汇编语言与逆向技术

第11章 C语言程序逆向分析

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本章知识点

- 识别函数
  - 难点：参数、局部变量、栈指针、函数调用约定
- 识别变量、数组、结构体
- 识别IF分支结构
- 识别Switch结构
- 识别循环结构

识别函数

主观题 10分

设置

Windows将程序转载到内存之后，执行的第一条指令是不是main函数的指令?

作答

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启动函数

- 在编写Win32应用程序时，在源码里都有一个WinMain函数。
- Windows程序的执行并不是从WinMain函数开始的，而是先执行启动函数
  - 首先执行启动函数的代码，启动函数是编译器生成的
  - 启动函数初始化进程完成后，才会执行WinMain函数

启动函数

- C/C++程序运行时，启动函数的作用基本相同
  - 检索指向新进程的命令行指针
  - 检索指向新进程的环境变量指针
  - 全局变量初始化
  - 内存栈初始化

启动函数

- 当所有的初始化操作完成后，启动函数就会调用应用程序的进入点函数(main和WinMain)。
- 调用WinMain函数的示例

```
GetStartupInfo (&StartupInfo);
Int nMainRetVal = WinMain(GetModuleHandle(NULL),NULL,pszCommandLineAnsi, \
                  (StartupInfo.dwFlags&STARTF_USESHOWWINDOW)?StartupInfo.\
                   wShowWindow:SW__SHOWDEFAULT);
```

启动函数

EXE文件的入口点并不是main函数，而是一段启动函数代码

Headers

Type:	PE 32-bit	Section Alignment:	0x1000
Machine:	I386	File Alignment:	0x200
Endianness:	Little	Checksum:	0x0
Subsystem:	WINDOWS_CUI	Base of Code:	0x401000
Timestamp:	Sun Dec 3 15:55:56 2023	Base of Data:	0x404000
Timestamp (Hex):	0x656c348c	Size of Code:	0x2e00
Current Base:	0x400000	Size of Init Data:	0x3800
Image Base:	0x400000	Size of Uninit Data:	0x0
Entry Point:	0x401014	Size of Headers:	0x400

```
00401014  uint32_t j__mainCRTStartup(void* __formal0)

00401014  e9d6080000          jmp     _mainCRTStartup
```

启动函数

```
00401779  call    j___get_initial_narrow_environment
0040177e  mov     edi, eax
00401780  call    j____p___argv
00401785  mov     esi, dword [eax]
00401787  call    j____p___argc
0040178c  push    edi {Target_1}
0040178d  push    esi {var_10_4}
0040178e  push    dword [eax] {var_14_2}
00401790  call    j__main
00401795  add     esp, 0xc
00401798  mov     esi, eax
0040179a  call    j____scrt_is_managed_app
0040179f  test    al, al
004017a1  je      0x40180e
```

函数

- 程序通过CALL指令来调用函数，在函数执行结束后，通过RET指令返回调用程序继续执行

```
00401510  int32_t _printf(char const* _Format, ...)

00401510  56              push    esi {__saved_esi}
00401511  8b742408        mov     esi, dword [esp+0x8 {_Format}]
00401515  6a01            push    0x1
00401517  ff15d8714000    call    dword [___acrt_iob_func]
0040151d  83c404          add     esp, 0x4
00401520  8d4c240c        lea     ecx, [esp+0xc {_ArgList}]
00401524  51              push    ecx {_ArgList} {var_8}
00401525  6a00            push    0x0 {var_c}
00401527  56              push    esi {var_10}
00401528  50              push    eax {var_14}
00401529  e87bfcffff      call    j____local_stdio_printf_options
0040152e  ff7004          push    dword [eax+0x4] {var_18}  {_OptionsStora
00401531  ff30            push    dword [eax] {var_1c}  {_OptionsStorage}
00401533  ff15e0714000    call    dword [___stdio_common_vfprintf]
00401539  83c418          add     esp, 0x18
0040153c  5e              pop     esi {__saved_esi}
0040153d  c3              retn    {__return_addr}
```

函数

- C++ 函数定义
- return_type function_name(parameter list) {

  body of the function

  }

主观题 10分

设置

函数的参数如何传递、局部变量如何定义、函数如何返回?

作答

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Call指令

- 函数调用使用Call指令
- 常见的Call指令的操作码是E8，操作数是32位有符号的相对位移，相对于EIP寄存器的值（a signed displacement relative to the current value of the instruction pointer in the EIP register）
- Call指令的地址是opcode + EIP

Opcode	Mnemonic	Description
E8 cw	CALL rel16	Call near, relative, displacement relative to next instruction
E8 cd	CALL rel32	Call near, relative, displacement relative to next instruction
FF /2	CALL r/m16	Call near, absolute indirect, address given in r/m16
FF /2	CALL r/m32	Call near, absolute indirect, address given in r/m32
9A cd	CALL ptr16:16	Call far, absolute, address given in operand
9A cp	CALL ptr16:32	Call far, absolute, address given in operand
FF /3	CALL m16:16	Call far, absolute indirect, address given in m16:16
FF /3	CALL m16:32	Call far, absolute indirect, address given in m16:32

```
00401483  e8ebfbffff      call    j__printf
00401488  8d442404        lea     eax, [esp+0x4 {var_54}]
0040148c  50              push    eax {var_54} {var_5c}
0040148d  684c4b4000      push    `string'::%s {var_60}  {"%s"}
00401492  e887fbffff      call    j__scanf
00401497  6a16            push    0x16 {var_64}
00401499  8d442410        lea     eax, [esp+0x10 {var_54}]
```

填空题 10分

设置

如下图所示，指令“call j__scanf”的二进制编码是e8 87 fb ff ff，该call指令所在的内存地址是00401492h，则j__scanf函数的入口地址是 [填空1].

注意：内存地址的书写格式，例如0040101Eh，可以写成0040101E、0040101eh、0040101e，都是正确的。32位的内存地址要保证8个有效字符，字符之间不加空格。

```
00401483  e8ebfbffff      call    j__printf
00401488  8d442404        lea     eax, [esp+0x4 {var_54}]
0040148c  50              push    eax {var_54} {var_5c}
0040148d  684c4b4000      push    `string'::%s {var_60}  {"%s"}
00401492  e887fbffff      call    j__scanf
00401497  6a16            push    0x16 {var_64}
00401499  8d442410        lea     eax, [esp+0x10 {var_54}]
```

正常使用填空题需3.0以上版本雨课堂

作答

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Call指令

- call指令的内存00401492h
- 下一条指令的地址是00401492h+5 = 00401497h
- call指令的操作数是一个有符号相对位移值0ffffb87h（符号位）
- j_scan函数的入口地址是00401497h + 0ffffb87h = 10040101Eh

栈

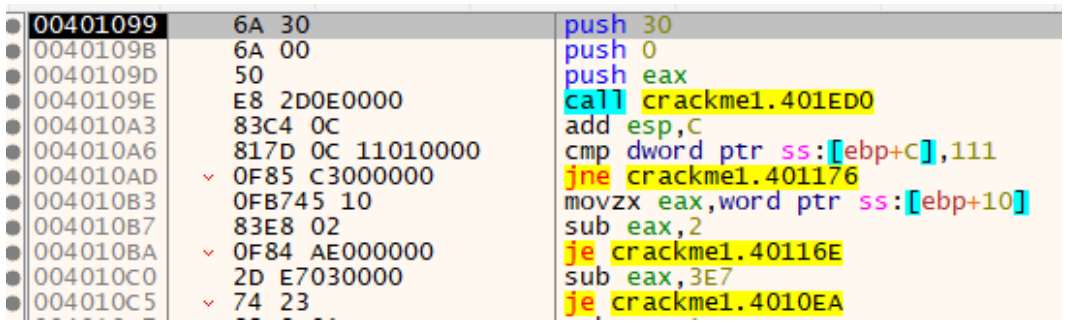
- 栈是一种后入先出的数据存储结构
- 函数的参数、局部变量、返回地址等被存储在栈中
- ESP (Extended Stack Pointer) 存储栈顶的内存地址，栈指针
- EBP (Extended Base Pointer) 存储栈底的内存地址，帧指针
- PUSH指令将数据压入栈顶
- POP指令从栈顶取出数据

