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Bringing display and 3D to the C.H.I.P computer

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Free Electrons

Embedded Linux
Developers

Maxime Ripard

- Embedded Linux engineer and trainer at Free Electrons
  - Embedded Linux **development**: kernel and driver development, system integration, boot time and power consumption optimization, consulting, etc.
  - Embedded Linux **training**, Linux driver development training and Android system development training, with materials freely available under a Creative Commons license.
  - `http://free-electrons.com`
- Contributions
  - **Co-maintainer for the sunXi SoCs** from Allwinner
  - Contributor to a couple of other open-source projects, **Buildroot**, **U-Boot**, **Barebox**
- Living in **Toulouse**, south west of France

Introduction

C.H.I.P. ?

- 9$ SBC
- Based on an Allwinner R8 (equivalent to A13)
- 1GHz Cortex-A8 CPU
- Mali 400 GPU
- Plenty of GPIOs to bitbang stuff (and real controllers too!)
- Running mainline-ish Linux kernel (4.3, soon to be 4.4)

Development effort

- A significant part of the work already done
- But key features for a desktop-like application were missing
    - Audio
    - NAND support
    - Display
- Plus board specific developments
    - Wifi regulators
    - DIP

How to display things in Linux?

Doing display things

- Different solutions, provided by different subsystems:
  - FBDEV: Framebuffer Device
  - DRM/KMS: Direct Rendering Manager / Kernel Mode Setting
  - More exotic ones: V4L2, auxdisplay
- How to choose one: it depends on your needs
  - Each subsytem provides its own set of features
  - Different levels of complexity
  - Different levels of activity

Which one to choose?

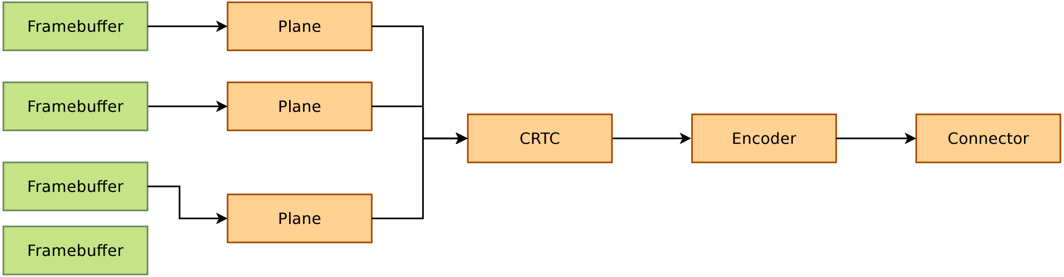
- DRM
  - Actively maintained
  - Provides fine grained control on the display pipeline
  - Widely used by user-space graphic stacks
  - Provides a full set of advanced features
- FBDEV
  - Deprecated?
  - Does not provides all the features found in the modern display controllers (overlays, sprites, hw cursor, ...)

DRM/KMS

DRM/KMS: Definition

- DRM stands for Direct Rendering Manager and was introduced to deal with graphic cards embedding GPUs
- KMS stands for Kernel Mode Setting and is a sub-part of the DRM API
- Though rendering and mode setting are now split in two different APIs (accessible through `/dev/dri/renderX` and `/dev/dri/controlDX`)
- KMS provide a way to configure the display pipeline of a graphic card (or an embedded system)
- KMS is what we're interested in when looking for an FBDEV alternative

