



Delegates

.NET

*A delegate is a data type that represents a reference to a method with a defined parameter and return type. A delegate can be associated with an instance of any method with the same signature and return type. The method can be called through the **delegate** instance.*

[HTTPS://DOCS.MICROSOFT.COM/EN-US/DOTNET/CSHARP/PROGRAMMING-GUIDE/DELEGATES/](https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/delegates/)

Binding - Overview

<https://docs.microsoft.com/en-us/dotnet/desktop-wpf/data/data-binding-overview#what-is-data-binding>

<https://docs.microsoft.com/en-us/dotnet/csharp/delegates-overview>

https://en.wikipedia.org/wiki/Late_binding#Late_binding_in_.NET

Binding - This process establishes a connection between an app UI and the data it displays. When the data changes its value, the elements (in memory) bound to the data reflect the changes automatically.

- Early Binding (AKA Static Binding, Static Dispatch, or Compile-Time Binding) – The compiler (or linker) directly associates a stack memory address to the function call. It replaces the call with a machine language instruction that tells the mainframe to leap to the address of the function.
- Late Binding (AKA Dynamic Binding, Dynamic Dispatch, Dynamic Linkage, or Run-Time Binding) – is when an algorithm is created that uses a caller-supplied method that implements part of the algorithm (like function pointers). In .NET, late binding refers to overriding a virtual method. The compiler builds virtual tables for every virtual or interface method call which is used at run-time to determine the implementation to execute.

Delegates use *late binding* in .NET.

Delegate – Overview

<https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/delegates/>

Delegates are used to pass methods as arguments to other methods. This ability to refer to a method as a parameter makes **delegates** ideal for defining callback methods.

A **delegate** is a **type** that represents references to methods with a defined parameter list and return **type**. When you instantiate a **delegate**, you can associate its instance with any method with a compatible signature and return type. You can invoke (call) the method through the **delegate** instance.

This example declares a **delegate** **Del** that can encapsulate any method that takes a **string** as an argument and returns **void**:

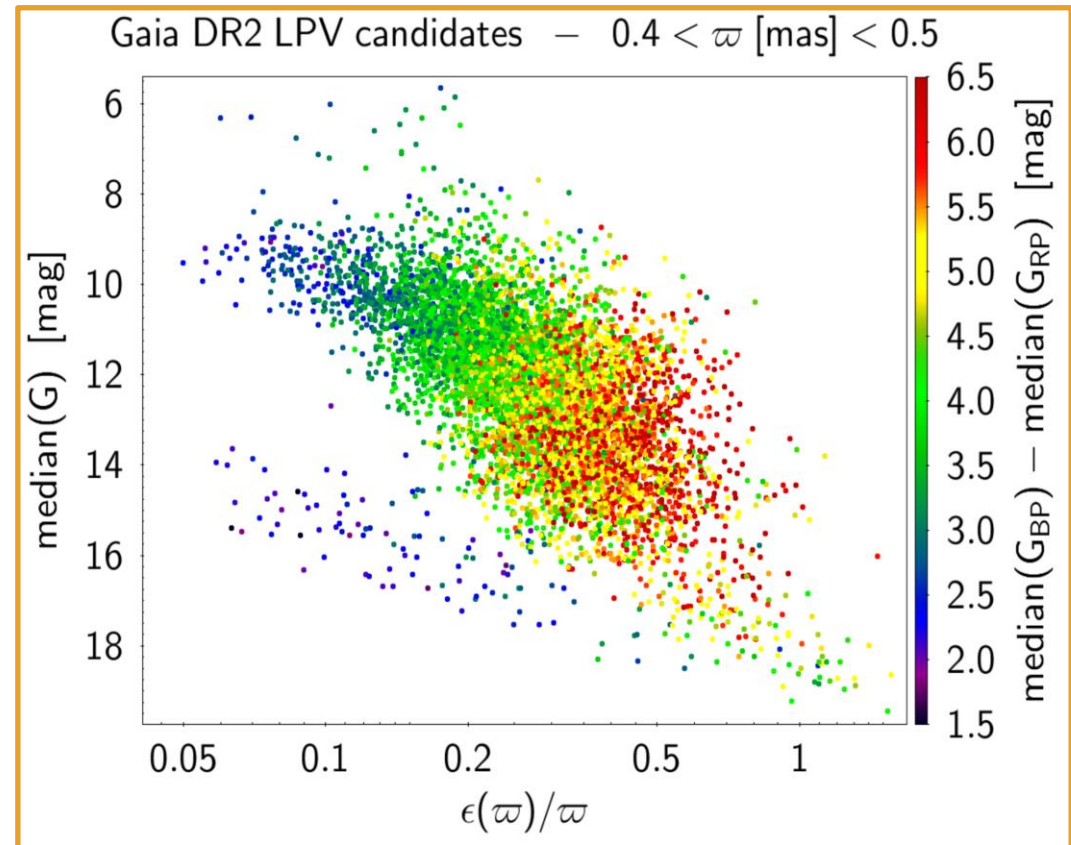
```
public delegate void Del(string message);
```

