Introduction to Reverse Engineering

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Research Manager

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Agenda

- Reverse Engineering Intro
- Ethical and Legal Aspects
- Process of Reverse Engineering
- Tools of the Trade

What is Reverse Engineering? 1/2

What is Reverse Engineering? 1/2

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What is Reverse Engineering? 1/2

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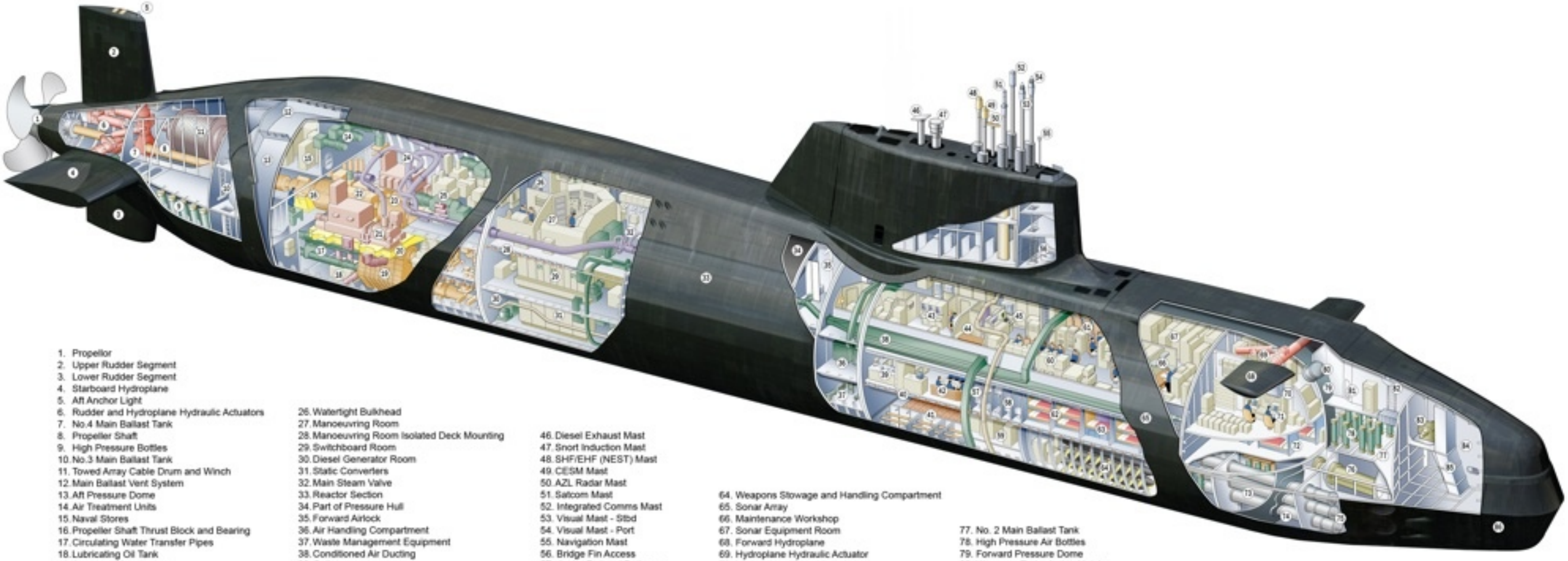
What is Reverse Engineering? 2/2

