UMassAmherst
The Commonwealth's Flagship Campus

Comprehensive Design Review

Team 22 - Coresidium

Advisor: Professor Siqueira

March 28, 2019

Coresidium – A School Security System

- Members
  - Valentin Degtyarev (CSE) - Acoustic Sensor & PCB Design
  - Andrew Eshak (CSE + EE) - Server Backend & Computation
  - Brandon Cross (CSE) - Thermal Sensor
  - Andrew LaMarche (CSE) - Communication & System Management



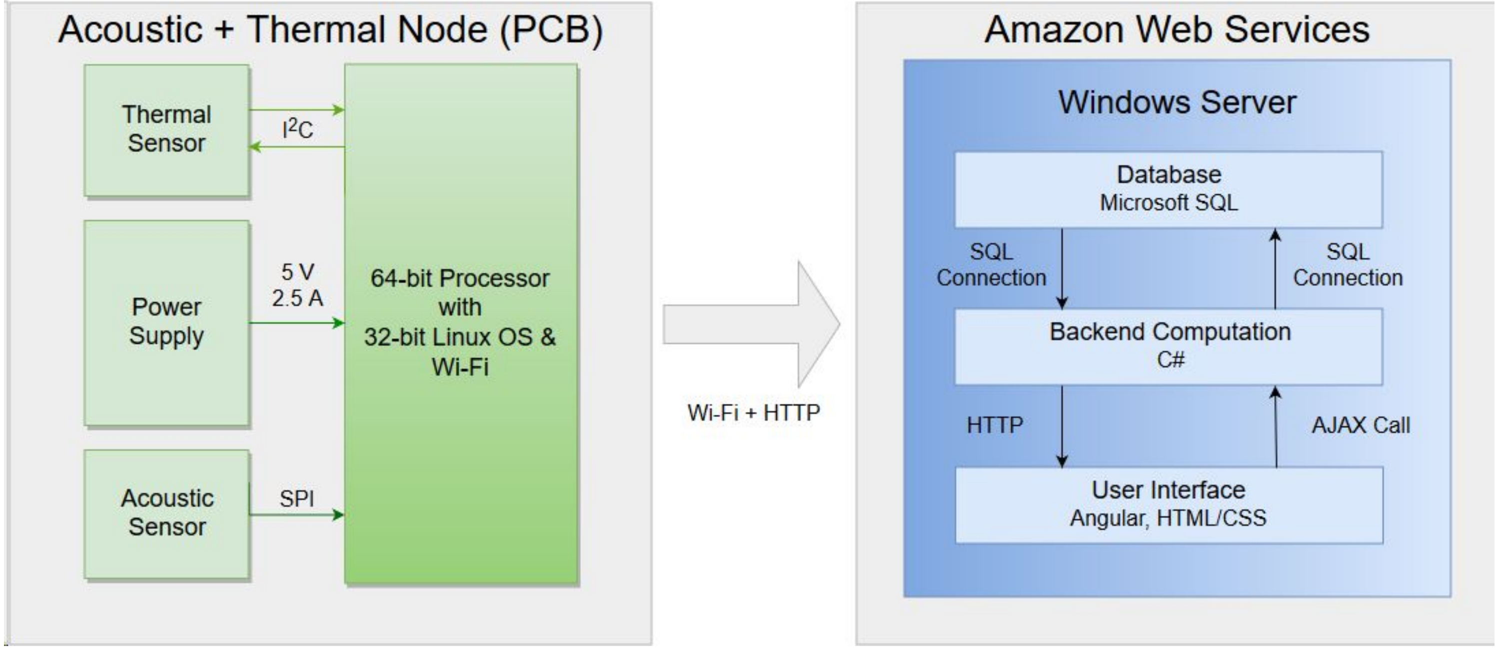

Agenda

- Problem Statement
- Hardware
- Accomplishments
- FPR Deliverables
- Demo

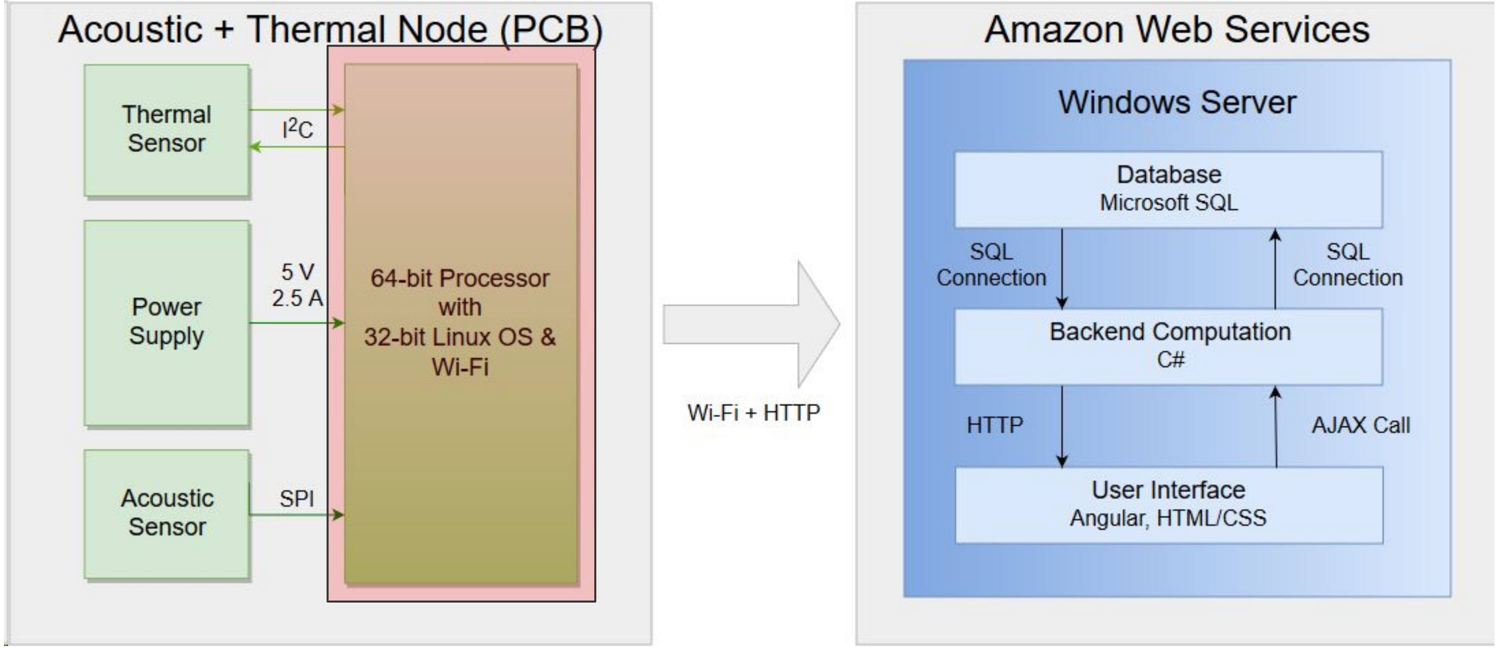
Problem Statement

- In the aftermath of a school shooting in the United States, it takes several hours for the campus to be declared safe. Due to