Practical Reflection

Using reflection in .NET while still keeping your sanity

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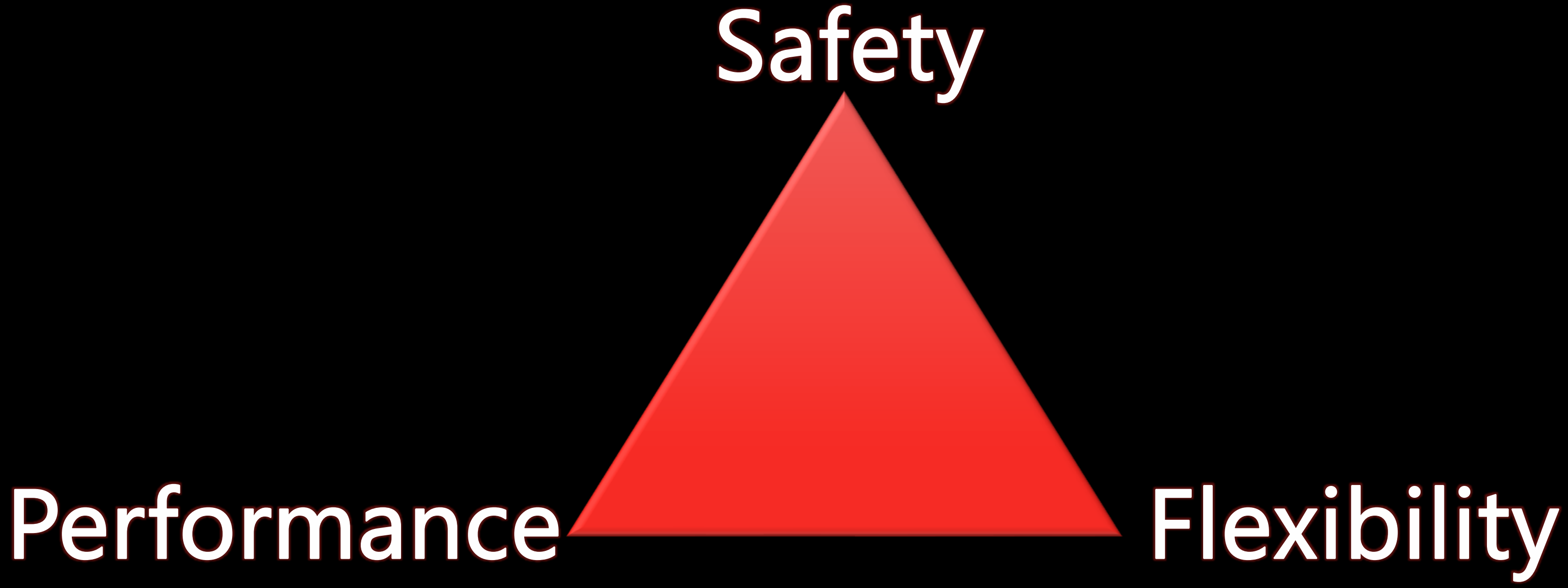
github.com/jeremybytes/sdd-2024

Just for Experts?

Goal

Explore the Practical Parts of Reflection



Safety

Performance

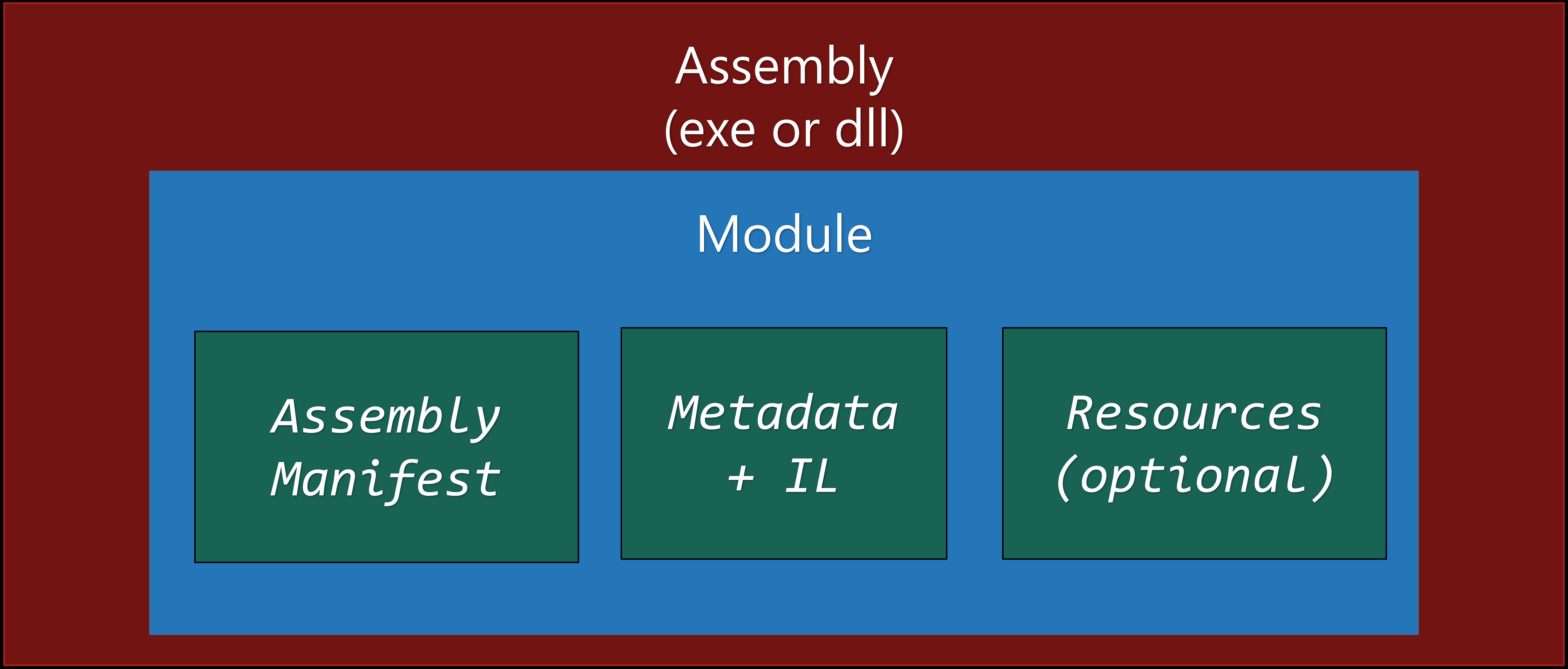
Flexibility

What is Reflection?

Inspecting the metadata and compiled code in an assembly.

- What is an assembly?
- What is metadata?
- How is the code compiled?

.NET Assemblies



Assembly
(exe or dll)

