Delegates and Lambdas

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Using a Delegate in C#

```
var read = Console.ReadLine;

var input = read();
```

Using a Delegate in C#

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var read = Console.ReadLine;

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```

Point to the method **Console.ReadLine()**

Example: Passing a Delegate to a Method

Replace or extend functionality in runtime

Receive a callbacks when operation completes

Delegate

“A **delegate** is **a type** that **represents references** to **methods** with a particular parameter list and return type.”

docs.microsoft.com/en-us/dotnet/csharp/programming-guide/delegates

Overview

Delegate keyword

Action and Action<T>

Func and Func<T>

Lambdas

Creating a Delegate

What is a **Delegate**?

Defines the **required method signature**

A **reference type** used to **reference** a **method**

Defined using the **delegate** **keyword**

Creating a Delegate

```
delegate Order Buy    (Item item, int quantity);
```

Creating a Delegate

```
delegate Order Buy    (Item item, int quantity);
```

Define the **required method signature:**
Return type and parameters

Creating a Delegate

```
delegate Order Buy    (Item item, int quantity);


Order AddToCart       (Item item, int quantity) { … }

ProcessedOrder BuyNow (Item item, int quantity) { … }
```

Creating a Delegate

```
delegate Order Buy    (Item item, int quantity);
```

Return type match (ProcessedOrder inherits from Order)

```
Order AddToCart       (Item item, int quantity) { … }

ProcessedOrder BuyNow (Item item, int quantity) { … }
```

Creating a Delegate

```
delegate Order Buy    (Item item, int quantity);


Order AddToCart       (Item item, int quantity) { … }

ProcessedOrder BuyNow (Item item, int quantity) { … }
```

Parameters match!

Return type cannot be less derived

Covariance and Contravariance

Parameters support Contravariance

Return type support Covariance

Using a Delegate

```
delegate Order Buy(Item item, int quantity);



void BuyAll(IEnumerable<Item> items, Buy buy)
{
    foreach(var item in items)
    {
        buy(item, 1);
    }
}
```

Using a Delegate

```
delegate Order Buy(Item item, int quantity);


void BuyAll(IEnumerable<Item> items, Buy buy)
{
    foreach(var item in items)
    {
        buy(item, 1);
    }
}
```

Accept a method reference (delegate)

Using a Delegate

```
delegate Order Buy(Item item, int quantity);



void BuyAll(IEnumerable<Item> items, Buy buy)
{
    foreach(var item in items)
    {
        buy(item, 1);
    }
}
```

Using a Delegate

```
delegate Order Buy(Item item, int quantity);



void BuyAll(IEnumerable<Item> items, Buy buy)
{
    foreach(var item in items)
    {
        buy(item, 1);
    }
}
```

