CMSC201
Computer Science I for Majors

Lecture 19 – Binary (and File I/O)

Last Class We Covered

- File I/O

- How to open a file
  - For reading or writing
- How to read from a file
- How to write to a file
- How to close a file

Any Questions from Last Time?

Today's Objectives

- To understand how data is represented and stored in memory

  - Binary numbers

  - Converting
    - Binary to Decimal
    - Decimal to Binary

- To review what we learned about file I/O

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"Bridge Course"

- We are offering CMSC 291 again this winter
  - Course for CMSC/CMPE students who earn a "C" instead of the "B" required for their major
    - Grade must be result of a single poor score (*e.g.*, did badly on the midterm or a project)
    - Won't change CMSC 201 grade, but will allow eligible students to take CMSC 202 in Spring 18

- An announcement will be made on Blackboard containing all of the details later this week

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Binary Numbers
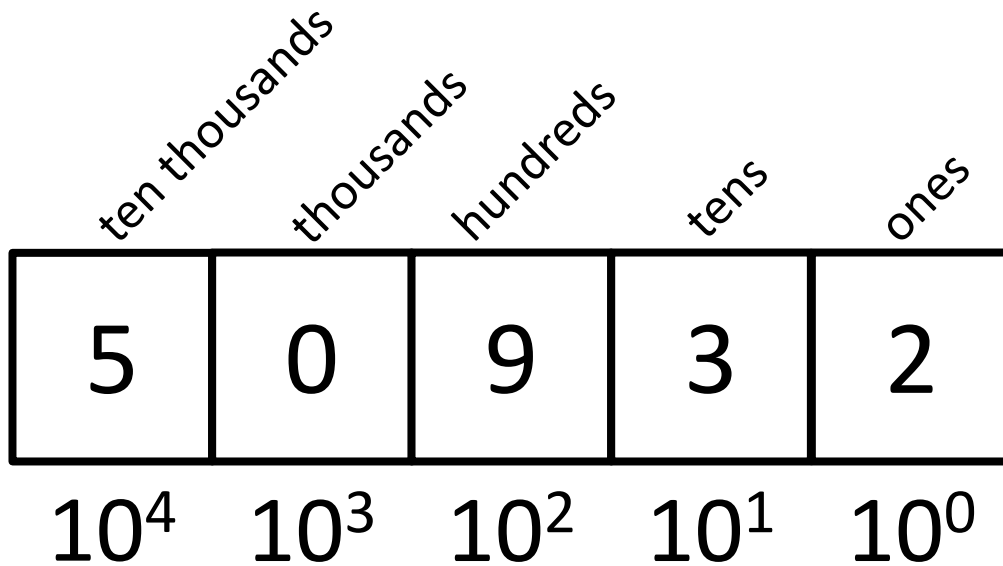
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Binary Numbers

- Computers store all information (code, text, images, sound,) as a binary representation
  - "Binary" means only two parts: 0 and 1

- Specific formats for each file help the computer know what type of item/object it is

- But why use binary?

Decimal vs Binary

- Why do we use decimal numbers?
  - Ones, tens, hundreds, thousands, etc.

- But computers don't have fingers…
  - What do they have instead?

- They only have two states: "on" and "off"

Decimal Example

- How do we represent a number like 50,932?

ten thousands	thousands	hundreds	tens	ones
5	0	9	3	2
10^4	10^3	10^2	10^1	10^0

```
2 x 10⁰ =       2
3 x 10¹ =      30
9 x 10² =     900
0 x 10³ =    0000
5 x 10⁴ = 50000
          ------
Total:    50932
```

$$2 \times 10^0 = 2$$
$$3 \times 10^1 = 30$$
$$9 \times 10^2 = 900$$
$$0 \times 10^3 = 0000$$
$$5 \times 10^4 = 50000$$