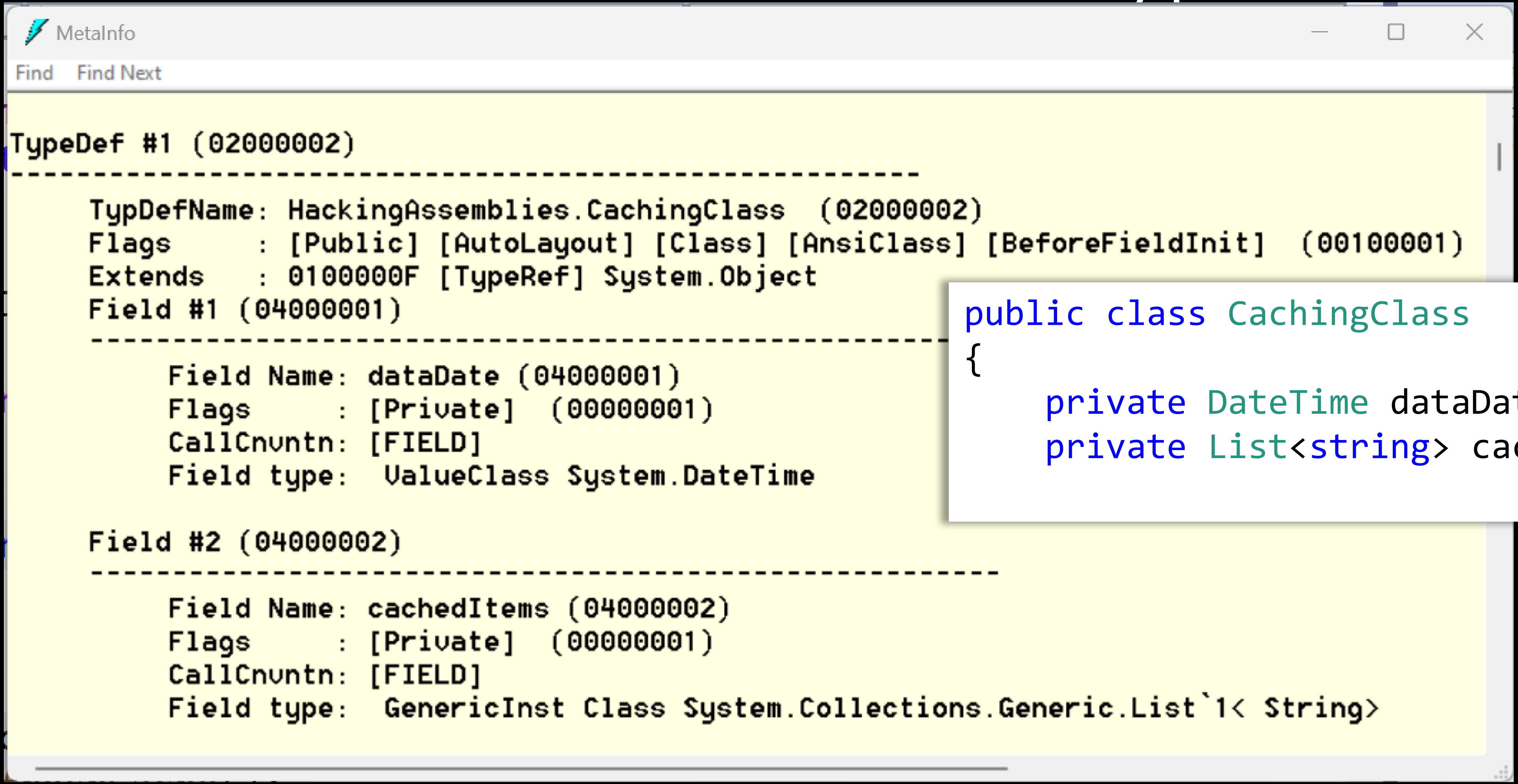
Module

Assembly Manifest

Metadata + IL

Resources (optional)

Type Definitions

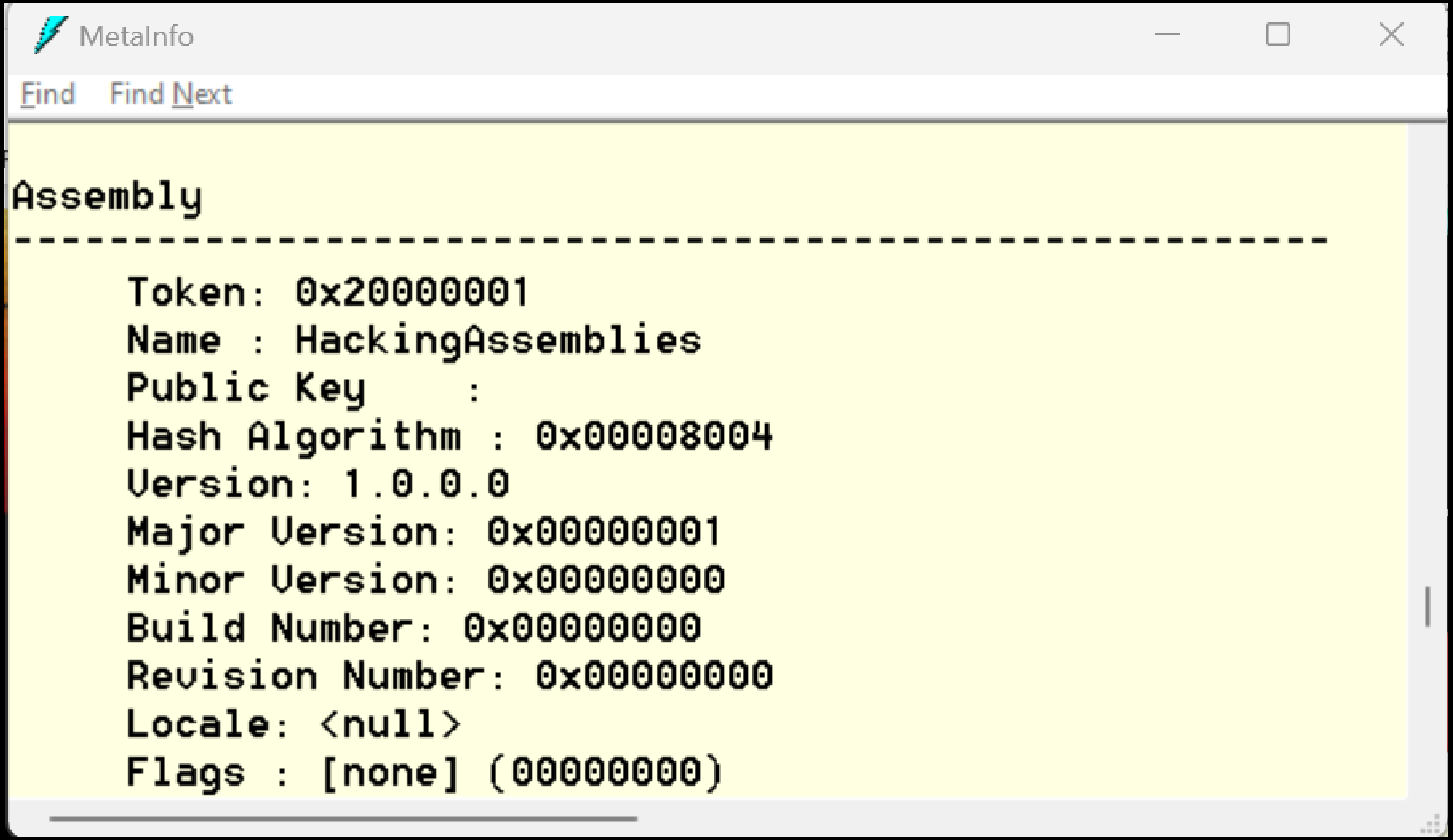


```
TypeDef #1 (02000002)
-------------------------------------------------------
	TypDefName: HackingAssemblies.CachingClass  (02000002)
	Flags     : [Public] [AutoLayout] [Class] [AnsiClass] [BeforeFieldInit]  (00100001)
	Extends   : 0100000F [TypeRef] System.Object
	Field #1 (04000001)
	-------------------------------------------------------
		Field Name: dataDate (04000001)
		Flags     : [Private]  (00000001)
		CallCnvntn: [FIELD]
		Field type:  ValueClass System.DateTime

	Field #2 (04000002)
	-------------------------------------------------------
		Field Name: cachedItems (04000002)
		Flags     : [Private]  (00000001)
		CallCnvntn: [FIELD]
		Field type:  GenericInst Class System.Collections.Generic.List`1< String>
```

