Lab 1

Analysis and thoughts

The algorithm

Given: an integer

Return: true iff integer is odd, else return false

```
function isOdd(n: integer)
    if (n % 2) equals 1
        return true
    else
        return false
```

- Manipulatable?
- Data transform?

Implementations

Go

```
package main

import (
    "fmt"
)

func isOdd(v int) bool {
    return (v%2)==1
}

func main() {
    for i:=0; i<5; i++ {
        fmt.Printf("%d  %v\n", i,
isOdd(i) )
    }
}
```

Java

```
public class V0 {
    public static boolean isOdd(int i) {
        return (i % 2) != 0;
    }

    public static void main(String[] args) {
        V0 v0 = new V0();
        for (int i = 0; i < 5; i++) {
            System.out.format("%d %b\n", i,
isOdd(i));
        }
    }
}
```

Python

```
def isOdd(x):
    return x%2==1

for k in range(5):
    print(k, isOdd(k))
```

Results

Go

0..5

```
0  false
1  true
2  false
3  true
4  false
```

-5..5

```
-5  false
-4  false
-3  false
-2  false
-1  false
0  false
1  true
2  false
3  true
4  false
```

Java

0..5

```
0 false
1 true
2 false
3 true
4 false
```

-5..5

```
-5 false
-4 false
-3 false
-2 false
-1 false
0 false
1 true
2 false
3 true
4 false
```

Python

0..5

```
0 False
1 True
2 False
3 True
4 False
```

-5..5

```
-5 True
-4 False
-3 True
-2 False
-1 True
0 False
1 True
2 False
3 True
4 False
```

- Results
  - Agreement on positive numbers
  - Java and Go differ from Python
    - Python seems correct
- Hypotheses
  - Java and Go reject concept of modulus on negative numbers
  - Java and Go implement modulus differently from Python

- H1: The "undefined" hypothesis.
  - Test: if % undefined for negative integers in Java, then a runtime exception would occur.
  - Rejected: no such exception occurs
- H2: % is different in Python and Go/Java for negative numbers
  - Test: Write a program to show x%5 for the numbers -10..0 (hard to see with %2)

```
Go          Java        Python
-10  0      -10  0      -10  0
-9  -4      -9  -4      -9   1
-8  -3      -8  -3      -8   2
-7  -2      -7  -2      -7   3
-6  -1      -6  -1      -6   4
-5   0      -5   0      -5   0
-4  -4      -4  -4      -4   1
-3  -3      -3  -3      -3   2
-2  -2      -2  -2      -2   3
-1  -1      -1  -1      -1   4
```

  - Conclusion: Python is Different!!!

Modulus ==? Modulus

- Knuth: mod(a, n) = a - n * floor(a / n)
- Floor?

Go		Java		Python	
-10	-2	-10	-2	-10	-2
-9	-1	-9	-2	-9	-2
-8	-1	-8	-2	-8	-2
-7	-1	-7	-2	-7	-2
-6	-1	-6	-2	-6	-2
-5	-1	-5	-1	-5	-1
-4	0	-4	-1	-4	-1
-3	0	-3	-1	-3	-1
-2	0	-2	-1	-2	-1
-1	0	-1	-1	-1	-1

Conclusions

- Go uses a different definition of floor than Java or Python
- Java and Python use same definition of floor
- Go and Python are consistent with Knuth given their different definitions of floor
- Java is not consistent with Knuth! (but is consistent with Go)

Fixed Algorithm

instead of checking for 1, check for 0

Given: an integer

Return: true iff integer is odd, else return false

```
function isOdd(n: integer)
if (n % 2) equals 0
        return false
    else
        return true
```

Part 2: Bitwise Operators

- Bitwise Operators are binary operations that work on the binary representation of a number.
- There are two main operators (same in Go, Java and Python)
  - & the result has a 1 in a bit position if both numbers have a 1 in that position
  - | the result has a 1 in a bit position if either number has a 1 in that position

Decimal	Binary		Decimal	Binary		Decimal	Binary		Decimal	Binary
&			|			&			&	
17	b10001		17	b10001		23	b10111		28	b11100
3	b00011		3	b00011		1	b00001		1	b00001
1	b00001		19	b10011		1	b00001		0	b00000

Binary Negative Numbers

- Most / all PLs used "2s complement" to represent signed integers
- Use the leftmost bit to indicate sign
- Negative number take the complement of positive numbers
- Importantly, odd negative numbers have a 1 in the rightmost bit, just like positive

1	b00000001		**-1**	b111111111
2	b00000010		**-2**	b11111110
3	b00000011		**-3**	b11111101
4	b00000100		**-4**	b11111100

- So, for positive and negative can determine oddness as "x&1==1"

Modulus using Bitwise Operator

Given: an integer

Return: true iff integer is odd, else return false

```
function isOdd(n: integer)
if (n & 1) ==1
        return true
    else
        return false
```

Part 3: Which is better?

- Idea, do a LOT of modulus operations and time how long that takes

Part 2: Timing Modulus

- Use the Unix "time" function
- For example:
  ```
  javac M.java
  time java M

  time go run M.go

  time python M.py
  ```

- **Problems??**

```java
public class V1 {
    public static boolean isOddBit(int i) {
        return (i & 1) == 1;
    }
    public static boolean isOdd(int i) {
        return (i % 2) != 0;
    }

    public static void timer() {
        {
            long st = System.nanoTime();
            int odd = 0;
            for (int j = 0; j < 10000000; j++) {
                for (int i = -100; i < 100; i++) {
                    if (isOddBit(i))
                        odd++;
                }
            }
            long en = System.nanoTime();
            System.out.print((en - st) / 1000000.0 + "; ");
        }
        {

            long st = System.nanoTime();
            int odd = 0;
            for (int j = 0; j < 10000000; j++) {
                for (int i = -100; i < 100; i++) {
                    if (isOdd(i))
                        odd++;
                }}
            long en = System.nanoTime();
            System.out.println((en - st) / 1000000.0);
        }}
    public static void main(String[] args) {
        for (int i = 0; i < 10; i++)
            timer();
    }
}
```

Start Timer

Bit Timing

End Timer

Elapsed Time in Milliseconds

Mod Timing

Stuff to be timed

- Timing:
  - As close to the problem as you can get
    - Read system clock before you start
    - Read system clock when you finish
    - subtract
- Why do the odd calculation $2*10^8$ times?
- Why do bit and mod as a pair?
  - Sequentially or in totally separate programs?
- Other problems??

```
public class V1 {
    public static boolean isOddBit(int i) {
        return (i & 1) == 1;
    }
    public static boolean isOdd(int i) {
        return (i % 2) != 0;
    }

    public static void timer() {
        {
            long st = System.nanoTime();
            int odd = 0;
            for (int j = 0; j < 10000000; j++) {
                for (int i = -100; i < 100; i++) {
                    if (isOddBit(i))
                        odd++;
                }
            }
            long en = System.nanoTime();
            System.out.print((en - st) / 1000000.0 + "; ");
        }
        {
            long st = System.nanoTime();
            int odd = 0;
            for (int j = 0; j < 10000000; j++) {
                for (int i = -100; i < 100; i++) {
                    if (isOddBit(i))
                        odd++;
                }}
            long en = System.nanoTime();
            System.out.println((en - st) / 1000000.0);
        }}
    public static void main(String[] args) {
        for (int i = 0; i < 10; i++)
            timer();
    }
}
```

isOddBit and isOdd
Not shown

```
public class V1 {
    public static void timer() {
        int odd = 0;
        long bs = System.nanoTime();
        for (int j = 0; j < 10000000 / 2; j++) {
            for (int i = -100; i < 100; i++) {
                odd++;
            }}
        long be = System.nanoTime();
        long tb = be - bs;
        {
            long st = System.nanoTime();
            odd = 0;
            for (int j = 0; j < 10000000; j++) {
                for (int i = -100; i < 100; i++) {
                    if (isOddBit(i))
                        odd++;
                }
            }
            long en = System.nanoTime();
            System.out.print(((en - st)-tb) / 1000000.0 + " ");
        }
        {
            long st = System.nanoTime();
            odd = 0;
            for (int j = 0; j < 10000000; j++) {
                for (int i = -100; i < 100; i++) {
                    if (isOddBit(i))
                        odd++;
                }}
            long en = System.nanoTime();
            System.out.println(((en - st)-tb) / 1000000.0);
        }}
    public static void main(String[] args) {
        for (int i = 0; i < 10; i++) {
            System.out.print(i + " ");
            timer();
        }}}
```

