LECTURE NOTES
ON

LINUX PROGRAMMING

III B. Tech II semester

(IARE-R16)

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COMPUTER SCIENCE AND ENGINEERING

COURSE LECTURE NOTES

Course Title	**LINUX PROGRAMMING**
Course Code	ACS010
Programme	B.Tech
Semester	VI
Chief Coordinator	Ms. K Radhika, Assistant Professor, CSE
Course Faculty	Mr. P Anjaiah, Assistant Professor, CSE Ms. G.Sulakshana, Assistant Professor, CSE Ms. N M Deepika, Assistant Professor, CSE

COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Interpret the Linux utilities to control the resources.
II	Learn basic concepts of shell scripts and file structures.
III	Understand the concepts of process creation and interruption for multitasking applications.
IV	Explore memory allocation and inter process communication methods.
V	Provide support for distributed and network applications in Linux environment.

COURSE LEARNING OUTCOMES (CLOs):

Students who complete the course, will have demonstrated the ability to do the following:

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
ACS010.01	CLO 1	Learn the importance of Linux architecture along with features.	PO 1	3
ACS010.02	CLO 2	Identify and use Linux utilities to create and manage simple file processing operations	PO 1 ,PO 2	2
ACS010.03	CLO 3	Apply the security features on file access permissions by restricting the ownership using advance Linux commands.	PO 1 ,PO 2	2
ACS010.04	CLO 4	Implement the SED Scripts, operation, addresses, and commands.	PO 1 ,PO 2, PO 3	3
ACS010.05	CLO 5	Implement the GREP and AWK commands for pattern matching and mathematical functions.	PO 3,PO 4	2
ACS010.06	CLO 6	Understand the shell responsibilities of different types of shells	PO 1,PO 2, PO 3	3

ACS010.07	CLO 7	Develop shell scripts to perform more complex tasks in shell programming environment.	PO 1,PO 2, PO 3	3
ACS010.08	CLO 8	Illustrate file processing operations such as standard I/O and formatted I/O.	PO 1 ,PO 2, PO 3	3
ACS010.09	CLO 9	Illustrate directory operations such as standard I/O and formatted I/O.	PO 1 ,PO 2, PO 3	3
ACS010.10	CLO 10	Understand process structure, scheduling and management through system calls.	PO 1,PO 2, PO 3	3
ACS010.11	CLO 11	Generalize signal functions to handle interrupts by using system calls.	PO 3,PO 4	2
ACS010.12	CLO 12	Illustrate memory management of file handling through file/region lock	PO 1,PO 2,	2
ACS010.13	CLO 13	Design and implement inter process communication (IPC) in client server environment by using pipe.	PO 1 ,PO 3	3
ACS010.14	CLO 14	Design and implement inter process communication (IPC) in client server environment by using named Pipes	PO 1,PO 2, PO 3	1
ACS010.15	CLO 15	Illustrate client server authenticated communication in IPC through messages queues, semaphores	PO 1,PO 3	3
ACS010.16	CLO 16	Illustrate client server authenticated communication in IPC through shared memory.	PO 1,PO 2, PO 3	3
ACS010.17	CLO 17	Demonstrate socket connections, socket attributes, socket addresses	PO 1,PO 2, PO 3	3
ACS010.18	CLO 18	Demonstrate various client server applications on network using TCP.	PO 1,PO 2, PO 3,	3
ACS010.19	CLO 19	Demonstrate various client server applications on network using UDP protocols.	PO 1,PO 2, PO 3,	3
ACS010.20	CLO 20	Design custom based network applications using the sockets interface in heterogeneous platforms	PO 2, PO 3, PO 4	3

SYLLABUS

UNIT-I	INTRODUCTION TO LINUX UTILITIES
Linux utilities: A brief history of UNIX, architecture and features of UNIX, introduction to vi editor. General purpose utilities, file handling utilities, security by file permissions, process utilities, disk utilities, networking commands; Text processing and backup utilities: Text processing utilities andbackup utilities; SED: Scripts, operation, addresses, commands; AWK: Execution, fields and records, scripts, operation, patterns, actions, associative arrays, string and mathematical functions, system commands in awk, applications.	
UNIT-II	**WORKING WITH THE BOURNE AGAIN SHELL (BASH)**
Shell: Shell responsibilities, types of shell, pipes and i/o redirection, shell as a programming language, here documents, running a shell script, the shell as a programming language, shell metacharacters, file name substitution, shell variables, command substitution, shell commands, quoting, test command, control structures, arithmetic in shell, interrupt processing, functions, and debugging scripts; File structure and directories: Introduction to file system, file descriptors, file types, file system structure; File metadata: Inodes; System calls for file I/O operations: open, create, read, write, close, lseek, dup2, file status information-stat family; File and record locking: fcntl function, file permissions, file ownership, links; Directories: Creating, removing and changing directories, obtaining current working directory, directory contents, scanning directories.	
UNIT-III	**PROCESS AND SIGNALS**
Process: Process identifiers, process structure: process table, viewing processes, system processes, process scheduling; Starting new processes: Waiting for a process, process termination, zombie processes, orphan process, system call interface for process management, fork, vfork, exit, wait, waitpid,exec. Signals: Signal functions, unreliable signals, interrupted system calls, kill, raise, alarm, pause, abort, system, sleep functions, signal sets.	
UNIT-IV	**DATA MANAGEMENT AND INTER PROCESS COMMUNICATION**
Data Management: Managing memory: malloc, free, realloc, calloc; File locking: Creating lock files, locking regions, use of read and write with locking, competing locks, other lock commands, deadlocks; Inter process communication: Pipe, process pipes, the pipe call, parent and child processes, named pipes, semaphores, shared memory, message queues; Shared memory: Kernel support for shared memory, APIs for shared memory, shared memory example; Semaphores: Kernel support for semaphores, APIs for semaphores, file locking with semaphores.	
UNIT-V	**SOCKETS**
Introduction to sockets: Socket, socket connections, socket attributes, socket addresses, socket system calls for connection oriented protocol and connectionless protocol, socket Communications, comparison of IPC mechanisms.	
Text Books:	
1. W. Richard, Stevens, Advanced Programming in the UNIX Environment, Pearson Education, 1st Edition,2005. 2. Sumitabha Das, Unix Concepts and Applications, Tata McGraw-Hill, 4thEdition,2006. 3. Neil Mathew, Richard Stones, Beginning Linux Programming, Wrox, Wiley India, 4thEdition, 2011.	
Reference Books:	
1. Sumitabha Das, Your Unix the Ultimate Guide, Tata McGraw-Hill, 4thEdition,2007. 2. W. R. Stevens, S. A. Rago, Advanced Programming in the Unix Environment Pearson Education, 2nd Edition,2009 3. B. A. Forouzan, R. F. Gilberg, Unix and Shell Programming, CengageLearning,3rd Edition, 2005.	

UNIT-I

Linux utilities

Linux utilities: A brief history of UNIX, architecture and features of UNIX, introduction to vi editor. General purpose utilities, file handling utilities, security by file permissions, process utilities, disk utilities, networking commands; Text processing and backup utilities: Text processing utilities and backup utilities; SED: Scripts, operation, addresses, commands; AWK: Execution, fields and records, scripts, operation, patterns, actions, associative arrays, string and mathematical functions, system commands in awk, applications.

Introduction to Linux:

Linux is a Unix-like computer operating system assembled under the model of free and open source software development and distribution. The defining component of Linux is the Linux kernel, an operating system kernel first released 5 October 1991 by Linus Torvalds.

Linux was originally developed as a free operating system for Intel x86-based personal computers. It has since been ported to more computer hardware platforms than any other operating system. It is a leading operating system on servers and other big iron systems such as mainframe computers and supercomputers more than 90% of today's 500 fastest supercomputers run some variant of Linux, including the 10 fastest. Linux also runs on embedded systems (devices where the operating system is typically built into the firmware and highly tailored to the system) such as mobile phones, tablet computers, network routers, televisions and video game consoles; the Android system in wide use on mobile devices is built on the Linux kernel.

Basic Features

Following are some of the important features of Linux Operating System.

- **Portable** - Portability means software‘s can works on different types of hardware‘s in same way. Linux kernel and application programs support their installation on any kind of hardware platform.
- **Open Source** - Linux source code is freely available and it is community based development project. Multiple Teams works in collaboration to enhance the capability of Linux operating system and it is continuously evolving.
- **Multi-User** - Linux is a multiuser system means multiple users can access system resources like memory/ ram/ application programs at same time.
- **Multiprogramming** - Linux is a multiprogramming system means multiple applications can run at same time.

- **Hierarchical File System** - Linux provides a standard file structure in which system files/ user files are arranged.

- **Shell** - Linux provides a special interpreter program which can be used to execute commands of the operating system. It can be used to do various types of operations, call application programs etc.
- **Security** - Linux provides user security using authentication features like password protection/ controlled access to specific files/ encryption of data.

Linux Advantages

1. **Low cost:** You don‘t need to spend time and money to obtain licenses since Linux and much of its software come with the GNU General Public License. You can start to work immediately without worrying that your software may stop working anytime because the free trial version expires. Additionally, there are large repositories from which you can freely download high quality software for almost any task you can think of.
2. **Stability:** Linux doesn‘t need to be rebooted periodically to maintain performance levels. It doesn‘t freeze up or slow down over time due to memory leaks and such. Continuous up- times of hundreds of days (up to a year or more) are not uncommon.
3. **Performance:** Linux provides persistent high performance on workstations and on networks. It can handle unusually large numbers of users simultaneously, and can make old computers sufficiently responsive to be useful again.
4. **Network friendliness:** Linux was developed by a group of programmers over the Internet and has therefore strong support for network functionality; client and server systems can be easily set up on any computer running Linux. It can perform tasks such as network backups faster and more reliably than alternative systems.
5. **Flexibility:** Linux can be used for high performance server applications, desktop applications, and embedded systems. You can save disk space by only installing the components needed for a particular use. You can restrict the use of specific computers by installing for example only selected office applications instead of the whole suite.
6. **Compatibility:** It runs all common UNIX software packages and can process all common file formats.
7. **Choice:** The large number of Linux distributions gives you a choice. Each distribution is developed and supported by a different organization. You can pick the one you like best; the core functionalities are the same; most software runs on most distributions.

8. **Fast and easy installation:** Most Linux distributions come with user-friendly installation and setup programs. Popular Linux distributions come with tools that make installation of additional software very user friendly as well.

9. **Full use of hard disk:** Linux continues work well even when the hard disk is almost full.

10. **Multi-tasking:** Linux is designed to do many things at the same time; e.g., a large printing job in the background won‘t slow down your other work.

11. **Security:** Linux is one of the most secure operating systems. ―Walls‖ and flexible file access permission systems prevent access by unwanted visitors or viruses. Linux users have to option to select and safely download software, free of charge, from online repositories containing thousands of high quality packages. No purchase transactions requiring credit card numbers or other sensitive personal information are necessary.

12. **Open Source:** If you develop software that requires knowledge or modification of the operating system code, LINUX‘s source code is at your fingertips. Most Linux applications are Open Source as well.

Difference between UNIX and LINUX

Features	LINUX	UNIX
Cost	Linux can be freely distributed, downloaded freely, distributed through magazines, Books etc. There are priced versions for Linux also, but they are normally cheaper than Windows.	Different flavors of Unix have different cost structures according to vendors
Development and Distribution	Linux is developed by Open Source development i.e. through sharing and collaboration of code and features through forums etc and it is distributed	Unix systems are divided into various other flavors, mostly developed by AT&T as well as various commercial vendors and non-profit organizations.
	by various vendors.	

Manufacturer	Linux kernel is developed by the community. Linus Torvalds oversees things.	Three biggest distributions are Solaris (Oracle), AIX (IBM) & HP-UX Hewlett Packard. And Apple Makes OSX, an unix based os..
User	Everyone. From home users to developers and computer enthusiasts alike.	Unix operating systems were developed mainly for mainframes, servers and workstations except OSX, Which is designed for everyone. The Unix environment and the client-server program model were essential elements in the development of the Internet
Usage	Linux can be installed on a wide variety of computer hardware, ranging from mobile phones, tablet computers and video game consoles, to mainframes and supercomputers.	The UNIX operating system is used in internet servers, workstations & PCs. Backbone of the majority of finance infrastructure and many 24x365 high availability solutions.
File system support	Ext2, Ext3, Ext4, Jfs, ReiserFS, Xfs, Btrfs, FAT, FAT32, NTFS	jfs, gpfs, hfs, hfs+, ufs, xfs, zfs format
Text mode interface	BASH (Bourne Again SHell) is the Linux default shell. It can support multiple command interpreters.	Originally the Bourne Shell. Now it's compatible with many others including BASH, Korn & C.
What is it?	Linux is an example of Open Source software development and Free Operating System (OS).	Unix is an operating system that is very popular in universities, companies, big enterprises etc.

GUI	Linux typically provides two GUIs, KDE and Gnome. But there are millions of alternatives such as LXDE, Xfce, Unity, Mate, twm, ect.	Initially Unix was a command based OS, but later a GUI was created called Common Desktop Environment. Most distributions now ship with Gnome.
Price	Free but support is available for a price.	Some free for development use (Solaris) but support is available for a price.
Security	Linux has had about 60-100 viruses listed till date. None of them actively spreads nowadays.	A rough estimate of UNIX viruses is between 85 -120 viruses reported till date.
Threat detection and solution	In case of Linux, threat detection and solution is very fast, as Linux is mainly community driven and whenever any Linux user posts any kind of threat, several developers start working on it from different parts of the world	Because of the proprietary nature of the original Unix, users have to wait for a while, to get the proper bug fixing patch. But these are not as common.
Processors	Dozens of different kinds.	x86/x64, Sparc, Power, Itanium, PA-RISC, PowerPC and many others.
Examples	Ubuntu, Fedora, Red Hat, Debian, Archlinux, Android etc.	OS X, Solaris, All Linux
Architectures	Originally developed for Intel's x86 hardware, ports available for over two dozen CPU types including ARM	is available on PA-RISC and Itanium machines. Solaris also available for x86/x64 based systems.OSX is PowerPC(10.0-

		10.5)/x86(10.4)/x64(10.5-10.8)
Inception	Inspired by MINIX (a Unix-like system) and eventually after adding many features of GUI, Drivers etc, Linus Torvalds developed the framework of the OS that became LINUX in 1992. The LINUX kernel was released on 17th September, 1991	In 1969, it was developed by a group of AT&T employees at Bell Labs and Dennis Ritchie. It was written in ―C‖ language and was designed to be a portable, multi-tasking and multi-user system in a time-sharing configuration

Linux Distribution (Operating System) Names

A few popular names:

1.Redhat Enterprise Linux

2.Fedora Linux

3. Debian Linux

4. Suse Enterprise Linux

5.Ubuntu Linux

Common things between Linux & UNIX

Both share many common applications such as:

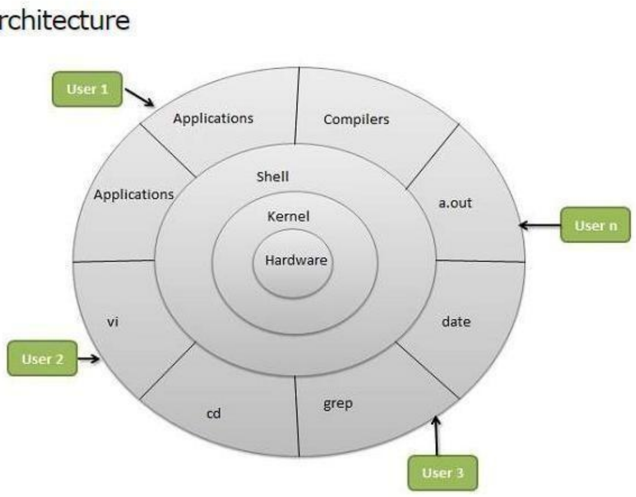
1.GUI, file, and windows managers (KDE, Gnome)

2.Shells (ksh, csh, bash)

3. Various office applications such as OpenOffice.org

4.Development tools (perl, php, python, GNU c/c++
compilers) 5.Posix interface

Layered Architecture:

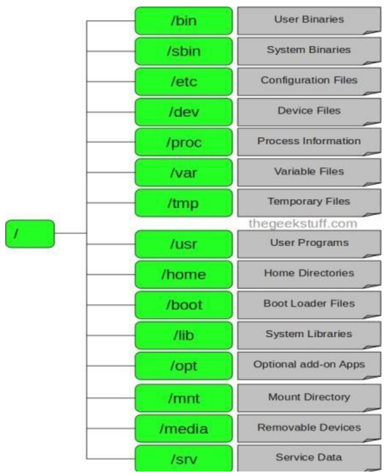


Linux System Architecture is consists of following layers

- **Hardware layer** - Hardware consists of all peripheral devices (RAM/ HDD/ CPU etc).
- **Kernel** - Core component of Operating System, interacts directly with hardware, provides low level services to upper layer components.
- **Shell** - An interface to kernel, hiding complexity of kernel's functions from users. Takes commands from user and executes kernel's functions.
- **Utilities** - Utility programs giving user most of the functionalities of an operating systems.

LINUX File system

Linux file structure files are grouped according to purpose. Ex: commands, data files, documentation. Parts of a Unix directory tree are listed below. All directories are grouped under the root entry "/". That part of the directory tree is left out of the below diagram.



1. / – Root
   - Every single file and directory starts from the root directory.
   - Only root user has write privilege under this directory.
   - Please note that /root is root user‘s home directory, which is not same as /.
2. /bin – User Binaries
   - Contains binary executables.
   - Common linux commands you need to use in single-user modes are located under this directory.
   - Commands used by all the users of the system are located here.
   - For example: ps, ls, ping, grep, cp.
3. /sbin – System Binaries
   - Just like /bin, /sbin also contains binary executables.
   - But, the linux commands located under this directory are used typically by system aministrator, for system maintenance purpose.
   - For example: iptables, reboot, fdisk, ifconfig, swapon
4. /etc – Configuration Files
   - Contains configuration files required by all programs.
   - This also contains startup and shutdown shell scripts used to start/stop individual programs.
   - For example: /etc/resolv.conf, /etc/logrotate.conf
5. /dev – Device Files
   - Contains device files.
   - These include terminal devices, usb, or any device attached to the system.
   - For example: /dev/tty1, /dev/usbmon0
6. /proc – Process Information
   - Contains information about system process.
   - This is a pseudo filesystem contains information about running process. For example: /proc/{pid} directory contains information about the process with that particular pid.
   - This is a virtual filesystem with text information about system resources. For example: /proc/uptime
7. /var – Variable Files
   - var stands for variable files.

- Content of the files that are expected to grow can be found under this directory.
- This includes — system log files (/var/log); packages and database files (/var/lib); emails (/var/mail); print queues (/var/spool); lock files (/var/lock); temp files needed across reboots (/var/tmp);

8. /tmp – Temporary Files
   - Directory that contains temporary files created by system and users.
   - Files under this directory are deleted when system is rebooted.
9. /usr – User Programs
   - Contains binaries, libraries, documentation, and source-code for second level programs.
   - /usr/bin contains binary files for user programs. If you can‛t find a user binary under /bin, look under /usr/bin. For example: at, awk, cc, less, scp
   - /usr/sbin contains binary files for system administrators. If you can‛t find a system binary under /sbin, look under /usr/sbin. For example: atd, cron, sshd, useradd, userdel
   - /usr/lib contains libraries for /usr/bin and /usr/sbin
   - /usr/local contains users programs that you install from source. For example, when you install apache from source, it goes under /usr/local/apache2
10. /home – Home Directories
    - Home directories for all users to store their personal files.
    - For example: /home/john, /home/nikita
11. /boot – Boot Loader Files
    - Contains boot loader related files.
    - Kernel initrd, vmlinux, grub files are located under /boot
    - For example: initrd.img-2.6.32-24-generic, vmlinuz-2.6.32-24-generic
12. /lib – System Libraries
    - Contains library files that supports the binaries located under /bin and /sbin
    - Library filenames are either ld* or lib*.so.*
    - For example: ld-2.11.1.so, libncurses.so.5.7
13. /opt – Optional add-on Applications
    - opt stands for optional.
    - Contains add-on applications from individual vendors.
    - add-on applications should be installed under either /opt/ or /opt/ sub-directory.
14. /mnt – Mount Directory
    - Temporary mount directory where sysadmins can mount filesystems.

15. /media – Removable Media Devices

- Temporary mount directory for removable devices.
- For examples, /media/cdrom for CD-ROM; /media/floppy for floppy drives; /media/cdrecorder for CD writer

16. /srv – Service Data

- srv stands for service.
- Contains server specific services related data.
- For example, /srv/cvs contains CVS related data.

Linux Utilities:

File Handling utilities:

Cat Command:

cat linux command concatenates files and print it on the standard output.

SYNTAX:

The Syntax is

```
cat [OPTIONS] [FILE]...
```

OPTIONS:

-A	Show all.
-b	Omits line numbers for blank space in the output.
-e	A $ character will be printed at the end of each line prior to a new line.
-E	Displays a $ (dollar sign) at the end of each line.
-n	Line numbers for all the output lines.
-s	If the output has multiple empty lines it replaces it with one empty line.
-T	Displays the tab characters in the output.
-v	Non-printing characters (with the exception of tabs, new-lines and form-feeds) are printed visibly.

Example:

To Create a new file:

```
cat > file1.txt
```

This command creates a new file file1.txt. After typing into the file press control+d (^d) simultaneously to end the file.

1. To Append data into the
   file: cat >> file1.txt
   To append data into the same file use append operator >> to write into the file, else
   the file will be overwritten (i.e., all of its contents will be erased).
2. To display a

   file: cat
   file1.txt
   This command displays the data in the file.
3. To concatenate several files and
   display: cat file1.txt file2.txt

   The above cat command will concatenate the two files (file1.txt and file2.txt) and it will display the output in the screen. Sometimes the output may not fit the monitor screen. In such situation you can print those files in a nlew file or display the file using less command.
   cat file1.txt file2.txt | less

4. To concatenate several files and to transfer the output to anotherfile.
   cat file1.txt file2.txt > file3.txt
   In the above example the output is redirected to new file file3.txt. The cat command will create new file file3.txt and store the concatenated output into file3.txt.

rm COMMAND:

rm linux command is used to remove/delete the file from the directory.

SYNTAX:

The Syntax is

rm [options..] [file | directory]

OPTIONS:

-f	Remove all files in a directory without prompting the user.
-i	Interactive. With this option, rm prompts for confirmation before removing any files.

-r (or) -R	Recursively remove directories and subdirectories in the argument list. The directory will be emptied of files and removed. The user is normally prompted for removal of any write-protected files which the directory contains.

EXAMPLE:

1. To Remove / Delete a file:

   rm file1.txt

   Here rm command will remove/delete the file file1.txt.

2. To delete a directory tree:

   rm -ir tmp

   This rm command recursively removes the contents of all subdirectories of the tmp directory, prompting you regarding the removal of each file, and then removes the tmp directory itself.

3. To remove more files at once

   rm file1.txt file2.txt

   rm command removes file1.txt and file2.txt files at the same time.

cd COMMAND:

cd command is used to change the directory.

SYNTAX:

The Syntax is

cd [directory | ~ | ./ | ../ | -]

OPTIONS:

-L	Use the physical directory structure.
-P	Forces symbolic links.

EXAMPLE:

1. cd linux-command

   This command will take you to the sub-directory(linux-command) from its parent directory.

2. cd **..**

   This will change to the parent-directory from the current working directory/sub-directory.

3. cd ~

This command will move to the user's home directory which is "/home/username".

cp COMMAND:

cp command copy files from one location to another. If the destination is an existing file, then the file is overwritten; if the destination is an existing directory, the file is copied into the directory (the directory is not overwritten).

SYNTAX:

The Syntax is

cp [OPTIONS]... SOURCE DEST

cp [OPTIONS]... SOURCE... DIRECTORY

cp [OPTIONS]... --target-directory=DIRECTORY SOURCE...

OPTIONS:

-a	same as -dpR.
--backup[=CONTROL]	make a backup of each existing destination file
-b	like --backup but does not accept an argument.
-f	if an existing destination file cannot be opened, remove it and try again.
-p	same as --preserve=mode,ownership,timestamps.
-preserve[=ATTR_LIST]	preserve the specified attributes (default: mode,ownership,timestamps) and security contexts, if possible additional attributes: links, all.
--no-preserve=ATTR_LIST	don't preserve the specified attribute.
--parents	append source path to DIRECTORY.

EXAMPLE:

Copy two

files: cp

file1 file2

The above cp command copies the content of file1.php to file2.php.

1. To backup the copied

   file: cp -b file1.php

file2.php

Backup of file1.php will be created with '~' symbol as file2.php~.

2. Copy folder and subfolders: cp -R scripts scripts1

   The above cp command copy the folder and subfolders from scripts to scripts1.

ls COMMAND:

ls command lists the files and directories under current working directory.

SYNTAX:

The Syntax is

ls [OPTIONS]... [FILE]

OPTIONS:

-l	Lists all the files, directories and their mode, Number of links, owner of the file, file size, Modified date and time and filename.
-t	Lists in order of last modification time.
-a	Lists all entries including hidden files.
-d	Lists directory files instead of contents.
-p	Puts slash at the end of each directories.
-u	List in order of last access time.
-i	Display inode information.
-ltr	List files order by date.
-lSr	List files order by file size.

EXAMPLE:

Display root directory contents:

ls /

lists the contents of root directory.

1. Display hidden files anddirectories:

   ls -a

   lists all entries including hidden files and directories.

2. Display inode information:

   ls -i

```
7373073 book.gif
7373074 clock.gif
7373082 globe.gif
7373078 pencil.gif
7373080 child.gif
7373081 email.gif
7373076 indigo.gif
```

The above command displays filename with inode value.

ln COMMAND:

ln command is used to create link to a file (or) directory. It helps to provide soft link for desired files. Inode will be different for source and destination.

SYNTAX:

The Syntax is

```
ln [options] existingfile(or directory)name newfile(or directory)name
```

OPTIONS:

-f	Link files without questioning the user, even if the mode of target forbids writing. This is the default if the standard input is not a terminal.
-n	Does not overwrite existing files.
-s	Used to create soft links.

EXAMPLE:

1. `ln -s file1.txt file2.txt`

   Creates a symbolic link to 'file1.txt' with the name of 'file2.txt'. Here inode for 'file1.txt' and 'file2.txt' will be different.
2. `ln -s nimi nimi1`

   Creates a symbolic link to 'nimi' with the name of 'nimi1'.

chown COMMAND:

chown command is used to change the owner / user of the file or directory. This is an admin command, root user only can change the owner of a file or directory.

SYNTAX:

The Syntax is

```
chown [options] newowner filename/directoryname
```

OPTIONS:

-R	Change the permission on files that are in the subdirectories of the directory that you are currently in.
-c	Change the permission for each file.
-f	Prevents chown from displaying error messages when it is unable to change the ownership of a file.

EXAMPLE:

1. chown hiox test.txt
   The owner of the 'test.txt' file is root, Change to new user hiox.
2. chown -R hiox test
   The owner of the 'test' directory is root, With -R option the files and subdirectories user also gets changed.
3. chown -c hiox calc.txt
   Here change the owner for the specific 'calc.txt' file only.

Security By File Permissions

Chmod Command:

chmod command allows you to alter / Change access rights to files and directories.

File Permission is given for users, group and others as,

Read	Write	Execute

User	☐
Group	☐
Others	☐
Permission	000

SYNTAX:

The Syntax is

```
chmod [options] [MODE] FileName
```

File Permission

#	File Permission
0	none
1	execute only

2	write only
3	write and execute
4	read only
5	read and execute
6	read and write
7	set all permissions

OPTIONS:

-c	Displays names of only those files whose permissions are being changed
-f	Suppress most error messages
-R	Change files and directories recursively
-v	Output version information and exit.

EXAMPLE:

1. To view your files with what permission they are:

   ls -alt

   This command is used to view your files with what permission they are.
2. To make a file readable and writable by the group and others.

   chmod 066 file1.txt
3. To allow everyone to read, write, and execute the file

   chmod 777 file1.txt

mkdir COMMAND:

mkdir command is used to create one or more directories.

SYNTAX:

The Syntax is

mkdir [options] directories

OPTIONS:

-m	Set the access mode for the new directories.
-p	Create intervening parent directories if they don't exist.
-v	Print help message for each directory created.

EXAMPLE:

1. Create directory:
   mkdir test
   The above command is used to create the directory 'test'.
2. Create directory and setpermissions:
   mkdir -m 666 test
   The above command is used to create the directory 'test' and set the read and write permission.

rmdir COMMAND:

rmdir command is used to delete/remove a directory and its subdirectories.

SYNTAX:

The Syntax is

rmdir [options..] Directory

OPTIONS:

-p	Allow users to remove the directory dirname and its parent directories which become empty.

EXAMPLE:

1. To delete/remove a directory

   rmdir tmp

   rmdir command will remove/delete the directory tmp if the directory is empty.

2. To delete a directory tree:

   rm -ir tmp

   This command recursively removes the contents of all subdirectories of the tmp directory, prompting you regarding the removal of each file, and then removes the tmp directory itself.

mv COMMAND:

mv command which is short for move. It is used to move/rename file from one directory to another. mv command is different from cp command as it completely removes the file from the source and moves to the directory specified, where cp command just copies the content from one file to another.

SYNTAX:

The Syntax is

mv [-f] [-i] oldname newname

OPTIONS:

-f	This will not prompt before overwriting (equivalent to --reply=yes). mv -f will move the file(s) without prompting even if it is writing over an existing target.
-i	Prompts before overwriting another file.

EXAMPLE:

1. To Rename / Move a file:

   mv file1.txt file2.txt

   This command renames file1.txt as file2.txt
2. To move a directory

   mv hscripts tmp

   In the above line mv command moves all the files, directories and sub-directories from hscripts folder/directory to tmp directory if the tmp directory already exists. If there is no tmp directory it rename's the hscripts directory as tmp directory.

3. To Move multiple files/More files into another directory

   mv file1.txt tmp/file2.txt newdir

   This command moves the files file1.txt from the current directory and file2.txt from the tmp folder/directory to newdir.

diff COMMAND:

diff command is used to find differences between two files.

SYNTAX:

The Syntax is

diff [options..] from-file to-file

OPTIONS:

-a	Treat all files as text and compare them line-by-line.
-b	Ignore changes in amount of white space.
-c	Use the context output format.
-e	Make output that is a valid ed script.
-H	Use heuristics to speed handling of large files that have numerous scattered small changes.

-i	Ignore changes in case; consider upper- and lower-case letters equivalent.
-n	Prints in RCS-format, like -f except that each command specifies the number of lines affected.
-q	Output RCS-format diffs; like -f except that each command specifies the number of lines affected.
-r	When comparing directories, recursively compare any subdirectories found.
-s	Report when two files are the same.
-w	Ignore white space when comparing lines.
-y	Use the side by side output format.

EXAMPLE:

Lets create two files file1.txt and file2.txt and let it have the following data.

Data in file1.txt	Data in file2.txt
HIOX TEST	HIOX TEST
hscripts.com	HSCRIPTS.com
with friend ship	with friend ship
hiox india	

1. Compare files ignoring white space:

   diff -w file1.txt file2.txt

   This command will compare the file file1.txt with file2.txt ignoring white/blank space and it will produce the following output.

```
2c2
< hscripts.com
---
> HSCRIPTS.com
4d3
< Hioxindia.com
```

2. Compare the files side by side, ignoring white space:

   diff -by file1.txt file2.txt

   This command will compare the files ignoring white/blank space, It is easier to differentiate the files.

```
HIOX TEST              HIOX TEST
```

```
hscripts.com      |      HSCRIPTS.com
with   friend   ship   with   friend   ship
Hioxindia.com  <
```

The third line(with friend ship) in file2.txt has more blank spaces, but still the -b ignores

the blank space and does not show changes in the particular line, -y printout the result side by side.

3. Compare the files ignoring case.

   diff -iy file1.txt file2.txt

   This command will compare the files ignoring case(upper-case and lower-case) and displays the following output.

```
HIOX TEST              HIOX TEST
hscripts.com           HSCRIPTS.com
with friend ship     | with friend ship
```

chgrp COMMAND:

chgrp command is used to change the group of the file or directory. This is an admin command. Root user only can change the group of the file or directory.

SYNTAX:

The Syntax is

chgrp [options] newgroup filename/directoryname

OPTIONS:

-R	Change the permission on files that are in the subdirectories of the directory that you are currently in.
-c	Change the permission for each file.
-f	Force. Do not report errors.

Hioxindia.com <

EXAMPLE:

1. chgrp hiox test.txt

   The group of 'test.txt' file is root, Change to newgroup hiox.

2. chgrp -R hiox test

   The group of 'test' directory is root. With -R, the files and its subdirectories also changes to newgroup hiox.

3. chgrp -c hiox calc.txt

They above command is used to change the group for the specific file('calc.txt') only.

About wc

Short for word count, wc displays a count of lines, words, and characters in a file.

Syntax

wc [-c | -m | -C] [-l] [-w] [file ...]

-c	Count bytes.
-m	Count characters.
-C	Same as -m.
-l	Count lines.
-w	Count words delimited by white space characters or new line characters. Delimiting characters are Extended Unix Code (EUC) characters from any code set defined by iswspace()
File	Name of file to word count.

Examples

wc myfile.txt - Displays information about the file myfile.txt. Below is an example of the output.

```
5    13    57 myfile.txt
```

5 = Lines

13 = Words

57 = Characters

About split

Split a file into pieces.

