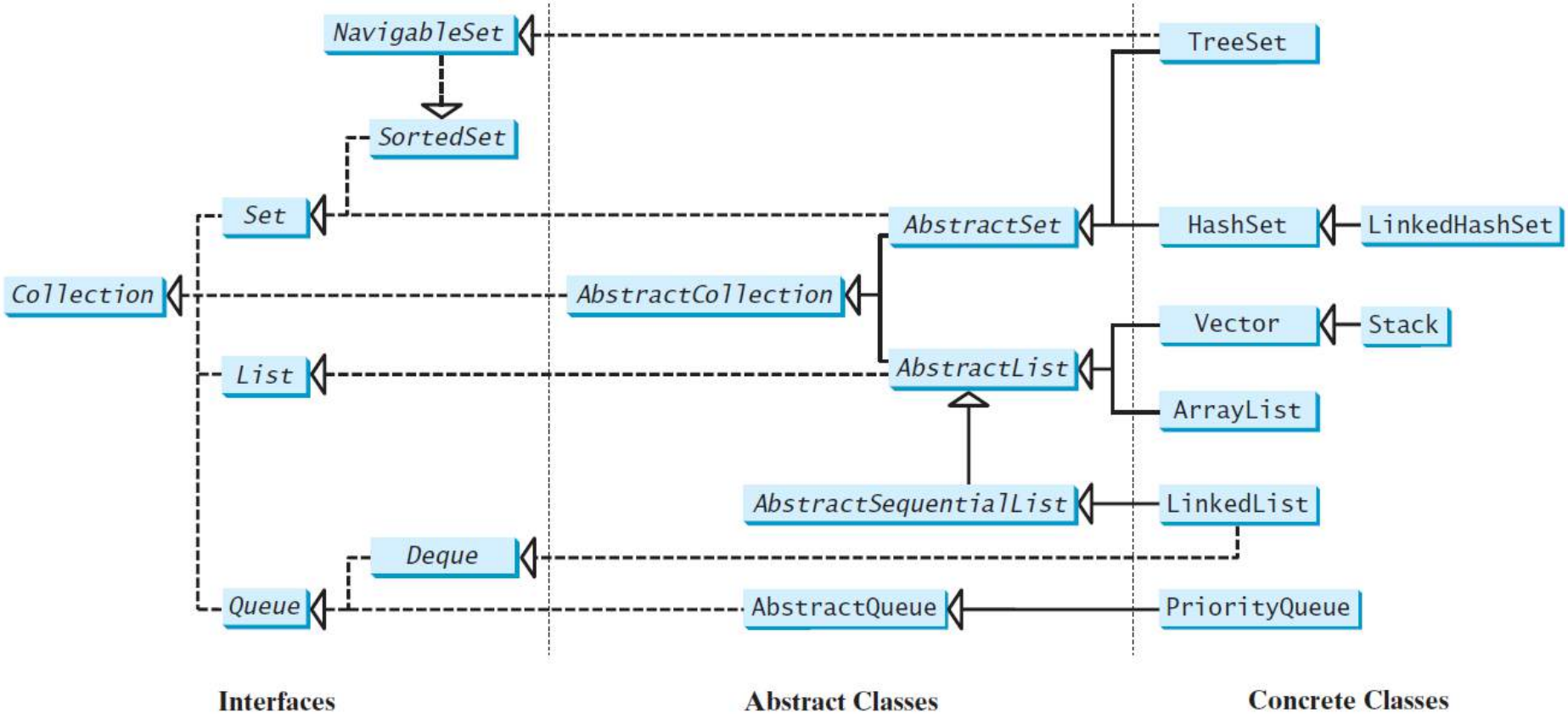
Chapter 20 Collection Framework: Sets , Lists and Maps

Java Collection Framework hierarchy

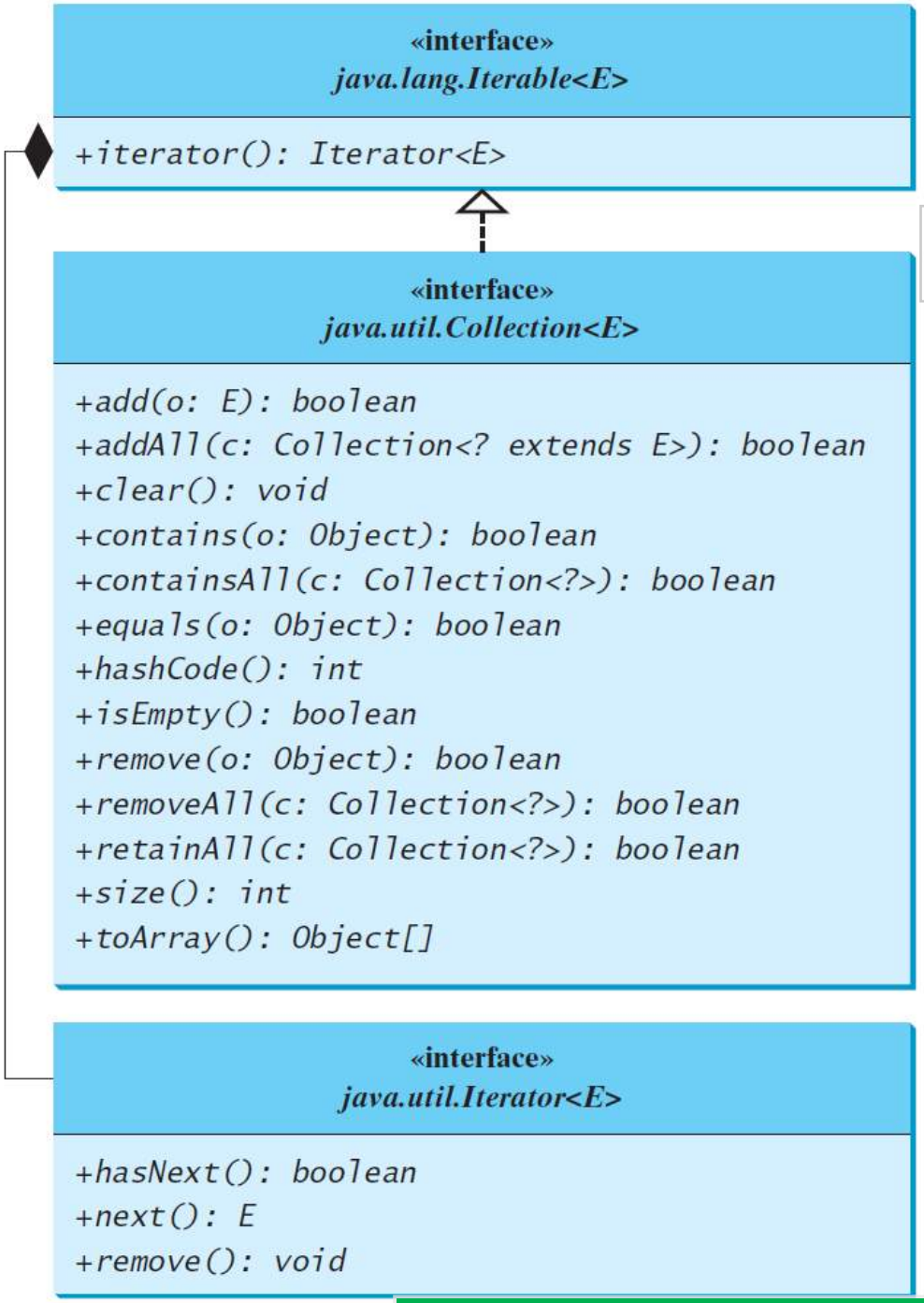
A *collection* is a container object, in fact Interface, that holds a group of objects, often referred to as *elements*. The Java Collections Framework supports three types of collections, named *lists, sets,* and *maps*.

Java Collection Framework hierarchy, cont.

Set and List are subinterfaces of Collection.



The Collection Interface



Returns an iterator for the elements in this collection.

The Collection interface is the root interface for manipulating a collection of objects.

