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# Java Collections

CSE 403, Spring 2004  
Software Engineering

<http://www.cs.washington.edu/education/courses/403/04sp/>

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# Readings and References

- "Collections", Java tutorial
- <http://java.sun.com/docs/books/tutorial/collections/index.html>

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# Java 2 Collections

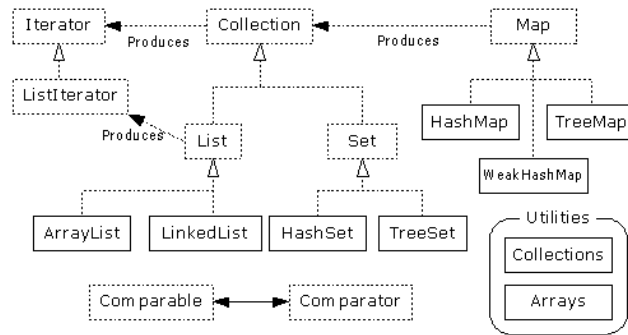
- A collection is an object that groups multiple elements into a single unit
- Very useful
  - » store, retrieve and manipulate data
  - » transmit data from one method to another
  - » data structures and methods written by hotshots in the field
    - Joshua Bloch, who also wrote the Collections tutorial

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# Collections Framework

- Unified architecture for representing and manipulating collections.
- A collections framework contains three things
  - » Interfaces
  - » Implementations
  - » Algorithms

## Collections Framework Diagram



• Interfaces, Implementations, and Algorithms  
• From Thinking in Java, page 462

## Collection Interface

- Defines fundamental methods
  - » `int size();`
  - » `boolean isEmpty();`
  - » `boolean contains(Object element);`
  - » `boolean add(Object element); // Optional`
  - » `boolean remove(Object element); // Optional`
  - » `Iterator iterator();`
- These methods are enough to define the basic behavior of a collection
- Provides an Iterator to step through the elements in the Collection

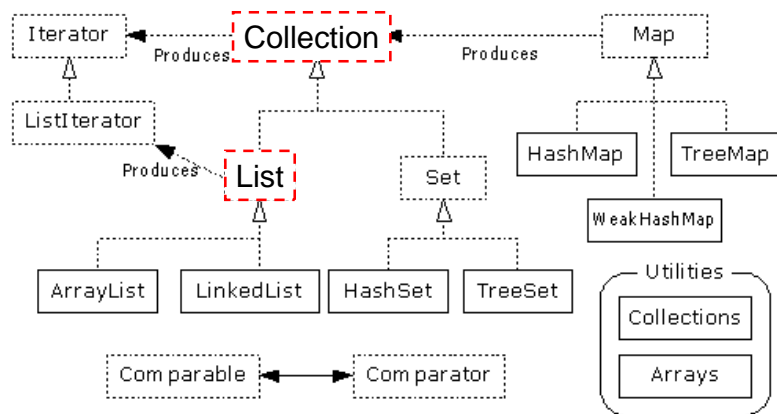
## Iterator Interface

- Defines three fundamental methods
  - » `Object next();`
  - » `boolean hasNext();`
  - » `void remove();`
- These three methods provide access to the contents of the collection
- An Iterator knows position within collection
- Each call to `next()` “reads” an element from the collection
  - » Then you can use it or remove it

## Example - SimpleCollection

```
public class SimpleCollection {
    public static void main(String[] args) {
        Collection c;
        c = new ArrayList();
        System.out.println(c.getClass().getName());
        for (int i=1; i <= 10; i++) {
            c.add(i + " * " + i + " = " + i*i);
        }
        Iterator iter = c.iterator();
        while (iter.hasNext())
            System.out.println(iter.next());
    }
}
```

## List Interface Context



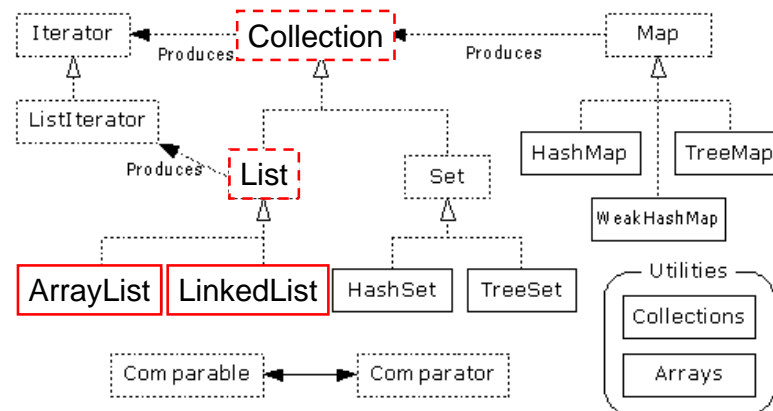
## List Interface

- The List interface adds the notion of *order* to a collection
- The user of a list has control over where an element is added in the collection
- Lists typically allow *duplicate* elements
- Provides a ListIterator to step through the elements in the list.

