Architecture Document

1. Introduction

This document describes the software architecture of the **TemperatureMonitor** project—a demonstration of a scalable embedded system for temperature monitoring. The design is organized in layers that separate low-level hardware access (I²C, GPIO, Timer, ADC) from higher-level domain logic (EEPROM, LED, Temperature Sensor) and the application layer. This architecture is designed to be maintainable, testable, and scalable.

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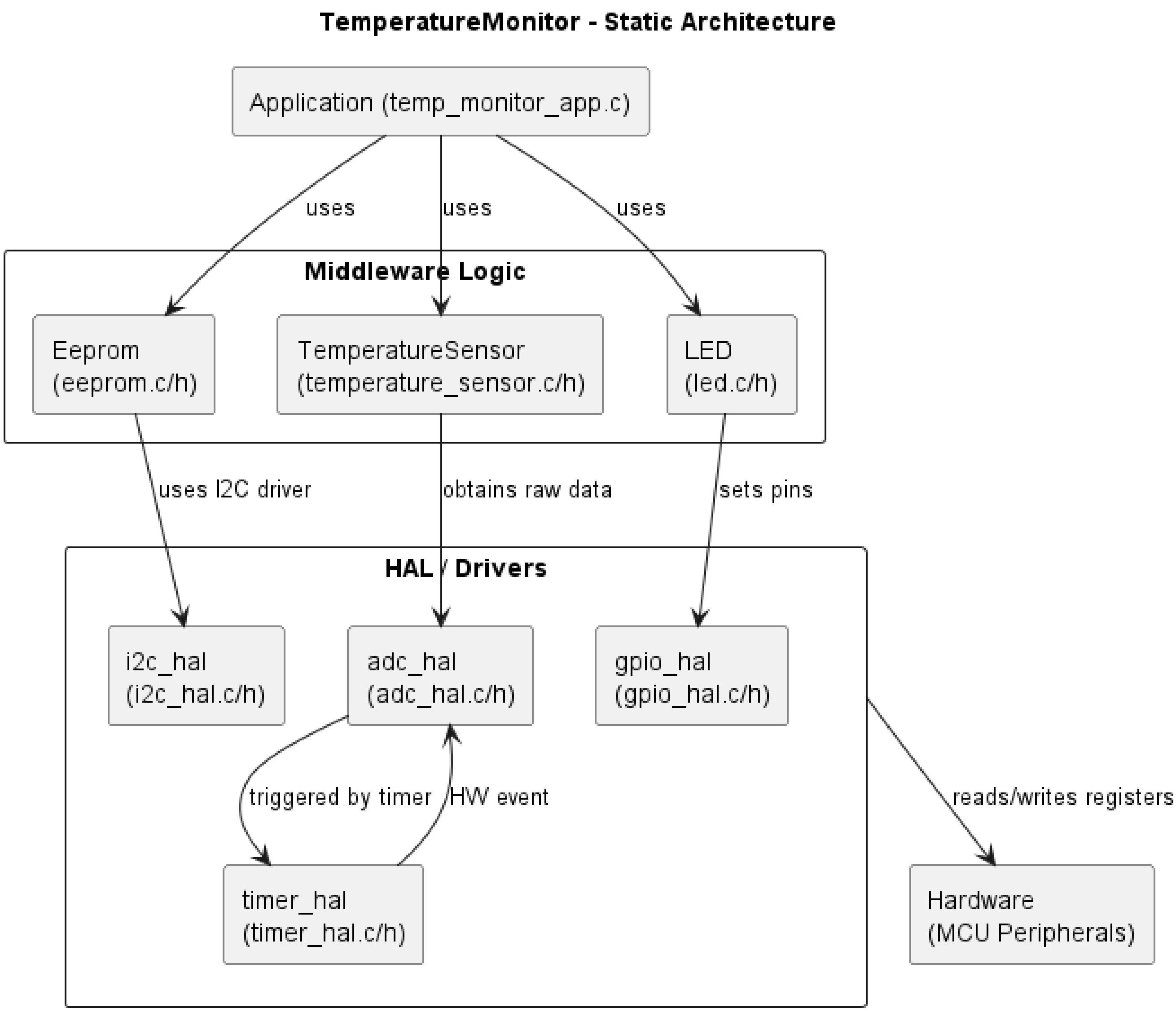
2. Static Architecture

2.1 Overall Layered Structure



2.2 Module Responsibilities

- **main**
  - A minimal entry point that calls `temp_monitor_app_init()` and `temp_monitor_app_run()`.

