Santa Monica College
Fall 2018

CS 20A: Data Structures with C++

Assignment 5

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Problem 1:

For all of the following, determine the **total operation count** and then the **Big-O** of the given code segments:

a.

```
for (int j = 0; j < n; j++)
    for (int k = 0; k < j; k++)
        sum++;
```

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

$$= \frac{3n(n-1)}{2} + 3n + 1$$

$$= \frac{3}{2}n^2 - \frac{3}{2}n + 3n + 1 = \boxed{\frac{3}{2}n^2 + \frac{3}{2}n + 1}$$

$$\boxed{O(n^2)}$$

b.

```
for (int i = 0; i < q*q; i++)
    for (int j = 0; j < i; j++)
        sum++;
```

$$f(n) = 1 + q^2 + q^2 + q^2 + \frac{q^2(q^2-1)}{2} + \frac{q^2(q^2-1)}{2} + \frac{q^2(q^2-1)}{2}$$

$$= \frac{3q^2(q^2-1)}{2} + 3q^2 + 1 = \frac{3}{2}q^4 - \frac{3}{2}q^2 + 3q^2 + 1 = \boxed{\frac{3}{2}q^4 + \frac{3}{2}q^2 + 1}$$

$$\boxed{O(q^4)}$$

For all of the following, just determine the **Big-O** of the given code segments:

c.

```
for (int i = 0; i < n; i++)
    for (int j = 0; j < i*i; j++)
        for (int k = 0; k < j; k++)
            sum++;
```

the 1st loop runs n times (fixed)

every time the 1st loop runs once, 2nd loop runs roughly n^2 times (max. value of i is $n-1$, rounded up to n)

every time the 2nd loop runs once, the 3rd loop runs roughly n^2 times (max. value of j is $\sim n^2-1$, rounded up to n^2)

$$n \cdot n^2 \cdot n^2$$

$$\boxed{O(n^5)}$$

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d.

```
for (int i = 0; i < p; i++)
    for (int j = 0; j < i*i; j++)
        for (int k = 0; k < i; k++)
            sum++;
```

p (fixed)

$i_{max} = p - 1$, rounded up to p → p^2

p

$p \cdot p^2 \cdot p$

$\boxed{O(p^4)}$

e.

```
for (int i = 0; i < n; i++)
{
    Circ arr[n];

    arr[i].setRadius(i);
}
```

n (fixed)

n (if calling Circ constructor qualifies as an operation, this is done n times. sidenote: n must be a constant)

$n \cdot n$

$\boxed{O(n^2)}$

f.

```
for (int i = 0; i < n; i++)
{
    int k = i;
    while (k > 1)
    {
        sum++;
        k = k / 2;
    }
}
```

n

log n

$\boxed{O(n \log n)}$

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Problem 2:

Given a vector of sets of ints, `vector< set<int> > v`, assume the vector v has **N** total sets and that each set has an average of **Q** items.

a. What is the Big-O of determining if the first set, v[0], contains the value 7?

$1 + \log Q$

$O(\log Q)$

b. What is the Big-O of determining if any set in v has the value 7?

$N \cdot \log Q$

$O(N \cdot \log Q)$

c. What is the Big-O of determining the number of even values in all of v?

$N \cdot Q$

$O(N \cdot Q)$

d. What is the Big-O of finding the first set with a value of 7 and then counting the number of even values in that set?

$N \cdot \log Q + Q$

$O(N \cdot \log Q + Q)$

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Problem 3:

Determine the data structure needed if we wanted to maintain a bunch of peoples' names and for each person, allows us to easily get all of the streets they lived on. Assume there are P total people and each person has lived on average E former streets. map < string, set < string>> m;

What is the Big-O cost of:

a. Finding the names of all people who lived on "Levering Street"?

$P \cdot \log E$

$\boxed{O(P \cdot \log E)}$

b. Determining if "Bill" ever lived on "Westwood Blvd"?

$\log P + \log E$

$\boxed{O(\log P + \log E)}$

c. Printing out every name along with each person's street addresses in alphabetical order?

? ☐ how to account for this

$P \cdot E$

$\boxed{O(P \cdot E)}$

d. Printing out all the streets that "Tala" has lived on?

$\log P + E$

$\boxed{O(\log P + E)}$

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Problem 4:

Fibonacci numbers are a sequence of numbers given by the relationship:

$$F_n = F_{n-1} + F_{n-2}$$

With $F_0 = 0$ and $F_1 = 1$. In other words, the nth Fibonacci number is given by the sum of the two Fibonacci numbers before it. For Example, the first 13 Fibonacci numbers are:

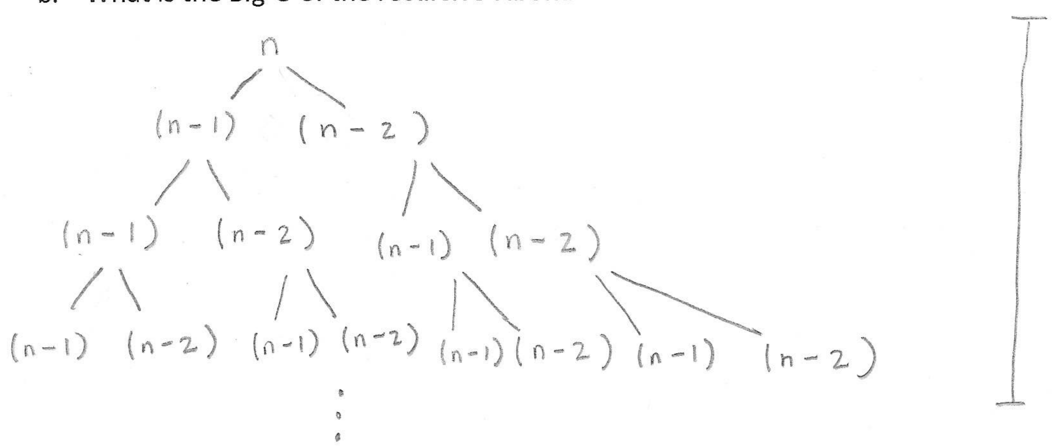
0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144

a. Implement a recursive function to compute the nth Fibonacci number:

```
int fibonacci(int n) {    // Precondition: n >= 0
    if ( n <= 1 ) {
        return n;
    }
    return (fibonacci(n-1) + fibonacci(n-2));

}
```

b. What is the Big-O of the recursive Fibonacci function?



$\boxed{O(2^n)}$

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Problem 5:

Given the following array show the result after one round of the each of the sorting algorithms indicated. One round being one full iteration of the algorithm's outer most for/while loop.

a. Selection Sort:

99	16	3	19	13	0	13	12	6
0	16	3	19	13	99	13	12	6

b. Insertion Sort:

99	16	3	19	13	0	13	12	6
16	99	3	19	13	0	13	12	6

c. Bubble Sort

99	16	3	19	13	0	13	12	6
16	3	19	13	0	13	12	6	99