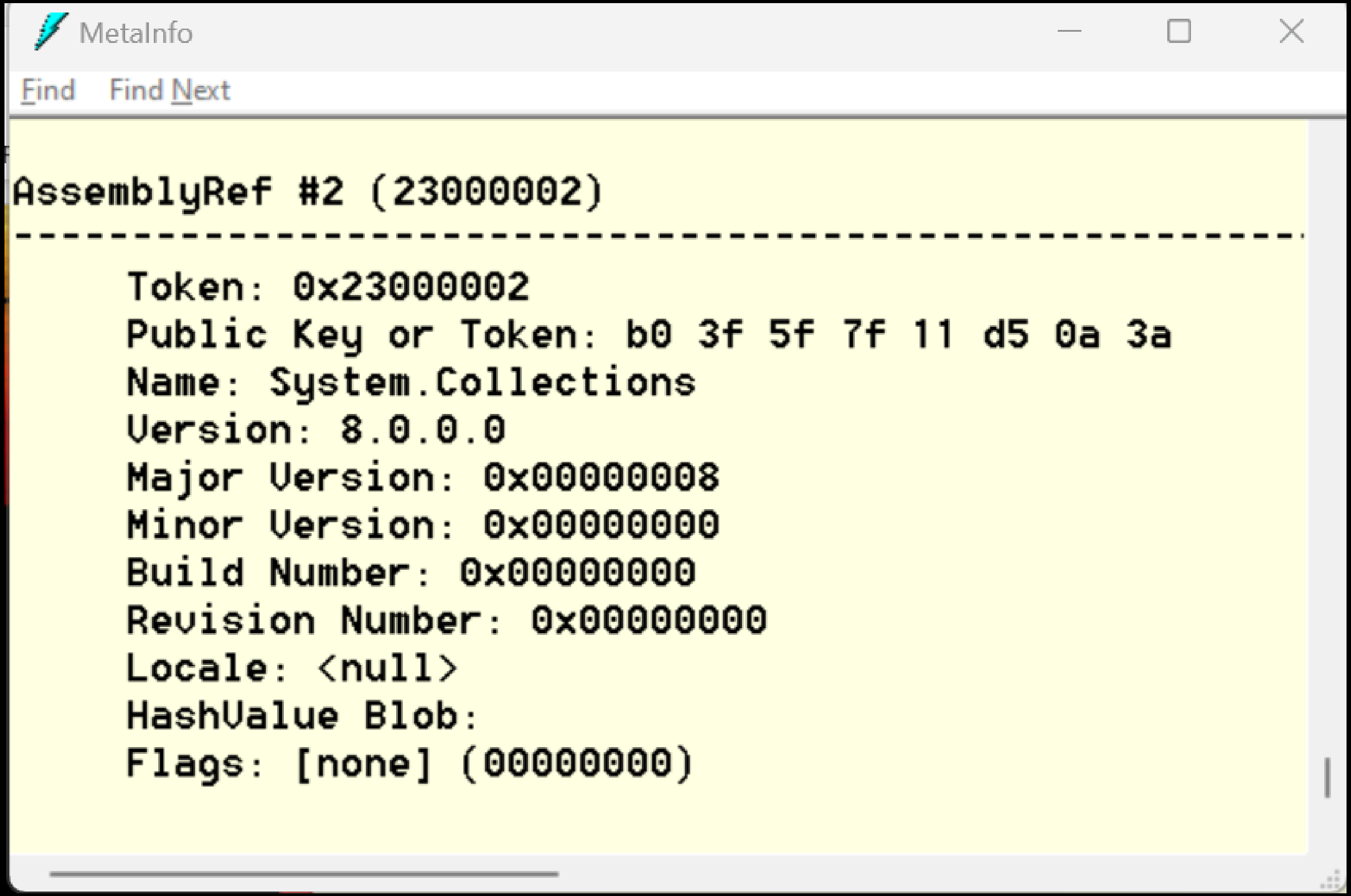
```
public class CachingClass
{
    private DateTime dataDate;
    private List<string> cachedItems;
```

Assembly Information



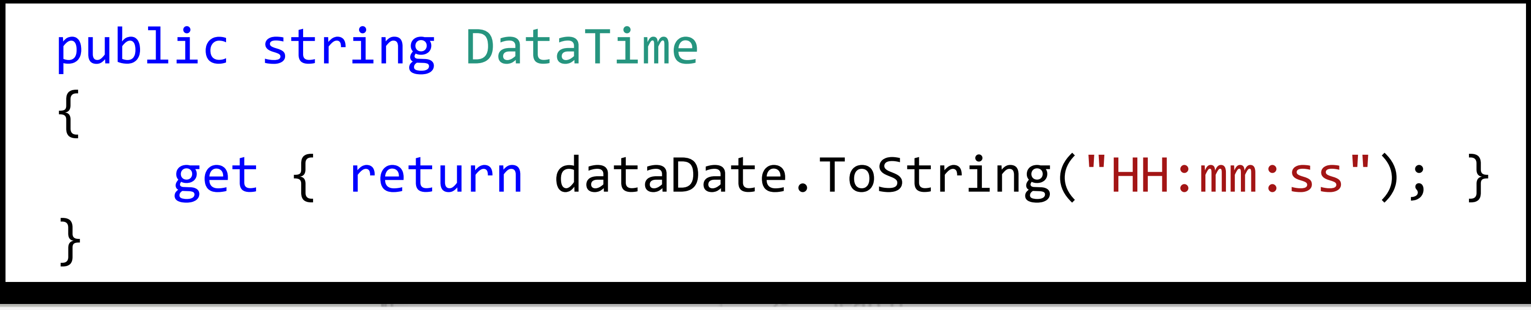
```
Assembly
-------------------------------------------------------
     Token: 0x20000001
     Name : HackingAssemblies
     Public Key    :
     Hash Algorithm : 0x00008004
     Version: 1.0.0.0
     Major Version: 0x00000001
     Minor Version: 0x00000000
     Build Number: 0x00000000
     Revision Number: 0x00000000
     Locale: <null>
     Flags : [none] (00000000)
```

Referenced Assemblies

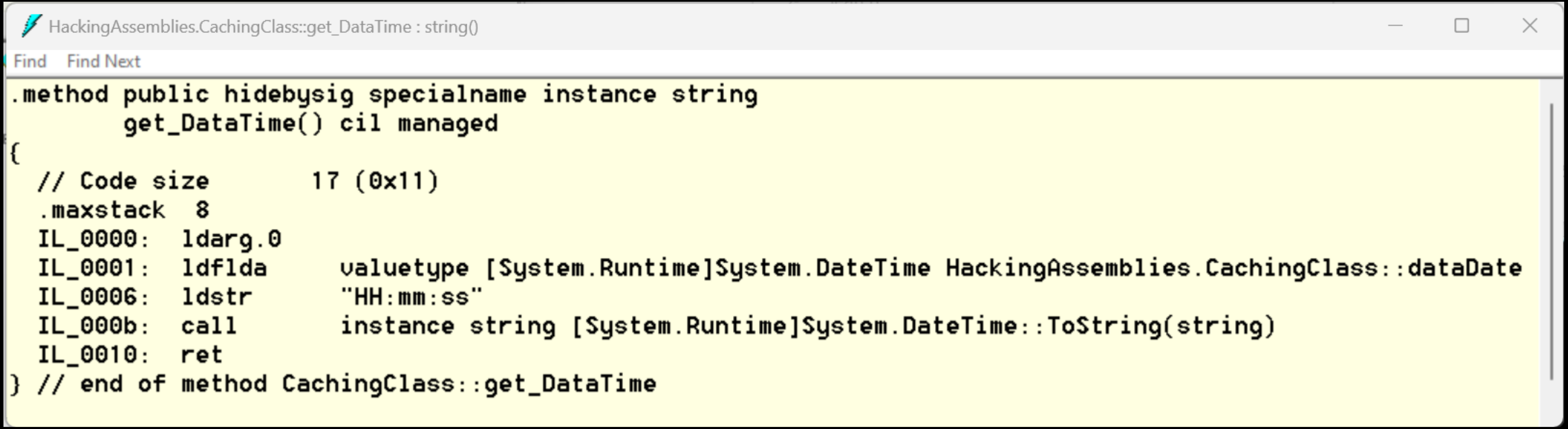


```
AssemblyRef #2 (23000002)
-------------------------------------------------------
	Token: 0x23000002
	Public Key or Token: b0 3f 5f 7f 11 d5 0a 3a
	Name: System.Collections
	Version: 8.0.0.0
	Major Version: 0x00000008
	Minor Version: 0x00000000
	Build Number: 0x00000000
	Revision Number: 0x00000000
	Locale: <null>
	HashValue Blob:
	Flags: [none] (00000000)
```

IL (Intermediate Language)



