

Reverse Engineering - 3

2021/12/03

Presented by LJP

whoami

- LJP / LJP-TW
- SQLab @ NYCU 碩一
- CTF @ 10sec / TSJ
- Pwner



Outline

- Sysinternals
- TLS Callback
- TEB
- Exception
- Packer
- Anti-Reverse

Sysinternals

Sysinternals

- 除了直接逆向逆起來，還可以先觀察程式跑起來時會做什麼
- e.g.
 - 創 child process
 - 讀寫檔案
 - 網路連線

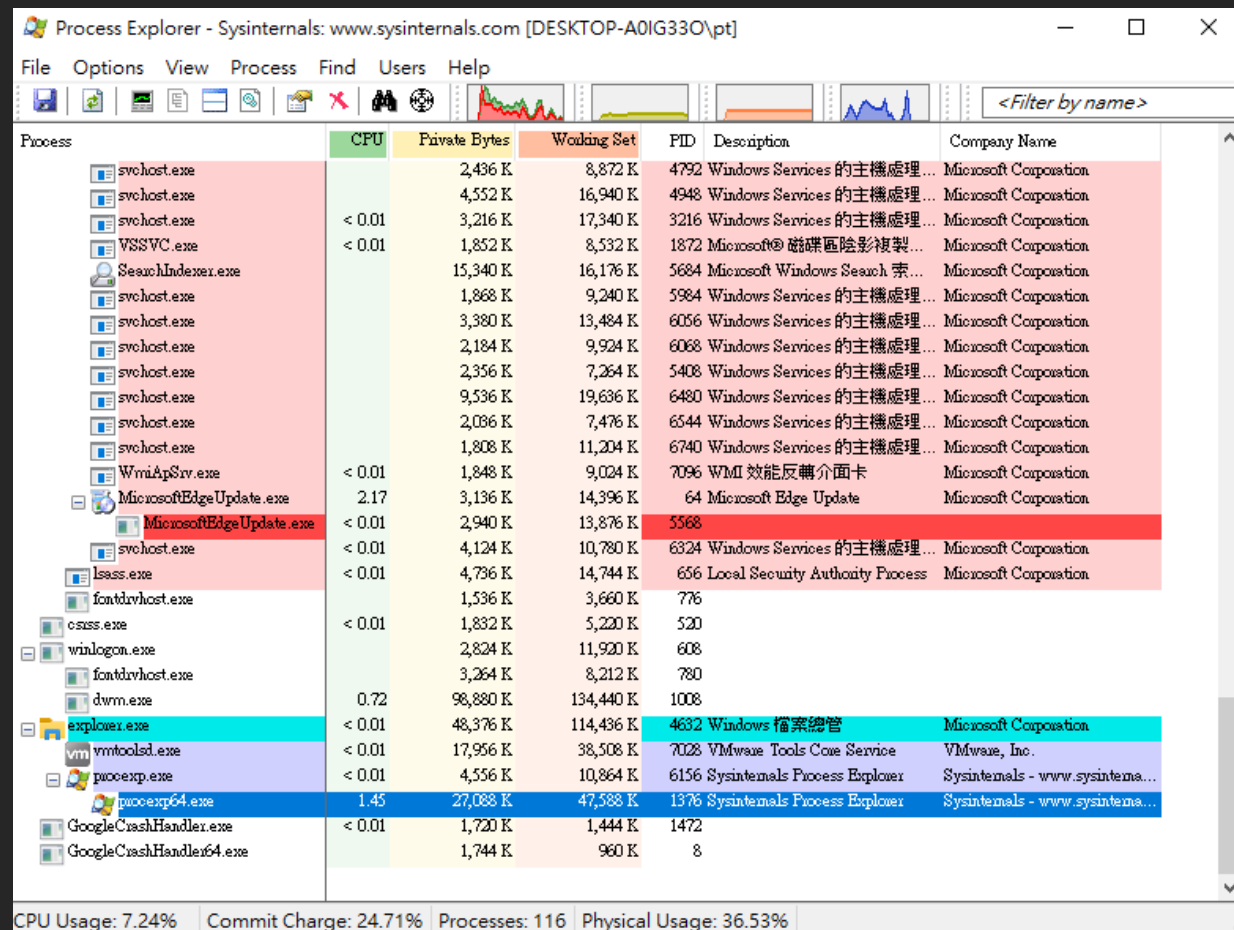
Sysinternals

- Sysinternals 集成了許多工具
- 介紹以下兩個工具, 其他工具可以自行摸索
- Procexp
- Procmon

Sysinternals

Procexp

- 好看版的工作管理員
- 這邊另外推薦與之類似的工具
 - Process Hacker

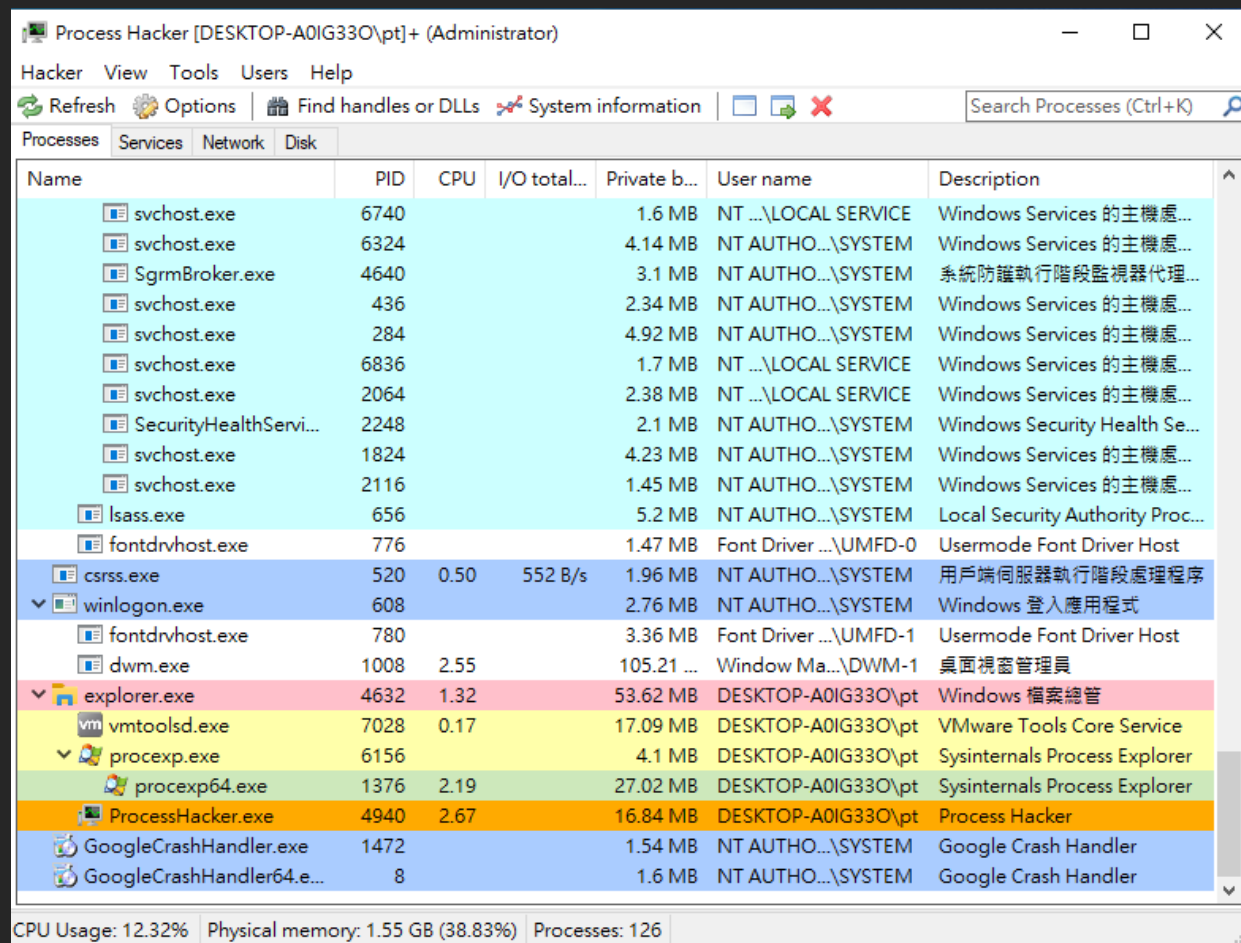


Process	CPU	Private Bytes	Working Set	PID	Description	Company Name
svchost.exe		2,436 K	8,872 K	4792	Windows Services 的主機處理...	Microsoft Corporation
svchost.exe		4,552 K	16,940 K	4948	Windows Services 的主機處理...	Microsoft Corporation
svchost.exe	< 0.01	3,216 K	17,340 K	3216	Windows Services 的主機處理...	Microsoft Corporation
VSSVC.exe	< 0.01	1,852 K	8,532 K	1872	Microsoft® 磁碟區陰影複製...	Microsoft Corporation
SearchIndexer.exe		15,340 K	16,176 K	5684	Microsoft Windows Search 索...	Microsoft Corporation
svchost.exe		1,868 K	9,240 K	5984	Windows Services 的主機處理...	Microsoft Corporation
svchost.exe		3,380 K	13,484 K	6056	Windows Services 的主機處理...	Microsoft Corporation
svchost.exe		2,184 K	9,924 K	6068	Windows Services 的主機處理...	Microsoft Corporation
svchost.exe		2,356 K	7,264 K	5408	Windows Services 的主機處理...	Microsoft Corporation
svchost.exe		9,536 K	19,636 K	6480	Windows Services 的主機處理...	Microsoft Corporation
svchost.exe		2,036 K	7,476 K	6544	Windows Services 的主機處理...	Microsoft Corporation
svchost.exe		1,808 K	11,204 K	6740	Windows Services 的主機處理...	Microsoft Corporation
WmiApSrv.exe	< 0.01	1,848 K	9,024 K	7096	WMI 效能反轉介面卡	Microsoft Corporation
MicrosoftEdgeUpdate.exe	2.17	3,136 K	14,396 K	64	Microsoft Edge Update	Microsoft Corporation
MicrosoftEdgeUpdate.exe	< 0.01	2,940 K	13,876 K	5568		
svchost.exe	< 0.01	4,124 K	10,780 K	6324	Windows Services 的主機處理...	Microsoft Corporation
lsass.exe	< 0.01	4,736 K	14,744 K	656	Local Security Authority Process	Microsoft Corporation
fontdrvhost.exe		1,536 K	3,660 K	776		
csrss.exe	< 0.01	1,832 K	5,220 K	520		
winlogon.exe		2,824 K	11,920 K	608		
fontdrvhost.exe		3,264 K	8,212 K	780		
dwm.exe	0.72	98,880 K	134,440 K	1008		
explorer.exe	< 0.01	48,376 K	114,436 K	4632	Windows 檔案總管	Microsoft Corporation
vmtoolsd.exe	< 0.01	17,956 K	38,508 K	7028	VMware Tools Core Service	VMware, Inc.
procexp.exe	< 0.01	4,556 K	10,864 K	6156	Sysinternals Process Explorer	Sysinternals - www.sysinterna...
procexp64.exe	1.45	27,088 K	47,588 K	1376	Sysinternals Process Explorer	Sysinternals - www.sysinterna...
GoogleCrashHandler.exe	< 0.01	1,720 K	1,444 K	1472		
GoogleCrashHandler64.exe		1,744 K	960 K	8		

CPU Usage: 7.24% | Commit Charge: 24.71% | Processes: 116 | Physical Usage: 36.53%

