26 - 28 NOVEMBER 2024
RIYADH, SAUDI ARABIA

.NET ALCHEMY
DISCOVERING PRIMITIVES FOR OFFENSIVE TOOLING

KYLE AVERY

ORGANISED BY:

IN ASSOCIATION WITH:

PRESENTATION SPONSOR:

WHOAMI

Kyle Avery

- Offensive Developer @ Outflank
- Red team background / .NET and C development
- Lone US Outflank member

AGENDA

Memory Allocation

- Indirect creation of executable memory

Deserialization Bugs

- Exploiting “intentional” vulnerabilities

Unmanaged Control

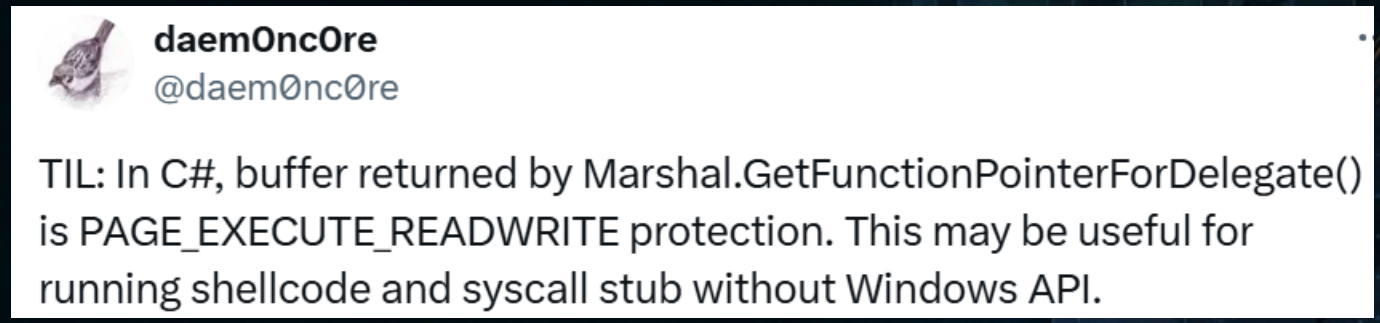
- Resolving and patching managed functions

