



# My Compiler Did What?!?

Mike Harris

# Agenda

- Hello World
- Record Type
- Enumerable
- Async / Await
- MoveNext()

# Agenda

- **Hello World**
- Record Type
- Enumerable
- Async / Await
- MoveNext()

top level  
statement

# Hello World

```
using System;

var conference = "That";
Console.WriteLine($"Hello {conference} Conference!");

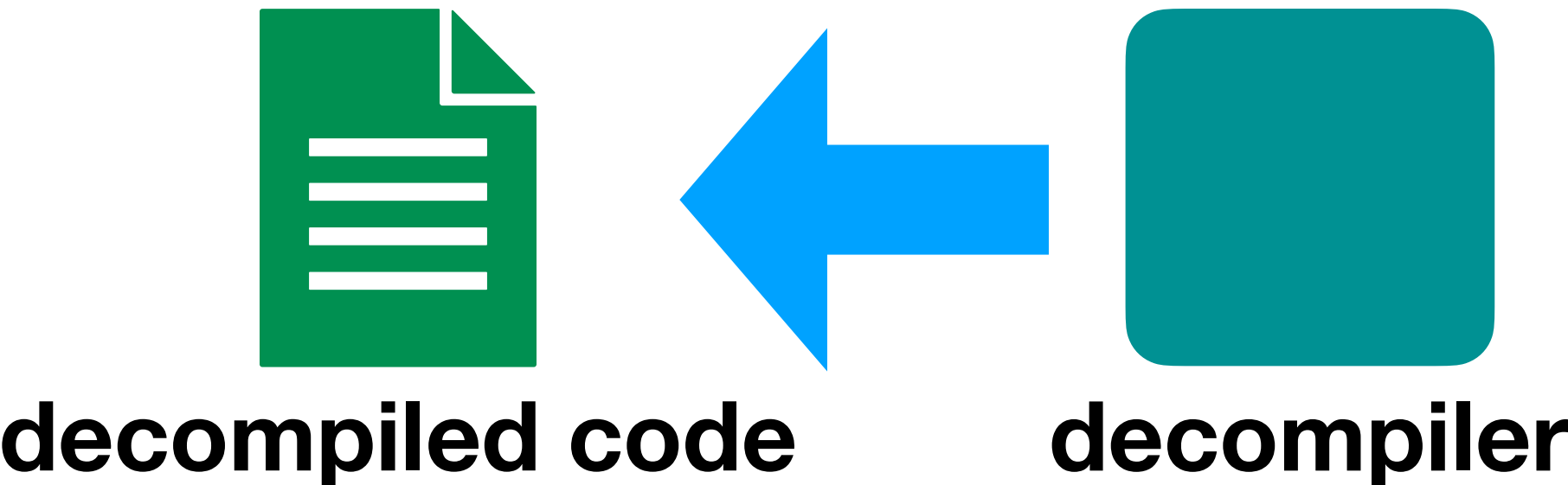
Action<string> sorry =
    conference => Console.WriteLine(
        $"Sorry, {conference} this is a bit ridiculous.");

sorry(conference);
Closing("fun");

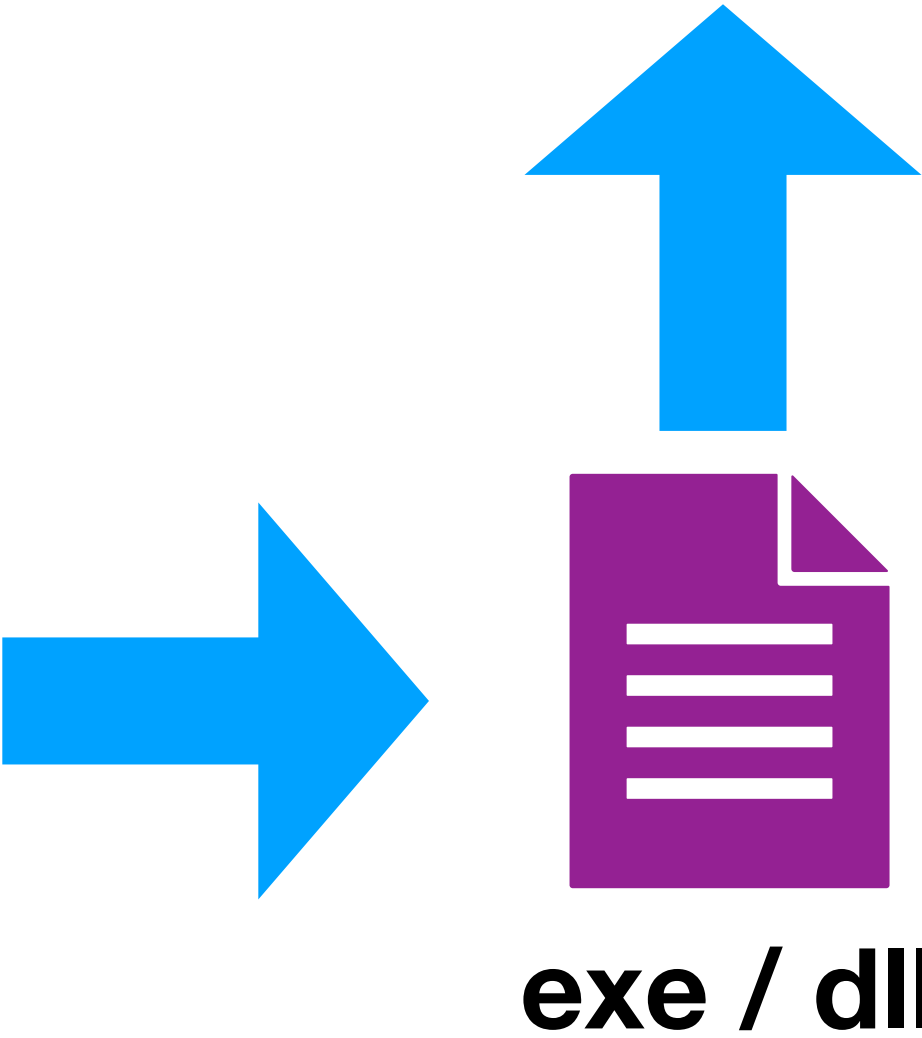
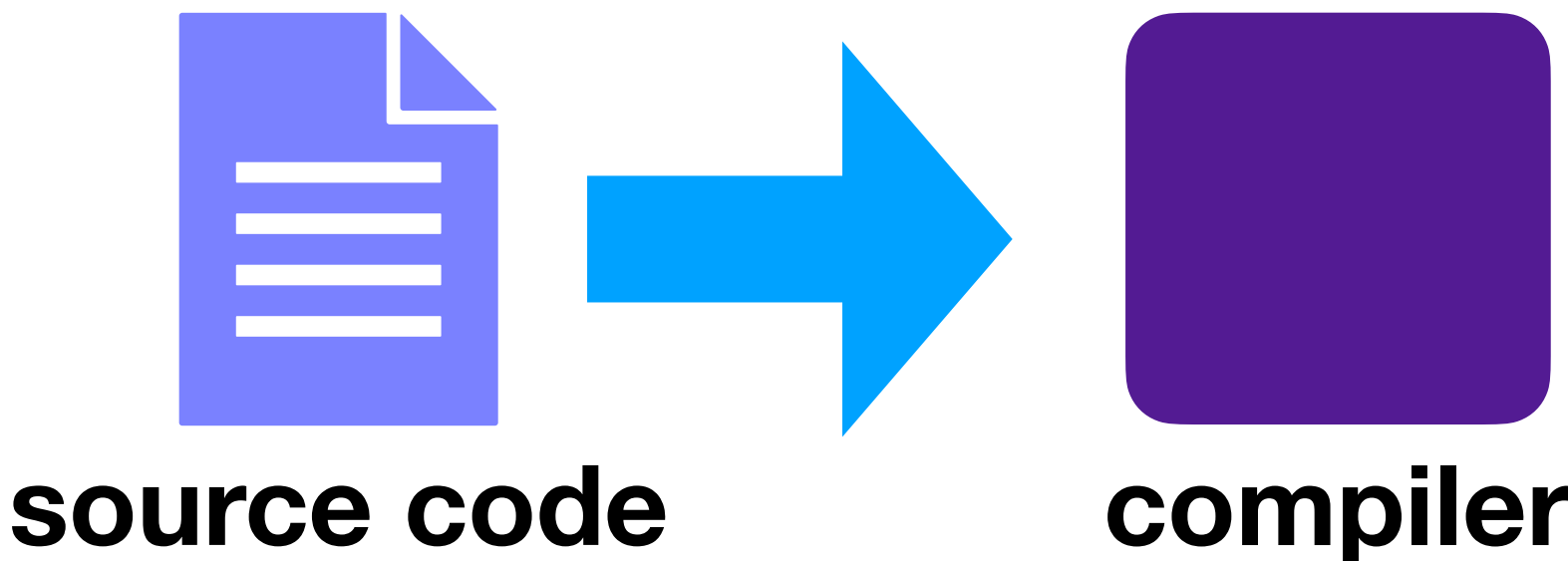
static void Closing(string state)
    => Console.WriteLine($"Hope you find it {state}!");
```

```
using System;

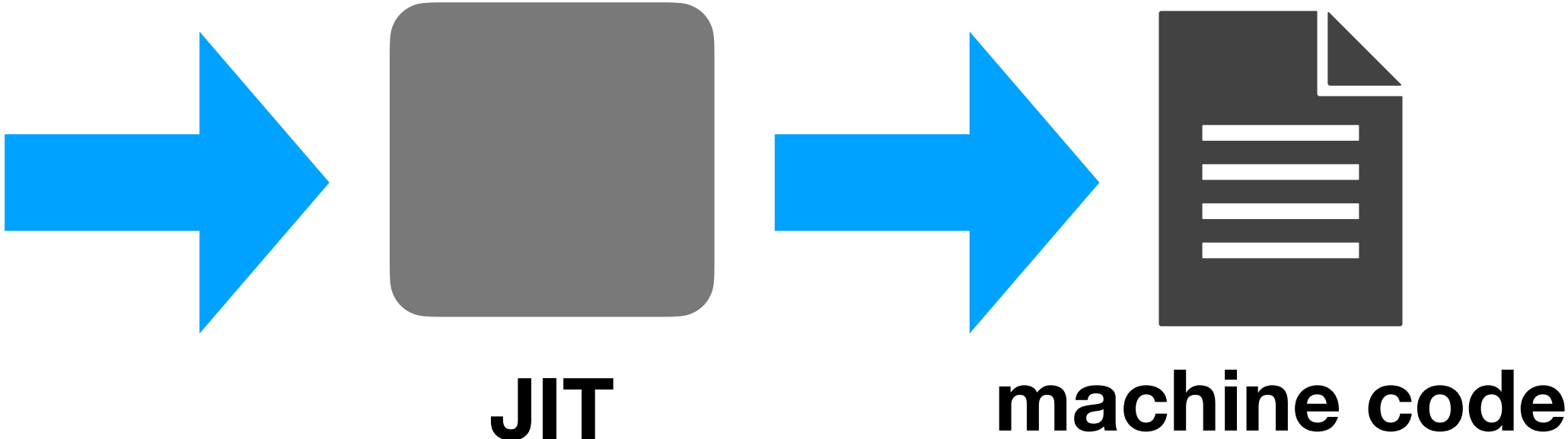
internal class Program
{
    private static void Main (string[] args)
    {
        string text = "That";
        Console.WriteLine ("Hello " + text + " Conference!");
        ((Action<string>)delegate (string conference) {
            Console.WriteLine ("Sorry, " + conference + " this is a bit ridiculous.");
        }) (text);
        Closing ("fun");
        static void Closing (string state)
        {
            Console.WriteLine ("Hope you find it " + state + "!");
        }
    }
}
```



dotnet build



dotnet run



```
using System;

var conference = "That";
Console.WriteLine($"Hello {conference} Conference!");

Action<string> sorry =
    conference => Console.WriteLine(
        $"Sorry, {conference} this is a bit ridiculous.");

sorry(conference);
Closing("fun");

static void Closing(string state)
    => Console.WriteLine($"Hope you find it {state}!");
```

Hello That Conference!  
Sorry, That this is a bit ridiculous.  
Hope you find it fun!

# Hello World

Original

Compiled

```
using System;

var conference = "That";
Console.WriteLine($"Hello {conference} Conference!");

Action<string> sorry =
    conference => Console.WriteLine(
        $"Sorry, {conference} this is a bit ridiculous.");

sorry(conference);
Closing("fun");

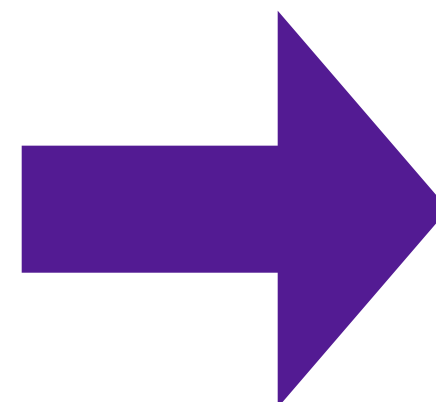
static void Closing(string state)
    => Console.WriteLine($"Hope you find it {state}!");
```

```
using System;

internal class Program
{
    private static void Main (string[] args)
    {
        string text = "That";
        Console.WriteLine ("Hello " + text + " Conference!");
        ((Action<string>)delegate (string conference) {
            Console.WriteLine ("Sorry, " + conference + " this i
        }) (text);
        Closing ("fun");
        static void Closing (string state)
        {
            Console.WriteLine ("Hope you find it " + state + "!"
        }
    }
}
```

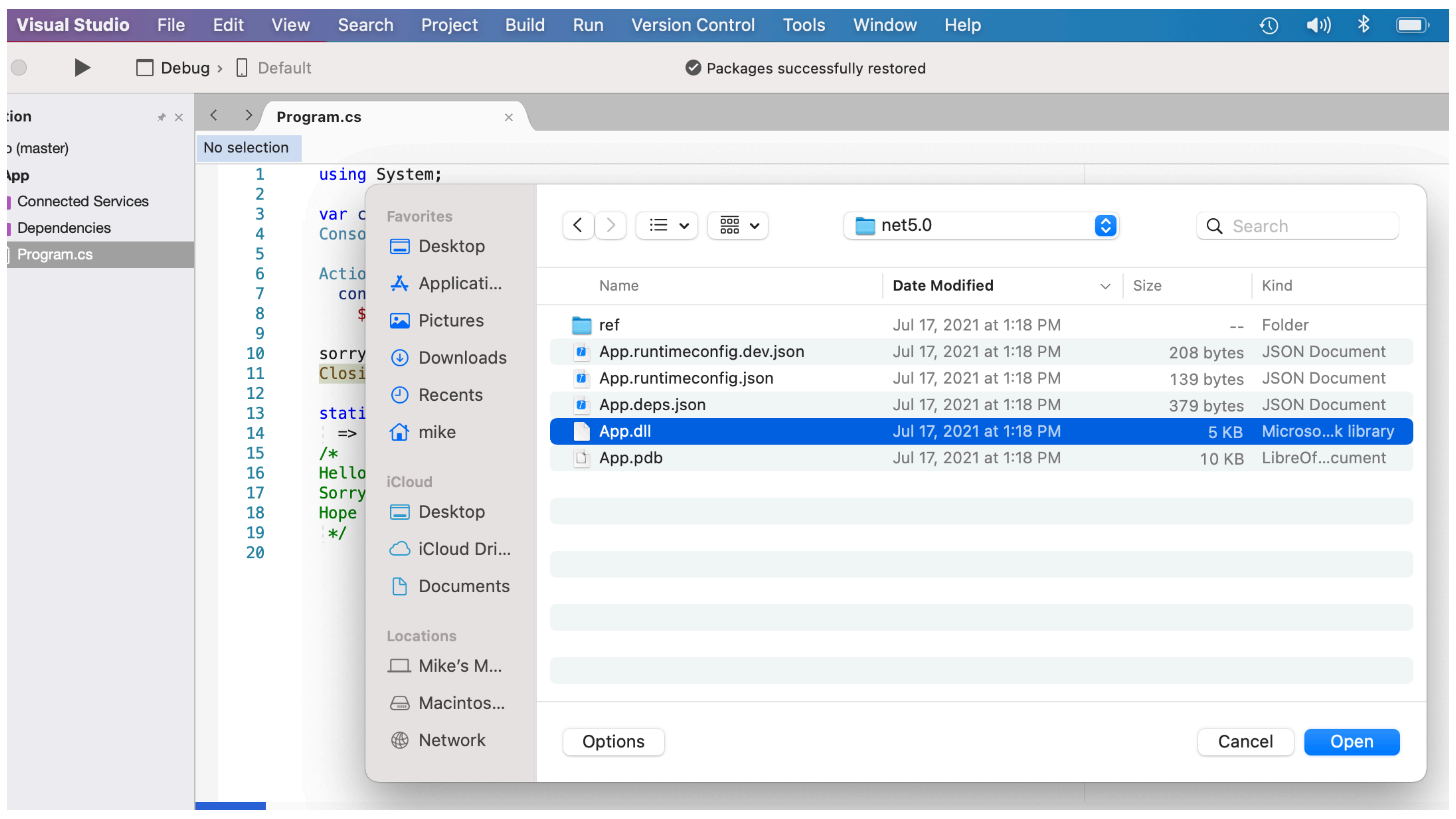


source code



decompiled code

simplified C#



```
1 using System;
2
3 var c
4 Conso
5
6 Actio
7 con
8 $
9
10 sorry
11 Closi
12
13 stati
14 =>
15 /*
16 Hello
17 Sorry
18 Hope
19 */
20
```

Favorites

Desktop

Applicati...

