Set-UID Programs and Vulnerabilities

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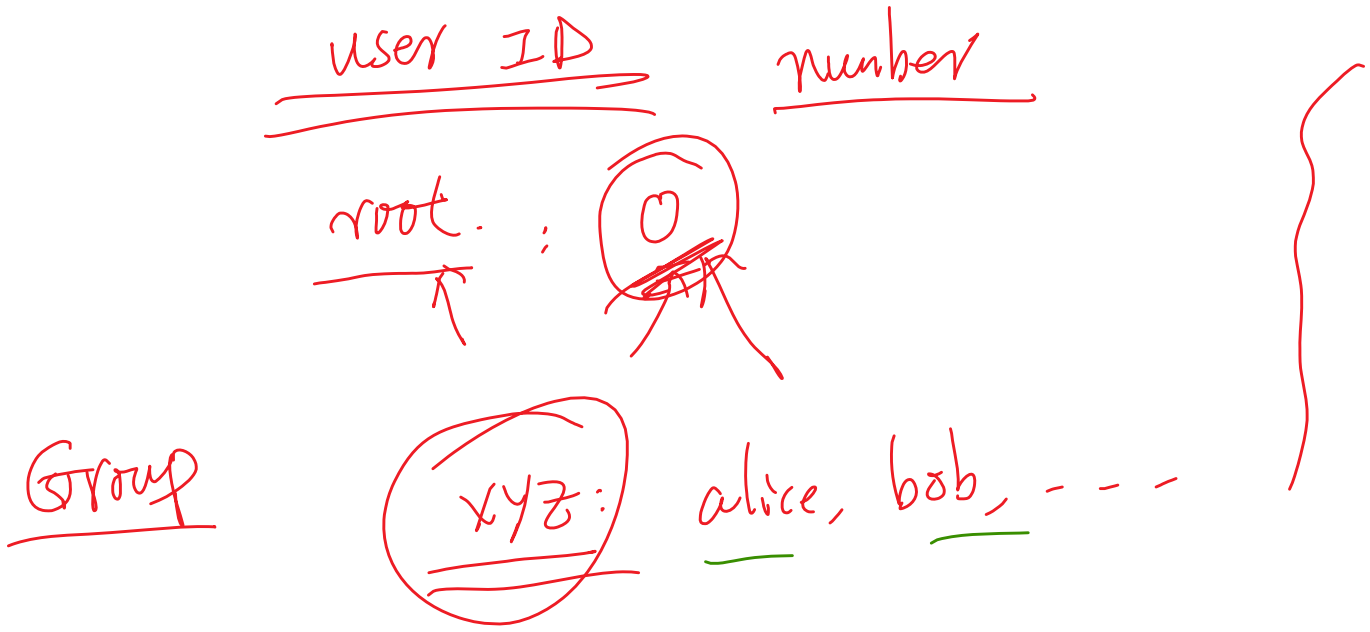
Unix Security Basics

- User
- Group
- Permissions
- Access control list

User and Group



User and Group Files

❖ /etc/passwd

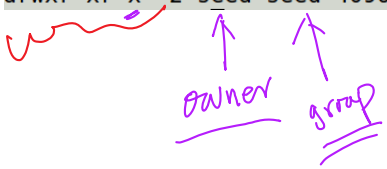
```
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/bin/sh
bin:x:2:2:bin:/bin:/bin/sh
sys:x:3:3:sys:/dev:/bin/sh
sync:x:4:65534:sync:/bin:/bin/sync
games:x:5:60:games:/usr/games:/bin/sh
man:x:6:12:man:/var/cache/man:/bin/sh
lp:x:7:7:lp:/var/spool/lpd:/bin/sh
mail:x:8:8:mail:/var/mail:/bin/sh
news:x:9:9:news:/var/spool/news:/bin/sh
uucp:x:10:10:uucp:/var/spool/uucp:/bin/sh
proxy:x:13:13:proxy:/bin:/bin/sh
www-data:x:33:33:www-data:/var/www:/bin/sh
seed:x:1000:1000:Seed,,,:/home/seed:/bin/bash
mysql:x:115:125:MySQL Server,,,:/nonexistent:/bin/false
bind:x:116:126::/var/cache/bind:/bin/false
snort:x:117:127:Snort IDS:/var/log/snort:/bin/false
ftp:x:118:128:ftp daemon,,,:/srv/ftp:/bin/false
```

