GENERIC ALLOCATOR UPDATE

James Jones, XDC 2017

NVIDIA

OVERVIEW

Current Design

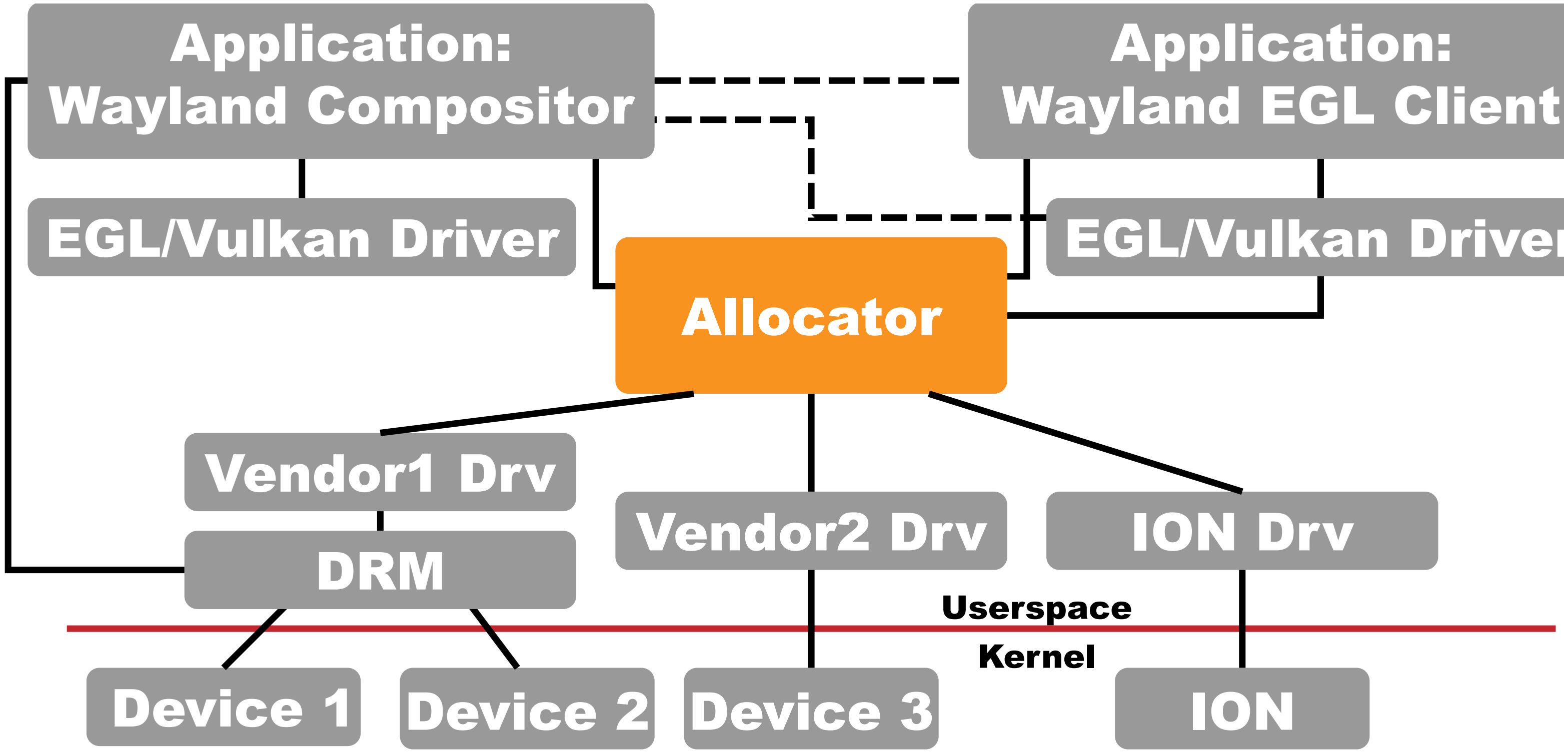
Prototype Status

Problems Encountered

Next Steps

CURRENT DESIGN

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

CURRENT WORKFLOW

Based on USAGE.md on github project

1. Initialize an allocator device from a device file descriptor
2. Query capability sets from the device given an assertion and list of usages
3. [Optional] Query capability sets from additional devices with the same parameters
4. [Optional] Merge capability sets of desired devices to find common capabilities
5. Try allocating a surface on available devices until allocation succeeds
6. Import surfaces to graphics APIs, mode setting APIs, video APIs, etc.

