CS2413 Data Structures · Spring 2024
Homework 1

Due Date: Feb 12, 11:59 p.m., please submit everything via Blackboard. Late submissions are accepted till February 14, 11:59 p.m., with 10% penalty each day.

Problems:

Q1. [3 points] Write a program to create a single linked list, with the following node struct and allow user to input integer numbers to initialize the list.

```
typedef struct listnode {       /* list node struct */
    int data;                   /* integer field */
    struct listnode *next;      /* self-referential pointer field*/
} node;
```

Given the `head` pointer of the above singly linked list, return *the middle node of the linked list*. If there are two middle nodes, return the second middle node.

What are the *time* complexity of finding the middle of the linked list size `n`? Explain.

Example 1:

- **Input**: `head` = [1,2,3,4,5]
- **Output**: [3,4,5]
- **Explanation**: The middle node of the list is node 3.

Example 2:

- **Input**: `head` = [1,2,3,4,5,6]
- **Output**: [4,5,6]
- **Explanation**: Since the list has two middle nodes with values 3 and 4, we return the second one.

Problem 2 [4 points]: Analyze the following programs and show their time complexity functions and big-O notations.

2.1

```
for (i = 1; i <= n; i *= 2) {
  for (j = 1; j <= i; j++) {
    // 7 assignment instructions
  }
}
```

2.2

```
for (i = 1; i <= n; i *= 2) {
  for (j = 1; j <= i; j *= 2) {
    // 9 assignment instructions
  }
}
```

2.3

```
for (i = 1; i < n; i *= 3) {
  for (j = i; j < n; j *= 2) {
    // 5 assignment instructions
  }
}
```

2.4

```
for(int i = 1; i <= n; i++) {
  for(int j=1; j <= n; j*=2) {
    // 3 assignments
  }
}
```

Problem 3 [3 points]

3.1 [1 point, 0.5 each] What are the **big-θ** notations for the following functions?

(1) $4n^3 + 3n^2 + 2n - 5$

(2) $n \log n + 3n - 15$

3.2 [2 point, 0.5 each] What are the **big-O** notations for the following functions?

(1) $n^3 \log(3n) + 2n^4 + 3n^2 + 127$

(2) $\sqrt{2n} + 30 \log(4n)^2 + 27n - 3$

(3) $(n+1)! + 2^n$

(4) $\sqrt[3]{n^2} + 3n \log^2(2n) + 4n^{\frac{6}{7}}$