# Game Engine Architecture

Chapter 7

Resources and the File System

# Overview

- File System
- Resource Manager

# Data

- Game engines are inherently data management systems
- Handle all forms of input media
  - Textures
  - 3D mesh data
  - Animations
  - Audio clips
  - World layouts
  - Physics data
- Memory is limited, so we need to manage these resources intelligently

# File system

- Resource managers make heavy use of the file system
- Often the file system calls are wrapped
  - Provides device independence
  - Provides additional features like file streaming
- Sometimes the calls for accessing different forms of media are distinct - Disk versus a memory card on a console
- Wrapping can remove this consideration

# Engine file system

- Game engine file systems usually address the following issues
  - Manipulating filenames and path
  - Opening, closing, reading and writing individual files
  - Scanning the contents of a directory
  - Handling asynchronous file I/O requests (for Streaming)

# File names and paths

- Path is a string describing the location of a file or directory
  - volume/directory1/directory2/…/directoryN/file-name
- They consist of an optional volume specifier followed by path components separated with a reserved character (/ or \)
- The root is indicated by a path starting with a volume specifier followed by a single path separator

# OS differences

- UNIX  and Mac OS X
  - Uses forward slash (/)
  - Supports current working directory, but only one
- Mac OS 8 and 9
  - Uses the colon (:)
- Windows
  - Uses back slash (\) – more recent versions can use either
  - Volumes are specified either as C: or \\some-computer\some-share
  - Supports current working directory per volume and current working volume
- Consoles – often used predefined names for different volumes

# Pathing

- Both windows and UNIX support absolute and relative pathing
  - Absolute
    - Windows - C:\Windows\System32
    - Unix - /usr/local/bin/grep
  - Relative
    - Windows – system32 (relative to CWD of c:\Windows)
    - Windows – X:animation\walk\anim (relative to CWD on the X volume)
    - Unix – bin/grep (relative to CWD of /usr/local)

# Search path

- Don't confuse path with search path
  - Path refers to a single file
  - Search path is multiple locations separated by a special character
- Search paths are used when trying to locate a file by name only
- Avoid searching for a file as much as possible – it's costly

# Path API

- Windows offers an API  for dealing with paths and converting them from absolute to relative
  - Called shlwapi.dll
  - https://docs.microsoft.com/en-us/windows/win32/api/shlwapi/
- Playstation 3 and 4 have something similar
- Often better to build your own stripped down version

# Basic file i/o

- Standard C library has two APIs for file I/O
  - Buffered
    - Manages its own data buffers
    - Acts like streaming bytes of data
  - Unbuffered
    - You manage your own buffers

# File operations

| Operation | Buffered API | Unbuffered API |
|---|---|---|
| Open a file | fopen() | open() |
| Close a file | fclose() | close() |
| Read from a file | fread() | read() |
| Write to a file | fwrite() | write() |
| Seek an offset | fseek() | seek() |
| Return current offset | ftell() | tell() |
| Read a line | fgets() | n/a |
| Write a line | fputs() | n/a |
| Read formatted string | fscanf() | n/a |
| Write a formatted string | fprintf() | n/a |
| Query file status | fstat() | stat() |

# File system specific

- On UNIX system, the unbuffered operations are native system calls
- On Windows, there is even a lower level
  - Some people wrap these calls instead of the standard C ones
- Some programmers like to handle their own buffering
  - Gives more control to when data is going to be written

# To wrap or not

- Three advantages to wrapping
  - Guarantee identical behavior across all platforms
  - The API can be simplified down to only what is required
  - Extended functionality can be provided
- Disadvantages
  - You have to write the code
  - Still impossible to prevent people from working around your API

# Synchronous file i/o

- The standard C file I/O functions are all synchronous

```
bool syncReadFile(const char* filePath, U8* buffer, size_t bufferSize, size_t& rBytesRead){
    FILE* handle = fopen(filePath, "rb");
    if(handle){
        size_t bytesRead = fread(buffer, 1, bufferSize, handle);  //blocks until all bytes are read
        int err = ferror(handle);
        fclose(handle);
        if(0==err){
            rBytesRead = bytesRead;
            return true;
        }
    }
    return false;
}
```

# Asynchronous I/O

- Often it is better to make a read call and set a callback function when data become available
- This involves spawning a thread to manage the reading, buffering, and notification
- Some APIs allow the programmer to ask for estimates of the operations durations
- They also allow external control

# Priorities

- It is important to remember that certain data is more important than others
  - If you are streaming audio or video then you cannot lag
- You should assign priorities to the operations and allow lower priority ones to be suspended

# Best practices

- Asynchronous file I/O should operate in its own thread
- When the main thread requests an operation, the request is placed on a queue (could be priority queue)
- The file I/O handles one request at a time
- Virtually *any* synchronous operation you can imagine can be transformed into an asynchronous operation by moving the code into a separate thread—or by running it on a physically separate processor, such as on one of the CPU cores on the PlayStation 4.

# Resource manager

- All good game engine have a resource manager
- Every resource manager has two components
  - Offline tools for integrating resource into engine ready form
  - Runtime resource management

# Off-line resource management

- Revision control - can be managed using a shared drive or a complex system like SVN or Perforce
- Cautions about data size
  - Remember that code is small compared to images or video
  - May not want many copies lying around (they all need to be backed up)
  - Some places deal with this by using symlinking

# Resource database

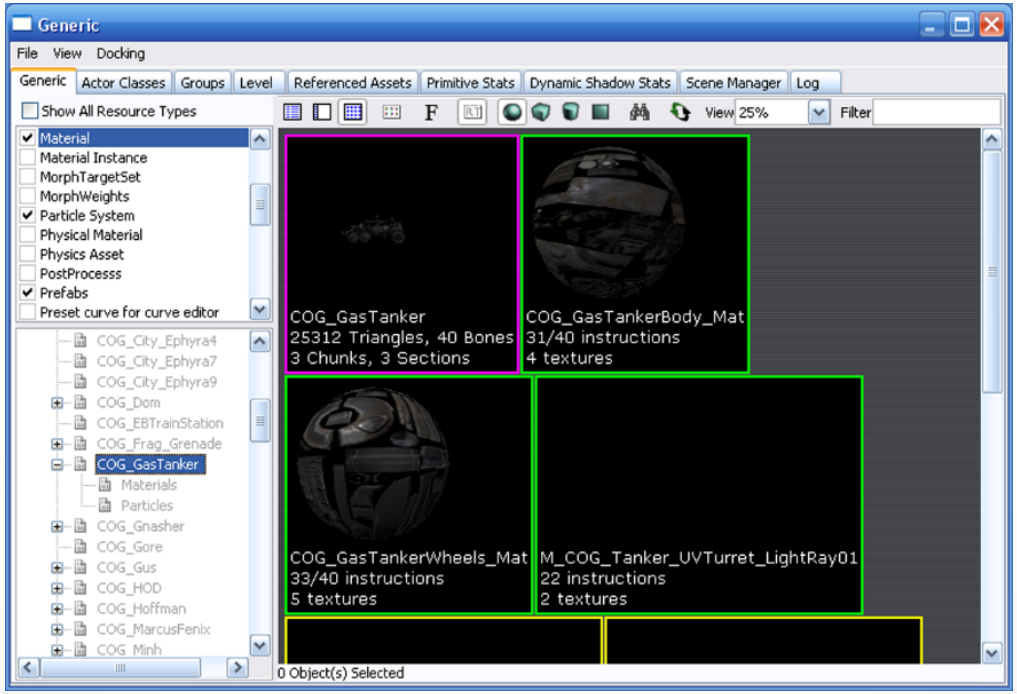
- The resource database contains information about how an asset needs to be conditioned to be useful in a game
- For example, an image may need to be flipped along its x-axis, some images should be scaled down
- This is particularly true when many people are adding assets

# Resource data

- The ability to deal with multiple types of resources
- The ability to create new resources
- The ability to delete resources
- The ability to inspect and modify resources
- The ability to move the resources source file to another location
- The ability for a resource to cross-reference another resource
- The ability to maintain referential integrity
- The ability to maintain revision history
- Searches and queries

