Sherlock
Smart Home Assistant

Team/Roles

Andrew:
PCB Design, Pi Networking, Computer Vision/Camera, Web App

Jack:
Sensors Testing, Microphone

June:
WiFi and Networking

Steven:
Sensors Testing, Microphone

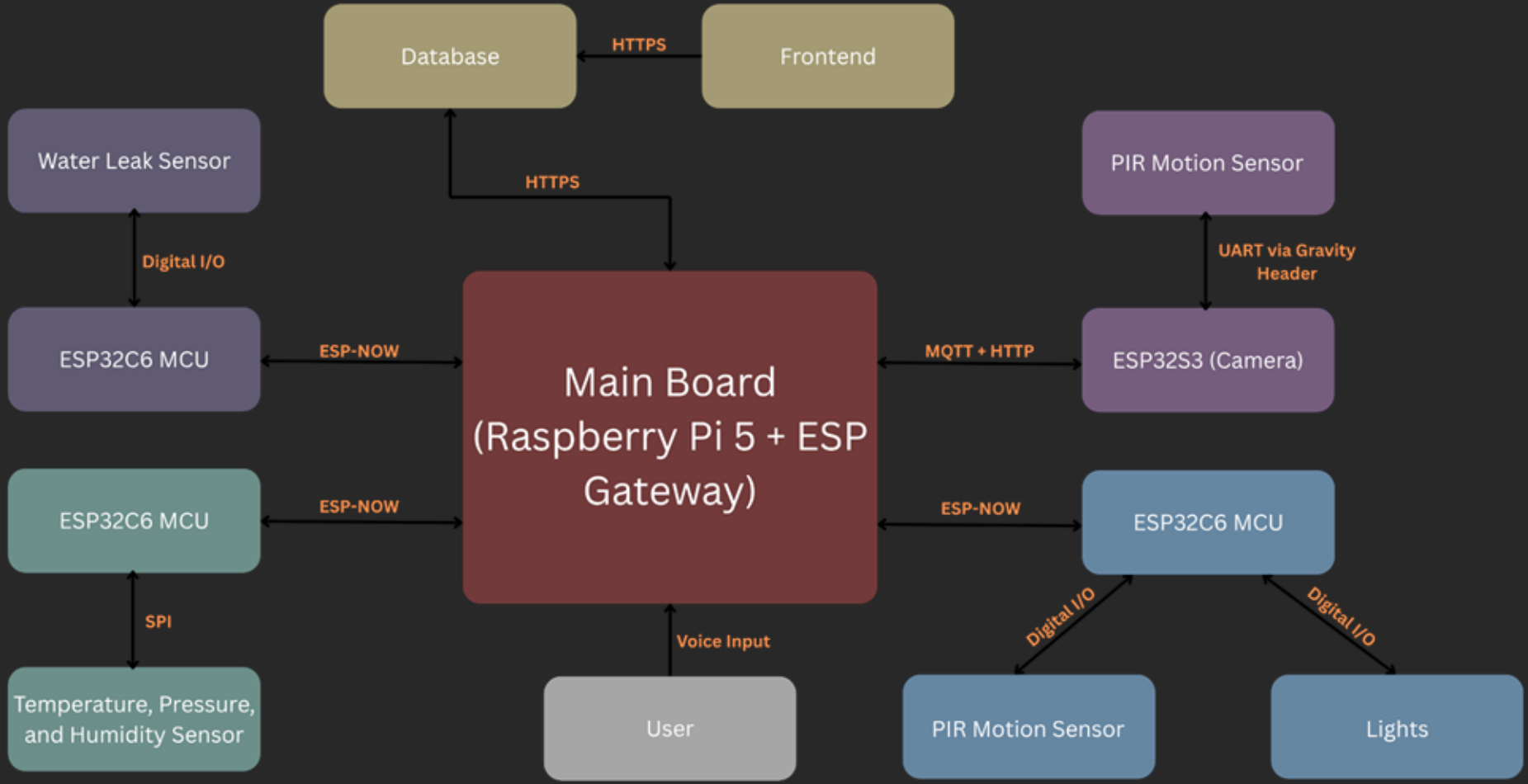
Rajvir:
Sensors Testing, Microphone

What is Sherlock?

