C# and .NET

From 4.8 Framework to .NET 7

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Sampension Seminar 2024-02-28

Agenda

- **8.00: Part 1: New Features in C# 7 and 8**
  - Recapping C# 7
  - Introducing C# 8
  - Break
  - Lab Session 1
  - More C# 8
- 11.00: Lunch break
- 12.00: Part 2: New Features in C# 9, 10, 11, and 12
- 15:30: Edlund
- 16:00: Seminar Concluded

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- 8.00: Part 1: New Features in C# 7 and 8
  - Recapping C# 7
    - Introduction
    - Value Tuples, Syntax, and Deconstructors
    - Introducing Pattern Matching
    - In Parameter Modifer
    - Spans
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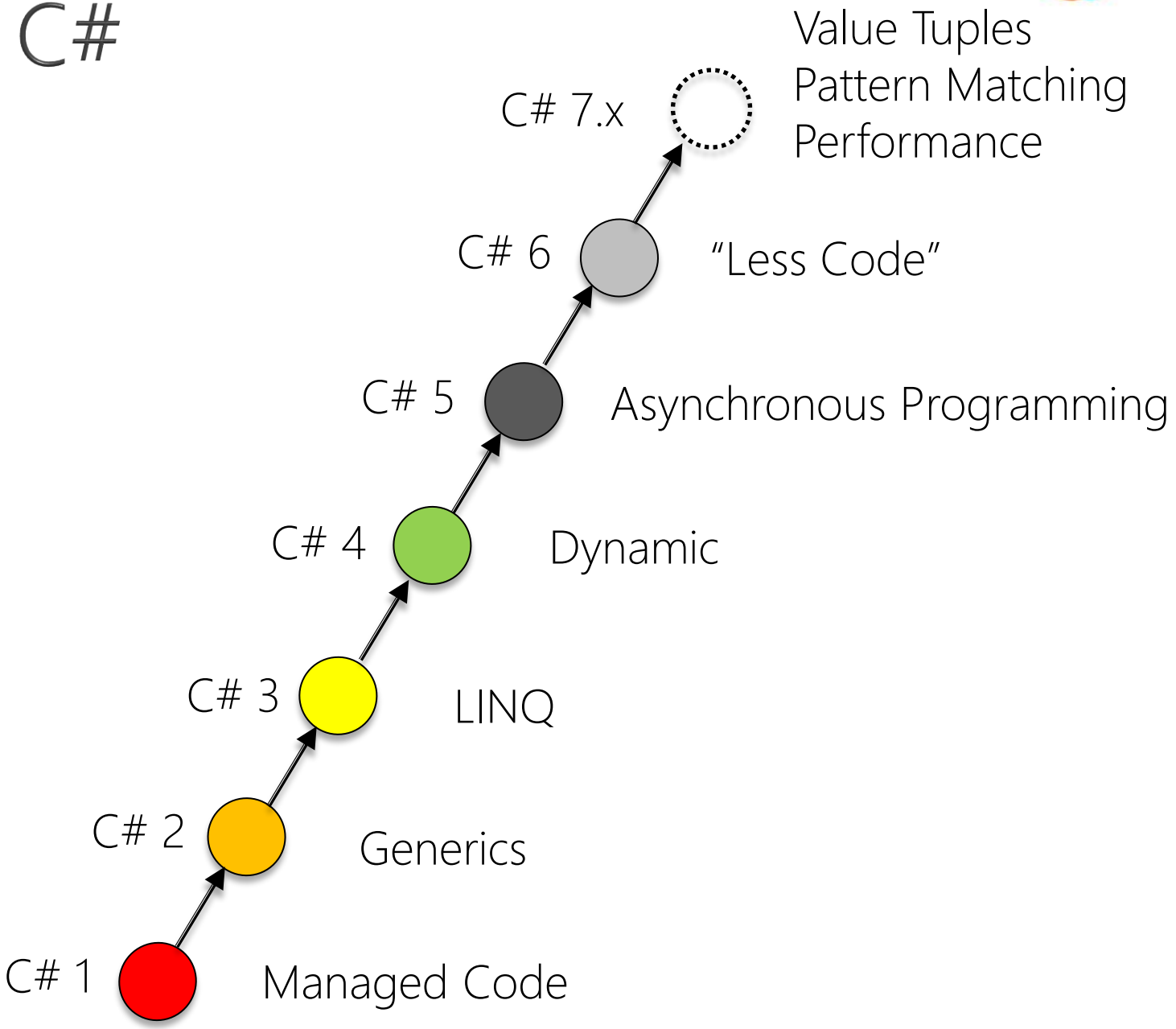
Evolution of C#



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Introducing Tuples

- Not the **Tuple<T1,T2>** type already in .NET 4.0
  - Instead it is a value type with dedicated syntax

```
(int, int) FindVowels( string s )
{
    int v = 0;
    int c = 0;
    foreach (char letter in s)
    {
        ...
    }
    return (v, c);
}
```

```
string input = ReadLine();

var t = FindVowels(input);
WriteLine($"There are {t.Item1} vowels and {t.Item2} consonants in
\"{input}\"");
```

Tuple Syntax, Literals, and Conversion

- Can be easily converted / deconstructed to other names

```
var (vowels, cons) = FindVowels(input);
(int vowels, int cons) = FindVowels(input);
WriteLine($"There are {vowels} vowels and {cons} consonants in ... ");
```

```
(int vowels, int cons) FindVowels( string s )
{
    var tuple = (v: 0, c: 0);
    ...
    return tuple;
}
```

- Tuples can be supplied with descriptive names
- Mutable and directly addressable
- Built-in: **`ToString()`** + **`Equals()`** + **`GetHashCode()`**

Deconstructors

- Can be easily deconstructed to individual parts

```
(int vowels, int cons) = FindVowels(input);
```

```
public class Employee
{
    ...
    public void Deconstruct( out string firstName, out string lastName )
    {
        firstName = FirstName;
        lastName = LastName;
    }
}
```

```
Employee elJefe = new Employee { ... };
var (first, last) = elJefe;
WriteLine(first);
```

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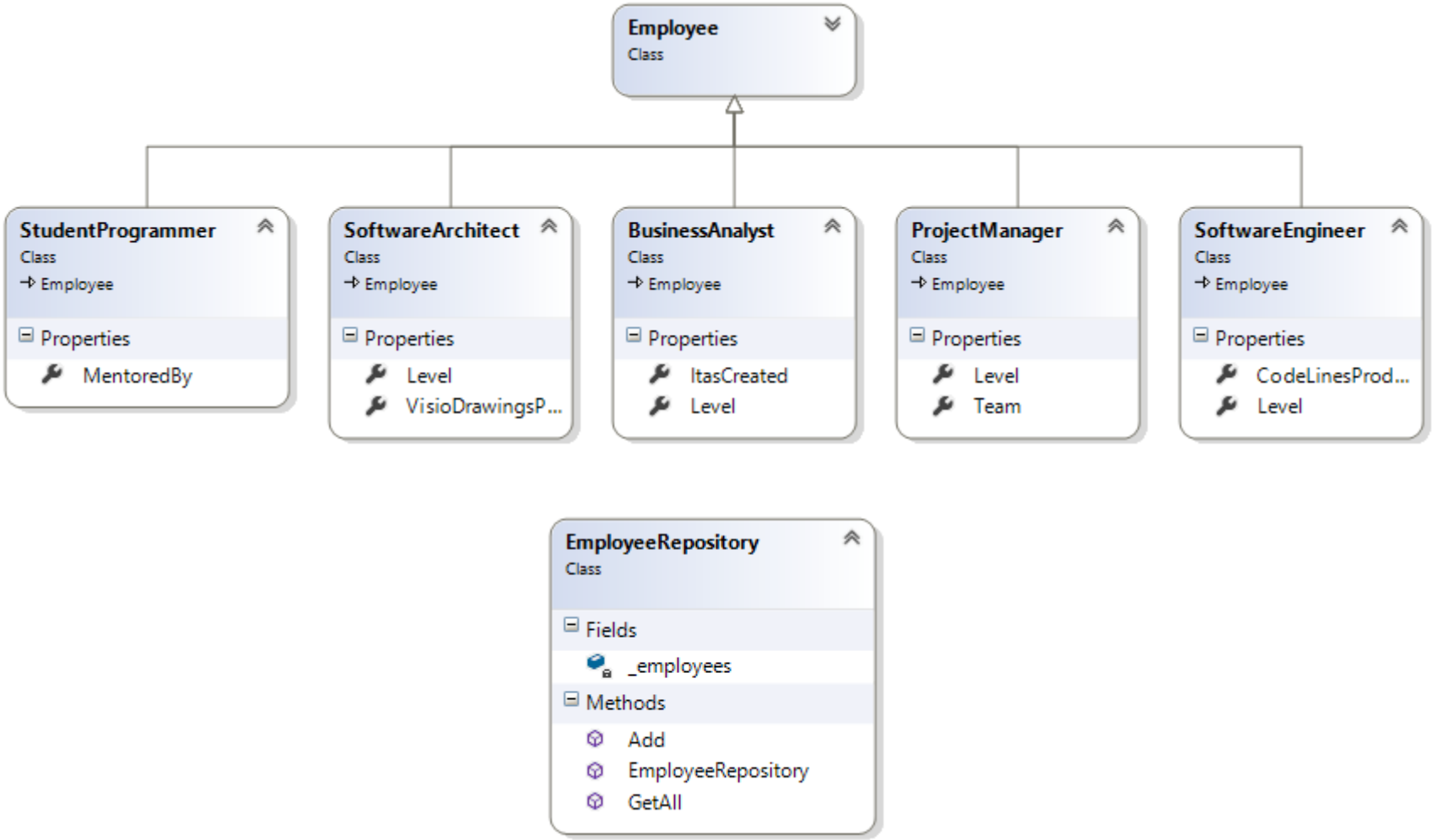
Example: Employee



