BINARY SEARCH TREES

LECTURE 11–1

JIM FIX, REED COLLEGE CSCI 121

COURSE INFO

- **Project 4:**
  - Just posted! Check it out. Many checkpoints w/ final version due 12/13.
  - Two options:
    - **adventure**: a text-based role-playing game
    - **arcade**: an 80s-style video game
  - You can work with a partner if you like.
  - ***Write a game (brief) proposal due Friday by 11:59pm.***

DEPARTMENT INFO

- **Talk today!!**
  -

DEPARTMENT

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  -

REED COLLEGE
COMPUTER SCIENCE DEPARTMENT
JOB TALK

ALEXA VANHATTUM

Cornell University

Formal Methods For Efficient, Reliable Systems Programming

Compilers are foundational—applications can only be as efficient and reliable as the underlying compiler stack that translates their logic to machine code. But compiler expertise is a finite resource, and engineers may have to choose whether to prioritize adding optimizations for efficiency or validating the compiler features they already have for reliability. In this talk, I'll show how my work pushes past this tension between performance and correctness by applying practical formal methods. I'll describe our Diospyros compiler for an energy-efficient embedded system, which uses automated reasoning over equalities to produce fast code with less manual programming effort. I will then show how our Kani verifier for Rust leverages compiler invariants to speed up correctness checks for low-level systems code. Finally, I'll address my ongoing work toward verifying machine code generation in a popular production compiler infrastructure and outline my goals for raising the level of abstraction in building efficient and reliable compilers for computer systems.

