Yusuf Ziya Dilek
ID: 21501462

# CS 201 Homework 2

**CPU: Intel i7 4720HQ (2.3 Ghz)**

**Note:** ns = nanosecond, µs = microsecond, ms = millisecond.

**Linear Search:**

| | i)Key close to begin | ii)Key close to middle | iii)Key close to end | iv) wrong key |
|---|---|---|---|---|
| **N = 100** | 55 ns | 231 ns | 405 ns | 403 ns |
| **N = 1000** | 60 ns | 1809 ns | 3555 ns | 3547 ns |
| **N = 10000** | 55 ns | 20 µs | 36 µs | 36 µs |
| **N = 100000** | 56 ns | 177 µs | 352 µs | 353 µs |
| **N = 1000000** | 57 ns | 1756 µs | 3516 µs | 3502 µs |
| **N = 10000000** | 54 ns | 19 ms | 36 ms | 37 ms |
| **N = 100000000** | 57 ns | 178 ms | 353 ms | 352 ms |

- Values grow very rapidly. It starts from nanosecond range and goes all the way up to microsecond range.

**Binary Search:**

| | i)Key close to begin | ii)Key close to middle | iii)Key close to end | iv) wrong key |
|---|---|---|---|---|
| **N = 100** | 99 ns | 53 ns | 96 ns | 95 ns |
| **N = 1000** | 124 ns | 55 ns | 117 ns | 117 ns |
| **N = 10000** | 138 ns | 57 ns | 149 ns | 149 ns |
| **N = 100000** | 182 ns | 54 ns | 172 ns | 175 ns |
| **N = 1000000** | 205 ns | 56 ns | 195 ns | 200 ns |
| **N = 10000000** | 242 ns | 52 ns | 229 ns | 232 ns |
| **N = 100000000** | 267ns | 59 ns | 271 ns | 271 ns |

- Values grow very slowly. Always stays in the nanosecond range.

**Note:** In order to find values in nanosecond range I run a loop M= 10^6 times and divided the results with M to found the nanosecond values.

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# Plots:

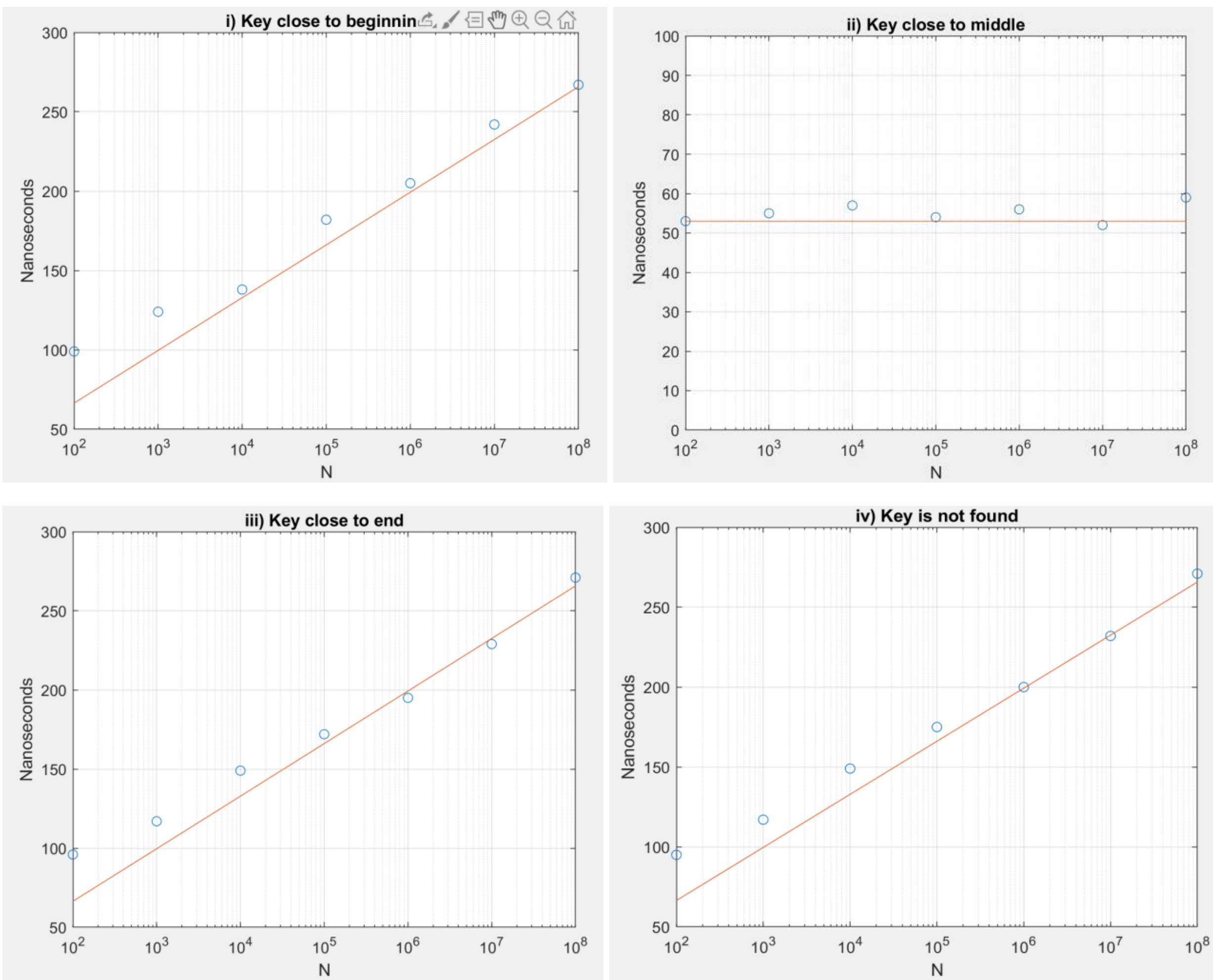
**Note1:** Red lines are theoretical values (O(N) for linear, O(log2N) for binary).