MEMORY ALLOCATION

INDIRECT CREATION OF EXECUTABLE MEMORY

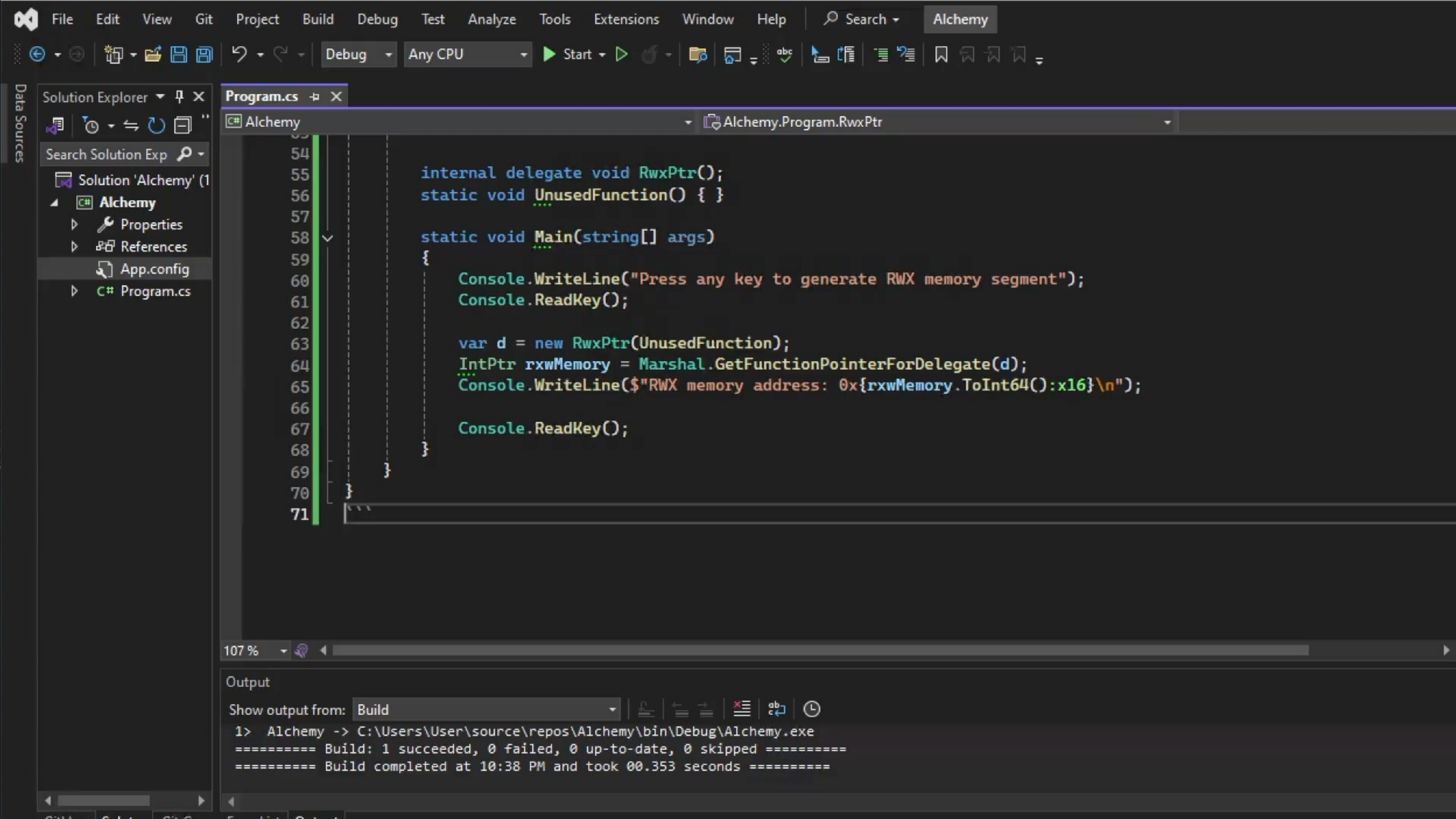
INDIRECT ALLOCATION

- Calling **`GetFunctionPointerForDelegate`** creates 5-6KB of RWX memory
  - Does not work reliably for x86
  - Too small for most shellcode




```
internal delegate void RWXPtr();
void UnusedFunction() {}

var d = new RWXPtr(UnusedFunction);
IntPtr rxwMemory = Marshal.GetFunctionPointerForDelegate(d);
```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Alchemy.Program.RwxPtr
internal delegate void RwxPtr();
static void UnusedFunction() { }
static void Main(string[] args)
{
Console.WriteLine("Press any key to generate RWX memory segment");
Console.ReadKey();
var d = new RwxPtr(UnusedFunction);
IntPtr rxwMemory = Marshal.GetFunctionPointerForDelegate(d);
Console.WriteLine($"RWX memory address: 0x{rxwMemory.ToInt64():x16}\n");
Console.ReadKey();
}
}
}
107 %
Output
Show output from: Build
1> Alchemy -> C:\Users\User\source\repos\Alchemy\bin\Debug\Alchemy.exe
========== Build: 1 succeeded, 0 failed, 0 up-to-date, 0 skipped ==========
========== Build completed at 10:38 PM and took 00.353 seconds ==========

INDIRECT ALLOCATION

- Alternative from SharpHellsGate:

```
static UInt32 Gate() {
    return new UInt32();
}

bool GenerateRWXMemorySegment() {
    BindingFlags gateFlags = BindingFlags_Public | BindingFlags_Instance;
    MethodInfo method = GetMethod(nameof(Gate), gateFlags);

    RuntimeHelpers.PrepareMethod(method.MethodHandle);
    IntPtr pMethod = method.MethodHandle.GetFunctionPointer();
}
```

INDIRECT ALLOCATION

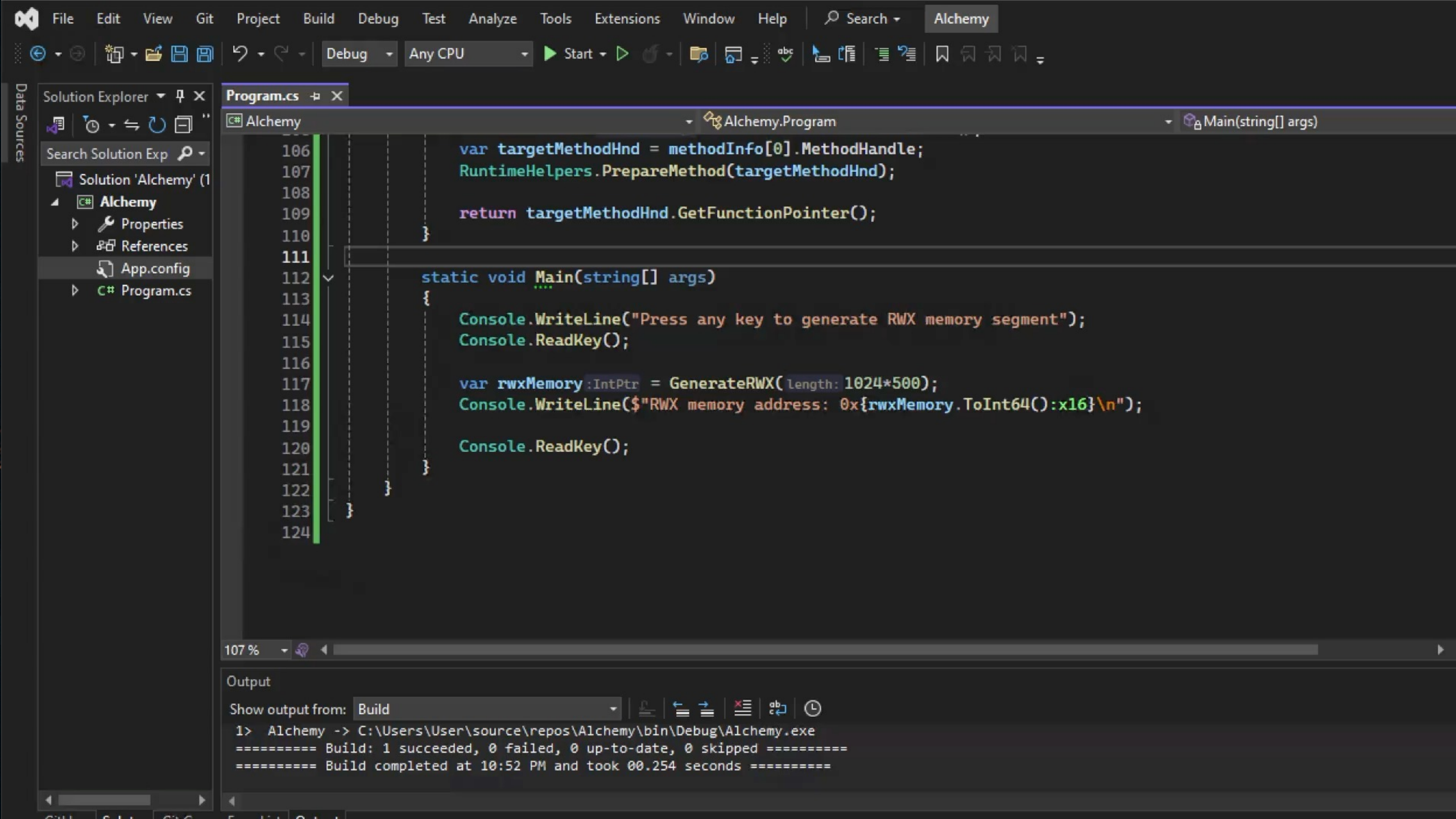
- Can we increase the size of JIT memory?
  - Yes! **Make the method larger** – crude but functional

```
static UInt32 Gate() {
    Console.WriteLine("A");
    Console.WriteLine("B");
    Console.WriteLine("C");
    ...

    return new UInt32();
}
```