Pattern Matching with **`is`**

- Three types of patterns for matching in C# 7
  - Constant patterns *c* e.g. **`null`**
  - Type patterns *T x* e.g. **`int x`**
  - Var patterns **`var`** *x*
- Matches and/or captures to identifiers to nearest surrounding scope
- More patterns are introduced in later C# versions

```
foreach (Employee e in all)
{
    if (e is SoftwareEngineer se)
    {
        WriteLine($"{se.FullName} has produced {se.CodeLinesProduced} lines of C#");
    }
}
```

- The **`is`** keyword is now compatible with patterns

Type Switch with Pattern Matching

- Can switch on any type
  - Case clauses can make use of patterns and new **when** conditions

```
Employee e = ...;
switch (e)
{
    case SoftwareArchitect sa:
        WriteLine($"{sa.FullName} plays with Visio");
        break;
    case SoftwareEngineer se when se.Level == SoftwareEngineerLevel.Lead:
        WriteLine($"{se.FullName} is a lead software engineer");
        break;
    case null:
    default:
        break;
}
```

- Cases are no longer disjoint – evaluated sequentially!

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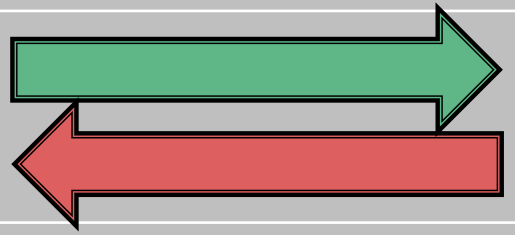
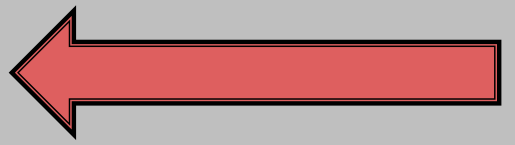
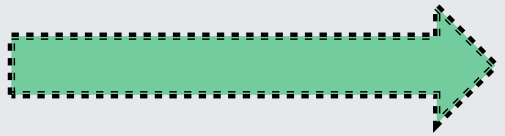
`in` Parameter Modifier

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));
```

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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);
}
```

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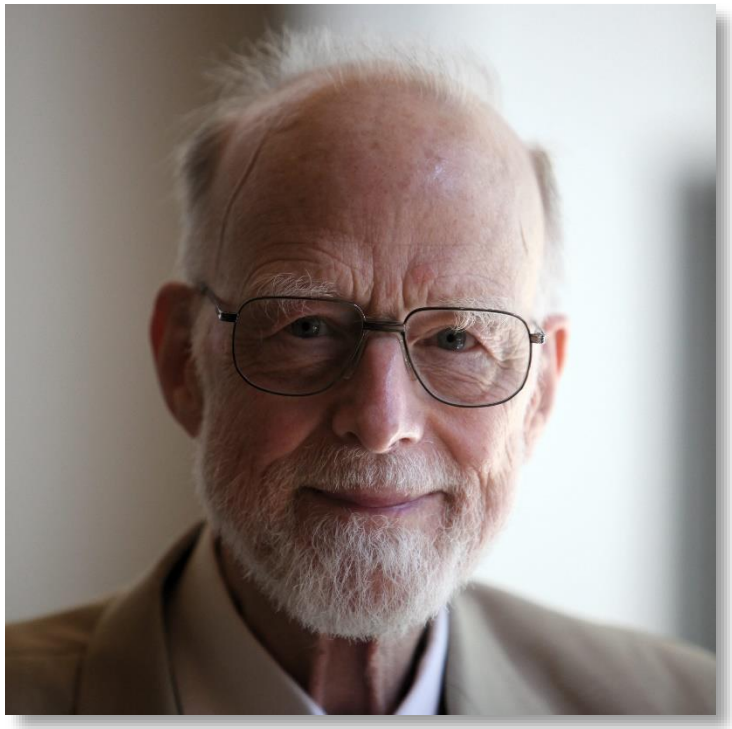
Null References: "The Billion-dollar Mistake"



"I call it my billion-dollar mistake. It was the invention of the null reference in 1965. At that time, I was designing the first comprehensive type system for references in an object oriented language (ALGOL W). My goal was to ensure that all use of references should be absolutely safe, with checking performed automatically by the compiler. But I couldn't resist the temptation to put in a null reference, simply because it was so easy to implement. This has led to innumerable errors, vulnerabilities, and system crashes, which have probably caused a billion dollars of pain and damage in the last forty years."

– Tony Hoare 2009

Introducing Nullable Reference Types

- C# 8 allows declaring intent of reference types
  - *Nonnullable Reference Types*
    - A reference is not supposed to be null
  - *Nullable Reference Types*
    - A reference is allowed to be null

```
class Person
{
    public string  FirstName { get; }  // Non-nullable string
    public string? MiddleName { get; } // Nullable string
    public string  LastName { get; }   // Non-nullable string

    ...
}
```

- Traditionally, C# reference types do not make this distinction!

Static Analysis

- Produces compile-time static analysis warning when
  - Setting a **nonnullable** to null
  - Dereferencing a **nullable** reference

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

    public Person( string firstName ) => FirstName = firstName;

    int GetLengthOfMiddleName( Person p ) => p.MiddleName.Length
}
```

Null-forgiving Operator

- You can assert to the compiler that a reference is not null using the *Null-forgiving Operator* **!**

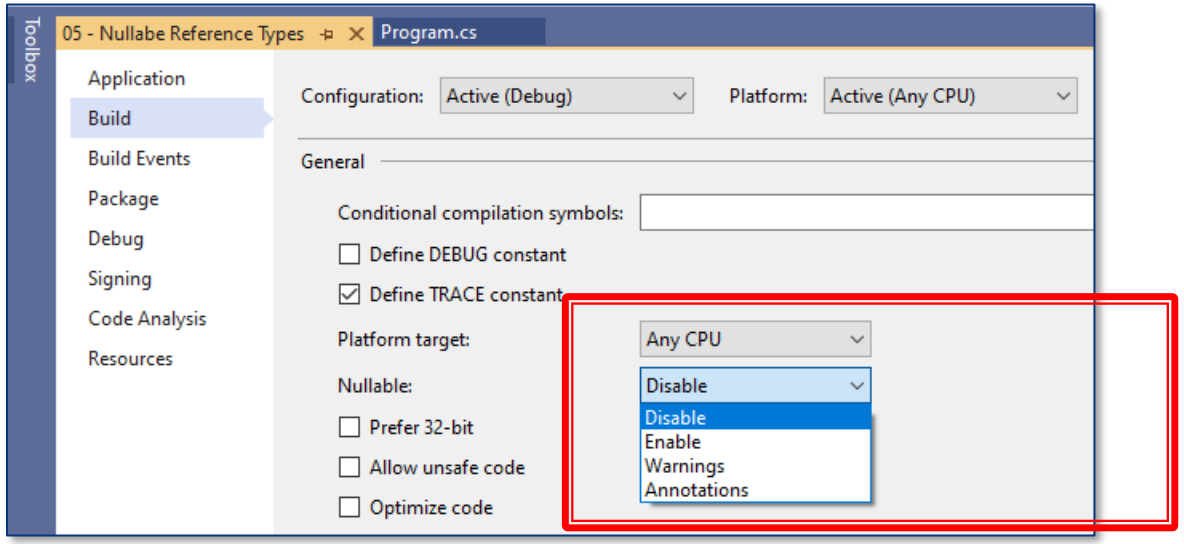
```
class Person
{
    public string FirstName { get; }
    public string? MiddleName { get; }
    public string LastName { get; }

    public Person( string firstName ) => FirstName = firstName;

    int GetLengthOfMiddleName( Person p ) => p.MiddleName!.Length;
}
```

Wait a Minute...!?

- Not Backwards Compatible with C# 7.x!
- Behavior can be controlled in Project Properties



- Nullable Contexts
  - Annotations
  - Warnings

Annotations + Warning Contexts

- Can also be enabled/disabled locally by means of compiler directive **#nullable**
  - **enable** / **disable** / **restore**
  - **warnings** / **annotations**

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

#nullable disable
    public Person( string firstName ) => FirstName = firstName;
#nullable restore
}
```

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Switch Expressions

- A new functionally-inspired **`switch`** expression

```
string? Choose( Employee employee ) =>
      employee switch
      {
          SoftwareArchitect sa => $"Hello, Mr. Architect {sa.LastName}",
          SoftwareEngineer se => "Please code!",
          StudentProgrammer sp => $"Please get coffee, {sp.FirstName}",
          _ => "Have a nice day... :-)"
      }
}
```

- Produces a value, so
  - no fallthrough!
  - **`case`** and **`:`** elements are replaced with **`=>`**
  - **`default`** case is replaced with a **`_`**
  - bodies can only be expressions (not statements!)

