LECTURE 20

BINARY SEARCH TREES

MCS 275 Spring 2021

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LECTURE 20: BINARY SEARCH TREES

Course bulletins:

- Project 2 due 6pm CST today.
- Starting on worksheet 8, problem 1 will have special instructions.
  - Tue discussion: Problem 1 will be presented as an example.
  - Thu discussion: Please do problem 1 ahead of time.

SAMPLE CODE

I've created a new directory trees in the course sample code repository.

Live coding examples from the next couple of lectures will be added there.

GOAL

Learn about **search** and **insert** operations on binary search trees.

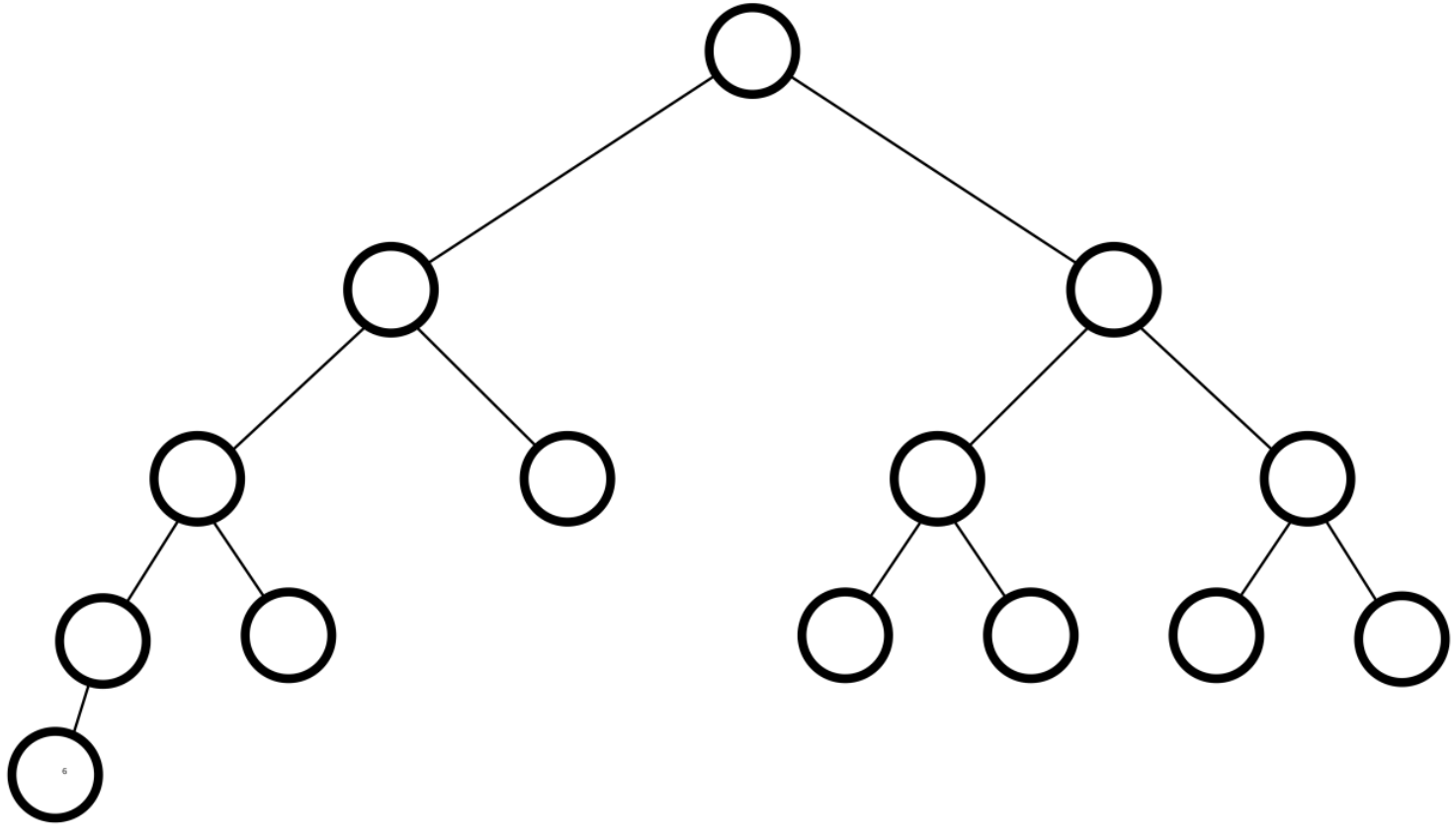
Explore an application to a fast data structure for storing a set of integers.

BINARY SEARCH TREE (BST)

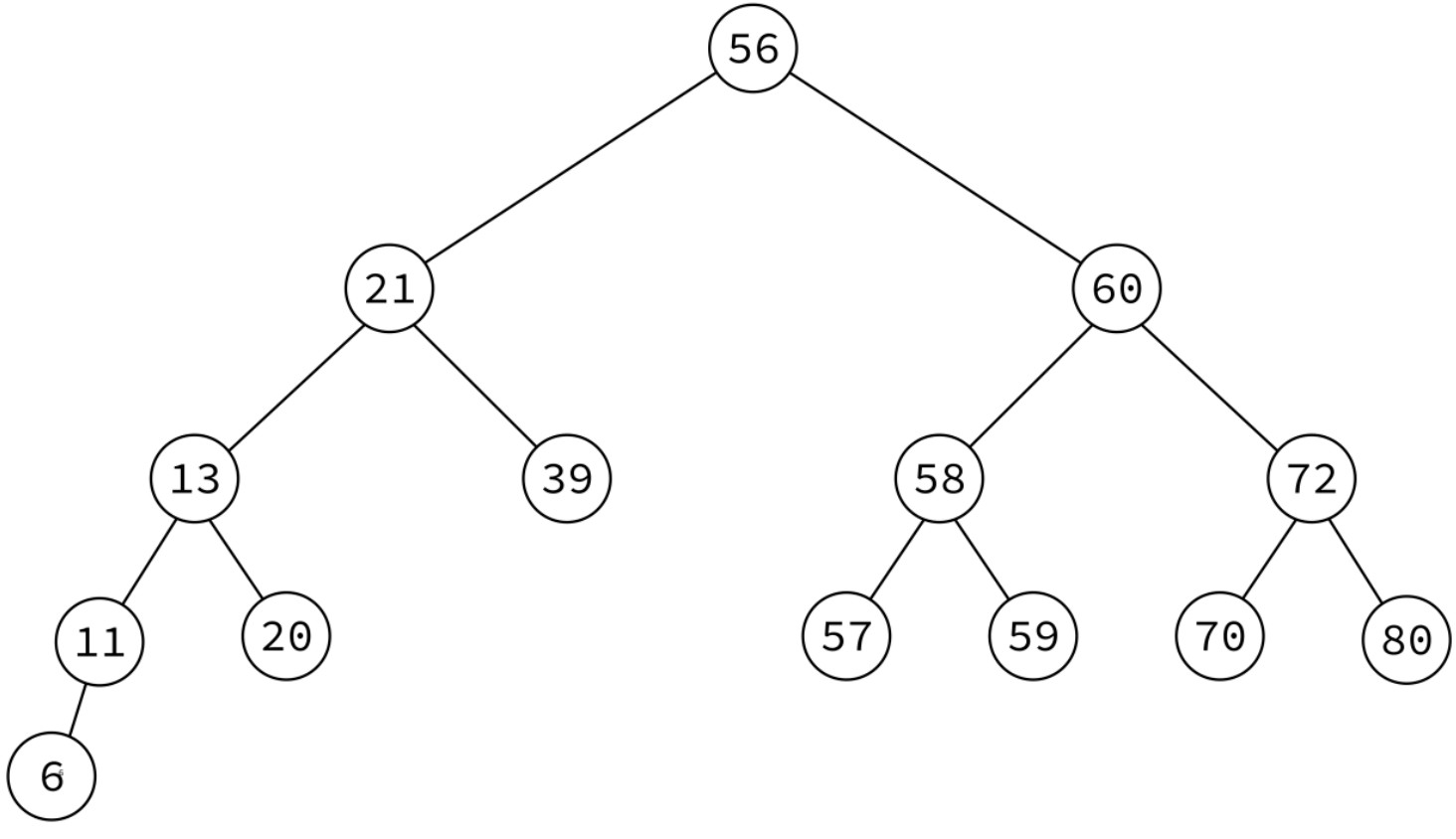
A binary tree in which:

- Nodes have **keys** that can be compared
- The key of a node is greater than or equal to any key in its left subtree.
- The key of a node is less than or equal to any key in its right subtree.

BINARY TREE



BST



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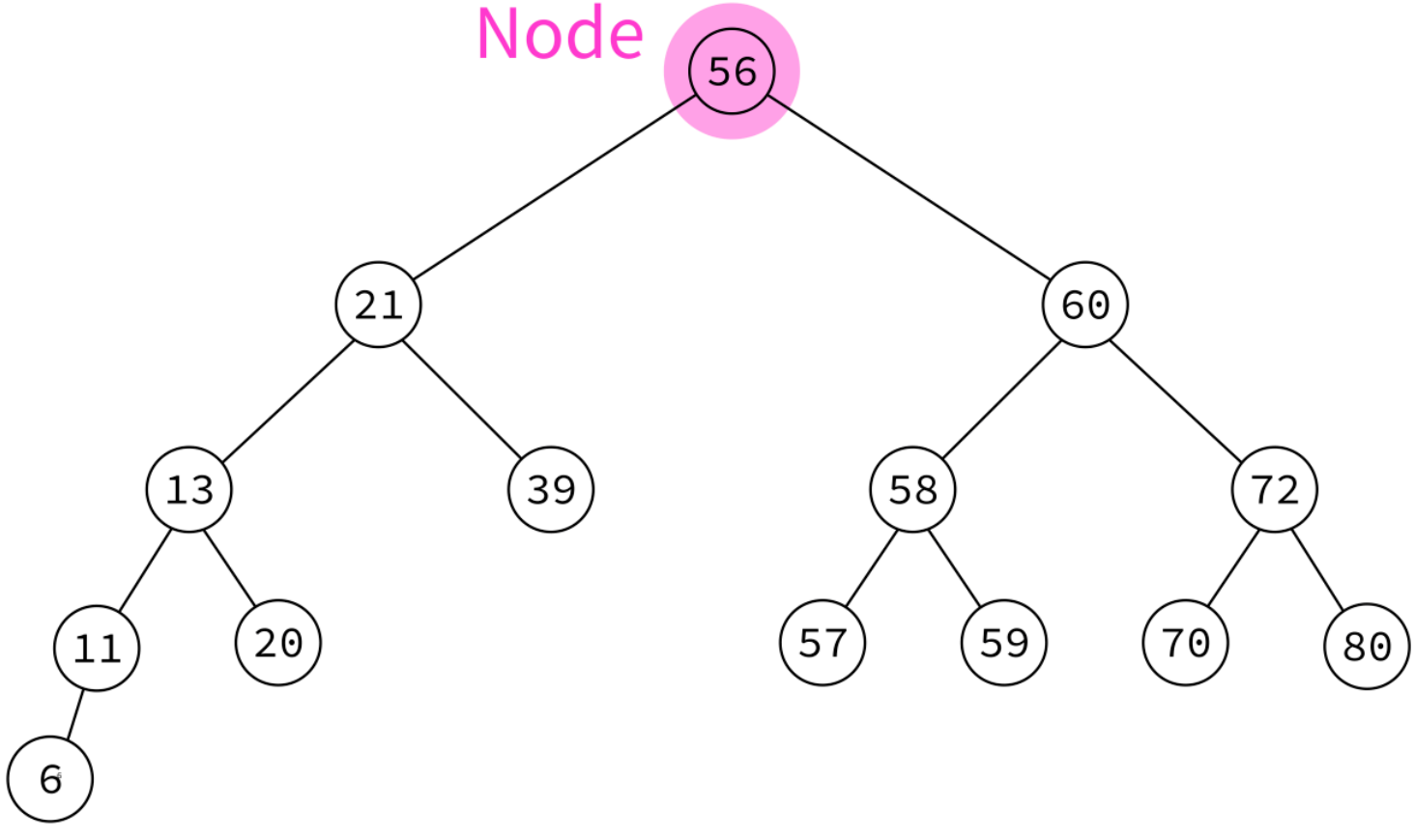

