



ACPI support on Radxa Orion 06

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Introduction to Radxa Orion O6

Arm V9 Motherboard

- Powered by the Cix CD8180 SoC
- Armv9.2 Architecture
- Efficient Power Consumption Management
- Comprehensive Security Engine
- Higher Performance, Lower Power, Better Security



12-Core CPU The Engine of Powerful Computing

- Quad Big Cortex®-A720
- Quad Medium Cortex®-A720
- Quad Little Cortex®-A520
- 12MB L3 shared across all cores

Arm® Immortals™ G720 MC10 GPU - High-Performance Desktop GPU

- Hardware-Based Ray Tracing Technology Enhances Graphic
- Multi-API Standards Showcase Superior Graphics Processing
- Efficient Rendering and Parallel Computing for Professional Performance
- OpenGL ES3.2, Vulkan 1.3, OpenGL 4.0, OpenCL 3.0 support

Heterogeneous Computing Power

- NPU computing power is up to 30TOPs
- Supporting models with parameters within ten billion



Introduction to Radxa Orion O6

Impressive Video Processing Capabilities

- Experience 8K Ultra-High Definition with Multiple Codec Support
- AV1 / H.265 / H.264 / VP9 / VP8 / H.263 / MPEG-4 / MPEG-2 video decoder up to 8K@60fps
- H.265 / H.264 / VP9 / VP8 video encoder up to 8K@30fps



Versatile Multi-Display Interfaces

- Up to 4x Display, DP Display Up to 4K@120Hz HDMI up to 4Kp60 display output
- DP up to 4Kp120 display output with MST (Multi-Stream Transport) support
- eDP with Touch Panel Interface
- USB Type-C with DisplayPort Alt Mode

Rich IO interface configuration

- Dual 5Gbps Ethernet Ports
- Supports the Latest Wi-Fi 7 Wireless Module
- Applicable to AI Accelerator Cards, Graphics Processors, Storage and Network Expansion
- 2x USB Type-C Port with DP, USB3.2 and PD power supply
- 2x USB 2.0 and 2x USB 3.2 HOST Type-A
- 2x MIPI Camera Interfaces
- Headphone Jack with Microphone Input
- Standard Mini ITX Size
- 40-Pin Header with I2C, SPI, I2S and GPIO
- 24-Pin ATX Power Connector
- 4-Pin Fan Header
- RTC Battery Connector
- UART / Debug Header

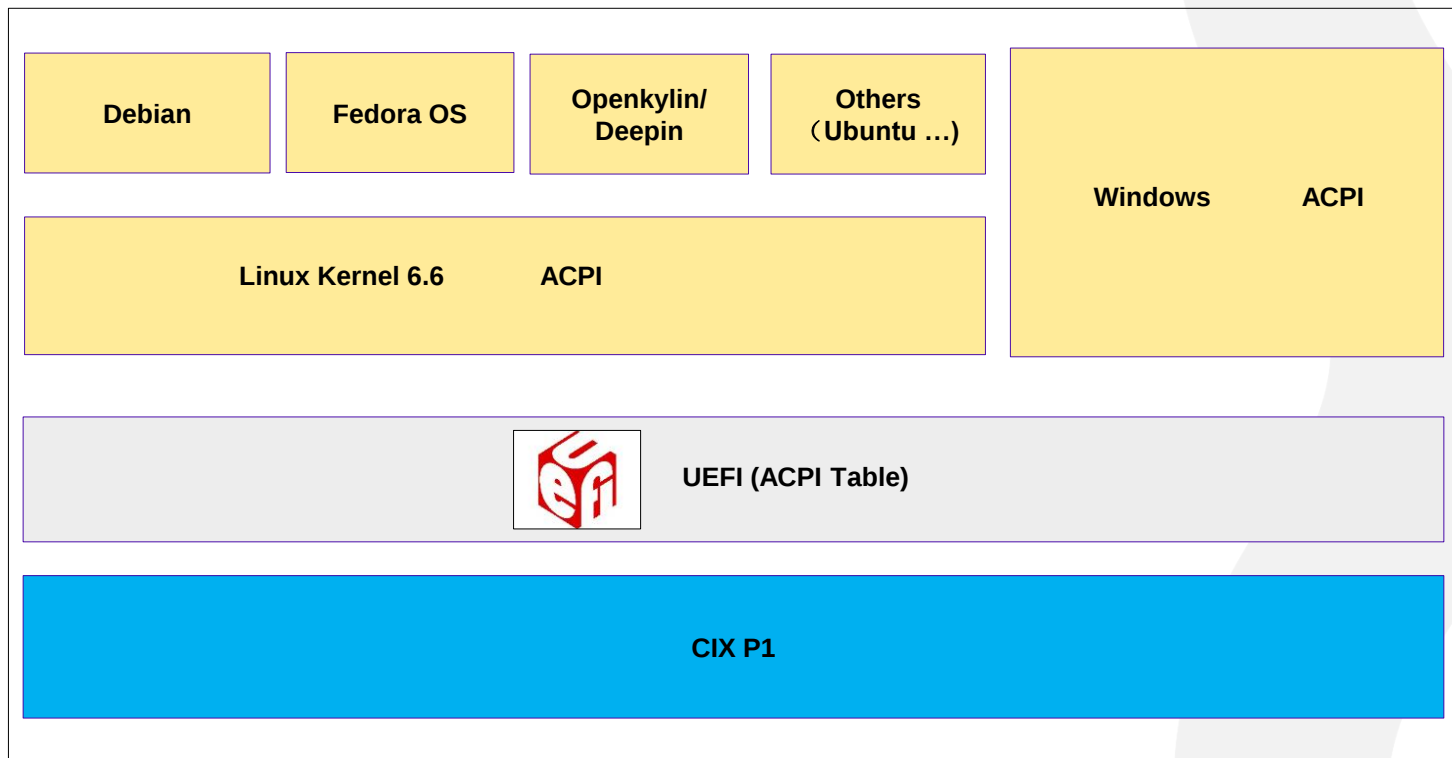
Native Linux / Debian support with UEFI / BIOS