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New Patterns for Matching

- C# 7 introduced three patterns for matching
  - Constant patterns *c* e.g. **`null`**
  - Type patterns *T x* e.g. **`int x`**
  - Var patterns **`var`** *x*

- C# 8 introduces three additional patterns for matching
  - Property patterns *Type*{ *p1: v1*, ... , *pn: vn* } e.g. **`{IsValid: false}`**
  - Tuple patterns (*x1*, ... , *xn*) e.g. **`(42, 87)`**
  - Positional patterns *Type*(*x1*, ... , *xn*) e.g. **`Album(s, age)`**

- Moreover, in C# 8 patterns are now be "compositional"!

Property Patterns

- Property patterns match member properties to values

```
string? Evaluate( SoftwareEngineer se ) =>
    se switch
    {
        { Level: Level.Lead } => $"{se.FullName} does great work",
        { Level: Level.Chief } => $"You da boss, {se.FullName}",
        null => "You're not even a software engineer, dude!",
        _ => $"Well done coding SOLID, {se.Level}... :-)"
     }
}
```

- Also works for multiple, simultaneous name-value pairs

Property Patterns Variations

- Can in fact simultaneously match the type as well…

```
string? Evaluate( Employee employee ) =>
    employee switch
    {
        SoftwareEngineer { Level: Level.Lead } => $"...",
        SoftwareArchitect { Level: Level.Chief } => $"...",
        _ => $"Well done making the company thrive... :-)"
     }
}
```

- Not tied to **`switch`** expressions: Also works for **`is`** etc.

Tuple Patterns

- Tuple patterns use two or more values for matching

```
Hand left = GetRandomMember<Hand>();
Hand right = GetRandomMember<Hand>();

Outcome winner = (left, right) switch
{
    (Hand.Paper, Hand.Rock) => Outcome.Left,
    (Hand.Paper, Hand.Scissors) => Outcome.Right,
    (Hand.Rock, Hand.Paper) => Outcome.Right,
    (Hand.Rock, Hand.Scissors) => Outcome.Left,
    (Hand.Scissors, Hand.Paper) => Outcome.Left,
    (Hand.Scissors, Hand.Rock) => Outcome.Right,
    (_,_) => Outcome.Tie
};
```

Positional Patterns

- Positional patterns use deconstructors for matching

```
Album album = new Album(
    "Depeche Mode",
    "Violator",
    new DateTime(1990, 3, 19)
);

string description = album switch
{
    Album(_, string s, int age) when age >= 25 => $"{s} is vintage <3",
    Album(_, string s, int age) when age >= 10 => $"{s} is seasoned",
    Album(_, string s, _) => $"{s} is for youngsters only! ;-)"
};
```

- Can be simplified using **`var`**

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Lab Session 1

- Lab 1.1
- Lab 1.2

- If you are **really** quick, feel free to check out any of the following:

- Lab X.3
- Lab X.2
- Lab X.5

github.com/wincubate/sampension-net7

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    - Default Interface Implementations
    - *If Time Permits:* Asynchronous Enumerables and Disposables
    - Using Declarations
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Indices

- The `^` operator describes the end of the sequence

```
string[] elements = new string[]
{
    "Hello", "World", "Booyah!", "Foobar"
};

Console.WriteLine(elements[^1]);
Console.WriteLine(elements[^0]); // ^0 == elements.length
Index i = ^2;
Console.WriteLine(elements[i]);
```

- Indices are captured by a new **`System.Index`** type
  - Can be manipulated using variables etc. as any other type

Ranges

- The .. operator specifies (sub)ranges using indices *i* and *j*
  - **`i..j`** Full sequence (start is inclusive, end is exclusive)
  - **`i..`** Half-open sequence (start is inclusive)
  - **`..i`** Half-open sequence (end is exclusive)
  - **`..`** Entire sequence (equivalent to **`0..^0`**)

```
foreach (var s in elements[0..^2])
{
    Console.WriteLine( s );
}

Range range = 1..;
```

- Ranges are captured by a new **`System.Range`** type
  - Can be manipulated using variables etc. as any other type

Supported Types

`string`	Indices	Ranges
`Array`	Indices	Ranges
`List<T>`	Indices	
`Span<T>`	Indices	Ranges
`ReadOnlySpan<T>`	Indices	Ranges

- Any type that provides an indexer with a `System.Index` or `System.Range` parameter (respectively) explicitly supports indices or ranges

- Compiler will implement some implicit support for indices and ranges

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Default Interface Members

- Allow better backwards compatibility in interfaces

```
interface ILogger
{
    void Log(LogLevel level, string message);
    void Log(Exception ex) => Log(LogLevel.Error, ex.ToString());
}
```

```
class FileLogger : ILogger
{
    public void Log(LogLevel level, string message) { ... }
}
```

```
class ConsoleLogger : ILogger
{
    public void Log(LogLevel level, string message) { ... }
    public void Log(Exception ex) { ... }
}
```

Static Members in Interfaces

```
interface ILogger
{
    static string ProduceExceptionLog(Exception exception) =>
                $"Exception occurred: {exception.Message}. " +
                $"Call stack size: {exception.StackTrace?.Length ?? 0}";

    void Log(LogLevel level, string message);
    void Log(Exception ex) =>
        Log(LogLevel.Error, ProduceExceptionLog(ex));
}
```

```
class ConsoleLogger : ILogger
{
    public void Log(Exception ex)  =>
        ... ILogger.ProduceExceptionLog(exception) ...
    ...
}
```

C# 8 Interfaces vs. Classes

- Default interface members cannot be invoked on concrete classes – only through the interface!
  - Bears resemblance to explicit interface implementation
- But…

- Static members can have access modifiers in interfaces..!
  - Default access modifier on interface members: `public`
  - Default access modifier on class members: `private`

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New C# 8.0 Async Features

- Use new types only in .NET Core 3.x, .NET 5, 6, and 7

- Async Enumerables a.k.a. "Async Streams"
- **`await foreach`** keyword
- Async Disposables
- **`await using`** keyword

IEnumerable<T>

- The traditional **IEnumerable<T>** designates a sequence for use with **foreach** or LINQ.

```
namespace System.Collections.Generic
{
    interface IEnumerable<out T> : IEnumerable
    {
        IEnumerator<T> GetEnumerator();
    }
}
```

```
interface IEnumerator<T>
{
    T Current { get; }
    bool MoveNext();
    void Reset();
}
```

IAsyncEnumerable<T>

- **IAsyncEnumerable<T>** designates an asynchronous sequence for use with **await foreach**

```
namespace System.Collections.Generic
{
    interface IAsyncEnumerable<out T>
    {
        IAsyncEnumerator<T> GetEnumerator(CancellationToken cts = default);
    }
}
```

```
interface IAsyncEnumerator<T>
{
    T Current { get; }
    ValueTask<bool> MoveNextAsync();
}
```

Example of Async Stream

```
async IAsyncEnumerable<string> GetWordsAsync(string[] urls)
{
    foreach (var url in urls)
    {
        WebClient wc = new WebClient();
        string result = await wc.DownloadStringTaskAsync(url);
        yield return result.Substring(0, 256);
    }
}
```

```
string[] urls = new string[] { ... };
await foreach (string s in GetWordsAsync(urls))
{
    Console.WriteLine(s);
}
```

IDisposable

- Traditionally, .NET has **IDisposable** interface built-in for implementing Dispose Pattern

```
public interface IDisposable
{
    void Dispose();
}
```

- The **using** keyword can be applied to ensure **Dispose()** is always invoked.

IAsyncDisposable

- Now, for asynchronous disposal .NET Core 3.x has **IDisposableAsync** interface built-in for implementing Dispose Pattern

```
public interface IAsyncDisposable
{
    ValueTask DisposeAsync();
}
```

- The **await using** keyword can be applied to ensure **DisposeAsync()** is always invoked.

Example of Async Disposables

```
class Connection : IAsyncDisposable
{
    public async ValueTask DisposeAsync()
    {
        ...
        await DisconnectAsync();
        ...
    }
}
```

```
await using (var connection = new Connection())
{
    await connection.ConnectAsync();
    // Do stuff...
}
```

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Using Declarations

- Instruct compiler to dispose at the end of the scope

```
using FileStream inStream = File.OpenRead(sourceFilePath);
using FileStream outStream = File.Create(destinationFilePath);
using DeflateStream compress = new DeflateStream(
    outStream, CompressionMode.Compress );

for (int i = 0; i < inStream.Length; i++)
{
    compress.WriteByte((byte)inStream.ReadByte());
}

// inStream, outStream, compress are disposed here at the end of the scope!
```

- Also works for the new async disposables **`await using`**!

