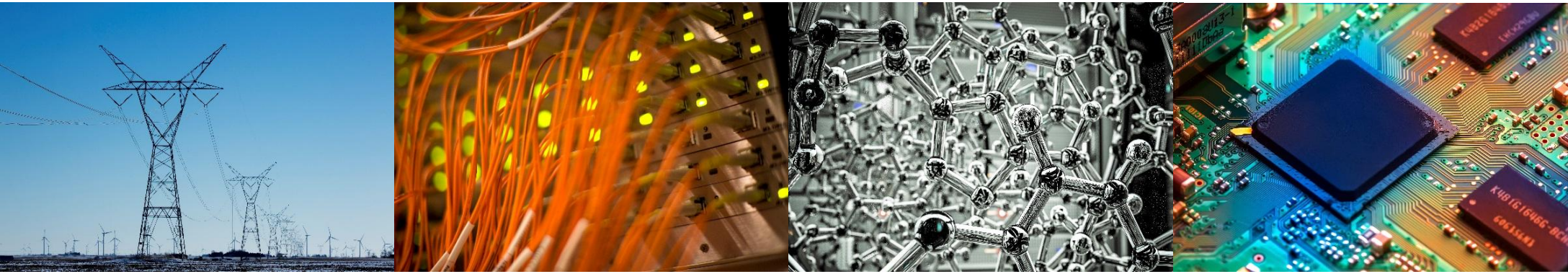
Temperature Sensor Network for Thermostat Control

ECE 445 Project Presentation
Team 33

Haige Chen, Ryan Finley, Heming Wang



ILLINOIS
Electrical & Computer Engineering
COLLEGE OF ENGINEERING

Introduction

An easy-to-install add-on to most of the current HVAC system to solve uneven heating/cooling problem in homes

