
COMP 4108 – COMPUTER SYSTEMS SECURITY

Assignment 1



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Preface

References to each question are available in the Bibliography page.

1.0: Kernel Abstractions - Unix UID and GIDs

The label User ID and Group ID can be applied at the top of the architecture where the User Program/Applications are run. However the labels first get applied much deeper at the Kernel Level where the processes are run.

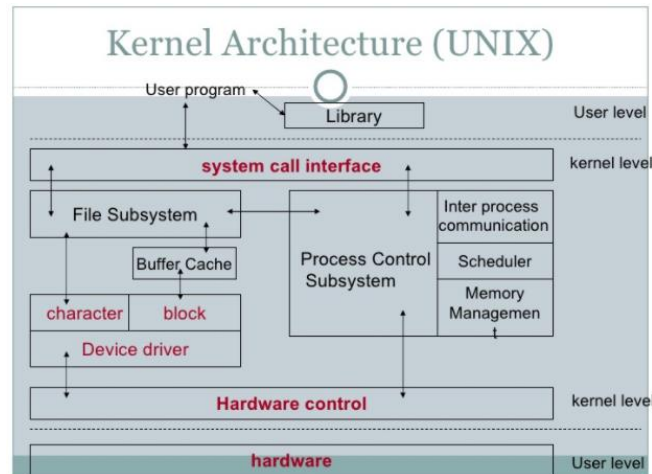


Figure 1: The UNIX Kernel Architecture.

As is demonstrated in Figure 1: The UNIX kernel Architecture we can see there exists several processes within the Kernel Level. Since we are interested in processes that deal with User ID's and Group IDs particular interest is the File Subsystem and the System Call Interface which are located within the kernel.

1.1: Kernel Abstractions – File Subsystem

The File Subsystem contains a system called inodes, the inodes keep a record of every file and the file ownership. Therefore if a file does not belong to a particular owner or group it will be the file subsystem that keeps a record of which files should be accessible to which users or groups.

1.2: Kernel Abstractions – System Call Interface

The System Call Interface is used to: 1) Interact with the user via a Unix Shell 2) Run System calls within the kernel. When the System Call Interface is used in conjunction with the file inodes it can prevent processes from executing in the Process Control Subsystem if the user attempts to run a process without the proper valid UID or GID.

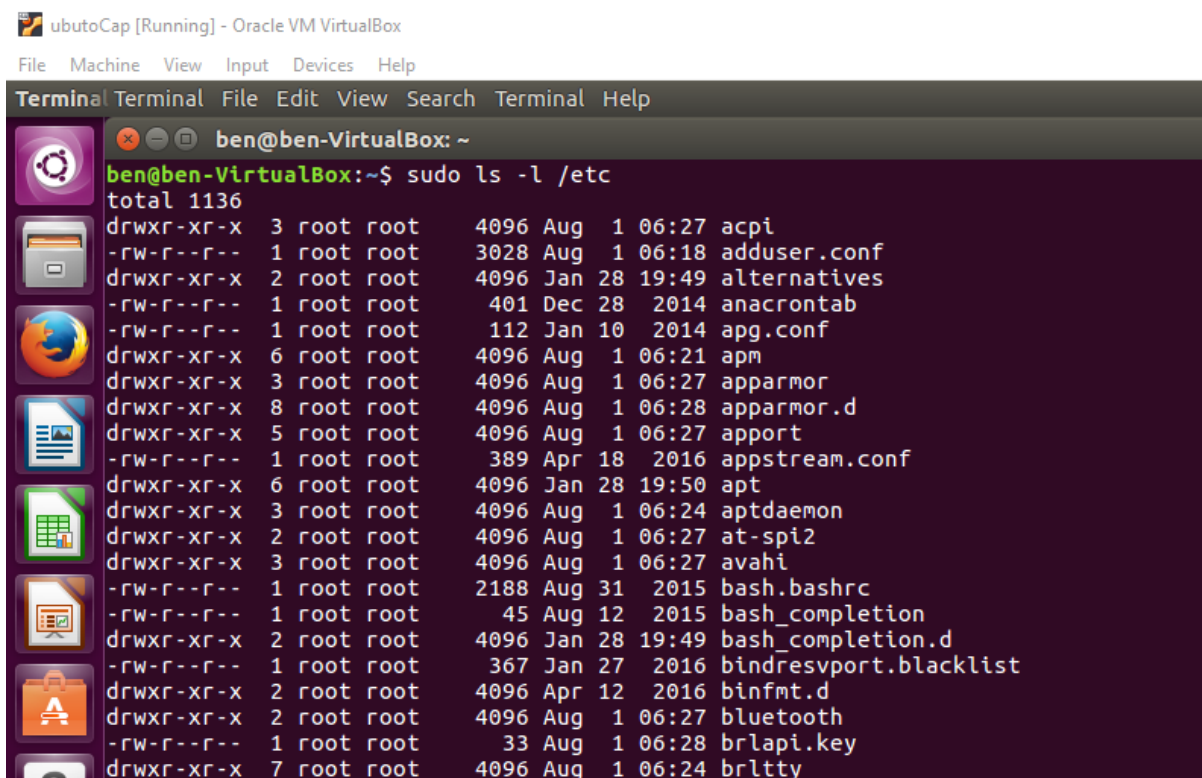
1.3: Kernel Abstractions – Conclusion

Thus it can be argued that since the File Subsystem keeps track of each file and their respective owners, the System Call Interface interacts with both the user and the Process Control Subsystem which is used to run the processes, its actually at the File Subsystem and System Call Interface are where the labels are actually first applied and then continues up to the top of the Unix Architecture.

2.0: Unix File Permissions

File permissions is Unix method to provide some security to critical files, these could include operating system files. However file permissions can be bypassed by taking advantage of the concept of **other permissions**.

