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Course: Operating Systems

Section: AM

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Assignment 1

Q 1. Multiple jobs can run in parallel and finish faster than if they had run sequentially. Suppose that 2 jobs, each of which needs 5 minutes of CPU time, start simultaneously. How long will the last one take to complete if they run sequentially? How long if they run in parallel? Assume 30% I/0 wait. (20 points)

Ans 1.

p = each of which needs 5 minutes of CPU time 30% I/0 = 30% = 0.3
n = 2 jobs = 2
$CPU\ Utilization$ = ?

Formula:

$$\boldsymbol{CPU\ Utilization = 1 - p^n}$$

Solution:

Simultaneously:

$CPU\ Utilization = 1 - p^n$
$CPU\ Utilization = 1 - (0.3)^1$
$CPU\ Utilization = 0.7 = 70\%$

CPU time = 5 mins,
Total job time = 10 mins each
Total time to complete if sequential:

Sequential = CPU time/*CPU Utilization*
Sequential = 5/0.7.
Sequential = 7.14 $minute$.

Total Sequential = 7.14 * 2 = **14.28 *minute***

Parallel:

$CPU\ Utilization = 1 - p^n$
$CPU\ Utilization = 1 - (0.3)^2$
$CPU\ Utilization = 0.91 = 91\%$

CPU time = 5 mins,
Total job time = 10 mins each
Total time to complete if parallel:

Parallel = CPU time/*CPU Utilization.*
Parallel = 5/0.91.
Parallel = 5.49 $minute$.

Total Sequential = 5.49 * 2 = **10.98 *minute***

Q 2. For this question, consider each part as in continuation with the previous one. Suppose that a computer has 64 GB of Memory, with the Operating System taking up 1 GB, and each User Process taking up 512 MB.

a) How many User Processes can simultaneously run in the computer? (4 points)

n = (Total Memory – Operating System Memory) / each User Process
n = (64 GB – 1 GB) / 512 MB
n = 63 GB / 512 MB
n = (63 * 1000) MB / 512 MB
n = 64512 MB / 512 MB
n = 126 Processes

b) If the I/O wait for each User Process is 35%, calculate CPU Utilization and CPU Waste. (8 points)

p = 35% = 0.35,

n = 126

$$\boldsymbol{CPU\ Utilization = 1 - p^n}$$

$$CPU\ Utilization = 1 - 0.35^{126}$$
$$\boldsymbol{CPU\ Utilization = 100\%}$$

$$\boldsymbol{CPU\ Waste} = 1 - CPU\ Utilization$$
$$\boldsymbol{CPU\ Waste = 1 - 1 = 0\ \%}$$

c) If 32 GB of Memory is now added to the computer, how many User Processes can now simultaneously run? (4 points)

n = (Total Memory + 32 GB – Operating System Memory) / each User Process
n = (96 GB – 1 GB) / 512 MB
n = 95 GB / 512 MB
n = (95 * 1000) MB / 512 MB
n = 97,280 MB / 512 MB
n = 192 Processes

d) Calculate the new CPU Utilization and CPU Waste. (8 points)

p = 35% = 0.35,

n = 192

$\boldsymbol{CPU\ Utilization = 1 - p^n}$

$CPU\ Utilization = 1 - 0.35^{192}$

$\boldsymbol{CPU\ Utilization = 100\%}$

$\boldsymbol{CPU\ Waste} = 1 - CPU\ Utilization$

$\boldsymbol{CPU\ Waste = 1 - 1 = 0\ \%}$

e) How many User Processes are simultaneously running in the computer defined in Part (c), if at an instant of time CPU Waste is 20%? (4 points)

$\boldsymbol{p = 0.35,}$

$\boldsymbol{CPU\ Waste = 20\ \% = 0.2}$

$\boldsymbol{n = ?}$

$\boldsymbol{CPU\ Waste} = p^n$

$0.2 = 0.35^n$

$\text{Log}_{0.35}\ 0.2 = \text{Log}_{0.35}\ 0.35^n$

$\text{Log}_{0.35}\ 0.2 = n$

$n = 1.533 \Rightarrow 1$

f) What would be the maximum I/O wait that can be tolerated for each User Process, in the computer defined in Part (c), if at an instant of time, 50 User Processes are simultaneously running, and the goal is 40% CPU Utilization?

Here, $n = 50$, $CPU\ Utilization = 40\% = 0.4$ and $p = ?$

$\boldsymbol{CPU\ Utilization = 1 - p^n}$

$0.7 = 1 - p^{50}$

$p^{50} = 0.4$

$p = \sqrt[50]{0.4}$

p = 0.9818

p = 98.18%