CISC 3115 TY3
C28a: Set

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Outline

- Discussed
    - Concept of data structure
    - Use data structures
        - List
    - Stack
    - Queue and priority queue
- To discuss
    - Set and map

Outline of This Lecture

- Concept of the Set data structure
- Set in Java
- HashSet, LinkedHashSet, and TreeSet
- Compare performance of Set and List
- Example programs
    - Word counting

Motivation

- In many applications, we do not allow duplications in a collection
  - Students enrolled in a class.
    - The class cannot have more than one objects of the same student.
  - Passengers on board an airplane
    - The passengers must also be unique.
- However, if we
  - ArrayList<Student> studentList = new ArrayList<>();
- We can do,
  - studentList.add(new Student(1, "John"));
  - studentList.add(new Student(1, "John"));
- Can we design a data structure that prevents this type of error?

Set

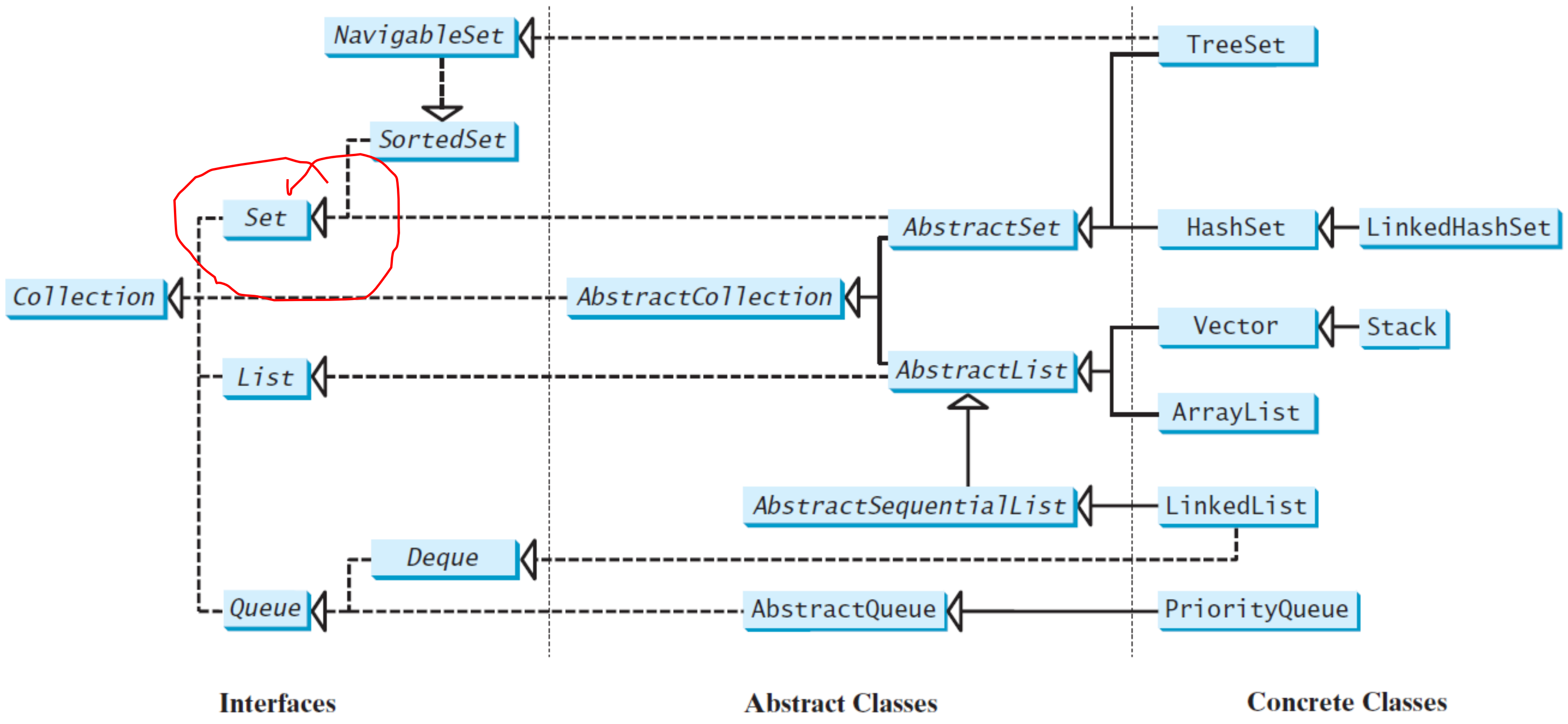
- A collection data structure where every item must be unique (no duplicates)

