Generic Programming & Java Collection Framework

Pertemuan 11

Topics

1. Generic Programming
2. Java Collection Framework
   a) List
   b) Set
   c) Map

Generic Programming

- Generic programming artinya menuliskan kode yang dapat diguna-ulang (reuse) pada suatu objek dengan tipe yang berbeda.
- Sebelum adanya *generic programming* tipe yang digunakan adalah objek, namun tipe objek memiliki kendala terkait dengan *type casting*.

Enumeration

- Enums are a datatype that contains a fixed set of constants
- Enum are good to use when you already know all possibilities of the values
- Can be declared on their own or within another class

```
package generic;

public class EnumClass {
    enum Level {
        LOW, MEDIUM, HIGH
    };

    public static void main(String[] args) {
        Level myVar = Level.MEDIUM;
        System.out.println(myVar);

        switch (myVar) {
        case LOW:
            System.out.println("Low Level");
            break;
        case MEDIUM:
            System.out.println("Medium Level");
            break;
        case HIGH:
            System.out.println("High Level");
            break;
        }

        for (Level myLevel : Level.values()){
            System.out.println(myLevel);
        }
    }

}
```


Generic class

- A generic class is a special type of class that associates one or more non-specified Java types upon instantiation
- This removes the risk of the runtime exception “ClassCastException” when casting between different types
- Generic types are declared by using angled brackets <> around a holder return type. E.g. <T>

Contoh : Generic Class

```java
package generic;

public class Cell<T> {
    private T data;

    public T getData() {
        return data;
    }

    public void setData(T data) {
        this.data = data;
    }


}
```

Class generic

```java
package generic;

public class CellDriver {

    public static void main(String[] args) {
        Cell<Integer> integerCell = new Cell<Integer>();
        Cell<String> stringCell = new Cell<String>();

        integerCell.setData(1);
        stringCell.setData("One");

        int num = integerCell.getData();
        String str = stringCell.getData();

        System.out.println("Integer value : " + num);
        System.out.println("String value : " + str);

    }
}
```

Class Main

Contoh : Generic Method

```
public class GenericMethodClass {

   public <T> void printArray(T[] array){
      for( T arrayitem : array ){
         System.out.println( arrayitem );
      }//endfor
   }//end method printArray

}//end class GenericMethodClass
```

Generic Method

```
public class GenericMethodDriver {
   public void main(String[] args) {
      GenericMethodClass gmc = new GenericMethodClass();

      Integer[] integerArray = {1, 2, 3};
      String[] stringArray = {"This","is","fun"};

      gmc.printArray(integerArray);
      gmc.printArray(stringArray);
   }//end method main
}//end class GenericMethodDriver
```

Class Main

```
1
2
3
This
is
fun
```

Output

Types Parameter

- The most commonly used types parameter names are :
  - E – Element (used extensively by JCF)
  - K – Key
  - N – Number
  - T – Type
  - V – Value
  - S,U,V etc. – 2nd, 3rd, 4th types

