Digital TV Kernel Pipelines via Media Controller API

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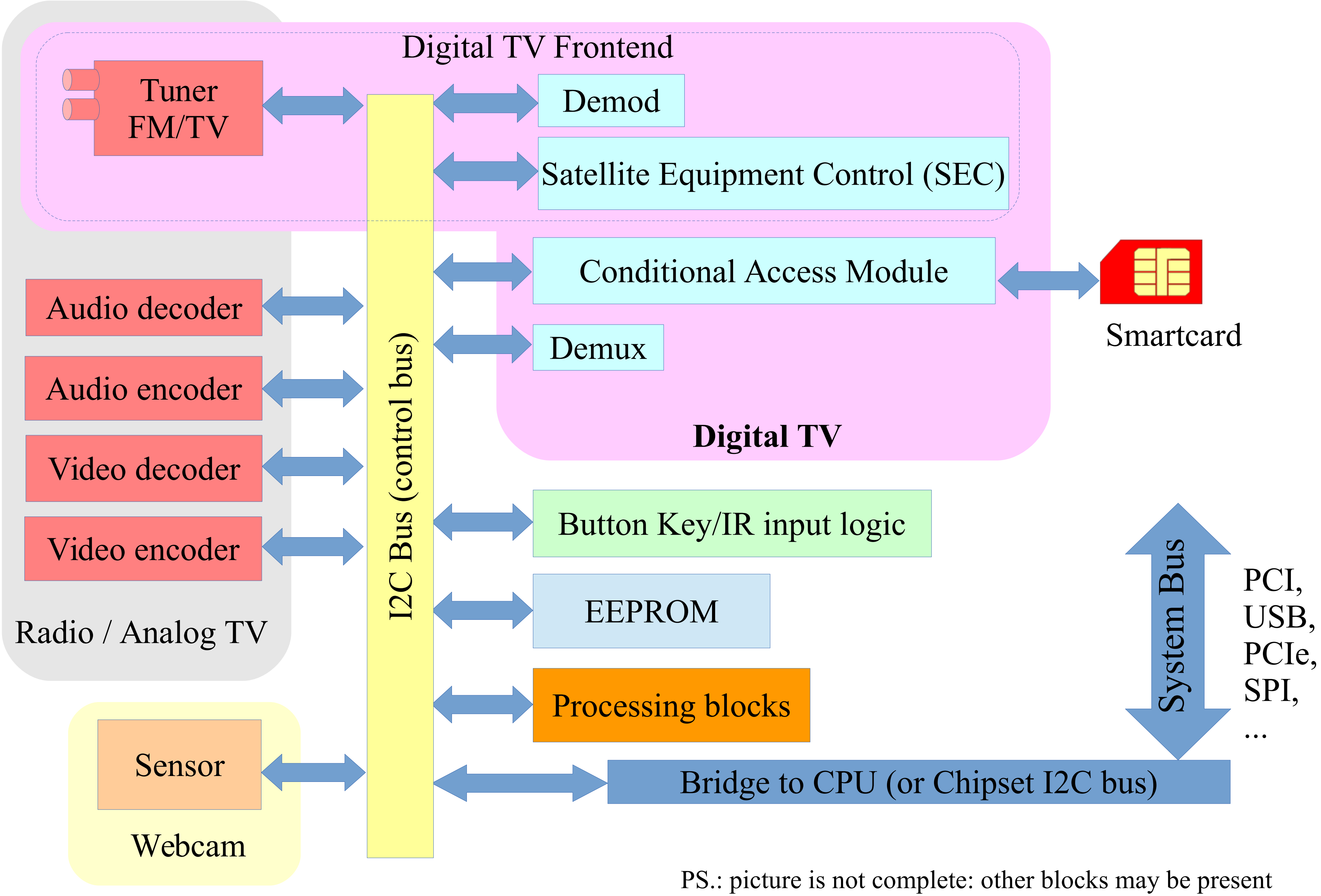
Digital TV devices

- A Digital TV device consists on a set of hardware blocks. The basic components are:
  - **Tuner**:
    - Tune into a physical frequency (tuner), and output the channel on an intermediate frequency (IF);
  - Demodulator (a. k. a. **demod**):
    - Gets an IF, decodes the sub-carrier(s) content and outputs the resulting MPEG-TS stream. It is specific for a given set of DTV standards;
  - Demultiplexer (a. k. a. **demux**):
    - Filters the MPEG-TS, extracting video, audio and other data information, like subtitles, Electronic Program Guide, etc
    - The **demux** may also extract TCP/IP packets from the MPEG-TS and send them via Linux network interfaces

NOTES:

- Satellite devices also have a Satellite Equipment Control(SEC), with controls external components at the antenna subsystem (switches, LNBf, rotors, …)
- Cheap devices don't have **demux**. Linux Kernel emulates it on such cases.
- Some devices may have a MPEG-TS multiplexer (for TCP/IP data send) and Conditional Access Module support (for Digital Rights Management).

Media devices block diagram



Digital TV Frontend

Tuner FM/TV

Demod

Satellite Equipment Control (SEC)

Conditional Access Module

Smartcard

Demux

Digital TV

Audio decoder

Audio encoder

Video decoder

Video encoder

Radio / Analog TV

I2C Bus (control bus)

Button Key/IR input logic

EEPROM

Processing blocks

Sensor

Webcam

Bridge to CPU (or Chipset I2C bus)