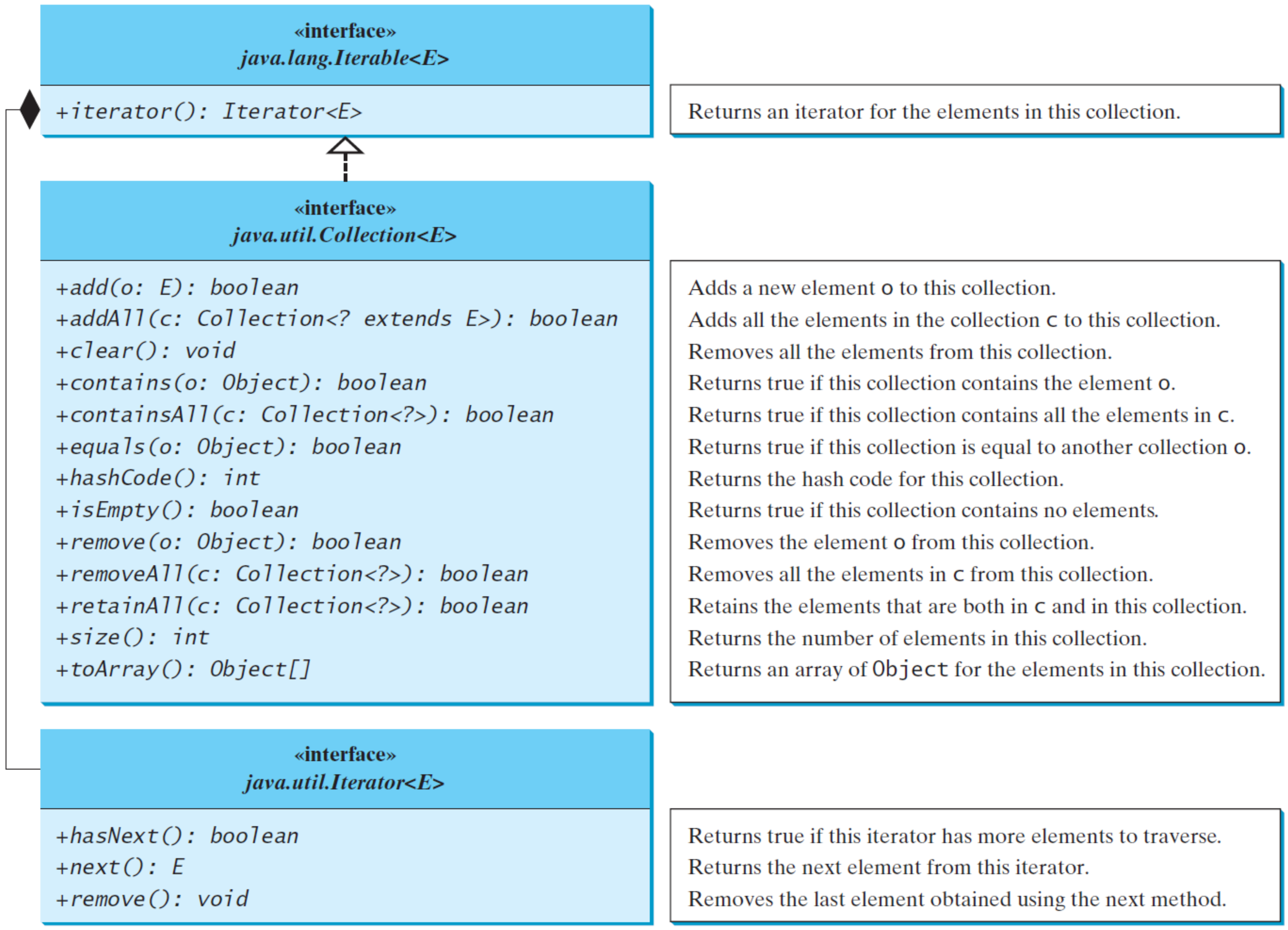
The Set Interface

- 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.
- Meaning of duplicates or uniqueness
  - No two elements e1 and e2 can be in the set such that e1.equals(e2) is true

