Garbage Collection

Filip Ekberg
Principal Consultant & CEO

@fekberg fekberg.com

C# is a **managed**
programming language

Unmanaged Memory

Bitmaps, Streams and other components may use unmanaged memory

Avoid unnecessary allocations by cleaning up

Collecting Resources

```
void Process()
{
    var temporaryList = new List<Order>();

    ...
}
```

Collecting Resources

```
void Process()
{
    var temporaryList = new List<Order>();

    ...
}
```

The **garbage collector** will **clean up** the instances that are no longer relevant **when it decides** to run

Do not manually run the garbage collector

Garbage **Collection**

Do not run manually

Trust that the garbage collector runs and collects resources

Follow the best practices

Avoid unnecssary allocations and leaks

Memory leaks?

Memory **Leak**

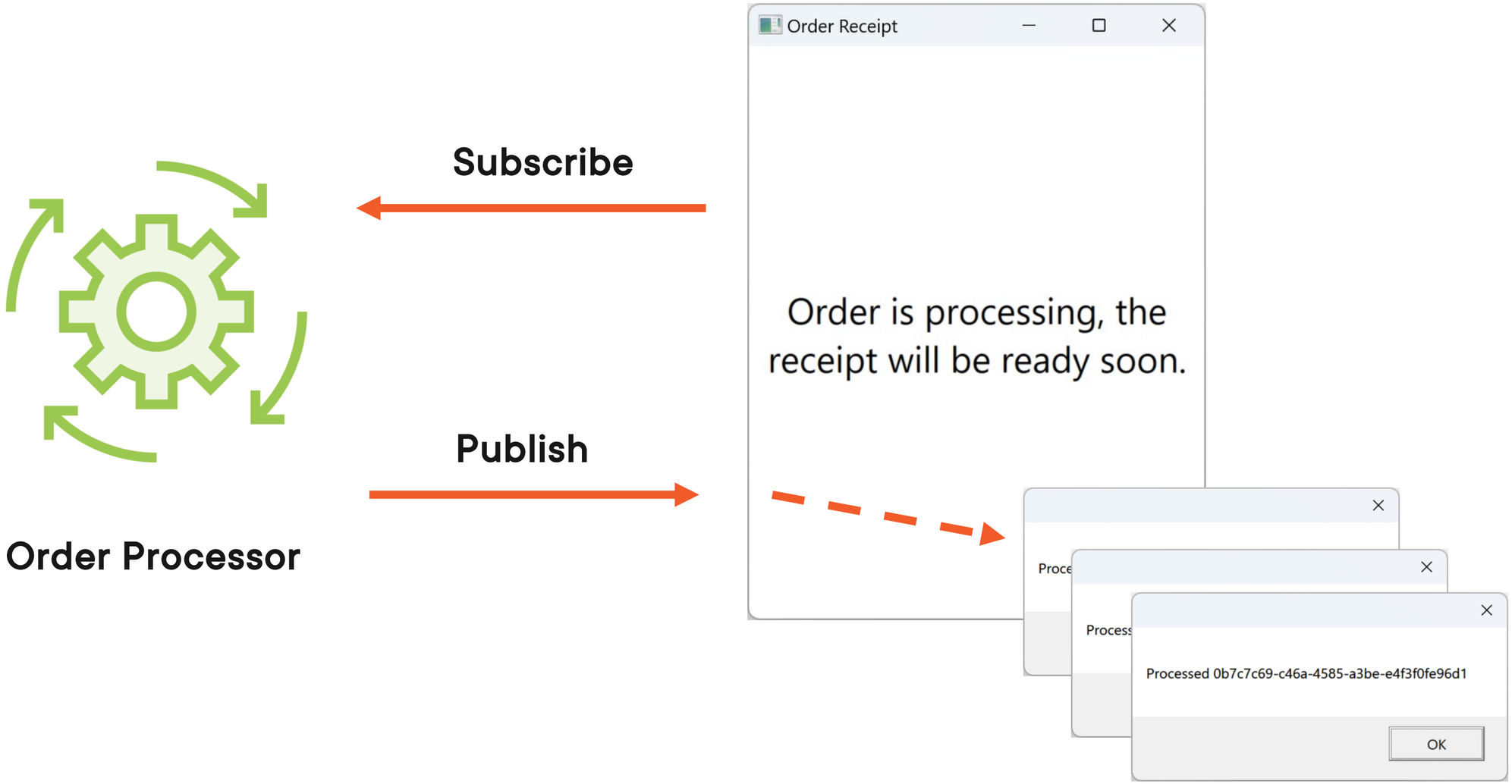
Allocating memory for longer than needed