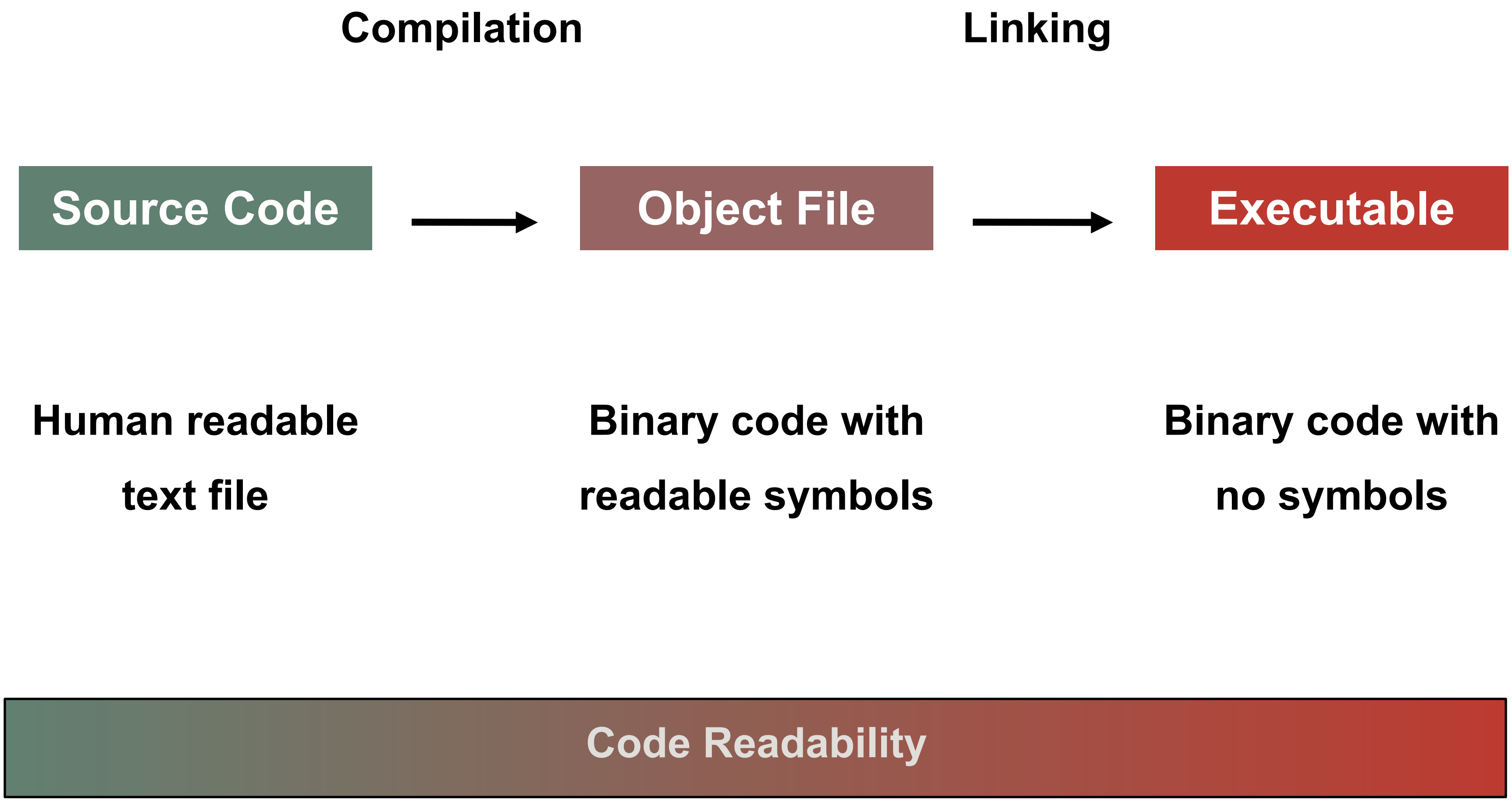


1. Propellor
2. Upper Rudder Segment
3. Lower Rudder Segment
4. Starboard Hydroplane
5. Aft Anchor Light
6. Rudder and Hydroplane Hydraulic Actuators
7. No.4 Main Ballast Tank
8. Propeller Shaft
9. High Pressure Bottles
10. No.3 Main Ballast Tank
11. Towed Array Cable Drum and Winch
12. Main Ballast Vent System
13. Aft Pressure Dome
14. Air Treatment Units
15. Naval Stores
16. Propeller Shaft Thrust Block and Bearing
17. Circulating Water Transfer Pipes
18. Lubricating Oil Tank
19. Starboard Condenser
20. Main Machinery Mounting Raft
21. Turbo Generators, Port & Starboard
22. Combining Gearbox
23. Main Turbines
24. Steam Delivery Ducting
25. Engine Room
26. Watertight Bulkhead
27. Manoeuvring Room
28. Manoeuvring Room Isolated Deck Mounting
29. Switchboard Room
30. Diesel Generator Room
31. Static Converters
32. Main Steam Valve
33. Reactor Section
34. Part of Pressure Hull
35. Forward Airlock
36. Air Handling Compartment
37. Waste Management Equipment
38. Conditioned Air Ducting
39. Galley
40. Fwd Section Isolated Deck Mountings
41. Batteries
42. Junior Ratings' Mess
43. RESM Office
44. Commanding Officer's Cabin
45. Port Side Communications Office
46. Diesel Exhaust Mast
47. Snort Induction Mast
48. SHF/EHF (NEST) Mast
49. CESM Mast
50. AZL Radar Mast
51. Satcom Mast
52. Integrated Comms Mast
53. Visual Mast - Stbd
54. Visual Mast - Port
55. Navigation Mast
56. Bridge Fin Access
57. Junior Ratings' Bathroom
58. Senior Ratings' Bathroom
59. Battery Switchroom
60. Control Room Consoles
61. Sonar Operators' Consoles
62. Senior Ratings Bunks
63. Medical Berth
64. Weapons Stowage and Handling Compartment
65. Sonar Array
66. Maintenance Workshop
67. Sonar Equipment Room
68. Forward Hydroplane
69. Hydroplane Hydraulic Actuator
70. Hydroplane Hinge Mounting
71. Ship's Office
72. Junior Ratings' Berths
73. Torpedo Tubes
74. Water Transfer Tank
75. Torpedo Tube Bow Caps
76. Air Turbine Pump
77. No. 2 Main Ballast Tank
78. High Pressure Air Bottles
79. Forward Pressure Dome
80. Weapons Embarkation Hatch
81. Gemini Craft Stowage
82. Hinged Fairlead
83. Anchor Windlass
84. No. 1 Main Ballast Tank
85. Anchor Cable Locker
86. Bow Sonar

Reverse Code Engineering

- Reverse Engineering is also known as RE or RCE
  - **RE**: Reverse Engineering
  - **RCE**: Reverse Code Engineering
- RE is the process of understanding an existing product
- Malware analysis and security research often involves RE

Compilation Process



Compilation

Linking

Source Code → Object File → Executable

Human readable text file

Binary code with readable symbols

Binary code with no symbols

Code Readability

Compilation Results

Compilation Results

```
int ExecFile(char *FileName)
{
    PyObject* PyFileObject = PyFile_FromString(FileName, "r");

    if (!PyFileObject)
    {
        return 0;
    }

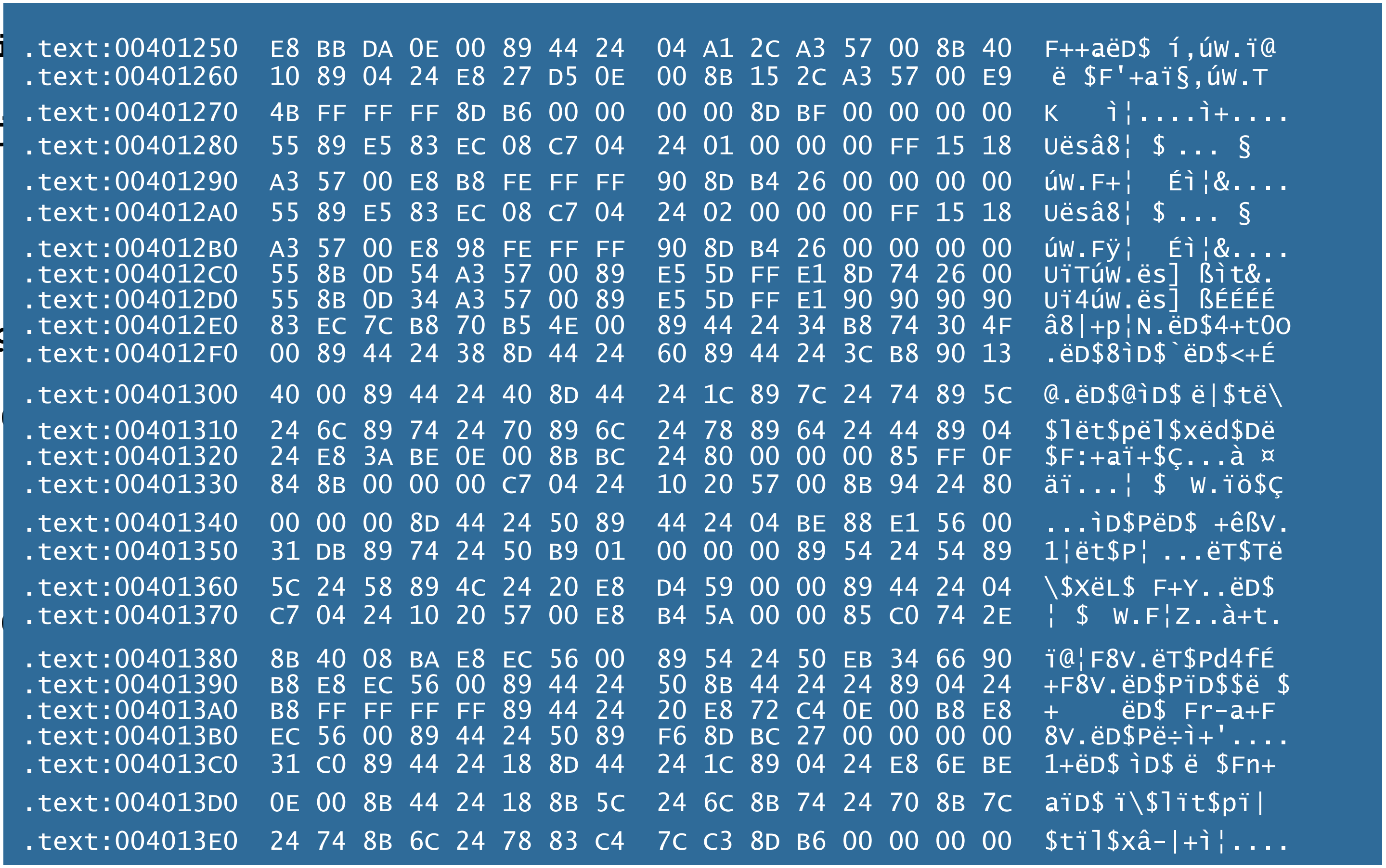
    if (PyRun_SimpleFile(PyFile_AsFile(PyFileObject), FileName) == 0)
    {
        Py_DECREF(PyFileObject);
        return 1;
    }
    else
    {
        Py_DECREF(PyFileObject);
        return 0;
    }
}
```

