

Attacking .Net at Runtime

By

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Abstract

This paper will introduce a high level attack that can control a live .NET program. This attack is a payload to be deployed after opening a backdoor inside of a target .NET application. Also basic information on delivery methods is included.

This paper has a C# implementation of this attack: DotNetSpike

Introduction

This attack can navigate and control a live program by using the rules of the Runtime system to control other .NET applications. Some rules can be bent, other can be broken. Once access to another program's Runtime is gained almost absolute control is at hand. Most every aspect from Objects to Events can be accessed, and most of the time modified. This allows for simple attacks like changing an Object's values or calling functionality; and more complex attacks like introducing or changing the basic logic of the target can be done with ease.

With this level of control the target can be forced to divulge protected information, carry out different functionality and send corrupted signals. This attack will also allow for accessing the code base and Object structure live. This platform can allow an attack to be developed and implemented in a matter of minutes or hours.

Once inside of the target program the necessary references can be established, and the full power of .NET can be used. After you have all the "keys" it can be a matter of changing one variable or introducing one line of code to subvert a program's logic.

Access Live .NET Program

The first step is to establish a connection inside of your target's Runtime; this is done in a number of ways. This can range from compromising the .NET Framework¹ to exploiting a glitch in a specific application. Each method of accessing another application's Runtime has a different impact on stability, foot print and security alerts. Also the method you pick will change what references you get to start with and what if any constraints you would have.

The method of access used in this paper is injection by the Windows OS. This method is platform dependent as well as highly detectable by Anti-Virus programs, and starts with no references. However, this method has a fast development cycle.

The security constraints come into play at this point. Is the target a weak program running on your system? Can it be attacked, dissected and restarted a million times? Or perhaps it is a heavily secured program on a server some ware that you only get one chance to compromise and have to make up the attack as you go. Depending on the environment and the goal you would select the delivery method that best fit.

No matter what you chose as an entry method the end effect is to create a way of gaining access to your targets Objects, Appdomain and code base. All this so the logic and values in a program can be accessed or manipulated.

This paper has a demo implementation of injection into a .NET application: Injector this is a C# program, with C++ unit, that will inject .NET application running on Microsoft Windows compatible with both 32 bit and 64 bit.

1 .NET Framework Rootkits By Erez Metul - at <http://www.applicationsecurity.co.il/english/NETFrameworkRootkits/tabid/161/Default.aspx>

Controlling the Runtime

After you are inside of your target's Runtime it is necessary to get a reference to your target Object(s). This is the weakest part of the attack as you have none of the keys, but luckily you also have no doors. So how do you get to an Object if you don't have any references? Luckily most programs have a GUI and the OS can retrieve a reference to this Object. In addition looking for other types of Objects like global variables can be an easy source of references.

After establishing a reference to an Object inside of the target's Runtime it can be leveraged to gain more references to other Objects. Depending on the layout of your target application and the manner of entry, it will take more or less work to get references and implement the necessary changes. As each Object is traversed the code for each function can be easily accessed. This along with clean readable code naming can make for an intuitive attack.

Say you wish to attack the GUI on a target program. Start out by asking the Windows OS about your target's GUI window handles (using an on screen location or PID) and use that information to build a Reference to the GUI Object. This GUI Object will be inside of your target's Runtime, and as such can now be accessed and controlled. Once this reference is created it can be used to find references to other Objects. Iterating over all the Form's child controls and their Event's can gain a far number of references. Perhaps you find a key Object of the application such as a timer or SQL connection that can be leveraged to affect the system.

Anything from changing a variable to invoking functionality can be implemented at this point. Objects can with some skill and effort be replaced live. This allows the attackers to change the core logic granting a god mode of sorts.

What is an Object at Runtime

Objects can be asked what Type they are, and what they implement. This in turn gives a Class list, on complex Objects this can be a few levels of inheritance and interfaces.

Once you know what Class an Object can be referenced as, the Class can be queried as to what functions it implements and what variables it contains. With this information, it is possible to access constructors, Events, variables, and properties. This allows an Object to be manipulated and controlled.

GUI

The Graphical User Interface(GUI) also known as a Form is a key part of most programs, and is an easy entry point for this attack. Using the Windows OS to get a reference to the GUI Objects will get you a good foothold into the heart of the program. After establishing a reference to the main GUI, a reference to each child control is easily accessed, and in turn will lead to most of the core Objects in the program.

A good place to start looking for references is in variables or Event lists. Take a Button on the main Form, assuming good N-Tier design, the Button will have a Click Event connected to some business logic deep in the program.

Your target could be the GUI it self, perhaps you need to access to a Check Box or wish to override the functionality of a Text Box. This is done with ease as the GUI Controls are Objects subject to the same modification and influences as any other Object. However, the GUI imposes an extra constraint of thread safety. Anytime you modify a GUI Control you must do it from a parent thread. To satisfy this you can move your execution point inside of a parent thread or call Invoke on a parent Object.

Events

Events are a key aspect of the logic flow to most programs today as well as a probable link to functionality and references. Events are an Object and as such can be controlled.