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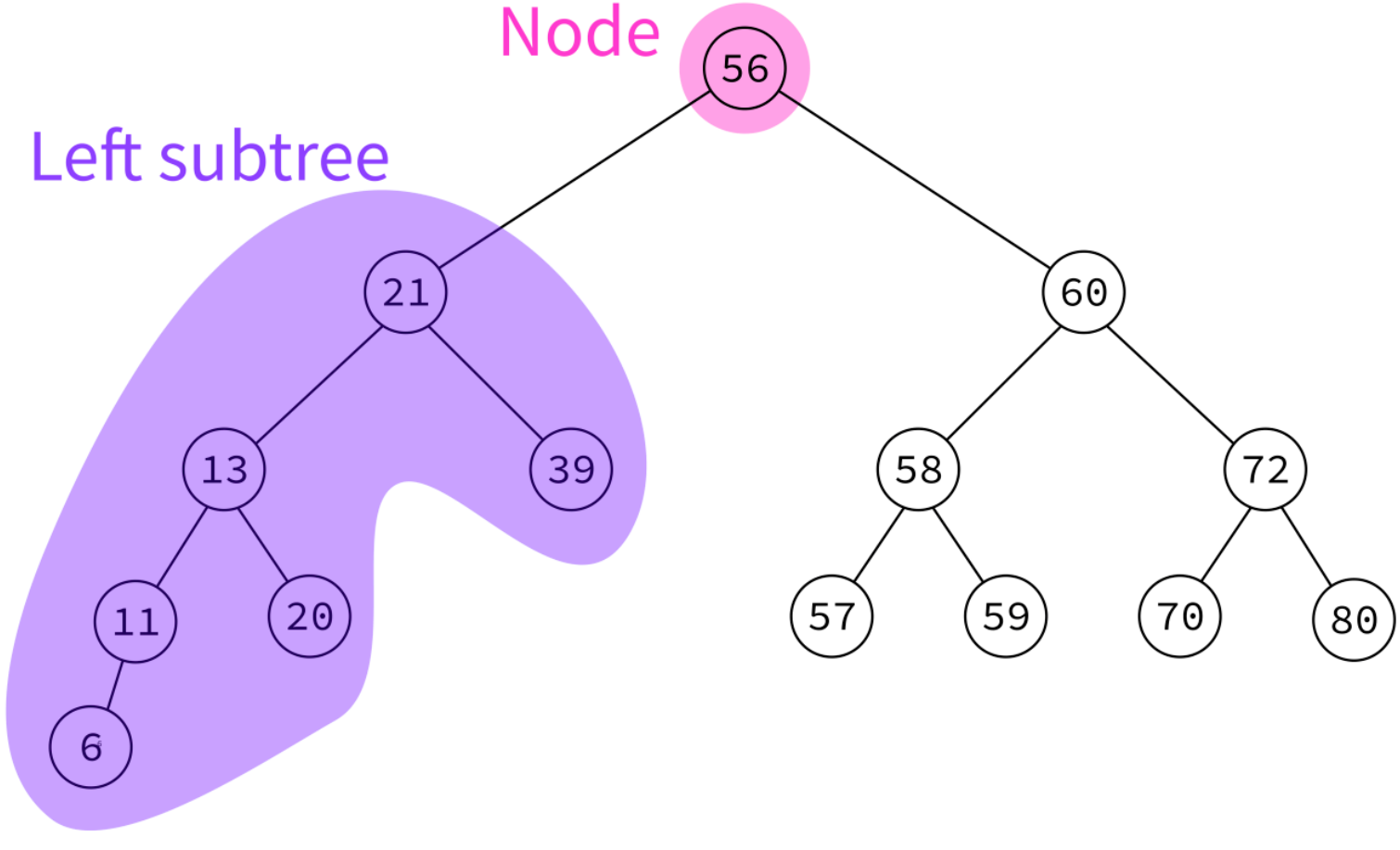

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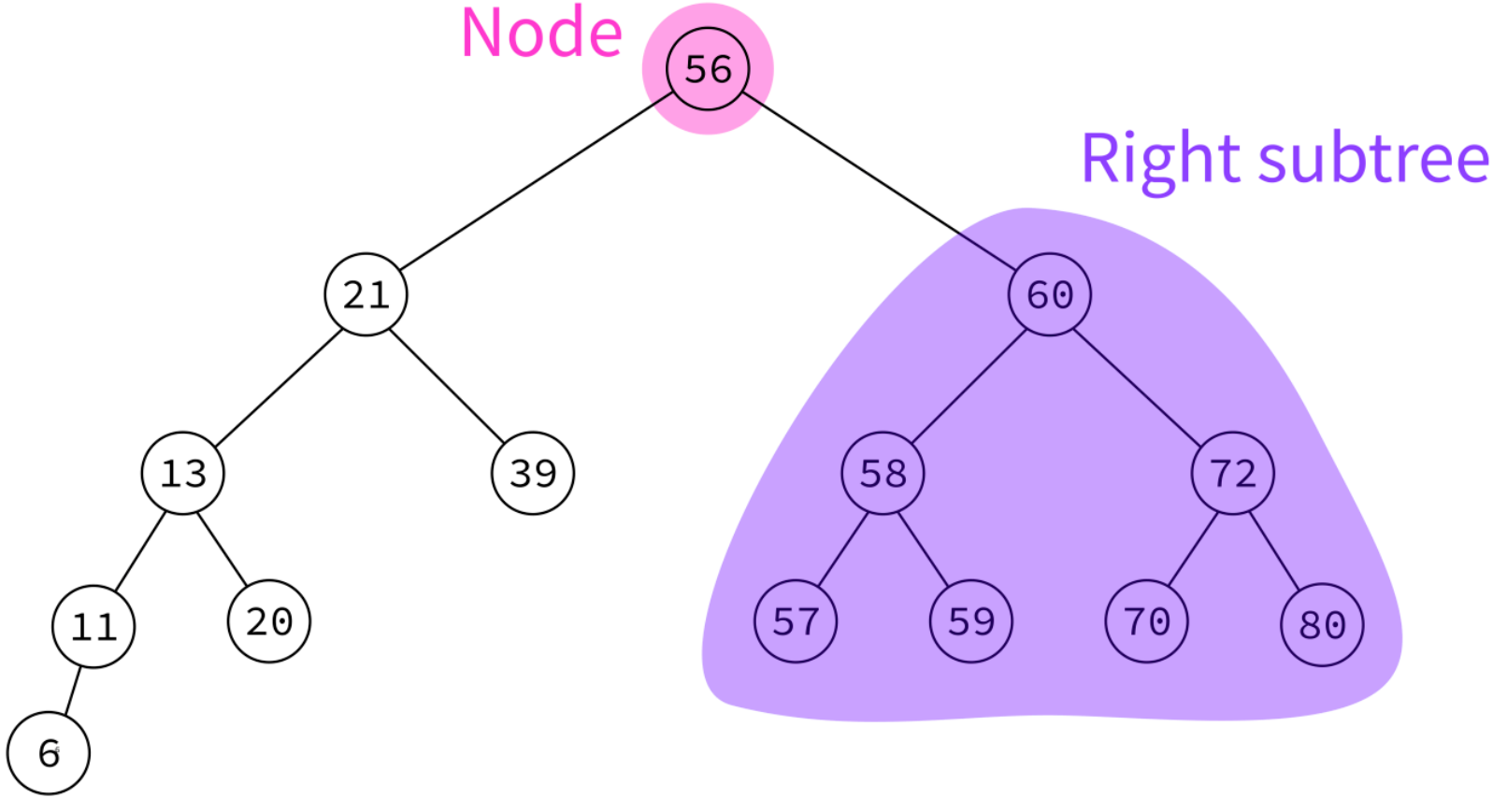

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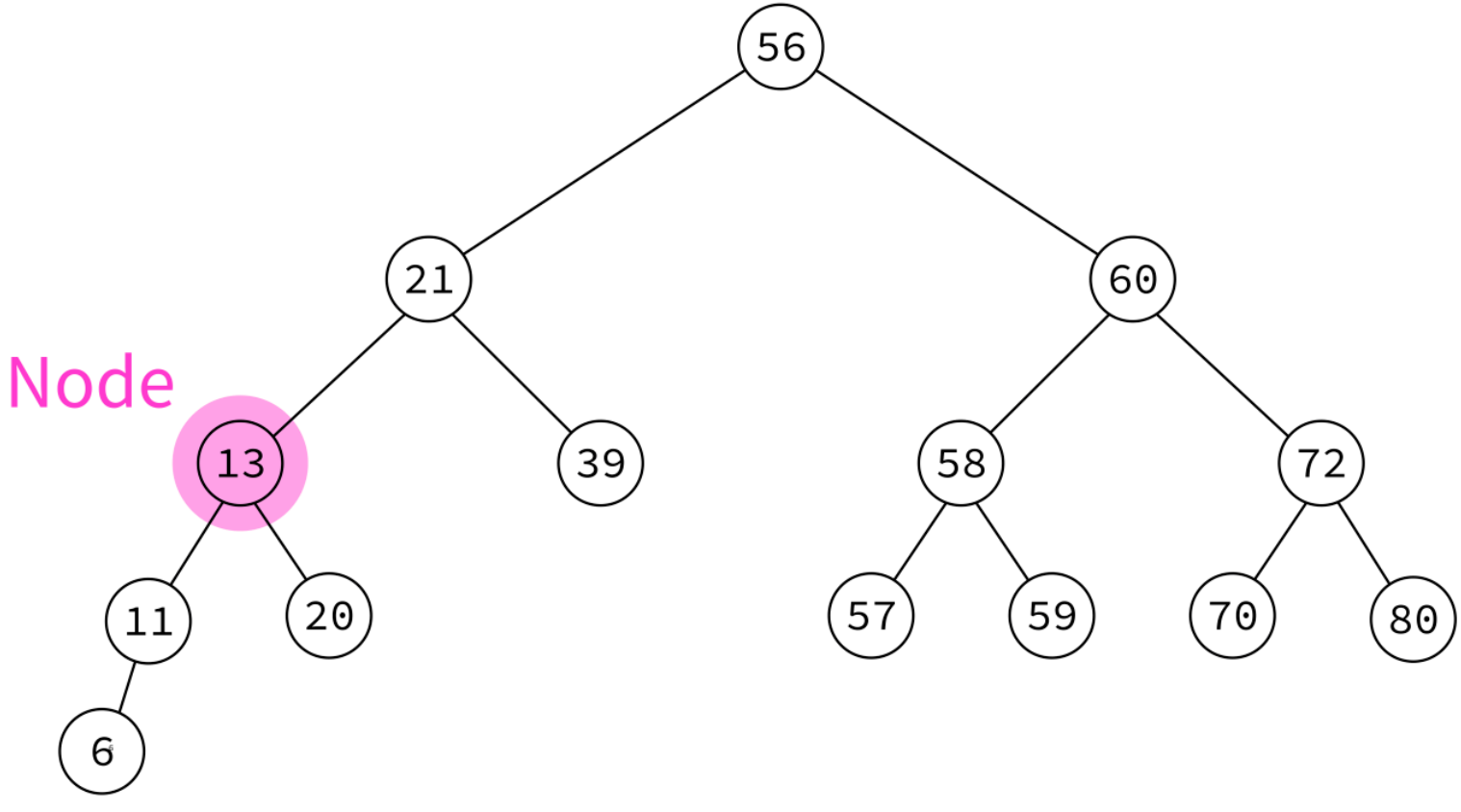

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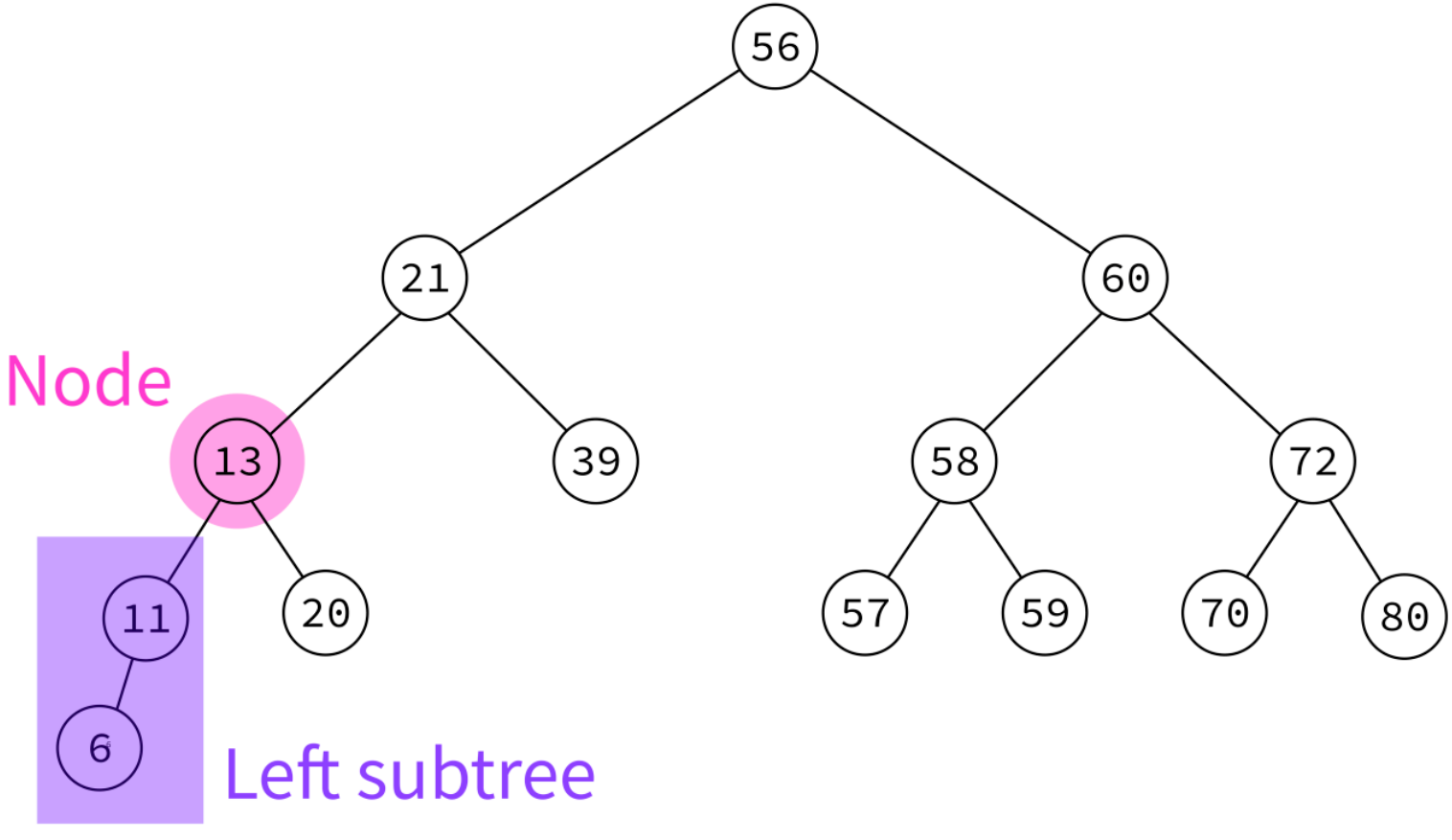

