PROCESS SCHEDULING

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

First Come First Serve (FCFS):

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

Shortest Job First (SJF):

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

Priority:

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

Round Robin:

All processes are processed one by one as they have arrived, but in rounds. Each process cannot take more than the time slice per round.

Round robin is a fair preemptive scheduling algorithm.

A process that is yet to complete in a round is preempted after the time slice and put at the end of the queue.

When a process is completely processed, it is removed from the queue.

LAB# 06
FCFS Scheduling

Task:

To schedule snapshot of processes queued according to FCFS (First Come First Serve) scheduling.

Algorithm:

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

Result:

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

Program:

```
/* FCFS Scheduling - fcfs.c */

#include <stdio.h>
 struct process
 {
      int pid;
      int btime;
      int wtime;
      int ttime;
} p[10];

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

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

```
awat = (float)twat / n;
atur = (float)ttur / n;
printf("\n FCFS Scheduling\n\n");
for(i=0; i<28; i++)
printf("-");
printf("\nProcess B-Time T-Time W- Time\n"); for(i=0; i<28;
i++) printf("-");
for(i=0; i<n; i++)
    printf("\nP%d\t%4d\t%3d\t%2d",
p[i].pid,p[i].btime,p[i].ttime,p[i].wtime); printf("\n");
for(i=0; i<28; i++)
    printf("-");
printf("\n\nGANTT Chart\n"); printf("-"); for(i=0; i<(p[n-1].ttime + 2*n); i++)
printf("-");
printf("\n"); printf("|");
for(i=0; i<n; i++)
{
    k = p[i].btime/2; for(j=0; j<k;
      j++) printf(" ");
    printf("P%d",p[i].pid);
      for(j=k+1; j<p[i].btime; j++) printf(" ");
    printf("|");
}
printf("\n");
printf("-"); for(i=0; i<(p[n-1].ttime + 2*n); i++)
printf("-");
printf("\n"); printf("0");
for(i=0; i<n; i++)
{
    for(j=0; j<p[i].btime; j++) printf(" ");
    printf("%2d",p[i].ttime);
}

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

Output:

```
rida@ubuntu:~$ gcc -o 1a 1a.c
rida@ubuntu:~$ ./1a
Enter no. of process : 5
Burst time for process P1 (in ms) : 10
Burst time for process P2 (in ms) : 8
Burst time for process P3 (in ms) : 10
Burst time for process P4 (in ms) : 8
Burst time for process P5 (in ms) : 4

 FCFS Scheduling

----------------------------
Process B-Time T-Time W- Time
----------------------------
 P1       10      10       0
 P2        8      18      10
 P3       10      28      18
 P4        8      36      28
 P5        4      40      36
----------------------------

GANTT Chart
---------------------------------------------------
|      P1     |     P2    |      P3     |     P4    |  P5 |
---------------------------------------------------
0           10         18          28         36    40

Average waiting time : 18.40ms
Average turn around time : 26.40ms
rida@ubuntu:~$
```

LAB# 07
SJF Scheduling

Task:

To schedule snapshot of processes queued according to SJF (Shortest Job First) scheduling.

Algorithm:

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

Result:

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

Program:

```
/* SJF Scheduling – sjf.c */

#include <stdio.h>
 struct process
 {
      int pid; int btime;
      int wtime;
 int ttime; } p[10],
temp;
 main()
 {
      int i,j,k,n,ttur,twat;
      float awat,atur;
 printf("Enter no. of process : ");
scanf("%d", &n);
      for(i=0; i<n; i++)
      {
           printf("Burst time for process P%d (in ms) : ",(i+1));
           scanf("%d", &p[i].btime); p[i].pid = i+1;
      }
 for(i=0; i<n-1; i++) {
           for(j=i+1; j<n; j++) {
                if((p[i].btime > p[j].btime) ||
                           (p[i].btime == p[j].btime && p[i].pid > p[j].pid))
                {
                     temp = p[i]; p[i] = p[j];
                      p[j] = temp;
                } } }
      p[0].wtime = 0;
 for(i=0; i<n; i++) {
           p[i+1].wtime = p[i].wtime + p[i].btime;
           p[i].ttime = p[i].wtime + p[i].btime; }
      ttur = twat = 0;
```

```
for(i=0; i<n; i++) {
    ttur += p[i].ttime; twat +=
    p[i].wtime; }
awat = (float)twat / n; atur =
(float)ttur / n;
printf("\n SJF Scheduling\n\n"); for(i=0; i<28; i++) printf("-");
    printf("\nProcess B-Time T-Time W-
Time\n"); for(i=0; i<28; i++) printf("-");
for(i=0; i<n; i++)
        printf("\nP%4d\t%4d\t%3d\t%2d",
p[i].pid,p[i].btime,p[i].ttime,p[i].wtime); printf("\n");
for(i=0; i<28; i++)
        printf("-");
printf("\n\nGANTT
    Chart\n"); printf("-");
for(i=0; i<(p[n-1].ttime + 2*n);
i++)    printf("-");    printf("\n|");
    for(i=0; i<n; i++) {
        k = p[i].btime/2;
         for(j=0; j<k;
            j++) printf(" ");
        printf("P%d",p[i].pid);
            for(j=k+1; j<p[i].btime; j++) printf(" ");
        printf("|");
        }
printf("\n-"); for(i=0; i<(p[n-1].ttime + 2*n);
    i++) printf("-"); printf("\n0");
for(i=0; i<n; i++) {
        for(j=0; j<p[i].btime; j++) printf("");
        printf("%2d",p[i].ttime);
    }
        printf("\n\nAverage waiting time: %5.2fms", awat);
printf("\nAverage turn around time : %5.2fms\n", atur); }
```

