UMassAmherst
The Commonwealth's Flagship Campus

Preliminary Design Review

Team 22 – Professor Siqueira

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Coresidium – A School Security System

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Authority Response Time

in Active Shooter Situations

Response Times

Often greater than 3 hours for authorities to clear a school and tend to victims. Officials navigate without knowing who they are looking for or where they are.

Columbine High School

- April 20th, 1999
- 5 hours and 28 minutes
- Attacker whereabouts unknown within school

Virginia Tech

- April 16th, 2007
- 3 hours and 37 minutes
- Attacker able to move buildings undetected

Stoneman Douglas High School

- February 14th, 2018
- 3 hours and 18 minutes
- Attacker able to leave school amid panicking students

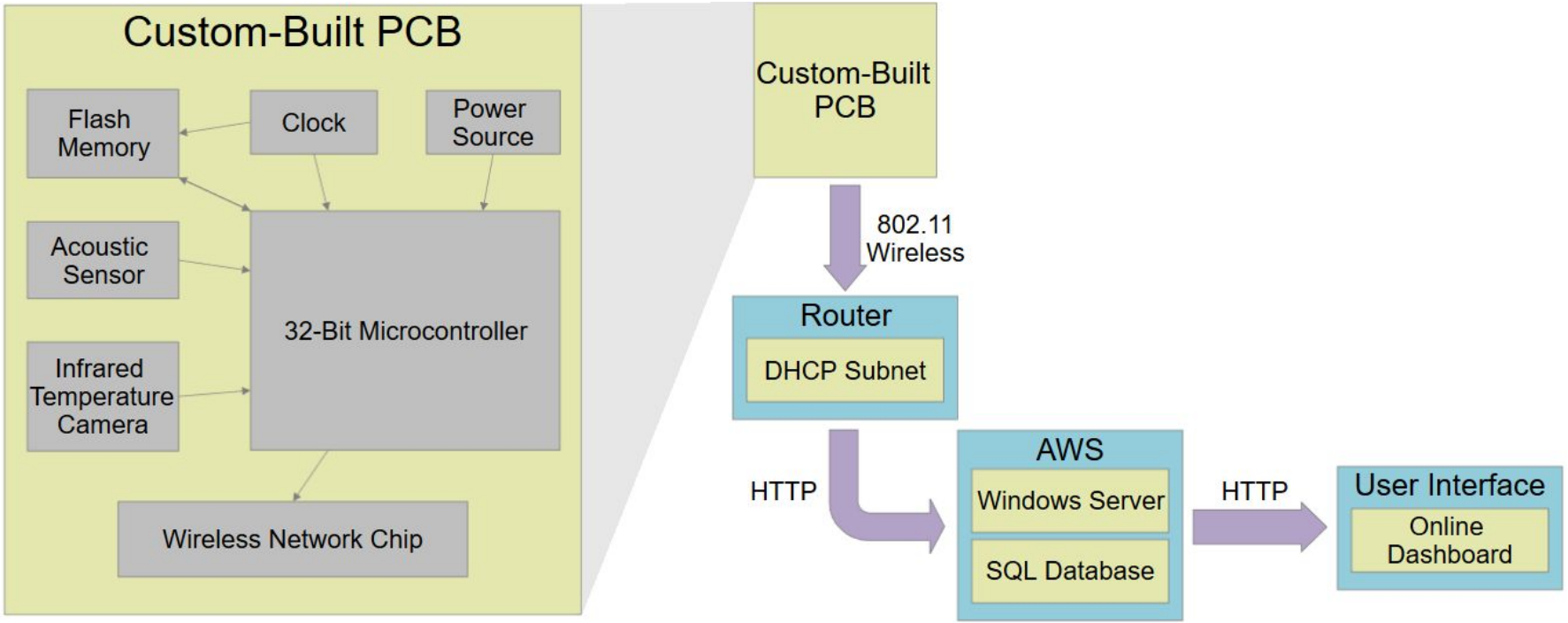
Current Approach

- Hunker down or exit the building
- Students inside barricade doors
- Law enforcement manually searches each room to declare building safe