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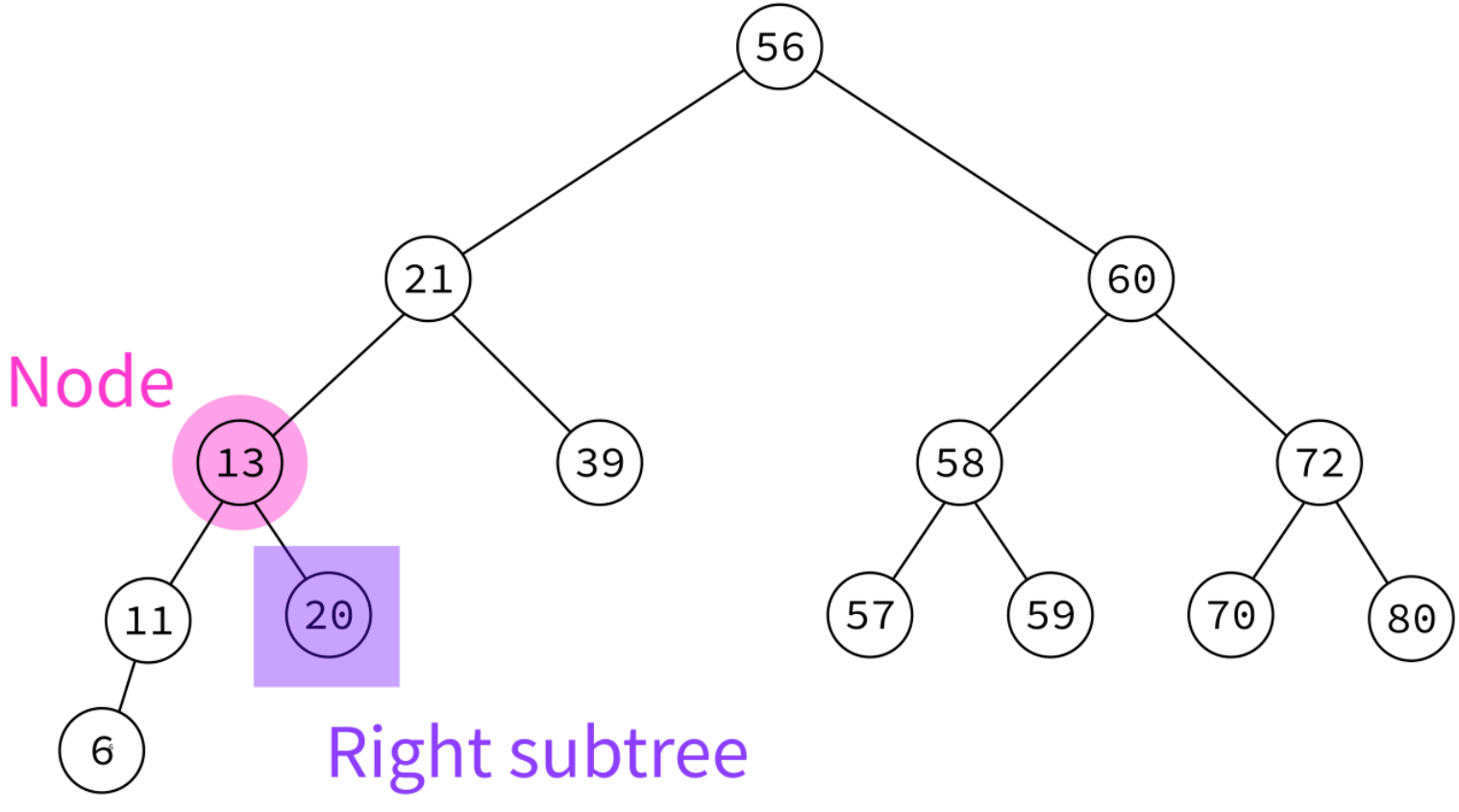
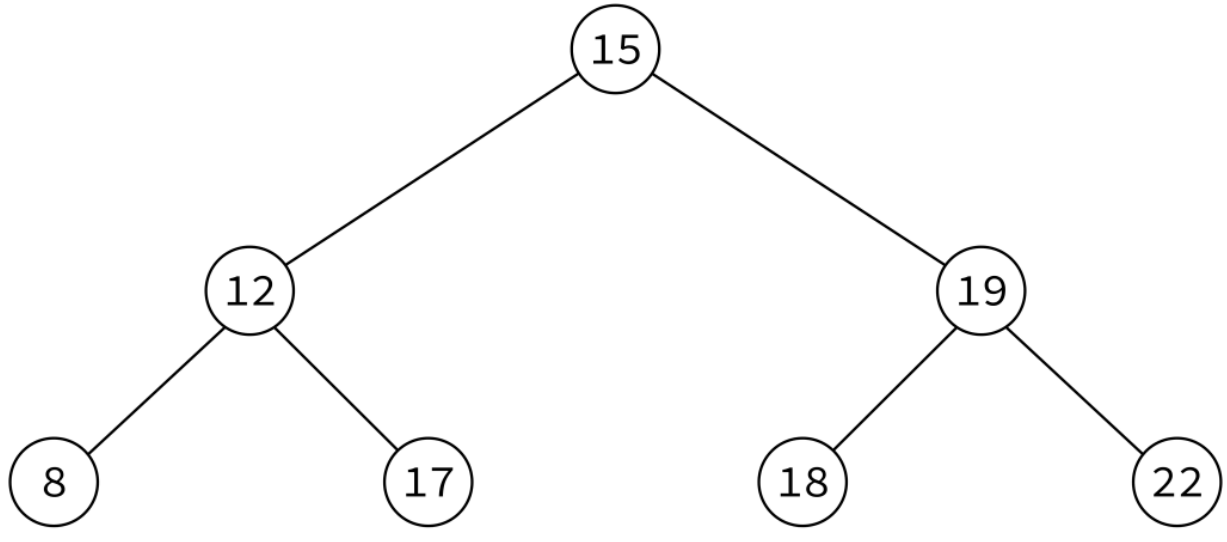


NOT A BST



This "just" is a binary tree with keys.

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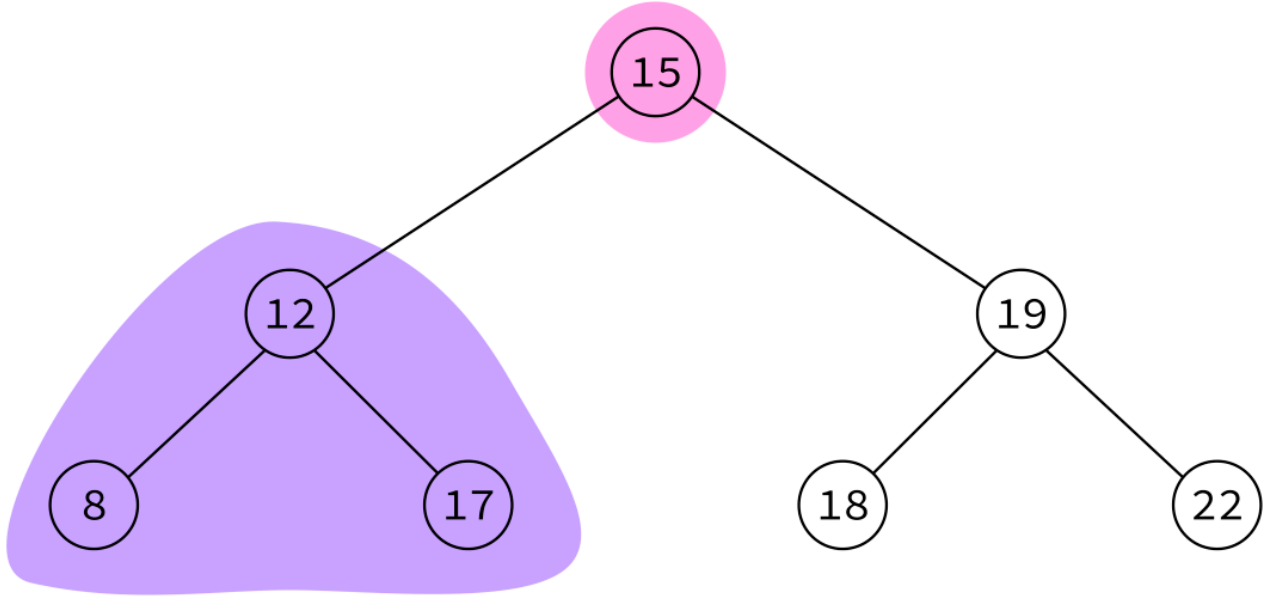

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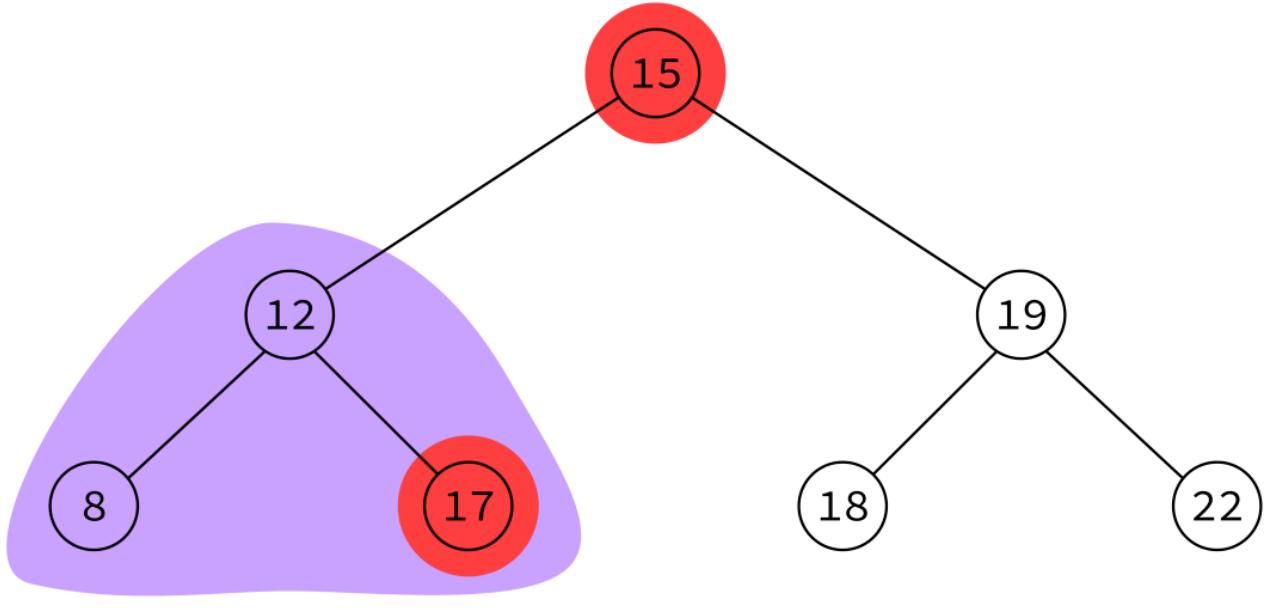

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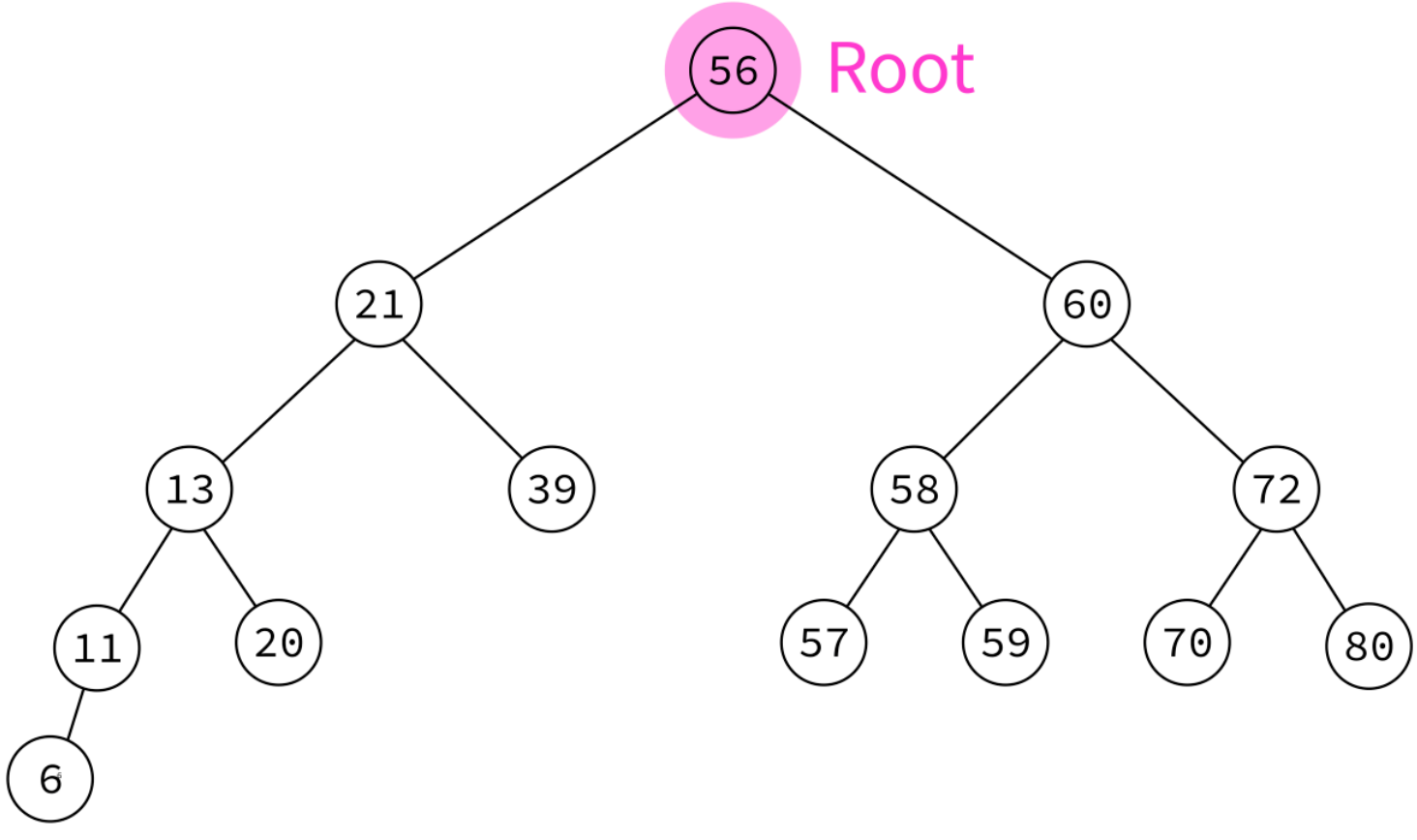
TREE TERMS



