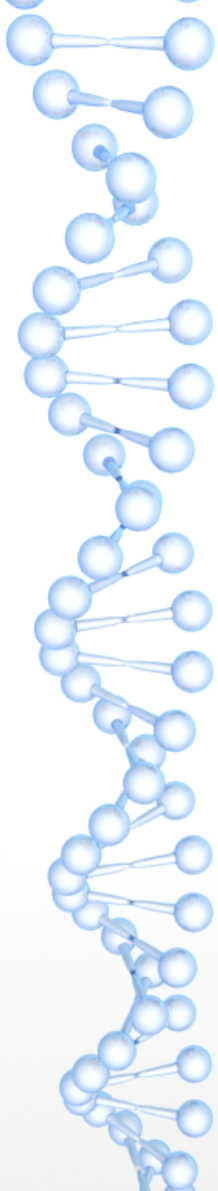
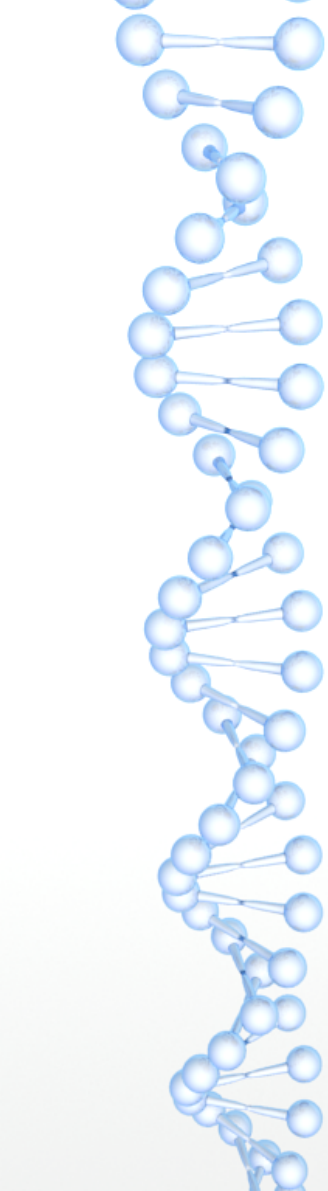


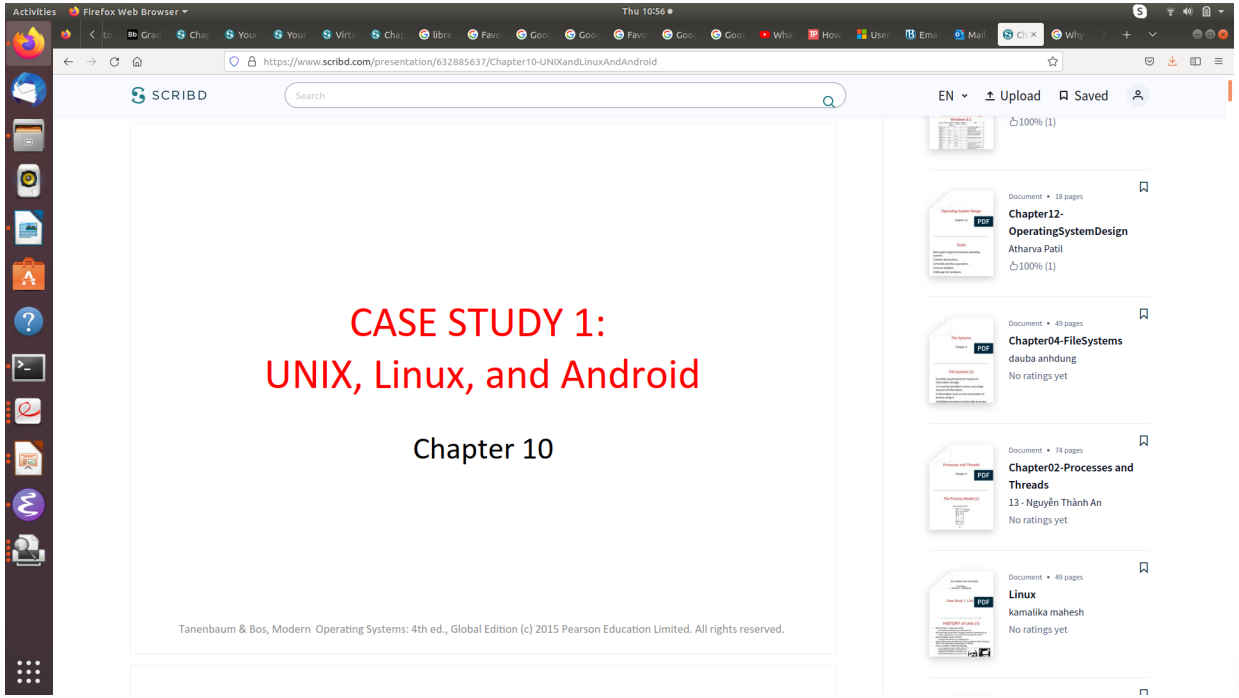
# Chapter 10 Linux/Unix/Android and Ch11/5.6 Windows11

We want to look at specifics for Linux, Android and Windows.



# Linux introduction

- 10.1 History of UNIX and Linux
- 10.2 Overview of Linux: goals, interfaces, shell, kernel
- 10.3 Processes in Linux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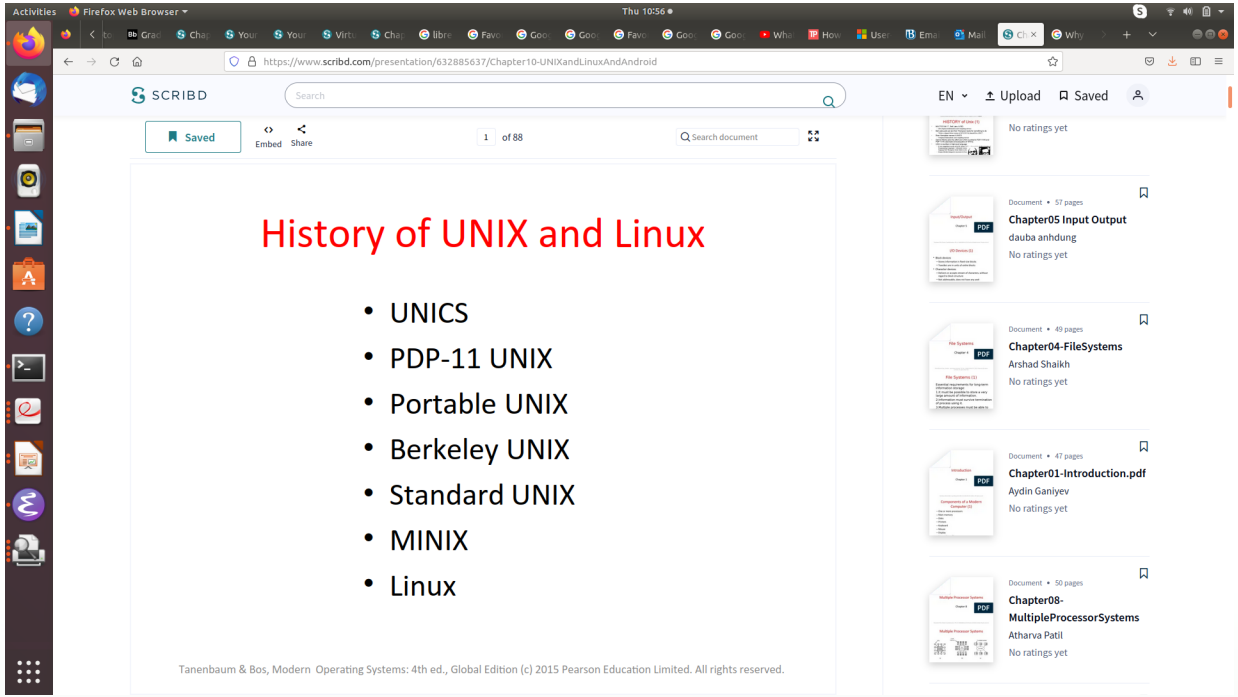
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Portable UNIX
Berkeley UNIX
Standard UNIX
MINIX
Linux
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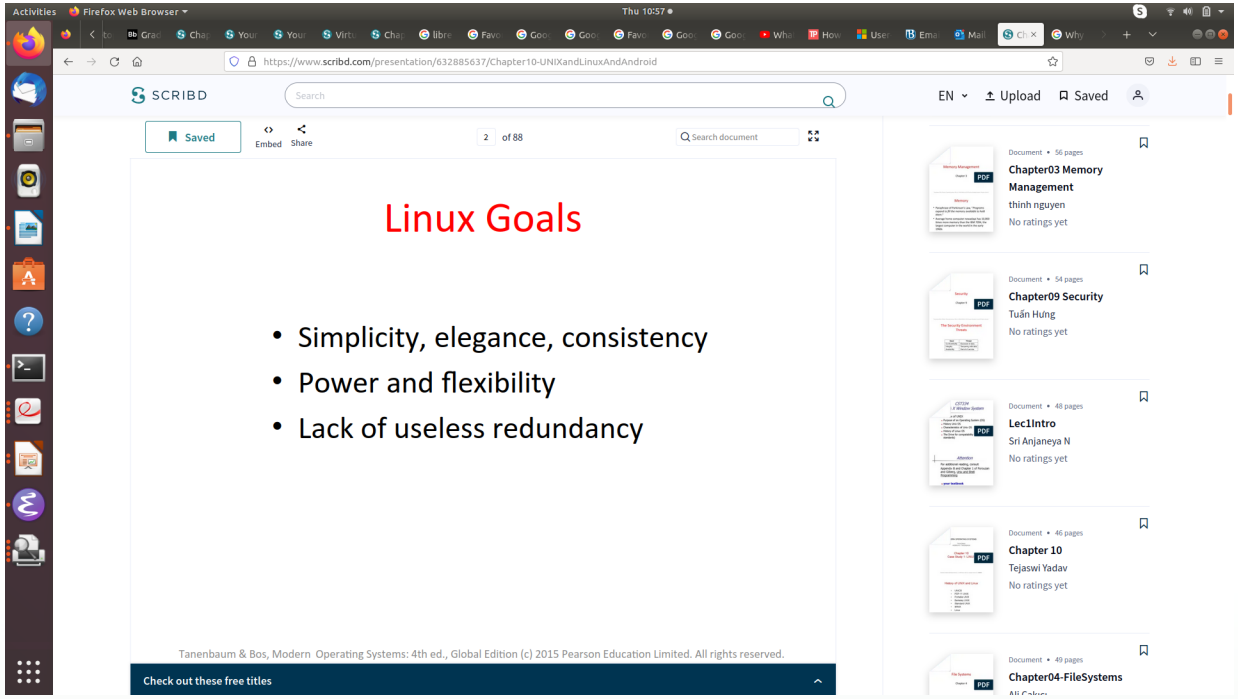
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Linux Goals
• Simplicity, elegance, consistency
• Power and flexibility
• Lack of useless redundancy
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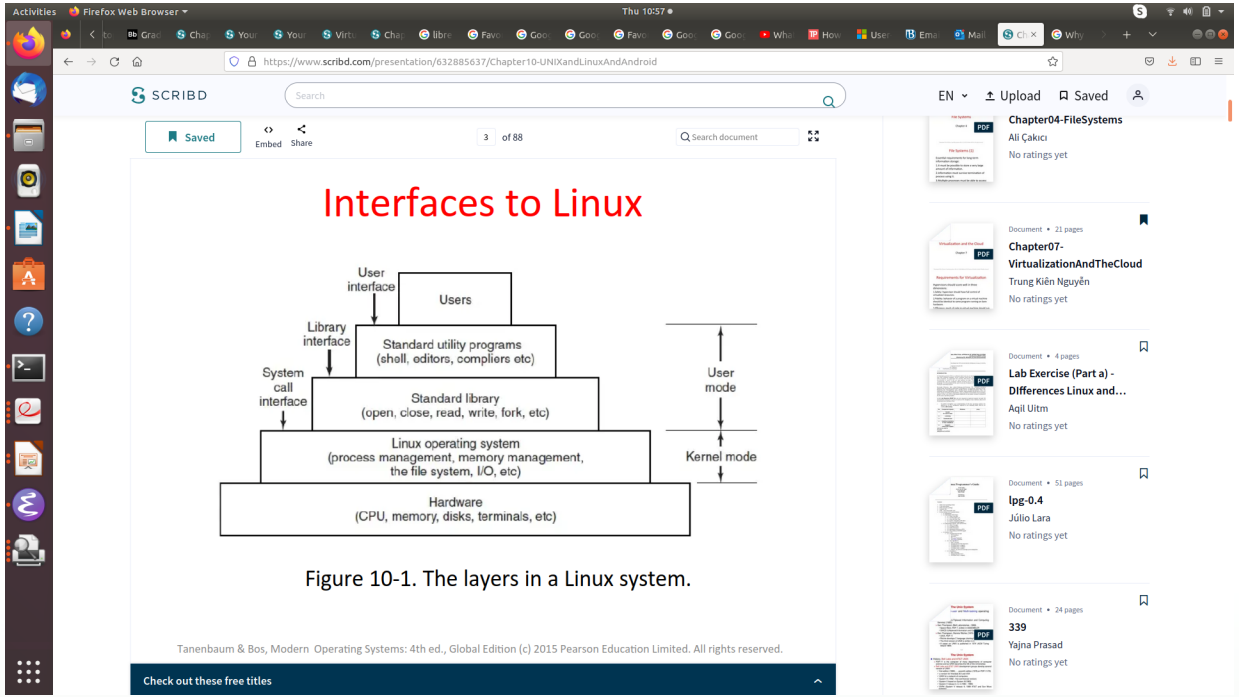
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Interfaces to Linux
User interface
Users
Library interface
Standard utility programs (shell, editors, compliers etc)
System call interface
Standard library (open, close, read, write, fork, etc)
Linux operating system (process management, memory management, the file system, I/O, etc)
Hardware (CPU, memory, disks, terminals, etc)
User mode
Kernel mode
Figure 10-1. The layers in a Linux system.
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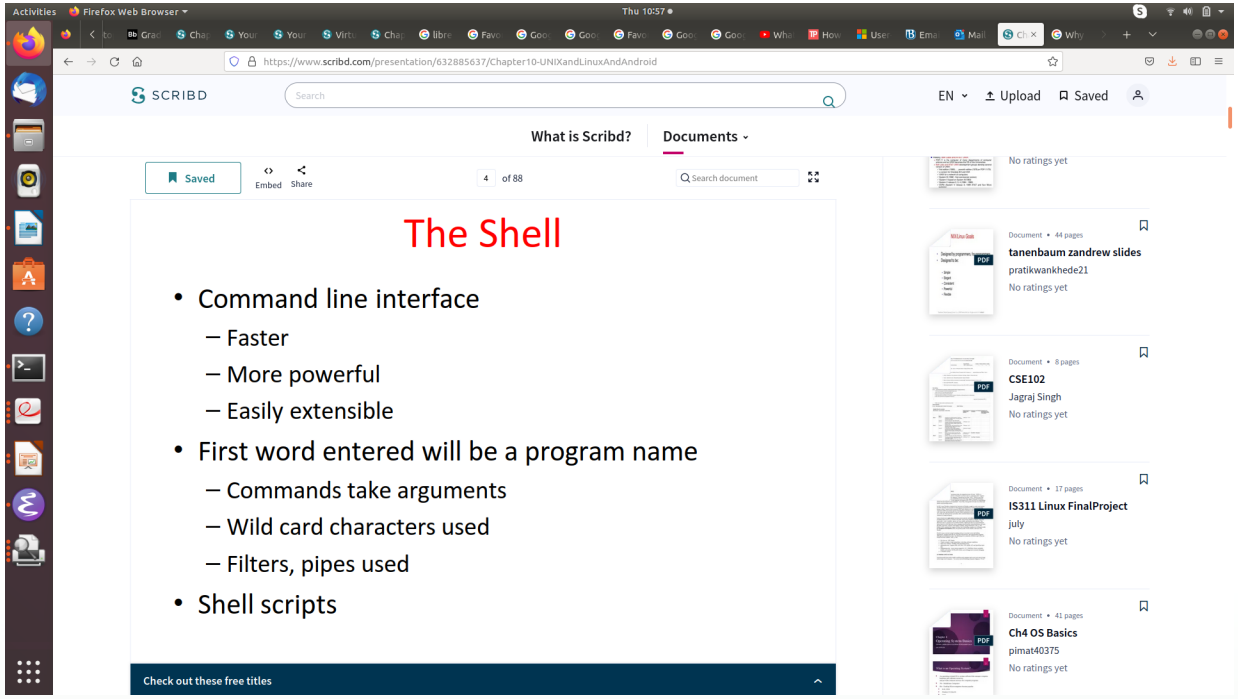
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The Shell
• Command line interface
– Faster
– More powerful
– Easily extensible
• First word entered will be a program name
– Commands take arguments
– Wild card characters used
– Filters, pipes used
• Shell scripts
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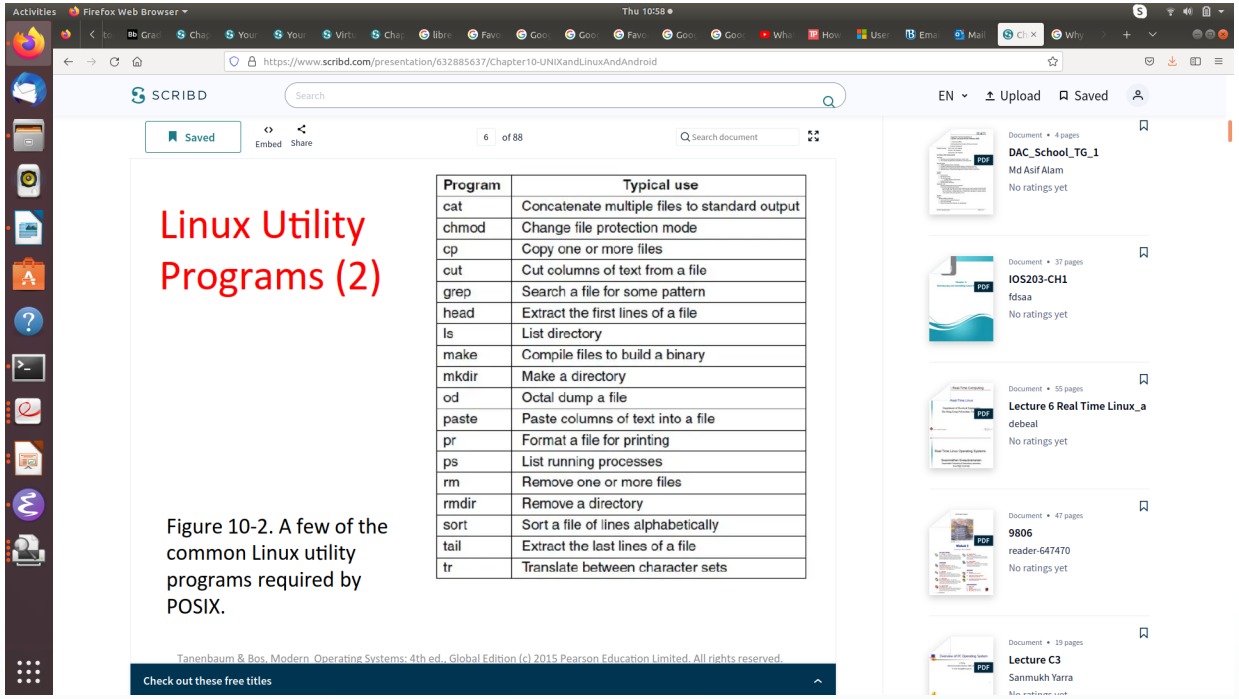
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Linux Utility Programs (2)
Program | Typical use
cat | Concatenate multiple files to standard output
chmod | Change file protection mode
cp | Copy one or more files
cut | Cut columns of text from a file
grep | Search a file for some pattern
head | Extract the first lines of a file
ls | List directory
make | Compile files to build a binary
mkdir | Make a directory
od | Octal dump a file
paste | Paste columns of text into a file
pr | Format a file for printing
ps | List running processes
rm | Remove one or more files
rmdir | Remove a directory
sort | Sort a file of lines alphabetically
tail | Extract the last lines of a file
tr | Translate between character sets
Figure 10-2. A few of the common Linux utility programs required by POSIX.
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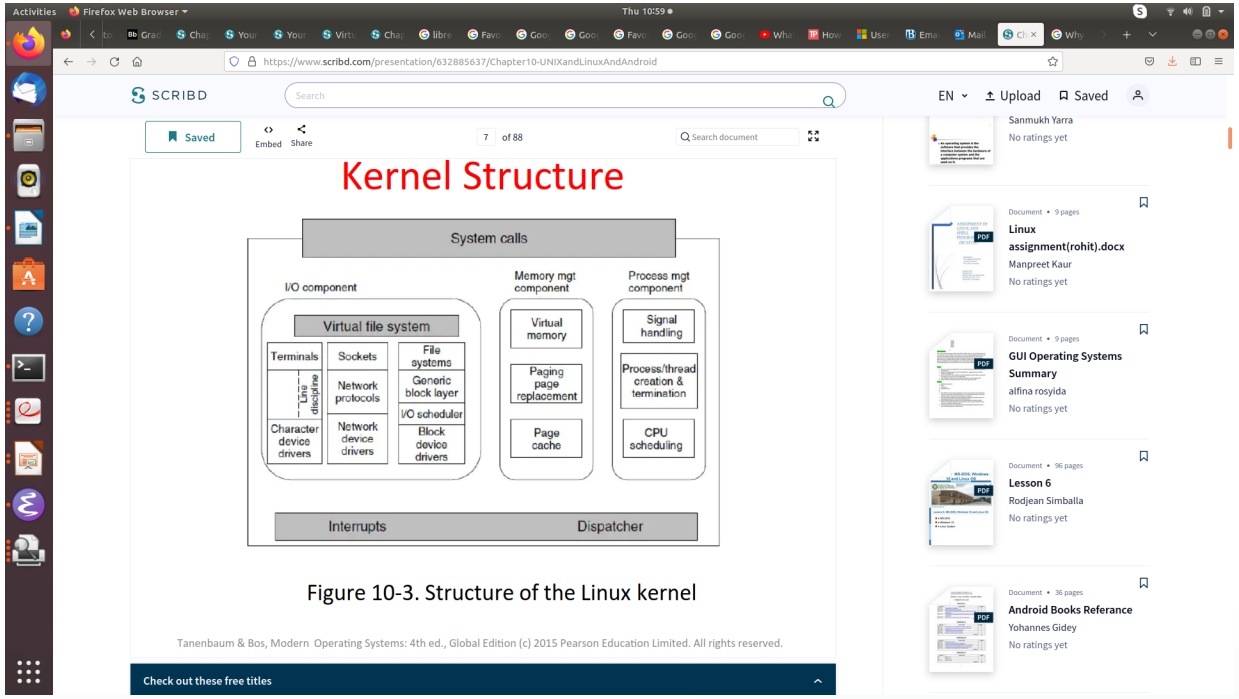
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Kernel Structure
System calls
I/O component
Memory mgt component
Process mgt component
Virtual file system
Terminals
Sockets
File systems
Line discipline
Network protocols
Generic block layer
I/O scheduler
Character device drivers
Network device drivers
Block device drivers
Virtual memory
Paging page replacement
Page cache
Signal handling
Process/thread creation & termination
CPU scheduling
Interrupts
Dispatcher
Figure 10-3. Structure of the Linux kernel
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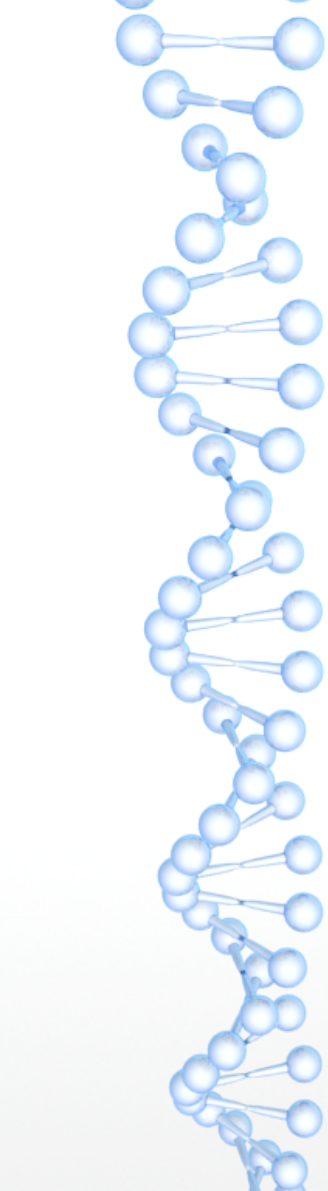
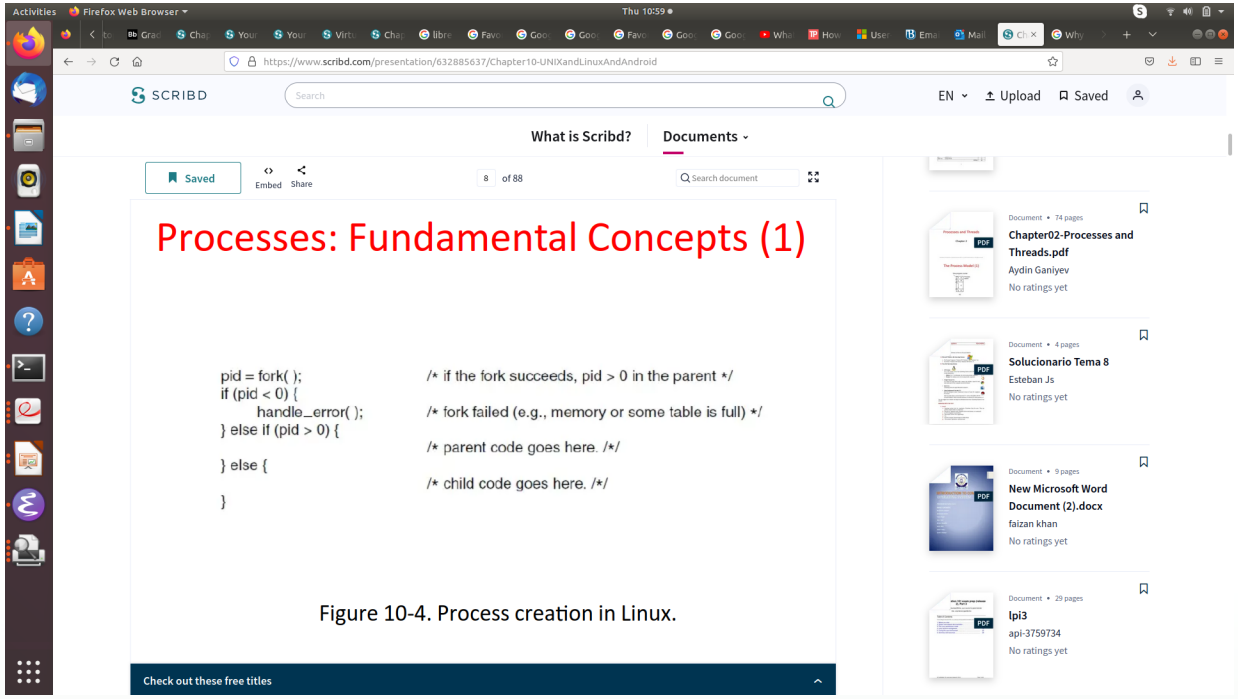


