

CMSC 412 Final Project

Using the reference string from Homework 6:

1	7	5	4	0	1	4	7	3	6	5	0	4	7	3	2	1
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Applying it to the algorithm:

Test Read Input

```

Choose next option:
1
Please enter the reference string.
You can enter in the string as just a row of numbers, or delimited by commas.
1 2 3 4 5 6 7 8 9
Would you like to set the amount of physical frames, by default it is 4.
Continue? ( Y / N ):
y
Enter value:5
0 - Exit
1 - Read Reference String
2 - Generate Reference String
3 - Display current reference string
4 - FIFO Simulation
5 - OPT Simulation
6 - LRU Simulation
7 - LFU Simulation

Choose next option:
2
0 - Exit
1 - Read Reference String
2 - Generate Reference String
3 - Display current reference string
4 - FIFO Simulation
5 - OPT Simulation
6 - LRU Simulation
7 - LFU Simulation

Choose next option:
3
2, 9, 6, 0, 3, 3, 4, 0, 3, 9, 4, 9, 0, 3, 0, 7, 0

0 - Exit
1 - Read Reference String
2 - Generate Reference String
3 - Display current reference string
4 - FIFO Simulation
5 - OPT Simulation
6 - LRU Simulation
7 - LFU Simulation

Choose next option:

```

Test FIFO #1

```

Please enter the reference string.
You can enter in the string as just a row of numbers, or delimited by commas.
1 7 5 4 0 1 4 7 3 6 5 0 4 7 3 2 1
Would you like to set the amount of physical frames, by default it is 4.
Continue? ( Y / N ):
y
Enter value:4
0 - Exit
1 - Read Reference String
2 - Generate Reference String
3 - Display current reference string
4 - FIFO Simulation
5 - OPT Simulation
6 - LRU Simulation
7 - LFU Simulation

Choose next option:
4

Reference String      1      7      5      4      0      1      4      7
3      6      5      0      4      7      3      2      1
Physical Frame 0
Physical Frame 1
Physical Frame 2
Physical Frame 3
Page Faults
Victim Frames

In the FIFO page-replacement algorithm, the victim frame is the oldest frame.
The simulation of the FIFO page-replacement algorithm assumes a hypothetical comput
er having 4
physical frames numbered 0 to 3, which form a FIFO queue. It assumes that the sing
le process that is
running has a virtual memory of 10 frames numbered 0 to 9. The reference string is
:
1, 7, 5, 4, 0, 1, 4, 7, 3, 6, 5, 0, 4, 7, 3, 2, 1
Continue? ( Y / N ):

```

FIFO #2

```

Command Prompt - java FinalProject

Physical Frame 3      1      7      5      5
Page Faults          F      F      F      F      F      F
Victim Frames         1      7

Virtual frame 4 is referenced.
Because virtual frame 4 is already present in the physical memory, in physical frame 2,
nothing else needs to be done.
No page fault is generated.
We have no victim frame.

Continue? ( Y / N ):
y

Reference String      1      7      5      4      0      1      4      7      3      6      5      0      4      7      3      2      1
Physical Frame 0      1      7      5      4      0      1      1      7      3
Physical Frame 1      1      7      5      4      0      0      1      7
Physical Frame 2      1      7      5      4      4      0
Physical Frame 3      1      7      5      5      4
Page Faults          F      F      F      F      F      F      F
Victim Frames         1      7      5

Virtual frame 7 is referenced.
Because virtual frame 7 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 5, according to the FIFO strategy used in this algorithm
Virtual frame 5 is swapped out, and virtual frame 7 is swapped in.

Continue? ( Y / N ):
y

Reference String      1      7      5      4      0      1      4      7      3      6      5      0      4      7      3      2      1
Physical Frame 0      1      7      5      4      0      1      1      7      3
Physical Frame 1      1      7      5      4      0      0      1      7
Physical Frame 2      1      7      5      4      4      0      1
Physical Frame 3      1      7      5      5      4      0
Page Faults          F      F      F      F      F      F      F      F
Victim Frames         1      7      5      4

Virtual frame 3 is referenced.
Because virtual frame 3 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 4, according to the FIFO strategy used in this algorithm
Virtual frame 4 is swapped out, and virtual frame 3 is swapped in.

Continue? ( Y / N ):