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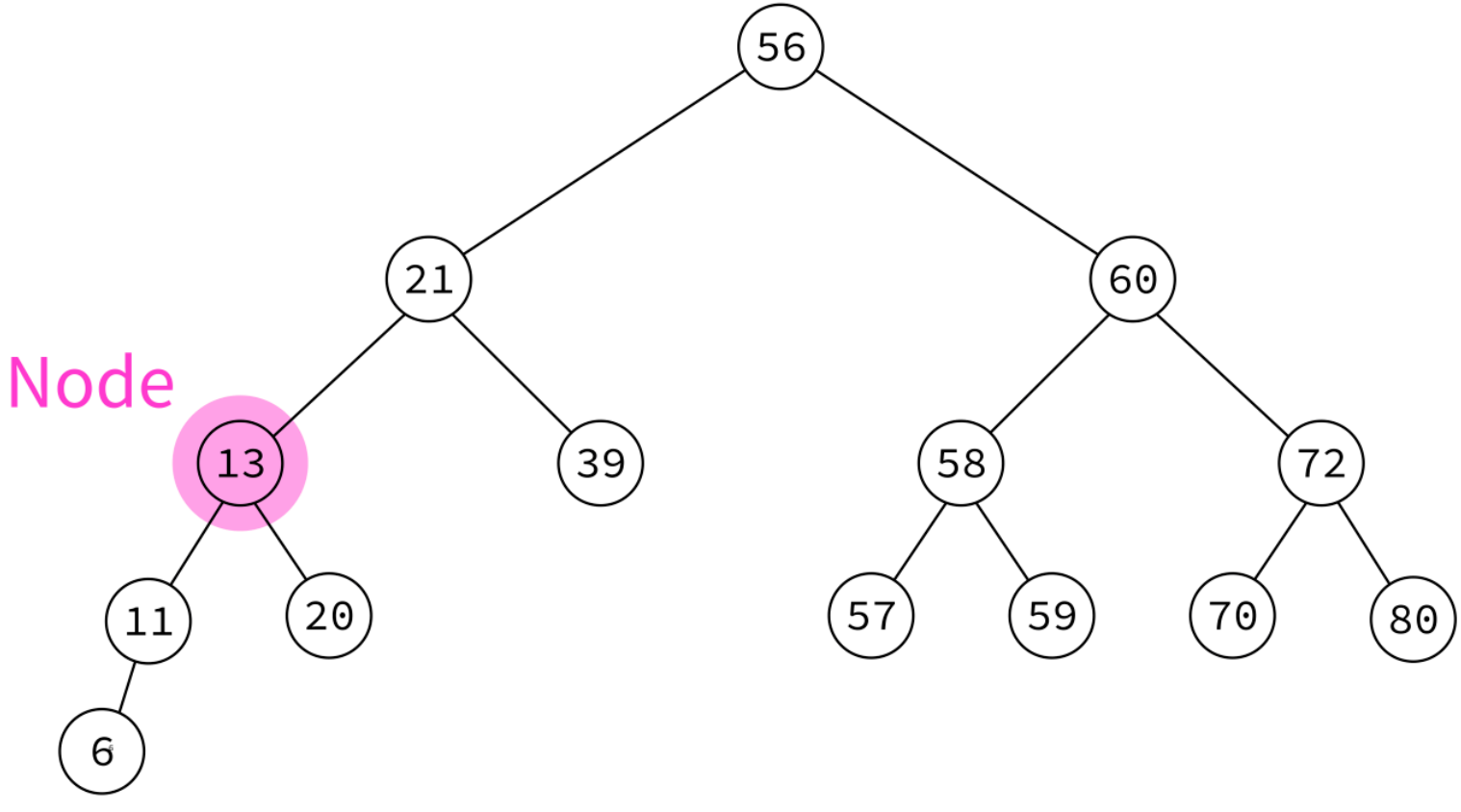

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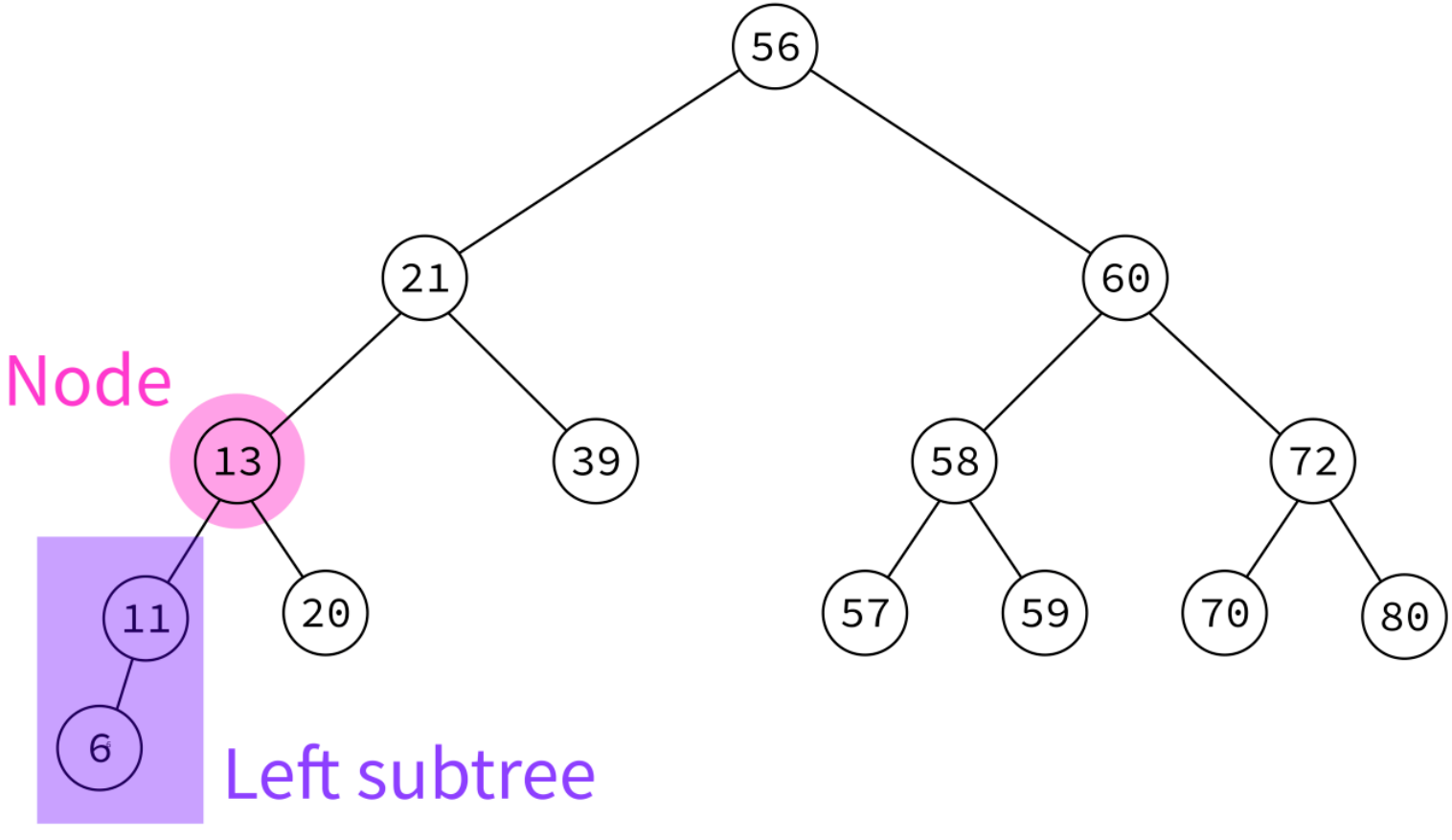

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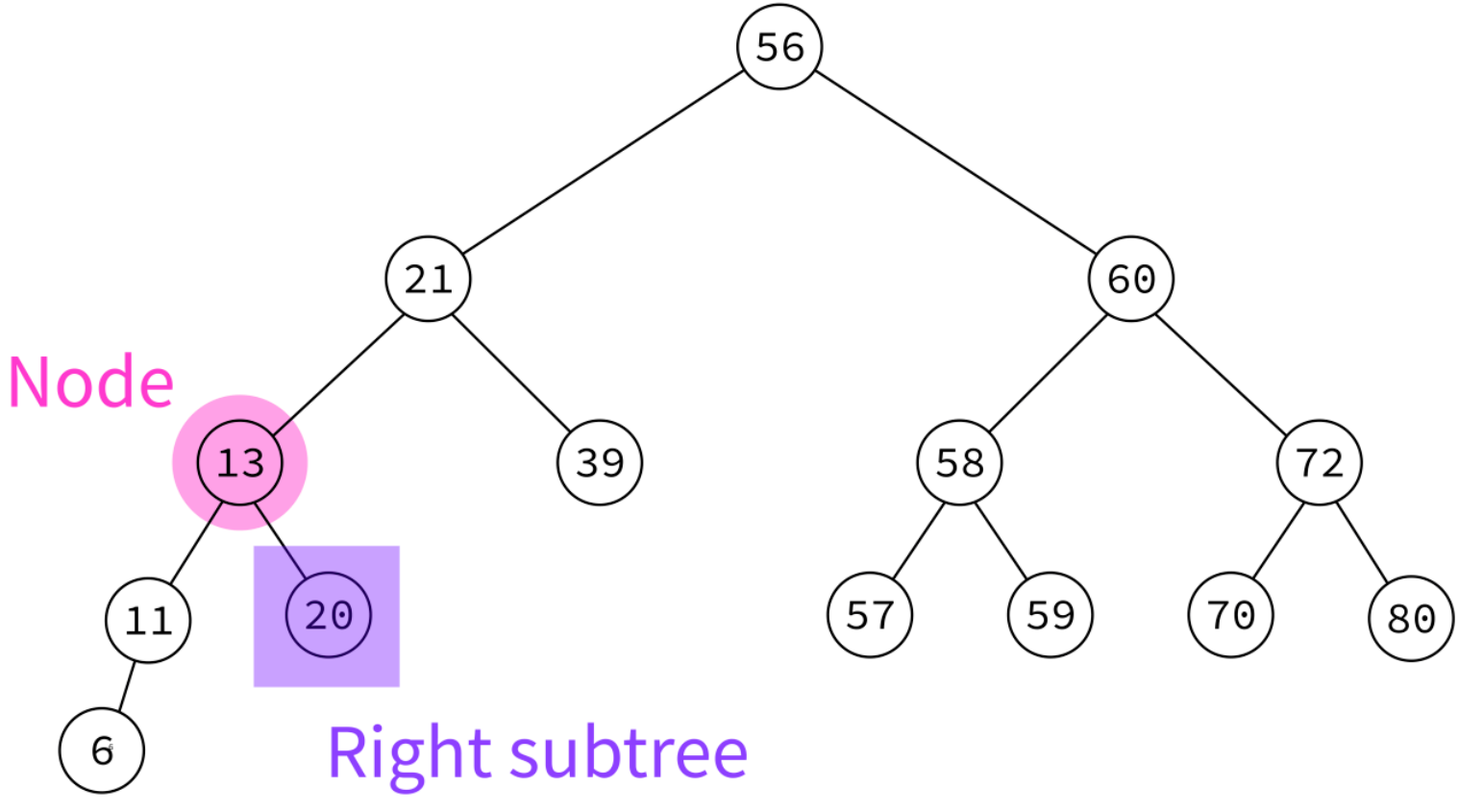