Process Hacker

- 相較於 Procexp, 提供更多訊息



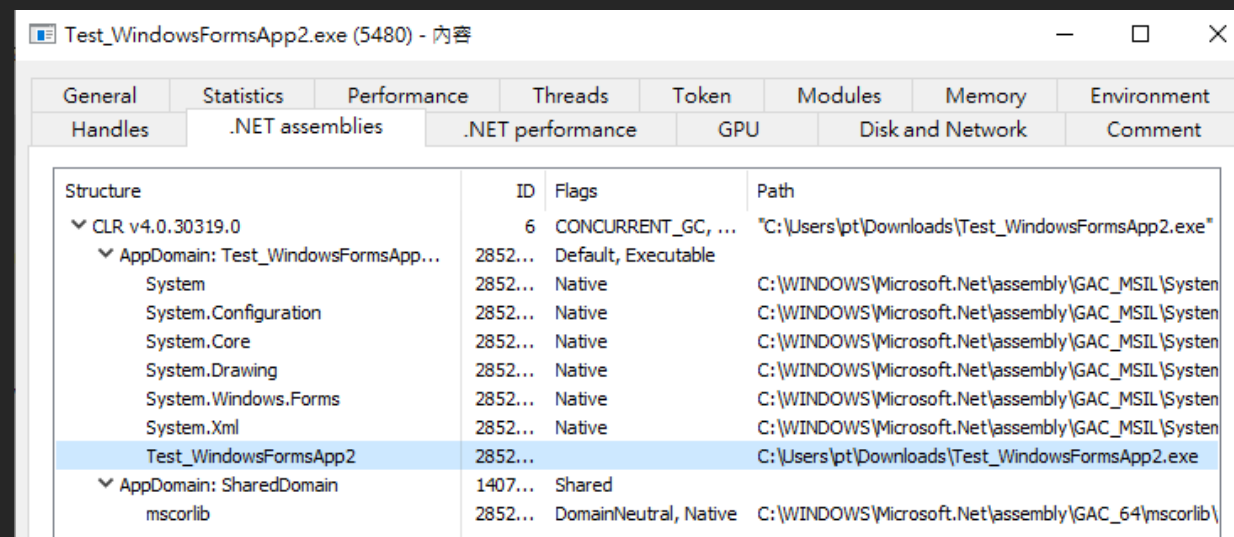
The screenshot shows the Process Hacker application window. The title bar reads "Process Hacker [DESKTOP-A0IG33O\pt] + (Administrator)". The menu bar includes "Hacker", "View", "Tools", "Users", and "Help". The toolbar contains "Refresh", "Options", "Find handles or DLLs", "System information", and a search icon. The "Processes" tab is selected, displaying a table of running processes. The table has columns for Name, PID, CPU, I/O total..., Private b..., User name, and Description. Processes are color-coded by user: SYSTEM (light blue), LOCAL SERVICE (light blue), NT AUTHORITY\SYSTEM (light blue), LOCAL SERVICE (light blue), LOCAL SERVICE (light blue), SECURITY HEALTH SERVICE (light blue), LOCAL SERVICE (light blue), LOCAL SERVICE (light blue), LOCAL SECURITY AUTHORITY PROCESS (light blue), FONT DRIVER...UMFD-0 (light blue), USERMODE FONT DRIVER HOST (light blue), USERMODE FONT DRIVER HOST (light blue), WINDOW MANAGER\DWM-1 (light blue), DESKTOP-A0IG33O\pt (pink), DESKTOP-A0IG33O\pt (yellow), DESKTOP-A0IG33O\pt (green), DESKTOP-A0IG33O\pt (orange), NT AUTHORITY\SYSTEM (light blue), and NT AUTHORITY\SYSTEM (light blue).

Name	PID	CPU	I/O total...	Private b...	User name	Description
svchost.exe	6740			1.6 MB	NT ...\LOCAL SERVICE	Windows Services 的主機處...
svchost.exe	6324			4.14 MB	NT AUTHO...\SYSTEM	Windows Services 的主機處...
SgrmBroker.exe	4640			3.1 MB	NT AUTHO...\SYSTEM	系統防範執行階段監視器代理...
svchost.exe	436			2.34 MB	NT AUTHO...\SYSTEM	Windows Services 的主機處...
svchost.exe	284			4.92 MB	NT AUTHO...\SYSTEM	Windows Services 的主機處...
svchost.exe	6836			1.7 MB	NT ...\LOCAL SERVICE	Windows Services 的主機處...
svchost.exe	2064			2.38 MB	NT ...\LOCAL SERVICE	Windows Services 的主機處...
SecurityHealthSevi...	2248			2.1 MB	NT AUTHO...\SYSTEM	Windows Security Health Se...
svchost.exe	1824			4.23 MB	NT AUTHO...\SYSTEM	Windows Services 的主機處...
svchost.exe	2116			1.45 MB	NT AUTHO...\SYSTEM	Windows Services 的主機處...
lsass.exe	656			5.2 MB	NT AUTHO...\SYSTEM	Local Security Authority Proc...
fontdrvhost.exe	776			1.47 MB	Font Driver ...\UMFD-0	Usermode Font Driver Host
csrss.exe	520	0.50	552 B/s	1.96 MB	NT AUTHO...\SYSTEM	用戶端伺服器執行階段處理程序
winlogon.exe	608			2.76 MB	NT AUTHO...\SYSTEM	Windows 登入應用程式
fontdrvhost.exe	780			3.36 MB	Font Driver ...\UMFD-1	Usermode Font Driver Host
dwm.exe	1008	2.55		105.21 ...	Window Ma...\DWM-1	桌面視窗管理員
explorer.exe	4632	1.32		53.62 MB	DESKTOP-A0IG33O\pt	Windows 檔案總管
vmtoolsd.exe	7028	0.17		17.09 MB	DESKTOP-A0IG33O\pt	VMware Tools Core Service
procexp.exe	6156			4.1 MB	DESKTOP-A0IG33O\pt	Sysinternals Process Explorer
procexp64.exe	1376	2.19		27.02 MB	DESKTOP-A0IG33O\pt	Sysinternals Process Explorer
ProcessHacker.exe	4940	2.67		16.84 MB	DESKTOP-A0IG33O\pt	Process Hacker
GoogleCrashHandler.exe	1472			1.54 MB	NT AUTHO...\SYSTEM	Google Crash Handler
GoogleCrashHandler64.e...	8			1.6 MB	NT AUTHO...\SYSTEM	Google Crash Handler

CPU Usage: 12.32% Physical memory: 1.55 GB (38.83%) Processes: 126

Process Hacker

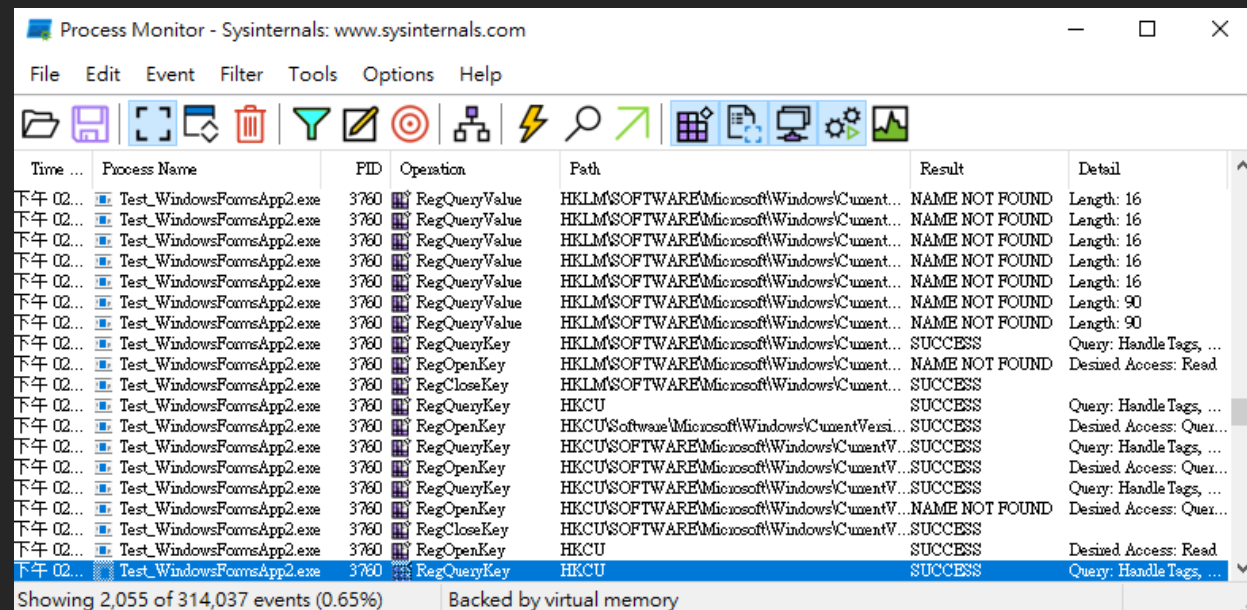
- 相較於 Procexp, 提供更多訊息
- e.g. .NET assemblies



Sysinternals

Procmon

- 監控程序行為
 - Registry
 - File system
 - Network
 - Process/Thread



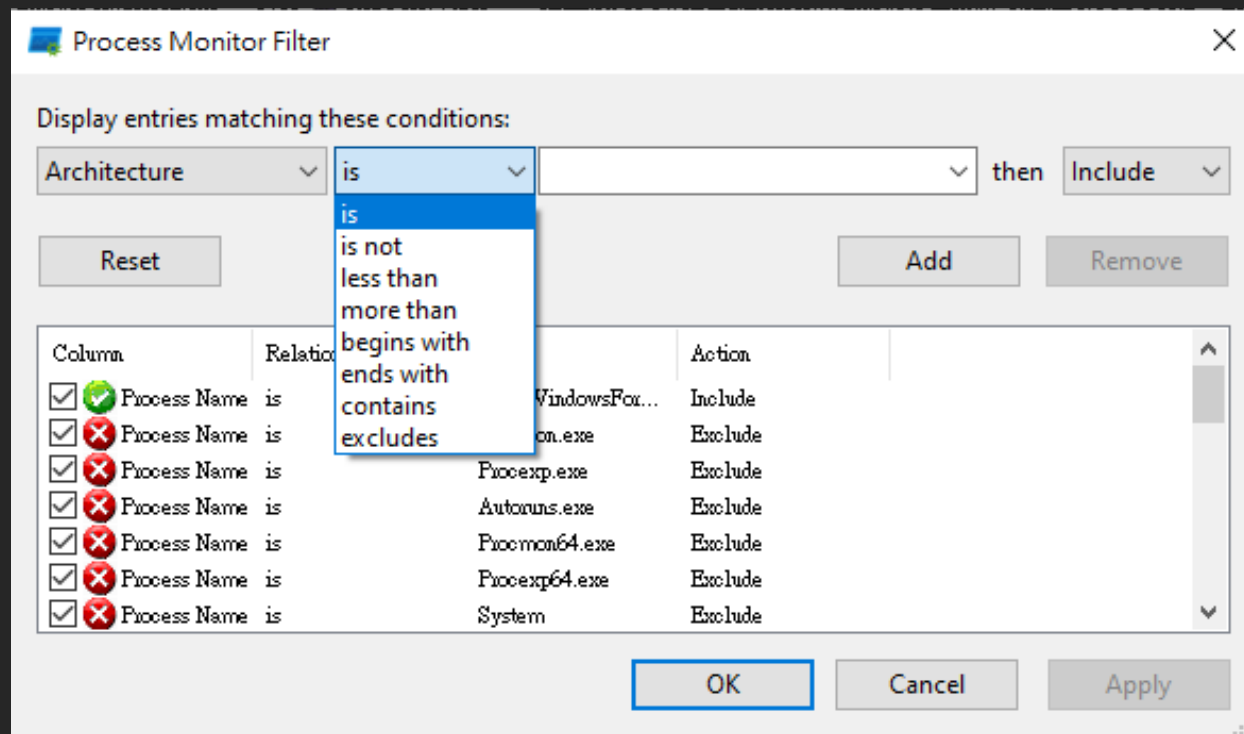
Time ...	Process Name	PID	Operation	Path	Result	Detail
下午 02...	Test_WindowsFormsApp2.exe	3760	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows\Cument...	NAME NOT FOUND	Length: 16
下午 02...	Test_WindowsFormsApp2.exe	3760	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows\Cument...	NAME NOT FOUND	Length: 16
下午 02...	Test_WindowsFormsApp2.exe	3760	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows\Cument...	NAME NOT FOUND	Length: 16
下午 02...	Test_WindowsFormsApp2.exe	3760	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows\Cument...	NAME NOT FOUND	Length: 16
下午 02...	Test_WindowsFormsApp2.exe	3760	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows\Cument...	NAME NOT FOUND	Length: 16
下午 02...	Test_WindowsFormsApp2.exe	3760	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows\Cument...	NAME NOT FOUND	Length: 90
下午 02...	Test_WindowsFormsApp2.exe	3760	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows\Cument...	NAME NOT FOUND	Length: 90
下午 02...	Test_WindowsFormsApp2.exe	3760	RegQueryKey	HKLM\SOFTWARE\Microsoft\Windows\Cument...	SUCCESS	Query: Handle Tags, ...
下午 02...	Test_WindowsFormsApp2.exe	3760	RegOpenKey	HKLM\SOFTWARE\Microsoft\Windows\Cument...	NAME NOT FOUND	Desired Access: Read
下午 02...	Test_WindowsFormsApp2.exe	3760	RegCloseKey	HKLM\SOFTWARE\Microsoft\Windows\Cument...	SUCCESS	
下午 02...	Test_WindowsFormsApp2.exe	3760	RegQueryKey	HKCU	SUCCESS	Query: Handle Tags, ...
下午 02...	Test_WindowsFormsApp2.exe	3760	RegOpenKey	HKCU\Software\Microsoft\Windows\CumentVersi...	SUCCESS	Desired Access: Quer...
下午 02...	Test_WindowsFormsApp2.exe	3760	RegQueryKey	HKCU\SOFTWARE\Microsoft\Windows\CumentV...	SUCCESS	Query: Handle Tags, ...
下午 02...	Test_WindowsFormsApp2.exe	3760	RegOpenKey	HKCU\SOFTWARE\Microsoft\Windows\CumentV...	SUCCESS	Desired Access: Quer...
下午 02...	Test_WindowsFormsApp2.exe	3760	RegQueryKey	HKCU\SOFTWARE\Microsoft\Windows\CumentV...	SUCCESS	Query: Handle Tags, ...
下午 02...	Test_WindowsFormsApp2.exe	3760	RegOpenKey	HKCU\SOFTWARE\Microsoft\Windows\CumentV...	NAME NOT FOUND	Desired Access: Quer...
下午 02...	Test_WindowsFormsApp2.exe	3760	RegCloseKey	HKCU\SOFTWARE\Microsoft\Windows\CumentV...	SUCCESS	
下午 02...	Test_WindowsFormsApp2.exe	3760	RegOpenKey	HKCU	SUCCESS	Desired Access: Read
下午 02...	Test_WindowsFormsApp2.exe	3760	RegQueryKey	HKCU	SUCCESS	Query: Handle Tags, ...