```

FIFO #3

```

Command Prompt - java FinalProject

Reference String      1      7      5      4      0      1      4      7      3      6      5      0      4      7      3      2      1
Physical Frame 0      1      7      5      4      0      1      1      7      3      6      5      0      4      7      3      2      1
Physical Frame 1      1      7      5      4      0      0      1      7      3      6      5      0      4      7      3      2      1
Physical Frame 2      1      7      5      4      4      0      1      7      3      6      5      0      4      7      3
Physical Frame 3      1      7      5      5      4      0      1      7      3      6      5      0      4      7
Page Faults          F      F      F      F      F      F      F      F      F      F      F      F      F      F      F      F
Victim Frames         1      7      5      4      0      1      7      3      6      5      0

Virtual frame 2 is referenced.
Because virtual frame 2 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 0, according to the FIFO strategy used in this algorithm
Virtual frame 0 is swapped out, and virtual frame 2 is swapped in.

Continue? ( Y / N ):
y

Reference String      1      7      5      4      0      1      4      7      3      6      5      0      4      7      3      2      1
Physical Frame 0      1      7      5      4      0      1      1      7      3      6      5      0      4      7      3      2      1
Physical Frame 1      1      7      5      4      0      0      1      7      3      6      5      0      4      7      3      2      1
Physical Frame 2      1      7      5      4      4      0      1      7      3      6      5      0      4      7      3
Physical Frame 3      1      7      5      5      4      0      1      7      3      6      5      0      4      7
Page Faults          F      F      F      F      F      F      F      F      F      F      F      F      F      F      F      F
Victim Frames         1      7      5      4      0      1      7      3      6      5      0

Virtual frame 1 is referenced.
Because virtual frame 1 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 4, according to the FIFO strategy used in this algorithm
Virtual frame 4 is swapped out, and virtual frame 1 is swapped in.

In the end, a total of 16 page faults and 12 victims were generated.

FIFO Simulation complete.

0 - Exit
1 - Read Reference String
2 - Generate Reference String
3 - Display current reference string
4 - FIFO Simulation
5 - OPT Simulation
6 - LRU Simulation
7 - LFU Simulation

Choose next option:

```

Test OPT #1

```

Choose next option:
5

Reference String      1   7   5   4   0   1   4   7   3   6   5   0   4   7   3   2   1
Physical Frame 0
Physical Frame 1
Physical Frame 2
Physical Frame 3
Page Faults
Victim Frames

The optimal page-replacement algorithm is an idealized algorithm in which the victim frame is the one
that will not be accessed for the longest period of time.
This simulation assumes a hypothetical computer having 4 physical frames numbered 0 to 3. It
assumes that the single process that is running has a virtual memory of 10 frames numbered 0 to 9.
The reference string is:

1, 7, 5, 4, 0, 1, 4, 7, 3, 6, 5, 0, 4, 7, 3, 2, 1

Continue? ( Y / N ):
y

Reference String      1   7   5   4   0   1   4   7   3   6   5   0   4   7   3   2   1
Physical Frame 0      1
Physical Frame 1
Physical Frame 2
Physical Frame 3
Page Faults           F
Victim Frames

Virtual frame 1 is referenced.
Because virtual frame 1 is not present in physical memory, a page fault is generated.
Virtual frame 1 is loaded into physical frame 0.
Because there was room in the physical memory, we have no victim frame.

Continue? ( Y / N ):

```

Test OPT #2

```

Command Prompt - java FinalProject

Physical Frame 3      4   4   4   4
Page Faults          F   F   F   F   F
Victim Frames        5

Virtual frame 4 is referenced.
Because virtual frame 4 is already present in the physical memory, in physical frame 3,
nothing else needs to be done.
No page fault is generated.
We have no victim frame.

Continue? ( Y / N ):
y

Reference String      1   7   5   4   0   1   4   7   3   6   5   0   4   7   3   2   1
Physical Frame 0      1   1   1   1   1   1   1   1   3
Physical Frame 1      7   7   7   7   7   7   7   7
Physical Frame 2      5   5   0   0   0   0   0
Physical Frame 3      4   4   4   4   4   4   4
Page Faults          F   F   F   F   F   F   F
Victim Frames        5

Virtual frame 7 is referenced.
Because virtual frame 7 is already present in the physical memory, in physical frame 1,
nothing else needs to be done.
No page fault is generated.
We have no victim frame.

Continue? ( Y / N ):
y

Reference String      1   7   5   4   0   1   4   7   3   6   5   0   4   7   3   2   1
Physical Frame 0      1   1   1   1   1   1   1   1   3
Physical Frame 1      7   7   7   7   7   7   7   7
Physical Frame 2      5   5   0   0   0   0   0
Physical Frame 3      4   4   4   4   4   4   4
Page Faults          F   F   F   F   F   F   F
Victim Frames        5   1

Virtual frame 3 is referenced.
Because virtual frame 3 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 1 which is the farthest (or does not occur again) in the reference string.
Virtual frame 1 is swapped out, and virtual frame 3 is swapped in.

Continue? ( Y / N ):

