KODI

Kodi and Embedded Linux

Moving Towards Common Windowing and Video Acceleration

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Overview

The Problem

- What problem are we trying to solve
- How bad is it really?

The Solution

- What have we done so far
- What is left to do?

Future work

- Where do we go next?
- How far are we away?

Demo

- Time permitting

Terminology

DRM/KMS - Direct Rendering Manager / Kernel Mode Setting

SBC - Single Board Computer

SOC - System on a Chip

V4L2 - Video 4 Linux 2

BSP - Board Support Package

RKMPP - Rockchip Media Process Platform

The Problem

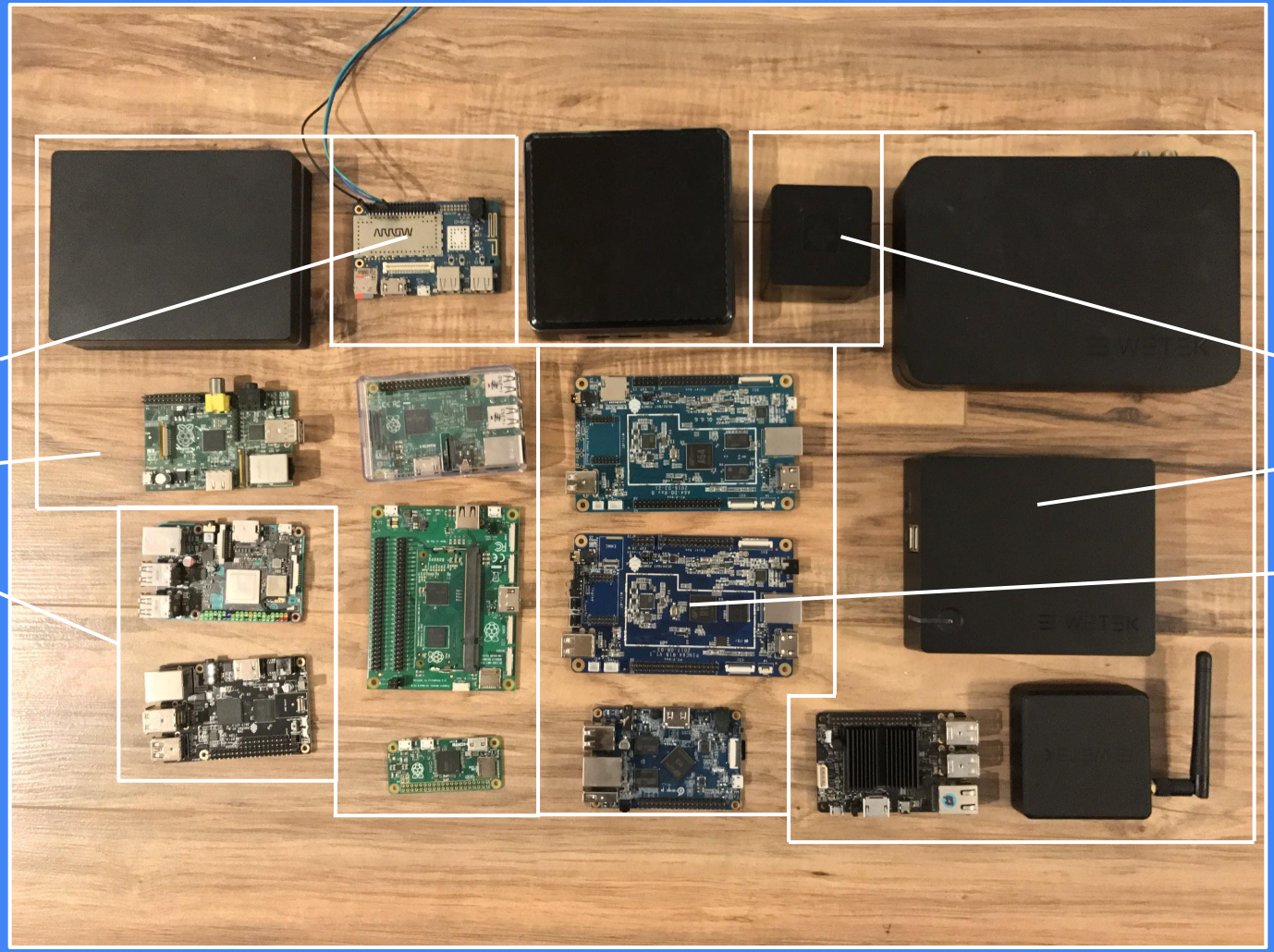
- Many SOC manufacturers each with their own proprietary blob
- Stuck with vendor BSP kernel which is often old and outdated
- Proprietary blob implements various functions such as windowing (using EGL) and video decoding
- Maintenance burden due to each method being different and requiring a unique code path.

