Assembly in C#

Prepared for Vth semester DDU-CE students
2022-23 WAD

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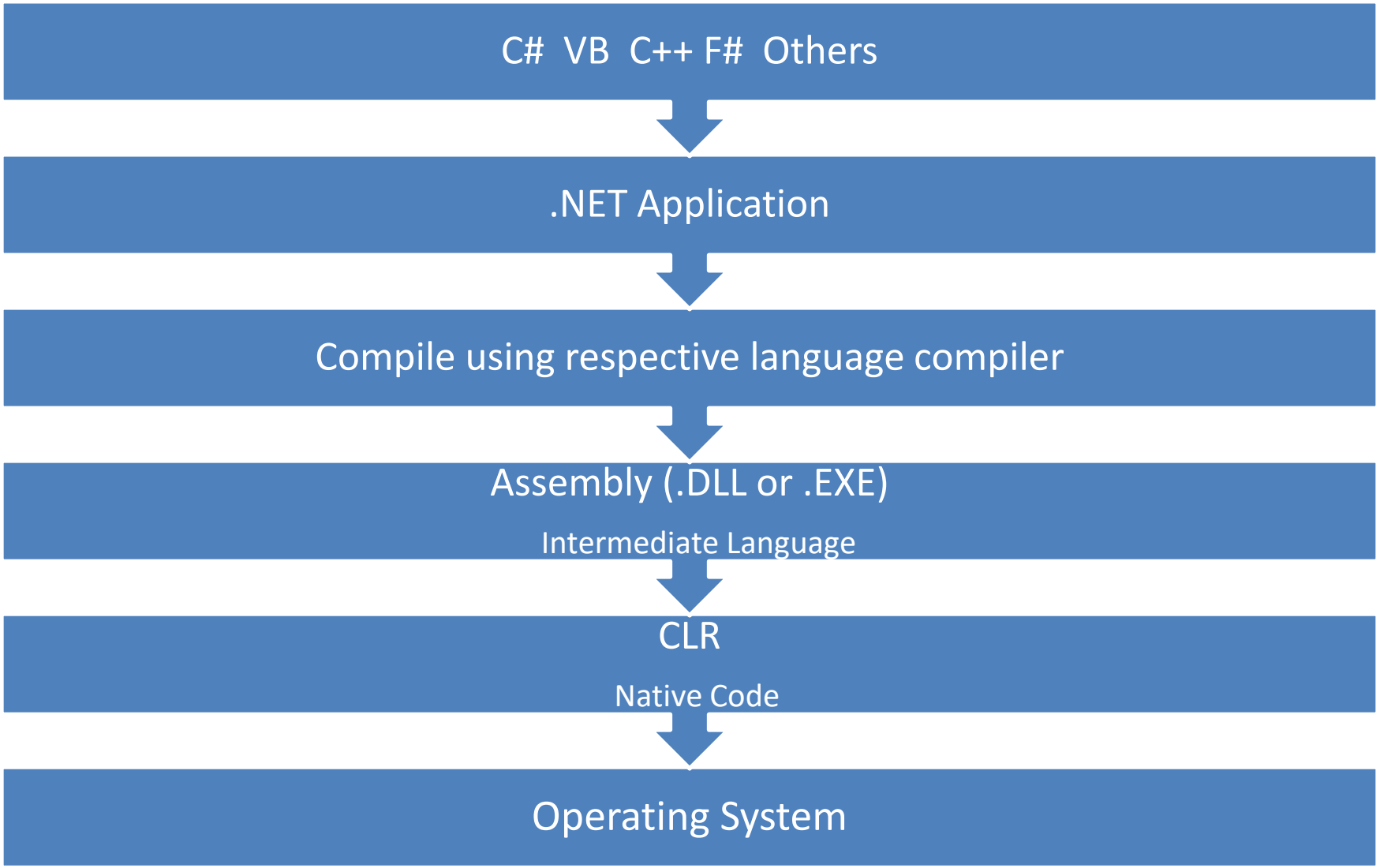
TIFR

- Tata Institute of Fundamental Research
  - A National Centre of the Government of India, under the umbrella of the Department of Atomic Energy
  - A deemed University awarding degrees for master's and doctoral programs.
  - Carry out basic research in physics, chemistry, biology, mathematics, **computer science** and science education.

Program execution



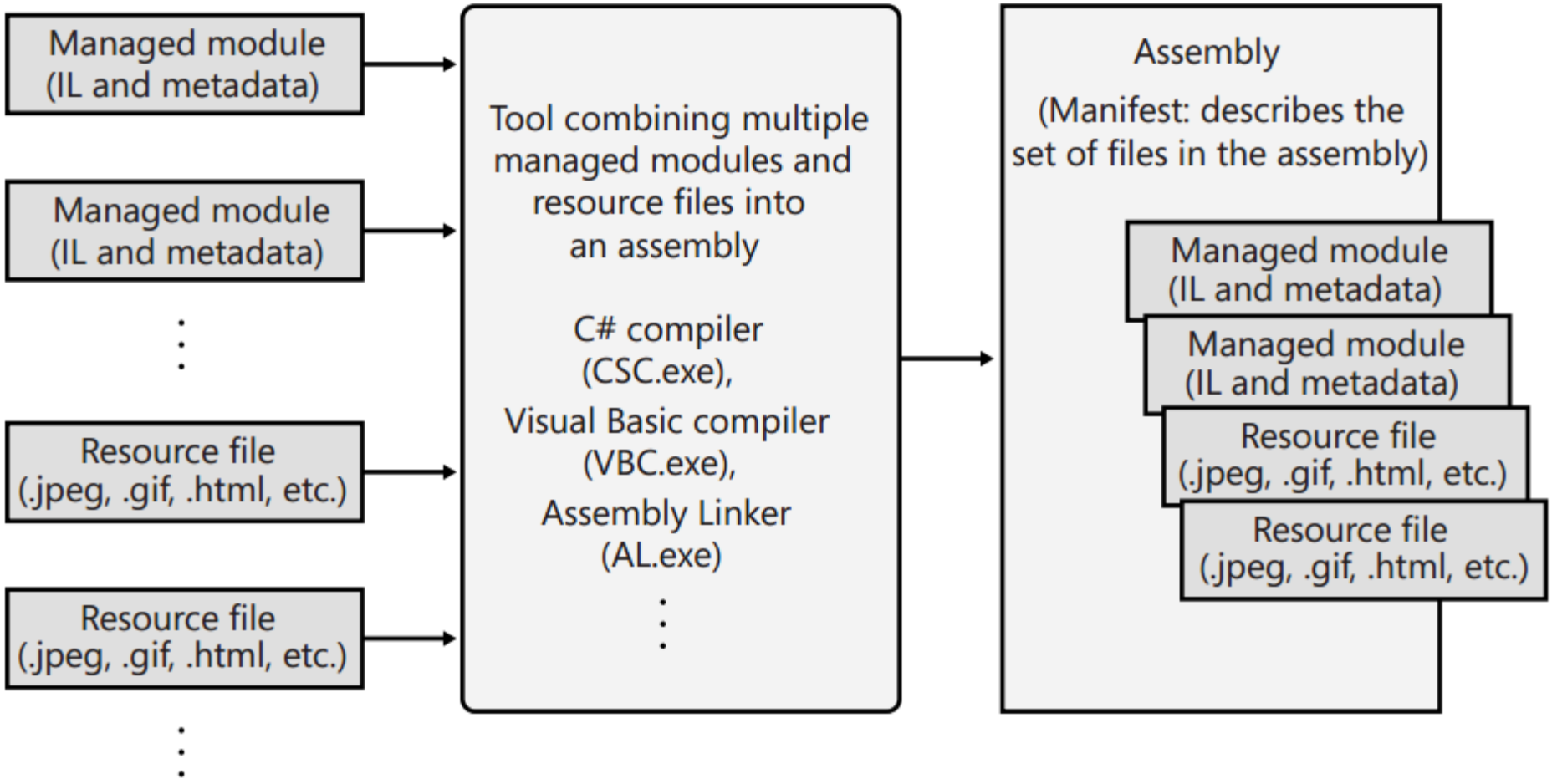
Introduction

- Assembly is the core part of the runtime.
  - Physical collection of classes.
- It is collection of all information required by the runtime to execute your application.
- IL + Metadata
- An assembly can be a **DLL file** or **a Portable Executable (EXE) file**

Safe vs Unsafe Code

- By default, Microsoft's C# compiler produces safe code. Safe code is code that is verifiably safe.
- Unsafe code is allowed to work directly with memory addresses and can manipulate bytes at these addresses.
- PEVerify.exe

Complete Definition



Purpose of Assembly

- Using assemblies allows you to semantically group functional units into a single file for purposes of deployment, versioning, and maintenance.

Manifest Data

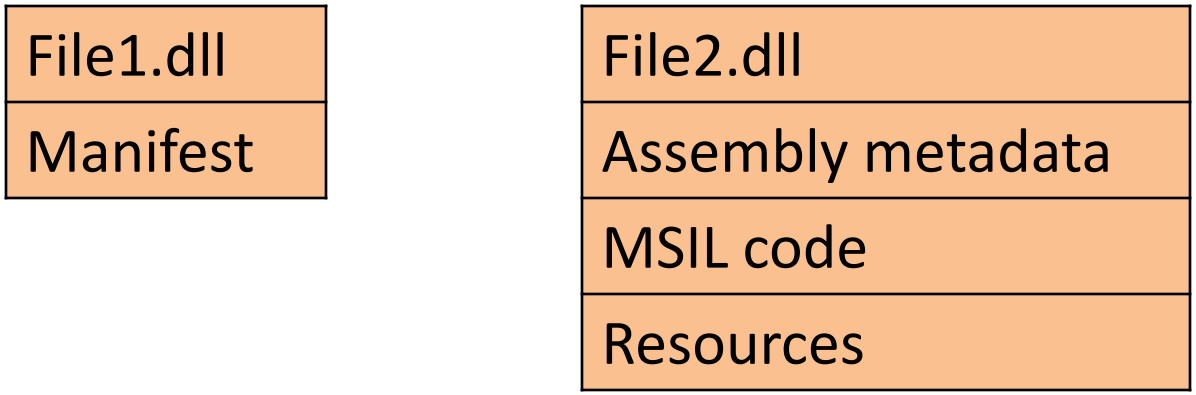
- PE32(+) file contains a block of data called the manifest
- Manifest: Another set of metadata
- Manifest describes the set of files in assembly

Content of Manifest

- Assembly name
- Version number
- Culture
- Strong name information
- List of all files in the assemblies
- Type reference information
- Information on referenced assemblies

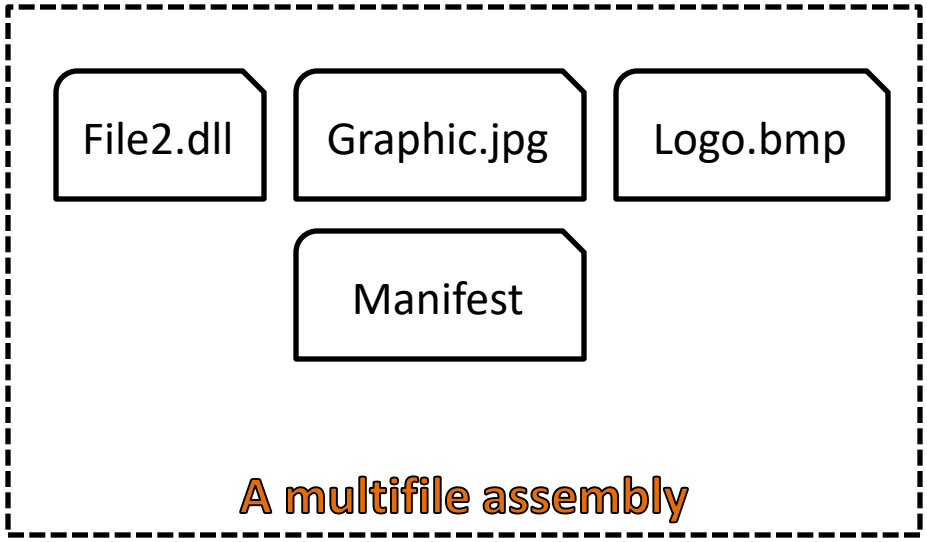
Single file assembly

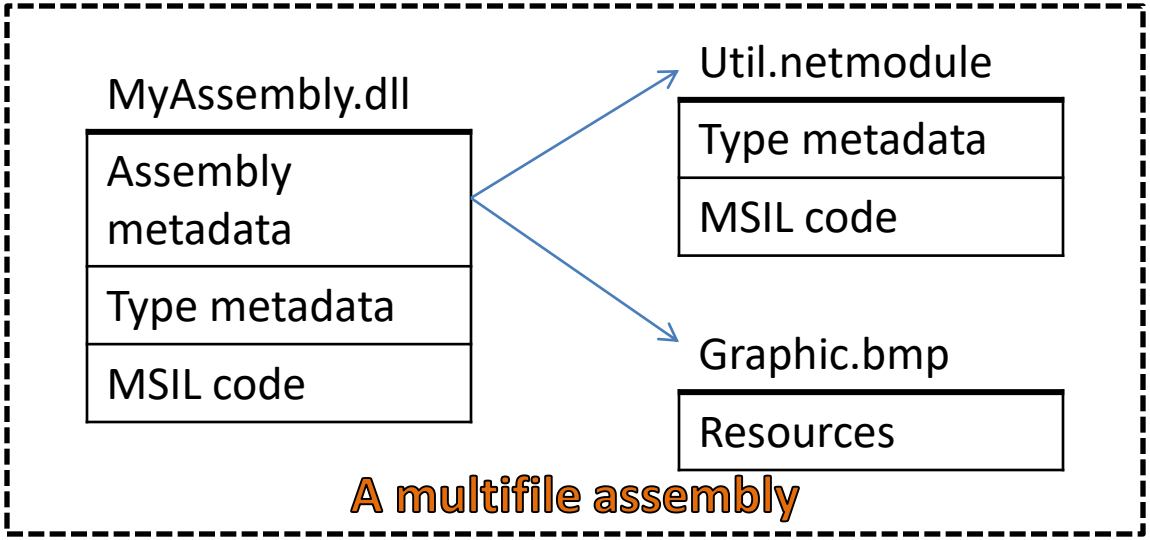
- If you were to compile a stand-alone application or DLL, the manifest would be incorporated into the resulting PE. This is known as a *single-file assembly.*



Multifile Assembly

- A multifile assembly can also be generated, with the manifest existing as either a **standalone** entity within the assembly or as an **attachment** to one of the modules within the assembly.


