CMSC 132:
Object-Oriented Programming II

Collection Abstractions & Java Collections

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Collection

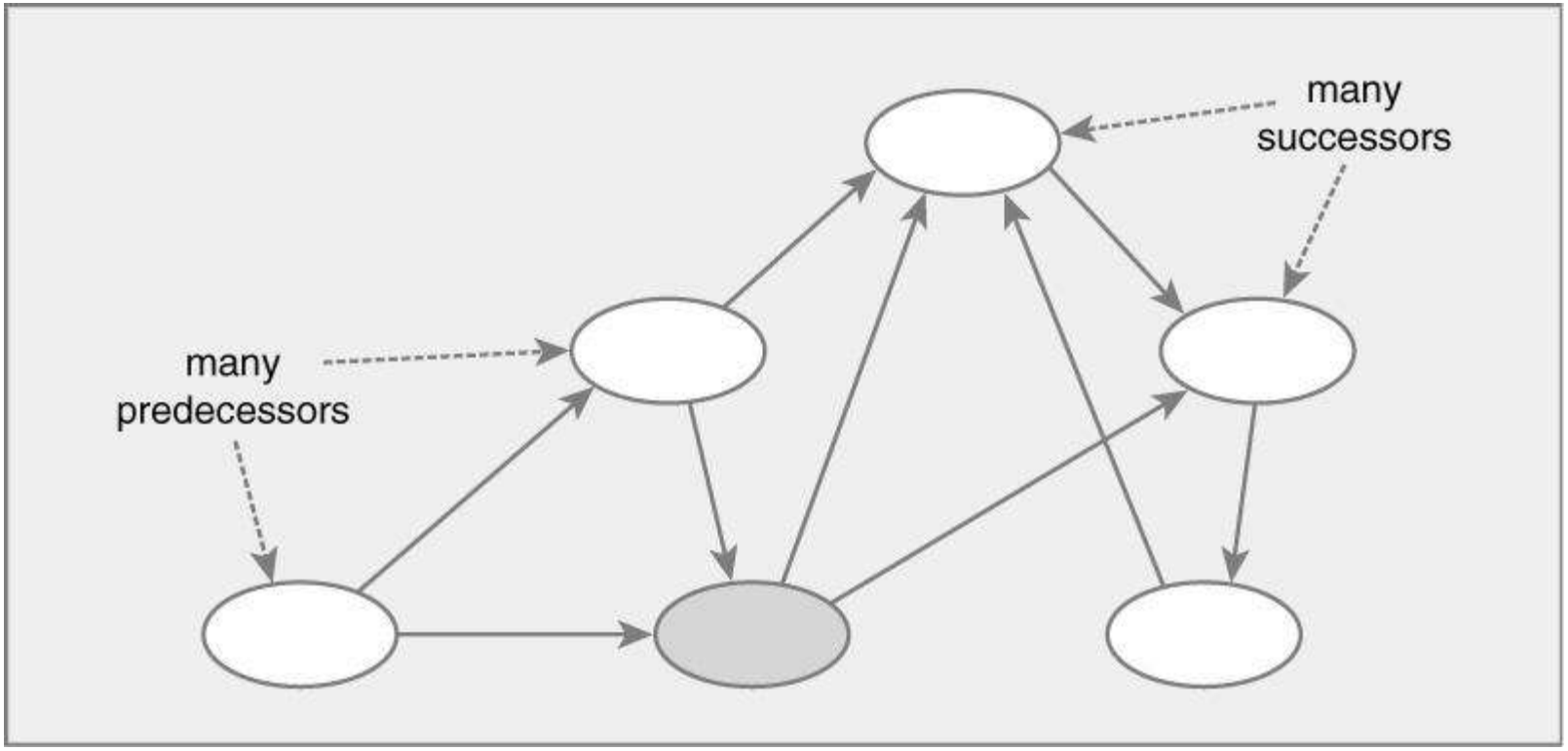
- **Programs represent and manipulate abstractions (chunks of information)**
  - **Examples: roster of students, deck of cards, a Tetromino**
- **One of the most universal abstractions is a collection**
  - **Represents an aggregation of multiple objects**
  - **Plus, perhaps, a relation between elements**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