Currently Supported SOC's in Kodi (v17 Krypton)

- Raspberry Pi
- Amlogic
- i.MX6

Rejected PR's for SOC's

- Allwinner (PR6268)
- Rockchip (PR11772)


Qualcomm
Broadcom
Rockchip
NXP
Amlogic
Allwinner

Some Statistics (Kodi v17 Krypton)

2013	xbmc/cores/VideoPlayer/DVDCodecs/Video/DVDVideoCodecIMX.cpp
454	xbmc/cores/VideoPlayer/DVDCodecs/Video/DVDVideoCodecIMX.h
237	xbmc/cores/VideoPlayer/VideoRenderers/HwDecRender/RendererIMX.cpp
69	xbmc/cores/VideoPlayer/VideoRenderers/HwDecRender/RendererIMX.h
24	xbmc/linux/imx/GlobalsIMX.cpp
243	xbmc/linux/imx/IMX.cpp
207	xbmc/linux/imx/IMX.h
453	xbmc/windowing/egl/EGLNativeTypeIMX.cpp
74	xbmc/windowing/egl/EGLNativeTypeIMX.h

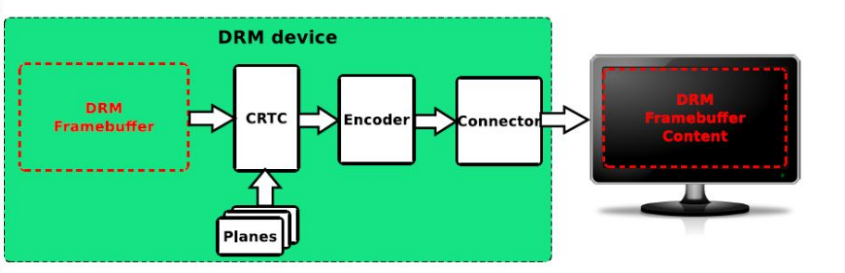
3774 Total lines of platform specific code

The Solution

- DRM/KMS Windowing Method
- FFmpeg decoders outputting AVDRMFrameDescriptor
- DRM Prime Video Rendering Method

DRM/KMS

- Initial implementation - Merged July 8, 2017
- Atomic and Legacy DRM support



Platforms running on DRM/KMS in Kodi

- Rockchip
- Allwinner
- NXP i.MX6
- Raspberry Pi (VC4)
- Qualcomm
- Other?

https://events.static.linuxfound.org/sites/events/files/slides/brezillon-drm-kms.pdf

DRM/KMS Lines of Code (as of January 31st, 2018)

64	xbmc/windowing/gbm/OptionalsReg.h
22	xbmc/windowing/gbm/CMakeLists.txt
39	xbmc/windowing/gbm/DRMLegacy.h
71	xbmc/windowing/gbm/WinSystemGbm.h
59	xbmc/windowing/gbm/WinSystemGbmGLESContext.h
43	xbmc/windowing/gbm/GBMUtils.h
43	xbmc/windowing/gbm/DRMAtomic.h
260	xbmc/windowing/gbm/DRMAtomic.cpp
48	xbmc/windowing/gbm/GLContextEGL.h
181	xbmc/windowing/gbm/OptionalsReg.cpp
105	xbmc/windowing/gbm/GBMUtils.cpp
106	xbmc/windowing/gbm/DRMUtils.h
172	xbmc/windowing/gbm/DRMLegacy.cpp
182	xbmc/windowing/gbm/WinSystemGbmGLESContext.cpp
252	xbmc/windowing/gbm/GLContextEGL.cpp
246	xbmc/windowing/gbm/WinSystemGbm.cpp
663	xbmc/windowing/gbm/DRMUtils.cpp
2556	**total**