Go

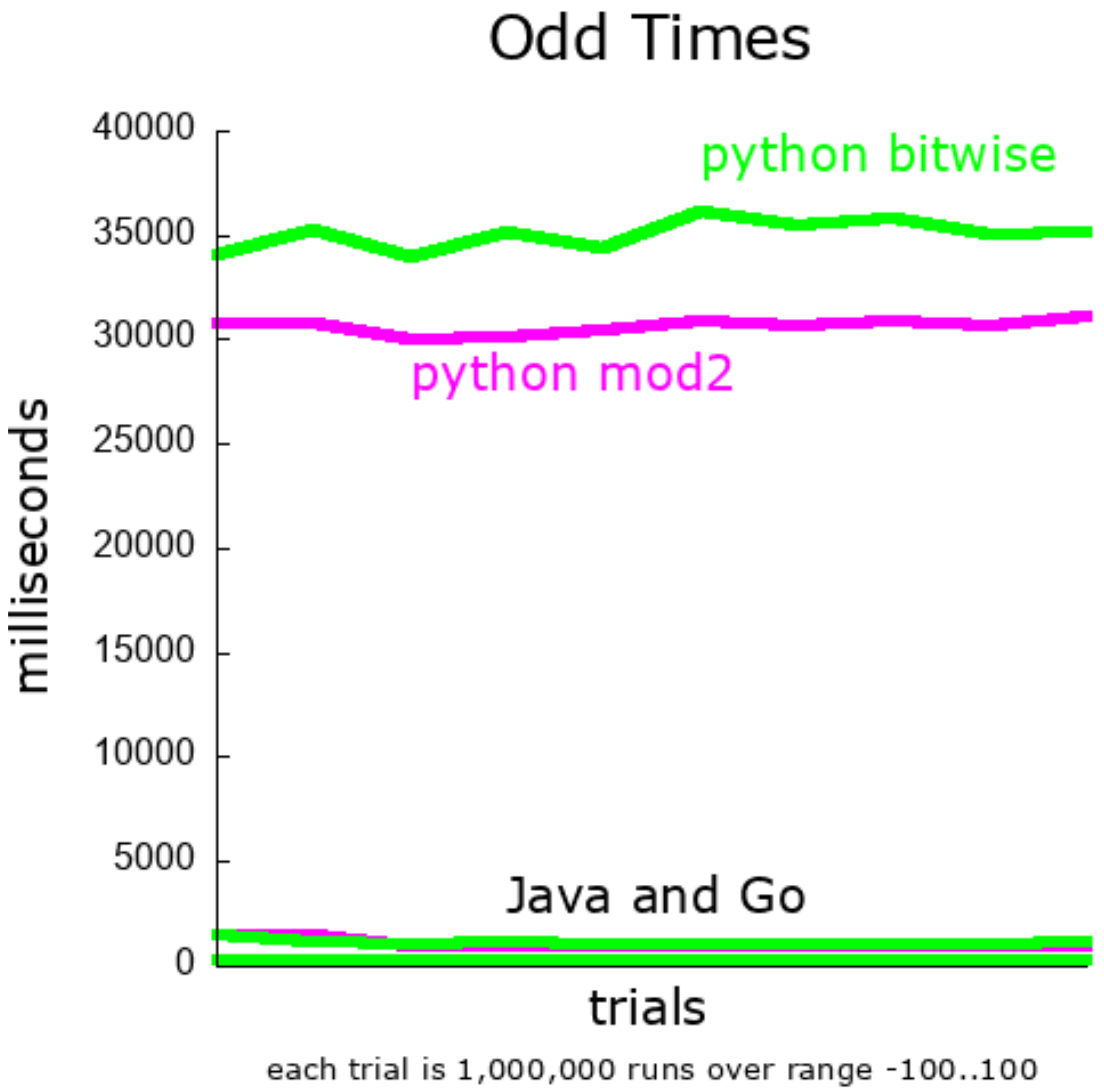
```go
func timeit(ff func(int)bool, ss string) {
    start :=  time.Now()
    odd:=0
    for i:=0; i<1000000; i++ {
        for j:=-100; j<=100; j++ {
            if ff(j) {
                odd++
            }
        }
    }
    duration := time.Since(start)
    fmt.Printf("%v %v  ", ss, duration)
}
```

Python

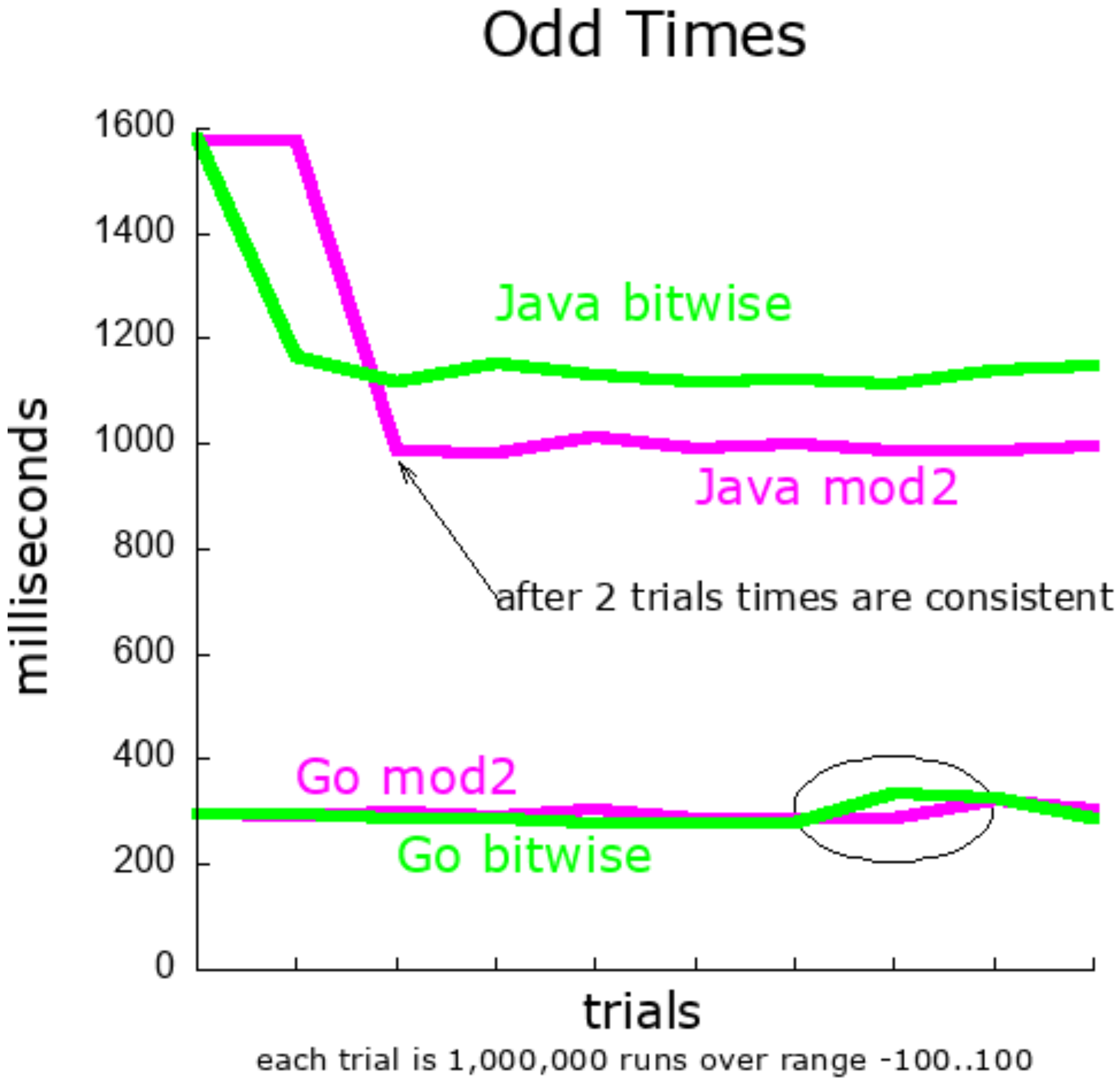
```python
  st = time.time()
  oddd=0
  for i in range(1000000):
      for j in range(-100, 100):
          if isOddBit(i):
              oddd += 1
  et = time.time()
  elapsed_time = et - st
  print('Execution time (bit):', elapsed_time,
'seconds')
```