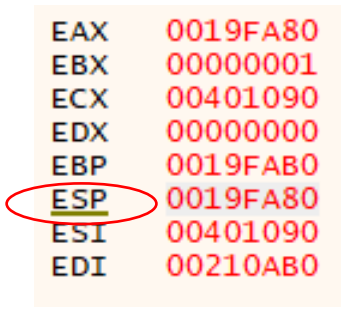
填空题 10分

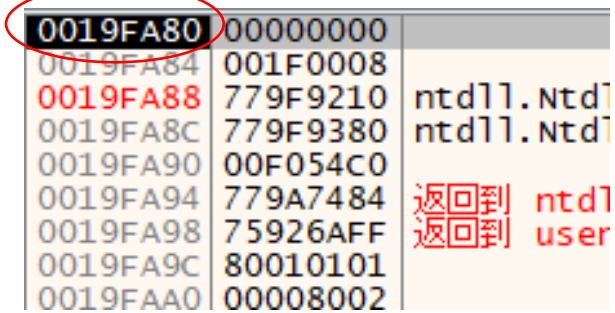
设置

如下图所示，指令“Push 30”执行之前，ESP的值是0019FA80。Push指令执行之后，ESP的值是[填空1]。

注意：32位的内存地址要保证8个有效字符，字符之间不加空格







正常使用填空题需3.0以上版本雨课堂

作答

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```
00401099    6A 30           push 30
0040109B    6A 00           push 0
0040109D    50              push eax
0040109E    E8 2D0E0000     call crackme1.401ED0
004010A3    83C4 0C         add esp,C
004010A6    817D 0C 11010000 cmp dword ptr ss:[ebp+C],111
004010AD    0F85 C3000000   jne crackme1.401176
004010B3    0FB745 10       movzx eax,word ptr ss:[ebp+10]
004010B7    83E8 02         sub eax,2
```

```
EAX   0019FA80
EBX   00000001
ECX   00401090
EDX   00000000
EBP   0019FAB0
ESP   0019FA7C
ESI   00401090
EDI   00210AB0
```

```
0019FA7C  00000030
0019FA80  00000000
0019FA84  001F0008
0019FA88  779F9210  ntdll.
0019FA8C  779F9380  ntdll.
0019FA90  00F054C0
0019FA94  779A7484  返回到
0019FA98  75926AFF  返回到
0019FA9C  80010101
0019FAA0  00008002
```

函数的调用过程

- （1）传参：使用push指令将参数压入栈中。
- （2）保存返回值：call memory_location
  - **call的返回地址压入栈中**
  - **修改EIP的值**
- （3）保存栈帧：push ebp，mov ebp，esp
- （4）创建局部变量：add esp xxx
  - xxx（局部标量占用的空间）
  - 在栈中分配局部变量的空间

传递参数、保存返回地址

```
• 0040101d   push    0x2
• 0040101f   push    0x1
• 00401021   call    func
• 00401026   add     esp, 0x8
```

```
_func:
00401000   push    ebp
00401001   mov     ebp, esp
00401003   sub     esp, 0x8

…….

0040101f   mov     esp, ebp
00401021   pop     ebp
00401022   retn
```

局部变量的初始化

```
; int __stdcall sub_401018(LPCVOID lpBuffer)
sub_401018      proc near               ; CODE XREF: start+A↑p
                                        |
nNumberOfBytesToWrite= dword ptr -0Ch
NumberOfBytesWritten= dword ptr -8
hFile           = dword ptr -4
lpBuffer        = dword ptr  8

                push    ebp
                mov     ebp, esp
                add     esp, 0FFFFFFF4h
                push    0FFFFFFF5h      ; nStdHandle
                call    GetStdHandle
```

