CSCI 136:
Data Structures
and
Advanced Programming

Lecture 25

Trees, part 3

Instructor: Dan Barowy

Williams

Topics

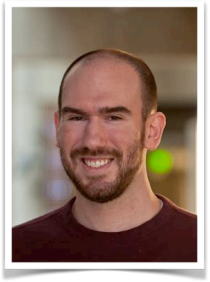
Binary tree traversals

Binary search trees

Your to-dos

1. Read **before Mon**: *Bailey*, Ch. 15-15.3.
2. Lab 8 (solo lab), **due Tuesday 4/26 by 10pm**.

Announcements



CS Colloquium
Friday, April 22
2:35pm in Wege

Crowdsourcing with Video Games
Seth Cooper (Northeastern University)

People and computers working together can solve problems neither could solve alone. To support this, video games provide a compelling approach: they are a natural space for problem solving and can foster the engagement necessary for people to make a contribution. Games have been used in this way to crowdsource approaches to protein design, software verification, and activity recognition. In this talk I will discuss a variety of approaches to making games that crowdsource the solution to problems, using image classification as a common application.

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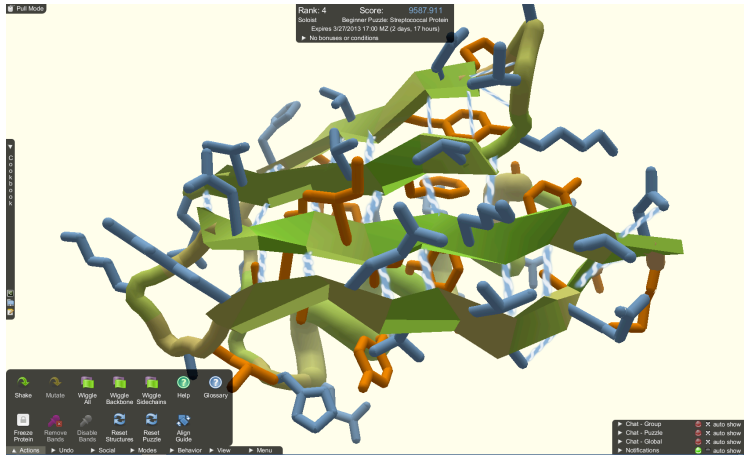


FoldIt!

Announcements

Spring pre-registration begins Wed, April 27 and runs until Fri, May 6.

The best way to get into the CS course you want is to **pre-register**.

Common "next steps" after CSCI 136:

CSCI 237: Computer Organization
CSCI 256: Algorithms
CSCI 334: Principles of Programming Languages

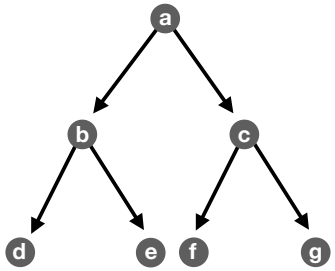
also, some electives.

Quiz

Binary tree traversals

Binary tree traversals

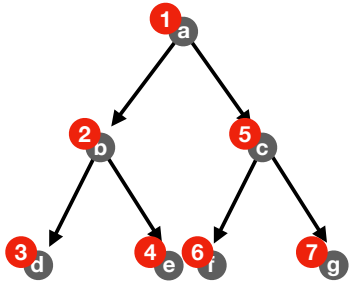
Suppose you are asked to write an `Iterator<T>` for a binary tree. What order do you choose?



Remember that tree nodes store data (`T`). A **traversal** corresponds with the order that data is returned.

Binary tree traversals

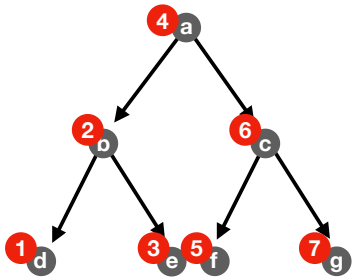
Pre-order traversal: Return data from each node **before its children**, and then return child data from **left to right**.



Returns the sequence: **a, b, d, e, c, f, g**

Binary tree traversals

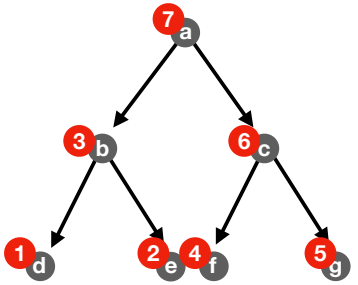
In-order traversal: Return data from each node **after its left child** and **before its right child**.