The concept of other permissions stems from the idea that each file has set permissions for its owner (UID), the group (GID) and how other users can access the file or directory. In essence *other permissions* are the set permissions for users that are neither the owner nor a member of the user group. Since outside users have their own set permissions for the file or directory they can change access by using the change mode or as its commonly referred to the **chmod** command.



```
ben@ben-VirtualBox: ~$ sudo ls -l /etc
total 1136
drwxr-xr-x  3 root root    4096 Aug  1 06:27 acpi
-rw-r--r--  1 root root    3028 Aug  1 06:18 adduser.conf
drwxr-xr-x  2 root root    4096 Jan 28 19:49 alternatives
-rw-r--r--  1 root root     401 Dec 28 2014 anacrontab
-rw-r--r--  1 root root    112 Jan 10 2014 apg.conf
drwxr-xr-x  6 root root    4096 Aug  1 06:21 apm
drwxr-xr-x  3 root root    4096 Aug  1 06:27 apparmor
drwxr-xr-x  8 root root    4096 Aug  1 06:28 apparmor.d
drwxr-xr-x  5 root root    4096 Aug  1 06:27 apport
-rw-r--r--  1 root root     389 Apr 18 2016 appstream.conf
drwxr-xr-x  6 root root    4096 Jan 28 19:50 apt
drwxr-xr-x  3 root root    4096 Aug  1 06:24 aptdaemon
drwxr-xr-x  2 root root    4096 Aug  1 06:27 at-spi2
drwxr-xr-x  3 root root    4096 Aug  1 06:27 avahi
-rw-r--r--  1 root root   2188 Aug 31 2015 bash.bashrc
-rw-r--r--  1 root root     45 Aug 12 2015 bash_completion
drwxr-xr-x  2 root root    4096 Jan 28 19:49 bash_completion.d
-rw-r--r--  1 root root    367 Jan 27 2016 bindresvport.blacklist
drwxr-xr-x  2 root root    4096 Apr 12 2016 binfmt.d
drwxr-xr-x  2 root root    4096 Aug  1 06:27 bluetooth
-rw-r--r--  1 root root     33 Aug  1 06:28 brlapi.key
drwxr-xr-x  7 root root    4096 Aug  1 06:24 brltty
```

Figure 2: Processes With Only Root Permissions

As is demonstrated in Figure 2 the root /etc folder is only accessible if the user has the correct UID and GID access.

2.1: The Chmod Command

The change mode or **chmod** command provides the ability to change permissions in two ways Absolute and Symbolic.

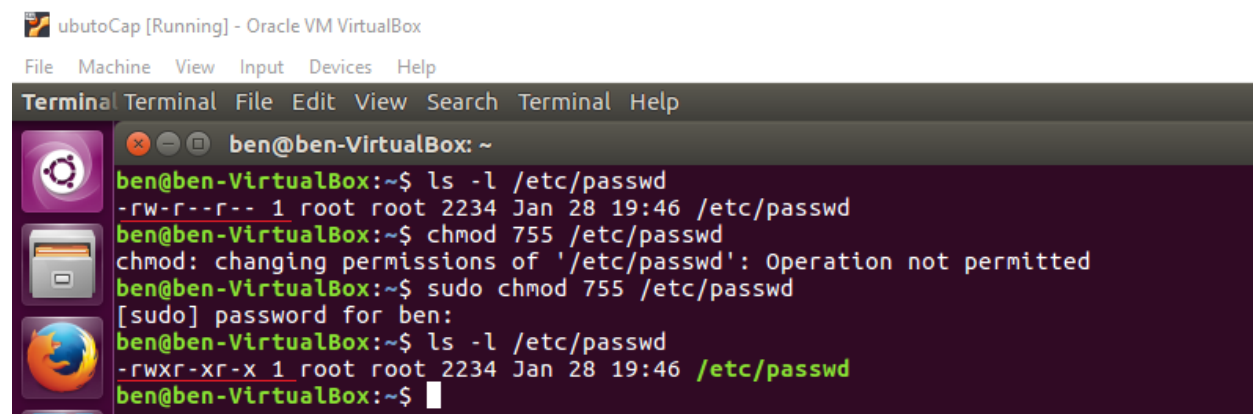
2.1.1: The Chmod Command (Absolute Mode)

Absolute permission changes work by changing the assigned permission bit permission based on a number between 0 – 7.

Number	Description	Ref
0	No Permission	---
1	Execute Permission	--x
2	Write Permission	-w-
3	Execute and Write permission	-wx
4	Read Permission	r--
5	Read and Execute Permission	r-x
6	Read and Write Permission	rw-
7	All Permission	rxw

Table 1: Changing Permission Bits

Using the information in Table 1: Changing Permission Bits we can change permissions by typing in the command : **chmod ### filename or directory.**



```
ubutuCap [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Terminal Terminal File Edit View Search Terminal Help
ben@ben-VirtualBox: ~
ben@ben-VirtualBox:~$ ls -l /etc/passwd
-rw-r--r-- 1 root root 2234 Jan 28 19:46 /etc/passwd
ben@ben-VirtualBox:~$ chmod 755 /etc/passwd
chmod: changing permissions of '/etc/passwd': Operation not permitted
ben@ben-VirtualBox:~$ sudo chmod 755 /etc/passwd
[sudo] password for ben:
ben@ben-VirtualBox:~$ ls -l /etc/passwd
-rwxr-xr-x 1 root root 2234 Jan 28 19:46 /etc/passwd
ben@ben-VirtualBox:~$
```

Figure 3: Using the Chmod 755 /file/passwd to add rwx and r-x permissions

As an example of how this works pay attention to the write permissions in Figure 3, notice how the /etc/passwd file initially only had -rw-r - -r permissions (read and write permissions). After inputting the command **Chmod 755 /file/passwd** we changed the permissions and were given permissions to execute the file.

2.1.2: The Chmod Command (Symbolic Mode)

The Symbolic Mode operates similar to absolute mode the only difference is instead of using numeric numbers symbolic mode uses arithmetic operators.

