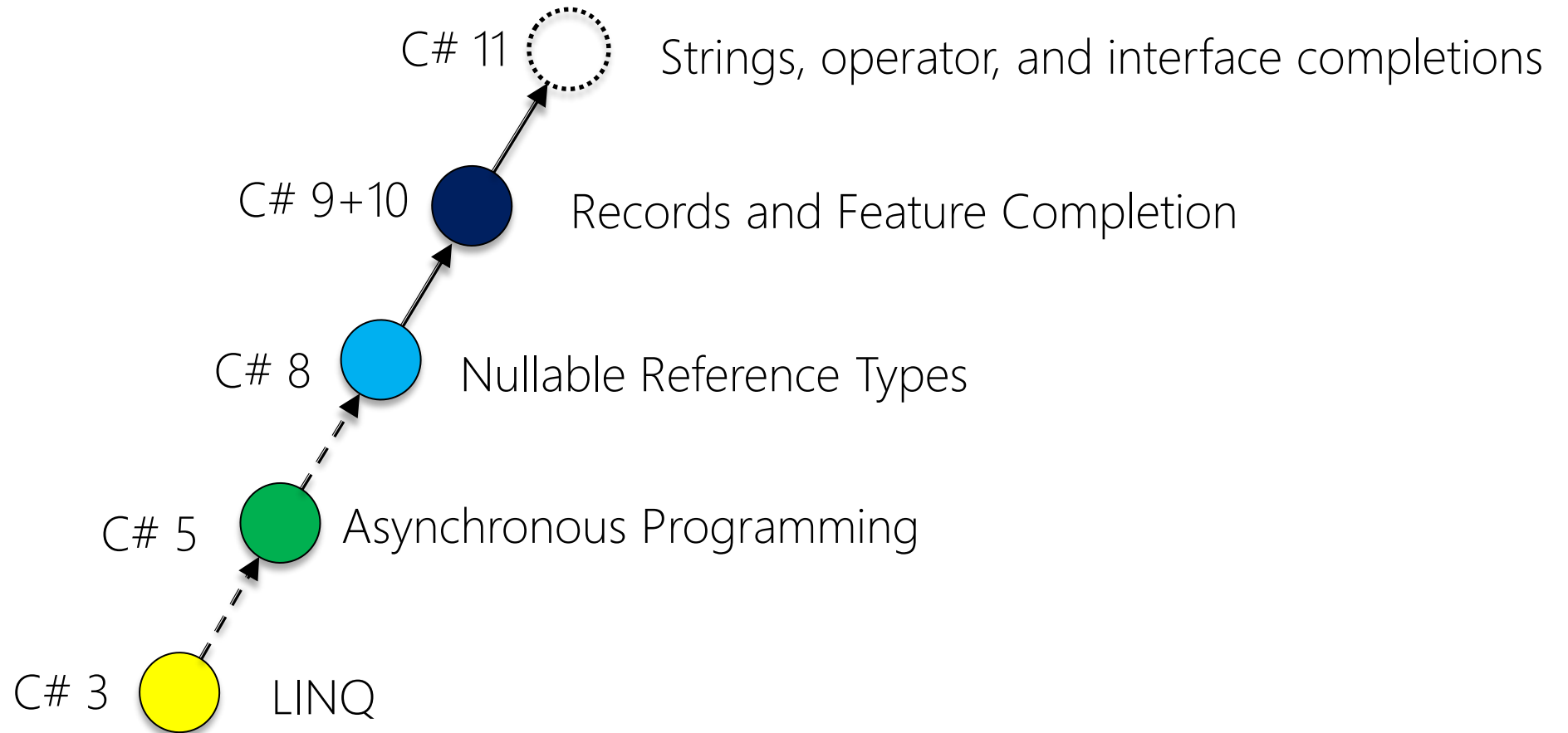


Module 02:

"What's New in C# 11?"



Major Evolutions of C#



Agenda

- ▶ Introduction
- ▶ **String Improvements**
- ▶ Expression Improvements
- ▶ Object-Oriented Improvements
- ▶ Math and Operators
- ▶ Zzzzz...
- ▶ Summary



Raw String Literals

- ▶ Strings now support multi-line string literals using `"""`

```
string s = """  
    Hello,  
    "World"  
    """;
```

```
Console.WriteLine(s);
```

- ▶ Excellent for e.g. JSON or XML string literals
- ▶ Blocks of n `'`'s in strings can be escaped using $n+1$ `'`'s in begin and end
- ▶ Indentions can also be controlled by ending white-space before `"""`



What about String Interpolation?

