CS & IT ENGINEERING

COMPUTER ORGANIZATION AND ARCHITECTURE

Pipeline Processing

Lecture No.- 01

By- Vishvadeep Gothi sir

Recap of Previous Lecture

Topic Multiple Sector Access

Topic Disk Cylinder

Topic Disk Addressing

Basics
Inst^n
CPU & C.U.
I/O
mem
cache
Disk

Topics to be Covered

- **Topic** Pipeline Processing
- **Topic** Pipeline Cycle Time
- **Topic** Speed Up

Topic : Parallel Processing

Parallel Processing: Simultaneous data processing

Types:

- Vector Processing
- Array Processing
- Pipeline Processing (Pipelining)

Topic : Flynn's Classification of Computers

1. SISD :- single Instn stream single Data stream
2. SIMD :- —— 11 —————— multiple —— 11 —— ⇒ ex:- Pipeline processor
3. MISD multiple —— 11 —— single —— 11 —— ⇒ only Theoretical
4. MIMD —— 11 —————— multiple —— 11 —— ⇒ ex:- super scalar computers

Topic : Pipeline Processing

- Pipelining is useful, When same processing is applied over multiple inputs

Topic : Pipeline Processing

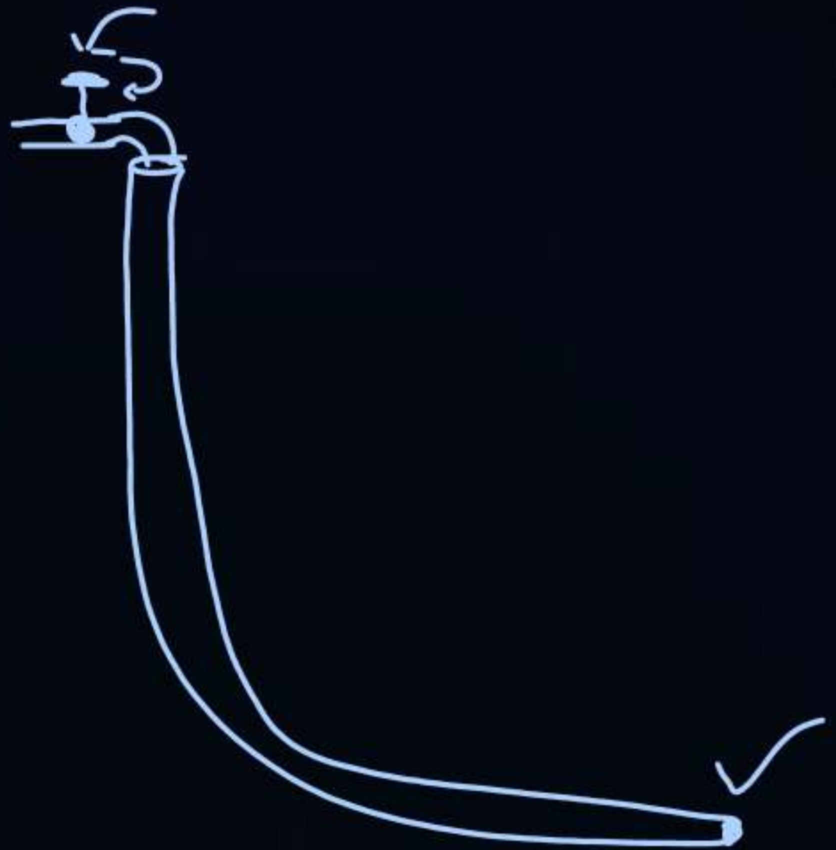
- Technique to decompose a sequential process into sub-operations
- Sub-operations are performed in segments / stages
- **Task:** One operation performed in all segments

Topic : Pipelining Example

$k = 4$ | $4+6-1$
$n = 6$ | $= 9$

shirt making

		cut	stitch	finish	Pack
0					
10 min	1	S1			
20 min	2	S2	S1		
30 min	3	S3	S2	S1	
	4	S4	S3	S2	S1
	5	S5	S4	S3	S2
	6	S6	S5	S4	S3
	7	—	S6	S5	S4
	8	—	—	S6	S5
	9	—	—	—	S6



	no. of cycles		
	non-pipeline (sequential)	pipeline	speed up
for $n = 6$ inputs	$4 * 6 = 24$	9	$\frac{24}{9} = 2.67$
$n = 7$	$4 * 7 = 28$	10	$\frac{28}{10} = 2.8$
$n = 8$	$4 * 8 = 32$	11	$\frac{32}{11} = 2.9$

Topic : Pipeline Cycle Time (t_p)

min. amount of time in which all segments can finish their respective suboperations.