**Note2:** Circles are table values that I have obtained from the c++ code.

**Note3:** You can check the Appendix 1 for the MATLAB code that I have used to draw plots.

**IMPORTANT NOTE:** I have used **logarithmic scale** since we are dealing with **large range of quantities**.

**Binary Search:**



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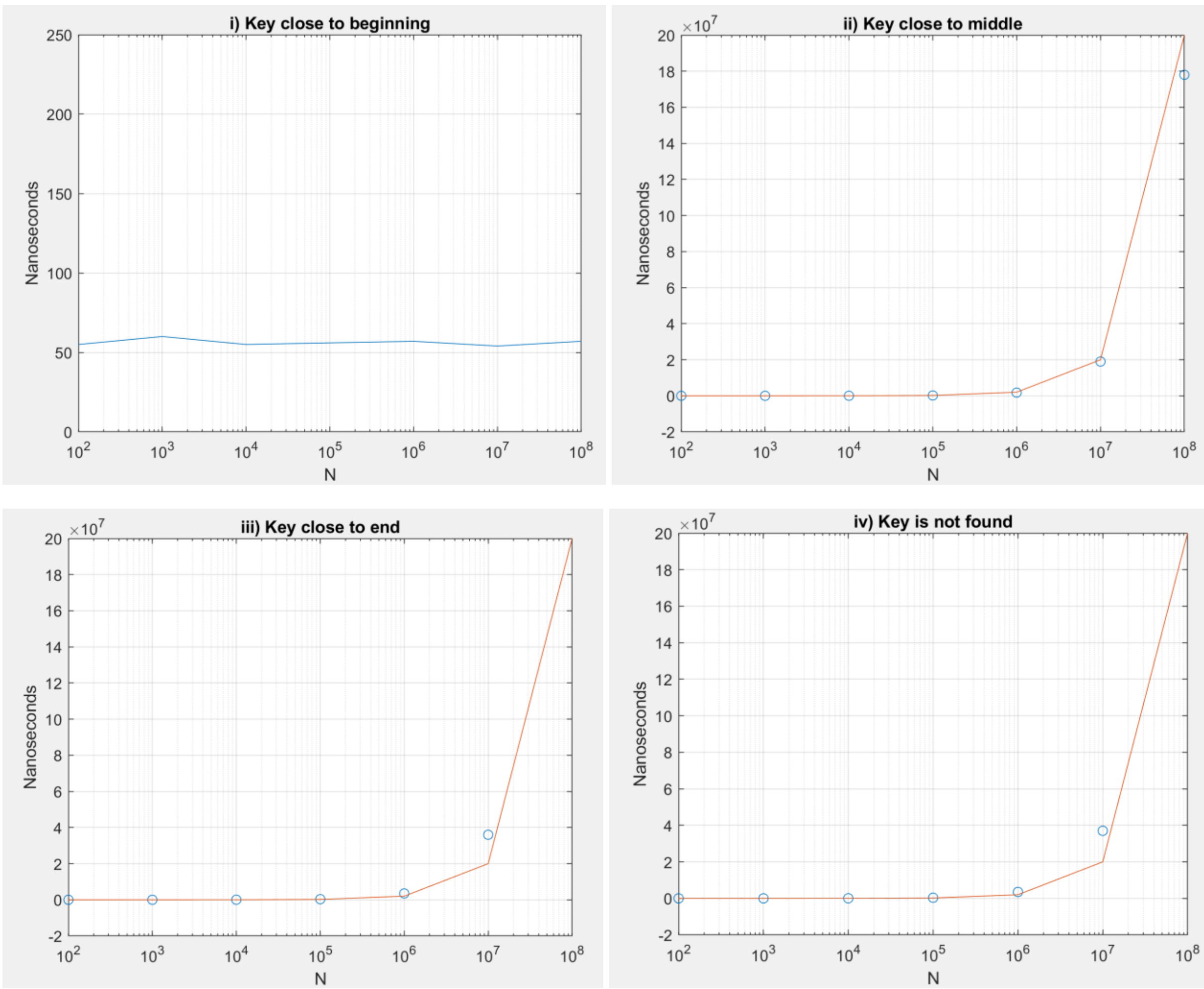
**Linear Search(Y axis is very large, it goes up to 20 x 10^7 nano seconds):**




## Comments:

**Best case scenario:** For Linear Search, it is when the key is close to beginning (it is around 54-60 ns), for Binary search when the key is exactly middle (it is around 53-59 ns). It just founds the key in first try so that it is very fast but this does not give us much information

**Worst case scenario:** For Linear Search, it is when the key is not found or very close to end (For biggest N it is around 352ms). For Binary search it is around 271 ns.

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**Average case scenario:** It is similar to worst case scenario linear search: 350ms and binary search: 270ns.