Java

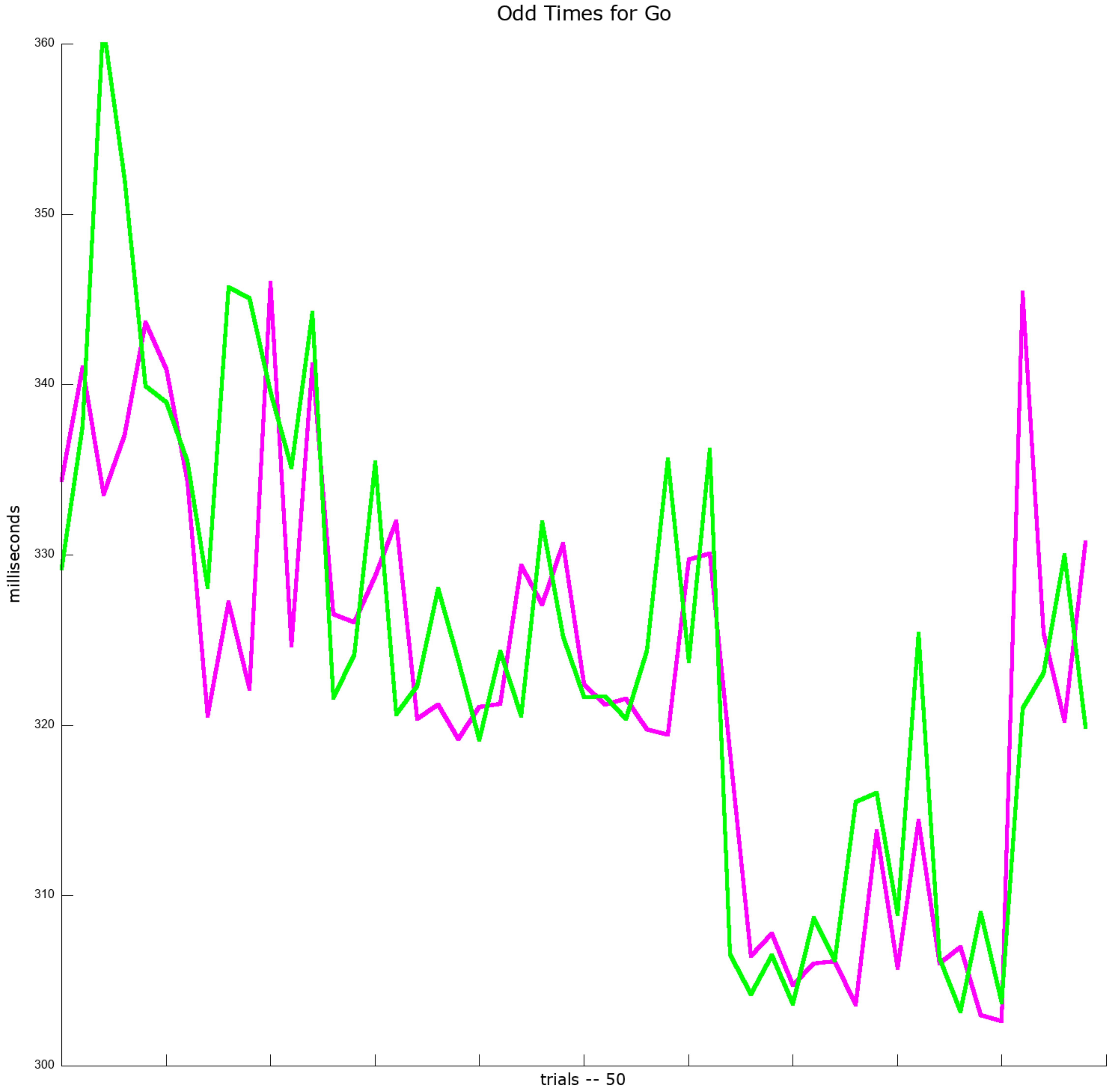
```java
long st = System.nanoTime();
int odd = 0;
for (int j = 0; j < 10000000; j++) {
    for (int i = -100; i < 100; i++) {
        if (isOddBit(i))
            odd++;
    }
}
long en = System.nanoTime();
System.out.print((en - st) / 1000000.0 + "; ");
```



