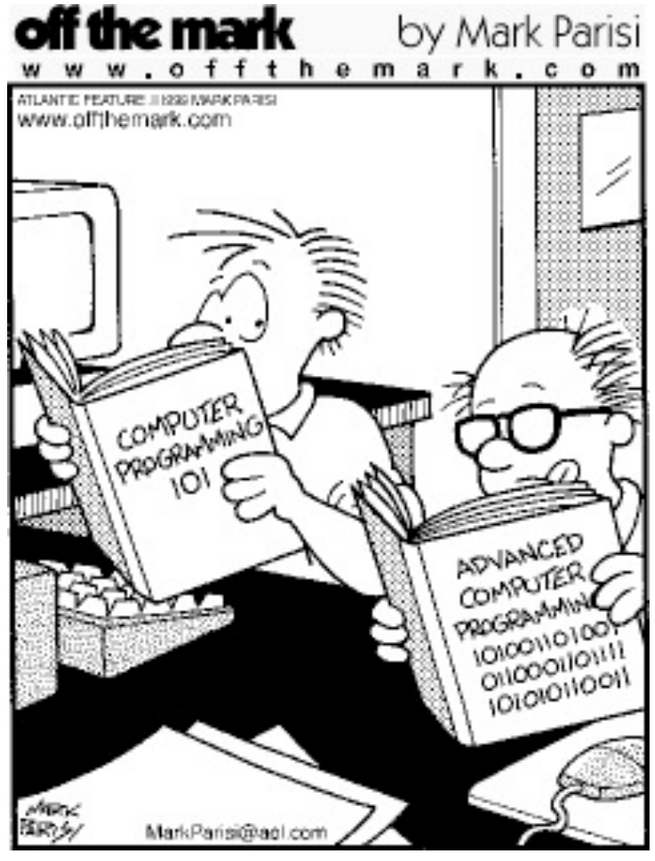
Garfield AP CS

Binary



Goals for today

- Understand computer architecture better
- Count to 1023 on your fingers
- Understand Java errors

Data representation

- Bits (short for binary digit)
- Bytes are groups of 8 bits
- In memory: a transistor switched on or off
- On magnetic disks: direction of field
- CD-ROMs: surface reflects light or doesn't
- Network: optical or sound waves

Base 2

- We count in base 10 because of our fingers
- Computers only have two states

decimal	binary
0	0
1	1
2	01
3	11
4	100
5	101
6	110
7	111
8	1000

2^4	2^3	2^2	2^1	2^0
0	0	1	1	0

2^4 * 0 + 2^3 * 0 + 2^2 * 1 + 2^1 * 1 + 2^0 * 0 = 6

Unit confusion!

- kB - kilobytes are 2^10 bytes
- kb - kilobits are 2^10 bits
- GB - gigabyte usually 10^9 bytes for harddrives but 2^30 for RAM!
- Gb - gigabit 10^9 or 2^30 bits

Conversion algorithms

- Can you come up with an algorithm (in English) to convert from binary to decimal?
- Can you come up with an algorithm (in English) to convert from decimal to binary?

Practice

- 11101
- 1001
- 100101
- 10101
- 12
- 15

Representing text

- American Standard Code for Information Interchange (ASCII)
- 7-bit character-encoding scheme
- Letter order makes it American
- How many possible characters?

Binary	Character
100 0001	A
100 0010	B
110 0001	a
110 0010	b
000 0111	Bell

Foreign languages?

- Extended (8-bit) ASCII
- Multiple standards exist so conflicts are possible
- Unicode is often used instead
  - Standard describes 75 scripts

Multiple standards

- ‘a’ not always represented the same way!
- Each file must mark how it should be interpreted
- One missing bit is a catastrophe

What the CPU does

- Runs commands expressed in binary on data expressed in binary
- Knows a limited set of commands
  - arithmetic (add, subtract)
  - logic (and, or, not)
  - data (move, input, load, store)
  - control flow (goto, if, return)
- Everything is converted to those commands

Binary today

- Very efficient representation
- Bit masks, boolean logic
- OS-level development
- Embedded systems
- Chip designers/electrical engineers

Hexadecimal

- A little easier for humans
- Often used for RGB color codes
- Base 16 (0-F)

Decimal	Binary	Hex
1	1	1
2	10	2
3	11	3
4	100	4
5	101	5
6	110	6
7	111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

Try it

- 17
- 23
- A0
- B2

32-bit vs. 64-bit architecture?

- A 64-bit computer can represent bigger numbers at once => faster
- A 32-bit computer must split numbers and process separately
- More memory can be addressed

Java int limits

Java int limits

- Integer.MAX_VALUE

Java int limits

- Integer.MAX_VALUE
- Integer.MIN_VALUE

Java int limits

- Integer.MAX_VALUE
- Integer.MIN_VALUE
- What do you think they are?

Java int limits

- Integer.MAX_VALUE
- Integer.MIN_VALUE
- What do you think they are?
  - Depends on the architecture!

Java int limits

- Integer.MAX_VALUE
- Integer.MIN_VALUE
- What do you think they are?
  - Depends on the architecture!
  - 2^31 - 1

Java int limits

- Integer.MAX_VALUE
- Integer.MIN_VALUE
- What do you think they are?
  - Depends on the architecture!
  - 2^31 - 1
  - -2^31

Fuzzy math

- 1.1 + .1
- 100.0 * 9.95
- .01 + .05 + .1 + .25
- .25 + .1 + .05 + .01

Errors

- That was a roundoff error caused by hardware implementation
- Logic error
- Compiler error
- Runtime error

Logic errors

- Calling the wrong method
- Ordering statements backwards
- We'll run into lots more!!

Compiler errors

- Something wrong with the structure
- A solid IDE can resolve many of them!

```
Hello.java:6: cannot find symbol
     symbol   : method pruntln(java.lang.String)
     location: class java.io.PrintStream
                       System.out.pruntln("Hello!);

Hello.java:7: ';' expected
               }
               ^
```

Runtime errors

- No syntax problems so program executes
- Impossible instruction
  - Divide by zero
  - Open a file that doesn't exist

```
Exception in thread "main"
java.lang.ArithmeticException: / by zero
```