Announcements

Log into iClicker. To enroll, go to EdStem post #4
Added CS10 late? Read #13 on EdStem
Pre-Semester Survey due 1/31
Attendance is required for lab, lecture, discussion. If you cannot attend, read the syllabus policies (there are makeup options)
OH starts this week, check schedule
Project 1 released!
Use the Partner Matching Thread #6!
Dan’s OH starts today: 3-4pm in 777 Soda
Come to the front after class to meet each other

UC Berkeley
Teaching Professor
Dan Garcia

The Beauty and Joy of Computing

Abstraction II

What I Wish I Knew When I Started My Software Career

Among the advice given:

- Don’t be afraid to learn on job
- Never ask for permission unless it would be reckless not
- Exercise
- Long hours: sometimes ok, usually harmful
- Learn as much as you can. It’s hard, and it takes work

lifehacker.com/what-i-wish-i-knew-when-i-started-my-career-as-a-softwa-1681002791

Abstraction: Numbers

Abstraction (revisited): Numbers

- **Number bases**, including binary and decimal, are used for reasoning about digital data
- Bits represent binary data using **base two** digits: 0, 1
- **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
001000000010
011011011011
011000000011
001000100010
001010001010
000101110010
000010000100
000001111000
```

Definition: Number vs Numeral

Numeral

A symbol or name that stands for a number
e.g., 4 , four , quatro , IV , IIII , …
…and Digits are symbols that make numerals

Above the abstraction line

Abstraction Line

Below the abstraction line

Number