Review: Java Collection Framework Type Hierarchy

- Set is a subinterface of Collection





«interface»
java.lang.Iterable<E>

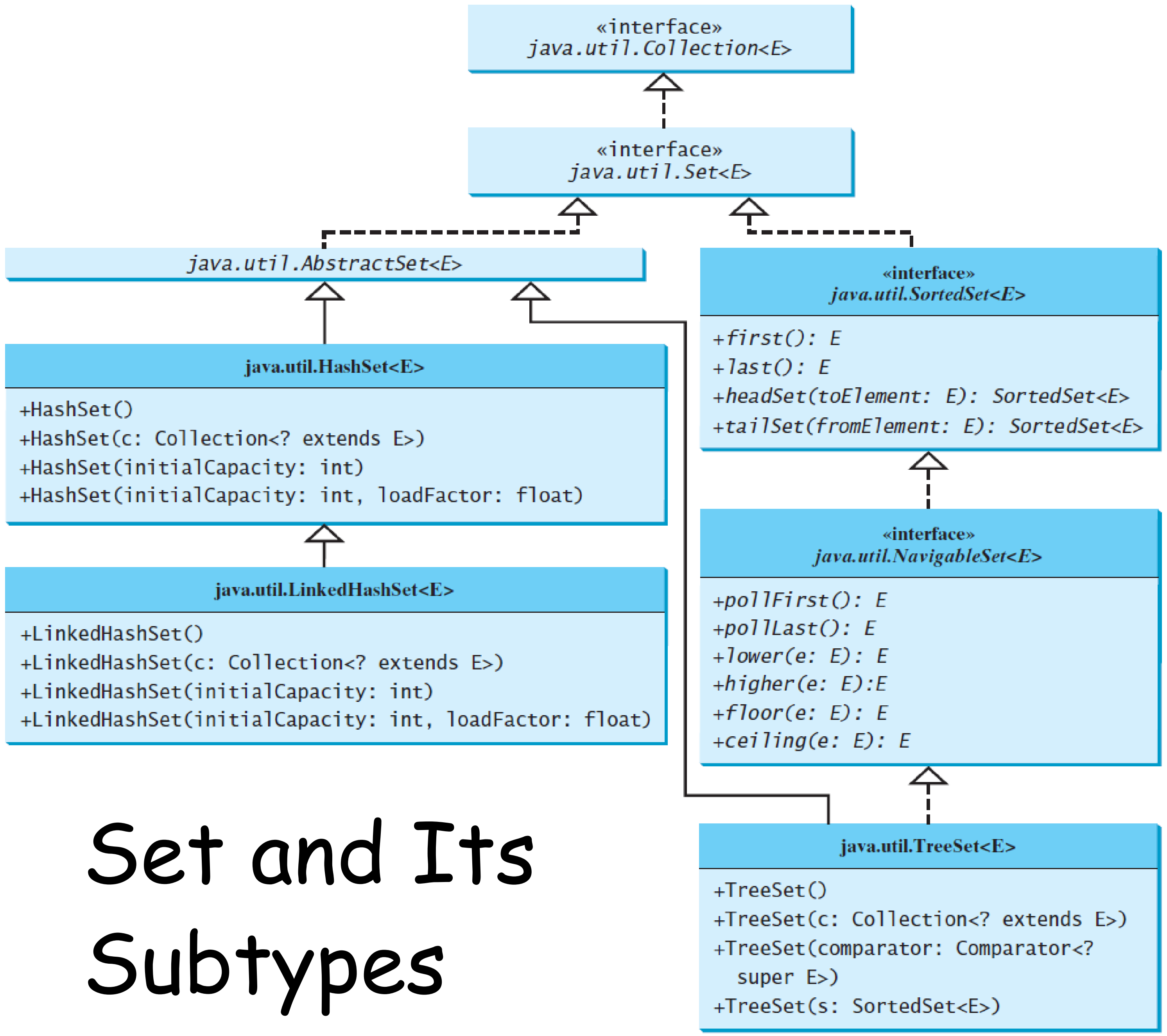
`+iterator(): Iterator<E>`	Returns an iterator for the elements in this collection.