File2.dll
Graphic.jpg
Logo.bmp
Manifest
A multifile assembly


MyAssembly.dll
Assembly metadata
Type metadata
MSIL code
Util.netmodule
Type metadata
MSIL code
Graphic.bmp
Resources
A multifile assembly

Benefits of Assembly

- Assemblies afford the developer numerous benefits, including packaging, deployment, and versioning.
- Increased performance.
- Better code management and encapsulation.
- Introduces the n-tire concepts and business logic.

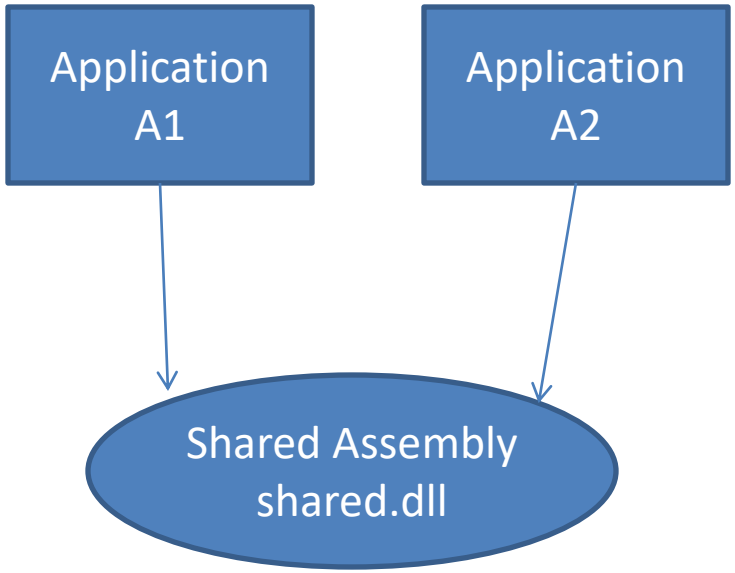
Deployment methods

- Private Assembly
  - An Assembly copied into same folder as referencing program.
- Shared Assembly
  - An Assembly deployed globally which can be consumed by any program.
- Assemblies can also be deployed worldwide via 3rd party package managers such as Nuget (Integrated with Visual Studio)

DLL Hell

- If the assembly is not signed with private-public key pair, the assembly is weak named and not guaranteed to be unique, and may cause DLL hell
- Strong named assemblies are guaranteed to be unique and solves DLL hell. You cannot install an assembly into GAC unless, the assembly is strongly named

DLL-Hell Problem



Continue...

- I have 2 applications. A1 and A2 installed on my machine
- Both of these applications use shared assembly shared.dll
- Now, I have a latest version of application A2 available on the internet
- I download the latest version of A2 and install it on my machine
- This new installation has over written shared.dll, which is also used by application A1
- Application A2 works fine, but A1 fails to work, because the newly installed shared.dll is not backward compatible

Continue...

- So, DLL HELL is a problem where one application will install a new version of the shared component that is not backward compatible with the version already on the machine causing all the other existing applications that rely on the shared component to break
- With .NET strong named assemblies we don’t have DLL HELL problem any more

Justify: CLR is introduced for portability in .NET framework.

What is the purpose of using assembly?

Differentiate: Safe code and Unsafe code

Differentiate: Single file assemblies and Multifile assemblies.

Drink water, please!

- About 75% of the brain is made up of water. This means that dehydration, even in small amounts, can have a negative effect on the brain functions.
- Our body is composed of about 60% water.
- Blood is more than 90% water, and blood carries oxygen to different parts of the body.

Versioning

- Versioning makes sure that even if new version of DLL is installed, still old application can use old DLL.

The MSCorLib Assembly

- **MSCorLib.dll** is a special file in that it contains all the core types
  - Byte, Char, String, Int32, and many more.
  - In fact, these types are so frequently used that the C# compiler automatically references the MSCorLib.dll assembly.

Program.cs

```
1  using System;
2
3  namespace ConsoleApplication1
4  {
5      class Program
6      {
7          static void Main(string[] args)
8          {
9              Console.WriteLine("DDU");
10             Console.ReadLine();
11         }
12     }
13 }
14
```

Cont…

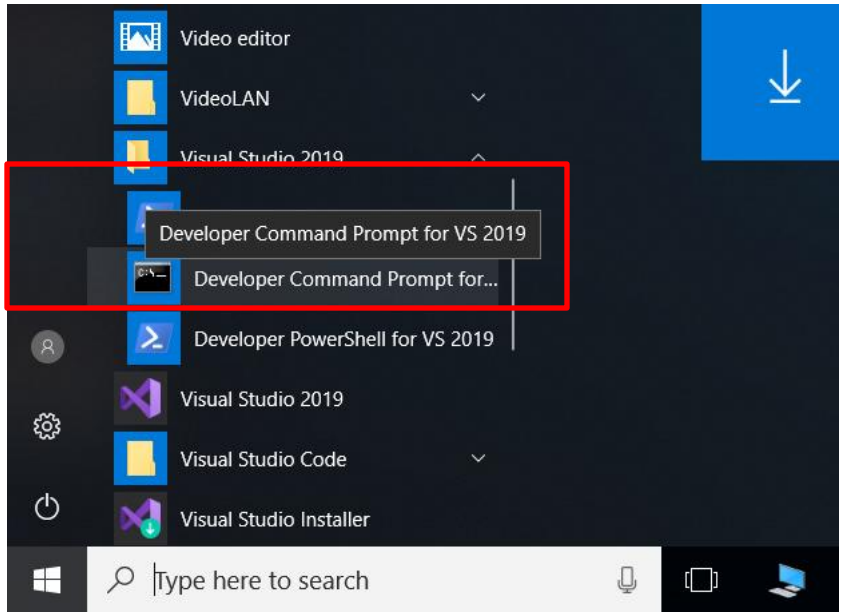
csc.exe /out:Program.exe /t:exe /r:MSCorLib.dll Program.cs

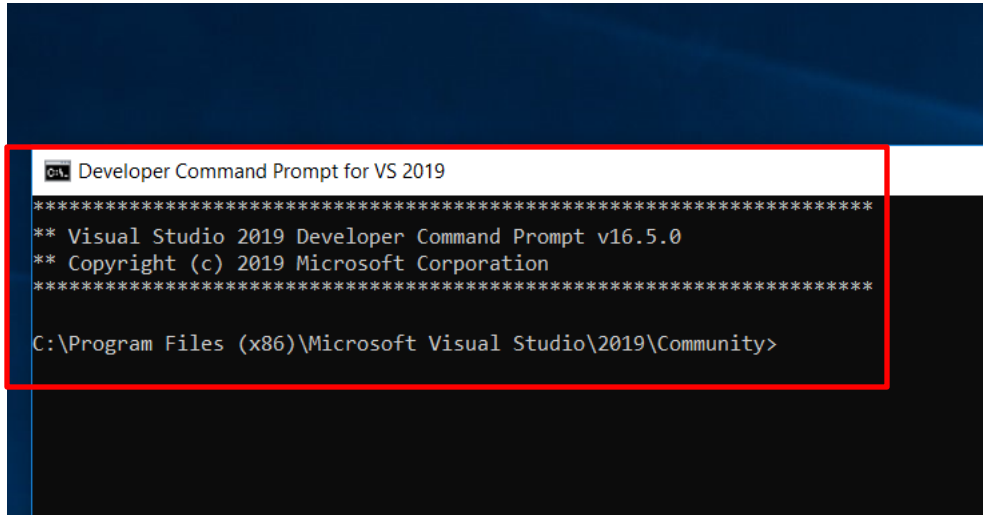
csc.exe /out:Program.exe /t:exe Program.cs

csc.exe Program.cs

/nostdlibswitch

csc.exe /out:Program.exe /t:exe /nostdlib Program.cs


Video editor
VideoLAN
Visual Studio 2019
Developer Command Prompt for VS 2019
Developer Command Prompt for...
Developer PowerShell for VS 2019
Visual Studio 2019
Visual Studio Code
Visual Studio Installer
Type here to search


Developer Command Prompt for VS 2019
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** Visual Studio 2019 Developer Command Prompt v16.5.0
** Copyright (c) 2019 Microsoft Corporation
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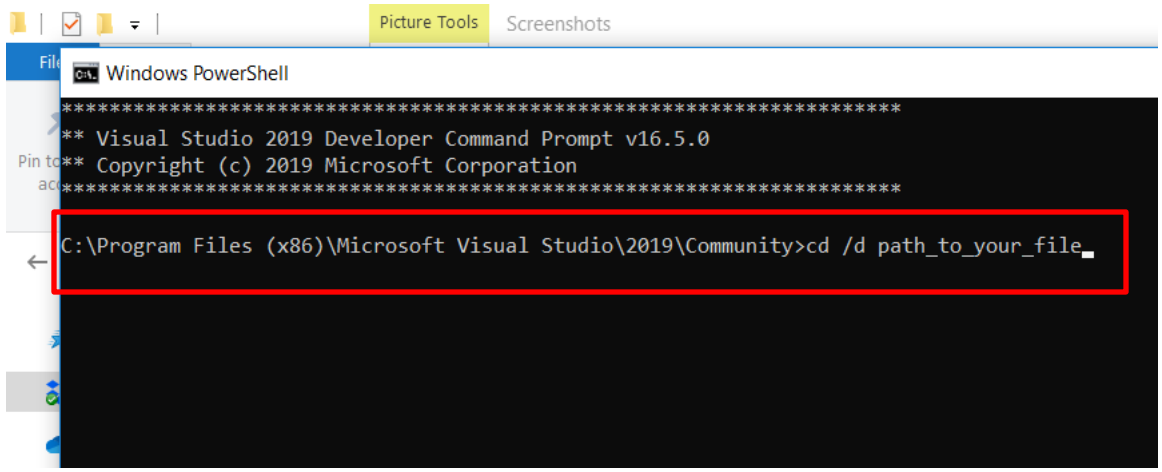
C:\Program Files (x86)\Microsoft Visual Studio\2019\Community>


Picture Tools
Screenshots
Windows PowerShell
** Visual Studio 2019 Developer Command Prompt v16.5.0
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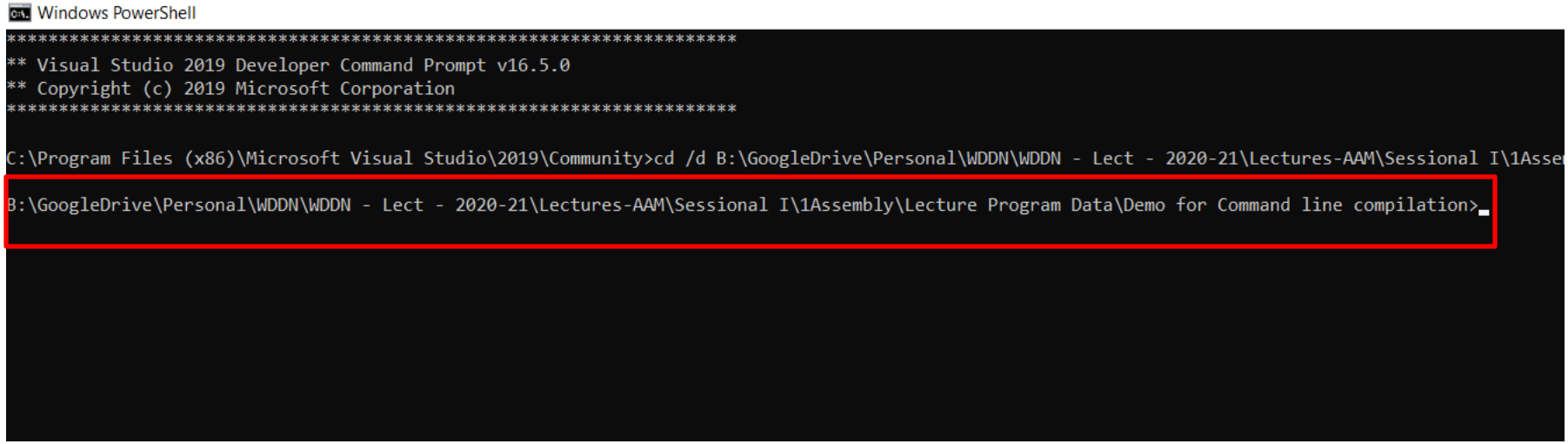
C:\Program Files (x86)\Microsoft Visual Studio\2019\Community>cd /d path_to_your_file


