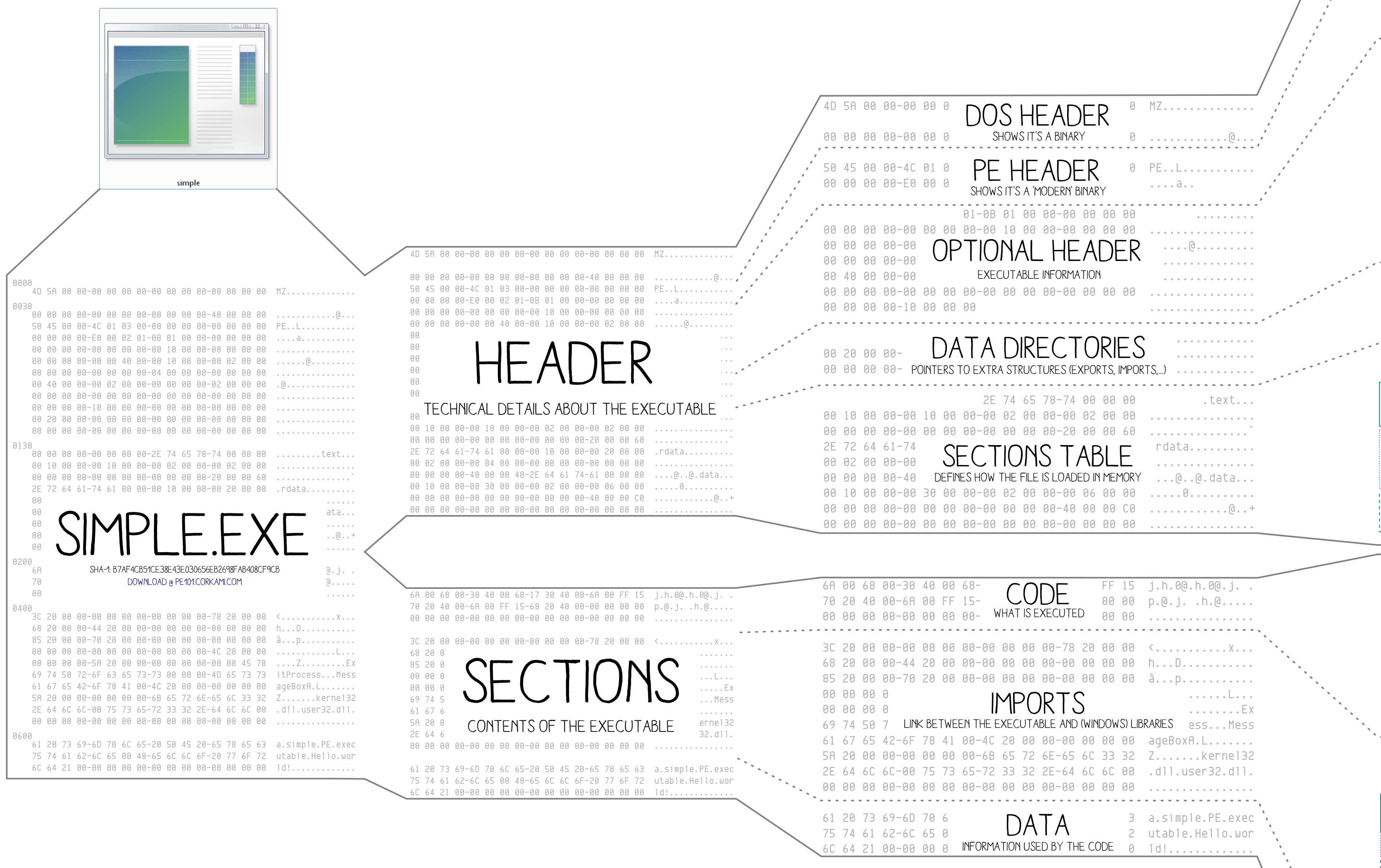
PE 101 a windows executable walkthrough

PORTABLE EXECUTABLE

V2.0L, 5TH DECEMBER 2012

ANGE ALBERTINI
CORKAMI.COM

DISSECTED PE


simple
SIMPLE.EXE
SHA-1: B7AF4CB51CE38E43E030656EB2698FAB408CF9CB
DOWNLOAD @ PE101.CORKAMI.COM
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 / FIELDS / VALUES / EXPLANATION

```
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  ............@...
```

