HOOKING

Potato ACADEMY

Vulnerability research

- Compilation Phases
- Linking
- Static vs Dynamic Linking
- Hooking

Compilation Phases

Preprocessing – generates macro code, removes comments, searches for included header files etc

Compiling – turns the code into assembly

Assembly – turns the assembly code into binary. This is known as object code (hence *.o files)

Linking – combines the object files from assembly into a single file, links calls from shared libraries

Static or dynamic linking

Static Linking

- Takes the functions from shared libraries and copies the code into the output binary
- To generate statically linked binaries, add the “-static” flag when compiling with gcc
- What would be the result of compiling this code statically?
- This code has 2 calls to external libraries –
  - atoi
  - printf

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

int main()
{
    char *c = "1";
    int i = atoi(c);

    printf("%d\n", i);
}
```

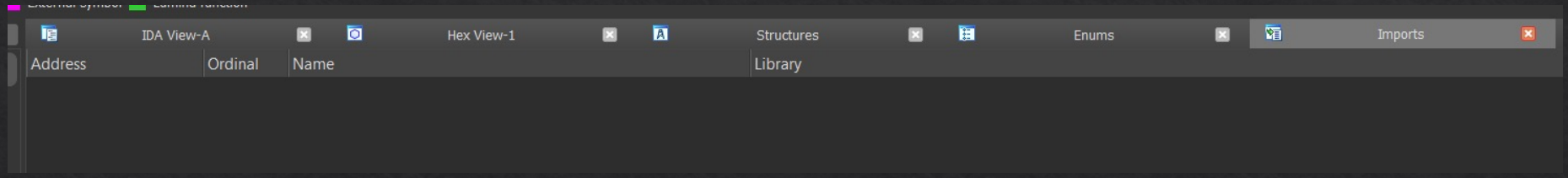
Static Linking

- The “file” command will tell you that it is statically or dynamically linked
- Note that the file size is 695k

```
┌──(kali㉿kali)-[~/vr_lessons/link]
└─$ gcc -m32 linking.c -o linking-static -static

┌──(kali㉿kali)-[~/vr_lessons/link]
└─$ file linking-static
linking-static: ELF 32-bit LSB executable, Intel 80386, version 1 (GNU/Linux), statically linked, BuildID[sha1]=a
ba4f159e87a98e857d40c45ce5ab3489de5b054, for GNU/Linux 3.2.0, not stripped

┌──(kali㉿kali)-[~/vr_lessons/link]
└─$ ls -lah linking-static
-rwxr-xr-x 1 kali kali 695K Nov 27 01:05 linking-static
```

Static Linking

- As the linker copies relevant external functions into the binary, there is nothing in the Imports tab in IDA



- Code for atoi is present in the binary. Other dependent functions like strtol will also be present

```
public atoi
atoi proc near

arg_0= dword ptr  4

; __unwind {
push    ebx
call    __x86_get_pc_thunk_bx
add     ebx, (offset _GLOBAL_OFFSET_TABLE_ - $)
sub     esp, 0Ch
push    0Ah
push    0
push    [esp+18h+arg_0]
call    strtol
add     esp, 18h
pop     ebx
retn
; } // starts at 804FBF0
atoi endp
```

Dynamic Linking

- Default setting if “-static” is not supplied when compiling
- Links external functions and doesn’t copy them into the binary
- Note that the file size is 15K compared to 695K when statically linked

```
┌──(kali㉿kali)-[~/vr_lessons/link]
└─$ gcc -m32 linking.c -o linking-static

┌──(kali㉿kali)-[~/vr_lessons/link]
└─$ file linking
linking: ELF 32-bit LSB pie executable, Intel 80386, version 1 (SYSV), dynamically linked, interpreter /lib/ld-li
nux.so.2, BuildID[sha1]=01edcb154f3df034acecdb2711e16d30624441cd, for GNU/Linux 3.2.0, not stripped

┌──(kali㉿kali)-[~/vr_lessons/link]
└─$ ls -lah linking
-rwxr-xr-x 1 kali kali 15K Nov 27 01:05 linking
```

Dynamic Linking

- Imports table in IDA shows import table with the linked functions

IDA View-A | Hex View-1 | Structures | Enums | Imports

Address	Ordinal	Name	Library
00004028		**printf@@GLIBC_2.0**	**.dynsym**
0000402C		**__cxa_finalize@@GLIBC_2.1.3**	**.dynsym**
00004030		**__libc_start_main@@GLIBC_2.0**	**.dynsym**
00004034		**atoi@@GLIBC_2.0**	**.dynsym**
00004038		_ITM_deregisterTMCloneTable	.dynsym
0000403C		__gmon_start__	.dynsym
00004040		_ITM_registerTMCloneTable	.dynsym

- Code for atoi doesn't exist in the binary

