4

Unreal Engine, C++, and You

Welcome to Chapter 4! Well done on working through to this point, we are finally ready to open Pandora's box and bring C++ into our Unreal Engine workflow! Unreal Engine has been designed specifically to allow game developers to utilize C++ to its full extent when creating content. By the end of this chapter, you will be able to leverage the low-level nature of C++ to create in-depth functionality that maximizes the potential of UE4. In fact, from this point forward, C++ will be our main avenue when it comes to creating functionality. If you do not already have a basic understanding of, or experience with, C++, I strongly recommend brushing up on the C++ programming language and Visual Studio 2015 IDE before continuing with this book.

This chapter will introduce you to the concepts and syntax that you will encounter when working with C++ and UE4. The relationship they have created between codebase and engine is robust and involved, this chapter will act as an introduction to the workings of this relationship. Through the remaining chapters we will continuously build on this knowledge so that you may master C++ with UE4. However, with power comes responsibility: C++ is a low-level language by nature, therefore by using it you are also exposing your projects to vulnerabilities brought about by buggy and incomplete code. The code provided in this and the following chapters will take steps to show you how to avoid these vulnerabilities.

In short, this chapter will cover the following points:

- Why you should use C++ with Unreal Engine 4
- How UE4 utilizes polymorphism and virtual inheritance
- How to create an UE4 C++ project
- How to read UE4 C++ code
- What is a pre-compile stage and how does Unreal Engine 4 utilize this?

- What are UE macros?
- How to write functions in C++ that the engine can see
- How to create C++ objects that can be seen by UE
- How to write C++ functions that need to be defined in Blueprints

UE and C++

UE was designed specifically with C++ development in mind. In the history of UE, you traditionally only had access to `UnrealScript`; unless you paid a great deal of money to become an UE developer. `UnrealScript` is a scripting language developed by the Engine team to allow you to create high-level content that would interface with the Engine. The purpose of this script was to provide a layer of abstraction between the developer and engine. You could say that Blueprint has largely replaced `UnrealScript` as the primary scripting tool for UE. UE4 is unique in that it provides immediate and direct access to C++ source and development to all users.

The engine itself was written in C++ and to get access to this source all you need to do is sign up to GitHub and register your GitHub login with your Unreal developer account. Through GitHub you will then be able to download and compile the latest version of the engine source. This design of *made with and for C*++ means that C++ should be your first option when developing with the engine. This chapter will not only detail when and why you should use C++ over Blueprint, but also when you should leverage the communication between the two to enhance the efficiency of your UE workflow.

Visual Studio is the IDE you must use when working with UE. Fear not though, installing the latest version of the engine also includes an installation of the 2015 community edition of Visual Studio. The engine also provides many Visual Studio integration tools that synergize the IDE with the engine. The steps to properly set up your Visual Studio with Unreal Engine can be found here at `https://docs.unrealengine.com/latest/INT/Programming/Development/VisualStudioSetup/index.html`.

The previous tutorials and guides are a fantastic resource to expand any knowledge you gain over the course of this book.

Why use C++

C++ is a very powerful programming language with many low-level tools that you can utilize as a developer. If you are already familiar with the language you will know of the advantages it provides when it comes to memory management, generic codebase via templated programming, and the power of **OOP** (**Object Oriented Programming**) using virtual inheritance and polymorphism. If you are unaware of those concepts I would strongly suggest that you go do some separate research on C++ and how to use it, as these concepts will be assumed as known when covering further topics. I find the following website to be a great resource for introductory C++ concepts—`http://www.cplusplus.com/doc/tutorial/`.

Knowing how to use C++ with UE4 is essential to becoming a skilled and competent UE developer. This knowledge will allow you to fully utilize the power and limitless potential of UE. This is not hyperbole either, as not only can you use C++ to create content on a project-by-project basis, but you may also edit and add to the engine's C++ source code to create core engine functionality and adaptions you feel are lacking by default.

The biggest advantage of using C++ as your main development tool instead of Blueprint is *stability*. During the course of a project, you may wish to update engine versions to gain access to up-to-date iterations of engine functionality. If the implementation of your project is heavily based in Blueprint, this upgrade can lead to very serious build-stability issues. As Blueprint is constantly changing and updating with each iteration of the engine, large, core portions of Blueprint may be subject to change.

This happens far less frequently in code and, when it does, it is much easier to debug so that you may make amendments to fix any issues that arise. With regards to debugging, using C++ allows us to debug UE code much the same as you would any other Windows application codebase. We are able to place break points, utilize the call stack, scrutinize memory states, observe variable states at runtime, place data break points, and any other C++ debugging features we are used to.

Another advantage is the speed at which you can implement new functionality using the various interfaces the engine provides to C++ developers. If you are already very familiar with the language, you will relish the toolset provided by the engine and begin to thoroughly enjoy your time working with it. It may even come down to development preference, I personally favor C++ when developing with the engine as that is what I am comfortable with.

Now, only using C++ to create your project is not advised as there are definitely some things that Blueprint does much better than C++. When it comes to establishing object associations and asset assignment, it is far easier to do this in Blueprint as you have the power of the Editor at your disposal. This book will teach you how to effectively combine C++ with the other toolsets of the engine to maximize your development capabilities.

Polymorphism, virtual inheritance and templates

If you do not already know what polymorphism, virtual inheritance or templates are, your C++ journey with UE will be confusing and difficult. Using the link provided previously and the power of Google I would strongly recommend learning up on these topics before continuing with this book.

All of the UE objects that you interact with will have some base established in C++ code. In turn, most of these objects will also feature virtual functionality thus extensibility via C++ code. This will be your main entry point into the Unreal codebase. For example, when you wish to create a character object in code, the first thing you will do is create a class that inherits from `UCharacter`, thus becoming a child class of `UCharacter`. This will give you access to the various interfaces, methods, and variables that make up the `UCharacter` base class.

Through the virtual functions featured in base classes we will be able to have the engine invoke and execute our own custom functionality in-place of, or appending what exists in, the base class. Each facet of integration will be detailed as we progress through the following chapters. The first thing you will notice is that your new custom classes can be seen by the engine, meaning you can create Blueprint abstractions of your custom classes!

The other major C++ feature that UE utilizes is templatization. When adding other engine-based components and accessing Unreal Engine functionality, you will be utilizing UE's template objects and template functions. These template objects and functions extend UE4's customizable nature by providing us with generic feature sets that will be compatible with our custom C++ objects.

Hello World for C++

Before we begin to create an in-depth game project like `Barrel Hopper`, we will first return to the good old `Hello World` idea. We are going to be creating something very similar to what we created in *Chapter 1*, *Introduction to Unreal Engine 4* yet, this time, purely in C++! We can start by creating a new C++ project. Open Unreal Engine 4.10 via the Epic Games Launcher then select the **New Project** tab like we did before, however this time we are going to be choosing the **C++** tab. From the collection of project templates, select **Basic Code**.

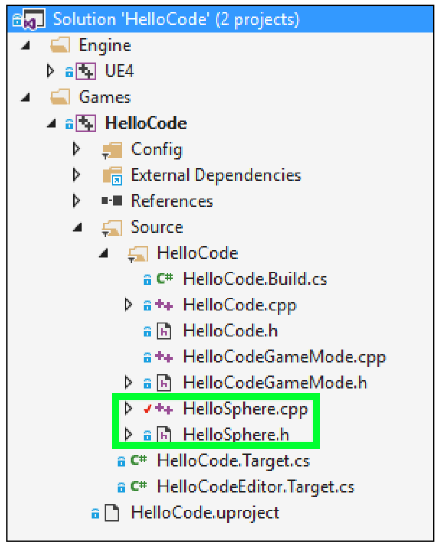
Call this project `Hello Code`. There will be a small waiting period while the engine prepares your project. Once finished you will be presented with an editor window and a Visual Studio project will have opened. The first thing we are going to do is add a new code class to our project. Do this by selecting **New C++ Class...** from the **File** dropdown located in the top left-hand corner of the main editor window.