- ▶ String interpolation proceeds as usual, but might need `$$` and `{{}}` (or more 😊)

```
string firstName = "Jesper";  
string lastName = "Gulmann";  
string company = "Wincubate ApS";  
  
string s = $$"  
    {  
        \"firstName\": \"{{firstName}}\",  
        \"lastName\": \"{{lastName}}\",  
        \"company\": \"{{company}}\"  
    }  
\"\"\";
```

- ▶ Note: Line breaks are now allowed within string interpolation expressions!



UTF-8 String Literals

```
ReadOnlySpan<byte> s1 = "Hello"u8;
```

```
ReadOnlySpan<byte> s2 = ""
```

```
    Hello,  
    "World"  
    ""u8;
```

► Note:

- Not strings exactly, but strings already encoded as bytes.
- Not compile-time constants, because `ReadOnlySpan<byte>` cannot be `const`

```
var moreBytes = "Hello, "u8 + "World"u8 + "!!"u8;
```

```
byte[] moreBytesArray = moreBytes.ToArray();
```

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Pattern-matching Enhancements

- ▶ C# 7, 8, 9, and 10 introduced a total of 13 patterns and enhancements
- ▶ C# 11 introduces 3 additional list and string patterns or enhancements:
 - List patterns `[a,b,c]` e.g. `[11,22,33]`
 - Slice (or range) patterns `..` e.g. `[11, ..]`
 - Spans of chars for constant string `"ABC"` e.g. `"ABC"`



List Patterns

- ▶ Can now match sequences against specific element patterns

```
var elements = new int[] { 11, 22, 33 };  
  
Console.WriteLine(elements is [11, 22, 33]);  
Console.WriteLine(elements is [11, 22, 33, 44]);  
Console.WriteLine(elements is [>10, <100, 33 or 44]);
```

- ▶ Works for types which are *countable* and *indexable*
- ▶ Discard pattern `_` can be used to match single elements in list patterns

```
Console.WriteLine(elements is [11, _, 33]);  
Console.WriteLine(elements is [11, _, _, _]);
```



Slice Patterns

- ▶ The Slice (a.k.a. Range) Pattern `..` can be used *at most once* within a list pattern

```
var elements = new int[] { 11, 22, 33 };  
  
Console.WriteLine(elements is [11, ..]);  
Console.WriteLine(elements is [.., 33, 44]);  
Console.WriteLine(elements is [11, ..] or [.., 44]);
```

- ▶ Works for types which are *countable* and *sliceable*
- ▶ Slice elements can also be extracted

```
if( elements is [11, ..var sub, _])  
{  
    // Print sub here  
}
```

Character Span Patterns

- ▶ Since C# 7 we have been able to match strings on a constant string
- ▶ In C# 11 this has been extended to `Span<char>` and `ReadOnlySpan<char>`

```
ReadOnlySpan<char> s1 = "Hello World";  
Console.WriteLine(s1 is "Hello");
```

- ▶ This way the spans will now work in e.g. switches

```
bool IsKnownAbbreviation(Span<char> s) =>  
    s switch  
    {  
        "etc" or "ie" => true,  
        _ => false  
    };
```

Extended **nameof** Scope

- ▶ The scope of **nameof** has been extended to include
 - Type parameter names
 - Parameter names

```
public static void Validate(  
    bool condition,  
    [CallerArgumentExpression(nameof(condition))] string? message = null)  
{  
    if (!condition)  
    {  
        throw new InvalidOperationException($"Argument failed validation: {message}");  
    }  
}
```

- 
- ▶ Works great for attributes!

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Required Members

- ▶ Express that a member must be initialized during construction
 - *Not* required to be initialized to a valid nullable state at the end of the constructor

```
class Person
{
    public required string FirstName { get; init; }
    public string? MiddleName { get; init; }
    public required string LastName { get; init; }
}
```

- ▶ Defer the check to the site of object construction
- ▶ Help address the shortcoming of nullability checks for reference types of C# 8
- ▶ But are actually completely orthogonal to non-nullable reference types
 - Also work for nullable types etc.



[SetsRequiredMembers]

- ▶ Asserts that a specific constructor initializes all required members

```
class Person
{
    ...
    [SetsRequiredMembers]
    public Person(string firstName, string lastName)
    {
        FirstName = firstName;
        LastName = lastName;
    }
}
```

- ▶ Essentially this is the “!” of required members at the constructor level
- ▶ Note: Static analysis does *not* check whether correct!



