

CMSC 132: Object-Oriented Programming II



Collection Abstractions & Java Collections

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Collection

- Programs represent and manipulate **abstractions** (chunks of information)
 - Examples: roster of students, deck of cards, a Tetromino
- One of the most universal abstractions is a **collection**
 - Represents an aggregation of multiple objects
 - Plus, perhaps, a relation between elements
 - Examples: list, set, ordered set, map, array, tree
 - Supporting different operations

Data Structures

- **Data structure**

- A way of representing & storing information

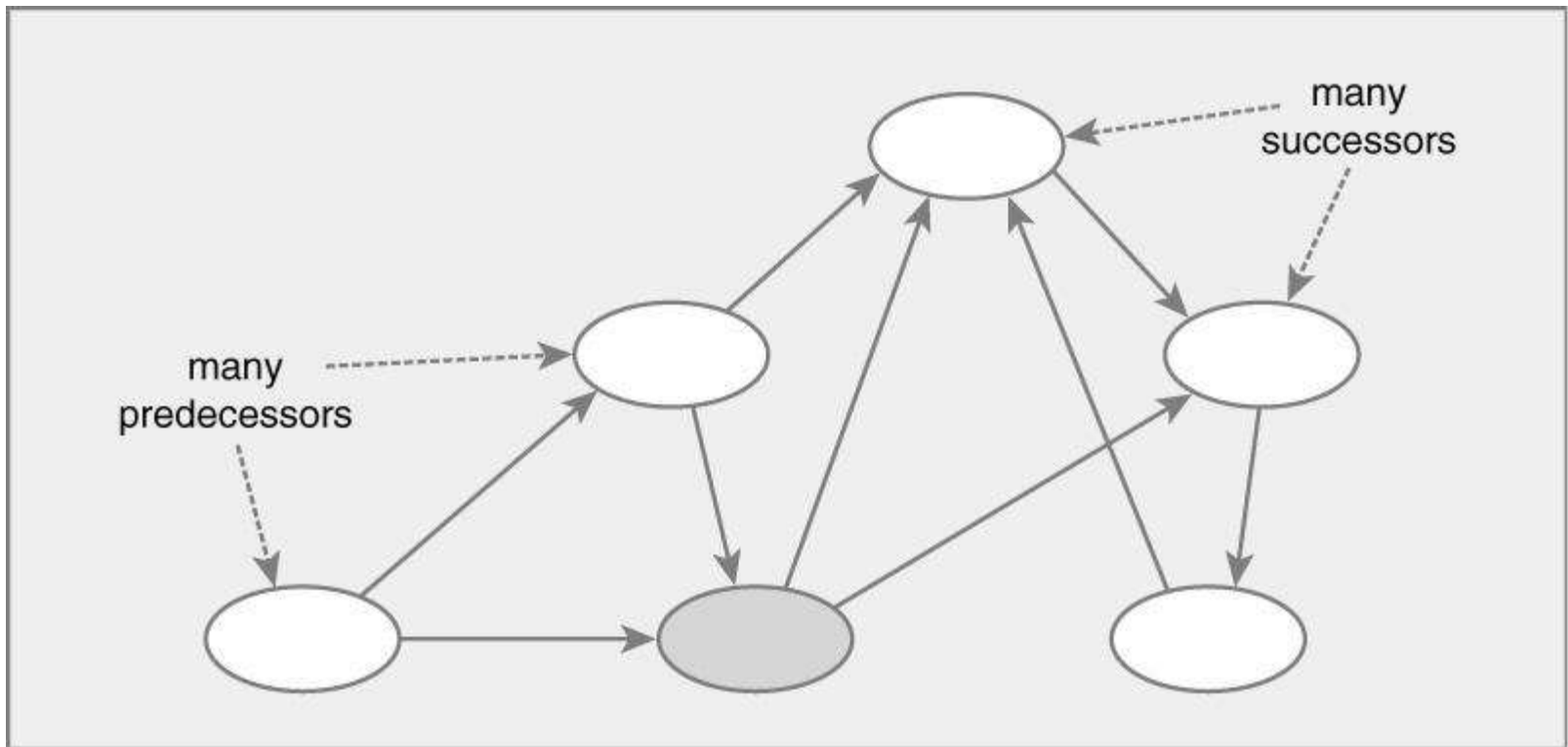
- **Choice of data structure affects**

- Abstractions supported
 - Amount of storage required
 - Which operations can be **efficiently** performed