Output:

```
rida@ubuntu:~$ gcc -o 1b 1b.c
rida@ubuntu:~$ ./1b
Enter no. of process : 5
Burst time for process P1 (in ms) : 10
Burst time for process P2 (in ms) : 8
Burst time for process P3 (in ms) : 10
Burst time for process P4 (in ms) : 8
Burst time for process P5 (in ms) : 4

 SJF Scheduling

----------------------------
Process B-Time T-Time W- Time
----------------------------
 P5         4      4      0
 P2         8     12      4
 P4         8     20     12
 P1        10     30     20
 P3        10     40     30
----------------------------

GANTT Chart
---------------------------------------------------
|  P5 |     P2    |     P4    |      P1     |      P3     |
---------------------------------------------------
0     4         12          20           30           40

Average waiting time : 13.20ms
Average turn around time : 21.20ms
rida@ubuntu:~$
```

LAB# 08
Priority Scheduling

Task:

To schedule snapshot of processes queued according to Priority scheduling.

Algorithm:

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

Result:

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

Program:

```
/* Priority Scheduling - pri.c */

#include <stdio.h>
 struct process
 {
      int pid; int btime;
      int pri; int wtime;
 int ttime; } p[10],
temp;
 main()
 {
      int i,j,k,n,ttur,twat;
      float awat,atur;
 printf("Enter no. of process : ");
scanf("%d", &n);
      for(i=0; i<n; i++)
      {
           printf("Burst time for process P%d (in ms) : ",
           (i+1)); scanf("%d", &p[i].btime); printf("Priority for
           process P%d : ", (i+1)); scanf("%d", &p[i].pri);
           p[i].pid = i+1;
      }
      for(i=0; i<n-1; i++) {
           for(j=i+1; j<n; j++) {
                if((p[i].pri > p[j].pri) ||
                (p[i].pri == p[j].pri && p[i].pid > p[j].pid))
                {
                     temp = p[i]; p[i] = p[j];
                      p[j] = temp;
                } } }
      p[0].wtime = 0;
      for(i=0; i<n; i++) {
           p[i+1].wtime = p[i].wtime + p[i].btime;
              p[i].ttime = p[i].wtime + p[i].btime; }
```

```
    ttur = twat = 0; for(i=0; i<n; i++)
{
        ttur += p[i].ttime; twat +=
        p[i].wtime;
}
    awat = (float)twat / n; atur =
    (float)ttur / n;
      printf("\n\t Priority
    Scheduling\n\n"); for(i=0; i<38; i++) printf("-");
    printf("\nProcess B-Time Priority T-Time W-
    Time\n"); for(i=0; i<38; i++) printf("-");
    for (i=0; i<n; i++)
    printf("\n P%-4d\t%4d\t%3d\t%4d\t%4d",
    p[i].pid,p[i].btime,p[i].pri,p[i].ttime,p[i].wtime); printf("\n");
for(i=0; i<38; i++)
        printf("-");
printf("\n\nGANTT
    Chart\n"); printf("-");
for(i=0; i<(p[n-1].ttime + 2*n);
    i++) printf("-"); printf("\n|");
for(i=0; i<n; i++) {
        k = p[i].btime/2; for(j=0; j<k;
            j++) printf(" ");
        printf("P%d",p[i].pid);
            for(j=k+1; j<p[i].btime; j++) printf(" ");
        printf("|"); }
printf("\n-"); for(i=0; i<(p[n-1].ttime + 2*n);
    i++) printf("-"); printf("\n0");
    for(i=0; i<n; i++)
    {
        for(j=0; j<p[i].btime; j++) printf(" ");
        printf("%2d",p[i].ttime); }
      printf("\n\nAverage waiting time : %5.2fms", awat);
      printf("\nAverage turn around time : %5.2fms\n", atur); }
```

Output:

```
rida@ubuntu:~$ gcc -o 1c 1c.c
rida@ubuntu:~$ ./1c
Enter no. of process : 5
Burst time for process P1 (in ms) : 10
Priority for process P1 : 3
Burst time for process P2 (in ms) : 7
Priority for process P2 : 1
Burst time for process P3 (in ms) : 6
Priority for process P3 : 3
Burst time for process P4 (in ms) : 13
Priority for process P4 : 4
Burst time for process P5 (in ms) : 5
Priority for process P5 : 2
```

```
         Priority Scheduling

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

GANTT Chart
----------------------------------------------------
|   P2    |  P5  |     P1     |  P3  |      P4      |
----------------------------------------------------
0        7      12           22      28            41

Average waiting time : 13.80ms
Average turn around time : 22.00ms
rida@ubuntu:~$
```