# 10.3 Processes in Linux

- Main activities in a Linux system are the processes.
- They are similar to classical sequential processes studied in Ch 2.
- Linux is multiprocessing so daemon processes run in background mode.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Processes: Fundamental Concepts (1)
pid = fork( );
if (pid < 0) {
handle_error( );
} else if (pid > 0) {
} else {
}
/* if the fork succeeds, pid > 0 in the parent */
/* fork failed (e.g., memory or some table is full) */
/* parent code goes here. /*/
/* child code goes here. /*/
Figure 10-4. Process creation in Linux.
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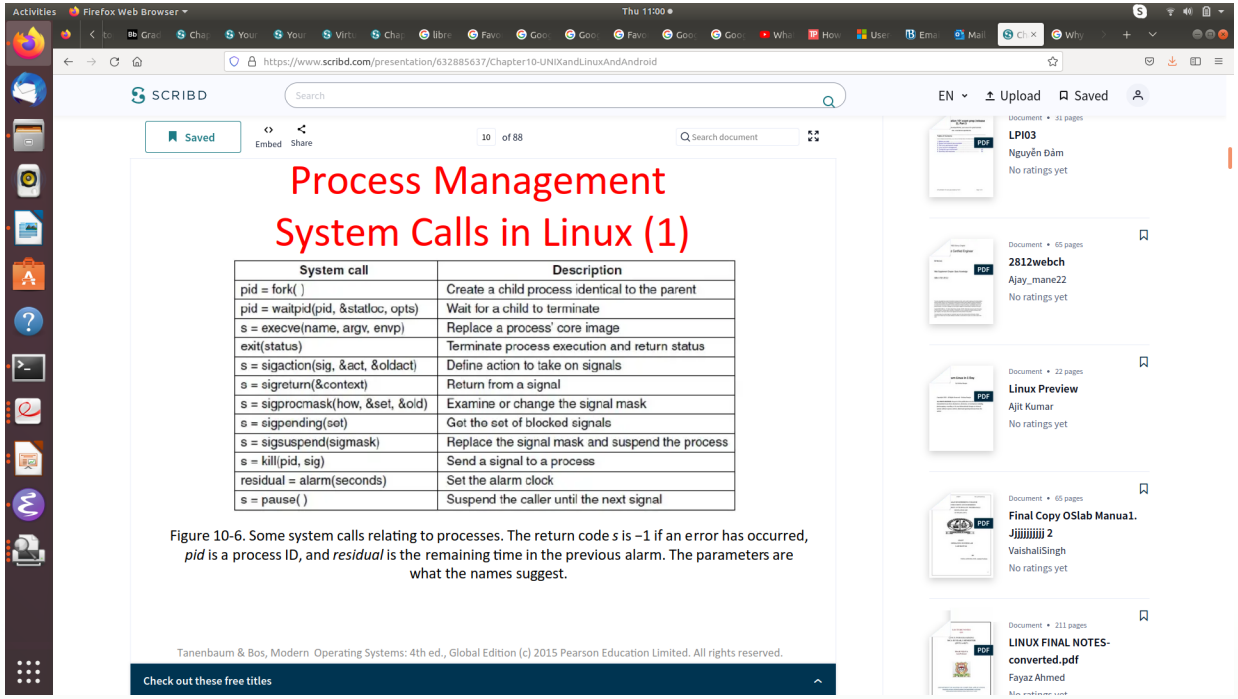
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Process Management
System Calls in Linux (1)
System call | Description
pid = fork( ) | Create a child process identical to the parent
pid = waitpid(pid, &statloc, opts) | Wait for a child to terminate
s = execve(name, argv, envp) | Replace a process' core image
exit(status) | Terminate process execution and return status
s = sigaction(sig, &act, &oldact) | Define action to take on signals
s = sigreturn(&context) | Return from a signal
s = sigprocmask(how, &set, &old) | Examine or change the signal mask
s = sigpending(set) | Get the set of blocked signals
s = sigsuspend(sigmask) | Replace the signal mask and suspend the process
s = kill(pid, sig) | Send a signal to a process
residual = alarm(seconds) | Set the alarm clock
s = pause( ) | Suspend the caller until the next signal
Figure 10-6. Some system calls relating to processes. The return code s is −1 if an error has occurred, pid is a process ID, and residual is the remaining time in the previous alarm. The parameters are what the names suggest.
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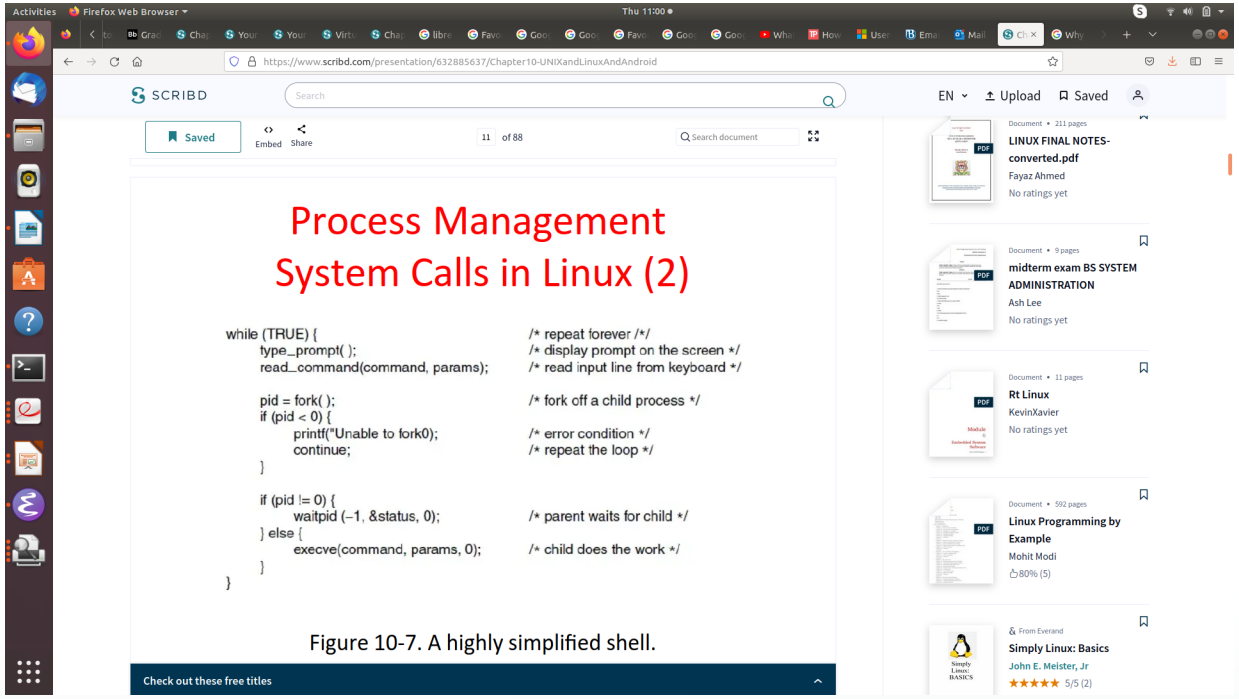
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Process Management
System Calls in Linux (2)
while (TRUE) {
type_prompt( );
read_command(command, params);
pid = fork( );
if (pid < 0) {
printf("Unable to fork0);
continue;
}
if (pid != 0) {
waitpid (–1, &status, 0);
} else {
execve(command, params, 0);
}
}
/* repeat forever */
/* display prompt on the screen */
/* read input line from keyboard */
/* fork off a child process */
/* error condition */
/* repeat the loop */
/* parent waits for child */
/* child does the work */
Figure 10-7. A highly simplified shell.
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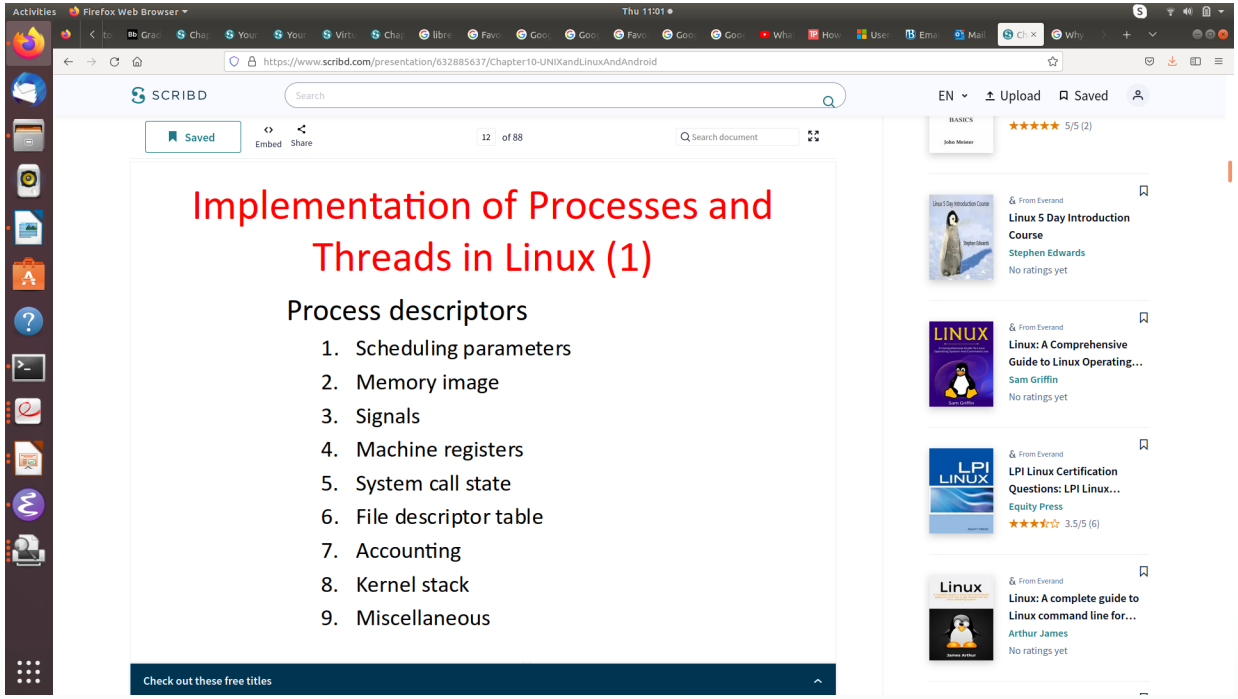
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Implementation of Processes and Threads in Linux (1)
Process descriptors
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3. Signals
4. Machine registers
5. System call state
6. File descriptor table
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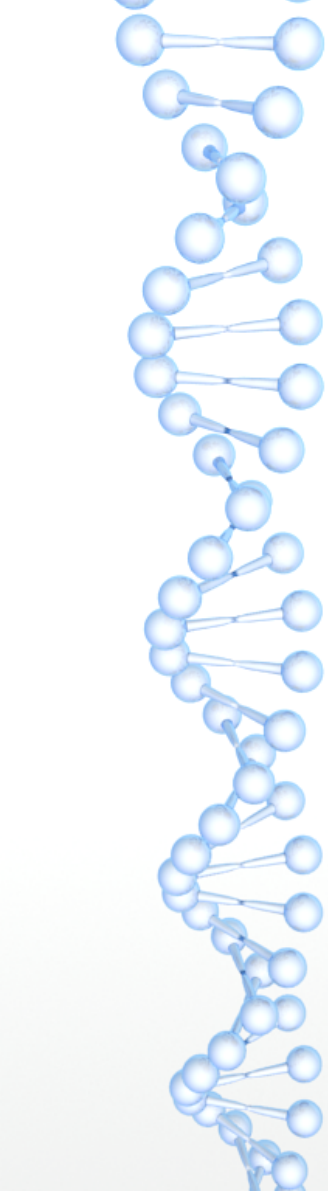