Pictures

Downloads

Recents

mike

iCloud

Desktop

iCloud Dri...

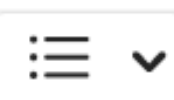
Documents

Locations

Mike's M...

Macintos...

Network



net5.0



Search

Name

Date Modified



Size

Kind



ref

Jul 17, 2021 at 1:18 PM

--

Folder



App.runtimeconfig.dev.json

Jul 17, 2021 at 1:18 PM

208 bytes

JSON Document



App.runtimeconfig.json

Jul 17, 2021 at 1:18 PM

139 bytes

JSON Document



App.deps.json

Jul 17, 2021 at 1:18 PM

379 bytes

JSON Document



App.dll

Jul 17, 2021 at 1:18 PM

5 KB

Microso...k library



App.pdb

Jul 17, 2021 at 1:18 PM

10 KB

LibreOf...cument

Options

Cancel

Open



**Solution**

- App (master)
  - App**
    - Connected Services
    - Dependencies
    - Program.cs

Program.cs Assembly Browser

Visibility All members

App (1.0.0.0)

- <Program>\$
  - Base Types
  - <Program>\$.<>c
    - <<Main>\$>g\_\_Closing|0\_1(String) : Void
    - <Main>\$(String[]) : Void
- System.Console (5.0.0.0)
- System.Private.CoreLib (5.0.0.0)
- System.Private.Uri (5.0.0.0)
- System.Runtime (5.0.0.0)
- App

```
using System;
using System.Runtime.CompilerServices;

[CompilerGenerated]
internal static class _003CProgram_003E_0024
{
    private static void _003CMain_003E_0024 (string[] args)
    {
        string text = "That";
        Console.WriteLine ("Hello " + text + " Conference!");
        ((Action<string>)delegate (string conference) {
            Console.WriteLine ("Sorry, " + conference + " this is a bit ridiculous.");
        }) (text);
        Closing ("fun");
        static void Closing (string state)
        {
            Console.WriteLine ("Hope you find it " + state + "!");
        }
    }
}
```



Visual Studio

FileEditViewSearchProjectBuildRunVersion ControlToolsWindowHelp

Visual Studio Community 2019 for Mac

Search solution

Solution

App (master)

App

Connected Services

Dependencies

Program.cs

Program.cs

Assembly Browser

VisibilityAll members

Search for types and members

LanguageIL

App (1.0.0.0)

<Program>\$

Base Types<Program>\$.<>c<<Main>\$>g\_\_Closing|0\_1(String) : Void<Main>\$(String[]) : Void

System.Console (5.0.0.0)

System.Private.CoreLib (5.0.0.0)

System.Private.Uri (5.0.0.0)

System.Runtime (5.0.0.0)

App

```
.class private auto ansi abstract sealed beforefieldinit '<Program>$'
  extends [System.Runtime]System.Object
{
  .custom instance void [System.Runtime]System.Runtime.CompilerServices.CompilerGeneratedAttribute::.ctor() = (
    01 00 00 00
  )
  // Nested Types
  .class nested private auto ansi sealed serializable beforefieldinit '<>c'
    extends [System.Runtime]System.Object
  {
    // Fields
    .field public static initonly class '<Program>$/' '<>c' '<>9'
    .field public static class [System.Runtime]System.Action`1<string> '<>9__0_0'

    // Methods
    .method private hidebysig specialname rtspecialname static
      void .ctor () cil managed
    {
      // Method begins at RVA 0x20be
      // Code size 11 (0xb)
      .maxstack 8

      IL_0000: newobj instance void '<Program>$/' '<>c'::.ctor()
      IL_0005: stsfld class '<Program>$/' '<>c' '<Program>$/' '<>c'::' '<>9'
      IL_000a: ret
    } // end of method '<>c'::.ctor

    .method public hidebysig specialname rtspecialname
      instance void .ctor () cil managed
    {
      // Method begins at RVA 0x20ca
      // Code size 7 (0x7)
      .maxstack 8
```

# Hello World

Original

```
using System;
```

top level  
statement

Compiled

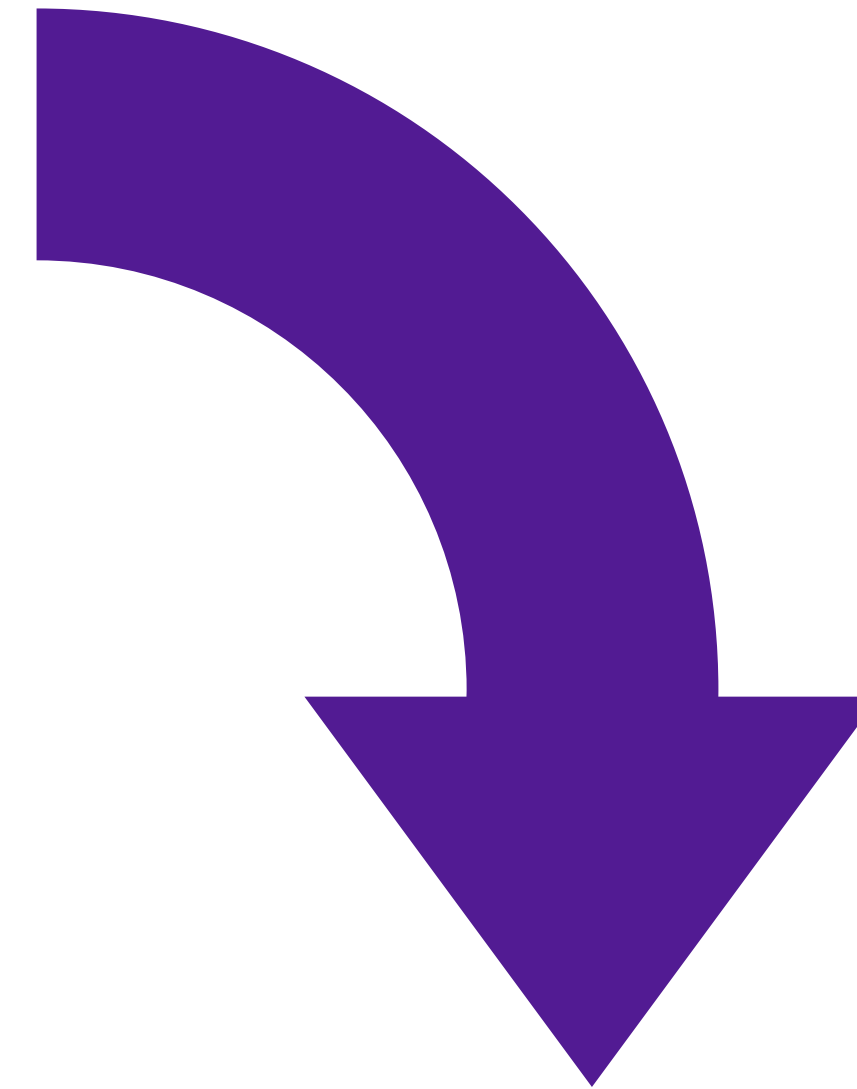
```
using System;  
  
internal class Program  
{  
    private static void Main (string[] args)  
    {  
  
    }  
}
```

# Hello World

## Original

```
var conference = "That";

Action<string> sorry =
    conference => Console.WriteLine(
        $"Sorry, {conference} this is a bit ridiculous.");
sorry(conference);
```



## Compiled

```
string text = "That";

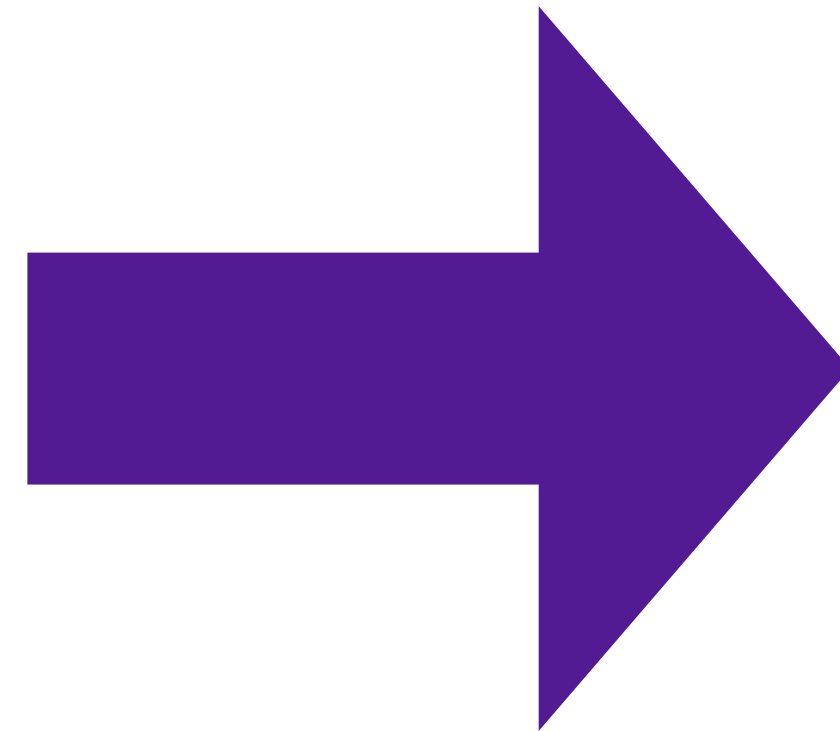
((Action<string>)delegate (string conference) {
    Console.WriteLine ("Sorry, " + conference + " this is a bit ridiculous.");
}) (text);
```

# Hello World

Compiled

Original

```
var conference = "That";
```



locals

```
.method private hidebysig static  
void '<Main>$' (  
    string[] args  
) cil managed  
{  
    .maxstack 3  
    .entrypoint  
    .locals init (  
        [0] string  
    )  
  
    IL_0000: ldstr "That"  
    IL_0005: stloc.00
```

load string

# Hello World

Original

```
Console.WriteLine($"Hello {conference} Conference!");
```

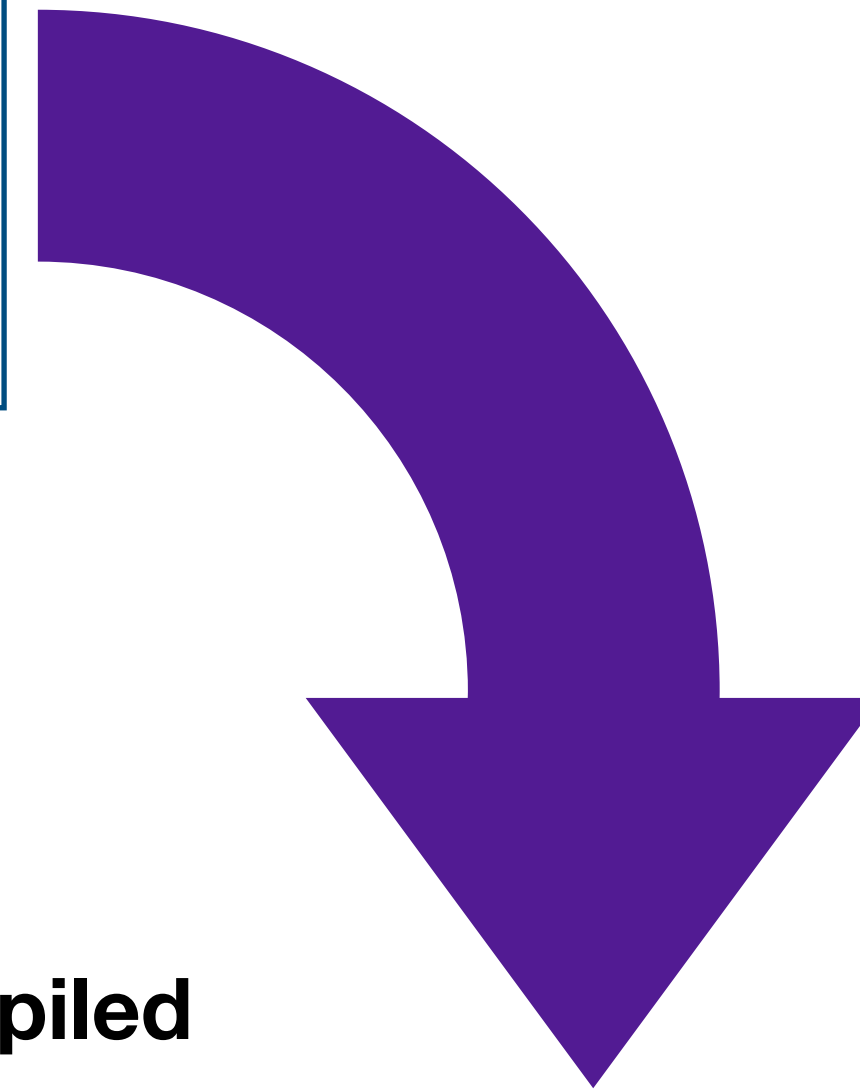
Compiled

```
Console.WriteLine ("Hello " + text + " Conference!");
```

# Hello World

Original

```
Closing( "fun" );  
  
static void Closing(string state)  
=> Console.WriteLine($"Hope you find it {state}!");
```



Compiled

```
Closing ( "fun" );  
static void Closing (string state)  
{  
    Console.WriteLine ( "Hope you find it " + state + "!" );  
}
```

simplified C#



# Agenda

- Hello World
- **Record Type**
- Enumerable
- Async / Await
- MoveNext()

# Record Type

```
using System;

namespace App
{
    public record PersonRecord(string FirstName, string LastName);

    public class PersonClass
    {
        public PersonClass(string first, string last)
            => (FirstName, LastName) = (first, last);

        public string FirstName { get; init; }
        public string LastName { get; init; }
    }
}
```

# Record Type

```
Console.WriteLine("Class record.");

var mikeRecord = new PersonRecord("Mike", "Harris");
var otherMikeRecord = new PersonRecord("Mike", "Harris");

Console.WriteLine($"\\tmikeRecord={mikeRecord}");
Console.WriteLine($"\\tHello {mikeRecord.FirstName}!");

if (mikeRecord == otherMikeRecord)
{
    Console.WriteLine($"\\tSame old {otherMikeRecord.FirstName}.");
}
else
{
    Console.WriteLine($"\\tYou have changed {mikeRecord.FirstName}.");
}
```

# Class

```
Console.WriteLine("Class example.");

var mikeClass = new PersonClass("Mike", "Harris");
var otherMikeClass = new PersonClass("Mike", "Harris");

Console.WriteLine($"\\tmikeClass={mikeClass}");
Console.WriteLine($"\\tHello {mikeClass.FirstName}!");

if (mikeClass == otherMikeClass)
{
    Console.WriteLine($"\\tSame old {otherMikeClass.FirstName}.");
}
else
{
    Console.WriteLine($"\\tYou have changed {mikeClass.FirstName}.");
}
```

# Record Type / Class

output

```
Class record.  
mikeRecord=PersonRecord { FirstName = Mike, LastName = Harris }  
Hello Mike!  
Same old Mike.  
Class example.  
mikeClass=App.PersonClass  
Hello Mike!  
You have changed Mike.
```

# Class

## Original

```
public class PersonClass
{
    public PersonClass(string first, string last)
        => (FirstName, LastName) = (first, last);
    public string FirstName { get; init; }
    public string LastName { get; init; }
}
```



## Compiled

```
public class PersonClass
{
    public string FirstName {
        get;
        set;
    }

    public string LastName {
        get;
        set;
    }

    public PersonClass (string first, string last)
    {
        string text2 = FirstName = first;
        text2 = (LastName = last);
    }
}
```





















# Record Type

**Original**

```
public record PersonRecord(string FirstName, string LastName);
```

# Record Type

Compiled

```
▼  PersonRecord
  ►  Base Types
     .ctor(PersonRecord)
     .ctor(String, String)
     <Clone>$() : PersonRecord
     <FirstName>k__BackingField : String
     <LastName>k__BackingField : String
     Deconstruct(String&, String&) : Void
     EqualityContract : Type
     Equals(PersonRecord) : Boolean
     Equals(Object) : Boolean
     FirstName : String
     GetHashCode() : Int32
     LastName : String
     op_Equality(PersonRecord, PersonRecord) : Boolean
     op_Inequality(PersonRecord, PersonRecord) : Boolean
     PrintMembers(StringBuilder) : Boolean
     ToString() : String
```

# Record Type

## Compiled

```
public class PersonRecord : IEquatable<PersonRecord>
{
    protected virtual Type EqualityContract {
        [System.Runtime.CompilerServices.NullableContext (1)]
        [CompilerGenerated]
        get {
            return typeof(PersonRecord);
        }
    }
}
```

# Record Type

Compiled

```
public PersonRecord (string FirstName, string LastName)
{
    this.FirstName = FirstName;
    this.LastName = LastName;
    base._002Ector ();
}

protected PersonRecord (PersonRecord original)
{
    FirstName = original.FirstName;
    LastName = original.LastName;
}
```

used by Clone

# Record Type

Compiled

```
public void Deconstruct (out string FirstName, out string LastName)
{
    FirstName = this.FirstName;
    LastName = this.LastName;
}
```

