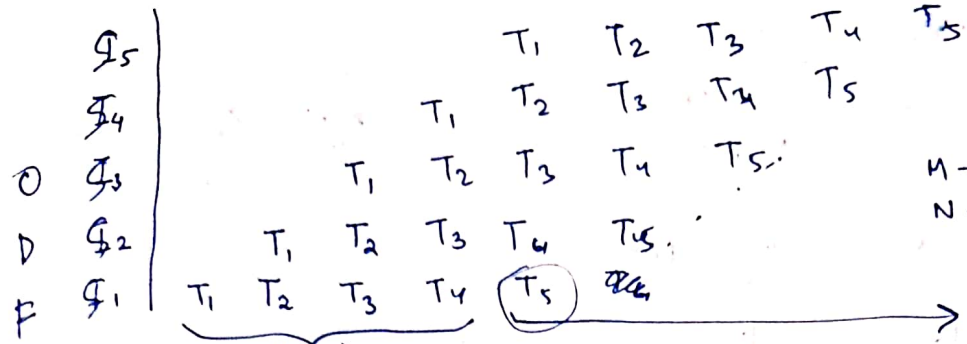


M → no. of stages
N → no. of instr.

serial pipeling

$5 + (4) = 9$.

- $T = M + (N-1) * C$

- Speed up : Time take w/o pipeline / Time take with pipeline

$$= \frac{M * N * C}{(M+N-1) * C} = \frac{MN}{M+N-1}$$

Max. : $\lim_{N \to \infty} \frac{M * N}{N\left(\frac{M}{N} + 1 - \frac{1}{N}\right)} = M$.

- Throughput : instruction per unit Time. $\left(T = \frac{1}{f}\right)$

$$= \frac{N}{T} = \frac{N}{M+(N-1) * C} \quad \left[C = \frac{1}{f}\right]$$

$$= \frac{N * f}{M+N-1}$$

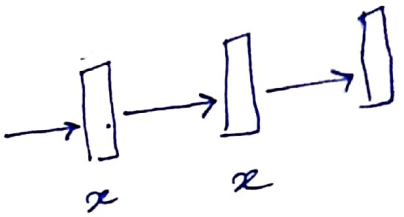
Max : $\lim_{N \to \infty} f$

f ↑ heat ↑ → multicore system

f/2 f/2 f/2 f/2 ⇒ 2f

4) Avg. No. of Instr

$$= \frac{NM}{M+N-1}$$

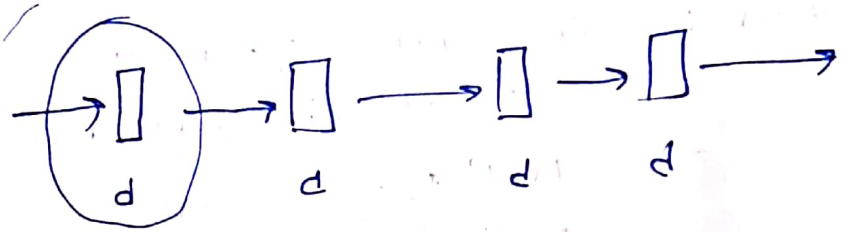


5) performance cost ratio

$$PCR = \frac{f}{cost} = \frac{f}{c+mn}$$

throughput ↑ performance ↑ PCR ↓

Q.



time $= \left(\frac{t}{m} + d\right)$

$$f = \frac{1}{\left(\frac{t}{m} + d\right)}$$

$$PCR = \frac{1}{\left(\frac{t}{m}+d\right)(c+mn)}$$

for what M? PCR be max.

$$0 = \frac{dPCR}{dM} = \frac{N}{\left((t/m)+d\right)(c+mn)^2} - \frac{t}{m^2\left((t/m)+d\right)^2(c+mn)}$$

$$\frac{N}{(t/m+d)*(c+mn)f} = \frac{t}{m^2((t/m)+d)^2(c+mn)}$$

$$\frac{N}{c+mn} = \frac{t}{m^2\left(\frac{t}{m}+d\right)}$$

$$\frac{N}{c+mn} = \frac{t}{tm + m^2 d}$$

$$Ntm + Nm^2 d = tc + tmn$$

$$M = \sqrt{\frac{tc}{Nd}}$$

n → cost of latch
c → cost of Gate
d → delay at each stage.

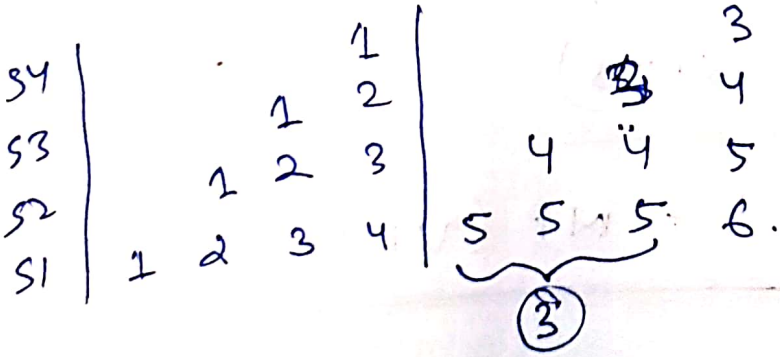
- Time due to branching

S → probility of branching NS

$$T = M + (N-1) + NS(M-1)$$

Speed up = $\frac{MN}{M+N-1+NS(M-1)}$ $\left(\lim_{N\to\infty}\right)$

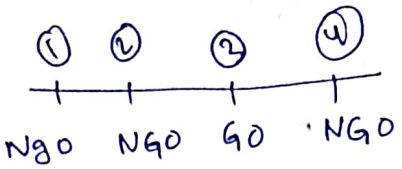
Max $\frac{N}{S(M-1)+1}$



Throughput = $\frac{N*t}{M+(N-1)} = \frac{N*t}{M+N-1+NS(M-1)}$

Max = $\frac{t}{1+S(M-1)}$

P → Probability that an branch instr.



uncond. → q

condition → γ

branching by cond Instr → s

- Avg No. of branch Instr. = NP
- " " " Cond. branch Instr = N * P * γ
- " " " Uncd " " = NP * q
- Avg no. of branching cause by Cond branch = NPγ * S

Time = M + N − 1 + NS(M − 1)

NS → NPγq + NpγS

NP(q + γS)

= M + N − 1 + NP(q + γS)