Hijacking Arbitrary .NET Application Control Flow

Topher Timzen

#whoami

Security Researcher, Intel

Security Trainer

TopherTimzen.com

@TTimzen

Overview

- Runtime Attacks
- Modify Control Flow
- Machine Code Editing

DEF CON

Why are we Here?

Tools Released

Use .NET as a pivot to attack

Using Objects on the Heap

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CLR Attacks

Controlling the Common Language Runtime

Accessing raw objects on Managed Heap

Manipulate AppDomains

- Controlling all Loaded Code
- Controlling Just-In-Time Compilation

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Attack With ASM

Manipulate Resources

Attack methods at ASM level

Alter application control flow

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Runtime

- .NET Process
  - CLR (2.0/4.0)
    - Assemblies
      - Objects
        - Properties
        - Fields
        - Instance Methods
      - Classes
        - Methods
        - Logic

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Demo

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The Tools

Gray Frost
&
Gray Storm

Gray Frost

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Gray Frost

- Payload delivery system
- C++ .NET CLR Bootstrapper
  - Creates or injects 4.0 runtime
  - Capability to pivot into 2.0 runtime
  - Contains raw payload
- 2 Rounds
  - ✦GrayFrostCpp
  - ✦GrayFrostCSharp
    - C# Payload

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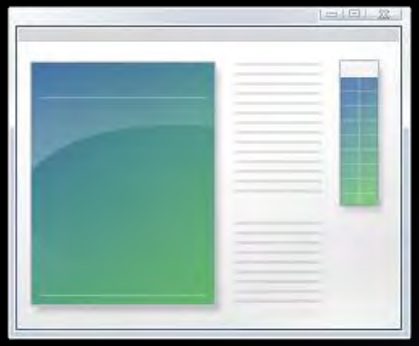
Round 1

.NET Process



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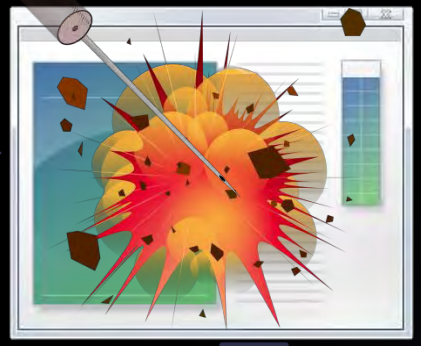
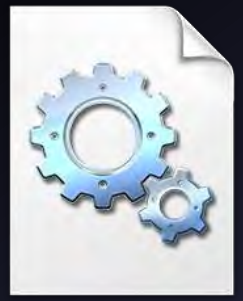
Round 1

GrayFrostCpp



Mscoree



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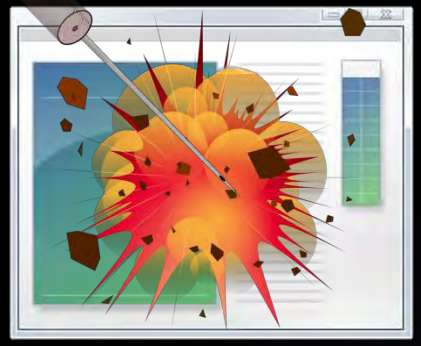
Round 1

