PROGRAMMING III
OOP. JAVA LANGUAGE

COURSE 4

PREVIOUS COURSE CONTENT

- **Inheritance**
  - Abstract classes
  - Interfaces
  - instanceof operator
- **Nested classes**
- **Enumerations**

COUSE CONTENT

Collections

- List
- Map
- Set
- Aggregate Operations

- **Generics**

COLLECTIONS

- **What is a collection?**

COLLECTIONS

- **What is a collection?**
  - a group of things that have been gathered [http://www.merriam-webster.com/dictionary/collection]

- **What is a collection in Java?**
  - are containers of Objects which by polymorphism can hold any class that derives from Object
  - GENERICS make containers aware of the type of objects they store
    - from Java 1.5

COLLECTIONS. EXAMPLE. JAVA < 1.5

```
static public void main(String[] args) {
    ArrayList argsList = new ArrayList();
    argsList.add(args.length);
    for(String str : args) {
        argsList.add(str);
    }
    if(argsList.contains("Java") {
       System.out.println("Found Java word in collection");
    }
    String first = (String)argsList.get(0);
    System.out.println("First: " + first);
}
```

COLLECTIONS. EXAMPLE. JAVA ≥ 1.5

```
static public void main(String[] args) {
    ArrayList<String> argsList = new ArrayList<String>();
    argsList.add(args.length); // ERROR way?
    for(String str : args) {
        argsList.add(str);
    }
    if(argsList.contains("Java") {
       System.out.println("Found Java word in collection");
    }
    String first = argsList.get(0); // NO CASTING
    System.out.println("First: " + first);
}
```

GENERICS

- **Introducesd in Java 1.5**
- **Allows class and methods definitions with parameters for types**
  - Classes or methods that have type parameters are called *parameterized class* or *generic definitions*, or, simply, *generics*
- **Can be**
  - defined by Java libraries
  - user defined

GENERICS. EXAMPLES FROM JAVA LIBRARY

```
public interface List<E> {
    void add(E x);
    Iterator<E> iterator();
}

public interface Iterator<E> {
    E next();
    boolean hasNext();
}

public interface Map<K,V> {
    V put(K key, V value);
}
```

GENERICS. EXAMPLES. USER DEFINED

```
public class MyPair<T1, T2> {
        private T1 leftValue;
        private T2 rightValue;

        public MyPair (T1 t1, T2 t2){
                leftValue = t1;
                rightValue = t2;
        }

        public String toString(){
                return "(" + leftValue + ", “
                    + rightValue + ")";
        }

    public T1 getLeftValue(){
            return leftValue;
     }

      public T2 getRightValue() {
            return rightValue;
      }

       public void setRightValue(T2
rightValue) {
            this.rightValue = rightValue;
       }

       public void setLeftValue(T1 leftValue) {
            this.leftValue = leftValue;
       }
}
```

GENERICS. EXAMPLES. USER DEFINED

```
public class Test {
        public static void main(String[] args) {
            MyPair<Integer, Integer> p1 = new MyPair<Integer, Integer>(10, 8);
            System.out.println("p1: " + p1);
            MyPair<String, Double> p2 = new MyPair<String, Double>("Coffe", 1.5);
            System.out.println("p2: " + p2);
        }
}
```

- Output

```
p1: (10, 8)
p2: (Coffe, 1.5)
```

GENERICS

- **Syntax**
  - class name<T1, T2, ..., Tn> { /* ... */ }
- **Parameterized Types**
  - can also substitute a type parameter (i.e., K or V) with a parameterized type
  - Example
    - MyPair< String, ArrayList<Characters>> p3;
- **Dyamond operator**
  - <>
  - from Java ≥ 1.7
  - can determine the type arguments from the context
  - Example
    - MyPair< String, ArrayList<Characters>> p3 = new MyPair< String, ArrayList<Characters>>();
    - Becomes: MyPair< String, ArrayList<Characters>> p3 = new MyPair<>();