this delay, help is not available to those who need it most. Our system aims to reduce this time by providing the relative location of where a shot has been fired. The proposed design uses infrared temperature cameras and acoustic sensors to accurately recognize an active shooting situation and notify the proper authorities.

Block Diagram

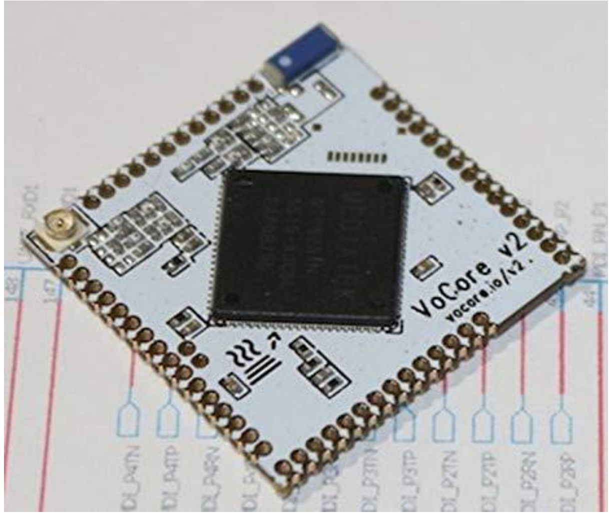


Processor


Acoustic + Thermal Node (PCB)
Thermal Sensor
I^2C
Power Supply
5 V
2.5 A
Acoustic Sensor
SPI
64-bit Processor with 32-bit Linux OS & Wi-Fi
Wi-Fi + HTTP
Amazon Web Services
Windows Server
Database
Microsoft SQL
SQL Connection
SQL Connection
Backend Computation
C#
HTTP
AJAX Call
User Interface
Angular, HTML/CSS

VoCore v2 (Original)