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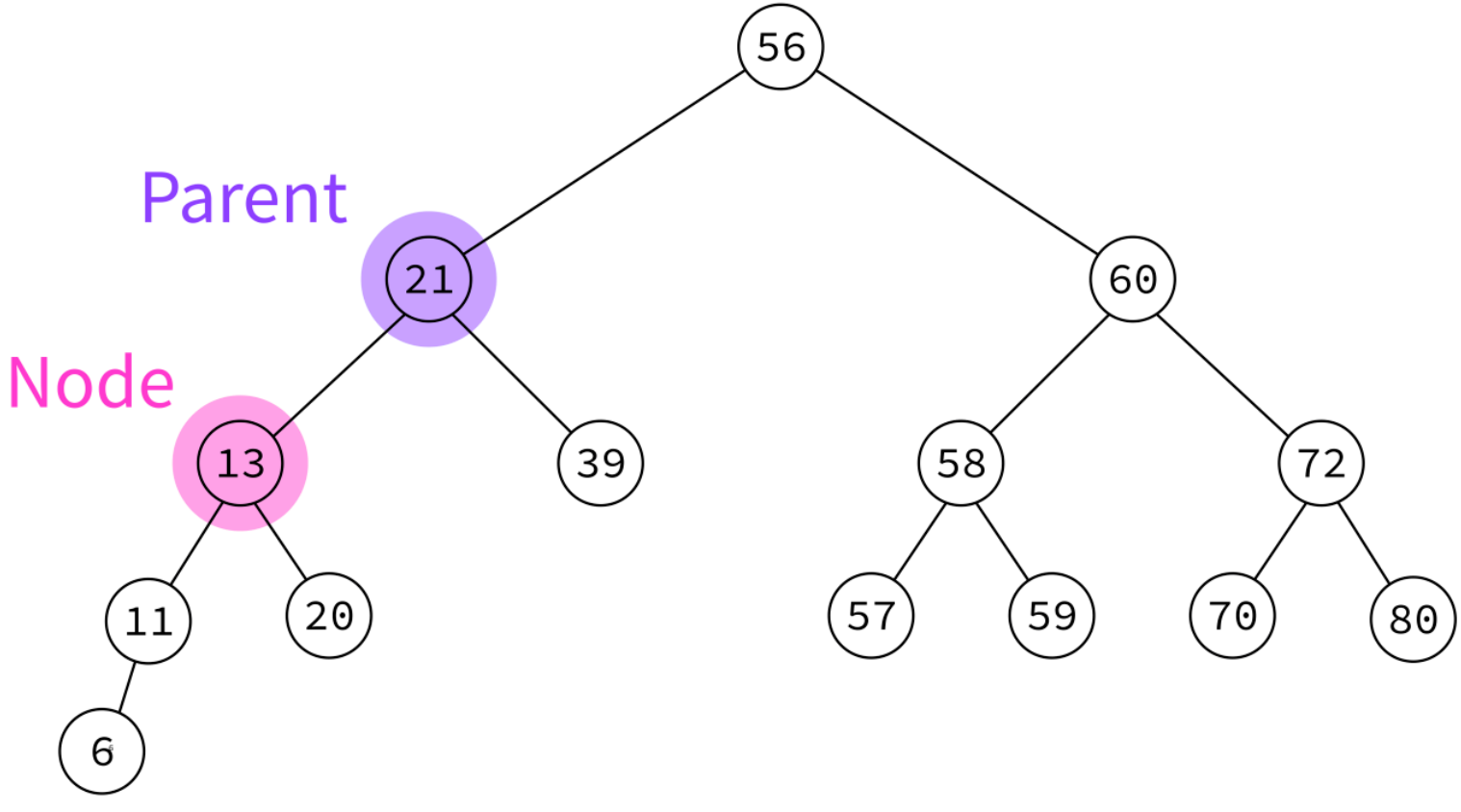

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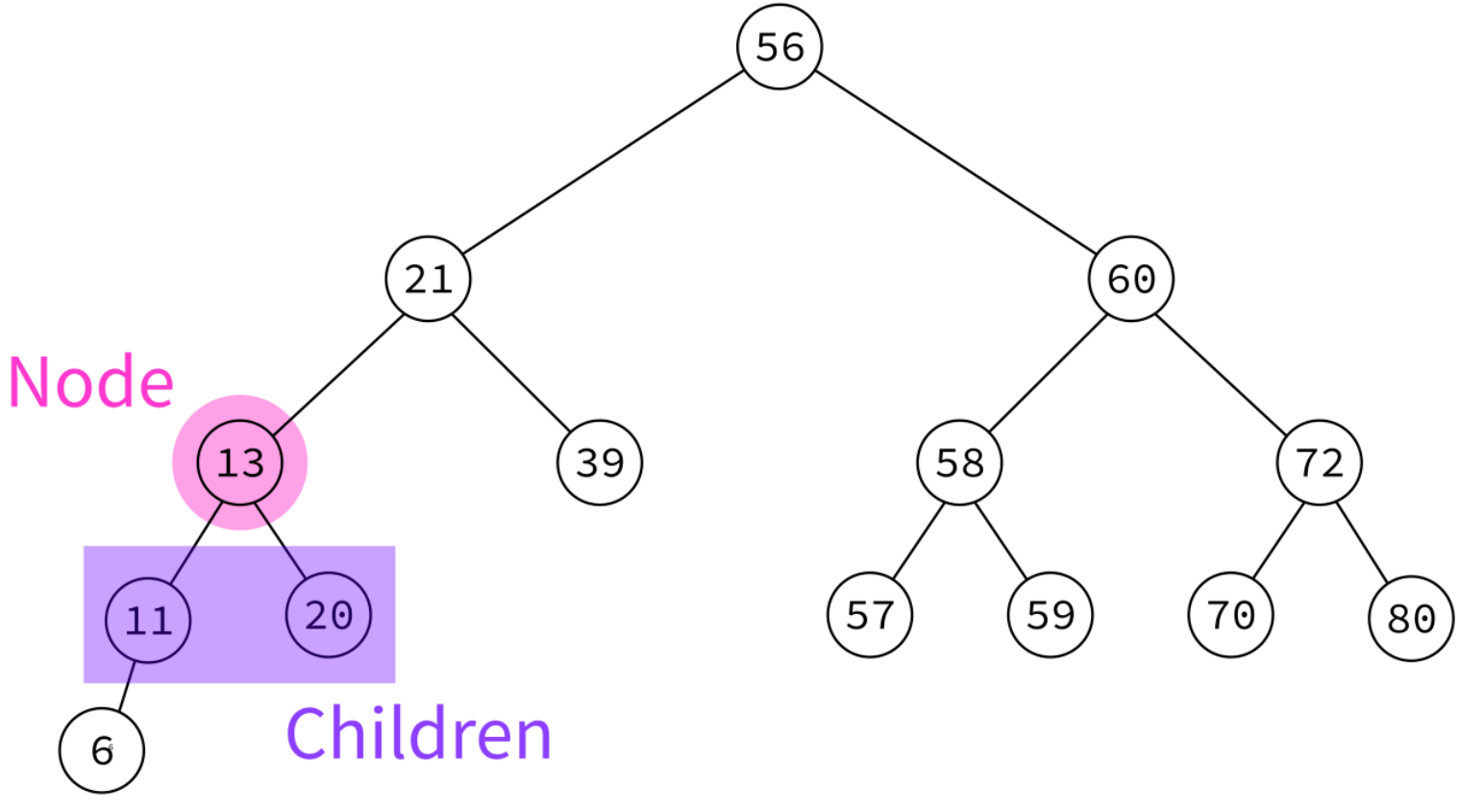

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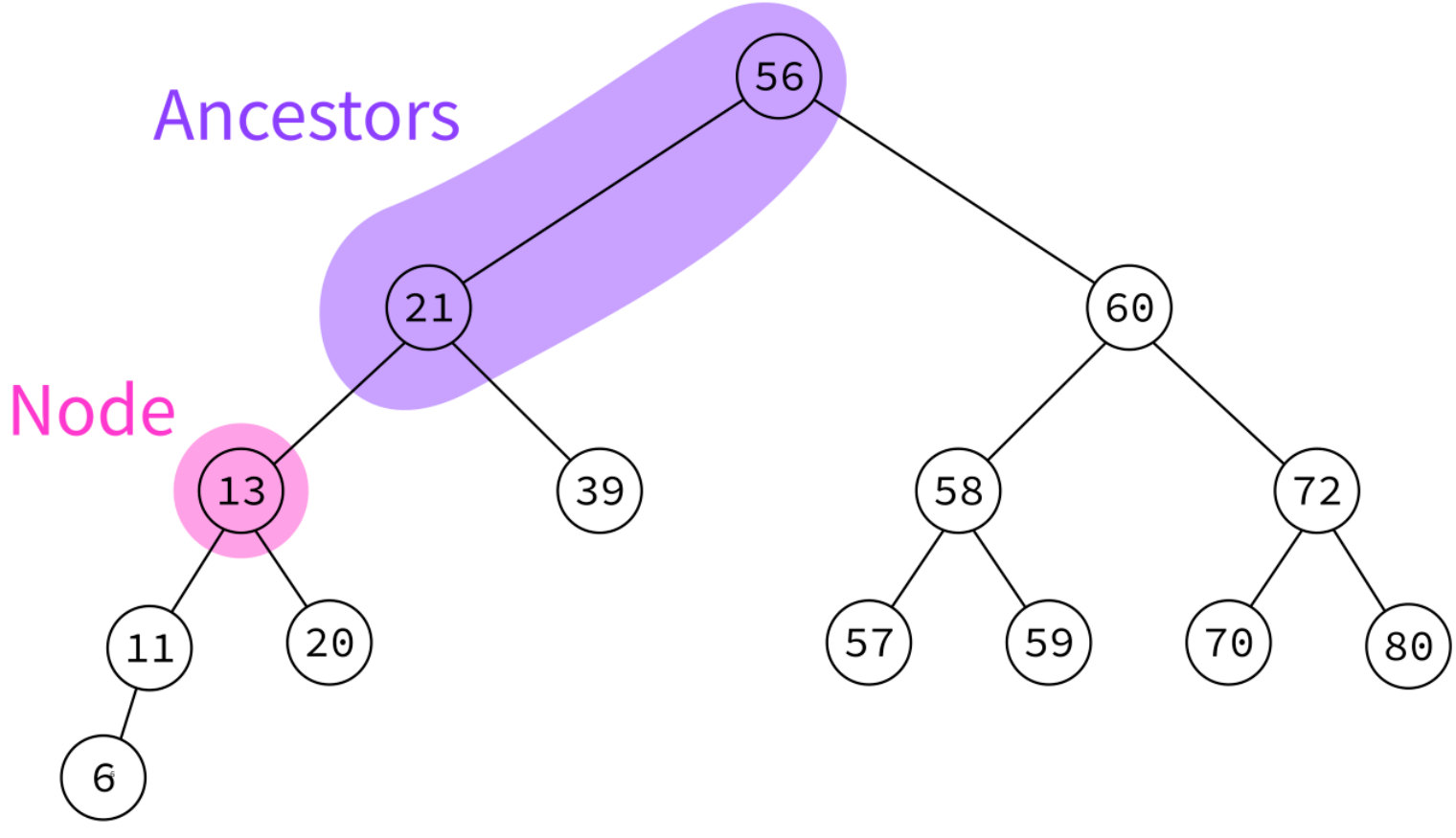

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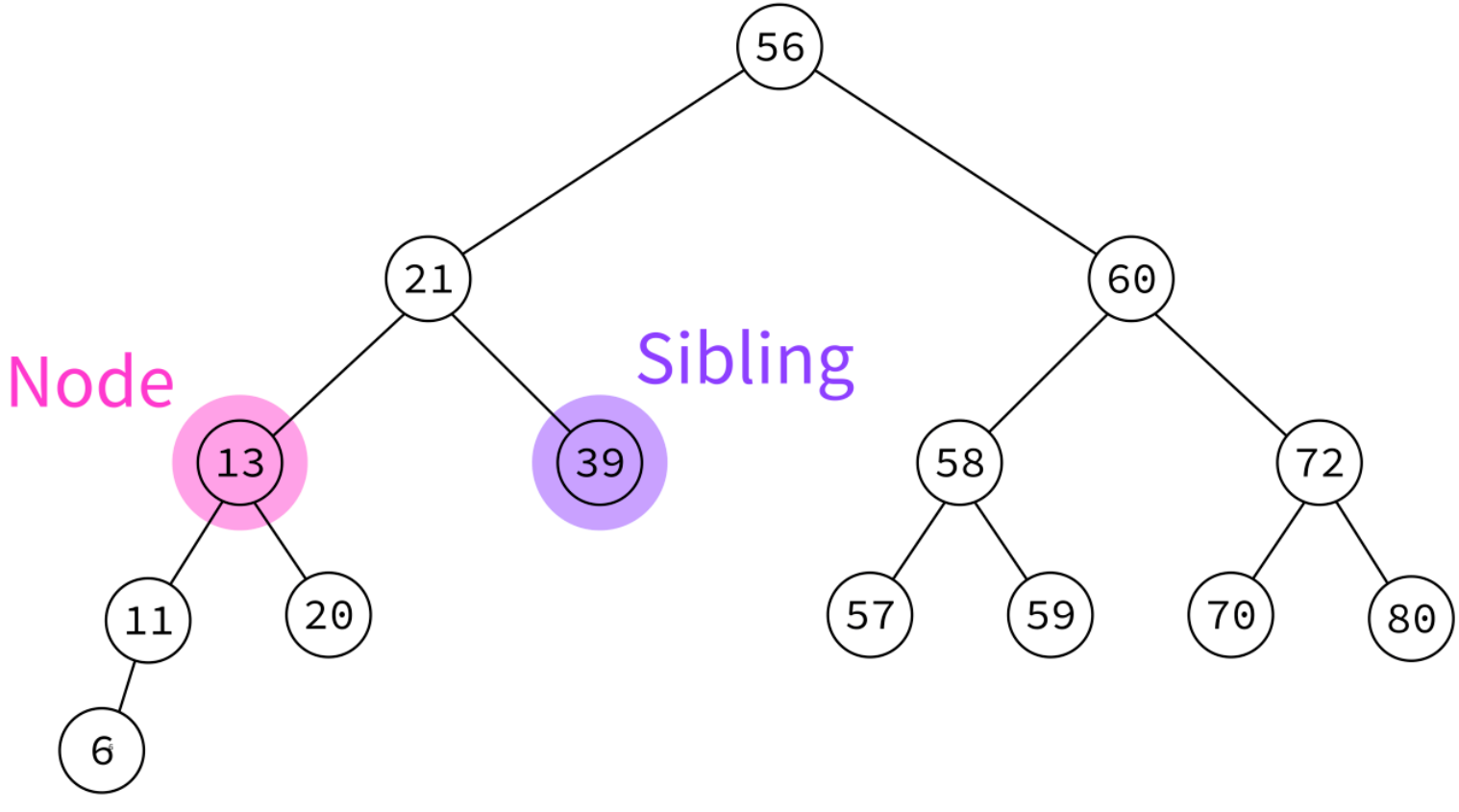

