

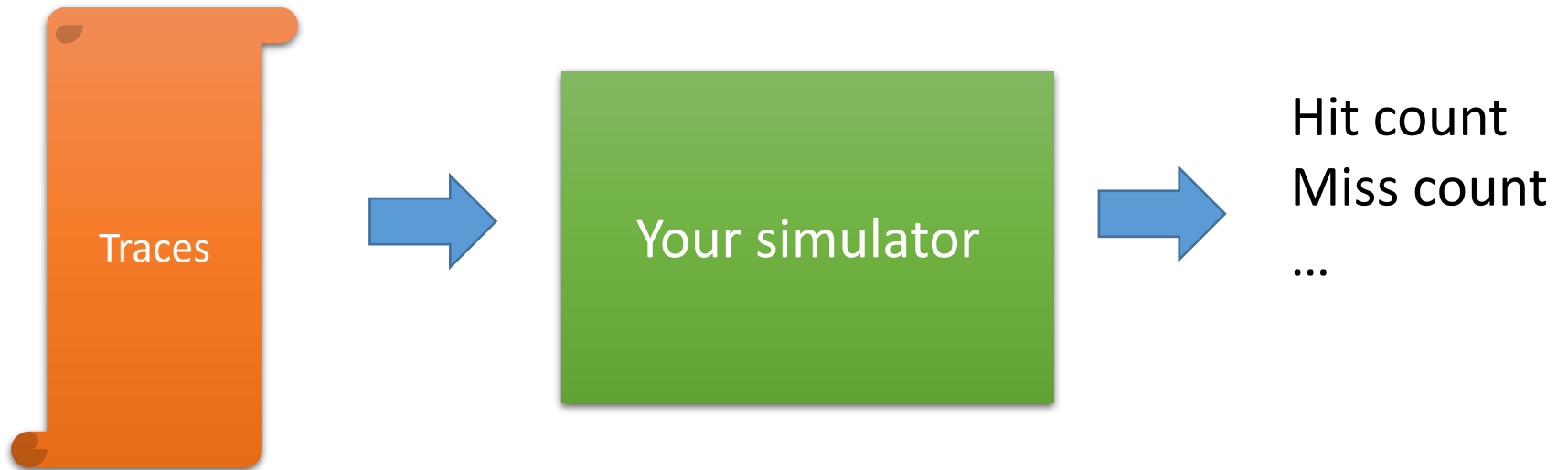
Operating Systems

Programming Assignment #5

Page Replacement Simulation: LRU and LFU

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Simulation



Trace File Format

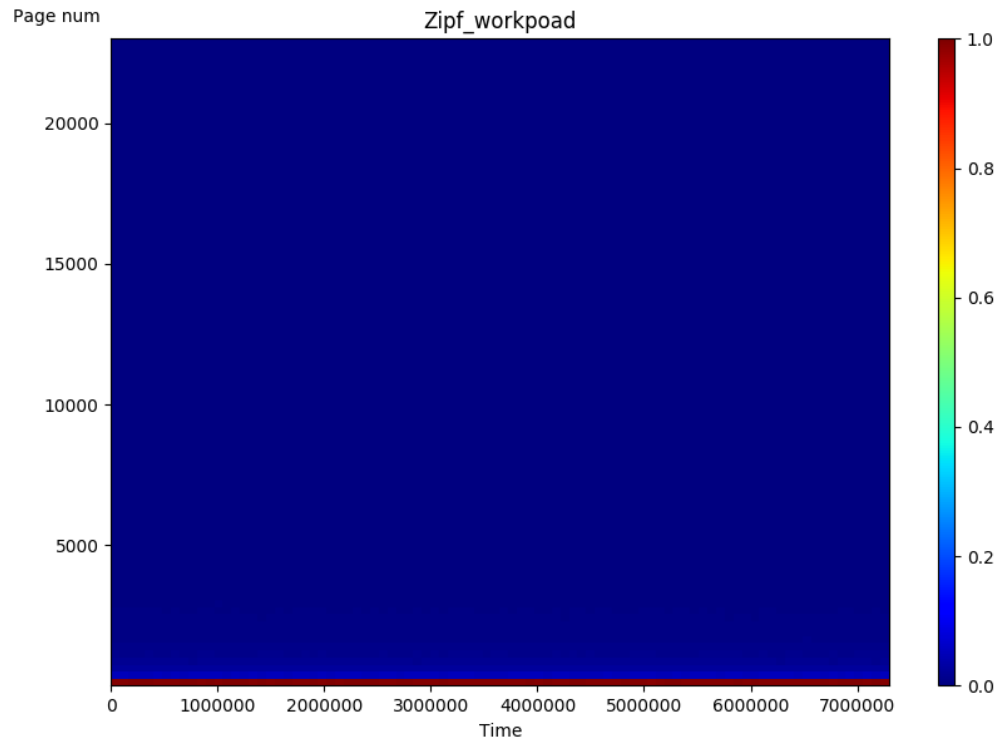
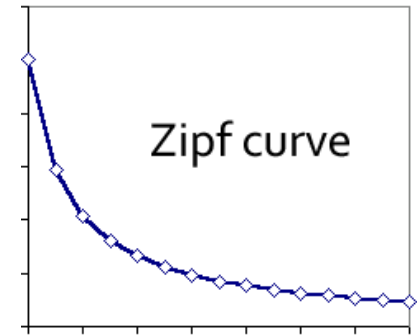
- Page number of referenced pages

```
1003  
1003  
9340  
1243  
1108  
1786  
1066  
1312  
1000  
1000  
1213  
1249  
2116
```