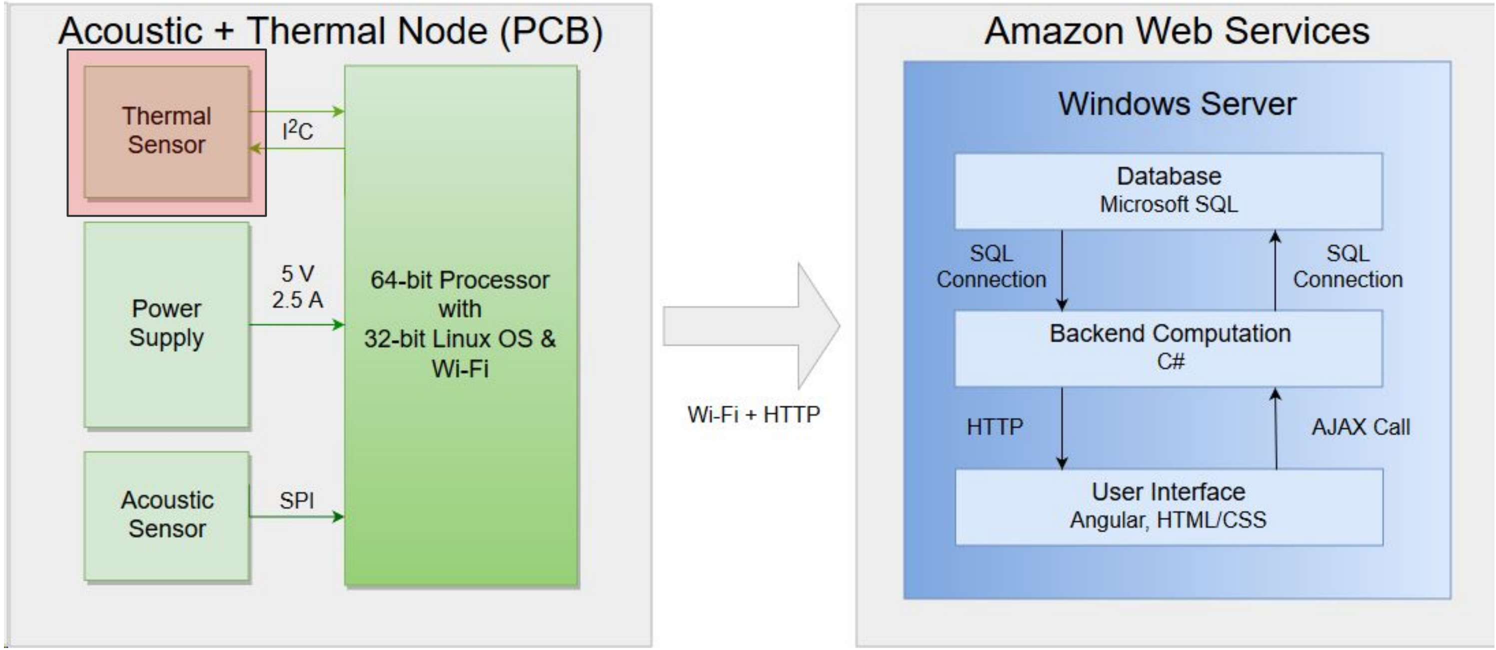
- Prebuilt with Linux and Wi-Fi
- MIPS architecture - Single Core
- 580 MHz clock speed
- Handles on-chip data processing
- Communicates data to server via HTTP
- 230 mA, 1.15 W



Raspberry Pi 3B (Updated)

- Prebuilt with Linux and Wi-Fi
- ARM architecture - Quad Core
- 1.2 GHz clock speed
- Handles on-chip data processing
- Communicates data to server via HTTP
- 1.34A, 6.7W

MLX90640 Thermal Sensor



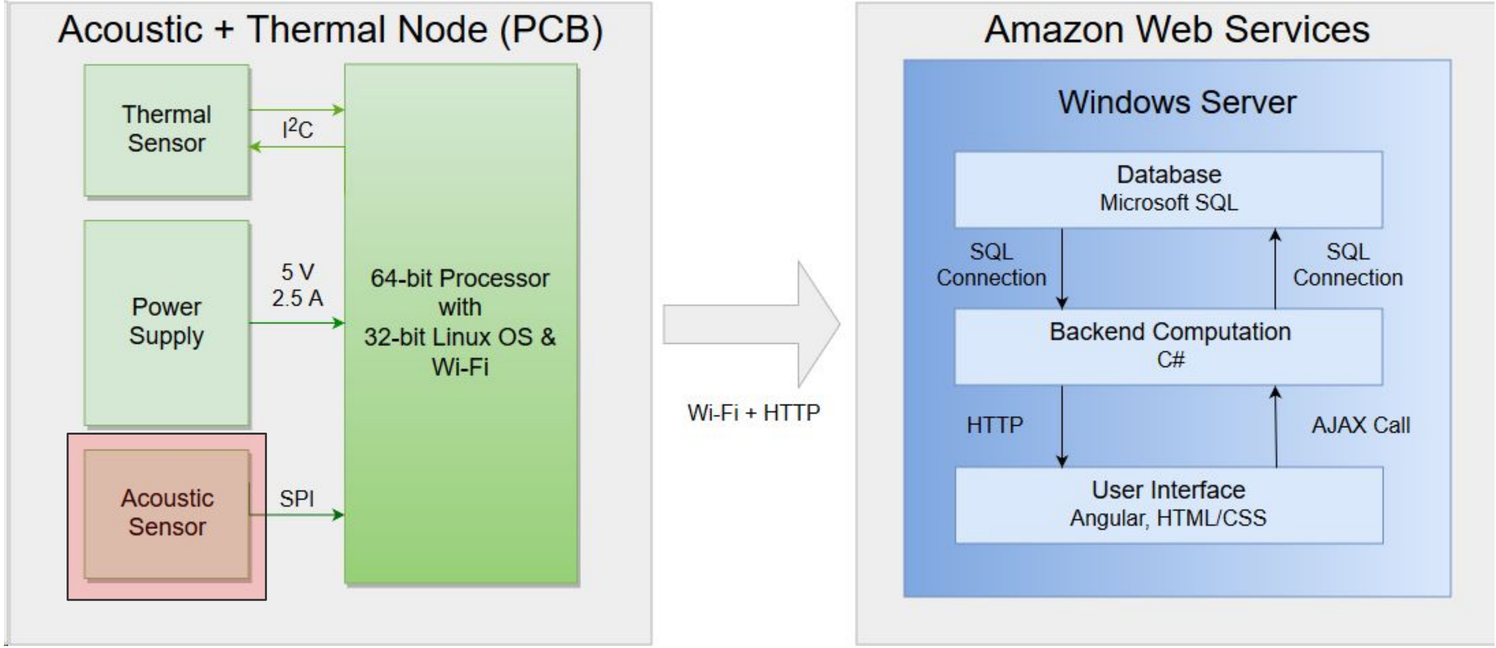
MLX90640 Thermal Sensor (Original)

