**Q5a) Implement menu-driven program for page replacement using MFU and LFU. Consider the total number of references made by CPU are 16. Take page reference string and number of page frames as run time input. Compute and display number of page faults, hit ratio and miss ratio. Use stack data structure to record most recent page references. Assume initially all 3 page frames are empty. Display stack content and number of page faults.**

**A5a)**
**Handwritten file:**

Q5a)

• Aim: To implement menu-driven program for page replacement using MFU and LFU algorithms.

• Required details:
1) Stack content
2) Page faults
3) Hit ratio
4) Miss ratio.

• Algorithms:

MFU:

BEGIN

1) Input the number of pages in the reference string.
2) Input the number of page frames.
3) Input the reference string.
4) Look out the ~~pos~~ location of the page on the memory disk.
5) Look for a free frame if free frame is available, use it..
6) Read the particular page into newly allocated free frame, change the frame and page tables accordingly.
7) Repeat the ~~whole~~ user process.

END.

LFU:

BEGIN

1) Input the no. of pages in reference string
2) Input the no. of page frames
3) Input the reference string.
4) Check the old page as well as frequency of that page.
5) If frequency of page is larger than the old page ⇒ we cannot remove it.
6) If all old are having same frequency, then take FIFO method and remove that page.
7) Display Page Faults, hit ratio, miss ratio.

END.



