EEL4768 Computer Architecture

Homework 4

Due date: March 19, 2017, 11:59PM (late submission is not accepted, solution will be uploaded on March 20, 2017)

Total points: 100

1. (20 points) Answer the following questions:

a) Which component does the addition 'PC+4' in the multi-cycle datapath?

b) Which component computes the branch address in the multi-cycle datapath?

c) Why did we add multiple registers in the multi-cycle datapath? (Instruction register, Memory data register, A, B, ALUOut)

d) What is the use of the 'PCWrite' signal in the multi-cycle datapath? When is it set to 1?

e) What is the use of the 'IRWrite' signal in the multi-cycle datapath? When is it set to 1?

f) How is the control unit implemented in the multi-cycle datapath?

g) In which cycle is the branch address computed in the multi-cycle datapath? Is it computed automatically for all the instructions or only for the branch instruction? Explain.

h) Is the multi-cycle implementation always faster than the single-cycle implementation? Explain.

2. (10 points) Modify the single-cycle datapath by implementing the conditional move instruction 'MOVZ'. Below is the syntax. The instruction below will move t1 into t0 if t2==0. Otherwise, t0 will be assigned as "0"

MOVZ $t0, $t1, $t2

This is the encoding of the instruction above

unique	t1	t2	t0	0	0
opcode	**rs**	**rt**	**rd**	**shamt**	**Funct**

Draw the changes on the datapath diagram and provide the values of all the control signals.

3. (10 points) Modify the single-cycle datapath by implementing the set bit instruction 'SBIT'. Below is the syntax. The instruction below sets the bit #4 (makes it 1) of register $t0 and leaves the other bits in $t0 unchanged

SBIT $t0, 4

This is the encoding of the instruction above

unique	0	t0	0	4	any value
opcode	**rs**	**rt**	**rd**	**shamt**	**Funct**

Draw the changes on the datapath diagram and provide the values of all the control signals.

4. (10 points) Modify the single-cycle datapath by implementing the 'jump indexed' instruction (jdx). Below is the syntax. The instruction below jumps to address (t0+t1+1024) and stores result of (t0+t1+1024) in the memory at address at zero. The immediate value used is always a multiple of 4. In the instruction, the rightmost 00 are dropped, hence, the immediate field in the instruction is 256. The immediate field is a signed value; it can be positive or negative.

jdx $t0, $t1, 1024

This is the encoding of the instruction above

unique	t0	t1	256
opcode	**rs**	**rt**	**immediate (signed)**

Draw the changes on the datapath diagram and provide the values of all the control signals.

5. (10 points) Modify the single-cycle datapath by implementing the instruction (inc). Below is the syntax. The instruction below increments two registers by 4

inc $t0, $t2

This is the encoding of the instruction above

unique	t1	t2	t0	0	0
opcode	**rs**	**rt**	**rd**	**shamt**	**Funct**

Draw the changes on the datapath diagram and provide the values of all the control signals.

6. (10 points) Modify the multi-cycle datapath by implementing the 'MOVZ' instruction mentioned above.

7. (10 points) Modify the multi-cycle datapath by implementing the 'SBIT' instruction mentioned above.

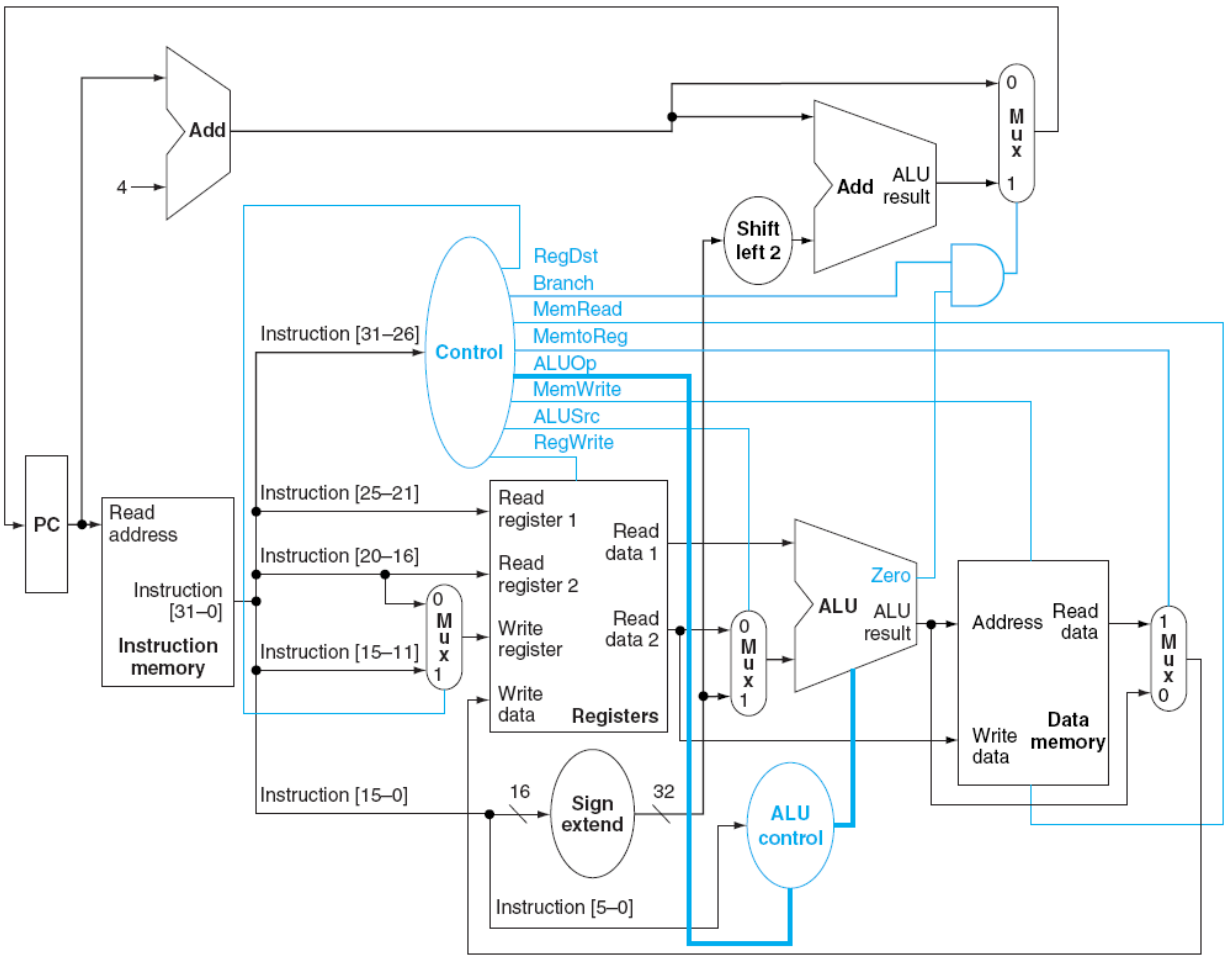
8. (10 points) Modify the multi-cycle datapath by implementing the 'jdx' instruction mentioned above.