- PC Boot-up in Line with X86 Conventions
- Support UEFI(EDKII) and Various Commercial BIOS
- Kernel 6.6 ACPI driver functionality fully compatible
- Debian 12 Native, Integrated with CD8180 Kernel Package and Extensions

Multiple Operating Systems Support

- Debian, Ubuntu, Fedora, AOSP, Openkylin, Deepin, etc.

ACPI support overview on Orion O6 Platform



ACPI support overview on Orion O6 Platform

Category	• Features
Arch	• Armv9, GIC, SMMU, GPIO and Pinctrl support with ACPI • Global timer, WDT, DMA support • Reset framework support with ACPI • Regmap/Syscon common API support with ACPI • Device CMA and DMA mem pool support with ACPI
IO	• I2C bus ACPI driver, PD and RTC driver support • NVMe with PCIe x4, RTL8126 NIC with PCIe x1, WLAN with PCIe x1 • USB TypeC with USB3.2, DP and Power supply, 4x USB TypeA
Audio	• HDA controller and codec, Jack detection and Headphone support
Multimedia	• VPU ACPI driver support, Gstreamer support with HW acceleration • CSI, CSI-DMA and ISP ACPI driver support, Gstreamer support camera capture and preview
Graphics & Display	• GPU ACPI driver support, Desktop rendering with HW acceleration • DPU, eDP/DP ACPI driver support, Multiple display support on different Linux OS
AI	• NPU ACPI driver support, ML runtime frameworks and application support
Low Power	• Linux Clock tree, Power domain ACPI support • CPU SMP/Hotplug, CPUIdle and CPUFreq ACPI driver support • System warm reset, S3/S5 and wakeup support • Device devfreq support for VPU, GPU, and NPU • Sky1 thermal ACPI driver support
BIOS	• UEFI + ACPI Table • Secure boot, GOP display support

ACPI Features on Orion O6 - Timers

PE Timer

- Generic Timer Description Table (GTDT) is required for Arm64 to provides timer information to OSPM
 - Per-processor timers:
 - Secure EL1 timer
 - Non-Secure EL1 timer
 - EL2 timer
 - Virtual EL1 timer
 - Virtual EL2 timer
 - Memory-mapped platform timers:
 - GT block
 - SBSA Generic Watchdog
- Linux OS timer driver is ACPI compliant.
- For Arm64, boot code should initialize CNTFRQ_EL0 register with correct value