Only accessible methods or structs that match the **delegate** type and return type can be assigned to the **delegate**. This is why **delegates** are object-oriented, type safe, and secure.

Delegate – Usage Example

Consider sorting a list of stars in an astronomy application. You may choose to sort those stars by their distance from the earth, or the magnitude of the star, or their perceived brightness.

In all those cases, the `Sort()` method does essentially the same thing. It arranges the items in the list based on some comparison. The code that compares two stars is different for each of the sort orderings.



Delegate – Step by Step

<https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/delegates/using-delegates>

1. Create a method to assign to a delegate.

```
// Create a method for a delegate.  
public static void DelegateMethod(string message)  
{  
    Console.WriteLine(message);  
}
```

2. Create a delegate type (**Del**) with the same return type and argument. This must be outside of a method.

```
public delegate void Del(string message);
```

3. Instantiate a delegate type variable and assign to it the chosen function (**DelegateMethod()**). The delegate variable is what gets passed to a function.

```
// Instantiate the delegate.  
Del handler = DelegateMethod;
```

4. Invoke the delegate variable. If the original method (**DelegateMethod()**) returns a value, it will be returned through the delegate variable (handler).

```
// Call the delegate.  
handler("Hello World");
```

Delegate – Multicasting

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

A ***delegate*** can call more than one method when invoked. This is referred to as multicasting. To add an extra method to the delegate's (ordered) method invocation list use the addition assignment operators ('+' or '+=').

allMethodsDelegate is a ***delegate type*** object that points to other ***delegate type*** objects that point to a ***delegate*** variable that refers to a function or invocation list. ***Arguments*** are passed from ***delegate*** obj to ***delegate*** obj to function.

```
public class MethodClass
{
    public void Method1(string message) { }
    public void Method2(string message) { }
}
```

```
var obj = new MethodClass();
Del d1 = obj.Method1;
Del d2 = obj.Method2;
Del d3 = DelegateMethod;

//Both types of assignment are valid.
Del allMethodsDelegate = d1 + d2;
allMethodsDelegate += d3;
```

Delegate – Multicasting

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

- **Reference** arguments are passed sequentially to each method in turn. Any changes by one method are visible to the next method.
- If any method in the **method invocation list** throws an uncaught exception, execution stops. The exception is passed to the caller of the **delegate**.
- If the **delegate** has a return value and/or **out** parameters, it returns the return value and/or **out** parameters of only the last method invoked.
- To remove a method from the invocation list, use the subtraction or subtraction assignment operators (- or -=).

```
//remove Method1  
allMethodsDelegate -= d1;  
  
// copy AllMethodsDelegate while removing d2  
Del oneMethodDelegate = allMethodsDelegate - d2;
```


Action and Action<T> Delegate

<https://docs.microsoft.com/en-us/dotnet/api/system.action?view=net-5.0>
<https://docs.microsoft.com/en-us/dotnet/api/system.action-2?view=net-5.0>

You can use an *Action delegate* to pass a method as a parameter without explicitly declaring a custom *delegate*.

Action Delegates always return *void*. The encapsulated method must correspond to the parameter list defined by the *Action delegate* and return *void*.