Syntax

split [-linecount | -l linecount] [-a suffixlength] [file [name]]

split -b n [k | m] [-a suffixlength] [file [name]]

-linecount | -l linecount	Number of lines in each piece. Defaults to 1000 lines.
-a suffixlength	Use suffixlength letters to form the suffix portion of the filenames of the split file. If -a is not specified, the default suffix length is 2. If the sum of the name operand and the suffixlength option-argument would create a filename exceeding NAME_MAX bytes, an error will result; split will exit with a diagnostic message

	and no files will be created.
-b n	Split a file into pieces n bytes in size.
-b n k	Split a file into pieces n*1024 bytes in size.
-b n m	Split a file into pieces n*1048576 bytes in size.
File	The path name of the ordinary file to be split. If no input file is given or file is -, the standard input will be used.
name	The prefix to be used for each of the files resulting from the split operation. If no name argument is given, x will be used as the prefix of the output files. The combined length of the basename of prefix and suffixlength cannot exceed NAME_MAX bytes; see OPTIONS.

Examples

split -b 22 newfile.txt new - would split the file "newfile.txt" into three separate files called newaa, newab and newac each file the size of 22.

split -l 300 file.txt new - would split the file "newfile.txt" into files beginning with the name "new" each containing 300 lines of text each

About settime and touch

Change file access and modification time.

Syntax

touch [-a] [-c] [-m] [-r ref_file | -t time] file

settime [-f ref_file] file

-a	Change the access time of file. Do not change the modification time unless -m is also specified.
-c	Do not create a specified file if it does not exist. Do not write any diagnostic messages concerning this condition.
-m	Change the modification time of file. Do not change the access time unless -a is also specified.
-r ref_file	Use the corresponding times of the file named by ref_file instead of the current time.

-t time	Use the specified time instead of the current time. time will be a decimal number of the form: [[CC]YY]MMDDhhmm [.SS] MM-The month of the year [01-12]. DD-The day of the month [01-31]. Hh –The hour of the day [00-23]. mm-The minute of the hour [00-59]. CC –The first two digits of the year. YY - The second two digits of the year. SS - The second of the minute [00-61].
-f ref_file	Use the corresponding times of the file named by ref_file instead of the current time.
File	A path name of a file whose times are to be modified.

Examples

settime myfile.txt

Sets the file myfile.txt as the current time / date.

touch newfile.txt

Creates a file known as "newfile.txt", if the file does not already exist. If the file already exists the accessed / modification time is updated for the file newfile.txt

About comm

Select or reject lines common to two files.

Syntax

comm [-1] [-2] [-3] file1 file2

-1	Suppress the output column of lines unique to file1.
-2	Suppress the output column of lines unique to file2.
-3	Suppress the output column of lines duplicated in file1 and file2.
file1	Name of the first file to compare.
file2	Name of the second file to compare.

Examples

comm myfile1.txt myfile2.txt

The above example would compare the two files myfile1.txt and myfile2.txt.

Process utilities:

ps Command:

ps command is used to report the process status. ps is the short name for Process Status.

SYNTAX:

The Syntax is

```
ps [options]
```

OPTIONS:

-a	List information about all processes most frequently requested: all those except process group leaders and processes not associated with a terminal..
-A or e	List information for all processes.
-d	List information about all processes except session leaders.
-e	List information about every process now running.
-f	Generates a full listing.
-j	Print session ID and process group ID.
-l	Generate a long listing.

EXAMPLE:

1. ps

   Output:

   ```
    PID TTY          TIME CMD
    2540 pts/1    00:00:00 bash
    2621 pts/1    00:00:00 ps
   ```

   In the above example, typing ps alone would list the current running processes.

2. ps -f

   Output:

   ```
   UID        PID  PPID  C STIME TTY          TIME CMD
   nirmala   2540  2536  0 15:31 pts/1    00:00:00 bash
   nirmala   2639  2540  0 15:51 pts/1    00:00:00       ps       -f
   ```

   Displays full information about currently runningprocesses.

kill COMMAND:

kill command is used to kill the background process.

SYNTAX:

The Syntax is

kill [-s] [-l] %pid

OPTIONS:

-s	Specify the signal to send. The signal may be given as a signal name or number.
-l	Write all values of signal supported by the implementation, if no operand is given.
-pid	Process id or job id.
-9	Force to kill a process.

EXAMPLE:

Step by Step process:

- Open a process music player.

  xmms

  press ctrl+z to stop the process.
- To know group id or job id of the background task.

  jobs -l
- It will list the background jobs with its job id as,
- xmms 3956

  kmail 3467
- To kill a job or process.

  kill 3956

kill command kills or terminates the background process xmms.

About nice

Invokes a command with an altered scheduling priority.

Syntax

nice [-increment | -n increment] command [argument ...]

-increment | -n increment	increment must be in the range 1-19; if not specified, an increment of 10 is assumed. An increment greater than 19 is equivalent to 19. The super-user may run commands with priority higher than normal by using a negative increment such as -10. A negative increment assigned by an unprivileged user is ignored.
command	The name of a command that is to be invoked. If command names any of the special built-in utilities, the results are undefined.
argument	Any string to be supplied as an argument when invoking command.

Examples

nice +13 pico myfile.txt - runs the pico command on myfile.txt with an increment of +13.

About at

Schedules a command to be ran at a particular time, such as a print job late at night.

Syntax

at	executes commands at a specified time.
atq	lists the user's pending jobs, unless the user is the superuser; in that case, everybody's jobs are listed. The format of the output lines (one for each job) is: Job number, date, hour, job class.
atrm	deletes jobs, identified by their job number.
batch	executes commands when system load levels permit; in other words, when the load average drops below 1.5, or the value specified in the invocation of atrun.

at [-c | -k | -s] [-f filename] [-q queuename] [-m] -t time [date] [-l] [-r]

-c	C shell. csh(1) is used to execute the at-job.
-k	Korn shell. ksh(1) is used to execute the at-job.
-s	Bourne shell. sh(1) is used to execute the at-job.
-f filename	Specifies the file that contains the command to run.
-m	Sends mail once the command has been run.

-t time	Specifies at what time you want the command to be ran. Format hh:mm. am / pm indication can also follow the time otherwise a 24-hour clock is used. A timezone name of GMT, UCT or ZULU (case insensitive) can follow to specify that the time is in Coordinated Universal Time. Other timezones can be specified using the TZ environment variable. The below quick times can also be entered: midnight-Indicates the time 12:00 am (00:00). noon-Indicates the time 12:00 pm. now - Indicates the current day and time. Invoking at-now will submit submit an at-job for potentially immediate execution.
date	Specifies the date you wish it to be ran on. Format month, date, year. The following quick days can also be entered: today-Indicates the current day. tomorrow - Indicates the day following the current day.
-l	Lists the commands that have been set to run.
-r	Cancels the command that you have set in the past.

Examples

at -m 01:35 < atjob = Run the commands listed in the 'atjob' file at 1:35AM, in addition all output that is generated from job mail to the user running the task. When this command has been successfully enter you should receive a prompt similar to the below example.

Commands will be executed using /bin/csh job 1072250520.a at Wed Dec 24 00:22:00 2003

at -l = This command will list each of the scheduled jobs as seen below.

1072250520.a Wed Dec 24 00:22:00 2003

at -r 1072250520.a = Deletes the job just created.

or

atrm 23 = Deletes job 23.

If you wish to create a job that is repeated you could modify the file that executes the commands with another command that recreates the job or better yet use the crontab command.

Disk utilities:

du (abbreviated from *disk usage*) is a standard Unix program used to estimate file space usage—space used under a particular directory or files on a file system.

dutakesasingleargument, specifyingapathnamefordutowork; if itisnotspecified, thecurrent directory is used. The SUS mandates for du the following options:

-a, display an entry for each file (and not directory) contained in the current directory

-H, calculate disk usage for link references specified on the command line

-k, show sizes as multiples of 1024 bytes, not 512-byte

-L, calculate disk usage for link references anywhere

-s, report only the sum of the usage in the current directory, not for each file

-x, only traverse files and directories on the device on which the pathname argument is specified.

Other Unix and Unix-like operating systems may add extra options. For example, BSD and GNU du specify a -h option, displaying disk usage in a format easier to read by the user, adding units with the appropriate SI prefix‘

```
$ du -sk *
 152304 directoryOne
 1856548 directoryTwo
```

Sum of directories in human-readable format (Byte, Kilobyte, Megabyte, Gigabyte, Terabyte and Petabyte):

```
 $ du -sh *
 149M directoryOne
 1.8G directoryTwo
```

disk usage of all subdirectories and files including hidden files within the current directory (sorted by filesize) :

```
 $ du -sk .[!.]* *| sort -n
```

disk usage of all subdirectories and files including hidden files within the current directory (sorted by reverse filesize) :

```
 $ du -sk .[!.]* *| sort –nr
```

The weight of directories:

```
$ du -d 1 -c -h
```

df command : Report file system disk space usage

Df command examples - to check free disk space

Type df -h or df -k to list free disk space:

```
$ df -h
```

OR

```
$ df –k
```

Output:

```
• Filesystem        Size Used Avail Use% Mounted on
• /dev/sdb1          20G 9.2G 9.6G 49% /
• varrun             393M 144k 393M  1%  /var/run
• varlock            393M 0 393M 0%  /var/lock
•  procbususb        393M 123k 393M 1% /proc/bus/usb
• udev               393M 123k 393M 1% /dev
• devshm             393M 0 393M 0% /dev/shm
• lrm                393M 35M 359M 9% /lib/modules/2.6.20-15-generic/volatile
• /dev/sdb5          29G 5.4G 22G 20% /media/docs
• /dev/sdb3          30G 5.9G 23G 21% /media/isomp3s
• /dev/sda1          8.5G   4.3G   4.3G  51% /media/xp1
• /dev/sda2          12G 6.5G 5.2G 56% /media/xp2
• /dev/sdc1          40G 3.1G 35G 9% /media/backup
```

du command examples

du shows how much space one ore more files or directories is using.

```
$ du -sh
103M
```

-s option summarize the space a directory is using and -h option provides "Human-readable" output.

Networking commands:

These are most useful commands in my list while working on Linux server , this enables you to quickly troubleshoot connection issues e.g. whether other system is connected or not , whether other host is responding or not and while working for FIX connectivity for advanced trading system this tools saves quite a lot of time .

This article is in continuation of my article How to work fast in Unix and Unix Command tutorials and Examples for beginners.

- finding host/domain name and IP address - **hostname**
- test network connection – **ping**
- getting network configuration – **ifconfig**

• Network connections, routing tables, interface statistics – **netstat**
• query DNS lookup name – **nslookup**
communicate with other hostname – **telnet**
outing steps that packets take to get to network host – **traceroute**

1. **Arp** manipulates the kernel‘s ARP cache in various ways. The primary options are clearing an address mapping entry and manually setting up one. For debugging purposes, the arp program also allows a complete dump of the ARP cache.ARP displays the IP address assigned to particular ETH card and mac address

```
[fasil@smashtech ]# arp
Address              HWtype HWaddress         Flags Mask        Iface
59.36.13.1           ether      C            eth0
```

2. **Ifconfig** is used to configure the network interfaces. Normally we use this command to check the IP address assigned to the system.It is used at boot time to set up interfaces as necessary. After that, it is usually only needed when debugging or when system tuning is needed.

```
[fasil@smashtech ~]# /sbin/ifconfig
eth0     UP BROADCAST RUNNING MULTICAST MTU:1500  Metric:1
         RX packets:126341 errors:0 dropped:0 overruns:0 frame:0
         TX packets:44441 errors:0 dropped:0 overruns:0 carrier:0
         collisions:0 txqueuelen:1000
```

3. **Netstat** prints information about the networking subsystem. The type of information which is usually printed by netstat are Print network connections, routing tables, interface statistics, masquerade connections, and multicast.

```
[fasil@smashtech ~]# netstat
Active Internet connections (w/o servers)
Proto Recv-Q Send-Q Local Address            Foreign Address          State
tcp        0      0                    .230.87:https          ESTABLISHED
Active UNIX domain sockets (w/o servers)
Proto RefCnt Flags Type State I-Node Path
    unix     10   [ ]      DGRAM                    4970 /dev/log
    unix     2    [ ]      DGRAM                    6625  @/var/run/hal/hotplug_socket
    unix     2    [ ]      DGRAM                   2952 @udevd
    unix     2    [ ]      DGRAM                   100564
    unix     3    [ ]      STREAM        CONNECTED     62438 /tmp/.X11-unix/X0
    unix     3    [ ]      STREAM        CONNECTED     62437
unix    3    [ ]      STREAM        CONNECTED    10271  @/tmp/fam-root-
unix    3    [ ]      STREAM        CONNECTED    10270
unix 3           ]    STR  AM       CONNECTED    9276
unix 3           ]    STR  AM       CONNECTED    9275
```

4. **ping** command is used to check the connectivity of a system to a network.Whenever there is problem in network connectivity we use ping to ensure the system is connected to network.

Filters:

more COMMAND:

more command is used to display text in the terminal screen. It allows only backward movement.

SYNTAX:

The Syntax is

more [options] filename

OPTIONS:

-c	Clear screen before displaying.
-e	Exit immediately after writing the last line of the last file in the argument list.
-n	Specify how many lines are printed in the screen for a given file.
+n	Starts up the file from the given number.

EXAMPLE:

1. more -c index.php
   Clears the screen before printing the file .
2. more -3 index.php

Prints first three lines of the given file. Press **Enter** to display the file line by line.

head COMMAND:

head command is used to display the first ten lines of a file, and also specifies how many lines to display.

SYNTAX:

The Syntax is

head [options] filename

OPTIONS:

-n	To specify how many lines you want to display.
-n number	The number option-argument must be a decimal integer whose sign affects the location in the file, measured in lines.
-c number	The number option-argument must be a decimal integer whose sign affects the location in the file, measured in bytes.

EXAMPLE:

1. head index.php
   This command prints the first 10 lines of 'index.php'.
2. head -5 index.php
   The head command displays the first 5 lines of 'index.php'.
3. head -c 5 index.php
   The above command displays the first 5 characters of 'index.php'.

tail COMMAND:

tail command is used to display the last or bottom part of the file. By default it displays last 10 lines of a file.

SYNTAX:

The Syntax is

tail [options] filename

OPTIONS:

-l	To specify the units of lines.
-b	To specify the units of blocks.
-n	To specify how many lines you want to display.
-c number	The number option-argument must be a decimal integer whose sign affects the location in the file, measured in bytes.
-n number	The number option-argument must be a decimal integer whose sign affects the location in the file, measured in lines.

EXAMPLE:

1. tail index.php
   It displays the last 10 lines of 'index.php'.
2. tail -2 index.php

It displays the last 2 lines of 'index.php'.

3. tail -n 5 index.php
   It displays the last 5 lines of 'index.php'.
4. tail -c 5 index.php
   It displays the last 5 characters of 'index.php'.

cut COMMAND:

cut command is used to cut out selected fields of each line of a file. The cut command uses delimiters to determine where to split fields.

SYNTAX:

The Syntax is

cut [options]

OPTIONS:

-c	Specifies character positions.
-b	Specifies byte positions.
-d flags	Specifies the delimiters and fields.

EXAMPLE:

1. cut -c1-3 text.txt
   Output:
   Thi
   Cut the first three letters from the above line.
2. cut -d, -f1,2 text.txt
   Output:
   This is, an example program
   The above command is used to split the fields using delimiter and cut the first two fields.

paste COMMAND:

paste command is used to paste the content from one file to another file. It is also used to set column format for each line.

SYNTAX:

The Syntax is

paste [options]

OPTIONS:

-s	Paste one file at a time instead of in parallel.
-d	Reuse characters from LIST instead of TABs .

EXAMPLE:

1. paste test.txt>test1.txt
   Paste the content from 'test.txt' file to 'test1.txt' file.
2. ls | paste - - - -
   List all files and directories in four columns for each line.

sort COMMAND:

sort command is used to sort the lines in a text file.

SYNTAX:

The Syntax is

sort [options] filename

OPTIONS:

-r	Sorts in reverse order.
-u	If line is duplicated display only once.
-o filename	Sends sorted output to a file.

EXAMPLE:

1. sort test.txt
   Sorts the 'test.txt'file and prints result in the screen.
2. sort -r test.txt
   Sorts the 'test.txt' file in reverse order and prints result in the screen.

About uniq
Report or filter out repeated lines in a file.

Syntax
uniq [-c | -d | -u] [-f fields] [-s char] [-n] [+m] [input_file [output_file]]

-c	Precede each output line with a count of the number of times the line occurred in the input.
-d	Suppress the writing of lines that are not repeated in the input.
-u	Suppress the writing of lines that are repeated in the input.

-f fields	Ignore the first fields fields on each input line when doing comparisons, where fields is a positive decimal integer. A field is the maximal string matched by the basic regular expression: [[:blank:]]*[^[:blank:]]* If fields specifies more fields than appear on an input line, a null string will be used for comparison.
-s char	Ignore the first chars characters when doing comparisons, where chars is a positive decimal integer. If specified in conjunction with the -f option, the first chars characters after the first fields fields will be ignored. If chars specifies more characters than remain on an input line, a null string will be used for comparison.
-n	Equivalent to -f fields with fields set to n.
+m	Equivalent to -s chars with chars set to m.
input_file	A path name of the input file. If input_file is not specified, or if the input_file is - ,the standard input will be used.
output_file	A path name of the output file. If output_file is not specified, the standard output will be used. The results are unspecified if the file named by output_file is the file named by input_file.

Examples
uniq myfile1.txt > myfile2.txt - Removes duplicate lines in the first file1.txt and outputs the results to the second file.

About tr
Translate characters.
Syntax
tr [-c] [-d] [-s] [string1] [string2]

-c	Complement the set of characters specified by string1.
-d	Delete all occurrences of input characters that are specified by string1.
-s	Replace instances of repeated characters with a single character.

string1	First string or character to be changed.
ring2	Second string or character to change the string1.

Examples

echo "12345678 9247" | tr 123456789 computerh - this example takes an echo response of '12345678 9247' and pipes it through the tr replacing the appropriate numbers with the letters. In this example it would return *computer hope*.

tr -cd '\11\12\40-\176' < myfile1 > myfile2 - this example would take the file myfile1 and strip all non printable characters and take that results to myfile2.

Text processing utilities and Backup utilities:

Text processing utilities:

cat : concatenate files and print on the standard output

Usage: cat [OPTION] [FILE]...

eg. cat file1.txt file2.txt

cat n

file1.txt

echo : display a line of text

Usage: echo [OPTION] [string] ...

eg. echo I love India

echo $HOME

wc: print the number of newlines, words, and bytes in files

Usage: wc [OPTION]... [FILE]...

eg. wc file1.txt

wc L

file1.txt

sort :sort lines of text files

Usage: sort [OPTION]... [FILE]...

eg. sort file1.txt

sort r

file1.txt

General Commands:

date COMMAND:

date command prints the date and time.

SYNTAX:

The Syntax is

```
date [options] [+format] [date]
```

OPTIONS:

-a	Slowly adjust the time by sss.fff seconds (fff represents fractions of a second). This adjustment can be positive or negative.Only system admin/ super user can adjust the time.
- date - string	Sets the time and date to the value specfied in the datestring. The datestr may contain the month names, timezones, 'am', 'pm', etc.
-u	Display (or set) the date in Greenwich Mean Time (GMT-universal time).

Format:

%a	Abbreviated weekday(Tue).
%A	Full weekday(Tuesday).
%b	Abbreviated month name(Jan).
%B	Full month name(January).
%c	Country-specific date and time format..
%D	Date in the format %m/%d/%y.
%j	Julian day of year (001-366).
%n	Insert a new line.
%p	String to indicate a.m. or p.m.
%T	Time in the format %H:%M:%S.
%t	Tab space.
%V	Week number in year (01-52); start week on Monday.

EXAMPLE:

date command

```
date
```

The above command will print Wed Jul 23 10:52:34 IST 2008

1. To use tab space:

```
date +"Date is %D %t Time is %T"
Date is 07/23/08 Time is 10:52:34
```

2. To know the week number of the year,

```
date -V
```

The above command will print 30

3. To set the date,

```
date -s "10/08/2008 11:37:23"
```

The above command will print Wed Oct 08 11:37:23 IST 2008

who COMMAND:

who command can list the names of users currently logged in, their terminal, the time they have been logged in, and the name of the host from which they have logged in.

SYNTAX:

The Syntax is

```
who [options] [file]
```

OPTIONS:

am i	Print the username of the invoking user, The 'am' and 'i' must be space separated.
-b	Prints time of last system boot.
-d	print dead processes.
-H	Print column headings above the output.
-i	Include idle time as HOURS:MINUTES. An idle time of . indicates activity within the last minute.
-m	Same as who am i.
-q	Prints only the usernames and the user count/total no of users logged in.
-T,-w	Include user's message status in the output.

EXAMPLE:

1. who –Uh

   Output:

   ```
   NAME     LINE         TIME          IDLE          PID COMMENT
   hiox     ttyp3        Jul 10 11:08 .            4578
   ```

   This sample output was produced at 11 a.m. The "." indiacates activity within the last minute.

2. who am i

   who am i command prints the user name.

echo COMMAND:

echo command prints the given input string to standard output.

SYNTAX:

The Syntax is

```
echo [options..] [string]
```

OPTIONS:

-n	do not output the trailing newline
-e	enable interpretation of the backslash-escaped characters listed below
-E	disable interpretation of those sequences in STRINGs

Without -E, the following sequences are recognized and interpolated:

\NNN	the character whose ASCII code is NNN (octal)
\a	alert (BEL)
\\	backslash
\b	backspace
\c	suppress trailing newline
\f	form feed
\n	new line
\r	carriage return
\t	horizontal tab
\v	vertical tab

EXAMPLE:

echo command

```
echo "hscripts Hiox India"
```

The above command will print as hscripts Hiox India

1. To use backspace:
   ```
   echo -e "hscripts \bHiox \bIndia"
   ```
   The above command will remove space and print as hscriptsHioxIndia
2. To use tab space in echo command
   ```
   echo -e "hscripts\tHiox\tIndia"
   ```
   The above command will print as hscripts	Hiox	India

passwd COMMAND:

passwd command is used to change your password.

SYNTAX:

The Syntax is

```
passwd [options]
```

OPTIONS:

-a	Show password attributes for all entries.
-l	Locks password entry for name.
-d	Deletes password for name. The login name will not be prompted for password.
-f	Force the user to change password at the next login byexpiring the password for name.

EXAMPLE:

1. passwd

   Entering just passwd would allow you to change the password. After entering passwd you will receive the following three prompts:

   ```
   Current Password:
   New Password:
   Confirm New Password:
   ```

   Each of these prompts must be entered correctly for the password to be successfully changed.

pwd COMMAND:

pwd - Print Working Directory. pwd command prints the full filename of the current working directory.

SYNTAX:

The Syntax is

```
pwd [options]
```

OPTIONS:

-P	The pathname printed will not contain symbolic links.
-L	The pathname printed may contain symbolic links.

EXAMPLE:

1. Displays the current working directory.

```
pwd
```

If you are working in home directory then, pwd command displays the current working directory as /home.

cal COMMAND:

cal command is used to display the calendar.

SYNTAX:

The Syntax is

```
cal [options] [month] [year]
```

OPTIONS:

-1	Displays single month as output.
-3	Displays prev/current/next month output.
-s	Displays sunday as the first day of the week.
-m	Displays Monday as the first day of the week.
-j	Displays Julian dates (days one-based, numbered from January 1).
-y	Displays a calendar for the current year.

EXAMPLE:

1. cal

Output:

```
  September 2008
Su Mo Tu We Th Fr Sa
    1 2 3 4 5 6
 7 8 9 10 11 12 13
14 15 16 17 18 19 20
21 22 23 24 25 26 27
```

```
28 29 30
```

cal command displays the current month calendar.

2. cal -3 5 2008

Output:

```
  April 2008            May 2008            June 2008

Su Mo Tu We Th Fr Sa Su Mo Tu We Th Fr Sa Su Mo Tu We Th Fr Sa

       1  2  3  4  5              1 2 3 1 2 3 4 5 6  7

 6 7 8 9 10 11 12 4 5 6 7 8 9 10 8 9 10 11 12 13 14

13 14 15 16 17 18 19  11 12 13 14 15 16 17  15 16 17 18 19 20 21

20 21 22 23 24 25 26  18 19 20 21 22 23 24  22 23 24 25 26 27 28

27 28 29 30           25 26 27 28 29 30 31 29 30
```

Here the cal command displays the calendar of April, May and June month of year 2008.

login Command

Signs into a new system.
Syntax
login [-p] [-d device] [-h hostname | terminal | -r hostname] [name [environ]]

-p	Used to pass environment variables to the login shell.
-d device	login accepts a device option, device. device is taken to be the path name of the TTY port login is to operate on. The use of the device option can be expected to improve login performance, since login will not need to call ttyname. The -d option is available only to users whose UID and effective UID are root. Any other attempt to use -d will cause login to quietly exit.
-h hostname | terminal	Used by in.telnetd to pass information about the remote host and terminal type.
-r hostname	Used by in.rlogind to pass information about the remote host.

Examples
login computerhope.com - Would attempt to login to the computerhope domain.
uname command
Print name of current system.
Syntax
uname [-a] [-i] [-m] [-n] [-p] [-r] [-s] [-v] [-X] [-S systemname]

-a	Print basic information currently available from the system.
-i	Print the name of the hardware implementation (platform).
-m	Print the machine hardware name (class). Use of this option is discouraged; use uname -p instead.
-n	Print the nodename (the nodename is the name by which the system is known to a communications network).
-p	Print the current host's ISA or processor type.
-r	Print the operating system release level.
-s	Print the name of the operating system. This is the default.
-v	Print the operating system version.
-X	Print expanded system information, one information element per line, as expected by SCO Unix. The displayed information includes: • system name, node, release, version, machine, and number of CPUs. • BusType, Serial, and Users (set to "unknown" in Solaris) • OEM# and Origin# (set to 0 and 1, respectively)
-S systemname	The nodename may be changed by specifying a system name argument. The system name argument is restricted to SYS_NMLN characters. SYS_NMLN is an implementation specific value defined in <sys/utsname.h>. Only the super-user is allowed this capability.

Examples

uname -arv

List the basic system information, OS release, and OS version as shown below.

```
SunOS hope 5.7 Generic_106541-08 sun4m sparc SUNW,SPARCstation-10
```

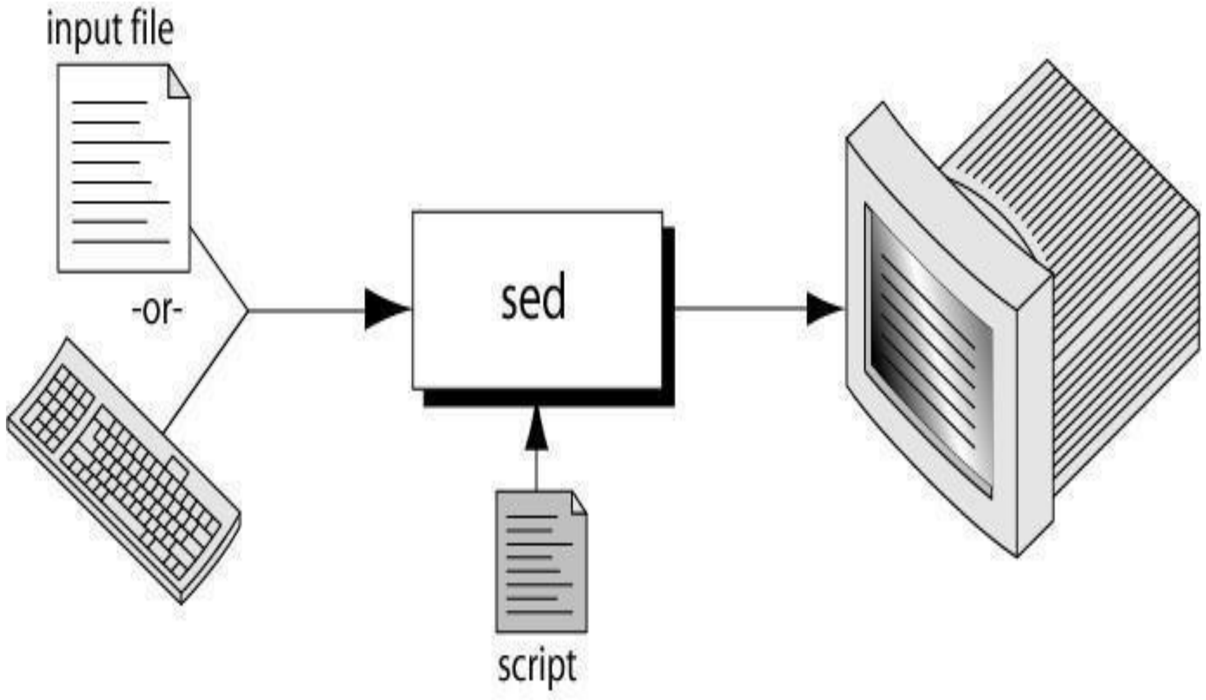
uname -p

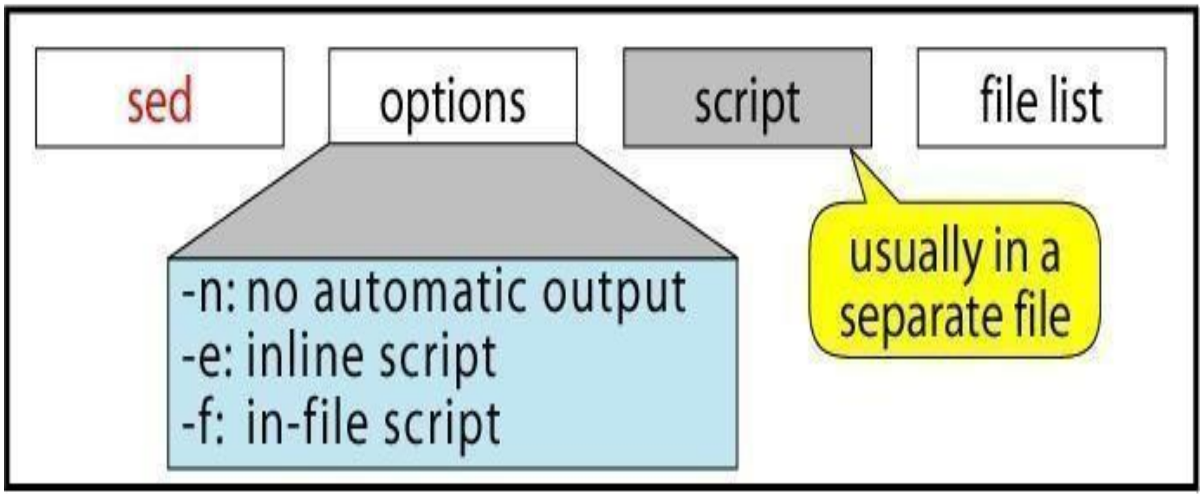
Display the Linux platform.

SED:

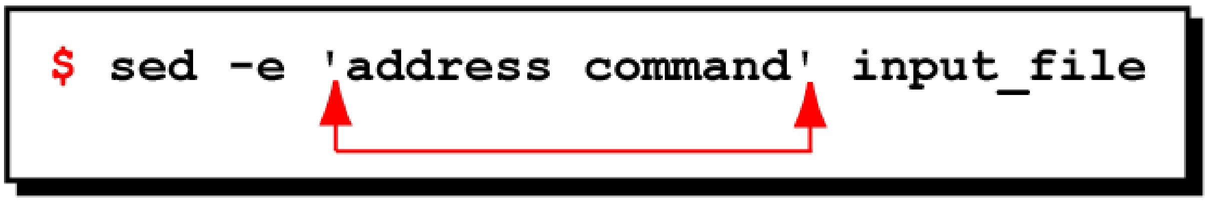
What is sed?

- A non-interactive stream editor
- Interprets sed instructions and performs actions
- Use sed to:
  - Automatically perform edits on file(s)
  - Simplify doing the same edits on multiple files
  - Write conversion programs



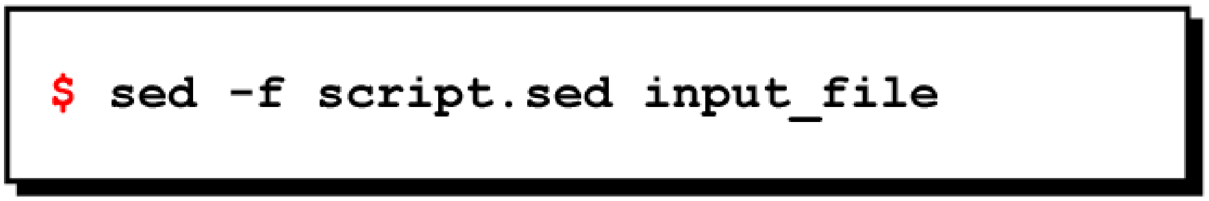


Sed Command Syntax(Sed Scripts):



```
$ sed -e 'address command' input_file
```

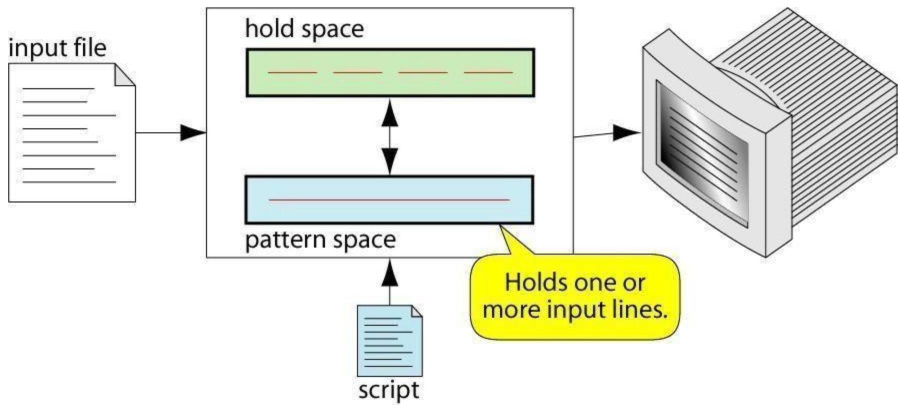
(a) Inline Script



```
$ sed -f script.sed input_file
```

(b) Script File

Sed Operation
How Does sed Work?



