НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ КОРАБЛЕБУДУВАННЯ ІМЕНІ АДМІРАЛА МАКАРОВА

Data Structures and Organization

(p.5 – Recursion. Binary Trees)

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Let’s start with example

Triangular Numbers

- Pythagorians, a band of mathematicians in ancient Greece felt a mystical connection with the series of numbers
  1, 3, 6, 10, 15, 21, …
- Can you find the next member of this series?

The n^{th} term in the series is obtained by adding n to the previous term.

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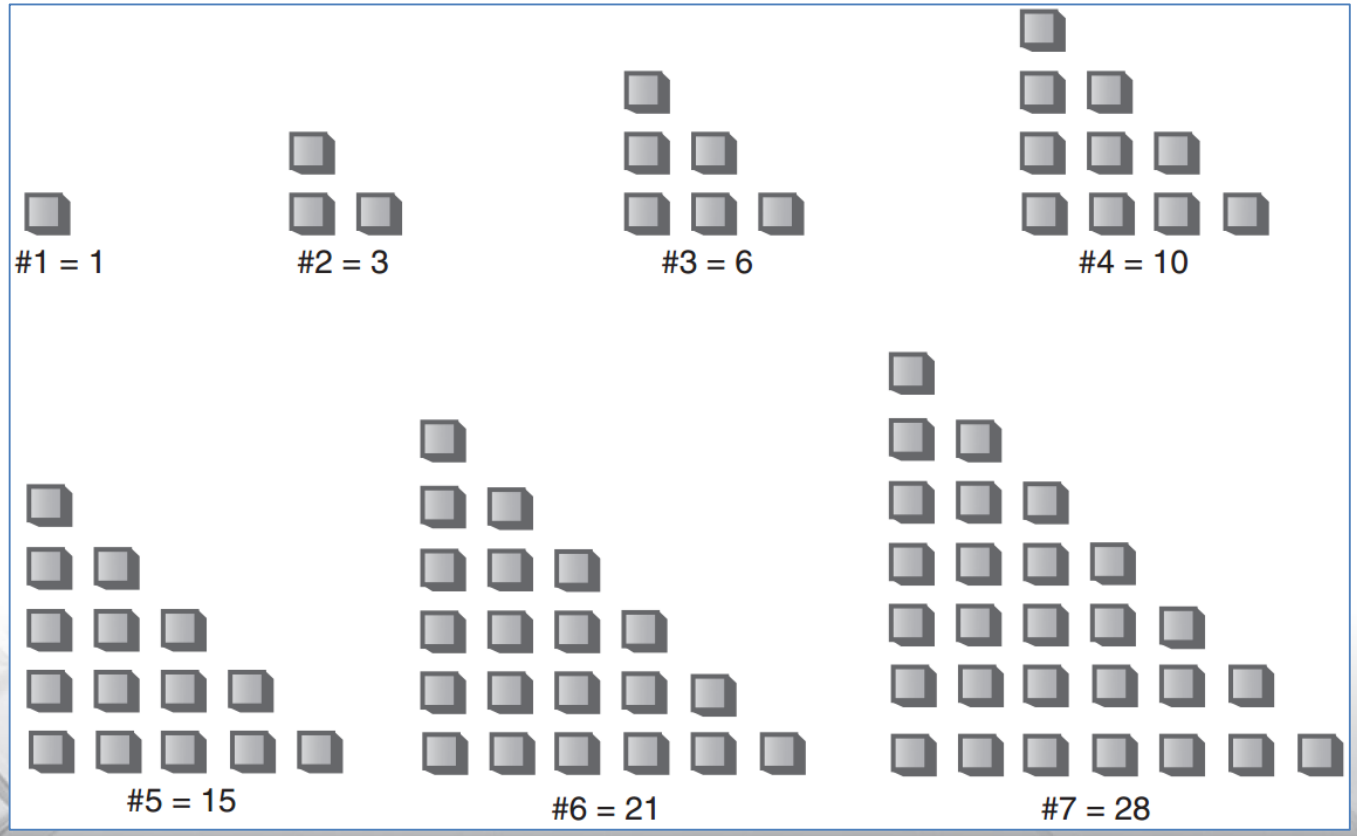
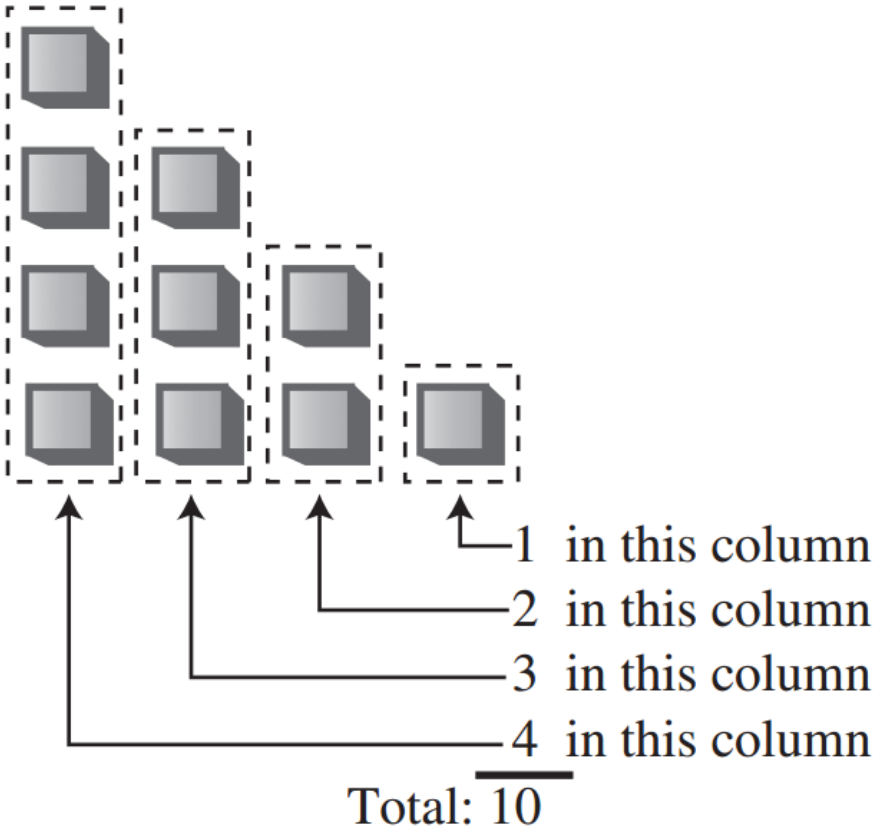
Triangle numbers

