二进制文件补丁技术 实验手册

一、实验目的

掌握二进制文件补丁技术的原理及常用方法，能够根据需要对存在漏洞的二进制程序进行修补。

二、实验内容

1、简单修改二进制文件实现漏洞修补；

2、插入补丁代码实现漏洞修补

3、利用 LIEF 库实现漏洞修补

三、简单修改二进制文件实现漏洞修补

1、格式化字符串漏洞 print_with_puts

漏洞源码，注意划线处：

```c
#include<stdio.h>

int main() {
        puts("test1");
        char s[20];
        scanf("%s", s);
        printf(s);
        return 0;
}
```

编译：

```
root@DESKTOP-HUI9I31:/# gcc print_with_puts.c -o print_with_puts
```

漏洞验证：

```
root@DESKTOP-HUI9I31:/# ./print_with_puts
test1
%s%s%s%s%s%s%s%s%s%s%s
段错误 (核心已转储)
```

在只有二进制文件而没有源代码的情况下，用 IDA 进行反编译，注意划线处：

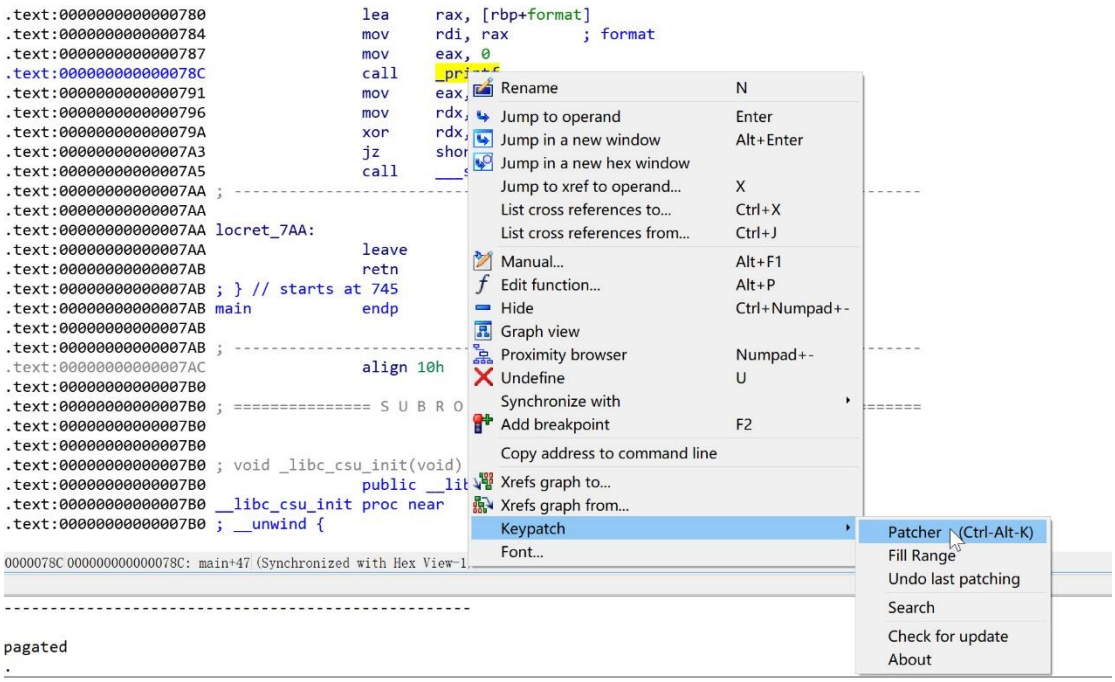
```
.text:0000000000000745                push    rbp
.text:0000000000000746                mov     rbp, rsp
.text:0000000000000749                sub     rsp, 20h
.text:000000000000074D                mov     rax, fs:28h
.text:0000000000000756                mov     [rbp+var_8], rax
.text:000000000000075A                xor     eax, eax
.text:000000000000075C                lea     rdi, s          ; "test1"
.text:0000000000000763                call    _puts
.text:0000000000000768                lea     rax, [rbp+format]
.text:000000000000076C                mov     rsi, rax
.text:000000000000076F                lea     rdi, aS         ; "%s"
.text:0000000000000776                mov     eax, 0
.text:000000000000077B                call    ___isoc99_scanf
.text:0000000000000780                lea     rax, [rbp+format]
.text:0000000000000784                mov     rdi, rax        ; format
.text:0000000000000787                mov     eax, 0
.text:000000000000078C                call    _printf
.text:0000000000000791                mov     eax, 0
.text:0000000000000796                mov     rdx, [rbp+var_8]
```

