drm_hwcomposer

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What is a Hardware Composer?
Layers of buffers

Image from https://source.android.com/ under the Creative Commons Attribution 3.0 license
Displaying buffers

Buffer → GPU → Display
Displaying buffers

Buffer → GPU → Display
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Displaying buffers

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Buffer → GPU → Display
History/Background
framebuffer_device_t

Originally part of the gralloc code

Structure to access the fbdev

Provided a post() hook to post a frame-buffer to the display
HWC1 (ICS)

Started as HAL for accelerated composition, utilizing overlays and 2d-blitters

Simple interface: prepare(), set(), vsync()
Android Sync (Jellybean)

Tool for explicit ownership and management of buffers as they move through the graphics pipeline

Conceptually similar to condition-variables

Allows different parts of the graphics pipeline (gpu, hwcomposer, display controller) to track when a buffer is ready to be displayed or has finished being displayed.
Single Buffering

GPU → Buffer → Display
Single Buffering

GPU

Display

Buffer
Tearing

GPU → Buffer → Display
Tearing

[Image]

Tear Point #1 --->

By Vanessaezekowitz - Own work, CC BY-SA 3.0, [https://commons.wikimedia.org/w/index.php?curid=7437859](https://commons.wikimedia.org/w/index.php?curid=7437859)
Double Buffering

GPU

Buffer

Buffer

Display
Double Buffering

GPU

Display

Buffer

Buffer
It's complicated
It's even more complicated
It's even more complicated
Triple Buffering

- GPU
- Display Setup
- Display On Screen
- Buffer
- Buffer
- Buffer
Triple Buffering

- GPU
- Display Setup
- Display On Screen

Buffers:
- Buffer
- Buffer
- Buffer
Triple Buffering

GPU

Display Setup

Display On Screen

Buffer

Buffer

Buffer
Triple Buffering

- GPU
- Display Setup
- Display On Screen

Buffers:
- Buffer
- Buffer
- Buffer
Ideally

- GPU
- Display Setup
- Display On Screen
- Buffer
- Buffer
- Buffer
Ideally

- GPU
- Display Setup
- Display On Screen
- Buffer
- Buffer
- Buffer
Android Sync Concepts

sync_timeline:

1  2  3  ...  ...  ...  16  17  18  19

sync_fence:

sync_pt: 2  8

6  7  8  ...  ...  ...  33  34  35  36
ADF - Atomic Display Framework (Lollipop)

Allowed for atomic changes to the display settings - all or nothing
- Avoids tearing, glitches, & getting into bad hardware states

API tied together with Sync points, allows for buffers to be marked ready and then after display marked as released.
Background Layer
(View-port crop RGBA8888)

Launcher UI
(Alpha Blended RGBA8888)

Navigation Bar
(Alpha Blended RGBA8888)

Status Bar
(Alpha Blended RGBA8888)

Picture in Picture
(Alpha Blended RGBA8888)

Picture in Picture
(Secure Buffer YV12)

Picture in Picture UI
(Alpha Blended RGBA8888)

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Navigation Bar
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Background Layer
(View-port crop RGBA8888)
GPU Squished Scene
(RGBA8888)

Picture in Picture UI
(Alpha Blended RGBA8888)

Picture in Picture
(Secure Buffer YV12)

Status Bar
(Alpha Blended RGBA8888)

Credit: By AOSP - Screenshot, Apache License 2.0, https://commons.wikimedia.org/w/index.php?curid=50949458
GPU Squished Scene (RGBA8888)

[View-port crop property not atomically removed]

Picture in Picture UI (Alpha Blended RGBA8888)

Picture in Picture (Secure Buffer YV12)

Status Bar (Alpha Blended RGBA8888)

Whoops, still has crop property
HWC2 (Nougat)

Increased the interface complexity (now 43 methods!)

Moved to non-speculative fencing ("buffer content no longer needed" to "buffer content is displayed")

Additional support for multiple displays
DRM Fences (landed ~v4.6)

context:

sync_file:

fence:
Atomic KMS/DRM (~v4.10)

High-level equivalent to Android’s ADF, but properly upstream

Allows for all-or-nothing changes to display settings

Signaled via DRM fences

Landed in 4.10 in the kernel (backported to android-4.9)
drm_hwccomposer
 DRM HWComposer

- HWC implementations, started by ChromeOS team
- Uses the kernel KMS/DRM interfaces
- HWC1 implementation shipped on the PixelC
- HWC2 implementation created, utilizing Atomic KMS interfaces, but never shipped
- Picked up by RobertFoss, RobHerring, and other community members
- Working on QEMU (virgil), db410c, db820c, raspi3, hikey, hikey960, + others.
- [https://gitlab.freedesktop.org/drm-hwcomposer/drm-hwcomposer](https://gitlab.freedesktop.org/drm-hwcomposer/drm-hwcomposer)
drm_hwcomposer goals