This will open the class creation wizard. You will see that it prompts you to choose a parent class for the new object. We are going to be creating another hello sphere, this time using C++. As we are going to be creating an object that exists in the game world as an interactable and visible entity, we need to extend this object from the `AActor` base class. The reason for this will be explained soon.

Tick the checkbox **Show All Classes** in the top right-hand side of the class creation wizard then select Actor from the shown classes. You can also use the search bar provided at the top of the class creation wizard to find the desired base class. Hit the green **Next** button at the bottom of the wizard and you will be asked to name the class. Call this class `HelloSphere` then click the green **Create Class** button. The wizard will then generate an .h and `.cpp` file for us.

Exploring your first code class

You will notice that the source for the new `HelloSphere` object has been added to your Visual Studio project automatically and can be found under the source filter **Source** | `HelloCode`.



As you can see, it has been included alongside your project source files and a default `HelloCodeGameMode` object. Before we start to write anything, let's first break down what is presented to you by default so we can better understand the workings of an UE Object. Let's address the `HelloSphere.h` header file. There is not too much here to begin with, you should be presented with the following:

```
// Fill out your copyright notice in the Description page of Project
Settings.
#pragma once

#include "GameFramework/Actor.h"
#include "HelloSphere.generated.h"

UCLASS()
class HELLOCODE_API AHelloSphere : public AActor
{
    GENERATED_BODY()

public:
    // Sets default values for this actor's properties
```

```
    AHelloSphere();

    // Called when the game starts or when spawned
    virtual void BeginPlay() override;

    // Called every frame
    virtual void Tick(float DeltaSeconds) override;
};
```

Accommodating for the Unreal Build Tool

As you can see, `#pragma once` is specified by default, this is a pre-processor instruction informing the compiler to only compile this header file once when building the project. The first thing that you may notice is the include list for the header file. As you can see, the header file for the object's parent class (`AActor`) is included. Underneath this however is `#include "HelloSphere.generated.h"`. This line is very important as this allows the **Unreal Build Tool** (**UBT**) to generate code for our custom object.

The UBT is a very core aspect of the Unreal C++ workflow. It is through this tool that the engine is able to create associations between our custom objects and the core facilities of the engine. You may have seen something similar with other engines. The UBT does its work during something called a *Pre-Compile* stage, which makes sense as it generates code based on what is already in your object, before they are compiled by the standard compiler. How we interact with UBT will be detailed as we continue to learn about using C++ with UE4.

Pre-Compile macros and you

Unlike a standard C++ object, you will see some macros being used outside and inside the class definition. Macros are simply keywords that are swapped out for previously constructed code at compile time. In our case, these macros are going to be picked up by the UBT and replaced with generated code.

The first one that we encounter is `UCLASS()`, located just before the definition of the object. This macro is responsible for informing the engine of this object and any meta data associated with this object. As you can see, this macro includes an empty parameter list denoted by `()`, it is with this that you may also include something called *specifiers*. Specifiers act like parameters for the macro and will change how the class is interpreted by the engine. We will be utilizing these specifiers later in the chapter. For now we can leave the `UCLASS()` macro empty.

Predominantly, the presence of these macros are found in object header files with the Class definition, as it is here where you will be detailing most of the association between your code objects and UE4, which is why they are so prolific in this small 9-line class definition. The other two macros present are `HELLOCODE_API`, found within the class definition itself, and `GENERATED_BODY()`.

`HELLOCODE_API` is used to define code set to which this object belongs and is used as an organizational tool when building the project. The macro itself will always follow the same format `[ProjectName]_API`, all capitalized. In this case the line `class HELLOCODE_API AHelloSphere : public AActor` can be interpreted as, this a class `AHelloSphere` that inherits from `AActor` publically that is part of the `HelloCode` project API.

`GENERATED_BODY()` is simply a macro that allows for code generation to be inserted within the body of the object by the UBT itself before the main compile stage.

Breaking down the rest of the header file

The rest of the object is fairly simple, it includes a default constructor `AHelloSphere()` and two `virtual` functions, `BeginPlay()` and `Tick()`. `BeginPlay()` is called when the actor is spawned in the level and functions in exactly the same way as `Event BeginPlay` in Blueprint. This function has been declared as virtual in the `AActor` base class, therefore we can override this function to execute our own functionality when this actor is spawned in a level. The other function `Tick()` is also virtual and provides us with the delta tick for the current frame via the `float DeltaSeconds` input parameter.

These two functions are included by default by the class wizard, as it is assumed that, at the very least, these two functions will be overridden by all custom objects that inherit from the `AActor` base class. Let's now look at the `HelloSphere.cpp` file. You are provided with basic function definitions for the default methods that were generated by the C++ class wizard.

The default constructor and include list

Before we begin to break down each of these function definitions, let's first look at the include list for this `.cpp`:

```
#include "HelloCode.h"
#include "HelloSphere.h"
```

As you can see, the include list for the `.cpp` of this object also includes the header file for the project (`HelloCode.h`). This provides access to the engine code base within this `cpp`, meaning we can make use of things such as object creators, object finders, and logging, among other very important features. Ok, let's now take a look at the definition for the default constructor of our `AHelloSphere` object:

```
// Sets default values
AHelloSphere::AHelloSphere()
{
    // Set this actor to call Tick() every frame.
    // You can turn this off to improve performance.
    PrimaryActorTick.bCanEverTick = true;
}
```

When working with UE objects it is within the default constructor that you will specify a majority of your object initialization functionality, as it is here that you are able to populate and initialize your object components. The reason we do this in the constructor and not in `BeginPlay()` is we wish the components to be added and initialized before our project is playing at what we could call *Editor time*. This means our object's components will be created and initialized when the project is run. We will then be able to work with these components within the editor, much like we have done so far in this book.

Within the definition of the default constructor (`AHelloSphere::AHelloSpehre()`) you will note the inclusion of `PrimaryActorTick.bCanEverTick = true`. This line flags this actor to be scrutinized for `Tick` calls. It is very important to include this line for any objects that you wish to `Tick` during runtime.

Virtual functions and calling the parent

Now let's look at the two virtual functions that have been provided by default:

```
// Called when the game starts or when spawned
void AHelloSphere::BeginPlay()
{
   Super::BeginPlay();
}

// Called every frame
void AHelloSphere::Tick(float DeltaTime)
{
   Super::Tick(DeltaTime);
}
```

You may have noticed that both of the definitions for the virtual functions include the line `Super::[FunctionName]`. This line of code executes the parent functionality of the same function. This is a very important tool as it means you are able to override parent functions without worrying about missing any core functionality that takes place in that parent call. This emphasizes the previous point of extensibility in C++. You are able to override the functions found in UE objects, call them, and write your own extension functionality.

Adding components and object creators

The first thing we want to do is add components to our new object so that we may duplicate the Hello Sphere functionality we had in *Chapter 1, Introduction to Unreal Engine 4*, Components are created via a template function titled `CreateDefaultSubobject()`. There are many object creation methods such as `CreateDefaultSubobject()` that will be used when working with the engine. One of the main reasons we will use these object creation methods is so that we utilize Unreal Engine's memory management systems.

These object creation methods will invoke UE4's memory managers, identifying and allocating the most efficient memory location for our objects. They will also register the `UObjects` we are trying to create with the **Unreal Garbage Collector**. The garbage collector automatically cleans up any `UObjects` that are no longer being referenced or have fallen out of scope. Because of this we do not have to worry about memory leaks and inefficient memory allocations.

