Smt. Chandibai Himathmal Mansukhani College

Contents

Smt. Chandibai Himathmal Mansukhani College

USCSP301 – USCS303: Operating System (OS) Practical – 09
Practical – 09: Page Replacement Algorithm Least Recently Used (LRU)

Practical Date: 30th August 2021
Practical Aim: Page Replacement Algorithm (LRU)

- **Algorithm**

  - ✓ **Page Replacement Algorithm**
    - ✦ In demand paging memory management technique, if a page demanded for execution is present in main memory, then a page fault occurs.
    - ✦ To load the page in demand into main memory, a free page frame is searched in main memory and allocated.
    - ✦ If no page frame is free, memory manager has to free a frame by swapping its contents to secondary storage and thus make room for the required page.
    - ✦ To swap pages, many schemes or strategies are used.

  - ✓ **Least Recently Used (LRU) Algorithm**
    - ✦ The **Least Recently Used (LRU) algorithm** replaces the page that has not been used for the longest period of time.
    - ✦ It is based on the observation that pages that have not been used for long time will probably remain unused for the longest time and are to be replaced.

- **Solved Example**

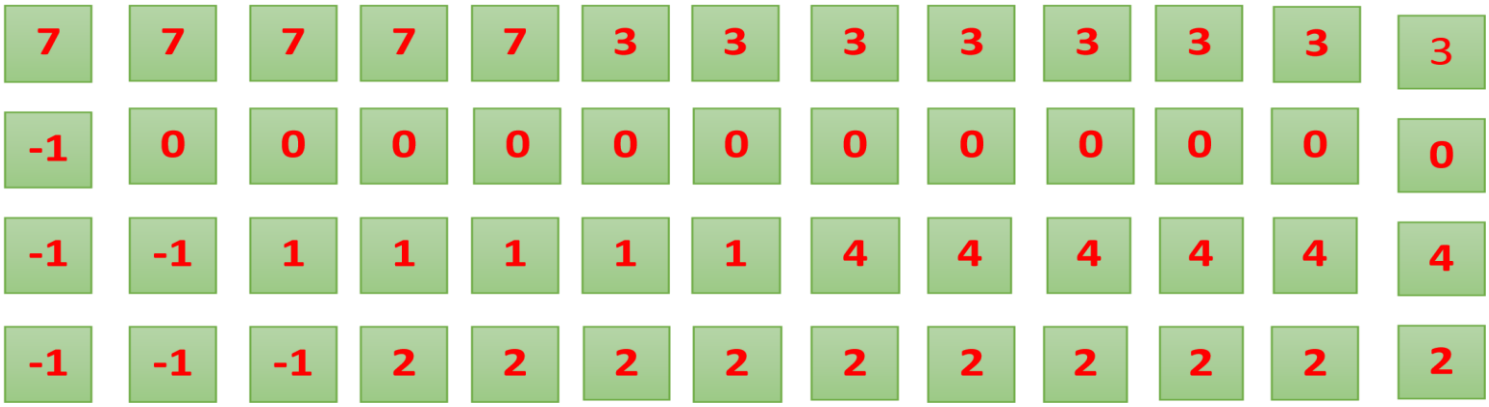
  - ✦ **Example – 01**
    - ◆ Apply the LRU replacement algorithms for the following page-reference strings: 7,0,1,2,0,3,0,4,2,3,0,3,2
    - ◆ Indicate the number of page faults for LRU algorithm assuming demand paging with four frames.
    - ◆ Find the number of hits, number of faults and hit ratio

