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Prep Smart. Score Better.

Computer Organization and Architecture

Virtual memory part-2

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- MTech with 20 years of Experience in Teaching GATE and Engineering colleges
- IIT NPTEL Course topper in Theory of computation with 96 %
- IGIP Certified (Certification on International Engineering educator)
- GATE Qualified
- Trained more than 50 Thousand students across the country
- Area of Expertise : TOC,OS,COA,CN,DLD

Virtual memory part-2

Allocation of Frames.

(1) Equal Allocation
(2) Proportional Allocation.

m - Free Frames (count)
n - Processes (count)

Equal Allocation

$= \frac{m}{n}$ Frames

100 Free Frames

P_1, P_2

$P_1 = \frac{100}{2} = 50$

$P_2 = \frac{100}{2} = 50$

$\boxed{P_1 = 90 \text{ Frames}}$

$\boxed{P_2 = 10 \text{ Frames}}$

☆ The Size of the Process is NOT considered, simply, it is allocating based on the Formula

Virtual memory part-2

Proportional Allocation

112 KB

P_1 P_2 P_3 P_4

$P_1 \rightarrow$ 2 KB

$P_2 \rightarrow$ 10 KB

$P_3 \rightarrow$ 50 KB

$P_4 \rightarrow$ 50 KB

$$a_i \approx \frac{s_i}{S} \times m$$

m = No. of free frames

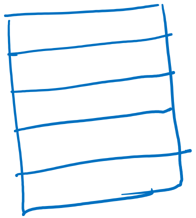
s_i = Logical Address Space of Process - P_i

a_i = No. of Frames to be allocated for a Process - P_i

$$S = \Sigma s_i$$

Page Size = 1 KBytes

$\boxed{m = 100}$



P_1 = 10 KBytes (10 Frames)

P_2 = 90 KBytes (90 Frames)

P_1

$$a_1 \approx \frac{10\,KB}{100\,KB} \times 100 = 10 \text{ Frames}$$

P_2

$$a_2 \approx \frac{90\,KB}{100\,KB} \times 100 = 90 \text{ "}$$

Virtual memory part-2

Equal Allocation →

$P_1 = 31$

$P_2 = 31$ $\quad \frac{m}{n}$

$62/2 = 31$

Consider two Processes P_1 and P_2, where P_1 is of Size $\boxed{10\text{ KB}}$ and P_2 is of Size $\boxed{127\text{ KBytes}}$. Assume that there are $\boxed{\text{62 free frames}}$ are available in memory. How Many frames will be allocated to each Process if Proportional frame allocation strategy is used?

Sol.

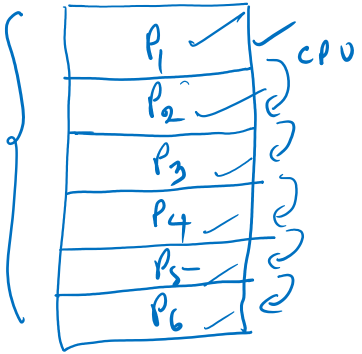
$$a_1 \approx \frac{10\text{KB}}{137\text{ KB}} \times 62 = \frac{620}{137} = 4.6$$

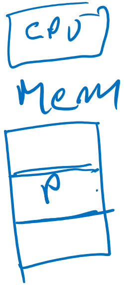
$$a_2 \approx \frac{127\text{KB}}{137\text{KB}} \times 62 = \frac{127 \times 62}{137} = 57.47$$

$\left.\begin{array}{l} P_1 = 5 \text{ Frames} \\ P_2 = 57 \text{ ''} \end{array}\right\}$ 62 frames

Virtual memory part-2

Paging

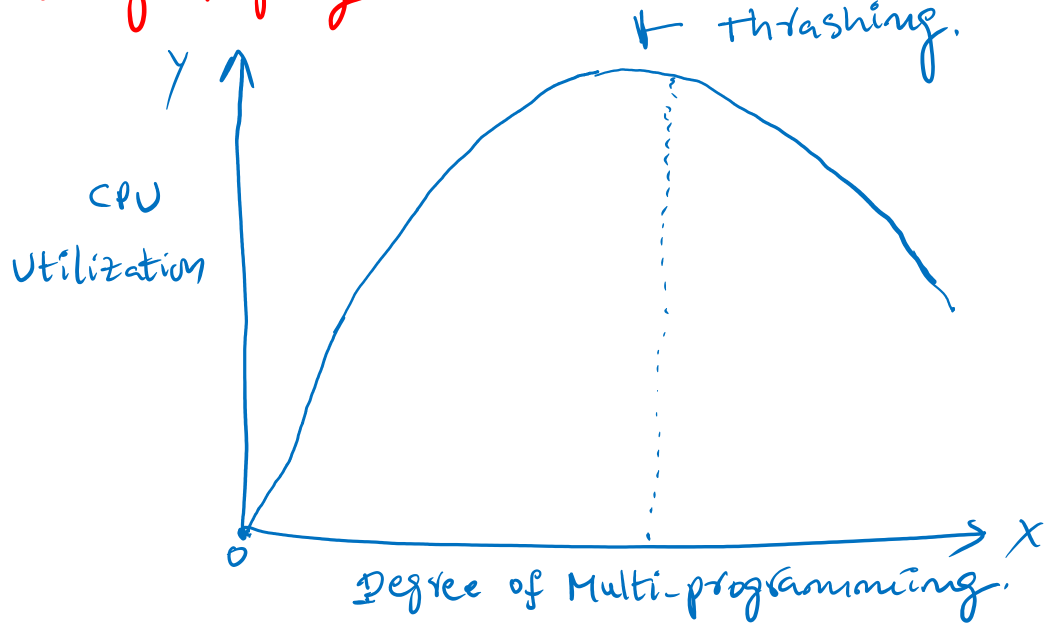




Thrashing

High Paging Activity. [Spending much of the time on doing Paging rather than execution]

CPU
↓
I/O
↓
CPU



Excessive Paging.