Topic : General Consideration About Pipeline

- Consider a k segment pipeline with clock cycle time = t_p to perform n tasks

no. of cycles needed to finish first task = k

—— " —— " —— remaining n-1 tasks = (n-1)

time

$k * t_p$

$(n-1) t_p$

· Total cycles needed to perform all n tasks = (k + n - 1)

· Total time —" —— " —— " —— = $(k+n-1) t_p$

Topic : General Consideration About Pipeline

- Consider a non-pipeline system that takes t_n time to perform a task

Total time needed to finish all n tasks = $n * t_n$

Topic : General Consideration About Pipeline

- Performance of a pipeline is given by Speed up ratio.

$$\text{speed up } (S) = \frac{\text{non-pipeline time}}{\text{pipeline time}}$$

$$\boxed{S = \frac{n * t_n}{(k+n-1)\, t_p}}$$

as the no. of tasks increases

$n >> k$

$$\boxed{S_{ideal} \text{ or } S_{max} = \frac{t_n}{t_p}}$$

ideal condition means ignore $k-1$ cycles to fill the pipe initially hence for each input pipeline takes 1 cycle.

for n inputs $\Rightarrow$ n cycles $= n * t_p$ time special case :-

Time needed to perform 1 task in pipeline is equal to time needed in non-pipeline system for 1 task.

$$t_n = k * t_p$$

$$\boxed{S_{ideal} = k}$$

[NAT]

#Q. A non-pipeline system takes 50 ns to process a task. The same task can be processed in a six-segment pipeline with a clock cycle of 10ns.

1. Determine the speedup ratio of the pipeline for 100 tasks.
2. What is the maximum speedup that can be achieved?

$t_n = 50\,ns$

$k = 6$

$t_p = 10\,ns$

1. $n = 100$

$$S = \frac{100 * 50}{(6+100-1)10} = 4.76$$

2.

