C# Events, Delegates and Lambdas

Dan Wahlin

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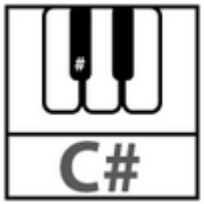
Pre-Req Classes



C# Fundamentals - Part 1

This course is designed to give you everything you need to become a productive C# developer on the .NET platform

Authored by: Scott Allen
Duration: 6h 17m
Level: Beginner

The Role of Events, Delegates and Event Handlers

Creating Delegates, Events and EventArgs

Handling Events

Lambdas, Action<T> and Func<T,TResult>

The Role of Events, Delegates and Event Handlers

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The Role of Events

The Role of Delegates

The Role of Event Handlers


Event Handler
EventArgs
Event Raiser
Delegate

The Role of Events

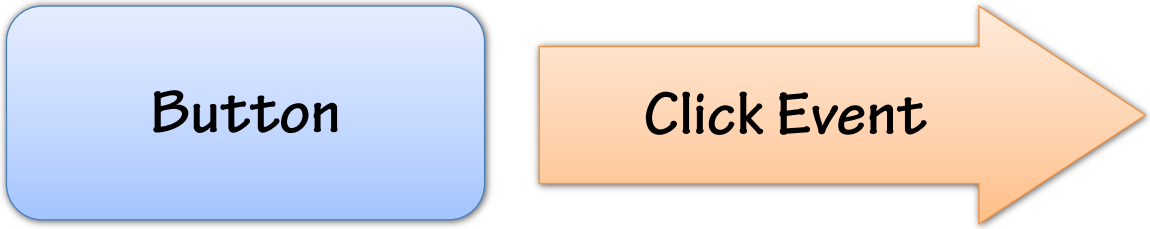

Event Raiser

What is an Event?

- Events are notifications
- Play a central role in the .NET framework
- Provide a way to trigger notifications from end users or from objects

The Role of Events

- Events signal the occurrence of an action/notification



- Objects that raise events don't need to explicitly know the object that will handle the event

- Events pass EventArgs (event data)

The Role of Delegates

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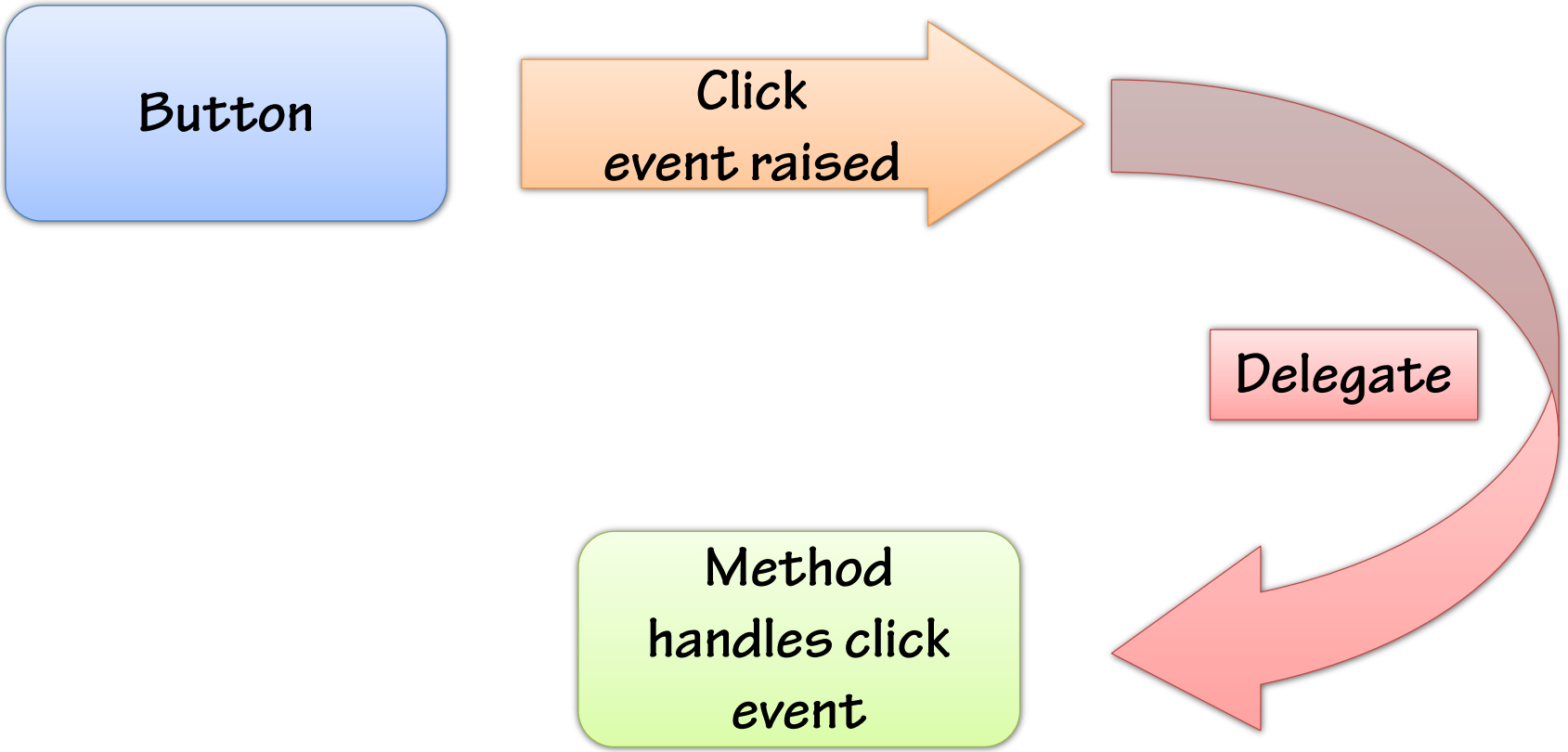
Delegate

What is a Delegate?

- A delegate is a specialized class often called a "Function Pointer"
- The glue/pipeline between an event and an event handler
- Based on a MulticastDelegate base class

Delegates are a Pipeline

The Role of Delegates



The Role of Event Handlers

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EventArgs
Event Handler

What is an Event Handler?

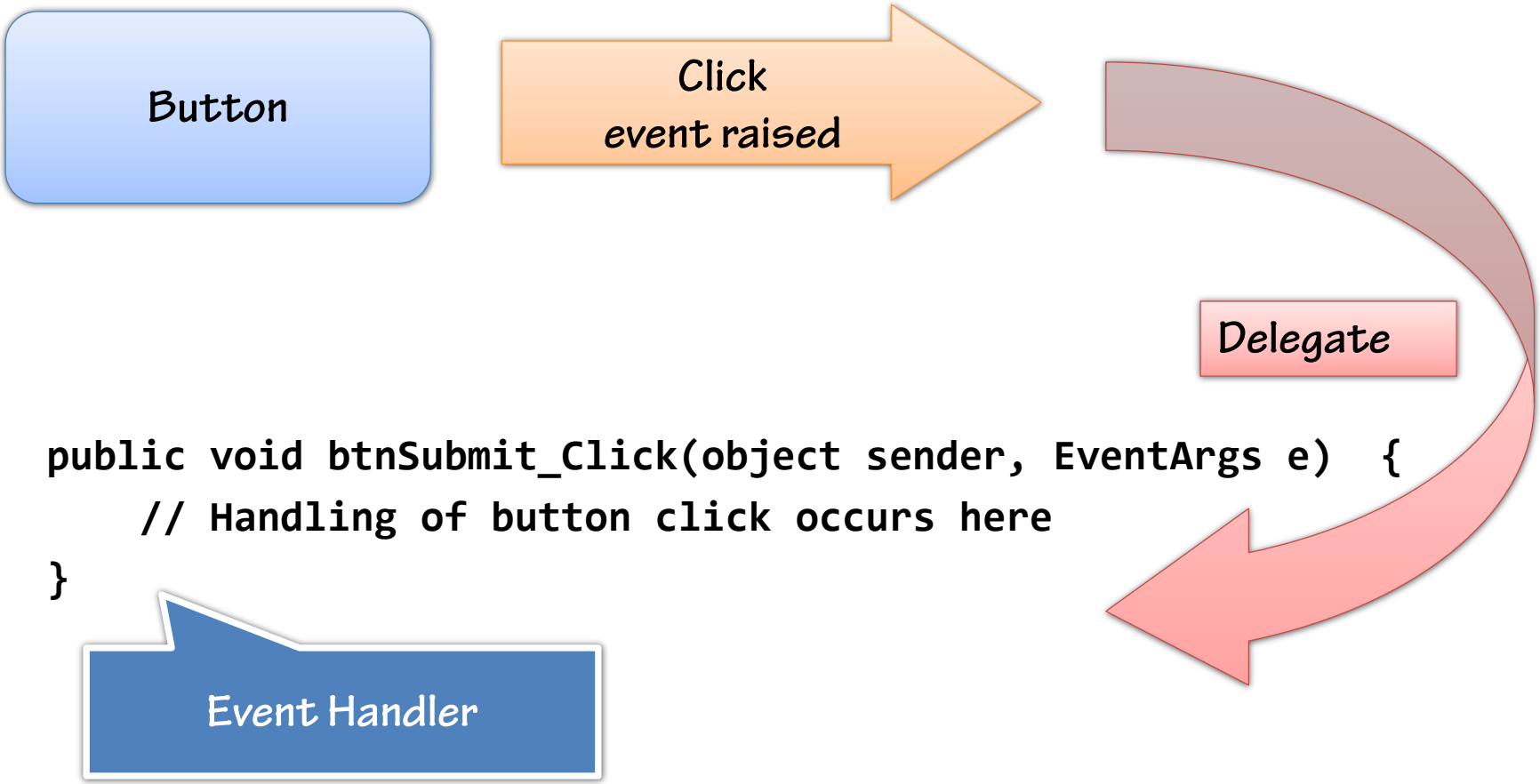
- **Event handler is responsible for receiving and processing data from a delegate**

- **Normally receives two parameters:**
  - Sender
  - EventArgs

- **EventArgs responsible for encapsulating event data**

The Role of Event Handlers

An event handler is responsible for accessing data passed by a delegate:



Summary

- The .NET framework relies heavily on events and delegates
- Events provide notifications and send data using EventArgs
- Delegates act as the glue/pipeline between events and event handlers
- Event Handlers receive and process EventArgs data

Creating Delegates, Events and EventArgs

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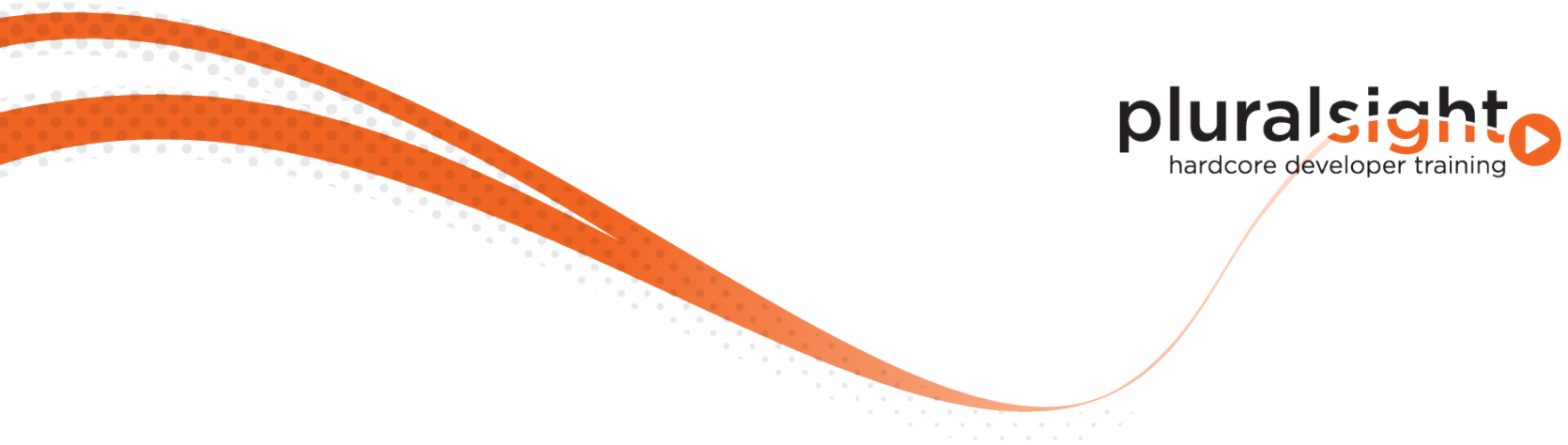
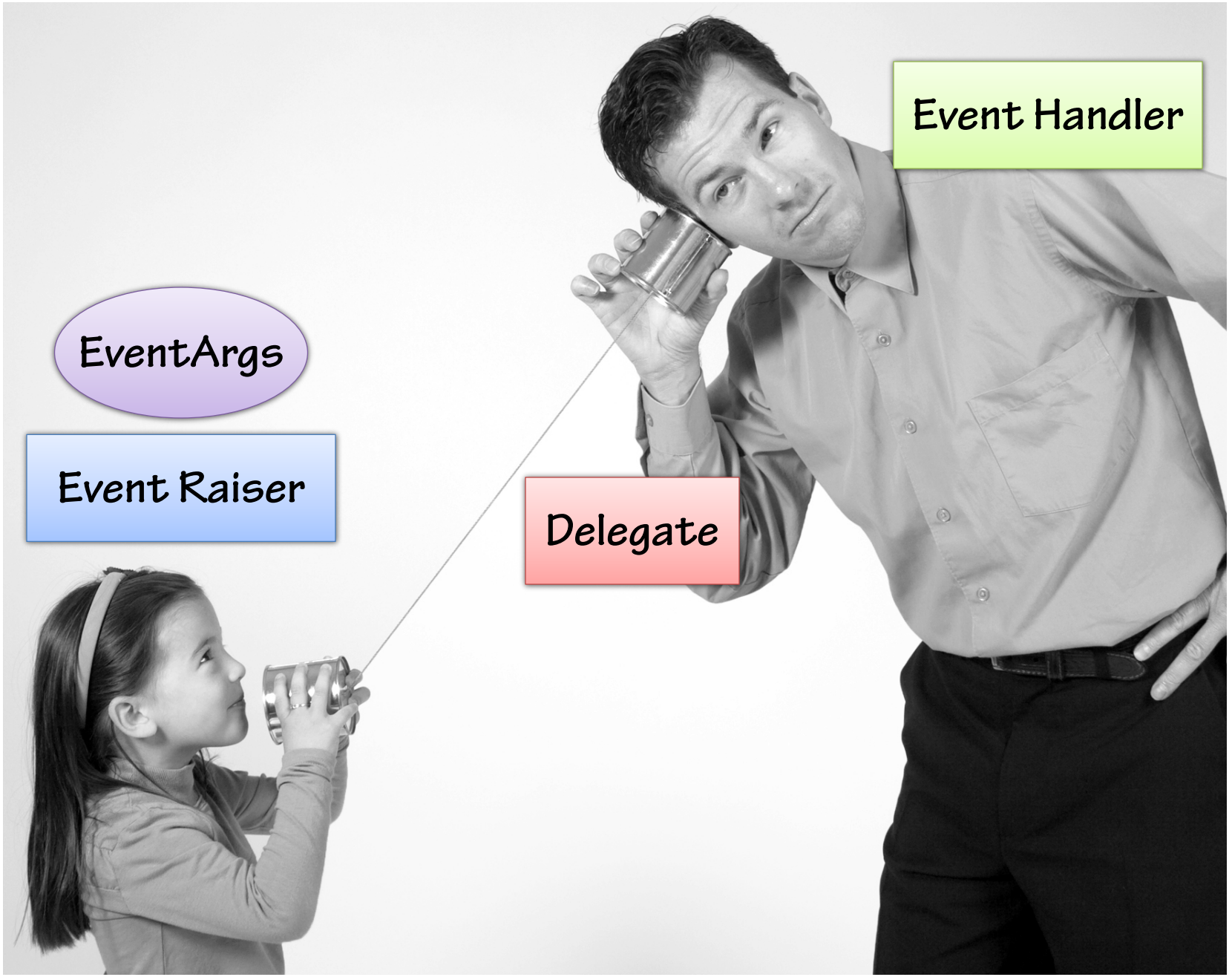


Creating a Delegate

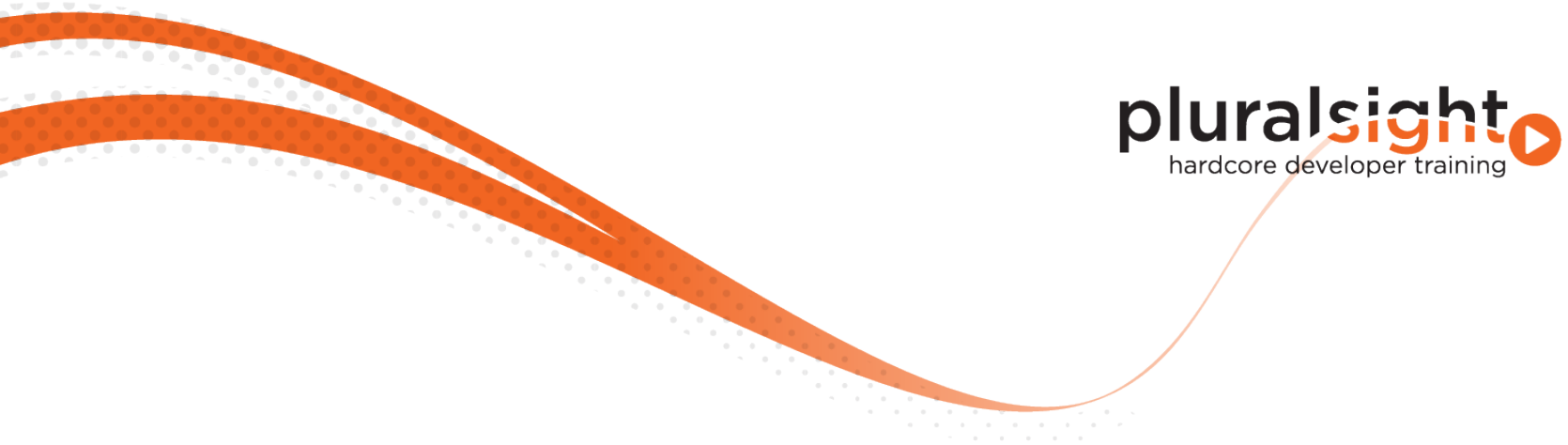
Defining an Event

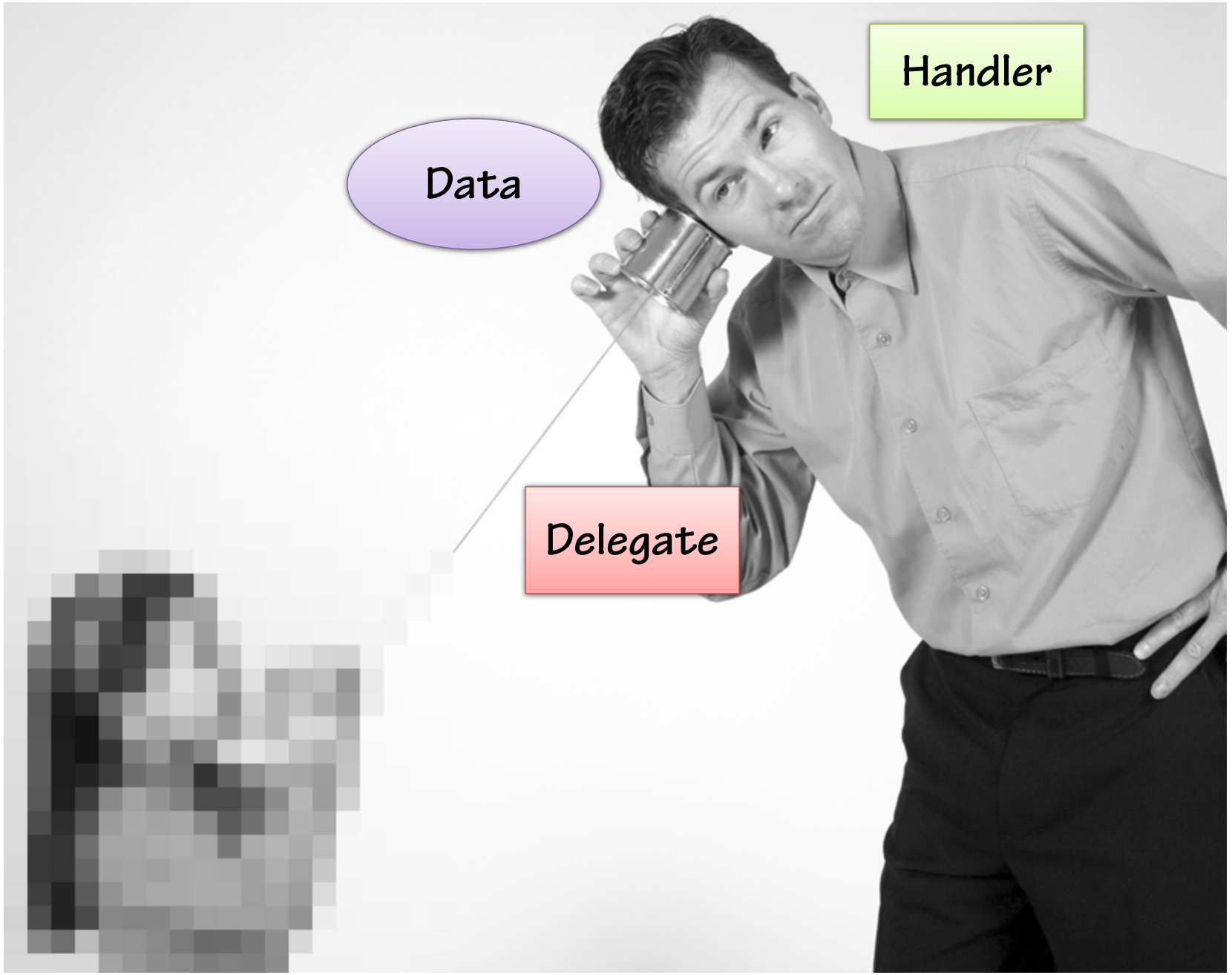
Raising Events

Creating an EventArgs Class


Event Handler
EventArgs
Event Raiser
Delegate

Creating a Delegate




Handler
Data
Delegate

Creating Delegates

- Custom delegates are defined using the **delegate** keyword:

```
public delegate void WorkPerformedHandler(int hours,
    WorkType workType);
```

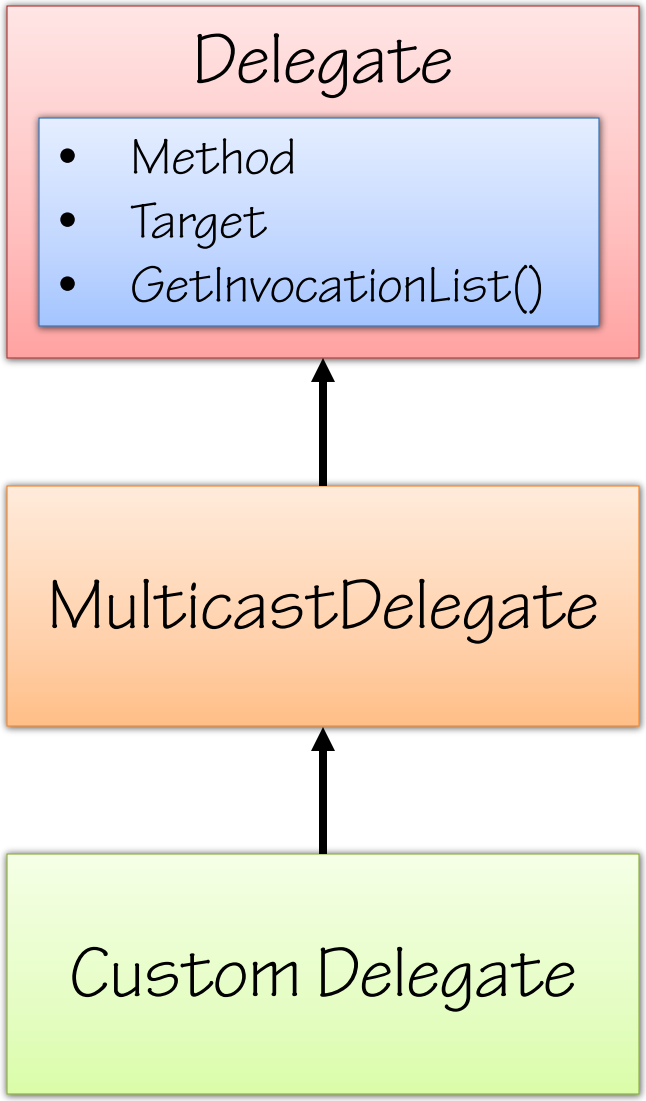
Delegate and Handler Method Parameters

- The delegate signature must be mimicked by a handler method:

```
public delegate void WorkPerformedHandler(int hours,
    WorkType workType);
```

```
public void Manager_WorkPerformed(int workHours,
   WorkType wType) {
   ...
}
```

Delegate Base Classes



What is a Multicast Delegate?

- Can reference more than one delegate function
- Tracks delegate references using an invocation list
- Delegates in the list are invoked sequentially

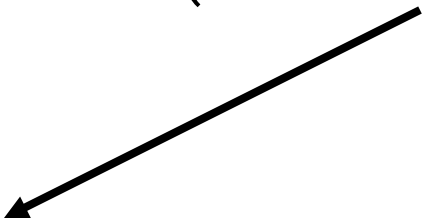
Creating a Delegate Instance

Delegate

```
public delegate void WorkPerformedHandler(int hours,
    WorkType workType);
```

Delegate Instance

```
WorkPerformedHandler del1 =
  new WorkPerformedHandler(WorkPerformed1);
```



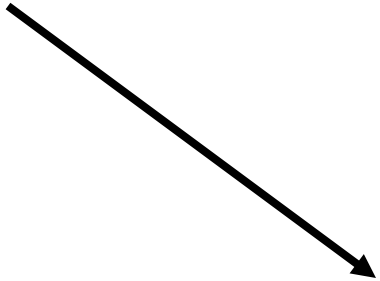
Handler

```
static void WorkPerformed1(int hours, WorkType workType)
{
    Console.WriteLine("WorkPerformed1 called");
}
```

Invoking a Delegate Instance

```
WorkPerformedHandler del1 =
  new WorkPerformedHandler(WorkPerformed1);

del1(5, WorkType.Golf);
```



```
static void WorkPerformed1(int hours, WorkType workType)
{
    Console.WriteLine("WorkPerformed1 called");
}
```

Adding to the Invocation List

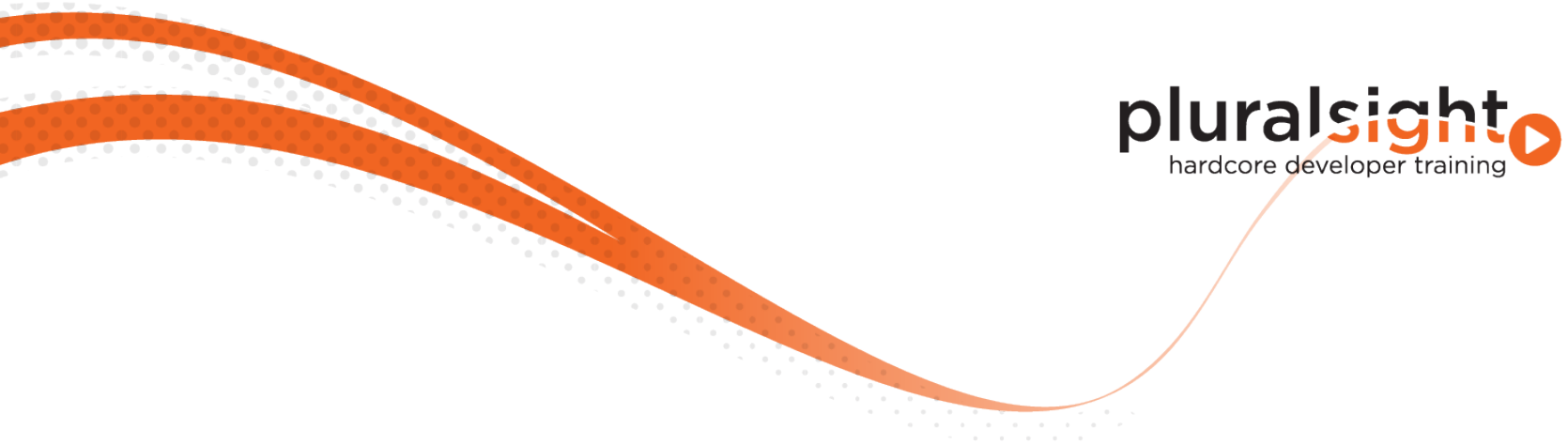
```
WorkPerformedHandler del1 =
  new WorkPerformedHandler(WorkPerformed1);

WorkPerformedHandler del2 =
  new WorkPerformedHandler(WorkPerformed2);

del1 += del2;

del1(5, WorkType.GoToMeetings);
```

Defining an Event



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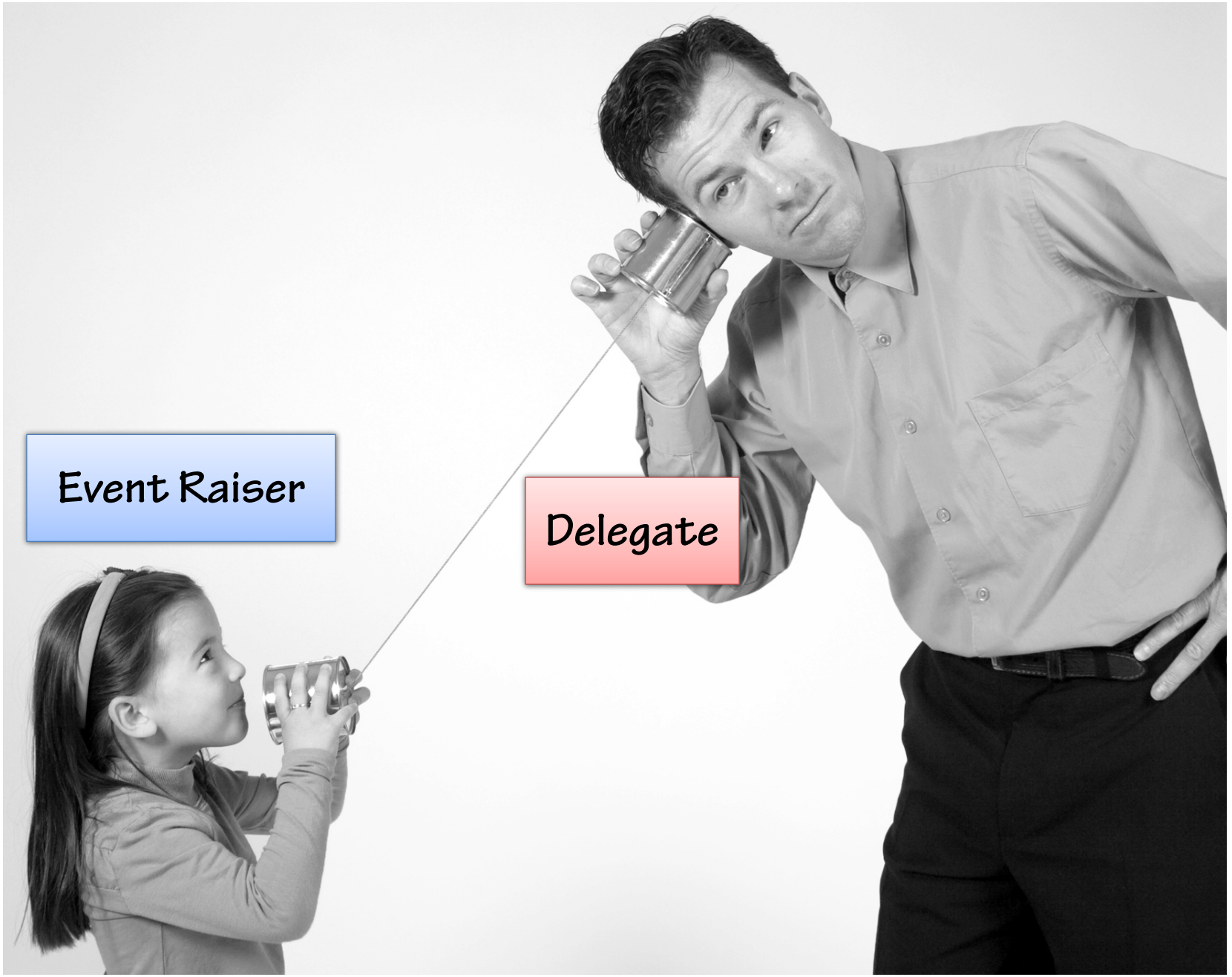

Event Raiser
Delegate

Defining an Event

- Events can be defined in a class using the **event** keyword

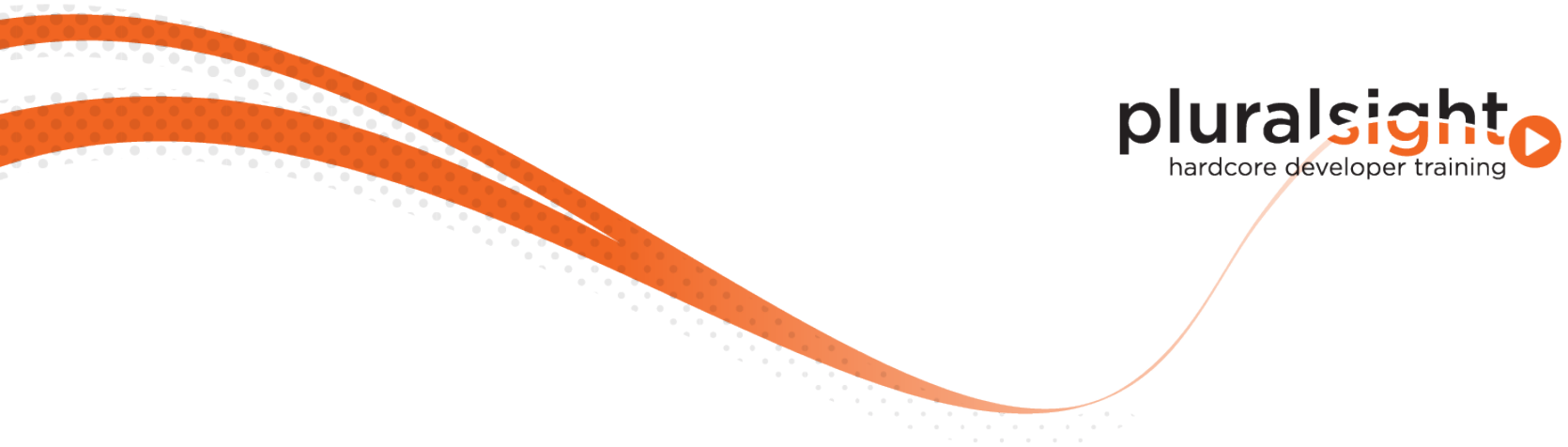
```
public event WorkPerformedHandler WorkPerformed;
```

Defining an Event with add/remove

- Events can be defined using add/remove accessors:

```
private WorkPerformedHandler _WorkPerformedHandler;
public event WorkPerformedHandler WorkPerformed
{
    [MethodImpl(MethodImplOptions.Synchronized)]
    add
    {
        _WorkPerformedHandler = (WorkPerformedHandler)Delegate.Combine(
          _WorkPerformedHandler, value);
    }
    [MethodImpl(MethodImplOptions.Synchronized)]
    remove
    {
        _WorkPerformedHandler = (WorkPerformedHandler)Delegate.Remove(
           _WorkPerformedHandler, value);
    }
}
```

Raising Events



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Raising Events

- Events are raised by calling the event like a method:

```
if (WorkPerformed != null) {
    WorkPerformed(8, WorkType.GenerateReports);
}
```

- Another option is to access the event's delegate and invoke it directly:

```
WorkPerformedHandler del = WorkPerformed as WorkPerformedHandler;
if (del != null) {
    del(8, WorkType.GenerateReports);
}
```

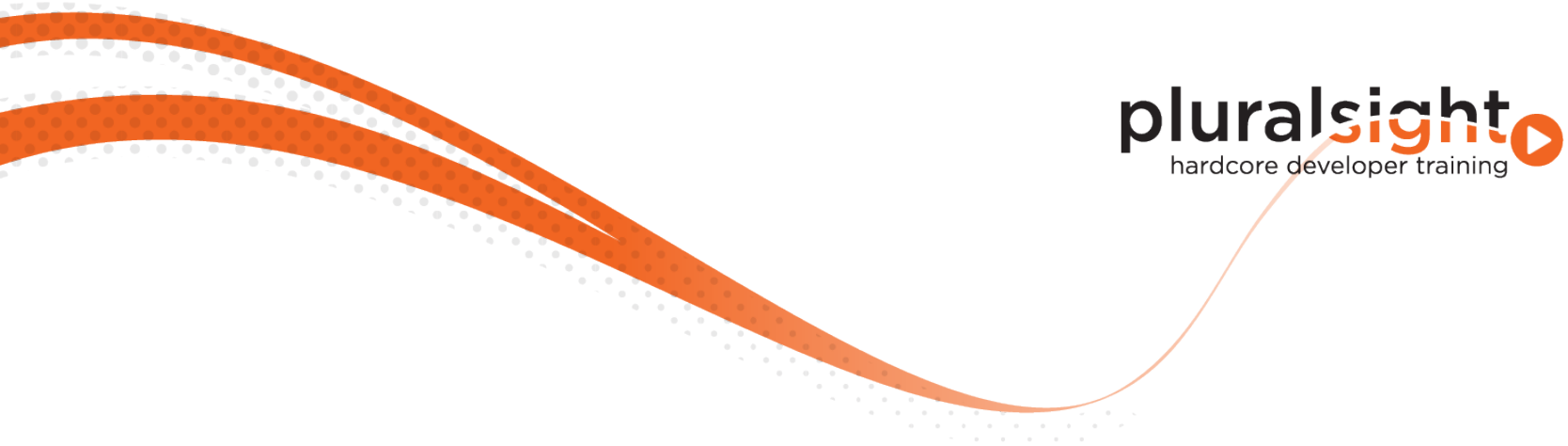
Exposing and Raising Events

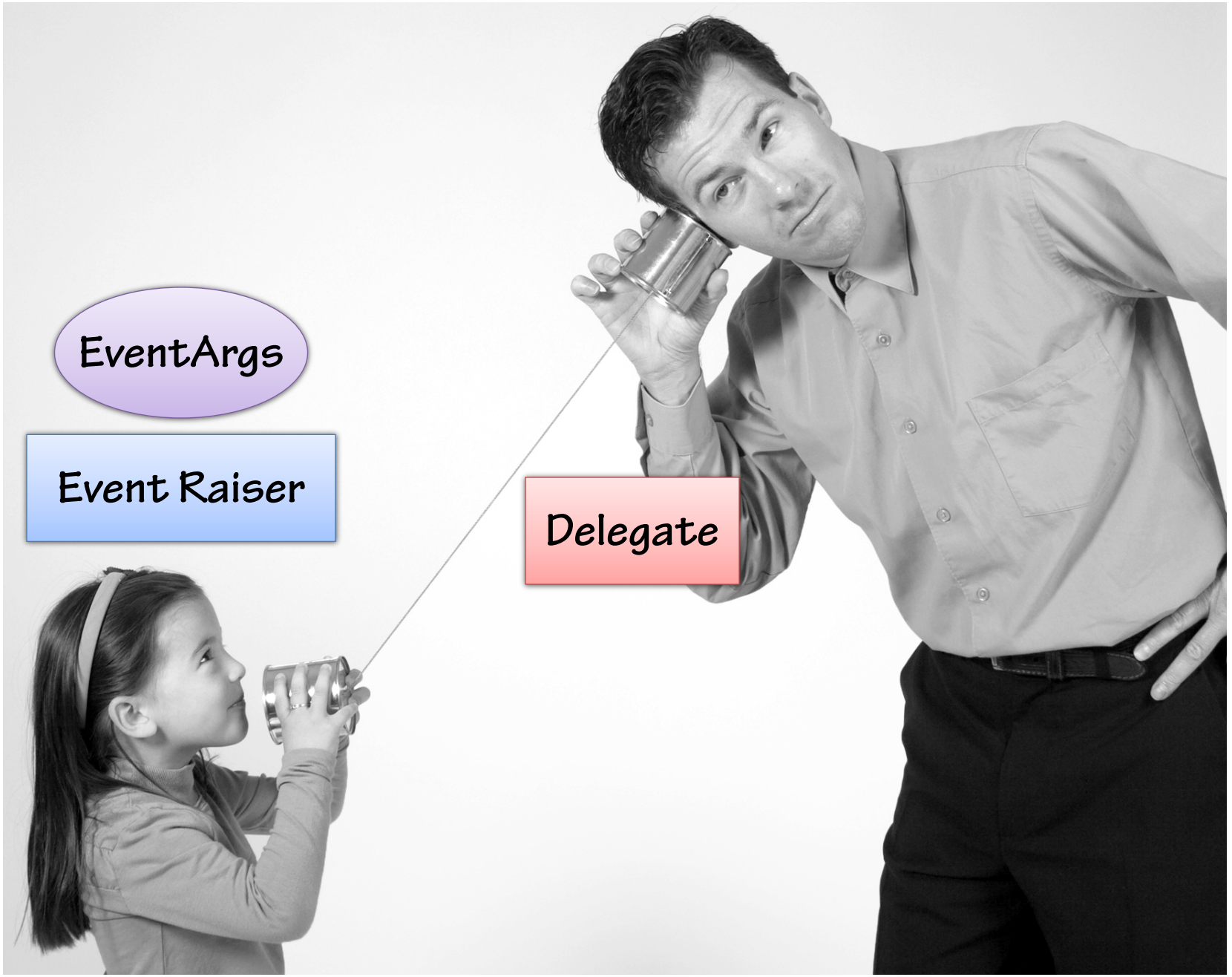
```
public delegate void WorkPerformedHandler(int hours, WorkType workType);
public class Worker
{
    public event WorkPerformedHandler WorkPerformed;
    public virtual void DoWork(int hours, WorkType workType)
    {
        // Do work here and notify consumer that work has been performed
        OnWorkPerformed(hours, workType);
    }

    protected virtual void OnWorkPerformed(int hours, WorkType workType)
    {
         WorkPerformedHandler del = WorkPerformed as WorkPerformedHandler;
         if (del != null) //Listeners are attached
         {
             del(hours, workType);
         }
    }
}
```

Event Definition

Raise Event

Creating an EventArgs Class




EventArgs
Event Raiser
Delegate

Creating a Custom EventArgs Class

- The **EventArgs** class is used in the signature of many delegates and event handlers:

```
public void button_Click(object sender, EventArgs e)
{
    // Handle button click
}
```

- When custom data needs to be passed the **EventArgs** class can be extended.

Deriving from the System.EventArgs Class

```
public class WorkPerformedEventArgs : System.EventArgs
{
    public int Hours { get; set; }
    public WorkType WorkType { get; set; }
}
```

Using a Derived System.EventArgs Class

- To use a custom EventArgs class, the delegate must reference the class in its signature:

```
public delegate void WorkPerformedHandler(object sender,
   WorkPerformedEventArgs e);
```

Holds event data

Sender of event

Using EventHandler<T>

.NET includes a generic **EventHandler<T>** class that can be used instead of a custom delegate:

```
public delegate                                    (object sender,
  WorkPerformedEv
```

```
public event EventHandler<WorkPerformedEventArgs> WorkPerformed;
```

Built-in Delegate

Summary

- Events are associated with Delegates
- A standard .NET event signature accepts:
  - Sender
  - Custom EventArgs
- The parameter signature for an event handler matches the delegate signature
- EventHandler<T> provides a simple way to create a custom delegate for an event

Handling Events

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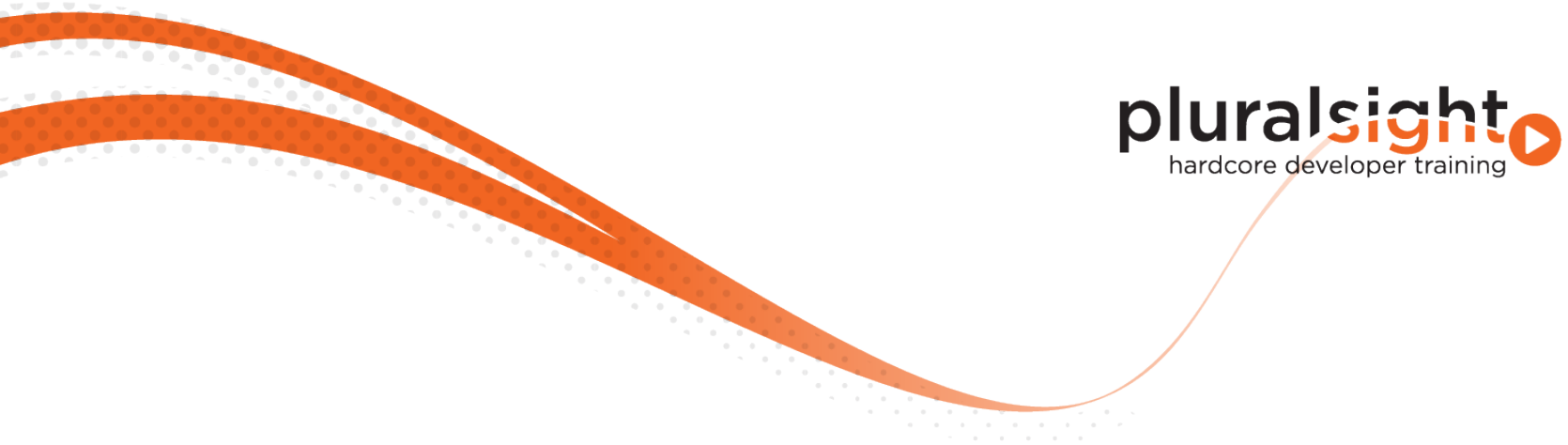
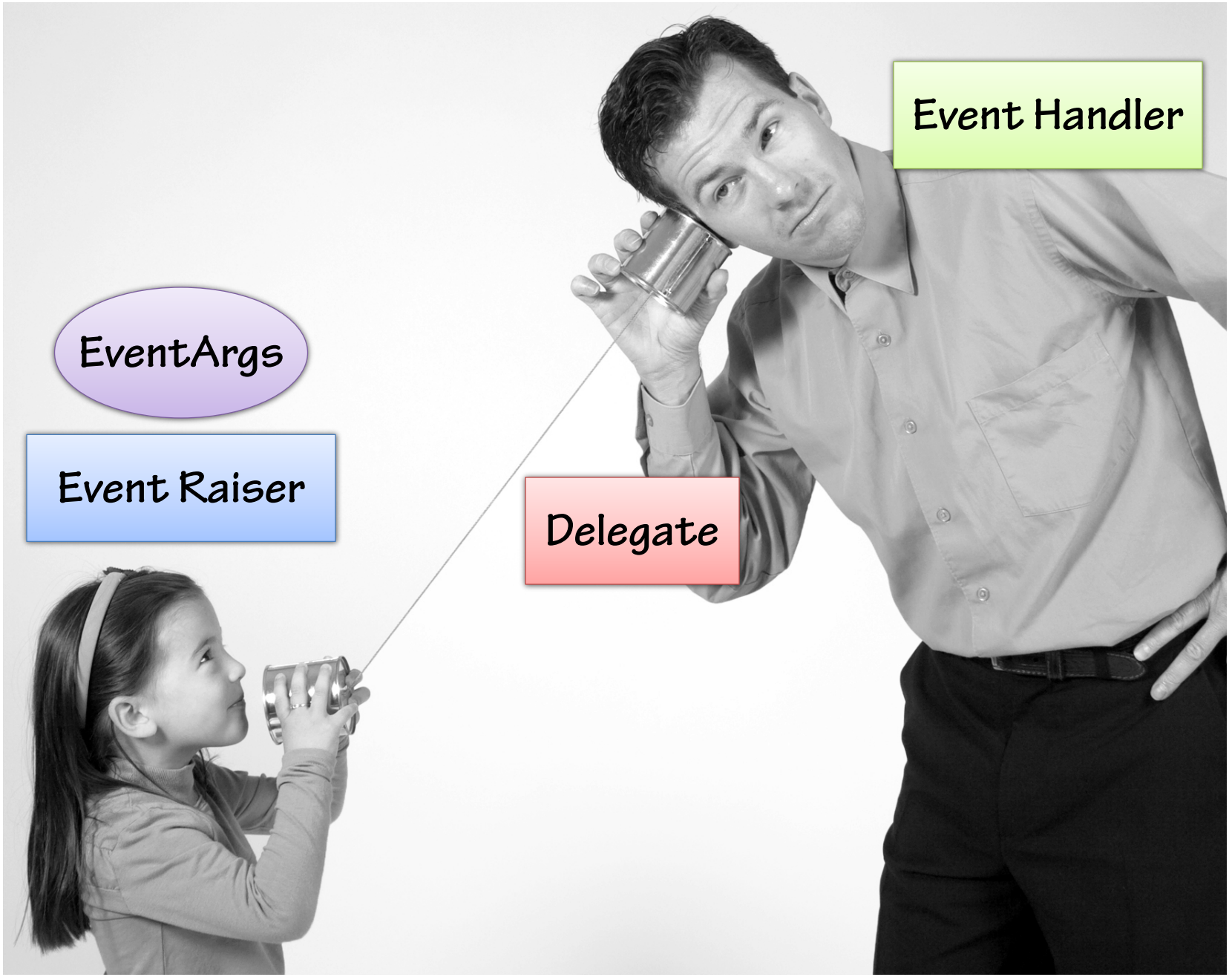


Instantiating Delegates and Handling Events

Delegate Inference

Using Anonymous Methods


Event Handler
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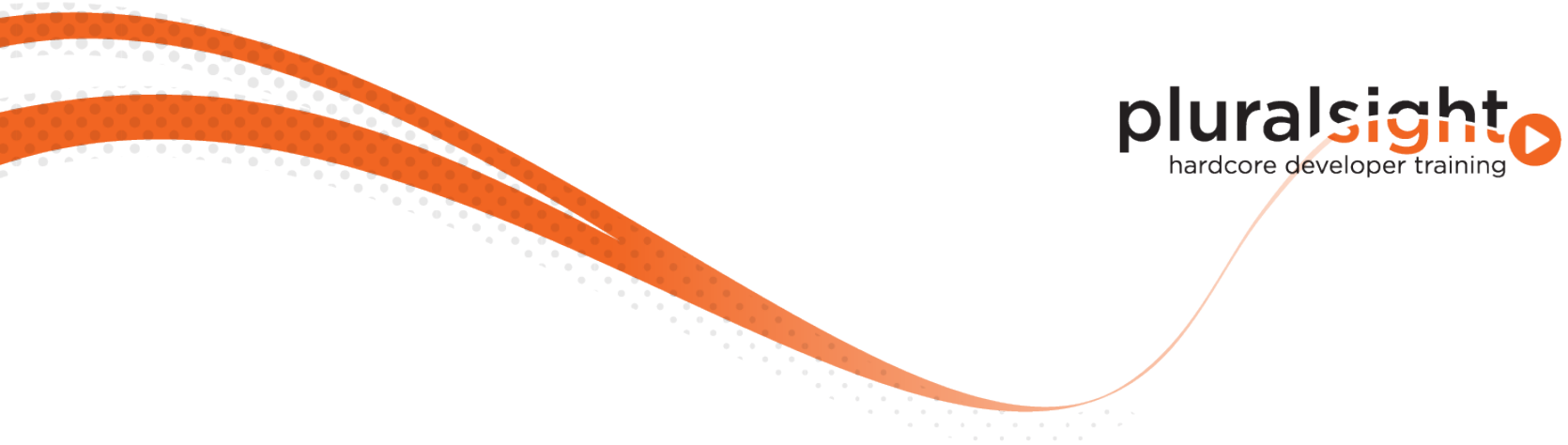
Instantiating Delegates and Handling Events



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Event Handler
Delegate

Delegate and Handler Method Parameters

- The delegate signature must be mimicked by a handler method:

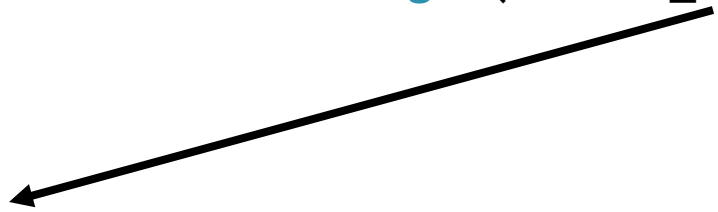
```
public delegate void WorkPerformedHandler(object sender,
    WorkPerformedEventArgs e);
```

```
public void Manager_WorkPerformed(object sender,
    WorkPerformedEventArgs e) {

    ...

}
```

Defining and Attaching Event Handlers

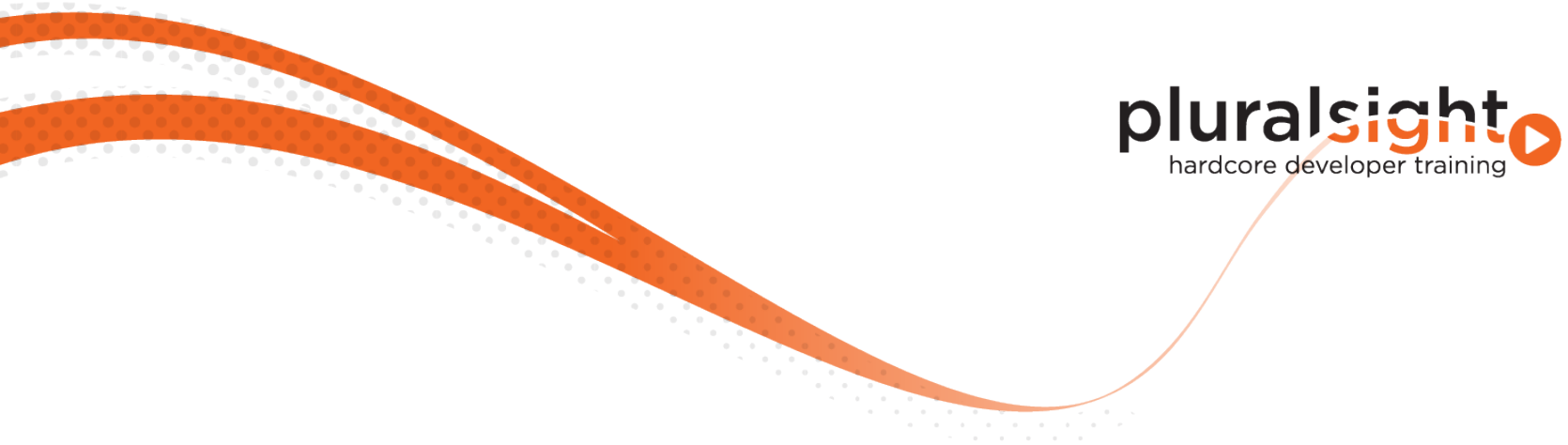
The += operator is used to attach an event to an event handler:

```
var worker = new Worker();
worker.WorkPerformed +=
    new EventHandler<WorkPerformedEventArgs>(worker_WorkPerformed);
```



```
void worker_WorkPerformed(object sender, WorkPerformedEventArgs e)
{
    Console.WriteLine(e.Hours.ToString());
}
```

Delegate Inference



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Delegate Inference

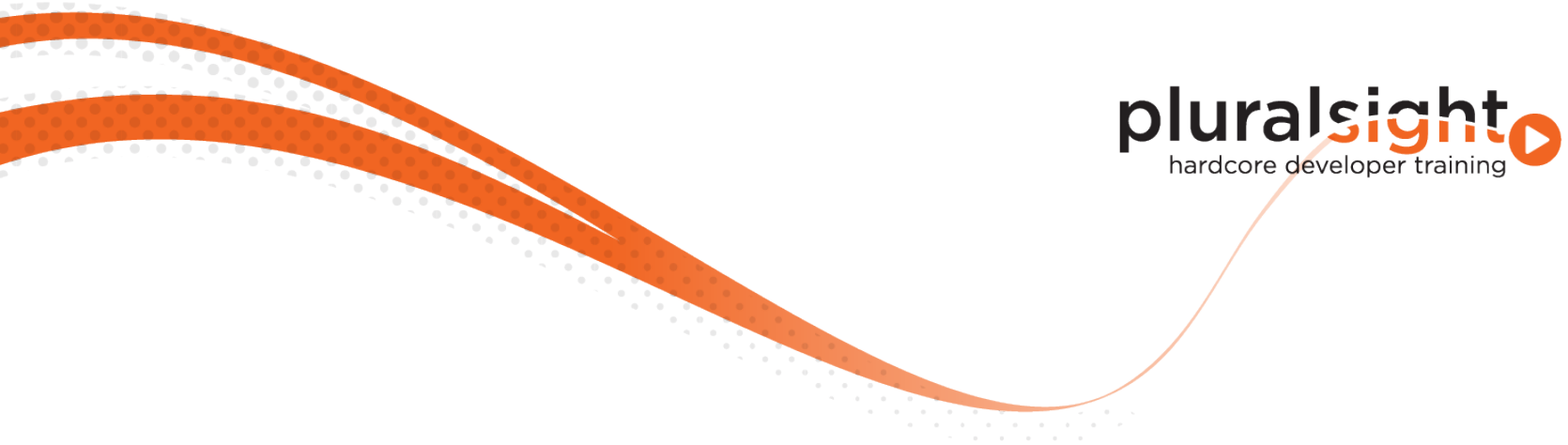
The += operator is used to attach an event to an event handler:

```
var worker = new Worker();
worker.WorkPerformed += worker_WorkPerformed;
```

Compiler will “infer” the delegate

```
void worker_WorkPerformed(object sender, WorkPerformedHandler e)
{
    Console.WriteLine(e.);
}
```

Using Anonymous Methods



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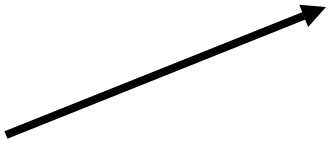
Attaching Event Handlers Directly to Events

What if you want to attach an event handler directly to an event?

```
var worker = new Worker();
worker.WorkPerformed += //Attach event handler here
```



```
void worker_WorkPerformed(object sender, WorkPerformedEventArgs e)
{
    Console.WriteLine(e.Hours.ToString());
}
```

Anonymous Methods

- Anonymous methods allow event handler code to be hooked directly to an event
- Anonymous methods are defined using the delegate keyword:

```
var worker = new Worker();
worker.WorkPerformed += delegate(object sender,
                                 WorkPerformedEventArgs e)
    {
        Console.WriteLine(e.Hours.ToString());
    }; //End of anonymous method
```

Summary

- To listen to an event you must construct a delegate and add it to the invocation list
- The C# compiler provides “delegate inference” functionality
- Event handler methods can be attached directly to events

Lambdas, Action<T> and Func<T,TResult>

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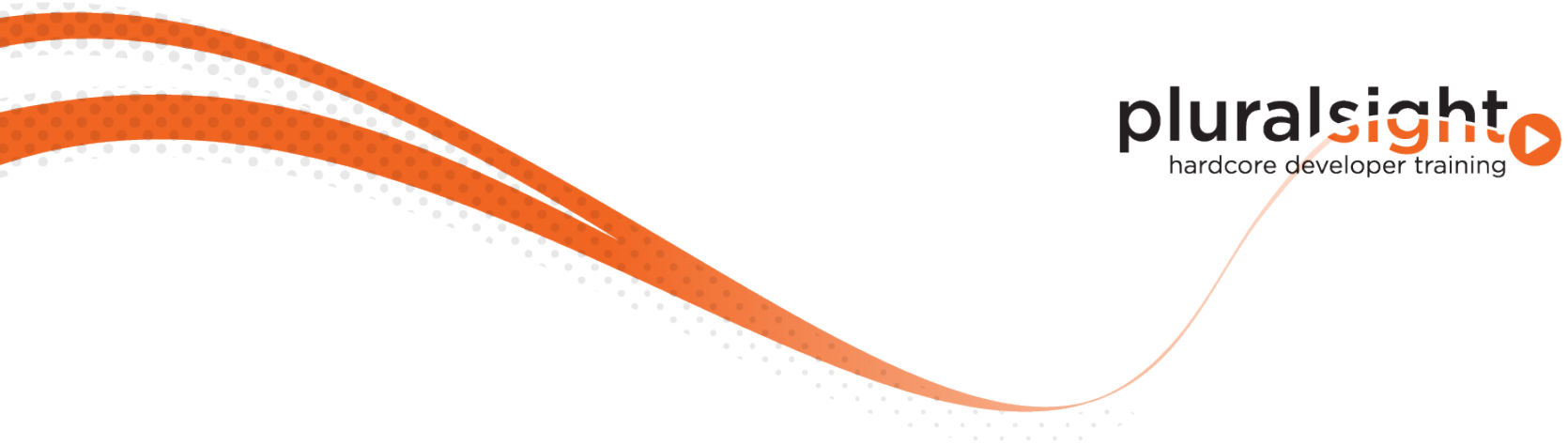

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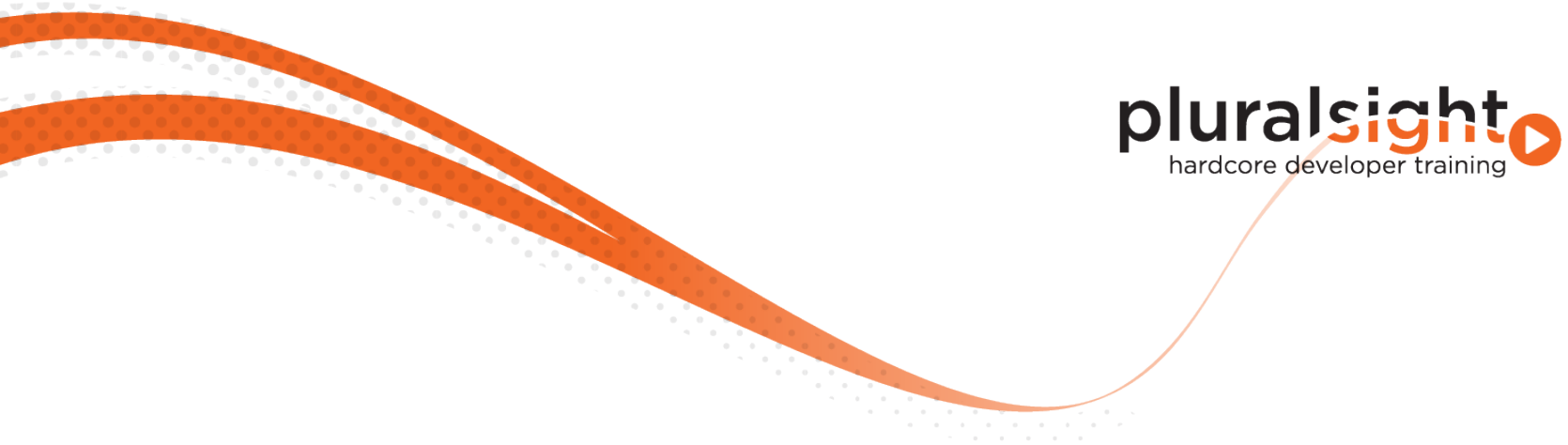
Lambdas and Delegates

Using Action<T>

Using Func<T,TResult>

Lambdas and Delegates



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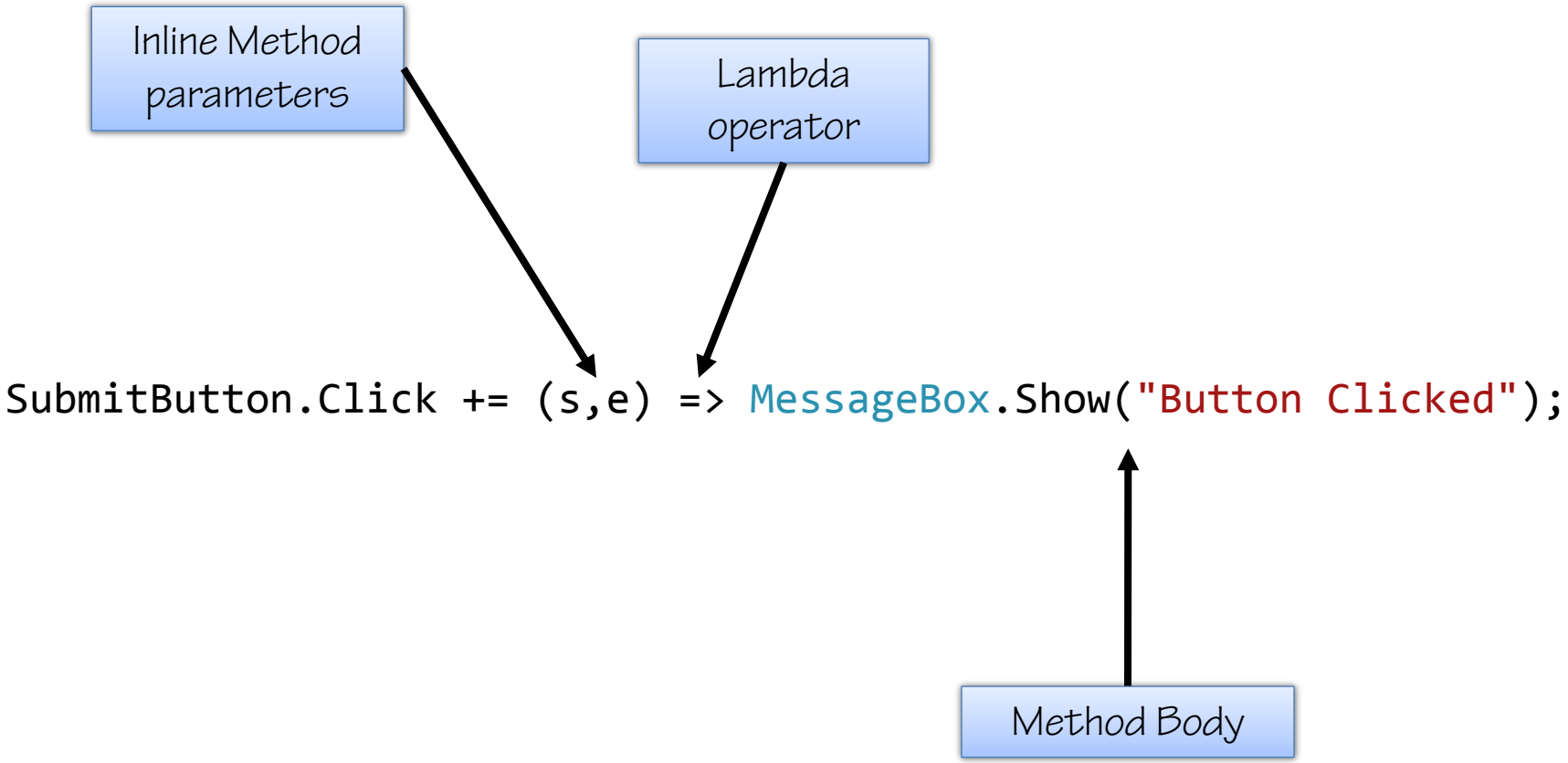
Anonymous Methods in Action

```
SubmitButton.Click += delegate(object sender, EventArgs e)
 {
     MessageBox.Show("Button Clicked");
 };
```

