GENERIC ALLOCATOR IN NOUVEAU

James Jones, XDC 2019

NVIDIA

OVERVIEW

Allocator Review

What Changed?

Implementation in Nouveau

Results and Next Steps

ALLOCATOR REVIEW

HIGH-LEVEL GOALS

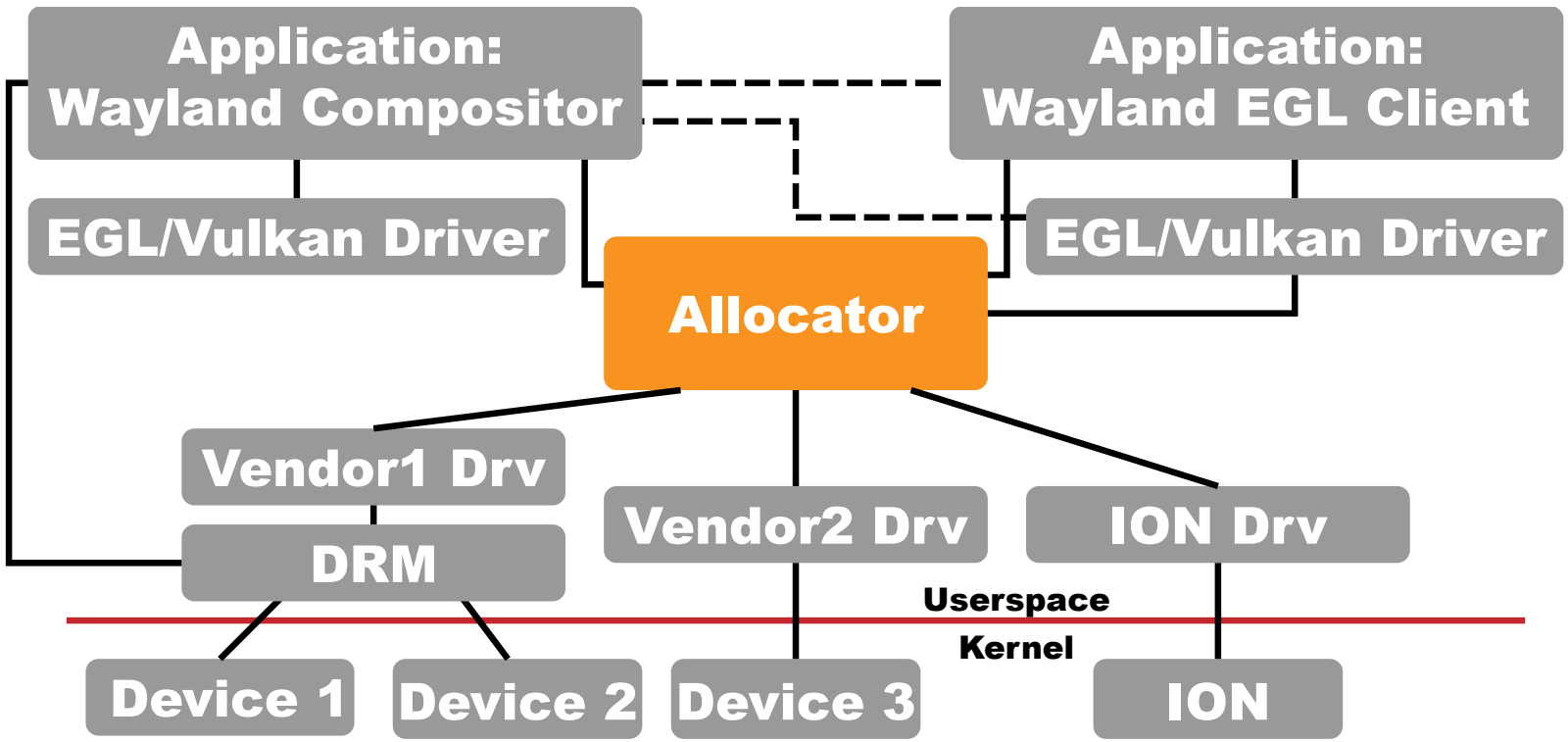
Arbitrate allocation properties across multiple devices and ”engines”/usages

Support for broad set of engines – Not a ”graphics” or “3D” API

Support Vendor-specific capabilities, including fully opaque capabilities

Support image usage “transitions”

ALLOCATOR'S SPOT IN THE ECOSYSTEM



ALLOCATOR OBJECTS

ASSERTION

The desired width, height, and format of a surface

USAGE

A single desired application of a surface, such as rendering, on a single device

CONSTRAINT

An imposed surface limitation for a given assertion and usage

CAPABILITY

A supported surface feature for a given assertion and usage

CAPABILITY SET

A valid combination of constraints and capabilities

USAGE TRANSITIONS

Vulkan introduced the idea of explicitly transitioning between various surface uses

Could be generalized across devices now that we can describe all usage explicitly

Apps could query usage transition “meta-data” from allocator for usage pairs

That meta-data could then be passed into GPU APIs to perform transitions

WHAT CHANGED?