Operator	Description
+	Adds The Designated Permission
-	Removes The Designated Permission
=	Sets The Designated Permission

Table 2: The Symbolic Chmod Commands

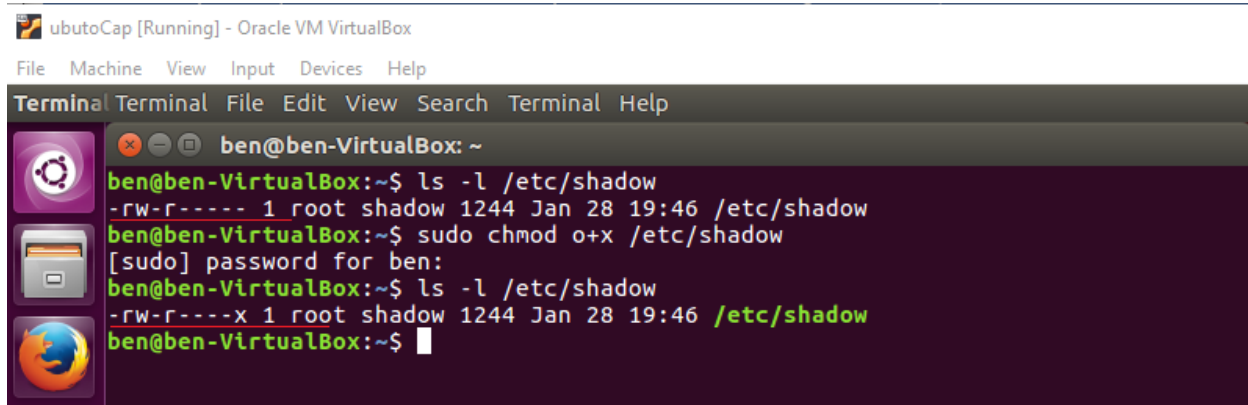
Using table 2 as a guide we can change the permissions by using the command:

chmod o#wg file

chmod o#x file

chmod g#rx file

Figure 4 below demonstrates how typing in the command **chmod o+x /etc/shadow** added the execute permission to the file.



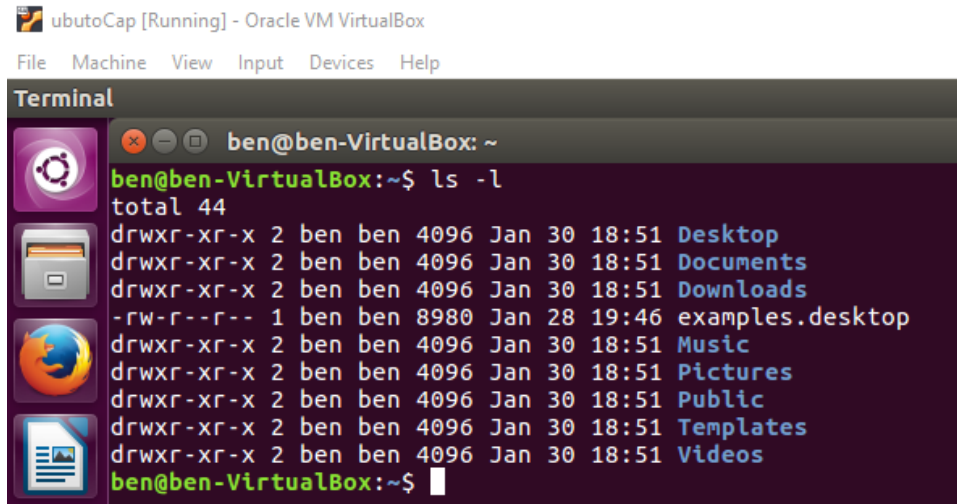
```
ubutoCap [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Terminal Terminal File Edit View Search Terminal Help
ben@ben-VirtualBox: ~
ben@ben-VirtualBox:~$ ls -l /etc/shadow
-rw-r----- 1 root shadow 1244 Jan 28 19:46 /etc/shadow
ben@ben-VirtualBox:~$ sudo chmod o+x /etc/shadow
[sudo] password for ben:
ben@ben-VirtualBox:~$ ls -l /etc/shadow
-rw-r-----x 1 root shadow 1244 Jan 28 19:46 /etc/shadow
ben@ben-VirtualBox:~$
```

Figure 4: Using the command **chmod o+x /etc/shadow** to add execute permissions

3.0: Read, Write and Execute Permissions

In the preceding section we saw how file permissions can be changed to read, write and or execute, in this section we will describe each and how they perform.

We can determine what the file/directories permissions are by typing in the command `ls -l` (Figure 5).



```
ubutoCap [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Terminal
ben@ben-VirtualBox: ~
ben@ben-VirtualBox:~$ ls -l
total 44
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Desktop
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Documents
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Downloads
-rw-r--r-- 1 ben ben 8980 Jan 28 19:46 examples.desktop
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Music
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Pictures
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Public
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Templates
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Videos
ben@ben-VirtualBox:~$
```

Figure 5: Displaying The File Permissions

3.1: Read Permissions

As the name suggests read permissions indicate that file/directory can be opened and viewed this is indicated by the letter **r**.