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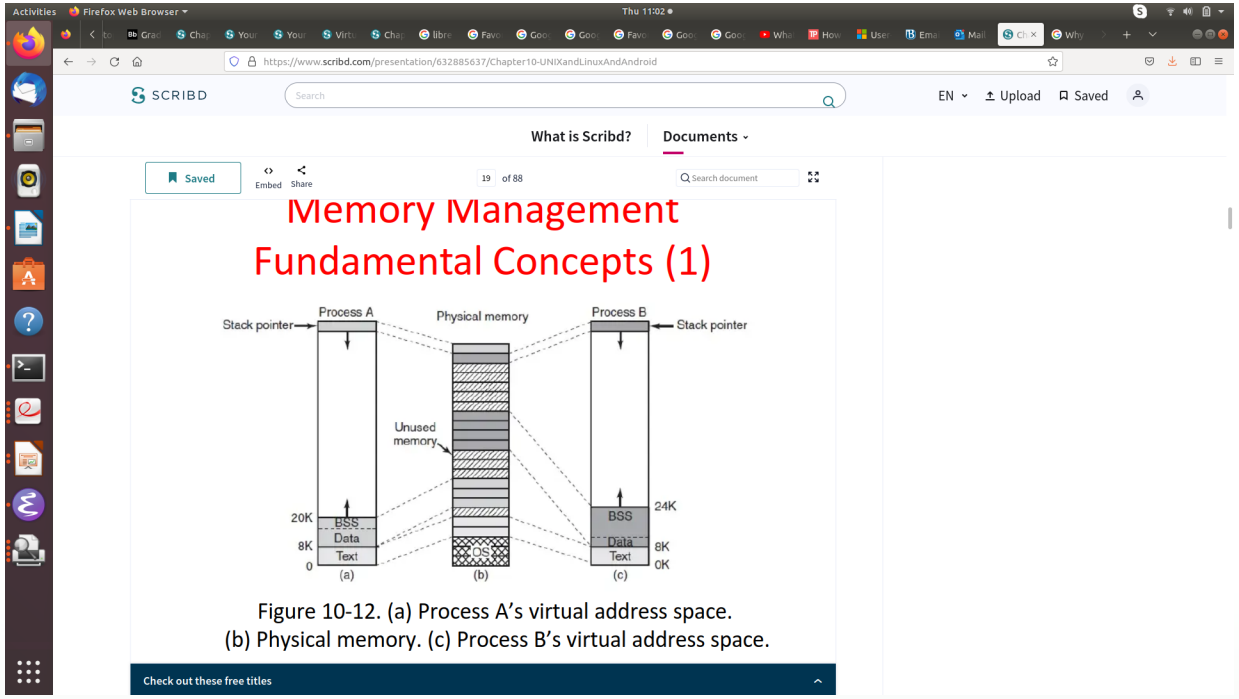
- 10.4 Memory Management in Linux
- 10.5 Input/Output in Linux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Memory Management
Fundamental Concepts (1)
Stack pointer
Process A
Physical memory
Process B
Stack pointer
Unused memory
20K
BSS
Data
Text
8K
0
(a)
OS
(b)
BSS
Data
Text
24K
8K
0K
(c)
Figure 10-12. (a) Process A's virtual address space.
(b) Physical memory. (c) Process B's virtual address space.
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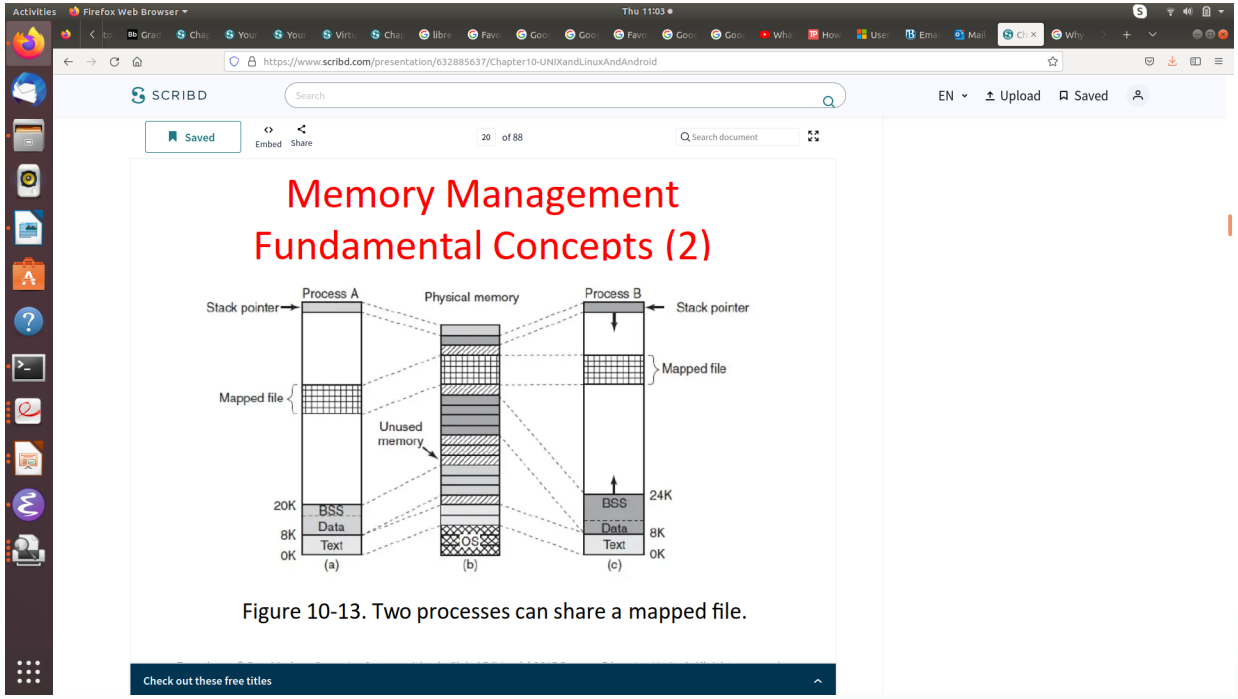
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Memory Management
Fundamental Concepts (2)
Process A
Physical memory
Process B
Stack pointer
Stack pointer
Mapped file
Mapped file
Unused memory
20K
8K
0K
BSS
Data
Text
OS
24K
BSS
Data
8K
Text
0K
(a)
(b)
(c)
Figure 10-13. Two processes can share a mapped file.
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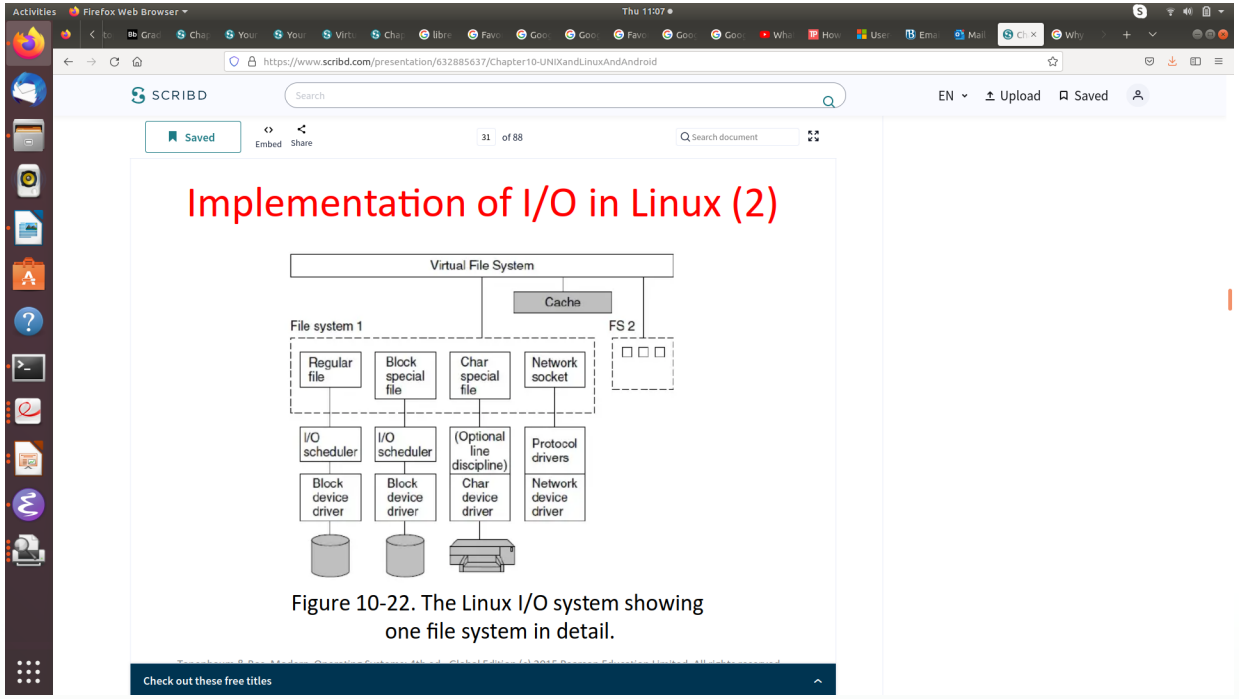
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Implementation of I/O in Linux (2)
Virtual File System
Cache
File system 1
FS 2
Regular file
Block special file
Char special file
Network socket
I/O scheduler
I/O scheduler
(Optional line discipline)
Protocol drivers
Block device driver
Block device driver
Char device driver
Network device driver
Figure 10-22. The Linux I/O system showing one file system in detail.
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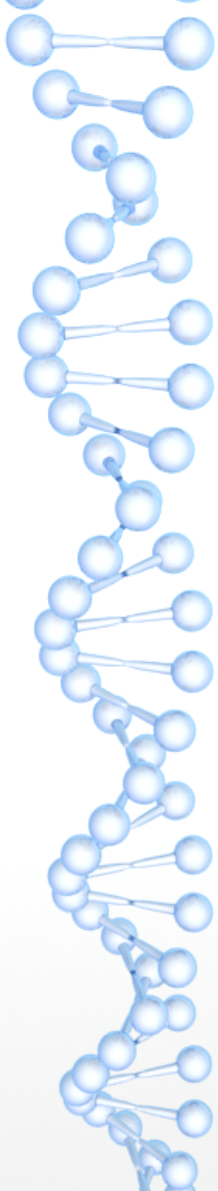
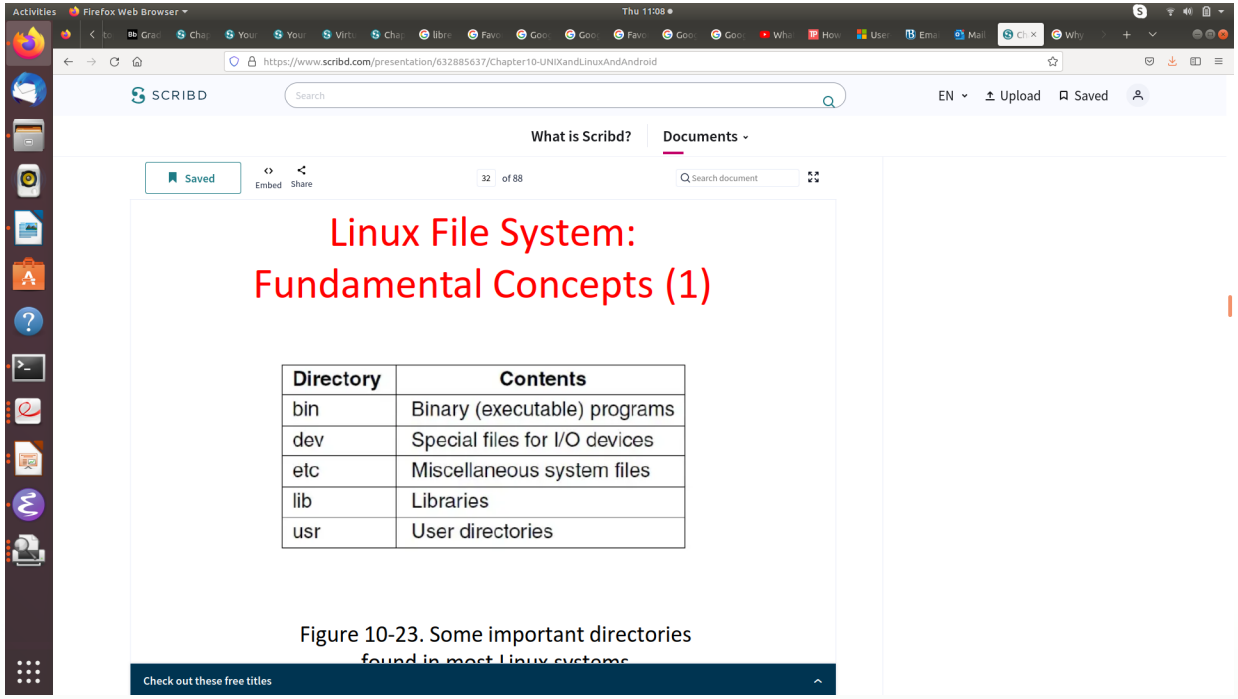