- Thermal detection of barrel upon firing
- Gunshot heats rifle barrel to ~150ºC
- -40ºC to 300ºC
- 32x24 resolution
- 64 frames per second (Raspberry Pi)
- 110° x 75°

MLX90640 Thermal Sensor (Updated)

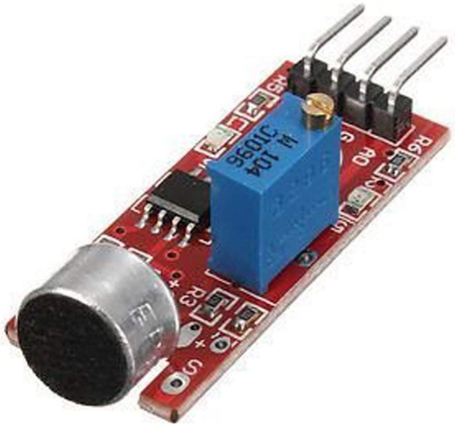
- 55° x 35°
- 4x previous distance
- Breakout board eliminated

KY-038 Acoustic Sensor

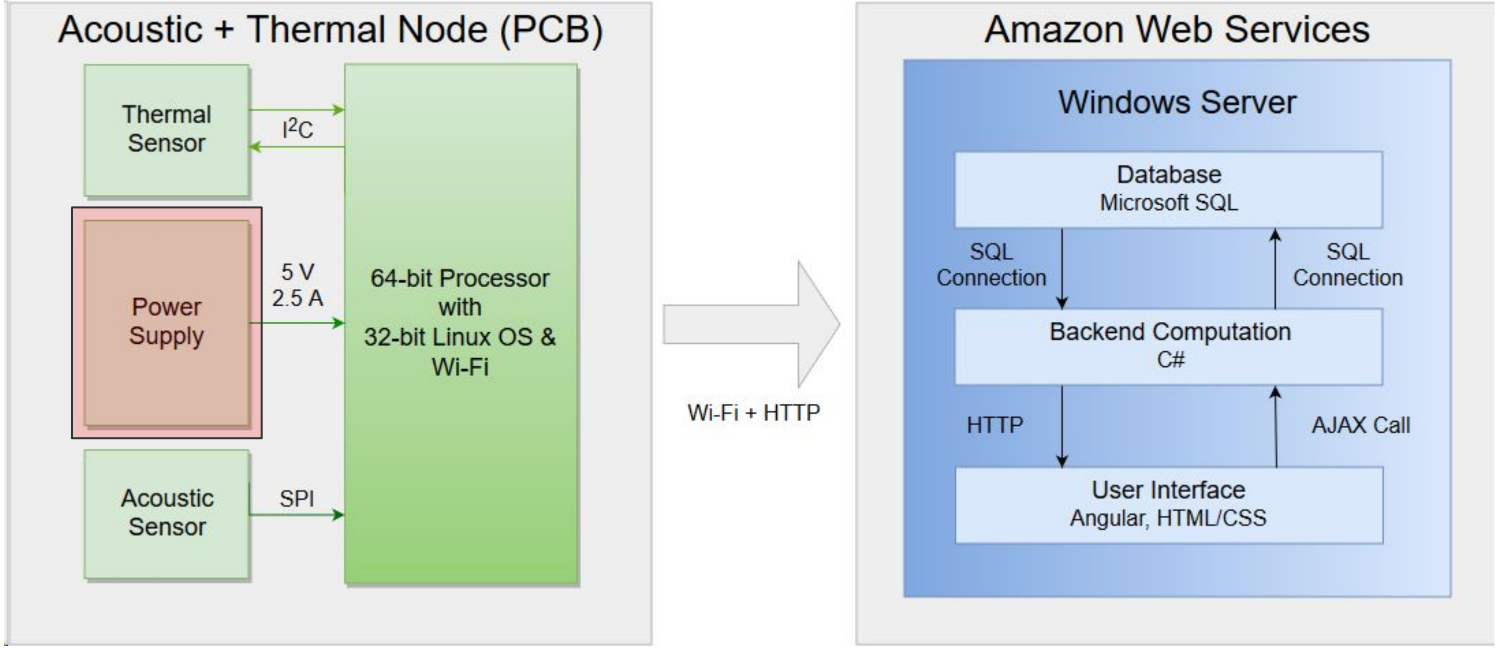


KY-038 Acoustic Sensor

- Large sound sensor to detect gunshot
- 130 dB peak detection
