

RK3399 and SOC

RockPi WiKi

➤ Rock Pi4 Wiki

➤ <https://wiki.radxa.com/Rockpi4>

➤ Rock Pi 4 Feture

➤ https://wiki.radxa.com/Rockpi4/getting_started

➤ Rock Pi 4 Debin

➤ <https://wiki.radxa.com/Rockpi4/Debian>

➤ <https://wiki.radxa.com/Rock4/downloads>

CPU

CPU (1)

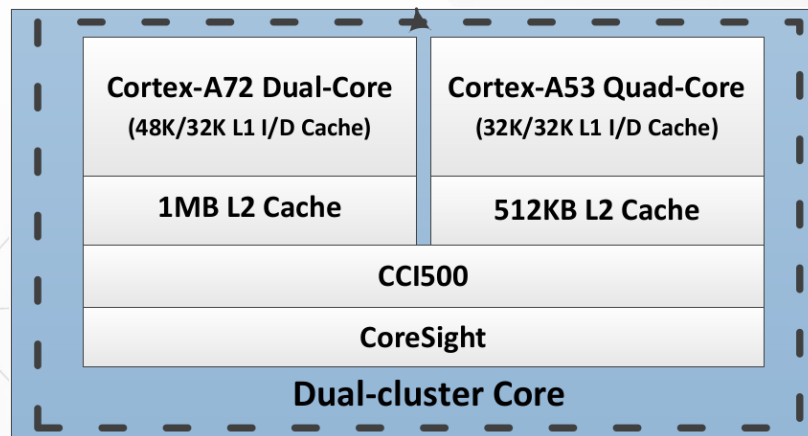
Two CPU clusters

Big cluster with dual-core Cortex-A72

- high-performance

Little cluster with quad-core Cortex-A53

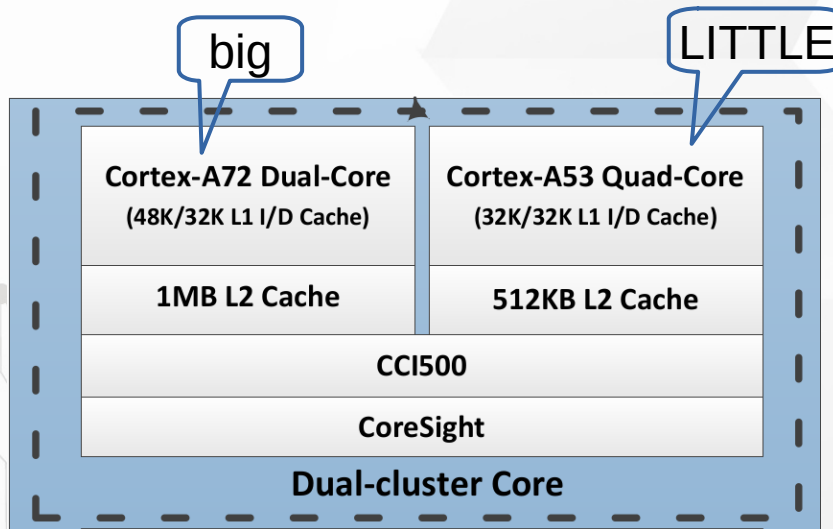
- low power



CPU (2)

Arm big.LITTLE technology

- ▶ "LITTLE" processors are designed for maximum power efficiency
- ▶ "big" processors are designed to provide maximum compute performance.



Memory

Memory

Internal ROM

- Internal BootRom (Size : 32KB)

- boot from

- SPI, eMMC, SD/MMC

Internal RAM

- 200KB

External

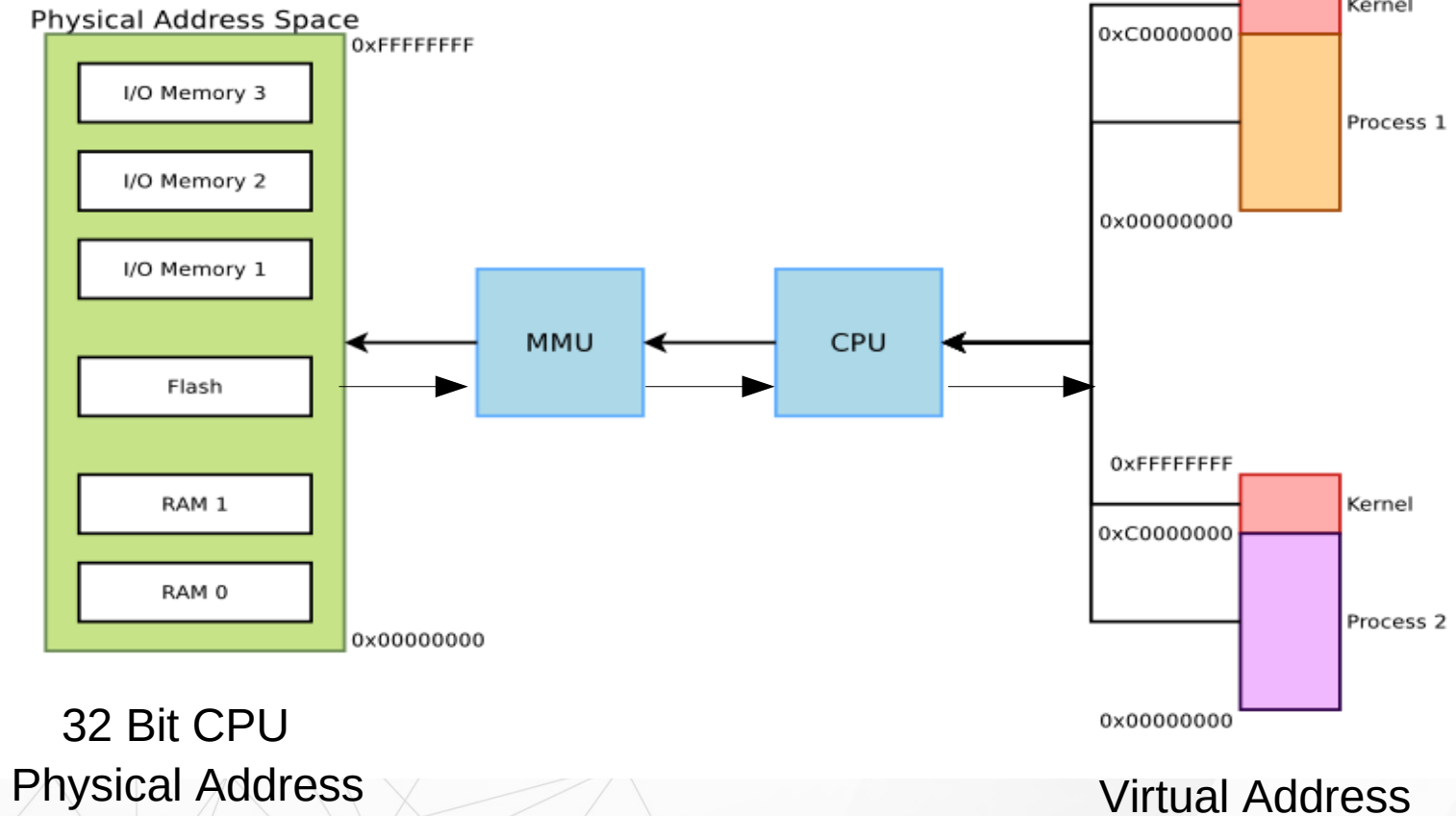
- DDR3/DDR3L/LPDDR3/LPDDR4

- SPI NOR/NAND Flash

- EMMC5.1

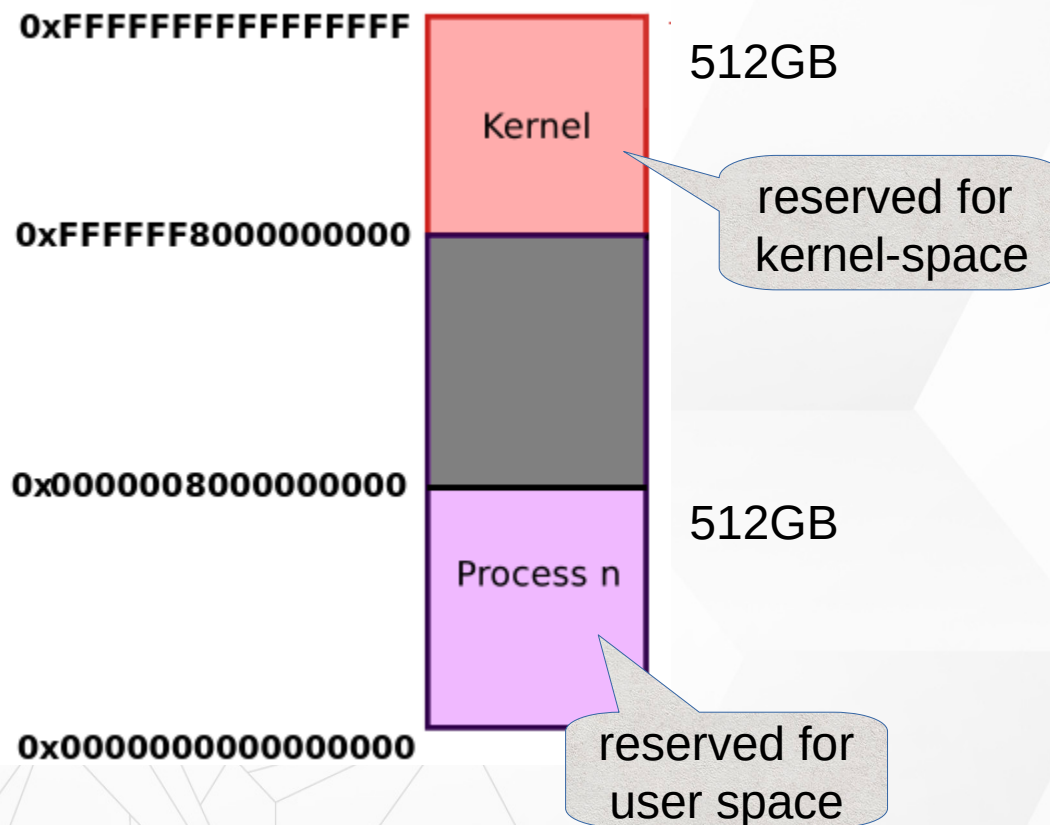
- SD3.0/MMC4.51

MMU (1)



MMU (2)

64 Bit CPU AArch64 Linux memory layout with 4KB pages + 3 levels



MMU (3)

