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DRM KMS overview

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This article gives information about the Linux®DRM/KMS display, graphic and composition framework.

Contents

1 Framework purpose

The purpose of this article is to provide a quick overview of the Direct Rendering Manager[1] & Kernel Mode Setting[2] Linux® framework, called the **"DRM/KMS"** framework for short, giving some hints on its architecture, configuration, usage, debug and related use cases.

The DRM/KMS framework is dedicated to the management of the display, graphic and composition subsystems. With the help of other Linux multimedia frameworks and applications, the DRM/KMS framework is typically used:

- to compose animated contents taking advantages of the hardware acceleration.
- to control both display interfaces and external displays including their settings (resolution, frequencie, multi-screen...).
- to display this animated contents on display panels or HDMI outputs.

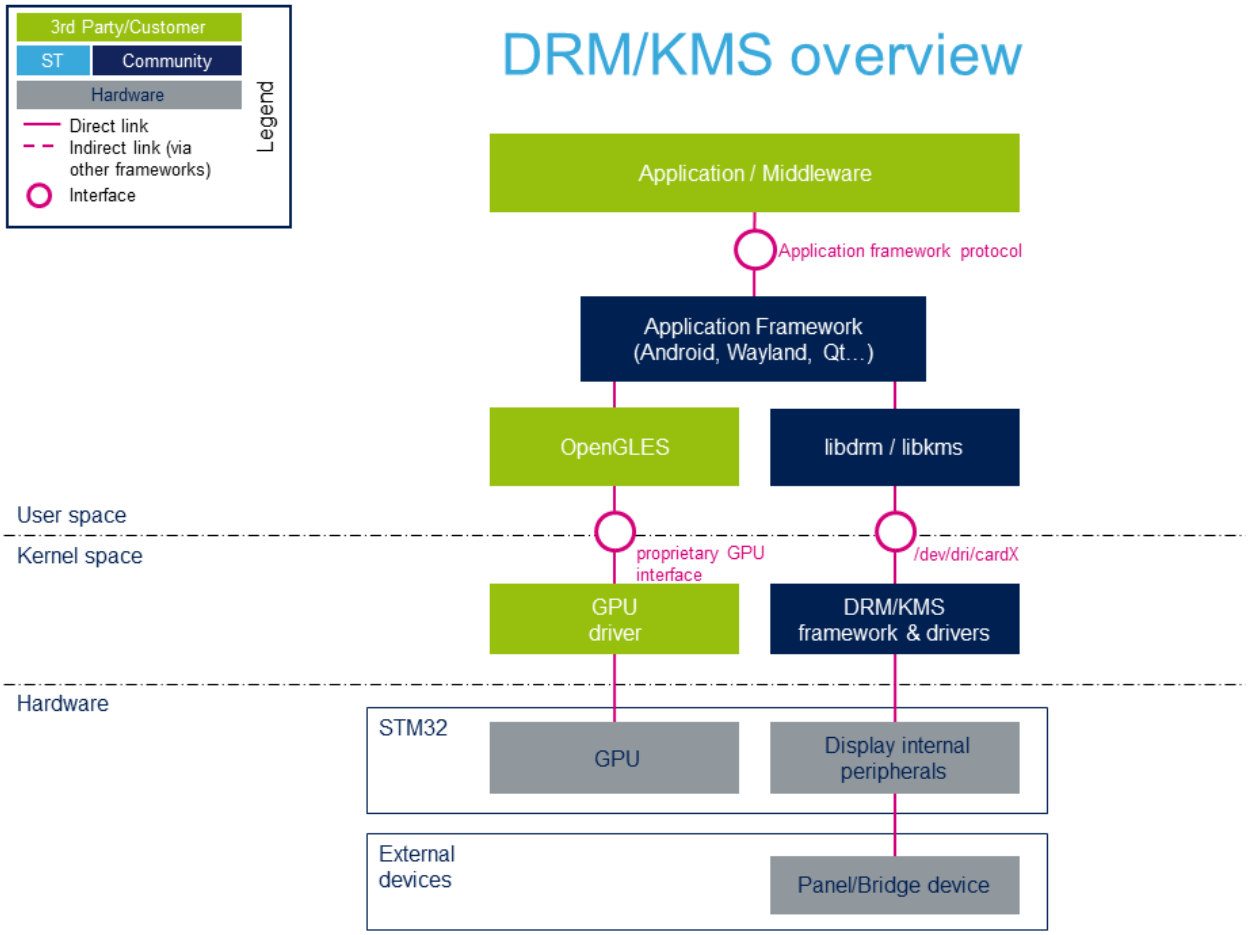
The DRM/KMS framework offers:

- a **kernel level interface driver** for display, graphic and composition internal and external hardware peripherals.
- a **userland level interface**, with the help of libdrm/libkms libraries, to get access to the related hardware features, configuration and hardware acceleration.

Examples of use cases involving the DRM/KMS framework:

- Display an animated content on a DSI or RGB panel.
- Configure the HDMI output to a given resolution and frame rate.
- Activate the HDMI output among several available display outputs.
- Create and manage memory buffers dedicated to the display, which contains graphical content (animations, 3D objects, videos...).
- Get display timing information to efficiently adjust the speed of animated content.

2 System overview



2.1 Component description

From Application/Middleware to Hardware

- **Application/Middleware** (User space)

The Application/Middleware "client" relying on the application framework and its related protocol. This client can be either a traditional application or a specific middleware.

- **Application Framework** (User space)

The application framework (Android, Wayland, Qt...) libraries implementing the related application framework protocol, including the display framework with the libdrm/libkms libraries and the GPU-based composition with the OpenGLES libraries.

- **OpenGLES** (User space)

The OpenGLES libraries used by the application framework for the GPU-based composition and by the application for creating animated contents.

- **libdrm/libkms** (User space)

The libdrm and libkms libraries are used by the application framework to configure, control and refresh the display paths and content. Incorporated wrapper functions are used to access the DRM/KMS ioctls.

- **GPU driver** (Kernel space)

The Linux kernel driver used to transfer OpenGLES instructions to the GPU hardware block.

- **DRM/KMS framework & drivers** (Kernel Space)

The DRM/KMS Linux kernel framework and related drivers used to access the display hardware block and the related user space API implementation.

- **GPU** (Hardware)

The GPU hardware block.

- **Display internal peripherals** (Hardware)

All internal display peripheral hardware blocks like the LTDC internal peripheral and the DSI internal peripheral.

- **Panel/Bridge device** (Hardware)

The physical Panel or Bridge device to display contents.

2.2 API description

The DRM/KMS framework userland API documentation:

- for the libdrm/libkms libraries : See libdrm source code and documentation[3]
- for the kernel/userland (uapi): See "Linux GPU Driver Developer's Guide / Userland interfaces"[4]

The internal DRM/KMS kernel framework API is documented in the official "Linux GPU Driver Developer's Guide / DRM Internals"[5]

3 Configuration

The objective of this chapter is to explain how to configure the Linux kernel and device tree to have the DRM/KMS framework and related drivers activated.

3.1 Kernel configuration

The DRM/KMS framework and related drivers are activated by default in all ST deliveries. Nevertheless, if a specific configuration is needed, this section indicates how the DRM/KMS framework and drivers can be activated/deactivated in the kernel.

Activate the DRM/KMS framework in kernel configuration with Linux Menuconfig tool: Menuconfig or how to configure kernel

```
Device Drivers  --->
    Graphics support  --->
    [*] Direct Rendering Manager (XFree86 4.1.0 and higher DRI support)  --->
```

Note: Most of the important kernel configuration flags related to the DRM/KMS framework are enabled by default in **multi_v7_defconfig** file.

The internal display peripherals (LTDC, DSI) and the related display panels/bridges, connected external peripherals must also be enabled. See the example below:

```
Device Drivers  --->
    Graphics support  --->
    [*] DRM Support for STMicroelectronics SoC Series
    [*]   STMicroelectronics specific extensions for Synopsys MIPI DSI
    Display Panels  --->
        [*] support for simple panels
        [*] Orise Technology otm8009a 480x800 dsi 2dl panel
        [*] Raydium RM68200 720x1280 DSI video mode panel
    Display Interface Bridges  --->
        [*] Silicon Image sii902x RGB/HDMI bridge
```

3.2 Device tree configuration

Refer to the LTDC device tree configuration and DSI device tree configuration articles for the complete documentation of the LTDC, DSI, display panel and bridge configuration supported by the Linux kernel device tree mechanism.

