“Why did the developer quit his job? He didn't get arrays.”

C# Lowering

What is it and why should I care?

Steven Giesel // .NET User Group Zurich // How to misuse sharplab.io for a whole talk!

```
$ ~ whoami --full
name: Steven Giesel
website: steven-giesel.com
github: linkdotnet
linkedin: Steven Giesel
twitter: -
working: Zühlke Engineering AG
```

```
foreach(var name in names)
{
   ...
}
```

Question: What does these two have in common?

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```

Answer: The C# compiler doesn’t know them when creating CIL code!

Motivation

"*Understand one level below your normal abstraction layer.*" -Neal Ford

- Understanding better what your C# really does
- Predicting performance (and) implications of your code
- Detect bugs / understand bugs or even better: Prevent them
- You want to understand why some constructs don't "really" exist like:
  foreach, var, lock, using, async / await, yield, Anonymous lambda, records, extension methods, LINQ query syntax, stackalloc, Pikachu, events, is / as operator, ?? / ?. operator, pattern matching, Blazor or Razor components, type interference, anonymous types, switch expression, index ranges, string concat of const strings via "+" operator, ternary operator, local functions, using static directive, ValueTuple, Deconstructor, Range …
- You are geeky like me and want to understand the core of your language

What is “Lowering”?

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Compiling

Translating one language to another language

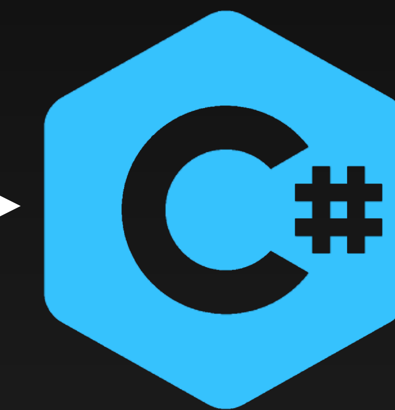
CIL

(Common Intermediate Language)

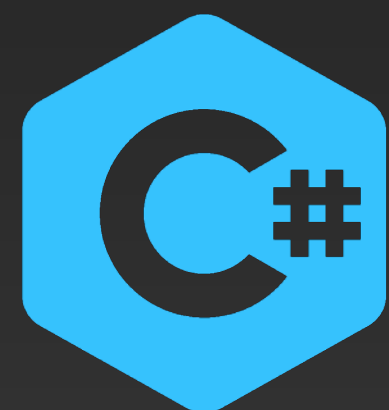
What is "Lowering"?

