FILE IO AND DATA REPRSENTATION

Problem Solving with Computers-I

Announcements

- Midterm next Thursday (Oct 25)
- No class on Tuesday (Oct 23)

I/O in programs

Different ways of reading data into programs

- cin
- Command line arguments (int main(int argc, char* argv[])
- Read from file

Ways to output data

- Std output: cout
- Std error: cerr
- Write to file

Where are files stored?

A. In main memory
B. In secondary memory
C. On the processor
D. In C++ programs
E. None of the above

Writing to files

```
#include <fstream>
ofstream ofs;  // Create a ifstream object
ofs.open(“animals.txt”); //Open a file to write to
ofs<<“Duck\n”<<“Cat\n”<<“Cow\n”;
```

Reading from files

- Open a file
- If open fails, exit
- In a loop
  - Read a line
  - If you reach the end of file, break
  - Else process the line that was read
- Close the file

Reading from files

```
#include <fstream>
ifstream ifs;  // Create a ifstream object
ifs.open("numbers.txt"); //Open a file to read
if(!ifs){
      // open failed
}
getline(ifs, line); // read a line from the file into a
                    // string line.
                    // If you attempt to read past the end
                    // of file, ifs change to false

// If the file was empty, ifs will be false at this point
ifs.close()
```

FILE IO: Which of the following is correct?

A.

```
while(1){
        getline(ifs, line);
        if (!ifs)
            break;
        cout<<line<<endl;
}
```

B.

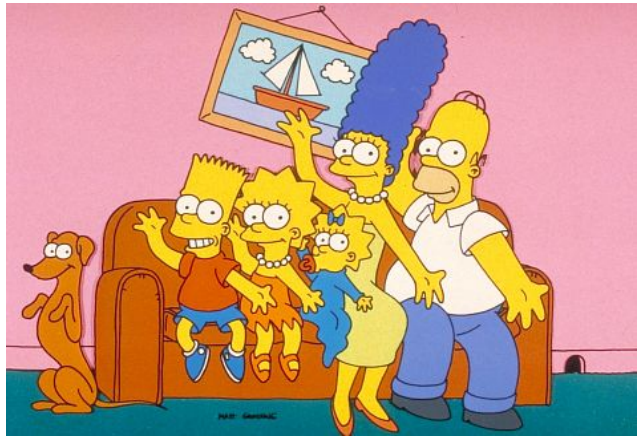
```
while(ifs){
        getline(ifs, line);
        cout<<line<<endl;
}
```

C. Both A and B are correct

D. Neither is correct

External vs. Internal Representation

- External representation:
  - Convenient for programmer
  - Decimal (base 10)



- Internal representation:
  - Actual representation of data in the computer's memory: Always binary (1's and 0's)

Binary representation (base 2)

- On a computer all data is stored in binary
- Only two symbols: 0 and 1
- Each position is called a *bit*
- *Bits take up space*
- 8 bits make a *byte*
- *Example of a 4-bit number*

- Actually the data is voltages
- We use the abstraction:
  - High voltage: 1 (true)
  - Low voltage: 0 (false)

Positional encoding for non-negative numbers

- Each position represents some power of the base
- Decimal (Base 10), Digits (0-9)
- Binary (Base 2), Digits (0,1)
- Hex (Base 16), Digits (0-9, A-F)

Why is each base important??

101_5 = ? In decimal

A. 26

B. 51

C. 126

D. 130

Converting between binary and decimal

Binary to decimal: $1\ 0\ 1\ 1\ 0_2 = ?_{10}$

Decimal to binary: $34_{10} = ?_2$

Hex to binary

- Each hex digit corresponds directly to four binary digits
- Programmers love hex, why?

$$25B_{16} = ? \text{ In binary}$$

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

Hexadecimal to decimal

$25B_{16} = ?$ Decimal

Hexadecimal to decimal

- Use polynomial expansion

- $25B_{16} = 2*256 + 5*16 + 11*1 = 512 + 80 + 11$

  $= 603$

- Decimal to hex: $36_{10}=?_{16}$

Binary to hex: 1000111100

A. 8F0

B. 23C

C. None of the above

BIG IDEA: Bits can represent anything!!

Numbers	Binary Code
0	
1	
2	
3	

How many (minimum) bits are required to represent the numbers 0 to 3?

BIG IDEA: Bits can represent anything!!

Colors	Binary code
Red	
Green	
Blue	

How many (minimum) bits are required to represent the three colors?

BIG IDEA: Bits can represent anything!!

Characters

‘a’

‘b’

‘c’

‘d’

‘e’

N bits can represent at most 2^N things

What is the minimum number of bits required to represent all the letters in the English alphabet in lower case?

A. 3
B. 4
C. 5
D. 6
E. 26

BIG IDEA: Bits can represent anything!!

- Logical values?
  - 0 ⇒ False, 1 ⇒ True
- colors ?

- Characters?
  - 26 letters ⇒ 5 bits ($2^5 = 32$)
  - upper/lower case + punctuation
    ⇒ 7 bits (in 8) ("ASCII")
  - standard code to cover all the world's languages ⇒ 8,16,32 bits ("Unicode")
    www.unicode.com

- locations / addresses? commands?

- MEMORIZE: N bits ⇔ at most 2^N things

What is the maximum positive value that can be stored in a byte?

A. 127

B. 128

C. 255

D. 256

Data types

Binary numbers in memory are stored using a finite, fixed number of bits typically:

8 bits (byte)

16 bits (half word)

32 bits (word)

64 bits (double word or quad)

Data type of a variable determines the:

- exact representation of variable in memory
- number of bits used (fixed and finite)
  - range of values that can be correctly represented

Next time

- Arrays