

Teaching Myself DirectX

The Device

A device is used to create resources and to enumerate the capabilities of a display adapter. A Direct3D device allocates and destroys objects, **renders primitives**, and **communicates with a graphics driver and the hardware**. In Direct3D 11, a device is separated into a device object for creating resources and a device-context object, which performs rendering. A device is represented with an [**ID3D11Device**](https://docs.microsoft.com/en-us/windows/desktop/api/D3D11/nn-d3d11-id3d11device) interface.

**Each application must have at least one device.**

[**D3D11CreateDevice**](https://docs.microsoft.com/en-us/windows/desktop/api/D3D11/nf-d3d11-d3d11createdevice) or [**D3D11CreateDeviceAndSwapChain**](https://docs.microsoft.com/en-us/windows/desktop/api/D3D11/nf-d3d11-d3d11createdeviceandswapchain) can be used to create a device.

Device Context

A device context is used to set **pipeline** state and generate rendering commands using the resources owned by a device.

Swap Chain

A swap chain is a collection of buffers that are used for displaying frames to the user. Each time an application presents a new frame for display, the first buffer in the swap chain takes the place of the displayed buffer. This process is called swapping or flipping.

A graphics adapter holds a **pointer** to a surface that represents the image being displayed on the monitor, called a **front buffer**. As the monitor is refreshed, the graphics card sends the contents of the front buffer to the monitor to be displayed. However, this leads to a problem when rendering real-time graphics. The heart of the problem is that monitor refresh rates are very slow in comparison to the rest of the computer. Common refresh rates range from 60 Hz (60 times per second) to 100 Hz. If your application is updating the front buffer while the monitor is in the middle of a refresh, the image that is displayed will be cut in half with the upper half of the display containing the old image and the lower half containing the new image. **This problem is referred to as tearing**.

Back buffering is the process of drawing a scene to an off-screen surface, called a back buffer. Note that any surface other than the front buffer is called an **off-screen surface because it is never directly viewed by the monitor**. By using a back buffer, an application has the freedom to render a scene whenever the system is idle (that is, no windows messages are waiting) without having to consider the monitor's refresh rate. Back buffering brings in an additional complication of how and when to move the back buffer to the front buffer.

The process of moving the back buffer to the front buffer is called surface flipping. Because the graphics card simply uses a pointer to a surface to represent the front buffer, a simple pointer change is all that is needed to set the back buffer to the front buffer. When an application asks Direct3D to present the back buffer to the front buffer, Direct3D simply "flips" the two surface pointers. The result is that the back buffer is now the new front buffer, and the old front buffer is the new back buffer. A surface flip is invoked whenever an application asks the Direct3D device to present the back buffer; however, Direct3D can be set up to queue the requests until a vertical sync occurs. This option is referred to as the Direct3D device's presentation interval. Note that the data in the new back buffer may not be reusable, depending on how an application specifies how Direct3D should handle surface flipping. Surface flipping is key in multimedia, animation, and game software; it is equivalent to the way you can do animation with a pad of paper. On each page, the artist changes the figures slightly, so that when you flip rapidly between sheets, the drawing appears animated.

Creating Device , Context and Swap Chain at once

HRESULT D3D11CreateDeviceAndSwapChain(

IDXGIAdapter \*pAdapter,

D3D\_DRIVER\_TYPE DriverType,

HMODULE Software,

UINT Flags,

const D3D\_FEATURE\_LEVEL \*pFeatureLevels,

UINT FeatureLevels,

UINT SDKVersion,

const DXGI\_SWAP\_CHAIN\_DESC \*pSwapChainDesc,

IDXGISwapChain \*\*ppSwapChain,

ID3D11Device \*\*ppDevice,

D3D\_FEATURE\_LEVEL \*pFeatureLevel,

ID3D11DeviceContext \*\*ppImmediateContext

);