```
0019FF5C  00000000
0019FF60  00000000
0019FF64  00000000
0019FF68  0019FF80  0 □
0019FF6C  0040100F  □□  返回到 hello.00401018 来自 hello.0040100F
0019FF70  00403000  □   ASCII "Hello World!",LF,CR
```

栈帧（Stack Frame）

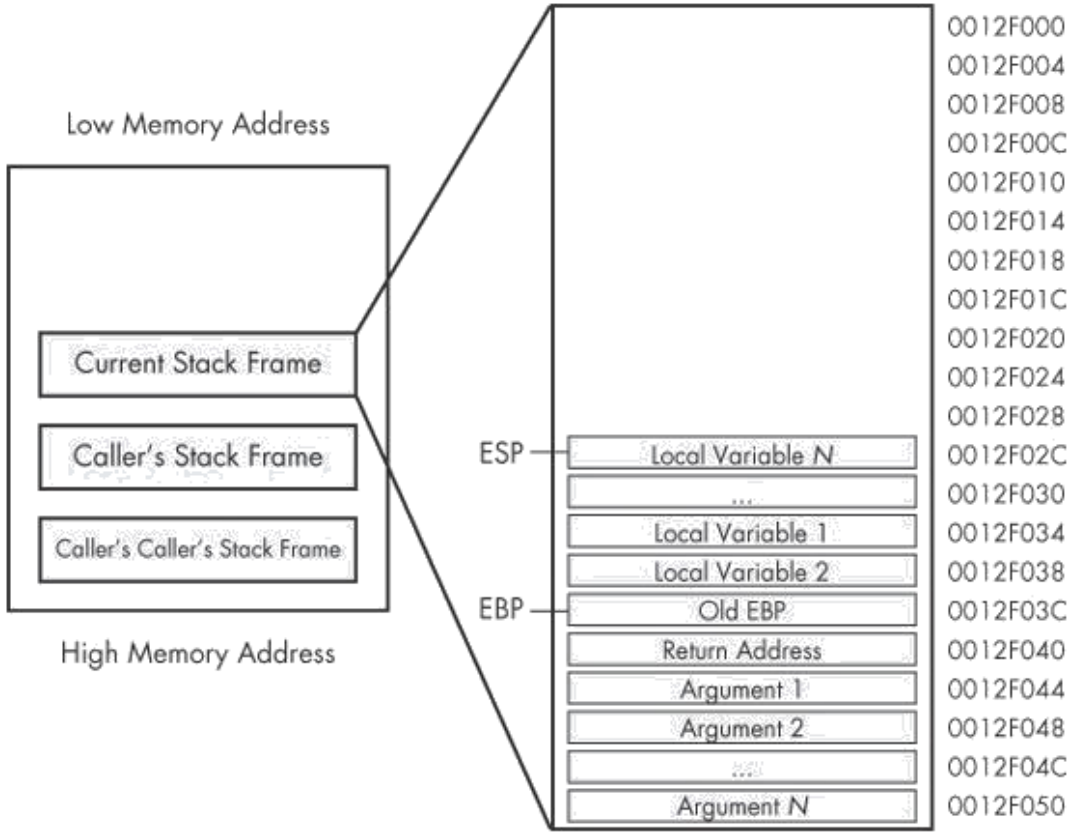


Figure 5-8. Individual stack frame

栈帧（Stack Frame）

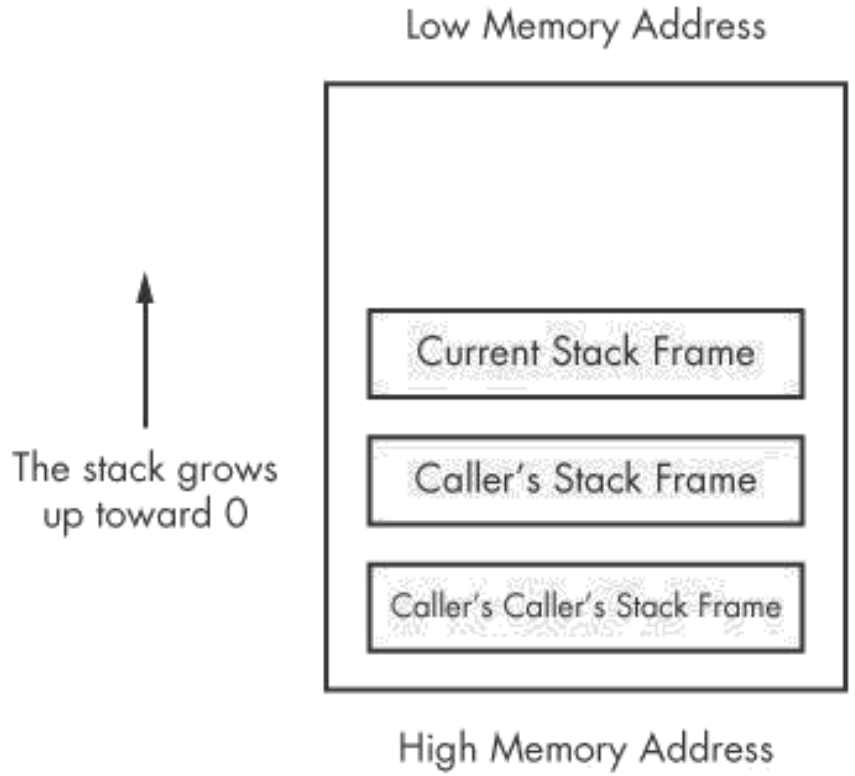
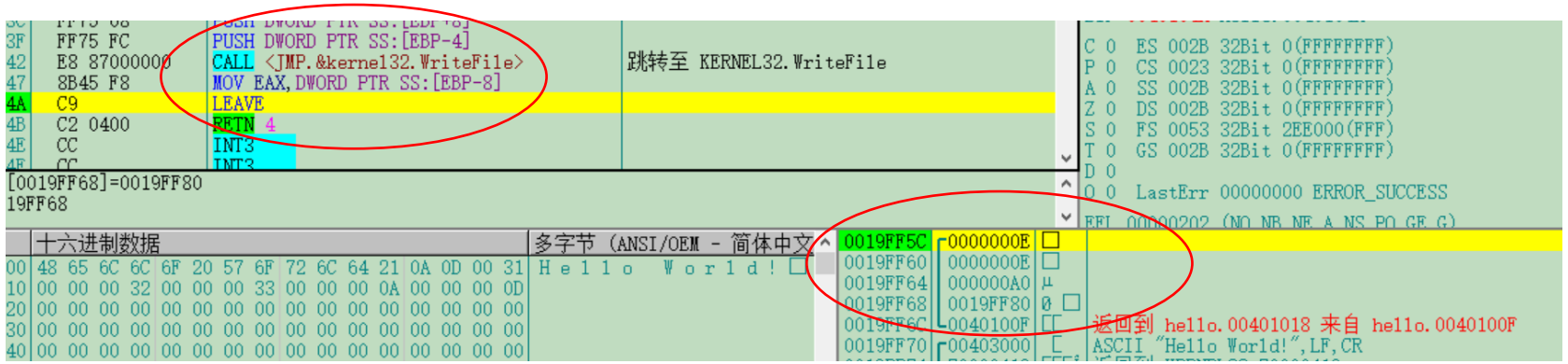


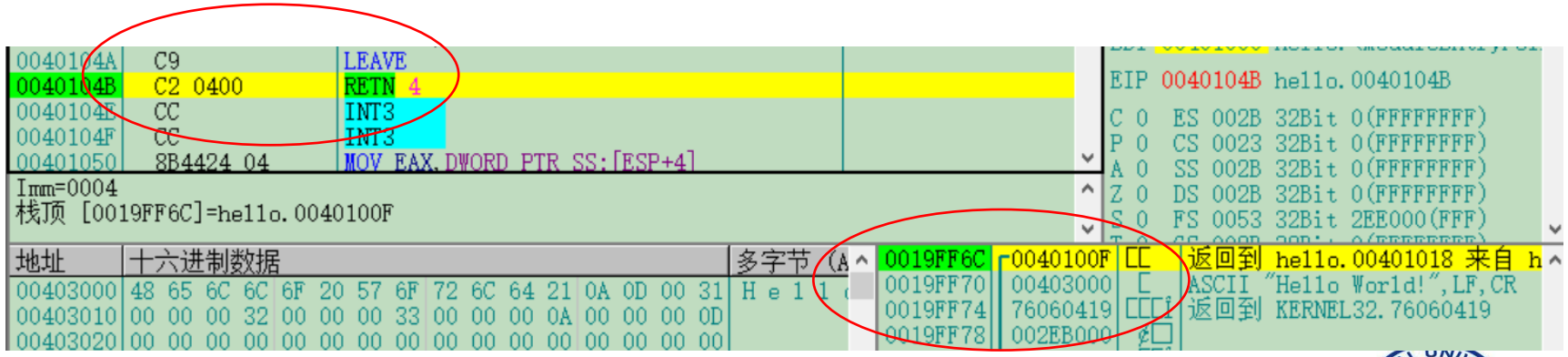
Figure 5-7. x86 stack layout

函数执行和返回过程

- （1）执行函数
- （2）清除局部变量占用的栈空间
- （3）ret指令从栈中读取返回地址，设置EIP
- （4）清除参数占用的栈空间

函数的调用过程


3F FF75 FC PUSH DWORD PTR SS:[EBP-4]
42 E8 87000000 CALL <JMP.&kernel32.WriteFile>
跳转至 KERNEL32.WriteFile
47 8B45 F8 MOV EAX,DWORD PTR SS:[EBP-8]
4A C9 LEAVE
4B C2 0400 RETN 4
4E CC INT3
4F CC INT3
[0019FF68]=0019FF80
19FF68
十六进制数据
多字节 (ANSI/OEM - 简体中文
00 48 65 6C 6C 6F 20 57 6F 72 6C 64 21 0A 0D 00 31 Hello World!
10 00 00 00 32 00 00 00 33 00 00 00 0A 00 00 00 0D
20 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
30 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
40 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0019FF5C 0000000E
0019FF60 0000000E
0019FF64 000000A0
0019FF68 0019FF80
0019FF6C 0040100F
0019FF70 00403000
返回到 hello.00401018 来自 hello.0040100F
ASCII "Hello World!",LF,CR
C 0 ES 002B 32Bit 0(FFFFFFFF)
P 0 CS 0023 32Bit 0(FFFFFFFF)
A 0 SS 002B 32Bit 0(FFFFFFFF)
Z 0 DS 002B 32Bit 0(FFFFFFFF)
S 0 FS 0053 32Bit 2EE000(FFF)
T 0 GS 002B 32Bit 0(FFFFFFFF)
D 0
O 0 LastErr 00000000 ERROR_SUCCESS


0040104A C9 LEAVE
0040104B C2 0400 RETN 4
0040104E CC INT3
0040104F CC INT3
00401050 8B4424 04 MOV EAX,DWORD PTR SS:[ESP+4]
Imm=0004
栈顶 [0019FF6C]=hello.0040100F
地址
十六进制数据
00403000 48 65 6C 6C 6F 20 57 6F 72 6C 64 21 0A 0D 00 31
00403010 00 00 00 32 00 00 00 33 00 00 00 0A 00 00 00 0D
00403020 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0019FF6C 0040100F