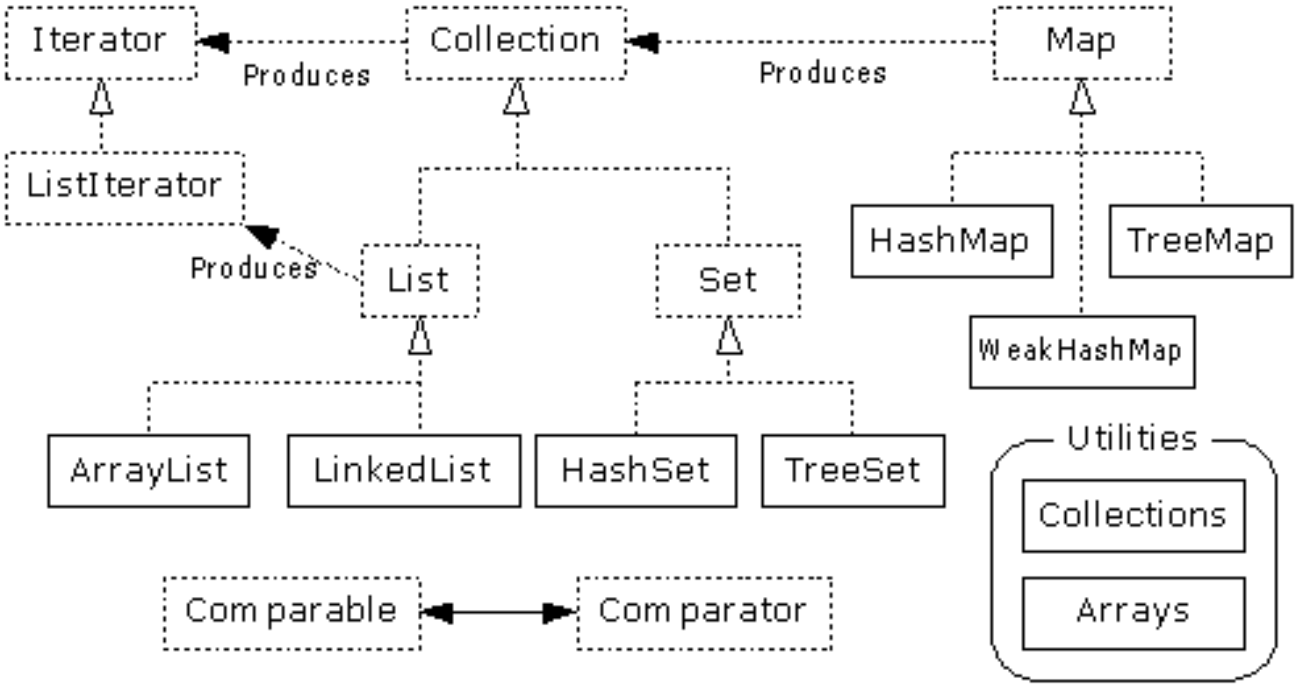
Java Collections

- Collection merupakan suatu objek yang mengelompokkan berbagai elemen kedalam satu unit
- Kegunaan :
  - Menyimpan, membaca dan memanipulasi data
  - Mengirimkan data dari satu method ke method lain
  - Struktur data

Collection Framework

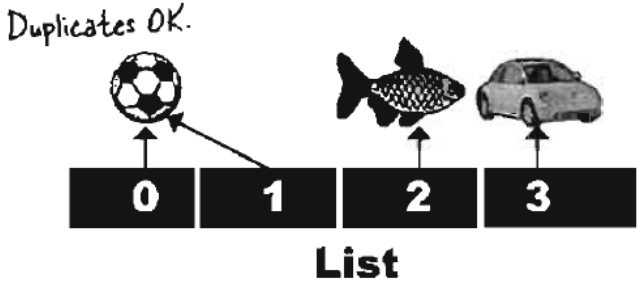
- Collection Framework merupakan suatu arsitektur untuk merepresentasikan dan mengelola suatu collection.
- Terdiri atas 3 (tiga) hal, yaitu :
  - Interfaces
  - Implementations
  - Algorithms