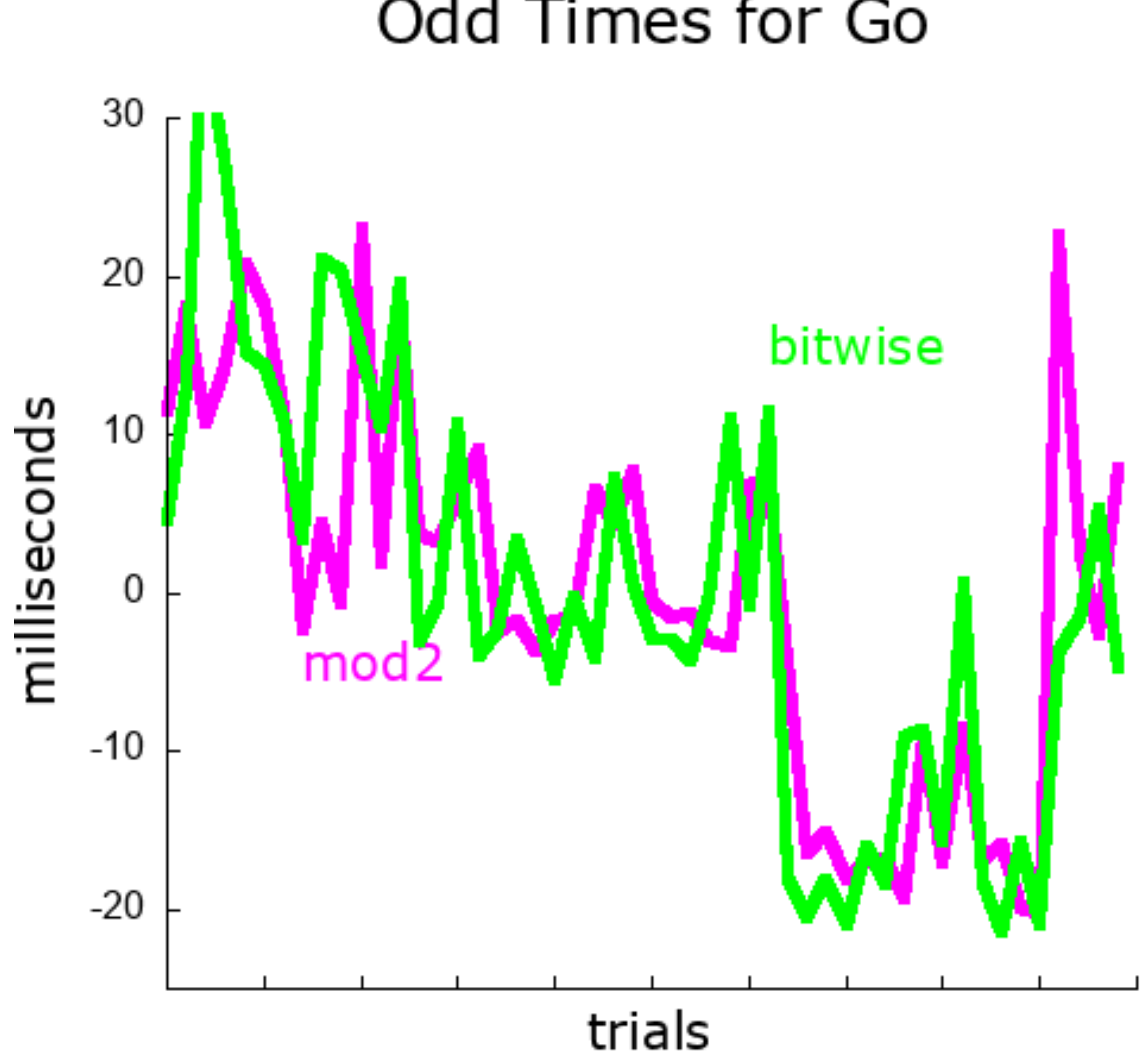
- All trials in a language are done using a single unix command
- Tentative conclusions:
    - python is a lot slower
    - bitwise odd is slower than modulus odd (at least for python)
        - need a better look at Java and Go



- Same data as previous chart, just eliminating python
- Tentative conclusions:
  - bitwise odd is slower than modulus odd -- at least for Java
  - Java has something weird at startup
    - Java oddness happens at every startup!
      - (data not shown)

