Example: Data Hazard and Stall Delay

- Rewrite the code assuming a machine without forwarding (by inserting nops).
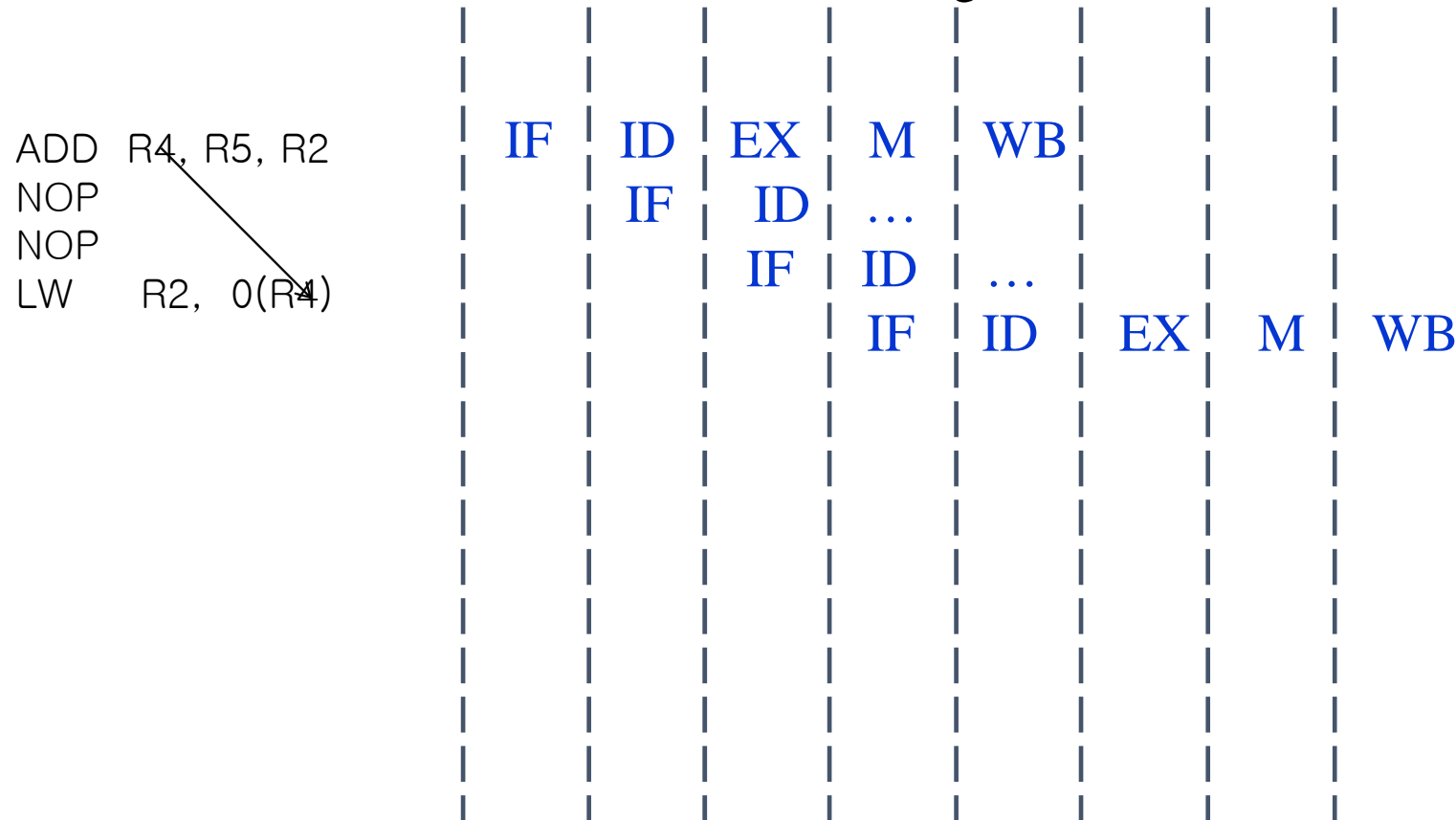
```
ADD      R4, R5, R2
LW       R2,  0(R4)
SW       R15,  4(R2)
```

NOTE:
1. Without forwarding, dependent instruction reads the source operands from the register file at ID stage.
2. Register file can be written and read at the same cycle.

Solution Templete

Between ADD and LW Without Forwarding

```
ADD  R4, R5, R2
NOP
NOP
LW    R2,  0(R4)
```

IF	ID	EX	M	WB				
	IF	ID	…					
		IF	ID	…				
			IF	ID	EX	M	WB	

Solution Templete

Between LW and SW Without Forwarding

LW R2, 0(R4)

NOP
NOP
SW R15, 4(R2)

	IF	ID	EX	M	WB					
		IF	ID	...						
			IF	ID	...					
				IF	ID	EX	M	WB		

Solution Templete – putting together

Without Forwarding

ADD   R4, R5, R2
nop
nop
LW   R2, 0(R4)
nop
nop
SW   R15, 4(R2)

IF | ID | EX | M | WB

IF | ID | EX | M | WB

IF | ID | EX