Showing 2,055 of 314,037 events (0.65%) Backed by virtual memory

Sysinternals

Procmon

- 訊息量過大, 請善用 Filter
- 可以直接在顯示面板對資料右鍵快速篩進/篩掉想要的資料



TLS callback

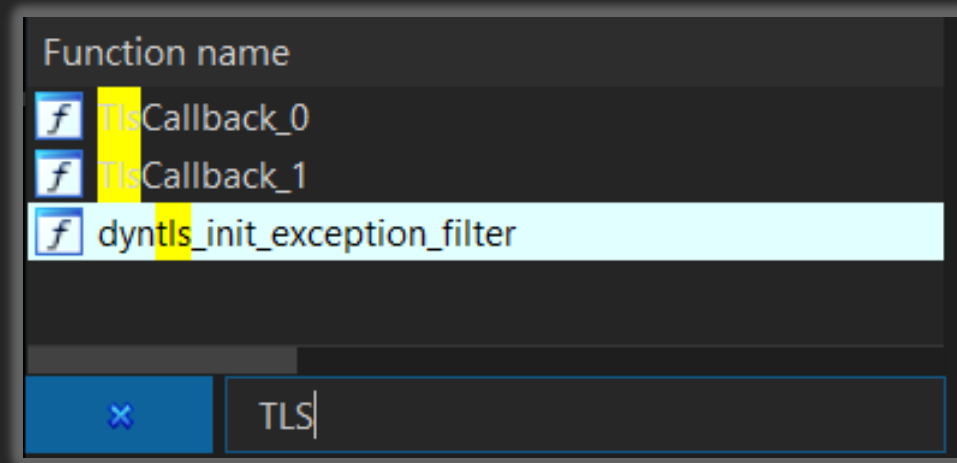
TLS Callback

- Process/Thread 的開始/結束時都會自動呼叫到 TLS Callback
- 跟之前討論過的 init/fini 不同
- 呼叫時機
 - TLS Cb -> Entry Point -> init -> main -> fini -> TLS Cb



TLS Callback

- IDA 能自動辨識出 TLS Callback
- How?



TLS Callback

- TLS Directory

Disasm	General	DOS Hdr	Rich Hdr	File Hdr	Optional Hdr	Section Hdrs
Offset	Name	Value	Value			
1A8	Exception Directory	20000	105C			
1B0	Security Directory	0	0			
1B8	Base Relocation Table	24000	66C			
1C0	Debug Directory	1B700	70			
1C8	Architecture Specific Data	0	0			
1D0	RVA of GlobalPtr	0	0			
1D8	TLS Directory	1B900	28			

TLS		
Offset	Name	Value
1A900	StartAddressOfRawData	14001BD40
1A908	EndAddressOfRawData	14001BD41
1A910	AddressOfIndex	14001EA90
1A918	AddressOfCallBacks	1400132C8
1A920	SizeOfZeroFill	0
1A924	Characteristics	100000
TLS Callbacks [2 entries]		
Offset	Callback	
122C8	140001070	
122D0	140001090	

TLS Callback

- TLS Directory
- AddressOfCallbacks

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
122C8	70	10	00	40	01	00	00	00	90	10	00	40	01	00	00	00
122D8	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

TLS		
Offset	Name	Value
1A900	StartAddressOfRawData	14001BD40
1A908	EndAddressOfRawData	14001BD41
1A910	AddressOfIndex	14001EA90
1A918	AddressOfCallbacks	1400132C8
1A920	SizeOfZeroFill	0
1A924	Characteristics	100000
TLS Callbacks [2 entries]		
Offset	Callback	
122C8	140001070	
122D0	140001090	

Lab 1

TEB

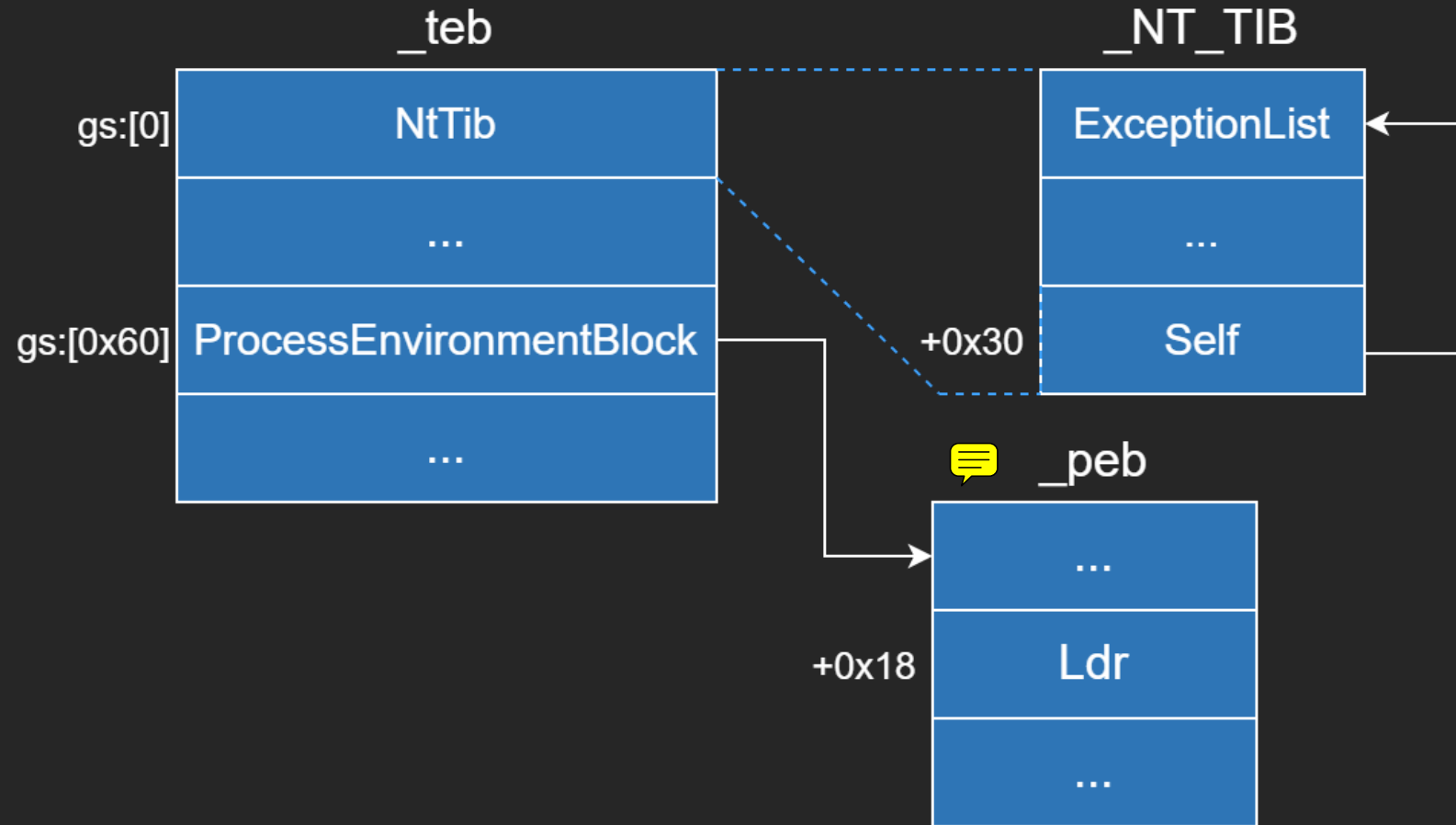
Thread Environment Block

TEB

- 前面我們講 PEB 時其實跳過了 TEB
- FS/GS 就是存放 TEB

- 取得 PEB
- 32bit
 - FS:[0x30]
- 64bit
 - GS:[0x60]

TEB (64-bit)



TEB

	ExceptionList	Self	PEB
32bit FS	[0]	[0x18]	[0x30]
64bit GS	[0]	[0x30]	[0x60]

TEB

所以那個 fs / gs 到底是啥



TEB

- 接下來的部分，你不知道也是可以繼續分析程式
- Segment Register
 - CS、DS、SS、ES、FS、GS
- FS:[0x30]?? GS:[0x60]??
- 這些咚咚有特別的記憶體算法

TEB

- FS:[0x30]
- 實際算法為 $\text{base address} + 0x30$
- Base address 怎麼來的?

TEB

- 如果是在 Compatibility mode ...

TEB

- 如果是在 Compatibility mode ...
- 等等 mode 是啥?!?!

TEB

- 各種模式

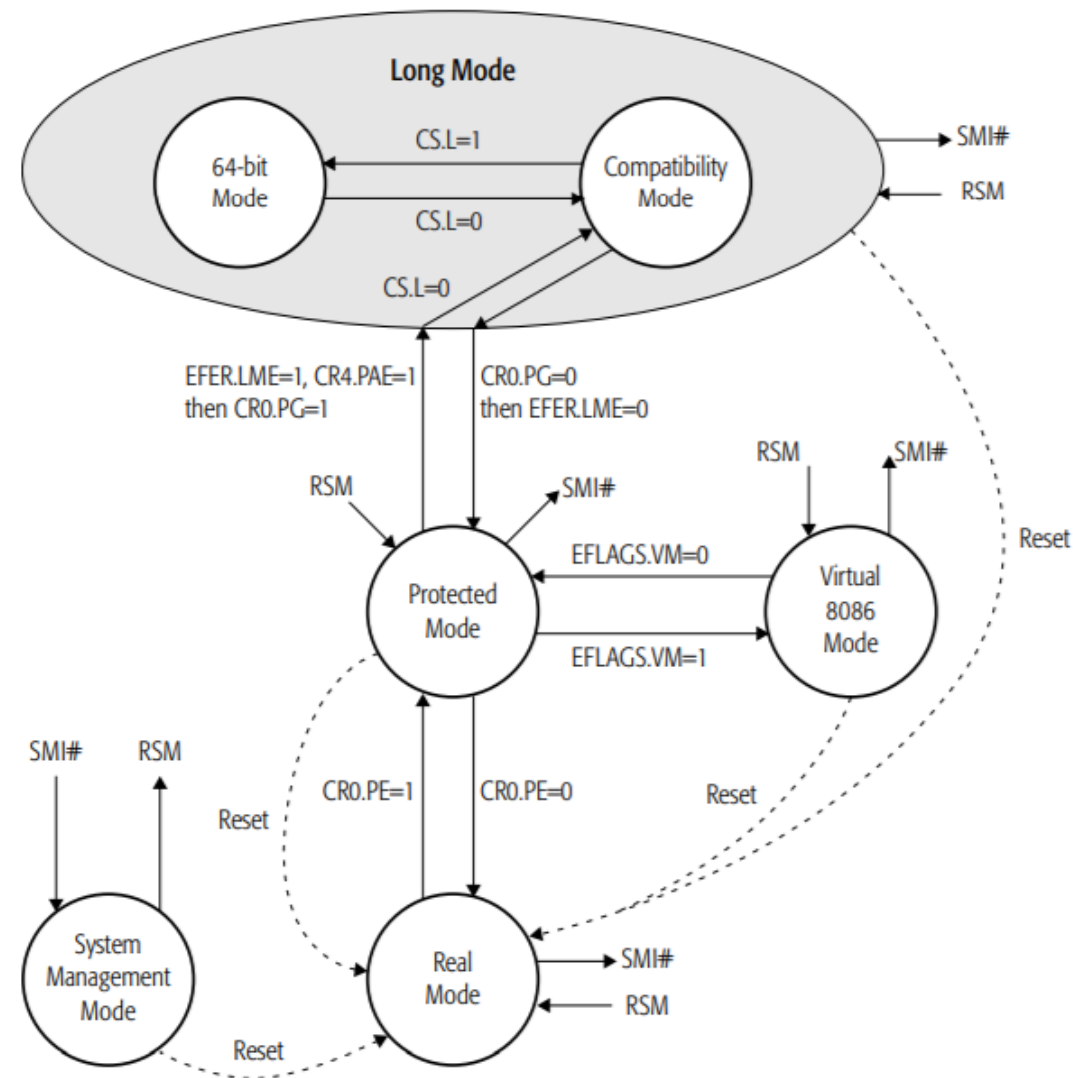


Figure 1-6. Operating Modes of the AMD64 Architecture

TEB

- 各種模式
- 實驗一下，如果 x64 windows 運行 x32 程式會在什麼模式

TEB

- CS.L = 0

```
32.1: kd> dg @cs
```

Sel	Base	Limit	Type	P	Si	Gr	Pr	Lo	ng	Flags
0023	00000000`00000000	00000000`ffffffff	Code RE Ac	3	Bg	Pg	P	Nl		00000cfb

```
32.1: kd> .formats @cs
Evaluate expression:
Hex:      00000000`00000023
Decimal:  35
Octal:    0000000000000000000043
Binary:   00000000 00000000 00000000 00000000 00000000 00000000 00000000 00100011
Chars:    .....#
Time:     Thu Jan  1 08:00:35 1970
Float:    low 4.90454e-044 high 0
Double:   1.72923e-322
```