System Bus

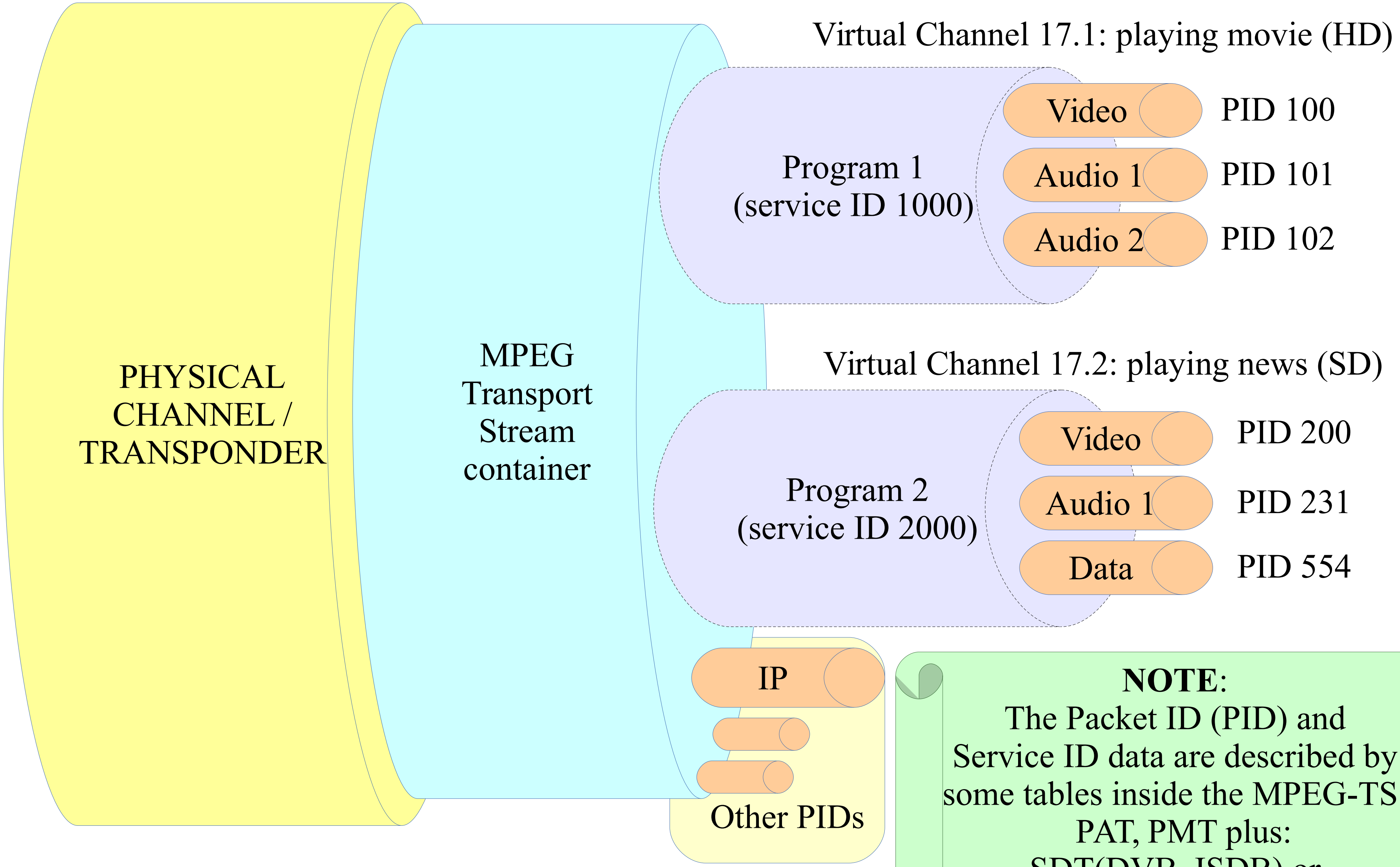
PCI,
USB,
PCIe,
SPI,
...

PS.: picture is not complete: other blocks may be present

Digital TV frontend

- The DTV frontend is the hardware part that:
  - Tunes into a physical channel;
  - Demodulates the channel data;
  - Controls the satellite and signal amplifiers.
- So, it consists of several sub-devices: **tuner**, **demod**, amplifiers and **SEC**.
- On Digital TV, tuning into a channel is a tightly coupled operation:
  - The IF used by the **demod** and **tuner** should be the same;
  - The **tuner** filters should be optimized to the digital TV standard in usage;
  - On some devices, the **demod** should control the tuner/amplifiers gains and set bandwidth filters dynamically, in order to increase the quality of the signal
  - On Satellite devices, sometimes the same hardware component have internally all 3 functions;
  - On several devices, a FPGA or a micro-controller handles the both **tuner** and **demod**. So, the tuner is not directly visible;
- The Linux DVB API was designed to expose the frontend as a single entity.
  - Yet, we may need to expose the sub-devices in some future

MPEG-TS container example



PHYSICAL CHANNEL / TRANSPONDER

MPEG Transport Stream container

Virtual Channel 17.1: playing movie (HD)

Program 1
(service ID 1000)

Video	PID 100
Audio 1	PID 101
Audio 2	PID 102

Virtual Channel 17.2: playing news (SD)

Program 2
(service ID 2000)