**Code:**

```
#include<stdio.h>
#include<stdlib.h>
int lfu();
int mfu()
{
   int hit=0,miss=0,i,j,noPages,noFrames,min;
   int frames[10],pages[20];
   int flag=0,flag1=0,flag2=0;
   int flagFound=0;
   int count=0;
   int frameAge[50],frameFREQ[50];
   printf("enter number of frames\n");
   scanf("%d",&noFrames);
   printf("enter number of pages\n");
   scanf("%d",&noPages);
   printf("enter the page string ");

   for(i=0;i<noPages;i++)
   {
      scanf("%d",&pages[i]);
   }
   for(i=0;i<noFrames;i++)
   {
      frames[i]=-1;
```

```
        frameAge[i]=-1;
    }
    for(j=0;j<noFrames;j++)
      frameFREQ[j]=0;
    for(j=0;j<noPages;j++)
    {
        int index;
        printf(" page:%d   ",pages[j] );
        flagFound=0,flag=0,flag2=0;
        for(i=0;i<noFrames;i++)
        {
            if(frames[i]==pages[j])
            {
                flagFound=1;
                flag=1;
                index=i;
                printf("hit ");
                hit++;
                break;
            }
        }
        if(flagFound==0)          //if frame not found and empty frame avalible
        {
            for(i=0;i<noFrames;i++)
            {
                if(frames[i]==-1)
                {
                    frames[i]=pages[j];
                    flag=1;
                    count++;
                    frameAge[i]=count;
                    miss++;
                    frameFREQ[i]=1;
                    printf("miss ");
                    break;
                }
            }
            if(flag==0)
            {
                int bestmfu=0;
                for(i=0;i<noFrames;i++)
                {
                    if(frameFREQ[i]>frameFREQ[bestmfu])
                        bestmfu=i;
                }
                frames[bestmfu]=pages[j];
                miss++;
```

```
                printf("miss ");
                frameFREQ[bestmfu]=1;
            }
        }  //FLAG FOUND ends
        else
        {
            frameFREQ[index]++;
        }
        for(i=0;i<noFrames;i++)
        {
            printf("   %d ",frames[i]);
        }
        printf("\n");
    }
    //printf("number of hits %d\n",hit);
    //printf("number of miss %d\n",miss);
    float faults;
    faults=noPages-hit;
    printf("\n\nPage Faults:\t%d\n",faults);
    printf("Page Hit:\t%d\n",hit);
    //printf("Page Miss:\t%d\n",miss);
    float hitratio;
    float hitt=hit;
    float pagess=noPages;
    hitratio=hitt/pagess;
    printf("Hit Ratio:\t%.2f\n",hitratio);
    float missratio;
    missratio=1-hitratio;
    printf("Miss Ratio:\t%.2f\n\n\n",missratio);
}
int lfu()
{
    int total_frames, total_pages, hit = 0;
    int pages[25], frame[10], arr[25], time[25];
    int m, n, page, flag, k, minimum_time, temp;
    printf("Enter Total Number of Pages: ");
    scanf("%d", &total_pages);
    printf("Enter Total Number of Frames: ");
    scanf("%d", &total_frames);
    for(m = 0; m < total_frames; m++)
    {
        frame[m] = -1;
    }
    for(m = 0; m < 25; m++)
    {
        arr[m] = 0;
    }
```

```
        printf("Enter Values of Reference String\n");
        for(m = 0; m < total_pages; m++)
        {
            printf("Enter Value No.[%d]:\t", m + 1);
            scanf("%d", &pages[m]);
        }
        printf("\n");
        for(m = 0; m < total_pages; m++)
        {
            arr[pages[m]]++;
            time[pages[m]] = m;
            flag = 1;
            k = frame[0];
            for(n = 0; n < total_frames; n++)
            {
                if(frame[n] == -1 || frame[n] == pages[m])
                {
                    if(frame[n] != -1)
                    {
                        hit++;
                    }
                    flag = 0;
                    frame[n] = pages[m];
                    break;
                }
                if(arr[k] > arr[frame[n]])
                {
                    k = frame[n];
                }
            }
            if(flag)
            {
                minimum_time = 25;
                for(n = 0; n < total_frames; n++)
                {
                    if(arr[frame[n]] == arr[k] && time[frame[n]] < minimum_time)
                    {
                        temp = n;
                        minimum_time = time[frame[n]];
                    }
                }
                arr[frame[temp]] = 0;
                frame[temp] = pages[m];
            }
            for(n = 0; n < total_frames; n++)
            {
                printf("%d\t", frame[n]);
```

```
            }
            printf("\n");
        }
        float faults;
        faults=total_pages-hit;
        printf("\n\nPage Faults:\t%d\n",faults);
        printf("Page Hit:\t%d\n",hit);
        float hitratio;
        float hitt=hit;
        float pagess=total_pages;
        hitratio=hitt/pagess;
        printf("Hit Ratio:\t%.2f\n",hitratio);
        float missratio;
        missratio=1-hitratio;
        printf("Miss Ratio:\t%.2f\n\n\n",missratio);
        return 0;
    }
    int main()
    {
            int ch;
            do{
                    printf("1.LFU\n2.MFU\n3.Exit\n");
                    //printf("for mfu press '2'\n");
                    printf("Enter your choice: ");
                    scanf("%d",&ch);
                    switch(ch)
                    {
                            case 1:
                                    lfu();
                        break;
                            case 2:
                                    mfu();
                        break;
                     case 3:
                        exit(0);
                        break;
                            default:
                                    printf("invalid choice");
                        break;
                        }
            }while(1);
    }
```

**Output(screenshots):**

**MFU:**

```
"C:\Users\Vibhu\Desktop\OS LABFAT\LFU & MFU.exe"
1.LFU
2.MFU
3.Exit
Enter your choice: 2
enter number of frames
3
enter number of pages
16
enter the page string 7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 1
 page:7   miss    7    -1    -1
 page:0   miss    7    0    -1
 page:1   miss    7    0    1
 page:2   miss    2    0    1
 page:0   hit    2    0    1
 page:3   miss    2    3    1
 page:0   miss    0    3    1
 page:4   miss    4    3    1
 page:2   miss    2    3    1
 page:3   hit    2    3    1
 page:0   miss    2    0    1
 page:3   miss    3    0    1
 page:2   miss    2    0    1
 page:1   hit    2    0    1
 page:2   hit    2    0    1
 page:1   hit    2    0    1


Page Faults:    0
Page Hit:       5
Hit Ratio:      0.31
Miss Ratio:     0.69
```

