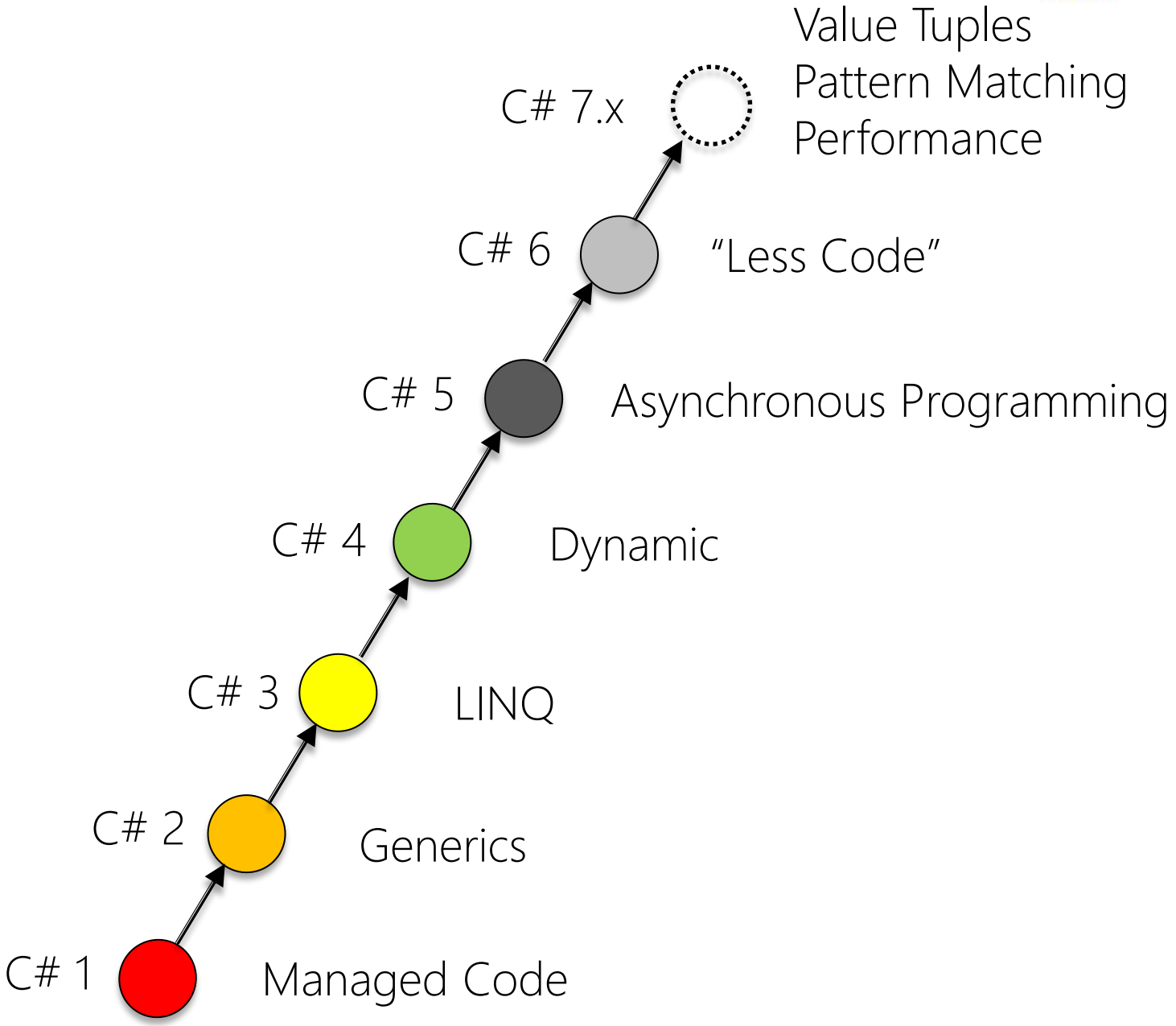
Module 01:

"Very Quick Recap of C# 7.x"

Evolution of C#



Agenda

- Introduction
- **Value Tuples and Syntax**
- Pattern Matching
- Method Improvements
- Other C# 7.x Additions

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}\"");
```

Syntax, Literals, and Conversions

- 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 ... ");
```

- Tuples can be supplied with descriptive names
- Mutable and directly addressable

```
(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()`** (but not **`==`** until C# 7.3)

Custom Tuple Deconstruction

- Can be easily deconstructed to individual parts

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

- Custom types can also be supplied with a *deconstructor* with out parameters

