Jonathan McKinsey

The Beauty and Joy of Computing

Lecture #3 Abstraction II

The Future of The Internet of Things (IoT)

- Started as Ubiquitous Computing coined by Mark Weisner in 1988.
- Gaining more momentum as smartphones and tablets become more prevalent.
- Current innovation tend to target private homes.

http://blogs.parc.com/files/2010/09/parcpad.jpg
http://dailytechtrends.com/wp-content/uploads/2014/12/Internet-of-Things-Nest-Thermostat.jpg

Abstraction: Numbers

Abstraction: Numbers

- Number bases, including binary and decimal, are used for reasoning about digital data.
- Bits represent binary data using base two digits: zero and one.
- Hexadecimal, or base-16, is often used in reasoning about data e.g., colors in images.
- Different bases help in reasoning about digital data; digital data is stored in bits.

```
000000100000
000111011100
001000000100
011011011011
011000000011
001000100010
001010001010
000101110010
000010000100
000001111000
```

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Base 10 #s, Decimals

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

Example: 3271

$$3271_{10} = (3 \times 10^3) + (2 \times 10^2) + (7 \times 10^1) + (1 \times 10^0)$$

Base 2 #s, Binary (to Decimal)

Digits: 0, 1 (binary digits → bits)

Example: "1101" in binary? ("0b1101")

$1101_2 = (1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0)$

$= 8 + 4 + 0 + 1$

$= 13$

Base 16 #s, Hexadecimal (to Decimal)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
10,11,12,13,14,15

Example: "A5" in Hexadecimal?

$0xA5 = A5_{16} = (10 \times 16^1) + (5 \times 16^0)$

$= 160 + 5$

$= 165$

Decimal vs Hexadecimal vs Binary

- N bits = 2^N things
- 4 Bits
  - 1 “Nibble”
  - 1 Hex Digit = 16 things
- 8 Bits
  - 1 “Byte”
  - 2 Hex Digits = 256 things
  - Color is usually 0-255 Red, 0-255 Blue, 0-255 Green (#4A00FF)

D	H	B
00	0	0000
01	1	0001
02	2	0010
03	3	0011
04	4	0100
05	5	0101
06	6	0110
07	7	0111
08	8	1000
09	9	1001
10	A	1010
11	B	1011
12	C	1100
13	D	1101
14	E	1110
15	F	1111

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Smallest to Largest?

a) 0xC < 0b1010 < 11

b) 0xC < 11 < 0b1010

c) 11 < 0b1010 < 0xC

d) 0b1010 < 11 < 0xC

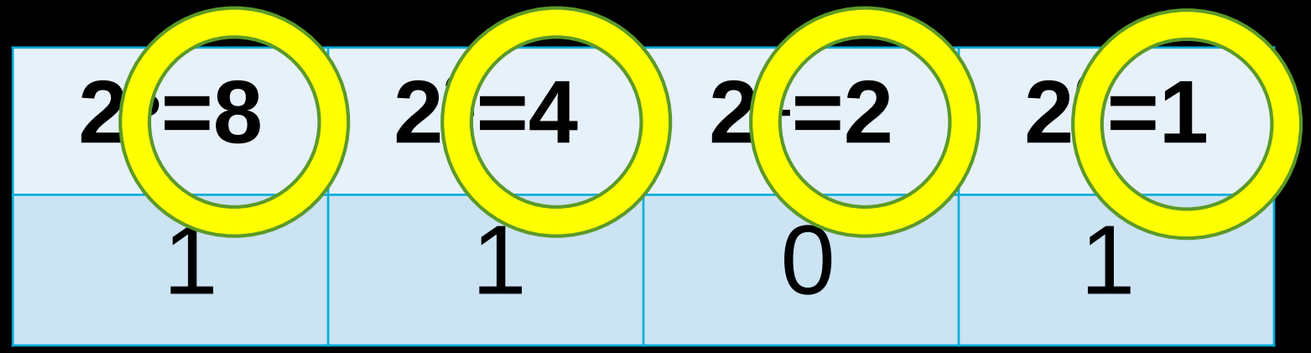
e) 0b1010 < 0xC < 11

Abstraction: Base Conversion

Convert FROM decimal TO binary

- E.g., 13 to binary?
- Start with the columns

~~13~~
~~5~~
~~1~~
0



- Left to right, is (column) ≤ number n?
  - If yes, put how many of that column fit in n, subtract column * that many from n, keep going.
  - If not, put 0 and keep going. (and Stop at 0)

