SRI SIVASUBRAMANIYA NADAR COLLEGE OF ENGINEERING

(AN AUTONOMOUS INSTITUTION, AFFILIATED TO ANNA UNIVERSITY)

Rajiv Gandhi Salai (OMR), Kalavakkam - 603 110.

LABORATORY RECORD

NAME : P. T. JAYANNTHAN

Reg. No. : 205001049

Dept. : CSE **Sem.** : IV **Sec.** : A

SSN

SRI SIVASUBRAMANIYA NADAR COLLEGE OF ENGINEERING, CHENNAI

(AN AUTONOMOUS INSTITUTION, AFFILIATED TO ANNA UNIVERSITY)

BONAFIDE CERTIFICATE

Certified that this is the bonafide record of the practical work done in the UCS1411 Operating Systems Laboratory by

Name P.T. JAYANNTHAN

Register Number 205001049

Semester IV

Branch C&E

Sri Sivasubramaniya Nadar College of Engineering, Kalavakkam.

During the Academic year 2021 - 2022.

9/6/2022

Faculty **Head of the Department**

Submitted for the.....Practical Examination held at SSNCE on.....

Internal Examiner **External Examiner**

INDEX

Name : P.T. JAYANNTHAN Reg. No. 205001049

Sem : IV Sec : A

Ex. No.	Date of Expt.	Title of the Experiment	Page No.	Signature of the Faculty	Remarks
1	28/2/22	Study of System Calls and System Commands		7/3/22	
2	7/3/22	Simulation of System commands using Calls		20/3/22	
3	20/3/22	CPU Scheduling : FCFS & SJF		4/4/22	
4	4/4/22	CPU Scheduling : Priority, Round Robin		11/4/22	
5	11/4/22	Inter-Process Communication		18/4/22	
6	18/4/22	Producer and Consumer using Semaphores		25/4/22	
7	25/4/22	Deadlock : Avoidance and Detection		2/5/22	
8	2/5/22	Implementation of memory management system		9/5/22	
9	9/5/22	Implementation of Paging Technique		16/5/22	
10	16/5/22	Page Replacement Techniques		23/5/22	
11	23/5/22	Threading		30/5/22	
12	30/5/22	File Allocation Technique		30/5/22	
13	30/5/22	File organization Technique		6/6/22	
					Completed 9/6/22

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

Lab Exercise 1 Study of System calls and System Commands

1. *Study the following system calls and system commands (using Linux manual pages)*

System Commands		System calls	
cp - -i	rmdir	fork()	opendir()
mv - -i	wc	execl()	readdir()
ls - -l	who	getpid()	open()
grep - -c,-v	head - -n	getppid()	read()
chmod	tail - -n	exit()	write()
cat	nl	wait()	creat()
mkdir	awk	close()	sleep()
rm			

Write the following in your ***observation*** for each of the commands and calls.

a) **System Commands:**
Name, Purpose, options, Syntax, Example

b) **System Calls:**
Name, Description, Header file, Syntax, Arguments, Return type (both : on success and on failure)

2. *Develop a C program to understand the working of fork().*
(Sample code is given in next file in LMS page for you to try)

3. *Develop a C program using system calls to open a file, read the contents of the same, display it and close the file. Use command line arguments to pass the file name to the program.*
(Reading material for command line argument is attached in the LMS page)

Submit the code with snapshot of the output for both programs (2 & 3) one after another in a single pdf in the LMS.

Maintain observation for all the assignments from now on.

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

LAB EXERCISE 1

Study of System calls and System Commands

Submission Date:10-03-2022

Name: Jayannthan P T *Dept: CSE 'A'* *Roll No.: 205001049*

1. Study the following system calls and system commands (using Linux manual pages)

a. System Commands

1) cp - -i

Name: Copy
Purpose: Copy SOURCE to DEST, or multiple SOURCE(s) to DIRECTORY.
Options: -i, --interactive
prompt before overwrite
Syntax: cp [*OPTION*]... *SOURCE... DIRECTORY*
Example: cp file1.txt file2.txt

2)mv - -i

Name: move
Purpose: Rename SOURCE to DEST, or move SOURCE(s) to DIRECTORY.
Options: -i, --interactive
prompt before overwrite
Syntax: mv [*OPTION*]... *SOURCE... DIRECTORY*
Example: mv file1.txt file2.txt

3)ls - -l

Name: list
Purpose: list directory contents
Options: -l use a long listing format
Syntax: ls [OPTION]... [FILE]...
Example: ls

4)grep - -c,-v

Name: Global Regular Expression Print
Purpose: print lines that match patterns
Options: -c uppress normal output; instead print a count of matching lines for each input file.
-v, --invert-match
option (see below), count non-matching lines
Syntax: grep [OPTION...] PATTERNS [FILE...]
Example: grep "^hello" file1

5)chmod

Name: Change mode
Purpose: changes the file mode bits of each given file according to mode, which can be either a symbolic representation of changes to make, or an octal number representing the bit pattern for the new mode bits.
Options: -R, --recursive
change files and directories recursively
Syntax: chmod [OPTION]... MODE[,MODE]... FILE...
chmod [OPTION]... OCTAL-MODE FILE...
Example: chmod 644 file

6)cat

Name: Concatenate
Purpose: concatenate files and print on the standard output
Options: -n number all output lines
Syntax: cat [OPTION]... [FILE]
Example: cat file1

7)mkdir

Name: Make directories
Purpose: print lines that match patterns
Options: - v print a message for each created directory
Syntax: mkdir [OPTION]... DIRECTORY
Example: mkdir files

8)rm

Name: Remove
Purpose: remove files or directories
Options: -i prompt before every removal

-R remove directories and their contents recursively

Syntax: rm [OPTION]... [FILE]

Example: rm files

9) rmdir

Name: Remove Directories

Purpose: remove empty directories

Options: -p remove DIRECTORY and its ancestors

-v output a diagnostic for every directory processed

Syntax: rmdir [OPTION]... DIRECTORY

Example: rmdir files

10) wc

Name: Word Count

Purpose: print newline, word, and byte counts for each file

Options: -c, print the byte counts

-m print the character counts

-l print the newline counts

Syntax: wc [OPTION]... [FILE]

Example: wc file

11) who

Name: who

Purpose: show who is logged on

Options: -q, all login names and number of users logged on

-t, last system clock change

Syntax: who [*OPTION*]

Example: who

12) head - -n

Name: head

Purpose: output the first part of files

Options: -n, print the first n lines

Syntax: head [*OPTION*]... [*FILE*]

Example: `head file`

13) tail - -n

Name: tail

Purpose: output the first part of files

Options: -n, print the first n lines
Syntax: head [*OPTION*]... [*FILE*]
Example: `head file`

14) nl

Name: number lines
Purpose: Write each FILE to standard output, with line numbers added.
Options: **-i, line number increment at each line**
-p, do not reset line numbers for each section
Syntax: nl [OPTION]... [FILE]
Example: nl file1

15) awk

Name: Aho, Weinberger, and Kernighan
Purpose: pattern scanning and processing language
Options: -F define the input field separator
-f Specify the pathname of the file progfile containing an awk program.
Syntax: awk [-F *sepstring*] [-v *assignment*]... *program* [*argument*...]

awk [-F *sepstring*] -f *progfile* [-f *progfile*]... [-v *assignment*]...[*argument*...]

Example:awk '{print}' file.txt

b. System Calls

1) fork()

Description: fork() creates a new process by duplicating the calling process.The new process is referred to as the *child* process. The calling process is referred to as the *parent* process.

Header File: unistd.h
Syntax: pid_t fork(void);
Arguments: none
Return type: *Negative Value*: creation of a child process was unsuccessful.
Zero: Returned to the newly created child process.
Positive value: Returned to parent or caller. The

value contains process ID of newly created child process.

2) execl()

Description: The *const char *arg* and subsequent ellipses can be thought of as *arg0*, *arg1*, ..., *argn*. Together they describe a list of one or more pointers to null-terminated strings that represent the argument list available to the executed program. The first argument, by convention, should point to the filename associated with the file being executed. The list of arguments *must* be terminated by a null pointer, and, since these are variadic functions, this pointer must be cast *(char *) NULL*.

Header File: unistd.h

Syntax: int execl(const char **pathname*, const char **arg*, /*, (char *) NULL */);

Arguments: char **pathname*, char **arg*

Return type: return only if an error has occurred. The return value is -1,

3) getpid()

Description: getpid() returns the process ID (PID) of the calling process.

Header File: unistd.h

Syntax: pid_t getpid(void);

Arguments: Nil

Return type: returns the process ID of the parent of the current process. It never throws any error therefore is always successful.

4) getppid()

Description: getppid() returns the process ID of the parent of the calling process.

Header File: unistd.h

Syntax: pid_t getppid(void);

Arguments: Nil

Return type: returns the process ID of the parent of the current process. It never throws any error therefore is always successful.

5) exit()

Description: The exit() function causes normal process termination and the least significant byte of *status* is returned to the parent

Header File: stdlib.h

Syntax: void exit(int *status*);

Arguments: Status to return the parent process

Return type: No return value

6) wait()

Description: wait for process to change state

Header File: sys/wait.h

Syntax: pid_t wait(int *wstatus);

Arguments: wstatus - store status information in the int to which it points.

Return type: on success, returns the process ID of the terminated child; on failure, -1 is returned.

7) close()

Description: close() closes a file descriptor, so that it no longer refers to any file and may be reused.

Header File: unistd.h

Syntax: int close(int fd);

Arguments: fd is the last file descriptor referring to the underlying open file description

Return type: close() returns zero on success. On error, -1 is returned

8) opendir()

Description: The opendir() function opens a directory stream corresponding to the directory name, and returns a pointer to the directory stream. The stream is positioned at the first entry in the directory.

Header File: sys/types.h, dirent.h

Syntax: DIR *opendir(const char *name);

Arguments: directory name

Return type: functions return a pointer to the directory stream. On error, NULL is returned

9) readdir()

Description: The readdir() function returns a pointer to a *dirent* structure representing the next directory entry in the directory stream pointed to by *dirp*.

Header File: dirent.h
Syntax: struct dirent *readdir(DIR *dirp);
Arguments: directory pointer
Return type: returns a pointer to a dirent structure, If the end of the directory stream is reached, NULL is returned and errno is not changed. If an error occurs, NULL is returned and errno is set to indicate the error.

10) open()

Description: The open() system call opens the file specified by pathname. If the specified file does not exist, it may be created by open().
Header File: fcntl.h
Syntax: int open(const char *pathname, int flags, mode_t mode);
int open(const char *pathname, int flags);
Arguments: Pathname of the file, The argument flags must include one of the following access modes: O_RDONLY, O_WRONLY, or O_RDWR
Return type: The return value of open() is a file descriptor. On error, -1 is returned

11) read()

Description: read() attempts to read up to count bytes from file descriptor fd into the buffer starting at buf and read from file descriptor
Header File: unistd.h
Syntax: ssize_t read(int *fd*, void **buf*, size_t *count*);
Arguments: file descriptor fd, starting buffer size, read size
Return type: On success, the number of bytes read is returned, else -1 is returned

12) write()

Description: write() writes up to count bytes from the buffer starting at buf to the file referred to by the file descriptor fd.
Header File: unistd.h
Syntax: ssize_t write(int *fd*, void **buf*, size_t *count*);

Arguments: file descriptor fd, starting buffer size, write size
Return type: On success, the number of bytes written is returned, else -1 is returned

13) creat()

Description: write() writes up to count bytes from the buffer starting at buf to the file referred to by the file descriptor fd.
Header File: sys/stat.h, fcntl.h
Syntax: int creat(const char *path, mode_t mode);
Arguments: path of file, open mode
Return type: On success, the number of bytes read is returned, else -1 is returned

14) sleep()

Description: sleep() causes the calling thread to sleep either until the number of real-time seconds specified in seconds have elapsed or until a signal arrives which is not ignored.
Header File: unistd.h>
Syntax: unsigned int sleep(unsigned int seconds);
Arguments: no. of seconds to sleep
Return type: Zero if the requested time has elapsed, or the number of seconds left to sleep, if the call was interrupted by a signal handler.

2. Develop a C program to understand the working of fork()

Algorithm:

1) Print a line before calling fork() to intimate it executes before calling fork().
2) Call fork() and store the return value in id.
3) If id is equal to zero then print it is a child process.
4) Else print it is a parent process.

Code:

```
#include <stdio.h>
#include <unistd.h>
int main()
{
    printf("Before forking- this line is printed once\n\n");
    int id = fork();
    printf("After forking\n");
    if (id == 0)
        printf("Child process underway\n\n");
```

```
    else
        printf("Parent process underway\n\n");
    return 0;
}
```

Output:

```
Before forking...

After forking
Parent process underway

After forking
Child process underway
```

3. Develop a C program using system calls to open a file, read the contents of the same, display it and close the file. Use command line arguments to pass the file name to the program

Algorithm:

1) If argc greater than 2, then print error : too many arguments
2) Else if argc is lesser than 1, then print error : arguments required
3) Else
   i. Open file using call open() using filename as argument provided in read-only mode and store the file pointer in file_descriptor
   ii. If file_descriptor is equal to -1 then print error and exit
   iii. Else then read the contents using call read() and store the return value in contents
   iv. Print the contents
   v. Close the file

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <fcntl.h>
int main(int argc, char *argv[])
{

    if (argc > 2)
        printf("Too many arguements\n");
    else if (argc < 1)
        printf("Atleast one arguement required\n");
    else
    {
        int file_descriptor = open(argv[1], O_RDONLY);
        if (file_descriptor == -1)
            printf("File does not exist\n");
```

```
        else
        {
            printf("File descriptor is: %d\n", file_descriptor);
            char contents[100];
            read(file_descriptor, contents, 100);
            printf("File contents : %s\n", contents);
            close(file_descriptor);
        }
    }
    return 0;
}
```

Output:

```
File descriptor is: 3
File contents : #include <stdio.h>

int main(void) {
  printf("Hello World\n");
  return 0;
}
```

Learning Outcome:

- Learned system commands and system calls
- Implemented fork() in C program

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

Lab Exercise 2 Implementation of System calls

AIM:

To develop a C program to implement the cp, ls, grep commands using system calls.

Sample Learning Outcome:

1. Implement the various system commands like cp, grep, ls, head, tail, wc using system calls

2. Learn to process command line arguments and error handling mechanism

3. Understand the relation between the system calls and commands

Best Practices:

1. Algorithm design

2. Naming convention – for file names, variables

3. Comment usage at proper places

4. Prompt messages during reading input and displaying output

5. Error handling mechanisms for failures in system calls

6. Incremental program development

7. Modularity

8. All possible test cases in output

cp command: basic cp, -i
To copy a file into another
ls command: basic ls, -1, -R
To list all files in the directory
grep command: basic grep, -c, -v, -n
To search the given pattern in the file

Procedure for cp:

1. The arguments should be obtained in command line and error messages should be printed if they are not sufficient.
2. Use open, read, write, creat ,close system calls to do the following.
   mycp sourcefilename destinationfilename
   -copies source file to destination file
3. The failure messages for opening a file, creating a file should be intimated.

Note: mycp is the user programs implementing cp.

Procedure for ls:

1. To view the files in a directory include dirent.h that helps for opening, reading, closing a directory.
2. Open the user named directory giving specific path using opendir system call. This returns a pointer to a DIR data structure that represents a directory.
3. Can even use "." to represent the current working directory.
4. Traverse the directory entries using readdir system call. readdir () returns a pointer to a dirent structure whose member d_name contains the name of the current file.
5. Output the entries of directory.
6. Close the directory pointer

NOTE: Use open, read, write, creat ,close, opendir, readdir, closedir system calls wherever necessary.

Procedure for grep:

1. Open the command line specified file using the required system call.
2. Read the contents iteratively till the end of the file and compare it with the pattern you are searching for.
3. If word found print the line on to the display.
4. Count the number of occurrences and display it finally.
5. Close the file descriptor.

NOTE: Use open, read, write, creat ,close system calls wherever necessary.

SAMPLE INPUT/OUTPUT:

cp:

Source.txt:
SSN COLLEGE OF ENGINEERING
Address.txt:
SSN NAGAR
KALAVAKKAM

mycp source.txt target.txt
FILE COPIED!

ls:

Enter the name of the directory (specify path name): ./lab

OUTPUT:
.
..
diros
diros.zip
Ex-3-cp-cat.doc
Ex-3-cp-cat.pdf
Ex-4-ls-grep.doc
fork.pdf
grep.doc
prgs.doc
sys-call prgs.doc

grep:
INPUT :
programname argument1 argument2
argument1: name of the file name to be opened
argument2: pattern to be searched in the argument 1
OUTPUT:
Display the contents of the file that has the pattern in it

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

LAB EXERCISE 2

Implementation of System calls

Submission Date:16-03-2022

Name: Jayannthan P T *Dept: CSE 'A'* *Roll No.: 205001049*

Implementing cp command in C using system calls

Algorithm:

1) If argc greater than 4, then print error : too many arguments
2) Else if argc is lesser than 2, then print error :more arguments required
3) Else
   i. Open file using call open() using filename as argument provided in read-only mode and store the file pointer in file_descriptor1
   ii. If file_descriptor1 is equal to -1 then print error and exit
   iii. Else then read the contents using call read() and store the return value in contents
   iv. Close the file
   v. If "i" is present in argument then
      a. Create a file using creat() and store the file pointer in file_ descriptor2
      b. If file_ descriptor2 is equal to -1 then print error and exit
      c. Write the "contents" into file_ descriptor2 using write() call
      d. Close the file
   vi. Else then
      a. Open a file using open() and store the file pointer in file_ descriptor2
      b. If file_ descriptor2 is less than 0 then prompt for overwrite
         - If answer is yes overwrite in the same file
         - Else create new file and write the contents into it
      c. Else then create new file and write the contents into it

Code:

```c
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include <fcntl.h>
int main(int argc, char *argv[])
{
```

```
if (argc > 4)
    printf("Too many arguements\n");
else if (argc < 2)
    printf("Atleast Two arguements required\n");
else
{
    printf("Opening file1:\n");
    int file_descriptor1 = open(argv[1], O_RDONLY);
    if (file_descriptor1 == -1)
        printf("Source File does not exist\n");
    else
    {
        char contents[100];
        printf("Reading file1:\n");
        int re = read(file_descriptor1, contents, 100);
        printf("Checking for i:\n");
        if (argc > 3 && strcmp(argv[3], "i") == 0)
        {
            printf("Found i:\n");
            printf("Creating file2:\n");

            int file_descriptor2 = creat(argv[2], S_IRUSR | S_IWUSR);
            if (file_descriptor2 < 0)
            {
                printf("!!!ERROR!!!\n");
            }
            else
            {

                printf("copying into file2:\n");
                int wr = write(file_descriptor2, contents, sizeof(contents));

                printf("Closing file2:\n");
                close(file_descriptor2);
                printf("\nSuccessfully Copied\n");
            }
            close(file_descriptor1);
        }
        else
        {

            printf("i not found:\n");

            printf("Checking file2:\n");
            int file_descriptor2 = open(argv[2], O_WRONLY);
            if (!(file_descriptor2 < 0))
            {
                char ch;
                printf("Overwrite %s file?(y/n) ", argv[2]);
                scanf(" %c", &ch);
                if (!(ch == 'y' || ch == 'Y'))
                {
                    close(file_descriptor2);
                    close(file_descriptor1);
```

```
                    }
                    else
                    {

                        printf("Creating file2:\n");
                        int file_descriptor2 = creat(argv[2], S_IRUSR | S_IWUSR);
                        if (file_descriptor2 < 0)
                        {
                            printf("!!!ERROR!!!\n");
                        }
                        else
                        {

                            printf("writing into file2:\n");
                            int wr = write(file_descriptor2, contents, sizeof(contents));
                            close(file_descriptor2);
                            printf("\nSuccessfully Copied\n");
                        }
                        close(file_descriptor1);
                    }
                }
                else
                {
                    printf("Creating file2:\n");

                    int file_descriptor2 = creat(argv[2], S_IRUSR | S_IWUSR);
                    if (file_descriptor2 < 0)
                    {
                        printf("!!!ERROR!!!\n");
                    }
                    else
                    {

                        printf("copying into file2:\n");
                        int wr = write(file_descriptor2, contents, sizeof(contents));

                        printf("Closing file2:\n");
                        close(file_descriptor2);
                        printf("\nSuccessfully Copied\n");
                    }
                    close(file_descriptor1);
                }
            }
        }
    }
    return 0;
}
```

Output:

```
~/OS-Lab$ ./cp main.c temp.c
Opening file1:
Reading file1:
Checking for i:
i not found:
Checking file2:
Creating file2:
copying into file2:
Closing file2:

Successfully Copied
```

```
~/OS-Lab$ ./cp main.c temp.c i
Opening file1:
Reading file1:
Checking for i:
Found i:
Creating file2:
copying into file2:
Closing file2:

Successfully Copied
```

```
Successfully Copied
~/OS-Lab$ ./cp main.c temp.c
Opening file1:
Reading file1:
Checking for i:
i not found:
Checking file2:
Overwrite temp.c file?(y/n) y
Creating file2:
writing into file2:

Successfully Copied
```

Implementing ls command in C using system calls

Algorithm:

1) If argc greater than 4, then print error: too many arguments
2) Else if argc is lesser than 1, then print error: more arguments required
3) Else if argc is equal to 2
    i. Open directory using call opendir() using directory-name as argument provided and store the file pointer in dir
    ii. If dir is null then print error and exit
    iii. Else display the names of all files and directories with name not starting with "."
    iv. Close the pointer dir
4) Else If "r" is present in argument then
    i. Open directory using call opendir() using directory-name as argument provided and store the file pointer in dir
    ii. If dir is null then print error and exit
    iii. Else display the names of all files and directories with name recursively
    iv. Close the pointer dir
5) Else If "a" is present in argument then
    i. Open directory using call opendir() using directory-name as argument provided and store the file pointer in dir
    ii. If dir is null then print error and exit

iii. Else display the names of all files and directory name
iv. Close the pointer dir

Code:

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

DIR *dir, *temp;
struct dirent *tmp;
void recursive(struct dirent *entry)
{
    if (entry == NULL)
    {
        return;
    }

    recursive(readdir(dir));
    printf("  %s\n", entry->d_name);
}

// void normal(struct dirent *entry, int n)
// {
//     if (entry == NULL)
//     {
//         return;
//     }
//     for (int i = 0; i < n; i++)
//     {
//         printf("\t");
//     }

//     printf("  %s\n", entry->d_name);

//     if (entry->d_type == DT_DIR && !(strcmp(entry->d_name, ".") == 0 || strcmp(entry->d_name, "..") == 0 || (entry->d_name[0] == '.')))
//     {
//         temp = opendir(entry->d_name);
//         tmp = readdir(temp);
//         normal(&tmp, n + 1);
//         closedir(temp);
//     }
//     normal(readdir(dir), n);
// }

int main(int argc, char *argv[])
{
    if (argc > 4)
        printf("Too many arguements\n");
    else if (argc < 1)
        printf("Atleast one arguement required\n");
```

```
    else
    {
        // printf("%d\n",argc);
        if (argc == 2)
        {
            struct dirent *entry;
            if ((dir = opendir(argv[1])) == NULL)
            {
                printf("CANNOT OPEN GIVEN DIRECTORY");
            }
            else
            {
                printf("Contents of the given:\n");
                while ((entry = readdir(dir)) != NULL)
                {
                    if (strcmp(entry->d_name, ".") == 0 || strcmp(entry->d_name, "..") ==
0 || (entry->d_name[0] == '.'))
                        continue;
                    printf("  %s\n", entry->d_name);
                }
                closedir(dir);
            }
        }
        else if (argc > 1 && strcmp(argv[2], "r") == 0)
        {
            printf("ls -R\n");
            struct dirent *entry;
            if ((dir = opendir(argv[1])) == NULL)
            {
                printf("CANNOT OPEN GIVEN DIRECTORY");
            }
            else
            {
                printf("Contents of the given:\n");
                recursive(&entry);
                closedir(dir);
            }
        }
        else if (argc > 1 && strcmp(argv[2], "a") == 0)
        {
            // DIR *dir;
            struct dirent *entry;
            if ((dir = opendir(argv[1])) == NULL)
            {
                printf("CANNOT OPEN GIVEN DIRECTORY");
            }
            else
            {
                printf("Contents of the given:\n");
                while ((entry = readdir(dir)) != NULL)
                {
                    printf("  %s\n", entry->d_name);
                }
                closedir(dir);
```

```
            }
        }
        // else if (argc > 1 && strcmp(argv[2], "R") == 0)
        // {
        //     // DIR *dir;
        //     struct dirent *entry;
        //     if ((dir = opendir(argv[1])) == NULL)
        //     {
        //         printf("CANNOT OPEN GIVEN DIRECTORY");
        //     }
        //     else
        //     {
        //         printf("Contents of the given:\n");
        //         if ((entry = readdir(dir)) != NULL)
        //         {
        //             normal(&entry, 0);
        //         }

        //         closedir(dir);
        //     }
        // }
    }
    return 0;
}
```