Total: 50932

Decimal uses 10 digits, so…

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Another Decimal Example

6	7	4	9	3
10^4	10^3	10^2	10^1	10^0
10000	1000	100	10	1
60000	7000	400	90	3

60000+7000+400+90+3 = 67493

Binary Example

- Let's do the same with 10110 in binary

sixteens	eights	fours	twos	ones
1	0	1	1	0
2^4	2^3	2^2	2^1	2^0
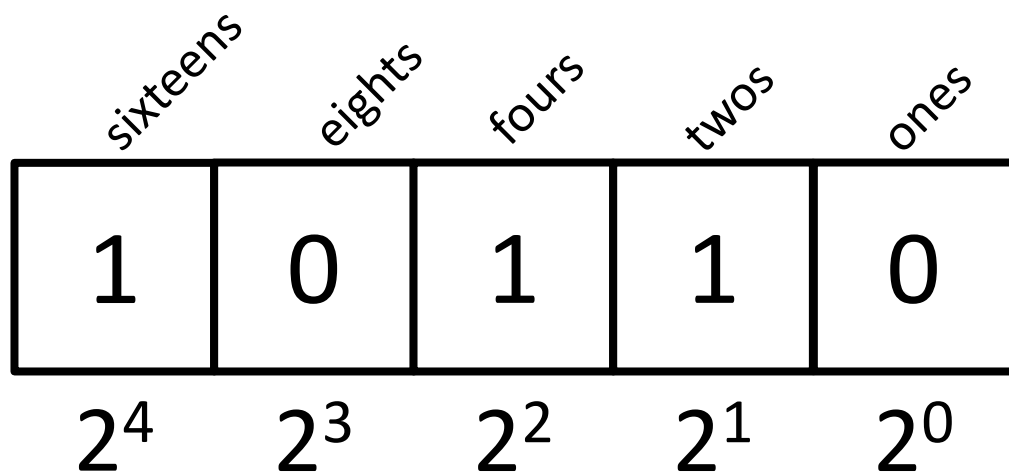
$$0 \times 2^0 = 0$$
$$1 \times 2^1 = 2$$
$$1 \times 2^2 = 4$$
$$0 \times 2^3 = 0$$
$$1 \times 2^4 = 16$$
$$--$$

Total: 22

Binary uses 2 digits, so our base isn't 10, but…

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Binary to Decimal Conversion

- Step 1: Draw Conversion Box
- Step 2: Enter Binary Number
- Step 3: Multiply
- Step 4: Add

1	0	0	0	1	1	0	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
128	0	0	0	8	4	0	1

128 + 0 + 0 + 0 + 8 + 4 + 0 + 1 = 141

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Exercise: Converting From Binary

- What are the decimals equivalents of…

  101

  1111

  100000

  101010

  0010 1010

  1000 0000

Longer binary numbers are often broken into blocks of four digits for the sake of readability

Exercise: Converting From Binary

- What are the decimals equivalents of…

```
101        = 4+0+1          = 5
1111       = 8+4+2+1        = 15
100000     = 32+0+0+0+0+0   = 32
101010     = 32+0+8+0+2+0   = 42
0010 1010  = 32+0+8+0+2+0   = 42
1000 0000  = 128+...+0+0    = 128
```

Decimal to Binary Conversion

- Step 1: Draw Conversion Box
- Step 2: Compare decimal to highest binary value
- Step 3: If binary value is smaller, put a 1 there and subtract the value from the decimal number
- Step 4: Repeat until 0

Convert 163 to binary

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
1	0	1	0	0	0	1	1

163-128 = 35   35-32 = 3   3-2=1   1-1=0

Converting to Binary

- What are the binary equivalents of…

  9

  27

  68

  216

  255

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Converting to Binary

- What are the binary equivalents of…

```
9    = 1001 (or 8+1)
27   = 0001 1011 (or 16+8+2+1)
68   = 0100 0100 (or 64+4)
216  = 1101 1000
         (or 128+64+16+8)
255  = 1111 1111
         (or 128+64+32+16+8+4+2+1)
```

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Binary Tips and Tricks

- Some "sanity checking" rules for conversions:
1. Binary can only be 1 or 0
   - If you get "2" of something, it's wrong
2. Odd numbers <u>must</u> have a 1 in the ones column
   - Why? (And what's the rule for even numbers?)
3. Each column's value is the sum of <u>all</u> of the previous columns (to the right) plus one
   - In decimal, what column comes after 999?