INDIRECT ALLOCATION

- Can we make the method larger at runtime?
  - Dylan Tran (@d_tranman) solved this by defining a dynamic assembly, module, and method

```
var name = new AssemblyName("FakeAssembly");
var ad = System.AppDomain.CurrentDomain;
var asm = ad.DefineDynamicAssembly(name, AssemblyBuilderAccess.Run);
var bld = asm.DefineDynamicModule("FakeModule");
var mtd = bld.DefineGlobalMethod("FakeMtd", Static, typeof(void), new Type[]{});

ILGenerator il = mtd.GetILGenerator();
il.EmitWriteLine("AAAA");
il.Emit(OpCodes.Ret);
```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Program.cs
Alchemy
Alchemy.Program
Main(string[] args)
var targetMethodHnd = methodInfo[0].MethodHandle;
RuntimeHelpers.PrepareMethod(targetMethodHnd);
return targetMethodHnd.GetFunctionPointer();
}
static void Main(string[] args)
{
Console.WriteLine("Press any key to generate RWX memory segment");
Console.ReadKey();
var rwxMemory :IntPtr = GenerateRWX(length: 1024*500);
Console.WriteLine($"RWX memory address: 0x{rwxMemory.ToInt64():x16}\n");
Console.ReadKey();
}
}
}
107 %
Output
Show output from: Build
1> Alchemy -> C:\Users\User\source\repos\Alchemy\bin\Debug\Alchemy.exe
========== Build: 1 succeeded, 0 failed, 0 up-to-date, 0 skipped ==========
========== Build completed at 10:52 PM and took 00.254 seconds ==========

DESERIALIZATION BUGS

EXPLOITING “INTENTIONAL” VULNERABILITIES

SERIALIZATION INTRODUCTION

- **Serialization** – Convert object in memory to a format that can be saved or transferred

- **Formatters** – .NET classes that serialize/deserialize objects:
  - `BinaryFormatter`
  - `SoapFormatter`
  - `XMLSerializer`
  - `JavaScriptSerialzier`
  - `NetDataContractSerializer`
  - …

SERIALIZATION INTRODUCTION

- **Deserialization** – Object is decoded and then its constructor is executed

- **Vulnerabilities** – Unsanitized data is passed to deserializer
  - Introduced by James Forshaw at Black Hat USA 2012
  - RCE methods discussed at Black Hat USA 2017

EXPLOITING “INTENTIONAL BUGS”

DotNetToJScript – Generate VBScript/JScript that loads a .NET assembly

- Uses **`BinaryFormatter`** to deserialize a **`delegate`**
- Works for VBScript/JScript because there are no CAS restrictions