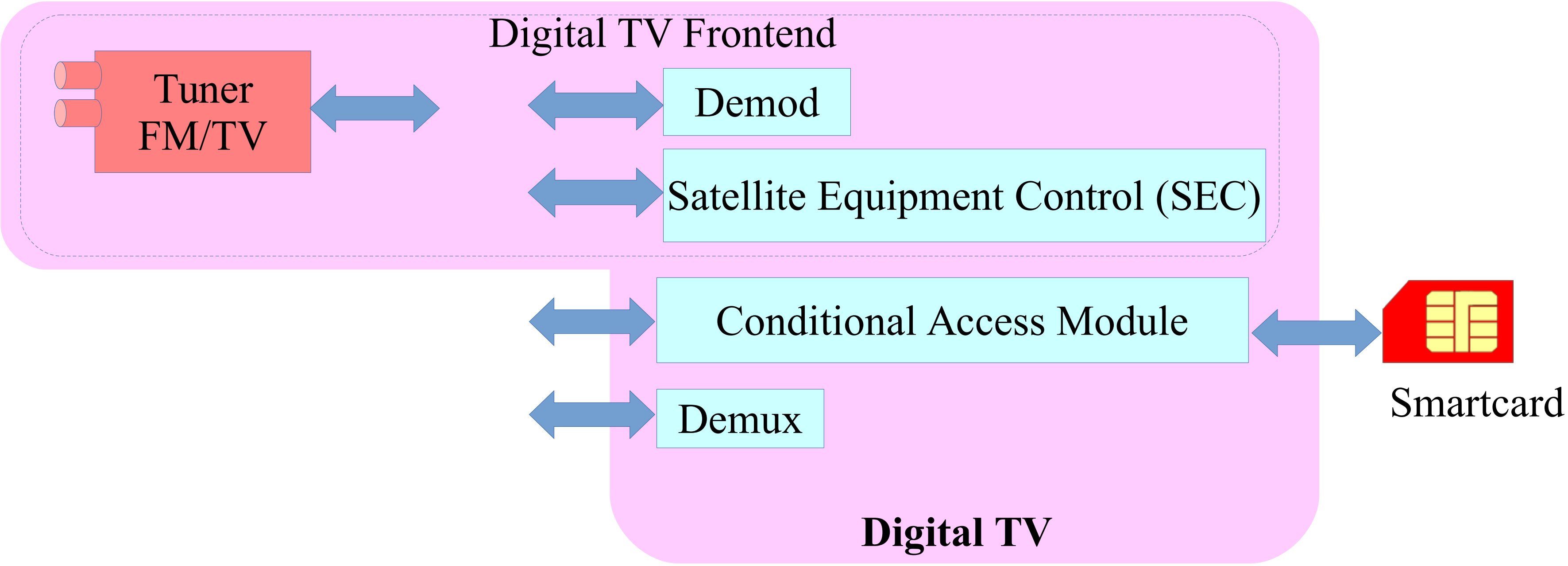
Video	PID 200
Audio 1	PID 231
Data	PID 554

IP

Other PIDs

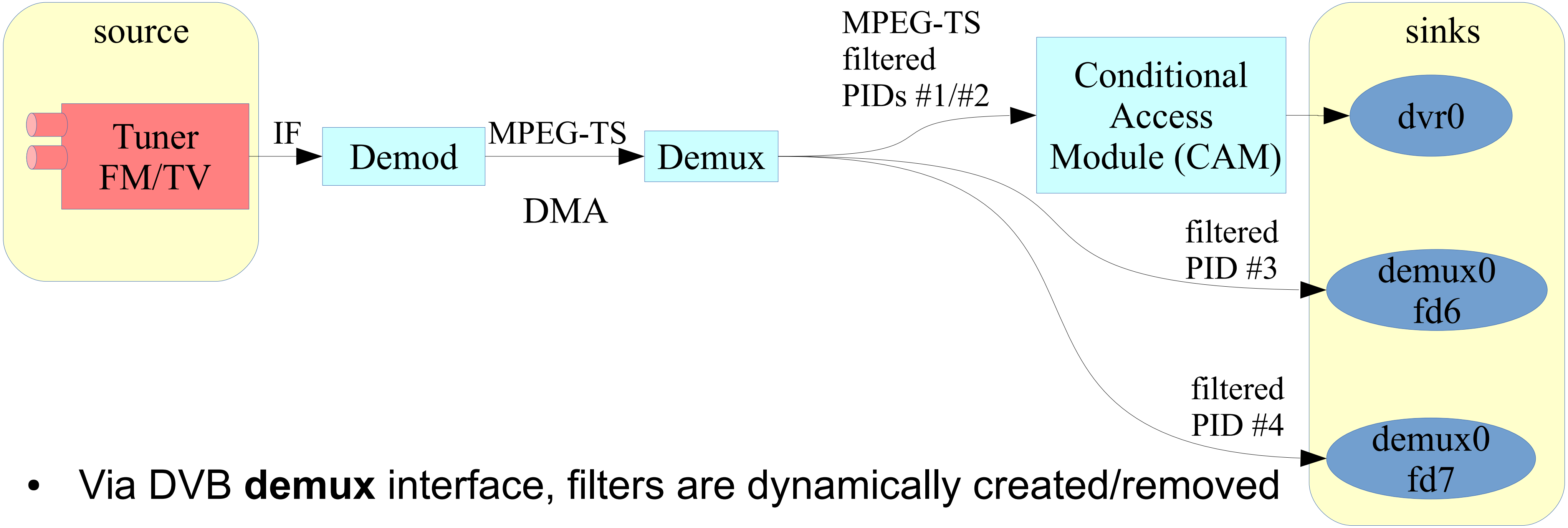
NOTE:
The Packet ID (PID) and
Service ID data are described by
some tables inside the MPEG-TS:
PAT, PMT plus:
SDT(DVB, ISDB) or
TVCT/CVCT (ATSC)