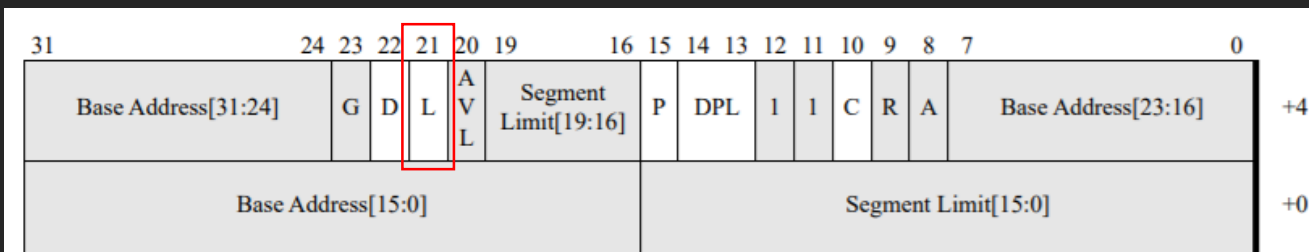
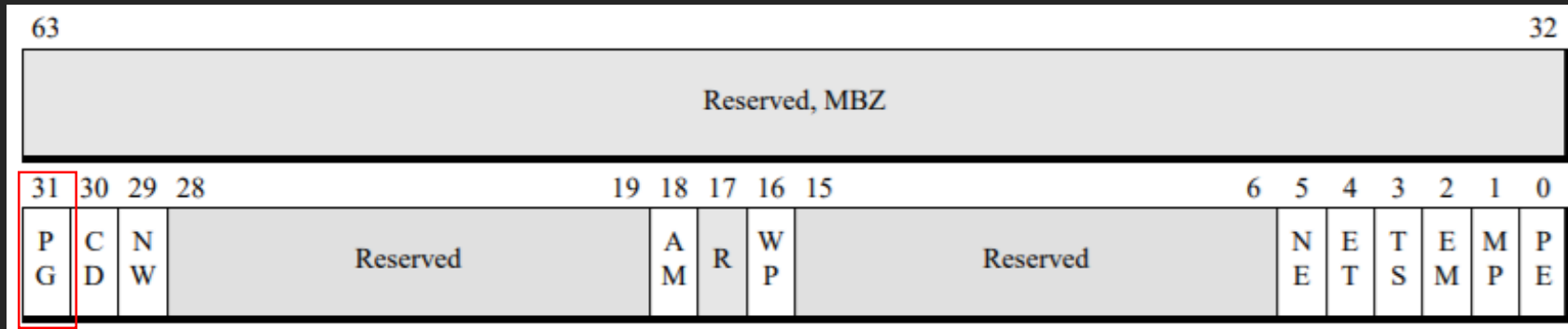


Figure 4-20. Code-Segment Descriptor—Long Mode

TEB

- CR0.PG = 1

```
32.1: kd> .formats @cr0
Evaluate expression:
Hex:      00000000`80050033
Decimal: 2147811379
Octal:    0000000000020001200063
Binary:   00000000 00000000 00000000 00000000 10000000 00000101 00000000 00110011
```



TEB

- 各種模式
- $CS.L = 0$
- $CR0.PG = 1$
- x64 windows 運行 x32 程式會在 Compatibility Mode

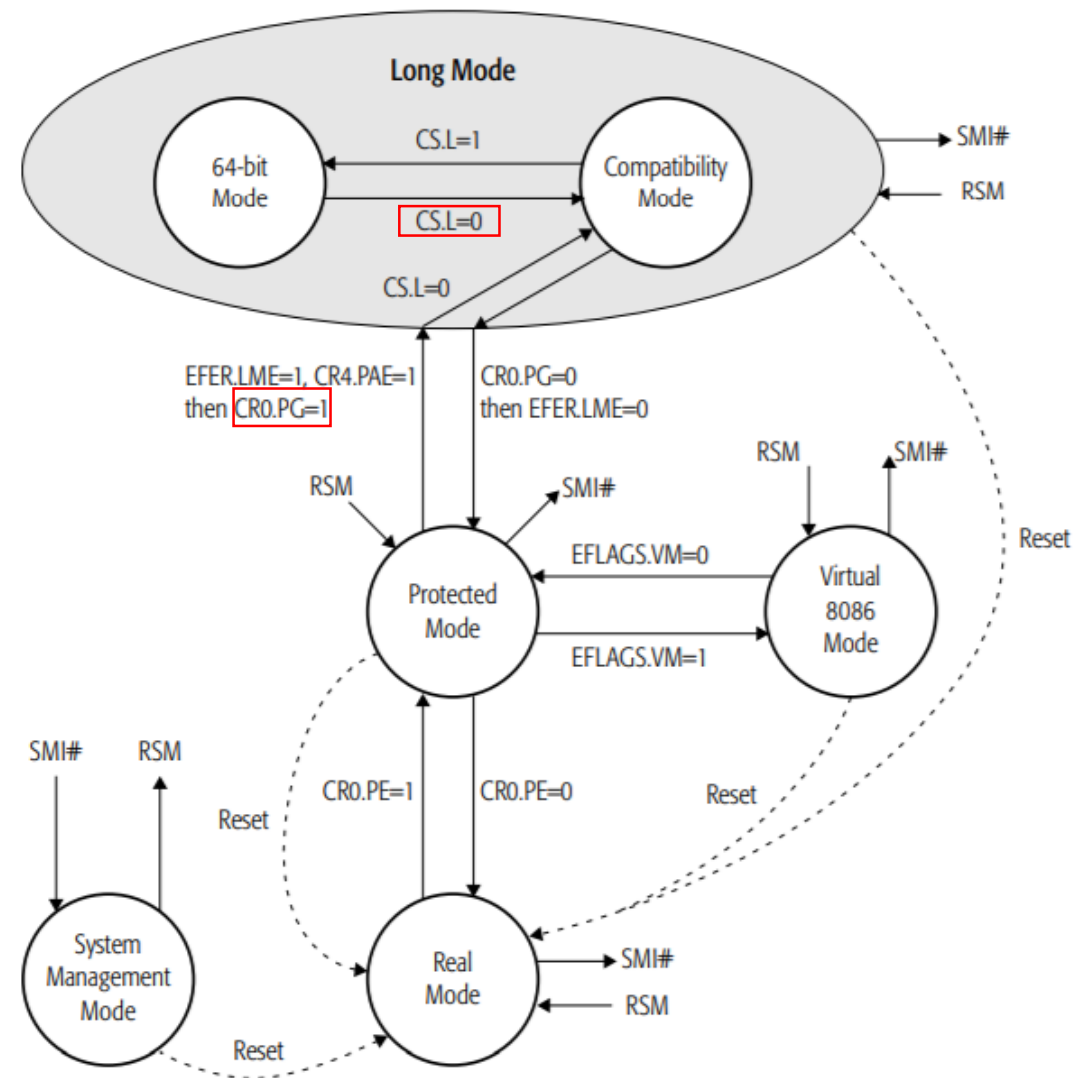
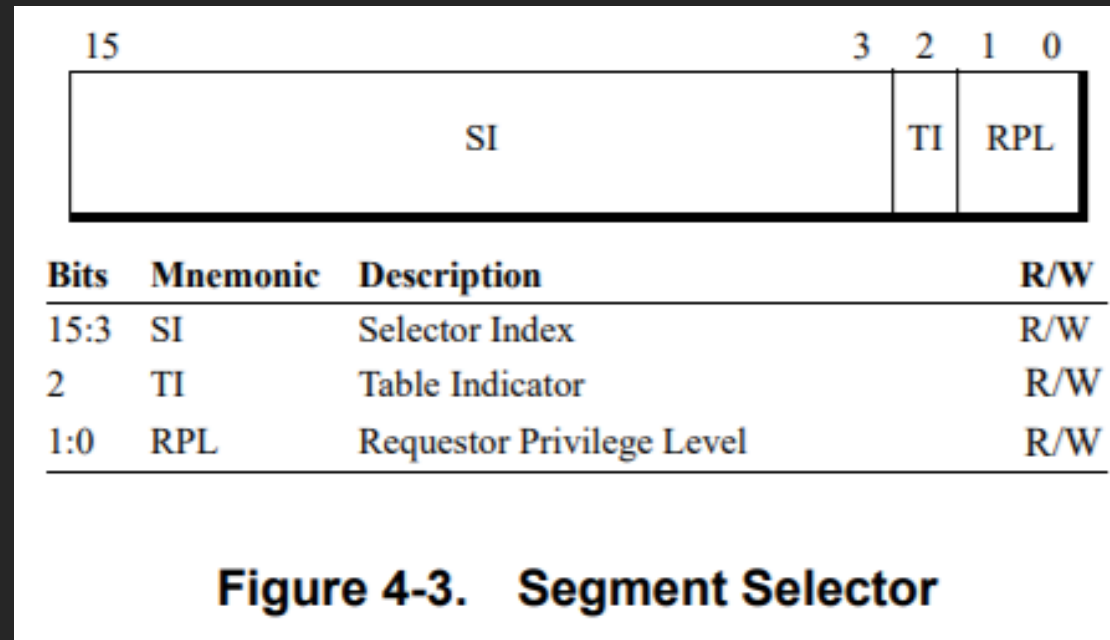


Figure 1-6. Operating Modes of the AMD64 Architecture

TEB

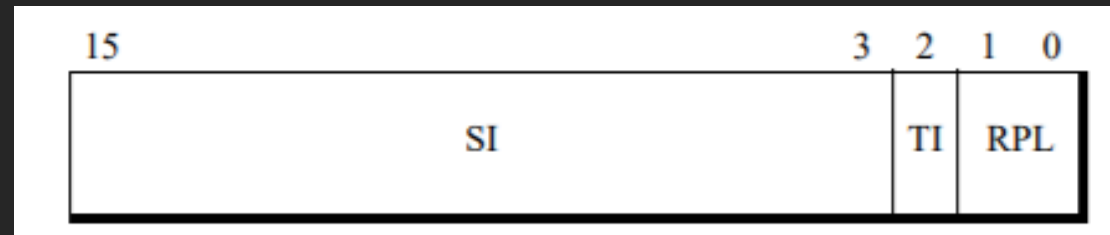
- 在 Compatibility mode 中, base address 是這樣來的...
- Segment Register 結構如下



TEB

- 看一下 FS
- FS = 0x53
- FS.TI = 0
- FS.SI = 1010 (bin) = 10 (dec)

```
32.1: kd> .formats fs
Evaluate expression:
Hex:      00000000`00000053
Decimal:  83
Octal:    0000000000000000000123
Binary:   00000000 00000000 00000000 00000000 00000000 00000000 00000000 01010011
```