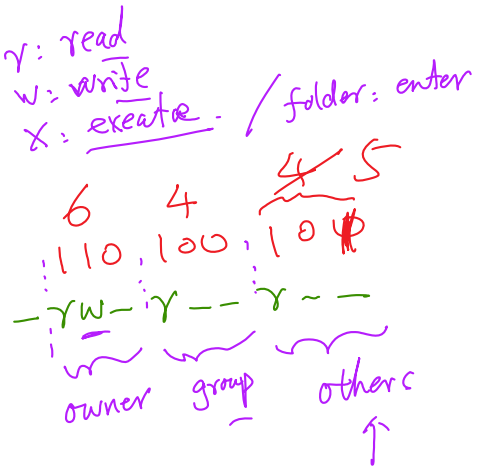
❖ /etc/group

```
dialout:x:20:
fax:x:21:
voice:x:22:
cdrom:x:24:seed
floppy:x:25:
tape:x:26:
sudo:x:27:seed
audio:x:29:pulse
```

Permissions

```
seed@ubuntu:~$ ls -l
total 64
drwxrwxr-x  5 seed seed 4096 Jul  7 09:31 ace2016_network
drwxr-xr-x  3 seed seed 4096 Jun 14 22:14 Desktop
drwxr-xr-x  3 seed seed 4096 Dec  9  2015 Documents
drwxr-xr-x  2 seed seed 4096 Sep 17  2014 Downloads
drwxrwxr-x  6 seed seed 4096 Sep 17  2014 elggData
-rw-r--r--  1 seed seed 8445 Aug 13  2013 examples.desktop
drwxrwxr-x 13 seed seed 4096 Aug 10 05:30 labs
drwxr-xr-x  2 seed seed 4096 Aug 13  2013 Music
drwxr-xr-x 24 root root 4096 Jan  9  2014 openssl-1.0.1
drwxr-xr-x  2 seed seed 4096 Jun 12 19:15 Pictures
drwxr-xr-x  2 seed seed 4096 Aug 13  2013 Public
drwxr-xr-x  2 seed seed 4096 Aug 13  2013 Templates
-rwxrwxr-x  1 seed seed  119 Jun 14 11:12 user2.desktop.desktop
drwxr-xr-x  2 seed seed 4096 Aug 13  2013 Videos
```





The Sudo Command

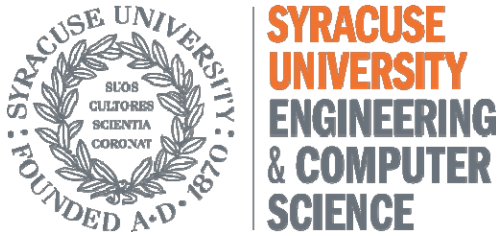
❖ Run the sudo command

```
seed@ubuntu:$ head /etc/shadow
head: cannot open '/etc/shadow' for reading: Permission denied
seed@ubuntu:$ sudo head /etc/shadow
[sudo] password for seed:
root:$6$012BPz.K$fbPkT6H6Db4/B8cLWbQI1cFjn0R25yqtqrSrFeWfCgybQWWnwR4ks
h/pDyc5U1BWOzkWh7T9ZGu.:15933:0:99999:7:::
daemon:*:15749:0:99999:7:::
bin:*:15749:0:99999:7:::
sys:*:15749:0:99999:7:::
sync:*:15749:0:99999:7:::
games:*:15749:0:99999:7:::
man:*:15749:0:99999:7:::
```

