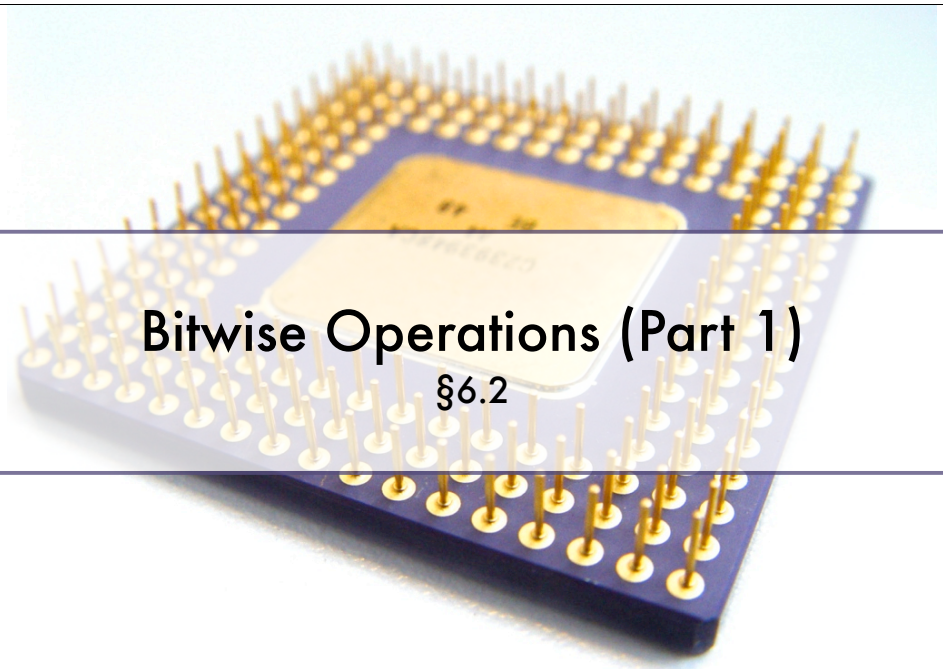
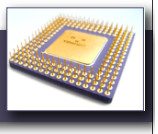


Bitwise Operations (Part 1)

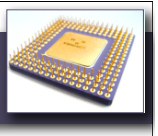
§6.2

Motivation: Flags



- The EFLAGS register holds 32 bits, like other registers
- However, each bit corresponds to a different flag:
  - Bit 0: Carry flag — Status flag
  - Bit 2: Parity flag — Status flag
  - Bit 4: Auxiliary carry flag — Status flag
  - Bit 6: Zero flag — Status flag
  - Bit 7: Sign flag — Status flag
  - Bit 9: Interrupt enable flag — Control flag
  - Bit 10: Direction flag — Control flag
  - Bit 11: Overflow flag — Status flag

Motivation: Flags

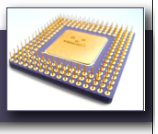


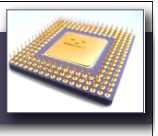
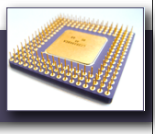
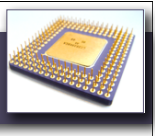
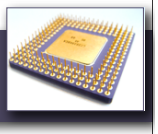
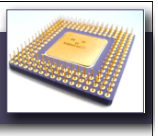
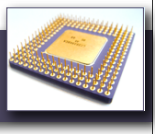
- *Example:*

  EFLAGS = 00000A92h
  = 00000000 00000000 00001010 10010010b

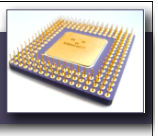
  - Bit 0: Carry flag = 0
  - Bit 2: Parity flag = 0
  - Bit 4: Auxiliary carry flag = 1
  - Bit 6: Zero flag = 0
  - Bit 7: Sign flag = 1
  - Bit 9: Interrupt enable flag = 1
  - Bit 10: Direction flag = 0
  - Bit 11: Overflow flag = 1

Motivation: Flags



- One way to copy the value of EFLAGS into EAX:
  - ```
    pushfd
    pop eax
    ```
  - *But how to determine if a particular bit in EAX is set?*
- ...and then set the value of EFLAGS from EAX:
  - *(put desired value in EAX)*
    ```
    push eax
    popfd
    ```
  - *Copy current value into EAX, then set/clear desired bits*
  - *But how to set/clear individual bits in EAX?*
    ```

Review from ELEC 2200/2210



- Recall the basic Boolean/logical operations:

Activity 13 #1

AND

x	y	x ∧ y
0	0	0
0	1	0
1	0	0
1	1	1

OR

x	y	x ∨ y
0	0	0
0	1	1
1	0	1
1	1	1

XOR

x	y	x ⊕ y
0	0	0
0	1	1
1	0	1
1	1	0

NOT

x	¬x
F	T
T	F

Bitwise Operations



- Boolean operations (AND, OR, XOR, NOT) can be applied *bitwise,* i.e., applied to every bit:

Activity 13 #2

```
  00111011
AND 00001111
    --------
    00001011
```

```
  00111011
XOR 00001111
    --------
    00110100
```

```
  00111011
OR  00001111
    --------
    00111111
```

```
NOT 00111011
    --------
    11000100
```

Topics Covered in Notes:



- AND, OR, XOR instruction
- NOT instruction

Activity 13 #3-4

Bit Masks & Testing Bits



- *bit mask:* a binary integer value (usually a constant) that is combined with another value using a bitwise operation in order to extract, set, or clear particular bits
  - Like using masking tape when painting
- E.g., how to tell if a number has bit 3 set?
  - `10011110 & 00001000 = 00001000`
    `01110011 & 00001000 = 00000000`
    `00000000 & 00001000 = 00000000`
  - Bitwise AND the number with the bit mask 00001000b, then check whether the result is nonzero

Bit Masks & Testing Bits



- E.g., how to tell if a number has either bit 0 or 3 set?
  - Activity 13 #5
  - ```
    10011110      01110011      00000000
    & 00001001  & 00001001  & 00001001
    00001000      00000001      00000000
    ```
  - Bitwise AND the number with the bit mask 00001001b, then check whether the result is nonzero
- Examples of bit masks with OR and XOR later...

TEST Instruction



- Performs a nondestructive AND operation between each pair of matching bits in two operands
- No operands are modified, but the Zero flag is affected.
- Example: jump to a label if either bit 0 or bit 1 in AL is set.
  - ```
    test al, 00000011b
    jnz  ValueFound
    ```
- Example: jump to a label if neither bit 0 nor bit 1 in AL is set.
  - ```
    test al, 00000011b
    jz   ValueNotFound
    ```

Activity 13 #6
    ```

Topics Covered in Notes:



- TEST instruction