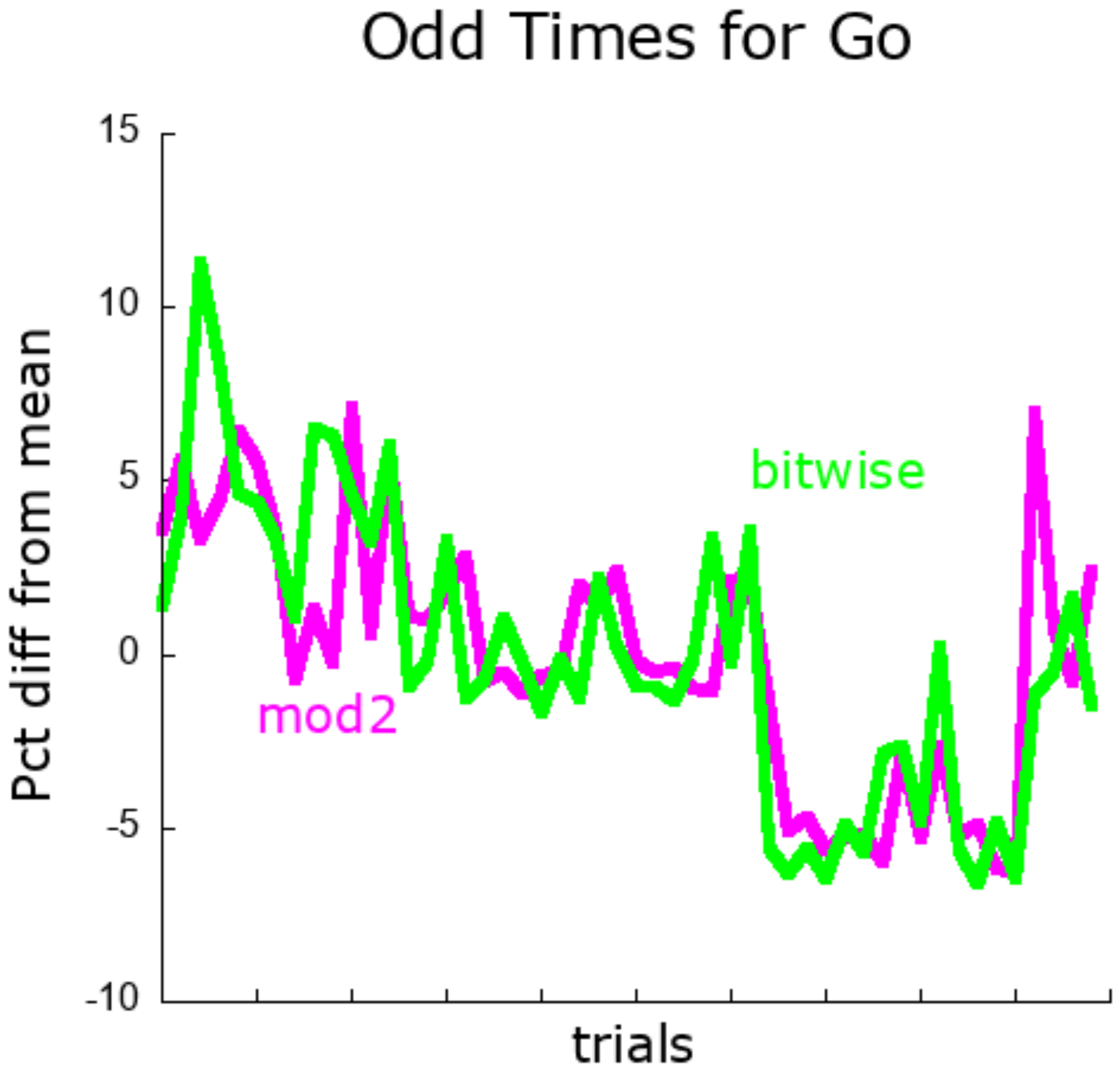


Odd Times for Go



Odd Times for Go

each trial is 1,000,000 runs over range -100..100

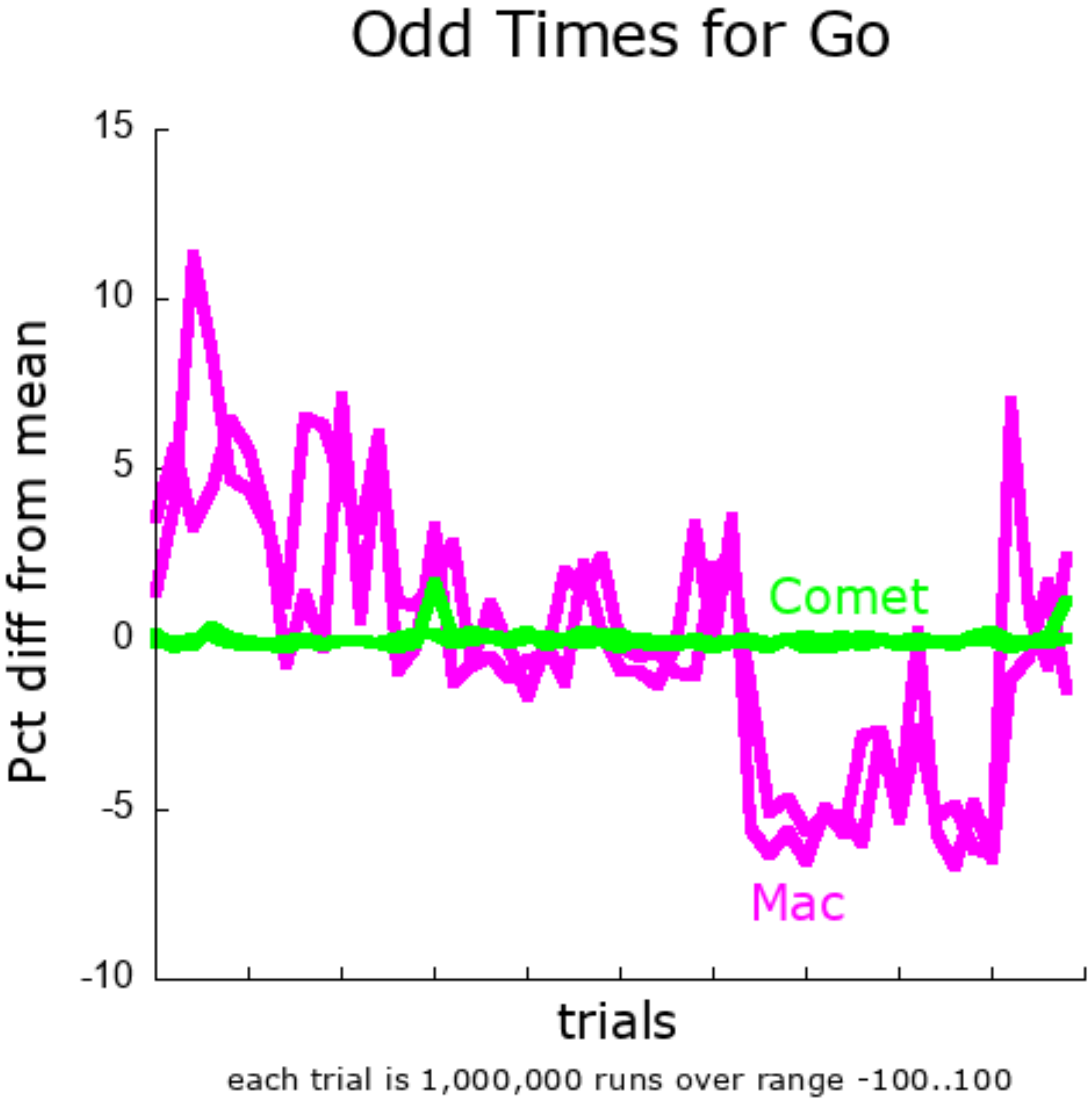


Odd Times for Go

each trial is 1,000,000 runs over range -100..100

Laptops do lots of things

As a result, times are not consistent



Description	Std Dev
Mac -- Mod	12.06
Mac -- Bit	13.57
Comet -- Mod	1.01
Comet -- Bit	1.19

Winston on Presentations

Pick

- Time
- The room
    - Shape matters (Park 227, Park 338)
    - A happy place

Practice

- Pick your location
- AV issues
- Lights on
- Chat up early arrivers

The talk

- Be Happy
- VSN-C
    - Start with Vision
    - Steps
    - News
    - Finish with Contributions

Contributions == Conclusions

- No "thank you"
- No collaborators
  - if needed, do early

"you have too many slides and all of them have too many words"

Winston

Do not read

No cute clip art

Avoid bullet lists

Use big fonts

(use even bigger fonts)

Progress bars -- maybe

"page 1 or 12"?

Props

Titles

Um

like

er...

you know

Bellow!

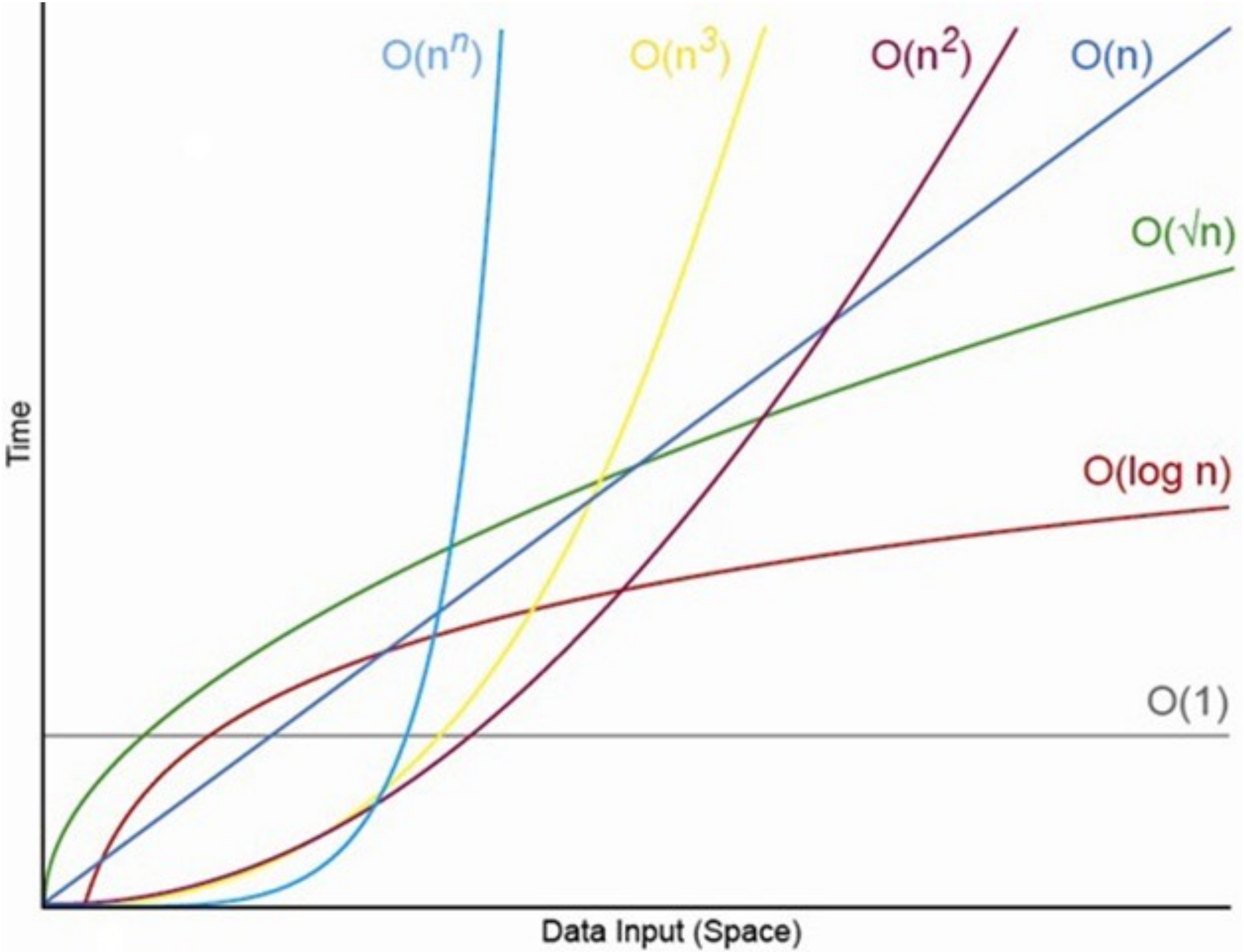
(use a mic, practice)

~~Monotone~~

~~Pockets~~

- Given an array, A of n integers arranged in ascending order, and an integer x:

$$\text{search}(A, n, x) = \begin{cases} i, such\ that\ A[i] = n \\ -1, \qquad\qquad otherwise \end{cases}$$



http://apelbaum.wordpress.com/2011/05/

How long to sort 10 million numbers?

