Embedded Graphics Stack 101

Introduction and case study

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Open First

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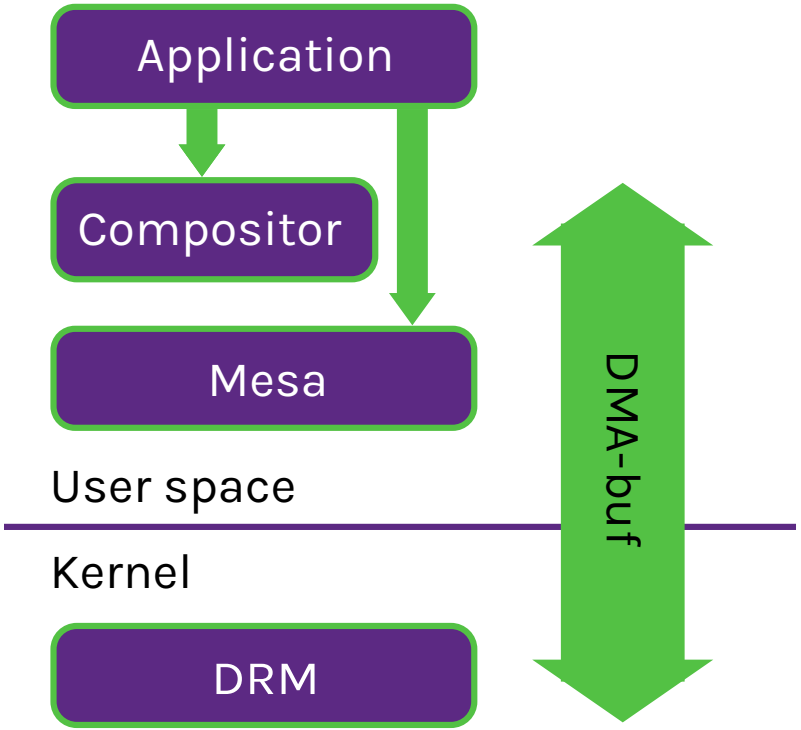
Introduction:
What are the essential pieces?

Why open-source graphics

- Open-source process benefits
  - Collaboration between companies
  - Community effort: No one entity has more power than the rest
  - “Given enough eyes, every bug is shallow”
- Source available to everyone
  - Anyone can see and play with it!
- <insert your own reasons>

Linux graphics stack at a glance



- Lots of options for compositors
- Rendering happens using OpenGL (ES) or Vulkan
- Rendered images are passed around as DMA-bufs

DMA-bufs

- File descriptors, representing memory
- Can encapsulate an image
  - When paired with a DRM format
  - … and usually a DRM format modifier.
- Concurrent access is syncronized uses DRM fences.

DRM formats

```
#define DRM_FORMAT_ARGB8888 fourcc_code('A', 'R', '2', '4') /* [31:0] A:R:G:B 8:8:8:8 […] */
#define DRM_FORMAT_ABGR8888 fourcc_code('A', 'B', '2', '4') /* [31:0] A:B:G:R 8:8:8:8 […] */
#define DRM_FORMAT_RGBA8888 fourcc_code('R', 'A', '2', '4') /* [31:0] R:G:B:A 8:8:8:8 […] */
#define DRM_FORMAT_BGRA8888 fourcc_code('B', 'A', '2', '4') /* [31:0] B:G:R:A 8:8:8:8 […] */
```

- These are a few common ones
- Lots more out there, like `DRM_FORMAT_RGB565` and `DRM_FORMAT_XRGB16161616F` to name a few

DRM format modifiers

```
#define DRM_FORMAT_MOD_INVALID fourcc_mod_code(NONE, DRM_FORMAT_RESERVED)
#define DRM_FORMAT_MOD_LINEAR  fourcc_mod_code(NONE, 0)
#define DRM_FORMAT_MOD_NONE    0
```

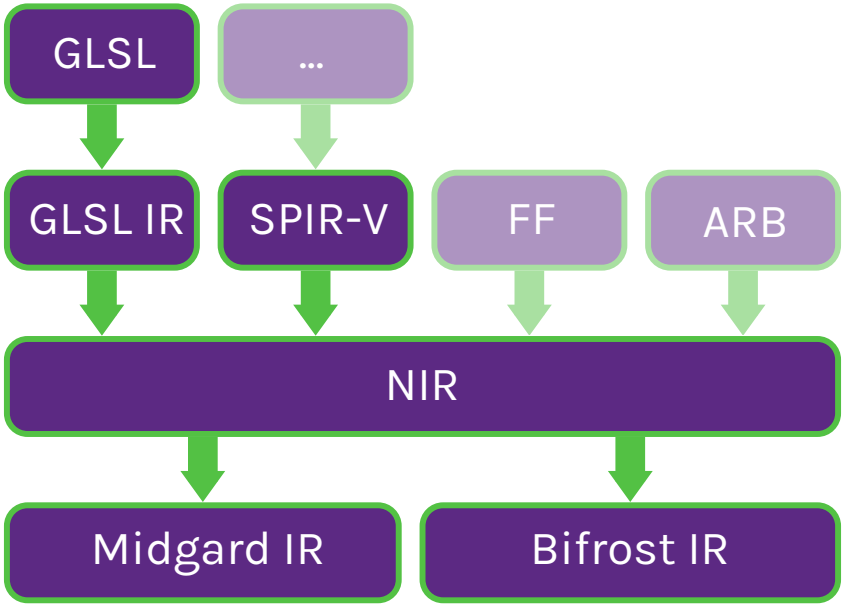
- These are a few common ones
- Lots more vendor specific ones out there, like

