

# CS 419: Computer Security

## Recitation: Project 2 Discussion

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# Assignment 6 (Project 2)

- **This assignment has two parts**
- **This is an individual assignment**
- **Goal: use function interposition**
  - Replace *readdir* and *time* functions in existing programs

# Environment

- **You must do this assignment on a Linux platform**
- **It uses shared library preloading, which is not available on BSD, macOS, or Windows systems**
- **Your personal Linux system will probably be fine**
  - But you are responsible to make sure it works on the Rutgers iLab machines

# Environment

Download `p2.zip` (see assignment on Canvas) and unzip it

You will see

- **Makefile** – you can use this to build the zip file for submitting your program
- **random** – this is a demo of using `LD_PRELOAD` to replace a function
- **hidefile** – this is for Part 1
- **unexpire** – this is for Part 2

# Background

**LD\_PRELOAD** is an environment variable that defines shared libraries that will be loaded & searched before any other libraries

- If a program needs to call a library function, this library will be checked first
- It's set as any shell environment variable:

```
export LD_PRELOAD=$PWD/mylib.so
```

## **This will:**

- Load the shared library `$PWD/mylib.so`
  - `$PWD` expands to the path of the current directory
- Check this library for any functions the program needs before checking other libraries

# Example

- We looked at this in class
- Here's a C program to print 10 random numbers

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

int
main(int argc, char **argv)
{
    int i;
    srand(time(NULL)); // seed the generator with the current time
    for (i=0; i < 10; i++)
        printf("%d\n", rand()%100);
    return 0;
}
```

random.c

# Example

If we compile and run it, we get:

```
$ gcc -o random random.c
$ ./random
90
36
89
26
3
31
87
71
79
10
```

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

int
main(int argc, char **argv)
{
    int i;
    srand(time(NULL));
    for (i=0; i < 10; i++)
        printf("%d\n", rand()%100);
    return 0;
}
```

random.c

# Example

Let's create a file `myrand.c` that redefines the *rand* function



```
int rand() {  
    return 42;  
}
```

`myrand.c`

Now compile it to a shared library & preload it

```
$ gcc -shared -fpic myrand.c -o myrand.so
```

```
$ export LD_PRELOAD=$PWD/myrand.so
```

## Notes:

- `shared` compiles a shared library
- `fpic` creates position-independent code
- `o myrand.so` names the library `myrand.so`

```
#include <time.h>  
#include <stdio.h>  
#include <stdlib.h>  
  
int  
main(int argc, char **argv)  
{  
    int i;  
    srand(time(NULL));  
    for (i=0; i < 10; i++)  
        printf("%d\n", rand()%100);  
    return 0;  
}
```

`random.c`



# Example

If we run the program again, it uses our function instead of the standard one

We did not have to recompile the program!

```
$ ./random
```

```
42  
42  
42  
42  
42  
42  
42  
42  
42  
42
```

```
int rand() {  
    return 42;  
}
```

myrand.c

```
#include <time.h>  
#include <stdio.h>  
#include <stdlib.h>  
  
int  
main(int argc, char **argv)  
{  
    int i;  
    srand(time(NULL));  
    for (i=0; i < 10; i++)  
        printf("%d\n", rand()%100);  
    return 0;  
}
```

random.c

# Part 1: Goal

- **Attackers sometimes try to hide their files on a system**
  - The best way is by modifying the kernel but we usually do not have the ability to modify the kernel
- **Instead, we will modify the *readdir* library function**
  - This is used by most tools that need to read directory contents on Linux
  - Example: *ls*, *find*, *zsh*, *sh*
- **We will create a new version of *readdir* that checks for a file name stored in the environment variable HIDDEN**
  - If the file is in the directory, it will not be made visible to the program that's looking at files in the directory
  - If you know it exists, you can still run it or open it by specifying its path

# Example

Preload our library, which replaces the *readdir* function

```
$ export LD_PRELOAD=$PWD/hidefile.so
```