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File Input and Output (Review)

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Quick Review

- Write the lines of code for the tasks below

1. Open the file "goodDogs.txt"

2. Read the file in (however you want), and print out each dog's name in the sentence "X is a good dog"

3. Finish using the file (what do you need to do?)

```
goodDogs.txt
Thor,Corgi
Coco,Chocolate Lab
Beethoven,St. Bernard
```

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Exercise: Jabberwocky

- Write a program that goes through a file and reports the longest line in the file

Example Input File:

carroll.txt

```
Beware the Jabberwock, my son,
the jaws that bite, the claws that catch,
Beware the JubJub bird and shun
the frumious bandersnatch.
```

Example Output:

```
>>> longest.py
longest line = 42 characters
the jaws that bite, the claws that catch,
```

Jabberwocky Solution Pseudocode

```
inside main:
    open the file "carroll.txt" (for reading)

    create a variable to store the "longest" line
    # we'll refer to this variable as "record"
    # what should this variable be initialized to?

    for each line of the input
        if the current line is longer than the record
            update the record to the current line

    print the length of the longest line
    print the longest line

call main
```

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Jabberwocky Solution Code

```python
def main():
    inputFile = open("carroll.txt")
    longest = ""
    lines = inputFile.readlines()
    for i in range(len(lines)):
        if len(lines[i]) > len(longest):
            longest = lines[i]

    print("Longest line =", len(longest))
    print(longest)

main()
```

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Jabberwocky Solution Walkthrough

line = ➡️

Beware the Jabberwock, my son,
the jaws that bite, the claws that catch,
Beware the JubJub bird and shun
the frumious bandersnatch.

line = "Beware the Jabberwock, my son,"

~~**longest** = ""~~

longest = "Beware the Jabberwock, my son,"

len(line) > len(longest)

    31   **>**   **0**

   ✓

➡️
```
for i in range(len(lines)):
    if len(lines[i]) > len(longest)
        longest = lines[i]
```

Jabberwocky Solution Walkthrough

line = ➡️

```
Beware the Jabberwock, my son,
the jaws that bite, the claws that catch,
Beware the JubJub bird and shun
the frumious bandersnatch.
```

line = "the jaws that bite, the claws that catch,"

~~**longest** = ""~~

~~**longest** = "Beware the Jabberwock, my son,"~~

longest = "the jaws that bite, the claws that catch,"

len(line) > len(longest)

    42   >   31

✓

➡️
```
for i in range(len(lines)):
    if len(lines[i]) > len(longest)
        longest = lines[i]
```

Jabberwocky Solution Walkthrough

```
Beware the Jabberwock, my son,
the jaws that bite, the claws that catch,
Beware the JubJub bird and shun
the frumious bandersnatch.
```

line = ➡️

line = "Beware the JubJub bird and shun"

~~**longest** = ""~~

~~**longest** = "Beware the Jabberwock, my son,"~~

longest = "the jaws that bite, the claws that catch,"

```
len(line) > len(longest)

    32    >    42
```
✖️

```
for i in range(len(lines)):
    if len(lines[i]) > len(longest)
        longest = lines[i]
```

Jabberwocky Solution Walkthrough

> Beware the Jabberwock, my son,
> the jaws that bite, the claws that catch,
> Beware the JubJub bird and shun
> the frumious bandersnatch.

line = ⟶

```
line     = "the frumious bandersnatch."

longest = ""
longest = "Beware the Jabberwock, my son,"
longest = "the jaws that bite, the claws that catch,"
```

```
len(line) > len(longest)

   27    >      42
            ✖
```

```
for i in range(len(lines)):
    if len(lines[i]) > len(longest)
        longest = lines[i]
```

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Daily CS History

- Katherine Johnson
  - Worked as a NASA "computer"
  - Calculated trajectories, launch windows, and return paths for flights in Project Mercury
    - Plotted Alan Shepard's 1961 journey to space (first American)
  - Also examined black box data from crashed air planes
  - Graduated college at age 18

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Announcements

- Homework 6 is available now
  - Recommended that you do the parts in order
  - Homework is due on Tuesday, November 21st

- No discussion next week (Thanksgiving)
  - No lecture on Wednesday

- Final exam is when?
- Friday, December 15th from 6 to 8 PM

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Image Sources

- Katherine Johnson:
  - https://commons.wikimedia.org/wiki/File:Katherine_Johnson_at_NASA,_in_1966.jpg

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