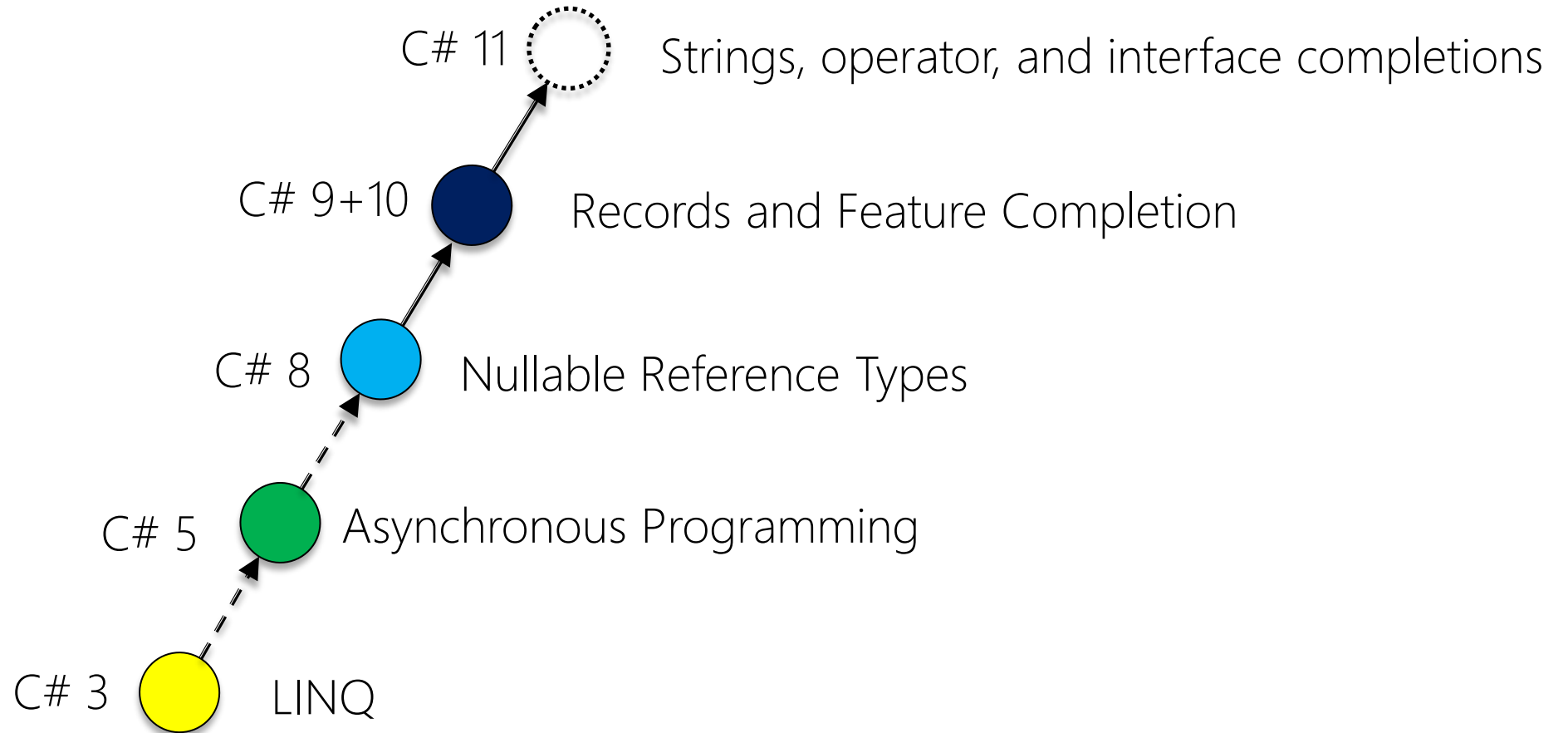


# Module 05:

## "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);
}
```

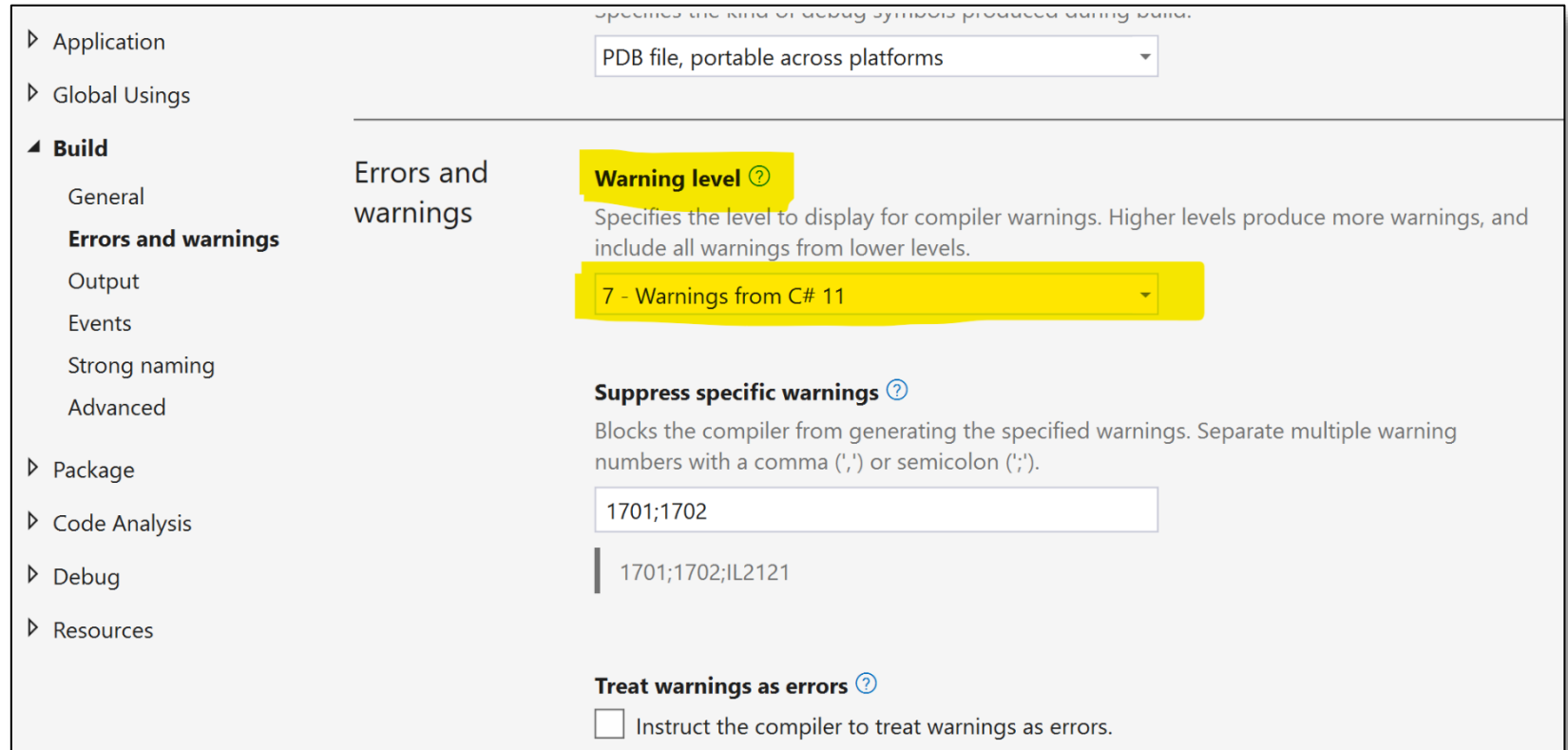
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# C# Warning Waves

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



The screenshot shows the Visual Studio Options dialog, specifically the Build > Errors and warnings section. The left sidebar lists various options, with 'Build' expanded and 'Errors and warnings' selected. The main area shows settings for compiler warnings. The 'Warning level' dropdown is set to '7 - Warnings from C# 11'. The 'Suppress specific warnings' text box contains '1701;1702'. The 'Treat warnings as errors' checkbox is unchecked.

Application  
Global Usings  
**Build**  
    General  
    **Errors and warnings**  
    Output  
    Events  
    Strong naming  
    Advanced  
Package  
Code Analysis  
Debug  
Resources

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**





# Summary

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- ▶ Math and Operators
- ▶ Zzzzzz...



