Learn to Love Lambdas

An overview of Lambda Expressions by JeremyBytes.com

Overview

Lambda expressions can be confusing the first time you walk up to them. But once you get to know them, you'll see that they are a great addition to your toolbox. Used properly, they can add elegance and simplicity to your code. And some .NET constructs (such as LINQ) lend themselves to lambda expressions. We'll take a look at how lambda expressions work and see them in action.

Lambda expressions come in two flavors: statement lambdas and expression lambdas. Both types are anonymous delegates (and we'll take a look at what that means). Statement lambdas perform some type of action; expression lambdas return some type of value.

Anatomy of a Lambda Expression

Lambda expressions consist of 3 parts:

1. A set of parameters
2. The "goes to" operator: =>
3. A set of statements that perform an action or return a value

Let's fire up a Silverlight application and look at lambdas in action.

The Set Up

We'll start with a skeleton of a WPF project that contains a business library. You can download the source code for the application here: http://www.jeremybytes.com/Downloads.aspx#LLL. The sample code we'll be looking at here is built using .NET 4.5 and Visual Studio 2012 (but this code will work all the way back to .NET 3.5). The download includes the starter application and the completed code. The starter application contains the following.

Projects

The solution contains 3 projects. PeopleViewer is the WPF project; PeopleViewer.Library is the business layer of the application (the Model) that supplies the data. These are the 2 projects that we'll be dealing with here. These projects are intentionally kept simple so that we can focus on Lambda expressions.

The third project is PeopleViewer.MVVM. This is a WPF application that splits the presentation into a View (XAML) and ViewModel (Presentation logic). This uses the PeopleViewer.Library as the data source. This project is provided as a reference sample for people wanting to see a more "real world" implementation of this application.

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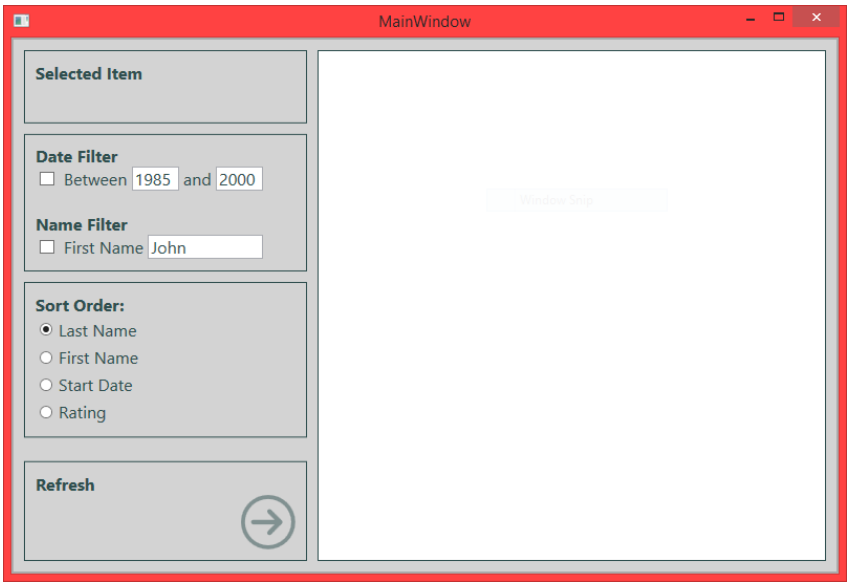
PeopleViewer Project

In the WPF application, the user interface has been implemented in the MainWindow.xaml class. Here's the running application:



The code-behind page (MainWindow.xaml.cs) has a single method added: an empty Click event handler for the Refresh button. We've also added a reference to the PeopleViewer.Library namespace; this is the namespace for the library where we'll get our data (this will be explained below). Here's the code:

```
using PeopleViewer.Library;
using System;
using System.Collections.Generic;
using System.Linq;
using System.Windows;

namespace PeopleViewer
{
    public partial class MainWindow : Window
    {
        public MainWindow()
        {
            InitializeComponent();
        }

        private void RefreshButton_Click(object sender, RoutedEventArgs e)
        {
        }
    }
}
```

To handle the data output, the WPF project also contains a Converters.cs file that contains a number of value converters. In addition, we have a number of custom styles and templates defined in the App.xaml file. If you are interested in the XAML and value converters in this project, you can look up the

Metrocizing XAML demo and sample code on the website:
http://www.jeremybytes.com/Downloads.aspx#MX.

PeopleViewer.Library Project

The PeopleViewer.Library project is where we'll get our data. We're going to treat this project as a bit of a "black box". In our scenario, another team has provided us with this library to access data, and we need to work with it our UI project. So, we'll just be taking a look at the public bits.

The library works with `Person` objects. This is defined in the Person.cs file:

```
using System;

    public class Person
    {
        public string FirstName { get; set; }
        public string LastName { get; set; }
        public DateTime StartDate { get; set; }
        public int Rating { get; set; }
    }
```

This is a simple class with 4 properties. In order to get a populated collection, the library provides us with a method and an event. These are located in PeopleRepository.cs:

```
    public class PeopleRepository
    {
        public void GetPeopleAsync() {...}
        public event EventHandler<GetPeopleCompletedEventArgs> GetPeopleCompleted;
        ...
    }

    public class GetPeopleCompletedEventArgs : EventArgs
    {
        public IEnumerable<Person> Result { get; set; }

        public GetPeopleCompletedEventArgs(IEnumerable<Person> people)
        {
            Result = people;
        }
    }
```

This uses an asynchronous pattern known as the Event Asynchronous Pattern (or EAP). With this pattern, there is an asynchronous method to kick off the process (`GetPeopleAsync`), and then an event fires when the process is complete (`GetPeopleCompleted`). We can then then use the Result property of the event arguments (`GetPeopleCompletedEventArgs`) to retrieve the populated collection of `Person` objects.

As a side note, there are a number of asynchronous patterns. The Task Asynchronous Pattern (or TAP) has gained popularity in recent years. But there are a number of libraries that use earlier patterns.

So with all this in place, let's get started!

Fetching the Data

We want to fetch the data when we click the Refresh button, so we'll add the code we need to the Click event handler. This consists of 4 steps.

1. Create an instance of the PersonRepository class:

```
var repository = new PeopleRepository();
```

2. Hook up the repository Completed event handler / callback. We'll let VisualStudio create the reference and stub for us. First, type "`repository.GetPeopleCompleted +=`". Visual Studio IntelliSense will offer to create a new event handler. If you press Tab twice, it will add the reference and generate the stub. Here's what we end up with:

```
repository.GetPeopleCompleted += repository_GetPeopleCompleted;
```

3. Call the Async method to kick off the method:

```
repository.GetPeopleAsync();
```

This will start the call to the repository asynchronously. When the call completes, the Completed event handler / callback will run.

4. Bind the data to the UI. Now, we just need to add code to the callback to put our data into the ListBox on our UI. Here's the code in its entirety:

```
public partial class MainWindow : Window
{
    public MainWindow()
    {
        InitializeComponent();
    }

    private void RefreshButton_Click(object sender, RoutedEventArgs e)
    {
        var repository = new PeopleRepository();
        repository.GetPeopleCompleted += repository_GetPeopleCompleted;
        repository.GetPeopleAsync();
    }

    void repository_GetPeopleCompleted(object sender, GetPeopleCompletedEventArgs e)
    {
        PersonListBox.ItemsSource = e.Result;
    }
}
```

Now, if we run the application, click the "Refresh" button, and then select an item in the list, we end up with something that looks like this:

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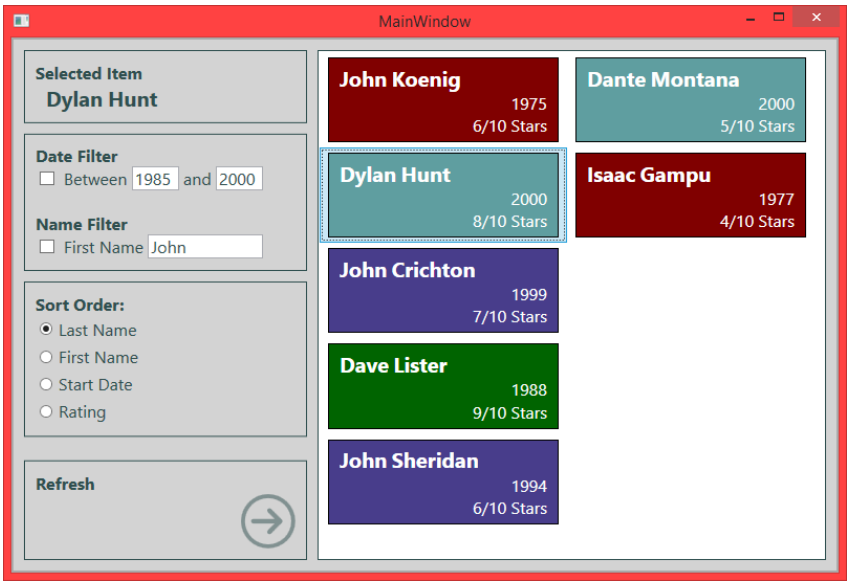

Notice that the "Selected Item" section shows which item we clicked. If you select another item, then this section updates automatically. Here's something interesting, though: if you click the "Refresh" button again, the selection disappears. This is because we are assigning a new data set to the ListBox each time we click the Refresh button. A little bit later, we'll take a look at how to keep the selection.

Upgrading to an Anonymous Delegate

What we have in place right now is a named delegate – or simply a "delegate". (An event handler is a special kind of delegate.) But instead of a named delegate, we can use an anonymous delegate. This basically in-lines the delegate code.