Compilation Results

```
int ExecFile(char *FileName)
{
    PyObject* PyFi

    if (!PyFileObj
    {
        return 0;
    }

    if (PyRun_Simp
    {
        Py_DECREF(
        return 1;
    }
    else
    {
        Py_DECREF(
        return 0;
    }
}
```



```
.text:00401250  E8 BB DA 0E 00 89 44 24  04 A1 2C A3 57 00 8B 40  F++aëD$ í,úW.ï@
.text:00401260  10 89 04 24 E8 27 D5 0E  00 8B 15 2C A3 57 00 E9   ë $F'+aï§,úW.T
.text:00401270  4B FF FF FF 8D B6 00 00  00 00 8D BF 00 00 00 00  K   ì¦....ì+....
.text:00401280  55 89 E5 83 EC 08 C7 04  24 01 00 00 00 FF 15 18  Uësâ8¦ $ ... §
.text:00401290  A3 57 00 E8 B8 FE FF FF  90 8D B4 26 00 00 00 00  úW.F+¦  Éì¦&....
.text:004012A0  55 89 E5 83 EC 08 C7 04  24 02 00 00 00 FF 15 18  Uësâ8¦ $ ... §
.text:004012B0  A3 57 00 E8 98 FE FF FF  90 8D B4 26 00 00 00 00  úW.Fÿ¦  Éì¦&....
.text:004012C0  55 8B 0D 54 A3 57 00 89  E5 5D FF E1 8D 74 26 00  UïTúW.ës] ßìt&.
.text:004012D0  55 8B 0D 34 A3 57 00 89  E5 5D FF E1 90 90 90 90  Uï4úW.ës] ßÉÉÉÉ
.text:004012E0  83 EC 7C B8 70 B5 4E 00  89 44 24 34 B8 74 30 4F  â8|+p¦N.ëD$4+t0O
.text:004012F0  00 89 44 24 38 8D 44 24  60 89 44 24 3C B8 90 13  .ëD$8ìD$`ëD$<+É
.text:00401300  40 00 89 44 24 40 8D 44  24 1C 89 7C 24 74 89 5C  @.ëD$@ìD$ ë|$të\
.text:00401310  24 6C 89 74 24 70 89 6C  24 78 89 64 24 44 89 04  $lët$pël$xëd$Dë
.text:00401320  24 E8 3A BE 0E 00 8B BC  24 80 00 00 00 85 FF 0F  $F:+aï+$Ç...à ¤
.text:00401330  84 8B 00 00 00 C7 04 24  10 20 57 00 8B 94 24 80  äï...¦ $  W.ïö$Ç
.text:00401340  00 00 00 8D 44 24 50 89  44 24 04 BE 88 E1 56 00  ...ìD$PëD$ +êßV.
.text:00401350  31 DB 89 74 24 50 B9 01  00 00 00 89 54 24 54 89  1¦ët$P¦ ...ëT$Të
.text:00401360  5C 24 58 89 4C 24 20 E8  D4 59 00 00 89 44 24 04  \$XëL$ F+Y..ëD$
.text:00401370  C7 04 24 10 20 57 00 E8  B4 5A 00 00 85 C0 74 2E  ¦ $  W.F¦Z..à+t.
.text:00401380  8B 40 08 BA E8 EC 56 00  89 54 24 50 EB 34 66 90  ï@¦F8V.ëT$Pd4fÉ
.text:00401390  B8 E8 EC 56 00 89 44 24  50 8B 44 24 24 89 04 24  +F8V.ëD$PïD$$ë $
.text:004013A0  B8 FF FF FF FF 89 44 24  20 E8 72 C4 0E 00 B8 E8  +    ëD$ Fr-a+F
.text:004013B0  EC 56 00 89 44 24 50 89  F6 8D BC 27 00 00 00 00  8V.ëD$Pë÷ì+'....
.text:004013C0  31 C0 89 44 24 18 8D 44  24 1C 89 04 24 E8 6E BE  1+ëD$ ìD$ ë $Fn+
.text:004013D0  0E 00 8B 44 24 18 8B 5C  24 6C 8B 74 24 70 8B 7C  aïD$ ï\$lït$pï|
.text:004013E0  24 74 8B 6C 24 78 83 C4  7C C3 8D B6 00 00 00 00  $tïl$xâ-|+ì¦....
```

Uses of Reverse Engineering

- Malware analysis
- Security / vulnerability research
- Driver development
- Compatibility fixes
- Legacy application support

Ethical and Legal Aspects

Disclaimer: I am not a lawyer, but here we go…

Image: Public Domain

Ethical and Legal Aspects

- Legality of reverse engineering is governed by copyright laws
- Copyright laws differ from country to country
- Reverse engineering is legal only is few specific cases
- Black box testing does not constitute reverse engineering
- Reverse engineering for compatibility fixes is legal
- Reverse engineering spyware is illegal in most countries
- When in doubt, **do not** reverse engineer!

Legal Uses of Reverse Engineering

- Recovery of own lost source code
- Recovery of data from legacy formats
- Malware analysis and research
- Security and vulnerability research
- Copyright infringement investigations
- Finding out the contents of any database you legally purchased