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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**
- Compiler generates more optimized code for these values

Read-only Members for Structs

- C# 7.2 allowed the **`readonly`** modifier on structs
- C# 8 makes this more fine-grained

```
struct Point3D
{
    public Point3D(double x, double y, double z) { ... }
    public readonly override string ToString() =>
        $"({X},{Y},{Z}) at distance {DistanceFrom()} from (0,0,0)";
    public readonly double DistanceFrom(in Point3D other = default)
    {
        double xDiff = X - other.X;
        double yDiff = Y - other.Y;
        double zDiff = Z - other.Z;
        return Sqrt(xDiff * xDiff + yDiff * yDiff + zDiff * zDiff);
     }
}
```

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- **12.00: Part 2: New Features in C# 9, 10, 11, and 12**
  - C# 9
  - C# 10
  - Break
  - Lab Session 2
  - C# 11
  - C# 12
  - Framework Improvements
- 15:30: Edlund
- 16:00: Seminar Concluded

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    - Init-only Setters
    - Record Classes
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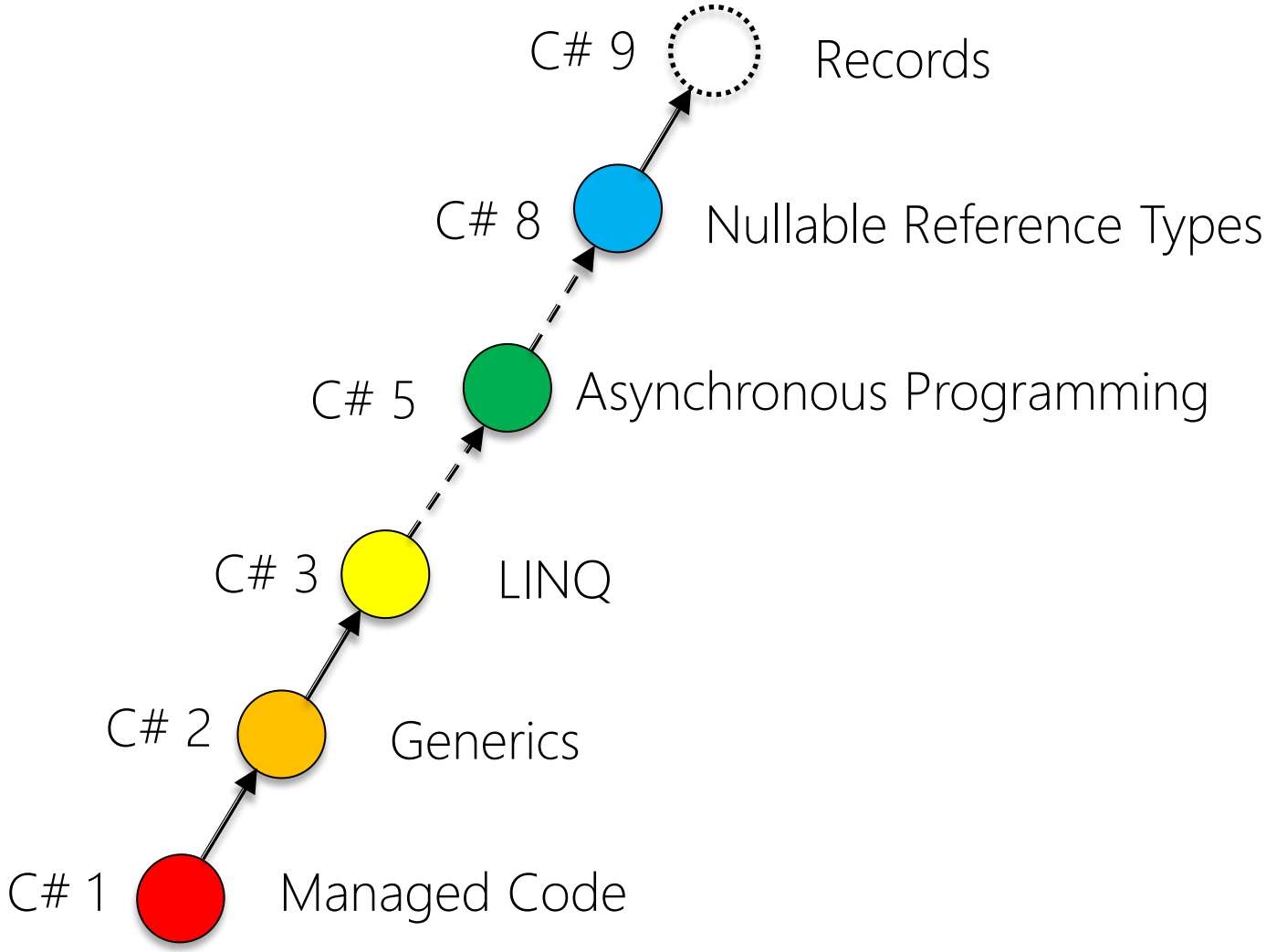
Major Evolutions of C#



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Records

- Records are simpler, immutable classes

```
record Person(string FirstName, string LastName);
```

- Defines init-only properties with “Primary Constructors”

- Can have additional properties + methods, of course

```
record Album(string Artist, string AlbumName, DateTime ReleaseDate)
{
    public int Age
    {
        get { ... }
    }
}
```

Built-in Features of Records

- Overrides
  - `ToString()`
  - `Equals()` (Implements `IEquatable<T>`)
  - `GetHashCode()`
  - `==` and `!=`
- What about `ReferenceEquals`?
- Supplies built-in deconstructors

Mutation-free Copying

- Additional keyword: Create copies using **with**

```
Album album = new Album("Prince",
                        "Purple Rain",
                        new DateTime(1984, 11, 02));

Album renamed = album with
{
    Artist = "The Artist Formerly Known as..."
};
```

- Does not mutate source record
  - Copies and replaces

Records and Inheritance

- Almost all OO aspects are identical to classes
  - Visibility, parameters, etc.
  - But Records and Classes cannot mix inheritance!

- Can override and change built-in method overrides, if needed

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Top-level Statements

- A fundamental rule of C# has now been relaxed:

```
using System;
namespace Wincubate.CS9.B
{
    class Program
    {
        static void Main(string[] args)
        {
            Console.WriteLine("Hello World!");
        }
    }
}
```

- But what about the arguments then?

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C# 9 Pattern Matching Enhancements

- C# 7 and 8 introduced a total of 6 patterns

- C# 9 introduces 6 additional patterns or enhancements:

• Type patterns	*Type*	e.g.	`int`
• Negation patterns	not *P1*	e.g.	`not null`
• Parenthesized patterns	(*P*)	e.g.	`(string)`
• Conjunctive patterns	*P1 and P2*	e.g.	`A and (not B)`
• Disjunctive patterns	*P1 or P2*	e.g.	`int or string`
• Relational patterns	*P1* < *P2*	e.g.	`< 87`
	P1 <= *P2*	e.g.	`<= 87`
	P1 > *P2*	e.g.	`> 87`
	P1 >= *P2*	e.g.	`>= 87`

Type Patterns

- This is more or less only a compiler-theoretic enhancement
  - But now it "mixes better" with the new or compound patterns

```
object o1 = 87;
object o2 = "Yeah!";

var t = (o1, o2);

if (t is (int, string))
{
    Console.WriteLine("o1 is an int and o2 is a string");
}
```

Negation Patterns

- At last(!) we are allowed negative pattern assertions

```
public void DoStuff(object o)
{
    if( o is not null )
    {
        Console.WriteLine(o);
    }
}
```

Parenthesized Patterns

- This is simply a means to disambiguate parsing
  - Carries not semantic meaning in itself

```
public string WhatIsIt(object o) =>
    o switch
    {
        (((string))) => "string",
        (((int))) => "int",
        _ => "Something else :-)",
     };
```

- But has tremendous significance for the other patterns following shortly…

Conjunctive Patterns

- Conjunctive patterns specify an **and** between patterns

```
string evalution = employee switch
{
    (not ProjectManager) and (not StudentProgrammer) =>
        "Codes a little",
    _ => "Probably codes a bit more..."
};

Console.WriteLine($"{employee.FullName}: {evalution}");
```

Disjunctive Patterns

- Disjunctive patterns specify an **`or`** between patterns

```
IEnumerable<object> elements = new List<object>
{
    42, "Yay", 87.0, "Nay", 12.7m
};

foreach (var o in elements)
{
    Console.WriteLine(o switch {
        int or double or decimal => $"{o} is a number",
        _ => "Not a number..."
    });
}
```

Relational Patterns

- The relational patterns are all the “usual” comparisons
  - **<** , **<=** , **>** , **>=**

```
int temperature = int.Parse(Console.ReadLine());
string forecast = temperature switch
{
    <= 0 => "Freezing...",
    < 12 => "Autumn-like",
    <= 19 => "Spring-ish",
    <= 40 => "Summer!",
    _ => "Death Valley?"
};
```

- Note that there is no **=>**

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Target-typed New

- Target-typed new expressions are essentially the "counterpart" of **`var`**

```
Dictionary<string, List<int>> field = new()
{
   { "item1", new() { 1, 2, 3 } }
};
```

- There are a number of disallowed scenarios:
  - Interfaces
  - Enums
  - Dynamic types
  - Tuples
  - …

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Covariant Return Types

- Return types for methods are now relaxed to covariance

```
public class ConfigProvider
{
   public virtual Config GetConfig() { ... }
}

public class AppleConfigProvider : ConfigProvider
{
    public override AppleConfig GetConfig() { ... }
}
```

- Must exist an implicit conversion

- What about interface, strings, int, doubles, … ?

