PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Department of Computer Engineering

Final Examination: Semester 1 **Academic Year**: 2015-2016

Date: 11th December 2015 **Time**: 13:30 – **16:30 (3 hours)**

Subject Number: 242-535 **Room**: R201

Subject Title: Algorithm Design and Analysis (ADA)

Lecturer: Aj. Andrew Davison

Exam Duration: 3 hours **Total**: 180 points

This paper has 6 questions, on 4 pages.

Authorized Materials:

- Writing instruments (e.g. pens, pencils).
- Books (e.g. dictionaries) and calculators are **not** permitted.

Instructions to Students:

- *Answer questions in English.* Perfect English is **not** required.
- Attempt all questions.
- Write your answers in an answer book.
- Start your answer to each question on a new page
- Clearly number your answers.
- Any unreadable parts will be considered wrong.
- When writing programs, use good layout, and short comments; marks will not be deducted for minor syntax errors.
- The marks for each part of a question are given in brackets (...).

Question 1

(30 minutes; 30 marks)

Use a divide-and-conquer algorithm to convert a binary search tree into a sorted double-linked list without creating any new nodes. You are allowed to change the links between nodes.

For example, after changing the links in the binary search tree in Figure 1 (a), the result is the sorted double-linked list in Figure 1 (b).

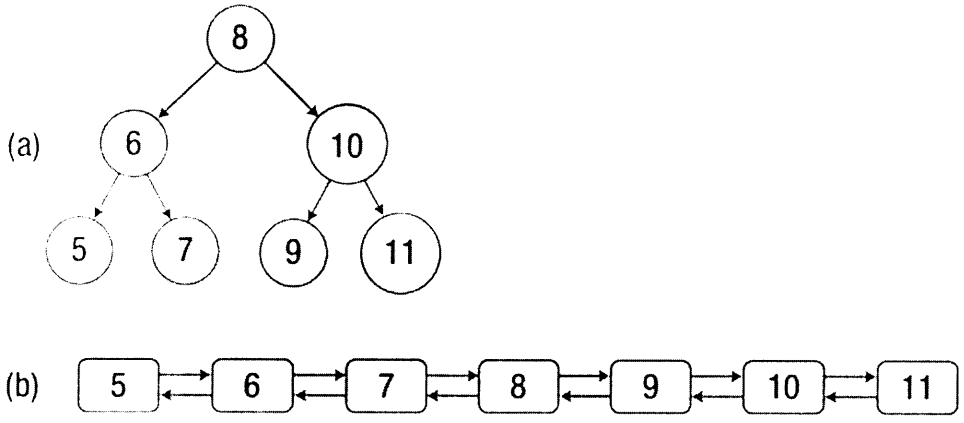


Figure 1. A binary search tree and its converted sorted double-linked list.

Assume the tree only stores positive integers.

Assume the existence of a `BST` class with suitable methods for accessing and changing left and right subtrees. Do **not** implement `BST`, but explain how you use it.

Make sure you explain in words how your algorithm employs divide-and-conquer.