Now let's begin writing some C++ code. We are going to be adding all of the components needed to recreate the `HelloSphere` from *Chapter 1, Introduction to Unreal Engine 4* We are going to require a `UStaticMeshComponent` for our sphere visual mesh, a `USphereComponent` so we may check for overlap events, a `UParticleSystemComponent` for our fire particles, and a `UTextRenderComponent` for our `HelloWorld` text. When adding components to an object we do not always need to include a code side handle in our class member variables. This is because `CreateDefaultSubobject()` will register our components with the base class. Unless we wish to reference a component outside of the class constructor, we can save on memory and not include a handle to the component in our class definition.

The only component that we will need access to after initialization is the `UTextRenderComponent`. We will want to change the text of the component when the default pawn overlaps the sphere component of the `AHelloSphere` actor. Navigate to `HelloSphere.h` now and add a handle to this component in our `AHelloSphere` class definition as a member variable:

```
protected:
class UTextRenderComponent* TextRenderComponent;
```

It's important to note that this has not created the component, we have merely added a handle in the form of a pointer that is of type `UTextRenderComponent`. We have also specified this handle to be encapsulated at a protected level as this handle will not be accessed outside of this object. You may have noticed the keyword class being used here. This is known as inline forward declaration. It is always advised to forward declare object types that may not be known to your class definition. This is to reduce including overheads in our .h files. Before we populate this handle with an initialized component, let's first create our other required components and initialize those with the appropriate values.

Navigate back to `HelloSphere.cpp` and within the definition of our default constructor (`AHelloSphere::AHelloSphere()`) add the following code:

```
// Our root component will be a sphere component that will inform us
of overlaps and collisions
USphereComponent* SphereComponent =
CreateDefaultSubobject<USphereComponent>(TEXT("RootComponent"));

RootComponent = SphereComponent;

// Assign properties to sphere component
SphereComponent->InitSphereRadius(220.0f);

SphereComponent->
SetCollisionProfileName(TEXT("OverlapAllDynamic"));
```

Here we are creating and initializing the sphere component that will be used to detect overlaps and collisions with the `HelloSphere` actor. As you can see, here we are utilizing the `CreateDefaultSubobject()` template function. This function will create a component of the templated type and return a handle to the newly created component. You can specify the component name as a parameter to this function via the `TEXT` macro. We are then assigning the newly created component into a temporary handle so we may access the component and change some of its properties. It is also important to note that we set the `SphereComponent` as our `RootComponent` by assigning it to the provided `RootComponent` variable handle.

Instead of using a **Details** panel to change properties on a component, we have instead used member functions and variables to set these values. In the previous example, we are setting the sphere radius to `220.0f` via `InitSphereRadius()` and then setting the collision profile to `OverlapAllDynamic` via `SetCollisionProfileName()`. The latter takes in an `FName` representing the collision profile you wish to change to. It will make any changes to the collision settings required to match this profile. This is very similar to what you would do in the collision section of the **Details** panel.

> I would strongly recommend that every time you are working with an Unreal Object for the first time, you research that object using the Unreal Engine Reference API found here at `https://docs.unrealengine.com/latest/INT/API/index.html`.

Construction helpers and object finders

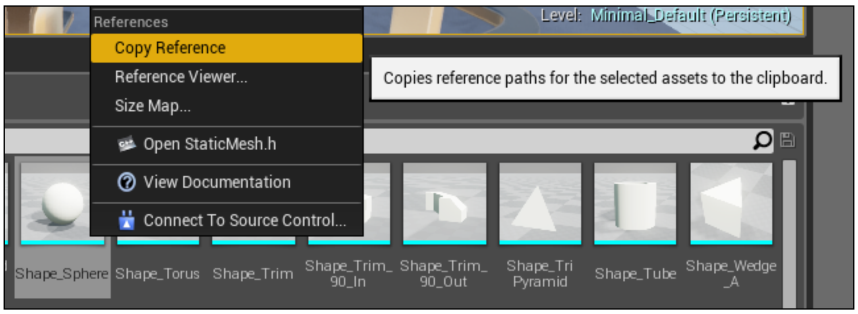
The next thing we are going to do is add our static mesh component that will be used to draw the sphere geometry of the object. We need to create a `UStaticMeshComponent` and then assign it a static mesh asset we have in our content browser. Unlike Blueprint, we do not have access to the drag-and-drop functionality of the content browser to create asset associations. Instead we must use a template object provided by the `Engine.h` header file (this header is included in the `HelloCode.h` by default). This template object is called a `FObjectFinder` and is part of the `ConstructorHelpers` namespace. You can initialize this object with the type of asset you wish to find as the template type, then provide a path to the asset you wish to populate the object with as a `FName` parameter to the object constructor. The following is the code that creates the appropriate static mesh component then uses a `FObjectFinder` object to assign the correct asset. Add the following code to the default constructor definition now:

```
// Create and attach a sphere mesh
UStaticMeshComponent* SphereVisual =
CreateDefaultSubobject<UStaticMeshComponent>(TEXT("SphereMesh"));
SphereVisual->AttachTo(RootComponent);

// Assign mesh to static mesh component through construction helper
ConstructorHelpers::FObjectFinder<UStaticMesh> SphereAsset(TEXT("/
Game/StarterContent/Shapes/Shape_Sphere.Shape_Sphere"));


// Adjust properties of the mesh if mesh asset was found
if (SphereAsset.Succeeded())
{
    SphereVisual->SetStaticMesh(SphereAsset.Object);
    SphereVisual->SetRelativeLocation(FVector(0.0f, 0.0f, -50.0f));
}
```

Here we have created a temporary handle (`SphereVisual`) to the `UStaticMeshComponent`. We then call `AttachTo()` on this newly created component. This function takes in a handle to the component we wish to attach to, in our case this is the `RootComponent` handle that currently points to the `SphereComponent` we created earlier. This attaching is the same as dragging one component onto another in the **Components** panel of the Blueprint Editor.

Next we create an `FObjectFinder` with the template type of `UStaticMesh` called `SphereAsset`. We then use the constructor of the `FObjectFinder` to initialize the finder with the path to a sphere asset in our content browser. This will then invoke the `FObjectFinder` to locate and assign the asset at the provided path to itself.

When providing the path to any given asset in the content browser, the easiest way is navigating to the asset in the **Content Browser,** right-clicking the desired asset, and selecting **Copy Reference**. This method can be seen as follows, along with the yielding result:



This will yield—`StaticMesh'/Game/StarterContent/Shapes/Shape_Sphere.Shape_Sphere`.

Everything following the object type surrounded by the (`'`) character is the path you must provide to the `FObjectFinder` constructor.

Following the construction of the `FObjectFinder` we ensure that this asset assignment was successful. We do this via the `Succeeded()` method. The `FObjectFinder` object includes the function `Succeeded()`, which returns a `bool` that represents whether the asset path provided at construction was valid and the asset has been found. If this function returns `true`, we assign the found static mesh to the `UStaticMeshComponent` we just created and adjust its relative position slightly.

We can assign the Mesh asset via the `Object` member of `FObjectFinder`. This member will be of the template type specified when creating the `FObjectFinder`, in this case `UStaticMesh`. We can use `Object` as an input parameter to the `SetStaticMesh()` function of the `UStaticMeshComponent`. We then slightly change the relative location of the sphere Mesh with `SetRelativeLocation()`, this is so that it sits in the center of our root sphere component. It is important to note that we are adjusting the relative location of the component. This means the position adjustment will be maintained as the `HelloSphere` object as a whole travels through world space.

