CS 225

Data Structures

October 4 – BST Remove

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MP Redo

- There will be two redos of MPs this semester. The redo will be done one the code in your repo on the last day of class December 8^{th}. The redo will change you grade to the following.

Max(old_grade, .90 * new_grade)

Honors Section

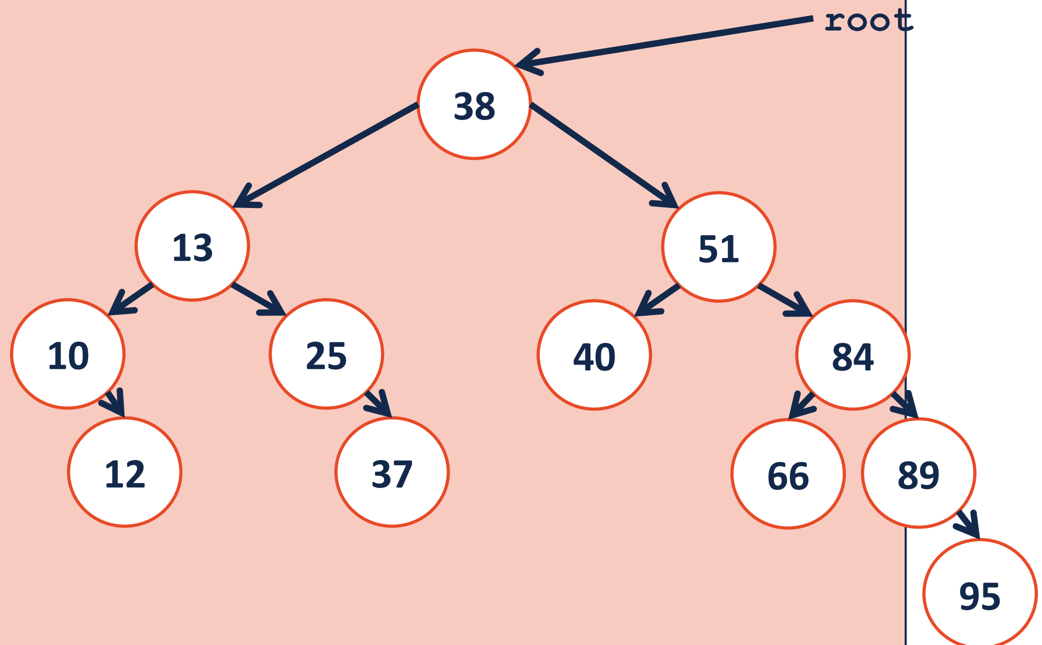
Functional Data Structures in Clojure

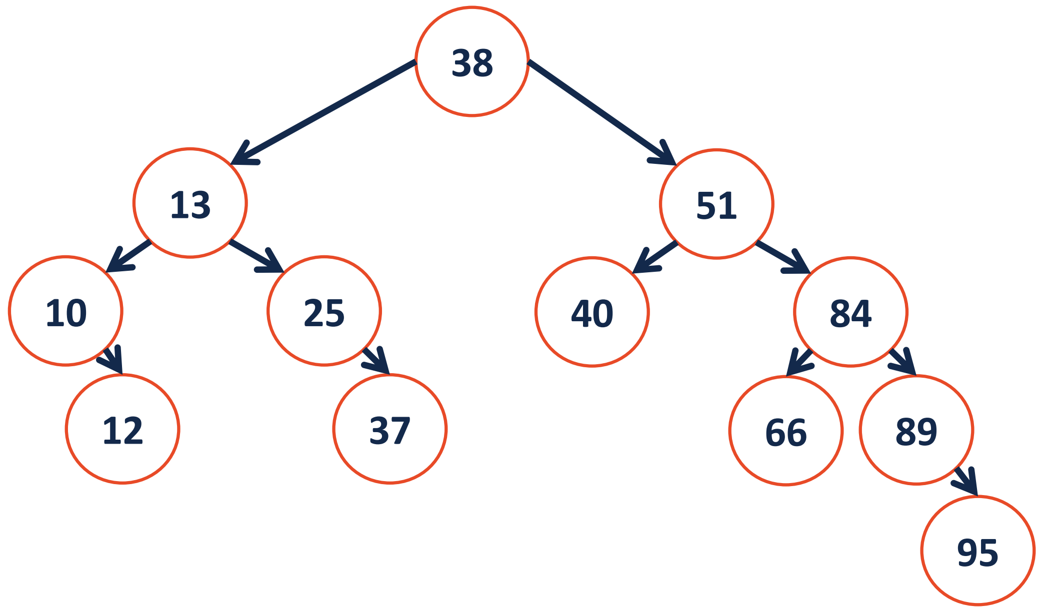
- Website https://uiuc-cs199-225-fa21.netlify.app/

