CMSC 132: OBJECT-ORIENTED PROGRAMMING II

Collection Abstractions & Java Collections

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Collection

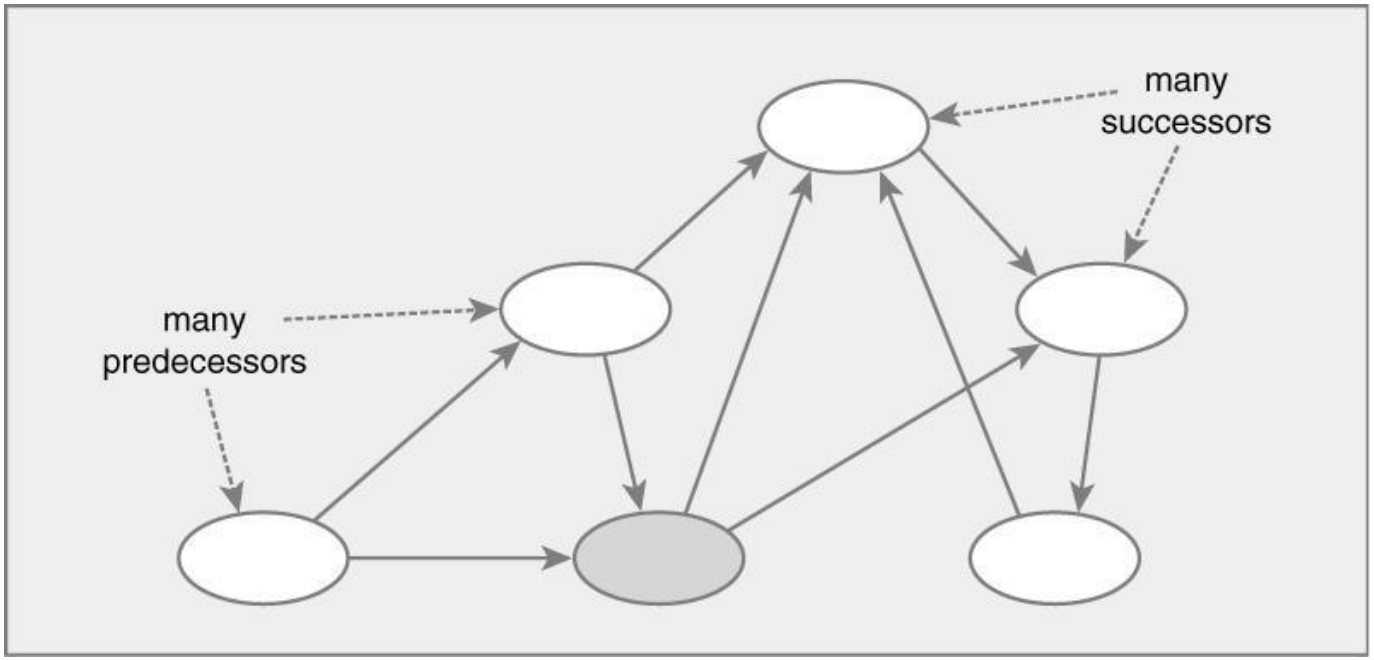
- Programs represent and manipulate abstractions (chunks of information)
  - **Examples:** roster of students, deck of cards
- One of the most universal abstractions is a collection
  - Represents an aggregation of multiple objects
  - Plus, perhaps, a relation between elements
  - **Examples:** list,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

