Lecture 24: Sample MicroArchitecture

- Control Unit
- ALU
- Registers
- Instructions
- Instruction Decoding
- MicroInstructions

About the Sample MicroArchitecture

- We'll be using a Sample Microarchitecture to learn about microprogramming.
- It's described in a handout on the web. This was generated by Prof. Hamel from a number of different sources (listed in the handout)
- Why not use Intel?
  - think back on how complicated the machine code was.
  - microcode to implement all those instructions would be too much to learn in three days!

Control Unit

- Control unit: works with the microprogram to interpret microinstructions.
- MAP – mapping memory used to get the start address in our microprogram.
- Control memory (Control store) – holds our microprogram
- MUX conditional codes – status bits from the ALU
  - N – set if ALU output is negative
  - Z – set if ALU output is zero

ALU

- ALU has three components:
  - general registers
  - ALU itself
  - Shift unit
- ALU Functions:
  - addition (+)
  - binary AND (and)
  - complement left operand (com)
  - pass left operand through unchanged (default)

ALU, cont.

- Shift functions:
  - left shift (lshift)
  - right shift (rshift)
  - no shift (default)
- A and B latches are used to present stable data to the ALU
- Status bits are N and Z (described earlier)

Internal Registers

- We've seen registers that the programmer has access to (for Intel: AX, BX, …).
- Units within the processor (such as the control unit or ALU) have their own internal registers.

MicroArchitecture Registers

- General Registers:
  - ACC (Register 0): Accumulator
  - PC (Register 1): Program counter
  - IR (Register 2): Instruction register
  - TMP (Register 3): Temporary register, used for instruction encoding and other things
  - AMASK (Register 4): Address mask, used to mask out the high-order bits of an instruction (leaving 13 address bits)
  - 1 (Register 5): Contains the constant 1

MicroArchitecture Registers

- Other Registers:
  - MAR: Memory address register, holds the address of an operand (13 bits wide)
  - MBR: Memory buffer register, holds the item read from memory
  - MIR: Microprogram instruction register – holds the current microinstruction
  - MPC: Microprogram program counter – points to the next microinstruction

MicroInstructions

- Microinstructions contain many fields, each controlling a different unit.
  - Commands (such as RD, WR) – set to one to send a signal on the respective control lines.
  - Function codes (such as ALU, SH) – represent which operation is required by the ALU or shifter.
  - Addresses (such as A, or B) – give the register number that should be operated on.

Instruction Set

- To keep things simple, we'll be using a simplified machine language (NOT Intel!)
- In this machine language instructions are 16 bits:
  - high-order 3 bits are the opcode
  - low-order 13 bits are the address

Instruction Set, cont.

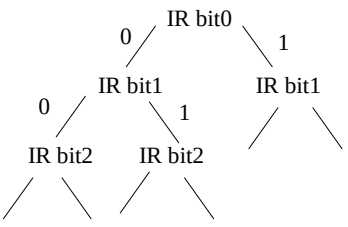
- Our instructions:

Instruction	Op Code	Description
ADD	000	ACC := ACC + (A)
SUB	001	ACC := ACC – (A)
LOAD	010	ACC := (A)
STORE	011	(A) := ACC
JUMP	100	PC := A
JZER	101	IF ACC==0 JUMP A

- A – our operand address (lower 13 bits of the instruction)

Instruction Decoding

- The opcode needs to be decoded so we can determine what portions ("subroutines") of the microprogram apply.
- One method: a decoding tree
  - microprogram makes as many comparisons as there are opcode bits:



Instruction Decoding, cont.

- The decoding tree is very time consuming.
- In reality, other methods are used:
  - jump tables
    - jump to the table
    - jump to the spot in the table with the address
    - jump to the address
  - mapping memory
    - opcode goes to special memory to find the start address.

The Microprogram

- in web handout

MicroInstruction Format Types

- Horizontal microinstructions – there are no coded fields. There is one bit in the microinstruction for each signal.
- Vertical microinstructions – contain coded fields (example: using a 3-bit address field to specify which one of 8 registers should be used).
- Vertical microinstructions save on control memory but are slower (need to decode the fields).
- Most microarchitectures (such as ours) use a mixture of formats – some fields are coded, others are not.

Our Microinstructions

- Our control store is a 64x27 bit read-only memory.
- Microinstruction format (and #bits/field) is:
- picture from handout

MicroInstruction Fields

- handout

Microprogram Syntax

- To be able to read our microprogram, we use a micro assembly language (MAL)
- One microinstruction per line, with different parts of the microinstruction separated by semicolons
- They are ordered on a line in the order in which they are carried out.
- Assigning a value, use ":="
  MAR := PC
- Jumps within the microcode are indicated by goto <line#>
  - goto 25

Microprogram Syntax, cont.

- Conditionals are written using if <condition> then
  - if N then goto 25 ;if negative go to 25
- ALU functions:
  - addition
    ACC := ACC + 1
  - and
    PC := and(IR, AMASK)
  - pass (default)
    TMP := TMP
  - complement (1's complement)
    TMP := com(MBR)
- Shifting:
  - right shift
    TMP := rshift(IR)
  - left shift
    TMP := lshift(IR)

Microprogram Syntax, cont.

- ALU and Shift functions can be combined:
  - adding, then shifting:
    TMP := lshift(IR + IR)
  - adds IR and IR, then shifts left and stores the result in TMP
- An ALU function and a conditional jump can be combined on one line:
  TMP := TMP; if N then goto 21