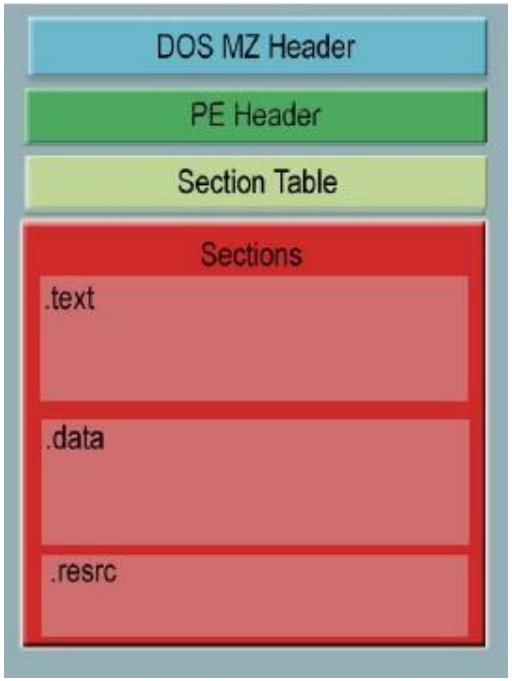
Class 11

# CSC 471 Modern Malware Analysis
# PE Structure (1)

Si Chen (schen@wcupa.edu)

# Portable Executable (PE) file

- A Portable Executable (**PE**) **file** is the standard binary **file** format for an **Executable (.exe) or DLL** under Windows NT, Windows 95, and Win32.
- Derived from COFF (Common Object File Format) in UNIX platform, and it is not really “portable”.



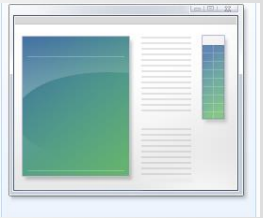

Now here is the kicker. Even though this specification is spelled out by Microsoft, compilers/linkers chose to ignore some parts of it.

To make things even worse, the Microsoft loader doesn't enforce a good portion of this specification and instead makes assumptions if things start getting weird.

So even though the spec outlined here says a particular field is supposed to hold a certain value, the compiler/linker or **even a malicious actor could put whatever they want in there and the program will likely still run.**..

# Portable Executable (PE) file

- PE formatted files include:
  - .exe, .scr (executable)
  - .dll, .ocx, .cpl, drv (library)
  - .sys, .vxd (driver files)
  - .obj (objective file)

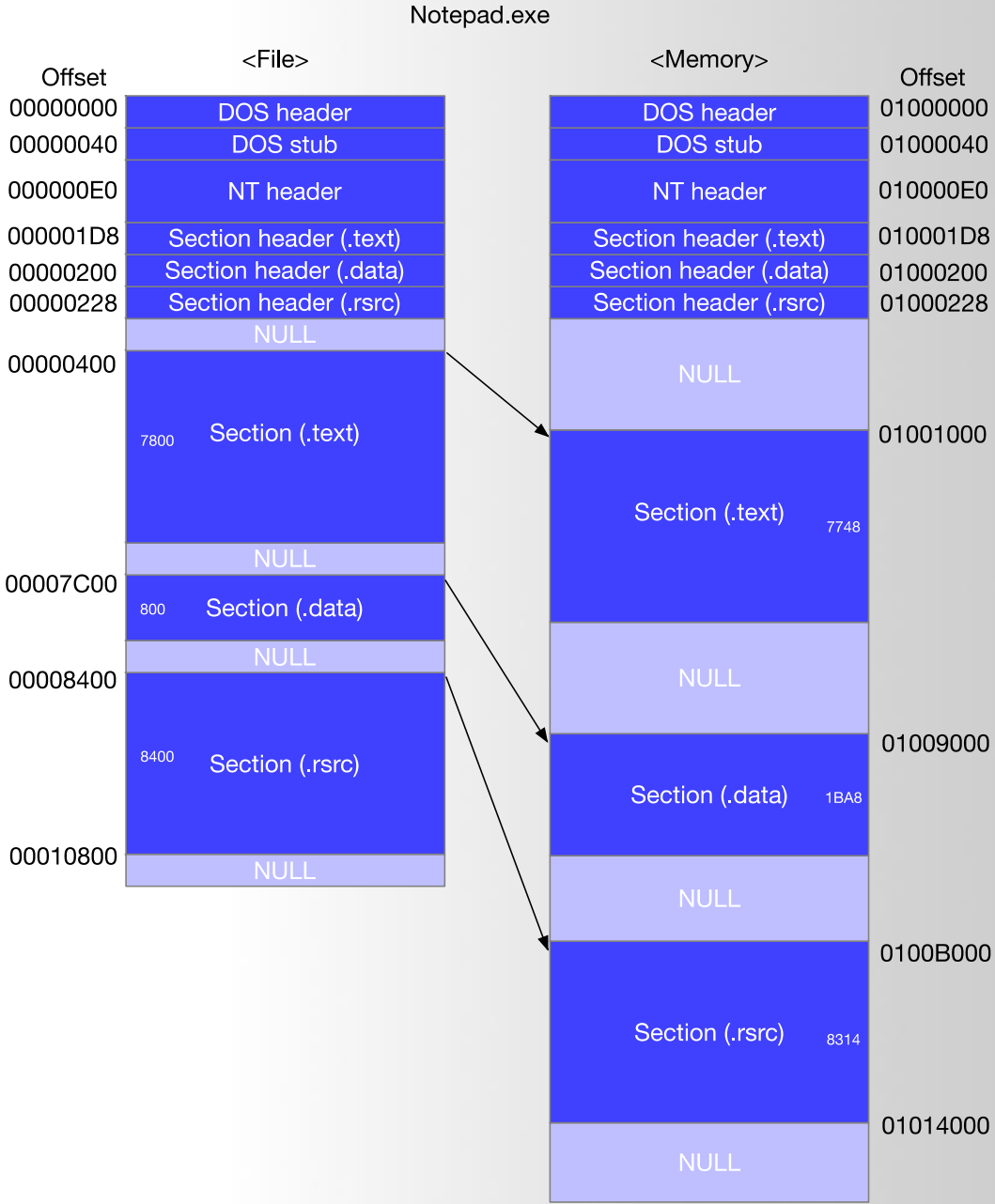


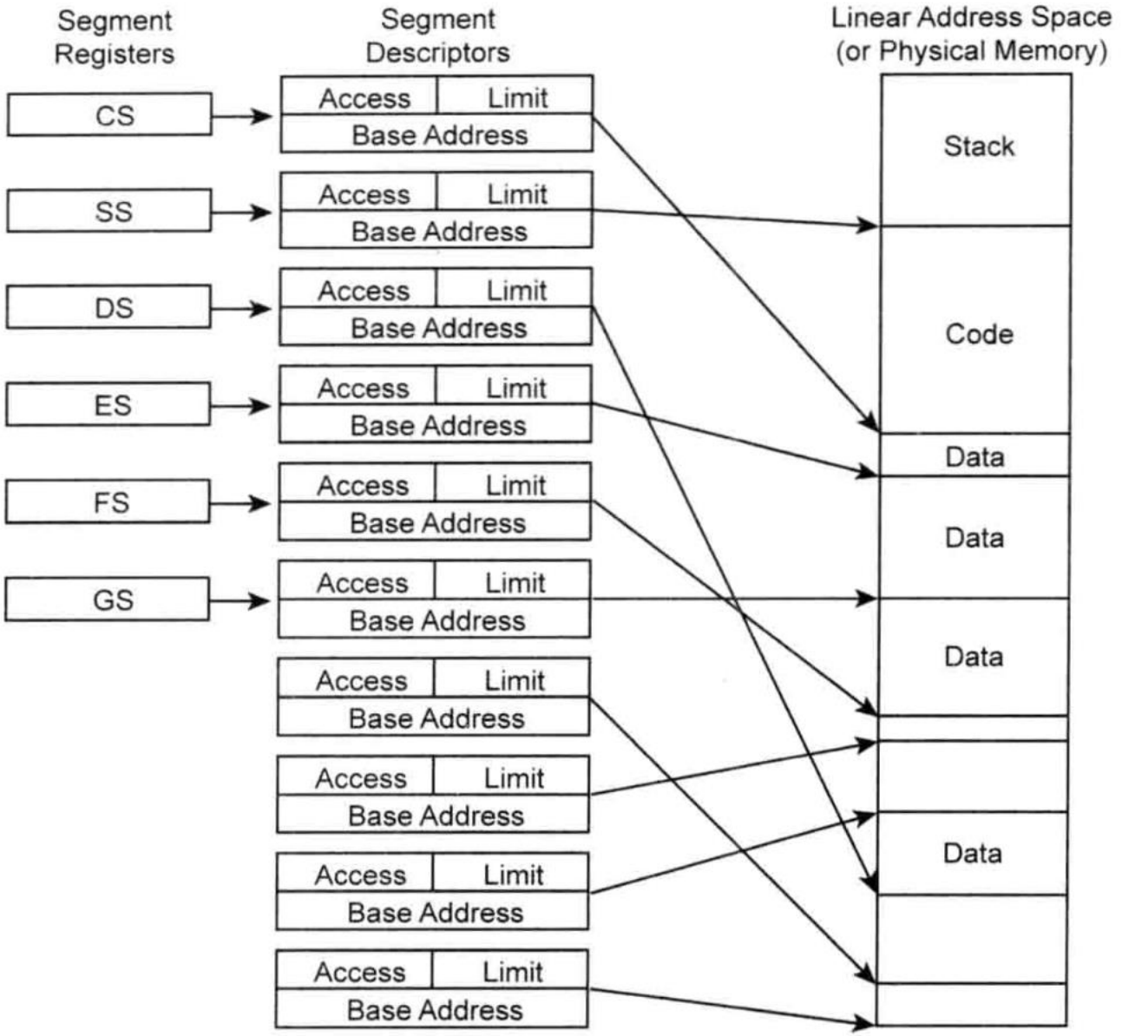
- All PE formatted files can be executed, except obj file.
  - .exe, .scr can be directly executed inside Shell (explorer.exe)
  - others can be executed by other program/service
- **PE refers to 32 bit** executable file, or **PE32**. **64 bit** executable file is named as **PE+ or PE32+.** (Note that it is not PE64).

# PE Example – Notepad.exe

```
00000000  4D 5A 90 00 03 00 00 00  04 00 00 00 FF FF 00 00  MZÉ.........  ..
00000010  B8 00 00 00 00 00 00 00  40 00 00 00 00 00 00 00  ╕.......@.......
00000020  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00000030  00 00 00 00 00 00 00 00  00 00 00 00 E8 00 00 00  ............Φ...
00000040  0E 1F BA 0E 00 B4 09 CD  21 B8 01 4C CD 21 54 68  ..╢..┤.=!╕.L=!Th
00000050  69 73 20 70 72 6F 67 72  61 6D 20 63 61 6E 6E 6F  is.program.canno
00000060  74 20 62 65 20 72 75 6E  20 69 6E 20 44 4F 53 20  t.be.run.in.DOS.
00000070  6D 6F 64 65 2E 0D 0D 0A  24 00 00 00 00 00 00 00  mode....$.......
00000080  A5 6D 16 9B E1 0C 78 C8  E1 0C 78 C8 E1 0C 78 C8  Ñm.¢ß.x╚ß.x╚ß.x╚
00000090  1B 2F 38 C8 E0 0C 78 C8  E1 0C 78 C8 E0 0C 78 C8  ./8╚α.x╚ß.x╚α.x╚
000000A0  1B 2F 61 C8 F2 0C 78 C8  E1 0C 79 C8 23 0C 78 C8  ./a╚≥.x╚ß.y╚#.x╚
000000B0  76 2F 3D C8 E0 0C 78 C8  3B 2F 64 C8 F2 0C 78 C8  v/=╚α.x╚;/d╚≥.x╚
000000C0  1B 2F 45 C8 E0 0C 78 C8  52 69 63 68 E1 0C 78 C8  ./E╚α.x╚Richß.x╚
000000D0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
000000E0  00 00 00 00 00 00 00 00  50 45 00 00 4C 01 03 00  ........PE..L...
000000F0  0D 84 7D 3B 00 00 00 00  00 00 00 00 E0 00 0F 01  .ä};........α...
00000100  0B 01 07 00 00 6E 00 00  00 A6 00 00 00 00 00 00  .....n...ª......
00000110  E0 6A 00 00 00 10 00 00  00 80 00 00 00 00 00 01  αj.......Ç......
00000120  00 10 00 00 00 02 00 00  05 00 01 00 05 00 01 00  ................
00000130  04 00 00 00 00 00 00 00  00 30 01 00 00 04 00 00  .........0......
00000140  55 D8 01 00 02 00 00 80  00 00 04 00 00 10 01 00  U╪.....Ç........
00000150  00 00 10 00 00 10 00 00  00 00 00 00 10 00 00 00  ................
00000160  00 00 00 00 00 00 00 00  20 6D 00 00 C8 00 00 00  .........m..╚...
00000170  00 A0 00 00 48 89 00 00  00 00 00 00 00 00 00 00  .á..Hë..........
00000180  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
00000190  40 13 00 00 1C 00 00 00  00 00 00 00 00 00 00 00  @...............
```

# Load PE file (Notepad.exe) into Memory




Segment Registers
Segment Descriptors
Linear Address Space (or Physical Memory)
CS
SS
DS
ES
FS
GS
Access
Limit
Base Address
Stack
Code
Data
Data
Data
Data

# VA & RVA

- VA (Virtual Address): The address is called a “VA” because **Windows creates a distinct** VA space for each process, **independent** of physical memory. For almost all purposes, a VA should be considered just an address. A VA is not as predictable as an RVA because the loader might not load the image at its preferred location.

