

# Module 02:

"What's New in  
C# 7.1, 7.2, and 7.3?"



# Agenda

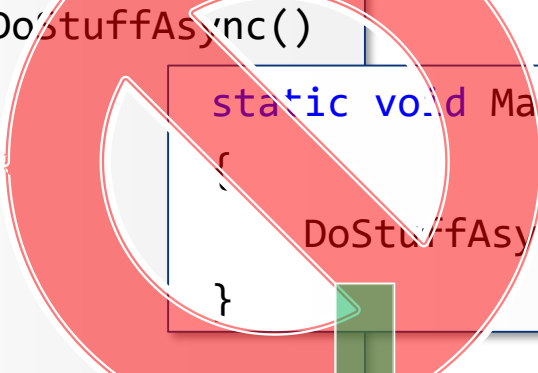
- ▶ **C# 7.1 Additions**
- ▶ C# 7.2 Additions
- ▶ C# 7.3 Additions



# Evolution of C# 7.1



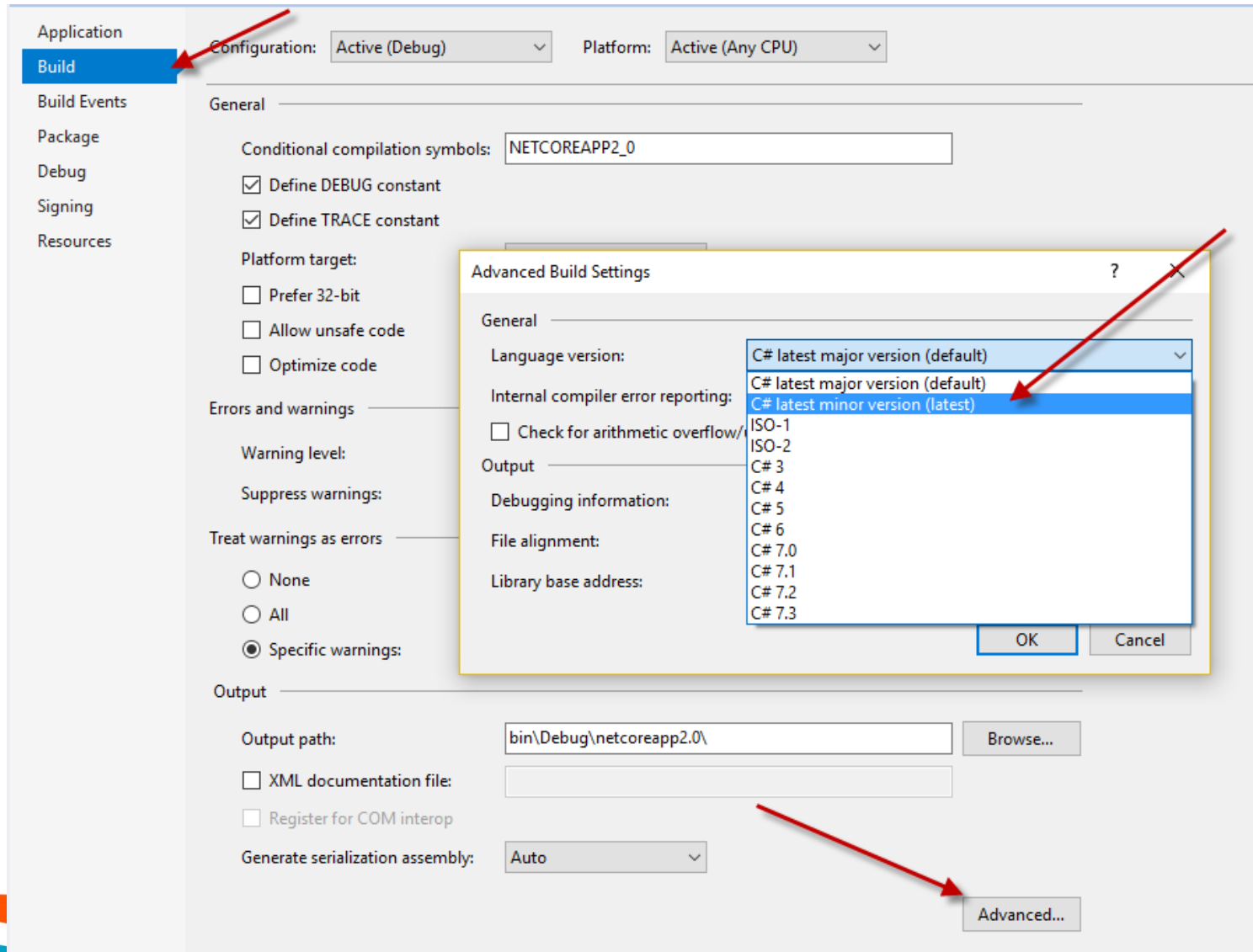
# Async Main()



```
static async Task DoStuffAsync()  
{  
    ... await ...  
    ... await ...  
    ... await ...  
}  
  
static void Main(string[] args)  
{  
    DoStuffAsync().GetAwaiter().GetResult();  
}
```

```
static async Task<int> Main( string[] args )  
{  
    ... await ...  
}  
  
int $GeneratedMain( string[] args )  
{  
    return Main(args).GetAwaiter().GetResult();  
}
```