Building the code

Alright! Now let's build our code for the first time. You may have noticed that our open Visual Studio project is not currently running our Editor (as no project instance is running). Close your UE Editor now but leave Visual Studio open. Ensure the `HelloCode` project is set as the start-up project by right-clicking on the project in the Solution Explorer and selecting **Set** as **Startup Project...**, also ensure that your Solution **Configuration** is set to **Development Editor** and **Solution Platforms** is set to **Win64**. You should see the following at the top of your IDE window:

Now, build the project by clicking the **Local Windows Debugger** button or pressing F5 and behold the glory of your (and Epic's) compiled code! If your project does not build cleanly, address the **Output** panel of the IDE for any errors or warnings you need to clear up.

Upon successful compilation you will be presented with the Level Editor, as you would if you had simply opened the project via the **Project Browser**. There will be one key difference however, our new `Hello Sphere` object will be included in the class lists! To see our C++ classes in the content browser there is a small button that will show or hide the sources panel. It is highlighted in the following image:

As you can see, our `HelloSphere` object can be located under the **C++ Classes** | **HelloCode** filter. Drag and drop our old friend into your level now and you will be presented with a sphere Mesh and sphere collider! Select this `HelloSphere` entry in the content browser and drag it into the level scene!

Adding Fire Particles and Hot Compilation

Ok, now we are going to finish creating the `AHelloSphere` object. We are going to be making edits to the code, however do not stop running the build of our project from the IDE. We are going to be Hot Compiling the following code modifications. What that is will be detailed soon. For now, let's set the `HelloSphere` on fire!

Setting the sphere on fire

We are going to set the sphere on fire by adding a `UParticleSystemComponent` to our object and then assigning this component a particle template in the same way we assigned a sphere mesh to the `UStaticMeshComponent`. Navigate to `HelloSphere.cpp` and add the following code to the `AHelloSphere::AHelloSphere()` constructor:

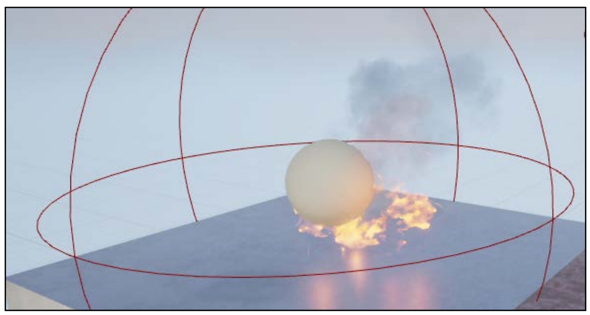
```
// Create the fire particle system
UParticleSystemComponent* FireParticles =
CreateDefaultSubobject<UParticleSystemComponent>(TEXT("Fire
Particles"));

FireParticles->AttachTo(SphereVisual);
FireParticles->bAutoActivate = true;

// Assign fire particle system to component
ConstructorHelpers::FObjectFinder<UParticleSystem> FireVisual(TEXT
("/Game/StarterContent/Particles/P_Fire.P_Fire"));

if (FireVisual.Succeeded())
{
    FireParticles->SetTemplate(FireVisual.Object);
}
```

We are creating the component via `CreateDefaultSubobject` as per usual. We are then attaching the newly created `UParticleSystemComponent` to the `UStaticMeshComponent` we created earlier. This is because we wish the particle system to move with the mesh when translated. We also ensure that the `bAutoActivate` member of `UParticleSystemComponent` is set to `true` as we want it to start playing as soon as the object is spawned in the level. We then use another `FObjectFinder`, this time of type `UParticleSystem`, to retrieve the `P_Fire` particle system template provided by the Unreal Starter content.

The next step is very similar to the assignment of the mesh asset to `UStaticMeshComponent`. Again we use the `Succeeded()` function to gauge the success of asset retrieval. If it succeeds, we provide the `Object` member of the `FObjectFinder` `FireVisual` to the `SetTemplate()` function of the `UParticleSystemComponent`. Because we created `FireVisual` with `UParticleSystem` as the template type, the `Object` member will be of type `UParticleSystem`, thus it is compatible as an input parameter for the `SetTemplate()` function. This is a great example of effective template use when working with C++ and UE4.

Hot Compilation

Now that we have made a change to the codebase, let's quickly demonstrate the power of Hot Compilation. Hot Compilation allows the developer to make changes to the codebase of an object without having to rebuild the entire project. To perform a hot compile, you must press the **Compile** button located in the **Toolbar** of the Level Editor. Ensure you have the `HelloSphere` object present in the viewport and then press the **Compile** button. You will notice a small popup appear in the bottom right-hand side of the screen that states **Compiling C++ Code…**. When the code compilation is successful you will see the `Hello Sphere` object in the level update to the latest version of the compiled asset! How can we tell the object has been updated? Well, it should not be aflame like so:



If the object has not updated properly, ensure that the code compiled successfully. If it did and the object has still not updated, simply re-drag the `HelloSphere` object into the scene and delete the original. This Hot Compilation feature is a very powerful tool as we do not have to worry about re-building the entire project whenever we make small changes to the codebase. However, large refactors or additions to the codebase will require a full re-compile from Visual Studio, especially with regards to changes made to header files, as this may have a direct impact on how the object associates with the engine. If you do experience any strange bugs after a Hot Compilation, be sure to recompile the project to see whether the bug still remains.

Hello world text and receiving events through delegates

Now it is time to finally add the 3D text that gives `AHelloSphere` a little personality. If you remember, the way we did this in Blueprint was simply by changing the text of a `TextRenderComponent` upon receiving an `OnBeginOverlap event`. We have to do this a little differently in code, instead of overriding the event function call in our `AHelloSphere` object or waiting for an event to be hit, we are going to be creating a function and binding it to the event delegate. The reason for this will be explained soon, for now let's add our `UTextRenderComponent` to the object.

Adding the 3D text

Navigate back to HelloSphere.cpp and, within the constructor definition (AHelloSphere::AHelloSpehre()) underneath the code we just added for the particle system, add the following code:

```
// Initialize Text Render component
TextRenderComponent =
CreateDefaultSubobject<UTextRenderComponent>(TEXT("Text"));

TextRenderComponent->AttachTo(SphereVisual);

TextRenderComponent->SetRelativeLocation(FVector(0.0f, 0.0f, 110.0f));

TextRenderComponent->SetHorizontalAlignment(EHTA_Center);
TextRenderComponent->SetYScale(2.0f);
TextRenderComponent->SetXScale(2.0f);
TextRenderComponent->SetVisibility(true);
TextRenderComponent->SetText(NSLOCTEXT("AnyNs", "Any", "HelloWorld"));
```

Here we create the UTextRenderComponent via the CreateDefaultSubobject() function, then attach it to the UStaticMeshComponent using AttachTo() and the SphereVisual handle. We then change some of the properties of the text render component. We want to have the text float above the sphere, thus we are changing the relative offset of the text by 110.0f on the Z axis via SetRelativeLocation(). We then want to ensure that the text aligns so that it is centered around its location in 3D space. We do this by changing the alignment type via SetHorizontalAllignment() to EHTA_Center. We then change the scale of the text and ensure the text is visible.

The way we set the text is fairly interesting, however we do this by using the macro NSLOCTEXT. This macro creates and returns an FText object for us to parse into the SetText() function. We only wish our text to say HelloWorld so why have we also provided the strings AnyNS and Any? In short, Any is a key and AnyNS is a namespace.