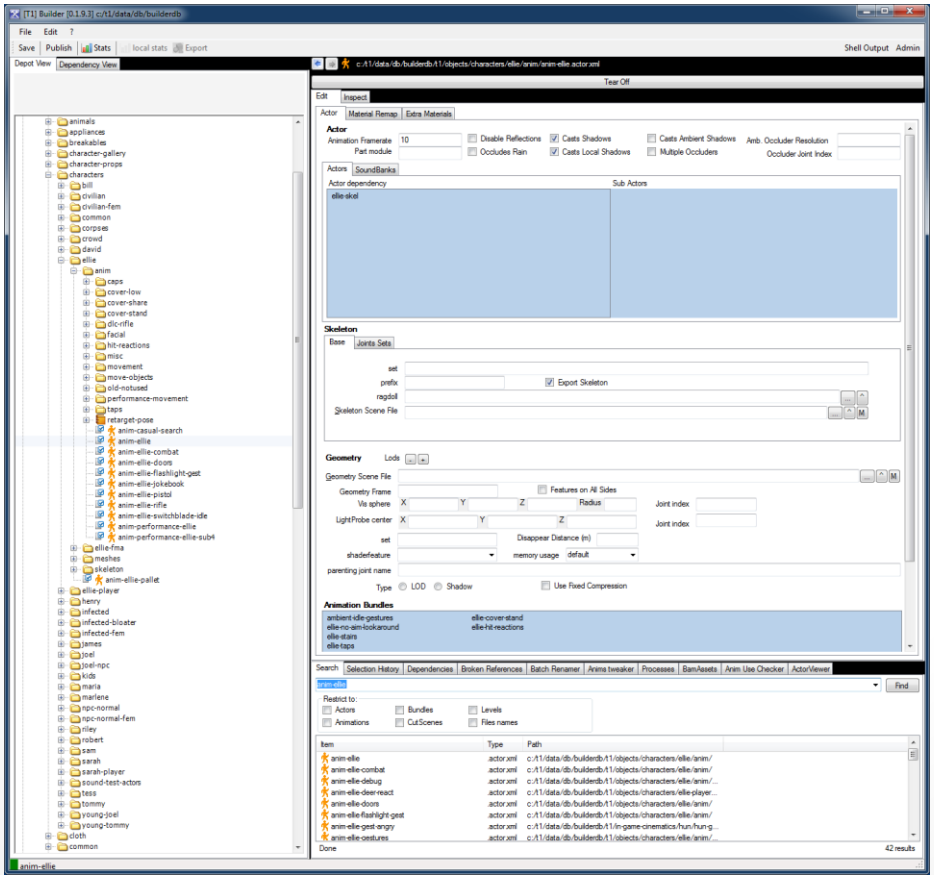
# Some successful designs

- UT4
  - All managed using UnrealEd
  - Has some serious advantages, but is subject to problems during multiple simultaneous updates
  - Stores everything in large binary files – impossible for SVN



# Another example

- Uncharted/Last of Us
  - Uses a MySQL database – later changed to XML using Perforce
  - Asset conditioning done using offline command prompt tools



# Still others…

- Ogre
  - Runtime only resource management
- XNA
  - A plugin to VS IDE called Game Studio Express

# Asset conditioning

- Assets are produced from many source file types
- They need to be converted to a single format for ease of management
- There are three processing stages
  - Exporters – These get the data out into a useful format
  - Resource compilers – pre-calculation can done on the files to make them easier to use
  - Resource linker – multiple assets can be brought together in one file

# Resource dependencies

- You have to be careful to manage the interdependencies in a game
- Assets often rely on one another and that needs to be documented
- Documentation can take written form or automated into a script
- *make* is a good tool for explicitly specifying the dependencies

# Runtime resource management

- Ensure that only *one copy* of an asset is in memory
- Manages the *lifetime* of the object
- Handles loading of *composite resources*
- Maintains *referential integrity*
- Manages *memory usage*
- Permits *custom processing*
- Provides a *unified interface*
- Handles *streaming*

# Resource files

- Games can manage assets by placing them loosely in directory structures
- Or use a zip file (Better)
  - Open format
  - Virtual file remember their relative position
  - They may be compressed
  - They are modular
- UT3 uses a proprietary format called pak (for package)

# Resource file formats

- Assets of the same type may come in many formats
  - Think images (BMP, TIFF, GIF, PNG…)
- Some conditioning pipelines standardize the set
- Other make up there own container formats
- Having your unique format makes it easier to control the layout in memory

# Resource guids

- You will need a way to uniquely identify assets in your game
- Come up with a naming scheme
  - Often involves more than just the file path and name
- In UT files are named using
  - *package.folder.file*

# Resource registry

- In order to only have an asset loaded once, you have to have a registry
- Usually done as a giant hashmap (keyed on GUID)
- Resources loading can be done on the fly, but that is usually a bad idea
  - Done in-between levels
  - In the background

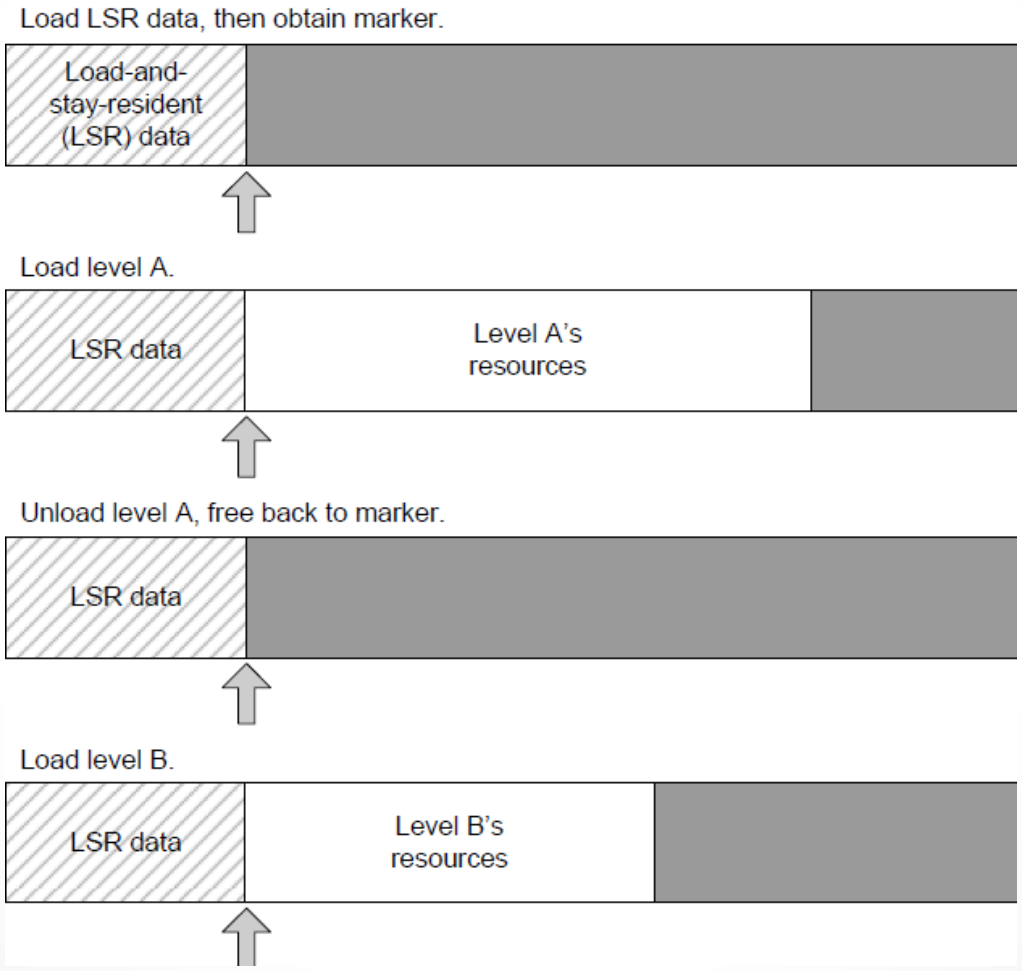
# Resource lifetime

- Some resources are LSR (load-and-stay resident)
  - Character mesh
  - HUD
  - Core Animations
- Some are level specific
- Some are very temporary – a cut-scene in a level
- Other are streaming
- Lifetime is often defined by use, sometimes by reference counting

# Memory management

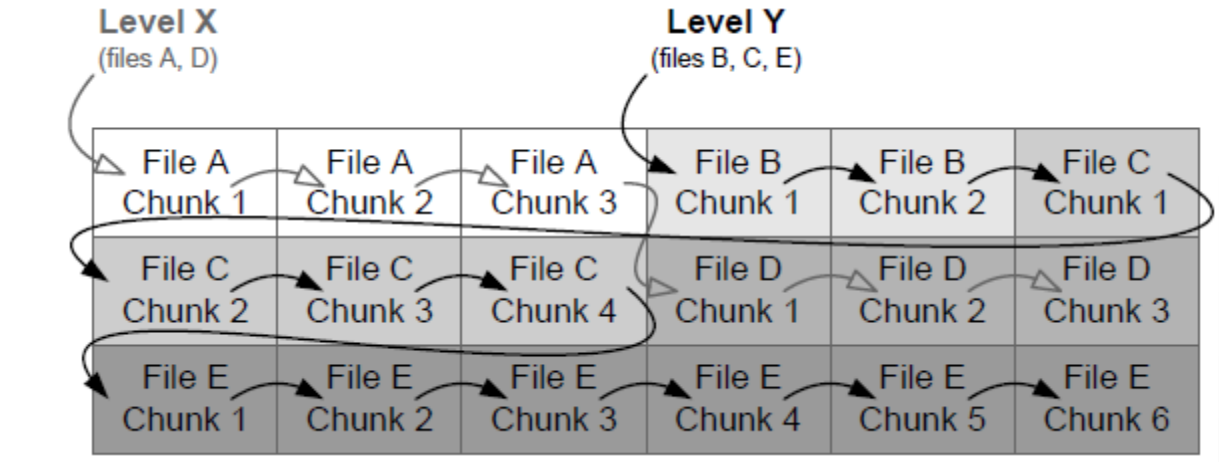
- Very closely tied to general memory management
- Heap allocation – allow the OS to handle it
  - Like malloc() or new
  - Works fine on a PC, not so much on a memory limited console
- Stack allocation
  - Can be used if
    - The game is linear and level centric
    - Each level fits in memory