To do this, we copy the parameters and the method body of our event handler (the highlighted parts):

```
    void repository_GetPeopleCompleted(object sender, GetPeopleCompletedEventArgs e)
    {
        PersonListBox.ItemsSource = e.Result;
    }
```

Then we go back to where we assign the event handler:

```
repository.GetPeopleCompleted += repository_GetPeopleCompleted;
```

And then we replace the "`repository_GetPeopleCompleted`" with the "`delegate`" keyword followed by the parameters and method body that we just copied. Here's the result (with the new parts highlighted):

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```
private void RefreshButton_Click(object sender, RoutedEventArgs e)
{
    var repository = new PeopleRepository();
    repository.GetPeopleCompleted +=
        delegate(object sender, GetPeopleCompletedEventArgs e)
        {
            PersonListBox.ItemsSource = repoArgs.Result;
        };
    repository.GetPeopleAsync();
}
```

One last change, since we already have something called "sender" and "e" in scope (from the button click event handler), we need to rename these parameters. We'll call them "repoSender" and "repoArgs":

```
private void RefreshButton_Click(object sender, RoutedEventArgs e)
{
    var repository = new PeopleRepository();
    repository.GetPeopleCompleted +=
        delegate(object repoSender, GetPeopleCompletedEventArgs repoArgs)
        {
            PersonListBox.ItemsSource = repoArgs.Result;
        };
    repository.GetPeopleAsync();
}
```

Then end result is that we have just "in-lined" the event handler code. Before, we had a named delegate called "repository_GetPeopleCompleted". Now we have an anonymous delegate – that is, a delegate without a name. We still have the same method parameters and method body, but this has all been in-lined in our code.

Now we can get rid of the named delegate:

```
//void repository_GetPeopleCompleted(object sender, GetPeopleCompletedEventArgs e)
//{
//    PersonListBox.ItemsSource = e.Result;
//}
```

When we run our application, we get exactly the same results that we had before. So creating an anonymous delegate did not change the functionality of our application at all.

And Now the Lambda Expression

As previously mentioned, a lambda expression is simply an anonymous delegate. This means that we can easily convert our anonymous delegate to a lambda expression. In this case, we will create a statement lambda – a lambda that performs some action (but does not return a value). This conversion is as simple as removing the delegate keyword and adding the "=>" operator (often called the "goes to" operator) between the parameters and the statement.

```
private void RefreshButton_Click(object sender, RoutedEventArgs e)
{
    var repository = new PeopleRepository();
    repository.GetPeopleCompleted +=
        (object repoSender, GetPeopleCompletedEventArgs repoArgs) =>
        {
            PersonListBox.ItemsSource = repoArgs.Result;
        };
    repository.GetPeopleAsync();
}
```

And that's all there is to creating a lambda expression!

But this is actually in a fairly verbose state. Lambda expressions offer us some syntactic sugar that makes them more compact.

Parameter Type Inference

The first of these is something known as "Parameter Type Inference". What this means is that the compiler can figure out the types of our parameters, so we don't have to include them. So this means that we can remove the "`object`" and "`GetPeopleCompletedEventArgs`" from our parameter descriptions:

```
private void RefreshButton_Click(object sender, RoutedEventArgs e)
{
    var repository = new PeopleRepository();
    repository.GetPeopleCompleted += (repoSender, repoArgs) =>
        {
            PersonListBox.ItemsSource = repoArgs.Result;
        };
    repository.GetPeopleAsync();
}
```

The parameters are still strongly typed. If you hover the mouse cursor over "`repoArgs`" you'll see that it is still of type `GetPeopleCompletedEventArgs`.

How does the compiler know this? Well it knows about the `GetPeopleCompleted` event (the event that we are assigning our event handler to). And the compiler also knows what types are required for the at event handler (`object` and `GetPeopleCompletedEventArgs`). Since the compiler can figure this out, we don't have to type it in ourselves.

If we run the application now, we will see exactly the same behavior as with the named delegate and the anonymous delegate. One of the reasons that I like this syntax is that it keeps the functionality together. Ultimately, when we click the button, we want to populate the data in the list box. Using the lambda expression, we keep the callback logic "inside" the button click method. This works fine for simple callbacks. If our callback starts getting larger, then we would probably want to factor it to a separate method for readability. But as we will see in just a bit, this does not mean that we want to give up the lambda expression.

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Syntactic Notes

A couple more syntactic notes:

If there is only one statement, then the curly braces are optional.
In our case, we'll be adding some more code, so we'll leave the braces.

If there is only one parameter, then the parentheses are optional.
Since we have two parameters in this example, we need the parentheses. A bit later, we'll see some examples with a single parameter.

The convention is to use single letter parameter names.
We can name the parameters of our lambda expressions whatever we like. But because of the shortened syntax that lambdas offer, developers commonly give the parameters single letter names. We'll do this in some later examples.

Here's the Cool Part: Captured Variables

We've done a lot of work so far, but ultimately, we end up with the same functionality we had when we started. So, what's the big deal? There's another cool feature of lambda expressions: captured variables. A lambda expression can actually use a variable after it has gone out of scope. How's this possible? Let's take a look at fixing our selection problem.

Problem: when we click the "Refresh" button, the selection goes away. To fix this, we'll save off the selected item from the ListBox before we refresh the data, then after the refresh, we'll locate that item and re-select it. Here's the code:

```
private void RefreshButton_Click(object sender, RoutedEventArgs e)
{
    Person selectedPerson = PersonListBox.SelectedItem as Person;

    var repository = new PeopleRepository();
    repository.GetPeopleCompleted += (repoSender, repoArgs) =>
        {
            PersonListBox.ItemsSource = repoArgs.Result;
            if (selectedPerson != null)
                foreach(Person person in PersonListBox.Items)
                    if (person.FirstName == selectedPerson.FirstName &&
                        person.LastName == selectedPerson.LastName)
                    {
                        PersonListBox.SelectedItem = person;
                    }
        };
    repository.GetPeopleAsync();
}
```

This a fairly straight forward process. First, we save off the currently selected item in the `selectedPerson` variable. Then in our callback, we check to see if the `selectedPerson` variable is

populated. If so, then we loop through the items in the ListBox and try to locate that person (based on the first name and last name properties). If we find a match, then we set the selected item.

But let's think about this for a moment. Here's a timeline of what happens:

1. The Refresh button is clicked in the UI.
2. The Click event fires and the `RefreshButton_Click` method runs
    a. The `selectedPerson` variable is set.
    b. The repository is created.
    c. The `GetPeopleCompleted` event handler is hooked up.
    d. The `GetPeopleAsync` method is called.
    e. The `RefreshButton_Click` method exits.
3. The data is returned from the service and the callback fires.
    a. The result data is assigned to the ListBox.
    b. The SelectedItem of the ListBox is set using the `selectedPerson` variable.

Step 3 runs after the `RefreshButton_Click` method exits, which means that the `selectedPerson` variable goes out of scope. You can check this yourself by setting a breakpoint and stepping through the code. So how does this work?

The lambda expression "captures" the variable. This means that the variable stays in scope even though it normally would be released. What makes this good in our case is that we can use a locally scoped variable. If we were to do this same process with the named delegate (where we started), then we would need a class-level variable to hold our selected value since we would need to reference that value in multiple methods.

This is a great feature, but there is one thing that we need to be aware of. When the captured variable is evaluated in the lambda expression, it contains the value at the time of evaluation, not the time of capture. Let's add a line of code to our click event to see what this means:

```
private void RefreshButton_Click(object sender, RoutedEventArgs e)
{
    Person selectedPerson = PersonListBox.SelectedItem as Person;

    var repository = new PeopleRepository();
    repository.GetPeopleCompleted += (repoSender, repoArgs) =>
        {
            PersonListBox.ItemsSource = repoArgs.Result;
            if (selectedPerson != null)
                foreach(Person person in PersonListBox.Items)
                    if (person.FirstName == selectedPerson.FirstName &&
                        person.LastName == selectedPerson.LastName)
                    {
                        PersonListBox.SelectedItem = person;
                    }
        };
    repository.GetPeopleAsync();
    selectedPerson = null;
}
```

Now, if we run our application, we will see that the selected person is not saved between refreshes (exactly the same behavior we had initially). This is because the value of `selectedPerson` is set to null before the lambda expression body is executed. So, even though `selectedPerson` had a value at the time it was captured (when the `GetPeopleCompleted` handler is assigned), it is null by the time the code is executed.

In this particular instance, we do not need to be concerned about this. But if you are capturing variables that are changing (such as an indexer from a "for" loop), you may find your results are not what you expect.

Note: before continuing, be sure to comment out or remove the line of code that we just added. We want to make sure that we continue to keep our selection as we go forward.

Lambdas and LINQ

Lambda expressions are used extensively in LINQ (Language Integrated Query). LINQ statements can be built with either query syntax or with extension method syntax. The extension methods included in the `System.Linq` namespace extend the `IEnumerable<T>` and `IQueryable<T>` interfaces. The good news is that most collections implement `IEnumerable<T>`.

Expression lambdas are lambda expressions that return a value. These are often used with these LINQ methods. Our UI has a couple of filtering options (by date range and by first name). Let's take a look at implementing these using LINQ. We will be using the `Where` method which has the following signature (from the Help documentation):

```
public static IEnumerable<TSource> Where<TSource>(
    this IEnumerable<TSource> source,
    Func<TSource, bool> predicate
)
```

So what does this mean? First, this is an extension method. We know this from the use of the `this` keyword before the first parameter (`source`). For an overview of extension methods, see *Quick Bytes: Extension Methods* on the website: http://www.jeremybytes.com/Downloads.aspx#QBEM. The second parameter (`predicate`) is listed as a `Func<TSource, bool>`. Func is a pre-defined delegate signature. If you want more details on Func, see *Quick Bytes: Get Func<>-y* on the website: http://www.jeremybytes.com/Downloads.aspx#QBGF. Here, the "`TSource`" denotes the incoming parameter value, and "`bool`" denotes the return value.

So this means that we need to provide a method that takes a `Person` as a parameter (our `TSource` type) and returns a true/false value (`bool`). This signature lends itself to implementation with a lambda expression.

Since our Where statement takes an IEnumerable<T> and returns an IEnumerable<T>, we can easily set up a method to handle our filters. We'll start with the easier of the 2 filters (the first name filter):