- RVA (Relative Virtual Address): The address of an item after it is loaded into memory, with the base address of the image file subtracted from it. The RVA of an item almost always differs from its position within the file on disk (file pointer).

**RVA + ImageBase = VA**

In 32bit Windows OS, each process has 4GB virtual memory which means the range of VA is: **00000000 - FFFFFFFF**

# DOS Header

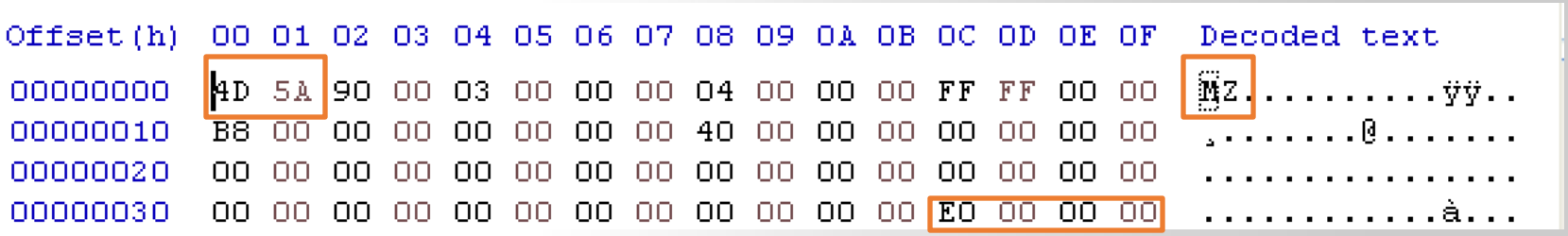
```
struct DOS_Header
{
// short is 2 bytes, long is 4 bytes
    char signature[2] = { 'M', 'Z' };
    short lastsize;
    short nblocks;
    short nreloc;
    short hdrsize;
    short minalloc;
    short maxalloc;
    void *ss; // 2 byte value
    void *sp; // 2 byte value
    short checksum;
    void *ip; // 2 byte value
    void *cs; // 2 byte value
    short relocpos;
    short noverlay;
    short reserved1[4];
    short oem_id;
    short oem_info;
    short reserved2[10];
    long  e_lfanew; // Offset to the 'PE\0\0' signature relative to the beginning of the file
}
```

The first 2 letters are **always** the letters "**MZ**", the initials of Mark Zbikowski, who created the first linker for DOS. To some people, the first few bytes in a file that determine the type of file are called the "**magic number**,"

# DOS Header

```
long   e_lfanew;
```

long → 32 bit → ? Byte

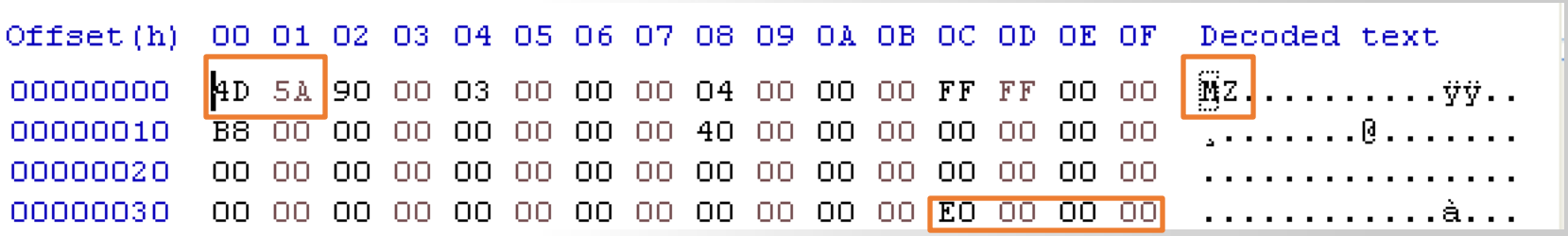


| Offset(h) | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 0A | 0B | 0C | 0D | 0E | 0F | Decoded text |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00000000 | 4D | 5A | 90 | 00 | 03 | 00 | 00 | 00 | 04 | 00 | 00 | 00 | FF | FF | 00 | 00 | MZ.....ÿÿ.. |
| 00000010 | B8 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 40 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | ¸.......@..... |
| 00000020 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | ..... |
| 00000030 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | E0 | 00 | 00 | 00 | .....à... |

E0 00 00 00

value for e_lfanew → ?

# DOS Header



| Offset(h) | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 0A | 0B | 0C | 0D | 0E | 0F | Decoded text |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00000000 | 4D | 5A | 90 | 00 | 03 | 00 | 00 | 00 | 04 | 00 | 00 | 00 | FF | FF | 00 | 00 | MZ.....ÿÿ.. |
| 00000010 | B8 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 40 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | ¸.......@..... |
| 00000020 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | ..... |
| 00000030 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | E0 | 00 | 00 | 00 | .....à... |

e_lfanew → 000000E0

# DOS stub

```
00000040  0E 1F BA 0E 00 B4 09 CD 21 B8 01 4C CD 21 54 68  ..°..´.Í!¸.LÍ!Th
00000050  69 73 20 70 72 6F 67 72 61 6D 20 63 61 6E 6E 6F  is program canno
00000060  74 20 62 65 20 72 75 6E 20 69 6E 20 44 4F 53 20  t be run in DOS
00000070  6D 6F 64 65 2E 0D 0D 0A 24 00 00 00 00 00 00 00  mode....$.......
00000080  EC 85 5B A1 A8 E4 35 F2 A8 E4 35 F2 A8 E4 35 F2  ì…[¡¨ä5ò¨ä5ò¨ä5ò
00000090  6B EB 3A F2 A9 E4 35 F2 6B EB 55 F2 A9 E4 35 F2  kë:ò©ä5òkëUò©ä5ò
000000A0  6B EB 68 F2 BB E4 35 F2 A8 E4 34 F2 63 E4 35 F2  këhò»ä5ò¨ä4òcä5ò
000000B0  6B EB 6B F2 A9 E4 35 F2 6B EB 6A F2 BF E4 35 F2  këkò©ä5òkëjò¿ä5ò
000000C0  6B EB 6F F2 A9 E4 35 F2 52 69 63 68 A8 E4 35 F2  këoò©ä5òRich¨ä5ò
000000D0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
```

https://virtualconsoles.com/online-emulators/dos/

```
C:\>notepad.exe
This program cannot be run in DOS mode.
```

# NT Header

## IMAGE_NT_HEADERS32 structure

12/04/2018 • 2 minutes to read

Represents the PE header format.

### Syntax

C++ Copy

```
typedef struct _IMAGE_NT_HEADERS {
  DWORD                   Signature;
  IMAGE_FILE_HEADER       FileHeader;
  IMAGE_OPTIONAL_HEADER32 OptionalHeader;
} IMAGE_NT_HEADERS32, *PIMAGE_NT_HEADERS32;
```

### Members

`Signature`

A 4-byte signature identifying the file as a PE image. The bytes are "PE\0\0".

`FileHeader`

An IMAGE_FILE_HEADER structure that specifies the file header.

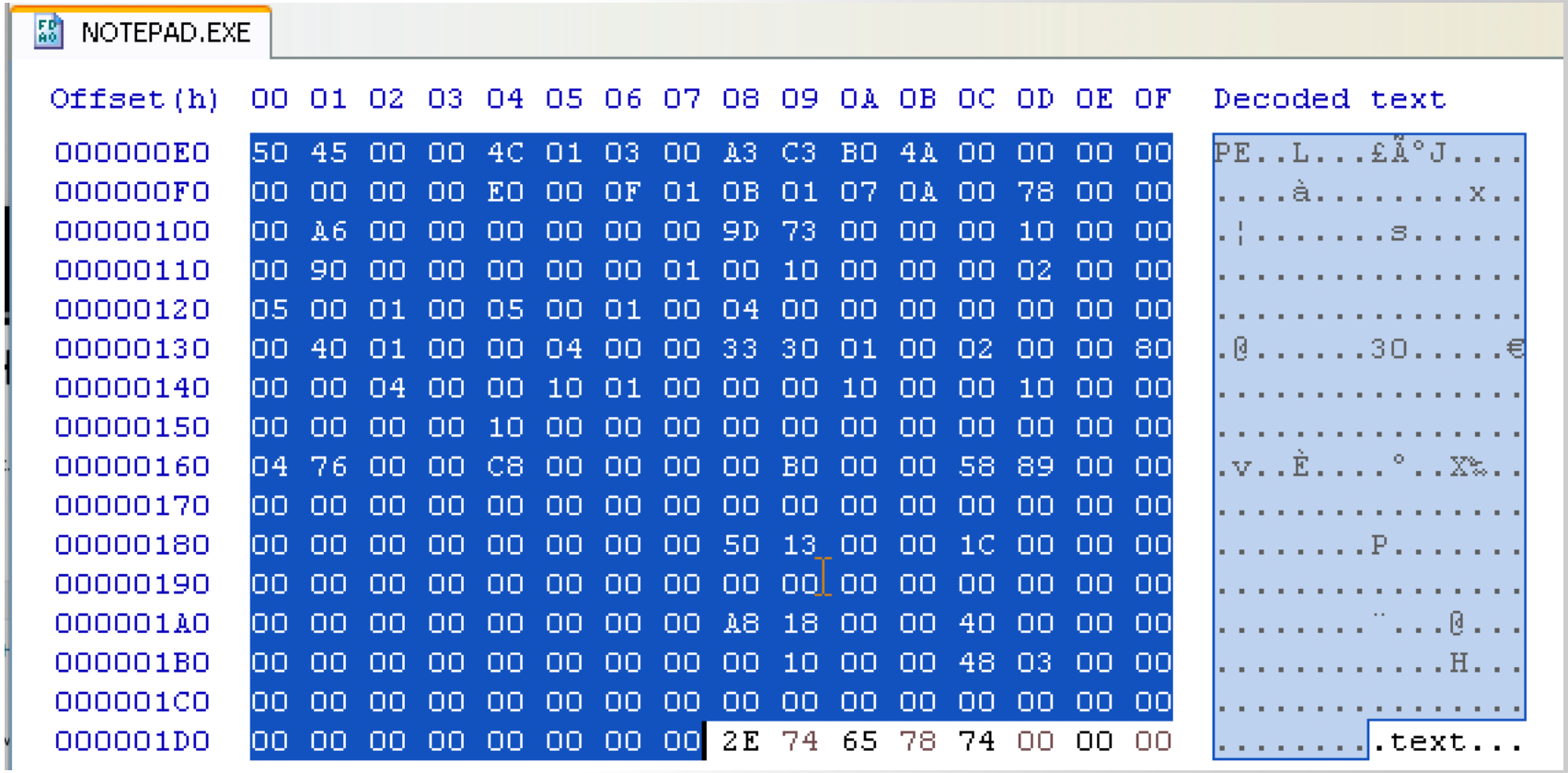
`OptionalHeader`

An IMAGE_OPTIONAL_HEADER structure that specifies the optional file header.