Linux Kernel DTV APIs



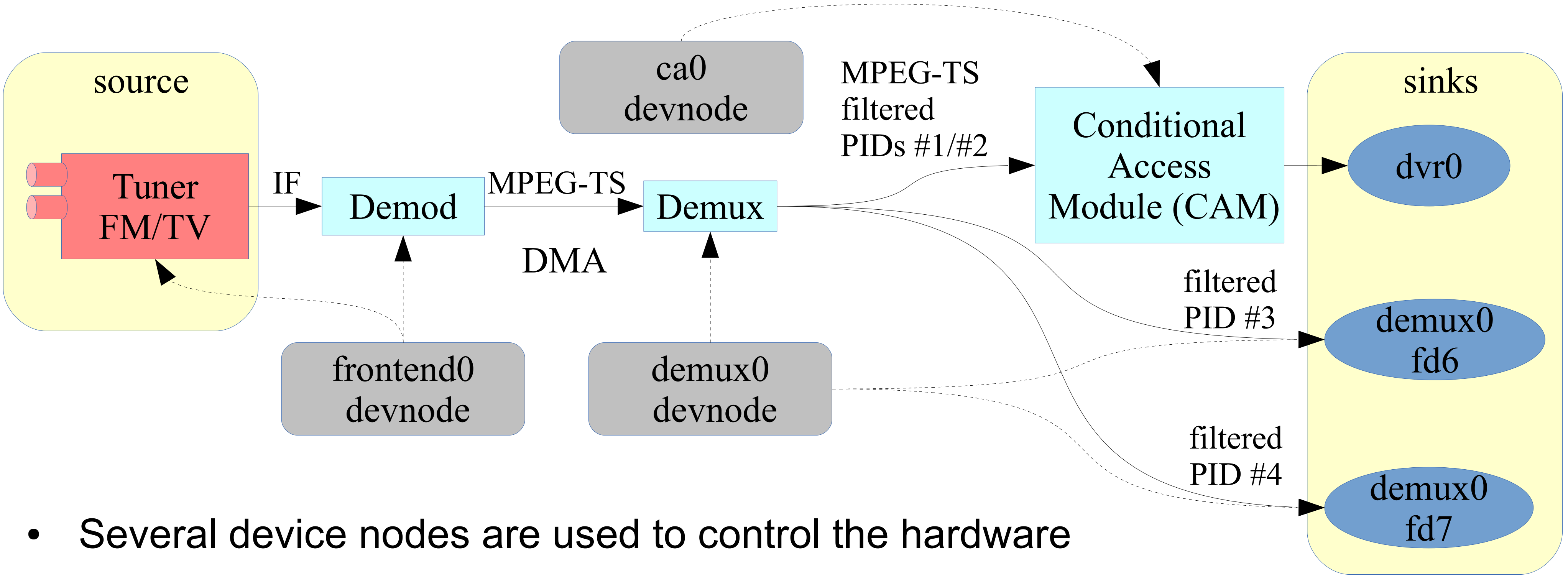
- There are several device nodes for Digital TV to control hardware components:
  - /dev/dvb/adapter?/frontend? - controls the tuner, demod and SEC
  - /dev/dvb/adapter?/ca? -controls the conditional access module;
  - /dev/dvb/adapter?/demux? - controls the demux
- There are other device nodes:
  - /dev/dvb/adapter?/dvr? - for the MPEG-TS filtered output
  - /dev/dvb/adapter?/net? - controls the MPEG-TS filter for a network adapter

Digital TV data flow pipeline



- Via DVB **demux** interface, filters are dynamically created/removed
  - Each filter contains a PID (PES filter) or a section filter (to filter tables)
- A PID set is output to userspace via a **dvr** devnode
  - Eventually after passing though CAM
  - Each single PID could, instead be sent to a per/PID file descriptor on **demux** devnode
- On embedded hardware, the sink can actually be a GPU pipeline.