# Stack allocation



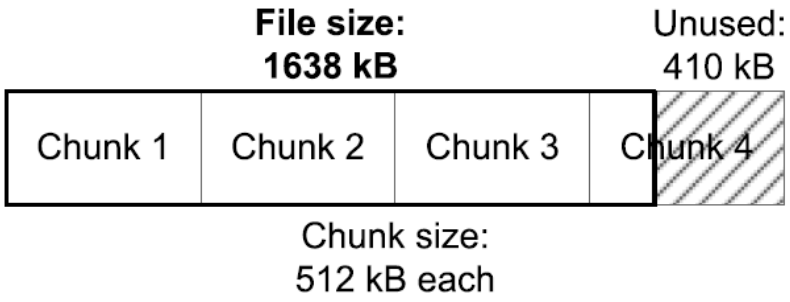
# Pool allocation

- Load the data in equal size chunks
  - Requires resource to be laid out to permit chunking
- Each chunk is associated with a level



# Pool allocation

- Chunks can be wasteful



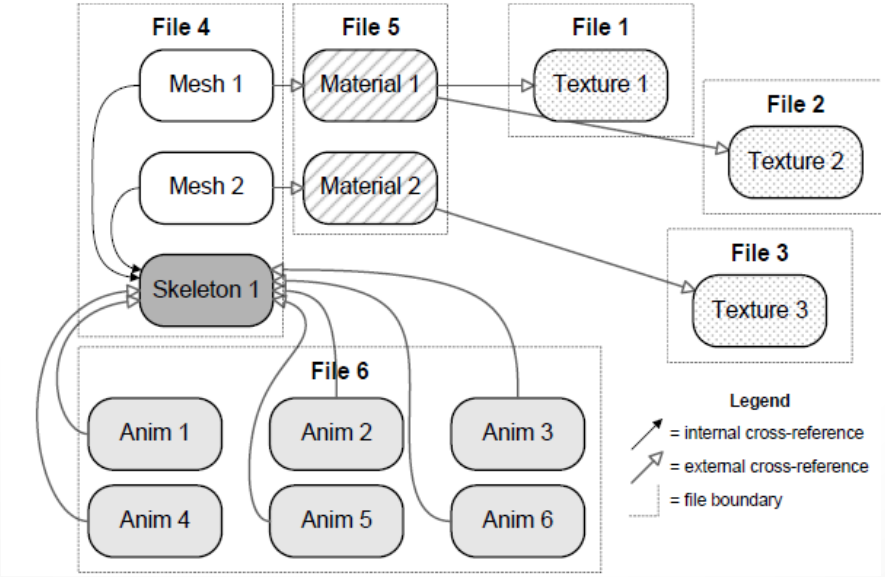

- Choose the chunk size carefully
  - Consider using the OS I/O buffer size as a guide

# Resource chunk allocator

- You can reclaim unused areas of chunks
- Use a linked list of all chunks with unused memory along with the size
- Works great if the original chunk owner doesn't free it
- Can be mitigated by considering lifetimes
  - Only allocated unused parts to short lifetime objects

# Composite resources

- Resource database contains multiple *resource files* each with one or more *data objects*
- Data objects can cross-reference each other in arbitrary ways
- This can be represented as a directed graph



# Composite resources

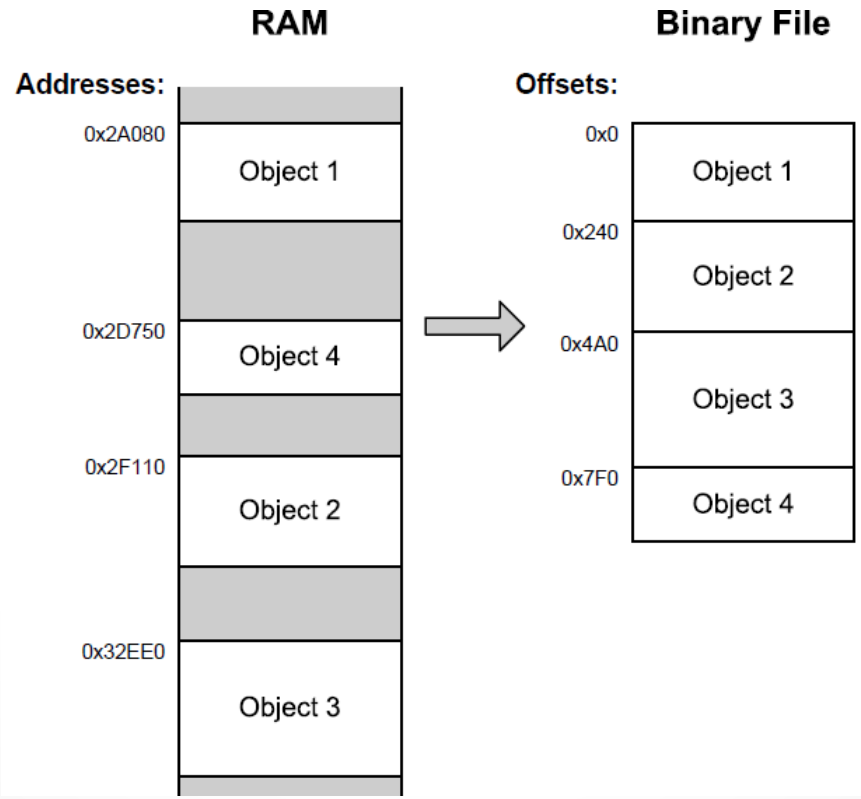
- A cluster of interdependent resources is referred to as a composite resource
- For example, a *model* consists of
  - One or more triangle meshes
  - Optional skeleton
  - Optional animations
  - Each mesh is mapped with a material
  - Each material refers to one or more textures

# Handling cross-references

- Have to ensure that referential integrity is maintained
  - Can't rely on a pointer because they are meaningless in a file
- One approach is to use GUIDs
  - When a resource is loaded the GUID is stored in a hashmap along with a reference to it

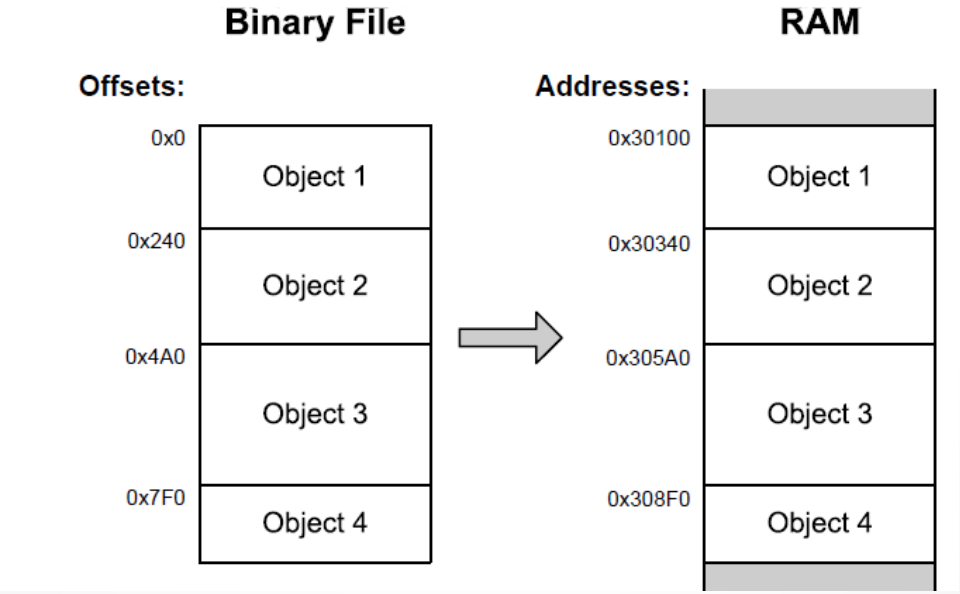
# Pointer fix-up tables

- Another approach is to convert pointers to file offsets



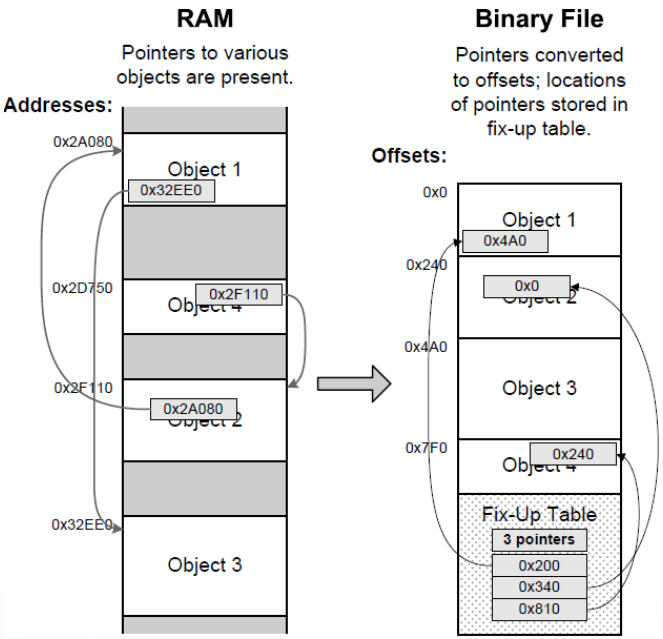
# Pointer fix-up tables

- During file writing all references are converted from pointers to the offset location in the file
  - Works because offsets are smaller than pointers
- During reading, we convert offsets back to pointers
  - Known are *pointer fix-ups*
  - Easy to do because now the file is contiguous in memory



# Pointer fix-up tables

- Also need to remember the location of all pointers that need fixing
- This is done by creating a table during file writing
  - Known as a *pointer fix-up table*



# Constructors

- When dealing with storing C++ objects make sure you call the object constructors
- You can save the location of the objects and use *placement new* syntax to call the constructor

```
void* pObject = convertOffsetToPointer(objectOffser, pAddressOfFileImage);
::new(pObject)  ClassName;
```

# Handling external references

- Externally referenced objects have to be handled differently
- Store the path along with the GUID or offset
- Load each file first then fix the references in a second pass

# Post-load initialization

- Cannot always load in a ready-to-go state
  - Unavoidable – need to move vertex data to the video card
  - Avoidable, but convenient – calculating spline data during development
- In C++ using virtual functions like init() and destroy() may be the simplest strategy

# Unity Assets Management

- Everything beneath the project's Asset folder

# What are Assets

- Unity-Native Types (Assets/Create Menu)
  - Scenes
  - Prefabs
  - Scriptable Objects
  - Sprites
- External Data Types (Added to Assets Folder)
  - Models
  - Images
  - Audio
  - Scripts
  - Folders

# Asset Handling and Pipeline

- By default assets are in binary format
  - This makes very difficult for version control system to work with
  - Unity handles this with “text serialization” in Yaml format (human readable)

# Unity Basic Asset LifeCycle

1. Assign a GUID
    1. Globally Unique Identifier
    2. 32 hex digits: 128 bit
    3. New Asset ➔ New GUID
    4. Unity uses this number to store and track the assets
    5. Stores the asset in a meta file
2. Generate a Metafile
    1. SomeScript.cs
    2. SomeScript.cs.meta
3. Process data to Library

# Meta file example

```
fileFormatVersion: 2
guid: 38e917c52987daa41af6a0305d9813c6
MonoImporter:
  externalObjects: {}
  serializedVersion: 2
  defaultReferences: []
  executionOrder: 0
  icon: {instanceID: 0}
  userData:
  assetBundleName:
  assetBundleVariant:
```

# Prefab Exercise

```
MonoBehaviour:
  m_ObjectHideFlags: 0
  m_CorrespondingSourceObject:
{fileID: 0}
  m_PrefabInstance: {fileID: 0}
  m_PrefabAsset: {fileID: 0}
  m_GameObject: {fileID:
1156415549007096 8}
  m_Enabled: 1
  m_EditorHideFlags: 0
  m_Script: {fileID: 11500000,
guid:
38e917c52987daa41af6a0305d9813c
6, type: 3}
  m_Name:
  m_EditorClassIdentifier:
  projectilePrefab: {fileID: 0}
```

- Create a script
- Look at its meta file
- Copy its GUID number
- Create a game object
- Attach the script to it
- Make a prefab
- Open the .prefab using visual studio
- And search for the GUID that you copied
- You should see it at the bottom of the YAML file in Monobehavior
- Notice, there is no file name!!!
- Notice, there is also “file id”

# Sound Asset Example

- Open the prototype 3
- Go to Assets/Course Library/Sound/Music
- Select one of the sound
- Look at the "Load In Background" checkbox in the inspector ➔ it's unchecked
- Open the folder in the File Explorer
- Open the sound "meta" file in the Visual Studio
- An change the "Load In Background" value to 1
- Save and check out the inspector
- Meta file stores all the "importer settings"

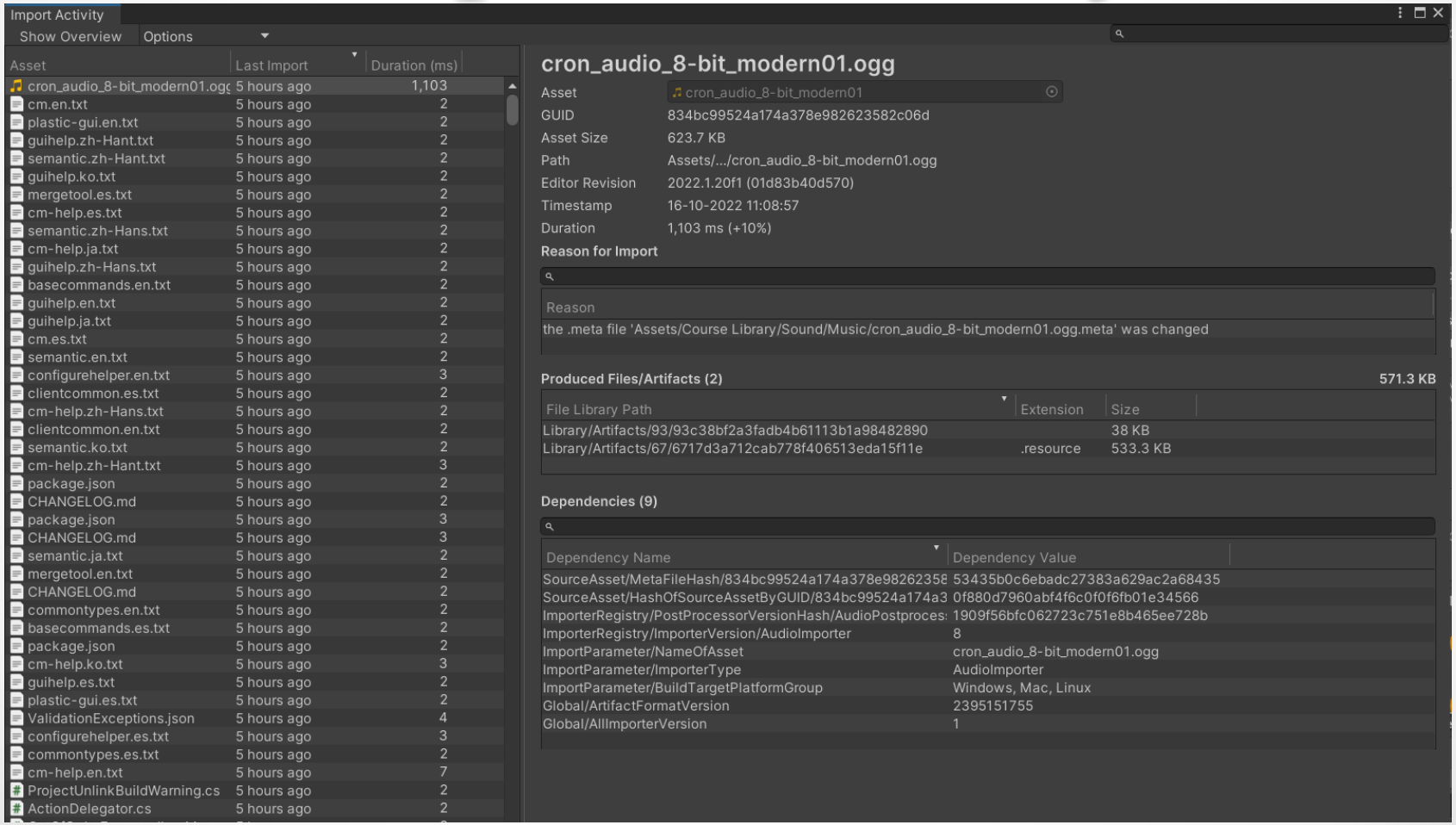
# Modify Sound meta file

```
fileFormatVersion: 2
guid: 834bc99524a174a378e982623582c06d
AudioImporter:
  externalObjects: {}
  serializedVersion: 6
  defaultSettings:
    loadType: 0
    sampleRateSetting: 0
    sampleRateOverride: 44100
    compressionFormat: 1
    quality: 1
    conversionMode: 0
  platformSettingOverrides: {}
  forceToMono: 0
  normalize: 1
  preloadAudioData: 1
  loadInBackground: 1
  ambisonic: 0
  3D: 1
  userData:
  assetBundleName:
  assetBundleVariant:
```

# Library

- Library is the Unity's data closet
- Go to explorer and look at "Library/Artifacts" or "Library/Import Data"
- There are 256 folders. Each folder is a combination of two hexa digits
- For example: our sound meta file, we had:
- guid: 834bc99524a174a378e982623582c06d
- Right Click on a "sound" file in the "project" panel, and select the "View In Import Activity Window"
- You can find the binary associated to that file!