观察到该程序中存在 puts 函数，且调用 puts 函数与调用 printf 函数的指令均为五个字节，想到可以将 call _printf 简单修改为 call _puts，方法如下：

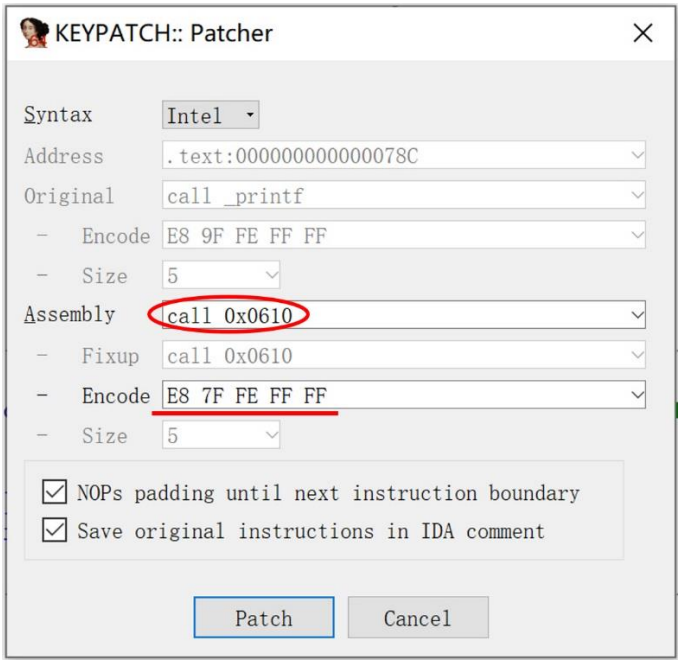
(1)查看 puts 函数的地址：结果为 0x0610

```
.plt:0000000000000610 _puts           proc near               ; CODE XREF: main+1E↓p
.plt:0000000000000610                 jmp     cs:puts_ptr
.plt:0000000000000610 _puts           endp
```

(2)选中调用 printf 指令的语句，通过鼠标右键或 Ctrl+Alt+K 快捷键调用 IDA 插件 Keypatch：



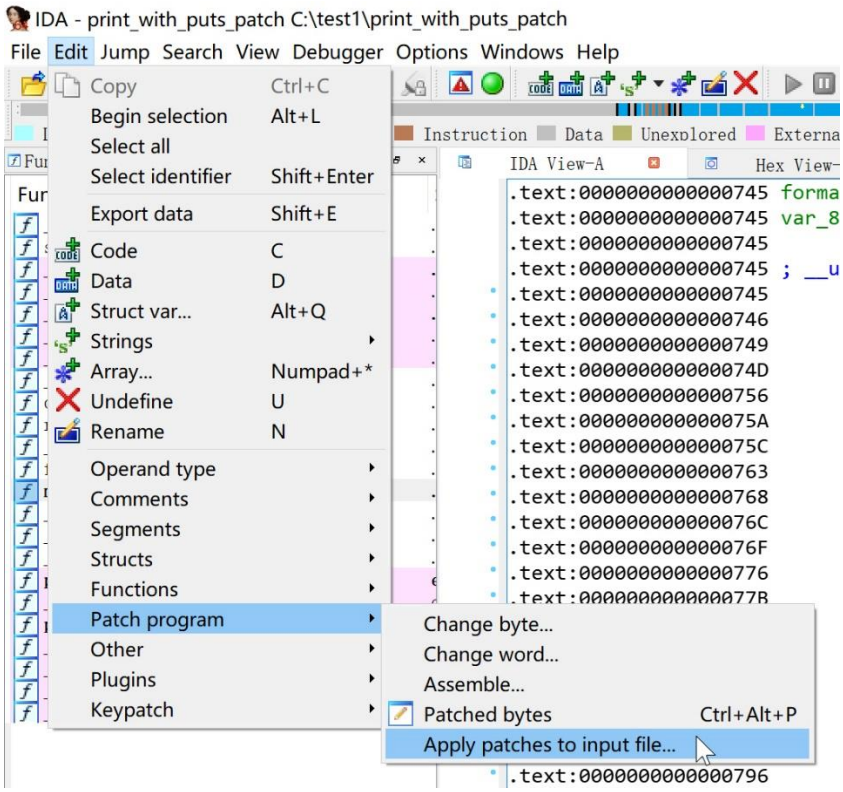
(3)将调用 printf 函数的语句修改为调用 puts 函数的语句，注意，由于 Keypatch 不能识别符号地址跳转,因此修改时不能使用 call _puts 这样的语句，而应该直接给定跳转地址，这也是第(1)步中必须准备好 puts 函数地址的原因：



