Smooth playback of adaptive video streams on Raspberry Pi with gst-mmal

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What were we trying to achieve?

The usual things really:

- Efficient handling of H.264 & MPEG-2 video
- Judder-free playback
- Proper A/V sync
- Smooth representation changes on adaptive streams
- Decent quality deinterlacing
- Efficient scaling and positioning of video window
- Fancy GL transformations *not* a priority
- Wanted to avoid ending-up with a single “blob” element

STB-like use cases on Raspberry Pi (2) “toy” platform

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Did we try gst-omx?

Yes, but we had some issues:

- Performance with *glimagesink* was not good (gst 1.6.0). Dropped frames and stuttering with 1080p streams
- Works much better with *eglglessink* from gst 1.2 - after patching for y-flip
- But, hangs-up on representation-change when playing adaptive streams
- Missing accelerated deinterlacing (s/w deinterlace not fast enough)

For more on gst-omx, see [1]

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So, we tried extending gst-omx...

- Tried hacking a new *omxvideosink* element
- Worked quite well for non-adaptive streams, but still some issues:
  - Splitting elements awkward due to OMX tunnelling
  - Dynamic reconfiguration very tricky to get right due to OMX state machine
  - Some issues with A/V sync & clocking
- Problems are really with OMX itself, more than gst-omx
- After *much* fiddling, we reluctantly gave up on OMX (for video)
- Then a question on RPi forums [2] pointed us to MMAL...

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So what's this MMAL thing?

- Multi-Media Abstraction Layer from Broadcom
- Host-side interface to VideoCore multimedia components
- Based on the concept of components, ports and buffer headers
  - Component -> Element, Port -> Pad
- Supports tunnelled configuration like OMX
- **Also supports "opaque buffers"** via userspace "buffer-headers"
  - Buffer headers are allocated by upstream elements & refcounted
  - Headers point to the "real" buffers in VC memory
  - GST elements pass buffers between MMAL components by passing headers
  - Makes it easier to split-out elements - no need to fake data-flow (like in tunneled case)
- For more on MMAL, see online docs [3]

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Current Elements

- Video decode: **- e.g. mmalh264dec**
  - H.264
  - MPEG-1, MPEG-2
  - VC-1 , WMV1,2,3
  - VP6,8
- Deinterlace - **mmaldeinterlace**
  - Uses “image_fx” VC component
- Video Sink - **mmalvideosink**
  - Uses VC-side clock & scheduler for smooth playback
- GL Uploader - **mmalglupload**
  - Use with glimagesinkelement
  - Experimental - use mmalvideosink instead for best results

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A few challenges we had to overcome

- VSync-aligned presentation & Pipeline/HDMI clock jitter
  - Solution: use VC Video Scheduler & Clock to pace final presentation
- GST & VC clock drift
  - Solution: video sink provides GST clock samples to VC clock component
- MMAL doesn’t like resizing buffers on rep change
  - Solution: always size buffers for max 1080
- Thread-safety in MMAL header refcounting
  - Solution: reimplemented those parts with atomics for now

