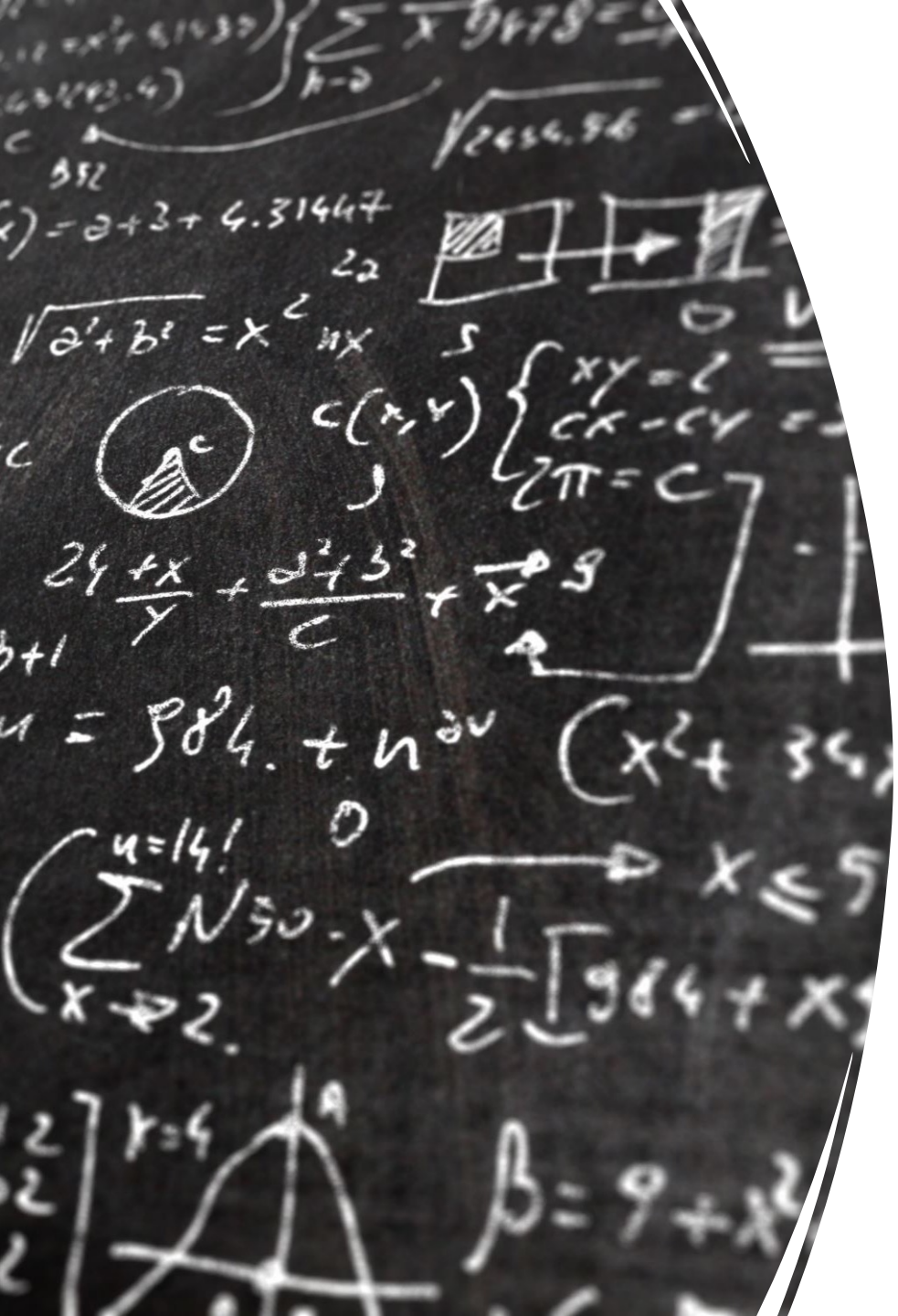


CS 113 – Computer Science I

Lecture 25 – Runtime II

Adam Poliak

04/25/2023

Announcements

HW09:

- Due 04/28 – released today (shorter)
- Building 2 Fancy classes that keeps track of Strings
  - SuperDuperArray
  - SuperDuperSortedArray
- fully autograded

Adam: Office Hours

- Thursday: 3-4:45
- Friday: 12-2pm
- Next week, TBA

Announcements

Final

- Wednesday 05/03 9:30am-12:30pm in Park 300
- Closed-notes and books
- Practice exam will be released this week
- Cumulative
- A bit longer than midterms (but not 2x)

Thursdays class:

- Review
- AMA

ChatBot Improv

Wednesday 04/26

5:30-6:30pm

Campus Center Lounge

Course evaluation

What do you see as the major strengths of Adam Poliak in this course? What areas do you see for improvement in instruction and/or in content?

How prepared were you to take this course? What courses, if any, would you have found useful to take before this course? Is this course listed at the appropriate level?

How did Adam Poliak effectively create an accessible and inclusive course experience? What areas do you see for commendation and/or improvement in the instructor's attention to accessibility and inclusivity?

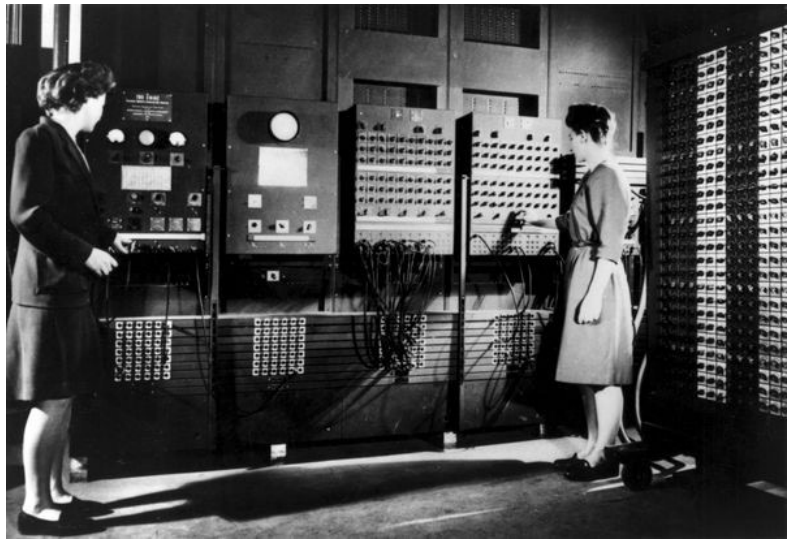
Would you recommend this course, as taught by Adam Poliak, to other students? Why or why not?

Title	Unique ID	Instructor	Enrollments	Responded	Response Rate
Computer Science I - bmc.CMSC.B113.001.SP23	bmc.CMSC.B113.001.SP23	Adam Poliak	32	2	6.25%
Computer Science I - bmc.CMSC.B113.00A.SP23	bmc.CMSC.B113.00A.SP23	Adam Poliak	32	4	12.5%
Computer Science I - bmc.CMSC.B113.001.SP23	bmc.CMSC.B113.001.SP23	Adam Poliak	32	6	18.75%
Computer Science I - bmc.CMSC.B113.00A.SP23	bmc.CMSC.B113.00A.SP23	Adam Poliak	32	8	25%
Computer Science I - bmc.CMSC.B113.001.SP23	bmc.CMSC.B113.001.SP23	Adam Poliak	32	11	34.38%
Computer Science I - bmc.CMSC.B113.00A.SP23	bmc.CMSC.B113.00A.SP23	Adam Poliak	32	13	40.63%

We did not double participation - but we got close-ish

Measuring performance

How do we quantify performance?



