Object Oriented Programming with Java

Todd Davies

April 3, 2014

Introduction

This course continues from COMP16121, using the same book 'Java Just in Time' plus some additional material.

Aims

Building on COMP16121, this course unit continues the theme of Object Oriented Design and Programming. The remaining core features of the language will be covered and some library packages will be introduced. Design principles for human-computer interfaces will also be taught.

Program design will be addressed by the use of a number of case studies in which larger programs will be developed from informal requirements expressed in English and this development will include the process identifying objects, classes and methods.

A practical introduction to team-working will be achieved through the mini- project that runs throughout the course unit.

The syllabus includes:

- Inheritance, polymorphism and collections
- GUIs
- Recursion and recursive datatypes
- Principles of HCI
- Advanced case studies

Contents

Ordered Binary Trees

Binary Trees

Ordered binary trees, also called *sorted binary trees* or *search trees* are a data structure commonly used in computer science.

First, let us define some terminology we can use throughout this section:

Node
: An Object containing data that has zero, one or two links to other nodes.

Root node
: The node at the top of the tree.

Child nodes
: Any node can have a left and/or right child, these are linked to the current node.

Empty node
: A node with no children, sometimes called a leaf of the tree.

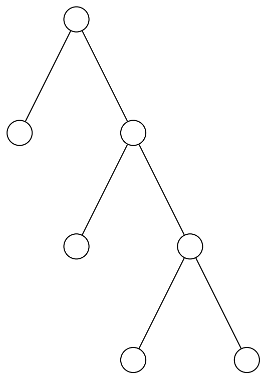
Tree depth
: The maximum number of levels in the tree. A tree with no nodes has a depth of 0.

Singleton tree
: A tree with only one node. It has a depth of one.

Note:

Note that if a node is not empty (i.e. it has one or more children), it will *always* have a left and a right child, even if one of them is null.

Here is an example of a binary tree:



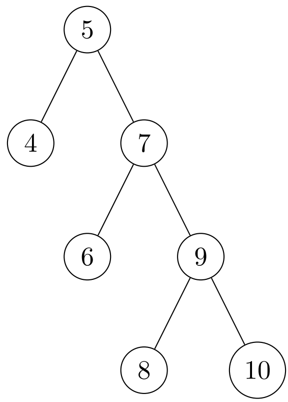
Ordering the trees

However, up to now, we've only looked at trees of generic objects, but when you're applying trees to real problems, it's often a requirement to have some sort of ordering. To make things easy, we'll populate our tree with natural numbers, since they are easy to order, but remember that any object that can be ordered will do.

Note:

In Java, any object that can be ordered usually means an Object that implements the `Comparable` interface.

An ordered binary tree with the same structure as the one above, but with actual data might look like this:



The data in the tree is the integers from 4 through until 10 (they don't need to be consecutive as in this example though!).

Why are OBT's useful?

Ordered Binary Trees are so commonly used because they can be traversed and searched relatively quickly, especially when compared to a list. In order to find an item in an OBT, you only ever need to do at most n operations, where n is the depth of the tree, while with a list, you may need to go through the whole list before you find the correct item.

Since OBT's are, by definition, sorted, you can use them to sort lists of objects. If you insert an unordered list of objects into the tree, then when you've finished inserting, all you need to do it read off the objects from left to right and you'll get the sorted list.

Balancing trees

A *balanced* tree is one where there is a difference of one between the number of items on the left of the tree and the number of items on the right. Any tree can be manipulated so that it is in this form, which is good since it makes searching the tree a lot faster.

A tree is said to be **fully** *balanced* if there are an equal number of nodes on the left and the right of the tree. This can only happen if the number of items in the tree is $2^x - 1$ for some x. If the tree is fully balanced, then it's depth will always be $log_2(N + 1)$ where N is the number of items in the tree.

> Note:
>
> The structure of a tree often depends on the order in which the items were inserted. For example, if they are inserted in ascending order, then the tree will have its maximum depth, and basically just be a `LinkedList`

.

Implementing ordered binary trees

Trees are, by their definition, recursive data structures. If you take any sub tree from within a tree, then it is also a tree in it's own right. That means that operations on trees are often implemented using recursion.