

# Vanilla Engine Developer Manual

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# 1. Introduction

Welcome to the Vanilla Engine Developer Manual. This documentation aims to make you fully understand the inner workings of a modern graphical rendering engine — specifically one specialised for the development of a 2D game.

Think of this manual as a “System Bible”. In here, you should find 3 answers for every component in the codebase:

- **How** does the engine work?
- **What** makes it work that way?
- **Why** was designed it that way?

Keep in mind that, despite its niche use-case and apparent lack of features when compared to other mainstream game engines, Vanilla is anything *but* a simple program. Building a game is the main idea behind the programming classes; understanding Vanilla’s architecture is a bonus—though something that would surely improve your ability to understand code and complex systems programming.

## 1.1. Why C?

Vanilla is being developed specifically to provide a easy-to-use environment for game development in C. Most game engines are designed around a paradigm known as “Object-Oriented Programming”—also known as OOP—which has become very popular since the introduction of programming languages such as Java, C++ and C#.

While OOP does lower the knowledge barrier needed to develop a functional game, it isn’t quite as interesting from a learning perspective. OOP is easier because it hides away a lot of the details that are needed to make a computer program run; but that same reason is exactly why it isn’t quite as good for learning. You will learn the high-level concepts, but you will likely develop bad practices since you don’t deeply understand what it is you’re asking your computer to do.

In summary: It is easier to write bad OOP code, because you don’t need to know as much to write valid OOP code (“valid” here meaning “it will compile without errors”). It is more difficult to write valid C code—but when you do, you’re more likely to understand the details of *why* your code is valid.

## 1.2. Why Vulkan?

To answer this question, first we must understand what Vulkan *is*.

Vulkan is, in technical terms, a **low-overhead, cross-platform graphical API**. Now let’s break that word soup down:

- **API:** the acronym stands for “Application Programming Interface”. A “Programming Interface” is, in essence, a standardised language used by an application—hence the name. An API is a standardised way that your computer talks to a component—in this case, your graphics card.
- **Graphical API:** If the communication between your CPU and GPU wasn’t standardised, you would have to program a version of your game for every single graphics card model out

on the market. That's why the Khronos Group created OpenGL (and Vulkan much later). They defined the rules for a standard language, and then told the GPU manufacturers "here, make your GPU speak this language." That way, we only need to learn how to use one API; It is the manufacturer's responsibility to make the graphics card speak our language. This language is what Vulkan is.

- **Cross-Platform:** This one is pretty self-explanatory; it means Vulkan works in any platform, assuming its components can "speak" Vulkan—which is basically everything these days.
- **Low-Overhead:** Here's where the issue of using Vulkan lives. Most software you use tries to be "helpful": if you make a mistake, it either fixes it or steers you in the right direction. The issue is, checking for your mistakes costs precious CPU cycles. Every time you want to render something on the screen, the CPU must send that information out to the GPU, which takes *ages* in computer-time. Seriously: If 1 CPU clock "tick" lasted 1 second, it would take around 2 and a half hours for your information to get there on the average modern computer. To add error checking, you'd need to delay the travel of information further to validate the commands—and this extra processing is called an "overhead". Therefore "low-overhead" means exactly what it says on the tin: it is blazing-fast, but it will do *exactly* what you tell it to—just like C!

While OpenGL still works just fine, it is being deprecated, as it was created in 1992 and received its last update in 2017. Vulkan was created by the same group (Khronos) as a successor to OpenGL, but with modern computers in mind. It is much faster, much more feature rich, and far, far more complex to use. But don't worry—you'll likely never have to interact with it yourself throughout this project. In fact, this takes us to our next question:

### 1.3. What is Vanilla?

This game engine is exactly the reason you won't need to touch Vulkan, and most of the reason game engines exist in the first place. Vanilla is a set of functions and structures that will allow you to focus on the game's logic, not on the complex handling of data between your game and the components on the computer.

