CMSC 132: Object-Oriented Programming II

Data Structures & 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
  - Different kinds of collections
    - Examples: list, set, ordered set, map, array, tree
  - Supporting different operations on data
Data Structures

Data structure
- A way of representing & storing information

Choice of data structure affects
- Amount of storage required
- Which operations can be efficiently performed

Collections may be implemented using many different data structures
## Data Structures Taxonomy

Classification scheme for data structures

- Based on relationships between element

<table>
<thead>
<tr>
<th>Category</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>one $\Rightarrow$ one</td>
</tr>
<tr>
<td>Hierarchical</td>
<td>one $\Rightarrow$ many</td>
</tr>
<tr>
<td>Graph</td>
<td>many $\Rightarrow$ many</td>
</tr>
<tr>
<td>Set</td>
<td>none $\Rightarrow$ none</td>
</tr>
</tbody>
</table>
Linear Data Structures

One-to-one relationship between elements

- Each element has unique predecessor
- Each element has unique successor
Example Linear Data Structures

- **List**
  - Collection of elements in order

- **Queue**
  - Elements removed in order of insertion
  - First-in, First-out (FIFO)

- **Stack**
  - Elements removed in opposite order of insertion
  - First-in, Last-out (FILO)
Hierarchical Data Structures

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

![Diagram of hierarchical data structures](image)
Example Hierarchical Data Structures

- **Tree**
  - Single root

- **Forest**
  - Multiple roots

- **Binary tree**
  - Tree with 0–2 children per node
Graph Data Structures

- Many-to-many relationship between elements
  - Each element has multiple predecessors
  - Each element has multiple successors
Example Graph Data Structures

- Undirected graph
  - Undirected edges

- Directed graph
  - Directed edges

- Directed acyclic graph (DAG)
  - Directed edges, no cycles
Set Data Structures

- No relationship between elements
  - Elements have no predecessor / successor
  - Only one copy of element allowed in set
Example Set Data Structures

- **Set**
  - Basic set

- **Map**
  - Map value to element in set

- **Hash Table**
  - Maps value to element in set using hash function
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 desirable operations on 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( )