Illegal Activities

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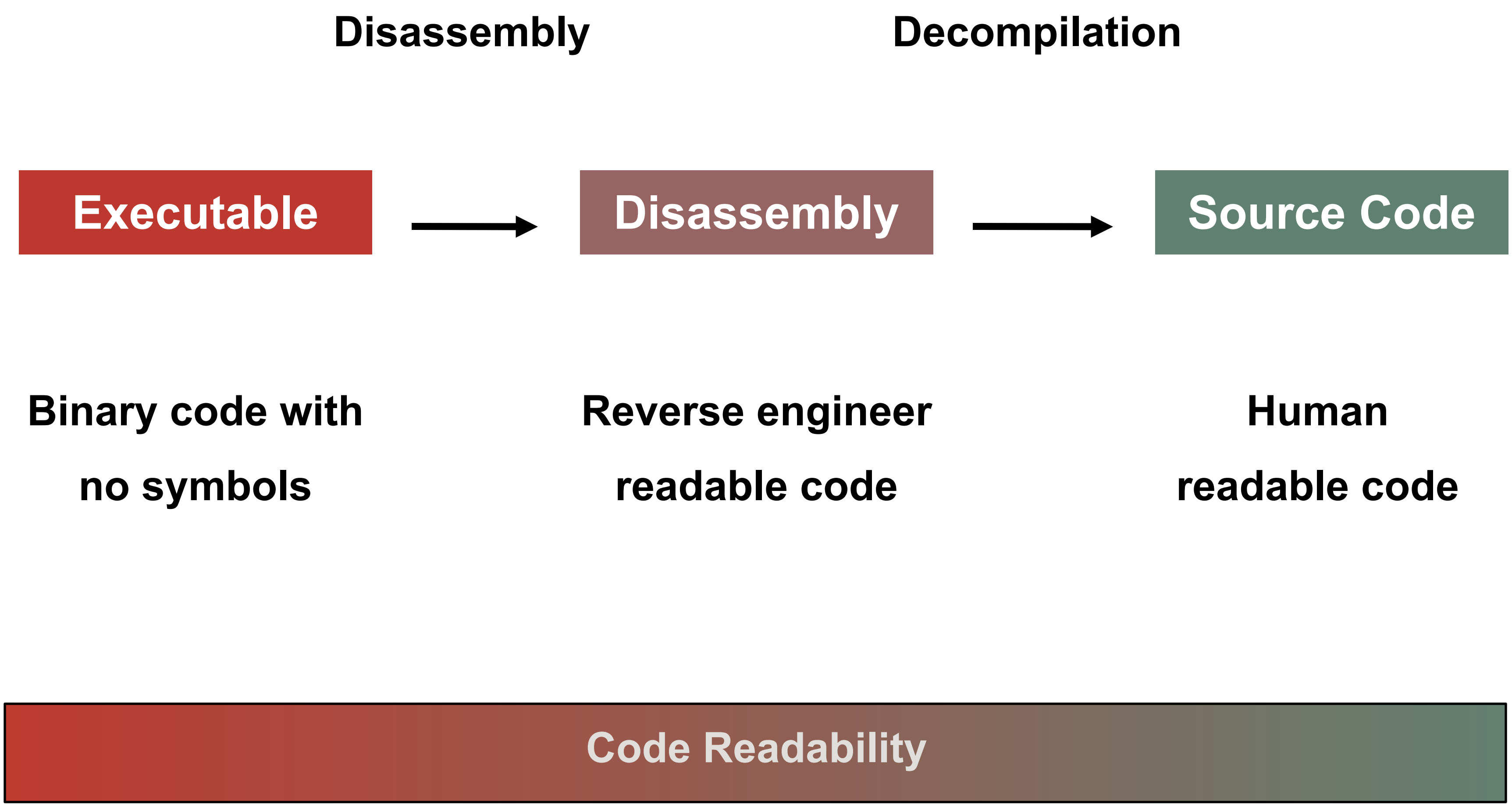
Illegal Activities

- Illegal to reverse engineer and sell a competing product
- Illegal to crack copy protections
- Illegal to distribute a crack/registration for copyrighted software
- Illegal to gain unauthorized access to any computer system
- Copyright protected software is off-limits in most cases
- Spyware/Adware with companies behind them are included

Decompilation Process



Disassembly

Decompilation

Executable → Disassembly → Source Code

Binary code with no symbols

Reverse engineer readable code

Human readable code

Code Readability

Disassembly Results

Disassembly Results

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.text:004012B0  A3 57 00 E8 98 FE FF FF  90 8D B4 26 00 00 00 00  úW.Fÿ¦  Éì¦&....
.text:004012C0  55 8B 0D 54 A3 57 00 89  E5 5D FF E1 8D 74 26 00  UïTúW.ës] ßìt&.
.text:004012D0  55 8B 0D 34 A3 57 00 89  E5 5D FF E1 90 90 90 90  Uï4úW.ës] ßÉÉÉÉ
.text:004012E0  83 EC 7C B8 70 B5 4E 00  89 44 24 34 B8 74 30 4F  â8|+p¦N.ëD$4+t0O
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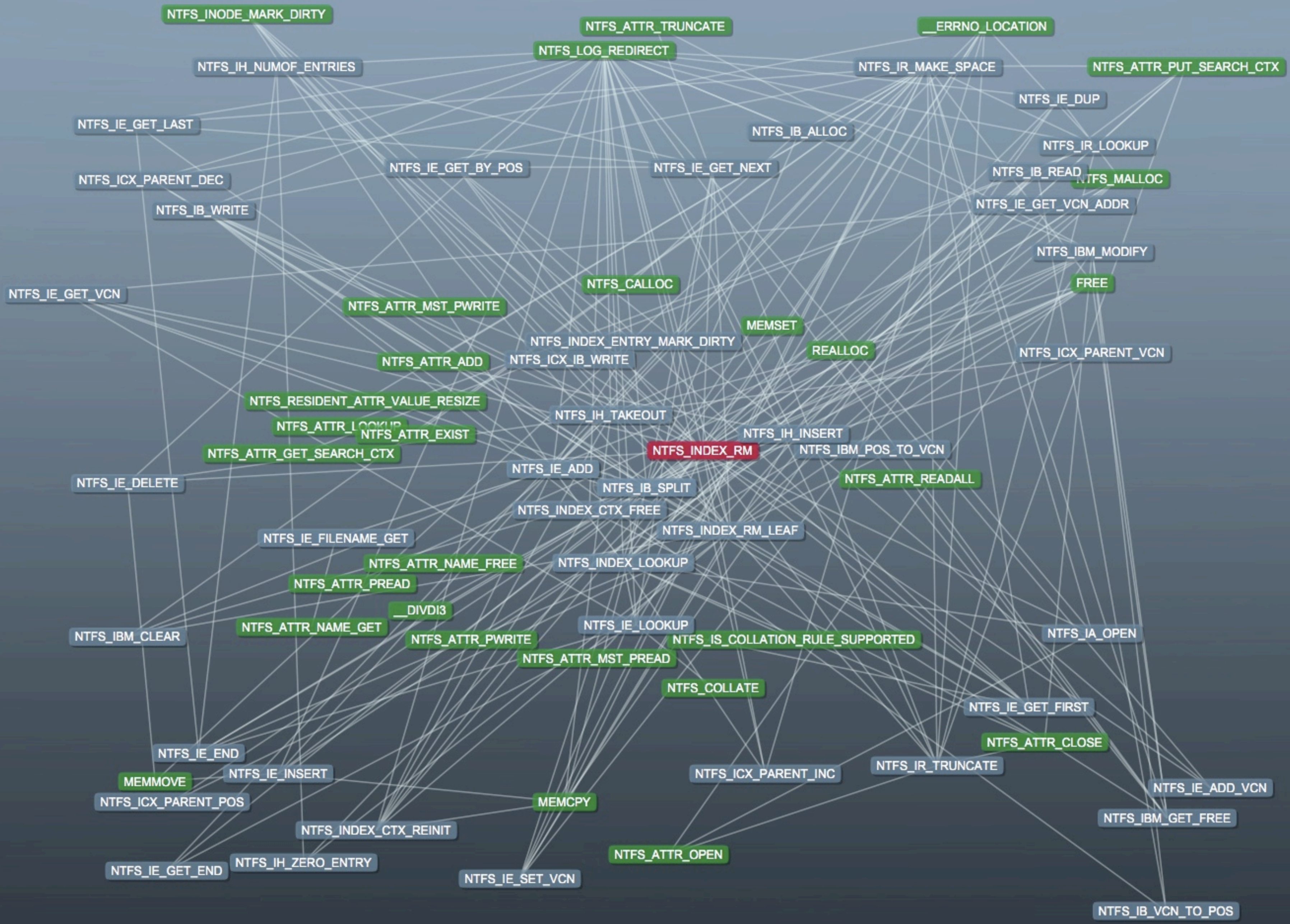
.text:00401390  B8 E8 EC 56 00 89 44 24  50 8B 44 24 24 89 04 24  +F8V.ëD$PïD$$ë $
.text:004013A0  B8 FF FF FF FF 89 44 24  20 E8 72 C4 0E 00 B8 E8  +    ëD$ Fr-a+F
.text:004013B0  EC 56 00 89 44 24 50 89  F6 8D BC 27 00 00 00 00  8V.ëD$Pë÷ì+'....
.text:004013C0  31 C0 89 44 24 18 8D 44  24 1C 89 04 24 E8 6E BE  1+ëD$ ìD$ ë $Fn+
.text:004013D0  0E 00 8B 44 24 18 8B 5C  24 6C 8B 74 24 70 8B 7C  aïD$ ï\$lït$pï|
.text:004013E0  24 74 8B 6C 24 78 83 C4  7C C3 8D B6 00 00 00 00  $tïl$xâ-|+ì¦....
```

Disassembly Results