Smt. Chandibai Himathmal Mansukhani College

Solution

Page Reference String: 7,0,1,2,0,3,0,4,2,3,0,3,2

Demand Paging or Number of Frames: 4



7	0	1	2	0	3	0	4	2	3	0	3	2
✘	✘	✘	✘	✔	✘	✔	✘	✔	✔	✔	✔	✔

Number of Hits: Count of no replacements = 7 ✔

Number of Faults: Count of replacements = 6 ✘

Hit Ratio: Number of Hits/Len (Ref String) = 7/13 = 0.53

Batch: B1 Name: Yash Anand Parab

Smt. Chandibai Himathmal Mansukhani College

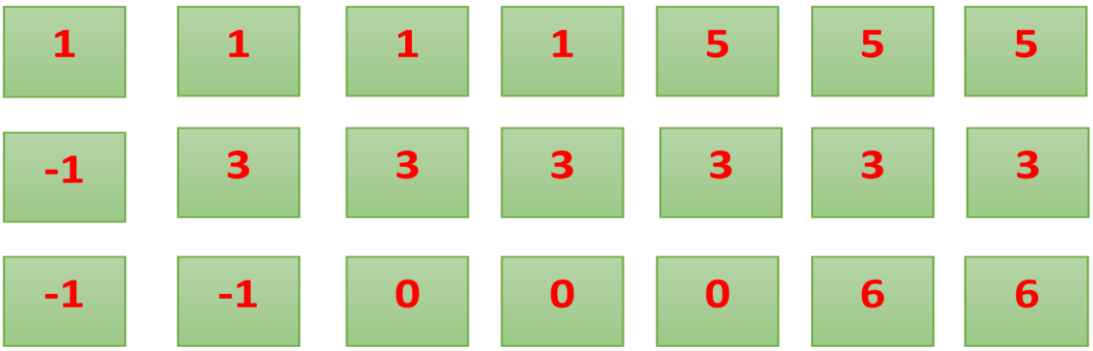
- **Example – 02**

  - Consider the following example 3 frames with 1,3,0,3,5,6,3 page-reference strings.
  - Find the number of hits, number of faults and hit ratio using LRU Page Replacement Algorithm.

Solution:

Page Reference String: 1,3,0,3,5,6,3

Demand Paging or Number of Frames: 3



1	3	0	3	5	6	3
✗	✗	✗	✓	✗	✗	✓

Number of Hits: Count of no replacements = 2 ✓

Number of Faults: Count of replacements = 5 ✗

Hit Ratio: Number of Hits/Len (Ref String) = 2/7= 0.28

Smt. Chandibai Himathmal Mansukhani College

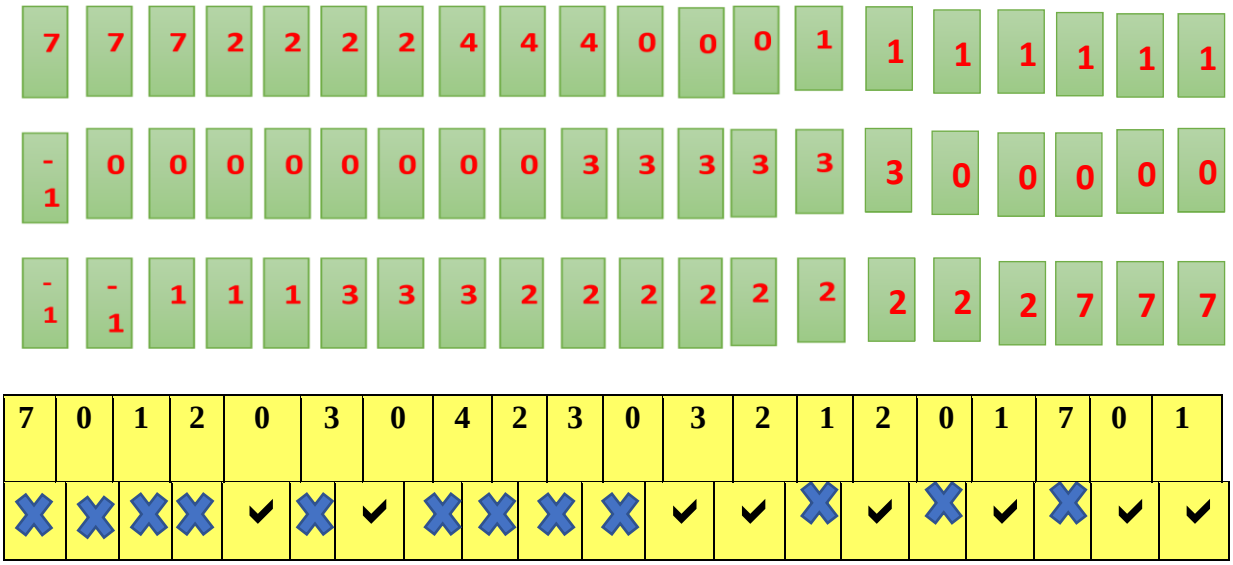
- **Example – 03**

  - Consider the following example 3 frames with 7,0,1,2,0,3,0,4,2,3,0,3,2,1,2,0,1,7,0,1 page-reference strings.
  - Find the number of hits, number of faults and hit ratio using LRU Page Replacement Algorithm.

Solution:

Page Reference String: 7,0,1,2,0,3,0,4,2,3,0,3,2,1,2,0,1,7,0,1

Demand Paging or Number of Frames: 3



Number of Hits: Count of no replacements = 8 ✔

Number of Faults: Count of replacements = 12 ✖

Hit Ratio: Number of Hits/Len (Ref String) = 8/20 = 0.4

- **Question**

  - Write a Java program that implements the LRU page-replacement algorithm.

- **Implementation**

File Name: P9_PR_LRU_YP.java

```
// Name: Yash Parab
// Batch: B1
// PRN: 2020016400922513
// Date: 30 August,2021
// Prac-09: Page Replacement Algorithm LRU

import java.io.*;
import java.util.*;
public class P9_PR_LRU_YP
{
public static void main(String[] args) throws IOException
{
        Scanner scan = new Scanner(System.in);
        int frames,pointer = 0, hit = 0, fault = 0,ref_len;
        Boolean isFull = false;
        int buffer[];
        ArrayList<Integer>stack = new ArrayList<Integer>();
        int reference[];
        int mem_layout[][];
        System.out.print("Please enter the number of Frames: ");
        frames = scan.nextInt();

        System.out.print("Please enter the length of the References strings: ");
        ref_len = scan.nextInt();
        reference = new int[ref_len];
        mem_layout = new int[ref_len][frames];
        buffer = new int[frames];
        for(int j = 0; j < frames; j++)
                buffer[j] = -1;
                System.out.print("Please enter the references strings: ");
                for(int i = 0; i < ref_len; i++)
                {
                        reference[i] = scan.nextInt();
                }
                System.out.println();
                for(int i = 0; i < ref_len; i++)
                {
```

```
if(stack.contains(reference[i]))
{
        stack.remove(stack.indexOf(reference[i]));
}
stack.add(reference[i]);
int search = -1;
for(int j = 0; j < frames; j++)
{
        if(buffer[j] == reference[i])
        {
                search = j;
                hit++;
                break;
        }
}
if(search == -1)
{
        if(isFull)
        {
                int min_loc = ref_len;
                for(int j = 0; j < frames; j++)
                {
                        if(stack.contains(buffer[j]))
                        {
                                int temp = stack.indexOf(buffer[j]);
                                if(temp < min_loc)
                                {
                                        min_loc = temp;
                                        pointer = j;
                                }
                        }
                }
        }
        buffer[pointer] = reference[i];
        fault++;
        pointer++;
        if(pointer == frames)
        {
                pointer = 0;
                isFull = true;
        }
```

```
                }
                for(int j = 0; j < frames; j++)
                        mem_layout[i][j] = buffer[j];
            }
            for(int i = 0; i < frames; i++)
            {
                for(int j = 0; j < ref_len; j++)
                        System.out.printf("%3d",mem_layout[j][i]);
                System.out.println();
            }

            System.out.println("The number of Hits: " + hit);
            System.out.println("Hit Ratio: " +(float)((float)hit/ref_len));
            System.out.println("The number of Faults: " + fault);
        }
}
```