# 10.6 The Linux File System

- Fundamental Concepts
- File System Calls
- Implementation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Linux File System:
Fundamental Concepts (1)
Directory
Contents
bin
Binary (executable) programs
dev
Special files for I/O devices
etc
Miscellaneous system files
lib
Libraries
usr
User directories
Figure 10-23. Some important directories
found in most Linux systems
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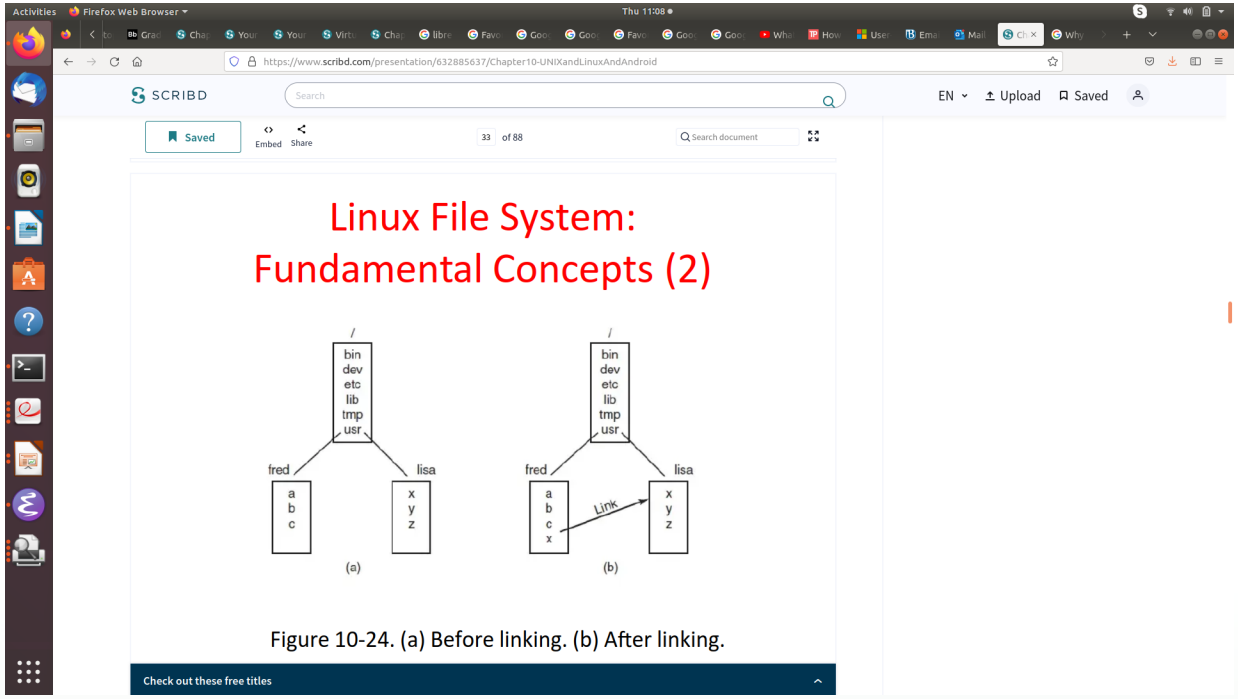
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Linux File System:
Fundamental Concepts (2)
/
bin
dev
etc
lib
tmp
usr
fred
lisa
a
b
c
x
y
z
(a)
Link
(b)
Figure 10-24. (a) Before linking. (b) After linking.
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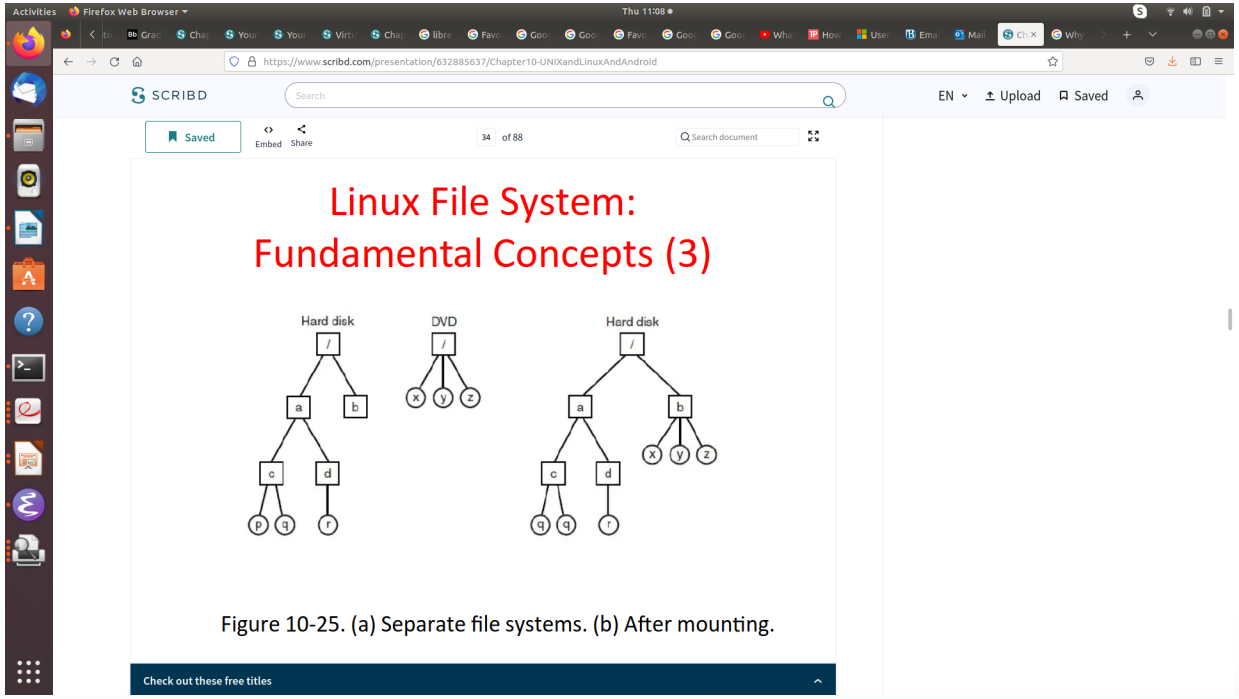
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Linux File System:
Fundamental Concepts (3)
Hard disk
DVD
Hard disk
Figure 10-25. (a) Separate file systems. (b) After mounting.
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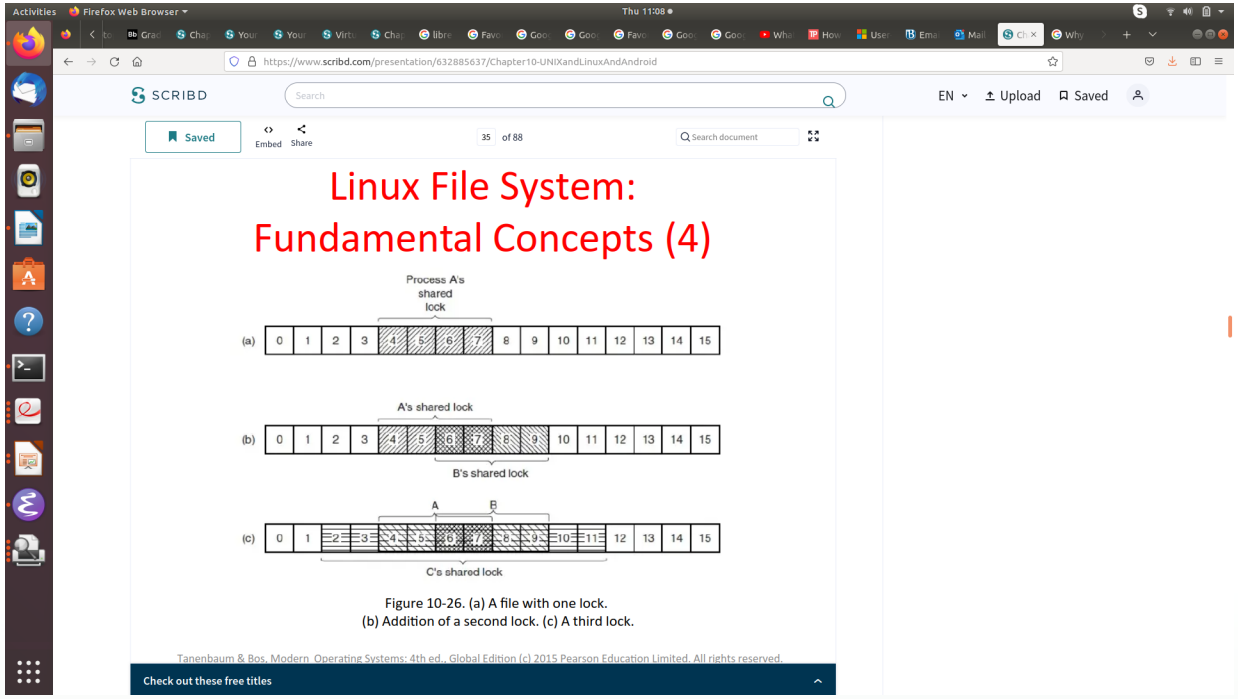
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Linux File System:
Fundamental Concepts (4)
Process A's shared lock
(a)
A's shared lock
(b)
B's shared lock
A
B
(c)
C's shared lock
Figure 10-26. (a) A file with one lock.
(b) Addition of a second lock. (c) A third lock.
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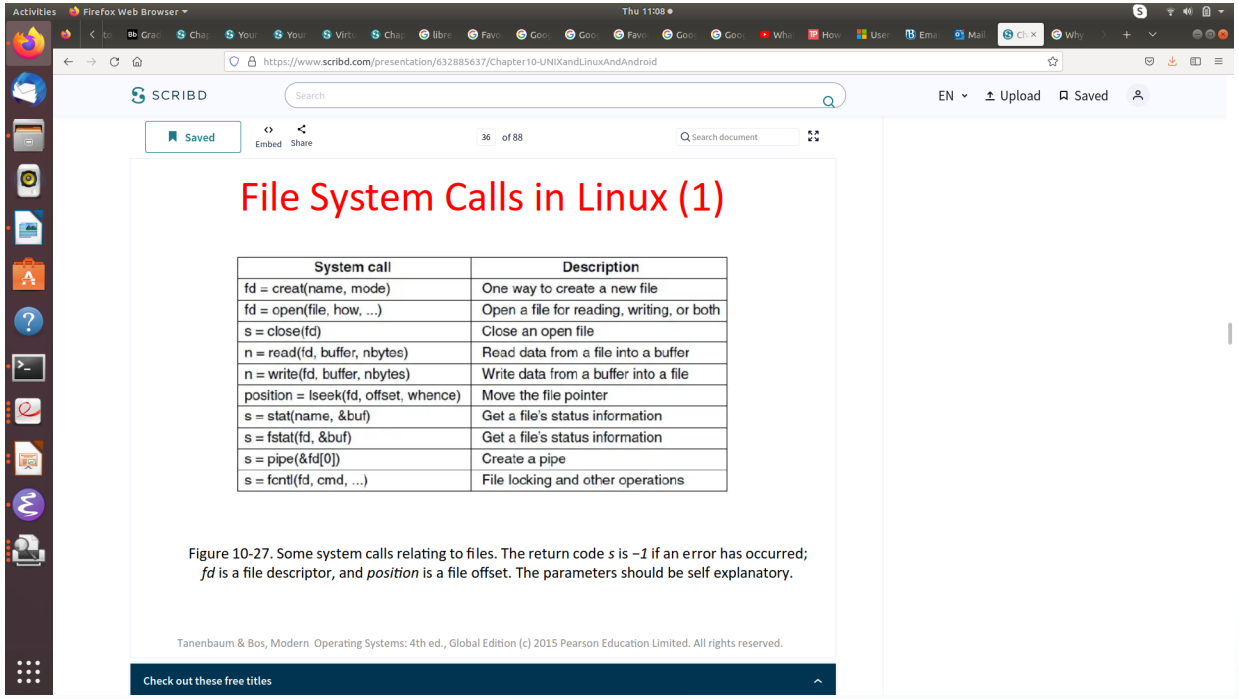
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File System Calls in Linux (1)
System call | Description
fd = creat(name, mode) | One way to create a new file
fd = open(file, how, ...) | Open a file for reading, writing, or both
s = close(fd) | Close an open file
n = read(fd, buffer, nbytes) | Read data from a file into a buffer
n = write(fd, buffer, nbytes) | Write data from a buffer into a file
position = lseek(fd, offset, whence) | Move the file pointer
s = stat(name, &buf) | Get a file's status information
s = fstat(fd, &buf) | Get a file's status information
s = pipe(&fd[0]) | Create a pipe
s = fcntl(fd, cmd, ...) | File locking and other operations
Figure 10-27. Some system calls relating to files. The return code s is −1 if an error has occurred; fd is a file descriptor, and position is a file offset. The parameters should be self explanatory.
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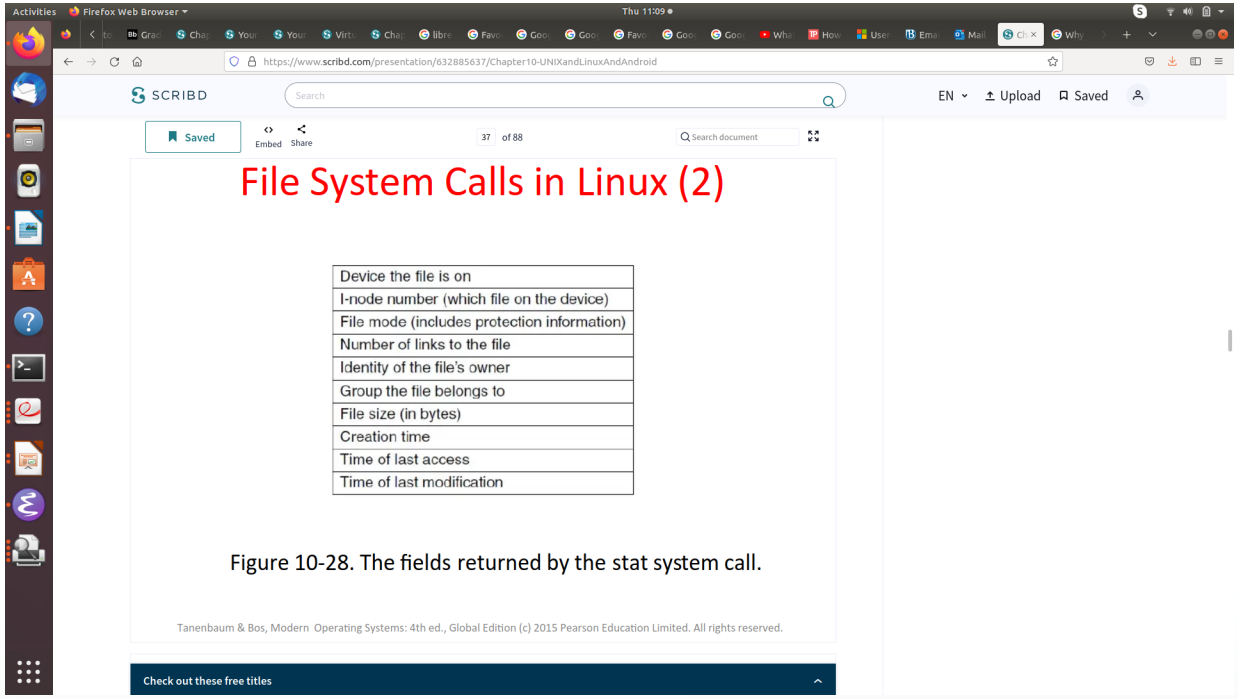
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File System Calls in Linux (2)
Device the file is on
I-node number (which file on the device)
File mode (includes protection information)
Number of links to the file
Identity of the file's owner
Group the file belongs to
File size (in bytes)
Creation time
Time of last access
Time of last modification
Figure 10-28. The fields returned by the stat system call.
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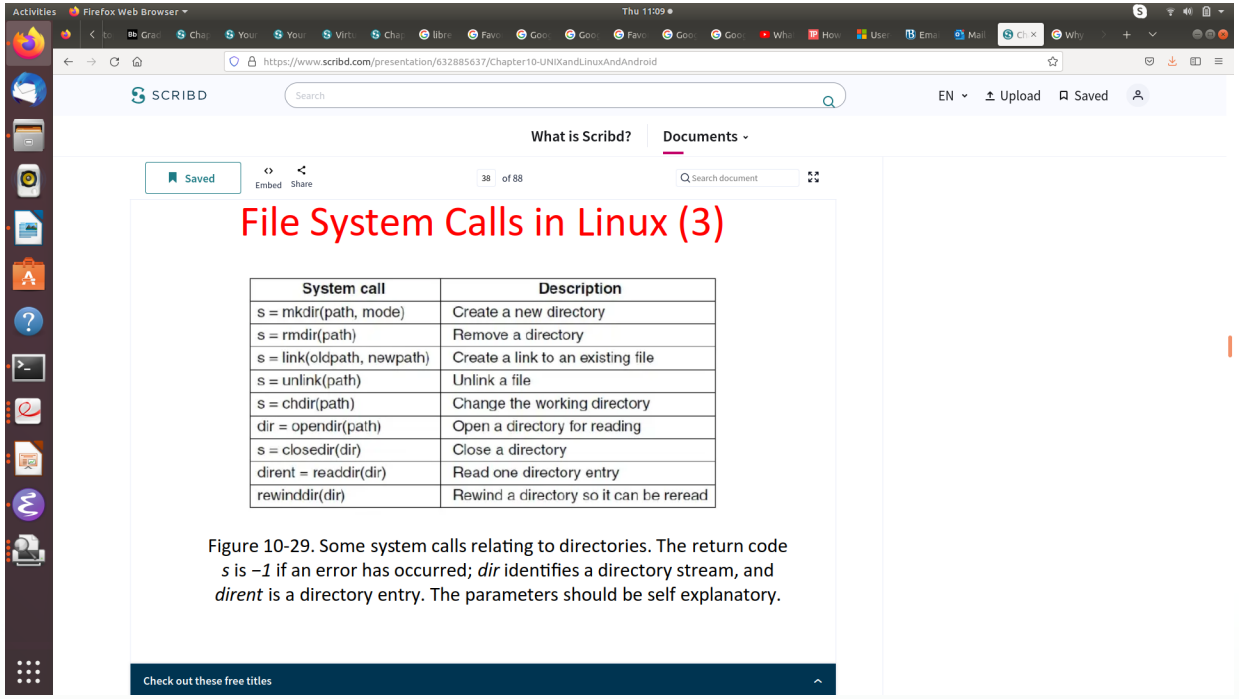
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File System Calls in Linux (3)
System call | Description
s = mkdir(path, mode) | Create a new directory
s = rmdir(path) | Remove a directory
s = link(oldpath, newpath) | Create a link to an existing file
s = unlink(path) | Unlink a file
s = chdir(path) | Change the working directory
dir = opendir(path) | Open a directory for reading
s = closedir(dir) | Close a directory
dirent = readdir(dir) | Read one directory entry
rewinddir(dir) | Rewind a directory so it can be reread
Figure 10-29. Some system calls relating to directories. The return code s is –1 if an error has occurred; dir identifies a directory stream, and dirent is a directory entry. The parameters should be self explanatory.
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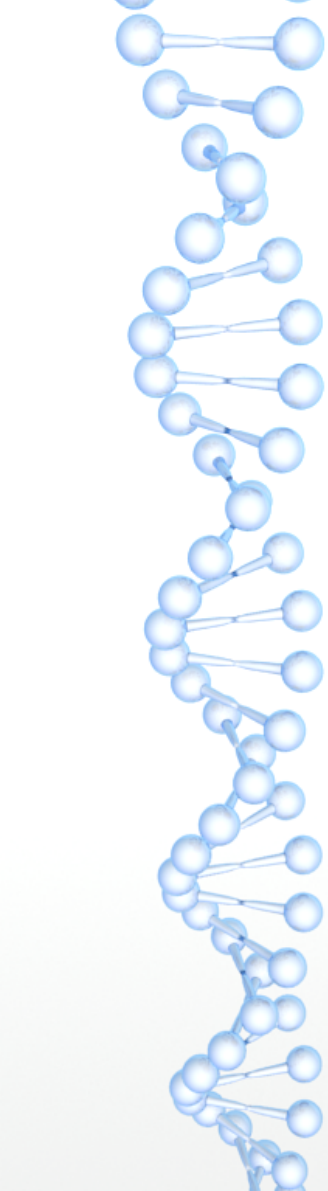
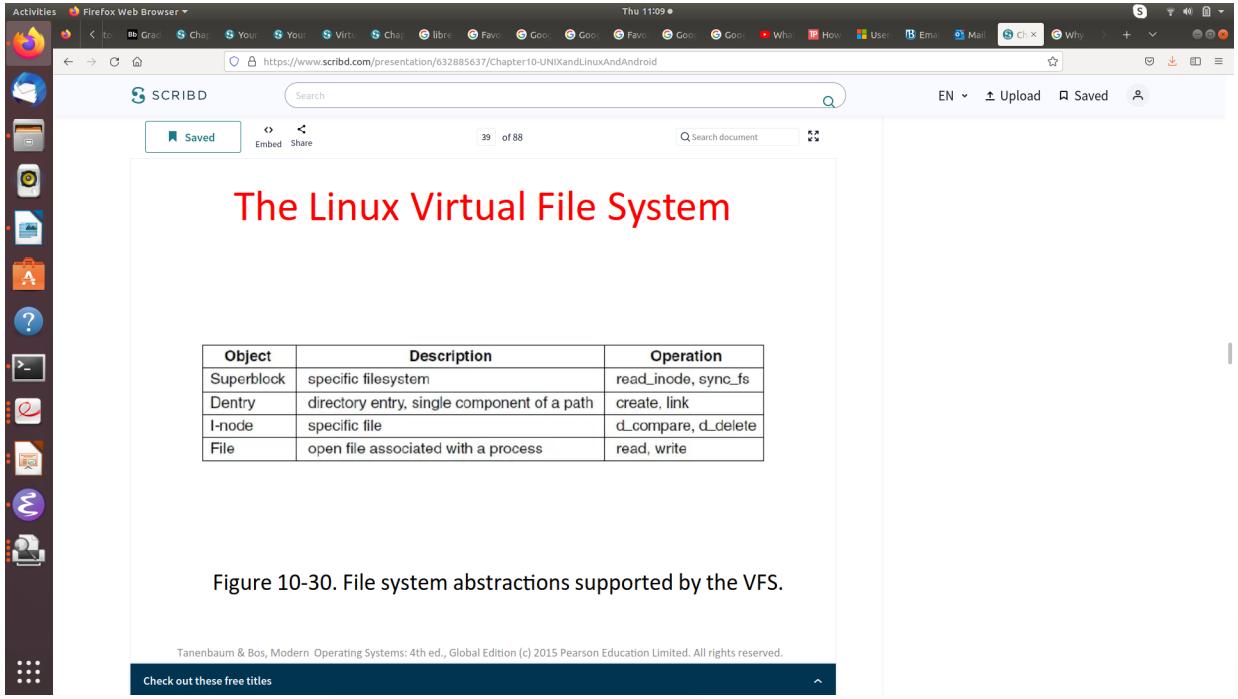