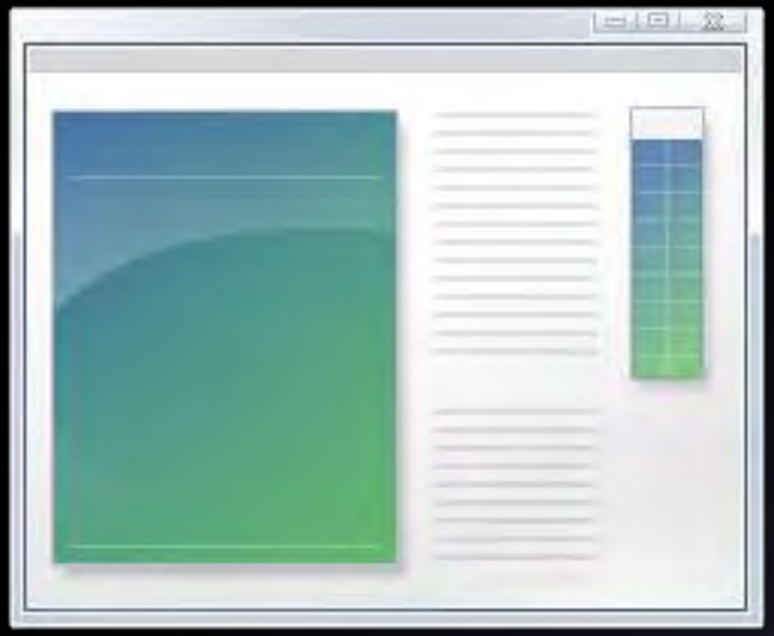
GrayFrostCpp



GrayFrostCSharp

Round 2

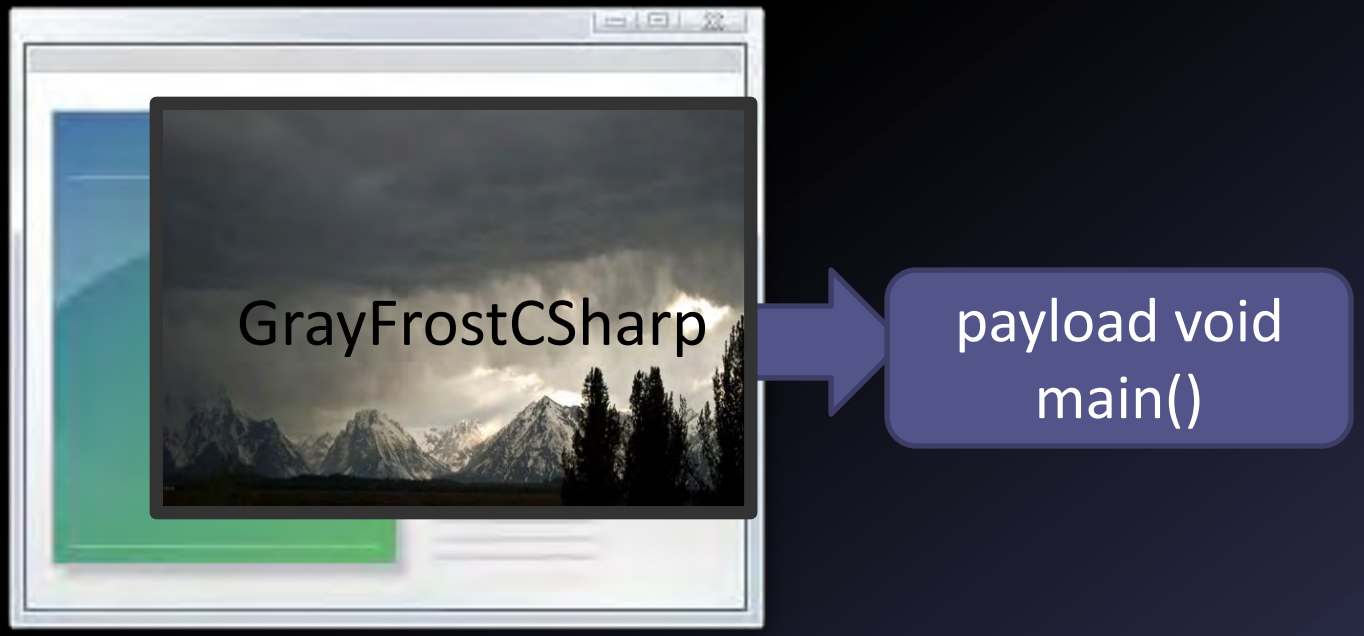
.NET Process



DEF CON

Round 2

.NET Process



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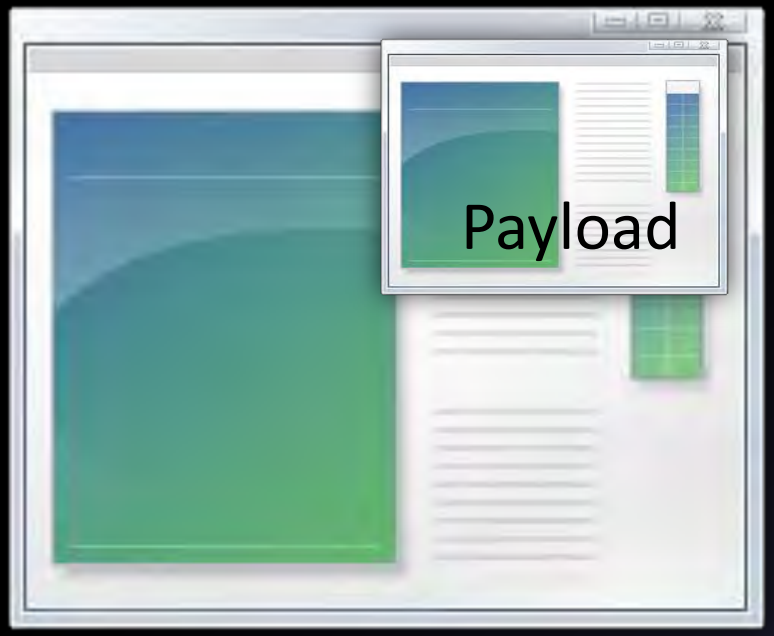
Round 2

