Course : CompSci 3SH3, Winter 2021
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ASSIGNMENT #3

CPU SCHEDULING

1. a) If the time quantum is 1 millisecond, then the CPU utilization for a Round-Robin scheduler will be ~91%. This is due to the time quantum being very small, 1 millisecond. Since each process is only allotted 1 ms of CPU time, a lot of context-switches takes place, where the currently running process is swapped out for a waiting process. As a result, the CPU utilization can be modelled by:

$$(1 / 1.1) * 100 = 90.90909091$$
$$\sim 90.9$$
$$\sim 91\%$$

1. b) If the time quantum is 10 milliseconds, then the CPU utilization for a Round-Robin scheduler will be ~95%. Since the I/O-bound tasks cause a context switch after every ms of CPU time, the equation used to model the system running 10 I/O-bound tasks, and 1 CPU-bound task is:

$$= \frac{(10 + (1 * 10))}{((10 * 1.1) + 10.1)} \times 100$$

$$= \frac{10 + 10}{11 + 10.1} \times 100$$

$$= (20 / 21.1) \times 100$$

$$= 0.947867298 \times 100$$

$$= 94.7867298\%$$

$$\sim 94.8\%$$

$$\sim 95\%$$

VIRTUAL MEMORY

2. a) LRU Replacement

The page reference is: 1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6

When Numbers Of Frames = 1

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6

After counting the number of entries in "Frame #1", there are 20 Faults.

When Numbers Of Frames = 2

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 3 2 5 2 * 7 3 1 3
Frame #2	2 4 1 6 1 3 6 2 * 6
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 18 Faults in total.

When Numbers Of Frames = 3

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 4 5 1 7 2 *
Frame #2	2 * 6 3 * *
Frame #3	3 1 2 * 6 1 6
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 15 Faults in total.

When Numbers Of Frames = 4

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 * * * *
Frame #2	2 * * * * *
Frame #3	3 5 3 * *
Frame #4	4 6 7 1
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 10 Faults in total.

When Numbers Of Frames = 5

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 * * * *
Frame #2	2 * * * * *
Frame #3	3 6 * *
Frame #4	4 3 * *
Frame #5	5 7
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 8 Faults in total.

When Numbers Of Frames = 6

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 * * * *
Frame #2	2 * * * * *
Frame #3	3 * * *

Frame #4	4
Frame #5	5 7
Frame #6	6 * *
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 7 Faults in total.

When Numbers Of Frames = 7

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 * * *
Frame #2	2 * * * * *
Frame #3	3 * * *
Frame #4	4
Frame #5	5
Frame #6	6 * *
Frame #7	7
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 7 Faults in total.

Summary For LRU	
Frame #	# Of Faults
1	20
2	18
3	15
4	10
5	08
6	07
7	07

2. b) FIFO Replacement

The page reference is: 1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6

When Numbers Of Frames = 1

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6

After counting the number of entries in "Frame #1", there are 20 Faults.

When Numbers Of Frames = 2

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 3 2 5 2 * 7 3 1 3
Frame #2	2 4 1 6 1 3 6 2 * 6
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 18 Faults in total.

When Numbers Of Frames = 3

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 4 6 3 * 2 * 6
Frame #2	2 * 1 2 * 7 1
Frame #3	3 5 1 6 3
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 16 Faults in total.

When Numbers Of Frames = 4

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 * 5 3 * 1
Frame #2	2 * 6 7 3
Frame #3	3 2 * 6 6
Frame #4	4 1 2 2
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 14 Faults in total.

When Numbers Of Frames = 5

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 * 6 * *
Frame #2	2 * * 1 *
Frame #3	3 2 * *
Frame #4	4 3 * *
Frame #5	5 7
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 10 Faults in total.

When Numbers Of Frames = 6

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 * * 7
Frame #2	2 * * * * 1
Frame #3	3 * * 2

Frame #4	4 3
Frame #5	5
Frame #6	6 * *
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 10 Faults in total.

