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Section: BSCS-6B

Assignment→ Amdahl's law for stand alone system

Problem 1:→ A system has a processor which takes 40% of the total execution time & can be improved by 50%. What is the maximum theoretical speedup we can achieve on this system?

Solution: According to Amdahl's law the maximum theoritical speedup is given by.

Max speedup = $1/[1-(P+(1-P)/S)]$

where P is the fraction of the program that cannot be parallelized & S is the speedup factor.

$S = 1+0.5 = 1.5$

$P = 0.4\ (40\%)$, $S = 1+50\% = 1.5$

max speedup $= 1/[1-(0.4+(1-0.4)/1.5)]$

$= 1/[1-0.8] = 5$

= 5, Therefore the max theoretical speedup can be acheived is $\boxed{5}$

Problem #2 A computer program has a serial portion that takes up 60% of the total execution time. If we can parallelize the remaining 40% of the program & acheive a speedup factor of 2. What is the maximum theoretical speedup we can acheive on this system?

Solution:

According to Amdahl's law

$$\text{Max Speedup} = \frac{1}{(1-P)+\frac{P}{S}}$$

where P is the fraction of program that can't be parallelized & S is speedup factor of parallelized part

$P = 0.6\ (60\%)$, $S = 2$

$$\text{Max speedup} = \frac{1}{(1-0.6)+\frac{0.6}{2}}$$

$$= \frac{1}{(1-0.8)}$$

$$= 5$$

Therefore the maximum theoretical speedup we can acheive on this system is $\boxed{5}$

Amdahl's law for Standalone system:-

It is a formula that calculate the maximum speedup that can be acheived when performing ~~that~~ task on system with multiprocessor & cores for standalone systems. It states that the max speedup is limited by the serial portion of the program.

Amdahl's law for distributed System

Explaination: In a distributed system, Amdahl's law takes into account both communication overhead & the serial portion of the program. The formula is similar to the standalone but with an additional term that accounts for the time spend communication b/w the processor.

Problem #1 A distributed system has a task that requires two sub-tasks to be completed. sub-task A cannot be parallelized & takes 60% of the total time, while sub-task B can be parallelized & takes 40% of the total time. if we add 4 more nodes to the system & sub-task B can be perfectly parallelized. what is the max theoritical speedup we can achieve on this system.

Solution

In a distributed system, Amdahl's law can be applied to each sub-task individually & then combined to calculate the overall max speedup.

For sub-task A, since it can't be parallelized.

$$\text{max speedup} = \frac{1}{(1-0.6)} = 2.5$$

For sub-task B with 4 nodes, the speedup factor is equal to the number of nodes added

$S = 4+1 = 5$

$\boxed{S=5}$

Therefore max speedup we can achieve is

$$= \frac{1}{\left(\frac{0.4}{5}+0.6\right)} = \boxed{2.5}$$

$$= \frac{1}{P + \left(\frac{1-P}{S-A} + \frac{1-P}{S-B}\right)}$$

So $P = 0.6$, $S-A = 2.5$ & $S-B = 2.5$

$$\text{max speedup} = \frac{1}{0.6 + \left(\frac{0.4}{2.5} + \frac{0.4}{2.5}\right)}$$

$$= \frac{1}{0.6 + 0.16 + 0.16}$$

$$= \frac{1}{0.92}$$

$$= \boxed{1.09}$$

Therefore, the maximum theoretical speedup we can achieve with 4 additional nodes is $\boxed{1.09}$.

Problem #2: A distributed system has a task that can be divided into 4 sub-tasks each taking an equal amount of time. The system has 8 nodes, but due to communication overhead only 95% of the sub-task can be parallelized. What is the max theoretical speedup we can acheive on this system?

Solution:

In this case, we use Amdahl's law to calculate the maximum theorithical speedup for each sub-task

$$\text{max speedup} = \frac{1}{P + \left(\frac{1-P}{S}\right)}$$

where P is the fraction of the sub-task that can't be parallelized & S is the speedup factor.

Sample 2

5

$P = 0.05$ (95% can be parallelized)

$N = 8 + 1 = 9$ (8 nodes +1 for serial portion)

max speedup for each subtask $= \dfrac{1}{0.05 + \left(\dfrac{1-0.05}{9}\right)}$

$= 9.82$

The overall maximum theoretical speedup is given by the combined effect of all 4 sub-task

$$\text{max speedup} = \frac{1}{P + \left(\frac{1-P}{S1}\right) + \left(\frac{1-P}{S2}\right) + \left(\frac{1-P}{S3}\right) + \left(\frac{1-P}{S4}\right)}$$

where P is fraction of the program that can't be parallelized & S1, S2, S3, S4 are speedup factor for each of the 4 sub-tasks.

Here $P = 0.05$

$S1 = S2 = S3 = S4 = 9.82$

$$\text{Max speedup} = \frac{1}{0.05 + \left(\frac{1-0.05}{9.82}\right) + \left(\frac{1-0.05}{9.82}\right) + \left(\frac{1-0.05}{9.82}\right) + \left(\frac{1-0.05}{9.82}\right)}$$

$= 5.48$

Therefore the maximum theoretical speedup we can achieve on this system is

$\boxed{5.48}$

Problem ... 5

P = 0.05 (95% can be parallelized)

S = 8 + 1 = 9 (8 nodes + 1 for serial portion)

max speedup for each sub-task $= \dfrac{1}{0.05 + \left(\dfrac{1-0.05}{9}\right)}$

$= 1.82$

The overall maximum theoritical speedup is given by the combined effect of all 4 sub-task

$$\text{max speedup} = \frac{1}{P + \left(\frac{1-P}{S1}\right) + \left(\frac{1-P}{S2}\right) + \left(\frac{1-P}{S3}\right) + \left(\frac{1-P}{S4}\right)}$$

where P is fraction of the program that can't be palallized & S1, S2, S3, S4 are speedup factor for each of the 4 sub-tasks.

Here P = ~~0.0~~ 0.05

S1 = S2 = S3 = S4 = 1.82

$$\text{Max speedup} = \frac{1}{0.05 + \left(\frac{1-0.05}{1.82}\right) + \left(\frac{1-0.05}{1.82}\right) + \left(\frac{1-0.05}{1.82}\right) + \left(\frac{1-0.05}{1.82}\right)}$$

$= 3.48$

Therefore the maximum theoritical speedup we can achieve on this system is

$\boxed{3.48}$