$$S_{max} = \frac{t_n}{t_p} = \frac{50}{10} = 5$$

$\Rightarrow$ if ideal speed up asked

or

if max speed up asked

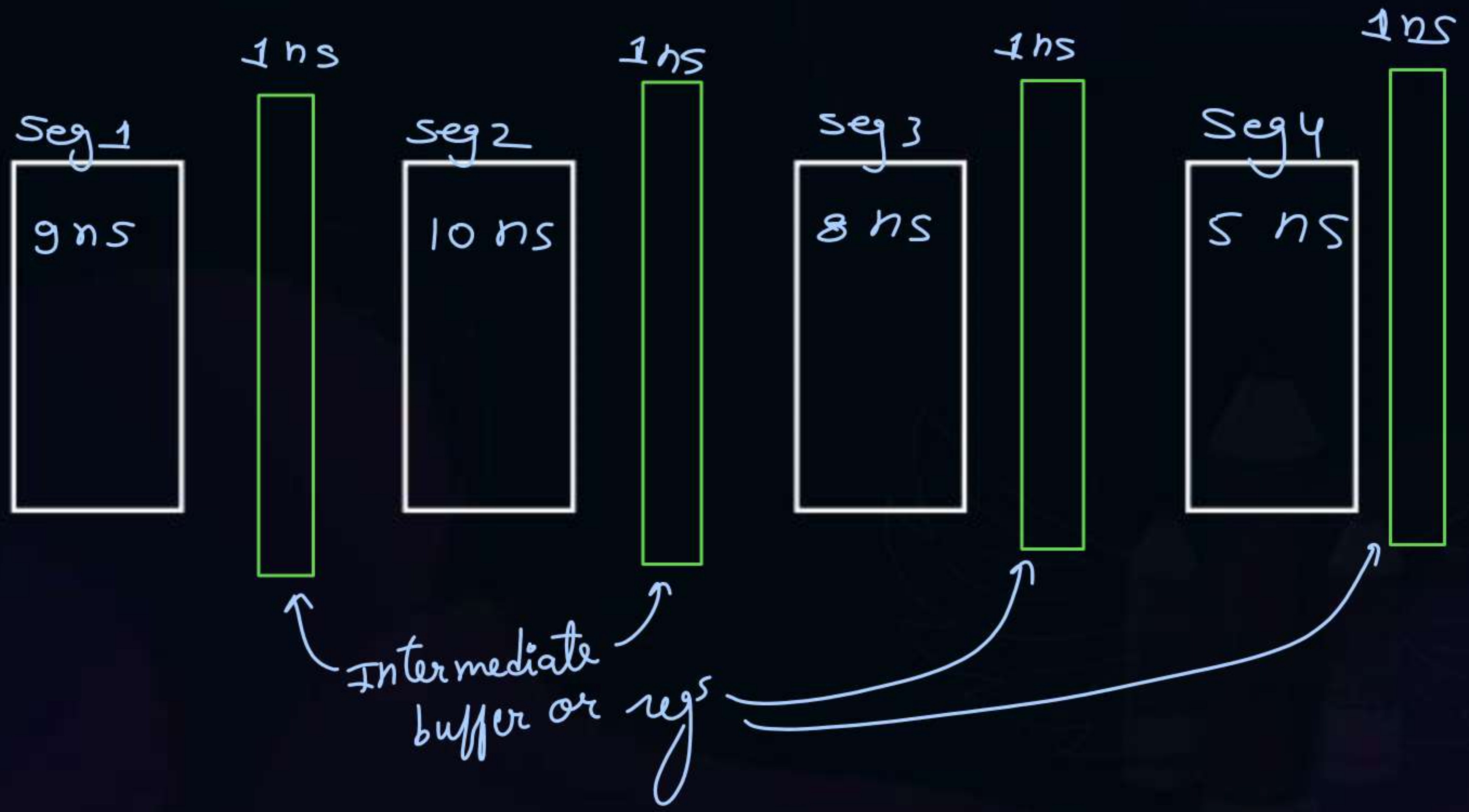
or

value of n is not mentioned

$\Rightarrow$ Use $\boxed{S = \frac{t_n}{t_p}}$

Topic : Synchronous Pipeline

ex:-



Topic : Cycle Time in Synchronous Pipeline

t_p = max of all segment delays $= \max(9, 10, 8, 5) = 10\,ns$

t_p = max of all segment delay + Reg. delay

$= \max(9, 10, 8, 5) + 1 = 11\,ns$

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t_n = sum of all segment delays

☆ non-pipeline system does not use buffer or reg.

[NAT]

#Q. Consider 6 segment pipeline with segment delay of segments as 20ns, 26ns, 21ns, 21ns, 24ns and 28ns respectively. Calculate processing time of pipeline for 1000 tasks?

$k = 6$

$t_p = max(20, 26, 21, 21, 24, 28) = 28\ ns$

$n = 1000$

pipeline time

$= (k + n - 1) t_p$

$= (6 + 1000 - 1) 28\ ns$

$= 28140\ ns$

[NAT]

#Q. The time delay of the four segments in pipeline are as shown follows:

$t_1 = 50$ ns, $t_2 = 30$ ns, $t_3 = 95$ ns, and $t_4 = 45$ ns.

The interface registers delay time $t_r = 5$ ns.

How long would it take to process 100 tasks in the pipeline?

$k = 4$

$n = 100$

$t_p = \max(50, 30, 95, 45) + 5$

$= 100\ ns$

$\text{time} = (k + n - 1)\, t_p$

$= (4 + 100 - 1)\, 100$

$= 10300\ ns$

[NAT]

Homework

#Q. How can we reduce the total time about the one-half of the time calculated in above question?

2 mins Summary

Topic Pipeline Processing

Topic Pipeline Cycle Time

Topic Speed Up

Happy Learning

THANK - YOU