

Module 10:

“What’s New in C# 7.x?”



TEKNOLOGISK
INSTITUT

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 )
```

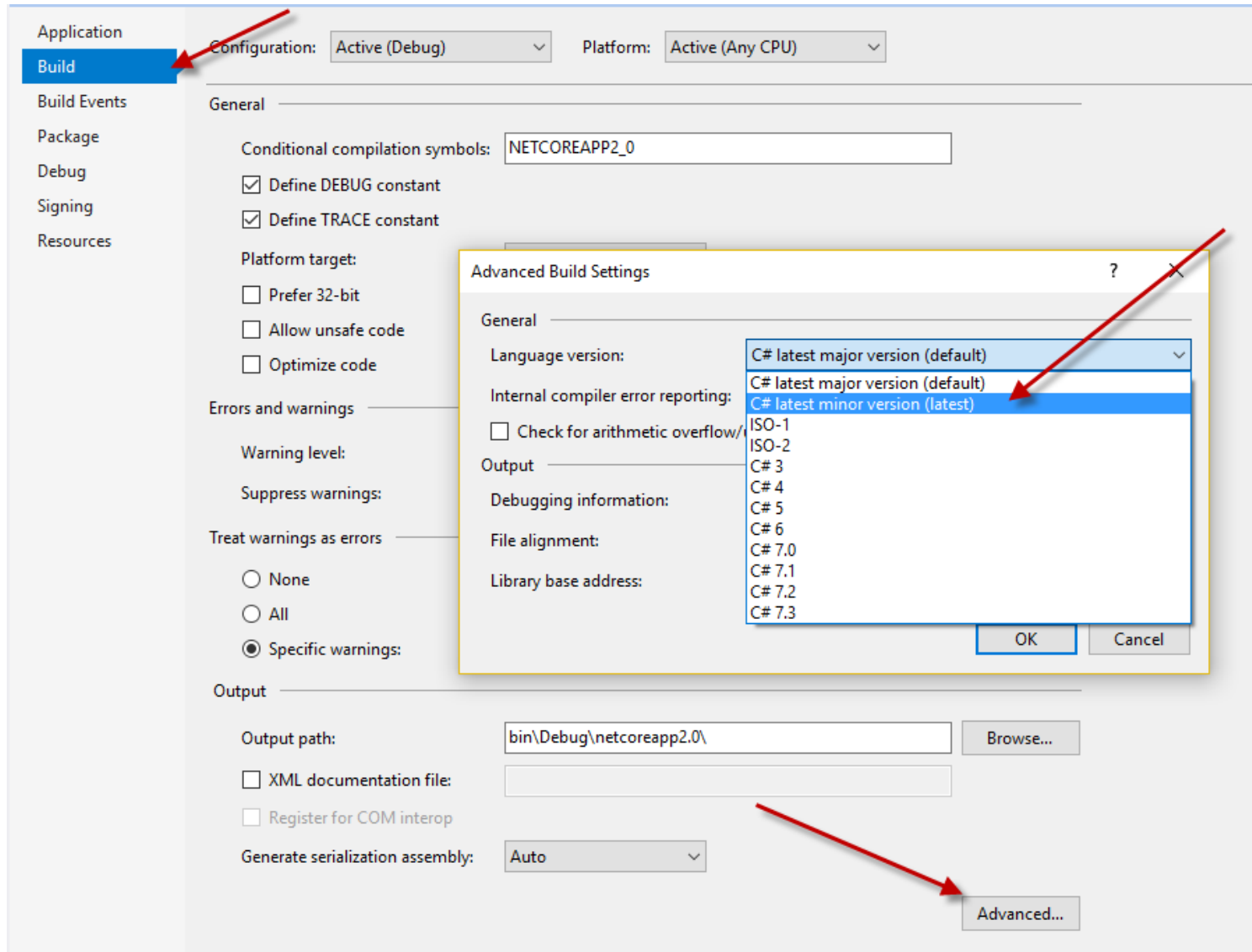
```
{
```