- **Collections may be implemented using many different data structures**

Graph Abstractions

- Many-to-many relationship between elements
 - Each element has **multiple** predecessors
 - Each element has **multiple** successors



Graph abstractions

- **Undirected graph**

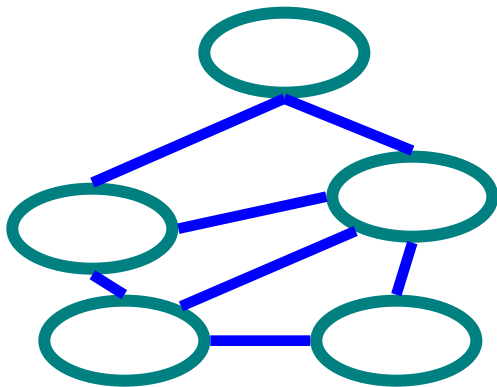
- Undirected edges

- **Directed graph**

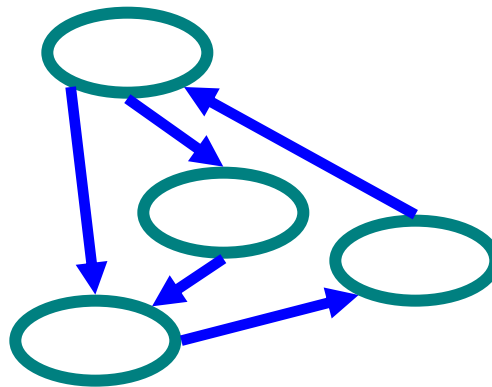
- Directed edges

- **Directed acyclic graph (DAG)**

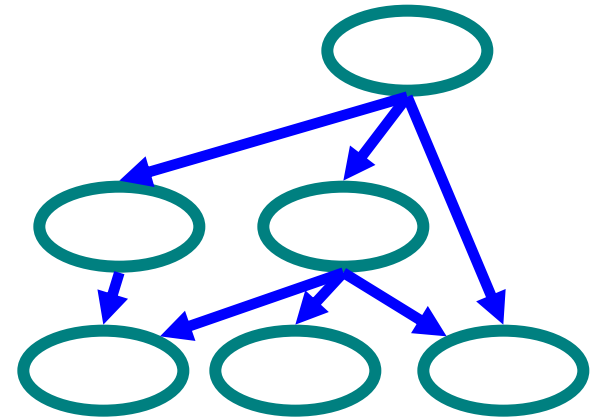