FText as an object has been designed with localization support in mind. This means you are able to easily localize your projects to whichever country you are building for. Because of this, when creating an FText object you need to provide not only a string value to write but also a key. The key will be used by the localization tools to identify the text value, even after the language has changed. Meaning that HelloWorld could be changed to こんにちは世界 if you were building to Japan via the localization tools, but the key Any will remain the same. Namespaces are simply used to group keys together so you may localize one namespace grouping of text but not another. If you do not wish to use FText you can use an FString object or FName object via the TEXT macro but this will result in a warning from the compiler.

> If you want to learn more about `FText` and the localization tools, go here https://docs.unrealengine.com/latest/INT/Programming/UnrealArchitecture/StringHandling/FText/index.html.

Ok, perform another hot compile and see the new text floating above our spherical friend:

Delegates and Events

Let's look into how we are going to be receiving the `BeginOverlap` event in our `AHelloSphere` code object. We have to add code to both our class definition in the `HelloSphere.h` file as well as the default constructor definition in the `HelloSphere.cpp`. We are going to be creating two functions `MyOnBeginOverlap()` and `MyOnEndOverlap()`. We are then going to provide these two functions to the corresponding delegates found in the `AActor` base class. Delegates are objects that act in a similar way to Event Dispatchers in Blueprint. We are able to provide multiple function handles to a delegate and have them all invoked when the delegate is instructed to broadcast.

Delegate objects are declared with a given function signature. A function signature is what defines the make-up of a function, for example the function `void Multiply(int a, int b)` has a function signature that looks like this `void function (int, int)` or void Function (<Param1>, <Param2>). Meaning a function that takes in two integer numbers as input parameters and does not return anything. You could then create a delegate called `MathDelegate` specifying this function signature at declaration. You would then be able to bind `Multiply()` to `MathDelegate` as well as any other functions with a matching function signature. When the `MathDelegate` is instructed to Broadcast `Multiply()`, any other bound functions will be invoked.

We can see the benefits of this delegate system when we utilize those provided by the `AActor` base class. For us to have the functionality to execute when an actor overlaps our sphere component, we need to create a function that we will bind to a delegate called `OnActorBeginOverlap`. We are then going to have to do the same thing with a different function for the `OnActorEndOverlap` delegate. The reason this has to be done via delegates instead of say, virtual functions, is so that we may have multiple functions bound to these delegates throughout the object's hierarchy, including those declared in Blueprints. You may have guessed already that whenever you add an event node to a blueprint graph you are really binding a new function to a backend code delegate of a similar name!

Let's first create the functions we are going to bind by adding the following code to the `HelloSphere.h` file within the class definition, just above the declaration of the `UTextRenderComponent` handle under the protected keyword:

```
// On Overlap implementation
UFUNCTION()
void MyOnBeginOverlap(AActor* OtherActor);

// On End Overlap implementation
UFUNCTION()
void MyOnEndOverlap(AActor* OtherActor);
```

Here we have created two functions that have the same signature `void function (AActor*)`. This is important as this is the signature of the `OnActorBeginOverlap` and `OnActorEndOverlap` delegates. We have also encountered a new pre-compiler macro `UFUNCITON()`. The `UFUNCITON()` macro lets us inform the engine of any crucial functions that we wish the engine to know about. We may also specify any unique properties of the function via specifiers but let's not get ahead of ourselves. The `UFUNCTION()` macro is present here as it is required if we wish to bind these functions to any delegates.

Next we need to actually bind these functions to the aforementioned delegates. Let's do this now by adding the following code to the definition of the constructor in the `HelloSphere.cpp` underneath the `UTextRenderComponent` initialization:

```
// Bind delegates
OnActorBeginOverlap.AddDynamic(this, &AHelloSphere::MyOnBeginOverlap);
OnActorEndOverlap.AddDynamic(this, &AHelloSphere::MyOnEndOverlap);
```

What we are doing here is adding the functions we just declared to the corresponding delegates via the `AddDynaminc` function. This function takes in a handle to the object that will invoke the function we are binding, and a handle to the function that is to be called. We are doing this via the `this` keyword and the address of the respective function.

The next thing we need to do is define the functions we just bound so they perform meaningful functionality. We can do this by adding the following code to the `HelloSphere.cpp`. Note that these function definitions are outside the scope of the constructor definition:

```
void AHelloSphere::MyOnBeginOverlap(AActor* OtherActor)
{
   FString outputString;
   outputString = "Hello " + OtherActor->GetName() + "!";
   TextRenderComponent->SetText(FText::FromString(outputString));
}

void AHelloSphere::MyOnEndOverlap(AActor* OtherActor)
{
   TextRenderComponent->SetText(NSLOCTEXT("AnyNs", "Any",
   "HelloWorld"));
}
```

The function `MyOnBeginOverlap()` will now concatenate an `FString` based on `Hello`, the name of the offending actor, and `!` will then convert this string to an `FText` value via `FText::FromString`. It will then set the text value of the `UTextRenderComponent` to the resultant `FText` value. `MyOnEndOverlap()` simply sets the text back to `HelloWorld` in the same way we did upon the initial creation of the `UTextRenderComponent`.

Hot compile our new changes and run the project! When you encroach on the `Hello sphere` it will greet our pawn object. You should see something similar to the following:

If you want to learn more about delegates now, go to `https://docs.unrealengine.com/latest/INT/Programming/UnrealArchitecture/Delegates/index.html`.

Polishing the sphere

There are a few more things we need to do before our C++ Hello Sphere is the same as the Blueprint one we made earlier. We need to add that Unreal Factor and give our sphere that nice metallic sheen that made it glisten in the light of its own fire.

Changing materials via C++

We are going to have to change a property of the UStaticMeshComponent we created after we have set the mesh of the object. This is very easy to do, all we need is another FObjectFinder that will be able to find the material object we require, then simply set the material value of the UStaticMeshComponent. This can be done by modifying our original UStaticMeshComponent initialization code in the HelloSphere.cpp within the constructor definition, to appear as follows:

```
// Assign mesh to static mesh component through constructions helper
ConstructorHelpers::FObjectFinder<UStaticMesh>
SphereVisualAsset(TEXT("/Game/StarterContent/Shapes/Shape_Sphere.
Shape_Sphere"));

ConstructorHelpers::FObjectFinder<UMaterial> SphereMaterial(TEXT("/
Game/StarterContent/Materials/M_Metal_Burnished_Steel.M_Metal_
Burnished_Steel"));

// Adjust properties of the mesh if mesh was created successfully
if (SphereVisualAsset.Succeeded() && SphereMaterial.Succeeded())
{
    SphereVisual->SetStaticMesh(SphereVisualAsset.Object);
    SphereVisual->SetMaterial(0, SphereMaterial.Object);
    SphereVisual->SetRelativeLocation(FVector(0.0f, 0.0f, -40.0f));
}
```

As you can see, all we needed to do was create another FObjectFinder of type UMaterial and ensure we check the result of the retrieval of this asset alongside that of the UMesh, and then simply set the material via the SetMaterial() function. It is important to note that the first parameter of the SetMaterial() function is the index of the material you wish to change. This is important when setting materials of meshes that have multiple material indexes.

With the previous code in place and compiled, we can finally say hello to a finished HelloSphere made entirely in C++!

Extending C++ into Blueprint

Ok, now that we have implemented a purely C++ based object, let's look at the ways we can extend our code classes into Blueprint and utilize specifiers to communicate more information from our code classes to the engine.

The first thing we are going to do is extend a custom class into Blueprint! This is a very powerful feature of the engine as it allows us to write backend functionality for objects in code, but utilize all of the association tools of the Editor for things such as assigning materials, meshes, sounds, and other asset-based functionality. To successfully extend a code class into blueprint you must provide information to the engine about the class through specifiers. These specifiers act as input arguments for macros such as `UFUNCITON()`, `UPROPERTY()`, and `UCLASS()`.

