

GENERAL PIPELINES, RESERVATION TABLES, CONFLICT-FREE SCHEDULING (Non-Linear Pipeline Design)

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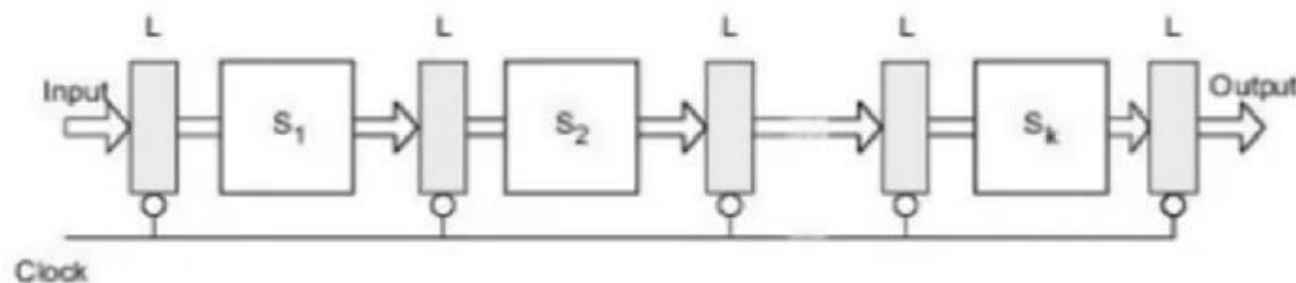
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GENERAL PIPELINES

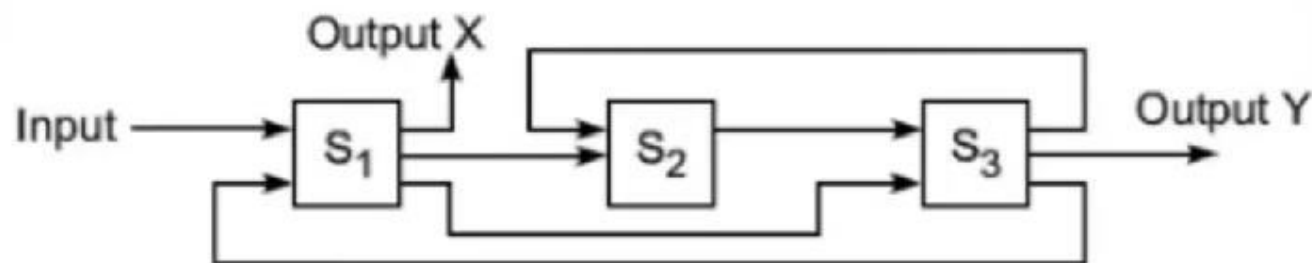
(Nonlinear Pipeline Design)

□ Two categories of pipelines:

- ▣ **Linear pipeline:** It has **streamline (cascade)** connections only



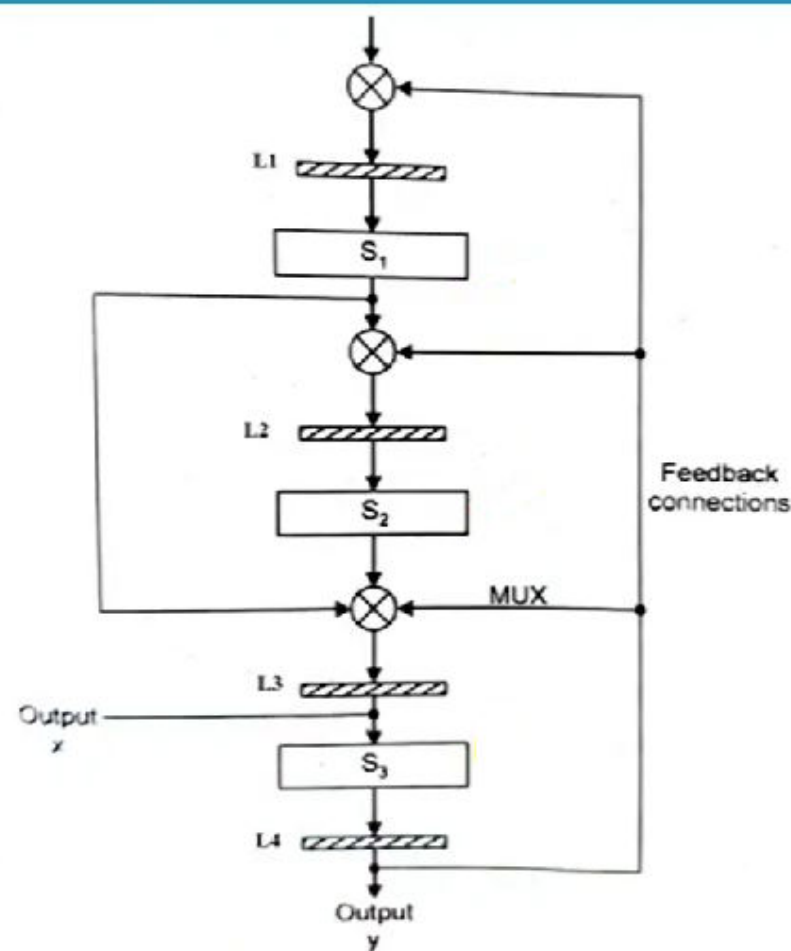
- ▣ **Non-linear pipeline:** It has **feed-back connections and feed-forward connections** along with streamline connections