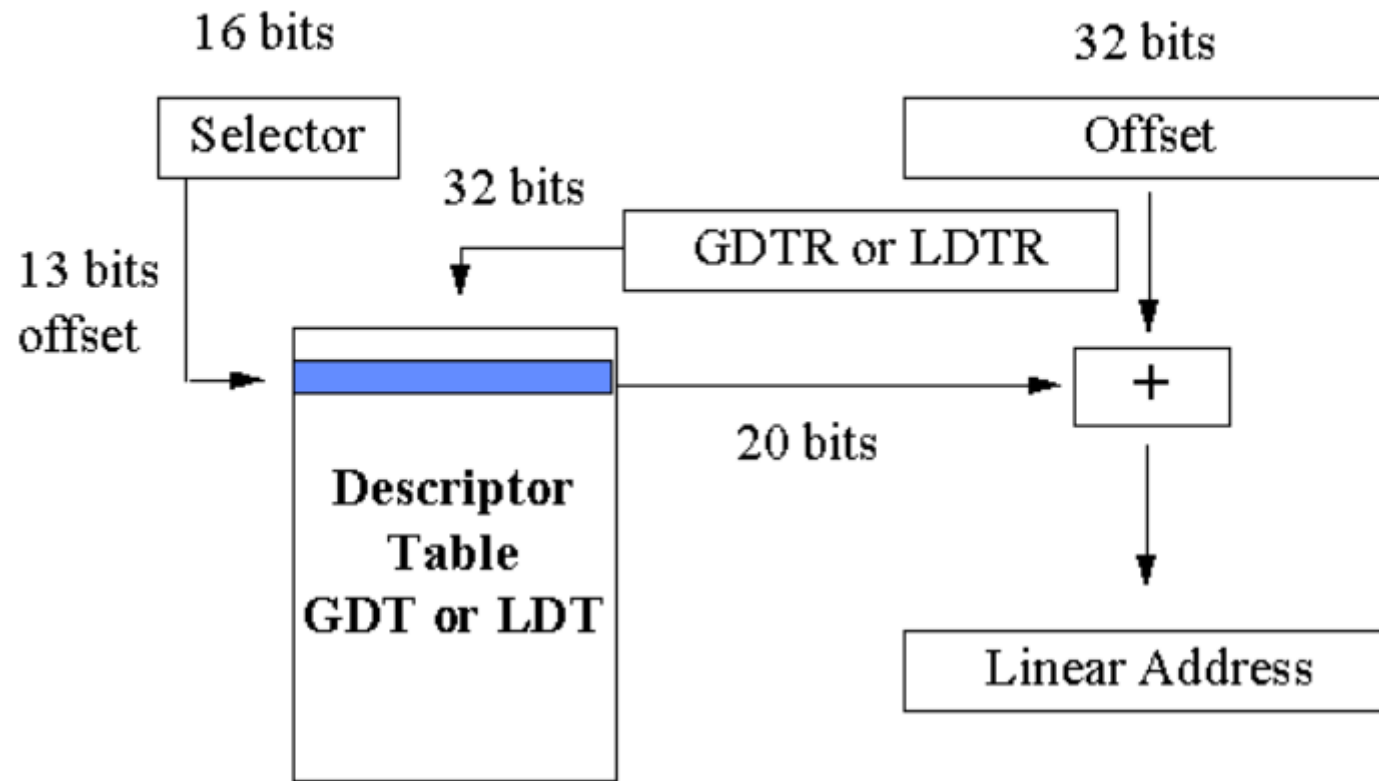
TEB

- 看一下 FS
- $FS = 0x53$
- $FS.TI = 0$
- $FS.SI = 1010 \text{ (bin)} = 10 \text{ (dec)}$
- 若 TI 為 0, 則用以下式子算 Segment Descriptor 位址
 - $GDT + SI * 8$
 - GDT: Global Descriptor Table
 - GDTR: GDT Register, 存放 GDT 值的暫存器

32.0: kd> dq (@gdtr + 0xa * 8) L1
002b:fffff805`15297000 0040f327`10003c00

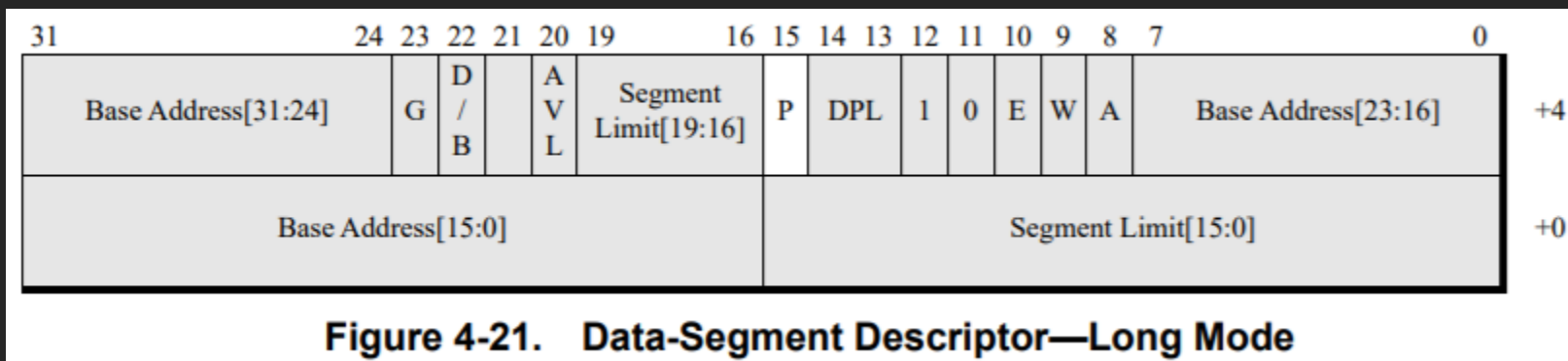
TEB

Intel x86: Segment Translation



TEB

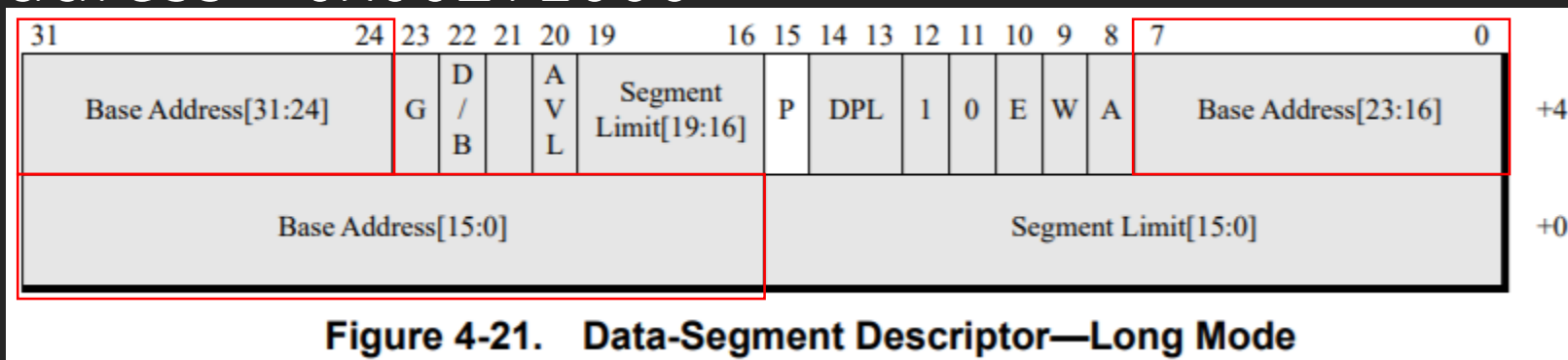
- Segment Descriptor 結構如下



```
32.0: kd> dq (@gdtr + 0xa * 8) L1
002b:fffff805`15297000 0040f327`10003c00
```

TEB

- Segment Descriptor 結構如下
- 組合一下 Base Address
- 算出 FS 值為 0x53 時, 從 GDT 爬出 Segment Descriptor, 得到 Base address = 0x00271000



```
32.0: kd> dq (@gdtr + 0xa * 8) L1
002b:fffff805`15297000 0040f327`10003c00
```

TEB

- Segment Descriptor 結構如下
- 組合一下 Base Address
- 算出 FS 值為 0x53 時, 從 GDT 爬出 Segment Descriptor, 爬到 Base address = 0x00271000



- TEB 位址: 0x00271000

Address:	271000
00000000~00271000	00 9E 4E 00 00 00 00 61 00 00 90 4E 00 00 00 00 00
00000000~00271010	00 1E 00 00 00 00 00 00 00 00 10 27 00 00 00 00 00
00000000~00271020	9C 22 00 00 A0 22 00 00 00 00 00 00 00 00 00 00 00
00000000~00271030	00 E0 26 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000000~00271040	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000000~00271050	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000000~00271060	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

Self

TEB

- 如果是在 64-bit mode ...
- x64 windows 跑 x64 程式
- 跳過驗證 CS.L = 1 的部分

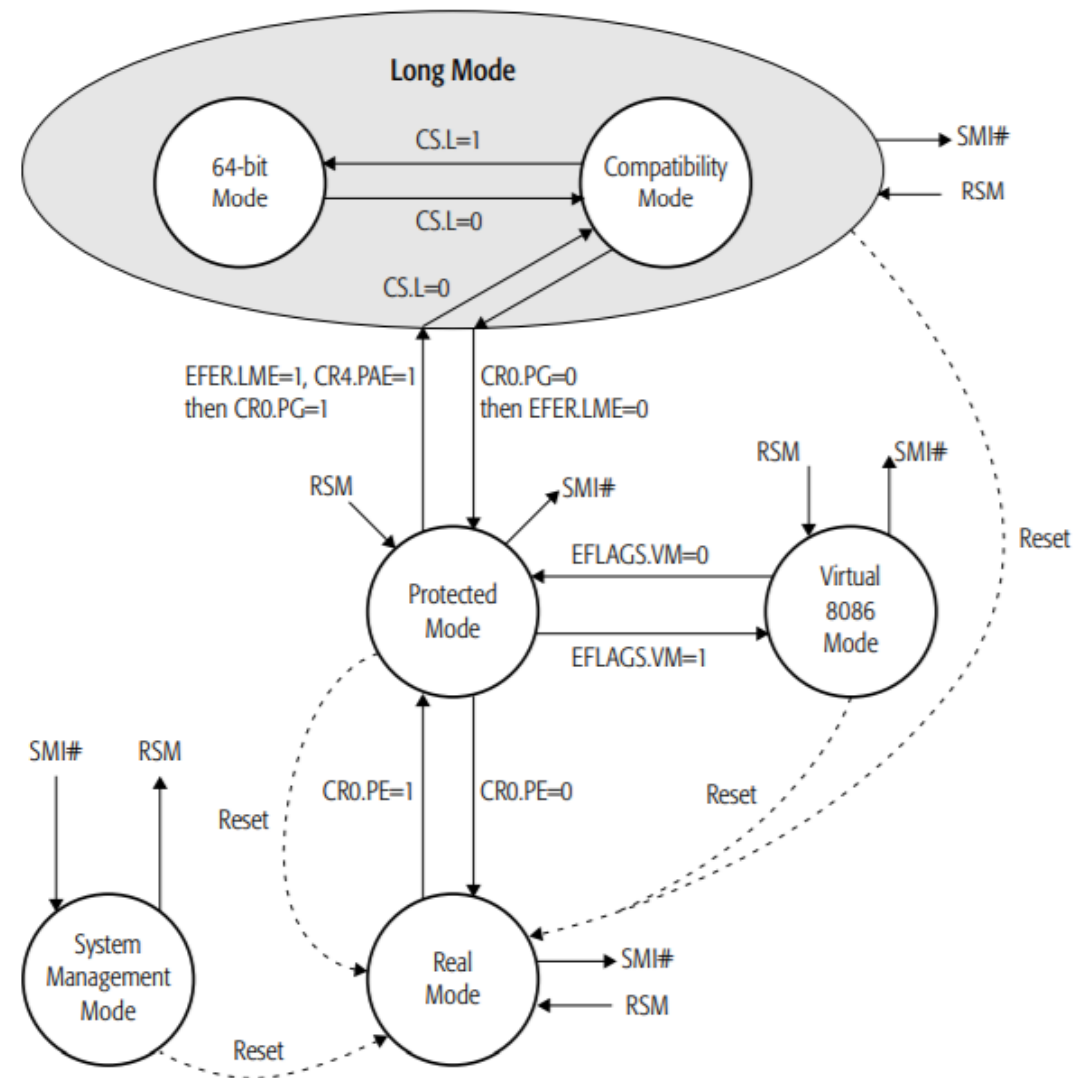


Figure 1-6. Operating Modes of the AMD64 Architecture

TEB

- GS 的 base 就是 MSR GS.Base
- GS.Base 的 MSR Address 為 0xc0000101
- 進到 Kernel 後, GS.Base 會跟另一個 MSR KernelGSBase 互換
- KernelGSBase 的 MSR Address 為 0xc0000102

TEB

- 直接就是 TEB, 不用爬 Descriptor



```
1: kd> rdmsr 0xC0000102  
msr[c0000102] = 00000000`0021f000
```

Address:	21f000
00000000`0021F000	00 00 00 00 00 00 00 00 00 00 00 00 61 00 00 00 00 00
00000000`0021F010	00 D0 60 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000000`0021F020	00 1E 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000000`0021F030	00 F0 21 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000000`0021F040	84 11 00 00 00 00 00 00 00 38 0D 00 00 00 00 00 00
00000000`0021F050	00 00 00 00 00 00 00 00 00 F0 2B 7F 00 00 00 00 00
00000000`0021F060	00 E0 21 00 00 00 00 00 00 00 00 00 00 00 00 00 00

TEB



TEB

- 總之, 結論是...