# Enabling C# 7.x Compilation



# Pattern Matching Open Types

- ▶ Patterns now play well with (sub-)type constraints for generic types


```
static void Promote<T>( T employee )
{
    switch (employee)
    {
        case SoftwareArchitect sa:
            sa.Level = SoftwareArchitectLevel.Lead;
            break;
        case SoftwareEngineer se:
            se.Level = SoftwareEngineerLevel.Chief;
            break;
    }
}
```

Compiles in C# 7.1, but not in C# 7.0

# Default Literal

- ▶ C# 7.1 now allows to omit the type in the default operator
  - When the type can be deferred from the context

```
bool flag = false;  
int i = flag ? 87 : default(int);  
WriteLine(i);
```



```
bool flag = false;  
int i = flag ? 87 : default;  
WriteLine(i);
```

- ▶ Compiles in C# 7.1, but not in C# 7.0
- ▶ Has a number of nice and simple uses such as

```
void DoStuff( int x, int y = default, bool z = default )  
{  
    WriteLine($"x={x}\ty={y}\tz={z}");  
}
```

# Inferred Tuple Names

## (aka. Tuple Projection Initializers 😊)

- ▶ Tuple names are redundant when they can be inferred from the context
  - Similar to what the anonymous types of C# 3.0

```
struct Equipment
{
    public string Console { get; set; }
    public int Controllers { get; set; }
    public bool IsVREnabled { get; set; }
}
```

```
Equipment e = new Equipment { ... };
var tuple = (e.Console, e.Controllers);

Console.WriteLine( tuple.Console );
```