1. A pointer to the video adapter to use when creating a [device](https://docs.microsoft.com/en-us/windows/desktop/direct3d11/overviews-direct3d-11-devices-intro). Pass **NULL** to use the default adapter, which is the first adapter enumerated by [IDXGIFactory1::EnumAdapters](https://docs.microsoft.com/en-us/windows/desktop/api/dxgi/nf-dxgi-idxgifactory-enumadapters).
2. The [D3D\_DRIVER\_TYPE](https://docs.microsoft.com/en-us/windows/desktop/api/d3dcommon/ne-d3dcommon-d3d_driver_type), which represents the driver type to create.

typedef enum D3D\_DRIVER\_TYPE {

D3D\_DRIVER\_TYPE\_UNKNOWN = 0,

D3D\_DRIVER\_TYPE\_HARDWARE,

D3D\_DRIVER\_TYPE\_REFERENCE,

D3D\_DRIVER\_TYPE\_NULL,

D3D\_DRIVER\_TYPE\_SOFTWARE,

D3D\_DRIVER\_TYPE\_WARP

} ;

<https://docs.microsoft.com/en-us/windows/win32/api/d3dcommon/ne-d3dcommon-d3d_driver_type>

<https://docs.microsoft.com/en-us/windows/win32/api/d3d11/nf-d3d11-d3d11createdeviceandswapchain>

***\*\*This function takes swap-chain descriptions and creates device , swap-chain and device context .***

Direct3D interface pointers(Windows interface pointers) need to be called release function for realising the object(freeing the memory) ,for that we should use ComPtr (under wrl.h header)

**Microsoft::WRL::ComPtr<TypeName> ptr for *RAII***

Microsoft::WRL::ComPtr<ID3D11Device> pDevice;

Microsoft::WRL::ComPtr<IDXGISwapChain> pSwapChain;

Microsoft::WRL::ComPtr<ID3D11DeviceContext> pDeviceContext;

Microsoft::WRL::ComPtr<ID3D11Resource> pBackBuffer;

Microsoft::WRL::ComPtr<ID3D11RenderTargetView> pTarget;

**ID3D11 vs IDXGI**

IDXGI is those interfaces which doesn’t change as frequently as direct3D ( Direct3D9 , Direct3D10, Direct3D11 , Direct3D12)

*It basically factored all the enumeration, display and adapter management, and presentation stuff out of Direct3D. That way, all sorts of graphics APIs can coexist without a need to have separate mechanisms for these common tasks in each of them. It allows, e.g., all the Direct3D APIs (>= 10) to only be concerned with drawing 3D content into buffers and not care about where these buffers come from, or whether and how they are going to be displayed.*

***Giving swapchain description***

DXGI\_SWAP\_CHAIN\_DESC sd = { 0 };

sd.BufferDesc.Width = 0; // look at the window and use it's size

sd.BufferDesc.Height = 0;

sd.BufferDesc.RefreshRate.Numerator = 0; // pick the default refresh rates

sd.BufferDesc.RefreshRate.Denominator = 0;

sd.BufferCount = 1;// one back buffer -> one back and one front doubleb uffering

sd.BufferDesc.Format = DXGI\_FORMAT\_B8G8R8A8\_UNORM; // this is the color format (BGRA) we can also use (RGBA)

sd.BufferDesc.Scaling = DXGI\_MODE\_SCALING\_UNSPECIFIED; // not specifying any scaling because we want the renedred frame same as window size

sd.BufferDesc.ScanlineOrdering = DXGI\_MODE\_SCANLINE\_ORDER\_UNSPECIFIED; // how buffer scaning will be done for copying all to video memory

sd.Flags = 0; // not setting any flags

sd.BufferUsage = DXGI\_USAGE\_RENDER\_TARGET\_OUTPUT; // use the buffer for render target

sd.OutputWindow = handle;

sd.SwapEffect = DXGI\_SWAP\_EFFECT\_DISCARD; // discard the effects for swapping frames

sd.Windowed = TRUE;

// for antialiasing we don't want it right now

sd.SampleDesc.Count = 1;

sd.SampleDesc.Quality = 0;

