PV204 Security technologies

In-Memory Malware Analysis

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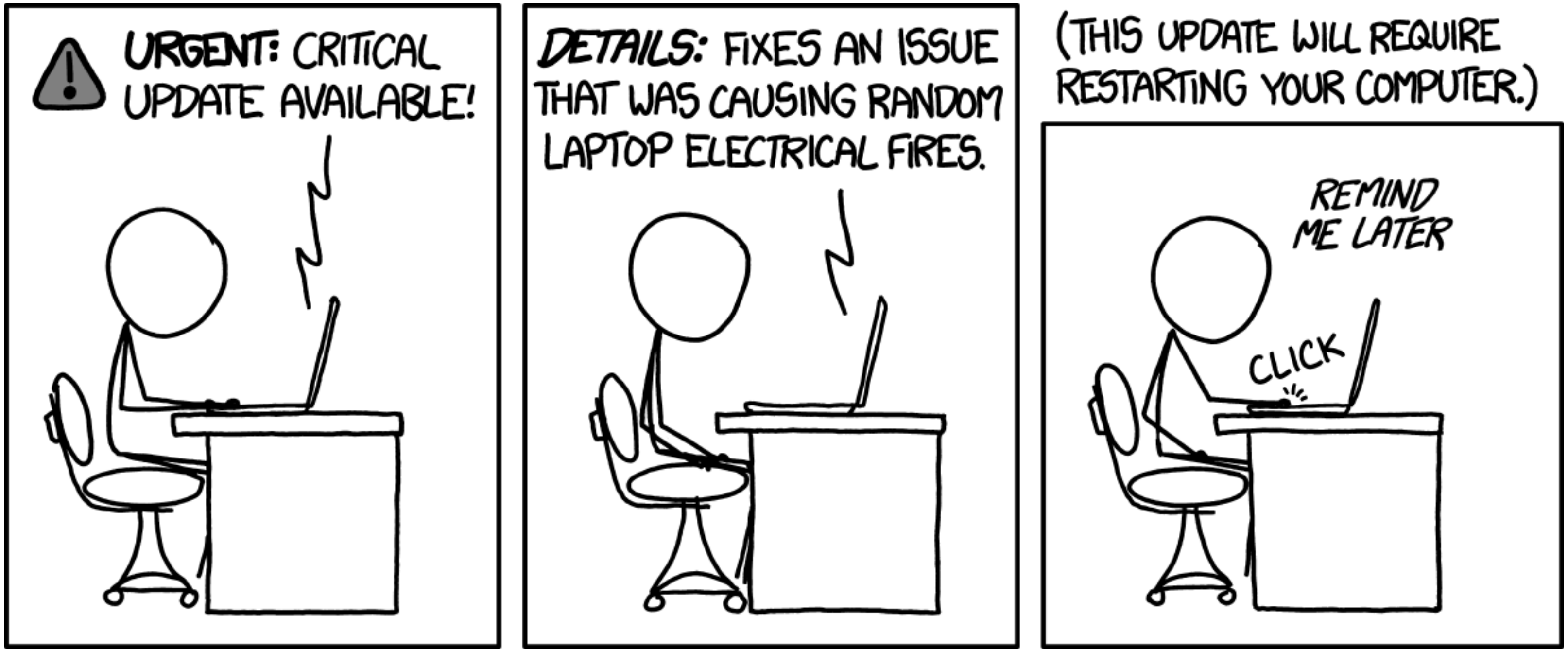
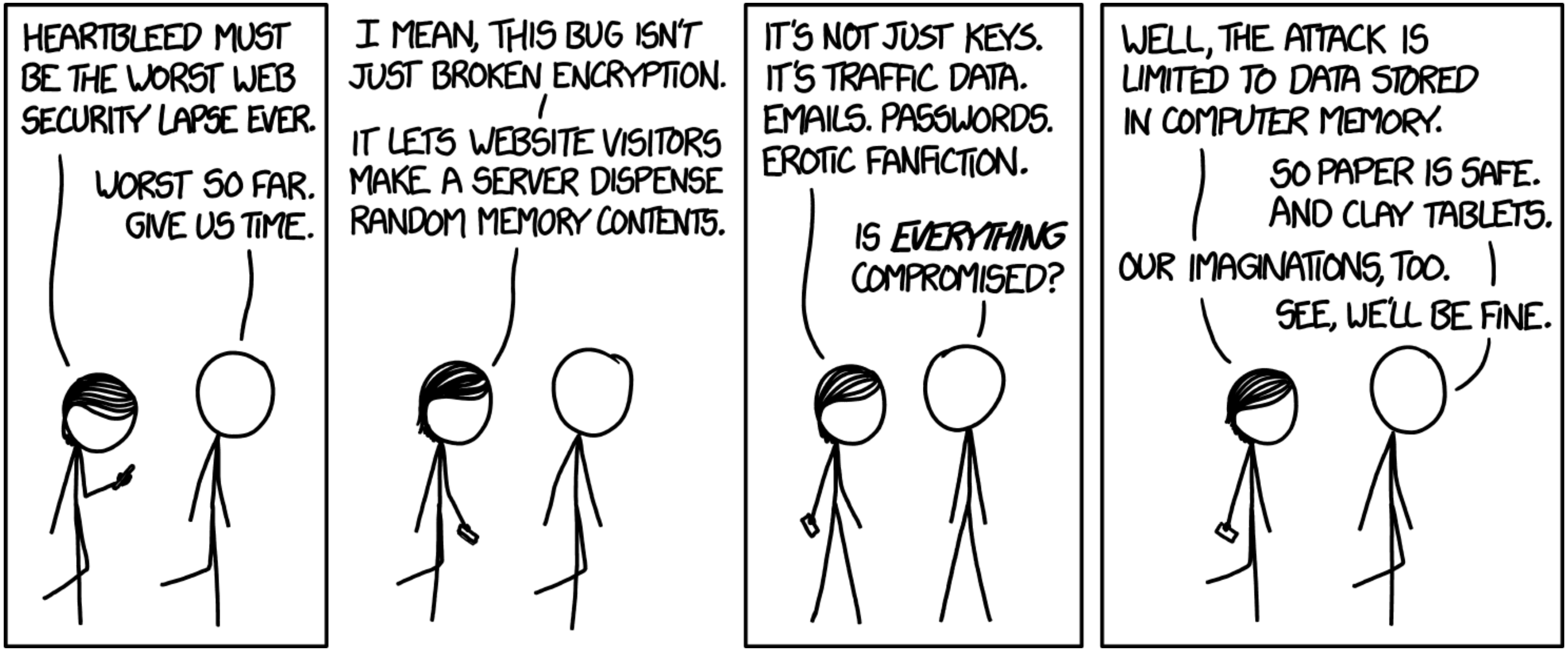

URGENT: CRITICAL UPDATE AVAILABLE!
DETAILS: FIXES AN ISSUE THAT WAS CAUSING RANDOM LAPTOP ELECTRICAL FIRES.
(THIS UPDATE WILL REQUIRE RESTARTING YOUR COMPUTER.)
REMIND ME LATER
CLICK

Agenda

- Basic intro
  - No x86 assembly required
  - No malware （de）obfuscation magic
- How does the OS look “inside”？
  - Processes and other data structures
  - How the memory is organized
- Common tools used for analysis
- Searching for system “oddities”
  - What are the important system indicators？
- Real samples discussed and analyzed！ （Labs）

Why memory analysis?

- It's fun!
- Acquiring evidence for legal investigations
  - It used to be different in the past
- Technical simplification of reverse engineering
  - No binary obfuscation present – the code has to run
- Incident response activities
  - Easy way how to learn more about the attackers
  - Malicious binary may only be present in memory
  - Fast: RAM is (usually) smaller than full hard-drive images

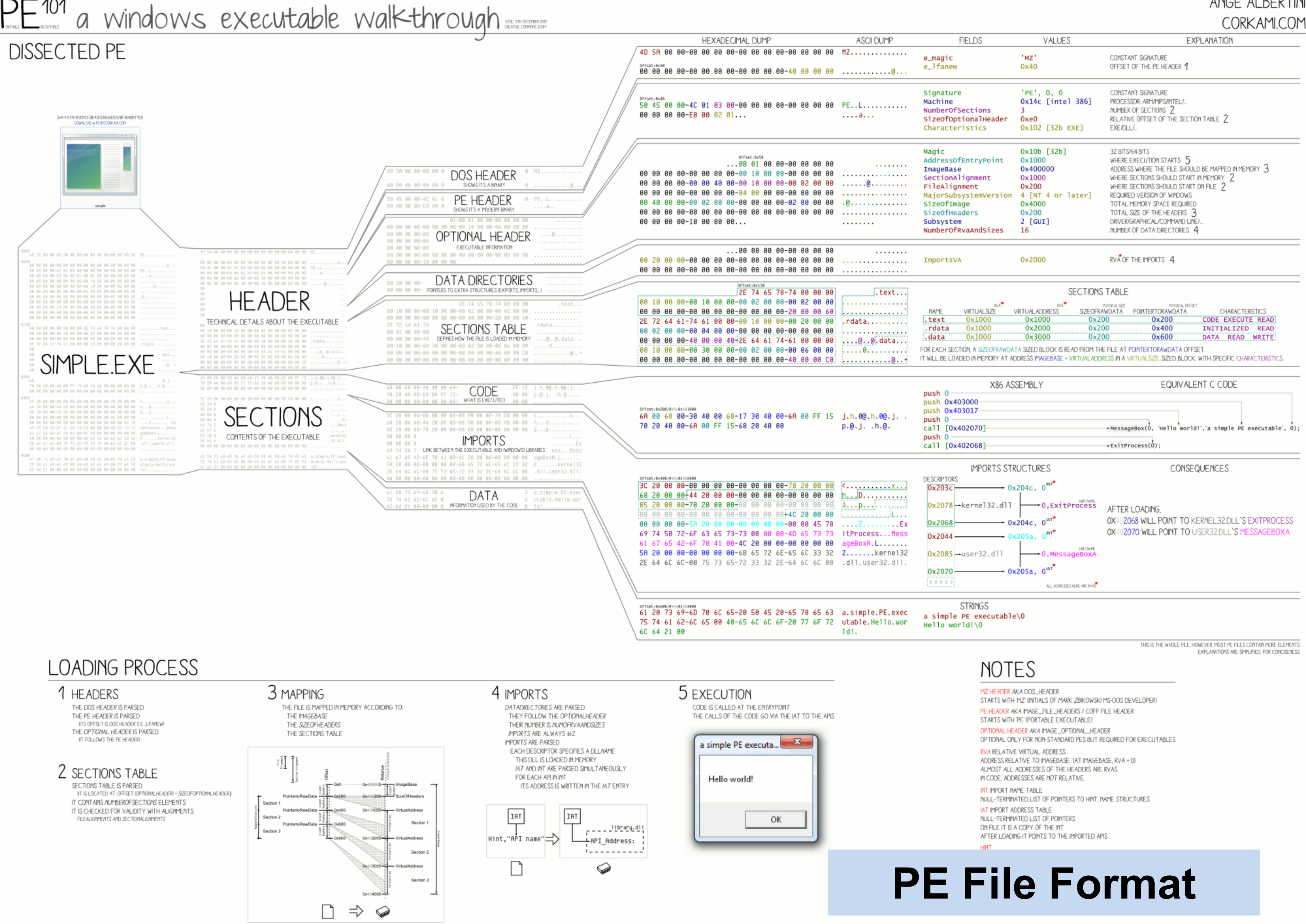

HEARTBLEED MUST BE THE WORST WEB SECURITY LAPSE EVER.
WORST SO FAR. GIVE US TIME.
I MEAN, THIS BUG ISN'T JUST BROKEN ENCRYPTION.
IT LETS WEBSITE VISITORS MAKE A SERVER DISPENSE RANDOM MEMORY CONTENTS.
IT'S NOT JUST KEYS. IT'S TRAFFIC DATA. EMAILS. PASSWORDS. EROTIC FANFICTION.
IS *EVERYTHING* COMPROMISED?
WELL, THE ATTACK IS LIMITED TO DATA STORED IN COMPUTER MEMORY.
SO PAPER IS SAFE. AND CLAY TABLETS.
OUR IMAGINATIONS, TOO.
SEE, WE'LL BE FINE.

HOTPLUG LT™
MOUSE JIGGLER
Prevents a computer from falling asleep while you work! (OR PLAY)
wiebetech
wiebetech PCD
our best ideas store yours™

Challenges in Reverse Engineering （RE）

- Assembly language （for multiple platforms）
  - Plus undocumented instructions （or behavior）
- Anti－debugging tricks
  - Exceptions， interrupts， PE manipulations， time checking， …
- Anti－VM tricks
  - Uncommon behavior of known instructions
  - Registry detections， HW detections
- Code obfuscation／packing
  - The most challenging to overcome， mostly

PE File Format



PE^101 a windows executable walkthrough

PORTABLE EXECUTABLE

V2.0L, 5TH DECEMBER 2012
CREATIVE COMMONS 3.0 BY

ANGE ALBERTINI
CORKAMI.COM

DISSECTED PE

SHA-1 87AF4C851CE38E436030656E8269BFAB408CF9CB
DOWNLOAD @ PE101.CORKAMI.COM

SIMPLE.EXE

HEADER
TECHNICAL DETAILS ABOUT THE EXECUTABLE

SECTIONS
CONTENTS OF THE EXECUTABLE

DOS HEADER
SHOWS IT'S A BINARY

PE HEADER
SHOWS IT'S A 'MODERN' BINARY

OPTIONAL HEADER
EXECUTABLE INFORMATION

DATA DIRECTORIES
POINTERS TO EXTRA STRUCTURES (EXPORTS, IMPORTS,...)