MONDAY, NOVEMBER 14, 2022
4:40PM
ELIOT 314

A (BINARY) TREE NODE CLASS

```
class BSTNode:
    def __init__(self,k,v):
        self.key = k
        self.value = v
        self.left = None
        self.right = None

>>> w = BSTNode("bob",22)
>>> x = BSTNode("abe",17)
>>> y = BSTNode("dog",5)
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```

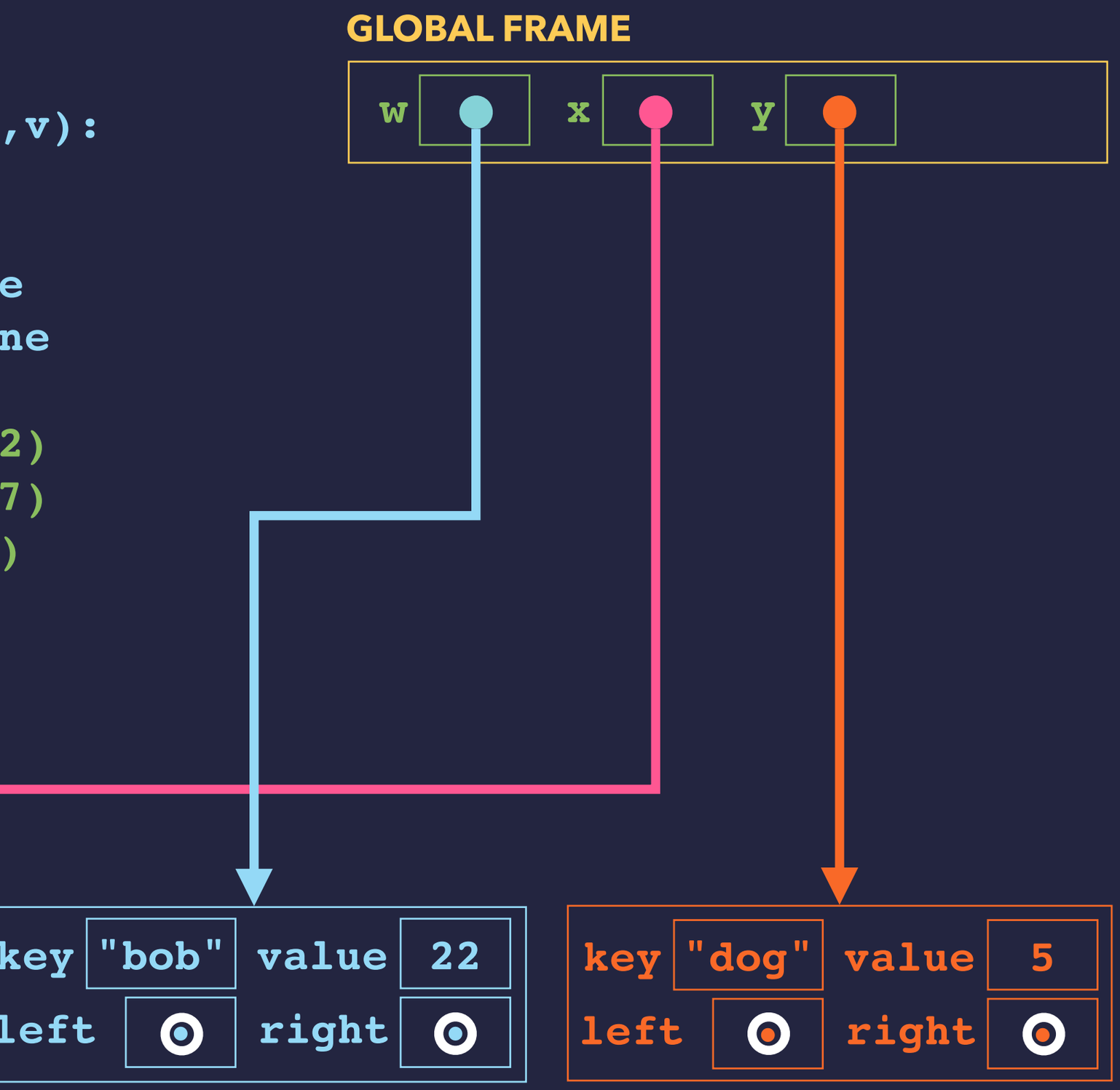

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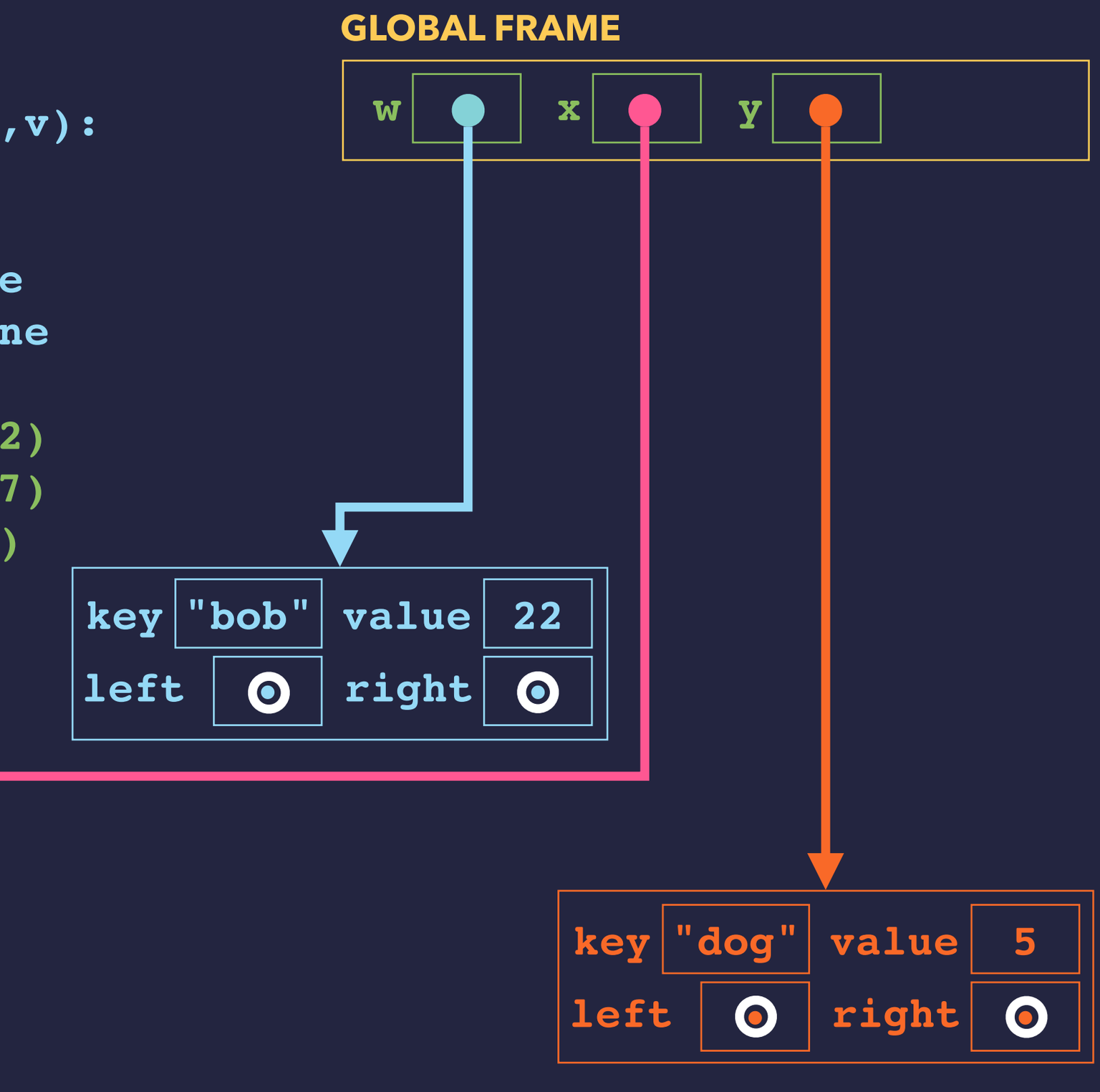

