Page replacement policies simulation

AOS - Project | Team - QuadSquad

INTRODUCTION

This Project is a memory management simulator that uses paging and measures the performances of page replacement algorithms such as -

- FIFO (first in first out)
- LRU (least recently used)
- NFU (not frequently used)
- OPT (optimal page replacement)
- Random
- NRU (Not Recently Used)
- FIFO with second chance
- Clock
- Working Set
- Aging
- WSClock

Keeping track of what pages are being loaded, we observed the performance of all these page replacement algorithms under different situations(number of frames allocated to process in main memory) and represented in the form of graphs.

PROBLEM DESCRIPTION

To evaluate the performance of above-mentioned algorithms using the parameters like number of frames and length of page streams. To analyse the miss ratio, the number of swaps, and Page faults for each algorithm.

SOLUTION APPROACH

For each page replacement policy, we have written an algorithm to mimic that policy and implemented it using C++.

We have used a Python program to represent the result of the analysis of each page replacement policy in the form of graphs. In those graphs, we have shown the behavior of each policy under different situations (number of frames allocated to process in main memory).

Finally, we have used a bash script to make all the c++ and python programs run, using a single command. Later in the report, we have attached an example that shows how our project is working.

WORK DISTRIBUTION

(Distribution of algorithms)
Aman Izardar - WSClock , Working set , Aging
Ayush Mittal - Clock ,FIFO with second chance , Not Recently Used
Annapoorani A. - First in First Out , Not Frequently Used
Diksha Daryani - Least Recently used , Optimal , Random

PROBLEMS FACED AND SHORTCOMINGS

One of the main problems was different elaboration of some page replacements policies on different websites. We have followed the standard resources in that case.

Making assumptions such as considering no. of clock cycles as page stream index. For Example, if it is 0th-page that is asking for a frame then we assumed that this page is asking for the frame at 0th cycle of cpu.

Working set Works on Sliding Window. So the main problem was to implement a dynamic frame allocator with a sliding window protocol. To represent a window we've used a timer of T CPU clocks. So if a page is referred in the last T cpu clocks then it will be in our Working set window, otherwise, it will be out of the window. So no. of frames allocated to a process in Working set algo will be dynamic.

Wsclock Works almost the same as Working-set algo with some modification so we've faced same problem that we faced in Working set and resolved the problem similarly.

With FIFO, the major problem faced is Belady's Anomaly. The number of page faults increases sometimes when the number of frames increases. This should ideally not be the case, however, FIFO suffers from this drawback. This is because it does not follow a stack based page replacement policy.

NFU page replacement has the problem that if some page is used repeatedly in the beginning, it's count increases. However, it may not be used in the future for a very long time and occupies space in memory. Also, pages that arrive newly are more likely to get replaced because of low frequency count. Thus it contributes to increased page faults.

NRU, is a hardware-based algorithm, making suitable assumptions and implementing that part was also tricky. Clock and FIFO with a second chance are very similar policies, but have differences in implementation, exactly knowing the difference took a lot of effort.

LEARNING

Implementing this project gave us a better understanding of page replacements policies, Not just how they work but also, which algo to opt-in different situations.

By implementing this simulator we have learnt how to plot different graphs in python using Matplotlib. It also helped us to understand how subplot works in Matplotlib.

Coding and analysing these algorithms allowed us to know how the operating system plays its role in memory management practically and it also helped us to understand and find the difference between the different algorithms and their behavior in different scenarios by plotting the graphs for the same.

It helped us to understand the concept of how VIRTUAL MEMORY can address more memory than the amount physically installed on the system. The visible advantage with virtual memory is that programs can be larger than physical memory as it allows us to extend the use of physical memory by using disk.