❖ The /etc/sudoer file

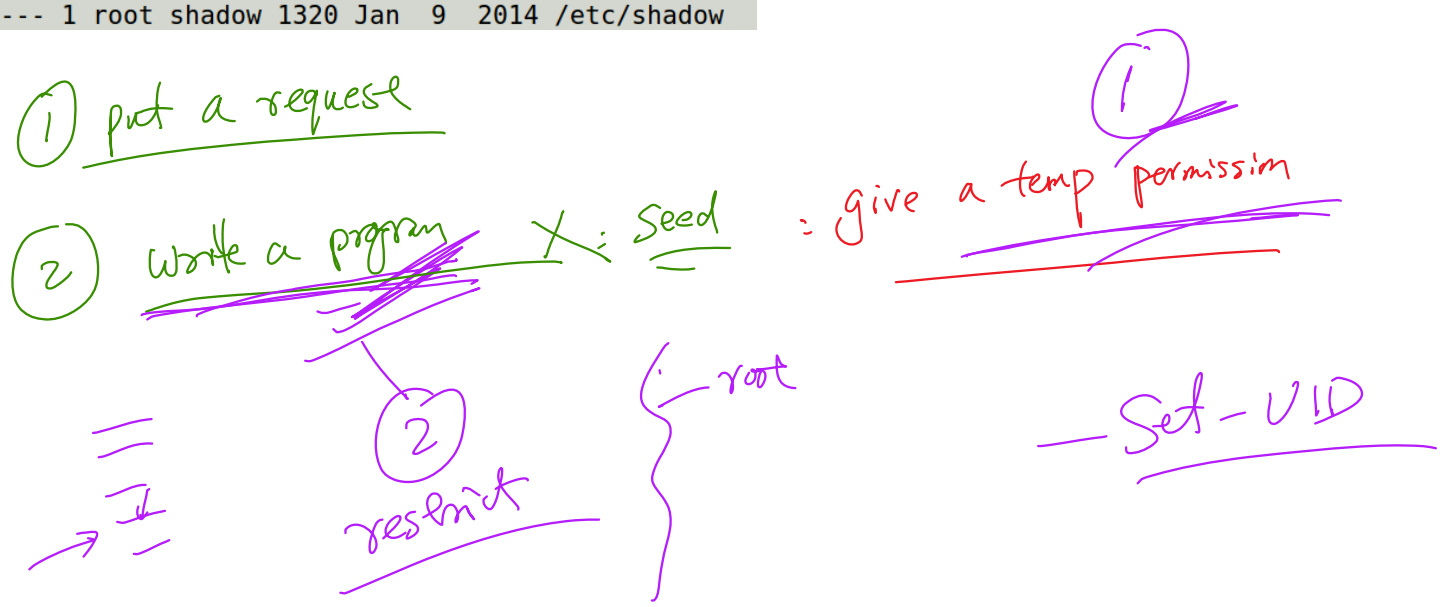
```
# User privilege specification
root    ALL=(ALL:ALL) ALL

# Members of the admin group may gain root privileges
%admin ALL=(ALL) ALL

# Allow members of group sudo to execute any command
%sudo   ALL=(ALL:ALL) ALL

# See sudoers(5) for more information on "#include" directives:

#includedir /etc/sudoers.d
seed@ubuntu:~$ id
uid=1000(seed) gid=1000(seed) groups=1000(seed),4(adm),24(cdrom),27(sudo),30(dip),
46(plugdev),109(lpadmin),124(sambashare),130(wireshark)
```

The Need for Privileged Programs



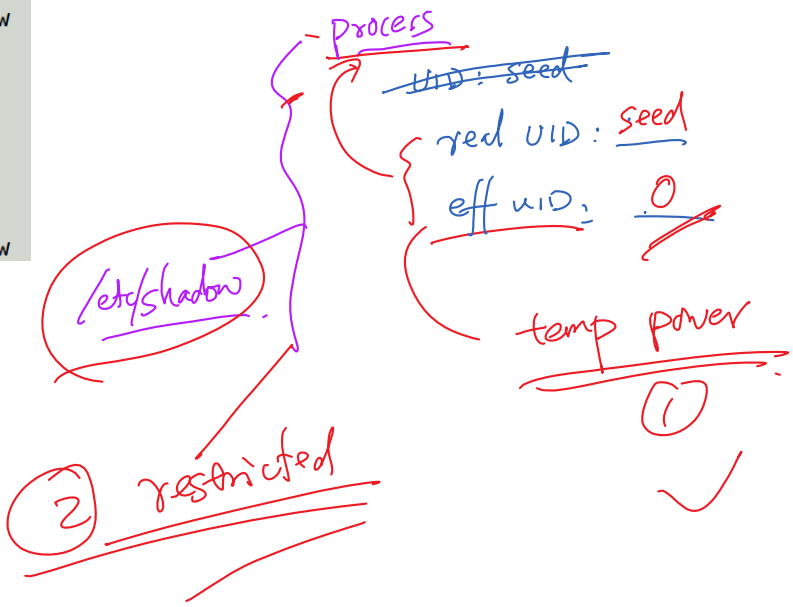
Password Dilemma: How to Change Password?

```
seed@ubuntu:~$ ls -l /etc/shadow
-rw-r----- 1 root shadow 1320 Jan  9  2014 /etc/shadow
```

