The Vulkan Profiles Toolset solution

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Vulkan®

Agenda

- A perspective on why Vulkan Profiles are relevant for Vulkan developers
- Presentation of the Vulkan Profiles Toolset components
- Tutorial on how to use the Vulkan Profiles Toolset components

Based on The Vulkan Profiles Toolset solution whitepaper

Expected audience for this presentation

- Developers who …
  - wrote some code with the Vulkan API.
  - know Vulkan Configurator workflow to setup Vulkan layers.
  - are interested in making sure the Vulkan application will run on end-user platforms.

Designing the Vulkan Profiles Toolset

Creating portable Vulkan Applications in terms of Vulkan capabilities

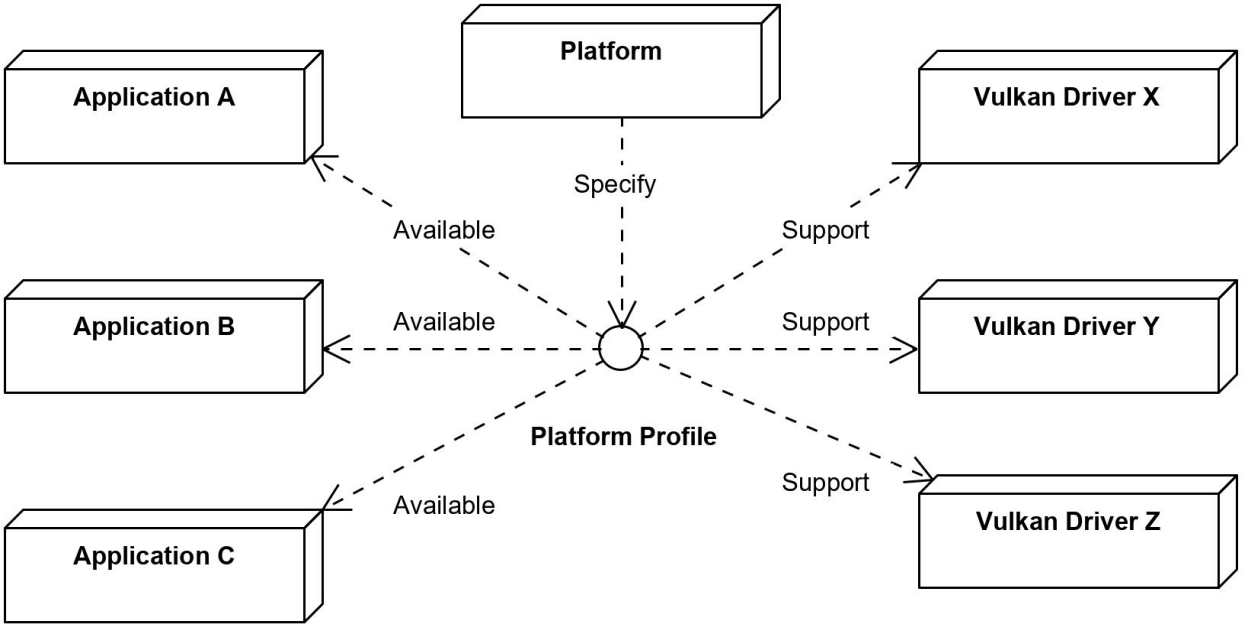
- *Vulkan Profiles: **Explicit** Vulkan capability requirements and/or supports.*
  - Nothing groundbreaking, just **a data convention** and **a toolset**.
  - Not targeting homogeneity of the ecosystem, specifying a domain of relevance.

- *Easier Vulkan development for a selected range of **actual** ecosystem devices.*
  - Making Vulkan Profiles usable from day one.

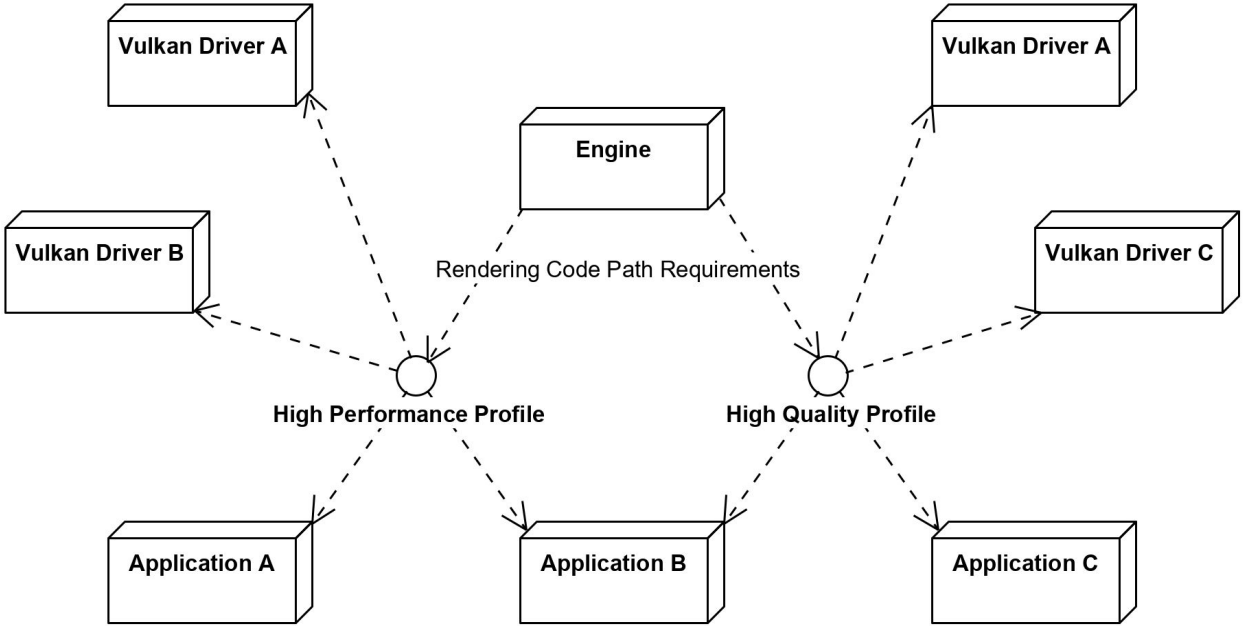
Vulkan Profiles usages:

- *Roadmap profiles*: to express guidance on the future direction of Vulkan devices.
- *Platform profiles*: to express the Vulkan support available on different platforms.
- *Device profiles*: to express the Vulkan support of a single Vulkan driver for a Vulkan device.
- *Architecture profiles*: to express the Vulkan support of a class of GPUs.
- *Engine profiles*: to express some rendering code paths requirements of an engine.
- Etc.

Examples of a Platform Profile



Examples of Engine Profiles



The Vulkan Profiles Toolset Components

The Vulkan Profiles Toolset Components

- The Vulkan Profiles schema
- The Vulkan Profiles comparison table
- The Vulkan Profiles layer
- The Vulkan Profiles library

Requires a Vulkan 1.0 driver that supports the `VK_KHR_get_physical_device_properties2` extension.

Delivered at BETA development stage.

The Vulkan Profiles Toolset Components

- The Vulkan Profiles schema
  - A JSON data format to communicate about Vulkan capabilities:
    - extensions, features, properties, formats, and queue properties.
  - Each revision of Vulkan API is represented by a schema that supersedes older versions of Vulkan API.
- The Vulkan Profiles comparison table
- The Vulkan Profiles layer
- The Vulkan Profiles library

The Vulkan Profiles Toolset Components

- The Vulkan Profiles schema
- The Vulkan Profiles comparison table
  - A markdown representation as a table of Vulkan Profiles to enable comparison.
- The Vulkan Profiles layer
- The Vulkan Profiles library

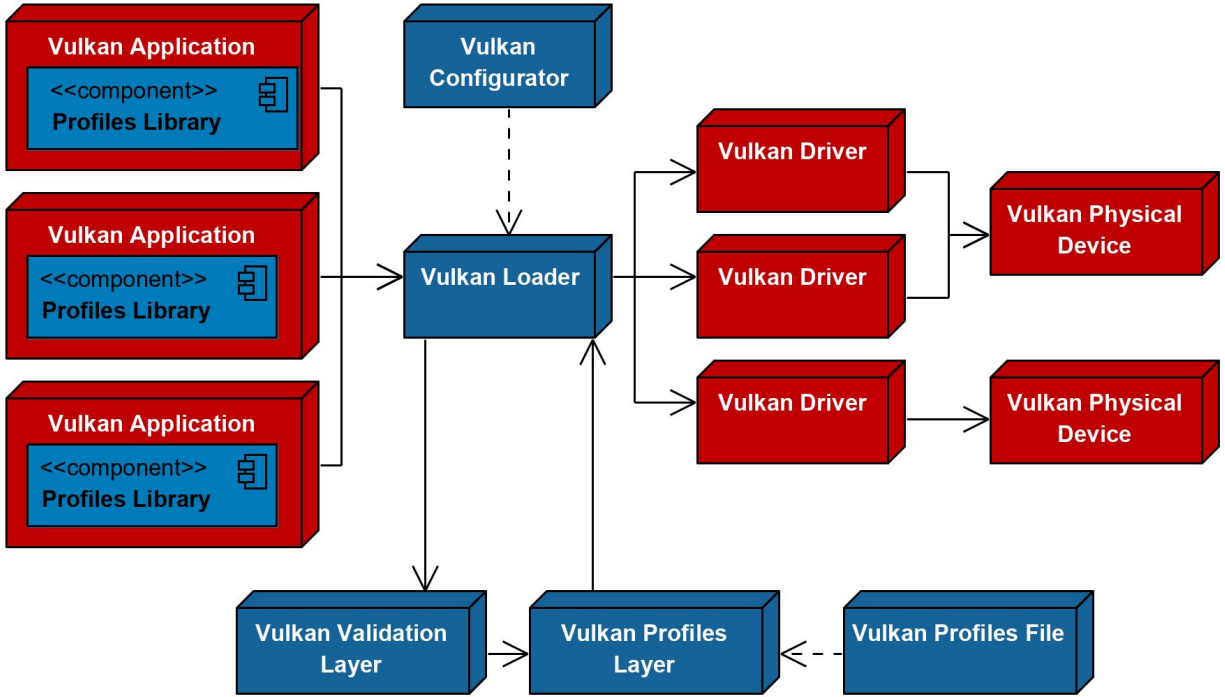
The Vulkan Profiles Toolset Components

- The Vulkan Profiles schema
- The Vulkan Profiles comparison table
- The Vulkan Profiles layer
  - Downgrade the Vulkan developer's system capabilities
  - Additional checking of the validity of a profile definition
- The Vulkan Profiles library

The Vulkan Profiles Toolset Components

- The Vulkan Profiles schema
- The Vulkan Profiles comparison table
- The Vulkan Profiles layer
- The Vulkan Profiles library
  - A header-only C++ library to use Vulkan Profiles in Vulkan applications.
  - Checking Profiles support on a device and creating a `VkDevice` instance with the profile features and extensions enabled.

