8)

Performance Laws

1) A uniprocessor computer can operate in either scaler or vector mode. Certain benchmark program took time t to run on the comp. Further its found that 25% of t was attributed to vector mode. In the remaining time machine op. in scaler mode.

a) Calc. effective speedup under above condition as compared with when vector mode not used at all.

b) Also calculate α, % of code vectorized in above program.

a)

$$\text{speed} = \frac{\text{time without enhancement}}{\text{time with enhancement}}$$

$$T = 0.75T\,(\text{scaler}) + 0.25T\,(\text{vector})$$

Ques condt. - Vector mode is 9 times faster than scaler mode

$$\Rightarrow \text{speedup} = \frac{0.75t + 0.25t \times 9}{t} = 3$$

b)

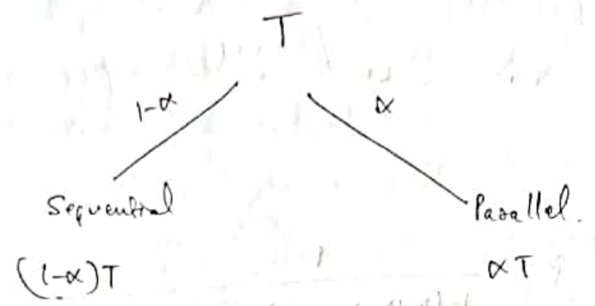
$\alpha =$

En

T_0

b)

$$\alpha = \frac{0.25t \times 9}{3t} = 0.75 \cdot 100 = 75\%$$



Enhancement only reduces parallel time

$$T_{\substack{\text{enhancement}\\ \text{with } n \\ \text{processors}}} = (1-\alpha)T + \frac{\alpha T}{n}$$

$$\text{speed}_{up} = \frac{T}{(1-\alpha)T + \frac{\alpha T}{n}} = \frac{1}{1-\alpha+\frac{\alpha}{9}}$$

$$3\left(1-\alpha+\frac{\alpha}{9}\right) = 1$$

$$3 - 3\alpha + \frac{\alpha}{3} = 1$$

$$2 = 3\alpha - \frac{\alpha}{3} \Rightarrow \alpha = \frac{3}{4}$$

$$\alpha = 75\%$$

Enhancement 1 $\alpha 1$ $S1$

Enhancement 2 $\alpha 2$ $S2$

Generalized Amdahl's Law

⋮

Enhancement n αn Sn

Overall speedup = $$\frac{1}{1-(\alpha_1+\alpha_2+\alpha_3+ - \alpha_n)+\frac{\alpha_1}{S_1}+\frac{\alpha_2}{S_2}+\frac{\alpha_3}{S_3}+ - \frac{\alpha n}{Sn}}$$

Fraction of reduced time no enhancement is used = $$\frac{1-(\alpha_1+\alpha_2+\alpha_3+ - - +\alpha_n)}{1-(\alpha_1+\alpha_2+\alpha_3+ - +\alpha_n)+\frac{\alpha_1}{S_1}+\frac{\alpha_2}{S_2}+\frac{\alpha_3}{S_3}+ - +\frac{\alpha n}{Sn}}$$

c) Suppose we double speed ratio b/w vector & scalar mode by hardware improvement. Calc. effective speedup that can be achieved.

d) Suppose same speedup obtained in c) must be obtained by compiler improvement instead of hardware. What would be new vectorization ratio α that should be supported by vectorization compiler for the same benchmark program.

c) Speedup $= \dfrac{1}{1-\alpha+\frac{\alpha}{s}} = \dfrac{1}{1-0.75+\frac{0.75}{18}} = 3.43$

d) $3.43 = \dfrac{1}{1-\alpha+\frac{\alpha}{9}}$

$3.43\left(1-\alpha+\frac{\alpha}{9}\right)=1$

$3.43\alpha - \dfrac{3.43\alpha}{9} = 2.43$

$\alpha\left(3.43-\dfrac{3.43}{9}\right)$

$3.43-0.38$

$\alpha = \dfrac{2.43}{3.05} = 0.79$

$\therefore$ 79%

Let α be the fraction of program code that can be executed simultaneously by n processors in a comp. sys. Assume that remaining code must be executed sequentially by a single processor. Each processor has an execution rate of x MIPS & all processors are assumed to be equally capable.

a) Derive exp for effective MIPS rate when using sys. for exclusive execution of this prog. in n, α, x

Let no. of instruction to be executed k millions

n processor Parallel		Sequential	
nx MIPS	αk	$(1-\alpha)k$	x MIPS

$$\Rightarrow \quad T = \frac{\alpha k}{nx} + \frac{(1-\alpha)k}{x} \text{ sec}$$

$$= \frac{k\left[\alpha + (1-\alpha)n\right]}{nx}$$

$$\text{Effective MIPS} = \frac{k}{\frac{k\left[\alpha+(1-\alpha)n\right]}{nx}} = \frac{nx}{\alpha + (1-\alpha)n}$$

hat can be
comp. sys.
ted
ors has
assumed
sys.

Consider comp which executed in 2 modes – regular & enhanced with probability distribution of α, $1-\alpha$ resp^n.

If α varies b/w a and b & ~~[illegible]~~ $0 \le a < b \le 1$.

Derive exp. for avg speed of ~~exp.~~ factor ~~vector~~ using harmonic mean concept.