- Low-cost
- Easy-to-setup
- Fits on top of standard air vents

Design Overview - Three Modules

1. Temperature Sensor Module

2. Central Hub

3. Air Vent Actuator Module

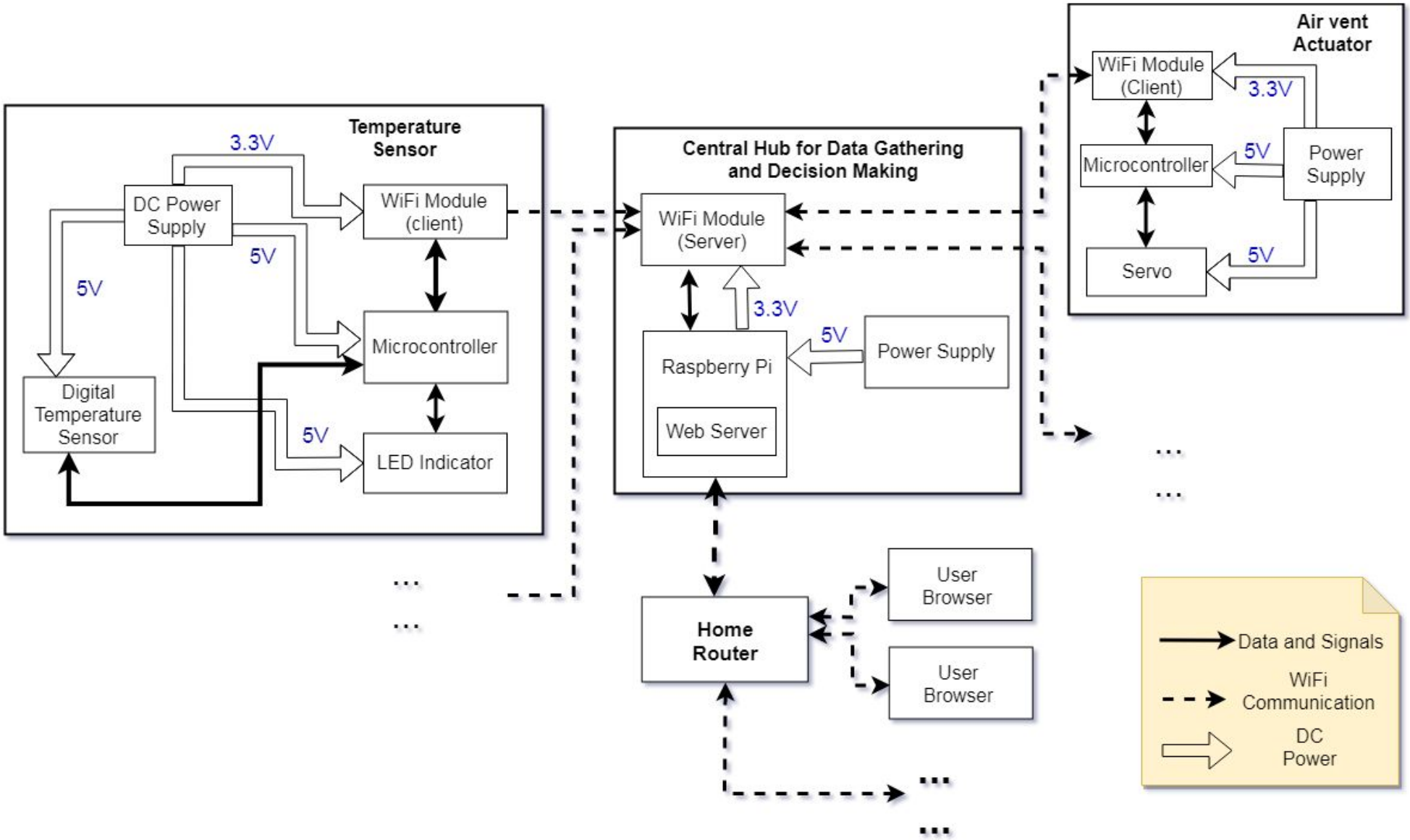
Objective

1. Real-time temperature measurement

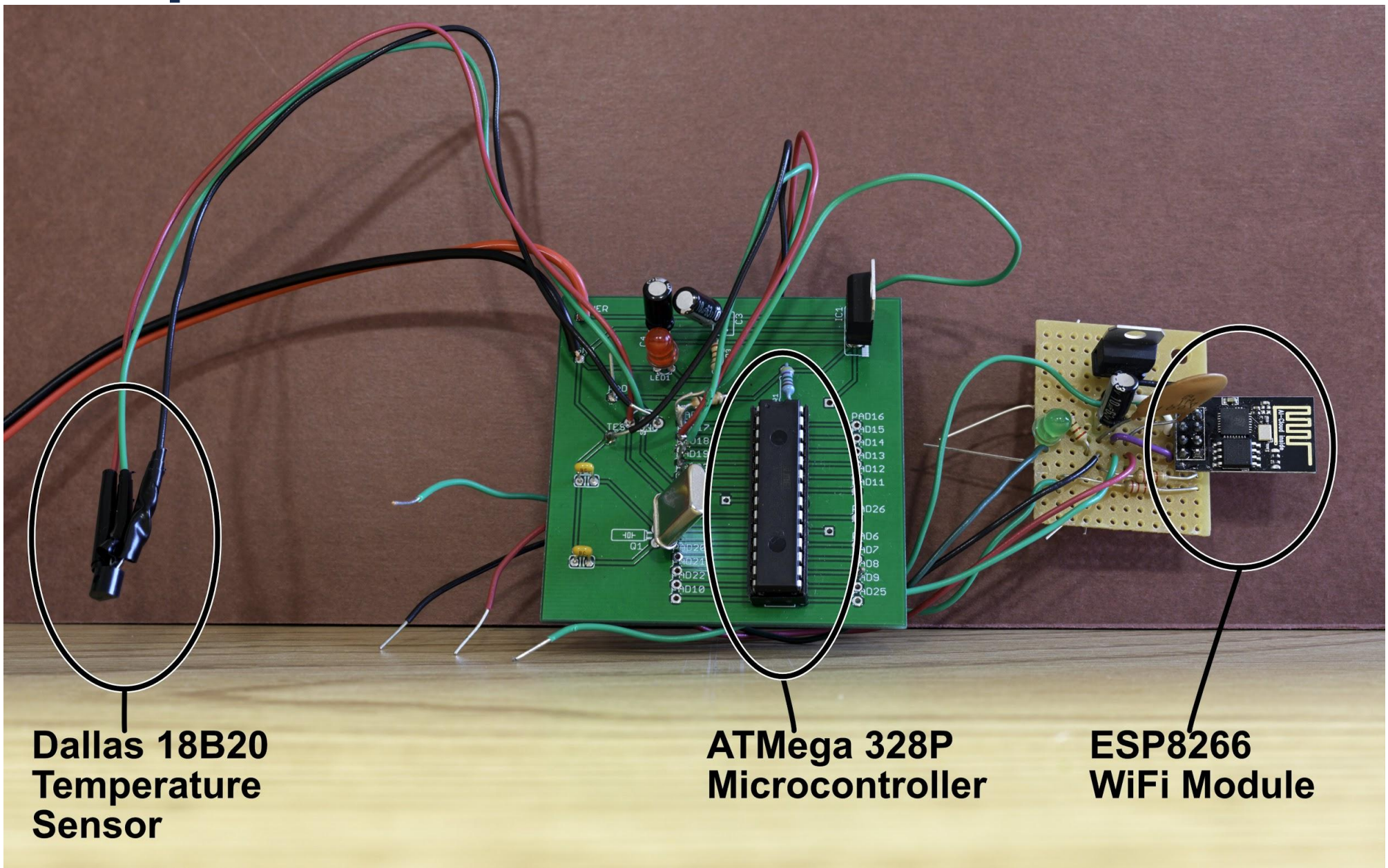
2. Air vent actions

3. Alerts and visualization

Block Diagram

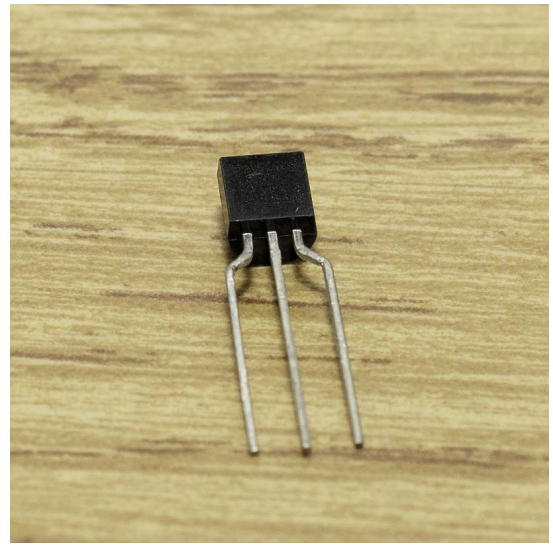


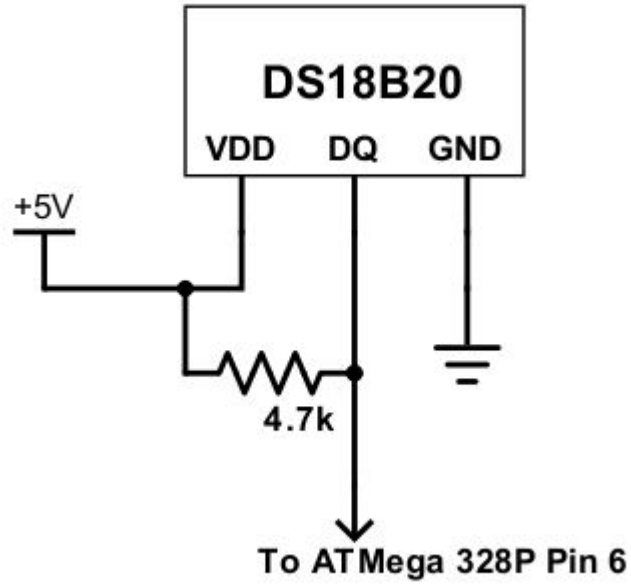
Temperature Sensor Module



Dallas 18B20 Digital Temperature Sensor

- Read ambient temperature
- Convert readings to 9-bit digital word
- Measuring range: -67°F to +257°F
- Accuracy: ±0.9°F from 14°F to 185°F





ESP8266 WiFi Module

- VCC 3.3V
- Can be controlled by microcontroller through serial communication (Tx, Rx)
- Contains firmware that supports AT commands

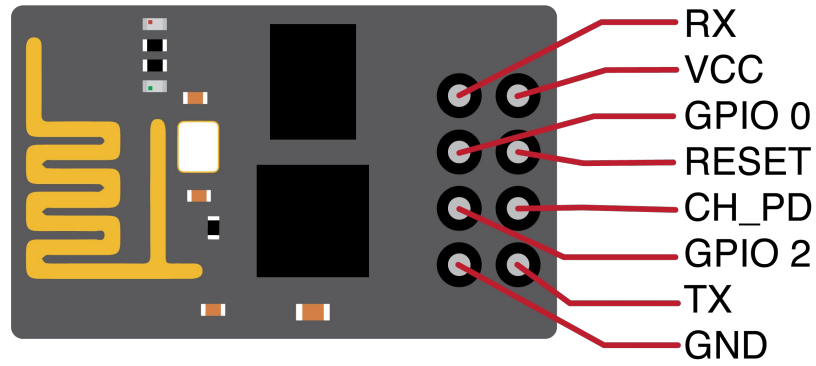
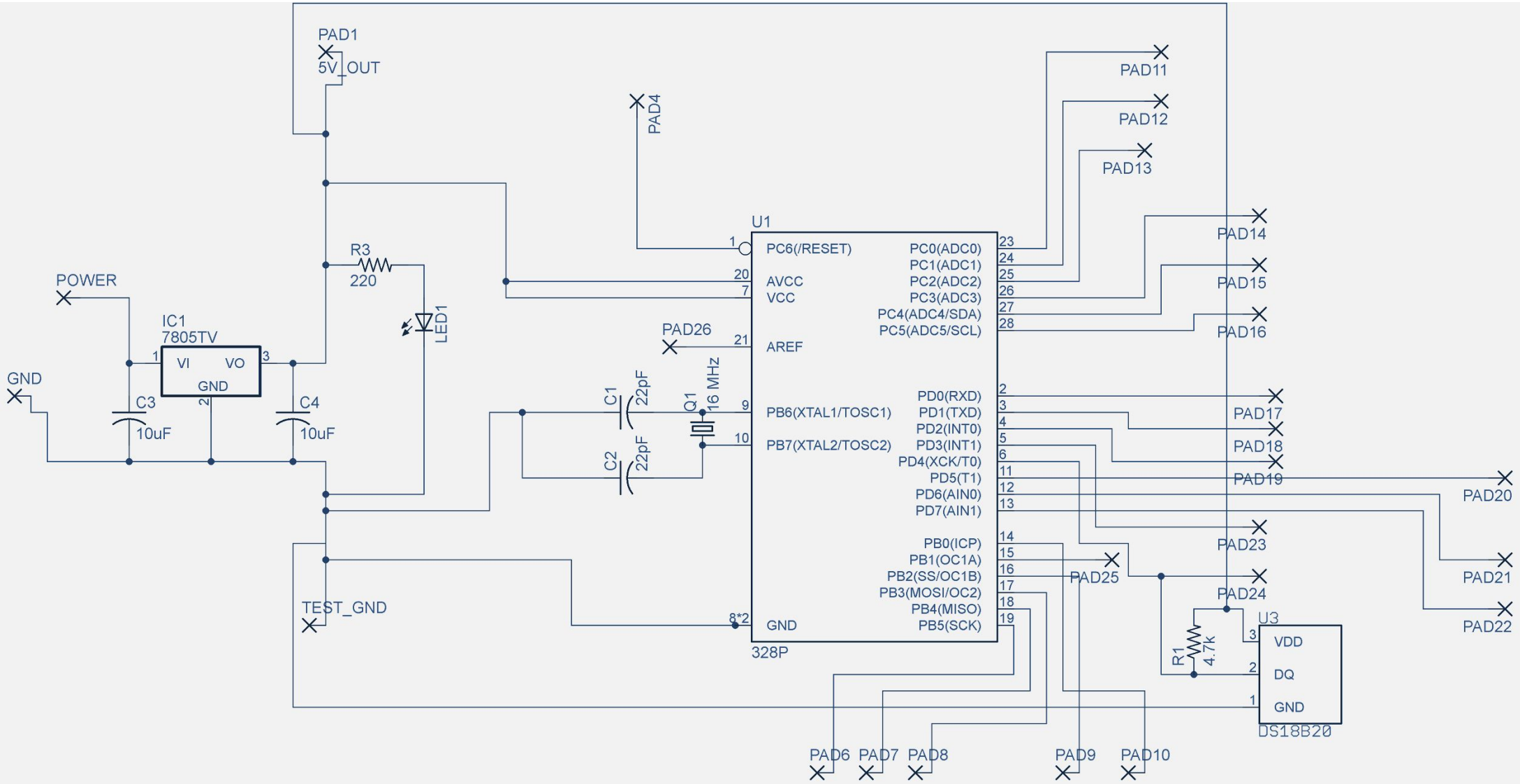