```

OPT #3

```

C:\Command Prompt - java FinalProject

Reference String 1 7 5 4 0 1 4 7 3 6 5 0 4 7 3 2 1
Physical Frame 0 1 1 1 1 1 1 1 3 6 5 5 5 5 3 2 1
Physical Frame 1 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
Physical Frame 2 5 5 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Physical Frame 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
Page Faults F F F F F F F F F F F F F F F F
Victim Frames 1 3 6 5 3

Virtual frame 2 is referenced.
Because virtual frame 2 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 3 which is the farthest (or does not occur again) in the reference string.
Virtual frame 3 is swapped out, and virtual frame 2 is swapped in.

Continue? ( Y / N ):
y

Reference String 1 7 5 4 0 1 4 7 3 6 5 0 4 7 3 2 1
Physical Frame 0 1 1 1 1 1 1 1 3 6 5 5 5 5 3 2 1
Physical Frame 1 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
Physical Frame 2 5 5 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Physical Frame 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
Page Faults F F F F F F F F F F F F F F F F
Victim Frames 5 1 3 6 5 3 2

Virtual frame 1 is referenced.
Because virtual frame 1 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 2 which is the farthest (or does not occur again) in the reference string.
Virtual frame 2 is swapped out, and virtual frame 1 is swapped in.

In the end, a total of 11 page faults and 7 victims were generated.

OPT Simulation complete.

0 - Exit
1 - Read Reference String
2 - Generate Reference String
3 - Display current reference string
4 - FIFO Simulation
5 - OPT Simulation
6 - LRU Simulation
7 - LFU Simulation

Choose next option:

```

Test LRU #1

```

Choose next option:
6

Reference String 1 7 5 4 0 1 4 7 3 6 5 0 4 7 3 2 1
Physical Frame 0
Physical Frame 1
Physical Frame 2
Physical Frame 3
Page Faults
Victim Frames

In the LFU page-replacement algorithm, the victim frame is the one that has the smallest number of references.
This simulation assumes a hypothetical computer having 4 physical frames numbered 0 to 3. It
assumes that the single process that is running has a virtual memory of 10 frames numbered 0 to 9.
The reference string is:
1, 7, 5, 4, 0, 1, 4, 7, 3, 6, 5, 0, 4, 7, 3, 2, 1

Continue? ( Y / N ):
y

Reference String 1 7 5 4 0 1 4 7 3 6 5 0 4 7 3 2 1
Physical Frame 0 1
Physical Frame 1
Physical Frame 2
Physical Frame 3
Page Faults F
Victim Frames

Virtual frame 1 is referenced.
because virtual frame 1 is not present in physical memory, a page fault is generated.
Virtual frame 1 is loaded into physical frame 0.
Because there was room in the physical memory, we have no victim frame.

Continue? ( Y / N ):

