CS 270 Lecture 1
Outline

- Review General Information Sheet (Handout)
- Overview of the Course
- Data Representation
Overview of Course

- Data Representation
- Introduction to Computer Organization
- Assembler Programming in MIPS
- C and Unix Programming
Data Representation

- Represent Data in Binary
  - Place-Valued Number Systems
  - Integers
  - Real Numbers (Floating Point)
- Characters
- Other data
Place-Values
Number Systems

• Also known as Positional Number Systems

• Base or Radix

• Digits
  • Base N requires N distinct digits
  • One of the digits will be 0 (or equivalent to 0)
Base 10

- 10 Digits
  - 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
Base 10

- Consider the base 10 number 7438
- This number (sequence of digits) represents
  - $7*10^3 + 4*10^2 + 3*10^1 + 8*10^0$
  - $7000+400+30+8 = 7438$

•
• Consider the base 10 number 273.61

• This number (sequence of digits) represents

  • $2 \times 10^2 + 7 \times 10^1 + 3 \times 10^0 + 6 \times 10^{-1} + 1 \times 10^{-2}$
  
  • $200 + 70 + 3 + 0.6 + 0.01 = 273.61$
Place-Valued Number Systems

- General Pattern for a base b number

- b digits
  - $d_0, d_1, \ldots, d_{b-1}$

- The first digit to the left of the decimal point (binary point…) is position 0

- Positions increase by 1 moving to the left and decrease by 1 moving to the right

- Consider the base b number $d_4d_0d_5.d_3d_4$

- The sequence of digits represents (using base 10 digits for the exponents)
  - $d_4 \times b^2 + d_0 \times b^1 + d_5 \times b^0 + d_3 \times b^{-1} + d_4 \times b^{-2}$
Place-Valued Notation

• Most common bases used in computer science
  – Base 2 (binary)
  – Base 8 (octal)
  – Base 10 (decimal)
  – Base 16 (hexadecimal)
Base 2

- Two Digits
  - 0 and 1
- Consider the base 2 number 100111
- This number represents
  \[ 1 \times 2^5 + 0 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 \]
- Since there are only two digits it is common to write the above expression using only the powers of 2 that are multiplied by 1
  \[ 2^5 + 2^2 + 2^1 + 2^0 \]
- This represents to base 10 number
  \[ 32 + 4 + 2 + 1 = 39 \]
- To indicate the base of a number a subscript is sometimes used at the end of the number
  \[ 100111_2 \]
Base 8

• Eight digits
  – 0, 1, 2, 3, 4, 5, 6, 7

• Consider the base 8 number 5072

• The number represents
  – $5 \times 8^3 + 0 \times 8^2 + 7 \times 8^1 + 2 \times 8^0$

• The is equivalent to the base 10 number
  – $5 \times 512 + 0 \times 64 + 7 \times 8 + 2 \times 1 = 2618$
Base 16

• Sixteen digits
• Consider the base 16 number B74D
• This number represents
  \[ B \times 16^3 + 7 \times 16^2 + 4 \times 16^1 + D \times 16^0 \]
  \[ 11 \times 16^3 + 7 \times 16^2 + 4 \times 16^1 + 13 \times 16^0 \]
• This is equivalent to the base 10 number
  \[ 11 \times 4096 + 7 \times 256 + 4 \times 16 + 13 \times 1 = 46925 \]
<table>
<thead>
<tr>
<th>Base 10</th>
<th>Base 2</th>
<th>Base 8</th>
<th>Base 16</th>
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<tr>
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<td>1111</td>
<td>17</td>
<td>F</td>
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</tbody>
</table>
Conversion Problems

• Convert between bases
• For example given the base 2 number 11001001 find the equivalent base 10 and base 16 number
• Base 10
  – 201
• Base 16
  – C9
Convert Base 2 to Base 16

- last4Bits(X)
  - last4Bits(11001101)
    • 1101

- bitsExcludingLast4(X)
  - bitsExcludingLast4(11001101)
    • 1100
Convert base 2 to base 16

• concatenate(A, B)
  – concatenate(6, 547)
    • 6547

• base16Digit(X)
  – base16Digit(1100)
    • C
Algorithm to Convert Base 2 to Base 16

Let $X$ be a string of 0s and 1s that is the base 2 representation of the number we want to convert to base 16
$B = ""$ (the empty string)
while $X \neq ""$
    $Y = \text{last4Bits}(X)$
    $Z = \text{base16Digit}(Y)$
    $B = \text{concatenate}(Z, B)$
    $X = \text{bitsExcludingLast4}(X)$
$B$ is the base 16 representation of the original $X$
Algorithm to convert base 10 representation to binary representation

Let X be the base 10 integer we want to convert to base 2
B = “”
while X != 0
    Y = X / 2 (integer quotient)
    Z = X % 2
    B = concatenate(Z, B)
    X = Y
B is now the binary representation of the original value of X
Practice Problems

• Convert the following base 10 numbers to base 2
  – 27
  – 43
  – 80

• How can you check your answer?
How Many Dots?

10101₂  25₈  21₁₀  15₁₆