Extending a class with no macro specifier support

Let's see what happens when we attempt to extend our `AHelloSphere` C++ class we just made, which exists purely in C++. The `AHelloSphere` has not specified any additional information about itself or any of the functions/properties contained within. Navigate to the `Content` folder of the Content browser and create a new `blueprint` class. For the base class, choose `HelloSphere` under the **All Classes** section. You will be presented with a new blueprint object that is an abstraction of `AHelloSphere`! Call this blueprint `BrokenBP`. Open this blueprint now and you will see the hello sphere we just created in the Blueprint Editor.

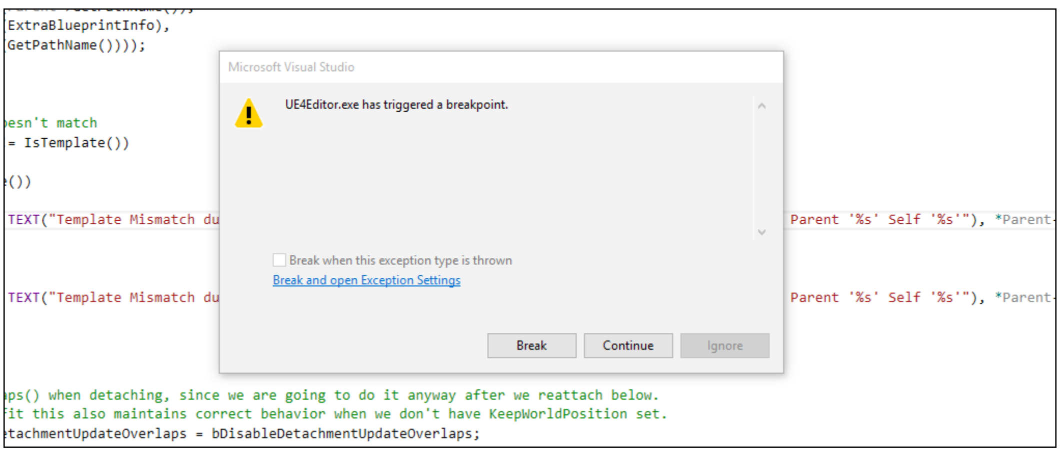
The first thing you might notice is that all of the components we added in code can be seen in the **Components** panel and that they have all been listed as **(Inherited)**, this means that the components are based in C++ code. When you select one of these inherited components, the details panel does not populate! That is because when creating the components, we neither declared the components with the `UPROPERTY()` macro in the header file of the object, nor specified any additional information about the property that would allow us to edit the component from Blueprint.

The result, none of these components may be changed in the Blueprint and they cannot be referenced in Blueprint graphs. They can't even be seen as variables in the **MyBlueprint** panel. This may be intended when creating some objects as you might wish to extend the object into Blueprint, but you do not want any of the components specified in C++ to be modified or referenced.

You may also want to view any inherited variables that exist in the C++ base class. To do this you need to select the dropdown next to the small eye icon in the **MyBlueprint** panel and select **Show Inherited Variables**.

As you can see, we do not have access to the `UTextRenderComponent` we declared in the header file of the `AHelloSphere` object. This is because, as stated previously, we did not specify via a `UPROPERTY()` macro that we wished it to be visible or changeable in blueprint. We will get to that in a moment but first, let's try dragging an instance of this `BrokenBP` into our level then run the project. Upon dragging the object into the level, everything seems fine, all of the components translate with the root component and they are all drawn properly. Now let's try running the project.

Oops! We have encountered a break point, the Editor has thrown an assertion.



You can break at this point by pressing the **Break** button and address the position of the execution arrow. You can see from the target line of code that the reason for the break is a *Template mismatch during attachment*. Meaning that when the BP version of our code class was constructed and it attempted to attach our components to one another, this assertion was hit! The actual reason this happened is because we have not informed the engine of any of our components that we created and attached at construction. We need to do this by declaring each of the component handles in the header file with the `UPROPERTY()` macro. Again, we will be making changes like this very soon. First, let's hit the continue button at the top of the IDE as this break is not crucial and the project can continue play. You will notice in the following that no matter where we position our `BrokenBP` in the level, it is positioned very strangely during play:

The core problem that is causing all of these issues is that we have attempted to extend a C++ class into blueprint without correctly informing the engine of all of the properties that the blueprint object interacts with. The best example of this is the components themselves. It is important to note that our instances of the C++ only code class still work perfectly well in UE. It is simply this Blueprint abstraction that is broken. Fear not however! Extending C++ objects into Blueprint is very welcome and supported by UE. We just have to ensure we write code correctly to allow this to happen. Let's do this now!

Extending a class with macro specifier support

Instead of editing our original `AHelloSphere`, let's create a new object called `HybridSphere`. Do this now by creating a new C++ class via **File | New C++ Class...** and choosing Actor as the base class again. This time we are going to be creating an object that is designed specifically to be extended into Blueprint. We are going to achieve the same end result via different methods.

For one, we are not going to be assigning materials and properties to the object in C++, we are only going to be creating and attaching the components. We will leave asset assignment to the designers that work with our object in UE (or us at a later point in time)! We are however still going to be writing our overlap functionality in code, but this time we will again provide functionality so that we may override our overlap functionality in blueprint if we wish.

Defining a class with macro specifiers

Let's start by including the appropriate components, macros, and specifiers to `AHybridSphere`. Usually, when creating objects that are to be extended into blueprint, you must specify that it is `BlueprintType` in the `UCLASS()` macro. `AActor` objects are by default specified as such, we will still include this line for the sake of being explicit. We are also going to have to add a handle to each of the components we wish our `AHybridSphere` to own and declare them all with `UPROPERTY()`. The following code does just that:

```
UCLASS(BlueprintType)
class HELLOCODE_API AHybridSphere : public AActor
{
GENERATED_BODY()

public:
   // Sets default values for this actor's properties
   AHybridSphere();

    // Called when the game starts or when spawned
    virtual void BeginPlay() override;

    // Called every frame
```

```
    virtual void Tick( float DeltaSeconds ) override;

protected:

     UPROPERTY(Category = "Components", EditAnywhere)
     class USphereComponent* Sphere;

     UPROPERTY(Category = "Components", EditAnywhere)
     class UStaticMeshComponent* Mesh;

     UPROPERTY(Category = "Components", EditAnywhere,
     BlueprintReadOnly)
     class UTextRenderComponent* Text;

     UPROPERTY(Category = "Components", EditAnywhere)
     class UParticleSystemComponent* Particles;
};
```

As you can see, we have specified in the `UCLASS()` macro that this object is a `BlueprintType`. We have also included a handle to each component we are going to create as a member variable in our `AHybridSphere` class definition. The reason for this being that we need to declare each one with the `UPROPERTY()` macro. We do this to avoid the issues we had before when attempting to extend a code class into blueprint. The inclusion of this macro informs the engine of the existence of this property so it will feature successfully and bug free in any blueprint abstractions. It also provides us with the use of the `UPROPERTY()` specifiers.

The two that we have used previously are `EditAnywhere` and `BlueprintReadOnly`. `EditAnywhere` affords us the ability to edit the component from within our Blueprint abstractions. This means that when we create our blueprint abstraction of this C++ object, we will have access to the components properties in the **Details** panel. This is much easier than writing asset assignments and adjusting component properties from within C++. This specifier also allows us to translate, attach, and positon the component within the viewport and components panel of the Blueprint editor.

`BlueprintReadOnly` is only specified on the `UTextRenderComponent`. This specifier informs the engine that we would like to be able to read the reference to this component from within Blueprint Graphs. Meaning we can get a reference to the `UTextRenderComponent` and call the appropriate functions. If we wished to also write to the reference, meaning replace the `UTextRenderComponent`, we can specify `BlueprintReadWrite`.