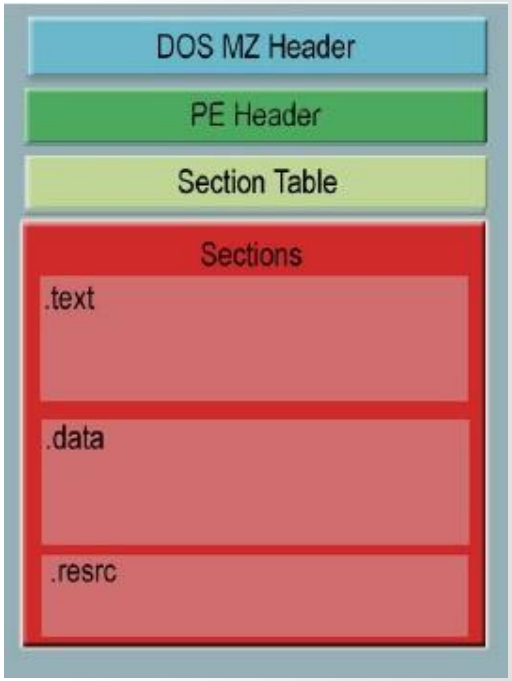
https://docs.microsoft.com/en-us/windows/desktop/api/winnt/

# NT Header


NOTEPAD.EXE

| Offset(h) | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 0A | 0B | 0C | 0D | 0E | 0F | Decoded text |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 000000E0 | 50 | 45 | 00 | 00 | 4C | 01 | 03 | 00 | A3 | C3 | B0 | 4A | 00 | 00 | 00 | 00 | PE..L...£Ã°J.... |
| 000000F0 | 00 | 00 | 00 | 00 | E0 | 00 | 0F | 01 | 0B | 01 | 07 | 0A | 00 | 78 | 00 | 00 | ....à.........x.. |
| 00000100 | 00 | A6 | 00 | 00 | 00 | 00 | 00 | 00 | 9D | 73 | 00 | 00 | 00 | 10 | 00 | 00 | .¦.......s...... |
| 00000110 | 00 | 90 | 00 | 00 | 00 | 00 | 00 | 01 | 00 | 10 | 00 | 00 | 00 | 02 | 00 | 00 | ................ |
| 00000120 | 05 | 00 | 01 | 00 | 05 | 00 | 01 | 00 | 04 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | ................ |
| 00000130 | 00 | 40 | 01 | 00 | 00 | 04 | 00 | 00 | 33 | 30 | 01 | 00 | 02 | 00 | 00 | 80 | .@......30.....€ |
| 00000140 | 00 | 00 | 04 | 00 | 00 | 10 | 01 | 00 | 00 | 00 | 10 | 00 | 00 | 10 | 00 | 00 | ................ |
| 00000150 | 00 | 00 | 00 | 00 | 10 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | ................ |
| 00000160 | 04 | 76 | 00 | 00 | C8 | 00 | 00 | 00 | 00 | B0 | 00 | 00 | 58 | 89 | 00 | 00 | .v..È....°..X‰.. |
| 00000170 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | ................ |
| 00000180 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 50 | 13 | 00 | 00 | 1C | 00 | 00 | 00 | ........P....... |
| 00000190 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | ................ |
| 000001A0 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | A8 | 18 | 00 | 00 | 40 | 00 | 00 | 00 | ........¨...@... |
| 000001B0 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 10 | 00 | 00 | 48 | 03 | 00 | 00 | ............H... |
| 000001C0 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | ................ |
| 000001D0 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 2E | 74 | 65 | 78 | 74 | 00 | 00 | 00 | .........text... |

# Section Header




| Name | Privilege |
|---|---|
| .code | Executable, read |
| .data | Non-Executable, read/write |
| .resource | Non-Executable, read |

# Section Header

# IMAGE_SECTION_HEADER structure

12/04/2018 • 4 minutes to read

Represents the image section header format.

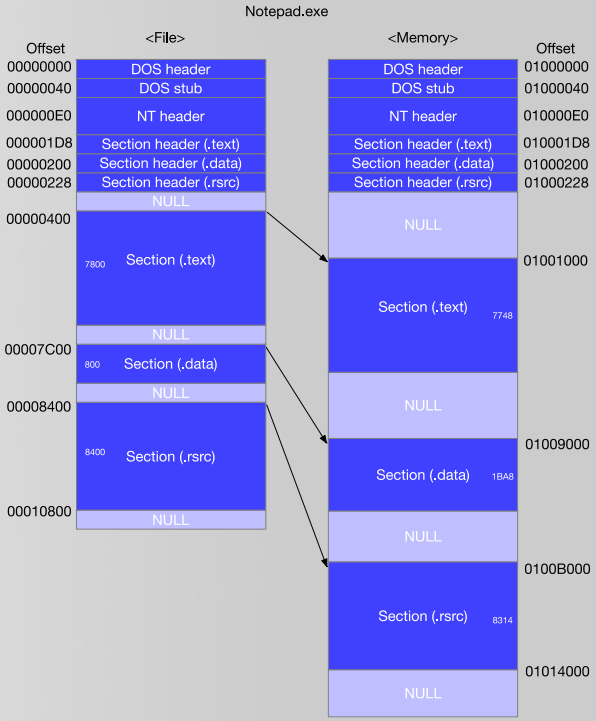
## Syntax

C++ Copy

```
typedef struct _IMAGE_SECTION_HEADER {
  BYTE  Name[IMAGE_SIZEOF_SHORT_NAME];
  union {
    DWORD PhysicalAddress;
    DWORD VirtualSize;
  } Misc;
  DWORD VirtualAddress;
  DWORD SizeOfRawData;
  DWORD PointerToRawData;
  DWORD PointerToRelocations;
  DWORD PointerToLinenumbers;
  WORD  NumberOfRelocations;
  WORD  NumberOfLinenumbers;
  DWORD Characteristics;
} IMAGE_SECTION_HEADER, *PIMAGE_SECTION_HEADER;
```

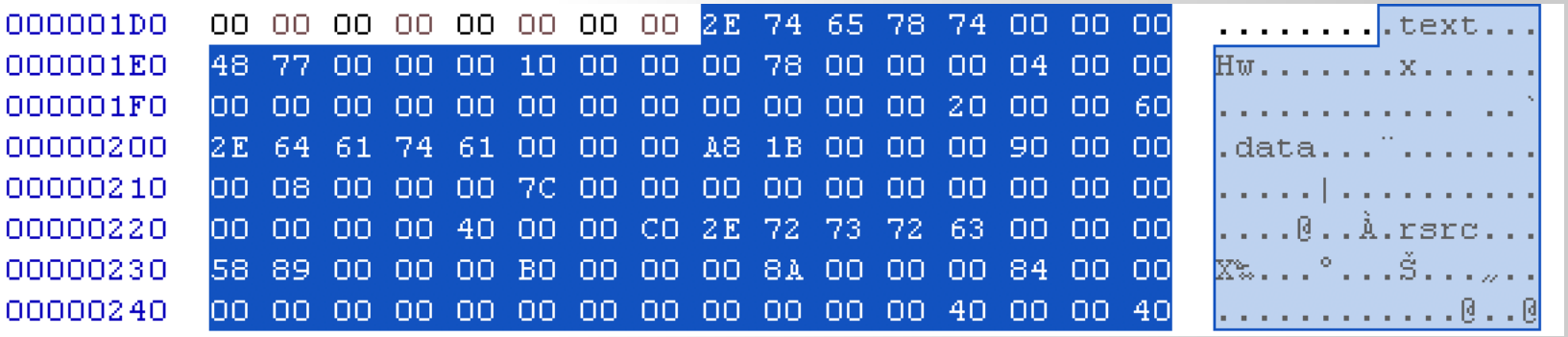
# Section Header

| Members | Meaning |
|---|---|
| VirtualSize | **The total size of the section** when loaded into memory, in bytes. |
| VirtualAddress | **The address of the first byte of the section** when loaded into memory (RVA) |
| SizeOfRaw Data | **The size of the section data on disk**, in bytes. |
| PointerToRawData | **The address of the first byte of the section on disk**. |
| Characteristics | The characteristics of the image. |




https://docs.microsoft.com/en-us/windows/desktop/api/winnt/ns-winnt-_image_section_header

# Section Header



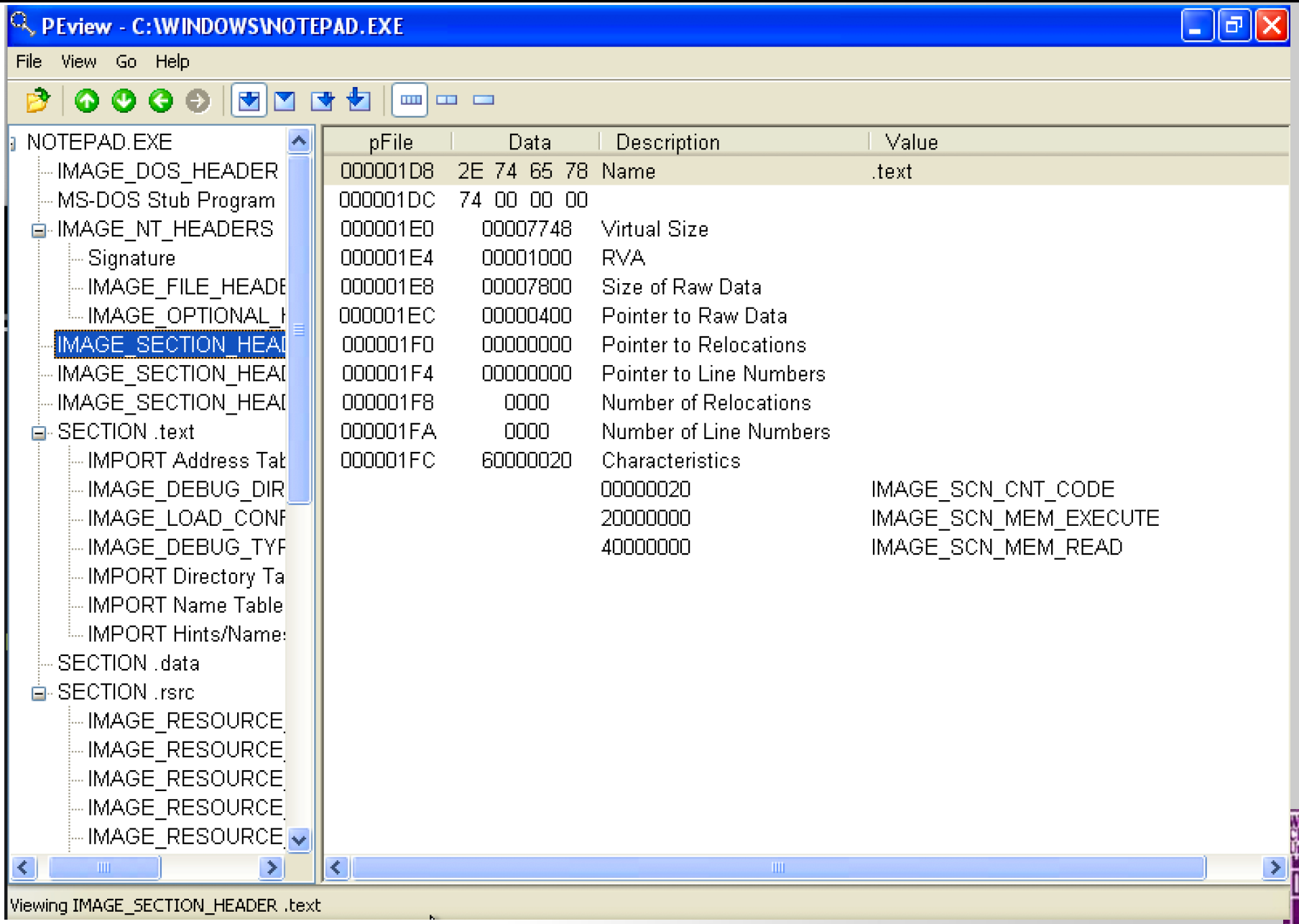
```
000001D0  00 00 00 00 00 00 00 00 2E 74 65 78 74 00 00 00  .........text...
000001E0  48 77 00 00 00 10 00 00 00 78 00 00 00 04 00 00  Hw.......x......
000001F0  00 00 00 00 00 00 00 00 00 00 00 00 20 00 00 60  ............ ..`
00000200  2E 64 61 74 61 00 00 00 A8 1B 00 00 00 90 00 00  .data...¨.......
00000210  00 08 00 00 00 7C 00 00 00 00 00 00 00 00 00 00  .....|..........
00000220  00 00 00 00 40 00 00 C0 2E 72 73 72 63 00 00 00  ....@..À.rsrc...
00000230  58 89 00 00 00 B0 00 00 00 8A 00 00 00 84 00 00  X‰...°...Š...„..
00000240  00 00 00 00 00 00 00 00 00 00 00 00 40 00 00 40  ............@..@
```