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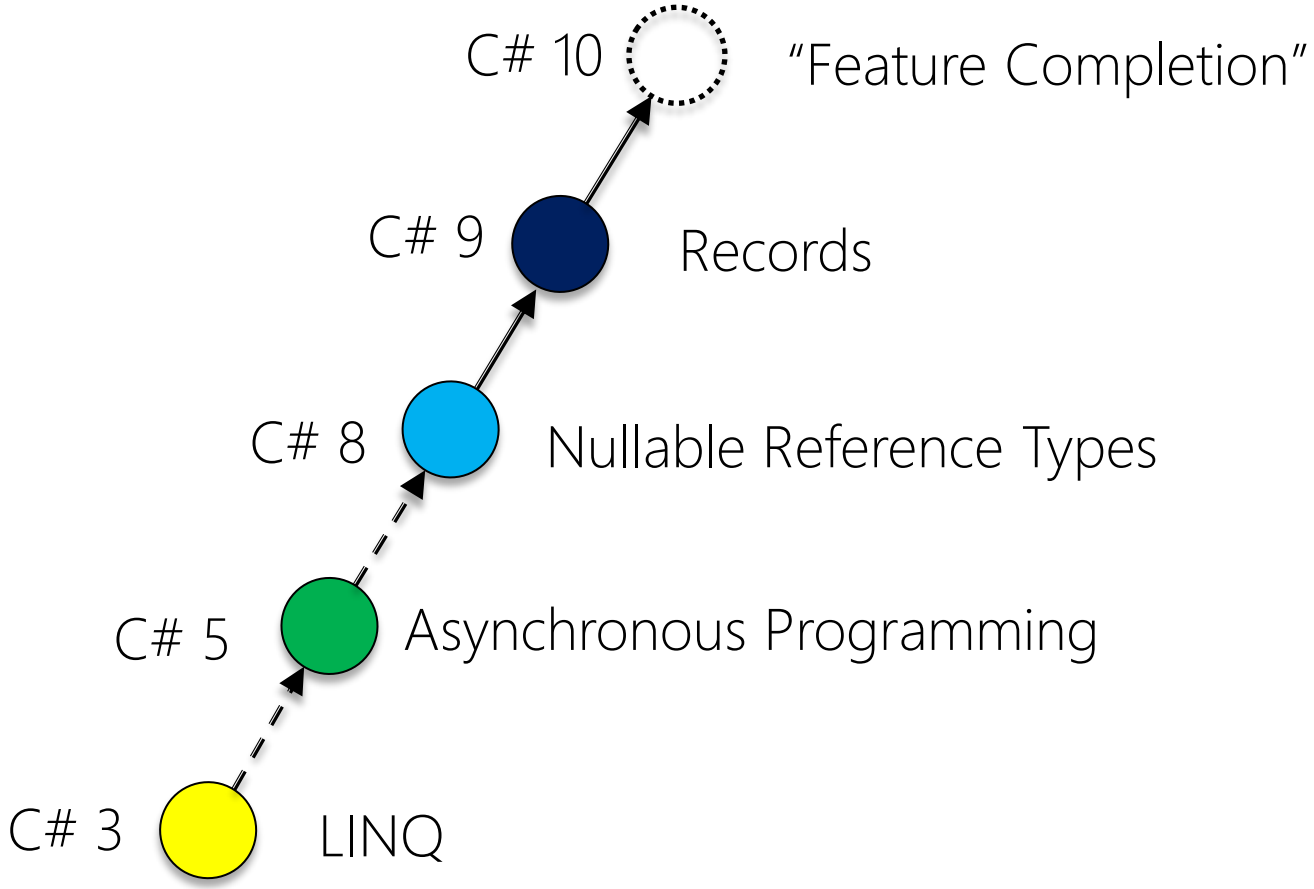

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File-scoped Namespace Declarations

- In spirit of the **`using`** directive, the **`namespace`** declarations have been "horizontally optimized" similarly

```
namespace Wincubate.CS10.Shapes;

interface IShape
{
    double Area { get; }
}

class Rectangle : IShape
{
    ...
}
```

- How often do you have multiple namespaces in same file?

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Global Using Directives

- Project-wide **`using`** directives are now supported

```
global using System.Text.Json;

namespace Wincubate.CS10.Shapes;

record Rectangle(double Width, double Height) : IShape
{
    public double Area => Width * Height;

    public string Serialize() => JsonSerializer.Serialize(this);
}
```

- Also works for **`using static`**

Implicit Usings

- Implicit **`using`**s are enabled in project file for **new** projects

```
<Project Sdk="Microsoft.NET.Sdk">

  <PropertyGroup>
    <OutputType>Exe</OutputType>
    <TargetFramework>net6.0</TargetFramework>
    <RootNamespace>Wincubate.CS10.A</RootNamespace>
    <ImplicitUsings>enable</ImplicitUsings>
    <Nullable>enable</Nullable>
  </PropertyGroup>

</Project>
```

- .NET libraries supply default implicit **`using`**s

Custom Implicit Usings

- You can configure your custom implicit **`using`**s

```
<Project Sdk="Microsoft.NET.Sdk">
  ...
 <ItemGroup Condition="'$(ImplicitUsings)' == 'enable'">
    <Using Remove="System.Threading" />
    <Using Include="System.Text.Json" />
    <Using Include="Wincubate.CS10.Shapes" />
    <Using Static="true" Include="System.Console"/>
  </ItemGroup>

</Project>
```

- An alternative to **`GlobalUsings.cs`** or similar

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C# 10 Object-oriented Topology

- Value Types:
- `struct`
  - `record struct`

- Reference Types:
- `class`
  - `record class`

- Anonymous Types

Record Structs and Record Classes

- Use **`record struct`** for "value-type records"

```
Money m1 = new(87, 25);
Money m2 = new(87, 25);

Console.WriteLine(m1 == m2);

record struct Money( int Euro, int Cents)
{
    public int TotalCents => Euro * 100 + Cents;
}
```

- Use **`record`** or **`record class`** for "reference-type records"

Comments on Record Structs

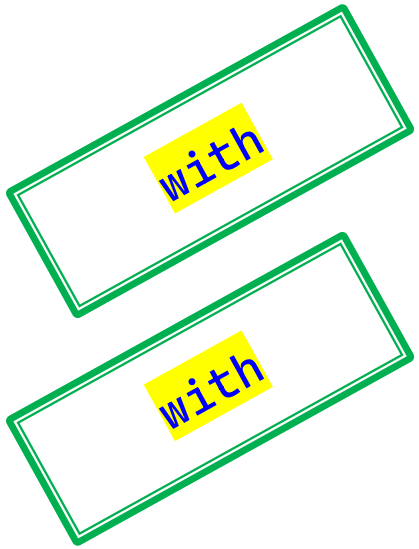
- **`record class`**
  - Immutable for primary constructor parameters
  - Mutable for other properties
- **`record struct`**
  - Mutable for primary constructor parameters
  - Mutable for other properties

- However, thinking back to C# 7.x:

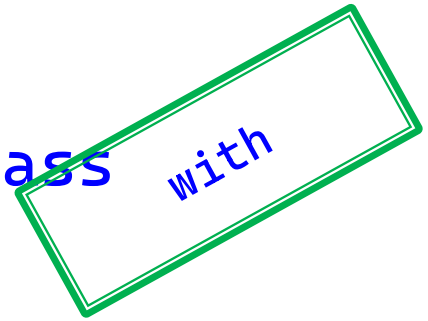
- **`readonly record struct`**
  - Immutable for primary constructor parameters
  - Other properties are not allowed to be mutable!

C# 10 Non-destructive Mutation

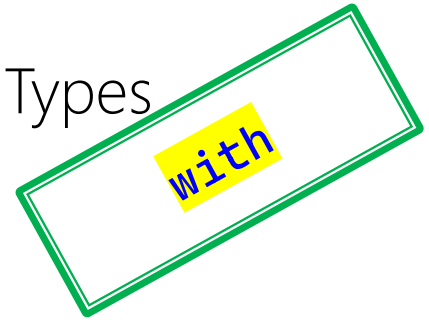
- Value Types:
  - `struct`
  - `record struct`



- Reference Types:
  - `class`
  - `record class`



- Anonymous Types



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LINQ Additions in .NET 6 Overview

- **`ElementAt<T>`** and **`ElementAtOrDefault<T>`**
  - New support for **`Index`**
- **`Take<T>`**
  - New support for **`Range`**

- ***`Xxx`*`OrDefault<T>`**
  - New support for supplying default
- **`Zip<T>`**
  - New support for three enumerables

- New **`Chunk<T>`** method
- New **`DistinctBy<T>`**, **`MinBy<T>`** and **`MaxBy<T>`** methods
- New **`UnionBy<T>`**, **`IntersectBy<T>`**, and **`ExceptBy<T>`**
- New **`TryGetNonEnumeratedCount<T>`**

LINQ Additions in .NET 6 for Movie Lovers ☺

```
IEnumerable<Movie> movies = new List<Movie>
{
    new("Total Recall", 2012, 6.2f),
    new("Evil Dead", 1981, 7.5f),
    new("The Matrix", 1999, 8.7f),
    new("Cannonball Run", 1981, 6.3f),
    new("Star Wars: Episode IV - A New Hope", 1977, 8.6f),
    new("Don't Look Up", 2021, 7.3f),
    new("Evil Dead", 2013, 6.5f),
    new("Who Am I", 2014, 7.5f),
    new("Total Recall", 1990, 7.5f),
    new("The Interview", 2014, 6.5f)
};
```

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Lab Session 2

- Lab 2.1
- Lab 2.2

- If you are **really** quick, feel free to check out any of the following:

- Lab X.9
- Lab X.8
- Lab X.7

github.com/wincubate/sampension-net7

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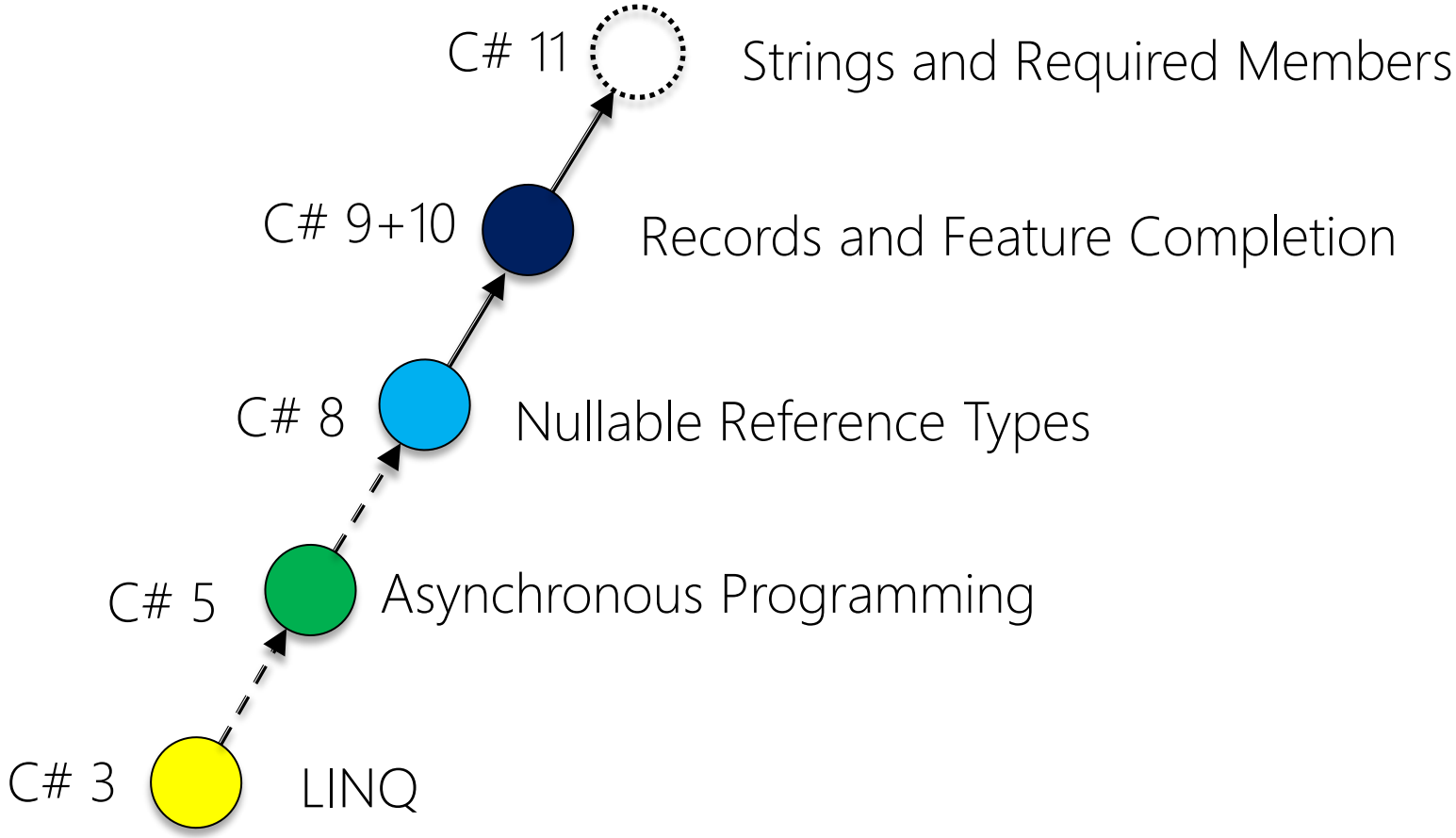

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Raw String Literals

- 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 """

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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
}
```

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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!

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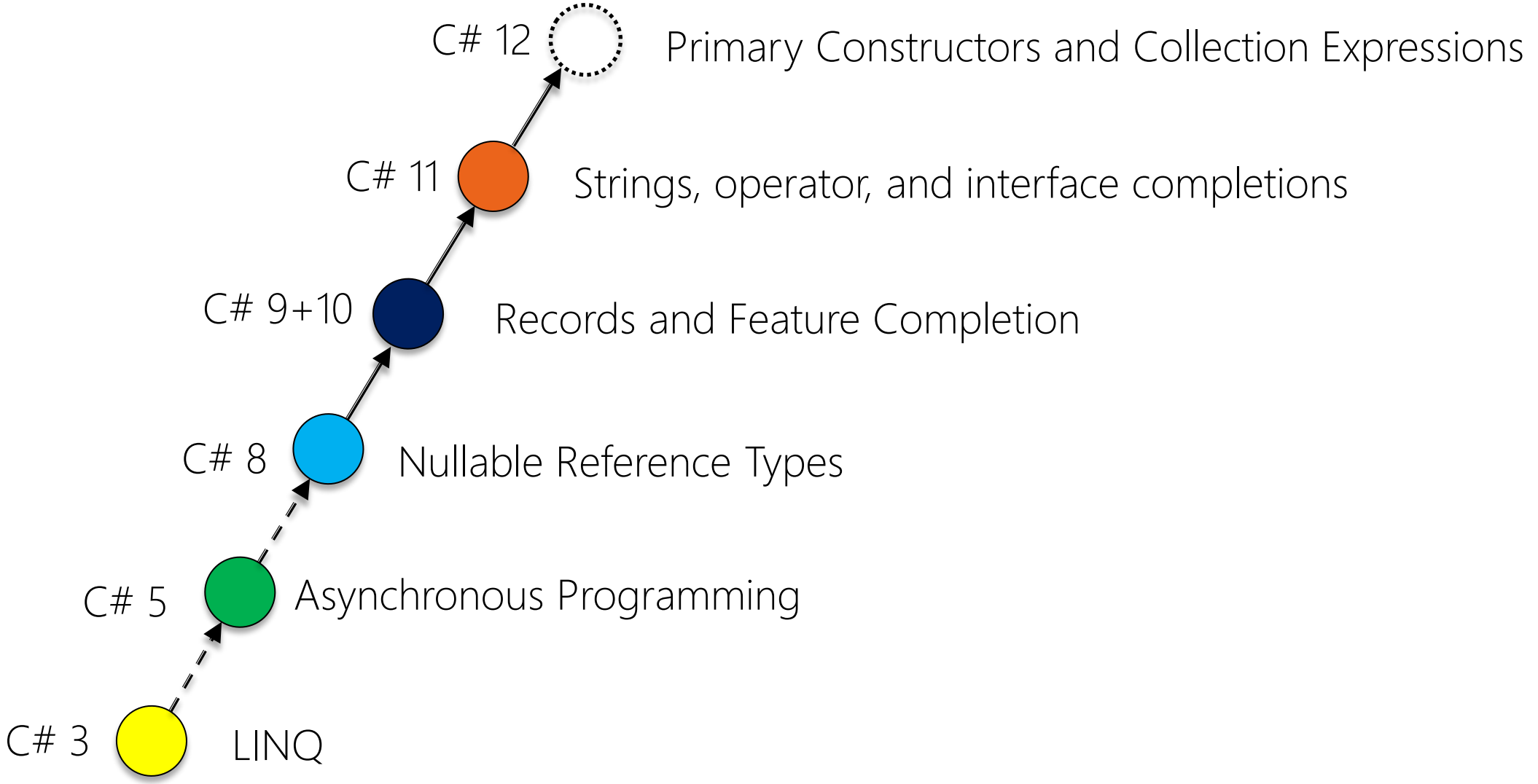

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Introducing Primary Constructors

- Classes can now have *primary constructors*

```
class BankAccount(decimal initialBalance)
{
    public decimal Balance { get; private set; } = initialBalance;

    public void Deposit(decimal amount) => Balance += amount;
}
```

- Looks like the primary constructors for records…
  - …but not identical!

- Note: Constructor parameters available throughout entire type

Constructor Chaining

- Primary constructor must be at the top of the constructor chain

```
class BankAccount(decimal initialBalance)
{
    public decimal Balance { get; private set; } = initialBalance;

    public BankAccount() : this(0)
    {
    }
}
```

- All other usual rules regarding constructor chaining apply
  - E.g. for inheritance

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Collection Expressions

- Unified collection syntax across a multitude of collection types

```
class LookupTable(List<string> elements, Func<string, string> mapping)
{
    public LookupTable() : this([], s => s) {}

    public string Get(Index index) => mapping(elements[index]);
}
```

```
List<string> elements = ["Hello", "World", "Booyah"];
```

- Essentially the construction syntax corresponding to the matching syntax of C# 11

Supported Collection Types

- Arrays
- `Span<T>` and `ReadOnlySpan<T>`
- Types with collection initializer, such as `List<T>` and `Dictionary<K, V>`
- (and actually more such as `ImmutableArray<T>` and custom types)

```
int[] array = [1, 2, 3, 4, 5, 6, 7, 8];
List<string> list = ["one", "two", "three"];
Span<char> span = ['a', 'b', 'c', 'd', 'e', 'f', 'h', 'i'];
int[][] array2d = [[1, 2, 3], [4, 5, 6], [7, 8, 9]];

// Create an enumerable? (WTF?!)
IEnumerable<int> enumerable = [1, 2, 3];
```

Spread Operator

- The *spread operator* replaces its argument with the elements from that collection