# Record Type

Compiled

```
public override string ToString ()
{
    StringBuilder stringBuilder = new StringBuilder ();
    stringBuilder.Append ("PersonRecord");
    stringBuilder.Append (" { ");
    if (PrintMembers (stringBuilder)) {
        stringBuilder.Append (" ");
    }
    stringBuilder.Append ("}");
    return stringBuilder.ToString ();
}
```



# Record Type

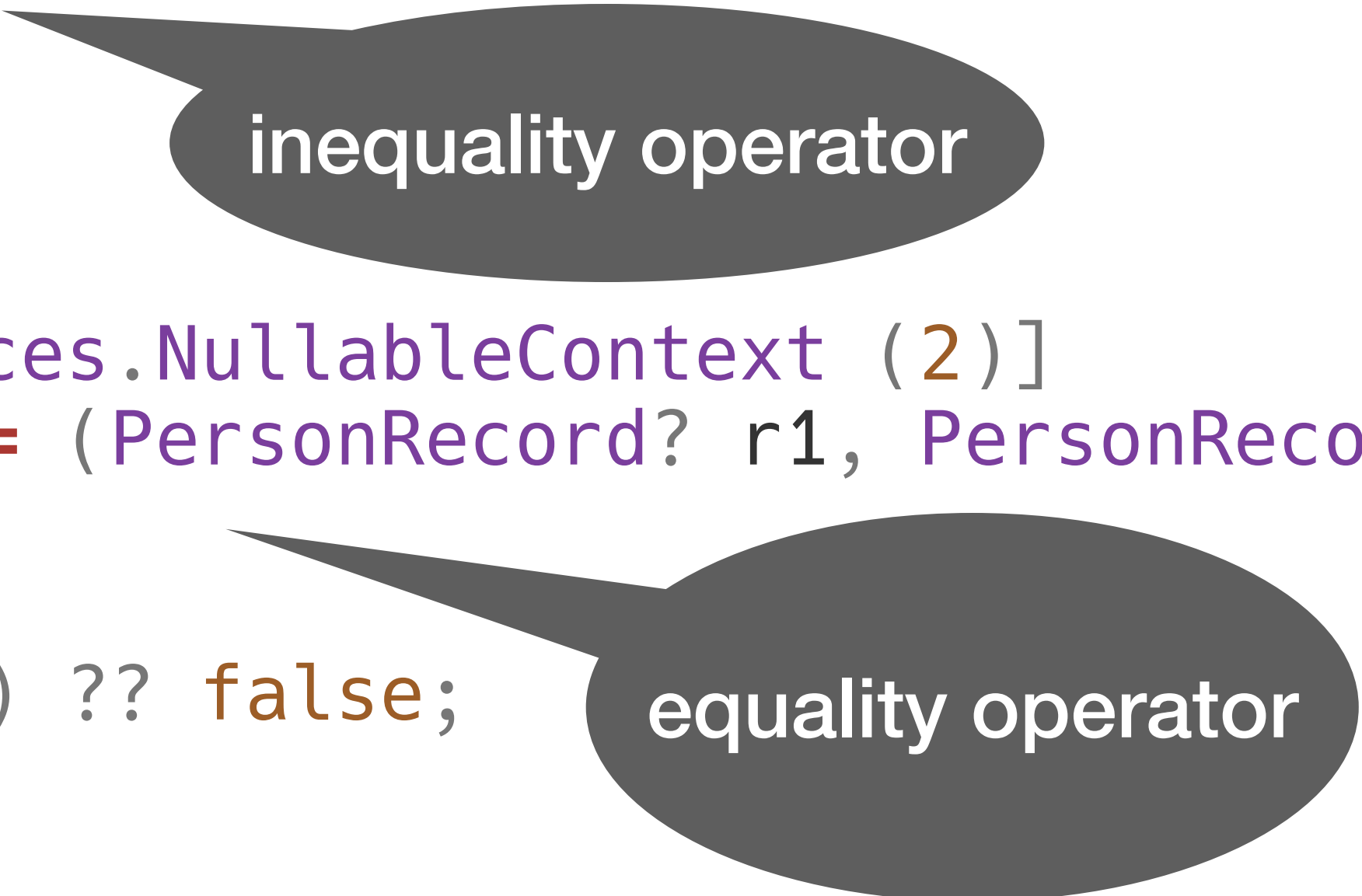
Compiled

```
protected virtual bool PrintMembers (StringBuilder builder)
{
    builder.Append ( "FirstName" );
    builder.Append ( " = " );
    builder.Append ( (object?)FirstName );
    builder.Append ( ", " );
    builder.Append ( "LastName" );
    builder.Append ( " = " );
    builder.Append ( (object?)LastName );
    return true;
}
```

# Record Type

## Compiled

```
[System.Runtime.CompilerServices.NullableContext (2)]  
public static bool operator != (PersonRecord? r1, PersonRecord? r2)  
{  
    return !(r1 == r2);  
}  
  
[System.Runtime.CompilerServices.NullableContext (2)]  
public static bool operator == (PersonRecord? r1, PersonRecord? r2)  
{  
    if ((object)r1 != r2) {  
        return r1?.Equals (r2) ?? false;  
    }  
    return true;  
}
```



inequality operator


equality operator

# Record Type

Compiled

```
public override bool Equals (object? obj)
{
    return Equals (obj as PersonRecord);
}

public virtual bool Equals (PersonRecord? other)
{
    if ((object)other != null && EqualityContract == other!.EqualityContract &&
    EqualityComparer<string>.Default.Equals (FirstName, other!.FirstName))
    {
        return EqualityComparer<string>.Default.Equals (LastName, other!.LastName);
    }
    return false;
}
```



value equality

# Record Type

Compiled

```
public override int GetHashCode ()  
{  
    return (EqualityComparer<Type>.Default.GetHashCode (EqualityContract) * -1521134295 +  
    EqualityComparer<string>.Default.GetHashCode (FirstName)) * -1521134295 +  
    EqualityComparer<string>.Default.GetHashCode (LastName);  
}
```

# Record Type

Compiled

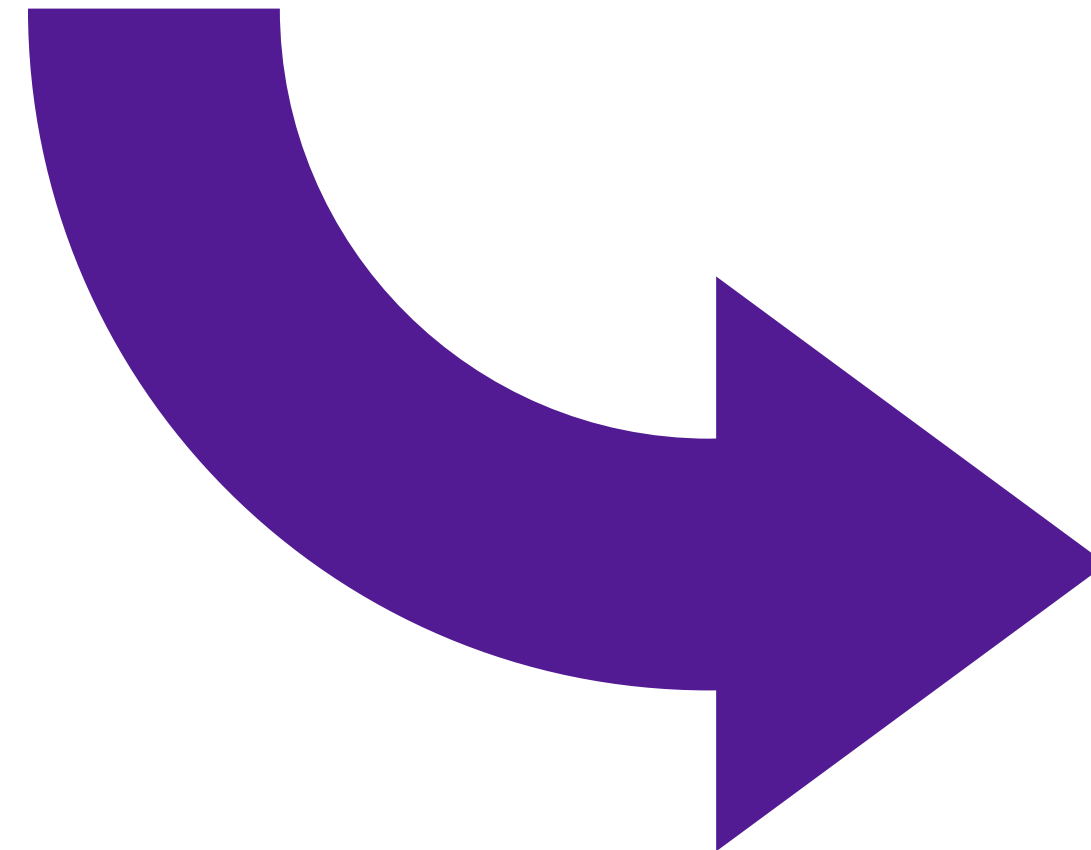
```
public virtual PersonRecord _003CClone_003E_0024 ( )  
{  
    return new PersonRecord (this);  
}
```

deep Clone

# Record Type

Original

```
public record PersonRecord(  
    string FirstName, string LastName);
```



Compiled

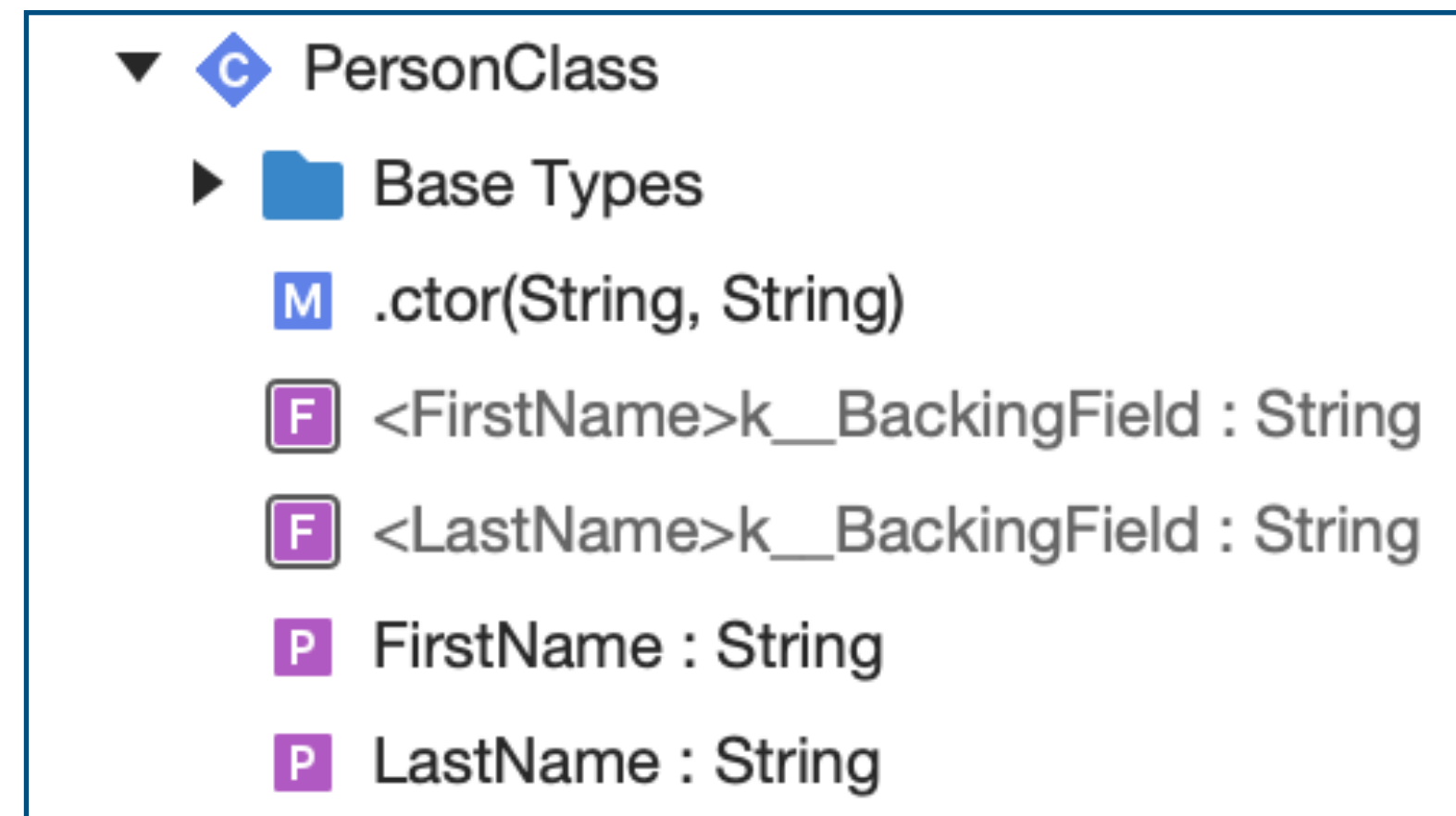
```
▼ C PersonRecord  
  ► Base Types  
    M .ctor(PersonRecord)  
    M .ctor(String, String)  
    M <Clone>$() : PersonRecord  
    F <FirstName>k__BackingField : String  
    F <LastName>k__BackingField : String  
    M Deconstruct(String&, String&) : Void  
    P EqualityContract : Type  
    M Equals(PersonRecord) : Boolean  
    M Equals(Object) : Boolean  
    P FirstName : String  
    M GetHashCode() : Int32  
    P LastName : String  
    M op_Equality(PersonRecord, PersonRecord) : Boolean  
    M op_Inequality(PersonRecord, PersonRecord) : Boolean  
    M PrintMembers(StringBuilder) : Boolean  
    M ToString() : String
```



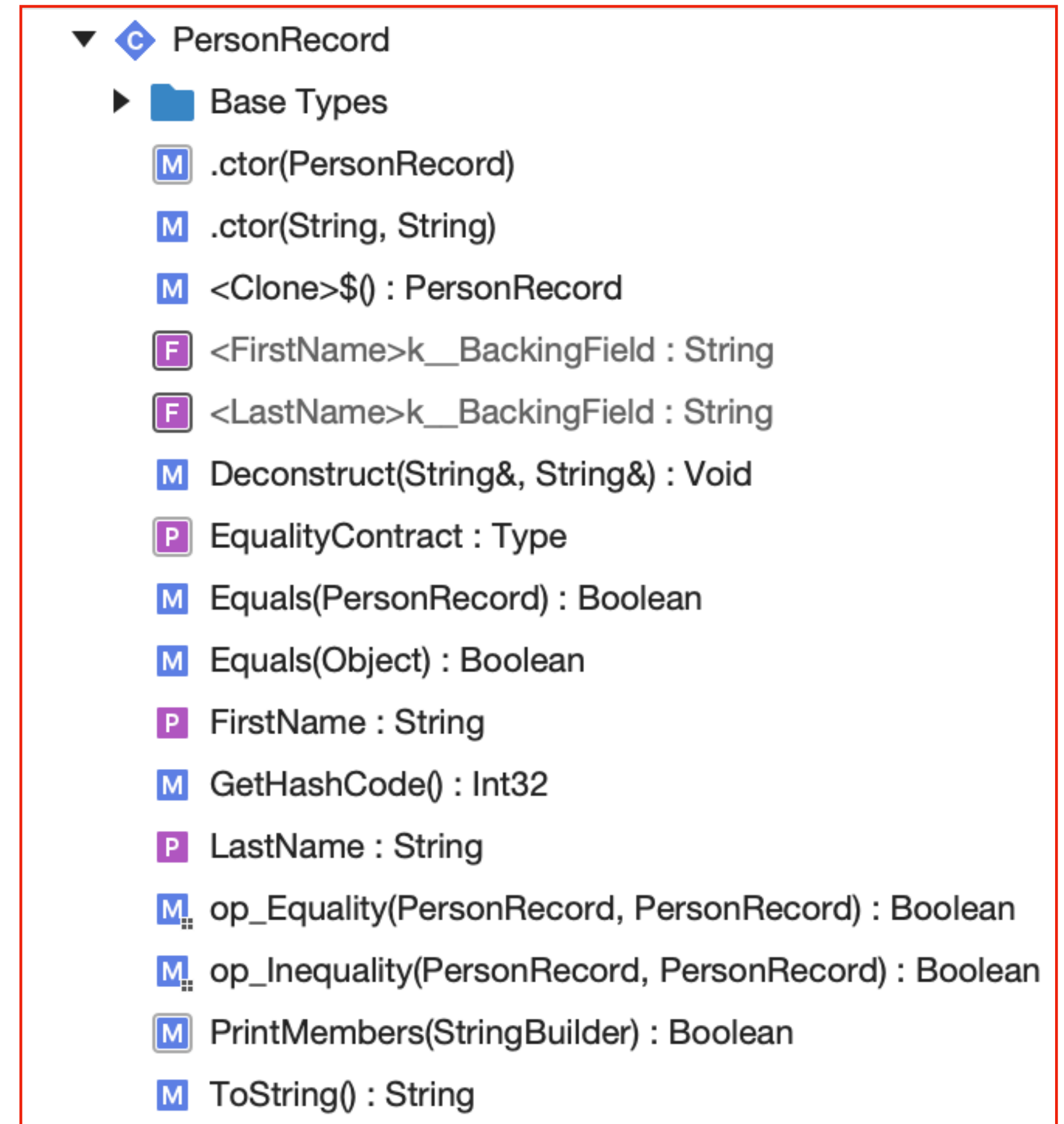
# Record Type

Record Type

## Class



Compare



# Agenda

- Hello World
- Record Type
- **Enumerable**
- Async / Await
- MoveNext()