A Proof of Concept Smart Home Assistant

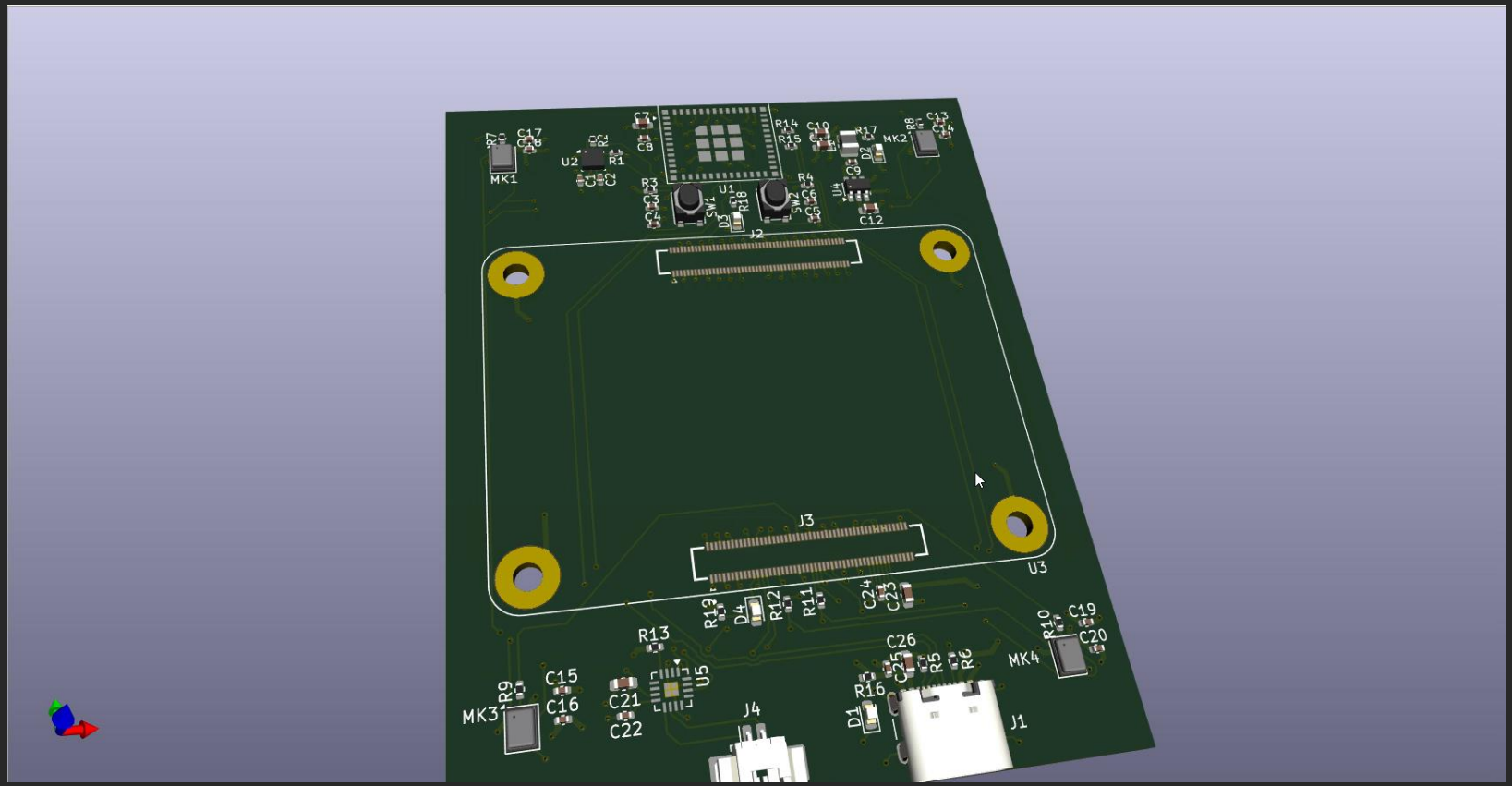
- Combined ESP32 + RPI platform
- Readily Available Sensors
- Hybrid Edge-Cloud Architecture
  - Low-Power Edge Nodes
  - Central Hub
  - Cloud Database
- A more **open** Smart Home Control System