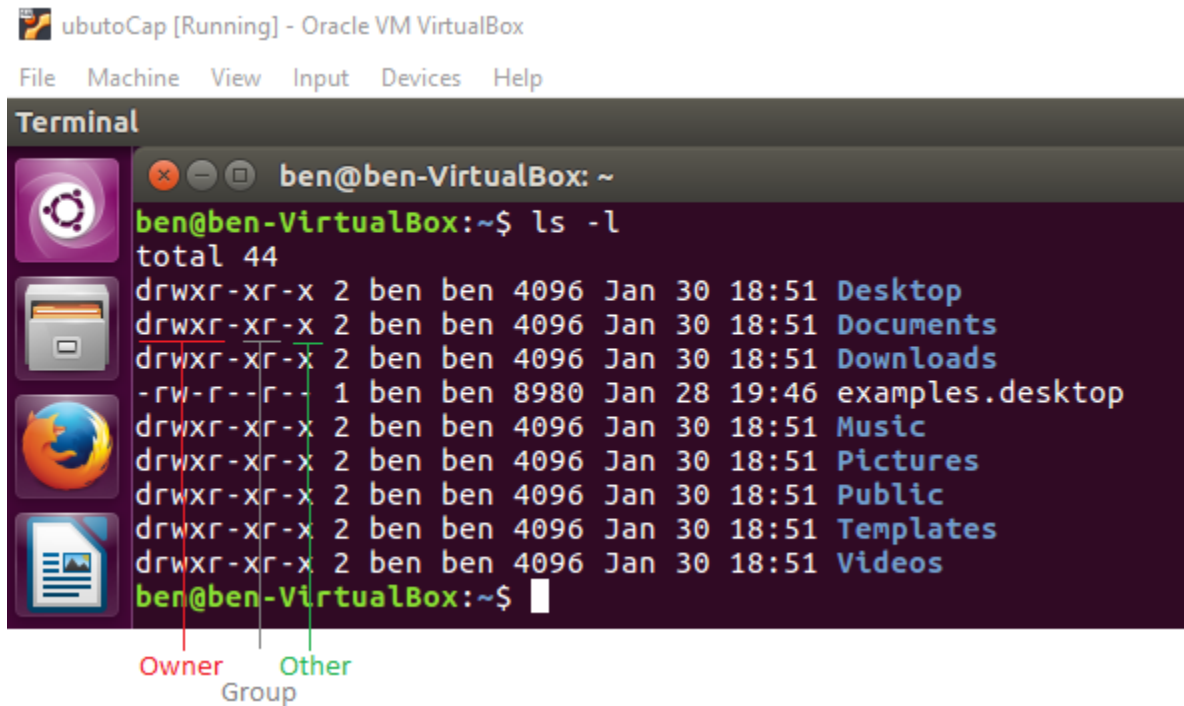
3.2: Write Permissions

Write permissions allow the user and root to modify the file/directory this is indicated by the letter **w**.

3.3: Execute Permissions

Execute permissions allow the user and root to run the file/directory this is indicated by the letter **x**.

3.4: Verification



```
ben@ben-VirtualBox: ~$ ls -l
total 44
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Desktop
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Documents
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Downloads
-rw-r--r-- 1 ben ben 8980 Jan 28 19:46 examples.desktop
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Music
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Pictures
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Public
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Templates
drwxr-xr-x 2 ben ben 4096 Jan 30 18:51 Videos
```

Owner Group Other

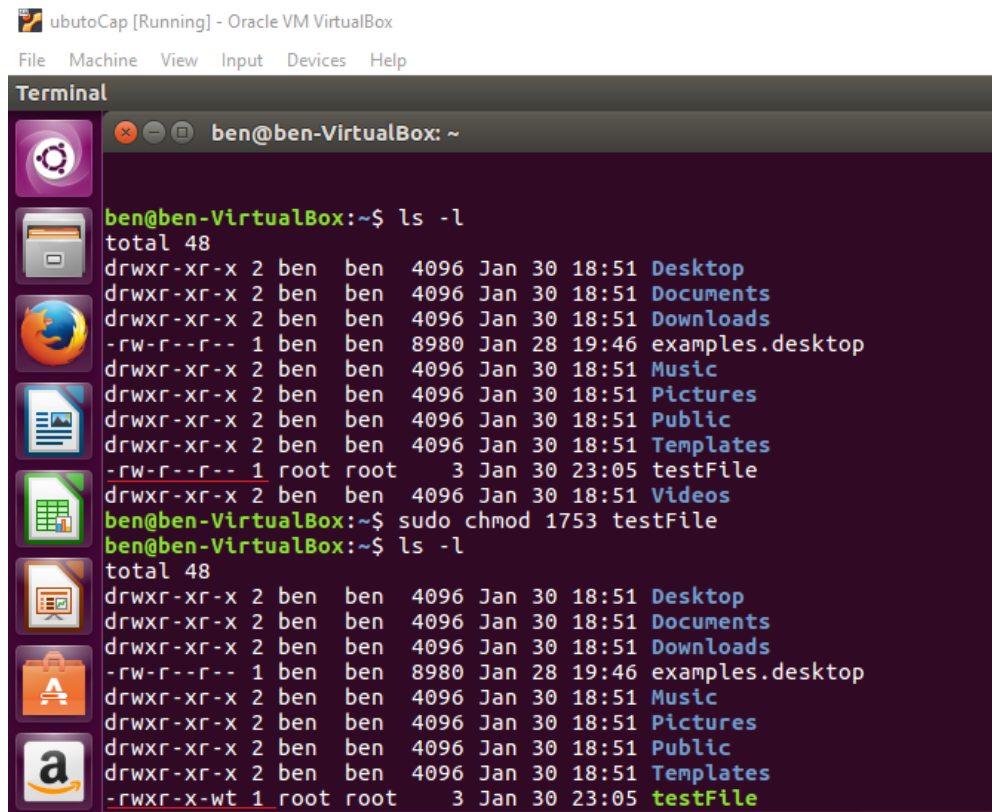
Figure 6: Displaying The Read, Write and Execute Permissions By User

Verification can be done by typing in the command `ls -l`, as we can see in Figure 6 each user has a different set of permissions. In the example above *other* users only have execute permissions while users that are member of that *group (GID)* have read and execute permissions.

4.0: Sticky Bit

4.1: Sticky Bit: Prevent Deletion

The phrase sticky bit refers to a method of preventing a critical file or directory from being deleted or used. In most cases this is done to protect system files where only users that have root privileges, or the user is owner of the file/directory or the user has privileges to delete the file. To declare a file or directory as a sticky bit the command `chmod 1753 file` or `chmod +t file` is used (Figure 7).