Alternative: **GadgetToJScript**

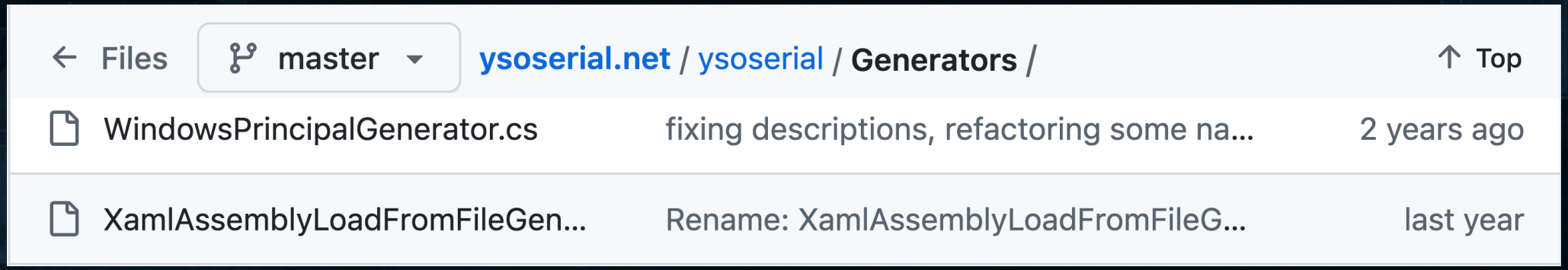
- Uses **`BinaryFormatter`** and **`ActivitySurrogateSelector`** gadget
- Must use an additional gadget to disable type protections in .NET 4.8

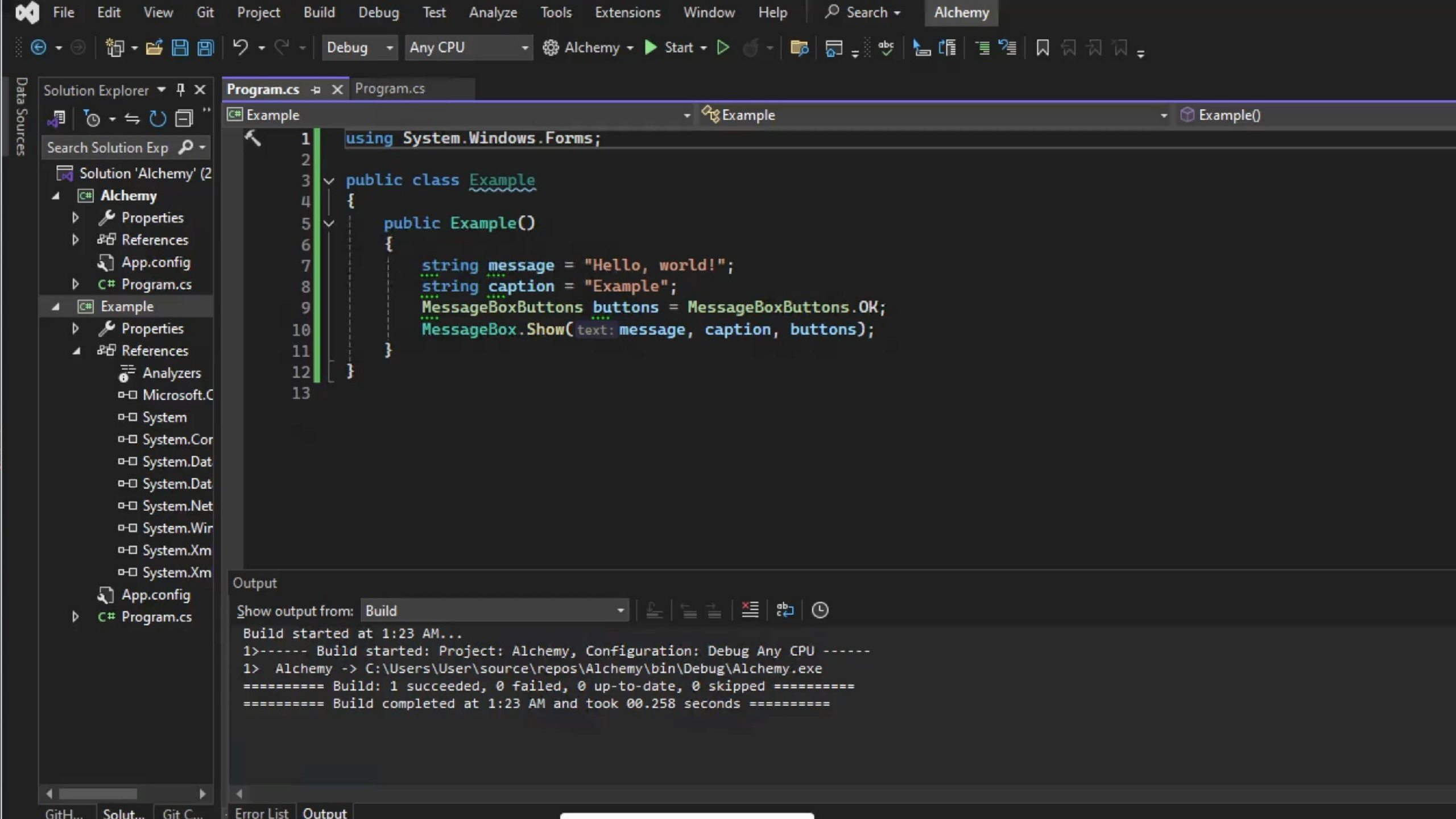
DESERIALIZATION GADGETS

- **Gadgets** – Serializable .NET classes that wrap unserializable classes
  - The **`Process`** and **`Assembly`** classes are not serializable – How can we execute code?
  - Serializable classes like **`ActivitySurrogateSelector`** can execute other .NET methods
- **YSoSerial.Net** – RCE payloads with support for **44 gadgets!**