Deployment of the Toolset components



Using the Vulkan Profiles schema

Content of Vulkan Profiles JSON files

- A collection of capability sets
  - Capabilities: extensions, features, properties, format properties, queue families properties
- A list of Vulkan Profiles referencing capabilities sets
  - Enable multiple Vulkan Profiles variants per file
- A specification of capabilities and the API we should use, eg:
  - VkPhysicalDeviceDescriptorIndexingFeaturesEXT
  - VkPhysicalDeviceDescriptorIndexingFeatures
  - VkPhysicalDeviceVulkan12Features
- There is a schema per Vulkan Header revision
  - To ensure that we don’t specify in the Profiles file unsupported capabilities for the required Vulkan API revision.

Vulkan Profiles file structure

```
{   "$schema": "https://schema.khronos.org/vulkan/profiles-0.8.0-204.json#",
    "capabilities": {
        "baseline": {
            "extensions": {},
            "features": {},
            "properties": {},
            "formats": {},
            "queueFamiliesProperties": []
        },
        "unused": {}
    },
    "profiles": {
        "VP_LUNARG_test_structure_complex": {
            "version": 1, "api-version": "1.2.198",
            "label": "LunarG Profiles Structure Complex unit test",
            "description": "For schema unit test on C.I.",
            "contributors": {},
            "history": [
            ],
            "capabilities": [
                "Baseline"
            ]
        }
    }
```

Finding the Vulkan Profiles JSON files

- In the Vulkan SDK package:
  - ${VULKAN_SDK}\Config\VK_LAYER_KHRONOS_profiles
- In Vulkan Profiles repository:
  - https://github.com/KhronosGroup/Khronos-Schemas/tree/main/vulkan
- On GPUInfo.org website:
  - Eg: https://vulkan.gpuinfo.org/displayreport.php?id=14151

Vulkan Schema Versioning

- profiles-0.8.0-204.json
  - 0.8 => Beta
  - 204 => Vulkan Header version
- profiles-0.8-latest.json

Finding the Vulkan Profiles Schemas

- In the Vulkan SDK package:
  - ${VULKAN_SDK}\share\vulkan\registry
- On Khronos Schemas website (Header 96 to latest):
  - https://schema.khronos.org/vulkan/
- On Khronos Schemas repository (Header 96 to latest):
  - https://github.com/KhronosGroup/Khronos-Schemas/tree/main/vulkan
- On Khronos Profiles repository (*latest.json only):
  - https://github.com/KhronosGroup/Vulkan-Profiles/tree/master/schema

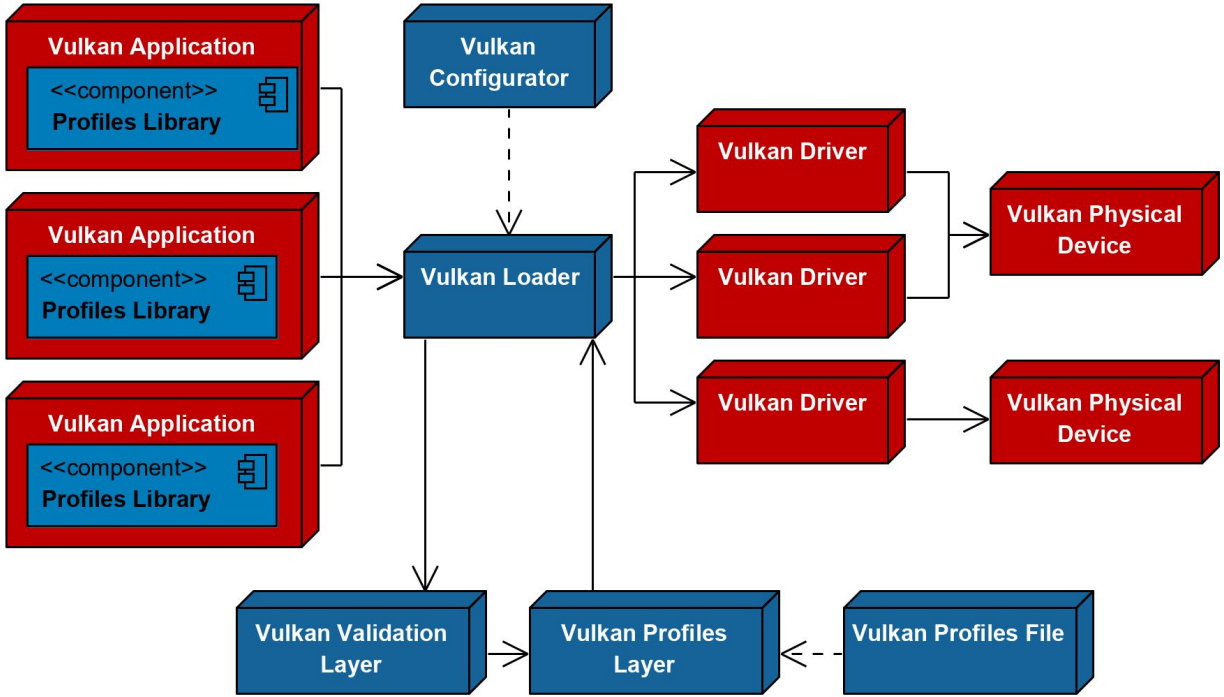
Validating the Roadmap 2022 JSON file. Demo…