- ▶ Compiles in C# 7.1, but not in C# 7.0



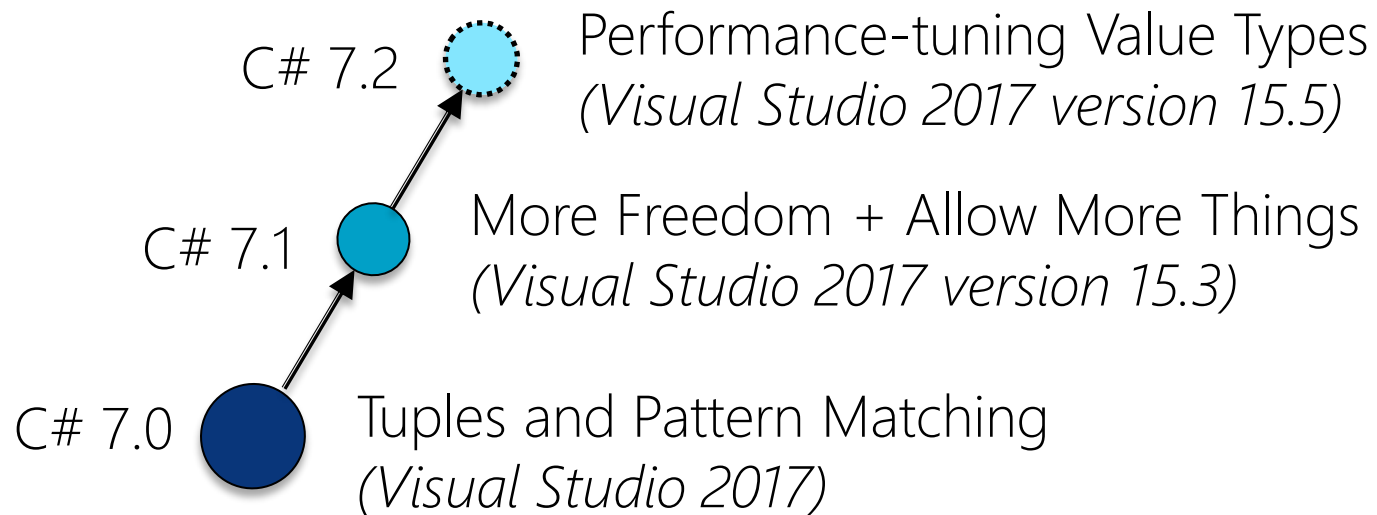


# Agenda


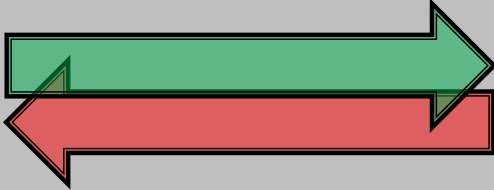


- ▶ C# 7.1 Additions
- ▶ **C# 7.2 Additions**
- ▶ C# 7.3 Additions



# Evolution of C# 7.2



# in Parameter Modifier

Modifier	Effect	Description
		Copies argument to formal parameter
ref		Formal parameters are synonymous with actual parameters. Call site must also specify <b>ref</b>
out		Parameter cannot be read. Parameter must be assigned. Call site must also specify <b>out</b>
in		Parameter is "copied". Parameter cannot be modified! Call site can optionally specify <b>in</b> .  ~ "readonly ref"

# in Parameter Modifier

- ▶ It can be passed as a reference by the runtime system for performance reasons

```
double CalculateDistance( in Point3D first, in Point3D second = default )
{
    double xDiff = first.X - second.X;
    double yDiff = first.Y - second.Y;
    double zDiff = first.Z - second.Z;

    return Sqrt(xDiff * xDiff + yDiff * yDiff + zDiff * zDiff);
}
```

- ▶ The call site does not need to specify **in**
- ▶ Can call with constant literal -> Compiler will create variable

```
Point3D p1 = new Point3D { X = -1, Y = 0, Z = -1 };
Point3D p2 = new Point3D { X = 1, Y = 2, Z = 3 };
double d = CalculateDistance(p1, p2));
```

# Ref Readonly Returns

- ▶ Ref Returns can be enforced read-only by the compiler

```
ref readonly int FindMax( int[] numbers )  
{  
    int indexOfMax = 0;  
    ...  
    return ref numbers[indexOfMax];  
}
```

```
ref readonly int max = ref FindMax(numbers);  
WriteLine($"{nameof(max)} is now {max}");
```

**max = 1000; // Not allowed!**

- ▶ Must manually create a copy to make it modifiable later

```
int maxCopy = FindMax(numbers); // Copy  
maxCopy = 999999;
```



# Readonly Structs

- ▶ Define immutable structs for performance reasons

```
readonly struct Point3D
{
    public double X { get; }
    public double Y { get; }
    public double Z { get; }

    public Point3D( double x, double y, double z ) { ... }

    public override string ToString() => $"({X},{Y},{Z})";
}
```

- ▶ Can always be passed as **in**
- ▶ Can always be **readonly ref** returned
- ▶ Compiler generates more optimized code for these values



# Ref Structs

- ▶ Structs can be enforced as “always stack allocated” using **ref struct**

```
ref struct Point3D
{
    public double X { get; }
    public double Y { get; }
    public double Z { get; }
    ...
}
```

- ▶ These values can never be allocated on the heap
  - Cannot be boxed
  - Cannot be declared members of a class or (non-ref) struct
  - Cannot be local variables in async methods
  - Cannot be declared local variables in iterators
  - Cannot be captured in lambda expressions or local functions



# Span<T> and ReadOnlySpan<T>

- ▶ Ref-like types to avoid allocations on the heap
  - Don't have own memory but points to someone else's
  - Essentially: "ref for sequence of variables"

```
int[] array = new int[10];  
...  
Span<int> span = array.AsSpan();  
Span<int> slice = span.Slice(2, 5);  
foreach (int i in slice)  
{  
    Console.WriteLine( i );  
}
```

```
string s = "Hello, World";  
ReadOnlySpan<char> span = s.AsSpan();  
ReadOnlySpan<char> slice =  
    span.Slice(7, 5);  
foreach (char c in slice)  
{  
    Console.Write(c);  
}
```