4 How to use the framework

4.1 modetest (DRM/KMS test tool)

The tool **modetest** provided by the libdrm library[3] is useful to:

- List all display capabilities: CRTCs, encoders & connectors (DSI, DPI, HDMI, ...), planes, modes, etc...
- Perform basic tests: display a test pattern, display 2 layers, perform a vsync test
- Specify the video mode: resolution and refresh rate

You can **get all display capabilities with modetest** whatever was running on top of DRM/KMS Linux framework (like Wayland Weston).
But if you want to **test displays with modetest**, the framework has to be stopped.
For instance, you can stop Weston with the following command:

```
Board $> systemctl stop weston
```

4.1.1 modetest help

You can get the help of **modetest** with the following command:

```
Board $> modetest --help
```

Result example:

```
~# modetest --help
usage: modetest [-acDdefMPpsCvw]

 Query options:

        -c      list connectors
        -e      list encoders
        -f      list framebuffers
        -p      list CRTCs and planes (pipes)

 Test options:

        -P <plane_id>@<crtc_id>:<w>x<h>[+<x>+<y>][*<scale>][@<format>]  set a plane
        -s <connector_id>[,<connector_id>][@<crtc_id>]:<mode>[-<vrefresh>]
[@<format>]   set a mode
        -C      test hw cursor
        -v      test vsynced page flipping
        -w <obj_id>:<prop_name>:<value> set property
        -a      use atomic API

 Generic options:

        -d      drop master after mode set
        -M module       use the given driver
        -D device       use the given device

        Default is to dump all info.
```

If you want to know more about DRM/KMS encoders, connectors, CRTCs and planes, refer to the presentations suggested in the To go further chapter.