.NET Process



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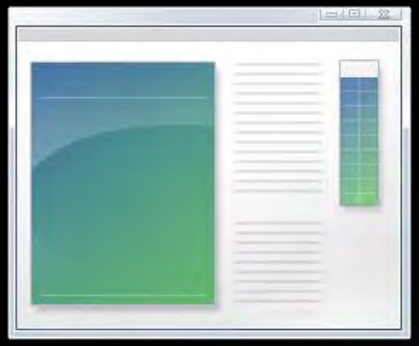
Pivoting between .NET runtimes

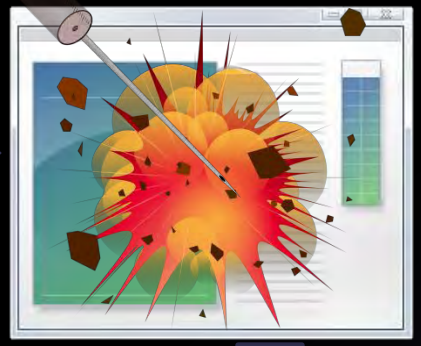
.NET Process



DEF CON

Pivoting between .NET runtimes

GrayFrostCpp

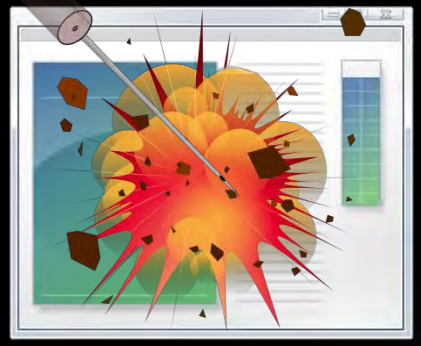


Mscoree

DEF CON

Pivoting between .NET runtimes

GrayFrostCpp



GrayFrostCSharp

DEF CON

Pivoting between .NET runtimes

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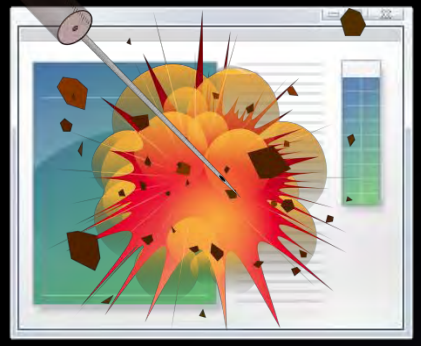

GrayFrostCSharp

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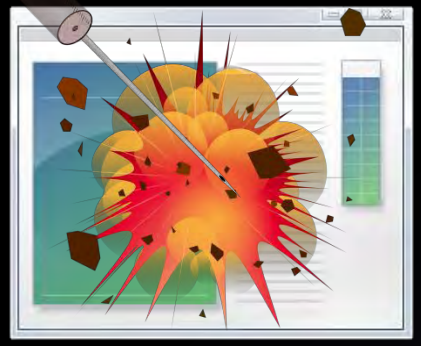

GrayFrostCSharp

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Gray Storm

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Gray Storm

Reconnaissance and attack payload

In-memory attack platform

Features

- ✦Attacking the .NET JIT
- ✦Attacking .NET at the ASM level
- ✦ASM and Metasploit payloads
- ✦Utilize objects on the Managed Heap

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Gray Storm Usage

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Controlling the JIT

Method Tables contain address of JIT stub for a class's methods.