GENERICS METHODS

- **Methods that introduce their own type parameters**
- **Static and non-static generic methods are allowed**
- **Example**

```
public class Util {
        public static <K, V> boolean compare(MyPair<K, V> p1,
                                                MyPair<K, V> p2) {
                return p1.getRightValue().equals(p2.getRightValue()) &&
                    p1.getLeftValue().equals(p2.getLeftValue());
        }
}
```

- Call

```
public class Test {
        public static void main(String[] args) {
                MyPair<Integer, Integer> p1 = new MyPair<Integer, Integer>(10, 8);
                MyPair<Integer, Integer> p3 = new MyPair<Integer, Integer>(15, 8);
                System.out.println("p1=p3? " + Util.compare(p1, p3));
        }
}
```

GENERICS METHODS

The restriction of the type can be aslo done in case of classes

- **Bounded Type Parameters**
  - restrict the types that can be used as type arguments in a parameterized type
  - Example

```
public class Util {
        public static <K extends Number, V extends Number> boolean
                compareJustNumbers(MyPair<K, V> p1, MyPair<K, V> p2)
{
                return p1.getRightValue().equals(p2.getRightValue()) &&
                        p1.getLeftValue().equals(p2.getLeftValue());
        }
}
```

    - Correct call is?

```
public static void main(String[] args) {
        MyPair<Integer, Integer> p1 = new MyPair<Integer, Integer>(10, 8);
        MyPair<String, Double> p2 = new MyPair<String, Double>("Coffee", 1.5);
        MyPair<Integer, Integer> p3 = new MyPair<Integer, Integer>(15, 8);
        MyPair<String, Double> p4 = new MyPair<String, Double>("Coffee", 1.5);
        System.out.println("p1=p3? " + Util.compareJustNumbers(p1, p3));
        System.out.println("p2=p4? " + Util.compareJustNumbers(p2, p4));
}
```

GENERICS

- **Bounded Type Parameters**
  - Also accepts multiple bounds
    - <T extends B1 & B2 & B3>
  - Example
    - class D <T extends A & B & C> { /* ... */ }

GENERICS

- What happends when a generic type is instantiated?

GENERICS

- **What happends when a generic type is instantiated?**
  - There is no real copy for each parameterized type (Unlike Templates in C++)
  - Compile time check (e.g. List<Integer> adds only Integers)
  - Compiler adds run-time casting (e.g. pulling item from List<Integer> goes through run-time casting to Integer)
  - At run-time, the parameterized types (e.g. <T>) are Erased – this technique is called Erasure
    - E.g. List<String> is converted to List
    - E.g. String t = stringlist.iterator().next() is converted to String t = (String) stringlist.iterator().next()