Windows PowerShell
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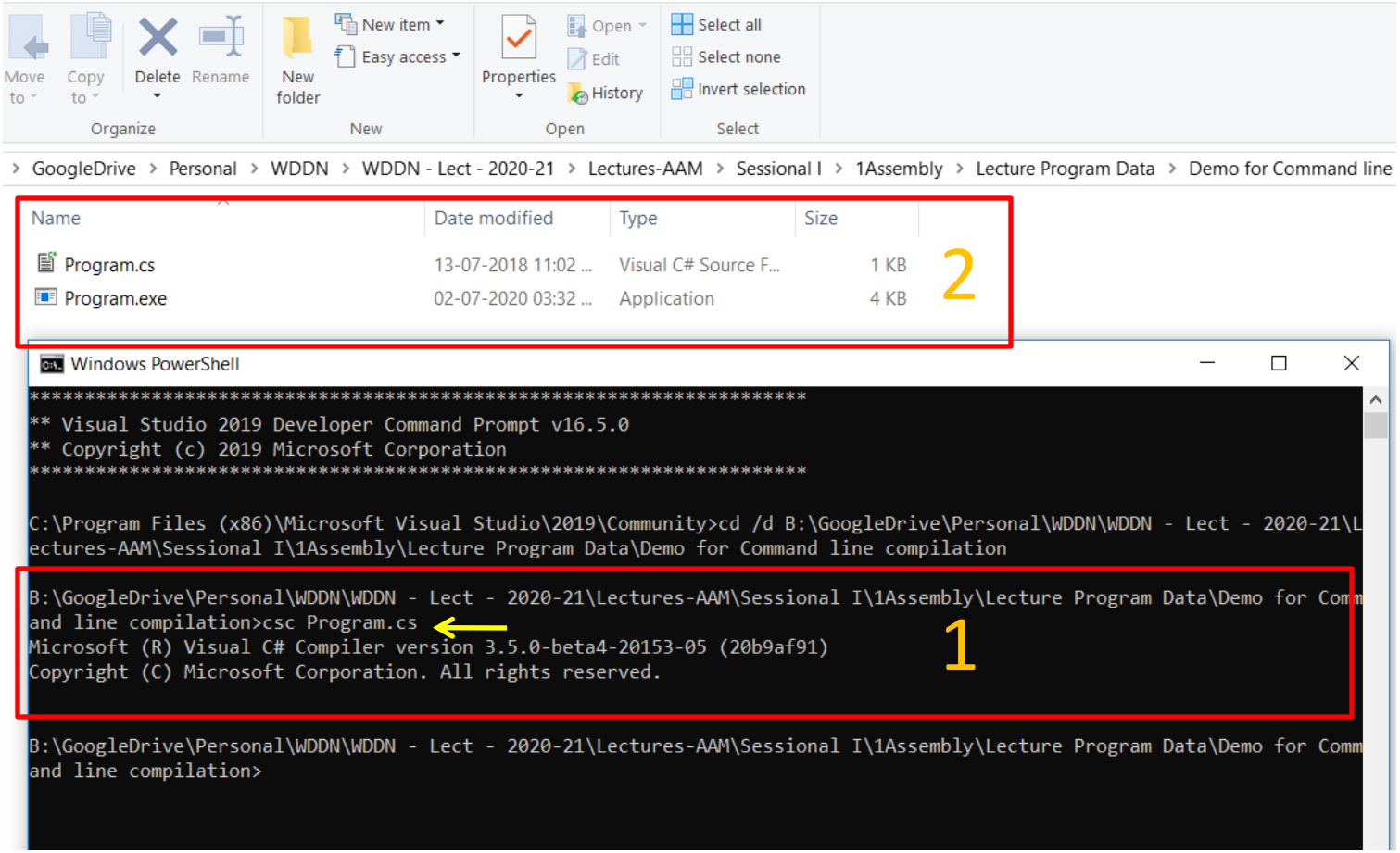
npilation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Program.cs
13-07-2018 11:02 ...
Visual C# Source F...
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Program.exe
02-07-2020 03:32 ...
Application
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Windows PowerShell
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Microsoft (R) Visual C# Compiler version 3.5.0-beta4-20153-05 (20b9af91)
Copyright (C) Microsoft Corporation. All rights reserved.
1
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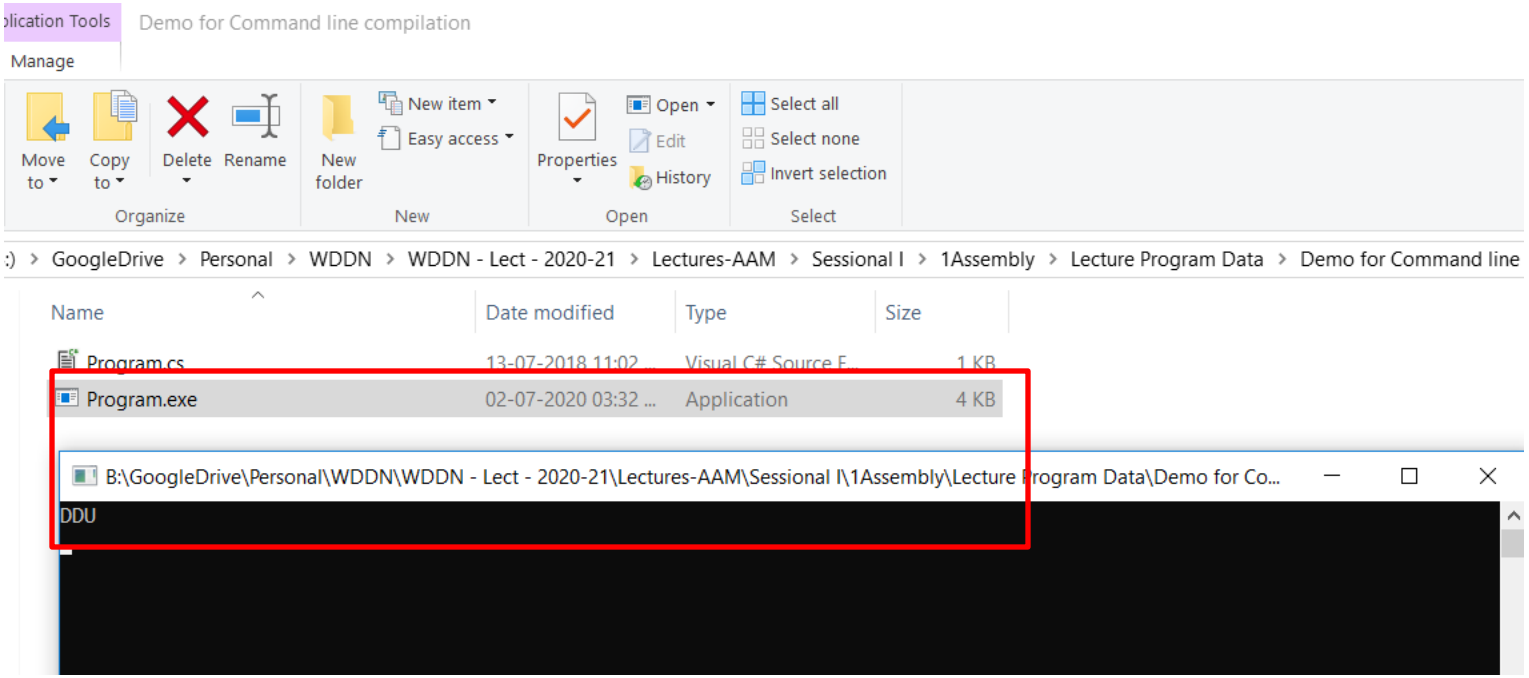
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DDU

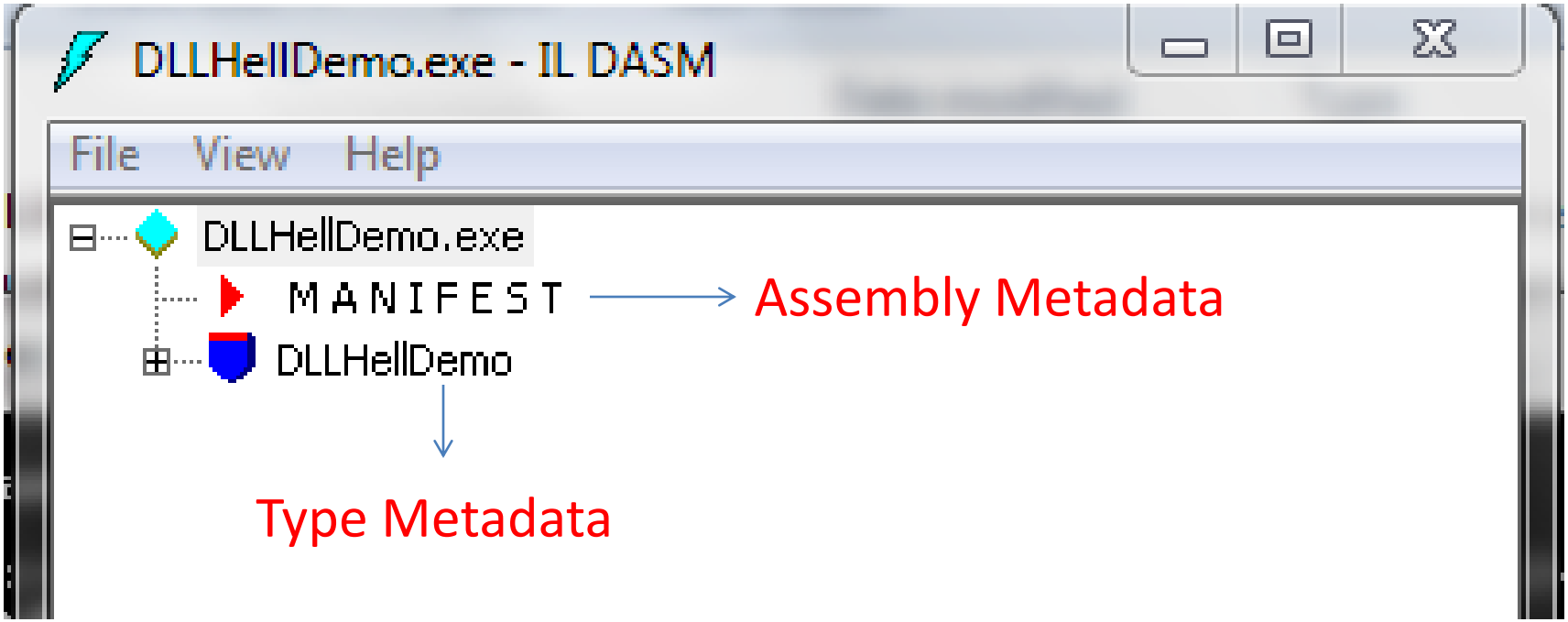
Cont…

- Windows supports three types of applications.
  - To build a console user interface (CUI) application, specify the **/t:exe** switch
  - To build a graphical user interface (GUI) application, specify the **/t:winexe** switch
  - To build a Windows Store app, specify the **/t:appcontainerexe** switch.

- Which component does convert IL to Native code?
- Which code is OS dependent?
- Which code is OS independent?
- Which components are required to be installed in order to execute any module containing managed code and managed data?

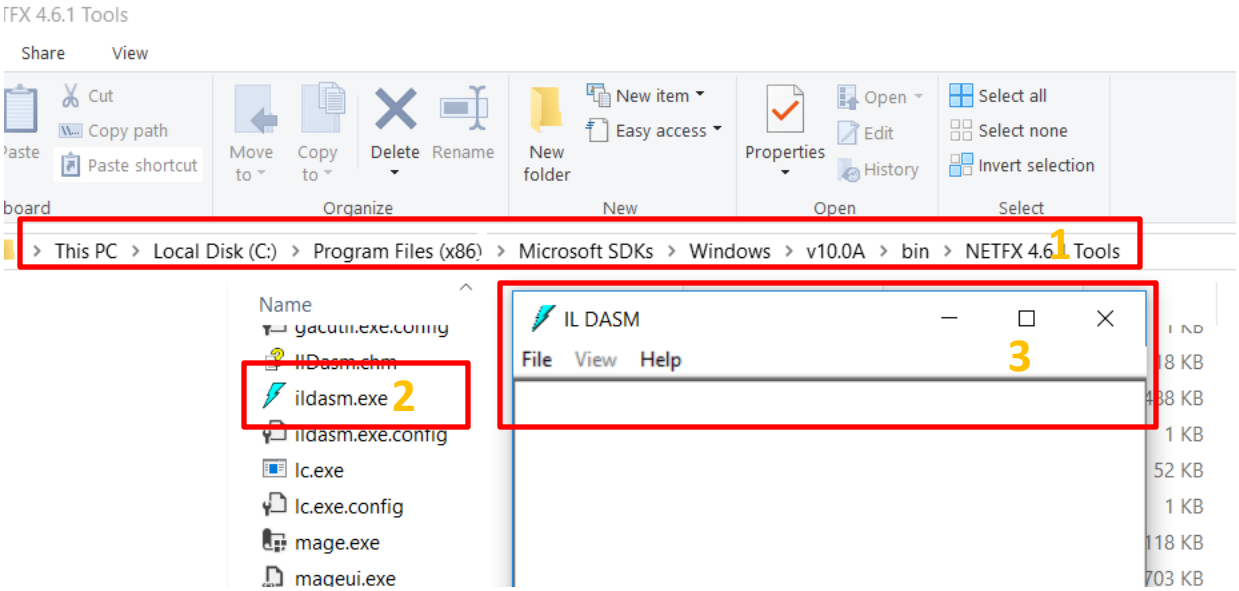
Manifest vs Metadata

- Manifest maintains the information about the assemblies like version, name locale and an optional strong name that uniquely identifying the assembly. This manifest information is used by the CLR.
- Metadata means data about the data. Metadata yields the types available in that assembly, viz. classes, interfaces, enums, structs, etc., and their containing namespaces etc.