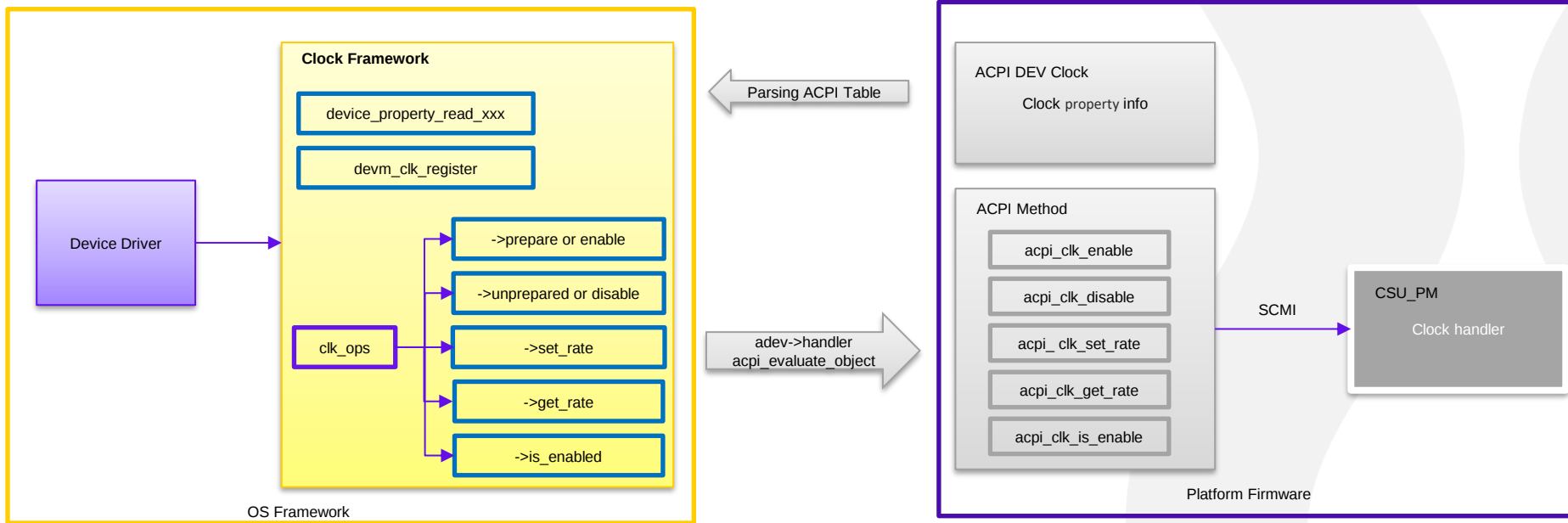
CIX GPT Timer

- System wakeup timer that can be used as broadcast timer when PE timers are gated off or powered down
- CIX P1 GPT timer driver is not ACPI compliant.
- CIX re-use DT GPT timer driver and register private _HID "CIXH1007"

ACPI Features on Orion O6 - Clock Management

Devices requires to configure clock for different operating points, specially for the case that re-used DT driver.

- Standard Clock Device
- AML-based SCMI approach to configure the clock
- Re-use Clock Framework



ACPI Features on Orion O6 - Pinctrl Management

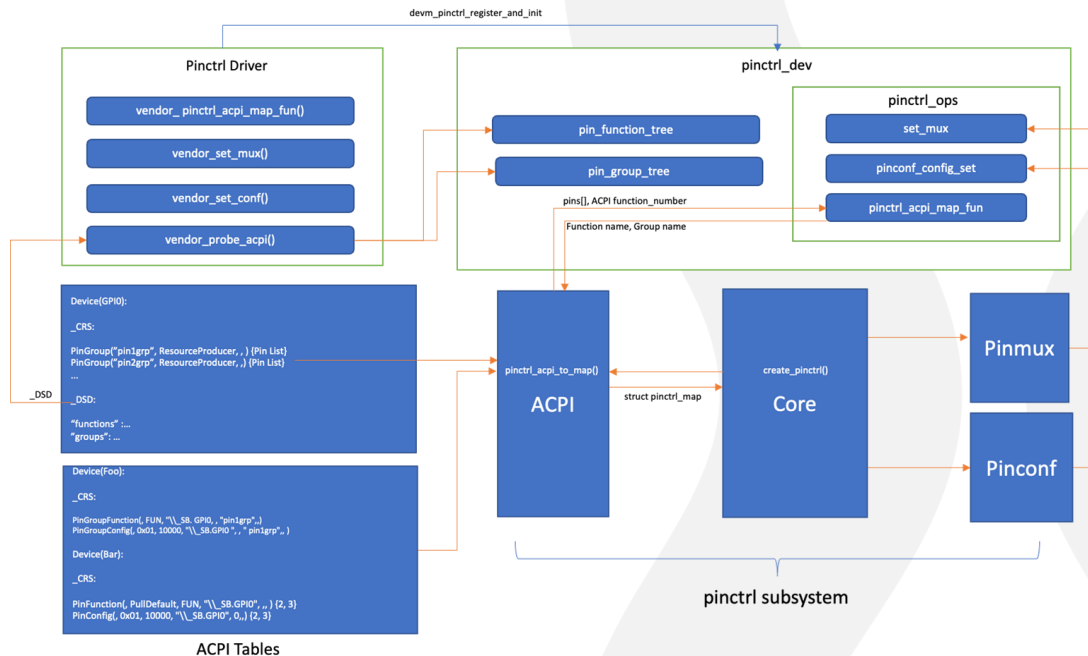
ACPI v6.2 introduced pin control resources