System Architecture(Block Diagram)

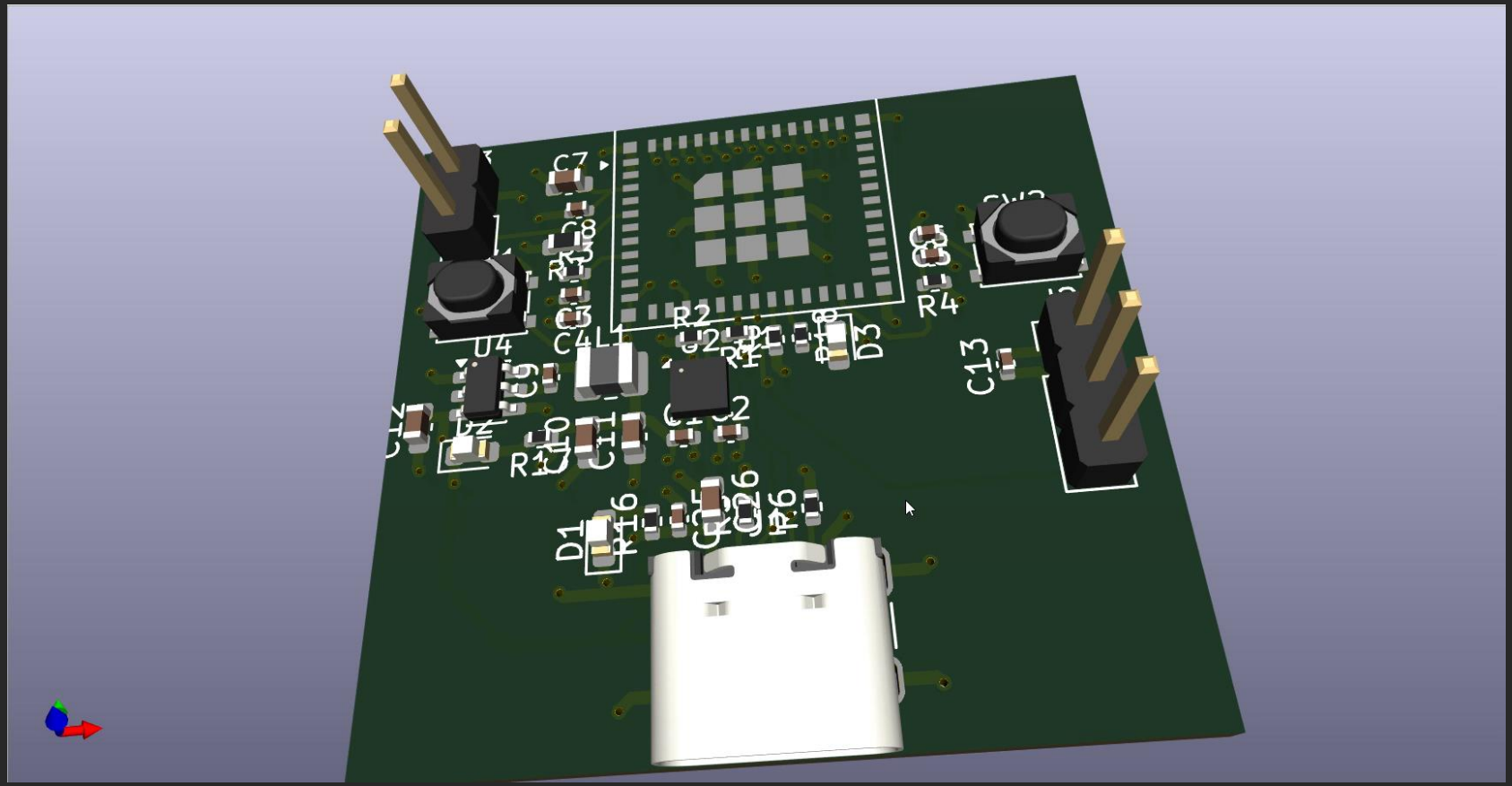

Database
HTTPS
Frontend
HTTPS
Water Leak Sensor
Digital I/O
ESP32C6 MCU
ESP-NOW
Main Board (Raspberry Pi 5 + ESP Gateway)
MQTT + HTTP
PIR Motion Sensor
UART via Gravity Header
ESP32S3 (Camera)
ESP32C6 MCU
ESP-NOW
ESP-NOW
ESP32C6 MCU
SPI
Temperature, Pressure, and Humidity Sensor