SECTIONS TABLE
DEFINES HOW THE FILE IS LOADED IN MEMORY

CODE
WHAT IS EXECUTED

IMPORTS
LINK BETWEEN THE EXECUTABLE AND (WINDOWS) LIBRARIES

DATA
INFORMATION USED BY THE CODE

HEXADECIMAL DUMP / ASCII DUMP

```
4D 5A 00 00-00 00 00 00-00 00 00 00-00 00 00 00  MZ..............
Offset:0x30
00 00 00 00-00 00 00 00-00 00 00 00-40 00 00 00  ............@...

Offset:0x40
50 45 00 00-4C 01 03 00-00 00 00 00-00 00 00 00  PE..L...........
00 00 00 00-E0 00 02 01...                       ....a...
```

FIELDS	VALUES	EXPLANATION
e_magic	'MZ'	CONSTANT SIGNATURE
e_lfanew	0x40	OFFSET OF THE PE HEADER 1
Signature	'PE', 0, 0	CONSTANT SIGNATURE
Machine	0x14c [intel 386]	PROCESSOR: ARM/MIPS/INTEL/...
NumberOfSections	3	NUMBER OF SECTIONS 2
SizeOfOptionalHeader	0xe0	RELATIVE OFFSET OF THE SECTION TABLE 2
Characteristics	0x102 [32b EXE]	EXE/DLL/...

```
Offset:0x58
                           ...0B 01 00 00-00 00 00 00          ........
00 00 00 00-00 00 00 00-00 10 00 00-00 00 00 00  ................
00 00 00 00-00 00 40 00-00 10 00 00-00 02 00 00  ......@.........
00 00 00 00-00 00 00 00-04 00 00 00-00 00 00 00  ................
00 40 00 00-00 02 00 00-00 00 00 00-02 00 00 00  .@..............
00 00 00 00-00 00 00 00-00 00 00 00-00 00 00 00  ................
00 00 00 00-10 00 00 00...                       ........
```

FIELDS	VALUES	EXPLANATION
Magic	0x10b [32b]	32 BITS/64 BITS
AddressOfEntryPoint	0x1000	WHERE EXECUTION STARTS 5
ImageBase	0x400000	ADDRESS WHERE THE FILE SHOULD BE MAPPED IN MEMORY 3
SectionAlignment	0x1000	WHERE SECTIONS SHOULD START IN MEMORY 2
FileAlignment	0x200	WHERE SECTIONS SHOULD START ON FILE 2
MajorSubsystemVersion	4 [NT 4 or later]	REQUIRED VERSION OF WINDOWS
SizeOfImage	0x4000	TOTAL MEMORY SPACE REQUIRED
SizeOfHeaders	0x200	TOTAL SIZE OF THE HEADERS 3
Subsystem	2 [GUI]	DRIVER/GRAPHICAL/COMMAND LINE/...
NumberOfRvaAndSizes	16	NUMBER OF DATA DIRECTORIES 4

```
                           ...00 00 00 00-00 00 00 00          ........
00 20 00 00-00 00 00 00-00 00 00 00-00 00 00 00  ................
00 00 00 00-00 00 00 00-00 00 00 00-00 00 00 00  ................
```

FIELDS	VALUES	EXPLANATION
ImportsVA	0x2000	RVA* OF THE IMPORTS 4

```
Offset:0x138
                           2E 74 65 78-74 00 00 00          .text...
00 10 00 00-00 10 00 00-00 02 00 00-00 02 00 00  ................
00 00 00 00-00 00 00 00-00 00 00 00-20 00 00 60  ...............`
2E 72 64 61-74 61 00 00-00 10 00 00-00 20 00 00  .rdata..........
00 02 00 00-00 04 00 00-00 00 00 00-00 00 00 00  ................
00 00 00 00-40 00 00 40-2E 64 61 74-61 00 00 00  ....@..@.data...
00 10 00 00-00 30 00 00-00 02 00 00-00 06 00 00  .....0..........
00 00 00 00-00 00 00 00-00 00 00 00-40 00 00 C0  ............@..+
```

SECTIONS TABLE

NAME	VIRTUALSIZE (RVA*)	VIRTUALADDRESS (RVA*)	SIZEOFRAWDATA (PHYSICAL SIZE)	POINTERTORAWDATA (PHYSICAL OFFSET)	CHARACTERISTICS
.text	0x1000	0x1000	0x200	0x200	CODE EXECUTE READ
.rdata	0x1000	0x2000	0x200	0x400	INITIALIZED READ
.data	0x1000	0x3000	0x200	0x600	DATA READ WRITE

FOR EACH SECTION, A SIZEOFRAWDATA SIZED BLOCK IS READ FROM THE FILE AT POINTERTORAWDATA OFFSET.
IT WILL BE LOADED IN MEMORY AT ADDRESS IMAGEBASE + VIRTUALADDRESS IN A VIRTUALSIZE SIZED BLOCK, WITH SPECIFIC CHARACTERISTICS.

```
Offset:0x200/RVA:0x401000
6A 00 68 00-30 40 00 68-17 30 40 00-6A 00 FF 15  j.h.0@.h.0@.j. .
70 20 40 00-6A 00 FF 15-68 20 40 00              p.@.j. .h.@.
```

X86 ASSEMBLY / EQUIVALENT C CODE

```
push 0
push 0x403000
push 0x403017
push 0
call [0x402070]        MessageBox(0, "Hello World!","a simple PE executable", 0);
push 0
call [0x402068]        ExitProcess(0);
```

```
Offset:0x400/RVA:0x402000
3C 20 00 00-00 00 00 00-00 00 00 00-78 20 00 00  <...........x...
68 20 00 00-44 20 00 00-00 00 00 00-00 00 00 00  h...D...........
85 20 00 00-70 20 00 00-00 00 00 00-00 00 00 00  à...p...........
00 00 00 00-00 00 00 00-00 00 00 00-4C 20 00 00  ............L...
00 00 00 00-5A 20 00 00-00 00 00 00-00 00 45 78  ....Z.........Ex
69 74 50 72-6F 63 65 73-73 00 00 00-4D 65 73 73  itProcess...Mess
61 67 65 42-6F 78 41 00-4C 20 00 00-00 00 00 00  ageBoxA.L.......
5A 20 00 00-00 00 00 00-6B 65 72 6E-65 6C 33 32  Z.......kernel32
2E 64 6C 6C-00 75 73 65-72 33 32 2E-64 6C 6C 00  .dll.user32.dll.
```

IMPORTS STRUCTURES

DESCRIPTORS

```
0x203c ──────────► 0x204c, 0 (INT*)
0x2078 ─► kernel32.dll      ─► 0, ExitProcess (HINT,NAME)
0x2068 ──────────► 0x204c, 0 (IAT*)
0x2044 ──────────► 0x205a, 0 (INT*)
0x2085 ─► user32.dll        ─► 0, MessageBoxA (HINT,NAME)
0x2070 ──────────► 0x205a, 0 (IAT*)
0 0 0 0 0
```

ALL ADDRESSES HERE ARE RVAS*

CONSEQUENCES

AFTER LOADING,
0X402068 WILL POINT TO KERNEL32.DLL'S EXITPROCESS
0X402070 WILL POINT TO USER32.DLL'S MESSAGEBOXA

```
Offset:0x600/RVA:0x403000
61 20 73 69-6D 70 6C 65-20 50 45 20-65 78 65 63  a.simple.PE.exec
75 74 61 62-6C 65 00 48-65 6C 6C 6F-20 77 6F 72  utable.Hello.wor
6C 64 21 00                                      ld!.
```

STRINGS

```
a simple PE executable\0
Hello world!\0
```

THIS IS THE WHOLE FILE, HOWEVER, MOST PE FILES CONTAIN MORE ELEMENTS.
EXPLANATIONS ARE SIMPLIFIED, FOR CONCISENESS.

LOADING PROCESS

1 HEADERS

THE *DOS HEADER* IS PARSED
THE *PE HEADER* IS PARSED
(ITS OFFSET IS *DOS HEADER'S E_LFANEW*)
THE *OPTIONAL HEADER* IS PARSED
(IT FOLLOWS THE *PE HEADER*)

2 SECTIONS TABLE

SECTIONS TABLE IS PARSED
(IT IS LOCATED AT: OFFSET (*OPTIONALHEADER*) + *SIZEOFOPTIONALHEADER*)
IT CONTAINS *NUMBEROFSECTIONS* ELEMENTS
IT IS CHECKED FOR VALIDITY WITH ALIGNMENTS:
FILEALIGNMENTS AND *SECTIONALIGNMENTS*

3 MAPPING

THE FILE IS MAPPED IN MEMORY ACCORDING TO:
THE *IMAGEBASE*
THE *SIZEOFHEADERS*
THE SECTIONS TABLE

4 IMPORTS

DATADIRECTORIES ARE PARSED
THEY FOLLOW THE *OPTIONALHEADER*
THEIR NUMBER IS *NUMOFRVAANDSIZES*
IMPORTS ARE ALWAYS #2
IMPORTS ARE PARSED
EACH DESCRIPTOR SPECIFIES A *DLLNAME*
THIS DLL IS LOADED IN MEMORY
IAT AND *INT* ARE PARSED SIMULTANEOUSLY
FOR EACH API IN *INT*
ITS ADDRESS IS WRITTEN IN THE *IAT* ENTRY

5 EXECUTION

CODE IS CALLED AT THE *ENTRYPOINT*
THE CALLS OF THE CODE GO VIA THE IAT TO THE APIS

NOTES

MZ HEADER *AKA* DOS_HEADER
STARTS WITH 'MZ' (INITIALS OF *MARK ZBIKOWSKI* MS-DOS DEVELOPER)

PE HEADER *AKA* IMAGE_FILE_HEADERS / COFF FILE HEADER
STARTS WITH 'PE' (PORTABLE EXECUTABLE)

OPTIONAL HEADER *AKA* IMAGE_OPTIONAL_HEADER
OPTIONAL ONLY FOR NON-STANDARD PES BUT REQUIRED FOR EXECUTABLES

RVA RELATIVE VIRTUAL ADDRESS
ADDRESS RELATIVE TO IMAGEBASE (AT IMAGEBASE, RVA = 0)
ALMOST ALL ADDRESSES OF THE HEADERS ARE RVAS
IN CODE, ADDRESSES ARE *NOT* RELATIVE.

INT IMPORT NAME TABLE
NULL-TERMINATED LIST OF POINTERS TO HINT, NAME STRUCTURES

IAT IMPORT ADDRESS TABLE
NULL-TERMINATED LIST OF POINTERS
ON FILE IT IS A COPY OF THE INT
AFTER LOADING IT POINTS TO THE IMPORTED APIS

HINT

PDF File Format

PDF^101^ an Adobe document walkthrough

PORTABLE DOCUMENT FORMAT

ANGE ALBERTINI
CORKAMI.COM

FILE

```
%PDF-1.1

1 0 obj
<<
  /Pages 2 0 R
>>
endobj

2 0 obj
<<
  /Type /Pages
  /Count 1
  /Kids [3 0 R]
>>
endobj

3 0 obj
<<
  /Type /Page
  /Contents 4 0 R
  /Parent 2 0 R
  /Resources <<
    /Font <<
      /F1 <<
        /Type /Font
        /Subtype /Type1
        /BaseFont /Arial
      >>
<< /Length 47 >>
stream
BT
  /F1 110
  Tf
  10 400 Td
  (Hello World!)Tj
ET
endstream
endobj

xref
0 5
0000000000 65535 f
0000000010 00000 n
0000000047 00000 n
0000000111 00000 n
0000000313 00000 n

trailer
<<
  /Root 1 0 R
>>

startxref
416
%%EOF
```

HEADER

```
%PDF-1.1
```

BODY

```
010:
    1 0 obj
    <<
      /Pages 2 0 R
    >>
    endobj
047:
    2 0 obj
    <<
      /Type /Pages
      /Count 1
      /Kids [3 0 R]
    >>
    endobj
111:
    3 0 obj
    <<
      /Type /Page
      /Contents 4 0 R
      /Parent 2 0 R
      /Resources <<
        /Font <<
          /F1 <<
            /Type /Font
            /Subtype /Type1
            /BaseFont /Arial
          >>
        >>
      >>
    >>
    endobj
313:
    4 0 obj
    << /Length 47 >>
    stream
    BT                       BEGIN TEXT
      /F1 110                  FONT F1 (ARIAL) SET TO SIZE 110
      Tf                       SELECT THIS FONT
      10 400 Td                MOVE TO COORDINATE 10, 400
      (Hello World!)Tj         OUTPUT TEXT "HELLO WORLD!"
    ET                       END TEXT
    endstream
    endobj
```

XREF TABLE

CROSS REFERENCE

```
416:
    xref                     CROSS REFERENCES
    0 5                      5 OBJECTS, STARTING AT INDEX 0
    0000000000 65535 f       (STANDARD FIRST EMPTY OBJECT 0
    0000000010 00000 n       OFFSET TO OBJECT 1, REV 0
    0000000047 00000 n       TO OBJECT 2...
    0000000111 00000 n       3...
    0000000313 00000 n       4
```

TRAILER

```
    trailer
    <<
      /Root 1 0 R
    >>

    startxref
    416
    %%EOF
```

BASICS

PDF IS TEXT BASED, WITH BINARY STREAMS

TYPES

(): STRING
  EX: `(Hello World!)`
/NAME (IDENTIFIERS)
  EX: `/Count 1`
<<>>: DICTIONARY
  EX: `<</key1 value1 /key2 value2>>`
[]: ARRAY
  EX: `[0 1 2 3 4]`

OBJECT REFERENCES

CONTENT IS STORED IN OBJECT
MOST CONTENT CAN BE INLINED OR REFERENCED IN A SEPARATE OBJECT

`/Key1 value` IS EQUIVALENT TO

```
/Key1 3 0 R
[...]

3 0 obj
value
endobj
```

<OBJECT NUMBER> <REVISION NUMBER> R

BINARY STREAMS

BINARY STREAM ARE STORED IN SEPARATE OBJECTS LIKE THIS:

```
<object number> <object revision> obj
<< <STREAM METADATA> >>
stream
<STREAM CONTENT>
endstream
endobj
```

STREAM LENGTH, COMPRESSION PARAMETERS....