DLLHellDemo.exe - IL DASM
File
View
Help
DLLHellDemo.exe
MANIFEST
Assembly Metadata
DLLHellDemo
Type Metadata

ILDASM.EXE

- We use ILDASM (intermediate language disassembler) to peek at the assembly manifest and IL.
- You can also use this tool to export manifest and IL to a text file
- MSIL + namespace + types + …


TFX 4.6.1 Tools
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New
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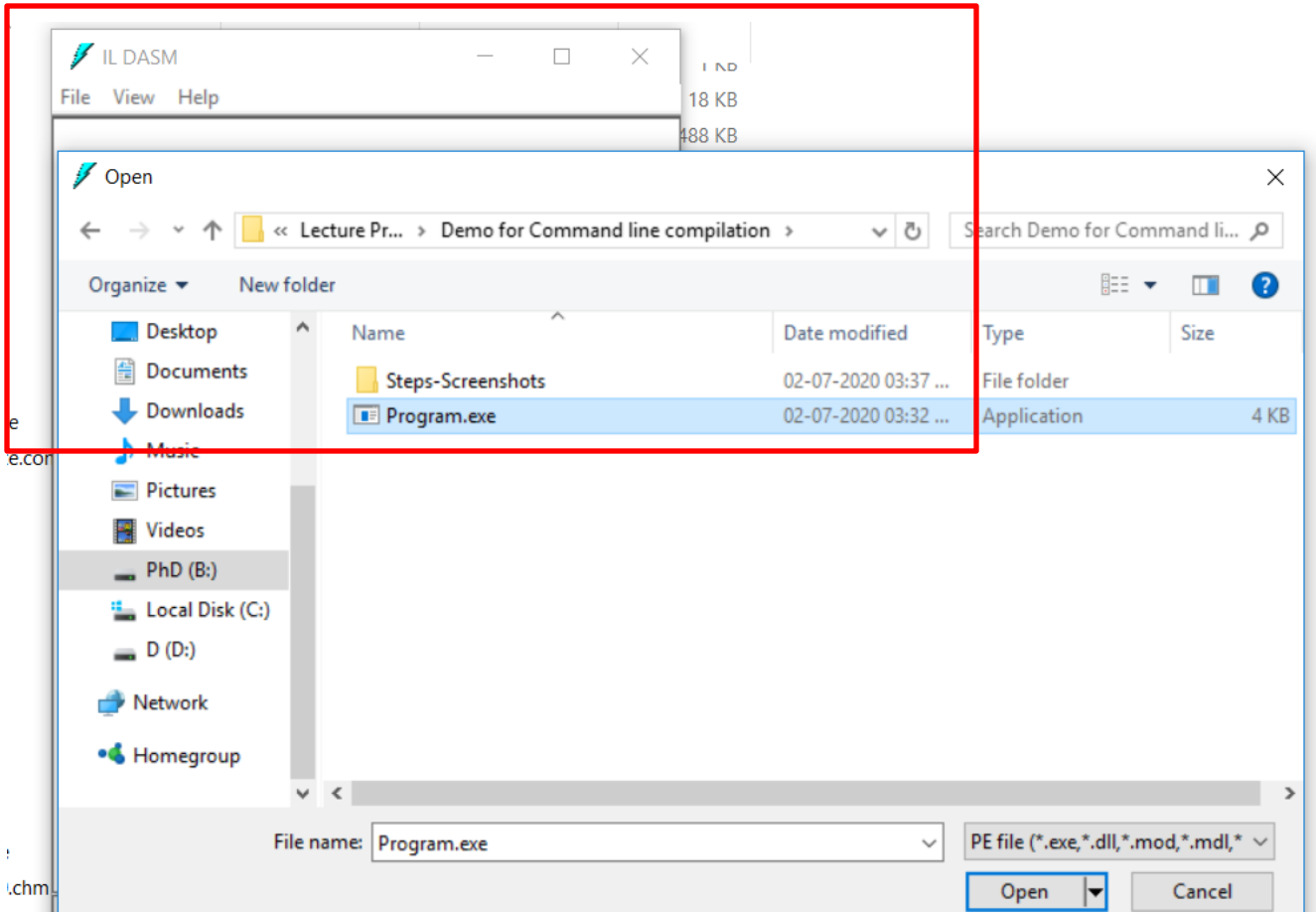
Select
This PC › Local Disk (C:) › Program Files (x86) › Microsoft SDKs › Windows › v10.0A › bin › NETFX 4.6 Tools
1
Name
ildasm.exe
2
ildasm.exe.config
lc.exe
lc.exe.config
mage.exe
mageui.exe
IL DASM
File
View
Help
3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PE file (*.exe,*.dll,*.mod,*.mdl,*
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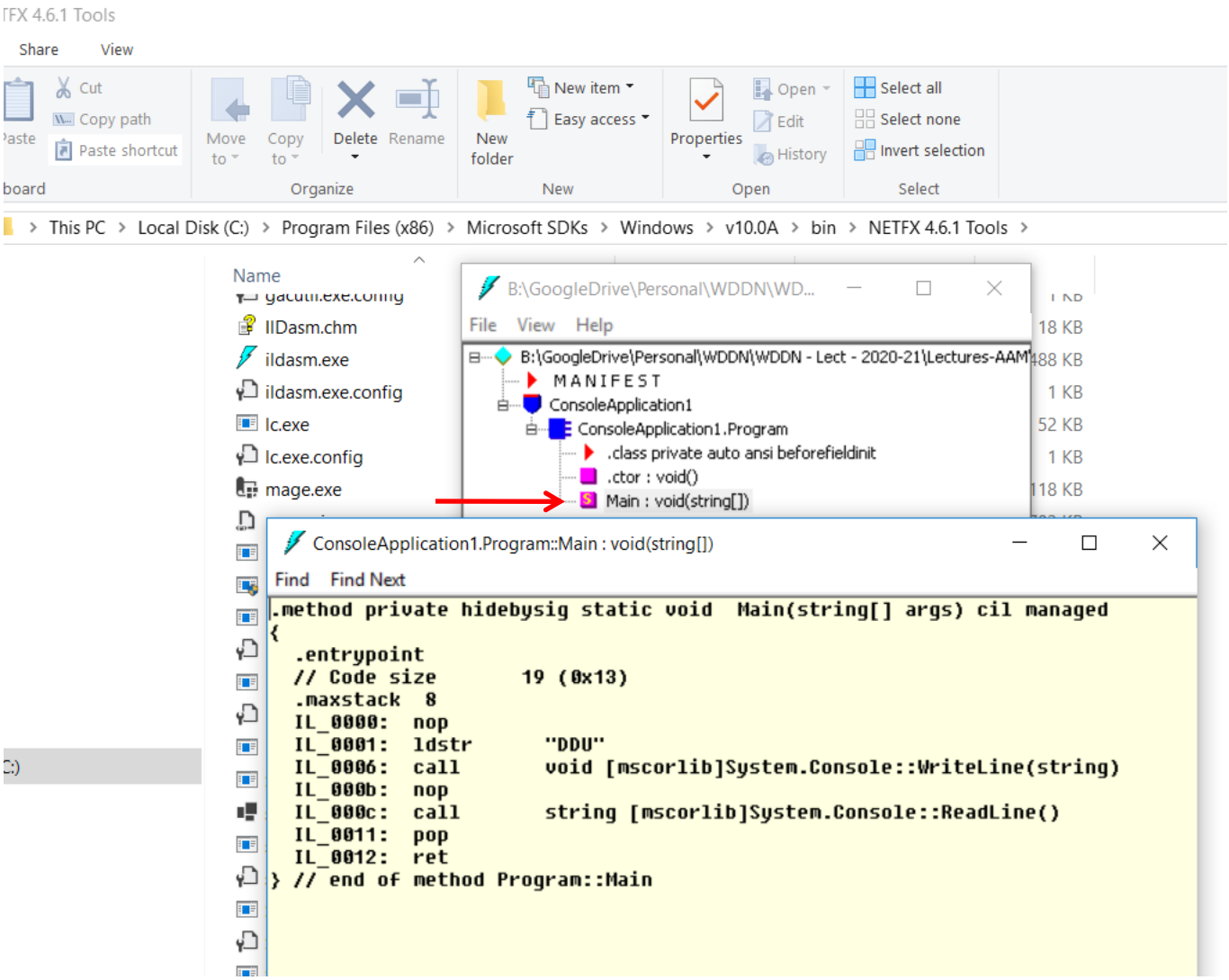
TFX 4.6.1 Tools
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mage.exe
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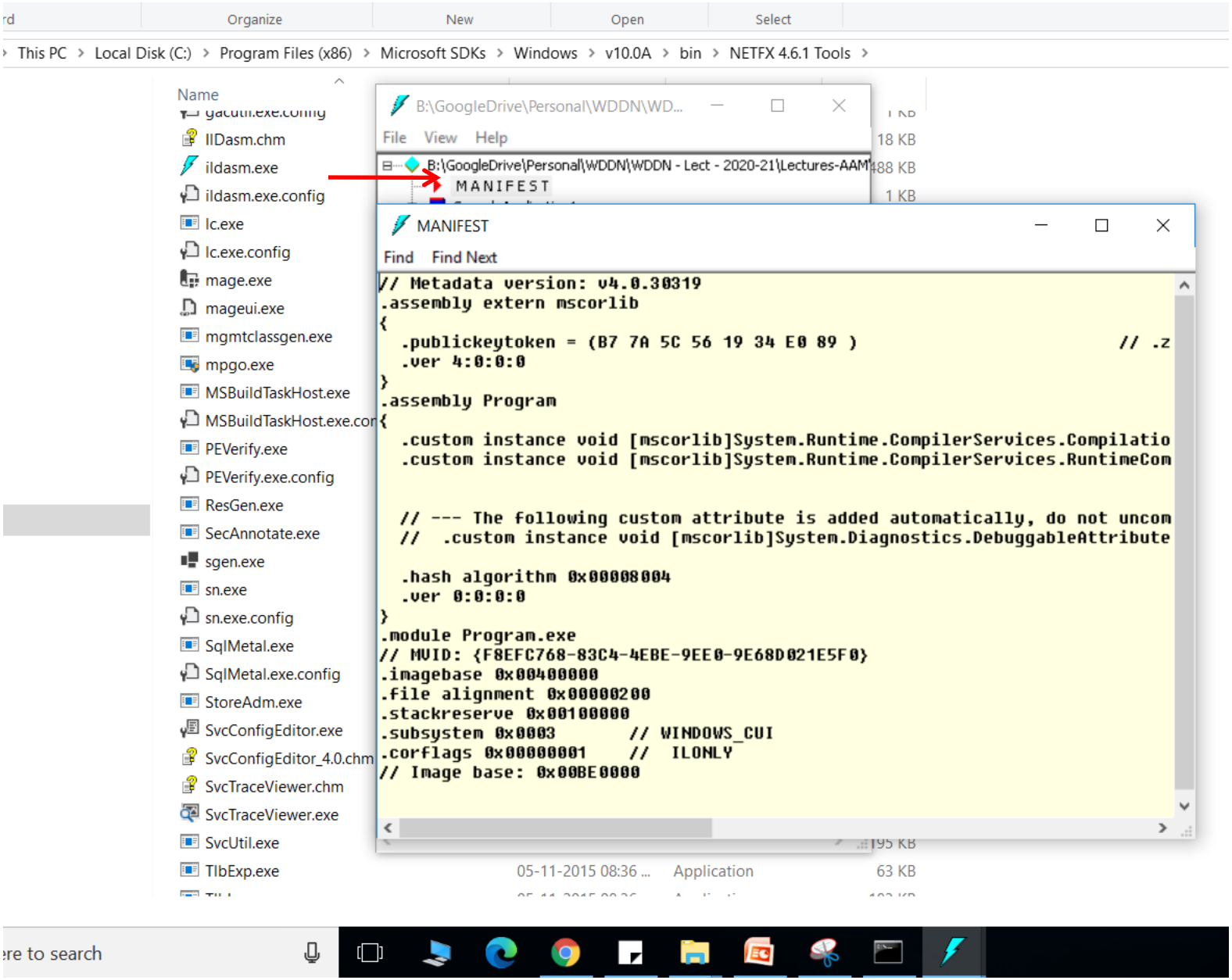
MANIFEST
ConsoleApplication1
ConsoleApplication1.Program
.class private auto ansi beforefieldinit
.ctor : void()
Main : void(string[])
ConsoleApplication1.Program::Main : void(string[])
Find Find Next
.method private hidebysig static void Main(string[] args) cil managed
{
.entrypoint
// Code size 19 (0x13)
.maxstack 8
IL_0000: nop
IL_0001: ldstr "DDU"
IL_0006: call void [mscorlib]System.Console::WriteLine(string)
IL_000b: nop
IL_000c: call string [mscorlib]System.Console::ReadLine()
IL_0011: pop
IL_0012: ret
} // end of method Program::Main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lc.exe
lc.exe.config
mage.exe
mageui.exe
mgmtclassgen.exe
mpgo.exe
MSBuildTaskHost.exe
PEVerify.exe
PEVerify.exe.config
ResGen.exe
SecAnnotate.exe
sgen.exe
sn.exe
sn.exe.config
SqlMetal.exe
SqlMetal.exe.config
StoreAdm.exe
SvcConfigEditor.exe
SvcConfigEditor_4.0.chm
SvcTraceViewer.chm
SvcTraceViewer.exe
SvcUtil.exe
TlbExp.exe
05-11-2015 08:36 ...
Application
63 KB
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File View Help
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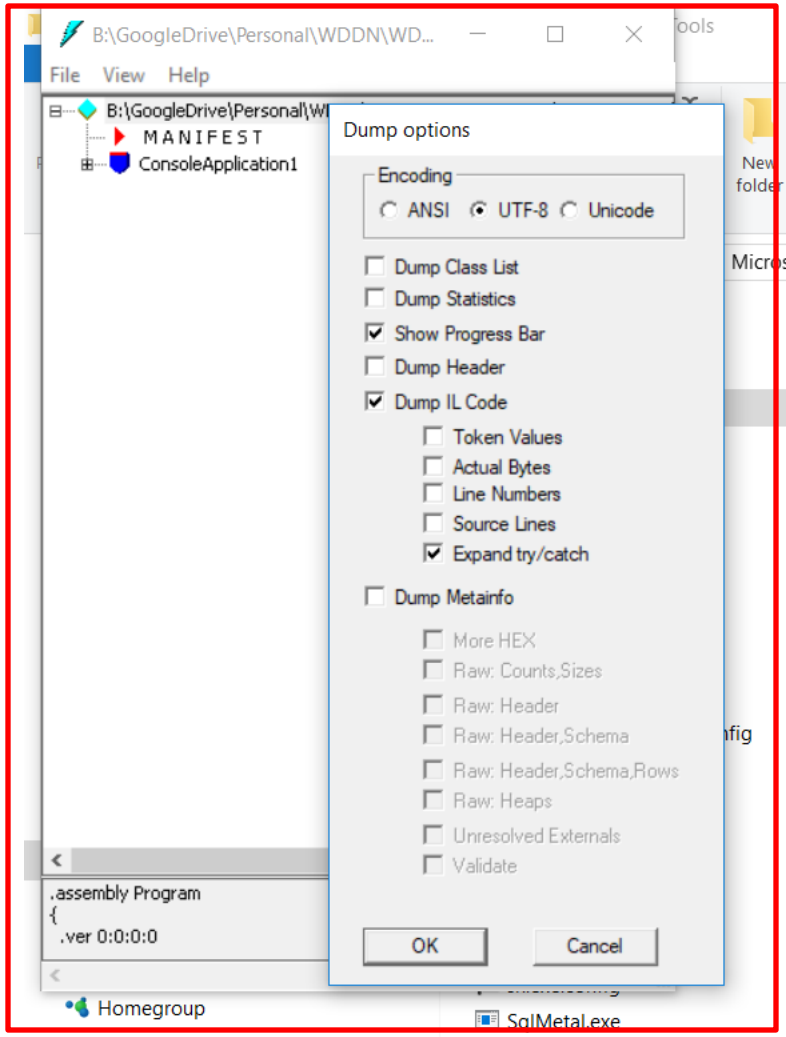
MANIFEST
MANIFEST
Find Find Next
// Metadata version: v4.0.30319
.assembly extern mscorlib
{
.publickeytoken = (B7 7A 5C 56 19 34 E0 89)
.ver 4:0:0:0
}
.assembly Program
{
.custom instance void [mscorlib]System.Runtime.CompilerServices.Compilatio
.custom instance void [mscorlib]System.Runtime.CompilerServices.RuntimeCom
// --- The following custom attribute is added automatically, do not uncom
// .custom instance void [mscorlib]System.Diagnostics.DebuggableAttribute
.hash algorithm 0x00008004
.ver 0:0:0:0
}
.module Program.exe
// MVID: {F8EFC768-83C4-4EBE-9EE0-9E68D021E5F0}
.imagebase 0x00400000
.file alignment 0x00000200
.stackreserve 0x00100000
.subsystem 0x0003 // WINDOWS_CUI
.corflags 0x00000001 // ILONLY
// Image base: 0x00BE0000
re to search