Validate Atomic DRM/KMS

Provide a working default HWC implementation (replace fbdev)

- Minimize system specific portions of HWC (Importer and Planner).
- Allow systems to share the rest - fairly complicated logic

Motivate vendors to converge to DRM/KMS display solutions
drm_hwcomposer limitations

- Requires v4.10 (or android-4.9) or newer kernels
- Fancy pre-compositor work done by ChromeOS team dropped as it wasn’t used by anyone.
- Current supported drivers are very simple compared to shipping vendor implementations.
- Importer and Planner are also tied closely to gralloc implementations (currently gbm_gralloc, hisi_grallocs, and minigbm_gralloc).
- Needs a lot of cleanup and generalization
drm_hwcomposer TODO

Major cleanup needed in Validate/Plan logic

Look at reimplementing Planner optimizations around squishing planes that don’t change.

Writeback support

Wider support of more advanced hardware
All are freedesktop.org hosted projects.

Recently updated AOSP projects to be closer to upstream

Work being done to upstream AOSP changes, and keep AOSP more closely aligned with upstream.

But this becomes more difficult to do as more shipping devices utilize these libraries
Possible Futures
Google deprecated ADF

From upstream perspective, Atomic KMS/DRM is the direction to go forward with.

Many vendors unfortunately still do their own thing, utilizing legacy fbdev drivers

Atomic KMS/DRM may have some functionality limits & we need to address them

Need vendors to start migrating to help find and address those issues

Plans to use drm_hwcomposer_to prototype Nextgen HWC/Gralloc
Design

SurfaceFlinger ➔ HWC

GL Fallback Compositor

Draw these 6 layers

I can only do 4

Ok, here’s 4 layers

HWC ➔ Display Driver

Negotiation

Ok, here’s 4 layers
In Practice

SurfaceFlinger

GL Fallback Compositor

Draw these 6 layers

Ok

HWC

Hardware optimized GL Compositor

Negotiation

Ok, here’s 4 layers

Display Driver
drm_hwcomposer previously

SurfaceFlinger

GL Fallback Compositor

Draw these 6 layers

Ok

negotiation

negotiation

Pre-Compositor

negotiation

Ok, here’s 4 layers
Current drm_hwcomposer

SurfaceFlinger

GL Fallback Compositor

Draw these 6 layers

I can only do 4

Ok, here’s 4 layers

drm_hwc

Planner

Negotiation

Ok, here’s 4 layers

DRM Driver
Current drm_hwcomposer

SurfaceFlinger

GL Fallback Compositor

Drum hwc

Planner

Draw these 6 layers

I can only do 4

Ok, here's 4 layers

Negotiation

Ok, here's 4 layers

DRM Driver
Current DRM HW composer

SurfaceFlinger

GL Fallback Composer

DRM Driver

Draw these 6 layers

I can only do 4

Ok, here's 4 layers

Ok, here's 4 layers

Negotiation

I can only do 4

Ok, here's 4 layers

Negotiation
Potential future???

Ok, here's 4 layers

- Negotiation
- SurfaceFlinger
  + drm_hwcomposer
  ?
- GL Fallback Compositor

Ok, here's 4 layers
Potential future???

Ok, here’s 4 layers

Negotiation

SurfaceFlinger + drm_hwcomposer?

Ok, here’s 1 layer

Ok, here’s 4 layers

DRM Driver

Planner

Hardware Optimized GPU Compositor

Squish 3 layers

Negotiation
Suggestions

● **Stop using fbdev** drivers & migrate to DRM/KMS drivers

● **Work with community** to get DRM infrastructure expanded to fully support your device needs!

● Send your display developers to XDC! - [https://xdc2018.x.org/](https://xdc2018.x.org/)

● **Upstream those DRM drivers!**
Credits

Eric Gilling’s LPC13 talk:  https://www.youtube.com/watch?v=rhNRItGn4-M

Greg Hackmann’s LPC13 talk:  https://www.youtube.com/watch?v=3wFqXysISQg

Marissa Wall, Sean Paul & Zach Reizner’s LPC16 talk:

Marissa Wall, Sean Paul & Nat Duca’s Prototyping Nextgen HWC/Gralloc via drm_hwcomposer doc:
https://docs.google.com/document/d/1wtkB2w2GL_oRJn4bHGvtF27wgv-EiYj5kF8KQtaBHI0/edit#

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Thank you!

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