Will eventually be collected but may cause issues before it is

Objects that are unable to be collected

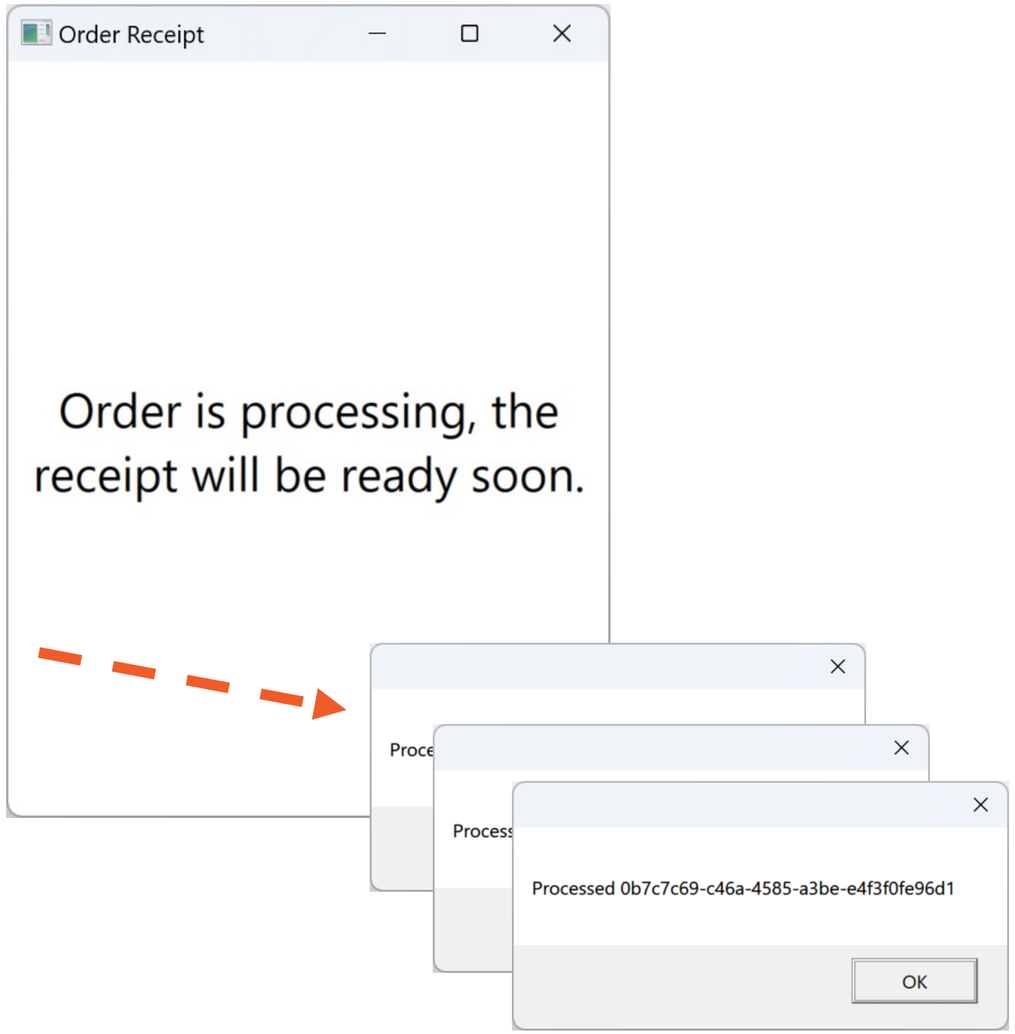
The garbage collector is unable to collect resources that still have references, such as event handler leaks

Event Handler Leak



Event Handler Leak

The garbage collector was **unable** to **clean up** the old receipt windows and thus there was a **leak**



Cleaned up when the application is terminated

What Uses **Unmanaged Memory**?

Streams

Bitmaps

UI

WARNING!