- **Input Of Example – 01**

```
C:\USCSP301_USCSP303_OS_B1\Prac_09_YashParab_30_08_2021>javac P9_PR_LRU_YP.java

C:\USCSP301_USCSP303_OS_B1\Prac_09_YashParab_30_08_2021>java P9_PR_LRU_YP
Please enter the number of Frames: 4
Please enter the length of the References strings: 13
Please enter the references strings: 7 0 1 2 0 3 0 4 2 3 0 3 2
```

- **Output Of Example – 01**

```
  7  7  7  7  7  3  3  3  3  3  3  3  3
 -1  0  0  0  0  0  0  0  0  0  0  0  0
 -1 -1  1  1  1  1  1  4  4  4  4  4  4
 -1 -1 -1  2  2  2  2  2  2  2  2  2  2
The number of Hits: 7
Hit Ratio: 0.53846157
The number of Faults: 6
```

- **Input Of Example – 02**

```
C:\USCSP301_USCSP303_OS_B1\Prac_09_YashParab_30_08_2021>java P9_PR_LRU_YP
Please enter the number of Frames: 3
Please enter the length of the References strings: 7
Please enter the references strings: 1 3 0 3 5 6 3
```

- **Output Of Example – 02**

```
  1  1  1  1  5  5  5
 -1  3  3  3  3  3  3
 -1 -1  0  0  0  6  6
The number of Hits: 2
Hit Ratio: 0.2857143
The number of Faults: 5
```

- **Input Of Example – 03**

```
C:\USCSP301_USCSP303_OS_B1\Prac_09_YashParab_30_08_2021>java P9_PR_LRU_YP
Please enter the number of Frames: 3
Please enter the length of the References strings: 20
Please enter the references strings: 7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1
```

- **Output Of Example – 03**

```
  7  7  7  2  2  2  2  4  4  4  0  0  0  1  1  1  1  1  1  1
 -1  0  0  0  0  0  0  0  0  3  3  3  3  3  3  0  0  0  0  0
 -1 -1  1  1  1  3  3  3  2  2  2  2  2  2  2  2  2  7  7  7
The number of Hits: 8
Hit Ratio: 0.4
The number of Faults: 12
```

- **Sample Output Of Example - 01**

```
C:\USCSP301_USCSP303_OS_B1\Prac_09_YashParab_30_08_2021>javac P9_PR_LRU_YP.java

C:\USCSP301_USCSP303_OS_B1\Prac_09_YashParab_30_08_2021>java P9_PR_LRU_YP
Please enter the number of Frames: 4
Please enter the length of the References strings: 13
Please enter the references strings: 7 0 1 2 0 3 0 4 2 3 0 3 2

  7  7  7  7  7  3  3  3  3  3  3  3  3
 -1  0  0  0  0  0  0  0  0  0  0  0  0
 -1 -1  1  1  1  1  1  4  4  4  4  4  4
 -1 -1 -1  2  2  2  2  2  2  2  2  2  2
The number of Hits: 7
Hit Ratio: 0.53846157
The number of Faults: 6
```

- **Sample Output Of Example – 02**

```
C:\USCSP301_USCSP303_OS_B1\Prac_09_YashParab_30_08_2021>java P9_PR_LRU_YP
Please enter the number of Frames: 3
Please enter the length of the References strings: 7
Please enter the references strings: 1 3 0 3 5 6 3

  1  1  1  1  5  5  5
 -1  3  3  3  3  3  3
 -1 -1  0  0  0  6  6
The number of Hits: 2
Hit Ratio: 0.2857143
The number of Faults: 5
```

- **Sample Output Of Example – 03**

```
C:\USCSP301_USCSP303_OS_B1\Prac_09_YashParab_30_08_2021>java P9_PR_LRU_YP
Please enter the number of Frames: 3
Please enter the length of the References strings: 20
Please enter the references strings: 7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1

  7  7  7  2  2  2  2  4  4  4  0  0  0  1  1  1  1  1  1  1
 -1  0  0  0  0  0  0  0  0  3  3  3  3  3  3  0  0  0  0  0
 -1 -1  1  1  1  3  3  3  2  2  2  2  2  2  2  2  2  7  7  7
The number of Hits: 8
Hit Ratio: 0.4
The number of Faults: 12
```