Unsigned integer

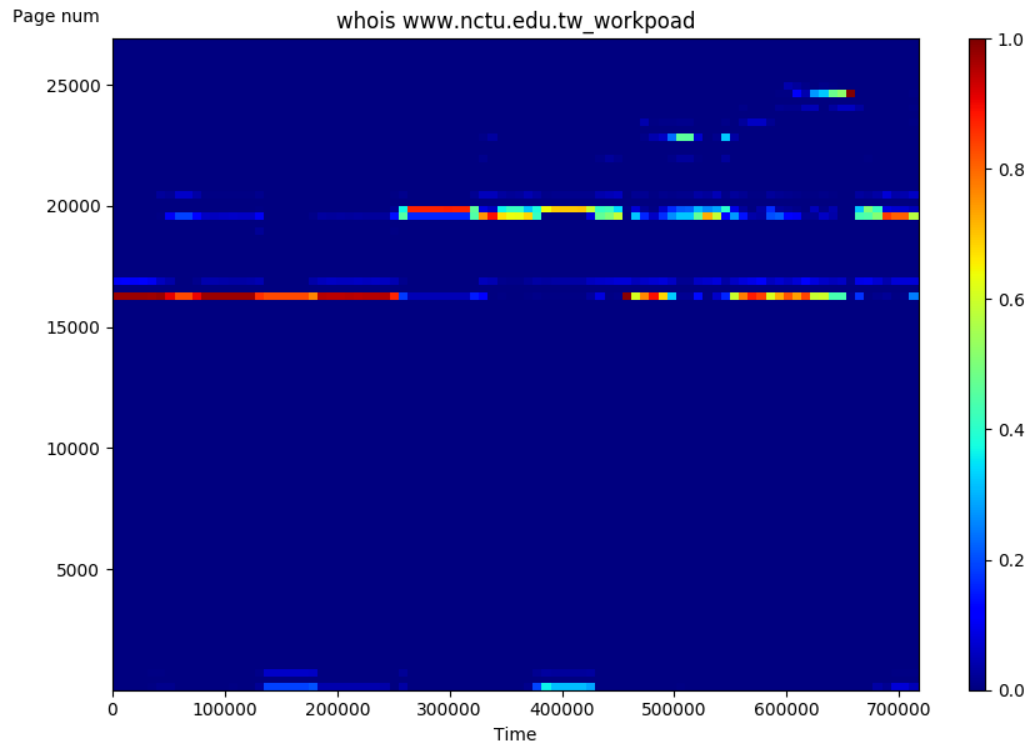
Test Workload (I)

- Zipfian distribution



Test Workload (II)