# Inspecting PE Header Information in Linux

```
1  import pefile
2  import sys
3
4  malware_file = sys.argv[1]
5  pe = pefile.PE(malware_file)
6  for section in pe.sections:
7      print "Name: %s VirtualSize: %s VirtualAddr: %s  SizeofRawData: %s PointerToRawData: %s" %
8                                  (section.Name,  hex(section.Misc_VirtualSize), hex(section.VirtualAddress), section.SizeOfRawData, section.PointerToRawData)
```

```
root@localhost ~ python display_sections.py a99c01d5748b1bfd203fc1763e6612e8
Name: .text VirtualSize: 0x7378 VirtualAddr: 0x1000  SizeofRawData: 29696 PointerToRawData: 1024
Name: .rdata VirtualSize: 0x261c VirtualAddr: 0x9000  SizeofRawData: 10240 PointerToRawData: 30720
Name: .data VirtualSize: 0x2cac VirtualAddr: 0xc000  SizeofRawData: 3584 PointerToRawData: 40960
Name: .rsrc VirtualSize: 0x1b4 VirtualAddr: 0xf000  SizeofRawData: 512 PointerToRawData: 44544
```

# Inspecting PE Header Information



# Inspecting file imports with pefile library

```
1   import pefile
2   import sys
3
4   malware_file = sys.argv[1]
5   pe = pefile.PE(malware_file)
6   if hasattr(pe, 'DIRECTORY_ENTRY_IMPORT'):
7       for entry in pe.DIRECTORY_ENTRY_IMPORT:
8           print "%s" % entry.dll
9           for imp in entry.imports:
10              if imp.name != None:
11                  print "\t %s" % (imp.name)
12              else:
13                  print "\tord(%s)" % (str(imp.ordinal))
14          print "\n"
```

# Inspecting file export with pefile library

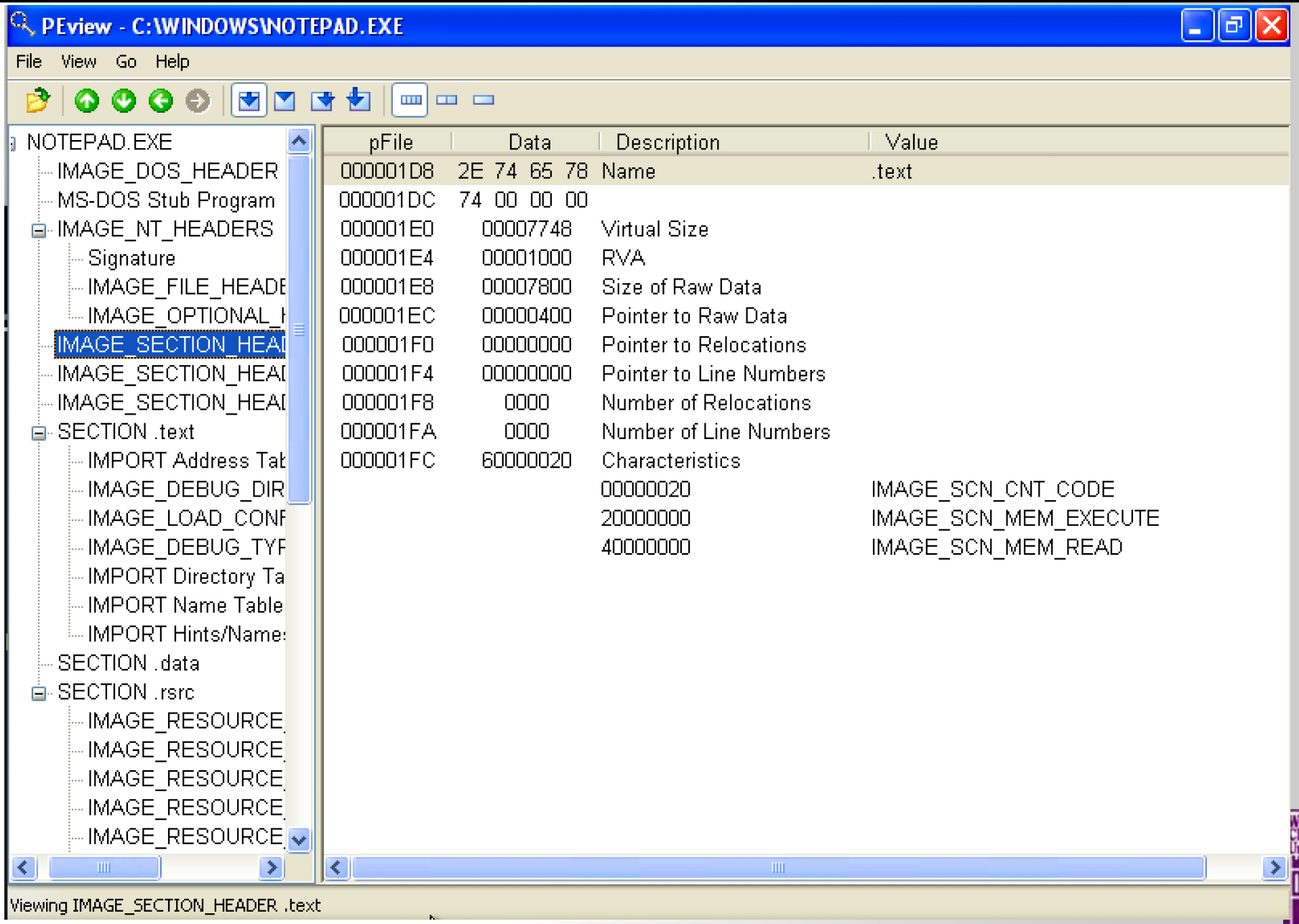
```
1   import pefile
2   import sys
3
4   malware_file = sys.argv[1]
5   pe = pefile.PE(malware_file)
6   if hasattr(pe, 'DIRECTORY_ENTRY_EXPORT'):
7       for exp in pe.DIRECTORY_ENTRY_EXPORT.symbols:
8           print "%s"  % exp.name
9
```

# Inspecting PE Header Information in Linux

```
1  import pefile
2  import sys
3
4  malware_file = sys.argv[1]
5  pe = pefile.PE(malware_file)
6  for section in pe.sections:
7      print "Name: %s VirtualSize: %s VirtualAddr: %s  SizeofRawData: %s PointerToRawData: %s" %
8                                  (section.Name,  hex(section.Misc_VirtualSize), hex(section.VirtualAddress), section.SizeOfRawData, section.PointerToRawData)
```

```
root@localhost ~ python display_sections.py a99c01d5748b1bfd203fc1763e6612e8
Name: .text VirtualSize: 0x7378 VirtualAddr: 0x1000  SizeofRawData: 29696 PointerToRawData: 1024
Name: .rdata VirtualSize: 0x261c VirtualAddr: 0x9000  SizeofRawData: 10240 PointerToRawData: 30720
Name: .data VirtualSize: 0x2cac VirtualAddr: 0xc000  SizeofRawData: 3584 PointerToRawData: 40960
Name: .rsrc VirtualSize: 0x1b4 VirtualAddr: 0xf000  SizeofRawData: 512 PointerToRawData: 44544
```

# Inspecting PE Header Information



# Examining PE Section Table and Sections

- https://hub.docker.com/r/remnux/pescanner/

# IAT (Import Address Table)

# IAT (Import Address Table)

- Let's review the concept of DLL (Dynamic Link Library) **again**…

# Dynamic Linking

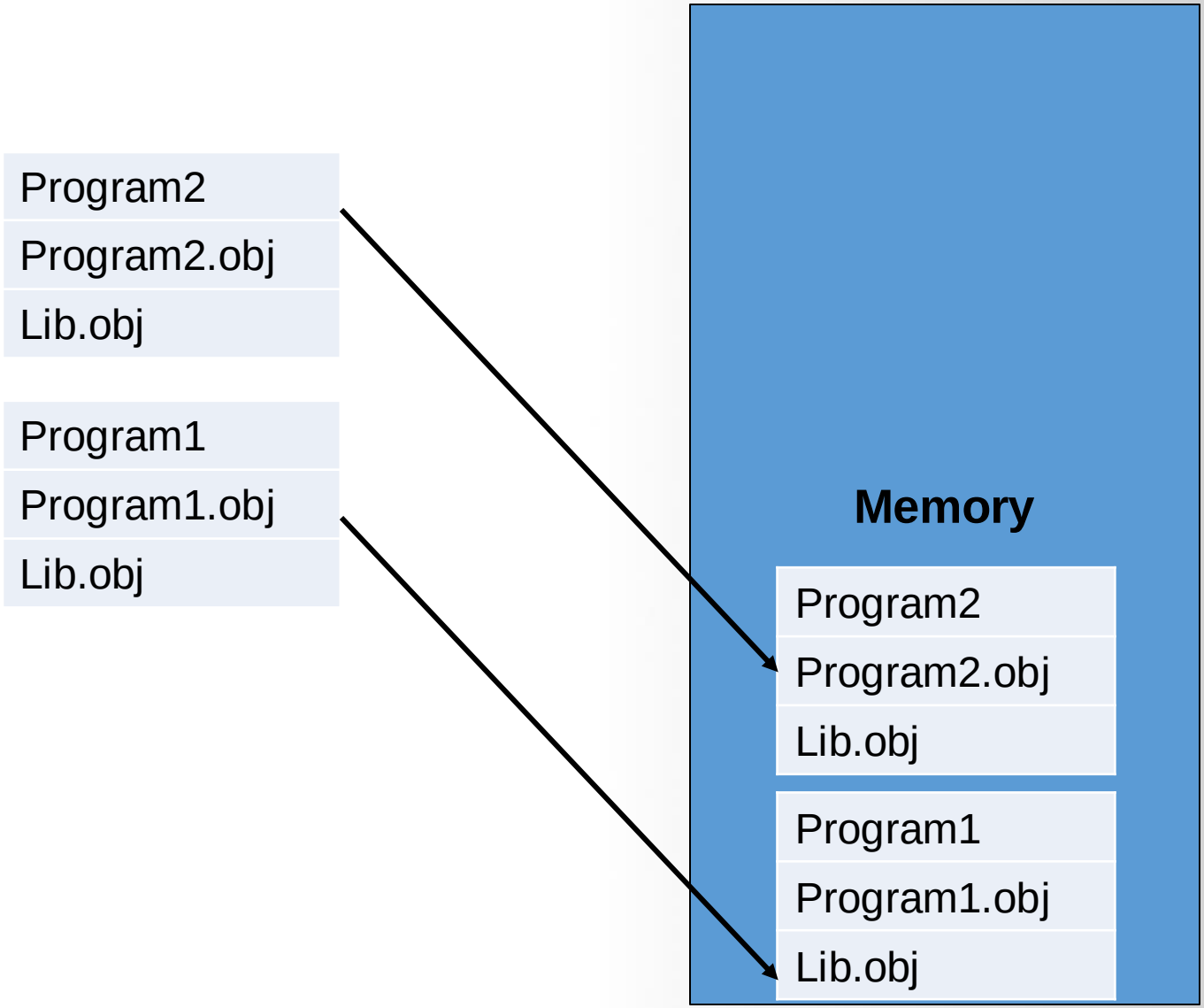
# 16-Bit DOS System

21. lab1.c (~) - VIM (ssh)

```c
#include <stdio.h>
#include <string.h>

void hacked()
{
>---/* change YOURNAME to your name :) */
>---puts("Hacked by YOURNAME!!!!");
}

void return_input(void)
{
>---/* Please set the array size equal to-
>--- the last two digits of your student ID
>--- e.g. 0861339 --> array size should set to 39 */
>---char array[39];--
>---gets(array);
>---printf("%s\n", array);
}

main()
{
>---return_input();
>---return 0;
}
```