## ListIterator Interface

- Extends the Iterator interface
- Defines three fundamental methods
  - » `void add(Object o)` - before current position
  - » `boolean hasPrevious()`
  - » `Object previous()`
- The addition of these three methods defines the basic behavior of an ordered list
- A ListIterator knows position within list

## ArrayList and LinkedList Context



## List Implementations

- ArrayList
  - » low cost random access
  - » high cost insert and delete
  - » array that resizes if need be
- LinkedList
  - » sequential access
  - » low cost insert and delete
  - » high cost random access

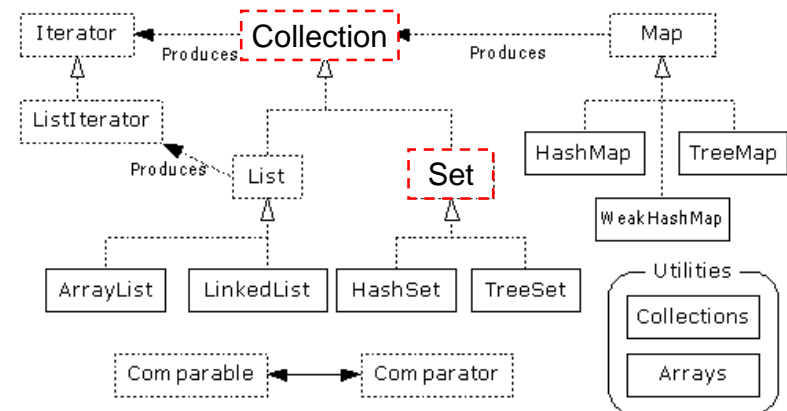
## ArrayList methods

- The indexed get and set methods of the List interface are appropriate to use since ArrayLists are backed by an array
  - » `Object get(int index)`
  - » `Object set(int index, Object element)`
- Indexed add and remove are provided, but can be costly if used frequently
  - » `void add(int index, Object element)`
  - » `Object remove(int index)`
- May want to resize in one shot if adding many elements
  - » `void ensureCapacity(int minCapacity)`

## LinkedList methods

- The list is sequential, so access it that way
  - » `ListIterator listIterator()`
- ListIterator knows about position
  - » use `add()` from ListIterator to add at a position
  - » use `remove()` from ListIterator to remove at a position
- LinkedList knows a few things too
  - » `void addFirst(Object o), void addLast(Object o)`
  - » `Object getFirst(), Object getLast()`
  - » `Object removeFirst(), Object removeLast()`

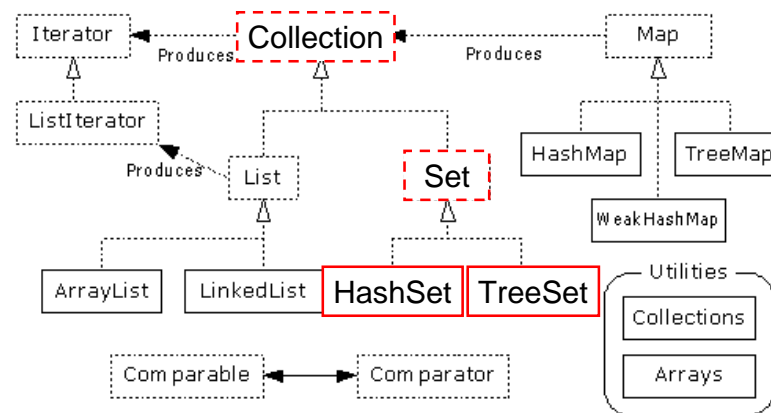
## Set Interface Context



## Set Interface

- Same methods as Collection
  - » different contract - no duplicate entries
- Defines two fundamental methods
  - » `boolean add(Object o)` - reject duplicates
  - » `Iterator iterator()`
- Provides an Iterator to step through the elements in the Set
  - » No guaranteed order in the basic Set interface
  - » There is a SortedSet interface that extends Set

## HashSet and TreeSet Context



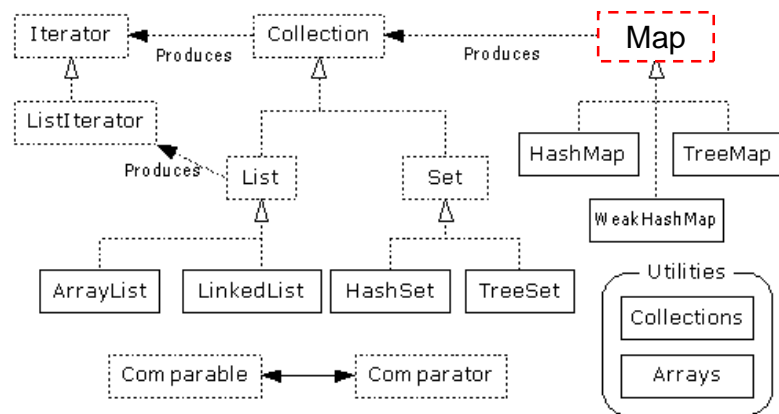
## HashSet

- Find and add elements very quickly
  - » uses hashing implementation in HashMap
- Hashing uses an array of linked lists
  - » The `hashCode()` is used to index into the array
  - » Then `equals()` is used to determine if element is in the (short) list of elements at that index
- No order imposed on elements
- The `hashCode()` method and the `equals()` method must be compatible
  - » if two objects are equal, they must have the same `hashCode()` value