ALTERNATIVE DESERIALIZATION GADGETS

- **New gadget – `XamlAssemblyLoadFromFile`**
  - Supports multiple formatters: **`Binary`**, **`Soap`**, **`Los`**, …
  - Example code already loads a .NET assembly

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System.Net
System.Wir
System.Xm
System.Xm
App.config
Program.cs
Program.cs
Program.cs
Example
Example
Example()
1 using System.Windows.Forms;
2
3 public class Example
4 {
5 public Example()
6 {
7 string message = "Hello, world!";
8 string caption = "Example";
9 MessageBoxButtons buttons = MessageBoxButtons.OK;
10 MessageBox.Show(text: message, caption, buttons);
11 }
12 }
13
Output
Show output from: Build
Build started at 1:23 AM...
1>------ Build started: Project: Alchemy, Configuration: Debug Any CPU ------
1> Alchemy -> C:\Users\User\source\repos\Alchemy\bin\Debug\Alchemy.exe
========== Build: 1 succeeded, 0 failed, 0 up-to-date, 0 skipped ==========
========== Build completed at 1:23 AM and took 00.258 seconds ==========
Error List
Output

FORTRA

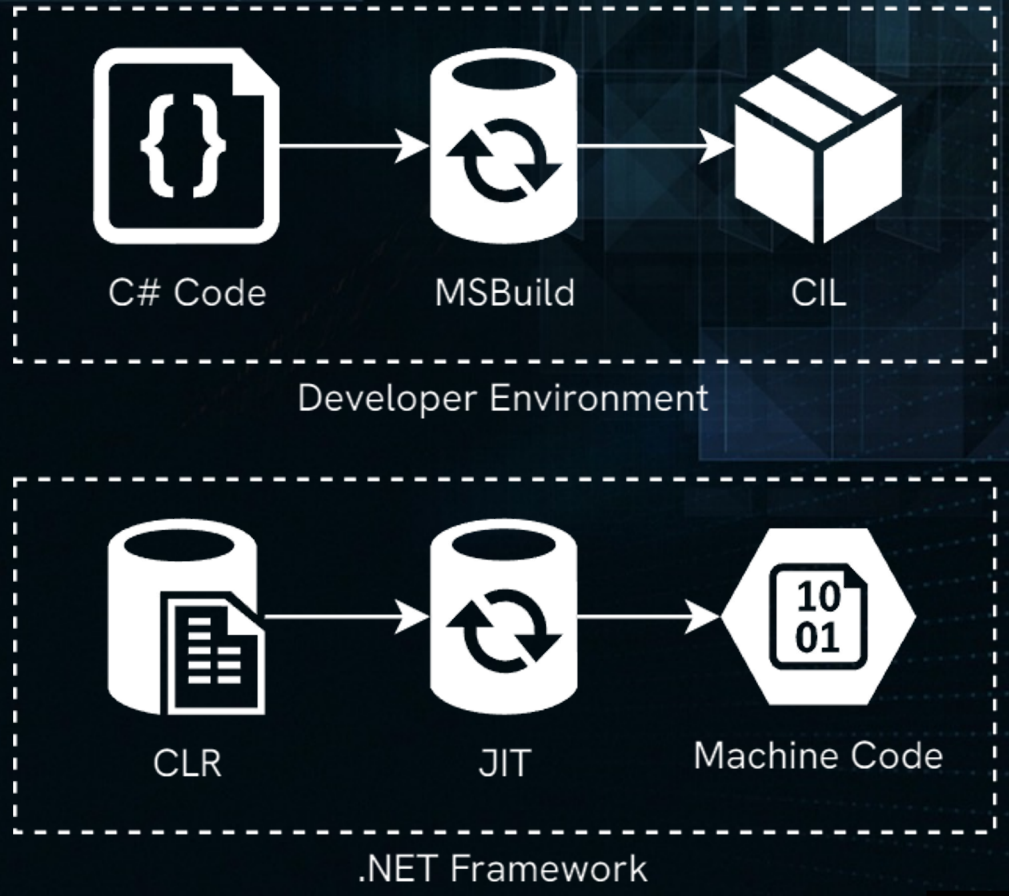
UNMANAGED CONTROL

RESOLVING AND PATCHING MANAGED FUNCTIONS

UNMANAGED CLR HOSTING API

- Common Language Runtime (CLR)
  - Executes “compiled” .NET projects

- Loading the .NET Runtime:
  1. Load the CLR
  2. Create an AppDomain (optional)
  3. Load a .NET assembly into an AppDomain



PATCHING MANAGED FUNCTIONS

- Some .NET functions cause issues or risk implant stability
- Resolve .NET functions reflectively:
  1. Define+resolve the managed method
  2. Use the method handle to get its unmanaged function pointer