  `DRM_FORMAT_MOD_ARM_16X16_BLOCK_U_INTERLEAVED`

Mesa

- Mesa contains user mode drivers for most modern GPUs
- Implements OpenGL, OpenGL ES, Vulkan and other APIs
- Responsible for compiling shaders and translating API calls into HW specific commands

Mesa compiler stack



- Various front-ends
- NIR is the central IR
- There's several hardware specific IRs

Kernel / DRM

- The kernel contains kernel mode drivers for most modern GPUs
- Implements DRM specific and HW specific interfaces
- Responsible for managing memory and executing GPU-specific commands on the HW

Compositors

- Many options out there
- Responsible for controlling the display and putting rendered images onto it **somehow**
- Needs to speak some protocol
  - for simplicity we're assuming Wayland today

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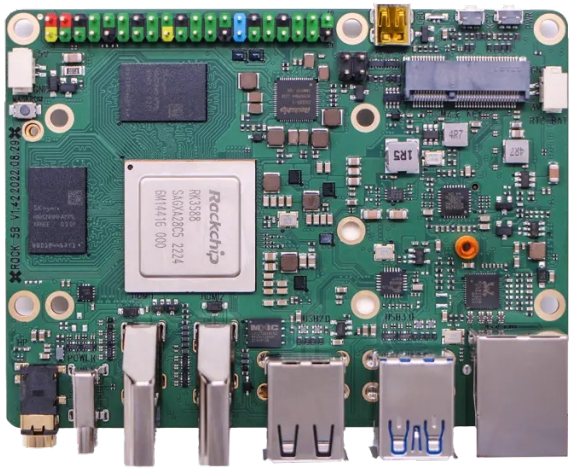
Embedded case study: Arm’s Mali GPUs and Panfrost

Arm Mali GPUs

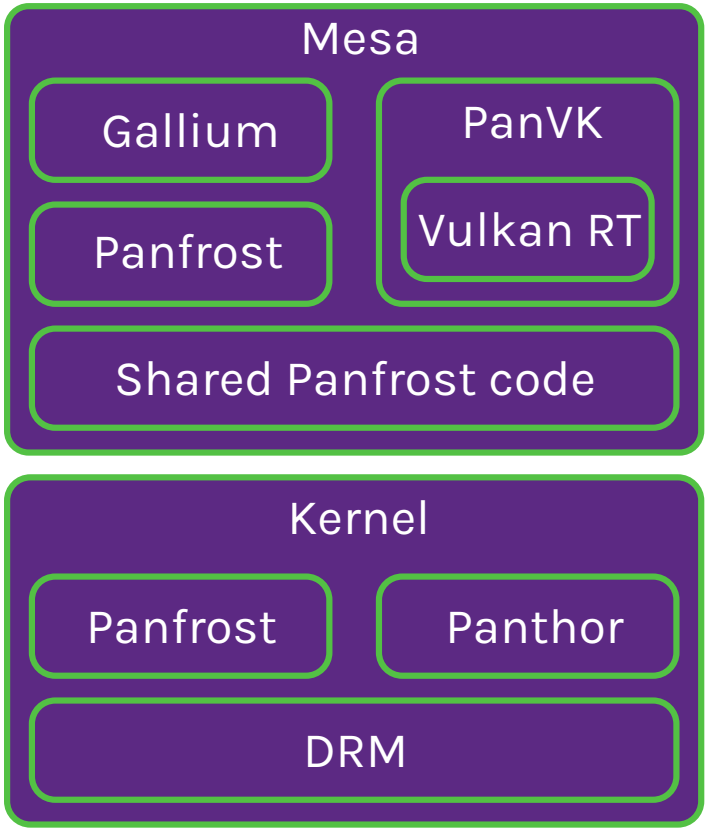
- Mobile / low-power oriented GPUs made by Arm
  - More than 12 billion shipped devices
  - Utgard, Midgard, Bifrost, Valhall
  - Tile-based renderer
- Supported upstream by two distinct projects:
  - Lima is for the older “Utgard” GPUs
  - Panfrost for the newer ones

Radxa Rock 5B

- Single-board computer with RK3588 SoC
  - Mali-G610 MC4 GPU (V10)
- Used by Collabora as the “reference” HW for modern Panfrost development
- Popular, good upstream support
- Easy to get your hands on



Panfrost driver stack



Mesa contains two drivers:

- OpenGL (ES): Panfrost
- Vulkan: PanVK

Kernel contains two drivers:

- Panfrost (V4-V9 GPUs)
- Panthor (v10+ GPUs)

Panfrost Gallium driver

- Supports and OpenGL 2.1 and OpenGL ES 3.1
  - Lacks HW support for geometry and tesselation shaders to support higher versions
- Upstream in Mesa
  - Source in: `src/gallium/drivers/panfrost/`
  - Battle tested

PanVK Vulkan driver

- Supports Vulkan 1.4
  - Including the latest maintenance extensions.
- Lacks support for V9 GPUs (e.g G57)
- Upstream in Mesa
  - Source in: `src/panfrost/vulkan`
  - Fairly new, still need time to mature

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Rip and tear: Modifying the driver

Where to go from here?

- Mesa development happens in a few places
  - gitlab.freedesktop.org: merge-requests, issues etc
  - #dri-devel on IRC (OFTC): general discussions
  - mesa-dev@lists.freedesktop.org - Quiet these days
- Decide on something fun, and submit merge-requests!

Internships?

- EVoC is being sunset, sadly
- GSoC: Google Summer of Code
  - https://www.x.org/wiki/SummerOfCodeIdeas/
- Collabora internships?
  - Reach out to me: erik.faye-lund@collabora.com

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Questions and answers!

Thank you!

We are hiring

col.la/careers