Video Decoding and Rendering

- Implementing a zero-copy path from decoding to rendering for each frame
- Allow the decoded frame to be passed directly to a DRM plane

DRMPRIME Decoder & Renderer Lines of Code

248	xbmc/cores/VideoPlayer/VideoRenderers/HwDecRender/RendererDRMPRIME.cpp
74	xbmc/cores/VideoPlayer/VideoRenderers/HwDecRender/RendererDRMPRIME.h
347	xbmc/cores/VideoPlayer/DVDCodecs/Video/DVDVideoCodecDRMPRIME.cpp
83	xbmc/cores/VideoPlayer/DVDCodecs/Video/DVDVideoCodecDRMPRIME.h
752	**total**

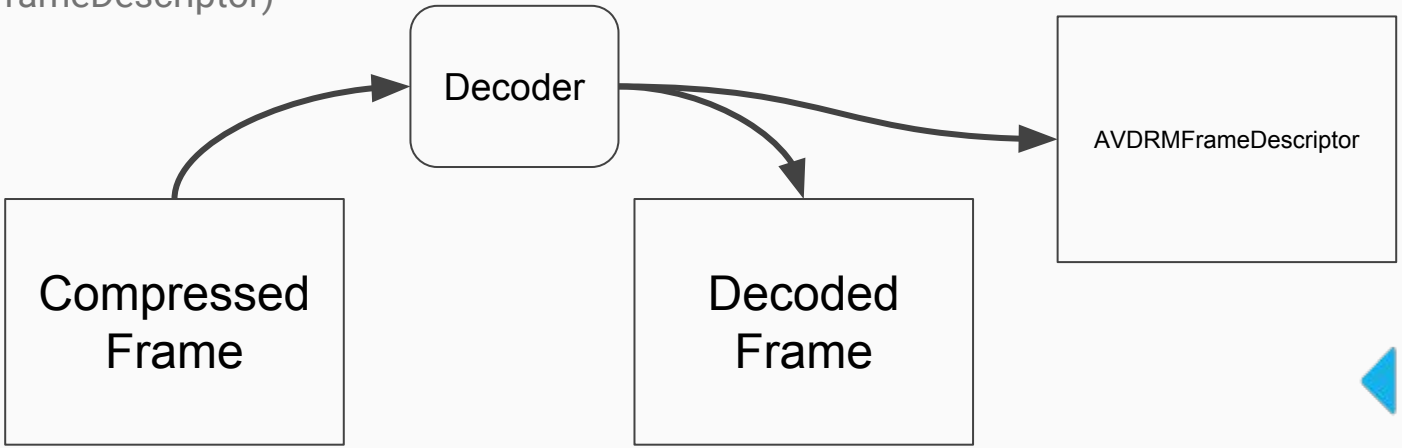
FFmpeg - libavutil/hwcontext_drm.h

```
typedef struct AVDRMFrameDescriptor {
    int nb_objects;
    AVDRMObjectDescriptor objects[AV_DRM_MAX_PLANES];
    int nb_layers;
    AVDRMLayerDescriptor layers[AV_DRM_MAX_PLANES];
};

typedef struct AVDRMObjectDescriptor {
    int fd;
    size_t size;
    uint64_t format_modifier;
}
```

FFmpeg Decoding via V4L2 and RKMPP

- Take the video frame, decode it, and place it in a memory buffer.
- Pass the fd and relevant information about this buffer to the renderer. (information contained in AVDRMFrameDescriptor)



Rendering

- Receive the decoded frame from FFmpeg
- Unpack the information in AVDRMFrameDescriptor
- Get the handle from the fd:

```
drmPrimeFDToHandle(m_DRM->m_fd, descriptor->objects[object].fd, &buffer->m_handles[object]);
```