«interface»
java.util.Collection<E>

`+add(o: E): boolean`	Adds a new element `o` to this collection.
`+addAll(c: Collection<? extends E>): boolean`	Adds all the elements in the collection `c` to this collection.
`+clear(): void`	Removes all the elements from this collection.
`+contains(o: Object): boolean`	Returns true if this collection contains the element `o`.
`+containsAll(c: Collection<?>): boolean`	Returns true if this collection contains all the elements in `c`.
`+equals(o: Object): boolean`	Returns true if this collection is equal to another collection `o`.
`+hashCode(): int`	Returns the hash code for this collection.
`+isEmpty(): boolean`	Returns true if this collection contains no elements.
`+remove(o: Object): boolean`	Removes the element `o` from this collection.
`+removeAll(c: Collection<?>): boolean`	Removes all the elements in `c` from this collection.
`+retainAll(c: Collection<?>): boolean`	Retains the elements that are both in `c` and in this collection.
`+size(): int`	Returns the number of elements in this collection.
`+toArray(): Object[]`	Returns an array of `Object` for the elements in this collection.

«interface»
java.util.Iterator<E>

`+hasNext(): boolean`	Returns true if this iterator has more elements to traverse.
`+next(): E`	Returns the next element from this iterator.
`+remove(): void`	Removes the last element obtained using the next method.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+HashSet(c: Collection<? extends E>)
+HashSet(initialCapacity: int)
+HashSet(initialCapacity: int, loadFactor: float)
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+pollLast(): E
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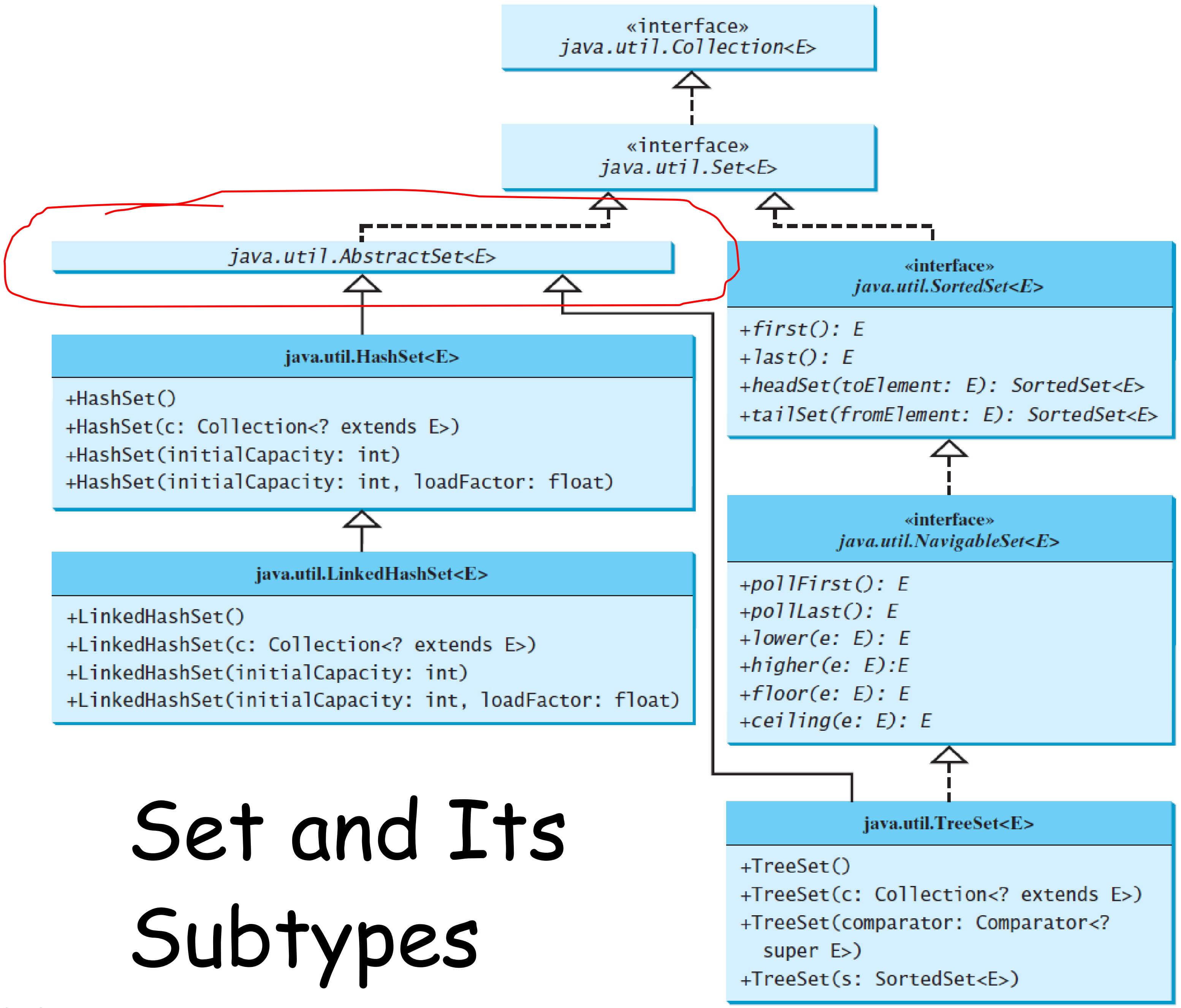
Set and Its Subtypes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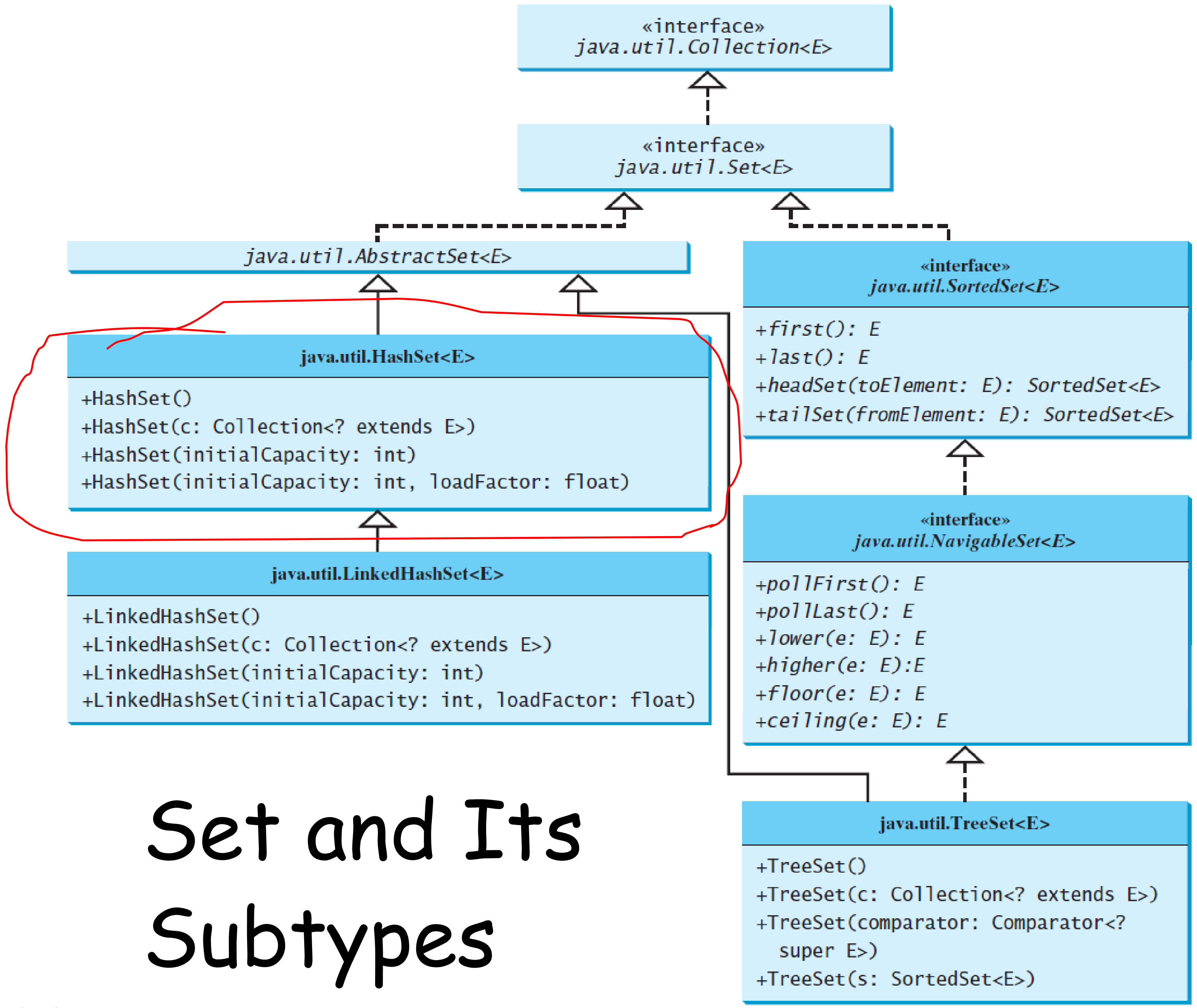
Set and Its Subtypes