# Import Activity



# BinaryToText

- Unity has a tool that converts binary to text
- Make sure that you change the highlighted version
- C:\Program Files\Unity\Hub\Editor\2022.1.20f1\Editor\Data\Tools
- Go to command line:
  - C:\Program Files\Unity\Hub\Editor\2022.1.20f1\Editor\Data\Tools>binary2text
  - Usage: binary2text inputbinaryfile [outputtextfile] [-detailed] [-largebinar yhashonly] [-hexfloat]
  - For example, Go to one of the script, find the binary file associated to it
  - C:\Program Files\Unity\Hub\Editor\2022.1.20f1\Editor\Data\Tools>binary2text "C:\Hooman\GBC\GAME3121\Unity\Create With Code\Prototype 3 - 1\Library\Artifacts\c2\c22670af92870d224e96663f8fcb2a0a“
  - It will create c22670af92870d224e96663f8fcb2a0a.txt  under the same artifact folder
  - Open it up

# Convert an audio binary file to text

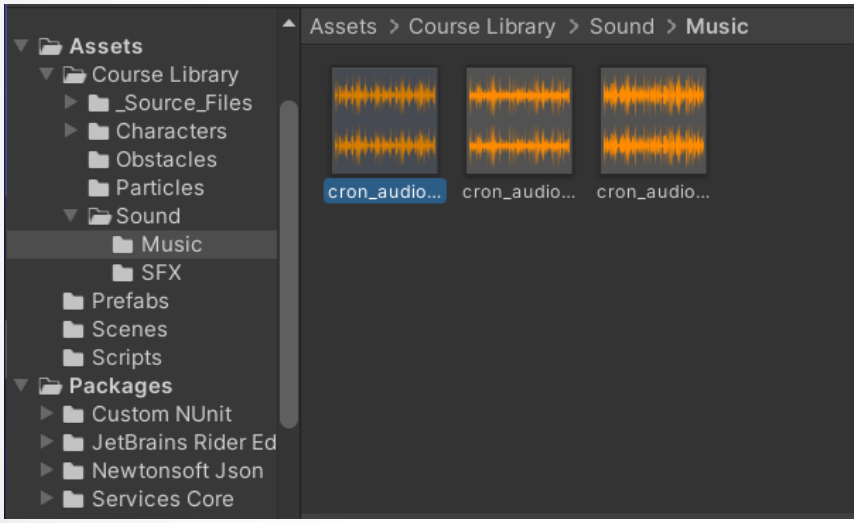
- Exercise: Try the same thing you did for the script for the audio file
  - Right Click on a "sound" file in the "project" panel, and select the "View In Import Activity Window"
  - Find the binary file
  - Right click show in the explorer
  - Go to command line and run
  - C:\Program Files\Unity\Hub\Editor\2022.1.20f1\Editor\Data\Tools>binary2text "C:\Hooman\GBC\GAME3121\Unity\Create With Code\Prototype 3 - 1\Library\Artifacts\93\93c38bf2a3fadb4b61113b1a98482890"
  - Open up the audio text version

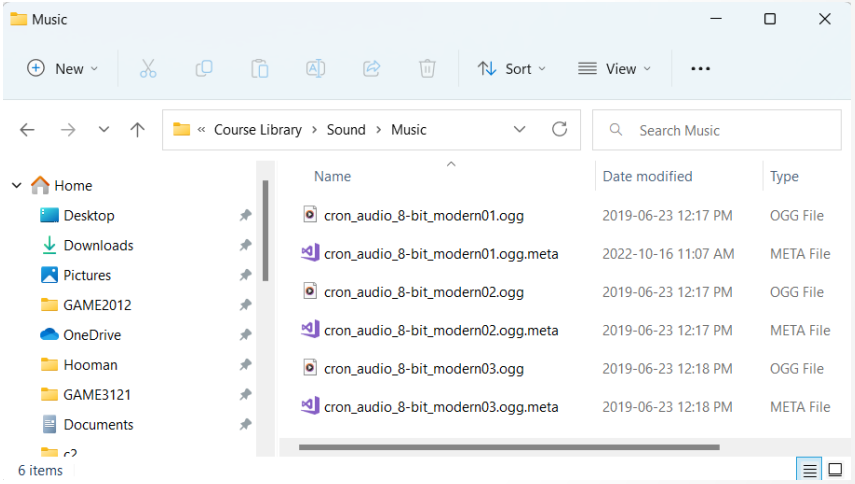
# m_Resource vs. m_EditorResource

- How Unity runs the audio in the "Editor" might not be the same format as "The build target"
- So if you change your taget setting to iOs, you might have a different format!

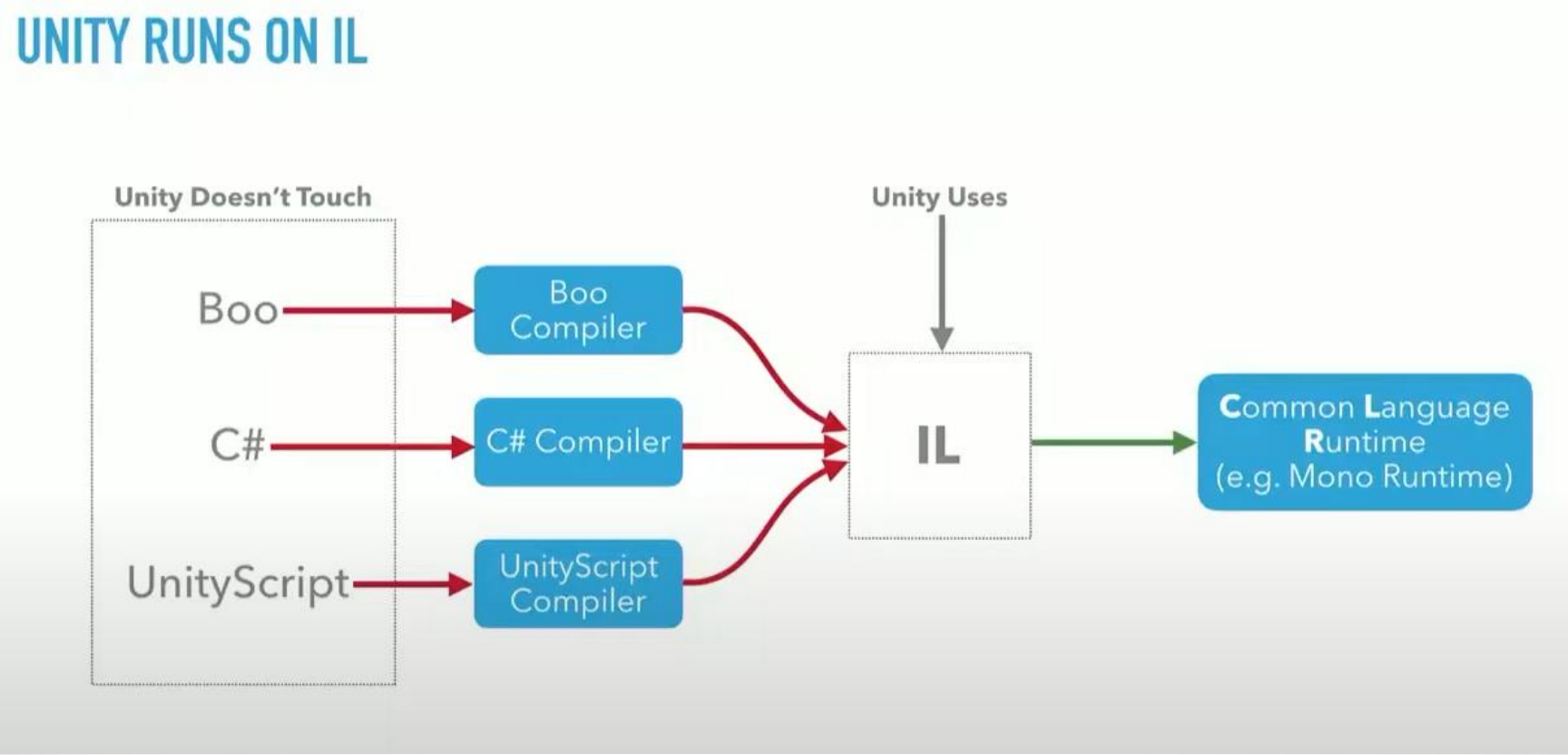
m_Resource (StreamedResource)
m_Source "VirtualArtifacts/Primary/834bc99524a174a378e982623582c06d.resource" (string)
m_Offset 0 (FileSize)
m_Size 546112 (UInt64)
m_CompressionFormat 1 (int)
m_EditorResource (StreamedResource)
m_Source "VirtualArtifacts/Primary/834bc99524a174a378e982623582c06d.resource" (string)
m_Offset 0 (FileSize)
m_Size 546112 (UInt64)