# Enumerable

```
using System;  
using System.Collections.Generic;  
using System.Linq;  
  
foreach(var n in Fibonacci().Take(10))  
{  
    Console.Write($"{n}, ");  
}  
Console.WriteLine($"{Fibonacci().ElementAt(10)}");
```

# Enumerable

```
static IEnumerable<int> Fibonacci( )  
{  
    yield return 0;  
  
    int value = 1;  
    int next = 1;  
    while (true)  
    {  
        yield return value;  
  
        int t = value;  
        value = next;  
        next += t;  
    }  
}
```

output

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55

# Enumerable

## Original

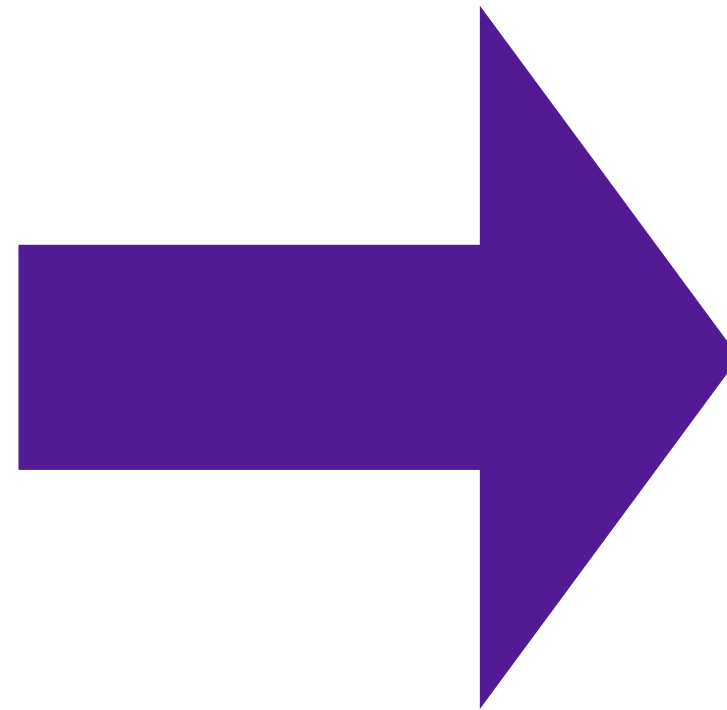
```
using System;
using System.Collections.Generic;
using System.Linq;

foreach(var n in Fibonacci().Take(10))
{
    Console.Write($"{n}, ");
}
Console.WriteLine($"{Fibonacci().ElementAt(10)}");

static IEnumerable<int> Fibonacci()
{
    yield return 0;

    int value = 1;
    int next = 1;
    while (true)
    {
        yield return value;

        int t = value;
        value = next;
        next += t;
    }
}
```




## Compiled















```
using System;
using System.Collections.Generic;
using System.Linq;

private static void _003CMain_003E_0024 (string[] args)
{
    foreach (int item in Fibonacci ().Take (10)) {
        Console.Write ("{" + item + ", ");
    }
    Console.WriteLine ("{" + Fibonacci ().ElementAt (10) + "}");
    static IEnumerable<int> Fibonacci ()
    {
        yield return 0;
        int value = 1;
        int next = 1;
        while (true) {
            yield return value;
            int num = value;
            value = next;
            next += num;
        }
    }
}
```

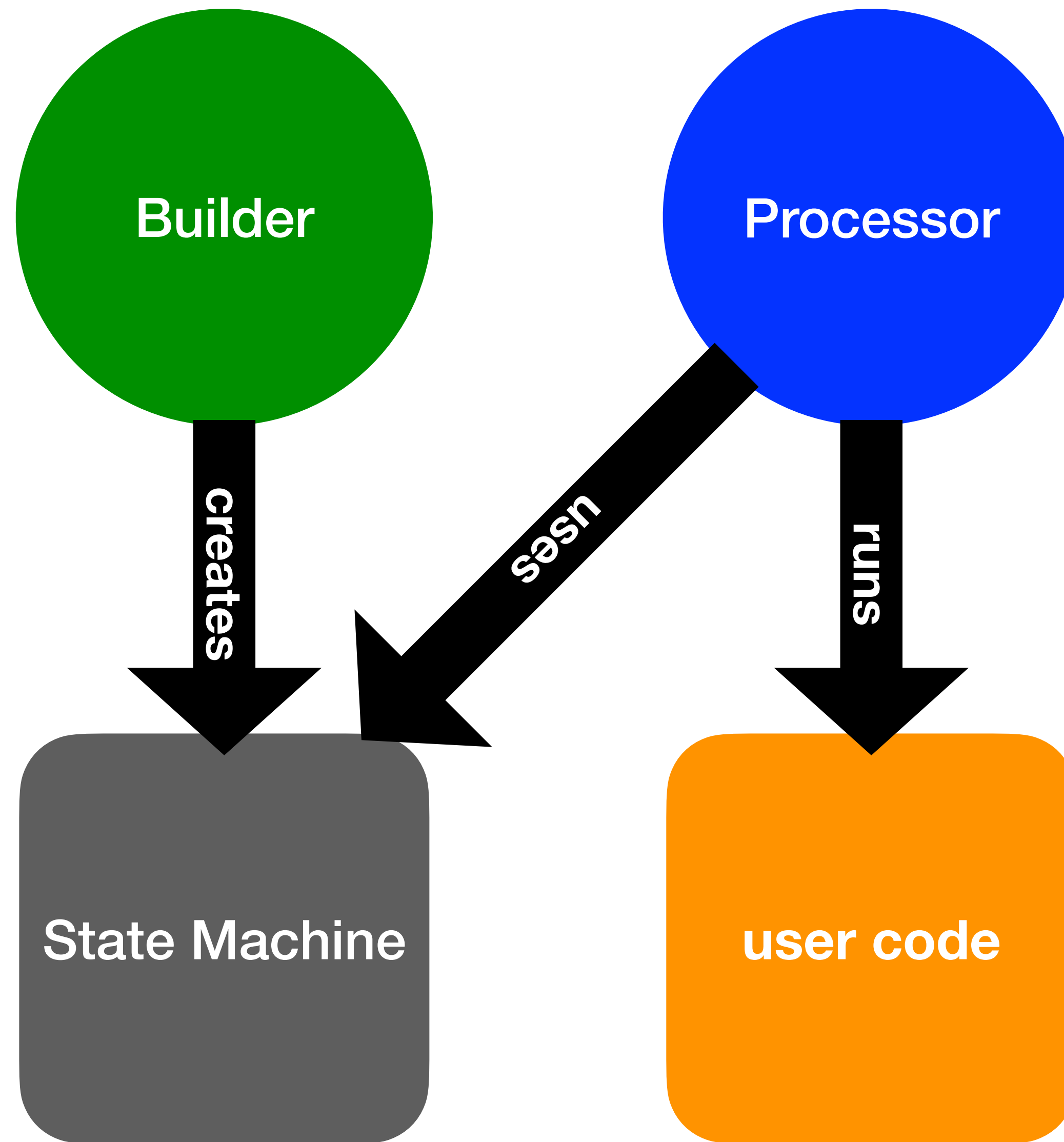
# Enumerable

Compiled

▼  <Program>\$.<<<Main>\$>g\_\_Fibonacci|0\_0>d

- ▶  Base Types
  -  .ctor(Int32)
  -  <>1\_\_state : Int32
  -  <>2\_\_current : Int32
  -  <>l\_\_initialThreadId : Int32
  -  <next>5\_\_3 : Int32
  -  <value>5\_\_2 : Int32
  -  MoveNext() : Boolean
  -  System.Collections.Generic.IEnumerable<System.Int32>.GetEnumerator() : IEnumerator<Int32>
  -  System.Collections.Generic.IEnumerator<System.Int32>.Current : Int32
  -  System.Collections.IEnumerable.GetEnumerator() : IEnumerator
  -  System.Collections.IEnumerator.Current : Object
  -  System.Collections.IEnumerator.Reset() : Void
  -  System.IDisposable.Dispose() : Void

# Enumerable



# Enumerable

Compiled

start state

```
var sequence = new EnumerableFibonacci(-2);  
foreach (var n in sequence.Take(10))  
{  
    Console.Write($"{n}, ");  
}  
Console.WriteLine($"{sequence.ElementAt(10)}");
```



# Enumerable

hidden class

Compiled

```
public class EnumerableFibonacci : IEnumerable<int>, IEnumerable, IEnumerator<int>,
IEnumerator, IDisposable
{
    private int _state;
    private int _current;
    private int _initialThreadId;

    private int value;
    private int next;
```

enumerable  
variables

local variables

# Enumerable

Compiled

```
public EnumerableFibonacci(int state)
{
    this._state = state;
    _initialThreadId = Environment.CurrentManagedThreadId;
}
```

# Enumerable

Compiled

```
IEnumerator<int> IEnumerable<int>.GetEnumerator( )  
{  
    if ( _state == -2 && _initialThreadId == Environment.CurrentManagedThreadId )  
    {  
        _state = 0;  
        return this;  
    }  
    return new EnumerableFibonacci(0);  
}
```

# Enumerable

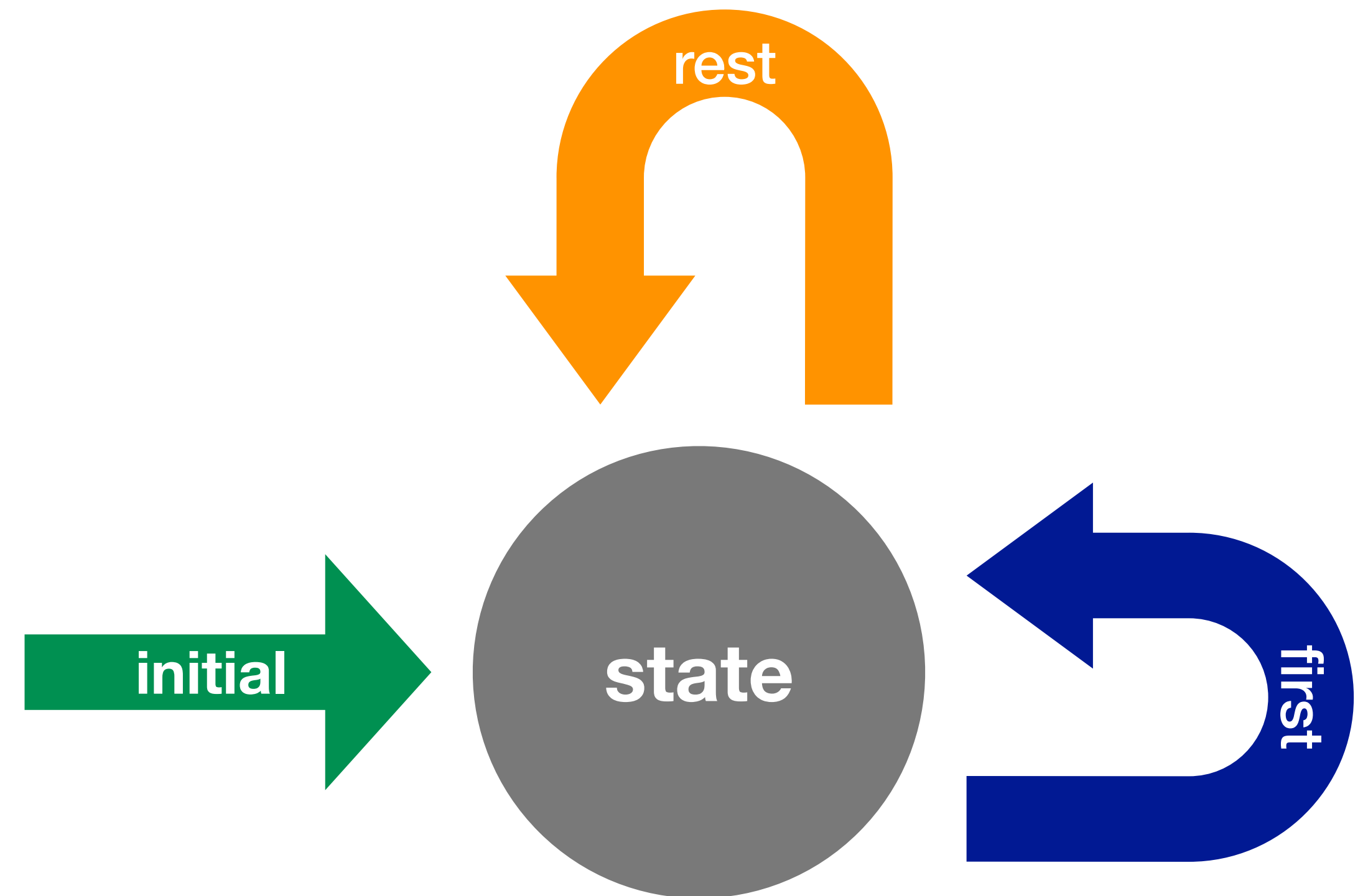
Compiled

```
int IEnumerator<int>.Current
{
    get
    {
        return _current;
    }
}
```

# Enumerable

## Compiled

```
private bool MoveNext()  
{  
    const int ERROR = -1;  
    switch (_state)  
    {  
        default:  
            return false;  
        case 0:  
            // initial  
            _state = ERROR;  
            _current = 0; // Fibonacci(0)  
            _state = 1;  
            return true;  
        case 1:  
            // 1st  
            _state = ERROR;  
            value = 1; // Fibonacci(1)  
            next = 1; // Fibonacci(2)  
            break;  
        case 2:  
            // rest  
            _state = ERROR;  
            int temp = value;  
            value = next;  
            next += temp;  
            break;  
    }  
    _current = value;  
    _state = 2;  
    return true;  
}
```



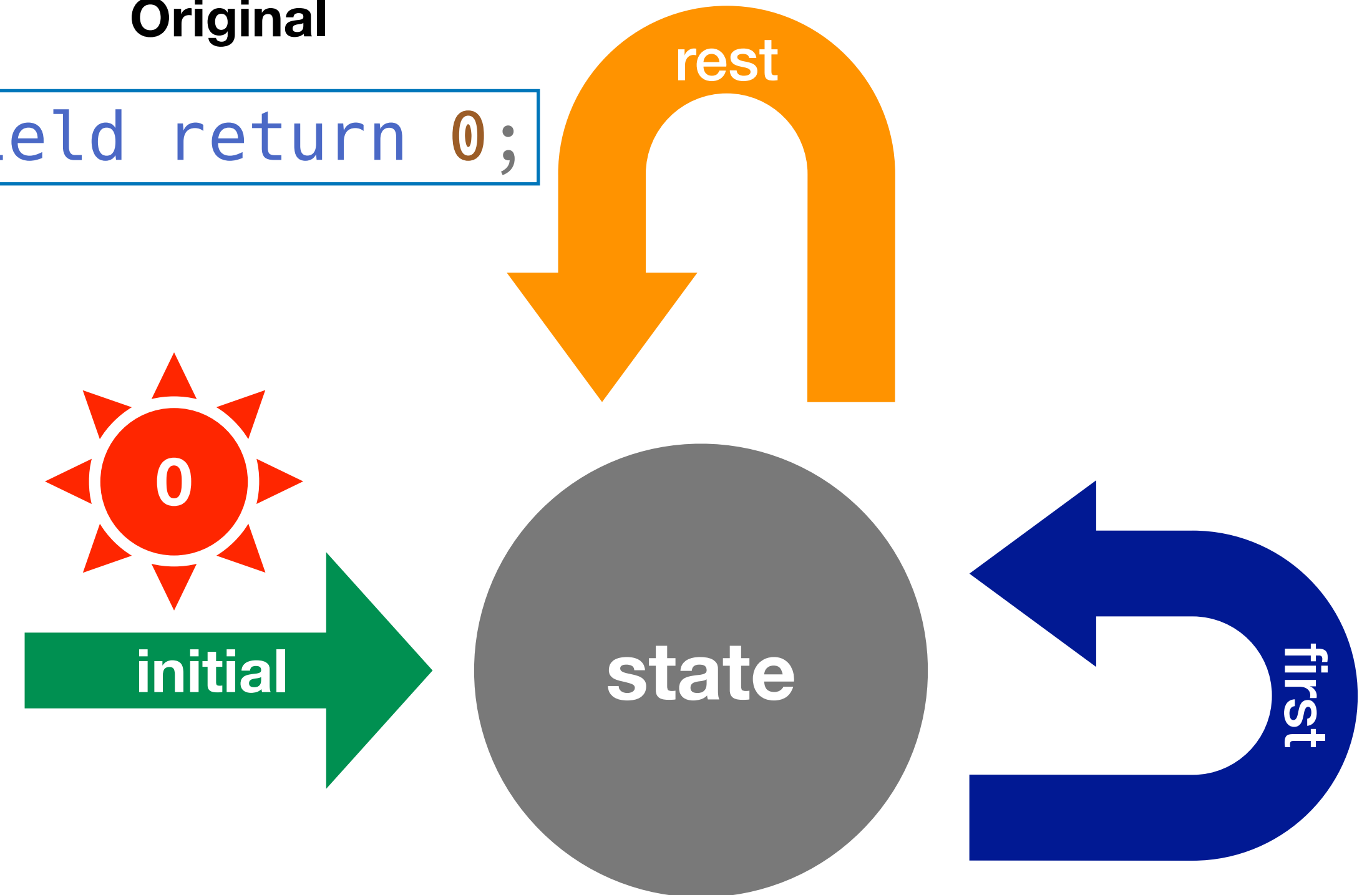
# Enumerable

Compiled

```
private bool MoveNext()
{
    const int ERROR = -1;
    switch (_state)
    {
        default:
            return false;
        case 0:
            // initial
            _state = ERROR;
            _current = 0; // Fibonacci(0)
            _state = 1;
            return true;
        case 1:
            // 1st
            _state = ERROR;
            value = 1; // Fibonacci(1)
            next = 1; // Fibonacci(2)
            break;
        case 2:
            // rest
            _state = ERROR;
            int temp = value;
            value = next;
            next += temp;
            break;
    }
    _current = value;
    _state = 2;
    return true;
}
```