- sed reads line of input
- line of input is copied into a temporary buffer called pattern space
- editing commands are applied
    - subsequent commands are applied to line in the pattern space, not the original input line
- once finished, line is sent to output (unless –n option was used)
    - line is removed from pattern space

- sed reads next line of input, until end of file

Note: input file is unchanged

sed instruction format(Sed Addresses):

- address determines which lines in the input file are to be processed by the command(s)
  - if no address is specified, then the command is applied to each input line
- address types:
  - Single-Line address
  - Set-of-Lines address
  - Range address
  - Nested address

Single-Line Address

- Specifies only one line in the input file
  - special: dollar sign ($) denotes last line of input file

Examples:

- show only line 3

sed -n -e '3 p' input-file

- show only last line

sed -n -e '$ p' input-file

- substitute –endif‖ with –fi‖ on line 10

sed -e '10 s/endif/fi/' input-file

Set-of-Lines Address

- use regular expression to match lines
  - written between two slashes
  - process only lines that match
  - may match several lines
  - lines may or may not be consecutives

Examples:

sed -e '/key/ s/more/other/' input-file

sed -n -e '/r..t/ p' input-file

Range Address

- Defines a set of consecutive lines

<u>Format:</u>

start-addr,end-addr (inclusive)

<u>Examples:</u>

10,50	line-number,line-number
10,/R.E/	line-number,/RegExp/
/R.E./,10	/RegExp/,line-number
/R.E./,/R.E/	/RegExp/,/RegExp/

Example: Range Address

```
% sed -n -e '/^BEGIN$/,/^END$/p' input-file
```

- Print lines between BEGIN and END, inclusive

```
BEGIN
Line 1 of input
Line 2 of input
Line3 of input
END
Line 4 of input
Line 5 of input
```

Nested Address

- Nested address contained within another address

<u>Example:</u>

print blank lines between line 20 and 30

```
20,30{

/^$/ p
```

}
Address with !

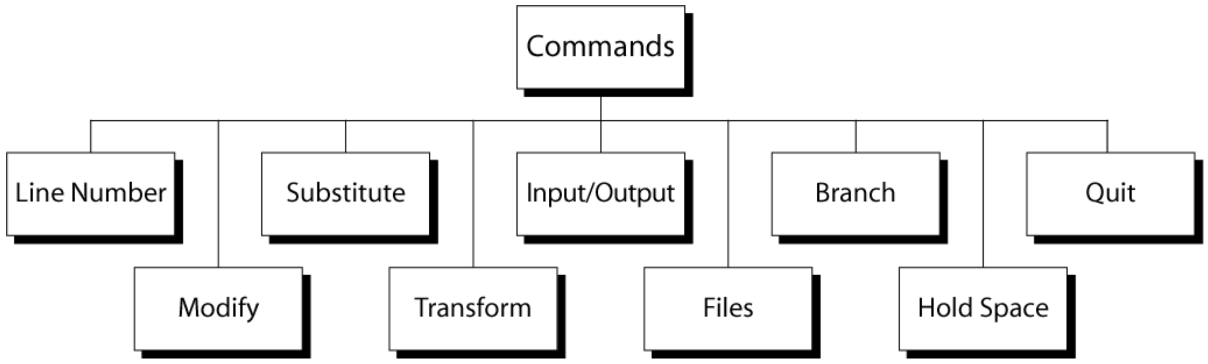
- address with an exclamation point (!):
  instruction will be applied to all lines that do not match the address

Example:

print lines that do not contain –obsoletel

sed -e '/obsolete/!p' input-file

sed commands



Line Number

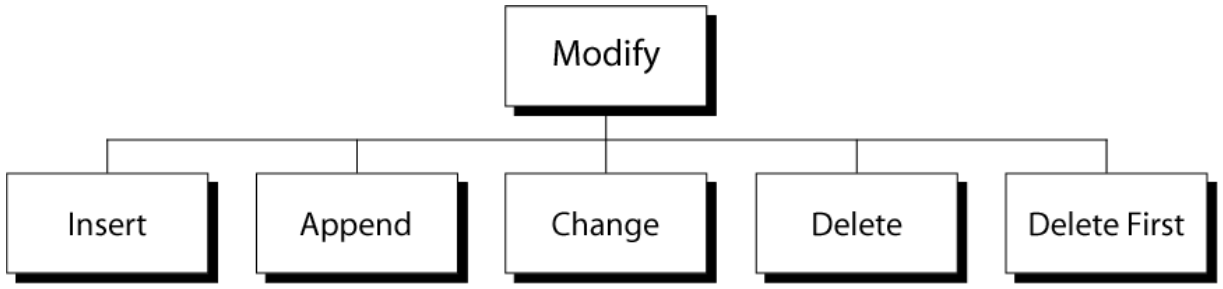
- line number command (=) writes the current line number before each matched/output line.

Examples:

sed -e '/Two-thirds-time/=' tuition.data

sed -e '/^[0-9][0-9]/=' inventory

modify commands



Insert Command: i

- adds one or more lines directly to the output before theaddress:
  - inserted –textl never appears in sed's pattern space
  - cannot be used with a range address; can only be used with the single-line andset-

of-lines address types

Syntax:

[address] i

text

Append Command: a

- adds one or more lines directly to the output after theaddress:
    - Similar to the insert command (i), append cannot be used with a range address.
    - Appended ―text‖ does not appear in sed‘s pattern space.

Syntax:

[address] a

text

Change Command: c

- replaces an entire matched line with new text
- accepts four address types:
    - single-line, set-of-line, range, and nested addresses.

Syntax:

[address1[,address2]]   c

text

Delete Command: d

- deletes the entire pattern space
    - commands following the delete command are ignored since the deleted text is no longer in the pattern space

Syntax:

[address1[,address2]] d

Substitute Command (s)

Syntax:

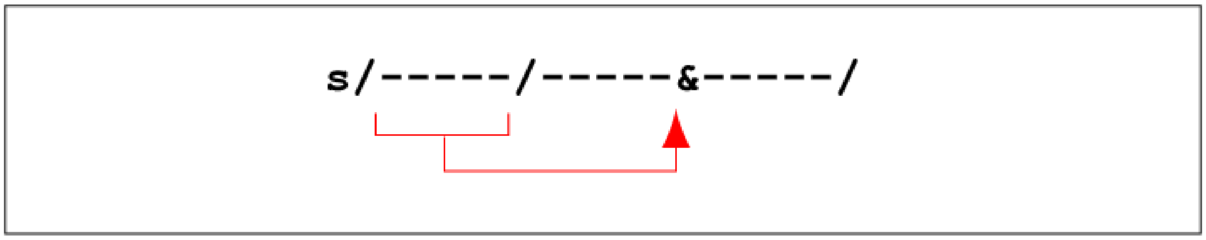
[addr1][,addr2] s/search/replace/[flags]

- replaces text selected by search string with replacementstring
- search string can be regular expression
- flags:
  - global (g), i.e. replace all occurrences
  - specific substitution count (integer), default 1

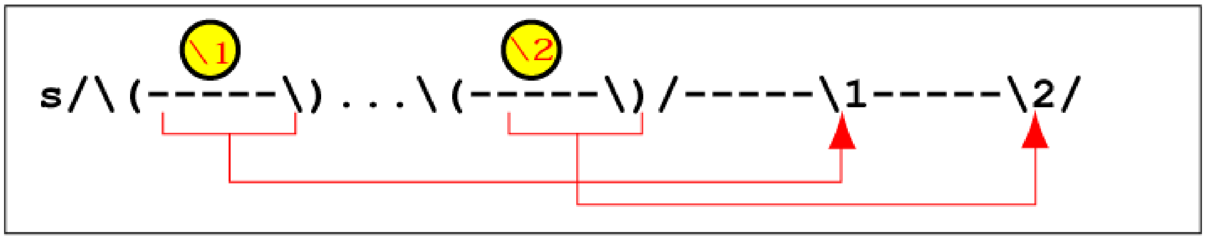
Regular Expressions: use with sed

Metacharacter	Description/Matches…
.	Any one character, except new line
*	Zero or more of preceding character
^	A character at beginning of line
$	A character at end of line
\char	Escape the meaning of *char* following it
[ ]	Any one of the enclosed characters
\(\)	Tags matched characters to be used later
x\{m\}	Repetition of character x, m times
\<	Beginning of word
\>	End of word

Substitution Back References



(a) Whole Pattern Substitution



(b) Numbered Buffer Substitution

Example: Replacement String &

$ cat datafile

```
Charles Main        3.0   .98   3    34

Sharon Gray         5.3   .97   5    23

Patricia Hemenway   4.0   .7    4    17

TB Savage           4.4   .84   5    20

AM Main Jr.         5.1   .94   3    13

Margot Weber        4.5   .89   5     9

Ann Stephens        5.7   .94   5    13
```

```
$ sed -e ‘s/[0-9][0-9]$/&.5/’ datafile

Charles Main        3.0   .98   3    34.5

Sharon Gray         5.3   .97   5    23.5
```

Patricia Hemenway	4.0	.7	4	17.5
TB Savage	4.4	.84	5	20.5
AM Main Jr.	5.1	.94	3	13.5
Margot Weber	4.5	.89	5	9
Ann Stephens	5.7	.94	5	13.5

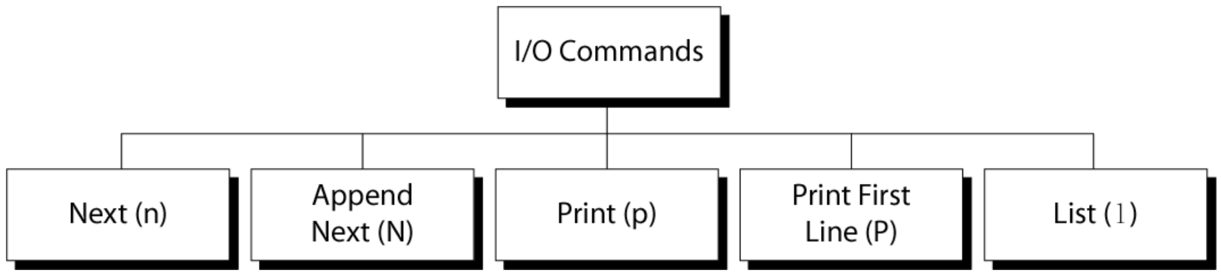
Transform Command (y)
Syntax:

[addr1][,addr2]y/a/b/

- translates one character 'a' to another 'b'
- cannot use regular expression metacharacters
- cannot indicate a range of characters
- similar to –tr| command

Example:

$ sed -e '1,10y/abcd/wxyz/' datafile
sed i/o commands



Input (next) Command: n and N

- Forces sed to read the next input line
    - Copies the contents of the pattern space to output
    - Deletes the current line in the pattern space
    - Refills it with the next input line
    - Continue processing

- N (uppercase) Command
    - adds the next input line to the current contents of the pattern space
    - useful when applying patterns to two or more lines at the same time

Output Command: p and P

- Print Command (p)
    - copies the entire contents of the pattern space to output
    - will print same line twice unless the option ―n‖ is used
- Print command: P
    - prints only the first line of the pattern space
    - prints the contents of the pattern space up to and including a new line character
    - any text following the first new line is not printed

List Command (l)

- The list command: l
    - shows special characters (e.g. tab, etc)
- The octal dump command (od -c) can be used to produce similarresult

Hold Space

- temporary storage area

  used to save the contents of the pattern space

- 4 commands that can be used to move text back and forth between the pattern space and the hold space:

  h, H
  g, G

File commands

- allows to read and write from/to file while processing standard input
- read: r command
- write: w command

Read File command

Syntax: **r filename**

- queue the contents of filename to be read and inserted into the output stream at the end of the current cycle, or when the next input line is read

- if filename cannot be read, it is treated as if it were an empty file, without any error indication
- single address only

Write File command

Syntax: **w filename**

- Write the pattern space to filename
- The filename will be created (or truncated) before the first input line is read
- all w commands which refer to the same filename are output through the same FILE stream

Branch Command (b)

- Change the regular flow of the commands in the script file

Syntax: **[addr1][,addr2]b[label]**

- Branch (unconditionally) to _label' or end of script
- If –label‖ is supplied, execution resumes at the line following :label; otherwise, control passes to the end of the script
- Branch label

:mylabel

Example: The quit (q) Command

Syntax: **[addr]q**

- Quit (exit sed) when addr is encountered.

Example: Display the first 50 lines and quit

% sed -e ’50q’ datafile

Same as:

% sed -n -e ‘1,50p’ datafile

% head -50 datafile

Awk

What is awk?

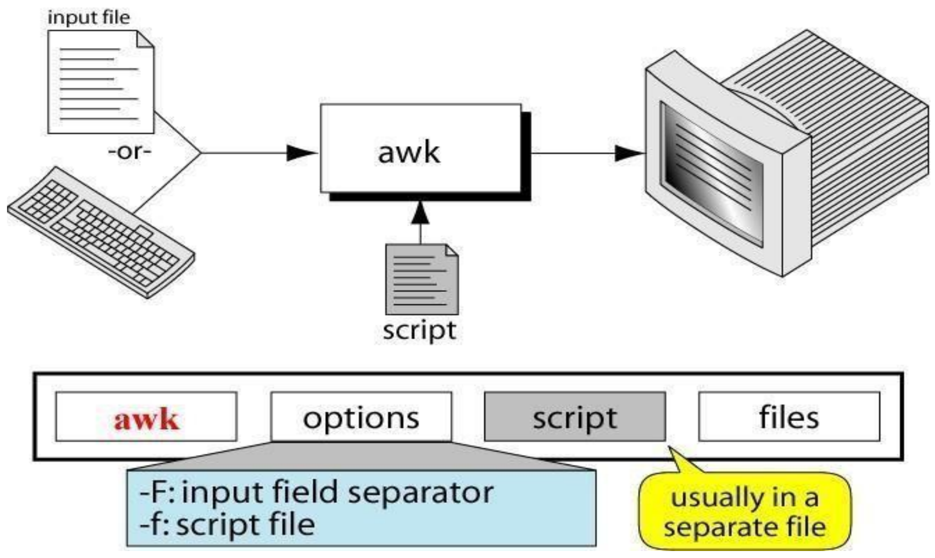
- created by: Aho, Weinberger, and Kernighan

- scripting language used for manipulating data and generating reports
- versions of awk
  - awk, nawk, mawk, pgawk, …
  - GNU awk: gawk

What can you do with awk?

- awk operation:
  - scans a file line by line
  - splits each input line into fields
  - compares input line/fields to pattern
  - performs action(s) on matchedlines
- Useful for:
  - transform data files
  - produce formatted reports
- Programming constructs:
  - format output lines
  - arithmetic and string operations
  - conditionals and loops

The Command: awk



Basic awk Syntax

- **awk [options] 'script' file(s)**

- **awk [options] –f scriptfile file(s)**

Options:

-F	to change input field separator
-f	to name script file

Basic awk Program

- consists of patterns & actions:
  pattern {action}
  - if pattern is missing, action is applied to all lines
  - if action is missing, the matched line is printed
  - must have either pattern or action

Example:

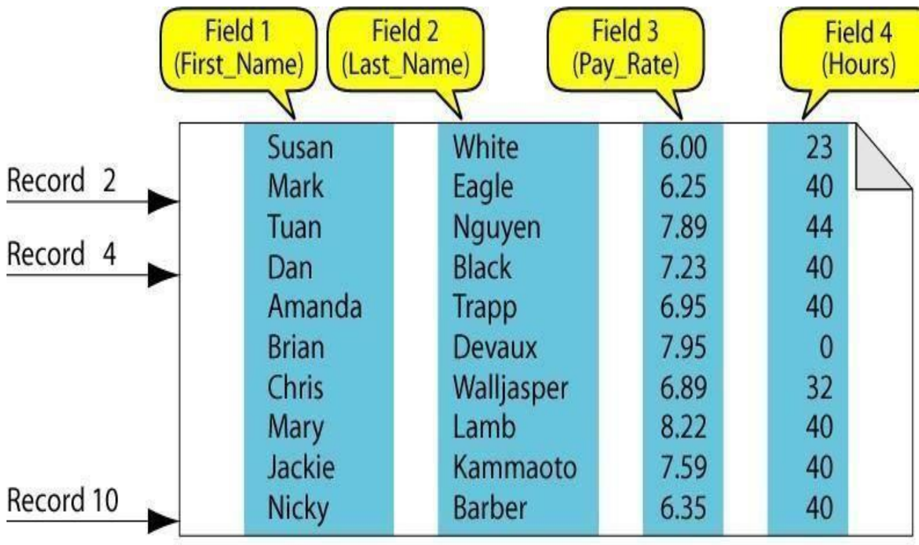
awk '/for/' testfile

  - prints all lines containing string –for‖ in testfile

Basic Terminology: input file

- A field is a unit of data in a line
- Each field is separated from the other fields by the field separator
  - default field separator is whitespace
- A record is the collection of fields in a line
- A data file is made up of records

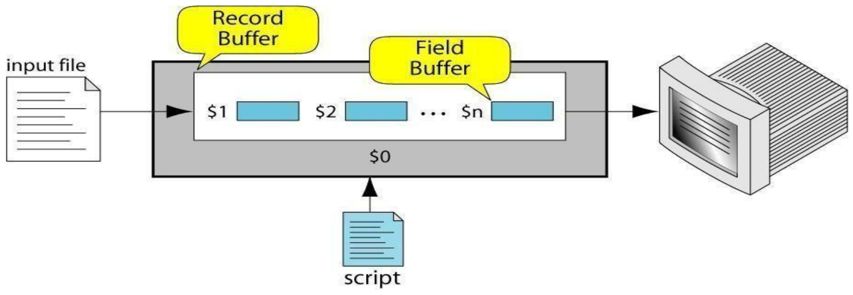
Example Input File


Record 2
Record 4
Record 10

Field 1 (First_Name)	Field 2 (Last_Name)	Field 3 (Pay_Rate)	Field 4 (Hours)
Susan	White	6.00	23
Mark	Eagle	6.25	40
Tuan	Nguyen	7.89	44
Dan	Black	7.23	40
Amanda	Trapp	6.95	40
Brian	Devaux	7.95	0
Chris	Walljasper	6.89	32
Mary	Lamb	8.22	40
Jackie	Kammaoto	7.59	40
Nicky	Barber	6.35	40

A file with 10 records, each with four fields

Buffers



- awk supports two types ofbuffers:

  <u>record</u> and <u>field</u>

- field buffer:
  - one for each fields in the current record.
  - names: $1, $2, …
- record buffer :
  - $0 holds the entire record

Some System Variables

FS	Field separator (default=whitespace)
RS	Record separator (default=\n)
NF	Number of fields in current record
NR	Number of the current record
OFS	Output field separator (default=space)
ORS	Output record separator(default=\n)
FILENAME	Current filename

Example: Records and Fields

```
% cat emps

Tom Jones       4424    5/12/66         543354

Mary Adams      5346    11/4/63       28765

Sally Chang     1654    7/22/54         650000

Billy Black     1683    9/23/44           336500

% awk '{print NR, $0}' emps

1 Tom Jones     4424    5/12/66         543354

2 Mary Adams    5346    11/4/63      28765

3 Sally Chang   1654    7/22/54        650000

4 Billy Black   1683    9/23/44           336500
```

Example: Space as Field Separator

```
% cat emps
```

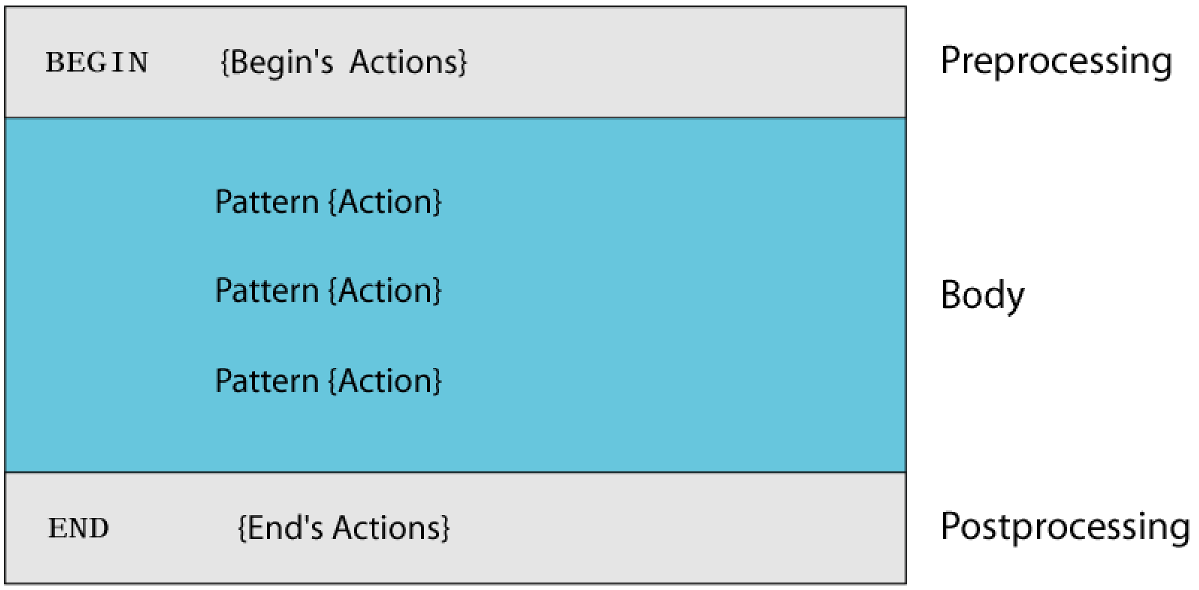
```
Tom Jones    4424    5/12/66 543354

Mary Adams 5346    11/4/63 28765

Sally Chang  1654    7/22/54 650000

Billy Black    1683    9/23/44 336500

% awk '{print NR, $1, $2, $5}' emps

1 Tom Jones 543354

2 Mary Adams 28765
3 Sally Chang 650000

4 Billy Black 336500
```

Example: Colon as Field Separator

```
% cat em2

Tom Jones:4424:5/12/66:543354

Mary  Adams:5346:11/4/63:28765

Sally  Chang:1654:7/22/54:650000

Billy Black:1683:9/23/44:336500

% awk -F: '/Jones/{print $1, $2}' em2

Tom Jones 4424
```

awk Scripts

- awk scripts are divided into three major parts:



- comment lines start with #
- BEGIN: pre-processing
    - performs processing that must be completed before the file processing starts (i.e., before awk starts reading records from the input file)
    - useful for initialization tasks such as to initialize variables and to create report headings
- BODY: Processing
    - contains main processing logic to be applied to input records
    - like a loop that processes input data one record at a time:
        - if a file contains 100 records, the body will be executed 100 times, one for each record
- END: post-processing
    - contains logic to be executed after all input data have been processed
    - logic such as printing report grand total should be performed in this part of the script

Pattern / Action Syntax

```
pattern {statement}
```

(a) One Statement Action

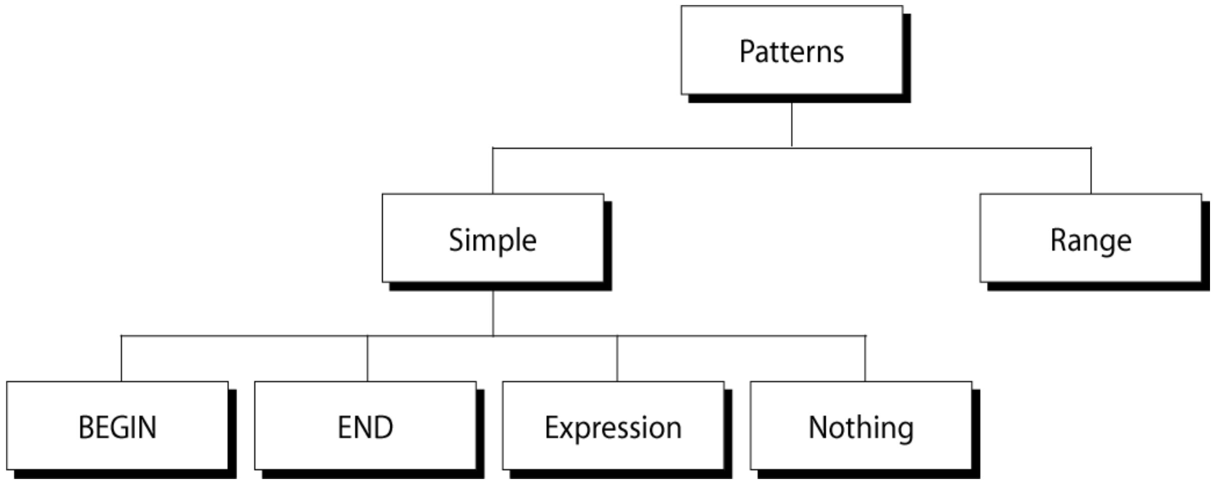
```
pattern {statement1; statement2; statement3}
```

(b) Multiple Statements Separated by Semicolons

```
pattern
{
    statement1
    statement2
    statement3
}
```

(c) Multiple Statements Separated by Newlines

Categories of Patterns



Expression Pattern types

- match
    - entire input record
    - regular expression enclosed by ‗/‘s
        - explicit pattern-matching expressions
    - ~ (match), !~ (not match)
    - expression operators
        - arithmetic
        - relational
        - logical

```
% cat employees2

Tom Jones:4424:5/12/66:543354
Mary   Adams:5346:11/4/63:28765
Sally Chang:1654:7/22/54:650000
Billy Black:1683:9/23/44:336500
% awk –F: '/00$/' employees2 Sally
Chang:1654:7/22/54:650000   Billy
Black:1683:9/23/44:336500
```

Example: explicit match

```
% cat datafile

northwest NW   Charles Main            3.0    .98    3 34

western WE       Sharon Gray           5.3    .97    5  23

southwest SW   Lewis Dalsass          2.7    .8     2 18

southern  SO      Suan Chin            5.1    .95    4 15

southeast SE     Patricia Hemenway   4.0      .7     4  17

eastern   EA      TB Savage           4.4    .84    5 20

northeast NE      AM Main             5.1    .94    3 13

north      NO    Margot Weber     4.5        .89    5    9

central   CT      Ann Stephens         5.7    .94    5 13

% awk '$5 ~ /\.[7-9]+/' datafile

southwest SW     Lewis Dalsass  2.7         .8      2 18

central   CT    Ann Stephens        5.7    .94    5 13
```

Examples: matching with REs

```
% awk '$2 !~ /E/{print $1, $2}' datafile
northwest NW
southwest   SW
southern      SO
north          NO
central CT
```

```
% awk '/^[ns]/{print $1}' datafile
northwest
southwest
southern
southeast
northeast
north
```

Arithmetic Operators

Operator	Meaning	Example
+	Add	x + y
-	Subtract	x – y
*	Multiply	x * y
/	Divide	x / y
%	Modulus	x % y
^	Exponential	x ^ y

Example:

% awk '$3 * $4 > 500 {print $0}' file

Relational Operators

Operator	Meaning	Example
<	Less than	x < y
< =	Less than or equal	x < = y
==	Equal to	x == y

!=	Not equal to	x != y
>	Greater than	x > y
> =	Greater than or equal to	x > = y
~	Matched by reg exp	x ~ /y/
!~	Not matched by req exp	x !~ /y/

Logical Operators

Operator	Meaning	Example
&&	Logical AND	a && b
||	Logical OR	a || b
!	NOT	! a

Examples:

% awk '($2 > 5) && ($2 <= 15)   {print $0}' file
% awk '$3 == 100 || $4 > 50' file

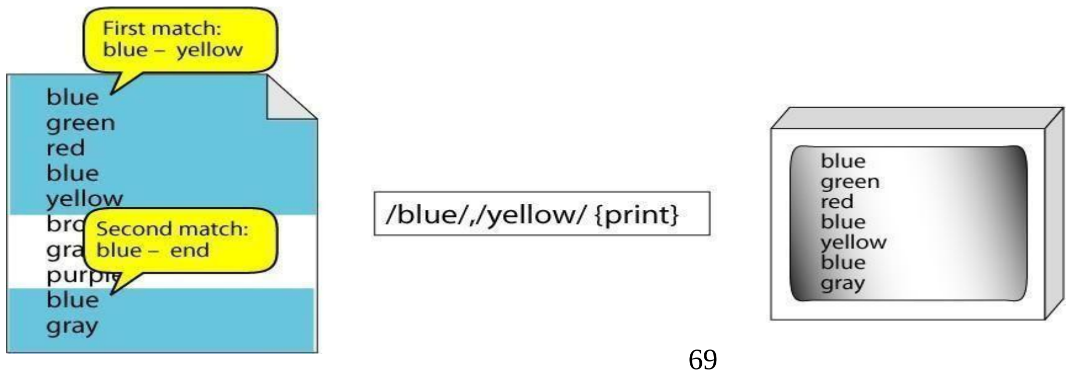
Range Patterns

- Matches ranges of consecutive input lines

Syntax:

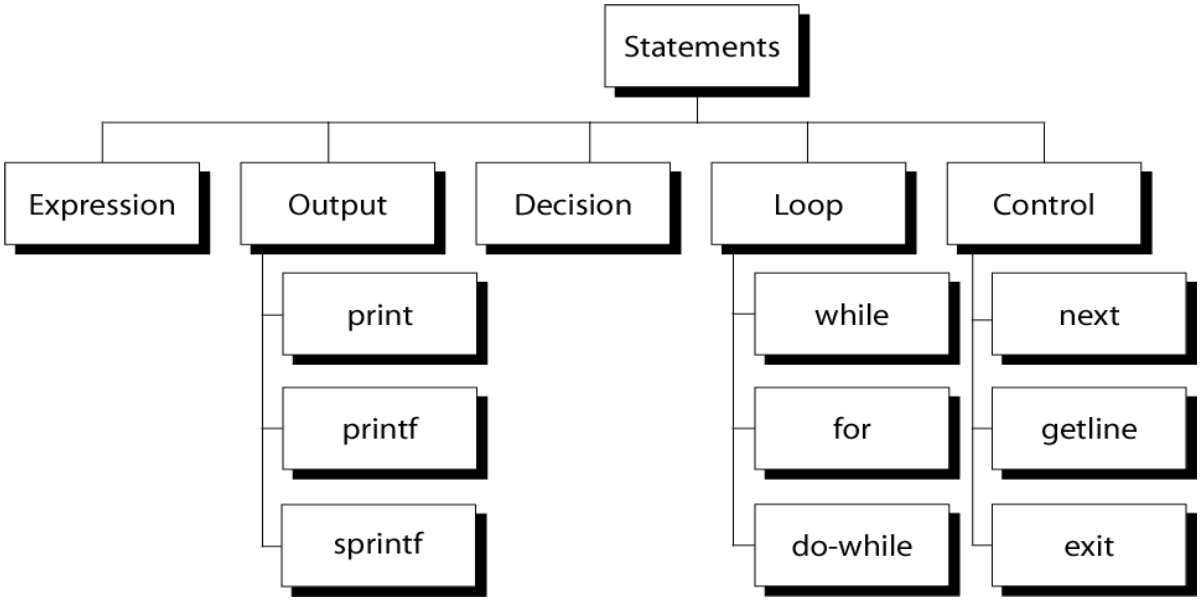
pattern1 , pattern2 {action}

- pattern can be any simple pattern
- **pattern1** turns action on
- **pattern2** turns action off



Range Pattern Example

awk Actions



awk expressions

- Expression is evaluated and returns value
    - consists of any combination of numeric and string constants, variables, operators, functions, and regular expressions
- Can involve variables
    - As part of expression evaluation
    - As target of assignment awk variables
- A user can define any number of variables within an awkscript
- The variables can be numbers, strings, or arrays
- Variable names start with a letter, followed by letters, digits, and underscore
- Variables come into existence the first time they are referenced; therefore, they do not need to be declared before use
- All variables are initially created as strings and initialized to a null string ―‖

awk Variables

<u>Format</u>

variable = expression

Examples:

```
% awk '$1 ~ /Tom/
        {wage = $3 * $4; print wage}'        filename
% awk '$4 == "CA"         {$4 = "California"; print $0}'        filename
```

awk assignment operators

=	assign result of right-hand-side expressionto left-hand-side variable
++	Add 1 to variable
--	Subtract 1 from variable
+=	Assign result of addition
-=	Assign result of subtraction
*=	Assign result of multiplication
/=	Assign result of division
%=	Assign result of modulo
^=	Assign result ofexponentiation

Awk example:

File: grades

```
john 85 92 78 94 88

andrea 89 90 75 90 86

jasper 84 88 80 92 84
```

- awk script: average

```
# average five grades

{ total = $2 + $3 + $4 + $5 + $6
  avg = total / 5
  print $1, avg }
```

- Run as:
  awk –f average grades

Output Statements

print

printf sprintf

print easy and simple output

print formatted (similar to C printf) format

string (similar to C sprintf)

Function: print

- Writes to standard output
- Output is terminated by ORS
    - default ORS is newline
- If called with no parameter, it will print $0
- Printed parameters are separated by OFS,
    - default OFS is blank
- Print control characters are allowed:
    - \n \f \a \t \\ … print example

```
% awk '{print}' grades
john 85 92 78 94 88
andrea 89 90 75 90 86
```

```
% awk '{print $0}' grades
john 85 92 78 94 88
andrea 89 90 75 90 86
```

```
% awk '{print($0)}' grades
john 85 92 78 94 88
andrea 89 90 75 90 86
```

Redirecting print output

- Print output goes to standard output

<u>unless</u> redirected via:

›   –file‖

>> –file‖

| –command‖

- will open file or command only once

- subsequent redirections append to already openstream

print Example

```
% awk '{print $1 , $2 > "file"}' grades
```

```
% cat file
john 85
andrea 89

jasper 84
```

```
% awk '{print $1,$2 | "sort"}' grades
andrea 89
jasper 84

john 85
```

```
% awk '{print $1,$2 | "sort –k 2"}' grades
jasper 84
john 85

andrea 89
```

```
% date

Wed Nov 19 14:40:07 CST 2008
```

% date |

```
        awk '{print "Month: " $2 "\nYear: ", $6}'
Mo0nth: Nov
Year:  2008
```

printf: Formatting output
<u>Syntax:</u>
printf(format-string, var1, var2, …)

- works like C printf
- each format specifier in –format-string‖ requires argument of matching type

Format specifiers

%d %i	decimal integer
%c	single character
%s	string of characters
%f	floating point number
%o	octal number
%x	hexadecimal number
%e	scientific floating point notation
%%	the letter –%‖

Format specifier examples
Format specifiermodifiers

- between –%‖ and letter

  %10s

  %7d

  %10.4f

  %-20s

- meaning:
  - width of field, field is printed right justified
  - precision: number of digits after decimal point
  - –-‖ will left justify sprintf: Formatting text

Syntax:

sprintf(format-string, var1, var2, …)

- Works like printf, but does not produce output
- Instead it returns formatted string

Example:

```
{
        text = sprintf("1: %d – 2: %d", $1, $2)
        print text
}
```

awk Array

- awk allows one-dimensional arrays

to store strings or numbers
- index can be number or string
- array need not be declared
    - its size
    - its elements
- array elements are created when first used
    - initialized to 0 or ―‖

Arrays in awk

Syntax:

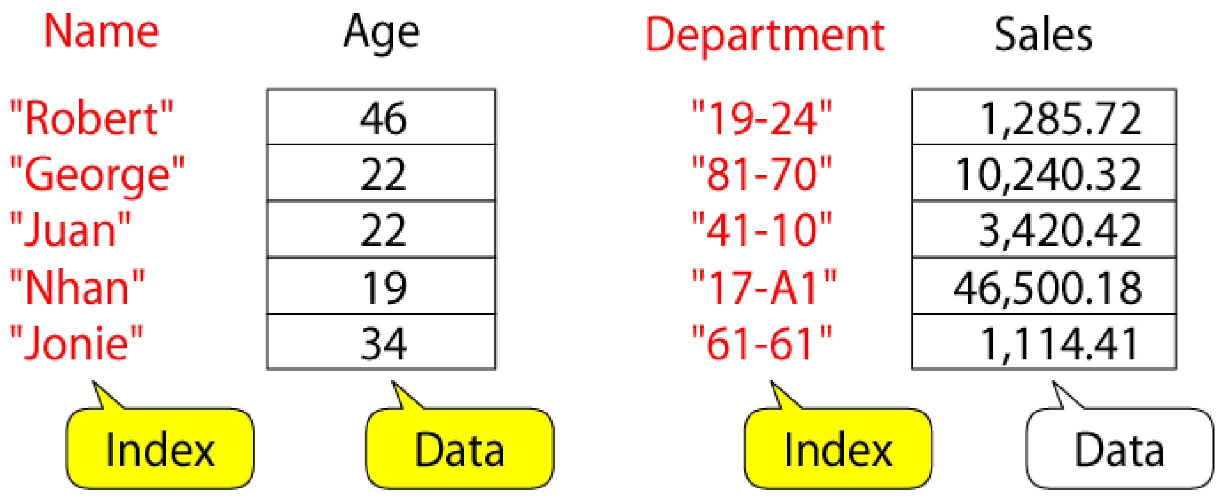
arrayName[index] = value

Examples:

list[1] = "one"
list[2] = "three"
list["other"] = "oh my !"