Computing the speed of your programs

Compute the time needed to execute a function

```
import java.lang.System.*;

public static void main(String[] args) {
    …..

    double start = System.currentTimeMillis()/1000.0; // converts to seconds
    bubbleSort(L);
    double end = System.currentTimeMillis()/1000.0;

    System.out.printf("Time: %.10f", (end-start));
}
```

Runtime analysis: Big-O notation

Quantifies worse-case performance

- theoretical measure of how performance changes with input size

Advantages

- Hardware-independent measure

- Allows us to analyze different approaches without implementing the algorithm first

Big-O counting

- defining, assigning variables (1 step)
- printing, reading input (built-in function calls: “k” steps)
- mul, divide, sub, add, mod, etc (1 step)
- testing conditions (1 step)

Big-O Example – Compute a sum

```
int sum = 0;
int i = 0;
while (i < n) {
   sum = sum + i;
   i++;
}
System.out.println(sum);
```

Runtime practice

a)

```
int n = getInputSize();
for (int i = 0; i < n; i++) {
    System.out.println(i);
}
```

Runtime practice

b)

```
int n = getInputSize();
for (int i = 0; i < 100; i++) {
    System.out.println(i*n);
}
```

Runtime practice

c)

```
int n = getInputSize();
for (int i = 0; i < n; i++) {
    System.out.println(i);
}

for (int j = 0; j < n; j++) {
   System.out. println(j);
}
```

Runtime practice

d)

```
int n = getInputSize();
for (int i = 0; i < n; i++) {
    for (int j = 0; j < n; j++) {
        System.out.println(i, j);
    }
}
```

Runtime practice

e)

```
int n = getInputSize();
for (int i = 0; i < n; i++) {
    for (int j = i; j < n; j++) {
        System.out.println(i, j);
    }
}
```

Runtime practice

h)

```
int[] lst = {1,2,3,5,7,12,19,34,55,67,99,101};
int n = lst.length;
int mid = floor(n/2);
System.out.println(lst[mid]);
```

Runtime practice

i)

```
int n = getInputSize();
for (int i = 0; i < n; i++) {
  k = n;
  while (k > 1) {
     System.out.println(i, k);
     k = k/2;
  }
}
```

Runtime practice

f)

```
int n = getInputSize();
for (int i = 0; i < n; i++) {
    for (int j = 0; j < 10; j++) {
        println(i, j);
    }
}
```

Runtime practice

g)

```
int n = getInputSize();
while (n > 1) {
    println(n);
    n = n/2;
}
```

Linear Search - revisited

```
public static int LinearSearch(int x, int[] L) {
	int index = -1;
	for (int i = 0; i < L.length; i++) {
		if (L[i] == x) {
			index = i;
		}
	}
	return index;
}
```

Binary Search – what is the runtime?

```
public static int search(int x, int[] L) {
    int low = 0;
    int high = L.length-1;
    while (low <= high) {
        int mid = (low + high)/2;
        if (x > L[mid]) {
            low = mid+1;
        }
        else if (x < L[mid]) {
            high = mid-1;
        }
        else {
            return mid;
        }
    }
    return -1;
}
```

BubbleSort Revisited – What is the runtime?

```
public static void bubbleSort(int[] L)  {

    for (int n = 0; n < L.length; n++) {
      for (int j = 1; j < L.length-n; j++) {
        if (L[j-1] > L[j]) {
          swap(j-1, j, L);
        }
      }
   }
}
```

Comparisons in BubbleSort

How many comparisons do we need to make to sort a list of size n?

$$\frac{n(n-1)}{2}$$

Why? (draw on the board)

$\frac{n(n-1)}{2}$ =

$$\frac{n^2 - n}{2}$$

So what's the Big-Oh?

