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CS 350 Final – Embedded Thermostat Prototype

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**SysTec Smart Thermostat: Phase 2 Architecture Report**

SysTec, a company known for analytics software for servers, is expanding into the smart home market with a focus on smart thermostats. With the global smart thermostat market projected to reach $9 billion by 2026, the company aims to capture a share by offering cloud-integrated temperature control systems.  
  
As part of this initiative, I developed a prototype that implements core thermostat functionality using a Raspberry Pi, GPIO sensors, buttons, and a display. This prototype successfully demonstrates low-level temperature control logic, button-driven state changes, and UART-based data reporting.  
  
This report proposes the next step in development: selecting a hardware platform that will serve as the production foundation for a Wi-Fi-enabled version of the thermostat capable of pushing data to SysTec’s server software.

**Business Requirements**

The production system must:  
1. Support the current peripherals, including:  
 - Temperature/humidity sensor via I2C (AHT20)  
 - LEDs for heat/cool status via PWM  
 - Buttons for state and setpoint control via GPIO  
 - 16x2 LCD via digital GPIO  
2. Provide Wi-Fi connectivity to push telemetry data to the cloud.  
3. Offer sufficient Flash and RAM to run control software, handle sensor polling, and support future updates such as secure data transmission and configuration menus.

**Hardware Architecture Comparison**

Three candidate platforms were analyzed:  
  
- Raspberry Pi Zero W: ARM Cortex-A53, 512MB RAM, onboard Wi-Fi, full Linux OS.  
- Microchip ATSAME54-XPRO: ARM Cortex-M4, 256KB RAM, requires external Wi-Fi, uses bare-metal or RTOS.  
- NXP/Freescale i.MX RT1060: ARM Cortex-M7, 1MB RAM, requires external Wi-Fi, uses RTOS or bare-metal.

**Recommendation**

The recommended platform is the Raspberry Pi Zero W.  
  
Justification:  
- Already proven compatible with all project peripherals.  
- Onboard Wi-Fi simplifies cloud connectivity.  
- Linux environment enables rapid Python development.  
- Ample memory and storage for future feature expansion.  
  
Microcontroller-based options may be reconsidered in future for mass production after cloud protocol requirements are finalized.

**Conclusion**

The Raspberry Pi Zero W meets all technical requirements and supports rapid iteration. It provides a robust platform for demonstrating cloud-connected thermostat functionality and will allow SysTec to move quickly into smart home product development. Once production scales, cost-optimized microcontroller options can be evaluated.

**Improved Hardware Architecture Comparison Table**

|  |  |  |  |
| --- | --- | --- | --- |
| Feature | Raspberry Pi Zero W | Microchip ATSAME54-XPRO | NXP i.MX RT1060 |
| CPU | ARM Cortex-A53 (1GHz) | ARM Cortex-M4F (120MHz) | ARM Cortex-M7 (600MHz) |
| RAM | 512MB | 256KB | 1MB |
| Flash Storage | microSD (8–32GB) | 1MB onboard | 4MB onboard + QSPI/SD |
| Wi-Fi | Yes (onboard) | Requires external module | Requires external module |
| GPIO Support | Yes (40-pin) | Yes | Yes |
| I2C, PWM, UART, LCD | Yes | Yes | Yes |
| OS Support | Linux (Raspberry Pi OS) | Bare-metal or RTOS | RTOS or bare-metal |
| Development Flexibility | High (Python/C++) | Moderate (C, Atmel Studio) | Moderate (C, MCUXpresso SDK) |
| Estimated Cost | $10–$15 | $30–$40 | $25–$35 |