Computer A

Speed: 10^{10} instructions/sec
Running O(n^2) sort
Requires $2n^2$ instructions

How long will it take?

Computer B

Speed: 10^7 instructions/sec
Running O($n \log n$) sort
Requires $50\, n \log n$ instructions

How long will it take?

How long to sort 10 million numbers?

Computer A

Speed: 10^{10} instructions/sec
Running O(n^2) sort
Requires $2n^2$ instructions

$$\frac{2 * (10^7)^2}{10^{10}} \approx 20{,}000s$$

~5.5 hours

Computer B

Speed: 10^7 instructions/sec
Running O($n \log n$) sort
Requires $50\, n \log n$ instructions

How long will it take?

How long to sort 10 million numbers?

Computer A

Speed: 10^{10} instructions/sec
Running O(n^2) sort
Requires $2n^2$ instructions

$$\frac{2 * (10^7)^2}{10^{10}} \approx 20{,}000s$$

~5.5 hours

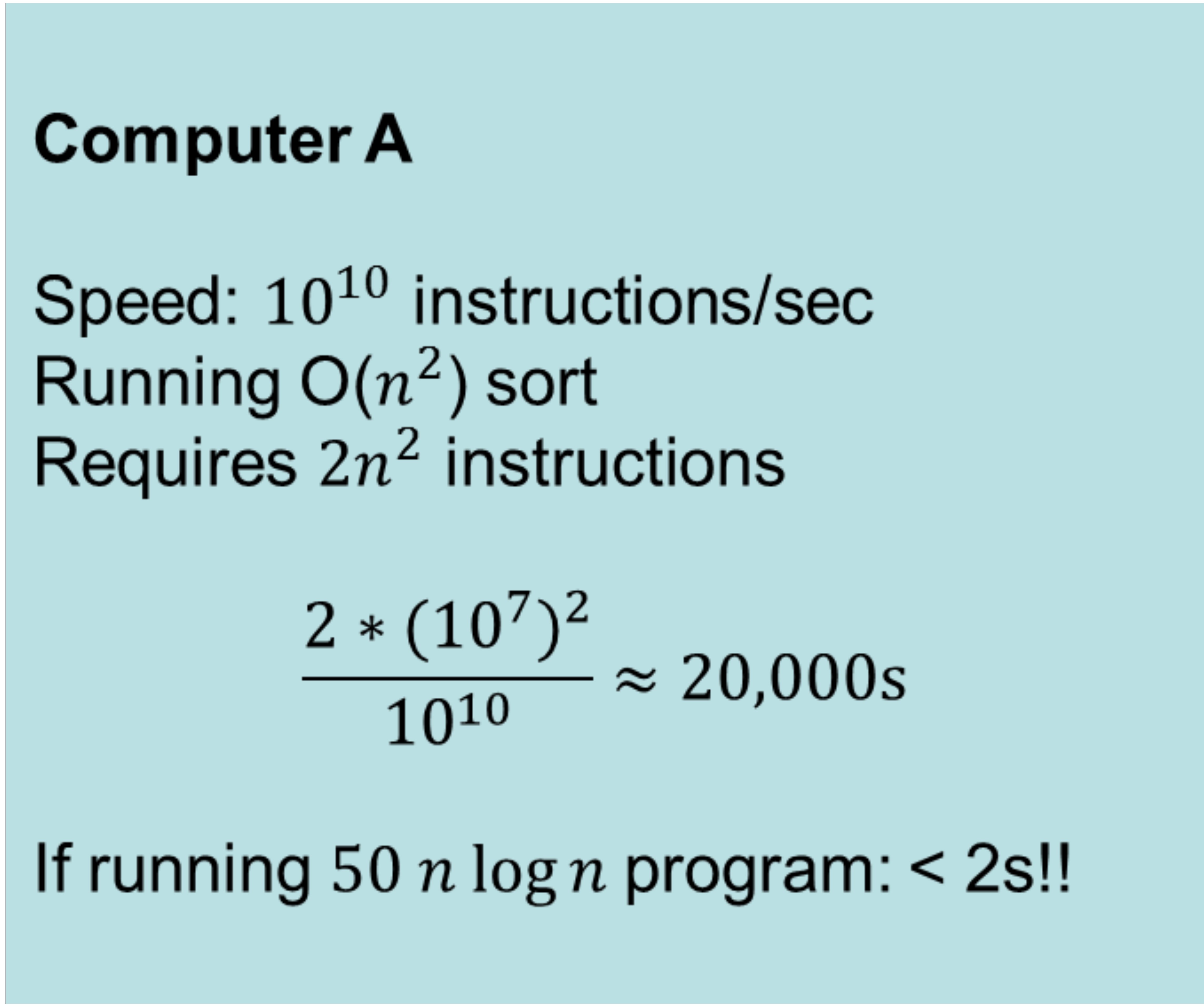
Computer B

Speed: 10^7 instructions/sec
Running O($n \log n$) sort
Requires $50\ n \log n$ instructions

$$\frac{50 * 10^7 * log10^7}{10^7} \approx 1163s$$

under 20 minutes!

How long to sort 10 million numbers?