- “whois www.nctu.edu.tw”



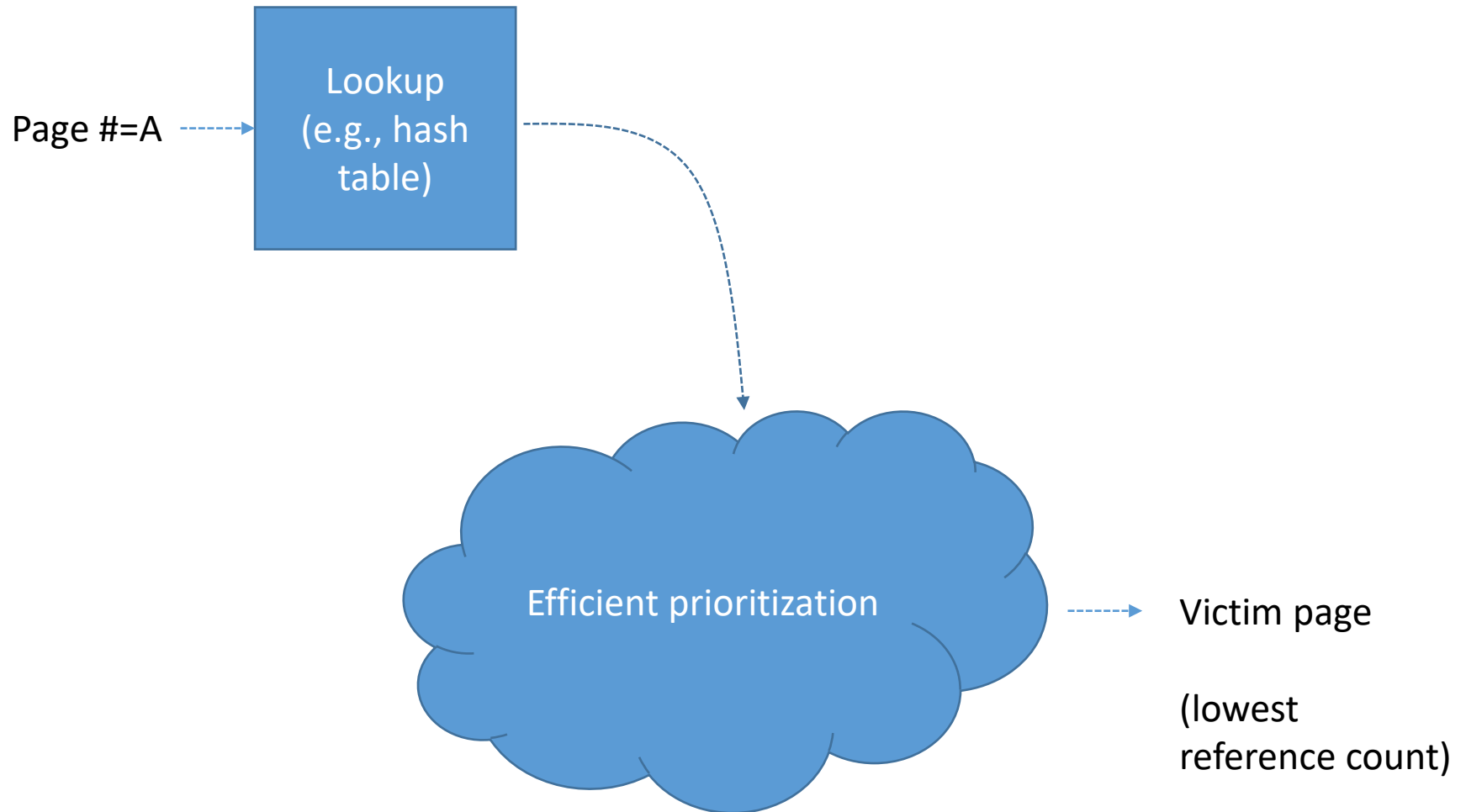
Page Replacement(LFU)