AbstractSet

- 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.
  - You may use it to determine if two sets are equal
  - 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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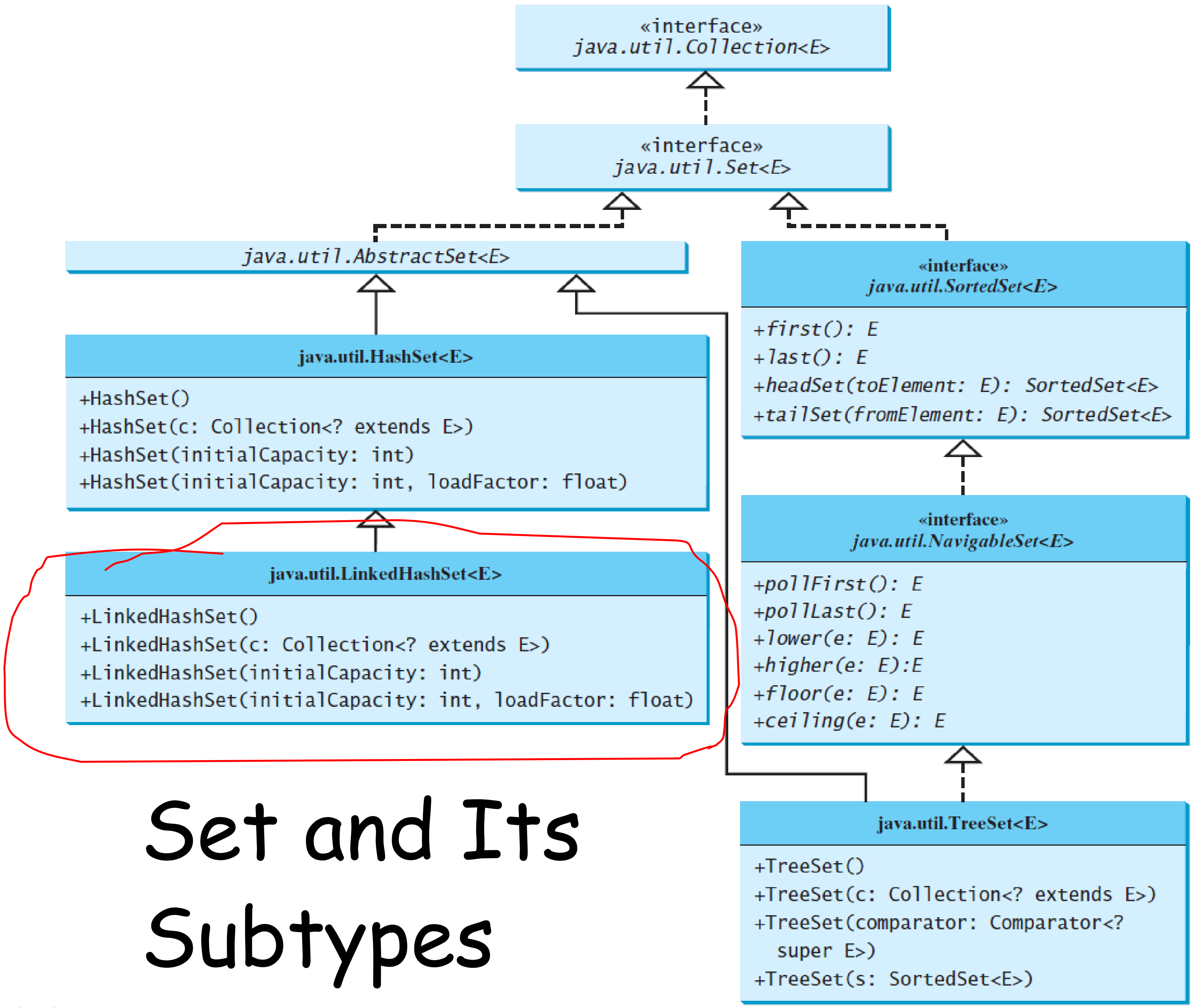
Set and Its Subtypes

HashSet

- 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
  - Recall the contract of the HashCode, and how the equals method should be overridden.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Set and Its Subtypes

LinkedHashSet

- LinkedHashSet retains the order of elements as they are inserted (insertion order) via a linked list
    - Note that insertion order is not affected if an element is re-inserted into the set.
    - Meaning of re-insertion
        - if (set.contains(element)) { set.add(element); }
- However, in a HashSet, the order of elements are unspecified and generally chaotic.