FIELDS	VALUES	EXPLANATION
e_magic	'MZ'	CONSTANT SIGNATURE
e_lfanew	0x40	OFFSET OF THE PE HEADER 1

```
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
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.

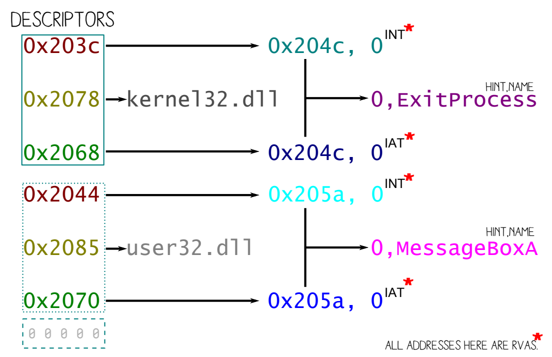
```
Offset:0x200/RVA:0x401000
6A 00 68 00-30 40 00 68-17 30 40 00-6A 00 FF 15  j.h.0@.h.0@.j. .
70 20 40 00-6A 00 FF 15-68 20 40 00              p.@.j. .h.@.
```

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

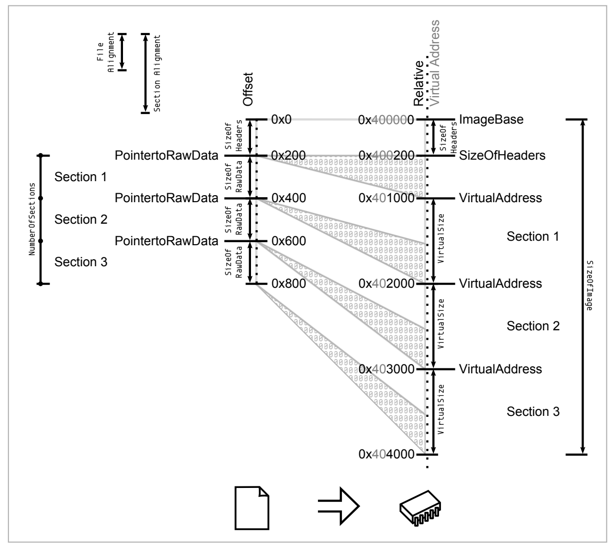
THE *DOS HEADER* IS PARSED
THE *PE HEADER* IS PARSED
(ITS OFFSET IS *DOS HEADER'S E_LFANEW*)
THE *OPTIONAL HEADER* IS PARSED
(IT FOLLOWS THE *PE HEADER*)

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*

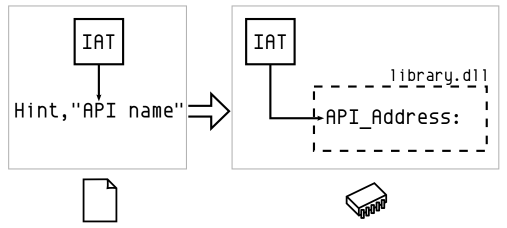
3 MAPPING

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



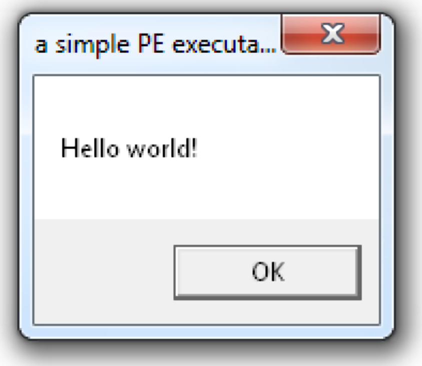
4 IMPORTS

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


a simple PE executa...

Hello world!

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
INDEX IN THE EXPORTS TABLE OF A DLL TO BE IMPORTED
NOT REQUIRED BUT PROVIDES A SPEED-UP BY REDUCING LOOK-UP