9. (10 points) Modify the multi-cycle datapath by implementing the 'inc' instruction mentioned above.

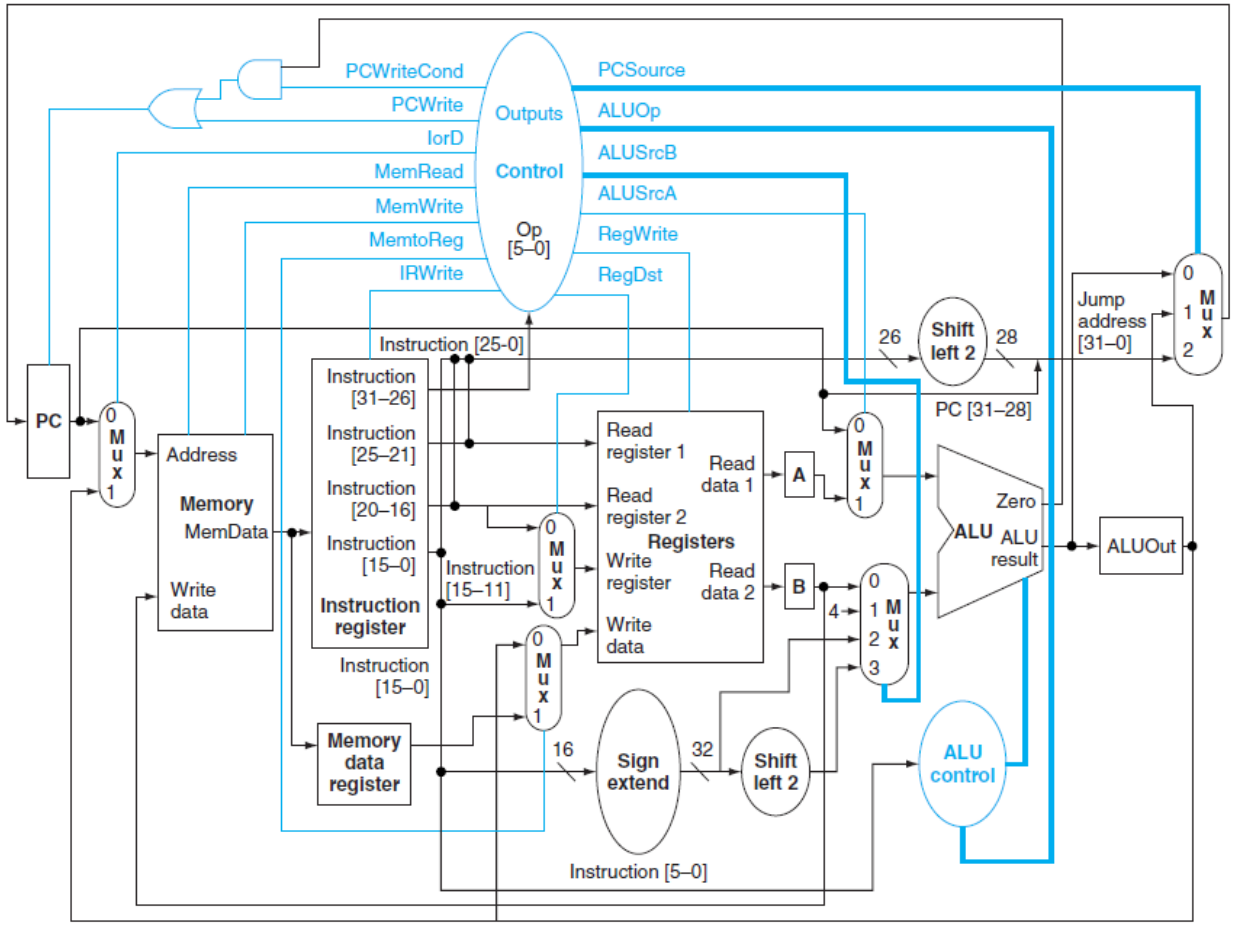
For each of questions 6 to 9

1) Explain how many cycles are needed and what's the task done in each cycle
2) Draw the changes on the datapath diagram
3) Draw the changes on the control state machine

For your reference, please use the following single cycle datapath for question 2-5



Please use the following multi-cycle datapath for question 6-9



Please use the following control state machine for question 6-9