- **temp_monitor_app**
  - Orchestrates system initialization (calls init functions for EEPROM, Temperature Sensor, LED, Timer, ADC, etc.) and manages the main application loop.
- **eeprom**
  - Uses the **i2c_hal** module to read and write configuration data (hardware revision and serial number) from an external EEPROM.
- **temperature_sensor**
  - Retrieves the most recent ADC reading (via `adc_hal_get_value()`) and converts it to a temperature (°C) using scaling factors based on the hardware revision (Rev-A vs. Rev-B).
- **led**
  - Determines which LED should be activated (green, yellow, or red) based on the current temperature and pre-defined thresholds.
  - Uses **gpio_hal** to actually set the pin states.
- **i2c_hal**
  - *Real Hardware:* Initializes I²C registers, sets up pins, configures bus speed, and handles actual I²C transactions.
  - *Simulation:* Prints debug messages and returns dummy data.
- **gpio_hal**
  - *Real Hardware:* Enables GPIO clocks, configures pin modes (e.g., output, push-pull), and writes directly to registers.
  - *Simulation:* Simply prints the intended pin state changes.
- **timer**
  - *Real Hardware:* Configures a timer with prescaler values for a precise 100 μs period, and sets up a trigger output to start ADC conversions automatically.
  - *Simulation:* Emulates a timer event by calling a function (e.g., `timer_emulate_period_event()`) that triggers the ADC conversion.
- **adc_hal**
  - *Real Hardware:* Configures the ADC (resolution, sampling time, external trigger via timer trigger) and uses an ADC conversion-complete interrupt (e.g., `ADC_IRQHandler`) to update a global value.
  - *Simulation:* Increments a mock ADC value and stores it in a global variable, mimicking an ISR behavior.

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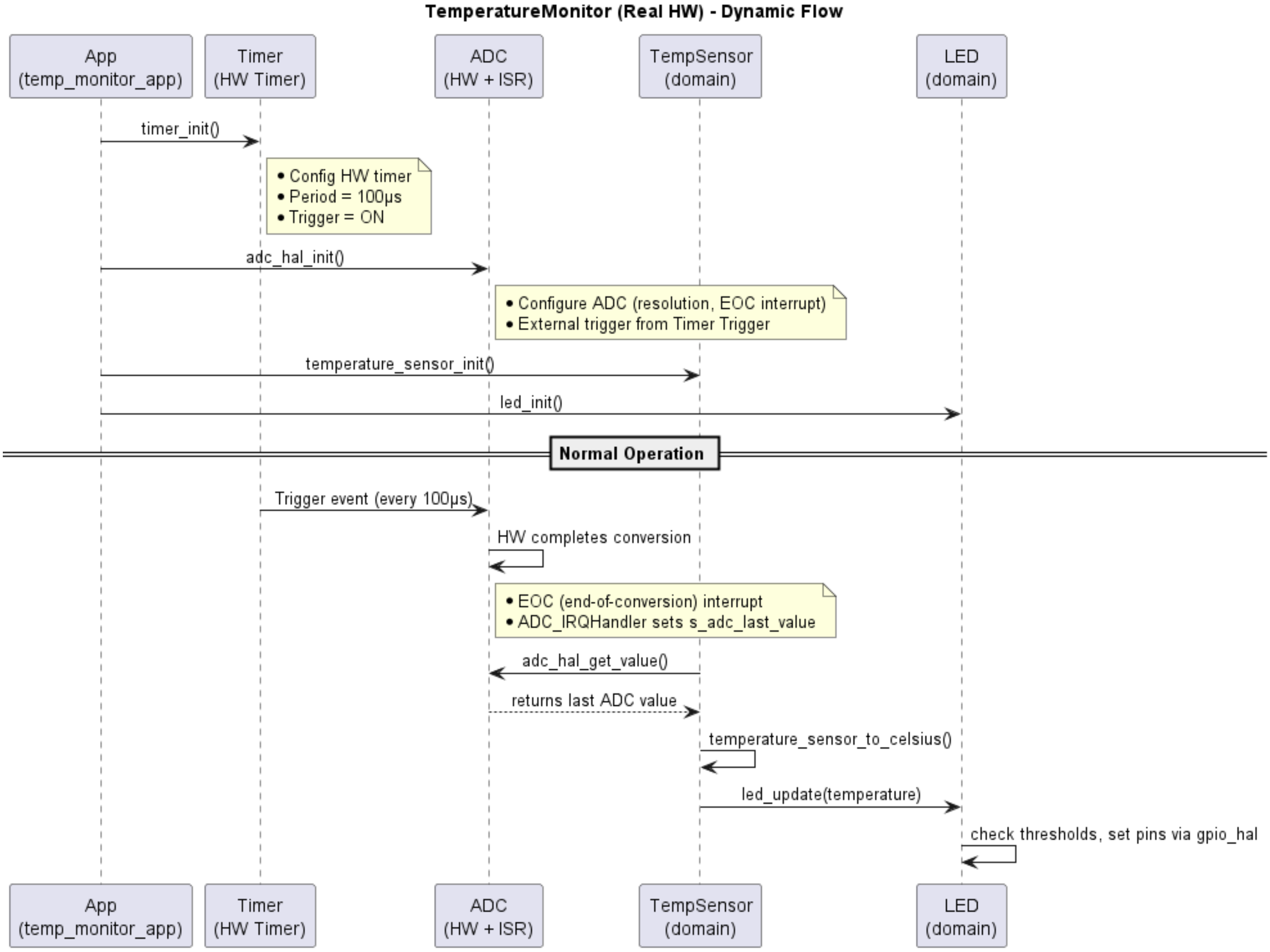
3. Dynamic Architecture