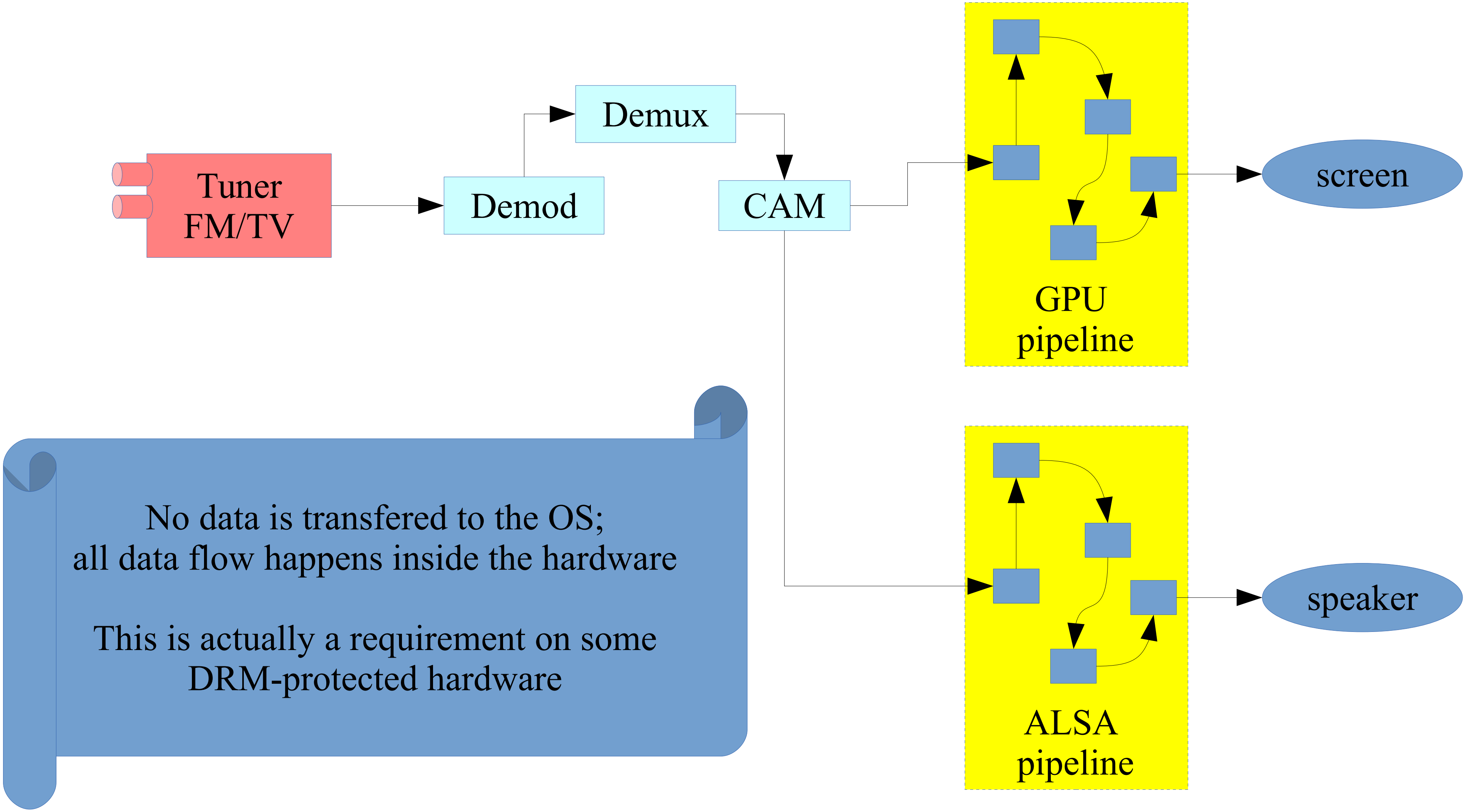
Digital TV control pipelines



- Several device nodes are used to control the hardware
  - There's currently a discussion about how to represent the control devnodes
    - As a property to the block?
    - As control entities?
  - multiple devnodes may control different aspects of the same device block
    - net? and demux? devnodes, for example controls the same demux
  - dvr? device nodes don't control anything. They're used just for data I/O

Digital TV without DMA data flow

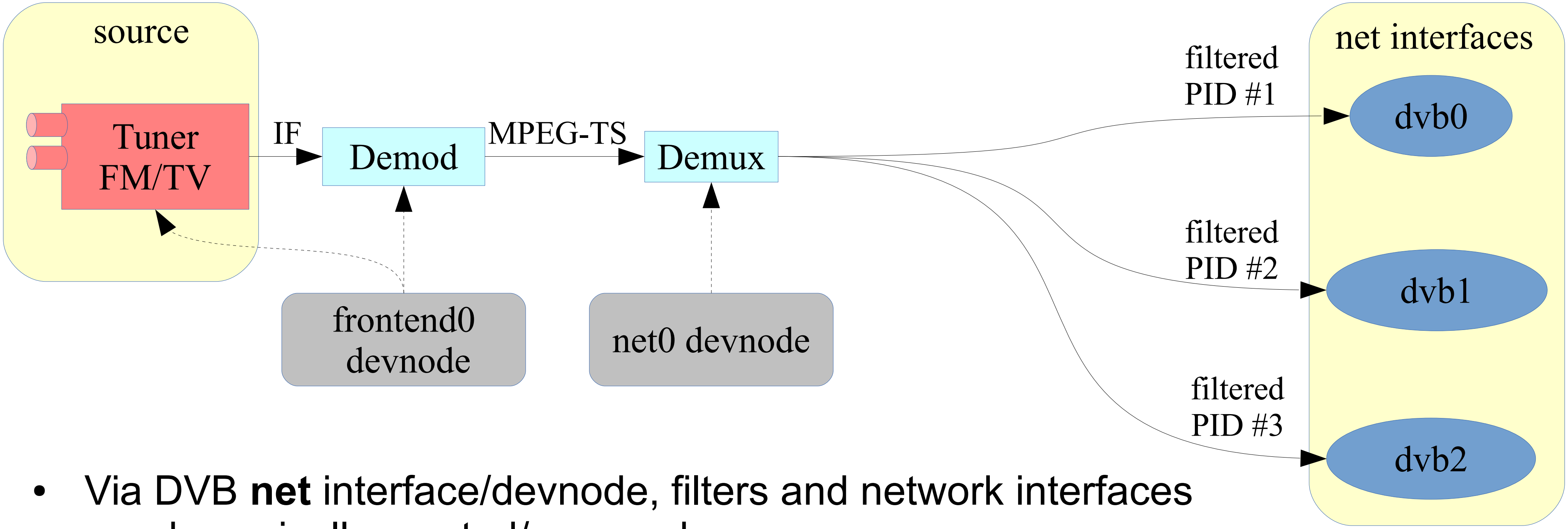
On embedded hardware, the sink can actually be a GPU and audio pipelines:



No data is transfered to the OS;
all data flow happens inside the hardware

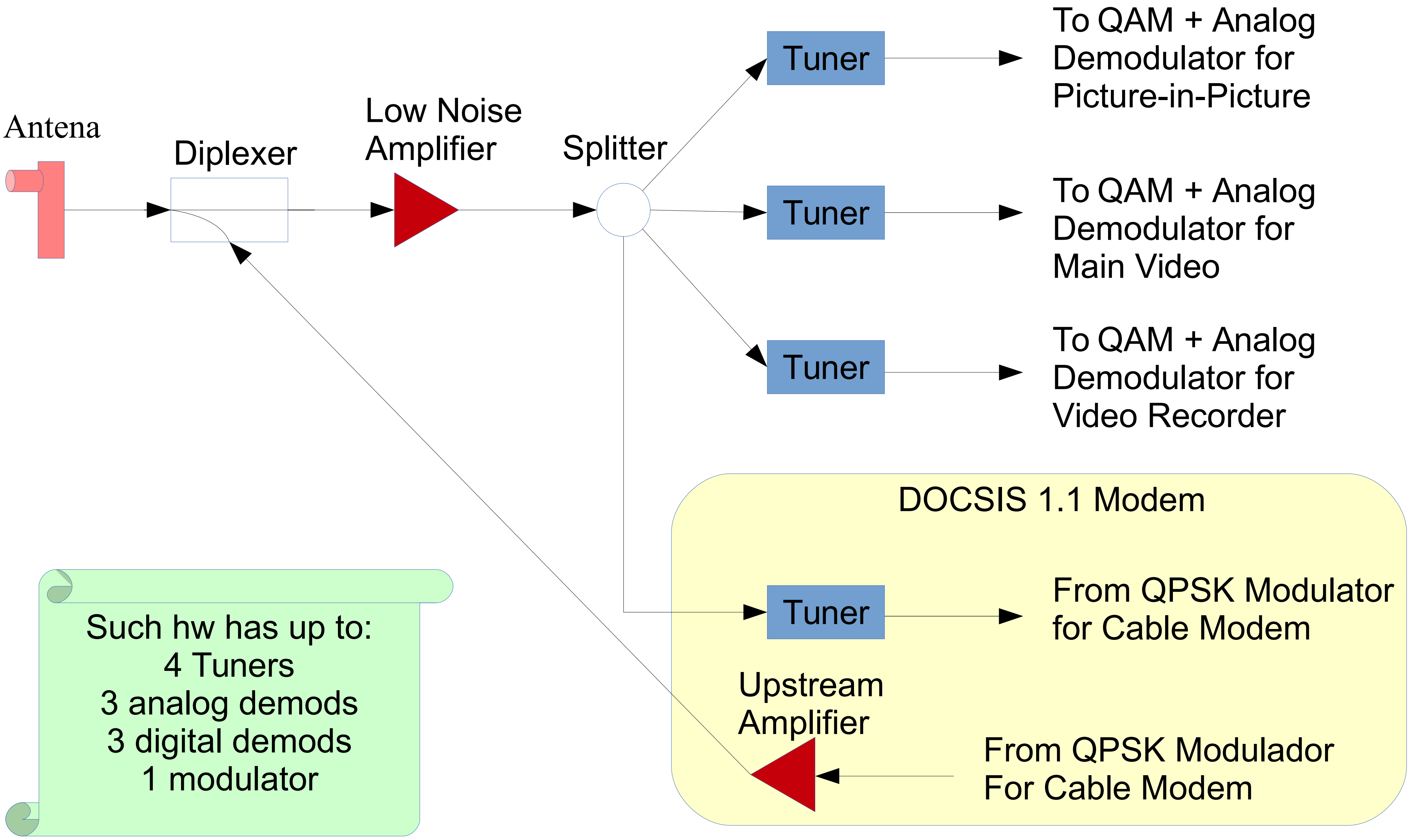
This is actually a requirement on some
DRM-protected hardware