```
int[] row0 = [1, 2, 3];
int[] row1 = [4, 5, 6];
int[] row2 = [7, 8, 9];

int[] all = [.. row0, .. row1, .. row2];

foreach (var element in all)
{
    Console.WriteLine(element);
}
```

- Argument must be an enumerable expression

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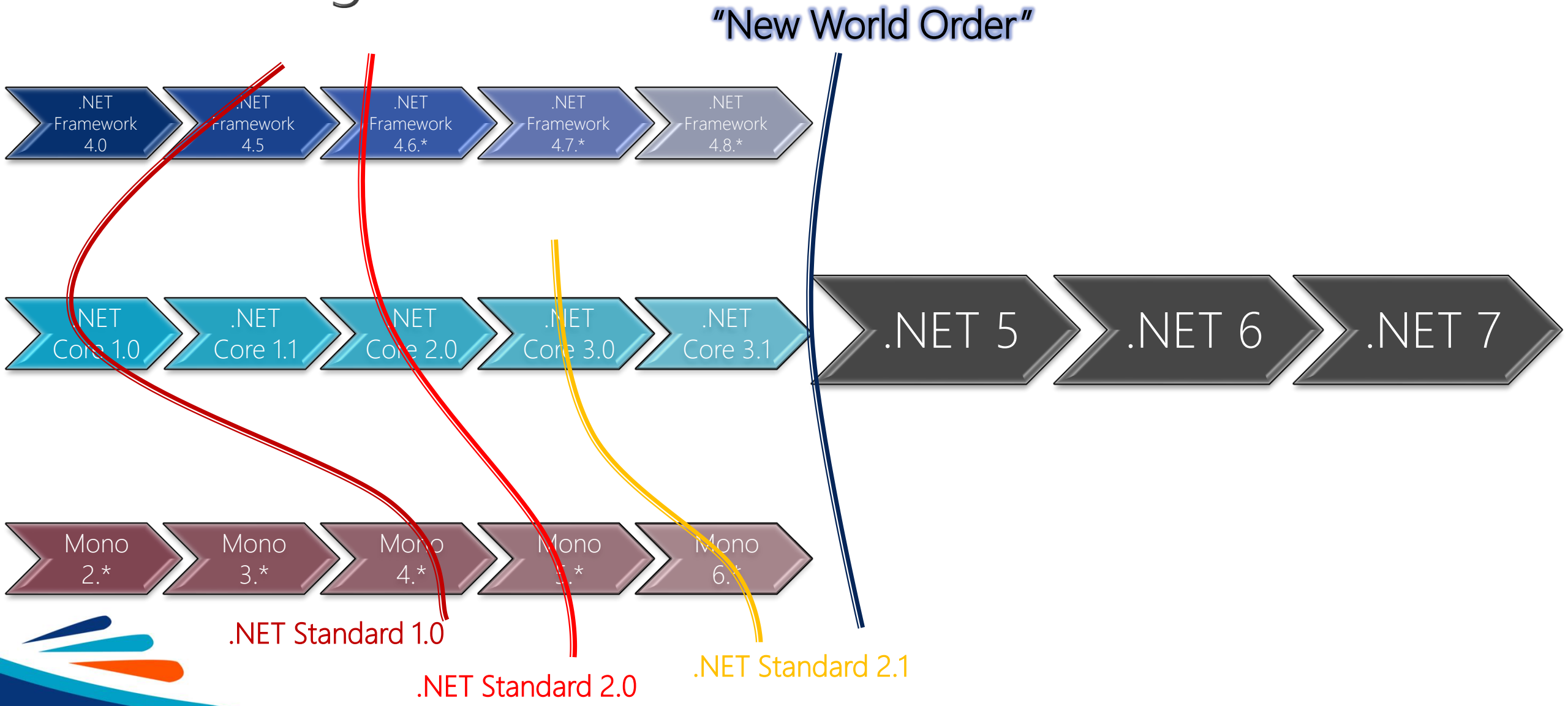
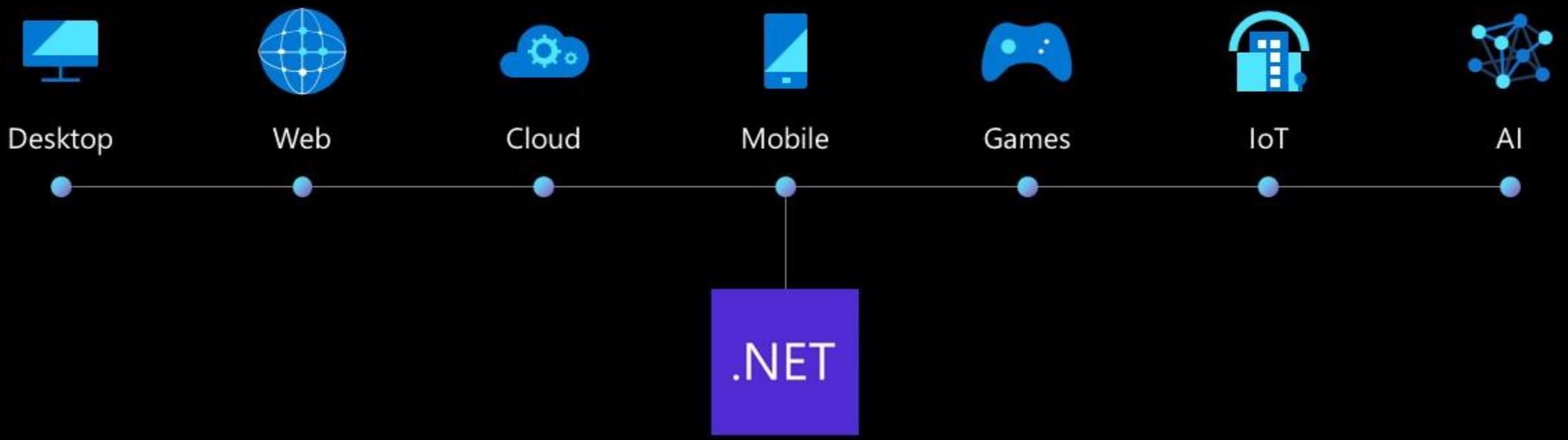
- 16:00: Seminar Concluded

.NET Jungle


"New World Order"
.NET Framework 4.0
.NET Framework 4.5
.NET Framework 4.6.*
.NET Framework 4.7.*
.NET Framework 4.8.*
.NET Core 1.0
.NET Core 1.1
.NET Core 2.0
.NET Core 3.0
.NET Core 3.1
.NET 5
.NET 6
.NET 7
Mono 2.*
Mono 3.*
Mono 4.*
.NET Standard 1.0
.NET Standard 2.0
.NET Standard 2.1

.NET

Your platform for building anything



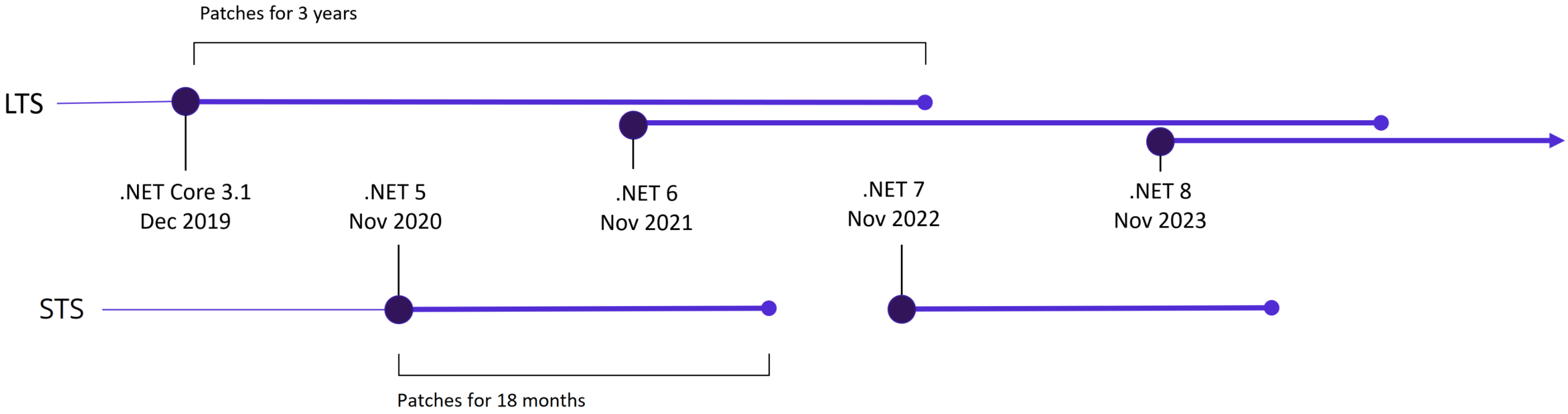
The .NET 7 Platform

- .NET 6 and 7 represents a shared code base for
  - .NET Core
  - Mono
  - Xamarin
- Instead of targeting **`netstandard`** we now target **`net6.0`** and **`net7.0`**

- For platform-specific project we now target
  - **`net7.0-windows`**
  - **`net7.0-android`**
  - **`net7.0-ios`**
  - **`net7.0-macos`**

- In this way **`net6.0`** and **`net7.0`** are the next .NET Standards…!

.NET Release Cadence



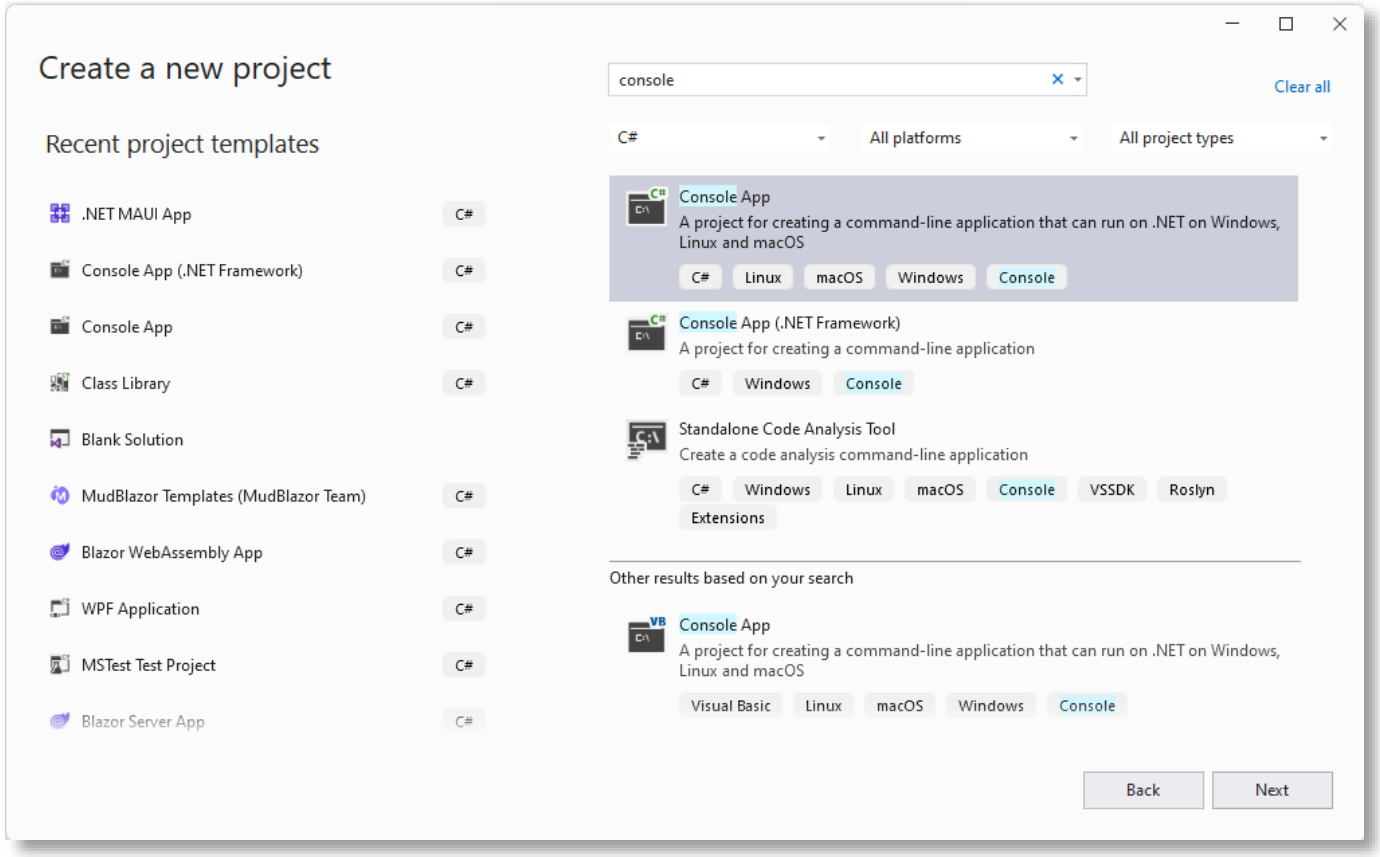
- 3-day **free** release conference at https://www.dotnetconf.net/

Most Important New Features

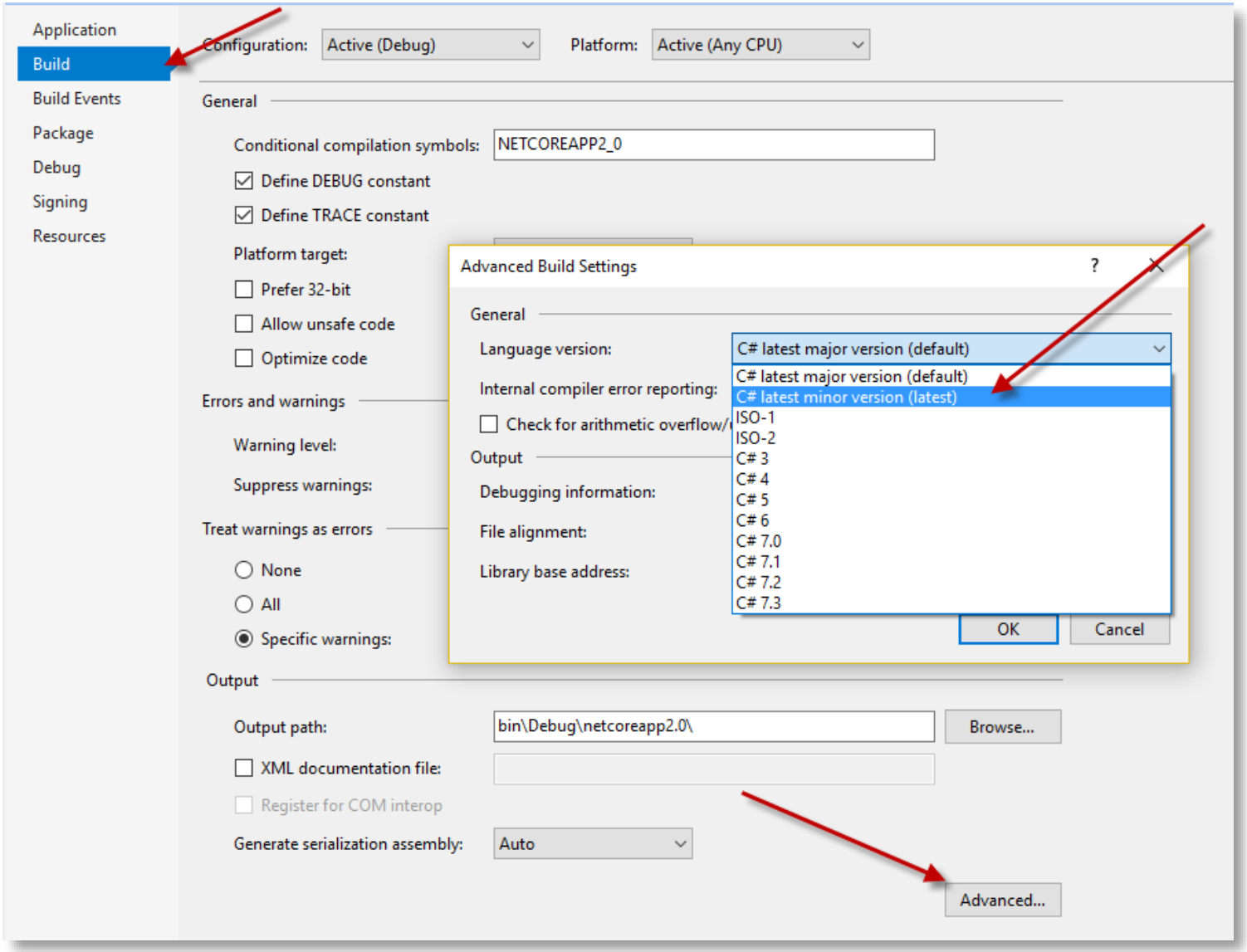
- **Visual Studio 2022 + Tooling**
  - New Language Infrastructure
  - Better Templates
  - More Integration
  - Hot Reload
  - Performance
  - CLI
  - Upgrade Assistant
- **.NET 6**
  - Blazor Server + WASM
  - .NET MAUI
  - Minimal APIs
  - EF Core 6
  - HTTP/3 + gRPC
  - System.Text.Json
