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Tutorial - 2

① Given that 40% of the time is consumed by the floating point operations

The speed up factor of floating point module is K

The formula for overall speedup is

$$S = \frac{1}{(1-P)+\frac{P}{K}}$$

proportion of floating point operations in the task is

$P = 0.4$

$$\Rightarrow S = \frac{1}{(1-0.4)+\frac{0.4}{K}} = \frac{1}{0.6+\frac{0.4}{K}} = \frac{K}{0.6K+0.4}$$

$$\boxed{S = \frac{K}{0.6K+0.4}}$$

② Given the benchmark program execution time is 480 sec

program execution time in system B is 360

$$\Rightarrow \text{Speed up of } B = \frac{\text{time execution of benchmark system}}{\text{time execution of system } B}$$

$$= \frac{480}{360} = \boxed{1.33}$$

program execution time in system C is 540 secs

$$\Rightarrow \text{Speedup of } C = \frac{480}{540} = \boxed{0.88}$$

program execution time in system D is 210 secs

$$\Rightarrow \text{Speed up of } D = \frac{480}{210} = \boxed{2.285}$$

③ Given that 20% of the total execution time has a bottleneck → Assuming that this is not parallelizable

⇒ 80% of the total execution time is parallelizable
(or) $P = 0.8$

Speedup achieved $= \dfrac{1}{(1-P) + \frac{P}{N}}$

where N = number of processors which is 5

$$\Rightarrow \frac{1}{(1-0.8)+\frac{0.8}{5}} = \frac{1}{0.2+\frac{0.8}{5}} = \frac{1}{0.2+0.16}$$

$$= \frac{1}{0.36} = 2.78$$

$$\therefore \boxed{S \simeq 2.78}$$

④ (a) Given that performance of 5% of the system can be doubled (which means speedup factor $K=2$)
⇒ $P_1 = 0.05$

So overall speedup contribution of component 1 $\left(\dfrac{1}{(1-P)+\frac{P}{K}}\right)$ $= \dfrac{1}{(1-0.05)+\frac{0.05}{2}} = \dfrac{100}{97.5}$

(b) Here it is given that 20% of system performance can be improved by 80% (Speedup factor $= \dfrac{1}{1-0.80} = 5$)

$P = 0.2$

⇒ overall speedup contribution of component 2 $= \dfrac{1}{(1-0.2)+\frac{0.2}{5}} = \dfrac{100}{84}$

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(c) Give that performance of 45% of system can be improved by 50% $\Rightarrow$ Speed up factor $k = \frac{1}{1-0.5} = 2$

$P = 0.45$

$\Rightarrow$ Overall Speedup contribution of component 3 $= \frac{1}{(1-0.45) + \frac{0.45}{2}}$

$= \frac{100}{77.5}$

(d) The remaining part has no contribution

$\therefore$ Clearly from the above, we can see that the component 3 have more speedup contribution compared to others

(5) (a) Given that floating point instructions account for 65% of the total execution time ($P = 0.65$)

$\Rightarrow$ The enhancement makes floating point instructions 7 times faster ($k = 7$)

Using Speedup formula $S = \frac{1}{(1-P) + \frac{P}{k}}$

$\Rightarrow \quad S = \frac{1}{(1-0.65) + \frac{0.65}{7}}$

$$\boxed{S = \frac{1}{0.442857} \approx 2.26}$$

So overall speed up is 2.26

The original speedup factor is $K = 1$

$\Rightarrow$ % increase in speed up is $\frac{2.26 - 1}{1} \times 100$

$$\boxed{= 126\%}$$

(b) The total execution time before enhancement is 29 secs

Two thirds of 29 secs is spent on FPI's

$\Rightarrow$ time spent on FPI's $= \frac{2}{3} \approx 0.667 \approx P_{new}$

$$\Rightarrow S_{new} = \frac{1}{(1 - P_{new}) + \frac{P_{new}}{K}}$$

$$= \frac{1}{(1 - 0.667) + \frac{0.667}{7}} \approx \frac{1}{0.4285}$$

$$\approx 2.33$$

So the speedup with 2/3 of the execution time spent on FPI's is approx 2.33

⑥ (a) Given N processors also given that 80% of the application is parallelizable so ignoring the cost of communication, the speedup is given by

$$S = \frac{1}{(1 - P) + \frac{P}{N}} = \frac{1}{(1 - 0.8) + \frac{0.8}{N}}$$

$$S = \frac{1}{0.2 + \frac{0.8}{N}} = \boxed{\frac{N}{0.2N + 0.8}}$$

(b) Given there are now 8 processors

Assuming that the communication overhead is for all 8 processors

so speedup is given by $\dfrac{1}{(1-p)+\frac{p}{N}+\text{Comm overhead}}$

$\text{Comm overhead}_{(N)} = \underline{\underline{\text{No}}} \text{ of processors} \times \%\text{ overhead of original execution time}$

$$= \frac{8 \times 0.5}{100} = \frac{4}{100} = 0.04$$

$$\therefore \text{Speedup} = \frac{1}{(1-0.8)+\frac{0.8}{8}+0.04}$$

$$S = \frac{1}{0.34} \approx \boxed{2.94}$$

(c) Given $N = 8$ processors

Communication overhead increases by 0.5% each time the number of processors doubles

$\Rightarrow \text{Total overhead} = \log_2(N) \times \%\text{ overhead of original execution time}$

$$= \log_2 8 \times 0.005$$

$$= 0.015$$

Hence speedup is given by

$$S(N) = \frac{1}{1-p+\frac{p}{N}+\text{total overhead}}$$

$$= \frac{1}{1-0.8+\frac{0.8}{8}+0.015}$$

$$S(8) = \frac{1}{0.315} \approx \boxed{3.17}$$

(d) Similar to the above question, here we are given N instead of 8

So total overhead $= 0.005 \times \log_2(N)$

$$\Rightarrow \boxed{\text{Speedup} = \frac{1}{(1-0.8)+\frac{0.8}{N}+\log_2 N(0.005)}}$$

(e) for N processors, we have

$$\text{Speedup} = \frac{1}{(1-\frac{P}{100})+\frac{P}{100N}+\text{overhead}(N)}$$

$$\text{overhead}(N) = 0.005 \times \log_2(N)$$

$$\Rightarrow S(N) = \frac{1}{(1-\frac{P}{100})+\frac{P}{100N}+0.005 \times \log_2(N)}$$

for maximum speedup $\Rightarrow \cancel{\frac{d}{dS(N)} = d}$

$$\frac{d}{dN}(S(N)) = 0$$

$$\Rightarrow \frac{dS}{dN} = \frac{-1}{\left((1-\frac{P}{100})+\frac{P}{100N}+0.005\log_2 N\right)^2} \times \left(\frac{-P}{100N^2}+\frac{0.005}{N\ln 2}\right) = 0$$

We can take $\frac{-P}{100N^2} + \frac{0.005}{N\ln 2}$ as first term $= 0$ for $N \to \infty$

$$\Rightarrow \frac{0.005}{\cancel{N}\ln 2} = \frac{P}{100N^{\cancel{2}}}$$

$$\frac{\cancel{5}}{2\cancel{1000}\ln 2} = \frac{P}{1\cancel{00}N}$$

$$\boxed{N = 2P\ln 2}$$ where N is an integer so we can use G.I.F (N)