4.1.2 Show display overall status

Get the status of all display capabilities:

```
Board $> modetest -M stm
```

Result example:

```
~# modetest -M stm
Encoders:
id      crtc    type    possible crtcs  possible clones
28      33      DPI     0x00000001      0x00000000
30      0       DSI     0x00000001      0x00000000

Connectors:
id      encoder status          name            size (mm)       modes   encoders
29      28      connected       HDMI-A-1        700x390         10      28
```

```
  modes:
        name refresh (Hz) hdisp hss hse htot vdisp vss vse vtot)
  1920x1080 30 1920 2008 2052 2200 1080 1084 1089 1125 74250 flags: phsync, pvsync;
type: driver
  1920x1080 25 1920 2448 2492 2640 1080 1084 1089 1125 74250 flags: phsync, pvsync;
type: driver
  1920x1080 24 1920 2558 2602 2750 1080 1084 1089 1125 74250 flags: phsync, pvsync;
type: driver
  1280x720 60 1280 1390 1430 1650 720 725 730 750 74250 flags: phsync, pvsync; type:
driver
  1280x720 60 1280 1390 1430 1650 720 725 730 750 74250 flags: phsync, pvsync; type:
driver
  1280x720 50 1280 1720 1760 1980 720 725 730 750 74250 flags: phsync, pvsync; type:
driver
  1280x720 50 1280 1720 1760 1980 720 725 730 750 74250 flags: phsync, pvsync; type:
driver
  800x600 75 800 816 896 1056 600 601 604 625 49500 flags: phsync, pvsync; type: driver
  720x576 50 720 732 796 864 576 581 586 625 27000 flags: nhsync, nvsync; type: driver
  720x480 60 720 736 798 858 480 489 495 525 27000 flags: nhsync, nvsync; type: driver
  props:
        1 EDID:
                flags: immutable blob
                blobs:

                value:
                        00ffffffffffff004c2d920900000000
                        0a160103804627780aee91a3544c9926
                        0f5054bdef80714f81c0810081809500
                        a9c0b3000101023a801871382d40582c
                        4500a05a0000001e662156aa51001e30
                        468f3300a05a0000001e000000fd0018
                        4b0f5117000a20202020202000000fc
                        0053414d53554e470a20202020200152
                        020330f14d901f041305140312202122
                        07162309070783010000e2000f72030c
                        001000b82d20d0080140073f405090a0
                        011d80d0721c1620102c2580a05a0000
                        009e011d8018711c1620582c2500a05a
                        0000009e011d00bc52d01e20b8285540
                        a05a0000001e011d007251d01e206e28
                        5500a05a0000001e0000000000000097
        2 DPMS:
                flags: enum
                enums: On=0 Standby=1 Suspend=2 Off=3
                value: 0
        5 link-status:
                flags: enum
                enums: Good=0 Bad=1
                value: 0
        6 non-desktop:
                flags: immutable range
                values: 0 1
                value: 0
        19 CRTC_ID:
                flags: object
                value: 33
31      0       connected       DSI-1           52x86           1       30
  modes:
        name refresh (Hz) hdisp hss hse htot vdisp vss vse vtot)
  480x800 50 480 600 664 784 800 814 828 842 33000 flags: ; type: preferred, driver
  props:
        1 EDID:
                flags: immutable blob
                blobs:

                value:
        2 DPMS:
```

```
                flags: enum
                enums: On=0 Standby=1 Suspend=2 Off=3
                value: 0
        5 link-status:
                flags: enum
                enums: Good=0 Bad=1
                value: 0
        6 non-desktop:
                flags: immutable range
                values: 0 1
                value: 0
        19 CRTC_ID:
                flags: object
                value: 0

CRTCs:
id      fb      pos     size
33      0       (0,0)   (1280x720)
  1280x720 60 1280 1390 1430 1650 720 725 730 750 74250 flags: phsync, pvsync; type:
driver
  props:
        20 ACTIVE:
                flags: range
                values: 0 1
                value: 1
        21 MODE_ID:
                flags: blob
                blobs:

                value:
                        0a22010000056e05960572060000d002
                        d502da02ee0200003c00000005000000
                        4000000031323830783237323000000000
                        0000000000000000000000000000000000
                        00000000
        18 OUT_FENCE_PTR:
                flags: range
                values: 0 18446744073709551615
                value: 0
        25 GAMMA_LUT:
                flags: blob
                blobs:

                value:
        26 GAMMA_LUT_SIZE:
                flags: immutable range
                values: 0 4294967295
                value: 256

Planes:
id      crtc    fb      CRTC x,y        x,y     gamma size      possible crtcs
32      0       0       0,0             0,0     0               0x00000001
  formats: AR24 XR24 RG24 RG16 AR15 XR15 AR12 XR12 C8
  props:
        7 type:
                flags: immutable enum
                enums: Overlay=0 Primary=1 Cursor=2
                value: 1
        16 FB_ID:
                flags: object
                value: 0
        17 IN_FENCE_FD:
                flags: signed range
                values: -1 2147483647
                value: -1
        19 CRTC_ID:
                flags: object
```

```
                value: 0
        12 CRTC_X:
                flags: signed range
                values: -2147483648 2147483647
                value: 0
        13 CRTC_Y:
                flags: signed range
                values: -2147483648 2147483647
                value: 0
        14 CRTC_W:
                flags: range
                values: 0 2147483647
                value: 1280
        15 CRTC_H:
                flags: range
                values: 0 2147483647
                value: 720
        8 SRC_X:
                flags: range
                values: 0 4294967295
                value: 0
        9 SRC_Y:
                flags: range
                values: 0 4294967295
                value: 0
        10 SRC_W:
                flags: range
                values: 0 4294967295
                value: 83886080
        11 SRC_H:
                flags: range
                values: 0 4294967295
                value: 47185920
34      0       0       0,0             0,0     0               0x00000001
  formats: AR24 RG24 RG16 AR15 AR12 C8
  props:
        7 type:
                flags: immutable enum
                enums: Overlay=0 Primary=1 Cursor=2
                value: 0
        16 FB_ID:
                flags: object
                value: 0
        17 IN_FENCE_FD:
                flags: signed range
                values: -1 2147483647
                value: -1
        19 CRTC_ID:
                flags: object
                value: 0
        12 CRTC_X:
                flags: signed range
                values: -2147483648 2147483647
                value: 0
        13 CRTC_Y:
                flags: signed range
                values: -2147483648 2147483647
                value: 0
        14 CRTC_W:
                flags: range
                values: 0 2147483647
                value: 0
        15 CRTC_H:
                flags: range
                values: 0 2147483647
                value: 0
        8 SRC_X:
```

```
                flags: range
                values: 0 4294967295
                value: 0
        9 SRC_Y:
                flags: range
                values: 0 4294967295
                value: 0
        10 SRC_W:
                flags: range
                values: 0 4294967295
                value: 0
        11 SRC_H:
                flags: range
                values: 0 4294967295
                value: 0

Frame buffers:
id      size    pitch
```