Keypatch 修改后的结果为：

```
.text:000000000000075A                xor     eax, eax
.text:000000000000075C                lea     rdi, s          ; "test1"
.text:0000000000000763                call    _puts
.text:0000000000000768                lea     rax, [rbp+format]
.text:000000000000076C                mov     rsi, rax
.text:000000000000076F                lea     rdi, aS         ; "%s"
.text:0000000000000776                mov     eax, 0
.text:000000000000077B                call    ___isoc99_scanf
.text:0000000000000780                lea     rax, [rbp+format]
.text:0000000000000784                mov     rdi, rax        ; s
.text:0000000000000787                mov     eax, 0
.text:000000000000078C                call    _puts           ; Keypatch modified this from:
.text:000000000000078C                                        ;   call _printf
.text:0000000000000791                mov     eax, 0
.text:0000000000000796                mov     rdx, [rbp+var_8]
```

(4)通过 IDA 将 Keypatch 的修改结果保存到二进制文件：



补丁验证：

```
root@DESKTOP-HUI9I31:/# ./print_with_puts_patch
test1
%s%s%s%s%s%s%s%s%s%s%s%s
%s%s%s%s%s%s%s%s%s%s%s%s
```

四、在.eh_frame 段插入补丁代码实现漏洞修补

1、格式化字符串漏洞 print_with_printf

漏洞源码，注意划线处：

```c
#include <stdio.h>

int main() {
        printf("test2.1");
        char s[10];
        scanf("%s", s);
        printf(s);
        return 0;
}
```

编译：

```
root@DESKTOP-HUI9I31:/# gcc print_with_printf.c -o print_with_printf
```

漏洞验证：

```
%proot@DESKTOP-HUI9I31:/# ./print_with_printf
test2.1%p
0xaroot@DESKTOP-HUI9I31:/#
root@DESKTOP-HUI9I31:/#
```

与实验一类似，用 IDA 进行反编译，注意划线处：

```
.text:000000000000071A                  push    rbp
.text:000000000000071B                  mov     rbp, rsp
.text:000000000000071E                  sub     rsp, 20h
.text:0000000000000722                  mov     rax, fs:28h
.text:000000000000072B                  mov     [rbp+var_8], rax
.text:000000000000072F                  xor     eax, eax
.text:0000000000000731                  lea     rdi, format     ; "test2.1"
.text:0000000000000738                  mov     eax, 0
.text:000000000000073D                  call    _printf
.text:0000000000000742                  lea     rax, [rbp+format]
.text:0000000000000746                  mov     rsi, rax
.text:0000000000000749                  lea     rdi, aS         ; "%s"
.text:0000000000000750                  mov     eax, 0
.text:0000000000000755                  call    ___isoc99_scanf
.text:000000000000075A                  lea     rax, [rbp+format]
.text:000000000000075E                  mov     rdi, rax        ; format
.text:0000000000000761                  mov     eax, 0
.text:0000000000000766                  call    _printf
.text:000000000000076B                  mov     eax, 0
.text:0000000000000770                  mov     rdx, [rbp+var_8]
```

与实验一不同，该程序中不存在 puts 函数，因此实验一中的漏洞修补方法不能用于该程序。观察到程序调用 scanf 函数时参数引用正确，不存在格式化字符串漏洞，想到可以修改存在漏洞的 printf 函数调用，修改后的函数调用可以写入程序的.eh_frame 段，方法如下：

(1)模仿 scanf 函数的调用写出补丁代码：

```
mov     rsi, rdi
lea     rdi, "%s"
call    _printf
```

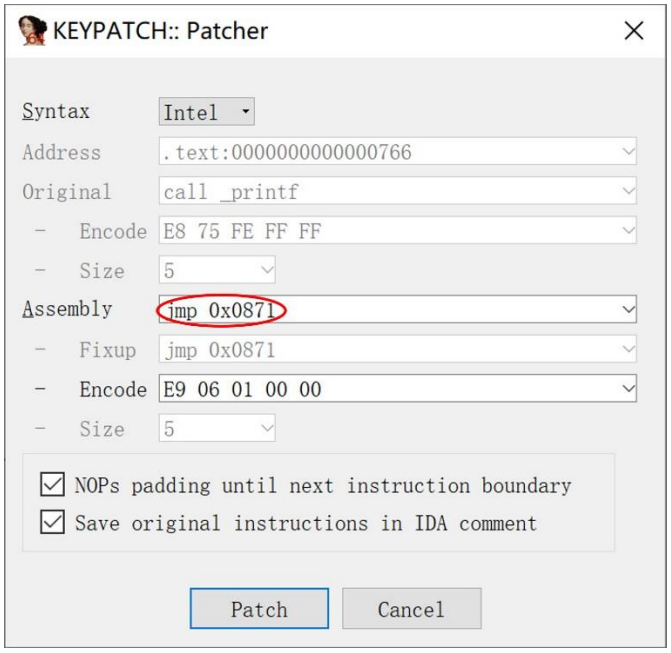
(2)查看 printf 函数的地址：结果为 0x05E0

```
.plt:00000000000005E0 _printf         proc near               ; CODE XREF: main+23↓p
.plt:00000000000005E0                                         ; main+4C↓p
.plt:00000000000005E0                 jmp     cs:printf_ptr
.plt:00000000000005E0 _printf         endp
```