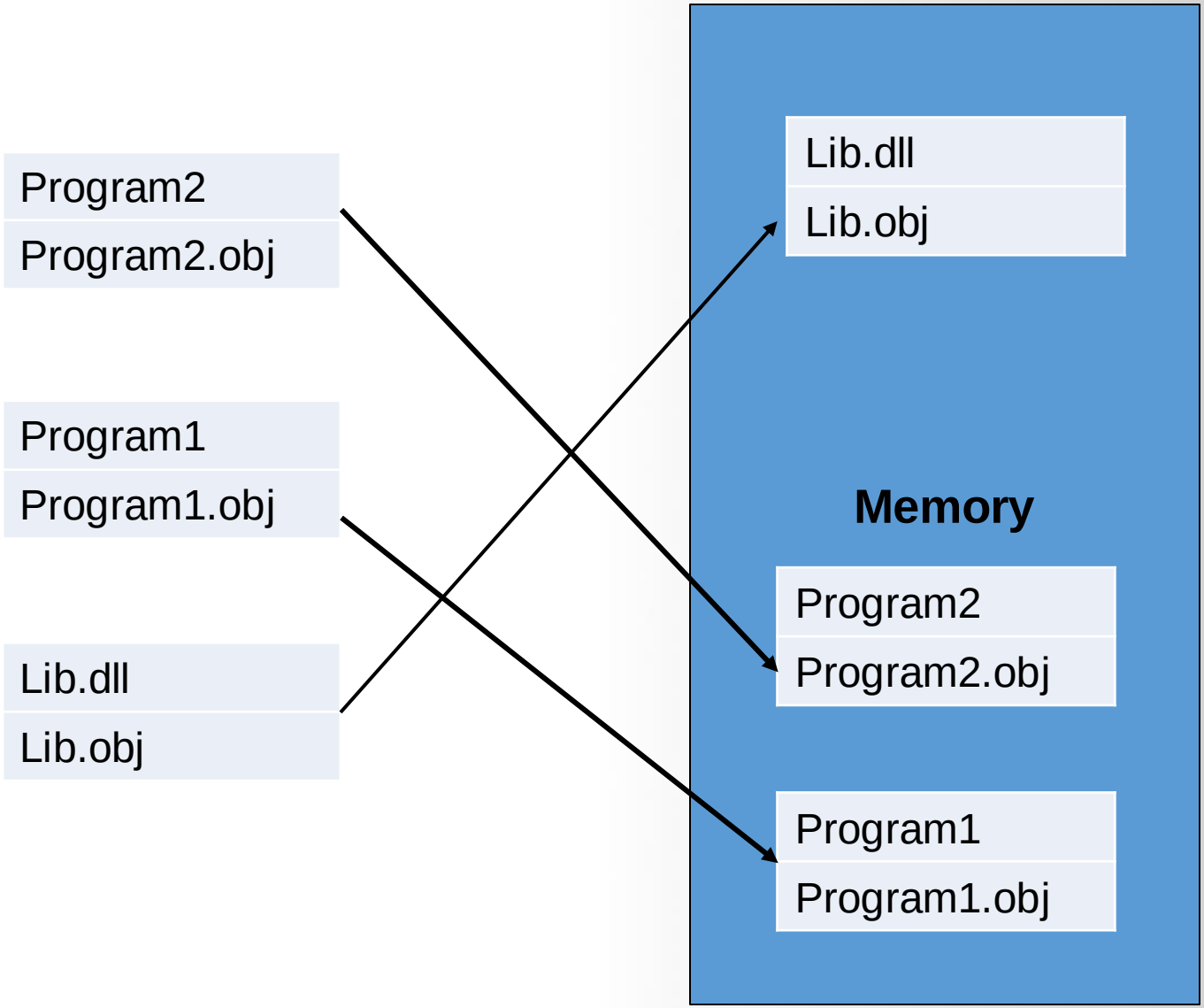
import Library → Put binary code of stdio library into the executable file

# Static Linking



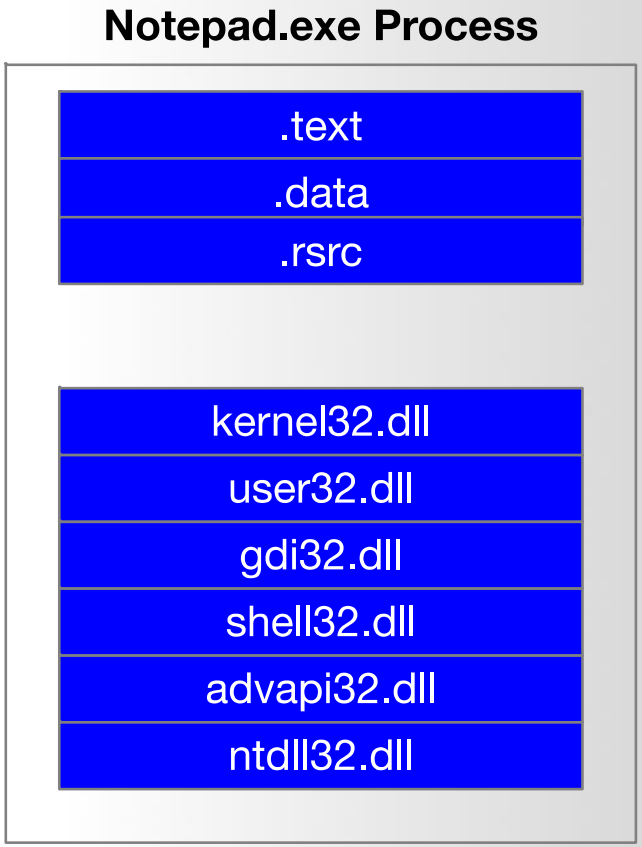

- Waste space
- Hard to maintain

# Dynamic Linking




Dynamic linking has the following advantages:
1.Saves memory
2.Saves disk space.
3.Upgrades to the DLL are easier.
4.Provides after-market support.
5.Supports multi language programs.
6.Eases the creation of international versions

# Two ways to Load DLL



# Two ways to Load DLL

An executable file links to (or loads) a DLL in one of two ways:

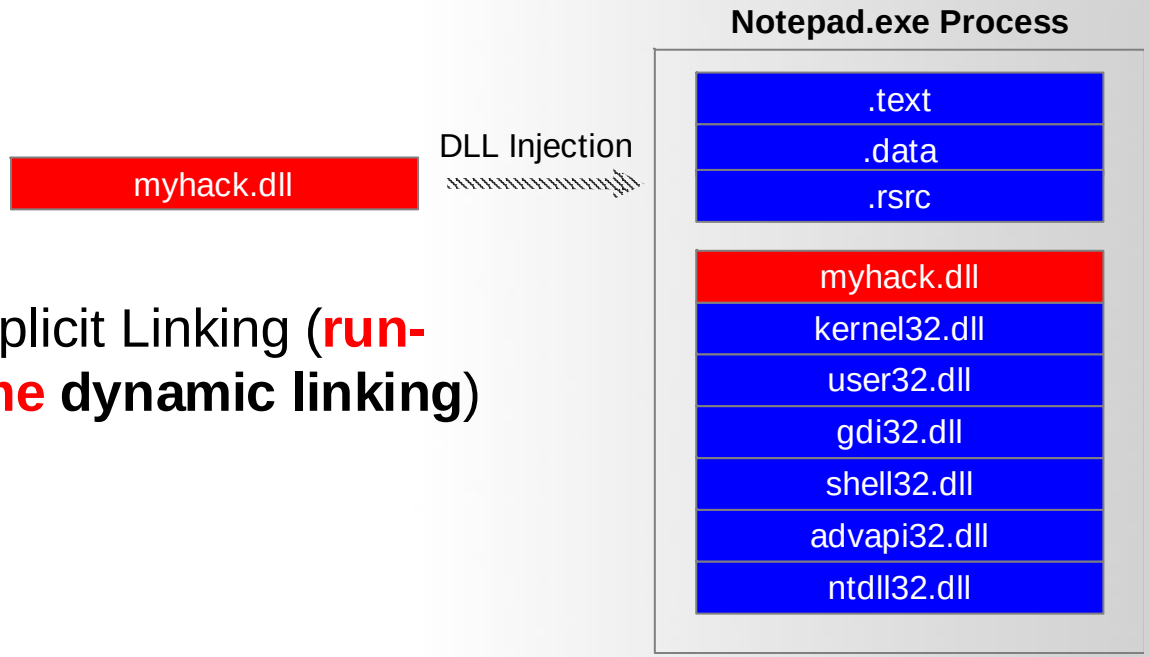
- Explicit Linking (**run-time dynamic linking**)
  - the executable using the DLL must make function calls to explicitly load and unload the DLL, and to access the DLL's exported functions.

1. Call LoadLibrary() (or a similar function) to load the DLL and obtain a module handle.
2. Call GetProcAddress() to obtain a function pointer to each exported function that the application wants to call.
3. Call FreeLibrary() when done with the DLL.

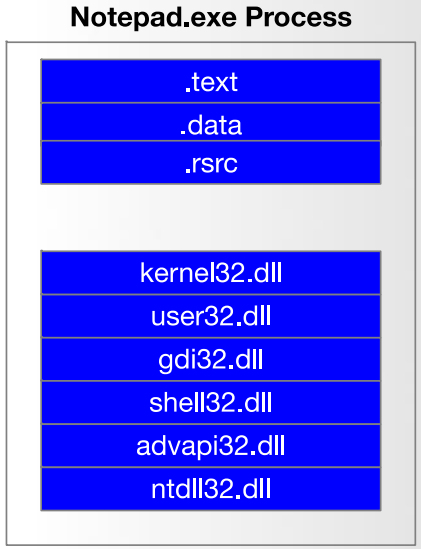
- Implicit Linking (**load-time dynamic linking**)
  - The operating system loads the DLL when the executable using it is loaded.

1. A header file (.H file) containing the declarations of the exported functions and/or C++ classes.
2. An import library (.LIB files) to link with. The linker creates the import library when the DLL is built.
3. The actual DLL (.DLL file).

# Two ways to Load DLL




Explicit Linking (**run-time dynamic linking**)




Implicit Linking (**load-time dynamic linking**)

# Two ways to Load DLL

An executable file links to (or loads) a DLL in one of two ways:

- Explicit Linking (**run-time dynamic linking**) ⇨ DLL Injection
  - the executable using the DLL must make function calls to explicitly load and unload the DLL, and to access the DLL's exported functions.