- PinFunction
- PinConfig
- PinGroup
- PinGroupFunction
- PinGroupConfig

Multiple devices could be sharing same pin with a different pin configuration requirement. E.g: I2C SCL muxed with GPIO pin for a display controller.

```
PinGroup ("pinctrl_fch_i2c0", ResourceProducer, ,
RawDataBuffer ()
{
    0x00, 0x78, 0x00, 0x47,
    0x00, 0x7c, 0x00, 0x47
})
{
    SKY1_IOMUXC_I2C0_CLK,
    SKY1_IOMUXC_I2C0_SDA
}
```

```
Name (_CRS, ResourceTemplate () {
    Memory32Fixed (ReadWrite, I2C2_BASE, I2C2_SIZE)
    Interrupt (ResourceConsumer, Level, ActiveHigh, Exclusive) { FCH_INTR_I2C2_INTERRUPT_ID }
    PinGroupFunction(Exclusive, 0x0, "\\_SB.MUX0", 0, "pinctrl_fch_i2c2", ResourceConsumer,)
})
```



ACPI Features on Orion O6 - High Speed IO - USB

CIX P1 USB comply Arm SystemReady, standard ACPI table can enable USB functions:

- `_HID` (Hardware ID): Identify the hardware type of the USB controller (PNP0D10 representing a universal container device).
- `_CRS` (Current Resource Settings): Allocate memory, I/O, and interrupt resources.
- `_UPC` (USB Port Capabilities): Define the connection properties and power capabilities of USB ports.
- `_PRW`(Power Resources Wakeup): lists the power resources that can be enabled during the system wake-up process.
- `_PSW`(Power State Wake): this control method used to enable/disable the device's ability to wake a sleep system.

ACPI Features on Orion O6 - High Speed IO - PCIe

CIX P1 PCIe comply Arm SystemReady and standard PCIe ECAM, standard ACPI table can enable PCIe functions.

DSDT/SSDT Table:

Key and standard methods to define PCI resource and capabilities:

- _HID: use standard PCI Root Bridge "PNP0A08"
- _CRS: define host bridge MMIO, memory space
- _PRT: declare PCI Interrupt Routing table
- _OSC: negotiate PCI capabilities with OS

Mcfg Table:

PCIe0 (x8):

```
{
{
0x20000000, //ECAM Base Address
0x0,       //Segment Group Number
0xC0,      //Start Bus Number
0xFF,      //End Bus Number
0x00000000, //Reserved
},
};
```

PCIe1 (x4):

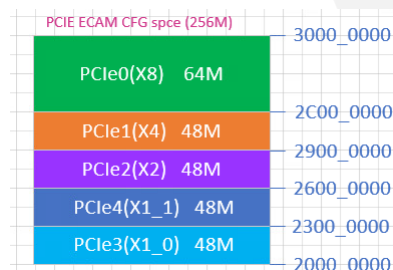
```
{
{
0x20000000, //ECAM Base Address
0x0,       //Segment Group Number
0x90,      //Start Bus Number
0xAF,      //End Bus Number
0x00000000, //Reserved
},
};
```