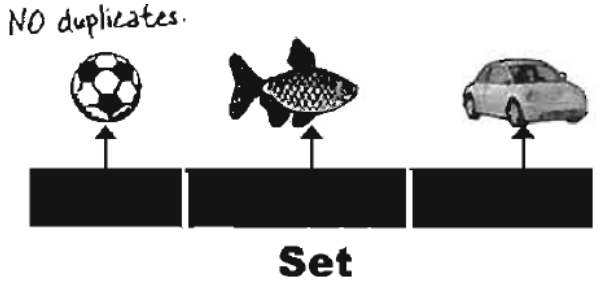
Collection Framework Diagram

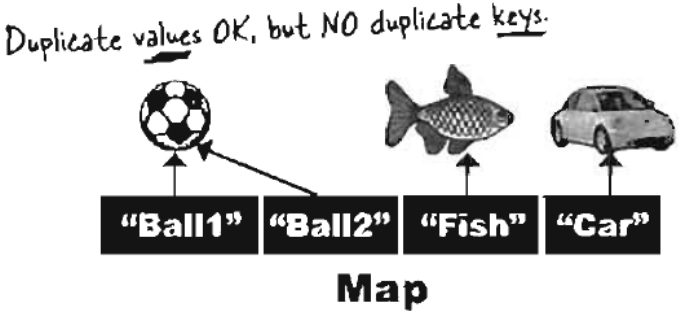


Beberapa tipe collection framework

- List :
  - Ketika urutan (sequence) menjadi pertimbangan
  - Ingin mengetahui posisi berdasarkan index
  - Boleh duplikasi value
- Set
  - Ketika keunikan (uniqueness) menjadi pertimbangan
  - Tidak boleh duplikasi value
- Map
  - Ketika mencari berdasarkan kunci menjadi pertimbangan
  - Boleh duplikasi value, namun tidak boleh duplikasi key