TRIVIA

THE PDF WAS FIRST SPECIFIED BY ADOBE SYSTEMS IN 1993

INITIAL VERSIONS OF ADOBE ACROBAT WERE NOT FREE

FILE STRUCTURE

HEAD OF THE FILE

THE %PDF-* SIGNATURE IDENTIFIES THE FORMAT
AND REQUIRED VERSION

XREF

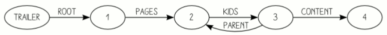
`xref`
<STARTING OBJECT> <OBJECT COUNT>
FOLLOWED BY XREF ENTRIES:
IF (OBJECT IN USE)
  <OFFSET:10> <GENERATION:5> `n`
ELSE
  <NEXT_FREE_OBJECT:10> <GENERATION:5> `f`

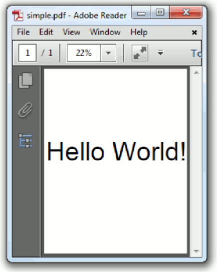
END OF THE FILE

`startxref`
<XREF OFFSET IN DECODED STREAM>
`%%EOF`

PARSING

THE HEADER **`%PDF-1.?`** SIGNATURE IS CHECKED TO IDENTIFY THE FILE FORMAT
THE XREF IS LOCATED VIA THE **`startxref`** OFFSET
THE **`xref`** TABLE GIVES OFFSET OF EACH OBJECT
THE **`trailer`** IS PARSED
EACH OBJECT REFERENCE IS FOLLOWED, BUILDING THE DOCUMENT
PAGES ARE CREATED, TEXT IS RENDERED





Hello World!

VERSION 1.00
2013/12/24

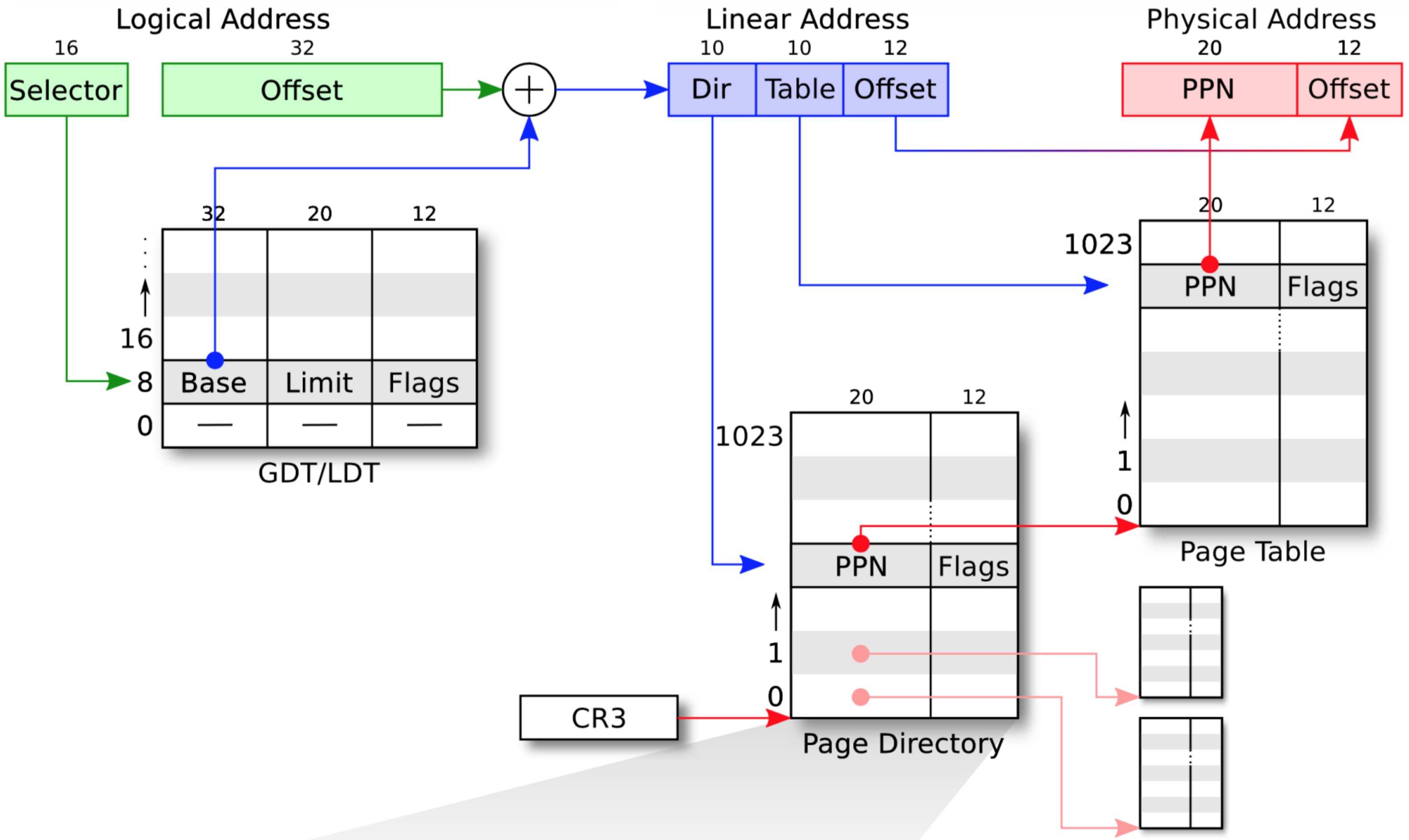
MEMORY ANALYSIS…

‘cause reverse engineering ninjas are busy

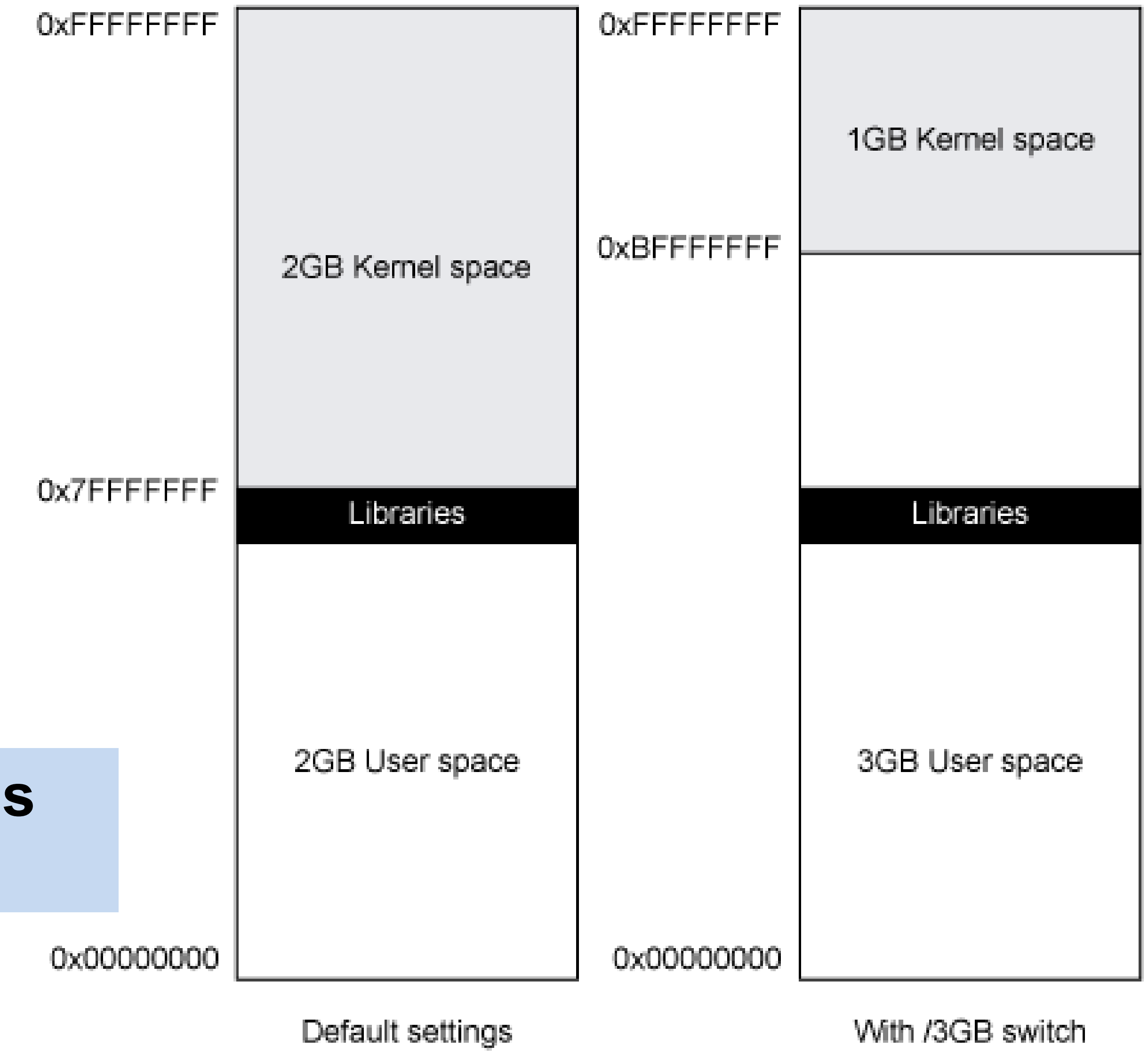
x86/x64 Memory organization

- Physical memory
  - RAM; what we really have installed
- Virtual memory
  - Separation of logical process memory from the physical
  - Logical address space > physical (e.g. swap)
  - Address space shared by several processes, yet separated
- Paging vs. Segmentation
  - Possible memory organization approaches

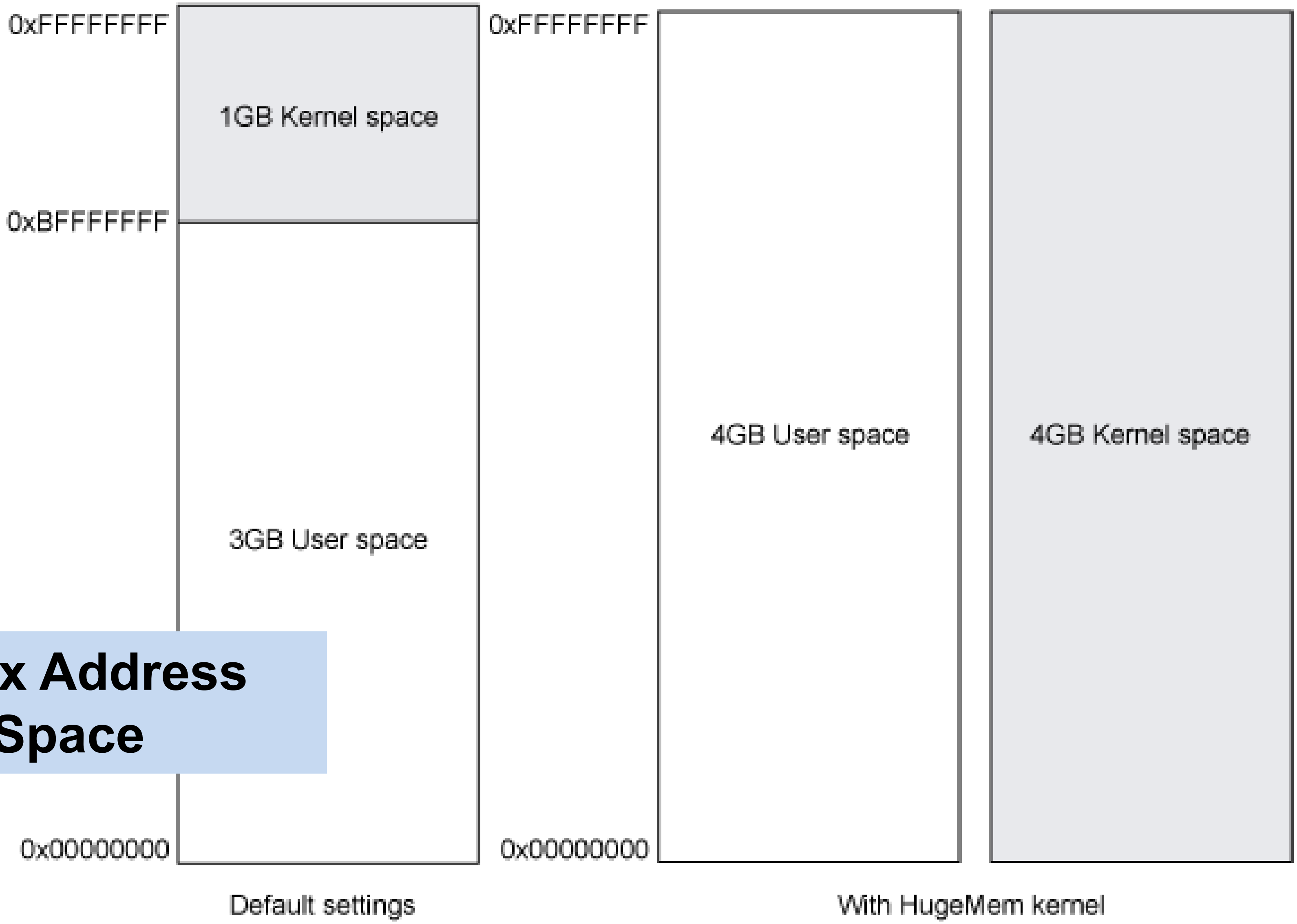
Segmentation → Paging → Physical Address