Voice Input
User
Digital I/O
Digital I/O
PIR Motion Sensor
Lights

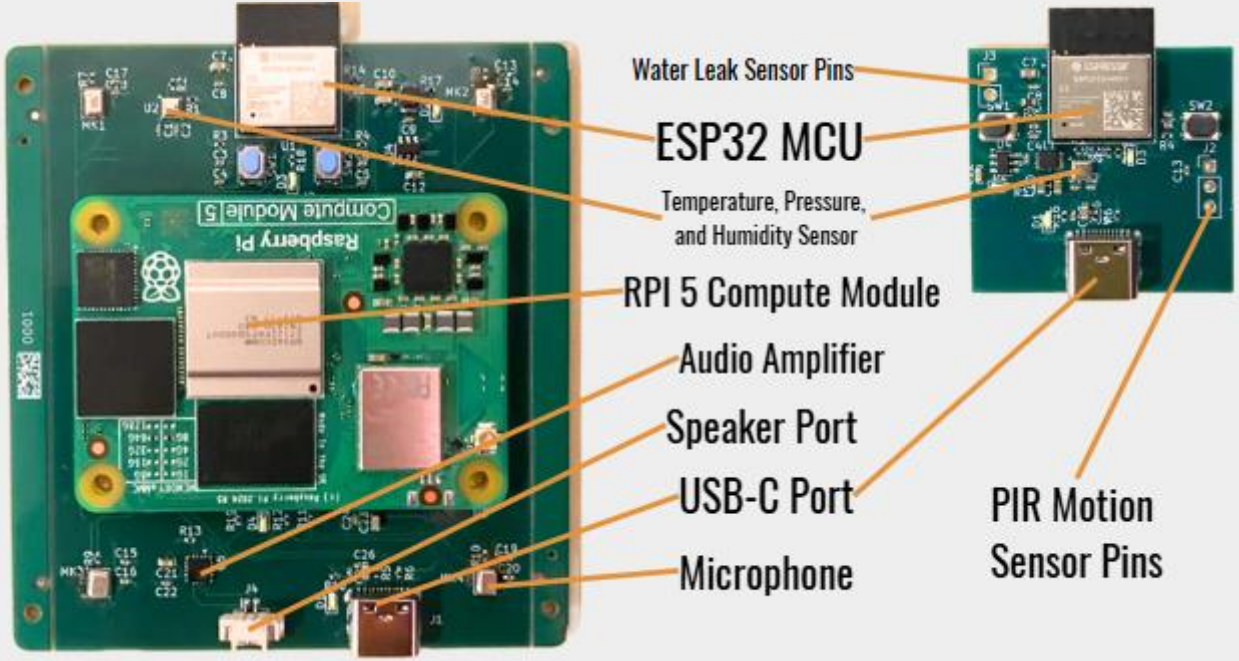
PCB Design

Main PCB


MK1
U2
R1
C1
C2
C7
C8
U1
R14
R15
C10
R17
D2
C9
MK2
R8
C13
C14
R3
C3
C4
SW1
D3
R18
SW2
C6
R4
U4
C12
J2
J3
U3
R13
D4
R12
R11
C24
C23
R10
C19
C20
C26
C25
R5
R6
MK4
R16
D1
J1
R13
R9
C15
C16
MK3
C21
C22
U5
J4