The basic idea of the Event is to execute a list of function calls. This can be used to gain a reference to an Object. For instance, you could find a timer that is the heart beat for the programs with a number of Objects connected directly to the Timer's Elapsed Event. Each entry in the Event list is a connection to a function that could lead to a reference.

A fair amount of key logic is connected to Events, such as, on a Button, Text Box , or Timer. This logic will (most of the time) be on key Objects. This can be used as a shortcut to get to the logic and Object you would like to control. Events can also be a good place to find references.

Accessing Source Code

The raw structure is maintained in IL, for example x passed into FOO(int varIN) is

```
0002 : ldarg.0
0003 : ldfld int App.Form1::x
0008 : call instance System.Void App.Form1::foo()
```

Assuming that the code is well written and not obfuscated we can move between Objects in an application with confidence. If we can see well-named variables and functionality it is no harder then working on someone else's code. If we do not have well-named Objects it can slow the process down, but with a good understanding of the basic functionality it would most likely only take a few(10-60) minutes to reconstruct a small peace of strongly obfuscated logic(code).

Dynamic function can be created and destroyed at Runtime, giving a nice path for incorporation of new logic. This logic can also be unloaded in an attempt to hide the foot print of this attack.

As for the language the target program is written in, it makes little difference to this attack. Because it should be expected that the code will be obfuscated and thus cannot be reversed (fully) to any wrapper language. So IL should be chosen as the primary language for long term work in this area.

Legitimate uses

This level of control over other applications has some powerful legitimate uses as well. This can be used to extend a program or implement a system wide upgrade.

With this it is possible to extend or reuse another application in new and different ways. It is also possible to combine other applications to form a new system, taking them far beyond the original purposes.

Conclusion: Going in Blind

If you are going up against an unknown program at Runtime you have to work in it's world, but you can bring your tools. If you have compromised the OS or Framework it will tip the balance of power in your favor, if the target has other programs or security setup to protect itself, the attack will be that much harder. Once a suitable way into the target is found the tactics of this attack should work the same.

Running the attack a few times to see the flow of the program can give insight into the target's design and infrastructure. Also if possible dissecting the target can reveal a fair amount and help in developing the attack. This dissection would be at non-Runtime and can be useful or necessary, but is not an area of focus for this paper.

The real strength of this attack is in how fast and easy it is to adapt and control a running program. The tools used are in the core of .NET, and for the most part, are in every version and as such should apply to any app.

Tools and rules of the Runtime:

Objects are derived from and instantiated by classes, and must be referenced by a chain of execution. This links every Object together in a predictable way.

A **Class** has a list of variables and functions that can be accessed (both public & private). This can be used to learn about an Object and it's connects, or to control and manipulate it.

The **code** is in IL (most of the time) and can be examined, but cannot be edited (this rule can be broken). The code is solid but the logic can be manipulated. This will allow the behavior of the program to be controlled as the attacker wishes.

A **reference** is needed in order to access an Object (this rule can be bent). It is easy to get around inside of a program to find the references you need, as most everything is connected. Additionally some references can be created from information.

Reflection is a complex topic, so in short, allows for information to be gathered about an Object. The long version would be, it is the part of .NET that allows for introspection of Objects, where do they come from, what are they made of, how can they be accessed, and what they will do. This is a key tool to understand for this attack but in order to cover this would take a paper in itself. *If you would like to find out more about reflection and how it works at the code level check out my paper: Reflection's Hidden Power*

Background & Basics of .NET

The .NET framework is an open standard implemented on a number of different platforms². .NET has the largest developer community ever, with a cross platform portability never before seen; surpassing the last generation of languages such as C++ and JAVA.

.NET runs on Intermediate Language(IL) code, this can be thought of as a meta language. Most people code in a wrapper language such as C#, VB.Net, MC++..... and more are created each year. The wrapper language allows programmers to work on a platform resembling the language they are accustomed to.

IL is the code that runs inside of .NET, it is code generated from compilation and processing of a wrapper language. IL is a base set of commands that strongly resembles assembly code. Every command in a wrapper language is converted into its component IL command(s). This is in turn converted at some later point on a user's computer to machine code for a specific hardware set.

.NET is a framework consisting of a Common Language Infrastructure(CLI) that houses the Common Language Runtime(CLR). The CLR is a virtual machine at the heart of .NET; it is commonly known as the .NET Runtime or just the Runtime. The Runtime is what most people think of as the core of .NET as it manages the Just-in-Time(JIT) compiler, threads, IO, garbage collector and more. The Runtime is predominantly what the attack in this paper is exploiting.

2 .NET is supported on - Linux, FreeBSD, OpenBSD, NetBSD, Microsoft Windows, Solaris, OS X, ARM, MIPS, iPhone, Nokia, Blackberry, Windows Mobile, Web and more.

References and Influences

James Devlin

www.codingthewheel.com

Sorin Serban

www.sorin.serbans.net/blog/

Erez Metula

paper: .NET reverse engineering
& .NET Framework Rootkits

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