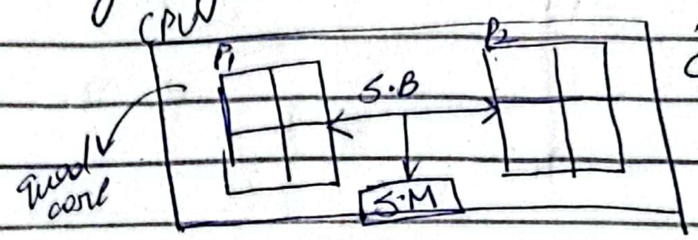
→ Cores in Processors are connected using system bus.



computer

↑

C_1/PC_1/S_1

↗ Server

Server S_1, S_2, S_7, S_3, S_4, S_5, S_6, ...

encryption algorithm : SHA-256

2^{256}

(computation not possible on uni-processor)

→ Before : MIPS - 40MHz Processor

↓

capacity

→ After : Pentium 4 - 2GHz

Core i5 - 3.6GHz per core

• inter communication of cores degrades the overall performance of the processor.

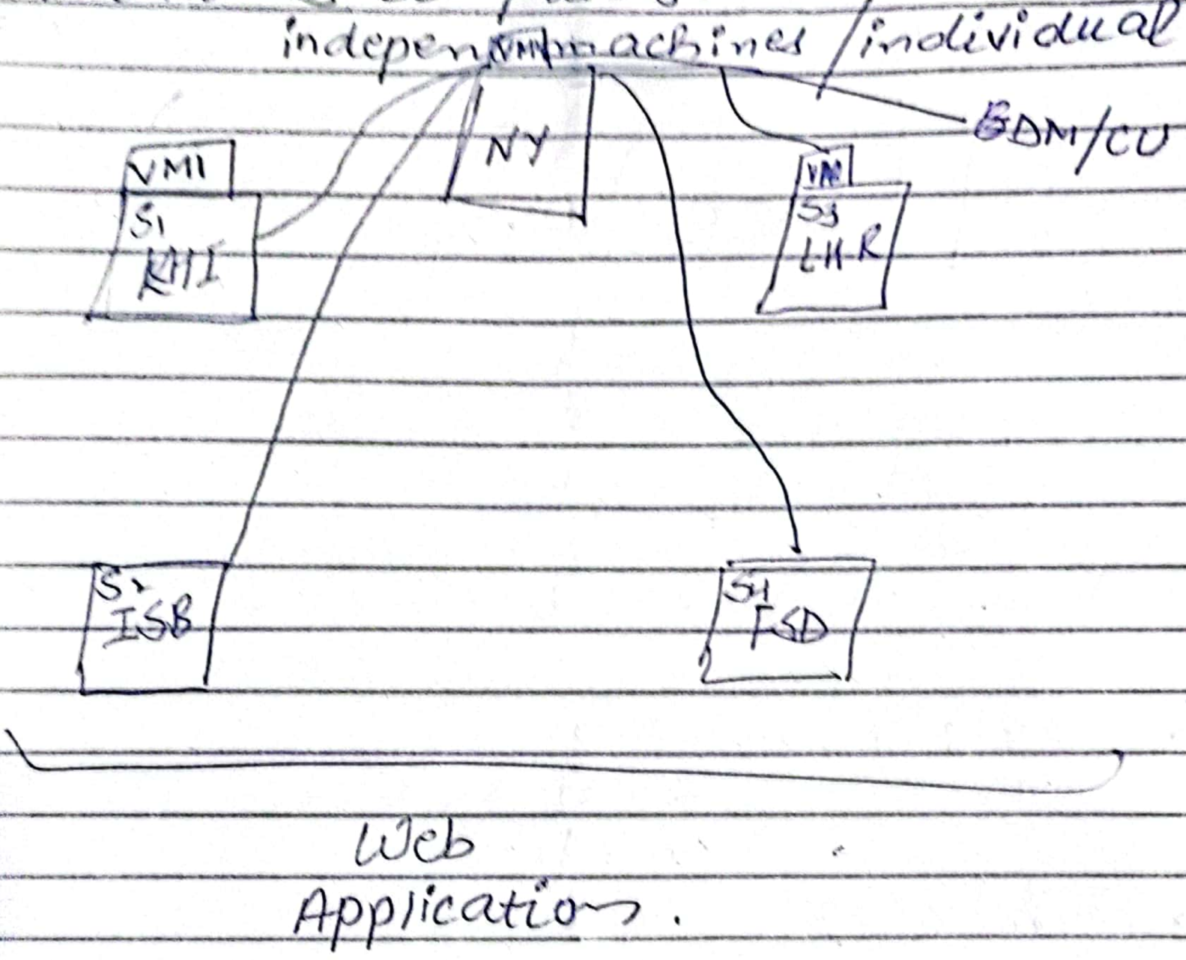
→ Moore's Law:

NO. of transistors in chip will be doubled after 18 months.