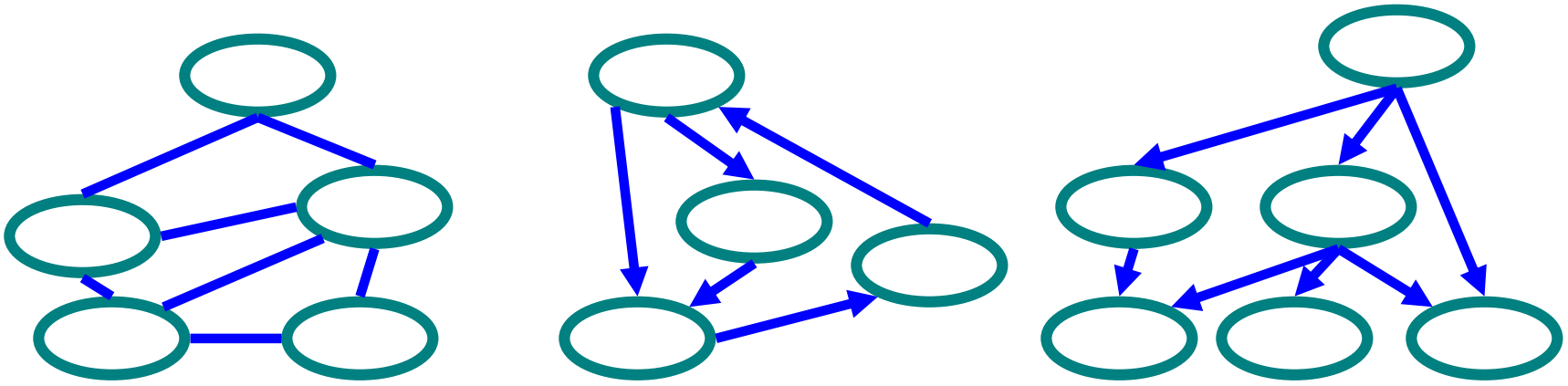
Graph Abstractions

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



Graph abstractions

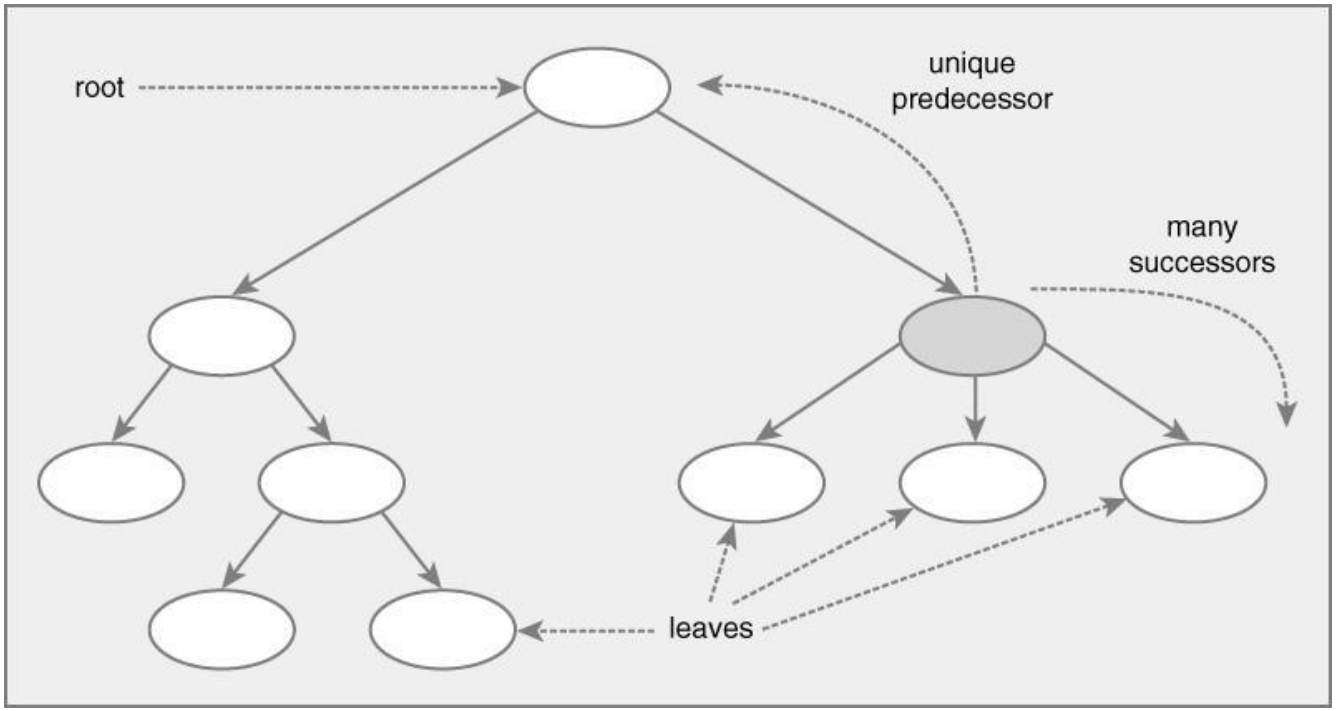
- Undirected graph
  - Undirected edges
- Directed graph
  - Directed edges
- Directed acyclic graph (DAG)
  - Directed edges, no cycles