Illustration: Associative Arrays

- awk arrays can use string as index



Awk builtin split functions

split(string, array, fieldsep)

- divides string into pieces separated by fieldsep, and stores the pieces in array
- if the fieldsep is omitted, the value of FS is used.

Example:

split("auto-da-fe", a, "-")

- sets the contents of the array a asfollows:

a[1] = "auto"

a[2] = "da"

a[3] = "fe"

Example: process sales data

- input file:
  - output:

Sales

```
1   clothing     3141
1   computers    9161
1   textbooks   21312
2   clothing     3252
2   computers   12321
2   supplies     2242
2   textbooks   15462
```

summary of category sales Illustration: process each input line

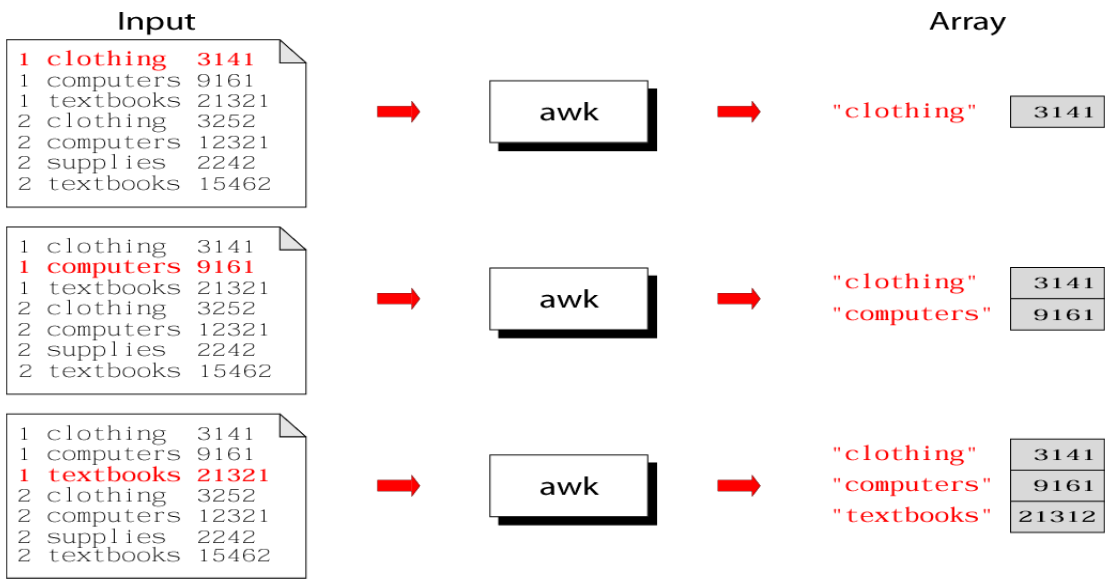
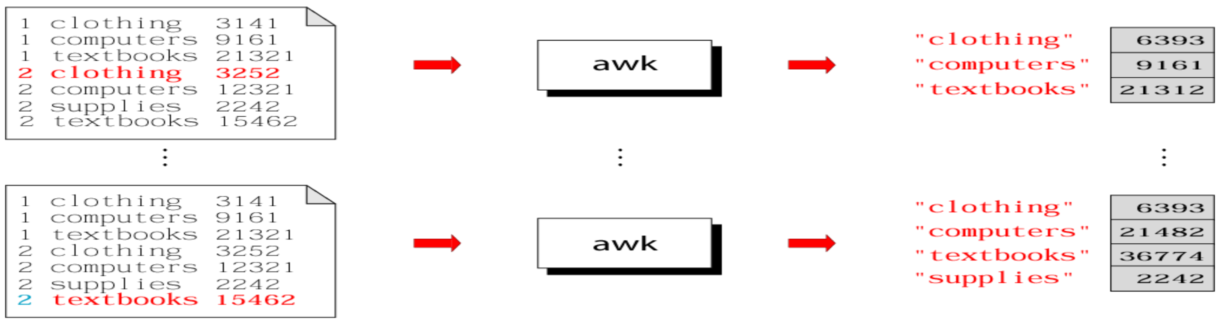
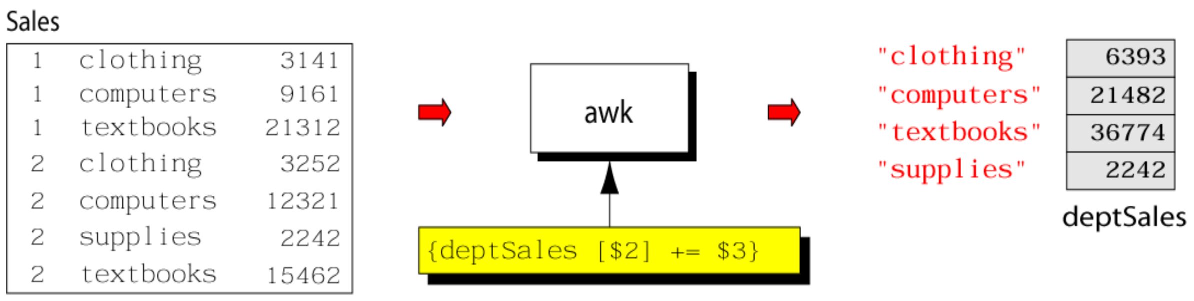


Illustration: process each input line



Summary: awk program



Example: complete program

```
% cat sales.awk
{
        deptSales[$2] += $3
}
END {
    for (x in deptSales)
                print x, deptSales[x]
}
% awk –f sales.awk sales
```

awk builtin functions

tolower(string)

- returns a copy of string, with each upper-case character converted to lower-case. Nonalphabetic characters are left unchanged.

Example: tolower("MiXeD cAsE 123")

returns "mixed case 123"

toupper(string)

- returns a copy of string, with each lower-case character converted to upper-case.

awk Example: list of products

```
103:sway	bar:49.99
101:propeller:104.99
104:fishing	line:0.99
113:premium fish bait:1.00
106:cup	holder:2.49
107:cooler:14.89
112:boat cover:120.00
109:transom:199.00
110:pulley:9.88
105:mirror:4.99
108:wheel:49.99
111:lock:31.00
102:trailer	hitch:97.95
```

awk Example: output

```
Marine Parts R Us



Main catalog

Part-id name              price

=======================================

 101    propeller      104.99

 102    trailer hitch  97.95

 103    sway bar       49.99

 104    fishing line        0.99

 105    mirror              4.99

 106    cup holder     2.49

 107    cooler             14.89

 108    wheel              49.99
109   transom              199.00
110   pulley               9.88

111     lock             31.00


Catalog has 13 parts
```

awk Example: complete

```
BEGIN {

        FS= ":"
        print "Marine Parts R Us"

        print "Main catalog"

        print "Part-id\tname\t\t\t price"

        print "===================================="

}
{
        printf("%3d\t%-20s\t%6.2f\n", $1, $2, $3)

        count++

}

END {

        print "===================================="

        print "Catalog has " count " parts"

    }
```

for Loop Syntax:

```
for (initialization; limit-test; update)

     statement
```

Example:

```
for (i = 1; i <= NR; i++)

{

    total += $i

    count++

}
```

for Loop for

arrays Syntax:

```
for (var in array) stateme nt
```

Example:

```
for (x in deptSales)
{
    print x, deptSales[x]

}
```

While Loop Syntax:

```
while (logical expression) tatement
```

Example:

```
i = 1
while (i <= NF)
{
    print i,
    $i i++
```

}

do-while Loop <u>Syntax:</u>

```
        do
         statment while (condition)
```

- statement is executed at least once, even if condition is false at

the beginning <u>Example:</u>

```
 i= 1
 d o{
   print
   $0 i++
 } while (i <= 10)
```

loop control statements

- **break**

  exits loop
- **continue**

  skips rest of current iteration, continues with next iteration

UNIT-II
WORKING WITH THE BOURNE AGAIN SHELL (BASH) Shell

WORKING WITH THE BOURNE AGAIN SHELL (BASH) Shell: Shell responsibilities, types of shell, pipes and i/o redirection, shell as a programming language, here documents, running a shell script, the shell as a programming language, shell meta characters, file name substitution, shell variables, command substitution, shell commands, quoting, test command, control structures, arithmetic in shell, interrupt processing, functions, and debugging scripts; File structure and directories: Introduction to file system, file descriptors, file types, file system structure; File metadata: Inodes; System calls for file I/O operations: open, create, read, write, close, lseek, dup2, file status information-stat family; File and record locking: fcntl function, file permissions, file ownership, links; Directories: Creating, removing and changing directories, obtaining current working directory, directory contents, scanning directories.

Shell Programming

The shell has similarities to the DOS command processor Command.com (actually Dos was design as a poor copy of UNIX shell), it's actually much more powerful, really a programming language in its own right.

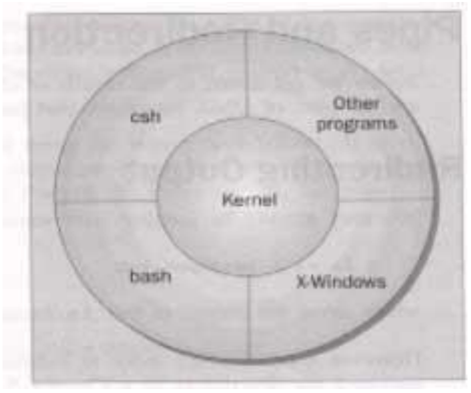
A shell is always available on even the most basic UNIX installation. You have to go through the shell to get other programs to run. You can write programs using the shell. You use the shell to administrate your UNIX system. For example:

```
ls -al | more
```

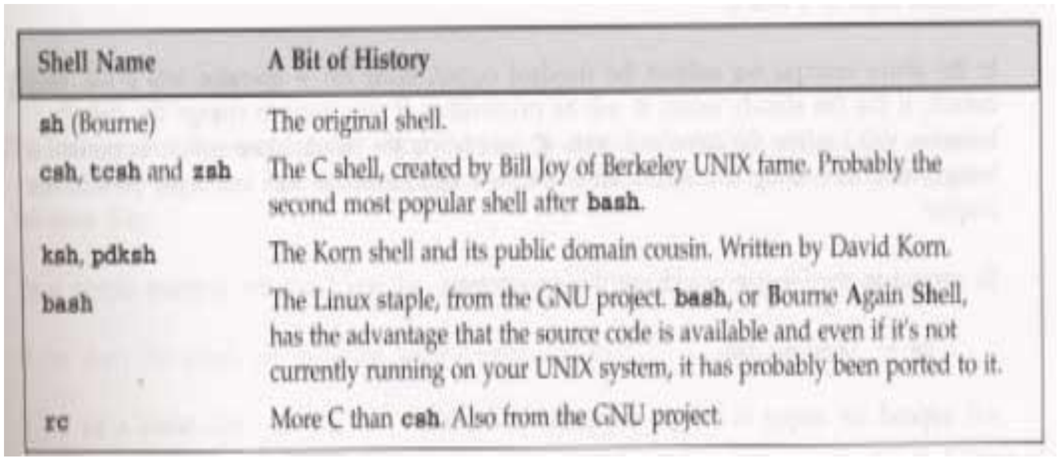
is a short shell program to get a long listing of the present directory and route the output through the more command.

What is a Shell?

A **shell** is a program that acts as the interface between you and the UNIX system, allowing you to enter commands for the operating system to execute.



Here are some common shells.



Shell Name	A Bit of History
sh (Bourne)	The original shell.
csh, **tcsh** and **zsh**	The C shell, created by Bill Joy of Berkeley UNIX fame. Probably the second most popular shell after **bash**.
ksh, **pdksh**	The Korn shell and its public domain cousin. Written by David Korn.
bash	The Linux staple, from the GNU project. **bash**, or Bourne Again Shell, has the advantage that the source code is available and even if it's not currently running on your UNIX system, it has probably been ported to it.
rc	More C than **csh**. Also from the GNU project.

Introduction- **Working with Bourne Shell**

- The Bourne shell, or sh, was the default Unix shell of Unix Version 7. It wasdeveloped by Stephen Bourne, of AT&T BellLaboratories.
- A Unix shell, also called "the command line", provides the traditional user interfacefor the Unix operating system and for Unix-like systems. Users direct the operation of the computer by entering command input as text for a shell toexecute.
- There are many different shells in use. Theyare
  - Bourne shell (sh)
  - C shell (csh)
  - Korn shell (ksh)

Bourne Again shell (bash)

- When we issue a command the shell is the first agency to acquire the information. It accepts and interprets user requests. The shell examines &rebuilds the commands &leaves the execution work to kernel. The kernel handles the h/w on behalf ofthese commands &all processes in the system.
- The shell is generally sleeping. It wakes up when an input is keyed in at the prompt.This input is actually input to the program that represents the shell.
-

Shell responsibilities

1. Program Execution
2. Variable and Filename Substitution
3. I/O Redirection
4. Pipeline Hookup
5. Environment Control
6. Interpreted ProgrammingLanguage

1.Program Execution:

- The shell is responsible for the execution of all programs that you request fromyour terminal.

- Each time you type in a line to the shell, the shell analyzes the line and thendetermines what to do.
- The line that is typed to the shell is known more formallyas the command line. The shell scans this command line and determines the name of the program to be executed and what arguments to pass to the program.

2. Variable and Filename Substitution:
   - Like any other programming language, the shell lets you assign values to variables. Whenever you specify one of these variables on the command line, preceded by adollar sign, the shell substitutes the value assigned to the variable at that point.
3. I/O Redirection:
   - It is the shell's responsibility to take care of input and output redirection on the command line. It scans the command line for the occurrence of the special redirection characters<, >, or >>.
4. Pipeline Hookup:
   - Just as the shell scans the command line looking for redirection characters, it also looks for the pipe character |. For each such character that it finds, it connects the standard output from the command preceding the | to the standard input of the one following the|. It then initiates execution of both programs.
5. Environment Control:
   - The shell provides certain commands that let you customize your environment. Your environment includes home directory, the characters that the shell displays toprompt you to type in a command, and a list of the directories to be searched whenever you request that a program be executed.
6. Interpreted Programming Language:
   - The shell has its own built-in programming language. This language is interpreted, meaning that the shell analyzes each statement in the language one line at a time and then executes it. This differs from programming languages such as C and FORTRAN, in which the programming statements are typically compiled into a machine-executable form before they are executed.
   - Programs developed in interpreted programming languages are typically easier to debug and modify than compiled ones. However, they usually take much longer to executethan their compiled equivalents.

Pipes and Redirection

Pipes connect processes together. The input and output of UNIX programs can be redirected.

Redirecting Output

The > operator is used to redirect output of a program. For example:

```
ls -l > lsoutput.txt
```

redirects the output of the list command from the screen to the file lsoutput.txt.
To 0append to a file, use the >> operator.

```
ps >> lsoutput.txt
```

Redirecting Input

You redirect input by using the < operator. For example:

```
more < killout.txt
```

Pipes

We can connect processes together using the pipe operator (|). For example, the following program means run the ps program, sort its output, and save it in the file pssort.out

```
ps | sort > pssort.out
```

The sort command will sort the list of words in a textfile into alphbetical order according to the ASCII code set character order.

Here Documents

A here document is a special way of passing input to a command from a shell script. The document starts and ends with the same leader after <<. For example:

```
#!/bin/sh

cat < this is a here
document
!FUNKY!
```

How It Works

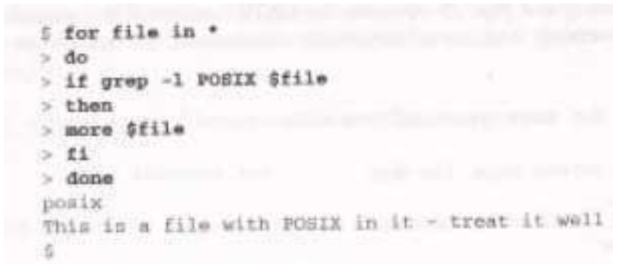
It executes the here document as if it were input commands.

Running a Shell Script

You can type in a sequence of commands and allow the shell to execute them interactively, or youu can sotre these commands in a file which you can invoke as a program.

Interactive Programs

A quick way of trying out small code fragments is to just type in the shell script on the command line. Here is a shell program to compile only files that contain the string POSIX.

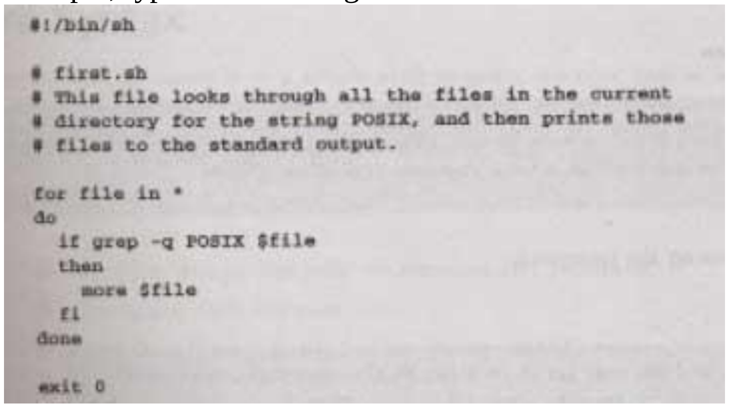


```
$ for file in *
> do
> if grep -l POSIX $file
> then
> more $file
> fi
> done
posix
This is a file with POSIX in it - treat it well
$
```

The Shell as a Programming Language

Creating a Script

To create a **shell script** first use a text editor to create a file containing the commands. For example, type the following commands and save them as first.sh



```
#!/bin/sh

# first.sh
# This file looks through all the files in the current
# directory for the string POSIX, and then prints those
# files to the standard output.

for file in *
do
  if grep -q POSIX $file
  then
    more $file
  fi
done

exit 0
```

Note: commands start with a #.

The line

#!/bin/sh

is special and tells the system to use the /bin/sh program to execute this program.

The command

exit 0

Causes the script program to exit and return a value of 0, which means there were not errors.

Making a Script Executable

There are two ways to execute the script. 1) invoke the shell with the name of the script file as a parameter, thus:

```
/bin/sh first.sh
```

Or 2) change the mode of the script to executable and then after execute it by just typing its name.

```
chmod +x first.sh
first.sh
```

Actually, you may need to type:

```
./first.sh
```

to make the file execute unles the path variable has your directory in it.

Shell Syntax

The modern UNIX shell can be used to write quite large, structured programs.

Shell metacharacters

The shell consists of large no. of metacharacters. These characters plays vital role in Unix programming.

Types of metacharacters:

1.File substitution

2.I/O redirection

3.Process execution

4. Quoting metacharacters

5.Positional parameters

6.Special characters

7.Command substitution

Filename substitution:

These metacharacters are used to match the filenames in a directory.

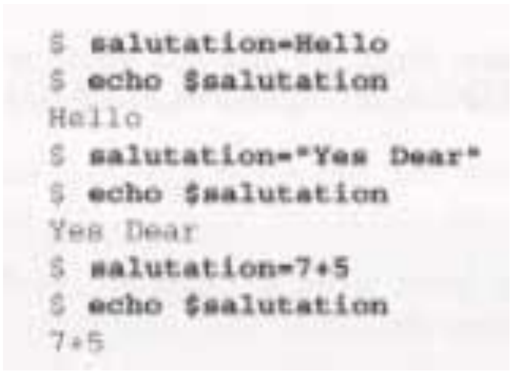
Metacharacter	significance
*	matches any no. of characters
?	matches a single character

[ijk]   matches a single character either i,j,k

[!ijk]   matches a single character that is not an I,j,k

Shell Variables

Variables are generally created when you first use them. By default, all variables are considered and stored as strings. Variable names are case sensitive.



```
$ salutation=Hello
$ echo $salutation
Hello
$ salutation="Yes Dear"
$ echo $salutation
Yes Dear
$ salutation=7+5
$ echo $salutation
7+5
```

- U can define & use variables both in the command line and shell scripts. These variables are called shell variables.
- No type declaration is necessary before u can use a shell variable.
- Variables provide the ability to store and manipulate the information with in the shell program. The variables are completely under the control ofuser.
- Variables in Unix are of two types.

1) **User-defined variables:**

   Generalized form:

      variable=value.

   Eg: $x=10

   $echo $x

   10

- To remove a variable use unset.
  - $unset x

- All shell variables are initialized to null strings by default. To explicitly set null values use
    - x=   or x=‗‘   or   x=―‖
- To assign multiword strings to a variable use
    - $msg=‗u have a mail‘

2) Environment Variables

- They are initialized when the shell script starts and normally capitalizedto distinguish them from user-defined variables in scripts
- To display all variables in the local shell and their values, type the **set** command
- The **unset** command removes the variable from the current shell and sub shell

Environment Variables	**Description**
$HOME	**Home directory**
$PATH	**List of directories to search for commands**
$PS1	**Command prompt**
$PS2	**Secondary prompt**
$SHELL	**Current login shell**
$0	**Name of the shell script**
$#	**No . of parameters passed**
$$	**Process ID of the shell script**

Command substitution and Shell commands:

- The read statement is a tool for taking input from the user i.e. making scripts interactive. It is used with one or more variables. Input supplied through the standard input is read into these variables.

$read name

What ever u entered is stored in the variable

name. printf:

Printf is used to print formatted

o/p. printf "format" arg1 arg2 ...

Eg:

```
$ printf "This is a number: %d\n" 10
This is a number: 10
$
```

Printf supports conversion specification characters like %d, %s ,%x

,%o…. Exit status of a command:

- Every command returns a value after execution .This value is called the exit status or return value of a command.
- This value is said to be true if the command executes successfully and false if it fails.
- There is special parameter used by the shell it is the $?. It stores the exit status of a command.

exit:

- The exit statement is used to prematurely terminate a program. When this statement is encountered in a script, execution is halted and control is returned to the calling program- in most cases the shell.

-
- U don‘t need to place exit at the end of every shell script because the shell knows when script execution is complete.

- Set is used to produce the list of currently defined variables.

$set

- Set is used to assign values to the positional parameters.

$set welcome to Unix

The do-nothing(:)Command

- It is a null command.
- In some older shell scripts, colon was used at the start of a line to introduce a comment, but modern scripts uses # now.
- expr:
- The expr command evaluates its arguments as an expression:

```
$ expr 8 + 6
$ x=`expr 12 / 4 `
$ echo $x
3
```

export variables

where variables is the list of variable names that you want exported. For any sub shells that get executed from that point on, the value of the exported variables will be passed down to the sub shell.

eval:

eval scans the command line twice before executing it. General form for eval

is eval command-line

Eg:

```
$ cat last

eval echo \$$#

$ last one two three four
four
```

${n}

If u supply more than nine arguments to a program, u cannot access the tenth and greater arguments with $10, $11, and so on.

${n} must be used. So to directly access argument 10, you must write
${10}

Shift command:

The shift command allows u to effectively left shift your positional parameters. If u execute the command

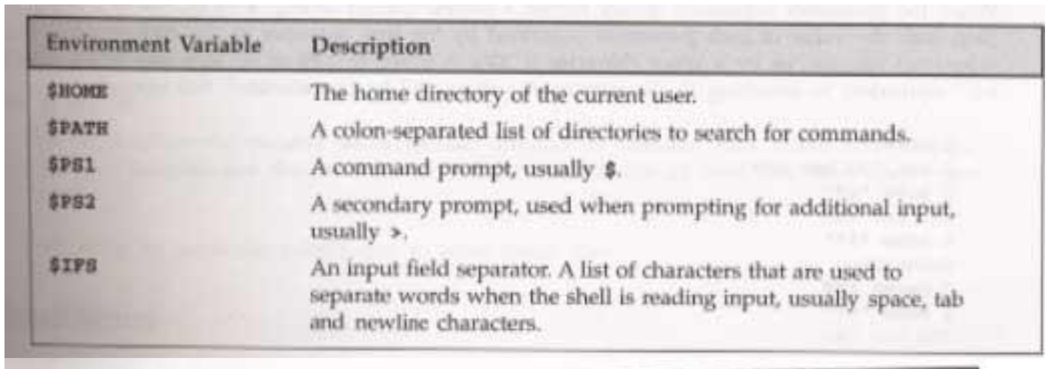
Shift

whatever was previously stored inside $2 will be assigned to $1, whatever was previously stored in $3 will be assigned to $2, and so on. The old value of $1 will be irretrievably lost.

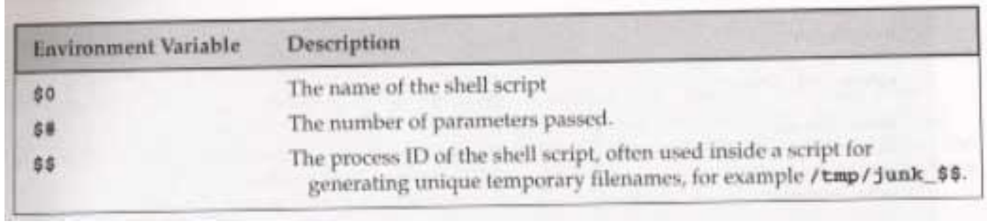
The Environment-Environment Variables

It creates the variable salutation, displays its value, and some parameter variables.

- When a shell starts, some variables are initialized from values in the environment. Here is a sample of some of them.



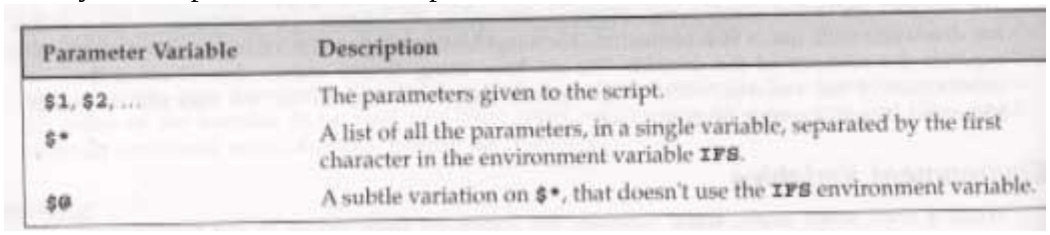
Environment Variable	Description
$HOME	The home directory of the current user.
$PATH	A colon-separated list of directories to search for commands.
$PS1	A command prompt, usually $.
$PS2	A secondary prompt, used when prompting for additional input, usually >.
$IFS	An input field separator. A list of characters that are used to separate words when the shell is reading input, usually space, tab and newline characters.



Environment Variable	Description
$0	The name of the shell script
$#	The number of parameters passed.
$$	The process ID of the shell script, often used inside a script for generating unique temporary filenames, for example /tmp/junk_$$.

Parameter Variables

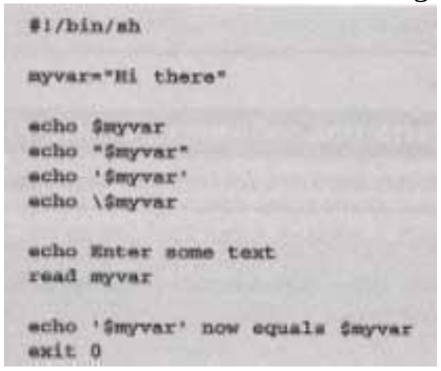
- If your script is invoked with parameters, some additional variables are created.



Parameter Variable	Description
$1, $2, ...	The parameters given to the script.
$*	A list of all the parameters, in a single variable, separated by the first character in the environment variable IFS.
$@	A subtle variation on $*, that doesn't use the IFS environment variable.

Quoting

Normally, parameters are separated by white space, such as a space. Single quot marks can be used to enclose values containing space(s). Type the following into a file called quot.sh

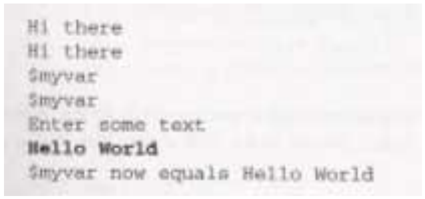


```
#!/bin/sh

myvar="Hi there"

echo $myvar
echo "$myvar"
echo '$myvar'
echo \$myvar

echo Enter some text
read myvar

echo '$myvar' now equals $myvar
exit 0
```

make sure to make it executable by typing the command:

< chmod a+x
quot.sh The results of executing

the file is:



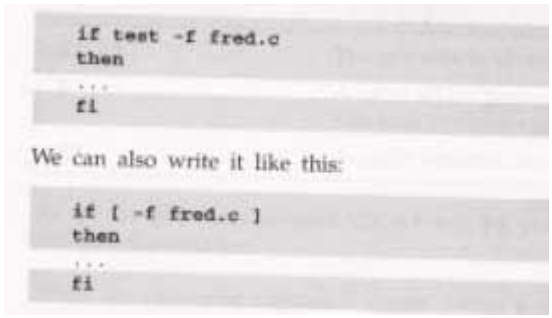
```
Hi there
Hi there
$myvar
$myvar
Enter some text
Hello World
$myvar now equals Hello World
```

How It Works

The variable myvar is created and assigned the string Hi there. The content of the variable is displyed using the echo $. Double quotes don't effect echoing the value. Single quotes and backslash do.

The test, or []Command

Here is how to check for the existance of the file fred.c using the test and using the [] command.

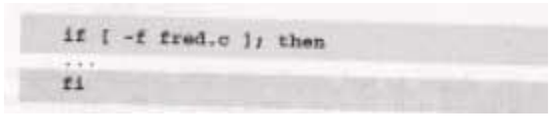


```
if test -f fred.c
then
...
fi
```

We can also write it like this:

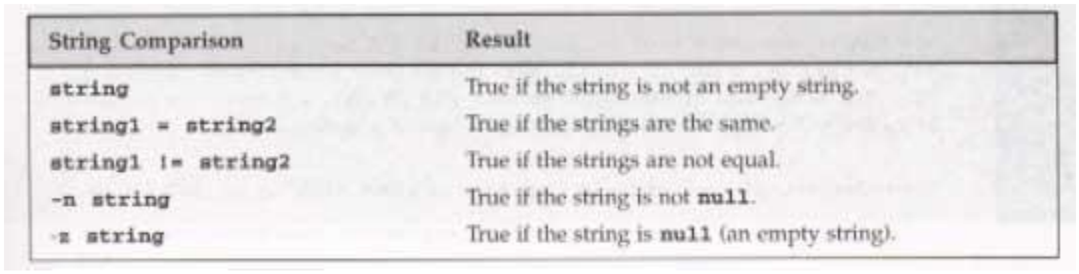
```
if [ -f fred.c ]
then
...
fi
```

You can even place the then on the same line as the if, if youu add a semicolon before the word then.