Network (MAC) pipelines



- Via DVB **net** interface/devnode, filters and network interfaces are dynamically created/removed
- Each filter contains:
  - a single PID with contains IP traffic
  - encoding: Ultra Lightweight Encoding (ULE) or Multi Protocol Encapsulation (MPE)
- The dvb network interfaces contain ethernet-like frames
  - with TCP/IP stack inside it, and a Maximum Transfer Unit (MTU) equal to 4096 bytes
  - The interfaces are dynamically created/removed when the filter is set/deleted

Embedded Set Top Box hardware



Antena

Diplexer

Low Noise Amplifier

Splitter

Tuner

To QAM + Analog Demodulator for Picture-in-Picture

Tuner

To QAM + Analog Demodulator for Main Video

Tuner

To QAM + Analog Demodulator for Video Recorder

DOCSIS 1.1 Modem

Tuner

From QPSK Modulator for Cable Modem

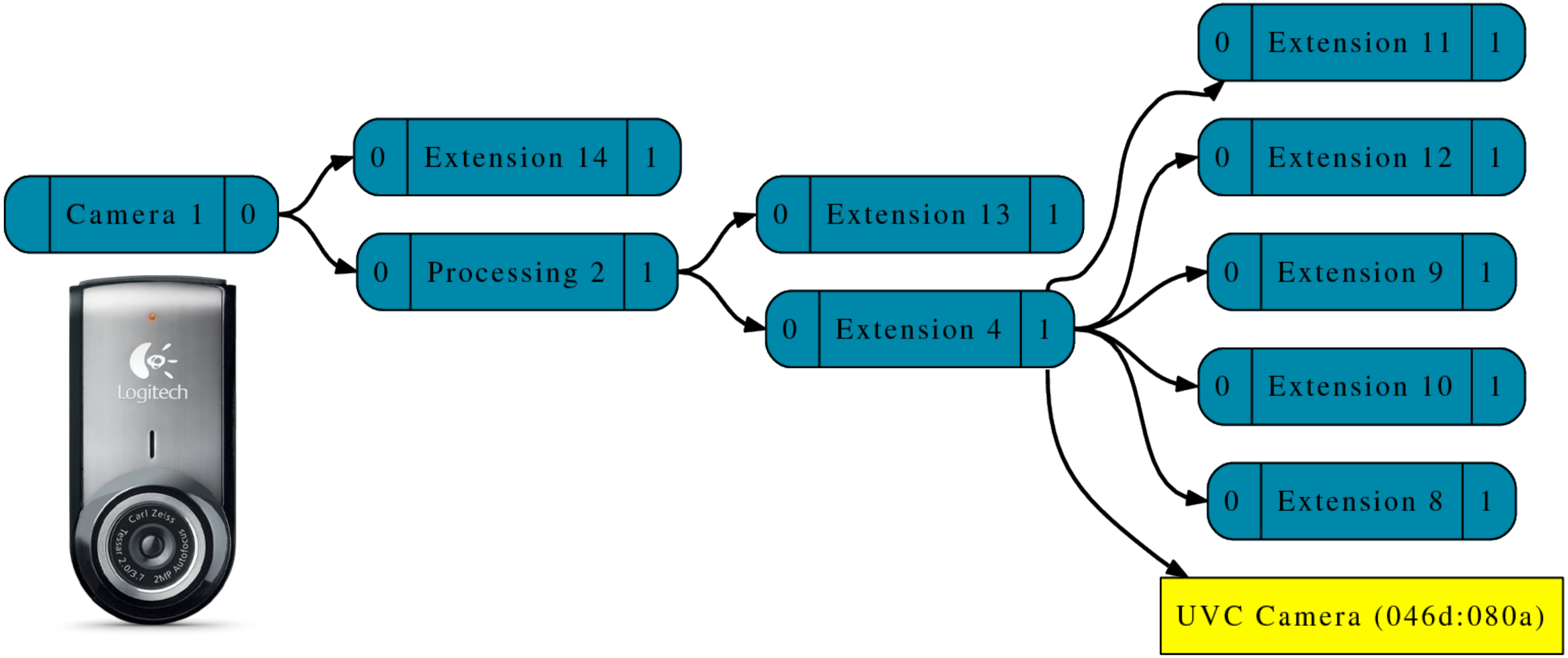
Upstream Amplifier

From QPSK Modulador For Cable Modem

Such hw has up to:
4 Tuners
3 analog demods
3 digital demods
1 modulator

Based on a picture found at: http://www.eetasia.com/ARTICLES/2005AUG/4/2005AUG22_EMS_NP.gif

