Assignment 2

Assigned: 25/10/2024
Due: 03/11/2024

Access Control Logging

For this assignment, you will develop an access control logging system using the C programming language. The access control logging system will monitor and keep track of every file access and modification that occurs in the system. So, each file access or file modification will generate an entry in a log file. This log file will be inspected by a separate high-privileged process.

You will use “LD_PRELOAD”, which instructs the linker to bind symbols provided by a shared library before any other library. This way, you will override the C standard library functions that handle file accesses and modifications (fopen, fwrite) with your own versions in order to offer the extra functionality you are requested.

Step 1: Access Control Logging tool

As already discussed, you are requested to develop a shared library, named “logger.so”, that overrides the C standard I/O library using the LD_PRELOAD. Specifically, your own versions of *fopen* and *fwrite* will collect and log the needed information for each file access, before continuing with the standard I/O operation. The log file should be named “file_logging.log”. The log file must be stored somewhere, where it can be accessible by all users. Each log entry should contain the following information:

1. **UID**: The unique user ID assigned by the system to a user (hint: see *getuid()* function).
2. **File name**: The path and name of the accessed file.
3. **Date**: The date that the action occurred.
4. **Timestamp**: The time that the action occurred (UTC timezone).
5. **Access type**: For *file creation*, the access type is 0. For *file open*, the access type is 1. For *file write*, the access type is 2.
6. **Is-action-denied flag**: This field reports if the action was denied to the user with no access privileges. It is 1 if the action was denied to the user, or 0 otherwise.
7. **File fingerprint**: The digital fingerprint of the file the time the event occurred. This digital fingerprint is the hash value of the file contents (hint: You can use the hash functions contained in evp.h).

Events that must be logged:

1. **File creation:** Every time a user creates a file, the log file must be updated with information about the creation of the file. **Make sure to modify the fopen() function in a way that the *creation* of a file can be distinguished from the *opening* of an existing file.**
2. **File opening:** Every time a user tries to open a file, the log file must be updated with the corresponding file access attempt information. For this case, fopen() functions need to be intercepted and information about the user and the file access has to be collected.
3. **File modification (write):** Every time a user tries to modify a file, the log file will be updated with the corresponding file modification attempt information. This means that fwrite() functions need to be intercepted and information about the user and the file access has to be collected.

Important: Every fopen()/fwrite() function should create a new entry in the log file (named "file_logging.log").

Step 2: Access Control Log Monitoring tool

Develop a simple log monitoring tool, named "acmonitor.c", which will be responsible for monitoring the logs created by the Access Control Logging tool (Step 1). This log monitoring tool will:

1. Parse the log file generated in Step 1 (i.e., "file_logging.log") and extract all incidents where malicious users[1] tried to access multiple files without having permissions. As an output, the tool should print all users that tried to access more than 5 different files without having permissions.
2. Given a filename, the log monitoring tool should track and report all users that have accessed the specific file. **By comparing the digital fingerprints/hash values, the log monitoring tool should check how many times the file was indeed modified.** As an output, the log monitoring tool is expected to print the number of times each user has modified it. Report the user name and the number of times the file was accessed.

Step 3: Test the Access Control Logging & Log Monitoring tools

Develop a simple tool, named "test_aclog.c", that will be used to test and demonstrate the above tasks. The "test_aclog.c" tool has to automatically create/open/modify files, in a way that will create the conditions that the "acmonitor.c" tool searches for. For instance, you should try to open files without having the permission to do so (Step 2.1), and modify specific files (Step 2.2).

[1] For this assignment, a "malicious user" is the user that tries to access multiple files without having the permission. For Step 2, when we refer to a "malicious user" we refer to the user that tries to access more than 5 different files without having the permission.

Executing the “test_aclog.c” tool with your custom fopen() and fwrite() functions preloaded, will create the required access control log file entries in “file_logging.log”. Then, use the log monitoring tool “acmonitor.c” to get the relevant reports (Step 2). *The only user input that is expected to be requested are the command line arguments described in the “Tool Specification” section below.*

Tool Specification

The Access Control Log Monitoring tool “test_aclog.c” (Step 2) will receive the required arguments from the command line upon execution.