Figure:
ESP8266 Module Pin Diagram

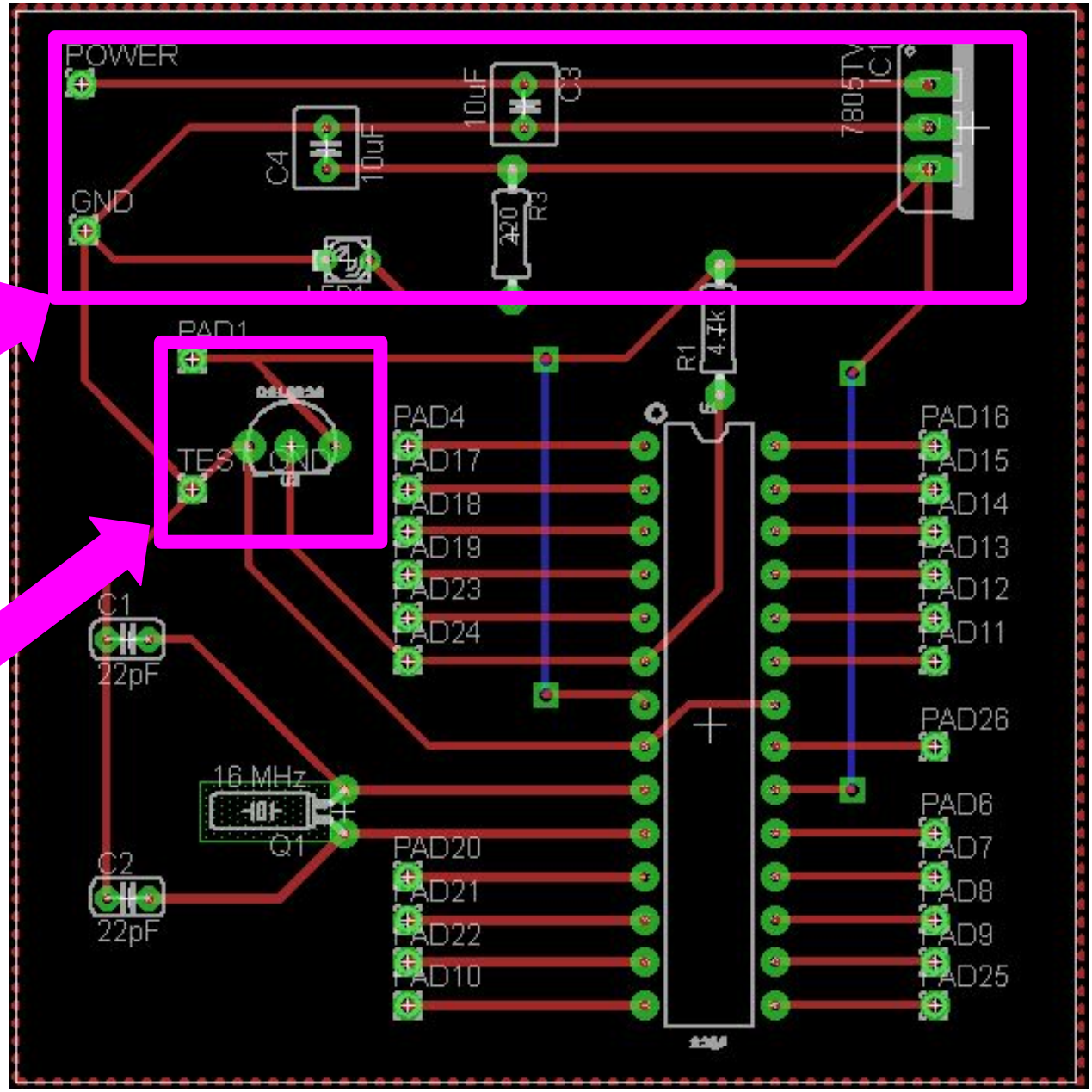
ATMega328p


PAD1
5V
OUT
PAD4
PAD11
PAD12
PAD13
PAD14
PAD15
PAD16
U1
PC6(/RESET)
AVCC
VCC
AREF
PB6(XTAL1/TOSC1)
PB7(XTAL2/TOSC2)
GND
PC0(ADC0)
PC1(ADC1)
PC2(ADC2)
PC3(ADC3)
PC4(ADC4/SDA)
PC5(ADC5/SCL)
PD0(RXD)
PD1(TXD)
PD2(INT0)
PD3(INT1)
PD4(XCK/T0)
PD5(T1)
PD6(AIN0)
PD7(AIN1)
PB0(ICP)
PB1(OC1A)
PB2(SS/OC1B)
PB3(MOSI/OC2)
PB4(MISO)
PB5(SCK)
328P
R3
220
LED1
POWER
IC1
7805TV
VI
VO
GND
C3
10uF
C4
10uF
GND
PAD26
C1
22pF
C2
22pF
Q1
16 MHz
TEST_GND
PAD17
PAD18
PAD19
PAD20
PAD21
PAD22
PAD23
PAD24
PAD25
U3
VDD
DQ
GND
DS18B20
R1
4.7k
PAD6
PAD7
PAD8
PAD9
PAD10

