Design Document

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CSSE 232 Computer Architecture I

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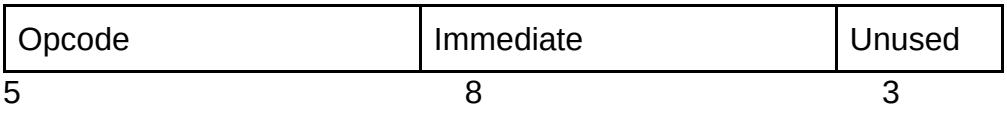
Link to the Google Doc DesignDocument

Description:

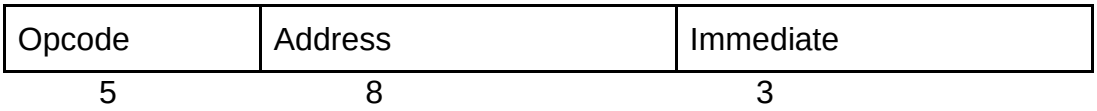
Our design uses a single register accumulator to store data and compare it to inputs. At all times we only use one register and use an allocated space in Memory for data. For our addresses we will use sign extensions to target specific places in memory to receive either data for destination. The input must have the correct first bit to target the proper place in memory.

We are going to use 2 registers, the accumulator($acc) and stack pointer($sp). The accumulator is the only register available by the programmer.

I:

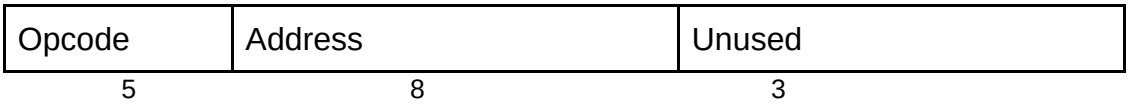


AI:



PC relative for bne and beq

A:



We left shift by 1 bit then we sign extent (the most significant bit will be 1 if it is a data and 0 if it is a instruction)

Instructions

Name	Type	Operation	Opcode
load a	A	acc = rt	00001
	Takes an 8 bit address a and loads the value at memory address a to the accumulator, using the address rule.		
save a	A	Mem[getAddr(rt)] = acc	00010

	Take an 8 bit address a and save the value in the accumulator into the memory with address a, using the address rule.		
loadui	I	acc = {imm, 8b'0}	00011
	Takes an 8 bit immediate and load it to the upper 8 bits of the accumulator		
beq a, imm	AI	if(acc == Mem[getAddr(rt)]) PC = PC + 2 + getAddr(imm)	00100
	Takes an 8 bit address and a 3 bit immediate. If the value stored at address a is equal to the value of the accumulator, then jump to the address calculated from the immediate using the branch address rule.		
bne a, imm	AI	if(acc != Mem[getAddr(rt)]) PC = PC + 2 + getAddr(imm)	00100
	Takes an 8 bit address and a 3 bit immediate. If the value stored at address a is not equal to the value of the accumulator, then jump to the address calculated from the immediate using the branch address rule.		
slt a	A	acc = acc < Mem[getAddr(rt)] ? 1:0	00110
	Compare the value in the accumulator with the value stored at address a, if the accumulator is less than a then we set the accumulator to 1, else we set the accumulator to 0.		
slti imm	I	acc = acc < SignExtent(imm) ? 1:0	00111
	Compare the value in the accumulator with the immediate, if the accumulator is less than the immediate then we set the accumulator to 1, else we set the accumulator to 0.		
j a	A	PC = getAddr(rt)	01000
	Jump to the instruction with address a, calculated using the address rule.		
jal a	I	Men[ra] = PC + 2 PC = getAddr(imm)	01001
	Jump to the instruction with address a, calculated using the address rule. Store the current PC + 2 to a fix memory location.		
sw imm	I	sp + SignExtent(imm) = acc	01010

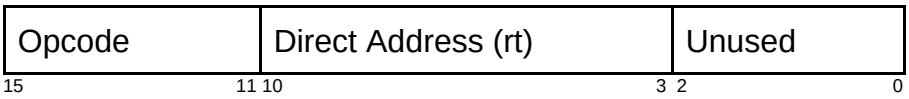
	Stored the value in the accumulator in to the stack where it is of offset imm to the stack pointer.			
lw imm	I	acc = sp + SignExtent(imm)	01011	
	Stored the value from the stack where it is off offset imm to the stack pointer to the accumulator.			
ms	I	sp = sp + SignExtent(imm)	01100	
	Move the stack pointer with the sign extended immediate.			
sub a	A	acc = acc - Mem[getAddr(rt)]	01101	
	Subtract the value stored at address a from the accumulator and store the result in the accumulator			
add a	A	acc = acc + Mem[getAddr(rt)]	01110	
	Add the value stored at address a to the accumulator and store the result in the accumulator			
addi imm	I	acc = acc + SignExtent(imm)	01111	
	Add the sign extended immediate to the accumulator and store the result in the accumulator			
and a	A	acc = acc & Mem[getAddr(rt)]	10000	
	And the value stored at address a to the accumulator and store the result in the accumulator			
or a	A	acc = acc | Mem[getAddr(rt)]	10001	
	Or the value stored at address a to the accumulator and store the result in the accumulator			
ori imm	I	acc = acc | ZeroExtent(imm)	10010	
	Or the zero extended immediate to the accumulator and store the result in the accumulator			
loadi	I	acc = SignExtent(imm)	10011	

	Load the sign extended immediate to the accumulator
getAddr = {7{address[7]}, address, 1'b0} ZeroExtent = {8b'0, imm} SignExtent = {8{address[7]},imm} ra = 0xFFFE sp = 0x1FFF	

Address rule: We left shift by 1 bit then we sign extent (the most significant bit will be 1 if it is a data and 0 if it is a instruction)
Branch address: Left shift the immediate by 1, sign extend it to 16 bits then add it to the value of the current PC plus 2.