- Directed edges, no cycles



Undirected



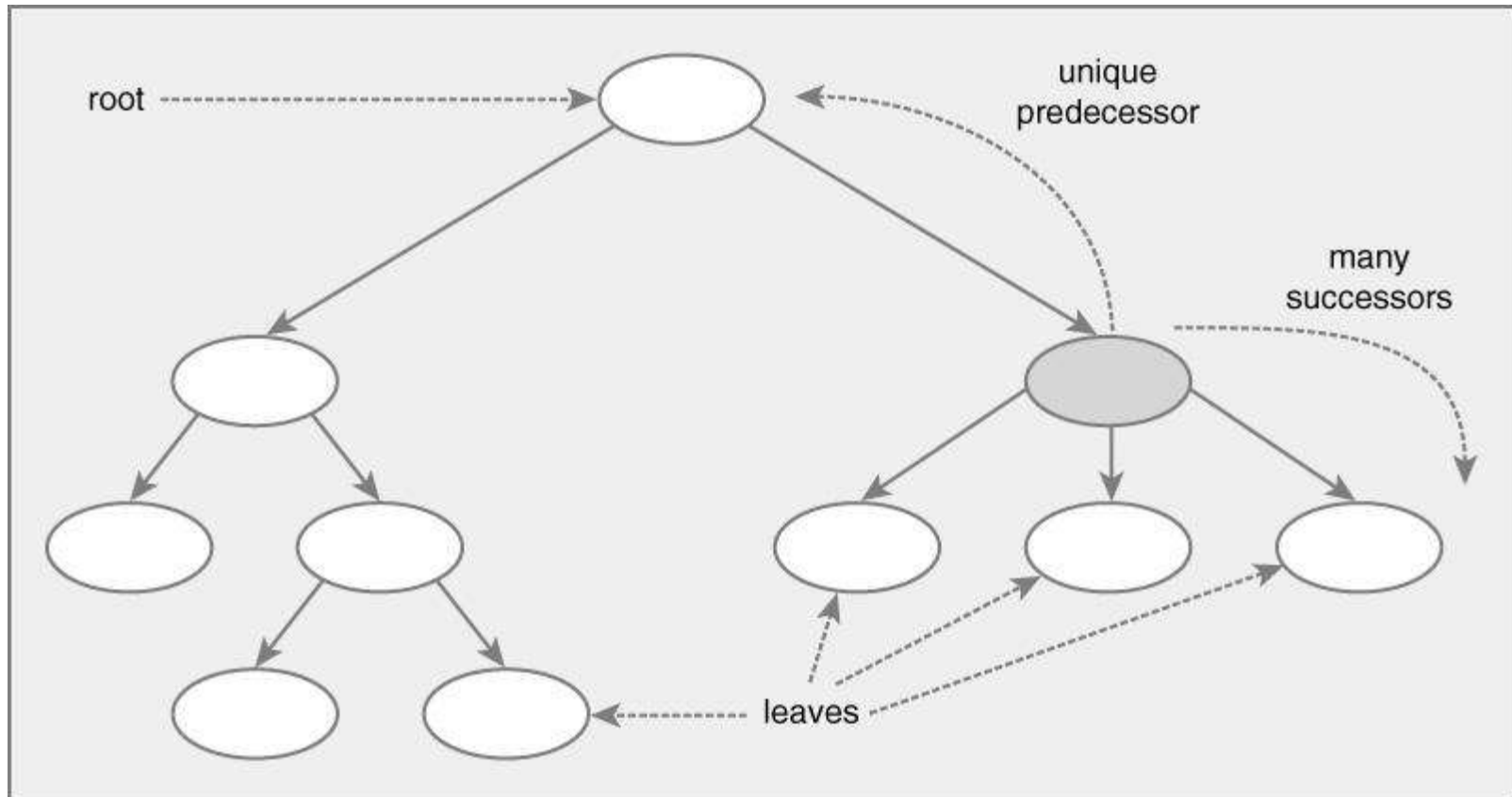
Directed



DAG

Tree abstractions

- One-to-many relationship between elements
 - Each element has **unique** predecessor
 - Each element has **multiple** successors



Tree Abstractions

■ Forest

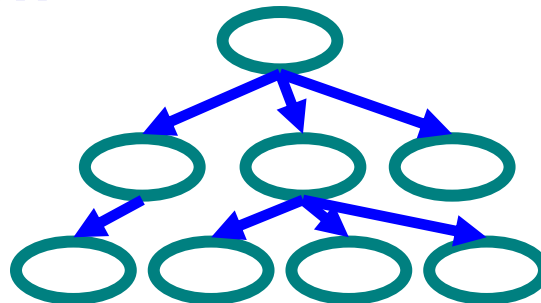
- DAG, but each node has at most one edge to it (from a parent)

■ Tree

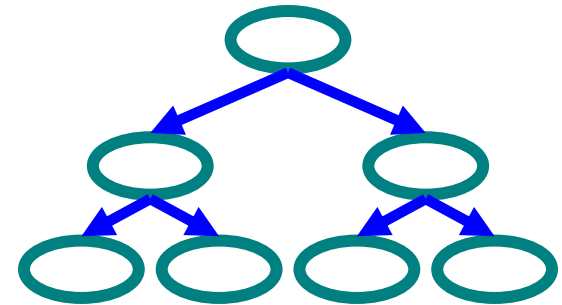
- Forest with only one node (the root) that doesn't have a parent