PCB

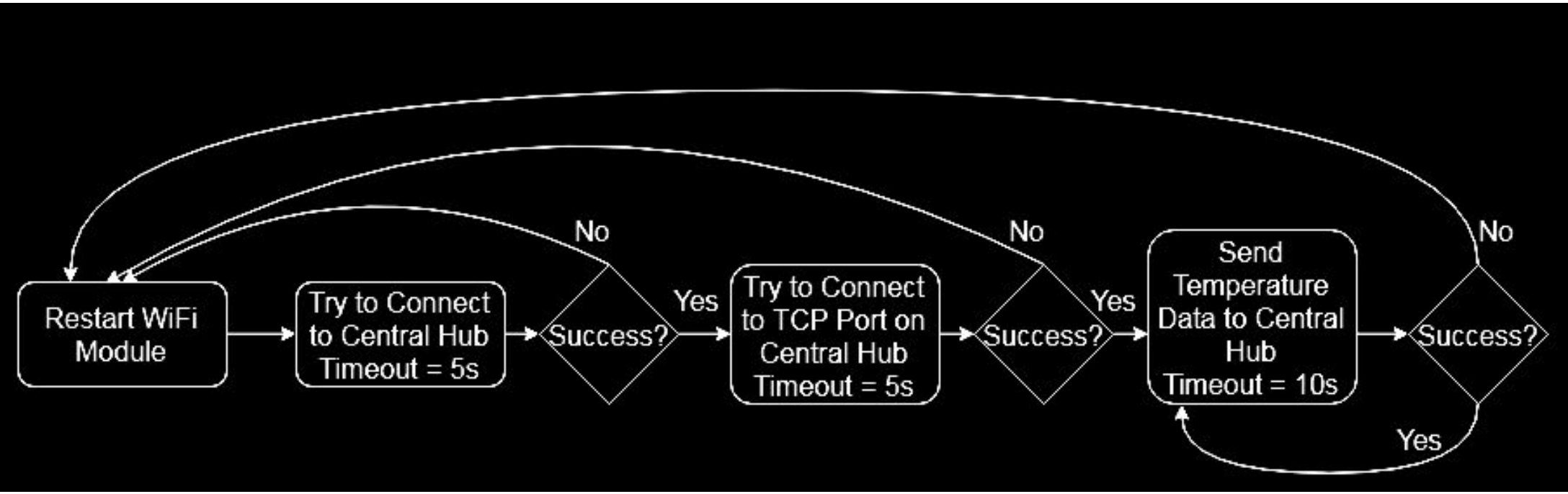
5V Voltage Regulator Circuit

DS18B20 Temperature Sensor



Microcontroller Logic

- A robust system should detect loss of connection and auto-reconnect

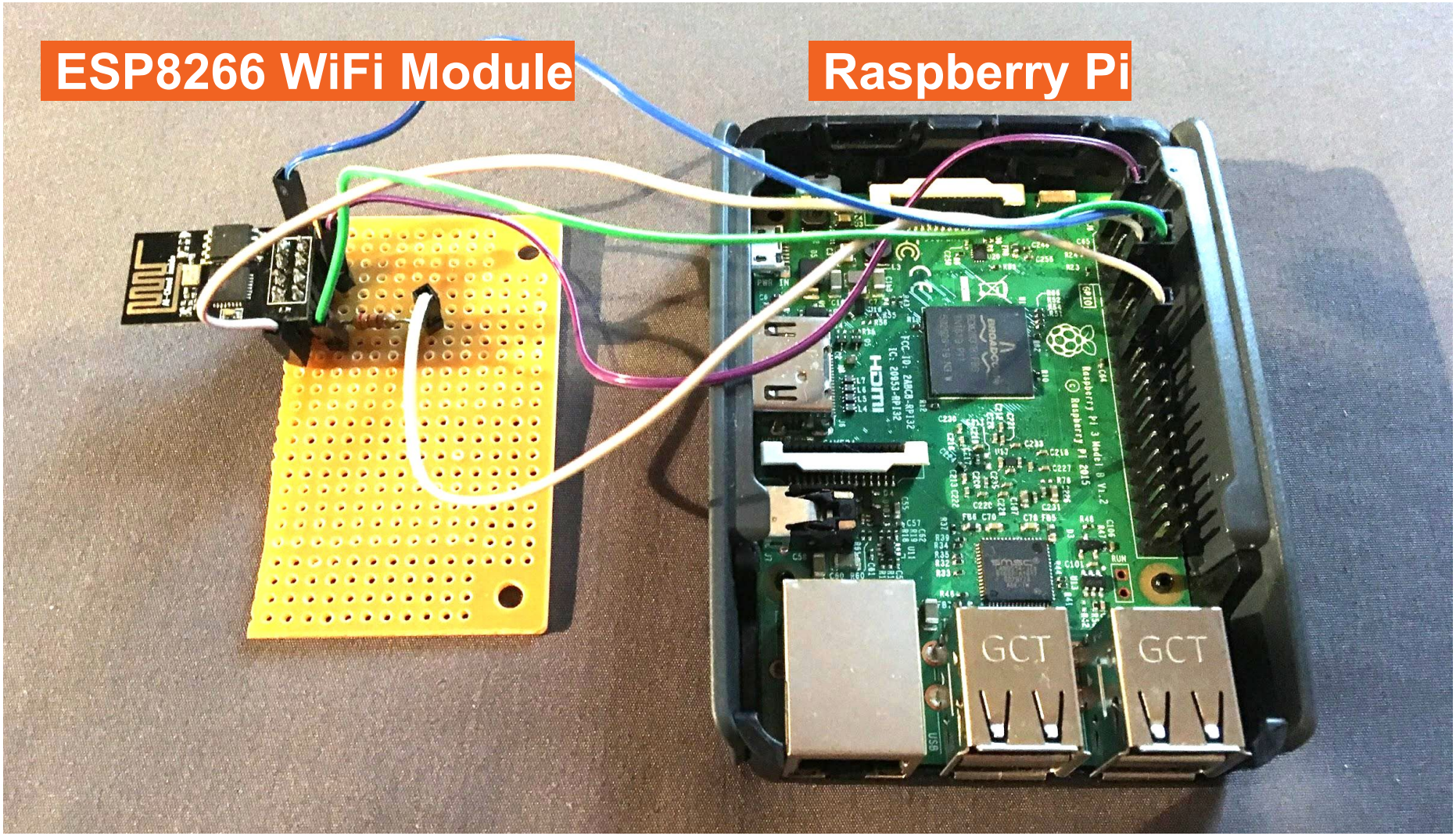


Flowchart: Link Loss Detection and Auto-Reconnection Algorithm

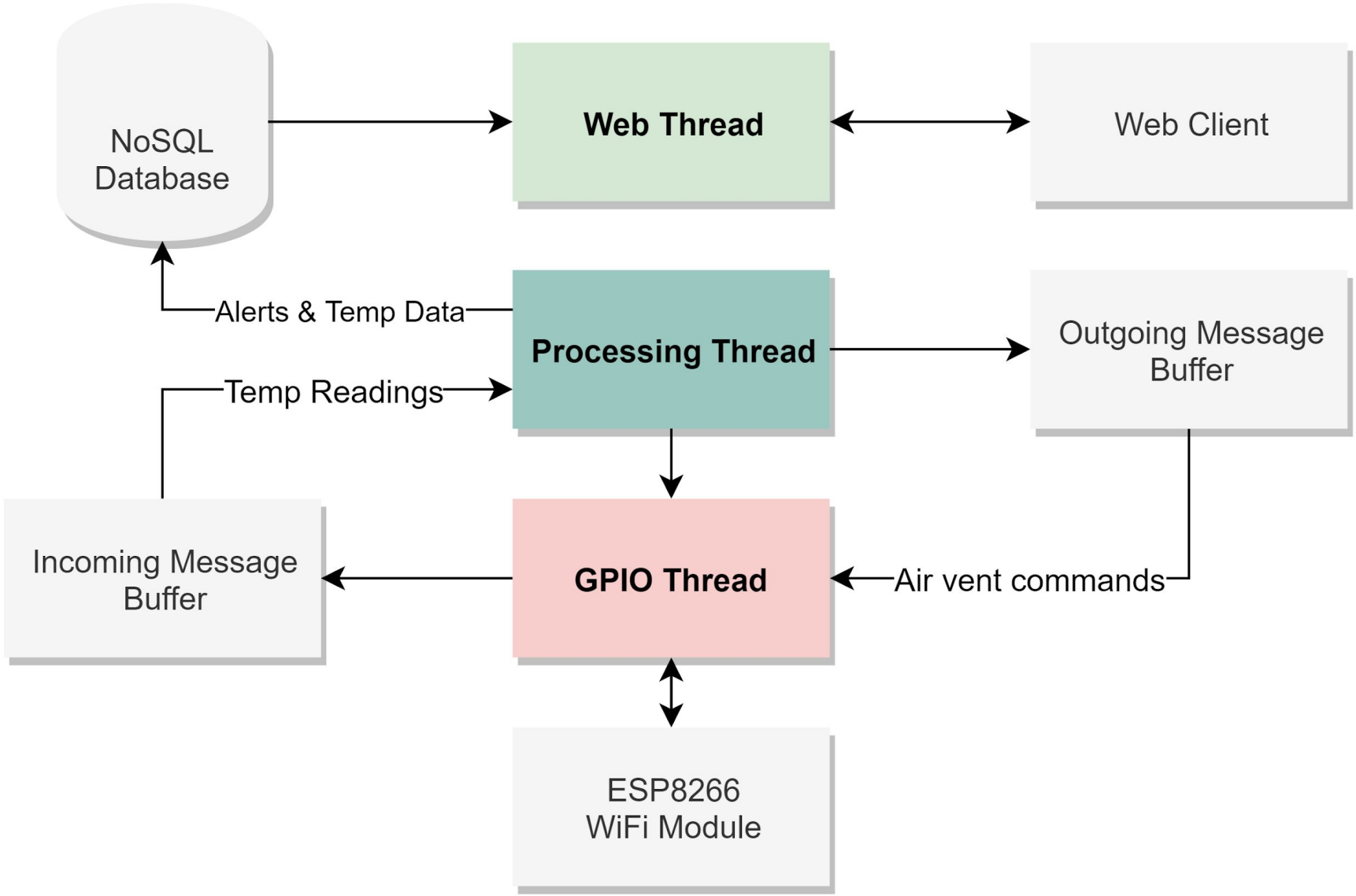
Central Hub

- Gather temperature measurements
- Generate alerts
- Send commands to air vents
- Interface with clients through web-app