PCIe2 (x2):

```
{
{
0x20000000, //ECAM Base Address
0x0,       //Segment Group Number
0x60,      //Start Bus Number
0x7F,      //End Bus Number
0x00000000, //Reserved
},
};
```

PCIe4 (x1):

```
{
{
0x20000000, //ECAM Base Address
0x0,       //Segment Group Number
0x30,      //Start Bus Number
0x4F,      //End Bus Number
0x00000000, //Reserved
},
};
```



PCIe3 (x1):

```
{
{
0x20000000, //ECAM Base Address
0x0,       //Segment Group Number
0x00,      //Start Bus Number
0x1F,      //End Bus Number
0x00000000, //Reserved
},
};
```

ACPI Features on Orion O6 - GPU/VPU/NPU

The current implementation method is to reuse DT drivers based on the DSDT ACPI table driver model:

- **_HID** (Hardware ID): Identify the hardware type, CIX define private HID for these driver:
 - "CIXH3010" for VPU, "CIXH5000" for GPU, "CIXH4000" for NPU
- **_CRS** (Current Resource Settings): Allocate memory, I/O, and interrupt resources.
- **_DSD** (Device Specific Data): provide device drivers with additional device properties and information, re-used DT properties definition.
- **Power resource**: PowerResource(PPRS, 0, 0) to define some Methods to handle power domain enable, disable and status.
- **_PR0** and **_PR3**: declare power resource to enter state D0 and D3hot

```

PowerResource(PPRS, 0, 0)
{
    OperationRegion(OPR0, SystemMemory, VPU_RCSU_PD_REG, 0x04)
    Field (OPR0, DWordAcc, NoLock, Preserve) {
        MSK0, 32,
    }
    Method(_STA, 0, Serialized)
    {
        Local0 = MSK0
        Local0 = Local0 & PGFSM_REG_CTRL2
        If (Local0 > 0)
        {
            Return (1)
        }
        Else
        {
            Return (0)
        }
    }
}

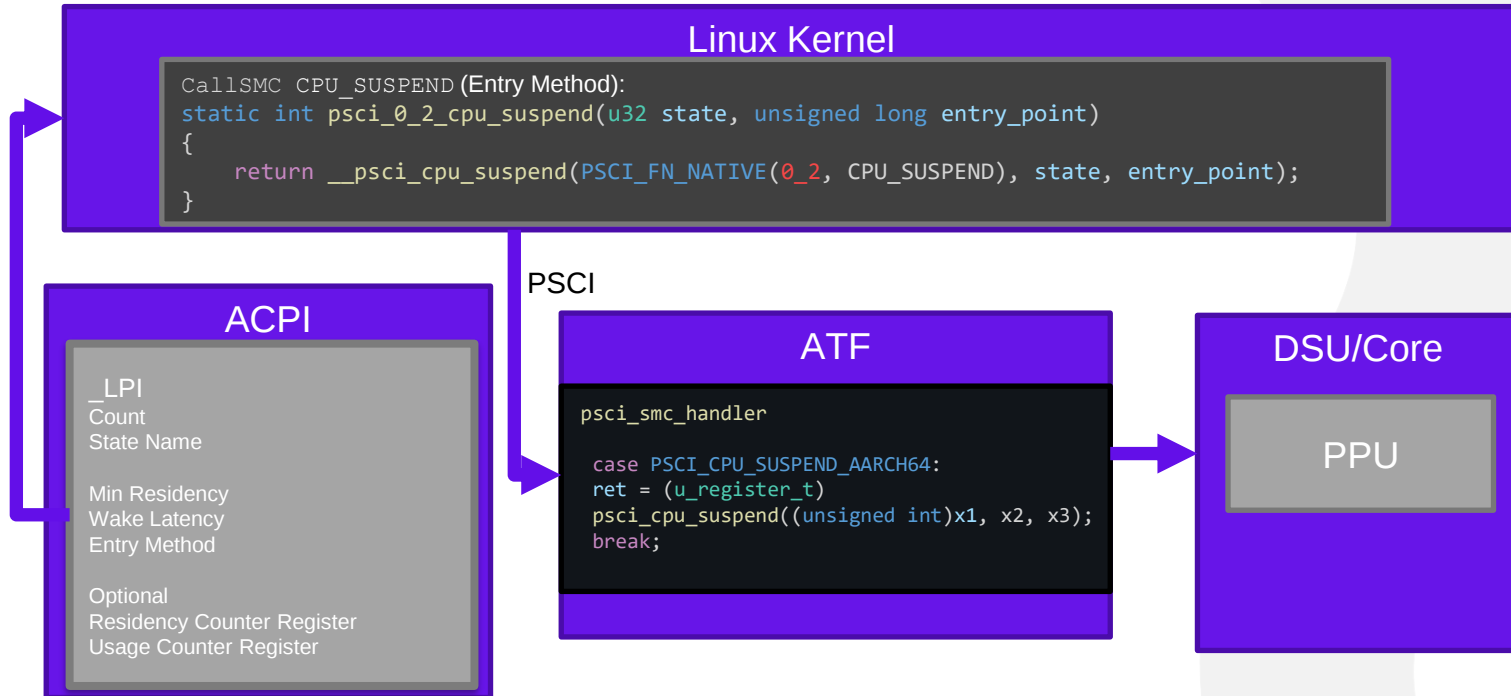
}
Method(_ON, 0, Serialized)
{
    Local0 = MSK0
    Local0 = Local0 | PGFSM_REG_CTRL2 | TIME_CYCLE_CNT
    MSK0 = Local0
}
Method(_OFF, 0, Serialized)
{
    Local0 = MSK0
    Local0 = Local0 & ~PGFSM_REG_CTRL2
    MSK0 = Local0
}
}

Name(_PR0, Package(1){PPRS})
Name(_PR3, Package(1){PPRS})