The screenshot shows a terminal window titled "ben@ben-VirtualBox: ~". The user runs the command `ls -l`, which lists the contents of the home directory. The output shows various directories and files, including `Desktop`, `Documents`, `Downloads`, `examples.desktop`, `Music`, `Pictures`, `Public`, `Templates`, `testFile`, and `Videos`. The permissions for `testFile` are `-rw-r--r--`. The user then runs the command `sudo chmod 1753 testFile`. After running this command, the user runs `ls -l` again, and the output shows that the permissions for `testFile` have been changed to `-rwxr-x-wt`, indicating it is now a sticky file.

```
ben@ben-VirtualBox:~$ ls -l
total 48
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Desktop
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Documents
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Downloads
-rw-r--r-- 1 ben  ben  8980 Jan 28 19:46 examples.desktop
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Music
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Pictures
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Public
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Templates
-rw-r--r-- 1 root root    3 Jan 30 23:05 testFile
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Videos
ben@ben-VirtualBox:~$ sudo chmod 1753 testFile
ben@ben-VirtualBox:~$ ls -l
total 48
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Desktop
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Documents
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Downloads
-rw-r--r-- 1 ben  ben  8980 Jan 28 19:46 examples.desktop
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Music
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Pictures
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Public
drwxr-xr-x 2 ben  ben  4096 Jan 30 18:51 Templates
-rwxr-x-wt 1 root root    3 Jan 30 23:05 testFile
```

Figure 7: Declaring A StickyBit File

As we can see in Figure 7 after applying the command **chmod 1753 testFile**, the file `testFile` now has a **t** added indicating it's a sticky file. **Note:** a sticky file or directory can be indicated by either a letter **t** and **s**.

4.2: Sticky Bit: Temporary Root Access

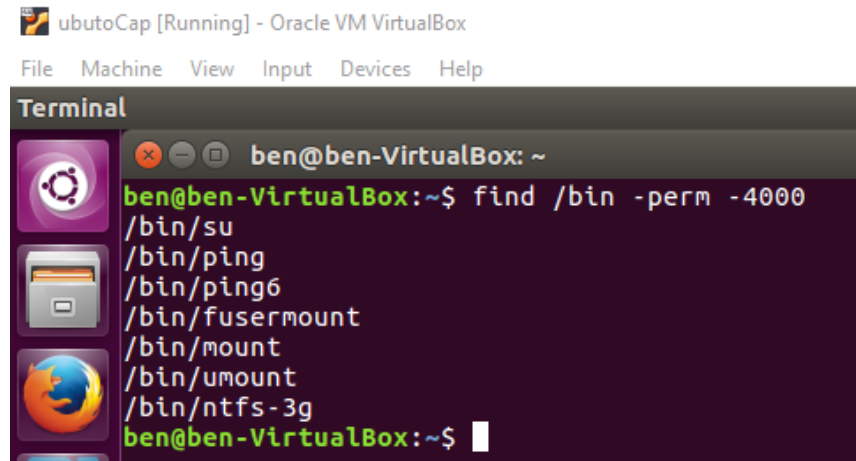
Another reason for using sticky bits is to allow users temporary root privileges to execute a particular file/directory. The user may gain root access, but only for that file/directory.

4.3: Sticky Bit Attacks

As previously mentioned the primary reasons for using a sticky bit is to prevent unauthorized users from accessing critical files and directories. By doing so we prevent critical files such as system files from being modified, replaced or overwritten.

5.0: Setuid Binaries

5.1: Setuid Binaries - What Are Setuid Binaries



```
ubuntoCap [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Terminal
ben@ben-VirtualBox: ~
ben@ben-VirtualBox:~$ find /bin -perm -4000
/bin/su
/bin/ping
/bin/ping6
/bin/fusermount
/bin/mount
/bin/umount
/bin/ntfs-3g
ben@ben-VirtualBox:~$
```

Figure 8: Displaying Setuid Binaries

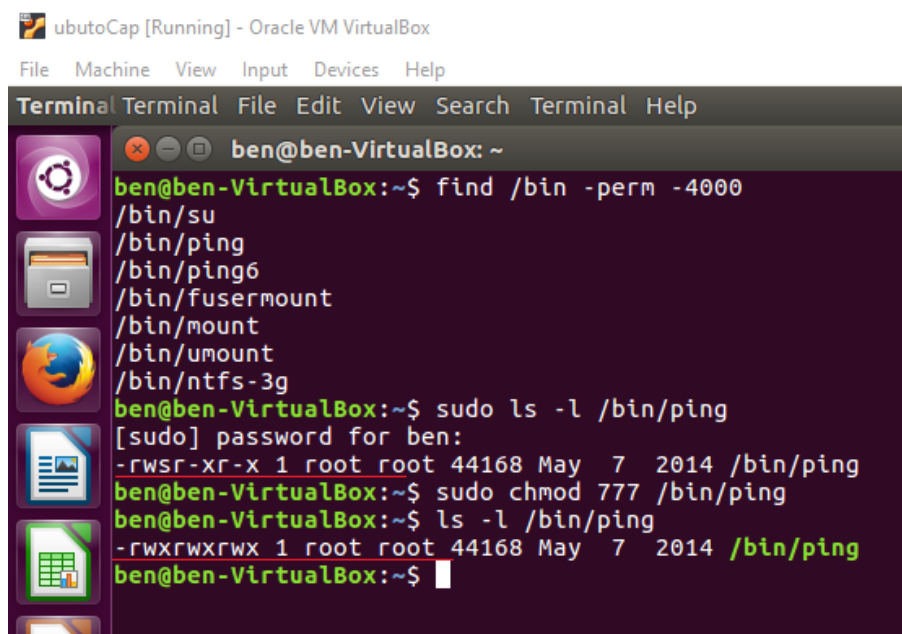
The setuid binaries are essentially sticky bit directory files that contain critical system files that can be accessed only by users who have the read, write and execution rights. A user who has read, write and execution rights to setuid directories will inherit root privileges, essentially changing the users capabilities to root or super root status.

