CS 3220-AM,BM,CM: Operating Systems

Assignment 1

Date Assigned: Apr 21st, 2021 Date Due: Apr 25th, 2021

(**Total Score**: 52 points)

(**Questions**: 2)

Instructions:

Labels of all figures and tables are mentioned below the figures and tables respectively. Show all your working where required. Provide all numerical results with two digits of precision only.

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 10 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 90% I/0 wait. **(20 points)**

Q 2. Suppose that a computer has 128 GB of Memory, with the Operating System taking up 512 MB, and each User Process taking up 512 MB.

- **a)** How many User Processes can simultaneously run in the computer? **(4 points)**
- **b)** If the I/O wait for each User Process is 95%, calculate CPU Utilization and CPU Waste. **(8 points)**
- **c)** If 64 GB of Memory is now added to the computer, how many User Processes can now simultaneously run? **(4 points)**
- **d)** Calculate the new CPU Utilization and CPU Waste. **(8 points)**
- **e)** How many User Processes (each with I/O wait of 95%) are simultaneously running in the computer defined in Part (c), if at an instant of time CPU Waste is 70%? **(4 points)**
- **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 70% CPU Utilization? **(4 points)**

A 1. Each job takes 10 minutes of CPU time, and has 90% I/O wait, i.e. $p = 0.9$.

If the 2 jobs run sequentially:

$$CPU\ Utilization = 1 - p^1$$

$$= 1 - 0.9^1 = 0.1 = 10\%$$

Hence, each job takes $10/CPU\ Utilization = 10/0.1 = 100\ minutes$ of total time in real. The total time the last job will take to complete (from beginning of first job to ending of second job) is $100 \times 2 = 200\ minutes$.

If the two jobs run in parallel:

$$CPU\ Utilization\ =\ 1\ -\ p^n$$

$$=\ 1\ -\ 0.9^2 =\ 0.19 = 19\%$$

Each job takes $10/CPU\ Utilization = 10/0.19 = 52.63\ minutes$ of total time in real. The total time the last job will take to complete (from beginning of first job to ending of second job) is $52.63 \times 2 = 105.26\ minutes$.

A 2. The computer has 128 GB of Memory, with the Operating System taking up 512 MB, and each User Process taking up 512 MB.

a) $Total\ number\ of\ User\ Processes\ that\ can\ simultaneously\ run\ in\ the\ computer\ = n = \frac{128GB - 512MB}{512MB} = \frac{(128\times1024)MB - 512MB}{512MB} = \frac{130{,}560MB}{512MB} = 255$

b) Here, $p = 0.95$

$$CPU\ Utilization\ =\ 1\ -\ p^n$$

$$=\ 1\ -\ 0.95^{255} =\ 0.9999 = 99.99\%$$

$$CPU\ Waste\ =\ 1\ -CPU\ Utilization$$

$$= 1 -\ 0.9999 = 0.0001 = 0.01\%$$

c) The computer has 192 GB of memory now, with the operating system taking up 512 MB, and each user process taking up 512 MB.

$$Total\ number\ of\ User\ Processes\ that\ can\ simultaneously\ run\ in\ the\ computer = n$$
$$= \frac{192GB\ -\ 512MB}{512MB} = \frac{(192 \times 1024)MB -\ 512MB}{512MB} = \frac{196{,}096MB}{512MB} = 383$$

d)

$$CPU\ Utilization\ =\ 1\ -\ p^n$$

$$= 1 - 0.95^{383} = 0.9999 = 99.99\%$$

$$CPU\ Waste = 1 - CPU\ Utilization$$

$$= 1 - 0.9999 = 0.0001 = 0.01\%$$

e) Here, $p = 0.95, CPU\ Waste = 0.7$ and n =?

$$CPU\ Waste = p^n$$

$$0.7 = 0.95^n$$

$$log_{0.95}0.7 = log_{0.95}0.95^n$$

$$log_{0.95}0.7 = n$$

$$n = \frac{log_2 0.7}{log_2 0.95} = \frac{-0.52}{-0.07} = 7.43 \approx 7$$

f) Here, $n = 50, CPU\ Utilization = 0.7$ and p =?

$$CPU\ Utilization = 1 - p^n$$

$$0.7 = 1 - p^{50}$$

$$p^{50} = 0.3$$

$$p = \sqrt[50]{0.3} = 0.9762 = 97.62\%$$