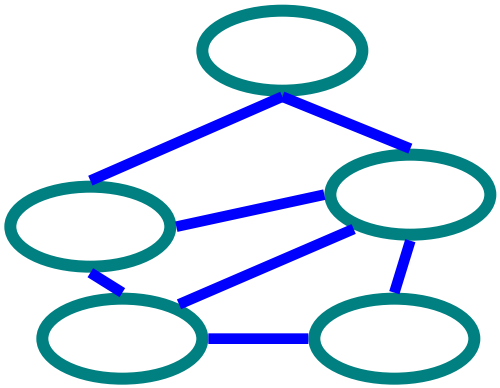
Graph Abstractions

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

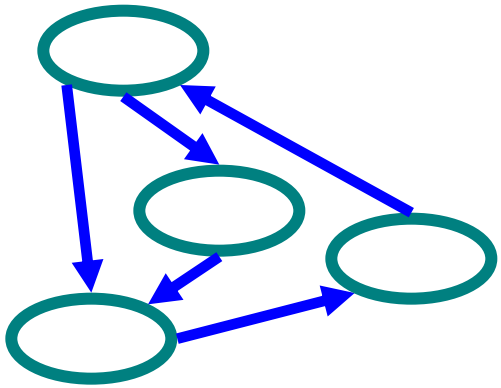


Graph abstractions

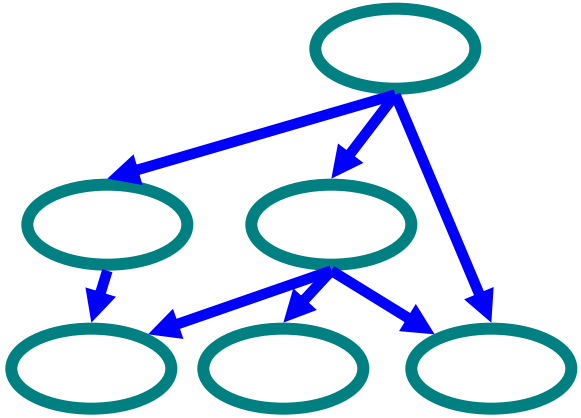
- **Undirected graph**
  - **Undirected edges**
- **Directed graph**
  - **Directed edges**
- **Directed acyclic graph (DAG)**
  - **Directed edges, no cycles**