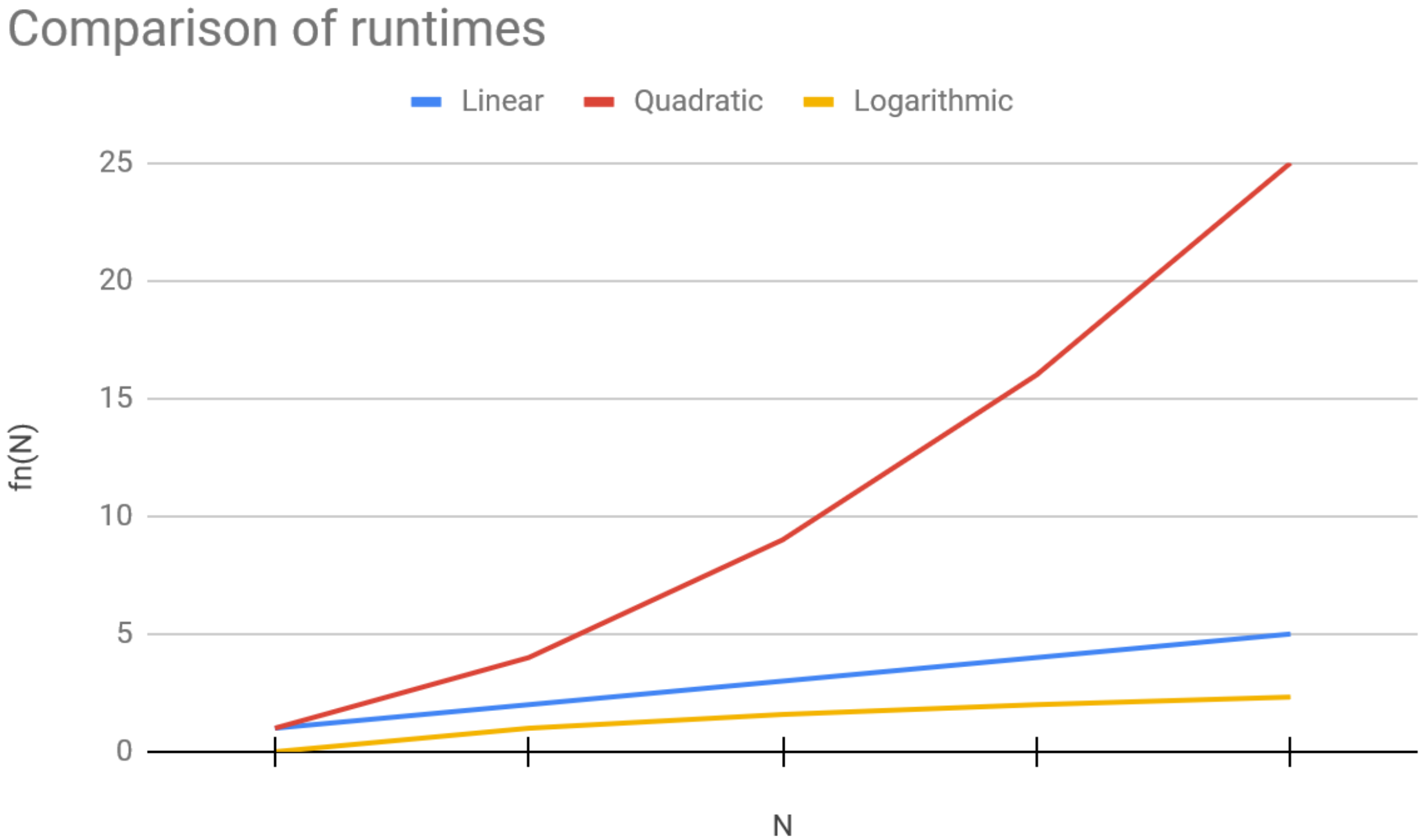
$O(n^2)$

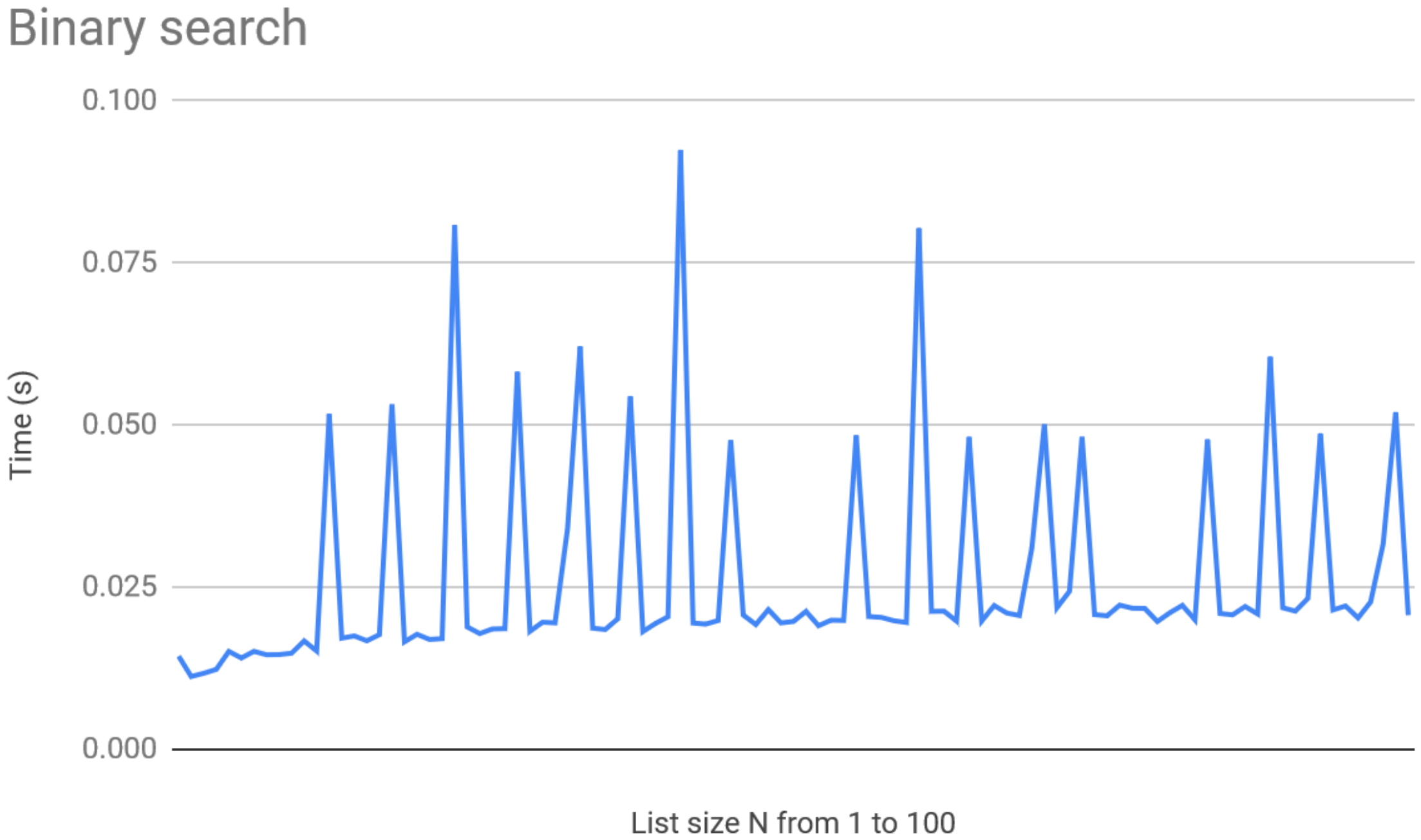
BubbleSort Revisited – What is the runtime?

```
public static void bubbleSort(int[] L)  {

    for (int n = 0; n < L.length; n++) {
      for (int j = 1; j < L.length-n; j++) {
        if (L[j-1] > L[j]) {
          swap(j-1, j, L);
        }
      }
   }
}
```

SelectionSort Revisited – What is the runtime?

```
public static void selectionSort(int[] L)   {

  for (int i = 0; i < L.length; i++) {
    int minIdx = i;
    for (int j = i+1; j < L.length; j++) {
      if (L[j] < L[minIdx]) {
        minIdx = j;
      }
    }
    swap(i, minIdx, L);
  }
}
```


Comparison of runtimes
Linear
Quadratic
Logarithmic
25
20
15
10
5
0
fn(N)
N


Binary search
0.100
0.075
0.050
0.025
0.000
Time (s)
List size N from 1 to 100

Linear Search