Project Report

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CS – 350

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**Prototype**

The thermostat prototype utilizes several embedded system peripherals to accomplish its tasks. The prototype was assembled using a Raspberry Pi 4 running Ubuntu OS, a Linux-based distribution. Making it lightweight and open source (free to use). The Raspberry Pi is connected to a GPIO board via ribbon cable, which is plugged into a solderless breadboard. This enables the Raspberry Pi to communicate with our components. Using male-to-male connectors, the prototype is connected to a 16x2 LCD screen, two LEDs (one red, one blue), and three buttons (green, red, and blue).

The temperature/humidity sensor is connected to the Raspberry Pi via a QWIIC cable. The temperature sensor reads the temperature and sends it to the Pi. The thermostat.py script then takes the reading and, based on the state, will control the lights, either off, pulsing, or steady on. The UART connected via USB is used to simulate the cloud connection. The data transmitted mirrors the format (CSV) and timing (every thirty seconds) that will eventually be sent to a remote cloud service once the networking stack is implemented. Using UART in this way allowed for early validation of data handling, parsing, and response logic in a controlled, offline environment, eliminating dependencies on network infrastructure during initial testing.

**IoT Architectures**

The goal of SysTec is to enter the cloud thermostat industry. Now that there is a working prototype of one, an Internet of Things (IoT) infrastructure and framework must be chosen for production. There are three major architectures we must consider: Raspberry Pi, Microchips, and Freescale.

The Raspberry Pi has many advantages. First, the prototype was built using one; thus, no time would be lost refactoring code or sourcing compatible peripherals. It supports all required interfaces, I2C for the temperature sensor, UART for simulated cloud communication, and GPIO for LEDs and buttons, with well-documented Python libraries that allow for rapid development. Many models, including the Pi 3 and Pi 4, have integrated Wi-Fi, making cloud connectivity straightforward. Additionally, the Raspberry Pi offers ample RAM and storage (CDEBYTE, 2024).

Microchip architecture is low-cost and readily available, with a long history of use in embedded and IoT products. They have native support for I2C, UART, and GPIO, making the peripherals compatible with the current design. Microchip devices offer less RAM and processing power than the Raspberry Pi but consume significantly less energy and have a smaller physical footprint, which could be beneficial for mass production and battery-powered versions. Some models include integrated Wi-Fi modules optimized for low power consumption. However, Microchip MCUs typically lack a Python interpreter, so the existing Python codebase would need to be rewritten in C or C++, which would increase development time (Microchip Technology Inc., 2024).

Freescale (now part of NXP) architecture offers both microcontrollers and high-performance application processors, making it a flexible choice for scaling between low-power and high-capability devices. Like Microchip, they fully support I²C, UART, and GPIO, ensuring compatibility with the prototype’s peripherals. Many NXP processors can integrate with Wi-Fi either through onboard modules or external components. Higher-end processors can run embedded Linux, which could allow the reuse of some existing Python code (Moor Insights & Strategy, 2015).

Based on SysTec’s business requirements and the current development status, the Raspberry Pi is the most suitable architecture for the production version of the smart thermostat. The prototype is already fully functional on the Raspberry Pi, which eliminates the need for significant code refactoring or hardware redesign. It offers integrated Wi-Fi for seamless cloud connectivity, full support for required peripherals (I²C, UART, and GPIO), and ample RAM and Flash storage for current functionality and future feature expansions. Selecting the Raspberry Pi ensures the fastest time to market, aligning with SysTec’s strategic goal of quickly entering the rapidly growing smart thermostat market.

**References**

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Moor Insights & Strategy. (2015, June 30). *Freescale Semiconductor, soon to be NXP, makes IoT hardware generic*. *Forbes*. Retrieved from https://www.forbes.com/sites/moorinsights/2015/06/30/freescale-semiconductor-soon-to-be-nxp-makes-iot-hardware-generic/