The numbers in this series are called triangular numbers because they can be visualized as a triangular arrangement of objects, shown as little squares in Figure



Finding the n^{th} Term Using a Loop




```
int triangle(int n) {
    int total = 0;
    while(n > 0) {
        total += n;
        n--;
    }
    return total;
}
```

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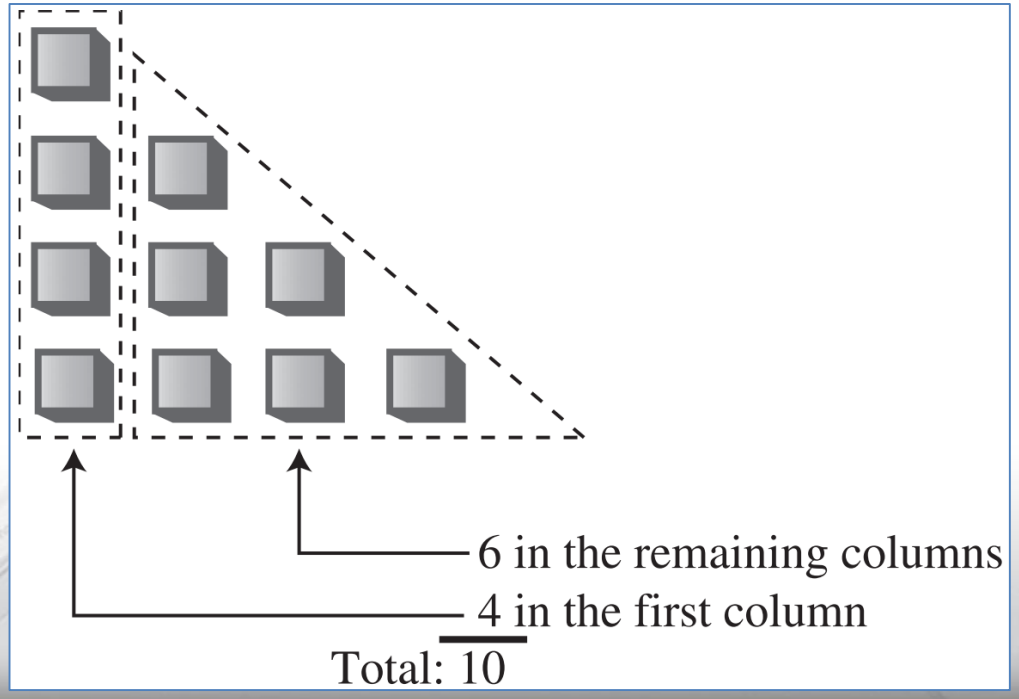
Finding the n^{th} Term Using Recursion