Adds a new element `o` to this collection.
Adds all the elements in the collection `c` to this collection.
Removes all the elements from this collection.
Returns true if this collection contains the element `o`.
Returns true if this collection contains all the elements in `c`.
Returns true if this collection is equal to another collection `o`.
Returns the hash code for this collection.
Returns true if this collection contains no elements.
Removes the element `o` from this collection.
Removes all the elements in `c` from this collection.
Retains the elements that are both in `c` and in this collection.
Returns the number of elements in this collection.
Returns an array of `Object` for the elements in this collection.

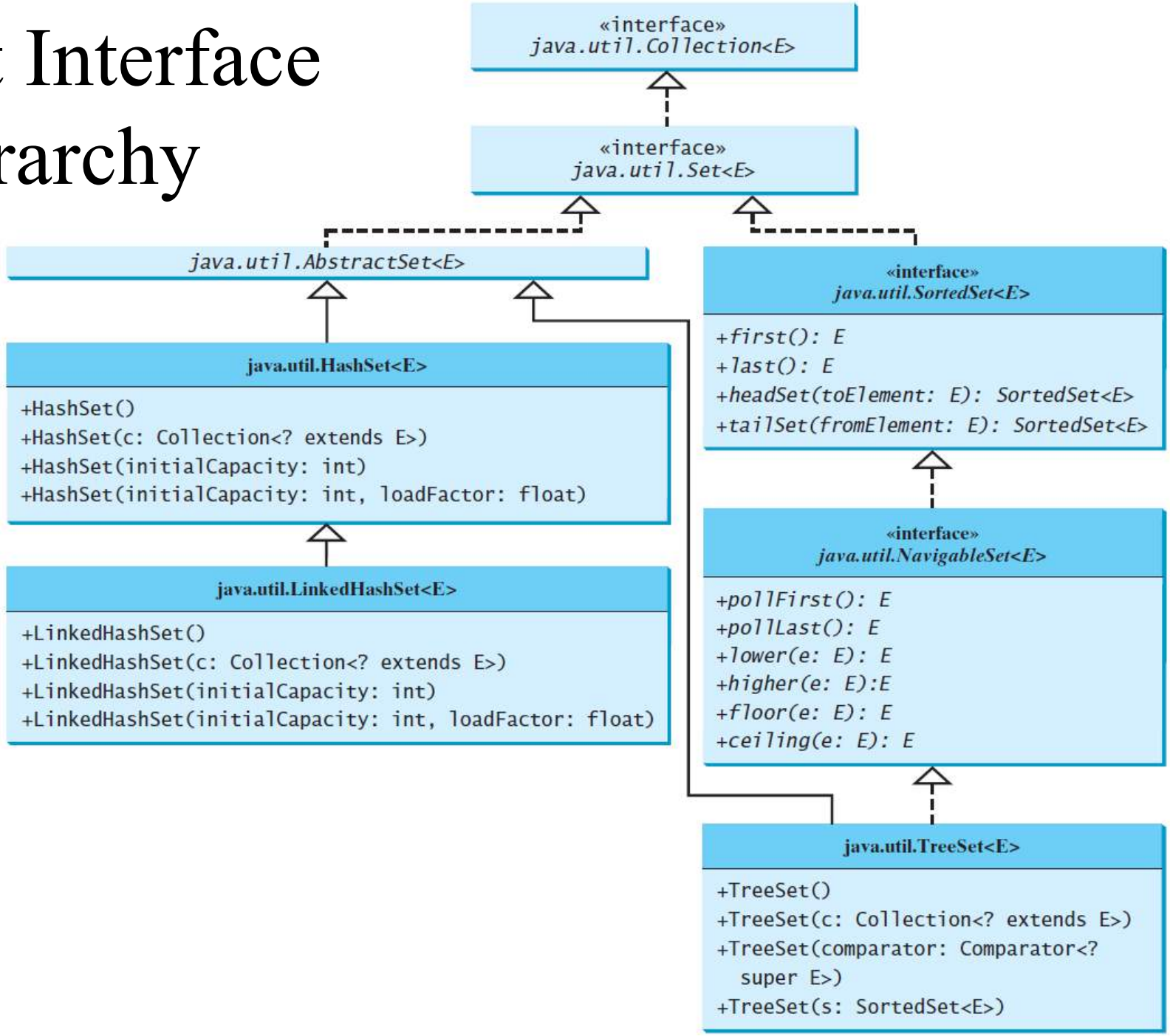
Returns true if this iterator has more elements to traverse.
Returns the next element from this iterator.
Removes the last element obtained using the next method.

TestMethodInCollection

The Set Interface

The Set interface extends the Collection interface. It does not introduce new methods or constants, but it stipulates that an instance of Set contains no duplicate elements. The concrete classes that implement Set must ensure that no duplicate elements can be added to the set. That is no two elements e1 and e2 can be in the set such that e1.equals(e2) is true.

The Set Interface Hierarchy



The AbstractSet Class

The AbstractSet class is a convenience class that extends AbstractCollection and implements Set. The AbstractSet class provides concrete implementations for the equals method and the hashCode method. The hash code of a set is the sum of the hash code of all the elements in the set. Since the size method and iterator method are not implemented in the AbstractSet class, AbstractSet is an abstract class.

The HashSet Class

The HashSet class is a concrete class that implements Set. It can be used to store duplicate-free elements. For efficiency, objects added to a hash set need to implement the hashCode method in a manner that properly disperses the hash code.

Example: Using HashSet and Iterator

This example creates a hash set filled with strings, and uses an iterator to traverse the elements in the list.

TestHashSet

TIP: for-each loop

You can simplify the code in Lines 21-26 using a JDK 1.5 enhanced for loop without using an iterator, as follows:

```
for (Object element: set)
  System.out.print(element.toString() + " ");
```

Example: Using LinkedHashSet

This example creates a hash set filled with Strings, and uses an iterator to traverse the elements in the list.

TestLinkedHashSet

The SortedSet Interface and the TreeSet Class

SortedSet is a subinterface of Set, which guarantees that the elements in the set are sorted. TreeSet is a concrete class that implements the SortedSet interface. You can use an iterator to traverse the elements in the sorted order. The elements can be sorted in two ways.

The SortedSet Interface and the TreeSet Class, cont.

One way is to use the Comparable interface.

The other way is to specify a comparator for the elements in the set if the class for the elements does not implement the Comparable interface, or you don't want to use the compareTo method in the class that implements the Comparable interface. This approach is referred to as *order by comparator*.