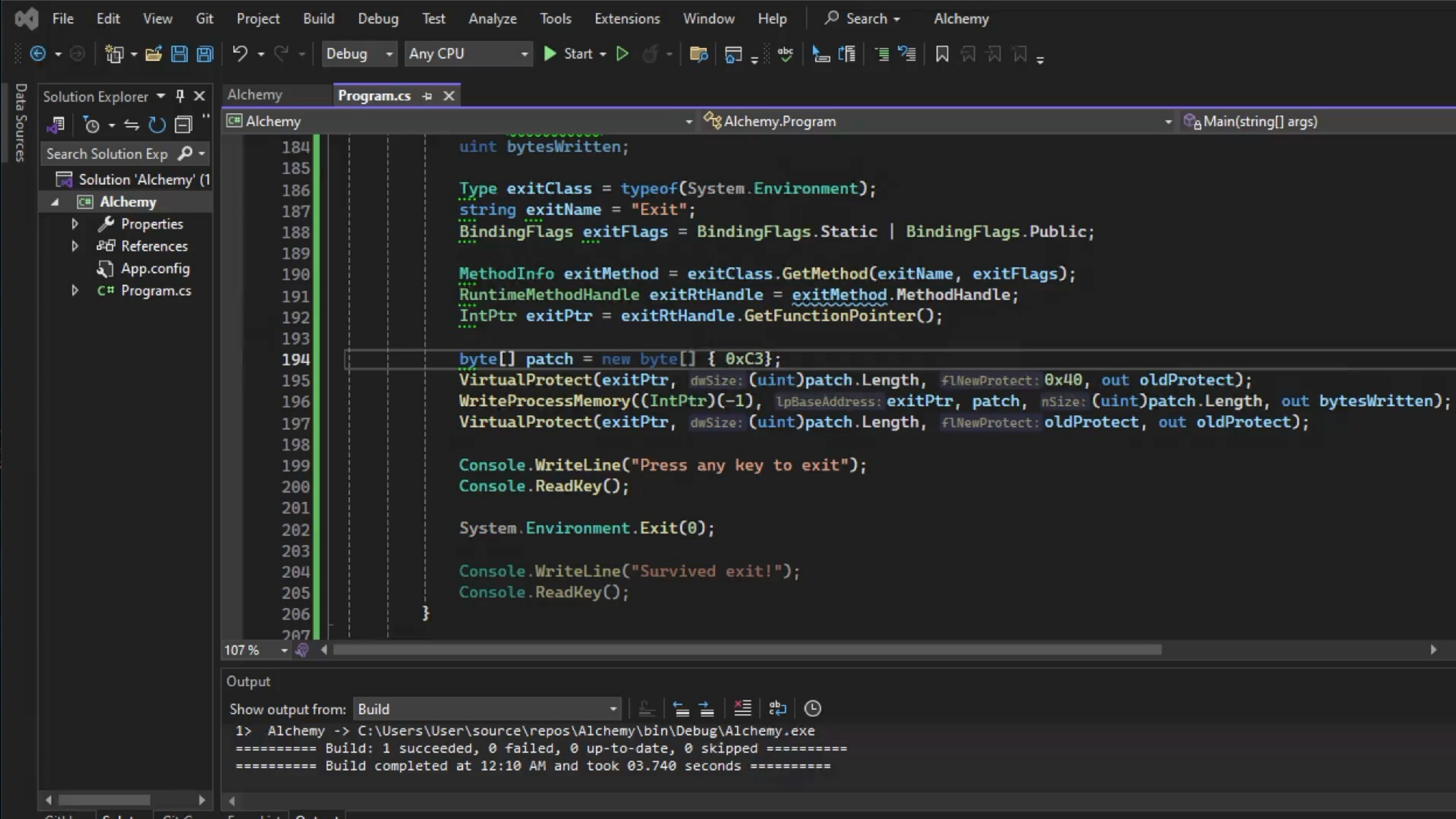
```
namespace EnvExitPatch
{
    internal class Program
    {
        static void Main(string[] args)
        {
            Console.WriteLine("About to exit...");
            Environment.Exit(0);
            Console.WriteLine("Survived exit!");
        }
```

```
Type exitClass = typeof(System.Environment);
string exitName = "Exit";
BindingFlags exitBinding = BindingFlags.Static | BindingFlags.Public;

MethodInfo exitInfo = exitClass.GetMethod(exitName, exitBinding);
RuntimeMethodHandle exitRtHandle = exitInfo.MethodHandle;
IntPtr exitPtr = exitRtHandle.GetFunctionPointer();
```

MDSec

Massaging your CLR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Program.cs
Alchemy
Alchemy.Program
Main(string[] args)
uint bytesWritten;
Type exitClass = typeof(System.Environment);
string exitName = "Exit";
BindingFlags exitFlags = BindingFlags.Static | BindingFlags.Public;
MethodInfo exitMethod = exitClass.GetMethod(exitName, exitFlags);
RuntimeMethodHandle exitRtHandle = exitMethod.MethodHandle;
IntPtr exitPtr = exitRtHandle.GetFunctionPointer();
byte[] patch = new byte[] { 0xC3};
VirtualProtect(exitPtr, dwSize: (uint)patch.Length, flNewProtect: 0x40, out oldProtect);
WriteProcessMemory((IntPtr)(-1), lpBaseAddress: exitPtr, patch, nSize: (uint)patch.Length, out bytesWritten);
VirtualProtect(exitPtr, dwSize: (uint)patch.Length, flNewProtect: oldProtect, out oldProtect);
Console.WriteLine("Press any key to exit");
Console.ReadKey();
System.Environment.Exit(0);
Console.WriteLine("Survived exit!");
Console.ReadKey();
}
107 %
Output
Show output from: Build
1> Alchemy -> C:\Users\User\source\repos\Alchemy\bin\Debug\Alchemy.exe
========== Build: 1 succeeded, 0 failed, 0 up-to-date, 0 skipped ==========
========== Build completed at 12:10 AM and took 03.740 seconds ==========