The value of the nth term can be thought of as the sum of only two things, instead of a whole series.
They are:

1. The first (tallest) column, which has the value **n**.
2. The sum of all the remaining columns.



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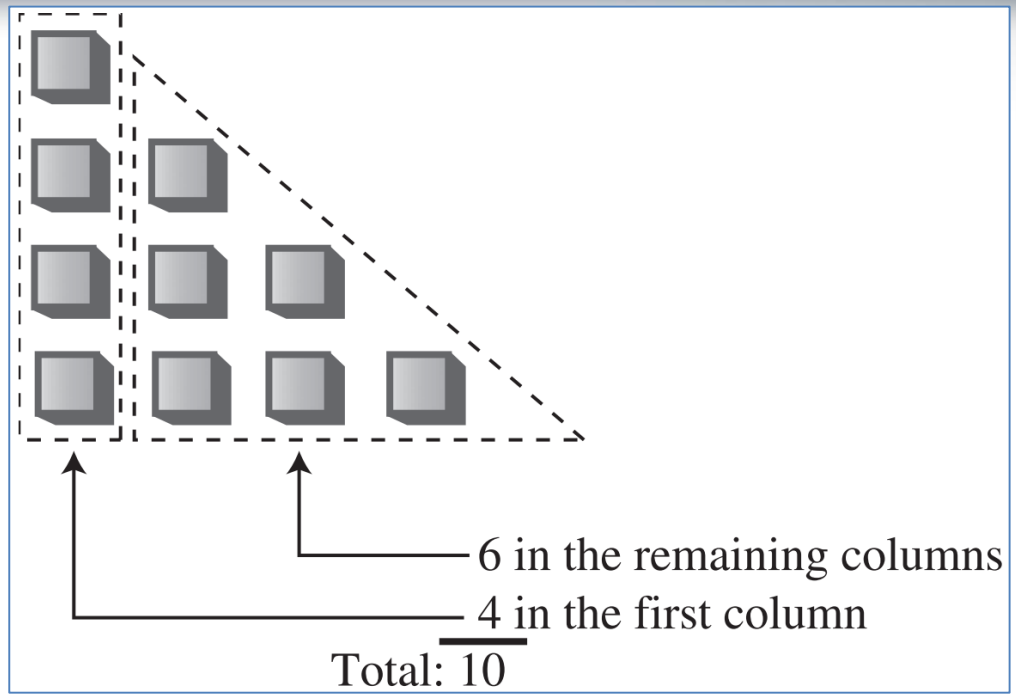
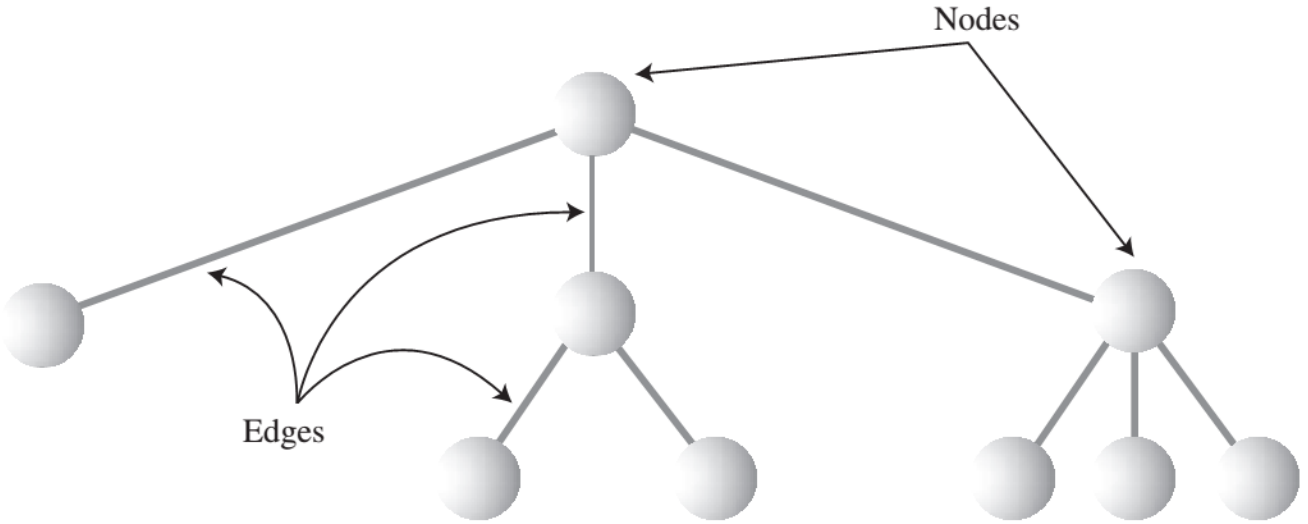
Finding the n^{th} Term Using Recursion




```
int triangle(int n) {
    if(n==1) return 1;
    return( n + triangle(n-1) );
}
```