- Example: Frame #=2

	LFU	Ref count					
	4000 4001 4002						
4001 (miss)	<table><tr><td>4001</td><td></td></tr></table>	4001		<table><tr><td>0</td><td>1</td><td>0</td></tr></table>	0	1	0
4001							
0	1	0					
4001 (hit)	<table><tr><td>4001</td><td></td></tr></table>	4001		<table><tr><td>0</td><td>2</td><td>0</td></tr></table>	0	2	0
4001							
0	2	0					
4000 (miss)	<table><tr><td>4000</td><td>4001</td></tr></table>	4000	4001	<table><tr><td>1</td><td>2</td><td>0</td></tr></table>	1	2	0
4000	4001						
1	2	0					
4002 (miss)	<table><tr><td>4002</td><td>4001</td></tr></table>	4002	4001	<table><tr><td>0</td><td>2</td><td>1</td></tr></table>	0	2	1
4002	4001						
0	2	1					
4000 (miss)	<table><tr><td>4000</td><td>4001</td></tr></table>	4000	4001	<table><tr><td>1</td><td>2</td><td>0</td></tr></table>	1	2	0
4000	4001						
1	2	0					

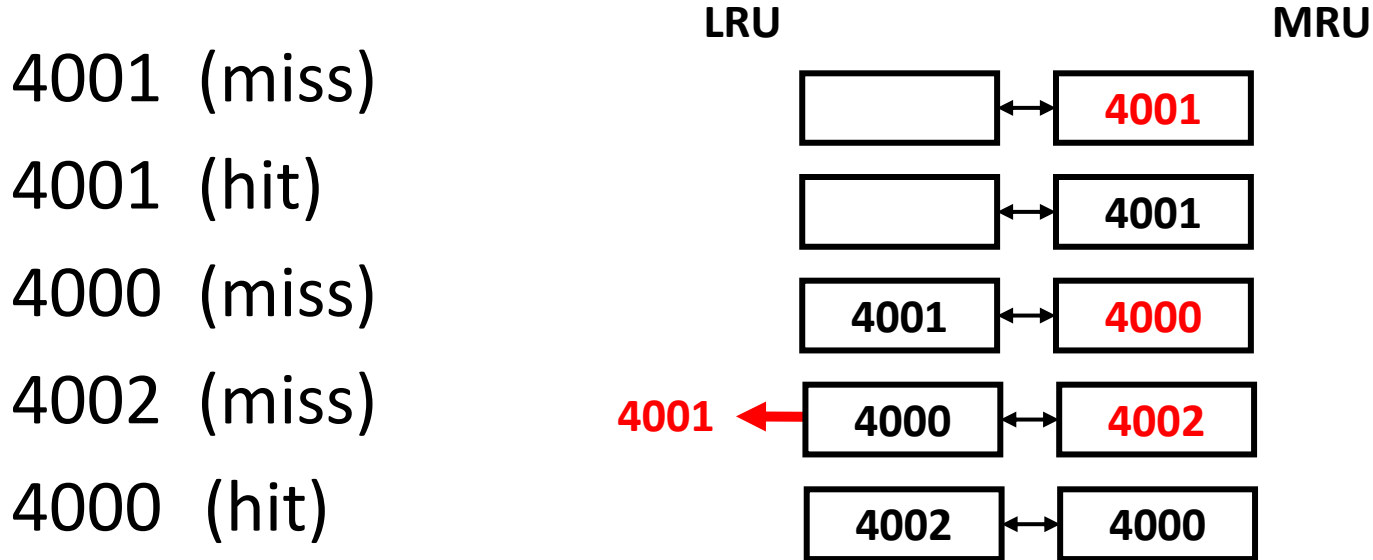
Placement candidates are those in-memory pages

Simulator Structure (LFU)