Output:

```
~/OS-Lab$ ./ls .
Contents of the given:
  replit.nix
  Makefile
  main.c
  Assignment1
  Assignment2
  duplicate_main.c
  full
  ls
  grep
  cp
  Assignment3
  a.out
```

```
~/OS-Lab$ ./ls . a
Contents of the given:
  .
  ..
  .cache
  .ccls-cache
  replit.nix
  .breakpoints
  Makefile
  .replit
  main.c
  Assignment1
  Assignment2
  duplicate_main.c
  full
  ls
  grep
  cp
  Assignment3
  a.out
```

```
~/OS-Lab$ ./ls . r
Contents of the given:
  ls
  a.out
  Assignment3
  cp
  grep
  full
  duplicate_main.c
  Assignment2
  Assignment1
  main.c
  .replit
  Makefile
  .breakpoints
  replit.nix
  .ccls-cache
  .cache
  ..
  .
```

Implementing grep command in C using system calls

Algorithm:

1) If argc greater than 4, then print error: too many arguments
2) Else if argc is lesser than 2, then print error: more arguments required
3) Else if
    i. Open file using call open() using filename as argument provided in read-only mode and store the file pointer in file_descriptor
    ii. If file_descriptor is equal to -1 then print error and exit
    iii. Else then read the contents using call read() and store the return value in buf
    iv. Close the file
    v. If argc is equal to 3 then
        a. Iterate through the buf and store each line in line
        b. Check for the input expression in line
        c. If it is present then display
    vi. Else If “c” is present in argument then
        a. Iterate through the buf and store each line in line
        b. Check for the input expression in line
        c. If it is present then increment the count value
        d. Display count

Code:

```c
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <string.h>
#include <dirent.h>
#include <fcntl.h>
int main(int argc, char *argv[])
{
    if (argc > 4)
        printf("Too many arguements\n");
    else if (argc < 2)
        printf("Two arguements required\n");
    else
    {
        int file_descriptor = open(argv[2], O_RDONLY);
        if (file_descriptor == -1)
            printf("File does not exist\n");
        else
        {
            if (argc == 3)
            {
                // printf("Normal Grep\n");
                char line[100], buf[1024];
                int l = 0, i = 0, nr, count = 0;
                nr = read(file_descriptor, buf, 1024);
                close(file_descriptor);
                while (l < nr)
```

```
                {
                    for (i = 0; buf[l] != '\n' && l < nr; i++, l++)
                    {
                        line[i] = buf[l];
                    }
                    line[i] = '\0';
                    l++;
                    if (strstr(line, argv[1]))
                        printf("%s\n", line);
                }
            }
            else if (argc > 3 && strcmp(argv[3], "c") == 0)
            {
                // printf("Grep -c\n");
                char line[100], buf[1024];
                int l = 0, i = 0, nr, count = 0;
                nr = read(file_descriptor, buf, 1024);
                close(file_descriptor);
                while (l < nr)
                {
                    for (i = 0; buf[l] != '\n' && l < nr; i++, l++)
                    {
                        line[i] = buf[l]; // extracting lines
                    }
                    line[i] = '\0';
                    l++;
                    if (strstr(line, argv[1]))
                    {
                        count++;
                    }
                }
                printf("%d\n", count);
            }
        }
    }
    return 0;
}
```

Output:

```
~/OS-Lab$ ./grep main main.c
int main(void) {
~/OS-Lab$ ./grep main main.c c
1
```

Learning Outcome:

- Implemented various system commands in C using system calls
- Learned to handle system calls in C program

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

Lab Exercise 3 Implementation of CPU Scheduling Policies: FCFS and SJF (Non-preemptive and Preemptive)

Aim:

Develop a menu driven C program to implement the CPU Scheduling Algorithms

FCFS and SJF

Algorithm:

1. Read the following
    a. Number of processes
    b. Process IDs
    c. Arrival time for each process
    d. Burst Time for each process
2. Design a menu with FCFS and SJF options
3. Upon selection of menu option apply the corresponding algorithm.
4. Compute the Turnaround Time, Average waiting Time for each of the algorithm.
5. Tabularize the results.
6. Display the Gantt Chart.

Sample Input & Output:

CPU SCHEDULING ALGORITHMS

1. FCFS
2. SJF

3. EXIT

Enter your option: 1

FCFS CPU SCHEDULER

Number of Processes: 5

Process ID: P1

Arrival Time: 0

Burst Time: 4

-

-

-

-

Process ID: P5

Arrival Time: 6

Burst Time: 3

Output:

Process ID	Arrival Time	Burst Time	Turnaround Time	Waiting Time
P1	0	4	***	***
***	***	***	***	***
***				
***				
		Average	***	***

Want to Continue (Y/N): Y

CPU SCHEDULING ALGORITHMS

1. FCFS

2. SJF

3. EXIT

Enter your option: 2

SJF CPU SCHEDULER

a. Non preemptive SJF

b. Pre emptive SJF

Enter your option: a

Number of Processes: 5

Process ID: P1

Arrival Time: 0

Burst Time: 4

-

-

-

-

Process ID: P5

Arrival Time: 6

Burst Time: 3

Output:

Process ID	Arrival Time	Burst Time	Turnaround Time	Waiting Time
***	***	***	***	***
***	***	***	***	***
***				
***				
		Average	***	***

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

LAB EXERCISE 3

Implementation of CPU Scheduling Policies

Submission Date:23-03-2022

Name: Jayannthan P T *Dept: CSE 'A'* *Roll No.: 205001049*

Develop a menu driven C program to implement the CPU Scheduling Algorithms FCFS and SJF

Algorithm for FCFS:

1) Get total no of process from the user.
2) Get process id, arrival time, burst time for all process.
3) Sort the process based on arrival time.
4) Loop until all process ends
    a) Set waiting time of process as sum of previous process waiting time and burst time by subtracting arrival time of the process
    b) Add current waiting time to total waiting time
    c) Set turnaround time of process as sum of waiting time and burst time
    d) Add current turnaround time to total turnaround time
5) Calculate average waiting time by dividing total waiting time by total no of process
6) Calculate average turnaround time by dividing total turnaround time by total no of process
7) Print process table
8) Print Gantt Chart

Algorithm for SJF - Non-Preemptive:

1) Get total no of process from the user.
2) Get process id, burst time for all process.
3) Sort the process based on burst time.
4) Loop until all process ends
    a) Set waiting time of process as sum of previous process waiting time and burst time by subtracting arrival time of the process
    b) Add current waiting time to total waiting time
    c) Set turnaround time of process as sum of waiting time and burst time
    d) Add current turnaround time to total turnaround time
5) Calculate average waiting time by dividing total waiting time by total no of process

6) Calculate average turnaround time by dividing total turnaround time by total no of process
7) Print process table
8) Print Gantt Chart

Code:

```c
/*Algorithm: 1. Read the following a. Number of processes b. Process IDs c. Arrival time for each process d. Burst Time for each process 2. Design a menu with FCFSand SJFoptions 3. Upon selection of menu option apply the corresponding algorithm. 4. Compute the Turnaround Time, Average waiting Time for each of the algorithm. 5. Tabularize the results. 6. Display the Gantt Chart.*/

#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <fcntl.h>
#include <string.h>
#include <dirent.h>
#include <ctype.h>

typedef struct process
{
    char pid[3];
    int arrival, burst, turnaround, waiting, completion;
} process;

void print_gantt_chart(process p[], int n)
{
    printf("\n\nGantt-Chart\n");
    int i, j;
    printf(" ");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < p[i].burst; j++)
            printf("--");
        printf(" ");
    }
    printf("\n|");

    for (i = 0; i < n; i++)
    {
        for (j = 0; j < p[i].burst - 1; j++)
            printf(" ");
        printf(" %s", p[i].pid);
        for (j = 0; j < p[i].burst - 1; j++)
            printf(" ");
        printf("|");
    }
    printf("\n ");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < p[i].burst; j++)
```

```
            printf("--");
        printf(" ");
    }
    printf("\n");

    printf("0");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < p[i].burst; j++)
            printf("  ");
        if (p[i].turnaround > 9)
            printf("\b");
        printf("%d", p[i].turnaround);
    }
    printf("\n");
}

int main()
{
    int no_of_process;
    int totalwaitingtime = 0, totalturnaround = 0;
    int pos;
    char ch = 'y';
    process p[100];
    while (ch == 'y' || ch == 'Y')
    {
        int choice;
        printf("\nMenu\n\t1.FCFS\n\t2.SJF-Non Preemptive\n\t3.SJF-Preemptive\nEnter
Choice:");
        scanf(" %d", &choice);
        switch (choice)
        {
        case 1:
        {
            printf("\nFCFS\n");
            int no_of_process;
            printf("\nNumber of Processes :");
            scanf(" %d", &no_of_process);
            for (int i = 0; i < no_of_process; i++)
            {
                printf("\n\nProcess %d\n", i + 1);
                printf("Process ID: ");
                scanf(" %s", p[i].pid);
                printf("Arrival Time :");
                scanf(" %d", &p[i].arrival);
                printf("Burst Time :");
                scanf(" %d", &p[i].burst);
            }

            process temppro;
            for (int i = 0; i < no_of_process; i++)
            {
                pos = i;
                for (int j = i + 1; j < no_of_process; j++)
```

```
            {
                if (p[j].arrival < p[pos].arrival)
                    pos = j;
            }
            temppro = p[i];
            p[i] = p[pos];
            p[pos] = temppro;
        }
        totalwaitingtime = 0, totalturnaround = 0;
        p[0].waiting = 0;
        p[0].turnaround = p[0].burst;
        totalturnaround += p[0].turnaround;
        for (int i = 1; i < no_of_process; i++)
        {
            if (p[i - 1].waiting + p[i - 1].burst - p[i].arrival > 0)
            {
                p[i].waiting = p[i - 1].waiting + p[i - 1].burst - p[i].arrival;
            }
            else
            {
                p[i].waiting = 0;
            }
            totalwaitingtime += p[i].waiting;
            p[i].turnaround = p[i].burst + p[i].waiting;
            totalturnaround += p[i].turnaround;
        }
        printf("\nP_ID\tArrival Time\tBurst Time\tTurnaround Time\t\tWaiting Time\n");
        for (int i = 0; i < no_of_process; i++)
        {
            printf("%s\t\t%d\t\t%d\t\t%d\t\t\t%d\n", p[i].pid, p[i].arrival,
p[i].burst, p[i].turnaround, p[i].waiting);
        }

        float avgwaiting = (float)(totalwaitingtime / no_of_process);
        float avgturnaround = (float)(totalturnaround / no_of_process);
        printf("\n\t\tAVERAGE  AverageTurnaroundTime=%.2f\tAverageWaitingTime=%.2f\n",
avgturnaround, avgwaiting);
        print_gantt_chart(p, no_of_process);
        break;
    }

    case 2:
    {
        printf("\nSJF-Non Preemptive\n");
        int no_of_process;
        printf("\nNumber of Processes :");
        scanf(" %d", &no_of_process);
        int totalwaitingtime = 0, totalturnaround = 0;
        char pid[no_of_process][5];
        for (int i = 0; i < no_of_process; i++)
        {
            printf("\n\nProcess %d\n", i + 1);
            printf("Process ID: ");
            scanf(" %s", p[i].pid);
```

```
            // printf("Arrival Time :");
            p[i].arrival = 0;
            printf("Burst Time :");
            scanf(" %d", &p[i].burst);
        }

        process temppro;
        for (int i = 0; i < no_of_process; i++)
        {
            pos = i;
            for (int j = i + 1; j < no_of_process; j++)
            {
                if ((p[j].arrival < p[pos].arrival) || ((p[j].arrival <=
p[pos].arrival) && (p[j].burst < p[pos].burst)))
                {
                    pos = j;
                }
            }

            temppro = p[i];
            p[i] = p[pos];
            p[pos] = temppro;
        }
        totalwaitingtime = 0, totalturnaround = 0;
        p[0].waiting = 0;
        p[0].turnaround = p[0].burst;
        totalturnaround += p[0].turnaround;
        for (int i = 1; i < no_of_process; i++)
        {
            if (p[i - 1].waiting + p[i - 1].burst - p[i].arrival > 0)
            {
                p[i].waiting = p[i - 1].waiting + p[i - 1].burst - p[i].arrival;
            }
            else
            {
                p[i].waiting = 0;
            }
            totalwaitingtime += p[i].waiting;
            p[i].turnaround = p[i].burst + p[i].waiting;
            totalturnaround += p[i].turnaround;
        }
        printf("\nP_IDs\tBurst Time\tTurnaround Time\t\tWaiting Time\n");
        for (int i = 0; i < no_of_process; i++)
        {
            printf("%s\t\t%d\t\t%d\t\t\t%d\n", p[i].pid, p[i].burst, p[i].turnaround,
p[i].waiting);
        }

        float avgwaiting = (float)(totalwaitingtime / no_of_process);
        float avgturnaround = (float)(totalturnaround / no_of_process);
        printf("\n\t\tAVERAGE  AverageTurnaroundTime=%.2f\tAverageWaitingTime=%.2f\n",
avgturnaround, avgwaiting);
        print_gantt_chart(p, no_of_process);
        break;
```

```
        }
        case 3:
        {
            printf("\nSJF - Preemptive\n");
            int no_of_process;
            printf("\nNumber of Processes :");
            scanf(" %d", &no_of_process);
            for (int i = 0; i < no_of_process; i++)
            {
                printf("\n\nProcess %d\n", i + 1);
                printf("Process ID: ");
                scanf(" %s", p[i].pid);
                printf("Arrival Time :");
                scanf(" %d", &p[i].arrival);
                printf("Burst Time :");
                scanf(" %d", &p[i].burst);
            }

            process temppro;
            for (int i = 0; i < no_of_process; i++)
            {
                pos = i;
                for (int j = i + 1; j < no_of_process; j++)
                {
                    if (p[j].arrival < p[pos].arrival)
                        pos = j;
                }
                temppro = p[i];
                p[i] = p[pos];
                p[pos] = temppro;
            }
            int rem_time[no_of_process];
            for (int i = 0; i < no_of_process; i++)
            {
                rem_time[i] = p[i].burst;
            }
            for (int cur_time = 0, completed = 0; completed < no_of_process; cur_time++)
            {
                int idx = -1;
                for (int i = 0; i < no_of_process; i++)
                {
                    if (p[i].arrival <= cur_time && rem_time[i] > 0 && (idx == -1 ||
rem_time[i] < rem_time[idx]))
                    {
                        idx = i;
                    }
                }
                if (idx != -1)
                {
                    rem_time[idx]--;
                    if (rem_time[idx] == 0)
                    {
                        completed++;
                        p[idx].completion = cur_time;
```

```
                    p[idx].turnaround = p[idx].completion - p[idx].arrival + 1;
                    p[idx].waiting = p[idx].turnaround - p[idx].burst;
                }
            }
        }

        for (int i = 0; i < no_of_process; i++)
        {
            //  p[i].turnaround=p[i].burst+p[i].waiting;
            totalwaitingtime += p[i].waiting;
            totalturnaround += p[i].turnaround;
        }
        printf("\nP_ID\tArrival Time\tBurst Time\tTurnaround Time\t\tWaiting Time\n");
        for (int i = 0; i < no_of_process; i++)
        {
            printf("%s\t\t%d\t\t%d\t\t%d\t\t\t%d\n", p[i].pid, p[i].arrival,
p[i].burst, p[i].turnaround, p[i].waiting);
        }

        float avgwaiting = (float)(totalwaitingtime / no_of_process);
        float avgturnaround = (float)(totalturnaround / no_of_process);
        printf("\n\t\tAVERAGE  AverageTurnaroundTime=%.2f\tAverageWaitingTime=%.2f\n",
avgturnaround, avgwaiting);
        print_gantt_chart(p, no_of_process);
        break;
    }
    case 4:
        printf("Exiting...");
        return 0;
    }
    printf("\nWant to Continue (Y/N):");
    scanf(" %c", &ch);
}
    return 0;
}
```

Output:

```
Number of Processes :4


Process 1
Process ID: P1
Arrival Time :0
Burst Time :10


Process 2
Process ID: P2
Arrival Time :3
Burst Time :2


Process 3
Process ID: P3
Arrival Time :1
Burst Time :6


Process 4
Process ID: P
Arrival Time :5
Burst Time :4
```

```
Menu
    1.FCFS
    2.SJF-Non Preemptive
    3.SJF-Preemptive
Enter Choice:1

FCFS
```

```
P_ID    Arrival Time    Burst Time  Turnaround Time     Waiting Time
P1      0       10      10          0
P3      1       6       15          9
P2      3       2       14          12
P       5       4       13          9

        AVERAGE  AverageTurnaroundTime=13.00    AverageWaitingTime=7.00


Gantt-Chart
 ------------------- ------------ ---- --------
|         P1        |      P3     |  P2 |    P   |
 ------------------- ------------ ---- --------
0                  10           15   14       13
```

```
SJF-Non Preemptive

Number of Processes :4


Process 1
Process ID: 1
Burst Time :6


Process 2
Process ID: 2
Burst Time :8


Process 3
Process ID: 3
Burst Time :7


Process 4
Process ID: 4
Burst Time :3
```

```
P_IDs   Burst Time  Turnaround Time     Waiting Time
4       3       3           0
1       6       9           3
3       7       16          9
2       8       24          16

        AVERAGE  AverageTurnaroundTime=13.00    AverageWaitingTime=7.00


Gantt-Chart
 ------ ------------ -------------- ----------------
|   4  |      1     |       3      |        2       |
 ------ ------------ -------------- ----------------
0      3            9              16               24
```

```
Process 1
Process ID: 1
Arrival Time :2
Burst Time :6


Process 2
Process ID: 2
Arrival Time :5
Burst Time :2


Process 3
Process ID: 3
Arrival Time :1
Burst Time :8


Process 4
Process ID: 4
Arrival Time :0
Burst Time :3


Process 5
Process ID: 5
Arrival Time :4
Burst Time :4
```

```
P_ID    Arrival Time    Burst Time  Turnaround Time        Waiting Time
4       0       3       3           0
3       1       8       22          14
1       2       6       13          7
5       4       4       6           2
2       5       2       2           0

        AVERAGE  AverageTurnaroundTime=28.00   AverageWaitingTime=15.00
```

Learning Outcome:

- Implemented FCFS Scheduling and SJF Scheduling in C program
- Displayed Gantt Chart for the above scheduling methods

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

Lab Exercise 4: Implementation of CPU Scheduling Policies: Priority and Round Robin

Aim:

Develop a menu driven C program to implement the CPU Scheduling Algorithms

Priority (Non-Preemptive and Preemptive) and Round Robin

Algorithm:

1. Read the following
    a. Number of processes
    b. Process IDs
    c. Arrival time for each process
    d. Burst Time for each process
2. Design a menu with Priority and Round Robin options
3. Upon selection of menu option apply the corresponding algorithm.
4. Compute the Turnaround Time, Average waiting Time for each of the algorithm.
5. Tabularize the results.
6. Display the Gantt Chart.

Sample Input & Output:

CPU SCHEDULING ALGORITHMS

1. ROUND ROBIN
2. PRIORITY
3. EXIT

Enter your option: 1

ROUND ROBIN CPU SCHEDULER

Number of Processes: 5

Process ID: P1

Arrival Time: 0

Burst Time: 4

-

-

-

-

Process ID: P5

Arrival Time: 6

Burst Time: 3

Output:

Process ID	Arrival Time	Burst Time	Turnaround Time	Waiting Time
P1	0	4	***	***
***	***	***	***	***
***				
***				
		Average	***	***

Want to Continue (Y/N): Y

CPU SCHEDULING ALGORITHMS

1. ROUND ROBIN
2. PRIORITY
3. EXIT

Enter your option: 2

PRIORITY CPU SCHEDULER

a. Non preemptive PRIORITY

b. Pre emptive PRIORITY

Enter your option: a

Number of Processes: 5

Process ID: P1

Arrival Time: 0

Burst Time: 4

-

-

-

-

Process ID: P5

Arrival Time: 6

Burst Time: 3

Output:

Process ID	Arrival Time	Burst Time	Turnaround Time	Waiting Time
***	***	***	***	***
***	***	***	***	***
***				
***				
		Average	***	***

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

LAB EXERCISE 4

Implementation of CPU Scheduling Policies

Submission Date:07-04-2022

Name: Jayannthan P T *Dept: CSE 'A'* *Roll No.: 205001049*

Develop a menu driven C program to implement the CPU Scheduling Algorithms

1. Priority (Non-Preemptive and Preemptive)
2. Round Robin

Algorithm for Priority Preemptive:

1) Get total no of process from the user.
2) Get process id, arrival time, burst time, priority for all process.
3) Take a temporary burst time(rem_time) to have a value of remining burst time of all the process
4) Have count of completed process, current time.
5) Loop until completed less than total no of process
    a) Compare priority of current running job and new entering job at that current time
    b) If priority is greater then stop the current processor and update rem_time and begin the new process
    c) Else continue until the process ends
    d) While the process ends set completion time as current time, waiting time as completion time minus sum of arrival time and burst time, turnaround time as sum of waiting time and burst time, update total turnaround time and total waiting time
6) Calculate average waiting time by dividing total waiting time by total no of process
7) Calculate average turnaround time by dividing total turnaround time by total no of process
8) Print process table
9) Print Gantt Chart

Algorithm for Round Robin:

1) Get total no of process, time quantum from the user.