Limitations of Vulkan Profiles schema validation

- The schema doesn’t handle duplicated capabilities within a block
  - Eg: runtimeDescriptorArray exists in:
    - VkPhysicalDeviceDescriptorIndexingFeaturesEXT
    - VkPhysicalDeviceDescriptorIndexingFeatures
    - VkPhysicalDeviceVulkan12Features
  - The Profiles layer will report messages if such a case occurs.
- The schema doesn’t handle old Vulkan version.
  - Eg: 1.1.204.
  - The Profiles layer will report messages if such a case occurs.
- The schema doesn’t support some capabilities:
  - memory types, surfaces, others?

Using the Vulkan Profiles layer

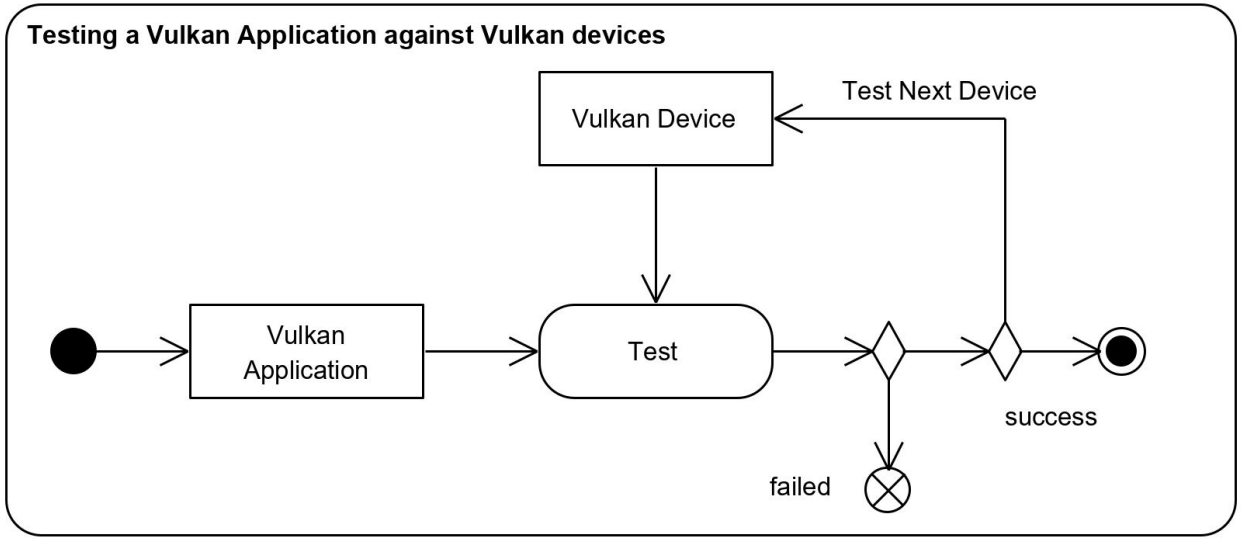
The Vulkan Profiles layer deployment



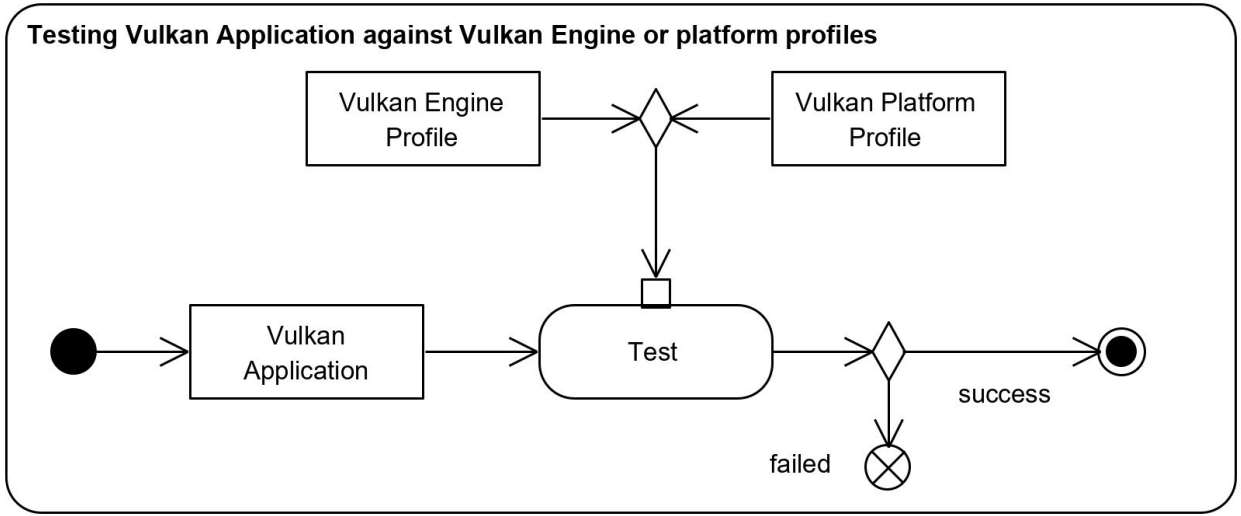
Simulate vs Emulate

- Downgrade the developer’s system Vulkan capabilities
- Only emulates VK_KHR_portability_subset
- No emulation of mobile specific feature on desktop hardware