Understanding Lambda Expressions



Assigning a Lambda to a Delegate

- Lambda expressions can be assigned to any delegate:

```
delegate int AddDelegate(int a, int b);

static void Main(string[] args){
    AddDelegate ad = (a,b) => a + b;
    int result = ad(1,1); //result = 2
}
```

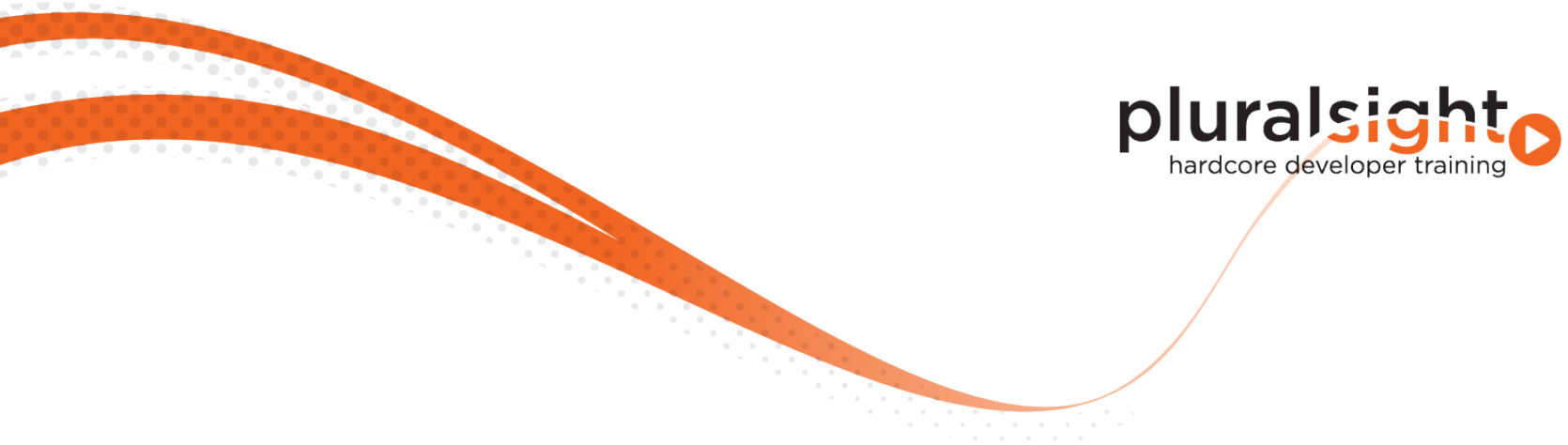
Handling Empty Parameters

- Delegates that don't accept any parameters can be handled using lambdas:

```
delegate bool LogDelegate();

static void Main(string[] args)
{
    LogDelegate ld = () =>
    {
        UpdateDatabase();
        WriteToEventLog();
        return true;
    };
    bool status = ld();
}
```

Using Action<T>



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Delegates in .NET

- The .NET framework provides several different delegates that provide flexible options:
  - **Action<T>** - Accepts a single parameter and returns no value
  - **Func<T,TResult>** - Accepts a single parameter and return a value of type TResult

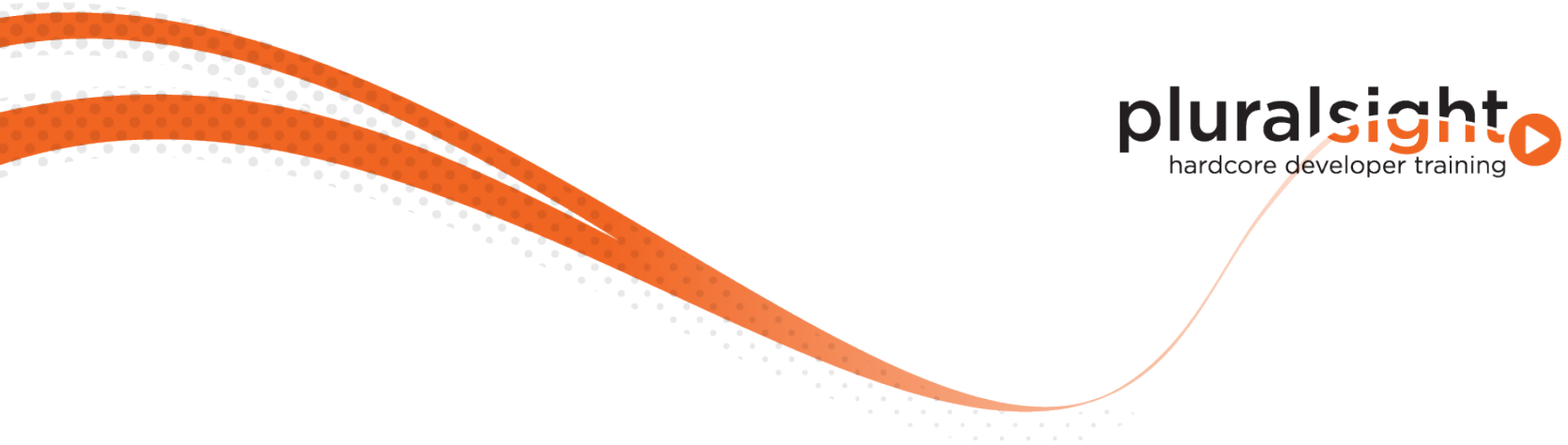
Using Action<T>

- Action<T> can be used to call a method that accepts a single parameter of type T:

```
public static void Main(string[] args)
{
    Action<string> messageTarget;
    if (args.Length > 1) messageTarget = ShowWindowsMessage;
    else messageTarget = Console.WriteLine;
    messageTarget("Invoking Action!");
}

private static void ShowWindowsMessage(string message)
{
    MessageBox.Show(message);
}
```

Using Func<T,TResult>



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Using Func<T,TResult>

- **Func<T,TResult>** supports a single parameter (T) and returns a value (TResult):

```
public static void Main(string[] args)
{
    Func<string, bool> logFunc;
    if (args[0] == "EventLog") logFunc = LogToEventLog;
    else logFunc = LogToFile;
    bool status = logFunc("Log Message");
}

private static bool LogToEventLog(string message) { /* log */ }
private static bool LogToFile(string message) { /*log */ }
```

Summary

- Lambdas provide a way to define inline methods using a concise syntax

- The .NET Framework provides several built-in delegate types such as:
  - Action<T>
  - Func<T, TResult>

Events and Delegates in Action

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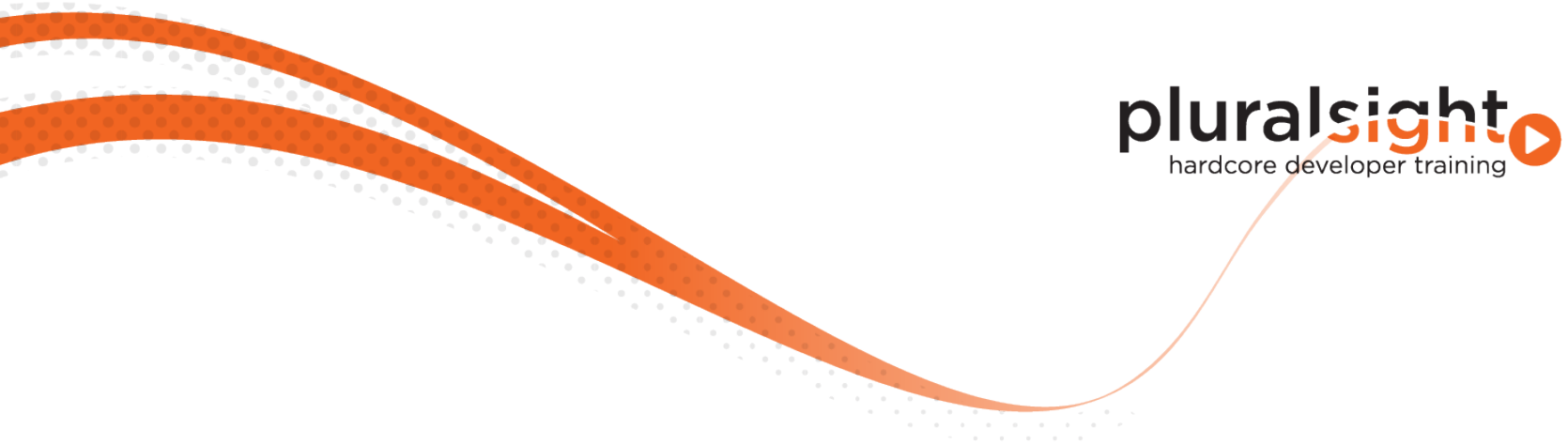

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Communicating Between Components

Asynchronous Delegates

Using BackgroundWorker Events

The Role of Delegates with Threads

Putting it All Together

Summary

- Events and Delegates can be used in many scenarios:
  - Communication between objects using events
  - To start asynchronous processes
  - To handle BackgroundWorker functionality
  - To start threads
  - Many more!