Undirected



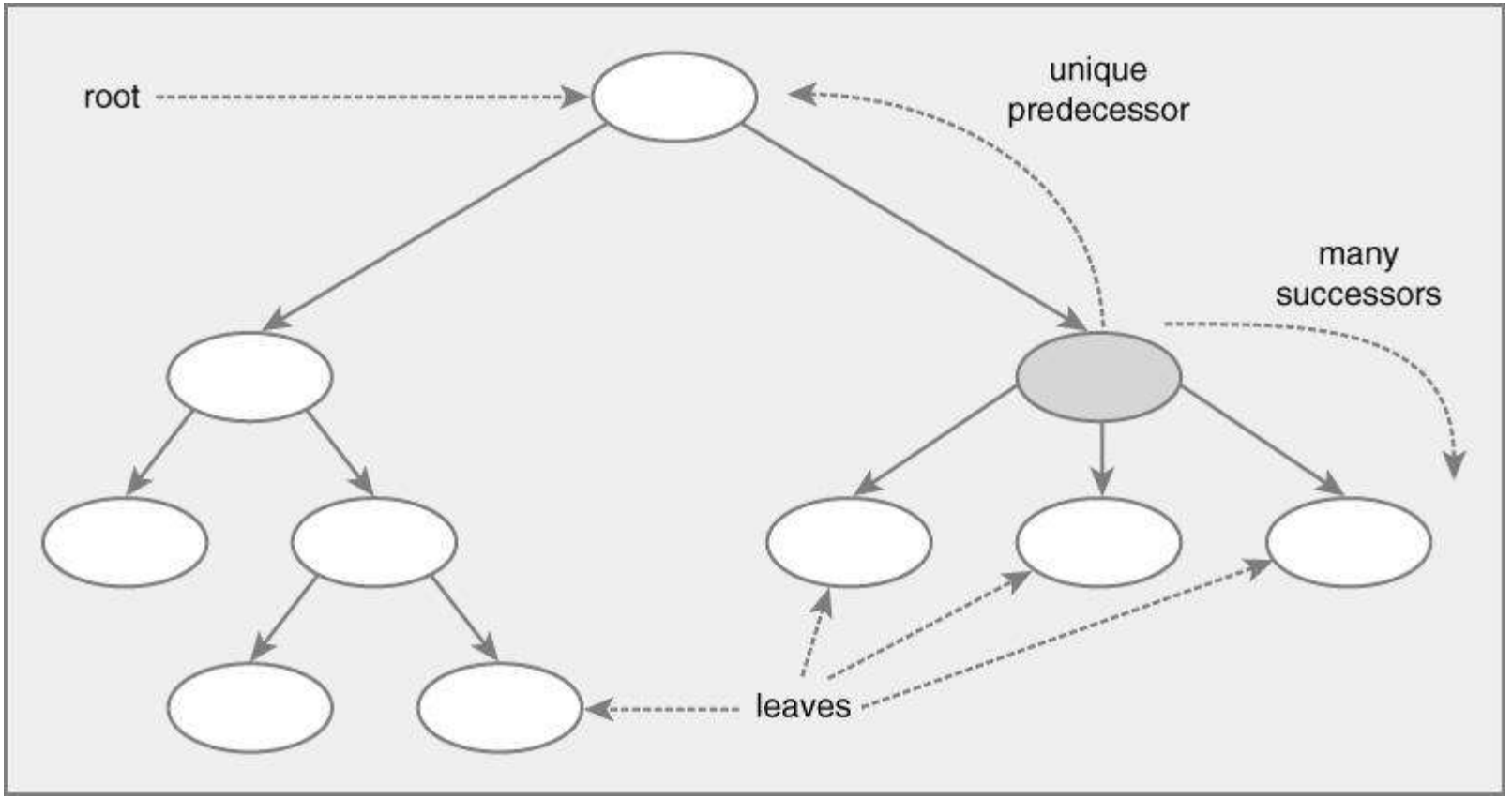
Directed



DAG

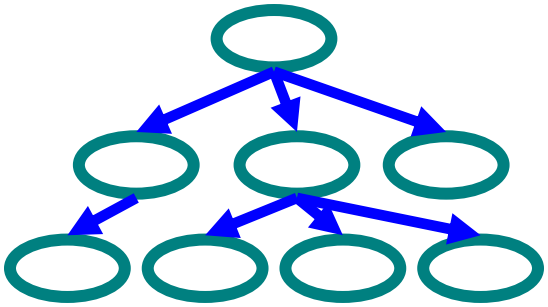
Tree abstractions

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

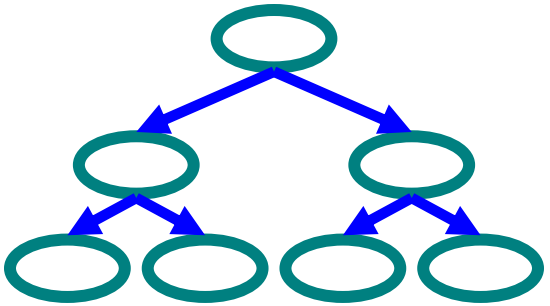


Tree Abstractions

- **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



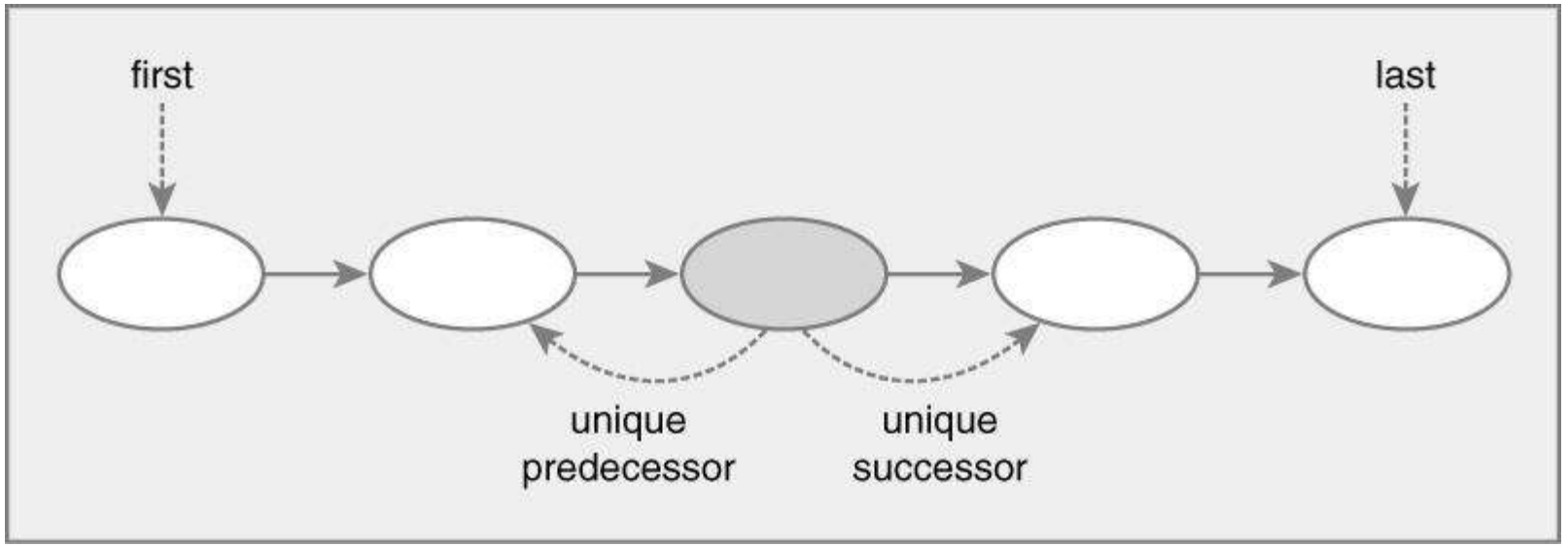
Tree



Binary Tree

Sequence Abstractions