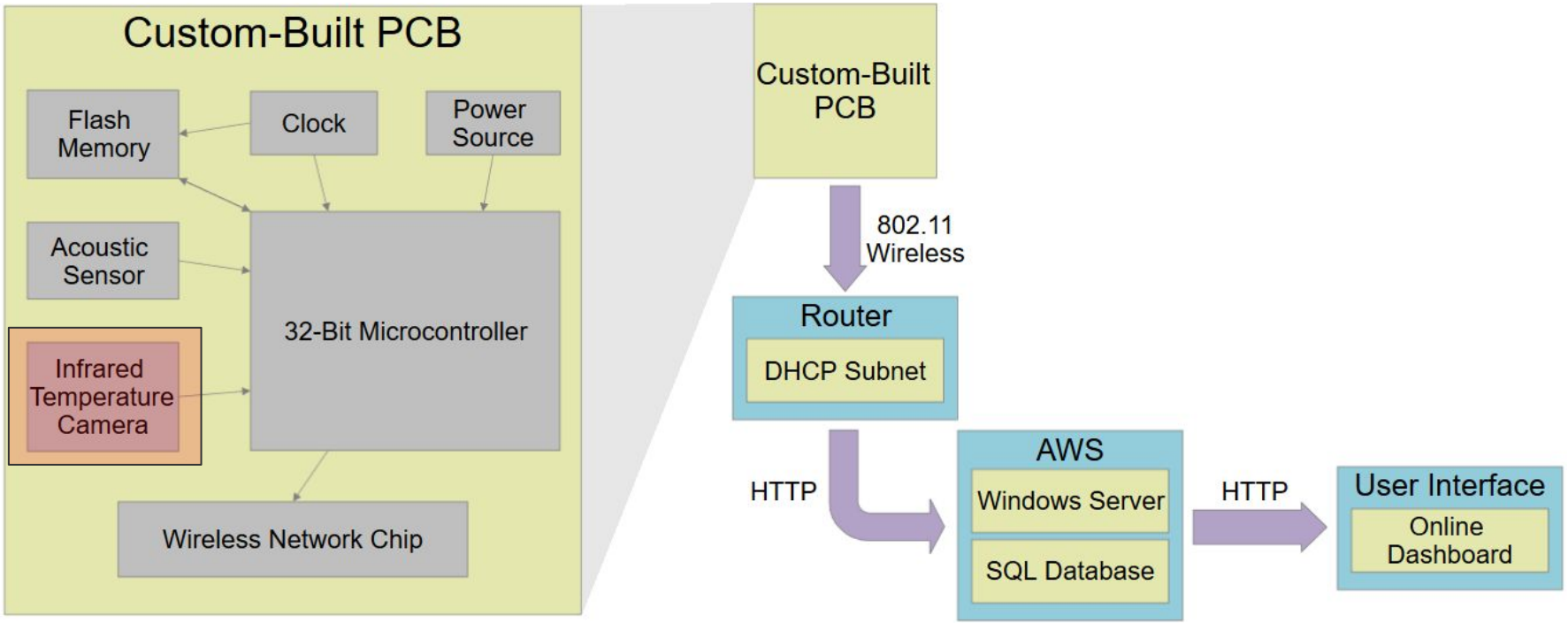
Problem Statement

- 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



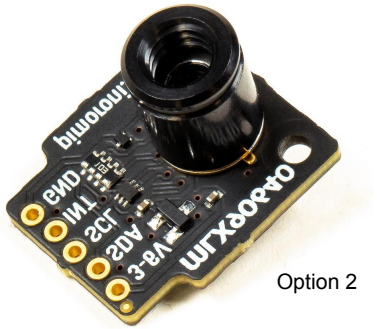
Infrared Thermal Camera



Infrared Thermal Camera