***Creating swapchain with device and immediate context***

D3D11CreateDeviceAndSwapChain(0, D3D\_DRIVER\_TYPE\_HARDWARE,

nullptr, 0, nullptr, 0,

D3D11\_SDK\_VERSION, &sd,

&pSwapChain, &pDevice, nullptr,

&pDeviceContext)

\*\*We also have to add a lib file **(d3d11.lib)** we can simply **#pragma comment(lib , “d3d11.lib”)** or goto **project\_properties -> linker -> input -> additional dependencies**

***Presenting new frame (or swapping the buffers of the swapchain)***

pSwapChain->Present(1u, 0u)

Present's first argument is the sync interval, which should be set to 1, and it will block until the monitor is ready to show the next frame.

<https://docs.microsoft.com/en-us/windows/win32/api/dxgi/nf-dxgi-idxgiswapchain-present>

***Clearing the backbuffer with a color***

pDeviceContext->ClearRenderTarget

**\*\*this function takes a render target view and a array of float values representing color (RGBA) .So we have to get the render target view pointer (or Creating a render target from the back buffer)**

// gain access to texture subresource in swap chain (back buffer)

Microsoft::WRL::ComPtr<ID3D11Resource> pBackBuffer;

//getting the id of the type to create (we want the back buffer so 0)

pSwap->GetBuffer( 0,\_\_uuidof(ID3D11Resource), &pBackBuffer );

//creating

Microsoft::WRL::ComPtr<ID3D11RenderTargetView> pTarget

pDevice->CreateRenderTargetView(

pBackBuffer,

nullptr,

&pTarget

);

float color[4] = {1.0f , 1.0f , 1.0f , 1.0f};

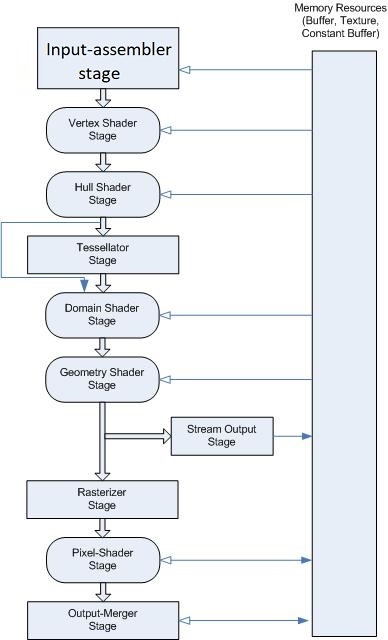
pDeviceContext->ClearRenderTargetView(pTarget ,color )

**\*\*\_\_uuidof is keyword used to retrive the GUID (an unique ID that is used in COM for doing stuffs)**

**This operator is a Microsoft language extension. It returns a GUID value from an expression. The expression can be an interface type name, a class name, or an interface pointer**

\*\*when we are using & operator on a com pointer object it releases the object it’s currently holding and returns a pointer to pointer.

**Setting Up the Pipeline and Drawing First Triangle**



<https://docs.microsoft.com/en-us/windows/win32/direct3d11/overviews-direct3d-11-graphics-pipeline>

The minimum requirement for creating triangles (or any primitives) are **vertex buffer(s)** , **Vertex shader** **, Input layout** , **Pixel shader** , **Viewport** , **Primitive topology**

**Creating and binding Vertex Buffer**

// base structure for every vertex type

struct VertexType

{

float x, y;

unsigned char r, g, b, a;

};

//creating an array of vertices that will be drawn

//below points are position for a triangle showing at the middle of the screen

//viewport's range is from -1.0f to 1.0f (x,y,z axis)

//triangle will be drawn using vertices at clockwise

VertexType vtx[] = {

0.5 , 0.5 , 0.0 , 255 , 255 , 255 , 255,

0.5 , -0.5 , 0.0 , 255 , 255 , 255 , 255,

-0.5 , -0.5 , 0.0 , 255 , 255 , 255 , 255,

};