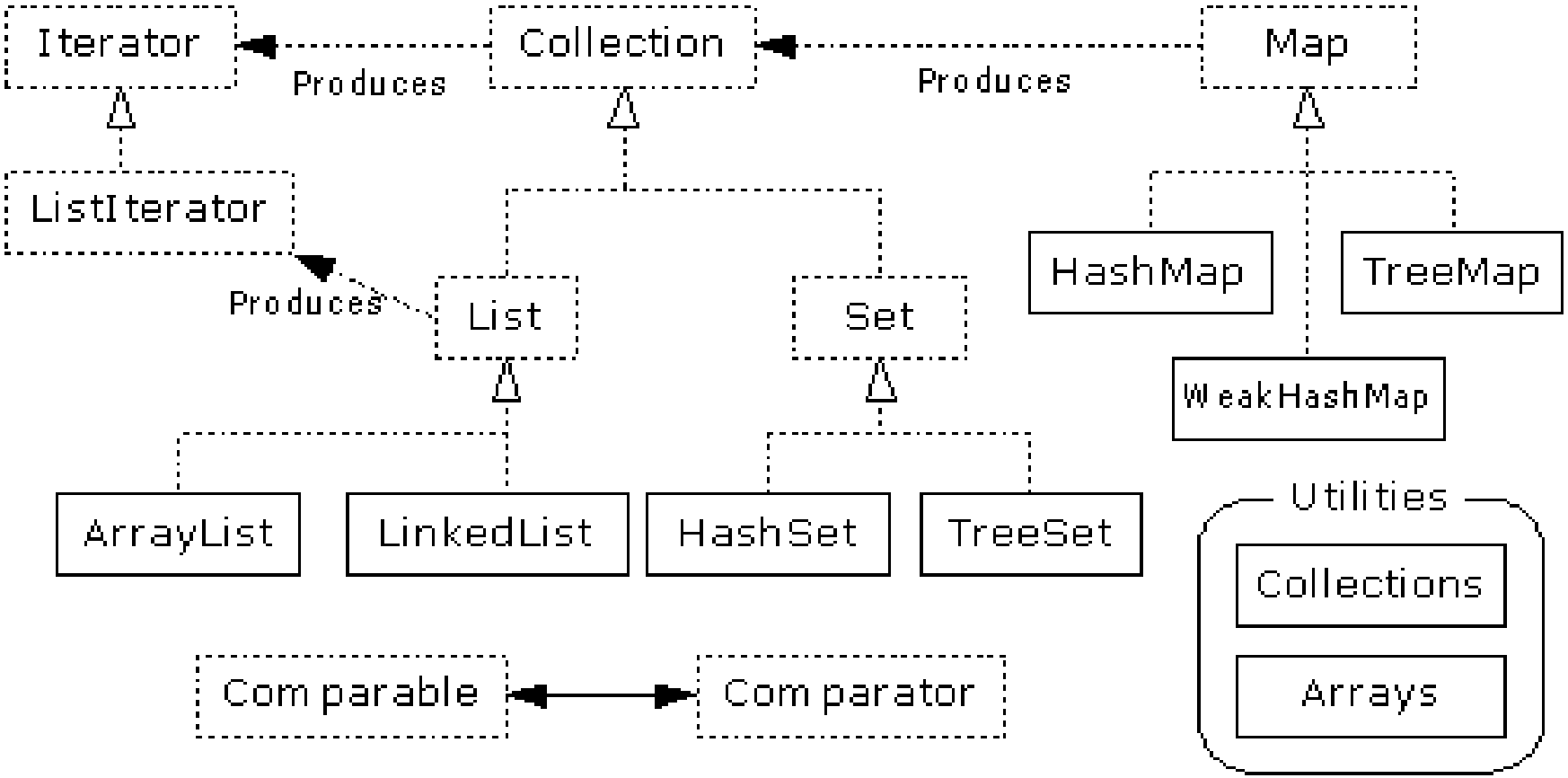
What would be the result of the following code?

```
List <String> l1 = new ArrayList<String>();
List<Integer> l2 = new ArrayList<Integer>();
System.out.println(l1.getClass() ==  l2.getClass());
```

COLLECTIONS

- **A collection is an object that groups multiple elements into a single unit**
- **Java propose a collection framework**
  - Unified architecture for representing and manipulating collections.
  - A collections framework contains three things
    - Interfaces
      - Each defines the operations and contracts for a particular type of collection (List, Set, Queue, etc)
      - Idea: when using a collection object, it's sufficient to know its interface
    - Implementations
      - Reusable classes that implement above interfaces (e.g. LinkedList, HashSet)
    - Algorithms
      - Useful polymorphic methods for manipulating and creating objects whose classes implement collection interfaces
      - Sorting, index searching, reversing, replacing etc.

COLLECTIONS



COLLECTIONS

- **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

COLLECTION ITERATOR

- **An Iterator is an object that enables to traverse through a collection and to remove elements from the collection selectively, if desired**
- ***iterator()* method is used to obtain an iterator for a collection**
- **Iterator interface**

```
public interface Iterator<E> {
    boolean hasNext();
    E next();
    void remove(); //optional
}
```

COLLECTION ITERATOR

- **Display a collection using an iterator**

```
List<String> list = new ArrayList<>();
list.add("course");list.add("four"); list.add("java");
for (Iterator<String> it = list.iterator(); it.hasNext();){
                System.out.println("List element: " + it.next());
}
```

- **Display a collectio using for-each statement**

```
List<String> list = new ArrayList<>();
list.add("course");list.add("four"); list.add("java");
for (String element: list){
                System.out.println("List element: " + element);
}
```