PATCHING MANAGED FUNCTIONS

- **Potential drawback** – Must load a .NET assembly before anything else
  - Can this code be replicated from an unmanaged context?

```
Type exitClass = typeof(System.Environment);
string exitName = "Exit";
BindingFlags exitBinding = BindingFlags.Static | BindingFlags.Public;

MethodInfo exitInfo = exitClass.GetMethod(exitName, exitBinding);
RuntimeMethodHandle exitRtHandle = exitInfo.MethodHandle;
IntPtr exitPtr = exitRtHandle.GetFunctionPointer();
```

UNMANAGED FUNCTION RESOLUTION

1. Resolve mscorlib in default AppDomain with **Load**:

```
IUnknownPtr appDomainUnk;
corRtHost->GetDefaultDomain(&appDomainUnk);

_AppDomain* appDomain;
appDomainUnk->QueryInterface(IID_PPV_ARGS(&appDomain));

_Assembly* mscorlib;
appDomain->Load_2(SysAllocString(L"mscorlib, Version=4.0.0.0"), &mscorlib);
```

UNMANAGED FUNCTION RESOLUTION

2. Resolve target class and method with **GetType** and **GetMethod**:

```
Type exitClass = typeof(System.Environment);
string exitName = "Exit";
BindingFlags exitBinding = BindingFlags.Static | BindingFlags.Public;

MethodInfo exitInfo = exitClass.GetMethod(exitName, exitBinding);
```

```
_Type* exitClass;
mscorlib->GetType_2(SysAllocString(L"System.Environment"), &exitClass);

_MethodInfo* exitInfo;
BindingFlags exitFlags = BindingFlags_Public | BindingFlags_Static;
exitClass->GetMethod_2(SysAllocString(L"Exit"), exitFlags, &exitInfo);
```

UNMANAGED FUNCTION RESOLUTION

3. Resolve **MethodHandle** property:

```
RuntimeMethodHandle exitRtHandle = exitInfo.MethodHandle;
```

```
_Type* methodInfoClass;
BSTR methodInfoStr = SysAllocString(L"System.Reflection.MethodInfo");
mscorlib->GetType_2(methodInfoStr, &methodInfoClass);

_PropertyInfo* methodHndProperty;
BindingFlags methodHndFlags = BindingFlags_Instance | BindingFlags_Public;
BSTR methodHndStr = SysAllocString(L"MethodHandle");
methodInfoClass->GetProperty(methodHndStr, methodHndFlags, &methodHndProperty);
```

UNMANAGED FUNCTION RESOLUTION

4. Get value of **MethodHandle** property:

```
RuntimeMethodHandle exitRtHandle = exitInfo.MethodHandle;
```

```
VARIANT methodHndPtr = { 0 };
methodHndPtr.vt = VT_UNKNOWN;
methodHndPtr.punkVal = exitInfo;

SAFEARRAY* methodHndArgs = SafeArrayCreateVector(VT_EMPTY, 0, 0);
VARIANT methodHndVal = { 0 };
methodHndProperty->GetValue(methodHndPtr, methodHndArgs, &methodHndVal);
```

UNMANAGED FUNCTION RESOLUTION

5. Resolve **GetFunctionPointer** method:

```
IntPtr exitPtr = exitRtHandle.GetFunctionPointer();
```

```
_Type* rtMethodHndType;
BSTR rtMethodHndStr = SysAllocString(L"System.RuntimeMethodHandle");
mscorlib->GetType_2(rtMethodHndStr, &rtMethodHndType);

_MethodInfo* getFuncPtrMtdInf;
BindingFlags getFuncPtrFlags = BindingFlags_Public | BindingFlags_Instance;
BSTR getFuncPtrStr = SysAllocString(L"GetFunctionPointer");
rtMethodHndType->GetMethod_2(getFuncPtrStr, getFuncPtrFlags, &getFuncPtrMtdInf);
```