Example: Using TreeSet to Sort Elements in a Set

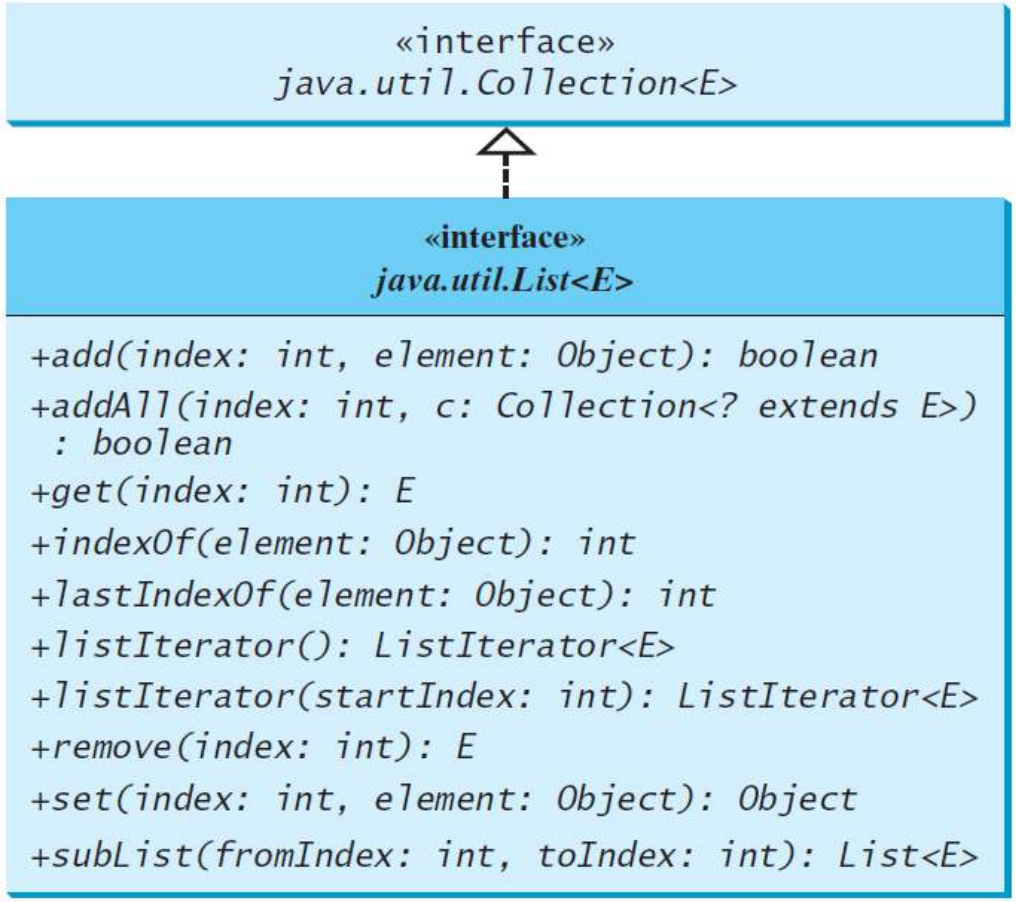
This example creates a hash set filled with strings, and then creates a tree set for the same strings. The strings are sorted in the tree set using the compareTo method in the Comparable interface. The example also creates a tree set of geometric objects. The geometric objects are sorted using the compare method in the Comparator interface.

TestTreeSet

The List Interface

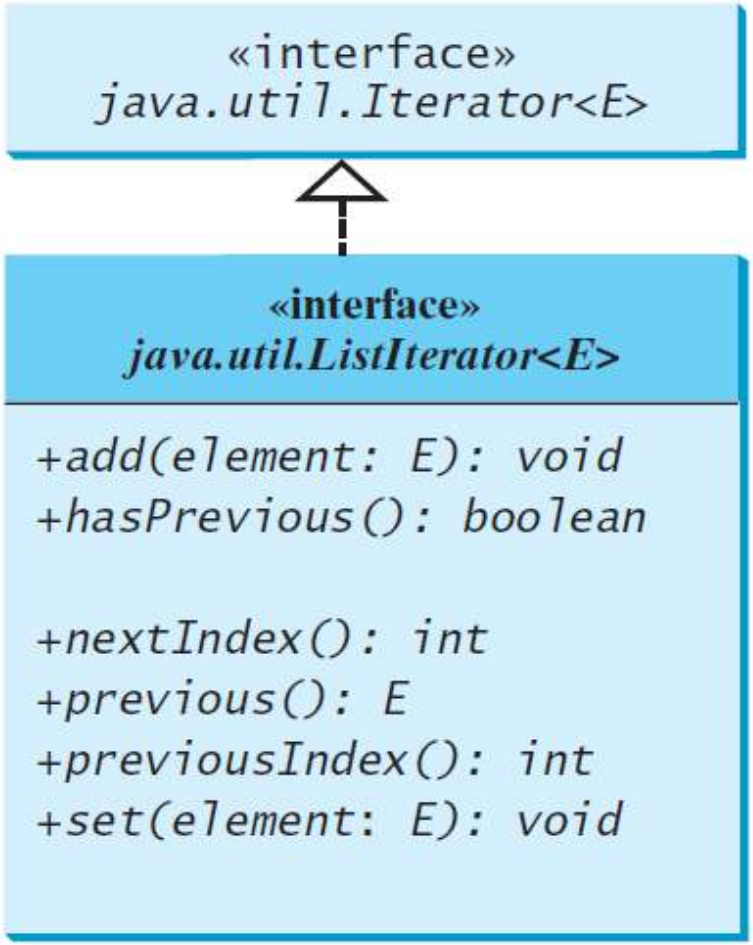
A list stores elements in a sequential order, and allows the user to specify where the element is stored. The user can access the elements by index.

The List Interface, cont.



`+add(index: int, element: Object): boolean`	Adds a new element at the specified index.
`+addAll(index: int, c: Collection<? extends E>) : boolean`	Adds all the elements in `c` to this list at the specified index.
`+get(index: int): E`	Returns the element in this list at the specified index.
`+indexOf(element: Object): int`	Returns the index of the first matching element.
`+lastIndexOf(element: Object): int`	Returns the index of the last matching element.
`+listIterator(): ListIterator<E>`	Returns the list iterator for the elements in this list.
`+listIterator(startIndex: int): ListIterator<E>`	Returns the iterator for the elements from `startIndex`.
`+remove(index: int): E`	Removes the element at the specified index.
`+set(index: int, element: Object): Object`	Sets the element at the specified index.
`+subList(fromIndex: int, toIndex: int): List<E>`	Returns a sublist from `fromIndex` to `toIndex-1`.

The List Iterator



Adds the specified object to the list.
Returns true if this list iterator has more elements when traversing backward.
Returns the index of the next element.
Returns the previous element in this list iterator.
Returns the index of the previous element.
Replaces the last element returned by the previous or next method with the specified element.

ArrayList and LinkedList

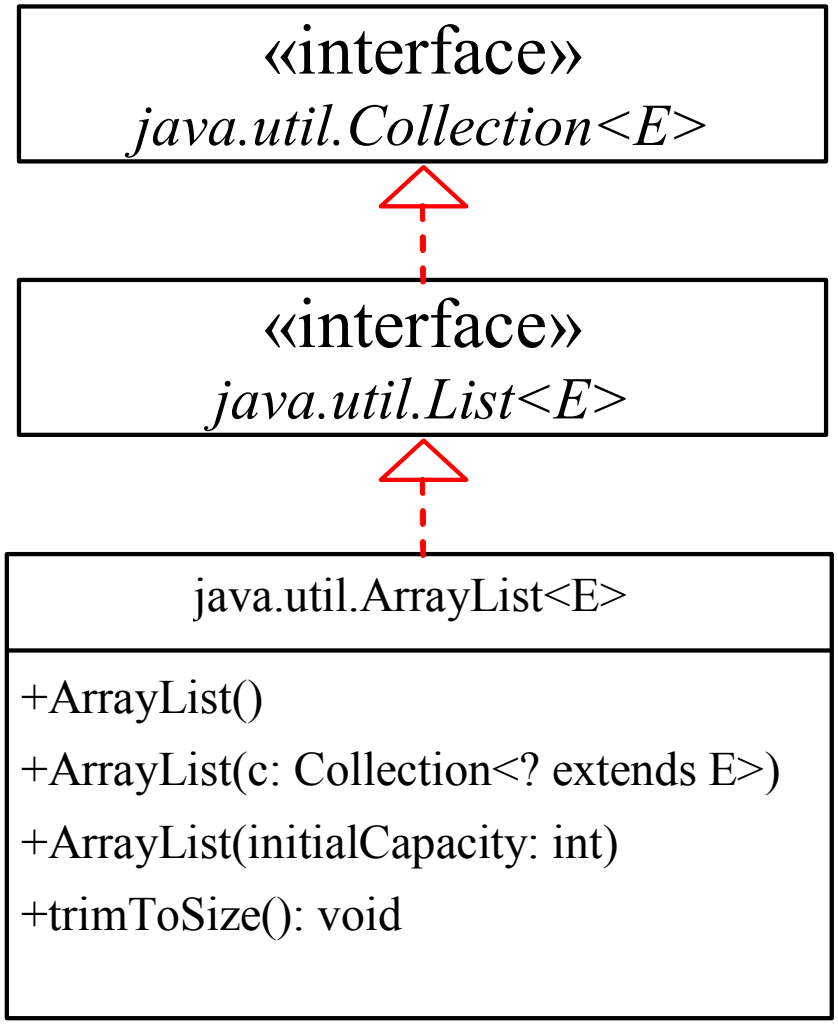
The ArrayList class and the LinkedList class are concrete implementations of the List interface.