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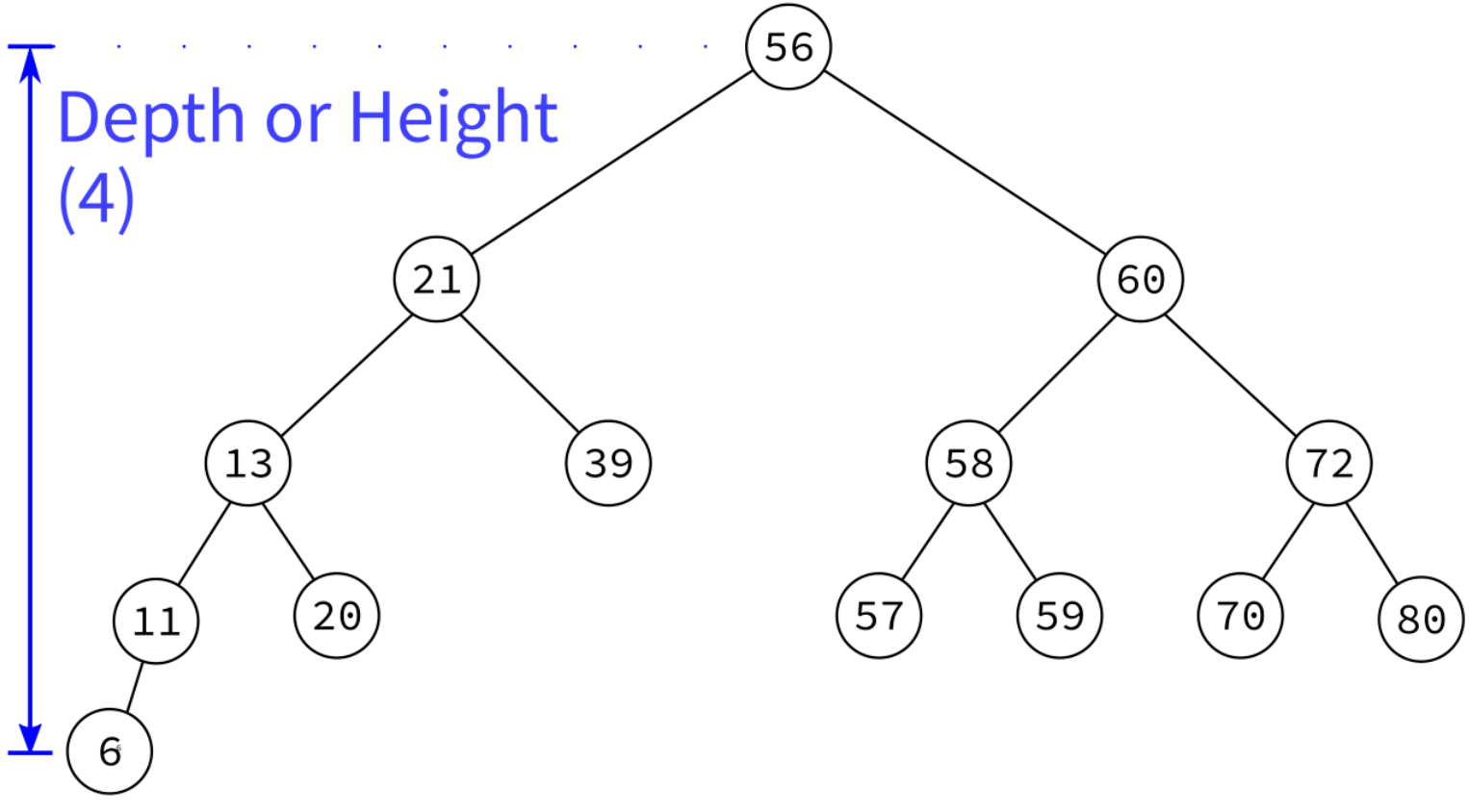


CODING

Let's build a class to represent nodes of a binary tree that also store keys.

TREEVIS

I provide a module `treevis` in the sample code repository that can "pretty print" a tree with the function `treeprint(root)`.

Challenge: Read the source of `treevis` and figure out how it works!

FROM TREE TO BST

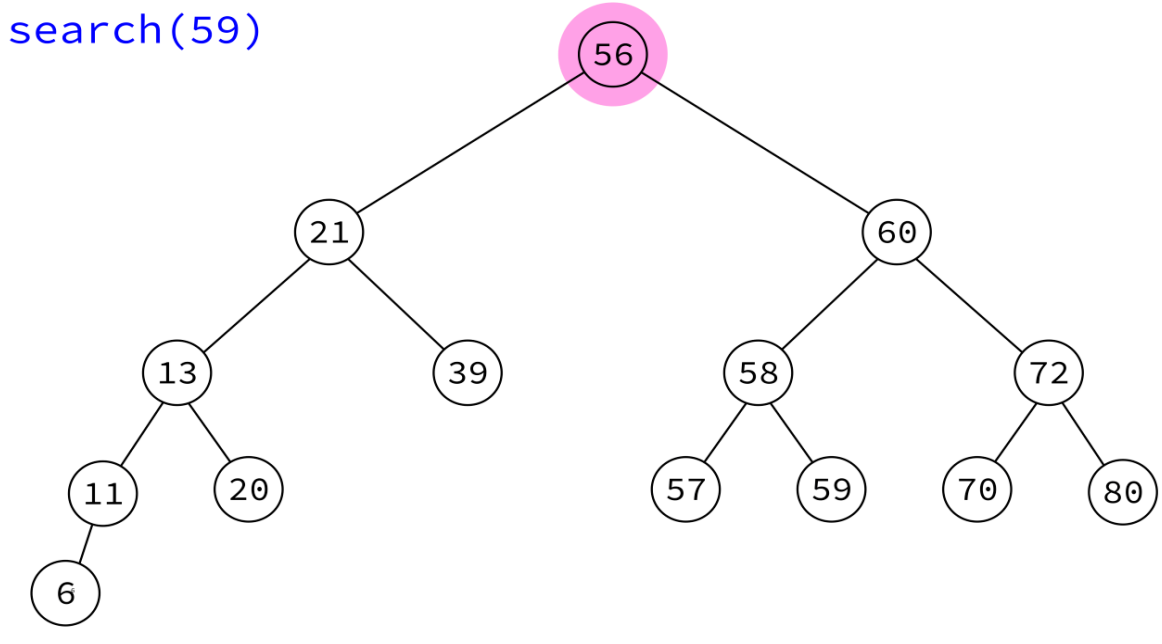
Now let's build a class that builds and manages a BST made of `Node` objects.

Desired features:

- Insert nodes (maintaining BST property)
- Search for nodes by key

SEARCH

Given `x`, find and return a node with key `x`. Return `None` if no such node exists.



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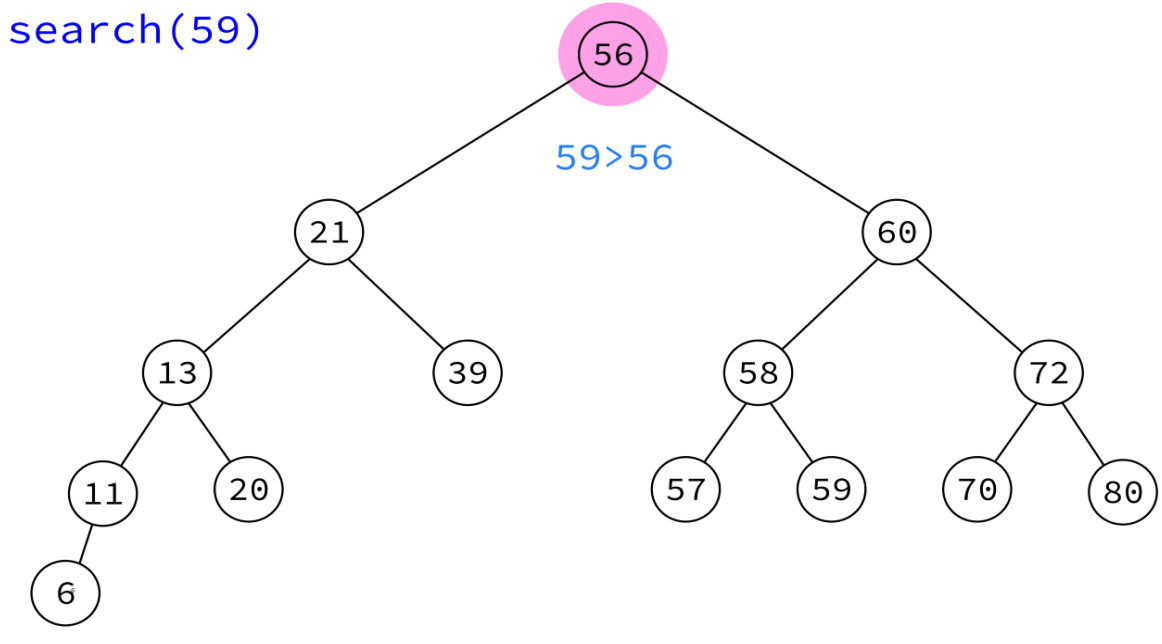

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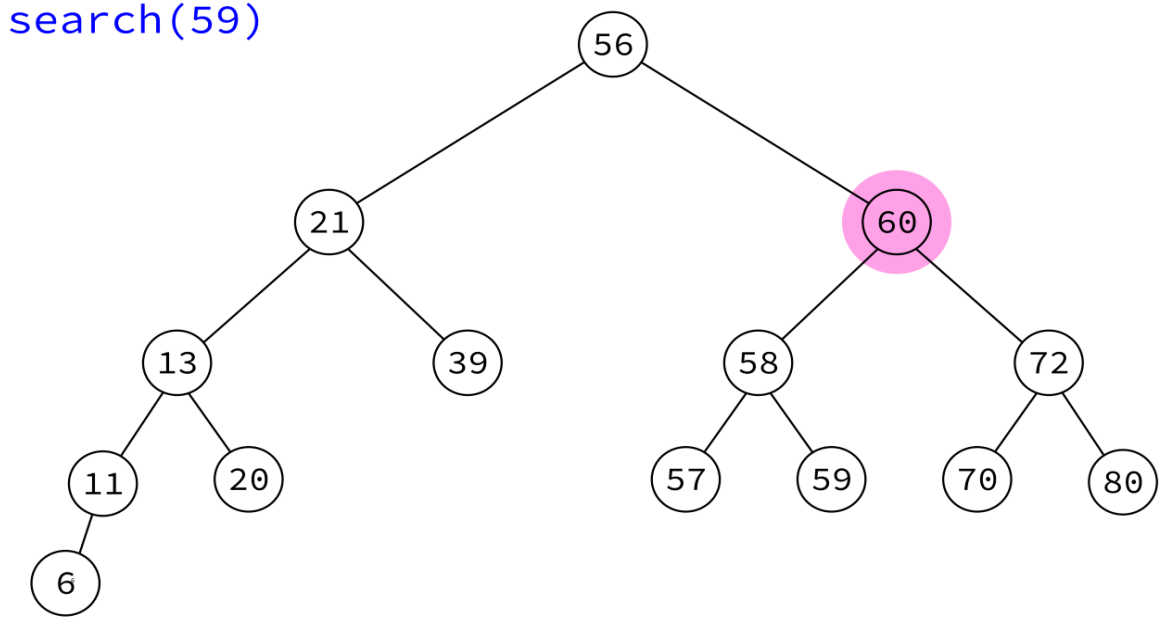

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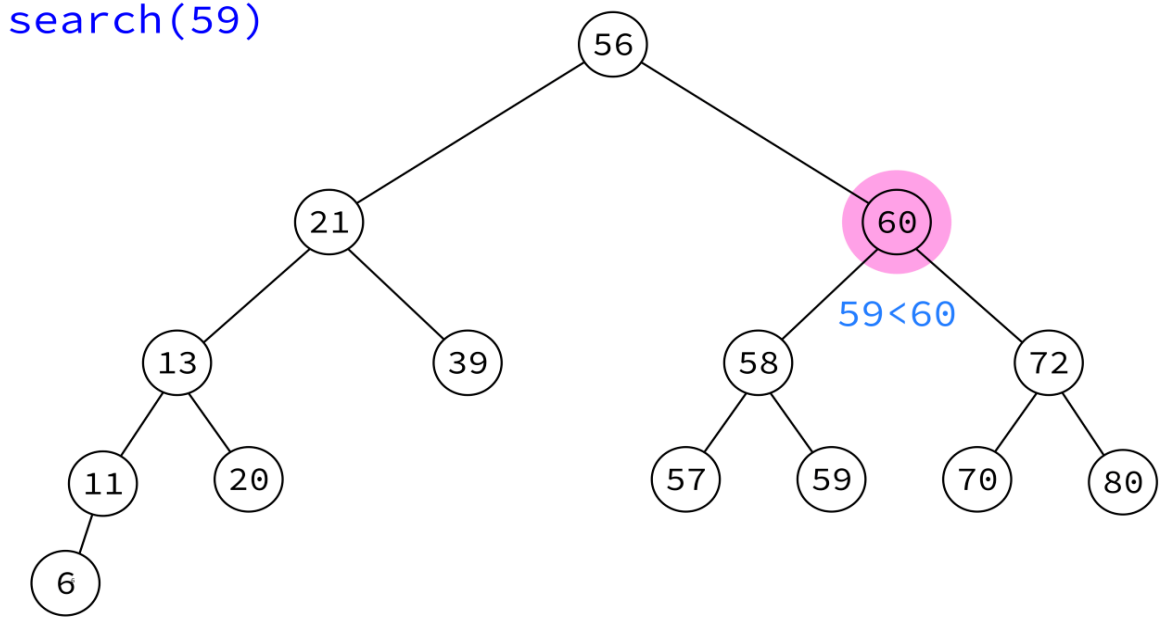