2) Get process id, arrival time, burst time for all process.
3) Take a temporary burst time(rem_time) to have a value of remining burst time of all the process
4) Sort the process based on arrival time.
5) Have count of completed process, current time.
6) Loop until all process ends
    a) If rem_time is less than or equal to quantum then current time is sum of current time and burst time of the process and set turnaround time as current time minus arrival time, waiting time as current time minus sum of arrival time and burst time, update total turnaround time and total waiting time
    b) Else update rem_time as rem_time minus quantum and current time is sum of current time and quantum
7) Calculate average waiting time by dividing total waiting time by total no of process
8) Calculate average turnaround time by dividing total turnaround time by total no of process
9) Print process table
10) Print Gantt Chart

Code:

```c
/*Develop a menu driven C program to implement the CPU Scheduling Algorithms - Priority (Non-Preemptive and Preemptive) and Round Robin
Algorithm: 1. Read the following a. Number of p b. Process IDs c. Arrival time for each process d. Burst Time for each process 2. Design a menu with FCFSand SJFoptions 3. Upon selection of menu option apply the corresponding algorithm. 4. Compute the Turnaround Time, Average waiting Time for each of the algorithm. 5. Tabularize the results. 6. Display the Gantt Chart.*/

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

typedef struct process
{
    char pid[3];
    int arrival, burst,teempburst, turnaround, waiting, completion, priority;
} process;

void print_gantt_chart(process p[], int n)
{
    printf("\n\nGantt-Chart\n");
    int i, j;
    printf(" ");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < p[i].burst; j++)
            printf("--");
        printf(" ");
    }
    printf("\n|");
```

```
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < p[i].burst - 1; j++)
            printf(" ");
        printf("P%s", p[i].pid);
        for (j = 0; j < p[i].burst - 1; j++)
            printf(" ");
        printf("|");
    }
    printf("\n ");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < p[i].burst; j++)
            printf("--");
        printf(" ");
    }
    printf("\n");

    printf("0");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < p[i].burst; j++)
            printf("  ");
        if (p[i].turnaround > 9)
            printf("\b");
        printf("%d", p[i].turnaround);
    }
    printf("\n");
}

int main()
{
    int no_of_process;
    int totalwaitingtime = 0, totalturnaround = 0;
    int pos;
    char ch = 'y';
    process p[100];
    while (ch == 'y' || ch == 'Y')
    {
        int choice;
        printf("\nMenu\n\t1.Priority-Non Preemptive\n\t2.Priority-Preemptive\n\t3.Round
Robin\n\t4.Exit\n\t\nEnter Choice:");
        scanf(" %d", &choice);
        switch (choice)
        {
        case 1:
        {
            printf("\nPriority-Non Preemptive\n");
            int no_of_process;
            printf("\nNumber of p :");
            scanf(" %d", &no_of_process);
            for (int i = 0; i < no_of_process; i++)
            {
                printf("\n\nProcess %d\n", i + 1);
```

```
            printf("Process ID: ");
            scanf(" %s", p[i].pid);
            printf("Burst Time :");
            scanf(" %d", &p[i].burst);
            printf("Priority :");
            scanf(" %d", &p[i].priority);
        }

        process temppro;
        for (int i = 0; i < no_of_process; i++)
        {
            pos = i;
            for (int j = i + 1; j < no_of_process; j++)
            {
                if (p[j].priority < p[pos].priority)
                    pos = j;
            }
            temppro = p[i];
            p[i] = p[pos];
            p[pos] = temppro;
        }
        totalwaitingtime = 0, totalturnaround = 0;
        p[0].waiting = 0;
        p[0].turnaround = p[0].burst;
        totalturnaround += p[0].turnaround;
        for (int i = 1; i < no_of_process; i++)
        {
            if (p[i - 1].waiting + p[i - 1].burst - p[i].arrival > 0)
            {
                p[i].waiting = p[i - 1].waiting + p[i - 1].burst - p[i].arrival;
            }
            else
            {
                p[i].waiting = 0;
            }
            totalwaitingtime += p[i].waiting;
            p[i].turnaround = p[i].burst + p[i].waiting;
            totalturnaround += p[i].turnaround;
        }
        printf("\nP_ID\tBurst Time\tPriority\tWaiting Time\t\tTurnaround Time\n");
        for (int i = 0; i < no_of_process; i++)
        {
            printf("%s\t\t%d\t\t%d\t\t%d\t\t\t%d\n", p[i].pid, p[i].burst,
p[i].priority, p[i].waiting, p[i].turnaround);
        }

        float avgwaiting = (float)(totalwaitingtime / no_of_process);
        float avgturnaround = (float)(totalturnaround / no_of_process);
        printf("\n\t\tAVERAGE \tWaitingTime =%.2f\t TurnaroundTime =%.2f\n",
totalwaitingtime / no_of_process, totalturnaround / no_of_process);
        print_gantt_chart(p, no_of_process);
        break;
    }
```

```
        case 2:
        {
            printf("\nPriority-Preemptive\n");
            int no_of_process;
            printf("\nNumber of process :");
            scanf(" %d", &no_of_process);
            int tempburst[100];
            for (int i = 0; i < no_of_process; i++)
            {
                printf("\n\nProcess %d\n", i + 1);
                printf("Process ID: ");
                scanf(" %s", p[i].pid);
                printf("Arrival Time :");
                scanf(" %d", &p[i].arrival);
                printf("Burst Time :");
                scanf(" %d", &p[i].burst);
                printf("Priority :");
                scanf(" %d", &p[i].priority);
                tempburst[i] = p[i].burst;
                p[i].teempburst = p[i].burst;
            }

            int rem_time[no_of_process];
            for (int i = 0; i < no_of_process; i++)
                rem_time[i] = p[i].burst;

            process tempro[100];
            int tempcount = 0;
            int completed = 0;
            int cur_time = 0;
            while (completed < no_of_process)
            {
                int idx = -1;
                for (int i = 0; i < no_of_process; i++)
                {
                    if (p[i].arrival <= cur_time && rem_time[i] > 0 && (idx == -1 ||
p[i].priority < p[idx].priority))
                        idx = i;
                }
                cur_time++;
                if (tempcount != 0 && strcmp(tempro[tempcount-1].pid,p[idx].pid))
tempcount--;
                else
                {
                    tempro[tempcount] = p[idx];
                }
                strcpy(tempro[tempcount].pid,p[idx].pid);
                tempro[tempcount].burst++;
                tempro[tempcount].turnaround = cur_time;
                tempcount++;
                rem_time[idx]--;
                if(rem_time[idx]==0)
                {
                    completed++;
```

```
                p[idx].completion = cur_time;
                p[idx].waiting = p[idx].completion - p[idx].arrival - p[idx].burst;
                p[idx].turnaround = p[idx].burst + p[idx].waiting;
            }
        }

        for (int i = 0; i < no_of_process; i++)
        {
            totalwaitingtime+=p[i].waiting;
            totalturnaround+=p[i].turnaround;
        }
        printf("\nP_ID\tArrival Time\tBurst Time\tPriority\tWaiting Time\t\tTurnaround
Time\n");
        for (int i = 0; i < no_of_process; i++)
        {
            printf("%s\t\t%d\t\t%d\t\t%d\t\t%d\t\t\t%d\n", p[i].pid, p[i].arrival,
p[i].burst, p[i].priority, p[i].waiting, p[i].turnaround);
        }
        float avgwaiting = (float)(totalwaitingtime / no_of_process);
        float avgturnaround = (float)(totalturnaround / no_of_process);
        printf("\n\t\tAVERAGE \tWaitingTime =%.2f\t TurnaroundTime =%.2f\n",
avgwaiting, avgturnaround);
        process temmptemppro[100];
        int temptempcount=-1;
        for(int i=0;i<tempcount;i++)
        {
            if(strcmp(tempro[i+1].pid,tempro[i].pid)!=0)
            {
                temmptemppro[++temptempcount]=tempro[i];
            }
        }


        print_gantt_chart(temmptemppro, temptempcount+1);
        print_gantt_chart(tempro, tempcount);
        break;
    }
    case 3:
    {
        printf("\nRound Robin\n");
        int no_of_process;
        int quantum;
        printf("\nNumber of p :");
        scanf(" %d", &no_of_process);
        int temp_nop = no_of_process;
        process temppro[100];
        int tempburst[100];
        int count = 0;
        int tempcount = -1;
        for (int i = 0; i < no_of_process; i++)
        {
            printf("\n\nProcess %d\n", i + 1);
            printf("Process ID: ");
            scanf(" %s", p[i].pid);
```

```
        printf("Arrival Time :");
        scanf(" %d", &p[i].arrival);
        printf("Burst Time :");
        scanf(" %d", &p[i].burst);
        tempburst[i] = p[i].burst;
    }

    process tempppro;
    for (int i = 0; i < no_of_process; i++)
    {
        pos = i;
        for (int j = i + 1; j < no_of_process; j++)
        {
            if (p[j].arrival < p[pos].arrival)
                pos = j;
        }
        tempppro = p[i];
        p[i] = p[pos];
        p[pos] = tempppro;
    }

    totalwaitingtime = 0, totalturnaround = 0;
    p[0].waiting = 0;
    printf("\nTime Quantum :");
    scanf(" %d", &quantum);
    for (int sum = 0, i = 0; temp_nop != 0;)
    {
        if (tempburst[i] <= quantum && tempburst[i] > 0)
        {
            int temptempburst = tempburst[i];
            sum = sum + tempburst[i];
            tempburst[i] = 0;
            count = 1;

            tempcount++;
            strcpy(temppro[tempcount].pid, p[i].pid);
            temppro[tempcount].burst = temptempburst;
            temppro[tempcount].arrival = p[i].arrival;
            temppro[tempcount].turnaround = sum;
        }
        else if (tempburst[i] > 0)
        {

            tempburst[i] = tempburst[i] - quantum;
            sum = sum + quantum;

            tempcount++;
            strcpy(temppro[tempcount].pid, p[i].pid);
            temppro[tempcount].burst = quantum;
            temppro[tempcount].arrival = p[i].arrival;
            temppro[tempcount].turnaround = sum;
            temppro[tempcount].waiting = sum - p[i].arrival - quantum;
        }
        if (tempburst[i] == 0 && count == 1)
```

```
                {
                    temp_nop--;


                    p[i].turnaround = sum - p[i].arrival;
                    p[i].waiting = sum - p[i].arrival - p[i].burst;
                    totalwaitingtime = totalwaitingtime + sum - p[i].arrival - p[i].burst;
                    totalturnaround = totalturnaround + sum - p[i].arrival;
                    count = 0;
                }

                if (p[i + 1].arrival <= sum)
                {
                    i++;
                }
                else
                {
                    i = 0;
                }
            }
            printf("\nP_ID\tArrival Time\tBurst Time\tWaiting Time\t\tTurnaround Time\n");
            for (int i = 0; i < no_of_process; i++)
            {
                printf("%s\t\t%d\t\t%d\t\t%d\t\t\t%d\n", p[i].pid, p[i].arrival,
p[i].burst, p[i].waiting, p[i].turnaround);
            }
            float avgwaiting = (float)(totalwaitingtime / no_of_process);
            float avgturnaround = (float)(totalturnaround / no_of_process);
            printf("\n\t\tAVERAGE \tWaitingTime =%.2f\t TurnaroundTime =%.2f\n",
avgwaiting, avgturnaround);
            print_gantt_chart(temppro, tempcount + 1);
            break;
        }
        case 4:
            printf("Exiting...");
            return 0;
        }
        printf("\nWant to Continue (Y/N):");
        scanf(" %c", &ch);
    }
    return 0;
}
```

Output:

```
Menu
        1.Priority-Non Preemptive
        2.Priority-Preemptive
        3.Round Robin
        4.Exit

Enter Choice:3
```

```
Round Robin

Number of p :5


Process 1
Process ID: 1
Arrival Time :0
Burst Time :10


Process 2
Process ID: 2
Arrival Time :0
Burst Time :1


Process 3
Process ID: 3
Arrival Time :0
Burst Time :2

Process 5
Process ID: 5
Arrival Time :0
Burst Time :5

Time Quantum :5
```

```
P_ID    Arrival Time    Burst Time      Waiting Time            Turnaround Time
1               0               10              9                       19
2               0               1               5                       6
3               0               2               6                       8
4               0               1               8                       9
5               0               5               9                       14

                AVERAGE         WaitingTime =7.00       TurnaroundTime =11.00


Gantt-Chart
 ---------- -- ---- -- ---------- ----------
|    P1    |P2| P3 |P4|    P5    |    P1    |
 ---------- -- ---- -- ---------- ----------
0          5  6    8  9         14         19
```

```
Priority-Preemptive

Number of process :3


Process 1
Process ID: 1
Arrival Time :0
Burst Time :5
Priority :3


Process 2
Process ID: 2
Arrival Time :1
Burst Time :3
Priority :1


Process 3
Process ID: 3
Arrival Time :2
Burst Time :2
Priority :2
```

```
PID   Arrival_Time   Burst_Time   Waiting_Time   Completion_Time    Turnaround_Time
1         0              5            5              10                 10
2         1              3            0              4                  3
3         2              2            2              6                  4

                Average Waiting time :  2.33     Turn_around time : 5.67
 --- ------- ----- ---------
| P1|  P2   | P3 |   P1    |
 --- ------- ----- ---------
0   1       4     6         10
```

Learning Outcome:

- Implemented Pre-emptive Priority Scheduling and Round Robin Scheduling in C program
- Displayed Gantt Chart for the above scheduling methods

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)
SSN College of Engineering

Department of Computer Science and Engineering

UCS1411 – Operating Systems Laboratory

II Year CSE - A Section (IV Semester)

Exercise – 5- Inter process communication

Lab Exercise 5 InterProcess Communications using Shared Memory

Study the following system calls.
Shared memory - shmget, shmat, shmdt, shmctl

Additional optional system calls
Pipe - pipe, mkfifo, mknod, open, read, write, close
Message Queue – msgget, msgsnd, msgrcv, msgctl

Aim:
Develop the following applications that uses interprocess communication concepts using shared memory.

1.Develop an application for getting a name in parent and convert it into uppercase in child using shared memory.
2.Develop an client / server application for file transfer using shared memory.
3. Develop an client/server chat application using shared memory.

Comment:

This program should be run as a single program in which parent is one process and child is another process.

Client / server:

Keep common code and parent code in one program as server.c

Keep common code and child code in another program as client.c

Run server.c in one terminal and client.c in another terminal. Communicate between the two processes.

Example :
Shared memory :

```
#include <sys/ipc.h>
# define NULL 0
#include <sys/shm.h>
#include <sys/types.h>
# include<unistd.h>
# include<stdio.h>
# include<stdlib.h>
# include<string.h>
#include <sys/wait.h>
#include <stdio_ext.h>
// parent writing a char in shared memory and child reads it and prints it.
int main()
{
        int pid;
        char *a,*b,c;
        int id,n,i;
        // you can create a shared memory between parent and child here or you can //create
        inside them separately.
        id=shmget(111,50,IPC_CREAT | 00666);
        pid=fork();
        if(pid>0) //parent
                {
                        // id=shmget(111,50,IPC_CREAT | 00666);
                        a=shmat(id,NULL,0);
                        a[0]='d';
                        wait(NULL);
                        shmdt(a);
                }
        else //child
                {
                        sleep(3);
                        //id=shmget(111,50,0);
                        b=shmat(id,NULL,0);
                        printf("\n child %c\n",b[0]);
                        shmdt(b);
                }
        shmctl(id, IPC_RMID,NULL);
}
```

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

LAB EXERCISE 5

Inter Process Communication

Submission Date:07-04-2022

Name: Jayannthan P T *Dept: CSE 'A'* *Roll No.: 205001049*

System Calls

1. Name:shmget()

    a. Description: returns the identifier for the shared memory segment associated with the value of the argument key
    b. Header file:sys/shm.h
    c. Syntax:int shmget(key_t key,size_t size,int shmflg);
    d. Arguments:
    e. Key - it identifies the shared memory segment
    f. Size - size of the shared segment
    g. Shmflg - specifies the required shared memory flag(s). Need to pass permissions as well.
    h. Return type:
    i. Success:returns valid shared memory identifier
    j. Failure:returns -1 and errno is set to indicate the error

2. Name:shmat()
    a. Description: attaches the shared memory segment identified by shmid to the address space of the calling process
    b. Header file:sys/shm.h
    c. Syntax:void *shmat(int shmid, const void *shmaddr, int shmflg);
    d. int shmdt(const void *shmaddr);
    e. Arguments:
    f. Shmid - shared memory identifier, which is the return value of shmget() system call.
    g. Shmaddr - specifies the address that attaches to the calling process.
    h. Shmflg - specifies the required shared memory flag/s.
    i. Return type:
    j. Success: returns address of the attached shared memory segment
    k. Failure:returns -1

3. Name:shmdt()
    a. Description:detaches the shared memory segment located at the address specified by shmaddr from the address space of the calling process
    b. Header file:sys/types.h
    c. Syntax:int shmdt(const void *shmaddr)

d. Arguments:Shmaddr - the address of the shared memory segment to be detached. The to-be-detached segment must be the address returned by the shmat() system call.
e. Return type:
f. Success:returns 0
g. Failure:returns -1

4. Name:shmctl()
   a. Description: performs the control option specified by cmd on the system shared memory segment whose identifier is given by shmid
   b. Header file:sys/shm.h
   c. Syntax:int shmctl(int shmid,int cmd,struct shmid_ds *buf);
   d. Arguments:
   e. Shmid - shared memory identifier, which is the return value of shmget() system call.
   f. Cmd - command to perform the required control operation on the shared memory segment.
   g. Buf - pointer to the shared memory structure named struct shmid_ds.
   h. Return type:
   i. Success:returns 0
   j. Failure:returns -1.

Develop the following applications that uses interprocess communication concepts using shared memory.

1.Develop an application for getting a name in parent and convert it into uppercase in child using shared memory.

Algorithm:

1) Fork() is called and the children id is stored in pid
2) If pid is equal to zero then
   a) Created a unique key for a project using ftok() and stored in key
   b) For the key, shared memory is allotted using shmget and returned id is stored in shmid
   c) Get input from the user which to be stored in shared memory
   d) Detach from the memory
3) Else then
   a) Created a unique key for a project using ftok() and stored in key
   b) For the key, shared memory is allotted using shmget and returned id is stored in shmid
   c) Read the data in shared memory and convert it to uppercase then display it
   d) Detach from the memory
   e) Erase the shared memory

Code:

```
#include <sys/ipc.h>
#define NULL 0
#include <sys/shm.h>
#include <sys/types.h>
#include <unistd.h>
#include <stdio.h>
#include <stdlib.h>
```

```c
#include <sys/wait.h>
#include <stdio_ext.h>

int main()
{
    int pid = fork();
    if (pid == 0)
    {
        int shmid = shmget(111, 1024, 0666 | IPC_CREAT);
        char *str = (char *)shmat(shmid, (void *)0, 0);
        printf("Data to be written in memory:");

        fgets(str, 100, stdin);
        // printf("Data written in memory: %s\n", str);
        shmdt(str);
    }
    else
    {
        wait(NULL);
        int shmid = shmget(111, 1024, 0666 | IPC_CREAT);
        char *str = shmat(shmid, (void *)0, 0);
        printf("\nActual Data read from memory: %s\n", str);

        for (int i = 0; str[i] != '\0'; i++)
        {
            if (str[i] >= 'a' && str[i] <= 'z')
            {
                str[i] = str[i] - 32;
            }
        }

        printf("Data to be displayed from memory: %s\n", str);
        shmdt(str);
        shmctl(shmid, IPC_RMID, NULL);
    }
}
```

Output:

```
jayannthan_hakr@jayannthan-Ubuntu:~/OS LAB/Assignment5$ ./1
Data to be written in memory:hi! how are you?

Actual Data read from memory: hi! how are you?

Data to be displayed from memory: HI! HOW ARE YOU?
```

2.Develop a client / server application for file transfer using shared memory.

Algorithm for server:

1) Created a unique key for a project using ftok() and stored in key

2) For the key, shared memory is allotted using shmget and returned id is stored in shmid
3) read input from the shared memory and store it in str
4) open file of name str and store file pointer in fp
5) read the file and write it into the shared memory using same str
6) close the file

Algorithm for client:

1) Created a unique key for a project using ftok() and stored in key
2) For the key, shared memory is allotted using shmget and returned id is stored in shmid
3) read input filename from the user and store it in the shared memory
4) After the server writes the file contents into the shared memory, display it and write it into a new file
5) Detach from the memory
6) Erase the memory

Code:

```c
/*Server Code*/

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/shm.h>
#include <unistd.h>

int main()
{

    int shmid = shmget(1, 50, 666 | IPC_CREAT);
    char *str = (char *)shmat(shmid, (void *)0, 0);

    while (str[0] == '\0')
        ;

    printf("File name received\n");

    FILE *fp;
    fp = fopen(str, "r");
    if (fp == NULL)
    {
        strcpy(str, "File not found\n");
    }
    else
    {
        printf("Reading the file...\n");
        char c;
```

```
        int i = 0;
        while ((c = fgetc(fp)) != EOF)
        {
            str[i] = c;
            i++;
        }
        str[i] = '\0';
        printf("File content fetched successfully!\n");
        fclose(fp);
    }
}
```

```
/*Client Code*/
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/shm.h>
#include <unistd.h>
#include <fcntl.h>
#include <sys/wait.h>

int main()
{

    int shmid = shmget(1, 50, 666 | IPC_CREAT);
    char *str = (char *)shmat(shmid, (void *)0, 0);

    printf("Enter file name : ");
    scanf("%s", str);

    printf("Waiting for file content from server...\n");
    sleep(1);

    if (strcmp(str, "File not found") == 0)
    {
        printf("File not found\n");
    }
    else
    {
        printf("Content received\n");
        printf("File Contents :\n%s", str);
    }
    shmdt(str);

    shmctl(shmid, IPC_RMID, NULL);
}
```

Output:

```
Enter filename: main.c

File: main.c
File Request Sent...
Contents of File:
#include <stdio.h>

int main(int argc, char const *argv[])
{
        printf("Hello World!!!\n");
        return 0;
}
```

3. Develop an client/server chat application using shared memory.

Algorithm for server:

1) Get process id using getpid() and store it in pid
2) Create a shared memory using shmget and returned id is stored in shmid
3) Attach the pointer of message structure (memory) into the shared memory
4) Set pid2 in the memory as pid
5) Set status as -1
6) Call signal(). Send SIGUSR2, handler function as parameters
7) Loop until exit
    a) If status is equal to 1 then wait for the other user to give input
    b) Else then get input from the user to chat
    c) Then set status as 1
    d) Signal all the process using kill. Send pid1, SIGUSR1 as parameters
8) Detach from the memory
9) Destroy the memory

Algorithm for client:

1) Get process id using getpid() and store it in pid
2) Create a shared memory using shmget and returned id is stored in shmid
3) Attach the pointer of message structure (memory) into the shared memory
4) Set pid2 in the memory as pid
5) Set status as -1
6) Call signal(). Send SIGUSR1, handler function as parameters
7) Loop until exit
    a) If status is equal to 1 then wait for the other user to give input
    b) Else then get input from the user to chat
    c) Then set status as 0
    d) Signal all the process using kill. Send pid2, SIGUSR2 as parameters
8) Detach from the memory
9) Destroy the memory

Code:

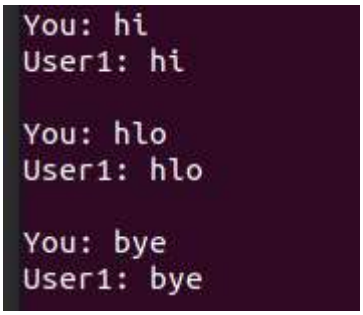
```
/*Server Code*/
```

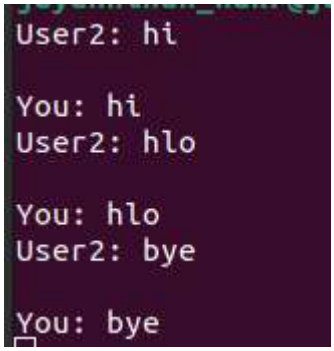
```c
#include <signal.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/ipc.h>
#include <sys/shm.h>
#include <sys/types.h>
#include <unistd.h>

struct memory
{
    char buff[100];
    int status, pid1, pid2;
};

struct memory *shmptr;
void handler(int signum)
{
    if (signum == SIGUSR2)
    {
        printf("User1: ");
        puts(shmptr->buff);
    }
}

int main()
{
    int pid = getpid();
    int shmid = shmget(111, sizeof(struct memory), IPC_CREAT | 0666);
    shmptr = (struct memory *)shmat(shmid, NULL, 0);
    shmptr->pid2 = pid;
    shmptr->status = -1;
    signal(SIGUSR2, handler);
    while (1)
    {
        while (shmptr->status == 1)
            continue;
        sleep(1);
        printf("You: ");
        fgets(shmptr->buff, 100, stdin);
        shmptr->status = 1;
        kill(shmptr->pid1, SIGUSR1);
    }
    shmdt((void *)shmptr);
    shmctl(shmid, IPC_RMID, NULL);
    return 0;
}
```

```c
/*Client Code*/

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

```c
#include <stdlib.h>
#include <string.h>
#include <sys/ipc.h>
#include <sys/shm.h>
#include <sys/types.h>
#include <unistd.h>

struct memory
{
    char buff[100];
    int status, pid1, pid2;
};

struct memory *shmptr;
void handler(int signum)
{
    if (signum == SIGUSR1)
    {
        printf("User2: ");
        puts(shmptr->buff);
    }
}

int main()
{
    int pid = getpid();
    int shmid = shmget(111, sizeof(struct memory), IPC_CREAT | 0666);
    shmptr = (struct memory *)shmat(shmid, NULL, 0);
    shmptr->pid1 = pid;
    shmptr->status = -1;
    signal(SIGUSR1, handler);
    while (1)
    {
        while (shmptr->status != 1)
            continue;
        sleep(1);
        printf("You: ");
        fgets(shmptr->buff, 100, stdin);
        shmptr->status = 0;
        kill(shmptr->pid2, SIGUSR2);
    }
    shmdt((void *)shmptr);
    shmctl(shmid, IPC_RMID, NULL);
    return 0;
}
```

Output:





Learning Outcome:

- Executed shared memory functions and system calls
- Executed server-side and client-side program using shared memory

Sri Sivasubramaniya Nadar College of Engineering

(An Autonomous Institution, Affiliated to Anna University, Chennai)

Department of Computer Science and Engineering

UCS1411 – Operating Systems Laboratory

Lab Exercise 6: Implementation of Producer/Consumer Problem using Semaphores

Study the following system calls

Semaphores – sem_init, sem_wait, sem_post, sem_destroy – POSIX, pthread

semget , semctl, semop (for your understanding)

Shared memory - shmget, shmat, shmdt, shmctl

Assignment 1:

Aim:

To write a C program to create parent/child processes to implement the producer/consumer problem using semaphores in pthread library.

Procedure:

1. Create a Shared memory for buffer and semaphores - empty, full, mutex

2. Create a parent and a child process one acting as a producer and the other consumer.

3. In the producer process, produce an item, place it in the buffer. Increment full and decrement empty using wait and signal operations appropriately.

4. In the consumer process, consume an item from the buffer and display it on the terminal. Increment empty and decrement full using wait and signal operations appropriately.

5. Compile the sample program with pthread library

cc prg.c - lpthread

Assignment 2:

Modify the program as separate client / server process programs to generate 'N' random numbers in producer and write them into shared memory. Consumer process should read them from shared memory and display them in terminal

Base Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <semaphore.h>
#include <pthread.h> // for semaphore operations sem_init,sem_wait,sem_post
#include <sys/ipc.h>
#include <sys/shm.h>
#include <sys/sem.h>
#include <sys/wait.h>
#include <sys/errno.h>
#include <sys/types.h>
extern int errno;
#define SIZE 10 /* size of the shared buffer*/
#define VARSIZE 1 /* size of shared variable=1byte*/
#define INPUTSIZE 20
#define SHMPERM 0666 /* shared memory permissions */
int segid; /* id for shared memory bufer */
int empty_id;
int full_id;
int mutex_id;
char * buff;
char * input_string;
sem_t *empty;
sem_t *full;
sem_t *mutex;
int p=0,c=0;

// Producer function
void produce()
{
        int i=0;
        while (1)
        {
            // If buffer not full, gain access to shared memory
                //write into memory one character at a time
            //release the semphores
         } //end-while
} //producer fn

// Consumer function
void consume()
{
     // If buffer not empty, gain access to shared memory
     //consume a character from memory and display it on screen
              //release the semphores
} //end -while
```

```
} //consumer fn
//---------------------------------------------------------------
Main function
//---------------------------------------------------------------
int main()
{
        int i=0;
        pid_t temp_pid;
        segid = shmget (IPC_PRIVATE, SIZE, IPC_CREAT | IPC_EXCL | SHMPERM );
        empty_id=shmget(IPC_PRIVATE,sizeof(sem_t),IPC_CREAT|IPC_EXCL|
        SHMPERM);
        full_id=shmget(IPC_PRIVATE,sizeof(sem_t),IPC_CREAT|IPC_EXCL|
        SHMPERM);
        mutex_id=shmget(IPC_PRIVATE,sizeof(sem_t),IPC_CREAT|IPC_EXCL|
        SHMPERM);
        buff = shmat( segid, (char *)0, 0 );
        empty = shmat(empty_id,(char *)0,0);
        full = shmat(full_id,(char *)0,0);
        mutex = shmat(mutex_id,(char *)0,0);
        // write code to initialize Semaphores Empty , Full & Mutex using sem_init()
        printf("\n Main Process Started \n");
        printf("\n Enter the input string (20 characters MAX) : ");

         //get string from user, write code to create parent and child and call producer and
consumer functions

        shmdt(buff);
        shmdt(empty);
        shmdt(full);
        shmdt(mutex);
        shmctl(segid, IPC_RMID, NULL);
        semctl( empty_id, 0, IPC_RMID, NULL);
        semctl( full_id, 0, IPC_RMID, NULL);
        semctl( mutex_id, 0, IPC_RMID, NULL);
        sem_destroy(empty);
        sem_destroy(full);
        sem_destroy(mutex);
        printf("\n Main process exited \n\n");
        return(0);
} //main
```

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

LAB EXERCISE 6

Implementation of Producer/Consumer Problem using Semaphores

Submission Date:21-04-2022

Name: Jayannthan P T *Dept: CSE 'A'* *Roll No.: 205001049*

1. To write a C program to create parent/child processes to implement the producer/consumer problem using semaphores in pthread library..