Central Hub

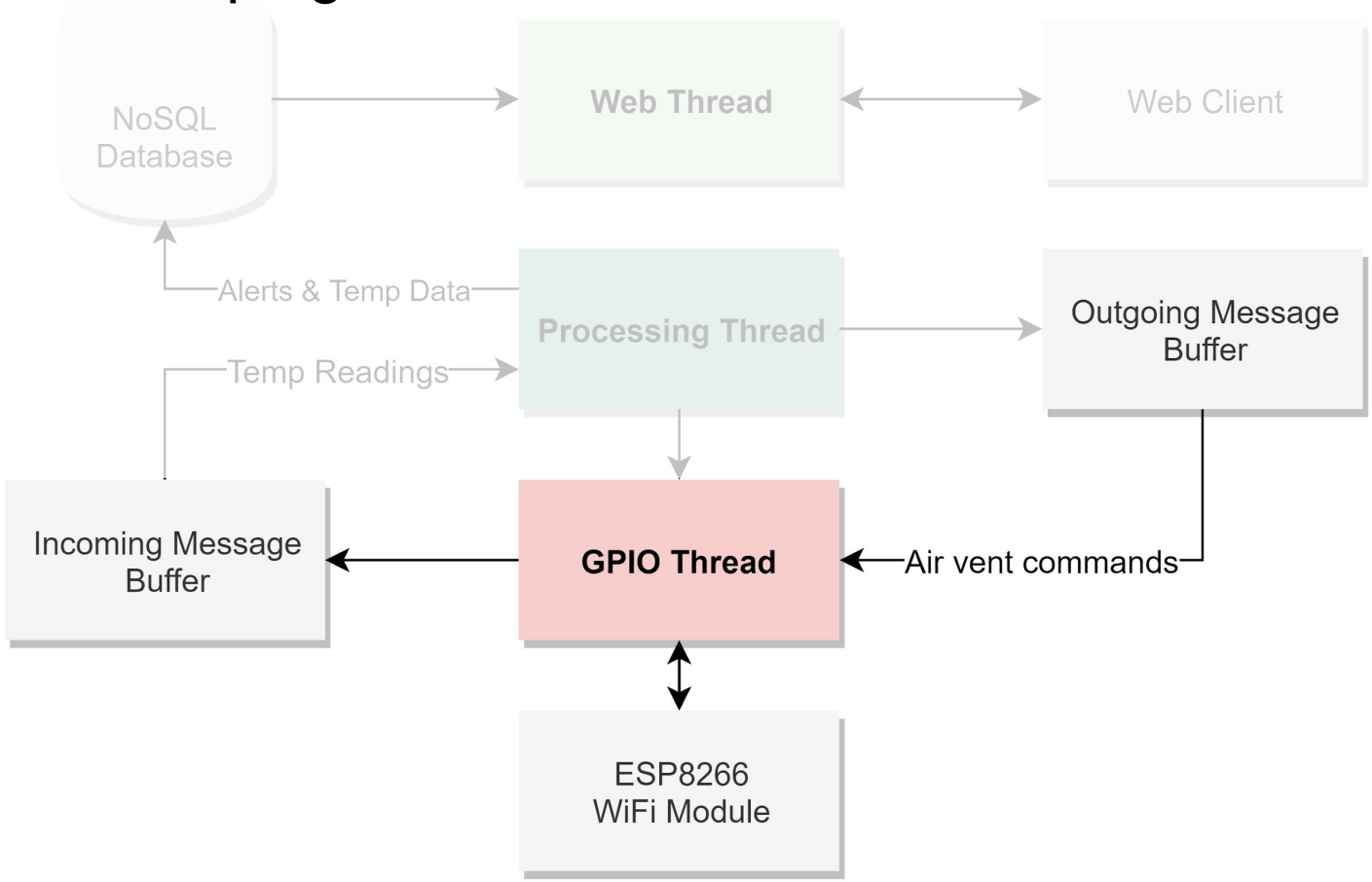


Communication between ESP and Web Server

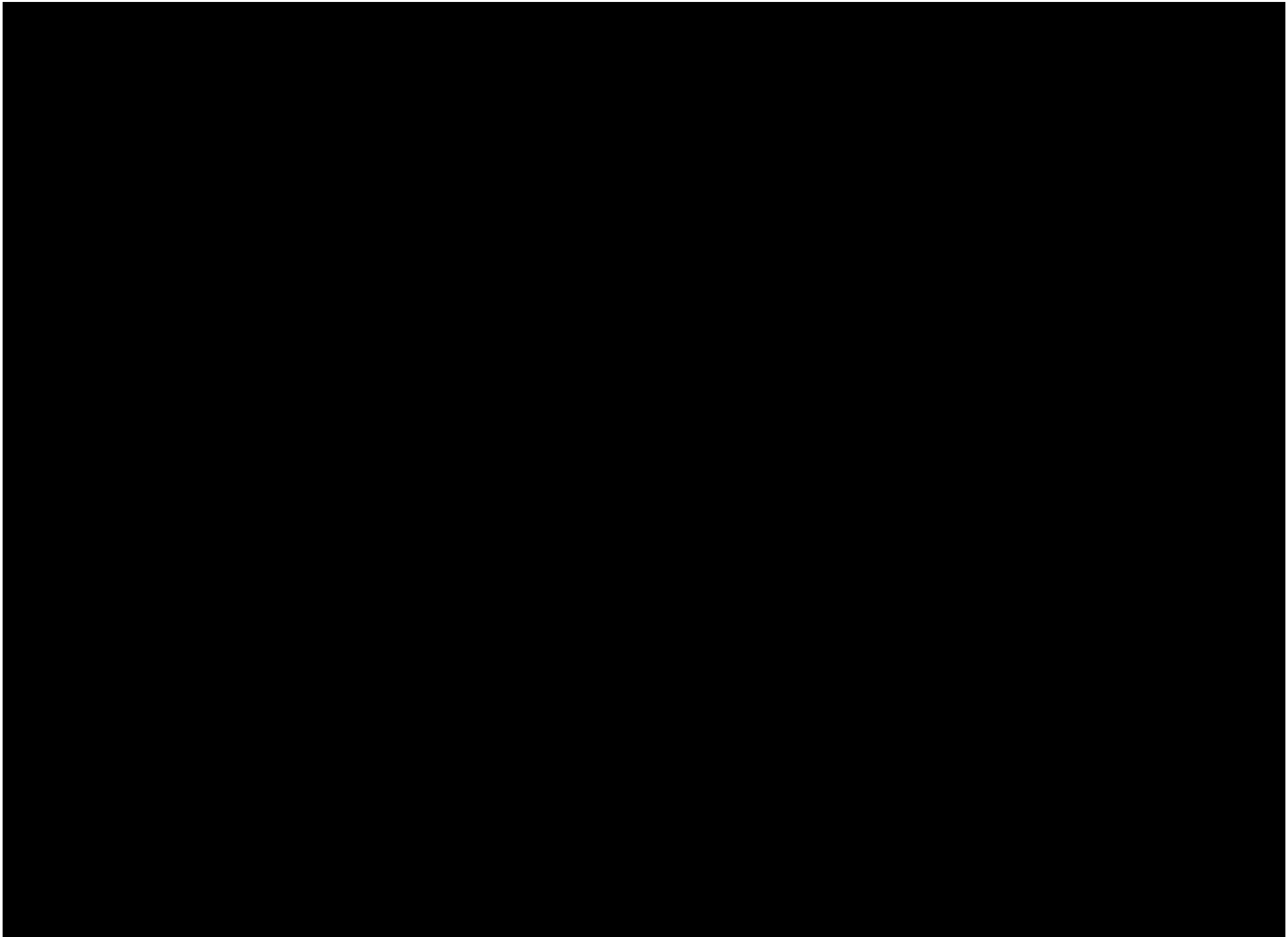


GPIO Thread

- ESP8266 communication module
- handles incoming and outgoing messages simultaneously
- updates and pings connections