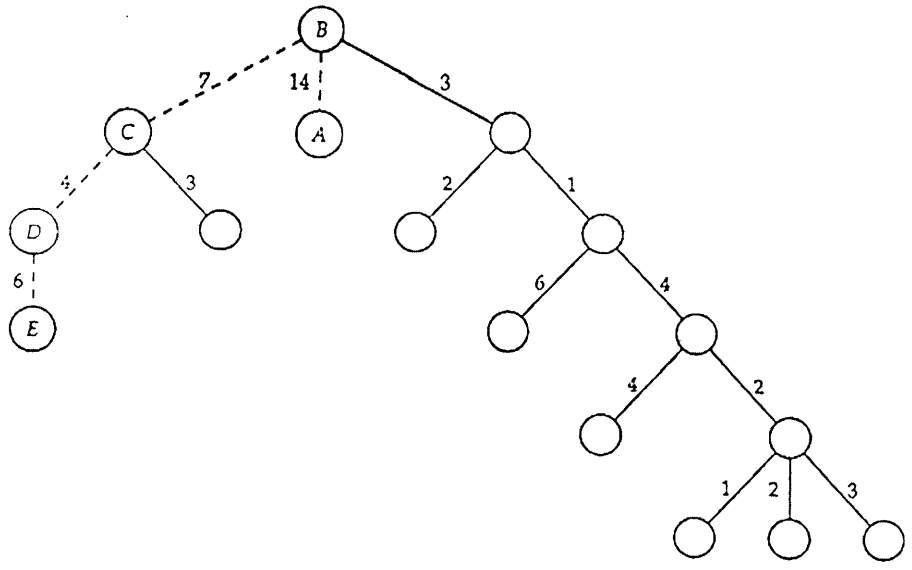
Question 2

(40 minutes; 40 marks)

a) Describe in words the main features and differences between depth-first and breadth-first search. Do not include any code, but use diagrams in your explanation. (10)

b) Write a function for calculating the maximum distance between two nodes in a tree. This distance is often called the **tree diameter**. (20)

For example, your `treeDiameter()` function would return 31 for the tree below. This is the distance between nodes A and E, via the path drawn using dashed lines:



Your `treeDiameter()` function should utilize a `TreeNode` class which stores a list of the edges going to its child nodes. An `Edge` object stores a `TreeNode` and the length of the edge to that node. Do **not** implement `TreeNode` or `Edge`, but explain how they are used in your `treeDiameter()` function.

Hint: your function will need to manipulate tree diameter *and* tree height.

c) Briefly explain the big-Oh running time for your `treeDiameter()` function. (10)

Question 3

(15 minutes; 15 marks)

Write a function which prints all the permutations of a given string. For example, the input string "abc" causes the printing of "abc", "acb", "bac", "bca", "cab", and "cba".

Draw a diagram showing the execution steps of your function when the input is "abc".

Question 4

(45 minutes; 45 marks)

a) Describe in words the main features of dynamic programming. (10)

b) Implement an efficient function that calculates the minimum number of coins with values $v_1, v_2, \ldots, v_n$, to make change equal to money with value t. (20)

For example, the minimum number of coins to make change for t == 15 out of a set of coins with values 1, 3, 9, and 10 is **3** (9 + 3 + 3).

Make sure to explain the algorithm used by your function in full detail. In particular, explain in words why it is 'efficient'.

c) Draw a table for the example above showing how subproblems are solved. (15)

Question 5

(30 minutes; 30 marks)

The table below shows the network links between the computers in the "Land of Oz" LAN, together with average times in milliseconds to send a message from the machine in the first column to the machine in the second column. For example, the first row says that it takes 5 ms to send a message from "dorothy" to "tinman".

From Machine	To Machine	Message Time
dorothy	tinman	5
dorothy	scarecrow	9
tinman	lion	9
tinman	glinda	8
tinman	wizard	11
scarecrow	glinda	8
scarecrow	wizard	7
glinda	toto	9
lion	toto	4

a) Draw a directed graph representing the table. The nodes must be the machines, and the arcs are the message communication links from one machine to another. Label each arc with its message sending time. (10)

b) Use Dijkstra's shortest path algorithm on the graph from part (a). Use "dorothy" as the start node. Find the shortest time to send a message from "dorothy" to "toto". **Show all your working;** do not only write down the time. (20)

Question 6

(20 minutes; 20 marks)

A universal sink in a directed graph G is a vertex with an in-degree of |V|-1 and out-degree of 0. (|V| is the number of vertices in the graph.)

Show that determining whether G contains a universal sink can be determined in O(V) time by using an adjacency matrix for G.

Write pseudo-code for this problem. Make sure to explain your big-Oh calculations.

--- End of Examination ---