LAB# 09
Round Robin Scheduling

Task:

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

Algorithm:

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

Result:

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

Program:

/* Round robin scheduling - rr.c */

```
#include <stdio.h>
 main() {
int i,x=-1,k[10],m=0,n,t,s=0;
     int a[50],temp,b[50],p[10],bur[10],bur1[10];
 int wat[10],tur[10],ttur=0,twat=0,j=0;
     float awat,atur;
 printf("Enter no. of process : "); scanf("%d",
     &n); for(i=0; i<n; i++) {
          printf("Burst time for process P%d : ", (i+1)); scanf("%d",
          &bur[i]);
          bur1[i] = bur[i]; }
     printf("Enter the time slice (in ms) :
     "); scanf("%d", &t);
     for(i=0; i<n; i++) {
          b[i] = bur[i] / t;
            if((bur[i]%t) != 0)
               b[i] += 1;
          m += b[i]; }
     printf("\n\t\tRound Robin Scheduling\n");
     printf("\nGANTT Chart\n"); for(i=0; i<m;
     i++)
     printf("--------");
     printf("\n");
     a[0] = 0; while(j < m) {
          if(x == n-1)
          x = 0; else x++;
          if(bur[x] >= t) {
               bur[x] -= t; a[j+1] = a[j] + t;
           if(b[x] == 1) {
                    p[s] = x; k[s] = a[j+1]; s++; }
                    j++; b[x] -= 1;
```

```
                printf(" P%d |", x+1); }
        else if(bur[x] != 0) {
            a[j+1] = a[j] + bur[x]; bur[x] = 0;
            if(b[x] == 1) {
                p[s] = x; k[s] =a[j+1];
                s++;
            } j++;
    b[x] -printf("= 1;P%d |",x+1); } }
    printf("\n");
    for(i=0;i<m;i++) printf("--------");
    printf("\n");
    for(j=0; j<=m; j++)
        printf("%d\t", a[j]);
    for(i=0; i<n; i++) {
        for(j=i+1; j<n; j++) {
            if(p[i] > p[j]) {
                temp = p[i]; p[i] = p[j];
                     p[j] = temp;
                temp = k[i]; k[i] = k[j];
                   k[j] = temp; } } }
    for(i=0; i<n; i++)
    { wat[i] = k[i] - bur1[i]; tur[i] = k[i]; }
    for(i=0; i<n; i++)
    { ttur += tur[i]; twat += wat[i]; }
    printf("\n\n"); for(i=0; i<30; i++)
        printf("-");
    printf("\nProcess\tBurst\tTrnd\tWait\n"); for(i=0;
    i<30; i++) printf("-");
    for (i=0; i<n; i++)
    printf("\nP%-4d\t%4d\t%4d\t%4d", p[i]+1,bur1[i],tur[i],wat[i]);
    printf("\n");
for(i=0; i<30; i++)
    printf("-"); awat = (float)twat / n; atur = (float)ttur / n;
    printf("\n\nAverage waiting time : %.2f ms", awat);
    printf("\nAverage turn around time : %.2f ms\n", atur); }
```

Output:

```
rida@ubuntu: ~
rida@ubuntu:~$ ./2c
Enter no. of process : 5
Burst time for process P1 : 10
Burst time for process P2 : 8
Burst time for process P3 : 10
Burst time for process P4 : 8
Burst time for process P5 : 4
Enter the time slice (in ms) : 5

                Round Robin Scheduling

GANTT Chart
-------- -------- -------- -------- -------- -------- -------- -------- ---
 P1 | P2 | P3 | P4 |= 1; P5 | P1 |= 1; P2 | P3 |= 1; P4 |
-------------------------------------------------------------------------
0       5       10      15      20      24      29      32      37      40

------------------------------
Process Burst   Trnd    Wait
------------------------------
P1         10      29      19
P2          8      32      24
P3         10      37      27
P4          8      40      32
P5          4      24      20
------------------------------

Average waiting time : 24.40 ms
Average turn around time : 32.40 ms
rida@ubuntu:~$
```

INTERPROCESS COMMUNICATION

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

Pipe:

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

Shared memory:

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

Message Queue:

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

Semaphores:

A semaphore is a counter used to synchronize access to a shared data amongst multiple processes.

To obtain a shared resource, the process should:

- Test the semaphore that controls the resource.
- If value is positive, it gains access and decrements value of semaphore.
- If value is zero, the process goes to sleep and awakes when value is > 0.
- When a process relinquishes resource, it increments the value of semaphore by 1.

Producer-Consumer problem:

A producer process produces information to be consumed by a consumer process.

A producer can produce one item while the consumer is consuming another one.

With bounded-buffer size, consumer must wait if buffer is empty, whereas producer must wait if buffer is full.