In the above output, the following results can be seen:

- 2 encoders
  - DPI
  - DSI
- 2 connectors
  - HDMI-A-1
    - the related encoder is DPI (id 28)
    - HDMI cable status is "connected"
    - many resolutions are supported (through the edid data)
  - DSI-1
    - no encoder is connected to the DSI panel
    - a single resolution is supported (480x800)
- 1 CRTC
- 2 planes with various supported color formats

Note: id values may differ depending on the application display hardware configuration.

If you want to know more about DRM/KMS encoders, connectors, CRTCs and planes, please have a look at the presentations suggested in the To go further chapter.

4.1.3 Set a particular video mode

Using the **modetest -M stm** command (see Show display overall status), let's assume that the application returns the following results:

- the HDMI-A-1 is on connector id **29**, is **connected** and supports a resolution of **1280x720-50**.
- the CRTC is on id **33**

The command to set the **1280x720-50** video:

```
Board $> modetest -M stm -s 29@33:1280x720-50 -d
```

By using the modetest option **-d** (drop master after mode set) in the above command, the next DRM-based application that will start will detect the current video mode and use it directly. For instance, with Weston, use "mode=current" in the weston.ini file to set preferred DRM video mode with the above command and restart weston to use it.

4.1.4 Send a test pattern to a display connector

Using the **modetest -M stm** command (see Show display overall status), let's assume you have identified that:

- the HDMI-A-1 is on connector id **29**, is **connected** and supports a resolution of **1280x720-50**.
- the CRTC is id **33**

So the command to send a test pattern is:

```
Board $> modetest -M stm -s 29@33:1280x720-50
```

The SMPTE color bars test pattern[6] will appear on the HDMI screen.

If you want to test another DRM/KMS connector, simply change the connector and resolution values in the command (in the example below the connector id **31** is associated with the connector DSI-1 supporting the 480x800 mode)

```
Board $> modetest -M stm -s 31@33:480x800
```

4.1.5 Test the display of 2 layers

A test using 2 layers can be run using the **-s** and **-P** options. For instance, the following command displays a SMPTE color bars test pattern in full screen on a first layer and a 256x256 test pattern on a 2nd layer positionned on top of the 1st layer at coordinates (100, 100) in AR24-fourcc color format:

```
Board $> modetest -M stm -s 31@33:480x800 -P 34@33:256x256+100+100@AR24
```

If a 2 layer **DRM atomic mode**[7] display test is needed using the modetest option **-a**, use the following command:

```
Board $> modetest -M stm -s 31@33:480x800 -P 32@33:480x480@AR24 -P 34@33:256x256@AR24 -a
```

- Check the list of supported plane color formats by referring to the Show display overall status chapter.
- Two planes may not work on higher display resolutions or/and on small systems (low DDR...).

4.1.6 Test Vsync

The following command flips between 2 buffers: the SMPTE pattern and a black/white screen. The flip is synchronized with the display Vsync. The screen continuously blinks, and the framerate is displayed in the console:

```
Board $> modetest -M stm -s 31@33:480x800 -v
```

Example results:

```
~# modetest -M stm -s 31@33:480x800 -v
setting mode 480x800-50Hz@XR24 on connectors 31, crtc 33
freq: 50.16Hz
freq: 49.99Hz
freq: 49.99Hz
```

If you want to test the Vsync with the **DRM atomic mode**[7] thanks to the modetest option **-a**, use the following command:

```
Board $> modetest -M stm -s 31@33:480x800 -P 32@33:256x256@AR24 -v -a
```

4.2 kmscube (DRM/KMS OpenGLES GPU test tool)

The small application **kmscube** (rotating cube) provided by Mesa[8] demonstrates that the GPU is running on top of the DRM /KMS framework.