Options

-m	Prints malicious users
-i <filename>	Prints users that modified the file given and the number of modifications
-h	Help message

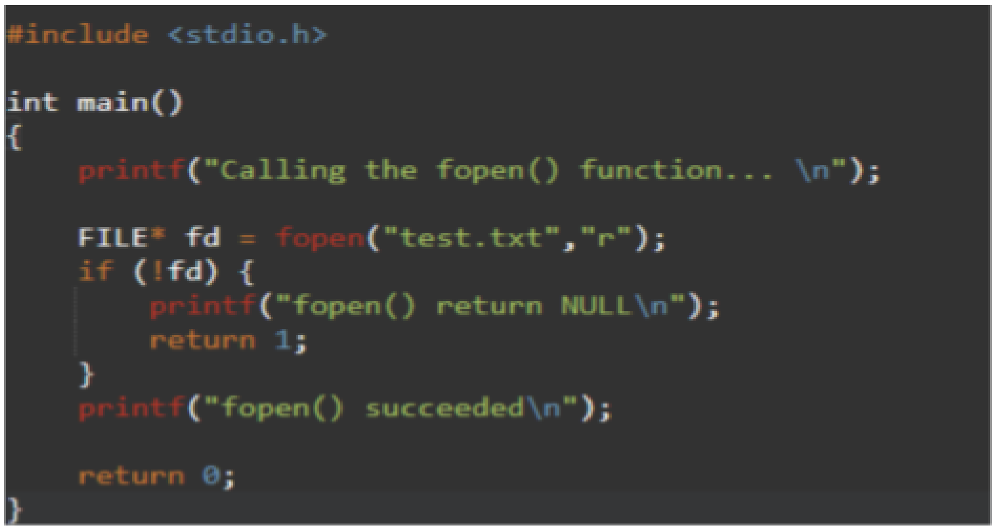
Notes

1. ***Important: Do not skip this assignment. It is possible to be used as a prerequisite to solve a future assignment.***
2. If no appropriate option was given, the Access Control Monitoring tool has to print the appropriate error/help message.
3. You need to create a Makefile to compile your library and programs (you must submit it with your source code) or you can use the one provided to you.
4. You are also provided with a corpus to build your own source code.
5. **You must create a README with your names, your logins and a short description (1-2 lines) of your implementation.**
6. **You must submit the following 6 files:**
    a. README,
    b. Makefile,
    c. logger.c,
    d. logger.so,

   e. acmonitor.c, and
   f. test_aclog.c
7. You should place all these files in a folder named <AM>_assign2 and then compress it as a .zip file. For example, if your logins are 2020123456 and 2020123666 the folder should be named 2020123456_2020123666_assign2 you should commit 2020123456_2020123666_assign2.zip.
8. The tool's corpus provided with this assignment is just an example. Feel free to define your own functions or change the signatures of the given functions **(except for fopen() and fwrite())**. You can even re-design it from scratch. However, **the options defined in the "Tool specification" section must remain as-is.**
9. Use the tab "Συζήτηση" in courses for questions.
10. **Questions will be answered only on certain days: Monday - Wednesday - Friday**

Hints

You need to use LD_PRELOAD to instruct the linker to load *your implementation* of fopen/fwrite before any other library. Example below:



```c
#include <stdio.h>

int main()
{
    printf("Calling the fopen() function... \n");

    FILE* fd = fopen("test.txt","r");
    if (!fd) {
        printf("fopen() return NULL\n");
        return 1;
    }
    printf("fopen() succeeded\n");

    return 0;
}
```

Figure 1: Example code in file main.c that calls the fopen() function, checks if it returns a pointer to FILE value (successful call) or NULL (failed call), prints a message and returns.