What Is a Tree?

- We'll be mostly interested in a particular kind of tree called a *binary tree*, but let's start by discussing trees in general before moving on to the specifics of binary trees.
- A tree consists of *nodes* connected by *edges*. Figure shows a tree. In such a picture of a tree (or in our Workshop applet) the nodes are represented as circles, and the edges as lines connecting the circles.

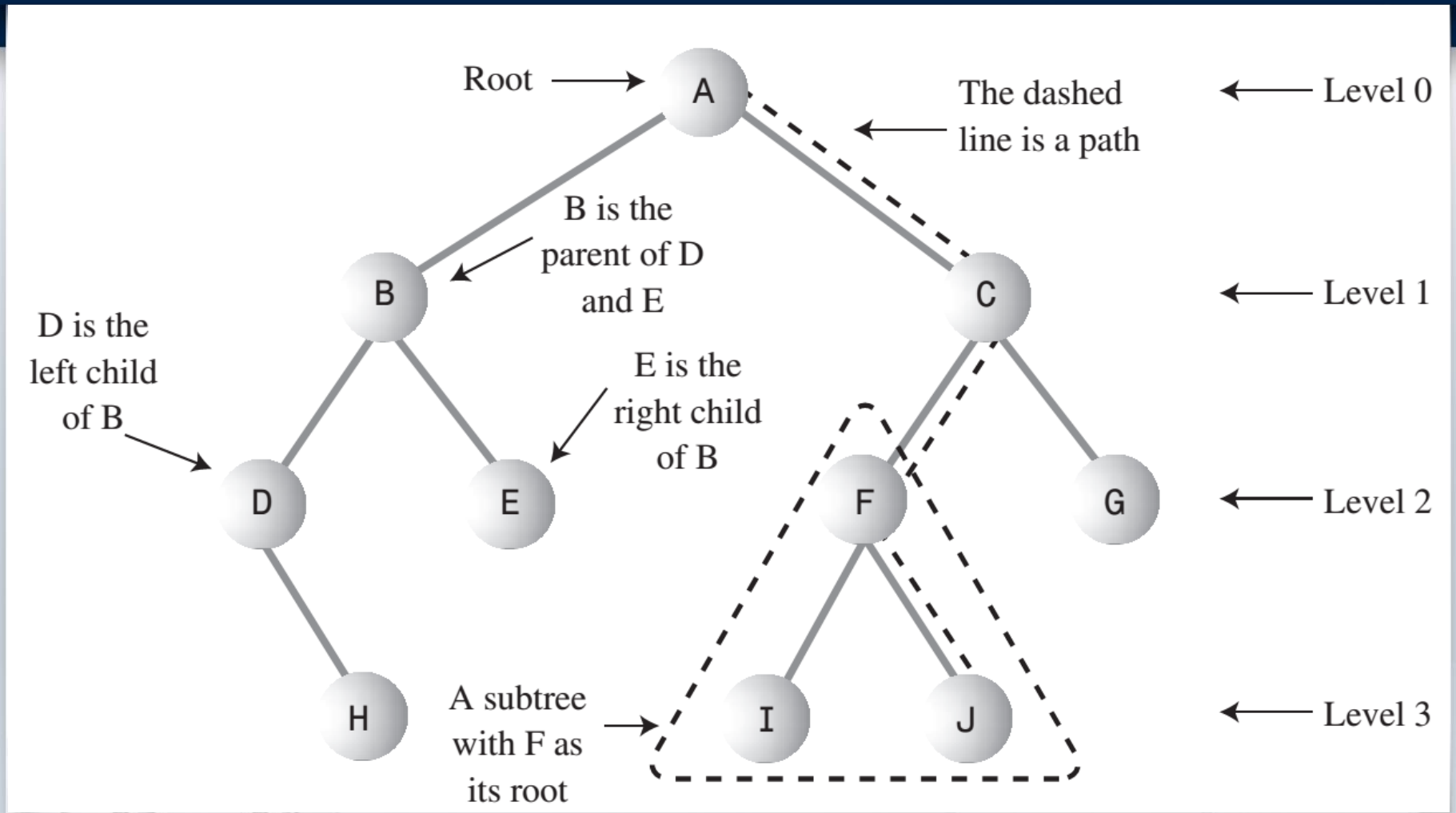


Why Use Binary Trees?

Why might you want to use a tree?

- Usually, because it combines the advantages of two other structures: an ordered array and a linked list.
- You can search a tree quickly, as you can an ordered array, and you can also insert and delete items quickly, as you can with a linked list.

Tree Terminology



H, E, I, J, and G are leaf nodes

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Tree Terminology

Path

Think of someone walking from node to node along the edges that connect them. The resulting sequence of nodes is called a *path*.

Root

The node at the top of the tree is called the *root*. There is only one root in a tree. For a collection of nodes and edges to be defined as a tree, there must be one (and only one!) path from the root to any other node.

Parent

Any node (except the root) has exactly one edge running upward to another node. The node above it is called the *parent* of the node.

Child

Any node may have one or more lines running downward to other nodes. These nodes below a given node are called its *children*.

Tree Terminology

Leaf

A node that has no children is called a *leaf node* or simply a *leaf*. There can be only one root in a tree, but there can be many leaves.

Subtree

Any node may be considered to be the root of a *subtree*, which consists of its children, and its children's children, and so on. If you think in terms of families, a node's subtree contains all its descendants.

Visiting

A node is *visited* when program control arrives at the node, usually for the purpose of carrying out some operation on the node, such as checking the value of one of its data fields or displaying it. Merely passing over a node on the path from one node to another is not considered to be visiting the node.

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Tree Terminology

Traversing

To *traverse* a tree means to visit all the nodes in some specified order. For example, you might visit all the nodes in order of ascending key value. There are other ways to traverse a tree, as we'll see later.

Levels

The *level* of a particular node refers to how many generations the node is from the root. If we assume the root is Level 0, then its children will be Level 1, its grandchildren will be Level 2, and so on.

Keys

We've seen that one data field in an object is usually designated a *key value*. This value is used to search for the item or perform other operations on it. In tree diagrams, when a circle represents a node holding a data item, the key value of the item is typically shown in the circle.