  - Performance
- **.NET 7**
  - Performance Optimization
    - Including LINQ
  - Improved Serialization
  - Generic Math
  - ML.NET and .NET MAUI updates
  - Multiple CPU Architectures
  - EF Core 7

Same Visual Studio, But…

- Different features depending upon .NET version
  - Separate project templates for e.g. Console App
  - Distinct property pages
  - …



Enabling C# 7.x in Visual Studio 2017



Visual Studio 2022 Default C# Versions

Target framework	version	C# language version default
.NET	8	C# 12
.NET	7	C# 11
.NET	6	C# 10
.NET	5	C# 9
.NET Core	3.x	C# 8
.NET Core	2.x	C# 7.3
.NET Standard	2.1	C# 8
.NET Standard	2.0	C# 7.3
.NET Standard	1.x	C# 7.3
.NET Framework	all	C# 7.3

- Visual Studio 2017 introduced **`LangVersion`** in project file
- Visual Studio 2019 + 2022 use defaults

.NET CLI

- Cross-platform command-line interface for projects and solutions

- **`dotnet`**
  - **`new`**
  - **`build`**
  - **`run`**
  - …

- More details at
  - https://learn.microsoft.com/en-us/dotnet/core/tools/

Migrating from .NET Framework 4.8 to .NET 7

- .NET Upgrade Assistant
  - `dotnet tool install -g upgrade-assistant`
  - See https://learn.microsoft.com/en-us/dotnet/core/porting/upgrade-assistant-overview for details
- Probably best to create new .NET 7 solution/projects and move
- Tutorials
  - https://learn.microsoft.com/en-us/dotnet/core/porting/upgrade-assistant-aspnetmvc
  - …

Agenda

- 8.00: Part 1: New Features in C# 7 and 8
- 11.00: Lunch break
- 12.00: Part 2: New Features in C# 9, 10, 11, and 12
- **15:30: Edlund**
  - **Sune will speak on Edlund framework**
- 16:00: Seminar Concluded

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