September 9th, 2010

Runtime Hardening

Hardening the runtime internals

Erez Metula | Founder
Application Security Expert

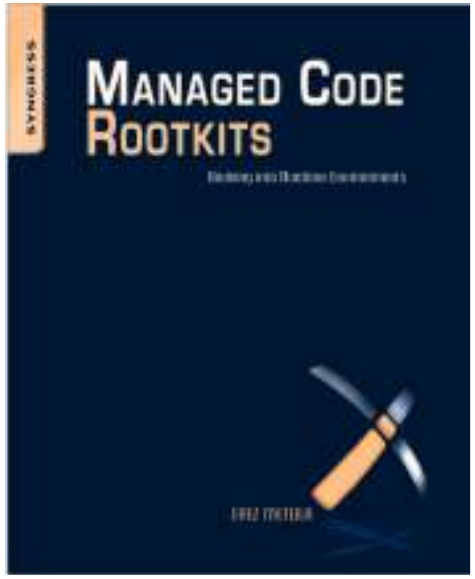
ErezMetula@AppSec.co.il

Agenda

- Background – Managed Code Rootkits (MCR)
- Customizing VM Runtime Frameworks
- ReFrameworker V1.0
- Disabling Dangerous Methods and Operations
- DEMOS!

Background

- I started playing with the idea of Managed Code language modification back in late 2008
  - It all began with the whitepaper " .NET Framework Rootkits – Backdoors inside your Framework"
- Extended the concept from .NET to other managed code frameworks – Java, Android Dalvik, Adobe AVM, etc..
  - Presented in BlackHat, Defcon, CanSecWest, RSA, OWASP, etc..
- The book is coming out soon
  - Published by Syngress
  - Covering information gathered while researching MCR
  - Covers MCR deployment and attack vector techniques



AppSec
Securing Your Applications

Reminder - What are MCR (Managed Code Rootkits)?

- Changing a framework's runtime internals
  - Implementation Code, Methods (Functions), Default values, Instructions, Event handlers, etc.
- Changing the Runtime influences the execution flow of applications depending on it
  - Creating an "alternate reality" for applications
  - Change the "matrix" in which they live in

- The MCR code runs as part of the managed code VM, acting as "root"

AppSec
Securing Your Applications

Example - class libraries manipulation

Application


```
static void Main(string[] args)
    {   //DO SOMETHING
        //EXAMPLE: call RuntimeMethod

        RuntimeMethod();
    }
```

Runtime Class Libraries

```
public void RuntimeMethod ()
{   //The implementation of RuntimeMethod ()

    //Implementation code
    //…..
}
```

OS APIs and services

The good news – A hardened VM Runtime

- The same “rootkit like” techniques used by malware can be used by legitimate software for better protection
  - Many AV uses rootkit techniques to protect themselves
- It can be used to create “Hardened VM Framework”, to protect against application level vulnerabilities
  - But without touching the applications themselves
- Removing dangerous functionality
- Create a set of restriction rules
  - Protecting from errors caused by developers
  - Can be used to enforce secure coding practices
- ReFrameworker can be used as a tool that <u>implements</u> such restriction