- Tonight, is the first lecture for the honors section zoom info

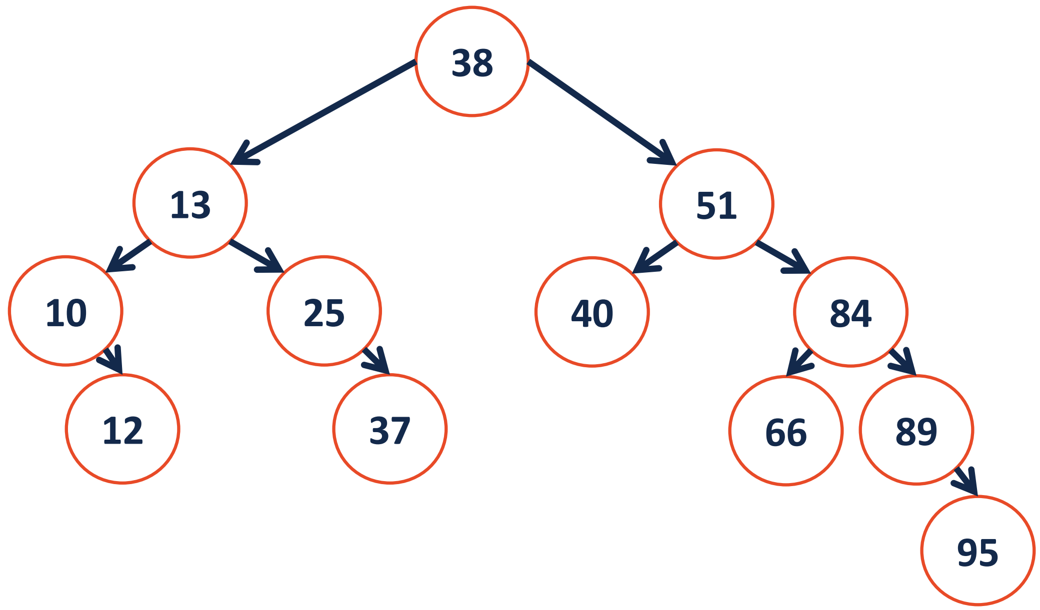
https://uiuc-cs199-225-fa21.netlify.app/docs/

```
template<typename K, typename V>
________________________ _remove(TreeNode *& root, const K & key) {
}
```