Edge PCB



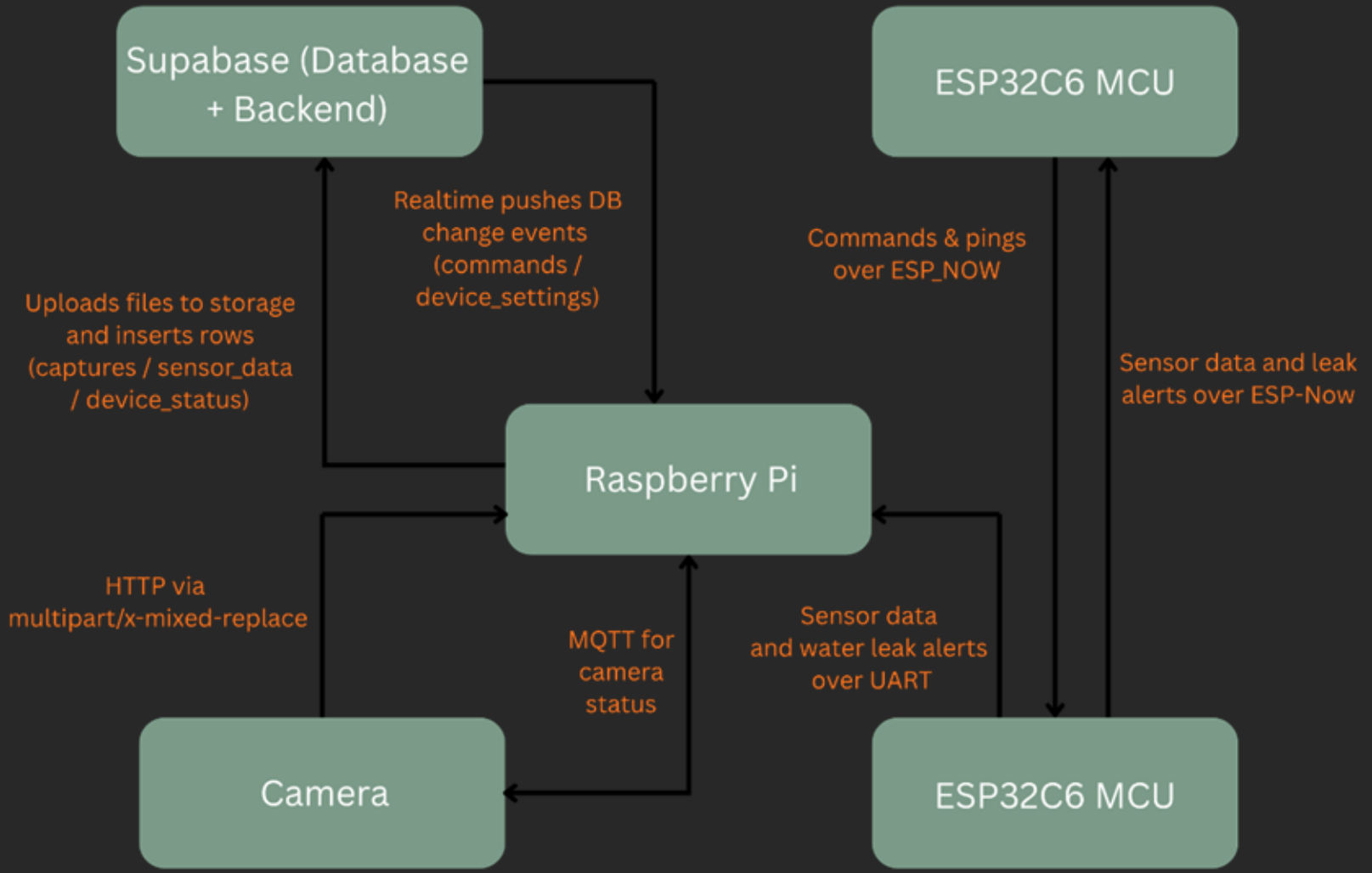

Water Leak Sensor Pins
ESP32 MCU
Temperature, Pressure, and Humidity Sensor
RPI 5 Compute Module
Audio Amplifier
Speaker Port
USB-C Port
Microphone
PIR Motion Sensor Pins