```
.text:004013F0 sub_4013F0      proc near                ; CODE XREF: sub_406AB0+6F"p
.text:004013F0                                          ; sub_4601D0+5D"p
.text:004013F0
.text:004013F0 var_1C          = dword ptr -1Ch
.text:004013F0 var_18          = dword ptr -18h
.text:004013F0 arg_0           = dword ptr  4
.text:004013F0
.text:004013F0                 push     edi
.text:004013F1                 push     esi
.text:004013F2                 push     ebx
.text:004013F3                 sub      esp, 10h
.text:004013F6                 mov      edi, [esp+1Ch+arg_0]
.text:004013FA                 test     edi, edi
.text:004013FC                 jz       short loc_40143D
.text:004013FE                 mov      [esp+1Ch+var_1C], offset dword_572010
.text:00401405                 call     sub_406F80
.text:0040140A                 mov      ebx, eax
.text:0040140C                 jmp      short loc_401439
.text:0040140C ; ---------------------------------------------------------------------------
.text:0040140E                 align 10h
.text:00401410
.text:00401410 loc_401410:                              ; CODE XREF: sub_4013F0+4B"j
.text:00401410                 mov      [esp+1Ch+var_18], ebx
.text:00401414                 mov      [esp+1Ch+var_1C], offset dword_572010
.text:0040141B                 call     sub_406E30
.text:00401420                 mov      [esp+1Ch+var_18], ebx
```


NTFS_INODE_MARK_DIRTY
NTFS_ATTR_TRUNCATE
__ERRNO_LOCATION
NTFS_LOG_REDIRECT
NTFS_IH_NUMOF_ENTRIES
NTFS_IR_MAKE_SPACE
NTFS_ATTR_PUT_SEARCH_CTX
NTFS_IE_DUP
NTFS_IE_GET_LAST
NTFS_IB_ALLOC
NTFS_IR_LOOKUP
NTFS_IE_GET_BY_POS
NTFS_IE_GET_NEXT
NTFS_ICX_PARENT_DEC
NTFS_IB_READ
NTFS_MALLOC
NTFS_IB_WRITE
NTFS_IE_GET_VCN_ADDR
NTFS_IBM_MODIFY
FREE
NTFS_CALLOC
NTFS_IE_GET_VCN
NTFS_ATTR_MST_PWRITE
MEMSET
NTFS_INDEX_ENTRY_MARK_DIRTY
REALLOC
NTFS_ICX_PARENT_VCN
NTFS_ATTR_ADD
NTFS_ICX_IB_WRITE
NTFS_RESIDENT_ATTR_VALUE_RESIZE
NTFS_IH_TAKEOUT
NTFS_ATTR_LOOKUP
NTFS_ATTR_EXIST
NTFS_IH_INSERT
NTFS_INDEX_RM
NTFS_IBM_POS_TO_VCN
NTFS_ATTR_GET_SEARCH_CTX
NTFS_IE_ADD
NTFS_IE_DELETE
NTFS_IB_SPLIT
NTFS_ATTR_READALL
NTFS_INDEX_CTX_FREE
NTFS_INDEX_RM_LEAF
NTFS_IE_FILENAME_GET
NTFS_ATTR_NAME_FREE
NTFS_INDEX_LOOKUP
NTFS_ATTR_PREAD
__DIVDI3
NTFS_IE_LOOKUP
NTFS_ATTR_NAME_GET
NTFS_IBM_CLEAR
NTFS_ATTR_PWRITE
NTFS_IS_COLLATION_RULE_SUPPORTED
NTFS_IA_OPEN
NTFS_ATTR_MST_PREAD
NTFS_COLLATE
NTFS_IE_GET_FIRST
NTFS_ATTR_CLOSE
NTFS_IE_END
NTFS_IE_INSERT
NTFS_ICX_PARENT_INC
NTFS_IR_TRUNCATE
MEMMOVE
NTFS_IE_ADD_VCN
NTFS_ICX_PARENT_POS
MEMCPY
NTFS_IBM_GET_FREE
NTFS_INDEX_CTX_REINIT
NTFS_ATTR_OPEN
NTFS_IE_GET_END
NTFS_IH_ZERO_ENTRY
NTFS_IE_SET_VCN
NTFS_IB_VCN_TO_POS

Required Skills

- General computer architecture knowledge
- Assembly programming of target processors
- Operating systems
- File formats
- Information search skills
- ...real persistence...

Most Commonly Used Tools

- Hex editor/viewer
- Disassembler
- Search engine
- Debugger
- Script language

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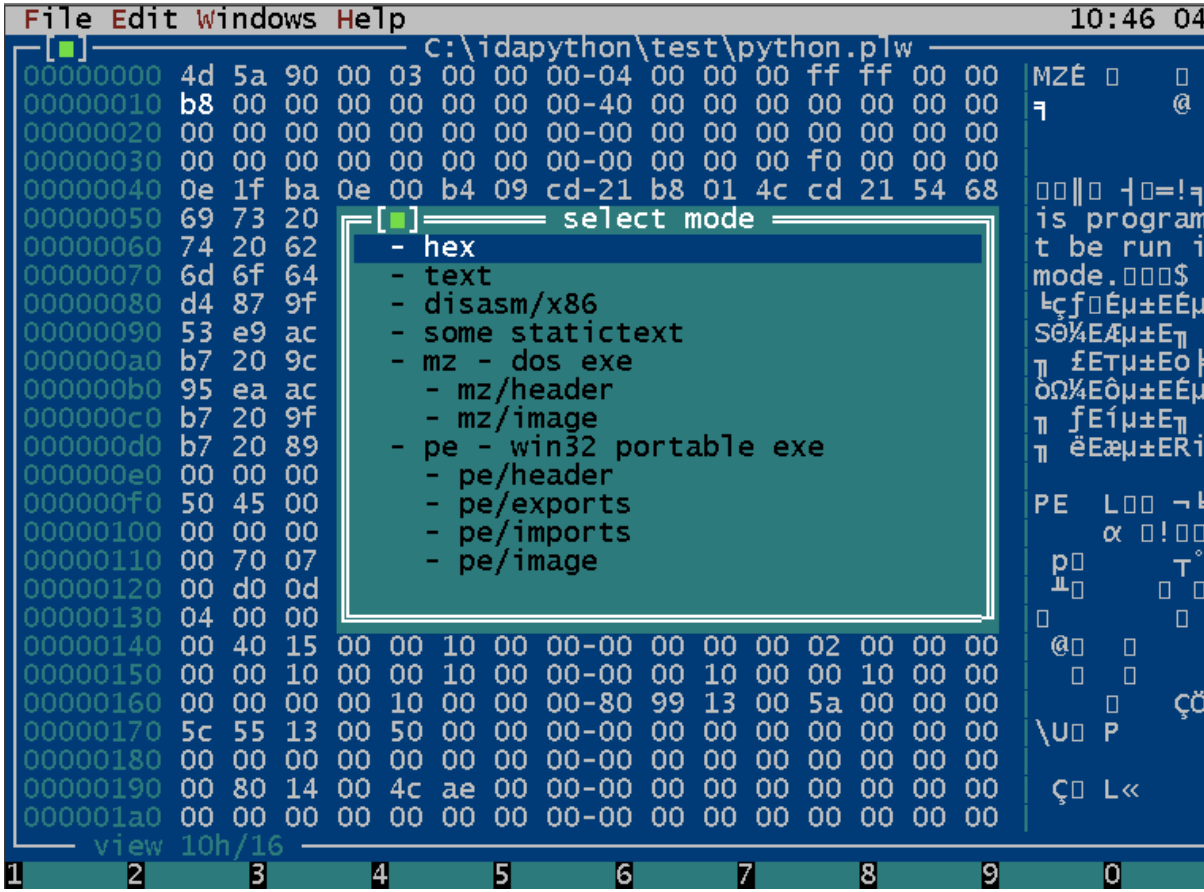