Typical testing strategy, a device and driver at a time

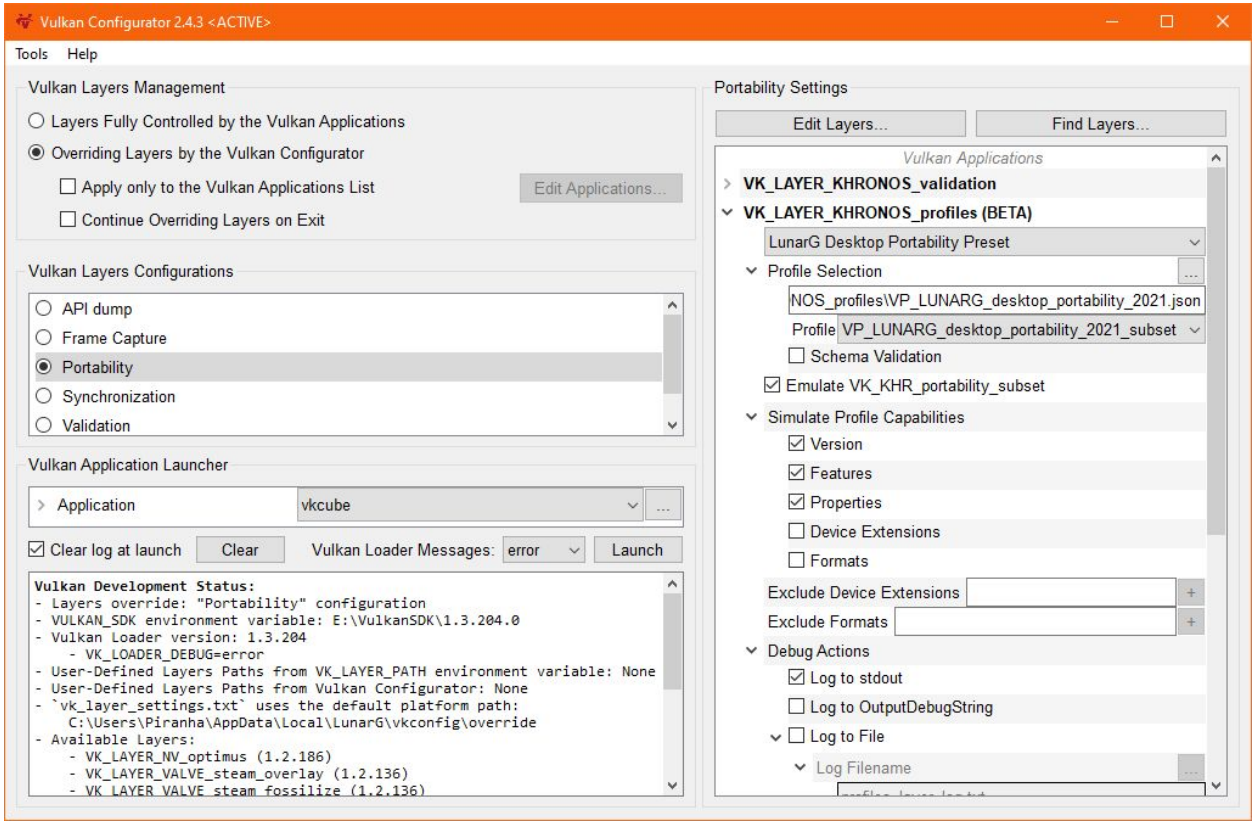


Testing Vulkan capabilities support against a Vulkan profile



The Vulkan Profiles layer use cases examples:

- Using C.I. to ensure that the Vulkan application never adds unintentional Vulkan capabilities requirements.
- Verifying the Vulkan application could on a less capable Vulkan device than the Vulkan developer device.
- Verifying that the Vulkan application falls back correctly when a driver doesn’t support a capability without updating the drivers or recompiling the Vulkan application.
- Verifying whether a Vulkan application behavior on a machine is due to the capabilities of that machine.
- Verifying the Vulkan Profile is well formed, with no unexpected duplicated references of Vulkan capabilities.
- Etc.