```

ACPI Features on Orion O6 - CPU Idle

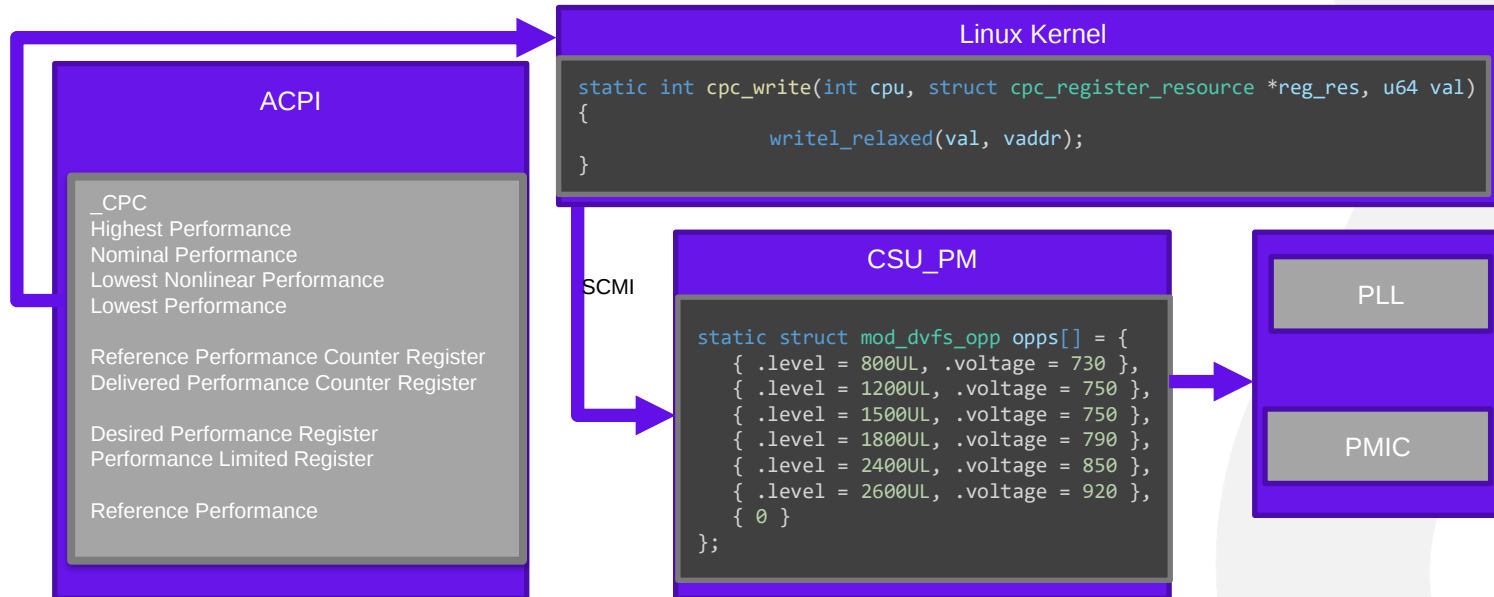
- In ACPI-compliant Arm platforms, Low Power Idle (LPI) can be utilized for CPU idle states.
- LPI is typically implemented using the Power State Coordination Interface (PSCI) or the Wait For Interrupt (WFI) instruction
- Idle state selection based on next event and firmware provided idle states exit latencies