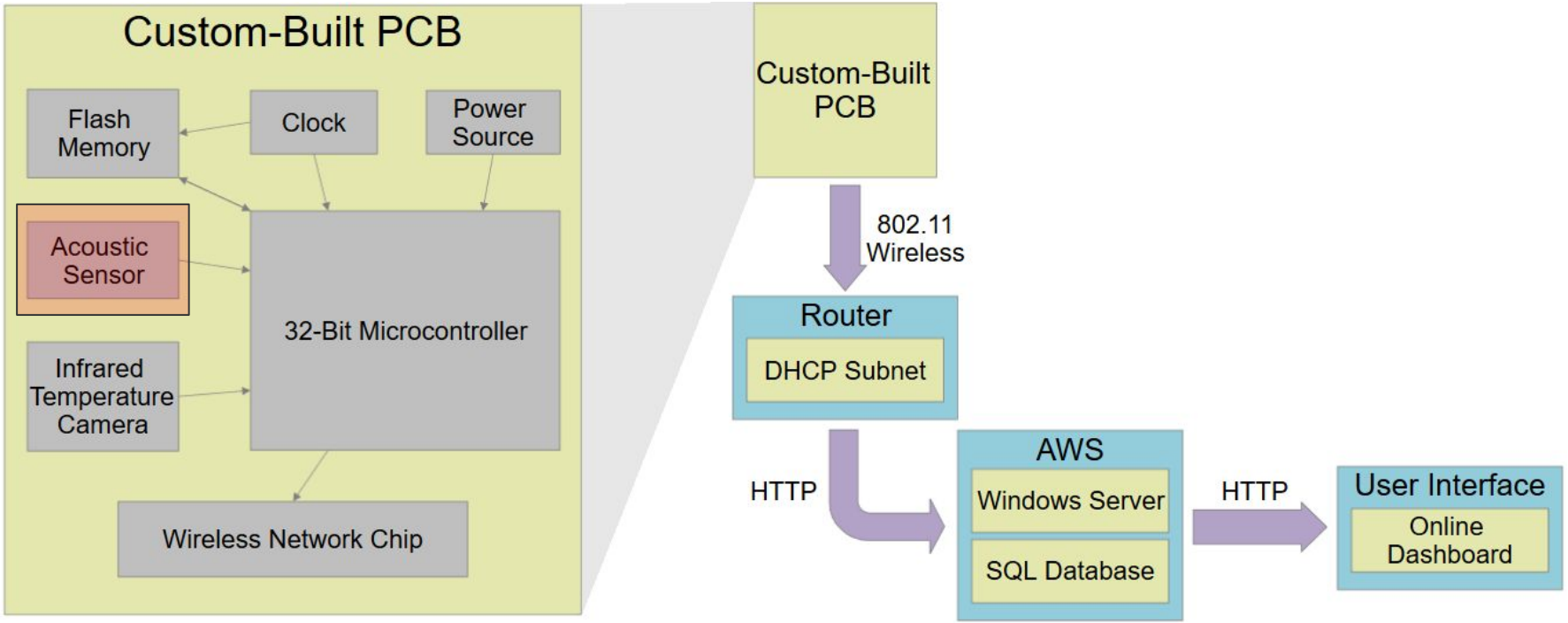
- Thermal detection of barrel upon firing
- 8x8[1] vs. 32x24[2] bit resolution
- 10 Hz refresh rate[1] vs. 64 Hz refresh rate[2]
- 0ºC to 80ºC[1] or -40ºC to 300ºC[2]
- Gunshot heats rifle barrel to ~150ºC