Could be either **AddToCart** or **BuyNow**

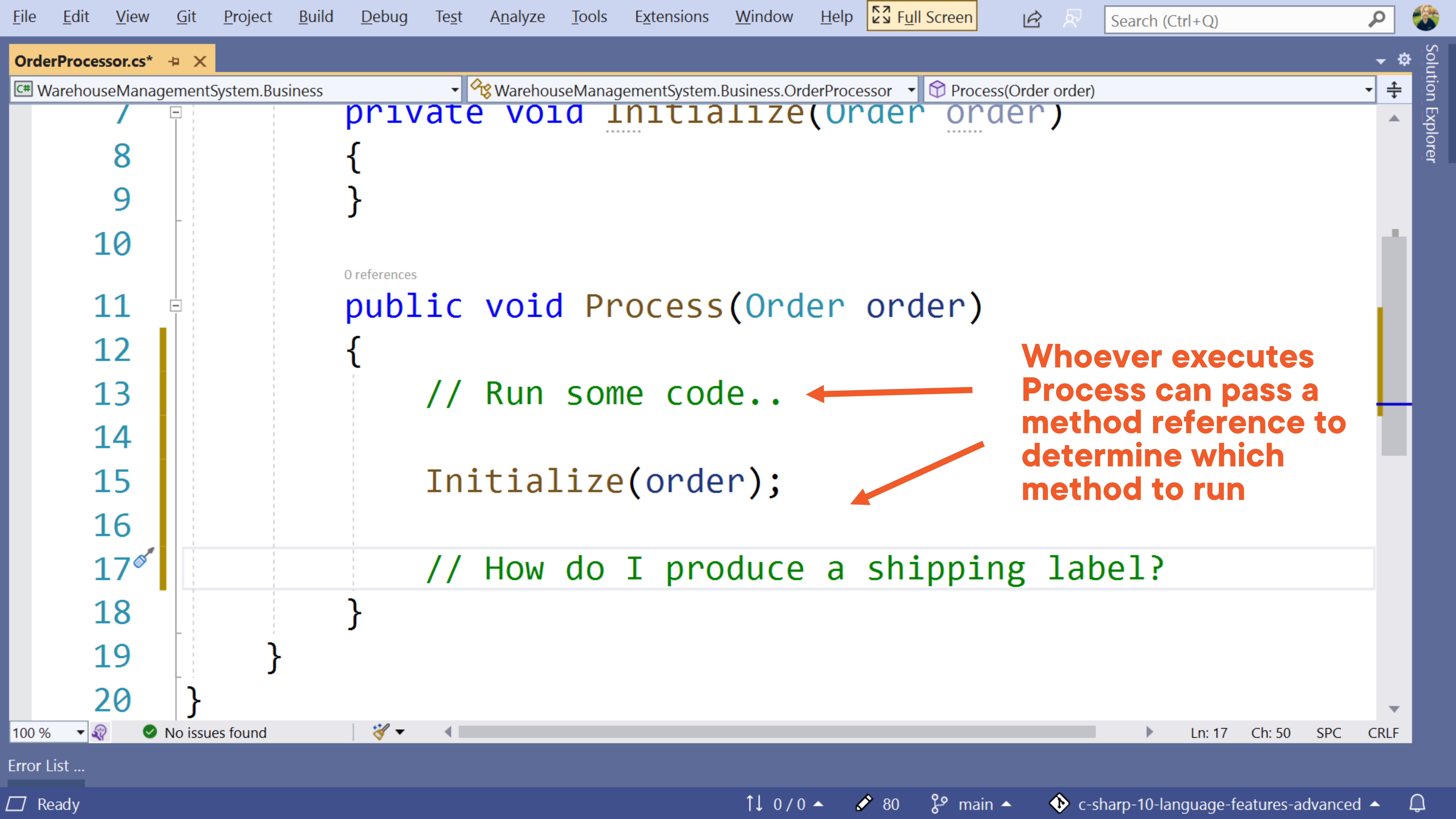
Delegates allow you to **reference** a **method** and **later invoke** it

When to Use Delegates

When you need a callback
Commonly used in the past when performing background work

Events
When a publisher notifies that an event has occurred, every subscriber is executed and can act on it

Extensibility
Allow a method to run additional functionality, or replace functionality during runtime


File Edit View Git Project Build Debug Test Analyze Tools Extensions Window Help Full Screen
Search (Ctrl+Q)
OrderProcessor.cs*
WarehouseManagementSystem.Business
WarehouseManagementSystem.Business.OrderProcessor
Process(Order order)
Solution Explorer
100 %
No issues found
Ln: 17 Ch: 50 SPC CRLF
Error List ...
Ready
0 / 0
80
main
c-sharp-10-language-features-advanced

```
        private void Initialize(Order order)
        {
        }

        0 references
        public void Process(Order order)
        {
            // Run some code..

            Initialize(order);

            // How do I produce a shipping label?
        }
    }
}
```

Whoever executes Process can pass a method reference to determine which method to run

Some **libraries** rely on **delegates** to **allow functionality** to be **determined by** the **consumer**

Examples of **Delegates in .NET**

```
var orderNumbers = new[] { 1337, 35, 101, 30 };

orderNumbers.OrderBy(number => number);
```

Examples of **Delegates in .NET**

```
var orderNumbers = new[] { 1337, 35, 101, 30 };

orderNumbers.OrderBy(number => number);

Task.Run(HeavyOperator)
    .ContinueWith(TheCallback);

void HeavyOperator() { }
void TheCallback(Task task) { }
```

Examples of **Delegates in .NET**

```
var orderNumbers = new[] { 1337, 35, 101, 30 };

orderNumbers.OrderBy(number => number);

Task.Run(HeavyOperator)
    .ContinueWith(TheCallback);

void HeavyOperator() { }
void TheCallback(Task task) { }
```

Delegates are a **powerful** language feature!