Original

yield return 0;



simplified C#

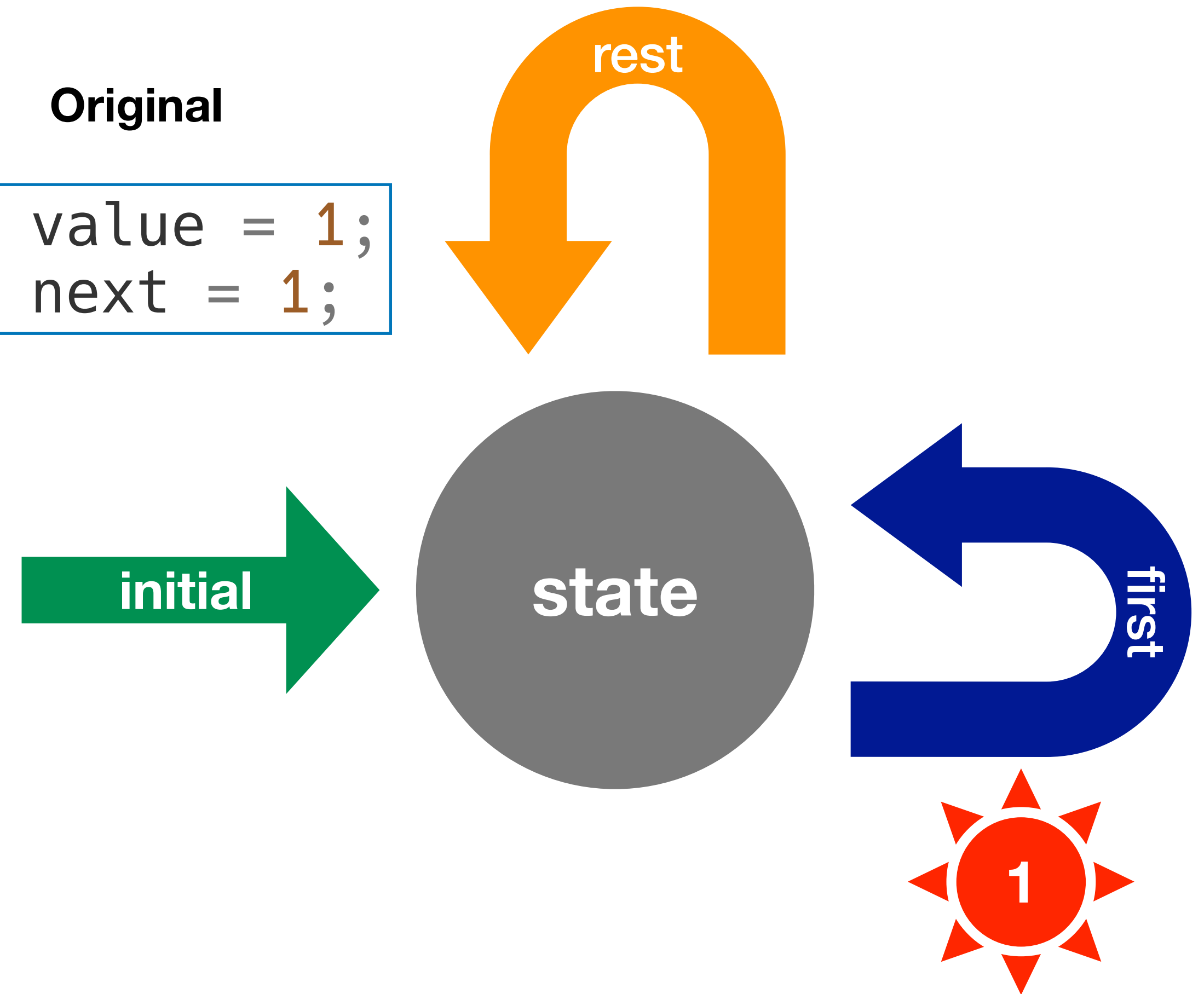
## Compiled

```
private bool MoveNext()  
{  
    const int ERROR = -1;  
    switch (_state)  
    {  
        default:  
            return false;  
        case 0:  
            // initial  
            _state = ERROR;  
            _current = 0; // Fibonacci(0)  
            _state = 1;  
            return true;  
        case 1:  
            // 1st  
            _state = ERROR;  
            value = 1; // Fibonacci(1)  
            next = 1; // Fibonacci(2)  
            break;  
        case 2:  
            // rest  
            _state = ERROR;  
            int temp = value;  
            value = next;  
            next += temp;  
            break;  
    }  
    _current = value;  
    _state = 2;  
    return true;  
}
```

# Enumerable

Original

```
int value = 1;  
int next = 1;
```



simplified C#

## Compiled

```
private bool MoveNext()  
{  
    const int ERROR = -1;  
    switch (_state)  
    {  
        default:  
            return false;  
        case 0:  
            // initial  
            _state = ERROR;  
            _current = 0; // Fibonacci(0)  
            _state = 1;  
            return true;  
        case 1:  
            // 1st  
            _state = ERROR;  
            value = 1; // Fibonacci(1)  
            next = 1; // Fibonacci(2)  
            break;  
        case 2:  
            // rest  
            _state = ERROR;  
            int temp = value;  
            value = next;  
            next += temp;  
            break;  
    }  
    _current = value;  
    _state = 2;  
    return true;  
}
```

