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Unit-4 → Performance Laws

Amdahl's Law

It is a law governing the speed-up by using parallel processors on a problem, vs using only one serial processor, under the assumption that the problem size remains the same when parallelized

eg – A → Car, B → Bus, C → walk → have to go to Party @ 5pm

could not join

Ily there are some processors which can't run parallel, they have to be sequential

Speedup $= \frac{T(1)}{T(n)}$

$= \frac{\text{Time taken to execute the program using single processor (sequential)}}{\text{Time taken to execute the prog using n no. of processors.}}$

eg – If $T(1) = 1$ sec, $n = 2$, then you take $= 0.5$ sec.

$S = \frac{T(1)}{T(n)} = \frac{1}{0.5} = 2$ (speedup ↑ces by 2 times)

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Characterizations

① It is based on fixed problem size
(But ideally, if no. of processors ↑, use ↑ the work load - problem size for maintaining efficiency of the system

* Amdahl's law tells that for a given problem size the speed up doesnot ↑se linearly as the no of processors.
The speedup tends to become saturated - doesnot ↑se after a point.

* It states that a small portion of the prog, which cannot be parallelized (serial part) will limit the overall speedup.

Computation problem = Serial part + Parallel part

Let 'f' be the fraction of operations in a computer that must be performed sequentially where $0 \le f \le 1$. The max. speedup achievable by a parallel computer with n processors is :-

Learn

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

f → serial part, $\frac{(1-f)}{n}$ → parallel part

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

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Quest 70% of a program's execution time occurs inside a loop that can be executed in parallel and rest 30% in serial. What is the max speedup we should expect from a parallel version of the program executing on 8 CPUs.

Solⁿ

$f = 0.3 =$ serial part
$n = 8$

$$S(8) \le \frac{8}{1 + (0.3 \times 7)}$$

$$S(8) \le 2.58$$

For 80% : 20%

speedup = 3.33

⇒ speedup ↑ses when processors are doing parallel processing

—x—

Ques2 Let a program have 40% of its code enhance to yield a system speedup 2.3 times faster. ~~than~~ What is the factor of improvement of the portion enhanced?

Ans2 40% enhanced → 2.3 times faster
(use formula of next page)

$$S = \frac{1}{(1-0.4) + \left(\frac{0.4}{2.3}\right)} = 1.292$$

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Ques Let a program have 40% of its code enhanced to run 2.5 times faster. What is the overall system speedup?

Zahra ppt

T = execution time before improvement
p = fraction of part benifitted from improvement

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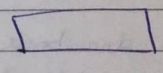
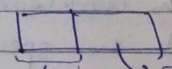
Let's — workload is fixed in Amdah's

CPU old  1 (takes 1 cycle)

CPU new 

1 − Fenhanced (unhenced) ← → Fenhanced (fraction enhanced portion of data)

takes same time (1 − F)

$\frac{F}{S}$ → at what scale it will be enhanced?

time taken by enhance part

Prachi Prachi Prachi

$$\boxed{S_{all} = \frac{t_{old}}{t_{new}} = \frac{1}{(1-F) + \frac{F}{S}}}$$

unenhanced, enhanced

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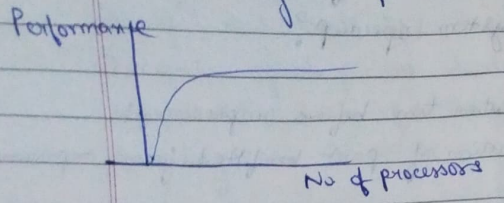
Performance becomes saturated as you keep on increasing the processors, as overhead also ↑s



But ideally, workload also increases as the no. of processors ↑se

This was the drawback of Amdahl's bcz it kept the workload constant and only ↑sed the speedup.
not dynamic workload

—— x ——

Gustafson's Law

- used for scaled programs
- we are scaling for higher accuracy
- Fixed time speedup (speedup doesnot change, ~~workload~~ workload & no. of processor changes)

$$T_p = t_s^* + t_p^*$$

t_s^* → computational time needed for sequential part

t_p^* → computational time needed for parallel part

- workload changes here

$$\boxed{S = f^* + N \cdot (1 - f^*)}$$

S → speedup, N → no. of processors, f^* → dynamic workload

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Ques 1- 10% of time on a 32 processor machine is spent on one single processor. Compute the scaled speedup using Gustafson's Law.

$f^* = 0.1$, $N = 32$

$S = 0.1 + 32(1 - 0.1)$

$\boxed{S = 28.9}$

—— x ——

Sun & Lee → Nahi karna ✗

—— x ——

Performance Benchmarks

Benchmarking?
It is measuring how the performance of something varies as you change the parameters.

In HPC systems, things that can vary are →

1. no. of parallel processes
2. no. of threads
3. distribution of processors / threads
4. i/p parameters.

→ All these result in performance variations.

Benchmarking - used for scaling
- Dhrystone Benchmark
- Whetstone Benchmark

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Dhrystone Benchmark

- This benchmark is used to measure and compare the performance of different computers, or the efficiency of the code generated for the same computer by different compilers.

- code gives ~~same~~ approx same performance irrespective of the compiler.

★★ - It uses no floating point operations.

Advantages
1. You can compare results of processors of different architecture.
2. Easy to compile & port (works on micro controller)

Disadv - ~~from PPT~~
1. uses a limited set of features
2. Doesn't allow you to use all the capabilities of the processor.
3. Strange code
4. The results are very dependent on compiler optimizations.

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Whetstone Benchmark

- It is used for evaluating the performance of both int & floating point nos. in CPU.

——— Unit - 4 done ———

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Unit - 5
Memory & Cache Coherency
(Completely theoretical)

Consistency
- needs to be maintained when sharing data.

what?

CPU	Cache	MM
	x=10	x=5

Not consistent X

Memory Consistency Model
A Consistency Model refers to the d. ...

from PPT

CPU	Cache	MM
P1	10	5
	x=5	

P2 → read x=10 — x=5 — inconsistent

⇒ next read should be from where then was last write to avoid inconsistency