Here are useful kmscube commands:

```
Board $> systemctl stop weston    # required only if Weston is running
Board $> kmscube --help
Board $> kmscube
Board $> kmscube -A               # use drm/kms atomic modesetting and fencing

Board $> kmscube --mode=rgba      # rgba textured cube
Board $> kmscube --mode=nv12-2img # yuv textured (color conversion in shader)
Board $> kmscube --mode=nv12-1img # yuv textured (single nv12 texture)

Board $> kmscube -V /dev/video0   # camera preview on the cube. /!\ depends on the
camera or webcam available color formats
Board $> kmscube -V video.mkv     # video playback on the cube. /!\ performances could
be low depending on the video format
```

4.3 Tips

4.3.1 How to get the name and current status of a DRM connector

Use the following command to get the DRM connector names and associated status:

```
Board $> for p in /sys/class/drm/*/status; do con=${p%/status}; echo -n "${con#*/card?-
}: "; cat $p; done
```

Result example:

```
DSI-1: connected
HDMI-A-1: connected
```

5 How to trace and debug the framework

The objective of this chapter is to give methods to monitor, trace and debug the DRM/KMS framework.

5.1 How to monitor

5.1.1 How to monitor with modetest

You can get the running configuration with **modetest**, please refer to the Show display overall status chapter.

5.1.2 How to monitor with debugfs

The DRM/KMS framework provides information with the Debugfs.

```
Board $> ls /sys/kernel/debug/dri/0/
DSI-1  HDMI-A-1  clients  crtc-0  framebuffer  gem_names  internal_clients  name  state
```

Get the status with the command:

```
Board $> cat /sys/kernel/debug/dri/0/state
```

Result example:

```
~# cat /sys/kernel/debug/dri/0/state
plane[32]: plane-0
        crtc=crtc-0
        fb=36
                allocated by = weston
                refcount=2
                format=XR24 little-endian (0x34325258)
                modifier=0x0
                size=480x800
                layers:
                        size[0]=480x800
                        pitch[0]=1920
                        offset[0]=0
                        obj[0]:
                                name=0
                                refcount=3
                                start=00010177
                                size=1536000
                                imported=yes
        crtc-pos=480x800+0+0
        src-pos=480.000000x800.000000+0.000000+0.000000
        rotation=1
        normalized-zpos=0
        color-encoding=ITU-R BT.601 YCbCr
        color-range=YCbCr limited range
        user_updates=0fps
plane[34]: plane-1
        crtc=(null)
        fb=0
```

```
        crtc-pos=0x0+0+0
        src-pos=0.000000x0.000000+0.000000+0.000000
        rotation=1
        normalized-zpos=0
        color-encoding=ITU-R BT.601 YCbCr
        color-range=YCbCr limited range
        user_updates=0fps
crtc[33]: crtc-0
        enable=1
        active=1
        planes_changed=1
        mode_changed=0
        active_changed=0
        connectors_changed=0
        color_mgmt_changed=0
        plane_mask=1
        connector_mask=2
        encoder_mask=2
        mode: 0:"480x800" 50 33000 480 600 664 784 800 814 828 842 0x48 0x0
connector[29]: HDMI-A-1
        crtc=(null)
connector[31]: DSI-1
        crtc=crtc-0
```

More information related to debugfs are available in the Debugfs article.