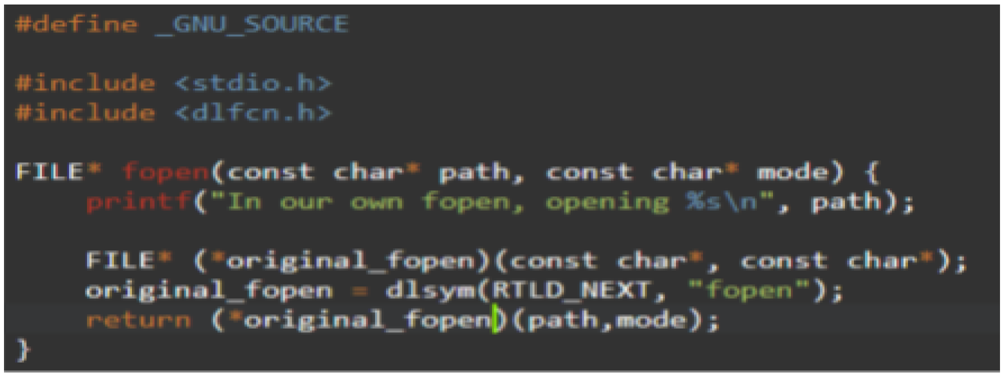

```c
#define _GNU_SOURCE

#include <stdio.h>
#include <dlfcn.h>

FILE* fopen(const char* path, const char* mode) {
    printf("In our own fopen, opening %s\n", path);

    FILE* (*original_fopen)(const char*, const char*);
    original_fopen = dlsym(RTLD_NEXT, "fopen");
    return (*original_fopen)(path,mode);
}
```

Figure 2: Our custom implementation of fopen(). This custom fopen() function prints a message and then calls the original fopen() from the C standard library using *dlsym* with the *RTLD_NEXT* flag (finds the next occurrence of a function in the search order after the current library).

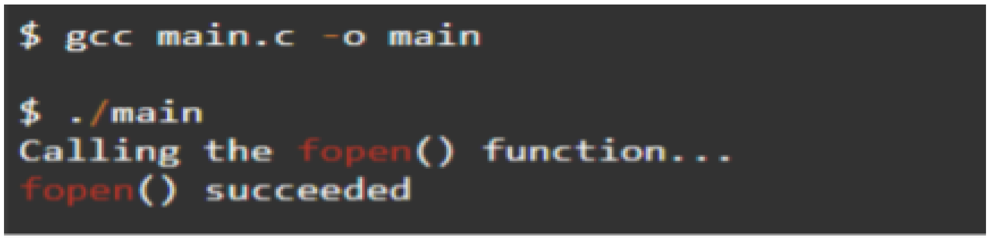

```
$ gcc main.c -o main

$ ./main
Calling the fopen() function...
fopen() succeeded
```

Figure 3: By compiling and executing the main.c we get this output. Without the use of LD_PRELOAD, the original fopen() function from the C standard library is called.

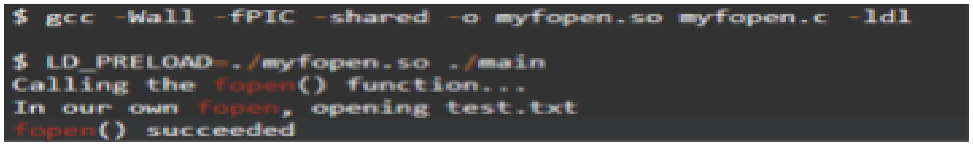

```
$ gcc -Wall -fPIC -shared -o myfopen.so myfopen.c -ldl

$ LD_PRELOAD=./myfopen.so ./main
Calling the fopen() function...
In our own fopen, opening test.txt
fopen() succeeded
```

Figure 4: We compile the "myfopen.c" source file in order to get the "myfopen.so" file. To execute "main", we first preload our custom fopen function using the following command "LD_PRELOAD=./myfopen.so. ./main". As occurs from the output, the message "In our own fopen,..." shows that the custom fopen was executed.