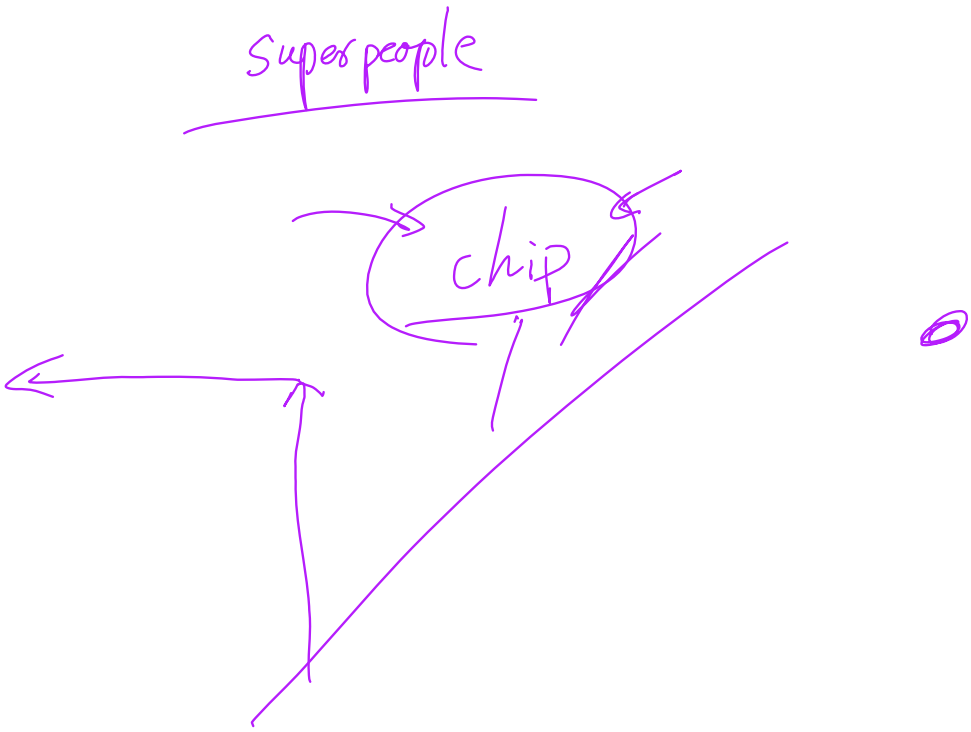


Privileged Programs

```
seed@ubuntu:~$ ls -l /etc/shadow
-rw-r----- 1 root shadow 1320 Jan  9  2014 /etc/shadow
seed@ubuntu:~$ passwd
Changing password for seed.
(current) UNIX password:
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
seed@ubuntu:~$ ls -l /etc/shadow
-rw-r----- 1 root shadow 1320 Sep  6 11:34 /etc/shadow
```