Undirected **Directed** **DAG**

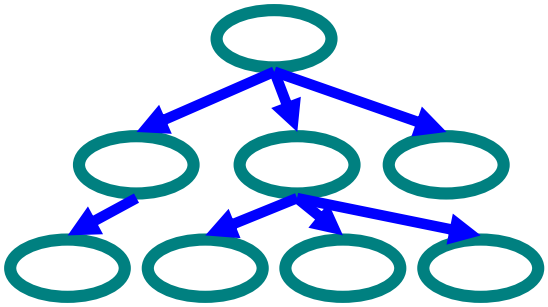
Tree abstractions

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

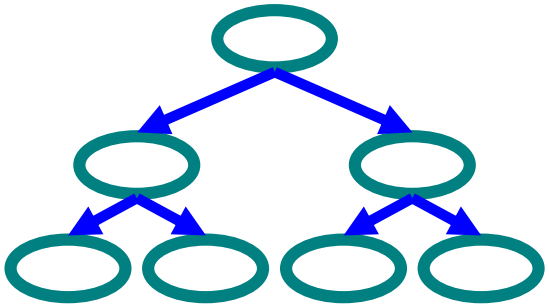


Tree Abstractions

- Tree
  - Only one node (the root) that doesn't have a parent
- Binary Tree
  - A tree where each node has at most 2 children