```
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);
```

- Works for two or more deconstruction parts
  - Deconstructors can be overloaded

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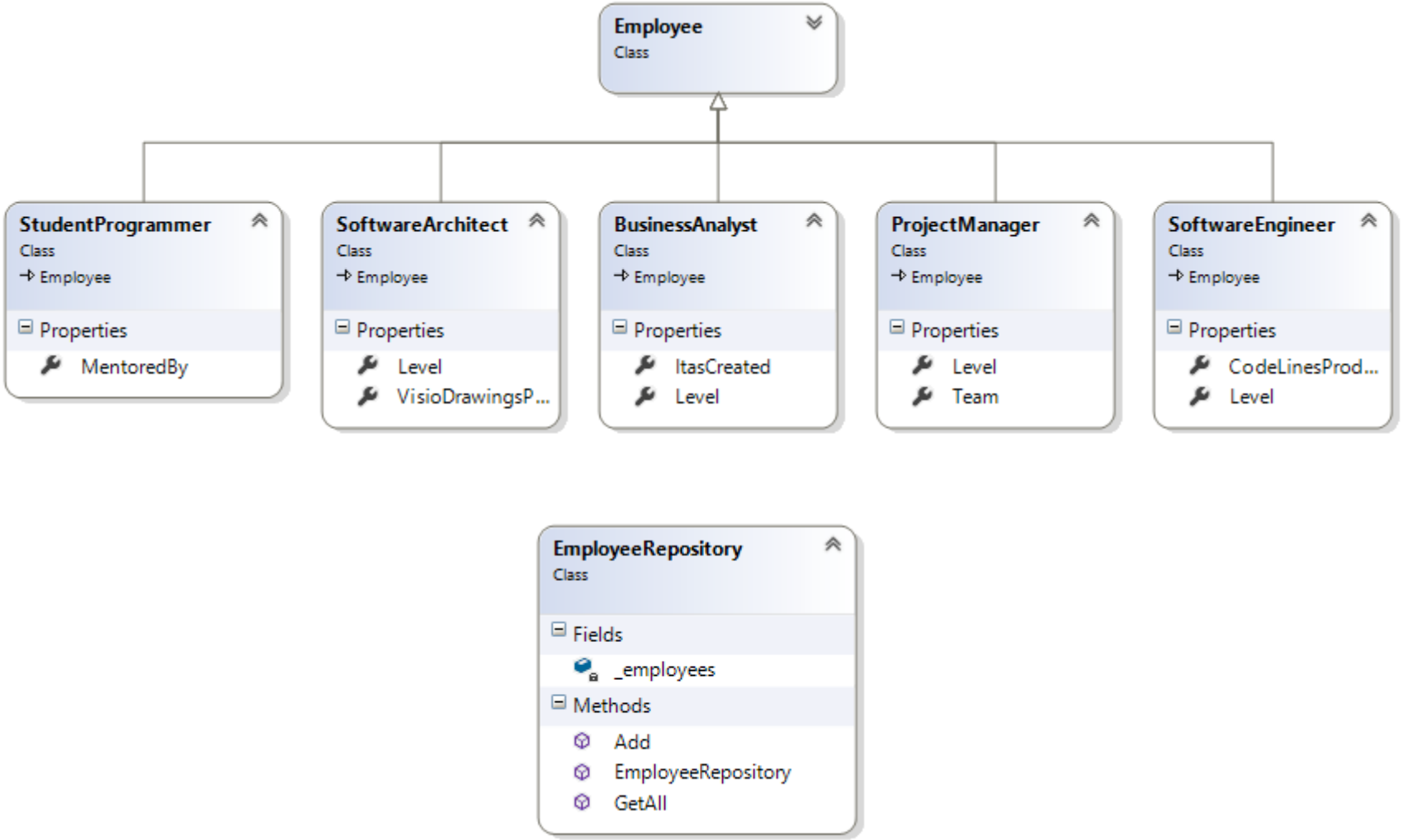
Example: Employee



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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Local Functions

- Methods within methods can now be defined

```
(int vowels, int cons) FindVowels( string s )
{
    ...
    foreach (char letter in s)
    {
        bool IsVowel( char letter )
        {
            ...
        }
        ...
    }
    return tuple;
}
```

- Has some advantages
  - Captures local variables
  - Avoids allocations

Ref Locals

- Can now create references in the style of C++
  - Similar to the **ref** modifier for parameters

```
int x = 42;
ref int y = ref x;

x = 87;
WriteLine(y);
```

Ref Returns

- Methods can now also return references

```
ref int FindMax( int[] numbers )
{
    int indexOfMax = 0;
    for (int i = 1; i < numbers.Length; i++)
    {
        if (numbers[i] > numbers[indexOfMax])
        {
            indexOfMax = i;
        }
    };

    return ref numbers[indexOfMax];
}
```

- Can only return references to heap-based values – not locals

Ref Readonly

- 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;
```

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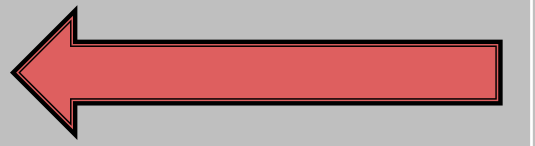
`in` Parameter Modifier

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));
```

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);
}
```

Summary

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