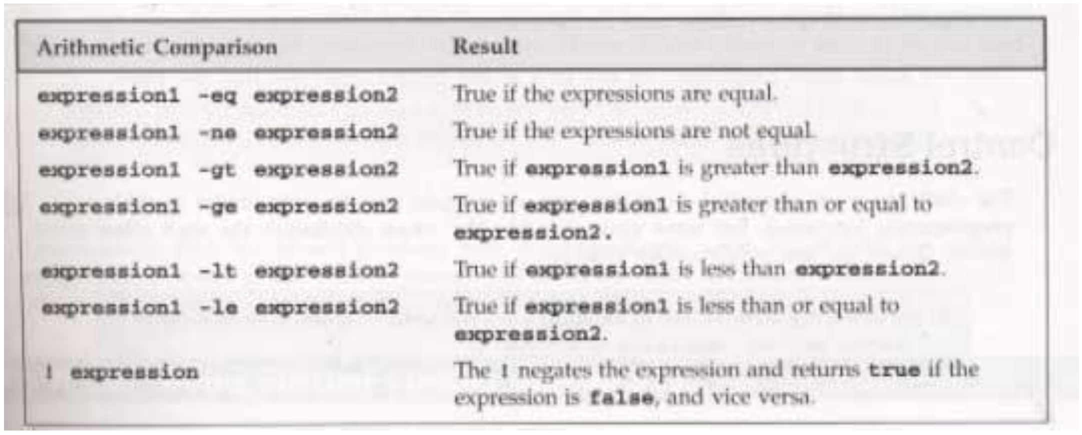
```
if [ -f fred.c ]; then
...
fi
```

Here are the conditon types that can be used with the test command. There are string comparison.



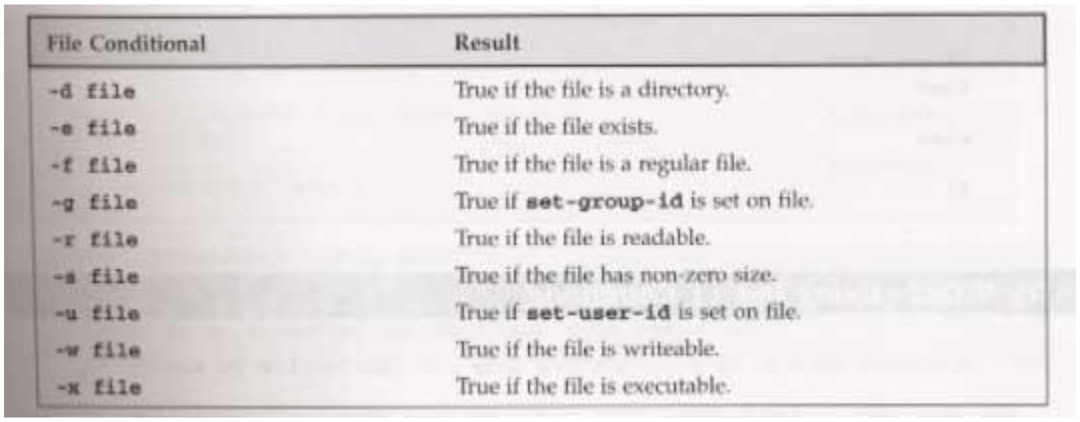
String Comparison	Result
`string`	True if the string is not an empty string.
`string1 = string2`	True if the strings are the same.
`string1 != string2`	True if the strings are not equal.
`-n string`	True if the string is not **null**.
`-z string`	True if the string is **null** (an empty string).

There are arithmetic comparison.



Arithmetic Comparison	Result
`expression1 -eq expression2`	True if the expressions are equal.
`expression1 -ne expression2`	True if the expressions are not equal.
`expression1 -gt expression2`	True if **expression1** is greater than **expression2**.
`expression1 -ge expression2`	True if **expression1** is greater than or equal to **expression2**.
`expression1 -lt expression2`	True if **expression1** is less than **expression2**.
`expression1 -le expression2`	True if **expression1** is less than or equal to **expression2**.
`! expression`	The **!** negates the expression and returns **true** if the expression is **false**, and vice versa.

There are file conditions.



File Conditional	Result
`-d file`	True if the file is a directory.
`-e file`	True if the file exists.
`-f file`	True if the file is a regular file.
`-g file`	True if **set-group-id** is set on file.
`-r file`	True if the file is readable.
`-s file`	True if the file has non-zero size.
`-u file`	True if **set-user-id** is set on file.
`-w file`	True if the file is writeable.
`-x file`	True if the file is executable.

Control Structures

The shell has a set of control structures.

if

The if statement is vary similar other programming languages except it ends with a fi.

```
if condition
then
        statements
else
        statements
fi
```

elif

the elif is better known as "else if". It replaces the else part of an if statement with another if statement. You can try it out by using the following script.

```
#!/bin/sh

echo "Is it morning? Please answer yes or no"
read timeofday

if [ $ti0meofday = "yes" ]
then
        echo "Good morning"
elif [ $timeofday = "no" ]; then
       echo "Good afternoon"
else
echo "Sorry, $timeofday not recognized. Enter yes
or no" exit 1 fi

exit 0
```

How It Works

The above does a second test on the variable timeofday if it isn't equal to yes.

A Problem with Variables

If a variable is set to null, the statement

```
if [ $timeofday = "yes" ]
```

looks like

```
if [ = "yes" ]
```

which is illegal. This problem can be fixed by using double quotes around the variable name.

```
        if [ "$timeofday" = "yes" ]
```

.

for

The for construct is used for looping through a range of values, which can be any set of strings. The syntax is:

```
        for variable in values
        do
                statements
        done
```

Try out the following script:

```
        #!/bin/sh

        for foo in bar fud 43
        do
                echo $foo
        done
        exit 0
```

When executed, the output should be:

```
        bar
        fud0
        43
```

How It Works

The above example creates the variable foo and assigns it a different value each time around the for loop.

How It Works

Here is another script which uses the $(command) syntax to expand a list to chap3.txt, chap4.txt, and chap5.txt and print the files.

```
        #!/bin/sh

        for file in $(ls chap[345].txt); do
                lpr $file
        done0
```

while

While loops will loop as long as some condition exist. OF course something in the body statements of the loop should eventually change the condition and cause the loop to exit. Here is the while loop syntax.

Here is a whil loop that loops 20 times.

```
#!/bin/sh
foo=1

while [ "$foo" -le 20 ]
do
done exit 0
```

How It Works
echo "Here we go again" foo=$(($foo+1))

The above script uses the [ ] command to test foo for <= the value 20. The line

```
foo=$(($fo0o+1))
```

increments the value of foo each time the loop executes..

until

The until statement loops until a condition becomes true! Its syntax is:

```
until condition
do
        statements
done
```

Here is a script using until.

```
#!/bin/sh

until who | grep "$1" > /dev/null
do
        Sl0eep 60
done

# now ring the bell and announce the expected user.

echo -e \\a
echo "**** $1 has just loogged in ****"

exit 0
```

case

The case statement allows the testing of a variable for more then one value. The case statement ends with the word esac. Its syntax is:

```
case variable in
        pattern [ | pattern] ...) statements;;
        pattern [ | pattern] ...) statements;;
        ...
esac
```

Here is a sample script using a case statement:

```
#!/bin/sh

echo "Is it morning? Please answer yes or no"
read timeofday

case "$timeofday" in
        "yes")  echo  "Good  Morning";;
        "no" ) echo "Good Afternoon";;
        0"y"  )  echo  "Good  Morning";;
        "n" ) echo "Good Afternoon";;
        * ) echo "Soory, answer not recognized";;
esac

exit 0
```

The value in the varaible timeofday is compared to various strings. When a match is made, the associated echo command is executed.

Here is a case where multiple strings are tested at a time, to do the some action.

```
case "$timeofday" in
        "yes" | "y" | "yes" | "YES" ) echo "good Morning";;
        "n"* | "N"* ) <echo "Good Afternoon";;
        * ) < echo "Sorry, answer not recognized";;
0esac
```

How It Works

The above has sever strings tested for each possible statement.

Here is a case statement that executes multiple statements for each case.

```
case "$timeofday" in
        "yes" | "y" | "Yes" | "YES" )
                echo "Good Morning"
                echo "Up bright and early this morning"
                ;;
```

When a match is found to the variable value of timeofday, all the statements up to the ;; are executed.

Arithmetic in shell

The $((...)) is a better alternative to the expr command, which allows simple arithmetic commands to be processed.

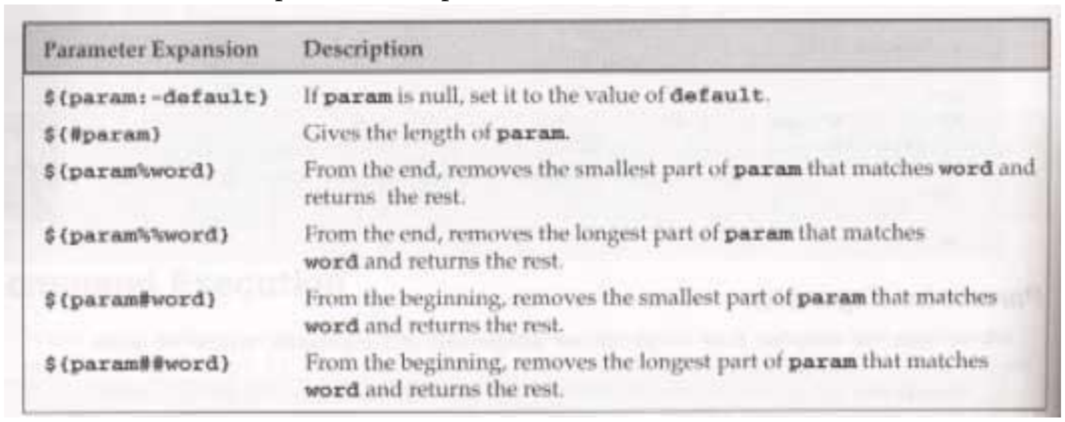
```
x=$(($x+1))
```

Parameter Expansion

Using { } around a variable to protect it against expansion.

```
#!/bin/sh

for i in 1 2
do
        my_secret_process ${i}_tmp
done
```

Here are some of the parameter expansion



Parameter Expansion	Description
`${param:-default}`	If **param** is null, set it to the value of **default**.
`${#param}`	Gives the length of **param**.
`${param%word}`	From the end, removes the smallest part of **param** that matches **word** and returns the rest.
`${param%%word}`	From the end, removes the longest part of **param** that matches **word** and returns the rest.
`${param#word}`	From the beginning, removes the smallest part of **param** that matches **word** and returns the rest.
`${param##word}`	From the beginning, removes the longest part of **param** that matches **word** and returns the rest.

How It Works

The try it out exercise uses parameter expansion to demonstrate how parameter expansion works.

Shell Script Examples

Example

#!/bin/sh

echo "Is it morning? (Answer yes or no)"

```
read timeofday

if [ $timeofday = "yes" ]; then
        echo "Good Morning"

else

        echo "Good afternoon"

fi

exit 0
```

elif - Doing further Checks

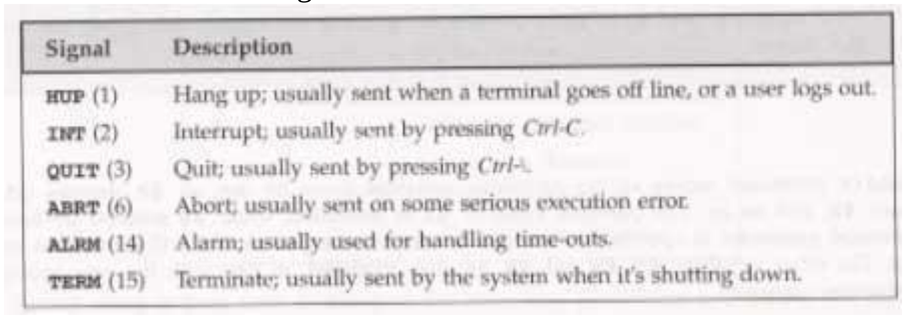
```
#!/bin/sh

echo "Is it morning? Please answer yes or no"

read timeofday

if [ $timeofday = "yes" ]; then

        echo "Good Morning"

elif [ $timeofday = "no" ]; then

        echo "Good afternoon"

else    echo "Wrong answer! Enter yes or no"

        exit 1

fi      exit 0
```

Interrupt Processing-trap

The trap command is used for secifying the actions to take on receipt of signals. It syntax is:

```
                trap command signal
```

Here are some of the signals.



Signal	Description
HUP (1)	Hang up; usually sent when a terminal goes off line, or a user logs out.
INT (2)	Interrupt; usually sent by pressing *Ctrl-C*.
QUIT (3)	Quit; usually sent by pressing *Ctrl-*.
ABRT (6)	Abort; usually sent on some serious execution error.
ALRM (14)	Alarm; usually used for handling time-outs.
TERM (15)	Terminate; usually sent by the system when it's shutting down.

How It Works

The try it out section has you type in a shell script to test the trap command. It creates a file and keeps saying that it exists until youu cause a control-C interrupt. It does it all again.

Functions

You can define functions inthe shell. The syntax is:

```
function_name () {
                statements
        }
```

Here is a sample function and its execution.

```
                #!/bin/sh

foo() {

}
                        echo "Function foo is executing"
echo "script starting"
foo
echo "script ended"

exit 0
```

How It Works

When the above script runs, it defines the funcion foo, then script echos script starting, then it runs the functions foo which echos Function foo is executing, then it echo script ended.

Here is another sample script with a function in it. Save it as my_name

```
#!/bin/sh

yes_or_no() {
        echo "Parameters are $*"
        while true
        do
                echo -n "Enter yes or no"
                read x
                case "$x" in
                        y | yes ) return 0;;
                        n | no ) return 1;;
*       ) echo "Answer yes or no"
                esac
        done
}

echo "Original parameters are $*"
if yes_or_no "IS your naem $1"
then
        echo "Hi $1"
else
        echo "Never mind"
fi

0exit 0
```

When my_name is execute with the statement:

```
                    my_name Rick and Neil
```

. gives the output of:

```
                    Original parameters are Rick and Neil
                    Parameters are Is your name Rick
                    Enter yes or no
                    no
                    Never mind
```

Commands

You can execute normal command and built-in commands from a shell script. Built-in commands are defined and only run inside of the script.

break

It is used to escape from an enclosing for, while or until loop before the controlling condition has been met.

The : Command

The colon command is a null command. It can be used for an alias for true..

Continue

The continue command makes the enclosing for, while, or until loop continue at the next iteration.

The Command

The dot command executes the command in the current shell:

```
                     shell_script
```

echo

The echo command simply outputs a string to the standard output device followed by a newline character.

Eval

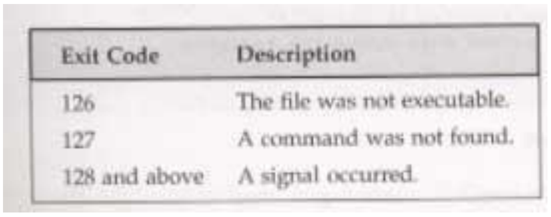
The eval command evaluates arguments and give s the results.

exec

The exec command can replace the current shell with a different program. It can also modify the current file descriptors.

exit n

The exit command causes the script to exit with exit code n. An exit code of 0 means success. Here are some other codes.



Exit Code	Description
126	The file was not executable.
127	A command was not found.
128 and above	A signal occurred.

export

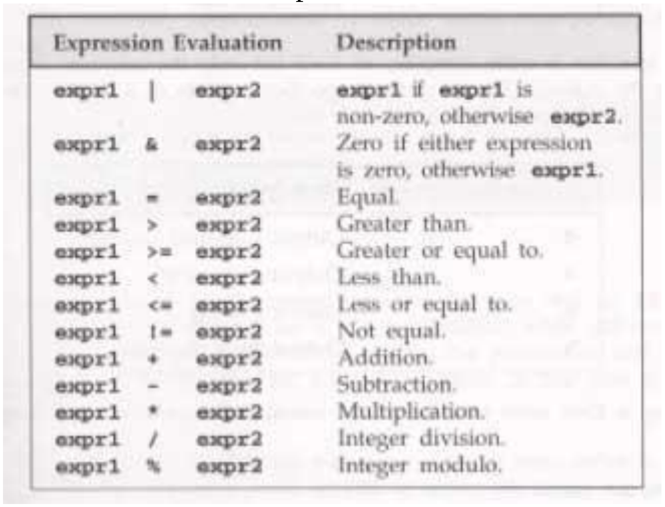
The export command makes the variable named as its parameter available in subshells.

expr

The expr command evaluates its arguments as an expression.

```
0x = `expr $x + 1`
```

Here are some of its expression evaluations



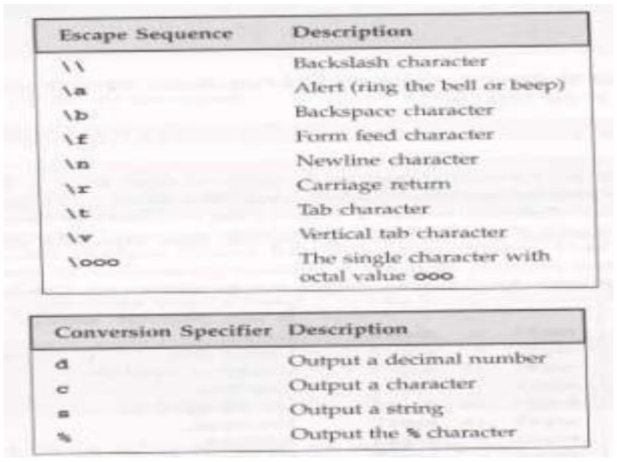
Expression Evaluation	Description
`expr1 | expr2`	`expr1` if `expr1` is non-zero, otherwise `expr2`.
`expr1 & expr2`	Zero if either expression is zero, otherwise `expr1`.
`expr1 = expr2`	Equal.
`expr1 > expr2`	Greater than.
`expr1 >= expr2`	Greater or equal to.
`expr1 < expr2`	Less than.
`expr1 <= expr2`	Less or equal to.
`expr1 != expr2`	Not equal.
`expr1 + expr2`	Addition.
`expr1 - expr2`	Subtraction.
`expr1 * expr2`	Multiplication.
`expr1 / expr2`	Integer division.
`expr1 % expr2`	Integer modulo.

printf

The printf command is only available in more recent shells. It works similar to the echo command. Its general form is:

```
printf "format string" parameter1 parameter2 ...
```

Here are some characters and format specifiers.



Escape Sequence	Description
`\\`	Backslash character
`\a`	Alert (ring the bell or beep)
`\b`	Backspace character
`\f`	Form feed character
`\n`	Newline character
`\r`	Carriage return
`\t`	Tab character
`\v`	Vertical tab character
`\ooo`	The single character with octal value `ooo`

Conversion Specifier	Description
`d`	Output a decimal number
`c`	Output a character
`s`	Output a string
`%`	Output the `%` character

return

The return command causes functions to return. It can have a value parameter which it returns.

set

The set command sets the parameter variables for the shell.

shift

The shift command moves all the parameters variables down by one, so $2 becomes $1, $3 becomes $2, and so on.

unset

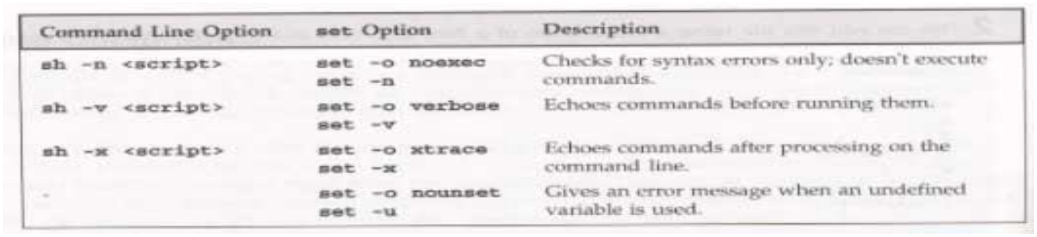
The unset command removes variables or functions from the environment.

Command Execution

The result of $(command) is simply the output string from the command, which is then available to the script.

Debugging Shell Scripts

When an error occurs in a script, the shell prints out the line number with an error. You can use the set command to set various shell option. Here are some of them.



Command Line Option	set Option	Description

`sh -n <script>`	`set -o noexec`
	`set -n`
		Checks for syntax errors only; doesn't execute commands.

`sh -v <script>`	`set -o verbose`
	`set -v`
		Echoes commands before running them.

`sh -x <script>`	`set -o xtrace`
	`set -x`
		Echoes commands after processing on the command line.

	`set -o nounset`
	`set -u`
		Gives an error message when an undefined variable is used.

Files and Directories

UNIX File Structure

In UNIX, everything is a file.

Programs can use disk files, serial ports, printers and other devices in the exactly the same way as they would use a file.

Directories, too, are special sorts of files.

File types

Most files on a UNIX system are regular files or directories, but there are additional types of files:

1. **Regular files**: The most common type of file, which contains data of some form. There is no distinction to the UNIX kernel whether this data is text or binary.
2. **Directory file:** A file contains the names of other files and pointers to information on these files. Any process that has read permission for a directory file can read the contents of the directory, but only the kernel can write to a directoryfile.
3. **Character special file**: A type of file used for certain types of devices on asystem.
4. **Block special file**: A type of file typically used for disk devices. All devices on a system are either character special files or block special files.
5. **FIFO**: A type of file used for interprocess communication between processes. It‘s sometimes called a named pipe.
6. **Socket:** A type of file used for network communication between processes. A socket can also be used for nonnetwork communication between processes on a singlehost.
7. **Symbolic link:** A type of file that points to another file.

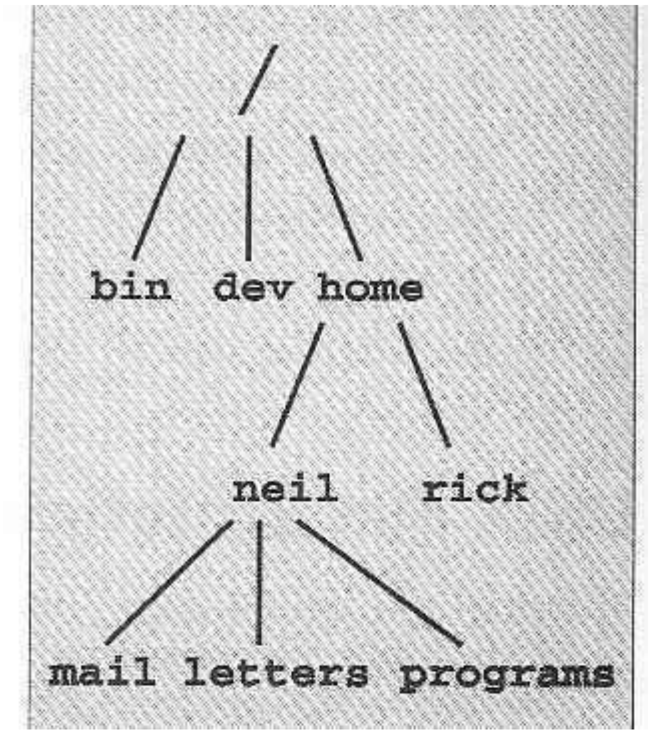
The argument to each of different file types is defined as follows_

Macro	Type of file
S_ISREG()	Regular file
S_ISDIR()	Directory file
S_ISCHR()	Character special file
S_ISBLK()	Block special file
S_ISFIFO()	Pipe or FIFO
S_ISLNK()	Symbolic link
S_ISSOCK()	Socket

File System Structure

Files are arranged in directories, which also contain subdirectories.

A user, **neil**, usually has his files stores in a 'home' directory, perhaps **/home/neil**.



Files and Devices

Even hardware devices are represented (mapped) by files in UNIX. For example, as **root**, you mount a CD-ROM drive as a file,

```
$ mount -t iso9660 /dev/hdc /mnt/cd_rom
$ cd /mnt/cd_rom
```

/dev/console - this device represents the system console.
/dev/tty - This special file is an alias (logical device) for controlling terminal (keyboard and screen, or window) of a process.
/dev/null - This is the null device. All output written to this device is discarded.

File Metadata Inodes

- A structure that is maintained in a separate area of the hard disk.
- File attributes are stored in the inode.
- Every file is associated with a table called the inode.
- The inode is accessed by the inode number.
- Inode contains the following attributes of a file: file type, file permissions , no. of links UID of the owner, GID of the group owner, file size date and time of last modification, last access, change.

File attributes

Attribute	**value meaning**
File type	type of the file
Access permission	file access permission for owner, group and others
Hard link count	no.of hard links of a file.
UID	file owner user ID.
GID	the file group ID.
File size	file size in bytes.

Inode number system inode number of the file.

File system ID file system ID where the file is stored.

Kernel Support For Files:

UNIX supports the sharing of open files between different processes. Kernel has three data structures are used and the relationship among them determines the effect one process has on another with regard to file sharing.

1. Every process has an entry in the process table. Within each process table entry is a table of open file descriptors, which is taken as a vector, with one entry per descriptor. Associated with each file descriptor are
   a. The file descriptor flags.
   b. A pointer to a file table entry.
2. The kernel maintains a file table for all open files. Each file table entry contains
   a. The file status flags for the file(read, write, append, sync, nonblocking, etc.),
   b. The current file offset,
   c. A pointer to the v-node table entry for the file.
3. Each open file (or device) has a v-node structure. The v-node contains information about the type of file and pointers to functions that operate on the file. For most files the v-node also contains the i-node for the file. This information is read from disk when the file is opened, so that all the pertinent information about the file is readily available.

The arrangement of these three tables for a single process that has two different files open one file is open on standard input (file descriptor 0) and the other is open standard output (file descriptor 1).

Here, the first process has the file open descriptor 3 and the second process has file open descriptor 4. Each process that opens the file gets its own file table entry, but only a single v-node table entry. One reason each process gets its own file table entry is so that each process has its own current offset for the file.

- After each _write‘ is complete, the current file offset in the file table entry is incremented by the number of bytes written. If this causes the current file offset to exceed the current file size, the current file size, in the i-node table the entry is to the current file offset(Ex: file is extended).
- If a file is opened with O_APPEND flag, a corresponding flag is set in the file status flags of the file table entry. Each time a _write‘ is performed for a file with this append flag

set, the current file offset in the file table entry is first set to the current file size from the i-node table entry. This forces every _write‘ to be appended to the current end of file.

- The _lseek‘ function only modifies the current offset in the file table entry. No I/O table place.
- If a file is positioned to its current end of file using lseek, all that happens is the current file offset in the file table entry is set to the current file size from the i-node tableentry.

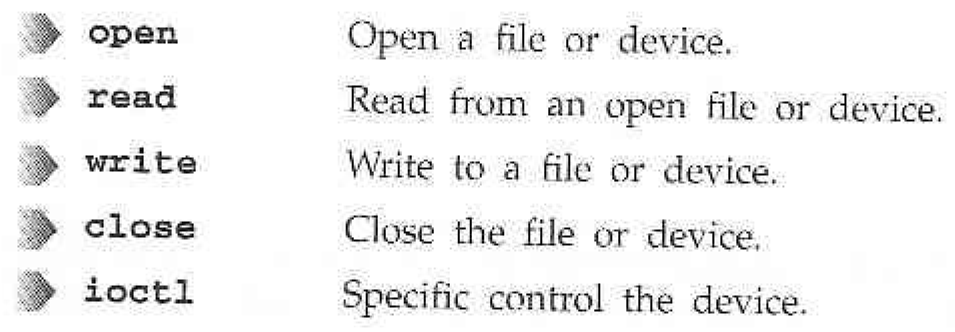
It is possible for more than a descriptor entry to point to the same file table only. The file descriptor flag is linked with a single descriptor in a single process, while file status flags are descriptors in any process that point to given file table entry.

System Calls and Device Drivers

System calls are provided by UNIX to access and control files and devices.

A number of **device drivers** are part of the kernel.

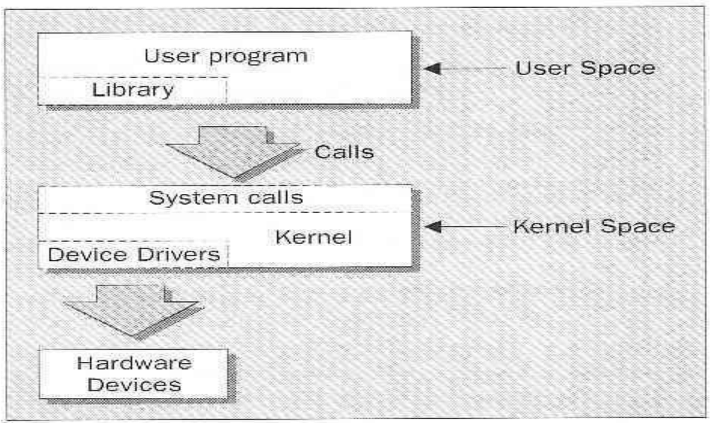
The system calls to access the device drivers include:



open	Open a file or device.
read	Read from an open file or device.
write	Write to a file or device.
close	Close the file or device.
ioctl	Specific control the device.

Library Functions

To provide a higher level interface to device and disk files, UNIIX provides a number of standard libraries.



Low-level File Access

Each running program, called a **process**, has associated with it a number of file descriptors.

When a program starts, it usually has three of these descriptors already opened. These are:

0	Standard input
1	Standard output
2	Standard error

```
#include <unistd.h>

size_t write(int fildes, const void *buf, size_t nbytes);
```

The **write** system call arranges for the first **nbytes** bytes from **buf** to be written to the file associated with the file descriptor **fildes**.

With this knowledge, let's write our first program, **simple_write.c**:

```
#include <unistd.h>

int main()
{
    if ((write(1, "Here is some data\n", 18)) != 18)
        write(2, "A write error has occurred on file descriptor 1\n",46);

    exit(0);
}
```

Here is how to run the program and its output.

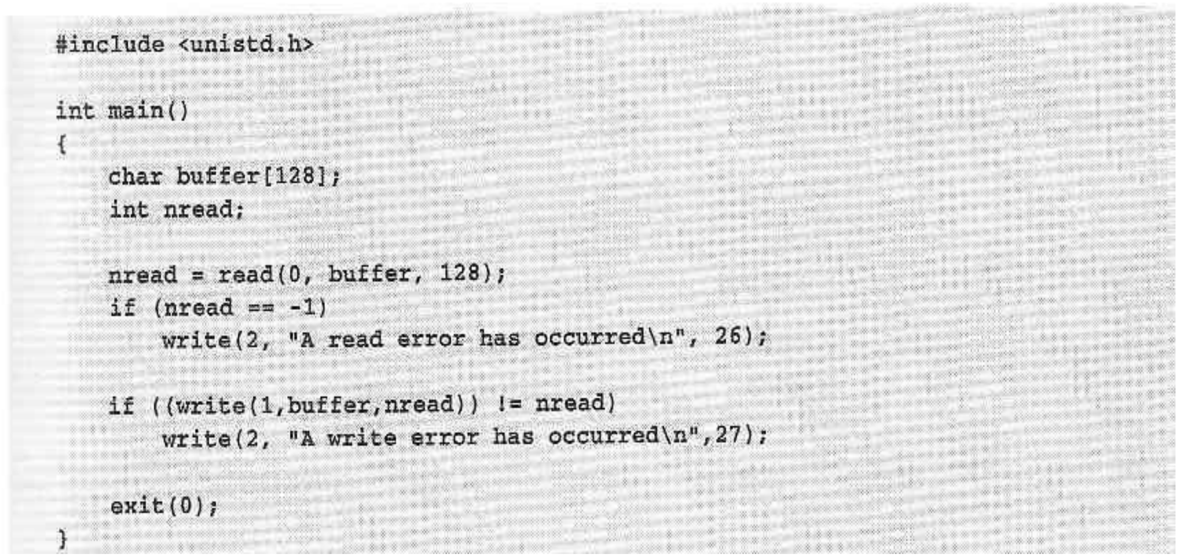
```
$    simple_write
Here is some data
$
```

read

```
#include <unistd.h>

size_t read(int fildes, void *buf, size_t nbytes);
```

The **read** system call reads up to **nbytes** of data from the file associated with the file decriptor **fildes** and places them in the data area **buf**.

This program, **simple_read.c**, copies the first 128 bytes of the standard input to the standard output.



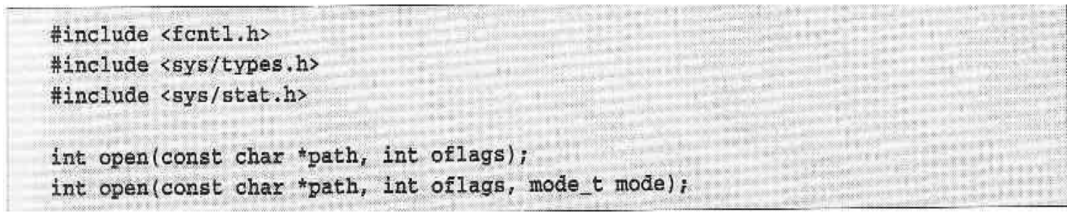
```
#include <unistd.h>

int main()
{
    char buffer[128];
    int nread;

    nread = read(0, buffer, 128);
    if (nread == -1)
        write(2, "A read error has occurred\n", 26);

    if ((write(1,buffer,nread)) != nread)
        write(2, "A write error has occurred\n",27);

    exit(0);
}
```

If you run the program, you should see:

```
$ echo hello there | simple_read
hello there
$ simple_read < draft1.txt
Files
```

open

To create a new file descriptor we need to use the **open** system call.