- Gunshot between 150 dB and 190 dB
- 21,000 samples per second (Raspberry Pi)
- Output analog sound amplitude
- Breakout board eliminated

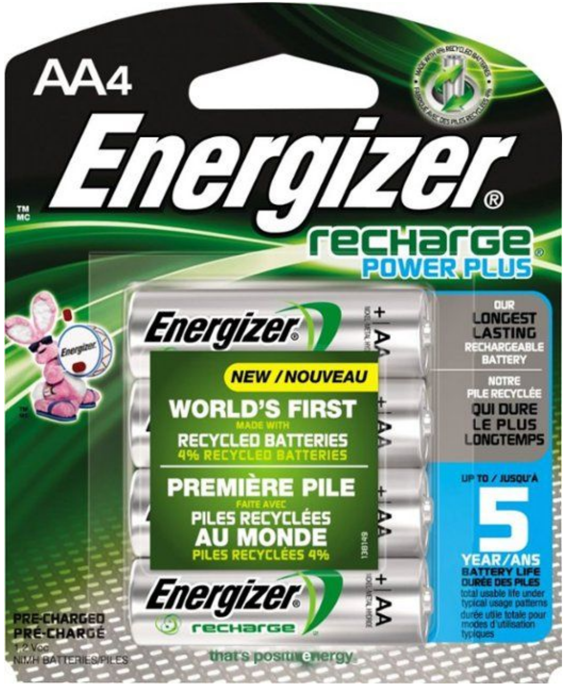


Power Source



Original (VoCore)

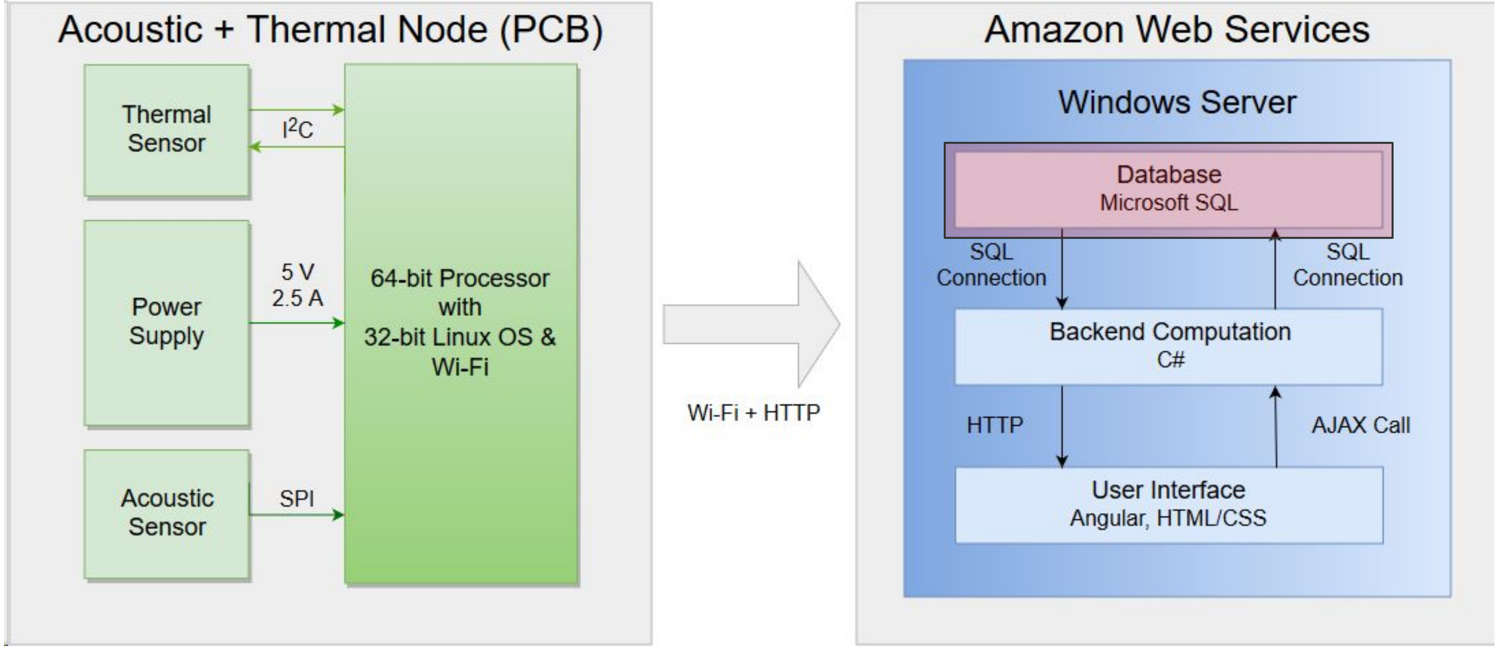
- Processor requires 5V and max ~240mA
- Thermal sensor requires max ~25mA
- Acoustic sensor requires max ~1mA
- 4 AA batteries in series
- Would last roughly 30 hours
- Portability and ease-of-use