↓

every

→ Autonomous computers:



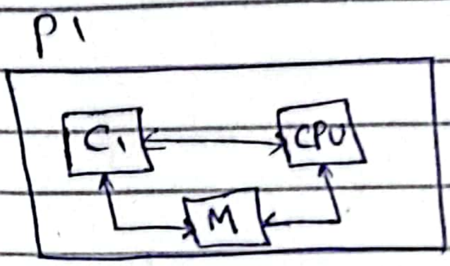
1.1 + 1.2 + 5.4
chapters.

Lecture - 4

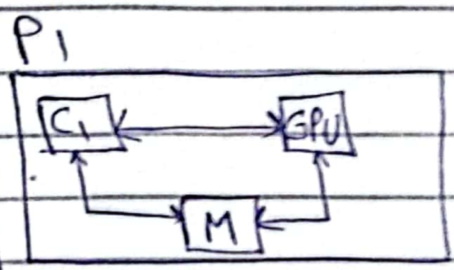
shared memory
multi-processors

→ Parallel computing:
(concurrent solutions)

many - core architecture



multi- core architecture



→ Distributed computing:
(developing algorithms)

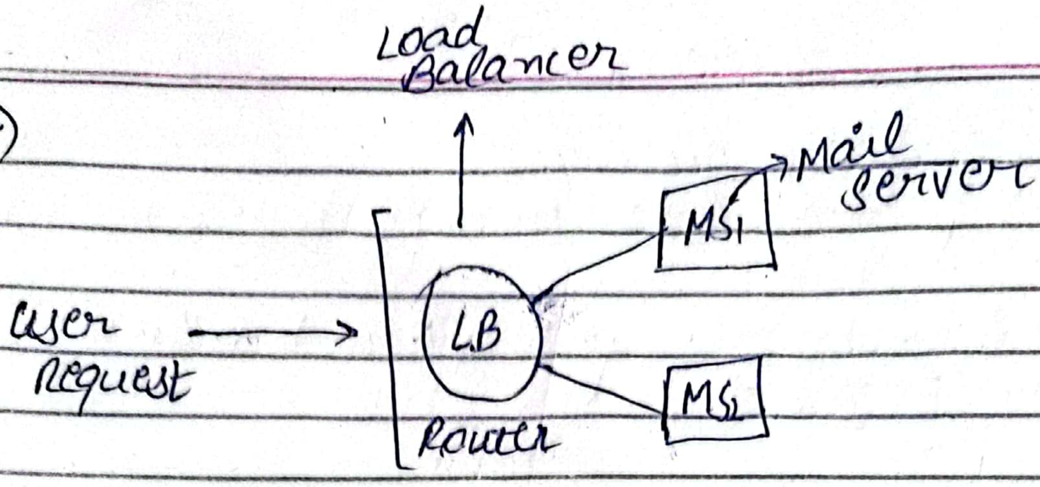
Clusters: group of computers.

	LHR		ISB		KHI
C1	S1	C2	S1	C3	S1
	S2		S2		S2
	S3		S3		S3

S = Server
C = Cluster

→ Practical Application of P & D
- Biology (characterization of genes & protiens)
- Computational physics & chemistry
- Evolution of galaxies, the data will be stored on different servers and will do multi-processing etc.

•)



$\boxed{MS_3}$ (If the load is increased, then one more mail server be used)

→ Load Balance & Router are used to move the traffic

→ Proper Parallelism:

100 lines code C++

20 variables → Sequential
20 loops → Parallel
40 function → Parallel
20 Results → Sequential

0.6 (Parallel) 0.4 (")

•) It will be complex when we have thousands of lines of code which consists of multiple classes and functions.