Media Controller (MC) API



- Designed originally for V4L2 devices
- Shows/changes the device's pipelines
- Focused on embedded devices
- Subdev API: controls each logical element on complex devices
  - Not sure yet if this is needed for DVB

Media controller API

- Discovering a device internal topology
  - hardware devices are modeled as an oriented graph
  - building blocks called **entities** connected through **pads**.
- An **entity** is a media hardware or software building block
  - correspond to logical blocks: physical/logical hardware devices, DMA channels, physical connectors
- A **pad** is a connection endpoint
  - Represents interactions between entities
  - Data flows from the entity's output to one or more entity inputs
- A **link** is a point-to-point oriented connection between two **pads**
  - Data flows from source to sink pads

Digital TV mapping via MC (1)

Example 1: A Siano Rio ISDB-T digital USB stick

```
$ media-ctl -p
Media controller API version 0.1.0

Media device information
------------------------
driver          usb
model           Siano Rio Digital Receiver
serial
bus info        1
hw revision     0x8
driver version  3.19.0
```

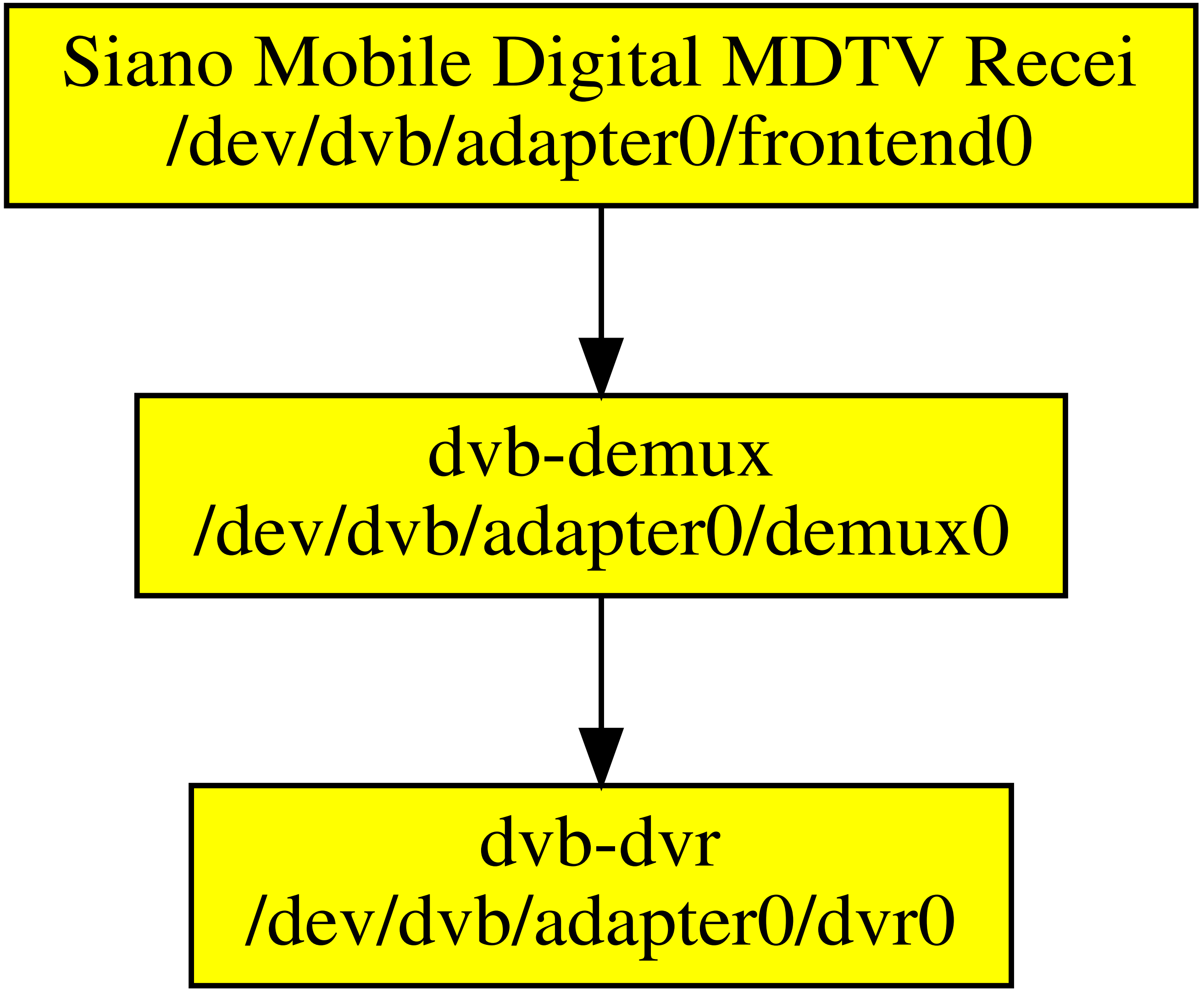
Digital TV mapping via MC (2)

```
Device topology
- entity 1: dvb-demux (2 pads, 2 links)
            type Node subtype DVB DEMUX flags 0
            device node name /dev/dvb/adapter0/demux0
pad0: Sink
<- "Siano Mobile Digital MDTV Recei":1 [ENABLED]
pad1: Source
-> "dvb-dvr":0 [ENABLED]

- entity 2: dvb-dvr (1 pad, 1 link)
            type Node subtype DVB DVR flags 0
            device node name /dev/dvb/adapter0/dvr0
pad0: Sink
<- "dvb-demux":1 [ENABLED]

- entity 3: Siano Mobile Digital MDTV Recei (2 pads, 1 link)
            type Node subtype DVB FE flags 0
            device node name /dev/dvb/adapter0/frontend0
pad0: Sink
pad1: Source
-> "dvb-demux":0 [ENABLED]
```