GENERAL PIPELINES

(Nonlinear Pipeline Design)

- In **general pipeline**, the pipeline may have **feed-back connections** and **feed-forward connections** along with streamline (cascade) connections. So it is **nonlinear**.
- A **general pipeline** may have multiple paths, parallel usage of multiple stages and non-linear flow of data.
- **Example:** A General Pipeline with 3-stages
 - It is a **two function pipeline** with function **x** and function **y**.
 - There are **three stages** S_1 , S_2 , S_3 .
 - The **crossed circles** are **multiplexers (MUX)**. They are used for selecting multiple connection paths in evaluating different functions.
 - The elements **L1 to L4** are **latches** which helps to just store and forward the input that they receive. These latches are also used as **delays** to synchronize the movement of data from one stage of pipeline to another stage and also they help **avoid** any intermediate **data loss**.



A General Pipeline

Reservation Table

- The utilization pattern of successive stages in a pipeline is specified by **Reservation Table**.
- **Rows** represents **stages** and **columns** represents **clock time units**
- The **total number of clock units** in the table is called the **evaluation time** for the given function.
- A **reservation table** represents the **flow of data** through the pipeline for **one complete evaluation of a given function**. i.e. Each function evaluation is specified by one reservation table.
- **Multiple reservation tables for different functions**
 - ❑ A **static pipeline** or linear pipeline is specified by a single reservation table.
 - ❑ A **dynamic pipeline** or dynamic pipeline may be specified by more than one reservation table.

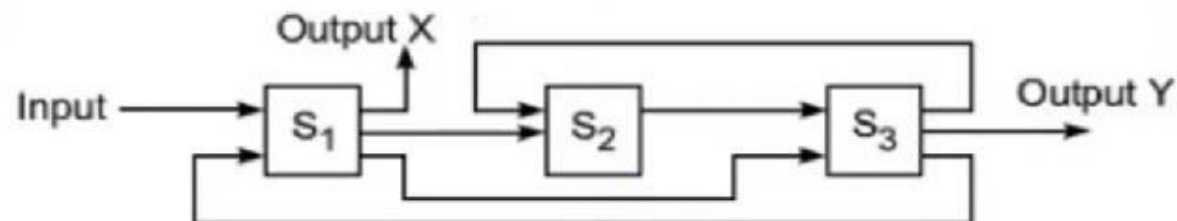
		→ Time							
		1	2	3	4	5	6	7	8
Stages	S ₁	X					X		X
	S ₂		X		X				
	S ₃			X		X		X	

Reservation table for function X

		→ Time					
		1	2	3	4	5	6
Stages	S ₁	Y				Y	
	S ₂			Y			
	S ₃		Y		Y		Y

Reservation table for function Y

Reservation Table for Non-Linear (Dynamic) Pipeline with two functions:



(a) A three-stage pipeline

		Time							
		1	2	3	4	5	6	7	8
Stages	S ₁	X					X		X
	S ₂		X		X				
	S ₃			X		X		X	

(b) Reservation table for function X

		Time					
		1	2	3	4	5	6
Stages	S ₁	Y				Y	
	S ₂			Y			
	S ₃		Y		Y		Y

(c) Reservation table for function Y

- **Evaluation time** of different functions may be different
 - **Function X** requires **8 clock cycles** to evaluate.
 - **Function Y** requires **6 clock cycles** to evaluate.
- A **Check Mark** in a reservation table indicates that corresponding stage is used at that time.
 - **Multiple check marks** in a row indicates **repeated usage** of the same stage in different cycles
 - **Multiple check marks** in a column indicates **simultaneous usage** of multiple stages in same cycle
 - **Contiguous check marks** in a row indicates **extended usage** of a stage over more than one cycle i.e. **slower stage** needing more time slots

Latency Analysis Terminologies

□ Latency:

- An **initiation** refers to the **start** of **single function evaluation**
- The **number of clock cycles** between **two initiations** of a pipeline is the **latency** between them.
- **Latency values** must be **positive integers**.