COLLECTION ITERATOR

- **Display a collection us**

```
List<String> list = new A
list.add("course");list.ad
for (Iterator<String> it =
                System.ou
}
```

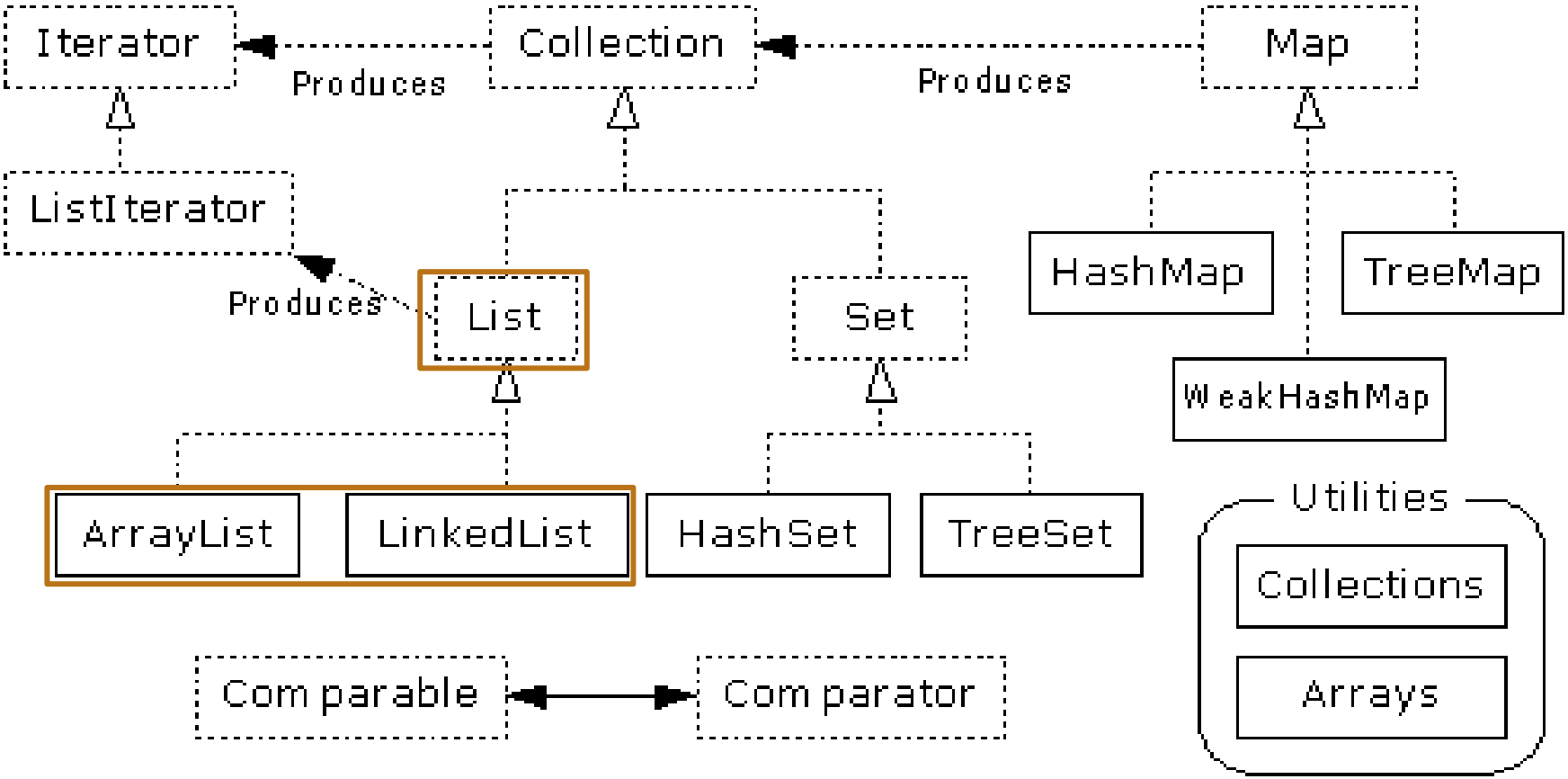
For-each statement can be used by arrays also.
Disadvantage: losing the index position
Example:

```
 int t[] = { 1, 2, 3, 4 };
// not using for-each
for (int i = 0; i < t.length; i++)
        System.out.println("El[" + i + "]=" + t[i]);
//using for-each
for(int el:t){
        System.out.println("El = "+ el);
```