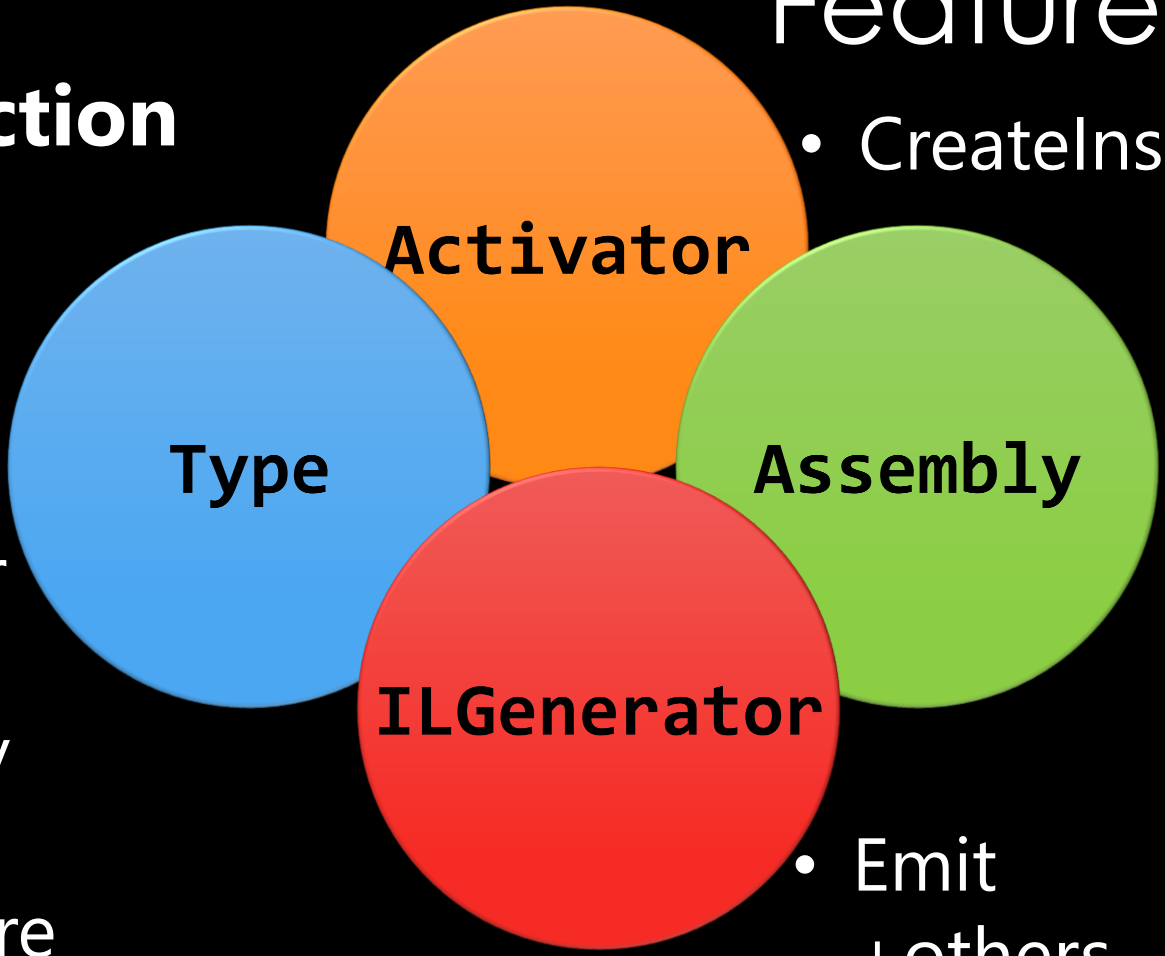
```
public string DataTime
{
    get { return dataDate.ToString("HH:mm:ss"); }
}
```



```
.method public hidebysig specialname instance string
        get_DataTime() cil managed
{
  // Code size       17 (0x11)
  .maxstack  8
  IL_0000:  ldarg.0
  IL_0001:  ldflda     valuetype [System.Runtime]System.DateTime HackingAssemblies.CachingClass::dataDate
  IL_0006:  ldstr      "HH:mm:ss"
  IL_000b:  call       instance string [System.Runtime]System.DateTime::ToString(string)
  IL_0010:  ret
} // end of method CachingClass::get_DataTime
```

Feature Overview

System.Reflection



Activator

- CreateInstance

Type

- GetType
- GetMember
- GetMethod
- GetProperty
- GetField

  + many more

Assembly

- Load
- LoadFrom
- GetTypes
- GetName
- GetFiles

  + many more

ILGenerator

- Emit

  +others

Things You Can Do

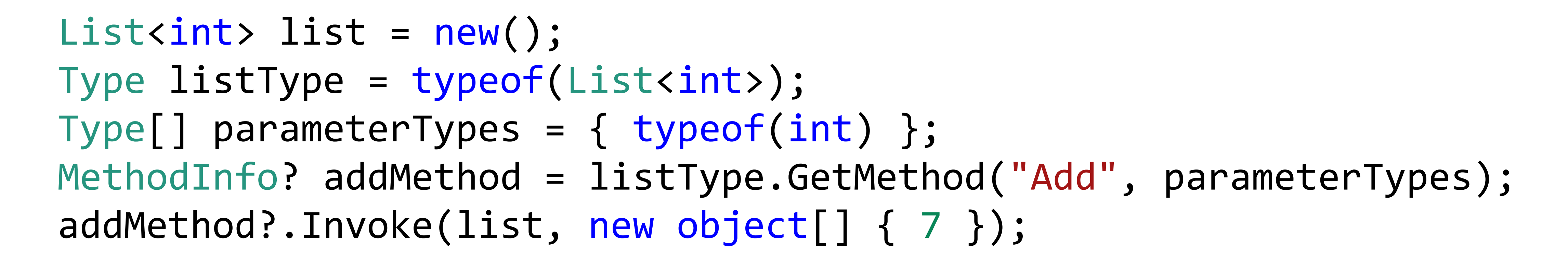
- Reflecting on a Property

```
CachingClass safeCacher = new();
Type cachingType = typeof(CachingClass);
PropertyInfo? cacheProperty = cachingType.GetProperty("CachedItems");
List<string> cacheValue = cacheProperty?.GetValue(safeCacher)
                              as List<string>;
```

- Useful for interacting with COM objects (pre-.NET 4.0)
- “dynamic” is a better choice for interacting with COM

Things You Can Do

- Reflecting on a Method



```
List<int> list = new();
Type listType = typeof(List<int>);
Type[] parameterTypes = { typeof(int) };
MethodInfo? addMethod = listType.GetMethod("Add", parameterTypes);
addMethod?.Invoke(list, new object[] { 7 });
```

- Useful for interacting with COM objects (pre-.NET 4.0)
- “dynamic” is a better choice for interacting with COM

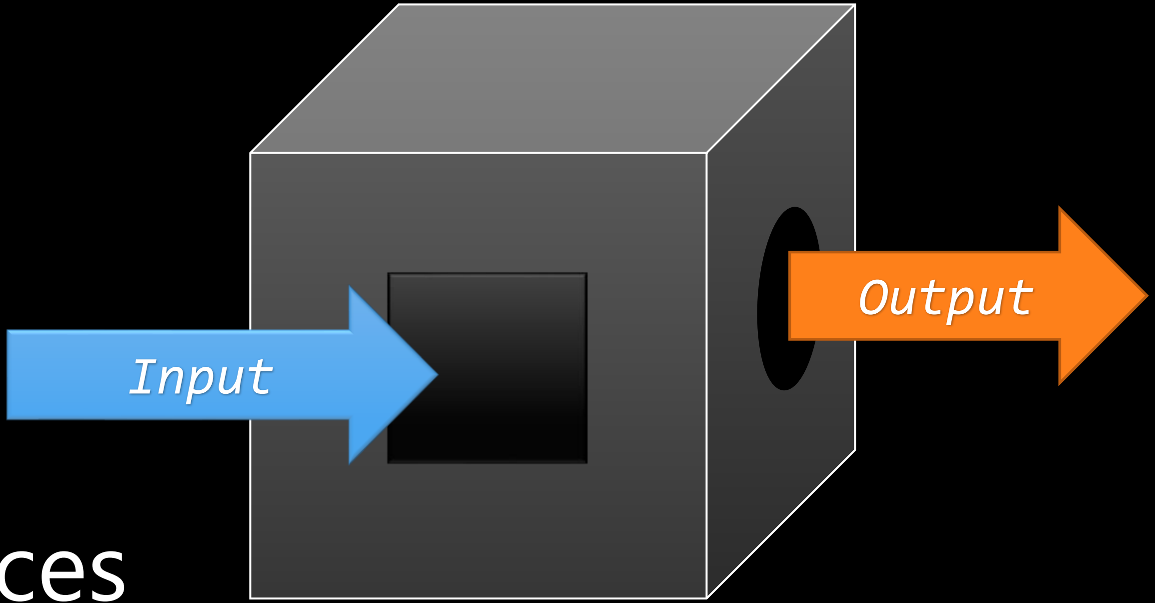
Things You Can Do

- Reflecting on a Private Field

```
CachingClass safeCacher = new();
Type cachingType = typeof(CachingClass);
FieldInfo? cacheField = cachingType.GetField("cachedItems",
                        BindingFlags.NonPublic | BindingFlags.Instance);
List<string>? cacheValue = cacheField?.GetValue(dangerousCacher)
                                                       as List<string>;
```