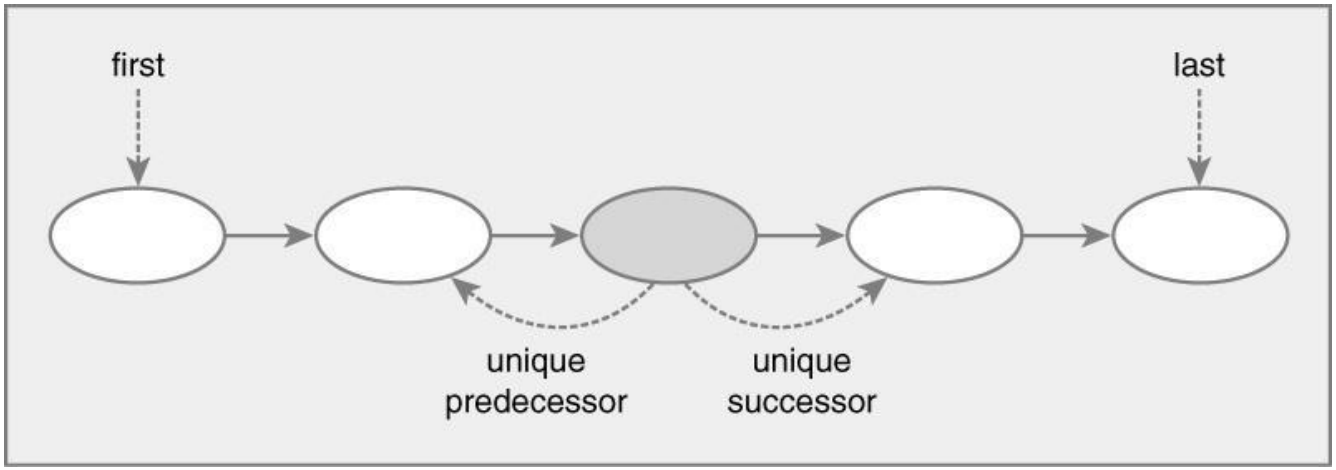
Tree



Binary Tree

Sequence Abstractions

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



Sequences or Ordered Collections

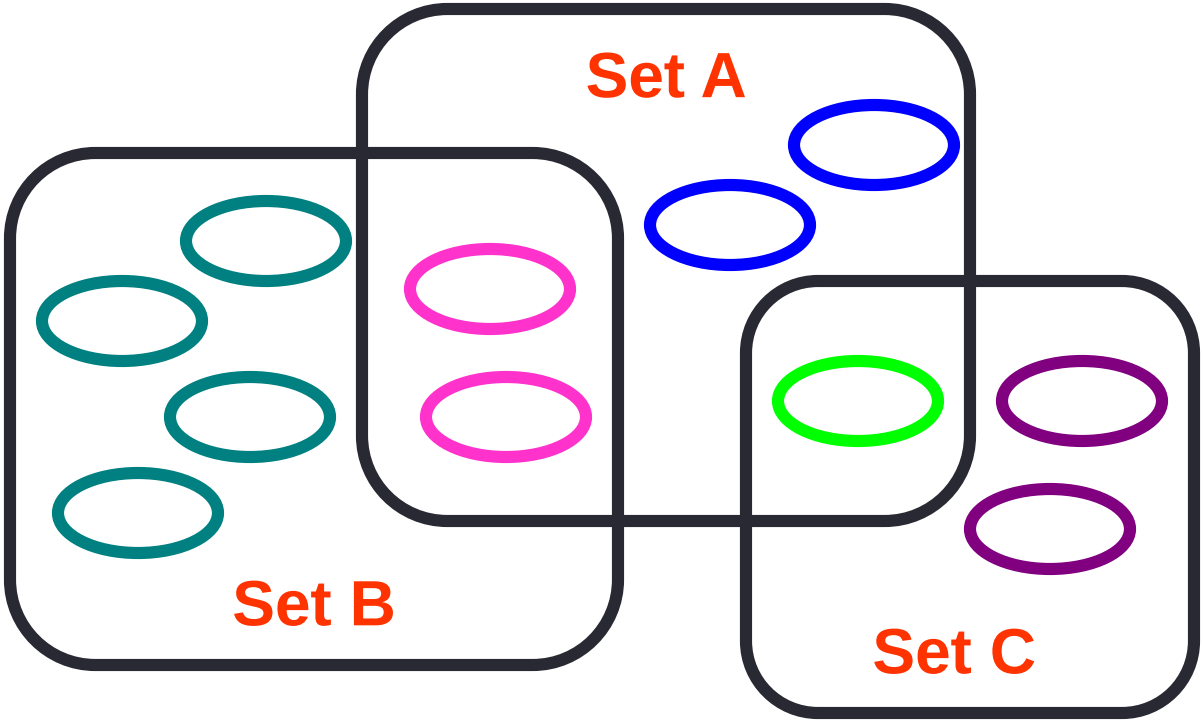
- List
  - A sequence of elements
  - The user of this interface has precise control over where in the list each element is inserted.
  - The user can access elements by their integer index (position in the list), and search for elements in the list.