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



Sequences or Ordered Collections

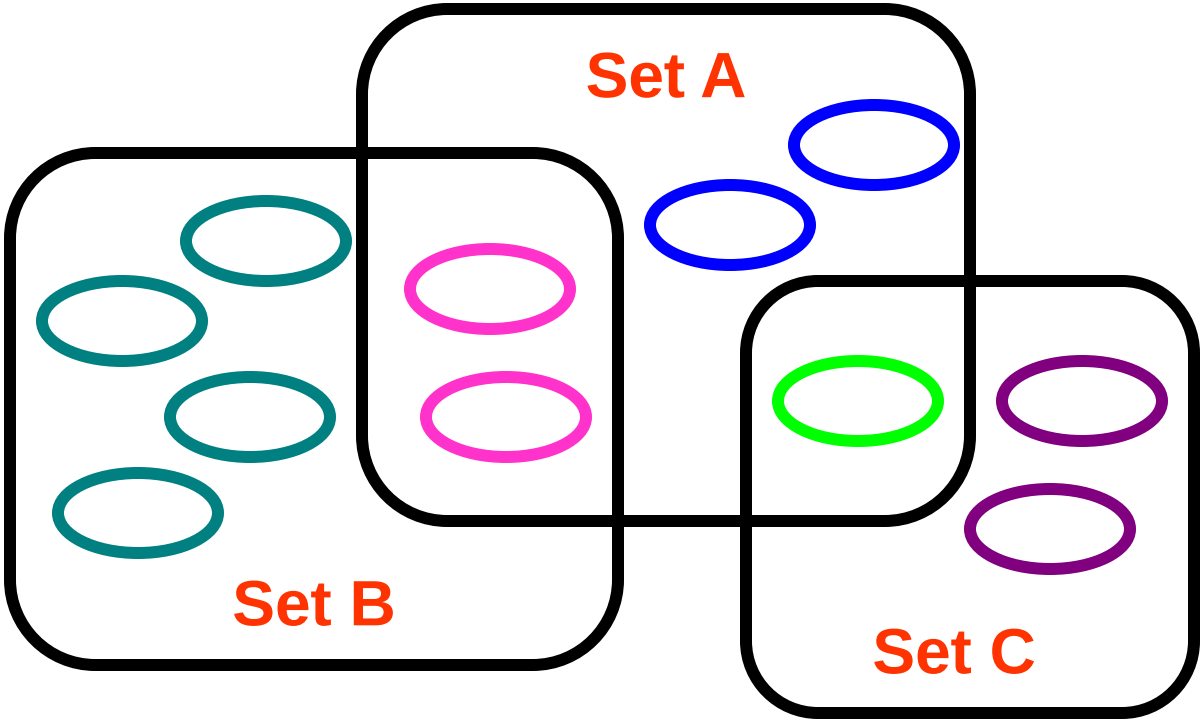
- **List**
  - **A sequence of elements**
  - **The user of this interface has precise control over where in the list each element is inserted.**
  - **The user can access elements by their integer index (position in the list), and search for elements in the list.**

