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Section : BCS-6A

Subject : Parallel Distributed Computing

Assignment: Amdahl's Law

Q:- Write Amdahl's law. For Stand alone and distributed systems Write and explain 2 to 3 Numericals of your choice.

Ans:- Amdahl's law is a law governing the speedup of using parallel processors on a problem, versus using only one serial processor, under the assumption that the problem size remain the same when parallelized.

• **Speedup:**

• Speedup metric is a quantitative measure of performance, which defines benefits of running a program in parallel.

• Speedup is the ratio of the time it takes to execute in serial (with one processor) to the time it takes to execute in parallel (with many processors).

Formula For SpeedUp

$$S(n) = \frac{T(1)}{T(n)} \Rightarrow \frac{\text{Time taken to execute on single processor}}{\text{Time taken to execute on multiple processor}}$$

For Example: $T(1) = 1$ sec & if $n = 2$ processors then $T(2) = \frac{1}{2} = 0.5$ sec

Hence $$S(n) = \frac{T(1)}{T(2)} = \frac{1}{0.5} = 2$$

mean Speedup increases by 2 times.

- The potential speedup of an algorithm on parallel computing platform is given by Amdahl's law.
- Amdahl's Law tells that for a given problem size, the speedup does not increase linearly as the number of processor increases. In fact, speedup tend to become saturated.
- Amdahl's law states that a small portion of the program which cannot be parallelized (serial part), will limit the overall speed-up, available from parallelization.

Computation Problem = Serial Part + Parallel Part

Amdahl's Law

- f indicate serial part that we will run sequentially.
- $0 \leq f \leq 1$

Maximum Speedup Achievable by a parallel computer with n processor is

$$\text{Maximum Speedup} = S(n) \leq \frac{1}{\underbrace{f}_{\text{Serial Part}} + \underbrace{\frac{(1-f)}{n}}_{\text{Parallel Part}}}$$

Proof of Amdahl's law

(a) Single Processor

$f t_s$	$(1-f) t_s$
Serial Section	Parallel Section

Let the total time taken is (1) and f indicates serial time and t_s (time taken when code run serially)
Then the time taken by parallel part will be $(1-f)t_s$
and 1 is the total time & remaining time will parallel section time.

Time To Perform Computation with Single Processor

$$t_s = f t_s + (1-f) t_s$$

$$= \cancel{f t_s} + t_s - \cancel{f t_s}$$

$$\boxed{t_s = t_s}$$

Time To Perform Computation in multiple 'n' processors

Time taken ~~to~~ to run serial part code will be same but the parallel part will be divided by n.

So, t_p indicate time in multiple processors.

$$t_p \geq f t_s + \frac{(1-f) t_s}{n}$$

Overall Speedup Factor will be:

$$S(n) = \frac{T(1)}{T(n)} = \frac{t_s}{t_p} = \frac{\text{Serial Execution time}}{\text{Parallel Execution time}}$$

$$S(n) = \frac{t_s}{t_p} \leq \frac{t_s}{f t_s + \frac{(1-f) t_s}{n}}$$

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$$= \frac{1}{f + \frac{(1-f)}{n}}$$

$$\boxed{S(n) \leq \frac{1}{f + \frac{(1-f)}{n}}}$$ → This is know as Amdahl's law.

By Further Solving

$$S(n) \leq \frac{n}{nf + (1-f)} = \frac{n}{1 + (n-1)f}$$

Problem 1: 70% of a program execution occurs inside a loop that can be executed in parallel and rest 30% in serial. What is the maximum speedup we should expect from a parallel version of the program executing on 8 CPU.

Solution:

$$S(n) \leq \frac{1}{f + \frac{(1-f)}{n}}$$

$$= \frac{1}{0.30 + \frac{(1-0.30)}{8}}$$

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$$= \frac{1}{0.3875}$$

$$\boxed{S(n) \le 2.6}$$

2.6 speedup if we use 8CPU's.

Problem 2: 80% of a program execution time occurs inside a loop & can be executed in parallel. & 20% is serial. What is the maximum speedup should we expect from a parallel version of the program executing on 8CPUS?

Solution:

$$S(n) = \frac{1}{0.20 + \frac{(1-0.20)}{8}} \Rightarrow \frac{1}{0.30}$$

$$= 3.33$$

Problem 3: If Parallel Part is 95% & 5% serial Now what is the Maximum Speedup.

Solution:

$$S(8) = \frac{1}{0.05 + \frac{(1-0.05)}{8}}$$

$$\boxed{S(8) \simeq 5.9}$$