See examples at the links above.

```
using System;
using System.Windows.Forms;

public class Name
{
    private string instanceName;

    public Name(string name)
    {
        this.instanceName = name;
    }

    public void DisplayToConsole()
    {
        Console.WriteLine(this.instanceName);
    }

    public void DisplayToWindow()
    {
        MessageBox.Show(this.instanceName);
    }
}

public class testTestDelegate
{
    public static void Main()
    {
        Name testName = new Name("Koani");
        Action showMethod = testName.DisplayToWindow;
        showMethod();
    }
}
```

```
using System;
using System.IO;

public class TestAction2
{
    public static void Main()
    {
        string message1 = "The first line of a message.";
        string message2 = "The second line of a message.";
        Action<string, string> concat;

        if (Environment.GetCommandLineArgs().Length > 1)
            concat = WriteToFile;
        else
            concat = WriteToConsole;

        concat(message1, message2);
    }

    private static void WriteToConsole(string string1, string string2)
    {
        Console.WriteLine("{0}\n{1}", string1, string2);
    }

    private static void WriteToFile(string string1, string string2)
    {
        StreamWriter writer = null;
        try
        {
            writer = new StreamWriter(Environment.GetCommandLineArgs()[1], false);
            writer.WriteLine("{0}\n{1}", string1, string2);
        }
        catch
        {
            Console.WriteLine("File write operation failed...");
        }
        finally
        {
            if (writer != null) writer.Close();
        }
    }
}
```

Func<TResult> Delegate

<https://docs.microsoft.com/en-us/dotnet/api/system.func-1?view=net-5.0>

Use **Func<TResult>** *delegate* to represent a method that can be passed as a parameter without explicitly declaring a custom *delegate*. The encapsulated method must correspond to the method signature that is defined by this *delegate*.

TResult is the **type** of the return value of the method that the **Func<TResult>** *delegate* encapsulates. This **type** parameter is covariant, meaning you can use your specified type or a more derived type.

Ex. **Func<TResult>** means that the encapsulated method must have no parameters and must return a value.

Func<T, TResult>, **Func<T1, T2, TResult>**, etc, are variations that have arguments along with the return type.

Func<TResult> Delegate

<https://docs.microsoft.com/en-us/dotnet/api/system.func-1?view=net-5.0>

```
using System;

static class Func1
{
    public static void Main()
    {
        // Note that each lambda expression has no parameters.
        LazyValue<int> lazyOne = new LazyValue<int>(() => ExpensiveOne());
        LazyValue<long> lazyTwo = new LazyValue<long>(() => ExpensiveTwo("apple"));

        Console.WriteLine("LazyValue objects have been created.");

        // Get the values of the LazyValue objects.
        Console.WriteLine(lazyOne.Value);
        Console.WriteLine(lazyTwo.Value);
    }

    static int ExpensiveOne()
    {
        Console.WriteLine("\nExpensiveOne() is executing.");
        return 1;
    }

    static long ExpensiveTwo(string input)
    {
        Console.WriteLine("\nExpensiveTwo() is executing.");
        return (long)input.Length;
    }
}
```

```
class LazyValue<T> where T : struct
{
    private Nullable<T> val;
    private Func<T> getValue;

    // Constructor.
    public LazyValue(Func<T> func)
    {
        val = null;
        getValue = func;
    }

    public T Value
    {
        get
        {
            if (val == null)
                // Execute the delegate.
                val = getValue();
            return (T)val;
        }
    }
}

/* The example produces the following output:

    LazyValue objects have been created.

    ExpensiveOne() is executing.
    1

    ExpensiveTwo() is executing.
    5

*/
```

Events – Overview

<https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/events/>

Events enable a class or object to notify other classes or objects when something of interest occurs. The class that sends (or *raises*) the **event** is called the **publisher** and the classes that receive (or *handle*) the **event** are called **subscribers**.

Events are a special kind of ***multicast delegate*** that can only be invoked from within the class or struct where they are declared (the “publisher” class). If other classes or structs subscribe to the **event**, their ***event handler*** methods will be called when the publisher class raises the event.

To register for, then trigger an **event**:

1. the recipient creates a method designed to handle the event, then
2. creates a ***delegate*** for that method and
3. passes the ***delegate*** to the event source.
4. The source calls the ***delegate*** when the **event** occurs.
5. The ***delegate*** then calls the **event** handling method on the recipient, delivering the event data. The ***delegate type*** for a given event is defined by the event source.

Events – Properties

<https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/events/>

- ***publisher*** – determines when an ***event*** is raised; the ***subscribers*** determine what action is taken in response to the ***event***.
- ***event*** – can have multiple ***subscribers***. A ***subscriber*** can handle multiple ***events*** from multiple ***publishers***.
- ***Events*** are typically used to signal user actions such as button clicks or menu selections in graphical user interfaces.
- When an ***event*** has multiple ***subscribers***, the event handlers are invoked synchronously.
- In the .NET class library, ***events*** are based on the ***EventHandler delegate*** and the ***EventArgs*** base class.