Vulkan Configurator 2.4.3 <ACTIVE>
Tools
Help
Vulkan Layers Management
Layers Fully Controlled by the Vulkan Applications
Overriding Layers by the Vulkan Configurator
Apply only to the Vulkan Applications List
Edit Applications...
Continue Overriding Layers on Exit
Vulkan Layers Configurations
API dump
Frame Capture
Portability
Synchronization
Validation
Vulkan Application Launcher
Application
vkcube
Clear log at launch
Clear
Vulkan Loader Messages:
error
Launch
Vulkan Development Status:
- Layers override: "Portability" configuration
- VULKAN_SDK environment variable: E:\VulkanSDK\1.3.204.0
- Vulkan Loader version: 1.3.204
- VK_LOADER_DEBUG=error
- User-Defined Layers Paths from VK_LAYER_PATH environment variable: None
- User-Defined Layers Paths from Vulkan Configurator: None
- `vk_layer_settings.txt` uses the default platform path:
C:\Users\Piranha\AppData\Local\LunarG\vkconfig\override
- Available Layers:
- VK_LAYER_NV_optimus (1.2.186)
- VK_LAYER_VALVE_steam_overlay (1.2.136)
- VK_LAYER_VALVE_steam_fossilize (1.2.136)
Portability Settings
Edit Layers...
Find Layers...
Vulkan Applications
VK_LAYER_KHRONOS_validation
VK_LAYER_KHRONOS_profiles (BETA)
LunarG Desktop Portability Preset
Profile Selection
NOS_profiles\VP_LUNARG_desktop_portability_2021.json
Profile
VP_LUNARG_desktop_portability_2021_subset
Schema Validation
Emulate VK_KHR_portability_subset
Simulate Profile Capabilities
Version
Features
Properties
Device Extensions
Formats
Exclude Device Extensions
Exclude Formats
Debug Actions
Log to stdout
Log to OutputDebugString
Log to File
Log Filename

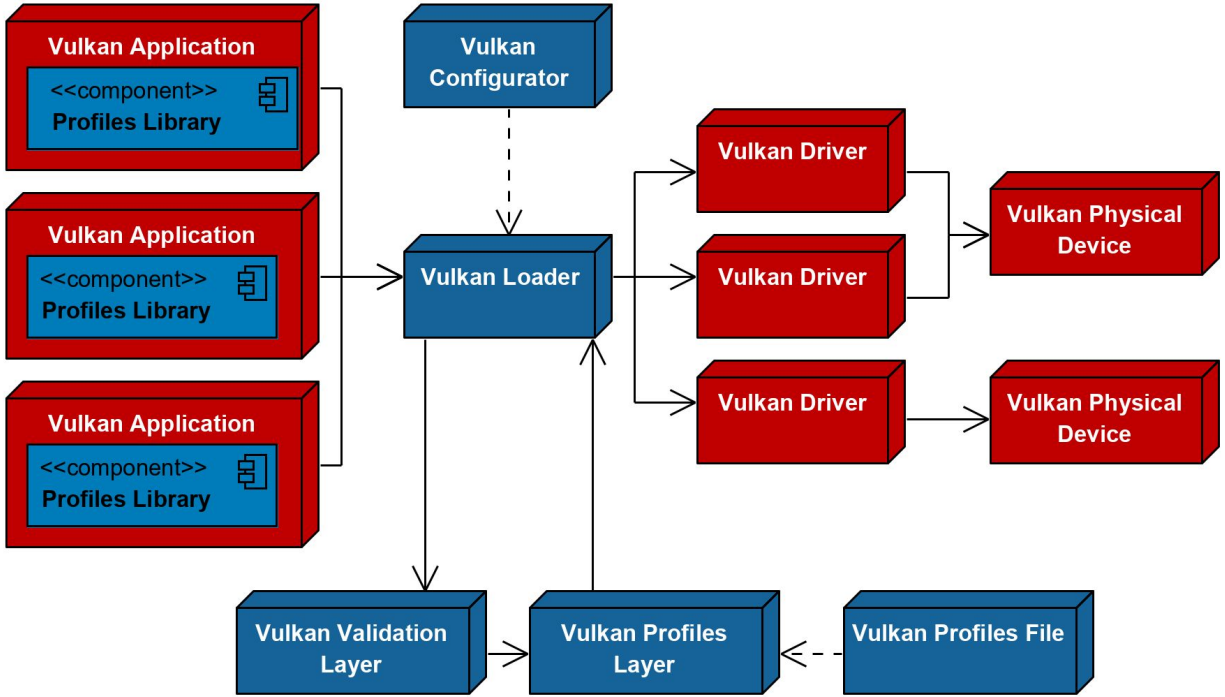
Using the Profiles layer with Vulkan Configurator. Demo…

Vulkan Profiles layer limitation

- It can’t override Vulkan instance extensions

Using the Vulkan Profiles library

The Vulkan Profiles library deployment



The Vulkan Profiles library API:

- Check Vulkan Profile support by the platform
- Create VkDevice with the profile features and extension enabled
  - Simplifies Vulkan initialization code
- Reflection on the Vulkan Profiles

- The Vulkan Profiles API is not part of the Vulkan API
- Part of a dedicated library
  - Only requires Vulkan 1.0 + VK_KHR_get_physical_device_properties2
  - Delivered with the Vulkan applications

Integration in a Vulkan application

- With a Vulkan SDK dependence
  - `#include <vulkan/vulkan_profiles.hpp>`
- From the Vulkan-Profiles repository
  - Copy paste in the code base:
    - Either `vulkan_profiles.hpp`
    - Or `vulkan_profiles.h` and `vulkan_profiles.cpp`

```
#define VK_ENABLE_BETA_EXTENSIONS 1
#include <vulkan/vulkan_profiles.hpp>
```

Vulkan Profiles Library API: defines

Example:

```
#if defined(VK_VERSION_1_3) && defined(VK_KHR_global_priority)
    #define VP_KHR_roadmap_2022 1
    #define VP_KHR_ROADMAP_2022_NAME "VP_KHR_roadmap_2022"
    #define VP_KHR_ROADMAP_2022_SPEC_VERSION 1
    #define VP_KHR_ROADMAP_2022_MIN_API_VERSION VK_MAKE_VERSION(1, 3, 204)
#endif
```

```
const VpProfileProperties profile = {VP_KHR_ROADMAP_2022_NAME, VP_KHR_ROADMAP_2022_SPEC_VERSION};
```