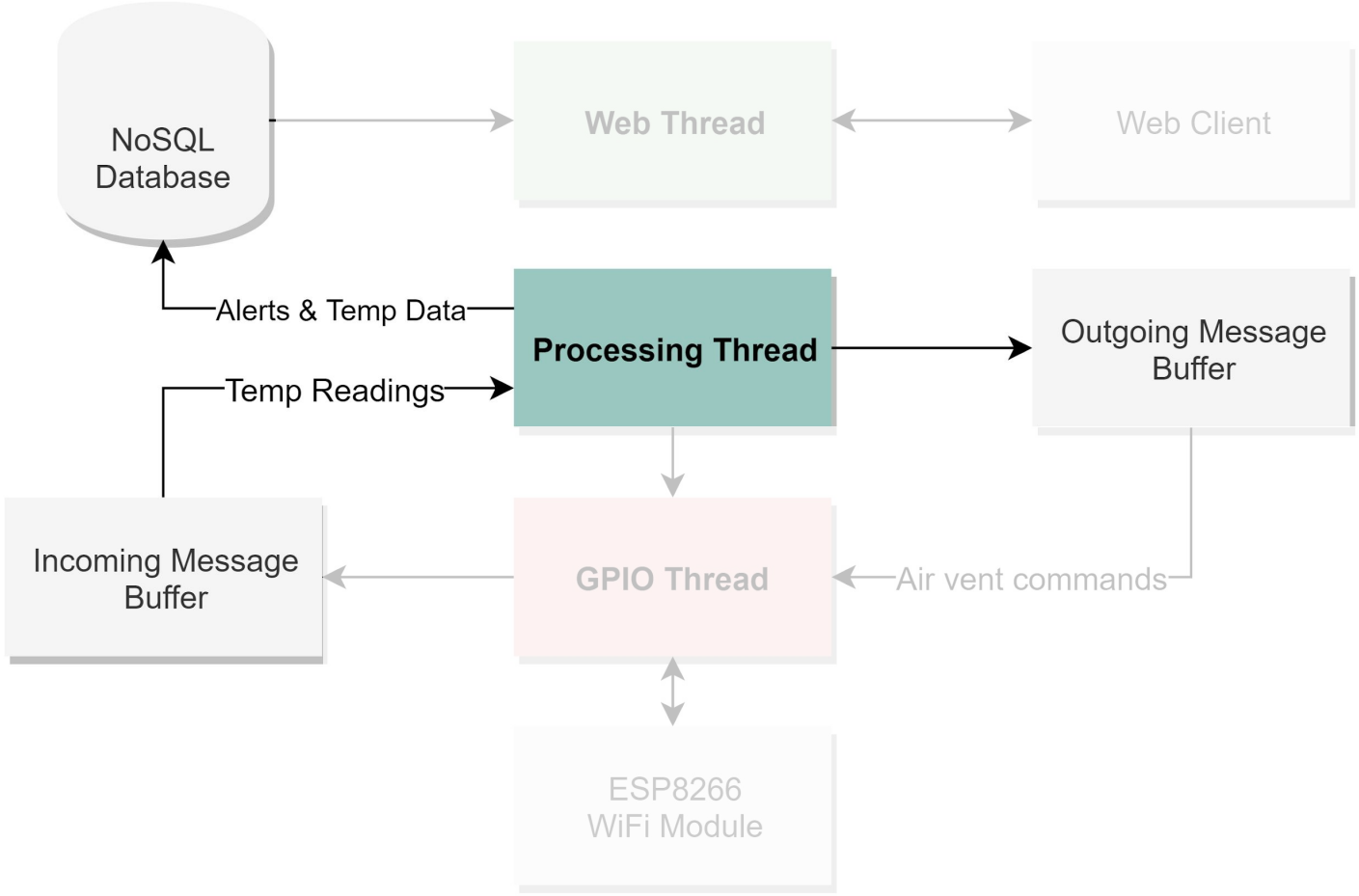


ESP message logging



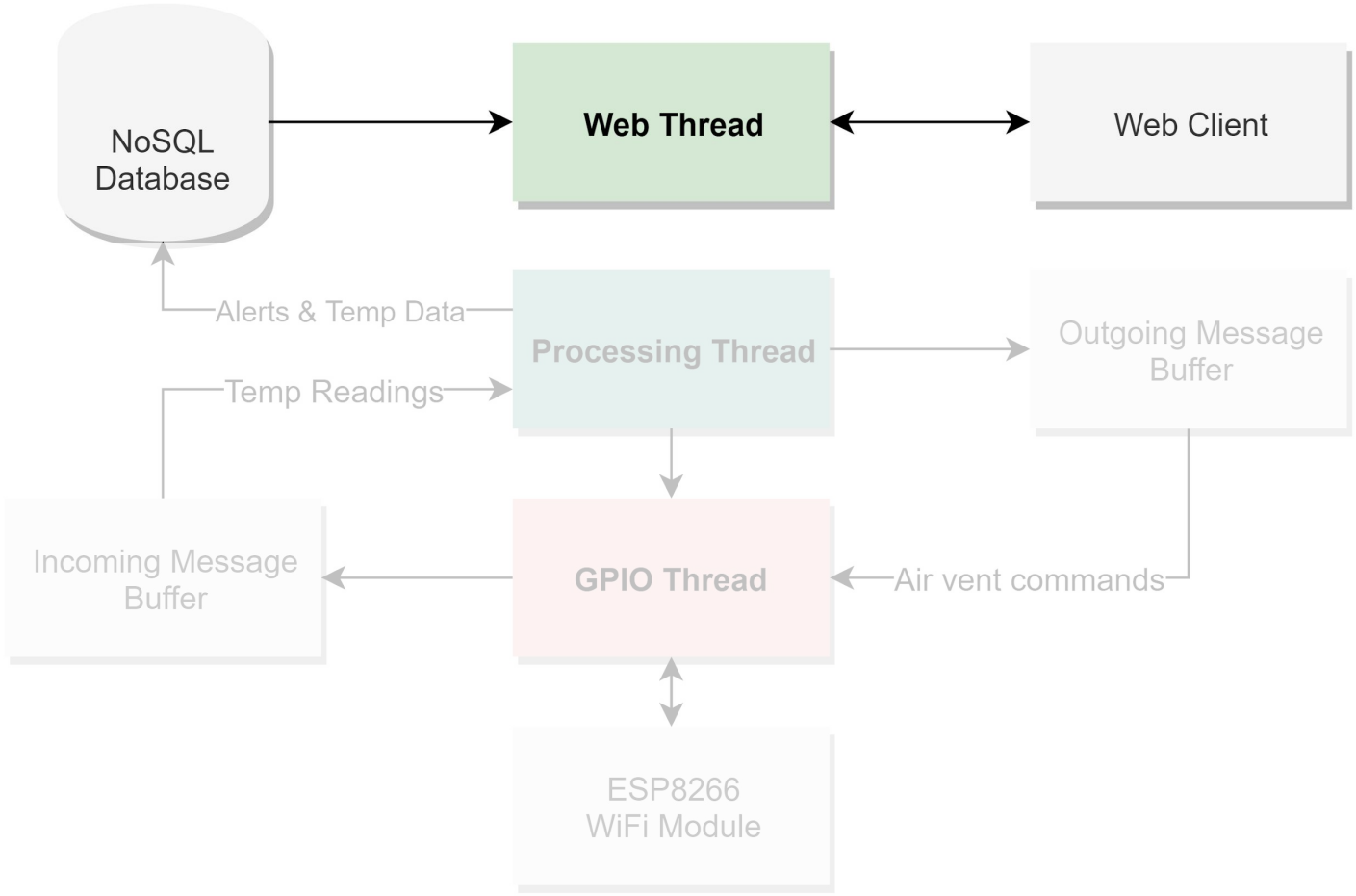
Processing Thread

- bridge between message buffers and database
- increases modularity and crash resilience