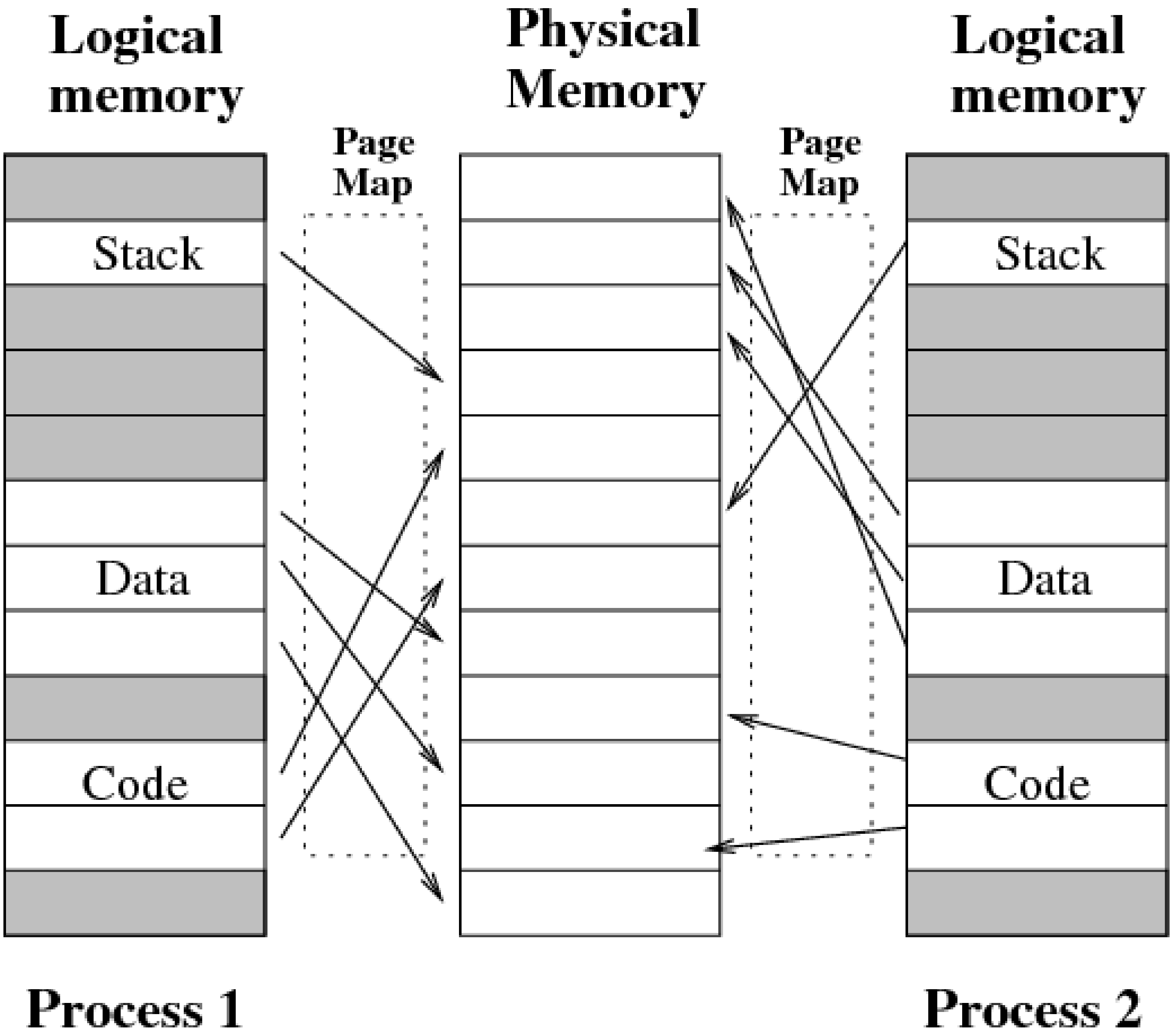


Win32 Address Space



Linux Address Space



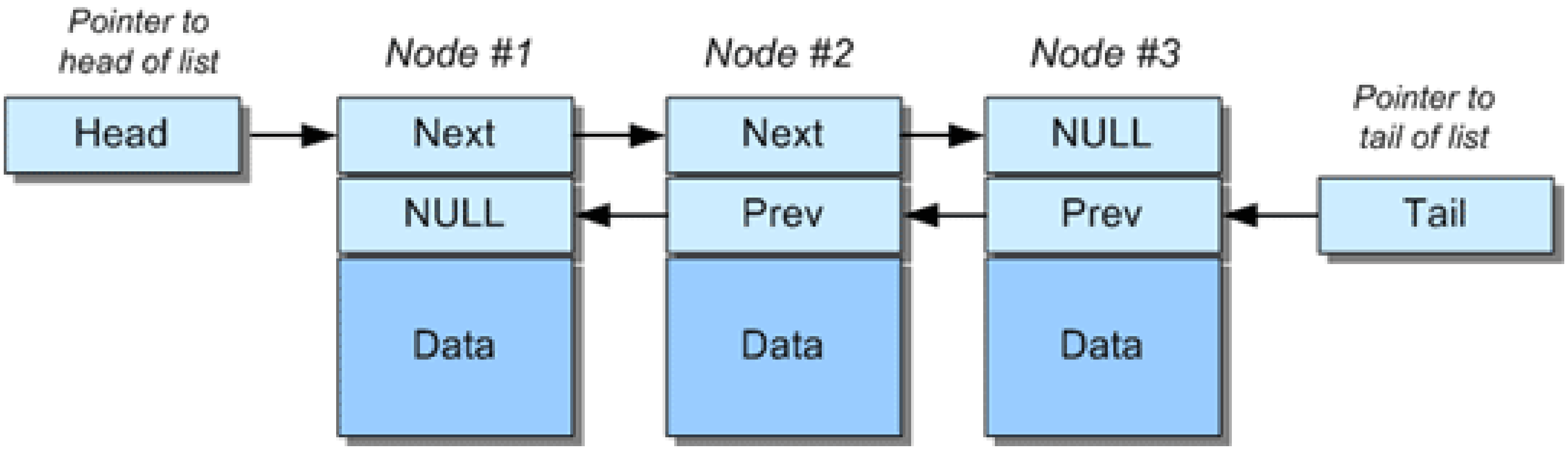

Logical memory
Physical Memory
Logical memory
Page Map
Page Map
Stack
Data
Code
Stack
Data
Code
Process 1
Process 2

MAN, I SUCK AT THIS GAME. CAN YOU GIVE ME A FEW POINTERS?
0x3A28213A
0x6339392C,
0x7363682E.
I HATE YOU.

Operating System Data Structures

- How the OS knows about processes, files, …?
  - A lot of ‘metadata’ for important data
  - Based on C/C++ data structures (see MSDN documentation)
- (Double-)linked list
  - Another common data structure (not only in OS)
  - Method for implementing lists in computer memory
- Direct Kernel Object Manipulation (DKOM)
  - Used for manipulating the structures to hide malicious stuff

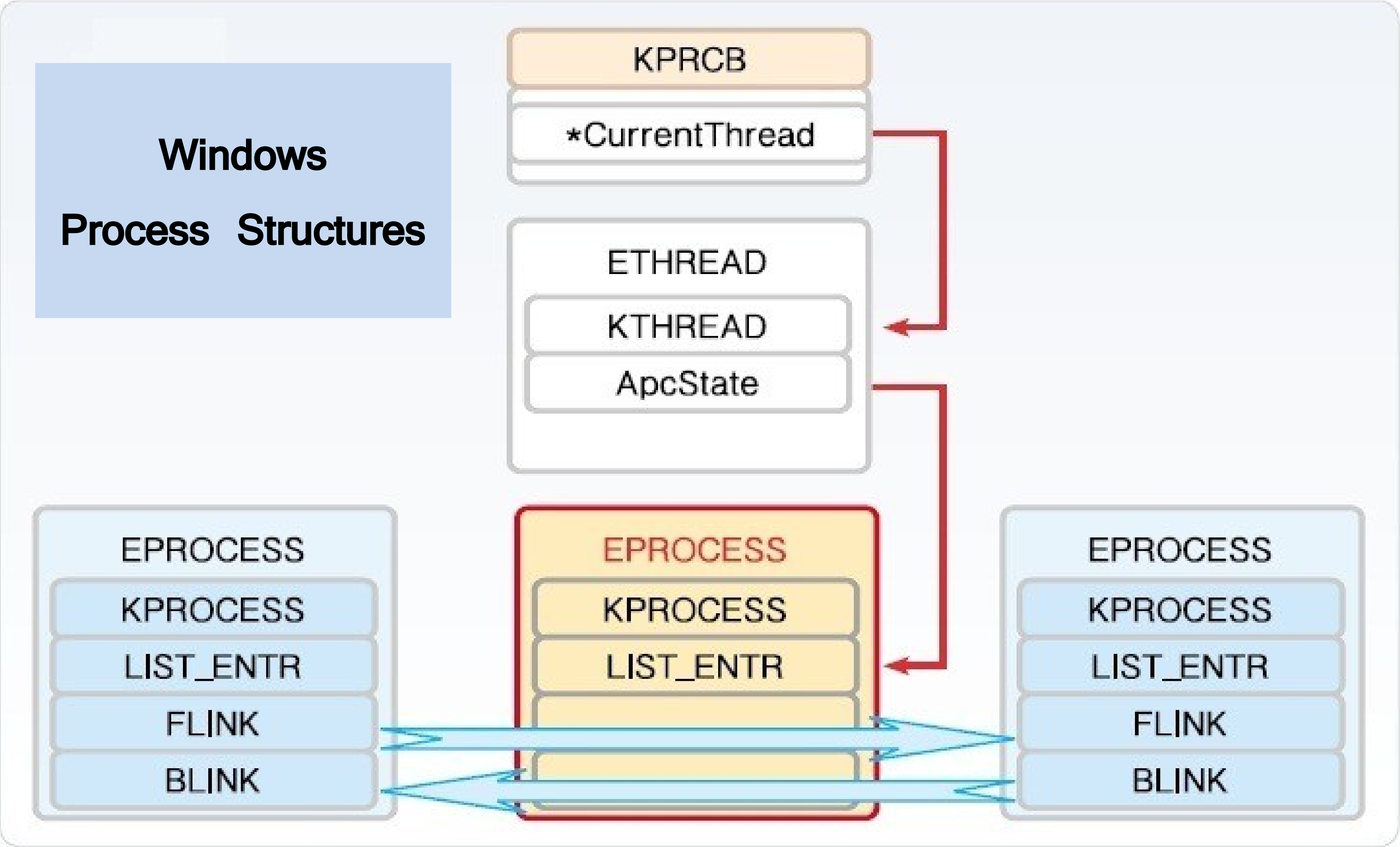
Double Linked Lists



DKOM – Direct Kernel Object Manipulation

- Dozens of various (double-)linked lists in Windows
  - Maintained by kernel
  - Processes, threads, opened files, memory allocations, …
- DKOM is used by rootkits
  - Hiding from the sight of the user
- Rootkit paradox
  - Rootkits need to run on the system
  - … and need to remain hidden at the same time
- Memory analysis can help to discover DKOM
  - Anti-analysis techniques are known as well

