

**ADHI COLLEGE OF ENGINEERING
AND
TECHNOLOGY**

Sankarapuram, Near Walajabad, Kancheepuram Dist, Pin: 631605

**DEPARTMENT OF
COMPUTER SCIENCE AND ENGINEERING**



**STUDENT NAME :
REGISTER NO :
SUBJECT CODE : CS 8461
SUBJECT NAME : OPERATING SYSTEMS LABORATORY
SEMESTER : IV**

(2021 - 2022)

**ADHI COLLEGE OF ENGINEERING
AND
TECHNOLOGY**

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LABORATORY RECORD NOTE BOOK

2021 – 2022

REGISTER NO:

This is to certify that this is a bonafide record of the work done by

Mr./Ms. _____ Register Number

_____ of the year _____ B.E / B.Tech., Department

of _____ in the _____

Laboratory in the _____ Semester University Examination held on _____.

Staff In-Charge

Head of the Department

Internal Examiner

External Examiner

ADHI COLLEGE OF ENGINEERING AND TECHNOLOGY

INSTITUTION VISION

- ❖ To become a benchmark of excellence in thrust areas of higher education in a global context.

INSTITUTION MISSION

- ❖ To impart knowledge through quality education.
- ❖ To create a sustainable teaching-learning ambience for honing skills to achieve in a global scenario.
- ❖ To prepare young minds for the challenges of an aspirational society through a holistic education.

COMPUTER SCIENCE AND ENGINEERING

VISION OF COMPUTER SCIENCE AND ENGINEERING

- ❖ To provide quality technical education and develop professionals imparting human values, employability, entrepreneurship and research capabilities, to meet the challenges in the globalized technological society and to strengthen the industry-academic partnership for the benefit of both.

MISSION OF COMPUTER SCIENCE AND ENGINEERING

- ❖ To prepare students for careers in industry, encourage entrepreneurship and mould them to take leadership for the betterment of the society.
- ❖ To guide the students to face the challenges ahead in terms of technology.
- ❖ To keep the state-of-the-art equipment in the department to facilitate the students to equip themselves for the fast-changing Computer Technology.
- ❖ To prepare the students to play their proper roles in a society that is now being driven more and more by advances in computer technology.

PROGRAM EDUCATIONAL OBJECTIVES(PEO'S)

PEO 1	Possess essential foundation on computer science profession and basics of engineering that makes them confident to develop computing solutions in various domains by applying evolving trends towards the emerging business trends and social needs
PEO 2	Excel in the field of software industry or in higher education with the spirit of research innovations and entrepreneurship by practicing the profession with ethics, integrity, leadership and with the attitude of teamwork.
PEO 3	Adaption towards forefront technologies in order to understand and demonstrate lifelong learning for their consistent skill improvements through practical training and specialized certification.

PROGRAM OUTCOMES(PO'S)

PO 1	Engineering Knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	Problem analysis	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO 3	Design/ Development of solutions	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO 4	Conduct investigations of complex problems	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
PO 5	Modern tool usage	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
PO 6	The engineer and society	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	Environment and sustainability	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO 9	Individual and team work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	Communication	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
PO 11	Project management and finance	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	Life-long learning	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSO'S)

PSO 1	To show ability in planning, implementing and evaluating team oriented- software programming solution to specific business problems and society needs.
PSO 2	To demonstrate professional skills in applying programming skills, proficiency and decision making capacity through hands-on experiences.
PSO 3	To apply logical thinking in analyzing complex real world problems, and use professional and moral behaviors to give proper solutions to those problems.
PSO 4	To demonstrate the ability to work effectively as part of a team in applying technology to business and personal situations.

Course Outcome:

At the end of this course, the students will be able to,

COs	Description
CO1	Make use of Linux commands, develop shell programs, implement system calls and simulate Linux commands
CO2	Test the implementation of processes and IPC
CO3	Compare the performance of various CPU scheduling algorithms
CO4	Experiment with the implementation of semaphores, deadlock avoidance algorithm and deadlock detection algorithm
CO5	Compare the implementation of various memory allocation, memory management and page replacement strategies.

PO – CO Correlation Matrix: ($\geq 80\%$ - 3, $\geq 60\%$ - 2, $\geq 40\%$ - 1)

COs	PROGRAM OUTCOMES / PROGRAM SPECIFIC OUTCOMES															
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	1	1	1	1	2	-	-	-	-	-	-	-	2
CO2	1	1	1	2	2	1	2	1	-	-	1	-	-	1	-	-
CO3	1	2	3	1	2	1	3	1	-	-	1	-	-	1	1	-
CO4	1	1	2	2	2	2	3	1	-	-	1	-	-	-	-	-
CO5	1	2	2	2	2	2	2	1	-	-	1	-	3	-	-	-

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2b		Wait System Call		
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2d		Stat system call		
2e		Readdir system call		
2f		Open system call		
2g		Read system call		
2h		Write system call		
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Exp. No. 1 Basic Unix Commands

Date :

Aim

To study and execute Unix commands.

Login

Type **telnet** *server_ipaddress* in **run** window.

User has to authenticate himself by providing *username* and *password*. Once verified, a greeting and \$ prompt appears. The shell is now ready to receive commands from the user. Options suffixed with a hyphen (-) and arguments are separated by space.

General commands

Command	Function
Date	Used to display the current system date and time.
date +%D	Displays date only
date +%T	Displays time only
date +%Y	Displays the year part of date
date +%H	Displays the hour part of time
Cal	Calendar of the current month
cal <i>year</i>	Displays calendar for all months of the specified year
cal <i>month year</i>	Displays calendar for the specified month of the year
Who	Login details of all users such as their IP, Terminal No, User name,
who am i	Used to display the login details of the user
Uname	Displays the Operating System
uname -r	Shows version number of the OS (kernel).
uname -n	Displays domain name of the server
echo \$HOME	Displays the user's home directory
Bc	Basic calculator. Press Ctrl+d to quit
lp <i>file</i>	Allows the user to spool a job along with others in a print queue.
man <i>cmdname</i>	Manual for the given command. Press q to exit
history	To display the commands used by the user since log on.
exit	Exit from a process. If shell is the only process then logs out

Directory commands

Command	Function
Pwd	Path of the present working directory
mkdir <i>dir</i>	A directory is created in the given name under the current directory
mkdir <i>dir1 dir2</i>	A number of sub-directories can be created under one stroke
cd <i>subdir</i>	Change Directory. If the <i>subdir</i> starts with / then path starts from root (absolute) otherwise from current working directory.
cd	To switch to the home directory.
cd /	To switch to the root directory.
cd ..	To move back to the parent directory
rmdir <i>subdir</i>	Removes an empty sub-directory.

File commands

Command	Function
<code>cat > filename</code>	To create a file with some contents. To end typing press <code>Ctrl+d</code> . The <code>></code> symbol means redirecting output to a file. (<code><</code> for input)
<code>cat filename</code>	Displays the file contents.
<code>cat >> filename</code>	Used to append contents to a file
<code>cp src des</code>	Copy files to given location. If already exists, it will be overwritten
<code>cp -i src des</code>	Warns the user prior to overwriting the destination file
<code>cp -r src des</code>	Copies the entire directory, all its sub-directories and files.
<code>mv old new</code>	To rename an existing file or directory. <code>-i</code> option can also be used
<code>mv f1 f2 f3 dir</code>	To move a group of files to a directory.
<code>mv -v old new</code>	Display name of each file as it is moved.
<code>rm file</code>	Used to delete a file or group of files. <code>-i</code> option can also be used
<code>rm *</code>	To delete all the files in the directory.
<code>rm -r *</code>	Deletes all files and sub-directories
<code>rm -f *</code>	To forcibly remove even write-protected files
<code>ls</code>	Lists all files and subdirectories (blue colored) in sorted manner.
<code>ls name</code>	To check whether a file or directory exists.
<code>ls name*</code>	Short-hand notation to list out filenames of a specific pattern.
<code>ls -a</code>	Lists all files including hidden files (files beginning with <code>.</code>)
<code>ls -x dirname</code>	To have specific listing of a directory.
<code>ls -R</code>	Recursive listing of all files in the subdirectories
<code>ls -l</code>	Long listing showing file access rights (read/write/execute- rw x for user/group/others- ugo).
<code>cmp file1 file2</code>	Used to compare two files. Displays nothing if files are identical.
<code>wc file</code>	It produces a statistics of lines (l), words(w), and characters(c).
<code>chmod perm file</code>	Changes permission for the specified file. (<code>r=4</code> , <code>w=2</code> , <code>x=1</code>) <code>chmod 740 file</code> sets all rights for user, read only for groups and no rights for others

The commands can be combined using the pipeline (`|`) operator. For example, number of users logged in can be obtained as.

```
who | wc -l
```

Finally to terminate the unix session execute the command **exit** or **logout**.

Output

```
$ date
Sat Apr  9 13:03:47 IST 2011
```

```
$ date +%D
04/09/11
```

```
$ date +%T
13:05:33
```

```
$ date +%Y
```

```
2011
```

```
$ date +%H
```

```
13
```

```
$ cal 08 1998
```

```
August 1998
```

```
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 31
```

```
$ who
```

```
root      :0                Apr  9 08:41
vijai     pts/0             Apr  9 13:00 (scl-64)
cse4001    pts/3             Apr  9 13:18 (scl-41.smkfomra.com)
```

```
$ uname
```

```
Linux
```

```
$ uname -r
```

```
2.4.20-8smp
```

```
$ uname -n
```

```
localhost.localdomain
```

```
$ echo $HOME
```

```
/home/vijai
```

```
$ echo $USER
```

```
vijai
```

```
$ bc
```

```
3+5
```

```
8
```

```
$ pwd
```

```
/home/vijai/shellscripts/loops
```

```
$ mkdir filter
```

```
$ ls
```

```
filter  list.sh  regexpr  shellscripts
```

```
$ cd shellscripts/loops/
```

```
$

$ cd
$

$ cd /
[vijai@localhost /]$

[vijai@localhost /]$ cd /home/vijai/shellscripts/loops/
$ cd ..
[vijai@localhost shellscripts]$

$ rmdir filter
$ ls
list.sh  regexpr  shellscripts

$ cat > greet
hi cse
wishing u the best

$ cat greet
hi ece-a
wishing u the best

$ cat >> greet
bye
$ cat greet
hi cse
wishing u the best
bye

$ ls
greet  list.sh  regexpr  shellscripts

$ ls -a
.                .bash_logout  .canna  .gtkrc  regexpr  .viminfo.tmp
..               .bash_profile .emacs  .kde    shellscripts .xemacs
.bash_history   .bashrc       greet   list.sh  .viminfo

$ ls -l
-rw-rw-r--  1 vijai  vijai          32 Apr 11 14:52 greet
-rw-rw-r--  1 vijai  vijai          30 Apr  4 13:58 list.sh
drwxrwxr-x  2 vijai  vijai       4096 Apr  9 14:30 regexpr

$ cp greet ./regexpr/
$ ls
greet  list.sh  regexpr  shellscripts
$ ls ./regexpr
```

```

demo greet

$ cp -i greet ./regexpr/
cp: overwrite 'greet'? n

$ mv greet greet.txt
$ ls
greet.txt  list.sh  regexpr  shellscripts

$ mv greet.txt ./regexpr/
$ ls
list.sh  regexpr  shellscripts

$ rm -i *.sh
rm: remove regular file 'fact.sh'? y
rm: remove regular file 'prime.sh'? y
$ ls
list.sh  regexpr  shellscripts

$ wc list.sh
   4      9      30 list.sh
$ wc -l list.sh
   4 list.sh

$ cmp list.sh fact.sh
list.sh fact.sh differ: byte 1, line 1

$ ls -l list.sh
-rw-rw-r--  1 vijai  vijai           30 Apr  4 13:58 list.sh

$ chmod ug+x list.sh

$ ls -l list.sh
-rwxrwxr--  1 vijai  vijai           30 Apr  4 13:58 list.sh
$ chmod 740 list.sh
$ ls -l list.sh
-rwxr-----  1 vijai  vijai           30 Apr  4 13:58 list.sh

```

Result

Thus the study and execution of Unix commands has been completed successfully.

Exp# 2a fork system call**Date:****Aim**

To create a new child process using fork system call.

fork()

- The fork system call is used to create a new process called *child* process.
 - The return value is 0 for a child process.
 - The return value is negative if process creation is unsuccessful.
 - For the parent process, return value is positive
- The child process is an exact copy of the parent process.
- Both the child and parent continue to execute the instructions following fork call.
- The child can start execution before the parent or vice-versa.

getpid() and getppid()

- The getpid system call returns process ID of the calling process
- The getppid system call returns parent process ID of the calling process

Algorithm

1. Declare a variable x to be shared by both child and parent.
2. Create a child process using fork system call.
3. If return value is -1 then
 - Print "Process creation unsuccessful"
 - Terminate using exit system call.
4. If return value is 0 then
 - Print "Child process"
 - Print process id of the child using getpid system call
 - Print value of x
 - Print process id of the parent using getppid system call
5. Otherwise
 - Print "Parent process"
 - Print process id of the parent using getpid system call
 - Print value of x
 - Print process id of the shell using getppid system call.
6. Stop

Program

```
/* Process creation - fork.c */

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

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

main()
{
    pid_t pid;
    int x = 5;
    pid = fork();
    x++;

    if (pid < 0)
    {
        printf("Process creation error");
        exit(-1);
    }
    else if (pid == 0)
    {
        printf("Child process:");
        printf("\nProcess id is %d", getpid());
        printf("\nValue of x is %d", x);
        printf("\nProcess id of parent is %d\n", getppid());
    }
    else
    {
        printf("\nParent process:");
        printf("\nProcess id is %d", getpid());
        printf("\nValue of x is %d", x);
        printf("\nProcess id of shell is %d\n", getppid());
    }
}
```

Output

```
$ gcc fork.c
```

```
$ ./a.out
```

```
Child process:
```

```
Process id is 19499
```

```
Value of x is 6
```

```
Process id of parent is 19498
```

```
Parent process:
```

```
Process id is 19498
```

```
Value of x is 6
```

```
Process id of shell is 3266
```

Result

Thus a child process is created with copy of its parent's address space.