5.2: Setuid Binaries – Why Are They Important

If a user gains or has access to a setuid binary he/she gains access to all the critical system files as they now become root or super root. Similarly they can also change the permissions of a set group id (SGID) and give members of the group id access as well. From a security perspective this can increase the risk of users accessing unauthorized system files.

5.3: Setuid Binaries – Security Risks

As we can see in Figure 8 the directory /bin/ping permissions were changed to read, write and execute for both the SUID and GUID. This means the file directory can now be tampered with. All the other setuid binaries share this risk.

A terminal window titled 'ben@ben-VirtualBox: ~' with a menu bar (File, Machine, View, Input, Devices, Help) and a toolbar. The terminal shows the following commands and output:

```
ben@ben-VirtualBox:~$ find /bin -perm -4000
/bin/su
/bin/ping
/bin/ping6
/bin/fusermount
/bin/mount
/bin/umount
/bin/ntfs-3g
ben@ben-VirtualBox:~$ sudo ls -l /bin/ping
[sudo] password for ben:
-rwsr-xr-x 1 root root 44168 May  7  2014 /bin/ping
ben@ben-VirtualBox:~$ sudo chmod 777 /bin/ping
ben@ben-VirtualBox:~$ ls -l /bin/ping
-rwxrwxrwx 1 root root 44168 May  7  2014 /bin/ping
ben@ben-VirtualBox:~$
```

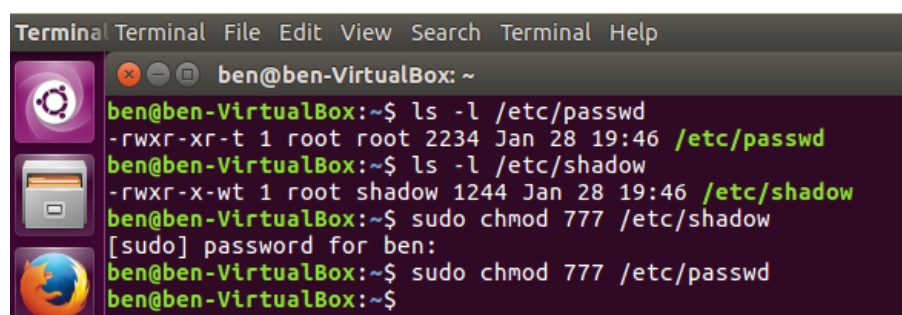
Figure 8: Changing The Permissions Of the /bin/ping Binary.

Once the permissions have been changed any user can now access the setuid binary, then become root and tamper with the system files.

6.0: Potential Vulnerability and Attack Of A Set UID

As an example of a vulnerability and attack we will change a users password by accessing the /etc/passwd and /etc/shadow setuid binaries.

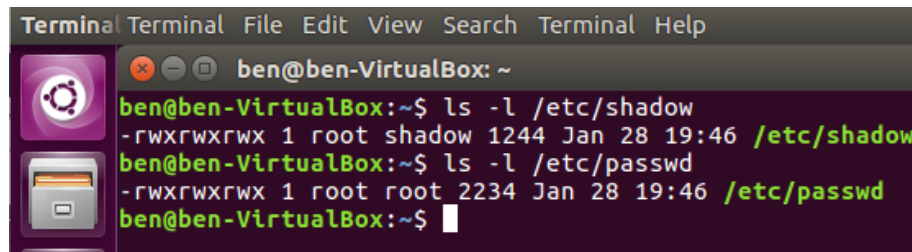
The first step is to change the set permissions with the chmod command to allow any user that becomes root when they access the setuid binaries full read, write and execute capabilities.

A terminal window titled 'ben@ben-VirtualBox: ~' with a menu bar (Terminal, File, Edit, View, Search, Terminal, Help) and a toolbar. The terminal shows the following commands and output:

```
ben@ben-VirtualBox:~$ ls -l /etc/passwd
-rwxr-xr-t 1 root root 2234 Jan 28 19:46 /etc/passwd
ben@ben-VirtualBox:~$ ls -l /etc/shadow
-rwxr-x-wt 1 root shadow 1244 Jan 28 19:46 /etc/shadow
ben@ben-VirtualBox:~$ sudo chmod 777 /etc/shadow
[sudo] password for ben:
ben@ben-VirtualBox:~$ sudo chmod 777 /etc/passwd
ben@ben-VirtualBox:~$
```

Figure 9: Changing The Permissions Of the /bin/ping Binary.

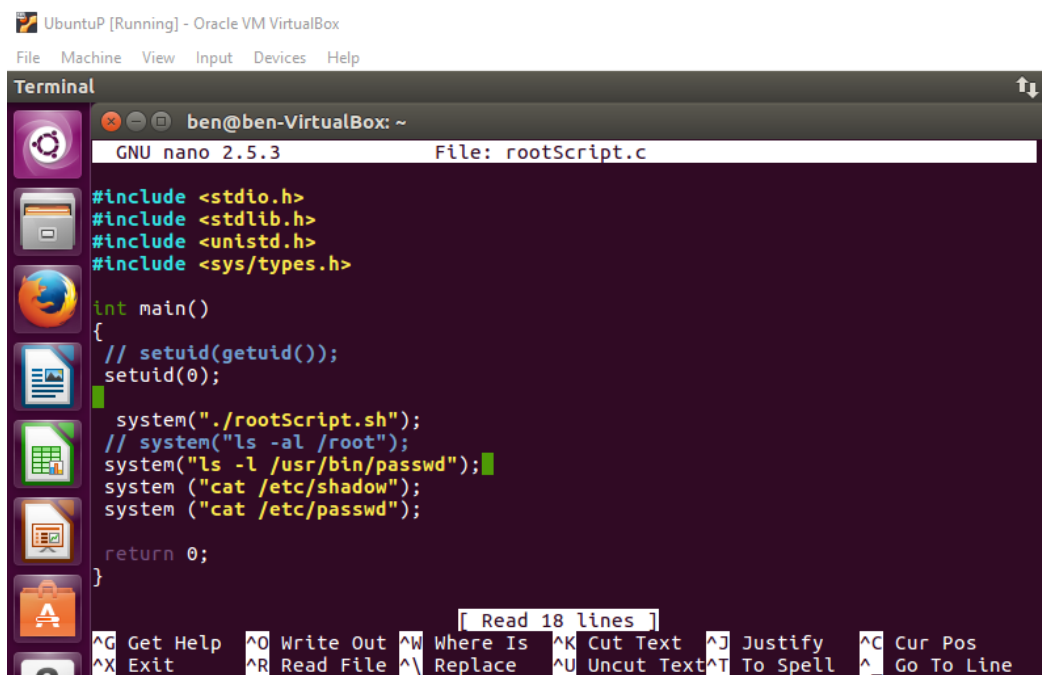
As we can see in Figure 10 below the read, write and execute permissions have been changed for the /etc/passwd and /etc/shadow binaries.



```
ben@ben-VirtualBox: ~  
ben@ben-VirtualBox:~$ ls -l /etc/shadow  
-rwxrwxrwx 1 root shadow 1244 Jan 28 19:46 /etc/shadow  
ben@ben-VirtualBox:~$ ls -l /etc/passwd  
-rwxrwxrwx 1 root root 2234 Jan 28 19:46 /etc/passwd  
ben@ben-VirtualBox:~$
```