The Untold Superman Story



How Set-UID Programs Work

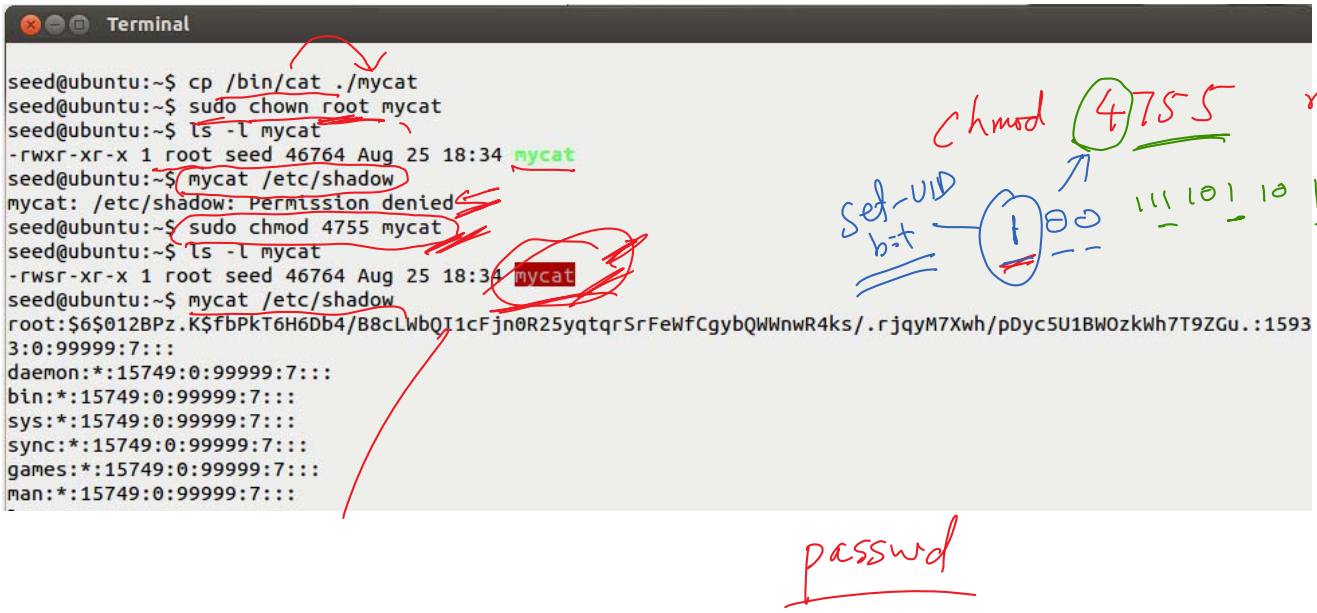
Turn a Program Into a Set-UID Program

root

chmod 4755 prog : enable the set-UID bit

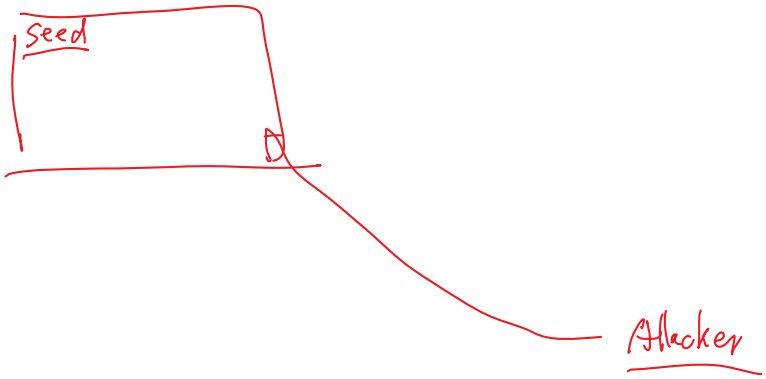
chown root prog . change the ownership

Example of Set-UID Program

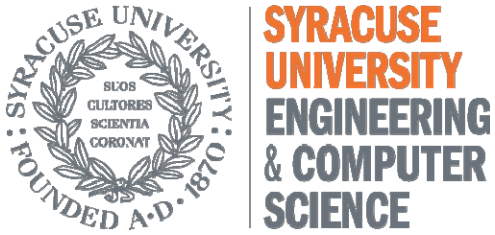


Exercise

Somebody gives you a chance to use his Unix account, and you have your own account on the same system. Can you take over this person's account in 10 seconds?



What Can Go Wrong in a Program?



An Attack on Superman's Program

Another Attack on Superman's Program

Attack Surfaces

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Risk Analysis: Attack Surface

Attacks via Environment Variables, Part 1

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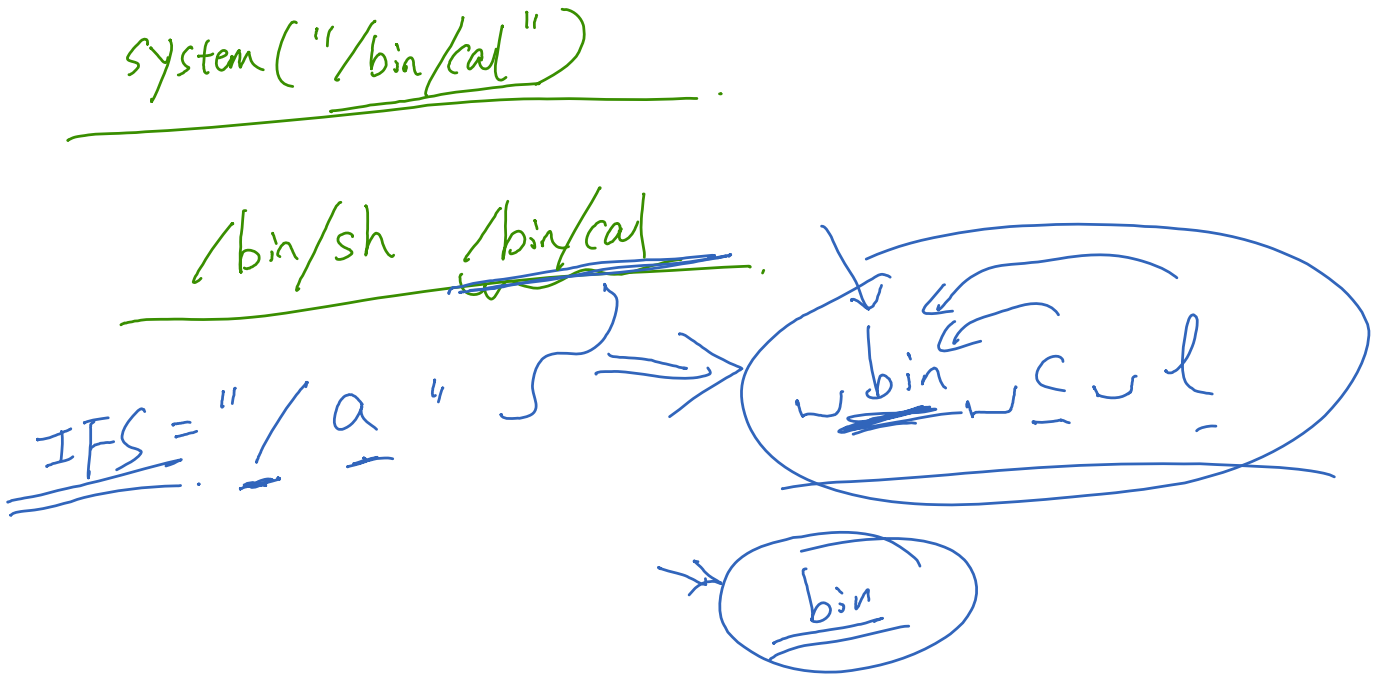
PATH Environment Variables

```c
#include <stdlib.h>
int main()
{
    system("cal");
}
```