```

Test LRU #2

```

Command Prompt - java FinalProject

Physical Frame 3      4      4      4      4
Page Faults          F      F      F      F      F      F
Victim Frames         1      0

Virtual frame 4 is referenced.
Because virtual frame 4 is already present in the physical memory, in physical frame 3,
nothing else needs to be done.
No page fault is generated.
We have no victim frame.

Continue? ( Y / N ):
y

Reference String      1      7      5      4      0      1      4      7      3      6      5      0      4      7      3      2      1
Physical Frame 0      1      1      1      1      0      1      1      1      1      1      1      0      0      0      3      2      1
Physical Frame 1      7      7      7      7      7      7      7      7      7      7      7      7      7      7      7      7      7
Physical Frame 2      5      5      5      5      5      5      5      5      5      5      5      5      5      5      5      5      5
Physical Frame 3      4      4      4      4      4      4      4      4      4      4      4      4      4      4      4      4      4
Page Faults           F      F      F      F      F      F      F      F      F      F      F      F      F      F      F      F      F
Victim Frames         1      0

Virtual frame 7 is referenced.
Because virtual frame 7 is already present in the physical memory, in physical frame 1,
nothing else needs to be done.
No page fault is generated.
We have no victim frame.

Continue? ( Y / N ):
y

Reference String      1      7      5      4      0      1      4      7      3      6      5      0      4      7      3      2      1
Physical Frame 0      1      1      1      1      0      1      1      1      1      1      1      0      0      0      3      2      1
Physical Frame 1      7      7      7      7      7      7      7      7      7      7      7      7      7      7      7      7      7
Physical Frame 2      5      5      5      5      5      5      5      5      5      5      5      5      5      5      5      5      5
Physical Frame 3      4      4      4      4      4      4      4      4      4      4      4      4      4      4      4      4      4
Page Faults           F      F      F      F      F      F      F      F      F      F      F      F      F      F      F      F      F
Victim Frames         1      0      5      F

Virtual frame 3 is referenced.
Because virtual frame 3 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 5.
Virtual frame 5 is swapped out, and virtual frame 3 is swapped in.

Continue? ( Y / N ):

```

Test LRU #3

```

Command Prompt - java FinalProject

Reference String      1      7      5      4      0      1      4      7      3      6      5      0      4      7      3      2      1
Physical Frame 0      1      1      1      1      0      1      1      1      1      1      0      0      0      0      3      2      1
Physical Frame 1      7      7      7      7      7      7      7      7      7      7      7      7      7      7      7      7      7
Physical Frame 2      5      5      5      5      5      5      5      5      5      5      5      5      5      5      5      5      5
Physical Frame 3      4      4      4      4      4      4      4      4      4      4      4      4      4      4      4      4      4
Page Faults           F      F      F      F      F      F      F      F      F      F      F      F      F      F      F      F      F
Victim Frames         1      0      5      3      6      1      0      3      2      F

Virtual frame 2 is referenced.
Because virtual frame 2 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 3.
Virtual frame 3 is swapped out, and virtual frame 2 is swapped in.

Continue? ( Y / N ):
y

Reference String      1      7      5      4      0      1      4      7      3      6      5      0      4      7      3      2      1
Physical Frame 0      1      1      1      1      0      1      1      1      1      1      0      0      0      0      3      2      1
Physical Frame 1      7      7      7      7      7      7      7      7      7      7      7      7      7      7      7      7      7
Physical Frame 2      5      5      5      5      5      5      5      5      5      5      5      5      5      5      5      5      5
Physical Frame 3      4      4      4      4      4      4      4      4      4      4      4      4      4      4      4      4      4
Page Faults           F      F      F      F      F      F      F      F      F      F      F      F      F      F      F      F      F
Victim Frames         1      0      5      3      6      1      0      3      2      F

Virtual frame 1 is referenced.
Because virtual frame 1 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 2.
Virtual frame 2 is swapped out, and virtual frame 1 is swapped in.

In the end, a total of 13 page faults and 9 victims were generated.

LRU Simulation complete.

0 - Exit
1 - Read Reference String
2 - Generate Reference String
3 - Display current reference string
4 - FIFO Simulation
5 - OPT Simulation
6 - LRU Simulation
7 - LFU Simulation

Choose next option:

```

Test LFU #1

```

Choose next option:
7
Reference String      1   7   5   4   0   1   4   7   3   6   5   0   4   7   3   2   1
Physical Frame 0
Physical Frame 1
Physical Frame 2
Physical Frame 3
Page Faults
Victim Frames

The LRU page-replacement algorithm is an approximation of the optimal page-replacement algorithm.
The victim frame is the one that has not been accessed for the longest period of time.
This simulation assumes a hypothetical computer having 4 physical frames numbered 0 to 3. It
assumes that the single process that is running has a virtual memory of 10 frames numbered 0 to 9.
The reference string is:

1, 7, 5, 4, 0, 1, 4, 7, 3, 6, 5, 0, 4, 7, 3, 2, 1

Continue? ( Y / N ):
y
Reference String      1   7   5   4   0   1   4   7   3   6   5   0   4   7   3   2   1
Physical Frame 0      1
Physical Frame 1
Physical Frame 2
Physical Frame 3
Page Faults           F
Victim Frames

Virtual frame 1 is referenced.
Because virtual frame 1 is not present in physical memory, a page fault is generated.
Virtual frame 1 is loaded into physical frame 0.
Because there was room in the physical memory, we have no victim frame.

Continue? ( Y / N ):

