Introduction to Computer Engineering

CS/ECE 252, Spring 2017
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University of Wisconsin – Madison
Revision
Chapter : 5 and 6
Note for all

- Mid-Term 3 on Friday April 7th
- Chapter 5 and 6 for Mid-Terms
- Discussion Session on April 5th
Chapter 5 Topics:

- Instruction Set Architecture
- Memory Organization
  - Address Space
  - Addressability
- Register Set
- Instruction Set
  - Opcodes
  - Data Types
  - Addressing Modes
Chapter 6

• Programing and Programing Constructs
  • Problem Solving principles
  • Three Constructs
    ➢ Sequential
    ➢ Conditional
    ➢ Iterative
  • Stepwise Refinement
  • Debugging Operations
    ➢ Using Breakpoints
LC 3 Instructions

• Operate Instructions
  • ADD, OR, NOT
  • Sources and Destinations never reference memory
  • Only ADD has three operands

• Load -- read data from memory to register
  • LD: PC-relative mode
  • LDR: base+offset mode
  • LDI: indirect mode

• Store -- write data from register to memory
  • ST: PC-relative mode
  • STR: base+offset mode
  • STI: indirect mode

• Load effective address -- compute address, save in register
  • LEA: immediate mode
  • The only Load instruction that does not access memory
LDR (Base+Offset)

LDR 0 1 1 0 Dst Base offset6
LDR (Base+Offset) Microinstructions

- MAR<- BaseR + SEXT(Offset6) ; set up the memory address
- MDR<- Memory[MAR]; read mem at BaseR + Offset
- DR<- MDR; Load Dr
What is the purpose of Signal Labeled A
What is the purpose of Signal Labeled A

Identify Branch Instruction
What is the purpose of Signal Labeled X and Y
What is the purpose of Signal Labeled X and Y
What Value is loaded in R6 ? and replace it with one instruction

• LEA R3 , OFFSET x3F , addr=x3010
• LDR R4,R3,#0
• LDR R6,R4,#0

• x3050       x70A4
• x70A2       x70A3
• x70A3       xFFFF
• x70A4       x123B
What Value is loaded in R6? and replace it with one instruction

- LEA R3, OFFSET x3F, addr=x3010
- LDR R4, R3, #0
- LDR R6, R4, #0

- x3050   x70A4
- x70A2   x70A3
- x70A3   xFFFF
- x70A4   x123B

- LDI R6, offset x3F
Solve Question Below:

Consider the LC-3 program below.

<table>
<thead>
<tr>
<th>Address</th>
<th>Instruction</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x4000</td>
<td>0101 100 100 1 00000</td>
<td></td>
</tr>
<tr>
<td>0x4001</td>
<td>0001 011 011 1 11011</td>
<td></td>
</tr>
<tr>
<td>0x4002</td>
<td>0101 011 011 1 11111</td>
<td></td>
</tr>
<tr>
<td>0x4003</td>
<td>0000 1 0 0 000000010</td>
<td></td>
</tr>
<tr>
<td>0x4004</td>
<td>0001 100 100 1 1110</td>
<td>R4 &lt;- R4 - 2</td>
</tr>
<tr>
<td>0x4005</td>
<td>0000 1 1 1 11111100</td>
<td>Branch if N, Z, or P is set to address 0x4001</td>
</tr>
<tr>
<td>0x4006</td>
<td>1111 0000 0000000</td>
<td>HALT</td>
</tr>
</tbody>
</table>
Solve Question Below:

- Set R4<-0
- R3<- R3-5
- Set Condition Flag
- Branch if n to HALT

Consider the LC-3 program below.

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</tr>
<tr>
<td>0x4002</td>
<td>0101 011 011 1 11111</td>
<td></td>
</tr>
<tr>
<td>0x4003</td>
<td>0000 1 0 0 000000010</td>
<td></td>
</tr>
<tr>
<td>0x4004</td>
<td>0001 100 100 1 11110</td>
<td>R4 &lt;- R4 - 2</td>
</tr>
<tr>
<td>0x4005</td>
<td>0000 1 1 1 111111000</td>
<td>Branch if N, Z, or P is set to address 0x4001</td>
</tr>
<tr>
<td>0x4006</td>
<td>1111 0000 00000000</td>
<td>HALT</td>
</tr>
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Solve Question Below:

• Suppose you are not allowed to use the LC-3 LDI instruction. Write a sequence of LC-3 instructions that would achieve the same result as the LC-3 LDI instruction 0xA80C.
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• 1010 100 000001100
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  • 1010 100 000001100
  • LDI , r4,#12
Solve Question Below:

- Suppose you are not allowed to use the LC-3 LDI instruction. Write a sequence of LC-3 instructions that would achieve the same result as the LC-3 LDI instruction 0xA80C.

- 1010 100 000001100
- LDI , r4,#12
- LD, r4,12
- LD, r4,12
- LDR, r4,r4,0
In-class Exercise: Fill in the Instructions and Comments in Table below

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<thead>
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<tr>
<td>0x3000</td>
<td>0001 011 011 0 00 010</td>
<td></td>
</tr>
<tr>
<td>0x3001</td>
<td>0000 100 000000010</td>
<td></td>
</tr>
<tr>
<td>0x3002</td>
<td>0001 010 010 1 00001</td>
<td></td>
</tr>
<tr>
<td>0x3003</td>
<td>0101 011 011 000 010</td>
<td></td>
</tr>
<tr>
<td>0x3004</td>
<td>1001 011 011 11111</td>
<td></td>
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<td>0x3000</td>
<td>0001 011 011 0 00 010</td>
<td>R3 = R3 + R2</td>
</tr>
<tr>
<td>0x3001</td>
<td>0000 100 000000010</td>
<td>If N, branch to x3004</td>
</tr>
<tr>
<td>0x3002</td>
<td>0001 010 010 1 00001</td>
<td>R2 = R2 + 1</td>
</tr>
<tr>
<td>0x3003</td>
<td>0101 011 011 000 010</td>
<td>R3 = R3 AND R2</td>
</tr>
<tr>
<td>0x3004</td>
<td>1001 011 011 11111</td>
<td>R3 = NOT(R3)</td>
</tr>
<tr>
<td>0x3005</td>
<td>1001 010 010 11111</td>
<td>R2 = NOT(R2)</td>
</tr>
</tbody>
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