```
; int atoi(const char *nptr)
extrn atoi:near
```

STATIC LINKING
VERSUS
DYNAMIC LINKING

STATIC LINKING	DYNAMIC LINKING
Process of copying all library modules used in the program into the final executable image	Process of loading the external shared libraries into the program and then bind those shared libraries dynamically to the program
Last step of compilation	Occurs at run time
Statistically linked files are larger in size	Dynamically linked files are smaller in size
Static linking takes constant load time	Dynamic linking takes less load time
There will be no compatibility issues with static linking	There will be compatibility issues with dynamic linking

Static vs Dynamic

- https://pediaa.com/what-is-the-difference-between-static-and-dynamic-linking/
- https://medium.com/@birnbera/static-vs-dynamic-libraries-5912efe9bf52

Dynamic Linking

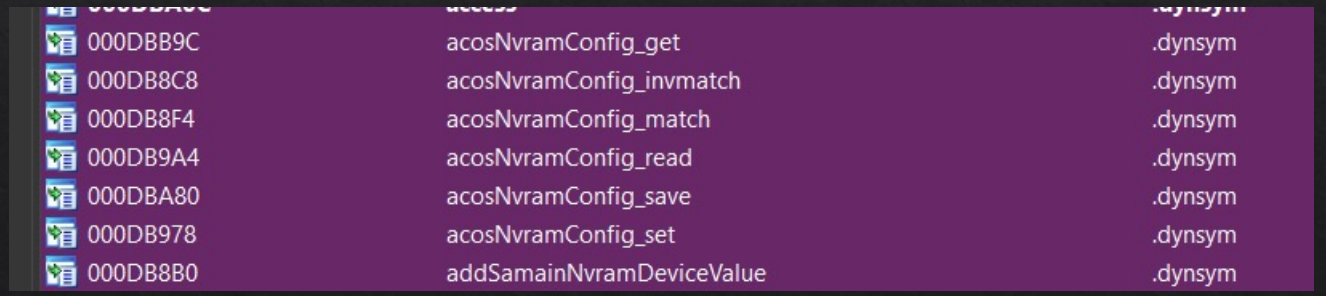
- Dynamic linking allows us to hook externally called functions and replace them with our own
- External functions are resolved during run time, when the function is called (lazy binding)
- https://bitguard.wordpress.com/2016/11/26/an-example-of-how-procedure-linkage-table-works/
- https://binaryresearch.github.io/2019/08/29/A-Technique-for-Hooking-Internal-Functions-of-Dynamically-Linked-ELF-Binaries.html

Hooking

- Why – when doing RE or fuzzing we may need to modify the behaviour of some functions
- Eg – replacing the random() call with a constant value to improve a fuzzer's stability
- Eg – replacing functions accessing hardware devices which may not be present during RE (disabling nvram_set and nvram_get calls when emulating a router's http service)
- Eg – execute a certain function in a binary as an entry point (useful for fuzzing)

Hooking Example

- upnpd binary in Netgear links to the following functions to interface with NVRAM
- In order to run upnpd in an emulated environment which does not include an NVRAM device, we will need to hook these functions
- How – by reimplementing those functions and configuring Linux to load it before the normal shared library
- LD_PRELOAD – Linux environment variable that modifies the paths to shared libraries



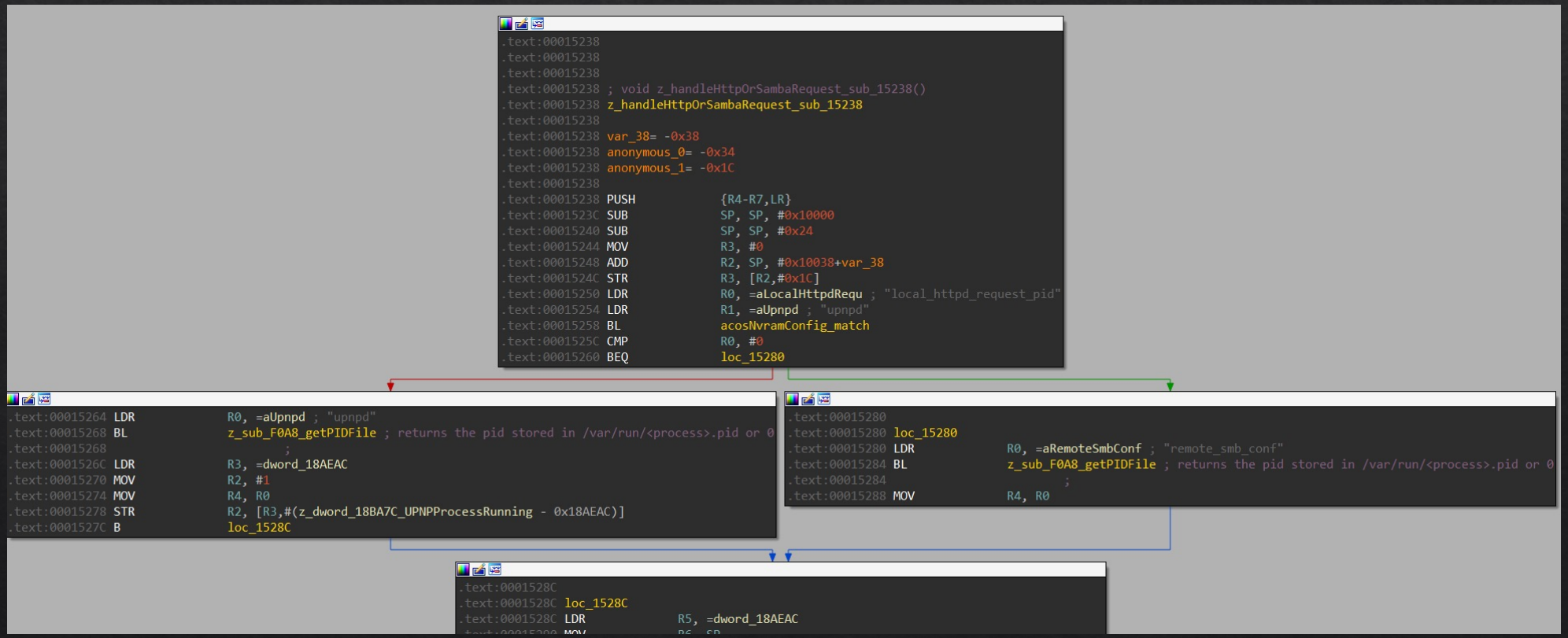
Hookin

- Reimplement functions with the same signature and return types
- Compile as a shared library eg “gcc hook.c –o hook.so –shared”
- Add “hook.so” as a value to LD_PRELOAD
- LD_PRELOAD=./hook.so /usr/sbin/upnpd
- https://catonmat.net/simple-ld-preload-tutorial