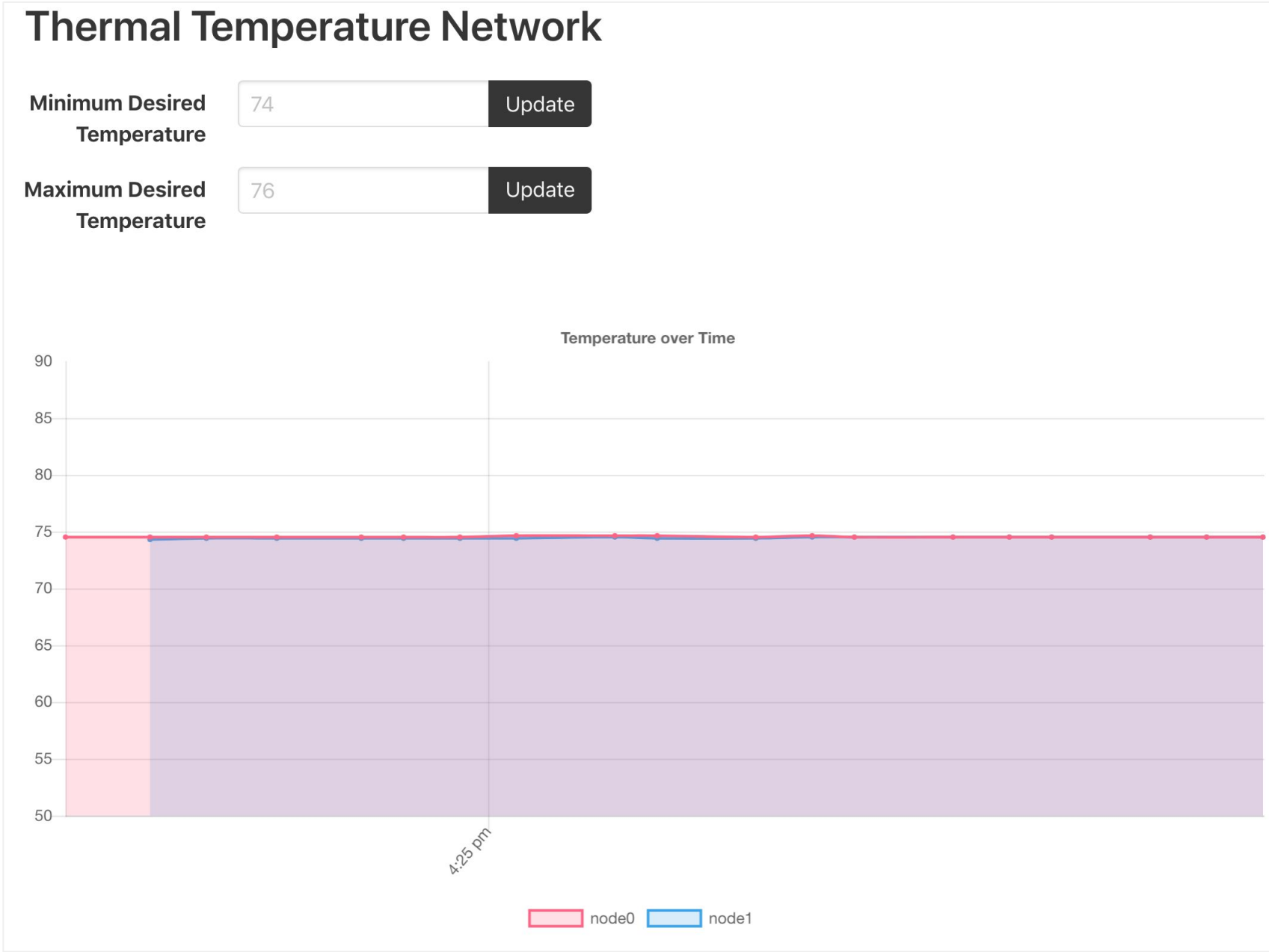


Web Thread

- temperature data and alerts → clients
- Customize alert parameters



Web Interface



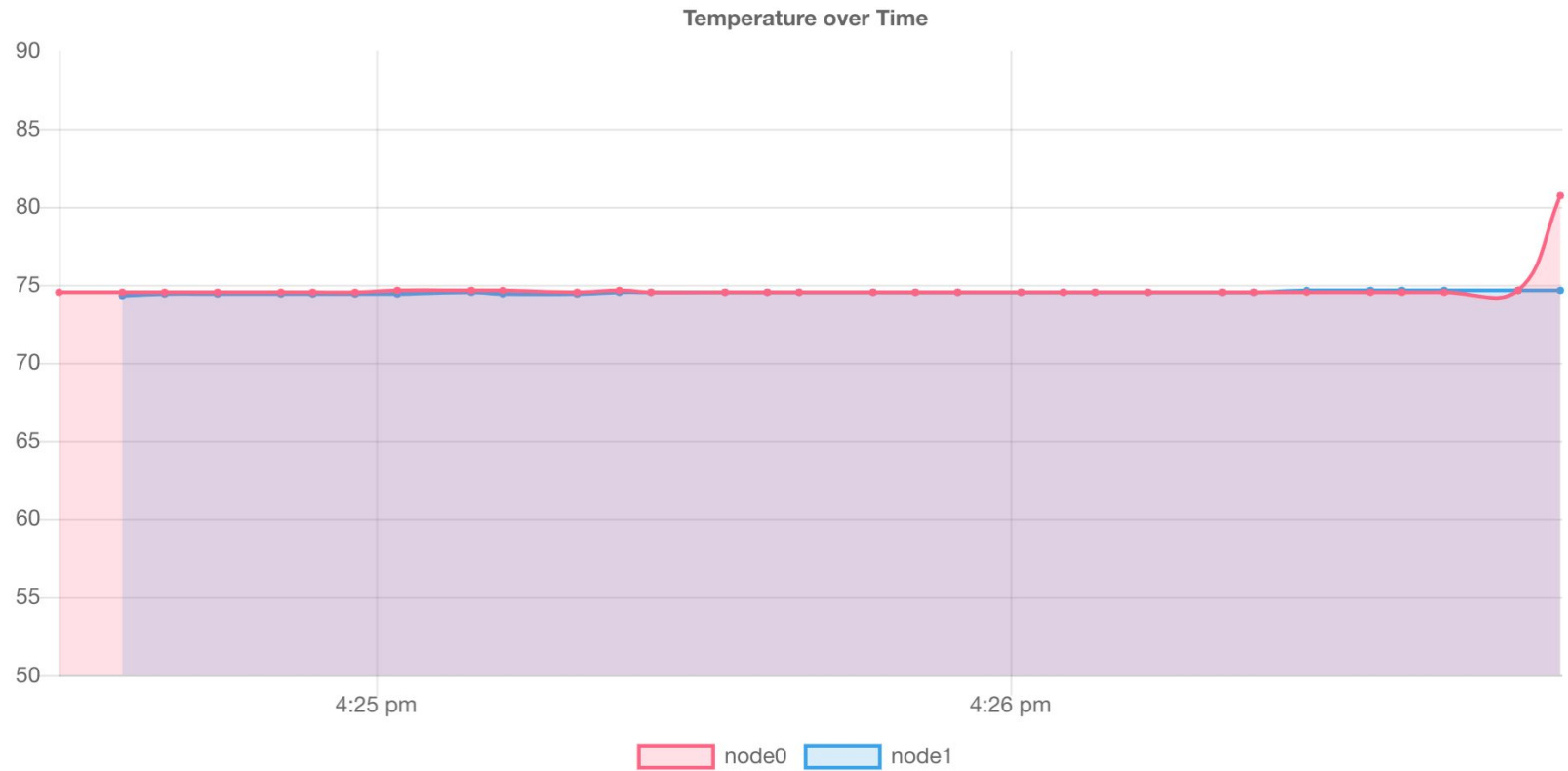
Thermal Temperature Network

Higher than expected temperature reading of 80.71 degrees Fahrenheit at node 0.

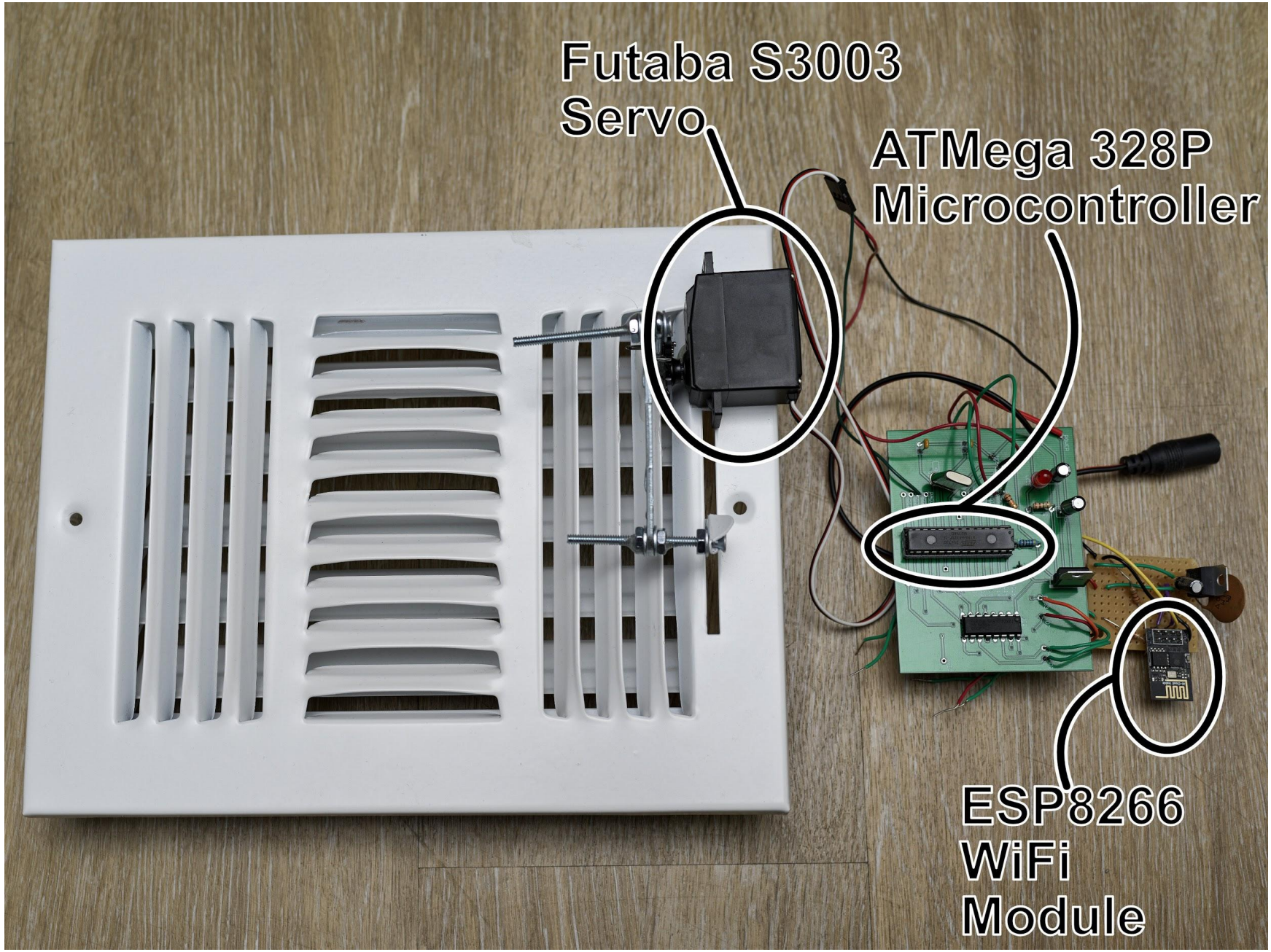
Large varance in temperature detected: 6 degrees Fahrenheit between highest and lowest temperature readings.