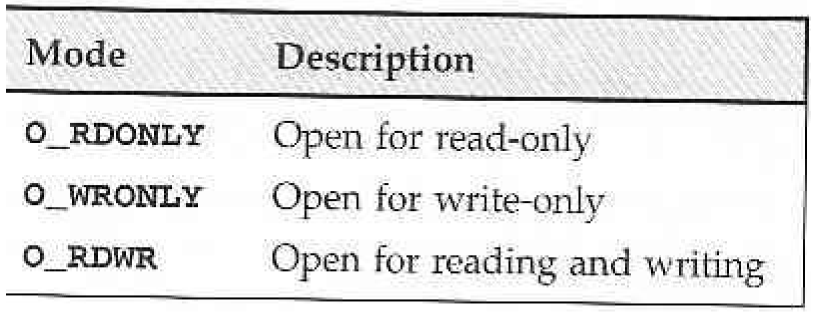


```
#include <fcntl.h>
#include <sys/types.h>
#include <sys/stat.h>

int open(const char *path, int oflags);
int open(const char *path, int oflags, mode_t mode);
```

open establishes an access path to a file or device.

The name of the file or device to be opened is passed as a parameter, **path**, and the **oflags** parameter is used to specify actions to be taken on opening the file.

The **oflags** are specified as a bitwise OR of a mandatory file access mode and other optional modes. The **open** call must specify one of the following file access modes:



Mode	Description
O_RDONLY	Open for read-only
O_WRONLY	Open for write-only
O_RDWR	Open for reading and writing

The call may also include a combination (bitwise OR) of the following optional modes in the **oflags** parameter:

O_APPEND	Place written data at the end of the file.
O_TRUNC	Set the length of the file to zero, discarding existing contents.
O_CREAT	Creates the file, if necessary, with permissions given in **mode**.
O_EXCL	Used with **O_CREAT**, ensures that the caller creates the file. The **open** is atomic, i.e. it's performed with just one function call. This protects against two programs creating the file at the same time. If the file already exists, **open** will fail.

Initial Permissions

When we create a file using the **O_CREAT** flag with **open**, we must use the three parameter form. **mode**, the third parameter, is made form a bitwise OR of the flags defined in the header file **sys/stat.h**. These are:

S_IRUSR	Read permission, owner.
S_IWUSR	Write permission, owner.
S_IXUSR	Execute permission, owner.
S_IRGRP	Read permission, group.
S_IWGRP	Write permission, group.
S_IXGRP	Execute permission, group.
S_IROTH	Read permission, others.
S_IWOTH	Write permission, others.
S_IXOTH	Execute permission, others.

For example

```
open ("myfile", O_CREAT, S_IRUSR|S_IXOTH);
```

Has the effect of creating a file called **myfile**, with read permission for the owner and execute permission for others, and only those permissions.

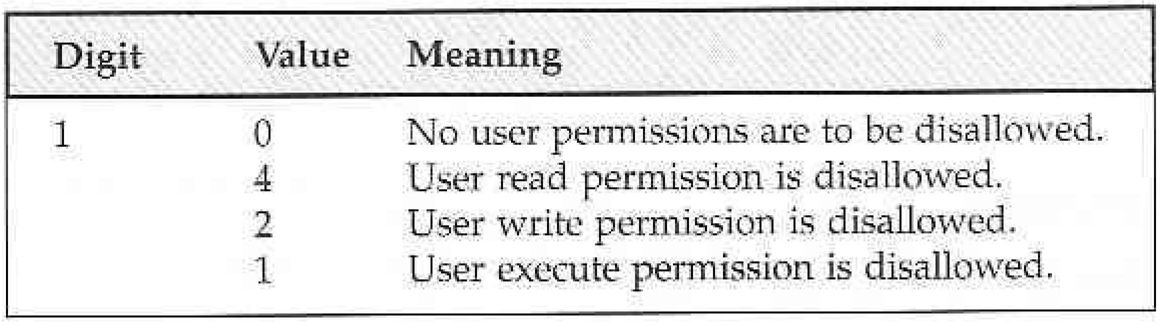
```
$ ls -ls myfile
0 -r-------x   1 neil     software         0 Sep 22 08:11 myfile*
```

umask

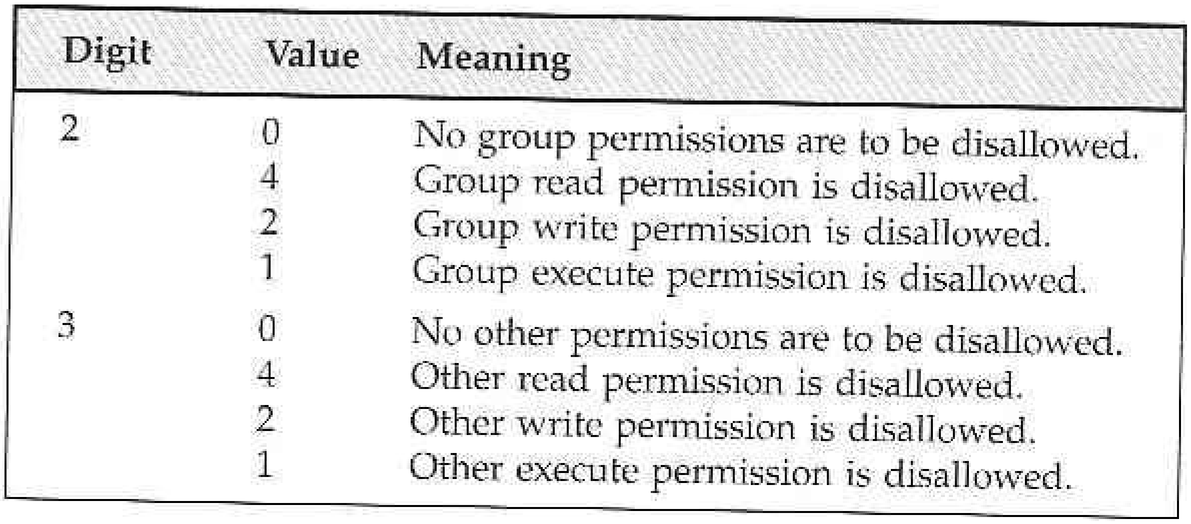
The **umask** is a system variable that encodes a mask for file permissions to be used when a file is created.

You can change the variable by executing the **umask** command to supply a new value.

The value is a three-digit octal value. Each digit is the results of ANDing values from 1, 2, or 4.

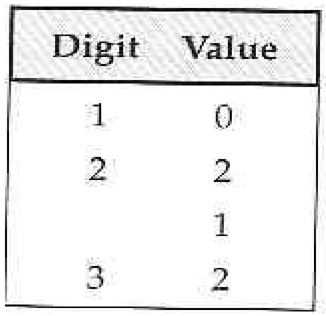


Digit	Value	Meaning
1	0	No user permissions are to be disallowed.
	4	User read permission is disallowed.
	2	User write permission is disallowed.
	1	User execute permission is disallowed.



Digit	Value	Meaning
2	0	No group permissions are to be disallowed.
	4	Group read permission is disallowed.
	2	Group write permission is disallowed.
	1	Group execute permission is disallowed.
3	0	No other permissions are to be disallowed.
	4	Other read permission is disallowed.
	2	Other write permission is disallowed.
	1	Other execute permission is disallowed.

For example, to block 'group' write and execute, and 'other' write, the **umask** would be:



Digit	Value
1	0
2	2
	1
3	2

Values for each digit are ANDed together; so digit 2 will have 2 & 1, giving 3. The resulting **umask** is **032**.

close

```
#include <unistd.h>

int close(int fildes);
```

We use **close** to terminate the association between a file descriptor, **fildes**, and its file.

ioctl

```
#include <unistd.h>

int ioctl(int fildes, int cmd, ...);
```

ioctl is a bit of a rag-bag of things. It provides an interface for controlling the behavior of devices, their descriptors and configuring underlying services.

ioctl performs the function indicated by **cmd** on the object referenced by the descriptor **fildes**.

Try It Out - A File Copy Program

We now know enough about the **open**, **read** and **write** system calls to write a low-level program, **copy_system.c**, to copy one file to another, character by character.

We'll do this in a number of ways during this chapter to compare the efficiency of each method. For brevity, we'll assume that the input file exists and the output file does not. Of course, in real-life programs, we would check that these assumptions are valid!

```
#include <unistd.h>
#include <sys/stat.h>
#include <fcntl.h>

int main()
{
    char c;
    int in, out;

    in = open("file.in", O_RDONLY);
    out = open("file.out", O_WRONLY|O_CREAT, S_IRUSR|S_IWUSR);
    while(read(in,&c,1) == 1)
        write(out,&c,1);

    exit(0);
}
```

Note that the `#include <unistd.h>` *line must come first as it defines flags regarding POSIX compliance that may affect other include files.*

We used the UNIX **time** facility to measure how long the program takes to run. It took 2 and one half minutes to copy the 1Mb file.

We can improve by copying in larger blocks. Here is the improved **copy_block.c** program.

```
#include <unistd.h>
#include <sys/stat.h>
#include <fcntl.h>

int main()
{
    char block[1024];
    int in, out;
    int nread;

    in = open("file.in", O_RDONLY);
    out = open("file.out", O_WRONLY|O_CREAT, S_IRUSR|S_IWUSR);
    while((nread = read(in,block,sizeof(block))) > 0)
        write(out,block,nread);

    exit(0);
}
```

Now try the program, first removing the old output file:

```
$ rm file.out
$ time copy_block
0.01user 1.09system 0:01.90elapsed 57%CPU
...
$ ls -ls file.in file.out
1029 -rw-r--r--   1 neil     users      1048576 Sep 17 10:46 file.in
1029 -rw-------   1 neil     users      1048576 Sep 17 10:57 file.out
```

The revised program took under two seconds to do the copy.

Other System Calls for Managing Files

Here are some system calls that operate on these low-level file descriptors.

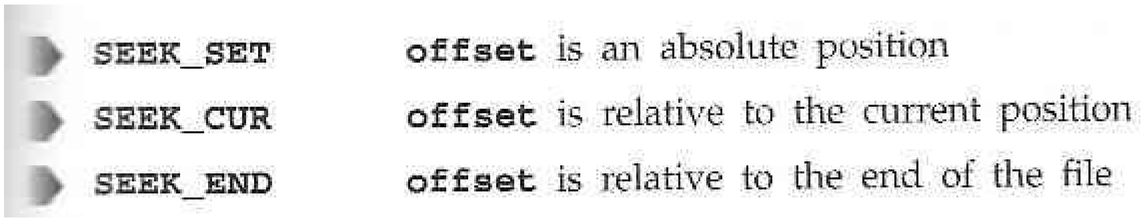
lseek

```
#include <unistd.h>

#include <sys/types.h>

off_t lseek(int fildes, off_t offset, int whence);
```

The **lseek** system call sets the read/write pointer of a file descriptor, **fildes**. You use it to set where in the file the next read or write will occur.

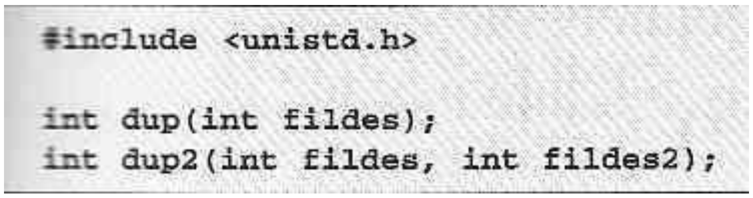
The **offset** parameter is used to specify the position and the **whence** parameter specifies how the offset is used.

whence can be one of the following:



SEEK_SET	offset is an absolute position
SEEK_CUR	offset is relative to the current position
SEEK_END	offset is relative to the end of the file

dup and dup2



```
#include <unistd.h>

int dup(int fildes);
int dup2(int fildes, int fildes2);
```

The **dup** system calls provide a way of duplicating a file descriptor, giving two or more, different descriptors that access the same file.

The **fstat** system call returns status information about the file associated with an open file descriptor.

The members of the structure, **stat**, may vary between UNIX systems, but will include:

stat Member	Description
st_mode	File permissions and file type information.
st_ino	The inode associated with the file.
st_dev	The device the file resides on.
st_uid	The user identity of the file owner.
st_gid	The group identity of the file owner.
st_atime	The time of last access.
st_ctime	The time of last change to mode, owner, group or content.
st_mtime	The time of last modification to contents.
st_nlink	The number of hard links to the file.

The permissions flags are the same as for the **open** system call above. File-type flags include:

S_IFBLK	Entry is a block special device.
S_IFDIR	Entry is a directory.
S_IFCHR	Entry is a character special device.
S_IFIFO	Entry is a FIFO (named pipe).
S_IFREG	Entry is a regular file.
S_IFLNK	Entry is a symbolic link.

Other mode flags include:

S_ISUID	Entry has **setUID** on execution.
S_ISGID	Entry has **setGID** on execution.

Masks to interpret the **st_mode** flags include:

S_IFMT	File type.
S_IRWXU	User read/write/execute permissions.
S_IRWXG	Group read/write/execute permissions.
S_IRWXO	Others read/write/execute permissions.

There are some macros defined to help with determining file types. These include:

S_ISBLK	Test for block special file.
S_ISCHR	Test for character special fi
S_ISDIR	Test for directory.
S_ISFIFO	Test for FIFO.
S_ISREG	Test for regular file.
S_ISLNK	Test for symbolic link.

To test that a file doesn't represent a directory and has execute permisson set for the owner and no other permissions, we can use the test:

```
struct stat statbuf;
mode_t modes;

stat("filename",&statbuf);
modes = statbuf.st_mode;

if(!S_ISDIR(modes) && (modes & S_IRWXU) == S_IXUSR)
    ...
```

File and record locking-fcntl function

- File locking is applicable only for regular files.
- It allows a process to impose a lock on a file so that other processes can not modify the file until it is unlocked by the process.
- Write lock: it prevents other processes from setting any overlapping read / write locks on the locked region of a file.
- Read lock: it prevents other processes from setting any overlapping write locks on the locked region of a file.

- Write lock is also called a exclusive lock and read lock is also called a shared lock.
- fcntl API can be used to impose read or write locks on either a segment or an entirefile.
- Function prototype:

    #include<fcntl.h>

    int fcntl (int fdesc, int cmd_flag, ….);

- All file locks set by a process will be unlocked when the process terminates.

File Permission-chmod

You can change the permissions on a file or directory using the **chmod** system call. Tis forms the basis of the **chmod** shell program.

```
#include <sys/stat.h>

int chmod(const char *path, mode_t mode);
```

chown

A superuser can change the owner of a file using the **chown** system call.

```
#include <unistd.h>

int chown(const char *path, uid_t owner, gid_t group);
```

Links-soft link and hard link

Soft link(symbolic links): Refer to a symbolic path indicating the abstract location of another file.

- Used to provide alternative means of referencing files.
- Users may create links for files using **ln** command by specifying **–s** option.

hard links : Refer to the specific location of physical data.

- A hard link is a UNIX path name for a file.
- Most of the files have only one hard link. However users may create additional hard links for files using **ln** command.

Limitations:

- Users cannot create hard links for directories unless they have super user privileges.
- Users cannot create hard links on a file system that references files on a different systems.

unlink, link, symlink

We can remove a file using **unlink**.

```
#include <unistd.h>

int unlink(const char *path);
int link(const char *path1, const char *path2);
int symlink(const char *path1, const char *path2);
```

The **unlink** system call decrements the link count on a file.

The **link** system call cretes a new link to an existing file.

The **symlink** creates a symbolic link to an existing file.

Directories

As well as its contents, a file has a name and 'administrative information', i.e. the file's creation/modification date and its permissions.

The permissions are stored in the **inode**, which also contains the length of the file and where on the disc it's stored.

A directory is a file that holds the inodes and names of other files.

mkdir, rmdir

We can create and remove directories using the **mkdir** and **rmdir** system calls.

```
#include <sys/stat.h>

int mkdir(const char *path, mode_t mode);
```

The mkdir system call makes a new directory with **path** as its name.

```
#include <unistd.h>

int rmdir(const char *path);
```

The **rmdir** system call removes an empty directory.

chdir

A program can naviagate directories using the **chdir** system call.

```
#include <unistd.h>

int chdir(const char *path);
```

Current Working Directory- getcwd

A program can determine its current working directory by calling the **getcwd** library function.

```
#include <unistd.h>

char *getcwd(char *buf, size_t size);
```

The **getcwd** function writes the name of the current directory into the given buffer, **buf**.

Scanning Directories

The directory functions are declared in a header file, **dirent.h**. They use a structure, **DIR**, as a basis for directory manipulation.

Here are these functions:

- **opendir, closedir**
- **readdir**
- **telldir**
- **seekdir**

opendir

The **opendir** function opens a directory and establishes a directory stream.

```
#include <sys/types.h>
#include <dirent.h>

DIR *opendir(const char *name);
```

readdir

```
#include <sys/types.h>
#include <dirent.h>

struct dirent *readdir(DIR *dirp);
```

The **readdir** function returns a pointer to a structure detailing the next directory entry in the directory stream **dirp**.

The **dirent** structure containing directory entry details included the following entries:

ino_t	d_ino	The inode of the file.
char	d_name[]	The name of the file.

telldir

```
#include <sys/types.h>
#include <dirent.h>

long int telldir(DIR *dirp);
```

The **telldir** function returns a value that records the current position in a directory stream.

seekdir

```
#include <sys/types.h>
#include <dirent.h>

void seekdir(DIR *dirp, long int loc);
```

The **seekdir** function sets the directory entry pointer in the directory stream given by **dirp**.

closedir

```
#include <sys/types.h>
#include <dirent.h>

int closedir(DIR *dirp);
```

The **closedir** function closes a directory stream and frees up the resources associated with it.

Try It Out - A Directory Scanning Program

1. The **printdir**, prints out the current directory. It willrecurse for subdirectories.

```
#include <unistd.h>
#include <stdio.h>
#include <dirent.h>
#include <string.h>
#include <sys/stat.h>

void printdir(char *dir, int depth)
{
    DIR *dp;
    struct dirent *entry;
    struct stat statbuf;

    if((dp = opendir(dir)) == NULL) {
        fprintf(stderr,"cannot open directory: %s\n", dir);
        return;
    }
    chdir(dir);
    while((entry = readdir(dp)) != NULL) {
        stat(entry->d_name,&statbuf);
```

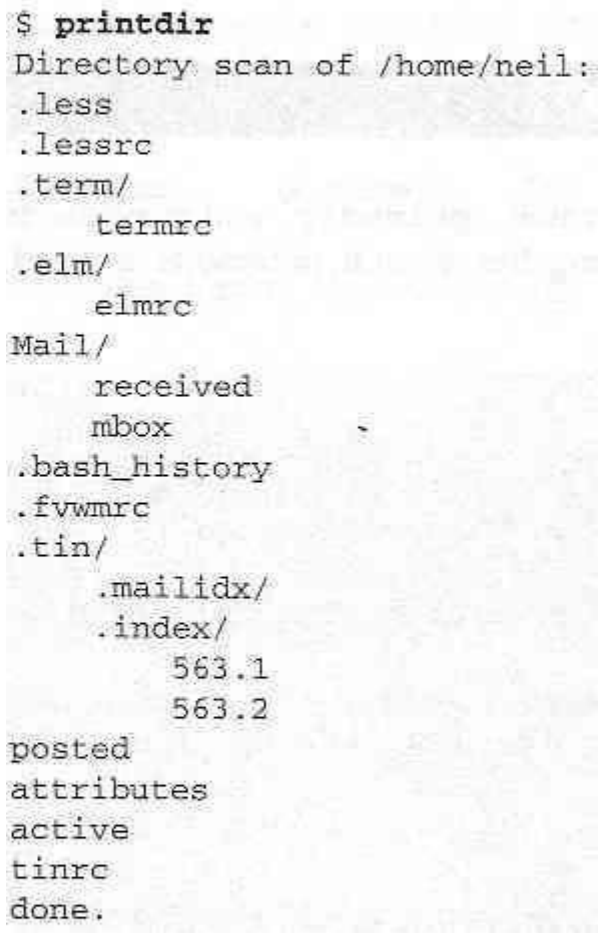
```
            if(S_ISDIR(statbuf.st_mode)) {
                /* Found a directory, but ignore . and .. */
                if(strcmp(".",entry->d_name) == 0 ||
                    strcmp("..",entry->d_name) == 0)
                    continue;
                printf("%*s%s/\n",depth,"",entry->d_name);
                /* Recurse at a new indent level */
                printdir(entry->d_name,depth+4);
            }
            else printf("%*s%s\n",depth,"",entry->d_name);
        }
        chdir("..");
        closedir(dp);
    }
```

2. Now we move onto the **main** function:

```
    int main()
    {
        printf("Directory scan of /home/neil:\n");
        printdir("/home/neil",0);
        printf("done.\n");

        exit(0);
    }
```

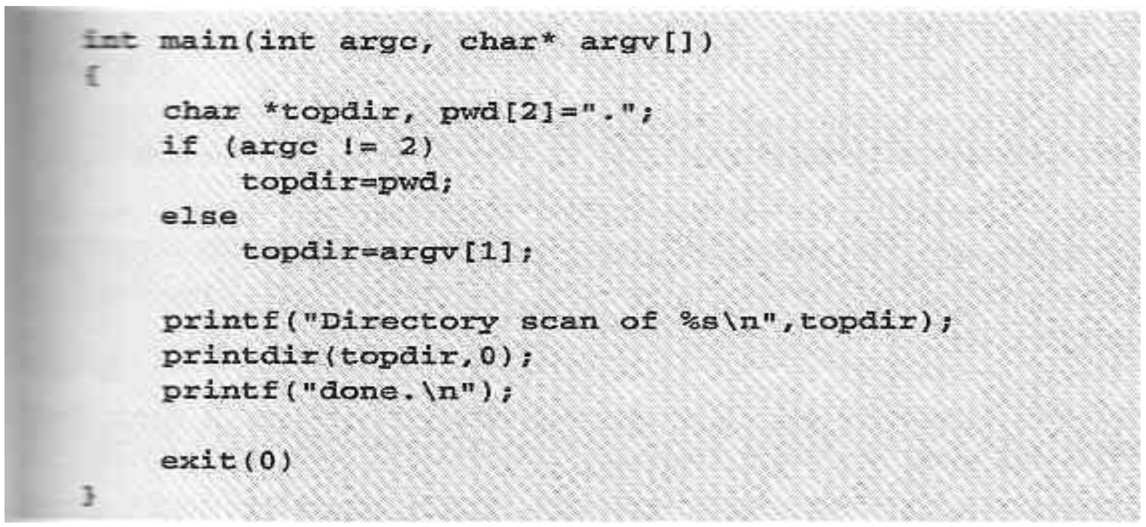
After some initial error checking, using **opendir**, to see that the directory exists, **printdir** makes a call to **chdir** to the directory specified. While the entries returned by **readdir** aren't null, the program checks to see whether the entry is a directory. If it isn't, it prints the file entry with indentation **depth**.

The program produces output like this (edited for brevity):How It Works



```
$ printdir
Directory scan of /home/neil:
.less
.lessrc
.term/
    termrc
.elm/
    elmrc
Mail/
    received
    mbox
.bash_history
.fvwmrc
.tin/
    .mailidx/
    .index/
        563.1
        563.2
posted
attributes
active
tinrc
done.
```

Here is one way to make the program more general.



```
int main(int argc, char* argv[])
{
    char *topdir, pwd[2]=".";
    if (argc != 2)
        topdir=pwd;
    else
        topdir=argv[1];

    printf("Directory scan of %s\n",topdir);
    printdir(topdir,0);
    printf("done.\n");

    exit(0)
}
```

You can run it using the command:

```
$ printdir /usr/local | more
```

UNIT- III
PROCESS

Process: Process identifiers, process structure: process table, viewing processes, system processes, And process scheduling; Starting new processes: Waiting for a process, process termination, zombie processes, orphan process, system call interface for process management, fork, vfork, exit, wait, waitpid, exec. Signals: Signal functions, unreliable signals, interrupted system calls, kill, raise, alarm, pause, abort, system, sleep functions,

What is a Process?

The X/Open Specification defines a process as an address space and single thread of control that executes within that address space and its required system resources.
A process is, essentially, a running program.

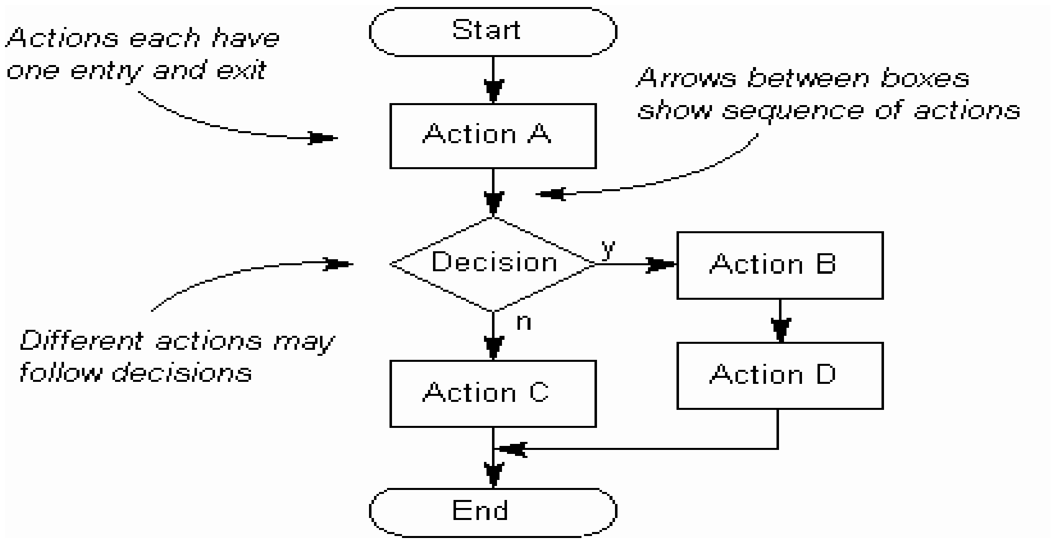
Process Identifier:

Every process has a unique process ID, a non-negative integer. There are two special processes. Process ID is usually the schedule process and is often known as the swapper‘. No program on disk corresponds to this process – it is part of the kernel and is known as a system process, process ID1 is usually the _init‘process and is invoked by the kernel at the end of the bootstrap procedure. The program files for this process loss
/etc/init in older version of UNIX and is /sbin/init is newer version. _init‘usually reads the system dependent initialization files and brings the system to a certain state. The _init‘process never dies.
_init‘becomes the parent process of any orphaned child process.

Process structure:

When interacting with your server through a shell session, there are many pieces of information that your shell compiles to determine its behavior and access to resources. Some of these settings are contained within configuration settings and others are determined by user input.

One way that the shell keeps track of all of these settings and details is through an area it maintains called the environment. The environment is an area that the shell builds every time that it starts a session that contains variables that define system properties.
In this guide, we will discuss how to interact with the environment and read or set environmental and shell variables interactively and through configuration files. We will be using an Ubuntu 12.04 VPS as an example, but these details should be relevant on any Linux system.Every time a shell session spawns, a process takes place to gather and compile information that should be available to the shell process and its child processes.
It obtains the data for these settings from a variety of different files and settings on the system.
Basically the environment provides a medium through which the shell process can get or set settings and, in turn, pass these on to its child processes.


Actions each have one entry and exit
Start
Arrows between boxes show sequence of actions
Action A
Decision
y
n
Action B
Different actions may follow decisions
Action C
Action D
End

Process table:
The environment is implemented as strings that represent key-value pairs. If multiple values are passed, they are typically separated by colon (:) characters. Each pair will generally will look something like this:

KEY=value1:value2:...

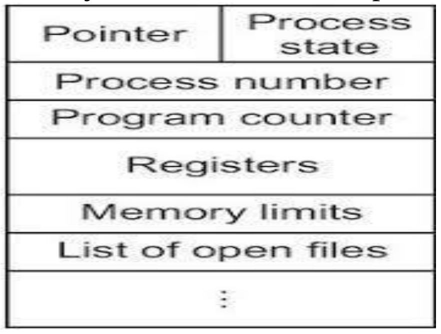
If the value contains significant white-space, quotations are used:

KEY="value with spaces"

The keys in these scenarios are variables. They can be one of two types, environmental variables or shell variables.

Environmental variables are variables that are defined for the current shell and are inherited by any child shells or processes. Environmental variables are used to pass information into processes that are spawned from the shell.

Shell variables are variables that are contained exclusively within the shell in which they were set or defined. They are often used to keep track of ephemeral data, like the current working directory.



Viewing processes:

The kernel runs the show, i.e. it manages all the operations in a Unix flavored environment. The kernel architecture must support the primary Unix requirements. These requirements fall in two categories namely, functions for process management and functions for file management (files include device files). Process management entails allocation of resources including CPU, memory, and offers services that processes may need. The file management in itself involves handling all the files required by processes, communication with device drives and regulating transmission of data to and from peripherals. The kernel operation gives the user processes a feel of synchronous operation, hiding all underlying asynchronism in peripheral and hardware operations (like the time slicing by clock). In summary, we can say that the kernel handles the following operations

a. It is responsible for scheduling running of user and other processes.

b. It is responsible for allocating memory.

c. It is responsible for managing the swapping between memory and disk.

d. It is responsible for moving data to and from the peripherals.

e. it receives service requests from the processes and honors them.

System processes:
These are most useful commands in my list while working on Linux server , this enables you to quickly troubleshoot connection issues e.g. whether other system is connected or not , whether other host is responding or not and while working for FIX connectivity for advanced trading system this tools saves quite a lot of time .

This article is in continuation of my article How to work fast in Unix and Unix Command tutorials and Examples for beginners.

- finding host/domain name and IP address - **hostname**
- test network connection – **ping**
- getting network configuration – **ifconfig**
- Network connections, routing tables, interface statistics – **netstat**
- query DNS lookup name – **nslookup**
- communicate with other hostname – **telnet**
- outing steps that packets take to get to network host – **traceroute**
- view user information – **finger**
- checking status of destination host - **telnet**

Example of System processes in Unix:
let's see some example of various networking command in Unix and Linux. Some of them are quite basic
e.g. ping and telnet and some are more powerful e.g. nslookup and netstat. When you used these commands in combination of find and grep you can get anything you are looking for
e.g. hostname, connection end points, connection status etc.

hostname with no options displays the machines host name **hostname –d** displays the domain name the machine belongs to **hostname –f** displays the fully qualified host and domain name **hostname –i** displays the IP address for the current machine

Process scheduling:

Scheduling Mechanism: how to switch. • Scheduling Policy: when to switch and what process to choose. Some scheduling objectives: – fast process response time – avoidance of process starvation – good throughput for background jobs – support for soft real time processes • Linux uses dynamically assigned process priorities for non real-time processes. Processes running for a long time have their priorities decreased while processes that are waiting have their priorities increased dynamically. Compute-bound versus I/O bound. Linux implicitly favors I/O bound processes over compute bound processes (why?).

• Another classification: – Interactive processes. Examples: shells, text editors, GUI applications. – Batch processes. Examples: compilers, database search engine, web server, number-crunching. – Real-time processes. Audio/video applications, data-collection from physical sensors, robot controllers.

Scheduling Parameters:

Processes are preemptible in user mode but not in kernel mode.

• How long is a quantum? Examine INIT TASK macro in include/linux/sched.h header file. All processes inherit the default quantum value via fork from the init task.

```
#define DEF_COUNTER (10*HZ/100) /* 100 ms time slice */ #define MAX_COUNTER
(20*HZ/100)
#define DEF_NICE (0)
```

Processes have two types of priorities: – Static priority. Between 1 and 99. Used by real-time processes. – Dynamic priority. For non real-time processes. Sum of the base time quantum and of the number of ticks of CPU time left to the process before its quantum expiers in the current epoch.

Starting new processes:

This is the function that decides how desirable a process is.You can weigh different processes against each other depending on what CPU they've run on lately etc to try to handle cache and TLB miss penalties. Return values. -1000: never select this. 0: out of time, recalculate counters (but it might still be selected) +ve: "goodness" value (the larger, the better). +1000: realtime process, select this.

a. treat current process
b. select process
c. switch process

Waiting for a process:

All of these system calls are used to wait for state changes in a child of the calling process, and obtain information about the child whose state has changed. A state change is considered to be: the child terminated; the child was stopped by a signal; or the child was resumed by a signal. In the case of a terminated child, performing a wait allows the system to release the resources associated with the child; if a wait is not performed, then terminated the child remains in a "zombie" state (see NOTES below).automatically restarted using the **SA_RESTART** flag of **sigaction**(2)). In the remainder of this page, a child whose state has changed and which has not yet been waited upon by one of these system calls is termed waitable.

Wait () and waitpid()

The **wait** () system call suspends execution of the current process until one of its children terminates. The call wait(&status) is equivalent to:

waitpid(-1, &status, 0);

The **waitpid**() system call suspends execution of the current process until a child specified by pid argument has changed state. By default, **waitpid**() waits only for terminated children, but this behaviour is modifiable via the options argument, as described below.

Process termination:

Now that we know what goes on when a process gets created, what is happening when we don't need it anymore? Be forewarned, sometimes Linux can get a little dark...

A process can exit using the _exit system call, this will free up the resources that process was using for reallocation. So when a process is ready to terminate, it lets the kernel know why it's terminating with something called a termination status. Most commonly a status of 0 means that the process succeeded. However, that's not enough to completely terminate a process. The parent process has to acknowledge the termination of the child process by using the wait system call and what this does is it checks the termination status of the child process. I know it's gruesome to think about, but the wait call is a necessity, after all what parent wouldn't want to know how their child died?

There is another way to terminate a process and that involves using signals, which we will discuss soon.

Orphan Processes:

When a parent process dies before a child process, the kernel knows that it's not going to get a wait call, so instead it makes these processes "orphans" and puts them under the care of init (remember mother of all processes). Init will eventually perform the wait system call for these orphans so they can die.