Option 1



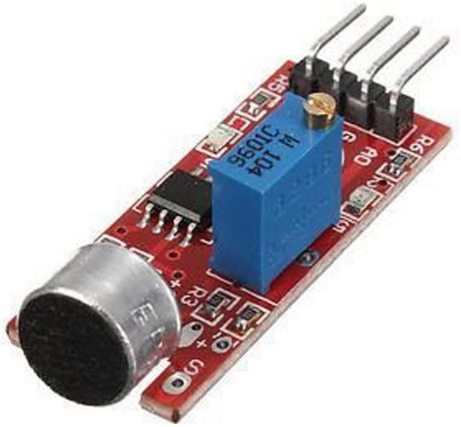
Option 2

Acoustic Sensor



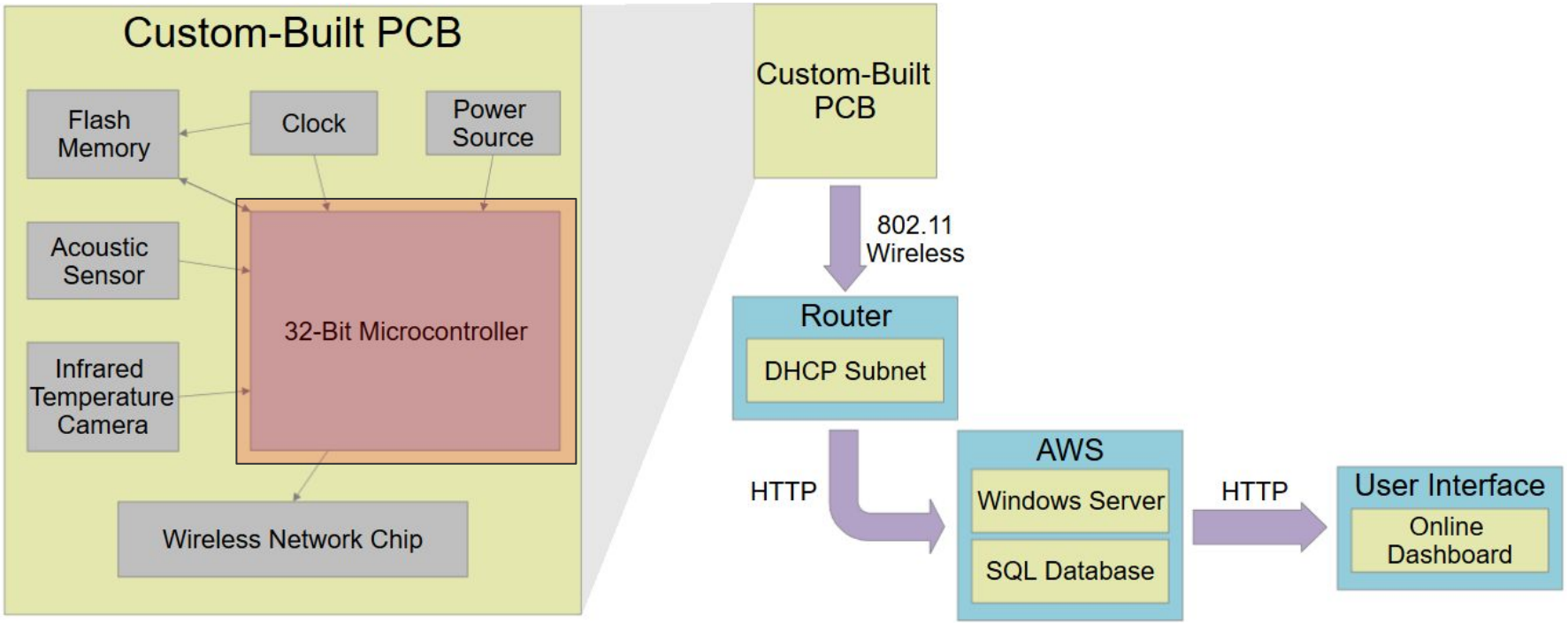
Acoustic Sensor

- Large sound sensor to detect gunshot noise
- 130 dB peak detection
- Gunshot between 150 dB and 190 dB
- Saturation vs. triangulation vs. insulation