- ▶ Note:
  - Located in System.Memory prerelease nuget package





# Ref Conditionals

- ▶ C# 7.2 allows the well-known selection operator `?:` for refs

```
int x = 42;  
int y = 87;  
bool b = ...;  
  
ref int z = ref (b ? ref x : ref y);  
  
z = 112;  
  
Console.WriteLine( $"x={x}, y={y}, z={z}" );
```



# Non-trailing Named Arguments

- ▶ As of C# 7.2 named arguments can now be followed by positional arguments...
  - ... but only if named argument is used in the correct position

```
void M( int x, int y = 87, bool z = default )  
{  
    Console.WriteLine($"x = {x}, y = {y}, z = {z}");  
}
```

```
M(1, 2, true);           // Allowed in C# 4.0  
M(x: 1, 2, z: true);    // Allowed in C# 7.2 (but not C# 7.1)  
M(z: true, 1 );         // Not allowed!
```



# Leading Underscores in Numeric Literals

- ▶ Starting from C# 7.2 the numeric literals of C# 7.0 are allowed to start with an underscore

```
int i = 0b00_00_00_00_00_00_01; // Allowed in C# 7.0
int j = 0b_00_00_00_00_00_00_01; // Allowed in C# 7.2
int k = 0x_ffff;                 // Allowed in C# 7.2
int m = 8__7;                    // Allowed in C# 7.0
int n = _8__7;                   // Not allowed
```

- ▶ Note:
  - Only allowed for hexadecimal and binary literals
  - Not decimals...!



# private protected Access Modifier

## ▶ private protected

- Is visible to containing types
- Is visible to derived classes in the same assembly

```
public class ClassInOtherAssembly
{
    private protected int X { get; set; }

    public void Print() => Console.WriteLine(X);
}
```

## ▶ protected internal

- Is visible to types in same assembly
- Is visible to derived classes (in same or other assemblies)