Zombie Processes:

What happens when a child terminates and the parent process hasn't called wait yet? We still want to be able to see how a child process terminated, so even though the child process finished, the kernel turns the child process into a zombie process. The resources the child process used are still freed up for other processes; however there is still an entry in the process table for this zombie. Zombie processes also cannot be killed, since they are technically "dead", so you can't use signals to kill them. Eventually if the parent process calls the wait system call, the zombie will disappear, this is known as "reaping". If the parent doesn't perform a wait call, init will adopt the zombie and automatically perform wait and remove the zombie. It can be a bad thing to have too many zombie processes, since they take up space on the process table, if it fills up it will prevent other processes from running.

Zombie Processes

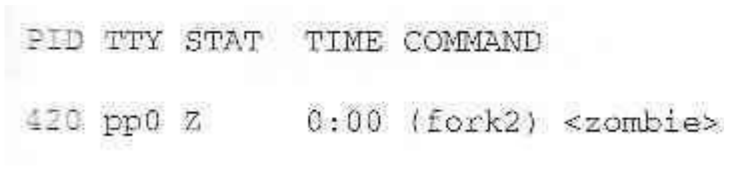
When a child process terminates, an association with its parent survives until the parent in turn either terminates normally or calls **wait**.

This terminated child process is known as a **zombie process**. **Try It Out – Zombies**

Fork2.c is jsut the same as **fork.c**, except that the number of messages printed by the child and parent processes is reversed.

How It Works
If we run the above program with **fork2 &** and then call the **ps** program after the child has finished

but before the parent has finished, we'll see a line like this:



```
PID TTY STAT  TIME COMMAND

420 pp0 Z     0:00 (fork2) <zombie>
```

Orphan Process

When the parent dies first the child becomes **Orphan**. The kernel clears the process table slot for the parent. #incldue<sys/types.h>
#include<unistd.h> pid_t getpid(void); uid_t getuid(void);

Fork Function:
The only way a new process is created by the UNIX kernel is when an existing process calls the fork function.
#include<sys/types.h> #include<unistd.h> pid_t fork(void);
Return: 0 is child; process ID of child in parent, -1 on error

The new process created by fork is called child process. This is called once, but return twice that is the return value in the child is 0, while the return value in the parent is the process ID of the new child. The reason the child‘s process ID is returned to the parent is because a process can have more than one child, so there is no function that allows a process to obtain the process IDs of its children. The reason fork return 0 to the child is because a process can have only a single parent, so that child can always call getppid to obtain the process ID of its parent.
Both the child and parent contain executing with the instruction that follows the call to fork. The child is copy of the parent. For example,the child gets a copy of the parent‘s data space, heap and stack. This is a copy for the child the parent and children don‘t share these portions of memory. Often the parent and child share the text segment, if it is read-only.

There are two users for fork:
When a process wants to duplicate itself so that the parent and child can each execute different sections of code at the same time. This is common for network servers_ the parent waits for a service requests from a client. When the request arrives, the parent calls fork and lets the child handle the request. The parent goes back to waiting for the next service request to arrive.When a process wants to execute a different program, this is common for shells. In this case the child does an exec right after it returns from the fork.

System call interface for process management:
we will look at the fundamentals of the process, from creation to termination. The basics have remained relatively unchanged since the earliest days of Unix. It is here, in the subject of process management, that the longevity and forward thinking of Unix’s original design shines brightest. Unix took an interesting path, one seldom traveled, separating the creation of a new process from the act of loading a

new binary image. Although the two tasks are performed in tandem much of the time, the division has allowed a great deal of freedom for experimentation and evolution for each of the tasks. This road less traveled has survived to this day, and while most operating systems offer a single system call to start up a new program, Unix requires two: a fork and an exec. But before we cover those system calls, let's look more closely at the process itself.
In computing, a **system call** is the programmatic way in which a computer program requests a service from the kernel of the operating system it is executed on. A system call is a way for programs to **interact with the operating system**. A computer program makes a system call when it makes a request to the operating system's kernel. System call **provides** the services of the operating system to the user programs via Application Program Interface (API). It provides an interface between a process and operating system to allow user-level processes to request services of the operating system. System calls are the only entry points into the kernel system. All programs needing resources must use system calls.

Services Provided by System Calls :

a. Process creation and management
b. Main memory management
c. File Access, Directory and File system management
d. Device handling(I/O)
e. Protection
f. Networking, etc.

Types of System Calls: There are 5 different categories of system calls
a.**Process control:** end, abort, create, terminate, allocate and free memory.
b.**File management:** create, open, close, delete, read file etc.
c.Device management
vfork Function: The function vfork has the same calling sequence and share return values as fork. But the semantics of the two functions differ. vfork is intended to create a new process when the purpose of the new process is to exec a new program.

vfork creates the new process, just like fork, without fully copying the address space of the parent into the child, since the child won't reference the address space – the child just calls exec right after the vfork. Instead, while the child is running, until it calls either exec or exit, the child runs in the address space of the parent. This optimization provides an efficiency gain on some paged virtual memory implementations of UNIX.
Another difference between the two functions is that vfork guarantees that the child runs first, until the parent resumes.

Exit Function:
There are three ways for a process to terminate normally, and two forms of abnormal termination.
Normal termination:
a. Executing a return from the main function. This is equivalent to calling exit b.Calling the exit function
c.Calling the _exit function
Abnormal termination
Calling abort: It generates the SIGABRT signal
When the process receives certain signals. The signal can be generated by the process itself.
Regardless of how a process terminates, the same code in the kernel is eventually executed. This kernel

code closes all the open descriptors for the process, releases the memory that it was using, and the like. For any of the preceding cases we want the terminating process to be able to notify its parent how it terminated. For the exit and _exit functions this is done by passing an exit status as the argument to these two functions. In the case of an abnormal termination however, the kernel generates a termination status to indicate the reason for the abnormal termination. In any case, the parent of the process can obtain the termination status from either the wait or waitpid .
function.The exit status is converted into a termination status by the kernel when _exit is finally called. If the child terminated normally, then the parent can obtain the exit status of the child.
If the parent terminates before the child, then init process becomes the parent process of any process, whose parent terminates; that is the process has been inherited by init. Whenever a process terminates the kernel goes through all active processes to see if the terminating process is the parent of any process that still exists. If so, the parent process ID of the still existing process is changed to be 1 to assume that every process has a parent process.
When a child terminates before the parent, and if the child completely disappeared, the parent wouldn‘t be able to fetch its termination status, when the parent is ready to seek if the child had terminated. But parent get this information by calling wait and waitpid, which is maintained by the kernel.

wait and waitpid Functions:
When a process terminates, either normally or abnormally, the parent is notified by the kernel sending the parent SIGCHLD signal. Since the termination of a child is an asynchronous event, this signal is the asynchronous notification from the kernel to the parent. The default action for this signal is to be ignored. A parent may want for one of its children to terminate and then accept it child‘s termination code by executing wait.
A process that calls wait and waitpid can
a. Block (if all of its children are still running).
b.Return immediately with termination status of a child (if a child has terminated and is waiting for its termination status to be fetched) or
c.Return immediately with an error (if it down have any child process).
If the process is calling wait because it received SIGCHLD signal, we expect wait to return immediately. But, if we call it at any random point in time, it can block.

#include<sys/types.h> #include<sys/wait.h> pid_t wait(int *statloc);
pid_t waitpid(pid_t pid, int *statloc, int options); Both return: process ID if OK, o or -1 on error

Wait can block the caller until a child process terminates, while waitpid has an option that prevents it from blocking.waitpid does not wait for the first child to terminate, it has a number of options.
If a child has already terminated and is a zombie, wait returns immediately with that child‘s status. Otherwise, it blocks the caller until a child terminates: if the caller blocks and has multiple children, wait returns when one terminates, we can know this process by PID return by the function.
For both functions, the argument statloc is pointer to an integer. If this argument is not a null pointer, the termination status of the terminated process is stored in the location pointed to by the argument.If we have more than one child, wait returns on termination of any of the children. A function that waits for a specific process is waitpid function.The interpretation of the pid argument for waitpid depends on its value: waitpid returns the process ID of the child that terminated, and its termination status is returned through statloc.
With wait the only error is if the calling process has no children. With waitpid, however, it‘s also possible to get an error if the specified process or process group does not exist or is not a child of the calling process.

Exec Function:
The fork function can create a new process that then causes another program to be executed by calling one of the exec functions. When a process calls one of the exec functions, that process is completely replaced by the new program and the new program starts executing at its main function. The process ID doesn‘t change across an exec because a new process is not created. exec merely replaces the current process with a brand new program from disk.There are six different exec functions. These six functions round out the UNIX control primitives. With fork we can create new processes, and with the exec functions we can initiate new programs. The exit function and the two wait functions handle termination and waiting for termination. These are the only process control primitives we need.

```
 #include<unistd.h>
    int execl(const char *pathname, const char *arg0, . . . /*(char *) 0*/ int execv(const char
    *pathname, char *const argv[]);
    int execle(const char *pathname, const char *arg0, . . . /* (char *) 0, char envp[]*/); int
    execve(const char *pathname, char *const argv[], char *const envp[]);
    int execlp(const char *pathname, const char *arg0, . . . /* (char *) 0*/); int execvp(const char
   *filename, char *const argv[]);
```

The first difference in these functions is that the first four take a pathname argument, while the last two take a filename argument. When a filename argument is specified:
a.If filename contains a slash, it is taken as a pathname.
b.Otherwise, the executable file is a searched for in directories specified by the PATH
The PATH variable contains a list of directories (called path prefixes) that are separated by colors. For example, the name=value environment string

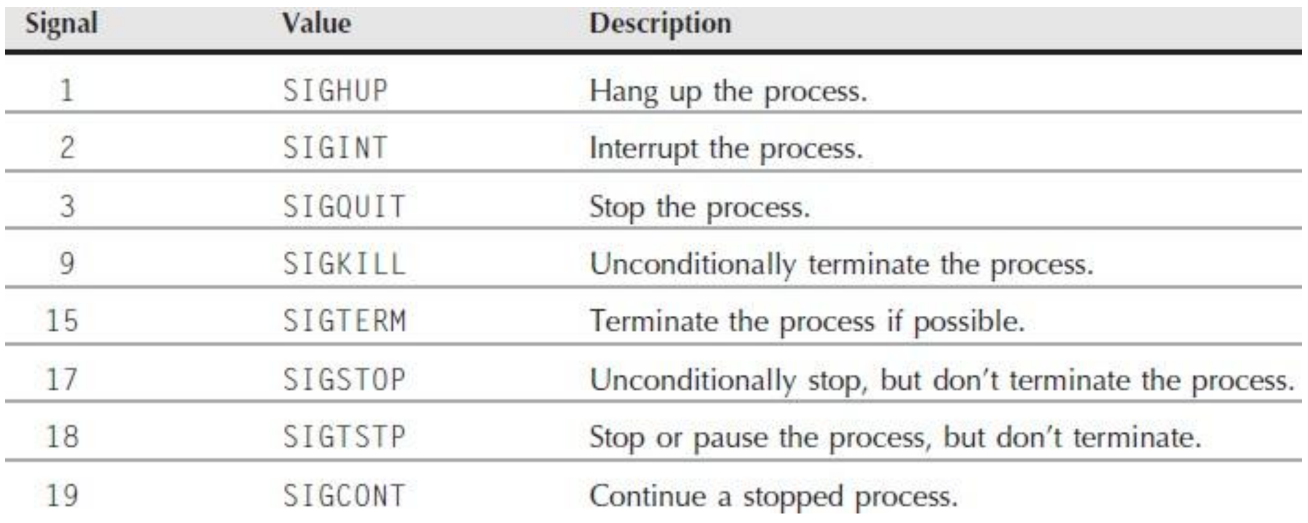
PATH=/bin:/usr/bin:usr/local/bin/:

Specifies four directories to search, where last one is current working directory.If either of the two functions, execlp or execvp finds an executable file using one of the path prefixes, but the file is not a machine executable that was generated by the link editor, it assumes the file is a shell script and tries to invoke /bin/sh with filename as input to the shell.The next difference concerns the passing of argument list. The function execl, execlp and execle require each of the command-line arguments to the new program to be specified as separate arguments. The end of the argument should be a null pointer. For the other three functions execv, execvp and execve, we have to build an array of pointers to the arguments, and the address of this array is the argument to these three functions.

The final difference is the passing of the environment list to the new program. The two functions execle and execve allow us to pass a pointer to an array of pointer to an array of pointer to an array of pointers to the environment strings.
The other four functions, however, use the environ variable in the calling process to copy the existing environment for the new program.

Signals:
Let's examine the case of power failure while a reliable process is running. When the power cable is pulled out, the power doesn't die out immediately. In fact, it takes a few milliseconds before the power is completely gone. This reliable process may need to be notified of such power failures to, for instance, save states before being forced to exit. Let's examine the possible approaches to accomplish this:

a. A bit in the file "/dev/power" would indicate the power status. In this approach, the reliable program periodically reads the file. If it reads 1, then it means the power is still on and the program would continue whatever it was doing. However, in case of reading 0, the process realizes that the power is gone and it must exit within, say, 10ms. This approach has two major disadvantages: (1) it requires all programs, that want to be reliable, to poll, and, (2) to make this to work, the applications have to incorporate this mechanism in their implementation.
b. Another approach would be reading from a pipe rather than a file. In this case, unlike the previous approach that needed to check for a change of a bit at every time interval, the process will hang until a character is written to the pipe, indicating a power failure. Clearly, this solution suffers from major drawbacks, not to mention the requirement for modification of all applications. In this approach the process is blocked while waiting for a change of power state, so the application cannot execute any of its actual code. To fix this we need multithreading. In other words, a separate thread should be delegated to reading the file for a signal of power failure, to ensure that the main thread is not blocked. But now the question is that how would the waiting thread tell the main thread that there is a power failure?
c. As another approach, the kernel can save the entire RAM to the disk once it realizes that the power failure has occurred. Then, later, when the system starts again, the kernel would restore the RAM. This approach, however, is not practical, since writing to disk is extremely slow, so it may take more time to save than the system actually has left.
d. The winner approach is sending `SIGPWR` signal to all processes in case of power failures. In this approach, the kernel signals the processes of such event, and it leaves it up to the processes to do what they want to do with it.



Signal	Value	Description
1	SIGHUP	Hang up the process.
2	SIGINT	Interrupt the process.
3	SIGQUIT	Stop the process.
9	SIGKILL	Unconditionally terminate the process.
15	SIGTERM	Terminate the process if possible.
17	SIGSTOP	Unconditionally stop, but don't terminate the process.
18	SIGTSTP	Stop or pause the process, but don't terminate.
19	SIGCONT	Continue a stopped process.

Signal functions:

Signal Handlers
A signal handler is special function (defined in the software program code and registered with the kernel) that gets executed when a particular signal arrives. This causes the interruption of current executing process and all the current registers are also saved. The interrupted process resumes once the signal handler returns.

The signal() Function
The simplest way to register signal handler function with the kernel is by using the **signal()** function.

Here is the syntax of **signal()** function :

```
#include <signal.h>

typedef void (*sighandler_t)(int);

sighandler_t signal(int signum, sighandler_t handler);
```

So you can see that a signal handler is a function that accepts an integer argument but returns void. The
signal handler can be registered with kernel using the **signal()** function (described above) that accepts a particular signal number and signal handler function name (though there can be other values for the second argument but we will discuss them later).If the shell and terminal driver are configured normally, typing the interrupt character (Ctrl-C) at the keyboard will result in the **SIGINT** signal being sent to the foreground process. This will cause the program to terminate.We can handle signals using the **signal** library function.

one of the alarm clocks per process. If, when we call alarm, there is a previously registered alarm **Signal dispositions:**Each signal has a current disposition, which determines how the process behaves when it is delivered the signal. The entries in the "Action" column of the tables below specify the default disposition for each signal.

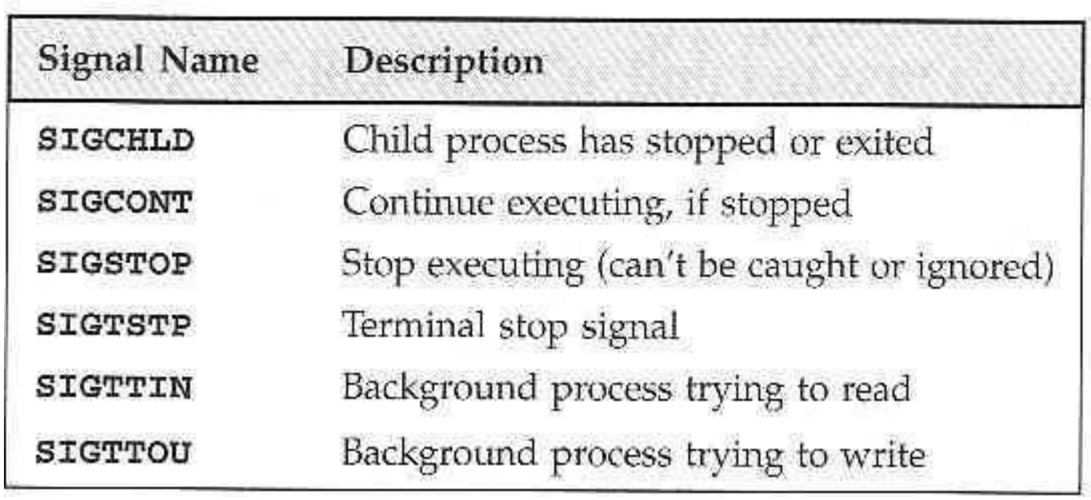
Kill And Raise Functions:
The kill function sends a signal to a process or a group of processes. The raise function allows a process to send a signal to it.
#include<sys/types.h> #include<signal.h>
int kill(pid_t pid, int signo); int raise(int signo);
Both return: 0 if OK, -1 on error
There are four different conditions for the pid argument to kill:

Alarm and pause Functions:
The alarm function allows us to get a timer that will expire at a specified time in the future. When the timer expires, the SIGALRM signal is generated. If we ignore or don‘t catch this signal, its default action is to terminate the process.
#include<unistd.h>
unsigned int alarm(unsigned int seconds);
Returns: 0 or number of seconds until previously set alarm.
The seconds value is the number of clock seconds in the future when the signal should be generated. There is only clock for the process that has not yet expired, the number of seconds left for that alarm clock to return as the value of this function. That previously registered alarm clock is replaced by the new value.
If there is a previously registered alarm clock for the process that has not yet expired and if the second’s value is 0, the previous alarm clock is cancelled. The number of seconds left for that previous alarm clock is still returned as the value of the function.
Although the default action for SIGALRM is terminating the process, most processes use an alarm clock catch this signal.

abort Function:abort function causes abnormal program termination. #include<stdlib.h>

Void abort(void);

This function never returns.
This function sends the SIGABRT signal to the process. A process should not ignore this signal.abort overrides the blocking or ignoring of the signal by the process.
sleep Function:
#include<unistd.h>
unsigned int sleep(unsigned int seconds); Returns: 0 or number of unslept seconds.
Sleep can be implemented with an alarm function. If alarm is used, however, there can be interaction between the two functions.



Signal Name	Description
SIGCHLD	Child process has stopped or exited
SIGCONT	Continue executing, if stopped
SIGSTOP	Stop executing (can't be caught or ignored)
SIGTSTP	Terminal stop signal
SIGTTIN	Background process trying to read
SIGTTOU	Background process trying to write

UNIT-1V
DATA MANAGEMENT

Data Management: Managing memory: malloc, free, realloc, calloc; File locking: Creating lock files, locking regions, use of read and write with locking, competing locks, other lock commands, deadlocks; Inter process communication: Pipe, process pipes, the pipe call, parent and child processes, named pipes, semaphores, shared memory, message queues; Shared memory: Kernel support for shared memory, APIs for shared memory, shared memory example; Semaphores: Kernel support for semaphores, APIs for semaphores, file locking with semaphores.

Managing memory:

Malloc: The **malloc**() function allocates size bytes and returns a pointer to the allocated memory. The memory is not initialized. If size is 0, then **malloc**() returns either NULL, or a unique pointer value.

free: The **free**() function frees the memory space pointed to by ptr, which must have been returned by a previous call to **malloc**(), **calloc**() or **realloc**(). Otherwise, or if free(ptr) has already been called before, undefined behavior occurs. If ptr is NULL, no operation is performed.

realloc: The **realloc**() function changes the size of the memory block pointed to by ptr to size bytes. The contents will be unchanged in the range from the start of the region up to the minimum of the old and new sizes. If the new size is larger than the old size, the added memory will not be initialized.

calloc: The calloc() function allocates memory for an array of nmemb elements of size bytes each and returns a pointer to the allocated memory. The memory is set to zero. If nmemb or size is 0, then calloc() returns either NULL, or a unique pointer value that can later be successfully passed to free().

Filelocking:
File locking is a mechanism which allows only one process to access a file at any specific time. By using file locking mechanism, many processes can read/write a single file in a safer way.

Creating lock files:
When a file can be accessed by more than one process, a synchronization problem occurs. What happens if two processes try to write in the same file location? Or again, what happens if a process reads from a file location while another process is writing into it?
In traditional Unix systems, concurrent accesses to the same file location produce unpredictable results. However, Unix systems provide a mechanism that allows the processes to *lock* a file region so that concurrent accesses may be easily avoided.
The POSIX standard requires a file-locking mechanism based on the `fcntl( )`system call. It is possible to lock an arbitrary region of a file (even a single byte) or to lock the whole file (including data appended in the future). Because a process can choose to lock only a part of a file, it can also hold multiple locks on different parts of the file.

This kind of lock does not keep out another process that is ignorant of locking. Like a semaphore used to protect a critical region in code, the lock is considered "advisory" because it doesn't work unless other processes cooperate in checking the existence of a lock before accessing the file. Therefore, POSIX's locks are known as *advisory locks* .
Traditional BSD variants implement advisory locking through the `flock( )`system call.

Use of read and write with locking:
File Locking is a simple mechanism for coordinating file accesses.There are two types of locking mechanisms, Mandatory and Advisory
Advisory locks are just conventions. If one process P1 locks a file,kernel doesn't stop any other process(say P2) from modifying that file. But if the other process P2 obeys the same convention as the process P1, it can check before modifying that the file is locked by some other process and thus it wouldn't be correct to modify it. Thus advisory locks require proper coordination between the processes.
Mandatory Locks are strict implications. They are enforced for all processes by the kernel.Locking in unix/linux is by default advisory. Mandatory locks are also supported but it needs special configuration.

There are two types of Advisory Locks: **Read Lock** and **Write Lock.**
Read Locks (also known as shared locks) are locks in which you can read now but if you want to write you'll have to wait for everyone to finish reading. Multiple shared locks can co-exist.
Write Locks (also known as exclusive locks) are locks in which there is a single writer. Everyone else has to wait for doing anything else (reading or writing). Only one write lock can exist at a time.
A Read lock and a Write Lock cannot co-exist. As an analogy, consider this
A class room containing a teacherwriter) and many students(readers). Let the blackboard be a lockable object.
While a teacher is writing something (exclusive lock) on the board:

1. Nobody can read it, because it's still being written, and she's blocking your view => If an object is exclusively locked, shared locks cannot be obtained.

2. Other teachers won't come up and start writing either, or the board becomes unreadable, and confuses students => If an object is exclusively locked, other exclusive locks cannot be obtained.

When the students are reading (shared locks) what is on the board:

1. They all can read what is on it, together => Multiple shared locks can co-exist.

2. The teacher waits for them to finish reading before she clears the board to write more => If one or more shared locks already exist, exclusive locks cannot be obtained.

Deadlocks:
A deadlock is a situation in which two computer programs sharing the same resource are effectively preventing each other from accessing the resource, resulting in both programs ceasing to function.
The earliest computer operating systems ran only one program at a time. All of the resources of the system were available to this one program. Later, operating systems ran multiple programs at once, interleaving them. Programs were required to specify in advance what resources they needed so that they could avoid conflicts with other programs running at the same time. Eventually some operating systems offered dynamic allocation of resources. Programs could request further allocations of resources after they had begun running. This led to the problem of the deadlock.

Here is the simplest example**.**
Program 1 requests resource A and receives it.
Program 2 requests resource B and receives it.
Program 1 requests resource B and is queued up, pending the release of B. Program 2 requests resource A and is queued up, pending the release of A.

Learning to deal with deadlocks had a major impact on the development of operating systems and the structure of databases. Data was structured and the order of requests was constrained in order to avoid creating deadlocks.

Inter process communication (IPC)
Inter process communication (IPC) includes thread synchronization and data exchange between threads beyond the process boundaries. If threads belong to the same process, they execute in the same address space, i.e. they can access global (static) data or heap directly, without the help of the operating system. However, if threads belong to different processes, they cannot access each other's address spaces without the help of the operating system.
There are two fundamentally different approaches in IPC:

- processes are residing on the same computer
- processes are residing on different computers

The first case is easier to implement because processes can share memory either in the user space or in the system space. This is equally true for uniprocessors and multiprocessors.

In the second case the computers do not share physical memory, they are connected via I/O device (for example serial communication or Ethernet). Therefore the processes residing in different computers cannot use memory as a means for communication.

IPC between processes on a Single System
Most of this chapter is focused on IPC on a single computer system, including four general approaches:

- Shared memory
- Messages
- Pipes
- Sockets

The synchronization objects considered in the previous chapter normally work across the process boundaries (on a single computer system). There is one addition necessary however: the synchronization objects must be named. The handles are generally private to the process, while the object names, like file names, are global and known to all processes.

```
h = init_CS("xxx");
h = init_semaphore(20,"xxx"); h = init_event("xxx"); h = init_condition("xxx");
h = init_message_buffer(100,"xxx");
```

IPC between processes on different systems:

IPC is Inter Process Communication, more of a technique to share data across different processes **within** one machine, in such a way that data passing binds the coupling of different processes. The first, is using memory mapping techniques, where a memory map is created, and other open the memory map for reading/writing.

The second is, using sockets, to communicate with one another...this has a high overhead, as each process would have to open up the socket, communicate across... although effective.

The third, is to use a pipe or a named pipe, a very good example.

PIPES:

A pipe is a **serial** communication device (i.e., the data is read in the order in which it was written), which allows a **unidirectional communication**. The data written to end is read back from the other end.
The pipe is mainly used to communicate between two threads in a single process or between parent and child process. Pipes can only connect the related process. In shell, the symbol can be used to create a pipe.
In pipes the **capacity of data is limited**. (i.e.) If the writing process is faster than the reading process which consumes the data, the pipe cannot store the data. In this situation the writer process will block until more capacity becomes available. Also if the reading process tries to read data when there is no data to read, it will be blocked until the data becomes available. By this, pipes **automatically synchronize the two process**.

Creating pipes:
The pipe() function provides a means of passing data between two programs and also allows to read and write the data.
#include<unistd.h>
int pipe(int file_descriptor[2]);

pipe()function is passed with an array of file descriptors. It will fill the array with new file descriptors and returns zero. On error, returns -1 and sets the err no to indicate the reason of failure.
The file descriptors are connected in a way that is data written to file_ descriptor [1] can be read back
from the file_descriptor [0].
Pipes are originally used in UNIX and are made even more powerful in Windows 95/NT/2000.

Pipes are implemented in file system. Pipes are basically files with only two file offsets: one for reading another for writing. Writing to a pipe and reading from a pipe is strictly in FIFO manner.

For efficiency, pipes are in-core files, i.e. they reside in memory instead on disk, as any other global data structure. Therefore pipes must be restricted in size, i.e. number of pipe blocks must be limited. (In UNIX the limitation is that pipes use only direct blocks.)Since the pipes have a limited size and the FIFO access discipline, the reading and writing processes are synchronized in a similar manner as in case of message buffers. The access functions for pipes are the same as for files: WriteFile() and ReadFile().

Pipe processing:(popen &pclose library functions)

The process of passing data between two programs can be done with the help of popen() and pclose() functions.
#include<stdio.h>
FILE *popen(const char *command , const char *open-mode); int pclose(FILE *stream_to_close);

popen():
The popen function allows a program to invoke another program as a new process and either write the data to it or to read from it. The parameter command is the name of the program to run. The open_mode parameter specifies in which mode it is to be invoked, it can be only either "r" or "w". On failure popen() returns a NULL pointer. If you want to perform bi-directional communication you have to use two pipes

pclose():
By using pclose(), we can close the filestream associated with popen() after the process started by it has been finished. The pclose() will return the exit code of the process, which is to be closed. If the process was already executed a wait statement before calling pclose, the exit status will be lost because the process has been finished. After closing the filestream, pclose() will wait for the child process to terminate**.**

Parent and Child Processes:

We can invoke the standard programs, ones that don‘t expect a file descriptor as a parameter.

```
#include<unistd.h>
int dup(int file_descriptor);
int dup2(int file_descriptor_1, int file_descriptor_2);
```

The purpose of dup call is to open a new file descriptor, which will refer to the same file as an existing file descriptor. In case of dup, the value of the new file descriptor is the lowest number available. In dup2 it is same as, or the first available descriptor greater than the parameter file_descriptor_2.

We can pass data between process by first closing the file descriptor 0 and call is made to dup. By this the new file descriptor will have the number 0.As the new descriptor is the duplicate of an existing one, standard input is changed to have the access. So we have created two file descriptors for same file or pipe, one of them will be the standard input.

```
//pipes.c #include<unistd.h> #include<stdlib.h> #include<stdio.h> #include<string.h>
int main()
{
int data_processed; int file_pipes[2];
const char some_data[]= "123"; pid_t fork_result; if(pipe(file_pipes)==0)
{
fork_result=fork(); if(fork_result==(pid_t)-1)
{
fprintf(stderr,"fork failure"); exit(EXIT_FAILURE);
}
if(fork_result==(pid_t)0)
{
close(0); dup(file_pipes[0]); close(file_pipes[0]);
close(file_pipes[1]); execlp("od","od","-c",(char *)0); exit(EXIT_FAILURE);
}
else
{
```

```
close(file_pipes[0]);              data_processed=write(file_pipes[1],
                                   some_data,strlen(some_data)); close(file_pipes[1]);
printf("%d -wrote %d bytes\n",(int) getpid(), data_processed);
}
} exit(EXIT_SUCCESS);
}
```

The program creates a pipe and then forks. Now both parent and child process will have its own file descriptors for reading and writing. Therefore totally there are four file descriptors.

The child process will close its standard input with close(0) and calls duo(file_pipes[0]). This will duplicate the file descriptor associated with the read end. Then child closes its original file descriptor. As child will never write, it also closes the write file descriptor, file_pipes[1].

Now there is only one file descriptor 0 associated with the pipe that is standard input. Next, child uses the exec to invoke any the file program that reads standard input.
The od command will wait for the data to be available from the user terminal.
Since the parent never read the pipe, it starts by closing the read end that is file_pipe[0]. When writing process of data has been finished, the write end of the parent is closed and exited. As there are no file descriptors open to write to pipe, the od command will be able to read the three bytes written to pipe, meanwhile the reading process will return 0 bytes indicating the end of.

There are two types of pipes:

- Named pipes.
- Unnamed pipes (Anonymous pipes)

Named pipes (FIFOs)

Similar to pipes, but allows for communication between unrelated processes. This is done by naming the communication channel and making it permanent.
Like pipe, FIFO is the unidirectional data stream.

FIFO creation:

int mkfifo (const char *pathname, mode_t mode);

- makes a FIFO special file with name pathname.
  (mode specifies the FIFO's permissions, as common in UNIX-like file systems).
- A FIFO special file is similar to a pipe, except that it is created in a different way. Instead of being an anonymous communications channel, a FIFO special file is entered into the file system by callingmkfifo()

Once a FIFO special file has been created, any process can open it for reading or writing, in the same way as an ordinary file.
A First-in, first-out(FIFO) file is a pipe that has a name in the file system. It is also called as med pipes.

Creation of FIFO:

We can create a FIFO from the command line and within a program.

To create from **command line** we can use either mknod or mkfifo commands.

```
$ mknod filename p
$ mkfifo filename
```

To create FIFO **within the program** we can use two system calls. They are,

```
 #include<sys/types.h>
#include<sys/stat.h> int mkfifo(const char
*filename,mode_t mode);
int mknod(const char *filename, mode_t mode|S_IFIFO,(dev_t) 0);
```

If we want to use the mknod function we have to use OR ing process of file access mode with S_IFIFO and the dev_t value of 0.Instead of using this we can use the simple mkfifo function.

Accessing FIFO:
Let us first discuss how to access FIFO in command line using file commands. The useful feature of named pipes is, as they appear in the file system, we can use them in commands.
We can read from the FIFO(empty)

```
$ cat < /tmp/my_fifo
```

Now, let us write to the FIFO.

```
$ echo "Simple!!!" > /tmp/my_fifo
```

(Note: These two commands should be executed in different terminals because first command will be waiting for some data to appear in the FIFO.)

FIFO can also be accessed as like a file in the program using low-level I/O functions or C library I/O functions.
The only difference between opening a regular file and FIFO is the use of open_flag with the option O_NONBLOCK. The only restriction is that we can't open FIFO for reading and writing with O_RDWR mode.