During JIT the Method Table is referenced

We can control the address

Lives after Garbage Collection

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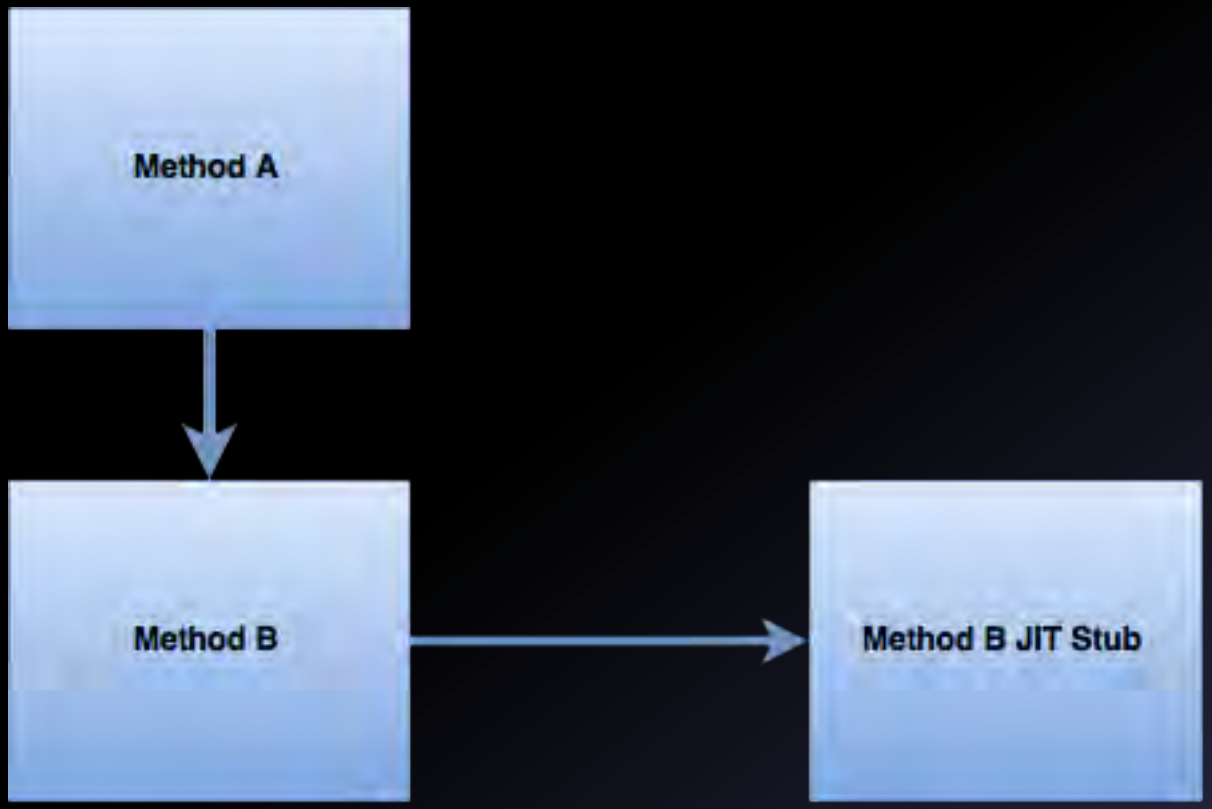
Controlling the JIT



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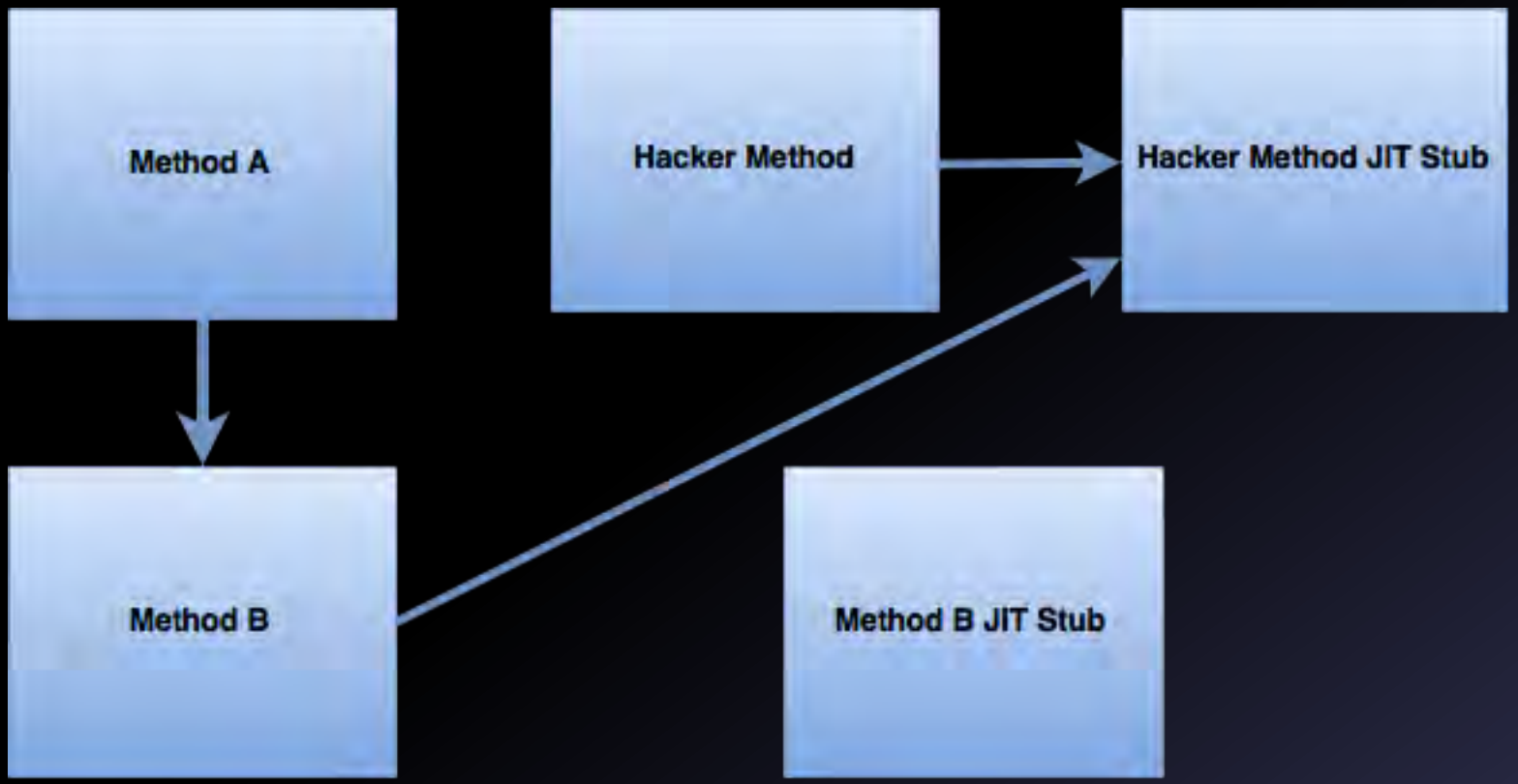
Controlling the JIT