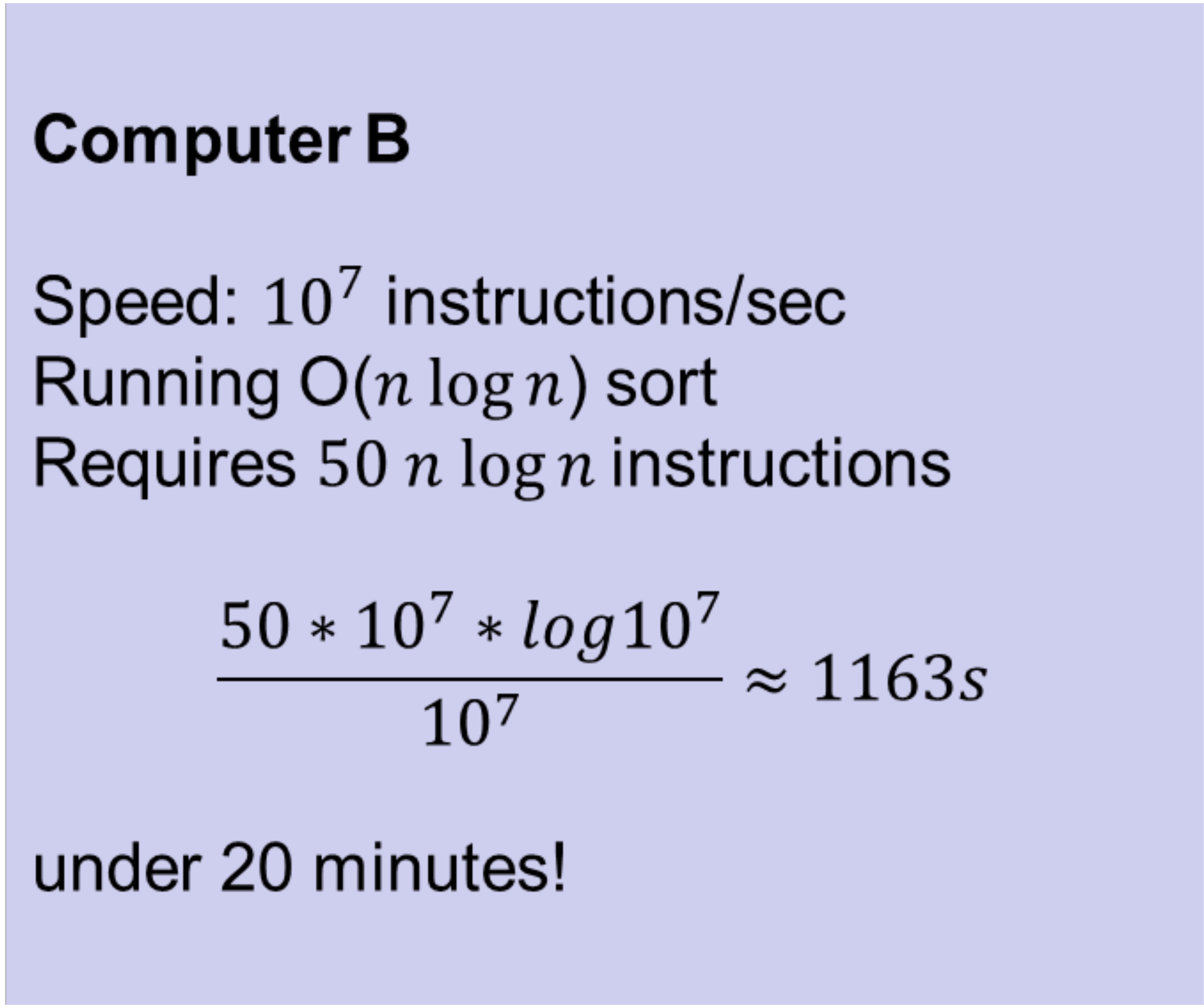


Computer A

Speed: 10^{10} instructions/sec
Running O(n^2) sort
Requires $2n^2$ instructions

$$\frac{2*(10^7)^2}{10^{10}} \approx 20{,}000s$$

If running $50\,n\log n$ program: < 2s!!



Computer B

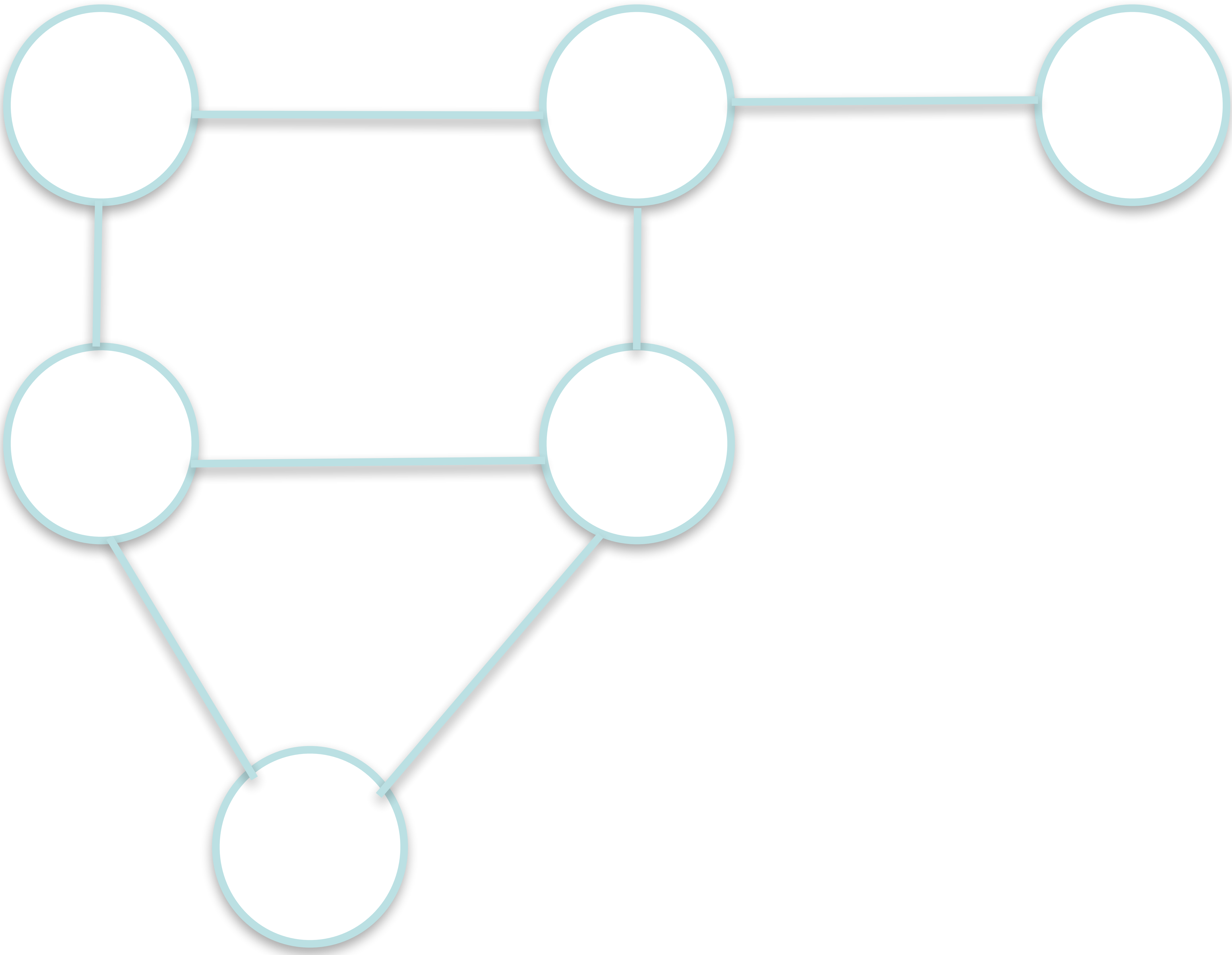
Speed: 10^7 instructions/sec
Running O($n\log n$) sort
Requires $50\,n\log n$ instructions

$$\frac{50*10^7*log10^7}{10^7} \approx 1163s$$

under 20 minutes!

P = NP?

- vertex cover of a graph is a set of vertices that includes at least one endpoint of every edge.