- Use the handle and relevant information to add a framebuffer and get a framebuffer ID:

```
drmModeAddFB2(m_DRM->m_fd, buffer->GetWidth(), buffer->GetHeight(), layer->format, handles, pitches, offsets, &buffer->m_fb_id, 0);
```

Rendering (Continued…)

- Set the relevant atomic properties:

```
atomic->AddPlaneProperty(atomic->m_req, atomic->m_primary_plane, "FB_ID",   buffer->m_fb_id);
atomic->AddPlaneProperty(atomic->m_req, atomic->m_primary_plane, "CRTC_ID", atomic->m_crtc->crtc->crtc_id);
atomic->AddPlaneProperty(atomic->m_req, atomic->m_primary_plane, "SRC_X",   src_x);
atomic->AddPlaneProperty(atomic->m_req, atomic->m_primary_plane, "SRC_Y",   src_y);
atomic->AddPlaneProperty(atomic->m_req, atomic->m_primary_plane, "SRC_W",   src_w);
atomic->AddPlaneProperty(atomic->m_req, atomic->m_primary_plane, "SRC_H",   src_h);
```

- Commit the atomic page flip

Rendering GUI and Video

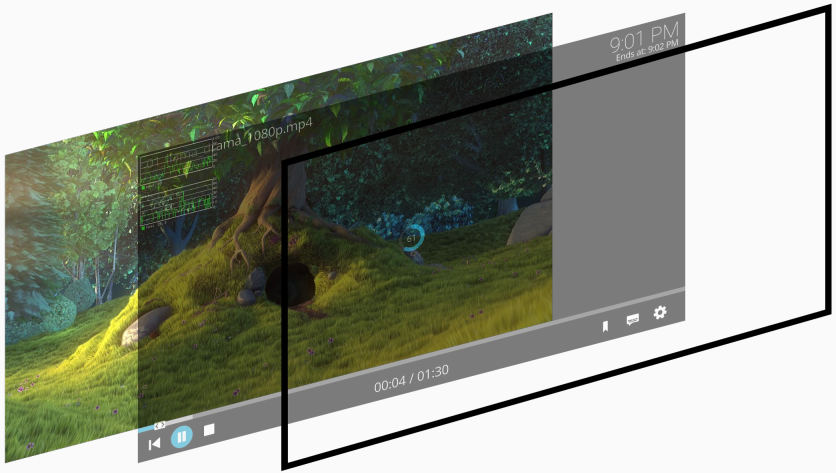
- Using Primary and Overlay DRM Planes

```
id      crtc    fb      CRTC x,y        x,y     gamma size      possible crtcs
29      0       0       0,0             0,0     0               0x000000ff
  formats: AR24 AB24 RA24 BA24 XR24 XB24 RX24 BX24 RG24 BG24 RG16 BG16 NV12 NV21 NV16 NV61 VYUY UYVY YUYV YVYU YU12 YV12
  props:
        6 type:
                flags: immutable enum
                enums: Overlay=0 Primary=1 Cursor=2
                value: 1

32      0       0       0,0             0,0     0               0x000000ff
  formats: AR24 AB24 RA24 BA24 XR24 XB24 RX24 BX24 RG24 BG24 RG16 BG16 NV12 NV21 NV16 NV61 VYUY UYVY YUYV YVYU YU12 YV12
  props:
        6 type:
                flags: immutable enum
                enums: Overlay=0 Primary=1 Cursor=2
                value: 0
```

Rendering GUI and Video (Continued…)

- No video = Kodi GUI on the primary plane
- Video = Kodi GUI on the overlay plane and video on the primary plane
- We can do this because everything is done in a single atomic commit. So we can switch planes (or disable them) instantly.
- z-pos atomic attribute not widely supported.