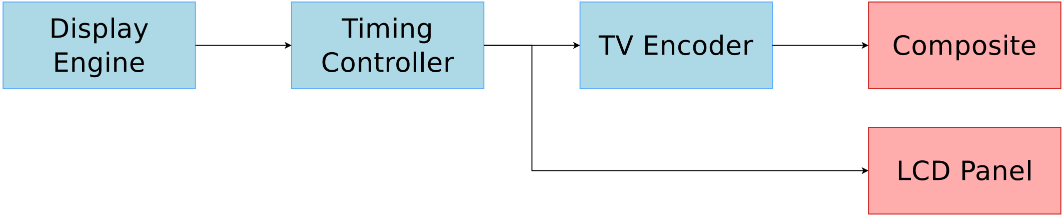
DRM/KMS pipeline



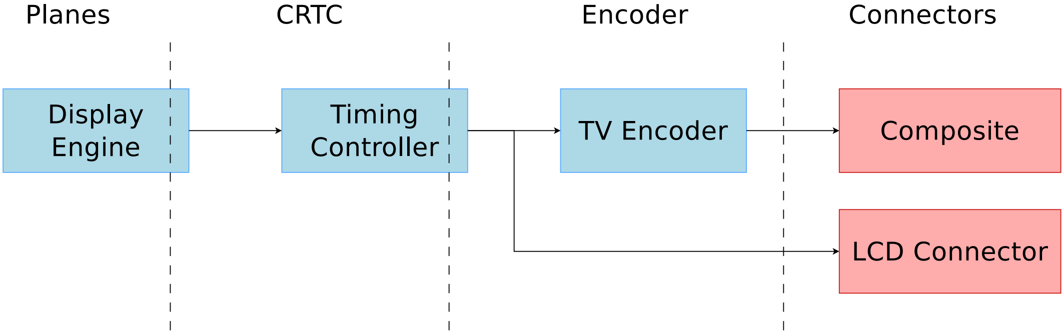
KMS components

- Planes
  - Image source
  - Associated with one (or more!) framebuffers
  - Holds a resized version of that framebuffer
- CRTCs
  - Take the planes, and does the composition
  - Contains the display mode and parameters
- Encoders
  - Take the raw data from the CRTC and convert it to a particular format
- Connectors
  - Outputs the encoded data to an external display
  - Handles hotplug events
  - Reads EDIDs