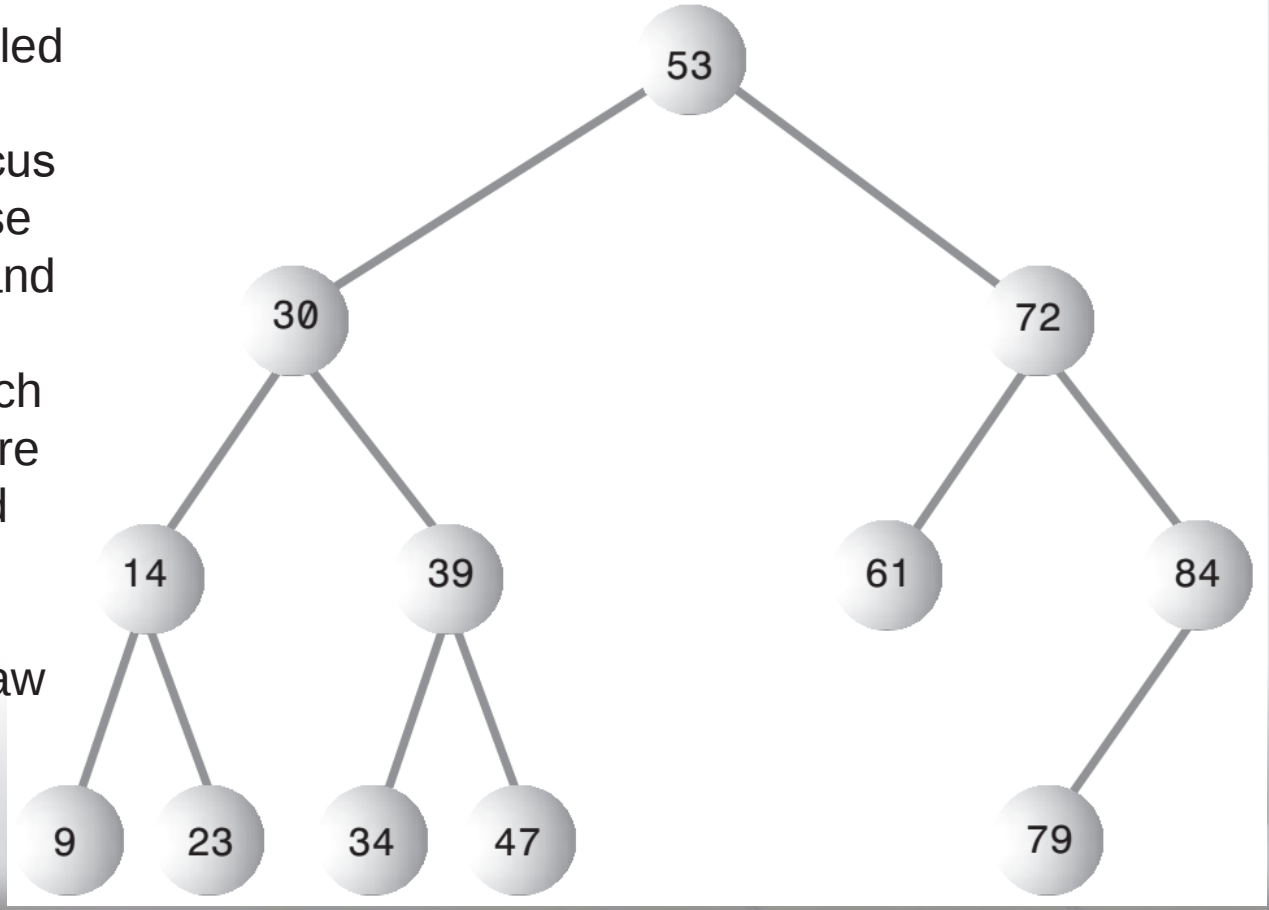
Tree Terminology

Binary Trees

If every node in a tree can have at most two children, the tree is called a *binary tree*.

In this chapter we'll focus on binary trees because they are the simplest and the most common.