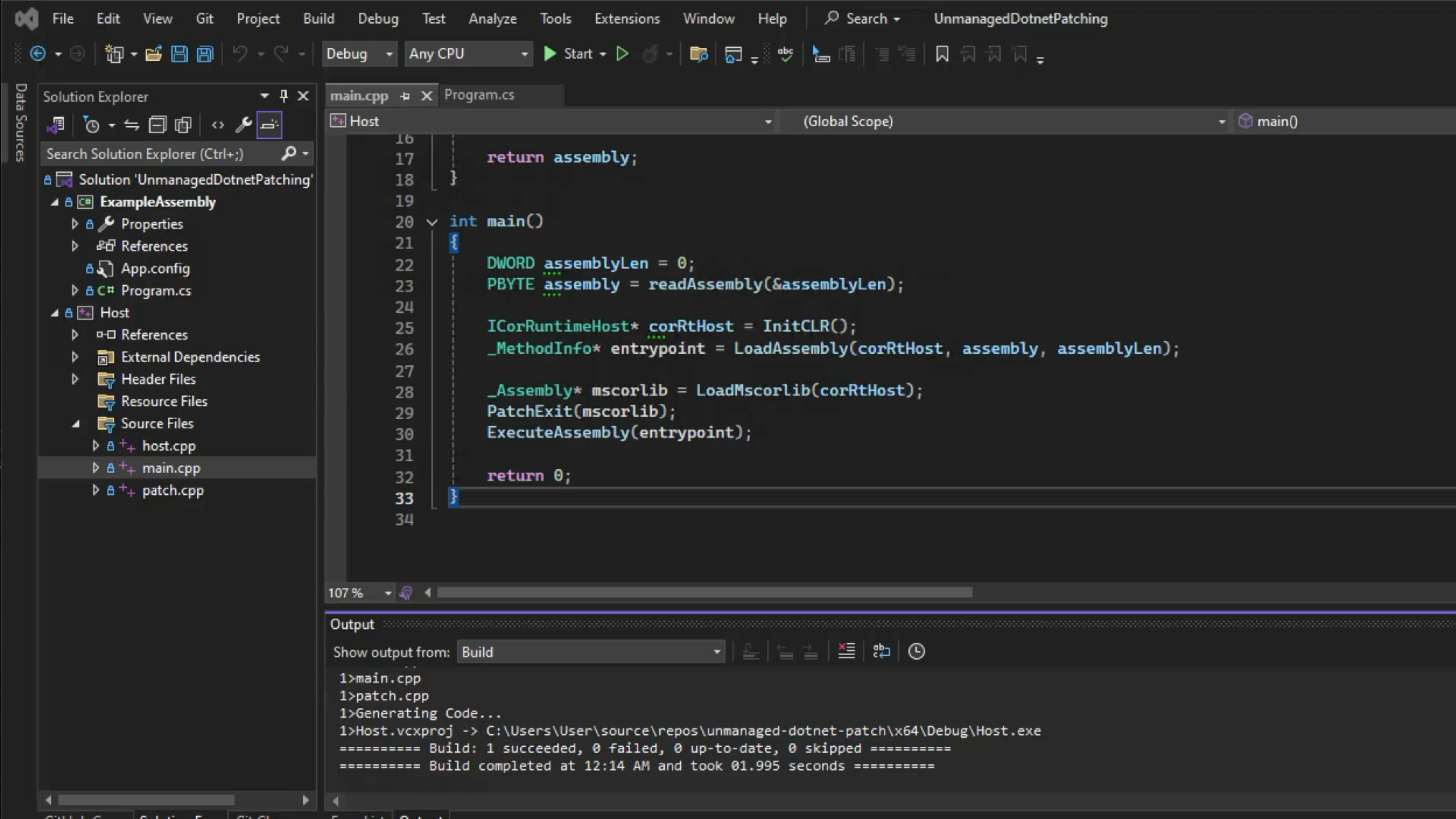
UNMANAGED FUNCTION RESOLUTION

6. Execute **GetFunctionPointer**:

```
IntPtr exitPtr = exitRtHandle.GetFunctionPointer();
```

```
SAFEARRAY* getFuncPtrArgs = SafeArrayCreateVector(VT_EMPTY, 0, 0);
VARIANT exitPtr = { 0 };
getFuncPtrMtdInf->Invoke_3(methodHndVal, getFuncPtrArgs, &exitPtr);

printf("Exit function pointer: 0x%p\n", exitPtr.byref);
```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Header Files
Resource Files
Source Files
host.cpp
main.cpp
patch.cpp
main.cpp
Program.cs
Host
(Global Scope)
main()
return assembly;
}
int main()
{
DWORD assemblyLen = 0;
PBYTE assembly = readAssembly(&assemblyLen);
ICorRuntimeHost* corRtHost = InitCLR();
_MethodInfo* entrypoint = LoadAssembly(corRtHost, assembly, assemblyLen);
_Assembly* mscorlib = LoadMscorlib(corRtHost);
PatchExit(mscorlib);
ExecuteAssembly(entrypoint);
return 0;
}
107 %
Output
Show output from: Build
1>main.cpp
1>patch.cpp
1>Generating Code...
1>Host.vcxproj -> C:\Users\User\source\repos\unmanaged-dotnet-patch\x64\Debug\Host.exe
========== Build: 1 succeeded, 0 failed, 0 up-to-date, 0 skipped ==========
========== Build completed at 12:14 AM and took 01.995 seconds ==========

EXECUTING MANAGED FUNCTIONS

- The “unmanaged patching” capability is useful, but what primitives does it use?
  1. Resolving managed functions
  2. Executing managed functions

```
Type exitClass = typeof(System.Environment);
string exitName = "Exit";
BindingFlags exitBinding = BindingFlags.Static | BindingFlags.Public;

MethodInfo exitInfo = exitClass.GetMethod(exitName, exitBinding);
RuntimeMethodHandle exitRtHandle = exitInfo.MethodHandle;
IntPtr exitPtr = exitRtHandle.GetFunctionPointer();
```

- Executing arbitrary .NET functions from unmanaged code: **Many possibilities!**

https://github.com/outflanknl/unmanaged-dotnet-patch


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