The buffer can be implemented using any IPC facility.

LAB# 10
Fibonacci and Prime Number

Task:

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

Algorithm:

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

Result:

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

Program:

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

#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <sys/types.h>
main() {
      pid_t pid; int pfd[2];
 int i,j,flg,f1,f2,f3; static unsigned int ar[25],br[25];
 if(pipe(pfd) == -1) {
           printf("Error in pipe"); exit(-1); }
     pid=fork(); if (pid == 0) {
           printf("Child process generates Fibonacci series\n"
           ); f1 = -1; f2 = 1;
           for(i = 0;i < 25; i++) {
          f3 = f1 + f2; printf("%d\t",f3);
          f1 = f2; f2 = f3; ar[i] = f3; }
           write(pfd[1],ar,25*sizeof(int)); }
      else if (pid > 0) {
           wait(NULL);
           read(pfd[0], br, 25*sizeof(int));
           printf("\nParent prints Fibonacci that are Prime\n");
           for(i = 0;i < 25; i++) {
        flg = 0; if (br[i] <= 1) flg = 1;
                for(j=2; j<=br[i]/2; j++) {
                     if (br[i]%j == 0) {
                     flg=1; break; } }
                if (flg == 0)
                      printf("%d\t", br[i]); }
           printf("\n"); }
else { printf("Process creation failed");
exit(-1); } }
```

Output:

```
rida@ubuntu: ~
rida@ubuntu:~$ gcc -o 1d 1d.c
rida@ubuntu:~$ ./1d
Child process generates Fibonacci series
0       1       1       2       3       5       8       13      21      34      5
5       89      144     233     377     610     987     1597    2584    4181    6
765     10946   17711   28657   46368
Parent prints Fibonacci that are Prime
2       3       5       13      89      233     1597    28657
rida@ubuntu:~$ 
```

LAB# 11
who | wc -l

Task:

To determine number of users logged in using pipe.

Algorithm:

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

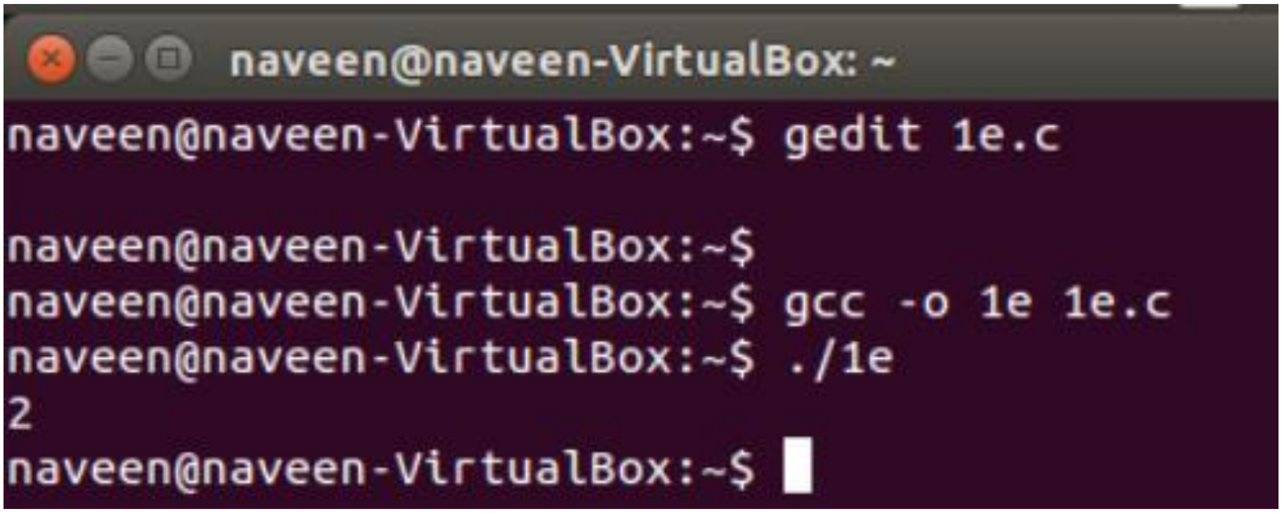
Result:

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

Program:

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

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

int main()

{
    int pfds[2];
    pipe(pfds);

    if (!fork())

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

Output:


naveen@naveen-VirtualBox: ~
naveen@naveen-VirtualBox:~$ gedit 1e.c
naveen@naveen-VirtualBox:~$
naveen@naveen-VirtualBox:~$ gcc -o 1e 1e.c
naveen@naveen-VirtualBox:~$ ./1e
2
naveen@naveen-VirtualBox:~$

LAB# 12
Chat Messaging

Task:

To exchange message between server and client using message queue.

Algorithm:

Server:

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

Client:

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

Result:

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

Program:

Server:

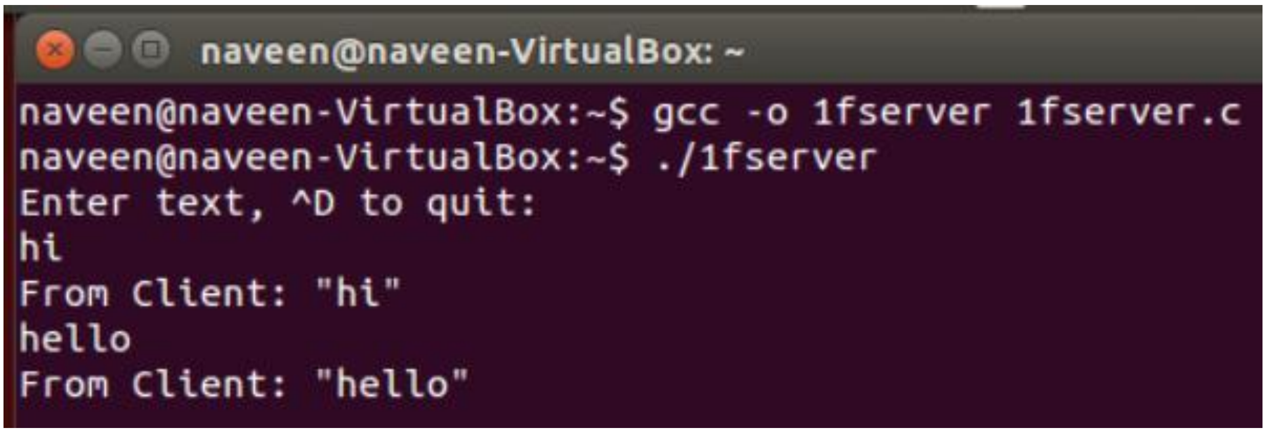
```
/* Server chat process - srvmsg.c */