➤ The MMU divides memory into **4KB** pages

➤ 2-level page table structure

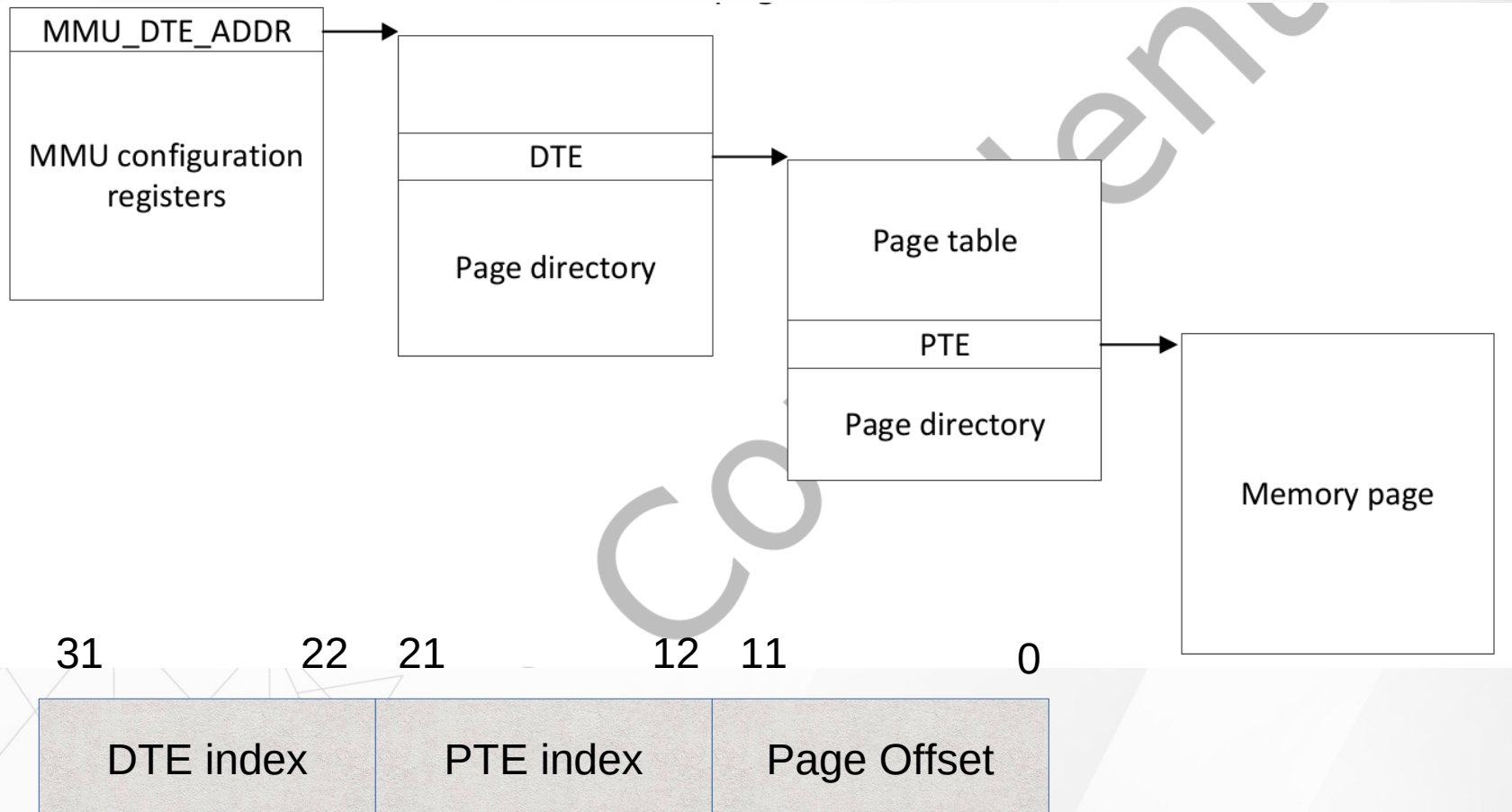
➤ The First level

- Page Directory consists of **1024** Directory Table Entries (DTEs)
- Each pointing to a Page Table.

➤ The Second level

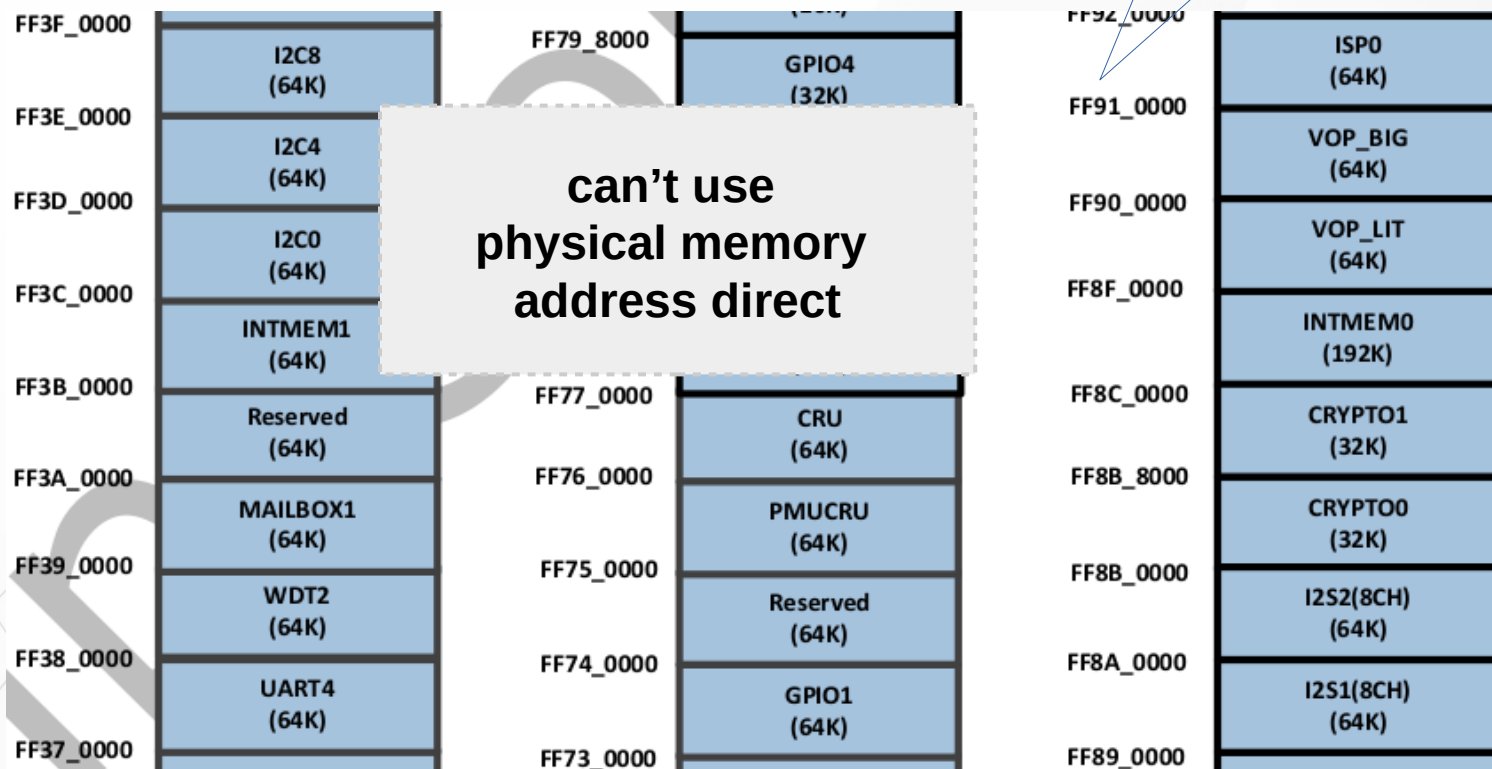
- The Page Table consists of **1024** Page Table Entries (PTEs)
- Each pointing to a page in memory

MMU (4)



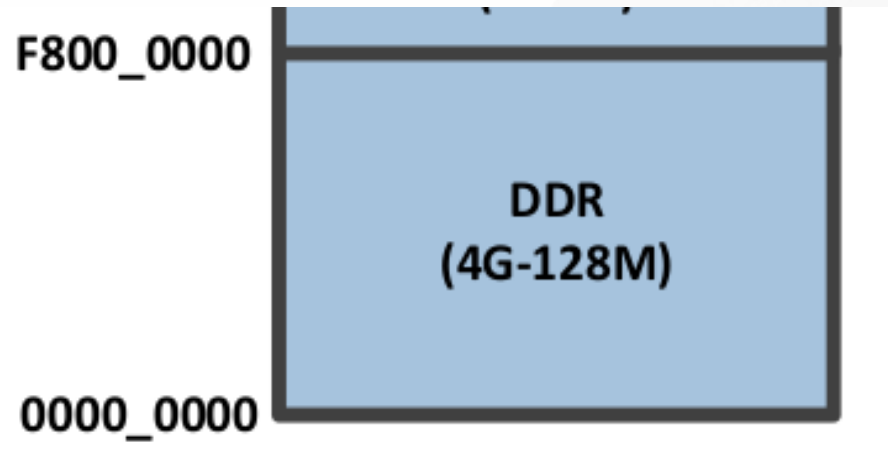
MMU (5)

I/O Address Mapping



MMU (6)

DDR SD RAM Memory



Interconnect Connect

Bus Architecture

➤ AMBA : Advanced Microcontroller Bus Architecture

➤ AXI

➤ AHB

➤ APB

Key AMBA specifications

CHI
Coherent Hub Interface

Credited coherent protocol
Layered architecture for scalability

ACE
AXI Coherency Extensions

ACE is a superset of AXI – system-wide coherency across multicore clusters

AXI
Adv. eXtensible Interface

AXI supports separate A/D phases, bursts, multiple outstanding addresses, OoO responses

AHB
Adv. High-performance Bus

AHB supports 64/128 bit multi-manager
AHB-Lite for single manager

APB
Adv. Peripheral Bus

System bus for low bandwidth peripherals

GPU



Graphics Engine (1)

- Graphics Process Unit

- Mali-T860MP4 GPU

 - OpenGL ES1.1/2.0/3.0, OpenCL1.2,

 - 3DGraphics Engine

 - 2D Graphics Engine



Graphics Engine (2)