□ Collision :

- An attempt by **two or more initiations** to **use** the **same pipeline stage** at the **same time** is called **collision**
- **Collision** implies **Resource Conflicts** between **two initiations**
- **Collisions** must be **avoided**

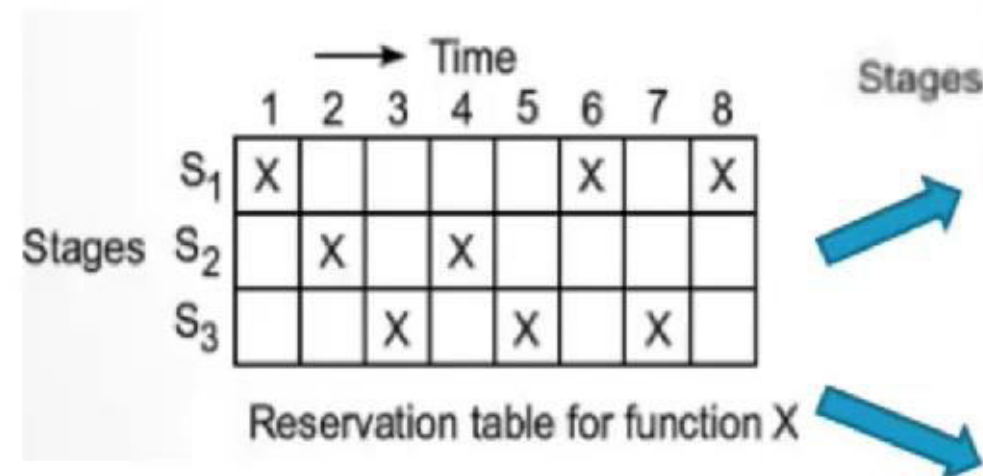
“Some latencies cause collisions and some not.”

→ Time

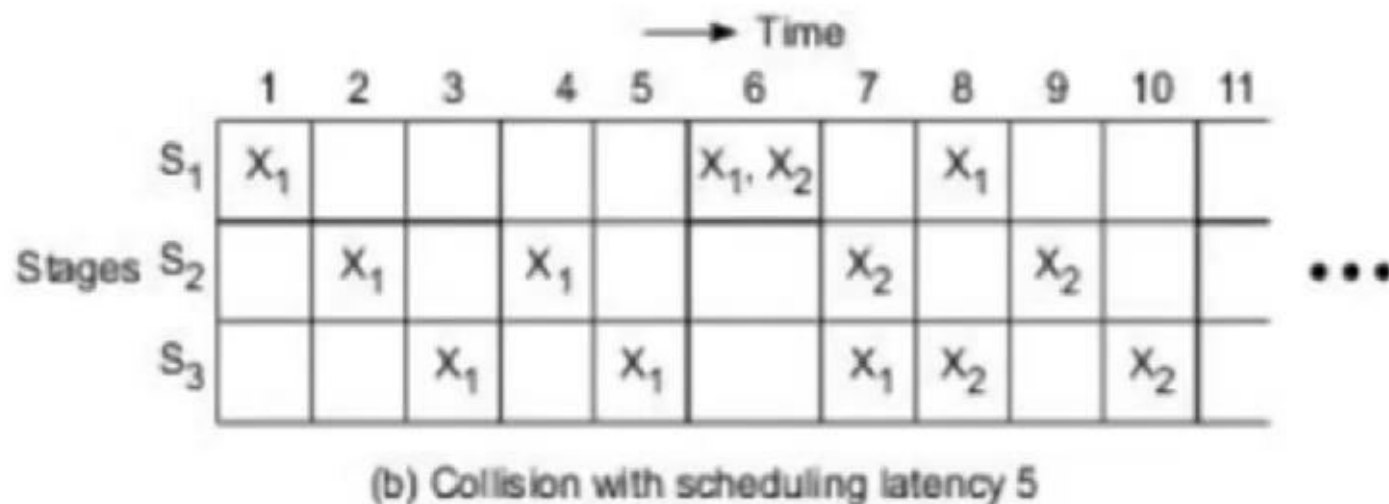
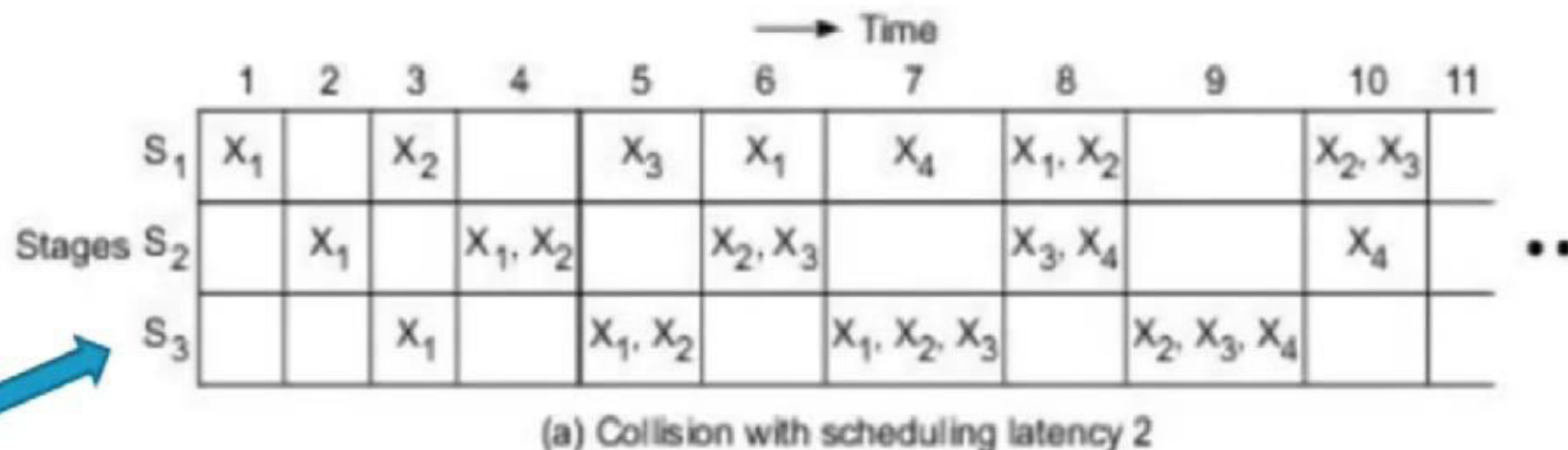
	1	2	3	4	5	6	7	8
Stages								
S ₁	X					X		X
S ₂		X		X				
S ₃			X		X		X	