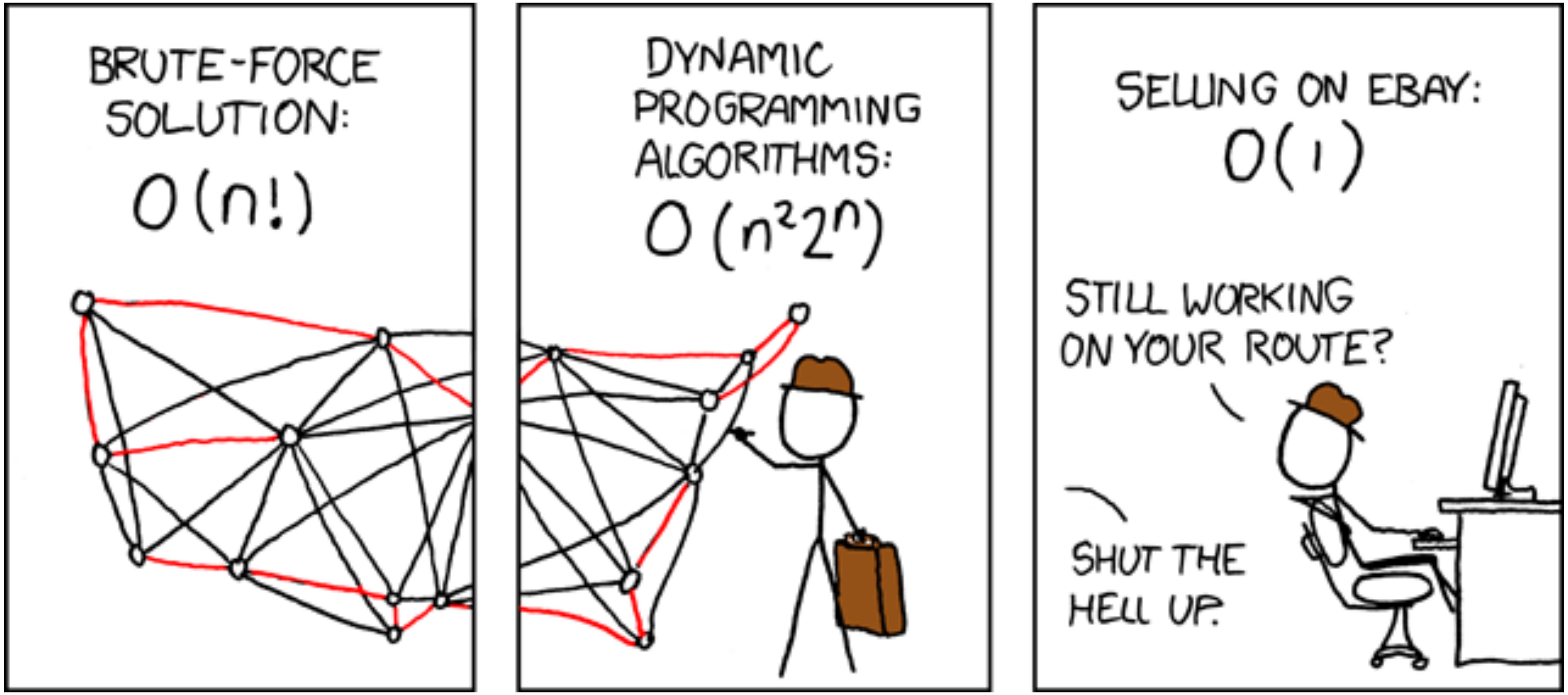
Vertex Cover Algorithm

- Find the minimum vertex cover of a graph
  - We will discuss graph representations, just make something up for now

NP-Complete

- NP = Non-determinitic Polynoimial
- in NP == Solution is verifiable in P time
- problem is provably equivalent to other NP complete problems

xkcd??



- More on xkcd.com

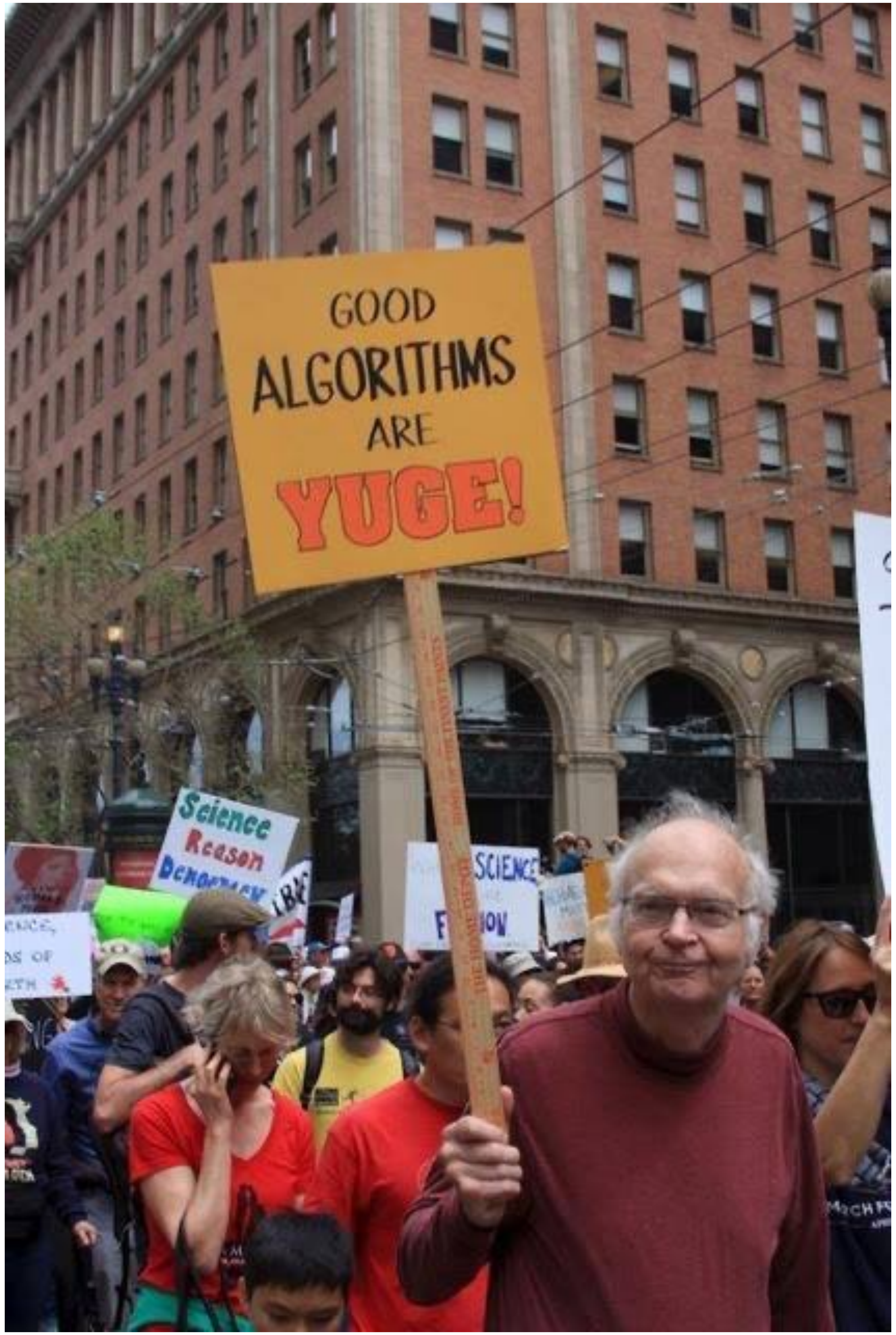
Algorithm for Algorithm Development

```
def algorithmDevelopment(problemSpec):
    correct = false
    while not correct or not fastEnough(runningTime):
        algorithm = deviseAlgorithm(problemSpec)
        correct = analyzeCorrectness(algorithm)
        runningTime = analyzeEfficiency(algorithm)
return algorithm
```

Algorithm for Program Development

```
def programDevelopment(algorithm, testSuite):
    language = pickLanguage(algorithm)
    program = code(algorithm, program)
    do:
        check = false
        while not check:
            program = debug(program)
            check = verifyProgram(program, testSuite)

        performance = measure(performance)
    while not acceptable(performance)
```


GOOD
ALGORITHMS
ARE
YUGE!
Science
Reason
Democracy
SCIENCE

An algorithm to consider

- Given two lists of integers
  - call these A and B
- Find: min(abs(A[i]-B[j])