	ExceptionList	Self	PEB
32bit FS	[0]	[0x18]	[0x30]
64bit GS	[0]	[0x30]	[0x60]

Exception

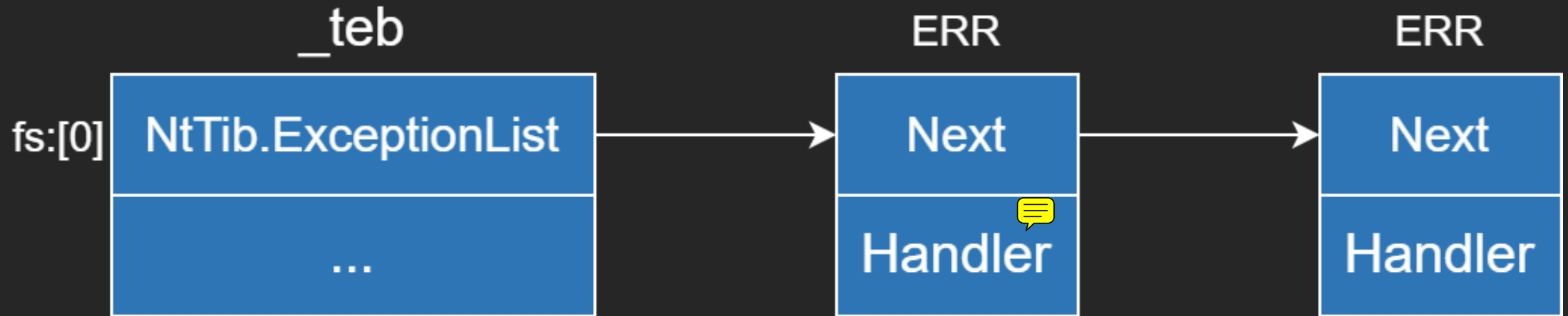
Exception

- Visual C++
 - Structured Exception Handling (SEH)
 - C++ Exception Handling (EH)
- GCC
 - RTTI
 - Sjlj exceptions
 - Zero-cost (table based)

SEH

- Structured Exception Handling
- Windows 的機制
- 32 bit 與 64bit 機制不同
- Try, catch, finally 可以利用此機制實作


SEH (32-bit)



☆ `ERR = _EXCEPTION_REGISTRATION_RECORD`

SEH

- Handler 為 function pointer



```
1 EXCEPTION_DISPOSITION
2 __cdecl _except_handler (
3     struct _EXCEPTION_RECORD *ExceptionRecord,
4     void * EstablisherFrame,
5     struct _CONTEXT *ContextRecord,
6     void * DispatcherContext
7 );
```


SEH

- 舉個例子

```

68 int func(void *ExceptionRecord, void *EstablisherFrame, struct _CONTEXT *ContextRecord, void *DispatcherContext)
69 {
70     printf("YOYOYOYO\n");
71     printf("eip: %x\n", ContextRecord->Eip);
72     ContextRecord->Eip += 4;
73     return 0;
74 }
75
76 int main(int argc, char **argv)
77 {
78     asm ("push %[func]\n\t"
79         "mov %%fs:0, %%eax\n\t"
80         "push %%eax\n\t"
81         "mov %%esp, %%fs:0\n\t"
82         ":"
83         : [func] "i" (func));
84
85     printf("GOGO!\n");
86
87     if (argc < 2) {
88         return 0;
89     }
90
91     int i = 1;
92     int zero = atoi(argv[1]);
93
94     printf("%d / %d = %d\n", i, zero, i / zero);
95 }

```

```

68 int func(void *ExceptionRecord, void *EstablisherFrame, struct _CONTEXT *ContextRecord, void *DispatcherContext)
69 {
70     printf("YOYOYOYO\n");
71     printf("eip: %x\n", ContextRecord->Eip);
72     ContextRecord->Eip += 4;
73     return 0;
74 }
75
76 int main(int argc, char **argv)
77 {
78     asm ("push %[func]\n\t"
79         "mov %%fs:0, %%eax\n\t"
80         "push %%eax\n\t"
81         "mov %%esp, %%fs:0\n\t"
82         ":"
83         : [func] "i" (func));
84
85     printf("GOGO!\n");
86
87     if (argc < 2) {
88         return 0;
89     }
90
91     int i = 1;
92     int zero = atoi(argv[1]);
93
94     printf("%d / %d = %d\n", i, zero, i / zero);
95 }

```

在 stack 創一個 ERR
Handler 指向自製 handler func

```

68 int func(void *ExceptionRecord, void *EstablisherFrame, struct _CONTEXT *ContextRecord, void *DispatcherContext)
69 {
70     printf("YOYOYOYO\n");
71     printf("eip: %x\n", ContextRecord->Eip);
72     ContextRecord->Eip += 4;
73     return 0;
74 }
75
76 int main(int argc, char **argv)
77 {
78     asm ("push %[func]\n\t"
79         "mov %%fs:0, %%eax\n\t"
80         "push %%eax\n\t"
81         "mov %%esp, %%fs:0\n\t"
82         ":"
83         : [func] "i" (func));
84
85     printf("GOGO!\n");
86
87     if (argc < 2) {
88         return 0;
89     }
90
91     int i = 1;
92     int zero = atoi(argv[1]);
93
94     printf("%d / %d = %d\n", i, zero, i / zero);
95 }

```

在 stack 創一個 ERR
Handler 指向自製 handler func

Zero 給 0, 製造 exception

```

68 int func(void *ExceptionRecord, void *EstablisherFrame, struct _CONTEXT *ContextRecord, void *DispatcherContext)
69 {
70     printf("YOYOYOYO\n");
71     printf("eip: %x\n", ContextRecord->Eip);
72     ContextRecord->Eip += 4;
73     return 0;
74 }

```

導致 exception 的指令 idiv 為 4 Bytes
+4 跳過 idiv 指令

```

76 int main(int argc, char **argv)
77 {
78     asm ("push %[func]\n\t"
79         "mov %%fs:0, %%eax\n\t"
80         "push %%eax\n\t"
81         "mov %%esp, %%fs:0\n\t"
82         ":"
83         : [func] "i" (func));
84
85     printf("GOGO!\n");
86
87     if (argc < 2) {
88         return 0;
89     }
90
91     int i = 1;
92     int zero = atoi(argv[1]);
93
94     printf("%d / %d = %d\n", i, zero, i / zero);
95 }

```

```

.text:004014ED F7 7C 24 18      idiv     [esp+28h+var_10]
.text:004014F1 89 44 24 0C      mov     [esp+28h+var_1C], eax

```

在 stack 創一個 ERR
Handler 指向自製 handler func

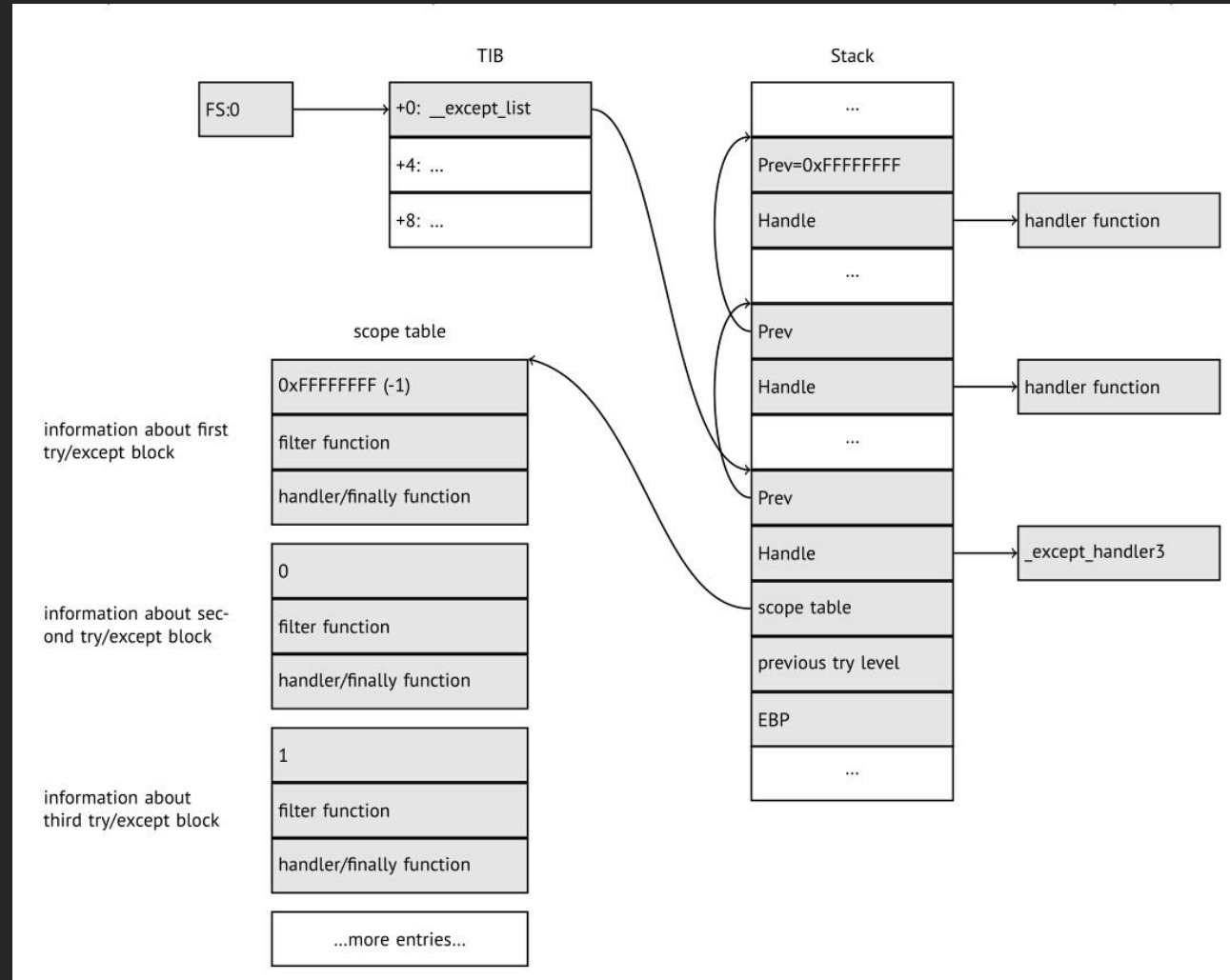
Zero 給 0, 製造 exception

```
PS C:\tmp\presentation\secure programming\code\LAB_9> .\except.exe 0  
GOGO!  
YOYOYOYO  
eip: 401502  
1 / 0 = 1  
PS C:\tmp\presentation\secure programming\code\LAB_9> |
```

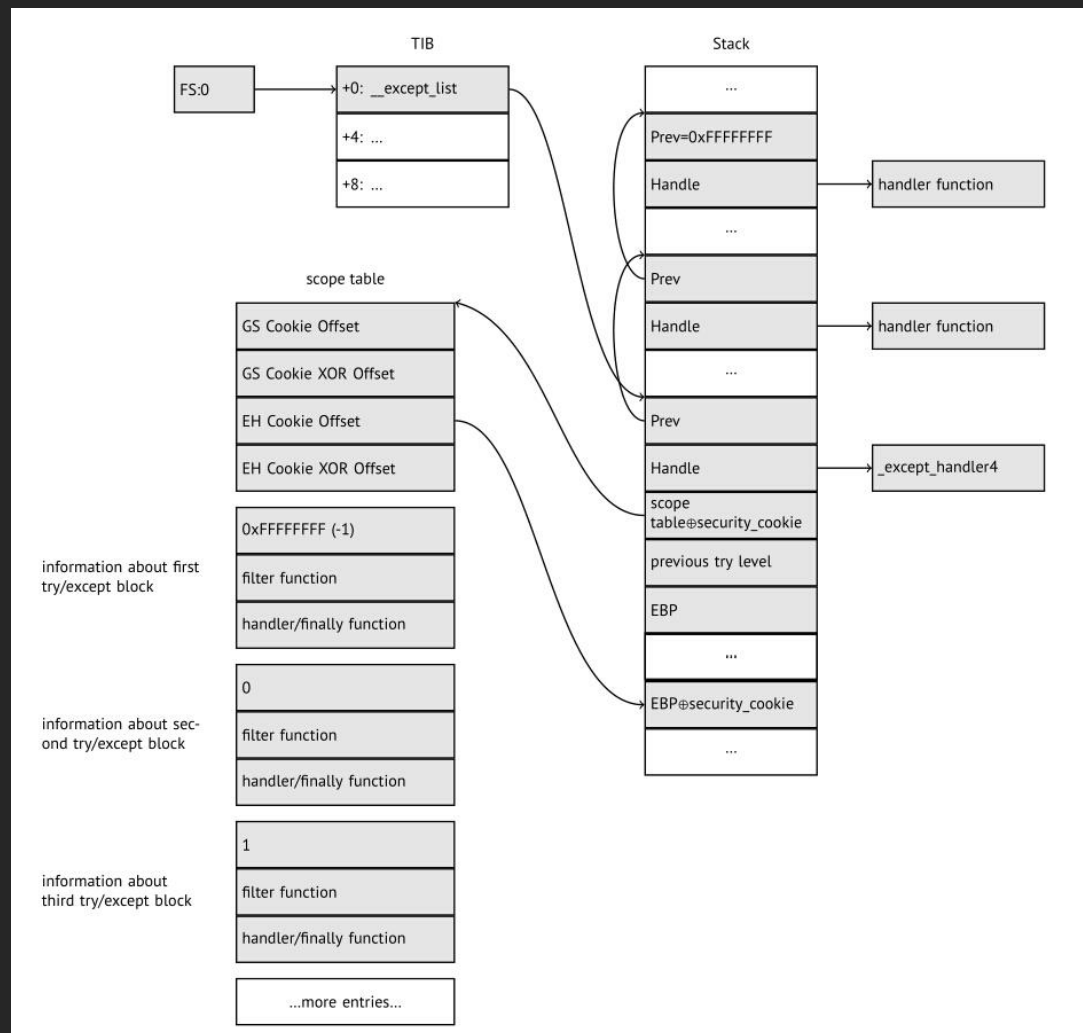
SEH

- 逆向方式就是逆 handler
- 不同 compiler 的 handler 實作都不同
- VS 用的 MSVC, handler 的實作...