If you need to support random access through an index without inserting or removing elements from any place other than the end, ArrayList offers the most efficient collection.

If, however, your application requires the insertion or deletion of elements from any place in the list, you should choose LinkedList.

A list can grow or shrink dynamically. An array is fixed once it is created. If your application does not require insertion or deletion of elements, the most efficient data structure is the array.

java.util.ArrayList



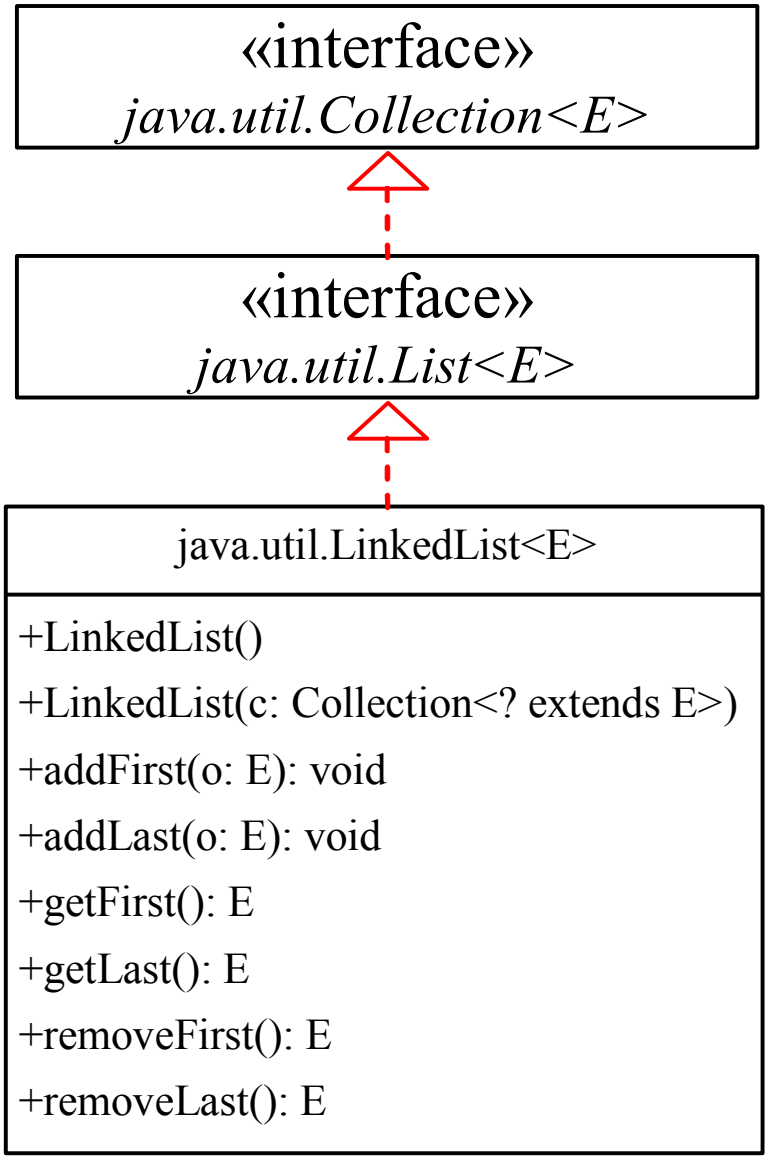
Creates an empty list with the default initial capacity.

Creates an array list from an existing collection.

Creates an empty list with the specified initial capacity.

Trims the capacity of this ArrayList instance to be the list's current size.

java.util.LinkedList



Creates a default empty linked list.

Creates a linked list from an existing collection.

Adds the object to the head of this list.

Adds the object to the tail of this list.

Returns the first element from this list.

Returns the last element from this list.

Returns and removes the first element from this list.

Returns and removes the last element from this list.

Example: Using ArrayList and LinkedList

This example creates an array list filled with numbers, and inserts new elements into the specified location in the list. The example also creates a linked list from the array list, inserts and removes the elements from the list. Finally, the example traverses the list forward and backward.

TestArrayAndLinkedList

The Comparator Interface

Sometimes you want to compare the elements of different types. The elements may not be instances of Comparable or are not comparable. You can define a comparator to compare these elements. To do so, define a class that implements the java.util.Comparator interface.

The Comparator interface has two methods, compare and equals.

The Comparator Interface

public int compare(Object element1, Object element2)

Returns a negative value if element1 is less than element2, a positive value if element1 is greater than element2, and zero if they are equal.

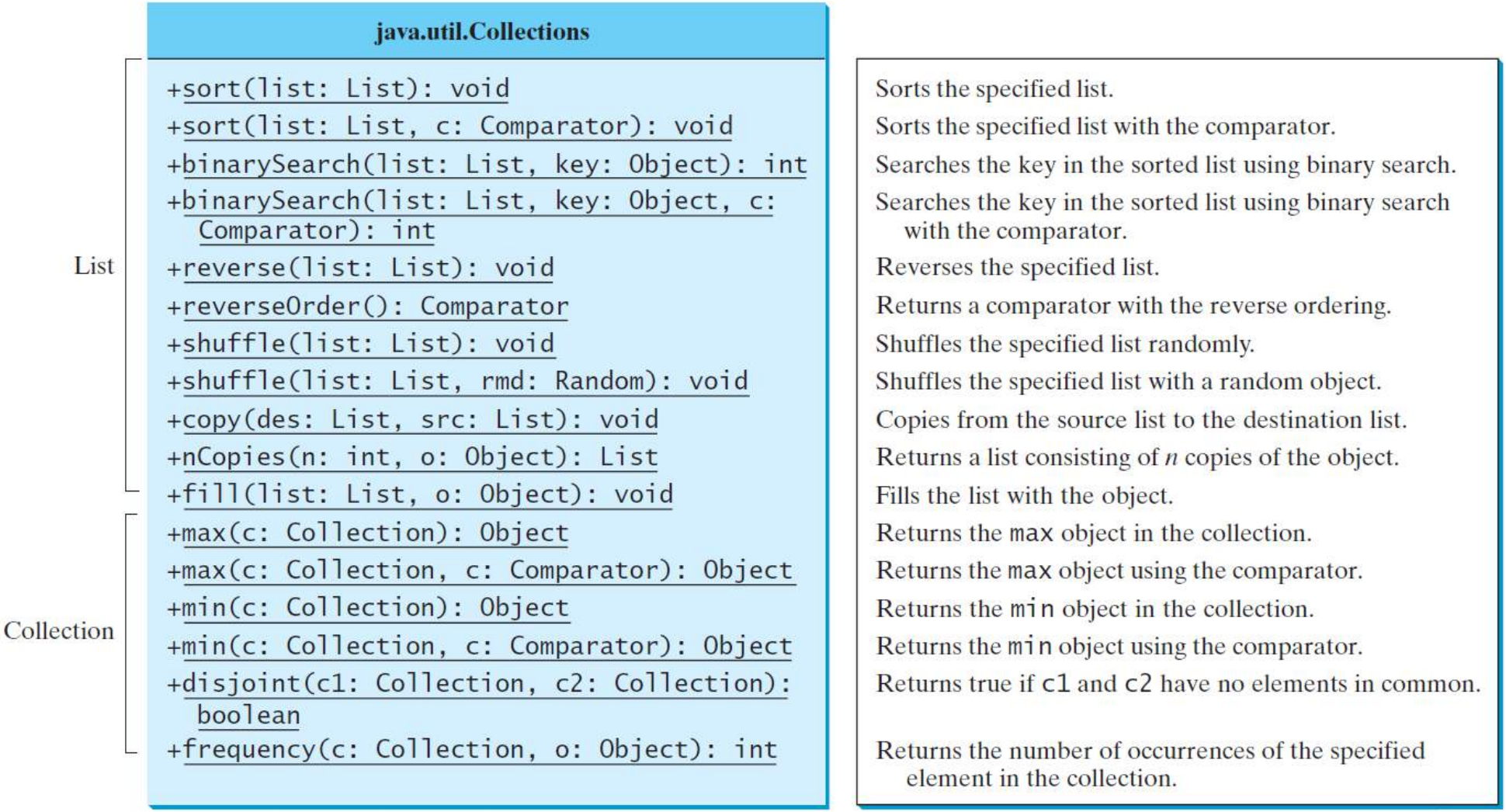
GeometricObjectComparator

TestTreeSetWithComparator

The Collections Class

The Collections class contains various static methods for operating on collections and maps, for creating synchronized collection classes, and for creating read-only collection classes.