IFS Attacks



What Is Dynamic-Link Library?

```
seed@ubuntu:$ gcc -o hello_dynamic hello.c
seed@ubuntu:$ gcc -static -o hello_static hello.c
seed@ubuntu:$ ls -l
-rw-rw-r-- 1 seed seed     68 Dec 31 13:30 hello.c
-rwxrwxr-x 1 seed seed   7162 Dec 31 13:30 hello_dynamic
-rwxrwxr-x 1 seed seed 751294 Dec 31 13:31 hello_static
```

Shared Library

❖ The ldd command

```
NAME
       ldd - print shared library dependencies

SYNOPSIS
       ldd [OPTION]...  FILE...

DESCRIPTION
       ldd  prints  the  shared  libraries  required by each program or shared
       library specified on the command line.
```

❖ Run ldd on a binary

```
void main()
{
   printf("Hello World\n");
}
seed@ubuntu:$ ldd a.out
      linux-gate.so.1 =>  (0xb7fff000)
      libc.so.6 => /lib/i386-linux-gnu/libc.so.6 (0xb7e42000)
      /lib/ld-linux.so.2 (0x80000000)
```

LD_PRELOAD

❖ How LD_PRELOAD affects Dynamic-Linked Library

```
void main()
{
   printf("Hello World\n");
   sleep(2);
}
seed@ubuntu:$ unset LD_PRELOAD
seed@ubuntu:$ ldd a.out
        linux-gate.so.1 =>  (0xb7fff000)
        libc.so.6 => /lib/i386-linux-gnu/libc.so.6 (0xb7e42000)
        /lib/ld-linux.so.2 (0x80000000)
seed@ubuntu:$ a.out
Hello World
seed@ubuntu:$ export LD_PRELOAD=./libmylib.so.7
seed@ubuntu:$ ldd a.out
        linux-gate.so.1 =>  (0xb7fff000)
        ./libmylib.so.7 (0xb7ffa000)
        libc.so.6 => /lib/i386-linux-gnu/libc.so.6 (0xb7e3f000)
        /lib/ld-linux.so.2 (0x80000000)
seed@ubuntu:$ a.out
Hello World
I am not sleeping!
```

```
seed@ubuntu:$ more sleep.c

#include <stdio.h>
void sleep(int s)
{
   printf("I am not sleeping!\n");
}
```

How LD_PRELOAD Affects Set-UID Programs

❖ Experiment

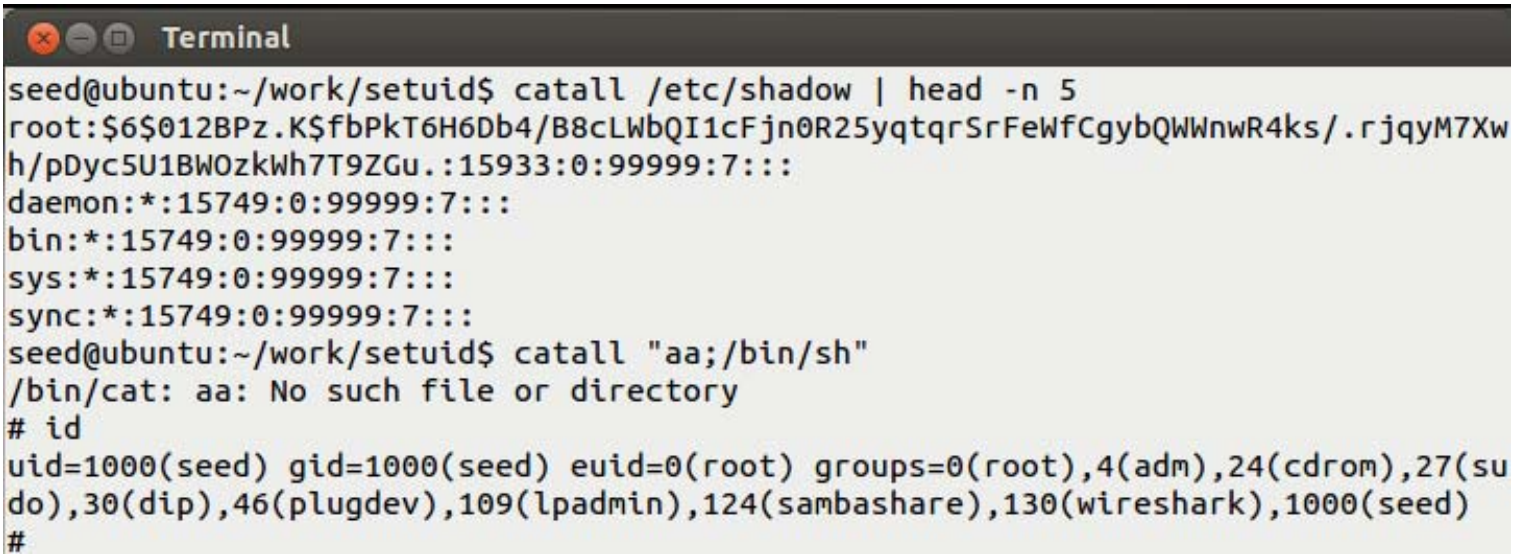
```
seed@ubuntu:$ cp /usr/bin/env ./myenv
seed@ubuntu:$ sudo chown root myenv
[sudo] password for seed:
seed@ubuntu:$ sudo chmod 4755 myenv
seed@ubuntu:$ ls -l myenv
-rwsr-xr-x 1 root seed 22060 Dec 27 09:30 myenv
```

