CPSC 418 **Advanced Computer Architecture** **Spring 1995**

Homework 4 Solutions

1(a) see figure 1

1(b) see figure 2

2(a)

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; initial values:  R2=A, R3=B, R4=C, R5=D, R6=E, R7=F
1000 :  ADD R5, R4, R6   ; G = C + E
1004 :  DIV R5, R5, R4   ; H = G / C
1008 :  SUB R5, R3, R4   ; I = B - C
100C :  ADD R4, R2, R3   ; J = A + B
1010 :  XOR R5, R6, R4   ; K = E ^ J
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2(b) see figure 3

2(c)

Performance gains for adding bypass after divide would not be very significant, because there are not very many divide instructions in most programs.

The cost would be extra hardware for signal lines, multiplexer on input to EX stage, and control logic in Fetch Operands. The multiplexer would likely increase the cycle time.

	0	1	2	3	4	5	6	7	8	9	10	11
PC	1000	1004	1008	100C								
FI		AND R7,R3,R4	XOR R3,R5,R6	SUB R7,R3,R4	ADD R7,R3,R7							
DI			R7=R3&R4	R3=R5^R6	R7=R3-R4	R7=R3+R7	R7=R3+R7					
FO				R7=S1&S2	R3=S1^S2	R7=R3-R4	R7=S1-S2	R7=R3+R7	R7=S1&S2			
EX					R7=F	R7=G		R7=H		R7=I		
WB						R7=F	R3=G		R7=H		R7=I	
S1				A	C		G		G			
S2				B	D		B		H			
R3			A				G					
R4			B									
R5			C									
R6			D									
R7			Q			F			H		I	

Figure 1: Problem 1a – no bypass path

	0	1	2	3	4	5	6	7	8	9	10	11
PC	1000	1004	1008	100C								
FI		AND R7,R3,R4	XOR R3,R5,R6	SUB R7,R3,R4	ADD R7,R3,R7							
DI			R7=R3&R4	R3=R5^R6	R7=R3-R4	R7=R3+R7						
FO				R7=S1&S2	R3=S1^S2	R7=BY-S2	R7=S1-BY					
EX					R7=F	R3=G	R7=H	R7=I				
WB						R7=F	R3=G	R7=H	R7=I			
BY					F	G	H	I				
S1				A	C		G					
S2				B	D	B						
R3			A				G					
R4			B									
R5			C									
R6			D									
R7			Q			F			I			

Figure 2: Problem 1b – bypass path

	0	1	2	3	4	5	6	7	8	9	10	11
PC	1000	1004	1008	100C	1010	1014	1014	1014				
FI		ADD R5,R4,R6	DIV R5,R5,R4	SUB R5,R3,R4	ADD R4,R2,R3	XOR R5,R6,R4	XOR R5,R6,R4	XOR R5,R6,R4				
DI			R5=R4+R6	R5=R5/R4	R5=R3-R4	R4=R2+R3	R4=R2+R3	R4=R2+R3	R5=R6^R4			
FO				R5=S1+S2	R5=BY/S2	R5=S1-S2	R5=S1-S2	R5=S1-S2	R4=S1+S2	R5=S1^BY		
EX					R5=G	R5=G/C			R5=I	R4=J	R5=K	
DIV							R5=G/C	R5=G/C				
WB						R5=G			R5=H	R5=I	R4=J	R5=K
BY					G				I	J	K	
S1				C		B	A	A	A	E		
S2				E	C	C	B	B	B			
R3			B									
R4			C								J	
R5			D							I		K
R6			E									

Figure 3: Problem 2 b – divide instruction

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