We have also specified a category for the properties via the Category specifier. This simply groups the properties under the **Components** category and will appear so when featured in variable lists within the engine. These categories are useful for organizing function and variables lists in blueprint abstractions.

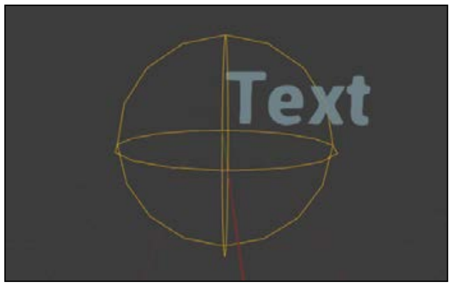
The next thing we need to do is create these components in the constructor definition. Navigate to `HybridSphere.cpp` and add the following code to `AHybridSphere::AHybridSphere()`:

```
// Create the remaining components and attach to appropriate parents
Sphere =
CreateDefaultSubobject<USphereComponent>(TEXT("OverlapSphere"));
RootComponent = Sphere;

Mesh = CreateDefaultSubobject<UStaticMeshComponent>(TEXT("Mesh"));
Mesh->AttachTo(Sphere);

Particles =
CreateDefaultSubobject<UParticleSystemComponent>(TEXT("Particles"));
Particles->AttachTo(Mesh);

Text = CreateDefaultSubobject<UTextRenderComponent>(TEXT("Text"));
Text->AttachTo(Mesh);
```

As you can see, we still create our components using the `CreateDefaultSubobject()` template function and create our component hierarchy with `AttachTo()` and by setting the `RootComponent`. However, this time we aren't writing any code that changes the properties of these components. We are going to do all that in the Blueprint Editor. Compile this code now, we are going to make our working blueprint abstraction.

Working with code created components

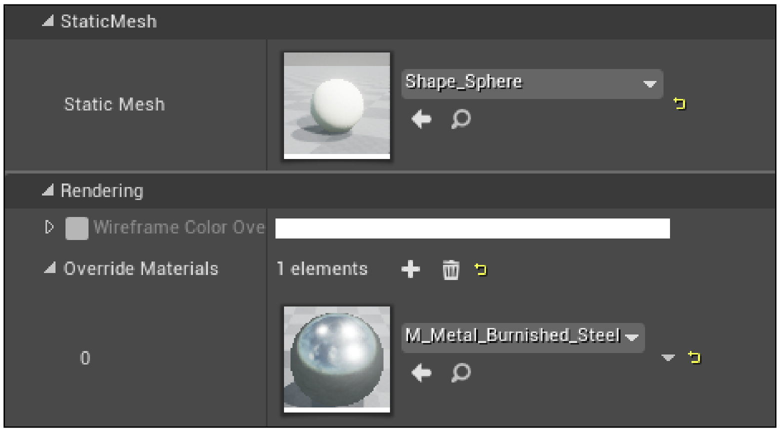
Navigate to the **Content** folder of the **Content** browser again and create another blueprint object, this time specifying the base class as **HybridSphere**. Call this blueprint `FixedBP`. Ensure you have deleted the `BrokenBP` from your level and content browser, we do not wish to have any hazardous objects featured anywhere in our project. Now open `FixedBP` and you will be presented with something in the viewport that looks like this:



That is because we are yet to define any of the properties of our components. You will notice that again our components have been listed as inherited, however this time when we select them, the details panel populates. You will notice that it looks slightly different to what we are used to. The main thing to notice here is the new layout of the code component details panel. Select the **Sphere(inherited)** component now and address the **Details** panel, you will see the following:

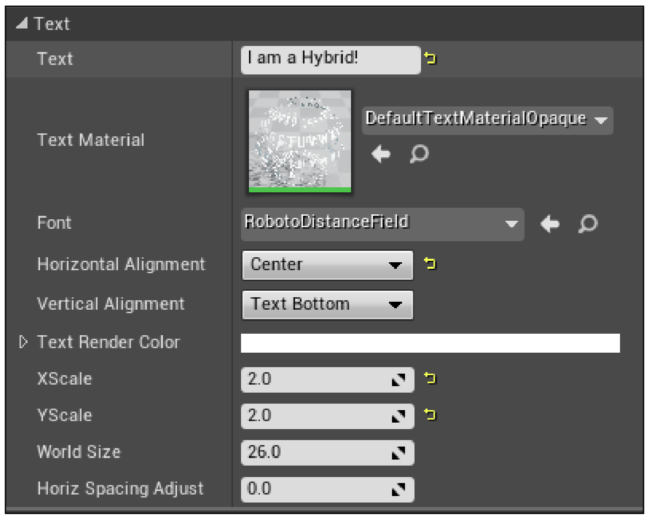
Click the small drop-down arrow next to Sphere and you will see all of the **Details** Panel sections you are familiar with when working with **Sphere Collision** components, even though they may appear different. This is how details appear when working with code-based objects within Blueprint. Alright, let's set up our sphere. Under the Shape section of the details panel, change the Sphere radius property to `220.0f`.

Next we must scrutinize the Mesh (Inherited) component. We need to set the mesh asset to the sphere we used earlier and the material to `M_Metal_Burnished_Steel`. We will also have to translate the Sphere as we did before so it sits in the middle of the Sphere Collision Volume. Select the mesh component and, under the details panel, expand the `Mesh` section. Under the `StaticMesh` section you will find the `StaticMesh` property dropdown, set this to `Shape_Sphere`. Changing the material will be a little different as this time we are going to utilize a property called `Override Materials`. What this will do is override a material of the given static mesh. Under the **Rendering** section you will find the `Override Materials` property list, click the small white plus (+) to add an element, then with this element search for the `M_Metal_Burnished_Steel` material. You should see something similar to this in your **Details** panel:

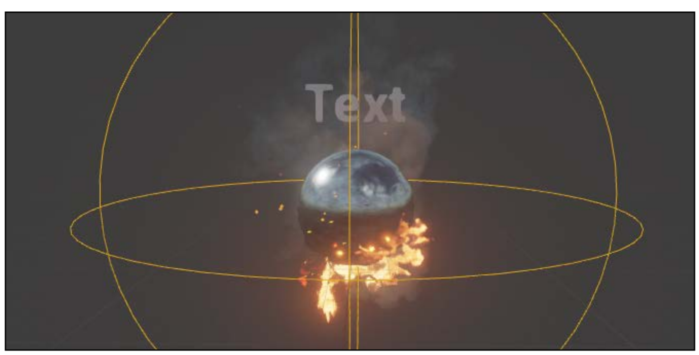


Next, to center our sphere, navigate to the **Transform** section and change the **Z** element of the Relative Location transform property to **-50.0**.

Next we must set the Particle component to the fire particle system we used before. With the **Particles (Inherited)** component selected, expand the **Particles** section of the **Details** panel and set the `Template` property to `P_Fire` via the dropdown. Finally, we have to set the properties of the **Text (Inherited)** component. Match the settings in the following screenshot then adjust the **Relative Location** property of the **Transform** section so that the **Z** element is **110.0f**:



You should now see something that looks like this in the viewport:



Ok, let's see how this looks in a level! Drag and drop our new `FixedBP` into the level somewhere and press **Play**. No crash! And our Blueprint object is translated to exactly where it is supposed to be.

Blueprint native events and you!