Modified (Raspberry Pi 3B)

- Raspberry Pi requires 5V and 2.1 A
- Thermal sensor requires max ~25mA
- Acoustic sensor requires max ~1mA
- Wall power supply (5V and 2.5 A)
- Non-portable

Database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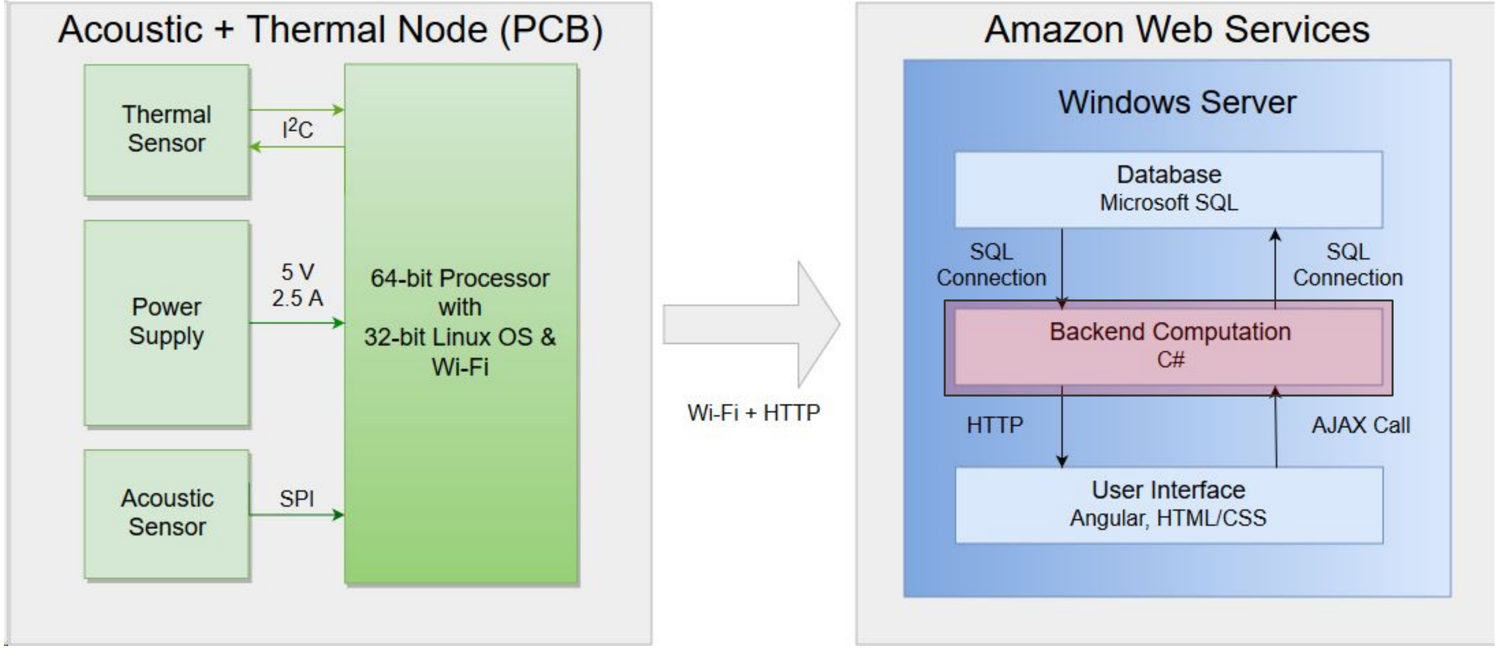
Database

- Microsoft SQL based
- Stores user account information, location mappings and incident log