5.1.3 How to monitor with /sys/class/drm

The DRM/KMS framework provides information from the **/sys/class/drm** directory.

```
Board $> ls /sys/class/drm
card0  card0-DSI-1  card0-HDMI-A-1  version
```

Examples of the available information:

- the status of a given connector (*connected* or *disconnected*). The following example gives the status of the DRM connector named "HDMI-A-1":

```
Board $> cat /sys/class/drm/card0-HDMI-A-1/status
connected
```

- the modes available on a given connector. The following example gives the available modes of the DRM connector named "DSI-1":

```
Board $> cat /sys/class/drm/card0-DSI-1/modes
480x800
```

5.1.4 How to monitor the display framerate

When an animation is running on the display, the related framerate can be monitored from the display driver level thanks to the command:

```
Board $> (while true; do export fps=`cat /sys/kernel/debug/dri/0/state | grep fps -m1
| grep -o '[0-9]\+'`; echo display ${fps}fps; sleep 4; done) &
```

The display framerate is then periodically output in the user console in "fps" (**f**rames **p**er **s**econd):

```
display 50fps
display 50fps
display 50fps
```

Notes:

- Stop monitoring the framerate with the command "kill -9 `ps -o ppid= -C sleep`".
- Adjust the framerate update period by modifying the "sleep" value (4 seconds in the example).
- Use the command "dmesg -n8" to mix both user and kernel console outputs.
- Debugfs configuration needs to be enabled.

The DRM/KMS framework does not offer natively a display framerate monitoring, the above solution is powered by the STMicroelectronics DRM/KMS implementation.

5.1.5 How to monitor the DMA-BUF and CMA memory usage

The DRM/KMS framework uses both DMA-BUF and CMA memory managers[9] as display dedicated buffers.

- CMA

```
Board $> cat /proc/meminfo | grep -i cma
```

Result example:

```
CmaTotal:         131072 kB
CmaFree:           85644 kB
```

- DMA-BUF

```
Board $> cat /sys/kernel/debug/dma_buf/bufinfo
```

Result example:

```
Dma-buf Objects:
size            flags           mode            count           exp_name
03522560        00000002        00080007        00000005        galcore
        Attached Devices:
        5a001000.display-controller
Total 1 devices attached

03522560        00000002        00080007        00000005        galcore
        Attached Devices:
        5a001000.display-controller
Total 1 devices attached

03522560        00000002        00080007        00000005        galcore
        Attached Devices:
        5a001000.display-controller
Total 1 devices attached
```

```
03686400        00000002        00080007        00000006        galcore
        Attached Devices:
        5a001000.display-controller
Total 1 devices attached

03686400        00000002        00080007        00000006        galcore
        Attached Devices:
        5a001000.display-controller
Total 1 devices attached

03686400        00000002        00080007        00000006        galcore
        Attached Devices:
        5a001000.display-controller
Total 1 devices attached

03686400        00000002        00080007        00000006        galcore
        Attached Devices:
        5a001000.display-controller
Total 1 devices attached


Total 7 objects, 25313280 bytes
```

5.2 How to trace

5.2.1 Enable DRM/KMS traces with the sysfs

The DRM/KMS traces can be enabled / disabled dynamically using the sysfs debug entry (**/sys/module/drm/parameters/debug**). The DRM/KMS traces are directed to the dmesg log.

The debug value to set is an OR combination of some debug levels defined in include/drm/drm_print.h . See below an extract of this file:

```
/*
 * The following categories are defined:
 *
 * CORE: Used in the generic drm code: drm_ioctl.c, drm_mm.c, drm_memory.c, ...
 *         This is the category used by the DRM_DEBUG() macro.
 *
 * DRIVER: Used in the vendor specific part of the driver: i915, radeon, ...
 *           This is the category used by the DRM_DEBUG_DRIVER() macro.
 *
 * KMS: used in the modesetting code.
 *        This is the category used by the DRM_DEBUG_KMS() macro.
 *
 * PRIME: used in the prime code.
 *          This is the category used by the DRM_DEBUG_PRIME() macro.
 *
 * ATOMIC: used in the atomic code.
 *          This is the category used by the DRM_DEBUG_ATOMIC() macro.
 *
 * VBL: used for verbose debug message in the vblank code
 *          This is the category used by the DRM_DEBUG_VBL() macro.
 *
 * Enabling verbose debug messages is done through the drm.debug parameter,
 * each category being enabled by a bit.
 *
 * drm.debug=0x1 will enable CORE messages
 * drm.debug=0x2 will enable DRIVER messages
 * drm.debug=0x3 will enable CORE and DRIVER messages
 * ...
```

```
 * drm.debug=0x3f will enable all messages
 *
 * An interesting feature is that it's possible to enable verbose logging at
 * run-time by echoing the debug value in its sysfs node:
 *   # echo 0xf > /sys/module/drm/parameters/debug
 */
```