(3)查看程序的.eh_frame 段，寻找可以写入补丁代码的空间：假设选择 0x0871 到 0x088F 作为存放补丁代码的空间

```
.eh_frame:0000000000000870                db  1Bh
.eh_frame:0000000000000871                db  0Ch
.eh_frame:0000000000000872                db    7
.eh_frame:0000000000000873                db    8
.eh_frame:0000000000000874                db  90h
.eh_frame:0000000000000875                db    1
.eh_frame:0000000000000876                db    7
.eh_frame:0000000000000877                db  10h
.eh_frame:0000000000000878                db  14h
.eh_frame:0000000000000879                db    0
.eh_frame:000000000000087A                db    0
.eh_frame:000000000000087B                db    0
.eh_frame:000000000000087C                db  1Ch
.eh_frame:000000000000087D                db    0
.eh_frame:000000000000087E                db    0
.eh_frame:000000000000087F                db    0
.eh_frame:0000000000000880                db  90h
.eh_frame:0000000000000881                db 0FDh
.eh_frame:0000000000000882                db 0FFh
.eh_frame:0000000000000883                db 0FFh
.eh_frame:0000000000000884                db  2Bh ; +
.eh_frame:0000000000000885                db    0
.eh_frame:0000000000000886                db    0
.eh_frame:0000000000000887                db    0
.eh_frame:0000000000000888                db    0
.eh_frame:0000000000000889                db    0
.eh_frame:000000000000088A                db    0
.eh_frame:000000000000088B                db    0
.eh_frame:000000000000088C                db    0
.eh_frame:000000000000088D                db    0
.eh_frame:000000000000088E                db    0
.eh_frame:000000000000088F                db    0
.eh_frame:0000000000000890                db  14h
```

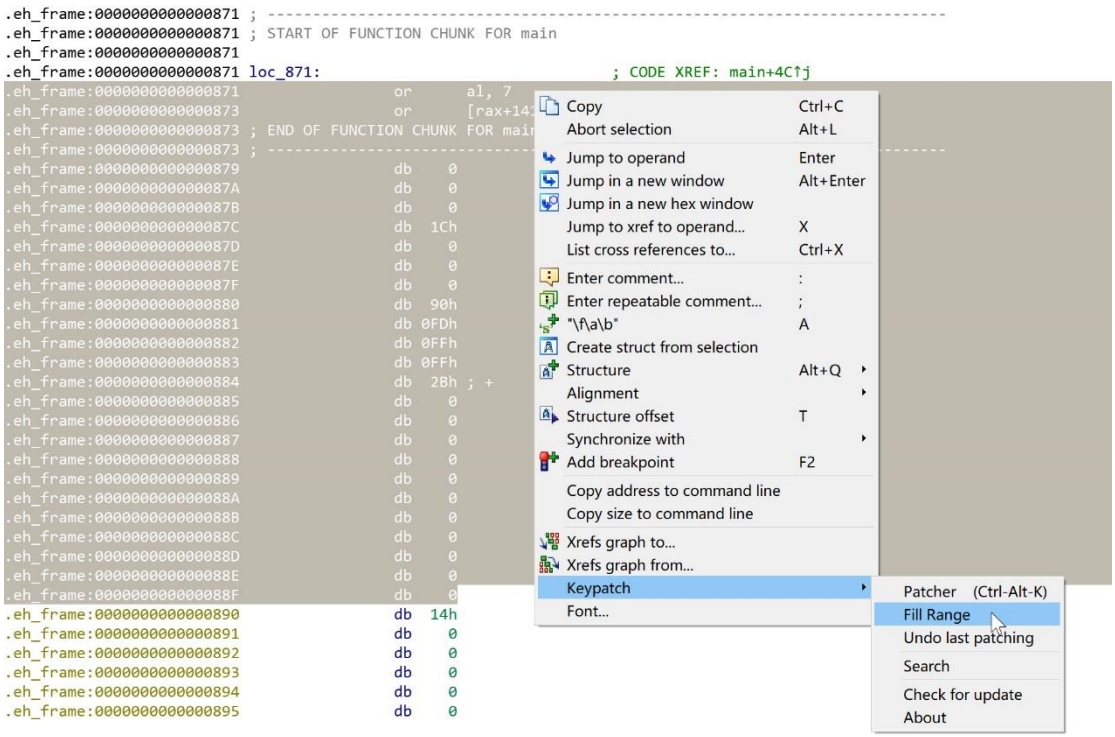
(4)将存在漏洞的 printf 函数调用语句修改为跳转语句，跳转到.eh_frame 段的补丁代码处执行，并查看其下一条语句的地址：



