Supporting the Camera Interface on the C.H.I.P

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  - Embedded Linux **development**: kernel and driver development, system integration, boot time and power consumption optimization, consulting, etc.
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  - `http://bootlin.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 (4.4 at the moment)

Development effort

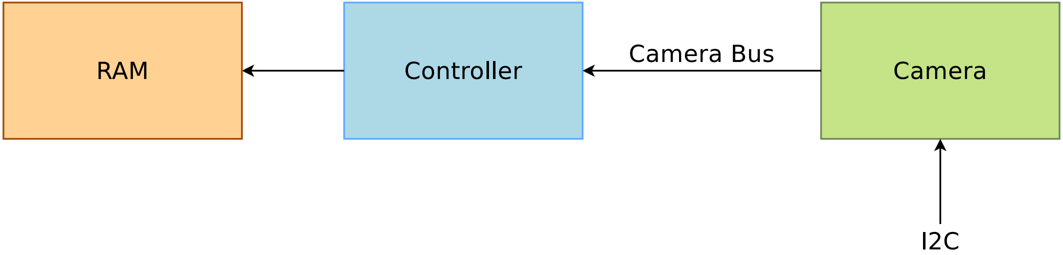
- A significant part of the work already done
- But key features for a desktop-like application were missing
  - NAND support
  - Display, GPU
  - Audio, Camera, VPU
- Plus board specific developments
  - WiFi regulators
  - DIP

Video Capture in Linux

V4L2

- Introduced in 2002, in 2.5.46
- Supports a wide range of devices
  - Video Capture (Camera, tuners)
  - Memory to memory devices (Hardware codecs, scalers, deinterlacers)
  - Radio receivers and transceivers
  - SDR

V4L2: A dumb pipeline



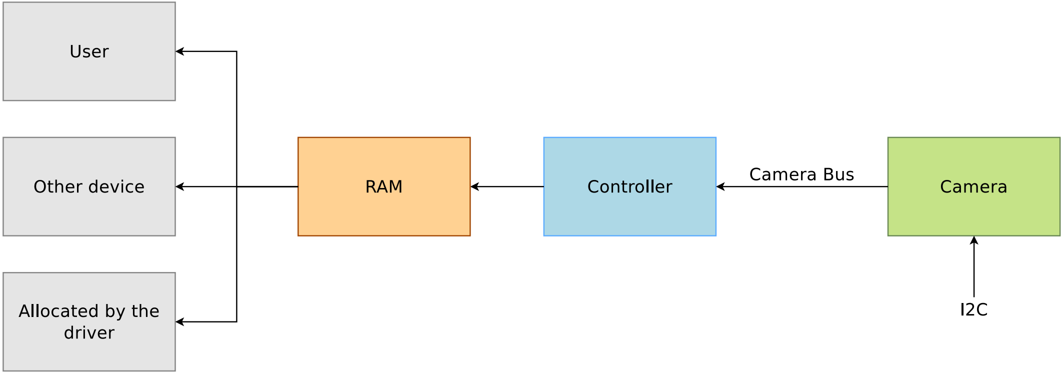
Formats

- There's a wide range of video formats...
- ... And even weird variations of them
- Most of the time, the controller and the sensor don't support the same set of formats
- Some negotiation needs to happen between the controller and the camera to agree on a common format.

Streaming

- You also need to implement the streaming hooks
- Addresses two things:
  - Memory Management: Buffer allocation, queuing and dequeuing
  - Streaming control
- With the formats, the only really needed operations