FEEDBACK

Where do DRM Format Modifiers fit into this?

Why not use existing APIs to describe usage and report capabilities?

Should the allocator build upon GBM or be a new API?

Is this project still a thing?

RE-EVALUATE HIGH-LEVEL GOALS

Arbitrate allocation properties across multiple devices and ”engines”/usages

- Support only intersection of capabilities, not union of constraints

Support for broad set of engines – Not a ”graphics” or “3D” API

- API-agnostic building blocks. Relies on Graphics APIs for some features

Support Vendor-specific capabilities~~, including fully opaque capabilities~~

- All participating driver components must be aware of capability to make use of it

Support image usage “transitions”

- Re-allocation still expensive, wasteful. Optimal steady-state still important

ALLOCATOR OBJECTS

ASSERTION

The desired width, height, and format of a surface

USAGE

A single desired application of a surface, such as rendering, on a single device

CONSTRAINT

CAPABILITY

A supported surface feature for a given assertion and usage

CAPABILITY SET

NEW ALLOCATOR CONCEPT MAPPINGS

ASSERTION - VULKAN/GL/GBM IMAGE CREATION PARAMETERS

The desired width, height, and format of a surface

USAGE – VULKAN IMAGE CREATION PARAMS, DRM, GL, ETC.

A single desired application of a surface, such as rendering, on a single device

CAPABILITY LIST – SINGLE DRM FORMAT MODIFIER

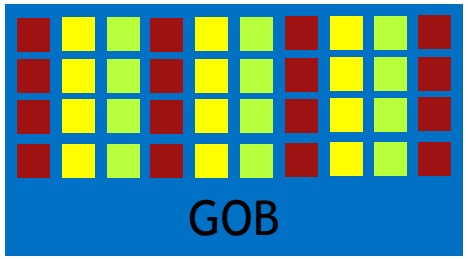
A set of supported surface features for a given assertion and usage. Constraints not expressed

USAGE TRANSITIONS – SWITCH FORMAT MODIFIERS IN PLACE

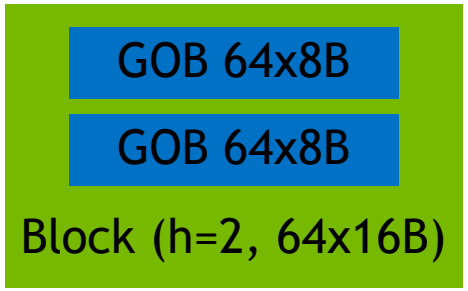
Driver reports “compatible” modifiers. Driver deduces necessary transition from modifier pair

IMPLEMENTATION IN NOUVEAU

THE BLOCK LINEAR TILING FORMAT

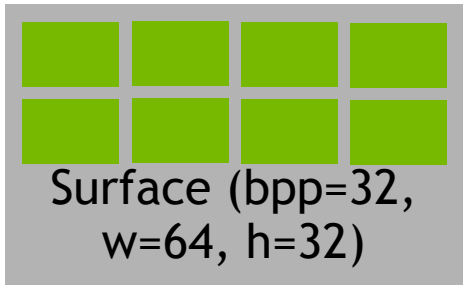


Blocks made up of 1+ GOBs, or “Groups of Bytes”



Block dimensions can vary in width, height, and depth

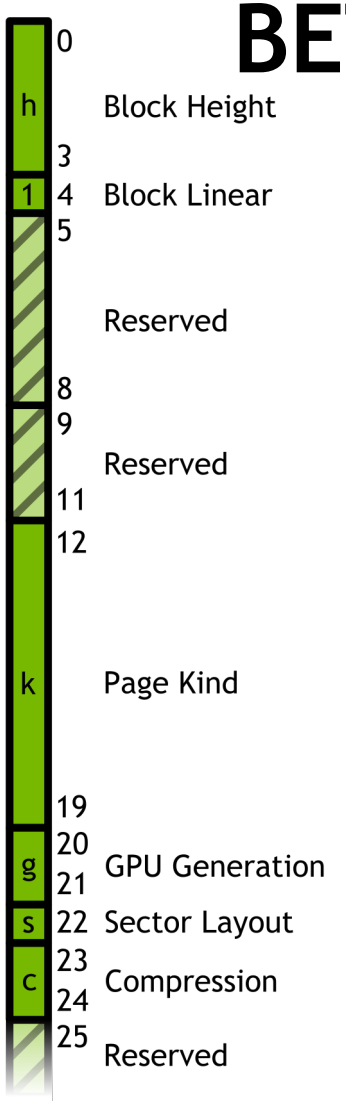
Block width, height, and depth must be a power of 2



