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Homework Chapter 1 – 1.12 & 1.15 (Extra Credit)

1.12) Section 1.10 cites as a pitfall the utilization of a subset of the performance equation as a performance metric. To illustrate this, consider the following two processors. P1 has a clock rate of 4 GHz, average CPI of 0.9, and requires the execution of 5.0E9 instructions. P2 has a clock rate of 3 GHz, an average CPI of 0.75, and requires the execution of 1.0E9 instructions.

Answer:

Processor	Clock Rate	CPI	Instructions
P1	4GHz = 4×10^9Hz	0.9	5.0E9 = 5×10^9
P2	3GHz = 3×10^9HZ	0.75	1.0E9 = 1×10^9

<u>Formula to Calculate CPU Time:</u>

CPU Time = CPI x Instruction Count / Clock Rate

→ Calculate execution time for P1 by substituting the values from the provided formula.

CPU Time = CPI x Instruction Count/ Clock Rate
$P1_{CPU} = 0.9 \times 5 \times 10^9 / 4 \times 10^9$
$= 0.9 \times 5 / 4$
$= 4.5 / 4$
$= 1.125$s

→ Calculate execution time for P2.

CPU Time = CPI x Instruction Count / Clock Rate
$P2_{CPU} = 0.75 \times 1 \times 10^9 / 3 \times 10^9$
$= 0.75 / 3$
$= 0.25$s

Therefore, CPU time of P1 ($P1_{CPU} = 1.125$s) is greater than the CPU time of P2 ($P2_{CPU} = 0.25$s).
Processor P2 performs better than the processor of P1.
Although that the clock rate of P1 is greater than the clock rate P2.
P2 performs better than P1, and the statement “the computer with the largest clock rate have the largest performance” is FALSE.

Extra Credit :: 1.15) When a program is adapted to run on multiple processors in a multiprocessor system, the execution time on each processor is comprised of computing time and the overhead time required for locked critical sections and/or to send data from one processor to another.

Assume a program requires t = 100 s of execution time on one processor. When run p processors, each processor requires t/p s, as well as an additional 4 s of overhead, irrespective of the number of processors. Compute the per-processor execution time for 2, 4, 8, 16, 32, 64, and 128 processors. For each case, list the corresponding speedup relative to a single processor and the ratio between actual speedup versus ideal speedup (speedup if there was no overhead).

Table below calculates the execution time and total time:

Processor 'p'	Execution Time = t/p (secs)	Total Time = t/p + 4 (secs)
1	100	100
2	50	54
4	25	29
8	12.5	16.5
16	6.25	10.25
32	3.125	7.125
64	1.5625	5.5625
128	0.78125	4.78125

→ Relative speed up is the ratio of execution time for one processor to the execution time of 'p' processors. The table shows the calculation of relative speedup.

Processor 'p'	Execution Time = t/p(secs)	Total time = t/p +4 (sec)	Relative Speedup
1	100	100	
2	50	54	100 / 54 = 1.85
4	25	29	100 / 29 = 3.45
8	12.5	16.5	100 / 16.5 = 6.06
16	6.25	10.25	100 / 10.25 = 9.76
32	3.125	7.125	100 / 7.125 = 14.04
64	1.5625	5.5625	100 / 5.5625 = 17.98
128	0.78125	4.78125	100 / 4.78125 = 20.92

→ Now we can calculate Actual Speed Up vs Ideal Speedup

Processor 'p'	Execution Time = t/p(secs)	Total time = t/p +4 (sec)	Relative Speedup	Actual/Ideal
1	100	100		
2	50	54	100 / 54 = 1.85	1.85/2 = 0.93
4	25	29	100 / 29 = 3.45	3.45/4 = 0.86
8	12.5	16.5	100 / 16.5 = 6.06	6.06/8 = 0.76
16	6.25	10.25	100 / 10.25 = 9.76	9.76/16 = 0.61
32	3.125	7.125	100 / 7.125 = 14.04	14.04/32 = 0.44
64	1.5625	5.5625	100 / 5.5625 = 17.98	17.98/64 = 0.28
128	0.78125	4.78125	100 / 4.78125 = 20.92	20.92/128