The "idea" in our minds…there is only ONE of these
e.g., the concept of "4"

Base 10 #s, Decimals

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

Example:

$$3274 = 3274_{10} =$$

$$(3 \times 10^{3}) + (2 \times 10^{2}) + (7 \times 10^{1}) + (4 \times 10^{0})$$

Base 2 #s, Binary (to Decimal)

Digits: 0, 1 (<u>bi</u>nary digi<u>ts</u> □ 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 usu. 0-255 Red, 0-255 Green, 0-255 Blue. #D0367F= (demo)

0b11011

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

(Cal) Smallest to Largest?

a) `0xC < 0b1010 < 11`

b) `0xC < 11 < 0b1010`

c) `11 < 0b1010 < 0xC`

d) `11 < 0xC < 0b1010`

e) `0b1010 < 11 < 0xC`

f) `0b1010 < 0xC < 11`

L03a Smallest to Largest?

- 0xC < 0b1010 < 11
- 0xC < 11 < 0b1010
- 11 < 0b1010 < 0xC
- 11 < 0xC < 0b1010
- 0b1010 < 11 < 0xC
- 0b1010 < 0xC < 11

Abstraction:
Base Conversion

Convert FROM decimal TO binary

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

~~1~~

~~5~~

~~1~~

0

$2^3=8$	$2^2=4$	$2^1=2$	$2^0=1$
1	1	0	1

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

Convert FROM decimal TO hexadecimal

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

~~16~~
~~5~~
0

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

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

Convert Binary Hexadecimal

- Binary Hex? Easy!
  - Always left-pad with 0s to make full nibbles, then look up!
  - E.g., `0b11110` to Hex?
    - `0b11110` `0b00011110`
    - Then look up: `0x1E`
- Hex Binary? Easy!
  - Just look up, drop leading 0s