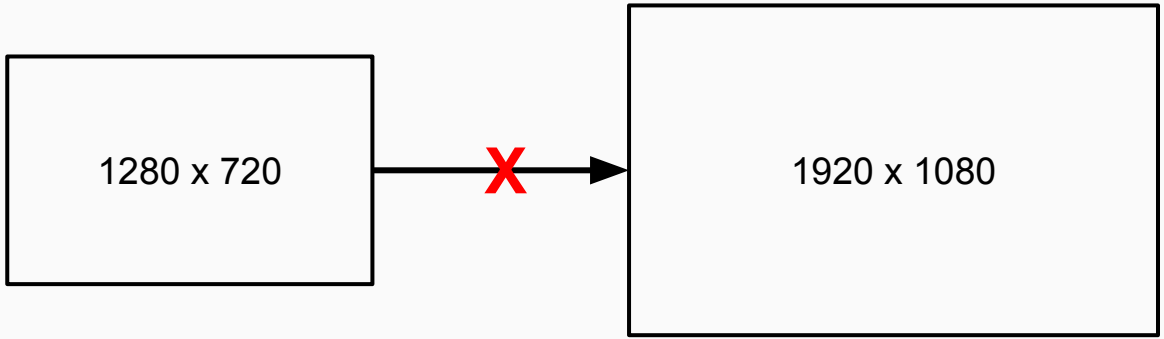


Video Playback

No Video Playback

Caveats

- Hardware or driver may not support plane scaling
  - If the screen is 1920x1080 but the video is 1280x720 it will fail (i.MX6)
- No video manipulation via shaders
  - Kodi supports scaling, color correction and deinterlacing via shaders



Alternative Solutions

- Instead of directly passing the fd to the plane we can import it into GLES directly
- Using the EGL extension EGL_EXT_image_dma_buf_import
- This allows us to import the image so we can do the processing in GL and output to a single plane.
- Current code requires GLES 3.0
- Can be done in GLES 2.0 and GL_TEXTURE_EXTERNAL_OES but requires the HW and GLES driver to allow importing NV12 or other formats directly.

EGL_EXT_image_dma_buf_import

```
GLint attribsY[] =
{
  EGL_LINUX_DRM_FOURCC_EXT, fourcc_code('R', '8', ' ', ' '),
  EGL_WIDTH, buffer->GetWidth(),
  EGL_HEIGHT, buffer->GetHeight(),
  EGL_DMA_BUF_PLANE0_FD_EXT, descriptor->objects[layer->planes[0].object_index].fd,
  EGL_DMA_BUF_PLANE0_OFFSET_EXT, layer->planes[0].offset,
  EGL_DMA_BUF_PLANE0_PITCH_EXT, layer->planes[0].pitch,
  EGL_NONE
 };

 eglImageY = m_interop.eglCreateImageKHR(m_interop.eglDisplay,
                                         EGL_NO_CONTEXT,
                                         EGL_LINUX_DMA_BUF_EXT,
                                         (EGLClientBuffer)NULL,
                                         attribsY);
```

EGL_EXT_image_dma_buf_import (Continued…)

```
GLint attribsVU[] =
{
  EGL_LINUX_DRM_FOURCC_EXT, fourcc_code('G', 'R', '8', '8'),
  EGL_WIDTH, (buffer->GetWidth() + 1) >> 1,
  EGL_HEIGHT, (buffer->GetHeight() + 1) >> 1,
  EGL_DMA_BUF_PLANE0_FD_EXT, descriptor->objects[layer->planes[1].object_index].fd,
  EGL_DMA_BUF_PLANE0_OFFSET_EXT, layer->planes[1].offset,
  EGL_DMA_BUF_PLANE0_PITCH_EXT, layer->planes[1].pitch,
  EGL_NONE
 };

 eglImageVU = m_interop.eglCreateImageKHR(m_interop.eglDisplay,
                                          EGL_NO_CONTEXT,
                                          EGL_LINUX_DMA_BUF_EXT,
                                          (EGLClientBuffer)NULL,
                                          attribsVU);
```

EGL_EXT_image_dma_buf_import (Continued…)

```
glGenTextures(1, &m_textureY);
glBindTexture(GL_TEXTURE_2D, m_textureY);
m_interop.glEGLImageTargetTexture2DOES(GL_TEXTURE_2D, eglImageY);

glGenTextures(1, &m_textureVU);
glBindTexture(GL_TEXTURE_2D, m_textureVU);
m_interop.glEGLImageTargetTexture2DOES(GL_TEXTURE_2D, eglImageVU);

glBindTexture(m_interop.textureTarget, 0);
```

