Computer Organization

Lecture 4: Operations on Bits

Computer Science and Technology Program
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Operations on Bits

- Arithmetic Operations
  - Addition and subtraction
  - Sign Extension
  - Overflow
- Logic Operations
  - AND
  - OR
  - NOT
  - XOR

Binary Addition Rules

- 0 + 0 = 0
- 0 + 1 = 1
- 1 + 0 = 1
- 1 + 1 = 0, with a carry bit to the next more significant bit
- Sum = 0 , carry = 1

Binary Addition Example

- 01001011 + 00101110 = ?
- 01101011 + 00101110 = ?

Binary Subtraction Rules

- 0 - 0 = 0
- 1 - 0 = 1
- 1 - 1 = 0
- 0 - 1 = 1, with a borrow bit from the next more significant bit.

Binary Subtraction Example

- The decimal subtraction 29 - 7 = 22 is the same as adding (29) + (-7) = 22
- Convert the number to be subtracted to its two's complement: 29 ---> 00011101, -7 ---> 11111001
- Add (ignore the final carry bit)

Exercises

- Try out the following additions in 8-bit 2's complement:
  - 24 + 9
  - 24 – 9
  - 9 – 24
  - – 24 – 9

Sign Extension

- To extend a signed integer from 8 bits to 16 bits or from 16 bits to 32 bits, append additional bits on the left side of the number. Fill each extra bit with the value of the smaller number's most significant bit (the sign bit).
- 1111 1111 ---> 1111 1111 1111 1111
- 0000 0001 ---> 0000 0000 0000 0001

Overflow

- Overflow occurs when a calculation produces a result that is greater in magnitude than what a given register or storage location can store or represent
- For example, 01101011 + 00101110 = ?

Logic Operations on Bits

- The AND operation
  - 0 and 0 = 0
  - 0 and 1 = 0
  - 1 and 0 = 0
  - 1 and 1 = 1
- The OR operation
  - 0 or 0 = 0
  - 0 or 1 = 1
  - 1 or 0 = 1
  - 1 or 1 = 1
- The NOT operation
  - Not 0 = 1
  - Not 1 = 0
- The XOR operation
  - 0 xor 0 = 0
  - 0 xor 1 = 1
  - 1 xor 0 = 1
  - 1 xor 1 = 0

Truth Table

- What is a truth table?
- Can you draw the truth table of all the arithmetic and logic operations discussed in this lecture?