0019FF70 00403000
0019FF74 76060419
0019FF78 002EB000
返回到 hello.00401018 来自
ASCII "Hello World!",LF,CR
返回到 KERNEL32.76060419
EIP 0040104B hello.0040104B
C 0 ES 002B 32Bit 0(FFFFFFFF)
P 0 CS 0023 32Bit 0(FFFFFFFF)
A 0 SS 002B 32Bit 0(FFFFFFFF)
Z 0 DS 002B 32Bit 0(FFFFFFFF)
S 0 FS 0053 32Bit 2EE000(FFF)

LEAVE指令

- The LEAVE instruction copies the frame pointer (in the EBP register) into the stack pointer register (ESP), which releases the stack space allocated to the stack frame.
- The old frame pointer is then popped from the stack into the EBP register, restoring the calling procedure's stack frame.
- 清除局部变量所占用的栈空间

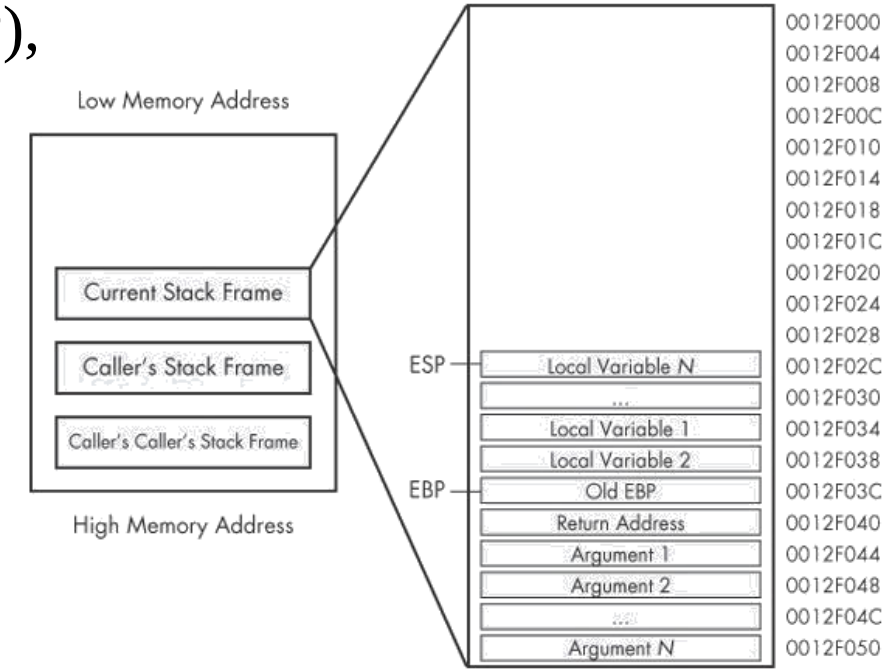


Figure 5-8. Individual stack frame

RETN 指令

- Transfers program control to a return address located on the top of the stack
- The optional source operand specifies the number of stack bytes to be released after the return address is popped; This operand can be used to release parameters from the stack that were passed to the called procedure and are no longer needed.
- 函数返回，并清除参数占用的栈空间。

主观题 10分

设置

ESP是0019FF6Ch，[ESP]的值是0040100Fh，retn 4指令执行之后，ESP的值和EIP的值是多少?

作答

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主观题 10分

设置

反汇编代码中，函数的开头都有__cdecl或者__stdcall符号，这些符号是什么?

作答

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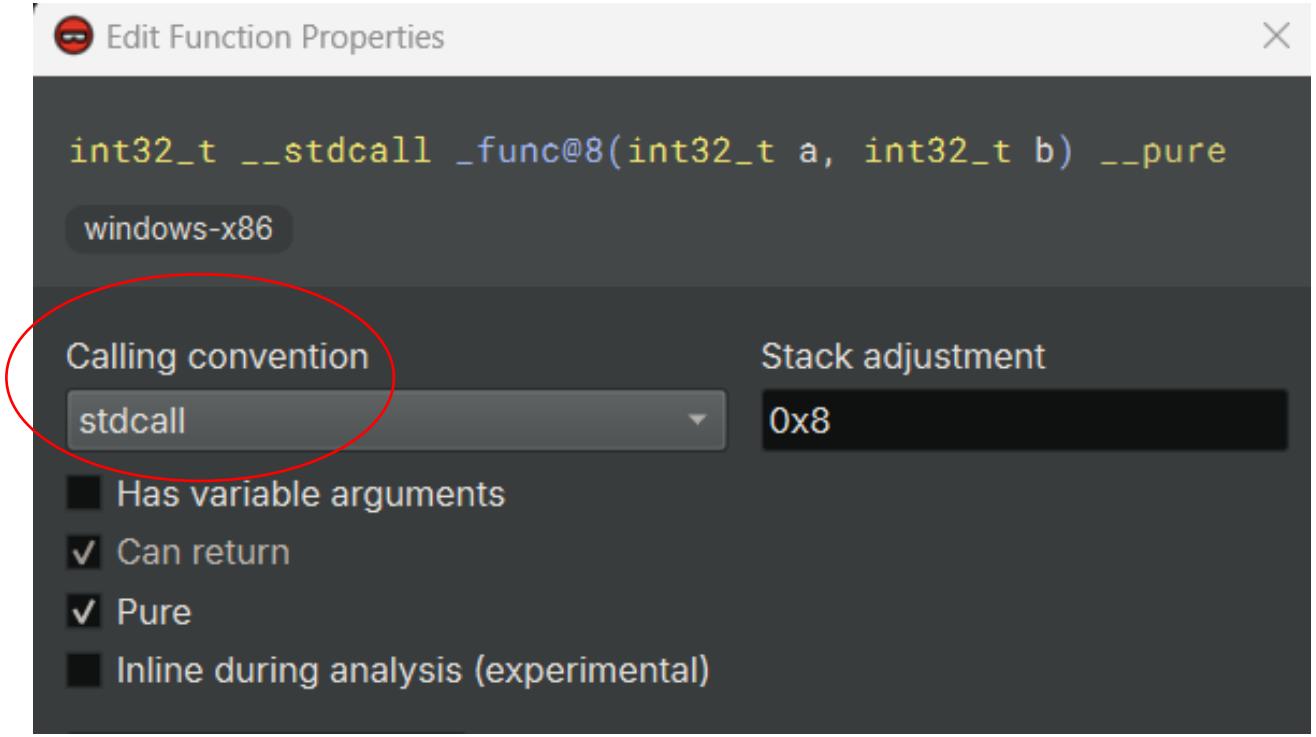
调用约定（Calling Convention）



Calling Convention

- 在x86平台，函数所有参数的宽度都是32bits
- 函数的返回值（Return values）的宽度是 32bits， 存储在EAX 寄存器中

Calling Convention

- 被调函数callee和主函数caller如何传递参数和返回值的约定
- VC 编译器支持以下两种调用约定
  - __cdecl
  - __stdcall

Calling Convention

- **__cdecl** 是 C and C++ 程序的标准函数调用

Element	Implementation
参数传递顺序 Argument-passing order	从右向左 Right to left.
栈的维护（谁负责清除参数） Stack-maintenance responsibility	主函数负责清除参数 Calling function pops the arguments from the stack.

__cdecl