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

struct mesgq
 {
 long type; char
text[200]; } mq;
 main()
{
      int msqid, len;
      key_t key = 2013;
 if((msqid = msgget(key, 0644|IPC_CREAT)) == -1) {
           perror("msgget");
           exit(1); }
 printf("Enter text, ^D to
      quit:\n"); mq.type = 1;
 while(fgets(mq.text, sizeof(mq.text), stdin) != NULL)
 {
           len = strlen(mq.text);
           if (mq.text[len-1] == '\n')
           mq.text[len-1] = '\0';
           msgsnd(msqid, &mq, len+1, 0);
          msgrcv(msqid, &mq, sizeof(mq.text), 0, 0);
          printf("From Client: \"%s\"\n", mq.text); }
          msgctl(msqid, IPC_RMID, NULL); }
```

Client:

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

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

struct mesgq
 {
     long type;
     char
     text[200]; } mq;
 main()
 {
     int msqid, len;
     key_t key = 2013;
 if ((msqid = msgget(key, 0644)) == -1)
     {
          printf("Server not
          active\n"); exit(1);
     }
 printf("Client ready :\n");
         while (msgrcv(msqid, &mq, sizeof(mq.text), 0, 0) != -1) {
          printf("From Server: \"%s\"\n", mq.text);
         fgets(mq.text, sizeof(mq.text), stdin); len = strlen(mq.text);
         if (mq.text[len-1] == '\n')
          mq.text[len-1] = '\0';
          msgsnd(msqid, &mq, len+1, 0);
     }
printf("Server Disconnected\n"); }
```

Output:

Server:



Client:

LAB# 13
Shared Memory

Task:

To demonstrate communication between process using shared memory.

Algorithm

Server

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

Client:

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

Result:

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

Program:

Server:

```
/* Shared memory server - shms.c */

#include <stdio.h>
#include <stdlib.h>
#include <sys/un.h>
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>
 #define shmsize 27

main() {
      char c;
 int shmid; key_t key = 2013;
      char *shm, *s;
 if ((shmid = shmget(key, shmsize, IPC_CREAT|0666)) < 0) {
           perror("shmget"); exit(1); }
      printf("Shared memory id : %d\n", shmid);
          if ((shm = shmat(shmid, NULL, 0)) == (char *) -1) {
           perror("shmat");
           exit(1); }
          memset(shm, 0, shmsize); s = shm;
          printf("Writing (a-z) onto shared memory\n");
for (c = 'a'; c <= 'z'; c++)
           *s++ = c; *s = '\0';
 while (*shm != '*');
          printf("Client finished reading\n");
          if(shmdt(shm) != 0)
     fprintf(stderr, "Could not close memory
    segment.\n"); shmctl(shmid, IPC_RMID, 0); }
```

Client:

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

#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>
#define shmsize 27

main() {
      int shmid; key_t key =
      2013;
      char *shm, *s;
 if ((shmid = shmget(key, shmsize, 0666)) < 0)
    {
           printf("Server not started\n");
            exit(1);
      }
  else printf("Accessing shared memory id : %d\n",shmid); if
          ((shm = shmat(shmid, NULL, 0)) == (char *) -1)
           {
           perror("shmat");
            exit(1);
           }
      printf("Shared memory contents:\n");
      for (s = shm; *s != '\0'; s++)
      putchar(*s); putchar('\n');