PROTOTYPE STATUS

SUPPORTED/PLANNED FUNCTIONALITY

Goal is to Encourage and Substantiate Design Discussion

Creating Devices – **IMPLEMENTED**

Querying Capabilities and Constraints – **IMPLEMENTED**

Merging Capabilities and Constraints - **IMPLEMENTED**

Creating Allocations from Capabilities and Constraints - **IMPLEMENTED**

Exporting/Importing Allocations – **TODO**

Using Allocations in Vulkan/OpenGL - **TODO**

Using Allocations in DRM/Non-Graphics Devices - **TODO**

CAPABILITY SET MATH

Core of the Design

Current set derivation algorithm: merge/union constraints, intersect capabilities

Capabilities can be “required”. If operation removes a required capability, it fails

Needs more validation. Throw your worst usage/constraints/capabilities at it!

CAPABILITY SET MATH EXAMPLE

DEV_1 SET 1 [A]

Constraints:

1. Address aligned to 32B

Capabilities:

1. NVIDIA tiling/layout (*)
2. NVIDIA FB compression

DEV_1 SET 2 [B]

Constraints:

1. Address aligned to 64B

Capabilities:

1. pitch-linear layout (*)

DEV_2 SET 1 [C]

Constraints:

1. Address aligned to 32B
2. Pitch aligned to 64B

Capabilities:

1. Pitch-linear layout (*)
2. Dev2 FB compression

CAPABILITY SET MATH EXAMPLE

DEV_1 SET 1 [A]

Constraints:

1. Address aligned to 32B

Capabilities:

1. ~~NVIDIA tiling/layout (*)~~
2. ~~NVIDIA FB compression~~

+

DEV_2 SET 1 [C]

Constraints:

1. Address aligned to 32B
2. Pitch aligned to 64B

Capabilities:

1. ~~Pitch-linear layout (*)~~
2. ~~Dev2 FB compression~~

=

FAIL!

Constraints:

1. Address aligned to 32B
2. Pitch aligned to 64B

Capabilities:

CAPABILITY SET MATH EXAMPLE

DEV_1 SET 2 [B]

Constraints:

1. Address aligned to 64B

Capabilities:

1. pitch-linear layout (*)

+

DEV_2 SET 1 [C]

Constraints:

1. Address aligned to 32B
2. Pitch aligned to 64B

Capabilities:

1. Pitch-linear layout (*)
2. ~~Dev2 FB compression~~

=

NEW VALID SET

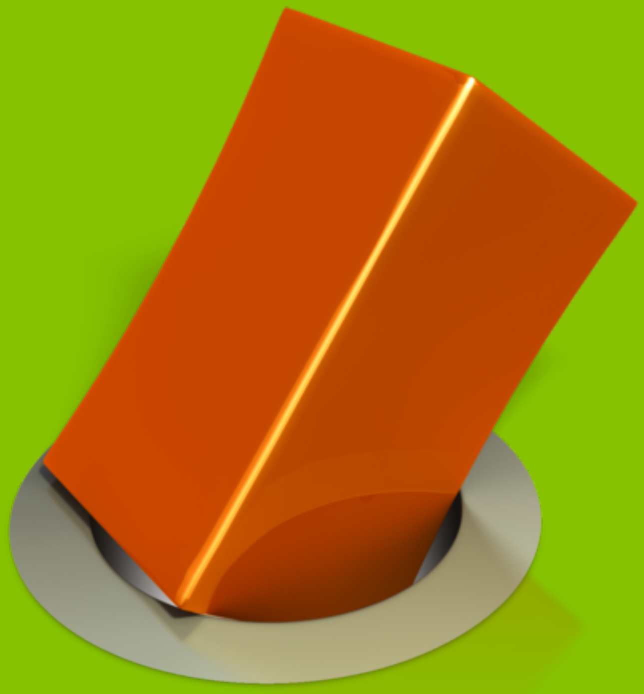
Constraints:

1. Address aligned to 64B
2. Pitch aligned to 64B

Capabilities:

1. Pitch-linear layout (*)

PROBLEMS ENCOUNTERED



DEVICE ENUMERATION/CREATION/IMPORT

Device file doesn’t necessarily uniquely identify a logical device object

Device creation from FD implies lack of need for additional /dev/file access

Alternative of exporting devices from APIs is problematic too

Enumeration/Correlation using UUID from Vulkan/GL APIs would provide consistency

NO DEVICE-LOCAL CAPABILITIES

Ex: local caching

GPU may have on-chip cache. When to use it? When capabilities say so of course!