HashSet: Example

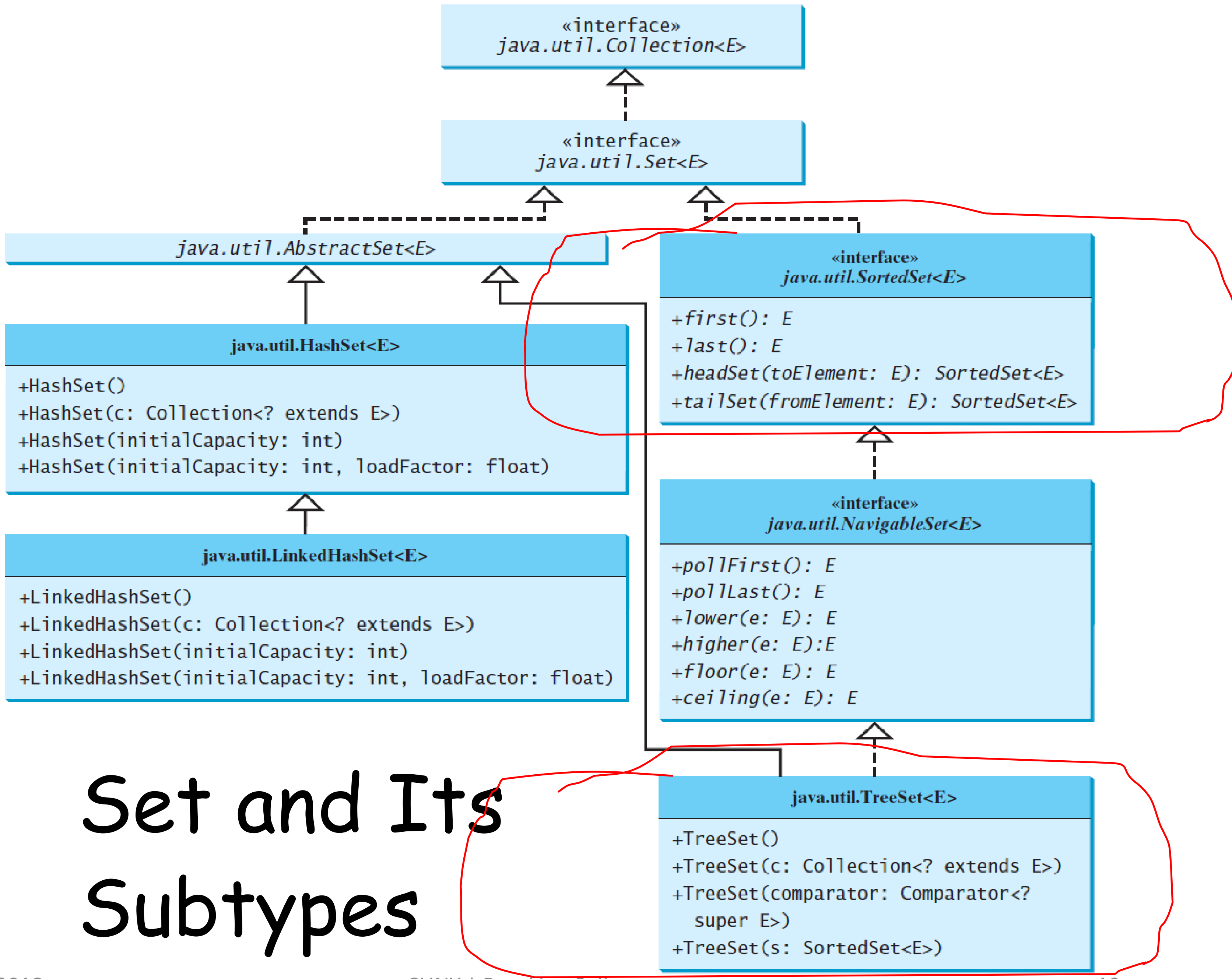
- This example creates a hash set filled with strings, and traverse the elements in the list.
  - Use the enhanced for loop
  - Use the Iterable::forEach method and the Consumer interface
- Note: pay attention to the order of the elements

LinkedHashSet: Example

- This example creates a linked hash set filled with strings, and traverse the elements in the list.
  - Use the enhanced for loop
  - Use the Iterable::forEach method and the Consumer interface
- Note: pay attention to the order of the elements

Questions?

- Concept of set
- Set in Java
- HashSet and LinkedHashSet, and difference?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Set and Its Subtypes

SortedSet and TreeSet

- 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.

Sorting in TreeSet

- The elements can be sorted in two ways
  - One way is to use the Comparable interface, which means elements (objects) needs to be comparable.
  - The other way is to specify a comparator for the elements, i.e., *order by comparator*.
    - 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

TreeSet: Example 1

- 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.

TreeSet: Example 2

- The example also creates a tree set of geometric objects.
  - The geometric objects are sorted using the compare method in the Comparator interface

Questions?

- SortedSet and TreeSet
- Based on what are SortedSet and TreeSet sorted?

List and Set

- Compare List and Set
- How much time does it take to do the following?
  - Test if the collection contains an element
  - Remove a given element
- See the example

Set: Example

- Write an application that counts the number of the keywords in a Java source file

Questions?

- Count keywords using Set