Figure 10: Displaying The Change In Permissions

Since the binary files are now accessible a simple script called rootScript.c can access the binaries and become root simply by making a system call to the corresponding files.



```
GNU nano 2.5.3 File: rootScript.c  
  
#include <stdio.h>  
#include <stdlib.h>  
#include <unistd.h>  
#include <sys/types.h>  
  
int main()  
{  
    // setuid(getuid());  
    setuid(0);  
  
    system("./rootScript.sh");  
    // system("ls -al /root");  
    system("ls -l /usr/bin/passwd");  
    system ("cat /etc/shadow");  
    system ("cat /etc/passwd");  
  
    return 0;  
}
```

Figure 11: The rootScript.c

As we can see in Figure 12 and Figure 13 shown below, we were able to view all the user passwords and change them by using rootScript.c.

```
UbuntuP [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help

Terminal
ben@ben-VirtualBox: ~
ben@ben-VirtualBox:~$ ./rootScript
-rwsr-xr-x 1 root root 54256 May 16 2017 /usr/bin/passwd
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/usr/sbin/nologin
bin:x:2:2:bin:/bin:/usr/sbin/nologin
sys:x:3:3:sys:/dev:/usr/sbin/nologin
sync:x:4:65534:sync:/bin:/bin/sync
games:x:5:60:games:/usr/games:/usr/sbin/nologin
man:x:6:12:man:/var/cache/man:/usr/sbin/nologin
lp:x:7:7:lp:/var/spool/lpd:/usr/sbin/nologin
mail:x:8:8:mail:/var/mail:/usr/sbin/nologin
news:x:9:9:news:/var/spool/news:/usr/sbin/nologin
uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
proxy:x:13:13:proxy:/bin:/usr/sbin/nologin
www-data:x:33:33:www-data:/var/www:/usr/sbin/nologin
backup:x:34:34:backup:/var/backups:/usr/sbin/nologin
list:x:38:38:Mailing List Manager:/var/list:/usr/sbin/nologin
irc:x:39:39:ircd:/var/run/ircd:/usr/sbin/nologin
gnats:x:41:41:Gnats Bug-Reporting System (admin)/var/lib/gnats:/usr/sbin/nologin
nobody:x:65534:65534:nobody:/nonexistent:/usr/sbin/nologin
systemd-timesync:x:100:102:systemd Time Synchronization,,,:/run/systemd:/bin/false
systemd-network:x:101:103:systemd Network Management,,,:/run/systemd/netif:/bin/false
systemd-resolve:x:102:104:systemd Resolver,,,:/run/systemd/resolve:/bin/false
systemd-bus-proxy:x:103:105:systemd Bus Proxy,,,:/run/systemd:/bin/false
syslog:x:104:108:/home/syslog:/bin/false
_apt:x:105:65534:/nonexistent:/bin/false
messagebus:x:106:110:/var/run/dbus:/bin/false
uuidd:x:107:111:/run/uuidd:/bin/false
lightdm:x:108:114:Light Display Manager:/var/lib/lightdm:/bin/false
whoopsie:x:109:117:/nonexistent:/bin/false
avahi-autoipd:x:110:119:Avahi autoip daemon,,,:/var/lib/avahi-autoipd:/bin/false
```

Figure 12: Displaying The User Passwords

```
Terminal
ben@ben-VirtualBox: ~
uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
proxy:x:13:13:proxy:/bin:/usr/sbin/nologin
www-data:x:33:33:www-data:/var/www:/usr/sbin/nologin
backup:x:34:34:backup:/var/backups:/usr/sbin/nologin
list:x:38:38:Mailing List Manager:/var/list:/usr/sbin/nologin
irc:x:39:39:ircd:/var/run/ircd:/usr/sbin/nologin
gnats:x:41:41:Gnats Bug-Reporting System (admin)/var/lib/gnats:/usr/sbin/nologin
nobody:x:65534:65534:nobody:/nonexistent:/usr/sbin/nologin
systemd-timesync:x:100:102:systemd Time Synchronization,,,:/run/systemd:/bin/false
systemd-network:x:101:103:systemd Network Management,,,:/run/systemd/netif:/bin/false
systemd-resolve:x:102:104:systemd Resolver,,,:/run/systemd/resolve:/bin/false
systemd-bus-proxy:x:103:105:systemd Bus Proxy,,,:/run/systemd:/bin/false
syslog:x:104:108:/home/syslog:/bin/false
_apt:x:105:65534:/nonexistent:/bin/false
messagebus:x:106:110:/var/run/dbus:/bin/false
uuidd:x:107:111:/run/uuidd:/bin/false
lightdm:x:108:114:Light Display Manager:/var/lib/lightdm:/bin/false
whoopsie:x:109:117:/nonexistent:/bin/false
avahi-autoipd:x:110:119:Avahi autoip daemon,,,:/var/lib/avahi-autoipd:/bin/false
avahi:x:111:120:Avahi mDNS daemon,,,:/var/run/avahi-daemon:/bin/false
dnsmasq:x:112:65534:dnsmasq,,,:/var/lib/misc:/bin/false
colord:x:113:123:colord colour management daemon,,,:/var/lib/colord:/bin/false
speech-dispatcher:x:114:29:Speech Dispatcher,,,:/var/run/speech-dispatcher:/bin/false
hplip:x:115:7:HPLIP system user,,,:/var/run/hplip:/bin/false
kernoops:x:116:65534:Kernel Oops Tracking Daemon,,,:/bin/false
pulse:x:117:124:PulseAudio daemon,,,:/var/run/pulse:/bin/false
rtkit:x:118:126:RealtimeKit,,,:/proc:/bin/false
saned:x:119:127:/var/lib/saned:/bin/false
usbmux:x:120:46:usbmux daemon,,,:/var/lib/usbmux:/bin/false
ben:x:1000:1000:ben,,,:/home/ben:/bin/bash
user1:x:1001:1001:User1,,,:/home/user1:/bin/bash
ben@ben-VirtualBox:~$
```