❖ Difference

```
seed@ubuntu:$ export LD_PRELOAD=./libmylib.so.1.0.1
seed@ubuntu:$ export LD_LIBRARY_PATH=.
seed@ubuntu:$ export LD_MYOWN="my own value"
seed@ubuntu:$ env | grep LD_
LD_PRELOAD=./libmylib.so.1.0.1
LD_LIBRARY_PATH=.
LD_MYOWN=my own value
seed@ubuntu:$ myenv | grep LD_
LD_MYOWN=my own value
```

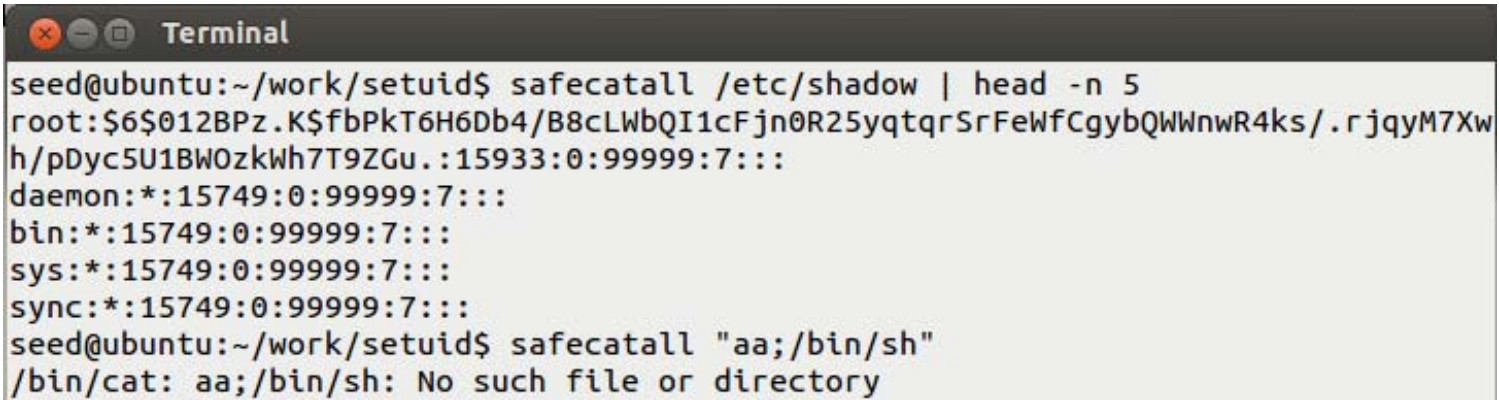
Attacks via Explicit User Inputs

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

int main(int argc, char *argv[])
{
  char *cat="/bin/cat";