Keypatch 修改后的结果为：

```
.text:000000000000072F                xor     eax, eax
.text:0000000000000731                lea     rdi, format     ; "test2.1"
.text:0000000000000738                mov     eax, 0
.text:000000000000073D                call    _printf
.text:0000000000000742                lea     rax, [rbp+format]
.text:0000000000000746                mov     rsi, rax
.text:0000000000000749                lea     rdi, aS         ; "%s"
.text:0000000000000750                mov     eax, 0
.text:0000000000000755                call    ___isoc99_scanf
.text:000000000000075A                lea     rax, [rbp+format]
.text:000000000000075E                mov     rdi, rax        ; format
.text:0000000000000761                mov     eax, 0
.text:0000000000000766                jmp     loc_871         ; Keypatch modified this from:
.text:0000000000000766                                        ;   call _printf
.text:000000000000076B ; ---------------------------------------------------------------------------
.text:000000000000076B                mov     eax, 0
.text:0000000000000770                mov     rdx, [rbp+var_8]
```

(5)根据前面查看的 printf 函数地址和下一条语句地址修改补丁代码，并将补丁代码写入.eh_frame 段：



Keypatch 修改后的结果为：

```
.eh_frame:0000000000000871
.eh_frame:0000000000000871 loc_871:                            ; CODE XREF: main+4C↑j
.eh_frame:0000000000000871                 mov     rsi, rdi    ; Keypatch filled range [0x871:0x88E] (30 bytes), replaced:
.eh_frame:0000000000000871                                     ;   or al, 7
.eh_frame:0000000000000871                                     ;   db 8
.eh_frame:0000000000000871                                     ;   nop
.eh_frame:0000000000000871                                     ;   add [rdi], eax
.eh_frame:0000000000000871                                     ;   adc [rax+rax], dl
.eh_frame:0000000000000871                                     ;   db 0
.eh_frame:0000000000000871                                     ;   add [rax+rax], bl
.eh_frame:0000000000000871                                     ;   db 0
.eh_frame:0000000000000871                                     ;   db 0
.eh_frame:0000000000000871                                     ;   nop
.eh_frame:0000000000000871                                     ;   std
.eh_frame:0000000000000871                                     ;   db 0FFh
.eh_frame:0000000000000871                                     ;   db 0FFh
.eh_frame:0000000000000871                                     ;   db 2Bh
.eh_frame:0000000000000871                                     ;   db 0
.eh_frame:0000000000000871                                     ;   db 0
.eh_frame:0000000000000871                                     ;   db 0
.eh_frame:0000000000000871                                     ;   db 0
.eh_frame:0000000000000871                                     ;   db 0
.eh_frame:0000000000000871                                     ;   db 0
.eh_frame:0000000000000871                                     ;   db 0
.eh_frame:0000000000000871                                     ;   db 0
.eh_frame:0000000000000871                                     ;   db 0
.eh_frame:0000000000000871                                     ;   db 0
.eh_frame:0000000000000874                 lea     rdi, aS     ; "%s"
.eh_frame:000000000000087B                 call    _printf
.eh_frame:000000000000087B ; END OF FUNCTION CHUNK FOR main
.eh_frame:0000000000000880                 jmp     loc_76B
.eh_frame:0000000000000880 ; ---------------------------------------------------------------------------
.eh_frame:0000000000000885                 db  90h
.eh_frame:0000000000000886                 db  90h
.eh_frame:0000000000000887                 db  90h
.eh_frame:0000000000000888                 db  90h
.eh_frame:0000000000000889                 db  90h
.eh_frame:000000000000088A                 db  90h
```

(6)与实验一类似地，通过 IDA 将 Keypatch 的修改结果保存到二进制文件即可。

补丁验证：

```
root@DESKTOP-HUI9I31:/# ./print_with_printf_patch
test2.1%p
%proot@DESKTOP-HUI9I31:/#
root@DESKTOP-HUI9I31:/#
```

