Solution of in-class Assignment-2

Data Hazard Resolution in MIPS:

F: instruction fetch
D: decode
X: execute
M: memory access
W: writeback

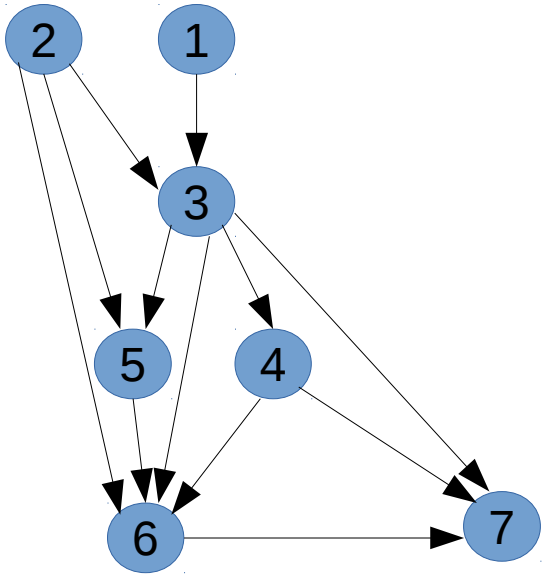
N : data hazard
S : Stall

MIPS 5 Stage pipeline before scheduling

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
r1 := a	F	D	X	M	W																	
r2 := b		F	D	X	M	W																
r3 := r1 + r2			F	N	N	N	D	X	M	W												
r3 := r3 + 1				F	N	N	N	N	N	N	D	X	M	W								
r2 := c					F	D	X	M	W													
r3 := r3 + r2						F	S	N	N	N	N	N	N	N	D	X	M	W				
a := r3							F	N	N	N	N	N	N	N	N	N	N	N	D	X	M	W

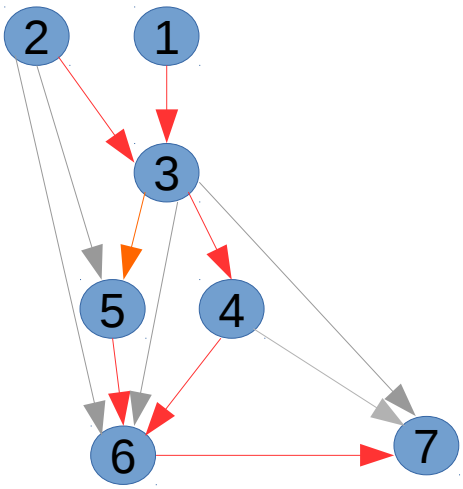
Dependency Preserving Directed Acyclic Graph (DAG) :

1	r1 := a
2	r2 := b
3	r3 := r1 + r2
4	r3 := r3 + 1
5	r2 := c
6	r3 := r3 + r2
7	a := r3



Topological sort of the above DAG to avoid data hazards and minimize pipeline stalls

1. {1, 2, 3, 4, 5, 6, 7}
2. {2, 1, 3, 4, 5, 6, 7}
3. {1, 2, 3, 5, 4, 6, 7}
4. {2, 1, 3, 5, 4, 6, 7}



To minimize stalls the following sequence is chosen:

a. candidates : {1, 2}
1. r1 := a

b. candidates : {2}

1. r1 := a
2. r2 := b

c. candidates : {3}

1. r1 := a
2. r2 := b
3. r3 := r1 + r2

d. candidates : {4, 5}

1. r1 := a
2. r2 := b
3. r3 := r1 + r2
5. r2 := c

e. candidates : {4}

1. r1 := a
2. r2 := b
3. r3 := r1 + r2
5. r2 := c
4. r3 := r3 + 1

f. candidates : {6}

1. r1 := a
2. r2 := b
3. r3 := r1 + r2
5. r2 := c
4. r3 := r3 + 1
6. r3 := r3 + r2

g. candidates : {7}
1. r1 := a
2. r2 := b
3. r3 := r1 + r2
5. r2 := c
4. r3 := r3 + 1
6. r3 := r3 + r2
7. a := r3

End of solution.

After scheduling (with data forwarding) : “D” in yellow marks forwarded data

Forwarded upto decode :

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	r1 := a	F	D	X	M	W													
2	r2 := b		F	D	X	M	W												
3	r3 := r1 + r2			F	N	N	D	X	M	W									
5	r2 := c				F	D	X	M	W										
4	r3 := r3 + 1					F	S	N	N	D	X	M	W						
6	r3 := r3 + r2						F	N	N	N	N	N	D	X	M	W			
7	a := r3							F	N	N	N	N	N	N	N	D	X	M	W

Forwarded upto execute :

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	r1 := a	F	D	X	M	W									
2	r2 := b		F	D	X	M	W								
3	r3 := r1 + r2			F	N	N	D	X	M	W					
5	r2 := c				F	D	X	M	W						
4	r3 := r3 + 1					F	S	N	D	X	M	W			
6	r3 := r3 + r2						F	N	N	D	X	M	W		
7	a := r3							F	N	N	N	D	X	M	W