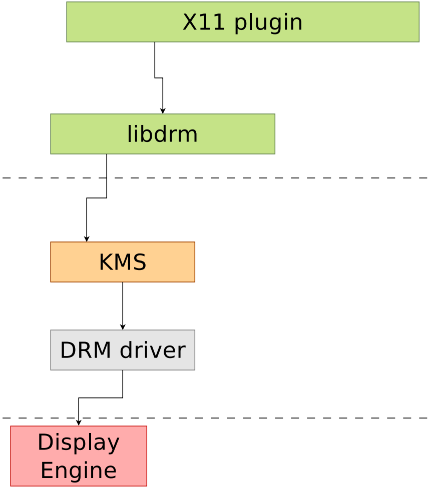
Allwinner display pipeline



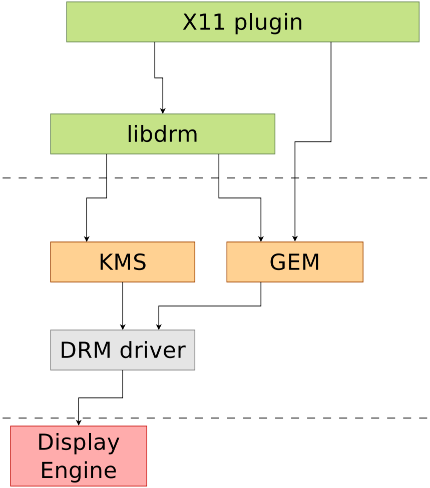
DRM vs SoC pipeline



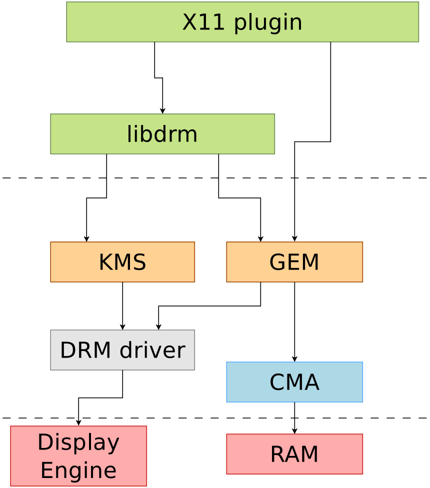
DRM Stack: KMS



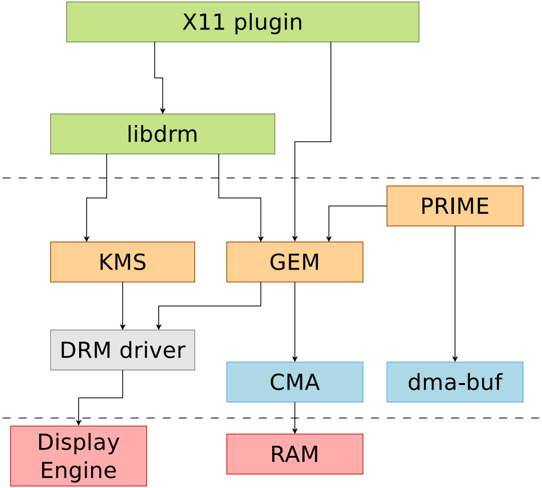
DRM Stack: GEM



DRM Stack: CMA



DRM Stack: PRIME

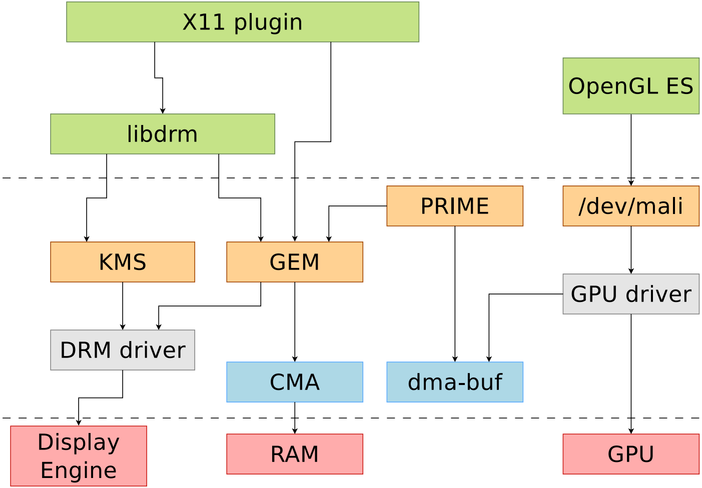


GPU integration

Solutions

- The GPU found in most Allwinner SoCs is the Mali-400 from ARM (with a variable number of cores)
- There are two options to support that GPU:
  - Lima
    - Reversed engineered proof-of-concept
    - Triggered the reverse engineering effort of the GPUs (freedreno, etnaviv, etc.)
    - Development (closed to?) stopped two years ago
  - ARM-Provided support
    - Featureful
    - Two parts: GPL kernel driver and proprietary OpenGL ES implementation

DRM Stack: GPU



Development

- Everything is provided by ARM on their website (if you're lucky)
- On the userspace side, you just need to put the library they provided on your system
- On the driver side, you need to create a platform glue that will deal with:
  - Memory mapping
  - Interrupts
  - Clocks
  - Reset lines
  - Power Domains
  - Basically everything needed for the GPU to operate properly on your SoC

X11 integration

- We need a DDX (Device Dependent X) driver
- `xf86-video-modesetting` is working on top of KMS and MESA (Gallium3D)
- ARM developped `xf86-video-armsoc` for SoC using a 3rd party GPU (Mali, PowerVR, Vivante, etc.)
- Relies on KMS for the display configuration, driver-specific ioctl for buffer allocations and vendor-provided OpenGL ES implementation
- Just have to write a small glue to use your driver allocator, and give some hints to X about what your hardware support (hw cursor, vblank, etc.)

Questions?

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`http://free-electrons.com/pub/conferences/2016/elc/ripard-drm`