Algorithm:

1) For the segment, shared memory is allotted using shmget and returned id is stored in segid
2) For the empty, shared memory is allotted using shmget and returned id is stored in empty_id
3) For the full, shared memory is allotted using shmget and returned id is stored in full_id
4) For the mutex, shared memory is allotted using shmget and returned id is stored in mutex_id
5) Attach buffer to segid, empty to empty_id, full to full_id, mutex to mutex_id
6) Initialise semaphore to empty, full and mutex
7) Get the string from user and store it in str
8) Fork the process using call fork() and store it in m_pid
9) If m_pid greater than 0 then call producer function
10) Else call consumer function
11) Detach buffer, empty, full, mutex from memory
12) Destroy all shared memory
13) Destroy semaphores

Producer function:

1) Initialise i=0
2) If I greater than string length then exit from producer
3) Else
    a) Empty semaphore acquired by producer
    b) mutex semaphore acquired by producer
    c) next character from string is written into buffer
    d) Empty semaphore released by producer
    e) mutex semaphore released by producer

Consumer function:

1) Initialise i=0
2) If I greater than string length then exit from consumer
3) Else
    a) Empty semaphore acquired by consumer
    b) mutex semaphore acquired by consumer
    c) next character from buffer is read and pointer to buffer is increased
    d) Empty semaphore released by consumer
    e) mutex semaphore released by consumer

Code:

```c
#include <stdio.h>
#include <semaphore.h>
#include <sys/shm.h>
#include <sys/sem.h>
#include <sys/wait.h>
#include <unistd.h>
#include <stdlib.h>
#include <sys/types.h>
#include <string.h>
#include <pthread.h>
#include <sys/ipc.h>
#define BUFSIZE 5

struct memory
{
    char buffer[BUFSIZE];
    int count;
    sem_t full;
    sem_t empty;
    sem_t mutex;
};

struct memory *shmptr;

char original[100], input_string[BUFSIZE];
int input_index = 0;
int c = 0;

void producer()
{
    do
    {
        if (shmptr->count >= BUFSIZE)
        {
            wait(NULL);
            continue;
        }

        sem_wait(&(shmptr->empty));
        sem_wait(&(shmptr->mutex));

        shmptr->buffer[shmptr->count++] = input_string[input_index++];
        shmptr->buffer[shmptr->count] = '\0';
        printf("Produced: %c\n", shmptr->buffer[shmptr->count - 1]);
```

```
        printf("Available items : ");
        for (int i = 0; i < strlen(shmptr->buffer); i++)
        {
            printf("%c ", shmptr->buffer[i]);
        }
        printf("\n");
        sem_post(&(shmptr->mutex));
        sem_post(&(shmptr->full));

        sleep(1);
    } while (input_index < strlen(original));
    printf("\nAll items produced\n");
}

void consumer()
{

    do
    {

        sem_wait(&(shmptr->full));
        sem_wait(&(shmptr->mutex));

        printf("Consumed %c\n", shmptr->buffer[0]);
        memmove(shmptr->buffer, shmptr->buffer + 1, strlen(shmptr->buffer));
        shmptr->count--;
        c++;

        printf("Available items : ");
        for (int i = 0; i < strlen(shmptr->buffer); i++)
            printf("%c ", shmptr->buffer[i]);
        printf("\n");
        sem_post(&(shmptr->mutex));
        sem_post(&(shmptr->empty));

        sleep(3);
    } while (c < strlen(input_string));

    printf("Consumed all the items\n");
    // exit(1);
}

int main()
{
    int shmid = shmget(IPC_PRIVATE, sizeof(struct memory), IPC_CREAT | 0666);
    shmptr = (struct memory *)shmat(shmid, NULL, 0);
    sem_init(&(shmptr->full), 1, 0);
    sem_init(&(shmptr->empty), 1, BUFSIZE);
    sem_init(&(shmptr->mutex), 1, 1);
    shmptr->count = 0;

    printf("Enter the string : ");
    scanf("%s", original);
```

```
    int pid = fork();

    if (pid == -1)
    {
        printf("Fork error\n");
    }
    else if (pid == 0)
    {
        consumer();
    }
    else
    {
        producer();
    }

    shmdt(shmptr);
    shmctl(shmid, IPC_RMID, NULL);
    sem_destroy(&(shmptr->empty));
    sem_destroy(&(shmptr->full));
    sem_destroy(&(shmptr->mutex));
    return 0;
}
```

Output:

```
jayannthan_hakr@jayannthan-Ubuntu:~/OS LAB/Assignment6$ ./1
Enter the string : abcdefgh;
producer starts
Produced: a
Available items : a
consumer starts
Consumed a
Available items :
Produced: b
Available items : b
Produced: c
Available items : b c
Consumed b
Available items : c
Produced: d
Available items : c d
Produced: e
Available items : c d e
Produced: f
Available items : c d e f
Consumed c
Available items : d e f
Produced: g
Available items : d e f g
Produced: h
Available items : d e f g h

!!!buffer full!!!cannot produce!!!
Consumed d
Available items : e f g h
Produced: ;
Available items : e f g h ;

All items produced
jayannthan_hakr@jayannthan-Ubuntu:~/OS LAB/Assignment6$ Consumed e
Available items : f g h ;
Consumed f
Available items : g h ;
Consumed g
Available items : h ;
Consumed h
Available items : ;
Consumed ;
Available items :
Consumed all the items
```

2. Modify the program as separate client / server process programs to generate 'N' random numbers in producer and write them into shared memory. Consumer process should read them from shared memory and display them in terminal.

Algorithm for server:

1) For the segment, shared memory is allotted using shmget and returned id is stored in segid

2) For the empty, shared memory is allotted using shmget and returned id is stored in empty_id
3) For the full, shared memory is allotted using shmget and returned id is stored in full_id
4) For the mutex, shared memory is allotted using shmget and returned id is stored in mutex_id
5) Attach buffer to segid, empty to empty_id, full to full_id, mutex to mutex_id
6) For the key, shared memory is allotted using shmget and returned id is stored in shmid
7) Loop until N becomes zero
    f) Empty semaphore acquired by Server
    g) mutex semaphore acquired by Server
    h) a new random number written into buffer and N is decremented
    i) Empty semaphore released by Server
    j) mutex semaphore released by Server

Algorithm for client:

1) For the segment, shared memory is allotted using shmget and returned id is stored in segid
2) For the empty, shared memory is allotted using shmget and returned id is stored in empty_id
3) For the full, shared memory is allotted using shmget and returned id is stored in full_id
4) For the mutex, shared memory is allotted using shmget and returned id is stored in mutex_id
5) Attach buffer to segid, empty to empty_id, full to full_id, mutex to mutex_id
6) For the key, shared memory is allotted using shmget and returned id is stored in shmid
7) Loop until N becomes zero
    a) Empty semaphore acquired by Client
    b) mutex semaphore acquired by Client
    c) a new random read from buffer and N is decremented
    d) Empty semaphore released by Client
    e) mutex semaphore released by Client

Code:

```c
/*Server Code*/
#include <stdio.h>
#include <semaphore.h>
#include <sys/shm.h>
#include <sys/sem.h>
#include <sys/wait.h>
#include <unistd.h>
#include <stdlib.h>
#include <sys/types.h>
#include <string.h>
#include <pthread.h>
#include <sys/ipc.h>
#include <time.h>
#define BUFSIZE 5
```

```c
struct memory
{
    int buffer[BUFSIZE];
    int count;
    sem_t full;
    sem_t empty;
    sem_t mutex;
    int n;
    int nstatus;

};

struct memory * shmptr;

int main()
{
    srand(time(0));
    int shmid = shmget(111, sizeof(struct memory), IPC_CREAT | 0666);
    shmptr = (struct memory *) shmat(shmid, NULL, 0);
    shmptr->nstatus = 0;
    shmptr->count = 0;
    printf("\nServer\n");
    while (1)
    {
        if (shmptr->nstatus != 0)
        {
            int i = shmptr->n;
            do {    sem_wait(&(shmptr->empty));
                sem_wait(&(shmptr->mutex));
                shmptr->buffer[shmptr->count++] = rand() % 100;
                printf("Newly Produced: %d\n", shmptr->buffer[shmptr->count - 1]);
                i--;
                sem_post(&(shmptr->mutex));
                sem_post(&(shmptr->full));
                sleep(0);
            } while (i > 0);
            printf("\nProduction done\n");
            if (i == 0) break;
        }
    }
    shmdt(shmptr);
    shmctl(shmid, IPC_RMID, NULL);
    sem_destroy(&(shmptr->empty));
    sem_destroy(&(shmptr->full));
    sem_destroy(&(shmptr->mutex));
    exit(1);
}
```

```c
/*Client Code*/
```

```c
#include <stdio.h>
#include <semaphore.h>
#include <sys/shm.h>
#include <sys/sem.h>
#include <sys/wait.h>
#include <unistd.h>
#include <stdlib.h>
#include <sys/types.h>
#include <string.h>
#include <pthread.h>
#include <sys/ipc.h>
#include <time.h>
#define BUFSIZE 5

struct memory
{
    int buffer[BUFSIZE];
    int count;
    sem_t full;
    sem_t empty;
    sem_t mutex;
    int n;
    int nstatus;

};

struct memory * shmptr;

int main()
{
    srand(time(0));
    int shmid = shmget(111, sizeof(struct memory), IPC_CREAT | 0666);
    shmptr = (struct memory *) shmat(shmid, NULL, 0);
    sem_init(&(shmptr->full), 1, 0);
    sem_init(&(shmptr->empty), 1, BUFSIZE);
    sem_init(&(shmptr->mutex), 1, 1);
    if (shmptr->nstatus == 0)
    {
        printf("Number of items to generate: ");
        scanf("%d", &(shmptr->n));
        shmptr->nstatus = 1;
    }
    int c = 0;
    do {
        sem_wait(&(shmptr->full));
        sem_wait(&(shmptr->mutex));
        printf("Available items : ");
        for (int i = 0; i < shmptr->count; i++)
        {
            printf("%d ", shmptr->buffer[i]);
        }
        printf("\n");
        printf("Consumes %d\n", shmptr->buffer[0]);
        memmove(shmptr->buffer, shmptr->buffer + 1, sizeof(shmptr->buffer));
```

```
        shmptr->count--;
        c++;
        sem_post(&(shmptr->mutex));
        sem_post(&(shmptr->empty));
        sleep(4);
    } while (c < shmptr->n);

    printf("\nFinished consuming all items\n");
    shmdt(shmptr);
    shmctl(shmid, IPC_RMID, NULL);
    sem_destroy(&(shmptr->empty));
    sem_destroy(&(shmptr->full));
    sem_destroy(&(shmptr->mutex));

    exit(1);

}
```

Output:

```
Server
Newly Produced: 41
Newly Produced: 16
Newly Produced: 18
Newly Produced: 8
Newly Produced: 27
Newly Produced: 14
Newly Produced: 0
!!!buffer full!!!
Newly Produced: 48
!!!buffer full!!!
!!!buffer full!!!
!!!buffer full!!!
Newly Produced: 49
!!!buffer full!!!
!!!buffer full!!!
!!!buffer full!!!
Newly Produced: 26

Production done
```

```
Number of items to generate: 10
Available items : 41
Consumes 41
Available items : 16 18 8
Consumes 16
Available items : 18 8 27 14 0
Consumes 18
Available items : 8 27 14 0 48
Consumes 8
Available items : 27 14 0 48 49
Consumes 27
Available items : 14 0 48 49 26
Consumes 14
Available items : 0 48 49 26
Consumes 0
Available items : 48 49 26
Consumes 48
Available items : 49 26
Consumes 49
Available items : 26
Consumes 26

Finished consuming all items
```

Learning Outcome:

- Executed semaphore functions and system calls
- Executed server-side and client-side program using shared memory and semaphores

Sri Sivasubramaniya Nadar College of Engineering

(An Autonomous Institution, Affiliated to Anna University, Chennai)

Department of Computer Science and Engineering

UCS1411 – Operating Systems Laboratory

Lab Exercise 7: Implementation of Banker's Algorithm (Deadlock Avoidance) and Deadlock Detection

Aim:

Assignment 1: Develop a C program to implement Banker's algorithm for deadlock avoidance with multiple instances of resource types

Assignment 2: Develop a C program to implement algorithm for deadlock detection with multiple instances of resource types and display the processes involved in deadlock

Deadlock Avoidance Algorithm:

1. Read the following
    a. Number of processes.
    b. Number of resources and number of instances of each resource available.
    c. Maximum requirement of each process,
    d. Allocated instances of resources
2. Determine the need of each process
3. Display menu as
    1) Check system state
    2) Resource Request.
4. If choice is 1 do the following
    4.1 Repeat the following till all processes are done.
        a. Check if need of process i is less than or equal to available instances
            i. If yes proceed with step 4.1.b
            ii. Otherwise wait till available
        b. Update the available vector by adding the resources released by Pi. Add Process Pi to safe sequence.
    4.2. If any of the process is not able to finish, then display as "Unsafe State". Else display the safe sequence.
5. If choice is 2 do the following
    5.1 Get the process id which requests the resource and the request vector
    5.2 If request <= need of process and request <= available then
        5.3 Pretend to allocate by updating the available, need and allocated vectors
        5.4 Run safety algorithm.
        5.5 If safe, grant the resources by updating the system state. Else, display "Resource request by P_i not granted" and revert back to original state.

SAMPLE INPUT & OUTPUT:

Banker's Algorithm

1. Read Data
2. Print Data
3. Check system state
4. Resource request
5.Exit

Enter the option :1
Number of processes: 5 P0, P1, P2, P3, P4
Number of resources: 3 A B C
Number of Available instances of A: 3
Number of Available instances of B: 3
Number of Available instances of C: 2
Maximum requirement for P0: 7 5 3
Maximum requirement for P1: 3 2 2
Maximum requirement for P2: 9 0 2
Maximum requirement for P3: 2 2 2
Maximum requirement for P4: 4 3 3
Allocated instances to P0: 0 1 0
Allocated instances to P1: 2 0 0
Allocated instances to P2: 3 0 2
Allocated instances to P3: 2 1 1
Allocated instances to P4: 0 0 2

Enter the option: 2

	Alloc	Max	Need	Avail
	A B C	A B C	A B C	A B C
P0	0 1 0	7 5 3	* * *	3 3 2
P1	2 0 0	3 2 2	* * *	
P2	3 0 2	9 0 2	* * *	
P3	2 1 1	2 2 2	* * *	
P4	0 0 2	4 3 3	* * *	

Enter the option: 3
Display the Safety Sequence:
* * * * *

Enter the option: 4

Enter the process id of process requesting for new resources: P1

Enter the request vector for P1: 4 3 3

Safe sequence is *****. Resource request by P1 can be granted

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

LAB EXERCISE 6

Implementation of Producer/Consumer Problem using Semaphores

Submission Date:21-04-2022

Name: Jayannthan P T *Dept: CSE 'A'* *Roll No.: 205001049*

1. Assignment 1: Develop a C program to implement Banker's algorithm for deadlock avoidance with multiple instances of resource types

Algorithm:

1) Get choice from user
2) If choice is equal to 1, then ask for data input
3) If choice is equal to 2, then print the data
4) If choice is equal to 3, then call bankers algorithm to execute
5) If choice is equal to 4 then call for resource request
6) Else exit

Algorithm for data input:

1) Get no of process, no of resources, available instances, maximum required matrix, allotted instances from user
2) Calculate need matrix by subtracting allocation matrix from maximum required matrix

Algorithm for bankers algorithm:

1) Set ind to 0
2) For i from 0 to no of process times
    a) If f[i] is equal to 0
        i. Set flag = 0
    b) For j no of resources times
        i. If need[I,j]greater than available[j] then set flag = 1
    c) If flag equal to 0 then
        i. Set safeseq[ind]=i
        ii. Increment ind
        iii. Set available [j] equal to sum of available[j] and allocstion[I,j]
        iv. Set f[i] is equal to 1
3) Set flag equal to 1
4) For i from 0 to no of process
    a) If f[i] is equal to 0 then print not a safe sequence and exit
    b) If flag is equal to 1 then print safe sequence

Algorithm for Resource Request:

1) Get process no from user to allocate
2) Get resource vector
3) Check if allocation[i] is greater than available[i] then exit
4) Else set available equal to available[i] minus allocationvector[i] and allocation[ind][i] equal to sum of allocation[ind][i] and allocationvector[i]
5) Now call bankers algorithm

Code:

```
// Assignment 1: Develop a C program to implement Banker's algorithm for deadlock
avoidance with multiple instances of resource types

#include <stdio.h>
#include <string.h>
#define max 100

typedef struct bankersdata
{
    int no_of_process;
    int no_of_resources;
    char process_name[max][5];
    char resources_name[max][5];
    int available_instance[max];   // available_instance[no_of_resources]
    int max_req[max][max];         // max_req[no_of_process][no_of_resources];
    int allocation[max][max];      // allocation[no_of_process][no_of_resources];
    int f[max], safesequence[max]; // f[no_of_process],safesequence[no_of_process]
    int need[max][max];
} bankersdata;

void printdata(bankersdata *bk)
{
    printf("Pid\tAlloc\tMax  \tNeed \tAvail\t\n--\t");
    for (int i = 0; i < bk->no_of_resources; i++)
    {
        printf("%s ", bk->resources_name[i]);
    }
    printf("\t");
    for (int i = 0; i < bk->no_of_resources; i++)
    {
        printf("%s ", bk->resources_name[i]);
    }
    printf("\t");
    for (int i = 0; i < bk->no_of_resources; i++)
    {
        printf("%s ", bk->resources_name[i]);
    }
    printf("\t");
    for (int i = 0; i < bk->no_of_resources; i++)
    {
        printf("%s ", bk->resources_name[i]);
    }
    // printf("\n");
    printf("\t");
```

```
    printf("\n---------------------------------\n");
    for (int i = 0; i < bk->no_of_process; i++)
    {
        printf("%s ", bk->process_name[i]);
        for (int j = 0; j < bk->no_of_resources; j++)
        {
            printf(" %d", bk->allocation[i][j]);
        }
        printf("\t");
        for (int j = 0; j < bk->no_of_resources; j++)
        {
            printf(" %d", bk->max_req[i][j]);
        }
        printf("\t");
        for (int j = 0; j < bk->no_of_resources; j++)
        {
            printf(" %d", bk->need[i][j]);
        }
        printf("\t");
        if (i == 0)
        {
            for (int j = 0; j < bk->no_of_resources; j++)
            {
                printf(" %d", bk->available_instance[j]);
            }
        }
        printf("\t\n");
    }
}
void bankersalgo(bankersdata *bk)
{
    printdata(bk);

    int ind = 0;
    int y = 0;
    for (int k = 0; k < 5; k++)
    {
        for (int i = 0; i < bk->no_of_process; i++)
        {
            if (bk->f[i] == 0)
            {
                int flag = 0;
                for (int j = 0; j < bk->no_of_resources; j++)
                {
                    if (bk->need[i][j] > bk->available_instance[j])
                    {
                        flag = 1;
                        break;
                    }
                }
                if (flag == 0)
                {
                    bk->safesequence[ind] = i;
                    ind++;
```

```
                    for (int j = 0; j < bk->no_of_resources; j++)
                    {
                        bk->available_instance[j] += bk->allocation[i][j];
                    }
                    bk->f[i] = 1;
                }
            }
        }
    }

    int flag = 1;
    for (int i = 0; i < bk->no_of_process; i++)
    {
        if (bk->f[i] == 0)
        {
            flag = 0;
            printf("NOT A SAFE SYSTEM");
            break;
        }
    }
    if (flag == 1)
    {
        printf("SAFE SEQUENCE\n");
        for (int i = 0; i < bk->no_of_process - 1; i++)
        {
            printf(" %s ->", bk->process_name[bk->safesequence[i]]);
        }
        printf(" %s", bk->process_name[bk->safesequence[bk->no_of_process - 1]]);
    }
    printdata(bk);
}

bankersdata getdata()
{
    bankersdata bk;
    printf("\nEnter no of process:");
    scanf("%d", &bk.no_of_process);
    printf("\nEnter process ids:\n");
    for (int i = 0; i < bk.no_of_process; i++)
    {
        printf("process name of process %d:", i + 1);
        scanf(" %s", &bk.process_name[i]);
    }

    printf("\nEnter no of resources:");
    scanf("%d", &bk.no_of_resources);
    printf("\nEnter resource ids:\n");
    for (int i = 0; i < bk.no_of_resources; i++)
    {
        printf("resource name of resource %d:", i + 1);
        scanf(" %s", &bk.resources_name[i]);
    }

    printf("\nEnter available instances:\n");
```

```
    for (int i = 0; i < bk.no_of_resources; i++)
    {
        printf("available instances of resource %s:", bk.resources_name[i]);
        scanf(" %d", &bk.available_instance[i]);
    }

    printf("\nEnter Maximum requirement:\n");
    for (int i = 0; i < bk.no_of_process; i++)
    {
        printf("Maximum requirement for process %s:", bk.process_name[i]);
        for (int j = 0; j < bk.no_of_resources; j++)
        {
            scanf(" %d", &bk.max_req[i][j]);
        }
    }

    printf("\nEnter Allocated instances:\n");
    for (int i = 0; i < bk.no_of_process; i++)
    {
        printf("Allocated instances for process %s:", bk.process_name[i]);
        for (int j = 0; j < bk.no_of_resources; j++)
        {
            scanf(" %d", &bk.allocation[i][j]);
        }
    }

    for (int i = 0; i < bk.no_of_process; i++)
    {
        bk.f[i] = 0;
        for (int j = 0; j < bk.no_of_resources; j++)
        {
            bk.need[i][j] = bk.max_req[i][j] - bk.allocation[i][j];
        }
    }
    return bk;
}

int main(int argc, char const *argv[])
{
    bankersdata bk = getdata();
    int choice = 0;
    printf("\nMenu:\n\t1.Enter new data\n\t2.PrintData\n\t3.Bankers State\n\t4.Resource
Request\n\t5.Exit\nEnter Choice:");
    scanf(" %d", &choice);
    while (choice)
    {
        switch (choice)
        {
        case 1:
        {
            bk = getdata();
            break;
        }
        case 2:
```

```
        {
            printdata(&bk);
            break;
        }

        case 3:
        {
            bankersalgo(&bk);
            break;
        }

        case 4:
        {
            char temp_process_name[5];
            printf("\nEnter process id for request:");
            scanf(" %s", &temp_process_name);
            int index_of_process = -1;
            for (int i = 0; i < bk.no_of_process; i++)
            {
                if (strcmp(temp_process_name, bk.process_name[i]) == 0)
                {
                    index_of_process = i;
                    break;
                }
            }
            if (index_of_process == -1)
            {
                printf("\nprocess name not correct!!!\n");
                break;
            }
            else
            {
                int allocation_vector[max];
                printf("\nEnter the request vector for %s:",
bk.process_name[index_of_process]);
                for (int i = 0; i < bk.no_of_resources; i++)
                {
                    scanf(" %d", &allocation_vector[i]);
                }
                int flag = 1;
                for (int i = 0; i < bk.no_of_resources; i++)
                {
                    if (allocation_vector[i] > bk.available_instance[i])
                    {
                        flag = 0;
                        break;
                    }
                }
                if (flag == 0)
                {
                    printf("\n!!!Resource cannot be allocated!!!");
                    break;
                }
                for (int i = 0; i < bk.no_of_resources; i++)
```

```
                {
                    bk.available_instance[i] -= allocation_vector[i];
                    bk.allocation[index_of_process][i] += allocation_vector[i];
                }
                bankersalgo(&bk);
            }
            break;
        }

        case 5:
            return 0;

        default:
        {
            printf("\n!!!Enter correct choice!!!\n");
            break;
        }
        }
        printf("\nMenu:\n\t1.Enter new data\n\t2.PrintData\n\t3.Bankers
State\n\t4.Resource Request\n\t5.Exit\nEnter Choice:");
        scanf(" %d", &choice);
    }
    return 0;
}
```