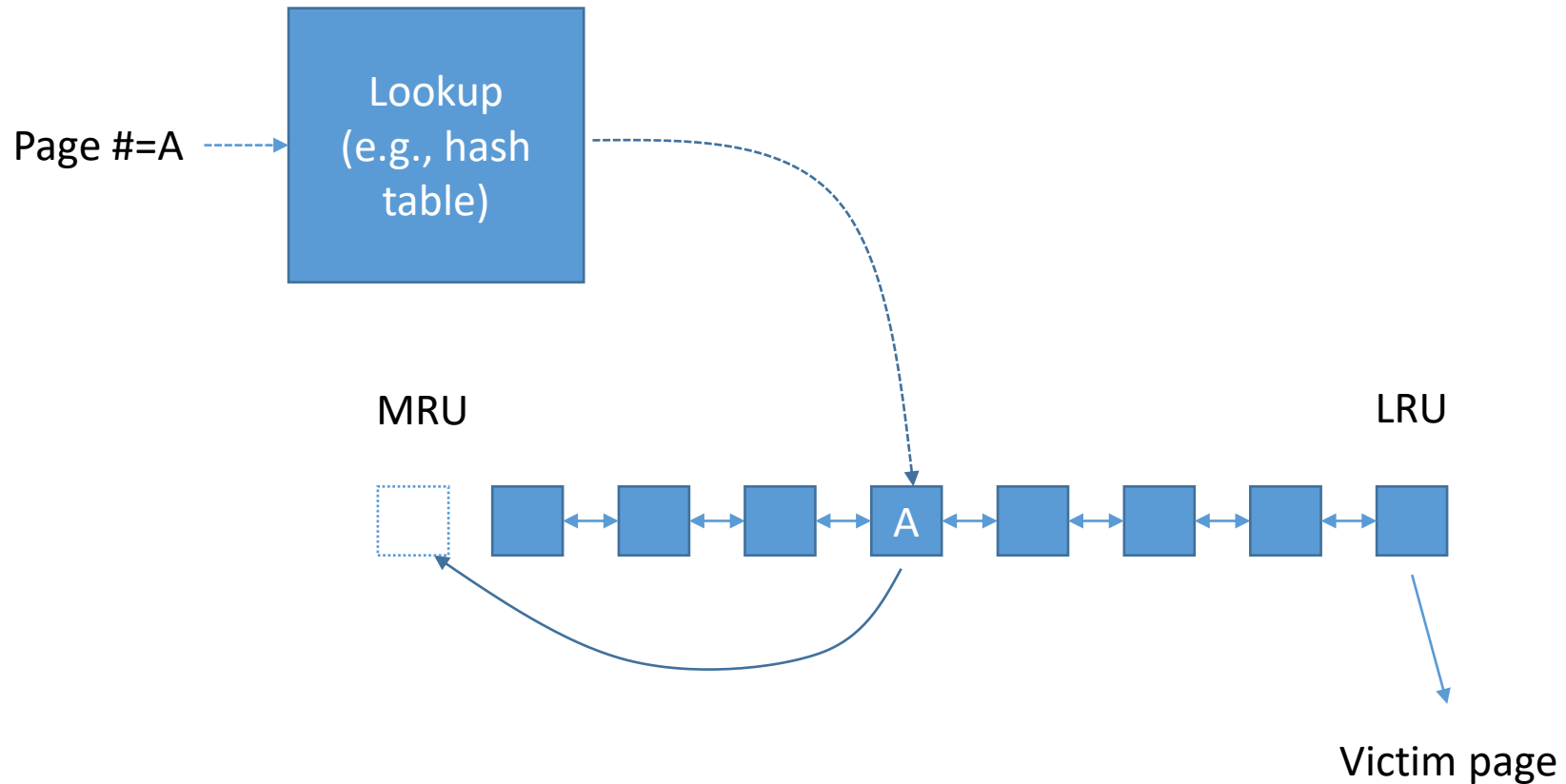
Page Replacement(LRU)

- Example: Frame #=2



Placement candidates are those in-memory pages

Simulator Structure (LRU)



Page Cache Operations

- Page lookup
 - Check whether or a new reference is a hit or a miss
 - Hash tables, binary search trees, skip lists....
- Do not use linear search!!!
 - You will receive a grade penalty if you do
 - Implement your own search, or reuse any existing libraries/classes for searching
 - TAs will examine your code
 - Duplication in this part does not count

Victim selection

- LFU
 - The least frequently used page
 - If two pages have the same access count, the page having a smaller reference sequence number is replaced
 - You may need to store the reference sequence number when a page is added to the page cache
- LRU
 - The least recently used page