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Working Set Model.

Locality of Reference

[Moving window]

Working set window.

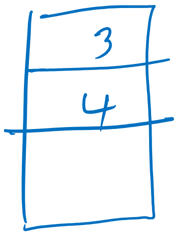
3, 4, 3, 4, 3, 4, 3, 4, 1, 2, 7, 5, 1, 7, 5, 2, 1 - - - -

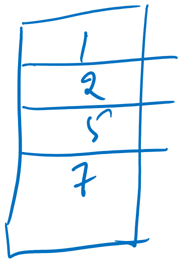
T_1 $\{3, 4\}$

T_2 $\{1, 2, 5, 7\}$

Window [3, 4] [1, 2, 5, 7]

"Limiting the thrashing."





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Counting Page Replacement Algorithms

(1) LFU [Least frequently used]

(2) MFU [Most frequently used] → Replace the Page with the max. count.

Page Table

P.No	F.No	Book-keeping: Count	T.O.D
0			
1			
2			
3			
4			
5			
6			
7			

LFU

Page	Count
5	(1)
1	(2)
2	(3)

[Replace the Page with least Count Value]

LFU

7, 1, 2, 1, 7, 3, 1, 4, 2, 7, 4, 9, 3, 1, 2 ...

10

7	7	7	7	7	7	7	7	7	7	7	7	7
	1	1	1	1	1	1	1	1	1	1	1	1
		2	2	2	3	3	4	2	2	4	9	3

Counts: $7^1, 7^1, 7^2, 7^2, 7^2, 7^2, 7^2, 7^3, 7^3, 7^3, 7^3$; $1^1, 1^2, 1^2, 1^2, 1^3, 1^3, 1^3, 1^3, 1^3, 1^3, 1^3$; $2^1, 2^1, 2^1, 3^1, 3^1, 4^1, 2^2, 2^2, 4^2, 9^1, 3^2$

7^3, 1^4, 3^2

7 (3)
1 (4)
2 (3)

Virtual memory part-2

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$4GB = 2^{32}$ Bytes

$1GB = 2^{30}$ Bytes

LA: 32 bits

PA: 30 bits

→ Consider a Logical address space of $\boxed{\text{4 GBytes}}$ and physical address space is 1 GBytes. Assume that Page Size is $\boxed{\text{4 KBytes}}$. Each entry of the page table also includes $\boxed{\text{14 bits}}$ for the book-keeping. what is the size of the page table?

32

P.No.	offset
20	12

$4KB = 2^{12}$

30

F.No	offset
18	12

i^{th}

2^{20} Pages

P.No	F.No.	B.K
	18	14

$= 32$ bits

$2^{20} \times 32$ bits

$2^{20} \times 4$ Bytes

$\boxed{\text{4 MBytes}}$

Virtual memory part-2

→ Consider a Virtual memory system which uses demand Paging having 34-bit logical addresses. physical address Space is 2GBytes. the Size of the Page is 8KBytes If Each entry of the Page table includes 6-bits for book-keeping, then how many frames are required to store the Page table?

34-bits   31-bits

$8\,KB = 2^{13}$ Bytes

No. of Frames $= \frac{6 \times 2^{20}}{2^{13}}$

128×6

768

Sol.

P.No	offset
21	13

(34)

F.No	offset
18	13

(31)

2^{21}

F.No.	B.K
18	6

= 24 bits

$2^{21} \times 3$ Bytes

$\boxed{6\,MBytes}$

$6 \times 2^{7} = 6 \times 128 = 768$ ✓

Virtual memory part-2

→ A Process has been allocated 3 Page frames. Pure demand Paging is used. The sequence of page references are as follows.

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

Find the no. of page faults in OPTIMAL and LRU Page replacement policies respectively?

Optimal

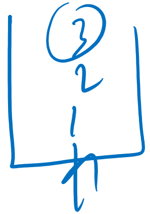
Knowledge of Future reference is required.

Sol :-

Optimal

1	1	1	1	1	1	1
	2	2	7	4	5	6
		3	3	3	3	3

→ 7 Faults



LRU [Least Recently used]

1	1	1	1	4	4	4	3	3
	2	2	7	7	7	6	6	6
		3	3	3	5	5	5	1

→ 9 Faults.

Virtual memory part-2

→ Consider the following reference string.

1, 2, 3, 4, 1, 4, 5, 3, 1, 2, 3, 4, 5

Find the no. of page faults using FIFO, for 3 and 4 page frames respectively. Assume that initially memory is empty. check for Belady's Anamoly ?

Sol :-