For example, let's write some example code to render a single sprite with texture on the screen, but using Vulkan directly (simplified so it fits in less than 5 pages):

```
// First, we wait for the previous frame to finish rendering.
vkWaitForFences(device, 1,
    &in_flight_fences[current_frame],
    VK_TRUE, UINT64_MAX);

// Then, we start the next frame
uint32_t image_index;
vkAcquireNextImageKHR(device, swapchain, UINT64_MAX,
    image_available_semaphore,
    VK_NULL_HANDLE, &image_index);

// (Continues on the next page...)
```

```

// Now we unlock the frame so we can draw on it (this lock is called a "fence")
vkResetFences(device, 1,
               &in_flight_fences[current_frame]);

// Only now we listen for the commands needed to render the image
vkResetCommandBuffer(command_buffers[current_frame], 0);
VkCommandBufferBeginInfo begin_info = {
    .sType = VK_STRUCTURE_TYPE_COMMAND_BUFFER_BEGIN_INFO,
    .flags = 0
};

if (vkBeginCommandBuffer(command_buffer[current_frame],
                        &begin_info) == VK_SUCCESS) {
    // Now we define where to draw things and how to clear the screen
    VkRenderPassBeginInfo render_pass_info = {
        .sType = VK_STRUCTURE_TYPE_RENDER_PASS_BEGIN_INFO,
        .renderPass = render_pass,
        .framebuffer = swapchain_framebuffers[image_index],
        .renderArea.offset = {0, 0},
        .renderArea.extent = swapchain_extent,
        .clearValueCount = 1,
        .pClearValues = &clear_colour
    };

    // Now we include the instructions to the GPU of how to render what we want
    // (these are called a "rendering pipeline")
    vkCmdBindPipeline(command_buffers[current_frame],
                      VK_PIPELINE_BIND_POINT_GRAPHICS,
                      graphics_pipeline);

    // Now we send the texture and other data to the GPU
    memcpy(uniform_buffer_mapped[current_frame], &ubi, sizeof(ubo));
    vkCmdBindDescriptorSets(command_buffers[current_frame],
                           VK_PIPELINE_BIND_POINT_GRAPHICS,
                           pipeline_layout, 0, 1,
                           &descriptor_sets[current_frame],
                           0, NULL);

    // Now we send to the GPU the vertices of the object to be drawn, alongside
    // texture coordinates and any other data we may have
    VkBuffer vertex_buffers[] = {vertex_buffer};
    VkDeviceSize offsets[] = {0};
    vkCmdBindVertexBuffers(command_buffers[current_frame],
                          0, 1, vertex_buffers, offsets);
    vkCmdDraw(command_buffers[current_frame], 6, 1, 0, 0); // drawing 2 triangles
    // (6 vertices) into 1 square.
    vkCmdEndRenderPass(command_buffers[current_frame]);
    vkEndCommandBuffer(command_buffers[current_frame]);
}

// Now we submit our commands to the graphics queue
VkSubmitInfo submit_info = {

```

```

.sType = VK_STRUCTURE_SUBMIT_INFO,
.waitSemaphoreCount = 1,
.pWaitSemaphores = &image_available_semaphores[current_frame],
.pWaitDstStageMask = (VkPipelineStageFlags[])
{VK_PIPELINE_STAGE_COLOR_ATTACHMENT_OUTPUT_BIT},
.commandBufferCount = 1,
.pCommandBuffers = &command_buffers[current_frame],
.signalSemaphoreCount = 1,
.pSignalSemaphores = &render_finished_semaphores[current_frame]
};

vkQueueSubmit(graphics_queue, 1, &submit_info,
              &in_flight_fences[current_frame]);

// And finally, we present the finished frame to the screen
VKPresentInfoKHR present_info = {
    .sType = VK_STRUCTURE_TYPE_PRESENT_INFO_KHR,
    .waitSemaphoreCount = 1,
    .pWaitSemaphores = &render_finished_semaphores[current_frame],
    .swapchainCount = 1,
    .pSwapchains = &swapchain,
    .pImageIndices = &image_index
};

vkQueuePresentKHR(present_queue, &present_info);
current_frame = (current_frame + 1) % MAX_FRAMES_IN_FLIGHT;

```

And, mind you, this is just to get a single static image on the screen; you can't interact with it in any way yet.