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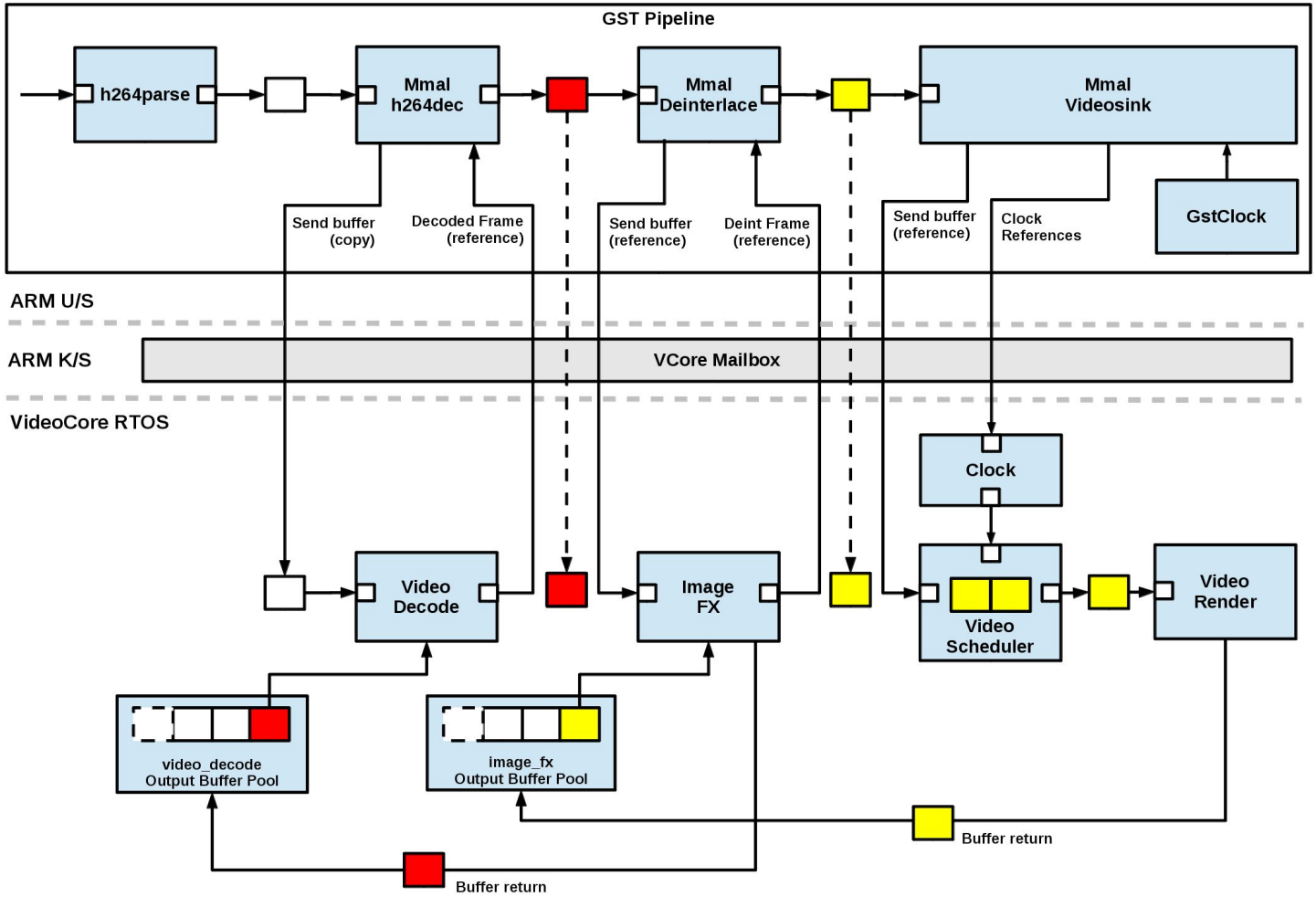
GST Pipeline
h264parse
Mmal
h264dec
Mmal
Deinterlace
Mmal
Videosink
Send buffer
(copy)
Decoded Frame
(reference)
Send buffer
(reference)
Deint Frame
(reference)
Send buffer
(reference)
Clock
References
GstClock
ARM U/S
ARM K/S
VCore Mailbox
VideoCore RTOS
Clock
Video
Decode
Image
FX
Video
Scheduler
Video
Render
video_decode
Output Buffer Pool
image_fx
Output Buffer Pool
Buffer return
Buffer return

A few outstanding issues

- Needs a good testsuite!
- Transition *between progressive and interlaced* representations is not as smooth as we'd like
- Deinterlacer could be smarter:
  - Doesn't always correctly detect mode
  - Image_fx is configured with undocumented "magic numbers"
- Video codecs other than H.264, MPEG-2 not well tested
- GL support could be improved
- No audio elements - OMX is fine for our audio needs
- Other components could be implemented - e.g. camera, encode, scaling/resize

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OK, that's it. Thanks for listening!

Source-code available on GitHub:

https://github.com/youviewtv/gst-mmal

Feedback & contributions welcome!

References:

[1] https://cgit.freedesktop.org/gstreamer/gst-omx

[2] https://www.raspberrypi.org/forums/viewtopic.php?f=70&t=127842

[3] http://www.jvcref.com/files/PI/documentation/html/

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