B:\GoogleDrive\Personal\WDDN\WD...
File View Help
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MANIFEST
ConsoleApplication1
.assembly Program
{
.ver 0:0:0:0
Homegroup
Dump options
Encoding
ANSI UTF-8 Unicode
Dump Class List
Dump Statistics
Show Progress Bar
Dump Header
Dump IL Code
Token Values
Actual Bytes
Line Numbers
Source Lines
Expand try/catch
Dump Metainfo
More HEX
Raw: Counts,Sizes
Raw: Header
Raw: Header,Schema
Raw: Header,Schema,Rows
Raw: Heaps
Unresolved Externals
Validate
OK
Cancel

New item
Easy access
New folder
New
Properties
Open
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Select all
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Date modified
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01-10-2015 02:15 ... Compiled HTML H... 18 KB
05-11-2015 08:36 ... Application 488 KB
05-11-2015 06:17 ... XML Configuration... 1 KB
05-11-2015 08:36 ... Application 52 KB
01-10-2015 02:21 ... XML Configuration... 1 KB
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05-11-2015 08:36 ... Application 703 KB
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05-11-2015 08:36 ... Application 238 KB
05-11-2015 08:36 ... Application 163 KB
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05-11-2015 08:36 ... Application 215 KB
05-11-2015 06:17 ... XML Configuration... 1 KB
05-11-2015 08:36 ... Application 90 KB
05-11-2015 08:36 ... Application 1,180 KB
05-11-2015 08:36 ... Application 67 KB
05-11-2015 10:25 ... Application 266 KB
05-11-2015 06:17 ... XML Configuration... 1 KB
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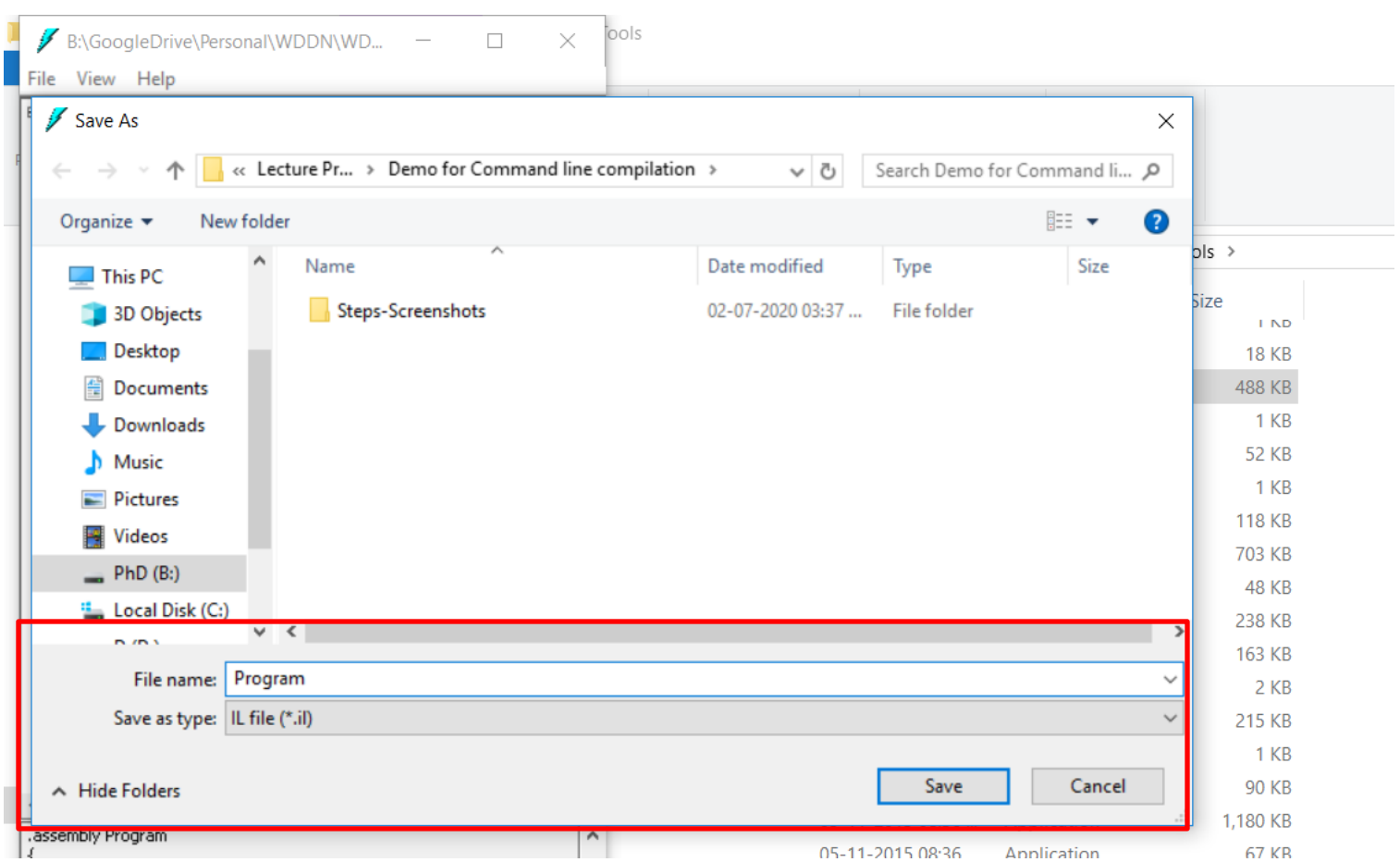
SqlMetal.exe



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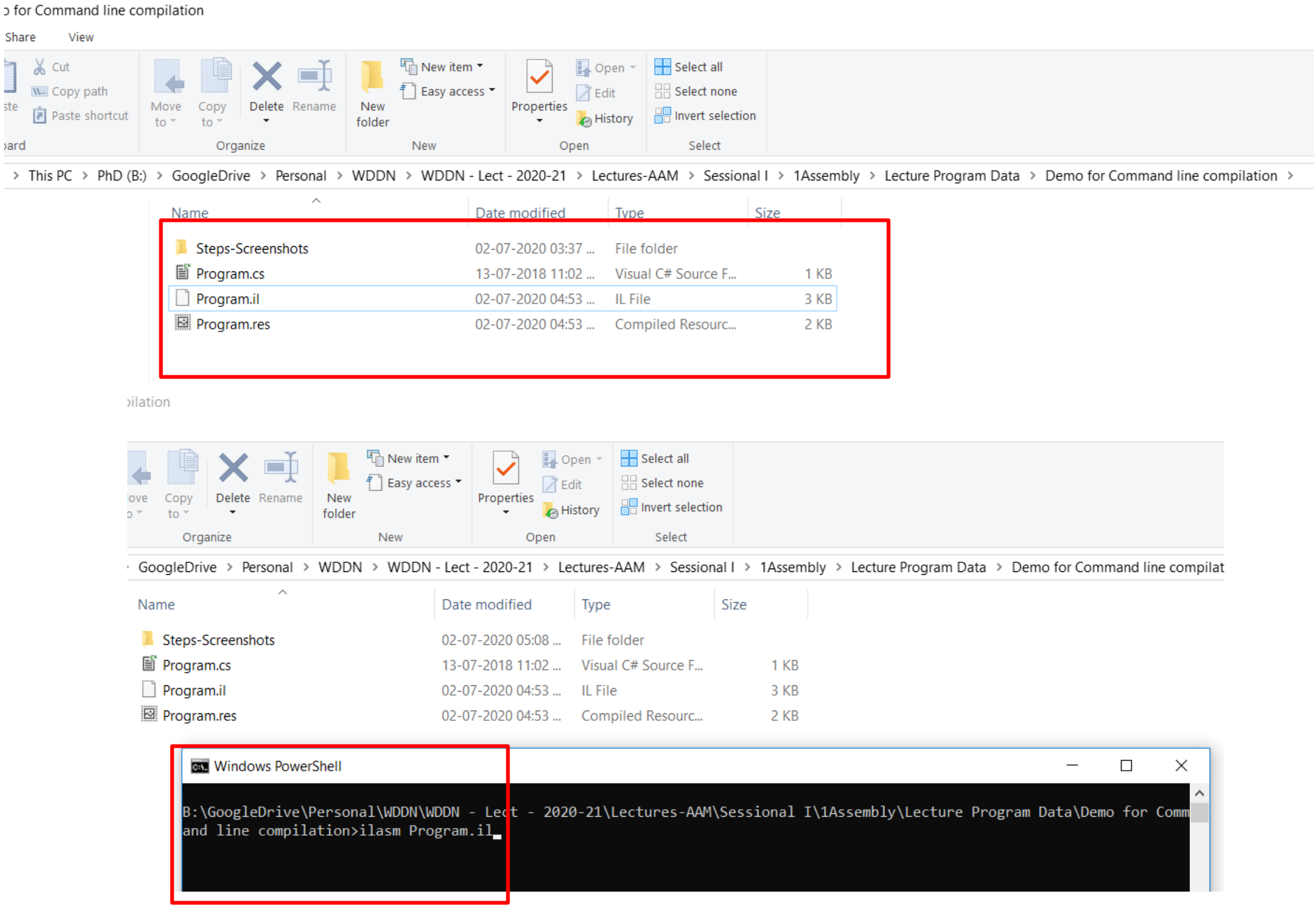
Name	Date modified	Type	Size
Steps-Screenshots	02-07-2020 03:37 ...	File folder	
Program.cs	13-07-2018 11:02 ...	Visual C# Source F...	1 KB
Program.exe	02-07-2020 03:32 ...	Application	4 KB
Program.il	02-07-2020 04:53 ...	IL File	3 KB
Program.res	02-07-2020 04:53 ...	Compiled Resourc...	2 KB

ILASM.EXE

- We use ILASM.EXE to reconstruct an assembly from a text file that contains manifest and IL


o for Command line compilation
Share
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Select all
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Steps-Screenshots
02-07-2020 03:37 ...
File folder
Program.cs
13-07-2018 11:02 ...
Visual C# Source F...
1 KB
Program.il
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IL File
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Program.res
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and line compilation>ilasm Program.il

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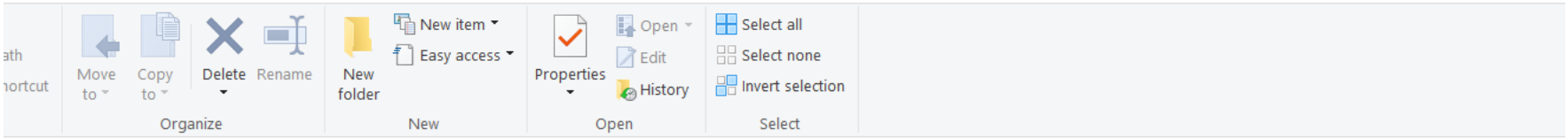

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Name	Date modified	Type	Size
Steps-Screenshots	02-07-2020 03:37 ...	File folder	
Program.cs	13-07-2018 11:02 ...	Visual C# Source F...	1 KB
Program.exe	02-07-2020 05:06 ...	Application	2 KB
Program.il	02-07-2020 04:53 ...	IL File	3 KB
Program.res	02-07-2020 04:53 ...	Compiled Resourc...	2 KB

Multifile Assemblies

- With command line compilers, you can split an assembly into multiple parts - where a single assembly's Manifest contains the information required to find information that's part of the assembly, but stored in a separate file.
- e.g., you can keep a resource image (ie: a .bmp) that is a large resource in its own file, so that it isn't necessary to load it just to open the assembly.