Use the `ls` command to list all the files in a directory

```
$ ls -l
total 196
-rw----- 1 pxk allusers 3855 Feb 20 18:02 present.pptx
-rw----- 1 pxk allusers  237 Feb 20 18:02 salaries.xlsx
-rw----- 1 pxk allusers 18198 Feb 20 18:02 secretfile
-rw----- 1 pxk allusers 3584 Feb 20 18:02 secretfile.docx
-rw----- 1 pxk allusers 24879 Feb 20 18:02 secretfile.txt
-rw----- 1 pxk allusers  805 Feb 20 18:01 status-report-1.txt
-rw----- 1 pxk allusers 13260 Feb 20 18:01 status-report-2.txt
-rw----- 1 pxk allusers 29878 Feb 20 18:02 status-report-3.txt
-rw----- 1 pxk allusers 19550 Feb 20 18:03 testfile.c
```

# Example

Set the file name that we want to hide

```
$ HIDDEN=secretfile.txt
```

Run the `ls` command again: `secretfile.txt` is missing!

```
$ ls -l
total 163
-rw----- 1 pxk allusers 3855 Feb 20 18:02 present.pptx
-rw----- 1 pxk allusers 237 Feb 20 18:02 salaries.xlsx
-rw----- 1 pxk allusers 18198 Feb 20 18:02 secretfile
-rw----- 1 pxk allusers 3584 Feb 20 18:02 secretfile.docx
-rw----- 1 pxk allusers 805 Feb 20 18:01 status-report-1.txt
-rw----- 1 pxk allusers 13260 Feb 20 18:01 status-report-2.txt
-rw----- 1 pxk allusers 29878 Feb 20 18:02 status-report-3.txt
-rw----- 1 pxk allusers 19550 Feb 20 18:03 testfile.c
```

# Example

We can run another command, like *find*  
Secretfile.txt is still missing!

```
$ find .  
./status-report-1.txt  
./present.pptx  
./testfile.c  
./status-report-3.txt  
./salaries.xlsx  
./secretfile  
./status-report-2.txt  
./secretfile.docx
```

# Example

If we change the file name that we want to hide

```
$ HIDDEN=status-report-1.txt
```

And run the `ls` command – `status-report-1.txt` is missing!

```
$ ls -l
total 188
-rw----- 1 pxk allusers 3855 Feb 20 18:02 present.pptx
-rw----- 1 pxk allusers 237 Feb 20 18:02 salaries.xlsx
-rw----- 1 pxk allusers 18198 Feb 20 18:02 secretfile
-rw----- 1 pxk allusers 3584 Feb 20 18:02 secretfile.docx
-rw----- 1 pxk allusers 24879 Feb 20 18:02 secretfile.txt
-rw----- 1 pxk allusers 13260 Feb 20 18:01 status-report-2.txt
-rw----- 1 pxk allusers 29878 Feb 20 18:02 status-report-3.txt
-rw----- 1 pxk allusers 19550 Feb 20 18:03 testfile.c
```

# Example

If we remove HIDDEN:

```
$ unset HIDDEN
```

Then we can see all the files:

```
$ ls -l
total 196
-rw----- 1 pxk allusers 3855 Feb 20 18:02 present.pptx
-rw----- 1 pxk allusers 237 Feb 20 18:02 salaries.xlsx
-rw----- 1 pxk allusers 18198 Feb 20 18:02 secretfile
-rw----- 1 pxk allusers 3584 Feb 20 18:02 secretfile.docx
-rw----- 1 pxk allusers 24879 Feb 20 18:02 secretfile.txt
-rw----- 1 pxk allusers 805 Feb 20 18:01 status-report-1.txt
-rw----- 1 pxk allusers 13260 Feb 20 18:01 status-report-2.txt
-rw----- 1 pxk allusers 29878 Feb 20 18:02 status-report-3.txt
-rw----- 1 pxk allusers 19550 Feb 20 18:03 testfile.c
```

# How to do the assignment

- **Write a version of *readdir* in `hidefile.c`**
  - Same interface as the standard *readdir* – look at the manual page
  - Each call to returns *readdir* one file
  - Call the REAL *readdir* function
  - If the file is the hidden file then do not return
    - Instead, call the REAL *readdir* function a second time to get the next file
- **Run *make* to compile it (see assignment instructions)**
- **Set `LD_PRELOAD=$PWD/hidefile.so` and run a command like `ls`**
  - See instructions
  - You can run `make test`  
This will create some test files and set `HIDDEN`



# Things to know

- **You still want to call the REAL *readdir* function inside yours**
  - To do this, use the *ldsym* function to load and access the real version of the function from your library
  - Read the references in the assignment for instructions on how to use *ldsym*
- **You need to read the value of the HIDDEN environment variable**
  - You can get this with a call to **getenv**

# This is a small project!

- **The implementation of `hidefile.c` will likely be <10 statements**
- **As always, develop and test incrementally**
  - Make sure you understand and can use & run the *random* example
  - Put *printf* statements so you know that your *readdir* is being called
  - Version 0: don't test files – just print a message and call the real *readdir*
  - Version 1: compare against a hard-coded name, such as "secret"
  - Version 2: get the environment variable and compare against that
  - Version 3: test – make sure it works and works if `HIDDEN` is not set
  - Version 4: remove your *printf* statements

# Part 2

- **You are given a Linux program called *unexpire***
  - Pretend this is an evaluation version of a program that has an expiration time coded into it
  - The program exits (expires) if the current date is after January 1, 2022
  - It also refuses to run with any date earlier than January 1, 2021.
- **GOAL:**  
**You wish to continue using this program past this hard-coded expiration time and you want to defeat its check for the time**

# Part 2: unexpire

- The program calls the C library function `time()` to get the current time
- You will create a file called `newtime.c` that:
  - Implements a different version of the `time()` function that returns a date in the range Jan 1 2021 ... Jan 1 2021 so the expiration check will pass
  - However, you want the program to report the correct time **after** the check takes place
    - Your `time()` function will pass future requests straight through to the standard library `time` function
- `newtime.c` will be compiled into a shared library that you will preload via  
`export LD_PRELOAD=$PWD/newtime.so`

# Example runs

If we run *unexpire*, it tells us that access has expired

```
$ ./unexpire
It is now Feb 20 2022 18:40:28
You cannot run this program before Fri Jan  1 00:00:00 2021
This software expires at Sat Jan  1 00:00:00 2022

ACCESS DENIED: It is now Feb 20 2022 18:40:28. Access expired at Sat Jan  1 00:00:00 2022
```

But if we preload our *time* library – `newtime.so` – and run *unexpire*:

```
$ LD_PRELOAD=$PWD/newtime.so ./unexpire
It is now Sep 01 2021 01:00:00
You cannot run this program before Fri Jan  1 00:00:00 2021
This software expires at Sat Jan  1 00:00:00 2022

Sep 01 2021 01:00:00: access granted!
The current time is: Feb 20 2022 18:41:46
PASSED! You reset the time successfully!
```

# What you need to do

- **This is similar to Part 1**

- Your library will load and call the real function ... in some cases

- **You need to define a suitable time**

- Pick a time in the range Jan 1 2021 ... Jan 1 2022
- Figure out how to encode it so *time* can return it
- You can compute this outside of the program
  - Or you can use a combination of *strptime* and *mktime* to set the time
  - *strptime*: converts a human-friendly time into a struct tm
  - *mktime*: converts a struct tm into seconds count that *time* can return
  - Do a bit of research – read the man pages – it's not hard!

- **You need to keep state**

- You want to return your custom time just the first time – then pass through to *time*
- You can keep state in a static or global variable

# What to submit

- You must do this assignment on an iLab system
- Submit a zip file that contains
  - `hidefile/hidefile.c` *your definition of `readdir` for Part 1*
  - `unexpire/newtime.c` *your definition of `time` for Part 2*

To prepare the zip file, you can go to the top-level directory of the download package and run

```
make zip
```

The End