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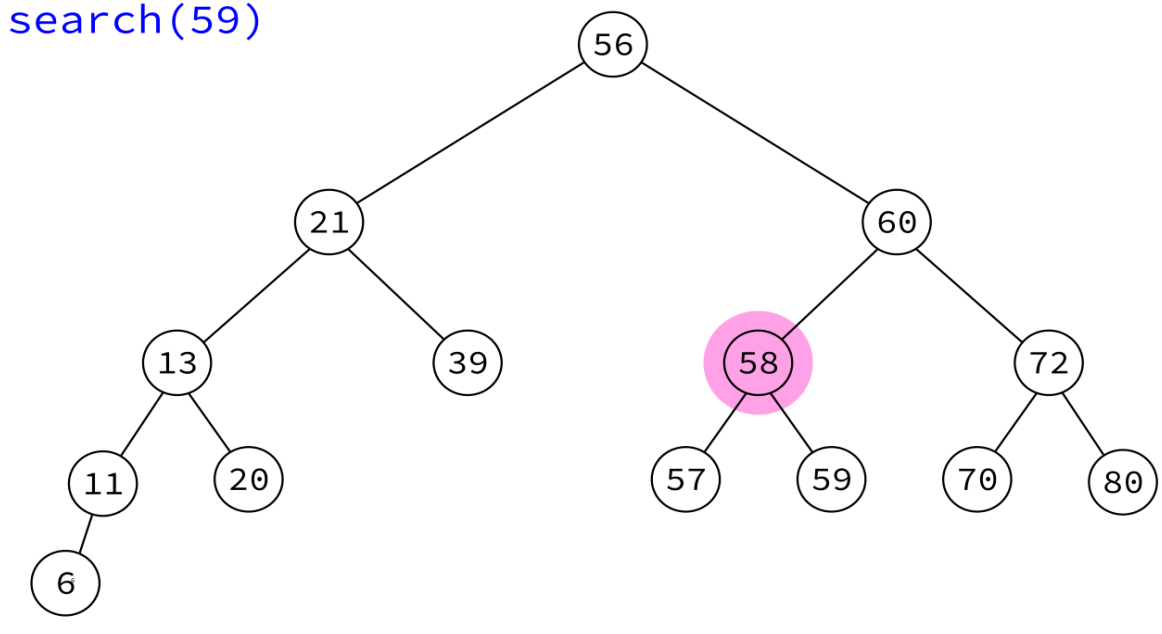

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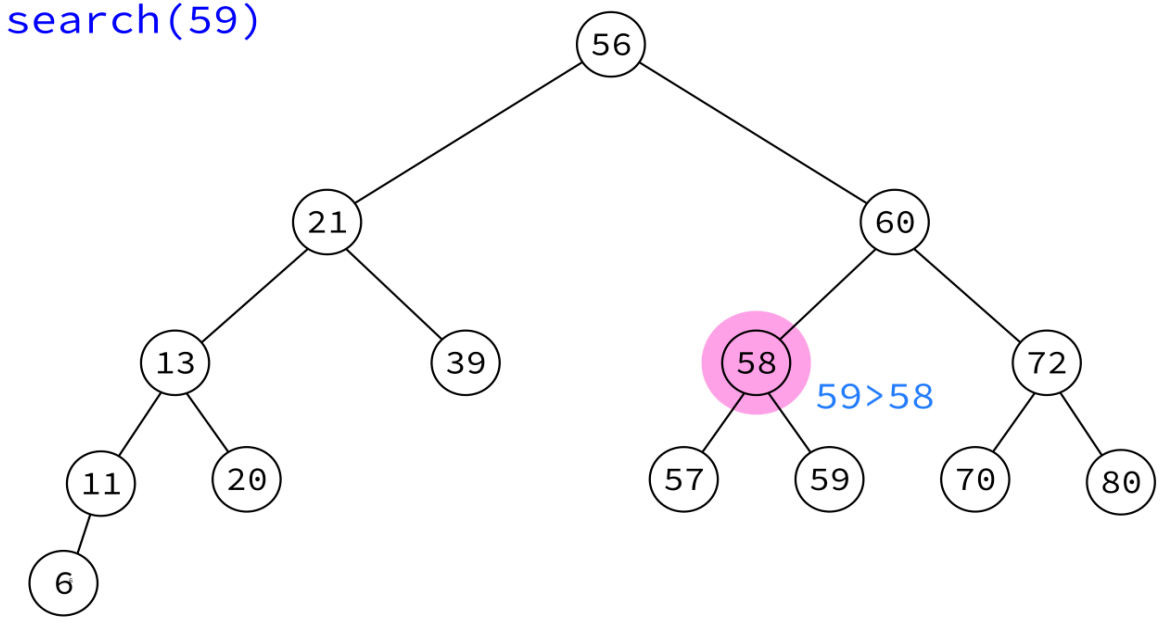

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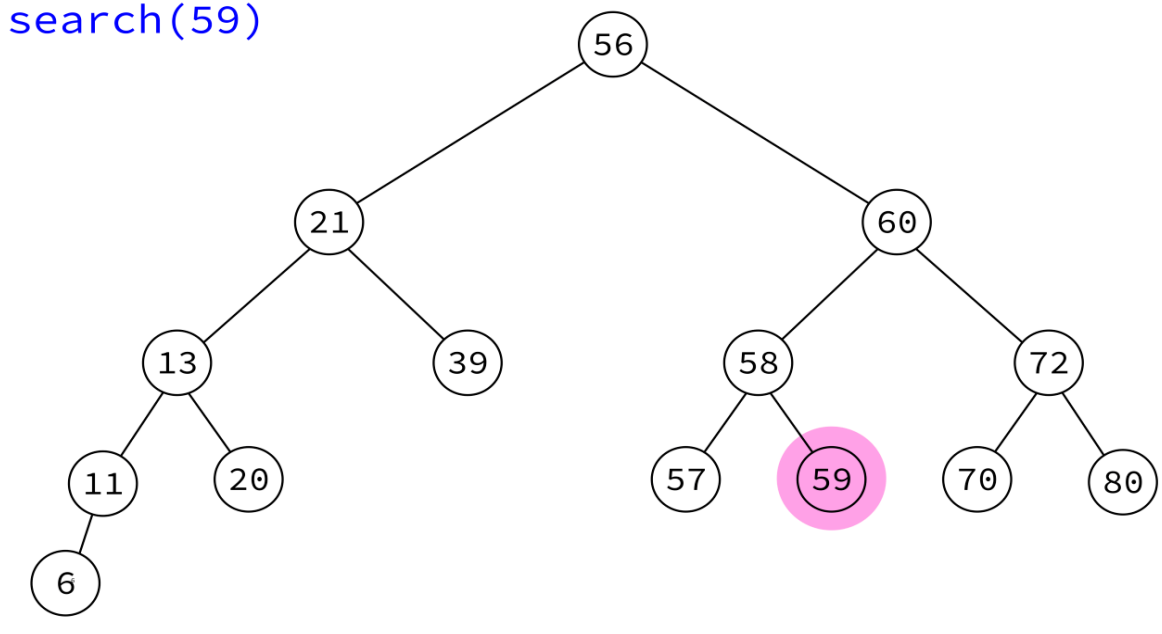

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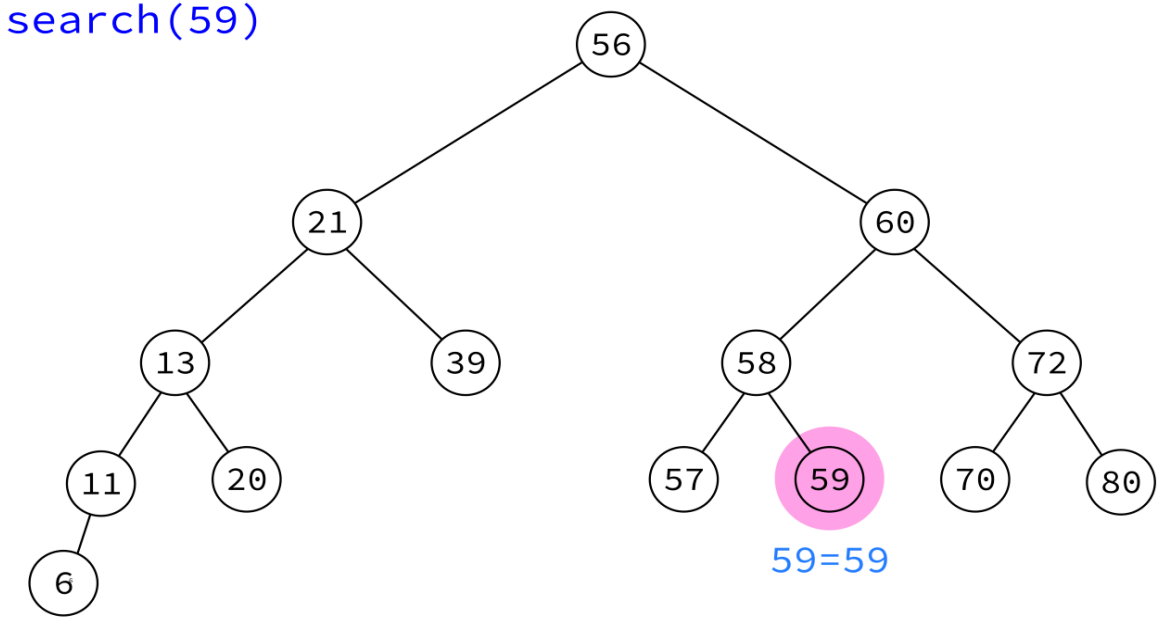

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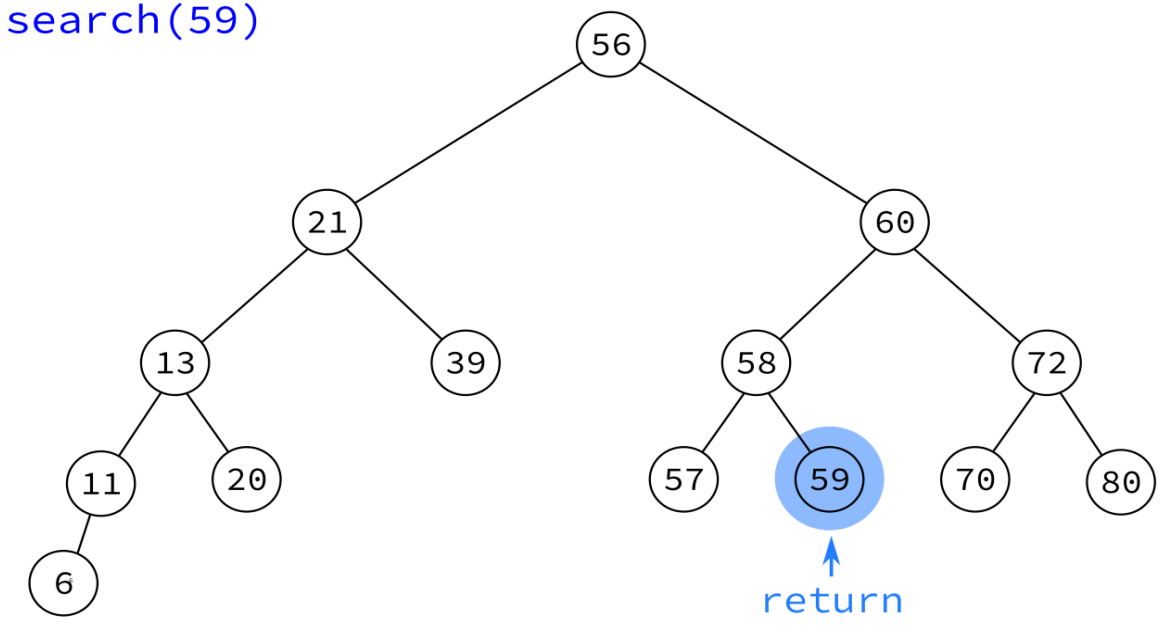
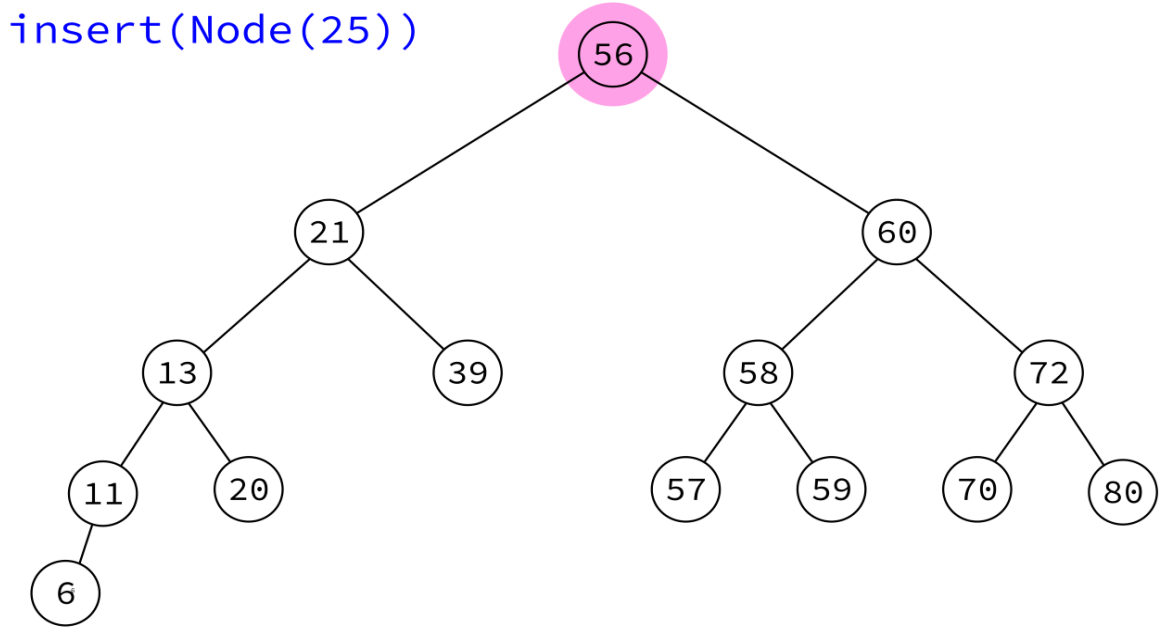


INSERT

Take a `Node` object and add it to the tree in a place that maintains the BST property.