■ Binary Tree

- A tree where each node has at most 2 children



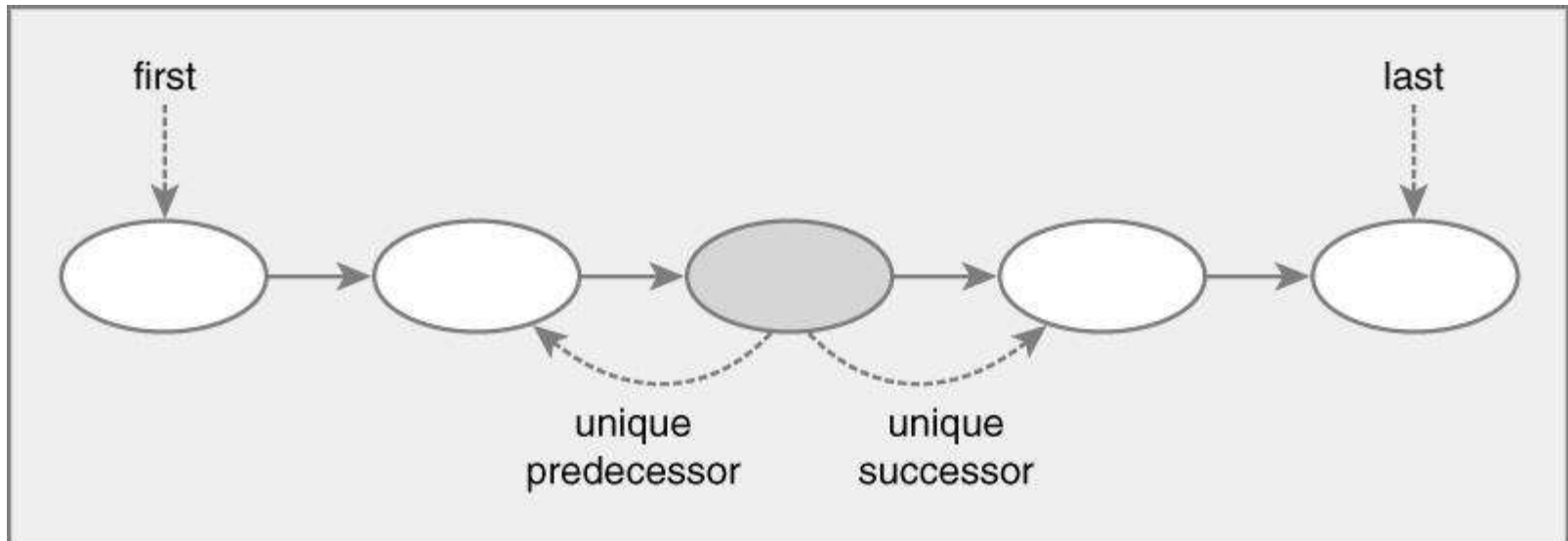
Tree



Binary Tree

Sequence Abstractions

- One-to-one relationship between elements
 - Each element has **unique** predecessor
 - Each element has **unique** successor



Sequences or Ordered Collections

■ List

- A sequence of elements
- The user of this interface has precise control over where in the list each element is inserted.
- The user can access elements by their integer index (position in the list), and search for elements in the list.

Limited Sequences

■ Queue

- Can add only at the tail
- Can only access or remove at the head
- First-in, First-out (FIFO)