If **processing** runs in the **background**, a **delegate** can **be used** to get **updated information**

Declaring a Delegate

```
// Outside a class
public delegate void ProcessCompleted();

// Inside a class
public class OrderProcessor
{
    public delegate void OrderInitialized();
}



OrderProcessor.OrderInitialized onInitialized     = SendMessageToWarehouse;

ProcessCompleted onCompleted                      = SendConfirmationEmail;
```

The method **could** be **decided during runtime**!

A normal **delegate** can be **invoked by anyone** that has access to it

Benefits of This Approach

Delegate the **implementation** elsewhere

Determine which **method** to reference **during runtime**

Extensibility and **flexibility** can be **achieved** in **many ways**. Using **delegates** is **one way**.

Returning a Delegate

```
OrderProcessor.OrderInitialized GetOnInitialized()
{
    return SendMessageToWarehouse;
}
```

Returning a Delegate

```
OrderProcessor.OrderInitialized GetOnInitialized()
{
    return SendMessageToWarehouse;
}
```

```
GetOnInitialized()(order);

GetOnInitialized()?.Invoke(order);
```

Returning a Delegate

```
OrderProcessor.OrderInitialized GetOnInitialized()
{
    return SendMessageToWarehouse;
}
```

Invokes the method **SendMessageToWarehouse**

```
GetOnInitialized()(order);

GetOnInitialized()?.Invoke(order);
```

Multicast **Delegates**

“The **multicast delegate** contains a **list of** the assigned **delegates**. When the multicast **delegate** is **called**, it **invokes** the **delegates** in **the list**, **in order**.

Only delegates of the same type can be combined.”

docs.microsoft.com/en-us/dotnet/csharp/programming-guide/delegates/how-to-combine-delegates-multicast-delegates

Invoke a **Multicast Delegate**

```
OrderProcessor.ProcessCompleted chain = SendConfirmationEmail;
chain += LogOrderProcessCompleted;
chain += UpdateStock;


// Invoke like a method
chain(order);

// Invoke through a method call
chain.Invoke(order);
```

Invoke a **Multicast Delegate**

```
OrderProcessor.ProcessCompleted chain = SendConfirmationEmail;
chain += LogOrderProcessCompleted;
chain += UpdateStock;


// Invoke like a method
chain(order);

// Invoke through a method call
chain.Invoke(order);
```

Invoked in the order they were added

Anyone with **access** to the **delegate** can **modify the chain**

Delegate.**Remove**

“**Removes** the **last occurrence** of the **invocation list** of a delegate from the invocation list of another delegate”

Subtracting a delegate uses Delegate.Remove() internally.

Example:

```
chain -= logMethod;
```

docs.microsoft.com/en-us/dotnet/api/system.delegate.remove

Define This Method Using a **Lambda**

Accept one parameter of type order

Return true or false depending on if the order has any items

A **lambda produces** an **anonymous function**

Lambda

Lambda

```
(parameter1, parameter2)
```

Lambda

```
(parameter1, parameter2) =>
```

Lambda

```
(parameter1, parameter2) =>
```

Lambda operator

Lambda

```
(parameter1, parameter2) => parameter1 + parameter2;
```

Lambda

```
(parameter1, parameter2) => parameter1 + parameter2;
```

Lambda

```
(parameter1, parameter2) => parameter1 + parameter2;
```

```
(parameter1, parameter2) =>
{
    return parameter1 + parameter2;
};
```