_except_handler3



_except_handler4



SEH

- 逆向方式就是逆 handler
- 不同 compiler 的 handler 實作都不同
- VS 用的 MSVC, handler 的實作...
- 事情變得很複雜, 但總之就是在 handler 裡面折騰就對ㄌ

SEH

- 回顧一下
- 若 function 需要自行新增 ERR (可能函數內有 try-catch)
- 此 function 需為了增加此 ERR 而在 prolog/epilog 加 code
- 但 exception 又是較少跑到的
- 加的那些 code 很常是跑心酸的

SEH (64-bit)

- 64 bit, SEH 不用鏈表了, 改成 table-based
- 什麼 table? 請看 Exception Directory

Disasm: .text		General	DOS Hdr	Rich Hdr	File Hdr	Optional Hdr	Section Hd
Offset	Name	Value		Value			
▼	Data Directory	Address		Size			
180	Export Directory	0		0			
188	Import Directory	3F16C		28			
190	Resource Directory	47000		1E0			
198	Exception Directory	43000		2904			
1A0	Security Directory	0		0			

SEH (64-bit)

- Exception Directory

Exception			
Offset	BeginAddress	EndAddress	UnwindInfoAddress
40400	1000	1017	3CE98
4040C	1020	1037	3CE98
40418	1038	1058	3CE98
40424	1058	1088	3CE98
40430	1088	10D8	3D234
4043C	10E4	1104	3CE98
40448	111C	113C	3CE98
40454	1180	11A4	3CE28

SEH (64-bit)

- 怎麼找 handler?
- 首先看你在哪裡丟出 exception
- 0x140002e55 除 0

RIP

0000000140002E55

idiv dword ptr ss:[rsp+24]

SEH (64-bit)

- 0x140002e55 除 0
- 將 0x140002e55 換算回 RVA: 0x2e55
- 查表

Exception			
Offset	BeginAddress	EndAddress	UnwindInfoAddress
40638	2DB0	2DE6	3CDF8
40644	2DF0	2EE4	3CED8

SEH (64-bit)

- 查看 UnwindInfoAddress



RVA 换算回 Raw Offset

3C2D8	19 0D 01 00 0D 62 00 00 AC D2 00 00 E8 CE 03 00
3C2E8	18 F5 CE 03 00 F8 CE 03 00 06 CF 03 00 04 08 10
3C2F8	02 00 00 02 00 CF 03 00 02 00 20 C6 02 00 06 00



Exception			
Offset	BeginAddress	EndAddress	UnwindInfoAddress
40638	2DB0	2DE6	3CDF8
40644	2DF0	2EE4	3CED8

SEH (64-bit)

- 查看 UnwindInfoAddress
- 對應其結構

3C2D8	19 0D 01 00 0D 62 00 00 AC D2 00 00 E8 CE 03 00
3C2E8	18 F5 CE 03 00 F8 CE 03 00 06 CF 03 00 04 08 10
3C2F8	02 00 00 02 00 CF 03 00 02 00 20 C6 02 00 06 00

```
1 typedef struct _UNWIND_INFO {
2     UBYTE Version      : 3;
3     UBYTE Flags        : 5;
4     UBYTE SizeOfProlog;
5     UBYTE CountOfCodes;
6     UBYTE FrameRegister : 4;
7     UBYTE FrameOffset   : 4;
8     UNWIND_CODE UnwindCode[1];
9 /* UNWIND_CODE MoreUnwindCode[((CountOfCodes + 1) & ~1) - 1];
10 * union {
11 *     OPTIONAL ULONG ExceptionHandler;
12 *     OPTIONAL ULONG FunctionEntry;
13 * };
14 * OPTIONAL ULONG ExceptionData[]; */
15 } UNWIND_INFO, *PUNWIND_INFO;
```

SEH (64-bit)

- 查看 UnwindInfoAddress
- 對應其結構

3C2D8	19 0D 01 00 0D 62 00 00 AC D2 00 00 E8 CE 03 00
3C2E8	18 F5 CE 03 00 F8 CE 03 00 06 CF 03 00 04 08 10
3C2F8	02 00 00 02 00 CF 03 00 02 00 20 C6 02 00 06 00

CountOfCodes = 1

```
1 typedef struct _UNWIND_INFO {
2     UBYTE Version      : 3;
3     UBYTE Flags        : 5;
4     UBYTE SizeOfProlog;
5     UBYTE CountOfCodes;
6     UBYTE FrameRegister : 4;
7     UBYTE FrameOffset   : 4;
8     UNWIND_CODE UnwindCode[1];
9 /* UNWIND_CODE MoreUnwindCode[((CountOfCodes + 1) & ~1) - 1];
10 * union {
11 *     OPTIONAL ULONG ExceptionHandler;
12 *     OPTIONAL ULONG FunctionEntry;
13 * };
14 * OPTIONAL ULONG ExceptionData[]; */
15 } UNWIND_INFO, *PUNWIND_INFO;
```

SEH (64-bit)

- 查看 UnwindInfoAddress
- 對應其結構

3C2D8	19 0D 01 00 0D 62 00 00 AC D2 00 00 E8 CE 03 00
3C2E8	18 F5 CE 03 00 F8 CE 03 00 06 CF 03 00 04 08 10
3C2F8	02 00 00 02 00 CF 03 00 02 00 20 C6 02 00 06 00

CountOfCodes = 1

UnwindCode 陣列

```
1 typedef struct _UNWIND_INFO {
2     UBYTE Version      : 3;
3     UBYTE Flags
4     UBYTE SizeOfProlog
5     UBYTE CountOfCodes
6     UBYTE FrameRegister : 4;
7     UBYTE FrameOffset   : 4;
8     UNWIND_CODE UnwindCode[1];
9 /* UNWIND_CODE MoreUnwindCode[((CountOfCodes + 1) & ~1) - 1];
10 * union {
11 *     OPTIONAL ULONG ExceptionHandler;
12 *     OPTIONAL ULONG FunctionEntry;
13 * };
14 * OPTIONAL ULONG ExceptionData[]; */
15 } UNWIND_INFO, *PUNWIND_INFO;
```

UNWIND_CODE 大小為 2 Bytes
陣列長度為 CountOfCodes

SEH (64-bit)

- 查看 UnwindInfoAddress
- 對應其結構

3C2D8	19	0D	01	00	0D	62	00	00	AC	D2	00	00	E8	CE	03	00
3C2E8	18	F5	CE	03	00	F8	CE	03	00	06	CF	03	00	04	08	10
3C2F8	02	00	00	02	00	CF	03	00	02	00	20	C6	02	00	06	00

CountOfCodes = 1

ExceptionHandler

UnwindCode 陣列

```
1 typedef struct _UNWIND_INFO {
2     UBYTE Version      : 3;
3     UBYTE Flags        : 5;
4     UBYTE SizeOfProlog;
5     UBYTE CountOfCodes;
6     UBYTE FrameRegister : 4;
7     UBYTE FrameOffset  : 4;
8     UNWIND_CODE UnwindCode[1];
9 /* UNWIND_CODE MoreUnwindCode[((CountOfCodes + 1) & ~1) - 1];
10 * union {
11 *     OPTIONAL ULONG ExceptionHandler;
12 *     OPTIONAL ULONG FunctionEntry;
13 * };
14 * OPTIONAL ULONG ExceptionData[]; */
15 } UNWIND_INFO, *PUNWIND_INFO;
```

SEH (64-bit)

- 查看 UnwindInfoAddress
- 對應其結構
- 找到 handler 開逆

3C2D8	19 0D 01 00 0D 62 00 00 AC D2 00 00 E8 CE 03 00
3C2E8	18 F5 CE 03 00 F8 CE 03 00 06 CF 03 00 04 08 10
3C2F8	02 00 00 02 00 CF 03 00 02 00 20 C6 02 00 06 00

CountOfCodes = 1

ExceptionHandler

UnwindCode 陣列

```
.text:000000014000D2AC __CxxFrameHandler4 proc near ; COI
.text:000000014000D2AC ; DA
.text:000000014000D2AC
.text:000000014000D2AC rawIP2StateRVA = byte ptr -48h
.text:000000014000D2AC var_40 = dword ptr -40h
.text:000000014000D2AC var_38 = qword ptr -38h
.text:000000014000D2AC recursive = byte ptr -30h
.text:000000014000D2AC FuncInfoDe = FH4::FuncInfo4 ptr -28h
.text:000000014000D2AC var_8 = byte ptr -8
.text:000000014000D2AC pRN = qword ptr 8
.text:000000014000D2AC
.text:000000014000D2AC mov rax, rsp
.text:000000014000D2AF mov [rax+10h], rbx
.text:000000014000D2B3 mov [rax+18h], rbp
.text:000000014000D2B7 mov [rax+20h], rsi
```

SEH (64-bit)

- IDA pro 很 pro, 都爬好了
- 但 freeware 沒有很 pro, 沒有爬 QQ

```
.text:0000000140002DF0 main                proc near                ; CODE X1
.text:0000000140002DF0                                ; DATA X1
.text:0000000140002DF0
.text:0000000140002DF0 _Val                = dword ptr -18h
.text:0000000140002DF0 var_14            = dword ptr -14h
.text:0000000140002DF0 var_10            = dword ptr -10h
.text:0000000140002DF0 arg_0             = dword ptr  8
.text:0000000140002DF0 arg_8             = qword ptr 10h
.text:0000000140002DF0
.text:0000000140002DF0 ; __unwind { // __CxxFrameHandler4
.text:0000000140002DF0 mov             [rsp+arg_8], rdx
.text:0000000140002DF5 mov             [rsp+arg_0], ecx
.text:0000000140002DF9 sub             rsp, 38h
.text:0000000140002DFD lea             rdx, _Val                ; "gogo"
```

Lab 2

Packer

Packer

- 目的是將程式變得難逆
- Packer 中文稱為加殼器
- 常見的殼類型分為
 - 壓縮殼
 - VM 殼

Packer

- 壓縮殼
 - 把 code 壓縮起來
 - 在執行時才把 code 解壓縮回來, 並且執行
 - UPX
- VM 殼
 - 實作另一套 VM
 - 把原始 code 變成給 VM 跑的 code
 - 想逆? 請直接逆完 VM
 - VMProtect

Packer

- UPX

```
PS C:\tmp\presentation\secure programming\code\lab_9> upx
          Ultimate Packer for eXecutables
    Copyright (C) 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004
UPX 1.25w      Markus F.X.J. Oberhumer & Laszlo Molnar      Jun 29th 2004

Usage: upx [-123456789dlthVL] [-qvfk] [-o file] file..

Commands:
  -1      compress faster                -9      compress better
  -d      decompress                    -l      list compressed file
  -t      test compressed file          -V      display version number
  -h      give more help                -L      display software license

Options:
  -q      be quiet                      -v      be verbose
  -oFILE  write output to 'FILE'
  -f      force compression of suspicious files
  -k      keep backup files
  file..  executables to (de)compress

This version supports: dos/exe, dos/com, dos/sys, djgpp2/coff, watcom/le,
                      win32/pe, rtm32/pe, tmt/adam, atari/tos, linux/386

UPX comes with ABSOLUTELY NO WARRANTY; for details type `upx -L'.
```

