Temperature Sensor Network for Thermostat Control

ECE 445 Project Presentation
Team 33

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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
Temperature Sensor Module

Dallas 18B20 Temperature Sensor

ATMega 328P Microcontroller

ESP8266 WiFi 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
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

ESP8266 WiFi Module

Raspberry Pi
Communication between ESP and Web Server

- **NoSQL Database**
  - Alerts & Temp Data

- **Web Thread**
- **Web Client**

- **Processing Thread**
  - Temp Readings

- **Incoming Message Buffer**
  - ESP8266 WiFi Module

- **GPIO Thread**
  - Air vent commands
  - Outgoing Message Buffer
**GPIO Thread**

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

![Diagram of GPIO Thread](image)
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

Minimum Desired Temperature: 74

Maximum Desired Temperature: 76

Temperature over Time

node0 node1
Thermal Temperature Network

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

Large variance 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 Servo
- ATmega 328P Microcontroller
- ESP8266 WiFi 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.
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

<table>
<thead>
<tr>
<th></th>
<th>Sensor 1</th>
<th>Sensor 2</th>
<th>Thermostat Reading</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room</td>
<td>74.75</td>
<td>75.09</td>
<td>75.5</td>
<td>0.7%</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th></th>
<th>Sensor Module</th>
<th>Air Vent Module</th>
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</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>20.10 s</td>
<td>14.31 s</td>
</tr>
<tr>
<td>Trial 2</td>
<td>15.88 s</td>
<td>14.41 s</td>
</tr>
<tr>
<td>Trial 3</td>
<td>16.21 s</td>
<td>13.19 s</td>
</tr>
<tr>
<td>Avg.</td>
<td>17.40 s</td>
<td>13.97 s</td>
</tr>
</tbody>
</table>
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!