Events – Publishing Based on the ***EventHandler*** Pattern

<https://docs.microsoft.com/en-us/dotnet/api/system.eventhandler?view=net-5.0>

<https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/events/how-to-publish-events-that-conform-to-net-framework-guidelines>

All **events** in the .NET class library are based on the ***EventHandler*** delegate. The standard signature of an ***eventHandler delegate*** defines a method that returns void. This method's first parameter is of **type** Object and refers to the instance that raises the **event**. Its second parameter is derived from **type EventArgs** and holds the **event** data.

```
[System.Runtime.InteropServices.ComVisible(true)]  
[System.Serializable]  
public delegate void EventHandler(object sender, EventArgs e);
```

All events should be based on the .NET pattern by using ***EventHandler***.

Events – Publishing Based on the *EventHandler* Pattern

<https://docs.microsoft.com/en-us/dotnet/api/system.eventhandler?view=net-5.0#examples>

[This example](#) shows an event named 'ThresholdReached' that is associated with an 'EventHandler' delegate. The method assigned to the *EventHandler* delegate is called in the 'OnThresholdReached' method.

A delegate connects an event with its handler. To raise an event, two elements are needed:

- A delegate identifying the method that provides the response to the event.
- (Optional) A class that holds the event data, if provided.

Click the link above to view this example online.

```
using System;

namespace ConsoleApplication1
{
    class Program
    {
        static void Main(string[] args)
        {
            Counter c = new Counter(new Random().Next(10)); //instantiate a class Counter instance
            c.ThresholdReached += c_ThresholdReached; //add the method to the ThresholdReached Event

            Console.WriteLine("press 'a' key to increase total");
            while (Console.ReadKey(true).KeyChar == 'a') //wait for 'a' to be pressed
            {
                Console.WriteLine("adding one");
                c.Add(1); //call the Add method of 'c' with '1'
            }

            static void c_ThresholdReached(object sender, ThresholdReachedEventArgs e)
            {
                Console.WriteLine("The threshold of {0} was reached at {1}.", e.Threshold, e.TimeReached);
            }
        }
    }
}
```

```
class Counter
{
    private int threshold; //this is passed on instantiation
    private int total; //this starts at 0

    public Counter(int passedThreshold) //constructor
    {
        threshold = passedThreshold;
    }

    //add one more to the running total
    public void Add()
    {
        total++;
        if (total >= threshold)
        {
            ThresholdReachedEventArgs args = new ThresholdReachedEventArgs();
            args.Threshold = threshold;
            args.TimeReached = DateTime.Now;
            OnThresholdReached(args);
        }
    }

    protected virtual void OnThresholdReached(ThresholdReachedEventArgs e)
    {
        EventHandler<ThresholdReachedEventArgs> handler = ThresholdReached;
        if (handler != null)
        {
            handler(this, e);
        }
    }

    public event EventHandler<ThresholdReachedEventArgs> ThresholdReached;

    public class ThresholdReachedEventArgs : EventArgs
    {
        public int Threshold { get; set; }
        public DateTime TimeReached { get; set; }
    }
}
```

//create a EventArgs Object

// add the threshold and current time // to the object then call the method

// check to make sure handler(ThresholdReached) was assigned at the beginning, then call handler(ThresholdReached)(c_ThresholdReached).

// This class has inherits .NET's EventArgs class and adds 2 more properties

Events – Publishing Based on the ***EventHandler*** Pattern

<https://docs.microsoft.com/en-us/dotnet/api/system.eventhandler?view=net-5.0#examples>
<https://docs.microsoft.com/en-us/dotnet/standard/events/?view=net-5.0>

The [EventHandler](#) ***delegate*** is a predefined ***delegate*** that specifically represents an ***event*** handler method for an ***event*** that does not generate data. If your ***event*** does generate data, you must use the generic [EventHandler<EventArgs>](#) ***delegate*** class.

To associate the ***event*** with the method that will handle the ***event***, add an instance of the ***EventHandler delegate*** to the event. The ***event*** handler is called whenever the ***event*** occurs, unless you remove the ***delegate***.