## LFU:

```
"C:\Users\Vibhu\Desktop\OS LABFAT\LFU & MFU.exe"
1.LFU
2.MFU
3.Exit
Enter your choice: 1
Enter Total Number of Pages: 16
Enter Total Number of Frames: 3
Enter Values of Reference String
Enter Value No.[1]:     7
Enter Value No.[2]:     0
Enter Value No.[3]:     1
Enter Value No.[4]:     2
Enter Value No.[5]:     0
Enter Value No.[6]:     3
Enter Value No.[7]:     0
Enter Value No.[8]:     4
Enter Value No.[9]:     2
Enter Value No.[10]:    3
Enter Value No.[11]:    0
Enter Value No.[12]:    3
Enter Value No.[13]:    2
Enter Value No.[14]:    1
Enter Value No.[15]:    2
Enter Value No.[16]:    1

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


Page Faults:    0
Page Hit:       7
Hit Ratio:      0.44
Miss Ratio:     0.56
```

**Q5b) Write a program to implement the following scenario using Bankers algorithm : Determine if a deadlock situation exists for the following description of a resource allocation graph, let the set of processes be P = { P1, P2, P3, P4}; let the set of resource types be: R = { R1, R2, R3, R4, R5, R6}; Here, R1 has two instance of resource type, R2 has one instance of resource type,R3 has two instance of resource type, R4 has two instance of resource type, R5 has one instance of resource type, and R6 has two instance of resource type; let the set of request and assignment edges be: E= { R1->P3, R1->P1, R2->P2, R3->P3,P1->R2, P1->R4, P4->R6, R4->P4, P3->R2, R5->P3, P2->R5,R4->P2, R6->P3 }**

**A5b)**
**Handwritten file:**

Q5b)

- Aim: To perform Bankers Algorithm with/without additional resource request for a resource allocation graph.

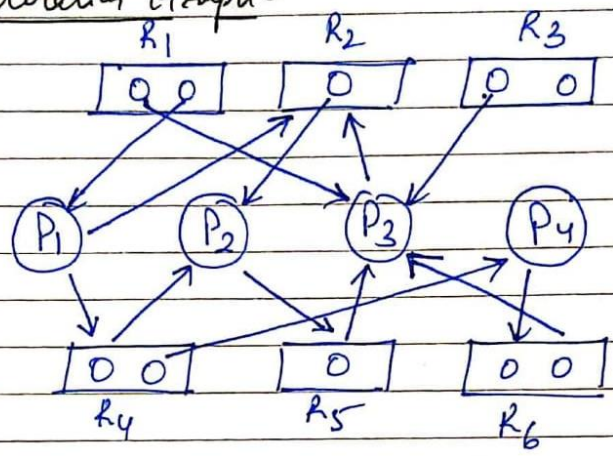
- Algorithm:

BANKER'S ALGORITHM:

1) Let work and Finish be vectors of length 'm' and 'n' respectively:
   initialize: work = Available
   Finish[i] = false; for i=1,2,3.....n
2) Find an i such that both
   a) Finish[i] = false
   b) $Need_i <= work$
   if no such i exist go to step(4).
3) work = work + Allocation[i]
   finish[i] = true
   goto step (2)
4) If finish[i] = true for all i
   then the system is in a safe state.