Streaming modes



Videobuf2

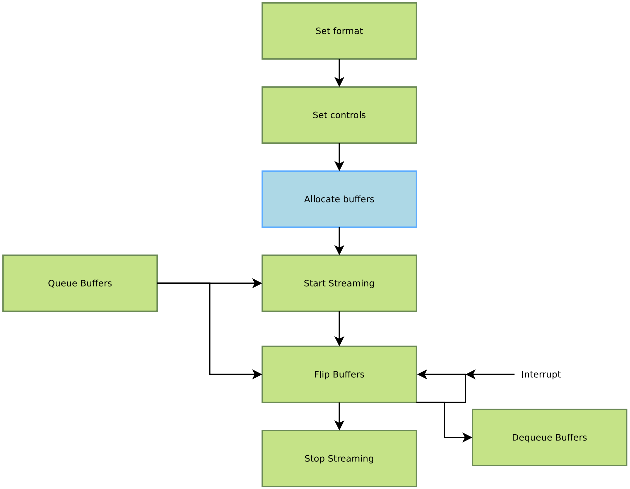
- Generic implementation of that streaming API
- Relies on a smaller, simpler set of callbacks to implement
- Different videobuf implementations, depending on your setup (backed by vmalloc, scatter gather DMA or contiguous DMA)
- Also has a notion of streaming modes, which control the source of the buffers, among
  - The driver
  - The user-space (if the device supports it)
  - Some other device (through DMA-BUF)
- The new callbacks are only there to tell videobuf the size and number of buffers to allocate, insert new buffers in a DMA chain, or start and stop the streaming

Controls

- Your device might need additional set up for things like
  - White balance
  - Saturation
  - Brightness
  - etc.
- By default, no controls are implemented, but the driver needs to declare them during probe, and handle them in a dedicated callback.

Driver view

- You'll usually have two drivers:
  - One for the controller, usually in `drivers/media/platform`
  - And one for the camera, in `drivers/media/i2c`
- By default, exposed to the userspace as one single device `/dev/videoX`
- You need some synchronization between the two: v4l2-async
- Very similar to what is found in ASoC or DRM
- Basically a two-stage probe

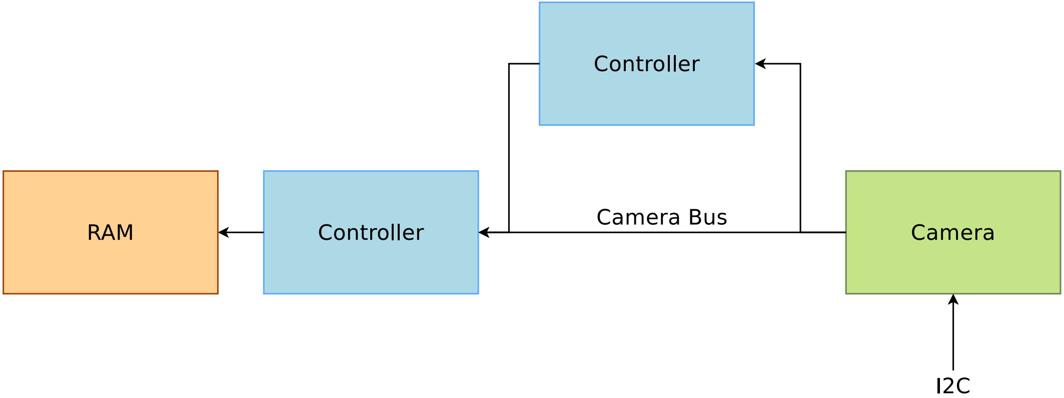


Set format
Set controls
Allocate buffers
Queue Buffers
Start Streaming
Flip Buffers
Interrupt
Dequeue Buffers
Stop Streaming

Multi-plane

- Some formats require multi-plane support
- Depending on the format, it might need 1 to 3 buffers
- Supported in v4l through a different capture type
- The callbacks are different too, but very similar
- You basically just have to deal with more buffers

More complicated setup



Media

- When the pipeline gets more complicated, the amount of controls to expose in the video device starts to be impossible to deal with
- The media controller API allows to expose one device file per component in the pipeline
- Each of them can be accessed independently, for example with media-ctl
- It might even simplify your driver, because all the format negotiation will not be relevant anymore.

Tests!

- v4l2-compliance is awesome
- v4l2-info
- yavta
- Any v4l enabled application (Cheese?)

Future developments

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Integration with DRM

- Our camera and display engines can work in the same format (but no driver support for it yet in the DRM driver)
- The display engine is even able to re-scale the video coming from the camera (but there's no driver support for it yet).
- Finding which component in userspace could do that. Gstreamer? Something a la ALSA cards configuration files?

VPU Support

- We have some work on-going to support the VPU on the Allwinner SoCs
- Reverse engineering
- Decoding works for some codecs and image formats
- Encoding is not really understood right now
- Figure it out and support encoding through the VPU

Questions? Suggestions? Comments?

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`http://bootlin.com/pub/conferences/2016/elce/ripard-v4l`