  if(argc < 2) {
    printf("Please type a file name.\n");
    return 1;
  }

  char *command = malloc(strlen(cat) + strlen(argv[1]) + 2);
  sprintf(command, "%s %s", cat, argv[1]);
  system(command);
  return 0 ;
}
```



Secure Way to Invoke External Programs

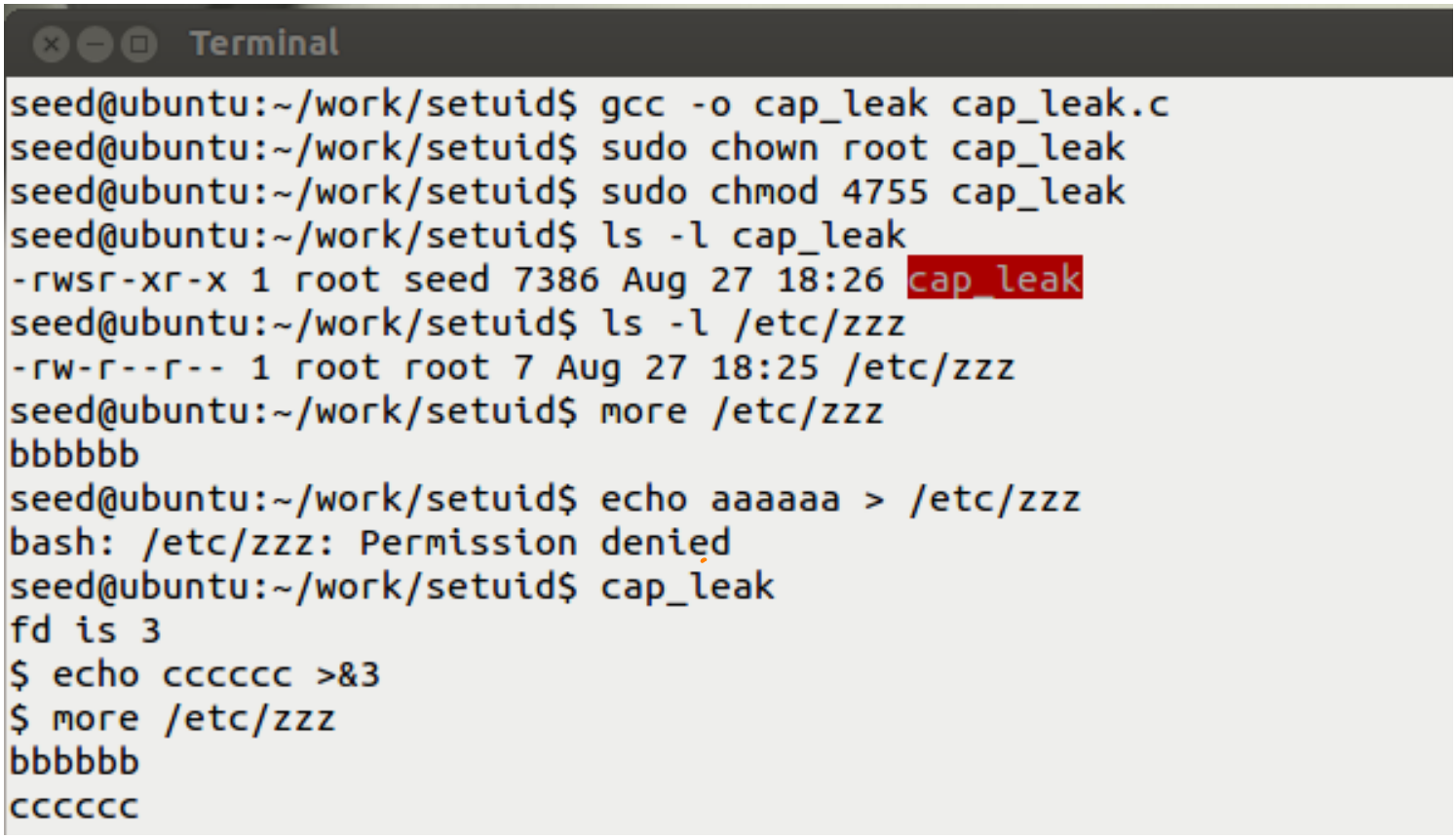
```c
#include <string.h>
#include <stdio.h>
#include <stdlib.h>

int main(int argc, char *argv[])
{
  char *v[3];

  if(argc < 2) {
    printf("Please type a file name.\n");
    return 1;
  }

  v[0] = "/bin/cat"; v[1] = argv[1]; v[2] = 0;
  execve(v[0], v, 0);

  return 0 ;
}
```



Capability Leaking

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

void main()
{
  int fd;
  char *v[2];

  /* Assume that /etc/zzz is an important system file,
   * and it is owned by root with permission 0644.
   * Before running this program, you should creat
   * the file /etc/zzz first. */
  fd = open("/etc/zzz", O_RDWR | O_APPEND);
  if (fd == -1) {
    printf("Cannot open /etc/zzz\n");
    exit(0);
  }

  // Print out the file descriptor value
  printf("fd is %d\n", fd);

  // Permanently disable the privilege by making the
  // effective uid the same as the real uid
  setuid(getuid());

  // Execute /bin/sh
  v[0] = "/bin/sh"; v[1] = 0;
  execve(v[0], v, 0);
}
```

Capability Leaking: Demo



Capability Leaking in OS X 10.10 (2015)

```
$  DYLD_PRINT_TO_FILE=/this_system_is_vulnerable su <some_username>
Password:
bash-3.2$ ls -la /this_system_is_vulnerable
-rw-r--r--  1 root  wheel  0 Jul 21 17:22 /this_system_is_vulnerable
bash-3.2$ echo "Test 1" >&3
bash-3.2$ echo "Test 2" >&3
bash-3.2$ cat /this_system_is_vulnerable
Test 1
Test 2
bash-3.2$ ls -la /this_system_is_vulnerable
-rw-r--r--  1 root  wheel  14 Jul 21 17:36 /this_system_is_vulnerable
```

Server Approach vs. Set-UID

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Comparisons

Discussion: Compare the Set-UID approach with the server approach.