3.1 Sequence Diagram



3.2 Detailed Flow

1. **Initialization:**
   The application layer (`temp_monitor_app_init()`) initializes all modules. In real hardware, each module configures its peripheral only once.

2. **ADC Triggering:**

   - In real hardware, a timer configured for 100 µs automatically generates a trigger signal that triggers the ADC.
   - In simulation mode, the timer module emulates this event by calling `adc_hal_trigger_conversion()`.

3. **ADC Conversion and ISR:**

   - The ADC begins conversion upon receiving the trigger and, once complete, raises an interrupt.
   - The official ISR (`ADC_IRQHandler`) is called and updates a global variable (`s_adc_last_value`).

4. **Data Flow to Temperature Sensor:**
   The temperature sensor module retrieves the ADC value via `adc_hal_get_value()`, converts it to Celsius (using hardware revision scaling), and passes this value to the LED module.

5. **LED Update:**
   The LED module uses temperature thresholds (configured in `cfg.h`) to determine which LED to activate,

calling `gpio_write_pin()` from the GPIO HAL.

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4. Real Hardware Considerations

- **EEPROM:**
  In a real system, the EEPROM module would use I²C communication (handled by the i2c_hal module) to read/write non-volatile configuration data.
  - *Example:* Using `HAL_I2C_Mem_Read()` on an STM32.
- **GPIO:**
  The GPIO HAL would set up the GPIO ports and pins by enabling clocks and configuring pin modes.
- **ADC:**
  The ADC module would be configured for the required resolution and sampling time. It would be set to start conversion via an external trigger, and its end-of-conversion interrupt (`ADC_IRQHandler`) would be used to update the latest reading.
- **Timer:**
  The timer module configures a hardware timer to operate at a 100 µs interval, outputting a trigger signal for the ADC.

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5. Conclusion

This architecture provides:

- A **static, layered structure** with well-defined modules (low-level drivers, middleware, and application layer).
- A **dynamic data flow** where the timer triggers the ADC, the ADC interrupt updates a global variable, the temperature sensor converts the value, and the LED module updates outputs accordingly.
- Clear separation of concerns that facilitates maintainability, testability, and scalability in a complex embedded system.

This document and accompanying diagrams illustrate both the **static architecture** (module structure and dependencies) and the **dynamic behavior** (runtime data flow), making it a comprehensive reference for understanding the TemperatureMonitor project's design.

End of Architecture Document