GL_TEXTURE_EXTERNAL_OES

```
GLint attribs[] =
{
  EGL_LINUX_DRM_FOURCC_EXT, fourcc_code('N', 'V', '1', '2'),
  EGL_DMA_BUF_PLANE0_FD_EXT, descriptor->objects[layer->planes[0].object_index].fd,
  EGL_DMA_BUF_PLANE0_OFFSET_EXT, layer->planes[0].offset,
  EGL_DMA_BUF_PLANE0_PITCH_EXT, layer->planes[0].pitch,
  EGL_DMA_BUF_PLANE1_FD_EXT, descriptor->objects[layer->planes[1].object_index].fd,
  EGL_DMA_BUF_PLANE1_OFFSET_EXT, layer->planes[1].offset,
  EGL_DMA_BUF_PLANE1_PITCH_EXT, layer->planes[1].pitch,
  EGL_NONE
};

eglImage = m_interop.eglCreateImageKHR(m_interop.eglDisplay,
                                       EGL_NO_CONTEXT,
                                       EGL_LINUX_DMA_BUF_EXT,
                                       (EGLClientBuffer)NULL,
                                       attribs);
```

GL_TEXTURE_EXTERNAL_OES (Continued…)

```
glGenTextures(1, &m_texture);
glBindTexture(GL_TEXTURE_EXTERNAL_OES, m_texture);
m_interop.glEGLImageTargetTexture2DOES(GL_TEXTURE_EXTERNAL_OES, (GLeglImageOES)eglImage);

glBindTexture(m_interop.textureTarget, 0);
```

Broadcom

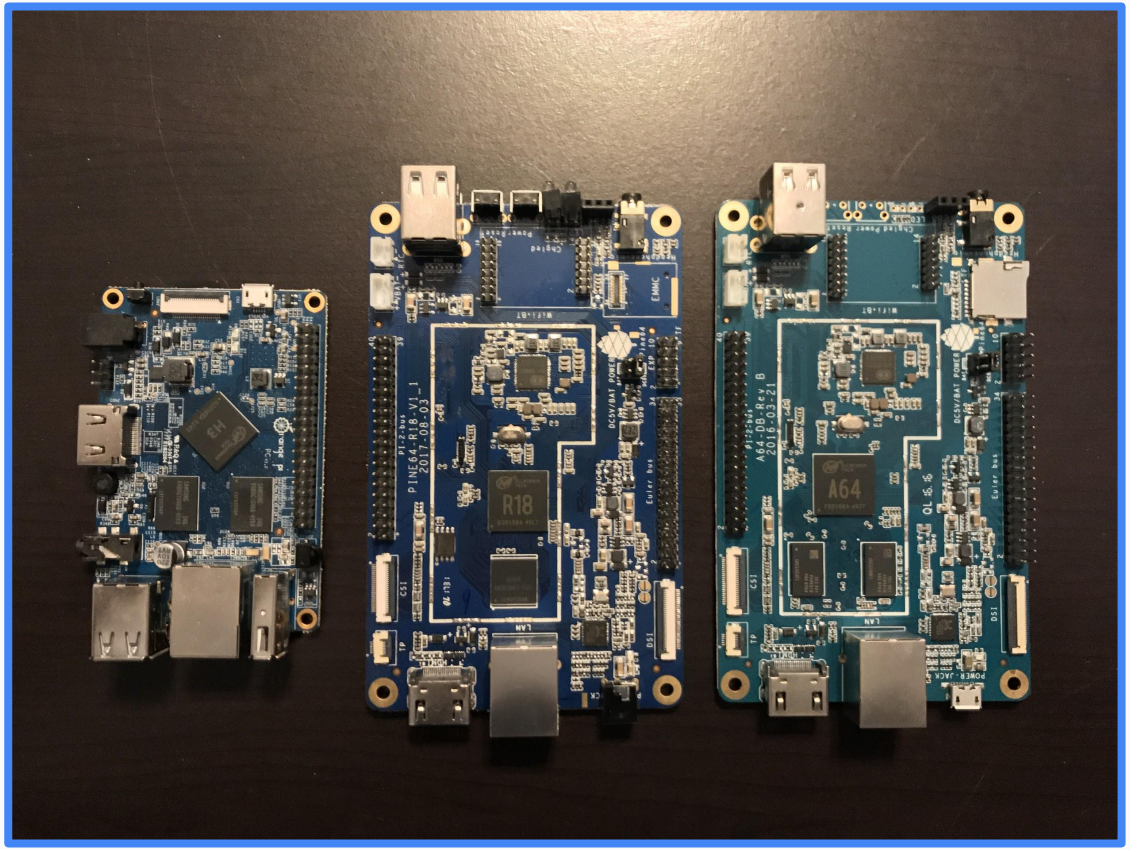
- Raspberry Pi
- No V4L2 Support
- Mainline mesa (not used)
- Proprietary bootloader
- Proprietary decoding