# Enumerable

## Original

```
yield return value;  
  
int t = value;  
value = next;  
next += t;
```





# Enumerable

**Main**

**foreach**

**Enumerable**

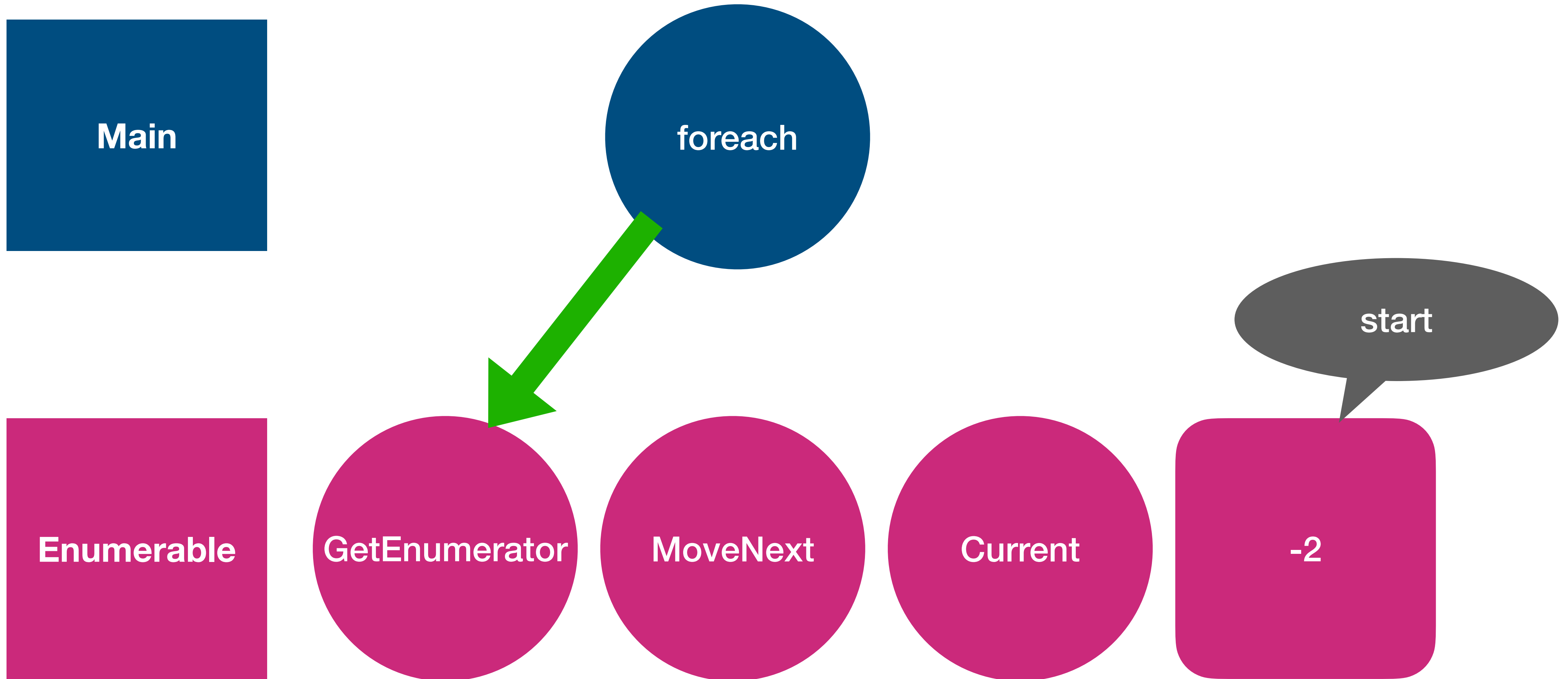
**GetEnumerator**

**MoveNext**

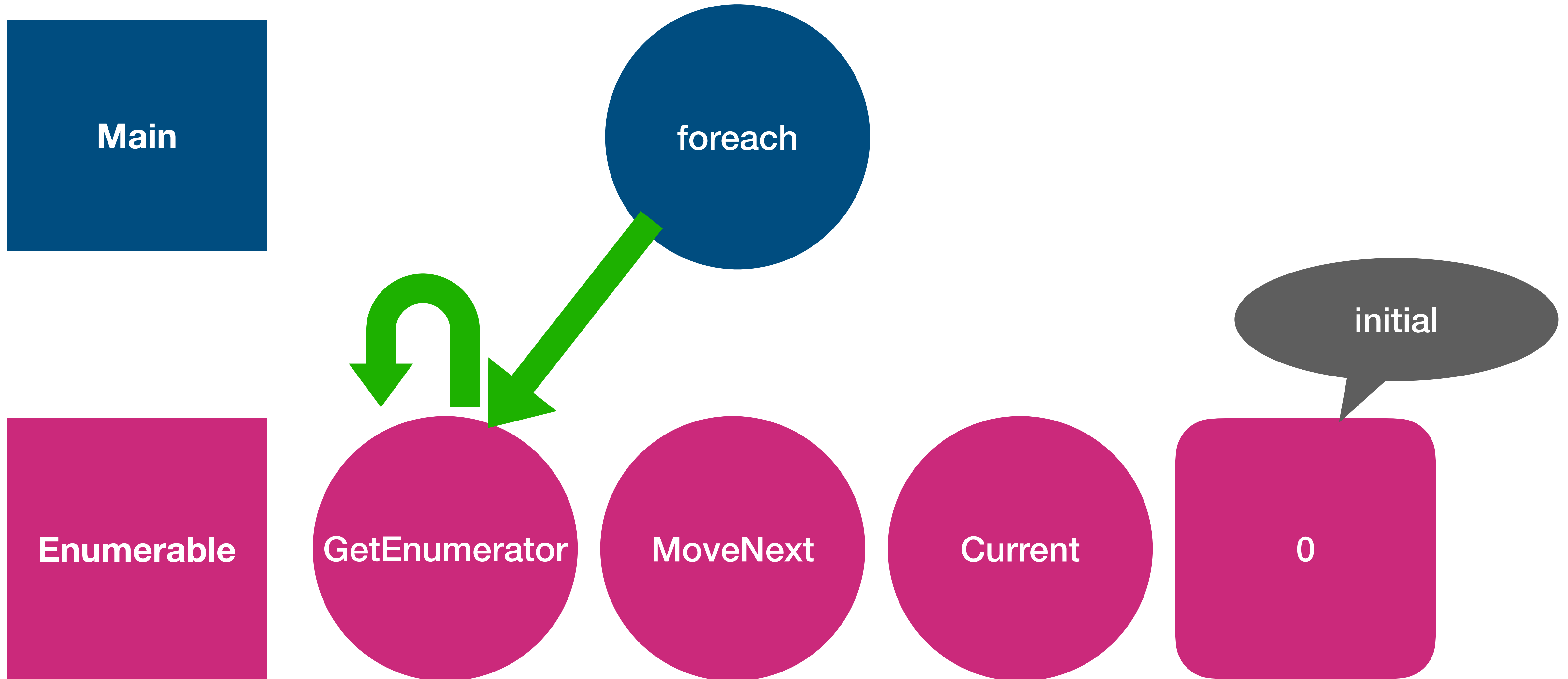
**Current**

**\_state**

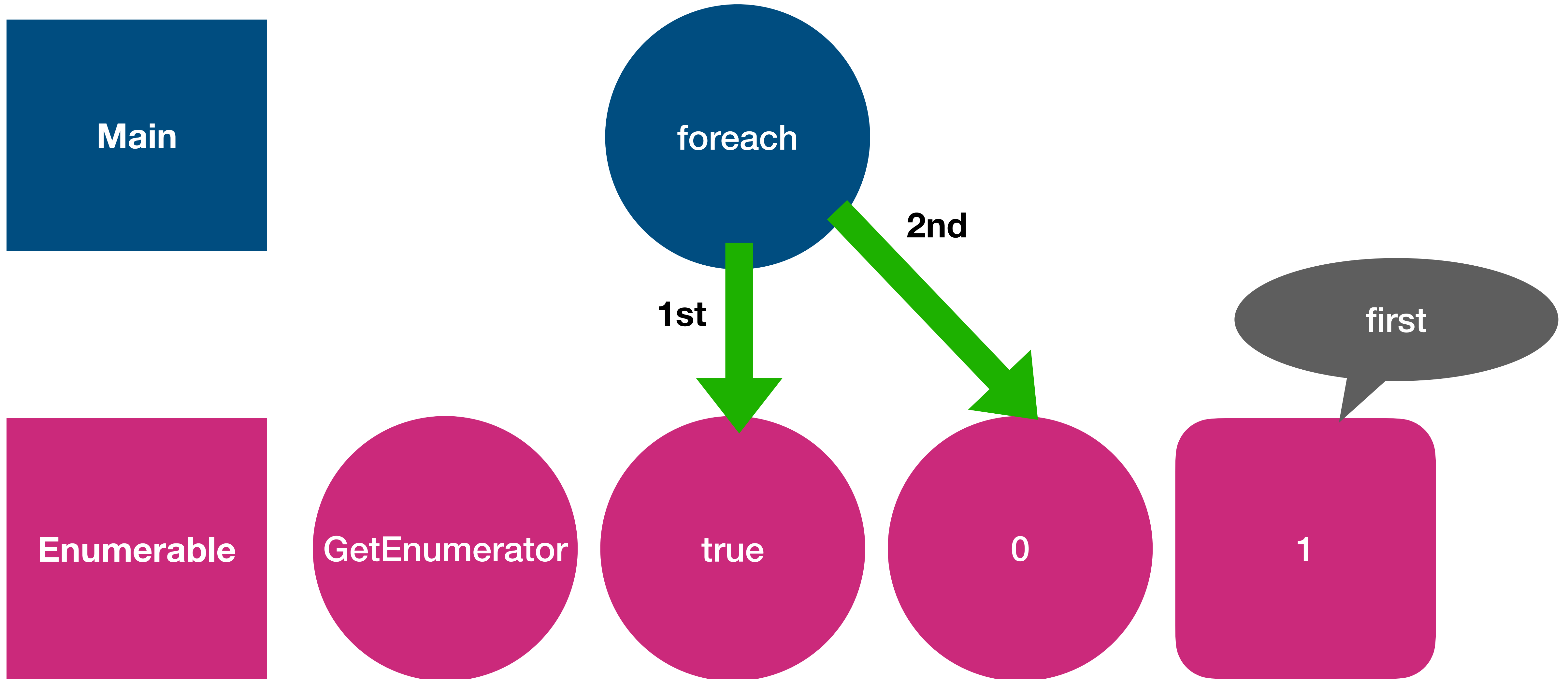
# Enumerable



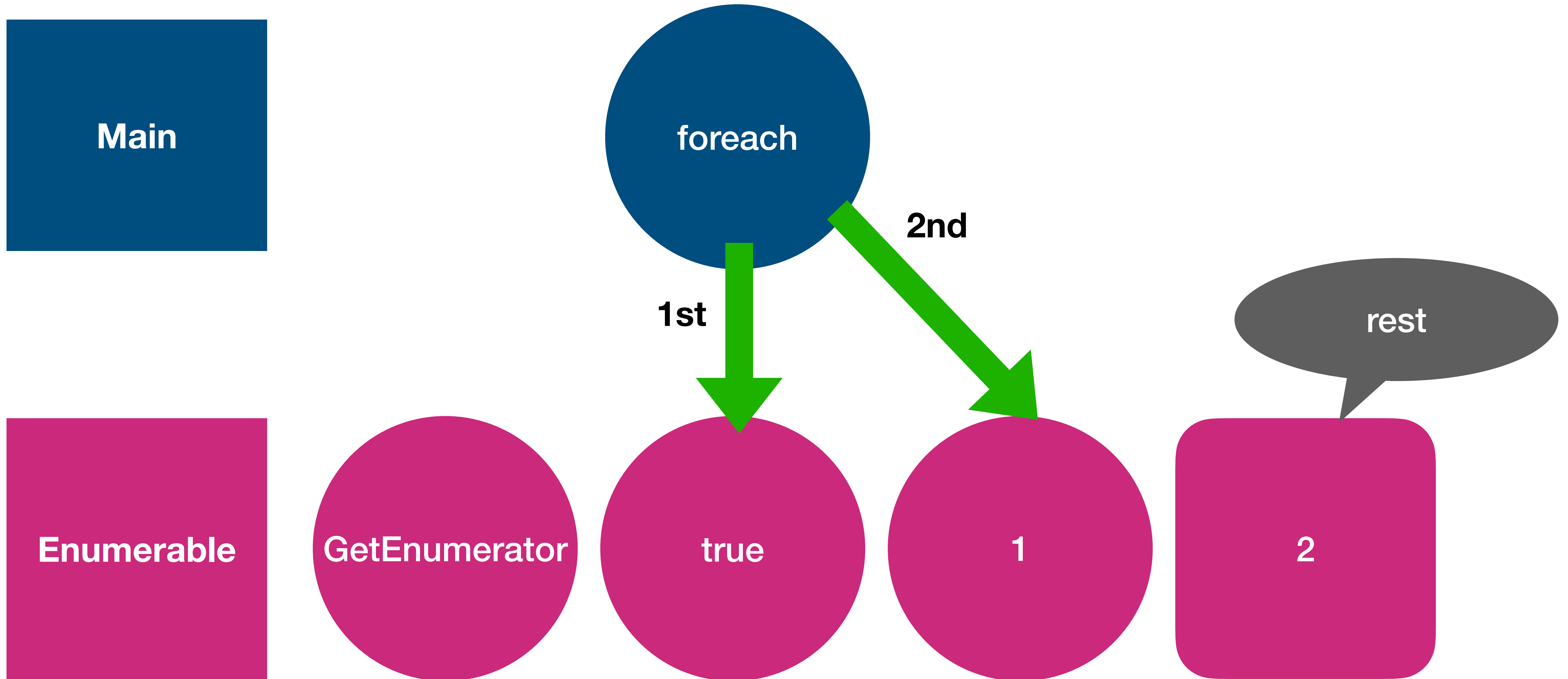
# Enumerable



# Enumerable



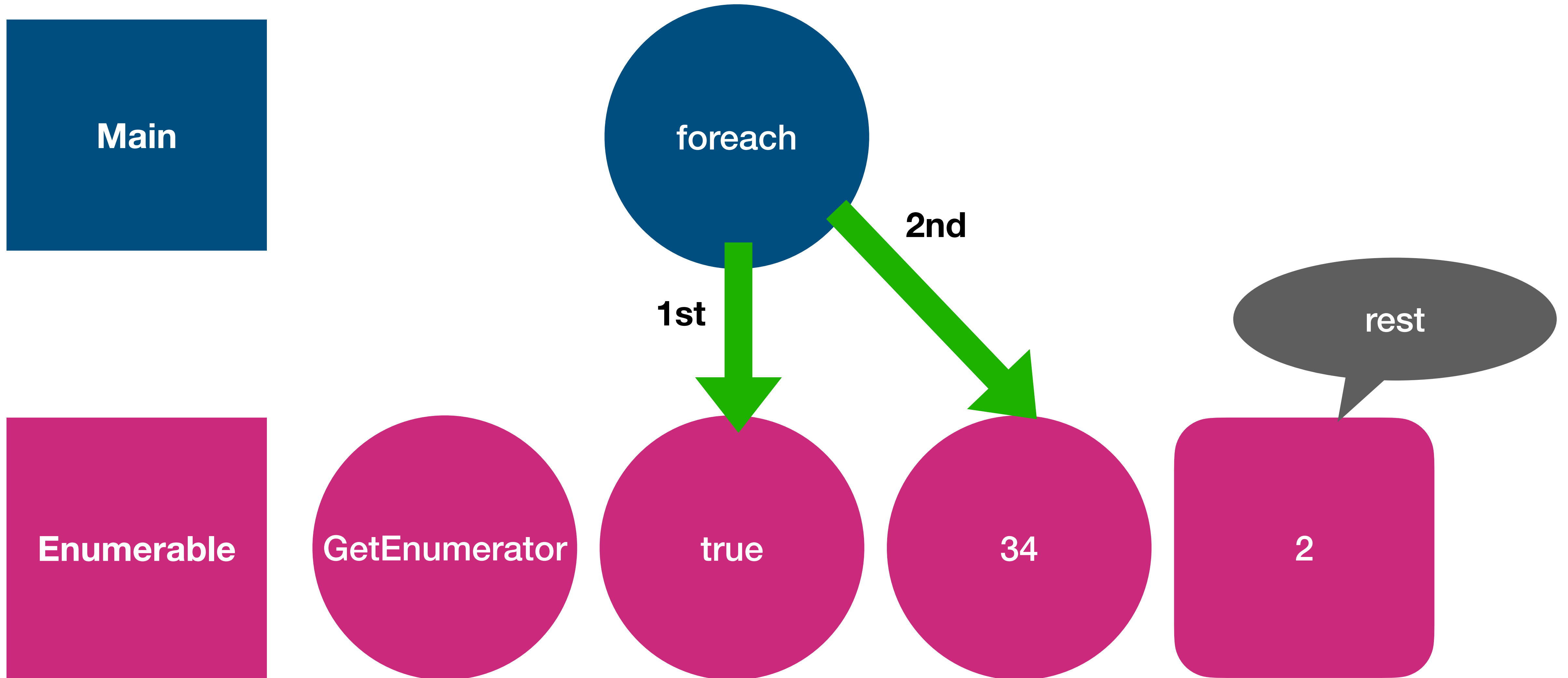
# Enumerable



# Enumerable

**skip to the end...**

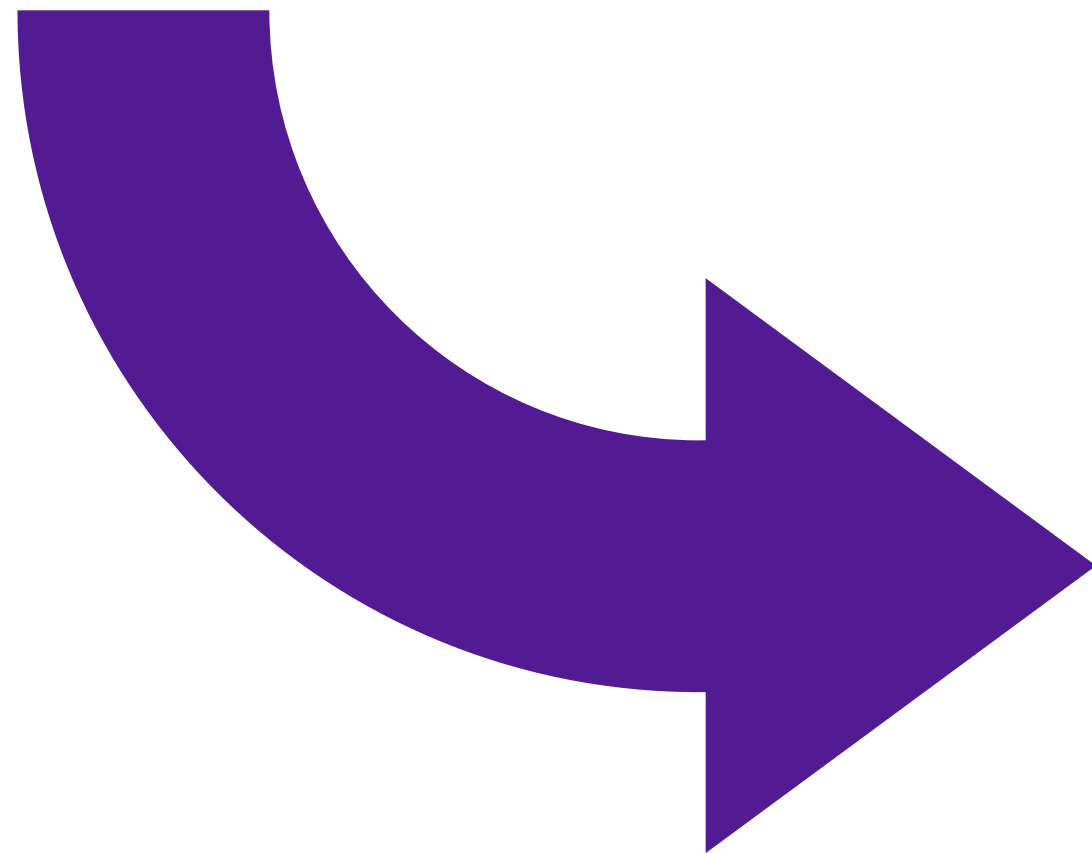
# Enumerable



# Enumerable

Original

```
foreach(  
    var n in Fibonacci( ).Take( 10 ) )  
{  
    Console.Write( $"{n}, " );  
}
```



```
▼ <Program>$.<<<Main>$>g__Fibonacci|0_0>d  
  ► Base Types  
    M .ctor(Int32)  
    F <>1__state : Int32  
    F <>2__current : Int32  
    F <>I__initialThreadId : Int32  
    F <next>5__3 : Int32  
    F <value>5__2 : Int32  
    M MoveNext() : Boolean  
    M System.Collections.Generic.IEnumerable<System.Int32>.GetEnumerator() : IEnumerator<Int32>  
    P System.Collections.Generic.IEnumerator<System.Int32>.Current : Int32  
    M System.Collections.IEnumerable.GetEnumerator() : IEnumerator  
    P System.Collections.IEnumerator.Current : Object  
    M System.Collections.IEnumerator.Reset() : Void  
    M System.IDisposable.Dispose() : Void
```



# Agenda

- Hello World
- Record Type
- Enumerable
- **Async / Await**
- MoveNext()

# Async / Await

```
using System;
using System.Threading.Tasks;

var x = Identity(6);
var y = await IdentityAsync(7);

Console.WriteLine($"{x:X4} + {y:X4} = {x * y:X4}");

static T Identity<T>(T x) => x;
static async Task<T> IdentityAsync<T>(T x) => x;
```

output

0006 + 0007 = 002A

only difference  
is async

# Async / Await

## Original

```
using System;
using System.Threading.Tasks;

var x = Identity(6);
var y = await IdentityAsync(7);

Console.WriteLine($"{x:X4} + {y:X4} = {x * y:X4}");

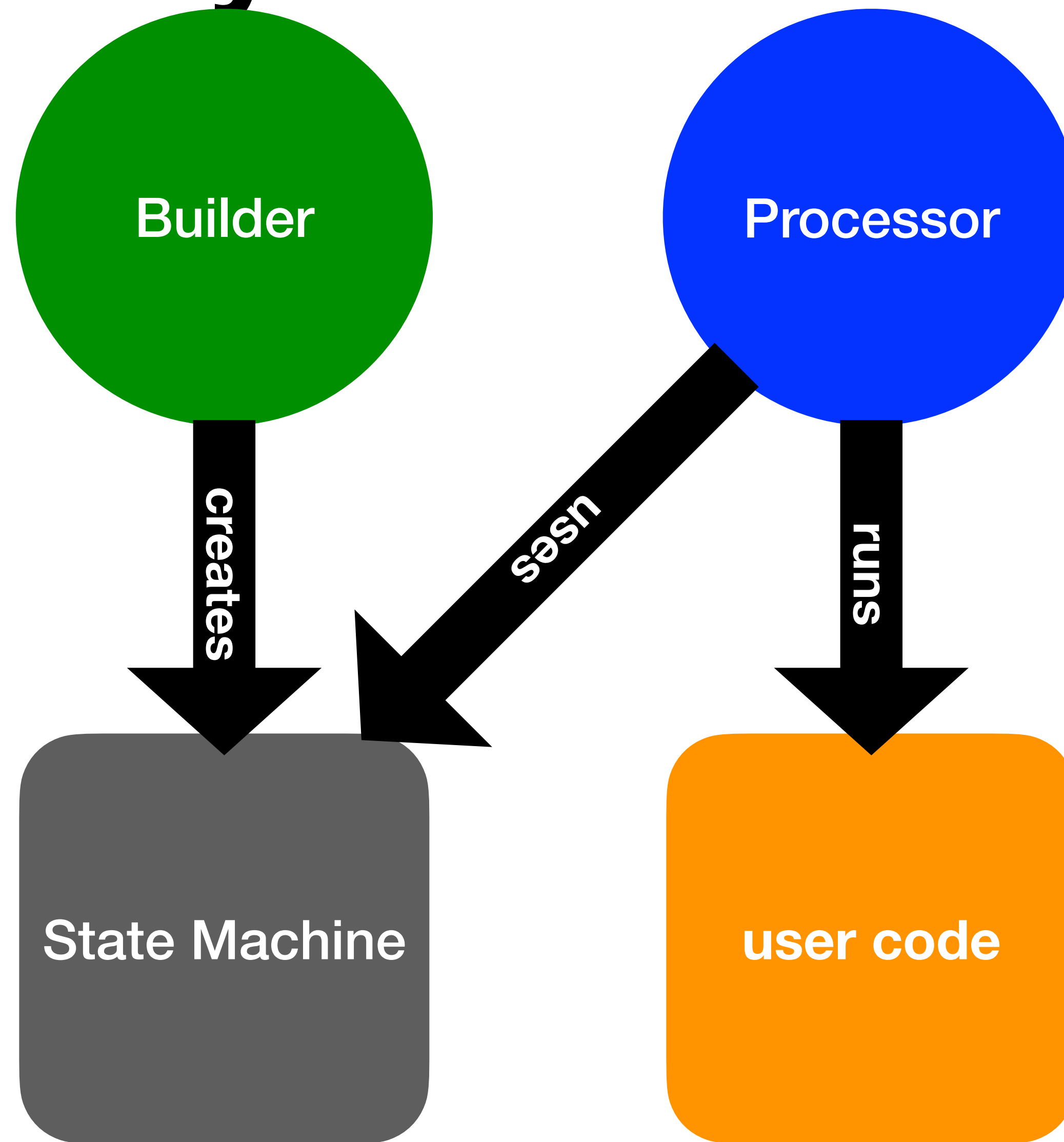
static T Identity<T>(T x) => x;
static async Task<T> IdentityAsync<T>(T x) => x;
```

## Compiled

```
using System;
using System.Runtime.CompilerServices;
using System.Threading.Tasks;

[CompilerGenerated]
internal static class _003CProgram_003E_0024
{
    private static async Task _003CMain_003E_0024 (string[] args)
    {
        int x2 = Identity<int> (6);
        int num = await IdentityAsync<int> (7);
        Console.WriteLine ($"{x2:X4} + {num:X4} = {x2 * num:X4}");
        static T Identity<T> (T x)
        {
            return x;
        }
        [AsyncStateMachine (typeof(_003C_003C_003CMain_003E_0024_003Eg__IdentityAsync_007C0_1_003Ed<>))]
        static Task<T> IdentityAsync<T> (T x)
        {
            _003C_003C_003CMain_003E_0024_003Eg__IdentityAsync_007C0_1_003Ed<T> stateMachine =
default(_003C_003C_003CMain_003E_0024_003Eg__IdentityAsync_007C0_1_003Ed<T>);
            stateMachine._003C_003Et__builder = AsyncTaskMethodBuilder<T>.Create ();
            stateMachine.x = x;
            stateMachine._003C_003E1__state = -1;
            stateMachine._003C_003Et__builder.Start (ref stateMachine);
            return stateMachine._003C_003Et__builder.Task;
        }
    }
}
```

# Async / Await



# Async / Await

Compiled

hidden class

```
[AsyncStateMachine(typeof(IdentityAsync<>))]
static Task<T> IdentityAsyncWraper<T>(T x)
{
    IdentityAsync<T> stateMachine = default(IdentityAsync<T>);
    stateMachine._builder = AsyncTaskMethodBuilder<T>.Create();
    stateMachine.x = x;
    stateMachine._state = -1;
    stateMachine._builder.Start(ref stateMachine);
    return stateMachine._builder.Task;
}
```

1. create State Machine
  - set Async Helper
  - set Parameters
  - set Initial State
2. call Async MoveNext
3. return Async Task