The Collections Class UML Diagram



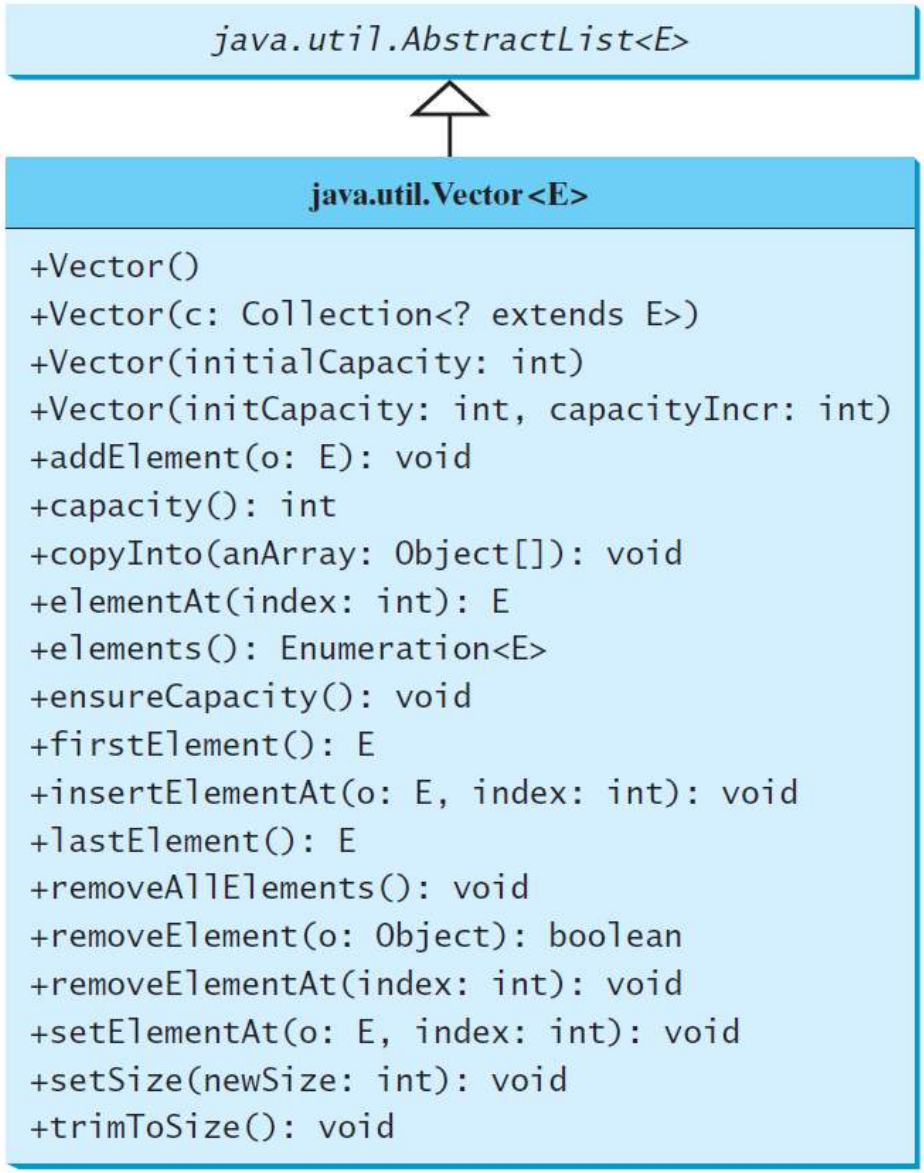
The Vector and Stack Classes

The Java Collections Framework was introduced with Java 2. Several data structures were supported prior to Java 2. Among them are the Vector class and the Stack class. These classes were redesigned to fit into the Java Collections Framework, but their old-style methods are retained for compatibility.

The Vector Class

In Java 2, Vector is the same as ArrayList, except that Vector contains the synchronized methods for accessing and modifying the vector. None of the new collection data structures introduced so far are synchronized. If synchronization is required, you can use the synchronized versions of the collection classes.

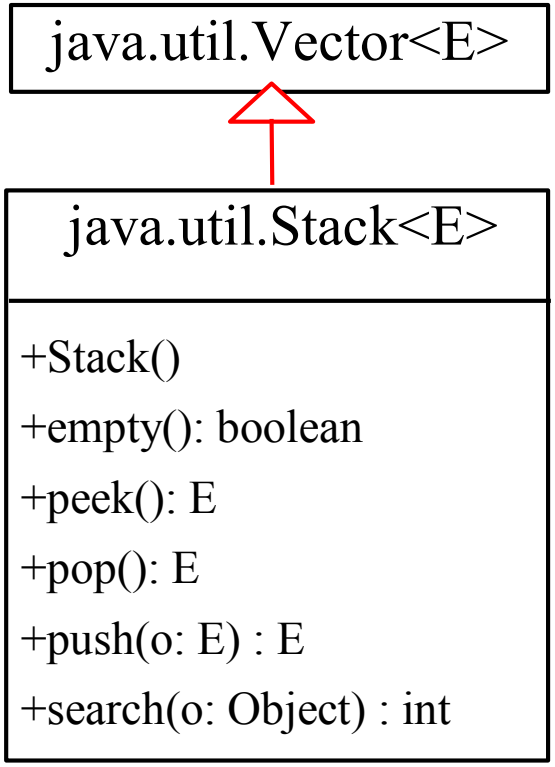
The Vector Class, cont.



Creates a default empty vector with initial capacity 10.
Creates a vector from an existing collection.
Creates a vector with the specified initial capacity.
Creates a vector with the specified initial capacity and increment.
Appends the element to the end of this vector.
Returns the current capacity of this vector.
Copies the elements in this vector to the array.
Returns the object at the specified index.
Returns an enumeration of this vector.
Increases the capacity of this vector.
Returns the first element in this vector.
Inserts o into this vector at the specified index.
Returns the last element in this vector.
Removes all the elements in this vector.
Removes the first matching element in this vector.
Removes the element at the specified index.
Sets a new element at the specified index.
Sets a new size in this vector.
Trims the capacity of this vector to its size.

The Stack Class

The Stack class represents a last-in-first-out stack of objects. The elements are accessed only from the top of the stack. You can retrieve, insert, or remove an element from the top of the stack.



Creates an empty stack.

Returns true if this stack is empty.

Returns the top element in this stack.

Returns and removes the top element in this stack.