These defines exist for each Vulkan Profiles implemented by the Profiles Library

Vulkan Profiles Library API: checking profile support

- ```
  VkResult vpGetInstanceProfileSupport(
      const char *pLayerName,
      const VpProfileProperties *pProfile,
      VkBool32 *pSupported);
  ```
  - Check whether a profile is supported at the instance level
- ```
  VkResult vpGetPhysicalDeviceProfileSupport(
      VkInstance instance, VkPhysicalDevice physicalDevice,
      const VpProfileProperties *pProfile,
      VkBool32 *pSupported);
  ```
  - Check whether a profile is supported by the physical device

Vulkan Profiles Library API: creating a VkDevice

- `VkResult vpCreateInstance(`
  `const VpInstanceCreateInfo *pCreateInfo,`
  `const VkAllocationCallbacks *pAllocator, VkInstance *pInstance);`
  - Create a VkInstance with the profile instance extensions enabled
- `VkResult vpCreateDevice(`
  `VkPhysicalDevice physicalDevice,`
  `const VpDeviceCreateInfo *pCreateInfo,`
  `const VkAllocationCallbacks *pAllocator, VkDevice *pDevice);`
  - Create a VkDevice with the profile features and device extensions enabled

Vulkan Profiles Library API: profile reflection

- `VkResult vpGetProfileInstanceExtensionProperties(const VpProfileProperties *pProfile, uint32_t *pPropertyCount, VkExtensionProperties *pProperties);`
  - Query the list of instance extensions of a profile
- `VkResult vpGetProfileDeviceExtensionProperties(const VpProfileProperties *pProfile, uint32_t *pPropertyCount, VkExtensionProperties *pProperties);`
  - Query the list of device extensions of a profile
- `VkResult vpGetProfileFeatureStructureTypes(const VpProfileProperties *pProfile, uint32_t *pStructureTypeCount, VkStructureType *pStructureTypes);`
  - Query the list of feature structure types specified by the profile
- `void vpGetProfileFeatures(const VpProfileProperties *pProfile, void *pNext);`
  - Fill the feature structures with the requirements of a profile
- `VkResult vpGetProfilePropertyStructureTypes(const VpProfileProperties *pProfile, uint32_t *pStructureTypeCount, VkStructureType *pStructureTypes);`
  - Query the list of property structure types specified by the profile
- `void vpGetProfileProperties(const VpProfileProperties *pProfile, void *pNext);`
  - Fill the property structures with the requirements of a profile

Vulkan Profiles Library API: profile reflection

- `VkResult vpGetProfileQueueFamilyProperties(const VpProfileProperties *pProfile, uint32_t *pPropertyCount, VkQueueFamilyProperties2KHR *pProperties);`
  - Query the requirements of queue families by a profile
- `VkResult vpGetProfileQueueFamilyStructureTypes(const VpProfileProperties *pProfile, uint32_t *pStructureTypeCount, VkStructureType *pStructureTypes);`
  - Query the list of query family structure types specified by the profile
- `VkResult vpGetProfileFormats(const VpProfileProperties *pProfile, uint32_t *pFormatCount, VkFormat *pFormats);`
  - Query the list of formats with specified requirements by a profile
- `void vpGetProfileFormatProperties(const VpProfileProperties *pProfile, VkFormat format, void *pNext);`
  - Query the requirements of a format for a profile
- `VkResult vpGetProfileFormatStructureTypes(const VpProfileProperties *pProfile, uint32_t *pStructureTypeCount, VkStructureType *pStructureTypes);`
  - Query the list of format structure types specified by the profile

Vulkan Profiles Library API: Listing profiles

- `VkResult vpGetProfiles(uint32_t *pPropertyCount, VpProfileProperties *pProperties);`
  - Query the list of available profiles in the library