Windows Process Structures



Interesting OS Structures

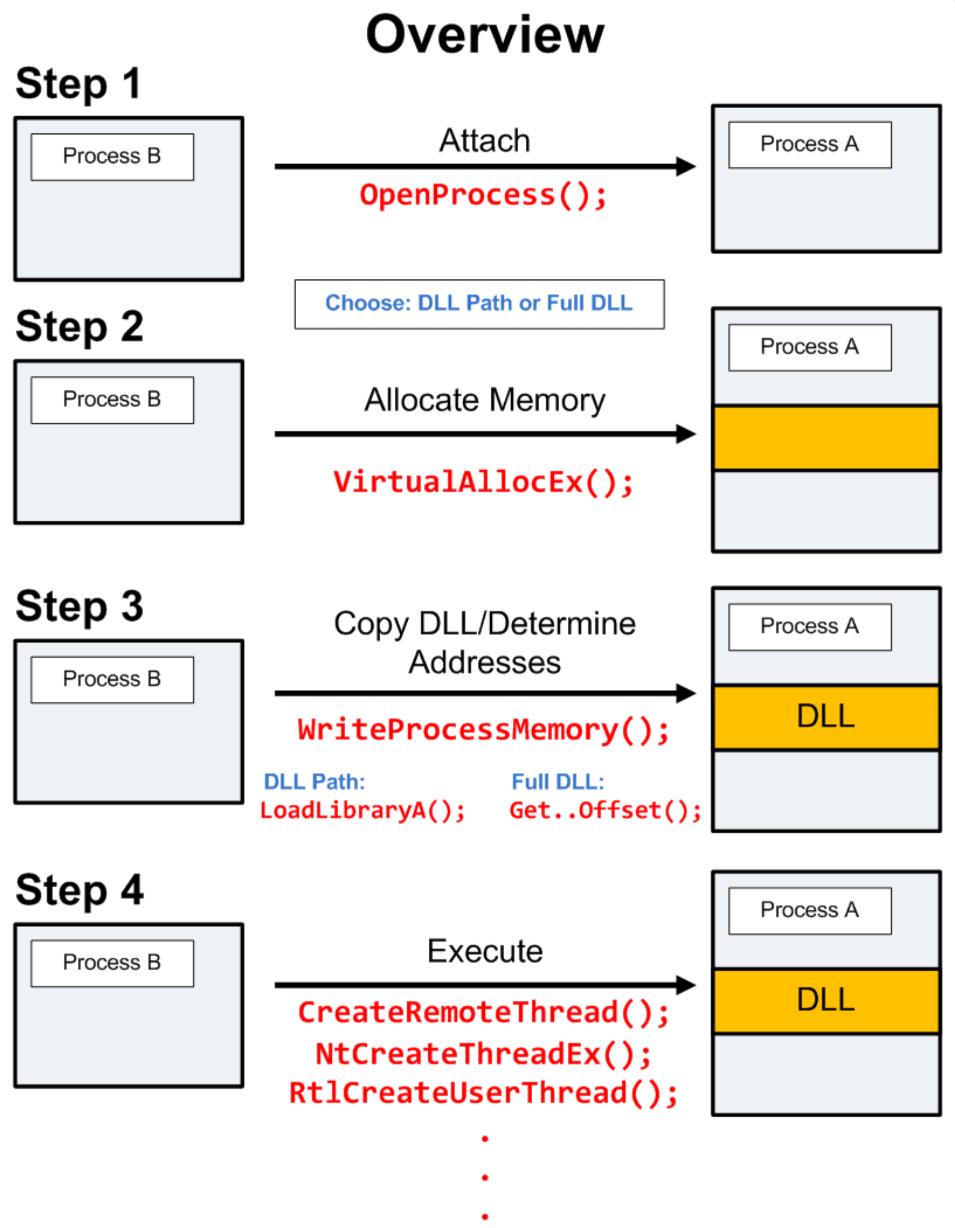
- Suspicious Memory Pages
- Processes
- Threads
- Sockets （Connections）
- Handles （Files）
- Modules／Libraries
- Mutexes
- LSA （Local Security Authority）
- Registry
- …

Memory Pages

- Various ‘flags’
  - Read/write/executable pages
  - Helping OS to organize memory efficiently
- Executable + Writable pages
  - Why is it bad?
- **Process Injection technique**
  - Allocating a memory that can be modified (unpacked, decoded, decrypted) and executed.
  - Used by legitimate processes too (Windows OLE)

DLL/Process Injection

So that Internet Explorer behaves like a malicious process…



Overview

Step 1

Process B

Attach

OpenProcess();

Process A

Choose: DLL Path or Full DLL

Step 2

Process B

Allocate Memory

VirtualAllocEx();

Process A

Step 3

Process B

Copy DLL/Determine Addresses

WriteProcessMemory();

DLL Path:
LoadLibraryA();

Full DLL:
Get..Offset();

Process A

DLL

Step 4

Process B

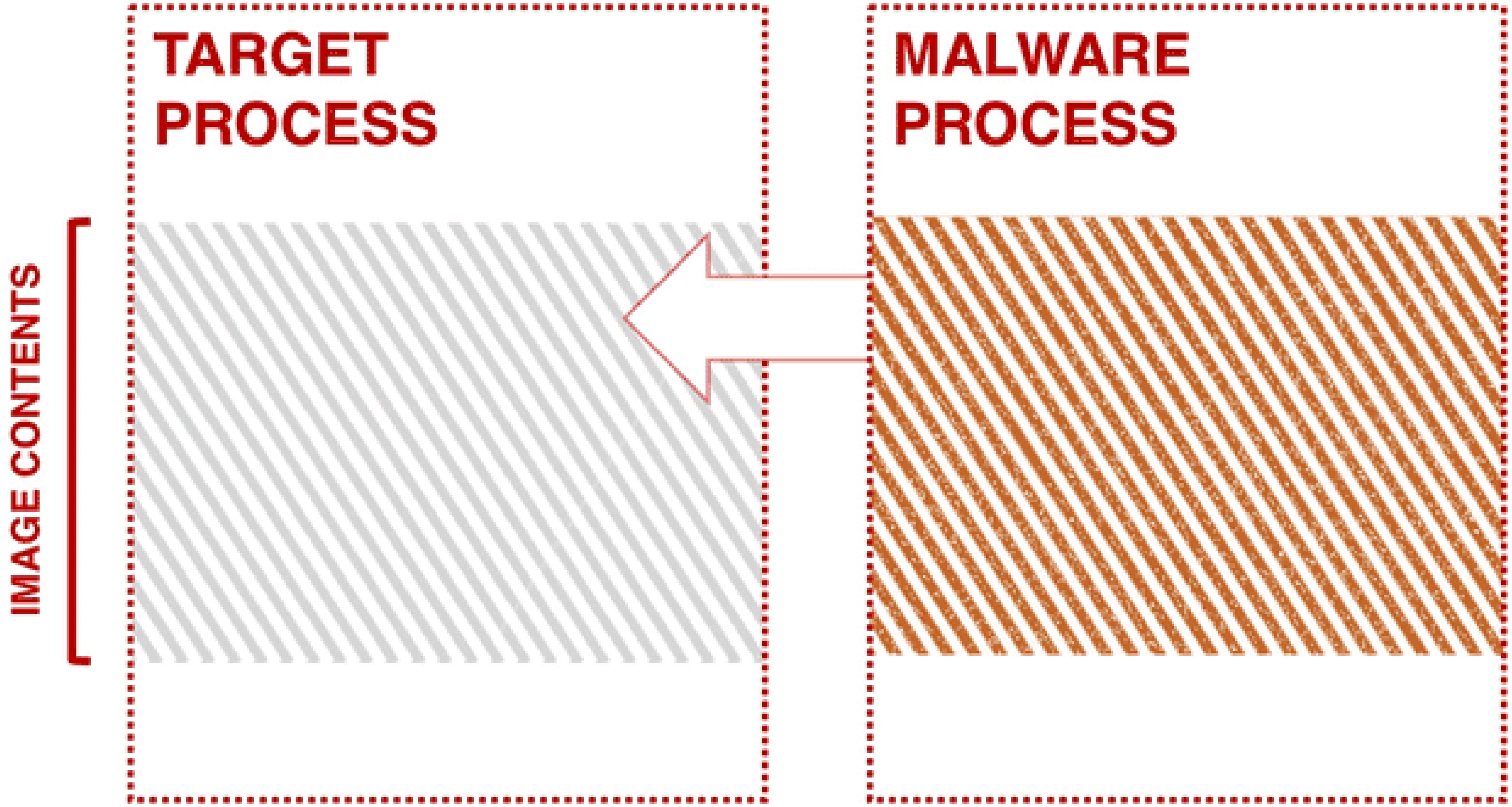
Execute

CreateRemoteThread();
NtCreateThreadEx();
RtlCreateUserThread();
.
.
.

Process A

DLL

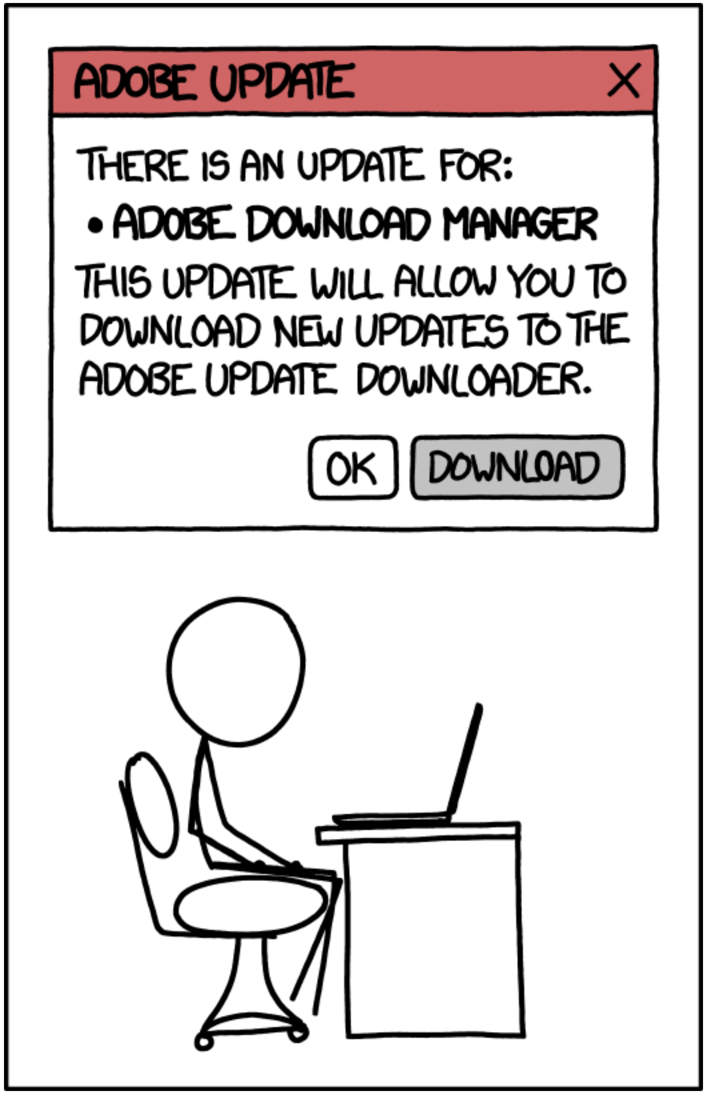
PROCESS HOLLOWING



ENDGAME.

And now something completely…

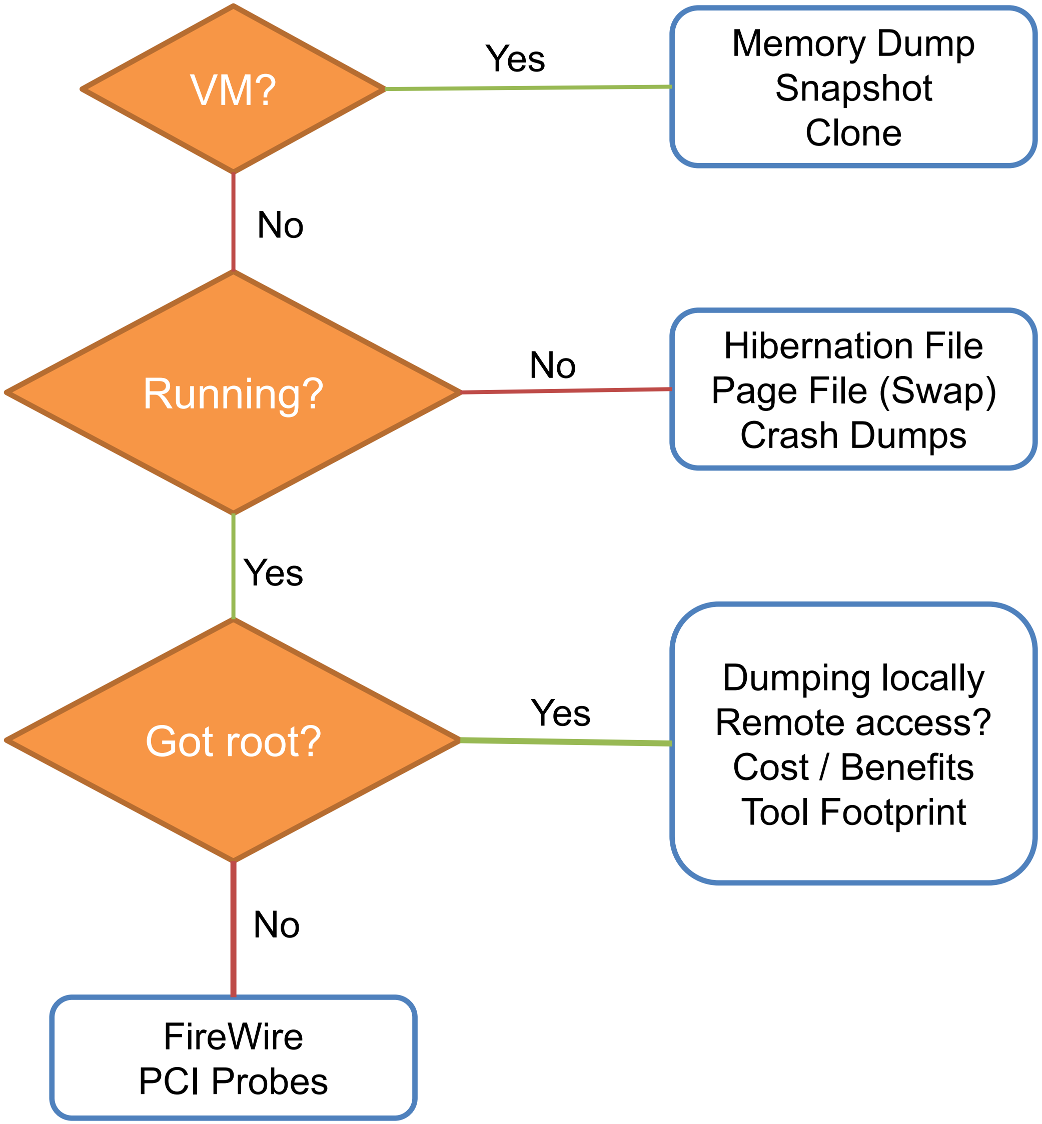
PRACTICAL


ADOBE UPDATE
X
THERE IS AN UPDATE FOR:
• ADOBE DOWNLOAD MANAGER
THIS UPDATE WILL ALLOW YOU TO DOWNLOAD NEW UPDATES TO THE ADOBE UPDATE DOWNLOADER.
OK
DOWNLOAD