Exp# 2b **wait system call****Date:****Aim**

To block a parent process until child completes using wait system call.

wait()

- The wait system call causes the parent process to be blocked until a child terminates.
- When a process terminates, the kernel notifies the parent by sending the SIGCHLD signal to the parent.
- Without wait, the parent may finish first leaving a *zombie* child, to be adopted by init process

Algorithm

1. Create a child process using fork system call.
2. If return value is -1 then
 - a. Print "Process creation unsuccessful"
3. Terminate using exit system call.
4. If return value is > 0 then
 - a. Suspend parent process until child completes using wait system call
 - b. Print "Parent starts"
 - c. Print even numbers from 0–10
 - d. Print "Parent ends"
5. If return value is 0 then
 - a. Print "Child starts"
 - b. Print odd numbers from 0–10
 - c. Print "Child ends"
6. Stop

Program

```

/* Wait for child termination - wait.c */

#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <sys/types.h>
#include <sys/wait.h>

main()
{
    int i, status;
    pid_t pid;

    pid = fork();

```



```

if (pid < 0)
{
    printf("\nProcess creation failure\n");
    exit(-1);
}
else if(pid > 0)
{
    wait(NULL);
    printf ("\nParent starts\nEven Nos: ");
    for (i=2;i<=10;i+=2)
        printf ("%3d",i);
    printf ("\nParent ends\n");
}
else if (pid == 0)
{
    printf ("Child starts\nOdd Nos: ");
    for (i=1;i<10;i+=2)
        printf ("%3d",i);
    printf ("\nChild ends\n");
}
}

```

Output

```
$ gcc wait.c
```

```
$ ./a.out
```

```
Child starts
```

```
Odd Nos:   1   3   5   7   9
```

```
Child ends
```

```
Parent starts
```

```
Even Nos:   2   4   6   8  10
```

```
Parent ends
```

Result

Thus using wait system call zombie child processes were avoided.

Exp# 2c**exec system call****Date:****Aim**

To load an executable program in a child processes exec system call.

execl()

- The exec family of function (execl, execv, execl, execve, execlp, execvp) is used by the child process to load a program and execute.
- execl system call requires path, program name and null pointer

Algorithm

1. Create a child process using fork system call.
2. If return value is -1 then
 - a. Print "Process creation unsuccessful"
3. Terminate using exit system call.
4. If return value is > 0 then
 - a. Suspend parent process until child completes using wait system call
 - b. Print "Child Terminated".
 - c. Terminate the parent process.
5. If return value is 0 then
 - a. Print "Child starts"
 - b. Load date program into child process using exec system call.
 - c. Terminate the child process.
6. Stop

Program

```
/* Load a program in child process - exec.c */
```

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <sys/types.h>
```

```
main()
{
    pid_t pid;

    switch(pid = fork())
    {
```

```
    case -1:
        perror("Fork failed");
        exit(-1);

    case 0:
        printf("Child process\n");
        execl("/bin/date", "date", 0);
        exit(0);

    default:
        wait(NULL);
        printf("Child Terminated\n");
        exit(0);
}
```

Output

```
$ gcc exec.c
```

```
$ ./a.out
```

```
Child process
```

```
Sat Feb 23 17:46:59 IST 2013
```

```
Child Terminated
```

Result

Thus the child process loads a binary executable file into its address space.

Exp# 2d**stat system call****Date:****Aim**

To display file status using stat system call.

exit()

- The exit system call is used to terminate a process either normally or abnormally
- Closes all standard I/O streams.

stat()

- The stat system call is used to return information about a file as a structure.

Algorithm

1. Get *filename* as command line argument.
2. If *filename* does not exist then stop.
3. Call stat system call on the *filename* that returns a structure
4. Display members st_uid, st_gid, st_blksize, st_block, st_size, st_nlink, etc.,
5. Convert time members such as st_atime, st_mtime into time using ctime function
6. Compare st_mode with mode constants such as S_IRUSR, S_IWGRP, S_IXOTH and display file permissions.
7. Stop

Program

```

/* File status - stat.c */
#include <stdio.h>
#include <sys/stat.h>
#include <stdlib.h>
#include <time.h>

int main(int argc, char*argv[])
{
    struct stat file;
    int n;
    if (argc != 2)
    {
        printf("Usage: ./a.out <filename>\n");
        exit(-1);
    }
    if ((n = stat(argv[1], &file)) == -1)
    {
        perror(argv[1]);
        exit(-1);
    }
}

```

```

printf("User id : %d\n", file.st_uid);
printf("Group id : %d\n", file.st_gid);
printf("Block size : %d\n", file.st_blksize);
printf("Blocks allocated : %d\n", file.st_blocks);
printf("Inode no. : %d\n", file.st_ino);
printf("Last accessed : %s", ctime(&(file.st_atime)));
printf("Last modified : %s", ctime(&(file.st_mtime)));
printf("File size : %d bytes\n", file.st_size);
printf("No. of links : %d\n", file.st_nlink);

printf("Permissions : ");
printf( (S_ISDIR(file.st_mode)) ? "d" : "-");
printf( (file.st_mode & S_IRUSR) ? "r" : "-");
printf( (file.st_mode & S_IWUSR) ? "w" : "-");
printf( (file.st_mode & S_IXUSR) ? "x" : "-");
printf( (file.st_mode & S_IRGRP) ? "r" : "-");
printf( (file.st_mode & S_IWGRP) ? "w" : "-");
printf( (file.st_mode & S_IXGRP) ? "x" : "-");
printf( (file.st_mode & S_IROTH) ? "r" : "-");
printf( (file.st_mode & S_IWOTH) ? "w" : "-");
printf( (file.st_mode & S_IXOTH) ? "x" : "-");
printf("\n");

if(file.st_mode & S_IFREG)
    printf("File type : Regular\n");
if(file.st_mode & S_IFDIR)
    printf("File type : Directory\n");
}

```

Output

```
$ gcc stat.c
```

```
$ ./a.out fork.c
```

```

User id : 0
Group id : 0
Block size : 4096
Blocks allocated : 8
Inode no. : 16627
Last accessed : Fri Feb 22 21:57:09 2013
Last modified : Fri Feb 22 21:56:13 2013
File size : 591 bytes
No. of links : 1
Permissions : -rw-r--r--
File type : Regular

```

Result

Thus attributes of a file is displayed using stat system call.

Exp# 2e**readdir system call****Date:****Aim**

To display directory contents using readdir system call.

opendir(), readdir() and closedir()

- The opendir system call is used to open a directory
 - It returns a pointer to the first entry
 - It returns NULL on error.
- The readdir system call is used to read a directory as a *dirent* structure
 - It returns a pointer pointing to the next entry in directory stream
 - It returns NULL if an error or end-of-file occurs.
- The closedir system call is used to close the directory stream
- Write to a directory is done only by the kernel.

Algorithm

1. Get directory *name* as command line argument.
2. If directory does not exist then stop.
3. Open the directory using opendir system call that returns a structure
4. Read the directory using readdir system call that returns a structure
5. Display d_name member for each entry.
6. Close the directory using closedir system call.
7. Stop

Program

```

/* Directory content listing - dirlist.c */

#include <stdio.h>
#include <dirent.h>
#include <stdlib.h>

main(int argc, char *argv[])
{
    struct dirent *dptr;
    DIR *dname;

    if (argc != 2)
    {
        printf("Usage: ./a.out <dirname>\n");
        exit(-1);
    }

    if((dname = opendir(argv[1])) == NULL)
    {
        perror(argv[1]);
        exit(-1);
    }

```

```
    }  
  
    while(dptr=readdir(dname))  
        printf("%s\n", dptr->d_name);  
  
    closedir(dname);  
}
```

Output

```
$ gcc dirlist.c
```

```
$ ./a.out vijai
```

```
wait.c
```

```
a.out
```

```
..
```

```
stat.c
```

```
dirlist.c
```

```
fork.c
```

```
.
```

```
exec.c
```

Result

Thus files and subdirectories in the directory was listed that includes hidden files.

Exp# 2f **open system call**

Date :

Aim

To create a file and to write contents.

open()

- Used to open an existing file for reading/writing or to create a new file.
- Returns a file descriptor whose value is negative on error.
- The mandatory flags are O_RDONLY, O_WRONLY and O_RDWR
- Optional flags include O_APPEND, O_CREAT, O_TRUNC, etc
- The flags are ORed.
- The mode specifies permissions for the file.

creat()

- Used to create a new file and open it for writing.
- It is replaced with open() with flags O_WRONLY|O_CREAT | O_TRUNC

Algorithm

1. Declare a character buffer *buf* to store 100 bytes.
2. Get the new filename as command line argument.
3. Create a file with the given name using open system call with O_CREAT and O_TRUNC options.
4. Check the file descriptor.
 - a) If file creation is unsuccessful, then stop.
5. Get input from the console until user types Ctrl+D
 - a) Read 100 bytes (max.) from console and store onto buf using read system call
 - b) Write length of *buf* onto file using write system call.
6. Close the file using close system call.
7. Stop

Program

```
/* File creation - fcreate.c */
```

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

```
main(int argc, char *argv[])
{
    int fd, n, len;
    char buf[100];
```



```

if (argc != 2)
{
    printf("Usage: ./a.out <filename>\n");
    exit(-1);
}

fd = open(argv[1], O_WRONLY|O_CREAT|O_TRUNC, 0644);
if(fd < 0)
{
    printf("File creation problem\n");
    exit(-1);
}

printf("Press Ctrl+D at end in a new line:\n");
while((n = read(0, buf, sizeof(buf))) > 0)
{
    len = strlen(buf);
    write(fd, buf, len);
}
close(fd);
}

```

Output

```
$ gcc fcreate.c
```

```
$ ./a.out hello
```

```
File I/O
```

```
Open system call is used to either open or create a file.
```

```
creat system call is used to create a file. It is seldom used.
```

```
^D
```

Result

Thus a file has been created with input from the user. The process can be verified by using cat command

Exp# 2g **read system call****Date:****Aim**

To read the given file and to display file contents.

read()

- Reads no. of bytes from the file or from the terminal.
- If read is successful, it returns no. of bytes read.
- The file offset is incremented by no. of bytes read.
- If end-of-file is encountered, it returns 0.

Algorithm

1. Declare a character buffer *buf* to store 100 bytes.
2. Get existing filename as command line argument.
3. Open the file for reading using open system call with O_RDONLY option.
4. Check the file descriptor.
 - a) If file does not exist, then stop.
5. Read until end-of-file using read system call.
 - a) Read 100 bytes (max.) from file and print it
6. Close the file using close system call.
7. Stop

Program

```

/* File Read - fread.c */

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

main(int argc, char *argv[])
{
    int fd,i;
    char buf[100];
    if (argc < 2)
    {
        printf("Usage: ./a.out <filename>\n");
        exit(-1);
    }

    fd = open(argv[1], O_RDONLY);
    if(fd == -1)
    {
        printf("%s file does not exist\n", argv[1]);
        exit(-1);
    }

```

```
    }

    printf("Contents of the file %s is : \n", argv[1]);
    while(read(fd, buf, sizeof(buf)) > 0)
        printf("%s", buf);

    close(fd);
}
```

Output

```
$ gcc fread.c
```

```
$ ./a.out hello
```

File I/O

open system call is used to either open or create a file.

creat system call is used to create a file. It is seldom used.

Result

Thus the given file is read and displayed on the console. The process can be verified by using cat command.

Exp# 2h **write system call****Date:****Aim**

To append content to an existing file.

write()

- Writes no. of bytes onto the file.
- After a successful write, file's offset is incremented by the no. of bytes written.
- If any error due to insufficient storage space, write fails.

close()

- Closes a opened file.
- When process terminates, files associated with the process are automatically closed.

Algorithm

1. Declare a character buffer *buf* to store 100 bytes.
2. Get existing filename as command line argument.
3. Create a file with the given name using `open` system call with `O_APPEND` option.
4. Check the file descriptor.
 - a) If value is negative, then stop.
5. Get input from the console until user types Ctrl+D
 - a) Read 100 bytes (max.) from console and store onto *buf* using `read` system call
 - b) Write length of *buf* onto file using `write` system call.
6. Close the file using `close` system call.
7. Stop

Program

```

/* File append - fappend.c */

#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <fcntl.h>

main(int argc, char *argv[])
{
    int fd, n, len;
    char buf[100];

    if (argc != 2)
    {
        printf("Usage: ./a.out <filename>\n");
        exit(-1);
    }

```

```
fd = open(argv[1], O_APPEND|O_WRONLY|O_CREAT, 0644);
if (fd < 0)
{
    perror(argv[1]);
    exit(-1);
}

while((n = read(0, buf, sizeof(buf))) > 0)
{
    len = strlen(buf);
    write(fd, buf, len);
}

close(fd);
}
```

Output

```
$ gcc fappend.c
```

```
$ ./a.out hello
```

```
read system call is used to read from file or console
```

```
write system call is used to write to file.
```

```
^D
```

Result

Thus contents have been written to end of the file. The process can be verified by using cat command.

Exp# 3a ls command**Date:****Aim**

To simulate ls command using UNIX system calls.

Algorithm

1. Store path of current working directory using getcwd system call.
2. Scan directory of the stored path using scandir system call and sort the resultant array of structure.
3. Display dname member for all entries if it is not a hidden file.
4. Stop.

Program

```
/* ls command simulation - list.c */

#include <stdio.h>
#include <dirent.h>

main()
{
    struct dirent **namelist;
    int n,i;
    char pathname[100];

    getcwd(pathname);
    n = scandir(pathname, &namelist, 0, alphasort);

    if(n < 0)
        printf("Error\n");
    else
        for(i=0; i<n; i++)
            if(namelist[i]->d_name[0] != '.')
                printf("%-20s", namelist[i]->d_name);
}
```

Output

```
$ gcc list.c -o list
```

```
$ ./list
```

a.out	cmdpipe.c	consumer.c
dirlist.c	ex6a.c	ex6b.c
ex6c.c	ex6d.c	exec.c
fappend.c	fcfs.c	fcreate.c
fork.c	fread.c	hello
list	list.c	pri.c
producer.c	rr.c	simls.c
sjf.c	stat.c	wait.c

Result

Thus the filenames/subdirectories are listed, similar to ls command

Exp# 3b **grep command****Date:****Aim**

To simulate grep command using UNIX system call.

Algorithm

1. Get filename and search string as command-line argument.
2. Open the file in read-only mode using open system call.
3. If file does not exist, then stop.
4. Let length of the search string be n .
5. Read line-by-line until end-of-file
 - a. Check to find out the occurrence of the search string in a line by examining characters in the range $1-n$, $2-n+1$, etc.
 - b. If search string exists, then print the line.
6. Close the file using close system call.
7. Stop.

Program

```

/* grep command simulation - mygrep.c */

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

main(int argc, char *argv[])
{
    FILE *fd;
    char str[100];
    char c;
    int i, flag, j, m, k;
    char temp[30];
    if(argc != 3)
    {
        printf("Usage: gcc mygrep.c -o mygrep\n");
        printf("Usage: ./mygrep <search_text> <filename>\n");
        exit(-1);
    }

    fd = fopen(argv[2], "r");
    if(fd == NULL)
    {
        printf("%s is not exist\n", argv[2]);
    }

```