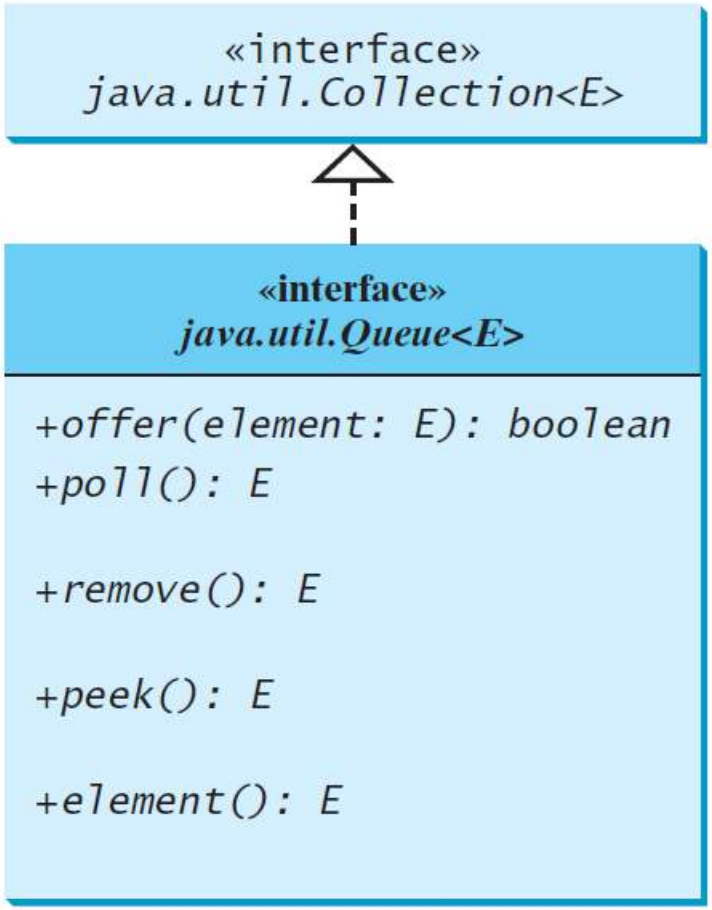
Adds a new element to the top of this stack.

Returns the position of the specified element in this stack.

Queues and Priority Queues

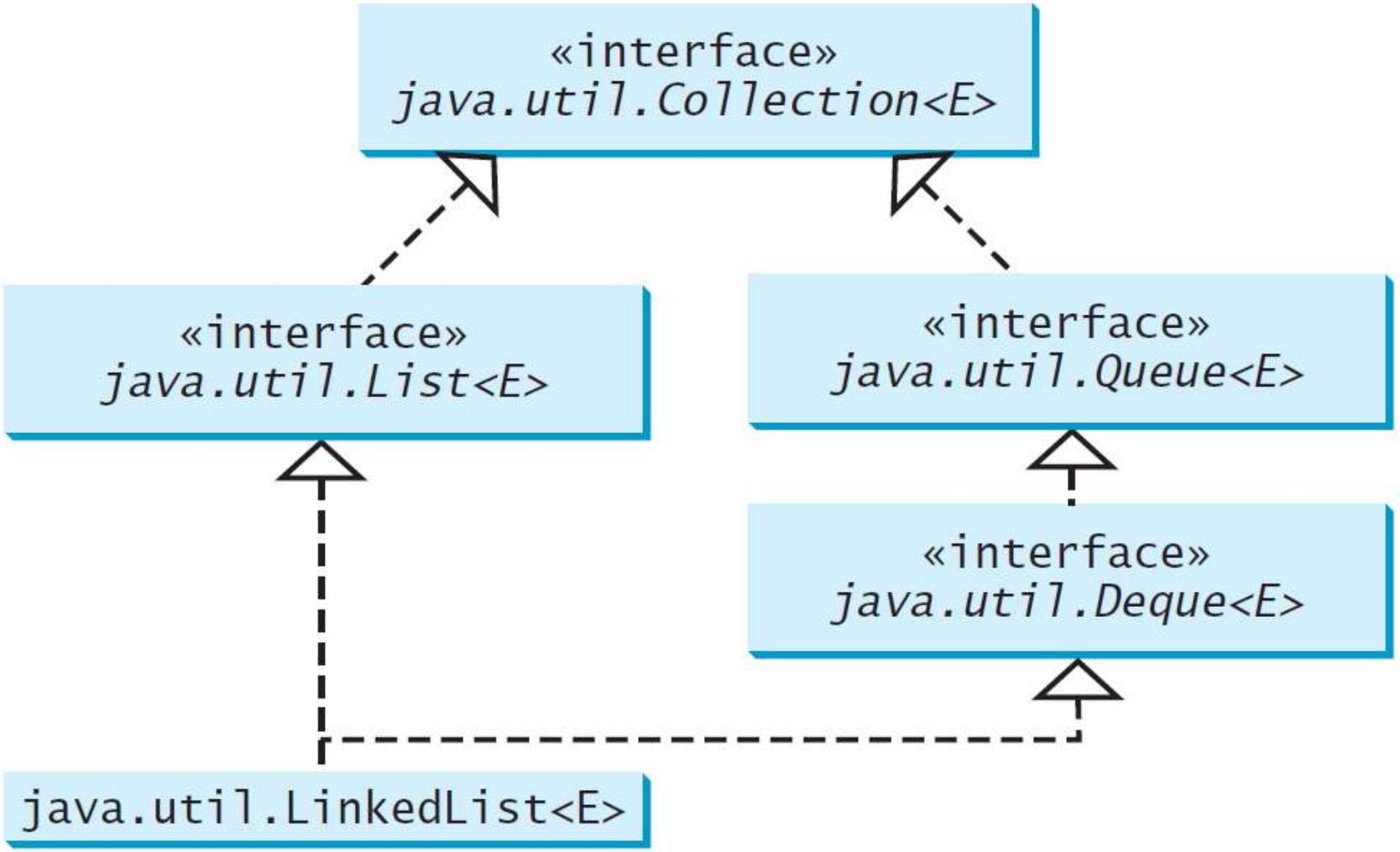
A queue is a first-in/first-out data structure. Elements are appended to the end of the queue and are removed from the beginning of the queue. In a priority queue, elements are assigned priorities. When accessing elements, the element with the highest priority is removed first.

The Queue Interface

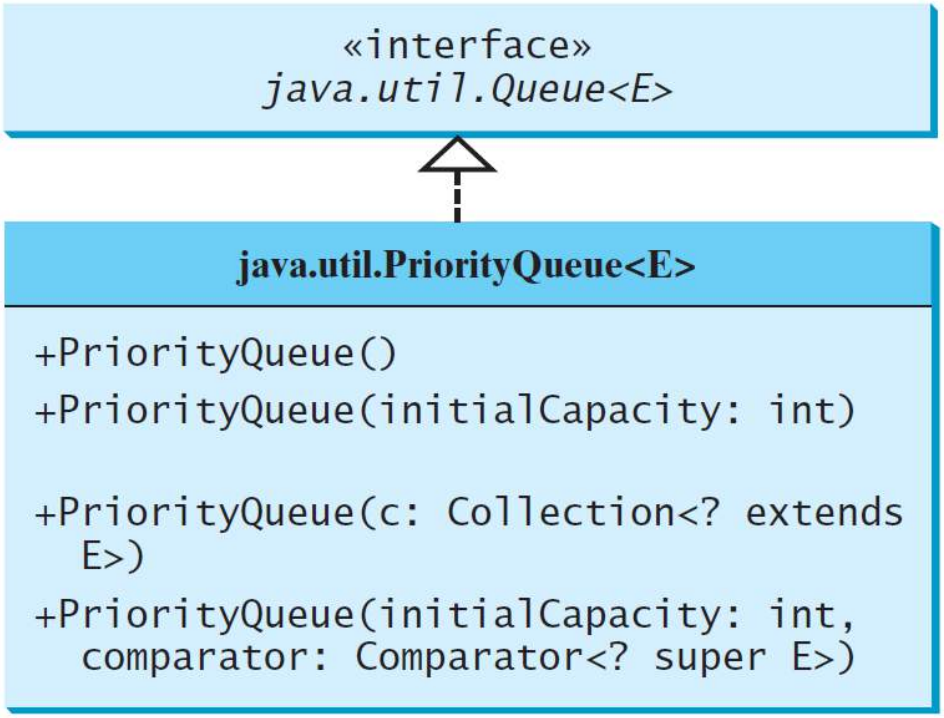


Inserts an element into the queue.	
Retrieves and removes the head of this queue, or `null` if this queue is empty.	
Retrieves and removes the head of this queue and throws an exception if this queue is empty.	
Retrieves, but does not remove, the head of this queue, returning `null` if this queue is empty.	
Retrieves, but does not remove, the head of this queue, throws an exception if this queue is empty.	