» OpenGL

» Open Graphics Library

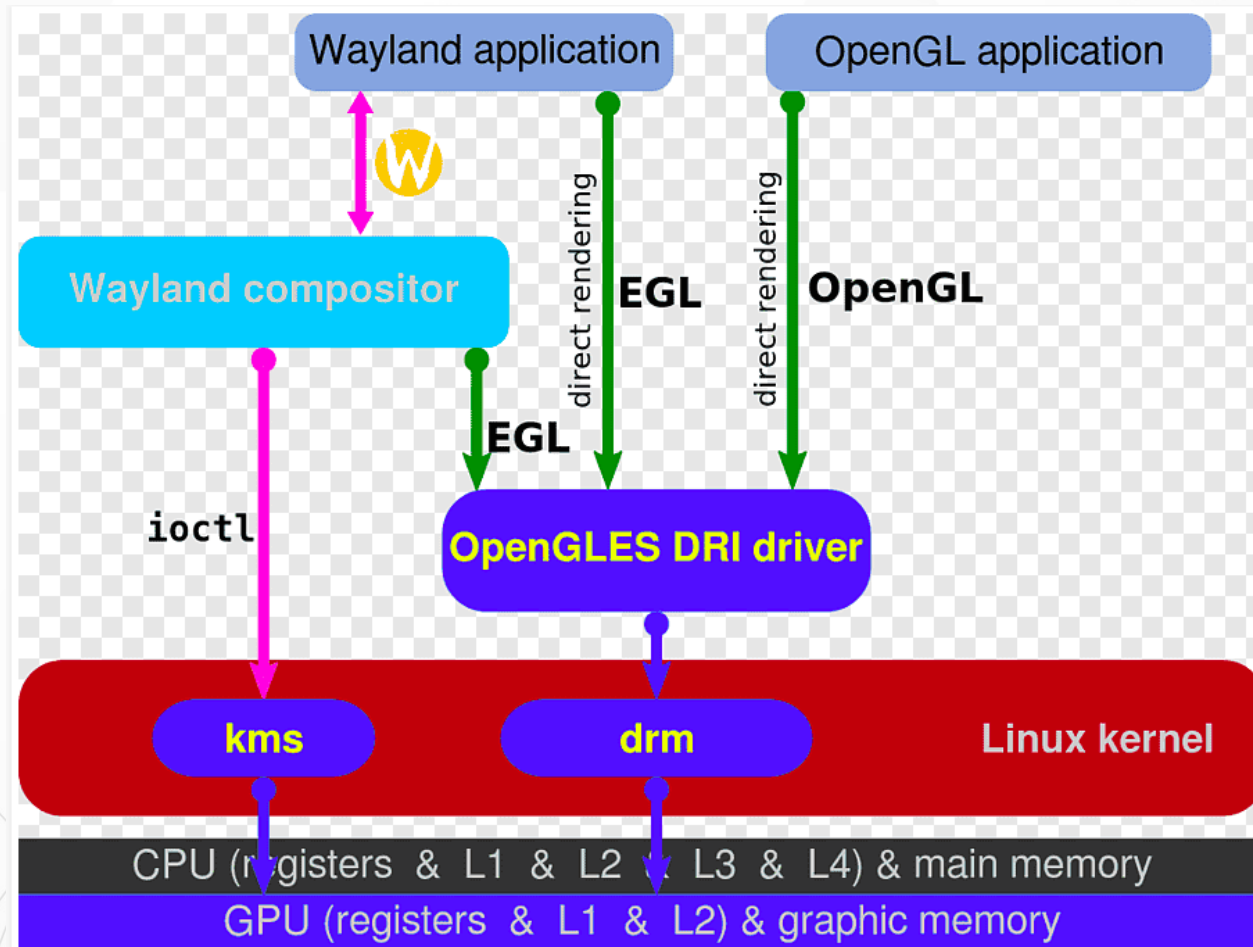
» OpenGL ES

» OpenGL for Embedded Systems

» EGL

» Native Platform Graphics Interface

Graphics Engine (3)



Connect

USB (1)

➤ USB Host

➤ RK3399

➤ OHCI : 1.1. Hardware Complex

➤ UHCI : 1.0, 1.1 Software Complex

➤ EHCI : 2.0

➤ XHCI : 3.0

➤ USB Device

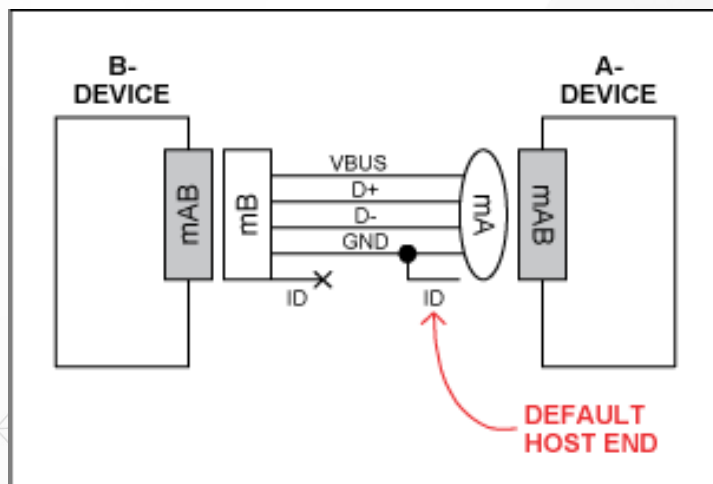
➤ USB Storage

USB (2)

➤ USB OTG

➤ USB_ID 信號為低時，該設備應作為 Host

➤ USB_ID 信號為高時，該設備作為 Slave



UART

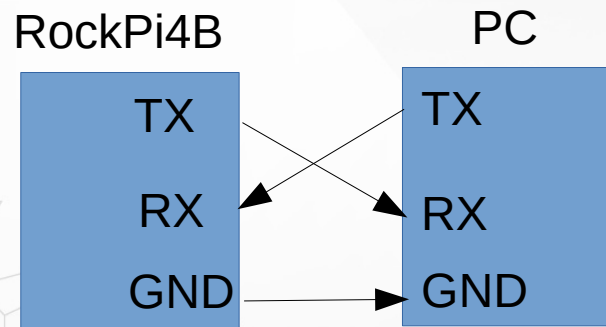
➤ The **U**niversal **A**synchronous **R**eceiver/**T**ransmitter

➤ Write Data

- CPU → Data → APB → UART

➤ Read Data

- Data → UART → APB → CPU

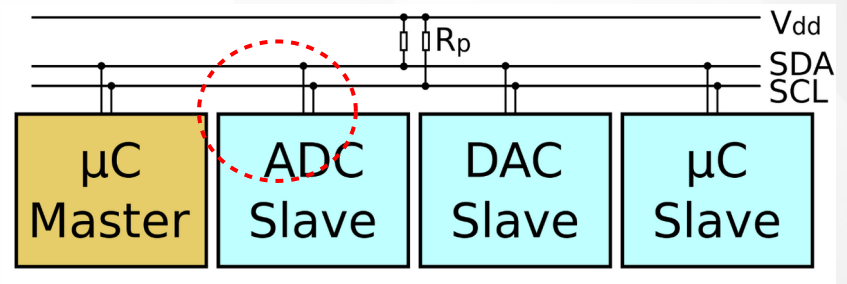


I2C (1)

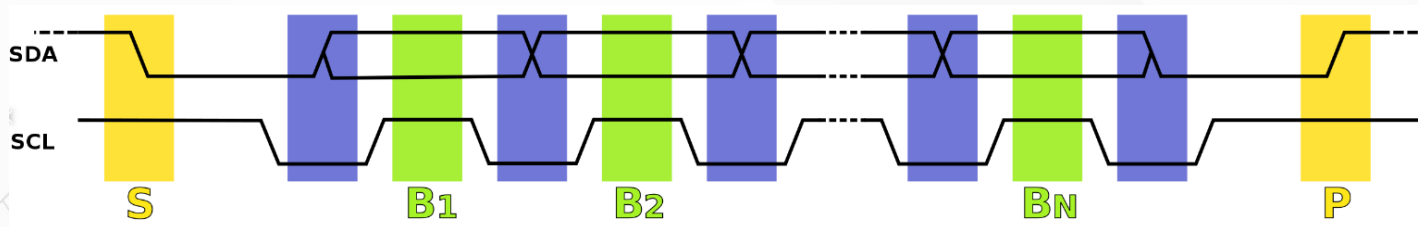
Serial bus

SDA data line

SCL clock line

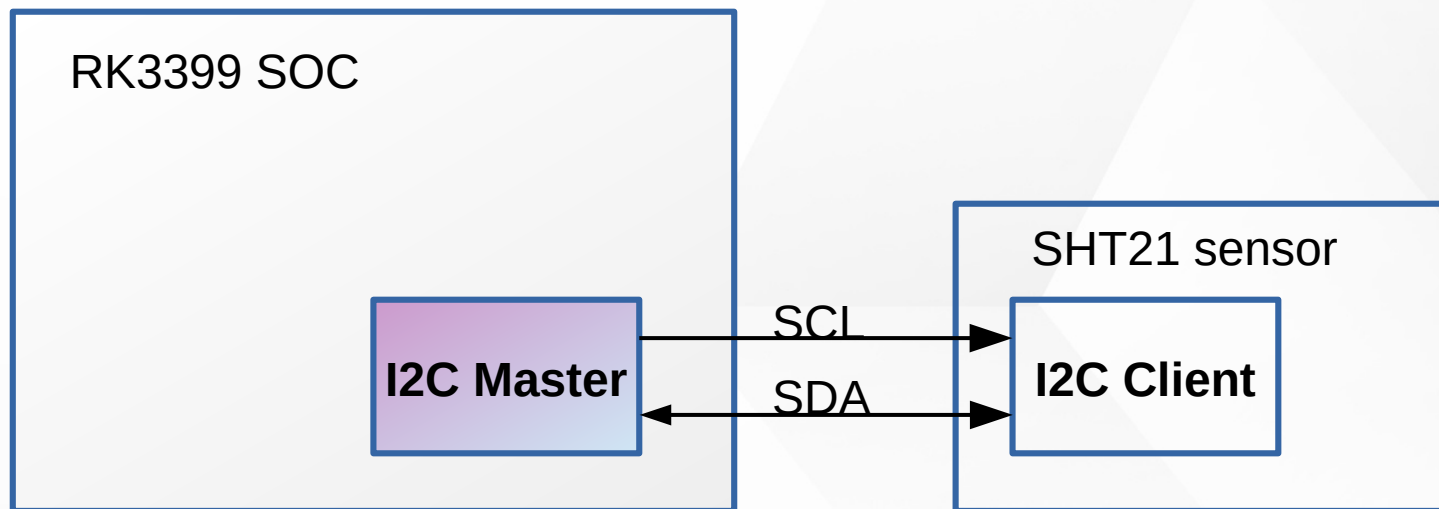


Protocol



I2C (2)