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

Iterator Position

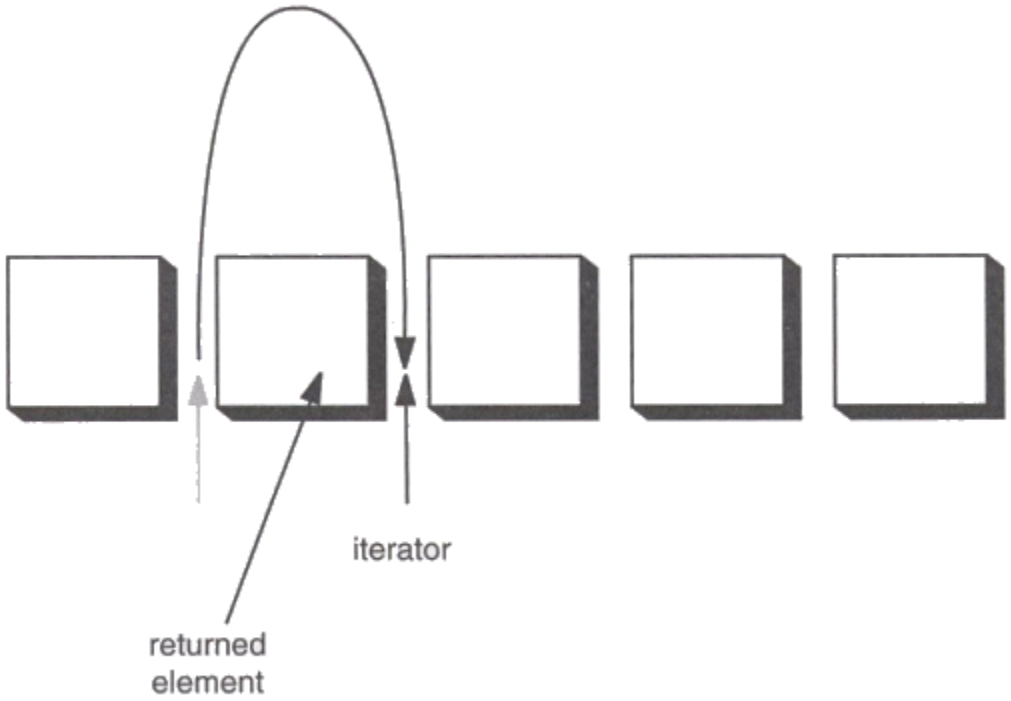
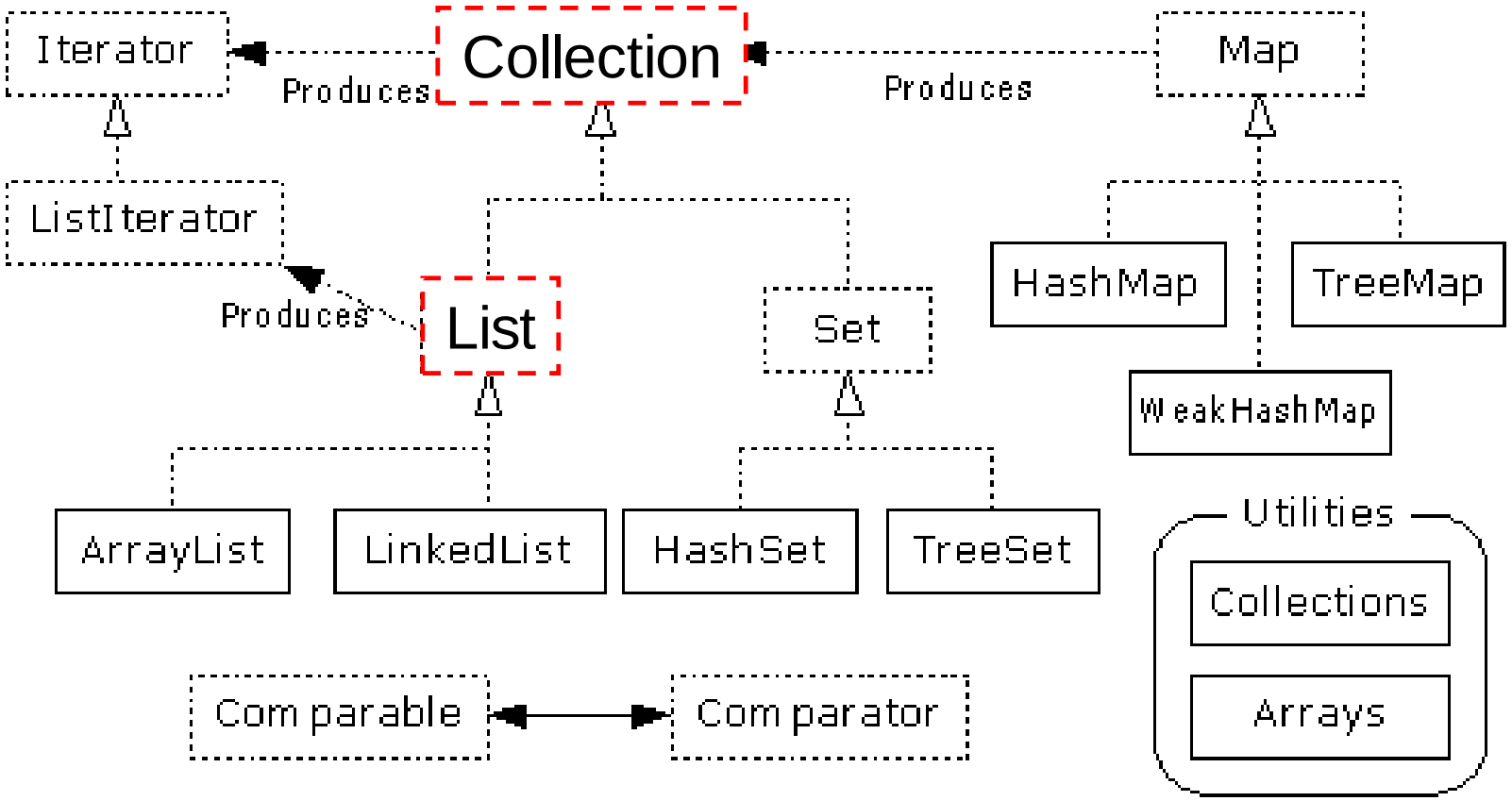