Output:

```
Menu:
        1.Enter new data
        2.PrintData
        3.Bankers State
        4.Resource Request
        5.Exit
Enter Choice:2
Pid     Alloc   Max     Need    Avail
--      A B C   A B C   A B C   A B C
---------------------------------
P0  0 1 0       7 5 3   7 4 3   3 3 2
P1  2 0 0       3 2 2   1 2 2
P2  3 0 2       9 0 2   6 0 0
P3  2 1 1       2 2 2   0 1 1
P4  0 0 2       4 3 3   4 3 1
```

```
Menu:
        1.Enter new data
        2.PrintData
        3.Bankers State
        4.Resource Request
        5.Exit
Enter Choice:4

Enter process id for request:P1

Enter the request vector for P1:1
0
2
Pid     Alloc   Max     Need    Avail
--      A B C   A B C   A B C   A B C
---------------------------------
P0  0 1 0       7 5 3   7 4 3   2 3 0
P1  3 0 2       3 2 2   0 2 0
P2  3 0 2       9 0 2   6 0 0
P3  2 1 1       2 2 2   0 1 1
P4  0 0 2       4 3 3   4 3 1
SAFE SEQUENCE
 P1 -> P3 -> P4 -> P0 -> P2
```

2. Assignment 2: Develop a C program to implement algorithm for deadlock detection with multiple instances of resource types and display the processes involved in deadlock

Algorithms:

1) Get no of process, no of resources, available instances, maximum required matrix, allotted instances from user
2) Calculate need matrix by subtracting allocation matrix from maximum required matrix
3) Set ind to 0
4) For i from 0 to no of process times
    c) If f[i] is equal to 0
        i. Set flag = 0
    d) For j no of resources times
        i. If need[I,j]greater than available[j] then set flag = 1
    e) If flag equal to 0 then
        i. Set safeseq[ind]=i
        ii. Increment ind
        iii. Set available [j] equal to sum of available[j] and allocstion[I,j]
        iv. Set f[i] is equal to 1
5) Set flag equal to 1
6) For i from 0 to no of process
    f) If f[i] is equal to 0 then print not a safe sequence and exit
    g) If flag is equal to 1 then print safe sequence

Code:

```c
#include <stdio.h>
//#include <conio.h>
#include <string.h>
#define max 100

typedef struct bankersdata
{
    int no_of_process;
    int no_of_resources;
    char process_name[max][5];
    char resources_name[max][5];
    int available_instance[max];    // available_instance[no_of_resources]
    int max_req[max][max];          // max_req[no_of_process][no_of_resources];
    int allocation[max][max];       // allocation[no_of_process][no_of_resources];
    int f[max], safesequence[max]; // f[no_of_process],safesequence[no_of_process]
    int need[max][max];
} bankersdata;

void printdata(bankersdata *bk)
{
    printf("Pid\tAlloc\tMax  \tNeed \tAvail\t\n--\t");
    for (int i = 0; i < bk->no_of_resources; i++)
    {
        printf("%s ", bk->resources_name[i]);
    }
    printf("\t");
    for (int i = 0; i < bk->no_of_resources; i++)
    {
        printf("%s ", bk->resources_name[i]);
    }
```

```
    printf("\t");
    for (int i = 0; i < bk->no_of_resources; i++)
    {
        printf("%s ", bk->resources_name[i]);
    }
    printf("\t");
    for (int i = 0; i < bk->no_of_resources; i++)
    {
        printf("%s ", bk->resources_name[i]);
    }
    printf("\t");
    printf("\n----------------------------------\n");
    for (int i = 0; i < bk->no_of_process; i++)
    {
        printf("%s ", bk->process_name[i]);
        for (int j = 0; j < bk->no_of_resources; j++)
        {
            printf(" %d", bk->allocation[i][j]);
        }
        printf("\t");
        for (int j = 0; j < bk->no_of_resources; j++)
        {
            printf(" %d", bk->max_req[i][j]);
        }
        printf("\t");
        for (int j = 0; j < bk->no_of_resources; j++)
        {
            printf(" %d", bk->need[i][j]);
        }
        printf("\t");
        if (i == 0)
        {
            for (int j = 0; j < bk->no_of_resources; j++)
            {
                printf(" %d", bk->available_instance[j]);
            }
        }
        printf("\t\n");
    }
}
void bankersalgo(bankersdata *bk)
{
    int ind = 0;
    int y = 0;
    for (int k = 0; k < 5; k++)
    {
        for (int i = 0; i < bk->no_of_process; i++)
        {
            if (bk->f[i] == 0)
            {
                int flag = 0;
                for (int j = 0; j < bk->no_of_resources; j++)
                {
                    if (bk->need[i][j] > bk->available_instance[j])
```

```
                    {
                        flag = 1;
                        break;
                    }
                }
                if (flag == 0)
                {
                    bk->safesequence[ind] = i;
                    ind++;
                    for (int j = 0; j < bk->no_of_resources; j++)
                    {
                        bk->available_instance[j] += bk->allocation[i][j];
                    }
                    bk->f[i] = 1;
                }
            }
        }
    }

    int flag = 1;
    for (int i = 0; i < bk->no_of_process; i++)
    {
        if (bk->f[i] == 0)
        {
            flag = 0;
            printf("\n\n!!!!NOT A SAFE SYSTEM!!!!\nDue to the following processes:");
            break;
        }
    }
    if (flag == 1)
    {
        printf("SAFE SEQUENCE\n");
        for (int i = 0; i < bk->no_of_process - 1; i++)
        {
            printf(" %s ->", bk->process_name[bk->safesequence[i]]);
        }
        printf(" %s", bk->process_name[bk->safesequence[bk->no_of_process - 1]]);
    }
    else
    {
        for (int i = 0; i < bk->no_of_process; i++)
        {
            if (bk->f[i] == 0)
            {
                printf(" %s ", bk->process_name[i]);
            }
        }
    }
}

bankersdata getdata()
{
    bankersdata bk;
    printf("\nEnter no of process:");
```

```
    scanf("%d", &bk.no_of_process);
    printf("\nEnter process ids:\n");
    for (int i = 0; i < bk.no_of_process; i++)
    {
        printf("process name of process %d:", i + 1);
        scanf(" %s", &bk.process_name[i]);
    }

    printf("\nEnter no of resources:");
    scanf("%d", &bk.no_of_resources);
    printf("\nEnter resource ids:\n");
    for (int i = 0; i < bk.no_of_resources; i++)
    {
        printf("resource name of resource %d:", i + 1);
        scanf(" %s", &bk.resources_name[i]);
    }

    printf("\nEnter available instances:\n");
    for (int i = 0; i < bk.no_of_resources; i++)
    {
        printf("available instances of resource %s:", bk.resources_name[i]);
        scanf(" %d", &bk.available_instance[i]);
    }

    printf("\nEnter Maximum requirement:\n");
    for (int i = 0; i < bk.no_of_process; i++)
    {
        printf("Maximum requirement for process %s:", bk.process_name[i]);
        for (int j = 0; j < bk.no_of_resources; j++)
        {
            scanf(" %d", &bk.max_req[i][j]);
        }
    }

    printf("\nEnter Allocated instances:\n");
    for (int i = 0; i < bk.no_of_process; i++)
    {
        printf("Allocated instances for process %s:", bk.process_name[i]);
        for (int j = 0; j < bk.no_of_resources; j++)
        {
            scanf(" %d", &bk.allocation[i][j]);
        }
    }

    for (int i = 0; i < bk.no_of_process; i++)
    {
        bk.f[i] = 0;
        for (int j = 0; j < bk.no_of_resources; j++)
        {
            bk.need[i][j] = bk.max_req[i][j] - bk.allocation[i][j];
        }
    }
    return bk;
}
```

```c
int main(int argc, char const *argv[])
{
    bankersdata bk = getdata();
    int choice = 0;
    printf("\nMenu:\n\t1.Enter new data\n\t2.PrintData\n\t3.Bankers State\n\t4.Exit\nEnter
Choice:");
    scanf(" %d", &choice);
    while (choice)
    {
        switch (choice)
        {
        case 1:
        {
            bk = getdata();
            break;
        }
        case 2:
        {
            printdata(&bk);
            break;
        }

        case 3:
        {
            bankersalgo(&bk);
            break;
        }

        case 4:
        {
            return 0;
            break;
        }

        default:
        {
            printf("\n!!!Enter correct choice!!!\n");
            break;
        }
        }
        printf("\nMenu:\n\t1.Enter new data\n\t2.PrintData\n\t3.Bankers
State\n\t4.Exit\nEnter Choice:");
        scanf(" %d", &choice);
    }
    return 0;
}
```

Output:

```
Enter Choice:3
SAFE SEQUENCE
 P1 -> P3 -> P4 -> P0 -> P2
```

Learning Outcome:

- Bankers algorithm implementation
- Importance of deadlock prevention
- Printing safe Sequence

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)
SSN College of Engineering
Department of Computer Science and Engineering
UCS1411 – Operating Systems Laboratory
II Year CSE - A Section (IV Semester)

Exercise – 8- Memory allocation techniques

Lab Exercise 8 Implementation of Memory Management Algorithms

Problem :

This problem can be implemented using linked list or arrays.

Free space is maintained as a linked list of nodes with each node having the starting byte address and the ending byte address of a free block. Each memory request consists of the process-id and the amount of storage space required in bytes. Allocated memory space is again maintained as a linked list of nodes with each node having the process id, starting byte address and the ending byte address of the allocated space. When a process finishes (taken as input), the appropriate node from the allocated list should be deleted and this free disk space should be added to the free space list. [Care should be taken to merge contiguous free blocks into one single block. This results in deleting more than one node from the free space list and changing the start and end address in the appropriate node]. For allocation use first fit, worst fit and best fit algorithms.

Steps:

1. Get the algorithm to work with. (First Fit, Best Fit, Worst Fit)

2. Implement this using Linked List / Arrays.

3. Let the options be 1. Entry / Allocate 2. Exit / Deallocate 3. Display (Memory allocated LL, Free Pool LL, Total Physical memory by Merging 2 LL) 4.Coalescing Holes.

4. Create a node using structure with the following details. Starting address, ending address, Size, Status (contains process id or H to denote that it is a hole).

5. Create a Alloted memory Linked list with a collection of nodes (Initially no nodes).

6. Create a Free Pool Linked List with a collection of nodes (Initially all partitions will be in free pool LL).

7. Get the memory representation as input from user. No of partitions, starting address and ending address of each partition. Calculate the Size of each partition. Initially all the partitions will be in free pool LL.

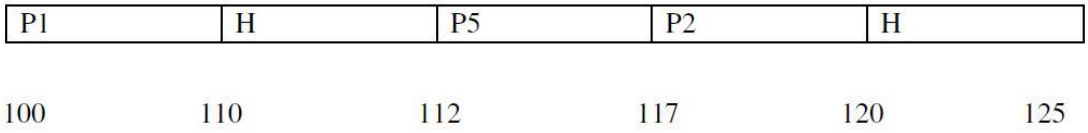
8. Now get whether a process enters / exits.

9. If ”Entry” then get the process id and its size in bytes. Using the algorithm allocate memory for it and store it in alloted memory linked list. Modify in Free pool Linked list also. [delete from free pool LL, insert into memory allocation LL]

10.If “exit” then get the process id and then deall ocate the process from memory allocation linked list and include it in free pool linked list. [delete from memory allocation LL, insert into free pool LL]

11.On display you have to display both LL separately and combined memory structure should be displayed by merging both LL.

Merged Output should be



12.For Coalescing of Holes scan the free pool LL and check for continuous holes. If so merge them as single hole by modifying ending address and size and delete the other hole.

13.For first fit select the first hole that satisfies the memory request.

14.For best fit select the hole that is large enough to accommodate the process but incurs minimum wastage of memory.

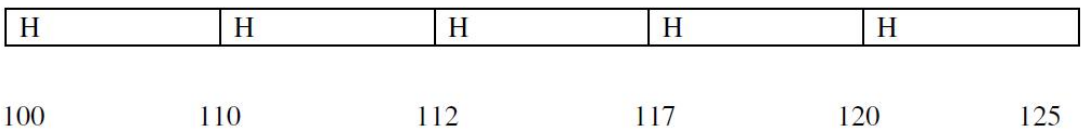
15.For worst fit select the hole that is the largest.

Sample Input and output:

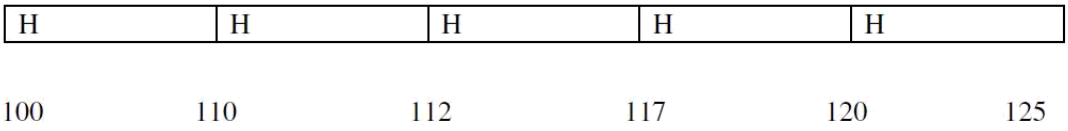
Enter the Memory Representation:
Enter the no. of partitions in memory : 5
Starting and ending address of partition 1: 100 110
Starting and ending address of partition 2: 110 112
.....

Alloted Memory LL -----> Null

Free Pool >



Physical Memory--->



Memory Allocation Algorithm:
1.First Fit
2.Best Fit
3.Worst Fit
4. Exit from program
Enter choice : 1

First Fit Memory Allocation Algorithm

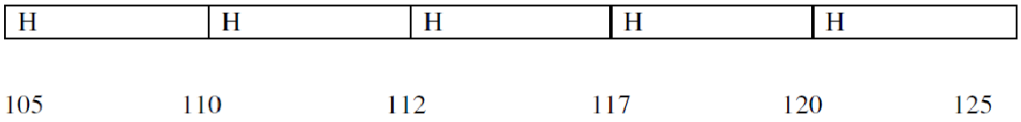
1.Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm

Enter choice : 1

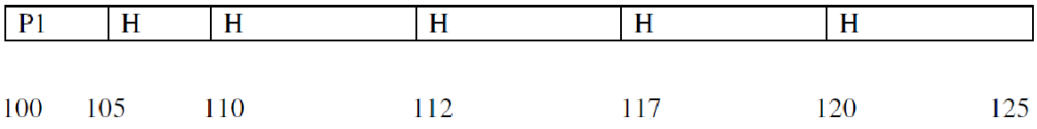
Enter process id : P1
Enter size needed : 5
Memory is alloted to P1

Alloted Memory LL---- >

Free Pool ------>



Physical Memory------>



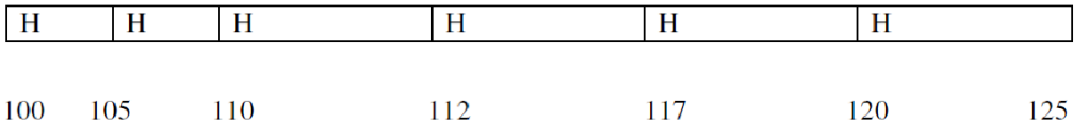
First Fit Memory Allocation Algorithm

1.Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
Enter choice : 2
Enter process id : P1

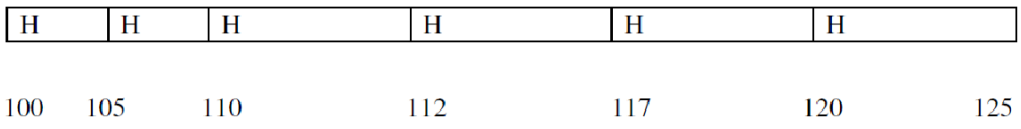
Memory is deallocated.

Alloted Memory LL ----> Null

Free Pool --



Physical Memory------>



SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

LAB EXERCISE 8

Implementation of Memory Management Algorithms

Submission Date:23-05-2022

Name: Jayannthan P T *Dept: CSE 'A'* *Roll No.: 205001049*

1. Free space is maintained as a linked list of nodes with each node having the starting byte address and the ending byte address of a free block. Each memory request consists of the process-id and the amount of storage space required in bytes. Allocated memory space is again maintained as a linked list of nodes with each node having the process id, starting byte address and the ending byte address of the allocated space. When a process finishes (taken as input), the appropriate node from the allocated list should be deleted and this free disk space should be added to the free space list. [Care should be taken to merge contiguous free blocks into one single block. This results in deleting more than one node from the free space list and changing the start and end address in the appropriate node]. For allocation use first fit, worst fit and best fit algorithms..

Algorithm:

1. We create a header file which defines the structure with components as start, end, sixe, status, id, next pointer to the node.
2. It also has a functions insertlast(), insertmiddle(), create new node() and sorted merging()
3. We create an instance of the structure in main function
4. Read the number of partitions of the memory from the usetr
5. Read the starting and ending points of each partitions
6. For each entry create new node and insertlast
7. Display the status after memory partitioning
8. Each hole is allotted a unique id by itself and is not changed until the program is ended
9. Inside the do while loop:
    - Ask the user to choose the algorithm
    - Have a 2D array where we store the choice of algorithm
    - Inside it we have another do while loop where we ask for entry/allocate, exit/deallocate, display, coalesce and exit
    - ALLOCATION:

Ask the user for the size of process

i. First fit:

a) Check which is the first hole that satisfies the given process's size and return the position of that node

ii. Best fit:
   a) Assumes min as a constant
   b) Iterates through the list to find the min difference between process size and node size
   c) If min value has changed the node pointed by the function is allocated for the process

iii. Worst fit:
   a) Assumes 0 as max value
   b) Iterates through the list to find the max difference
   c) If max value is changed allocate the process to the node pointed by the function

allocate()
If ptrsize is equal to the node size we allocate the nide as it is
If ptrsize is greater than the process size we insert 2 node one with size equal to process size and other with size as difference between the pointed node

- DEALLOCATION:
  i. We search the pid in the list and find the node in which the process is allocated.
  ii. Change the status of the node to 'H' and delete the process
  iii. It also the combine function which combines the holes with same id to bring back the initial state
- DISPLAY:
  i. Displays the list with free spaces and the other list with accommodation of processes
- COALESCING:
  i. It combines all the adjacent partitions with status 'H' irrespective of the hole id

Code:

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

struct node
{
    int start;
    int end;
    int size;
    char status[3];
    struct node *next;
};

struct node *newNode(int start, int end);
int insert(struct node *temp, struct node **head);
struct node *insertEnd(struct node *, struct node *);
struct node *clone(struct node *list);
struct node *merge(struct node *h1, struct node *h2);

struct node *newNode(int start, int end)
```

```
{
    struct node *temp = (struct node *)malloc(sizeof(struct node));
    strcpy(temp->status, "H");
    temp->end = end;
    temp->start = start;
    temp->size = temp->end - temp->start;
    temp->next = NULL;
    return temp;
}

struct node *insertEnd(struct node *p, struct node *temp)
{
    struct node *ptr = p;
    if (!ptr)
    {
        p = temp;
        p->next = NULL;
    }
    else
    {
        while (ptr->next)
            ptr = ptr->next;
        ptr->next = temp;
        temp->next = NULL;
    }
    return p;
}

int insert(struct node *temp, struct node **head)
{
    if (!temp)
        return 0;
    struct node *ptr = *head;
    if (!*head)
    {
        *head = insertEnd(*head, temp);
        return 1;
    }
    if (temp->start < ptr->start)
    {
        temp->next = *head;
        *head = temp;
        return 1;
    }
    while (ptr->next && temp->start > ptr->next->start)
        ptr = ptr->next;
    temp->next = ptr->next;
    ptr->next = temp;
    return 1;
}

struct node *clone(struct node *list)
{
    if (!list)
```

```
        return NULL;

    struct node *result = (struct node *)malloc(sizeof(struct node));
    result->start = list->start;
    result->end = list->end;
    result->size = list->size;
    strcpy(result->status, list->status);
    result->next = clone(list->next);
    return result;
}

struct node *merge(struct node *h1, struct node *h2)
{
    if (!h1)
        return h2;
    if (!h2)
        return h1;
    if (h1->start < h2->start)
    {
        h1->next = merge(h1->next, h2);
        return h1;
    }
    else
    {
        h2->next = merge(h1, h2->next);
        return h2;
    }
}

void combine(struct node **p)
{
    struct node *ptr = *p, *temp;
    while (ptr)
    {
        temp = ptr;
        while (temp->next && temp->end == temp->next->start)
            temp = temp->next;
        ptr->next = temp->next;
        ptr->end = temp->end;
        ptr = ptr->next;
    }
}

struct node *deallocate(struct node **p, char *pid)
{
    struct node *ptr = *p, *prev;
    if (ptr && strcmp(ptr->status, pid) == 0)
    {
        *p = ptr->next;
        strcpy(ptr->status, "H");
        return ptr;
    }
    while (ptr && strcmp(ptr->status, pid))
    {
```

```
        prev = ptr;
        ptr = ptr->next;
    }
    if (!ptr)
        return NULL;
    strcpy(ptr->status, "H");
    prev->next = ptr->next;
    return ptr;
}

void table(struct node *p, char str[])
{
    struct node *ptr = p;
    if (!ptr)
    {
        printf("NULL\n\n");
        return;
    }
    for (int i = 0; i < strlen(str); i++)
        printf("%c", str[i] == '|' ? '+' : str[i] == '-' ? ' '
                                                         : '-');

    printf("\n%s\n", str);

    for (int i = 0; i < strlen(str); i++)
        printf("%c", str[i] == '|' ? '+' : str[i] == '-' ? ' '
                                                         : '-');
    printf("\n");

    int end, s;
    end = ptr->end;
    s = strlen(ptr->status);

    while (ptr)
    {
        if (!ptr->next || ptr->end == ptr->next->start)
            printf("%-*d", 9 + strlen(ptr->status), ptr->start);
        else
            printf("%-*d%-*d", 9 + strlen(ptr->status), ptr->start, 9, ptr->end);
        end = ptr->end;
        s = strlen(ptr->status);
        ptr = ptr->next;
    }
    printf("%d", end);
    printf("\n\n\n");
}

void disp(struct node *p)
{
    char buf[100], mem[1000];
    struct node *ptr = p;
    strcpy(mem, "|");
    while (ptr)
    {
```