```
private IEnumerable<Person> AddFilters(IEnumerable<Person> data)
{
    if (NameFilterCheckBox.IsChecked.Value)
        data = data.Where((Person p) => p.FirstName == NameTextBox.Text);

    return data;
}
```

Our method takes an `IEnumerable<Person>` (`data`) and returns an `IEnumerable<Person>`. In going back to our definition of `Where`, the `source` is `data` (the parameter passed to the method) and the `predicate` is our lambda expression. Since `Where` is an extension method on `IEnumerable<T>`, we can treat it as if it were a method of our `data` object. The `predicate` (our lambda) then becomes the only parameter. The parameter for the lambda expression is "`Person p`"; the type is determined by the type of the collection. The parameter name is up to you. As mentioned earlier, by convention lambda expressions have a single character parameter; I chose "p" for `Person` – our underlying data type.

The body of the lambda expression is a comparison of the `FirstName` property and the contents of our text box. As we noted earlier, we can exclude the parameter type from the declaration since the compiler already knows it. Also, since we only have 1 parameter, we can exclude the parentheses as well. Here's our slightly modified version:

```
private IEnumerable<Person> AddFilters(IEnumerable<Person> data)
{
    if (NameFilterCheckBox.IsChecked.Value)
        data = data.Where(p => p.FirstName == NameTextBox.Text);

    return data;
}
```

A note about the `if` statement: the `NameFilterCheckBox.IsChecked` property is actually a 3-state value (true, false, null/unknown). Because of this, we need to check the `Value` property (which uses false for null/unknown). `if` supports true/false values, but not nulls.

With all of this in mind, let's go ahead and implement the other filter (the date range filter). Our final method looks like this:

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```
private IEnumerable<Person> AddFilters(IEnumerable<Person> data)
{
    int startYear = Int32.Parse(StartDateTextBox.Text);
    int endYear = Int32.Parse(EndDateTextBox.Text);

    if (DateFilterCheckBox.IsChecked.Value)
        data = data
            .Where(p => p.StartDate.Year >= startYear)
            .Where(p => p.StartDate.Year <= endYear);

    if (NameFilterCheckBox.IsChecked.Value)
        data = data.Where(p => p.FirstName == NameTextBox.Text);

    return data;
}
```

The first "`if`" condition checks to see if the `DateFilterCheckBox` is checked and then compares the values for the start and end years. Note the syntax inside the conditional:

```
data = data
    .Where(p => p.StartDate.Year >= startYear)
    .Where(p => p.StartDate.Year <= endYear);
```

The second and third lines are continuations of the first line. This syntax kind of threw me the first time I saw it. But this is the equivalent of this:

```
data = data.Where(…).Where(…);
```

The line breaks get ignored by the compiler. The lambda expressions should look pretty familiar now. Each takes a single parameter ("`p`") which is of type `Person`. The expressions compare the `StartDate` of the Person to the start and end years from the UI. We could also have included a single "`Where`" statement with an "&&" between the conditions. This would actually be a better way to implement this, but I wanted to show that we could use combine multiple `Where` methods together.

This works because most of the LINQ extensions on `IEnumerable<T>` also return an `IEnumerable<T>`. You can keep appending methods together basically piping the result of one method to the parameter of the next. And being able to append multiple `Where` methods is important for the second conditional in our `AddFilters` method (which we saw earlier):

```
data = data.Where(p => p.FirstName == NameTextBox.Text);
```

Note that our `AddFilters` method will work if one, both, or neither of the filters is selected from the UI. If both filters are selected, then the `data` object ends up internally like this:

```
data = data
    .Where(p => p.StartDate.Year >= startYear)
    .Where(p => p.StartDate.Year <= endYear);
    .Where(p => p.FirstName == NameTextBox.Text);
```


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This is more the magic of LINQ than the magic of lambda expressions, but you can see how being able to append multiple where conditions makes this method fairly readable.

Calling the AddFilters Method

The last step to getting our filters to work is to call the `AddFilters` method when we Refresh the data. Here's our updated method:

```
private void RefreshButton_Click(object sender, RoutedEventArgs e)
{
    Person selectedPerson = PersonListBox.SelectedItem as Person;

    var repository = new PeopleRepository();
    repository.GetPeopleCompleted += (repoSender, repoArgs) =>
        {
            PersonListBox.ItemsSource = AddFilters(repoArgs.Result);
            if (selectedPerson != null)
                foreach(Person person in PersonListBox.Items)
                    if (person.FirstName == selectedPerson.FirstName &&
                        person.LastName == selectedPerson.LastName)
                    {
                        PersonListBox.SelectedItem = person;
                    }
        };
    repository.GetPeopleAsync();
    selectedPerson = null;
}
```

We can use the `AddFilters` method like this because it takes an IEnumerable<T> as a parameter and spits out an IEnumerable<T> as a result. This makes the types transparent. Our `repoArgs.Result` implements IEnumerable<T>, so we can use this as our parameter. And the output can be assigned to the `PersonListBox.ItemsSource` property.

In a production application, we probably would not want to implement filters this way. This is just a simplification so that we can see how the filtering with LINQ and lambdas works. One of the problems we would want to avoid in production is the need to refresh the data each time we apply a filter. Instead, we could keep an in-memory copy of the data from our service and then apply the filters as needed, potentially by hooking into the Click or Checked events of the checkboxes. If you want to see a better implementation, check the PeopleViewer.MVVM project.

Now that everything is hooked up, we can include one or both of our filters. Here's what our application looks like if we check both filters with their default values:

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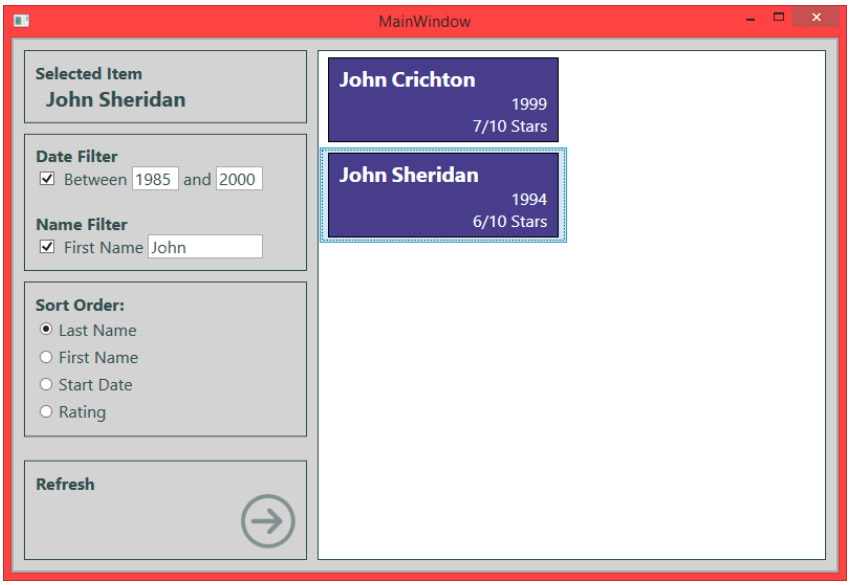

At this point, we can make a selection and experiment with the filters. If you select a person, then include a filter that includes the person, then that person will still be selected after applying the filter. If you select a person that is not included in the filter, then the selection is cleared after applying the filter.

Now that we have filtering, let's look at sorting.

Implementing the Sort Order

For sorting, we'll use some LINQ methods that have a different signature. The most important of these is `OrderBy`:

```
public static IOrderedEnumerable<TSource> OrderBy<TSource, TKey>(
    this IEnumerable<TSource> source,
    Func<TSource, TKey> keySelector
)
```

The first parameter (`source`) is the same as the `Where` method. But the second parameter (`keySelector`) is of type `Func<TSource, TKey>`. To use a lambda expression with this Func, we use the same `TSource` as the incoming parameter value, but return a `TKey` – this will be a property of our `Person` object in our case. Also note that the output is an `IOrderedEnumerable` (instead of `IEnumerable`).

Here's the method signature for our `AddSort`:

```
private IOrderedEnumerable<Person> AddSort(IEnumerable<Person> data)
```

This takes the same `IEnumerable<Person>` parameter (`data`) as we had in our filter method. But notice that the return type is `IOrderedEnumerable<Person>`.

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Here's a simple snippet from the method:

```
if (DateSortButton.IsChecked.Value)
    return data.OrderBy(p => p.StartDate);
```

Our lambda expression is pretty simple. Our one parameter is "p" (of type `Person`), and the body of the lambda is just a property name. This will be the `TKey` and will be sorted using the default comparison method for the data type. For this to be valid, the `TKey` type must implement the `IComparable` interface (and many .NET types do). In our case, `StartDate` is a `DateTime` which does implement `IComparable`. There is also an overload of `OrderBy` that takes a custom `IComparer` if the object does not implement `IComparable` or you want to define a custom method of sorting.

In addition to `OrderBy`, there is `OrderByDescending` (which will order items in descending order – largest to smallest), as well as `ThenBy` (which allows you to include a secondary or tertiary sort). The `ThenBy` method takes an `IOrderedEnumerable<T>`, so it is generally used in conjunction with an `OrderBy`.

With all of these options in mind, here's our final `AddSort` method:

```
private IOrderedEnumerable<Person> AddSort(IEnumerable<Person> data)
{
    if (LastNameSortButton.IsChecked.Value)
        return data.OrderBy(p => p.LastName);

    if (FirstNameSortButton.IsChecked.Value)
        return data.OrderBy(p => p.FirstName).ThenBy(p => p.LastName);

    if (DateSortButton.IsChecked.Value)
        return data.OrderBy(p => p.StartDate);

    if (RatingSortButton.IsChecked.Value)
        return data.OrderByDescending(p => p.Rating);

    return data.OrderBy(p => p.LastName);
}
```

Note: since our sort selection in the UI is made up of radio buttons, only one sort field is selected at a time. This allows us to simply `return` our value.

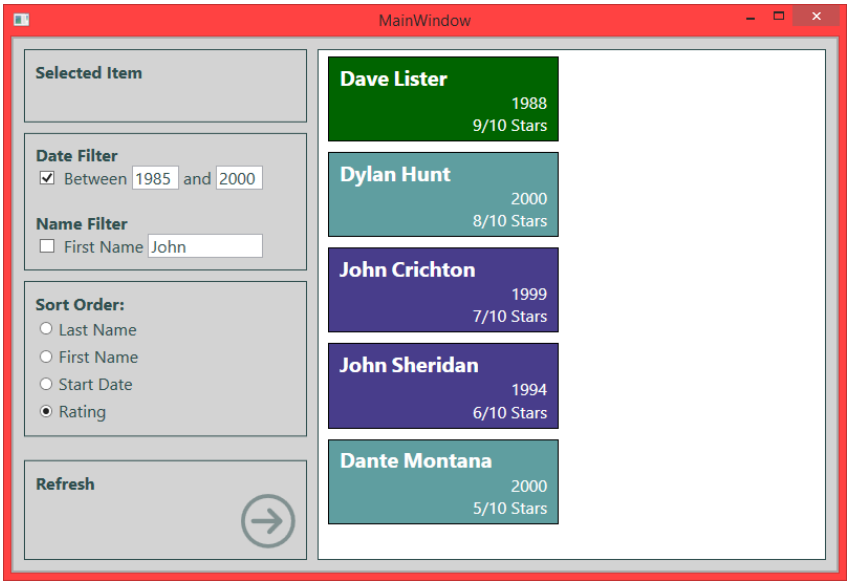
Calling the AddSort Method

The last step is to call the `AddSort` method. We're going to nest our method calls. Here's our assignment to the `PersonListBox.ItemsSource` that is in our callback:

```
repository.GetPeopleCompleted += (repoSender, repoArgs) =>
    {
        PersonListBox.ItemsSource = AddSort(AddFilters(repoArgs.Result));
        if (selectedPerson != null)
            foreach(Person person in PersonListBox.Items)
                if (person.FirstName == selectedPerson.FirstName &&
                    person.LastName == selectedPerson.LastName)
                {
                    PersonListBox.SelectedItem = person;
                }
    };
```

We can nest our `AddSort` and `AddFilters` methods because `AddFilters` returns an `IEnumerable<Person>` and `AddSort` takes an `IEnumerable<Person>` as a parameter. Now we can use any combination of filtering and sorting in our application.

Here's our output:



We've got a filter set ("Between 1985 and 2000") and a sort order ("Rating"). Since the Rating implemented with `OrderByDescending`, the highest rating is on top.

Refactoring a Bit

Now that we're comfortable with lambda expressions and LINQ, let's take a look at refactoring our button click method just a little bit. The problem is with the `foreach` loop that we use to set our selection:

```
            foreach(Person person in PersonListBox.Items)
                if (person.FirstName == selectedPerson.FirstName &&
                    person.LastName == selectedPerson.LastName)
                {
                    PersonListBox.SelectedItem = person;
                }
```

What are we trying to do here? Well, we are trying to set the `SelectedItem` of the List Box to the value of `selectedPerson` (if we can find it in the list). This `foreach` loop seems a little inside-out to me. Our assignment is nested 2 levels deep. And it's not particularly clear what would happen if the value is not found, or even worse, if there are two matching values found. We can use LINQ and lambdas to make this more readable.

For this, we'll use the `SingleOrDefault` method. Here's the signature (from the Help documentation):

```
public static TSource SingleOrDefault<TSource>(
    this IEnumerable<TSource> source,
    Func<TSource, bool> predicate
)
```

You'll notice that this signature is very similar to the Where method that we saw earlier. The parameters (`source` and `predicate`) are the same. The only difference is that it returns a single object (`TSource`) instead of a collection (`IEnumerable<TSource>`).

The `SingleOrDefault` method returns a single value based on a condition (the `predicate`). If there are no values found, then the default value for the type is returned. In our case, we'll be using this with a collection of `Person` objects. If no matching object is found, then a `null` (the "Default") is returned.

Here's our updated implementation:

```
private void RefreshButton_Click(object sender, RoutedEventArgs e)
{
    Person selectedPerson = PersonListBox.SelectedItem as Person;

    var repository = new PeopleRepository();
    repository.GetPeopleCompleted += (repoSender, repoArgs) =>
        {
            PersonListBox.ItemsSource = AddSort(AddFilters(repoArgs.Result));
            if (selectedPerson != null)
                PersonListBox.SelectedItem =
                    PersonListBox.Items.OfType<Person>().SingleOrDefault(
                        p => p.FirstName == selectedPerson.FirstName &&
                             p.LastName == selectedPerson.LastName);
        };
    repository.GetPeopleAsync();
}
```

First we need a `source` for `SingleOrDefault`. This will come from our PersonListBox.Items. This happens to be an `IEnumerable<object>`, so we run the `OfType<Person>` method on it. This has the

effect of casting the results to `IEnumerable<Person>`. This becomes the `source` for `SingleOrDefault`.