Figure 2–3: Advancing an iterator

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());
  }
}
```


a. List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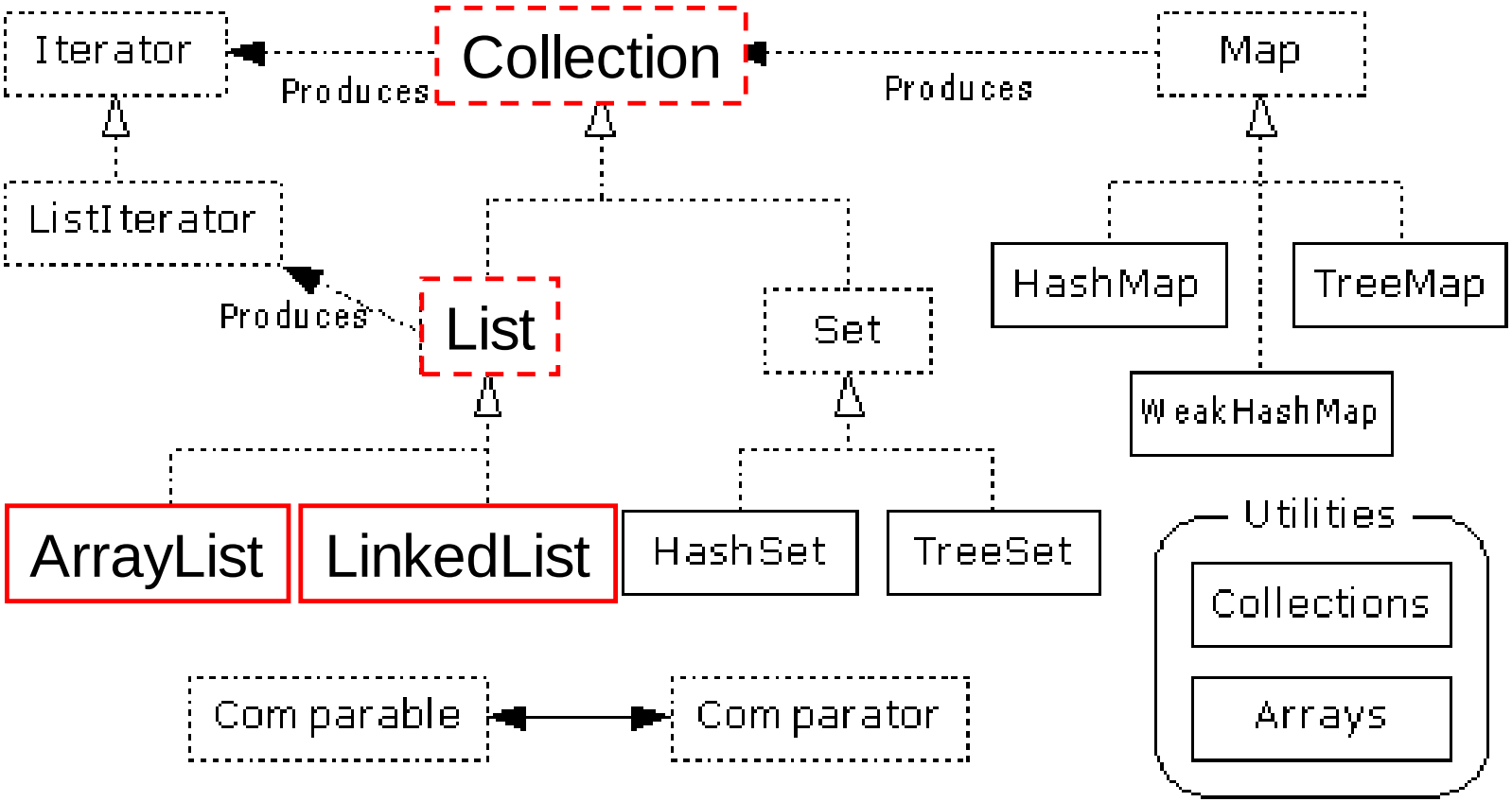
ArrayList and LinkedList Context



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 overview

- Constant time positional access (it's an array)
- One tuning parameter, the initial capacity