The two children of each node in a binary tree are called the *left child* and the *right child*, corresponding to their positions when you draw a picture of a tree, as shown in Figure



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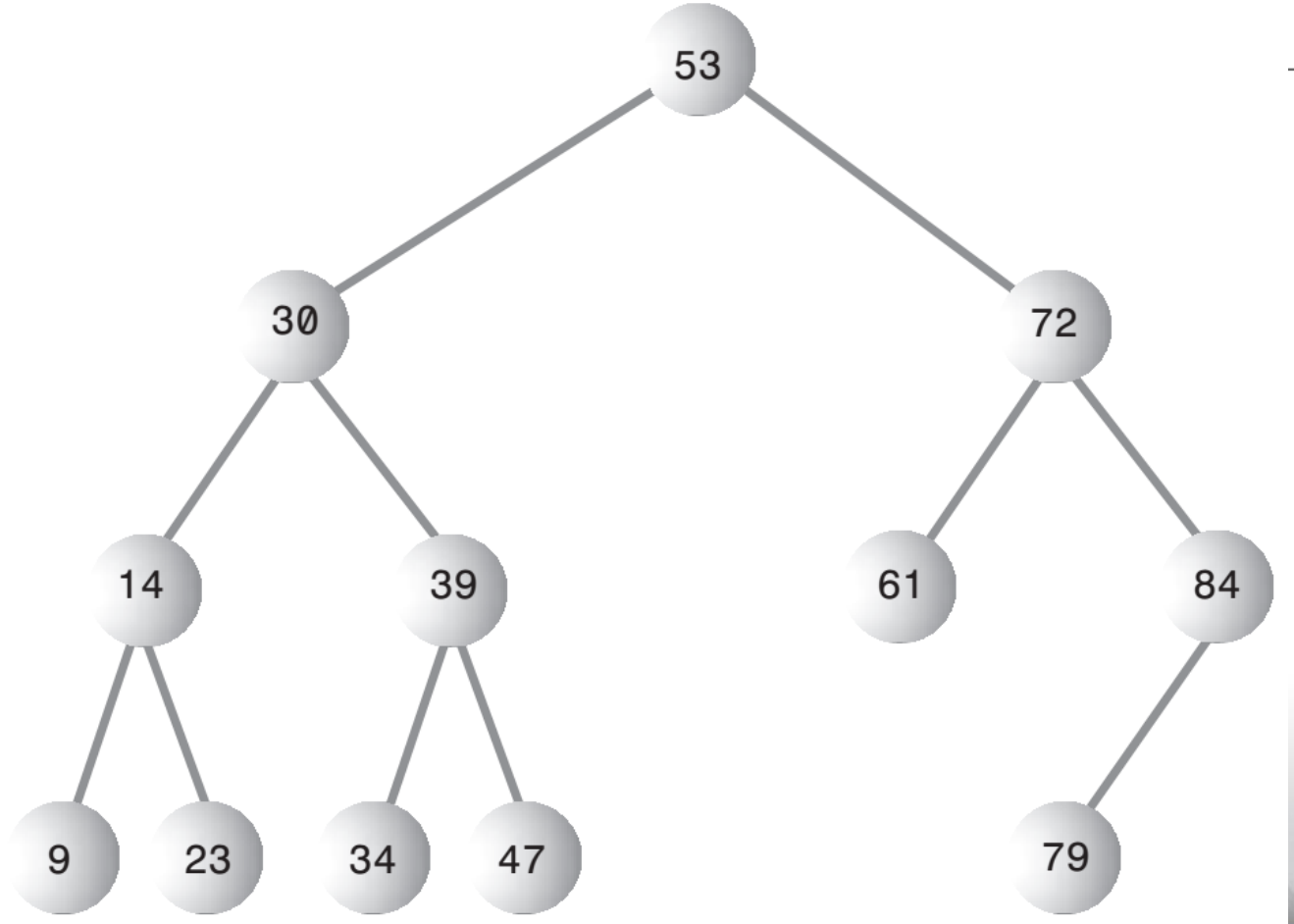
Tree Terminology

NOTE

The defining characteristic of a binary search tree is this: A node's left child must have a key less than its parent, and a node's right child must have a key greater than or equal to its parent.



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Example

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Questions?

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