API



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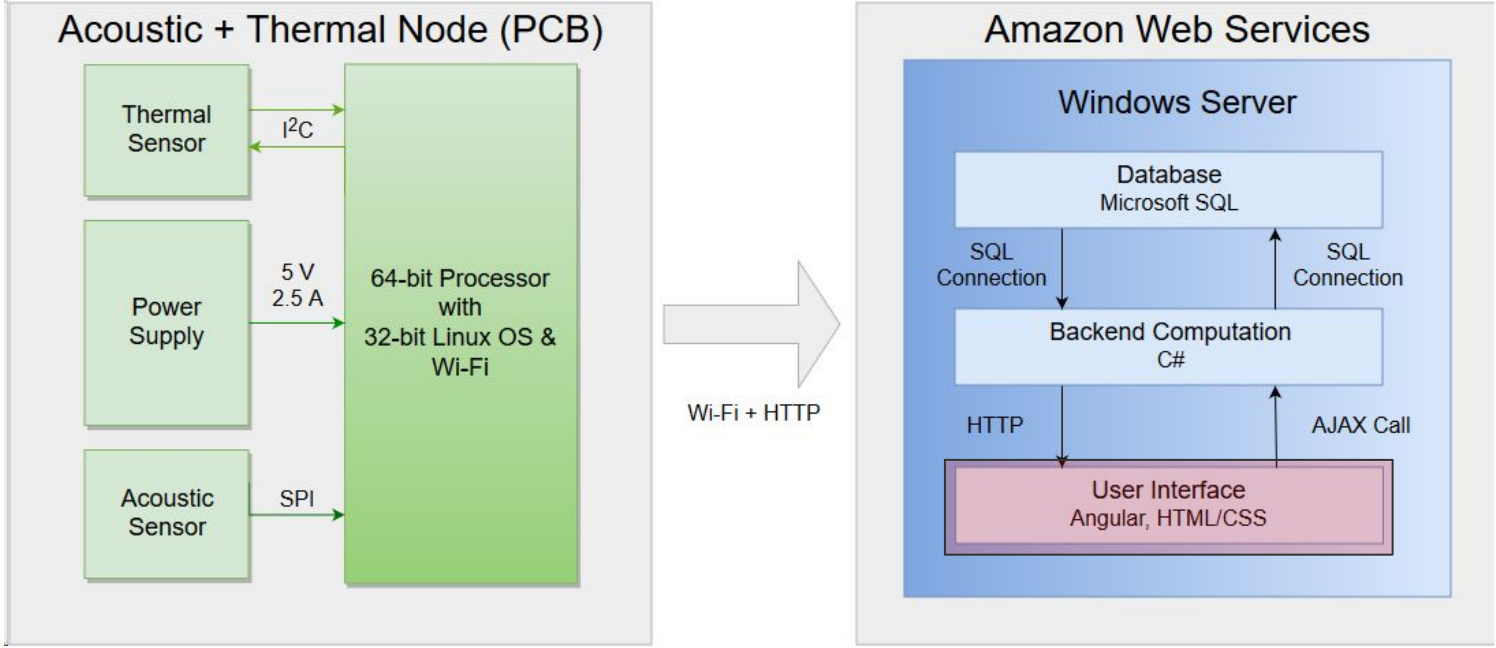
API

- Implemented in C#
- HTTP based
- Communication to the modules and to the dashboard
- Performs queries on the database as necessary
- backend.coresidium.com

Dashboard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Dashboard

- Implemented in Angular, HTML/CSS
- Receives data from API
- Communicates location information to user
- dashboard.coresidium.com

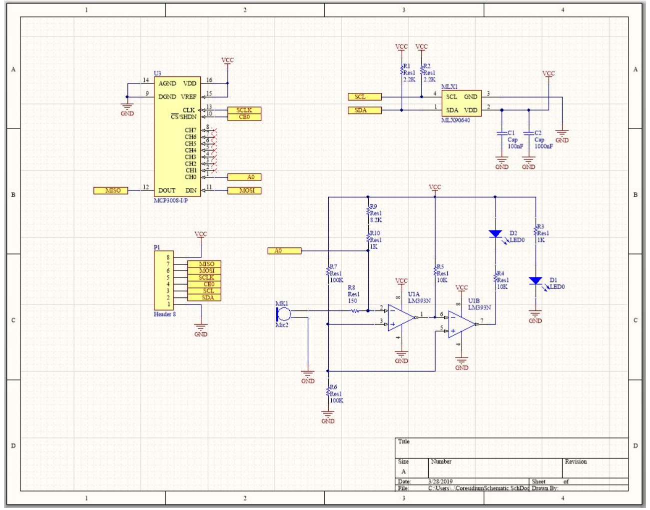
Accomplishments (PI)