Master and Client



I2C protocol - Write

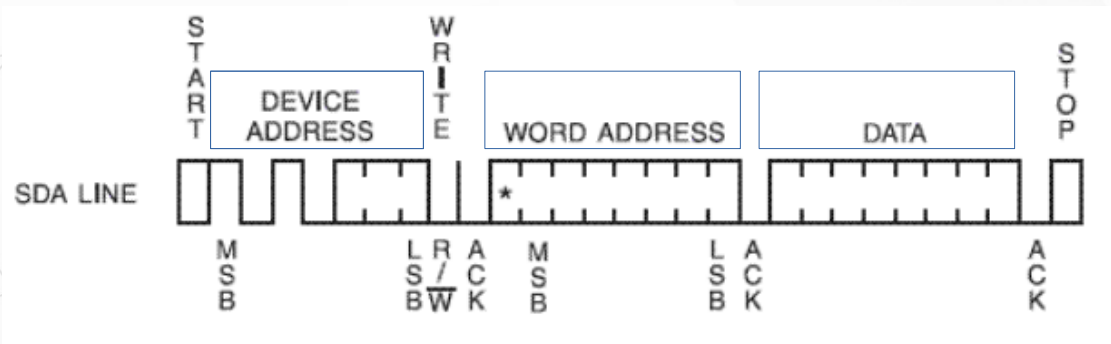
Write

- byte write
- page write

Device address

Read/write bit : 0

ACK



I2C protocol - Read

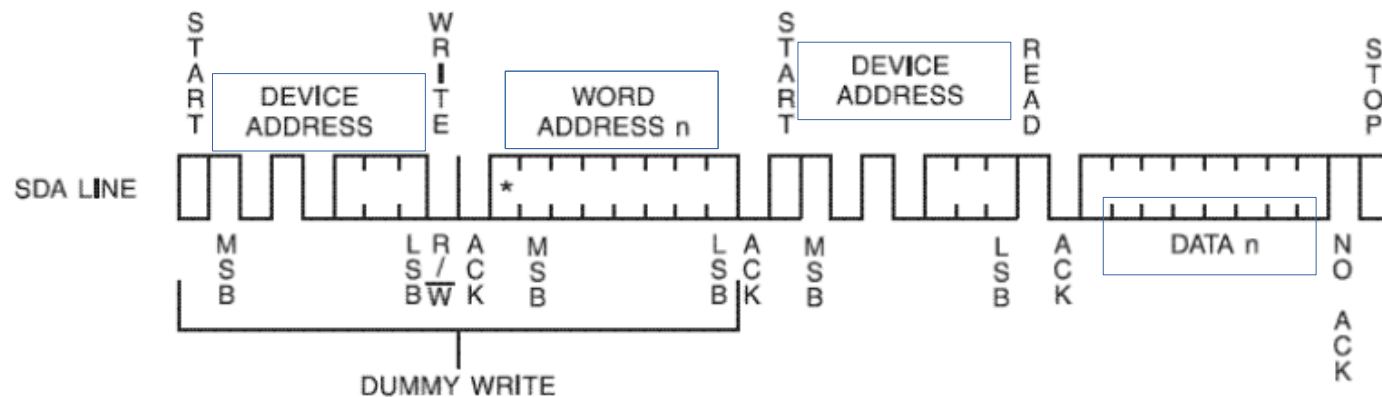
Read

- byte read
- page read

Device address

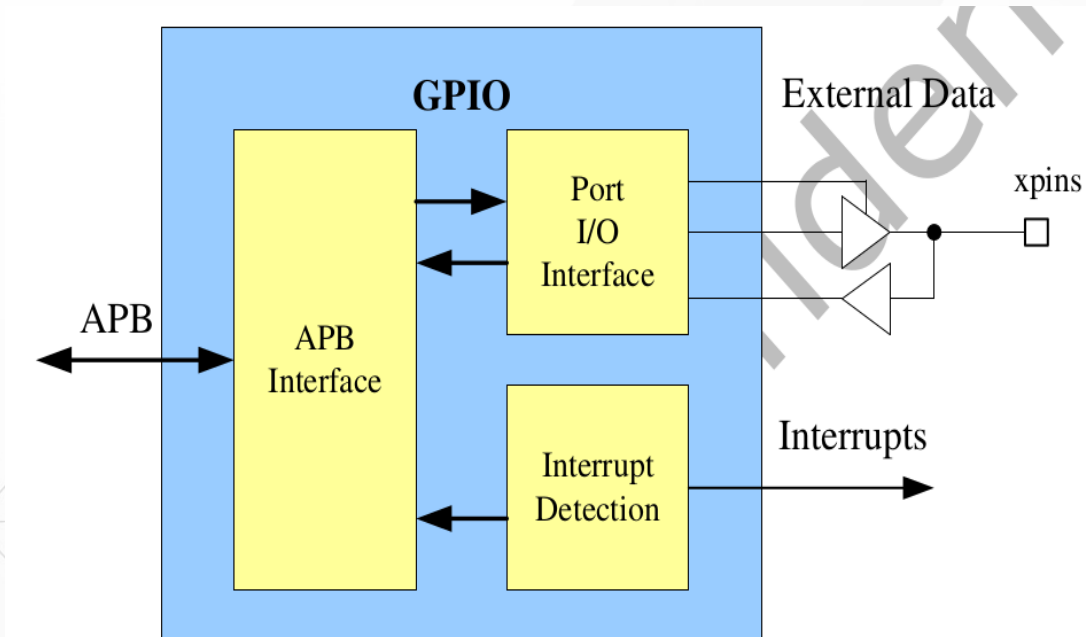
Read/write bit : 1

ACK



GPIO

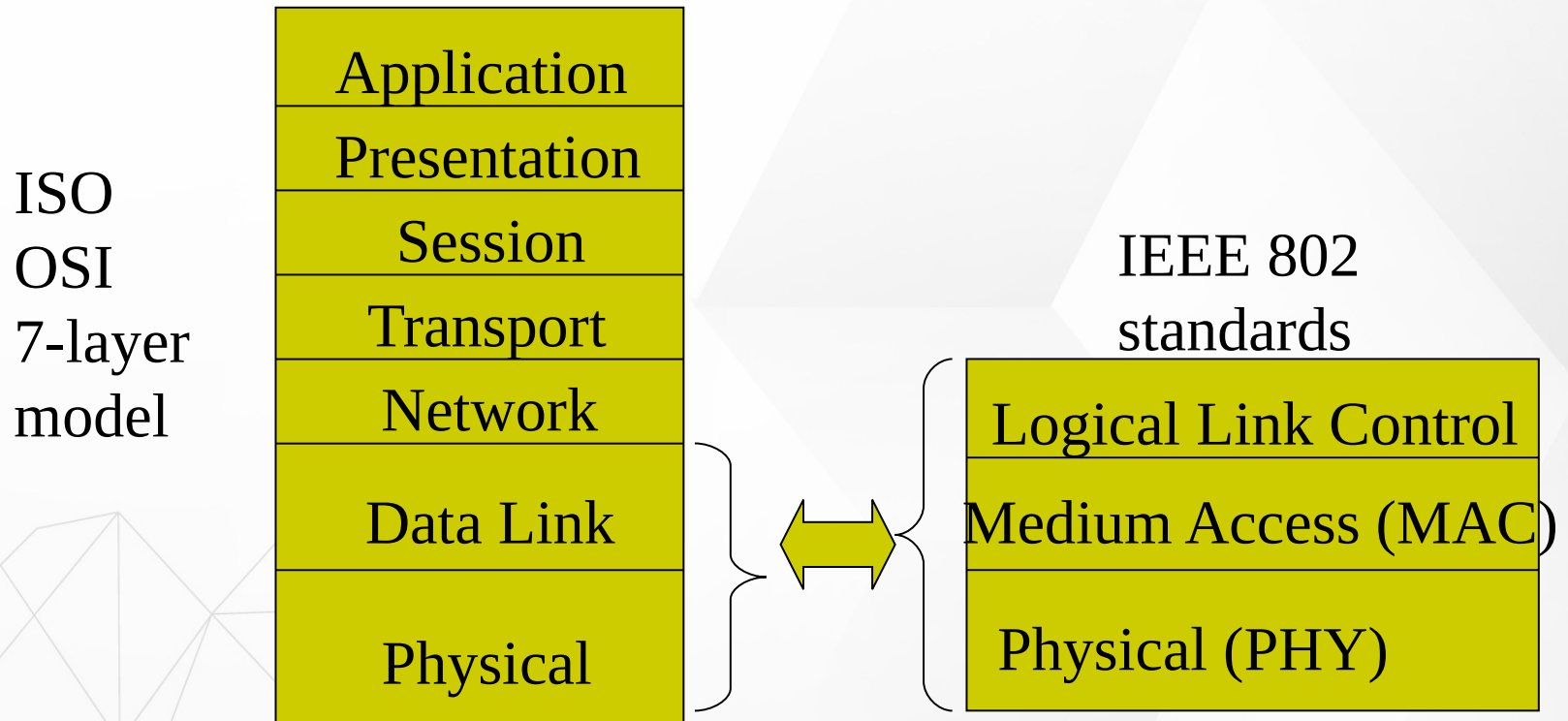
- General Purpose Programming I/O
- GPIO controls the output data and direction of external I/O pads



WiFi Basic

WIFI – 802.11 (1)