Now that we have the sphere constructed properly via the Editor, let's include the functionality that gets the `AHybridSphere` saying hello and goodbye. We are going to be creating this functionality a little differently this time. We are again going to be utilizing the delegate system detailed previously, but this time we are going to be writing functions that have a base functionality in code, which then may be overridden in a Blueprint if deemed necessary. This means we can create C++ functions that provide a default functionality set that will execute if no override has been defined in Blueprint. These functions are declared via the `UFUNCTION()` macro and the `BlueprintNativeEvent` specifier. Navigate to `HybridSphere.h` and add the following code to the `AHybridSphere` class definition underneath the virtual `Tick` function declaration:

```
// On Overlap implementation
UFUNCTION(BlueprintNativeEvent)
void MyOnBeginOverlap(AActor* OtherActor);

void MyOnBeginOverlap_Implementation(AActor* OtherActor);

// On End Overlap implementation
UFUNCTION(BlueprintNativeEvent)
void MyOnEndOverlap(AActor* OtherActor);

void MyOnEndOverlap_Implementation(AActor* OtherActor);
```

As you can see, we have created the same `MyOnBeginOverlap()` function, however this time we have specified that it is a `BlueprintNativeEvent`. That means that this event can be defined in any Blueprint abstractions. However, if it is not, look at this code class for a base implementation. You will also notice that we have included the function `MyOnBeginOverlap_Implementation()`. This is simply so that when we define the base implementation in our `.cpp`, the **UBT** knows where to look. For every `BlueprintNativeEvent` that you define, you must include an accompanying Implementation version of the function with the following format `[FunctionName]_Implementation(Same parameter list)`. Without this the compiler will throw an error.

Alright, let's add the definition for our new overlap functions to the HybridSphere.cpp. We will be adding the definition to the Implementation versions of the collision functions. Navigate, to `HybridSphere.cpp` and add the following code:

```
void AHybridSphere::MyOnBeginOverlap_Implementation(AActor*
OtherActor)
{
    FString outputString;
```

```
        outputString = "Hello From C++!";
        Text->SetText(FText::FromString(outputString));
    }

    void AHybridSphere::MyOnEndOverlap_Implementation(AActor* OtherActor)
    {
        Text->SetText(NSLOCTEXT("AnyNS", "Any", "Goodbye From C++"));
    }
```

As you can see, it is very similar to the code we used in our `AHelloSphere` except this time we have changed the greeting to `Hello From C++`. This is so it is clear whether we are using the C++ base implementation of the `BlueprintNativeEvent` or our Blueprint Extension.

The last thing we need to do is provide these functions to the on begin and end overlap delegates! Add the following code to the constructor definition under our component creation code:

```
OnActorBeginOverlap.AddDynamic(this,
&AHybridSphere::MyOnBeginOverlap);
OnActorEndOverlap.AddDynamic(this, &AHybridSphere::MyOnEndOverlap);
```

It is important that you provide the original `BlueprintNativeEvent` function not the Implementation version of the function as the `BlueprintNativeEvent` will be calling our base implementation.

Ok, let's hot compile this code and check that it works in the level! When the compilation is complete, ensure there is a `FixedBP` object in your level, press play, and navigate towards the `HybridSphere` to be greeted from C++!

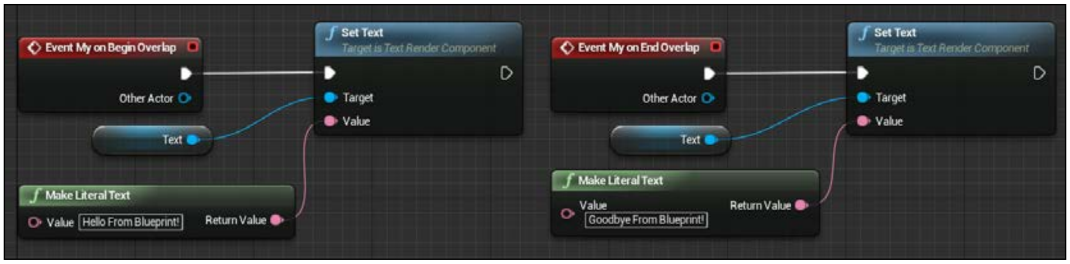
Overriding a BlueprintNativeEvent

Ok, now let's demonstrate the power of Blueprint Native Events. We are going to duplicate our `FixedBP` to create a new separate blueprint within which we can then specify our `BlueprintNativeEvent` functionality. Specifying this functionality will override our C++ base implementation and it will no longer be used when an overlap begins or ends.

Do this now by right-clicking `FixedBP` in the **Content** browser and selecting **Duplicate**, this will create a blueprint that is, by default, called `FixedBP2`. You can change this if you like or keep it as is. You will notice that all of the changes we made to the components in the Blueprint editor for the original `FixedBP` have been preserved.

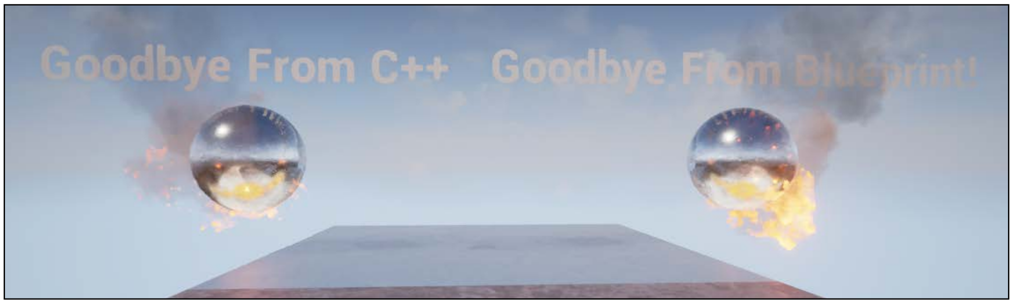
Open the `FixedBP2` Blueprint and navigate to the **Event Graph**. Here we are going to be summoning two event nodes, `Event MyOnBeginOverlap` and `Event MyOnEndOverlap`. By summoning these two nodes we are effectively stating that we wish to override the C++ base implementation of these two events and use the node arrangement following these event nodes instead of the C++ base implementation. What we are going to do is set the text on our **Text (inherited)** component. Now it will be made obvious as to why we specified our `UTextRenderComponent` in `AHybridSphere` with `BlueprintReadOnly`.

Ensure that you have checked **Show Inherited variables** and, under the **Variables** section of the **MyBlueprint** panel, you will see a new category titled **Components**. Expand this now and you will see a reference to our `UTextRenderComponent` titled **Text**. Drag a reference to this component as a `get` node into the event graph and summon a `Set Text` node from it. Then summon a `make literal text` node, enter `Hello From Blueprint`! for the input to this literal node, and plug the output into the `set text` node. Connect the `Set Text` node to the `Event MyOnBeginOverlap` node. Duplicate the set text functionality and connect these new nodes to the Event `MyEndBeginOverlap` node. In the copied `make literal` text node, populate the input with `Goodbye From Blueprint!`. You should have an arrangement that looks similar to this:



Now compile the Blueprint and drag an instance of it into the level next to our original `FixedBP` object. Ensure that there is enough space between the two of them so that we may interact with one but not the other, this should be easy as our pawn is currently flying.

Run into both in turn and you will see an output like this:



As you can see, the `FixedBP2` object on the right has deferred to using the Blueprint implementation of the event where our original `FixedBP` object is still using the code definition, as there is no Blueprint specification provided. Keep in mind that both objects inherit from the same base class!

Summary

Congratulations! You have completed your Hello World exercise for using C++ with UE! We have learnt about the C++ workflow for Unreal Engine, how to write pure C++ objects we can then load into our levels, how to create components in C++, how to create objects in C++ that can be extended into blueprint, Blueprint native events, the Unreal Build Tool, and much more! We are going to be building on these skills in the next chapter to further hone your Unreal C++ skills when we endeavor to create your very first UE C++ title, Bounty Dash!