```

        exit(-1);
    }

    while(!feof(fd))
    {
        i = 0;
        while(1)
        {
            c = fgetc(fd);
            if(feof(fd))
            {
                str[i++] = '\0';
                break;
            }
            if(c == '\n')
            {
                str[i++] = '\0';
                break;
            }
            str[i++] = c;
        }
        if(strlen(str) >= strlen(argv[1]))
            for(k=0; k<=strlen(str)-strlen(argv[1]); k++)
            {
                for(m=0; m<strlen(argv[1]); m++)
                    temp[m] = str[k+m];
                temp[m] = '\0';
                if(strcmp(temp,argv[1]) == 0)
                {
                    printf("%s\n",str);
                    break;
                }
            }
        }
    }
}

```

Output

```

$ gcc mygrep.c -o mygrep

$ ./mygrep printf dirlist.c
    printf("Usage: ./a.out <dirname>\n");
    printf("%s\n", dptr->d_name);

```

Result

Thus the program simulates grep command by listing lines containing the search text.

Exp# 3c **cp command**

Date:

Aim

To simulate cp command using UNIX system call.

Algorithm

1. Get source and destination *filename* as command-line argument.
2. Declare a buffer of size 1KB
3. Open the source file in readonly mode using open system call.
4. If file does not exist, then stop.
5. Create the destination file using creat system call.
6. If file cannot be created, then stop.
7. File copy is achieved as follows:
 - a. Read 1KB data from source file and store onto buffer using read system call.
 - b. Write the buffer contents onto destination file using write system call.
 - c. If end-of-file then step 8 else step 7a.
8. Close source and destination file using close system call.
9. Stop.

Program

```
/* cp command simulation - copy.c */

#include <stdio.h>
#include <stdlib.h>
#include <fcntl.h>
#include <sys/stat.h>

#define SIZE 1024

main(int argc, char *argv[])
{
    int src, dst, nread;
    char buf[SIZE];

    if (argc != 3)
    {
        printf("Usage: gcc copy.c -o copy\n");
        printf("Usage: ./copy <filename> <newfile> \n");
        exit(-1);
    }

    if ((src = open(argv[1], O_RDONLY)) == -1)
```

```
{
    perror(argv[1]);
    exit(-1);
}

if ((dst = creat(argv[2], 0644)) == -1)
{
    perror(argv[1]);
    exit(-1);
}

while ((nread = read(src, buf, SIZE)) > 0)
{
    if (write(dst, buf, nread) == -1)
    {
        printf("can't write\n");
        exit(-1);
    }
}

close(src);
close(dst);
}
```

Output

```
$ gcc copy.c -o copy
```

```
$ ./copy hello hello.txt
```

Result

Thus a file is copied using file I/O. The `cmp` command can be used to verify that contents of both file are same

Exp# 3d **rm command**

Date:

Aim

To simulate rm command using UNIX system call.

Algorithm

1. Get *filename* as command-line argument.
2. Open the file in read-only mode using read system call.
3. If file does not exist, then stop.
4. Close the file using close system call.
5. Delete the file using unlink system call.
6. Stop.

Program

```
/* rm command simulation - del.c */

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

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

    if (argc != 2)
    {
        printf("Usage: gcc del.c -o del\n");
        printf("Usage: ./del <filename>\n");
        exit(-1);
    }

    fd = open(argv[1], O_RDONLY);
    if (fd != -1)
    {
        close(fd);
        unlink(argv[1]);
    }
    else
        perror(argv[1]);
}
```

Output

```
$ gcc del.c -o del
```

```
$ ./del hello.txt
```

Result

Thus files can be deleted in a manner similar to rm command. The deletion of file can be verified by using ls command.

Exp. No. 4**Shell Programming****Date:****Aim**

To write simple shell scripts using shell programming fundamentals.

The activities of a shell are not restricted to command interpretation alone. The shell also has rudimentary programming features. Shell programs are stored in a file (with extension **.sh**). Shell programs run in interpretive mode. The original UNIX came with the Bourne shell (**sh**) and it is universal even today. C shell (**csh**) and Korn shell (**ksh**) are also widely used. Linux offers Bash shell (**bash**) as a superior alternative to Bourne shell.

Preliminaries

1. Comments in shell script start with **#**.
2. Shell variables are loosely typed i.e. not declared. Variables in an expression or output must be prefixed by **\$**.
3. The **read** statement is shell's internal tool for making scripts interactive.
4. Output is displayed using **echo** statement.
5. Expressions are computed using the **expr** command. Arithmetic operators are + - * / %. Meta characters * () should be escaped with a \.
6. The shell scripts are executed

\$ sh filename

Decision-making

Shell supports decision-making using **if** statement. The **if** statement like its counterpart in programming languages has the following formats.

```
if [ condition ]
then
    statements
fi
```

```
if [ condition ]
then
    statements
else
    statements
fi
```

```
if [condition ]
then
    statements
elif [ condition ]
then
    statements
. . .
else
    statements
fi
```

The set of relational operators are `-eq -ne -gt -ge -lt -le` and logical operators used in conditional expression are `-a -o !`

Multi-way branching

The `case` statement is used to compare a variables value against a set of constants. If it matches a constant, then the set of statements followed after `)` is executed till a `;;` is encountered. The optional *default* block is indicated by `*`. Multiple constants can be specified in a single pattern separated by `|`.

```
case variable in
    constant1)
        statements ;;
    constant2)
        statements ;;
    ...
    *)
        statements
esac
```

Loops

Shell supports a set of loops such as **for**, **while** and **until** to execute a set of statements repeatedly. The body of the loop is contained between **do** and **done** statement.

The **for** loop doesn't test a condition, but uses a list instead.

```
for variable in list
do
    statements
done
```

The **while** loop executes the *statements* as long as the condition remains true.

```
while [ condition ]
do
    statements
done
```

The **until** loop complements the while construct in the sense that the *statements* are executed as long as the condition remains false.

```
until [ condition ]
do
    statements
done
```

A) Swapping values of two variables

```
# Swapping values - swap.sh
echo -n "Enter value for A : "
read a
echo -n "Enter value for B : "
read b
t=$a
a=$b
b=$t
echo "Values after Swapping"
echo "A Value is $a and B Value is $b"
```

Output

```
$ sh swap.sh
Enter value for A : 12
Enter value for B : 23
Values after Swapping
A Value is 23 and B Value is 12
```

B) Farenheit to Centigrade Conversion

```
# Degree conversion - degconv.sh
echo -n "Enter Fahrenheit : "
read f
c=`expr \( $f - 32 \) \* 5 / 9`
echo "Centigrade is : $c"
```

Output

```
$ sh degconv.sh
Enter Fahrenheit : 213
Centigrade is : 100
```

C) Biggest of 3 numbers

```
# Biggest - big3.sh
echo -n "Give value for A B and C: "
read a b c
if [ $a -gt $b -a $a -gt $c ]
then
    echo "A is the Biggest number"
elif [ $b -gt $c ]
then
    echo "B is the Biggest number"
else
    echo "C is the Biggest number"
fi
```

Output

```
$ sh big3.sh
Give value for A B and C: 4 3 4
C is the Biggest number
```


D) Grade Determination

```
# Grade - grade.sh
echo -n "Enter the mark : "
read mark
if [ $mark -gt 90 ]
then
    echo "S Grade"
elif [ $mark -gt 80 ]
then
    echo "A Grade"
elif [ $mark -gt 70 ]
then
    echo "B Grade"
elif [ $mark -gt 60 ]
then
    echo "C Grade"
elif [ $mark -gt 55 ]
then
    echo "D Grade"
elif [ $mark -ge 50 ]
then
    echo "E Grade"
else
    echo "U Grade"
fi
```

Output

```
$ sh grade.sh
Enter the mark : 65
C Grade
```

E) Vowel or Consonant

```
# Vowel - vowel.sh
echo -n "Key in a lower case character : "
read choice
case $choice in
    a|e|i|o|u) echo "It's a Vowel";;
    *) echo "It's a Consonant"
esac
```

Output

```
$ sh vowel.
Key in a lower case character : e
It's a Vowel
```

F) Simple Calculator

```
# Arithmetic operations - calc.sh
echo -n "Enter the two numbers : "
read a b
echo " 1. Addition"
echo " 2. Subtraction"
echo " 3. Multiplication"
echo " 4. Division"
echo -n "Enter the option : "
read option
case $option in
  1) c=`expr $a + $b`
    echo "$a + $b = $c";;
  2) c=`expr $a - $b`
    echo "$a - $b = $c";;
  3) c=`expr $a \* $b`
    echo "$a * $b = $c";;
  4) c=`expr $a / $b`
    echo "$a / $b = $c";;
  *) echo "Invalid Option"
esac
```

Output

```
$ sh calc.sh
Enter the two numbers : 2 4
 1. Addition
 2. Subtraction
 3. Multiplication
 4. Division
Enter the option : 1
2 + 4 = 6
```

G) Multiplication Table

```
# Multiplication table - multable.sh
clear
echo -n "Which multiplication table? : "
read n
for x in 1 2 3 4 5 6 7 8 9 10
do
  p=`expr $x \* $n`
  echo -n "$n X $x = $p"
  sleep 1
done
```

Output

```
$ sh multable.sh
Which multiplication table? : 6
6 X 1 = 6
6 X 2 = 12
.....
```

H) Number Reverse

```
# To reverse a number - reverse.sh
echo -n "Enter a number : "
read n
rd=0
while [ $n -gt 0 ]
do
    rem=`expr $n % 10`
    rd=`expr $rd \* 10 + $rem`
    n=`expr $n / 10`
done
echo "Reversed number is $rd"
```

Output

```
$ sh reverse.sh
Enter a number : 234
Reversed number is 432
```

I) Prime Number

```
# Prime number - prime.sh
echo -n "Enter the number : "
read n
i=2
m=`expr $n / 2`
until [ $i -gt $m ]
do
    q=`expr $n % $i`
    if [ $q -eq 0 ]
    then
        echo "Not a Prime number"
        exit
    fi
    i=`expr $i + 1`
done
echo "Prime number"
```

Output

```
$ sh prime.sh
Enter the number : 17
Prime number
```

Result

Thus shell scripts were executed using different programming constructs

Exp. No. 5a FCFS Scheduling**Date:****Aim**

To schedule snapshot of processes queued according to FCFS scheduling.

Process Scheduling

- CPU scheduling is used in multiprogrammed operating systems.
- By switching CPU among processes, efficiency of the system can be improved.
- Some scheduling algorithms are FCFS, SJF, Priority, Round-Robin, etc.
- Gantt chart provides a way of visualizing CPU scheduling and enables to understand better.

First Come First Serve (FCFS)

- Process that comes first is processed first
- FCFS scheduling is non-preemptive
- Not efficient as it results in long average waiting time.
- Can result in starvation, if processes at beginning of the queue have long bursts.

Algorithm

1. Define an array of structure *process* with members *pid*, *btime*, *wtime* & *ttime*.
2. Get length of the ready queue, i.e., number of process (say *n*)
3. Obtain *btime* for each process.
4. The *wtime* for first process is 0.
5. Compute *wtime* and *ttime* for each process as:
 - a. $wtime_{i+1} = wtime_i + btime_i$
 - b. $ttime_i = wtime_i + btime_i$
6. Compute average waiting time *awat* and average turnaround time *atur*
7. Display the *btime*, *ttime* and *wtime* for each process.
8. Display GANTT chart for the above scheduling
9. Display *awat* time and *atur*
10. Stop

Program

```

/* FCFS Scheduling - fcfs.c */

#include <stdio.h>

struct process
{
    int pid;
    int btime;
    int wtime;
    int ttime;
} p[10];

main()
{
    int i,j,k,n,ttur,twat;
    float awat,atur;

    printf("Enter no. of process : ");
    scanf("%d", &n);
    for(i=0; i<n; i++)
    {
        printf("Burst time for process P%d (in ms) : ",(i+1));
        scanf("%d", &p[i].btime);
        p[i].pid = i+1;
    }

    p[0].wtime = 0;
    for(i=0; i<n; i++)
    {
        p[i+1].wtime = p[i].wtime + p[i].btime;
        p[i].ttime = p[i].wtime + p[i].btime;
    }
    ttur = twat = 0;
    for(i=0; i<n; i++)
    {
        ttur += p[i].ttime;
        twat += p[i].wtime;
    }
    awat = (float)twat / n;
    atur = (float)ttur / n;

    printf("\n          FCFS Scheduling\n\n");
    for(i=0; i<28; i++)
        printf("-");
    printf("\nProcess B-Time T-Time W-Time\n");
    for(i=0; i<28; i++)
        printf("-");

```

```

for(i=0; i<n; i++)
    printf("\n  P%d\t%4d\t%3d\t%2d",
           p[i].pid,p[i].btime,p[i].ttime,p[i].wtime);
printf("\n");
for(i=0; i<28; i++)
    printf("-");

printf("\n\nAverage waiting time      : %5.2fms", awat);
printf("\nAverage turn around time : %5.2fms\n", atur);

printf("\n\nGANTT Chart\n");
printf("-");
for(i=0; i<(p[n-1].ttime + 2*n); i++)
    printf("-");
printf("\n");
printf("|");
for(i=0; i<n; i++)
{
    k = p[i].btime/2;
    for(j=0; j<k; j++)
        printf(" ");
    printf("P%d",p[i].pid);
    for(j=k+1; j<p[i].btime; j++)
        printf(" ");
    printf("|");
}
printf("\n");
printf("-");
for(i=0; i<(p[n-1].ttime + 2*n); i++)
    printf("-");
printf("\n");
printf("0");
for(i=0; i<n; i++)
{
    for(j=0; j<p[i].btime; j++)
        printf(" ");
    printf("%2d",p[i].ttime);
}
}

```

Output

Enter no. of process : 4
 Burst time for process P1 (in ms) : 10
 Burst time for process P2 (in ms) : 4
 Burst time for process P3 (in ms) : 11
 Burst time for process P4 (in ms) : 6

FCFS Scheduling

Process	B-Time	T-Time	W-Time
P1	10	10	0
P2	4	14	10
P3	11	25	14
P4	6	31	25

Average waiting time : 12.25ms
 Average turn around time : 20.00ms

GANTT Chart

	P1	P2	P3	P4
0	10	14	25	31

Result

Thus waiting time & turnaround time for processes based on FCFS scheduling was computed and the average waiting time was determined.

Exp. No. 5b SJF Scheduling**Date:****Aim**

To schedule snapshot of processes queued according to SJF scheduling.

Shortest Job First (SJF)

- Process that requires smallest burst time is processed first.
- SJF can be preemptive or non-preemptive
- When two processes require same amount of CPU utilization, FCFS is used to break the tie.
- Generally efficient as it results in minimal average waiting time.
- Can result in starvation, since long critical processes may not be processed.

Algorithm

1. Define an array of structure *process* with members *pid*, *btime*, *wtime* & *ttime*.
2. Get length of the ready queue, i.e., number of process (say *n*)
3. Obtain *btime* for each process.
4. Sort the processes according to their *btime* in ascending order.
 - a. If two process have same *btime*, then FCFS is used to resolve the tie.
5. The *wtime* for first process is 0.
6. Compute *wtime* and *ttime* for each process as:
 - a. $wtime_{i+1} = wtime_i + btime_i$
 - b. $ttime_i = wtime_i + btime_i$
7. Compute average waiting time *awat* and average turn around time *atur*.
8. Display *btime*, *ttime* and *wtime* for each process.
9. Display GANTT chart for the above scheduling
10. Display *awat* and *atur*
11. Stop

Program