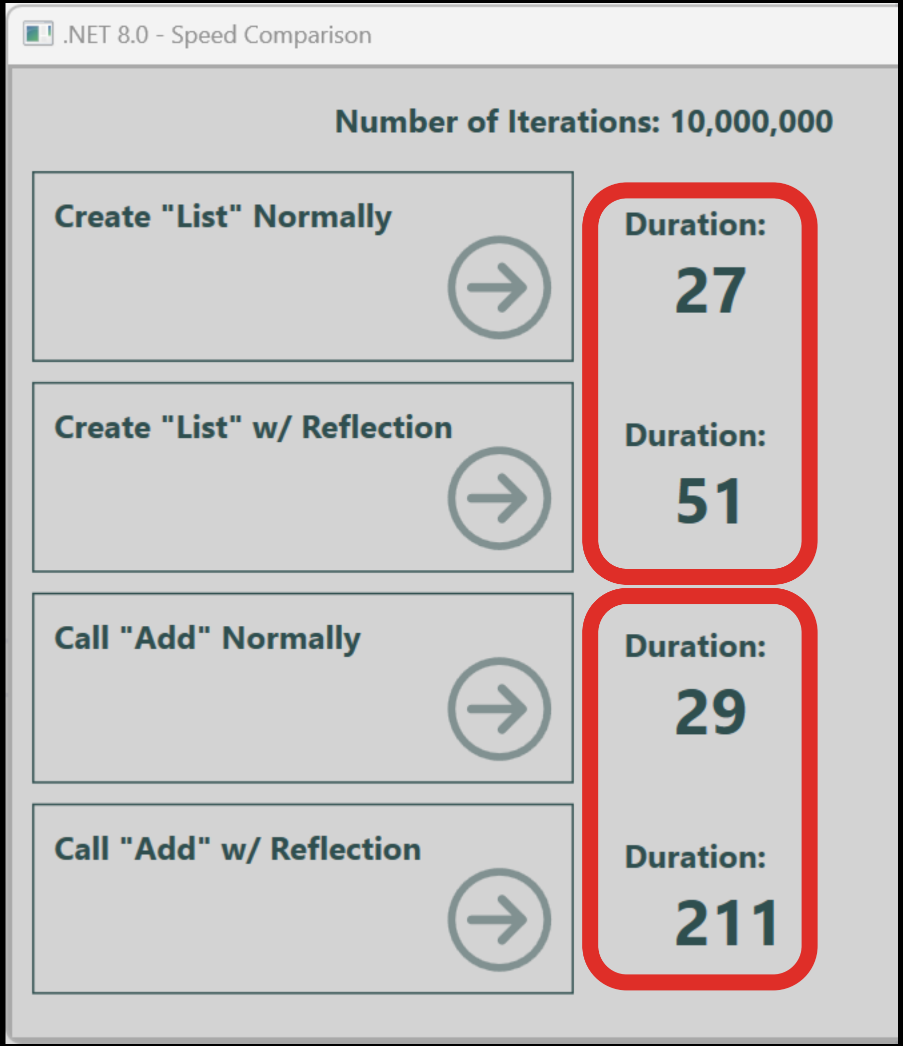
- BindingFlags give us access to non-public members
- DANGER DANGER DANGER

Encapsulation



- Use the exposed interfaces
- Don’t peek inside the box

Performance



.NET 8.0 - Speed Comparison

Number of Iterations: 10,000,000

Create "List" Normally

Duration: 27

Create "List" w/ Reflection

Duration: 51

Call "Add" Normally

Duration: 29

Call "Add" w/ Reflection

Duration: 211

Reflection 2x slower

Reflection 7x slower

Best Practice

Program to an abstraction rather than a concrete type

Practical Reflection Strategy

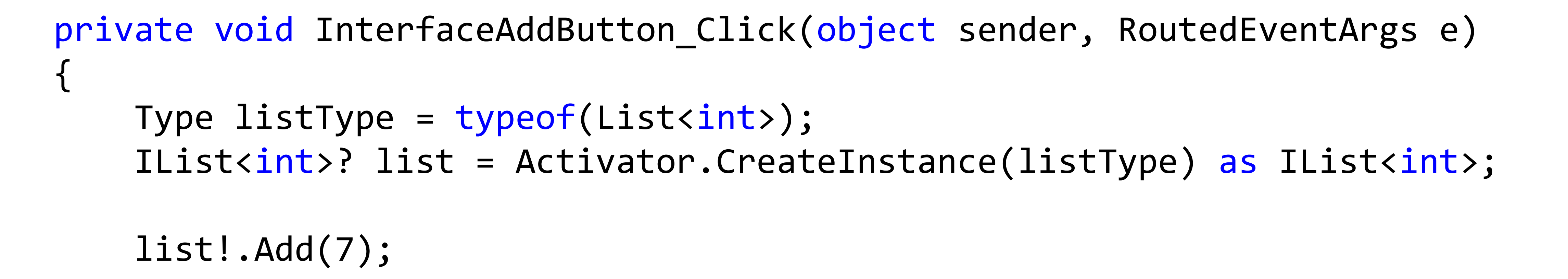
- **Dynamically Load Assemblies**
  - Happens one time (at start up)

- **Dynamically Load Types**
  - Happens one time (at start up)

- **Cast Types to a Known Interface**
  - All method calls go through the interface
  - No dynamic method calls – no MethodInfo.Invoke
  - Avoid interacting with private members

Practical Reflection Strategy

- **Sample – Cast to an Interface**

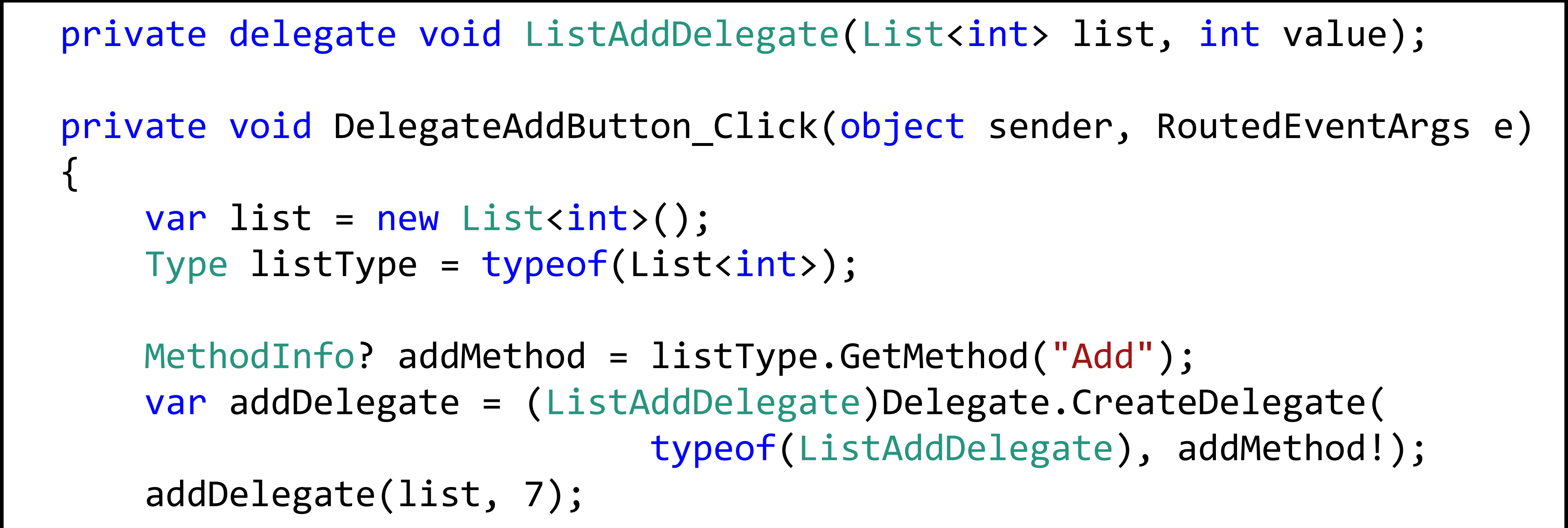


```
private void InterfaceAddButton_Click(object sender, RoutedEventArgs e)
{
    Type listType = typeof(List<int>);
    IList<int>? list = Activator.CreateInstance(listType) as IList<int>;

    list!.Add(7);
```

