# Parallel Computing Models

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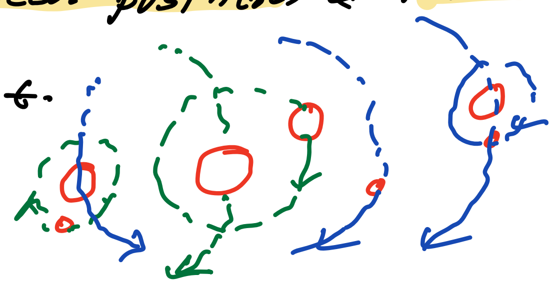
1) Shared memory model - thread-based parallel programs
2) Distributed system model - message passing parallel progs
3) GPUs based models - stream-based programs.

What is a parallel program?
we consider following n-body problem to understand parallel program:

Problem statement:
Given n-number of bodies (planets, stars, and satellites), which move under the influence of gravity, find out their positions & momentum with respect to time t.

n-bodies →



**Problem:** to determine

| **positions** | **momentums** |
| --- | --- |
| $x(t)$ | $mv_x(t)$ |
| $y(t)$ | $mv_y(t)$ |
| $z(t)$ | $mv_z(t)$ |

$\therefore$ $6n$ differential equations need to be solved through numerical methods, as a function of time.

This can be done using a sequential Algorithm; that computes 6 values for each body for each time t.

**Alternative approach:** Multiprocessors & parallel programs.

Challenge: → 1) How to partition the work into subtasks to be execute in parallel

2) Which processor shall execute what subtask

3) How to collaborate among the processors
⇒ so that all processors contribute to their maximum.

To answer above or have an idea about utilization of resources, we assume that there is a problem $\Pi$ and there is a program P that solves it.

Programs are infinite
- sequential program
- parallel program

Let P is a parallel program.
↳ executes on computer, say
multiprocessor — $C_1$ or
pipeline — $C_2$, or
sequential — $C_3$

Let p is number of processors, ∴ computer is $C(p)$. We are interested in its performance.

Time to execute P on $p$ no. of processors is say $T_p$. (Parallel execution)

If P executes on a sequential processor then say, execution time $= T_s$

$$S = \frac{T_s}{T_p} = \text{speedup}, \quad S \geq 1$$

there are $p$ processor units in computation

$$T_p \leq T_s \leq p\,T_p$$

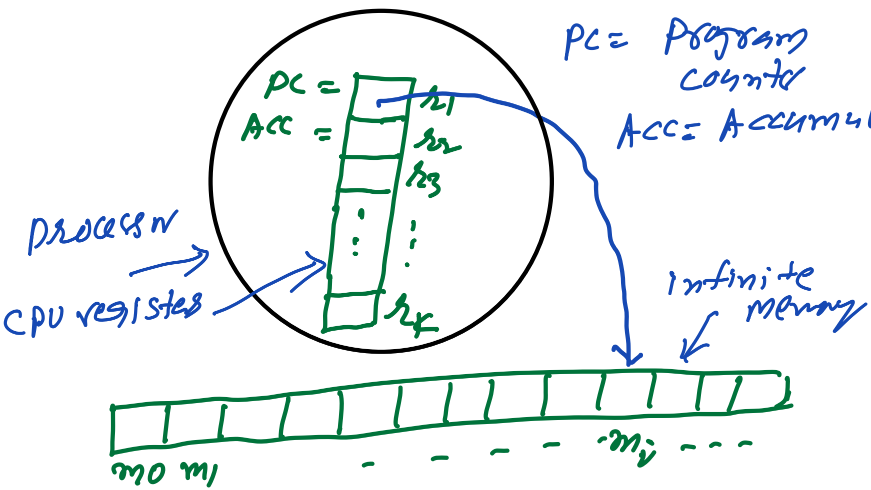
$$E = \frac{S}{p} \quad (\text{Efficiency} \leq 1)$$

Each $p$ contributes to $\frac{1}{p}$ in efficiency

We have following questions:

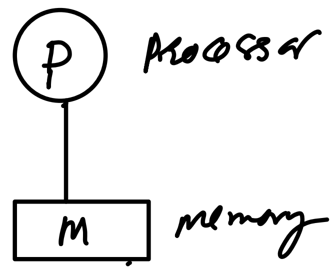
- How to determine $T_p$?
- How to determine $T_s$?
- What properties of computers effects $T_p, T_s$?

To answer these questions we must have a model of parallel computers.




PC = Program counter

ACC = Accumulator




↑ RAM model (Random Access Machine) model.

PRAM = Parallel Random Access Machine