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Control Flow Attacks

.NET uses far and relative calls

- 0xE8; Call [imm]
- 0xFF 0x15; Call dword segmentRegister[imm]

relCall = dstAddress - (currentLocation+ lenOfCall)

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ASM Payloads

Address of a method known through Reflection

Overwrite method logic with new ASM

Steal stack parameters

Change events

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ASM Payloads

- Change return TRUE to return FALSE
  - ✦Password validation
  - ✦Key validation
  - ✦Licensing validation
  - ✦SQL Sanitization
- Destroy security Mechanisms
- Overwrite logic
- Update Mechanisms

DEF CON

ASM Payloads

```
public bool VerifyLicense(string licenseKey, string email)
{
    if (string.IsNullOrEmpty(licenseKey) || string.IsNullOrEmpty(email))
    {
        return false;
    }

    this.License = this.Decrypt(licenseKey);

    if (this.License != null && this.License.Email != null &&
       this.License.Product != null)
    {
        bool flag = this.License.Email.Equals(email,
           StringComparison.OrdinalIgnoreCase);
        bool flag2 = this.License.Product == "Licensed";
        return flag && flag2;
    }
    return false;
}
```

```
0x55 push ebp
0x8B mov ebp , esp
0x57 push edi
0x56 push esi
0x53 push ebx
0x83 sub esp , 00000014h
0x89 mov dword [ebp-14h] , ecx
0x89 mov dword [ebp-18h] , edx
[snip]
0x8B mov ecx , esi
0xE8 call 53A7CE80h
0x85 test edi , edi
0xF95 setne al
0xFB6 movzx eax , al
0x8D lea esp , dword [ebp-0Ch]
0x5B pop ebx
0x5E pop esi
0x5F pop edi
0x5D pop ebp
0xC3 ret
```

```
0x31 xor eax , eax
0x40 inc eax
0xC3 ret
```

```
public bool VerifyLicense(string licenseKey, string email)
{
    return true;
}
```

DEF CON

ASM Payloads

Metasploit

Hand Rolled

Portable Environment Block (PEB) changes

DEF CON

Portable Environment Block

```
0:005> !peb
PEB at 7efde000
    InheritedAddressSpace:    No
    ReadImageFileExecOptions: No
    BeingDebugged:            Yes
    ImageBaseAddress:         012b0000
    Ldr                       77b40200
    Ldr.Initialized:          Yes
    Ldr.InInitializationOrderModuleList: 00273a80 . 00301d48
    Ldr.InLoadOrderModuleList:           002739e0 . 00301d38
    Ldr.InMemoryOrderModuleList:         002739e8 . 00301d40
            Base TimeStamp                     Module
         12b0000 54f4a118 Mar 02 09:42:48 2015 C:\\Users\\Blob\\DllInjector.exe
        77a40000 521ea8e7 Aug 28 18:50:31 2013 C:\\Windows\\SysWOW64\\ntdll.dll
        73a10000 4b90752b Mar 04 19:06:19 2010 C:\\Windows\\SYSTEM32\\MSCOREE.DLL
        75fc0000 53159a85 Mar 04 01:19:01 2014 C:\\Windows\\syswow64\\KERNEL32.dll
```

http://www.tophertimzen.com/blog/shellcodeDotNetPEB/

Object Hunting in Memory

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Object Hunting in Memory

Objects are IntPtrs

- **Point to Object Instance on Managed Heap**

All instantiated objects of the same class share the same Method Table

Reflection

Object Hunting

Win

Finding Objects at Runtime

i. Construct an object and find location of Managed Heap
ii. Signature instantiated type
iii. Scan Managed Heap for object pointers
iv. Convert object pointers to raw objects
v. ????
vi. PROFIT