# Async / Await

Compiled

```
[StructLayout(LayoutKind.Auto)]
struct IdentityAsync<T> : IAsyncStateMachine
{
    public int _state;
    public AsyncTaskMethodBuilder<T> _builder;

    public T x;

    private void SetStateMachine(IAsyncStateMachine stateMachine)
    {
        _builder.SetStateMachine(stateMachine);
    }

    void IAsyncStateMachine.SetStateMachine(IAsyncStateMachine stateMachine)
    {
        this.SetStateMachine(stateMachine);
    }
}
```

parameter

place State Machine on Heap

simplified C#

# Async / Await

Compiled

```
private void MoveNext( )
{
    T result;
    try
    {
        result = x;
    }
    catch (Exception exception)
    {
        _state = -2;
        _builder.SetException(exception);
        return;
    }
    _state = -2;
    _builder.SetResult(result);
}
```

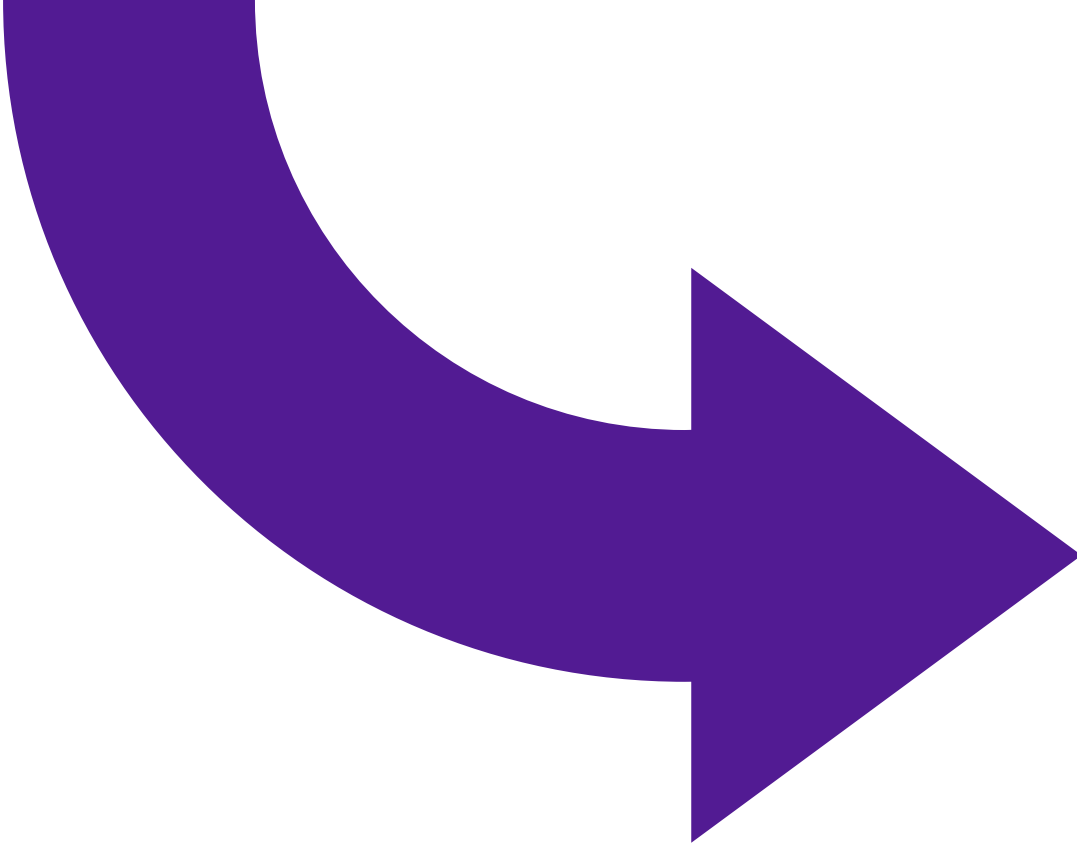
**-2 state = complete**

# Async / Await

Original

```
static async Task<T> IdentityAsync<T>(T x) => x;
```

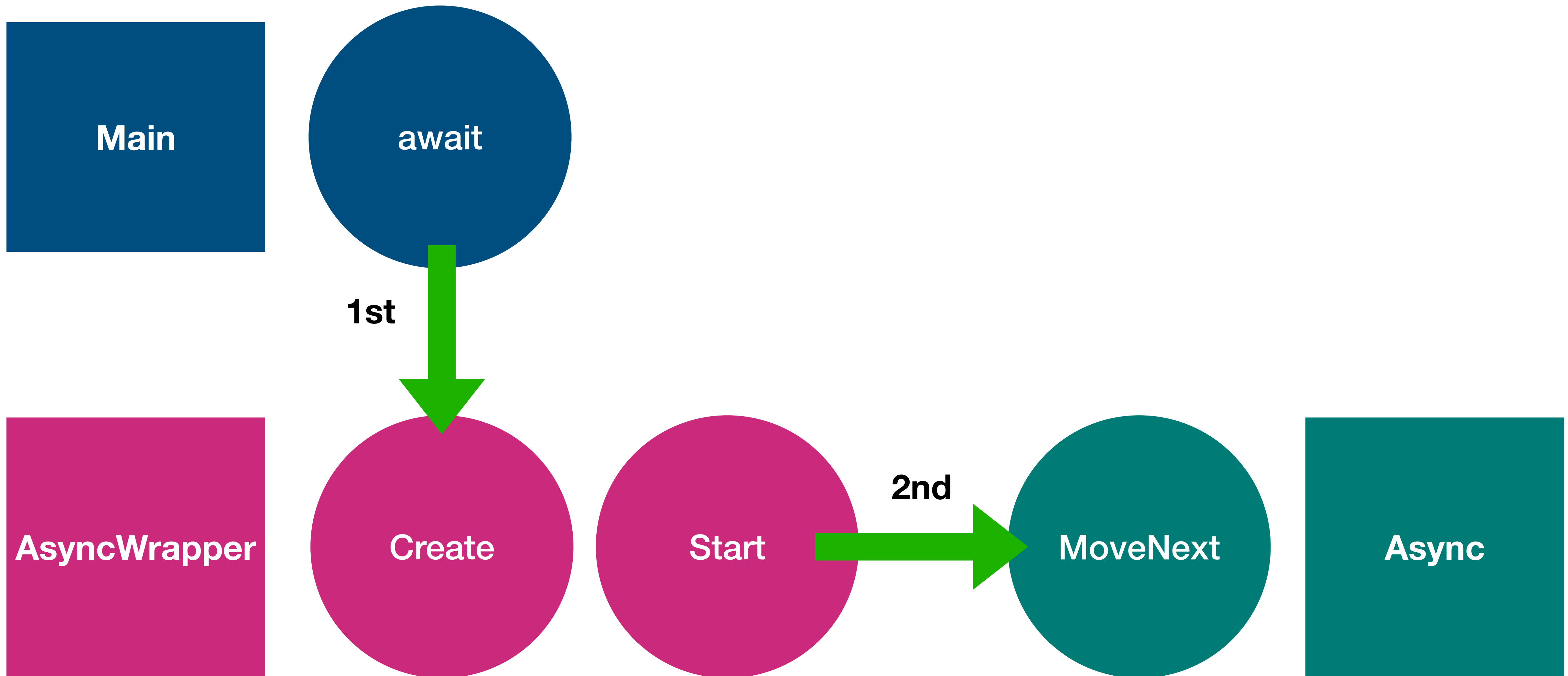
Compiled



```
▼ <Program>$.<<<Main>$>g__IdentityAsync|0_1>d<T>  
  ► Base Types  
    M .ctor()  
    F <>1__state : Int32  
    F <>t__builder : AsyncTaskMethodBuilder<T>  
    M MoveNext() : Void  
    M SetStateMachine(IAsyncStateMachine) : Void  
    F x : T
```



# Async / Await



# *Async / Await*

**something more interesting...**

# Async / Await

```
using System;
using System.Threading.Tasks;

await PrintAndWait(TimeSpan.FromMilliseconds(10));

static async Task PrintAndWait(TimeSpan delay)
{
    Console.WriteLine("before delays");
    await Task.Delay(delay);
    Console.WriteLine("between delays");
    await Task.Delay(delay);
    Console.WriteLine("after delays");
}
```

output

```
before delays
between delays
after delays
```

# Async / Await

## Original

```
using System;
using System.Threading.Tasks;

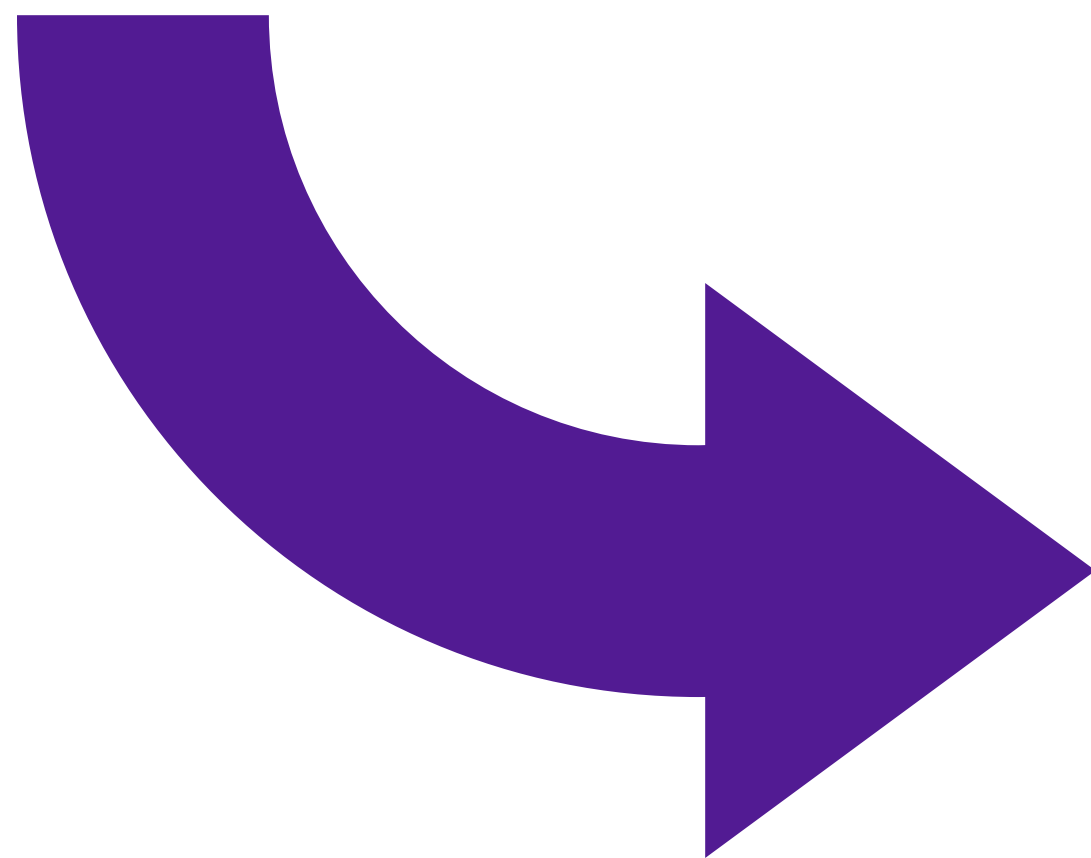
await PrintAndWait(TimeSpan.FromMilliseconds(10));

static async Task PrintAndWait(TimeSpan delay)
{
    Console.WriteLine("before delays");
    await Task.Delay(delay);
    Console.WriteLine("between delays");
    await Task.Delay(delay);
    Console.WriteLine("after delays");
}
```

## Compiled

```
using System;
using System.Runtime.CompilerServices;
using System.Threading.Tasks;

[CompilerGenerated]
internal static class _003CProgram_003E_0024
{
    private static async Task _003CMain_003E_0024 (string[] args)
    {
        await PrintAndWait (TimeSpan.FromMilliseconds (10.0));
        [AsyncStateMachine (typeof(_003C_003C_003CMain_003E_0024_003Eg__PrintAndWait_007C0_0_003Ed))]
        static Task PrintAndWait (TimeSpan delay)
        {
            _003C_003C_003CMain_003E_0024_003Eg__PrintAndWait_007C0_0_003Ed stateMachine4 =
default(_003C_003C_003CMain_003E_0024_003Eg__PrintAndWait_007C0_0_003Ed);
            stateMachine4._003C_003Et__builder = AsyncTaskMethodBuilder.Create ();
            stateMachine4.delay = delay;
            stateMachine4._003C_003E1__state = -1;
            stateMachine4._003C_003Et__builder.Start (ref stateMachine4);
            return stateMachine4._003C_003Et__builder.Task;
        }
    }
}
```



Compiled

# Async / Await

```
[StructLayout(LayoutKind.Auto)]
struct PrintAndWaitAsync : IAsyncStateMachine
{
    public int _state;
    public AsyncTaskMethodBuilder _builder;

    public TimeSpan delay;

    private TaskAwaiter _awaiter;

    private void SetStateMachine(IAsyncStateMachine stateMachine)
    {
        _builder.SetStateMachine(stateMachine);
    }

    void IAsyncStateMachine.SetStateMachine(IAsyncStateMachine stateMachine)
    {
        this.SetStateMachine(stateMachine);
    }
}
```

hidden class

parameter

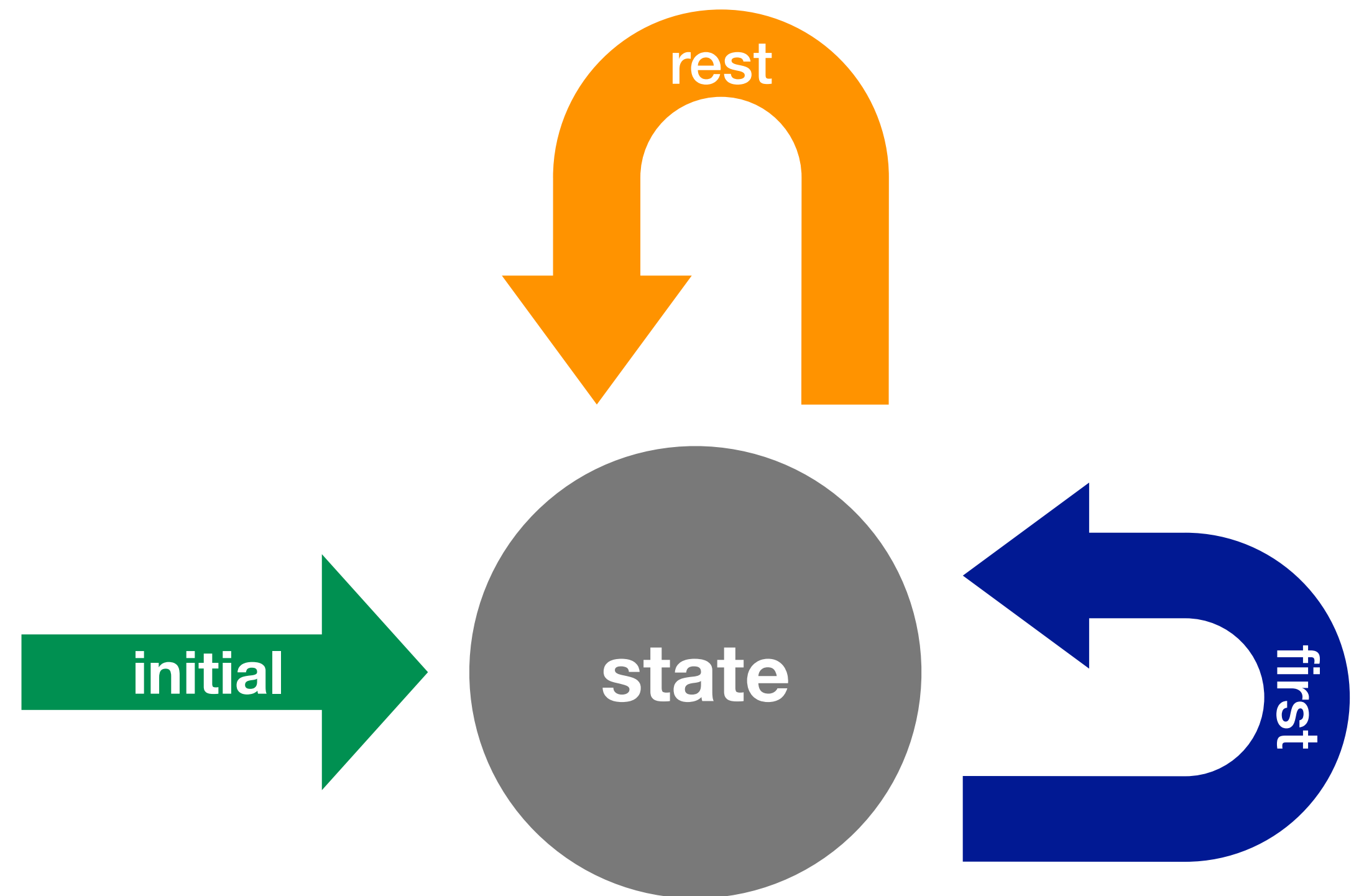
place State Machine on Heap

simplified C#

## Compiled

```
private void MoveNext()
{
    int num = _state;
    try
    {
        TaskAwaiter awaiter;
        if (num != 0)
        {
            if (num == 1)
            {
                awaiter = _awaiter;
                _awaiter = default(TaskAwaiter);
                num = (_state = -1);
                goto done;
            }
            Console.WriteLine("before delays");
            awaiter = Task.Delay(delay).GetAwaiter();
            if (!awaiter.IsCompleted)
            {
                num = (_state = 0);
                _awaiter = awaiter;
                _builder.AwaitUnsafeOnCompleted(ref awaiter, ref this);
                return;
            }
        }
        else
        {
            awaiter = _awaiter;
            _awaiter = default(TaskAwaiter);
            num = (_state = -1);
        }
        awaiter.GetResult();
        Console.WriteLine("between delays");
        awaiter = Task.Delay(delay).GetAwaiter();
        if (!awaiter.IsCompleted)
        {
            num = (_state = 1);
            _awaiter = awaiter;
            _builder.AwaitUnsafeOnCompleted(ref awaiter, ref this);
            return;
        }
        goto done;
    }
    done:
        awaiter.GetResult();
        Console.WriteLine("after delays");
    }
    catch (Exception exception)
    {
        _state = -2;
        _builder.SetException(exception);
        return;
    }
    _state = -2;
    _builder.SetResult();
}
```