```
    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 );
```

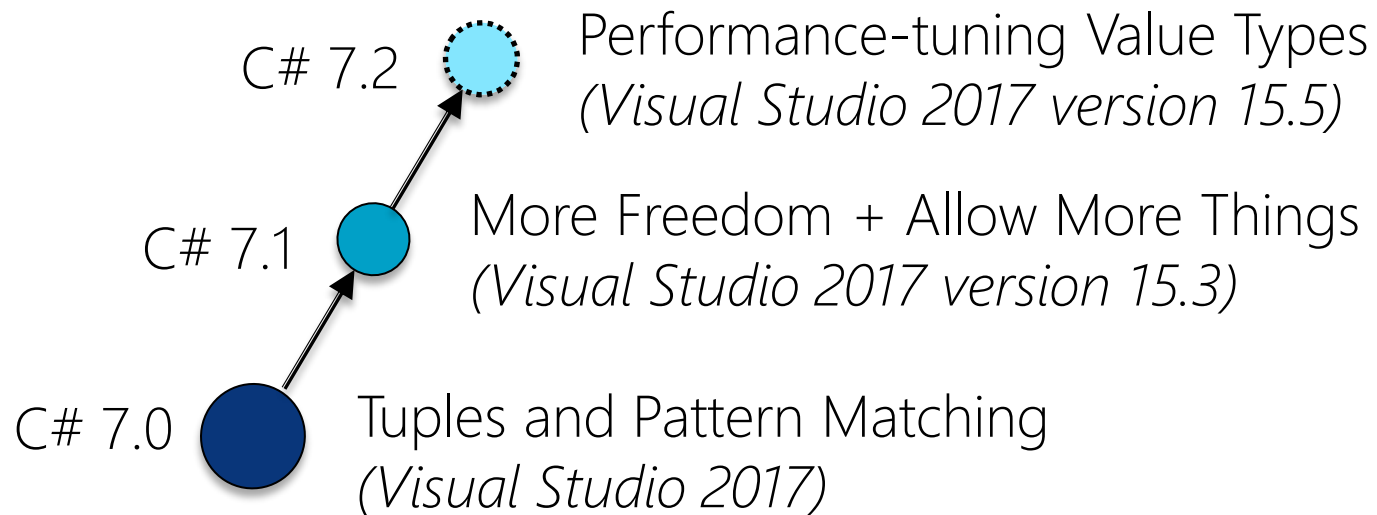
- ▶ Compiles in C# 7.1, but not in C# 7.0




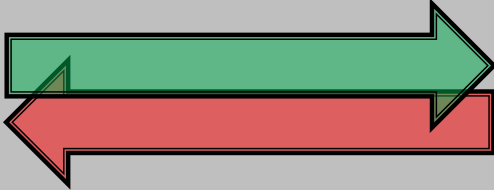


Agenda

- ▶ 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 ref
out		Parameter cannot be read. Parameter must be assigned. Call site must also specify out
in		Parameter is "copied". Parameter cannot be modified! Call site can optionally specify in . ~ "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

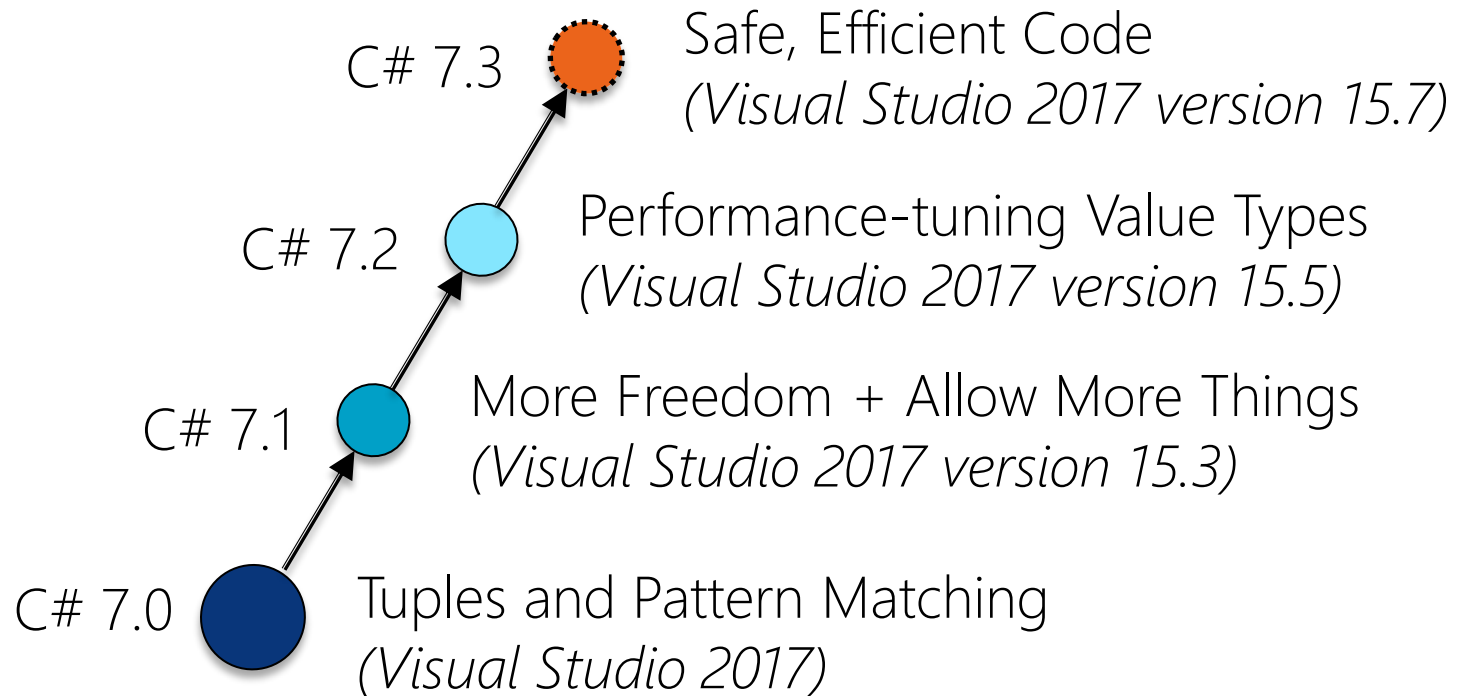
- Is visible to types in same assembly
- Is visible to derived classes (in same or other assemblies)



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 System.ValueType
<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 System.Enum T can now be System.Delegate
<code>where T : Interface</code>	T must implement the interface <i>Interface</i>
<code>where T : unmanaged</code>	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

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



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