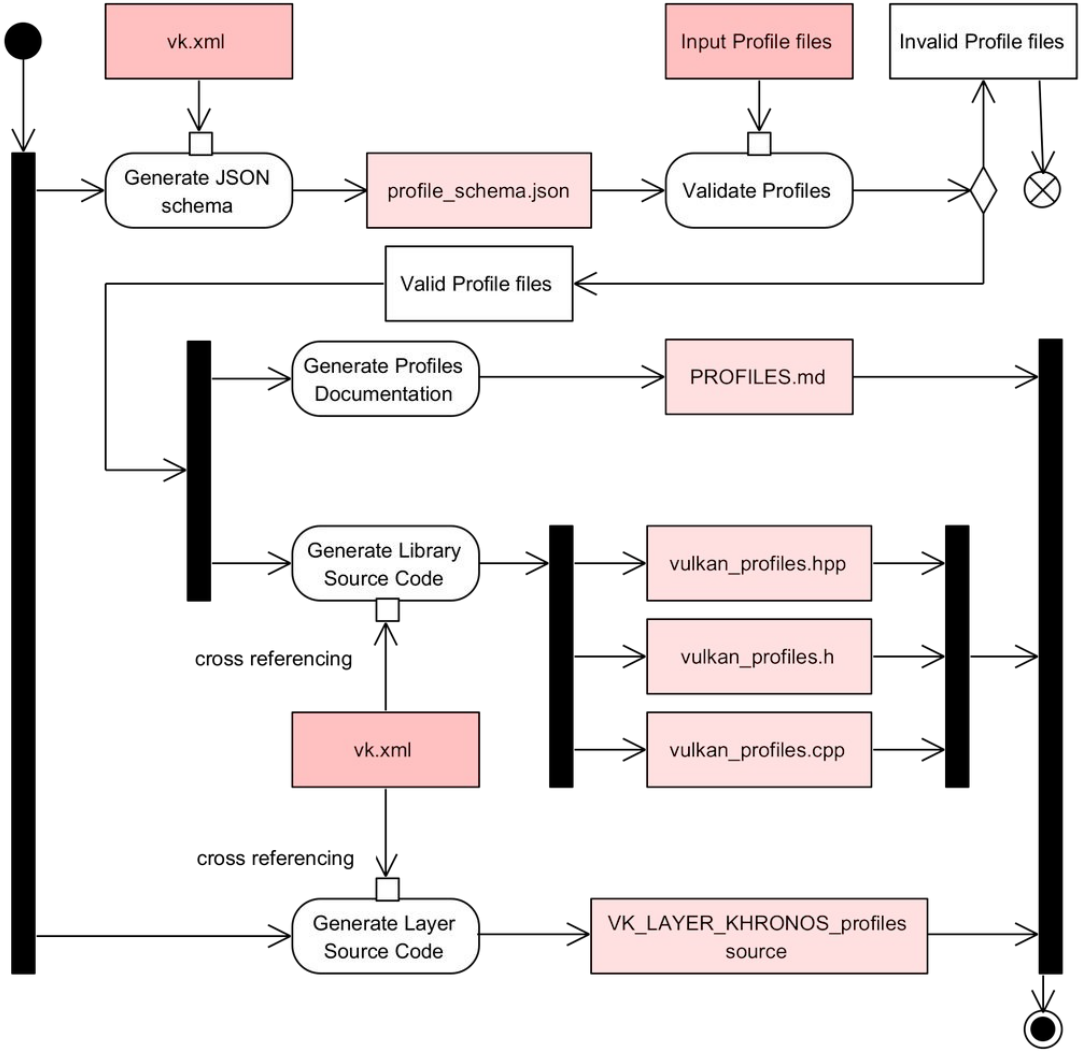
- `VkResult vpGetProfileFallbacks(const VpProfileProperties *pProfile, uint32_t *pPropertyCount, VpProfileProperties *pProperties);`
  - List the recommended fallback profiles of a profile

Vulkan Profiles library sample

A Vulkan sample is available for demonstrating Vulkan Profiles library usage.

Using the Profiles library in `test_profile_example.cpp`. Demo…

The Vulkan Profiles Toolset code generation


vk.xml
Input Profile files
Invalid Profile files
Generate JSON schema
profile_schema.json
Validate Profiles
Valid Profile files
Generate Profiles Documentation
PROFILES.md
Generate Library Source Code
vulkan_profiles.hpp
vulkan_profiles.h
vulkan_profiles.cpp
cross referencing
vk.xml
cross referencing
Generate Layer Source Code
VK_LAYER_KHRONOS_profiles source

Exercise: a Vulkan 1.2 roadmap 2022 profile

```
"VP_KHR_roadmap_2022_1_2": {
	"version": 1,
	"api-version": "1.2.197",
	"label": "Khronos Roadmap 2022 profile on Vulkan 1.2",
	"description": "This roadmap profile is intended to implement the Vulkan Roadmap 2022 profile on Vulkan 1.2.",
	"capabilities": [
		"vulkan10requirements",
		"vulkan10requirements_roadmap2022",
		"vulkan11requirements",
		"vulkan11requirements_roadmap2022",
		"vulkan12requirements",
		"vulkan12requirements_roadmap2022",
		"vulkan13requirements_1_2",
		"vulkan13requirements_roadmap2022_1_2"
	]
}
```

Exercise: a Vulkan 1.2 roadmap 2022 profile

```
"vulkan13requirements_roadmap2022": {
	"extensions": {
		"VK_KHR_global_priority": 1
	},
	"features": {
		"VkPhysicalDeviceVulkan13Features": {
			"descriptorBindingInlineUniformBlockUpdateAfterBind": true
		}
	}
},
"vulkan13requirements_roadmap2022_1_2": {
	"extensions": {
		"VK_EXT_global_priority": 1,
		"VK_EXT_inline_uniform_block": 1
	},
	"features": {
		"VkPhysicalDeviceInlineUniformBlockFeaturesEXT": {
			"descriptorBindingInlineUniformBlockUpdateAfterBind": true
		}
	}
}
```

Rebuilding the repository with additional Vulkan Profiles. Demo…

Future Improvement:
Improving Vulkan Profiles creation

Improving Vulkan Profiles creation

- Vulkaninfo export of Device profiles JSON files (PR)
- Tool to combine profiles
  - Either accumulating the requirements (For Engine profiles)
  - Or subtracting available support (For Platform profiles)
- Tool to validate a profile against another
- Better handling of platform specific capabilities
  - Surface extensions are necessary but platform specific
- Add more Vulkan capabilities to the schema (memory types, surfaces?)
- Improvements on vk.xml:
  - Default values for capabilities, improved limit types, etc
- Vulkan Configurator integration?

Thanks
Q&A?

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