Minimum Desired Temperature 74 Update

Maximum Desired Temperature 76 Update

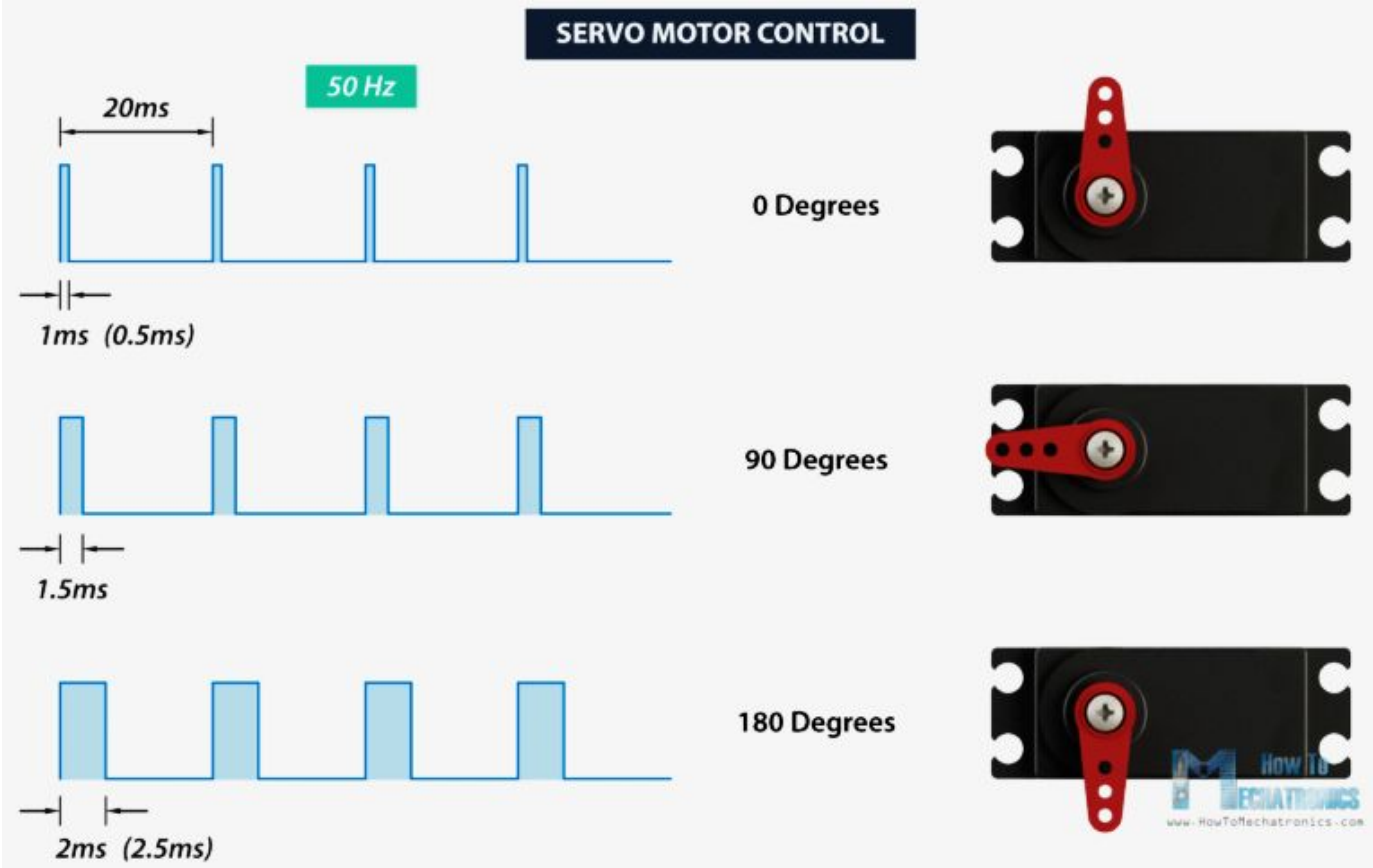


Air vent Actuator Module



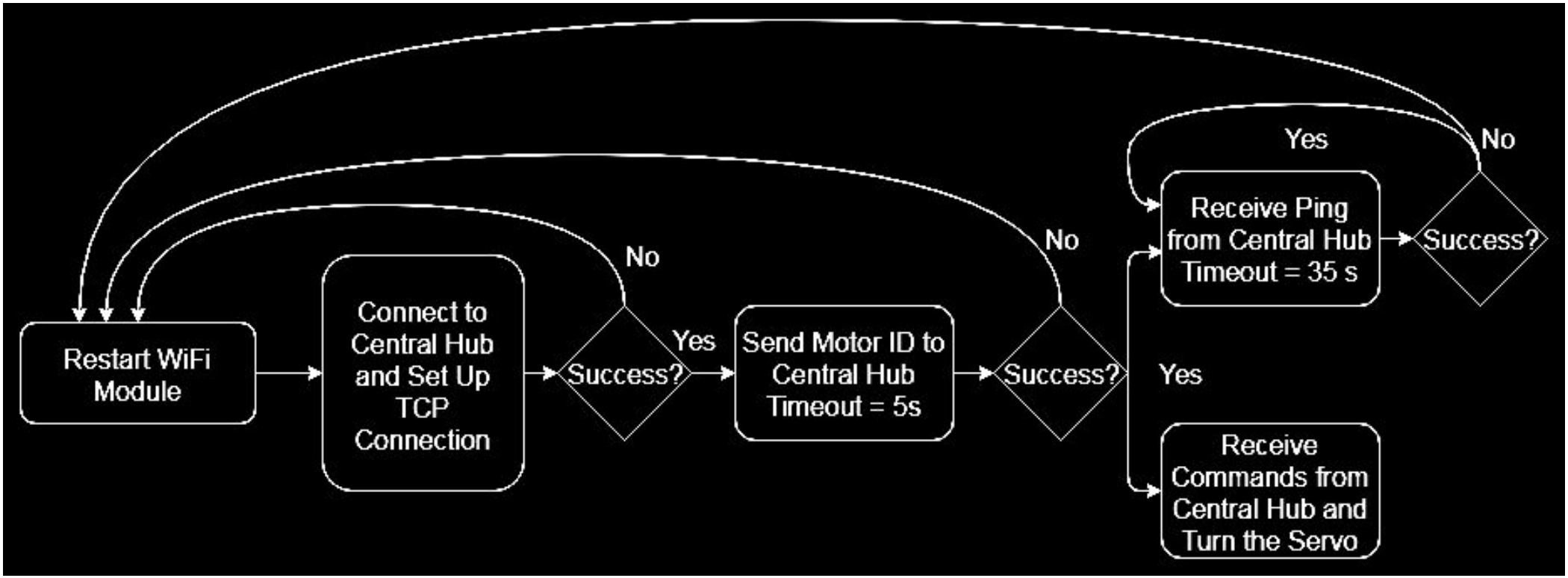
Futaba S3003 Actuator Servo

- Opening and closing the vents
- 3.2 kg-cm torque at 4.8V
- Microcontroller uses PWM signal to control the angle of the servo motor



Microcontroller Logic

- Again, a robust system should detect loss of connection and auto-reconnect



Flowchart: Link Loss Detection and Auto-Reconnection Algorithm

Results

1. Fully functional implementation with two sensors and two actuators

2. Fully functional web interface for settings, alerts and visualization

Testing-Temperature Sensor Accuracy

- Comparing sensor measurement to AC controller reading in ECEB

	Sensor 1	Sensor 2	Thermostat Reading	Accuracy
Room	74.75	75.09	75.5	0.7%

Testing-WiFi Range

Line of sight: able to cover the full length of ECEB hallway and reconnect; at least 50m

Indoors: about 10 meters with at least two walls in between (tested in ECEB)

Testing-Reconnection Time

- Measured the time between power-on and establishment of connection

	Sensor Module	**Air Vent Module**
Trial 1	20.10 s	14.31 s
Trial 2	15.88 s	14.41 s
Trial 3	16.21 s	13.19 s
Avg.	17.40 s	13.97 s

Potential Future Work

1. Scalability: more sensor modules and air vent actuators

2. User friendly: easy installation

3. Customizable: expose more configs to client

4. Cost and form factor: cheaper and smaller

Conclusion

SUCCESS!