## TreeSet

- Elements can be inserted in any order
- The TreeSet stores them in order
  - » Red-Black Trees out of Cormen-Leiserson-Rivest
- An iterator always presents them in order
- Default order is defined by natural order
  - » objects implement the Comparable interface
  - » TreeSet uses `compareTo(Object o)` to sort
- Can use a different Comparator
  - » provide Comparator to the TreeSet constructor

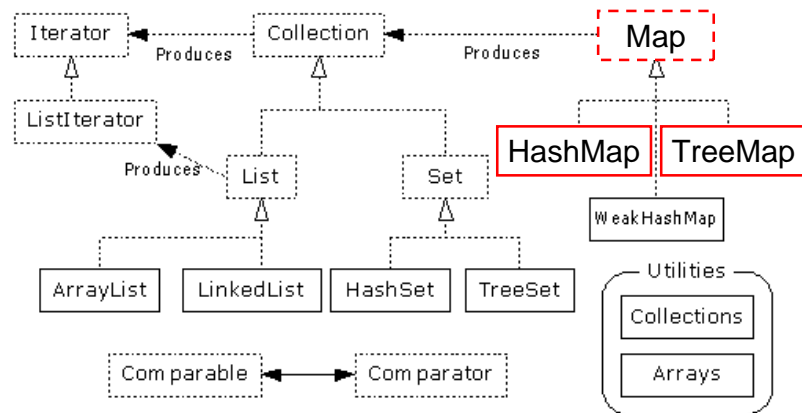
## Map Interface Context



## Map Interface

- Stores key/value pairs
- Maps from the key to the value
- Keys are unique
  - » a single key only appears once in the Map
  - » a key can map to only one value
- Values do not have to be unique

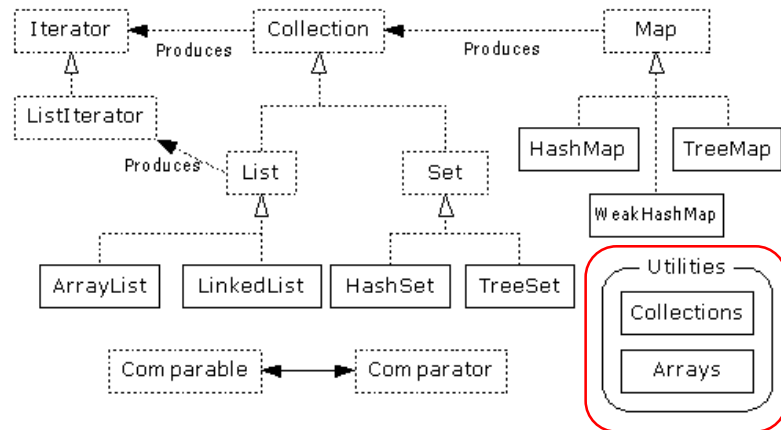
## HashMap and TreeMap Context



## HashMap and TreeMap

- **HashMap**
  - » The keys are a set - unique, unordered
  - » Fast
- **TreeMap**
  - » The keys are a set - unique, ordered
  - » Same options for ordering as a TreeSet
    - *Natural order* (*Comparable*, *compareTo(Object)*)
    - *Special order* (*Comparator*, *compare(Object, Object)*)

## Utilities Context



## Utilities

- The Collections class provides a number of static methods for fundamental algorithms
- Most operate on Lists, some on all Collections
  - » Sort, Search, Shuffle
  - » Reverse, fill, copy
  - » Min, max
- Wrappers
  - » synchronized Collections, Lists, Sets, etc
  - » unmodifiable Collections, Lists, Sets, etc

## Appendix

## Legacy classes

- Still available
- Don't use for new development
  - » unless you have to, eg, J2ME, J2EE in some cases
- Retrofitted into Collections framework
- Hashtable
  - » use HashMap
- Enumeration
  - » use Collections and Iterators
  - » if needed, can get an Enumeration with Collections.enumeration(Collection c)

## More Legacy classes

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- Vector
  - » use ArrayList
- Stack
  - » use LinkedList
- BitSet
  - » use ArrayList of boolean, unless you can't stand the thought of the wasted space
- Properties
  - » legacies are sometimes hard to walk away from ...
  - » see next few pages

## Properties class

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- Located in java.util package
- Special case of Hashtable
  - » Keys and values are Strings
  - » Tables can be saved to/loaded from file

## System properties

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- Java VM maintains set of properties that define system environment
  - » Set when VM is initialized
  - » Includes information about current user, VM version, Java environment, and OS configuration

```
Properties prop = System.getProperties();
Enumeration e = prop.propertyNames();
while (e.hasMoreElements()) {
    String key = (String) e.nextElement();
    System.out.println(key + " value is " +
        prop.getProperty(key));
}
```