Lowering

Translating high level features to low level features in the **same** language



Compiling



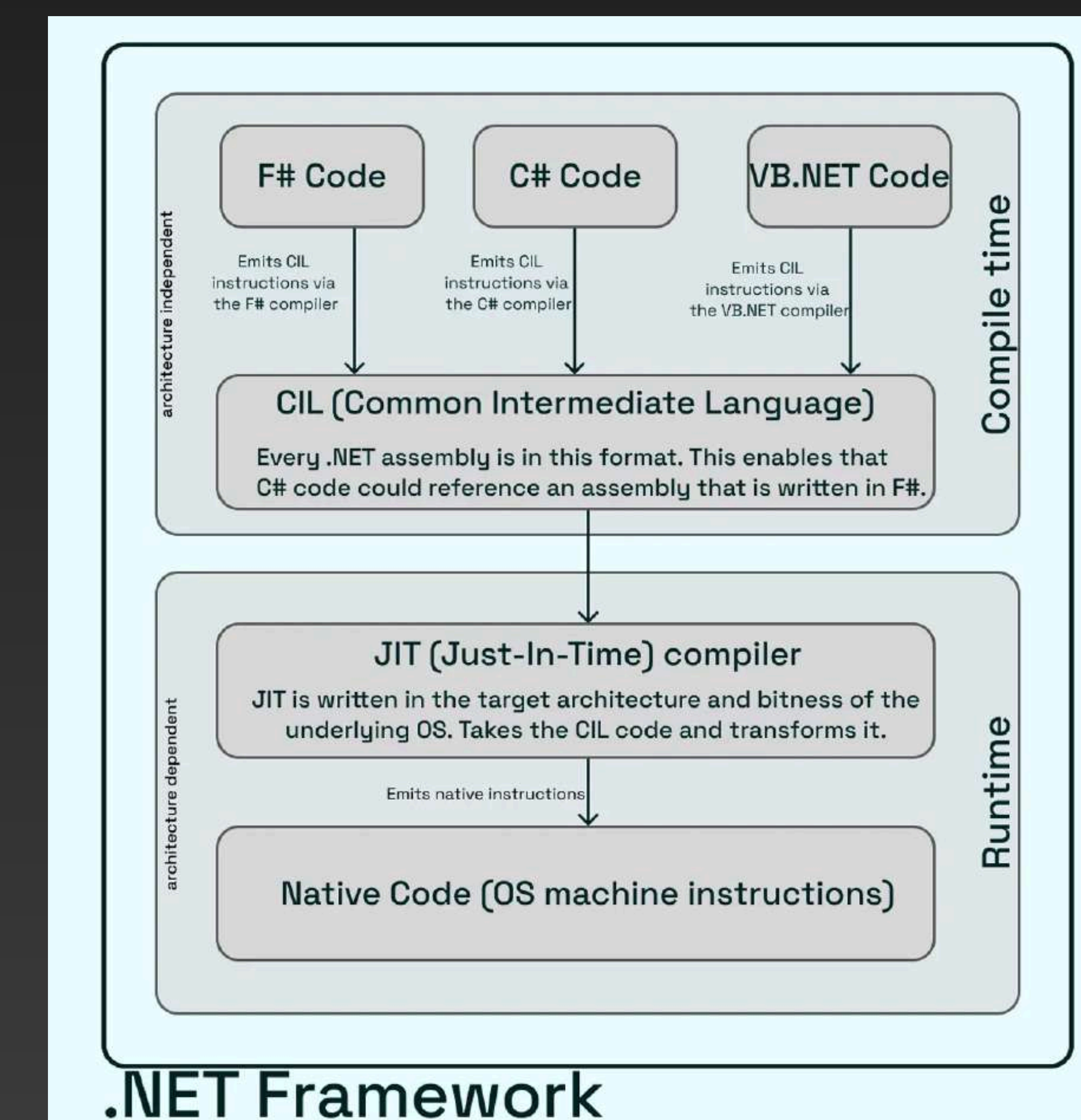
Translating one language to another language

CIL

(Common Intermediate Language)

What is “Lowering”?

- Another name you know for that is “syntactic sugar”
- Or “compiler magic”
- Lowering is part of the whole process, when you compile your C# code into an assembly (CIL code)
- Lowering is like synonyms in the same language:
  “a or b or both” instead for “a and/or b”
  “from now on” instead of “henceforth”
- Can bring benefits in terms of optimization



Let's start easy - var

```csharp
var myString = "Hello World";

Console.Write(myString);
```

```csharp
string myString = "Hello World";

Console.Write(myString);
```

- Easy one, var does not exist and gets resolved to its concrete type
- That is called type interference (the ability to deduct the type from the context)

Case Study 2.1: foreach array

```
var range = new[] { 1, 2 };

foreach(var item in range)
    Console.Write(item);
```

Gets lowered to →

```
int[] array = new int[2];
array[0] = 1;
array[1] = 2;
int[] array2 = array;
int num = 0;
while (num < array2.Length)
{
    int value = array2[num];
    Console.Write(value);
    num++;
}
```

- There is no foreach anymore in the lowered code
  - Translated into a while loop
  - Also for loops get usually lowered to a while loop
- Also there is no collection initializer anymore

Case Study 2.2: foreach list

```
var list = new List<int> { 1, 2 };

foreach(var item in list)
    Console.Write(item);
```

```
List<int> list = new List<int>();
list.Add(1);
list.Add(2);
List<int>.Enumerator enumerator = list.GetEnumerato
try
{
    while (enumerator.MoveNext())
    {
        Console.Write(enumerator.Current);
    }
}
finally
{
    ((IDisposable)enumerator).Dispose();
}
```

- Still no foreach in sight
- We are using Enumerators with (MoveNext and Current)
  - IEnumerable is like a basket full of apples
  - IEnumerator goes through one at a time, until you find the perfect apple
- Try-Finally block as Enumerator inherits from Disposable