Memory (re)sources

- Live RAM
  - The most common source for analysis
  - Easier to obtain from virtualized hosts
- Paging file/Swap
  - Used by operating systems to allocate more memory then available RAM
- Hibernation file
- Memory crash dumps
  - Limited analysis options

Memory Acquisition



Memory Acquisition

- **Virtual Machines**
  - VMWare, VirtualBox, …
  - `VirtualBox -dbg -startvm “MalwareVM”` (and `.pgmphystofile` command or `vboxmanage debugvm`)
- Directly from the system! (if we have permissions to do that)
  - `windd`, `fastdump`, dumpit, `memorize`, **`winpmem`**
  - Or we can hibernate the system (hiberfil.sys)
- Remotely
  - Encase Enterprise, Mandiant Intelligent Response, Access Data FTK
- Common issues
  - Unsupported OS (Linux, MacOS; 32bit/64bit)
  - Swap (portions of memory on drive)
  - Malware not running inside a virtual machine

Memory Acquisition (2)

- **Local memory acquisition** notes
  - Unless you have plenty of money, try to get root/admin access to the host
  - Better to acquire to external storage (USB, network)
  - The lower tool's memory footprint, the better
  - If you run malware in VM, better have less RAM
    - Faster analysis
    - .. And configure no swap for the system too
    - However: malware can check for the available memory

Memory Acquisition （3）

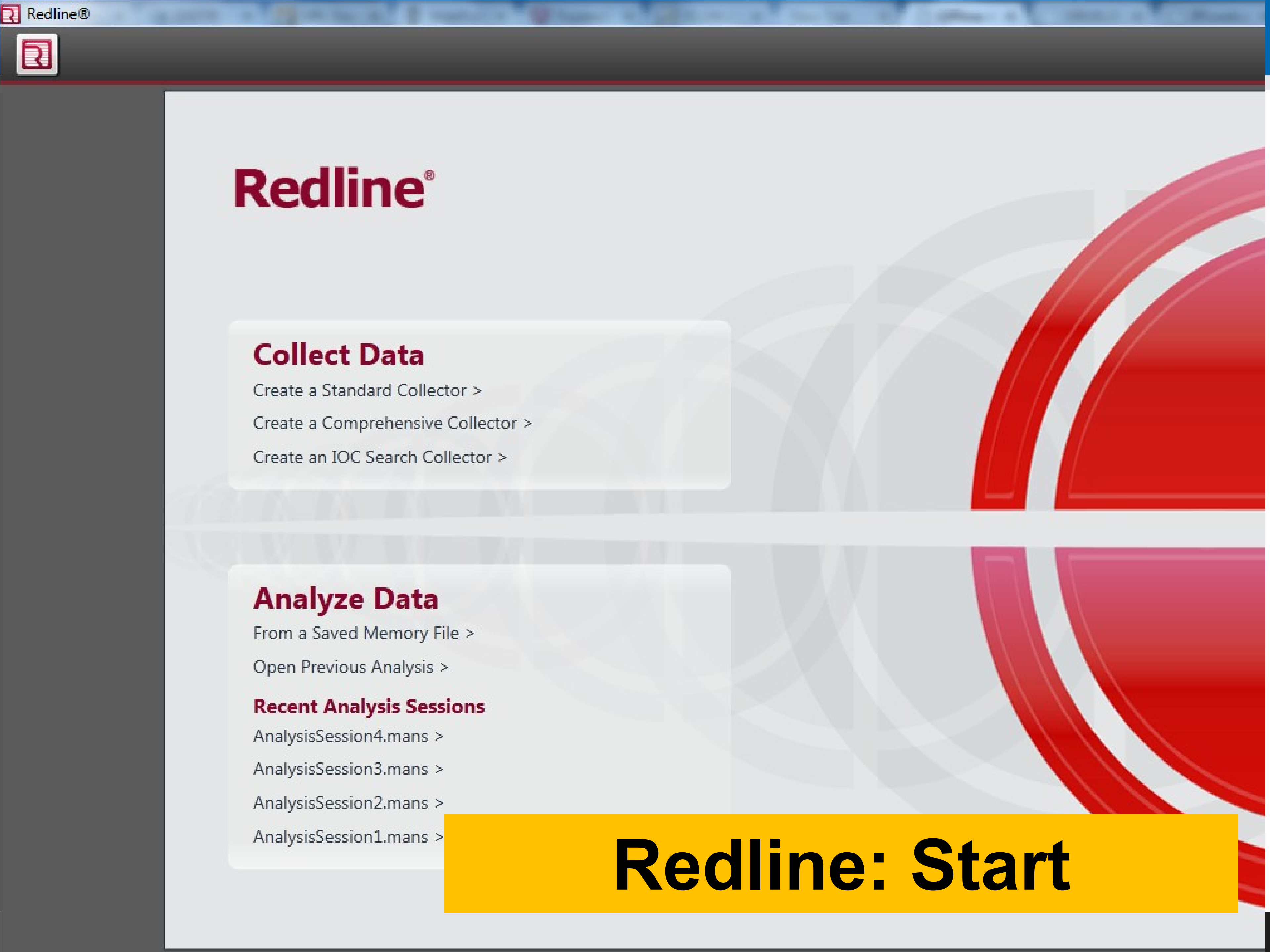
- **Remote memory acquisition**
  - Very useful for fast Incident Response
  - Requires enterprise licenses for the commercial tools
  - Acquisition is done over network
  - Agents already in memory, no extra memory demands
- Open source alternative？
  - GRR （Google Rapid Response）
    - Still in development, primarily Incident Response tool
    - Allows remote memory acquisition
  - Rekall （still a beta）

Memory Analysis Tools

- Mandiant Redline
  - Free, available for Windows
- HBGary/CounterTack Responder (CE/Pro)
  - Community Edition available against registration
- **Volatility Framework**
  - Open source, no GUI
- Google Rekall
  - Open source, 'Volatility done right', GUI
  - Google supported (part of GRR agent)

Mandiant/FireEye Redline

- Free tool for Incident Response
  - Not open-source, though
  - .NET executable (runs only under Windows)
- Nice and simple user interface
  - Very nice analysis workflow
  - Perfect for searching for string information
  - Rates the level of suspiciousness over processes
- Sad things
  - Memory analysis not reliable, process rating as well