ACPI Features on Orion O6 - CPU DVFS

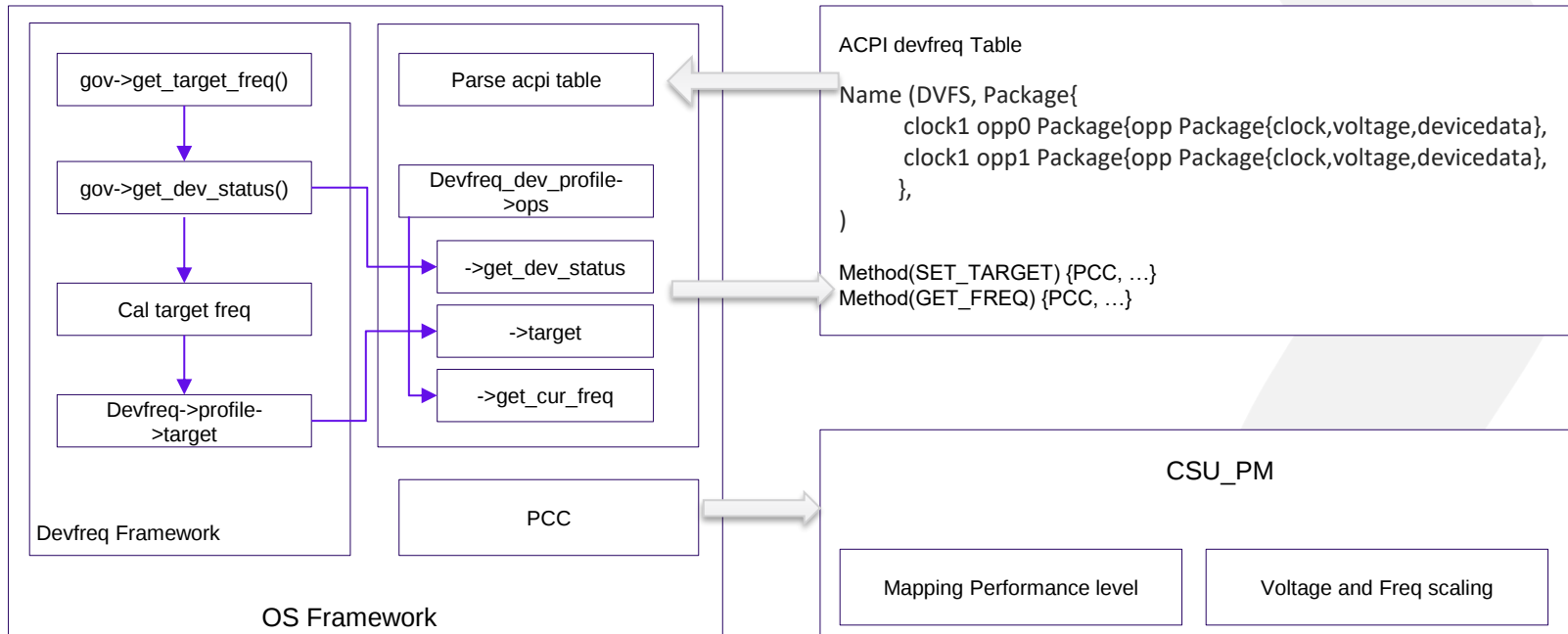
OS Monitor processor Performance and Controlling Processor Performance
 OS requests the desired performance to the platform over the SCMI fastchannel
 AMU activity Monitor Unit in Armv8.4:

- AMUv1 supports four architected event counters for performance monitoring:
- Processor frequency counter: Delivered Performance Counter Register
- Constant frequency counter: Reference Performance Counter Register



