CS2123 Data Structures
ArraySet

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Week03: ArraySet

Outline

1 Set
   - Concept of Set
   - Implementation of SetADT
   - Development Strategy
   - Analysis of Complexity

This Week’s Tasks

- Use the SetADT in simple code
- Case Study: Implement the SetADT collection using an array
- Case Study: Compare three ways to implement a contains operation:
  - Approach 1: Write code in the main method in a test class
  - Approach 2: Write a static method contains in a test class
  - Approach 3: Add contains to the SetADT interface and add an implementation of contains to ArraySet

Set

Definition
A set is a collection of elements, which are related to each other only because they are members of the same set.

- Elements are unique (no duplicate)
- Order is not important

Example
- \( S = \{1, 2, 3, 4\} \)
- \( M = \{\text{Sam}, \text{Marry}, \text{Ken}\} \)
- \( \{1, 2, 3\} = \{3, 2, 1\} = \{2, 1, 3\} \)
public interface SetADT<T> {
    public void add(T element);
    public void addAll(SetADT<T> set);
    public T removeRandom();  
    public T remove(T element);
    public SetADT<T> union(SetADT<T> set);
    public boolean contains(T target);
    public boolean equals(SetADT<T> set);
    public boolean isEmpty();
    public int size();
    public Iterator<T> iterator();
    public String toString();
}

A SetADT can be implemented in several ways depending on how elements are stored.

- Elements can be stored in an array or in a linked list, which is built using references
- Different storage options require different algorithms to implement methods defined in SetADT, leading to different time/space complexities
- Choice of implementation techniques does not change the concept of the SetADT

An ArraySet implements the SetADT by storing elements in an array.

**Design Decisions**

- Use an array of a generic type.
- Add new elements to the end of the array.
  - If necessary, increase the capacity of the array.
- When an element is removed, use the last element to fill the position just opened.
- The iterator of an ArraySet should go thru the array.
  - it must has a references to the array and indexes of the current and the next elements
Incremental Development

- Start with an executable skeleton and keep it executable
- Expand the code gradually
- Use debug code to help trace program execution

Example

- implement constructor, toString(), tester class, and code for debug
- implement contains(), add() and more test code
- implement isEmpty(), size(), expandCapacity(), and more tester code
- implement remove() and add more test code statements
- ......

Algorithm Analysis

Example

The time complexity of add() method in ArrayADT class is $O(n)$.

```java
// O(n)
public void add(T element) {
    if (!contains(element)) { // O(n)
        if (myCt == contents.length) { // O(1)
            expandCapacity(); // O(n)
        }
    }
    contents[myCt] = element; // O(1)
    myCt++; // O(1)
}
```