Reasons to use MF Assemblies

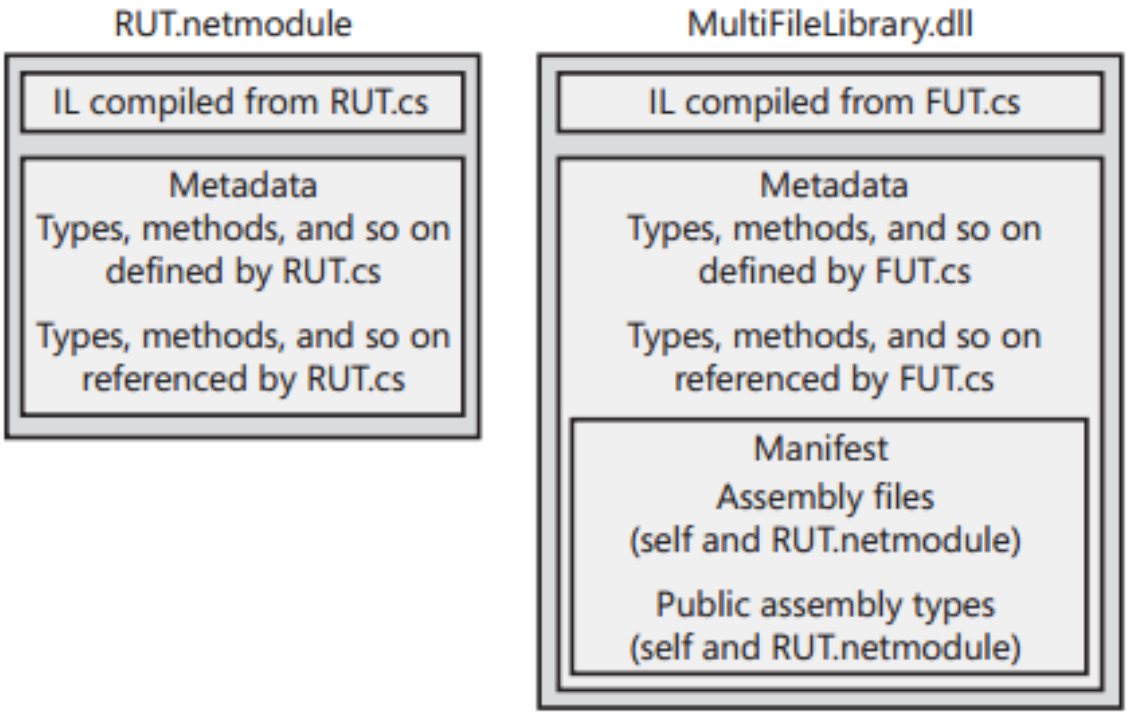
- You can partition your types among separate files, allowing for files to be incrementally downloaded
- You can add resource or data files to your assembly.
- You can create assemblies consisting of types implemented in different programming languages.

Creating MF Assemblies

- There are many ways to add a module to an assembly.
  - If you're using the C# compiler to build a PE file with a manifest, you can use the **/addmodule** switch.

Example

- csc /t:module RUT.cs
- csc /out:MultiFileLibrary.dll /t:library /addmodule:RUT.netmodule FUT.cs



Continue…

- Any client code that consumes the MultiFileLibrary.dll assembly's types must be built using the

  /r*[reference]:* MultiFileLibrary.dll compiler switch.

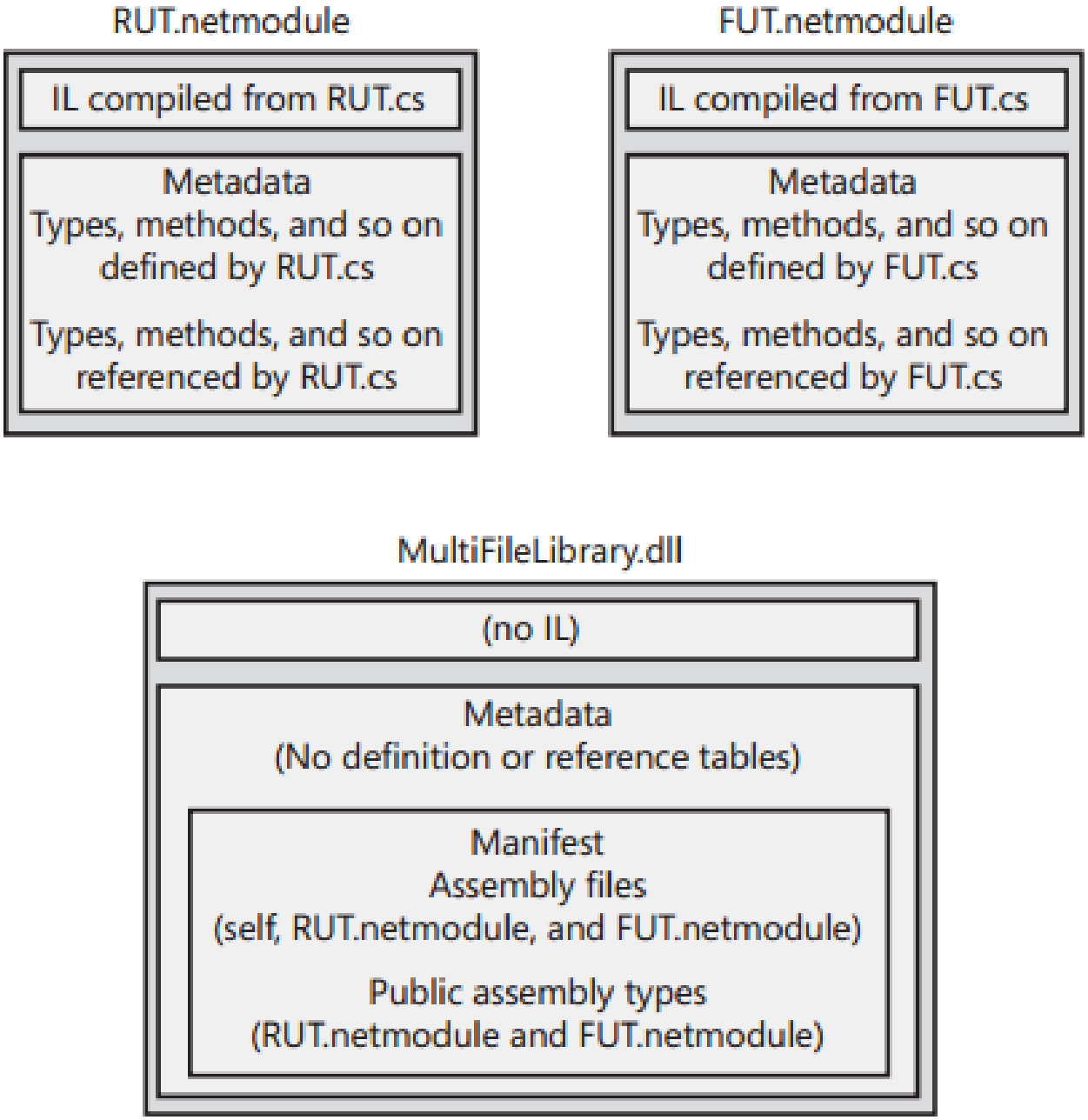
- If you were to delete the RUT.netmodule file, the C# compiler would produce the error.

Assembly Linker Utility (al.exe)

- The Assembly Linker is useful if you want to create an assembly consisting of modules built from different compilers.
- You can also use AL.exe to build resource-only assemblies, called satellite assemblies, which are typically used for localization purposes.

Example

- csc /t:module RUT.cs
- csc /t:module FUT.cs
- al /out: MultiFileLibrary.dll
  /t:library FUT.netmodule RUT.netmodule


RUT.netmodule
IL compiled from RUT.cs
Metadata
Types, methods, and so on defined by RUT.cs
Types, methods, and so on referenced by RUT.cs
FUT.netmodule
IL compiled from FUT.cs
Metadata
Types, methods, and so on defined by FUT.cs
Types, methods, and so on referenced by FUT.cs
MultiFileLibrary.dll
(no IL)
Metadata
(No definition or reference tables)
Manifest
Assembly files
(self, RUT.netmodule, and FUT.netmodule)
Public assembly types
(RUT.netmodule and FUT.netmodule)

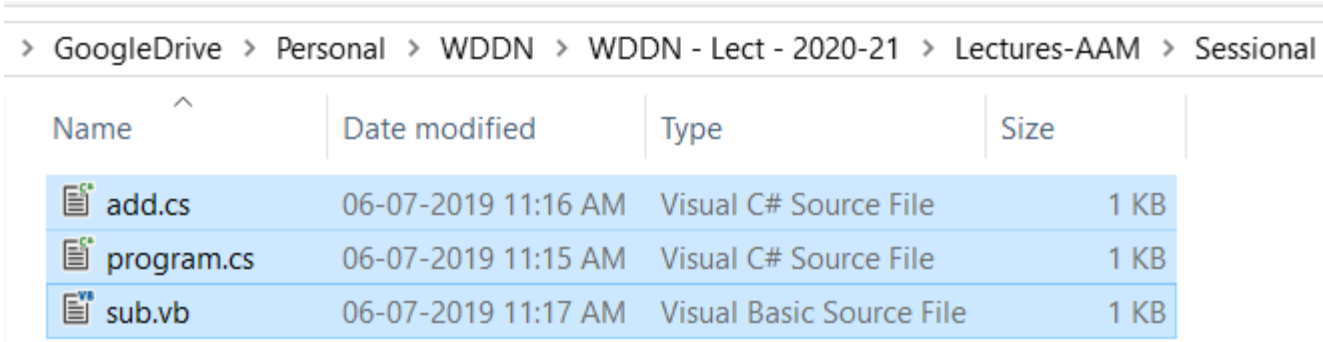
Multifile Assembly - Demo

sub.vb | add.cs | program.cs

```
1  namespace Calc
2  {
3      public class Add
4      {
5          public static int Sum(int a, int b)
6          {
7              return a+b;
8          }
9      }
10 }
```

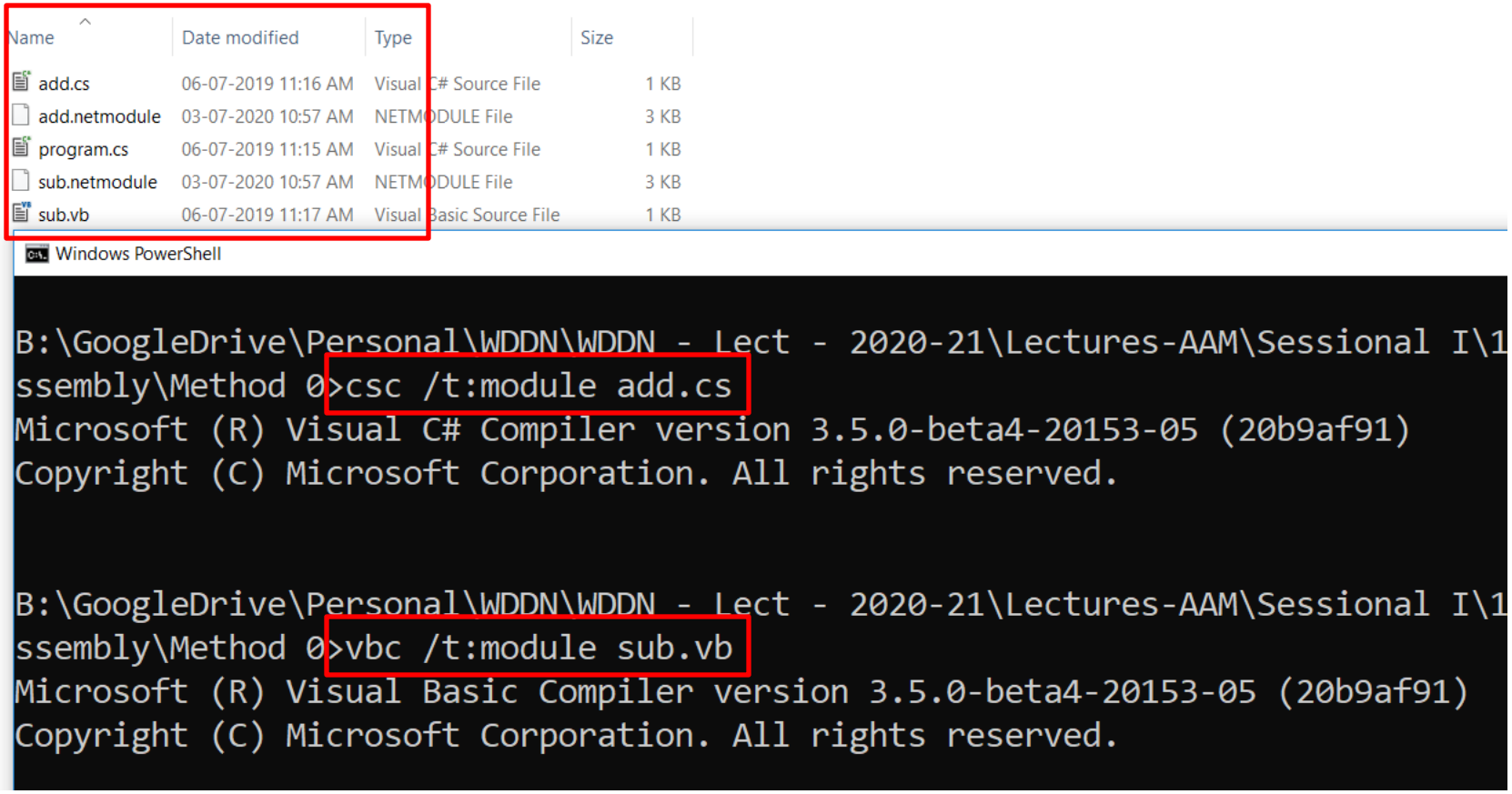
sub.vb | add.cs | program.cs

```
1  Namespace Calc
2      Public Class [Sub]
3          Public Shared Function [Sub]
4          (ByVal a As Integer, ByVal b As Integer) As Integer
5              Return a - b
6          End Function
7      End Class
8  End Namespace
```



sub.vb | add.cs | program.cs

```
1  using System;
2  using Calc;
3
4  namespace Test
5  {
6      public class MyProgram
7      {
8          public static void Main(string[] args)
9          {
10             int sum = Add.Sum(1,2);
11             int sub = Sub.Sub(1,2);
12
13             Console.WriteLine("Sum: {0}, Sub: {1}", sum, sub);
14             Console.ReadLine();
15         }
16     }
17 }
```