Digital TV mapping via MC (3)



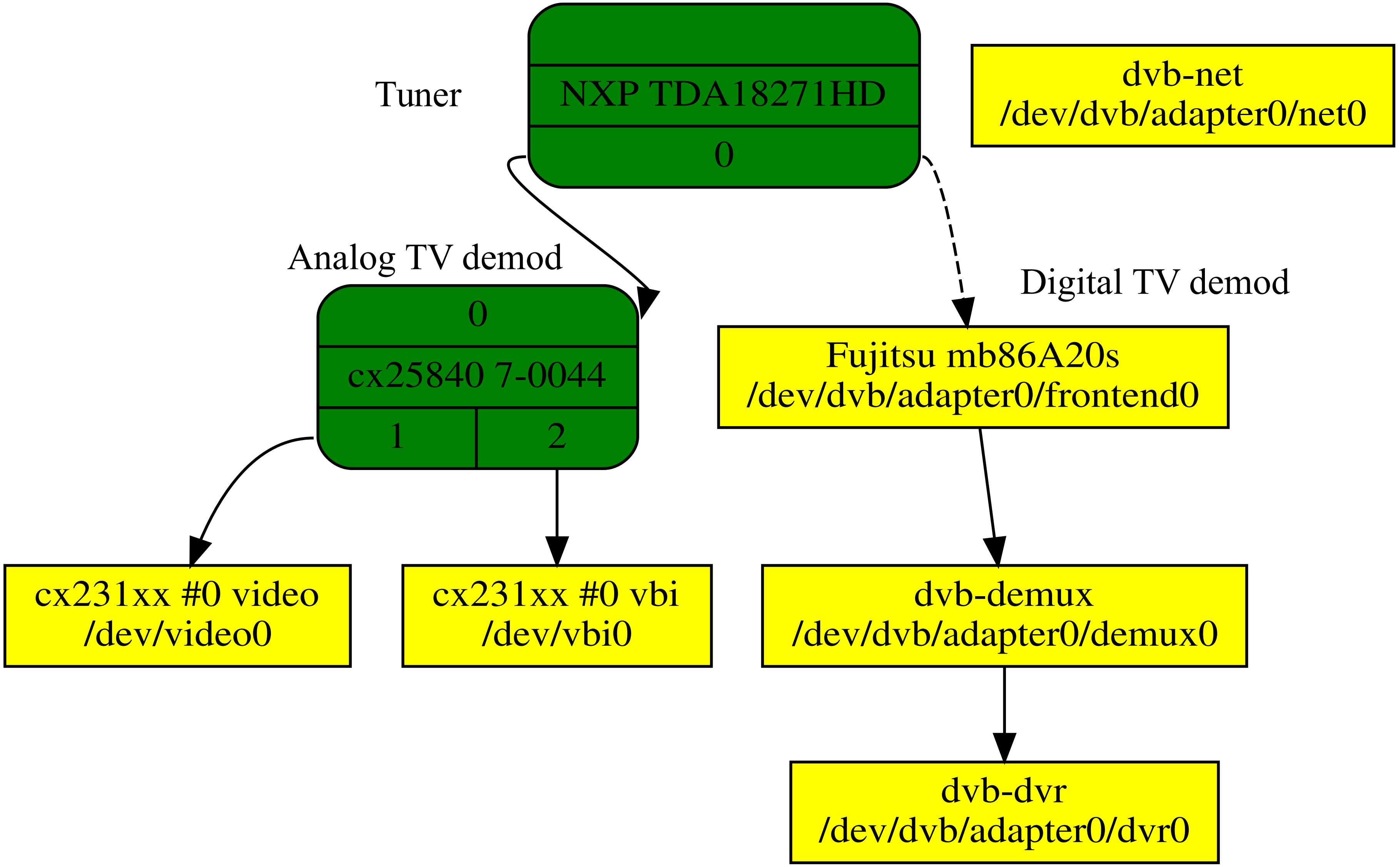
Note that the tuner subdev is not shown.

In this specific device, the tuner is not even visible to the driver, as a micro-controller handles it internally

Created with: media-ctl --print-dot|dot -T svg -o siano.svg

Digital TV mapping via MC (4)

Example 2: An hybrid analog TV/ISDB-T device based on cx231xx



Current status

- Currently, experimental patches were merged at linux-media development tree, with initial Media Controller support for DVB
- Several drivers already exposing the DVB device nodes via the Media Controller API:
  - Siano sms1xxx driver;
  - Conexant cx231xx driver – helps to demonstrate the hybrid analog/digital case;
  - Both DVB-USB drivers: dvb-usb and dvb-usb-v2.
- Only the device nodes are currently created
  - And tuner subdev, for hybrid devices
- The dynamic per-filter part of the pipeline and the demux sink is not represented
- No subdev API usage for DVB yet
- Discussions will happen at the Linux Media Summit, on March, 26, in order to address the pending stuff.

You're invited to join us

How to contribute

- Main discussions and patches for TV on Linux:
  - Userspace/kernelspace: **linux-media@vger.kernel.org**
- Upstream trees:
  - To test Kernel drivers: **http://git.linuxtv.org/media_build.git**
  - To develop Kernel drivers: **http://git.linuxtv.org/media_tree.git**
  - V4l-utils, including media-ctl: **http://git.linuxtv.org/v4l-utils.git**
- Documentation:
  - Media APIs **http://linuxtv.org/downloads/v4l-dvb-apis**
- Wiki pages: http://linuxtv.org/wiki/
- IRC channel: irc.freenode.net
  - Digital TV channel **#linuxtv**
  - Can be assessed via **http://webchat.freenode.net/**

Thank you.

Questions?