Amlogic

- Mainline DRM driver (not used)
- No V4L2 support
- Android partitioning
- Mali proprietary blob
- Magic decoding through libamcodec

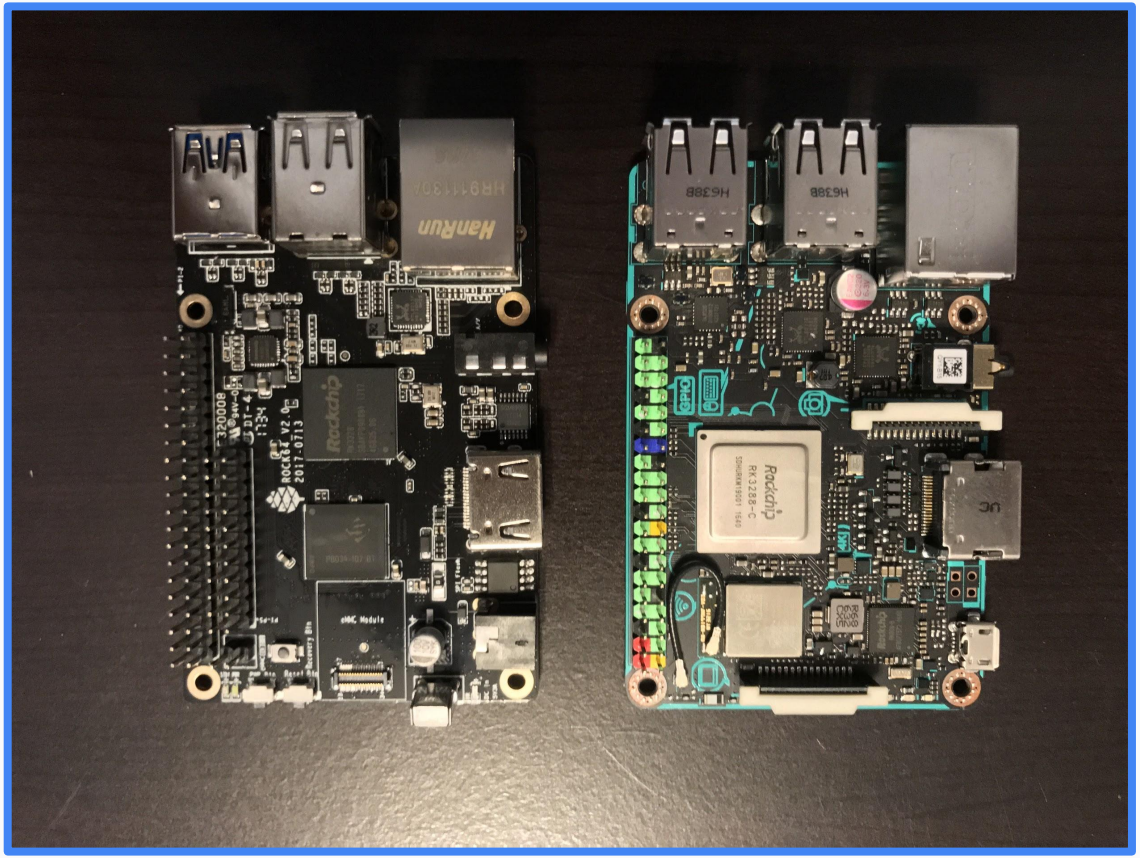
Allwinner

- DRM driver almost mainline
- Early V4L2 support
- Mainline u-boot
- Mali proprietary blob