```
 File  Edit  Windows  Help                                          10:46 04
 [■]              C:\idapython\test\python.plw
00000000 4d 5a 90 00 03 00 00 00-04 00 00 00 ff ff 00 00 |MZÉ □    □
00000010 b8 00 00 00 00 00 00 00-40 00 00 00 00 00 00 00 |╕        @
00000020 00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00 |
00000030 00 00 00 00 00 00 00 00-00 00 00 f0 00 00 00 00 |
00000040 0e 1f ba 0e 00 b4 09 cd-21 b8 01 4c cd 21 54 68 |□□║□ ┤□=!╕
00000050 69 73 20 ╔[■]═══════ select mode ══════════╗ |is program
00000060 74 20 62 ║ - hex                            ║ |t be run i
00000070 6d 6f 64 ║ - text                           ║ |mode.□□□$
00000080 d4 87 9f ║ - disasm/x86                     ║ |╘çƒ□Éµ±EÉµ
00000090 53 e9 ac ║ - some statictext                ║ |SÖ¼EÆµ±E╖
000000a0 b7 20 9c ║ - mz - dos exe                   ║ |╖ £ETµ±Eo╟
000000b0 95 ea ac ║   - mz/header                    ║ |òΩ¼EÔµ±EÉµ
000000c0 b7 20 9f ║   - mz/image                     ║ |╖ ƒEíµ±E╖
000000d0 b7 20 89 ║ - pe - win32 portable exe        ║ |╖ ëEæµ±ERi
000000e0 00 00 00 ║   - pe/header                    ║ |
000000f0 50 45 00 ║   - pe/exports                   ║ |PE  L□□ ¬╘
00000100 00 00 00 ║   - pe/imports                   ║ |    α □!□□
00000110 00 70 07 ║   - pe/image                     ║ | p□     ┬°
00000120 00 d0 0d ║                                  ║ | ╨□    □ □
00000130 04 00 00 ╚══════════════════════════════════╝ |□      □
00000140 00 40 15 00 00 10 00 00-00 00 00 00 02 00 00 00 | @□   □
00000150 00 00 10 00 00 10 00 00-00 00 10 00 00 10 00 00 |   □   □
00000160 00 00 00 00 10 00 00 00-80 99 13 00 5a 00 00 00 |     □    çÖ
00000170 5c 55 13 00 50 00 00 00-00 00 00 00 00 00 00 00 |\U□ P
00000180 00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00 |
00000190 00 80 14 00 4c ae 00 00-00 00 00 00 00 00 00 00 | Ç□ L«
000001a0 00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00 |
      view 10h/16
1        2        3        4        5        6        7        8        9        0
```

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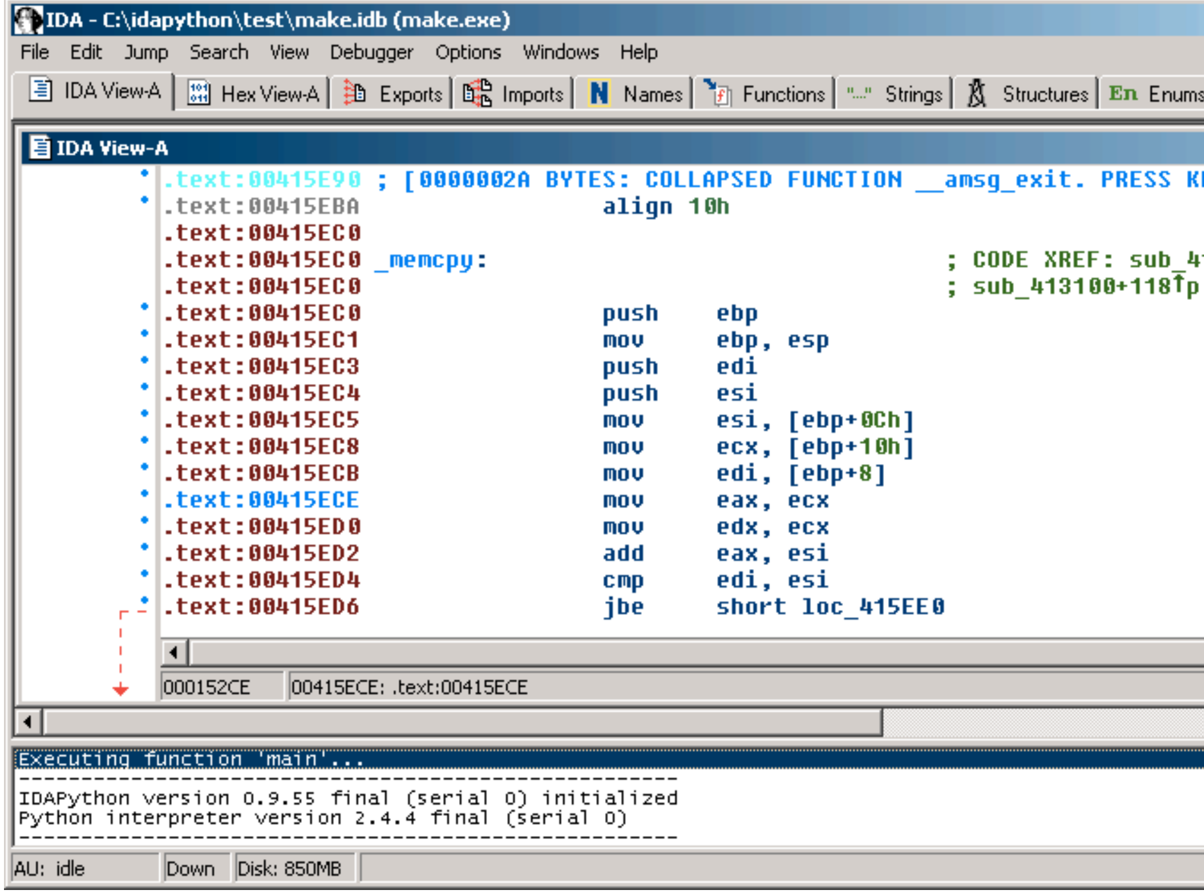
IDA - C:\idapython\test\make.idb (make.exe)
File Edit Jump Search View Debugger Options Windows Help
IDA View-A
Hex View-A
Exports
Imports
Names
Functions
Strings
Structures
Enums
IDA View-A