```
        if (!ptr->next || ptr->end == ptr->next->start)
            sprintf(buf, "    %s    |", ptr->status);
        else if (ptr->end != ptr->next->start)
            sprintf(buf, "    %s    |---------|", ptr->status);
        strcat(mem, buf);
        ptr = ptr->next;
    }
    table(p, mem);
}

void display(struct node *p, struct node *q)
{
    printf("\nAllocated Memory Space\n\n");
    disp(p);
    printf("Free Memory Space\n\n");
    disp(q);
    struct node *r = merge(clone(p), clone(q));
    printf("Physical Memory Space\n\n");
    disp(r);
    free(r);
}

int first(struct node *f, int size)
{
    struct node *ptr = f;
    while (ptr && !(ptr->size >= size))
    {
        ptr = ptr->next;
    }
    if (!ptr)
        return -1;
    return ptr->size;
}

int best(struct node *f, int size)
{
    struct node *ptr = f;
    int min = INT_MAX;
    while (ptr)
    {
        if (ptr->size - size > 0 && min > ptr->size - size)
            min = ptr->size - size;
        ptr = ptr->next;
    }
    if (min == INT_MAX)
        return -1;
    return min + size;
}

int worst(struct node *f, int size)
{
    struct node *ptr = f;
    int max = INT_MIN;
    while (ptr)
```

```
    {
        if (ptr->size - size > 0 && max < ptr->size - size)
            max = ptr->size - size;
        ptr = ptr->next;
    }
    if (max == INT_MIN)
        return -1;
    return max + size;
}

int whichfit(struct node *f, int size, int ch)
{
    if (ch == 1)
        return first(f, size);
    if (ch == 2)
        return best(f, size);
    if (ch == 3)
        return worst(f, size);
}

struct node *allocate(struct node **f, char *pid, int size, int ptrsize)
{
    if (ptrsize - size < 0)
        return NULL;
    struct node *ptr = *f, *prev;

    if (ptr->size == ptrsize)
    {
        if (ptr && ptr->size >= size)
        {
            if (ptr->size == size)
            {
                *f = ptr->next;

                strcpy(ptr->status, pid);
                return ptr;
            }
            else
            {
                struct node *temp1 = newNode(ptr->start, ptr->start + size);
                struct node *temp2 = newNode(ptr->start + size, ptr->end);
                *f = temp2;
                temp2->next = ptr->next;
                strcpy(temp1->status, pid);
                free(ptr);
                return temp1;
            }
        }
    }

    while (ptr && !(ptr->size == ptrsize))
    {
        prev = ptr;
        ptr = ptr->next;
```

```
    }
    if (!ptr)
        return NULL;
    if (ptr->size == size)
    {
        prev->next = ptr->next;
        strcpy(ptr->status, pid);
        return ptr;
    }
    else
    {
        struct node *temp1 = newNode(ptr->start, ptr->start + size);
        struct node *temp2 = newNode(ptr->start + size, ptr->end);
        prev->next = temp2;
        temp2->next = ptr->next;
        strcpy(temp1->status, pid);
        free(ptr);
        return temp1;
    }
}

int main()
{
    int ch, n, start, end;
    printf("\nEnter the Memory Representation:");
    printf("\nEnter the no.of partitions in memory: ");
    scanf("%d", &n);
    struct node *mempool = NULL, *alloc = NULL, *temp = NULL;
    for (int i = 0; i < n; i++)
    {
        printf("Enter Starting and ending address of partition %d: ", i + 1);
        scanf("%d%d", &start, &end);
        if (start >= end || i && temp->end != start)
        {
            i--;
            printf("Invalid entry,enter again\n");
        }
        else
        {
            temp = newNode(start, end);
            mempool = insertEnd(mempool, temp);
        }
    }

    display(alloc, mempool);

    do
    {
        printf("\n1. First Fit\n2. Best Fit \n3. Worst Fit \n4. Exit \nEnter your choice:
");
        scanf("%d", &ch);
        switch (ch)
        {
        case 1:
```

```
        case 2:
        case 3:
            break;
        case 4:
            printf("Exiting...\n");
            return 0;
            break;
        default:
            printf("\nInvalid Input!\n");
        }
        int ch1, size;
        char pid[3];
        char fits[3][15] = {"First Fit", "Best Fit", "Worst Fit"};
        do
        {
            printf("\n\t\t%s Memory Allocation Algorithm\n\n1. Entry / Allocate\n2. Exit /
Deallocate \n3. Display \n4. Coalescing of Holes \n5. Back to Algorithm \n6. Exit\nEnter
your choice: ", fits[ch - 1]);
            scanf("%d", &ch1);
            switch (ch1)
            {
            case 1:
                printf("\nEnter process id : ");
                scanf("%s", pid);
                printf("Enter size needed : ");
                scanf("%d", &size);
                if (size <= 0)
                {
                    printf("\nInvalid size!\n");
                    break;
                }
                if (!insert(allocate(&mempool, pid, size, whichfit(mempool, size, ch)),
&alloc))
                {
                    printf("\nCouldn't allocate memory to %s!\n", pid);
                    break;
                }
                else
                    printf("\nMemory is allocted to %s\n", pid);
                display(alloc, mempool);
                break;
            case 2:
                printf("\nEnter process id : ");
                scanf("%s", pid);
                if (!insert(deallocate(&alloc, pid), &mempool))
                {
                    printf("\nProcess %s is not there!\n", pid);
                    break;
                }
                else
                    printf("\n%s's memory is deallocted\n", pid);
                display(alloc, mempool);
                break;
            case 3:
```

```
                display(alloc, mempool);
                break;
            case 4:
                combine(&mempool);
                display(alloc, mempool);
                break;
            case 5:
                break;
            case 6:
                printf("Exiting...\n");
                return 0;
                break;
            default:
                printf("\nInavlid Input!\n");
            }
        } while (!(ch1 == 5 || ch1 == 6));
    } while (ch != 4);
    return 0;
}
```

Output:

1.

```
Enter the Memory Representation:
Enter the no.of partitions in memory: 5
Enter Starting and ending address of partition 1: 100 110
Enter Starting and ending address of partition 2: 110 112
Enter Starting and ending address of partition 3: 112 117
Enter Starting and ending address of partition 4: 117 120
Enter Starting and ending address of partition 5: 120
125

Allocated Memory Space

NULL

Free Memory Space

+---------+---------+---------+---------+---------+
|    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+
100       110       112       117       120       125


Physical Memory Space

+---------+---------+---------+---------+---------+
|    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+
100       110       112       117       120       125



1. First Fit
2. Best Fit
3. Worst Fit
4. Exit
```

```
                First Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 1

Enter process id : 1
Enter size needed : 5

Memory is allocted to 1

Allocated Memory Space

+---------+
|    1    |
+---------+
100       105


Free Memory Space

+---------+---------+---------+---------+---------+---------+
|    H    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+
105       110       112       117       120       125


Physical Memory Space

+---------+---------+---------+---------+---------+---------+---------+
|    1    |    H    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+
100       105       110       112       117       120       125
```

```
                First Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 1

Enter process id : 2
Enter size needed : 3

Memory is allocted to 2

Allocated Memory Space

+---------+---------+
|    1    |    2    |
+---------+---------+
100       105       108


Free Memory Space

+---------+---------+---------+---------+---------+
|    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+
108       110       112       117       120       125


Physical Memory Space

+---------+---------+---------+---------+---------+---------+---------+
|    1    |    2    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+
100       105       108       110       112       117       120       125
```

```
                First Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 1

Enter process id : 3
Enter size needed : 5

Memory is allocted to 3

Allocated Memory Space

+---------+---------+         +---------+
|    1    |    2    |---------|    3    |
+---------+---------+         +---------+
100       105       108      112       117


Free Memory Space

+---------+---------+         +---------+---------+
|    H    |    H    |---------|    H    |    H    |
+---------+---------+         +---------+---------+
108       110       112      117       120       125


Physical Memory Space

+---------+---------+---------+---------+---------+---------+---------+---------+
|    1    |    2    |    H    |    H    |    3    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+
100       105       108       110       112       117       120       125
```

```
                First Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 2

Enter process id : 2

2's memory is deallocted

Allocated Memory Space

+---------+         +---------+
|    1    |---------|    3    |
+---------+         +---------+
100       105       112       117


Free Memory Space

+---------+---------+---------+         +---------+---------+
|    H    |    H    |    H    |---------|    H    |    H    |
+---------+---------+---------+         +---------+---------+
105       108       110       112       117       120       125


Physical Memory Space

+---------+---------+---------+---------+---------+---------+---------+
|    1    |    H    |    H    |    H    |    3    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+
100       105       108       110       112       117       120       125
```

```
                First Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 4

Allocated Memory Space

+---------+         +---------+
|    1    |---------|    3    |
+---------+         +---------+
100       105       112       117


Free Memory Space

+---------+         +---------+
|    H    |---------|    H    |
+---------+         +---------+
105       112       117       125


Physical Memory Space

+---------+---------+---------+---------+
|    1    |    H    |    3    |    H    |
+---------+---------+---------+---------+
100       105       112       117       125
```

```
                First Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 2

Enter process id : 1

1's memory is deallocted

Allocated Memory Space

+---------+
|    3    |
+---------+
112       117


Free Memory Space

+---------+---------+         +---------+
|    H    |    H    |---------|    H    |
+---------+---------+         +---------+
100       105       112      117       125


Physical Memory Space

+---------+---------+---------+---------+
|    H    |    H    |    3    |    H    |
+---------+---------+---------+---------+
100       105       112       117       125
```

```
                First Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 2

Enter process id : 3

3's memory is deallocted

Allocated Memory Space

NULL

Free Memory Space

+---------+---------+---------+---------+
|    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+
100       105       112       117       125


Physical Memory Space

+---------+---------+---------+---------+
|    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+
100       105       112       117       125
```

```
                Best Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 1

Enter process id : 1
Enter size needed : 5

Memory is allocted to 1

Allocated Memory Space

+---------+
|    1    |
+---------+
100       105


Free Memory Space

+---------+---------+---------+---------+---------+---------+
|    H    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+
105       110       112       117       120       125


Physical Memory Space

+---------+---------+---------+---------+---------+---------+---------+
|    1    |    H    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+
100       105       110       112       117       120       125
```

```
                Best Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 1

Enter process id : 1
Enter size needed : 4

Memory is allocted to 1

Allocated Memory Space

+---------+
|    1    |
+---------+
112       116


Free Memory Space

+---------+---------+         +---------+---------+---------+
|    H    |    H    |---------|    H    |    H    |    H    |
+---------+---------+         +---------+---------+---------+
100       110       112      116       117       120       125


Physical Memory Space

+---------+---------+---------+---------+---------+---------+
|    H    |    H    |    1    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+
100       110       112       116       117       120       125
```

```
                Best Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 1

Enter process id : 2
Enter size needed : 3

Memory is allocted to 2

Allocated Memory Space

+---------+         +---------+
|    1    |---------|    2    |
+---------+         +---------+
112       116       120       123


Free Memory Space

+---------+---------+         +---------+---------+         +---------+
|    H    |    H    |---------|    H    |    H    |---------|    H    |
+---------+---------+         +---------+---------+         +---------+
100       110       112       116       117       120       123       125


Physical Memory Space

+---------+---------+---------+---------+---------+---------+---------+
|    H    |    H    |    1    |    H    |    H    |    2    |    H    |
+---------+---------+---------+---------+---------+---------+---------+
100       110       112       116       117       120       123       125
```

```
                Best Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 2

Enter process id : 2

2's memory is deallocted

Allocated Memory Space

+---------+
|    1    |
+---------+
112       116


Free Memory Space

+---------+---------+         +---------+---------+---------+---------+
|    H    |    H    |---------|    H    |    H    |    H    |    H    |
+---------+---------+         +---------+---------+---------+---------+
100       110       112       116       117       120       123       125


Physical Memory Space

+---------+---------+---------+---------+---------+---------+---------+
|    H    |    H    |    1    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+
100       110       112       116       117       120       123       125
```

```
                Best Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 2

Enter process id : 1

1's memory is deallocted

Allocated Memory Space

NULL

Free Memory Space

+---------+---------+---------+---------+---------+---------+---------+---------+
|    H    |    H    |    H    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+---------+
100       110       112       116       117       120       123       125


Physical Memory Space

+---------+---------+---------+---------+---------+---------+---------+---------+
|    H    |    H    |    H    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+---------+
100       110       112       116       117       120       123       125
```

```
                Worst Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 1

Enter process id : 1
Enter size needed : 1

Memory is allocted to 1

Allocated Memory Space

+---------+
|    1    |
+---------+
100       101


Free Memory Space

+---------+---------+---------+---------+---------+---------+
|    H    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+
101       110       112       117       120       125


Physical Memory Space

+---------+---------+---------+---------+---------+---------+---------+
|    1    |    H    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+
100       101       110       112       117       120       125
```

```
                Worst Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 1

Enter process id : 3
Enter size needed : 3

Memory is allocted to 3

Allocated Memory Space

+---------+         +---------+
|    1    |---------|    3    |
+---------+         +---------+
100       101       104       107


Free Memory Space

+---------+         +---------+---------+---------+---------+---------+---------+
|    H    |---------|    H    |    H    |    H    |    H    |    H    |    H    |
+---------+         +---------+---------+---------+---------+---------+---------+
101       104       107       109       110       112       117       120       125


Physical Memory Space

+---------+---------+---------+---------+---------+---------+---------+---------+---------+
|    1    |    H    |    3    |    H    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+---------+---------+
100       101       104       107       109       110       112       117       120       125
```

```
                Worst Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 2

Enter process id : 3

3's memory is deallocted

Allocated Memory Space

+---------+
|    1    |
+---------+
100       101


Free Memory Space

+---------+---------+---------+---------+---------+---------+---------+---------+
|    H    |    H    |    H    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+---------+
101       104       107       109       110       112       117       120       125


Physical Memory Space

+---------+---------+---------+---------+---------+---------+---------+---------+---------+
|    1    |    H    |    H    |    H    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+---------+---------+
100       101       104       107       109       110       112       117       120       125
```

```
                Worst Fit Memory Allocation Algorithm

1. Entry / Allocate
2. Exit / Deallocate
3. Display
4. Coalescing of Holes
5. Back to Algorithm
6. Exit
Enter your choice: 2

Enter process id : 1

1's memory is deallocted

Allocated Memory Space

NULL

Free Memory Space

+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
|    H    |    H    |    H    |    H    |    H    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
100       101       104       107       109       110       112       117       120       125


Physical Memory Space

+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
|    H    |    H    |    H    |    H    |    H    |    H    |    H    |    H    |    H    |    H    |
+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
100       101       104       107       109       110       112       117       120       125
```

Learning Outcome:

- Learnt how to allocate memory for processes
- Learnt to manipulate memory and linked lists

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)
SSN College of Engineering

Department of Computer Science and Engineering

UCS1411 – Operating Systems Laboratory

II Year CSE - A Section (IV Semester)

Exercise – 9 – Paging Technique

Lab Exercise 9 Implementation of Paging Technique-

Aim:

To develop a C program to implement the paging technique in memory management.

Procedure:

1. Get the total size of the physical memory and the page size.
2. Divide the physical memory into frames.
3. Initialize the physical memory structure using random number generation (Some frames must be free and some random frames are already allotted to other process)
4. Construct the free frame list.
5. Get the Process memory requirement. Divide the LAS into n pages.
6. If n free frames are available, allot the process and update the page table.
7. **Show the conversion of any logical address into the corresponding physical address.**
8. Do de-allocation accordingly.
9. Repeat the steps 5-8 for N processes.

SAMPLE INPUT/OUTPUT:

Paging Technique

Enter the physical memory size: 32 KB

Enter the page size = 1 KB

Physical memory is divided into 32 frames.

After initialization

Free Frames: 3 6 9 12 1 2 18 30 25

1. **Process request**
2. **Deallocation**
3. **Page Table display for all input process**

4. **Free Frame list display**
5. **Exit**

Enter the option:1

Enter the Process requirement(ID,size): P1, 4 KB

Process is divided into 4 pages

Page Table for P1:

Page 0 : Frame 3

Page 1: Frame 6

Page 2 : Frame 9

Page 3: Frame 12

Enter the option: 4

Free Frames: 1 2 18 30 25

Enter the option: 1

Enter the Process requirement(ID,size): P2, 2 KB

Process is divided into 2 pages

Page Table for P2:

Page 0 : Frame 1

Page 1: Frame 2

Enter the option: 4

Free Frames: 18 30 25

Enter the option: 3

Page Table for P1:

Page 0 : Frame 3

Page 1: Frame 6

…..

Page Table for P2:

Page 0 : Frame 1

Page 1: Frame 2

Enter the option: 2

Enter the process ID to be de-allocated:P1

Enter the option:4

Free Frames: 18 30 25 3 6 9 12 (freed frames appended at end)

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

LAB EXERCISE 9

Paging Technique

Submission Date:23-05-2022

Name: Jayannthan P T *Dept: CSE 'A'* *Roll No.: 205001049*

1. To develop a C program to implement the paging technique in memory management

Algorithm:

1. Generate a random number using the srand() function.
2. Create an array of processes of type table.
3. Input the size of the physical memory and the size of each page.
4. Assign the ceil value of the quotient when the size of physical memory is divided by size of page as number of frames.
5. Initially, assign 0 to all elements of the frames array.
6. Assign -1 to random frames.
7.-1 indicate that the frames are free
8. Input an integer option.
9. If option is equal to 1, execute steps 9.1 to 9.6.
    9.1. Input the process ID and its size.
    9.2. Calculate the number of frames that will be occupied by the process.
    9.3. If the number of frames required by the process is less than the number of free frames allocate. Else, print that there aren't enough frames.
10. If option is equal to 2, execute steps 10.1 to 10.2.
    10.1. Input the ID of the process to be deallocated.
    10.2. Assign -1 to all the frames allocated to the process to indicate that the process frames have been deallocated. Remove the process from the process list as well.
11. If option is equal to 3, print the page table for all processes.
12. If option is equal to 4, print all the free frames, i.e., print all the frames where the (j+1)th element in the frames array is equal to -1.
13. If option is equal to 5, exit the program.
14. Else, declare that the user has entered an invalid input.

Code:

```c
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <time.h>
```

```c
#define MAX 50
struct table
{
    int page[MAX];
    int frame[MAX];
    int no_of_pages;
};
int main()
{
    srand(time(0));
    int no_of_frames, option, process, frames_req, no_of_free_frames = 0, no_of_process =
0, m = 1;
    double size, memory_size, page_size;
    int frames[MAX], process_[MAX];
    struct table processes_[MAX];
    printf("\nPAGING TECHNIQUE\n");
    printf("\nEnter the physical memory size: ");
    scanf(" %lf", &memory_size);
    printf("Enter the page size: ");
    scanf(" %lf", &page_size);
    no_of_frames = ceil(memory_size / page_size);
    printf("\nPhysical memory is divided into %d frames.", no_of_frames);
    for (int i = 1; i <= no_of_frames; i++)
        frames[i] = 0;
    int n = 10;
    for (int i = 1; i <= n; i++)
    {
        frames[rand() % no_of_frames + 1] = -1;
        no_of_free_frames++;
    }
    printf("\n\nAfter Initialisation: \n\nFree Frames: ");
    for (int i = 1; i <= no_of_frames; i++)
    {
        if (frames[i] == -1)
            printf("%d ", i);
    }
    int p = 0;
    printf("\n\nMENU:\n\t1. Process request\n\t2. Deallocation\n\t3. Page Table display
for all input process\n\t4. Free Frame list display\n\t5. Exit\n");
    do
    {
        printf("\nEnter the option: ");
        scanf("%d", &option);
        switch (option)
        {
        case 1:
            printf("\nEnter the process requirement (ID,size): P");
            scanf(" %d %lf", &process, &size);
            frames_req = ceil(size / page_size);
            processes_[process].no_of_pages = frames_req;
            printf("\nProcess is divivded into %d pages.\n\nPage Table for P%d:\n",
frames_req, process);
            if (frames_req <= no_of_free_frames)
            {
```

```
                p = 0;
                no_of_process++;
                process_[no_of_process] = process;
                for (int i = 1; i <= frames_req;)
                {
                    for (int j = m, k = 1; k <= no_of_frames; k++)
                    {
                        if (frames[j] == -1)
                        {
                            printf("\n\tPage %d : Frame %d \n", i - 1, j);
                            no_of_free_frames--;
                            frames[j] = process;
                            processes_[process].page[p] = i - 1;
                            processes_[process].frame[p] = j;
                            i++;
                            p++;
                            break;
                        }
                        j = j % no_of_frames + 1;
                        m = j;
                    }
                }
            }
            else
                printf("\nThere is no enough free frames to allocate for this
process!\n");
            break;
        case 2:
            printf("\nEnter the process to be deallocated: P");
            scanf(" %d", &process);
            for (int i = 1; i <= no_of_frames; i++)
            {
                if (frames[i] == process)
                {
                    frames[i] = -1;
                    no_of_free_frames++;
                }
            }
            for (int i = 1; i <= no_of_process; i++)
            {
                if (process_[i] == process)
                {
                    process_[i] = -1;
                    break;
                }
            }
            break;
        case 3:
            for (int k = 1; k <= no_of_process; k++)
            {
                if (process_[k] != -1)
                {
                    printf("\nPage table for P%d:\n", process_[k]);
                    int i = 0;
```

```
                    for (; i < processes_[process_[k]].no_of_pages; i++)
                        printf("\n\tPage %d : Frame %d \n",
processes_[process_[k]].page[i], processes_[process_[k]].frame[i]);
                }
            }
            break;
        case 4:
            printf("\nFree Frames: ");
            for (int i = 1, j = m; i <= no_of_frames; i++)
            {
                if (frames[j] == -1)
                    printf("%d ", j);
                j = j % no_of_frames + 1;
                m = j;
            }
            printf("\n");
            break;
        case 5:
            printf("\nProgram terminated\n");
            break;
        default:
            printf("\nInvalid option\n");
            break;
        }
    } while (option != 5);
}
```

Output:

```
PAGING TECHNIQUE

Enter the physical memory size: 32
Enter the page size: 1

Physical memory is divided into 32 frames.

After Initialisation:

Free Frames: 1 2 11 14 18 21 27 28

MENU:
        1. Process request
        2. Deallocation
        3. Page Table display for all input process
        4. Free Frame list display
        5. Exit
```

```
Enter the option: 1

Enter the process requirement (ID,size): P1 5

Process is divivded into 5 pages.

Page Table for P1:

        Page 0 : Frame 1

        Page 1 : Frame 2

        Page 2 : Frame 11

        Page 3 : Frame 14

        Page 4 : Frame 18
```

```
Enter the option: 1

Enter the process requirement (ID,size): P1 5

Process is divivded into 5 pages.

Page Table for P1:

        Page 0 : Frame 1

        Page 1 : Frame 2

        Page 2 : Frame 11

        Page 3 : Frame 14

        Page 4 : Frame 18

Enter the option: 1

Enter the process requirement (ID,size): P2
2

Process is divivded into 2 pages.

Page Table for P2:

        Page 0 : Frame 21

        Page 1 : Frame 27
```

```
Enter the option: 4

Free Frames: 28
```

```
Enter the option: 2

Enter the process to be deallocated: P1

Enter the option: 4

Free Frames: 28 1 2 11 14 18
```

```
Enter the option: 1

Enter the process requirement (ID,size): P3 3

Process is divivded into 3 pages.