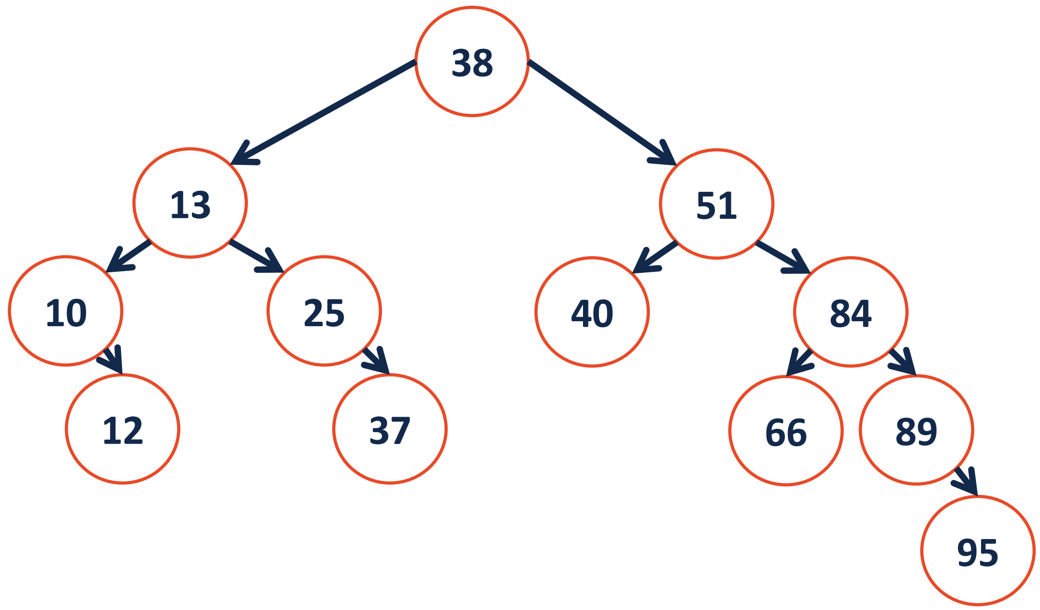




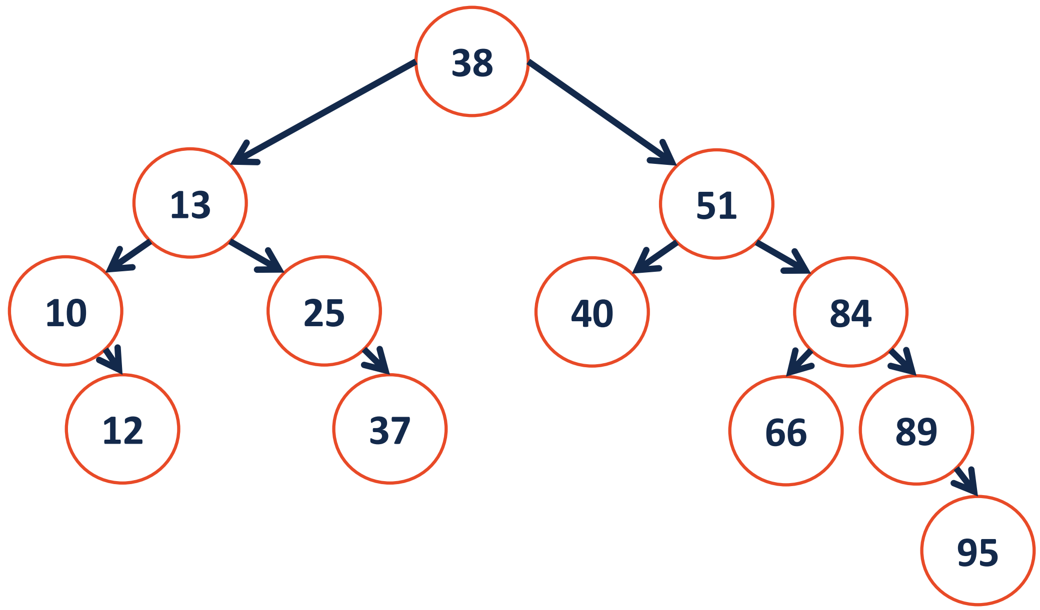

```
remove(40);
```




```
remove(25);
```




```
remove(10);
```




```
remove(13);
```

BST Analysis – Running Time

Operation	BST Worst Case
find	
insert	
delete	
traverse	

BST Analysis

Every operation that we have studied on a BST depends on the height of the tree: **O(h)**.

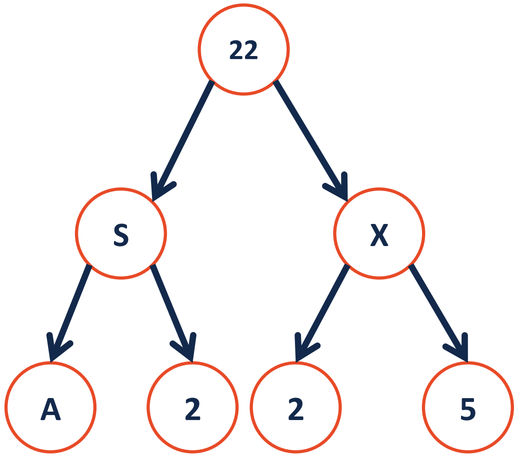
…what is this in terms of **n**, the amount of data?

We need a relationship between **h** and **n**:

$$f(h) \leq n \leq g(h)$$

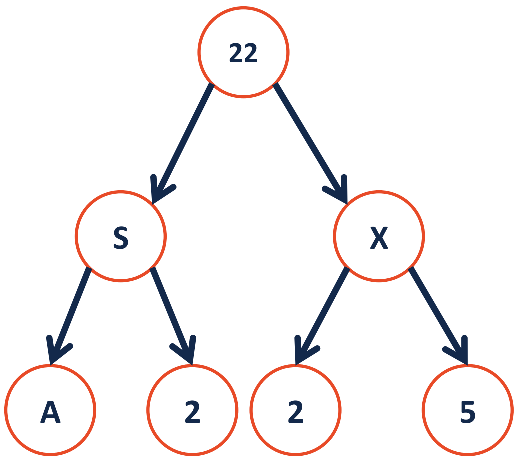
BST Analysis

Q: What is the maximum number of nodes in a tree of height **h**?



BST Analysis

Q: What is the minimum number of nodes in a tree of height **h**?



What is the maximum height for a tree of **n** nodes?

BST Analysis

Therefore, for all BST:

Lower bound:

U**pper bound:**

BST Analysis

The height of a BST depends on the order in which the data is inserted into it.

ex: 1 3 2 4 5 7 6 vs. 4 2 3 6 7 1 5

Q: How many different ways are there to insert keys into a BST?

Q: What is the average height of all the arrangements?

BST Analysis

Q: How many different ways are there to insert keys into a BST?

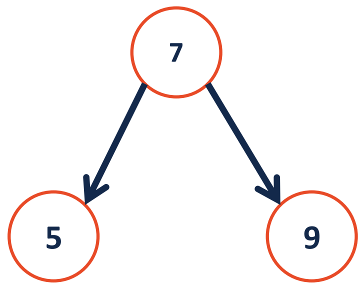
Q: What is the average height of all the arrangements?

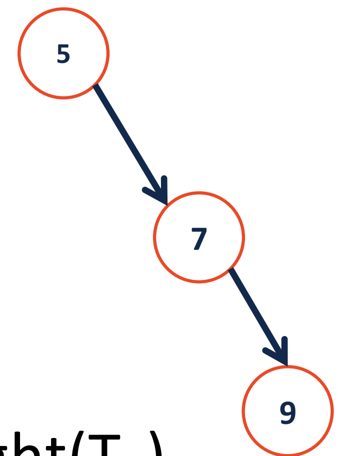
BST Analysis – Running Time

Operation	BST Average case	BST Worst case	Sorted array	Sorted List
find				
insert				
delete				
traverse				

Height-Balanced Tree

What tree makes you happier?





Height balance: $b = \text{height}(T_L) - \text{height}(T_R)$

A tree is height balanced if: