



Hands-On Lab

Lab Manual

ILL-061 Creating and Using Generics in the .NET Framework 2.0

Please do not remove this manual from the lab
The lab manual will be available from CommNet

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Lab 1: Generics Lab

Exercise 1 –Generic Stack

In this exercise, you will develop a generic stack, and experience the benefits of generics.

Task 1 – Develop a Generic Stack

Open the *Generics.sln* solution in the Generics lab folder. The solution is a simple console application that uses a stack. Open the *ObjectStack.cs* file. It contains an object-based stack:

```
public class Stack
{
    readonly int m_Size;
    int m_StackPointer = 0;
    object[] m_Items;
    public Stack():this(100)
    {}
    public Stack(int size)
    {
        m_Size = size;
        m_Items = new object[m_Size];
    }
    public void Push(object item)
    {
        if(m_StackPointer >= m_Size)
            throw new StackOverflowException();
        m_Items[m_StackPointer] = item;
        m_StackPointer++;
    }
    public object Pop()
    {
        m_StackPointer--;
        if(m_StackPointer >= 0)
        {
            return m_Items[m_StackPointer];
        }
        else
        {
            m_StackPointer = 0;
            throw new InvalidOperationException("Cannot pop an empty stack");
        }
    }
}
```

The `Main()` method uses the object-based stack:

```
static void Main(string[] args)
{
    Stack stack = new Stack();
    stack.Push(1);
    stack.Push(2);
    int number = (int)stack.Pop();
    Debug.Assert(number == 2);
    Console.WriteLine(number);
    Console.ReadLine();
}
```

Modify the object-based stack to a generic stack. First, save the file under the name *GenericStack.cs*. Next, change the object-based stack to a generic stack, by adding <T> to the class definition, and by replacing the use of an object with a type parameter T:

```
public class Stack<T>
{
    readonly int m_Size;
    int m_StackPointer = 0;
    T[] m_Items;
    public Stack():this(100)
    {}
    public Stack(int size)
    {
        m_Size = size;
        m_Items = new T[m_Size];
    }
    public void Push(T item)
    {
        if(m_StackPointer >= m_Size)
            throw new StackOverflowException();
        m_Items[m_StackPointer] = item;
        m_StackPointer++;
    }
    public T Pop()
    {
        m_StackPointer--;
        if(m_StackPointer >= 0)
        {
            return m_Items[m_StackPointer];
        }
        else
        {
            m_StackPointer = 0;
            throw new InvalidOperationException("Cannot pop an empty stack");
        }
    }
}
```

Modify the Main () method to use the generic stack:

```
static void Main(string[] args)
{
    Stack<int> stack = new Stack<int>();
    stack.Push(1);
    stack.Push(2);
    int number = stack.Pop();
    Debug.Assert(number == 2);
}
```

Build and test to make sure all is well. Try using Stack<T> with integers and strings, to experience first-hand the productivity benefits of generics.

Task 2 – Testing the Generic Stack

Next, you will test the performance advantage of the generic stack you built in the previous step. Open the solution *GenericsPerfs.sln*. The solution is a micro-benchmark application, which you will use to execute a stack in a tight loop. It will let you experiment with value and reference types on an Object-based stack and a generic stack, as well as changing the number of loop iterations to see the effect generics have on performance.

Copy the files *ObjectStack.cs* and *GenericStack.cs* to the GenericsPerfs solution folder by adding the files to the project: right-click on the GenericsPerfs solution in Microsoft® Visual Studio® 2005, and select Add|Add Existing Item... to add *ObjectStack.cs* and *GenericStack.cs* to the solution. Build the solution to make sure they were added properly. The performance tester uses a delegate to invoke different tests, using the delegate *TestMethod*, defined as:

```
delegate void TestMethod();
```

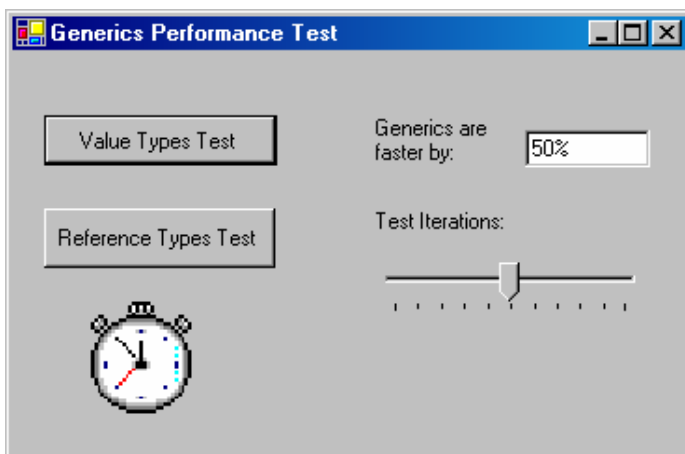
The test routine *GetTestTime()* uses the *Stopwatch* class to measure the test time. It invokes the delegate, and returns the test duration in milliseconds:

```
long GetTestTime(TestMethod testMethod)
{
    Stopwatch stopper = new Stopwatch();

    stopper.Start();
    testMethod();
    stopper.Stop();

    return stopper.ElapsedMilliseconds;
}
```

The test client is the Microsoft Windows® Forms class *TestClient*. It has two buttons, allowing you to test value and reference types, as well as controlling the number of test iterations:



The method `OnValueTest()` handles the click event for the Value Type Test button. It calls `GetTestTime()`, invoking it once with the object-based stack (via the `TestValueBoxed()` method) and once with the generic stack, (via the `TestValueGeneric()` method):

```
void OnValueTest(object sender,EventArgs e)
{
    float boxedTime = GetTestTime(TestValueBoxed);
    float genericTime = GetTestTime(TestValueGeneric);

    float perf = 100 * (1-(genericTime / boxedTime));

    m_TextResultBox.Text = Math.Round(perf) + "%";
}
```

`OnValueTest()` then calculates the difference in performance and updates the display.

In a similar manner, the `OnReferenceTest()` method handles the Click event for the Reference Type Test button, using reference types:

```
void OnReferenceTest(object sender,EventArgs e)
{
    float boxedTime = GetTestTime(TestReference);
    float genericTime = GetTestTime(TestReferenceGeneric);

    float perf = 100 * (1-(genericTime / boxedTime));

    m_TextResultBox.Text = Math.Round(perf) + "%";
}
```

Next, you need to add the code for the actual four test methods. Add the following code to the test methods:

```
void TestValueBoxed()
{
    Stack stack = new Stack();

    long temp = 0;
    long iteration = Count * m_IterationBar.Value;

    for(long i = 0;i < iteration;i ++)
    {
        stack.Push(i);
        temp = (long)stack.Pop();
    }
}
```

```

void TestValueGeneric()
{
    Stack<long> stack = new Stack<long>();

    long temp = 0;
    long iteration = Count * m_IterationBar.Value;

    for(long i = 0;i < iteration;i ++)
    {
        stack.Push(i);
        temp = stack.Pop();
    }
}
void TestReference()
{
    Stack stack = new Stack();

    string temp = String.Empty;
    long iteration = Count * m_IterationBar.Value;

    for(long i = 0;i < iteration;i ++)
    {
        stack.Push("AAAAA");
        temp = (string)stack.Pop();
    }
}
void TestReferenceGeneric()
{
    Stack<string> stack = new Stack<string>();

    string temp = String.Empty;
    long iteration = Count * m_IterationBar.Value;

    for(long i = 0;i < iteration;i ++)
    {
        stack.Push("AAAAA");
        temp = stack.Pop();
    }
}

```

Build and run the performance test client. Experiment with different number of test iteration to see the effect of generics both on value types (about 50% performance improvement) and on reference types (10% performance improvement).

Resources:

[An Introduction to C# Generics](#)

By Juval Lowy, MSDN® November 2003, Updated January 2005

[Generics FAQ](#)

By Juval Lowy, MSDN June 2005

[Programming .NET Components 2nd Edition](#)

By Juval Lowy, O'Reilly 2005

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