Foreach without IEnumerable

Let’s code some magic

Foreach without IEnumerable

Foreach without IEnumerable

Range-object is not enumerable ... normally

```
foreach (int number in 2..5)
{
    Console.WriteLine(number);
}
```

Foreach without IEnumerable

Range-object is not enumerable … normally

```
foreach (int number in 2..5)
{
    Console.WriteLine(number);
}

public static class Extensions
{
    public static IEnumerator<int> GetEnumerator(this Range r)
        => Enumerable.Range(r.Start.Value, r.End.Value - r.Start.Value)
            .GetEnumerator();
}
```

C# 3: If IEnumerable isn’t implemented try to grab appropriate GetEnumerator method.
C# 9: Extension GetEnumerator support for foreach loops.

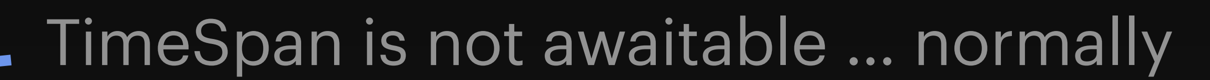
Extra: Await everything

Extra: Await everything

```
await 2.Seconds();
await TimeSpan.FromSeconds(2);
```

TimeSpan is not awaitable ... normally

Extra: Await everything




```
await 2.Seconds();
await TimeSpan.FromSeconds(2);

public static class Extensions
{
    public static TaskAwaiter GetAwaiter(this TimeSpan ts)
        => Task.Delay(ts).GetAwaiter();

    public static TimeSpan Seconds(this int s)
        => TimeSpan.FromSeconds(s);
}
```

Back on track

Case Study 3: using

```
Task<string> GetContentFromUrlAsync(string url)
{
    // Don't do this! Creating new HttpClients
    // is expensive and has other caveats
    // This is for the sake of demonstration
    using var client = new HttpClient();
        return client.GetStringAsync(url);
}
```

- Let’s have a look how using works to understand what might be an issue here

Case Study 3: using

```
Task<string> GetContentFromUrlAsync(string url)
{
    // Don't do this! Creating new HttpClients
    // is expensive and has other caveats
    // This is for the sake of demonstration
    using var client = new HttpClient();
        return client.GetStringAsync(url);
}
```

Gets lowered to

```
HttpClient httpClient = new HttpClient();
try
{
    return httpClient.GetStringAsync(url);
}
finally
{
    if (httpClient != null)
    {
        ((IDisposable)httpClient).Dispose();
    }
}
```

- using guarantees* to dispose via a finally block
- The finally block gets executed after return
- This will dispose the HttpClient and therefore the awaiter of our call with be presented with a nice ObjectDisposedException

* If you don't pull the plug out of your PC, get hit by a meteor or kill it via task manager

Case Study 4: is operator

Are these code snippets equal?

```
int Do(Person? p)
{
    if (p is { Age: < 25 })
        return 1;
    return 10;
}
```

```
int Do(Person? p)
{
    if (p.Age < 25)
        return 1;
    return 10;
}
```

Case Study 4: is operator

Are these code snippets equal?

```
int Do(Person? p)
{
    if (p is { Age: < 25 })
        return 1;
    return 10;
}
```

```
p != null && p.Age < 25;
```

```
int Do(Person? p)
{
    if (p.Age < 25)
        return 1;
    return 10;
}
```

Case Study 4: is operator

Are these code snippets equal?

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int Do(Person? p)
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    if (p is { Age: < 25 })
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int Do(Person? p)
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    if (p.Age < 25)
        return 1;
    return 10;
}
```

```
p != null && p.Age < 25;
```

- is checks also for null values.
- This is also true if you have nested properties

Bonus: Case Study 5: anonymous functions

What is the output of the following snippet?

```
for (var i = 0; i < 5; i++)
{
    list.Add(() => Console.WriteLine(i));
}

list.ForEach(action => action());
```

Let’s try it out on sharplab.io.

A detailed example can be found here.

Thanks to sharplab.io for making my presentation possible ;)

And of course: You <3