Name
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add.cs
06-07-2019 11:16 AM
Visual C# Source File
1 KB
add.netmodule
03-07-2020 10:57 AM
NETMODULE File
3 KB
program.cs
06-07-2019 11:15 AM
Visual C# Source File
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sub.netmodule
03-07-2020 10:57 AM
NETMODULE File
3 KB
sub.vb
06-07-2019 11:17 AM
Visual Basic Source File
1 KB
Windows PowerShell
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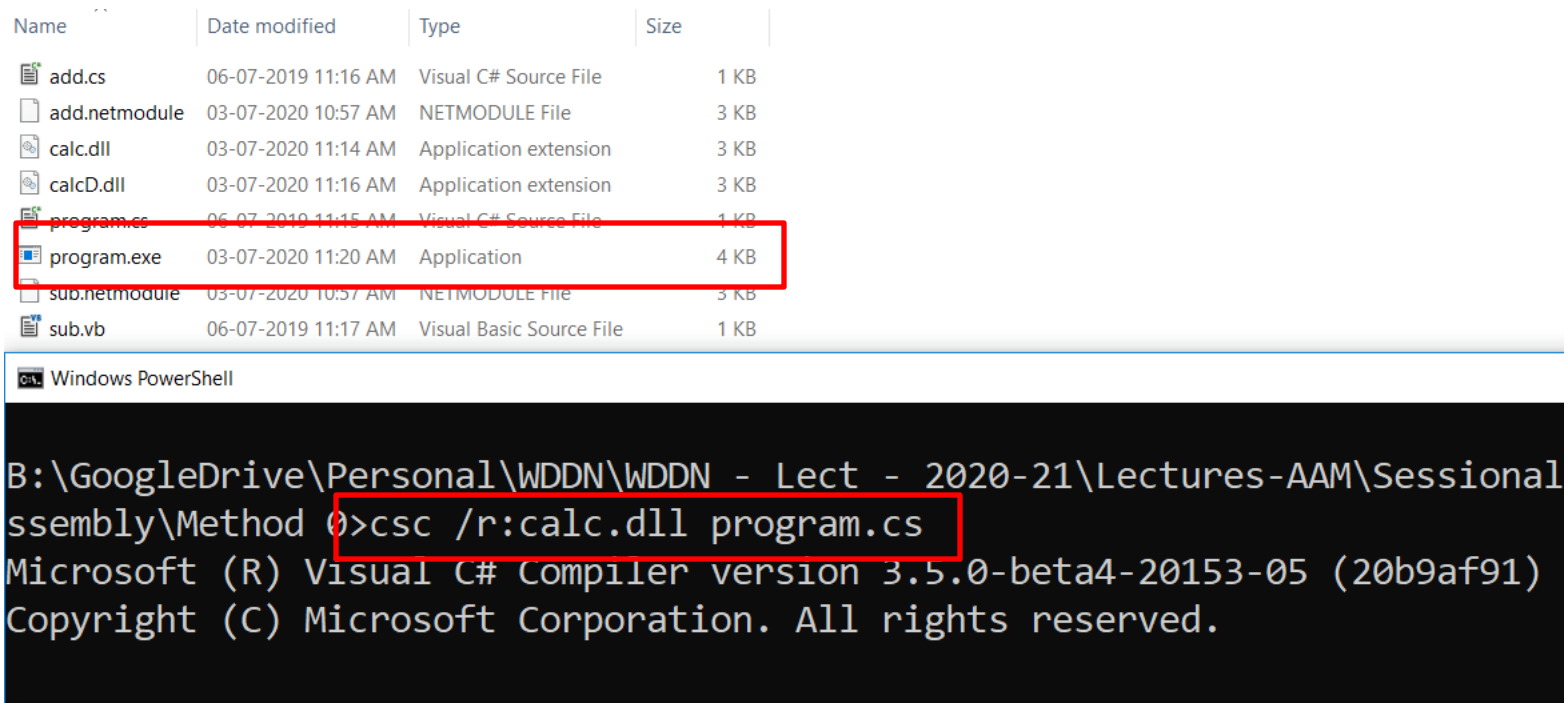
ssembly\Method 0>csc /t:module add.cs
Microsoft (R) Visual C# Compiler version 3.5.0-beta4-20153-05 (20b9af91)
Copyright (C) Microsoft Corporation. All rights reserved.
B:\GoogleDrive\Personal\WDDN\WDDN - Lect - 2020-21\Lectures-AAM\Sessional I\1
ssembly\Method 0>vbc /t:module sub.vb
Microsoft (R) Visual Basic Compiler version 3.5.0-beta4-20153-05 (20b9af91)
Copyright (C) Microsoft Corporation. All rights reserved.

Name	Date modified	Type	Size
add.cs	06-07-2019 11:16 AM	Visual C# Source File	1 KB
add.netmodule	03-07-2020 10:57 AM	NETMODULE File	3 KB
calc.dll	03-07-2020 11:14 AM	Application extension	3 KB
program.cs	06-07-2019 11:15 AM	Visual C# Source File	1 KB
sub.netmodule	03-07-2020 10:57 AM	NETMODULE File	3 KB
sub.vb	06-07-2019 11:17 AM	Visual Basic Source File	1 KB

Windows PowerShell

```
B:\GoogleDrive\Personal\WDDN\WDDN - Lect - 2020-21\Lectures-AAM\Sessional I
ssembly\Method 0>al /t:library /out:calc.dll add.netmodule sub.netmodule
Microsoft (R) Assembly Linker version 14.8.3928.0
Copyright (C) Microsoft Corporation. All rights reserved.
```


```
>csc /t:library /out:calcD.dll /addmodule:add.netmodule /addmodule:sub.netmodule
```


Name
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Visual C# Source File
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calc.dll
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03-07-2020 10:57 AM
NETMODULE File
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sub.vb
06-07-2019 11:17 AM
Visual Basic Source File
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Windows PowerShell
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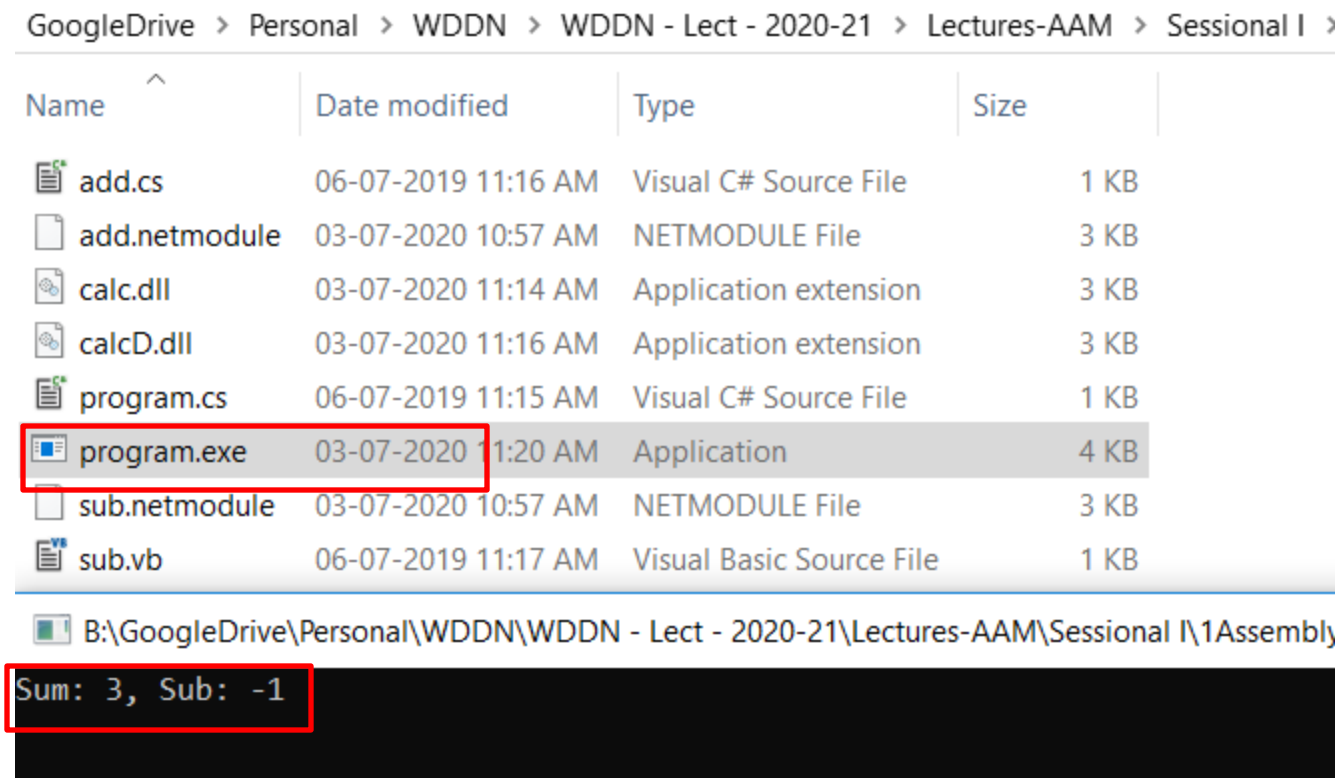
ssembly\Method 0>csc /r:calc.dll program.cs
Microsoft (R) Visual C# Compiler version 3.5.0-beta4-20153-05 (20b9af91)
Copyright (C) Microsoft Corporation. All rights reserved.



Please, try other methods for creating multifile assemblies, as given in PDF.
Inspect, .dll/.netmodule with ILDASM.exe, it will give you more clarification.

Assembly Version Resource Info

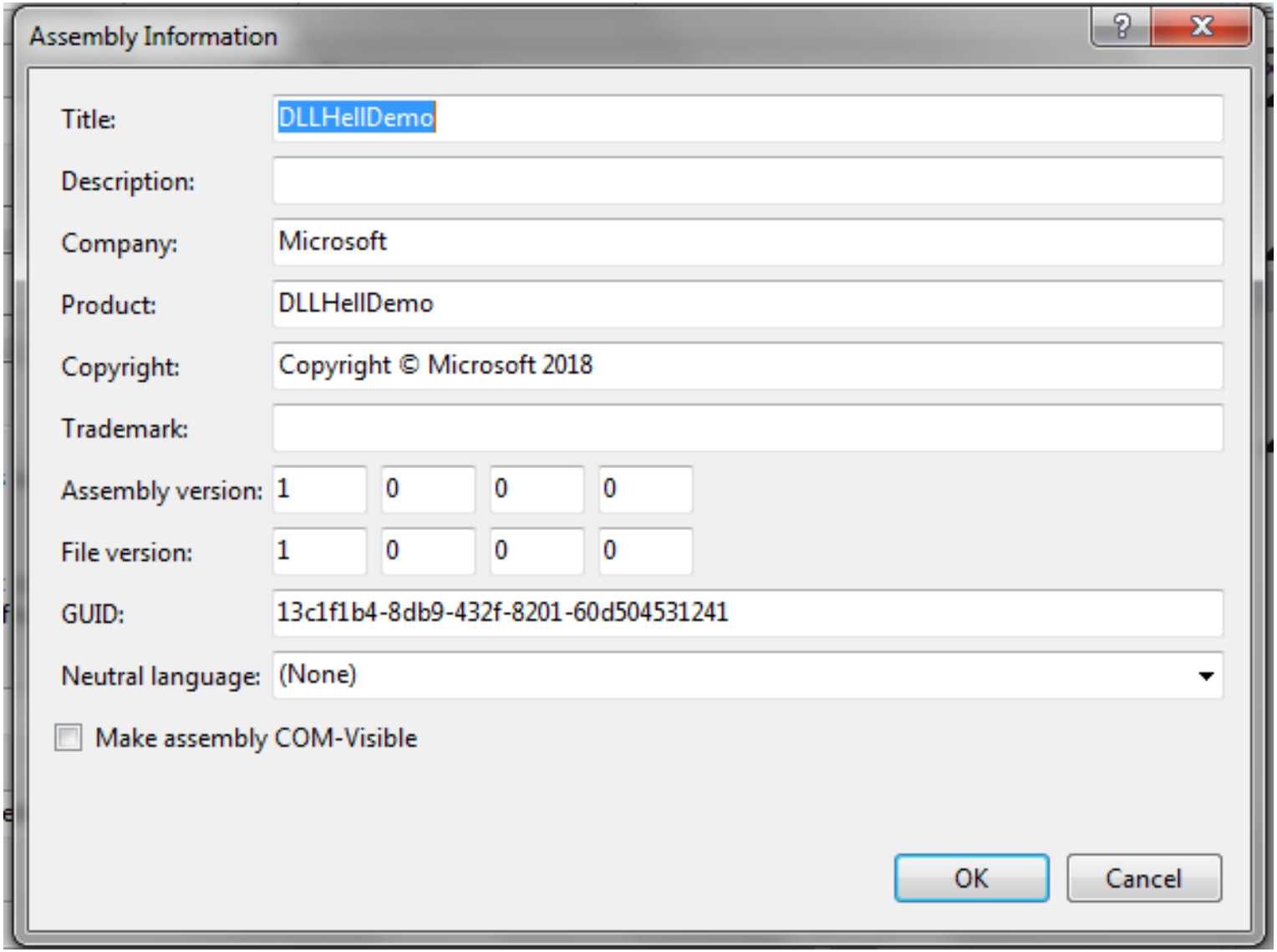
- When AL.exe or CSC.exe produces a PE file assembly, it also embeds into the PE file a standard Win32 version resource.
  - Users can examine this resource by viewing the file's properties.
- Application code can also acquire and examine this information at run time by calling System.Diagnostics.FileVersionInfo's static GetVersionInfo method.

Continue…

- When building an assembly, you should set the version resource fields by using custom attributes that you apply at the assembly level in your source code.

- Version can be set in source code or using assembly linking (al.exe) process.
  - al /version:0.0.0.0

Assembly Info in C#



Assembly Version System

	Major Number	Minor Number	Build Number	Revision Number
Example:	2	5	719	2

- What is the difference between .netmodule and .dll file?
- When should we promote usage of .netmodule file over .dll file?
- When should we use multifile assembly?

