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Final Project Report

The global smart thermostat market is expanding rapidly, projected to reach nearly nine billion dollars by 2026. SysTec’s CEO sees this as a major opportunity for the company to diversify its business, which has traditionally focused on analytics software for servers. Drawing on my experience with embedded systems, I was asked to create a working prototype of a smart thermostat that could eventually integrate with SysTec’s software platform. The purpose of this first stage was to design the low-level functionality of a thermostat before moving toward a Wi-Fi connected, cloud-based version.

The prototype was developed using a Raspberry Pi as the core controller. It incorporates an AHT20 temperature and humidity sensor, a 16x2 LCD display, and two LEDs that represent heating and cooling modes. Three pushbuttons were added to allow users to toggle between system states—Off, Heat, and Cool—and to adjust the desired temperature set point, which defaults to 72°F. The system functions as a simple state machine: when in Heat mode, the red LED gradually fades when the current temperature is below the set point and glows steadily once the target temperature is reached. In Cool mode, the blue LED behaves in the opposite way. When the system is turned Off, both LEDs remain inactive.

The LCD screen alternates between displaying the current date and time and the thermostat’s operational details, such as the temperature reading, mode, and set point. Additionally, every thirty seconds, the thermostat transmits a comma-delimited string over the UART interface containing key data for potential monitoring or logging. This feature represents the initial step toward future cloud integration, where data will be sent wirelessly to SysTec’s servers. Through these features, the prototype successfully demonstrates the core logic and user interface of a modern thermostat while remaining modular and easy to expand.

As SysTec moves into the next phase of development, the priority will be connecting the thermostat to the cloud via Wi-Fi. This will allow real-time data transmission to SysTec’s analytics software, enabling features like remote monitoring, adaptive energy management, and performance tracking. To plan this next step, I analyzed three potential hardware architectures—Raspberry Pi, Microchip PIC32, and Freescale (NXP i.MX)—to determine which would best meet SysTec’s technical and business needs. The criteria used in this comparison included peripheral support, Wi-Fi connectivity, and available Flash and RAM.

The Raspberry Pi supports a wide range of peripherals, including I²C, UART, PWM, and general-purpose input/output pins, all of which are used in the prototype. It also includes built-in Wi-Fi, large memory capacity, and a flexible Linux-based operating system, making it ideal for rapid prototyping. However, the Raspberry Pi is not optimized for low-power operation or long-term embedded deployment, which limits its practicality for mass production.

The Microchip PIC32 family offers efficient power consumption and supports the required interfaces, but typically requires an external Wi-Fi module such as the ATWINC1500. While this architecture is suitable for small-scale embedded designs, its limited memory—around 2 MB of Flash and 512 KB of RAM—would constrain future expansion, especially if SysTec wants to add complex analytics or a graphical interface.

In contrast, the Freescale (NXP i.MX) architecture offers an excellent balance between performance and efficiency. The i.MX RT1060 series, for instance, includes multiple I²C and UART channels, PWM capabilities, and optional integrated Wi-Fi. With up to 8 MB of Flash and 1 MB of RAM, it provides ample resources for multitasking and cloud communication. The architecture also supports either FreeRTOS or embedded Linux, offering flexibility for integrating SysTec’s analytics software while maintaining low power consumption suitable for continuous operation.

Based on this comparison, I recommend the Freescale (NXP i.MX) platform for the production version of SysTec’s smart thermostat. It provides the necessary hardware support, scalability, and connectivity to meet both current and future requirements. While the Raspberry Pi remains an excellent development tool, transitioning to an NXP-based system will reduce production costs and improve long-term stability. The Microchip PIC32 could serve as an alternative for a lower-end product line, but it would require more development time and additional hardware to meet Wi-Fi and performance expectations.

In conclusion, the prototype developed on the Raspberry Pi effectively demonstrates the foundational logic and functionality of a smart thermostat. It accurately reads temperature data, responds to user input, controls heating and cooling indicators, updates an LCD display, and communicates over UART. The next phase of development will focus on integrating Wi-Fi connectivity and cloud communication using the Freescale (NXP i.MX) architecture. This approach aligns with SysTec’s strategic goals of entering the smart home market with a reliable, connected, and data-driven product that leverages the company’s analytics expertise. With the groundwork laid by this prototype, SysTec is well-positioned to move from concept to production, establishing a strong presence in the growing world of smart home technology.