

Class 2: Numbering Systems

- Numbering systems
 - Decimal
 - Binary
 - Hexadecimal
- Hexadecimal to Binary Conversion
- Data Organization
- Homework 1 -> due a week from today!

Why different numbering systems?

Different ways of representing the same value



- How many frogs?

Decimal System (a review)

- Commonly used by: people!
- Each digit represents a power of 10
- Digits go from 0 to 9
- Also known as Base 10
- Example:

$$123_{10} =$$

If moving to the right of the decimal point, powers decrease:

$$2.45_{10} =$$

Binary System

- Used by: computer internal representation.
- In binary, each digit represents a power of 2.
- Binary numbers are made entirely of 0 and 1.
- Also known as Base 2.
- Binary digits are also known as bits.

Binary System, continued

- For convenience, a numeric value can be assigned to each bit position:

$x_7 x_6 x_5 x_4 x_3 x_2 x_1 x_0$

Binary to Decimal Conversion

- multiply the digit by 2 to the power of the bit position

- Examples:

$$101_2 =$$

$$11001010_2 =$$

Decimal to Binary Conversion: Method 1

- Divide by Decreasing Powers of 2

Example: Converting 76_{10} to Binary

Decimal to Binary Conversion: Method 2

- Disadvantage: need to know the powers of two
- Alternative: repeatedly divide by 2

-- picture from Irvine, p 575

Hexadecimal System

- Used by: Debug utility.
- Also used as a more compact way to represent numbers rather than binary.
- In hexadecimal (or hex), each digit represents a power of 16.
- Digits are 0 to 9 and A to F.
- Hexadecimal numbers are denoted by the number, followed by an H or h.

Decimal to Hex Conversion

- A good method is to repeatedly divide by 16.
- Example: Converting $15,268_{10}$ to hexadecimal

Hex to Decimal Conversion

- Convert each digit to decimal.
- Multiply the digit by 16 to the power of the bit position.
- Example:
3BA4h =

Converting between Hex and Binary

- Each hexadecimal digit represents four binary digits.
- Lookup tables (or, better yet, memorized bit patterns) can be used to do the conversions.
- No multiplication or addition required!

Binary/Hexadecimal Conversion Table

- from AoA

Binary to Hexadecimal

- Break the number up into four digit (bit) pieces, starting from the least significant (right-most) bit
- Convert each four digit segment into the corresponding hexadecimal digit
- Example:
10101011100101111000011011100101

Hexadecimal to Binary

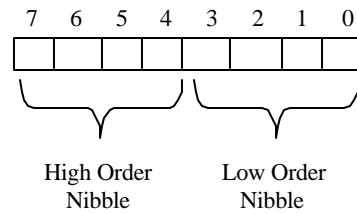
- Convert each hex digit into the four digit (bit) binary representation
- Example:
8A2640

Data Organization

- Computers work with groups of bits (binary digits)
- Common groups of bits are:
 - Single bits
 - Groups of 4 bits – nibbles
 - Groups of 8 bits – bytes
 - Groups of 16 bits – words
 - Groups of 32 bits – double words

Bytes

Bit numbering in a byte:

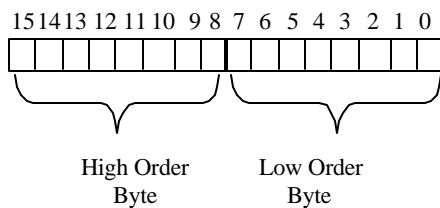


A byte can represent values:
0..255 (unsigned)
-128..+127 (signed)

or, special data types that require no more than 256 different values

Words

Bit numbering in a word:



A word can represent values:
0..65,535 (unsigned)
-32,768..+32,767 (signed)