Figure 13: Changing The User Passwords

Again, this is just one example of how an attack could be carried out there exists many other ways of exploiting setuid. But it demonstrates the risks setuid binaries have if they are tampered with and the wrong users are given higher privileges.

7.0: TCP Wrappers and Firewalls Protection



Figure 14: An Artist Depiction Of A Firewall

As the name suggests a firewall or TCP wrapper acts as a barrier between the network and other networks the user(s) may connect to. TCP wrappers and firewalls protect the network by creating rules that govern the network. These rules include blocking incoming packets from specific IPs to filtering protocol access of incoming/outgoing traffic from specific ports. The primary reason why these rules are in place is to prevent threats from malicious code, these include viruses and malware that may enter the network or machine.

8.0: TCP Wrappers vs Firewalls – Technical Differences

8.1: Firewalls

A host based firewall is a firewall that is installed on every machine and monitors incoming packet traffic on the individual machine.

8.2: TCP Wrapper

Unlike host based firewalls a TCP wrapper is essentially an access control list (ACL) library that controls UNIX processes and their user privileges. As an example suppose that root only access is maintained throughout the system. As such the ACL will prevent outside network traffic from accessing files/directories and even processes from being executed because it does not have root privileges.

9.0: VPN System Changes and Behaviour

When a user connects to a virtual private network the user may experience changes in the delivery of content he/she may have access to. For example in countries such as China where certain websites are censored or blocked the user may now be able to access full content. Moreover the VPN will also assign the user a new IP which will replace their previous IP.

The user can verify that they connected to the VPN once the *handshake* takes place, this is when both the VPN and user exchange their public keys. Once the public keys have been authenticated the *handshake* confirms that the VPN is indeed the VPN and the user is indeed the user.

10.0: VPN Organization Security

One of the primary reasons why an organization may setup a VPN is to allow its employees to securely connect to the organization's network while being connected to an insecure local network. The local network maybe insecure but the point to point connection between the employee's machine and the network is secure because both the network and client are authenticating each other via their public keys.

The disadvantage to a VPN is once the network becomes infected it will spread to every user that connects to the VPN. An excellent example how this may take place is let's assume a client starts to open their Outlook and view all their incoming emails. The client may not be aware or forgets to connect to the VPN, as the user opens their emails they receive a malware which infects their machine. The client then realizes they are not connected to the VPN and decides to connect but while doing so they infect the VPN network.

Moreover the VPN does not completely solve the problem of public key authentication, the connection between the user and the VPN maybe secure but once traffic leaves the VPN on the behalf of the user the connection again becomes insecure. In essence a VPN only serves as an intermediate between the user and accessing the world wide web.

11.0: Carleton VPN

The primary VPN used by the Carleton University network is AnyConnect.

After initial installation the AnyConnect VPN works by sending a digital certificate which is then installed onto the user's browser.

Some of the advantages to using the VPN are accessing the OpenStack Dashboard off campus, accessing your personal network drives and the department network drives.

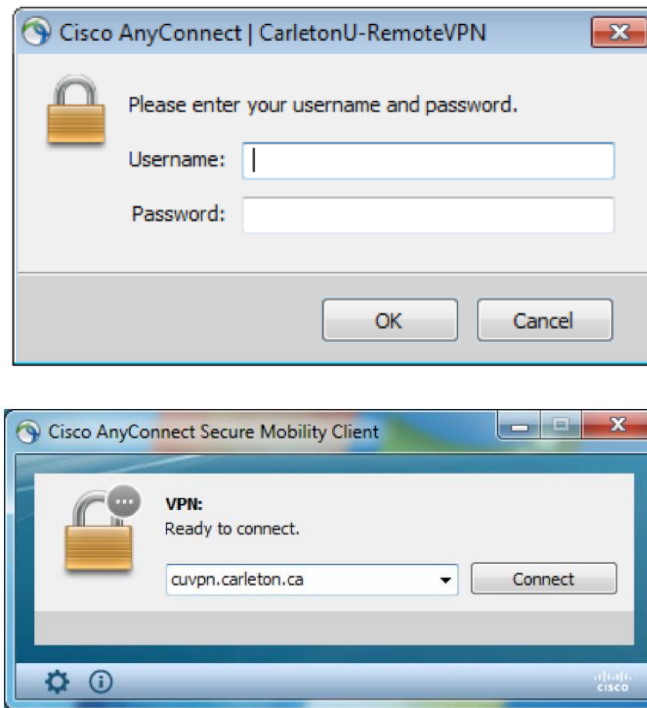


Figure 15: Connecting With The AnyConnect VPN

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