Reservation table for function X

Collision: Examples



Eg: Latencies 2 & 5 cause collision



Latency Analysis Terminologies ...

❑ Forbidden Latencies:

❑ Latencies that cause collisions are called **forbidden latencies**.

- To detect a forbidden latency, one needs simply to check the distance between any 2 checkmarks in the same row of the reservation table.

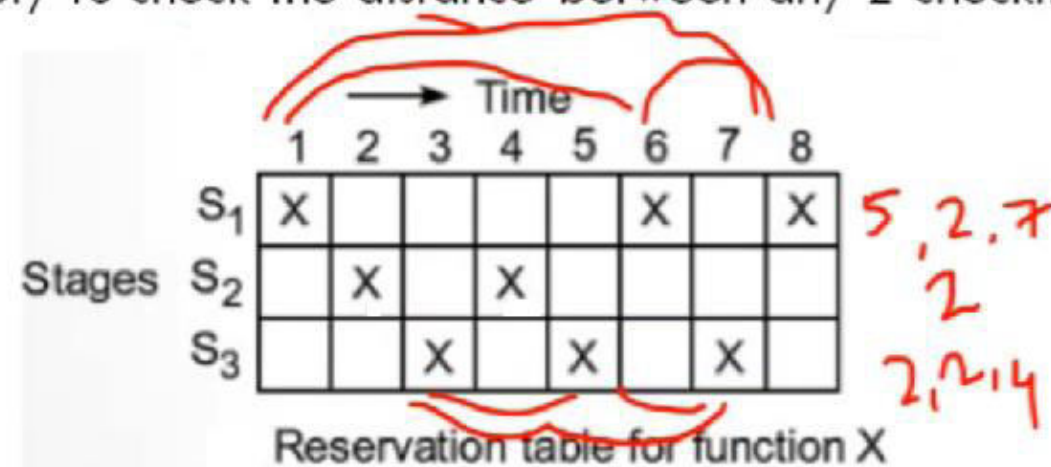
❑ Eg: Consider the reservation table

S1: $\{(6-1), (8-1), (8-6)\}$ i.e. **5, 7, 2**

S2: $\{(4-2)\}$ i.e. **2**

S3: $\{(5-3), (7-3), (7-5)\}$ i.e. **2, 4, 2**

Forbidden latencies = {2, 4, 5, 7}



❑ Permissible Latencies:

❑ Latencies that does not cause collisions are **permissible latencies**.

❑ Eg: **Permissible latencies = {1, 3, 6, 8}**