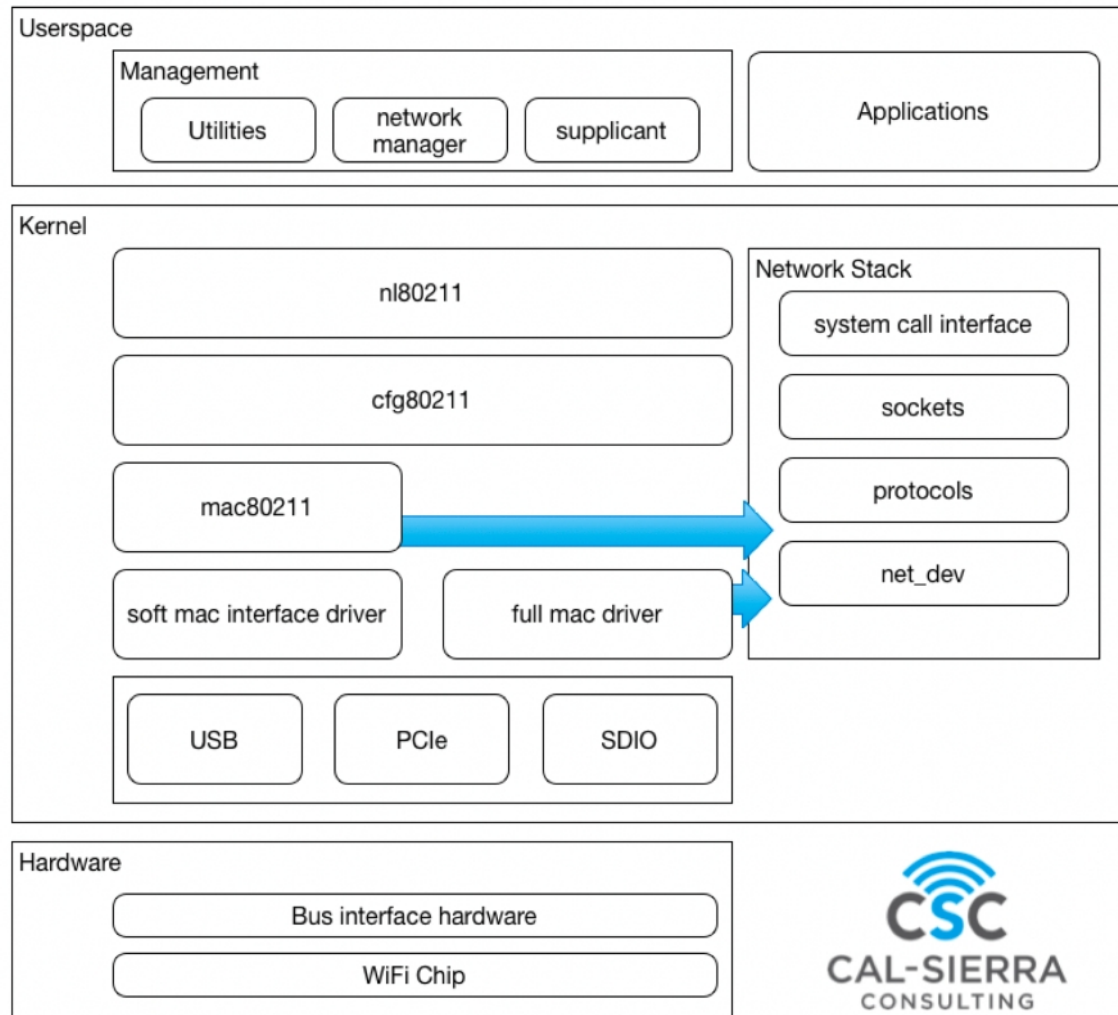
IEEE 802.11 – 無線區域網路



WIFI – 802.11 (2)

| 世代名稱 ^[註 1] ◆ | IEEE標準 | | 最大速率 (Mbit/s) ◆ | 頻率 (GHz) ◆ |
|--|----------|-------------------------|-------------------------|------------------|
| | 名稱 ◆ | 發布年份 ◆ | | |
| Wi-Fi 7 | 802.11be | (2024) ^[註 2] | 1376~46120 | 2.4/5/6 |
| Wi-Fi 6E | 802.11ax | 2020 | 574~9608 ^[1] | 6 ^[2] |
| Wi-Fi 6 | | | 2019 | 2.4/5 |
| Wi-Fi 5 | 802.11ac | 2014 | 433~6933 | 5 ^[3] |
| Wi-Fi 4 | 802.11n | 2008 | 72~600 | 2.4/5 |
| Wi-Fi 3 ^[註 3] | 802.11g | 2003 | 6~54 | 2.4 |
| Wi-Fi 2 ^[註 3] | 802.11a | 1999 | 6~54 | 5 |
| Wi-Fi 1 ^[註 3] | 802.11b | 1999 | 1~11 | 2.4 |
| Wi-Fi 0 ^[註 3] | 802.11 | 1997 | 1~2 | 2.4 |
| <p>1. ^ Wi-Fi是Wi-Fi聯盟的商標</p> <p>2. ^ 預定的發布年份</p> <p>3. ^ 3.0 3.1 3.2 3.3 Wi-Fi聯盟未定義 Wi-Fi 0/1/2/3 的世代名稱^{[4][5]}</p> | | | | |

WiFi – Linux & 802.11 (1)



WIFI – Linux & 802.11 (2)

➤ mac80211

- most associated to hardware offloading

- the **802.11 protocol state machine lives here**

➤ cfg80211

- middle-layer **Handles Everything Configurable**

➤ nl80211

- The **API between user-land and kernel-land**

- Relies on the **netlink** protocol to exchange messages between the two worlds



WIFI – Tool

➤ Show / manipulate wireless devices and their configuration

➤ iw

➤ For connecting to a WPA/WPA2 network

➤ wpa_supplicant

Audio

ALSA Overview

▶ Advanced Linux Sound Architecture

- ▶ Linux kernel

- ▶ Software framework

▶ Sound Servers

- ▶ PulseAudio, JACK ...

▶ ALSA stream is a data flow representing sound

- ▶ PCM (Pulse-code modulation)

ALSA Overview

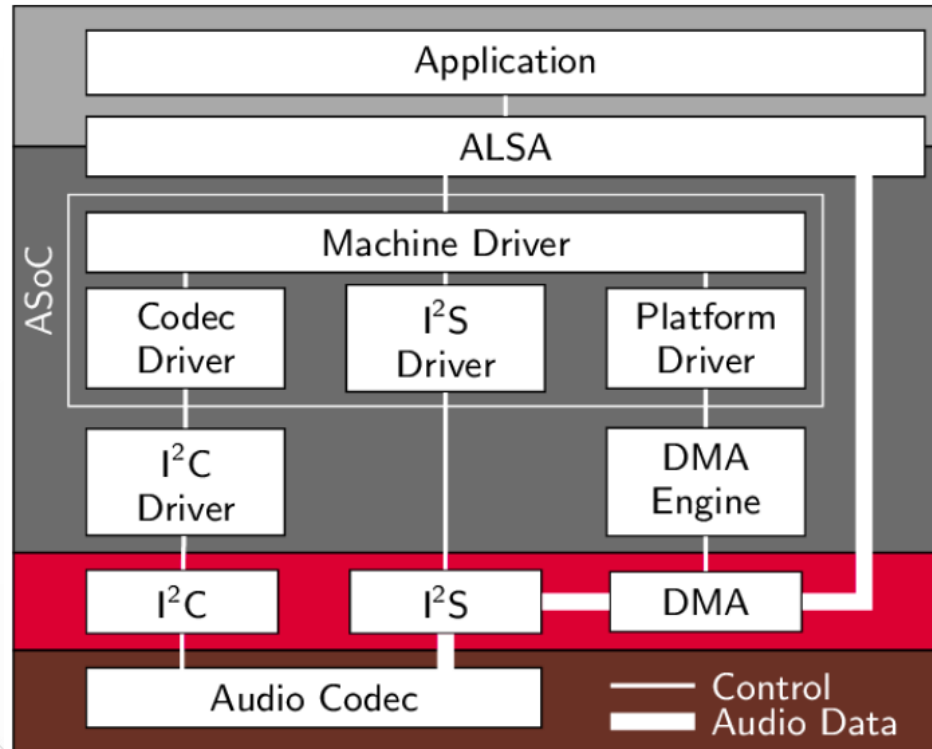
▶ Audio Codec

▶ Audio Codec 就是音樂訊號（Audio）壓縮 / 解壓縮 (Compress/DECompress) 的演算法或程式，前後加起來就是 Audio Codec.

▶ Parameters of the hardware

- ▶ sampling rate : 44100 Hz
- ▶ sample width : 8 bit, 16 bit, 24 bit
- ▶ sample encoding : endianness
- ▶ number of channels : 1 channel, 2 channel ...

ALSA Overview



https://www.researchgate.net/figure/Structure-of-ASoC-and-the-embedment-into-the-Linux-audio-framework_fig2_262112720

Sound Card in Linux (1)

[CMD] ls /proc/asound/ -l

```
lrwxrwxrwx    1 root root 5 Apr 30 06:51 HDMICODEC -> card1
dr-xr-xr-x    4 root root 0 Apr 30 06:51 card0
dr-xr-xr-x    3 root root 0 Apr 30 06:51 card1
-r--r--r--    1 root root 0 Apr 30 06:51 cards
-r--r--r--    1 root root 0 Apr 30 06:51 devices
-r--r--r--    1 root root 0 Apr 30 06:51 hwdep
-r--r--r--    1 root root 0 Apr 30 06:51 pcm
lrwxrwxrwx    1 root root 5 Apr 30 06:51 rockchip8316c -> card0
dr-xr-xr-x    2 root root 0 Apr 30 06:51 seq
-r--r--r--    1 root root 0 Apr 30 06:51 timers
-r--r--r--    1 root root 0 Apr 30 06:51 version
```

Sound Card in Linux (2)

[CMD] cat /proc/asound/cards

0 [rockchipes8316c]: rockchip_es8316 - rockchip,es8316-codec
rockchip,es8316-codec

1 [HDMICODEC]: HDMI-CODEC - HDMI-CODEC
HDMI-CODEC

Sound card 0

Sound card 1

Sound Card in Linux (3)