AppSec
Securing Your Applications

Create your own customized hardened framework

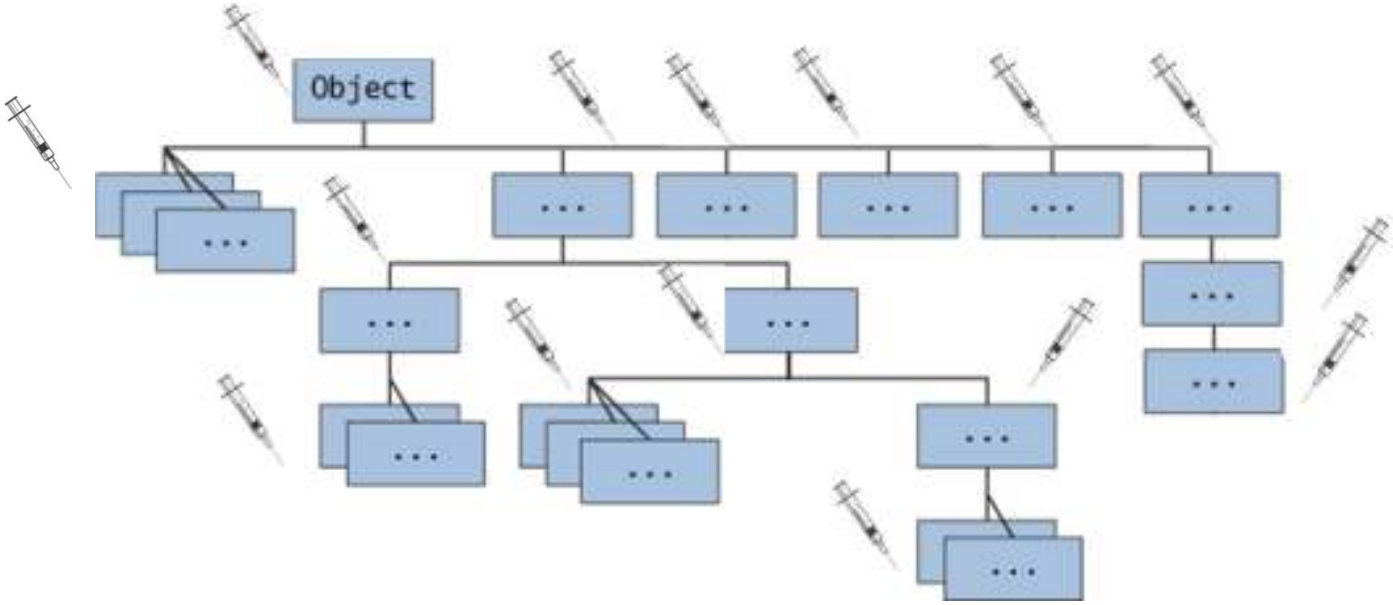
- Code that runs on the hardened VM must obey specific rules
- The VM is fixated to use secure defaults, while disabling the rest
- Some examples
  - Disable dangerous mechanisms
    - Example - Disable dynamic SQL queries leading to SQL Injection
  - Perform automatic HTML encoding (XSS mitigation)
  - Confuse banner grabbing techniques
    - Example - Make a Java app to look like a .NET app
  - Disable detailed error messages
  - Allow only secure crypto algorithms and operations
    - Example - Remove the ability to use DES, Remove ECB mode, etc..
  - Enforce secure authentication modes
    - Example - Encryption in Basic authentication, forms authentication, etc..

Intervention strategies

- Completely remove the code, eliminating its existence for good.
  - The problem with this approach is that removing the offending code might break references in other sections of the code
- Throw an exception
  - Requires less effort, adding small pieces of code to the method while leaving the rest of the method as is
  - Allows us to attach an error message to the exception
- Delay the method invocation
- Halt the application (example: perform an endless loop)
- Reboot the machine (in case identifying a severe event)

Attaching into the “Object” class

- All classes automatically extend the class “Object”
- Object contains generic code that is shared among all the other objects
- Injecting a new method to “Object” class will influence ALL existing classes



AppSec
Securing Your Applications

Automating the process with ReFrameworker V1.1

- Things were getting very complicated to implement
- I needed a **general purpose Framework modification tool**
- So I wrote one and called it ReFrameworker
  - Originally called ".NET-Sploit".
- Able to perform all previous steps
  - Extract target binary from the Framework
  - Inject code and perform required modifications
  - Generate deployers to be used on target machine
- Easy to extend by adding new code modules

ReFrameworker module concept

- Generic modules concept
  - Payload – injected code
  - Method – a new method
  - Class – a new class
  - Reference – external DLL reference
  - Item – injection descriptor
- Comes with a set of predefined modules
  - Most of the scenarios have a PoC using ReFrameworker
  - List of included items (partial list):
    - HideFile.item
    - HideProcess.item
    - Conditional Reverse shell.item
    - DNS_Hostname_Fixation.item
    - Backdoor forms authentication with magic password.item
    - Send Heart Bit method execution signal to remote attacker.item

Item example (simplified)

```
<Item name="Reverse Shell">
    <Description>open reverse shell to attacker.com at port 1234</Description>

    <BinaryName> mscorlib.dll </BinaryName>
    <BinaryLocation>c:\WINDOWS\assembly\GAC_32\mscorlib\2.0.0.0__b77
    a5c561934e089 </BinaryLocation>

    <Payload>
        <FileName> ReverseShell.payload.il</FileName>
        <Location>
            <![CDATA[void_Run(Form) cil managed ]]>
        </Location>
    </Payload >
</Item>
```

Target

Location

Injected Code

Hooking point

Disabling Dangerous Methods and Operations

- It would be great if we could disable specific runtime functionality that is considered insecure.
- We could remove such functionality entirely from the runtime
- Preventing developers from using it from the first place
  - Eliminate the path toward a possible mistake by disabling the ability to use a feature that might cause the mistake
- Examples
  - Usage of dynamic SQL queries leading to SQL injection
  - Insecure cryptography algorithms and encryption modes
  - Inherently insecure authentication modes such as Basic authentication