## Conclusion:

We can see that the Sequential Search behaves in like O(N). It starts from low number but when the N is increased the execution times skyrockets. Binary search follows O(logN) growth. As you can see the values start from 90ns range and only goes up to 270ns range unlike sequential which goes up to millisecond range. When the N is small Sequential Search and Binary search don't have any noticeable but as the N increases, the Sequential Search becomes extremely slow. It goes from nanoseconds range to milliseconds range, grows very fast compared to binary search.

**Appendix 1**

```
N = [100 1000 10000 100000 1000000 10000000 100000000];
x = log2(N).*10;

binary1 = [99 124 138 182 205 242 267];
binary2 = [53 55 57 54 56 52 59];
binary3 = [96 117 149 172 195 229 271];
binary4 = [95 117 149 175 200 232 271];

figure(1)
semilogx(N, binary1,'o');
hold on
semilogx(N, x);
title("i) Key close to beginning");
xlabel("N");
ylabel("Nanoseconds");
grid on

figure(2)
semilogx(N, binary2,'o');
hold on
semilogx(N, 53.*ones(1, length(N)));
ylim([0 100])
title("ii) Key close to middle");
xlabel("N");
ylabel("Nanoseconds");
grid on

figure(3)
semilogx(N, binary3,'o');
hold on
semilogx(N, x);
title("iii) Key close to end");
xlabel("N");
ylabel("Nanoseconds");
grid on

figure(4)
semilogx(N, binary4,'o');
hold on
semilogx(N, x);
title("iv) Key is not found");
xlabel("N");
ylabel("Nanoseconds");
grid on
```