Practical Reflection Strategy

- **Alternate – Create a Delegate**

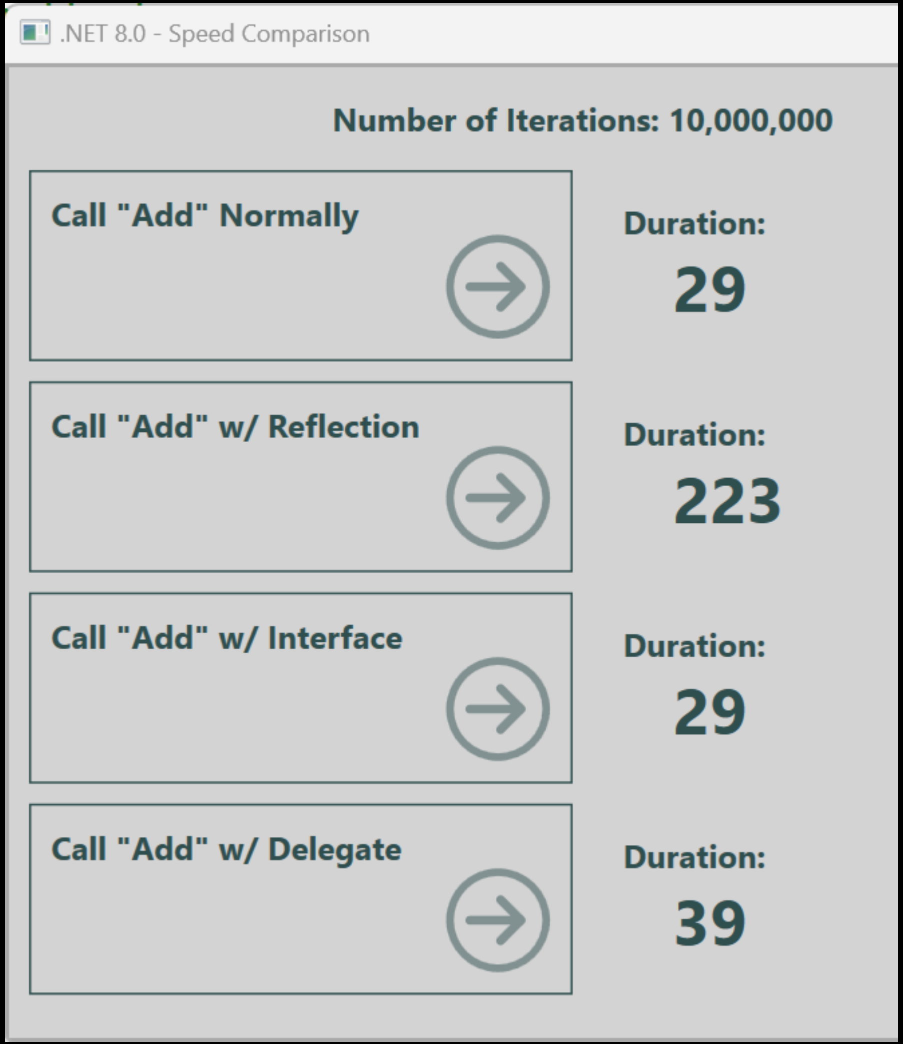


```
private delegate void ListAddDelegate(List<int> list, int value);

private void DelegateAddButton_Click(object sender, RoutedEventArgs e)
{
    var list = new List<int>();
    Type listType = typeof(List<int>);

    MethodInfo? addMethod = listType.GetMethod("Add");
    var addDelegate = (ListAddDelegate)Delegate.CreateDelegate(
                            typeof(ListAddDelegate), addMethod!);
    addDelegate(list, 7);
```

Performance



.NET 8.0 - Speed Comparison

Number of Iterations: 10,000,000

Call "Add" Normally	Duration: 29
Call "Add" w/ Reflection	Duration: 223
Call "Add" w/ Interface	Duration: 29
Call "Add" w/ Delegate	Duration: 39