Byte layout in GOBs varies by “Page Kind”, and by GPU family

BETTER NVIDIA FORMAT MODIFIERS

Block-Linear is complicated, but finite



DRM_FORMAT_MOD_NVIDIA_BLOCK_LINEAR_2D(c, s, g, k, h)

Backwards-compatible with DRM_FORMAT_MOD_NVIDIA_16BX2_BLOCK()

Uniquely defines surface layout down to bit level across all shipping NVIDIA GPUs

Reserves fields for more complex surfaces in the future

In practice, block width is always 1, depth 1 for 2D surfaces

Few “Page Kind” values used for single-sample 2D color surfaces

Max ~24 modifiers per GPU

WIRED UP FORMAT MODIFIERS

Existing Mesa Nouveau format modifier support was limited

Only useful for sharing buffers between Mesa and TegraDRM

Added format modifier support to Nouveau DRM-KMS for Tesla through Turing

Added support for new format modifier layout to TegraDRM

Added support for setting EGLImage GEM buffer layout from format modifier on nvc0

Added support for compressed layout format modifiers in Mesa nvc0 driver

EXPOSED USAGE TRANSITIONS

[EGL,GL]_EXT_transition_format_modifier

```
// Query a list of format mods a given “source” mod can be transitioned to
eglQueryDmaBufCompatibleModifiersEXT(EGLDisplay dpy, EGLuint64KHR srcMod,
                                     EGLint *maxDstMods, EGLuint64KHR *dstMods,
                                     EGLint *numDstMods);


// Transition layout from one modifier to another
glTransitionFormatModifierEXT(GLbitfield mask, GLuint64 dstMod, GLuint64 srcMod);
```

”mask” is similar to glClear(), but limited to color buffer for now

Could use multi-buffer and/or DSA versions as well

When intersecting two format modifier lists, allow modifiers only in one list if a compatible modifier is in the other list

IMPLEMENTED USAGE TRANSITIONS

NVIDIA 3D hardware supports internal lossless compression for most common formats

Enabled globally for a 3D engine instance, as well as per-mapping via “page kind”

NVIDIA display hardware does not support this compression

“compressed” page kinds can have corresponding uncompressed page kind

Newer hardware can transition between the two by decompressing in place:

- NV_A297_DECOMPRESS_SURFACE method
- Also “invalidates” compression. Transition back to “compressed” layout is a no-op

OTHER TRANSITIONS

Some NVIDIA Tegra engines also support a Color Decompression Engine (CDE) format

Tegra GPUs can translate GPU's compression data to CDE without decompressing

CDE treated as read-only mapping. Transition back to GPU compression still a no-op

Did not attempt to implement this in current patches

RESULTS AND NEXT STEPS

PERFORMANCE GAINS DEPEND ON USAGE

Modified kmscube to use compressed layouts, decompress-in-place

Performance comparable to non-compressed case, as expected, when decompressing

Performance 50-300% better when not decompressing

A further-modified kmscube that behaves like a composited desktop steady-state presentation workflow gains ~80% overall

NEXT STEPS

Collect Feedback and Review, Productize

Get format modifier layout reviewed & committed

Clean up mesa patches adding format modifiers, get reviewed & committed

Write extension spec for EXT_transition_format_modifier – Collect Feedback

Integrate support into Wayland protocols/compositors and client libraries

Implement equivalent support in our binary drivers

Tackle Other Allocator Issues…

OPEN ISSUES

Constraints – Fix bugs like https://gitlab.freedesktop.org/xorg/xserver/issues/895

Capability Set – Need association between modifier and its constraints

Vendor-agnostic dma-buf factory – Is this needed?

API-agnostic capability set generator – Is this needed?

Comptags – 19-bit identifiers for compression store of a page. Where to stash them?

Persistent Transitions – Requires modifying mappings or separate mappings

Protected content – property of memory (GEM buffer) or mapping (Format modifier)?

QUESTIONS?