      *shm = '*';
   }
```

Output:

Server:

```
rida@ubuntu: ~
rida@ubuntu:~$ gedit 1h.c
rida@ubuntu:~$ gcc -o 1h 1h.c
rida@ubuntu:~$ ./1h
Shared memory id : 3899411
Writing (a-z) onto shared memory
```

Client:

```
rida@ubuntu: ~
rida@ubuntu:~$ gcc -o 1i 1i.c
rida@ubuntu:~$ ./1i
Accessing shared memory id : 3899411
Shared memory contents:
abcdefghijklmnopqrstuvwxyz
rida@ubuntu:~$
```

LAB# 14
Producer-Consumer Problem

Task:

To synchronize producer and consumer processes using semaphore.

Algorithm:

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

Result:

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

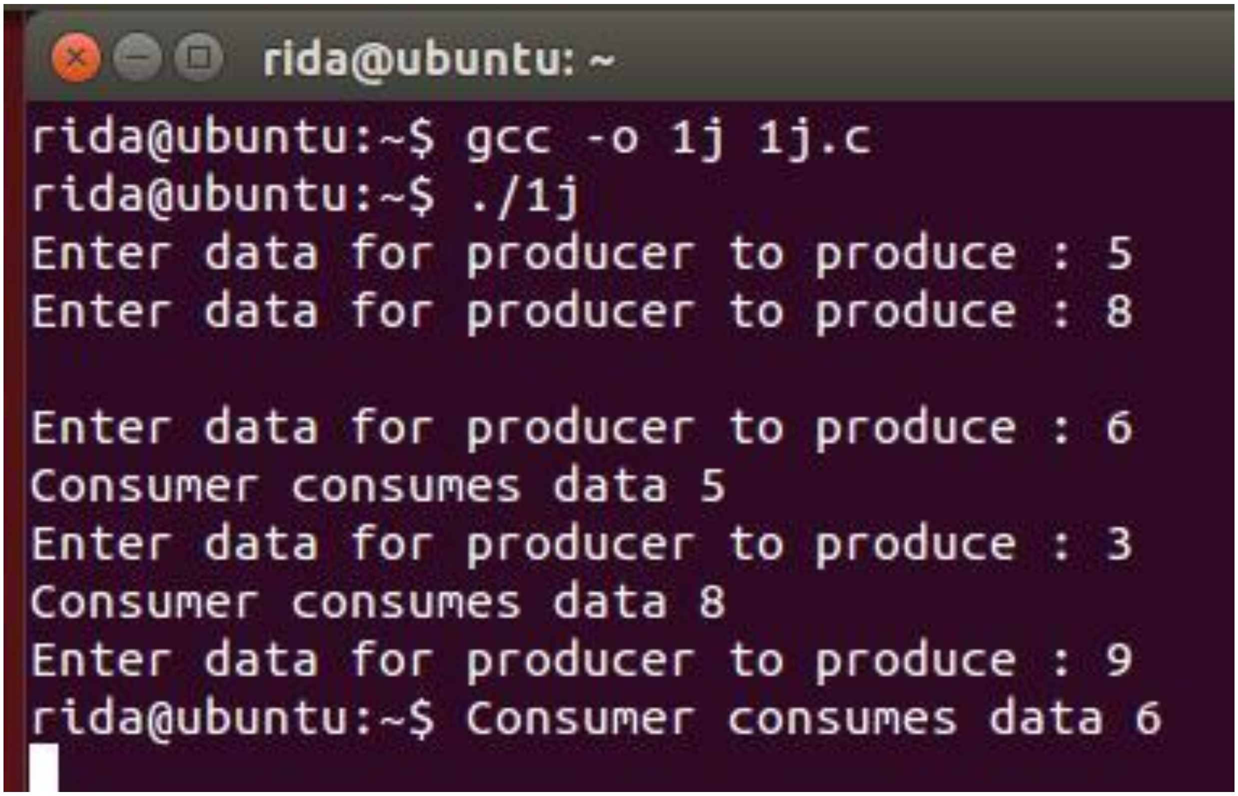
Program:

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

#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>
#include <sys/sem.h>
#define N 5
#define BUFSIZE 1
#define PERMS 0666

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

/* semaphore variables */

void producer() {
    int data;
    if(nextp == N)
    nextp = 0;
printf("Enter data for producer to produce : ");
    scanf("%d",(buffer + nextp));
nextp++; }
void consumer() {
    int g;
if(nextc == N)
nextc = 0;
    g = *(buffer + nextc++);
printf("\nConsumer consumes data %d", g); }
void sem_op(int id, int value) {
    struct sembuf op;
```

```
int v; op.sem_num = 0;
 op.sem_op = value;
 op.sem_flg = SEM_UNDO;
 if((v = semop(id, &op, 1)) < 0)
printf("\nError executing semop instruction"); }
void sem_create(int semid, int initval) {
      int semval;
      union semun {
            int val; struct semid_ds *buf;
           unsigned short *array; } s;
           s.val = initval;
 if((semval = semctl(semid, 0, SETVAL, s)) <0)
printf("\nError in executing semctl"); } void
sem_wait(int id) {
      int value = -1;
 sem_op(id, value);
}
void sem_signal(int id)
{
      int value = 1;
 sem_op(id, value);
}
main()
{
      int shmid, i;
      pid_t pid;
 if((shmid = shmget(1000, BUFSIZE, IPC_CREAT|PERMS)) < 0)
      {
            printf("\nUnable to create shared
            memory"); return;
      }
      if((buffer = (int*)shmat(shmid, (char*)0, 0)) == (int*)-1)
      {
            printf("\nShared memory allocation
               error\n"); exit(1);
      }
```