# 10.6.3 Implementation

- Linux Virtual File System
- Earlier Ext2
- Ext3 and Ext4 are journaling file system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The Linux Virtual File System
Object | Description | Operation
Superblock | specific filesystem | read_inode, sync_fs
Dentry | directory entry, single component of a path | create, link
I-node | specific file | d_compare, d_delete
File | open file associated with a process | read, write
Figure 10-30. File system abstractions supported by the VFS.
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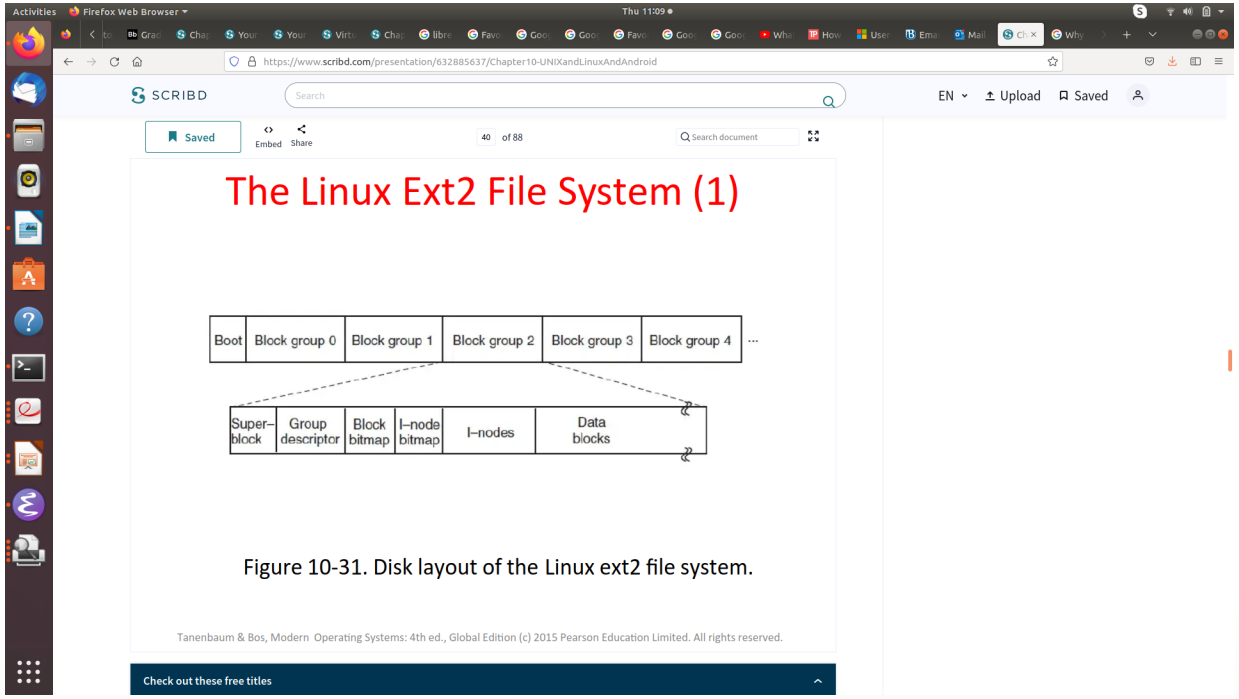
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The Linux Ext2 File System (1)
Boot
Block group 0
Block group 1
Block group 2
Block group 3
Block group 4
Super-block
Group descriptor
Block bitmap
I-node bitmap
I-nodes
Data blocks
Figure 10-31. Disk layout of the Linux ext2 file system.
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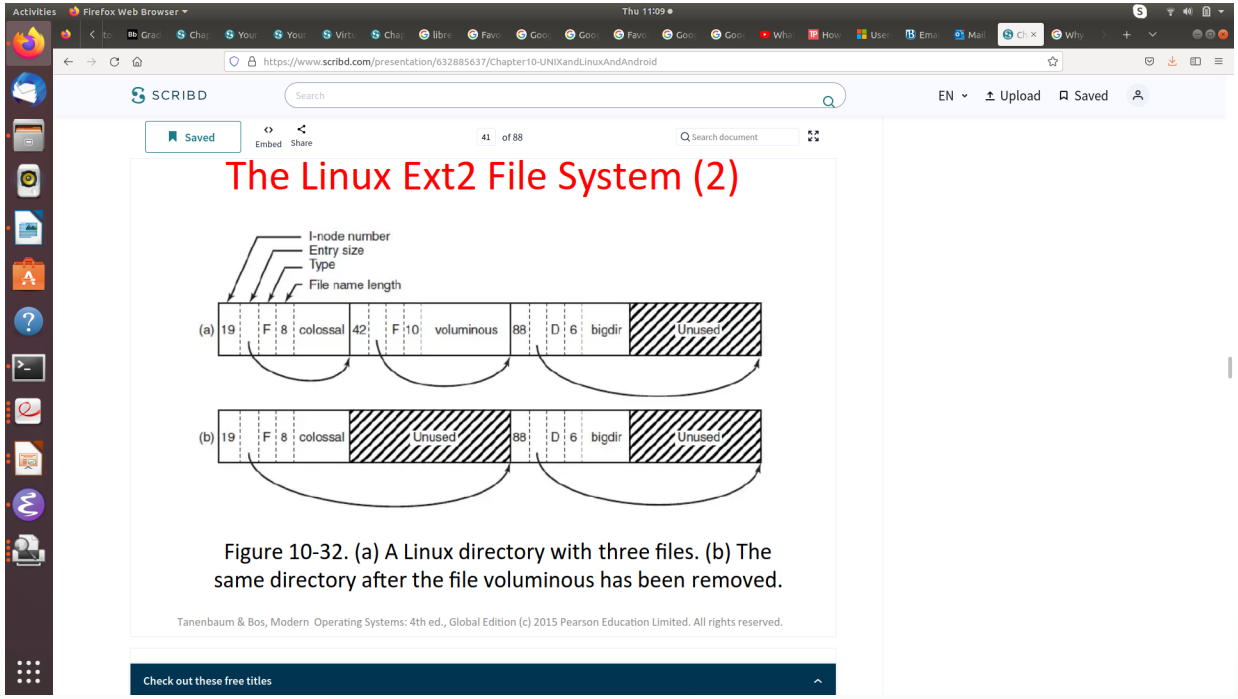
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The Linux Ext2 File System (2)
I-node number
Entry size
Type
File name length
(a) 19 F 8 colossal 42 F 10 voluminous 88 D 6 bigdir Unused
(b) 19 F 8 colossal Unused 88 D 6 bigdir Unused
Figure 10-32. (a) A Linux directory with three files. (b) The same directory after the file voluminous has been removed.
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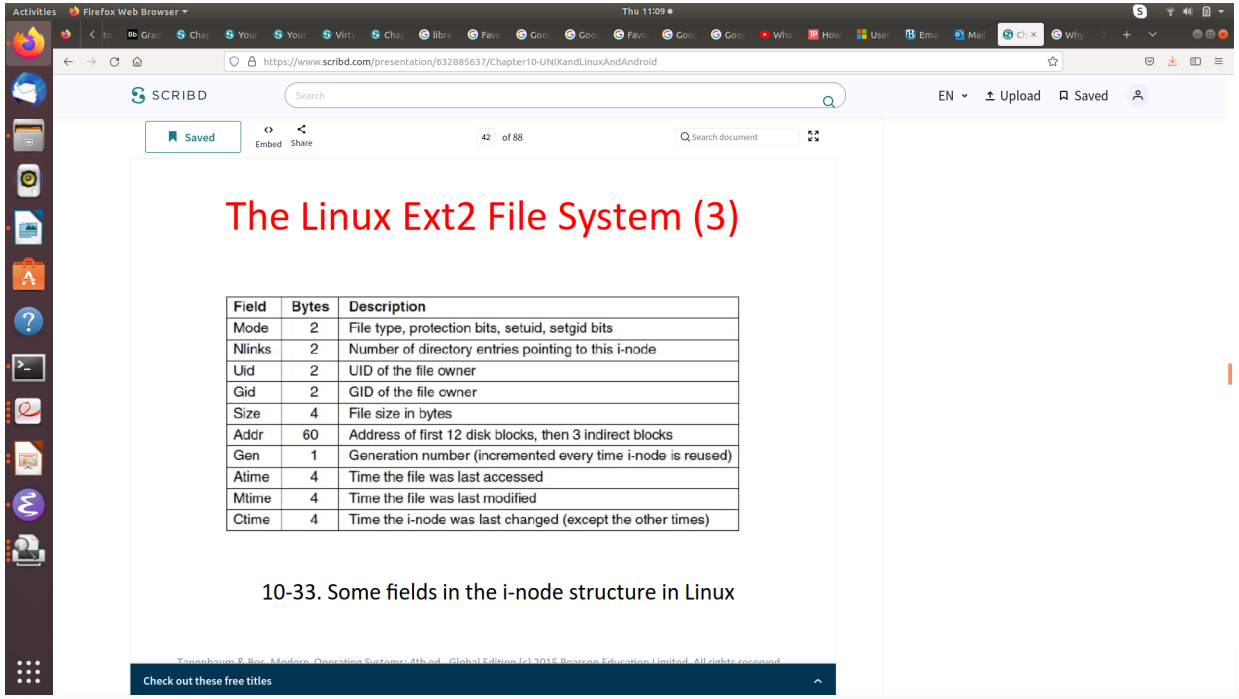
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The Linux Ext2 File System (3)
Field | Bytes | Description
Mode | 2 | File type, protection bits, setuid, setgid bits
Nlinks | 2 | Number of directory entries pointing to this i-node
Uid | 2 | UID of the file owner
Gid | 2 | GID of the file owner
Size | 4 | File size in bytes
Addr | 60 | Address of first 12 disk blocks, then 3 indirect blocks
Gen | 1 | Generation number (incremented every time i-node is reused)
Atime | 4 | Time the file was last accessed
Mtime | 4 | Time the file was last modified
Ctime | 4 | Time the i-node was last changed (except the other times)
10-33. Some fields in the i-node structure in Linux
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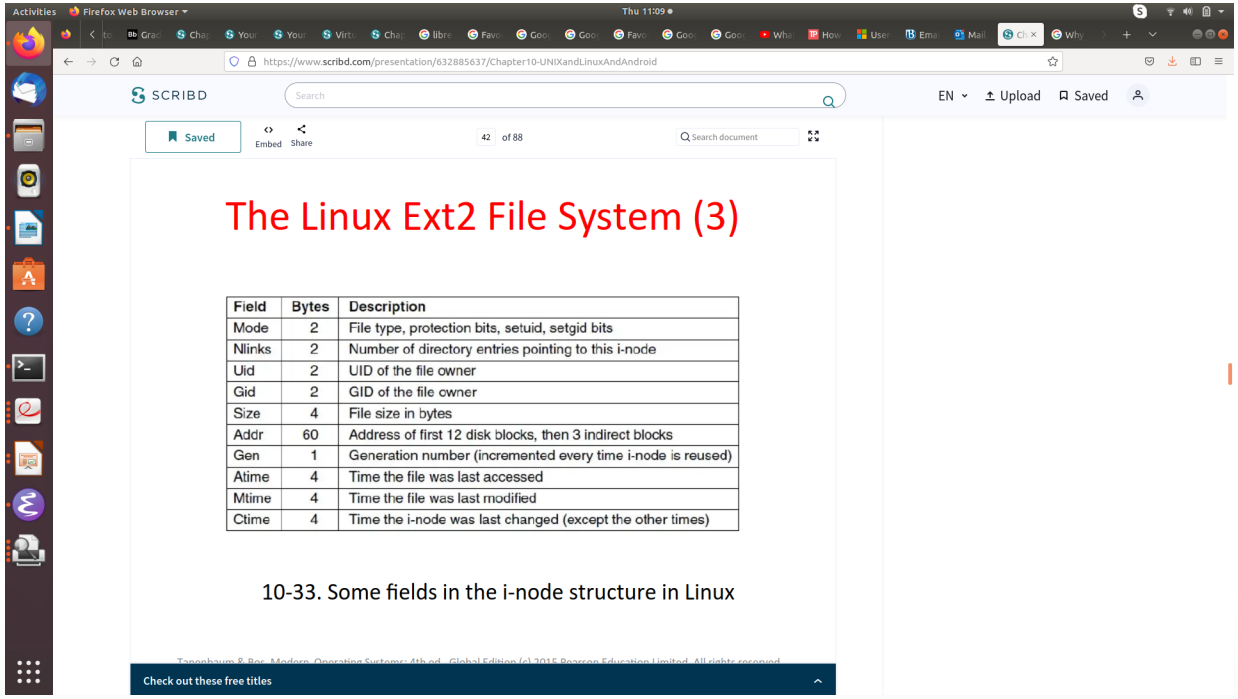
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The Linux Ext2 File System (3)
Field | Bytes | Description
Mode | 2 | File type, protection bits, setuid, setgid bits
Nlinks | 2 | Number of directory entries pointing to this i-node
Uid | 2 | UID of the file owner
Gid | 2 | GID of the file owner
Size | 4 | File size in bytes
Addr | 60 | Address of first 12 disk blocks, then 3 indirect blocks
Gen | 1 | Generation number (incremented every time i-node is reused)
Atime | 4 | Time the file was last accessed
Mtime | 4 | Time the file was last modified
Ctime | 4 | Time the i-node was last changed (except the other times)
10-33. Some fields in the i-node structure in Linux
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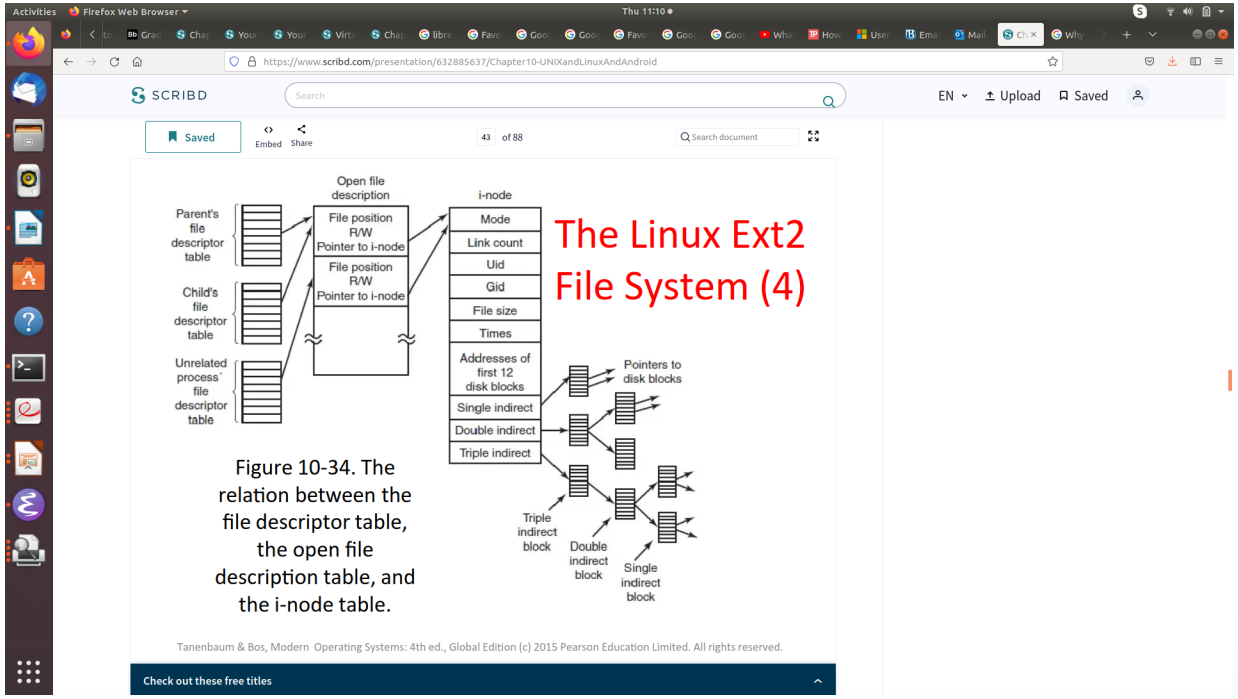
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Open file description
i-node
Parent's file descriptor table
Child's file descriptor table
Unrelated process' file descriptor table
File position R/W Pointer to i-node
File position R/W Pointer to i-node
Mode
Link count
Uid
Gid
File size
Times
Addresses of first 12 disk blocks
Single indirect
Double indirect
Triple indirect
Pointers to disk blocks
Triple indirect block
Double indirect block
Single indirect block
The Linux Ext2 File System (4)
Figure 10-34. The relation between the file descriptor table, the open file description table, and the i-node table.
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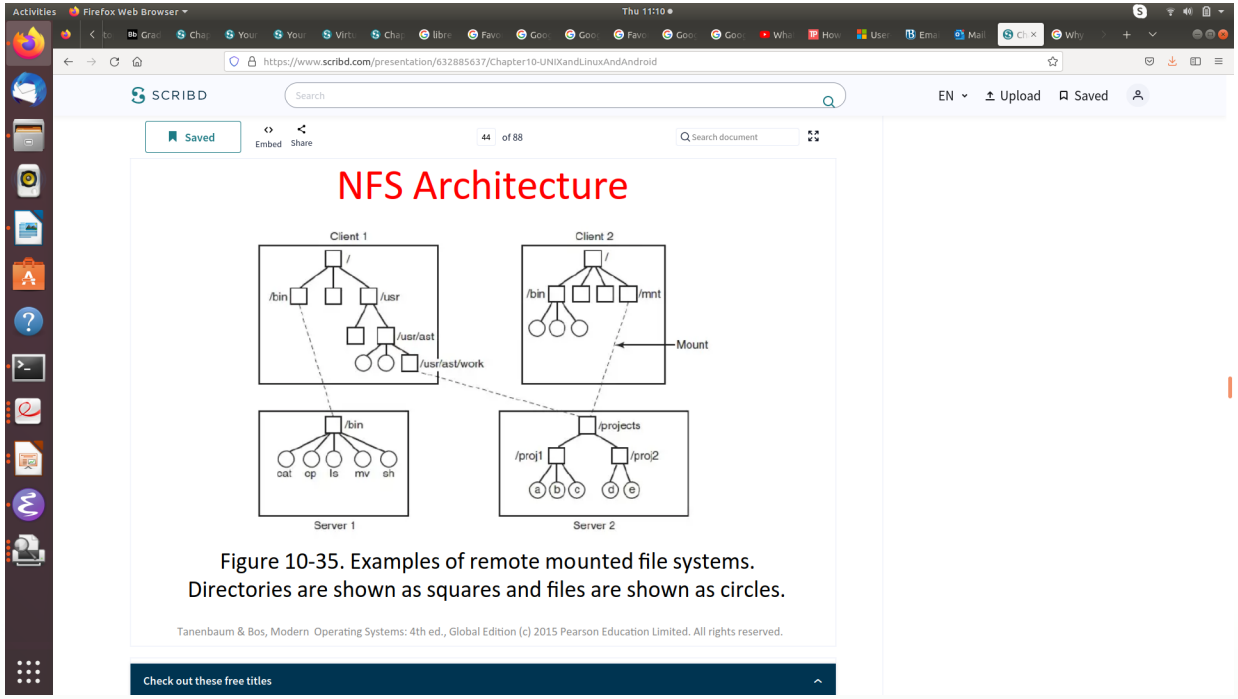
# 10.6.4 NFS: The Network File System