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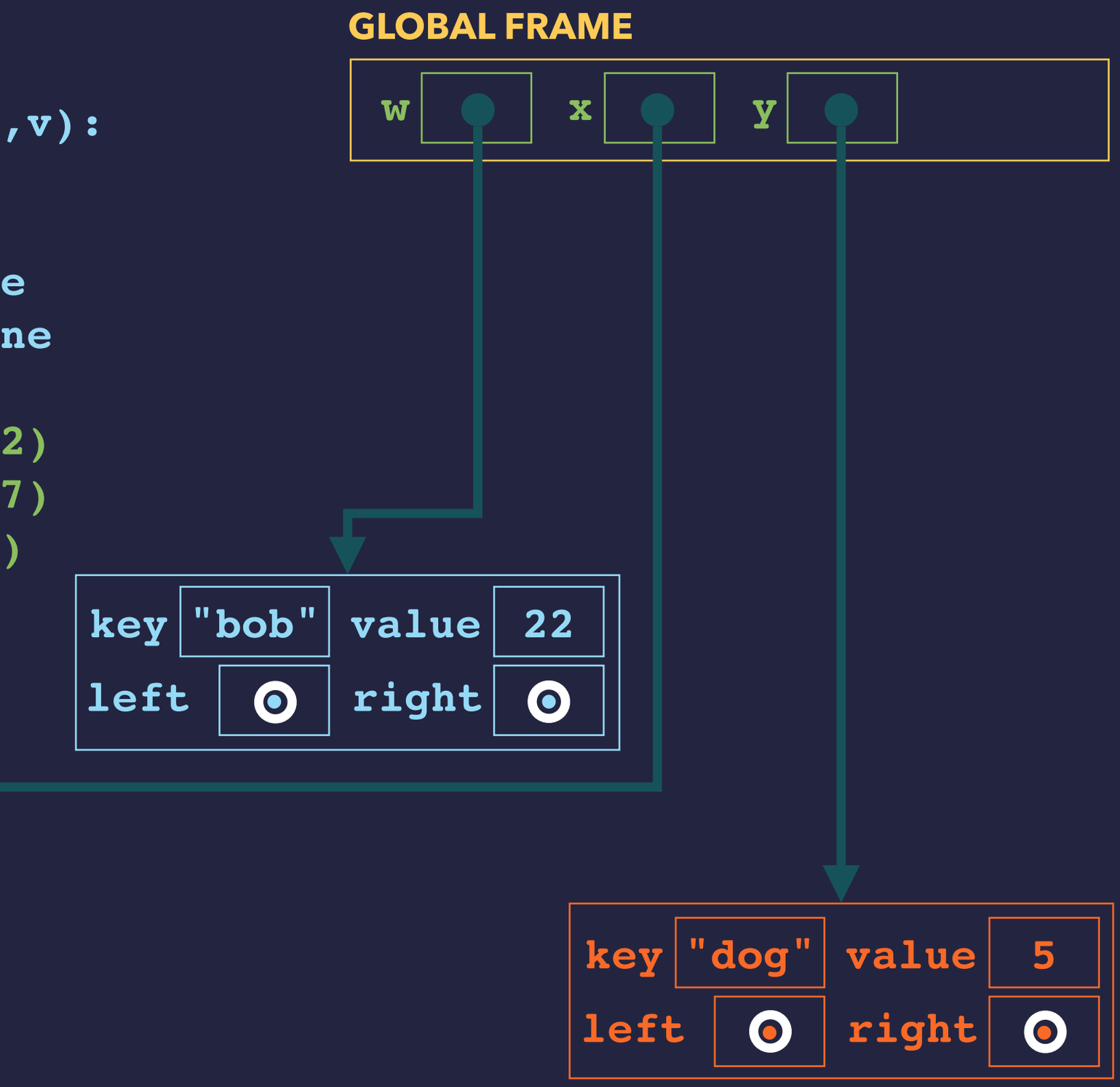

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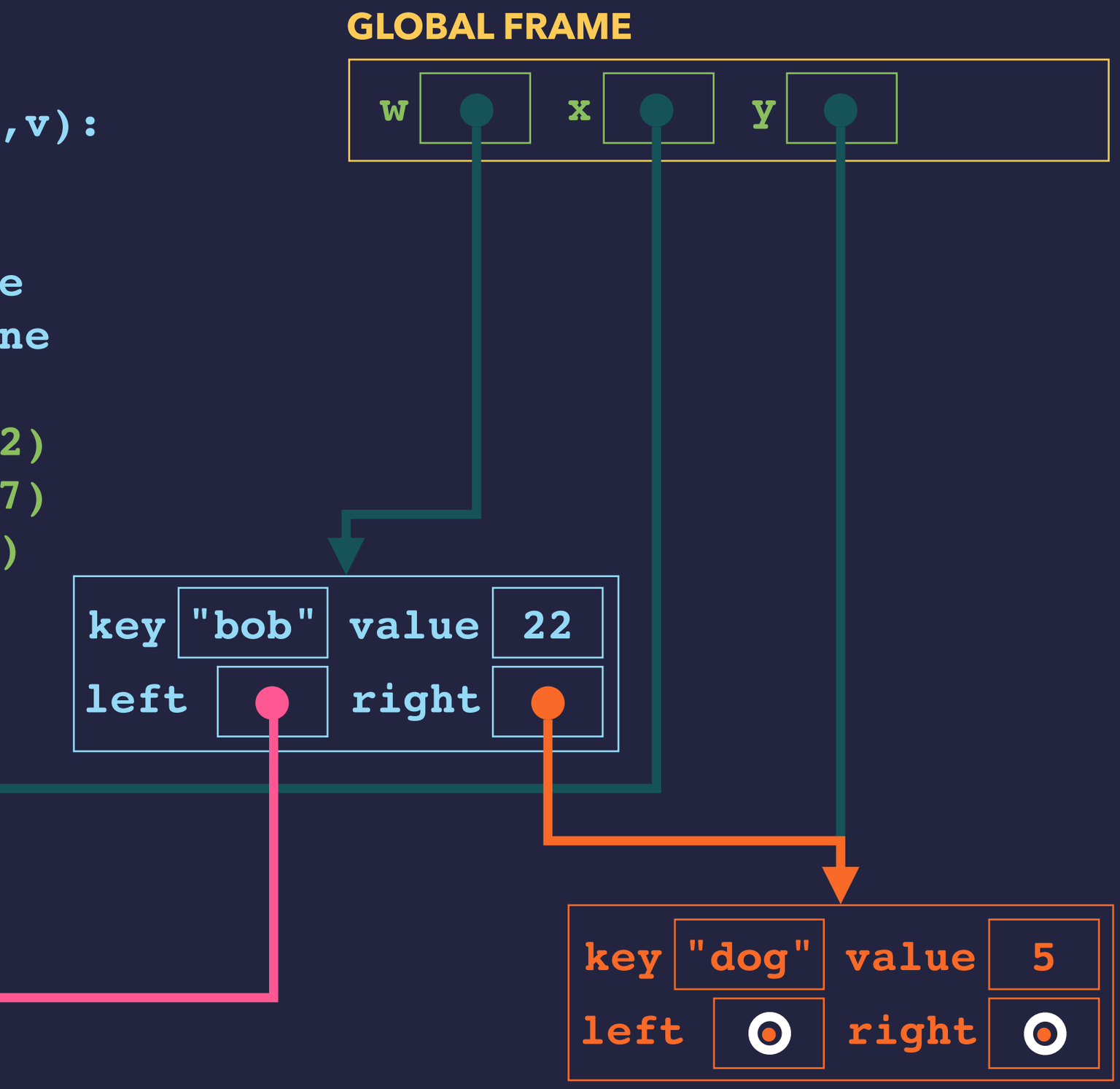

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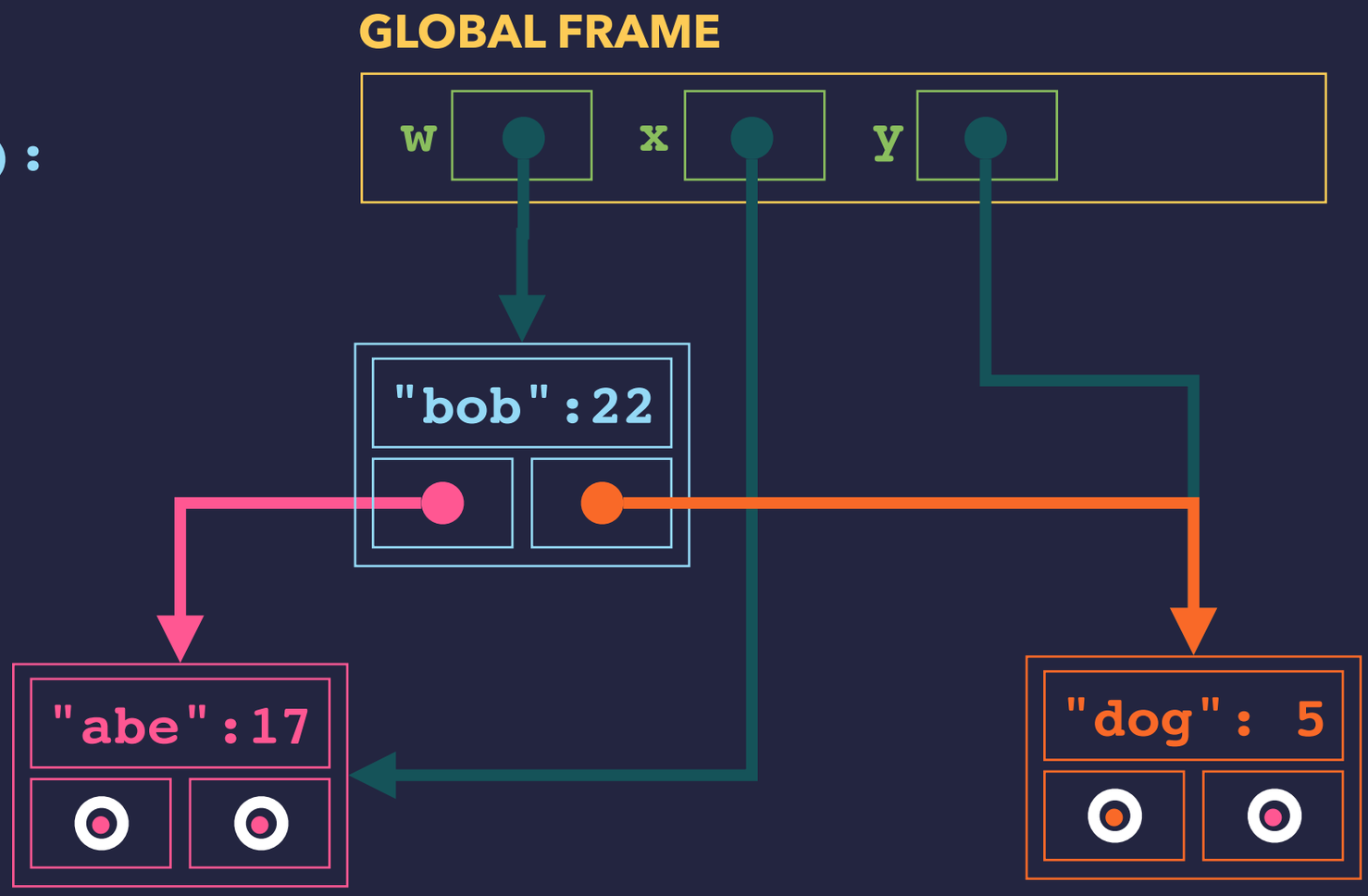