Redline: Start

Redline®

Redline®

Collect Data

Create a Standard Collector >

Create a Comprehensive Collector >

Create an IOC Search Collector >

Analyze Data

From a Saved Memory File >

Open Previous Analysis >

Recent Analysis Sessions

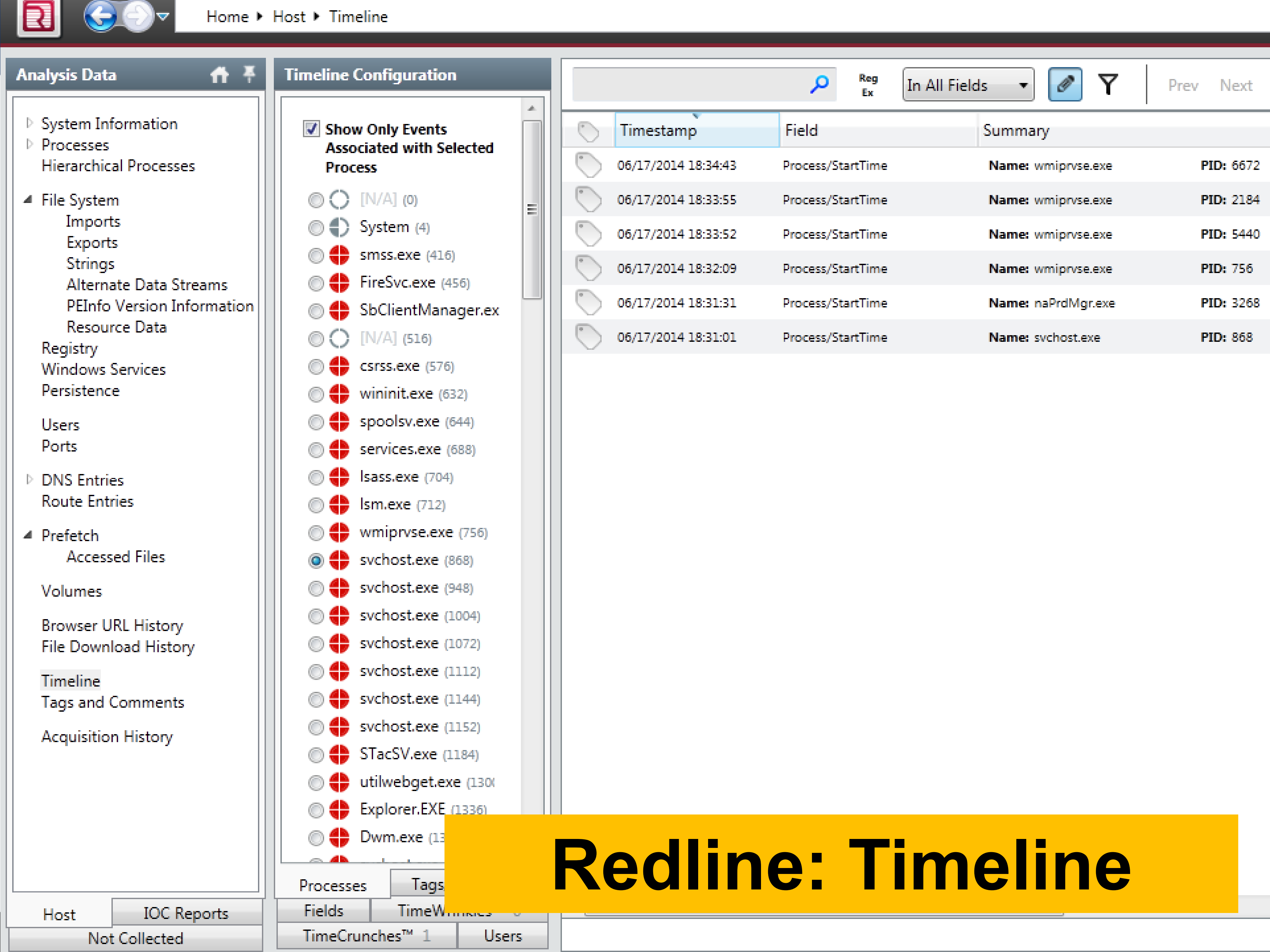
AnalysisSession4.mans >

AnalysisSession3.mans >

AnalysisSession2.mans >

AnalysisSession1.mans >

Redline: Timeline

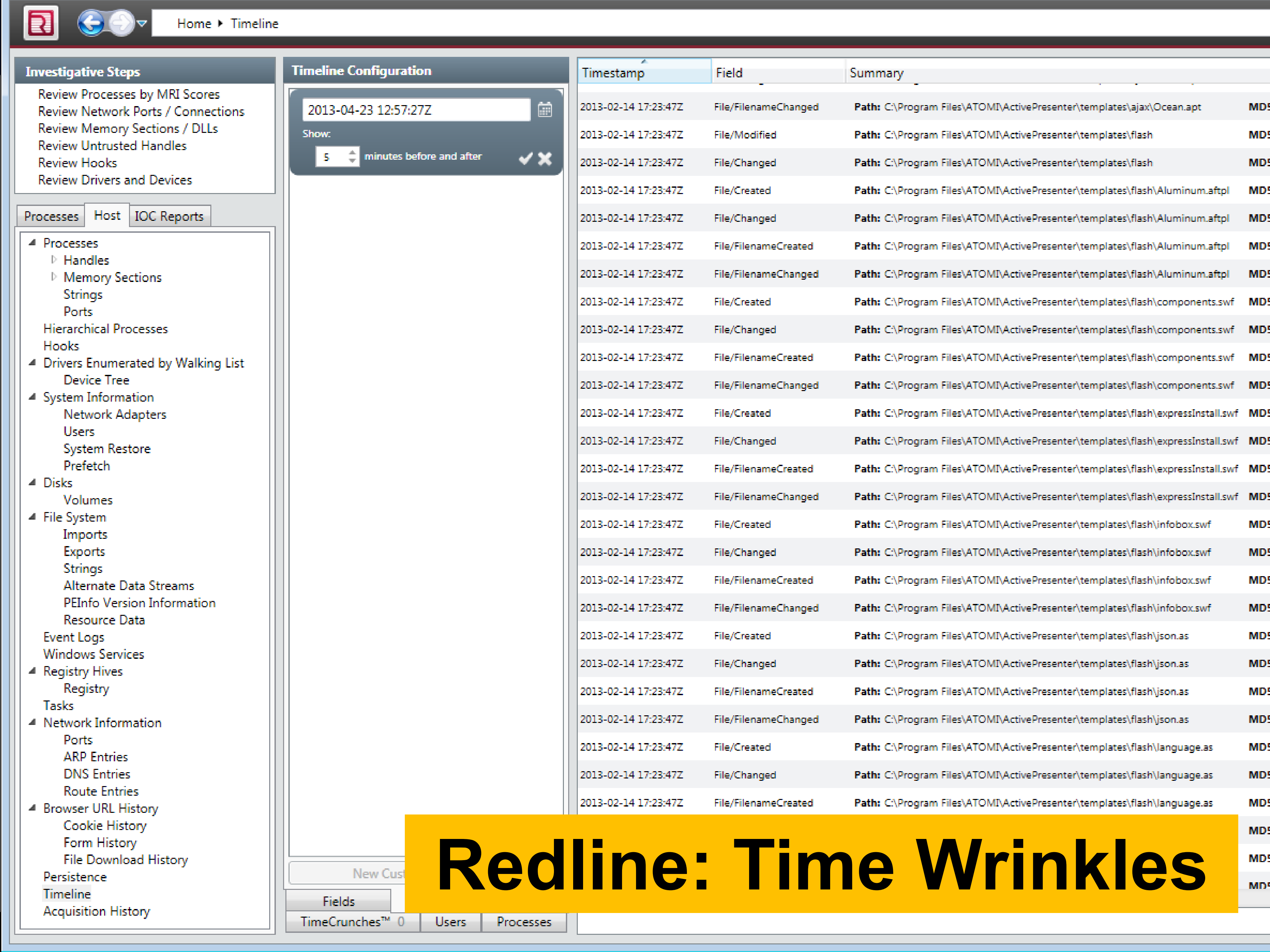


☑ Show Only Events Associated with Selected Process

- ○ [N/A] (0)
- ○ System (4)
- ○ smss.exe (416)
- ○ FireSvc.exe (456)
- ○ SbClientManager.ex
- ○ [N/A] (516)
- ○ csrss.exe (576)
- ○ wininit.exe (632)
- ○ spoolsv.exe (644)
- ○ services.exe (688)
- ○ lsass.exe (704)
- ○ lsm.exe (712)
- ○ wmiprvse.exe (756)
- ● svchost.exe (868)
- ○ svchost.exe (948)
- ○ svchost.exe (1004)
- ○ svchost.exe (1072)
- ○ svchost.exe (1112)
- ○ svchost.exe (1144)
- ○ svchost.exe (1152)
- ○ STacSV.exe (1184)
- ○ utilwebget.exe (130
- ○ Explorer.EXE (1336)
- ○ Dwm.exe (13

Timestamp	Field	Summary	
06/17/2014 18:34:43	Process/StartTime	**Name:** wmiprvse.exe	**PID:** 6672
06/17/2014 18:33:55	Process/StartTime	**Name:** wmiprvse.exe	**PID:** 2184
06/17/2014 18:33:52	Process/StartTime	**Name:** wmiprvse.exe	**PID:** 5440
06/17/2014 18:32:09	Process/StartTime	**Name:** wmiprvse.exe	**PID:** 756
06/17/2014 18:31:31	Process/StartTime	**Name:** naPrdMgr.exe	**PID:** 3268
06/17/2014 18:31:01	Process/StartTime	**Name:** svchost.exe	**PID:** 868

Redline: Time Wrinkles



2013-04-23 12:57:27Z

Show: 5 minutes before and after

Timestamp	Field	Summary	
2013-02-14 17:23:47Z	File/FilenameChanged	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\ajax\Ocean.apt	MD5
2013-02-14 17:23:47Z	File/Modified	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash	MD5
2013-02-14 17:23:47Z	File/Changed	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash	MD5
2013-02-14 17:23:47Z	File/Created	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\Aluminum.aftpl	MD5
2013-02-14 17:23:47Z	File/Changed	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\Aluminum.aftpl	MD5
2013-02-14 17:23:47Z	File/FilenameCreated	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\Aluminum.aftpl	MD5
2013-02-14 17:23:47Z	File/FilenameChanged	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\Aluminum.aftpl	MD5
2013-02-14 17:23:47Z	File/Created	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\components.swf	MD5
2013-02-14 17:23:47Z	File/Changed	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\components.swf	MD5
2013-02-14 17:23:47Z	File/FilenameCreated	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\components.swf	MD5
2013-02-14 17:23:47Z	File/FilenameChanged	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\components.swf	MD5
2013-02-14 17:23:47Z	File/Created	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\expressInstall.swf	MD5
2013-02-14 17:23:47Z	File/Changed	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\expressInstall.swf	MD5
2013-02-14 17:23:47Z	File/FilenameCreated	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\expressInstall.swf	MD5
2013-02-14 17:23:47Z	File/FilenameChanged	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\expressInstall.swf	MD5
2013-02-14 17:23:47Z	File/Created	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\infobox.swf	MD5
2013-02-14 17:23:47Z	File/Changed	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\infobox.swf	MD5
2013-02-14 17:23:47Z	File/FilenameCreated	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\infobox.swf	MD5
2013-02-14 17:23:47Z	File/FilenameChanged	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\infobox.swf	MD5
2013-02-14 17:23:47Z	File/Created	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\json.as	MD5
2013-02-14 17:23:47Z	File/Changed	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\json.as	MD5
2013-02-14 17:23:47Z	File/FilenameCreated	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\json.as	MD5
2013-02-14 17:23:47Z	File/FilenameChanged	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\json.as	MD5
2013-02-14 17:23:47Z	File/Created	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\language.as	MD5
2013-02-14 17:23:47Z	File/Changed	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\language.as	MD5
2013-02-14 17:23:47Z	File/FilenameCreated	**Path:** C:\Program Files\ATOMI\ActivePresenter\templates\flash\language.as	MD5
			MD5
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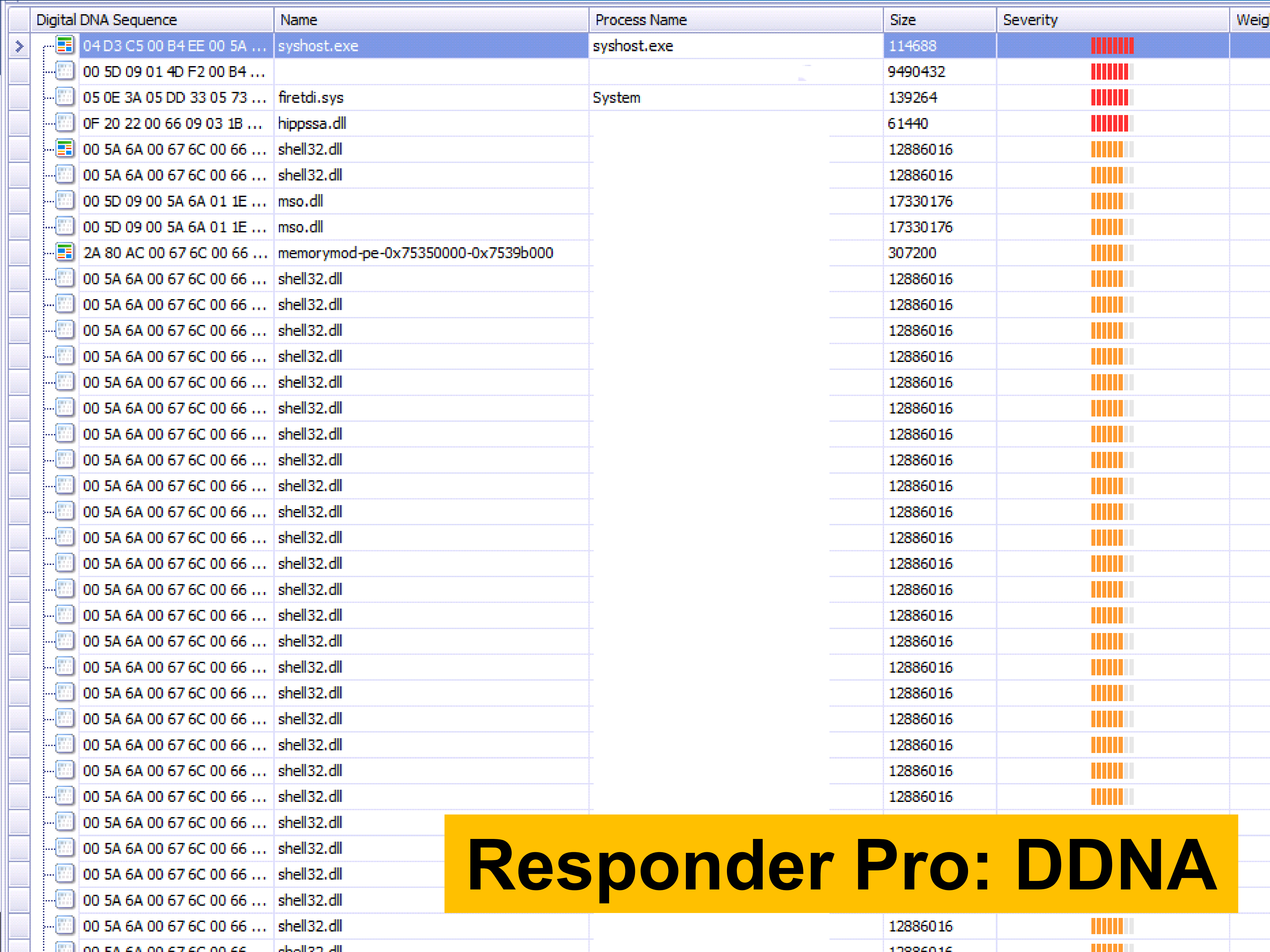
			MD5

HBGary Responder (Pro/CE)

- Professional Tool
  - Very expensive
  - Yet not very well maintained in the last few years
- Windows only
  - .NET written, supports only Windows images
- ‘Killer’ features
  - Digital DNA
    - automatic rating of suspicious processes
  - Visual ‘Canvas’ debugger
- Supports the analysis of (unpacked) binaries
- Replaced with CounterTack Responder Pro

HBGary Responder Pro －－ DDNA

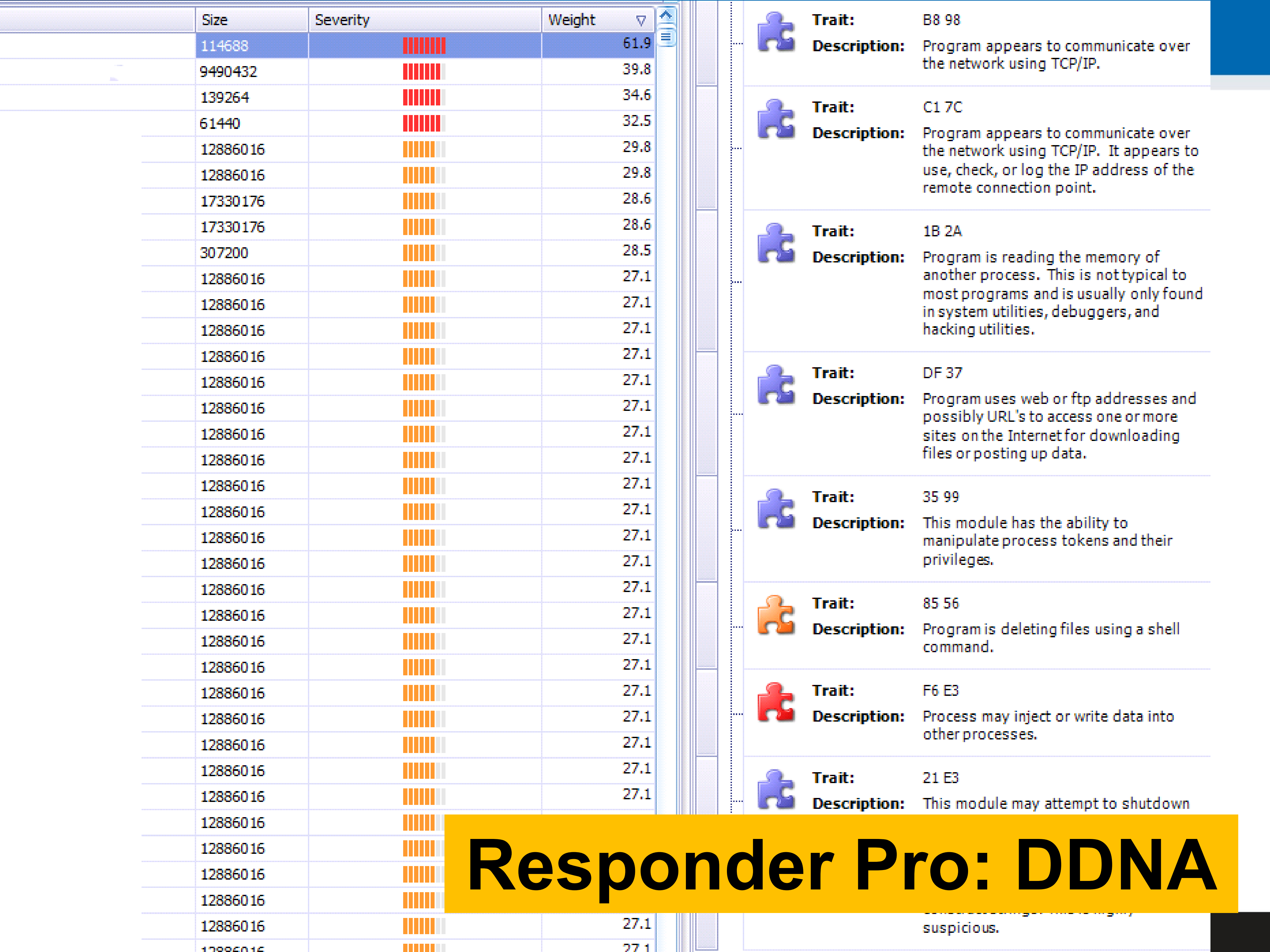
- Examples of the ‘reasoning’ behind DDNA
  - Does the process communicate over TCP／IP？
  - Does it manipulate with registry？
  - Did the analysis reveal any known bad stuff （strings， IPs， mutexes？）
  - Does the process access any other process in the system？
  - Does it access some system－critical process？
  - Did the analysis find any evidence of obfuscation？