[CMD] ls -l /proc/asound/card0/

rockchipes8316c

```
-r--r--r-- 1 root root 0 Apr 30 06:59 id  
dr-xr-xr-x 3 root root 0 Apr 30 06:59 pcm0c  
dr-xr-xr-x 3 root root 0 Apr 30 06:59 pcm0p
```

capture

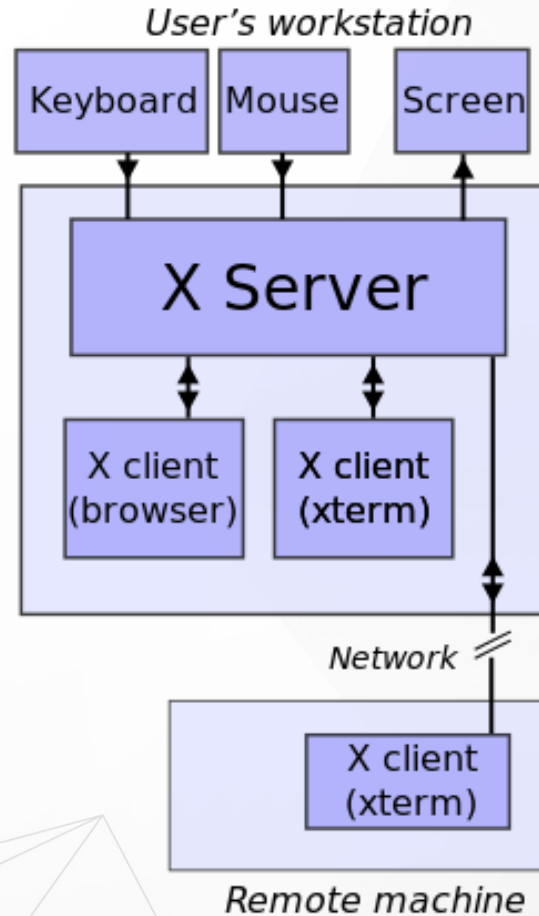
playback

[CMD] ls -l /proc/asound/card1/

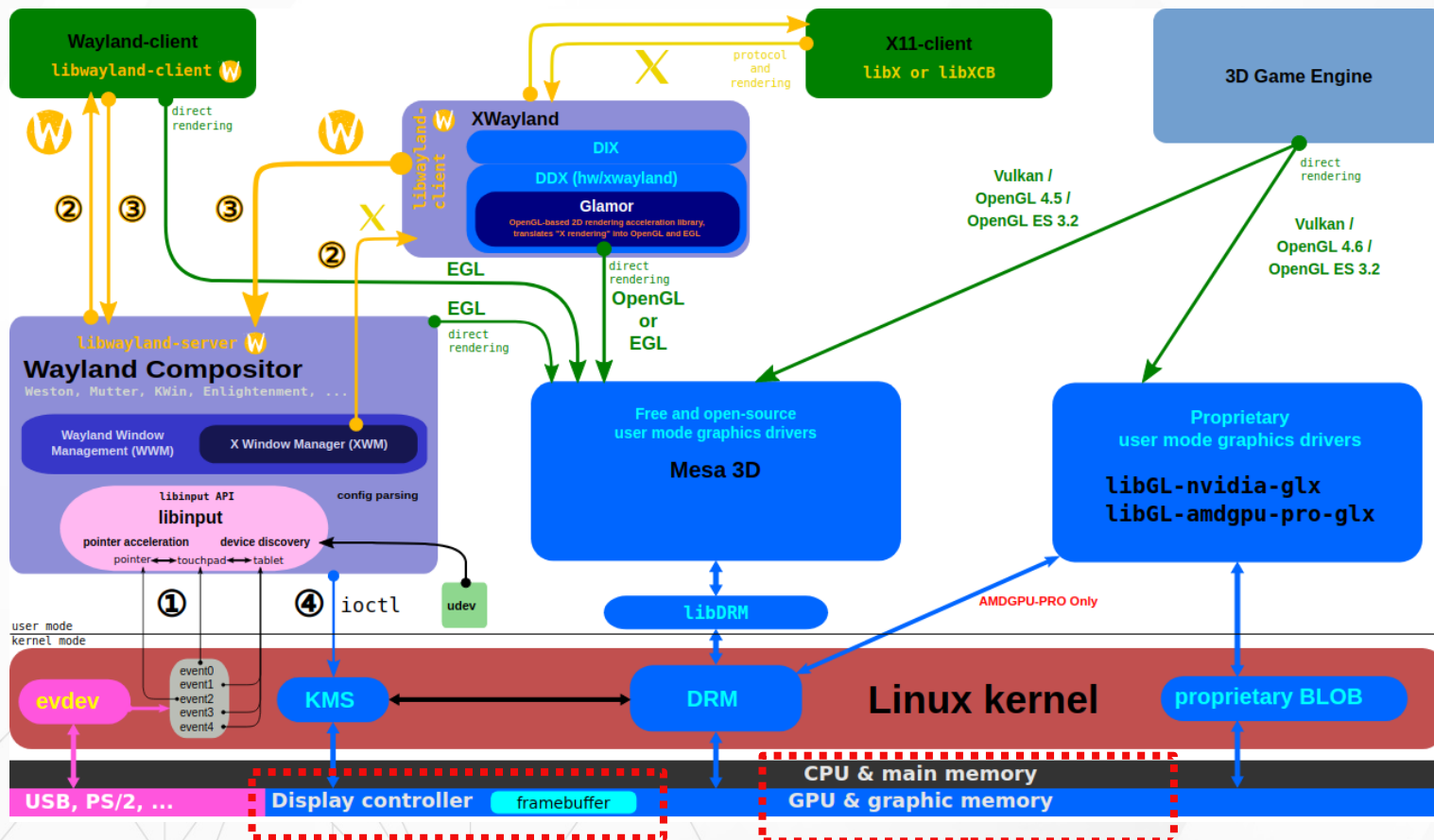
```
-r--r--r-- 1 root root 0 Apr 30 07:01 id  
dr-xr-xr-x 3 root root 0 Apr 30 07:01  
pcm0p
```

Linux Display Subsystem

Linux Windows System (1)

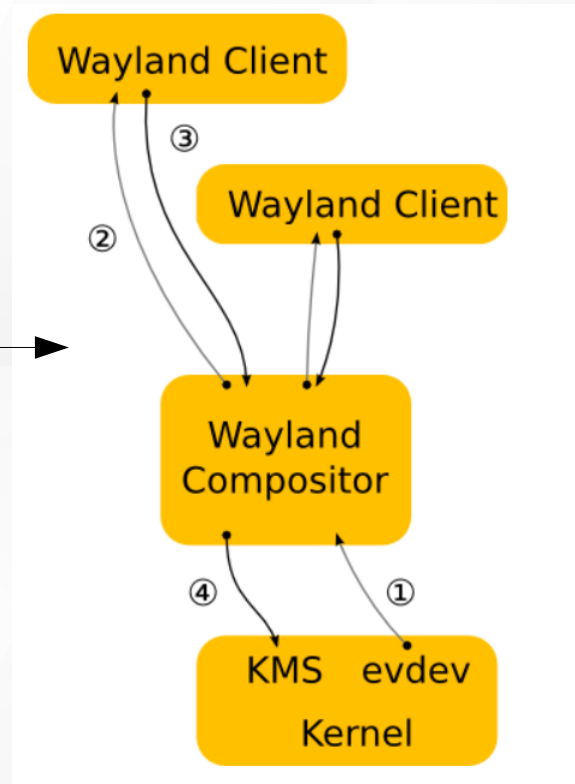
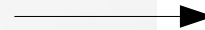
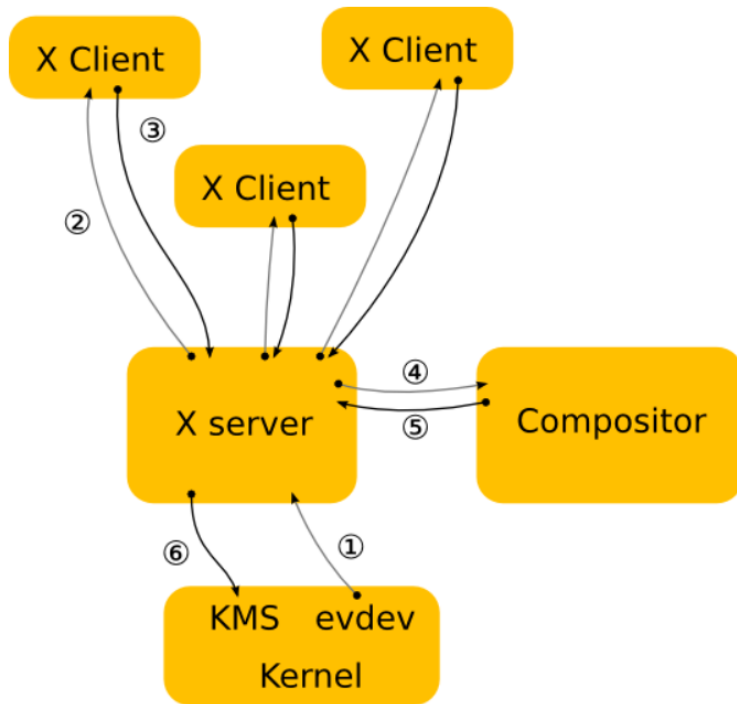


Linux Windows System (2)



Linux Windows System (3)

Wayland is a replacement for the X11 window system protocol



GTK and Gnome

- **GTK**

- GTK (formerly GTK+) is a free and open-source cross-platform widget toolkit for creating graphical user interfaces (GUIs).

-

- **GNOME**

- GNOME is the default desktop environment of many major Linux distributions
- originally an acronym for GNU Network Object Model Environment
- free and open-source desktop environment for Linux and other Unix-like[10] operating systems

<https://en.wikipedia.org/wiki/GNOME>

<https://en.wikipedia.org/wiki/GTK>

OpenGL and EGL

- **EGL**
 - EGL Native Platform Graphics Interface is an interface portable layer for graphics resource management.
 - works between rendering APIs such as OpenGL ES or OpenVG and the underlying native platform window system
- **OpenGL**
 - OpenGL (Open Graphics Library) is a cross-language, cross-platform application programming interface (API) for rendering 2D and 3D vector graphics
- **Mesa**
 - Mesa, also called Mesa3D and The Mesa 3D Graphics Library
 - it is an open source implementation of OpenGL, Vulkan, and other graphics API specifications

<https://en.wikipedia.org/wiki/OpenGL>

[https://en.wikipedia.org/wiki/Mesa_\(computer_graphics\)](https://en.wikipedia.org/wiki/Mesa_(computer_graphics))

