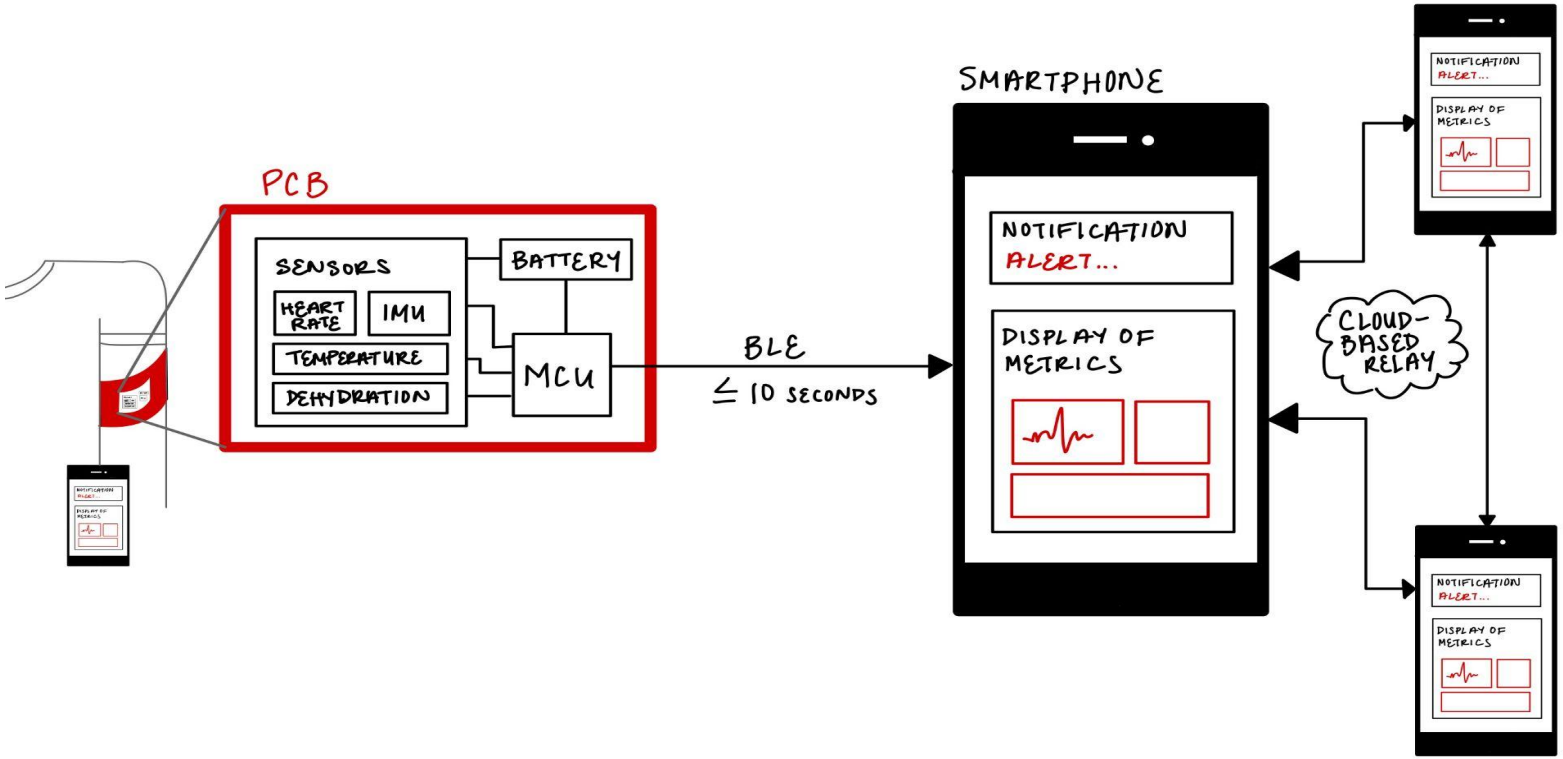
Battery Life

- >= 12 hours of continuous operation for full outdoor work shift
- Rechargeable

Alert Latency:

- <= 30s for heat strain
- <= 10s for fall as injury risk increases quickly after fall

Use Case Requirements



Technical challenges and mitigation strategies

Technical Challenges	Mitigation Techniques
Low-latency	- BLE for communication to a paired smartphone - cloud to relay notifications to nearby workers
Accurate Physiological Readings	- commercially validated sensors - filtering techniques to reduce noise from motion and sweat. - Calibrate to account for the difference in baselines

Technical challenges and mitigation strategies

Technical Challenges	Mitigation Techniques
False positives	- Combine multiple sensor readings - use trends over a set time window - Have separate alerts for warning vs emergency.
Battery life lasting for full shift	- MCU with wireless communication. - Minimize BLE transmission by performing computations on device itself. - duty cycling.
Wearability	- material that is lightweight, weather-resistant, and safe to be worn for extended period of time

Solution Approach: Sampling and Risk Scoring

1. Wearable armband continuously samples sensors. Component options:

- MCU: Nordic nRF52840
- HR: MAX86141
- Skin temperature: MAX30205, TMP117
- IMU: LSM6DSOX, MPU-6050

2. On-device risk scoring runs rules and a simple model using:

- personalized baselines
- environment adjusted heat-stress metrics
- motion/heart rate patterns for overexertion or collapse

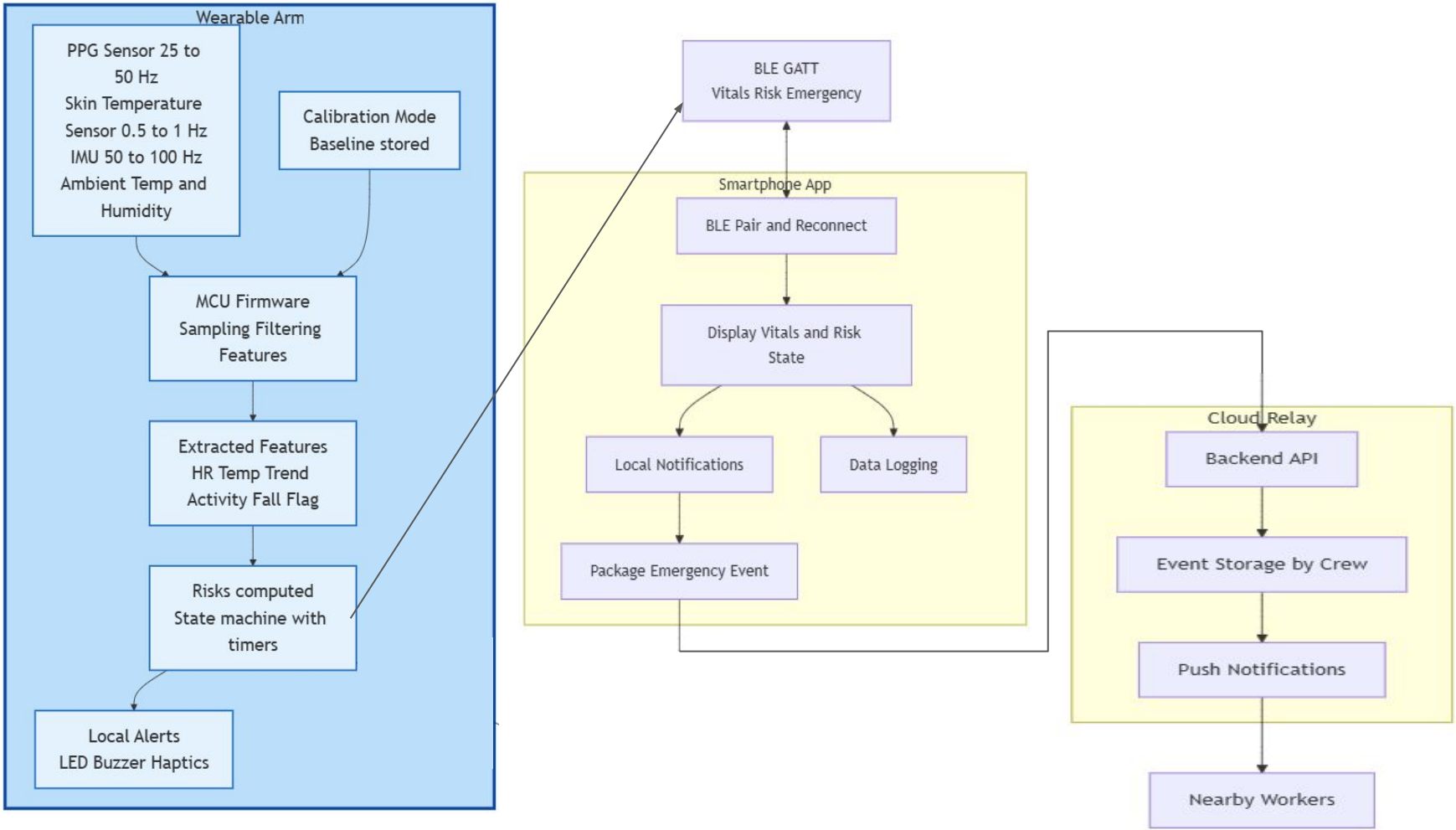
Solution Approach: Phone App and Propagation