→ Amdahl's Law: (to analyze scalability)
used in parallel computing

- used to predict speedup when multiple processes are used.

$$\text{Speedup} = \frac{1}{(1-P) + P/n}$$

8 → processors
30% → code parallelizable

$$= \frac{1}{(1-0.3) + \frac{0.3}{8}} = 1.36$$

- very difficult to compute 'p' as we cannot do it according to compiler's working/pov.

- Unaffected → sequential Portion.

→ Karp-Flatt Metric:
used to calculate a serial fraction for given parallel configuration
- caters all the things that Amdahl's Law ignore

$$e = \frac{1/s - 1/p}{1 - 1/p}$$

s: speedup
p: processing-unit

Quiz – 20th Feb

Distributed System → how many nodes are added

Distributed computing → deals middle ware with ~~#~~ dis ?

Flynn's Classical Taxonamy

- SISD
- SIMD
- MISD
- MIMD

Hardware architecture classifications:

- Flynn
-

Lecture-5

SIMD → mostly used in graphical processing.

sequential processor ~~transforms~~

dedicated to particular applications like graphical etc.

MIMD → used in our laptops
- ↳ shared-memory architecture
- ↳ each CPU has it's own memory
- ↳ CPU address space is used as a global space.

- Non-uniform Memory Access (not constant)
  - access time of 2 CPU is not same
- Uniform Memory Access:
  - acess time of CPU's are same.

Cross Bar Network:

Horizontal → Memory Blocks

Vertical → processor electronics

→ Multistage Omega Network:

Stages = $\log_2(P)$ ∵ P → no. of input/output

Nodes = $\frac{P}{2} \times \log_2(P)$

Cost = $P \times \log_2(P)$

Ex:

Stages $= \log_2(8) = 3$

Nodes $= \frac{8}{2}\log_2 8 = 12$

Cost $= 8 \times \log_2 8 = 24$

PDC

- Omega Network can be used for communication b/w processors.

Route → Path from source → destination

→ Linear Array:

simplest (every node has 2 neighbours.

→ HyperCube:

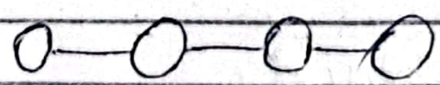
$d = \log p$ (dimensions $= \log$(nodes))

•) Each node has $\log p$ neighbours.

No. of Links (Linear)