Examples:

- Enable all the DRM/KMS logs:

```
Board $> echo 0xff > /sys/module/drm/parameters/debug
```

- Enable only driver DRM/KMS logs:

```
Board $> echo 0x02 > /sys/module/drm/parameters/debug
```

- Disable all DRM/KMS logs:

```
Board $> echo 0 > /sys/module/drm/parameters/debug
```

5.2.2 Enable DRM/KMS traces with the kernel dynamic debug

It is possible to have a partial or full trace of the DRM/KMS driver with the kernel dynamic debug.

5.3 How to debug

5.3.1 Errors

Errors are unconditionnaly traced in the kernel dmesg log.

```
Board $> dmesg
[ 2898.424338] [drm] ltdc fifo underrun: please verify display mode
```

6 Source code location

6.1 Kernel space

Hereafter a list of the most important DRM/KMS Linux kernel source code locations:

- DRM/KMS Linux kernel:
  - main source code in drivers/gpu/drm directory .
  - panel drivers in drivers/gpu/drm/panel directory .
  - bridge drivers (drivers/gpu/drm/bridge directory) .
  - stm drivers in drivers/gpu/drm/stm directory .

- DRM/KMS upstream:
  - DRM kernel graphics driver development tree.
  - Kernel DRM miscellaneous fixes and cross-tree changes.

6.2 User space

Hereafter a list of the most important DRM/KMS user space libraries source code locations:

- DRM/KMS libraries official git: libdrm Direct Rendering Manager library and headers.
  - libkms.
  - modetest.

7 To go further

You can find good overviews of the DRM/KMS framework in the following presentations:

- "DRM Driver Development For Embedded Systems", Inki Dae, 2011.
- "The DRM/KMS subsystem from a newbie's point of view", Boris Brezillon, 2014.
- "Kernel Recipes 2017 - An introduction to the Linux DRM subsystem", Maxime Ripard, 2017.

You can also refer to the official DRM/KMS documentation:

- "Linux GPU Driver Developer's Guide" and the following sub-chapters:
  - Userland Interfaces.
  - Kernel Mode Setting.

8 References

- Direct Rendering Manager article on Wikipedia
- Kernel Mode Setting article on Wikipedia
- 3.03.1 libdrm source code and documentation
- Linux GPU Driver Developer's Guide / Userland interfaces
- Linux GPU Driver Developer's Guide / DRM Internals
- SMPTE Color Bars test pattern on Wikipedia
- 7.07.1 Linux GPU Driver Developer's Guide / Kernel Mode Setting (KMS) / Atomic Mode Setting
- kmscube source code in Mesa
- Linux GPU Driver Developer's Guide / DRM Memory Management

Direct Rendering Manager (kernel module that gives direct hardware access to DRI clients, find more information on official DRI web site http://dri.freedesktop.org/wiki/DRM)

Kernel Mode Setting

High-Definition Multimedia Interface (HDMI standard)

Display Serial Interface (MIPI® Alliance standard)

Graphics Processing Units

Open Graphics Library for Embedded System (See http://www.khronos.org/opengles/ for more details)

Application programming interface

Direct Rendering Infrastructure (Linux framework for allowing direct access to graphics hardware... find more information on official DRI web site http://dri.freedesktop.org/wiki/FrontPage)

LCD TFT Display Controller (STM32 specific)

Mobile Industry Processor Interface, open membership organization that includes leading companies in the mobile industry that share the objective of defining and promoting open specifications for interfaces inside mobile terminals, see MIPI® Alliance standard web site https://www.mipi.org

Display Pixel Interface (MIPI® Alliance standard)

Extended Display Identification Data (HDMI standard)

Frame Buffer (could be the Kernel framebuffer linked to the display, a GPU framebuffer, an imaging framebuffer...)

Doubledata rate (memory domain)

Debug File System (See https://en.wikipedia.org/wiki/Debugfs for more details)

BlueTooth

Direct Memory Access

System File System (See https://en.wikipedia.org/wiki/Sysfs for more details)