3. Phone app connects to wearable over BLE:

- Shows status and alerts to the wearer
- Establishes BLE GATT connection with wearable
- Relays alerts to nearby people

4. Local propagation

- Phone-to-phone transmissions using cloud-based relay
- FCM used to broadcast emergency alerts


Wearable Arm
PPG Sensor 25 to 50 Hz
Skin Temperature Sensor 0.5 to 1 Hz
IMU 50 to 100 Hz
Ambient Temp and Humidity
Calibration Mode
Baseline stored
MCU Firmware
Sampling Filtering
Features
Extracted Features
HR Temp Trend
Activity Fall Flag
Risks computed
State machine with timers
Local Alerts
LED Buzzer Haptics
BLE GATT
Vitals Risk Emergency
Smartphone App
BLE Pair and Reconnect
Display Vitals and Risk State
Local Notifications
Data Logging
Package Emergency Event
Cloud Relay
Backend API
Event Storage by Crew
Push Notifications
Nearby Workers

Testing, Verification, and Metrics

Alerts

- Verify alert triggers at 38.5 ± 0.5 °C
- Verify wearable heart rate data alerts near 120 ± 5 bpm based on resting heart rate
- Verify alert trigger when IMU detects high impact acceleration followed by minimal movement

System Response

- Alerts do not exceed one second and are successful within a radius of 10 meters
- Wear until the battery is depleted and note duration
- Ensure vitals appear in real-time on a phone UI
- Test in various conditions