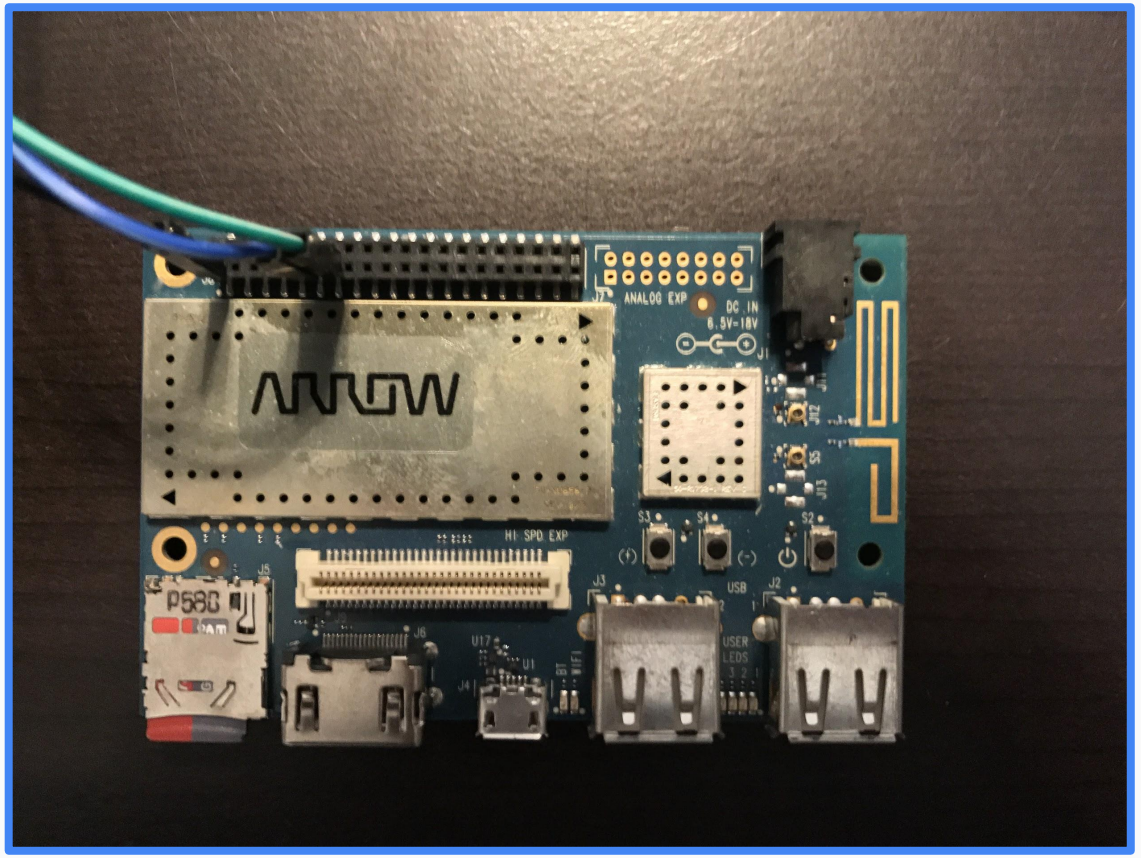
Rockchip

- 4.4 based kernel
- No V4L2 support
- Mainline u-boot
- Mali proprietary blob
- Vendor specific decoding



Qualcomm

- Mainline kernel (almost)
- Great V4L2 support
- Android partitioning
- Mainline mesa
- DB820 soon



Freescale

- Mainline kernel
- Mainline u-boot
- Good V4L2 support
- Mainline mesa
- i.MX8 coming soon

Future Work

FFmpeg

- Mainline support for v4l2 outputting AVDRMFrameDescriptor

Kodi

- HDR output

Demo

Questions?