- **Display a collectio using for-each statement**

```
List<String> list = new ArrayList<>();
list.add("course");list.add("four"); list.add("java");
for (String element: list){
                System.out.println("List element: " + element);
}
```

COLLECTIONS



COOLECTION. LIST INTFACE

- **Java provides 3 concrete classes which implement the list interface**
  - Vector
  - ArrayList
  - LinkedList
- **Vectors try to optimize storage requirements by growing and shrinking as required**
  - Methods are synchronized (used for Multi threading)
- **ArrayList is roughly equivalent to Vector except that its methods are not synchronized**
- **LinkedList implements a doubly linked list of elements**
  - Methods are not synchronized

COOLECTION. LIST INTFACE

- **A List is an ordered Collection (sometimes called a sequence).**
- **Lists may contain duplicate elements.**
- **In addition to the operations inherited from Collection, the List interface includes operations for the following:**
  - Positional access
    - Manipulates elements based on their numerical position in the list
    - Includes methods such as get, set, add, addAll, and remove.
  - Search
    - Searches for a specified object in the list and returns its numerical position.
    - Search methods include indexOf and lastIndexOf.
  - Iteration
    - Extends Iterator semantics to take advantage of the list's sequential nature. The listIterator methods provide this behavior.
  - Range-view
    - The sublist method performs arbitrary range operations on the list.

COOLECTION. LIST INTFACE

- **Example**

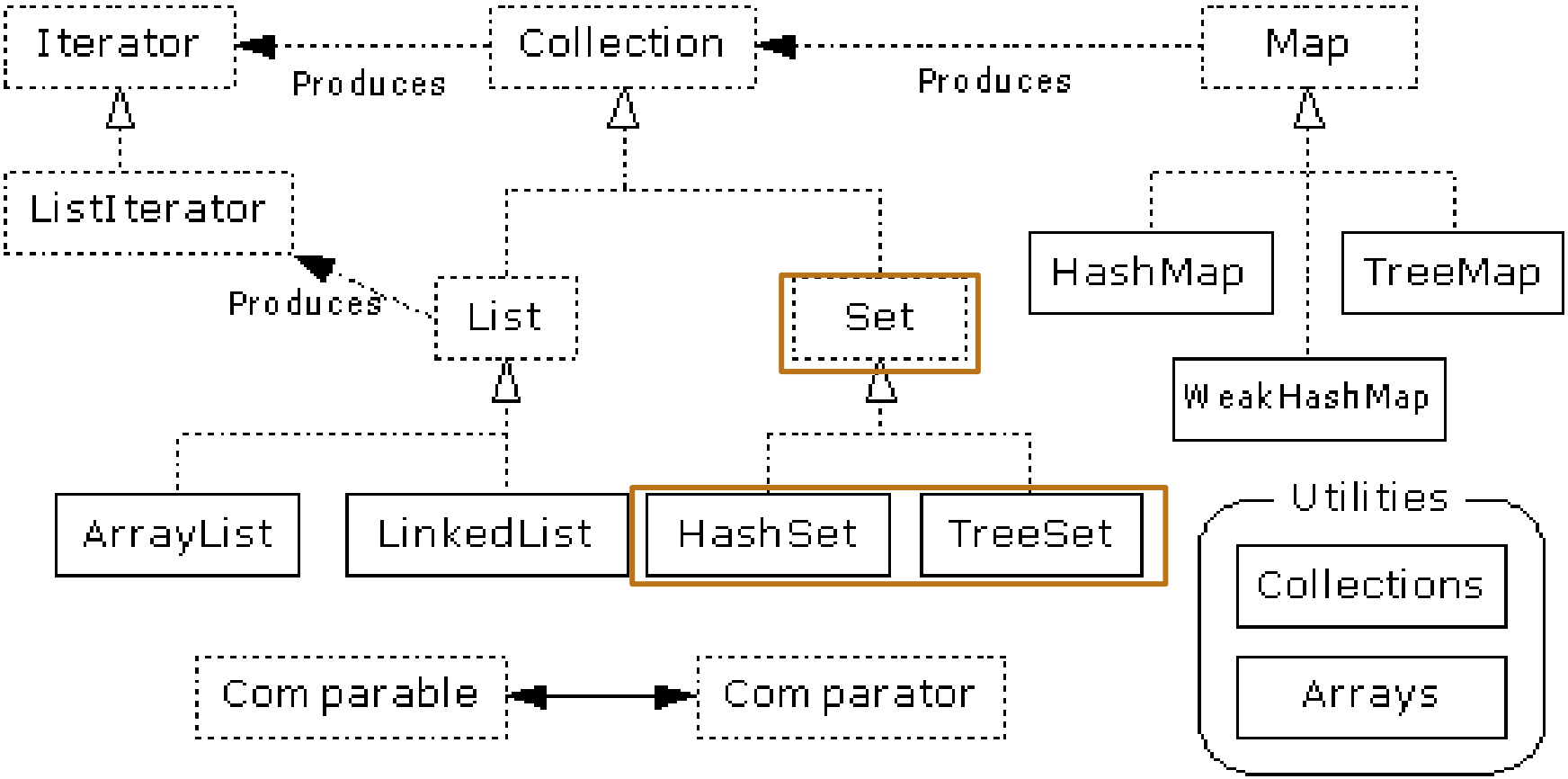
```
List a1 = new ArrayList();
a1.add("Course");
a1.add("Programming");
a1.add("III");
System.out.println(" ArrayList Elements");
System.out.print("\t" + a1);

List a2 = new LinkedList();
a2.addAll(a1);
System.out.print(“Element on position 2 in list: ” + a2.get(2));

a1.set(2, “Java”);

a1.remove(“Programming”)

int i = a2.lastIndex(“III”);
```