//fifo1.c

```
#include <unistd.h>
 #include <stdlib.h> #include <stdio.h> #include <string.h> #include <fcntl.h> #include
<limits.h> #include <sys/types.h> #include <sys/stat.h>
#define FIFO_NAME "/tmp/my_fifo" #define BUFFER_SIZE PIPE_BUF #define TEN_MEG
(1024 * 1024 * 10) int main()
{
int pipe_fd; int res;
int open_mode = O_WRONLY; int bytes_sent = 0; char buffer[BUFFER_SIZE + 1];
if (access(FIFO_NAME, F_OK) == -1) { res = mkfifo(FIFO_NAME, 0777);
if (res != 0) {
fprintf(stderr, "Could not create fifo %s\n", FIFO_NAME); exit(EXIT_FAILURE);
}
}
printf("Process %d opening FIFO O_WRONLY\n", getpid()); pipe_fd = open(FIFO_NAME,
open_mode);
printf("Process %d result %d\n", getpid(), pipe_fd); if (pipe_fd != -1) {
while(bytes_sent < TEN_MEG) {
res = write(pipe_fd, buffer, BUFFER_SIZE); if (res == -1) { fprintf(stderr, "Write error on pipe\n");
exit(EXIT_FAILURE);
 }

  (void)close(pipe_fd);
  }
  else { exit(EXIT_FAILURE);
  }
  printf("Process %d finished\n", getpid()); exit(EXIT_SUCCESS);
        }
```

//fifo2.c

```
#include <unistd.h> #include <stdlib.h> #include <stdio.h> #include <string.h> #include <fcntl.h>
#include <limits.h> #include <sys/types.h> #include <sys/stat.h>
#define FIFO_NAME "/tmp/my_fifo" #define BUFFER_SIZE PIPE_BUF int main()

{
int pipe_fd; int res;
int open_mode = O_RDONLY; char buffer[BUFFER_SIZE + 1]; int bytes_read = 0;
memset(buffer, '\0', sizeof(buffer));
printf("Process %d opening FIFO O_RDONLY\n", getpid()); pipe_fd = open(FIFO_NAME,
open_mode);
printf("Process %d result %d\n", getpid(), pipe_fd); if (pipe_fd != -1) { do {
res = read(pipe_fd, buffer, BUFFER_SIZE); bytes_read += res;
} while (res > 0); (void)close(pipe_fd);
}
else                              {
exit(EXIT_FAILURE);
}
printf("Process %d finished, %d bytes read\n", getpid(), bytes_read); exit(EXIT_SUCCESS);
}
```

Both fifo1.c and fifo2.c programs use the FIFO in blocking mode.
First fifo1.c is executed .It blocks and waits for reader to open the named pipe. Now writer unblocks and starts writing data to pipe. At the same time, the reader starts reading data from the pipe.

Semaphore:
While we are using threads in our programs in multi-user systems, multiprocessing system, or a combination of two, we may often discover critical sections in the code. This is the section where we have to ensure that a single process has exclusive access to the resource.

For this purpose the semaphore is used. It allows in managing the access to resource. To prevent the problem of one program accessing the shared resource simultaneously, we are in Need to generate and use atoken which guarantees the access to only one thread of execution in the critical section at a time. It is counter variable, which takes only the positive numbers and upon which programs can only act atomically. The positive number is the value indicating the number of units of the shared resources are available for sharing.
The common form of semaphore is the binary semaphore, which will control a single resource, and its value is initialized to 0.

Shared Memory:
Shared memory is a highly efficient way of data sharing between the running programs. It allows

two unrelated processes to access the same logical memory. It is the fastest form of IPC because all processes share the same piece of memory. It also avoids copying data unnecessarily.

As kernel does not synchronize the processes, it should be handled by the user. Semaphore can also be used to synchronize the access to shared memory.

Message queue:
This is an easy way of passing message between two process. It provides a way of sending a block of data from one process to another. The main advantage of using this is, each block of data is considered to have a type, and a receiving process receives the blocks of data having different type values independently.

Creation and accessing of a message queue:
You can create and access a message queue using the msgget() function. #include<sys/msg.h> int msgget(key_t key,int msgflg);

The first parameter is the key value, which specifies the particular message queue. The special constant IPC_PRIVATE will create a private queue. But on some Linux systems the message queue may not actually be private.

The second parameter is the flag value, which takes nine permission flags.

Adding a message:
The msgsnd() function allows to add a message to a message queue. #include<sys/msg.h> int msgsnd(int msqid,const void *msg_ptr ,size_t msg_sz,int msgflg);

The first parameter is the message queue identifier returned from an msgget function.
The second parameter is the pointer to the message to be sent. The third parameter is the size of the message pointed to by msg ptr. The fourth parameter, is the flag value controls what happens if either the current message queue is full or within the limit. On success, the function returns 0 and a copy of the message data has been taken and placed on the message queue, on failure -1 is returned.

Retrieving a message:
The smirch() function retrieves message from the message queue. #include<sys/msg.h> int msgsnd(int msqid,const void *msg_ptr, size_t msg_sz , long int msgtype,int msgflg);

The second parameter is a pointer to the message to bereceived.

The fourth parameter allows a simple form of reception priority. If its value is 0,the first available message in the queue is retreived. If it is greater than 0,the first message type is retrieved. If it is less than 0,the first message that has a type the same a or less than the absolute value of msgtype is retrieved

On success, msgrcv returns the number on bytes placed in the receive buffer, the message is copied into the user-allocated buffer and the data is deleted from the message queue. It returns -1 on error.

Controlling the message queue:
This is very similar that of control function of shared memory. #include<sys/msg.h>
int msgctl(int msgid, int command, struct msqid_ds *buf); The second parameter takes the values as given below:

1.) **IPC_STAT** - Sets the data in the msqid_ds to reflect the values associated with the message queue.

2.) **IPC_SET** - If the process has the permission to do so, this sets the values associated with the message queue to those provided in the msgid_ds data structure.

3.) **IPC_RMID**-Deletes the message queue.

Client /server Example:

```
//msgq1.c       #include<stdlib.h>      #include<stdio.h>       #include<string.h>
                #include<errno.h> #include<unistd.h>
#include<sys/msg.h> struct my_msg_st
{
Long int my_msg_type; char some_text[BUFSIZ];
};
int main()
{
int running = 1; int msgid;
struct my_msg_st some_data; long int msg_to_receive = 0; msgid = msgget( (key_t)1234, 0666 |
IPC_CREAT);
if (msgid == -1)
{
fprintf(stderr, "failed to get:\n"); exit(EXIT_FAILURE);
}
while (running)
{
if(msgrcv(msgid, (void *)&some_data, BUFSIZ,msg_to_receive,0) == -1)
{
 fprintf(stderr, "failedto receive: \n"); exit(EXIT_FAILURE);
}
printf("You Wrote:%s", some_data.some_text);
if(strncmp(some_data.some_text, "end", 3)== 0)
{
running = 0;
}
}
if (msgctl(msgid, IPC_RMID, 0) == -1)
{
fprintf(stderr, "failed to delete\n"); exit(EXIT_FAILURE);
} exit(EXIT_SUCCESS);
        }
```

//msgq2.c

```
#include<stdlib.h> #include<stdio.h> #include<string.h> #include<errno.h> #include<unistd.h>
#include<sys/msg.h> #define MAX_TEXT 512 struct my_msg_st
{
```

```
long int my_msg_type;
char some_text[MAX_TEXT];
};
int main()
{
int running = 1;
struct my_msg_st some_data; int msgid;
char buffer[BUFSIZ];
msgid = msgget( (key_t)1234, 0666 | IPC_CREAT); if (msgid == -1)
{
fprintf(stderr, "failed to create:\n"); exit(EXIT_FAILURE);
}
while(running)
{
printf("Enter Some Text: ");
fgets(buffer, BUFSIZ, stdin); some_data.my_msg_type = 1; strcpy(some_data.some_text, buffer);
if(msgsnd(msgid, (void *)&some_data, MAX_TEXT, 0) == -1)
{
fprintf(stderr, "msgsnd failed\n"); exit(EXIT_FAILURE);
}
if(strncmp(buffer, "end", 3) == 0)
{
running = 0;
}
} exit(EXIT_SUCCESS);
}
```

The msgq1.c program will create the message queue using msgget() function. The msgid identifier is returned by the msgget().The message are received from the queue using msgrcv() function until the string "end" is encountered. Then the queue is deleted using msgctl() function.

The msgq2.c program uses the msgsnd() function to send the entered text to the queue.

Shared Memory:

Shared memory is a highly efficient way of data sharing between the running programs. It allows two unrelated processes to access the same logical memory. It is the fastest form of IPC because all processes share the same piece of memory. It also avoids copying data unnecessarily.

As kernel does not synchronize the processes, it should be handled by the user. Semaphore can also be used to synchronize the access to shared memory.

Usage of shared memory:

To use the shared memory, first of all one process should allocate the segment, and then each process desiring to access the segment should attach the segment. After accessing the segment, each process should detach it. It is also necessary to de allocate the segment without fail.

Allocating the shared memory causes virtual pages to be created. It is important to note that allocating the existing segment would not create new pages, but will return the identifier for the existing pages.

All the shared memory segments are allocated as the integral multiples of the system's page size, which is the number of bytes in a page of memory.

1. Name
2. Creator user ID and group ID.
3. Assigned owner user ID and group ID.
4. Read-write access permission of the region.
5. The time when the last process attached to the region.
6. The time when the last process detached from the region.
7. The time when the last process changed control data of the region.
8. The size, in no. of bytes of the region.

UNIX APIs for shared memory shmget

- Open and create a shared memory.
- Function prototype: #include<sys/types.h> #include<sys/ipc.h> #include<sys/shm.h>
  int shmget (key_t key, int size, int flag);
- Function returns a positive descriptor if it succeeds or -1 if it fails.

Shmat

- Attach a shared memory to a process virtual address space.
- Function prototype:

#include<sys/types.h> #include<sys/ipc.h> #include<sys/shm.h>
void * shmat (int shmid, void *addr, int flag);

- Function returns the mapped virtual address of he shared memory if it succeeds or -1 ifit fails.

Shmdt

- Detach a shared memory from the process virtual addressspace. Function prototype:
  #include<sys/types.h> #include<sys/ipc.h> #include<sys/shm.h> int shmdt (void *addr);
- Function returns 0 if it succeeds or -1 if it fails.

Shmctl

- Query or change control data of a shared memory or delete thememory.
- Function prototype: #include<sys/types.h>

```
#include<sys/ipc.h> #include<sys/shm.h>
int shmctl ( int shmid, int cmd, struct shmid_ds *buf );
```

Function returns 0 if it succeeds or -1 if it fails.

Shared memory Example

```
//shmry1.c #include<unistd.h> #include<stdlib.h> #include<stdio.h> #include<string.h>
#include<sys/shm.h> #define TEXT_SZ 2048 struct shared_use_st
{
int written_by_you;
char some_text[TEXT_SZ];
};
int main()
{
int running = 1;
void *shared_memory = (void *)0; struct shared_use_st *shared_stuff; int shmid;
srand( (unsigned int)getpid() ); shmid = shmget( (key_t)1234, sizeof(struct shared_use_st), 0666
|IPC_CREAT );
if (shmid == -1)
{
fprintf(stderr, "shmget failed\n");
exit(EXIT_FAILURE);
}
shared_memory = shmat(shmid,(void *)0, 0); if (shared_memory == (void *)-1)
{
fprintf(stderr," shmat failed\n"); exit(EXIT_FAILURE);
}
printf("Memory Attached at %x\n", (int)shared_memory); shared_stuff = (struct shared_use_st *)
shared_memory; shared_stuff->written_by_you=0; while(running)
{
if(shared_stuff->written_by_you)
{
printf("You Wrote: %s", shared_stuff->some_text); sleep( rand() %4 );
shared_stuff->written_by_you = 0;
if (strncmp(shared_stuff->some_text, "end", 3)== 0)
{
running = 0;
}
}
}
if (shmdt(shared_memory) == -1)
{
fprintf(stderr, "shmdt failed\n"); exit(EXIT_FAILURE);
}
if (shmctl(shmid, IPC_RMID, 0) == -1)
{
fprintf(stderr, "failed to delete\n");
exit(EXIT_FAILURE);
} exit(EXIT_SUCCESS);
```

}

```
//shmry2.c
#include<unistd.h> #include<stdlib.h> #include<stdio.h> #include<string.h>
#include<sys/shm.h>
#define TEXT_SZ 2048 struct shared_use_st
{
int written_by_you;
char some_text[TEXT_SZ];
};
int main()
{
int running =1
void *shared_memory = (void *)0; struct shared_use_st *shared_stuff; char buffer[BUFSIZ]; int
shmid;
shmid=shmget((key_t)1234                                          sizeof(struct
shared_use_st),
0666 | IPC_CREAT);
if (shmid == -1)
{
fprintf(stderr, "shmget failed\n"); exit(EXIT_FAILURE);
}
shared_memory=shmat(shmid, (void *)0, 0); if (shared_memory == (void *)-1)
{
fprintf(stderr,"shmat failed\n"); exit(EXIT_FAILURE);
}
printf("Memory Attached at %x\n", (int) shared_memory); shared_stuff=(struct shared_use_st
*)shared_memory; while(running)
{
while(shared_stuff->written_by_you== 1)
{
sleep(1);
printf("waiting for client... \n");
}
printf("Enter Some Text: "); fgets (buffer, BUFSIZ, stdin); strncpy(shared_stuff->some_text,
buffer, TEXT_SZ); shared_stuff->written_by_you = 1;
if(strncmp(buffer, "end", 3) == 0)
{
running = 0;
}
}
if (shmdt(shared_memory) == -1)
{
fprintf(stderr, "shmdt failed\n"); exit(EXIT_FAILURE);
} exit(EXIT_SUCCESS);
}
```

The shmry1.c program will create the segment using shmget() function and returns the identifier shmid. Then that segment is attached to its address space using shmat() function.
The structure share_use_st consists of a flag written by you is set to 1 when data is available. When it is set, program reads the text, prints it and clears it to show it has read the data. The string

end is used to quit from the loop. After this the segment is detached and deleted.

The shmry2.c program gets and attaches to the same memory segment. This is possible with the help of same key value 1234 used in the shmget() function. If the written_by_you text is set, the process will wait until the previous process reads it. When the flag is cleared, the data is written and sets the flag. This program too will use the string "end" to terminate. Then the segment is detached.

Semaphore:

While we are using threads in our programs in multi-user systems, multiprocessing system, or a combination of two, we may often discover critical sections in the code. This is the section where we have to ensure that a single process has exclusive access to the resource.

For this purpose the semaphore is used. It allows in managing the access to resource. To prevent the problem of one program accessing the shared resource simultaneously, we are in Need to generate and use atoken which guarantees the access to only one thread of execution in the critical section at a time.

It is counter variable, which takes only the positive numbers and upon which programs can only act atomically. The positive number is the value indicating the number of units of the shared resources are available for sharing.

The common form of semaphore is the binary semaphore, which will control a single resource, and its value is initialized to 0.

Creation of semaphore:

The shmget() function creates a new semaphore or obtains the semaphore key of an existing semaphore.

#include<sys/sem.h> intshmget(key_tkey,intnum_sems, intsem_flags);

The first parameter, key, is an integral value used to allow unrelated process to access the same semaphore. The semaphore key is used only by semget. All others use the identifier return by the semget(). There is a special key value IPC_PRIVATE which allows to create the semaphore and to be accessed only by the creating process.

The second parameter is the number of semaphores required, it is almost always 1. The third parameter is the set of flags. The nine bits are the permissions for the semaphore.

On success it will return a positive value which is the identifier used by the other semaphore functions. On error, it returns -1.

Changing the value:

The function semop() is used for changing the value of the semaphore. #include<sys/sem.h>
int semop(int sem_id,struct sembuf
*sem_ops,size_t num-_sem_ops);

The first parameter is the shmid is the identifier returned by the semget().
The second parameter is the pointer to an array of structure. The structure may contain at least the following members:
struct sembuf{ short sem_num; short sem_op; short sem_flg;
}

The first member is the semaphore number, usually 0 unless it is an array of semaphore. The sem_op is the value by which the semaphore should be changed. Generally it takes -1,which is operation to wait for a semaphore and +1, which is the operation to signal the availability of semaphore.
The third parameter, is the flag which is usually set to SET_UNDO. If the process terminates without releasing the semaphore, this allows to release it automatically.

Controlling the semaphore:
The semctl() function allows direct control of semaphore information. #include<sys/sem.h>
int semctl(int sem_id,int sem_num, int command,.../*union semun arg */);

The third parameter is the command, which defines the action to be taken. There are two common values:
1.) **SETVAL**: Used for initializing a semaphore to a known value. 2.) **IPC_RMID**:Deletes the semaphore identifier.

File locking with semaphores
//sem.c

```
#include <unistd.h> #include <stdlib.h> #include <stdio.h> #include <sys/sem.h>
#include<sys/ipc.h> #include<sys/types.h> union semun
{
int val;
struct semid_ds *buf; unsigned short *array;
};
static void del_semvalue(void); static int set_semvalue(void); static int
{
union semun sem_union; sem_union.val = 1;
if (semctl(sem_id, 0, SETVAL, sem_union) == -1) return(0); return(1);
}
static void del_semvalue()
{
union semun sem_union;
if (semctl(sem_id, 0, IPC_RMID, sem_union) == -1) fprintf(stderr, "Failed to delete
semaphore\n");
}
static int semaphore_p()
{
Struct sembuf sem_b; sem_b.sem_num =0;
sem_b.sem_op = -1; sem_b.sem_flg = SEM_UNDO;
if (semop(sem_id, &sem_b, 1) == -1)
{
fprintf(stderr, "semaphore_p failed\n"); return(0);
}
return(1);
}
static int semaphore_v()
{
Struct sembuf sem_b; sem_b.sem_num=0;


sem_b.sem_op = 1; sem_b.sem_flg = SEM_UNDO;
```

```
if (semop(sem_id, &sem_b, 1) == -1)
{
fprintf(stderr,"semaphore_vfailed\n"); return(0);
}
return(1);
}
int main(int argc, char *argv[])
{
int i;
int pause_time; char op_char = 'O'; srand((unsigned int)getpid());
sem_id = semget((key_t)1234, 1, 0666 | IPC_CREAT); if (argc > 1)
{
if (!set_semvalue())
{
fprintf(stderr, "Failed to initialize semaphore\n"); exit(EXIT_FAILURE);
}
op_char = 'X'; sleep(2);
}
for(i = 0; i < 10; i++)
{
if(!semaphore_p()) exit(EXIT_FAILURE);
printf("%c", op_char);
fflush(stdout); pause_time = rand() % 3; sleep(pause_time); printf("%c", op_char);fflush(stdout);
if (!semaphore_v()) exit(EXIT_FAILURE);
 pause_time = rand() % 2; sleep(pause_time);
}
printf("\n%d - finished\n", getpid()); if (argc > 1)
{
sleep(10); del_semvalue();
} exit(EXIT_SUCCESS);
```

UNIT-V
INTRODUCTION TO SOCKETS

Introduction to sockets: Socket, socket connections, socket attributes, socket addresses, socket system calls for connection oriented protocol and connectionless protocol, socket communications, comparison of IPC mechanisms.

Sockets

A socket is a bidirectional communication device that can be used to communicate with another process on the same machine or with a process running on other machines. Sockets are the only inter process communication we‘ll discuss in this chapter that permit communication between processes on different computers. Internet programs such as Telnet, rlogin, FTP, talk, and the World Wide Web use sockets.

For example, you can obtain the WWW page from a Web server using the Telnet program because they both use sockets for network communications. To open a connection to a WWW server at www.codesourcery.com, use telnet www.codesourcery.com 80.The magic constant 80 specifies a connection to the Web server programming running www.codesourcery.com instead of some other process.Try typing GET / after the connection is established. This sends a message through the socket to the Web server, which replies by sending the home page‘s HTML source and then closing the connection—for example:

```
% telnet www.codesourcery.com 80 Trying 206.168.99.1...
Connected to merlin.codesourcery.com (206.168.99.1). Escape character is ‗^]‘. GET /
<html>
<head>
<meta http-equiv=‖Content-Type‖ content=‖text/html; char set=iso-8859-1‖>
...
```

3. Note that only Windows NT can create a named pipe; Windows 9x programs can form only client connections.
4. Usually, you‘d use telnet to connect a Telnet server for remote logins. But you can also use telnet to connect to a server of a different kind and then type comments directly at it.

Introduction to Berkeley sockets

Berkeley sockets (or BSD sockets) is a computing library with an application programming interface (API) for internet sockets and Unix domain sockets, used for inter-process communication (IPC).

This list is a summary of functions or methods provided by the Berkeley sockets API library:

a. socket() creates a new socket of a certain socket type, identified by an integer number, and allocates system resources to it.
b. bind() is typically used on the server side, and associates a socket with a socket address structure, i.e. a specified local port number and IP address.
c. listen() is used on the server side, and causes a bound TCP socket to enter listening state.
d. connect() is used on the client side, and assigns a free local port number to a socket. In case of a TCP socket, it causes an attempt to establish a new TCP connection.accept() is used on the server side. It accepts a received incoming attempt to create a new TCP connection from the remote client, and creates a new socket associated with the socket address pair of this connection.
e. send() and recv(), or write() and read(), or sendto() and recvfrom(), are used for sending and

f. receiving data to/from a remote socket.

g. close() causes the system to release resources allocated to a socket. In case of TCP, the connection is terminated.

h. gethostbyname() and gethostbyaddr() are used to resolve host names and addresses. IPv4 only.

i. select() is used to pend, waiting for one or more of a provided list of sockets to be ready to read, ready to write, or that have errors.

j. poll() is used to check on the state of a socket in a set of sockets. The set can be tested to see if any socket can be written to, read from or if an error occurred.

k. getsockopt() is used to retrieve the current value of a particular socket option for the specified socket.

l. setsockopt() is used to set a particular socket option for the specified socket.

Socket Communications

Most interprocess communication uses the *client server model*. These terms refer to the two processes which will be communicating with each other. One of the two processes, the *client*, connects to the other process, the *server*, typically to make a request for information. A good analogy is a person who makes a phone call to another person.

Notice that the client needs to know of the existence of and the address of the server, but the server does not need to know the address of (or even the existence of) the client prior to the connection being established. Notice also that once a connection is established, both sides can send and receive information.

The system calls for establishing a connection are somewhat different for the client and the server, but both involve the basic construct of a *socket*. A socket is one end of an interprocess communication channel. The two processes each establish their own socket.

The steps involved in establishing a socket on the *client* side are as follows:

1 Create a socket with the `socket()` system call

2 Connect the socket to the address of the server using the `connect()` system call

3 Send and receive data. There are a number of ways to do this, but the simplest is to use the `read()` and `write()` system calls.

The steps involved in establishing a socket on the *server* side are as follows:

1. Create a socket with the `socket()` system call
2. ind the socket to an address using the `bind()` system call. For a server socket on the Internet, an address consists of a port number on the host machine.
3. Listen for connections with the `listen()` system call
4. Accept a connection with the `accept()` system call. This call typically blocks until a client connects with the server.
5. Send and receive data Socket Types

When a socket is created, the program has to specify the *address domain* and the *socket type*. Two processes can communicate with each other only if their sockets are of the same type and in the same domain. There are two widely used address domains, the *unix domain*, in which two processes which share a common file system communicate, and the *Internet domain*, in which two processes running on any two hosts on the Internet communicate. Each of these has its own address format.

The address of a socket in the Unix domain is a character string which is basically an entry in the file system.

The address of a socket in the Internet domain consists of the Internet address of the host machine (every computer on the Internet has a unique 32 bit address, often referred to as its IP address). In addition, each socket needs a port number on that host. Port numbers are 16 bit unsigned integers. The lower numbers are reserved in Unix for standard services. For example, the port number for the FTP server is 21. It is important that standard services be at the same port on all computers so that clients will know their addresses. However, port numbers above 2000 are generally available.

There are two widely used socket types, *stream sockets*, and *datagram sockets*. Stream sockets treat communications as a continuous stream of characters, while datagram sockets have to read entire messages at once. Each uses its own communciations protocol. Stream sockets use TCP (Transmission Control Protocol), which is a reliable, stream oriented protocol, and datagram sockets use UDP (Unix Datagram Protocol), which is unreliable and message oriented.

Socket Attributes

NAME
socket - create an endpoint for communication SYNOPSIS
#include<sys/socket.h>

int socket(int `domain`, int `type`, int `protocol`);

DESCRIPTION
The socket() function shall create an unbound socket in a communications domain, and return a file descriptor that can be used in later function calls that operate on sockets.

The socket() function takes the following arguments:

domain
Specifies the communications domain in which a socket is to be created. type
Specifies the type of socket to be created. protocol
Specifies a particular protocol to be used with the socket. Specifying a protocol of 0 causes socket() to
use an unspecified default protocol appropriate for the requested socket type.
The domain argument specifies the address family used in the communications domain. The address families supported by the system are implementation-defined.

SOCKET ADDRESSES

Various structures are used in Unix Socket Programming to hold information about the address and port, and other information. Most socket functions require a pointer to a socket address structure as an argument. Structures defined in this chapter are related to Internet Protocol Family.

sockaddr

The first structure is sockaddr that holds the socket information −

```
struct sockaddr {

   unsigned short   sa_family;

   char             sa_data[14];

};
```

This is a generic socket address structure, which will be passed in most of the socket function calls. The following table provides a description of the member fields −

Attribut e	Values	Description
sa_famil y	AF_INET AF_UNIX AF_NS AF_IMPLIN K	It represents an address family. In most of the Internet-based applications, we use AF_INET.
sa_data	Protocol-specific Address	The content of the 14 bytes of protocol specific address are interpreted according to the type of address. For the Internet family, we will use port number IP address, which is represented by sockaddr_in structure defined below.

sockaddr in

The second structure that helps you to reference to the socket's elements is as follows −

```
struct sockaddr_in {

   short int            sin_family;

   unsigned short int   sin_port;

   struct in_addr       sin_addr;
```

Connection Oriented vs Connectionless Communication Connection Oriented Communication
Analogous to the telephone network. The sender requests for a communication (dial the number), the receiver gets an indication (the phone ring) the receiver accepts the connection (picks up the phone) and the sender receives the acknowledgment (the ring stops). The connection is established through a dedicated link provided for the communication. This type of communication is characterized by a high level of reliability in terms of the number and the sequence of bytes.

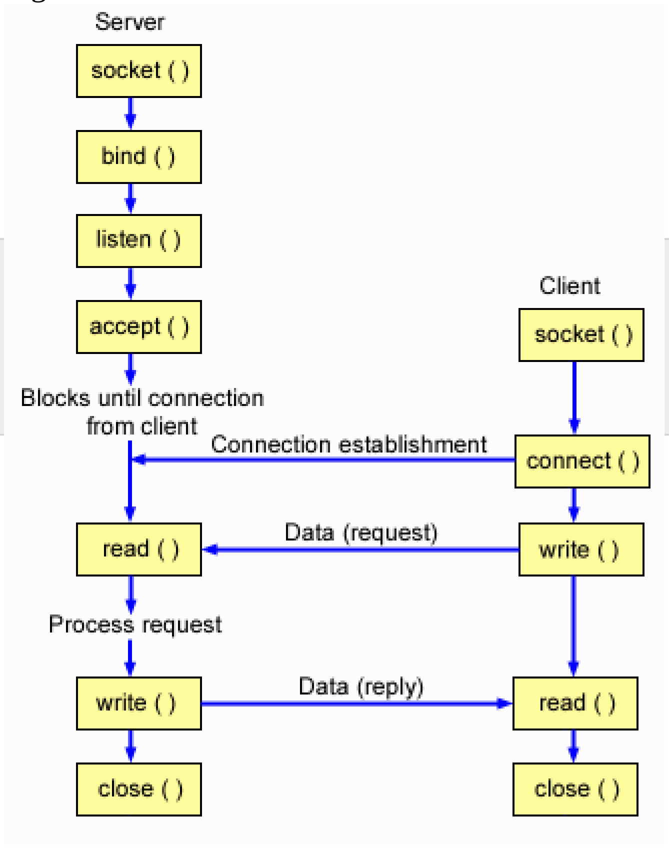
Connectionless Communication

Analogous to the postal service. Packets(letters) are sent at a time to a particular destination. For greater reliability, the receiver may send an acknowledgement (a receipt for the registered letters). Based on this for two types of communication, two kinds of sockets are used:

1. **stream sockets:** used for connection-oriented communication, when reliability in connection is desired.
2. **datagram sockets:** used for connectionless communication, when reliability is not as much as an issue compared to the cost of providing that reliability. For eg. streaming audio/video is always send over such sockets so as to diminish network traffic.

Sequence of System Calls for Connection Oriented communication

The typical set of system calls on both the machines in a connection-oriented setup is shown in Figure below.



The sequence of system calls that have to be made in order to setup a connection is given below.

1. The socket system call is used to obtain a socket descriptor on both the client and the server. Both these calls need not be synchronous or related in the time at which they are called.
The synopsis is given below

```
#include<sys/types.h>
#include<sys/socket.h>
int socket(int domain,
int type, int protocol);
```

2. Both the client and the server 'bind' to a particular port on their machines using the bind system call. This function has to be called only after a socket has been created and has to be passed the socket descriptor returned by the socket call. Again this binding on both the machines need not be in any particular order. Moreover the binding procedure on the client is entirely optional. The bind system call requires the address family, the port number and the IP address. The address family is known to be AF_INET, the IP address of the client is already known to the operating system. All that remains is the port number. Of course the programmer can specify which port to bind to, but this is not necessary. The binding can be done on a random port as well and still everything would work fine. The way to make this happen is not to call bind at all. Alternatively bind can be called with the port number set to 0. This tells the operating system to assign a random port number to this socket. This way whenever the program tries to connect to a remote machine through this socket, the operating system binds this socket to a random local port. This procedure as mentioned above is not applicable to a server, which has to listen at a standard predeterminedport.

3. The next call has to be listen to be made on the server. The synopsis of the listen call is given below.

```
#include<
sys/socket
.h>
int
listen(int
skfd, int
backlog);
```

skfd is the socket descriptor of the socket on which the machine should start listening.
backlog is the maximum length of the queue for accepting requests.

4. The connect system call signifies that the server is willing to accept connections and thereby start communicating.

5. Actually what happens is that in the TCP suite, there are certain messages that are sent to and fro and certain initializations have to be performed. Some finite amount of time is required to setup the resources and allocate memory for whatever data structures that will be needed. In this time if another request arrives at the same port, it has to wait in a queue. Now this queue cannot be arbitrarily large. After the queue reaches a particular size limit no more requests are accepted by the operating system. This size limit is precisely the backlog argument in the listen call and is something that the programmer can set. Today's processors are pretty speedy in their computations and memory allocations. So under normal circumstances the length of the queue never exceeds 2 or 3. Thus a backlog value of 2-3 would be fine, though the value typically used is around Note that this call is different from the concept of "parallel" connections.The established connections are not counted in n. So, we may have 100 parallel connection running at a time when n=5.

6. The connect function is then called on the client with three arguments, namely the socket descriptor, the remote server address and the length of the address data structure. The synopsis of the function is as follows:

```
#include<sys/socket.h>
#include<netinet/in.h> /* only for AF_INET , or the INET Domain */
int connect(int skfd, struct sockaddr* addr, int addrlen);
```

This function initiates a connection on a socket. skfd is the same old socket descriptor. addr is again the same kind of structure as used in the bind system call. More often than not, we will be creating a structure of the type sockaddr_in instead of sockaddr and filling it with appropriate data. Just while sending the pointer to that structure to the connect or even the bind system call, we cast it into a pointer to a sockaddr structure. The reason for doing all this is that the sockaddr_in is more convenient to use in case of INET domain applications. addr basically contains the port number and IP address of the server which the local machine wants to connect to. This call normally blocks until either the connection is established or is rejected. addrlen is the length of the socket address structure, the pointer to which is the second argument.

7. The request generated by this connect call is processed by the remote server and is placed in an operating system buffer, waiting to be handed over to the application which will be calling the accept function. The accept call is the mechanism by which the networking program on the server receives that requests that have been accepted by the operating system. This synopsis of the accept system call is given below.

```
                #include<sys/socket.h>
                int accept(int skfd, struct sockaddr* addr, int addrlen);
```

For each connection at least one of these has to be unique. Therefore multiple connections on one port of the server, actually are different.

8. Finally when both connect and accept return the connection has been established.
9. The socket descriptors that are with the server and the client can now be used identically as a normal I/O descriptor. Both the read and the write calls can be performed on this socket descriptor. The close call can be performed on this descriptor to close the connection. Man pages on any UNIX type system will furnish further details about these generic I/O calls.
10. Variants of read and write also exist, which were specifically designed for networking applications. These are recv and send.

```
#include<sys/socket.h>

                int recv(int skfd, void *buf,
                    int buflen, int flags);
                int send(int skfd, void *buf,
                    int buflen, int flags);
```

Except for the flags argument the rest is identical to the arguments of the read and write calls.
Possible values for the flags are:

used for	macro for the flag	comment
recv	**MSG_PEEK**	look at the message in the buffer but do not consider it read
send	**MSG_DONT_ROUT E**	send message only if the destination is on the same network
recv & sen d	**MSG_OOB**	used for transferring data out of sequence, when some bytes in a stream might be more important than others.

11. To close a particular connection the shutdown call can also be used to achieve greater flexibility.

Comparison of IPC Mechanisms.

IPC mechanisms are mainly 5 types

1. pipes:it is related data only send from one pipe output is giving to another pipe input to share resources pipe are used drawback: it is only related process only communicated

2. message queues: message queues are un related process are also communicate with message queues.

3. sockets:sockets also ipc it is communicate clients and server 193 with socket system calls connection oriented and connection less also

4. PIPE: Only two related (eg: parent & child) process can be communicated. Data reading would be first in first out manner. Named PIPE or FIFO : Only two processes (can be related or unrelated) can communicate. Data read from FIFO is first in first out manner.

5. Message Queues: Any number of processes can read/write from/to the queue. Data can be read selectively. (need not be in FIFO manner)

6. Shared Memory: Part of process's memory is shared to other processes. other processes can read or write into this shared memory area based on the permissions. Accessing Shared memory is faster than any other IPC mechanism as this does not involve any kernel level switching (Shared memory resides on user memory area).

7. Semaphore: Semaphores are used for process synchronization. This can't be used for bulk data transfer between processes.