Page Table for P3:

        Page 0 : Frame 28

        Page 1 : Frame 1

        Page 2 : Frame 2
```

```
Enter the option: 2

Enter the process to be deallocated: P2

Enter the option: 4

Free Frames: 11 14 18 21 27
```

```
Enter the option: 2

Enter the process to be deallocated: P3

Enter the option: 4

Free Frames: 2 11 14 18 21 27 28 1
```

Learning Outcome:

- Learned about the use of paging technique.
- Learned how to allocate memory to processes using paging technique.

SN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)
Department of Computer Science and Engineering

UCS1411 – Operating Systems Laboratory

II Year CSE - A Section (IV Semester)

Exercise – 10 – Page Replacement Technique

Lab Exercise 10 Implementation of Page Replacement Algorithms

Aim:

Develop a C program to implement the page replacement algorithms (FIFO, Optimal, LRU and LFU) using linked list.

Algorithm:

Implement the following modules and its operations using linked list.

Read module:

1. Read the number of frames.
2. Read the number of frames required by the process N.
3. Read the reference string for allocation of page frames.

Page replacement module:

FIFO REPLACEMENT

1. Allocate the first N pages into the frames and increment the page faults accordingly.
2. When next frame in the reference string is not already available in the allocated list do
    a. Look for the oldest one in the allocated frames and replace it with the next page frame.
    b. Increment the page fault whenever a frame is replaced.

OPTIMAL REPLACEMENT

1. Allocate the first N pages into the frames and increment the page faults accordingly.
2. When next frame in the reference string is not already available in the allocated list do
    a. Look for a frame in the reference string will not be used for longest period of time.
    b. Increment the page fault whenever a frame is replaced. (Hint: Locate the position of each allocated frame in the reference string; identify a frame for replacement with largest index position)
3. Display the allocated frame list after every replacement.

LRU REPLACEMENT

1. Allocate the first N pages into the frames and increment the page faults accordingly.
2. When next frame in the reference string is not already available in the allocated list do
    a. Look for a frame which is not used recently.
    b. Increment the page fault whenever a frame is replaced.
3. Display the allocated frame list after every replacement

LFU REPLACEMENT

1. Allocate the first N pages into the frames and increment the page faults accordingly.
2. When next frame in the reference string is not already available in the allocated list do
    a. Look for a frame which is least frequently used.
    b. Increment the page fault whenever a frame is replaced.
3. Display the allocated frame list after every replacement

Sample input & output:

PAGE REPLACEMENT ALGORITHMS

1. READ_INPUT

2. FIFO

3. OPTIMAL

4. LRU

5. LFU

6. EXIT

Enter your option: 1

Enter the number of free frames: 10

Enter the number of frames required by the process: 4

Enter the reference string: 7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1

Enter your option: 2

FIFO Page Replacement Algorithm

The reference string: 7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1

Page ref → memory → PF

7 → 7 - - - →1

0 → 7 0 - - → 2

1 → 7 0 1 - → 3

2 → 7 0 1 2 → 4

0 → 7 0 1 2 → -

3 → 3 0 1 2 → 5

7	7	7	7	3	3	3	3	2	2
	0	0	0	0	4	4	4	4	7
		1	1	1	1	0	0	0	0
			2	2	2	2	1	1	1

Total Number of Page Faults: 10

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

LAB EXERCISE 10

Implementation of Page Replacement Algorithms

Submission Date:23-05-2022

Name: Jayannthan P T *Dept: CSE 'A'* *Roll No.: 205001049*

1. Develop a C program to implement the page replacement algorithms (FIFO, Optimal, LRU and LFU) using linked list.

Algorithm:

1. Start.
2. Get user input and reference string.
3. Get user choice for the page replacement algorithm.

FIFO:

1. Create an empty linked list.
2. Get frame from reference string.
3. Search and check if the frame is already present in the list of frames.
    a) If not found.
    b) Insert into list.
    c) Increase size.
    d) Check for the oldest frame.
    e) Replace the oldest frame with the current frame.
    f) Increment the oldest frame.
4. Insert into table.
5. Increment number of faults.
6. Display table.

Optimal:

1. Create an empty linked list.
2. Search if the frame from the reference string is in the current list.
3. If not
    - If size is lesser than list size then insert and increment size.
    - Iterate through the list.
    - For each frame in the list check the next occurrence in the reference string in the future.
    - Assign and find the max distance.

- Replace the frame with greater future distance.

4. Increment the no of page faults.
5. Display table.

LRU:

1. Create an empty list.
2. Search if the frame from the reference string is in the current list.
3. If not,
    - If size is less than no of frames then insert and increment size.
    - Iterate through the list.
    - Check the previous frames and assign distance.
    - Calculate max distance for each frame.
    - Replace the frame with max distance.
4. Increment the no of page faults.
5. Display table.

LFU:

1. Create an empty list.
2. Search if the frame from the reference string is in the current list.
3. If not
    - If size is lesser than list size then insert and increment size.
    - If not, iterate through the list and increment frequency.
    - Go backwards and check frequency.
    - CHeck the least frequency with the frame.
4. If found, increment the frequency.
5. Increment the number of faults.
6. Display table.

Code:

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

struct memory
{
    char page;
    struct memory * next;
};
void init_frame(struct memory *frame)
{
    struct memory *ptr = frame->next;
    while (ptr != NULL)
    {
        ptr->page = '-';
        ptr = ptr->next;
    }
}
void insert_frame(struct memory *frame, char page)
{
    struct memory *new_frame = (struct memory *) malloc(sizeof(struct memory));
    new_frame->page = page;
```

```
    new_frame->next = NULL;
    struct memory *ptr = frame;
    while (ptr->next != NULL)
    {
        ptr = ptr->next;
    }
    ptr->next = new_frame;
}
void delete_frame(struct memory *frame)
{
    while (frame->next != NULL)
    {
        struct memory *temp = frame->next;
        frame->next = frame->next->next;
        free(temp);
    }
}
void replace(struct memory *frame, int cur_fault, char page)
{
    int count = 0;
    struct memory *ptr = frame->next;
    while (count < cur_fault && ptr != NULL)
    {
        ptr = ptr->next;
        count++;
    }
    if (ptr != NULL)
    {
        ptr->page = page;
    }
}
int present(struct memory *frame, int start, int end, char page)
{
    int count = 0;
    struct memory *ptr = frame->next;
    while (count != start)
    {
        count++;
        ptr = ptr->next;
    }
    while (count < end && ptr != NULL)
    {
        if (page == ptr->page)
        {
            return count;
        }
        count++;
        ptr = ptr->next;
    }
    return 100;
}
int present_ref(char str_ref[], int start, int end, char page)
{
    for (int i = start; i < end; i++)
```

```
    {
        if (page == str_ref[i])
        {
            return i;
        }
    }
    return 100;
}
int present_last(struct memory *frame, int start, int end, char page)
{
    int pos;
    int count = 0;
    struct memory *ptr = frame->next;
    while (count != start)
    {
        count++;
        ptr = ptr->next;
    }
    while (count <= end && ptr != NULL)
    {
        if (page == ptr->page)
        {
            pos = count;
        }
        count++;
        ptr = ptr->next;
    }
    return pos;
}
int present_last_ref(char ref_str[], int start, int end, char page)
{
    int pos;
    for (int i = start; i <= end; i++)
    {
        if (page == ref_str[i])
        {
            pos = i;
        }
    }
    return pos;
}
int max(int duration[], int page_follow[], int no_frames)
{
    int first = page_follow[0], first_pos = 0;
    for (int i = 0; i < no_frames; i++)
    {
        if (page_follow[i] > first)
        {
            first = page_follow[i];
            first_pos = i;
        }
    }
    if (page_follow[first_pos] == 100)
    {
```

```
        first = duration[first_pos];
        for (int i = 0; i < no_frames; i++)
        {
            if ((duration[i] > first) && (page_follow[i] == 100))
            {
                first = duration[i];
                first_pos = i;
            }
        }
    }
    return first_pos;
}
int min(int page_past[], int no_frames)
{
    int first = page_past[0], first_pos = 0;
    for (int i = 0; i < no_frames; i++)
    {
        if (page_past[i] < first)
        {
            first = page_past[i];
            first_pos = i;
        }
    }
    return first_pos;
}
int frequency(char ref_str[], int start, int end, char page)
{
    int freq = 0;
    for (int i = start; i <= end; i++)
    {
        if (page == ref_str[i])
        {
            freq++;
        }
    }
    return freq;
}
int min_freq(int duration[], int page_past[], int no_frames)
{
    int first = page_past[0], first_pos = 0, count = 0;
    for (int i = 0; i < no_frames; i++)
    {
        if (page_past[i] < first)
        {
            first = page_past[i];
            first_pos = i;
        }
    }
    for (int i = 0; i < no_frames; i++)
    {
        if (page_past[i] == page_past[first_pos])
        {
            count++;
        }
```

```
    }
    if (count >= 2)
    {
        first = duration[first_pos];
        int pos = 0;
        for (int i = 0; i < no_frames; i++)
        {
            if ((duration[i] > first) && (page_past[i] == page_past[pos]))
            {
                first = duration[i];
                pos = i;
            }
        }
        return pos;
    }
    return first_pos;
}
void print_frame(char page, struct memory *frame, int page_fault)
{
    printf("\n%c\t--->\t", page);
    struct memory *ptr = frame->next;
    while (ptr != NULL)
    {
        printf("%c\t", ptr->page);
        ptr = ptr->next;
    }
    if (!page_fault) {}
    else
    {
        printf("\tPage fault : %d", page_fault);
    }
}
char frame_page(struct memory *frame, int index)
{
    struct memory *ptr = frame->next;
    int count = 0;
    while (ptr != NULL && count < index)
    {
        ptr = ptr->next;
        count++;
    }
    return ptr->page;
}
void fifo(struct memory *frame, int no_frames, char ref_str[])
{
    init_frame(frame);
    int page_fault = 0, cur_fault = 0;
    for (int i = 0; ref_str[i] != '\0'; i++)
    {
        if (present(frame, 0, no_frames, ref_str[i]) == 100)
        {
            replace(frame, cur_fault, ref_str[i]);
            page_fault++;
            cur_fault = (cur_fault + 1) % no_frames;
```

```
            print_frame(ref_str[i], frame, page_fault);
        }
        else
        {
            print_frame(ref_str[i], frame, 0);
        }
    }
    printf("\nTotal page faults : %d", page_fault);
}
void optimal(struct memory *frame, int no_frames, char ref_str[])
{
    init_frame(frame);
    int duration[100];
    for (int i = 0; i < no_frames; i++)
    {
        duration[i] = 0;
    }
    int page_fault = 0, cur_fault = 0;
    for (int i = 0; ref_str[i] != '\0'; i++)
    {
        if (present(frame, 0, no_frames, '-') != 100 && present(frame, 0,
                no_frames, ref_str[i]) == 100)
        {
            cur_fault = present(frame, 0, no_frames, '-');
            replace(frame, cur_fault, ref_str[i]);
            page_fault++;
            print_frame(ref_str[i], frame, page_fault);
        }
        else if (present(frame, 0, no_frames, ref_str[i]) == 100)
        {
            int page_follow[100];
            for (int j = 0; j < no_frames; j++)
            {
                char item = frame_page(frame, j);
                page_follow[j] = present_ref(ref_str, i + 1, strlen(ref_str),
                    item);
            }
            int cur_fault = max(duration, page_follow, no_frames);
            replace(frame, cur_fault, ref_str[i]);
            page_fault++;
            for (int j = 0; j < no_frames; j++)
            {
                if (j != cur_fault)
                {
                    duration[j]++;
                }
                else
                {
                    duration[j] = 0;
                }
            }
            print_frame(ref_str[i], frame, page_fault);
        }
        else
```

```
        {
            print_frame(ref_str[i], frame, 0);
        }
    }
    printf("\nTotal page faults = %d", page_fault);
}
void lru(struct memory *frame, int no_frames, char ref_str[])
{
    init_frame(frame);
    int page_fault = 0, cur_fault = 0;
    for (int i = 0; ref_str[i] != '\0'; i++)
    {
        if (present(frame, 0, no_frames, '-') != 100 && present(frame, 0,
                no_frames, ref_str[i]) == 100)
        {
            cur_fault = present(frame, 0, no_frames, '-');
            replace(frame, cur_fault, ref_str[i]);
            page_fault++;
            print_frame(ref_str[i], frame, page_fault);
        }
        else if (present(frame, 0, no_frames, ref_str[i]) == 100)
        {
            int page_follow[100];
            for (int j = 0; j < no_frames; j++)
            {
                char item = frame_page(frame, j);
                page_follow[j] = present_last_ref(ref_str, 0, i - 1, item);
            }
            int cur_fault = min(page_follow, no_frames);
            replace(frame, cur_fault, ref_str[i]);
            page_fault++;
            print_frame(ref_str[i], frame, page_fault);
        }
        else
        {
            print_frame(ref_str[i], frame, 0);
        }
    }
    printf("\nTotal page faults = %d", page_fault);
}
void lfu(struct memory *frame, int no_frames, char ref_str[])
{
    init_frame(frame);
    int duration[100];
    for (int i = 0; i < no_frames; i++)
    {
        duration[i] = 0;
    }
    int page_fault = 0, cur_fault = 0;
    for (int i = 0; ref_str[i] != '\0'; i++)
    {
        if (present(frame, 0, no_frames, '-') != 100 && present(frame, 0,
                no_frames, ref_str[i]) == 100)
        {
```

```
            cur_fault = present(frame, 0, no_frames, '-');
            replace(frame, cur_fault, ref_str[i]);
            page_fault++;
            print_frame(ref_str[i], frame, page_fault);
        }
        else if (present(frame, 0, no_frames, ref_str[i]) == 100)
        {
            int page_past[100]; //Finding frequency of page usage
            for (int j = 0; j < no_frames; j++)
            {
                char item = frame_page(frame, j);
                page_past[j] = frequency(ref_str, 0, i - 1, item);
            }
            int cur_fault = min_freq(duration, page_past, no_frames);
            replace(frame, cur_fault, ref_str[i]);
            page_fault++;
            for (int j = 0; j < no_frames; j++)
            {
                if (j != cur_fault)
                {
                    duration[j]++;
                }
                else
                {
                    duration[j] = 0;
                }
            }
            print_frame(ref_str[i], frame, page_fault);
        }
        else
        {
            print_frame(ref_str[i], frame, 0);
        }
    }
    printf("\nTotal page faults = %d", page_fault);
}
int main()
{
    struct memory *frame = (struct memory *) malloc(sizeof(struct memory));
    int no_frames, ref_len;
    char frames[100], ref_str[100];

    delete_frame(frame);
    printf("Number of frames: ");
    scanf(" %d", &no_frames);
    for (int i = 0; i < no_frames; i++)
    {
        insert_frame(frame, '-');
    }
    printf("\nReference string length: ");
    scanf(" %d", &ref_len);
    printf("\nReference string: ");
    for (int i = 0; i < ref_len; i++)
    {
```

```
        scanf(" %c", &ref_str[i]);
    }
    ref_str[ref_len] = '\0';

    while (1)
    {
        printf("\n1. FIFO\n2. Optimal\n3. LRU\n4. LFU\n5.Exit\nEnter your choice: ");
        int ch;
        scanf(" %d", &ch);
        switch (ch)
        {
            case 1:
                {
                    fifo(frame, no_frames, ref_str);
                    break;
                }
            case 2:
                {
                    optimal(frame, no_frames, ref_str);
                    break;
                }
            case 3:
                {
                    lru(frame, no_frames, ref_str);
                    break;
                }
            case 4:
                {
                    lfu(frame, no_frames, ref_str);
                    break;
                }
            case 5:
                {
                    exit(1);
                    break;
                }
            default:
                {
                    printf("\nInvalid choice!");
                    break;
                }
        }
    }
    printf("\n");
    return 0;
}
```

Output:

```
1. FIFO
2. Optimal
3. LRU
4. LFU
5.Exit
Enter your choice: 1

7       --->    7       -       -               Page fault : 1
0       --->    7       0       -               Page fault : 2
1       --->    7       0       1               Page fault : 3
2       --->    2       0       1               Page fault : 4
0       --->    2       0       1
3       --->    2       3       1               Page fault : 5
0       --->    2       3       0               Page fault : 6
4       --->    4       3       0               Page fault : 7
2       --->    4       2       0               Page fault : 8
3       --->    4       2       3               Page fault : 9
0       --->    0       2       3               Page fault : 10
3       --->    0       2       3
2       --->    0       2       3
1       --->    0       1       3               Page fault : 11
2       --->    0       1       2               Page fault : 12
0       --->    0       1       2
1       --->    0       1       2
7       --->    7       1       2               Page fault : 13
0       --->    7       0       2               Page fault : 14
1       --->    7       0       1               Page fault : 15
Total page faults : 15
```

```
Enter your choice: 2

7       --->    7       -       -               Page fault : 1
0       --->    7       0       -               Page fault : 2
1       --->    7       0       1               Page fault : 3
2       --->    2       0       1               Page fault : 4
0       --->    2       0       1
3       --->    2       0       3               Page fault : 5
0       --->    2       0       3
4       --->    2       4       3               Page fault : 6
2       --->    2       4       3
3       --->    2       4       3
0       --->    2       0       3               Page fault : 7
3       --->    2       0       3
2       --->    2       0       3
1       --->    2       0       1               Page fault : 8
2       --->    2       0       1
0       --->    2       0       1
1       --->    2       0       1
7       --->    7       0       1               Page fault : 9
0       --->    7       0       1
1       --->    7       0       1
Total page faults = 9
```

```
Enter your choice: 3

7       --->    7       -       -               Page fault : 1
0       --->    7       0       -               Page fault : 2
1       --->    7       0       1               Page fault : 3
2       --->    2       0       1               Page fault : 4
0       --->    2       0       1
3       --->    2       0       3               Page fault : 5
0       --->    2       0       3
4       --->    4       0       3               Page fault : 6
2       --->    4       0       2               Page fault : 7
3       --->    4       3       2               Page fault : 8
0       --->    0       3       2               Page fault : 9
3       --->    0       3       2
2       --->    0       3       2
1       --->    1       3       2               Page fault : 10
2       --->    1       3       2
0       --->    1       0       2               Page fault : 11
1       --->    1       0       2
7       --->    1       0       7               Page fault : 12
0       --->    1       0       7
1       --->    1       0       7
Total page faults = 12
```

```
Enter your choice: 4

7       --->    7       -       -               Page fault : 1
0       --->    7       0       -               Page fault : 2
1       --->    7       0       1               Page fault : 3
2       --->    2       0       1               Page fault : 4
0       --->    2       0       1
3       --->    2       0       3               Page fault : 5
0       --->    2       0       3
4       --->    4       0       3               Page fault : 6
2       --->    4       0       2               Page fault : 7
3       --->    3       0       2               Page fault : 8
0       --->    3       0       2
3       --->    3       0       2
2       --->    3       0       2
1       --->    3       0       1               Page fault : 9
2       --->    3       0       2               Page fault : 10
0       --->    3       0       2
1       --->    1       0       2               Page fault : 11
7       --->    7       0       2               Page fault : 12
0       --->    7       0       2
1       --->    1       0       2               Page fault : 13
Total page faults = 13
```

Learning Outcome:

- Learnt to implement page replacement techniques

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)
Department of Computer Science and Engineering

UCS1411 – Operating Systems Laboratory

II Year CSE - A Section (IV Semester)

Exercise – 11 – Threading Applications

Lab Exercise 11 Threading Applications

1. Write a multithreaded program that calculates various statistical values for a list of numbers. This program will be passed a series of numbers on the command line and will then create three separate worker threads. One thread will determine the average of the numbers, the second will determine the maximum value, and the third will determine the minimum value. For example, suppose your program is passed the integers

   90 81 78 95 79 72 85

   The program will report
   The average value is 82
   The minimum value is 72
   The maximum value is 95

The variables representing the average, minimum, and maximum values will be stored globally. The worker threads will set these values, and the parent thread will output the values once the workers have exited. (We could obviously expand this program by creating additional threads that determine other statistical values, such as median and standard deviation.)

Example:
Main thread creates a thread to find the summation of given ‘n’

```
#include < pthread.h>
#include <stdio.h>
int sum; /* this data is shared by the thread(s) */
void *runner(void *param); /* threads call this function */
int main(int argc, char *argv[])
{
pthread_t tid; /* the thread identifier */
pthread_attr_t attr; /* set of thread attributes */
if (argc != 2)
{
fprintf(stderr,"usage: a.out <integer value>\n");
```

```
return -1;
}
if (atoi(argv[1]) < 0)
{
fprintf(stderr,"%d must be >= 0 \n",atoi(argv[1]));
return -1;
}
/* get the default attributes */
pthread_attr_init(&attr);
/* create the thread */
pthread_create(&tid,&attr,runner,argv[1]);
/* wait for the thread to exit */
pthread_join(tid,NULL);
printf("sum = %d\n",sum);
}
/* The thread will begin control in this function */
void *runner(void *param)
{
int i, upper = atoi(param);
sum = 0;
for (i = 1; i <= upper; i++)
sum += i;
pthread_exit(0);
}
```

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

LAB EXERCISE 11

Threading Applications

Submission Date:23-05-2022

Name: Jayannthan P T *Dept: CSE 'A'* *Roll No.: 205001049*

1. Write a multithreaded program that calculates various statistical values for a list of numbers. This program will be passed a series of numbers on the command line and will then create three separate worker threads. One thread will determine the average of the numbers, the second will determine the maximum value, and the third will determine the minimum value. For example, suppose your program is passed the integers
90 81 78 95 79 72 85
The program will report
The average value is 82
The minimum value is 72
The maximum value is 95

Algorithm:

1. Initialize global variables sum, min, max, avg
2. Create functions to calculate avg, min, max
3. Inside the main function, create thread identifiers and set of thread attributes
4. Read the argument from the user as command line arguments and have it in the array
5. Get default attributes and create thread for each function
6. Wait for thread to exit before each creation
7. Using join function, close the existing executed thread to compile and link it
8. Print the data obtained from the thread

Code:

```
#include <stdio.h>
#include <pthread.h>
int arr[50], n, i;

void *calc_avg()
{
```

```
    float sum = 0;
    float average;
    /*printf("enter size:");
    scanf("%d", &n);
    printf("\nenter array elements:\n");
    for (i = 0; i < n; i++)
    {
        scanf("%d", &arr[i]);
    }*/
    for (i = 0; i < n; i++)
    {
        sum = sum + arr[i];
    }
    average = sum / n;
    printf("The average value is:%.2f", average);
}
void *calc_min()
{

    int temp = arr[0];
    for (int i = 1; i < n; i++)
    {
        if (temp > arr[i])
        {
            temp = arr[i];
        }
    }
    printf("\nThe Minimum  value is:=%d", temp);
}
void *calc_max()
{

    int temp = arr[0];
    for (int i = 1; i < n; i++)
    {
        if (temp < arr[i])
        {
            temp = arr[i];
        }
    }
    printf("\nThe Maximum  value is:=%d\n", temp);
}
int main(int argc,char* argv[])
{
    int m;
    n=argc-1;
    for (i = 0; i < n; i++)
    {
        arr[i]=atoi(argv[i+1]);
    }
    pthread_t t;
    m = pthread_create(&t, NULL, &calc_avg, NULL);
    pthread_join(t, NULL);
    m = pthread_create(&t, NULL, &calc_min, NULL);
```

```
    pthread_join(t, NULL);
    m = pthread_create(&t, NULL, &calc_max, NULL);
    pthread_join(t, NULL);
}
```

Output:

```
root@spl25:~/Jayannthan/Threads# ./threads 1 2 3 4 5
The average value is:3.00
The Minimum  value is:=1
The Maximum  value is:=5
```

Learning Outcome:

- Implemented threading application
- Learnt the importance of threading

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)
Department of Computer Science and Engineering

UCS1411 – Operating Systems Laboratory

II Year CSE - A Section (IV Semester)

Lab Exercise 12: File Allocation Techniques

AIM:

To develop a C program to implement the various file allocation techniques.

Algorithm:

1. Get Main memory size and block size as input.
2. Create a Main memory with 'n' number of blocks of equal size.
3. Main memory is maintained as Linked List with structure containing block id, Free / Filename, Link to next Memory block , Link to Next File block (only for Linked Allocation), File block table(integer array to hold block numbers only for Indexed Allocation)
4. Get the number of files and their size as input.
5. Calculate the no. of blocks needed for each file.
6. Select the Allocation Algorithm.
   – For every algorithm display Directory information and File information.
7. For Contiguous Allocation - For each file do the following
   i. Generate a random number between 1 to 'n'
   ii. Check for continuous number of needed file free blocks starting from that random block no.
   iii. If free then allot that file in those continuous blocks and update the directory structure.
   iv. else repeat step 1
   v. If no continuous blocks are free then 'no enough memory error'
   vi. The Directory Structure should contain Filename, Starting Block, length (no. of blocks)
8. For Linked Allocation- For each file do the following
   i. Generate a random number between 1 to 'n' blocks.
   ii. Check that block is free or not.

iii. If free then allot it for file. Repeat step 1 to 3 for the needed number of blocks for file and create linked list in Main memory using the field "Link to Next File block".

iv. Update the Directory entry which contains Filename, Start block number, Ending Block Number.

v. Display the file blocks starting from start block number in Directory upto ending block number by traversing the Main memory Linked list using the field "Link to Next File block".