Reflection 7x slower

Interface – no penalty

Delegate – small penalty

Various Data Sources

Microsoft SQL Server

MongoDB

CSV

REST Service

WebAPI

Oracle

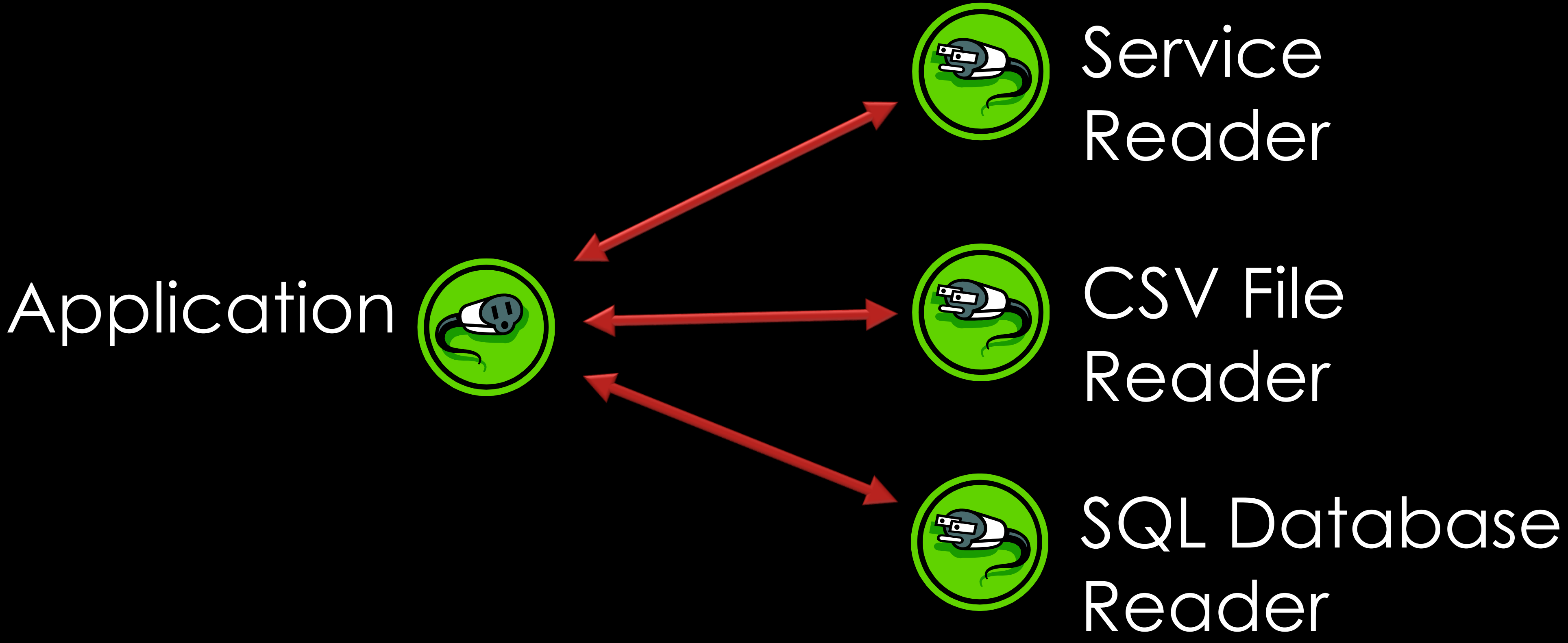
Amazon RDS

JSON

Hadoop

Azure Cosmos DB

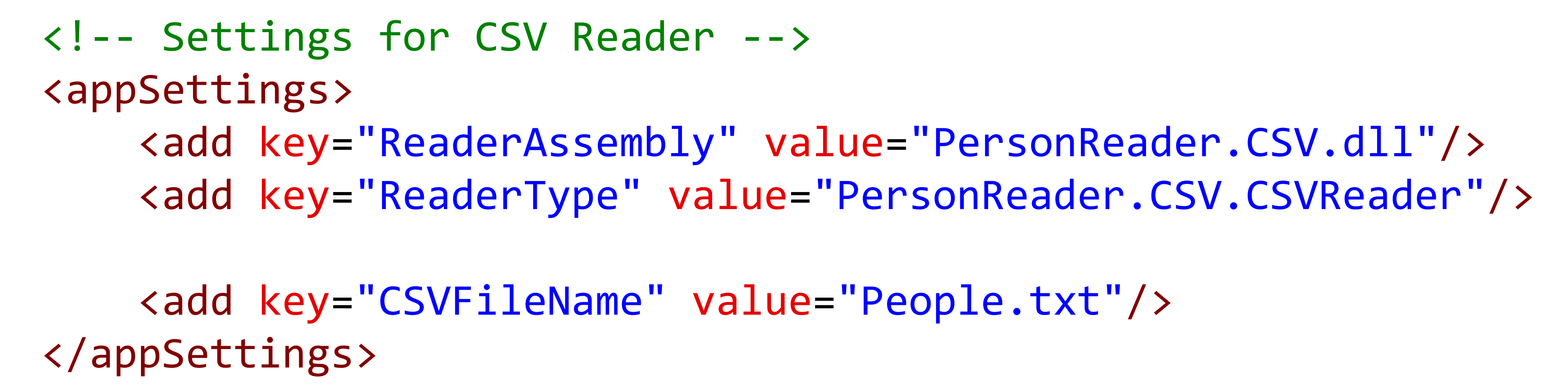
Pluggable Data Readers



Benefits of Dynamic Loading

- Only ship 1 data reader assembly
- Remove dependency on concrete data readers
- New data readers can be added without modifying existing code

Configuration



```
<!-- Settings for CSV Reader -->
<appSettings>
    <add key="ReaderAssembly" value="PersonReader.CSV.dll"/>
    <add key="ReaderType" value="PersonReader.CSV.CSVReader"/>

    <add key="CSVFileName" value="People.txt"/>
</appSettings>
```

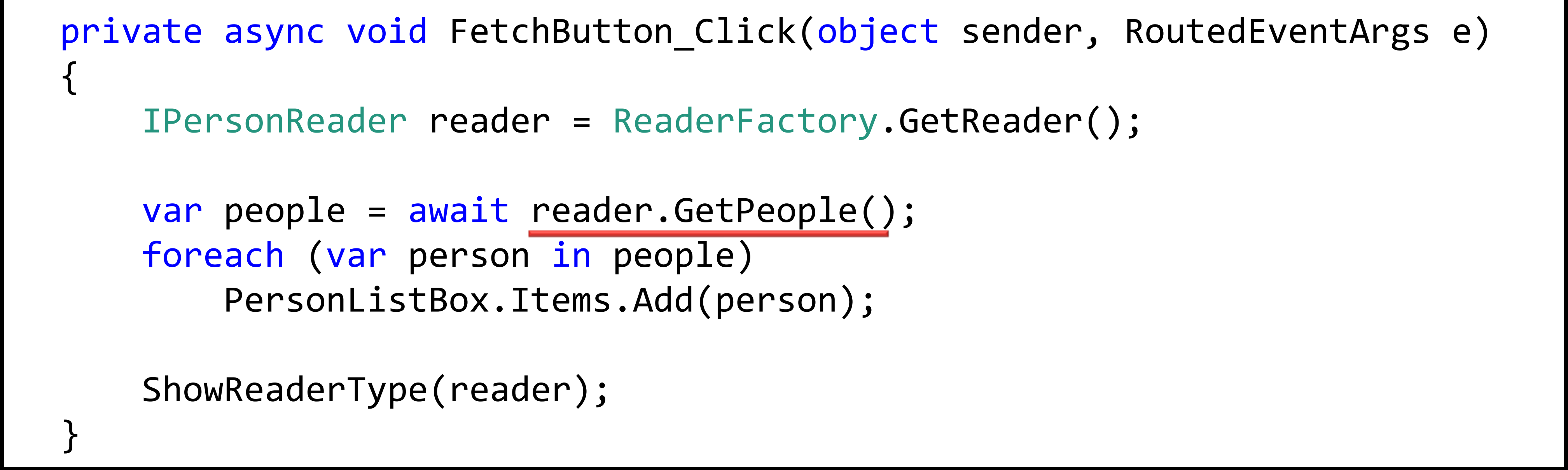
- Assembly File Name
- Fully-Qualified Type Name
- Other configuration

Steps

- Get assembly file name from configuration
- Create a custom load context
- Load the assembly into the context
- Get data reader type name from configuration
- Reflect into the assembly to get the reader type
- Use the Activator to create an instance of the reader

https://jeremybytes.blogspot.com/2020/01/dynamically-loading-types-in-net-core.html

Limiting Reflection



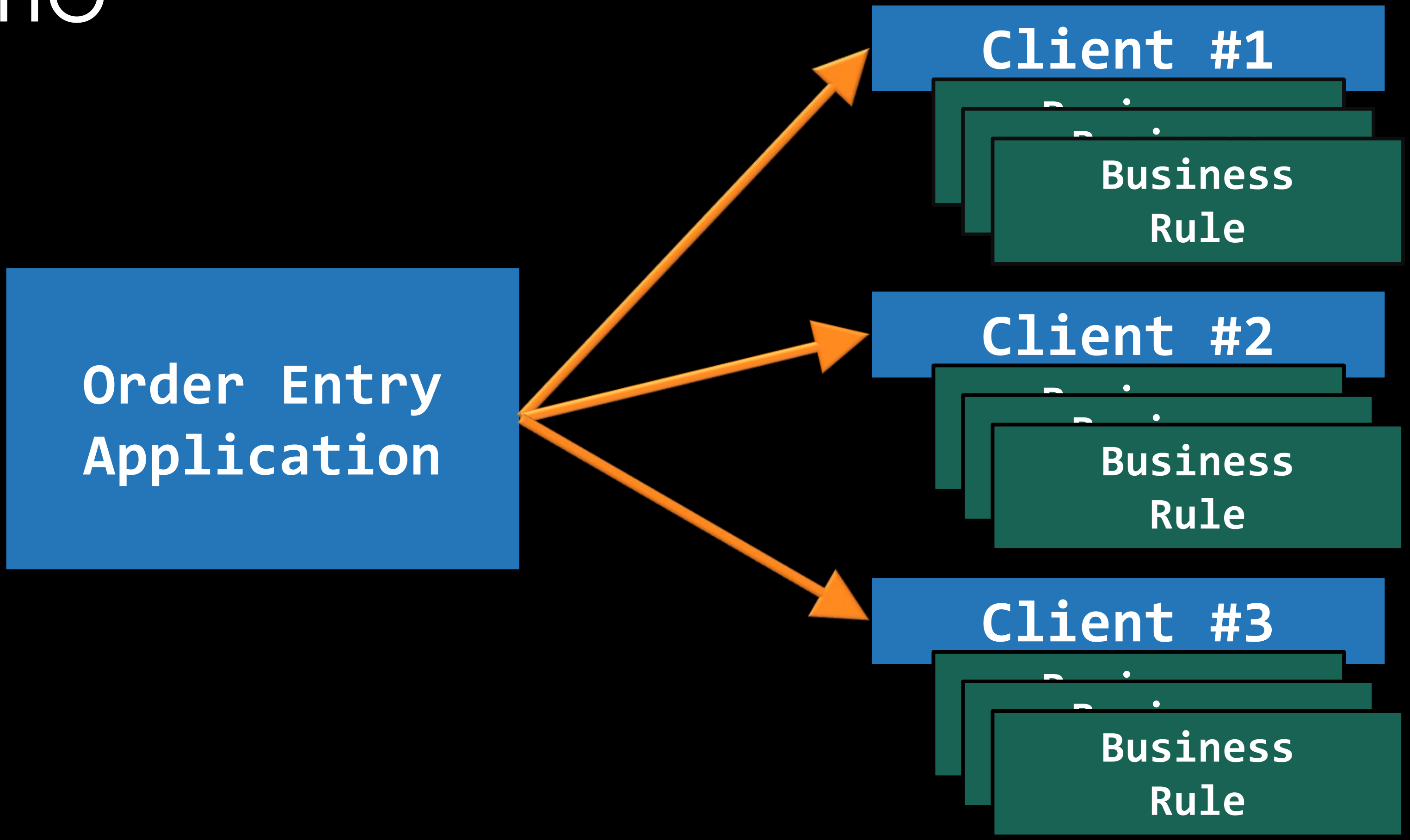
```
private async void FetchButton_Click(object sender, RoutedEventArgs e)
{
    IPersonReader reader = ReaderFactory.GetReader();

    var people = await reader.GetPeople();
    foreach (var person in people)
        PersonListBox.Items.Add(person);

    ShowReaderType(reader);
}
```