File Accessibility Modifier

- ▶ New access modifier on type definitions only
 - Restricts visibility to defining *file*

```
file class C
{
    public static void M()
    {
        Console.WriteLine("Hello from File1");
    }
}
```

- ▶ No accessibility modifiers can be used in combination with **file**
- ▶ Overriding rules apply



Static Abstract Members in Interfaces

- ▶ You can add static abstract members in interfaces

```
interface ICanBeEmpty<T>
{
    static abstract T Empty { get; }
}
```

- ▶ Can define static abstract properties, methods, events, and operators
 - We will make crucial use of this in the “Math and Operators” section later!

```
class Person : ICanBeEmpty<Person>
{
    public static Person Empty => new Person { ... };

    ...
}
```

Static Virtual Members in Interfaces

- ▶ Similarly, static virtual members are now allowed in interfaces

```
interface ICanCreateDefault<T> where T : ICanCreateDefault<T>, new()  
{  
    static virtual T CreateDefault() => new();  
}
```

- ▶ Enables polymorphism where the method called depends on the compile-time type rather than the runtime instance type
- ▶ Static members are also allowed to be **sealed**



Auto-default Structs

- ▶ Structs are now default initialized automatically in C# 11 (*if no field initializers*)

```
struct Money
{
    public int Euro { get; set; }
    public int Cents { get; set; }

    public Money()
    {
        Not needed
        Not needed
    }
}
```

Generic Attributes

- ▶ C# 11 finally allows custom generic attributes

```
[AttributeUsage(AttributeTargets.All)]  
public class DeveloperAttribute<T> : Attribute  
{  
    public T Info { get; init; }  
  
    public DeveloperAttribute(T info)  
    {  
        Info = info;  
    }  
}
```



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Generic Math Support

- ▶ Goal: Use mathematical operators in generic types
- ▶ **static abstract** / **virtual** members in interfaces
- ▶ checked user defined operators
- ▶ relaxed shift operators
- ▶ unsigned right-shift operator



INumber<T>

- ▶ Math operators are now generic

```
T MultSequence<T>( IEnumerable<T> sequence ) where T : INumber<T>
{
    T total = T.One;
    foreach (T i in sequence)
    {
        total *= i;
    }
    return total;
}
```



Revisiting Checked Contexts

- ▶ Since C# 1.0 integral-type arithmetic operations have been performed in either
 - **checked** contexts, or
 - **unchecked** contexts

```
int a = int.MaxValue;  
Console.WriteLine(a + 1);
```

Check for arithmetic overflow ?

☐ Throw exceptions when integer arithmetic produces out of range values.

User-Defined Checked and Unchecked Operators

- ▶ As part of the generic math support, we can define custom checked and unchecked operators

```
record struct Money(int Euro, int Cents)
{
    ...
    public static Money operator +(Money left, Money right) =>
        new(left.TotalCents + right.TotalCents);

    public static Money operator checked +(Money left, Money right)
    {
        checked
        {
            return new(left.TotalCents + right.TotalCents);
        }
    }
}
```

Unsigned Right Shift Operator

- ▶ Before C# 11: to force an unsigned right-shift, you would need to
 - cast any signed integer type to an unsigned type
 - perform the shift
 - cast the result back to a signed type
- ▶ C# 11 introduces the new `>>>` called *unsigned right shift operator*

```
int x = -8;  
int y = x >> 2;  
int z = x >>> 2;
```



Relaxing Shift Operator Requirements

- ▶ Before C# 11: constraint for $x \ll y$ or $x \gg y$ was
 - y must be an integer, or
 - y must be implicitly convertible to an integer
- ▶ C# 11 relaxes this constraint to allow the second operand to implementing generic type
 - Or indeed any type 😊

```
record struct Money(int Euro, int Cents)
{
    ...
    public static Money operator <<(Money left, string right) =>
        new(left.TotalCents << right.Length);
}
```