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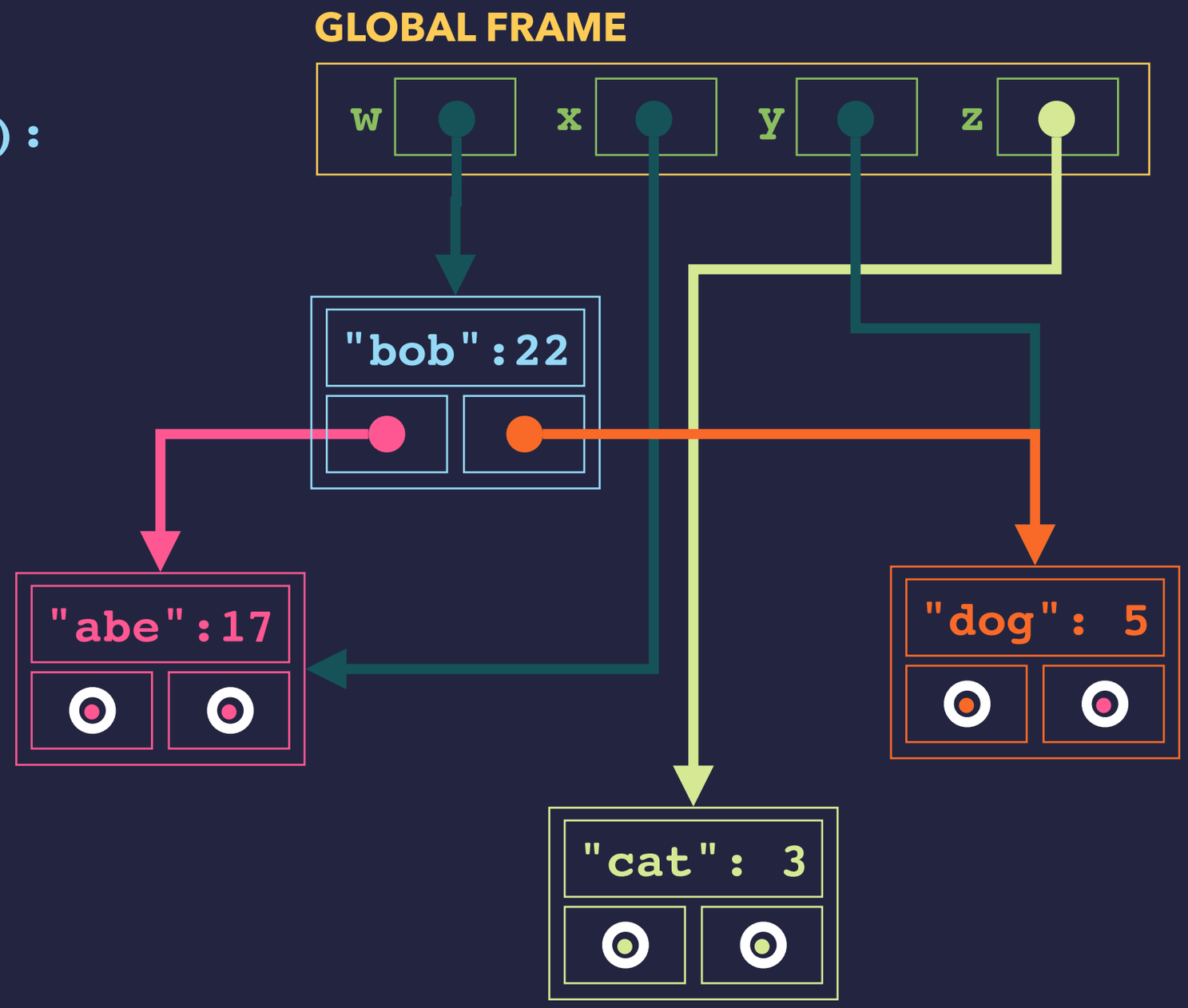

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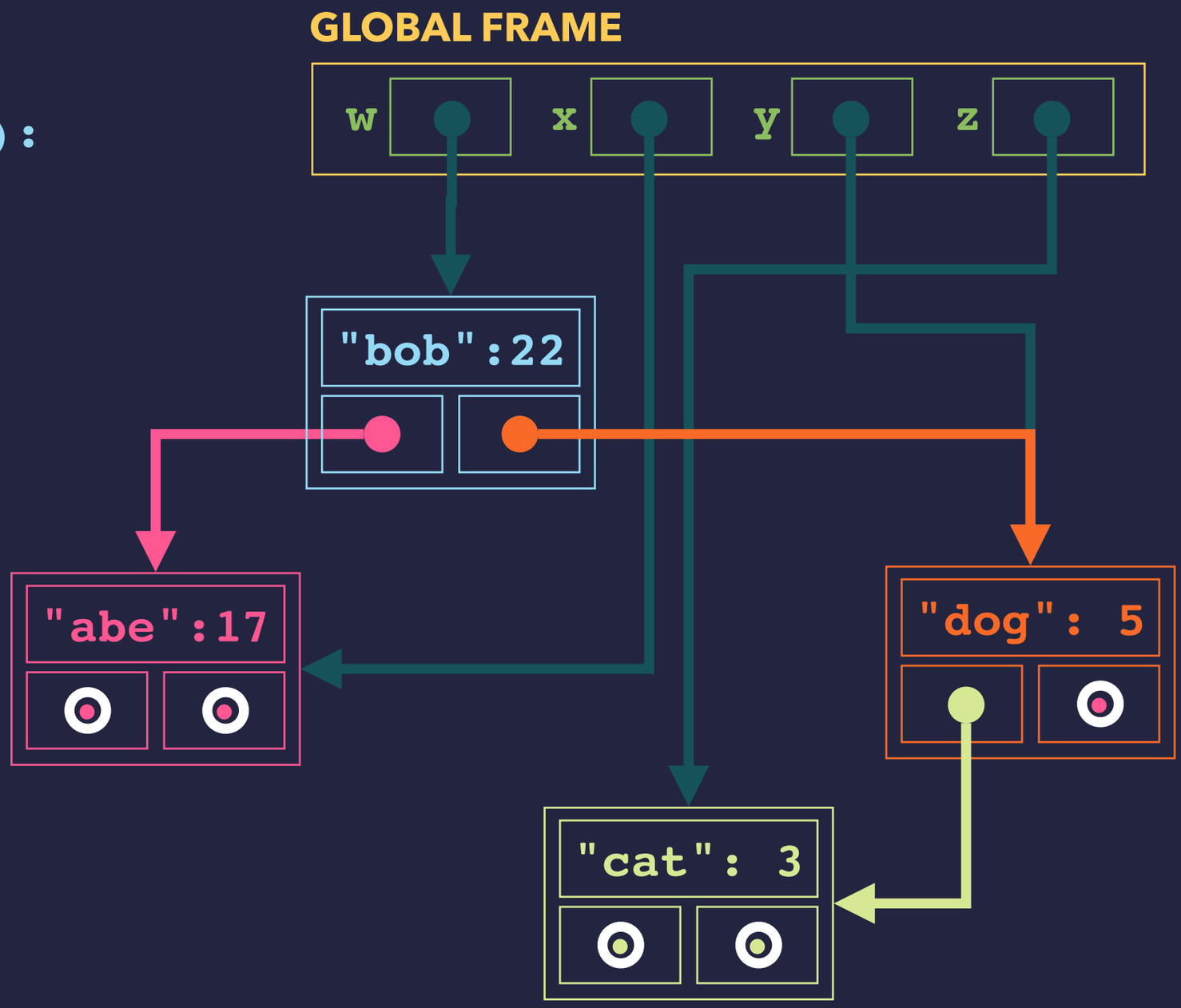