END

• Resource Allocation Graph:




| Process | Allocation (1 2 3 4 5 6) | Max (1 2 3 4 5 6) | Need | Available |
|---|---|---|---|---|
| $P_1$ | 1 0 0 0 0 0 | 1 1 0 1 0 0 | 0 1 0 1 0 0 | 0 0 1 0 0 1 |
| $P_2$ | 0 1 0 1 0 0 | 0 1 0 1 1 0 | 0 0 0 0 1 0 | |
| $P_3$ | 1 0 1 0 1 1 | 1 1 1 0 1 1 | 0 1 0 0 0 0 | |
| $P_4$ | 0 0 0 1 0 0 | 0 0 0 1 0 1 | 0 0 0 0 0 1 | |
| | 2 1 1 2 1 1 | | | |



**Code:**

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

void print(int x[][10],int n,int m){
        int i,j;
        for(i=0;i<n;i++){
                printf("\n");
                for(j=0;j<m;j++){
                        printf("%d\t",x[i][j]);
                }
        }
}

//Resource Request algorithm
void res_request(int A[10][10],int N[10][10],int AV[10][10],int pid,int m)
{
        int reqmat[1][10];
        int i;
        printf("\n Enter additional request :- \n");
        for(i=0;i<m;i++){
                printf(" Request for resource %d : ",i+1);
                scanf("%d",&reqmat[0][i]);
        }
```

```
        for(i=0;i<m;i++)
                if(reqmat[0][i] > N[pid][i]){
                        printf("\n Error encountered.\n");
                        exit(0);
        }

        for(i=0;i<m;i++)
                if(reqmat[0][i] > AV[0][i]){
                        printf("\n Resources unavailable.\n");
                        exit(0);
                }

        for(i=0;i<m;i++){
                AV[0][i]-=reqmat[0][i];
                A[pid][i]+=reqmat[0][i];
                N[pid][i]-=reqmat[0][i];
        }
}

//Safety algorithm
int safety(int A[][10],int N[][10],int AV[1][10],int n,int m,int a[]){

        int i,j,k,x=0;
        int F[10],W[1][10];
        int pflag=0,flag=0;
        for(i=0;i<n;i++)
                F[i]=0;
        for(i=0;i<m;i++)
                W[0][i]=AV[0][i];

        for(k=0;k<n;k++){
                for(i=0;i<n;i++){
                        if(F[i] == 0){
                                flag=0;
                                for(j=0;j<m;j++){
                                        if(N[i][j] > W[0][j])
                                                flag=1;
                                }
                                if(flag == 0 && F[i] == 0){
                                        for(j=0;j<m;j++)
                                                W[0][j]+=A[i][j];
                                        F[i]=1;
                                        pflag++;
                                        a[x++]=i;
                                }
                        }
                }
```

```
		if(pflag == n)
			return 1;
	}
	return 0;
}


//Banker's Algorithm
void accept(int A[][10],int N[][10],int M[10][10],int W[1][10],int *n,int *m){
	int i,j;
	printf("\n Enter total no. of processes : ");
	scanf("%d",n);
	printf("\n Enter total no. of resources : ");
	scanf("%d",m);
	for(i=0;i<*n;i++){
		printf("\n Process %d\n",i+1);
		for(j=0;j<*m;j++){
			printf(" Allocation for resource %d : ",j+1);
			scanf("%d",&A[i][j]);
			printf(" Maximum for resource %d : ",j+1);
			scanf("%d",&M[i][j]);
		}
	}
	printf("\n Available resources : \n");
	for(i=0;i<*m;i++){
		printf(" Resource %d : ",i+1);
		scanf("%d",&W[0][i]);
	}

	for(i=0;i<*n;i++)
		for(j=0;j<*m;j++)
			N[i][j]=M[i][j]-A[i][j];

	printf("\n Allocation Matrix");
	print(A,*n,*m);
	printf("\n Maximum Requirement Matrix");
	print(M,*n,*m);
	printf("\n Need Matrix");
	print(N,*n,*m);

}

int banker(int A[][10],int N[][10],int W[1][10],int n,int m){
	int j,i,a[10];
	j=safety(A,N,W,n,m,a);
	if(j != 0 ){
		printf("\n\n");
```