```
.text:00415E90 ; [0000002A BYTES: COLLAPSED FUNCTION __amsg_exit. PRESS KI
.text:00415EBA                 align 10h
.text:00415EC0
.text:00415EC0 _memcpy:                                ; CODE XREF: sub_41
.text:00415EC0                                         ; sub_413100+118↑p
.text:00415EC0                 push    ebp
.text:00415EC1                 mov     ebp, esp
.text:00415EC3                 push    edi
.text:00415EC4                 push    esi
.text:00415EC5                 mov     esi, [ebp+0Ch]
.text:00415EC8                 mov     ecx, [ebp+10h]
.text:00415ECB                 mov     edi, [ebp+8]
.text:00415ECE                 mov     eax, ecx
.text:00415ED0                 mov     edx, ecx
.text:00415ED2                 add     eax, esi
.text:00415ED4                 cmp     edi, esi
.text:00415ED6                 jbe     short loc_415EE0
```

```
000152CE    00415ECE: .text:00415ECE
```

```
Executing function 'main'...
-----------------------------------------------------
IDAPython version 0.9.55 final (serial 0) initialized
Python interpreter version 2.4.4 final (serial 0)
-----------------------------------------------------
```

```
AU:  idle    Down    Disk: 850MB
```

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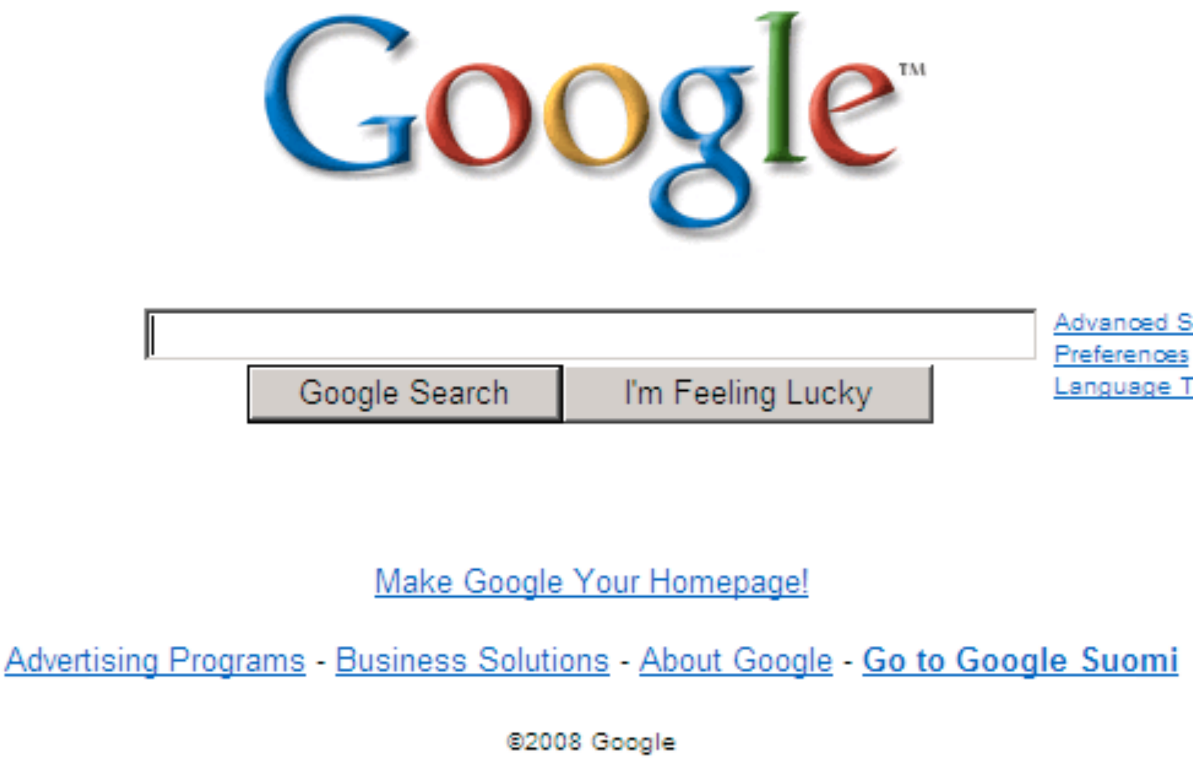
Google™
Google Search
I'm Feeling Lucky
Advanced S
Preferences
Language T
Make Google Your Homepage!
Advertising Programs - Business Solutions - About Google - Go to Google Suomi
©2008 Google

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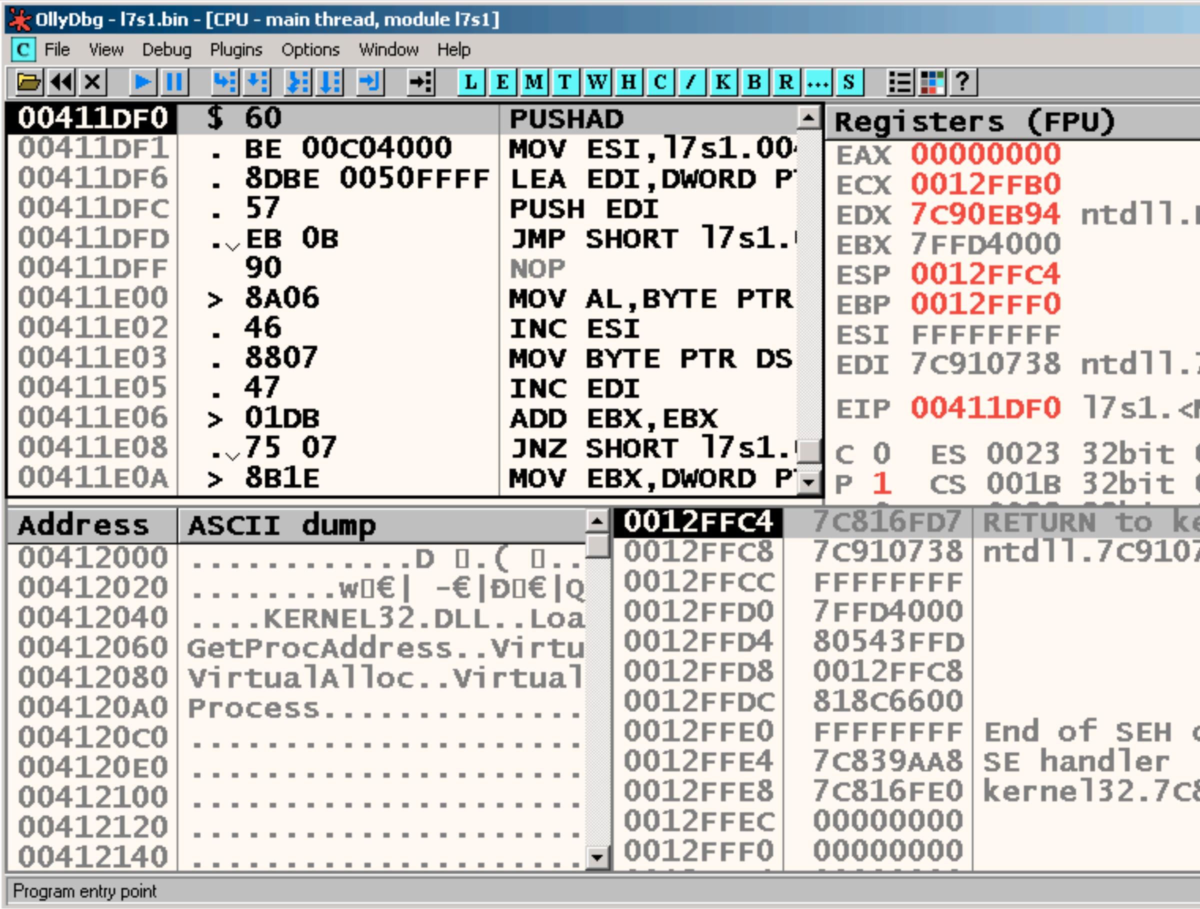