Networking

- Raspberry Pi to ESP32C6: UART
- Raspberry Pi to ESP32S3: MQTT + HTTPS
- ESP32C6 to ESP32C6: ESP-NOW
- Unicast format used to issue commands to edge boards, e.g. sleep

ESP-NOW unicast packet data format						
Usage	CRC	CRC	Key	Key	Data type	Payload
Byte	0	1	2	3	4	5+

ESP-NOW broadcast packet data format				
Usage	CRC	CRC	Key	Key
Byte	0	1	2	3


Supabase (Database + Backend)
ESP32C6 MCU
Realtime pushes DB change events (commands / device_settings)
Commands & pings over ESP_NOW
Uploads files to storage and inserts rows (captures / sensor_data / device_status)
Sensor data and leak alerts over ESP-Now
Raspberry Pi
HTTP via multipart/x-mixed-replace
MQTT for camera status
Sensor data and water leak alerts over UART
Camera
ESP32C6 MCU

ESP-NOW

- Trivial setup
- Doesn’t require connection to existing network
- Great software support libraries
- Sufficient range & paired peer count

MQTT

- Established smart home communication protocol
- Great existing codebase
- Widespread support & extensibility

Hardware Overview

Microcontroller and Compute Module

ESP32C6 Microcontroller

- Low-Power
- Built-in WiFi + Bluetooth
- ESPNow Protocol
- UART, SPI, I2C, I2S

Raspberry Pi 5

- Central Compute
- Computer Vision
- Audio Processing
- UART to ESP32
- I2S

Sensors and Components

Panasonic PIR motion sensor

- 5m detection distance with a 94° x 82° field of view
- Ultra-low power consumption
- Noise resistance
- GPIO output signal

DFRobot ESP32-S3 AI Camera

- OV3660: 160° wide-angle infrared camera

- Motion sensor triggers video streaming upon detecting human movement
- Video processed by Raspberry Pi 5 using MQTT + HTTP protocols

Camera

- Trigger:
  - PIR Sensor detects infrared heat movement.
- Activation:
  - ESP32-S3 wakes its camera, starts a Local Web Server, publishes to MQTT, outputs audio.
- Capture:
  - ESP32-S3 captures frames pushed to a stream, which is polled by the Pi on command.
- Intelligence:
  - Pi5 uses OpenCV to correct the image and then pass it to ArcFace model, which matches faces based on cosine similarity.

SHERLOCK

Pi Online · Camera Active

Controls | Captures (0) | Sensors

Sensor Uploads — ENABLED

Stream BME280 and tilt readings to Supabase.

Capture Uploads — ENABLED

Allow the Pi to upload face captures and create capture records.

◉ Capture Now | ▶ Wake Camera | ■ Sleep Camera | ✕ Clear All

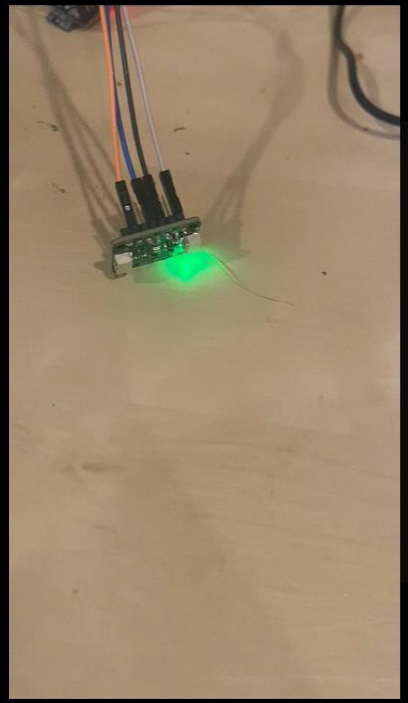
System ready

Adafruit BME280 Temperature/Humidity/Barometric Pressure Sensor

- Measuring temperature, pressure, and humidity
- SPI interface

Level Sense Liquid Sensor

- Behaves as open circuit w/o water and a 1.4MΩ resistor when water presents
- Analog I/O