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

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

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


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

Output:



```
rida@ubuntu: ~
rida@ubuntu:~$ gcc -o 1j 1j.c
rida@ubuntu:~$ ./1j
Enter data for producer to produce : 5
Enter data for producer to produce : 8

Enter data for producer to produce : 6
Consumer consumes data 5
Enter data for producer to produce : 3
Consumer consumes data 8
Enter data for producer to produce : 9
rida@ubuntu:~$ Consumer consumes data 6
```

Memory Management

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

First fit:

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

Best fit:

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

Worst fit:

Allocate the largest hole.
The list of free holes is kept sorted according to size in descending order.
This strategy produces the largest leftover hole.
The widely used page replacement algorithms are FIFO and LRU.

FIFO:

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

LRU:

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

LAB# 15
First Fit Allocation

Task:

To allocate memory requirements for processes using first fit allocation.

Algorithm:

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

Result:

Thus processes were allocated memory using first fit method.

Program:

```
/* First fit allocation - ffit.c */

#include <stdio.h>

struct process

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

main()

{
      int i, np, nh, j;

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

      printf("\nEnter number of process : "
      ); scanf("%d",&np);
      for(i=0;i<np;i++)
      {
```

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

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

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

    printf("\n\nHole\tActual\tAvailable"); for(i=0;
    i<nh ;i++)

        printf("\nH%d\t%d\t%d", i, h[i].actual,
h[i].size); printf("\n");
}
```

Output:

```
rida@ubuntu: ~
rida@ubuntu:~$ gcc -o 1k 1k.c
rida@ubuntu:~$ ./1k
Enter the number of Holes : 5
Enter size for hole H0 : 100
Enter size for hole H1 : 500
Enter size for hole H2 : 200
Enter size for hole H3 : 300
Enter size for hole H4 : 600

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

        First fit

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

Hole    Actual  Available
H0      100     100
H1      500     176
H2      200     200
H3      300     300
H4      600     183
rida@ubuntu:~$
```

LAB# 16
Best Fit Allocation

Task:

To allocate memory requirements for processes using best fit allocation.

Algorithm:

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

Result:

Thus processes were allocated memory using best fit method.

Program:

```
/* Best fit allocation - bfit.c */

#include <stdio.h>
 struct process
 {
      int size; int flag;
 int holeid; } p[10];
struct hole
{
int hid; int size;
 int actual;
} h[10];
main()
{
 int i, np, nh, j; void bsort(struct hole[], int);
      printf("Enter the number of Holes : ");
       scanf("%d", &nh);
      for(i=0; i<nh; i++)
 {
printf("Enter size for hole H%d :
",i); scanf("%d", &h[i].size); h[i].actual = h[i].size;
             h[i].hid = i;
      }
 printf("\nEnter number of process : " );
 scanf("%d",&np);
      for(i=0;i<np;i++)
     {
           printf("enter the size of process P%d :
           ",i); scanf("%d", &p[i].size); p[i].flag = 0;
      }
 for(i=0; i<np; i++) {
           bsort(h, nh);
           for(j=0; j<nh; j++)
```

```
        {
            if(p[i].flag != 1)
            {
                if(p[i].size <= h[j].size)
                {
                    p[i].flag = 1; p[i].holeid = h[j].hid;
                    h[j].size -= p[i].size;
                }
            }
        }
    }
        printf("\n\tBest fit\n");
        printf("\nProcess\tPSize\tHole");
        for(i=0; i<np; i++) {
            if(p[i].flag != 1)
            printf("\nP%d\t%d\tNot allocated", i,
        p[i].size); else printf("\nP%d\t%d\tH%d", i, p[i].size, p[i].holeid);
    }
 printf("\n\nHole\tActual\tAvailable"); for(i=0; i<nh ;i++)
printf("\nH%d\t%d\t%d", h[i].hid,
h[i].actual, h[i].size); printf("\n");
}
 void bsort(struct hole bh[], int n) {
    struct hole temp; int i,j;
    for(i=0; i<n-1; i++)
    {
        for(j=i+1; j<n; j++)
        {
            if(bh[i].size > bh[j].size)
            {
                temp = bh[i]; bh[i] = bh[j];
                bh[j] = temp;
            }
        }
    }
}
```

Output:

```
rida@ubuntu: ~
rida@ubuntu:~$ gcc -o 1l 1l.c
rida@ubuntu:~$ ./1l
Enter the number of Holes : 5
Enter size for hole H0 : 100
Enter size for hole H1 : 500
Enter size for hole H2 : 200
Enter size for hole H3 : 300
Enter size for hole H4 : 600

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

        Best fit

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

Hole    Actual  Available
H1      500     83
H3      300     88
H2      200     88
H0      100     100
H4      600     174
rida@ubuntu:~$
```

LAB# 17
FIFO Page Replacement

Task:

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

Algorithm:

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

Result:

Thus page replacement was implemented using FIFO algorithm.

Program:

```
/* FIFO page replacement - fifopr.c */

#include <stdio.h>
 main()
 {
      int i,j,l,rs[50],frame[10],nf,k,avail,count=0;
      printf("Enter length of ref. string : ");
      scanf("%d", &l);

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

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

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

Output:

```
rida@ubuntu: ~
rida@ubuntu:~$ ./1m
Enter length of ref. string : 20
Enter reference string :
1 2 3 4 5 4 3 2 1 6 7 8 9 6 7 8 9 4 3 2
Enter number of frames : 5

Ref. str Page frames
   1        1  -1  -1  -1  -1
   2        1   2  -1  -1  -1
   3        1   2   3  -1  -1
   4        1   2   3   4  -1
   5        1   2   3   4   5
   4
   3
   2
   1
   6        6   2   3   4   5
   7        6   7   3   4   5
   8        6   7   8   4   5
   9        6   7   8   9   5
   6
   7
   8
   9
   4        6   7   8   9   4
   3        3   7   8   9   4
   2        3   2   8   9   4

Total no. of page faults : 12
rida@ubuntu:~$
```

LAB# 18
LRU (Least Recently Used) Page Replacement

Task:

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

Algorithm:

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

Result:

Thus page replacement was implemented using LRU algorithm.

Program:

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

#include <stdio.h>

int arrmin(int[], int);
 main()

{
      int i,j,len,rs[50],frame[10],nf,k,avail,count=0; int
      access[10], freq=0, dm;
         printf("Length of Reference string :
 "); scanf("%d", &len);

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

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

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

```
        {
            dm = 0;
            for(k=0; k<nf; k++)
            {
                if(frame[k] == 1) dm = 1;
                    break;
            }
            if(dm == 1)

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

int arrmin(int a[], int n)

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

Output:

```
rida@ubuntu: ~
rida@ubuntu:~$ gcc -o 1n 1n.c
rida@ubuntu:~$ ./1n
Length of Reference string :10
Enter reference string :
1 2 3 4 5 6 5 4 3 2
Enter no. of frames :3

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

Total no. of page faults : 9
rida@ubuntu:~$
```

File Allocation

The three methods of allocating disk space are:

a. Contiguous allocation
b. Linked allocation
c. Indexed allocation

Contiguous Allocation:

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

Linked Allocation:

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

Indexed Allocation:

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

LAB# 19
Contiguous Allocation

Task:

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

Algorithm:

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

Result:

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

Program:

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

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

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

void directory()

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

void display()

{
 int i;
      for(i=0; i<20; i++)
      printf("%4d",i); printf("\n");
      for(i=0; i<20; i++)
              printf("%4s", a[i]);
}
 main()
 {
      int i,n,k,temp,st,nb,ch,flag;
      char id[4];

      for(i=0; i<20; i++) strcpy(a[i], "");
      printf("Disk space before allocation:\n"); display();
```

```
    do
  {
        printf("\nEnter File name (max 3 char) :
"); scanf("%s", id); printf("Enter start block :
        "); scanf("%d", &st); printf("Enter no. of blocks
        :
        "); scanf("%d", &nb);
       strcpy(fid[num], id);
       length[num] = nb; flag=0;
       if((st+nb) > 20)
        {
           printf("Requirement exceeds
             range\n"); continue;
        }
       for(i=st; i<(st+nb); i++) if(strcmp(a[i], "") != 0)

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

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

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

Output:

```
rida@ubuntu:~$ gcc -o 1o 1o.c
rida@ubuntu:~$ ./1o
Disk space before allocation:
   0   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19

Enter File name (max 3 char) :  rnk
Enter start block : 4
Enter no. of blocks : 3
Allocation done

Any more allocation (1. yes / 2. no)? : 1

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

```
Enter File name (max 3 char) :  rda
Enter start block : 12
Enter no. of blocks : 3
Allocation done

Any more allocation (1. yes / 2. no)? : 1

Enter File name (max 3 char) :  zee
Enter start block : 4
Enter no. of blocks : 7
Contiguous allocation not possible.

Enter File name (max 3 char) :  mdy
Enter start block : 0
Enter no. of blocks : 2
Allocation done

Any more allocation (1. yes / 2. no)? : 2

                        Contiguous Allocation
Directory:
File Start Length
rnk    4      3
rda   12      3
mdy    0      2

Disk space after allocation:
   0   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19
 mdy mdy         rnk rnk rnk                         rda rda rda
rida@ubuntu:~$
```