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	Relationship
Graph	many ⇒ many
Hierarchical	one ⇒ many
Linear	one ⇒ one
Set	no explicit relationship

Desert Island Abstraction

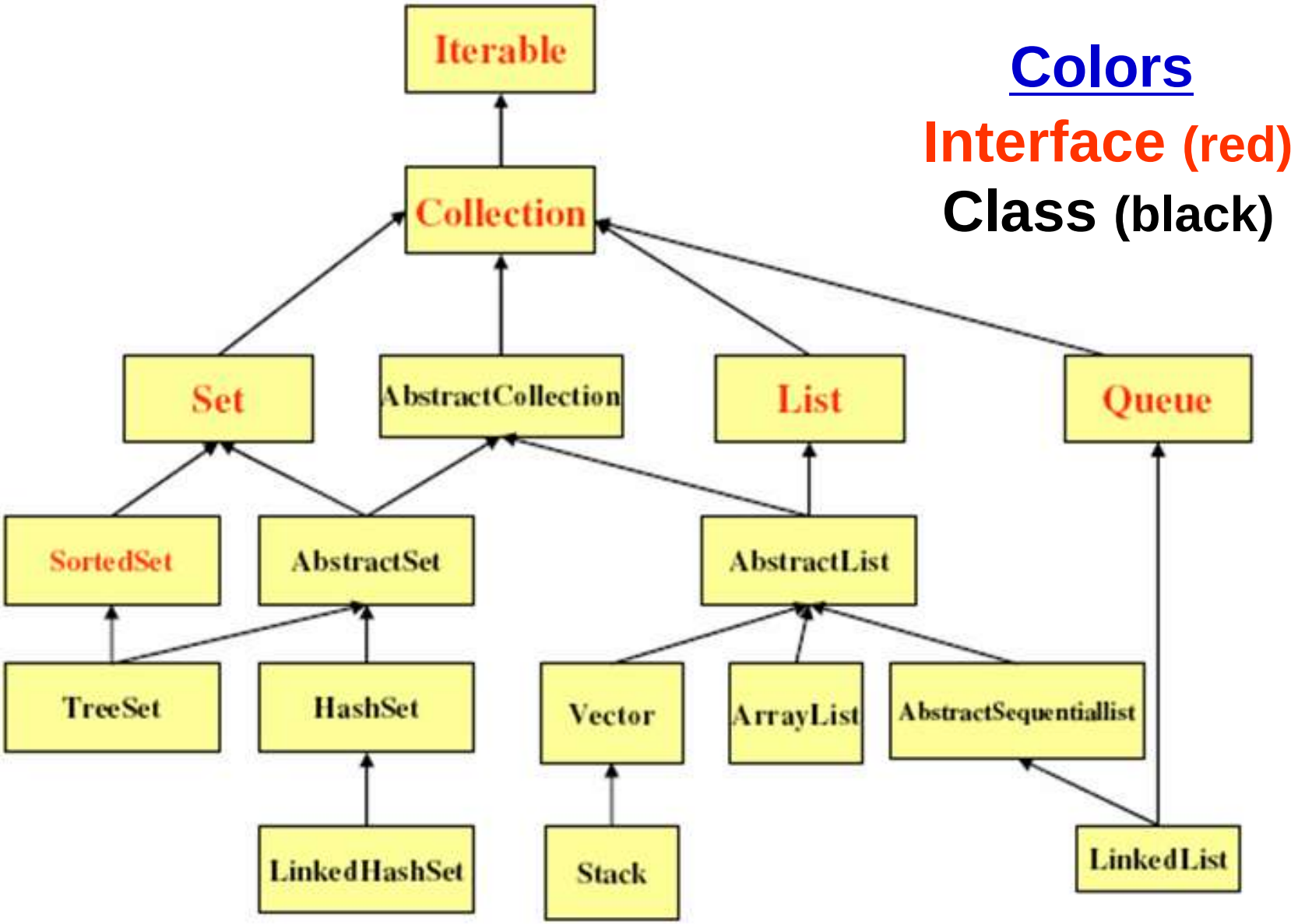
- If you could have only one abstraction with you on a desert island…
- Graph is the most general
  - Can represent any of the other abstractions
    - E.g., A set is a graph with no edges
- But more specific abstractions have advantages
  - Some things are unique and well defined (e.g., first element)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