Using LinkedList for Queue



The PriorityQueue Class



+PriorityQueue()	Creates a default priority queue with initial capacity 11.
+PriorityQueue(initialCapacity: int)	Creates a default priority queue with the specified initial capacity.
+PriorityQueue(c: Collection<? extends E>)	Creates a priority queue with the specified collection.
+PriorityQueue(initialCapacity: int, comparator: Comparator<? super E>)	Creates a priority queue with the specified initial capacity and the comparator.

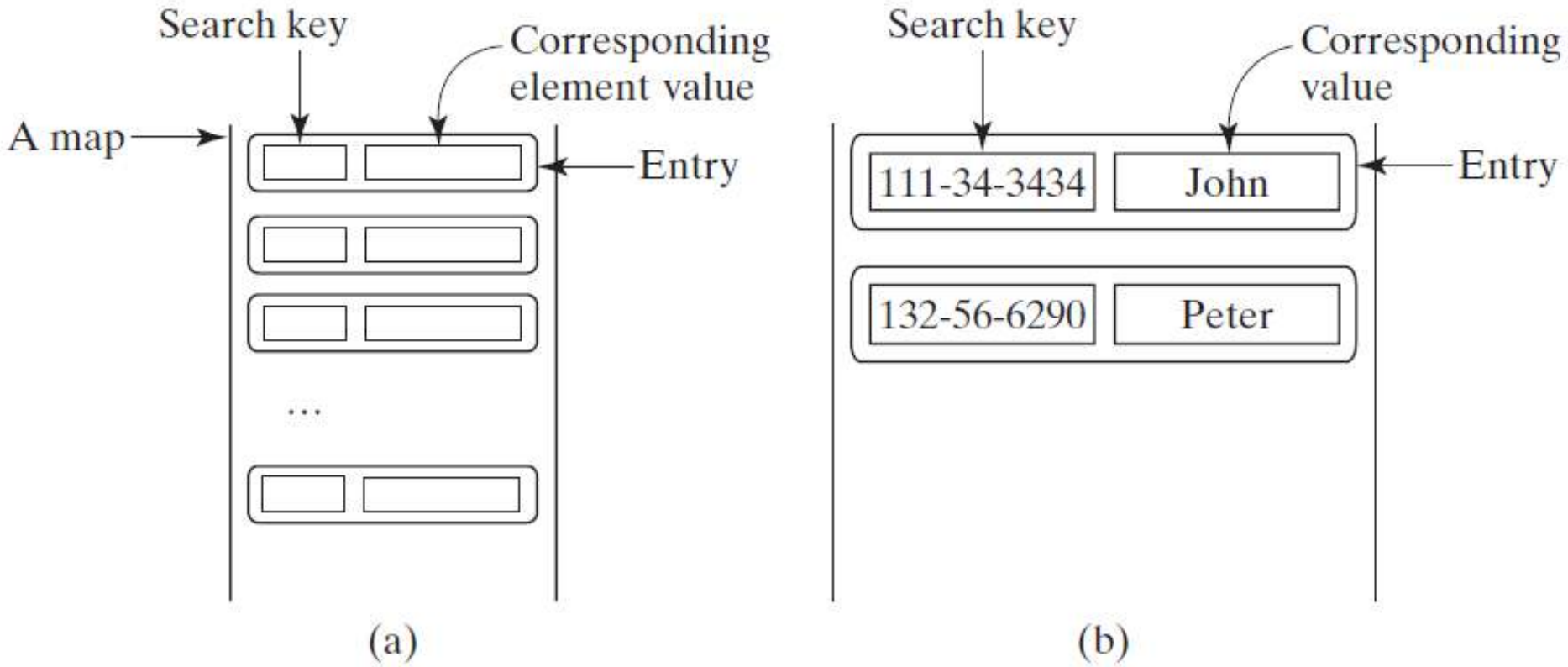
PriorityQueueDemo

Performance of Sets and Lists

SetListPerformanceTest

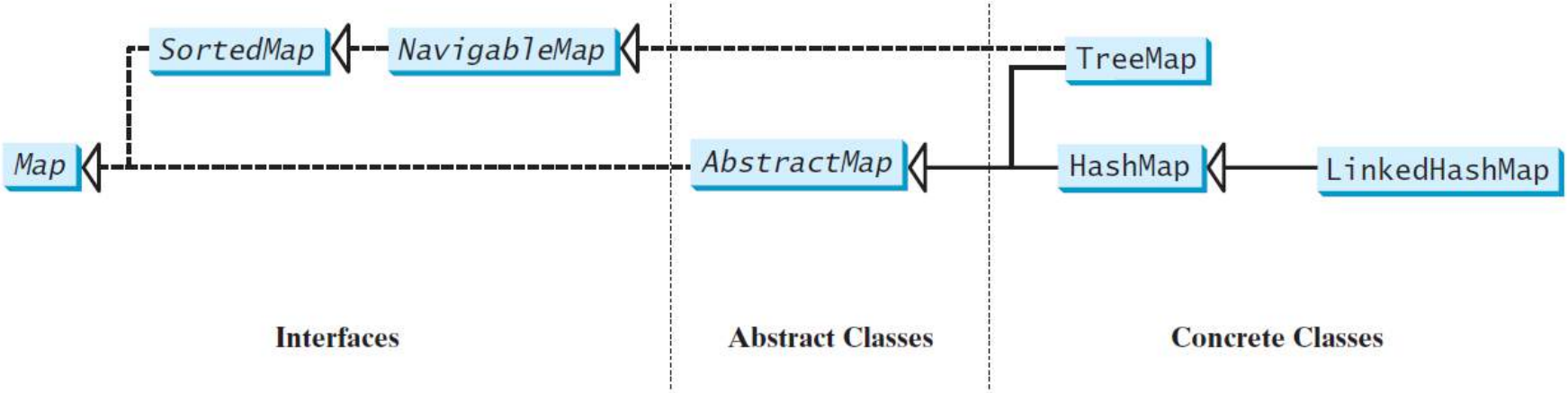
The Map Interface

The Map interface maps keys to the elements. The keys are like indexes. In List, the indexes are integer. In Map, the keys can be any objects.