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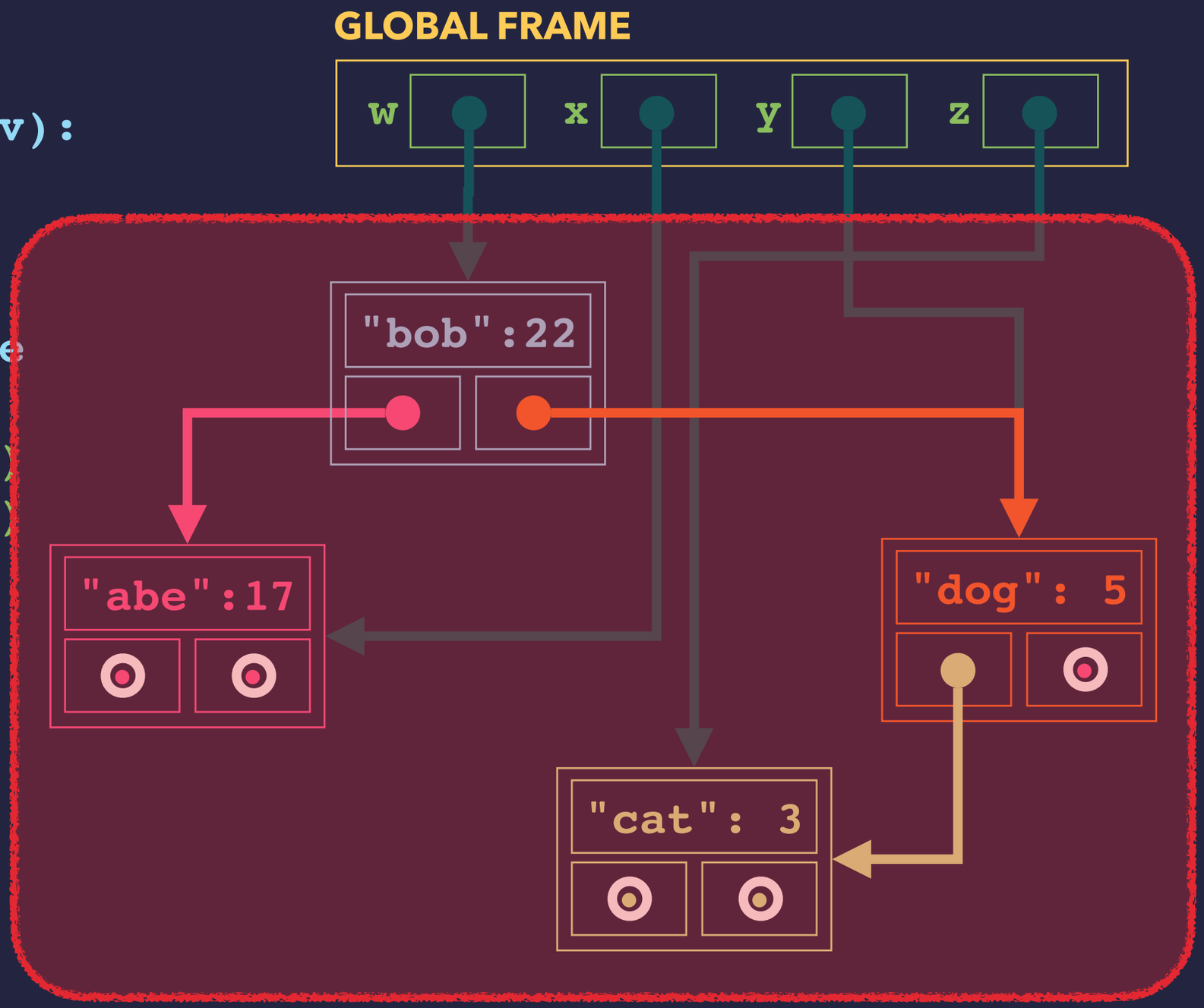
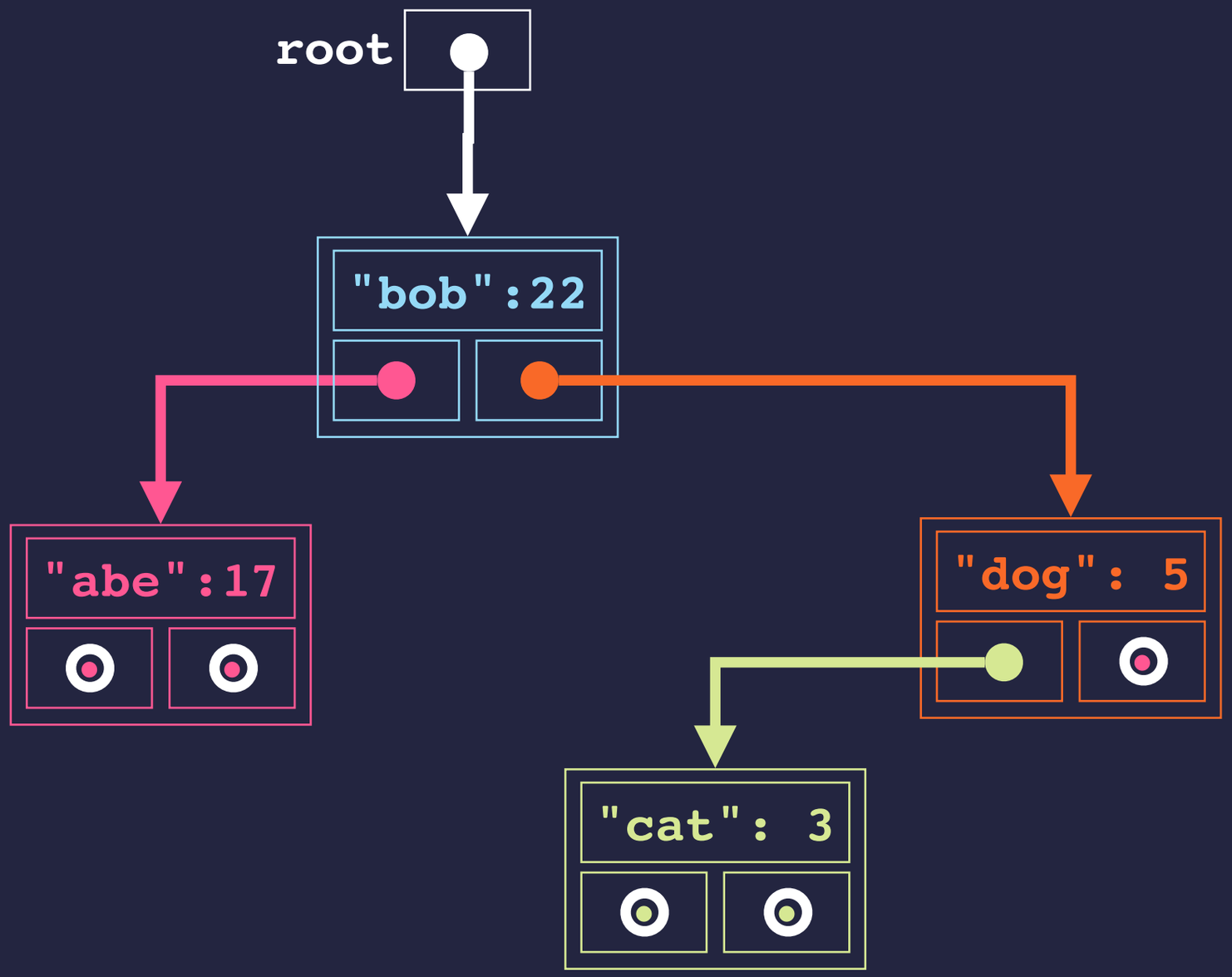
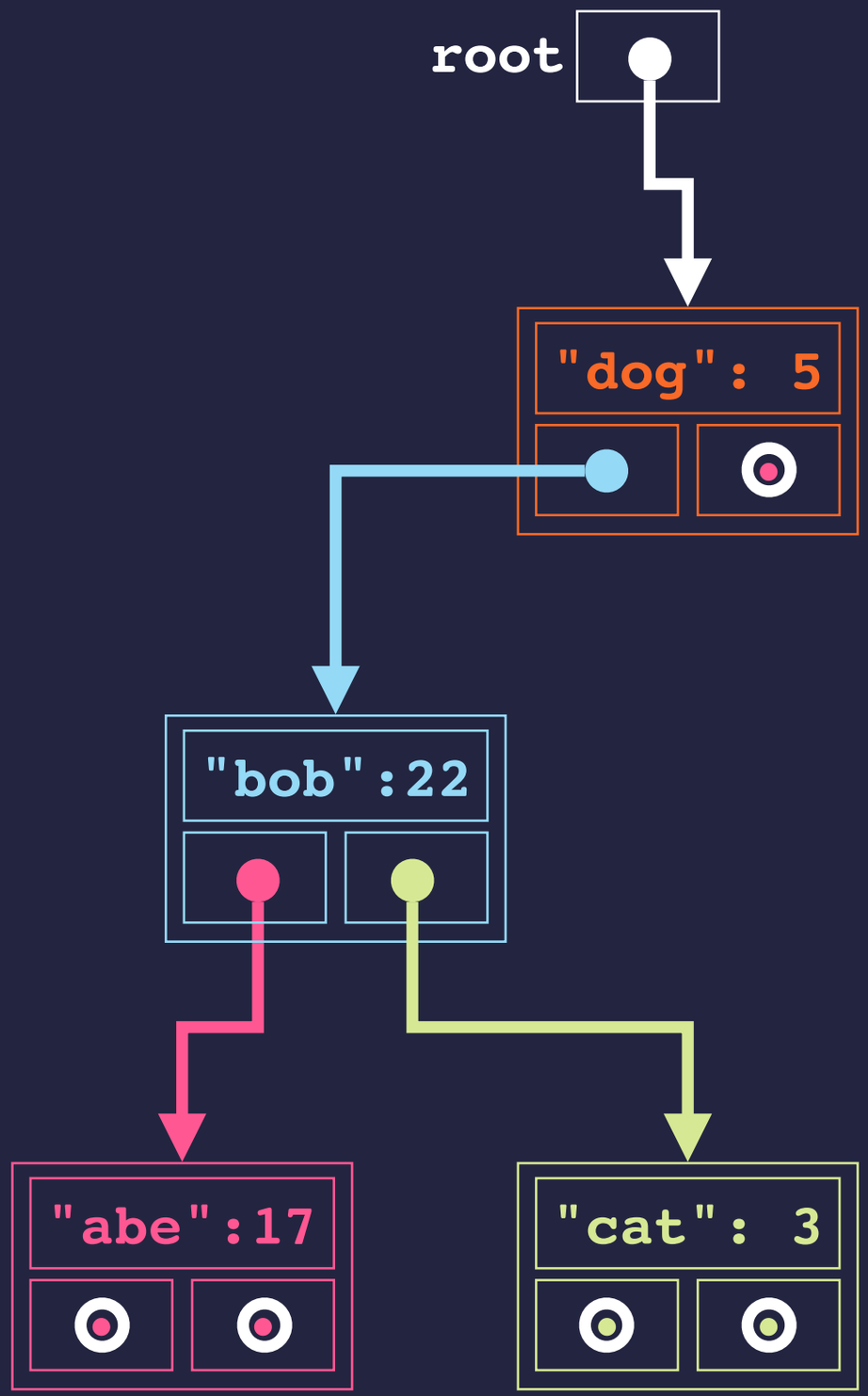


THIS STRUCTURE IS CALLED A BINARY SEARCH TREE

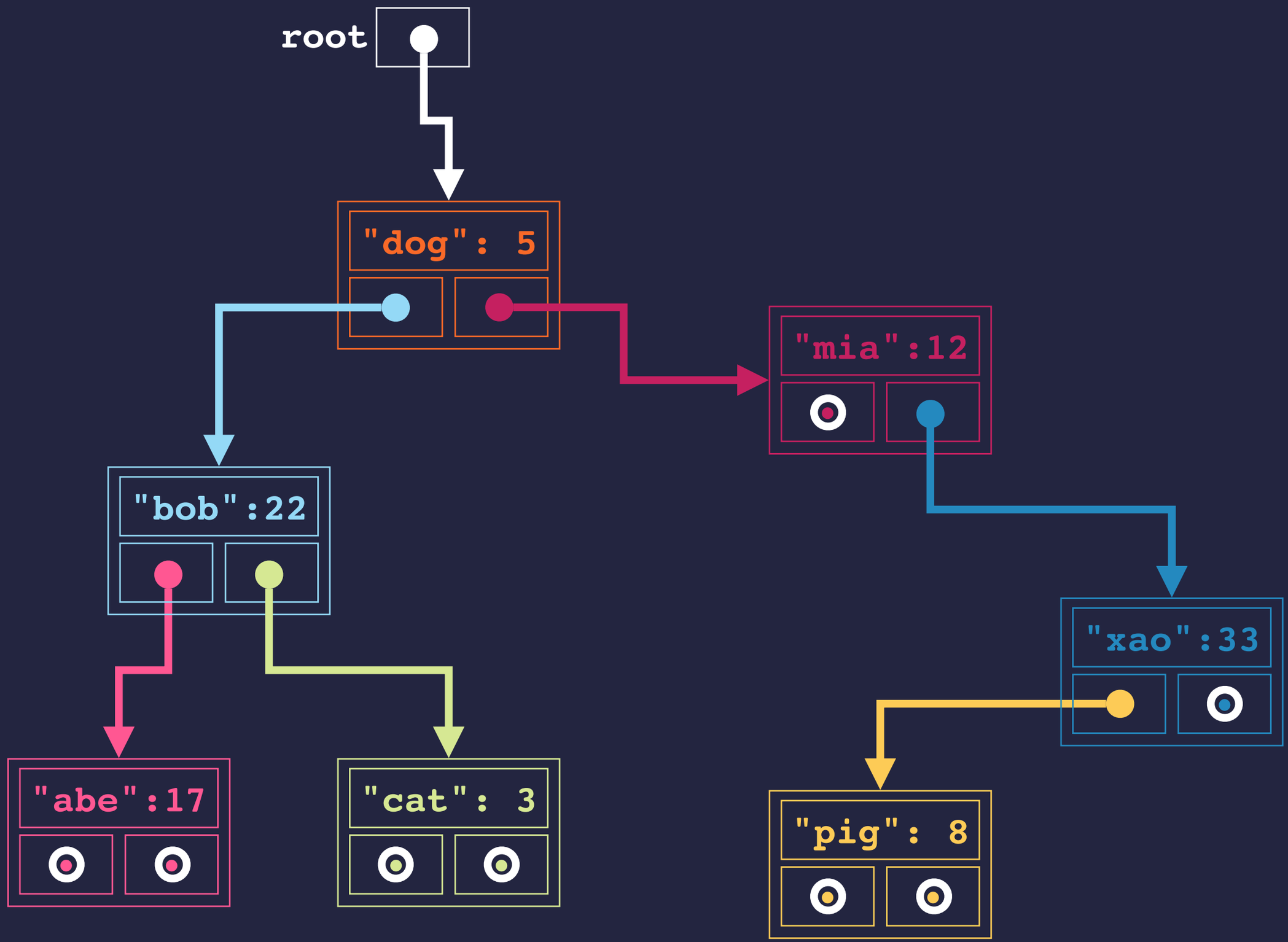