<https://www.khronos.org/egl/>

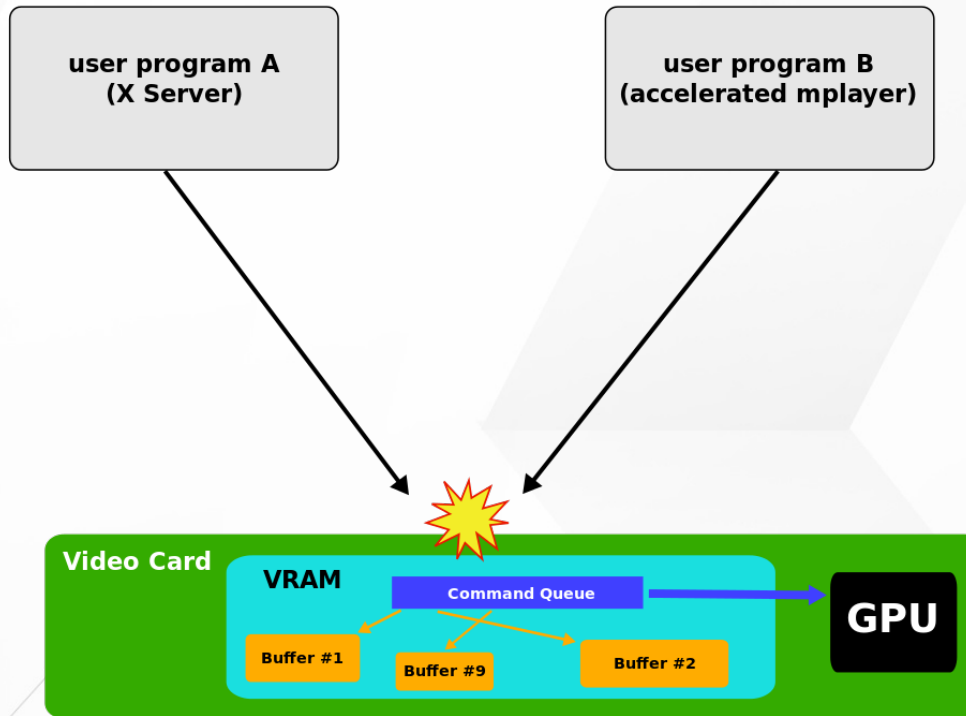


Direct Rendering Manager (DRM)

- Direct Rendering Manager
 - Management of buffers and free space within that memory.
 - Solve Frame buffer driver cannot be used GPU and multi-user process.
- DRM consists of
 - libdrm
 - libdrm provides a user space library for accessing the DRM
 - KMS : Kernel Mode Setting
 - Change resolution and depth
 - DRI : Direct Rendering Infrastructure
 - Interfaces to access hardware directly
 - GEM : Graphics Execution Manager
 - Buffer management
 - DRM Driver in kernel side
 - Access hardware

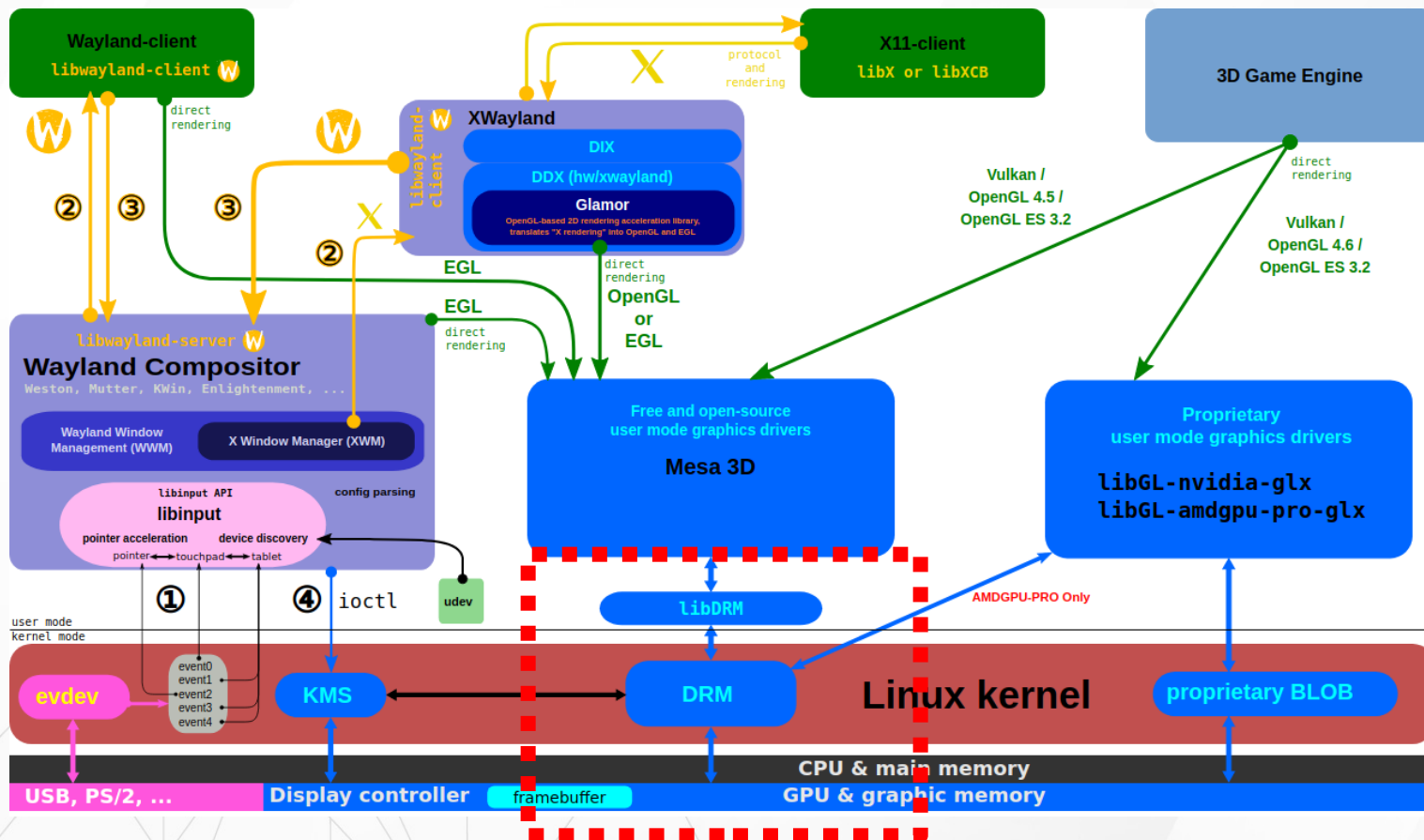
Direct Rendering Manager (DRM)

If no use DRM



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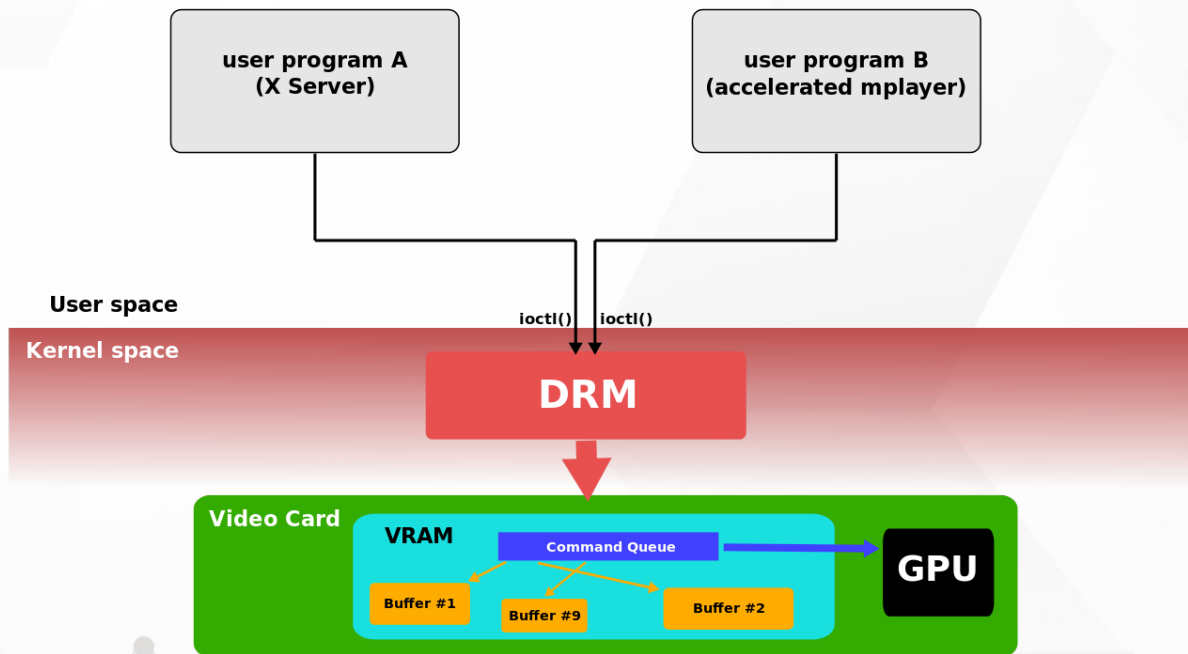
Direct Rendering Manager (DRM)



https://upload.wikimedia.org/wikipedia/commons/2/2d/The_Linux_Graphics_Stack_and_glamor.svg

Direct Rendering Manager (DRM)

Use DRM



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Kernel Mode Setting (KMS)

