Truth Tables and Control Signal Descriptions

	MemtoReg	RegWrite	RegWrite2	MemRead	MemWrite	Branch	Jump	ALUOp	ALUOp0	Immed Op2	ALU src	r15mux	LoadBy	StoreBy
Signed Addition	0	1	0	0	0	0	0	1	0	0	0	0	0	0
Signed Subtraction	0	1	0	0	0	0	0	1	0	0	0	0	0	0
Signed Multiplication	0	1	1	0	0	0	0	1	0	0	0	0	0	0
Signed Division	0	1	1	0	0	0	0	1	0	0	0	0	0	0
AND immediate	0	1	0	0	0	0	0	1	0	1	0	0	0	0
OR immediate	0	1	0	0	0	0	0	1	0	1	0	0	0	0
Load Byte Unsigned	1	1	0	1	0	0	0	0	0	0	1	0	1	0
Store Byte	0	0	0	0	1	0	0	0	0	0	1	0	0	1
Load	1	1	0	1	0	0	0	0	0	0	1	0	0	0
Store	0	0	0	0	1	0	0	0	0	0	1	0	0	0
Branch on Less Than	0	0	0	0	0	1	0	0	1	1	0	1	0	0
Branch on greater Than	0	0	0	0	0	1	0	0	1	1	0	1	0	0
Branch on Equal	0	0	0	0	0	1	0	0	1	1	0	1	0	0
Jump	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Halt	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Forwarding Unit

Mux control	Source	Explanation
ForwardA = 00	ID/EX	The first ALU operand comes from the register file.
ForwardA = 10	EX/MEM	The first ALU operand is forwarded from the prior ALU result.
ForwardA = 01	MEM/WB	The first ALU operand is forwarded from data memory or an earlier ALU result.
ForwardB = 00	ID/EX	The second ALU operand comes from the register file.
ForwardB = 10	EX/MEM	The second ALU operand is forwarded from the prior ALU result.
ForwardB = 01	MEM/WB	The second ALU operand is forwarded from data memory or an earlier ALU result.

Hazard Detection

This unit has one input, which indicates that MemRead was asserted. It has 3 outputs that control PCWrite, IF/IDWrite and the mux to send all zeros to ID/EX. When MemRead is asserted, PC and IF/ID stops writing, and all zeros are sent to ID/EX to create a bubble.

MemRead	PCWrite	ID/EXWrite	BubbleMux
0	1	1	0
0	1	1	0

ALU Control Unit

	ALUOp	Type	ALU Action	Funct Field	
Load Word	000	B	add	XXXX	0010
Store Word	000	B	add	XXXX	0010
Branch on Equal	001	C	subtract	XXXX	0110
Branch on Less Than	011	C	compare less	XXXX	0101
Branch on greater Than	101	C	compare greater	XXXX	0100
Signed Addition	010	A	add	0000	0010
Signed Subtraction	010	A	subtract	0001	0110
Signed Multiplication	010	A	multiply	0100	1000
Signed Division	010	A	divide	0101	1001
AND immediate	110	D	AND	XXXX	0000
OR immediate	111	D	OR	XXXX	0001

NEW CONTROL SIGNAL DESCRIPTIONS

Immed Op2 - similar to ALUSrc, it chooses the second operand of the ALU. 0 means the forwarded op2 data goes into the ALU. 1 means the immediate op2, appended with 8 zeros in front, will go into the ALU.
r15mux - Used in branch instructions, this allows 15 to go into op2 read register input, so that the value in register 15 will be compared with the value in op1. actual op2 in the instruction is sign extended, shifted left, and added to PC to become new instruction address.
LoadBy - used in Load Byte, so that after data from data memory is out, only 8 bottom bits and zeros as top bits are sent to op1, the destination.
StoreBy - used is Store Byte, so only bottom 8 bits of op1 result is written in the data memory.