Lambda

```
// Lambda Expression
(parameter1, parameter2) => parameter1 + parameter2;



(parameter1, parameter2) =>
{
    return parameter1 + parameter2;
};
```

Lambda

```
// Lambda Expression
(parameter1, parameter2) => parameter1 + parameter2;


// Lambda Statement
(parameter1, parameter2) =>
{
    return parameter1 + parameter2;
};
```

Inferring Types

```
OrderProcessor.OrderInitialized action = (order) =>
{
    return order.IsReadyForShipment;
};
```

Inferring Types

```
OrderProcessor.OrderInitialized action = (order) =>
{
    return order.IsReadyForShipment;
};
```

The type is **inferred from** the delegate **OrderInitialized**

Use a **lambda statement** for **anonymous functions** that does **not return** anything

Removing an **anonymous function** from a **multicast delegate** is **not simple**

You should **aim** to keep **anonymous functions** as **simple** as possible to **reduce complexity**

Explicit Types

```
OrderProcessor.OrderInitialized action = bool (order) =>
{
    return order.IsReadyForShipment;
};
```

Explicit Types

```
OrderProcessor.OrderInitialized action = bool (order) =>
{
    return order.IsReadyForShipment;
};
```

Return type

Explicit Types

```
OrderProcessor.OrderInitialized action = bool (Order order) =>
{
    return order.IsReadyForShipment;
};
```

Explicit Types

```
OrderProcessor.OrderInitialized action = bool (Order order) =>
{
    return order.IsReadyForShipment;
};
```

Parameter type

Attributes can be used **with lambdas**

Delegate expected?

You can use a **lambda**!

Lambda + LINQ

```
people.Where(person => person.Age > 20);
```

Lambda + LINQ

```
people.Where(person => person.Age > 20);
```

Uses the delegate
to find matches

Creating a **generic delegate** means that it is **reusable**

What Would This Delegate Look Like?

Generic Parameter

No Return Value

Creating a Generic Delegate

Creating a Generic Delegate

```
delegate
```

Creating a Generic Delegate

```
delegate void Action
```

Creating a Generic Delegate

```
delegate void Action<T>
```

Creating a Generic Delegate

```
delegate void Action<T>(T input);
```

Creating a Generic Delegate

```
delegate void Action<T>(T input);

Action<Order> action = SendConfirmationEmail;

Action<Order> action = (order) => { };
```

Creating a Generic Delegate with Return Value

```
delegate TResult Func<T, TResult>(T input);
```

Creating a Generic Delegate with Return Value

```
delegate TResult Func<T, TResult>(T input);
```

Add one more generic type

Creating a Generic Delegate with Return Value

```
delegate TResult Func<T, TResult>(T input);

Func<Order, bool> func = SendMessageToWarehouse;

Func<Order, bool> func = (order) => order.IsReadyForShipment;
```

Action<T> and **Func<T, TResult>** are already a **part** of **.NET**!

Delegate

```
delegate bool OrderInitialized(Order order);
```

Delegate

```
delegate bool OrderInitialized(Order order);
```

All methods that return bool with a parameter of type order (alternatively its base class if any) **will match this delegate**

Delegate

```
delegate bool OrderInitialized(Order order);


void Process(OrderInitialized onInitialized)
{ ... }
```

Delegate

```
delegate bool OrderInitialized(Order order);

void Process(OrderInitialized onInitialized)
{ ... }
```

Use like any other reference type

A **delegate** is simply a **method reference** and has a **very small memory footprint**

Using a Delegate

```
void Process(OrderInitialized onInitialized)
{ ... }
```

Using a Delegate

```
void Process(OrderInitialized onInitialized)
{ ... }
```

↑

Accepts a method reference to any method matching the given delegate

Using a Delegate

```
void Process(OrderInitialized onInitialized)
{ ... }

Process(SendMessageToWarehouse);
```

Using a Delegate

```
void Process(OrderInitialized onInitialized)
{ ... }

Process(SendMessageToWarehouse);

Process(order => order.IsReadyForShipment);
```