2、释放重引用漏洞 use_after_free

漏洞源码，注意划线处：

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

typedef struct obj {
        char *name;
        void (*func)(char *str);
} OBJ;

void obj_func(char *str) {
        printf("%s\n", str);
}

void fake_obj_func() {
        printf("This is a fake obj_func which means uaf vul.\n");
}

int main() {
        OBJ *obj_1;
        obj_1 = (OBJ *)malloc(sizeof(struct obj));
        obj_1->name = "obj_name";
        obj_1->func = obj_func;
        obj_1->func("This is an object.");
        free(obj_1);
        printf("The objcet has been freed, use it again will lead crash.\n");
        obj_1->func("But it seems that...");
        obj_1->func = fake_obj_func;
        obj_1->func("Try again.\n");
}
```

编译：

```
root@DESKTOP-HUI9I31:/# gcc use_after_free.c -o use_after_free
```

漏洞验证：

```
root@DESKTOP-HUI9I31:/# ./use_after_free
This is an object.
The objcet has been freed, use it again will lead crash.
But it seems that...
This is a fake obj_func which means uaf vul.
root@DESKTOP-HUI9I31:/#
```

用 IDA 进行反编译，注意划线处：

```
.text:00000000000006F8                push    rbp
.text:00000000000006F9                mov     rbp, rsp
.text:00000000000006FC                sub     rsp, 10h
.text:0000000000000700                mov     edi, 10h        ; size
.text:0000000000000705                call    _malloc
.text:000000000000070A                mov     [rbp+ptr], rax
.text:000000000000070E                mov     rax, [rbp+ptr]
.text:0000000000000712                lea     rdx, aObjName   ; "obj_name"
.text:0000000000000719                mov     [rax], rdx
.text:000000000000071C                mov     rax, [rbp+ptr]
.text:0000000000000720                lea     rdx, obj_func
.text:0000000000000727                mov     [rax+8], rdx
.text:000000000000072B                mov     rax, [rbp+ptr]
.text:000000000000072F                mov     rax, [rax+8]
.text:0000000000000733                lea     rdi, aThisIsAnObject ; "This is an object."
.text:000000000000073A                call    rax
.text:000000000000073C                mov     rax, [rbp+ptr]
.text:0000000000000740                mov     rdi, rax        ; ptr
.text:0000000000000743                call    _free
.text:0000000000000748                lea     rdi, aTheObjcetHasBe ; "The objcet has been freed, use it again"...
.text:000000000000074F                call    _puts
.text:0000000000000754                mov     rax, [rbp+ptr]
.text:0000000000000758                mov     rax, [rax+8]
.text:000000000000075C                lea     rdi, aButItSeemsThat ; "But it seems that..."
.text:0000000000000763                call    rax
.text:0000000000000765                mov     rax, [rbp+ptr]
.text:0000000000000769                lea     rdx, fake_obj_func
.text:0000000000000770                mov     [rax+8], rdx
.text:0000000000000774                mov     rax, [rbp+ptr]
.text:0000000000000778                mov     rax, [rax+8]
.text:000000000000077C                lea     rdi, aTryAgain  ; "Try again.\n"
.text:0000000000000783                call    rax
.text:0000000000000785                mov     eax, 0
```

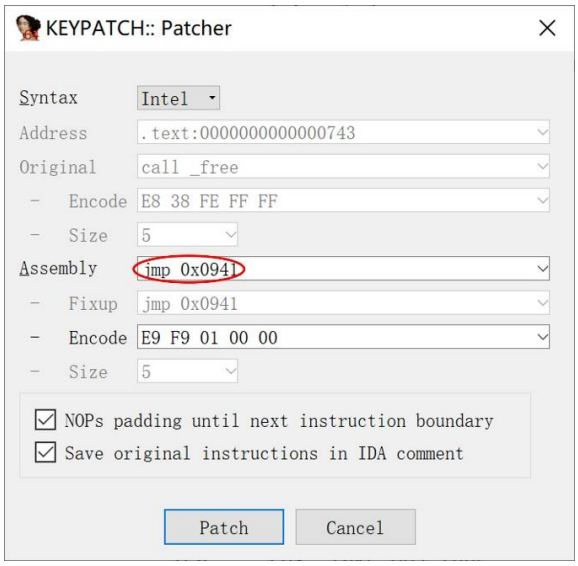
考虑 UAF 漏洞的成因，主要是调用 free 函数释放对象时，没有将指向该对象的指针置为 0，导致产生可被恶意调用的悬垂指针。修补时只需要在调用 free 函数的同时将对象指针置为 0 即可，补丁代码可以写入程序的.eh_frame 段，方法如下：

(1)查看 free 函数的地址：结果为 0x0580

