

GAM160: Further Games Programming

8: Memory

Learning outcomes

- ▶ **Understand** Memory in modern object orientated languages
- ▶ **Compare** memory models in managed and unmanaged languages
- ▶ **Understand** the role of the profiler in measuring performance in games

Memory



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 - ▶ Static memory, allocated on the **Stack** and is **fixed size**

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- ▶ Values allocated on the stack are local, when they drop out of scope they are deallocated
- ▶ Values passed into functions are copied onto the stack
- ▶ The stack is of fixed size
 - ▶ C# - **1MB**

Stack Memory Example 1

```
void Update()  
{  
    int x=10;  
    int y=10;  
  
    Vector2 pos=Vector2(x,y);  
} //<-- x, y and pos drop out of scope here
```

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- ▶ This heap is managed by the garbage collector in C#

Heap Memory Example 1 - C#

```
public class MonsterStats
{
    private int health;
    private int strength;

    public MonsterStats()
    {
        health=100;
        strength=10;
    }

    public void ChangeHealth(int h)
    {
        health+=h;
    }//<- h drops out of scope here

    void ChangeStrength(int s)
    {
        strength+=s;
    }//<- s drops out of scope here
}

void Start()
{
    //Create an instance of the class on the Heap
    MonsterStats new stats=MonsterStats();
    stats.ChangeHealth(10);
    stats.ChangeStrength(-2);
}
```

Data Types in C#

- ▶ Value types include primitives such as int, bool, float etc
- ▶ Structs are custom value types (see example below)
- ▶ Reference types are anything declare with the **class**, **interface** & **delegate**
- ▶ In addition to this strings are also **reference types**
- ▶ Value types are allocated on the stack
- ▶ Reference type are allocated on the heap

Struct Example - C#

```
public struct MonsterStats
{
    private int health;
    private int strength;

    public MonsterStats()
    {
        health=100;
        strength=10;
    }
}

void Start()
{
    //Create an instance of the struct on the stack
    MonsterStats stats=new MonsterStats();
    stats.ChangeHealth(10);
    stats.ChangeStrength(-2);
}
```

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- ▶ If you pass a variable using **out** keyword it can be initialised in a function
- ▶ Reference types are always passed by reference, you do not need to use the **keyword**

Passing Example 1 - C#

```
int x=10;

void Adder(ref int value,int v)
{
    value+=v;
}

Adder(ref x,10);
//x would now be 20 after this
```

Passing Example 2 - C#

```
void SetupMonster(ref MonsterStats stats, int health, int strength)
{
    //if we use the ref keyword MonsterStats has to be initialised
    stats.health=health;
    stats.strength=strength;
}

void CreateMonster(out MonsterStats stats, int health, int strength)
{
    //when we use out, it means we can initialise inside the function
    stats=new MonsterStats();
    stats.health=health;
    stats.strength=strength;
}

//Calling code
MonsterStats goblinStats=new MonsterStats();
SetupMonster(ref goblinStats,10,2);

MonsterStats orcStats;
CreateMonster(out orcStats,20,4);
```

Strings



Strings

- ▶ Strings act like value types but they are actually reference types (C#)
- ▶ This means we need to be careful in allocating new strings
- ▶ **And** doing any operations using strings such as concatenation using +
- ▶ In C# you should use the **StringBuilder** class

String Builder Example - C#

```
//We need to use the namespace - System.Text  
using namespace System.Text  
  
//Create the string builder with a capacity of 1024  
StringBuilder sb=new StringBuilder(1024,1024);  
  
//Append some text  
sb.Append("Name: ");  
sb.Append("Brian");  
sb.Append(" Health: ");  
sb.Append(100);  
  
//Get the String from the String Builder  
string s=sb.ToString();
```

Memory Management



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- ▶ This process is automatic and tuned for maximum performance
- ▶ <https://unity3d.com/learn/tutorials/topics/performance-optimization/optimizing-garbage-collection-unity-games>

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 - ▶ C++ - <http://gameprogrammingpatterns.com/object-pool.html>

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 - ▶ Unity - <https://unity3d.com/learn/tutorials/topics/scripting/object-pooling>
 - ▶ C++ - <http://gameprogrammingpatterns.com/object-pool.html>
- ▶ Cache frequently used objects

Exercise



Exercise - All Students

- ▶ Complete exercise from last week
- ▶ Then move onto this weeks (on next slides)

String Exercise - All Students

- ▶ Download one of the following Projects
 - ▶ BA Students - `https://github.com/Falmouth-Games-Academy/GAM160-Exercises`
 - ▶ BSc Students - `https://github.com/Falmouth-Games-Academy/COMP140-Exercises`
- ▶ Replace all string processing with `StringBuilder` if using C# or `StringStream` if using C++

Debugging Exercise - BA Students

- ▶ Watch the following video - <https://unity3d.com/learn/tutorials/topics/scripting/debugging-unity-games-visual-studio>
- ▶ Open DebugExercise from the GAM160 Exercises Repository
- ▶ Use the debugger to find answers to the questions which are shown as comments within the Start() function

Debugging Exercise - BSc Students

- ▶ Read the following - `https://tutorials.visualstudio.com/vs-get-started/debugging`
- ▶ Open DebugExercise project
- ▶ Use the debugger to find answers to the questions Q1 and Q2 which are shown as comments within the main function