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



AbstractionTaxonomy

- Classification scheme for data structures
  - Based on relationships between element
- Category — Relationship
  - Graph — many $\Rightarrow$ many
  - Hierarchical — one $\Rightarrow$ many
  - Linear — one $\Rightarrow$ one
  - Set — no explicit relationship

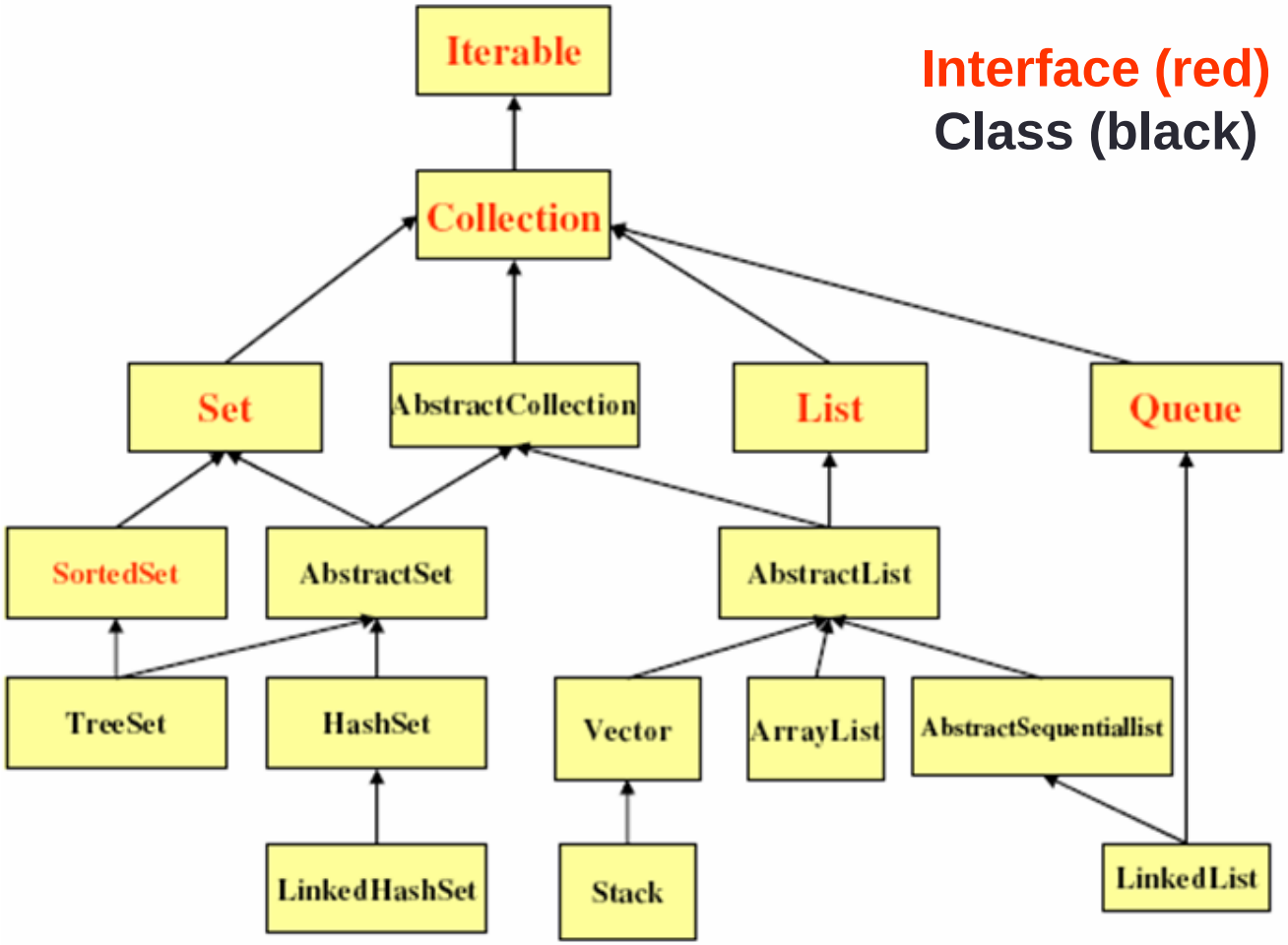
Desert Island Abstraction

- 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



Collection Interface

- http://docs.oracle.com/javase/8/docs/api/java/util/Collection.html
- 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
  - Collections is a class