- Architecture
- Protocols
- Implementation
- NFS Version 4 is stateful – permitting better integration of remote files and works better with Linux and Windows file system semantics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NFS Architecture
Client 1
Client 2
/
/bin
/usr
/usr/ast
/usr/ast/work
/mnt
Mount
/bin
cat
cp
ls
mv
sh
/projects
/proj1
/proj2
a
b
c
d
e
Server 1
Server 2
Figure 10-35. Examples of remote mounted file systems.
Directories are shown as squares and files are shown as circles.
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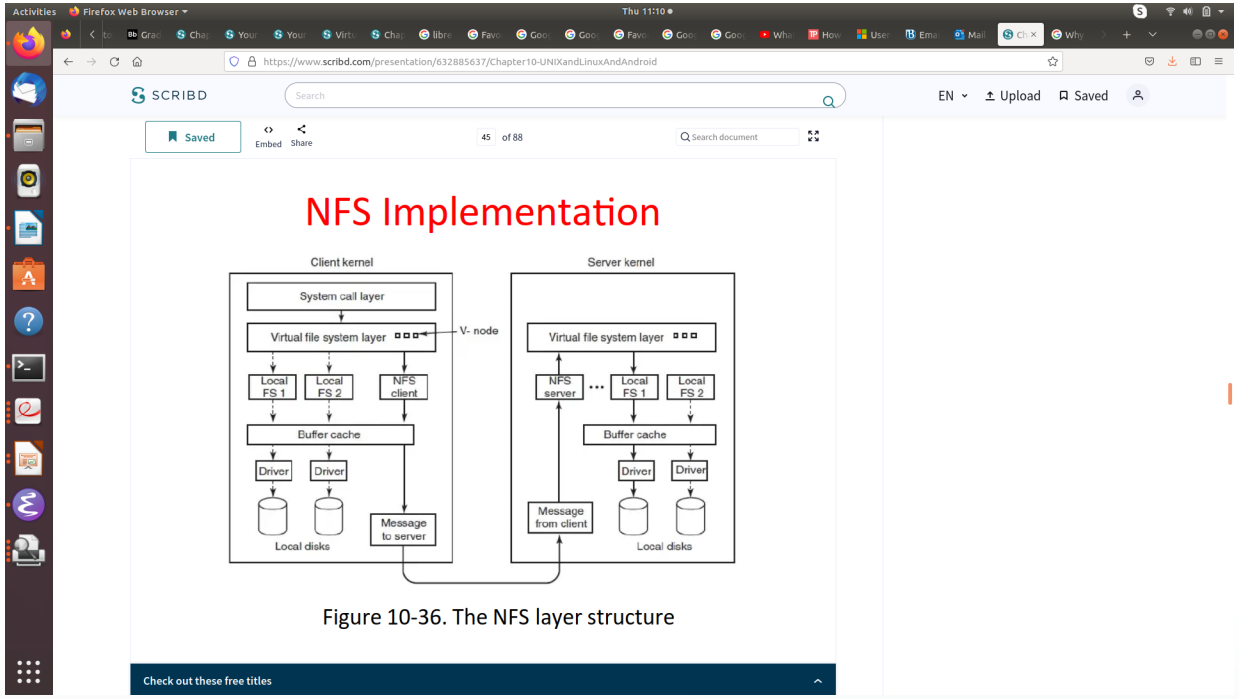
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NFS Implementation
Client kernel
Server kernel
System call layer
Virtual file system layer
V- node
Local FS 1
Local FS 2
NFS client
Buffer cache
Driver
Driver
Local disks
Message to server
Virtual file system layer
NFS server
Local FS 1
Local FS 2
Buffer cache
Driver
Driver
Message from client
Local disks
Figure 10-36. The NFS layer structure
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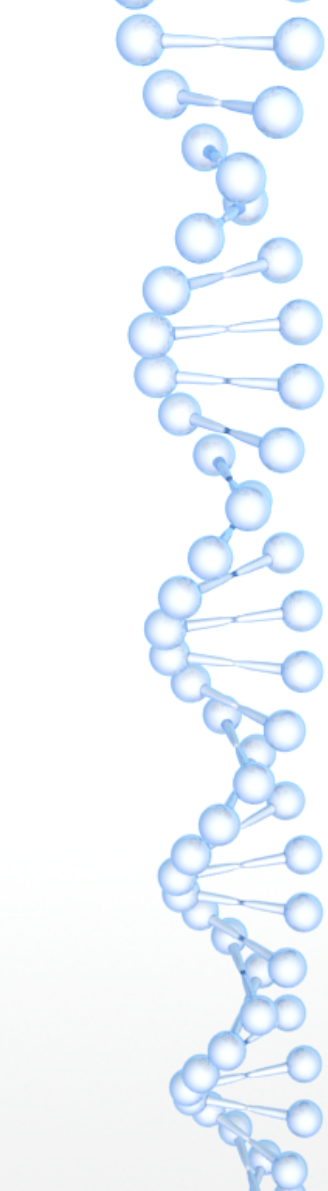
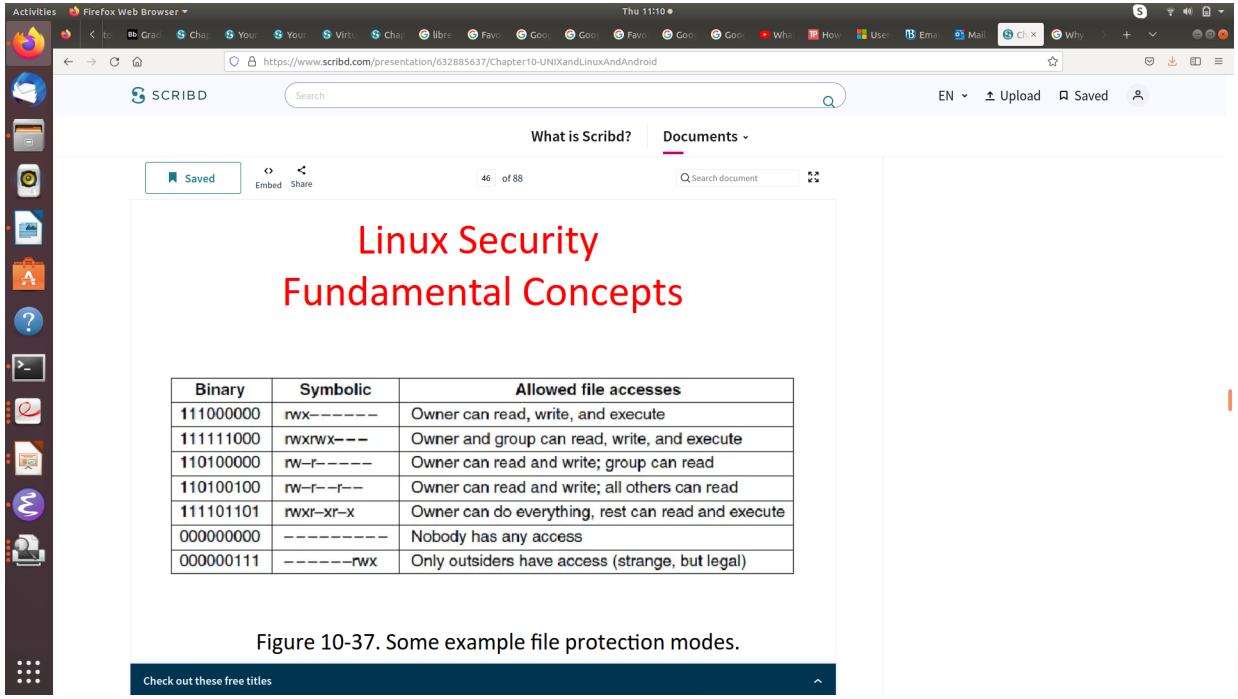