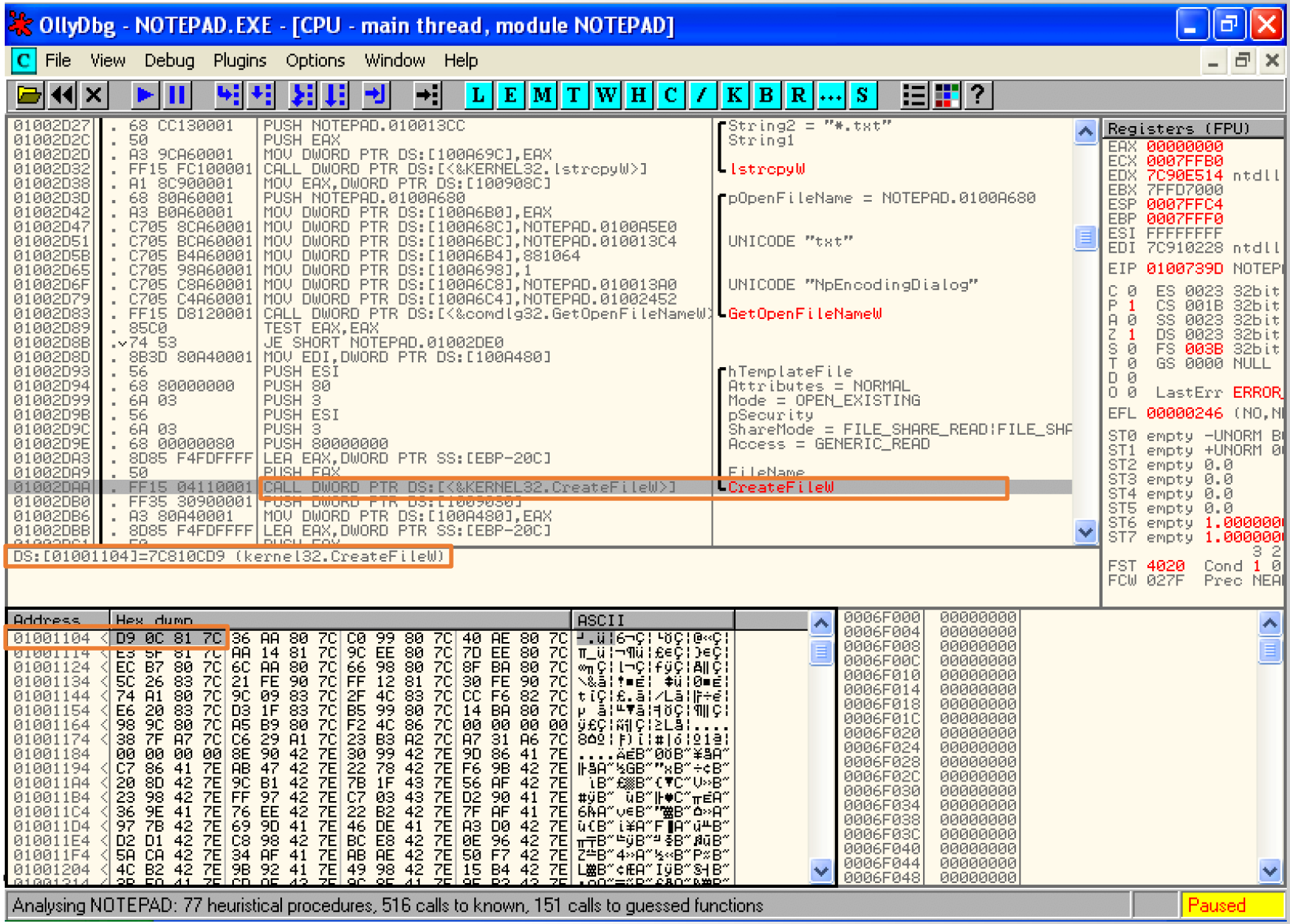
1. Call LoadLibrary() (or a similar function) to load the DLL and obtain a module handle.
2. Call GetProcAddress() to obtain a function pointer to each exported function that the application wants to call.
3. Call FreeLibrary() when done with the DLL.

- Implicit Linking (**load-time dynamic linking**) ⇨ IAT Table
  - The operating system loads the DLL when the executable using it is loaded.

1. A header file (.H file) containing the declarations of the exported functions and/or C++ classes.
2. An import library (.LIB files) to link with. The linker creates the import library when the DLL is built.
3. The actual DLL (.DLL file).

# Implicit Linking and IAT (Import Address Table)

- Notepad.exe Call CreateFileW() → Call **0x01001104** → Call **0x7C810CD9**



# Implicit Linking and IAT (Import Address Table)

- Notepad.exe Call CreateFileW() → Call **0x01001104** → Call **0x7C810CD9**

Call **0x01001104**

↓ Look up

IAT Table

| Function Name | IAT Address | Real Address |
|---|---|---|
| … | | |
| CreateFileW() | **0x01001104** | **0x7C810CD9** |
| … | | |

When the application was first compiled, it was designed so that all API calls will **NOT** use **direct hardcoded addresses** but rather work through a function pointer.

This was accomplished through the use of **an import address table**. This is a table of function pointers filled in by the windows loader as the dlls are loaded.

# IAT (Import Address Table)

Why IAT?

# IAT (Import Address Table)

- **Support different Windows Version (9X, 2K, XP, Vista, 7, 8, 10)**

Call CreateFileW() --> Call **0x01001104**



Look up

**XP** IAT Table

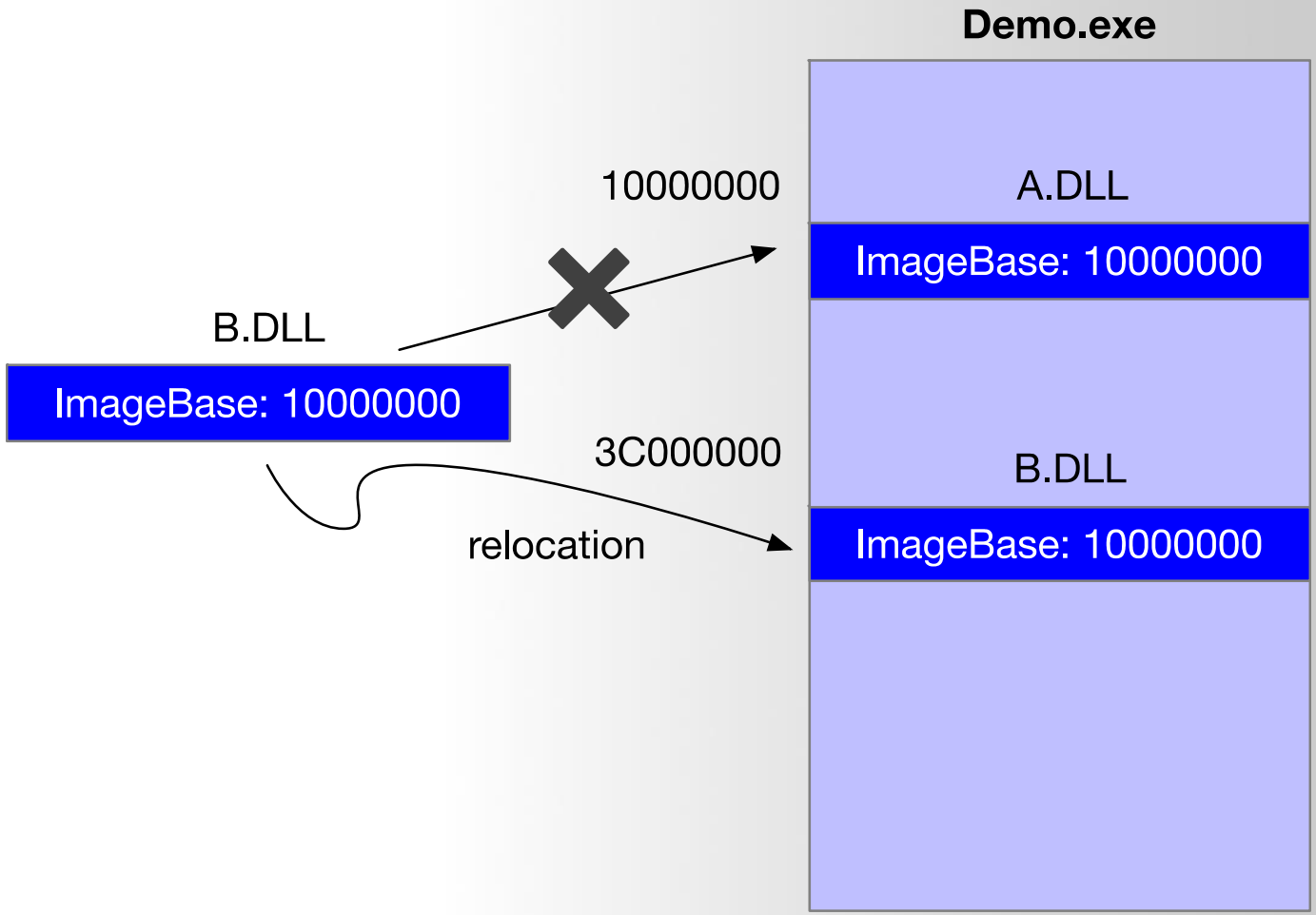
| Function Name | IAT Address | Real Address |
|---|---|---|
| … | | |
| CreateFileW() | **0x01001104** | **0x7C810CD9** |
| … | | |

**Windows 7**

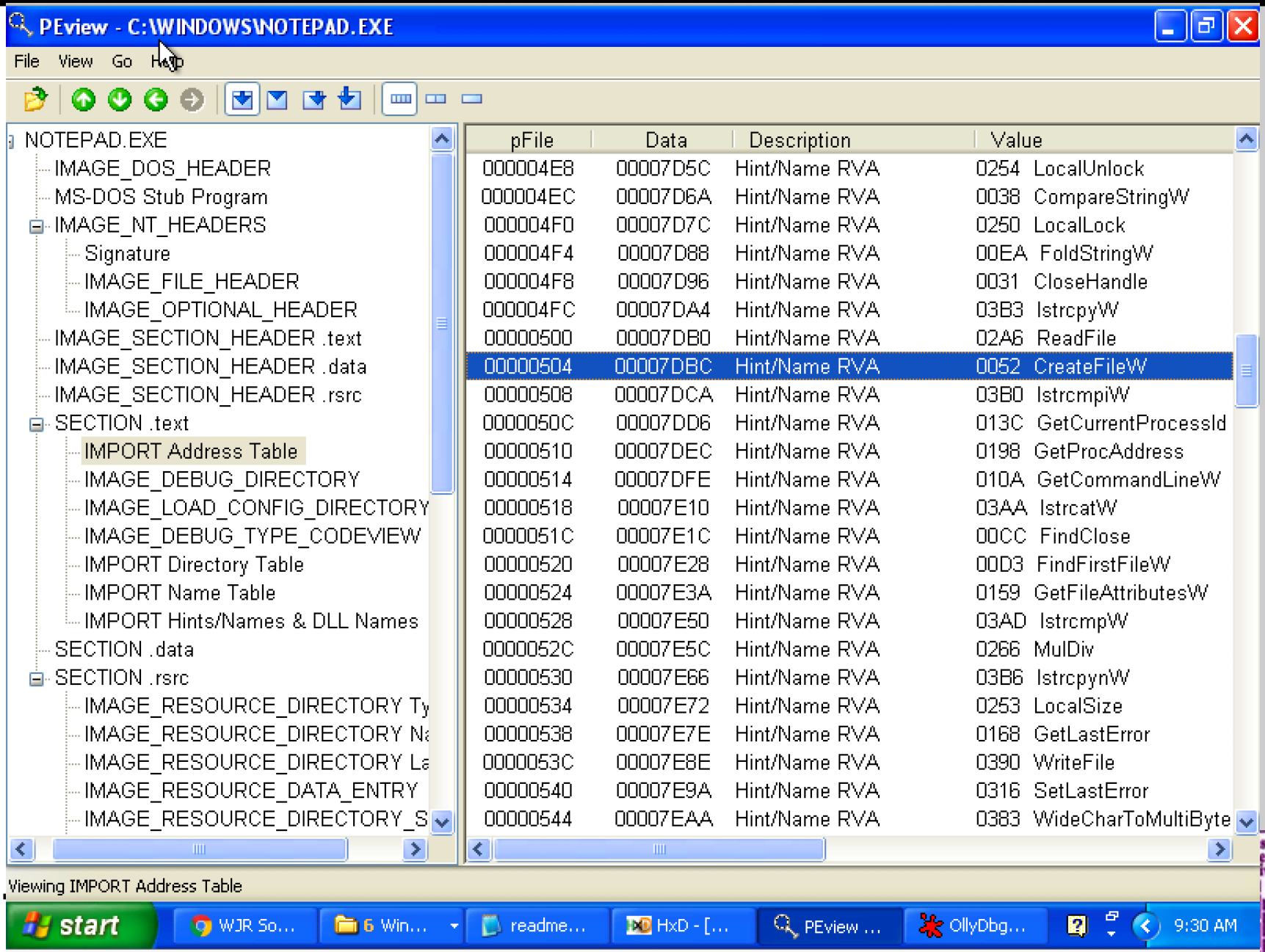
| Function Name | IAT Address | Real Address |
|---|---|---|
| … | | |
| CreateFileW() | **0x01001104** | **0x7C81FFFF** |
| … | | |