//vertex buffer description

D3D11\_BUFFER\_DESC bd = { 0 };

bd.ByteWidth = sizeof(vtx); //total array size

bd.Usage = D3D11\_USAGE\_DEFAULT;// how buffer data will be used (read/write protections for GPU/CPU)

bd.BindFlags = D3D11\_BIND\_VERTEX\_BUFFER;// What type of buffer would it be

bd.CPUAccessFlags = 0u;// we don't want any cpu access for now so setting it to 0 for now

bd.MiscFlags = 0u;// misscellinious flag for buffer configuration (we don't want it now either)

bd.StructureByteStride = sizeof(VertexType); // Size of every vertex in the array

//holds the data pointer that will be used in vertex buffer

D3D11\_SUBRESOURCE\_DATA subd = { 0 };

subd.pSysMem = vtx; // pointer to array so that it can copy all the array data to the buffer

Microsoft::WRL::ComPtr<ID3D11Buffer> VBuffer;

pDevice->CreateBuffer(&bd, &subd, &VBuffer);

UINT stride = sizeof(VertexType); // size of every vertex

UINT offset = 0u; // displacement after which the actual data start (so 0 because no displacement is there)

//statrting slot(from 0) , number of buffers(1 buffer) , pp ,

pDeviceContext->IASetVertexBuffers(0u, 1u, VBuffer.GetAddressOf(), &stride, &offset);

**Creating and Binding VertexShader**

Shaders:

Shaders are GPU programs that runs on GPU hardware. **Vertex shader** - in the most basic form , transforms vertices (bundles of information including spatial coordinates) from model space into screen space.

**\*\*homogeneous coordinates**

**In homogeneous coordinate system, two-dimensional coordinate positions (x, y) are represented by triple-coordinates.**

**Translation of point by the change of coordinate cannot be combined with other transformation by using simple matrix application. Such a combination is essential if we wish to rotate an image about a point other than origin by translation, rotation again translation.**

**To combine these three transformations into a single transformation, homogeneous coordinates are used**.

For three-dimensional geometric transformation, we can choose homogeneous parameter h to any non-zero value. For our convenience take it as one. Each three-dimensional position is then represented with homogeneous coordinates (x, y , z, 1).

**Creating Shader:**

//the input and output need to be labeled by semantics

struct VertexShaderOut // this is the ouput type

{

float4 color : COLOR; // this is the user defined semantic for color which will be passed to pixel shader

float4 pos : SV\_POSITION; // this is the SYSTEM\_VALUE SEMANTIC this is fixed (and defined by the API)

};

// main is the entry point and it takes 2 parameters

// first one is position and second one is color

// "POSITION" and "COLOR" is the semantic name which will be used to input the data from

// our cpu

// So our main returns a color and a position (for which every color that is returned with will be drawn)

VertexShaderOut main(float3 pos : POSITION , float4 col : COLOR)

{

VertexShaderOut Out;

Out.pos = float4(pos , 1.0f) ;

Out.color = col;

return Out;

}

**Loading Shader:**

For loading we have premade function named **D3DReadFileToBlob** for that we have to add a library “**D3DCompiler.lib**” we can also compile shders at runtime using it.

Microsoft::WRL::ComPtr<ID3D11VertexShader> vS; // shader pointer

Microsoft::WRL::ComPtr<ID3DBlob> blb; // holds the compiled shader bytecode

D3DReadFileToBlob(L"VertexShader.cso", &blb); // reading the bytecode and storing it to blob

pDevice->CreateVertexShader(blb->GetBufferPointer(), blb->GetBufferSize(), nullptr, &vS); // creating vertex shader

pDeviceContext->VSSetShader(vS.Get(), nullptr, 0u); // binding vertex shader

\*\*By Default the compiled shader outputs to the executable directory , but this can make a problem when we would try to run our program from VisualStudio (it would not find it unless we give it the full path or move it to the working directory). We can move it by right click->properties->Object file name -> $(ProjectDir)%(Filename).cso