# 10.7 Security in Linux

- Fundamental Concepts
- System calls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Linux Security
Fundamental Concepts
Binary | Symbolic | Allowed file accesses
111000000 | rwx------ | Owner can read, write, and execute
111111000 | rwxrwx--- | Owner and group can read, write, and execute
110100000 | rw-r----- | Owner can read and write; group can read
110100100 | rw-r--r-- | Owner can read and write; all others can read
111101101 | rwxr-xr-x | Owner can do everything, rest can read and execute
000000000 | ---------- | Nobody has any access
000000111 | ------rwx | Only outsiders have access (strange, but legal)
Figure 10-37. Some example file protection modes.
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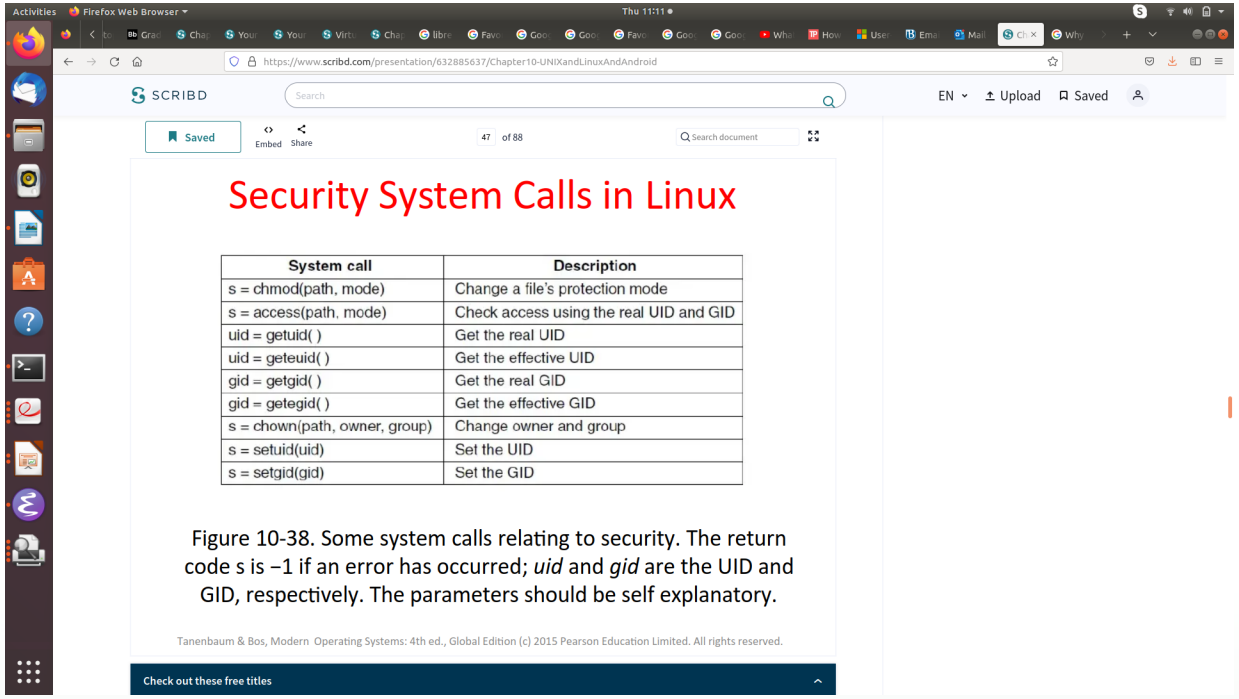
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Security System Calls in Linux
System call | Description
s = chmod(path, mode) | Change a file's protection mode
s = access(path, mode) | Check access using the real UID and GID
uid = getuid( ) | Get the real UID
uid = geteuid( ) | Get the effective UID
gid = getgid( ) | Get the real GID
gid = getegid( ) | Get the effective GID
s = chown(path, owner, group) | Change owner and group
s = setuid(uid) | Set the UID
s = setgid(gid) | Set the GID
Figure 10-38. Some system calls relating to security. The return code s is −1 if an error has occurred; uid and gid are the UID and GID, respectively. The parameters should be self explanatory.
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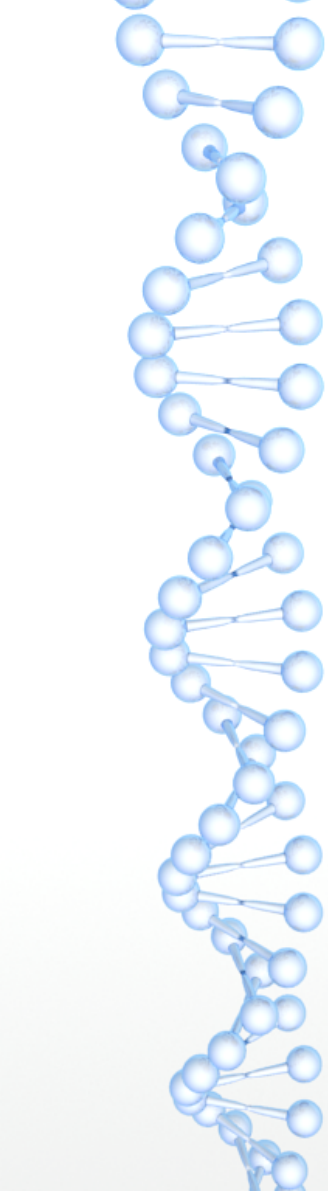
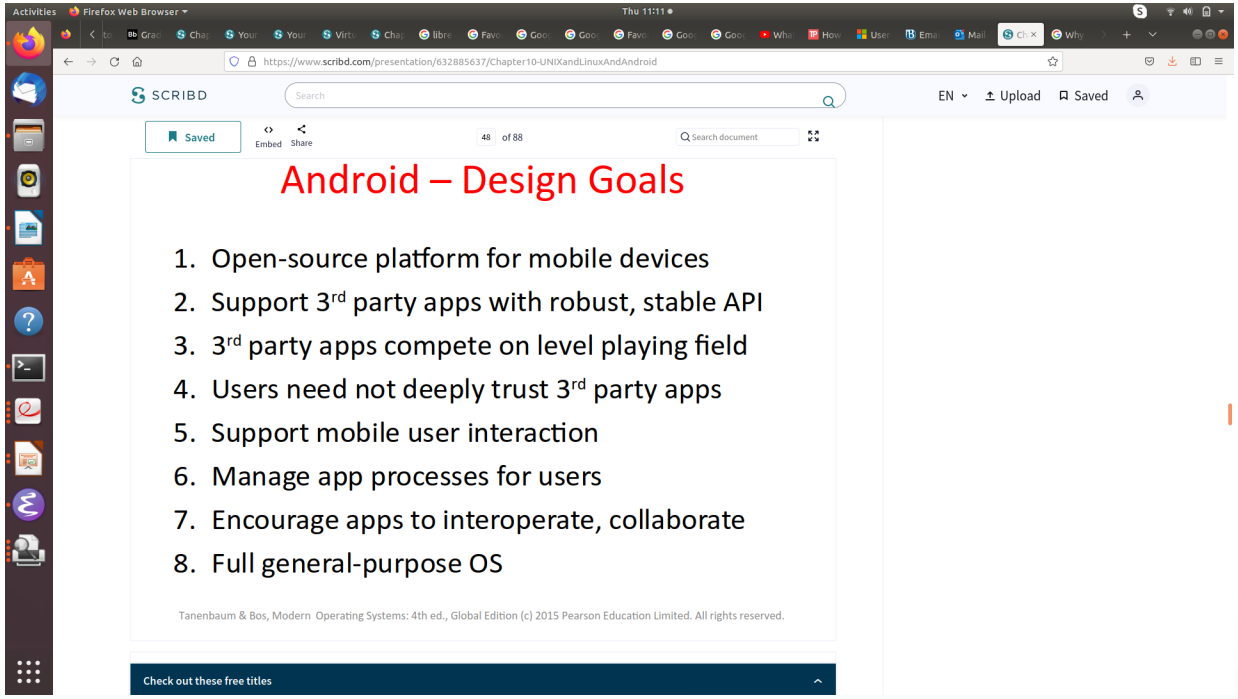


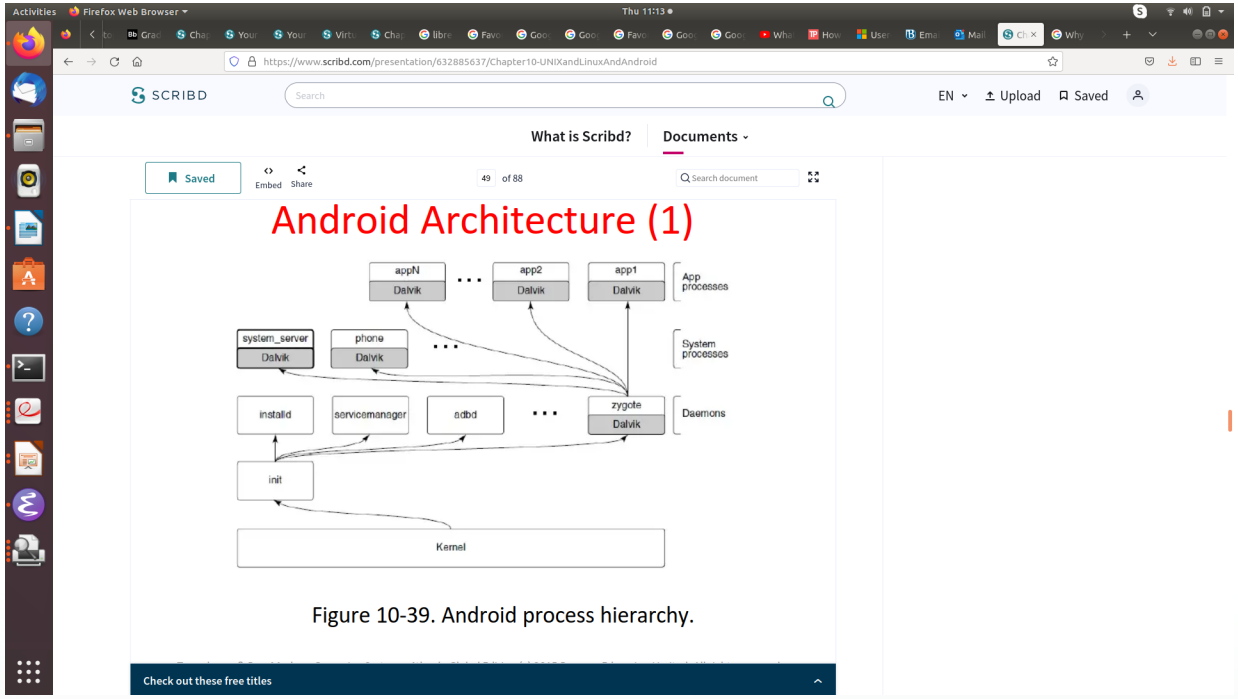
# 10.8 Android

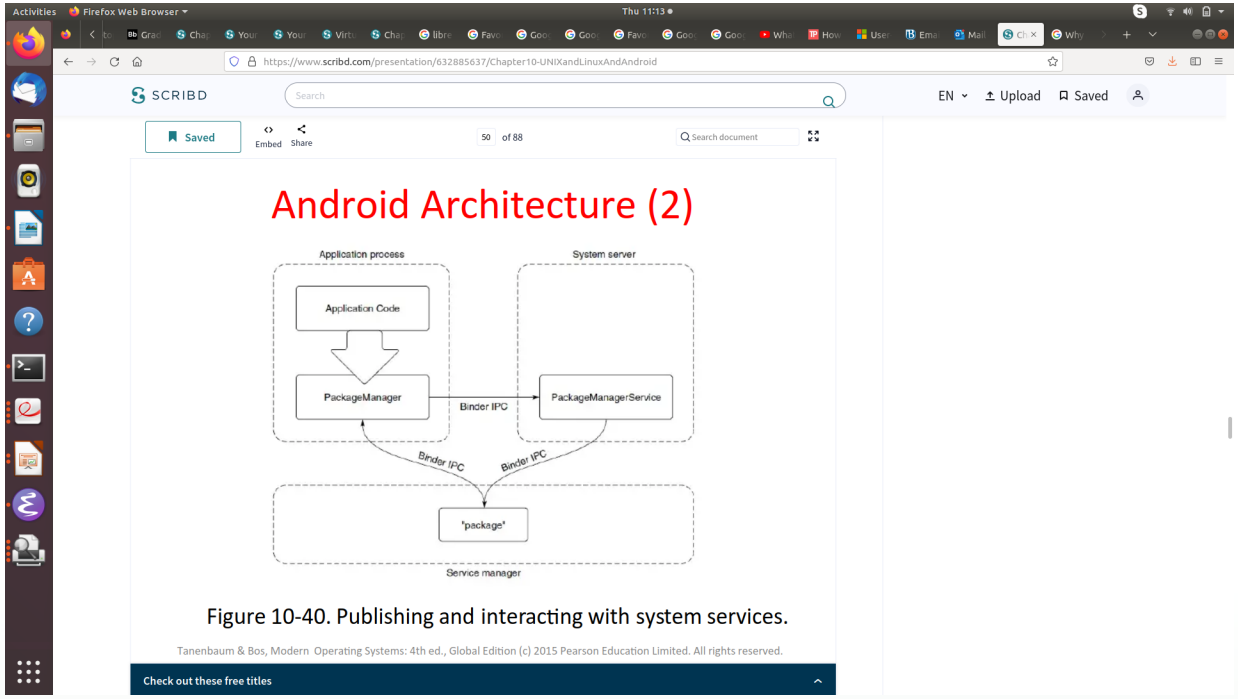
- Mobile Android
- Sits on Linux
- Manages power well
- Boots up fast

# 10.8.3 Design Goals



# 10.8.4 Android Architecture

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Android Architecture (2)
Application process
System server
Application Code
PackageManager
Binder IPC
PackageManagerService
Binder IPC
Binder IPC
'package'
Service manager
Figure 10-40. Publishing and interacting with system services.
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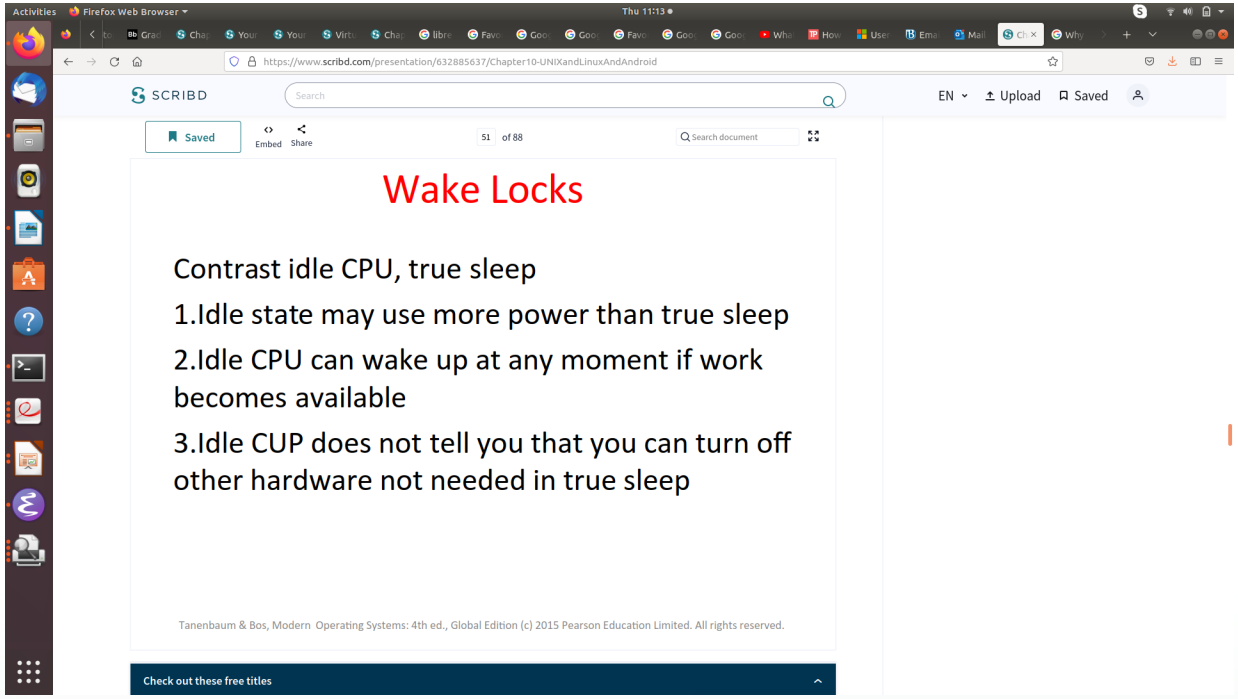
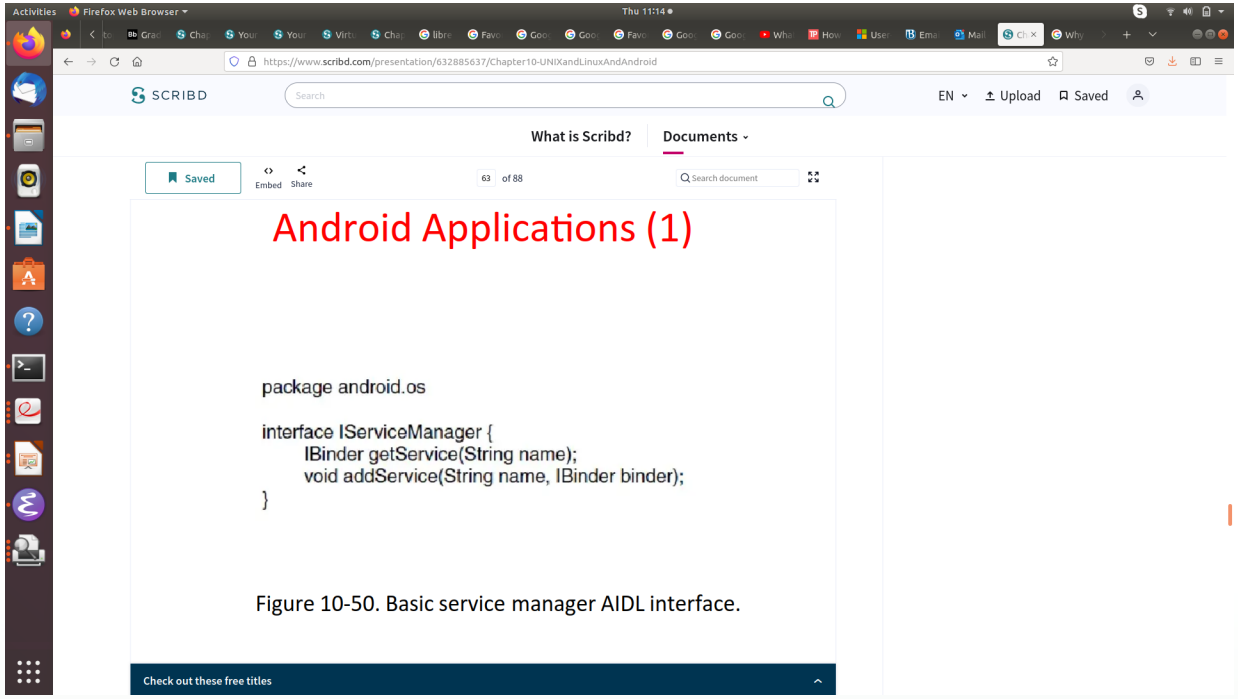
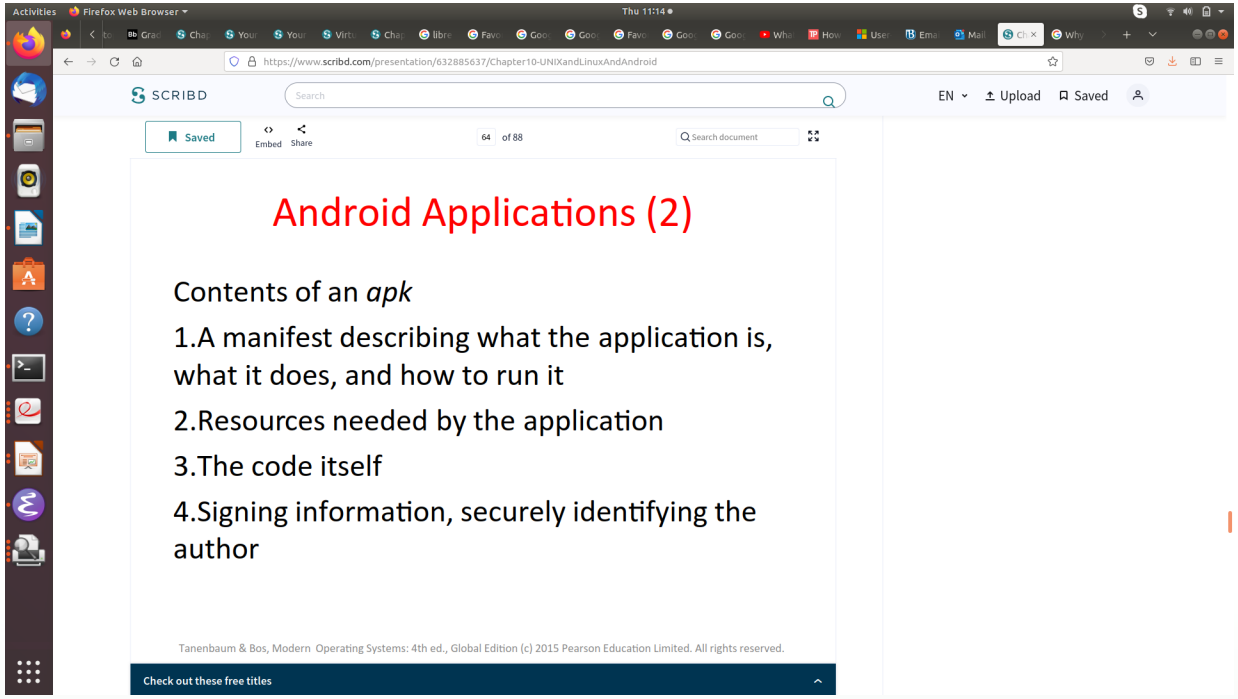
# 10.8.5 Linux extensions to stock Linux kernel Wake Locks manage how system sleeps