```
char* acosNvramConfig_get(char *key)
{
    return nvram_get(key);
}

int acosNvramConfig_set(char *key, char *value)
{
    nvram_set(key, value);
    return 0;
}

int acosNvramConfig_match(char *key, char *value)
{
    int return_value = 1;

    if (compare_keys(key, "wan_status"))
    {
        return_value = 0;
    }
    if (compare_keys(key, "wan_proto"))
    {
        if (compare_keys(value, "dhcp"))
        {
            return_value = 1;
        }
        else
            return_value = 0;
    }
    if (compare_keys(key, "httpsEnable"))
    {
        return_value = 0;
    }
    ….
    return return_value;

}
```

Hooking Example – Entry Point

- We can also modify the entry point of a binary for fuzzing or other automated testing
- Example – we may want to fuzz the method below at 0x15238



Hooking Example – Entry Point

- When binaries are loaded, the “main” method as defined by the programmer is *not* the first method executed
- The first method being executed is the main method of the runtime C library
  - Libc for Linux
  - Uclibc for embedded Linux
  - CRT for Windows (C runtime)
- Sets up the execution environment such collecting command line args to pass to main(), initialise threading subsystems, perform security checks, etc…
- __libc_start_main, __uClibc_main…

Hooking Example – Entry Point

- We can overwrite the libc main function to change the entry point
- Seems that exact method signature does not matter. But name must match, eg for uClibc runtimes, the function name must be __uClibc_main
- The code below overwrites the normal __uClibc_main (which calls main) and instead calls 2 functions by addresses, bootstrap at 0x15494 and handleHTTPOrSambaRequest at 0x15238
- When the program is compiled and run, our version of __uClibc_main will be called

```
void __uClibc_main(void *main, int argc, char** argv)
{
    void (*bootstrap)() = (void*)0x00015494;
    bootstrap();

    // need request in /tmp/tmp_http_request.txt
    void (*handleHTTPOrSambaRequest)() = (void*)0x00015238;
    handleHTTPOrSambaRequest();
}
```