```

Test LFU #2

```

Command Prompt - java FinalProject
Physical Frame 3      4   4   4   4
Page Faults          F   F   F   F   F
Victim Frames         1   7

Virtual frame 4 is referenced.
Because virtual frame 4 is already present in the physical memory, in physical frame 3,
nothing else needs to be done.
No page fault is generated.
We have no victim frame.

Continue? ( Y / N ):
y
Reference String      1   7   5   4   0   1   4   7   3   6   5   0   4   7   3   2   1
Physical Frame 0      1   1   1   1   0   0   0   0   0   0   3
Physical Frame 1      7   7   7   7   1   1   1   1   1
Physical Frame 2      5   5   5   5   5   5   5   7   7
Physical Frame 3      4   4   4   4   4   4   4   4   4
Page Faults          F   F   F   F   F   F   F   F   F
Victim Frames         1   7   5   7   5   0   F

Virtual frame 7 is referenced.
Because virtual frame 7 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 5 which was not used (referenced) for the longest period of time.
Virtual frame 5 is swapped out, and virtual frame 7 is swapped in.

Continue? ( Y / N ):
y
Reference String      1   7   5   4   0   1   4   7   3   6   5   0   4   7   3   2   1
Physical Frame 0      1   1   1   1   0   0   0   0   0   3
Physical Frame 1      7   7   7   7   1   1   1   1   1
Physical Frame 2      5   5   5   5   5   5   5   7   7
Physical Frame 3      4   4   4   4   4   4   4   4   4
Page Faults          F   F   F   F   F   F   F   F   F
Victim Frames         1   7   5   0   F

Virtual frame 3 is referenced.
Because virtual frame 3 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 0 which was not used (referenced) for the longest period of time.
Virtual frame 0 is swapped out, and virtual frame 3 is swapped in.

Continue? ( Y / N ):

```

Test LFU #3

```

Command Prompt - java FinalProject

Reference String 1 7 5 4 0 1 4 7 3 6 5 0 4 7 3 2 1
Physical Frame 0 1 1 1 1 0 0 0 3 3 3 3 4 4 4 4 1
Physical Frame 1 7 7 7 7 1 1 1 6 6 6 6 7 7 7 7 7
Physical Frame 2 5 5 5 5 5 5 7 7 7 7 0 0 0 0 2
Physical Frame 3 4 4 4 4 4 4 4 5 5 5 5 5 3 3 3
Page Faults F F F F F F F F F F F F F F F
Victim Frames 1 7 5 0 1 4 7 3 6 5 0 4

Virtual frame 2 is referenced.
Because virtual frame 2 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 0 which was not used (referenced) for the longest period of time.
Virtual frame 0 is swapped out, and virtual frame 2 is swapped in.

Continue? ( Y / N ):
y

Reference String 1 7 5 4 0 1 4 7 3 6 5 0 4 7 3 2 1
Physical Frame 0 1 1 1 1 0 0 0 3 3 3 3 4 4 4 4 1
Physical Frame 1 7 7 7 7 1 1 1 6 6 6 6 7 7 7 7 7
Physical Frame 2 5 5 5 5 5 5 7 7 7 7 0 0 0 0 2
Physical Frame 3 4 4 4 4 4 4 4 5 5 5 5 5 3 3 3
Page Faults F F F F F F F F F F F F F F F
Victim Frames 1 7 5 0 1 4 7 3 6 5 0 4

Virtual frame 1 is referenced.
Because virtual frame 1 is not present in physical memory, a page fault is generated.
Because there is no more room in the physical memory, a frame must be replaced.
The victim frame is virtual frame 4 which was not used (referenced) for the longest period of time.
Virtual frame 4 is swapped out, and virtual frame 1 is swapped in.

In the end, a total of 16 page faults and 12 victims were generated.

LFU Simulation complete.

0 - Exit
1 - Read Reference String
2 - Generate Reference String
3 - Display current reference string
4 - FIFO Simulation
5 - OPT Simulation
6 - LRU Simulation
7 - LFU Simulation

Choose next option:

```