The case for a virtual Rust stateless codec driver

Daniel Almeida

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Video codecs explained (quickly)

- Raw video is *huge*
- Video signals contain exploitable redundancies
- Video codecs compress and decompress video by capitalizing on this

Video codecs explained (quickly)

- Usually this process is lossy
- The objective is to arrive at a passable approximation
- At a given bitrate and power envelope

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But..we want things to be fast and cool...

Hardware accelerators

- Tend to be faster, more power efficient
- Frees up the main CPU
- Less flexible (usually only a few profiles supported)
- Need driver support and an API to communicate with userland

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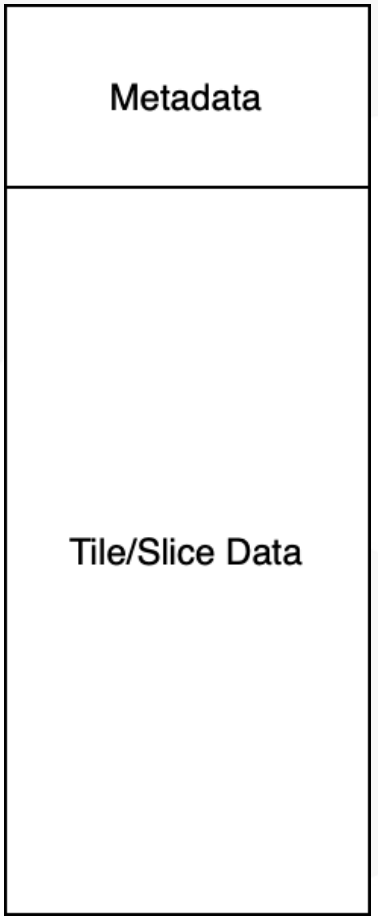
To understand codec drivers, we must look inside the bitstream

Inside a codec bitstream



Inside the bitstream

- Metadata
  - Controls the decoding process
  - May persist between frames or relate to a single frame
  - e.g.: VPS/SPS/PPS, etc.
- Slice and/or tile data
  - Actual compressed data

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And how can we talk to these devices?

V4L2 Codec API types

- Stateful
  - Hardware parses bitstream itself
  - Hardware keeps track of bitstream metadata
- Stateless
  - Userland parses stream
  - Userland sends metadata to driver
  - Driver uses metadata to program the device

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We have a virtual stateless driver :)

visl (Virtual Stateless Decoder Driver)

- A virtual stateless driver
- Pretends it’s decoding data
- Instead gives the programmer a lot of debug information

What is visl good for?

- Developing new userland (based on a working one)
- Fixing bugs on existing userland implementations
- Testing userland when hardware is not available
- Prototyping new codec APIs

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Great! What’s the problem then?

What the metadata looks like

```
    allFrames = (1 << NUM_REF_FRAMES) - 1                                   
    if ( reduced_still_picture_header ) {                                   
        show_existing_frame = 0                                             
        frame_type = KEY_FRAME                                              
        FrameIsIntra = 1                                                    
        show_frame = 1                                                      
        showable_frame = 0                                                  
    } else {                                                                
        show_existing_frame                                          f(1)   
        if ( show_existing_frame == 1 ) {                                   
            frame_to_show_map_idx                                    f(3)   
            if ( decoder_model_info_present_flag && !equal_picture_interval ) {
                temporal_point_info( )                                      
            }                                                               
            refresh_frame_flags = 0                                         
            if ( frame_id_numbers_present_flag ) {                          
                display_frame_id                                     f(idLen)
            }                                                               
            frame_type = RefFrameType[ frame_to_show_map_idx ]              
            if ( frame_type == KEY_FRAME ) {                                
                refresh_frame_flags = allFrames                             
            }                                                               
            if ( film_grain_params_present ) {                              
                load_grain_params( frame_to_show_map_idx )                  
            }                                                               
            return                                                          
        }                                                                   
        frame_type                                                   f(2)   
        FrameIsIntra = (frame_type == INTRA_ONLY_FRAME ||                   
                        frame_type == KEY_FRAME)                            
        show_frame                                                   f(1)   
        if ( show_frame && decoder_model_info_present_flag && !equal_picture_interval ) {
            temporal_point_info( )                                          
        }                                                                   
        if ( show_frame ) {                                                 
            showable_frame = frame_type != KEY_FRAME                        
        } else {                                                            
            showable_frame                                           f(1)   
        }                                                                   
        if ( frame_type == SWITCH_FRAME ||                                  
             ( frame_type == KEY_FRAME && show_frame ) )                    
            error_resilient_mode = 1                                        
        else                                                                
            error_resilient_mode                                     f(1)   
    }                                                                       
    if ( frame_type == KEY_FRAME && show_frame ) {                          
        for ( i = 0; i < NUM_REF_FRAMES; i++ ) {                            
            RefValid[ i ] = 0                                               
            RefOrderHint[ i ] = 0                                           
```

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There are pages and more pages of this...

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Not only this can be *very* complex but...

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...we index into arrays and use loop variables from data read directly from the bitstream

The case for Rust

- We are handling a *lot* of metadata per frame
- This metadata is highly structured/complex
- The meaning of fields may change based on the value of other fields
- You may have to juggle multiple versions of a given set of metadata (e.g.: only one is active)

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This problem is exacerbated in real drivers :/

The case for Rust

- You have to carefully read the specs to make the right use of said metadata
- Otherwise you may wrongly program the device
- This may hang the device or worse:
- **This can change the decoding process in unknown ways**

The case for Rust

- Clearly there's value to having Rust in codec drivers
- A virtual driver is the perfect candidate to experiment
- We can make it even simpler (no debug information)
- If we can make a virtual driver work with Rust, we will have the foundations for real drivers

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What do we have so far?

What we have so far

- Abstractions for some V4L2 data types
- A *very* thin videobuf2 abstraction (you can spawn a queue)
- Abstractions for some V4L2 ioctls
- The necessary code to get the driver to probe
- A sample module that merely prints to the terminal

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What do we need?

Rust abstractions we need

- V4L2 controls (to get the metadata)
- Media controller (for V4L2 Request support)
- mem2mem (for device_run() and friends)
- More ioctl support

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We still need a green light from maintainers

Feedback and roadblocks

- V4L2 can’t keep up with the workload as is
- Not enough reviewers and maintainers
- Long-standing issues with some C frameworks
- Fear of breaking C code
- **Who is going to maintain the Rust layer?**

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We want to unblock this effort

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Which is why we are proposing a virtual driver in Rust

Summary

- Stateless codec drivers take in a lot of untrusted data from userland
- We can minimize the attack surface with Rust
- The visl virtual driver is a prime candidate for experimentation

Thank you!

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