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Convert FROM decimal TO hexadecimal

- E.g., 165 to hexadecimal?
- Start with the columns

~~165~~
~~5~~
0

16^3=4096	16^2=256	16^1=16	16^0=1
0	0	(10) A	5

- Left to right, is (column) ≤ number n?
  - If yes, put how many of that column fit in n, subtract column * that many from n, keep going.
  - If not, put 0 and keep going. (and Stop at 0)

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Convert Binary ←→ Hexadecimal

- Binary → Hex? Easy!
  - Always left-pad with 0s to make full nibbles, then look up!
  - E.g., `0b11110` to Hex?
    - `0b11110` → `0001 1110`
    - Then look up: `0x1E`
- Hex → Binary? Easy!
  - Just look up, drop leading 0s
    - `0x1E`→`0001 1110`→`0b11110`

D	H	B
00	0	0000
01	1	0001
02	2	0010
03	3	0011
04	4	0100
05	5	0101
06	6	0110
07	7	0111
08	8	1000
09	9	1001
10	A	1010
11	B	1011
12	C	1100
13	D	1101
14	E	1110
15	F	1111

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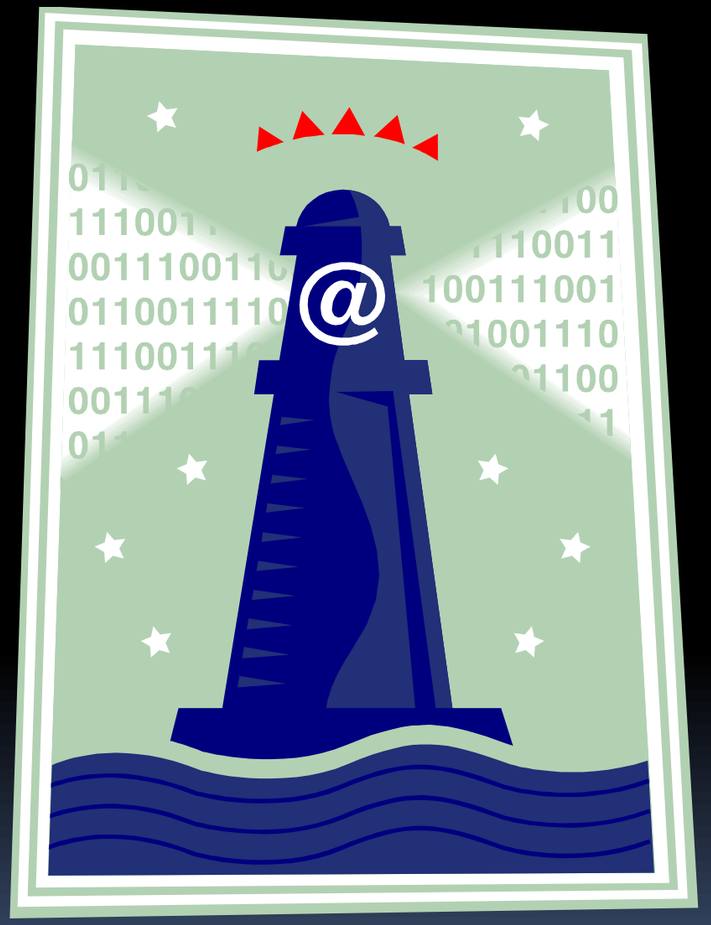
Abstraction: Power, Limitations

Abstraction (revisited): Digital Data

- A combination of abstractions is used to represent digital data.
- At the lowest level
  all digital data are represented by bits.
  - **Bits can represent anything!**
- Bits are grouped to represent higher-level abstractions including numbers and characters.
  - Logical values? 0 → False, 1 → True
  - Colors? 00 → Red, 01 → Green, 10 → Blue
  - Characters? 00000 → ‘a’, 00001 → ‘b’, …
- Higher-level abstractions such as Internet protocol (IP) packets, images, and audio files are comprised of groups of bits that represent different parts of the abstractions.