Packer

- UPX

```
PS C:\tmp\presentation\secure programming\code\LAB_9> upx64 .\unpackme.exe -o pack.exe
      Ultimate Packer for eXecutables
      Copyright (C) 1996 - 2020
UPX 3.96w      Markus Oberhumer, Laszlo Molnar & John Reiser   Jan 23rd 2020

      File size      Ratio      Format      Name
      -----
      15360 ->      8192      53.33%      win64/pe      pack.exe

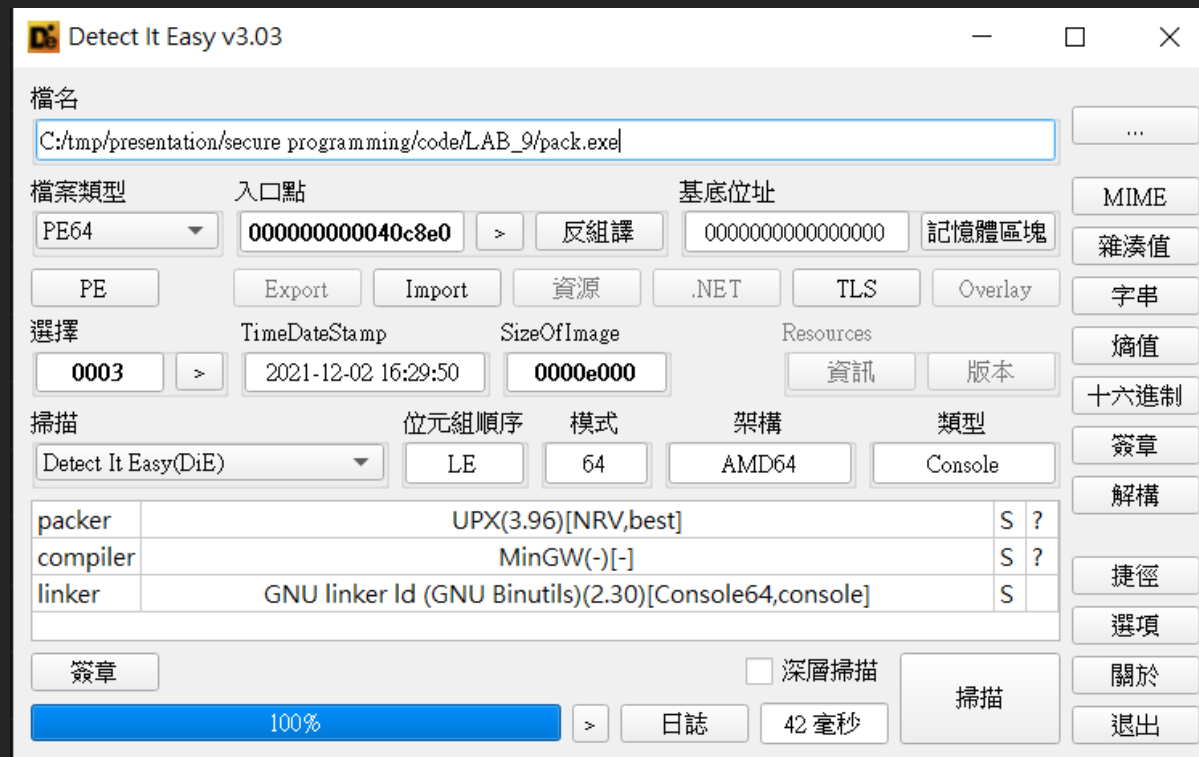
Packed 1 file.
PS C:\tmp\presentation\secure programming\code\LAB_9> ls

目錄: C:\tmp\presentation\secure programming\code\LAB_9

Mode                LastWriteTime         Length Name
----                -
-a----            2021/12/2 下午 03:59             132 Makefile
-a----            2021/12/2 下午 04:29             8192 pack.exe
-a----            2021/12/2 下午 03:58              64 unpackme.c
-a----            2021/12/2 下午 04:29          15360 unpackme.exe
```

Packer

- DIE (Detect It Easy)
- 查殼的工具
- 查到殼後再上網找脫殼器
- 再不行才自己脫殼



Anti-Reverse

Anti-Reverse

- 蠻多花招可以反逆向工程
- 其實前面講的幾個點就是在反逆向工程
- 太多招了, 可以參考 Reference 連結
- 這個章節舉幾個例子

Anti-Disassembly

- 想一下怎麼實作反組譯器
- Linear disassembly
 - 一行一行的反組譯下去
- Flow-oriented disassembly
 - 如果反組譯到 jmp, 則順著執行流程反組譯
 - IDA

Anti-Disassembly

- 舉個例子

Anti-Disassembly

```
3  ✓ int evil_func()
4  {
5      printf("Bye~\n");
6
7      asm ("call SELF\n\t"
8          "SELF:\n\t"
9          "pop %%rax\n\t"
10         "add $0xd, %%rax\n\t"
11         "jmp *%%rax\n\t"
12         ":"
13         :
14         :
15     );
16
17     asm ("1: .byte 0xe9, 0x80, 0x87, 0x55, 0x66, 0x01 \n\t":::);
18
19     printf("YO!\n");
20 }
```

Anti-Disassembly

```
3  ✓ int evil_func()
4  {
5      printf("Bye~\n");
6
7      asm ("call SELF\n\t"
8           "SELF:\n\t"
9           "pop %%rax\n\t"
10          "add $0xd, %%rax\n\t"
11          "jmp *%%rax\n\t"
12          ":"
13          :
14          :
15         );
16
17     asm ("1: .byte 0xe9, 0x80, 0x87, 0x55, 0x66, 0x01 \n\t":::);
18
19     printf("YO!\n");
20 }
```

取得當前指令位址, 加上 offset 後跳過去

Anti-Disassembly

```
3  ✓ int evil_func()
4  {
5      printf("Bye~\n");
6
7      asm ("call SELF\n\t"
8          "SELF:\n\t"
9          "pop %%rax\n\t"
10         "add $0xd, %%rax\n\t"
11         "jmp *%%rax\n\t"
12         ":"
13         :
14         :
15         );
16
17     asm ("1: .byte 0xe9, 0x80, 0x87, 0x55, 0x66, 0x01 \n\t":::);
18
19     printf("YO!\n");
20 }
```

取得當前指令位址, 加上 offset 後跳過去

實際上就是跳到這邊

Anti-Disassembly

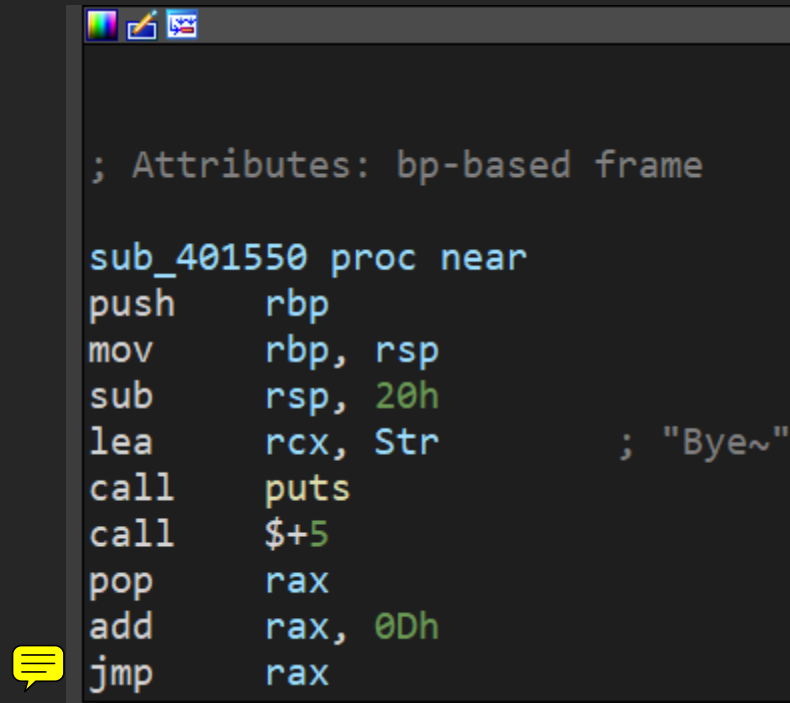
```
3  ✓ int evil_func()
4  {
5      printf("Bye~\n");
6
7      asm ("call SELF\n\t"
8          "SELF:\n\t"
9          "pop %%rax\n\t"
10         "add $0xd, %%rax\n\t"
11         "jmp *%%rax\n\t"
12         ":"
13         :
14         :
15         );
16
17     asm ("1: .byte 0xe9, 0x80, 0x87, 0x55, 0x66, 0x01 \n\t":);
18
19     printf("YO!\n");
20 }
```

取得當前指令位址, 加上 offset 後跳過去

在這之間塞一坨垃圾

實際上就是跳到這邊

Anti-Disassembly



```
; Attributes: bp-based frame

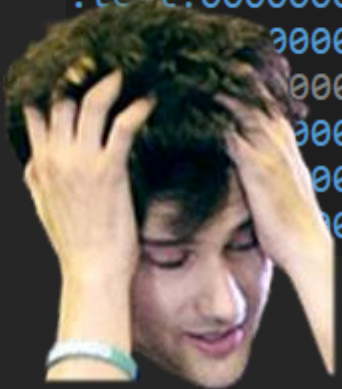
sub_401550 proc near
push    rbp
mov     rbp, rsp
sub     rsp, 20h
lea     rcx, Str          ; "Bye~"
call    puts
call    $+5
pop     rax
add     rax, 0Dh
jmp     rax
```

Graph View 不行? 換 Text View?

Anti-Disassembly

```
.text:0000000000401550 sub_401550      proc near          ; CODE XREF: main+19↓p
.text:0000000000401550                                     ; DATA XREF: .pdata:000000000040506C↓o
.text:0000000000401550      push      rbp
.text:0000000000401551      mov       rbp, rsp
.text:0000000000401554      sub       rsp, 20h
.text:0000000000401558      lea       rcx, Str          ; "Bye~"
.text:000000000040155F      call      puts
.text:0000000000401564      call      $+5
.text:0000000000401569      pop       rax
.text:000000000040156A      add       rax, 0Dh
.text:000000000040156E      jmp       rax
0000000040156E ; -----
00000000401570      dq      8D480166558780E9h, 151EE800002A880Dh, 5D20C48348900000h
00000000401588 ; -----
00000000401588      retn
000000401588 sub_401550      endp
```

不好意思, IDA 不知道哪邊是 code, 請手動定義



Anti-Disassembly

00401550	PUSH	RBP	
00401551	MOV	RBP, RSP	
00401554	SUB	RSP, 0x20	
00401558	LEA	RCX, [DAT_00404000]	
0040155f	CALL	MSVCRT.DLL::puts	
00401564	CALL	LAB_00401569	
		LAB_00401569	
00401569	POP	RAX	
0040156a	ADD	RAX, 0xd	
0040156e	JMP	RAX=>LAB_00401576	
00401570	??	E9h	
00401571	??	80h	
00401572	??	87h	
00401573	??	55h	U
00401574	??	66h	f
00401575	??	01h	
		LAB_00401576	
00401576	LEA	RCX, [DAT_00404005]	
0040157d	CALL	MSVCRT.DLL::puts	
00401582	NOP		
00401583	ADD	RSP, 0x20	
00401587	POP	RBP	
00401588	RET		

但 Ghidra 解的出來, 太神啦

Anti-Debug

- 偵測是不是正在被 debug
- IsDebuggerPresent
- CheckRemoteDebuggerPresent
- ...
- x64dbg 可以用 ScyllaHide 來反制

Anti-Debug

- Debugger 是怎麼達到“設定中斷點”這件事情的?
- x64dbg 預設方式是用 int 3, opcode 為 0xcc
- 把設斷點的位址內容改成 0xcc
- 執行到 int 3 時會觸發 exception_breakpoint
- Debugger 接收此 exception, 並且把原本指令填回去

Anti-Debug


- 直接掃 code 段記憶體是否有 0xcc
- 就知道有沒有被設中斷點
- 就知道有沒有 debugger

Anti-VM

- 分析者通常是把惡意程式丟進 VM 裡面動態分析
- 各種 VM 會有自己特別的檔案 / Registry / 行為 / 裝置 / 程序
- 用這些資訊來判斷自己是不是在 VM 裡面

Anti-VM

- 舉個例子: cpuid



```
1 mov rax, 0x40000000
2 cpuid
```

- 執行完後, ebx ecx edx 的值會有特徵

Anti-VM

	00007FFD47600671	B8 00000040	mov eax,40000000
	00007FFD47600676	0FA2	cuid
RIP →	00007FFD47600678	CC	int3

```
RAX 0000000040000010
RBX 0000000061774D56
RCX 000000004D566572
RDX 0000000065726177
```

```
>>> bytes.fromhex('61774D56')[::-1]
b'VMwa'
>>> bytes.fromhex('4D566572')[::-1]
b'reVM'
>>> bytes.fromhex('65726177')[::-1]
b'ware'
```

Q & A

下課囉 \(. _ .)>