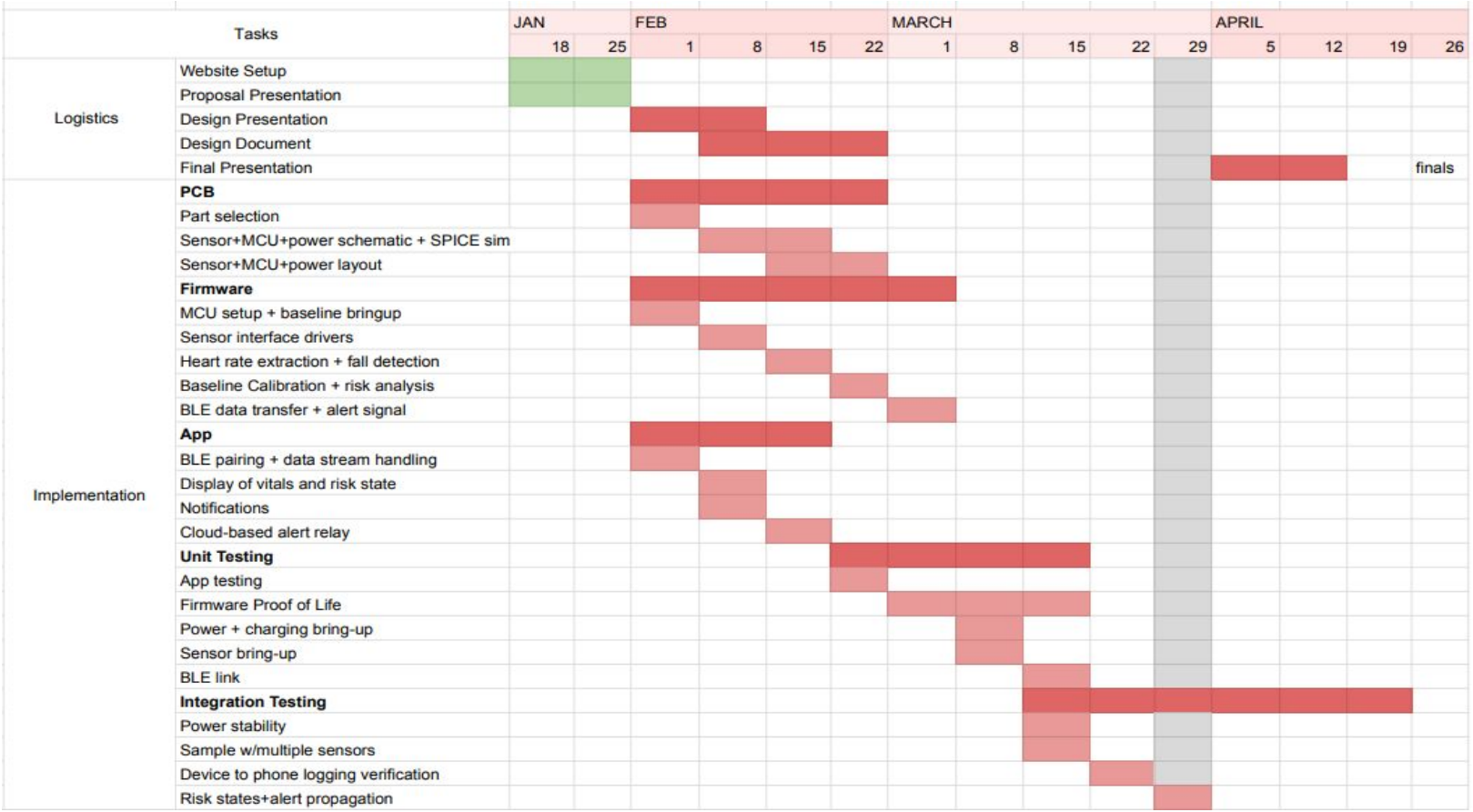
Wearability & Comfort

- Conduct short-term wear tests during simulated work tasks
- Survey users on comfort, weight, interference with movement, and app experience

Tasks and Division of Labour

Emily Allendorf	• MCU firmware development • Sensor calibration and testing • Mechanical design and assembly • Final presentation
Sharia Farhan	• Component selection • MCU and power board design • Board testing and integration • Device-to-phone communication and firmware integration • Proposal presentation
Vidhi Challani	• Heat strain and overexertion detection algorithm implementation • Smartphone interface • System-level testing • Design presentation

Schedule


Tasks
JAN
18
25
FEB
1
8
15
22
MARCH
1
8
15
22
29
APRIL
5
12
19
26
Logistics
Website Setup
Proposal Presentation
Design Presentation
Design Document
Final Presentation
finals
Implementation
PCB
Part selection
Sensor+MCU+power schematic + SPICE sim
Sensor+MCU+power layout
Firmware
MCU setup + baseline bringup
Sensor interface drivers
Heart rate extraction + fall detection
Baseline Calibration + risk analysis
BLE data transfer + alert signal
App
BLE pairing + data stream handling
Display of vitals and risk state
Notifications
Cloud-based alert relay
Unit Testing
App testing
Firmware Proof of Life
Power + charging bring-up
Sensor bring-up
BLE link
Integration Testing
Power stability
Sample w/multiple sensors
Device to phone logging verification
Risk states+alert propagation