```
public ArrayList(int initialCapacity) {
   super();
   if (initialCapacity < 0)
    throw new IllegalArgumentException(
       "Illegal Capacity: "+initialCapacity);
   this.elementData = new Object[initialCapacity];
}
```


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 overview

- Stores each element in a node
- Each node stores a link to the next and previous nodes
- Insertion and removal are inexpensive
  - just update the links in the surrounding nodes
- Linear traversal is inexpensive
- Random access is expensive
  - Start from beginning or end and traverse each node while counting

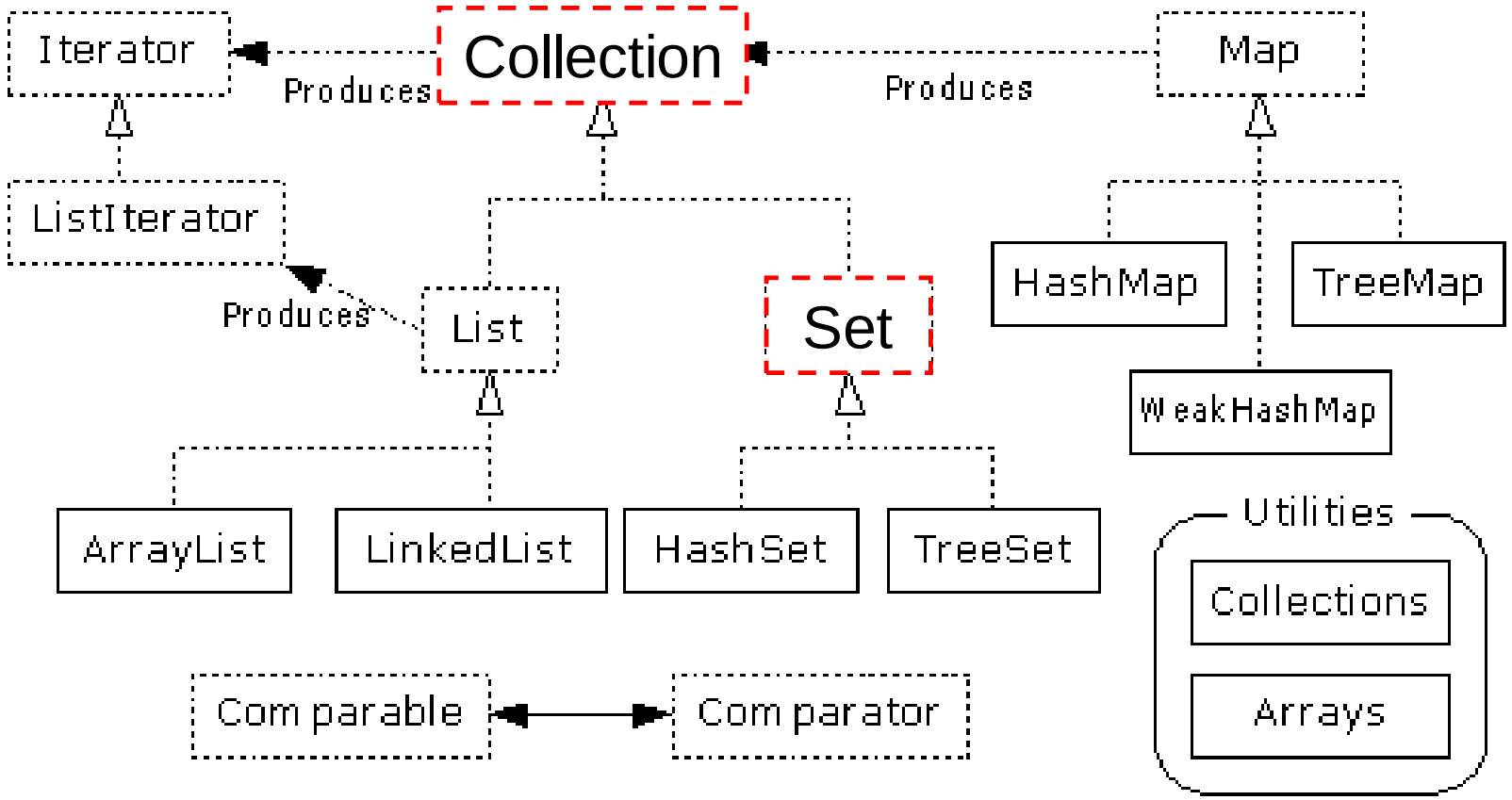
LinkedList entries

```
private static class Entry {
   Object element;
   Entry next;
   Entry previous;

