**how computers work (1)**

more on representing information digitally

**overview**

- already seen: decimal numbers, pictures can be represented using bits (0's and 1's)
- today:
  - using bits to represent text, keyboard inputs
  - subtleties of number representation

**symbols represent information in many contexts**

- dots and dashes in Morse code
- raised dots are used to represent symbols in Braille
- nucleotides (A,C,G,T) in our DNA encode our genetic makeup
- bits represent then information stored in a computer's memory

**why bits?**

- electrical signals used to transmit information can be on or off
- data storage media such as disks have positions that are positively or negatively charged
- two possibilities – on/off, +voltage/-voltage – are represented as 0 and 1
- (there is nothing particularly special about 0 and 1, any pair of symbols would work just as well)

**digitizing text, keyboard inputs**

- text contains the symbols we see: letters, numbers, punctuation marks, spaces, and other symbols (e.g. for arithmetic, business)
- text also contains "nonprintable" characters: new-line, tab
- keyboards have yet more symbols on their keys, such as backspace, function keys

**ASCII standard (American Standard Code for Information Interchange, 1960s)**

- The ASCII standard uses bit strings of length 8 to represent symbols.
- See ASCII standard table in text, Chapter 8.
- For example, “A” is represented as “01000001”, and the symbol “@” is represented as “01000000”.
- How many symbols in total can be represented with 8 bits?
representing text in binary

<table>
<thead>
<tr>
<th>symbol</th>
<th>bit representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>01100001</td>
</tr>
<tr>
<td>b</td>
<td>01100010</td>
</tr>
<tr>
<td>c</td>
<td>01100011</td>
</tr>
<tr>
<td>d</td>
<td>01100100</td>
</tr>
</tbody>
</table>

- “bad” is represented as “01100010 011000101100100”.
- What does “01100011011000101100010” represent?

decimal digits in ASCII

- Decimal digits also have ASCII representations.
- For example, the CS department’s phone number, “822-3061”, is represented as “00111000 00110010 00110010 00101101 00110011 00110000 00110110 00110001”. (Even the dash has an ASCII code!)
- Decimal numbers embedded in text are represented in ASCII, not by converting to their binary representation.

confusion with number representation

- When doing computer arithmetic, it is appropriate to represent numbers using binary notation.
- When treating numbers as symbols (e.g., phone number), it is appropriate to represent the digits using ASCII notation.

> When using numbers in a program, it can be important to know which representation is used!

example: numbers in JavaScript

- Suppose ‘number’ is declared as a variable:

  ```javascript
  var number;
  ```

- Depending on how ‘number’ is used in the code, it may store a number as a text string, or as an integer.

numbers in JavaScript

- Suppose `number` has value 1.
- If `number` is a string, `number + 2 + 3` is the string “123”.
- If number is an integer, then `number + 2 + 3` is 6!
- To help programmers, JavaScript provides ways to convert from text format to integer format.
  - If `number` is a string, then `parseInt(number) + 2 + 3` is 6.

numbers in java

- Java syntax is designed to avoid any confusion about the representation of numbers.
- The words `int` and `String` are used in variable declarations, to declare right from the start which type the variable has.

Examples:

  ```java
  int width;
  String userName;
  ```
resources

- text chapter 8 (required reading)

- A Brief History of Character Codes, http://tronweb.super-nova.co.jp/characcodehist.html (useful additional reading)

- an on-line ASCII table + some additional information: www.jimprice.com/jim-asc.htm