➤ KMS device model

- CRTC's

- Connectors

- Encoders

- Planes

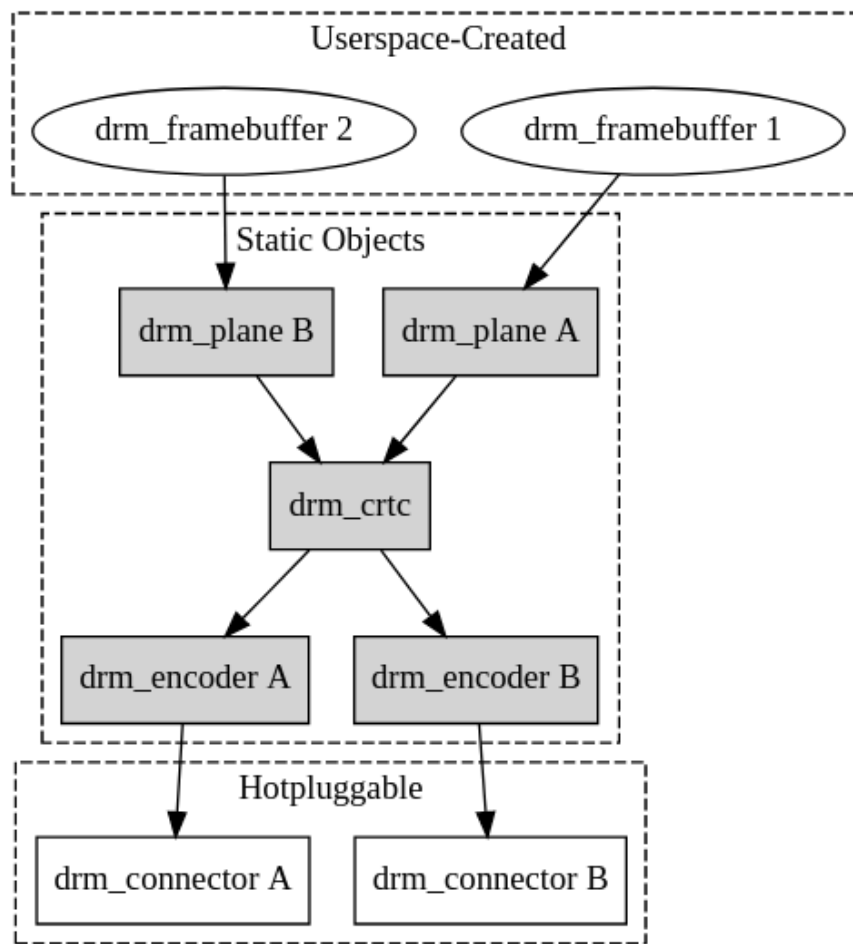
➤ Kernel Mode Setting

- screen resolution

- color depth and

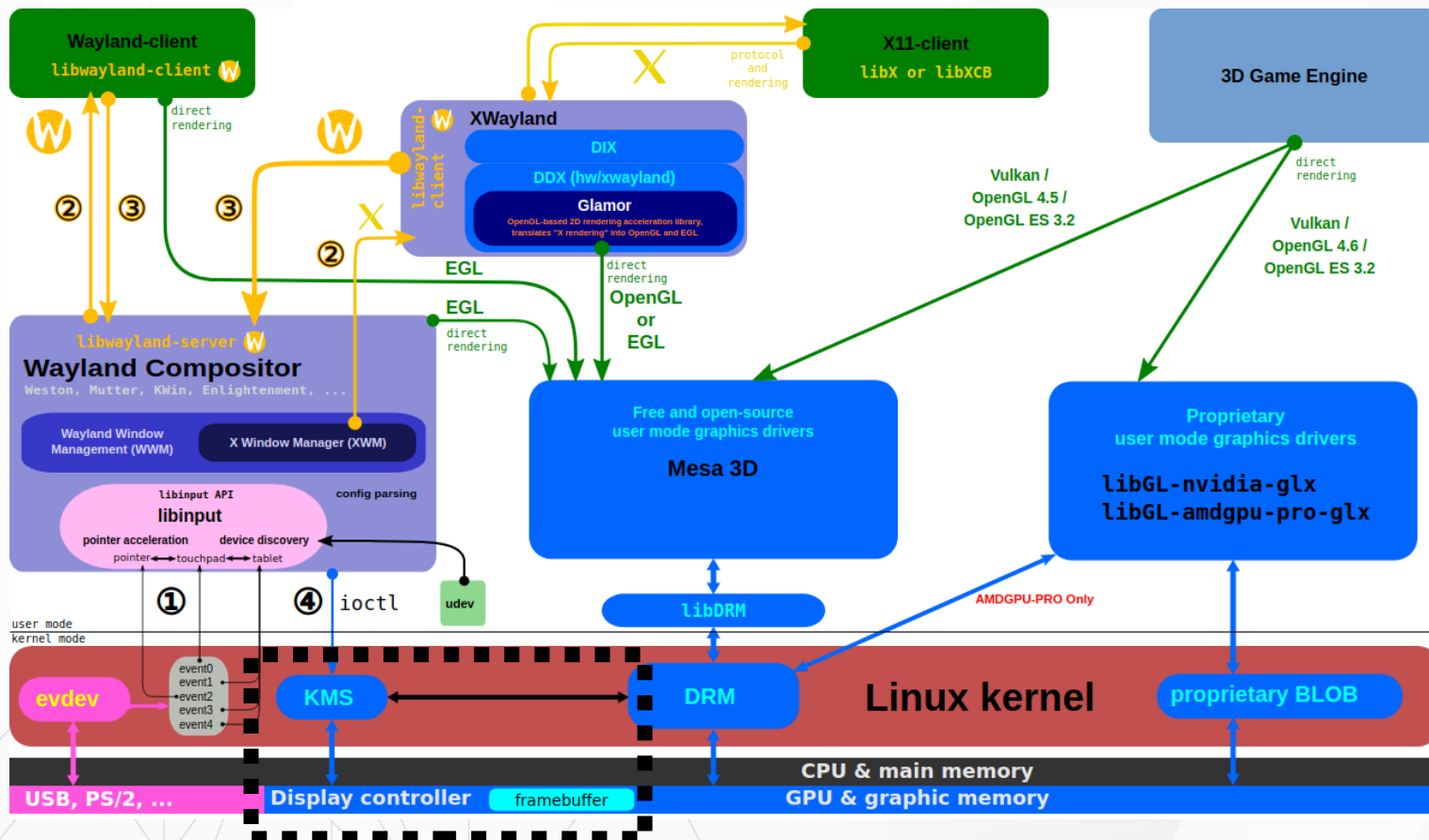
- refresh rate

Kernel Mode Setting (KMS)



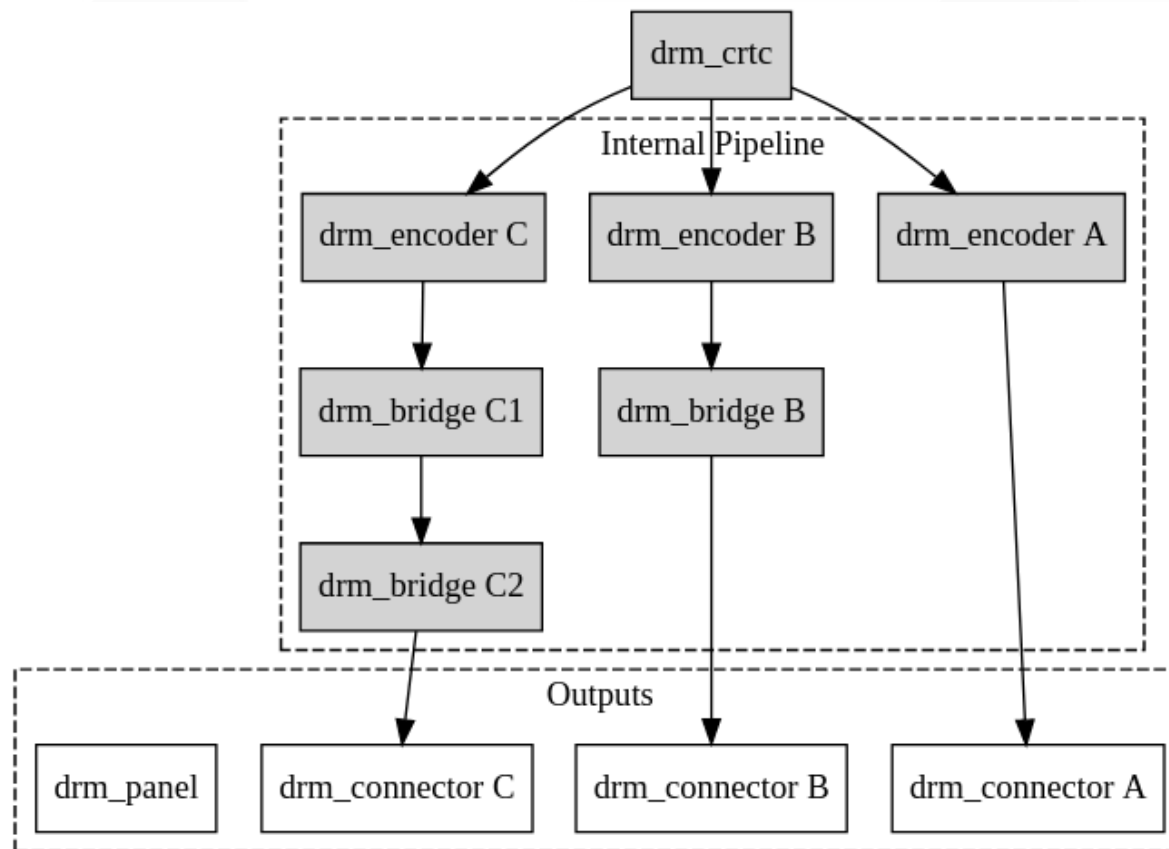
<https://www.kernel.org/doc/html/v4.15/gpu/drm-kms.html>

Kernel Mode Setting (KMS)



https://upload.wikimedia.org/wikipedia/commons/2/2d/The_Linux_Graphics_Stack_and_glamor.svg

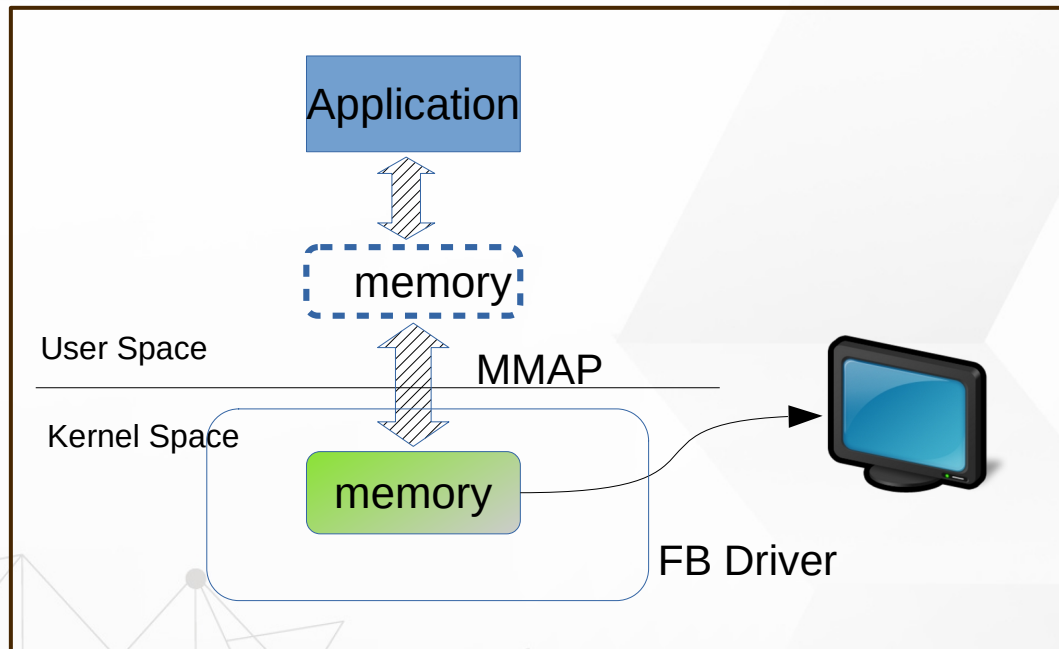
Kernel Mode Setting (KMS)



<https://www.kernel.org/doc/html/v4.15/gpu/drm-kms.html>

Video Frame Buffer

- ▶ The frame buffer device provides an abstraction for the graphics hardware.



Kernel Mode Setting (KMS)