REFERENCES

Nouveau Kernel tree: https://gitlab.freedesktop.org/cubanismo/linux

Nouveau Mesa tree: https://gitlab.freedesktop.org/cubanismo/mesa

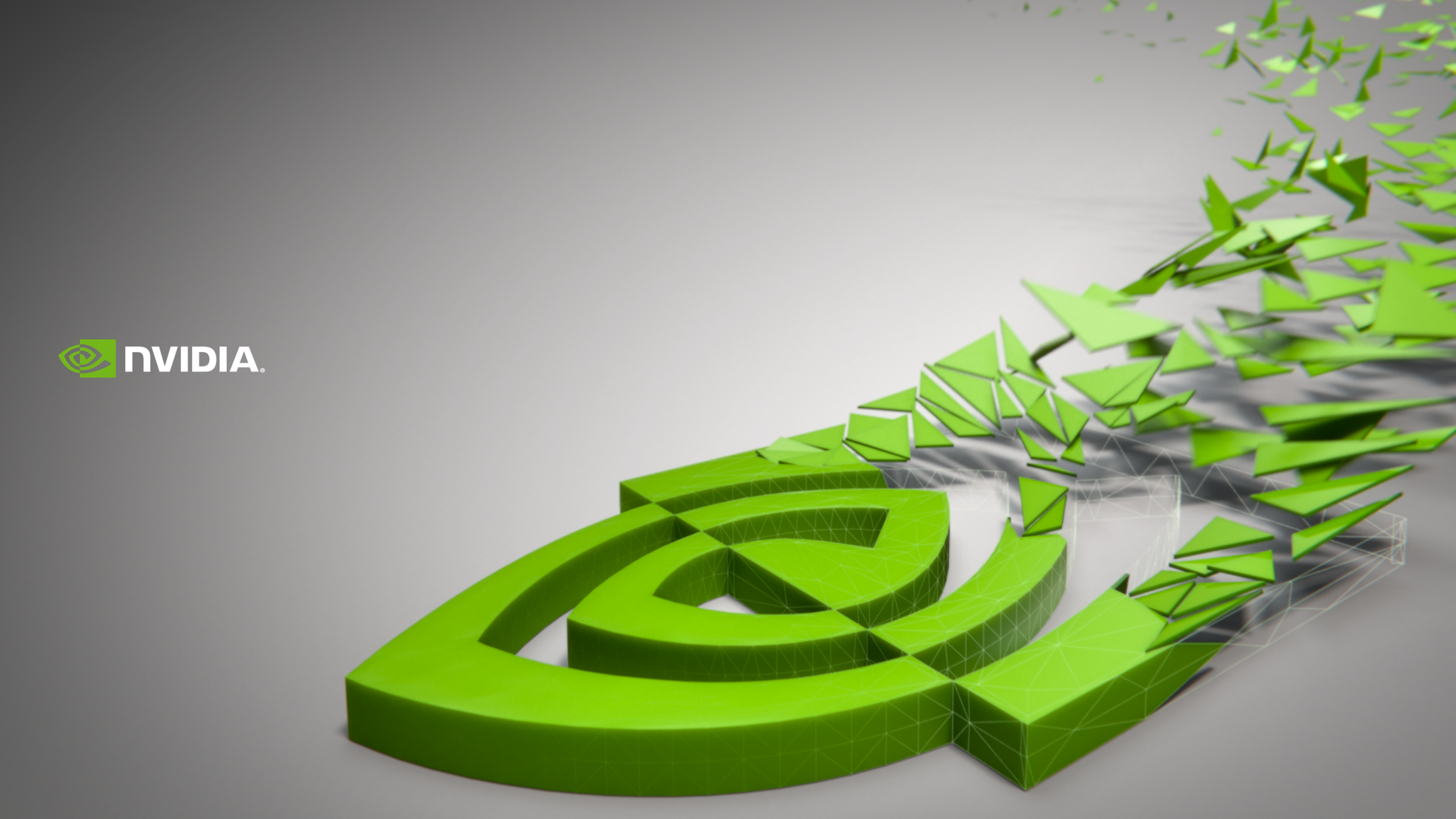
kmscube Testing tree: https://gitlab.freedesktop.org/cubanismo/kmscube

Original allocator prototype: https://gitlab.freedesktop.org/allocator/allocator

XDC 2017 Allocator Talk:

https://www.x.org/wiki/Events/XDC2017/Program/#james_jones

XDC 2016 Allocator Talk:
https://www.x.org/wiki/Events/XDC2016/Program/jones_unix_device_mem_alloc/


NVIDIA