Acoustic Sensor

32-Bit Microcontroller

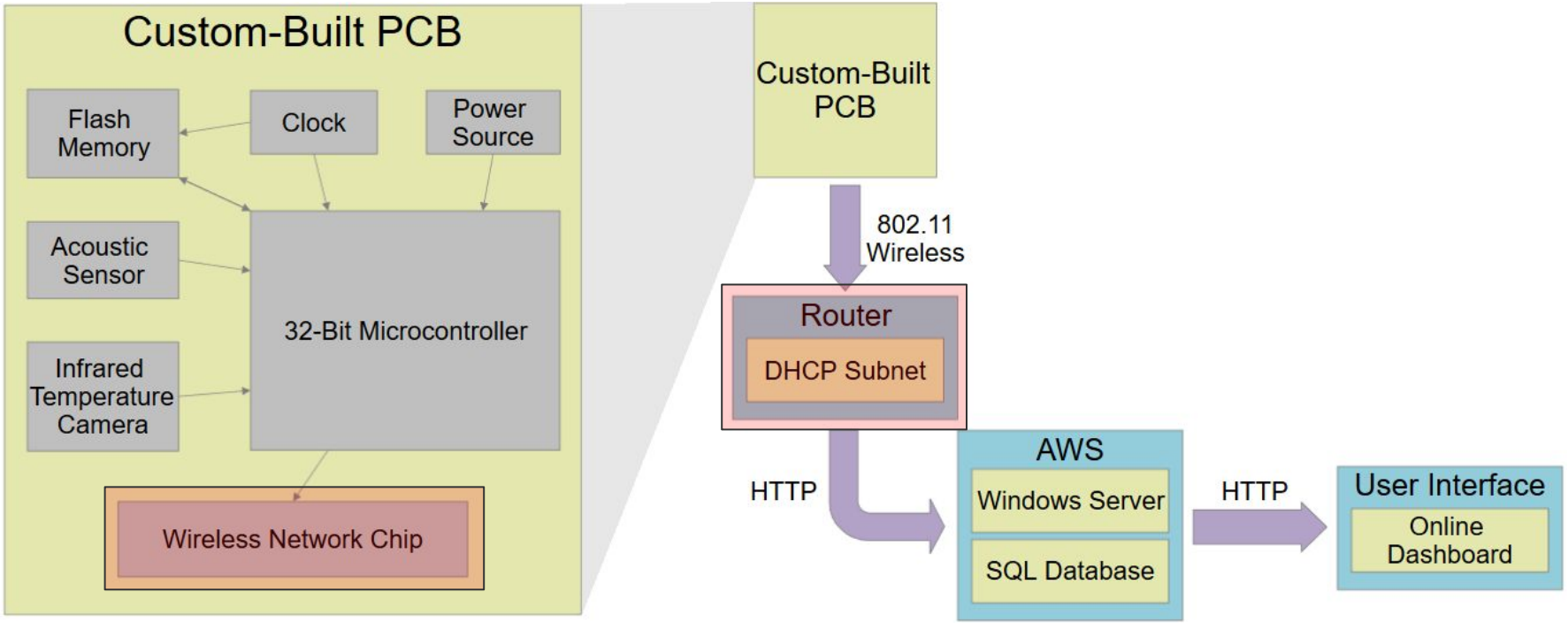


32-Bit Microcontroller

- Processes raw data from sensors
  - Audio: filter out noises below threshold, distinguish loud noises from ambient
  - Thermal: Detect temperatures above set threshold
- Classifies threat based on data collected
- Timestamps and sends data to server in case of threat