# Project View is not a view of the File System

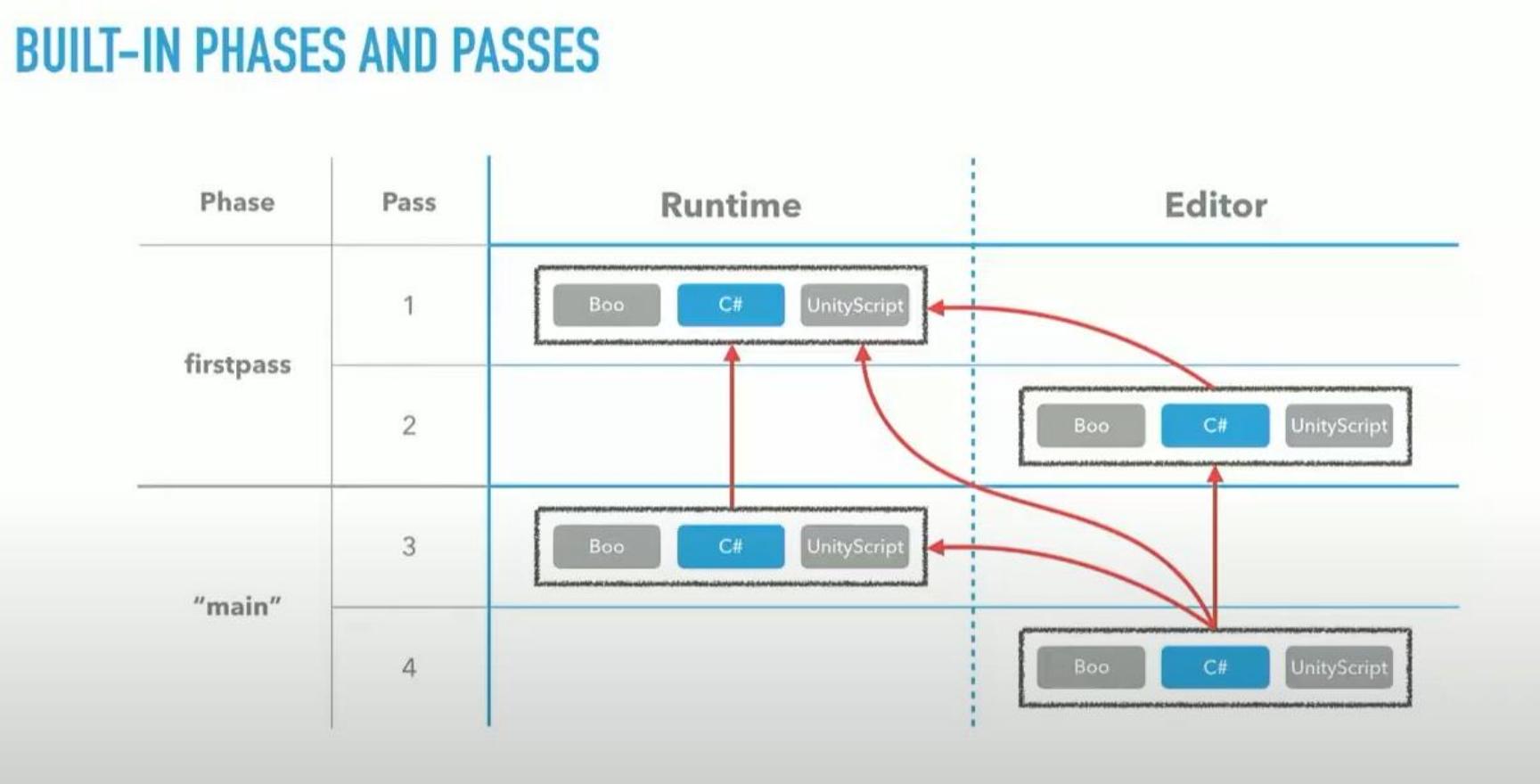


# Script Compilation



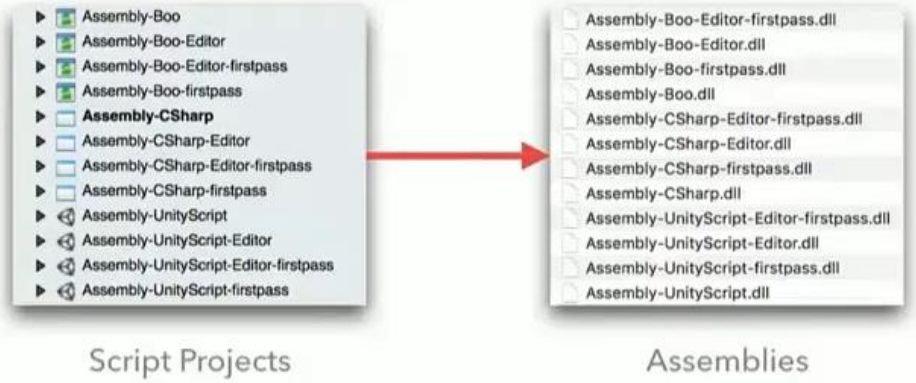
# Script Compilation in 4 passes



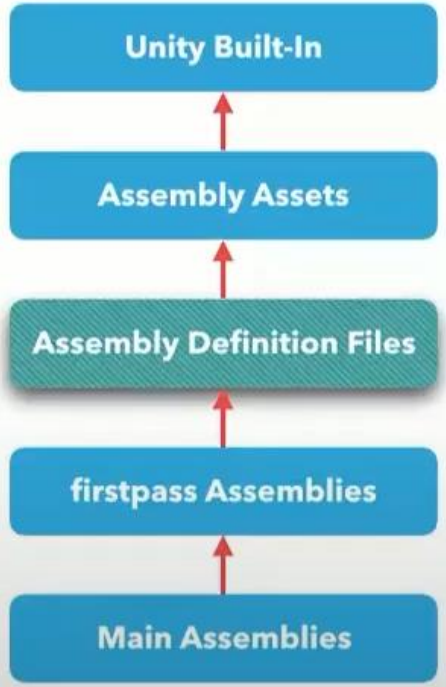
# Assembly Definitions

- Unity creates one single assembly for your whole project: Assembly-CSharp.dll by default which is located under Library\ScriptAssemblies
- Assembly Definitions and Assembly References are assets that you can create to organize your **scripts** into smaller assemblies.
- An assembly is a C# code library that contains the compiled classes and structs that are defined by your scripts and which also define references to other assemblies.
- By default, Unity compiles almost all of your game scripts into the *predefined* assembly, *Assembly-CSharp.dll*.

# Assembly Definition Files




**Assembly Definition Files** - JSON-formatted files that allow you to specify your own compilation pass (and output assembly).

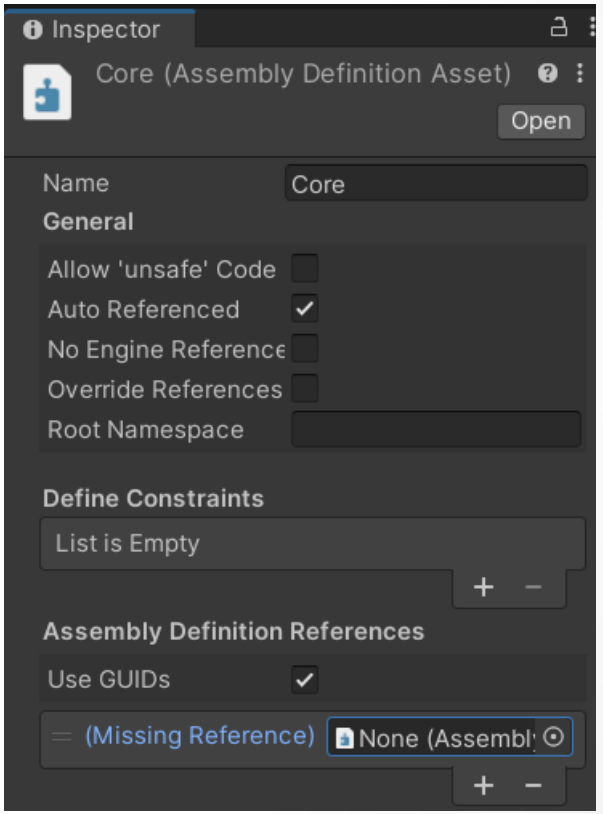


# Creating an Assembly Definition asset

1. Create a brand new application
2. Create a folder called Script and subfolder called “Core”
3. Under Core, create a script called mytestscript
4. Look at the Assembly Information (Assembly-CSharp.dll)
5. In the **Project** window, locate the folder containing the scripts you want to include in the assembly.
6. Create an Assembly Definition asset in the “Core” folder (menu: **Assets** > **Create** > **Assembly Definition**).
7. Assign a “Core” name to it.
8. Look at the Assembly Information (Core.dll)

# Assembly Definition References

- If your assembly has a dependency, you can add a reference to other assembly definitions using Assembly Definition References!



# Resources

- The Resources class allows you to find and access Objects including assets.
- In the editor, Resources.FindObjectsOfTypeAll can be used to locate assets and Scene objects.
- All assets that are in a folder named "Resources" anywhere in the Assets folder can be accessed via the Resources.Load functions. Multiple "Resources" folders may exist and when loading objects each will be examined.
- In Unity you usually don't use path names to access assets, instead you expose a reference to an asset by declaring a member-variable, and then assign it in the inspector.
- When using this technique Unity can automatically calculate which assets are used when building a player. This radically minimizes the size of your players to the assets that you actually use in the built game.
- When you place assets in "Resources" folders this can not be done, therefore all assets in the "Resources" folders will be included in a build.