```

/* SJF Scheduling - sjf.c */

#include <stdio.h>

struct process
{
    int pid;
    int btime;
    int wtime;
    int ttime;
} p[10], temp;

main()
{
    int i,j,k,n,ttur,twat;
    float awat,atur;

    printf("Enter no. of process : ");
    scanf("%d", &n);
    for(i=0; i<n; i++)
    {
        printf("Burst time for process P%d (in ms) : ",(i+1));
        scanf("%d", &p[i].btime);
        p[i].pid = i+1;
    }

    for(i=0; i<n-1; i++)
    {
        for(j=i+1; j<n; j++)
        {
            if((p[i].btime > p[j].btime) ||
                (p[i].btime == p[j].btime && p[i].pid > p[j].pid))
            {
                temp = p[i];
                p[i] = p[j];
                p[j] = temp;
            }
        }
    }
    p[0].wtime = 0;
    for(i=0; i<n; i++)
    {
        p[i+1].wtime = p[i].wtime + p[i].btime;
        p[i].ttime = p[i].wtime + p[i].btime;
    }
    ttur = twat = 0;

```

```

for(i=0; i<n; i++)
{
    ttur += p[i].ttime;
    twat += p[i].wtime;
}
awat = (float)twat / n;
atur = (float)ttur / n;

printf("\n      SJF Scheduling\n\n");
for(i=0; i<28; i++)
    printf("-");
printf("\nProcess B-Time T-Time W-Time\n");
for(i=0; i<28; i++)
    printf("-");
for(i=0; i<n; i++)
    printf("\n  P%-4d\t%4d\t%3d\t%2d",
           p[i].pid,p[i].btime,p[i].ttime,p[i].wtime);
printf("\n");
for(i=0; i<28; i++)
    printf("-");
printf("\n\nAverage waiting time      : %5.2fms", awat);
printf("\nAverage turn around time : %5.2fms\n", atur);

printf("\n\nGANTT Chart\n");
printf("-");
for(i=0; i<(p[n-1].ttime + 2*n); i++)
    printf("-");
printf("\n|");
for(i=0; i<n; i++)
{
    k = p[i].btime/2;
    for(j=0; j<k; j++)
        printf(" ");
    printf("P%d",p[i].pid);
    for(j=k+1; j<p[i].btime; j++)
        printf(" ");
    printf("|");
}
printf("\n-");
for(i=0; i<(p[n-1].ttime + 2*n); i++)
    printf("-");
printf("\n0");
for(i=0; i<n; i++)
{
    for(j=0; j<p[i].btime; j++)
        printf(" ");
    printf("%2d",p[i].ttime);
}
}

```

Output

```

Enter no. of process : 5
Burst time for process P1 (in ms) : 10
Burst time for process P2 (in ms) : 6
Burst time for process P3 (in ms) : 5
Burst time for process P4 (in ms) : 6
Burst time for process P5 (in ms) : 9

```

SJF Scheduling

Process	B-Time	T-Time	W-Time
P3	5	5	0
P2	6	11	5
P4	6	17	11
P5	9	26	17
P1	10	36	26

```

Average waiting time      : 11.80ms
Average turn around time : 19.00ms

```

GANTT Chart

0	5	11	17	26	36
P3	P2	P4	P5	P1	

Result

Thus waiting time & turnaround time for processes based on SJF scheduling was computed and the average waiting time was determined.

Exp. No. 5c

Priority Scheduling

Date:

Aim

To schedule snapshot of processes queued according to Priority scheduling.

Priority

- Process that has higher priority is processed first.
- Priority can be preemptive or non-preemptive
- When two processes have same priority, FCFS is used to break the tie.
- Can result in starvation, since low priority processes may not be processed.

Algorithm

1. Define an array of structure *process* with members *pid*, *btime*, *pri*, *wtime* & *ttime*.
2. Get length of the ready queue, i.e., number of process (say *n*)
3. Obtain *btime* and *pri* for each process.
4. Sort the processes according to their *pri* in ascending order.
 - a. If two process have same *pri*, then FCFS is used to resolve the tie.
5. The *wtime* for first process is 0.
6. Compute *wtime* and *ttime* for each process as:
 - a. $wtime_{i+1} = wtime_i + btime_i$
 - b. $ttime_i = wtime_i + btime_i$
7. Compute average waiting time *awat* and average turn around time *atur*
8. Display the *btime*, *pri*, *ttime* and *wtime* for each process.
9. Display GANTT chart for the above scheduling
10. Display *awat* and *atur*
11. Stop

Program

```

/* Priority Scheduling - pri.c */

#include <stdio.h>

struct process
{
    int pid;
    int btime;
    int pri;
    int wtime;
    int ttime;
} p[10], temp;

main()
{
    int i,j,k,n,ttur,twat;
    float awat,atur;

    printf("Enter no. of process : ");
    scanf("%d", &n);
    for(i=0; i<n; i++)
    {
        printf("Burst time for process P%d (in ms) : ", (i+1));
        scanf("%d", &p[i].btime);
        printf("Priority for process P%d : ", (i+1));
        scanf("%d", &p[i].pri);
        p[i].pid = i+1;
    }

    for(i=0; i<n-1; i++)
    {
        for(j=i+1; j<n; j++)
        {
            if((p[i].pri > p[j].pri) ||
                (p[i].pri == p[j].pri && p[i].pid > p[j].pid) )
            {
                temp = p[i];
                p[i] = p[j];
                p[j] = temp;
            }
        }
    }
    p[0].wtime = 0;
    for(i=0; i<n; i++)
    {
        p[i+1].wtime = p[i].wtime + p[i].btime;
        p[i].ttime = p[i].wtime + p[i].btime;
    }
}

```

```

ttur = twat = 0;
for(i=0; i<n; i++)
{
    ttur += p[i].ttime;
    twat += p[i].wtime;
}
awat = (float)twat / n;
atur = (float)ttur / n;

printf("\n\t Priority Scheduling\n\n");
for(i=0; i<38; i++)
    printf("-");
printf("\nProcess B-Time Priority T-Time  W-Time\n");
for(i=0; i<38; i++)
    printf("-");
for (i=0; i<n; i++)
    printf("\n  P%-4d\t%4d\t%3d\t%4d\t%4d",
        p[i].pid,p[i].btime,p[i].pri,p[i].ttime,p[i].wtime);
printf("\n");
for(i=0; i<38; i++)
    printf("-");

printf("\n\nAverage waiting time      : %5.2fms", awat);
printf("\nAverage turn around time : %5.2fms\n", atur);

printf("\n\nGANTT Chart\n");
printf("-");
for(i=0; i<(p[n-1].ttime + 2*n); i++)
    printf("-");
printf("\n|");
for(i=0; i<n; i++)
{
    k = p[i].btime/2;
    for(j=0; j<k; j++)
        printf(" ");
    printf("P%d",p[i].pid);
    for(j=k+1; j<p[i].btime; j++)
        printf(" ");
    printf("|");
}
printf("\n-");
for(i=0; i<(p[n-1].ttime + 2*n); i++)
    printf("-");
printf("\n0");
for(i=0; i<n; i++)
{
    for(j=0; j<p[i].btime; j++)
        printf(" ");
    printf("%2d",p[i].ttime);
}
}

```

Output

```

Enter no. of process : 5
Burst time for process P1 (in ms) : 10
Priority for process P1 : 3
Burst time for process P2 (in ms) : 7
Priority for process P2 : 1
Burst time for process P3 (in ms) : 6
Priority for process P3 : 3
Burst time for process P4 (in ms) : 13
Priority for process P4 : 4
Burst time for process P5 (in ms) : 5
Priority for process P5 : 2

```

Priority Scheduling

Process	B-Time	Priority	T-Time	W-Time
P2	7	1	7	0
P5	5	2	12	7
P1	10	3	22	12
P3	6	3	28	22
P4	13	4	41	28

```

Average waiting time      : 13.80ms
Average turn around time : 22.00ms

```

GANTT Chart

	P2		P5		P1		P3		P4	
0	7	12	22	28	41					

Result

Thus waiting time & turnaround time for processes based on Priority scheduling was computed and the average waiting time was determined.

Exp. No. 5d Round Robin Scheduling**Date:****Aim**

To schedule snapshot of processes queued according to Round robin scheduling.

Round Robin

- All processes are processed one by one as they have arrived, but in rounds.
- Each process cannot take more than the time slice per round.
- Round robin is a fair preemptive scheduling algorithm.
- A process that is yet to complete in a round is preempted after the time slice and put at the end of the queue.
- When a process is completely processed, it is removed from the queue.

Algorithm

1. Get length of the ready queue, i.e., number of process (say n)
2. Obtain *Burst* time B_i for each processes P_i .
3. Get the *time slice* per round, say TS
4. Determine the number of rounds for each process.
5. The wait time for first process is 0.
6. If $B_i > TS$ then process takes more than one round. Therefore turnaround and waiting time should include the time spent for other remaining processes in the same round.
7. Calculate *average* waiting time and turn around time
8. Display the GANTT chart that includes
 - a. order in which the processes were processed in progression of rounds
 - b. Turnaround time T_i for each process in progression of rounds.
9. Display the *burst* time, *turnaround* time and *wait* time for each process (in order of rounds they were processed).
10. Display *average* wait time and turnaround time
11. Stop

Program

```

/* Round robin scheduling - rr.c */

#include <stdio.h>

main()
{
    int i,x=-1,k[10],m=0,n,t,s=0;
    int a[50],temp,b[50],p[10],bur[10],bur1[10];
    int wat[10],tur[10],ttur=0,twat=0,j=0;
    float awat,atur;

    printf("Enter no. of process : ");
    scanf("%d", &n);
    for(i=0; i<n; i++)
    {
        printf("Burst time for process P%d : ", (i+1));
        scanf("%d", &bur[i]);
        bur1[i] = bur[i];
    }
    printf("Enter the time slice (in ms) : ");
    scanf("%d", &t);

    for(i=0; i<n; i++)
    {
        b[i] = bur[i] / t;
        if((bur[i]%t) != 0)
            b[i] += 1;
        m += b[i];
    }

    printf("\n\t\tRound Robin Scheduling\n");

    printf("\nGANTT Chart\n");
    for(i=0; i<m; i++)
        printf("-----");
    printf("\n");

    a[0] = 0;
    while(j < m)
    {
        if(x == n-1)
            x = 0;
        else
            x++;
        if(bur[x] >= t)
        {
            bur[x] -= t;
            a[j+1] = a[j] + t;

```

```

        if(b[x] == 1)
        {
            p[s] = x;
            k[s] = a[j+1];
            s++;
        }
        j++;
        b[x] -= 1;
        printf("  P%d    |", x+1);
    }
    else if(bur[x] != 0)
    {
        a[j+1] = a[j] + bur[x];
        bur[x] = 0;
        if(b[x] == 1)
        {
            p[s] = x;
            k[s] = a[j+1];
            s++;
        }
        j++;
        b[x] -= 1;
        printf("  P%d    |", x+1);
    }
}

printf("\n");
for(i=0; i<m; i++)
    printf(" -----");
printf("\n");

for(j=0; j<=m; j++)
    printf("%d\t", a[j]);

for(i=0; i<n; i++)
{
    for(j=i+1; j<n; j++)
    {
        if(p[i] > p[j])
        {
            temp = p[i];
            p[i] = p[j];
            p[j] = temp;

            temp = k[i];
            k[i] = k[j];
            k[j] = temp;
        }
    }
}
}

```

```

for(i=0; i<n; i++)
{
    wat[i] = k[i] - bur1[i];
    tur[i] = k[i];
}
for(i=0; i<n; i++)
{
    ttur += tur[i];
    twat += wat[i];
}

printf("\n\n");
for(i=0; i<30; i++)
    printf("-");
printf("\nProcess\tBurst\tTrnd\tWait\n");
for(i=0; i<30; i++)
    printf("-");
for (i=0; i<n; i++)
    printf("\nP%-4d\t%4d\t%4d\t%4d", p[i]+1, bur1[i],
        tur[i], wat[i]);
printf("\n");
for(i=0; i<30; i++)
    printf("-");

awat = (float)twat / n;
atur = (float)ttur / n;
printf("\n\nAverage waiting time      : %.2f ms", awat);
printf("\nAverage turn around time : %.2f ms\n", atur);
}

```

Output

```

Enter no. of process : 5
Burst time for process P1 : 10
Burst time for process P2 : 29
Burst time for process P3 : 3
Burst time for process P4 : 7
Burst time for process P5 : 12
Enter the time slice (in ms) : 10

```

Round Robin Scheduling

GANTT Chart

P1		P2		P3		P4		P5		P2		P5		P2	
0	10	20	23	30	40	50	52	61							

Process	Burst	Trnd	Wait
P1	10	10	0
P2	29	61	32
P3	3	23	20
P4	7	30	23
P5	12	52	40

```

Average waiting time      : 23.00 ms
Average turn around time : 35.20 ms

```

Result

Thus waiting time and turnaround time for processes based on Round robin scheduling was computed and the average waiting time was determined.

Exp. No. 6 Semaphore Implementation

Date:

Aim

To demonstrate the utility of semaphore in synchronization and multithreading.

Semaphore

- The POSIX system in Linux has its own built-in semaphore library.
- To use it, include `semaphore.h`.
- Compile the code by linking with `-lpthread -lrt`.
- To lock a semaphore or wait, use the **sem_wait** function.
- To release or signal a semaphore, use the **sem_post** function.
- A semaphore is initialised by using **sem_init**(for processes or threads)
- To declare a semaphore, the data type is `sem_t`.

Algorithm

1. 2 threads are being created, one 2 seconds after the first one.
2. But the first thread will sleep for 4 seconds after acquiring the lock.
3. Thus the second thread will not enter immediately after it is called, it will enter $4 - 2 = 2$ secs after it is called.
4. Stop.

Program