$n-1$

nodes

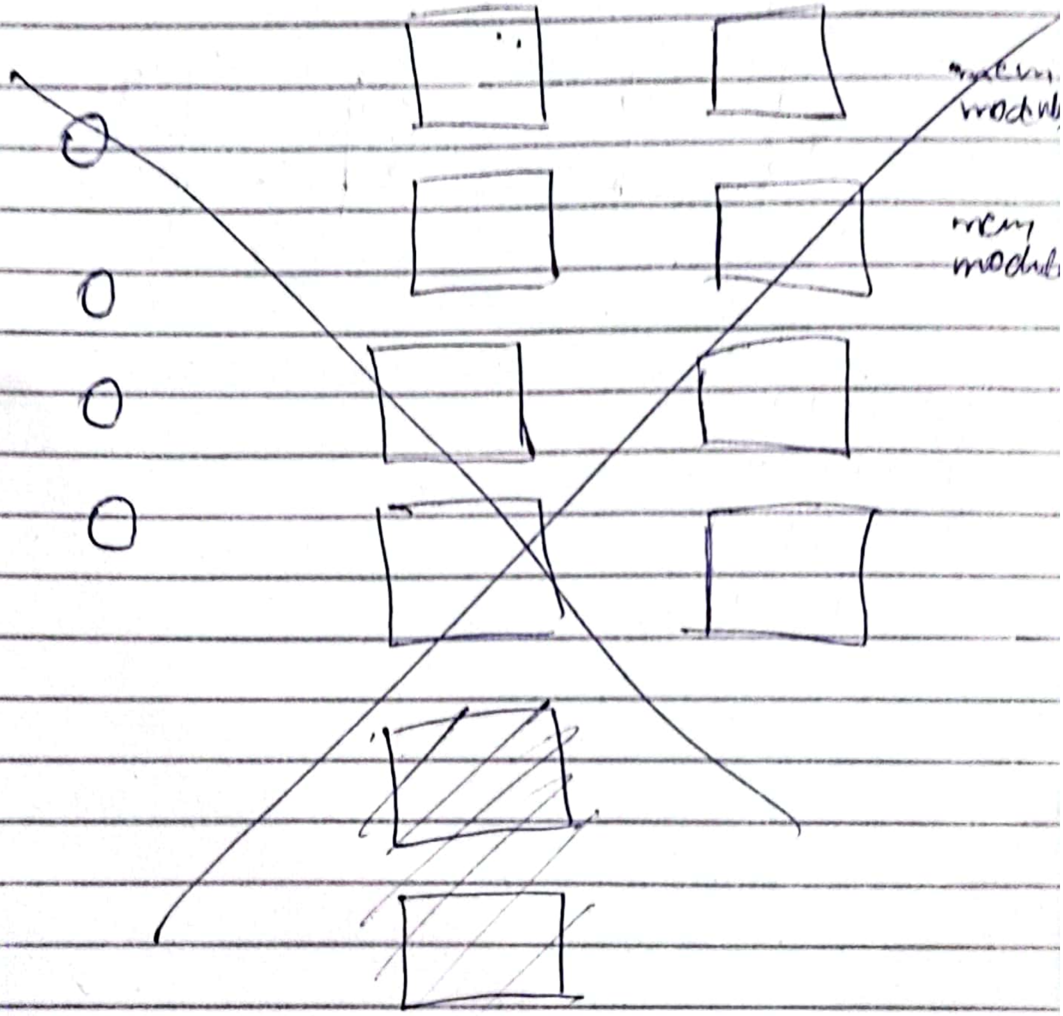


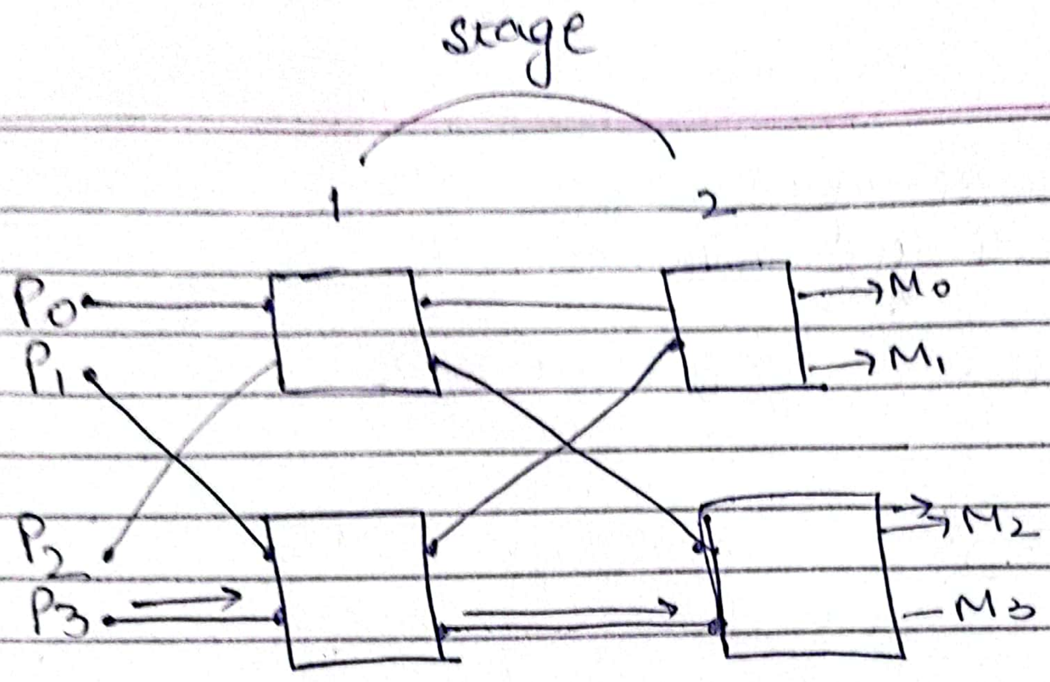
$4-1=3$

Ex: stages $= \log_2 4 = 2$

Nodes $= \frac{4}{2} \times \log_2 4 = 2 \times 2 = 4$

cost $= 4 \times \log_2(4) = 4 \times 2 = 8$





$00 \Rightarrow 00$

$01 \Rightarrow 10 = 2$

$10 \Rightarrow 01 = 1$

$11 \Rightarrow 11 = 3$