- No Reflection Here
- Method calls through IPersonReader

Scenario



Order Entry Application

Client #1

Business Rule

Client #2

Business Rule

Client #3

Business Rule

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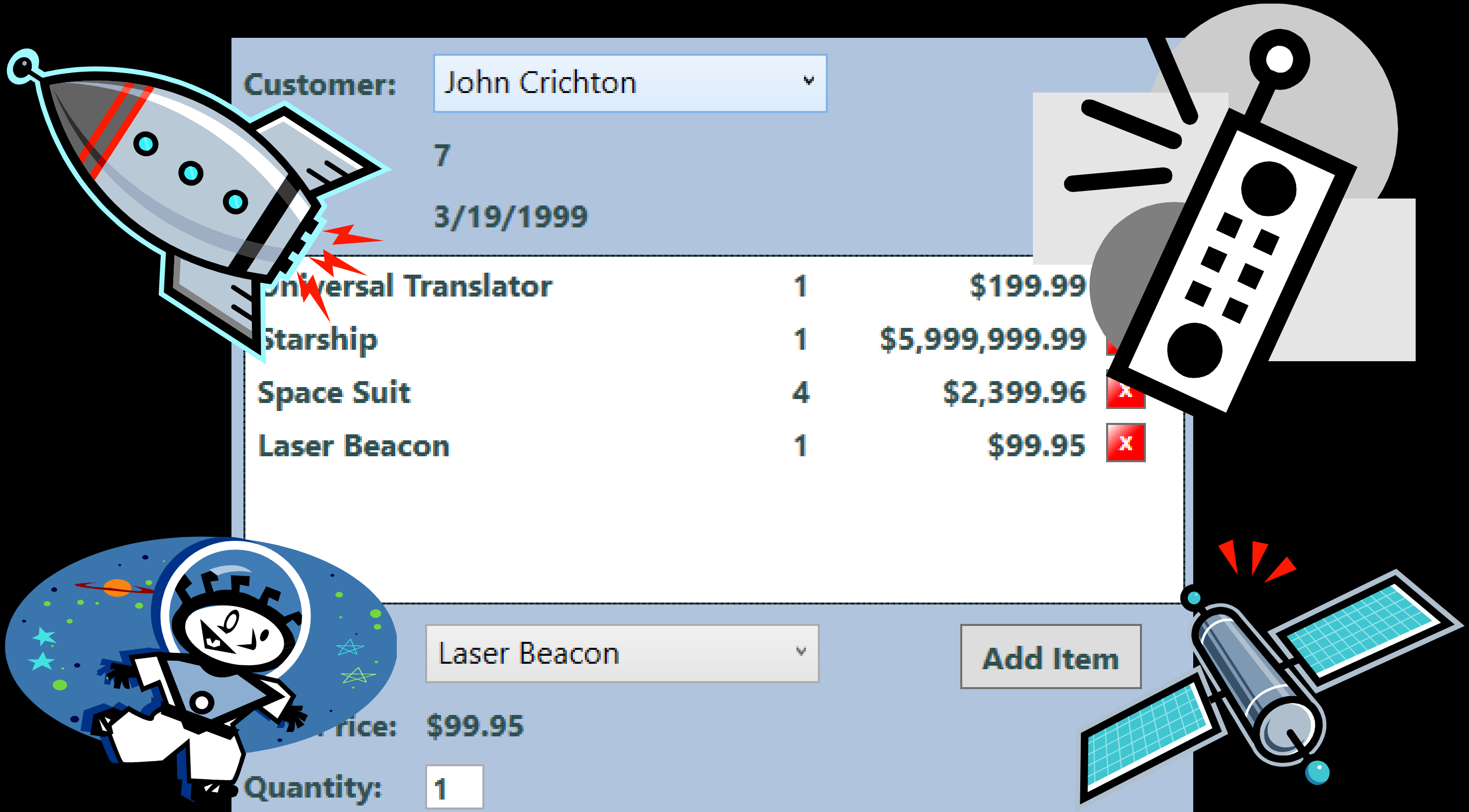
Application



Customer: John Crichton

7

3/19/1999

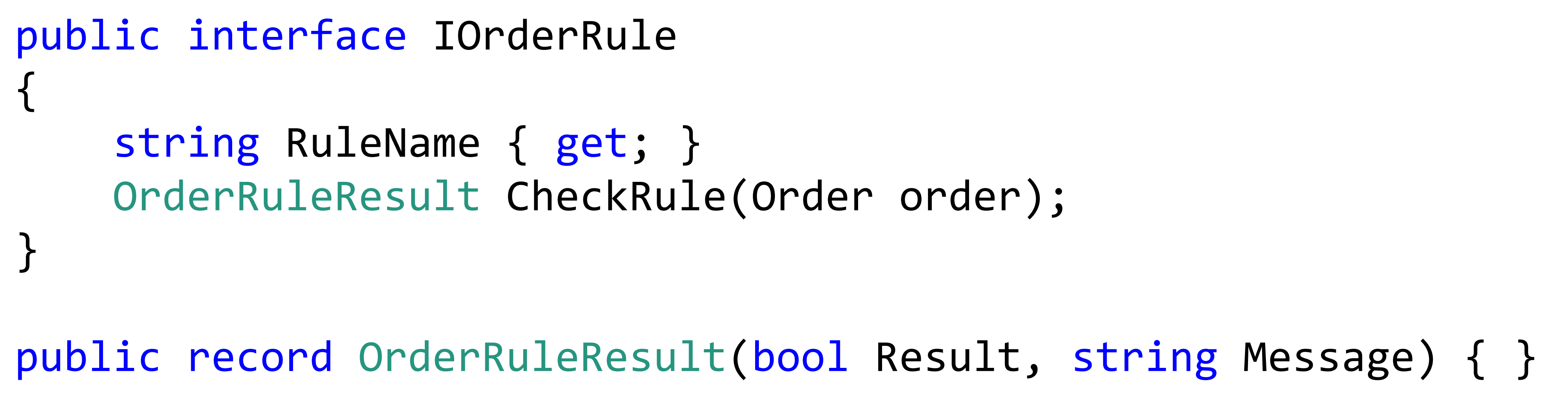
Universal Translator	1	$199.99	
Starship	1	$5,999,999.99	
Space Suit	4	$2,399.96	X
Laser Beacon	1	$99.95	X

Laser Beacon

Price: $99.95

Quantity: 1

Business Rule Interface



```
public interface IOrderRule
{
    string RuleName { get; }
    OrderRuleResult CheckRule(Order order);
}

public record OrderRuleResult(bool Result, string Message) { }
```

Business Rules

Maximum Discount based on Customer Rating

Only 1 Captain’s Chair Allowed

Maximum of 1 Starship per Order

Name Badge must match Customer Name

Discovery Process

- Locate all assemblies in the “Rules” folder
- Load each assembly
- Enumerate the types in the assembly that implement the Rule interface
- Create an instance of each Rule
- Add it to the Rule instance to the Rule Catalog

Summary

- There are lots of things you *can* do
- Some things that are dangerous (such as accessing private members)
- Reflection is slow
  - Limit the amount of reflection
  - Use interfaces or delegates
- Dynamic loading of assemblies is very useful in certain applications

Thank You!

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