Now, let's see how you'd do the same thing using Vanilla:

```

// First, let's define a player object
Vnl_Sprite player = {
    .texture = player_tex,
    .position = {100.0f, 250.0f},
    .scale = {1.0f, 1.0f},
    .rotation = 0.0f
};

// And now we tell Vanilla to draw it
while (vnl_game_open()) {
    vnl_begin_frame();

    // Let's make our player move right when we press 'D'
    if (vnl_key_is_down(VNL_KEY_D)) {
        player.position.x += 5.0f;
    }

    // (Continues on the next page...)
}

```

```
// Now, we render the sprite to the screen
vnl_draw(&player);
vnl_end_frame();
}
```

And we're done. Yes, Vanilla uses Vulkan—but on the back-end. You'll never have to see it if you don't look on its insides. That is the purpose of a game engine (and, more generally, of systems programming): to take some of the technical complexity away from the code.

Now that we've cleared what the idea behind Vanilla is, let's take a look at how it works.

## 2. The Architecture

### 2.1. Game Lifecycle

### 2.2. Abstraction Layers

### 2.3. Handling Memory

## 3. The Developer's Interface

### 3.1. Quickstart

#### 3.1.1. Adding Vanilla Into Your Project

#### 3.1.2. Configuration File

Vanilla needs to know some basic information about your game before launching it. This information should be provided to the engine in the form of C macros (`#define <MACRO_NAME>`). To simplify game compilation and organisation, Vanilla assumes that all the information it needs will be found in a header file named `vnl_config.h`, which must exist, even if it is empty. It should exist in the same directory as `vanilla.h`. A basic setup for the config file would be:

```
#ifndef VANILLA_CONFIG_H_ // Header Guards
#define VANILLA_CONFIG_H_

#define VNL_GAME_NAME "Test" // This sets the name of the game's window

// This would set the game to version "0.1.0".
#define VNL_GAME_VERSION_MAJOR 0
#define VNL_GAME_VERSION_MINOR 1
#define VNL_GAME_VERSION_PATCH 0

#endif // VANILLA_CONFIG_H_
```

There are many other macros that you can use and/or customise on your game, and you can see them in Section 3.3.

You should include `vnl_config.h` **before** including `vanilla.h` into your project.

## 3.2. Common Game Structures/Objects

### 3.3. Vanilla Macros

As discussed in Section 3.1.2, Vanilla makes use of macros to retrieve the information it needs to configure itself to suit your game. Some of them are overridable, meaning you get to customise their values to your specific needs. Generally, if a macro is customisable, you can assume it has a default value unless stated otherwise—you don't have to manually configure every single one, just the ones you need. To configure your Vanilla environment and macros, you use `#define` directives in `vnl_config.h`.

#### 3.3.1. Game Name Macro

This will set the name of the window where your game runs. It only accepts strings.

```
#define VNL_GAME_NAME "Very Cool Game"
```

If not set, the window will be named “Untitled Vanilla Project” by default.

#### 3.3.2. Game Version Macros

Often, you'll want to define a version number for your game (e.g. “1.2.0”). To achieve that, you may define a set of macros that follow an X.Y.Z format, where X, Y and Z are integer numbers.

```
// Major release version (The "X")
#define VNL_GAME_VERSION_MAJOR 1

// Minor release version (The "Y")
#define VNL_GAME_VERSION_MINOR 2

// Patch/Bugfix release version (The "Z")
#define VNL_GAME_VERSION_PATCH 0
```

They are defined like this to both be used by the game and the Vulkan metadata. If you wish to use the game's version somewhere, such as a version number indicator on the main or settings menu, you may use these macros to your liking. If not set, version will be “0.0.0” by default.

**3.4. Using Vanilla Data Structures**

**3.5. Using Vanilla Strings**

**3.6. Resource Management**

**3.7. Input & Timing**

**4. Vanilla Objects Reference**

**5. Vanilla Functions Reference**

**6. The Backend Implementation**

**6.1. Fixed Function Pipeline**

**6.2. Synchronization**

**6.3. Vertex Layout**