# Resources Example

- This example shows how you can load your resources automatically
- When the game starts into your database!
- Create a folder called "Resources"
- Create a subfolder called "Enemies"
- Create 4 prefabs/gameobjects under Enemies
- Create a script called EnemyType
- Attach EnemyType script to all of the prefabs
- Run the application and see allEnemies

# Database Script

```
public class Database : MonoBehaviour
{
    public EnemyType singleEnemy;
    public EnemyType[] allEnemies;
    // Start is called before the first frame update
    void Start()
    {
        //load a single resource
        singleEnemy = Resources.Load<EnemyType>("Enemies/Enemy1");

        //load all resources
        allEnemies = Resources.LoadAll<EnemyType>("Enemies");
    }

    // Update is called once per frame
    void Update()
    {

    }
}
```

# Asset Bundles (Unity)

- An AssetBundle is an archive file that contains platform-specific non-code Assets (such as Models, Textures, Prefabs, Audio clips, and even entire Scenes) that Unity can load at run time.
- AssetBundles can express dependencies between each other; for example, a Material in one AssetBundle can reference a Texture in another AssetBundle. For efficient delivery over networks,
- you can compress AssetBundles with a choice of built-in algorithms depending on use case requirements (LZMA and LZ4).

- AssetBundles can be useful for downloadable content (DLC), reducing initial install size, loading assets optimized for the end-user's platform, and reduce runtime memory pressure.

# Bundles, save in Google drive and import it!)

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEditor;
using System.IO;

public class CreateAssetBundle : MonoBehaviour
{
    [MenuItem("Assets/Build Assetbundles")]
    static void BuildAssetBundle()
    {
        string AssetBundleDirectory =
"Assets/AssetBundle";
        if(!Directory.Exists(AssetBundleDirectory))
        {

Directory.CreateDirectory(AssetBundleDirectory);
        }
        else
        {

BuildPipeline.BuildAssetBundles(AssetBundleDirector
y,
                BuildAssetBundleOptions.None,
BuildTarget.StandaloneWindows);


        }
    }
}
```

- Create a folder called Editor
- Create a script called CreateAssetBundle (inside the folder)

# LoadAssetBundle

- Create another C# script under “assets” folder and name it “LoadAssetBundle”
- Attach the script to the camera

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class LoadAssetBundle : MonoBehaviour
{

    string url = "";
    void Start()
    {
        WWW www = new WWW(url);
        StartCoroutine(WebReg(www));
    }

    // Update is called once per frame
    IEnumerator WebReg(WWW www)
    {
        yield return www;

        while (!www.isDone)
        {
            yield return null;
        }

        AssetBundle Bundle = www.assetBundle;

        if(www.error == null)
        {
            GameObject obj = (GameObject)Bundle.LoadAsset("");
        }
        else
        {
            Debug.Log(www.error);
        }
    }
}
```

# Asset Store

- Download some free assets from asset store (free trees)
- Go to Package manager, download and import
- Go to Free-Trees → Meshes and select a tree mesh (Fir Tree)
- In the inspector, click on AssetBundle dropdown → new → firtree
- Go to Unity Editor's Asset → Build AssetBundle
- Now you can see a directory under Asset named "AssetBundle"
- "Again", Go to Unity Editor's Asset → Build AssetBundle , this time you should see some files under that directory
- One of the files "firtree" → Right click → Show in the explorer and copy that file into your google drive
- Make the file in the Google drive shareable with public and copy the "link"

# Google Drive Direct Link Generator

- Google: Google Drive Direct Link Generator
- https://sites.google.com/site/gdocs2direct/
- This tool allows you to generate a direct download link to files you have stored in Google Drive. A direct link will immediately start downloading the file, rather than opening a preview of the file in Google Drive.
- Copy the link there and generate the direct link
- For example mine is:
  - https://drive.google.com/uc?export=download&id=1I1e8ewZ8l29gzxn5y3yJLFBGi9jn8Dfa

# LoadAssetBundle

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class LoadAssetBundle : MonoBehaviour
{

    string url =
"https://drive.google.com/uc?export=download&id=1I1e8ewZ8I29gzxn5y3yJLFBG
i9jn8Dfa\r\n";
    void Start()
    {
        WWW www = new WWW(url);
        StartCoroutine(WebReg(www));
    }

    // Update is called once per frame
    IEnumerator WebReg(WWW www)
    {
        yield return www;

        while (!www.isDone)
        {
            yield return null;
        }

        AssetBundle Bundle = www.assetBundle;

        if(www.error == null)
        {
            GameObject obj = (GameObject)Bundle.LoadAsset("Fir_Tree");
            Instantiate(obj);
        }
        else
        {
            Debug.Log(www.error);
        }
    }
}
```

- Place this in your LoadAssetBundle script

```
public class LoadAssetBundle : MonoBehaviour
{

    string url =
"https://drive.google.com/uc?export=download&id=1I1e8ewZ8I
29gzxn5y3yJLFBGi9jn8Dfa\r\n";
```

- Place the proper asset name in LoadAssetBunde
- `GameObject obj = (GameObject)Bundle.LoadAsset("Fir_Tree");`
- And then instantiate it!
- Now you can run the application

# Using UnityWebRequest

```
public class LoadAssetBundle : MonoBehaviour
{
    void Start()
    {
        StartCoroutine(GetAssetBundle());
    }

    IEnumerator GetAssetBundle()
    {
        UnityWebRequest www =
UnityWebRequestAssetBundle.GetAssetBundle("https://drive.google.com/uc?export=download&id=1I1e8ew
Z8I29gzxn5y3yJLFBGi9jn8Dfa\r\n");
        yield return www.SendWebRequest();

