Lecture 25: Microprogramming

- The Microprogram
- Encoding instructions
- Decoding Instructions

The Microprogram

- microprogram from handout

Fetch and Decode

0: MAR := PC; READ; // gets low-order 13 bits
1: READ;            // data returned in MBR
2: PC := PC + 1;
3: IR := MBR; if N then goto 25 // check bit 0 of opcode
4: TMP := lshift(IR + IR); if N then goto 16 // check bit 1
5: TMP := TMP; if N then goto 10; // check bit 2

ADD

6: MAR := IR; READ; // ADD (000)
7: READ;
8: ACC := MBR + ACC;
9: goto 0;
SUB

10: MAR := IR; READ;       // SUB (001)
11: READ;
12: ACC := ACC + 1;
13: TMP := com(MBR);      // 1's complement
14: ACC := ACC + TMP;
15: goto 0;

LOAD

16: TMP := TMP; if N then goto 21 // check bit 2
17: MAR := IR; READ;       // LOAD (010)
18: READ;
19: ACC := MBR;
20: goto 0;

STORE

21: MAR := IR;            // STORE (011)
22: MBR := ACC; WRITE;
23: WRITE;
24: goto 0;

More Decoding

25: TMP := lshift(IR+IR); if N then goto 0;
     // No opcodes 11...
26: TMP := TMP; if N then goto 29
**JUMP**

27: PC := and(IR, AMASK); // JUMP (100)
28: goto 0;

**JZER**

29: ACC := ACC; if Z then goto 27; // JZER (101)
30: goto 0;

27: PC := and(IR, AMASK); // JUMP (100)
28: goto 0;

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**MicroInstruction Format**

- review format (handout)

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**Instruction encoding example:**

2: PC := PC + 1

**Fields:**

- MUX
- COND
- ALU
- SH
- MBR
- MAR
- RD
- WR
- ST
- C
- B-Latch
- A-Latch
- ADDR

**Answer:**
• Another example:
  13: TMP := com(MBR)

• Fields:
  MUX =
  COND =
  ALU =
  SH =
  MBR =
  MAR =
  RD =
  WR =
  ST =
  C =
  B-Latch =
  A-Latch =
  ADDR =

• Answer:

• More than one MAL instruction per microinstruction!:
  16: TMP := TMP; if N then goto 21

• Fields:
  MUX =
  COND =
  ALU =
  SH =
  MBR =
  MAR =
  RD =
  WR =
  ST =
  C =
  B-Latch =
  A-Latch =
  ADDR =

• Answer:

• Another example:
  17: MAR := IR; READ;

• Fields:
  MUX =
  COND =
  ALU =
  SH =
  MBR =
  MAR =
  RD =
  WR =
  ST =
  C =
  B-Latch =
  A-Latch =
  ADDR =

• Answer:

• Another example:
  27: PC := and(IR, AMASK)

• Fields:
  MUX =
  COND =
  ALU =
  SH =
  MBR =
  MAR =
  RD =
  WR =
  ST =
  C =
  B-Latch =
  A-Latch =
  ADDR =

• Answer:
Decoding

- Decoding hints:
  - break the binary up into the fields as shown
  - an unused field is not necessarily going to be zero! Any non applicable fields (addresses if not jumping, B-latch values for single operand instructions) should be ignored.

- Decode Example
  0 01 00 01 0 0 0 0 1 011 010 010 00000

  Fields:
  MUX =  
  COND =  
  ALU =  
  SH =  
  MBR =  
  MAR =  
  RD =  
  WR =  
  ST =  
  C =  
  B-Latch =  
  A-Latch =  
  ADDR =  

- Answer: ???

- Decode Example
  0 11 10 00 0 0 0 0 0 011 101 010 00000

  Fields:
  MUX =  
  COND =  
  ALU =  
  SH =  
  MBR =  
  MAR =  
  RD =  
  WR =  
  ST =  
  C =  
  B-Latch =  
  A-Latch =  
  ADDR =  

- Answer: ???