Lecture-27: Pipelining Basics

01 April 2024 13:16

How to increase the performance of a system?

Alternative 1 :- Increase hadware.
1 adder → 5 adder

Alternative 2 :- Pipelining

Pipelining :-

A mechanism of "overlapped execution" of some input sets by partitioning the computations into "k" stages.

Ideal speed up is "k".

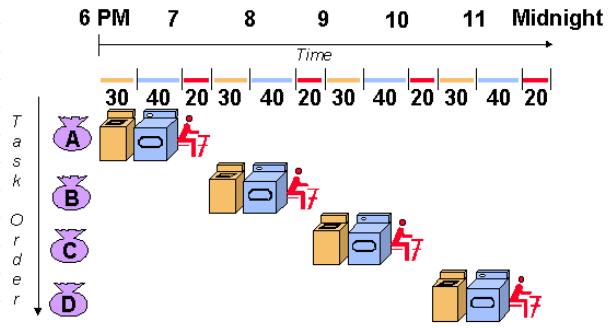
Uses :-

1. Instruction execution.
   multiple instructions executed in some sequence.
2. Arithmetic computation.
   multiple operation on some data sets.
3. Memory access
   multiple accesses to consecutive memory locations.

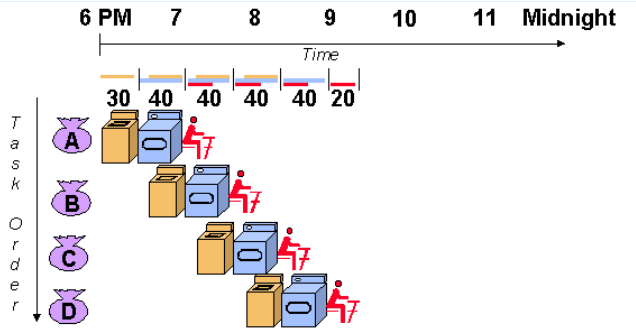
Laundry Analogy of pipelining :-

Wash Clothes

1. Wash (30 min)
2. Dry (40 min)
3. Fold (20 min)



PIPELINING approach :—



Let T_W, T_D, T_F be the time required for washing, drying and folding, respectively.

Non-pipelined setup :—

⇒ For N bundles of clothes

Total time $T_{NP} = (T_W + T_D + T_F) . N$

for $T_W = T_D = T_F$

$$\boxed{T_{NP} = 3T_W . N} \quad \text{—— (1)}$$

Pipelined setup :—

①	T_W	T_D	T_F				- ...
②		T_W	T_D	T_F			- .
③			T_W	T_D	T_F		- ..
④				T_W	T_D	T_F	- ..
	!	!	!	!	!	!	! ⋱
	!	!	!	!	!	!	.

Bundle 1 — $3.T_W$

Bundle 2 — $4.T_W$

Bundle 3 — $5.T_W$

⋮

Bundle N — $(N+2).T_W$

$$T_p = (N+2).T_W \quad \text{—— (2)}$$

Speed up (S), of N-stage pipeline over non-pipelined setup.

$$S = \frac{T_{NP}}{T_p} = \frac{3N.T_W}{(N+2)T_W} \quad \text{—— (3)}$$

Classification of processors based on various pipeline parameters :-

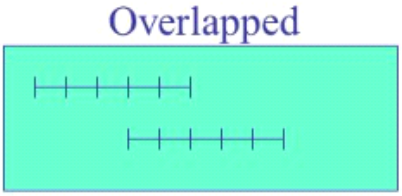
1. Degree of overlap :-

(a) Serial :-

The next operation can start only after the previous operation finishes.

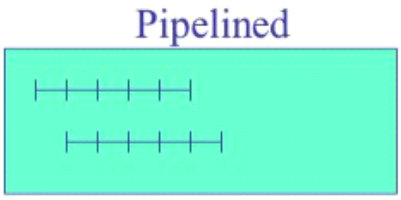
(b) Overlapped :-

There is some overlap between successive operations.



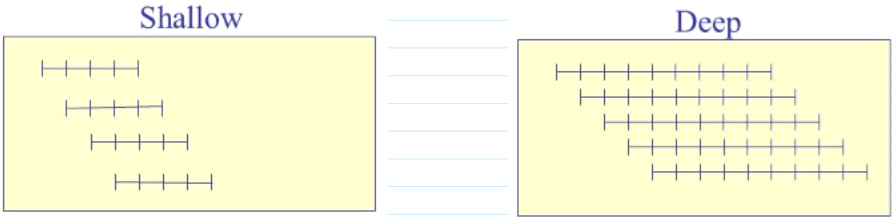
(c) Pipelined :-

Fine-grain overlap between successive operation.



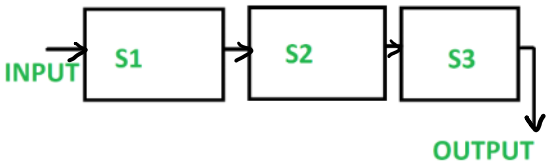
2. Depth of Pipeline :-

- Shallow Pipeline ⇒ fewer number of stages.
- Deep Pipeline ⇒ large number of stages.

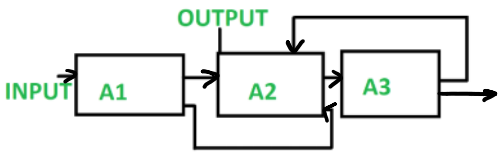


3. Structure of Pipeline :-

- Linear Pipeline
- Non-linear Pipeline



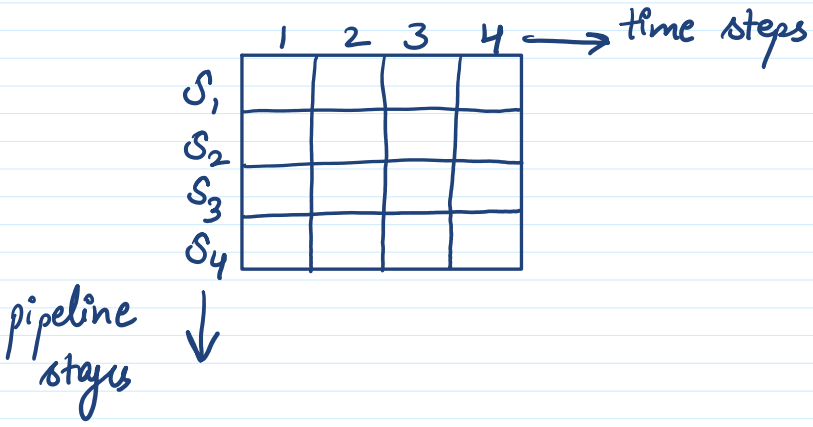
The stages are executed one by one in a sequence.



Stages may not execute in a linear sequence/ A particular stage may execute more than once

Reservation Table :-

A data structure that represents the pipeline.



a space-time diagram of the pipeline that shows precedence relationships among pipeline stages.