We have not yet applied the best practices.

The **stream** and **bitmap should be cleaned up**.

Resources such as **streams**, **bitmaps** or if they **require** to **clean up** should follow the **disposable pattern**

IDisposable

“Provides a mechanism for releasing unmanaged resources.”

Example:

```
class Stream : IDisposable
{
    public void Dispose() { /* Release resources */ }
}
```

docs.microsoft.com/en-us/dotnet/api/system.idisposable

Disposable Pattern

```
// Using statement - resource disposed after the statement
using(var stream = new MemoryStream(data))
{
    ... // Use the stream
}

// Using declaration - resource disposed when method completes
using var stream = new MemoryStream(data);
```

Disposable Pattern

```
// Using statement - resource disposed after the statement
using(var stream = new MemoryStream(data))
{
    ... // Use the stream
}

// Using declaration - resource disposed when method completes
using var stream = new MemoryStream(data);
```

Disposable Pattern

```
// Using statement - resource disposed after the statement
using(var stream = new MemoryStream(data))
{
    ... // Use the stream
}

// Using declaration - resource disposed when method completes
using var stream = new MemoryStream(data);
```

You can implement
IDisposable in any class that
needs to clean up resources

Finalize

“Allows an object to try to **free resources** and **perform** other **cleanup** operations **before** it is **reclaimed by garbage collection**.”

This will only be called if the garbage collector is capable of collecting the object!

docs.microsoft.com/en-us/dotnet/api/system.object.finalize

Finalizer will **only** be **called if** the **garbage collector** is **capable of collecting** the object!

Creating a **Finalizer**

Creating a **Finalizer**

```
class OrderProcessor
{
    ~OrderProcessor()
    {
        // Clean up resources prior to being collected by the GC
    }
}
```

Implement IDisposable to clean up resources!

Both managed and unmanaged

Visual Studio will **NOT** tell you if you **forget** to call **Dispose**() through a **using statement** or **using declaration**!

Can you clean up resources asynchronously?

Yes!

Implement IDisposable when
you need to clean up!

Boxing and **unboxing** requires **additional memory!**

This may negatively impact performance

Boxing and Unboxing

```
int number          = 10;

// Boxing
object boxedValue = number;
```

Boxing and Unboxing

```
int number         = 10;

// Boxing
object boxedValue = number;

// Unboxing
int unboxedValue  = (int)boxedValue;
```

Boxing a Value Type

Implicit conversion

Passing a value type to a method that accepts an object

Transfers the value type from the stack to the heap

Stored in an object

Unboxing

Explicit conversion

Transfers the value type from the heap to the stack

Think of it like wrapping and unwrapping

If you **fail** to **clean up**
resources you may eventually
run out of memory!

Avoiding Leaks

Unsubscribe Event Handlers

Dispose your IDisposables

IAsyncDisposable

IAsyncDisposable

```
public class FileProcessor : IDisposable, IAsyncDisposable
{
    public void Dispose() { }

    public ValueTask DisposeAsync()
    {
        Dispose();

        return ValueTask.CompletedTask;
    }
}

await using var fileProcessor = new FileProcessor();
```

Alternative to Implement IDisposable

Alternative to Implement IDisposable

```
override void OnClosing(...)
{
    processor.OrderCreated -= Processor_OrderCreated;

    // Clean up all event handlers and resources

    base.OnClosing();
}
```

The Finalizer Is Never Called

The Finalizer Is Never Called

```
public class FileProcessor
{
    public FileProcessor(OrderProcessor processor)
    {
        this.processor = processor;
        this.processor.OrderCreated += ...;
    }

    ~FileProcessor() => Console.WriteLine("Cleaning up");
}
```

The Finalizer Is Never Called

```
public class FileProcessor
{
    public FileProcessor(OrderProcessor processor)
    {
        this.processor = processor;
        this.processor.OrderCreated += ...;
    }

    ~FileProcessor() => Console.WriteLine("Cleaning up");
}
```

Never called because the event keeps the instance of the FileProcessor alive!

Boxing and **Unboxing**

Boxing

Implicit conversion that wraps the value type in an object and transfers it to the heap

Unboxing

Explicit conversion that unwraps the value from an object and transfers it to the stack

Use generics whenever you can!