Sets and Maps

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Set ADT
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Set ADT

Set Description

- **Set** objects are data collections with specific properties:
  - Sets are not indexed
  - Sets are not ordered
  - Sets implement search and information retrieval efficiently
  - Elements can be removed without shifting other elements
  - Elements are unique

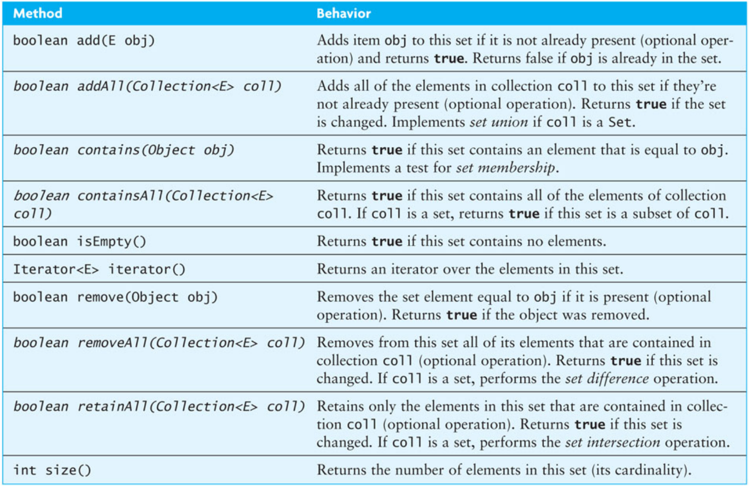
Set ADT

- A **Set** contains no duplicates
- Operations on sets:
  - adding an element
  - removing an element
  - membership query
  - union: $A \cup B$
  - intersection: $A \cap B$
  - difference: $A \setminus B$
  - subset query: $A \subseteq B$

Set Review

- union: $\{1,3,5\} \cup \{1,2,3\} = \{1,2,3,5\}$
- intersection: $\{1,3,5\} \cap \{1,2,3\} = \{1,3\}$
- difference: $\{1,3,5\} \setminus \{1,2,3\} = \{5\}$
- subset query: $\{1,3,5\} \subseteq \{1,2,3\}$ is false, $\{1,3\} \subseteq \{1,2,3\}$ is true

Set Interface



Method	Behavior
boolean add(E obj)	Adds item obj to this set if it is not already present (optional operation) and returns **true**. Returns false if obj is already in the set.
boolean addAll(Collection<E> coll)	Adds all of the elements in collection coll to this set if they're not already present (optional operation). Returns **true** if the set is changed. Implements *set union* if coll is a Set.
boolean contains(Object obj)	Returns **true** if this set contains an element that is equal to obj. Implements a test for *set membership*.
boolean containsAll(Collection<E> coll)	Returns **true** if this set contains all of the elements of collection coll. If coll is a set, returns **true** if this set is a subset of coll.
boolean isEmpty()	Returns **true** if this set contains no elements.
Iterator<E> iterator()	Returns an iterator over the elements in this set.
boolean remove(Object obj)	Removes the set element equal to obj if it is present (optional operation). Returns **true** if the object was removed.
boolean removeAll(Collection<E> coll)	Removes from this set all of its elements that are contained in collection coll (optional operation). Returns **true** if this set is changed. If coll is a set, performs the *set difference* operation.
boolean retainAll(Collection<E> coll)	Retains only the elements in this set that are contained in collection coll (optional operation). Returns **true** if this set is changed. If coll is a set, performs the *set intersection* operation.
int size()	Returns the number of elements in this set (its cardinality).

List Comparisons

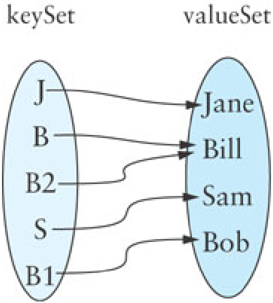
- List elements are not unique so `List.add` operations succeed (with enough memory)
- Set elements may fail on `Set.add` calls if they were already in the set
- Set does not have a `get` operation because elements do not have an index
- Set implements Iterable, but there is no guarantee on the order in which elements are iterated

Maps

Map Description

- **Map**s are related to **Set**s
- A Map is a set of ordered pairs of elements
- These ordered pairs (k, v) have a key first, value second
- Keys must be unique
- Values may have repeats
- The **Map** provides a translation from key to value
- We have seen a special case of a map already: arrays map integers to any type

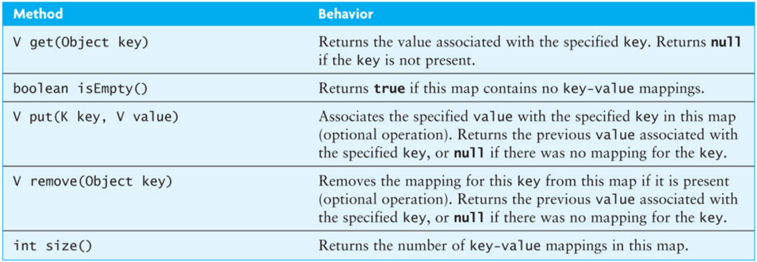
Example Search Path



Map of keys to values

This represents the set of pairs:
$\{(J,Jane),(B,Bill),(S,Sam),(B1,Bob),(B2,Bill)\}$

Map Interface



Method	Behavior
`V get(Object key)`	Returns the value associated with the specified `key`. Returns **`null`** if the `key` is not present.
`boolean isEmpty()`	Returns **`true`** if this map contains no `key-value` mappings.
`V put(K key, V value)`	Associates the specified `value` with the specified `key` in this map (optional operation). Returns the previous `value` associated with the specified `key`, or **`null`** if there was no mapping for the `key`.
`V remove(Object key)`	Removes the mapping for this `key` from this map if it is present (optional operation). Returns the previous `value` associated with the specified `key`, or **`null`** if there was no mapping for the `key`.
`int size()`	Returns the number of `key-value` mappings in this map.

Array Equivalence

- Arrays are maps but use atypical syntax:
  - `myArr[2] = x` translates to `myMap.put(2, x)`
  - `x = myArr[2]` translates to `x = myMap.get(2)`
  - Arrays don't have a built-in `remove` operation
- Maps follow Java's OOP syntax and interface of other Collections
- Sometimes maps are referred to as *associative arrays*

Example Uses For Maps

- Countries: Coordinate → Country Name
- User Database: User ID → User Record
- Academic Papers: doi → article
- Memory: Address → Value
- Note that all of these have `unique` keys. If you have data with repeats of keys (like an English dictionary, first names, age, etc.), a map cannot store their information