COOLECTION. 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

COLLECTIONS



COLLECTIONS. SET INTERFACE

- **Java provides 2 concrete classes which implement the Set interface**
  - HashSet
  - TreeSet

- **The elements cannot be duplicated.**

- **The Set interface contains only methods inherited from Collection and adds the restriction that duplicate elements are prohibited.**

COLLECTIONS. SET INTERFACE

- **Example**

```
int count[] = {34, 22,10,60,30,22};
Set<Integer> set = new HashSet<Integer>();
for(int i = 0; i < 5; i++) {
        set.add(count[i]);
 }
System.out.println(set);

TreeSet sortedSet = new TreeSet<Integer>(set);
System.out.println("The sorted list is:");
System.out.println(sortedSet);

System.out.println("The First element of the set is: "+ (Integer)sortedSet.first());
System.out.println("The last element of the set is: "+ (Integer)sortedSet.last());
```

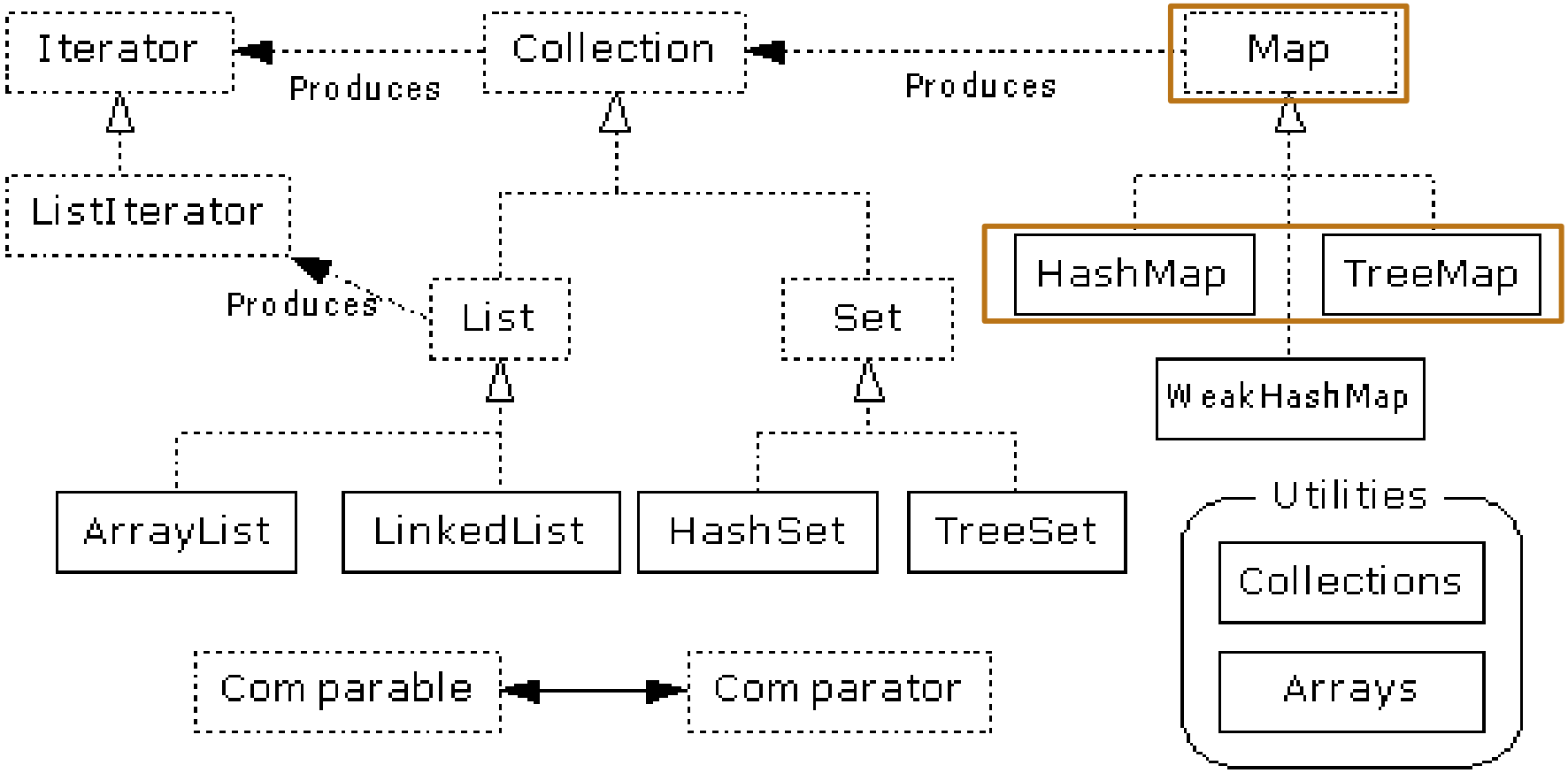
COLLECTION. HASHSET

- **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

COLLECTION. TREESET

- **Elements can be inserted in any order**
- **The TreeSet stores them in order**
- **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

COLLECTIONS



COLLECTION. 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**

COLLECTION. MAP INTERFACE

- **Operations**

  - Object put(Object key, Object value)
  - Object get(Object key)
  - Object remove(Object key)
  - boolean containsKey(Object key)
  - boolean containsValue(Object value)
  - int size()
  - boolean isEmpty()

COLLECTION. MAP INTERFACE

- **Iterating over the keys and values in a Map**
  - Set keySet()
    - returns the Set of keys contained in the Map
  - Collection values()
    - returns the Collection of values contained in the Map.
    - this Collection is not a Set, as multiple keys can map to the same value.
  - Set entrySet()
    - returns the Set of key-value pairs contained in the Map.
    - Map interface provides a small nested interface called Map.Entry that is the type of the elements in this Set.

COLLECTION. MAP INTERFACE IMPLEMENTATIONS

- **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))

MAP. EXAMPLE

- **Exercise**
  - Create a map thet contains the number of appearences of a letter into a word.
    - ex: “maria”
      - m - 1 times
      - a - 2 times
      - r - 1 times
      - i - 1 times