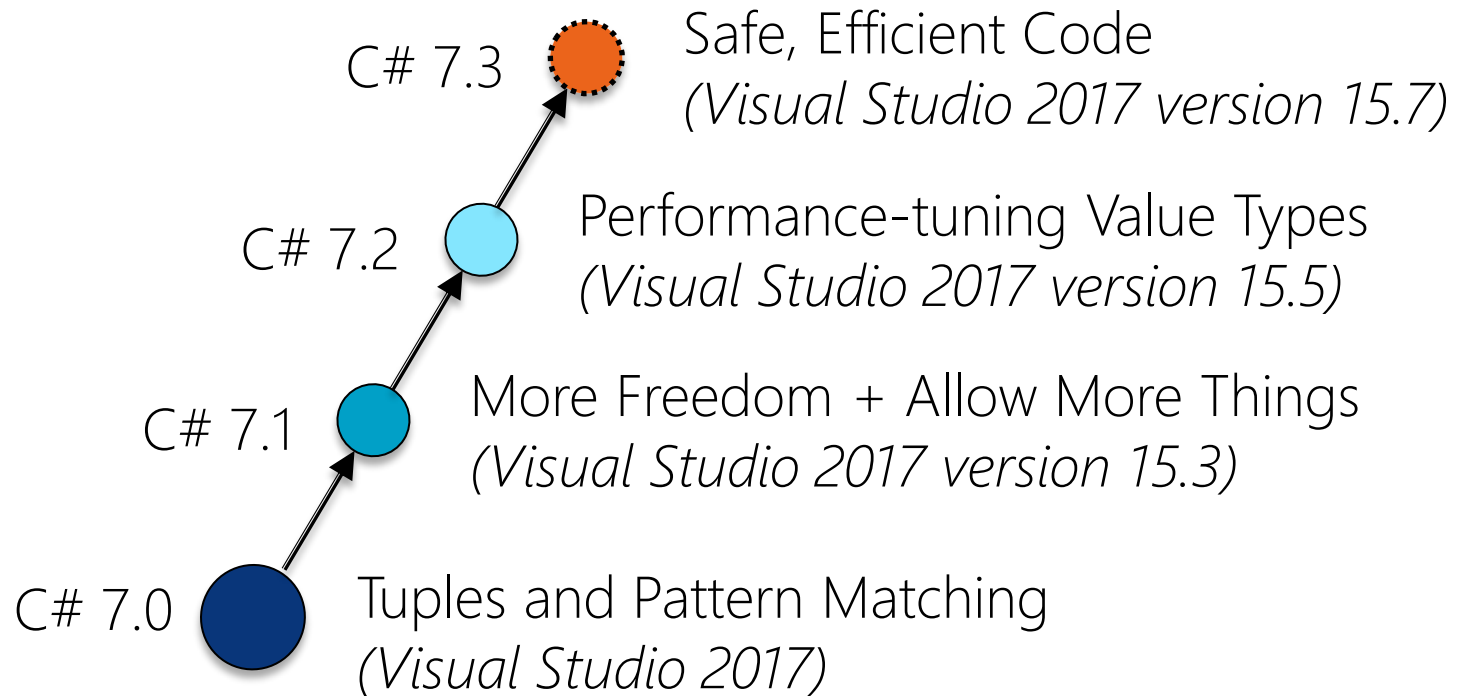


# Summary

- ▶ C# 7.1 Additions
- ▶ C# 7.2 Additions
- ▶ **C# 7.3 Additions**



# Evolution of C# 7.3



# Tuple Comparison Now Works...!

- ▶ C# 7.0 built-in implicit tuple conversions
  - **ToString()** + **Equals()** + **GetHashCode()**
- ▶ C# 7.3 completes comparison by adding **==** and **!=**

```
var t0 = (4, 8);  
  
var t1 = (a: 8, b: 4);  
var t2 = (8, 4);  
(int x, int y) t3 = (8, 4);  
(double p, double q) t4 = (8, 4);
```

```
WriteLine(t0 != t1);  
  
WriteLine(t1 == t2);  
WriteLine(t1 == t3);  
WriteLine(t2 == t3);  
WriteLine(t3 == t4);
```

- ▶ Performs component-wise **==** and **!=** with implicit conversions



# Ref Locals Reassignment

- ▶ C# 7.0 added references in the style of C++
- ▶ C# 7.3 completes ref locals by allowing them to be reassigned

```
int x = 42;  
int y = 87;  
ref int z = ref x; // Declaration and Initialization of z;  
  
x = 112;  
WriteLine($"z = {z}");  
  
z = ref y; // Reassignment of z;  
WriteLine($"z = {z}");
```





# Expression Variables in Initializers

- ▶ More flexible initialization was introduced in C# 7.0
- ▶ C# 7.3 extends out var and pattern variables to initializers

```
class Base
{
    public int Coordinate { get; } =
        int.TryParse("hello", out int x) ? x : default;

    public Base( int coordinate = default ) => Coordinate = coordinate;
}
```

```
class Derived : Base
{
    public Derived( object o ) : base(o is Point p ? p.X : default)
    {
    }
}
```

# Attributes on Backing Fields

- ▶ C# 7.3 allows attributes targeting the backing fields for auto-properties

```
[Serializable]
class ShoppingCartItem
{
    public int ProductId { get; }
    public decimal Price { get; }
    public int Quantity { get; }
    [field:NonSerialized]
    public decimal Total { get; }

    public ShoppingCartItem( int productID, decimal price, int quantity )
    {
        ProductId = productID;
        Price = price;
        Quantity = quantity;
        Total = price * quantity;
    }
}
```

# More Generic Constraints

Generic Constraint	Description
<code>where T : struct</code>	T must ultimately derive from <b>System.ValueType</b>
<code>where T : class</code>	T must be a reference type
<code>where T : new()</code>	T must have a default constructor
<code>where T : BaseClass</code>	T must derive from the class <i>BaseClass</i>  T can now be <b>System.Enum</b> T can now be <b>System.Delegate</b>
<code>where T : Interface</code>	T must implement the interface <i>Interface</i>
<b><code>where T : unmanaged</code></b>	T must be unmanaged, i.e. can take unmanaged pointer to T



# Misc. Unmanaged Interop

- ▶ Now **stackalloc** expressions can have initializers

```
Span<int> span = stackalloc int[] { 11, 22, 33 };
```

- ▶ Indexing movable fixed buffers (without pinning)

```
unsafe struct S  
{  
    public fixed int FixedField[10];  
}
```

```
static S s;  
...  
// No fixed required  
int i = s.FixedField[5];
```

- ▶ Custom fixed statement

```
byte[] byteArray = new byte[10];  
fixed (byte* ptr = byteArray)  
{  
    // byteArray is protected from being moved/collected by the GC  
    // for the duration of this block  
}
```

# Summary

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