Types

A:



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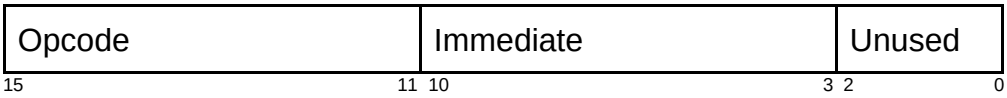

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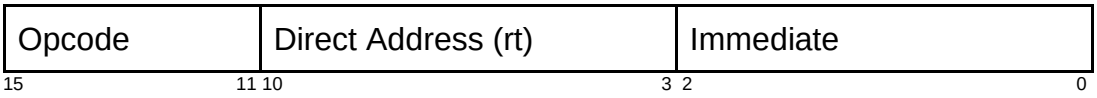

Call procedure

For the callers, they are responsible to store the $acc register value, and put the return address on the $acc. For callees, they are responsible to restore the value in the Data memory, and callees will move the stack to store the original value of the data in the stack memory, and restore them back before return. Also, it's callee's responsibility to store the return address in the stack memory and use them for return.

Example program(s)

High Level Code	Assembly	Machine Code	Addresses

int **relPrime**(int n) {		loadi 2	10011 00000010 000	0x 0030
int m;		save m	00010 10000011 000	0x 0032
m = 2;		ms -12	01100 11110110 000	0x 0034
while (gcd(n, m) != 1) {	loop:	load m	00001 10000011 000	0x 0036
m = m + 1;		sw 0	01010 00000000 000	0x 0038
}		save a	00010 10000000 000	0x 003A
return m;		load n	00001 10000100 000	0x 003C
}		sw 4	01010 00000100 000	0x 003E
		save b	00010 10000001 000	0x 0040
		load ra	00001 11111111 000	0x 0042
		sw 8	01010 00001000 000	0x 0044
		jal gcd	01001 11100111 000	0x 0046
		save o	00010 10000101 000	0x 0048
		lw 0	01011 00000000 000	0x 004A
		save m	00010 10000011 000	0x 004C
		lw 4	01011 00000100 000	0x 004E
		save n	00010 10000100 000	0x 0050
		lw 8	01011 00001000 000	0x 0052
		save ra	00010 11111111 000	0x 0054
		loadi 1	10011 00000001 000	0x 0056
		bne o, end	00100 10000101 100	0x 0058
		load m	00001 10000011 000	0x 005A
		add 1	01110 00000001 000	0x 005C
		save m	00010 10000011 000	0x 005E
		j loop	01000 00011011 000	0x 0060
	end:	ms 12	01100 00001100 000	0x 0062
		j ra	01000 11111111 000	0x 0064

int **gcd**(int a, int b) {
  if (a == 0) {
  return b;
  }
  while (b != 0) {
  if (a > b) {
  a = a - b;
  } else {
  b = b - a;
  }
  }
  return a;
}
	gcd:
	  loadi 0
	  bne a, loop
	  load b
	  j ra
	loop:
	  loadi 0
	  bne b, go
	  j end
	go: load b
	  slt a
	  save i
	  loadi 1
	  bne i, else
	  load a
	  sub b
	  save a
	  j loop
	else: load b
	  sub a
	  save b
	  j loop
	end: load a
	  j ra
		10011 00000000 000
		00100 10000000 010
		00001 10000001 000
		01000 11111111 000
		
		10011 00000000 000
		00100 10000001 001
		01000 00010110 000
		00001 10000001 000
		00110 10000000 000
		00010 10000010 000
		10011 00000001 000
		00100 10000010 011
		00001 10000000 000
		01101 10000001 000
		00010 10000000 000
		01000 00000101 000
		00001 10000001 000
		01101 10000000 000
		00010 10000001 000
		00010 00000101 000
		00001 10000000 000
		00010 11111111 000
			0x 0002
			0x 0004
			0x 0006
			0x 0008
			0x 000A
			0x 000C
			0x 000E
			0x 0010
			0x 0012
			0x 0014
			0x 0016
			0x 0018
			0x 001A
			0x 001C
			0x 001E
			0x 0020
			0x 0022
			0x 0024
			0x 0026
			0x 0028
			0x 002A
			0x 002C
			0x 002E

Data: 0xFF00 a(value = m) 0xFF02 b(value = n) 0xFF04 i 0xFF06 m 0xFF08 n 0xFF0A o		Stack: 0x1FFF	

if (n == 0) {
  n++;
} else {
  n = 2;
}
	bne n, else
	else:
			0x 0002
			0x 0004
			0x 0006
			0x 0008
			0x 000A
			0x 000C
			0x 000E

while (n != 0) {
  n = n - m
}			

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int count = 0;
for (int i = 0; i < n; i++) {
count++;
}			

Team repo: set upped, goto link in M1 and join yellow