Using a Delegate

```
void Process(OrderInitialized onInitialized)
{ ... }

Process(SendMessageToWarehouse);

Process(order => order.IsReadyForShipment);
```

**Anonymous method defined with a lambda.
This results in a delegate that matches OrderInitialized**

Benefits of Using a Lambda

Makes the code easier to read

The logic is defined in-place and the intent is clearly communicated

Can capture local variables

Consuming a Delegate

```
void Process(OrderInitialized onInitialized)
{
   var result = onInitialized();


}
```

Consuming a Delegate

```
void Process(OrderInitialized onInitialized)
{
    var result = onInitialized();


}
```

Could throw null a reference exception!

Consuming a Delegate

```
void Process(OrderInitialized onInitialized)
{


    var result = onInitialized?.Invoke();
}
```

Avoid using **BeginInvoke** and **EndInvoke**

Curious about asynchronous programming?

Asynchronous Programming in C#

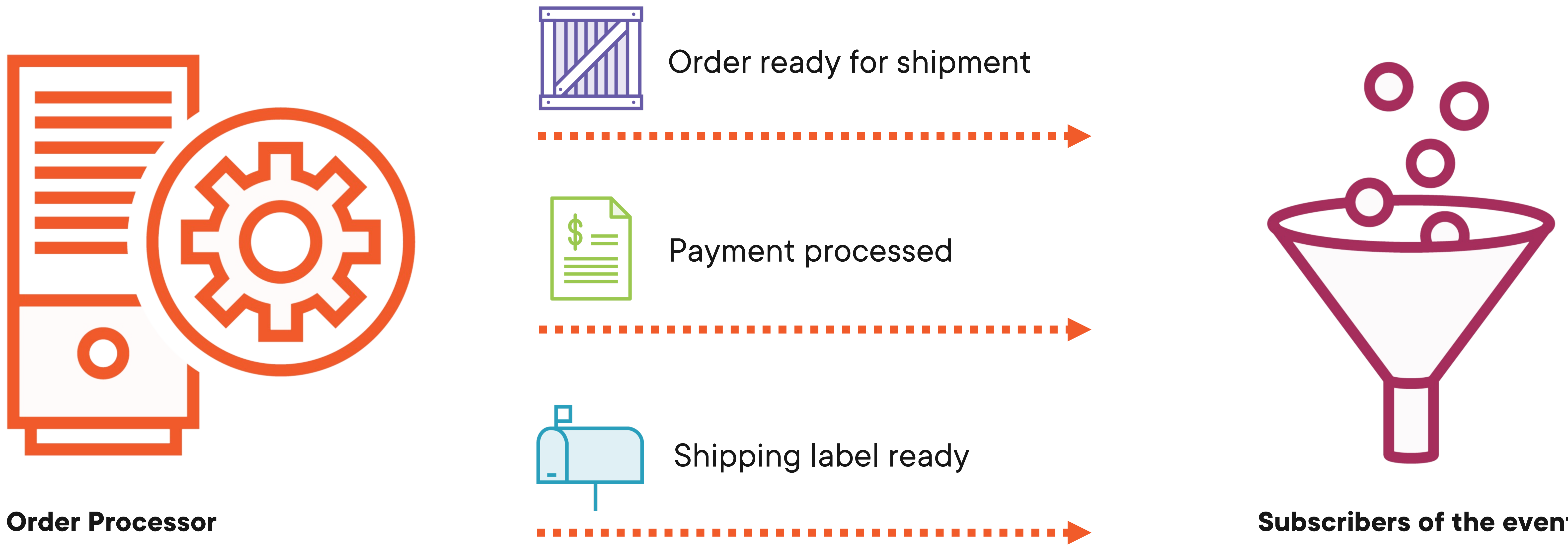
Filip Ekberg

Using Func and Action

```
void Process(Func<Order, bool> onInitialized,
             Action callback)
{
   var result = onInitialized?.Invoke();

   callback?.Invoke();
}
```

Broadcasting Events



Next: **Events**