DEF CON

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DEF CON

Construct an Object

Use Reflection to invoke a constructor

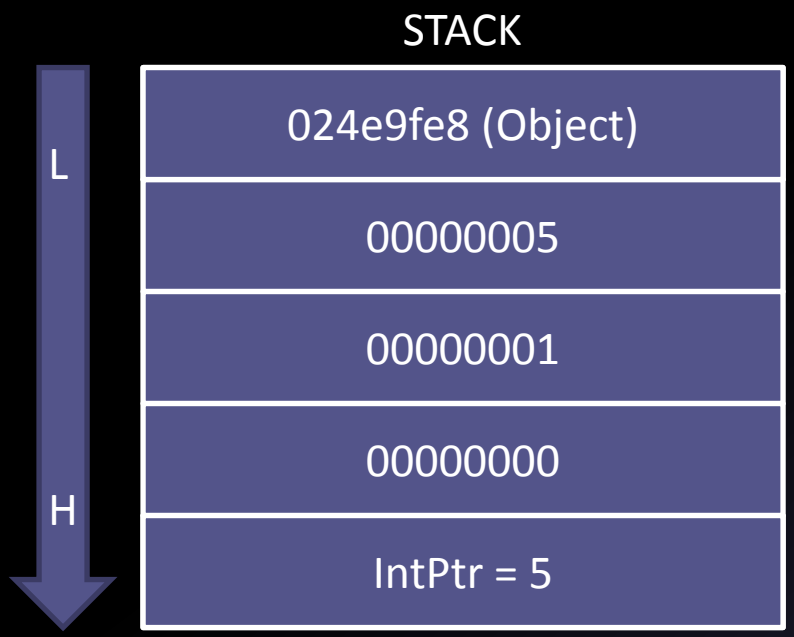
Can instantiate any object

If a constructor takes other objects, nullify them

https://gist.github.com/tophertimzen/010b19fdbde77f251414

DEF CON

Find location of Managed Heap



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DEF CON

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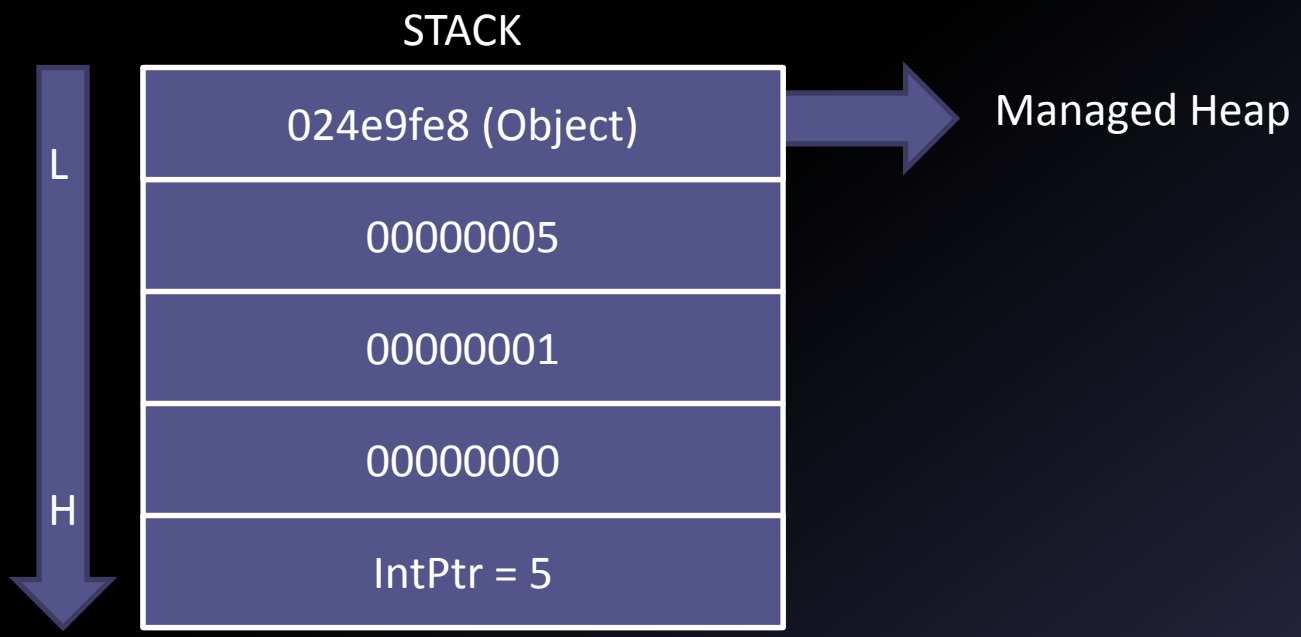