```
.plt:0000000000000580 _free           proc near               ; CODE XREF: main+4B↓p
.plt:0000000000000580                 jmp     cs:free_ptr
.plt:0000000000000580 _free           endp
```

(2)查看程序的.eh_frame 段，寻找可以写入补丁代码的空间：假设选择 0x0941 到 0x0960 作为存放补丁代码的空间

(3)将 free 函数调用语句修改为跳转语句，跳转到.eh_frame 段中补丁所在处，并查看其下一条语句的地址：



Keypatch 修改后的结果为：

```
.text:0000000000000733                lea     rdi, aThisIsAnObject ; "This is an object."
.text:000000000000073A                call    rax
.text:000000000000073C                mov     rax, [rbp+ptr]
.text:0000000000000740                mov     rdi, rax        ; ptr
.text:0000000000000743                jmp     near ptr unk_941 ; Keypatch modified this from:
.text:0000000000000743                                        ;   call _free
.text:0000000000000748 ; ---------------------------------------------------------------------------
.text:0000000000000748                lea     rdi, aTheObjcetHasBe ; "The objcet has been freed, use it again"...
```

(4)根据前面查看的 free 函数地址和下一条语句地址写出补丁代码，并将其写入.eh_frame 段，修改后的结果为：

```
.eh_frame:0000000000000941 loc_941:                                ; CODE XREF: main+4B↑j
.eh_frame:0000000000000941                mov     [rbp+ptr], 0
.eh_frame:0000000000000949                call    _free
.eh_frame:000000000000094E                jmp     loc_748
.eh_frame:000000000000094E ; END OF FUNCTION CHUNK FOR main
.eh_frame:000000000000094E ; ---------------------------------------------------------------------------
.eh_frame:0000000000000953                db  90h
.eh_frame:0000000000000954                db  90h
.eh_frame:0000000000000955                db  90h
.eh_frame:0000000000000956                db  90h
.eh_frame:0000000000000957                db  90h
.eh_frame:0000000000000958                db  90h
.eh_frame:0000000000000959                db  90h
.eh_frame:000000000000095A                db  90h
.eh_frame:000000000000095B                db  90h
.eh_frame:000000000000095C                db  90h
.eh_frame:000000000000095D                db  90h
.eh_frame:000000000000095E                db  90h
.eh_frame:000000000000095F                db  90h
```

(5)通过 IDA 将 Keypatch 的修改结果保存到二进制文件即可。补丁验证：

```
root@DESKTOP-HUI9I31:/# ./use_after_free_patch
This is an object.
The objcet has been freed, use it again will lead crash.
段错误 (核心已转储)
root@DESKTOP-HUI9I31:/#
```

五、利用 LIEF 库实现漏洞修补

LIEF 是一个开源的跨平台的可执行文件修改工具，它能够解析 ELF、PE 等二进制程序文件，并提供一个用户友好的 API 来将一个二进制程序中的机器码写到另一个二进制程序中，从而方便地实现补丁编写和漏洞修补。LIEF 对外提供了 Python、C++、C 的编程接口，下面以 Python 接口为例来进行实验。

1、使用 LIEF 增加 segment 实现漏洞修补

实验程序的源代码如下：

```c
#include <stdio.h>
#include <stdlib.h>
int main(int argc, char** argv) {
  printf("/bin/sh%d",102);
  puts("let's go\n");
  printf("/bin/sh%d",102);
  puts("let's gogo\n");
  return EXIT_SUCCESS;
}
```

编写一个包含补丁代码的静态函数库，将 printf 函数修改为一个新的“补丁”函数 write(0,”/bin/sh%d”,0x20)：

```
void myprintf(char *a,int b){
        asm(
                "mov %rdi,%rsi\n"
                "mov $0,%rdi\n"
                "mov $0x20,%rdx\n"
                "mov $0x1,%rax\n"
                "syscall\n"
                );
}
void myputs(char *a){
        asm(
                "push $0x41414141\n"
                "push $0x42424242\n"
                "push %rsp\n"
                "pop  %rsi\n"
                "mov $0,%rdi\n"
                "mov $0x20,%rdx\n"
                "mov $0x1,%rax\n"
                "syscall\n"
                "pop %rax\n"
                "pop %rax\n"
                );
}
```

利用 LIEF 提供的 add 参数为二进制文件增加 segment，segment 的内容就是上面的补丁代码：

```
binary    = lief.parse(binary_name)
lib  = lief.parse(lib_name)
segment_add = binary.add(lib.segments[0])
```

修改跳转逻辑，将 call printf 改为 call myprintf，由于 call 指令的寻址方式是相对寻址，即 call addr = EIP + addr，因此需要计算写入的新函数距离要修改指令的偏移，计算方法如下：