20.For Indexed Allocation - For each file do the following

i. Generate a random number between 1 to 'n' blocks for index block.

ii. Check if it is free else repeat index block selection

iii. Generate needed number of free blocks in random order for the file and store those block numbers in index block as array in File block table array.

iv. Display the Directory structure which contains the filename and index blocknumber. Display the File Details by showing the index block number's File Block Table.

SAMPLE INPUT & OUTPUT:

Main Memory size: 500
Size of each block in the disk: 10 KB
Number of files to be allocated: 5
Name of the File1: ****
Size of the file1: ****
•
•

FILE ALLOCATION TECHNIQUES

1. **Contiguous**
2. **Linked**
3. **Indexed**

Choose the Allocation scheme: 1

CONTIGUOUS ALLOCATION

Directory

File Name	Start	length
*****	***	***
*****	***	***
•		
•		
•		
*****	***	***

Choose the Allocation scheme: **2**

LINKED ALLOCATION

Directory

File Name	Start	End
*****	***	***
*****	***	***
•		
•		
•		
*****	***	***

Individual File listing

File name	Data-block 1	Data-block j	Data-block k	Data-block l	Data-block final

Choose the Allocation scheme: **3**

INDEXED ALLOCATION

Directory

File Name	Indexed Block
*****	***
*****	***
•	
•	
•	
*****	***

Display the Index table for all the files in the following manner

File Name	Block Indexed
***	Data-block 1
	Data-block j
	Data-block k
	Data-block l
	Data-block final

•
•

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

LAB EXERCISE 12

File Allocation Techniques

Submission Date:30-05-2022

Name: Jayannthan P T *Dept: CSE 'A'* *Roll No.: 205001049*

1. To develop a C program to implement the various file allocation techniques.

Algorithm:

1. Get Main memory size and block size as input.
2. Create a Main memory with 'n' number of blocks of equal size.
3. Main memory is maintained as Linked List with structure containing block id, Free / Filename, Link to next Memory block , Link to Next File block (only for Linked Allocation), File block table(integer array to hold block numbers only for Indexed Allocation)
4. Get the number of files and their size as input.
5. Calculate the no. of blocks needed for each file.
6. Select the Allocation Algorithm. – For every algorithm display Directory information and File information.
7. For Contiguous Allocation - For each file do the following
    i. Generate a random number between 1 to 'n'
    ii. Check for continuous number of needed file free blocks starting from that random block
    no.
    iii. If free then allot that file in those continuous blocks and update the directory structure.
    iv. else repeat step 1
    v. If no continuous blocks are free then 'no enough memory error'
    vi. The Directory Structure should contain Filename, Starting Block, length (no. of blocks)
8. For Linked Allocation- For each file do the following
    i. Generate a random number between 1 to 'n' blocks.
    ii. Check that block is free or not.
    iii. If free then allot it for file. Repeat step 1 to 3 for the needed number of blocks for file and create linked list in Main memory using the field "Link to Next File block".
    iv. Update the Directory entry which contains Filename, Start block number, Ending Block Number.
    v. Display the file blocks starting from start block number in Directory upto ending block number by traversing the Main memory Linked list using the field "Link to Next File block.

9.For Indexed Allocation - For each file do the following

i.Generate a random number between 1 to ‘n’ blocks for index block.

ii. Check if it is free else repeat index block selection

iii. Generate needed number of free blocks in random order for the file and store those block numbers in index block as array in File block table array.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>
#include <string.h>
#include <math.h>
typedef struct
{
    char fname[20];
    int start;
    int length;
    int end;
    struct dir *next;
} dir;
typedef struct
{
    char fname[20];
    int blockid;
    int fileblocktable[100];
    struct node *next;
    struct node *link;
} node;
typedef struct
{
    char fname[20];
    int fsize;
    int fileblocks;
} fileDetails;

void insert(node *head, node data)
{
    node *t;
    node *newnode;
    newnode = (node *)malloc(sizeof(node));
    newnode->blockid = data.blockid;
    strcpy(newnode->fname, data.fname);
    newnode->next = NULL;
    t = head;
    while (t->next != NULL)
    {
        t = t->next;
    }
    t->next = newnode;
}
void contiguous_alloc(node *mainmem, fileDetails filedata[])
{
    dir d[noOfFiles];
    int i, j;
```

```
    int alloc = 0;
    int randno;
    int occur[noOfBlocks + 1];
    node *t;
    node *start;
    int found;
    int count_rand;
    for (i = 0; i < noOfFiles; i++)
    {
        found = 0;
        count_rand = 0;
        for (j = 1; j <= noOfBlocks; j++)
            occur[j] = 0;
        while (count_rand != noOfBlocks)
        {
            randno = (rand() % noOfBlocks) + 1;
            while (occur[randno] != 0)
                randno = (rand() % noOfBlocks) + 1;
            count_rand++;
            occur[randno] = 1;
            t = mainmem;
            for (j = 0; j < randno; j++)
                t = t->next;
            start = t;
            found = 1;
            for (j = 0; j < filedata[i].fileblocks; j++)
            {
                if (t == NULL)
                    break;
                if (strcmp(t->fname, "free") == 0)
                {
                    t = t->next;
                    continue;
                }
                else
                {
                    found = 0;
                    break;
                }
            }
            if (found == 1)
            {
                d[alloc].start = start->blockid;
                d[alloc].length = filedata[i].fileblocks;
                strcpy(d[alloc].fname, filedata[i].fname);
                for (j = 0; j < filedata[i].fileblocks; j++)
                {
                    strcpy(start->fname, filedata[i].fname);
                    start = start->next;
                }
                break;
            }
        }
        if (found == 0)
```

```
            printf("\nMEMORY UNAVAILABLE\n");
        else
            alloc++;
    }
    printf("No. of files allocated:%d\n", alloc);
    printf("\nDirectory\n");
    printf("\tFile Name\tStart\tLength\n");
    for (i = 0; i < alloc; i++)
        printf("\t%s\t\t%d\t%d\n", d[i].fname, d[i].start, d[i].length);
}
void linked_alloc(fileDetails filedata[], node *mainmem)
{
    node *temp, *start, *new;
    int i, j, k;
    int randno;
    int found;
    dir d[noOfFiles];
    int startpos;
    for (i = 0; i < noOfFiles; i++)
    {
        for (j = 0; j < filedata[i].fileblocks; j++)
        {
            found = 0;
            while (found == 0)
            {
                randno = (rand() % noOfBlocks) + 1;
                temp = mainmem;
                for (k = 0; k < randno; k++)
                    temp = temp->next;
                if (strcmp(temp->fname, "free") == 0)
                {
                    strcpy(temp->fname, filedata[i].fname);
                    found = 1;
                    if (j == 0)
                    {
                        new = temp;
                        strcpy(d[i].fname, filedata[i].fname);
                        d[i].start = temp->blockid;
                    }
                    else if (j == filedata[i].fileblocks - 1)
                    {
                        new->link = temp;
                        temp->link = NULL;
                        d[i].end = temp->blockid;
                    }
                    else
                    {
                        new->link = temp;
                        new = new->link;
                    }
                }
            }
        }
    }
```

```
    printf("\nDirectory\n");
    printf("\tFile Name\tStart\tEnd\n");
    for (i = 0; i < noOfFiles; i++)
        printf("\t%s\t\t%d\t%d\n", d[i].fname, d[i].start, d[i].end);
    printf("\nIndividual File listing\n");
    for (i = 0; i < noOfFiles; i++)
    {
        printf("File Name: %s\n", d[i].fname);
        startpos = d[i].start;
        temp = mainmem;
        for (j = 0; j < startpos; j++)
            temp = temp->next;
        printf("\tData-block %d\n", temp->blockid);
        temp = temp->link;
        while (temp != NULL)
        {
            printf("\tData-block %d\n", temp->blockid);
            temp = temp->link;
        }
    }
}
void indexed_alloc(fileDetails filedata[], node *mainmem)
{
    node *temp, *start, *indexblock;
    int i, j, k;
    int indexblockid;
    int randno;
    int found;
    dir d[noOfFiles];
    for (i = 0; i < noOfFiles; i++)
    {
        found = 0;
        while (found != 1)
        {
            randno = (rand() % noOfBlocks) + 1;
            temp = mainmem;
            for (k = 0; k < randno; k++)
                temp = temp->next;
            if (strcmp(temp->fname, "free") == 0)
            {
                found = 1;
                strcpy(temp->fname, filedata[i].fname);
            }
        }
        indexblock = temp;
        strcpy(d[i].fname, filedata[i].fname);
        d[i].start = indexblock->blockid;
        for (j = 0; j < filedata[i].fileblocks; j++)
        {
            found = 0;
            while (found != 1)
            {
                randno = (rand() % noOfBlocks) + 1;
                temp = mainmem;
```

```
                for (k = 0; k < randno; k++)
                    temp = temp->next;
                if (strcmp(temp->fname, "free") == 0)
                {
                    found = 1;
                    strcpy(temp->fname, filedata[i].fname);
                    indexblock->fileblocktable[j] = temp->blockid;
                }
            }
        }
    }
    printf("\nDirectory\n");
    printf("\tFile Name\tIndexed Block\n");
    for (i = 0; i < noOfFiles; i++)
        printf("\t%s\t\t%d\n", d[i].fname, d[i].start);
    printf("\n\nIndex Table\n");
    printf("File Name\t\tBlock Indexed\n");
    for (i = 0; i < noOfFiles; i++)
    {
        indexblockid = d[i].start;
        temp = mainmem;
        for (j = 0; j < indexblockid; j++)
            temp = temp->next;
        printf("\n%s", temp->fname);
        for (j = 0; j < filedata[i].fileblocks; j++)
            printf("\t\t\tData-block %d\n", temp->fileblocktable[j]);
    }
}

void main()
{
    int mem_size, choice, i;
    node data;
    node *mainmem;
    node *temp;
    fileDetails filedata[100];
    char c;
    mainmem = malloc(sizeof(node));
    mainmem->next = NULL;
    printf("Enter the main memory size:");
    scanf("%d", &mem_size);
    printf("Enter the block size:");
    scanf("%d", &block_size);
    noOfBlocks = (int)mem_size / block_size;
    printf("Total no. of blocks available:%d\n", noOfBlocks);
    for (i = 0; i < noOfBlocks; i++)
    {
        data.blockid = i + 1;
        strcpy(data.fname, "free");
        insert(mainmem, data);
    }
    printf("Number of files to be allocated:");
    scanf("%d", &noOfFiles);
    for (i = 0; i < noOfFiles; i++)
```

```
    {
        printf("\nName of file %d:", i + 1);
        scanf("%s", filedata[i].fname);
        printf("Size of file %d(in KB):", i + 1);
        scanf("%d", &filedata[i].fsize);
        filedata[i].fileblocks = ceil((float)filedata[i].fsize / (float)block_size);
    }
    do
    {
        printf("\n\nFILE ALLOCATION TECHNIQUES\n");
        printf("1.Contiguous\n");
        printf("2.Linked\n");
        printf("3.Indexed\n");
        printf("Enter choice:");
        scanf("%d", &choice);
        temp = mainmem->next;
        while (temp != NULL)
        {
            strcpy(temp->fname, "free");
            temp = temp->next;
        }
        srand(time(NULL));
        switch (choice)
        {
        case 1:
            contiguous_alloc(mainmem, filedata);

            break;
        case 2:
            linked_alloc(filedata, mainmem);
            break;
        case 3:
            indexed_alloc(filedata, mainmem);
            break;
        }
        printf("\nDo you want to continue?:");
        scanf("%s", &c);
    } while (c == 'y');
}
```

Output:

```
Enter the main memory size:500
Enter the block size:10
Total no. of blocks available:50
Number of files to be allocated:5

Name of file 1:f1
Size of file 1(in KB):10

Name of file 2:f2
Size of file 2(in KB):20

Name of file 3:f3
Size of file 3(in KB):10

Name of file 4:f4
Size of file 4(in KB):5

Name of file 5:f5
Size of file 5(in KB):5
```

```
FILE ALLOCATION TECHNIQUES
1.Contiguous
2.Linked
3.Indexed
Enter choice:1
No. of files allocated:5

Directory
        File Name       Start   Length
        f1              32      1
        f2              17      2
        f3              36      1
        f4              14      1
        f5              33      1
```

```
FILE ALLOCATION TECHNIQUES
1.Contiguous
2.Linked
3.Indexed
Enter choice:2

Directory
        File Name       Start   End
                        7       0
        f2              36      28
        f3              14      32764
        f4              8       0
        f5              43      0

Individual File listing
File Name:
        Data-block 7
File Name: f2
        Data-block 36
        Data-block 28
File Name: f3
        Data-block 14
File Name: f4
        Data-block 8
File Name: f5
        Data-block 43
```

```
FILE ALLOCATION TECHNIQUES
1.Contiguous
2.Linked
3.Indexed
Enter choice:3

Directory
        File Name       Indexed Block
                        9
        f2              11
        f3              14
        f4              26
        f5              12


Index Table
File Name               Block Indexed

                        Data-block 21

f2                      Data-block 1
                        Data-block 35

f3                      Data-block 47

f4                      Data-block 17

f5                      Data-block 33
```

Learning Outcome:

- Learnt about the various file allocation techniques
- Learnt to implement the c program for the various file allocation techniques

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)
Department of Computer Science and Engineering

UCS1411 – Operating Systems Laboratory

II Year CSE - B Section (IV Semester)

Lab Exercise 13 File Organization Techniques

AIM:

To develop a C program to implement the following file organization techniques

a) Single level Directory

b) Hierarchical Structure

Procedure:

1. Single Level Directory
    a. Maintain a table containing the filename and the starting address location of that file.
    b. Give options for creating a new file.
    c. When creating the file, check for name collision.
    d. Update the table accordingly.

2. Tree Structured Directory
    a. Maintain tables for each directory starting from root.
    b. Create a structure for a node in tree which contains an array to hold directories and an array to hold files.
    c. Limit each directory to have a maximum of three sub-directories and files.
    d. For each sub-directory follow the same table structure as described above.

SAMPLE INPUT & OUTPUT:

File Organization techniques

1.Single Level Directory
2. Tree structures directory

Enter your option: 1

1.Create a file
2.List the files

Enter your option:1

Enter the name of the file: file1
File created!

1.Create a file
2.List the files

Enter your option:1

Enter the name of the file: file2

File created!

1.Create a file
2.List the files

Enter your option:1

Enter the name of the file: file2
File already exists!

Enter your option:2
Contents of root directory

File Name	Location
file1	1000
file2	3500
•	
•	

- Similarly, for all other structures

SSN COLLEGE OF ENGINEERING, KALAVAKKAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

UCS1411 - OPERATING SYSTEMS LAB

LAB EXERCISE 13

File Organization Techniques

Submission Date:30-05-2022

Name: Jayannthan P T *Dept: CSE 'A'* *Roll No.: 205001049*

1. To develop a C program to implement the following file organization techniques
   a) Single level Directory
   b) Hierarchical Structure.

Algorithm:

1. Single Level Directory
   a. Maintain a table containing the filename and the starting address location of that file.
   b. Give options for creating a new file.
   c. When creating the file, check for name collision.
   d. Update the table accordingly.
2. Tree Structured Directory
   a. Maintain tables for each directory starting from root.
   b. Create a structure for a node in tree which contains an array to hold directories and an array to hold files.
   c. Limit each directory to have a maximum of three sub-directories and files.
   d. For each sub-directory follow the same table structure as described above

Code:

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

char files[100][20];
int address[100];
int cur = 1;
typedef struct dir
{
    char dirname[20];
    char filename[100][10];
    int address[100];
```

```
    int curfile;
    struct dir *ptr1, *ptr2, *ptr3;
}
dir;
dir * root;
dir* create(char name[20])
{
    dir *p = (dir*) malloc(sizeof(dir));
    p->ptr1 = NULL;
    p->ptr2 = NULL;
    p->ptr3 = NULL;
    p->curfile = 0;
    strcpy(p->dirname, name);
    return p;
}
void singleLevel()
{
    cur = 1;
    printf("\n\t\t\tSINGLE LEVEL FILE SYSTEM\n");
    int choice = -1;
    printf("\n\tMenu : \n\t1.Create file\n\t2.Print files \n\t3.Exit\n\t\tEnter Choice:");
    scanf("%d", &choice);
    do
    {   // if (choice == 3)return;
        if (choice == 2)
        {
            printf("\nFiles.....\n");
            for (int i = 1; i <= cur-1; i++) printf("%d.%s\t \n", i, files[i]);
            printf("\nFiles printed...\n");
        }
        else if (choice == 1)
        {
            char name[20];
            int found = 0;
            printf("\n\tName of the file : ");
            scanf("%s", name);
            for (int i = 1; i <= cur-1; i++)
            {
                if (strcmp(name, files[i]) == 0)
                {
                    found = 1;
                    break;
                }
            }
            if (found)
            {
                printf("\n\tFile name already exists!\n");
            }
            else
            {
                strcpy(files[cur++], name);
                address[cur - 1] = rand() % 10000;
                printf("\n\tFile created succcessfully!\n");
            }
```

```
        }

        printf("\n\tMenu : \n\t1.Create file\n\t2.Print files \n\t3.Exit\n\t\tEnter
Choice: ");
        scanf("%d", &choice);
    } while (choice != 3);
}
dir* find(dir *p, char name[20])
{
    if (p == NULL) return NULL;
    if (strcmp(p->dirname, name) == 0) return p;
    dir *p1 = find(p->ptr1, name);
    if (p1 != NULL) return p1;
    dir *p2 = find(p->ptr2, name);
    if (p2) return p2;
    dir *p3 = find(p->ptr3, name);
    if (p3) return p3;
    return NULL;
}
void print(dir *p)
{
    printf("\nDirectory Name : %s\n", p->dirname);
    if (p->curfile == 0)
    {
        printf("\n\tNO FILES IN DIRECTORY!\n");
    }
    else
    {
        printf("Files in Directory :");
        for (int i = 1; i <= p->curfile; i++)
        {
            printf("\n\t%s", p->filename[i]);
        }
    }
    if (p->ptr1 == NULL) return;
    printf("\n\tSubdirectories :");
    if (p->ptr1 != NULL)
    {
        printf("\n\t\t%s", p->ptr1->dirname);
    }
    if (p->ptr2 != NULL)
    {
        printf("\n\t\t%s", p->ptr2->dirname);
    }
    if (p->ptr3 != NULL)
    {
        printf("\n\t\t%s", p->ptr3->dirname);
    }
    printf("\n\n");
}

void display(dir *p)
{
    if (p == NULL)
```

```
        return;;
    print(p);
    display(p->ptr1);
    display(p->ptr2);
    display(p->ptr3);
}
void hierarchial()
{
    cur = 1;
    root = create("root");
    printf("\n\t\t\tTREE LEVEL FILE SYSTEM\n");
    int choice = -1;
    printf("\n\tMenu : \n\t1.Create directory\n\t2.Create file\n\t3.Print files
\n\t4.Exit\n\t\tEnter Choice: ");
    scanf("%d", &choice);
    do
    {
        if (choice == 1)
        {
            char name[20];
            printf("\n\tName of directory to be created :");
            scanf("%s", name);
            char parent[20];
            printf("\n\tParent name : ");
            scanf("%s", parent);
            dir *p = find(root, parent);
            if (p == NULL) printf("\n\tDirectory not found!");
            else
            {
                if (p->ptr1 == NULL)
                {
                    dir *temp = create(name);
                    p->ptr1 = temp;
                    printf("\n\tDirectory succcessfully created!\n");
                }
                else if (p->ptr2 == NULL)
                {
                    if (strcmp(p->ptr1->dirname, name) == 0) printf("\n\t Name already
exists!\n");
                    else
                    {
                        dir *temp = create(name);
                        p->ptr2 = temp;
                        printf("\n\tDirectory succcessfully created!\n");
                    }
                }
                else if (p->ptr3 == NULL)
                {
                    if (strcmp(p->ptr1->dirname, name) == 0 || strcmp(p->ptr2->dirname,
name) == 0) printf("\n\tDirectory Name already exists!\n");
                    else
                    {
                        dir *temp = create(name);
                        p->ptr3 = temp;
```

```
                    printf("\n\tDirectory succcessfully created!\n");
                }
            }
            else printf("\nCannot create directory. Space exceeded!\n");
        }
    }
    else if (choice == 2)
    {
        char file[20];
        printf("\n\tEnter file name : ");
        scanf("%s", file);
        printf("\n\tEnter directory under which you want to create the file : ");
        char direc[20];
        scanf("%s", direc);
        dir *p = find(root, direc);
        if (p == NULL)
        {
            printf("\n\tDirectory does not exist!");
        }
        else
        {
            int found = 0;
            for (int i = 1; i <= p->curfile; i++)
            {
                if (strcmp(p->filename[i], file) == 0)
                {
                    found = 1;
                    break;
                }
            }
            if (found) printf("\n\tFilename already exists!");
            else
            {
                strcpy(p->filename[++p->curfile], file);
                p->address[p->curfile] = rand() % 10000;
                printf("\n\tFile succcessfully created!");
            }
        }
    }
    else if (choice == 3)
    {
        printf("\nDisplaying directory structure.....\n");
        display(root);
    }
    else
    {
        printf("\n Enter Valid Choice\n");
    }
    printf("\n\tMenu : \n\t1.Create directory\n\t2.Create file\n\t3.Print files
\n\t4.Exit\n\t\tEnter Choice: ");
    scanf("%d", &choice);
  } while (choice != 4);
}
int main()
```

```
{
    int option = -1;
    printf("\nMenu : \n1.Single level\n2.Hierarchial \n3.Exit\n\tEnter Choice: ");
    scanf("%d", &option);
    do {
        switch (option)
        {
            case 1:
                singleLevel();
                break;
            case 2:
                hierarchial();
                break;
            default:
                printf("\n Enter Valid Choice\n");
                break;
        }
        printf("\nMenu : \n1.Single level\n2.Hierarchial \n3.Exit\n\tEnter Choice: ");
        scanf("%d", &option);
    } while (option != 3);
    return 0;
}
```

Output:

```
Menu :
1.Single level
2.Hierarchial
3.Exit
```

```
Enter Choice: 1

                SINGLE LEVEL FILE SYSTEM

Menu :
1.Create file
2.Print files
3.Exit
        Enter Choice:
```

```
                SINGLE LEVEL FILE SYSTEM

Menu :
2.Print files
3.Exit
        Enter Choice:1

Name of the file : f1

File created succcessfully!

Menu :
1.Create file
2.Print files
3.Exit
        Enter Choice: 1

Name of the file : f1

File name already exists!

Menu :
1.Create file
2.Print files
3.Exit
        Enter Choice: 1

Name of the file : f2

File created succcessfully!
```

```
        Menu :
        1.Create file
        2.Print files
        3.Exit
                Enter Choice: 2

Files.....
1.f1
2.f2
```

```
                TREE LEVEL FILE SYSTEM

Menu :
1.Create directory
2.Create file
3.Print files
4.Exit
```

```
                TREE LEVEL FILE SYSTEM

Menu :
1.Create directory
2.Create file
3.Print files
4.Exit
        Enter Choice: 1

Name of directory to be created :dir1

Parent name : root

Directory succcessfully created!

Menu :
1.Create directory
2.Create file
3.Print files
4.Exit
        Enter Choice: 1

Name of directory to be created :dir1

Parent name : root

 Name already exists!
```

```
Menu :
1.Create directory
2.Create file
3.Print files
4.Exit
        Enter Choice: 2

Enter file name : f1

Enter directory under which you want to create the file : root
3.Print files
4.Exit
        Enter Choice: 2

Enter file name : f1

Enter directory under which you want to create the file : dir1

File succcessfully created!
Menu :
1.Create directory
2.Create file
3.Print files
4.Exit
        Enter Choice: 1

Name of directory to be created :dir2

Parent name : dir1

Directory succcessfully created!

Menu :
1.Create directory
2.Create file
3.Print files
4.Exit
        Enter Choice: 2

Enter file name : f1

Enter directory under which you want to create the file : dir2

File succcessfully created!
```

Learning Outcome:

- Learnt about the different directory structures
- Implemented single level directory and tree structured directory using c program