Procedure

1. Algorithm=LFU
2. For (frame # = 64, 128, 256, and 512) do
 - Read the trace file
 - Run simulation
 - Print out the hit count, miss count, page fault ratio
3. Print out the total elapsed time of Step 2
4. Algorithm=LRU
5. For (frame # = 64, 128, 256, and 512) do
 - Read the trace file
 - Run simulation
 - Print out the hit count, miss count, page fault ratio
6. Print out the total elapsed time of Step 5

The scenario of program

Output format

LFU policy: (\n)

Frame	(\t)	Hit	(\t\t)	Miss	(\t\t)	Page fault ratio(\n)
64	(\t)	%d	(\t\t)	%d	(\t\t)	%.10f(\n)
128	(\t)	%d	(\t\t)	%d	(\t\t)	%.10f(\n)
256	(\t)	%d	(\t\t)	%d	(\t\t)	%.10f(\n)
512	(\t)	%d	(\t\t)	%d	(\t\t)	%.10f(\n)

Total elapsed time %.4f sec(\n) (\n)

LRU policy: (\n)

Frame	(\t)	Hit	(\t\t)	Miss	(\t\t)	Page fault ratio(\n)
64	(\t)	%d	(\t\t)	%d	(\t\t)	%.10f(\n)
128	(\t)	%d	(\t\t)	%d	(\t\t)	%.10f(\n)
256	(\t)	%d	(\t\t)	%d	(\t\t)	%.10f(\n)
512	(\t)	%d	(\t\t)	%d	(\t\t)	%.10f(\n)

Total elapsed time %.4f sec(\n)

The scenario of program

- Your output should be exactly the same as follows
- Test case : whois www.nctu.edu.tw

```
ubuntu@ubuntu:~/C-project/OS/oshw5$ ./osSummerHW5 ./testcase/whois.txt
LFU policy:
Frame   Hit           Miss           Page fault ratio
64       689115         83143          0.1076622062
128      729104         43154          0.0558802887
256      771124         1134           0.0014684212
512      771921         337            0.0004363827
Total elapsed time 0.1785 sec

LRU policy:
Frame   Hit           Miss           Page fault ratio
64       771056         1202           0.0015564746
128      771663         595            0.0007704679
256      771909         349            0.0004519215
512      771921         337            0.0004363827
Total elapsed time 0.1916 sec
```

- Your output should be exactly the same as follows
- Test case : zipfian

```
ubuntu@ubuntu:~/C-project/OS/oshw5$ ./osSummerHW5 ./testcase/zipf.txt
LFU policy:
Frame    Hit           Miss           Page fault ratio
64       7880135         2119865         0.2119865000
128      8382340         1617660         0.1617660000
256      8807903         1192097         0.1192097000
512      9134227         865773          0.0865773000
Total elapsed time 2.5885 sec

LRU policy:
Frame    Hit           Miss           Page fault ratio
64       7215568         2784432         0.2784432000
128      7880805         2119195         0.2119195000
256      8425224         1574776         0.1574776000
512      8871063         1128937         0.1128937000
Total elapsed time 2.0990 sec
```

Correctness

- The TAs will prepare **another workload** to validate your implementation
- Except the total elapsed time, your results should be exactly the same as ours
- Do not use linear search in anywhere of your program; otherwise, you will receive a score penalty

More details

- Total request # ≤ 10 millions
- Highest page address == 0xfffff
- The path+file name of the trace file is an argument of your program (see the screen shot), do not hard-coding the pathname of the trace file
- For each iteration, you should open the file, run the simulation, print the result and close the file
- Do not store the trace data in memory to speed up the next iteration
- Use `gettimeofday()` to get the total elapsed time

Header of your .c or .cpp

```
/*
```

```
Student No.: <your student id>
```

```
Student Name: <your name>
```

```
Email: <your email>
```

```
SE tag: xnxcctxuxoxsx
```

```
Statement: I am fully aware that this program is not  
supposed to be posted to a public server, such as a  
public GitHub repository or a public web page.
```

```
*/
```

Testing OS Environment

- Ubuntu 18.04
- Install as a VM or on a physical machine