    - `0x1E0b000111100b11110`

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

(Cal) Why do we use different bases?

a) Binary is used by computers, since transistors are bistable (at two values)

b) Hex is used by humans for encoding binary information because it's 4 times more efficient (number of chars)

c) Decimal because we have 10 fingers

d) The fact that computers use binary is below our level of abstraction

e) All of the above

When poll is active, respond at **pollev.com/ddg**

Text **DDG** to **22333** once to join

L03b Why do we use different bases?

Binary is used by computers, since transistors are bistable (at two values)

Hex is used by humans for encoding binary information because it's 4 times more efficient (number of chars)

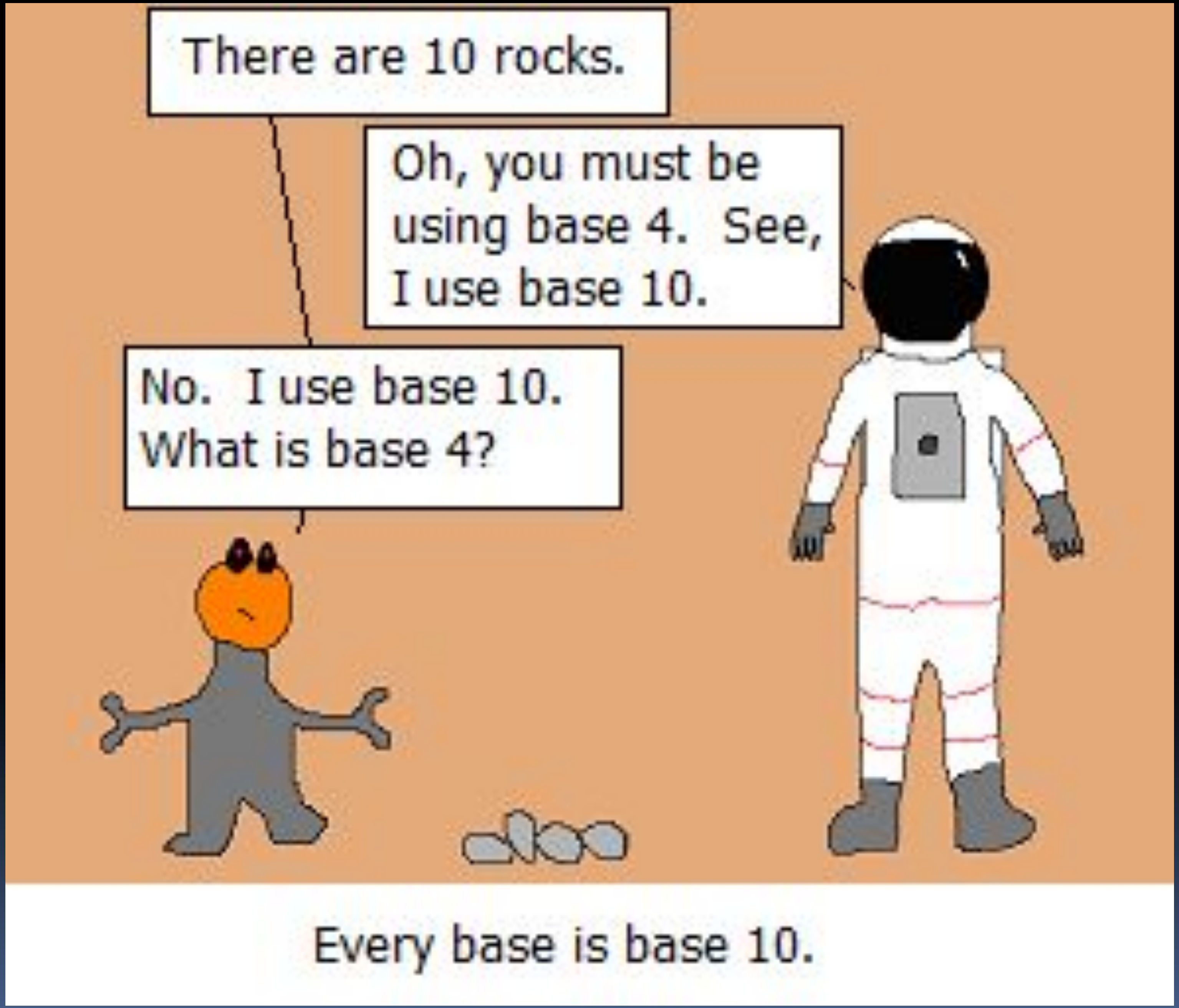
Decimal because we have 10 fingers

The fact that computers use binary is below our level of abstraction

All of the above

math.stackexchange.com/questions/166869/is-10-a-magical-number-or-i-am-missing-something

Joke: Every Base is Base 10...



Garcia

Abstraction:
Power, Limitations

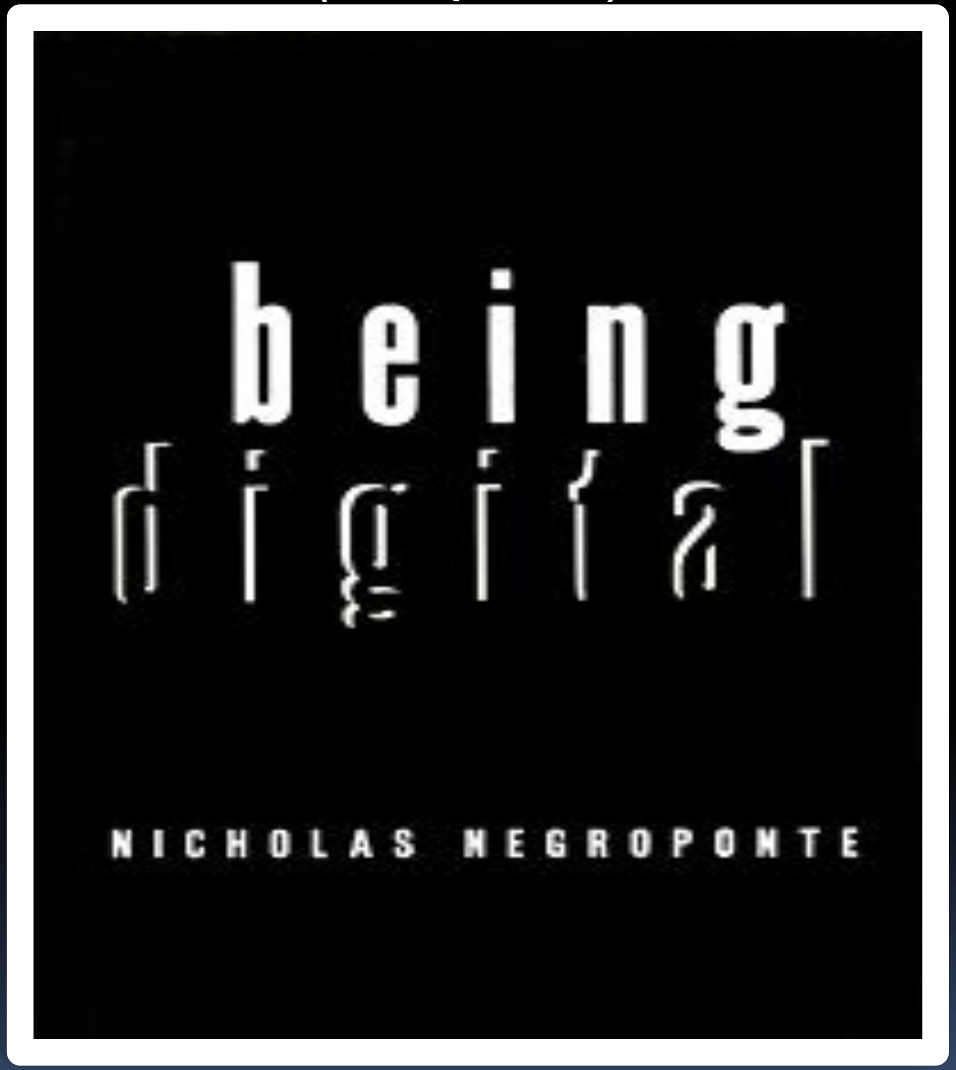
Abstraction (revisited): Digital Data

- A combination of abstractions is often 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.

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)



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 with 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., $\pi = 3.14$
  - 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.