

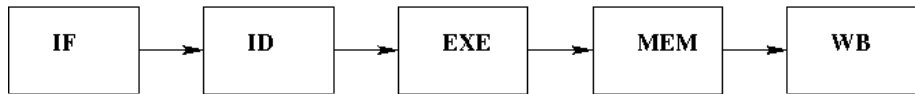
# Summary Pipelining - Methods

<b>Dependency</b>	<b>Hazard</b>	<b>Method</b>
Data	RAW	Forwarding, Scheduling, Register Renaming
Name	WAR, WAW	Register Renaming
Control	Control	Branch Prediction, Speculation, Delayed branch
Precise exceptions		in-order commit
ILP		Scheduling, Loop unrolling

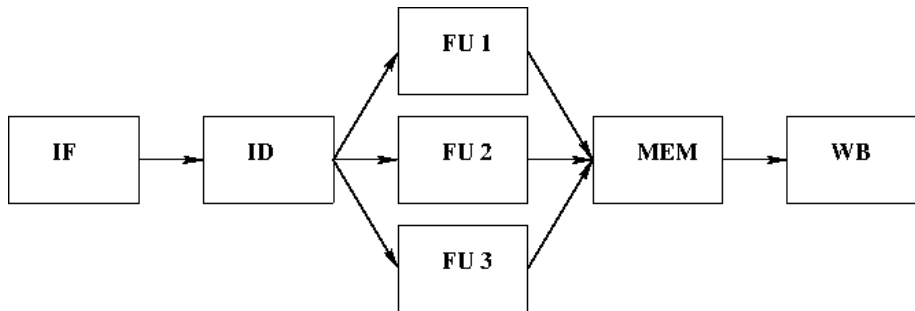
# Summary Pipelining - Implementation

<b>Problem</b>	<b>Simple</b>	<b>Scoreboard</b>	<b>Tomasulo</b>	<b>Tomasulo + Speculation</b>
	Static Sch	Dynamic Scheduling		
RAW	forwarding stall	wait (Read)	CDB stall	CDB stall
WAR	-	wait (Write)	Reg. rename	Reg. rename
WAW	-	wait (Issue)	Reg. rename	Reg. rename
Exceptions	precise	?	?	precise, ROB
Issue	in-order	in-order	in-order	in-order
Execution	in-order	out-of-order	out-of-order	out-of-order
Completion	in-order	out-of-order	out-of-order	in-order
Structural hazard	-	many FU stall	many FU, CDB, stall	many FU, CDB, stall
Control hazard	Delayed br., stall	Branch prediction	Branch prediction	Br. pred, speculation

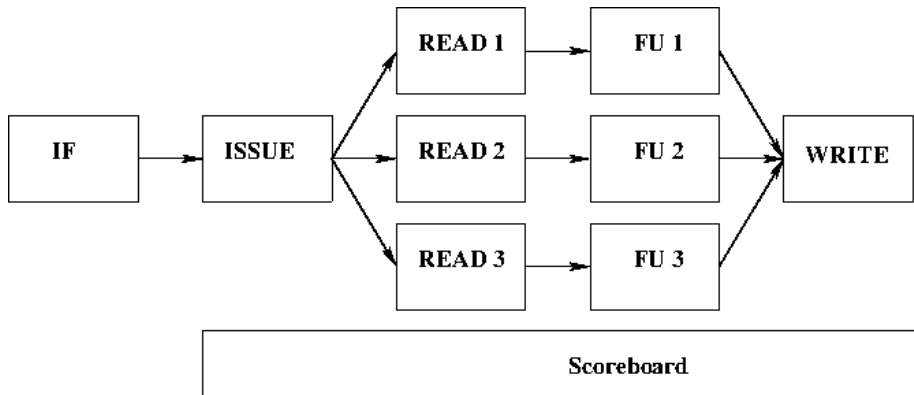
# Basic 5 stage pipeline



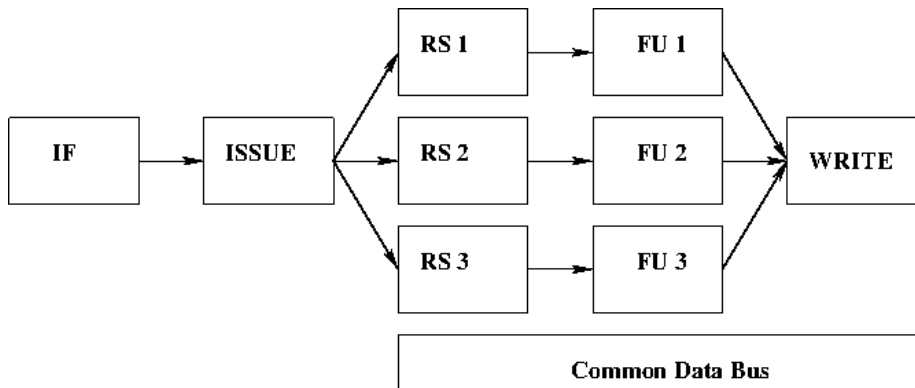
# Pipeline with several Functional units



# Scoreboard pipeline



# Basic Tomasulo pipeline



# Tomasulo pipeline with speculation