```
lea     ecx, [eax+7]
mov     dl, [eax+6]
push    ecx
push    edx
lea     eax, [esp+70h+var_64]
push    offset aS_0     ; "%*s"
push    eax             ; char *
call    _sprintf
add     esp, 10h
lea     ecx, [esp+68h+var_64]
push    0               ; int
```

Calling Convention

- **__stdcall** 是Win32 API 函数的调用约定

Element	Implementation
参数传递顺序 Argument-passing order	从右向左 Right to left.
栈的维护（谁负责清除参数） Stack-maintenance responsibility	被调用函数负责清除参数 Called function pops its own arguments from the stack.

__stdcall

```
loc_438E61:                             ; CODE XREF: __lseek+36↑j
                push    [esp+0Ch+dwMoveMethod] ; dwMoveMethod
                push    0               ; lpDistanceToMoveHigh
                push    [esp+14h+lDistanceToMove] ; lDistanceToMove
                push    eax             ; hFile
                call    ds:SetFilePointer
                mov     ebx, eax
                cmp     ebx, 0FFFFFFFFh
                jnz     short loc_438E81
                call    ds:GetLastError
                jmp     short loc_438E83
```

设置

函数URLDownloadToFileA的调用约定是?

```
push    0                       ; LPBINDSTATUSCALLBACK
push    0                       ; DWORD
push    offset aCEmpdownload_e ; "c:\tempdownload.exe"
mov     eax, [ebp+var_4]
mov     ecx, [eax]
push    ecx                     ; LPCSTR
push    0                       ; LPUNKNOWN
call    URLDownloadToFileA
mov     esp, ebp
pop     ebp
retn
endp
```

A __cdecl

B __stdcall

提交

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识别变量、数组、结构体

局部变量和全局变量

- 全局变量
  - 可以任意函数访问和修改的变量
- 局部变量
  - 只能在定义该变量的函数内部，访问和修改

全局变量和局部变量

```
int x = 1;
int y = 2;

void main() {
  x = x+y;
  printf("Total = %d\n", x);
}
```

```
void main() {
  int x = 1;
  int y = 2;
  x = x+y;
  printf("Total = %d\n", x);
}
```

全局变量

```
00401003        mov     eax, dword_40CF60
00401008        add     eax, dword_40C000
0040100E        mov     dword_40CF60, eax ❶
00401013        mov     ecx, dword_40CF60
00401019        push    ecx
0040101A        push    offset aTotalD  ;"total = %d\n"
0040101F        call    printf
```

局部变量

```
00401006        mov     dword ptr [ebp-4], 0
0040100D        mov     dword ptr [ebp-8], 1
00401014        mov     eax, [ebp-4]
00401017        add     eax, [ebp-8]
0040101A        mov     [ebp-4], eax
0040101D        mov     ecx, [ebp-4]
00401020        push    ecx
00401021        push    offset aTotalD  ; "total = %d\n"
00401026        call    printf
```

单选题 10分

设置

mov eax, [ebp+var_4]”
[ebp+var_4] 一个全局变量还是局部变量？

A 局部变量

B 全局变量

提交

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数组

- 数组是相同数据类型的元素的集合，它们在内存中按顺序连续存放在一起。
- 在汇编状态下访问数组一般是通过基址加变址寻址实现的

数组

- int ary[4] = {1, 2, 3, 4}
  - 每个整数占用4个字节，数组占用了16个字节，假设数组的首地址是0x1000
  - ary[0] 的位置是0x1000
  - ary[1]的位置是0x1004
  - ary[2]的位置是0x1008
  - ary[3]的位置是0x100C
- 数组元素的地址=数组首地址+ sizeof(元素类型)*索引值

数组

- 数组a是局部
- 变量，数组b是全局变量

```
int b[5] = {123,87,487,7,978};
void main()
{
   int i;
   int a[5];

   for(i = 0; i<5; i++)
   {
      a[i] = i;
      b[i] = i;
   }
}
```

数组

```
00401006          mov     [ebp+var_18], 0
0040100D          jmp     short loc_401018
0040100F loc_40100F:
0040100F          mov     eax, [ebp+var_18]
00401012          add     eax, 1
00401015          mov     [ebp+var_18], eax
00401018 loc_401018:
00401018          cmp     [ebp+var_18], 5
0040101C          jge     short loc_401037
0040101E          mov     ecx, [ebp+var_18]
00401021          mov     edx, [ebp+var_18]
00401024          mov     [ebp+ecx*4+var_14], edx ❶
00401028          mov     eax, [ebp+var_18]
0040102B          mov     ecx, [ebp+var_18]
0040102E          mov     dword_40A000[ecx*4], eax ❷
00401035          jmp     short loc_40100F
```

结构体

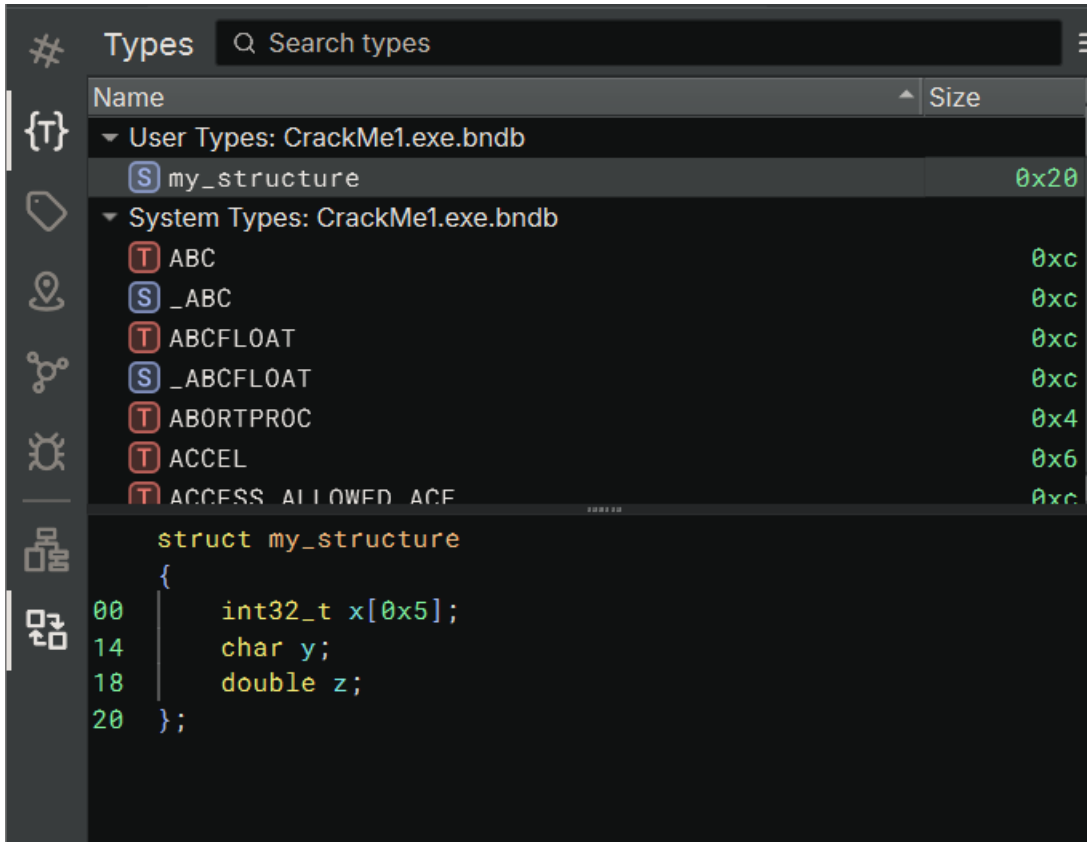
- 在c语言中，结构体(struct)是一种数据结构，可以将不同类型的数据结构组合到一个复合的数据类型中

结构体

```
struct my_structure { ❶
      int x[5];
      char y;
      double z;
};

struct my_structure *gms; ❷

void test(struct my_structure *q)
{
      int i;
      q->y = 'a';
      q->z = 15.6;
      for(i = 0; i<5; i++){
            q->x[i] = i;
      }
}

void main()
{
      gms = (struct my_structure *) malloc(
      sizeof(struct my_structure));
      test(gms);
}
```

```
00401000          push    ebp
00401001          mov     ebp, esp
00401003          push    ecx
00401004          mov     eax,[ebp+arg_0]
00401007          mov     byte ptr [eax+14h], 61h
0040100B          mov     ecx, [ebp+arg_0]
0040100E          fld     ds:dbl_40B120 ❶
00401014          fstp    qword ptr [ecx+18h]
00401017          mov     [ebp+var_4], 0
0040101E          jmp     short loc_401029
00401020 loc_401020:
00401020          mov     edx,[ebp+var_4]
00401023          add     edx, 1
00401026          mov     [ebp+var_4], edx
00401029 loc_401029:
00401029          cmp     [ebp+var_4], 5
0040102D          jge     short loc_40103D
0040102F          mov     eax,[ebp+var_4]
00401032          mov     ecx,[ebp+arg_0]
00401035          mov     edx,[ebp+var_4]
00401038          mov     [ecx+eax*4],edx ❷
0040103B          jmp     short loc_401020
0040103D loc_40103D:
0040103D          mov     esp, ebp
0040103F          pop     ebp
00401040          retn
```

结构体


Types
Search types
Name
Size
User Types: CrackMe1.exe.bndb
my_structure
0x20
System Types: CrackMe1.exe.bndb
ABC
0xc
_ABC
0xc
ABCFLOAT
0xc
_ABCFLOAT
0xc
ABORTPROC
0x4
ACCEL
0x6
struct my_structure
{
00 int32_t x[0x5];
14 char y;
18 double z;
20 };

识别IF分支结构

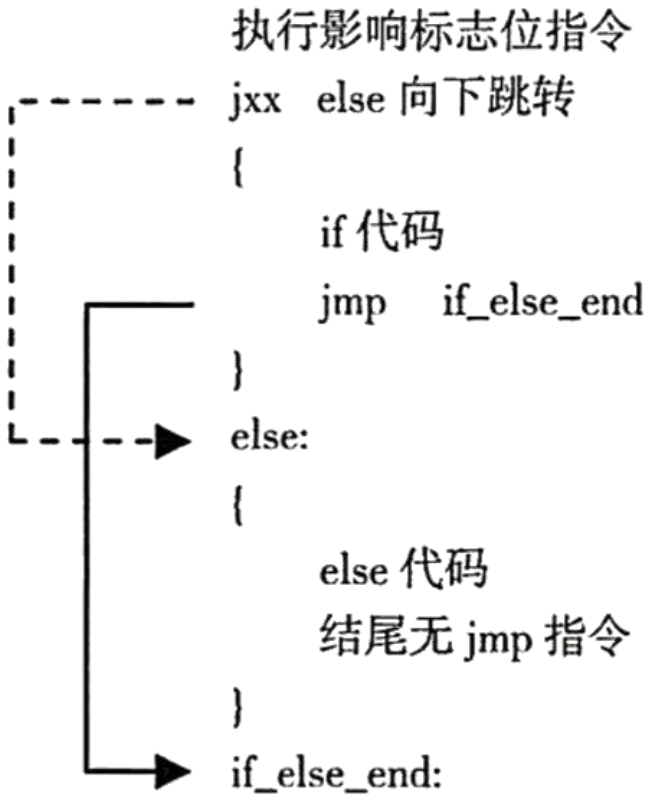
识别IF分支结构

```
int x = 1;
int y = 2;

if(x == y){
      printf("x equals y.\n");
}else{
      printf("x is not equal to y.\n");
}
```

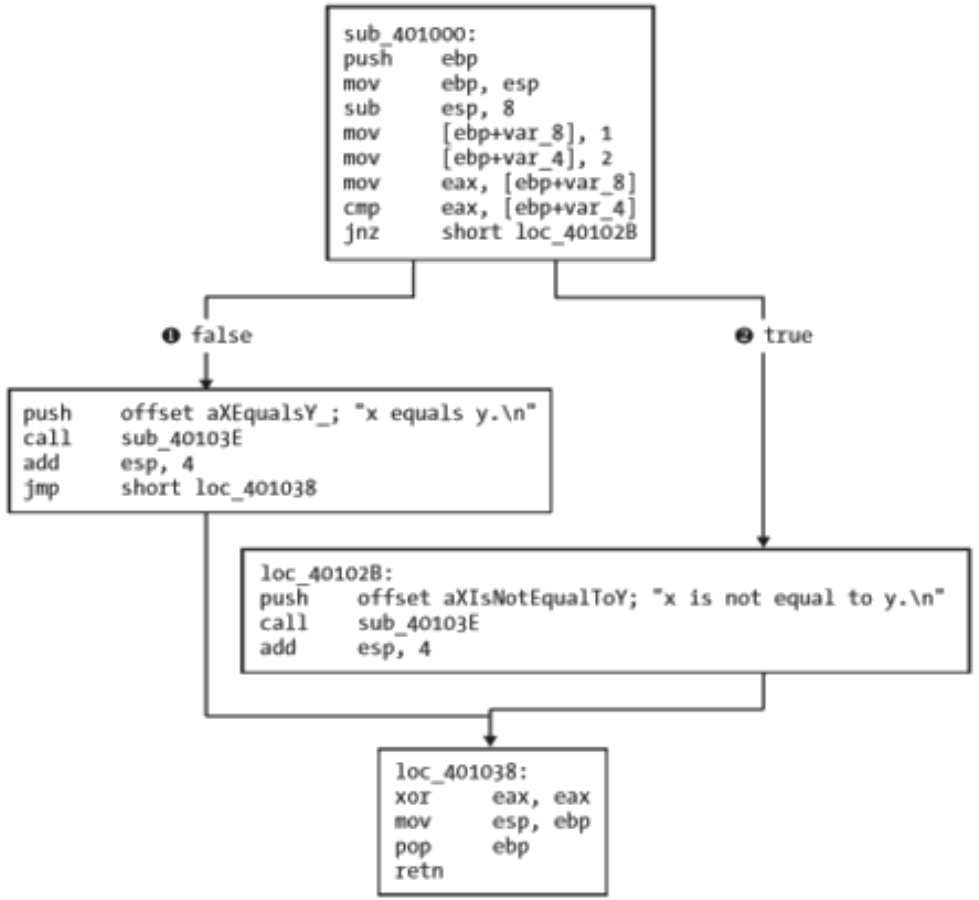
```
00401006          mov     [ebp+var_8], 1
0040100D          mov     [ebp+var_4], 2
00401014          mov     eax, [ebp+var_8]
00401017          cmp     eax, [ebp+var_4] ❶
0040101A          jnz     short loc_40102B ❷
0040101C          push    offset aXEqualsY_ ; "x equals y.\n"
00401021          call    printf
00401026          add     esp, 4
00401029          jmp     short loc_401038 ❸
0040102B loc_40102B:
0040102B          push    offset aXIsNotEqualToY ; "x is not equal to y.\n"
00401030          call    printf
```

识别IF分支结构

- IF语句的识别特征，jxx的跳转和一个无条件jmp指令



识别IF分支结构

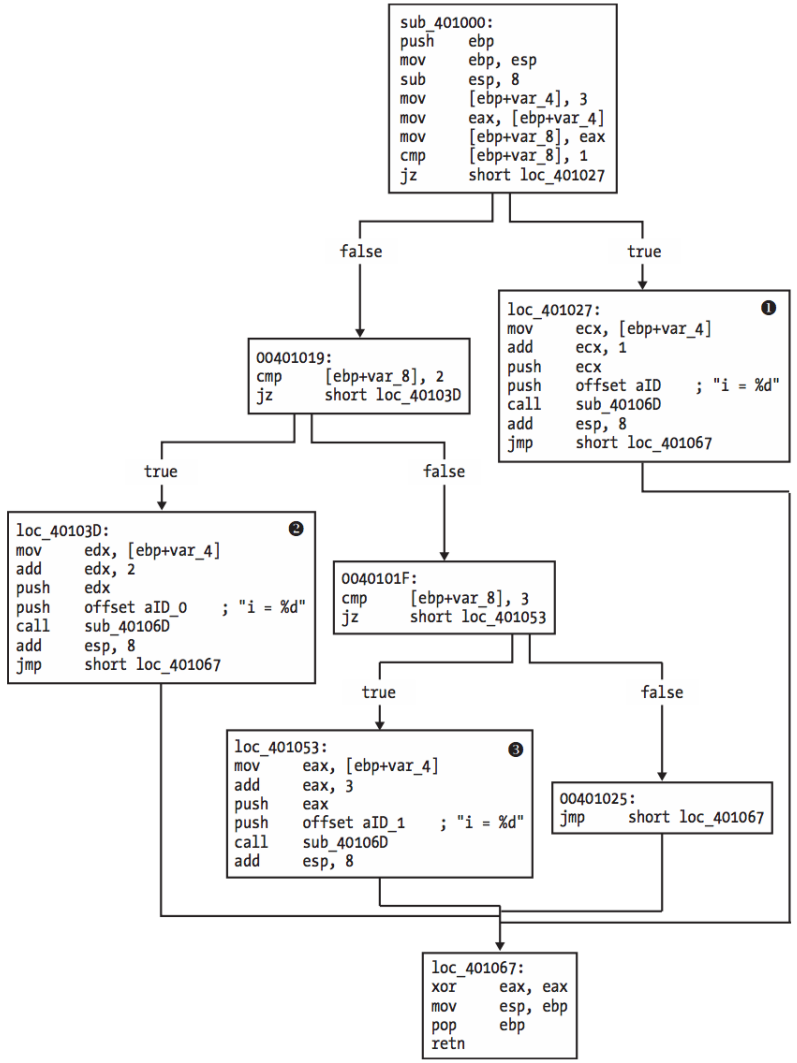

sub_401000:
push ebp
mov ebp, esp
sub esp, 8
mov [ebp+var_8], 1
mov [ebp+var_4], 2
mov eax, [ebp+var_8]
cmp eax, [ebp+var_4]
jnz short loc_40102B
❶ false
❷ true
push offset aXEqualsY_; "x equals y.\n"
call sub_40103E
add esp, 4
jmp short loc_401038
loc_40102B:
push offset aXIsNotEqualToY; "x is not equal to y.\n"
call sub_40103E
add esp, 4
loc_401038:
xor eax, eax
mov esp, ebp
pop ebp
retn

识别Switch结构

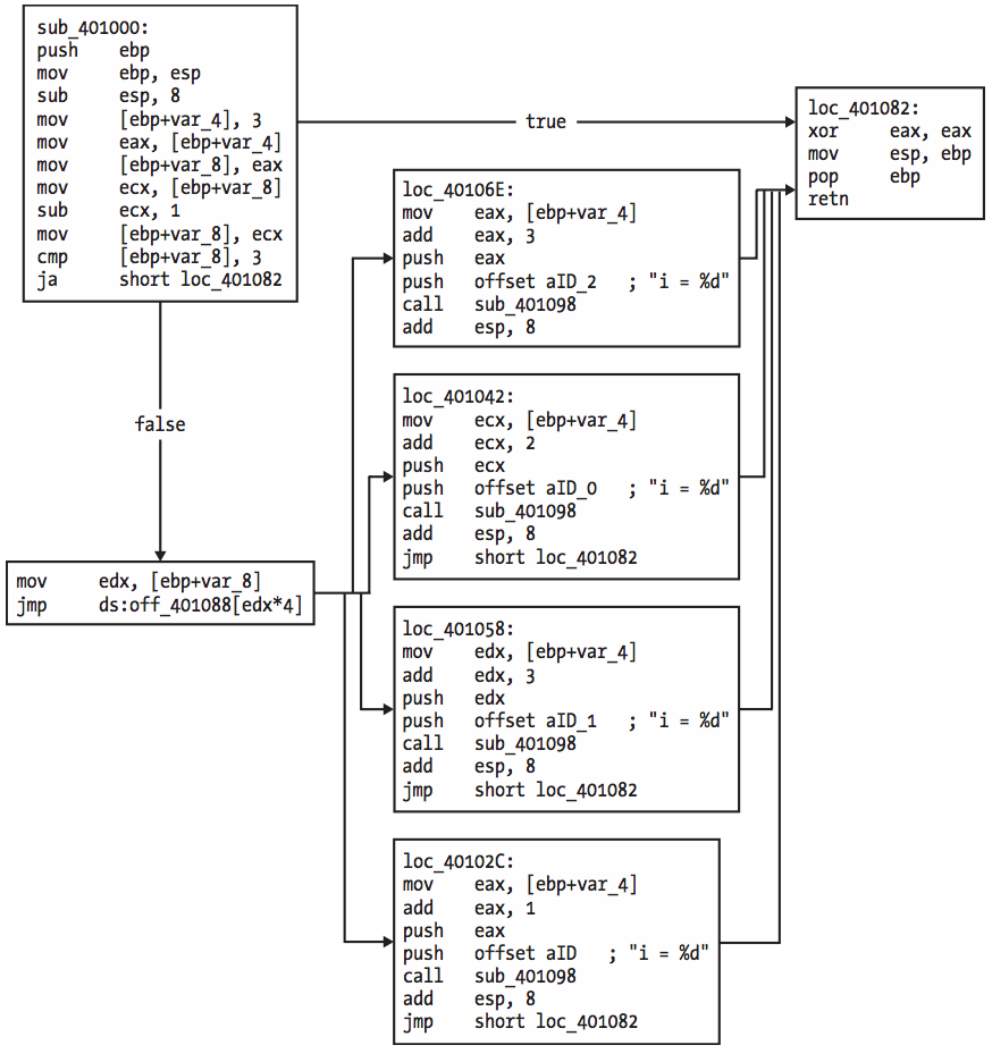
识别Switch结构

- Switch结构用来实现基于字符或者整数的决策。
- Switch结构通常以两种方式被编译
  - 使用IF方式
  - 使用跳转表

识别Switch结构


sub_401000:
push ebp
mov ebp, esp
sub esp, 8
mov [ebp+var_4], 3
mov eax, [ebp+var_4]
mov [ebp+var_8], eax
cmp [ebp+var_8], 1
jz short loc_401027
false
true
loc_401027:
mov ecx, [ebp+var_4]
add ecx, 1
push ecx
push offset aID ; "i = %d"
call sub_40106D
add esp, 8
jmp short loc_401067
00401019:
cmp [ebp+var_8], 2
jz short loc_40103D
true
false
loc_40103D:
mov edx, [ebp+var_4]
add edx, 2
push edx
push offset aID_0 ; "i = %d"
call sub_40106D
add esp, 8
jmp short loc_401067
0040101F:
cmp [ebp+var_8], 3
jz short loc_401053
true
false
loc_401053:
mov eax, [ebp+var_4]
add eax, 3
push eax
push offset aID_1 ; "i = %d"
call sub_40106D
add esp, 8
00401025:
jmp short loc_401067
loc_401067:
xor eax, eax
mov esp, ebp
pop ebp
retn

跳转表


sub_401000:
push ebp
mov ebp, esp
sub esp, 8
mov [ebp+var_4], 3
mov eax, [ebp+var_4]
mov [ebp+var_8], eax
mov ecx, [ebp+var_8]
sub ecx, 1
mov [ebp+var_8], ecx
cmp [ebp+var_8], 3
ja short loc_401082
true
false
mov edx, [ebp+var_8]
jmp ds:off_401088[edx*4]
loc_401082:
xor eax, eax
mov esp, ebp
pop ebp
retn
loc_40106E:
mov eax, [ebp+var_4]
add eax, 3
push eax
push offset aID_2 ; "i = %d"
call sub_401098
add esp, 8
loc_401042:
mov ecx, [ebp+var_4]
add ecx, 2
push ecx
push offset aID_0 ; "i = %d"
call sub_401098
add esp, 8
jmp short loc_401082
loc_401058:
mov edx, [ebp+var_4]
add edx, 3
push edx
push offset aID_1 ; "i = %d"
call sub_401098
add esp, 8
jmp short loc_401082
loc_40102C:
mov eax, [ebp+var_4]
add eax, 1
push eax
push offset aID ; "i = %d"
call sub_401098
add esp, 8
jmp short loc_401082

识别循环

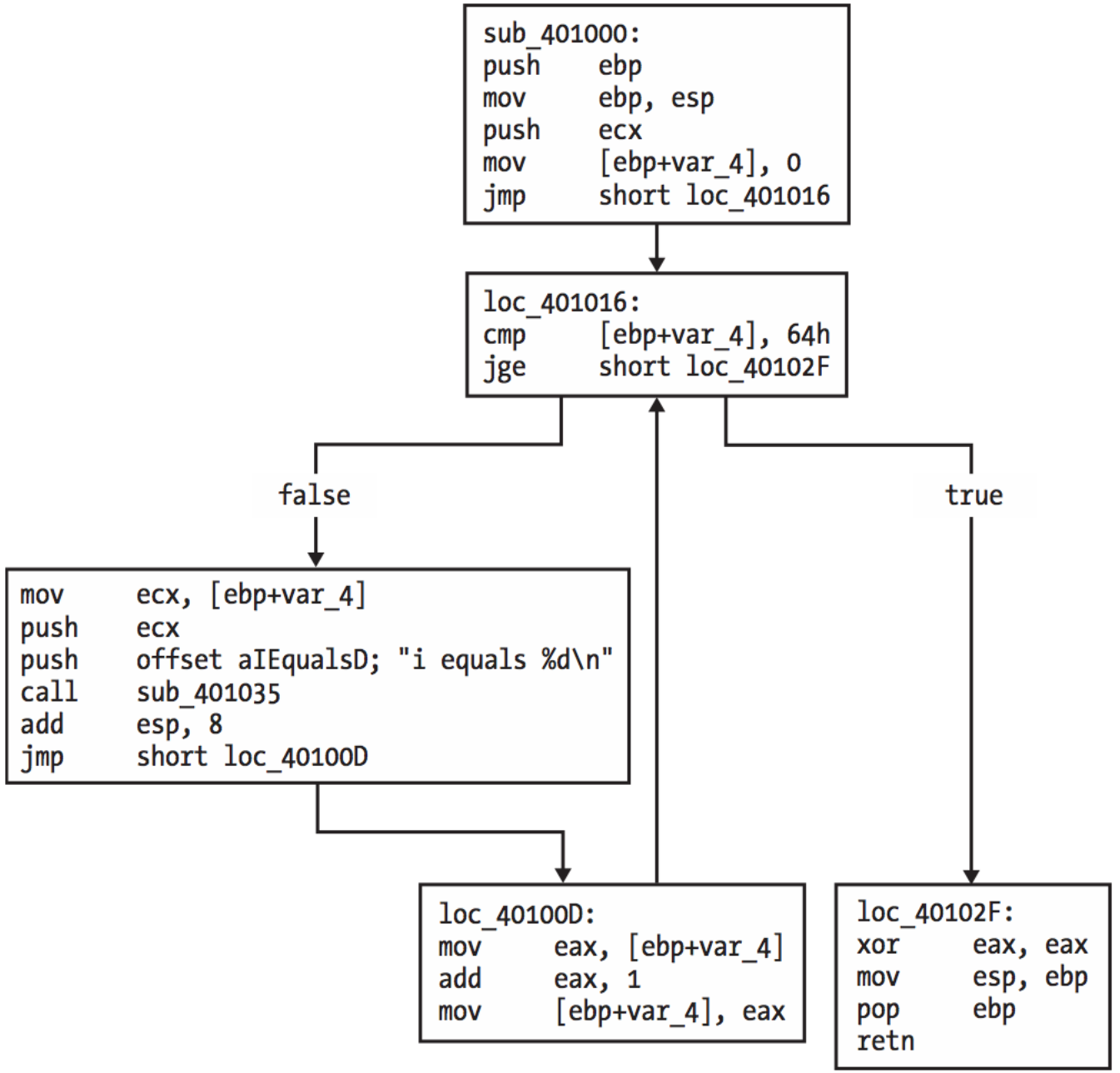
识别循环

- FOR循环是一个C/C++编程使用的基本循环机制。
- FOR循环有4个组件：
  - 初始化
  - 比较
  - 指令执行体
  - 递增或递减

识别循环

```
int i;

for(i=0; i<100; i++)
{
   printf("i equals %d\n", i);
}
```

```
00401004          mov     [ebp+var_4], 0 ❶
0040100B          jmp     short loc_401016 ❷
0040100D loc_40100D:
0040100D          mov     eax, [ebp+var_4] ❸
00401010          add     eax, 1
00401013          mov     [ebp+var_4], eax ❹
00401016 loc_401016:
00401016          cmp     [ebp+var_4], 64h ❺
0040101A          jge     short loc_40102F ❻
0040101C          mov     ecx, [ebp+var_4]
0040101F          push    ecx
00401020          push    offset aID  ; "i equals %d\n"
00401025          call    printf
0040102A          add     esp, 8
0040102D          jmp     short loc_40100D ❼
```



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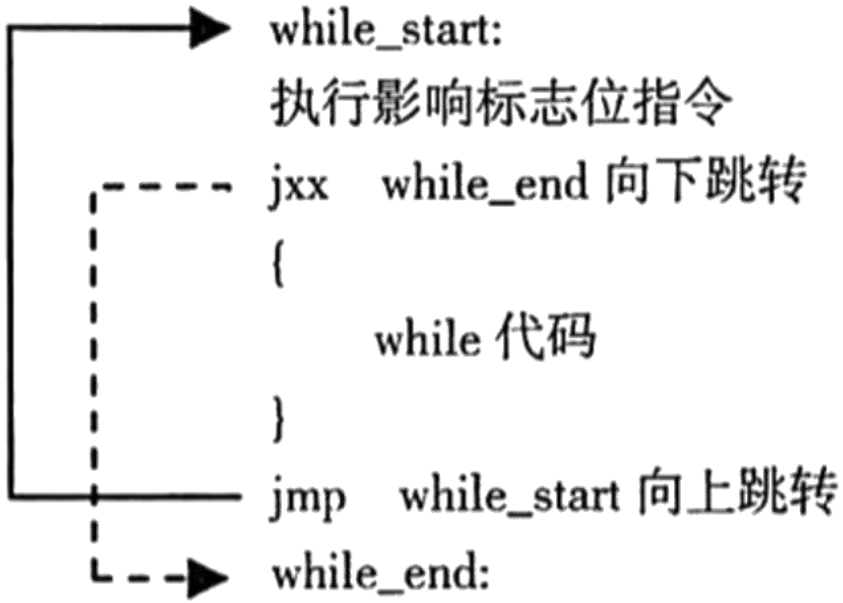
While循环

```
int status=0;
int result = 0;

while(status == 0){
     result = performAction();
     status = checkResult(result);
}
```

```
00401036          mov     [ebp+var_4], 0
0040103D          mov     [ebp+var_8], 0
00401044 loc_401044:
00401044          cmp     [ebp+var_4], 0
00401048          jnz     short loc_401063 ❶
0040104A          call    performAction
0040104F          mov     [ebp+var_8], eax
00401052          mov     eax, [ebp+var_8]
00401055          push    eax
00401056          call    checkResult
0040105B          add     esp, 4
0040105E          mov     [ebp+var_4], eax
00401061          jmp     short loc_401044 ❷
```

While循环的识别特征



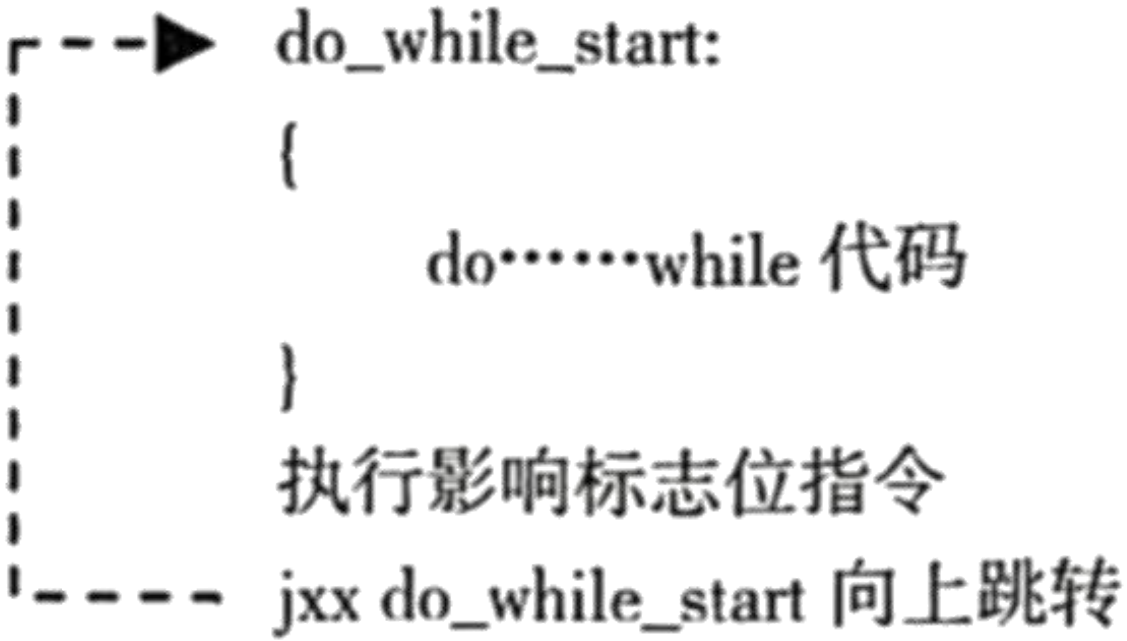
Do循环

```
#include "stdafx.h"

int _tmain(int argc, _TCHAR* argv[]) {
    int nCount = 0;
    do
    {
        printf("%d\r\n", nCount);
        nCount++;
    } while (nCount < argc);

    return 0;
}
```

Do循环

```
mov     edx, [rsp+20h]          ;参数 2: edx=nCount
lea     rcx, asc_14000678C      ;参数 1: "%d\r\n"
call    cs:printf               ;调用 printf 函数
mov     eax, [rsp+20h]
inc     eax
mov     [rsp+20h], eax          ;nCount=nCount+1
mov     eax, [rsp+40h]          ;eax=argc
cmp     [rsp+20h], eax
jl      short loc_140001039 ;if(nCount<argc)，跳转到 do 循环开始
```

Do循环的识别特征



本章知识点

1. 识别函数

   难点：参数、局部变量、栈指针、函数调用约定

2. 识别变量、数组、结构体

3. 识别IF分支结构

4. 识别Switch结构

5. 识别循环结构

汇编语言与逆向技术

第11章 C语言程序逆向分析

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