        if (www.result != UnityWebRequest.Result.Success)
        {
            Debug.Log(www.error);
        }
        else
        {
            AssetBundle bundle = DownloadHandlerAssetBundle.GetContent(www);
            GameObject obj = (GameObject)bundle.LoadAsset("Fir_Tree");
            Instantiate(obj);
        }
    }
}
```

# Addressable Asset Management

- The Addressable Asset System provides an easy way to load assets by “address”.
- It handles asset management overhead by simplifying content pack creation and deployment.
- The Addressable Asset System uses asynchronous loading to support loading from any location with any collection of dependencies.
- Whether you are using direct references, traditional asset bundles, or Resource folders, addressable assets provide a simpler way to make your game more dynamic.

# Addressable Asset

- What is an asset?
  - An asset is content that you use to create your game or app. An asset can be a prefab, texture, material, audio clip, animation, etc.
- What is an address?
  - An address identifies the location in which something resides. For example, when you call a mobile phone, the phone number acts as an address. Whether the person is home, at work, in Paris or Pittsburgh, the phone number can connect you.
- What is an Addressable Asset?
  - Once an asset is marked "addressable", the addressable asset can be called from anywhere. Whether that addressable asset resides in the local player or on a content delivery network, the system will locate and return it. You can load a single addressable via its address or load many addressables using a customized group label that you define.
- Why do I care?
  - Traditionally, structuring game assets to efficiently load content has been difficult. Using Addressable Assets shortens your iteration cycles, allowing you to devote more time to designing, coding, and testing your application. With Addressable Assets you identify the asset as addressable and load it.

# What problems does the Addressable Asset System solve?

- Iteration time: Referring to content by its address is super-efficient. With an address reference, the content just gets retrieved. Optimizations to the content no longer require changes to your code.
- Dependency management: The system not only returns content at the address, but also returns all dependencies of that content. The system informs you when the entire asset is ready, so all meshes, shaders, animations, and so forth are loaded before the content is returned.
- Memory management: The address not only loads assets, but also unloads them. References are counted automatically and a robust profiler helps you spot potential memory problems.
- Content packing: Because the system maps and understands complex dependency chains, it allows for efficient packing of bundles, even when assets are moved or renamed. Assets can be easily prepared for both local and remote deployment to support downloadable content (DLC) and reduced application size.

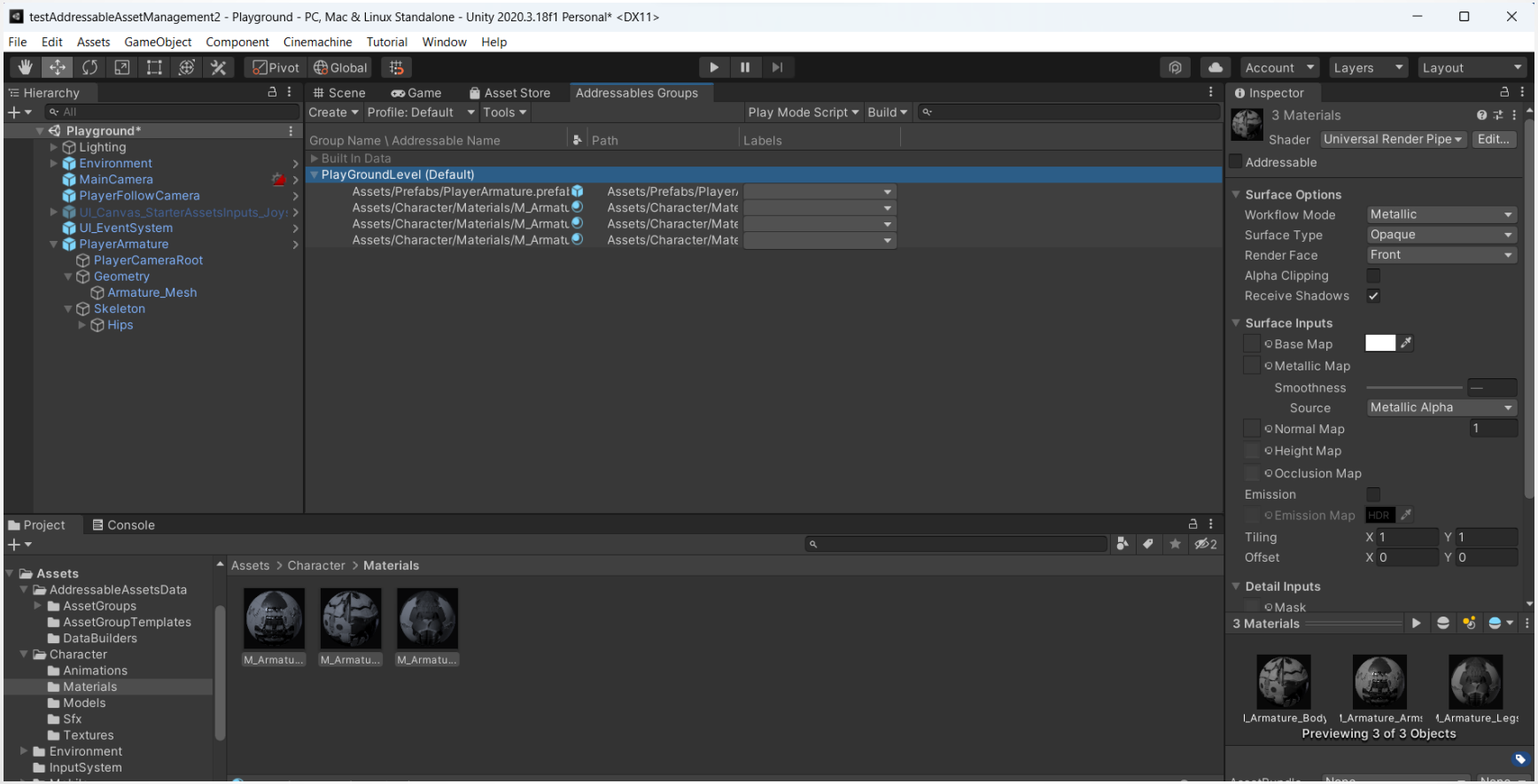
# Exercise

- Start with a third person template in Unity
- Download/Import “Addressables” Package (search for “add”)
- On Editor, go to Window → Addressable Asset Management → Addressables → Groups →Create an addressable setting
- Create a “New” “Packed Assets” group, and name it “PlayGroundLevel”
- Set “PlayGroundLevel” as default and remove the default group

# Create "Player Armature" Dynamically

- Drag "Player Armature" from Assets/Prefab and drop it to "PlayGroundLevel" group that we just created
- Select "Player Armature" from hierarchy, go to Geometry→ Armature Mesh
- In the inspector, find M_Armature_Body (Material), right click and click "select material", now you should see all the materials in the Materials folder
- Drag all the materials and drop it to "PlayGroundLevel" group that we just created

# PlayGroundLevel group



# Audio

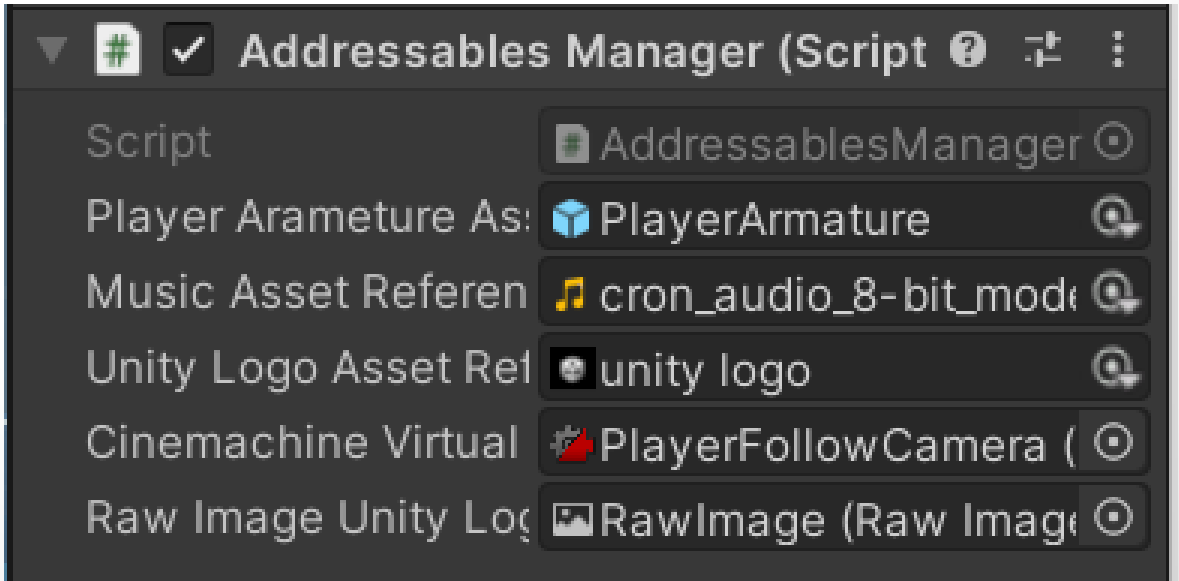
- Let's also have an audio file to play when the game starts
- Create a folder called Audio
- Find an mp3/ogg music that you would like to play
- I am copying my music file from Prototype 3 \Assets\Course Library\Sound\Music\cron_audio_8-bit_modern02.ogg to my Audio folder
- And the drag this audio file to the "PlayGroundLevel" group as well

# Textures

- Create a "Textures" folder under Assets
- Find Unity Logo png file from Internet and download to this folder
- Drag the logo and paste it to "PlayGroundLevel" group as well
- Now if you click on every asset on the group and look at the inspector, you see the addressable is checked!
- Remove "Player Armature" from hierarchy (we want to create it dynamically)
- The idea is to add all the assets that need to be changed dynamically without changing the build to the group!!!

# Addressable Manager Game Object

- Create an "AddressablesManager" GameObject and "AddressableManager" script and attach the script to the game object.
- Create a Canvas in the hierarchy with a raw image so we can put the logo in
- Attach the corresponding game objects in the inspector



# Addressable Manager Script

```
using Cinemachine;
using System;
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.AddressableAssets;
using UnityEngine.AddressableAssets.ResourceLocators;
using UnityEngine.ResourceManagement.AsyncOperations;
using UnityEngine.UI;

[Serializable]
public class AssetReferenceAudioClip : AssetReferenceT<AudioClip>
{
    public AssetReferenceAudioClip(string guid) : base(guid) { }
}

public class AddressablesManager : MonoBehaviour
{
    [SerializeField]
    private AssetReference playerAramentureAssetReference;

    [SerializeField]
    private AssetReferenceAudioClip musicAssetReference;

    [SerializeField]
    private AssetReferenceTexture2D unityLogoAssetReference;

    [SerializeField]
    private CinemachineVirtualCamera cinemachineVirtualCamera;

    //UI Component
     [SerializeField]
    private RawImage rawImageUnityLogo;

    private GameObject playerController;

    // Start is called before the first frame update
    void Start()
    {
        Debug.Log("Initializing Addressables...");
        Addressables.InitializeAsync().Completed += AddressablesManager_Completed;
    }

    private void AddressablesManager_Completed(AsyncOperationHandle<IResourceLocator>
obj)
    {
        playerAramentureAssetReference.InstantiateAsync().Completed += (go) =>
        {
            playerController = go.Result;
            cinemachineVirtualCamera.Follow =
playerController.transform.Find("PlayerCameraRoot");
        };

        musicAssetReference.LoadAssetAsync<AudioClip>().Completed += (clip) =>
        {
            var audioSource = gameObject.AddComponent<AudioSource>();
            audioSource.clip = clip.Result;
            audioSource.playOnAwake = false;
            audioSource.loop = true;
            audioSource.Play();
        };

        unityLogoAssetReference.LoadAssetAsync<Texture2D>();

    }

    // Update is called once per frame
    void Update()
    {
        if (unityLogoAssetReference.Asset != null && rawImageUnityLogo.texture ==
null)
        {
            rawImageUnityLogo.texture = unityLogoAssetReference.Asset as Texture2D;
            Color currentColor = rawImageUnityLogo.color;
            currentColor.a = 1.0f;
            rawImageUnityLogo.color = currentColor;
        }
    }

    private void OnDestroy()
    {
        playerAramentureAssetReference.ReleaseInstance(playerController);
        unityLogoAssetReference.ReleaseAsset();
    }
}
```