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DEF CON

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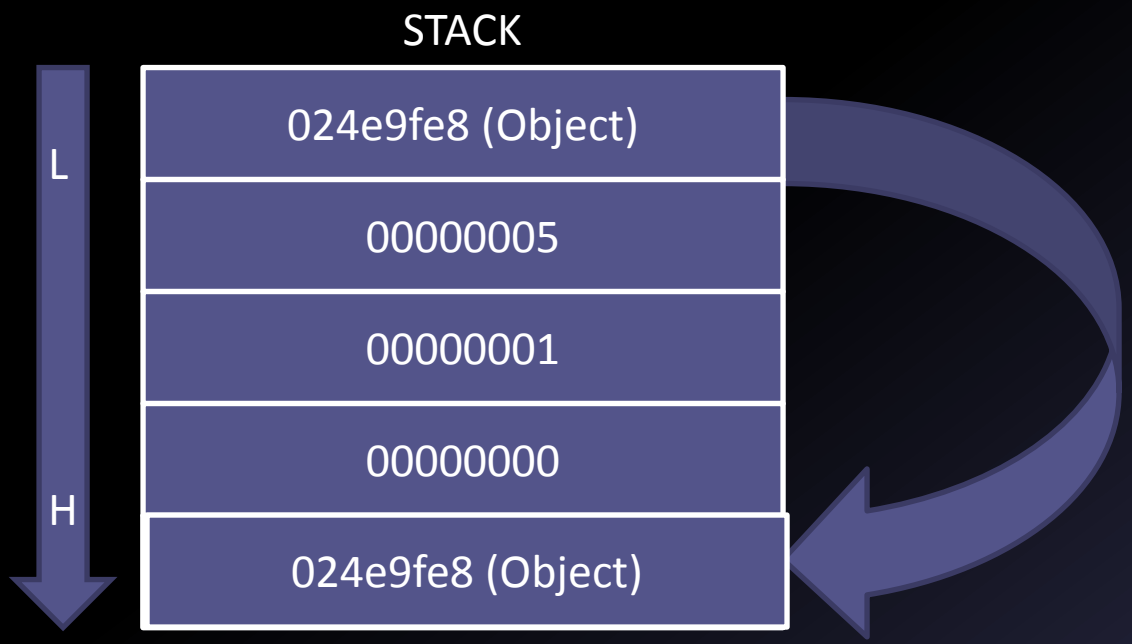

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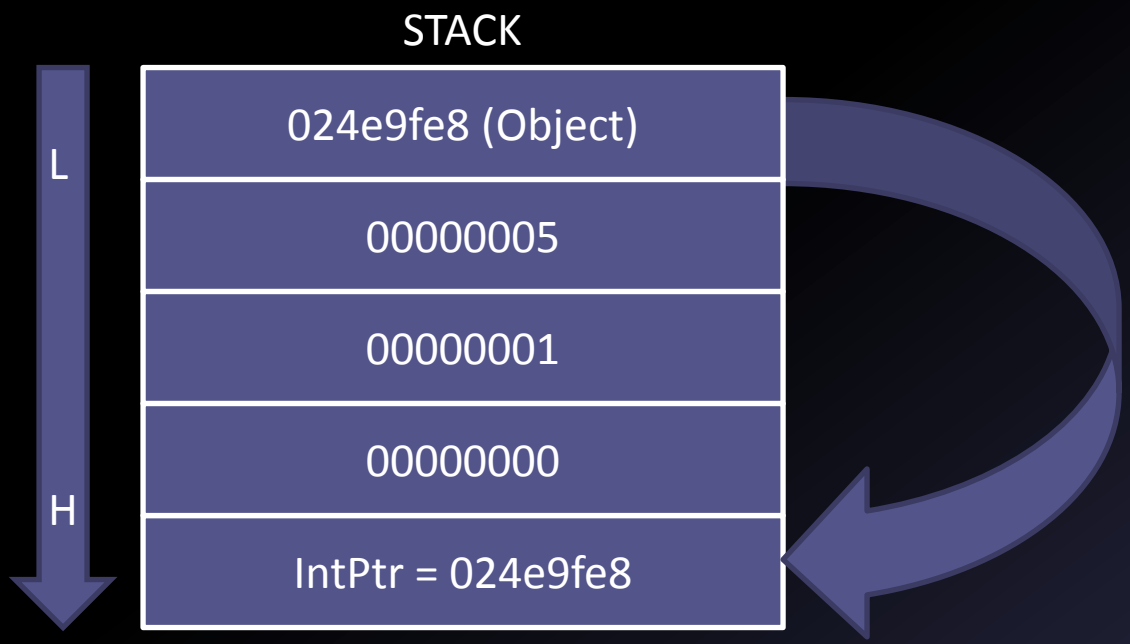
DEF CON