# IAT (Import Address Table)

- **Support DLL Relocation**

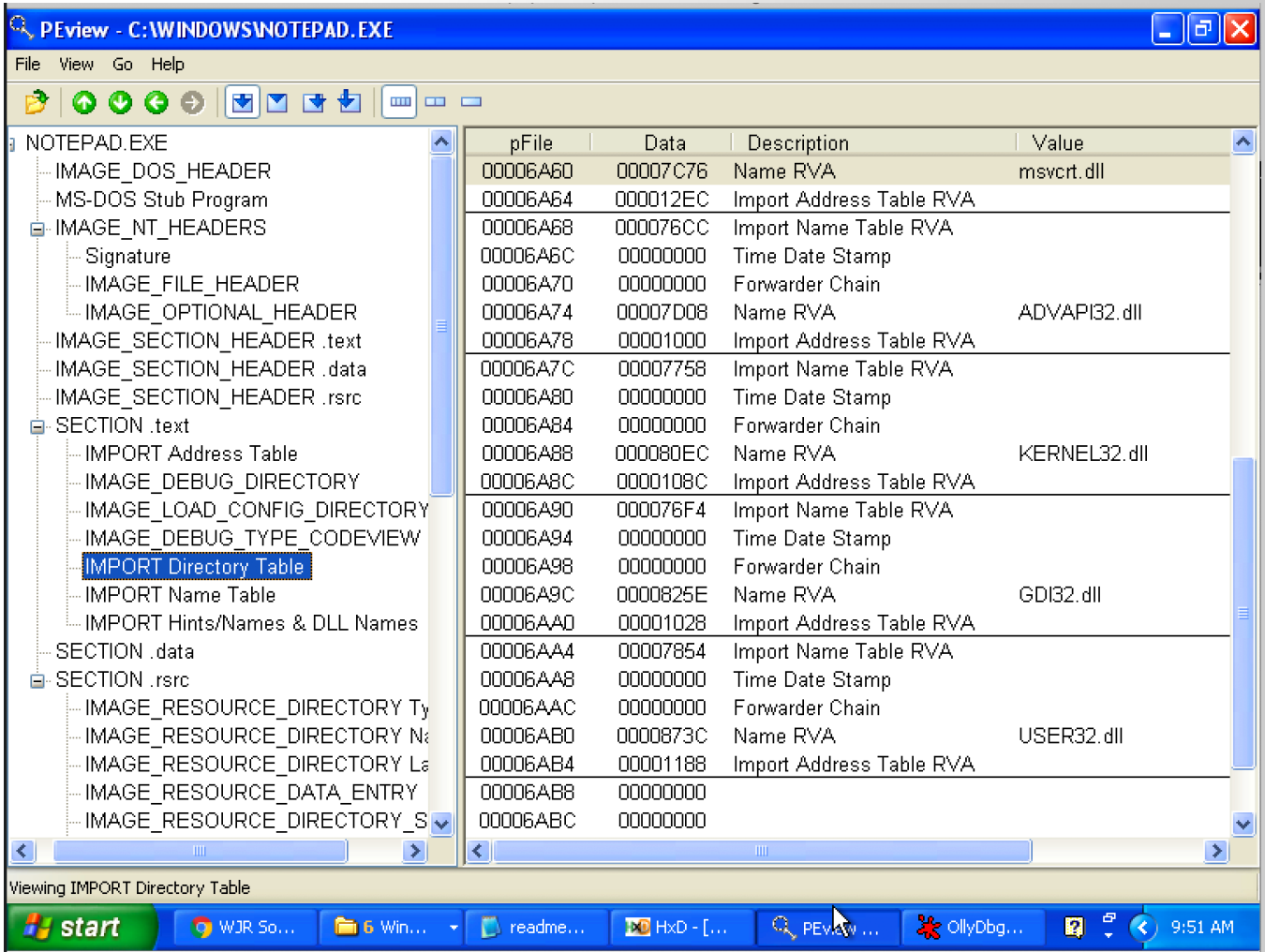


# Look up IAT Table with PEview



# Import Directory Table

- The Import Directory Table contains entries for every DLL which is loaded by the executable. Each entry contains, among other, Import Lookup Table (ILT) and **Import Address Table (IAT)**



# Inspecting file imports with pefile library

```
import pefile
import sys

malware_file = sys.argv[1]
pe = pefile.PE(malware_file)
if hasattr(pe, 'DIRECTORY_ENTRY_IMPORT'):
    for entry in pe.DIRECTORY_ENTRY_IMPORT:
        print "%s" % entry.dll
        for imp in entry.imports:
            if imp.name != None:
                print "\t %s \t %s" % (hex(imp.address), imp.name)
            else:
                print "\tord(%s)" % (str(imp.ordinal))
        print "\n"
```

```
root@localhost ~ python enum_imports.py myhack.dll
KERNEL32.dll
        0x1000c000      GetModuleFileNameW
        0x1000c004      OutputDebugStringW
        0x1000c008      CloseHandle
        0x1000c00c      CreateThread
        0x1000c010      WriteConsoleW
        0x1000c014      CreateFileW
        0x1000c018      UnhandledExceptionFilter
        0x1000c01c      SetUnhandledExceptionFilter
        0x1000c020      GetCurrentProcess
        0x1000c024      TerminateProcess
        0x1000c028      IsProcessorFeaturePresent
        0x1000c02c      QueryPerformanceCounter
        0x1000c030      GetCurrentProcessId
        0x1000c034      GetCurrentThreadId
        0x1000c038      GetSystemTimeAsFileTime
        0x1000c03c      InitializeSListHead
        0x1000c040      IsDebuggerPresent
        0x1000c044      GetStartupInfoW
        0x1000c048      GetModuleHandleW
        0x1000c04c      InterlockedFlushSList
        0x1000c050      RtlUnwind
        0x1000c054      GetLastError
        0x1000c058      SetLastError
        0x1000c05c      EnterCriticalSection
        0x1000c060      LeaveCriticalSection
        0x1000c064      DeleteCriticalSection
        0x1000c068      InitializeCriticalSectionAndSpinCount
        0x1000c06c      TlsAlloc
        0x1000c070      TlsGetValue
        0x1000c074      TlsSetValue
        0x1000c078      TlsFree
        0x1000c07c      FreeLibrary
        0x1000c080      GetProcAddress
        0x1000c084      LoadLibraryExW
        0x1000c088      RaiseException
        0x1000c08c      ExitProcess
        0x1000c090      GetModuleHandleExW
        0x1000c094      HeapAlloc
        0x1000c098      HeapFree
        0x1000c09c      FindClose
        0x1000c0a0      FindFirstFileExW
        0x1000c0a4      FindNextFileW
        0x1000c0a8      IsValidCodePage
        0x1000c0ac      GetACP
        0x1000c0b0      GetOEMCP
        0x1000c0b4      GetCPInfo
        0x1000c0b8      GetCommandLineA
        0x1000c0bc      GetCommandLineW
        0x1000c0c0      MultiByteToWideChar
        0x1000c0c4      WideCharToMultiByte
        0x1000c0c8      GetEnvironmentStringsW
        0x1000c0cc      FreeEnvironmentStringsW
        0x1000c0d0      GetStdHandle
        0x1000c0d4      GetFileType
        0x1000c0d8      LCMapStringW
        0x1000c0dc      GetProcessHeap
        0x1000c0e0      GetStringTypeW
        0x1000c0e4      HeapSize
        0x1000c0e8      HeapReAlloc
        0x1000c0ec      SetStdHandle
        0x1000c0f0      FlushFileBuffers
        0x1000c0f4      WriteFile
        0x1000c0f8      GetConsoleCP
        0x1000c0fc      GetConsoleMode
        0x1000c100      SetFilePointerEx
        0x1000c104      DecodePointer


urlmon.dll
        0x1000c10c      URLDownloadToFileW
```

# Real-world Case Study

16d6b0e2c77da2776a88dd88c7cfc672

(**Trojan.Win32.Dllhijack.a**)

# 16d6b0e2c77da2776a88dd88c7cfc672

```
root@li254-249 ~ python enum_exports.py 16d6b0e2c77da2776a88dd88c7cfc672
0x100011e0      CreateDatabaseQueryObject       1
0x100011e0      DataImporterMain        2
0x100011e0      FlashboxMain    3
0x100010d0      KugouMain       4
```

# KuGou

From Wikipedia, the free encyclopedia

**KuGou** (Chinese: 酷狗音乐) is a Chinese music streaming and download service established in 2004 and owned by Tencent Music.[1][2] It is the largest music streaming service in the world, with more than 450 million monthly active users.[2] KuGou is the largest online music service in China, with a market share of 28%.[1] It has more than 800 million users.[1] A merger between China Music Corporation and Tencent's QQ Music was announced on July 15, 2016.[1][3] The services are expected to continue being offered separately.[1] Together with Kuwo, another online music service also owned by Tencent Music and the third largest one in China,[1] KuGou holds a music award ceremony, the KU Music Asian Music Awards,[4] also known as Cool Music Asia Festival Award.[5]

**KuGou**

| | |
|---|---|
| **Developer(s)** | Tencent Music |
| **Initial release** | 2004; 15 years ago |
| **Operating system** | Android, iOS, Web, Windows |
| **Type** | Music streaming |
| **Website** | www.kugou.com |

## References [ edit ]


1. ^ a b c d e f Zen Soo (July 15, 2016). "Tencent to merge QQ Music service with China Music Corp to create streaming giant". *South China Morning Post*. Retrieved August 20, 2016.
2. ^ a b Jubb, Nathan (October 19, 2016). "The Future of Music Streaming Lies in China's Small Cities". *Sixth Tone*. Retrieved October 27, 2016.
3. ^ Millward, Steven (July 15, 2016). "In China, 'Spotify' is free". *Tech In Asia*. Retrieved August 20, 2016.
4. ^ Kim Dong-Joo (March 31, 2016). "Kang Ta & SHINee garner awards at 'KU MUSIC ASIAN MUSIC AWARDS'". *sg.style.yahoo.com*. Retrieved August 20, 2016.
5. ^ "FTISLAND Wins "Asia's Popular Band" Award at Cool Music Asia Festival Award". *Soompi*. April 23, 2015. Retrieved August 20, 2016.


## External links [ edit ]

- Official website (in Chinese)

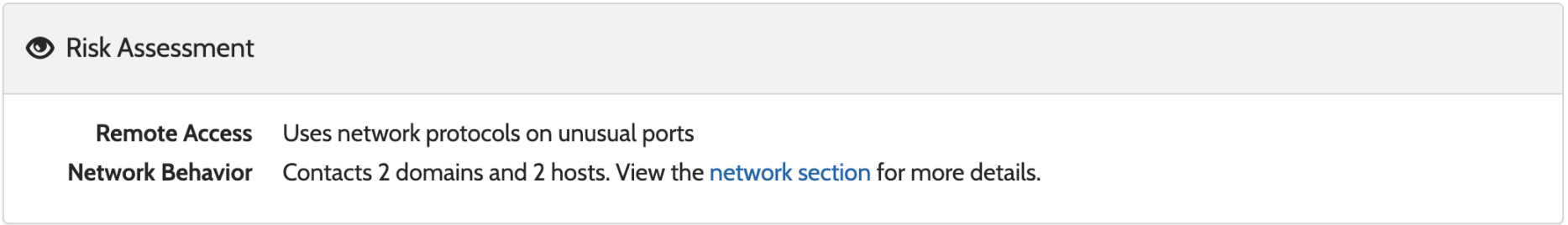
# 16d6b0e2c77da2776a88dd88c7cfc672

```
root@li254-249 ~ python enum_exports.py 16d6b0e2c77da2776a88dd88c7cfc672
0x100011e0      CreateDatabaseQueryObject       1
0x100011e0      DataImporterMain        2
0x100011e0      FlashboxMain    3
0x100010d0      KugouMain       4
```

```
Dump of assembler code for function kugou!FlashboxMain:
   0x100011e0 <+0>:     xor    eax,eax
   0x100011e2 <+2>:     ret
   0x100011e3 <+3>:     nop
   0x100011e4 <+4>:     nop
   0x100011e5 <+5>:     nop
   0x100011e6 <+6>:     nop
   0x100011e7 <+7>:     nop
   0x100011e8 <+8>:     nop
   0x100011e9 <+9>:     nop
   0x100011ea <+10>:    nop
   0x100011eb <+11>:    nop
   0x100011ec <+12>:    nop
   0x100011ed <+13>:    nop
   0x100011ee <+14>:    nop
   0x100011ef <+15>:    nop
```