Returns the sequence: **d, b, e, a, f, c, g**

Binary tree traversals

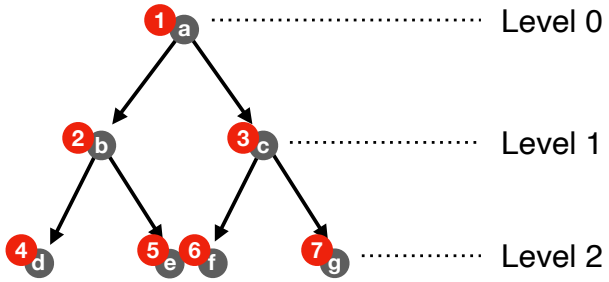
Post-order traversal: Return data from each node **after its children**; return child data from **left to right**.



Returns the sequence: **d, e, b, f, g, c, a**

Binary tree traversals

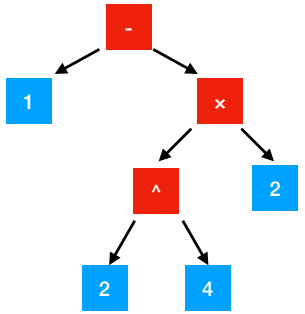
Level-order traversal (aka **breadth-first order**): Return data from each node in **level *i*** before data in **level *i+1***.



Returns the sequence: **a, b, c, d, e, f, g**

What traversal should I use?

Suppose I encode the arithmetic expression $1 - 2^4 \times 2$ using the following tree and want to "evaluate" it.



Ordered Trees

Binary search tree

A **binary search tree** is a binary tree that maintains the **binary search property** as elements are added or removed. In other words, the **key** in each node:

- must be ≥ any **key** stored in the left subtree, and
- must be ≤ any **key** stored in the right subtree.

As with other ordered structures, order is maintained **on insertion.**

Key, Value nodes

Note that I said **key** instead of **element**.

Storing a **key** and a **value** in each node allows the greatest flexibility when arranging a tree. I.e., the key type `K` need not be the value type `V`.

Restriction: keys must be **comparable** in some way (e.g., `Comparable<K>` or `Comparator<K>`).

Example

Insert the following elements: `71,20,27,17,91,14,87`

Assume `K` and `V` are the same.

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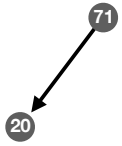

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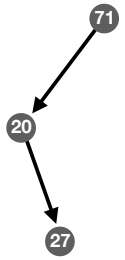

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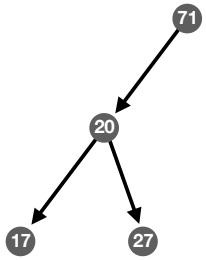

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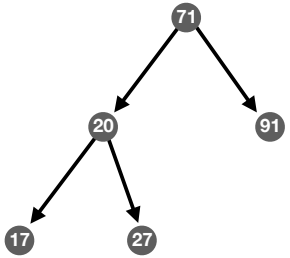

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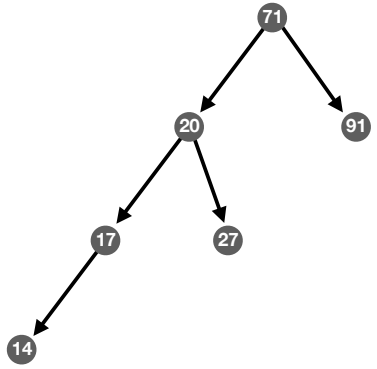

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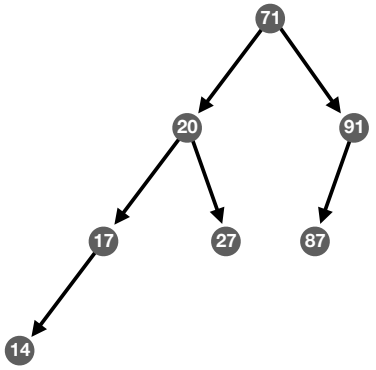

Binary Search Tree

Let's implement this together.

Recap & Next Class

Today:

Binary tree traversals

Binary search trees

Next class:

Tree balance

Asymptotic analysis