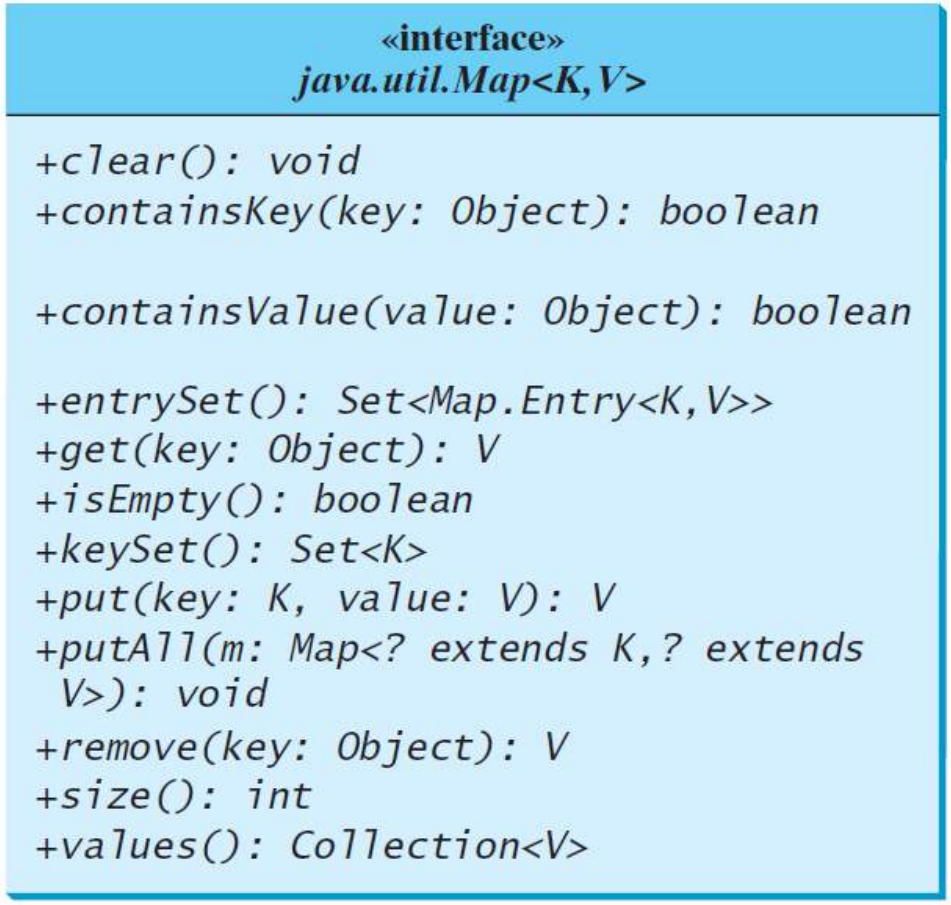


Map Interface and Class Hierarchy

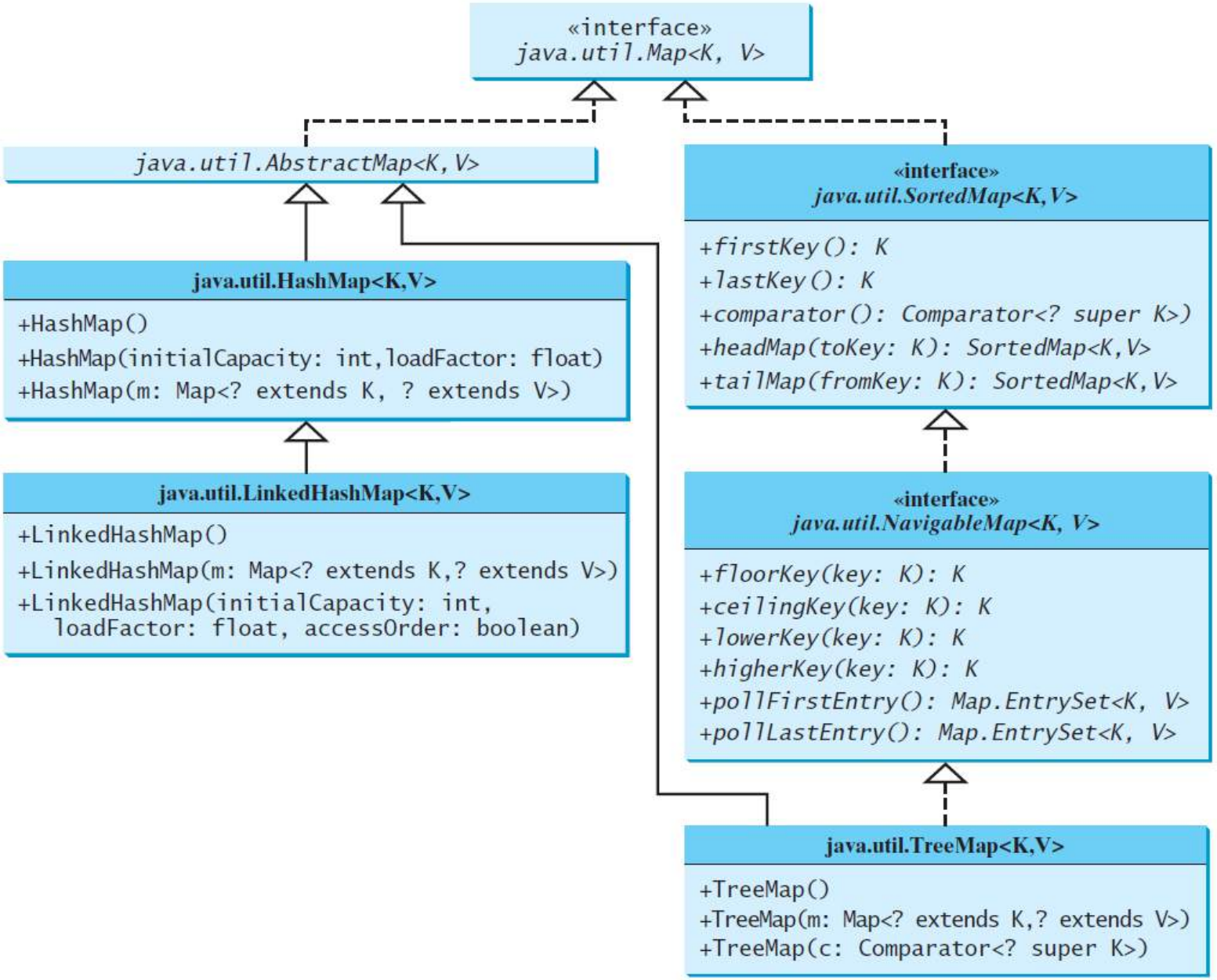
An instance of Map represents a group of objects, each of which is associated with a key. You can get the object from a map using a key, and you have to use a key to put the object into the map.



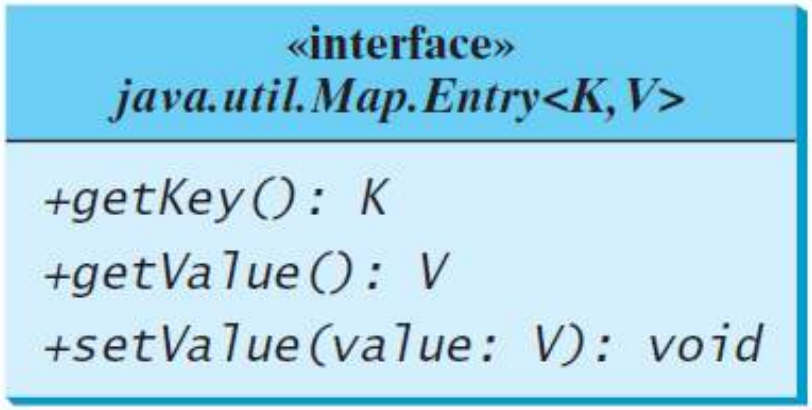
The Map Interface UML Diagram



Concrete Map Classes



Entry



Returns the key from this entry.

Returns the value from this entry.

Replaces the value in this entry with a new value.

HashMap and TreeMap

The HashMap and TreeMap classes are two concrete implementations of the Map interface.

The HashMap class is efficient for locating a value, inserting a mapping, and deleting a mapping.

The TreeMap class, implementing SortedMap, is efficient for traversing the keys in a sorted order.

LinkedHashMap

LinkedHashMap was introduced in JDK 1.4. It extends HashMap with a linked list implementation that supports an ordering of the entries in the map. The entries in a HashMap are not ordered, but the entries in a LinkedHashMap can be retrieved in the order in which they were inserted into the map (known as the insertion order), or the order in which they were last accessed, from least recently accessed to most recently (access order). The no-arg constructor constructs a LinkedHashMap with the insertion order. To construct a LinkedHashMap with the access order, use the LinkedHashMap(initialCapacity, loadFactor, true).

Example: Using HashMap and TreeMap

This example creates a hash map that maps borrowers to mortgages. The program first creates a hash map with the borrower's name as its key and mortgage as its value. The program then creates a tree map from the hash map, and displays the mappings in ascending order of the keys.

TestMap

Case Study: Counting the Occurrences of Words in a Text

This program counts the occurrences of words in a text and displays the words and their occurrences in ascending order of the words. The program uses a hash map to store a pair consisting of a word and its count. For each word, check whether it is already a key in the map. If not, add the key and value 1 to the map. Otherwise, increase the value for the word (key) by 1 in the map. To sort the map, convert it to a tree map.

CountOccurrenceOfWords

The Singleton and Unmodiable Collections