# 16d6b0e2c77da2776a88dd88c7cfc672

## Incident Response




- https://www.hybrid-analysis.com/sample/037203d274cb66bad34559c0f426e9e1bf91a048155240581f4aa554be17925c?environmentId=100

0fd6e3fb1cd5ec397ff3cdbaac39d80c

```
root@li254-249 ~ python enum_exports.py 0fd6e3fb1cd5ec397ff3cdbaac39d80c
0x10002628      AheadLib_LpkPresent     36
0x10002634      AheadLib_ScriptApplyDigitSubstitution   37
0x10002640      AheadLib_ScriptApplyLogicalWidth        38
0x1000264c      AheadLib_ScriptBreak    39
0x10002658      AheadLib_ScriptCPtoX    40
0x10002664      AheadLib_ScriptCacheGetHeight   41
0x10002670      AheadLib_ScriptFreeCache        42
0x1000267c      AheadLib_ScriptGetCMap          43
0x10002688      AheadLib_ScriptGetFontProperties        44
0x10002694      AheadLib_ScriptGetGlyphABCWidth         45
0x1000271f      AheadLib_ScriptGetLogicalWidths         46
0x1000272b      AheadLib_ScriptGetProperties    47
0x10002737      AheadLib_ScriptIsComplex        48
0x10002743      AheadLib_ScriptItemize          49
0x10003091      AheadLib_ScriptJustify          50
0x1000309d      AheadLib_ScriptLayout   51
0x100030a9      AheadLib_ScriptPlace    52
0x100030b5      AheadLib_ScriptRecordDigitSubstitution          53
0x100030c1      AheadLib_ScriptShape    54
0x100030cd      AheadLib_ScriptStringAnalyse    55
0x100030d9      AheadLib_ScriptStringCPtoX      56
0x100030e5      AheadLib_ScriptStringFree       57
0x100030f1      AheadLib_ScriptStringGetLogicalWidths   58
0x100030fd      AheadLib_ScriptStringGetOrder   59
0x10003109      AheadLib_ScriptStringOut        60
0x10003115      AheadLib_ScriptStringValidate   61
0x10003121      AheadLib_ScriptStringXtoCP      62
0x1000312d      AheadLib_ScriptString_pLogAttr          63
0x10003139      AheadLib_ScriptString_pSize     64
0x10003145      AheadLib_ScriptString_pcOutChars        65
0x10003151      AheadLib_ScriptTextOut          66
0x1000315d      AheadLib_ScriptXtoCP    67
0x10003169      AheadLib_UspAllocCache          68
0x10003175      AheadLib_UspAllocTemp   69
0x10003181      AheadLib_UspFreeMem     70
0x100023cf      LpkDllInitialize        311
0x100023db      LpkDrawTextEx   411
0x1001d040      LpkEditControl          71
0x100023f3      LpkExtTextOut   611
0x100023ff      LpkGetCharacterPlacement        711
0x100025f3      LpkGetTextExtentExPoint         811
0x100023b7      LpkInitialize   111
0x10002604      LpkPSMTextOut   911
0x10002628      LpkPresent      1
0x100023c3      LpkTabbedTextOut        211
0x10002610      LpkUseGDIWidthCache     1011
0x100023cf      MemCode_LpkDllInitialize        72
0x100023db      MemCode_LpkDrawTextEx   73
0x100023e7      MemCode_LpkEditControl          74
0x100023f3      MemCode_LpkExtTextOut   75
0x100023ff      MemCode_LpkGetCharacterPlacement        76
0x100025f3      MemCode_LpkGetTextExtentExPoint         77
0x100023b7      MemCode_LpkInitialize   78
0x10002604      MemCode_LpkPSMTextOut   79
0x100023c3      MemCode_LpkTabbedTextOut        80
0x10002610      MemCode_LpkUseGDIWidthCache     81
0x1000261c      MemCode_ftsWordBreak    82
0x10002634      ScriptApplyDigitSubstitution    2
0x10002640      ScriptApplyLogicalWidth         3
```

```
gdb-peda$ disas ScriptBreak
Dump of assembler code for function drc!ScriptBreak:
   0x1000264c <+0>:     push   0x1001d804
   0x10002651 <+5>:     call   0x1000233d
   0x10002656 <+10>:    jmp    eax
End of assembler dump.
```

```
gdb-peda$ disas LpkPresent
Dump of assembler code for function drc!LpkPresent:
   0x10002628 <+0>:     push   0x1001d7c0
   0x1000262d <+5>:     call   0x1000233d
   0x10002632 <+10>:    jmp    eax
End of assembler dump.
```

6a764e4e6db461781d080034aab85aff
&
cc3c6c77e118a83ca0513c25c208832c

```
root@li254-249 ~ python enum_exports.py 6a764e4e6db461781d080034aab85aff
0x10004f00      AheadLib_ScriptApplyDigitSubstitution   36
0x10004f10      AheadLib_ScriptApplyLogicalWidth        37
0x10004f20      AheadLib_ScriptBreak    38
0x10004f30      AheadLib_ScriptCPtoX    39
0x10004f40      AheadLib_ScriptCacheGetHeight   40
0x10004f50      AheadLib_ScriptFreeCache        41
0x10004f60      AheadLib_ScriptGetCMap          42
0x10004f70      AheadLib_ScriptGetFontProperties        43
0x10004f80      AheadLib_ScriptGetGlyphABCWidth         44
0x10004f90      AheadLib_ScriptGetLogicalWidths         45
0x10004fa0      AheadLib_ScriptGetProperties    46
0x10004fb0      AheadLib_ScriptIsComplex        47
0x10004fc0      AheadLib_ScriptItemize          48
0x10004fd0      AheadLib_ScriptJustify          49
0x10004fe0      AheadLib_ScriptLayout   50
0x10004ff0      AheadLib_ScriptPlace    51
0x10005000      AheadLib_ScriptRecordDigitSubstitution          52
0x10005010      AheadLib_ScriptShape    53
0x10005020      AheadLib_ScriptStringAnalyse    54
0x10005030      AheadLib_ScriptStringCPtoX      55
0x10005040      AheadLib_ScriptStringFree       56
0x10005050      AheadLib_ScriptStringGetLogicalWidths   57
0x10005060      AheadLib_ScriptStringGetOrder   58
0x10005070      AheadLib_ScriptStringOut        59
0x10005080      AheadLib_ScriptStringValidate   60
0x10005090      AheadLib_ScriptStringXtoCP      61
0x100050a0      AheadLib_ScriptString_pLogAttr          62
0x100050b0      AheadLib_ScriptString_pSize     63
0x100050c0      AheadLib_ScriptString_pcOutChars        64
0x100050d0      AheadLib_ScriptTextOut          65
0x100050e0      AheadLib_ScriptXtoCP    66
0x100050f0      AheadLib_UspAllocCache          67
0x10005100      AheadLib_UspAllocTemp   68
0x10005110      AheadLib_UspFreeMem     69
0x10004ef0      AheadLib_mmLpkPresent   70
0x10004e50      LpkDllInitialize        311
0x10004e60      LpkDrawTextEx   411
0x1000e92c      LpkEditControl          71
0x10004e80      LpkExtTextOut   611
0x10004e90      LpkGetCharacterPlacement        711
0x10004ea0      LpkGetTextExtentExPoint         811
0x10004e30      LpkInitialize   111
0x10004ec0      LpkPSMTextOut   911
0x10004ef0      LpkPresent      1
0x10004e40      LpkTabbedTextOut        211
0x10004ed0      LpkUseGDIWidthCache     1011
0x10004e50      MemCode_LpkDllInitialize        72
0x10004e60      MemCode_LpkDrawTextEx   73
0x10004e70      MemCode_LpkEditControl          74
0x10004e80      MemCode_LpkExtTextOut   75
0x10004e90      MemCode_LpkGetCharacterPlacement        76
0x10004ea0      MemCode_LpkGetTextExtentExPoint         77
0x10004e30      MemCode_LpkInitialize   78
0x10004ec0      MemCode_LpkPSMTextOut   79
0x10004e40      MemCode_LpkTabbedTextOut        80
0x10004ed0      MemCode_LpkUseGDIWidthCache     81
0x10004ee0      MemCode_ftsWordBreak    82
0x10004f00      ScriptApplyDigitSubstitution    2
0x10004f10      ScriptApplyLogicalWidth         3
```

```
root@li254-249 ~ python enum_exports.py cc3c6c77e118a83ca0513c25c208832c
0x10001100      LpkPresent      1
0x10001120      ScriptApplyDigitSubstitution    2
0x10001140      ScriptApplyLogicalWidth         3
0x10001160      ScriptBreak     4
0x10001180      ScriptCPtoX     5
0x100011a0      ScriptCacheGetHeight    6
0x100011c0      ScriptFreeCache         7
0x100011e0      ScriptGetCMap   8
0x10001200      ScriptGetFontProperties         9
0x10001220      ScriptGetGlyphABCWidth          10
0x10001240      ScriptGetLogicalWidths          11
0x10001260      ScriptGetProperties     12
0x10001280      ScriptIsComplex         13
0x100012a0      ScriptItemize   14
0x100012c0      ScriptJustify   15
0x100012e0      ScriptLayout    16
0x10001300      ScriptPlace     17
0x10001320      ScriptRecordDigitSubstitution   18
0x10001340      ScriptShape     19
0x10001360      ScriptStringAnalyse     20
0x10001380      ScriptStringCPtoX       21
0x100013a0      ScriptStringFree        22
0x100013c0      ScriptStringGetLogicalWidths    23
0x100013e0      ScriptStringGetOrder    24
0x10001400      ScriptStringOut         25
0x10001420      ScriptStringValidate    26
0x10001440      ScriptStringXtoCP       27
0x10001460      ScriptString_pLogAttr   28
0x10001480      ScriptString_pSize      29
0x100014a0      ScriptString_pcOutChars         30
0x100014c0      ScriptTextOut   31
0x100014e0      ScriptXtoCP     32
0x10001890      ServiceMain     36
0x10001500      UspAllocCache   33
0x10001520      UspAllocTemp    34
0x10001540      UspFreeMem      35
```

e0bed0b33e7b6183f654f0944b607618

# e0bed0b33e7b6183f654f0944b607618

```
root@li254-249 ~ python enum_exports.py e0bed0b33e7b6183f654f0944b607618
0x100165f0      LsaApCallPackage        1
0x10016610      LsaApCallPackagePassthrough     2
0x10016600      LsaApCallPackageUntrusted       3
0x100165e0      LsaApInitializePackage          4
0x10016620      LsaApLogonTerminated    5
0x10016470      LsaApLogonUserEx2       6
0x10016560      SpInitialize    7
0x100165d0      SpInstanceInit          8
0x10016570      SpLsaModeInitialize     9
0x100165c0      SpUserModeInitialize    10
```

db8199eeb2d75e789df72cd8852a9fbb

(Rootkit.Win32.blackken.b)

# db8199eeb2d75e789df72cd8852a9fbb

```
root@li254-249 ~ python enum_exports.py db8199eeb2d75e789df72cd8852a9fbb
0x10006707      ?Start@@YGKPAX@Z        1
0x10006707      MakeCache       2
```

Is this claim correct?

**If two export functions share the same address, it's a malware.**

1c1131112db91382b9d8b46115045097

# 1c1131112db91382b9d8b46115045097

```
 root@li254-249  ~  python enum_exports.py 1c1131112db91382b9d8b46115045097
0x100014a0       AfxGetHttpRaquestMgr    3
0x100014b0       AfxGetHttpRequastMgr    4
0x10001490       InitInstance    2
0x10001490       MessageLoop     1
```

# EAT (Export Address Table)

- Similar to IAT, EAT data is stored in IMAGE_EXPORT_DIRECTORY
- EAT contains an RVA that points to an array of pointers to **(RVAs of) the functions in the module**.

# Q & A