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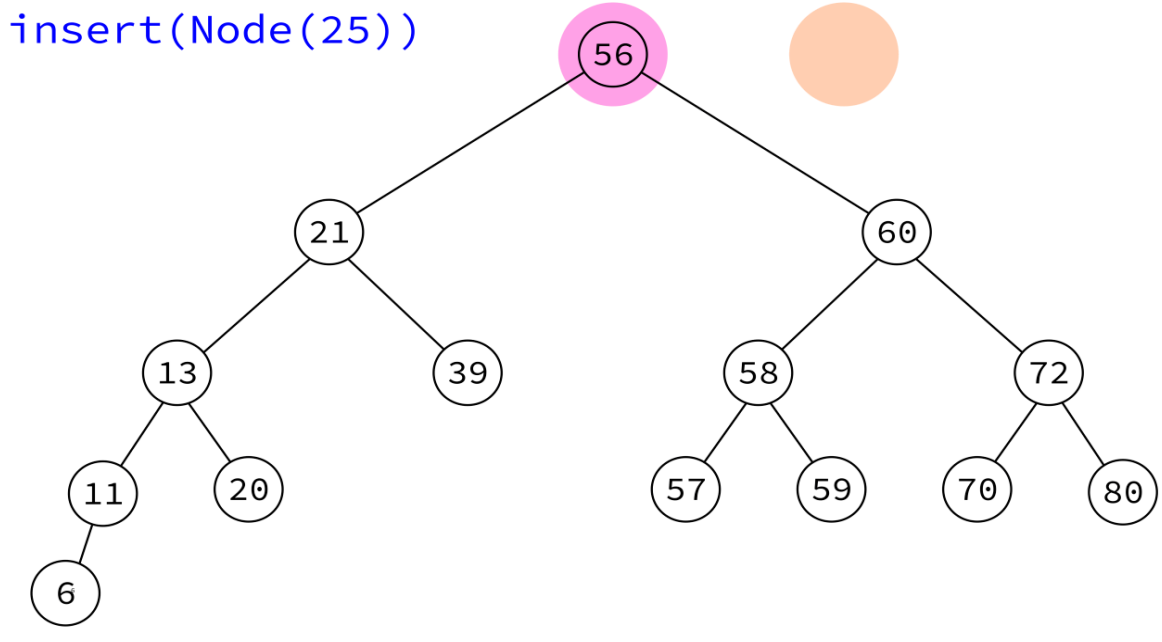

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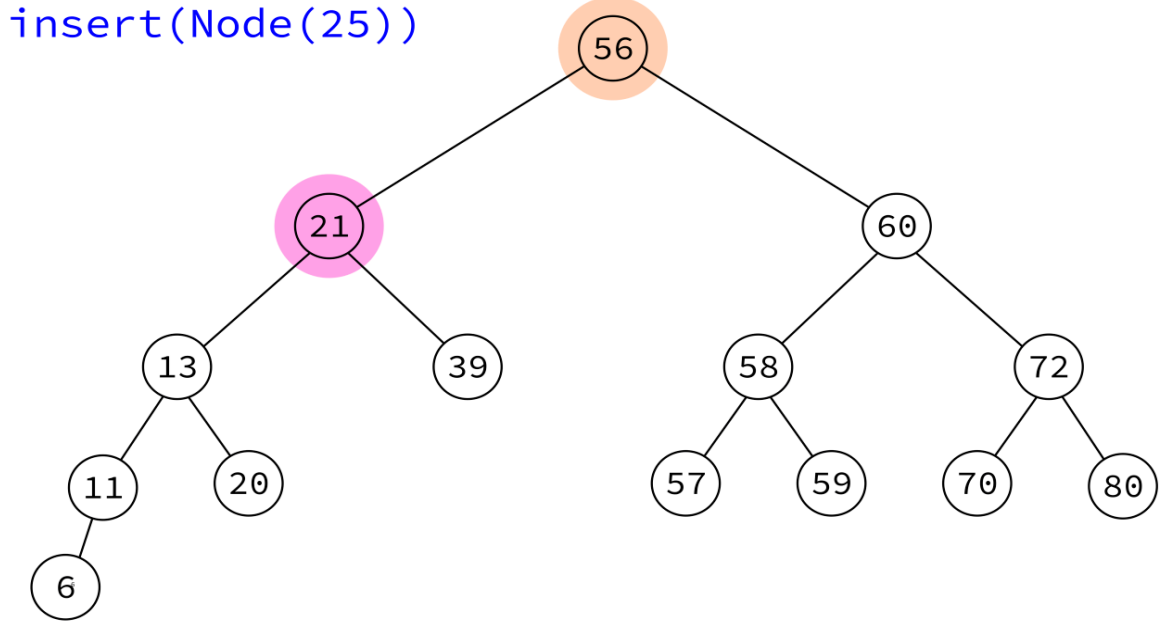

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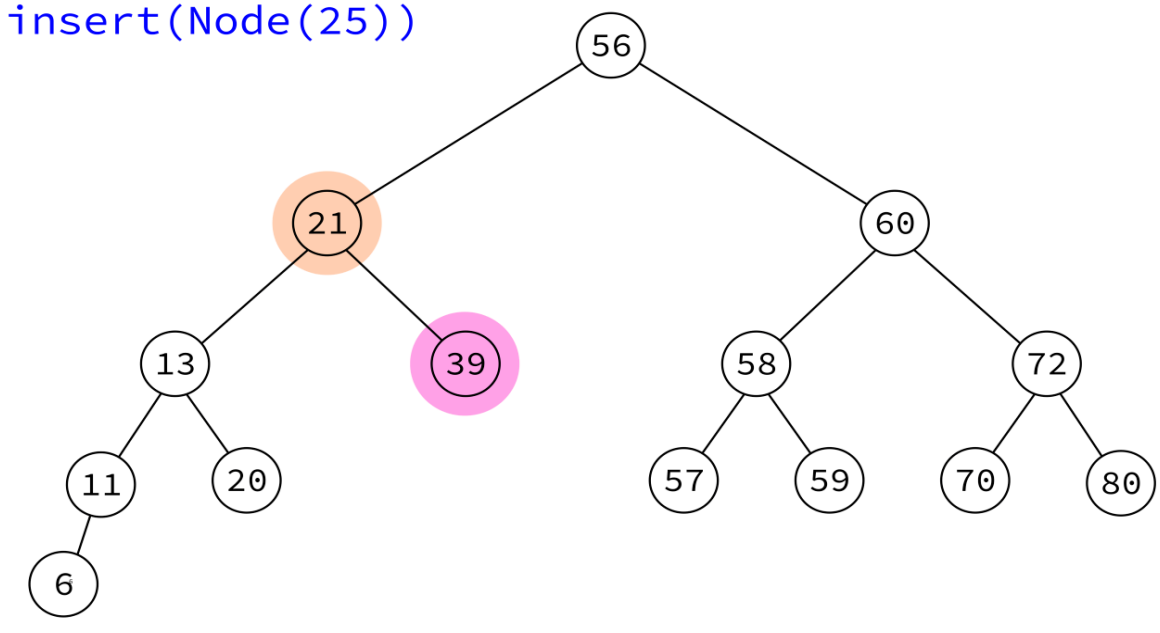

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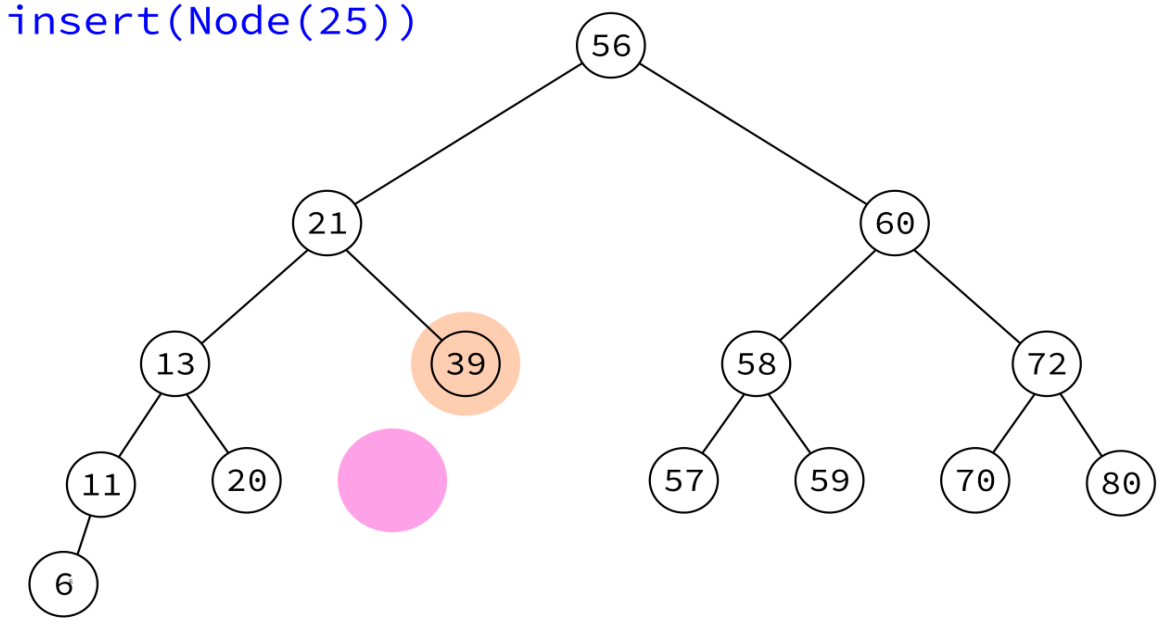

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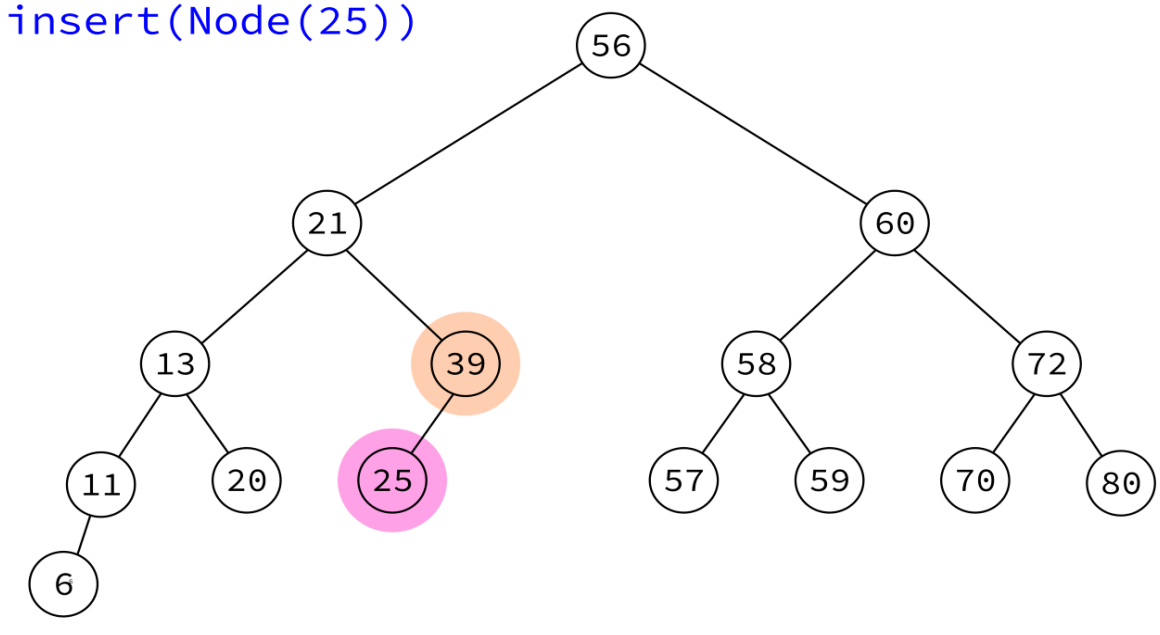

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INTEGERSET

Let's use this to build a class to store a collection of integers that supports fast insertion and membership testing.

IMPLEMENTATION HIDING

To use `BST`, you need to know about and work with `Node` objects.

In contrast, `IntegerSet` has an interface based directly on the values to be stored. It hides the fact that its implementation uses a BST.

REFERENCES

- In optional course texts:
  - Problem Solving with Algorithms and Data Structures using Python by Miller and Ranum, discusses binary trees in Chapter 7.
- Elsewhere:
  - Cormen, Leiserson, Rivest, and Stein discusses graph theory and trees in Appendices B.4 and B.5, and binary search trees in Chapter 12.

REVISION HISTORY

- 2021-02-26 Fix incorrect integer comparison in one figure; add link to sample code
- 2021-02-25 Initial publication