```
/* C program to demonstrate working of Semaphores */

#include <stdio.h>
#include <pthread.h>
#include <semaphore.h>
#include <unistd.h>

sem_t mutex;

void* thread(void* arg)
{
    //wait
    sem_wait(&mutex);
    printf("\nEntered..\n");

    //critical section
    sleep(4);
}
```

```
        //signal
        printf("\nJust Exiting...\n");
        sem_post(&mutex);
    }

int main()
{
    sem_init(&mutex, 0, 1);
    pthread_t t1,t2;
    pthread_create(&t1,NULL,thread,NULL);
    sleep(2);
    pthread_create(&t2,NULL,thread,NULL);
    pthread_join(t1,NULL);
    pthread_join(t2,NULL);
    sem_destroy(&mutex);
    return 0;
}
```

Output

```
$ gcc sem.c -lpthread
```

```
$ ./a.out
```

```
Entered..
Just Exiting...
Entered..
Just Exiting...
```

Result

Thus semaphore implementation has been demonstrated.

Exp. No. 7a Fibonacci & Prime Number**Date:****Aim**

To generate 25 fibonacci numbers and determine prime amongst them using pipe.

Interprocess Communication

- Inter-Process communication (IPC), is the mechanism whereby one process can communicate with another process, i.e exchange data.
- IPC in linux can be implemented using pipe, shared memory, message queue, semaphore, signal or sockets.

Pipe

- Pipes are unidirectional byte streams which connect the standard output from one process into the standard input of another process.
- A pipe is created using the system call *pipe* that returns a pair of file descriptors.
- The descriptor *pfid[0]* is used for reading and *pfid[1]* is used for writing.
- Can be used only between parent and child processes.

Algorithm

1. Declare a array to store fibonacci numbers
2. Decalre a array *pfid* with two elements for pipe descriptors.
3. Create pipe on *pfid* using *pipe* function call.
 - a. If return value is -1 then stop
4. Using *fork* system call, create a child process.
5. Let the child process generate 25 fibonacci numbers and store them in a array.
6. Write the array onto pipe using *write* system call.
7. Block the parent till child completes using *wait* system call.
8. Store fibonacci nos. written by child from the pipe in an array using *read* system call
9. Inspect each element of the fibonacci array and check whether they are prime
 - a. If prime then print the fibonacci term.
10. Stop

Program

```
/* Fibonacci and Prime using pipe - fibprime.c */

#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <sys/types.h>

main()
{
    pid_t pid;
```

```

int pfd[2];
int i,j,flg,f1,f2,f3;
static unsigned int ar[25],br[25];

if(pipe(pfd) == -1)
{
    printf("Error in pipe");
    exit(-1);
}

pid=fork();
if (pid == 0)
{
    printf("Child process generates Fibonacci series\n" );
    f1 = -1;
    f2 = 1;
    for(i = 0;i < 25; i++)
    {
        f3 = f1 + f2;
        printf("%d\t",f3);
        f1 = f2;
        f2 = f3;
        ar[i] = f3;
    }
    write(pfd[1],ar,25*sizeof(int));
}
else if (pid > 0)
{
    wait(NULL);
    read(pfd[0], br, 25*sizeof(int));
    printf("\nParent prints Fibonacci that are Prime\n");

    for(i = 0;i < 25; i++)
    {
        flg = 0;
        if (br[i] <= 1)
            flg = 1;
        for(j=2; j<=br[i]/2; j++)
        {
            if (br[i]%j == 0)
            {
                flg=1;
                break;
            }
        }
        if (flg == 0)
            printf("%d\t", br[i]);
    }
    printf("\n");
}

```



```

    else
    {
        printf("Process creation failed");
        exit(-1);
    }
}

```

Output

```
$ gcc fibprime.c
```

```
$ ./a.out
```

Child process generates Fibonacci series

0	1	1	2	3	5	8	13
21	34	55	89	144	233	377	610
987	1597	2584	4181	6765	10946	17711	28657
46368							

Parent prints Fibonacci that are Prime

2	3	5	13	89	233	1597	28657
---	---	---	----	----	-----	------	-------

Result

Thus fibonacci numbers that are prime is determined using IPC pipe.

Exp. No. 7b **who | wc -l**

Date:

Aim

To determine number of users logged in using pipe.

Algorithm

1. Declare an array *pfds* with two elements for pipe descriptors.
2. Create pipe on *pfds* using pipe function call.
 - a. If return value is -1 then stop
3. Using fork system call, create a child process.
4. Free the standard output (1) using close system call to redirect the output to pipe.
5. Make a copy of write end of the pipe using dup system call.
6. Execute **who** command using **execlp** system call.
7. Free the standard input (0) using close system call in the other process.
8. Make a close of read end of the pipe using dup system call.
9. Execute **wc -l** command using **execlp** system call.
10. Stop

Program

```
/* No. of users logged - cmdpipe.c */

#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>

int main()
{
    int pfd[2];
    pipe(pfd);

    if (!fork())
    {
        close(1);
        dup(pfd[1]);
        close(pfd[0]);
        execlp("who", "who", NULL);
    }
}
```

```
    else
    {
        close(0);
        dup(pfds[0]);
        close(pfds[1]);
        execlp("wc", "wc", "-l", NULL);
    }
}
```

Output

```
$ gcc cmdpipe.c
```

```
$ ./a.out
15
```

Result

Thus standard output of who is connected to standard input of wc using pipe to compute number of users logged in.

Exp# 7c**Chat Messaging****Date:****Aim**

To exchange message between server and client using message queue.

Message Queue

- A message queue is a linked list of messages stored within the kernel
- A message queue is identified by a unique identifier
- Every message has a positive long integer type field, a non-negative length, and the actual data bytes.
- The messages need not be fetched on FCFS basis. It could be based on type field.

AlgorithmServer

1. Declare a structure *mesgq* with *type* and *text* fields.
2. Initialize *key* to 2013 (some random value).
3. Create a message queue using *msgget* with *key* & *IPC_CREAT* as parameter.
 - a. If message queue cannot be created then stop.
4. Initialize the message *type* member of *mesgq* to 1.
5. Do the following until user types Ctrl+D
 - a. Get message from the user and store it in *text* member.
 - b. Delete the newline character in *text* member.
 - c. Place message on the queue using *msgsend* for the client to read.
 - d. Retrieve the response message from the client using *msgrcv* function
 - e. Display the *text* contents.
6. Remove message queue from the system using *msgctl* with *IPC_RMID* as parameter.
7. Stop

Client

1. Declare a structure *mesgq* with *type* and *text* fields.
2. Initialize *key* to 2013 (same value as in server).
3. Open the message queue using *msgget* with *key* as parameter.
 - a. If message queue cannot be opened then stop.
4. Do while the message queue exists
 - a. Retrieve the response message from the server using *msgrcv* function
 - b. Display the *text* contents.
 - c. Get message from the user and store it in *text* member.
 - d. Delete the newline character in *text* member.
 - e. Place message on the queue using *msgsend* for the server to read.
5. Print "Server Disconnected".

6. Stop

Program

Server

```

/* Server chat process - srvmsg.c */

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/msg.h>

struct mesgq
{
    long type;
    char text[200];
} mq;

main()
{
    int msqid, len;
    key_t key = 2013;

    if((msqid = msgget(key, 0644|IPC_CREAT)) == -1)
    {
        perror("msgget");
        exit(1);
    }

    printf("Enter text, ^D to quit:\n");
    mq.type = 1;

    while(fgets(mq.text, sizeof(mq.text), stdin) != NULL)
    {
        len = strlen(mq.text);
        if (mq.text[len-1] == '\n')
            mq.text[len-1] = '\0';
        msgsnd(msqid, &mq, len+1, 0);

        msgrcv(msqid, &mq, sizeof(mq.text), 0, 0);
        printf("From Client: \"%s\"\n", mq.text);
    }
    msgctl(msqid, IPC_RMID, NULL);
}

```

Client

```
/* Client chat process - climsg.c */

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/msg.h>

struct msgq
{
    long type;
    char text[200];
} mq;

main()
{
    int msqid, len;
    key_t key = 2013;

    if ((msqid = msgget(key, 0644)) == -1)
    {
        printf("Server not active\n");
        exit(1);
    }

    printf("Client ready :\n");
    while (msgrcv(msqid, &mq, sizeof(mq.text), 0, 0) != -1)
    {
        printf("From Server: \"%s\"\n", mq.text);

        fgets(mq.text, sizeof(mq.text), stdin);
        len = strlen(mq.text);
        if (mq.text[len-1] == '\\n')
            mq.text[len-1] = '\\0';
        msgsnd(msqid, &mq, len+1, 0);
    }
    printf("Server Disconnected\n");
}
```

Output

Server

```
$ gcc srvmsg.c -o srvmsg

$ ./srvmsg
Enter text, ^D to quit:
hi
From Client: "hello"
Where r u?
From Client: "I'm where i am"
bye
From Client: "ok"
^D
```

Client

```
$ gcc climsg.c -o climsg

$ ./climsg
Client ready:
From Server: "hi"
hello
From Server: "Where r u?"
I'm where i am
From Server: "bye"
ok
Server Disconnected
```

Result

Thus chat session between client and server was done using message queue.

Exp. No 7d**Shared Memory****Date:****Aim**

To demonstrate communication between process using shared memory.

Shared memory

- Two or more processes share a single chunk of memory to communicate randomly.
- Semaphores are generally used to avoid race condition amongst processes.
- Fastest amongst all IPCs as it does not require any system call.
- It avoids copying data unnecessarily.

AlgorithmServer

1. Initialize size of shared memory *shmsize* to 27.
2. Initialize *key* to 2013 (some random value).
3. Create a shared memory segment using *shmget* with *key* & *IPC_CREAT* as parameter.
 - a. If shared memory identifier *shmid* is -1, then stop.
4. Display *shmid*.
5. Attach server process to the shared memory using *shmat* with *shmid* as parameter.
 - a. If pointer to the shared memory is not obtained, then stop.
6. Clear contents of the shared region using *memset* function.
7. Write a–z onto the shared memory.
8. Wait till client reads the shared memory contents
9. Detach process from the shared memory using *shmdt* system call.
10. Remove shared memory from the system using *shmctl* with *IPC_RMID* argument
11. Stop

Client

1. Initialize size of shared memory *shmsize* to 27.
2. Initialize *key* to 2013 (same value as in server).
3. Obtain access to the same shared memory segment using same *key*.
 - a. If obtained then display the *shmid* else print "Server not started"
4. Attach client process to the shared memory using *shmat* with *shmid* as parameter.
 - a. If pointer to the shared memory is not obtained, then stop.
5. Read contents of shared memory and print it.
6. After reading, modify the first character of shared memory to '*'
7. Stop

Program

Server

```

/* Shared memory server - shms.c */

#include <stdio.h>
#include <stdlib.h>
#include <sys/un.h>
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>

#define shmsize 27

main()
{
    char c;
    int shmid;
    key_t key = 2013;
    char *shm, *s;

    if ((shmid = shmget(key, shmsize, IPC_CREAT|0666)) < 0)
    {
        perror("shmget");
        exit(1);
    }
    printf("Shared memory id : %d\n", shmid);

    if ((shm = shmat(shmid, NULL, 0)) == (char *) -1)
    {
        perror("shmat");
        exit(1);
    }

    memset(shm, 0, shmsize);
    s = shm;
    printf("Writing (a-z) onto shared memory\n");
    for (c = 'a'; c <= 'z'; c++)
        *s++ = c;
    *s = '\0';

    while (*shm != '*');
    printf("Client finished reading\n");

    if(shmdt(shm) != 0)
        fprintf(stderr, "Could not close memory segment.\n");

    shmctl(shmid, IPC_RMID, 0);
}

```

Client

```
/* Shared memory client - shmc.c */

#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>

#define shmsize 27

main()
{
    int shmid;
    key_t key = 2013;
    char *shm, *s;

    if ((shmid = shmget(key, shmsize, 0666)) < 0)
    {
        printf("Server not started\n");
        exit(1);
    }
    else
        printf("Accessing shared memory id : %d\n",shmid);

    if ((shm = shmat(shmid, NULL, 0)) == (char *) -1)
    {
        perror("shmat");
        exit(1);
    }

    printf("Shared memory contents:\n");
    for (s = shm; *s != '\0'; s++)
        putchar(*s);
    putchar('\n');

    *shm = '*';
}
```

Output

Server

```
$ gcc shms.c -o shms
```

```
$ ./shms
```

```
Shared memory id : 196611
```

```
Writing (a-z) onto shared memory
```

```
Client finished reading
```

Client

```
$ gcc shmc.c -o shmc
```

```
$ ./shmc
```

```
Accessing shared memory id : 196611
```

```
Shared memory contents:
```

```
abcdefghijklmnopqrstuvwxyz
```

Result

Thus contents written onto shared memory by the server process is read by the client process.

Exp. No 7e

Producer-Consumer problem

Date:

Aim

To synchronize producer and consumer processes using semaphore.

Semaphores

- A semaphore is a counter used to synchronize access to a shared data amongst multiple processes.
- To obtain a shared resource, the process should:
 - Test the semaphore that controls the resource.
 - If value is positive, it gains access and decrements value of semaphore.
 - If value is zero, the process goes to sleep and awakes when value is > 0 .
- When a process relinquishes resource, it increments the value of semaphore by 1.

Producer-Consumer problem

- A producer process produces information to be consumed by a consumer process
- A producer can produce one item while the consumer is consuming another one.
- With bounded-buffer size, consumer must wait if buffer is empty, whereas producer must wait if buffer is full.
- The buffer can be implemented using any IPC facility.

Algorithm

1. Create a shared memory segment *BUFSIZE* of size 1 and attach it.
2. Obtain semaphore id for variables *empty*, *mutex* and *full* using *semget* function.
3. Create semaphore for *empty*, *mutex* and *full* as follows:
 - a. Declare *semun*, a union of specific commands.
 - b. The initial values are: 1 for *mutex*, N for *empty* and 0 for *full*
 - c. Use *semctl* function with *SETVAL* command
4. Create a child process using *fork* system call.
 - a. Make the parent process to be the *producer*
 - b. Make the child process to the *consumer*
5. The *producer* produces 5 items as follows:
 - a. Call *wait* operation on semaphores *empty* and *mutex* using *semop* function.
 - b. Gain access to buffer and produce data for consumption
 - c. Call *signal* operation on semaphores *mutex* and *full* using *semop* function.
6. The *consumer* consumes 5 items as follows:
 - a. Call *wait* operation on semaphores *full* and *mutex* using *semop* function.
 - b. Gain access to buffer and consume the available data.
 - c. Call *signal* operation on semaphores *mutex* and *empty* using *semop* function.
7. Remove shared memory from the system using *shmctl* with *IPC_RMID* argument
8. Stop

Program

```

/* Producer-Consumer problem using semaphore - pcsem.c */

#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>
#include <sys/sem.h>

#define N 5
#define BUFSIZE 1
#define PERMS 0666

int *buffer;
int nextp = 0, nextc = 0;
int mutex, full, empty;    /* semaphore variables */

void producer()
{
    int data;
    if(nextp == N)
        nextp = 0;
    printf("Enter data for producer to produce : ");
    scanf("%d", (buffer + nextp));
    nextp++;
}

void consumer()
{
    int g;
    if(nextc == N)
        nextc = 0;
    g = *(buffer + nextc++);
    printf("\nConsumer consumes data %d", g);
}

void sem_op(int id, int value)
{
    struct sembuf op;
    int v;
    op.sem_num = 0;
    op.sem_op = value;
    op.sem_flg = SEM_UNDO;
    if((v = semop(id, &op, 1)) < 0)
        printf("\nError executing semop instruction");
}

```

```

void sem_create(int semid, int initval)
{
    int semval;
    union semun
    {
        int val;
        struct semid_ds *buf;
        unsigned short *array;
    } s;

    s.val = initval;
    if((semval = semctl(semid, 0, SETVAL, s)) < 0)
        printf("\nError in executing semctl");
}

void sem_wait(int id)
{
    int value = -1;
    sem_op(id, value);
}

void sem_signal(int id)
{
    int value = 1;
    sem_op(id, value);
}

main()
{
    int shmid, i;
    pid_t pid;

    if((shmid = shmget(1000, BUFSIZE, IPC_CREAT|PERMS)) < 0)
    {
        printf("\nUnable to create shared memory");
        return;
    }
    if((buffer = (int*)shmat(shmid, (char*)0, 0)) == (int*)-1)
    {
        printf("\nShared memory allocation error\n");
        exit(1);
    }

    if((mutex = semget(IPC_PRIVATE, 1, PERMS|IPC_CREAT)) == -1)
    {
        printf("\nCan't create mutex semaphore");
        exit(1);
    }
}

```

```

if((empty = semget(IPC_PRIVATE, 1, PERMS|IPC_CREAT)) == -1)
{
    printf("\nCan't create empty semaphore");
    exit(1);
}
if((full = semget(IPC_PRIVATE, 1, PERMS|IPC_CREAT)) == -1)
{
    printf("\nCan't create full semaphore");
    exit(1);
}

sem_create(mutex, 1);
sem_create(empty, N);
sem_create(full, 0);

if((pid = fork()) < 0)
{
    printf("\nError in process creation");
    exit(1);
}
else if(pid > 0)
{
    for(i=0; i<N; i++)
    {
        sem_wait(empty);
        sem_wait(mutex);
        producer();
        sem_signal(mutex);
        sem_signal(full);
    }
}
else if(pid == 0)
{
    for(i=0; i<N; i++)
    {
        sem_wait(full);
        sem_wait(mutex);
        consumer();
        sem_signal(mutex);
        sem_signal(empty);
    }
    printf("\n");
}
}

```

Output

```
$ gcc pcsem.c

$ ./a.out
Enter data for producer to produce : 5

Enter data for producer to produce : 8
Consumer consumes data 5
Enter data for producer to produce : 4
Consumer consumes data 8
Enter data for producer to produce : 2
Consumer consumes data 4
Enter data for producer to produce : 9
Consumer consumes data 2
Consumer consumes data 9
```

Result

Thus synchronization between producer and consumer process for access to a shared memory segment is implemented.

Ex.No:8 BANKERS ALGORITHM FOR DEAD LOCK AVOIDANCE**Date:****AIM**

To implement deadlock avoidance by using Banker's Algorithm.

ALGORITHM

1. Start the program.
2. Get the values of resources and processes.
3. Get the avail value.
4. After allocation find the need value.
5. Check whether its possible to allocate.
6. If it is possible then the system is in safe state.
7. Else system is not in safety state.
8. If the new request comes then check that the system is in safety or not if we allow the request.
9. Stop.

PROGRAM

```

#include <stdio.h>
#include <stdio.h>

main()
{
    int r[1][10], av[1][10];
    int all[10][10], max[10][10], ne[10][10], w[10], safe[10];
    int i=0, j=0, k=0, l=0, np=0, nr=0, count=0, cnt=0;

    clrscr();
    printf("enter the number of processes in a system");
    scanf("%d", &np);
    printf("enter the number of resources in a system");
    scanf("%d", &nr);
    for(i=1; i<=nr; i++)
    {
        printf("Enter no. of instances of resource R%d " ,i);
        scanf("%d", &r[0][i]);
        av[0][i] = r[0][i];
    }

    for(i=1; i<=np; i++)
        for(j=1; j<=nr; j++)
            all[i][j] = ne[i][j] = max[i][j] = w[i]=0;

```

```

printf("Enter the allocation matrix");
for(i=1; i<=np; i++)
{
    for(j=1; j<=nr; j++)
    {
        scanf("%d", &all[i][j]);
        av[0][j] = av[0][j] - all[i][j];
    }
}

printf("Enter the maximum matrix");
for(i=1; i<=np; i++)
{
    for(j=1; j<=nr; j++)
    {
        scanf("%d",&max[i][j]);
    }
}

for(i=1; i<=np; i++)
{
    for(j=1; j<=nr; j++)
    {
        ne[i][j] = max[i][j] - all[i][j];
    }
}

for(i=1; i<=np; i++)
{
    printf("pocess P%d", i);
    for(j=1; j<=nr; j++)
    {
        printf("\n allocated %d\t",all[i][j]);
        printf("maximum %d\t",max[i][j]);
        printf("need %d\t",ne[i][j]);
    }
    printf("\n_____ \n");
}

printf("\nAvailability ");
for(i=1; i<=nr; i++)
    printf("R%d %d\t", i, av[0][i]);
printf("\n_____");
printf("\n safe sequence");

```

```

for(count=1; count<=np; count++)
{
    for(i=1; i<=np; i++)
    {
        Cnt = 0;
        for(j=1; j<=nr; j++)
        {
            if(ne[i][j] <= av[0][j] && w[i]==0)
                cnt++;
        }
        if(cnt == nr)
        {
            k++;
            safe[k] = i;
            for(l=1; l<=nr; l++)
                av[0][l] = av[0][l] + all[i][l];
            printf("\n P%d ",safe[k]);
            printf("\t Availability ");
            for(l=1; l<=nr; l++)
                printf("R%d %d\t", l, av[0][l]);
            w[i]=1;
        }
    }
}
getch();
}

```

Output

```

enter the number of processes in a system 3
enter the number of resources in a system 3

```

```

enter no. of instances of resource R1 10
enter no. of instances of resource R2 7
enter no. of instances of resource R3 7

```

Enter the allocation matrix

```

3 2 1
1 1 2
4 1 2

```

Enter the maximum matrix

```

4 4 4
3 4 5
5 2 4

```

process P1

allocated 3	maximum 4	need 1
allocated 2	maximum 4	need 2
allocated 1	maximum 4	need 3

process P2

allocated 1	maximum 3	need 2
allocated 1	maximum 4	need 3
allocated 2	maximum 5	need 3

process P3

allocated 4	maximum 5	need 1
allocated 1	maximum 2	need 1
allocated 2	maximum 4	need 2

Availability	R1 2	R2 3	R3 2
--------------	------	------	------

safe sequence

P3	Availability	R1 6	R2 4	R3 4
P1	Availability	R1 9	R2 6	R3 5
P2	Availability	R1 10	R2 7	R3 7

Result

Thus bankers algorithm for dead lock avoidance was executed successfully.

Ex.No: 9 DEAD LOCK PREVENTION**Date:****Aim**

To determine whether the process and their request for resources are in a deadlocked state.

Algorithm

1. Mark each process that has a row in the Allocation matrix of all zeros.
2. Initialize a temporary vector W to equal the Available vector.
3. Find an index i such that process i is currently unmarked and the i th row of Q
4. is less than or equal to W . That is, $Q_{ik} \leq W_k$, for $1 \leq k \leq m$. If no such row is
5. found, terminate the algorithm.
5. If such a row is found, mark process i and add the corresponding row of the
6. allocation matrix to W . That is, set $W_k = W_k + A_{ik}$, for $1 \leq k \leq m$. Return
7. to step 3.

Program

```
#include<stdio.h>
#include<conio.h>
int max[100][100];
int alloc[100][100];
int need[100][100];
int avail[100];
int n, r;
void input();
void show();
void cal();

main()
{
    int i,j;
    printf("Deadlock Detection Algo\n");
    input();
    show();
    cal();
    getch();
}

void input()
{
    int i,j;
    printf("Enter the no of Processes\t");
    scanf("%d",&n);
    printf("Enter the no of resource instances\t");
    scanf("%d",&r);

    printf("Enter the Max Matrix\n");
```

```

    for(i=0; i<n; i++)
        for(j=0; j<r; j++)
            scanf("%d", &max[i][j]);

    printf("Enter the Allocation Matrix\n");
    for(i=0; i<n; i++)
        for(j=0; j<r; j++)
            scanf("%d", &alloc[i][j]);
    printf("Enter the available Resources\n");
    for(j=0; j<r; j++)
        scanf("%d", &avail[j]);
}

void show()
{
    int i, j;
    printf("Process\t Allocation\t Max\t Available\t");
    for(i=0; i<n; i++)
    {
        printf("\nP%d\t", i+1);
        for(j=0; j<r; j++)
        {
            printf("%d ", alloc[i][j]);
        }
        printf("\t");
        for(j=0; j<r; j++)
        {
            printf("%d ", max[i][j]);
        }
        printf("\t");
        if(I == 0)
        {
            for(j=0; j<r; j++)
                printf("%d ", avail[j]);
        }
    }
}

void cal()
{
    int finish[100], temp, need[100][100], flag=1, k, c1=0;
    int dead[100];
    int safe[100];
    int i, j;
    for(i=0; i<n; i++)
    {
        finish[i] = 0;
    }
}

```

```

/*find need matrix */
for(i=0; i<n; i++)
{
    for(j=0; j<r; j++)
    {
        need[i][j]= max[i][j] - alloc[i][j];
    }
}

while(flag)
{
    flag=0;
    for(i=0;i<n;i++)
    {
        int c=0;
        for(j=0;j<r;j++)
        {
            if((finish[i]==0) && (need[i][j] <= avail[j]))
            {
                c++;
                if(c == r)
                {
                    for(k=0; k<r; k++)
                    {
                        avail[k] += alloc[i][j];
                        finish[i]=1;
                        flag=1;
                    }
                    if(finish[i] == 1)
                    {
                        i=n;
                    }
                }
            }
        }
    }
}

J = 0;
Flag = 0;
for(i=0; i<n; i++)
{
    if(finish[i] == 0)
    {
        dead[j] = i;
        j++;
        flag = 1;
    }
}

```

```

    if(flag == 1)
    {
        printf("\n\nSystem is in Deadlock and the Deadlock
process are\n");
        for(i=0;i<n;i++)
        {
            printf("P%d\t", dead[i]);
        }
    }
    else
    {
        printf("\nNo Deadlock Occur");
    }
}

```

Output

***** Deadlock Detection Algo *****

Enter the no of Processes 3

Enter the no of resource instances 3

Enter the Max Matrix

3 6 0

4 3 3

3 4 4

Enter the Allocation Matrix

3 3 3

2 0 3

1 2 4

Enter the available Resources

1 2 0

Process	Allocation	Max	Available
P1	3 3 3	3 6 0	1 2 0
P2	2 0 3	4 3 3	
P3	1 2 4	3 4 4	

System is in Deadlock and the Deadlock process are

P0 P1 P2

Result

Thus using given state of information deadlocked process were determined.

Ex. No. 10 Threading and Synchronization**Date:****Aim**

To demonstrate threading and synchronization using mutex.

Description

- Thread synchronization is defined as a mechanism which ensures that two or more concurrent processes or threads do not simultaneously execute some particular program segment known as critical section.
- Processes' access to critical section is controlled by using synchronization techniques.
- When one thread starts executing the critical section (serialized segment of the program) the other thread should wait until the first thread finishes.
- If proper synchronization techniques are not applied, it may cause a race condition where the values of variables may be unpredictable
- A Mutex is a lock that we set before using a shared resource and release after using it.
- When the lock is set, no other thread can access the locked region of code. So this ensures a synchronized access of shared resources in the code.

Algorithm

1. Create two threads
2. Let the threads share a common resource, say counter
3. Even if thread2 is scheduled to start while thread was not done, access to shared resource is not done as it is locked by mutex
4. Once thread1 completes, thread2 starts execution
5. Stop

Program

```

#include <stdio.h>
#include <string.h>
#include <pthread.h>
#include <stdlib.h>
#include <unistd.h>

pthread_t tid[2];
int counter;
pthread_mutex_t lock;

void* trythis(void *arg)
{
    pthread_mutex_lock(&lock);

    unsigned long i = 0;
    counter += 1;
    printf("\n Job %d has started\n", counter);

    for(i=0; i<(0xFFFFFFFF);i++);

```

```

    printf("\n Job %d has finished\n", counter);

    pthread_mutex_unlock(&lock);

    return NULL;
}

main()
{
    int i = 0;
    int error;

    if (pthread_mutex_init(&lock, NULL) != 0)
    {
        printf("\n mutex init has failed\n");
        return 1;
    }

    while(i < 2)
    {
        err = pthread_create(&(tid[i]), NULL, &trythis, NULL);
        if (error != 0)
            printf("\nThread    can't    be    created    :[%s]",
strerror(error));
        i++;
    }

    pthread_join(tid[0], NULL);
    pthread_join(tid[1], NULL);
    pthread_mutex_destroy(&lock);

    return 0;
}

```

Output

```

$ gcc filename.c -lpthread

$ ./a.out
Job 1 started
Job 1 finished
Job 2 started
Job 2 finished

```

Result

Thus concurrent threads were synchronized using mutex lock.

Exp# 11a First Fit Allocation**Date:****Aim**

To allocate memory requirements for processes using first fit allocation.

Memory Management

- The first-fit, best-fit, or worst-fit strategy is used to select a free hole from the set of available holes.

First fit

- Allocate the first hole that is big enough.
- Searching starts from the beginning of set of holes.

Algorithm

1. Declare structures *hole* and *process* to hold information about set of holes and processes respectively.
2. Get number of holes, say *nh*.
3. Get the size of each hole
4. Get number of processes, say *np*.
5. Get the memory requirements for each process.
6. Allocate processes to holes, by examining each hole as follows:
 - a. If hole size > process size then
 - i. Mark process as allocated to that hole.
 - ii. Decrement hole size by process size.
 - b. Otherwise check the next from the set of hole
7. Print the list of process and their allocated holes or unallocated status.
8. Print the list of holes, their actual and current availability.
9. Stop

Program

```

/* First fit allocation - ffit.c */

#include <stdio.h>

struct process
{
    int size;
    int flag;
    int holeid;
} p[10];
struct hole
{
    int size;

```

```

    int actual;
} h[10];

main()
{
    int i, np, nh, j;

    printf("Enter the number of Holes : ");
    scanf("%d", &nh);
    for(i=0; i<nh; i++)
    {
        printf("Enter size for hole H%d : ",i);
        scanf("%d", &h[i].size);
        h[i].actual = h[i].size;
    }

    printf("\nEnter number of process : " );
    scanf("%d",&np);
    for(i=0;i<np;i++)
    {
        printf("enter the size of process P%d : ",i);
        scanf("%d", &p[i].size);
        p[i].flag = 0;
    }

    for(i=0; i<np; i++)
    {
        for(j=0; j<nh; j++)
        {
            if(p[i].flag != 1)
            {
                if(p[i].size <= h[j].size)
                {
                    p[i].flag = 1;
                    p[i].holeid = j;
                    h[j].size -= p[i].size;
                }
            }
        }
    }

    printf("\n\tFirst fit\n");
    printf("\nProcess\tPSize\tHole");
    for(i=0; i<np; i++)
    {
        if(p[i].flag != 1)
            printf("\nP%d\t%d\tNot allocated", i, p[i].size);
        else
            printf("\nP%d\t%d\tH%d", i, p[i].size, p[i].holeid);
    }
}

```

```

printf("\n\nHole\tActual\tAvailable");
for(i=0; i<nh ;i++)
    printf("\nH%d\t%d\t%d", i, h[i].actual, h[i].size);
printf("\n");
}

```

Output

```

Enter the number of Holes : 5
Enter size for hole H0 : 100
Enter size for hole H1 : 500
Enter size for hole H2 : 200
Enter size for hole H3 : 300
Enter size for hole H4 : 600

Enter number of process : 4
enter the size of process P0 : 212
enter the size of process P1 : 417
enter the size of process P2 : 112
enter the size of process P3 : 426

```

First fit

Process	PSize	Hole
P0	212	H1
P1	417	H4
P2	112	H1
P3	426	Not allocated

Hole	Actual	Available
H0	100	100
H1	500	176
H2	200	200
H3	300	300
H4	600	183

Result

Thus processes were allocated memory using first fit method.

Exp# 11b Best Fit Allocation**Date:****Aim**

To allocate memory requirements for processes using best fit allocation.

Best fit

- Allocate the smallest hole that is big enough.
- The list of free holes is kept sorted according to size in ascending order.
- This strategy produces smallest leftover holes

Algorithm

1. Declare structures *hole* and *process* to hold information about set of holes and processes respectively.
2. Get number of holes, say *nh*.
3. Get the size of each hole
4. Get number of processes, say *np*.
5. Get the memory requirements for each process.
6. Allocate processes to holes, by examining each hole as follows:
 - a. Sort the holes according to their sizes in ascending order
 - b. If hole size > process size then
 - i. Mark process as allocated to that hole.
 - ii. Decrement hole size by process size.
 - c. Otherwise check the next from the set of sorted hole
7. Print the list of process and their allocated holes or unallocated status.
8. Print the list of holes, their actual and current availability.
9. Stop

Program

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

```
struct process
{
    int size;
    int flag;
    int holeid;
} p[10];
```

```
struct hole
{
    int hid;
    int size;
    int actual;
} h[10];
```

```

main()
{
    int i, np, nh, j;
    void bsort(struct hole[], int);
    printf("Enter the number of Holes : ");
    scanf("%d", &nh);
    for(i=0; i<nh; i++)
    {
        printf("Enter size for hole H%d : ",i);
        scanf("%d", &h[i].size);
        h[i].actual = h[i].size;
        h[i].hid = i;
    }
    printf("\nEnter number of process : " );
    scanf("%d",&np);
    for(i=0;i<np;i++)
    {
        printf("enter the size of process P%d : ",i);
        scanf("%d", &p[i].size);
        p[i].flag = 0;
    }
    for(i=0; i<np; i++)
    {
        bsort(h, nh);
        for(j=0; j<nh; j++)
        {
            if(p[i].flag != 1)
            {
                if(p[i].size <= h[j].size)
                {
                    p[i].flag = 1;
                    p[i].holeid = h[j].hid;
                    h[j].size -= p[i].size;
                }
            }
        }
    }
    printf("\n\tBest fit\n");
    printf("\nProcess\tPSize\tHole");
    for(i=0; i<np; i++)
    {
        if(p[i].flag != 1)
            printf("\nP%d\t%d\tNot allocated", i, p[i].size);
        else
            printf("\nP%d\t%d\tH%d", i, p[i].size, p[i].holeid);
    }
    printf("\n\nHole\tActual\tAvailable");
    for(i=0; i<nh ;i++)
        printf("\nH%d\t%d\t%d", h[i].hid, h[i].actual,
h[i].size);

```

```

        printf("\n");
    }

void bsort(struct hole bh[], int n)
{
    struct hole temp;
    int i,j;
    for(i=0; i<n-1; i++)
    {
        for(j=i+1; j<n; j++)
        {
            if(bh[i].size > bh[j].size)
            {
                temp = bh[i];
                bh[i] = bh[j];
                bh[j] = temp;
            }
        }
    }
}

```

Output

```

Enter the number of Holes : 5
Enter size for hole H0 : 100
Enter size for hole H1 : 500
Enter size for hole H2 : 200
Enter size for hole H3 : 300
Enter size for hole H4 : 600
Enter number of process : 4
enter the size of process P0 : 212
enter the size of process P1 : 417
enter the size of process P2 : 112
enter the size of process P3 : 426

```

Best fit

Process	PSize	Hole
P0	212	H3
P1	417	H1
P2	112	H2
P3	426	H4

Hole	Actual	Available
H1	500	83
H3	300	88
H2	200	88
H0	100	100
H4	600	174

Result

Thus processes were allocated memory using best fit method.

Ex. No. 12

Paging Technique

Date:

Aim

To determine physical address of a given page using page table.

Algorithm

1. Get process size
2. Compute no. of pages available and display it
3. Get relative address
4. Determine the corresponding page
5. Display page table
6. Display the physical address

Program

```
#include <stdio.h>
#include <math.h>

main()
{
    int size, m, n, pgno, pagetable[3]={5,6,7}, i, j, frameno;
    double m1;
    int ra=0, ofs;

    printf("Enter process size (in KB of max 12KB):");
    scanf("%d", &size);
    m1 = size / 4;
    n = ceil(m1);
    printf("Total No. of pages: %d", n);
    printf("\nEnter relative address (in hexa) \n");
    scanf("%d", &ra);

    pgno = ra / 1000;
    ofs = ra % 1000;
    printf("page no=%d\n", pgno);
    printf("page table");
    for(i=0;i<n;i++)
        printf("\n %d [%d]", i, pagetable[i]);
    frameno = pagetable[pgno];
    printf("\nPhysical address: %d%d", frameno, ofs);
}
```

Output

Enter process size (in KB of max 12KB):12

Total No. of pages: 3

Enter relative address (in hexa):

2643

page no=2

page table

0 [5]

1 [6]

2 [7]

Physical address : 7643

Result

Thus physical address for the given logical address is determining using Paging technique.

Exp. No. 13a**FIFO Page Replacement****Date:****Aim**

To implement demand paging for a reference string using FIFO method.

FIFO

- Page replacement is based on when the page was brought into memory.
- When a page should be replaced, the oldest one is chosen.
- Generally, implemented using a FIFO queue.
- Simple to implement, but not efficient.
- Results in more page faults.
- The page-fault may increase, even if frame size is increased (Belady's anomaly)

Algorithm

1. Get length of the reference string, say l .
2. Get reference string and store it in an array, say rs .
3. Get number of frames, say nf .
4. Initialize $frame$ array upto length nf to -1.
5. Initialize position of the oldest page, say j to 0.
6. Initialize no. of page faults, say $count$ to 0.
7. For each page in reference string in the given order, examine:
 - a. Check whether page exist in the $frame$ array
 - b. If it does not exist then
 - i. Replace page in position j .
 - ii. Compute page replacement position as $(j+1)$ modulus nf .
 - iii. Increment $count$ by 1.
 - iv. Display pages in $frame$ array.
8. Print $count$.
9. Stop

Program

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

```
main()
```

```
{
    int i,j,l,rs[50],frame[10],nf,k,avail,count=0;

    printf("Enter length of ref. string : ");
    scanf("%d", &l);
    printf("Enter reference string :\n");
    for(i=1; i<=l; i++)
        scanf("%d", &rs[i]);
    printf("Enter number of frames : ");
    scanf("%d", &nf);
```

```

for(i=0; i<nf; i++)
    frame[i] = -1;
j = 0;
printf("\nRef. str   Page frames");
for(i=1; i<=l; i++)
{
    printf("\n%4d\t", rs[i]);
    avail = 0;
    for(k=0; k<nf; k++)
        if(frame[k] == rs[i])
            avail = 1;
    if(avail == 0)
    {
        frame[j] = rs[i];
        j = (j+1) % nf;
        count++;
        for(k=0; k<nf; k++)
            printf("%4d", frame[k]);
    }
}
printf("\n\nTotal no. of page faults : %d\n",count);
}

```

Output

```

Enter length of ref. string : 20
Enter reference string :
1 2 3 4 2 1 5 6 2 1 2 3 7 6 3
Enter number of frames : 5

```

Ref. str	Page frames				
1	1	-1	-1	-1	-1
2	1	2	-1	-1	-1
3	1	2	3	-1	-1
4	1	2	3	4	-1
2					
1					
5	1	2	3	4	5
6	6	2	3	4	5
2					
1	6	1	3	4	5
2	6	1	2	4	5
3	6	1	2	3	5
7	6	1	2	3	7
6					
3					

Total no. of page faults : 10

Result

Thus page replacement was implemented using FIFO algorithm.

Exp. No. 13b**LRU Page Replacement****Aim**

To implement demand paging for a reference string using LRU method.

LRU

- Pages used in the recent past are used as an approximation of future usage.
- The page that has not been used for a longer period of time is replaced.
- LRU is efficient but not optimal.
- Implementation of LRU requires hardware support, such as counters/stack.

Algorithm

1. Get length of the reference string, say *len*.
2. Get reference string and store it in an array, say *rs*.
3. Get number of frames, say *nf*.
4. Create *access* array to store counter that indicates a measure of recent usage.
5. Create a function *arrmin* that returns position of minimum of the given array.
6. Initialize *frame* array upto length *nf* to -1.
7. Initialize position of the page replacement, say *j* to 0.
8. Initialize *freq* to 0 to track page frequency
9. Initialize no. of page faults, say *count* to 0.
10. For each page in reference string in the given order, examine:
 - a. Check whether page exist in the *frame* array.
 - b. If page exist in memory then
 - i. Store incremented *freq* for that page position in *access* array.
 - c. If page does not exist in memory then
 - i. Check for any empty frames.
 - ii. If there is an empty frame,
 - Assign that frame to the page
 - Store incremented *freq* for that page position in *access* array.
 - Increment *count*.
 - iii. If there is no free frame then
 - Determine page to be replaced using *arrmin* function.
 - Store incremented *freq* for that page position in *access* array.
 - Increment *count*.
 - iv. Display pages in *frame* array.
11. Print *count*.
12. Stop

Program

```
/* LRU page replacement - lrupr.c */

#include <stdio.h>
```

```

int arrmin(int[], int);

main()
{
    int i,j,len,rs[50],frame[10],nf,k,avail,count=0;
    int access[10], freq=0, dm;

    printf("Length of Reference string : ");
    scanf("%d", &len);
    printf("Enter reference string :\n");
    for(i=1; i<=len; i++)
        scanf("%d", &rs[i]);
    printf("Enter no. of frames : ");
    scanf("%d", &nf);

    for(i=0; i<nf; i++)
        frame[i] = -1;
    j = 0;

    printf("\nRef. str  Page frames");
    for(i=1; i<=len; i++)
    {
        printf("\n%4d\t", rs[i]);
        avail = 0;
        for(k=0; k<nf; k++)
        {
            if(frame[k] == rs[i])
            {
                avail = 1;
                access[k] = ++freq;
                break;
            }
        }
        if(avail == 0)
        {
            dm = 0;
            for(k=0; k<nf; k++)
            {
                if(frame[k] == -1)
                {
                    dm = 1;
                    break;
                }
            }
            if(dm == 1)
            {
                frame[k] = rs[i];
                access[k] = ++freq;
                count++;
            }
        }
    }
}

```

```

        else
        {
            j = arrmin(access, nf);
            frame[j] = rs[i];
            access[j] = ++freq;
            count++;
        }
        for(k=0; k<nf; k++)
            printf("%4d", frame[k]);
    }
    printf("\n\nTotal no. of page faults : %d\n", count);
}

int arrmin(int a[], int n)
{
    int i, min = a[0];
    for(i=1; i<n; i++)
        if (min > a[i])
            min = a[i];
    for(i=0; i<n; i++)
        if (min == a[i])
            return i;
}

```

Output

```

Length of Reference string : 15
Enter reference string :
1 2 3 4 2 1 5 6 2 1 2 3 7 6 3
Enter no. of frames : 5
Ref. str  Page frames
  1         1  -1  -1  -1  -1
  2         1   2  -1  -1  -1
  3         1   2   3  -1  -1
  4         1   2   3   4  -1
  2
  1
  5         1   2   3   4   5
  6         1   2   6   4   5
  2
  1
  2
  3         1   2   6   3   5
  7         1   2   6   3   7
  6
  3
Total no. of page faults : 8

```

Result

Thus page replacement was implemented using LRU algorithm.

Ex. No. 14a Single-Level Directory**Date:****Aim**

To organize files in a single level directory structure, I.e., without sub-directories.

Algorithm

1. Get name of directory for the user to store all the files
2. Display menu
3. Accept choice
4. If choice =1 then
 - Accept filename without any collision
 - Store it in the directory
5. If choice =2 then
 - Accept filename
 - Remove filename from the directory array
6. If choice =3 then
 - Accept filename
 - Check for existence of file in the directory array
7. If choice =4 then
 - List all files in the directory array
8. If choice =5 then
 - Stop

Program

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

struct
{
    char  dname[10];
    char  fname[25][10];
    int  fcnt;
}dir;

main()
{
    int i, ch;
    char f[30];
    clrscr();
    dir.fcnt = 0;
    printf("\nEnter name of directory -- ");
    scanf("%s", dir.dname);

    while(1)
    {
        printf("\n\n 1. Create File\t2. Delete File\t3. Search
        File \n4. Display Files\t5. Exit\nEnter your choice--");
        scanf("%d",&ch);
```



```

switch(ch)
{
    case 1:
        printf("\n Enter the name of the file -- ");
        scanf("%s", dir.fname[dir.fcnt]);
        dir.fcnt++;
        break;

    case 2:
        printf("\n Enter the name of the file -- ");
        scanf("%s", f);
        for(i=0; i<dir.fcnt; i++)
        {
            if(strcmp(f, dir.fname[i]) == 0)
            {
                printf("File %s is deleted ",f);
                strcpy(dir.fname[i], dir.fname[dir.fcnt-1]);
                break;
            }
        }
        if(i == dir.fcnt)
            printf("File %s not found", f);
        else
            dir.fcnt--;
        break;

    case 3:
        printf("\n Enter the name of the file -- ");
        scanf("%s", f);
        for(i=0; i<dir.fcnt; i++)
        {
            if(strcmp(f, dir.fname[i]) == 0)
            {
                printf("File %s is found ", f);
                break;
            }
        }
        if(i == dir.fcnt)
            printf("File %s not found", f);
        break;

    case 4:
        if(dir.fcnt == 0)
            printf("\n Directory Empty");
        else
        {
            printf("\n The Files are -- ");
            for(i=0; i<dir.fcnt; i++)
                printf("\t%s", dir.fname[i]);
        }
        break;
}

```

```

        default:
            exit(0);
    }
}
getch();
}

```

Output

Enter name of directory -- CSE

1. Create File 2. Delete File 3. Search File
4. Display Files 5. Exit

Enter your choice -- 1

Enter the name of the file -- fcfs

1. Create File 2. Delete File 3. Search File
4. Display Files 5. Exit

Enter your choice -- 1

Enter the name of the file -- sjf

1. Create File 2. Delete File 3. Search File
4. Display Files 5. Exit

Enter your choice -- 1

Enter the name of the file -- lru

1. Create File 2. Delete File 3. Search File
4. Display Files 5. Exit

Enter your choice -- 3

Enter the name of the file -- sjf

File sjf is found

1. Create File 2. Delete File 3. Search File
4. Display Files 5. Exit

Enter your choice -- 3

Enter the name of the file -- bank

File bank is not found

1. Create File 2. Delete File 3. Search File
4. Display Files 5. Exit

Enter your choice -- 4

The Files are -- fcfs sjf lru bank

1. Create File 2. Delete File 3. Search File
4. Display Files 5. Exit

Enter your choice -- 2

Enter the name of the file -- lru

File lru is deleted

Result

Thus files were organized into a single level directory.

Ex. No. 14b Two-Level Directory**Date:****Aim**

To organize files as two-level directory with each user having his own user file directory (UFD).

Algorithm

1. Display menu
2. Accept choice
3. If choice =1 then
 - Accept directory name
 - Create an entry for that directory
4. If choice =2 then
 - Get directory name
 - If directory exist then accept filename without collision else report error
5. If choice =3 then
 - Get directory name
 - If directory exist then Get filename
 - If file exist in that directory then delete entry else report error
6. If choice =4 then
 - Get directory name
 - If directory exist then Get filename
 - If file exist in that directory then Display filename else report error
7. If choice =5 then Display files directory-wise
8. If choice =6 then Stop

Program

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

struct
{
    char dname[10], fname[10][10];
    int fcnt;
}dir[10];

main()
{
    int i, ch, dcnt, k;
    char f[30], d[30];
    clrscr();
    dcnt=0;
    while(1)
    {
        printf("\n\n 1. Create Directory\t 2. Create File\t 3.
Delete File");
        printf("\n 4. Search File \t \t 5. Display \t 6. Exit \n
Enter your choice -- ");
```

```

scanf("%d", &ch);
switch(ch)
{
    case 1:
        printf("\n Enter name of directory -- ");
        scanf("%s", dir[dcnt].dname);
        dir[dcnt].fcnt = 0;
        dcnt++;
        printf("Directory created");
        break;

    case 2:
        printf("\n Enter name of the directory -- ");
        scanf("%s", d);
        for(i=0; i<dcnt; i++)
            if(strcmp(d,dir[i].dname) == 0)
            {
                printf("Enter name of the file -- ");
                scanf("%s", dir[i].fname[dir[i].fcnt]);
                dir[i].fcnt++;
                printf("File created");
                break;
            }
        if(i == dcnt)
            printf("Directory %s not found",d);
        break;

    case 3:
        printf("\nEnter name of the directory -- ");
        scanf("%s", d);
        for(i=0; i<dcnt; i++)
        {
            if(strcmp(d,dir[i].dname) == 0)
            {
                printf("Enter name of the file -- ");
                scanf("%s", f);
                for(k=0; k<dir[i].fcnt; k++)
                {
                    if(strcmp(f, dir[i].fname[k]) == 0)
                    {
                        printf("File %s is deleted ", f);
                        dir[i].fcnt--;
                        strcpy(dir[i].fname[k],
                            dir[i].fname[dir[i].fcnt]);
                        goto jmp;
                    }
                }
                printf("File %s not found",f);
                goto jmp;
            }
        }
}

```

```

        printf("Directory %s not found",d);
    jmp : break;

    case 4:
        printf("\nEnter name of the directory -- ");
        scanf("%s", d);
        for(i=0; i<dcnt; i++)
        {
            if(strcmp(d,dir[i].dname) == 0)
            {
                printf("Enter the name of the file -- ");
                scanf("%s", f);
                for(k=0; k<dir[i].fcnt; k++)
                {
                    if(strcmp(f, dir[i].fname[k]) == 0)
                    {
                        printf("File %s is found ", f);
                        goto jmp1;
                    }
                }
                printf("File %s not found", f);
                goto jmp1;
            }
        }
        printf("Directory %s not found", d);
    jmp1: break;

    case 5:
        if(dcnt == 0)
            printf("\nNo Directory's ");
        else
        {
            printf("\nDirectory\tFiles");
            for(i=0;i<dcnt;i++)
            {
                printf("\n%s\t\t",dir[i].dname);
                for(k=0;k<dir[i].fcnt;k++)
                    printf("\t%s",dir[i].fname[k]);
            }
        }
        break;

    default:
        exit(0);
    }
}
getch();
}

```

Output

1. Create Directory 2. Create File 3. Delete File 4. Search File 5. Display 6. Exit

Enter your choice -- 1

Enter name of directory -- CSE

Directory created

1. Create Directory 2. Create File 3. Delete File 4. Search File 5. Display 6. Exit

Enter your choice -- 1

Enter name of directory -- ECE

Directory created

1. Create Directory 2. Create File 3. Delete File 4. Search File 5. Display 6. Exit

Enter your choice -- 2

Enter name of the directory -- ECE

Enter name of the file -- amruth

File created

1. Create Directory 2. Create File 3. Delete File 4. Search File 5. Display 6. Exit

Enter your choice -- 2

Enter name of the directory -- CSE

Enter name of the file -- kowshik

File created

1. Create Directory 2. Create File 3. Delete File 4. Search File 5. Display 6. Exit

Enter your choice -- 2

Enter name of the directory -- CSE

Enter name of the file -- pranesh

File created

1. Create Directory 2. Create File 3. Delete File 4. Search File 5. Display 6. Exit

Enter your choice -- 2

Enter name of the directory -- ECE

Enter name of the file -- ajith

File created

1. Create Directory 2. Create File 3. Delete File 4. Search File 5. Display 6. Exit

Enter your choice -- 5

Directory Files

CSE kowshik pranesh

ECE amruth ajith

1. Create Directory 2. Create File 3. Delete File 4. Search File 5. Display 6. Exit

Enter your choice -- 3

Enter name of the directory -- ECE

Enter name of the file -- ajith

File ajith is deleted

Result

Thus user files have been stored in their respective directories and retrieved easily.

Exp. No. 15a**Contiguous Allocation****Aim**

To implement file allocation on free disk space in a contiguous manner.

File Allocation

The three methods of allocating disk space are:

1. Contiguous allocation
2. Linked allocation
3. Indexed allocation

Contiguous

- Each file occupies a set of contiguous block on the disk.
- The number of disk seeks required is minimal.
- The directory contains address of starting block and number of contiguous block (length) occupied.
- Supports both sequential and direct access.
- First / best fit is commonly used for selecting a hole.

Algorithm

1. Assume no. of blocks in the disk as 20 and all are free.
2. Display the status of disk blocks before allocation.
3. For each file to be allocated:
 - a. Get the *filename*, *start* address and file *length*
 - b. If $start + length > 20$, then goto step 2.
 - c. Check to see whether any block in the range (start, start + length-1) is allocated. If so, then go to step 2.
 - d. Allocate blocks to the file contiguously from start block to start + length – 1.
4. Display directory entries.
5. Display status of disk blocks after allocation
6. Stop

Program

```
/* Contiguous Allocation - cntalloc.c */

#include <stdio.h>
#include <string.h>

int num=0, length[10], start[10];
char fid[20][4], a[20][4];

void directory()
{
    int i;
    printf("\nFile Start Length\n");
```

```

        for(i=0; i<num; i++)
            printf("%-4s  %3d  %6d\n",fid[i],start[i],length[i]);
    }

void display()
{
    int i;
    for(i=0; i<20; i++)
        printf("%4d",i);
    printf("\n");
    for(i=0; i<20; i++)
        printf("%4s", a[i]);
}

main()
{
    int i,n,k,temp,st,nb,ch,flag;
    char id[4];

    for(i=0; i<20; i++)
        strcpy(a[i], "");
    printf("Disk space before allocation:\n");
    display();
    do
    {
        printf("\nEnter File name (max 3 char) : ");
        scanf("%s", id);
        printf("Enter start block : ");
        scanf("%d", &st);
        printf("Enter no. of blocks : ");
        scanf("%d", &nb);
        strcpy(fid[num], id);
        length[num] = nb;
        flag = 0;

        if((st+nb) > 20)
        {
            printf("Requirement exceeds range\n");
            continue;
        }

        for(i=st; i<(st+nb); i++)
            if(strcmp(a[i], "") != 0)
                flag = 1;
        if(flag == 1)
        {
            printf("Contiguous allocation not possible.\n");
            continue;
        }
        start[num] = st;
        for(i=st; i<(st+nb); i++)

```



```

        strcpy(a[i], id);
        printf("Allocation done\n");
        num++;

        printf("\nAny more allocation (1. yes / 2. no)? : ");
        scanf("%d", &ch);
    } while (ch == 1);
    printf("\n\t\t\t\t\tContiguous Allocation\n");
    printf("Directory:");
    directory();
    printf("\nDisk space after allocation:\n");
    display();
}

```

Output

```

Disk space before allocation:
  0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19

Enter File name (max 3 char) : cp
Enter start block : 14
Enter no. of blocks : 3
Allocation done
Any more allocation (1. yes / 2. no)? : 1

Enter File name (max 3 char) : tr
Enter start block : 18
Enter no. of blocks : 3
Requirement exceeds range

Enter File name (max 3 char) : tr
Enter start block : 10
Enter no. of blocks : 3
Allocation done
Any more allocation (1. yes / 2. no)? : 1

Enter File name (max 3 char) : mv
Enter start block : 0
Enter no. of blocks : 2
Allocation done
Any more allocation (1. yes / 2. no)? : 1

Enter File name (max 3 char) : ps
Enter start block : 12
Enter no. of blocks : 3
Contiguous allocation not possible.
Any more allocation (1. yes / 2. no)? : 2

                                Contiguous Allocation
Directory:
File Start Length
cp    14      3
tr    10      3
mv     0      2

Disk space after allocation:
  0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19
mv mv                                tr tr tr    cp cp cp

```

Result

Thus contiguous allocation is done for files with the available free blocks.

Ex. No. 15b LINKED FILE ALLOCATION**Date:****Aim**

To st

Linked

- Each file is a linked list of disk blocks.
- The directory contains a pointer to first and last blocks of the file.
- The first block contains a pointer to the second one, second to third and so on.
- File size need not be known in advance, as in contiguous allocation.
- No external fragmentation.
- Supports sequential access only.

Indexed

- In indexed allocation, all pointers are put in a single block known as index block.
- The directory contains address of the index block.
- The i^{th} entry in the index block points to i^{th} block of the file.
- Indexed allocation supports direct access.
- It suffers from pointer overhead, i.e wastage of space in storing pointers.

Algorithm

1. Get no. of files
2. Accept filenames and no. of blocks fo each file
3. Obtrain start block for each file
4. Obtain other blocks for each file
5. Check block availability before allocation
6. If block is unavailable then report error
7. Accept file name
8. Display linked file allocation blocks for that file
9. Stop

Program

```
#include <stdio.h>
#include <conio.h>
#include <string.h>

main()
{
    static int b[20], i, j, blocks[20][20];
    char F[20][20], S[20], ch;
    int sb[20], eb[20], x, n;
    clrscr();
    printf("\n Enter no. of Files ::");
    scanf("%d", &n);
```

```

for(i=0;i<n;i++)
{
    printf("\n Enter file %d name ::", i+1);
    scanf("%s", &F[i]);
    printf("\n Enter No. of blocks::", i+1);
    scanf("%d",&b[i]);
}

for(i=0;i<n;i++)
{
    printf("\n Enter Starting block of file%d::",i+1);
    scanf("%d", &sb[i]);
    printf("\nEnter blocks for file%d::\n", i+1);
    for(j=0; j<b[i]-1;)
    {
        printf("\n Enter the %dblock ::", j+2);
        scanf("%d", &x);
        if(b[i] != 0)
        {
            blocks[i][j] = x;
            j++;
        }
        else
            printf("\n Invalid block::");
    }
}

printf("\nEnter the Filename :");
scanf("%s", &S);
for(i=0; i<n; i++)
{
    if(strcmp(F[i],S) == 0)
    {
        printf("\nFname\tBsize\tStart\tBlocks\n");
        printf("\n_____ \n");
        printf("\n%s\t%d\t%d\t", F[i], b[i], sb[i]);
        printf("%d->",sb[i]);
        for(j=0; j<b[i]; j++)
        {
            if(b[i] != 0)
                printf("%d->", blocks[i][j]);
        }
    }
}
printf("\n_____ \n");
getch();
}

```

Output

Enter no. of Files ::2

Enter file 1 name ::fcfs

Enter No. of blocks::3

Enter file 2 name ::sjf

Enter No. of blocks::2

Enter Starting block of file1::8

Enter blocks for file1::

Enter the 2block ::3

Enter the 3block ::5

Enter Starting block of file2::2

Enter blocks for file2::

Enter the 2block ::6

Enter the Filename ::fcfs

Fname	Bsize	Start	Blocks
fcfs	3	8	8->3->5

Result

Thus blocks for file were allocation using linked allocation method.