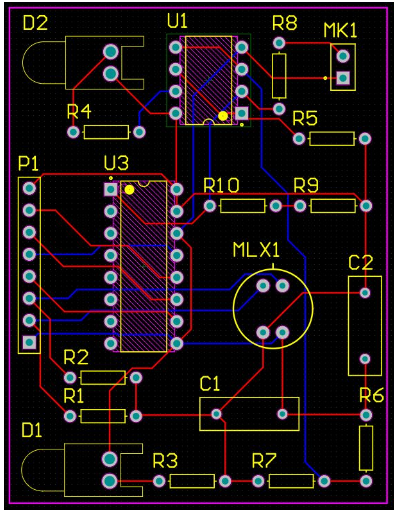
- One executable binary
- Multithreaded
- Keepalive implemented

Thread 1 Acoustic Processor	**Thread 2** Thermal Processor	**Thread 3** Acoustic Keepalive	**Thread 4** Thermal Keepalive
- Read data from acoustic sensor - If value is greater than threshold, timestamp and send to server	- Read data from thermal sensor - If value is greater than threshold, timestamp and send to server	- Read data from acoustic sensor every hour - Send to server if data valid and no other issues	- Read data from thermal sensor every hour - Send to server if data valid and no other issues

Accomplishments (Sensor)

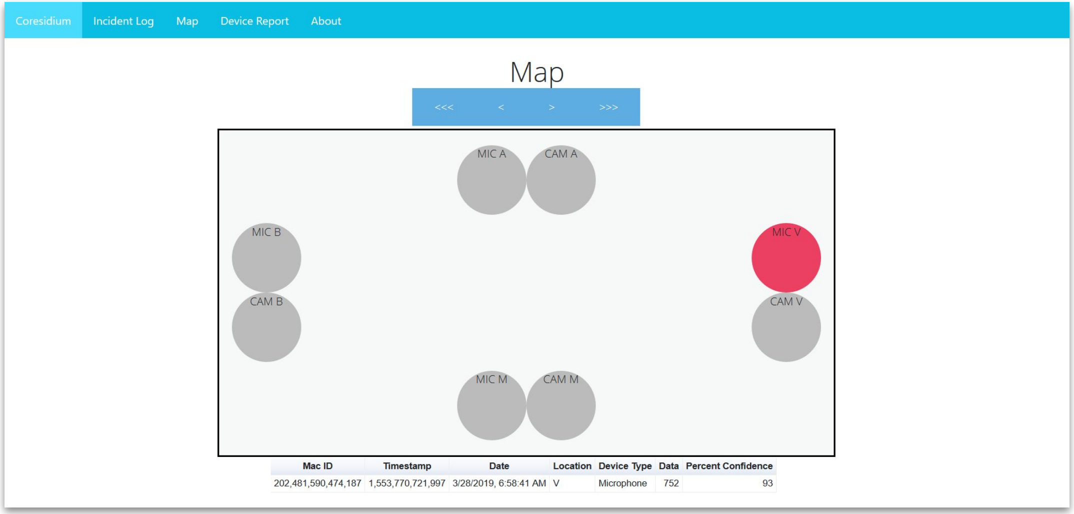
- Highest value in pixels vs. first value above threshold
- Calibration and variation
- Custom PCB designed





Accomplishments (Dashboard)

- Keep Alive Page
- Percent certainty column
- Map display



Testing Procedure

- Pop 25 balloons from 12 feet away from 4 acoustic sensors
  - Repeat test in environment with different ambient noise
  - Record ratio between success rate and total attempts
  - Varying balloon size
  - Direct line of sight
- Ignite a lighter 25 times from 3 feet away from thermal sensor for 0.5 seconds

Results

- Acoustic Sensors Test #1 (No ambient noise)
  - Average success rate of acoustic sensors - 92%
- Acoustic Sensors Test #2 (With ambient noise)
  - Average success rate of acoustic sensors - 92%
- Thermal Sensor Test #1 (3 feet)
  - Average success rate of thermal sensor - 100%
- Thermal Sensor Test #2 (8 feet)
  - Average success rate of thermal sensor - 100%

CDR Deliverables

- ✓ 90% sound sensor accuracy
- ✓ 70% thermal sensor accuracy
- ✓ Eliminate breakout boards for acoustic/thermal sensors
- ✓ Implement keepalive for each node
- ✓ Voting/redundancy system
- ✓ Improve dashboard UI
- ? Functional VoCore

FPR Deliverables

- PCB ordered and assembled
- Three demo modules assembled
- Custom casing for module
- Demo Ready
- Additional testing of system

Expenses (per device)

• Raspberry Pi 3B+	$35.00
• Thermal Sensor (MLX90640):	$40.00
• Analog to Digital Converter (MCP3008):	$2.75
• 2.2k Ohm Resistor x2	$0.60
• 1k Ohm Resistor x2	$0.60
• 8.2K Ohm Resistor	$0.60
• 10k Ohm Resistor x2	$0.60
• 100k Ohm Resistor x2	$0.60
• 1uF Capacitor	$0.25
• 100nF Capacitor	$0.25
• Diodes x2	$0.25
• LM393N	$1.00
• Header	$0.01
• Custom PCB	$8.00
• Electret Microphone	$0.67
• Total:	**$93.58**

DEMO