■ Stack

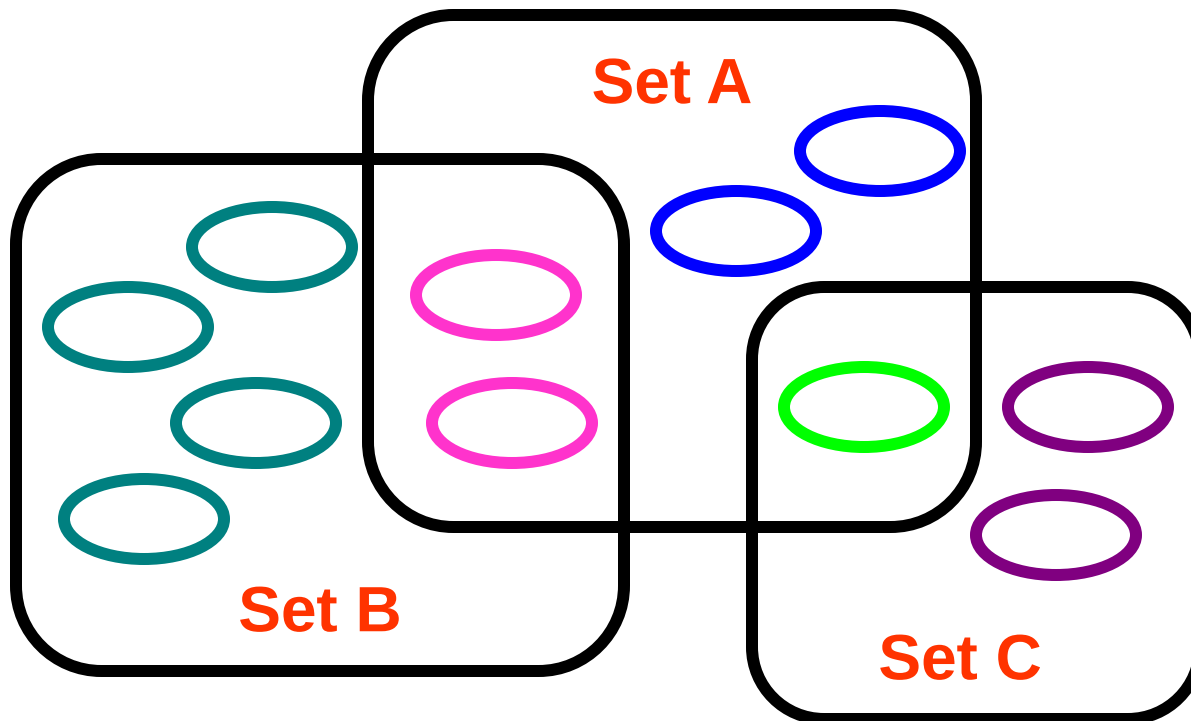
- Can add only at the top
- Can only access or remove at the top
- Last-in, First-out (LIFO)

■ Deque: double ended queue

- Can add, access or remove at either end

Set Data Structures

- No relationship between elements
 - Elements have **no** predecessor / successor
 - Only **one** copy of element allowed in set



Set Abstractions

■ Set

- E.g., {Mitt, Mike, John, Ron}

■ Map

- Like a set, but each element in the set is mapped to a value
- E.g., {Mitt=280, Mike=243, John=843, Ron=14}

■ SortedSet

- Elements must be comparable, or a comparator must be provided
- Elements can be accessed in order

AbstractionTaxonomy

■ Classification scheme for data structures

- Based on relationships between element

■ Category

- Graph
- Hierarchical
- Linear
- Set

Relationship

many $\Rightarrow$ many

one $\Rightarrow$ many

one $\Rightarrow$ one

no explicit relationship

Desert Island Abstraction

- If you could have only one abstraction with you on a desert island...
- Graph is the most general
 - Can represent any of the other abstractions
 - E.g., A set is a graph with no edges
- But more specific abstractions have advantages
 - Some things are unique and well defined (e.g., first element)
 - Implementations for more specific abstractions can support more efficient operations