# 10.8.8 Android Applications

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Android Applications (2)
Contents of an apk
1.A manifest describing what the application is, what it does, and how to run it
2.Resources needed by the application
3.The code itself
4.Signing information, securely identifying the author
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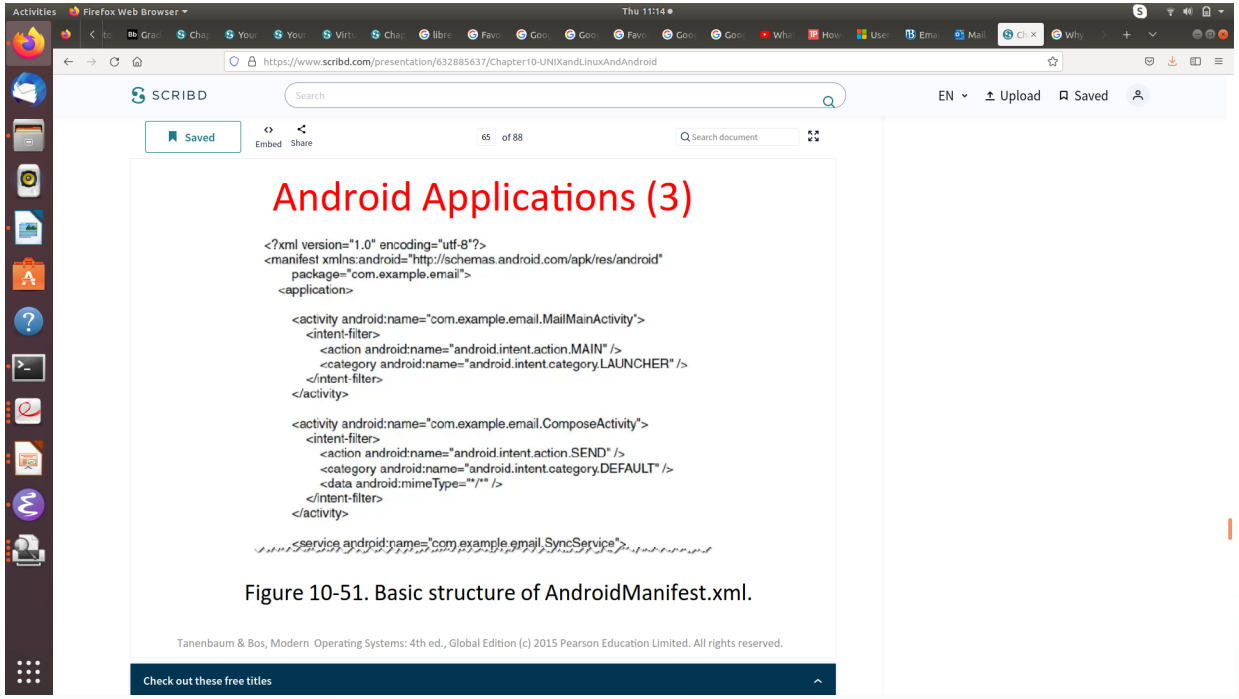
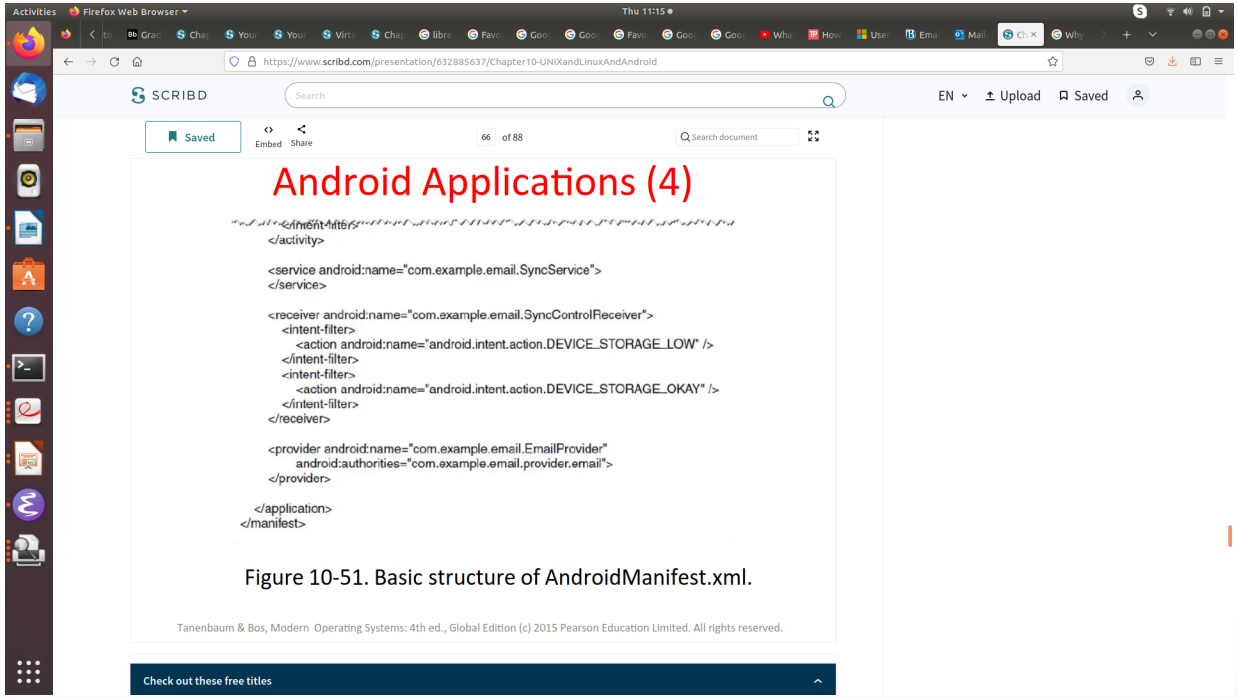
# XML is used, more lightweight than html

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Android Applications (4)
</intent-filter>
</activity>
<service android:name="com.example.email.SyncService">
</service>
<receiver android:name="com.example.email.SyncControlReceiver">
<intent-filter>
<action android:name="android.intent.action.DEVICE_STORAGE_LOW" />
</intent-filter>
<intent-filter>
<action android:name="android.intent.action.DEVICE_STORAGE_OKAY" />
</intent-filter>
</receiver>
<provider android:name="com.example.email.EmailProvider"
android:authorities="com.example.email.provider.email">
</provider>
</application>
</manifest>
Figure 10-51. Basic structure of AndroidManifest.xml.
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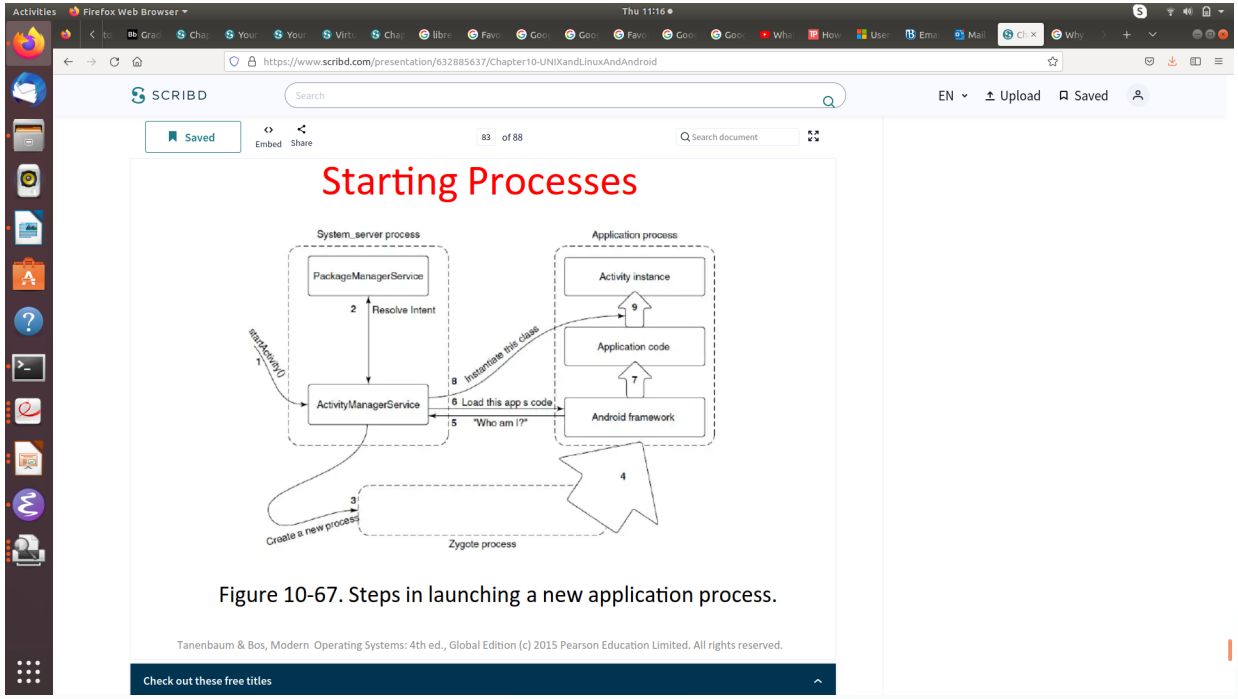
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Starting Processes
System_server process
Application process
PackageManagerService
Activity instance
2 Resolve Intent
9
Application code
7
startActivity()
1
8 Instantiate this class
ActivityManagerService
6 Load this app s code
5 "Who am I?"
Android framework
4
3
Create a new process
Zygote process
Figure 10-67. Steps in launching a new application process.
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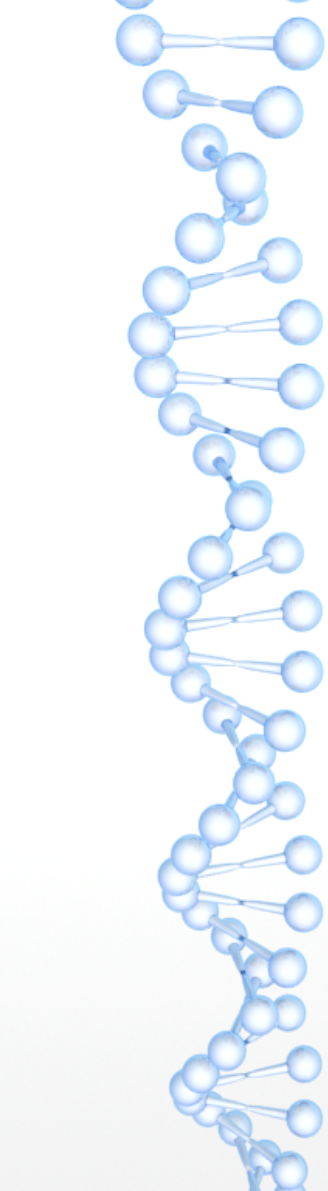
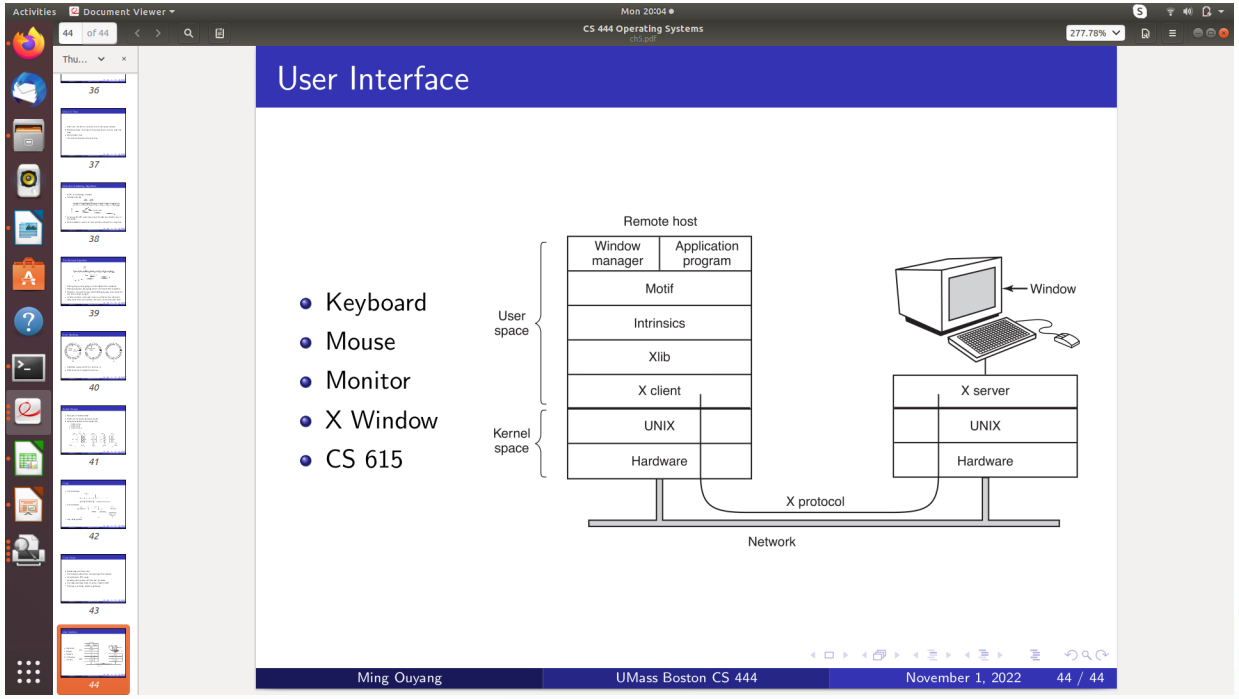


# Chapter 11: Case Study: Windows 11

- Look back at Ch 5.6 Windowing
- Compare windowing in both Linux and Windows

# Windowing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User Interface
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Mouse
Monitor
X Window
CS 615
Remote host
Window manager
Application program
Motif
Intrinsics
Xlib
X client
UNIX
Hardware
User space
Kernel space
X protocol
Network
Window
X server
UNIX
Hardware
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# Consider Windows

- Very sensitive to running legacy systems
- Not open source, so we have limited information
- Nice diagram of Windows 365, Cloud

# An overview of Windows in the Cloud