Adrienne Ayala

CS-350

**SysTec Smart Thermostat Prototype Report**

**Introduction**

The global smart thermostat market is expected to reach nearly $9 billion by 2026, which presents a major opportunity for SysTec to expand into the embedded device space. As part of the engineering department, I developed a low-level prototype thermostat using a Raspberry Pi 4B development board. The prototype demonstrates the basic system functionality that will be needed for a cloud-connected device. It includes temperature sensing, LED output, user input through buttons, LCD display feedback, and serial data transmission. This report explains how the prototype supports all required peripherals and evaluates three possible hardware architectures for the next phase of the project: Raspberry Pi, Microchip, and Freescale. The next step will involve adding Wi-Fi capability and cloud communication.

**System Design Overview**

The prototype thermostat measures room temperature through an AHT20 sensor that communicates using I2C. Two PWM LEDs indicate whether the system is heating or cooling. Three GPIO buttons control the mode (off, heat, or cool) and adjust the temperature set point. A 16x2 LCD display shows the date, time, current temperature, and thermostat mode. The system also sends information through UART serial communication to simulate data being transmitted to a server. This combination of peripherals demonstrates the low-level functions that will remain the same when the design is transferred to a production-ready model with built-in Wi-Fi.

**Hardware Architecture Comparison**

**Raspberry Pi**

The Raspberry Pi 4B supports multiple I2C, UART, and GPIO connections, which makes it fully compatible with the sensors, LEDs, and display used in the prototype. It runs a complete Linux operating system that allows easy programming and testing in Python. The board includes built-in Wi-Fi and Bluetooth, which satisfies SysTec’s requirement for cloud connectivity. Its RAM ranges from 1 GB to 8 GB, and it uses SD card storage between 8 GB and 32 GB. This is far more memory than the thermostat requires, but it increases both cost and power use compared to smaller embedded systems.

**Microchip**

Microchip microcontrollers are made for low-power IoT devices and often include built-in Wi-Fi, such as the SAMW25 with an ARM Cortex-M0+ core. These systems have enough Flash memory (up to 2 MB) and RAM (up to 256 KB) to store the thermostat firmware and Wi-Fi software stack. They also support GPIO, PWM, UART, and I2C interfaces that work with the same peripherals used in the prototype. Although they are programmed in C or C++, they are very efficient for long-term operation and are ideal for mass production.

**Freescale**

Freescale, now part of NXP, produces the Kinetis and i.MX RT series that can also connect to Wi-Fi using companion modules. These processors use ARM Cortex-M4 or M7 cores and include many input and output options. Flash memory ranges from 512 KB to 2 MB, and RAM is available up to 512 KB, which is enough for embedded networking. Development tools such as MCUXpresso make firmware development straightforward. However, Wi-Fi modules are usually external, which adds complexity to the final design.

**Recommendation and Conclusion**

For continued prototyping and testing, the Raspberry Pi provides the most flexibility because it already has Wi-Fi and a well-supported Python environment for all the peripherals. For large-scale production, SysTec should move to a Microchip SAMW25 or a similar low-power microcontroller that includes Wi-Fi capability. This type of hardware would reduce cost, power use, and size while maintaining all necessary interfaces for sensors, displays, and LEDs.

This plan allows the design to evolve from a simple prototype to a practical embedded system that supports cloud communication. The completed prototype already demonstrates all of the hardware features needed for a connected thermostat and establishes a strong base for SysTec’s future product line.

References

Microchip Technology Inc. (2023). *SAMW25 Smart Connect Wi-Fi module*. Retrieved from https://www.microchip.com/en-us/product/ATWILC1000

NXP Semiconductors. (2023). *i.MX RT series crossover MCUs*. Retrieved from https://www.nxp.com/products/processors-and-microcontrollers/arm-microcontrollers/i-mx-rt-series

Raspberry Pi Foundation. (2023). *Raspberry Pi 4 Model B specifications*. Retrieved from https://www.raspberrypi.com/products/raspberry-pi-4-model-b/