Other devices don't necessarily need to be aware of this cache usage

Intersecting capabilities from other devices will remove this "local cache" capability

FORMAT SPECIFICATION

Still an open issue that needs to be resolved. Prototype assumes RGBA8888

Khronos Data-format spec, FOURCC, ???

Needs to handle HDR formats

Should there be supported format enumeration?

IMPORT TO EXTERNAL APIS

Unlike Vulkan/OpenGL import APIs, additional meta-data is needed

How should that meta-data be packaged? DRM format modifiers not sufficient

Does the capability set suffice? If so, see issue with device-local capabilities

Is some level of in-kernel meta-data preferred? Limits future suballocation usage

RELATIONSHIP TO DMA-BUF

Unclear if it should be required that import/export consume/produce DMA-BUF FDs

Might bake Linux-specific assumptions into the API or usage

Even FDs can be non-portable

Any value in using DMA-BUF when usage is limited to a single device or driver stack?

NEXT STEPS

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 transitions “meta-data” from allocator for usage pairs

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

MOTIVATION FOR USAGE TRANSITIONS

Alternative proposal	Re-allocate when usage changes
Justification	Simpler API Steady-state is still optimal
Problems	Allocation can be expensive Transitions have consistent cost Usage may change at inconvenient times

USAGE TRANSITIONS (EXAMPLE)

```
// Some existing usage definitions
extern const usage_t samplingUsage;
extern const usage_t displayUsage;

// Usage lists
const usage_t sampling[] = { samplingUsage };
const usage_t samplingAndDisp[] =
  { samplingUsage, displayNVUsage };
const usage_t dispOnly[] = { displayUsage };
void *transitionData;
size_t transitionDataSize;

// Query a usage transition from an allocator library device
query_transition(dev,
                 ARRAYLEN(sampling), sampling,
                 ARRAYLEN(samplingAndDisp), samplingAndDisp,
                 &transitionDataSize, &transitionData);
```

USAGE TRANSITIONS (EXAMPLE)

```
// Program the transition in Vulkan
VkImageMemoryCrossDeviceBarrierEXT crossDeviceBarrierData = {
    VK_STRUCTURE_TYPE_IMAGE_MEMORY_CROSS_DEVICE_BARRIER_EXT, // sType
    NULL, // pNext
    transitionDataSize, // dataSize
    transitionData // data
};

VkImageMemoryBarrier usageTransitionBarrier = {
    VK_STRUCTURE_TYPE_IMAGE_MEMORY_BARRIER, // sType
    &crossDeviceBarrierData, // pNext, takes precedence over oldLayout/newLayout members

    ...
};

vkCmdPipelineBarrier(..., 1, &usageTransitionBarrier);
```

WAYLAND INTEGRATION

Getting Back to our Original Goal…

Last year NVIDIA presented a vendor-agnostic EGL winsys client integration layer API

The sample implementation used EGLStream, but the API is mechanism-agnostic

Key functionality: Ability to build an EGLSurface from some lower-level primitive

How do we build an EGLSurface from allocator surfaces?

WHERE DOES THE ALLOCATOR CODE GO?

The prototype is a stand-alone library with runtime-loadable driver backends

However, the key mechanisms could live anywhere

Is it easier to move to this new library, merge functionality into GBM, or ???

If we keep the allocator library, does it need a better name than liballocator?

QUESTIONS & ANSWERS?

QUESTIONS I ASKED:

1. Any situations capability set math does not handle?
2. How should device-local capabilities be handled?
3. How should formats be defined?
4. How should surface meta-data be represented?
5. Is DMA-BUF a requirement? If so, why?
6. How should EGLSurface integration work?
7. Where does the allocator implementation live?

https://github.com/cubanismo/allocator

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REFERENCES

https://github.com/cubanismo/allocator - Prototype Allocator Implementation & Documentation

https://github.com/cubanismo/allocator/blob/master/USAGE.md - Allocator Example Usage

https://www.khronos.org/registry/DataFormat/ - Khronos Data Format Spec

https://github.com/torvalds/linux/blob/master/include/uapi/drm/drm_fourcc.h - DRM FOURCC formats

https://www.khronos.org/registry/vulkan/specs/1.0-extensions/html/vkspec.html - Vulkan 1.0 spec