```
                for(i=0;i<n;i++)
                    printf(" P%d  ",a[i]);
                printf("\n A safety sequence has been detected.\n");
                return 1;
        }else{
                printf("\n Deadlock has occured.\n");
                return 0;
        }
}


int main(){
        int ret;
        int A[10][10];
        int M[10][10];
        int N[10][10];
        int W[1][10];
        int n,m,pid,ch;
        printf("\n DEADLOCK AVOIDANCE USING BANKER'S ALGORITHM\n");
        accept(A,N,M,W,&n,&m);
        ret=banker(A,N,W,n,m);
        if(ret !=0 ){
                printf("\n Do you want make an additional request ? (1=Yes|0=No)");
                scanf("%d",&ch);
                if(ch == 1){
                        printf("\n Enter process no. : ");
                        scanf("%d",&pid);
                        res_request(A,N,W,pid-1,m);
                        ret=banker(A,N,W,n,m);
                        if(ret == 0 )
                                exit(0);
                }
        }else
                exit(0);
        return 0;
}
```

# Output(screenshots):

```
"C:\Users\Vibhu\Desktop\Fall Semester 20-21\OS\OS LABCAT\Bankers Algotithm\Bankers Algorithm(with resource request).exe"

DEADLOCK AVOIDANCE USING BANKER'S ALGORITHM

Enter total no. of processes : 4

Enter total no. of resources : 6

Process 1
Allocation for resource 1 : 1
Maximum for resource 1 : 1
Allocation for resource 2 : 0
Maximum for resource 2 : 1
Allocation for resource 3 : 0
Maximum for resource 3 : 0
Allocation for resource 4 : 0
Maximum for resource 4 : 1
Allocation for resource 5 : 0
Maximum for resource 5 : 0
Allocation for resource 6 : 0
Maximum for resource 6 : 0

Process 2
Allocation for resource 1 : 0
Maximum for resource 1 : 0
Allocation for resource 2 : 1
Maximum for resource 2 : 1
Allocation for resource 3 : 0
Maximum for resource 3 : 0
Allocation for resource 4 : 1
Maximum for resource 4 : 1
Allocation for resource 5 : 0
Maximum for resource 5 : 1
Allocation for resource 6 : 0
Maximum for resource 6 : 0

Process 3
Allocation for resource 1 : 1
Maximum for resource 1 : 1
Allocation for resource 2 : 0
Maximum for resource 2 : 1
Allocation for resource 3 : 1
Maximum for resource 3 : 1
Allocation for resource 4 : 0
Maximum for resource 4 : 0
Allocation for resource 5 : 1
Maximum for resource 5 : 1
Allocation for resource 6 : 1
Maximum for resource 6 : 1
```

```
"C:\Users\Vibhu\Desktop\Fall Semester 20-21\OS\OS LABCAT\Bankers Algotithm\Bankers Algorithm(with resource request).exe"

 Process 4
 Allocation for resource 1 : 0
 Maximum for resource 1 : 0
 Allocation for resource 2 : 0
 Maximum for resource 2 : 0
 Allocation for resource 3 : 0
 Maximum for resource 3 : 0
 Allocation for resource 4 : 1
 Maximum for resource 4 : 1
 Allocation for resource 5 : 0
 Maximum for resource 5 : 0
 Allocation for resource 6 : 0
 Maximum for resource 6 : 1

 Available resources :
 Resource 1 : 0
 Resource 2 : 0
 Resource 3 : 1
 Resource 4 : 0
 Resource 5 : 0
 Resource 6 : 1

 Allocation Matrix
1       0       0       0       0       0
0       1       0       1       0       0
1       0       1       0       1       1
0       0       0       1       0       0
 Maximum Requirement Matrix
1       1       0       1       0       0
0       1       0       1       1       0
1       1       1       0       1       1
0       0       0       1       0       1
 Need Matrix
0       1       0       1       0       0
0       0       0       0       1       0
0       1       0       0       0       0
0       0       0       0       0       1
 Deadlock has occured.
```

**INFERENCE: Deadlock will occur and there is no safety sequence detected.**