Digital DNA Sequence	Name	Process Name	Size	Severity	Weig
04 D3 C5 00 B4 EE 00 5A …	syshost.exe	syshost.exe	114688		
00 5D 09 01 4D F2 00 B4 …			9490432		
05 0E 3A 05 DD 33 05 73 …	firetdi.sys	System	139264		
0F 20 22 00 66 09 03 1B …	hippssa.dll		61440		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5D 09 00 5A 6A 01 1E …	mso.dll		17330176		
00 5D 09 00 5A 6A 01 1E …	mso.dll		17330176		
2A 80 AC 00 67 6C 00 66 …	memorymod-pe-0x75350000-0x7539b000		307200		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66 …	shell32.dll				
00 5A 6A 00 67 6C 00 66 …	shell32.dll				
00 5A 6A 00 67 6C 00 66 …	shell32.dll				
00 5A 6A 00 67 6C 00 66 …	shell32.dll				
00 5A 6A 00 67 6C 00 66 …	shell32.dll		12886016		
00 5A 6A 00 67 6C 00 66	shell32.dll		12886016		

Responder Pro: DDNA

Responder Pro: DDNA



Size	Severity	Weight
114688	🟥	61.9
9490432	🟥	39.8
139264	🟥	34.6
61440	🟥	32.5
12886016	🟧	29.8
12886016	🟧	29.8
17330176	🟧	28.6
17330176	🟧	28.6
307200	🟧	28.5
12886016	🟧	27.1
12886016	🟧	27.1
12886016	🟧	27.1
12886016	🟧	27.1
12886016	🟧	27.1
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12886016	🟧	
12886016	🟧	
12886016	🟧	
12886016	🟧	27.1
12886016	🟧	27.1

Trait: B8 98
Description: Program appears to communicate over the network using TCP/IP.

Trait: C1 7C
Description: Program appears to communicate over the network using TCP/IP. It appears to use, check, or log the IP address of the remote connection point.

Trait: 1B 2A
Description: Program is reading the memory of another process. This is not typical to most programs and is usually only found in system utilities, debuggers, and hacking utilities.

Trait: DF 37
Description: Program uses web or ftp addresses and possibly URL's to access one or more sites on the Internet for downloading files or posting up data.

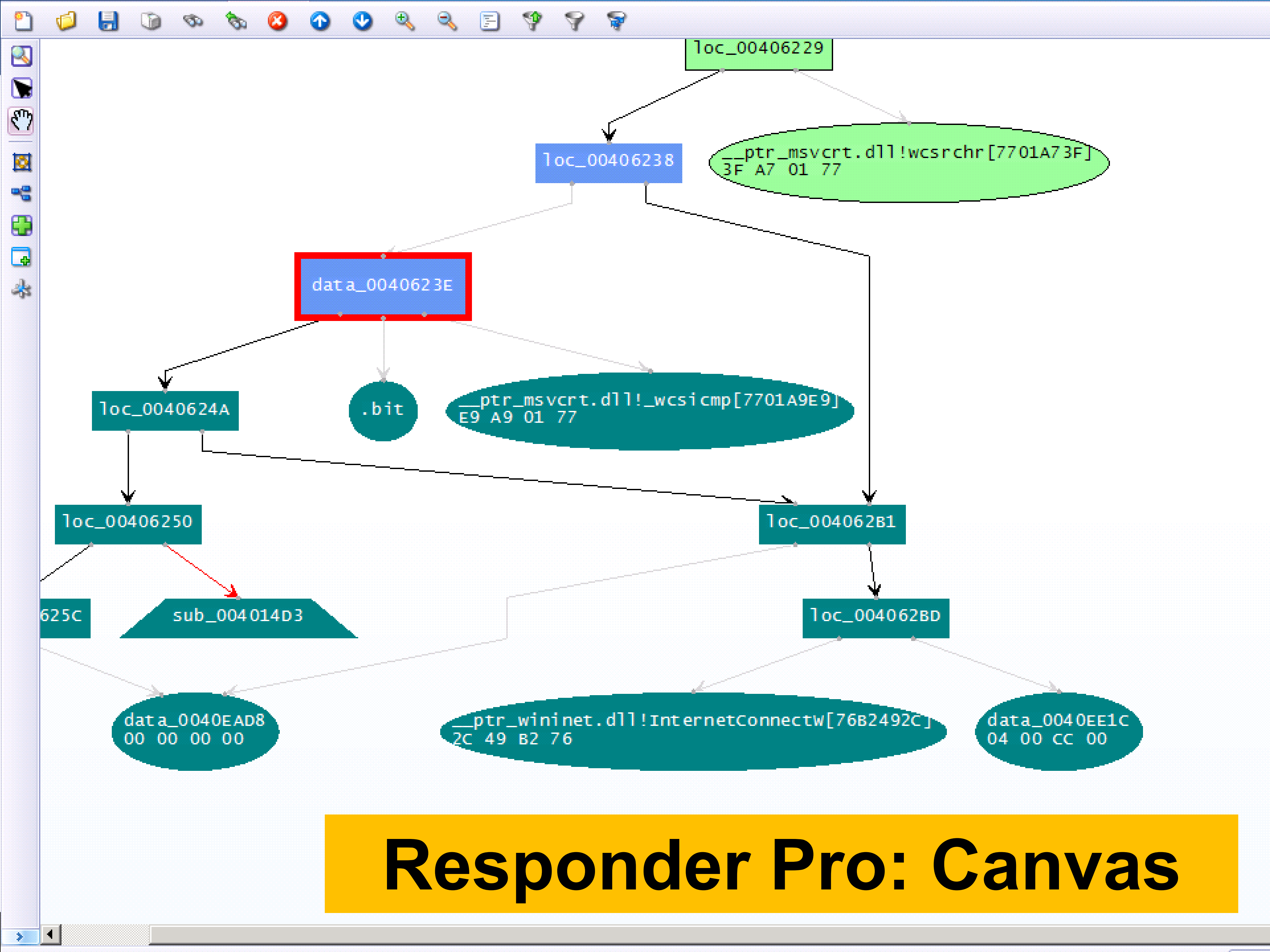
Trait: 35 99
Description: This module has the ability to manipulate process tokens and their privileges.

Trait: 85 56
Description: Program is deleting files using a shell command.

Trait: F6 E3
Description: Process may inject or write data into other processes.

Trait: 21 E3
Description: This module may attempt to shutdown

suspicious.



Responder Pro: Canvas

Volatility Framework

- Open source tool
  - GPL licensed
- Written in Python
  - Available for variety of platforms (Linux, Windows, Mac OS)
  - Can be automated; many contributed plugins
- Supports analysis of memory dumps from various OSs
  - Windows, Linux, MacOS, Android
  - Both 32-bit and 64-bit versions
- Command-line driven
- Two (experimental) web GUIs

Google Rekall

- Another open source tool
- Supported by Google
  - Included as a part of GRR (Google Rapid Response) agent
- Originally based on the code of Volatility
  - Shared commands
  - Different architectural concepts
- Proof-of-concept GUI
  - Better workflows

Additional Important Tools

- **Strings**
  - Both *nix and Windows
  - Extracts strings information from the file
  - Can be used in cooperation with Volatility/Rekall
  - Beware of text encoding! (ascii, utf-8, …)
- **Foremost**
  - Forensic tool
  - Can extract various data files from an image (or process)
    - Images, executables, documents, …

Forensic analysis of RAM？

- Are there any benefits？
- Collecting forensic evidence
  - Executable images
  - PDF/Doc documents
    - Possible origin of the infection？
  - Images
  - URLs
- Getting approximate timeline
  - Works better on servers （always online， higher uptime， way more RAM）

What to search for in Operating System?

- Command & Control (C2) communication
- Hidden processes
- Process/DLL injection evidence
- Non-standard/infamous binaries/mutexes
- Open sockets and files
- Registry records
- Command-line history
- Encryption keys!

Known Bad Mutexes

- *Conficker*: `.*-7 and .*-99`
- *Sality.AA*: `Op1mutx9`
- *Flystud.??*: `Hacker.com.cn_MUTEX`
- *NetSky*: `'D'r'o'p'p'e'd'S'k'y'N'e't'`
- *Sality.W*: `u_joker_v3.06`
- *Poison Ivy*: `)!VoqA.I4` (and 10 thousand others)
- *Koobface*: `35fsdfsdfgfd5339`

Known Good Processes/Locations

Process Name	Expected Path
lsass.exe	\windows\system32
services.exe	\windows\system32
csrss.exe	\windows\system32
explorer.exe	\windows
spoolsv.exe	\windows\system32
smss.exe	\windows\system32
svchost.exe	\windows\system32
iexplore.exe	\program files \program files (x86)
winlogon.exe	\windows\system32

Operational Security (OpSec)

- Basics of OpSec
  - “Think before you act” mentality
  - Limited information sharing
- Specifics of memory analysis
  - You can often upload acquired executables to VirusTotal
    - MD5/SHA1 of the dump is different from the executable
    - This doesn’t apply for documents/HTML pages!
  - **However, incomplete binaries still can infect your system!**
    - Running in VM or other OS is recommended

Recommended Analysis Process

- **Use Internet!** (Google, VirusTotal, ...)
- **Make notes!**
  - What OS is being analyzed? (imageinfo)
  - Network connections? (+ whois records, ...)
  - Processes (hidden, odd, non-standard; timestamps, ...)
  - Mutexes (+ files open)
  - Dump processes when needed (OpSec!)
  - Strings (URIs, C-like strings %s %d, domains, ...)
- **Summarize your findings in final report**

More information

- Web pages of this course
  - https://dior.ics.muni.cz/~valor/pv204
- **Additional resources**
  - Public memory images for analysis
  - Reverse Engineering for Beginners (amazing PDF doc)
  - REMnux: All you need to start with RE
  - ContagioDump blog (for additional malware samples)
  - Malware Traffic Analysis (both traffic & samples)

Thank you for your attention.

Answers & Questions

LAB

Lab Requirements

- Oracle VirtualBox
  - And enough space on your hard drive (12 GB at least)
- **Volatility Framework**
- Mandiant Redline
- Unix tools
  - `strings`, `foremost`
- Your favorite text editor for notes
- Javascript/PDF analysis tools

Recommended Analysis Process

- **Use Internet!** (Google, VirusTotal, …)
- **Make notes!**
  - What OS is being analyzed?
  - Network connections? (+ whois records, …)
  - Processes (hidden, odd, non-standard; timestamps, …)
  - Mutexes (+ files open)
  - Strings (URIs, C-like strings %s %d, domains, …)
  - …
- **Summarize your findings in final report**

Volatility Framework – cheat sheet

- psxview (search for hidden processes)
- apihooks
- driverscan
- ssdt / driverirp / idt
- connections / connscan (WinXP, active network connections)
- netscan (Win7, opened network sockets and connections)
- pslist / psscan (process listing from WinAPI vs. EPROCESS blocks)
- malfind / ldrmodules (code injection + dump / DLL detection)
- hivelist (registry lookup and parsing) / hashdump
- handles / dlllist / filescan (filelist / DLL files / FILE_OBJECT handles)
- cmdscan / consoles (cmd.exe history / console buffer)
- shimcache (application compatibility info)
- memdump / procmemdump / procexedump

Analysis: xp-infected.vmem

- Recommended tools
  - Volatility, Rekall (or Redline)
- Objectives:
  - Get familiar with memory of your first infected system

Analysis: win7_x64.vmem

- Recommended tools
  - Volatility, Rekall (or Redline)
- Objectives:
  - Get familiar with memory of Win7 x64 system
  - Can you see any differences from the previous sample?

Analysis: zeus.vmem

- Recommended tools
  - Volatility, Rekall
- Objectives:
  - Find suspicious network connections
  - Find process responsible for the network activity
  - Can you figure out what infections this

Analysis： zeus2x4.vmem

- Recommended tools
  - Volatility， Rekall
- Objectives：
  - Find suspicious network connections
  - Find process responsible for the network activity
  - Can you figure out what infections this
  - Can you dump the virus configuration？

Analysis： bob.vmem

- Recommended tools
  - Volatility， Rekall， Foremost， Strings
- Objectives：
  - Find suspicious network connections
  - Find process responsible for the network activity
  - Can you figure out what caused the infection？
  - Can you dump the initial source vector？
  - What known vulnerability （CVE） has been exploited？

More information

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Answers & Questions