↻ Refresh

ENVIRONMENT SENSORS

BME280 Sensor

LIVE

22.2 °C
TEMPERATURE

67 %
HUMIDITY

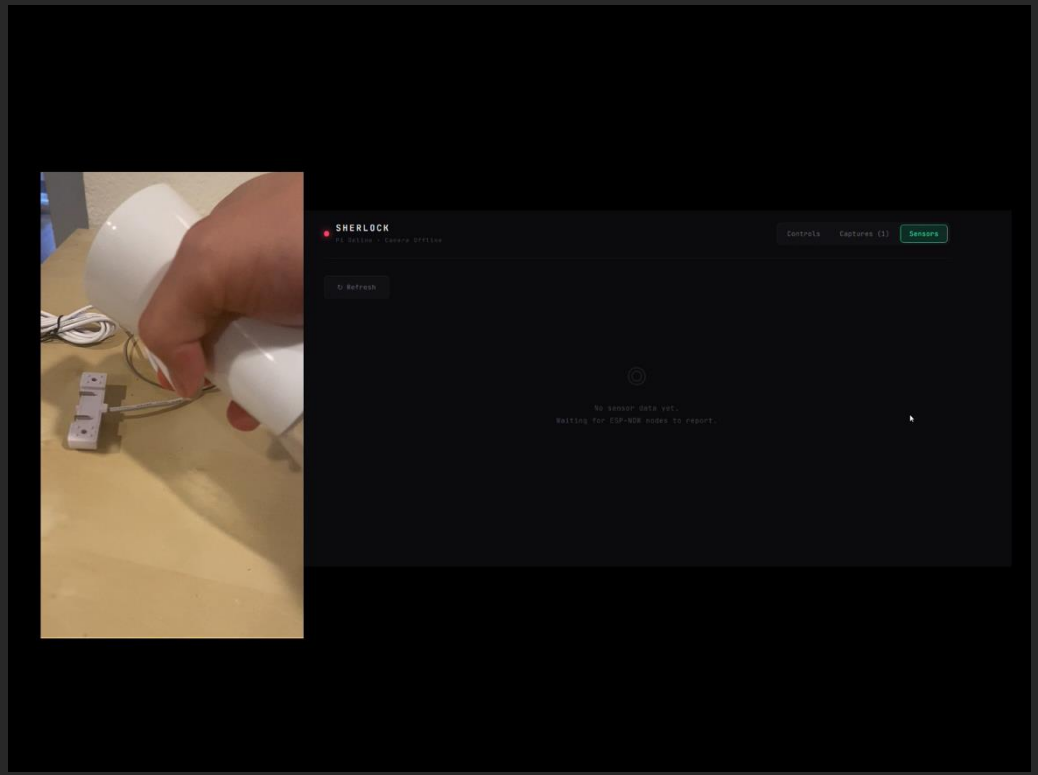
1014 hPa
PRESSURE

Temp | Humidity | Pressure

Last reading: just now · 23 data points

Water leak sensor

- Detection
- ESP-NOW communication



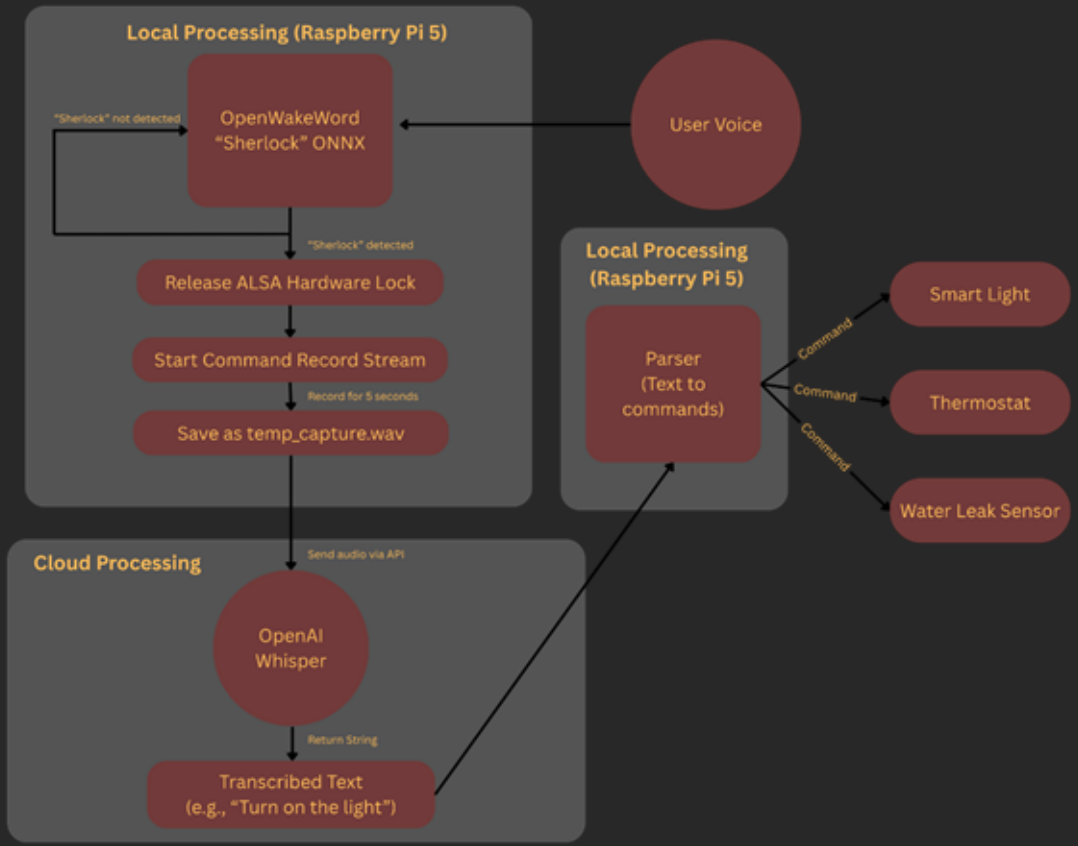
Audio System & Signal Analysis

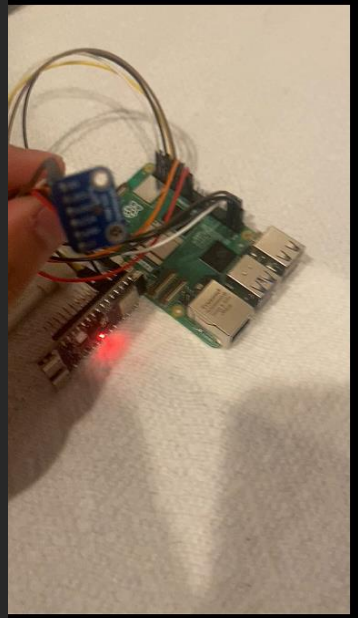
Adafruit I2S MEMS Microphone

- Direct 24-bit I2S output, allowing it to connect directly to Raspberry Pi 5
- High Signal-to-Noise Ratio (SNR) of 65dB(A) and a flat frequency response, ensuring high-fidelity audio capture across a wide range of frequencies

Pipeline from one word of the mic to communicate with the whole system

- Pre-trained Module Integration for text recognition
  - Converting captured vocal data into actionable text commands that trigger the system
  - OpenAI Whisper model on cloud
- Initially inactive, the microphone is activated once the keyword “Sherlock” is captured
  - OpenWakeWord model’s one-word recognition feature
  - Lower power consumption and processor workload





username@pi5: ~/sherlock-pi

```
[SENSOR] FC:01:2C:F9:00:2C | Temp: 21.4°C | Humidity: 68.1% | Pressure: 1015.1 hPa
[UART] Sensor uploads disabled — skipping environment packet

[SENSOR] FC:01:2C:F9:00:5C | Temp: 21.5°C | Humidity: 69.4% | Pressure: 1015.0 hPa
[UART] Sensor uploads disabled — skipping environment packet

[SENSOR] FC:01:2C:F9:00:2C | Temp: 21.4°C | Humidity: 68.0% | Pressure: 1015.1 hPa
[UART] Sensor uploads disabled — skipping environment packet

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[UART] Sensor uploads disabled — skipping environment packet
```

Sherlock,
Smart Home Assistant

Special Thanks:

IFT

Dr. Yogananda Isukapalli

Lucas Liang

Laritech