The ***delegate*** model follows the observer design pattern, which enables a ***subscriber*** to register with and receive notifications from a ***provider***. An ***event*** sender pushes a notification that an ***event*** has happened. An ***event*** receiver receives that notification and defines a response to it.

Events – Publishing Based on the ***EventHandler*** Pattern

<https://docs.microsoft.com/en-us/dotnet/api/system.eventhandler?view=net-5.0#examples>
<https://docs.microsoft.com/en-us/dotnet/standard/events/?view=net-5.0>

The object that raises the ***event*** is called the ***event sender***. The ***event*** is typically a member (method) of the ***event sender***. To define an ***event***, use the ***event*** keyword in the signature of your event class and specify the type of ***delegate*** for the event.

Add a method that is marked as ***protected*** and ***virtual***, conventionally named '***On[EventName]()***' ('***OnDataReceived()***'). The method should take one parameter of object ***type EventArgs*** (or a derived ***type***).

Derived classes can ***override*** this method. A derived class should always call the '***On[EventName]()***' method of the base class to ensure that registered ***delegates*** receive the event.

```
class Counter
{
    public event EventHandler ThresholdReached;

    protected virtual void OnThresholdReached(EventArgs e)
    {
        EventHandler handler = ThresholdReached;
        handler?.Invoke(this, e);
    }

    // provide remaining implementation for the class
}
```

Events – Publishing Based on the ***EventHandler*** Pattern – Step by Step

<https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/events/how-to-publish-events-that-conform-to-net-framework-guidelines>

1. (If not sending custom data with your event, go to 3a) Declare the class for your custom data at a scope that is visible to both your publisher and subscriber classes. Then, add the required members to hold your custom event data. → → → → → → →

2. (Skip if using generic version of ***EventHandler<TEventArgs>***). Declare a delegate in your publishing class. Use a name ending with ***EventHandler***. The second parameter specifies your custom ***EventArgs*** class type.

```
public class CustomEventArgs : EventArgs
{
    public CustomEventArgs(string s)
    {
        msg = s;
    }
    private string msg;
    public string Message
    {
        get { return msg; }
    }
}
```

```
public delegate void CustomEventHandler(object sender, CustomEventArgs a);
```

Events – Publishing Based on the ***EventHandler*** Pattern – Step by Step

<https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/events/how-to-publish-events-that-conform-to-net-framework-guidelines>

3. Declare the event in your publishing class by using one of the following steps.

a. If you have no custom EventArgs class, your Event type will be the non-generic EventHandler delegate. You do not have to declare the delegate because it is already declared in the System namespace. Add the following code to your publisher class.

```
public event EventHandler RaiseCustomEvent;
```

b. If you are using the non-generic version of EventHandler AND have a custom class derived from EventArgs, declare your event inside your publishing class and use your delegate from step 2 as the type.

```
public event CustomEventHandler RaiseCustomEvent;
```

c. If you are using the generic version, you do not need a custom delegate. Instead, in your publishing class, specify your event type as ***EventHandler<CustomEventArgs>***, substituting the name of your own class between the angle brackets.

```
public event EventHandler<CustomEventArgs> RaiseCustomEvent;
```

Events – Subscribing

<https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/events/how-to-subscribe-to-and-unsubscribe-from-events#to-subscribe-to-events-programmatically>

1. Define an event handler method whose signature matches the delegate signature for the event.

```
void HandleCustomEvent(object sender, CustomEventArgs a)
{
    // Do something useful here.
}
```

2. Use the addition assignment operator (+=) to attach an event handler to the event. In the following example, assume that a class object named publisher has an event named RaiseCustomEvent.

```
publisher.RaiseCustomEvent += HandleCustomEvent;
```


Events – Unsubscribing / Garbage Collection

<https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/events/how-to-subscribe-to-and-unsubscribe-from-events#unsubscribing>

To prevent your **event handler** from being invoked when the **event** is raised, **unsubscribe** from the event. In order to prevent resource leaks, you should **unsubscribe** from **events** before you dispose of a **subscriber** object. Until you **unsubscribe** from an event, the multicast **delegate** that underlies the **event** in the **publishing** object has a reference to the **delegate** that encapsulates the **subscriber's event handler**. As long as the **publishing** object holds that reference, **garbage collection** will not delete your **subscriber** object.

```
publisher.RaiseCustomEvent -= HandleCustomEvent;
```

When all subscribers have **unsubscribed** from an event, the event instance in the publisher class is set to null.