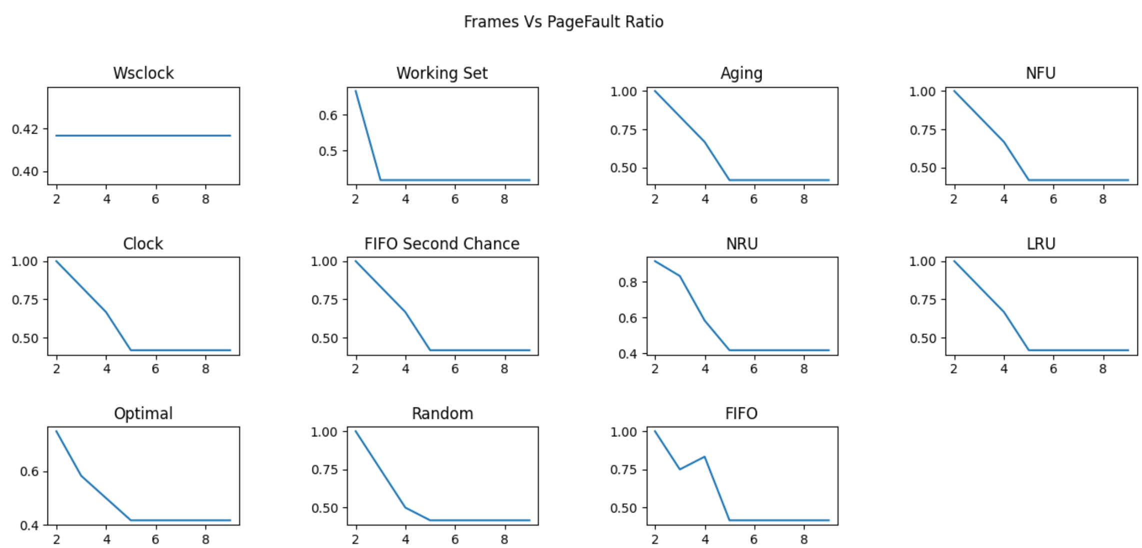
RESULT

This is taking page reference string and producing the result for different numbers of frames allocated to process in main memory. Using those results, graphs are made. These graphs show how different policies work/perform under different situations i.e., how no. of frames impact the performance of these policies.

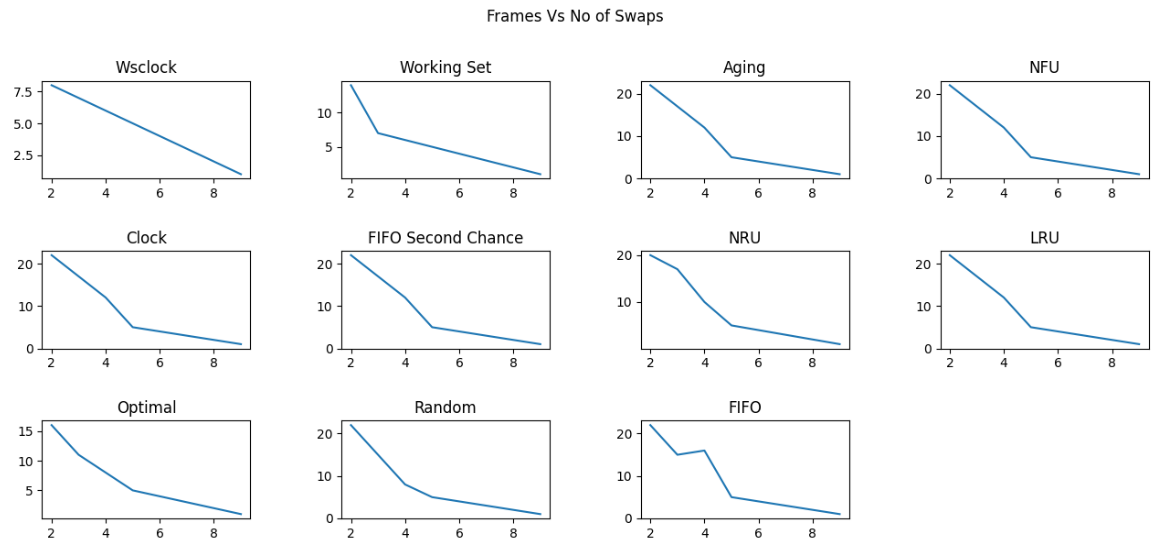
This is one Example of how our simulator is Working. It is taking no. of Frames followed by page stream also dirty page info bits as the input and generating the following Graph.

This is how various algo behaves on different no. of Frames:

First one is Frames Vs Miss Ratio Graph:



Second is Frames vs No. of Swaps Graph :



ASSUMPTION

No. of Swaps = No. of Swap in + No. of Swap out

No. of Swap in = No. of page faults

No. of Swap out = No. of page faults - No. of frames

In NRU, we're considering that reference bits are getting reset after every 5-page references.

In NFU(or LFU), the pages having the same frequency count are getting swapped out based on FIFO policy.

Input format :

> A single line, the first integer is no. Of frames, followed by space-separated page stream followed by a comma and dirty page stream.
>
> For example :-
>
> 4 1 3 2 1 , 0 1 0 0

CONCLUSION

The optimal algorithm replaces the page referenced last among the current pages. Unfortunately, there is no way to determine which page will be last, so in practice, this algorithm cannot be used. It is useful as a benchmark against which other algorithms can be measured, however.

The NRU algorithm divides pages into four classes depending on the state of the *R* and *M* bits. A random page from the lowest numbered class is chosen. This algorithm is easy to implement, but it is very crude. Better ones exist.

FIFO keeps track of the order pages were loaded into memory by keeping them in a linked list. Removing the oldest page then becomes trivial, but that page might still be in use, so FIFO is a bad choice.

Second chance is a modification to FIFO that checks if a page is in use before removing it. If it is, the page is spared. This modification greatly improves the performance. Clock is simply a different implementation of second chance. It has the same performance properties but takes a little less time to execute the algorithm.

LRU is an excellent algorithm, but it cannot be implemented without special hardware. If this hardware is not available, it cannot be used. NFU is a crude attempt to approximate LRU. It is not very good. However, aging is a much better approximation to LRU and can be implemented efficiently. It is a good choice.

The last two algorithms use the working set. The working set algorithm is reasonable performance, but it is somewhat expensive to implement. WSClock is a variant that not only gives good performance but is also efficient to implement.

All in all, the two best algorithms are Working Set and WSClock. They are based on LRU and the working set, respectively. Both give good paging performance and can be implemented efficiently. A few other algorithms exist, but these two are probably the most important in practice.

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