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Interpretation of a Binary Sequence…

- …depends on how it is used (e.g., as instruction, number, text, sound, or image).
- The sequence of bits that represents…
  - …an instruction may also represent data processed by that instruction.
  - …a character/letter may also represent a number.
  - …a color in an image may also represent a sound in an audio file.

(Wikipedia)

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Detail Removal Often Comes At A Cost

- Removing detail isn't universally a positive thing.
  - The simplification often takes out the subtle aspects of the original
  - Cliff notes not always better than novel!

The London Underground 1928 Map & Harry Beck 1933 map.

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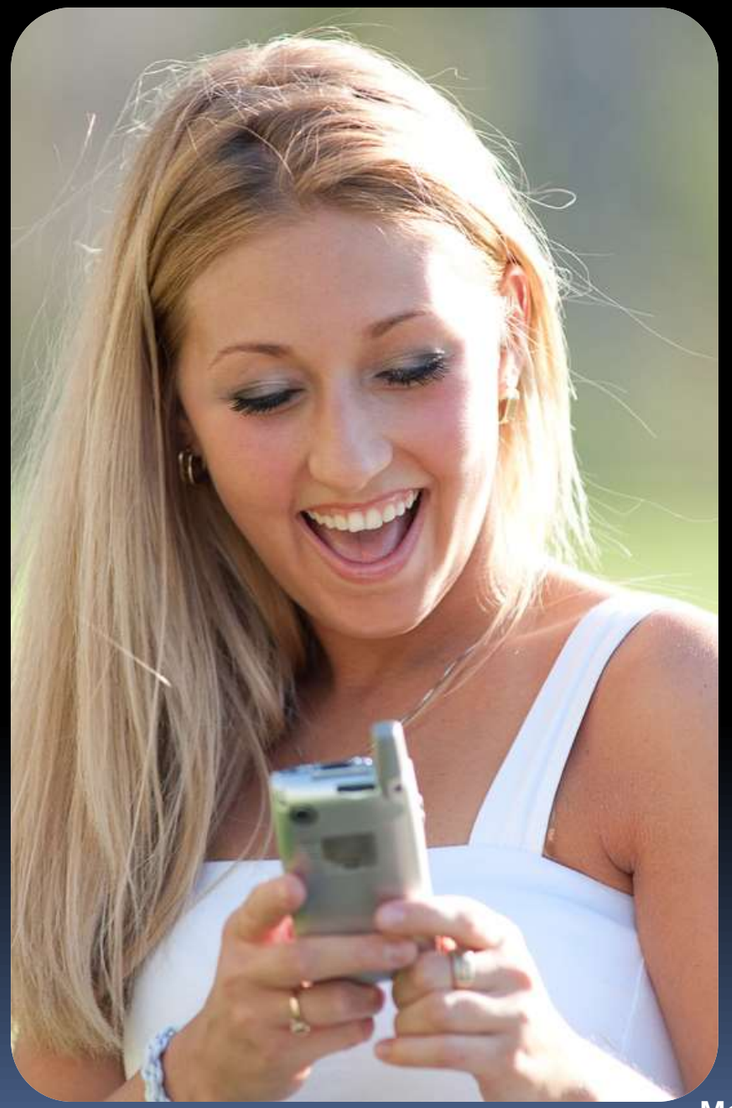
Overflow and Roundoff

- Overflow
  - When the number of represented things exceeds digits allocated for it.
  - E.g., Odometer rollover
    - 99999→00000
  - E.g., Adding 15 + 2 using 4 bits:
    - 0b1111 + 0b10 = 0b1
- Roundoff error
  - When the true real number can't be stored exactly given the encoding due to the fixed number of bits
    - E.g., π = 3.14
  - Sometimes this error accumulates causing problems!

Summary: Abstractions everywhere!

- Applications and systems are designed, developed, and analyzed using levels of hardware, software, and conceptual abstractions.
  - E.g., Mobile apps and systems
  - E.g,. Web services (both an application and a system)
- This course will include examples of abstractions used in modeling the world, managing complexity, and communicating with people as well as with machines.



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