SOME EXAMPLES

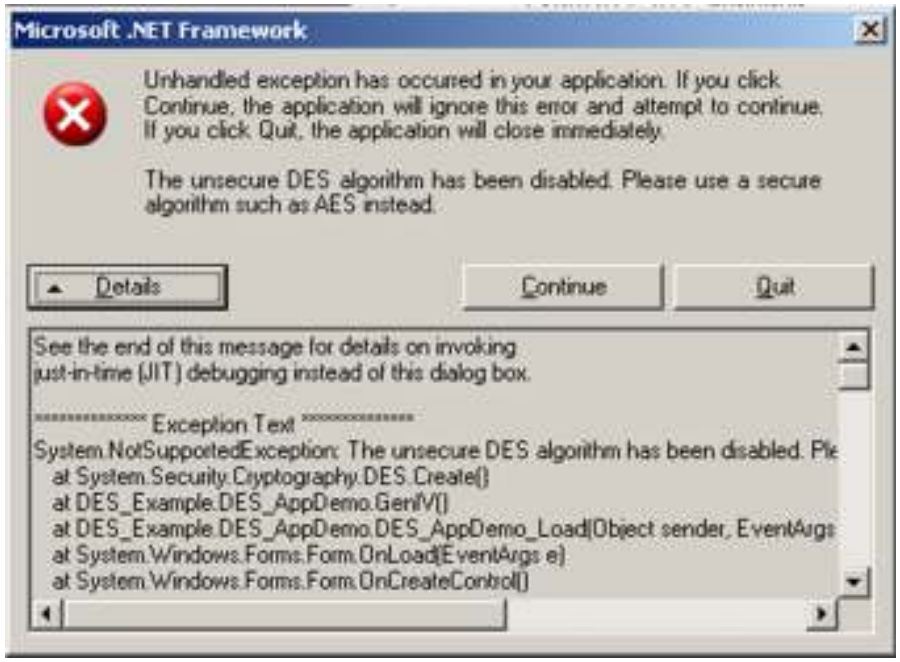
AppSec
Securing Your Applications

Disabling bad crypto modes

- Bad crypto is sometimes worse than not doing crypto at all
  - False sense of security
- Examples:
  - Bad crypto algo
  - Bad crypto modes

Original image

Encrypted (AES, ECB mode)



DEMO:

DISABLING THE USAGE OF UNSECURE DES ALGORYTHM

AppSec
Securing Your Applications

Reporting specific events

- The injected method “SendToUrl(string url, string data)" is used to transfer information to the defender’s collector page
- Report specific security events
  - Login
  - Logout
  - Detected attacks
  - Runtime exceptions
  - Connection to external resources (example: DB)
  - Etc..
- When such information is detected, it is sent to the collector mechanism

AppSec
Securing Your Applications

Protecting specific files

- Manipulate the machine-wide method responsible for providing a list of files in a given directory
  - " File[] GetFiles()" in .NET
  - "File[] listFiles()" in Dalvik and Java
- Our code controls specific files from the returned array
  - Example: Hide the existence of "SensitiveFile.txt"
- Can also be used to
  - Create false information about non-existing files
  - Redirect the content of other files
  - Create "locked", read only files
  - Etc..

AppSec
Securing Your Applications

DNS manipulation

- Manipulating DNS queries / responses
- Example
  - Fixate the runtime DNS resolver to return a specific IP address, a control point performing content filtering by the defender
    - Dns::GetHostAddresses(string host) (.NET)
    - InetAddress::getByName(string host) (Java)
  - All communication will be directed to us
  - Can also be used to ban specific addresses
  - Etc..
- Affects **ALL** network API methods

AppSec
Securing Your Applications

Enforcing secure coding policy

- Organizations often creates a secure coding policy stating rules developers must follow when writing code.
  - It would probably list prohibited classes or methods, dictate how certain things should be implemented, and so on.
- Who makes sure the developers follow the document's instructions?
- Runtime patching can be a low-level technique to implement such a policy, while making sure no one changes the policy
  - The policy is hard-coded into the runtime

```
Successfully connected to the Database.

Trying to execute a dynamic SQL query using the Statement class...

java.lang.Exception: The Statement class is prune to Sql Injection therefore not
 supported by this hardened Java Runtime. Please use the PreparedStatement class
 instead.
        at com.microsoft.jdbc.base.BaseStatement.<init>(BaseStatement.j)
        at com.microsoft.jdbc.base.BaseConnection.createStatement(Unknown Source
)
        at com.microsoft.jdbc.base.BaseConnection.createStatement(Unknown Source
)
        at Test.<init>(Test.java:53)
        at Test.main(Test.java:94)
```