When Numbers Of Frames = 7

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 * * *
Frame #2	2 * * * * *
Frame #3	3 * * *
Frame #4	4
Frame #5	5
Frame #6	6 * *
Frame #7	7
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 7 Faults in total.

Summary For FIFO	
Frame #	# Of Faults
1	20
2	18
3	16
4	14
5	10
6	10
7	07

2. c) Optimal Replacement

The page reference is: 1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6

When Numbers Of Frames = 1

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6

After counting the number of entries in "Frame #1", there are 20 Faults.

When Numbers Of Frames = 2

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 3 4 1 5 6 1 3 7 6 3 1 3 6
Frame #2	2 * * * * *
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 15 Faults in total.

When Numbers Of Frames = 3

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 * * 3 * *
Frame #2	2 * * * 7 2 *
Frame #3	3 4 5 6 * 1 6
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 11 Faults in total.

When Numbers Of Frames = 4

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 * * 7 1
Frame #2	2 * * * * *
Frame #3	3 * * *
Frame #4	4 5 6 * *
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 8 Faults in total.

When Numbers Of Frames = 5

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 * * *
Frame #2	2 * * * * *
Frame #3	3 * * *
Frame #4	4 7
Frame #5	5 6 * *
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 7 Faults in total.

When Numbers Of Frames = 6

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 * * *
Frame #2	2 * * * * *
Frame #3	3 * * *

Frame #4	4
Frame #5	5 7
Frame #6	6 * *
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 7 Faults in total.

When Numbers Of Frames = 7

Data	1 2 3 4 2 1 5 6 2 1 2 3 7 6 3 2 1 2 3 6
Frame #1	1 * * *
Frame #2	2 * * * * *
Frame #3	3 * * *
Frame #4	4
Frame #5	5
Frame #6	6 * *
Frame #7	7
Note: The Asterisk (*) means "No Page Fault"	

After counting the number of entries in "Frame #'s", there are 7 Faults in total.

Summary For Optimal	
Frame #	# Of Faults
1	20
2	15
3	11
4	08
5	07
6	07
7	07

MASSIVE STORAGE

3. a) System contains 1000 disk drives
MTBF for a single drive is 750,000 hours

MTBF of some disk in system of 1000 disk drives = 750000 / 1000
= 750 hours

750 hours = 31.25 days
~ A month

750 hours = 45,000 minutes = 2,700,000 seconds

A drive failure will occur about once a month in this disk farm.
This is the best way to describe the MTBF of this disk farm.

3. b) Mortality rate for a (healthy) 20/21 year old is:
1/1000
OR
0.001

Now, the MTBF can be calculated via:
MTBF = 1 / 0.001
= 1000
years

1000 years = 12,000 months ~ 365,000 days ~ 8,760,000 hours
(Leap years not included in the calculation for days and hours)

This means that the mean time between failure for a 20/21 year old American is 1000 years. Clearly this tells us nothing about the expected lifetime of a 20/21 year old American. The oldest person who ever lived is Jeanne Calment; she died at the advanced age of 122.

FILE MANAGEMENT

4) Information from question:
- 9 pointers are to (single) direct data sectors
- 1 pointer to double indirect data sector
- Size of each disk sector = 512 bytes
- Size of `int` = 4

Single Direct Data Sector:
9 x 512 = 4608 bytes
- This calculation is trivial. We can multiply the number of single direct data sectors with the size of the disk sector. No other calculations are required because this is a direct data sector.

Double Indirect Data Sector:
 (512 / 4) * (512 / 4) * 512 = 8388608
     - This calculation can be explained in 3 parts:
         1. The disk sector size is divided by 4, because it is an
            indirect data sector.
         2. The value from #1 is squared (or multiplied by itself),
            because it is double (indirect) data sector.
         3. The value from #1 and #2 is multipled by the disk
            sector size.

Total Size = Direct Data Sector + Double Indirect Data Sector
           = 4608 + 8388608
           = 8393216
             (bytes)

Therefore, the maximum file size in this system is:
 8393216 bytes
 8196.5 kilobytes
 8.0044 megabytes

END