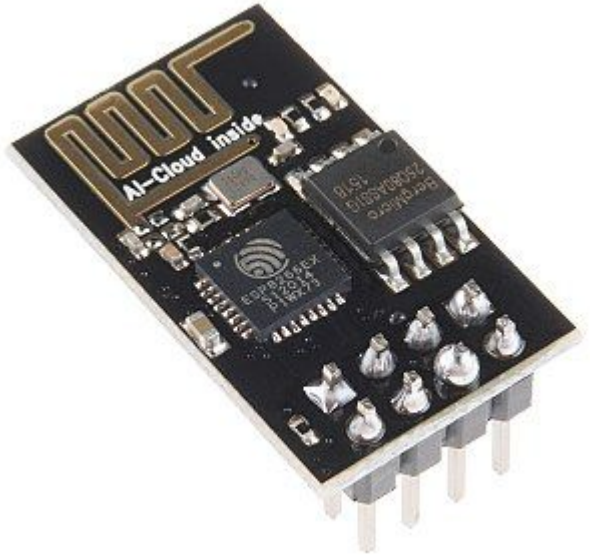
Arbitrary Microprocessor

Network Module



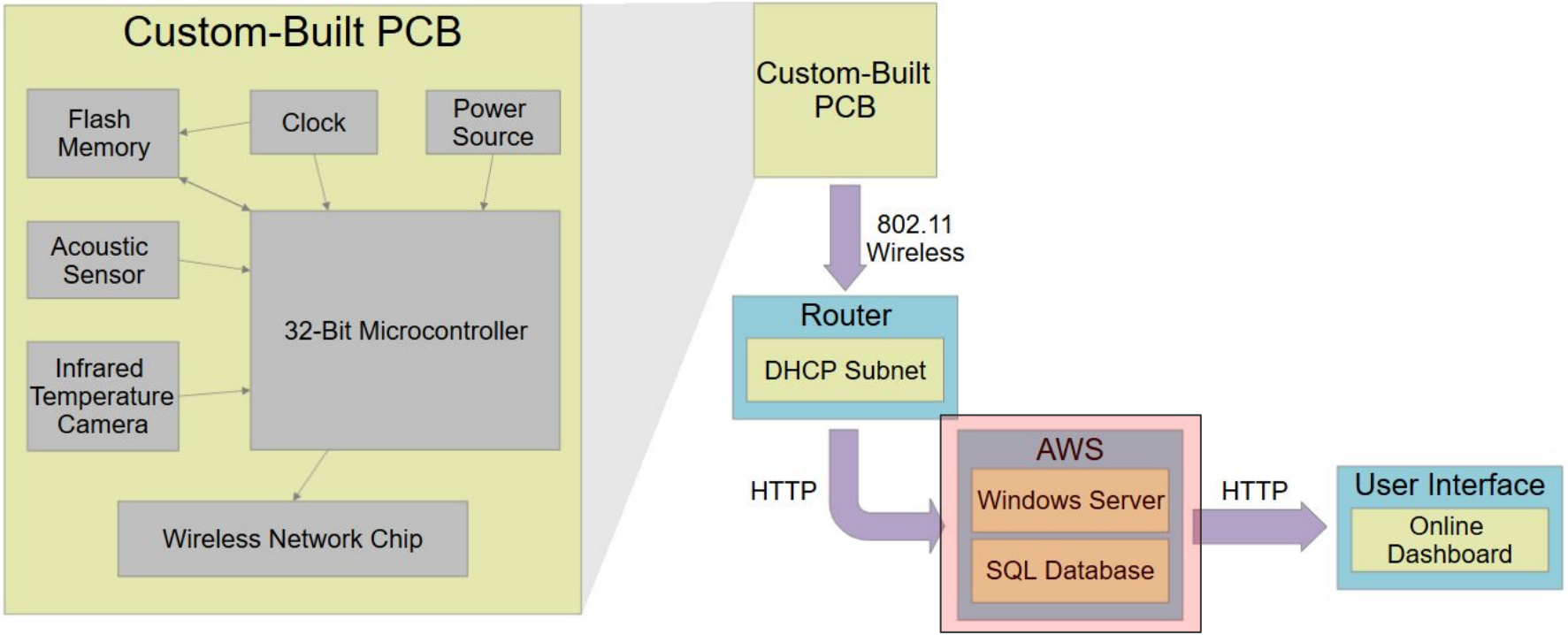
Wireless Network

- Wi-Fi chip to communicate to server
- Send module ID, timestamp, threat level



Wi-Fi Chip

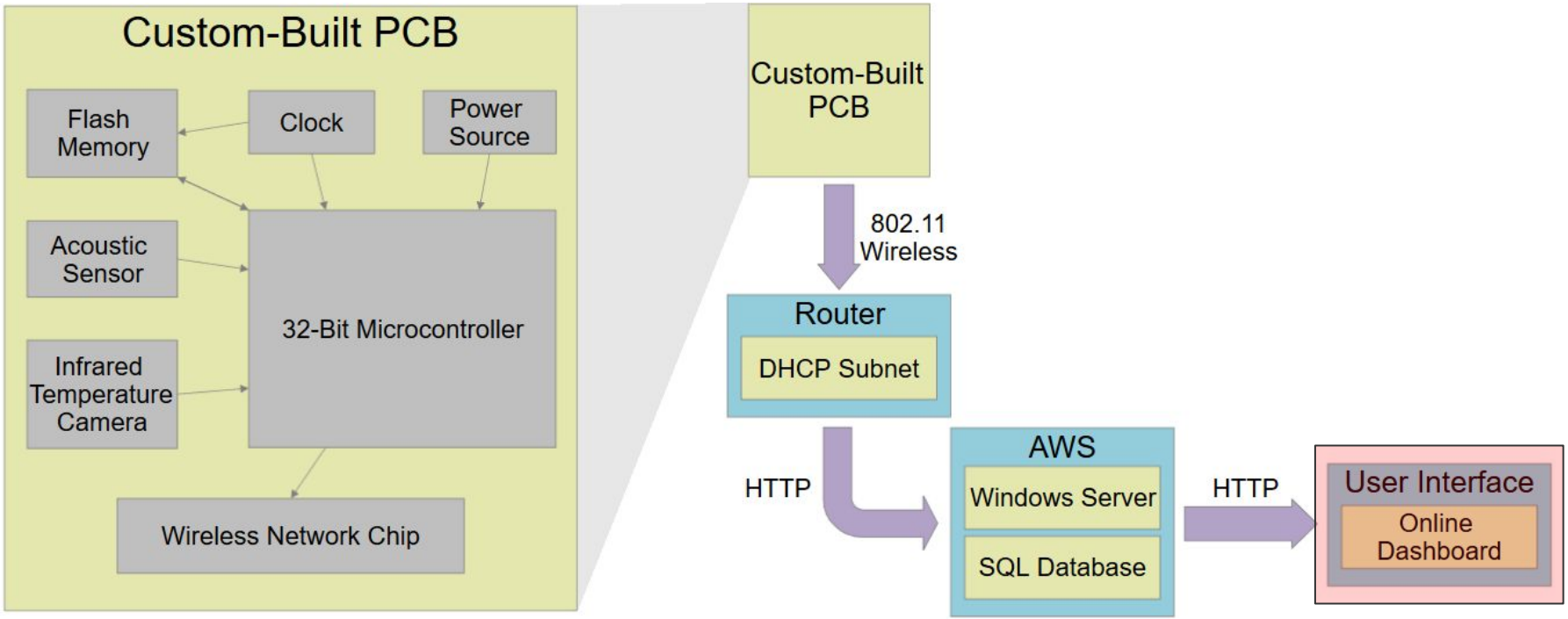
Amazon Web Services (AWS)



Amazon Web Services (AWS)

- Windows Server
- Microsoft SQL
  - Store sensor information
- HTTP to transfer data from modules
- C# for further computation and coordination
- Hosts user interface

User Interface



User Interface

- Web-based dashboard
- User authentication system
- Provide relative location information to authorities

System Progress Report

- Dashboard has functional user authentication system
- Detection of loud noise using three acoustic sensors
- Configured Wi-Fi Module
- SQL database configured for module data

Challenges

- Indoor sound propagation/echoing
- Coordination between multiple sound sensors
- Insulation of acoustic sensor
- Privacy/Recording

Testing

- Scale model
- Balloon Popping
- Flint striker/lighter/matches
- Dickinson Hall ROTC/Former Wilbraham High School (UMPD)

MDR Goals

- Find acceptable insulation for microphone
- Acoustic module identifies simulated gunshot with 65% accuracy
- Thermal camera recognizes objects above 120°C for 0.5 seconds
- Store data in SQL, compute location and coordinate between modules
- Simple online dashboard with relative location of threat (floor & side)

Alternative approach

- Use cameras, microphones, and artificial intelligence to provide location of threat
- YOLO (You Only Look Once) detection algorithm
- Requires camera and high performance local computing system
  - Dedicated graphics processor(s) for neural network
  - Real-time object detection

Pricing

- Custom PCB
  - 1x Thermal Infrared Sensors = $39.95 or $57.22
  - 1x Large Sound Sensor = $0.45
  - 1x 32-bit Microcontroller = $5.95
  - 1x WiFi Chip = $2.69
  - 1x Flash Memory = $1.36
  - 1x Clock = $0.95
  - 1x Power Supply = $8.00
  - PCB Fabrication = $40.00
  - Estimated total for single PCB: **$99.35 or $116.62**

Existing Competition

- ShotSpotter
  - Outdoor capability only
  - Relies on microphones
  - Requires human input to assess acoustic signatures
- Shooter Detection Systems
  - indoor detection with no human input
  - uses high pressure sound sensors and infrared sensors
  - Around $400,000 per 900 students

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