# Async / Await



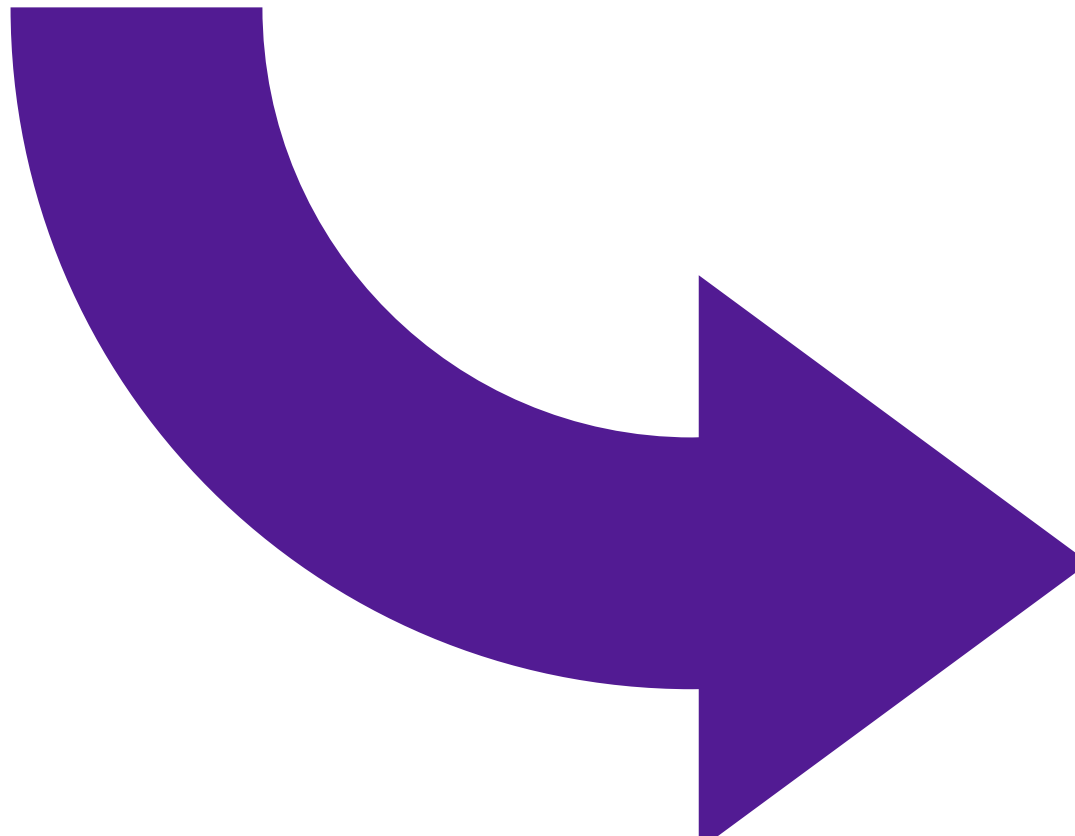
simplified C#

# Async / Await

Original

```
Console.WriteLine("before delays");  
await Task.Delay(delay);
```

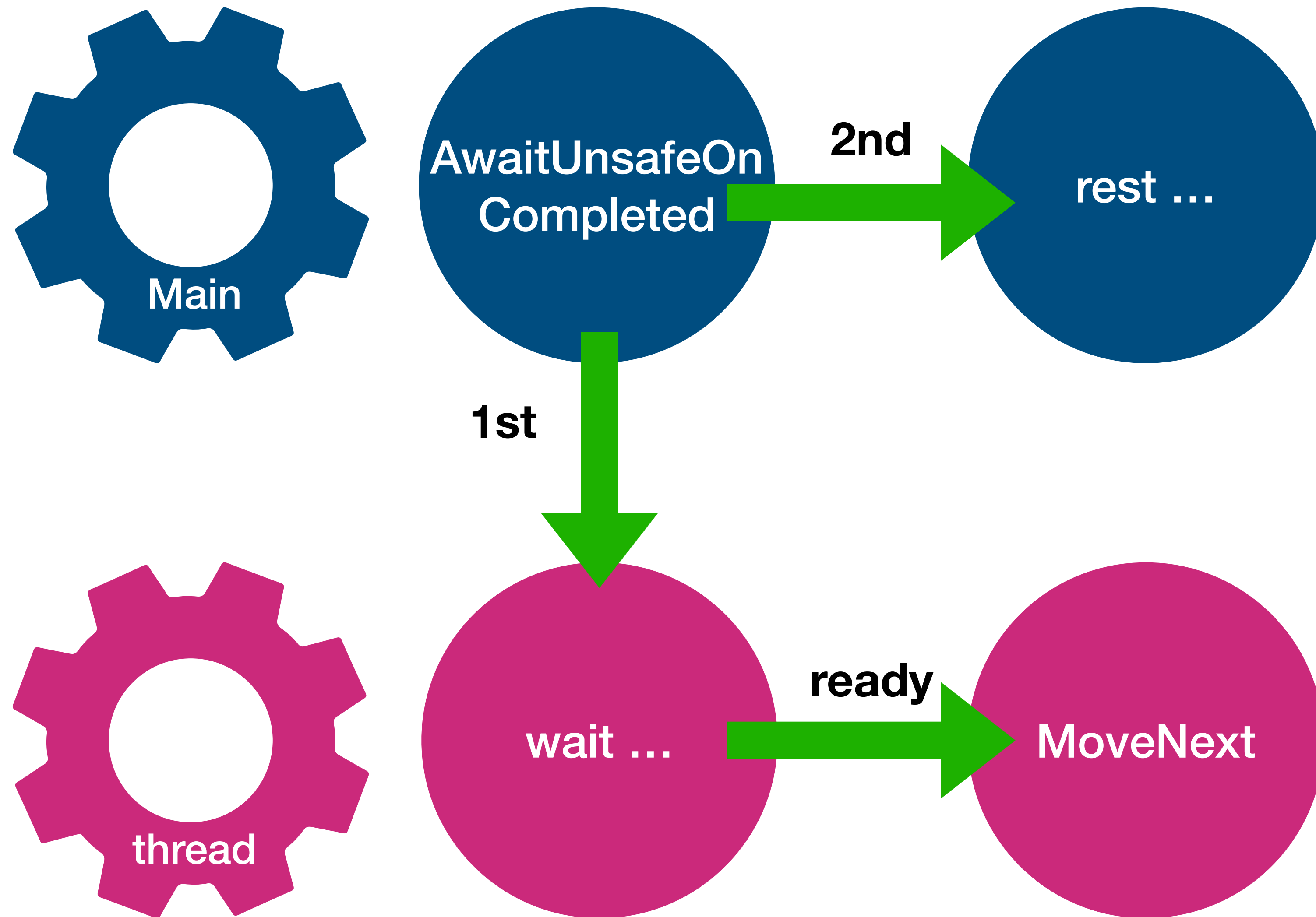
Compiled



```
Console.WriteLine("before delays");  
awaiter = Task.Delay(delay).GetAwaiter();  
if (!awaiter.IsCompleted)  
{  
    num = (_state = 0);  
    _awaiter = awaiter;  
    _builder.AwaitUnsafeOnCompleted(ref awaiter, ref this);  
    return;  
}
```

creates thread with awaiter

# Async / Await





# Async / Await

Original

```
Console.WriteLine("between delays");  
await Task.Delay(delay);
```

Compiled

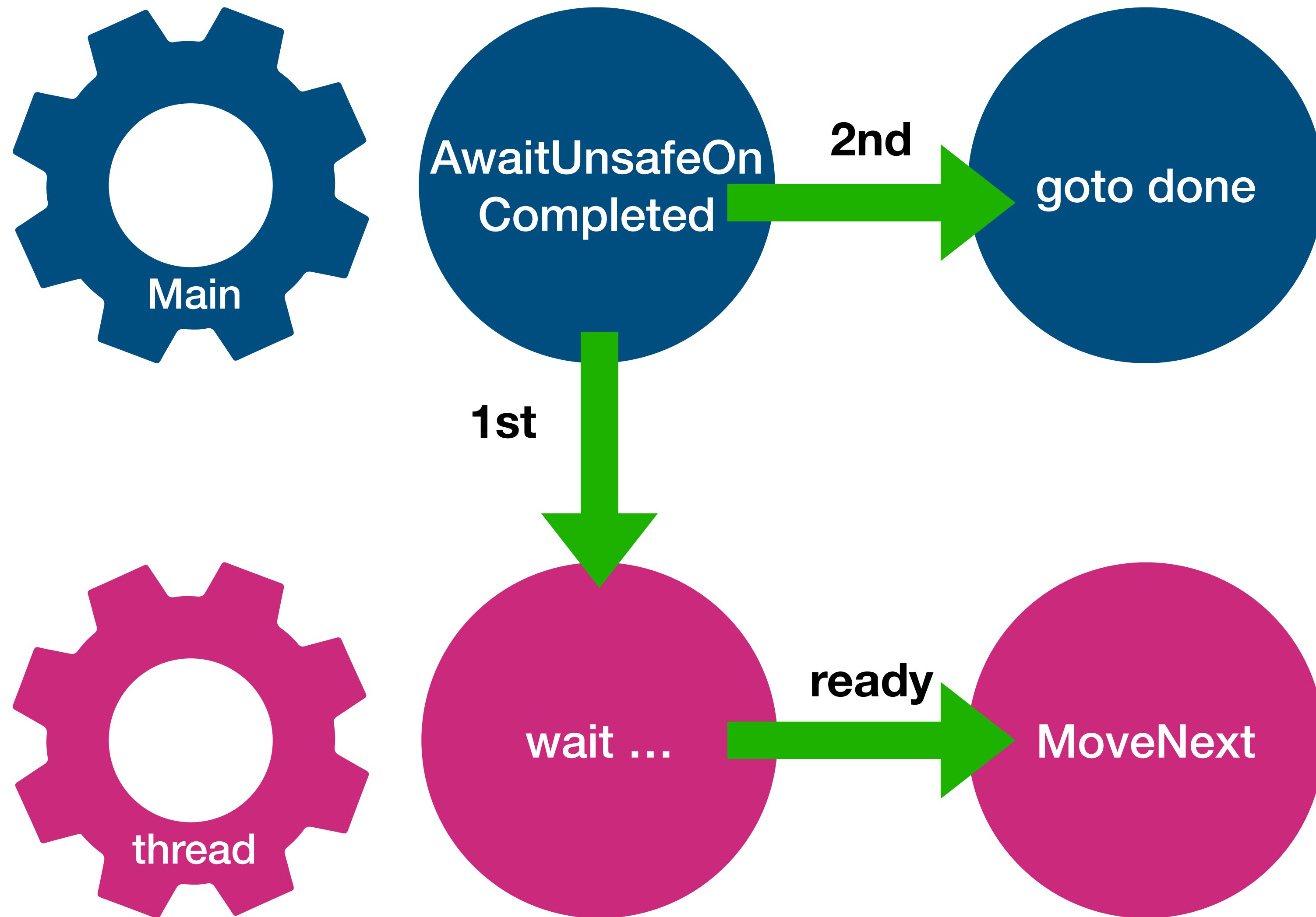


```
awaiter.GetResult();  
Console.WriteLine("between delays");  
awaiter = Task.Delay(delay).GetAwaiter();  
if (!awaiter.IsCompleted)  
{  
    num = (_state = 1);  
    _awaiter = awaiter;  
    _builder.AwaitUnsafeOnCompleted(ref awaiter, ref this);  
    return;  
}  
goto done;
```

done with async

creates thread with awaiter

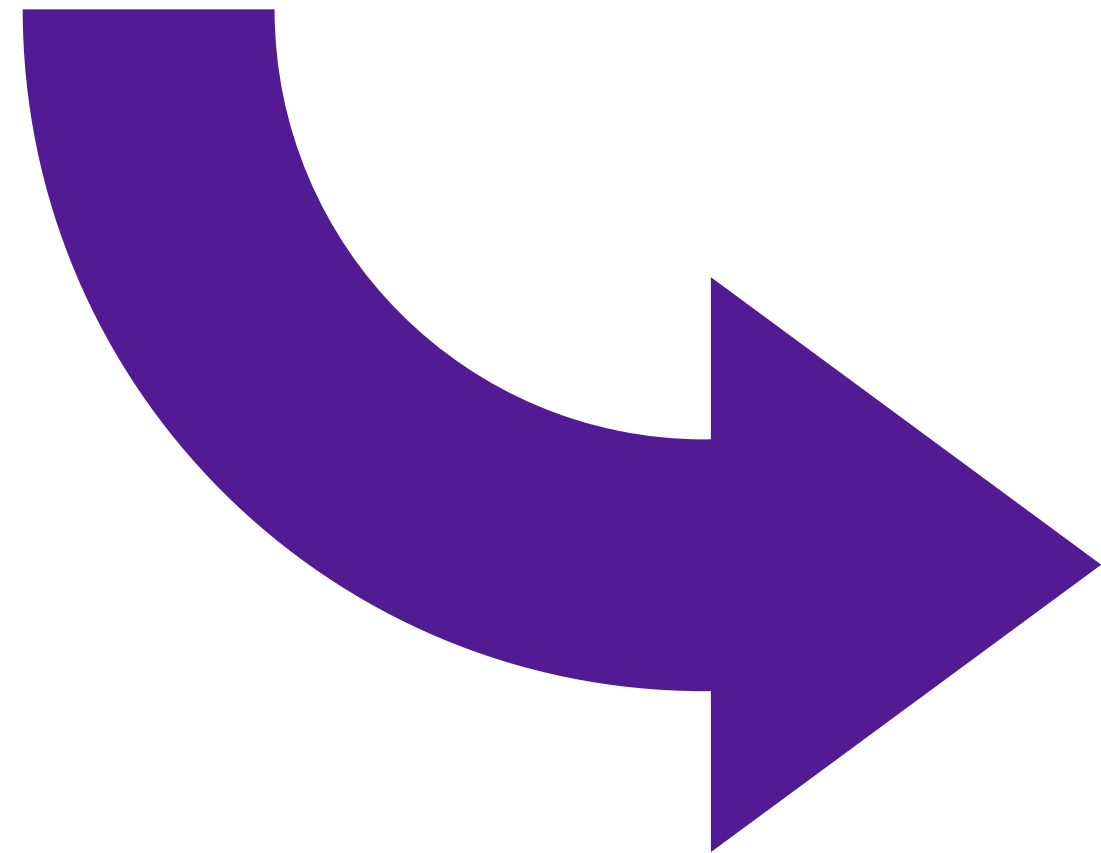
# Async / Await



# Async / Await

Original

```
Console.WriteLine("after delays");
```



Compiled

```
done:  
    awaiter.GetResult( );  
    Console.WriteLine("after delays");  
  
state = -2;  
_builder.SetResult( );
```

result of Task

# Original Async / Await

```
using System;
using System.Threading.Tasks;

await PrintAndWait(TimeSpan.FromMilliseconds(10));

static async Task PrintAndWait(TimeSpan delay)
{
    Console.WriteLine("before delays");
    await Task.Delay(delay);
    Console.WriteLine("between delays");
    await Task.Delay(delay);
    Console.WriteLine("after delays");
}
```

## Compiled

```
▼ [S] <Program>$.<<<Main>$>g__PrintAndWait|0_0>d
    ► [Folder] Base Types
        [M] .ctor()
        [F] <>1__state : Int32
        [F] <>t__builder : AsyncTaskMethodBuilder
        [F] <>u__1 : TaskAwaiter
        [F] delay : TimeSpan
        [M] MoveNext() : Void
        [M] SetStateMachine(IAsyncStateMachine) : Void
```

# Agenda

- Hello World
- Record Type
- Enumerable
- Async / Await
- **MoveNext()**

# Next Steps

- **C# in Depth**, Fourth Edition by **Jon Skeet**  
chapter 6
- **Working with C# Records** by **Roland Guijt** on Pluralsight  
[https://app.pluralsight.com/library/courses/working-c-sharp-records/  
table-of-contents](https://app.pluralsight.com/library/courses/working-c-sharp-records/table-of-contents)
- **ILSpy**  
<https://github.com/icsharpcode/ILSpy>





# Thank you

Mike Harris

My Compiler Did What?!?

@MikeMKH

<https://github.com/MikeMKH/talk-my-compiler-did-what>