Culture

- Like version numbers, assemblies also have a culture as part of their identity.
- Cultures are identified via a string that contains a primary and a secondary tag

Primary Tag	Secondary Tag	Culture
De	(none)	German
De	AT	Austrian German
De	CH	Swiss German
En	(none)	English
En	GB	British English
En	US	U.S. English

Continue…

- Culture neutral assembly + Satellite assembly
- You should create one satellite assembly for each culture you intend to support.
- You'll usually use the AL.exe tool to build a satellite assembly. You won't use a compiler: Why?

```
// Set assembly's culture to Swiss German
[assembly:AssemblyCulture("de-CH")]
```

```
>al /t:library /embed:resource /culture:de /out:MyApp.dll
```

al /t:lib /embed:gujarati.png /c:gu-IN /out:guj.dll

Two Kinds of Assemblies

- Weakly (*Not strongly*) named assemblies
- Strongly named assemblies.
- Both are structurally identical
  - PE file format
  - PE32(+) header
  - CLR header
  - Metadata
  - Manifest
  - IL

Difference

- A strongly named assembly is signed with a publisher's public/private key pair that uniquely identifies the assembly's publisher.
- This key pair allows the assembly to be uniquely identified, secured, and versioned, and it allows the assembly to be deployed anywhere on the user's machine or even on the Internet.

Two kinds of deployment

Kind of Assembly	Can Be Privately Deployed	Can Be Globally Deployed
Weakly named	Yes	No
Strongly named	Yes	Yes

Giving an assembly strong name

- Why?
- Is file name enough for differentiating assemblies?
- Strongly named assembly
  - Some mechanism that helps uniquely identify an assembly

Attributes of Strongly named assembly

- a file name (w/o extension)
- a version number
- a culture identity
- a public key
  - public key token

Assembly display name

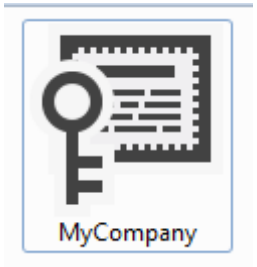
assembly identity strings

```
"MyTypes, Version=1.0.8123.0, Culture=neutral, PublicKeyToken=b77a5c561934e089"

"MyTypes, Version=1.0.8123.0, Culture="en-US", PublicKeyToken=b77a5c561934e089"

"MyTypes, Version=2.0.1234.0, Culture=neutral, PublicKeyToken=b77a5c561934e089"

"MyTypes, Version=1.0.8123.0, Culture=neutral, PublicKeyToken=b03f5f7f11d50a3a"
```

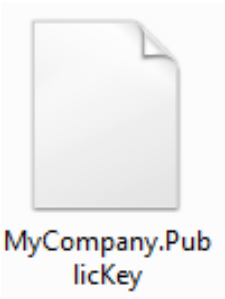
Create strongly named assembly

- Strong Name utility, SN.exe

  SN –k MyCompany.snk



  SN –p MyCompany.snk MyCompany.PublicKey sha256



Continue…

SN –tp MyCompany.PublicKey

```
Microsoft (R) .NET Framework Strong Name Utility  Version 4.0.30319.0
Copyright (c) Microsoft Corporation.  All rights reserved.

Public key (hash algorithm: sha256):
002400000c800000940000000602000000240000525341310004000001000100 5bfb9e986c0247
58b4b2052fb8ce19370813341862895 30d18d6e56fb5db7118cf981e549d7c05c6788679435647
b4ac435ccc33f2c3103bf43cc5202d6a03d4cf1c328bd3f4de7256943725ed393a9fa4a3a633a9
3a6ad544fceaf98f6a45f613ae8f130beeceeff4853e15964935c9cc1a9f544d7117212a07cb3
16fa24a2

Public key token is 7f7f6c090563eda9
```

To display private key? ☺

Continue…

csc /keyfile:MyCompany.snk Program.cs

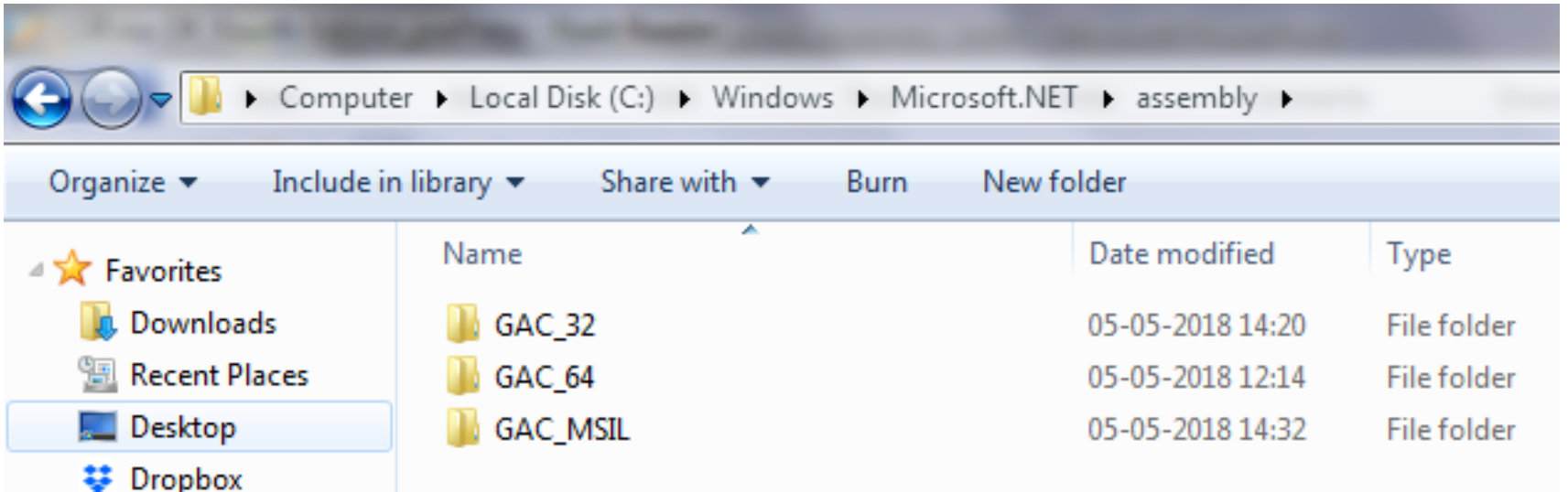
How do we create key and sign to project in visual studio?

Public key and Public key token

Does CLR use public key token?

The Global Assembly Cache

- An assembly can be accessed by multiple applications.
- Exact location of GAC is implementation details.
- GAC directory is structured.



GACUtil.exe

- Only strongly named assembly can be placed into GAC
- Need administrative rights
- /i to install
- /u to uninstall

Registering Assembly

- Two companies each produce an OurLibrary assembly consisting of one file: OurLibrary.dll.
- Obviously, both of these files can’t go in the same directory
- When you install an assembly into the GAC, dedicated subdirectories are created under the %SystemRoot%\Microsoft.NET\Assembly directory, and the assembly files are copied into one of these subdirectories.

Steps

sn –k Company1.snk

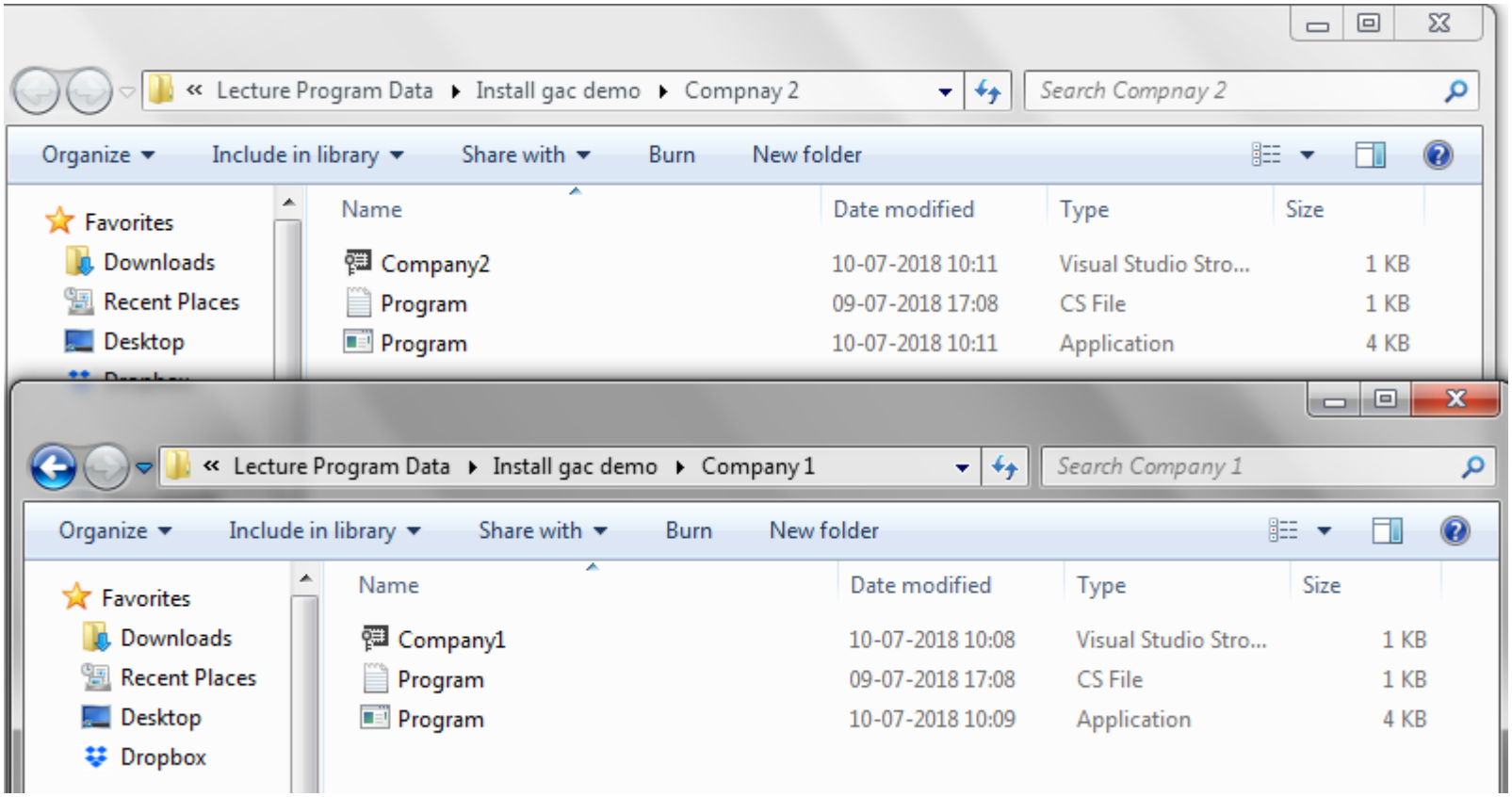
csc /keyfile:Company1.snk Program.cs

gacutil /i Program.exe

sn –k Company2.snk

csc /keyfile:Company2.snk Program.cs

gacutil -i Program.exe


« Lecture Program Data ▸ Install gac demo ▸ Compnay 2
Search Compnay 2
Organize
Include in library
Share with
Burn
New folder
Favorites
Downloads
Recent Places
Desktop
Name
Date modified
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Company2
10-07-2018 10:11
Visual Studio Stro...
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Application
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New folder
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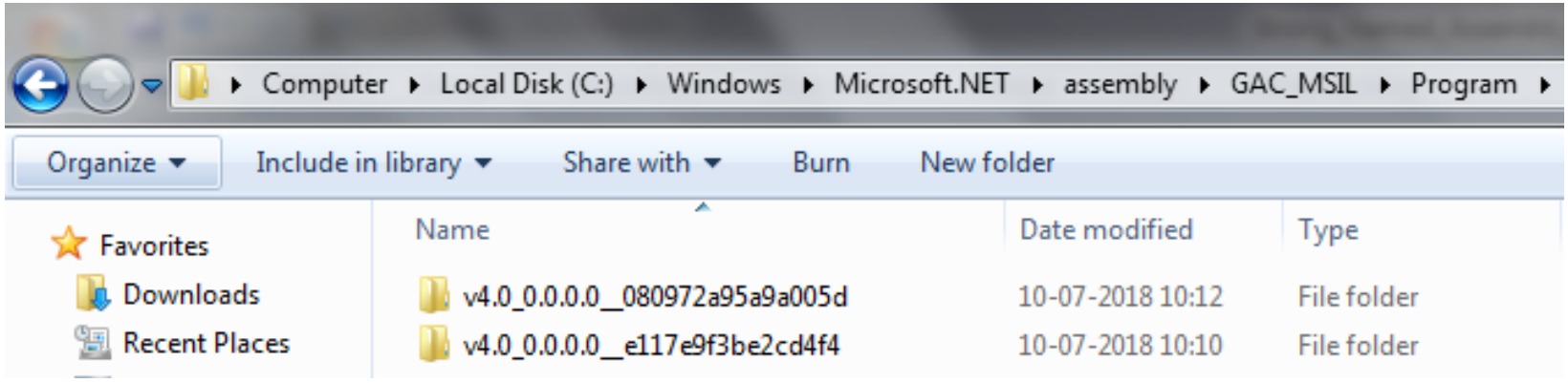
Computer ▸ Local Disk (C:) ▸ Windows ▸ Microsoft.NET ▸ assembly ▸ GAC_MSIL ▸ Program ▸
Organize
Include in library
Share with
Burn
New folder
Favorites
Downloads
Recent Places
Name
Date modified
Type
v4.0_0.0.0.0__080972a95a9a005d
10-07-2018 10:12
File folder
v4.0_0.0.0.0__e117e9f3be2cd4f4
10-07-2018 10:10
File folder

When you build an assembly, the assembly will have references to other strongly named assemblies.

True

False

Building source Program

- How does csc.exe find assemblies?

- When you install the .NET Framework, two copies of Microsoft's assembly files are actually installed.