DEMO:

PREVENTING SQL INJECTION BY BANNING DYNAMIC SQL QUERIES

AppSec
Securing Your Applications

Masking the web application technology using runtime camouflaging

- Information gathering is a crucial step for the attacker in terms of determining his next steps
  - It also affects the tools and techniques that will soon be utilized.
- Let's subvert him by planting false information to mask the real identity of the underlying app technology
  - AKA "anti banner grabbing for the application level"
  - It will not stop the attacker, but it will confuse him and his tools.
- Confuse information gathering techniques by making an app to look like it was developed by another technology

Example – making a .NET app look like a Java app

- Adding jsp extension and handler to web.config

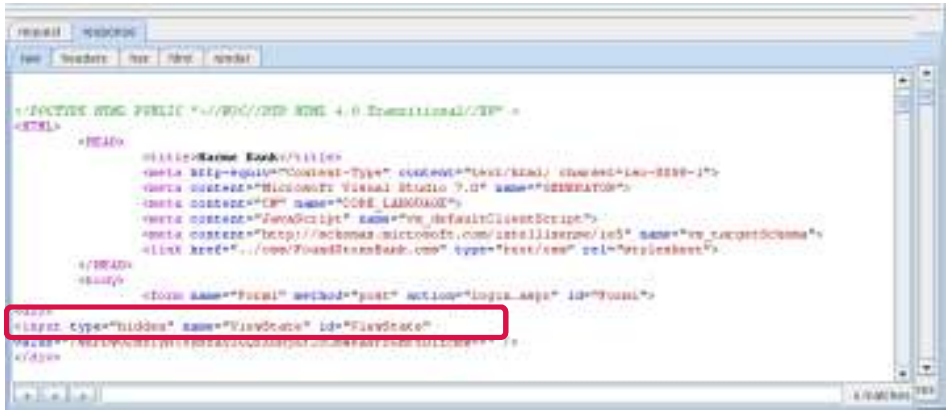
```
<buildProviders>
<add extension=".jsp" type="System.Web.Compilation.PageBuildProvider"/>
</buildProviders>

<httpHandlers>
<add verb="*" path="*.jsp" type="System.Web.UI.PageHandlerFactory"/>
</httpHandlers>
```

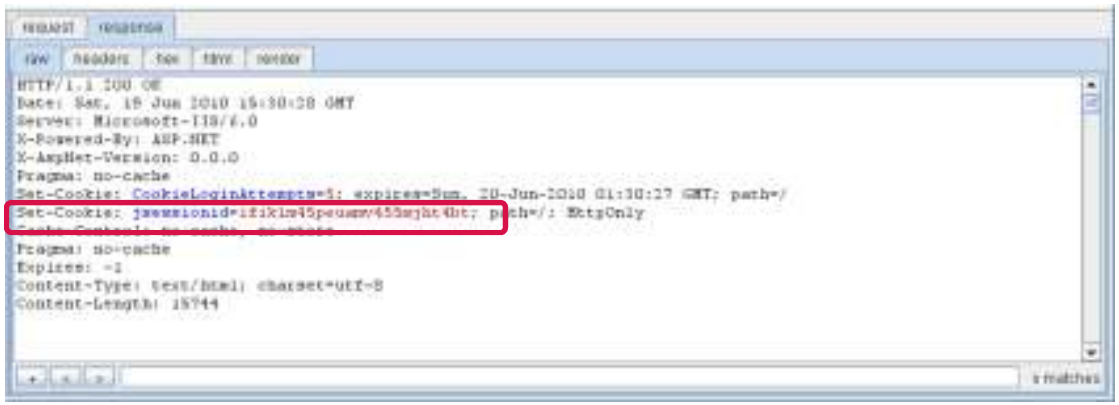
- Adding jsp extension to IIS

Camouflaging deeper at into the application level

- Making View state



- Session id



- And so on..

AppSec
Securing Your Applications

DEMO:

RUNTIME CAMOUFLAGING (.NET -> JAVA)

AppSec
Securing Your Applications

Summary

- Malicious code can be hidden inside an application VM
- We as the good guys can embrace similar techniques to harden the runtime
  - Harden the Framework from the inside
  - Disabling Dangerous Methods and Operations
- Each framework has its own modification technique
  - The concept stays the same
- ReFrameworker simplifies Runtime modifications
  - Lot's of other PoC examples. Look at the modules code

Questions ?

Thank you !

Materials (code, tool, PoC, etc.) can be found here:
http://www.AppSec.co.il

And here (soon):

Feel free to contact me:
ErezMetula@AppSec.co.il

AppSec
Securing Your Applications