The `predicate` is our conditional expression. The parameter for our lambda expression is "`Person p`". The type is `Person` because this is the type of our collection that we're operating on (the `source`).

The body of our lambda expression is a comparison of the `FirstName` and `LastName` properties.

Let's compare our 2 implementations:

```
foreach (Person person in PersonListBox.Items)
    if (person.FirstName == selectedPerson.FirstName &&
        person.LastName == selectedPerson.LastName)
    {
        PersonListBox.SelectedItem = person;
    }

PersonListBox.SelectedItem =
    PersonListBox.Items.OfType<Person>().SingleOrDefault(
        p => p.FirstName == selectedPerson.FirstName &&
             p.LastName == selectedPerson.LastName);
```

These two statements accomplish the same function. But which is more readable? Personally, I like the version with the lambda expression. It's very clear what we are doing in the first line: we are assigning the `SelectedItem` property of the ListBox. In addition, the lambda expression itself makes it clear which element of the "Items" collection we're looking for (assuming that we are comfortable with lambda expression syntax). Finally, since we are using `SingleOrDefault`, we know that we will only get one value back. If there is more than one value matching the predicate, then we will get a runtime error. If there are no matching values, then our `SelectedItem` will be set to null.

Refactoring a Bit More

Earlier I mentioned that we may want to look at factoring out the callback if it gets too complex. Let's look at how we can do that and still keep our lambda expression and the benefits we've seen with the capture variable.

First, we'll highlight the body of the lambda expression (this is just the part between the curly braces, not the parameters or the "=>" operator). Then we right-click, choose "Refactor", then "Extract Method". We can then give it a name like "UpdateUI". Here's the result we end up with:

```
private void RefreshButton_Click(object sender, RoutedEventArgs e)
{
    Person selectedPerson = PersonListBox.SelectedItem as Person;

    var repository = new PeopleRepository();
    repository.GetPeopleCompleted += (repoSender, repoArgs) =>
        {
            UpdateUI(selectedPerson, repoArgs);
        };
    repository.GetPeopleAsync();
    //selectedPerson = null;
}

private void UpdateUI(Person selectedPerson, GetPeopleCompletedEventArgs repoArgs)
{
    PersonListBox.ItemsSource = AddSort(AddFilters(repoArgs.Result));
    if (selectedPerson != null)
        PersonListBox.SelectedItem =
            PersonListBox.Items.OfType<Person>().SingleOrDefault(
                p => p.FirstName == selectedPerson.FirstName &&
                     p.LastName == selectedPerson.LastName);
}
```

Notice that Visual Studio was helpful enough to include the `selectedPerson` and `repoArgs` as parameters when it extracted the method. This means that we maintain a reference to our captured variable, and our separate method simply references it through the parameter that is passed in. So, we lose the benefit of keeping everything together in the click method (that was mentioned above), but we still manage to keep the "flow" of the process together. As with all things in programming, most of the time we are finding the balance between readability and maintainability. And it usually makes sense to extract methods when they reach a certain level of complexity.

Why I Love Lambdas

We've taken a look at using lambda expressions in some useful ways. Based on what we've done, here's why I have become a huge fan of lambdas.

No Explicit Parameter Types Needed

Since the compiler can figure out the parameter types, there is no need to explicitly state them. This is especially useful when you are implementing an unfamiliar event handler. I know that there is a "sender", but sometimes I don't know the specific EventArgs type that I need to use. This way, I can just name the parameter and let the compiler figure out the specific type.

Implementation Code Near the Calling Code

In our initial callback implementation with the named delegate, the callback method (`GetPeopleCompleted`) is separated from the initial call (`GetPeopleAsync`). I like how the lambda expression keeps the callback implementation near the initiating call. And even if we end up factoring out complex methods, we still keep the "flow" together.

Captured Variables

We saw how useful captured variables are when saving off and restoring a selected item in our list. I like the idea of using a locally-scoped variable as opposed to a class-level variable. This follows the best practice of limiting your variable exposure.

Readability

Once I got used to reading lambda expressions, I found them to be more understandable in most situations. We saw this above when we converted our "SelectedItem" assignment from a foreach loop to a LINQ method with a lambda expression.

Easy Implementation of Func<T> and Action<T>

As we saw when looking at the LINQ methods, Func<T> and Action<T> (and their variants) are used as pre-defined delegates. These were made to be implemented with lambda expressions. It is possible to create a named delegate based on Func<T>, but it is very unusual.

Wrap Up

So, lambda expressions are extremely useful in a variety of situations. We only looked at a couple here (a callback handler plus some LINQ methods), but there are many others. We have seen that lambda expressions are simply anonymous delegates. With this understanding in hand, lambdas become very readable and easy to use – a great addition to your developer toolbox.

Happy coding!