Find location of Managed Heap



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DEF CON

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DEF CON

Signature instantiated type

Object Instances contain a Method Table pointer to their corresponding type.

```
0:009> dd 024e9fe8
024e9fe8  00774828 0000038c 00000001 00000000
```

(x86)

Bytes 0-3 are the Method Table (MT)

Bytes 4-7 in MT is Instance Size

DEF CON

Signature instantiated type

Object Instances contain a Method Table pointer to their corresponding type.

```
0:008> dd 00000000024e9fe8
00000000`0286b8e0  ea774828 000007fe
```

(x64)

Bytes 0-7 are the Method Table (MT)

Bytes 4-7 in MT is Instance Size

DEF CON

Finding Objects at Runtime

i. Construct an object and find location of Managed Heap
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DEF CON

Scan Managed Heap

Scan down incrementing by size of object

Scan linearly up to top of heap

Compare object's Method Table to the reference

If they match, get IntPtr address of object

DEF CON

Finding Objects at Runtime

i. Construct an object and find location of Managed Heap
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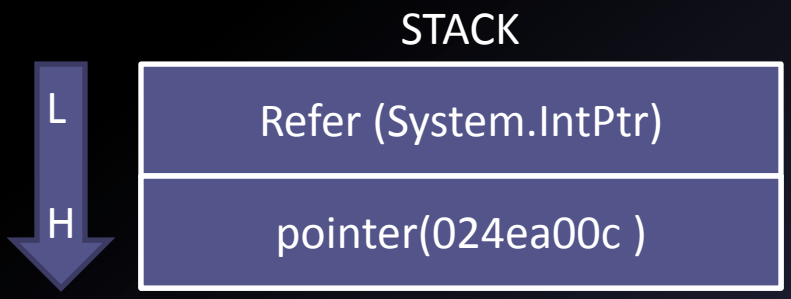
vi. PROFIT

DEF CON

Convert object ptr -> raw obj

```
public static object GetInstance(IntPtr ptrIN)
{
    object refer = ptrIN.GetType();
    IntPtr pointer = ptrIN;
    unsafe
    {
        *(&pointer - 1) = *(&pointer);
    }
    return refer;
 }
```



https://gist.github.com/tophertimzen/1da2b0aab6245ed1c27b

DEF CON

Convert object ptr -> raw obj

```
public static object GetInstance(IntPtr ptrIN)
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    object refer = ptrIN.GetType();
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    unsafe
    {
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    }
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```

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DEF CON

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DEF CON

????

DEF CON

PROFIT

DEF CON

Superpowers and Things?

- Change Keys
- Change Fields / Properties
- Call Methods
  - With arguments!

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Constructing Attack Chains

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How to construct attack chains

Gray Wolf / IL Decompiler

- Find Methods, Fields & Properties of interest
- Locate meaningful objects
- Discover high level control flow

Gray Storm “Debugging” functionality

- Breakpoint at constructors or methods from Method Pointers
- Use with WinDbg

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Hybrid .NET/ASM Attacks

- Hybrid C#/ASM code in .NET
- Encrypting .NET payloads and unwinding
- Encrypting ASM Payloads

DEF CON

Payload System

C# is easy

Can use Gray Frost in any application

Low and High level gap is easy

DEF CON

.NET Hacking Space

Small

Few tools

- Mostly hacking WoW

Previous DEF CON talks

- DEF CON 18 & 19 - Jon McCoy

DEF CON

Conclusion

- Arbitrary .NET applications can be injected and changed
- New .NET attack possibilities
- New tools that support automation
- Get Gray Frost and Storm

  github.com/graykernel

DEF CON

Questions?

Contact Me

- @TTimzen
- https://www.tophertimzen.com

Get Gray Frost and Storm

- github.com/graykernel

White Papers

- Hijacking Arbitrary .NET Application Control Flow
- Acquiring .NET Objects from the Managed Heap

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