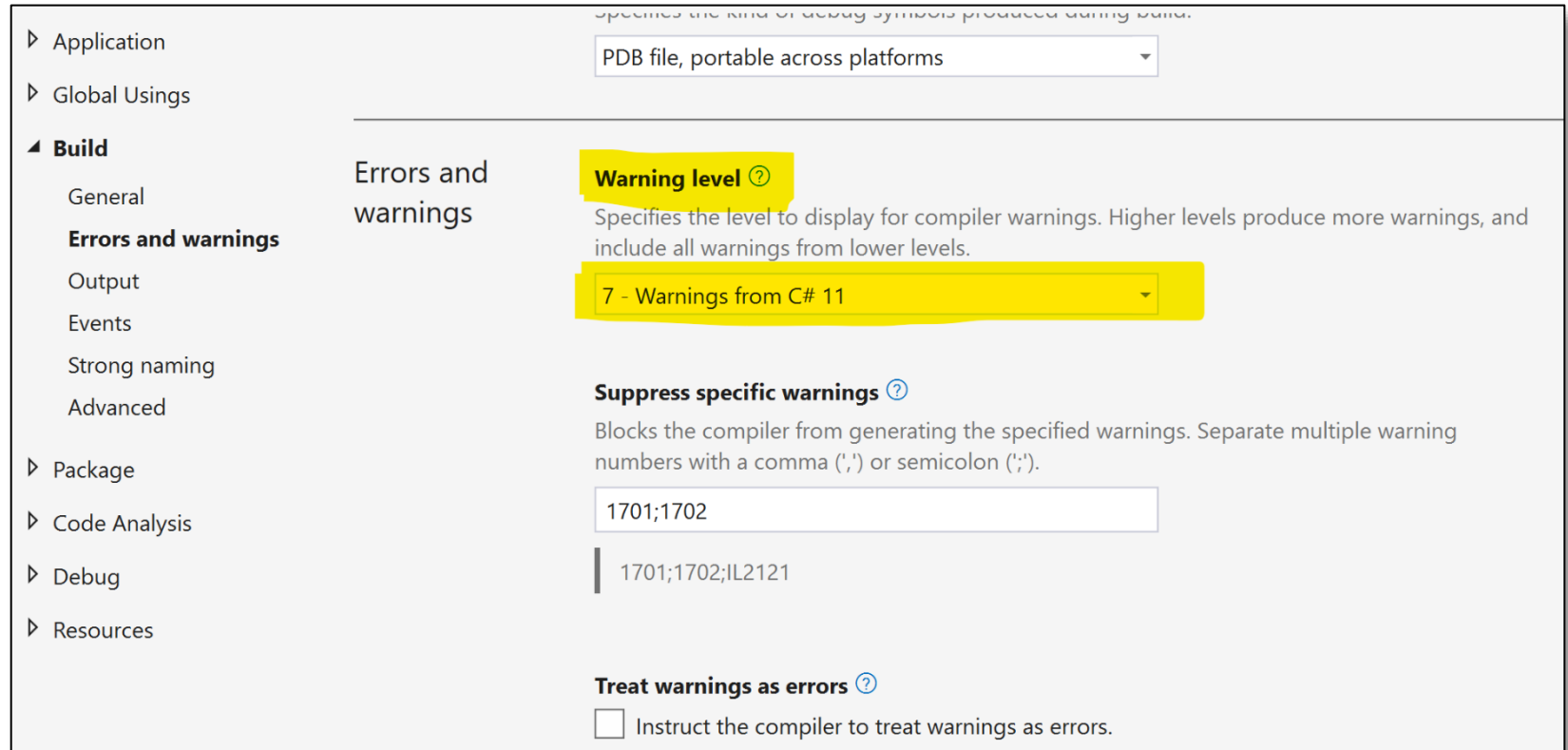
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C# Warning Waves

- ▶ Wave 5 ~ C# 9
- ▶ Wave 6 ~ C# 10
- ▶ Wave 7 ~ C# 11



Specifies the kind of debug symbols produced during build.

PDB file, portable across platforms

Build

- General
- Errors and warnings**
- Output
- Events
- Strong naming
- Advanced

Errors and warnings

Warning level ⓘ

Specifies the level to display for compiler warnings. Higher levels produce more warnings, and include all warnings from lower levels.

7 - Warnings from C# 11

Suppress specific warnings ⓘ

Blocks the compiler from generating the specified warnings. Separate multiple warning numbers with a comma (',') or semicolon (';').

1701;1702

1701;1702;IL2121

Treat warnings as errors ⓘ

☐ Instruct the compiler to treat warnings as errors.

Wave 7

- ▶ Wave 7 consists of just one additional rule:
- ▶ *Any new keywords added for C# will be all lower-case ASCII characters. This warning ensures that none of your types conflict with future keywords. The following code produces CS8981:*

```
class strangelynamedclass
{
    public int X { get; set; }
}
```



ref fields and **scoped ref** variables

- ▶ **ref struct** can now have **ref** fields

```
readonly ref struct Span<T>
{
    readonly ref T _field;
    readonly int _length;

    public Span(scoped ref T value) { ... }
}
```

- ▶ **scoped ref** limits the scope of ref values to e.g. current method



Numeric IntPtr

- ▶ **nint** is now type alias for **System.IntPtr**
- ▶ **nuint** is now type alias for **System.UIntPtr**



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