A BINARY SEARCH TREE



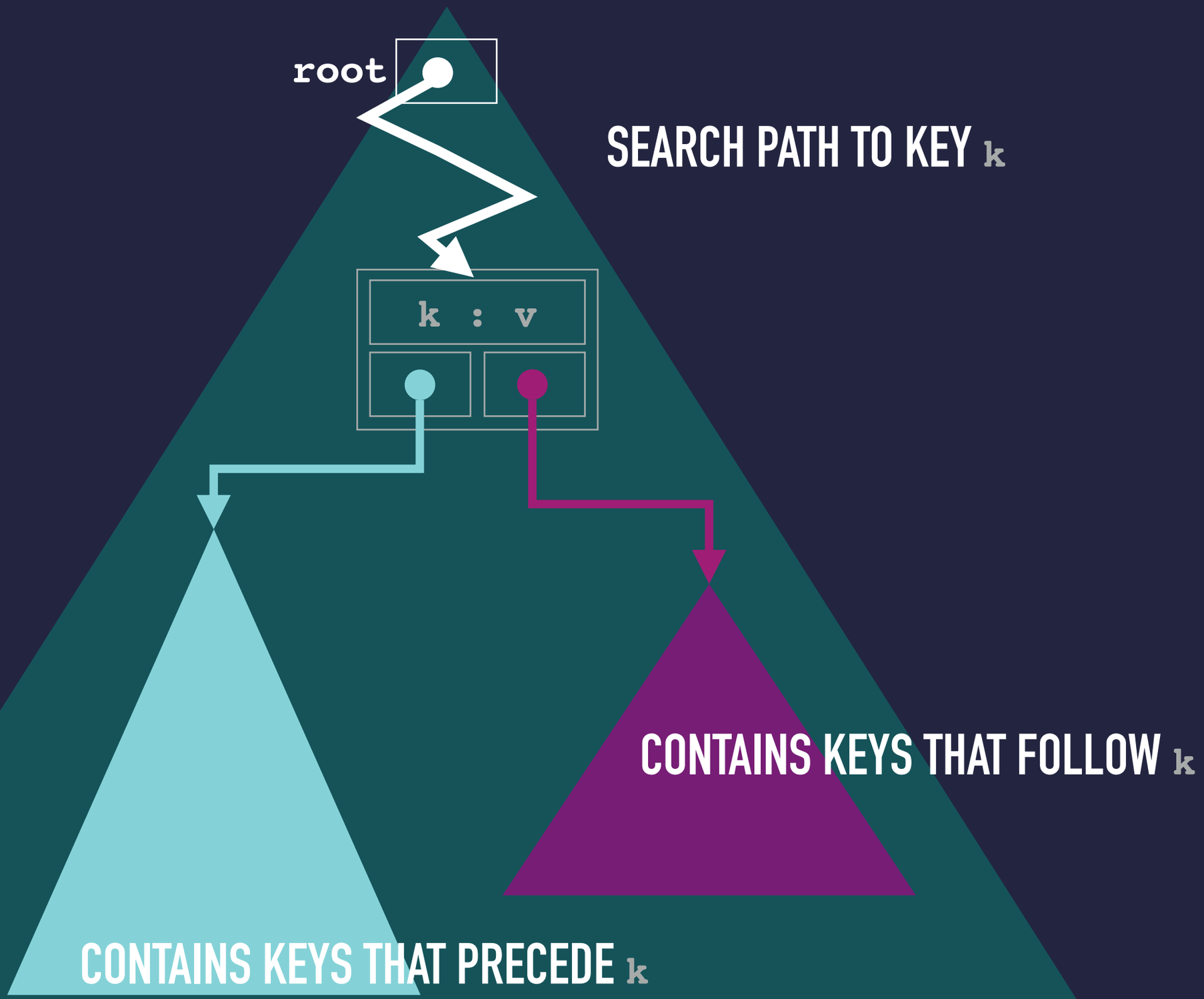
ANOTHER BINARY SEARCH TREE



AND YET ANOTHER BINARY SEARCH TREE



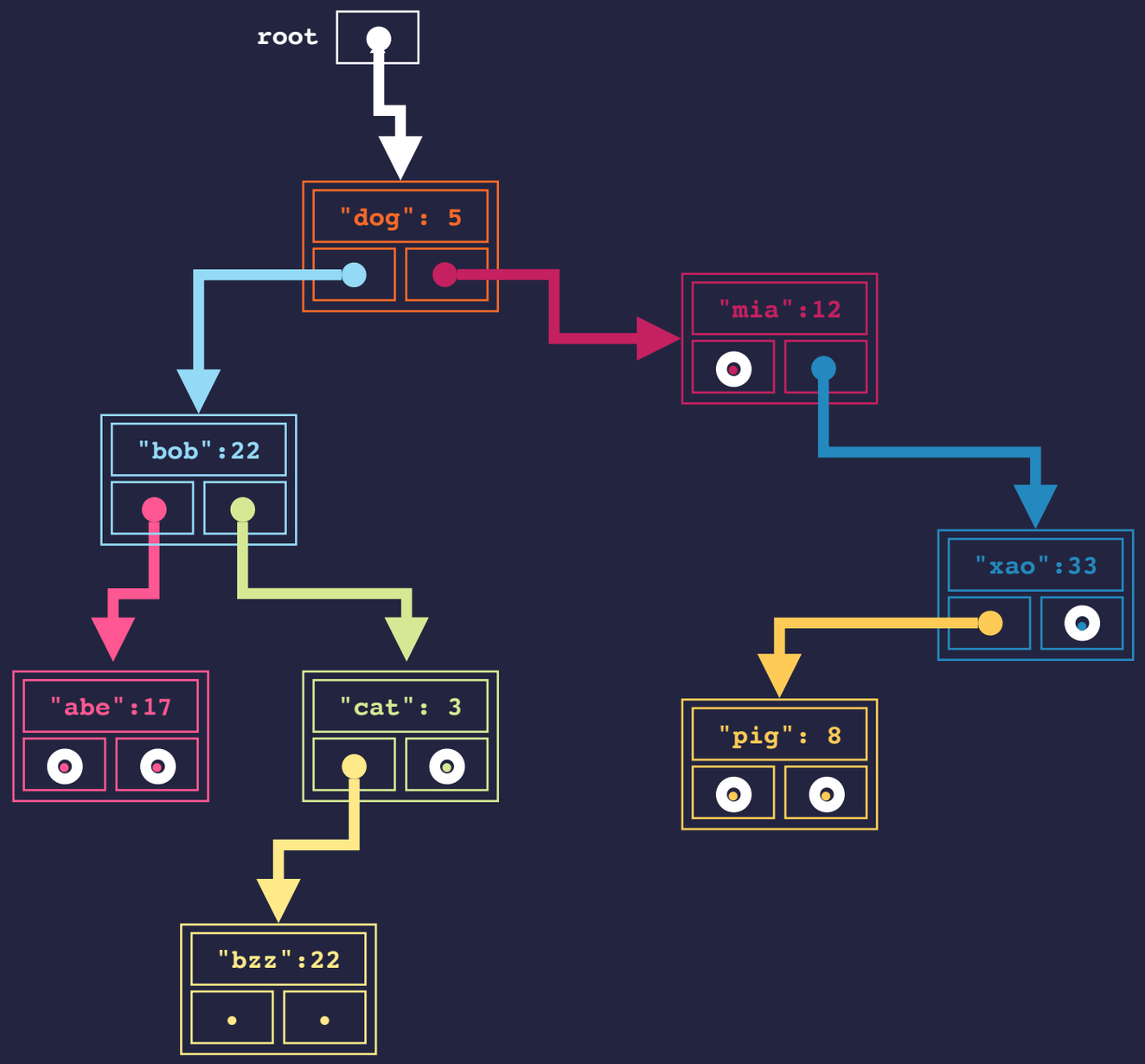
PROPERTIES OF A BINARY SEARCH TREE



SEARCHING FOR AN ENTRY IN A BST