```
call xxx=(addr of new segment + offset function ) - (addr of order + 5/*length of call xx*/)
```

由于偏移地址是补码表示的，因此计算时需要对结果异或 0xffffffff，最终的 LIEF 脚本如下：

```
def patch_call(file,where,end,arch = "amd64"):
        print hex(end)
        length = p32((end - (where + 5 )) & 0xffffffff)
        order = '\xe8'+length
        print disasm(order,arch=arch)
        file.patch_address(where,[ord(i) for i in order])
```

执行上面的脚本之后可以看到 patch 成功：

```
int __cdecl main(int argc, const char **argv, const char **envp)
{
  sub_8022F9("/bin/sh%d");
  puts("let's go\n");
  printf("/bin/sh%d", 102LL, argv);
  puts("let's gogo\n");
  return 0;
}
__int64 __fastcall sub_8022F9(const char *buf)
{
  __int64 result; // rax

  result = 1LL;
  __asm { syscall; LINUX - sys_write }
  return result;
}
```

2、使用 LIEF 修改.eh_frame 段实现漏洞修补

section 对象中的 content 属性就是该 section 的内容，因此，要修改程序的.eh_frame 段，写入补丁代码，只需将补丁程序中的.text 段赋值到.eh_frame 段即可。赋值完成后，通过与前面相同的方法修改函数跳转地址，使漏洞程序跳转到.eh_frame 段来执行补丁代码。最终的 LIEF 脚本如下：

```
import lief
from pwn import *

def patch_call(file,srcaddr,dstaddr,arch = "amd64"):
        print hex(dstaddr)
        length = p32((dstaddr - (srcaddr + 5 )) & 0xffffffff)
        order = '\xe8'+length
        print disasm(order,arch=arch)
        file.patch_address(srcaddr,[ord(i) for i in order])

binary = lief.parse("./vulner")
hook = lief.parse('./hook')

# write hook's .text content to binary's .eh_frame content
sec_ehrame = binary.get_section('.eh_frame')
print sec_ehrame.content
sec_text = hook.get_section('.text')
print sec_text.content
sec_ehrame.content = sec_text.content
print binary.get_section('.eh_frame').content

# hook target call
dstaddr = sec_ehrame.virtual_address
srcaddr = 0x400584

patch_call(binary,srcaddr,dstaddr)

binary.write('vulner.patched')
```

执行上面的脚本之后可以看到 patch 成功：

```
.eh_frame:0000000000400698 ; Segment type: Pure data
.eh_frame:0000000000400698 ; Segment permissions: Read
.eh_frame:0000000000400698 ; Segment alignment 'qword' can not be represented in assembly
.eh_frame:0000000000400698 _eh_frame       segment para public 'CONST' use64
.eh_frame:0000000000400698                 assume cs:_eh_frame
.eh_frame:0000000000400698                 ;org 400698h
.eh_frame:0000000000400698                 push    rbp
.eh_frame:0000000000400699                 mov     rbp, rsp
.eh_frame:000000000040069C                 mov     [rbp-8], rdi
.eh_frame:00000000004006A0                 mov     [rbp-0Ch], esi
.eh_frame:00000000004006A3                 mov     rsi, rdi
.eh_frame:00000000004006A6                 mov     rdi, 0
.eh_frame:00000000004006AD                 mov     rdx, 20h
.eh_frame:00000000004006B4                 mov     rax, 1
.eh_frame:00000000004006BB                 syscall                 ; LINUX - sys_write
.eh_frame:00000000004006BD                 nop
.eh_frame:00000000004006BE                 pop     rbp
.eh_frame:00000000004006BF                 retn
.eh_frame:00000000004006BF _eh_frame       ends
.eh_frame:00000000004006BF
LOAD:00000000004006C0 ; ===========================================================================
```

六、作业

1、参考实验手册的第三部分和第四部分，对二进制程序 overflow 进行修补。

程序 overflow 实现了一个非常简单的用户交互：输入学号，若输入的学号为 10 个字符，则在屏幕上打印一段感谢和表扬的话。程序共包含一个逻辑缺陷和一个栈溢出漏洞，要求同学们在没有源代码的情况下对其进行修补，修补后的程序仅打印与自己性别相对应的话，且无论输入多长的字符串均不会触发栈溢出漏洞。修改后的程序执行结果如下图所示：

```
Please input your student number:
a201900001
Thank you! You are a good girl.
```

七、分析报告

撰写分析报告，详细陈述完成作业的过程、方法及学习心得等，具体内容可参考实验手册。