**hal\_core: Core Hardware Abstraction Layer (HAL) Package**

The hal\_core package serves as the foundational layer of the **Hardware Abstraction Layer++ (HAL++)**, enabling seamless communication between the kernel and underlying hardware. It provides essential services for managing hardware components dynamically, ensuring portability, scalability, and security.

**Key Functionalities of hal\_core**

**1. Device Discovery & Enumeration**

* Identifies and categorizes connected hardware components.
* Supports plug-and-play and hot-swappable hardware.
* Uses a **unified device tree** or **dynamic hardware graph** for real-time detection.

**2. Dynamic Hardware Configuration**

* Allows real-time reconfiguration of hardware resources.
* Provides API hooks for modifying device parameters.
* Supports **firmware updates** and **hardware patching**.

**3. Standardized API for Drivers**

* Defines **uniform interfaces** for drivers, independent of hardware vendors.
* Provides abstraction layers for different **instruction set architectures (ISA)**.
* Supports backward compatibility for legacy devices.

**4. High-Performance Interrupt Handling**

* Implements an **intelligent interrupt controller** with low-latency processing.
* Supports **hardware-accelerated event-driven execution**.
* Provides **priority-based interrupt handling** with AI-driven scheduling.

**5. Secure Hardware Access**

* Implements a **privilege separation model** to control access to hardware.
* Uses **memory isolation techniques** to prevent unauthorized access.
* Supports **secure boot mechanisms** and **device attestation**.

**6. Power Management & Efficiency**

* Optimizes power consumption based on **real-time workload adaptation**.
* Integrates **AI-based predictive power scaling**.
* Supports **dynamic voltage and frequency scaling (DVFS)**.

**7. Virtualization & Multi-Tenant Hardware Access**

* Provides a **hardware partitioning framework** for secure multi-user environments.
* Implements **fine-grained resource control** for virtualized workloads.
* Enables **seamless hardware sharing across multiple OS instances**.

**Modules within hal\_core**

| **Module Name** | **Description** |
| --- | --- |
| **hal\_core\_init** | Initializes the HAL core and detects hardware components. |
| **hal\_core\_config** | Manages system-wide hardware configurations dynamically. |
| **hal\_core\_api** | Provides a standardized API for drivers and applications. |
| **hal\_core\_security** | Enforces access control, secure boot, and encrypted communication. |
| **hal\_core\_interrupts** | Manages efficient interrupt handling and event-driven execution. |
| **hal\_core\_virtualization** | Handles hardware virtualization and multi-tenant access. |
| **hal\_core\_pm** | Implements AI-driven power management and efficiency mechanisms. |