```
class BSTNode:
    def __init__(self,k,v):
        self.key = k
        self.value = v
        self.left = None
        self.right = None
```

```
def search(root,k):
    curr = root
    while curr is not None:
        if k == curr.key:
            return curr.value
        if k < curr.key:
            curr = curr.left
        if k > curr.key:
            curr = curr.right
    return None
```



BINARY SEARCH TREES

- Binary search trees are a way of keeping track of a ***sorted*** collection.
- Here, we are using them as an *ordered dictionary*.
- For our dictionaries, there is at most one entry per key.
- The link structure sorts the entries; maintains a sorted order.
  - The keys are usually organized alphabetically when strings.
  - The keys are usually sorted smaller/larger if numbers.
- (Generally, in binary search trees, keys might appear more than once; have multiple entries.)
- (Generally, in binary search trees, the nodes might only contain keys without associated values.)

A BST CLASS

- **Operations:**
  - Adding an entry, ordered according to key.
  - Searching for an entry by key.
  - Removing an entry.
  - Visiting/traversing all the entries in sorted order.
- The first three operations rely on a *search*.
  - This works from the root, moving left or right.
- An *in-order traversal* is a recursive method. Example: printing all the entries
  - You print all of the entries left of the root entry.
  - Then you print the root entry.
  - And then you print all of the entries right of the root entry.

A TOUR OF THE BST CLASS CODE

- **Look at `BSTree.py`**