Wireless Embedded Sensor Monitoring

STUDENTS:
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Overview

Project Objective: Develop a model of **a low-cost wireless sensor network** for embedded **monitoring on naval equipment** and infrastructural components. Sensor types shall be of a small form factor, consisting of an **accelerometer, pressure transducer, fluid flow, current, voltage, and temperature sensor.**
Project Scope: RF communication, **200ft distance** of up to 6 standard 4-20mA loop-based RTD sensors. Include sensor readings. Storage 32sec samples at bitrate of **~1 Mbit/sec (10kHz @ 16bit x 6 channels)**.
Milestone:

- Establish Wireless Communication
- Support RF Communication up to 200 ft Distance
- Implement 6 Sensors & Calibration
- Data Validation & Store Data at 1 Mbit/sec
- Develop Event Trigger and Battery System
- Data Security

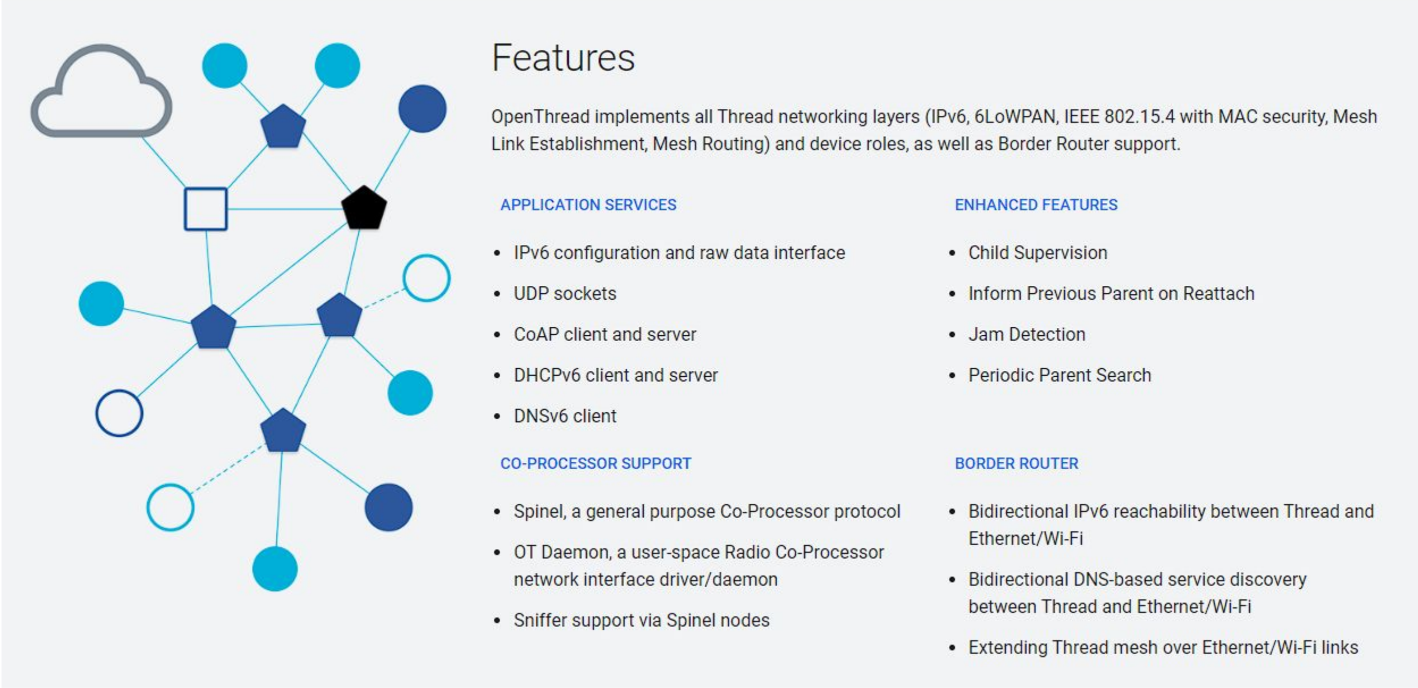
Hardware

- Processing Components:
  - NUCLEO-STM32WB55RG
  - Raspberry Pi 3B
- Battery System:
  - 2 Cell Battery Management System (BMS) Module
  - 3.7V Li-ion Battery Fuel Gauge Module (ModelGauge)
  - Low Dropout Step-Down Linear Voltage Regulator Module
- Sensor:
  - K-Type Surface Thermocouple
  - Hall Effect Flow Sensor
  - Voltage Divider Voltage Sensor
  - Hall Effect AC Current Clamp
  - Capacitance Pressure Sensor
  - *NCD* 3-axis Accelerometer + Wireless USB Modem
- Piezoelectric Trigger System

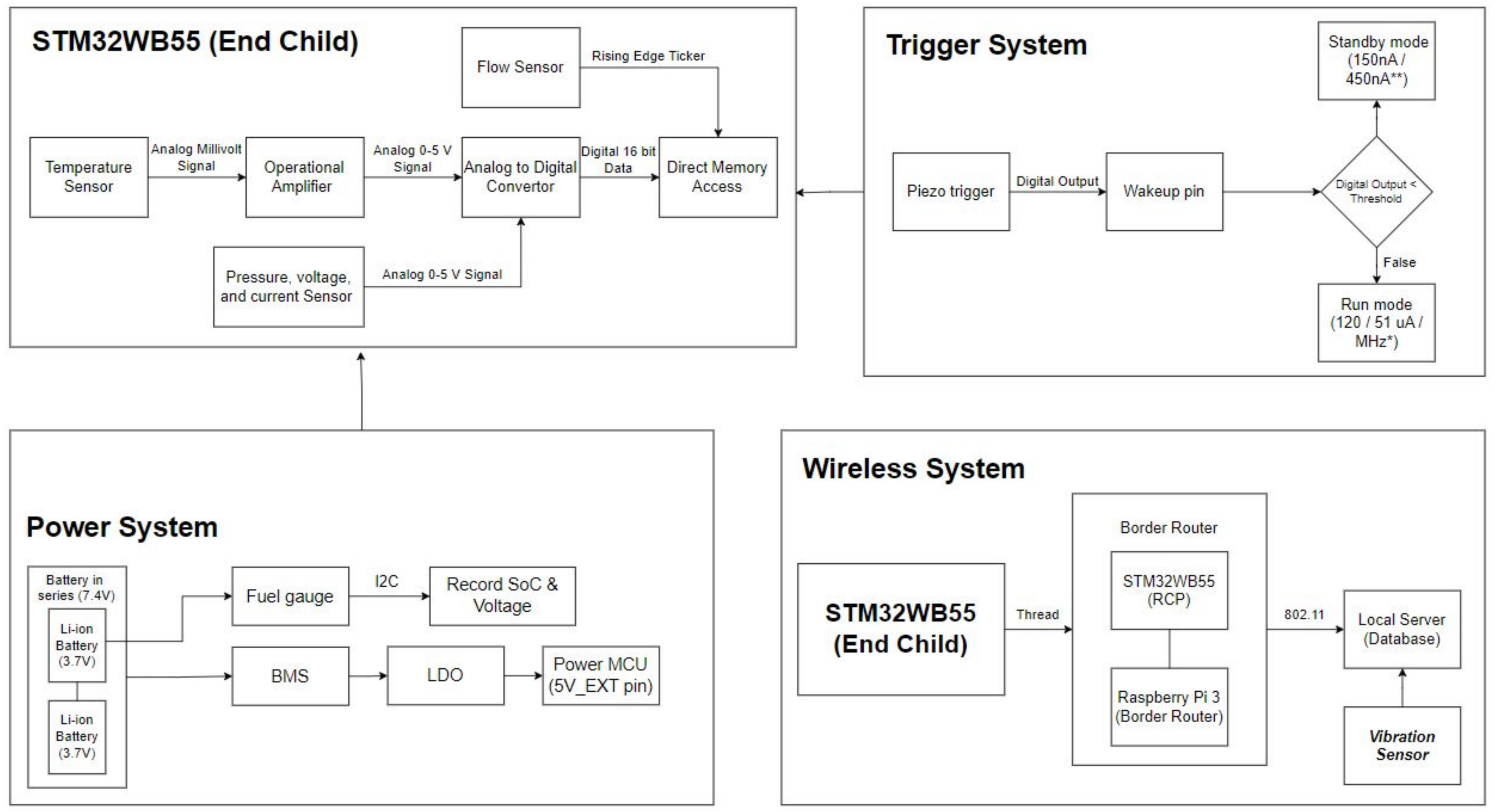
Software

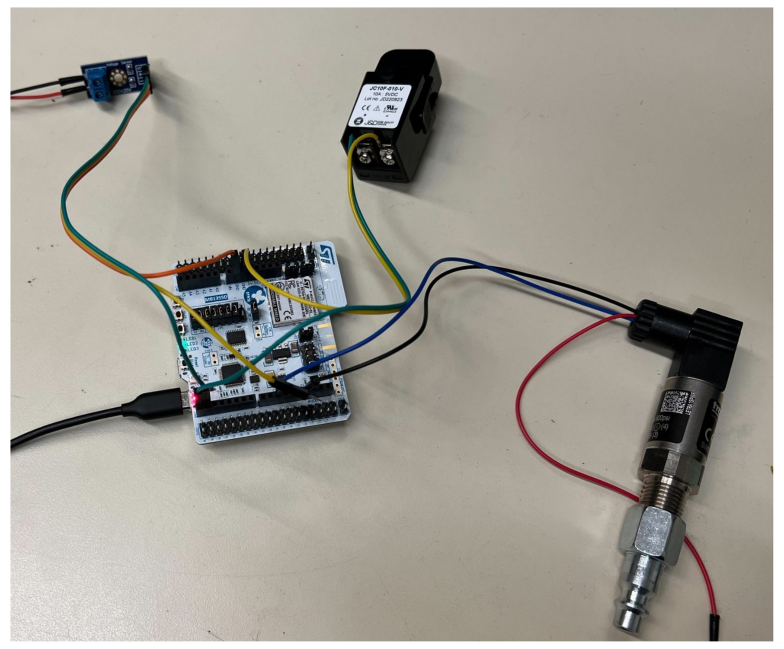
- STM32Cube Hardware Abstraction Layer
- OpenThread Border Router & Commissioner
- Raspberry Pi OS

Thread Protocol

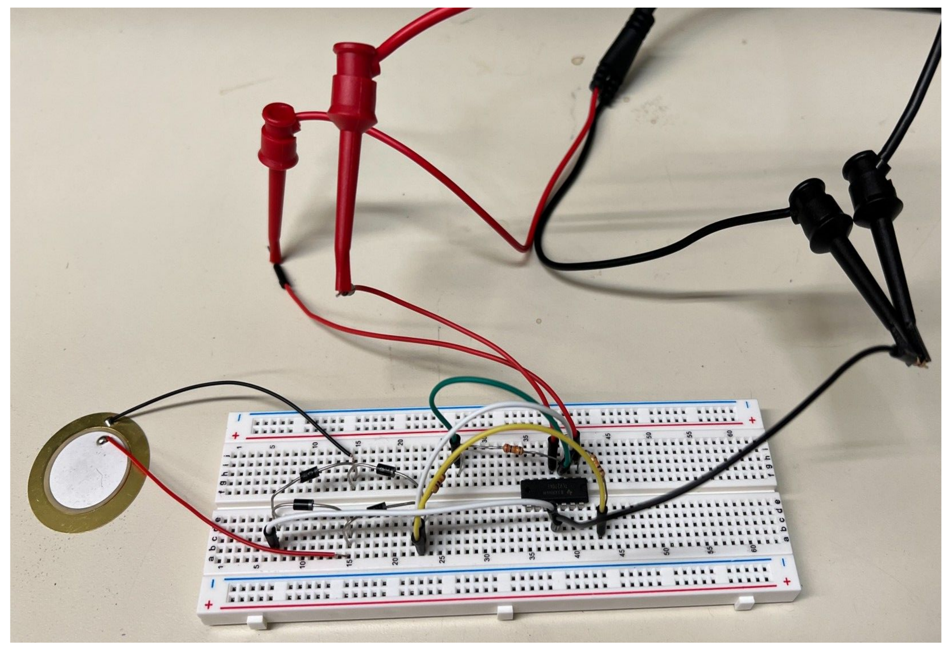


Implementation

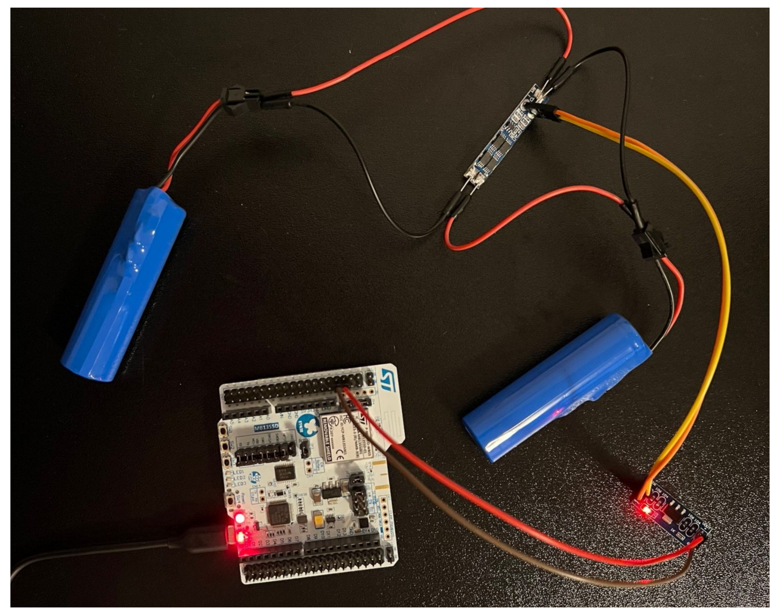




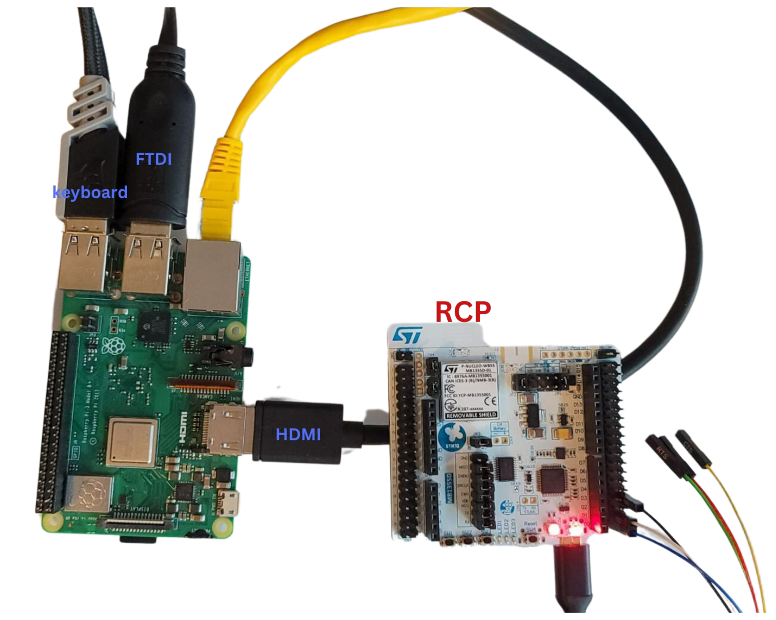
STM32WB55 (End Child)



Trigger system



Power system



Wireless system

Test Results & Conclusion

Sensors:

- Thermocouple, pressure transducer, voltage, and current can all work under required conditions with accuracy of ±1%.
- Accelerometer operates with the sampling rate of 5kHz.
- The calibrated sensor data undergoes processing via a high-performance, multi-channel 16-bit ADC with DMA functionality.

Network:

- Established a robust Thread network between the Raspberry Pi border router and STM32 end device for communication and connectivity.
- The end child node instantaneously transmits data to the border router through UDP connection.

Trigger system:

- To optimize power efficiency, we have incorporated a low power mode that leverages a wakeup piezo trigger system.

Power system:

- The Battery Management System (BMS) ensures the safety of the Li-ion battery as well as regulates the voltage through the Low Dropout (LDO) mechanism to power the MCU.
- Incorporates real-time monitoring with fuel gauge that directly linked to the battery to accurately track the battery percentage for enhanced usability and efficiency.

Future works

- Sensors : Implementation of a more accurate flow sensor.
- Battery : Consider implementing a double cell fuel gauge for more precise reading of battery level.
- Hardware Network : Adopt Aruba network system to create local, self-contained, and secure communication.
- Software Implementation :
  - Optimize data transfer methodology
  - Change communication protocol from UDP to CoAP or TCP
  - Improve data encryption method
  - Gain access and utilize STM32's non-public documentation

Acknowledgments

- Faculty: Prof. Tai Chen
- Lab Resources:
  - UW Aeronautics and Astronautics Lab (Thijs Masmeijer)
  - UW Power Lab (Daniel Kirschen)
- Industry Experts: Luna Labs (Kevin Farinholt and David Alibakhshi)

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SPONSOR: Naval Surface Warfare Center, Philadelphia Division