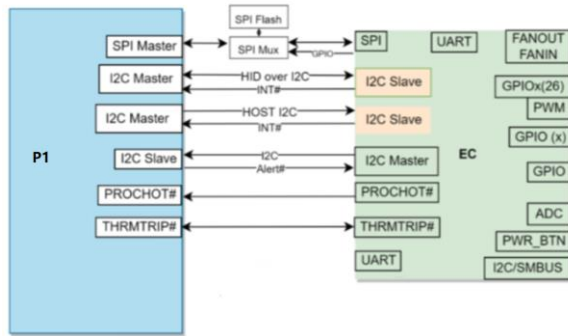
ACPI Features on Orion O6 - Device DFS

- Devices (non-CPU) may have multiple operable frequency and voltage sets (OPP) and OSPM can choose one of them in order to reduce power consumption for an acceptable performance.
- Power saving possible with DVFS for devices like GPU, NPU, VPU, Interconnect, ISP etc.
- Linux supports DevFreq with DeviceTree, reuse the DevFreq framework.



ACPI Features on Orion O6 - EC

Laptop EC Block



Fan:

```
Device(ECFP)
{
    Name(_HID,EISAID("PNP0C0B"))
    Name(_UID,0)
    Name(_PR0,Package(1){ECFN})
}
```

ThermalZone:

```
ThermalZone(ECTZ) {
    Name(_TZD,Package () { \_SB })

    Method(_TMP, 0, Serialized) {
        ...
    }
    Method(_TZP) { Return(300) }
}
```

PWR_BTN:

```
Device(PWRB)
{
    Name(_HID,EISAID("PNP0C0C"))
    Method(_STA)
    {
        Return(0x0F)
    }
}
```

Fan Auto/Mute/Perf Mode:

```
// Name: SFAT [Set EC Fan to Auto Mode]
Method(SFAT, 0, Serialized){
    Name(BUF0, Buffer(10){0xDA,0x03,0xA9,0x00,0x52,0x00,0x00,0x00,0x01,0x01})
    Name(BUF1, Buffer(10){})
    TRAS(BUF0,Sizeof(BUF0),BUF1,Sizeof(BUF1))
}

// Name: SFMT [Set EC Fan to Mute Mode]
Method(SFMT, 0, Serialized){
    Name(BUF0, Buffer(10){0xDA,0x03,0xA8,0x00,0x52,0x00,0x00,0x00,0x01,0x02})
    Name(BUF1, Buffer(10){})
    TRAS(BUF0,Sizeof(BUF0),BUF1,Sizeof(BUF1))
}
```

```
}

// Name: SFPF [Set EC Fan to Performance Mode]
Method(SFPF, 0, Serialized){
    Name(BUF0, Buffer(10){0xDA,0x03,0xA6,0x00,0x52,0x00,0x00,0x00,0x01,0x04})
    Name(BUF1, Buffer(10){})
    TRAS(BUF0,Sizeof(BUF0),BUF1,Sizeof(BUF1))
}
```

Public Source code for Orion O6

SystemReady Certification on Radxa Orion O6

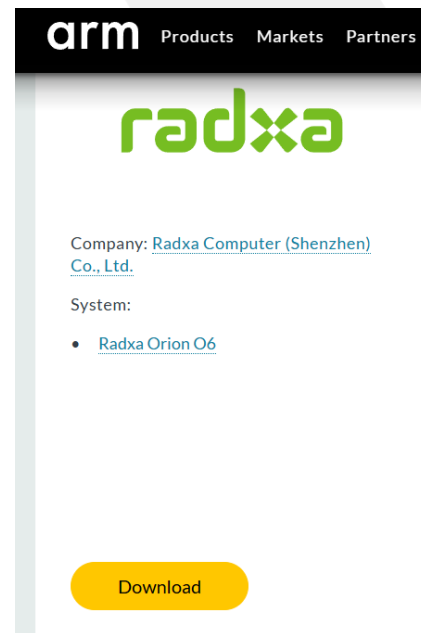
- SystemReady Certification SR v2.5 <https://www.arm.com/architecture/system-architectures/systemready-compliance-program/systemready-past-certifications#sr>
- CIX P1 system is the second SBSA L6 compliant SoC
- The certificated BIOS is available from <https://dl.radxa.com/orion/o6/images/bios/SystemReady/>

UEFI EDK2 Source code

- https://gitlab.com/cix-linux/cix_opensource/release

ACPI Kernel Source code

- https://gitlab.com/cix-linux/cix_opensource/linux





Thank You!