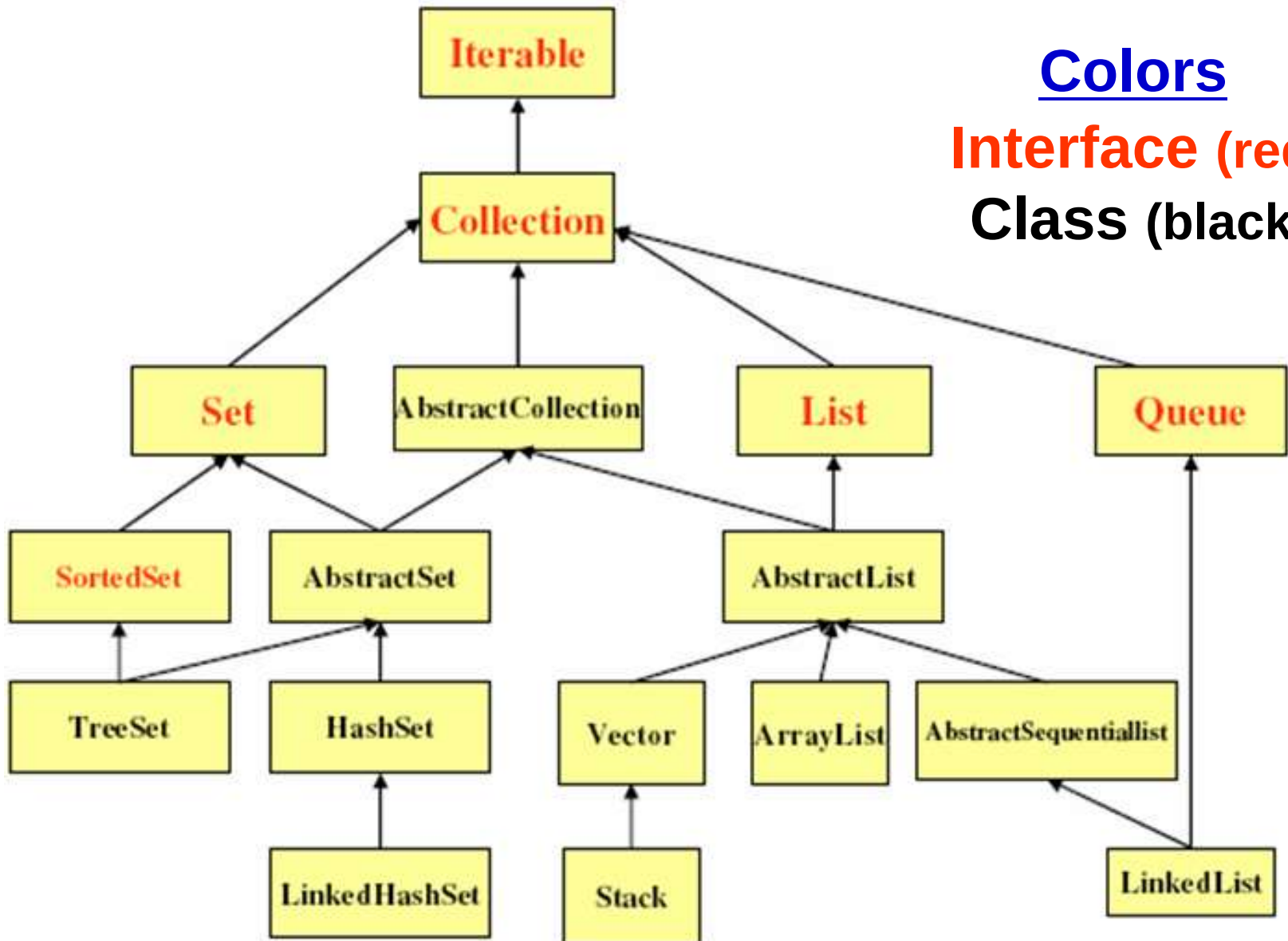
Java Collection Framework (JCF)

- Java provides several interfaces and classes for manipulating & organizing data
 - Example: List, Set, Map interfaces
- Java Collection **Framework** consists of
 - Interfaces
 - Abstract data types
 - Implementations
 - Reusable data structures
 - Algorithms
 - Reusable functionality

Collection Hierarchy

Colors

Interface (red)
Class (black)



Collection Interface

■ Core operations

- Add element
- Remove element
- Determine size (# of elements)
- Iterate through all elements

■ Additional operations supported by some collections

- Find first element
- Find k^{th} element
- Find largest element
- Sort elements

Collection vs. Collections

■ Collection

■ Interface

- Root interface of collection hierarchy

- Methods: `add()`, `contains()`, `remove()`, `size()`

■ Collections

■ Class

- Contains static methods that operate on collections

- Methods: `shuffle()`, `copy()`, `list()`