```
00411DF0  $ 60             PUSHAD
00411DF1  . BE 00C04000    MOV ESI,l7s1.00
00411DF6  . 8DBE 0050FFFF  LEA EDI,DWORD P
00411DFC  . 57             PUSH EDI
00411DFD  .⌄EB 0B          JMP SHORT l7s1.
00411DFF    90             NOP
00411E00  > 8A06           MOV AL,BYTE PTR
00411E02  . 46             INC ESI
00411E03  . 8807           MOV BYTE PTR DS
00411E05  . 47             INC EDI
00411E06  > 01DB           ADD EBX,EBX
00411E08  .⌄75 07          JNZ SHORT l7s1.
00411E0A  > 8B1E           MOV EBX,DWORD P
```

```
Registers (FPU)
EAX 00000000
ECX 0012FFB0
EDX 7C90EB94 ntdll.
EBX 7FFD4000
ESP 0012FFC4
EBP 0012FFF0
ESI FFFFFFFF
EDI 7C910738 ntdll.

EIP 00411DF0 l7s1.<

C 0   ES 0023 32bit
P 1   CS 001B 32bit
```

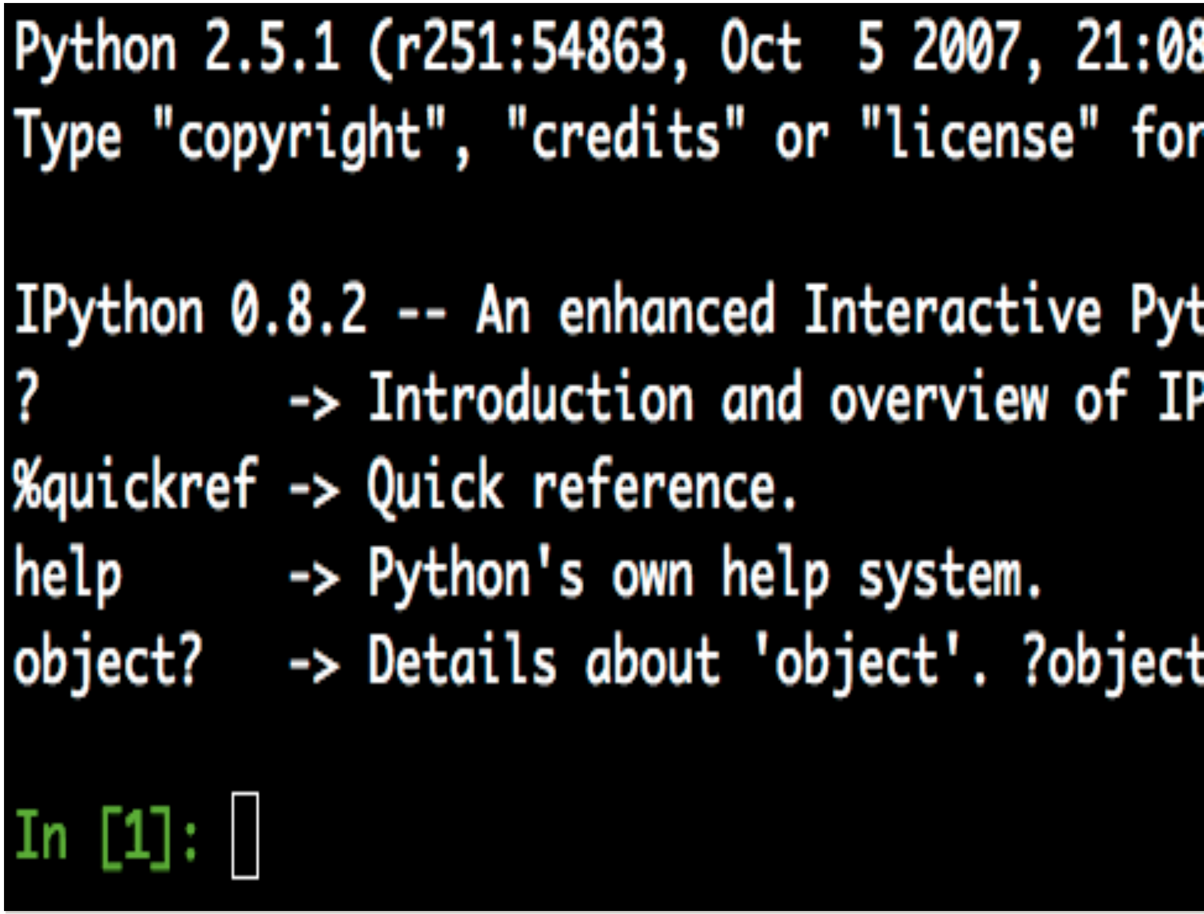
```
Address   ASCII dump
00412000  ............D □.( □..
00412020  ........w□€| -€|Ð□€|Q
00412040  ....KERNEL32.DLL..Loa
00412060  GetProcAddress..Virtu
00412080  VirtualAlloc..Virtual
004120A0  Process..............
004120C0  .....................
004120E0  .....................
00412100  .....................
00412120  .....................
00412140  .....................
```

```
0012FFC4  7C816FD7  RETURN to ke
0012FFC8  7C910738  ntdll.7C9107
0012FFCC  FFFFFFFF
0012FFD0  7FFD4000
0012FFD4  80543FFD
0012FFD8  0012FFC8
0012FFDC  818C6600
0012FFE0  FFFFFFFF  End of SEH
0012FFE4  7C839AA8  SE handler
0012FFE8  7C816FE0  kernel32.7C8
0012FFEC  00000000
0012FFF0  00000000
```

Program entry point

Most Commonly Used Tools

- Hex editor/viewer
- Disassembler
- Search engine
- Debugger
- Script language



```
Python 2.5.1 (r251:54863, Oct  5 2007, 21:08
Type "copyright", "credits" or "license" for

IPython 0.8.2 -- An enhanced Interactive Pyt
?         -> Introduction and overview of IP
%quickref -> Quick reference.
help      -> Python's own help system.
object?   -> Details about 'object'. ?object

In [1]: 
```

Getting Started

- Master your tools
- Identify the target binary format
- Identify the target processor
- Identify the target operating system
- …dig in and find out as much as you can…