   Entry(Object element, Entry next, Entry previous) {
        this.element = element;
        this.next = next;
        this.previous = previous;
   }
}

private Entry header = new Entry(null, null, null);

public LinkedList() {
   header.next = header.previous = header;
}
```


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()`

b. Set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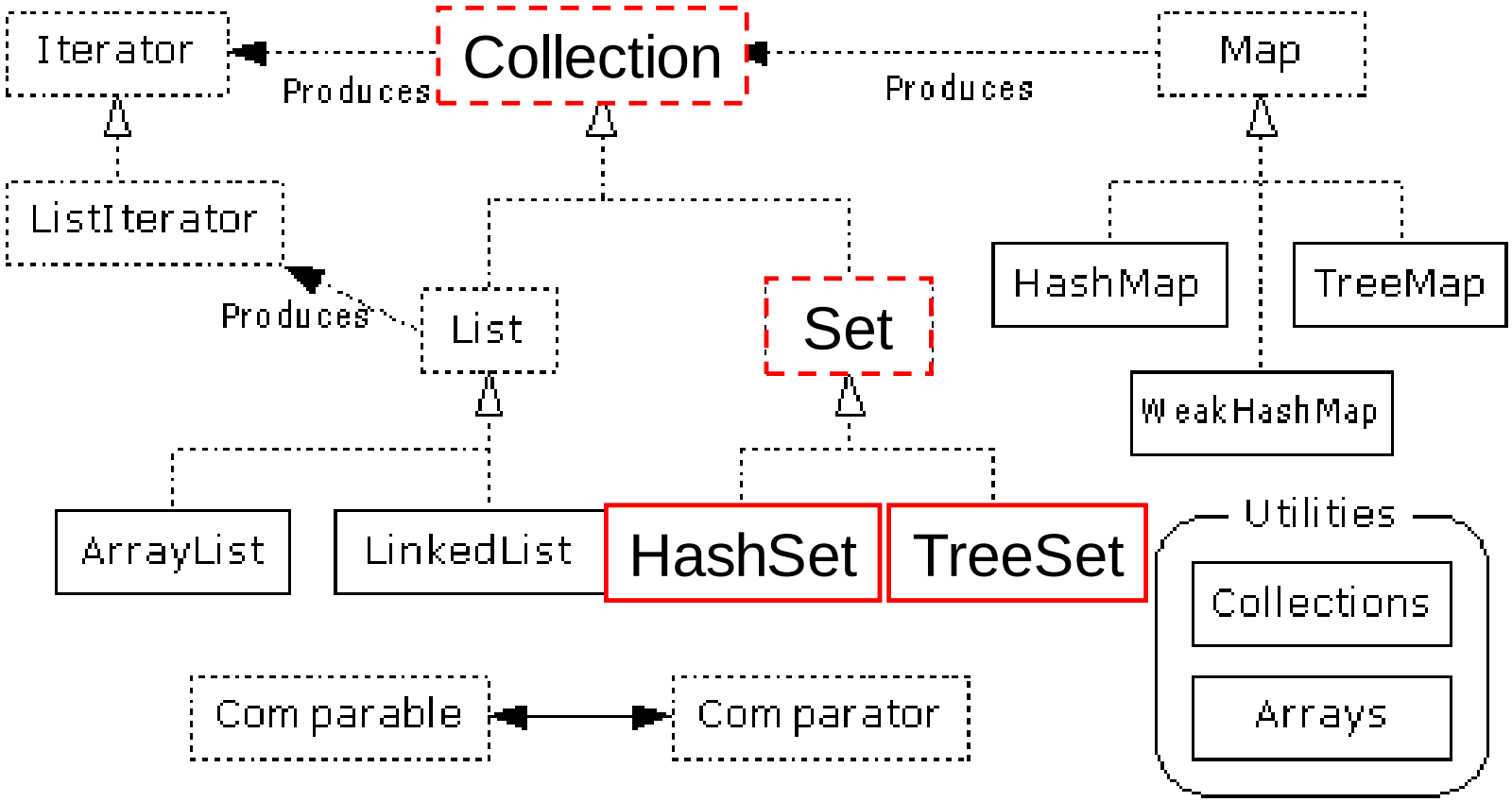
Set Interface

- 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



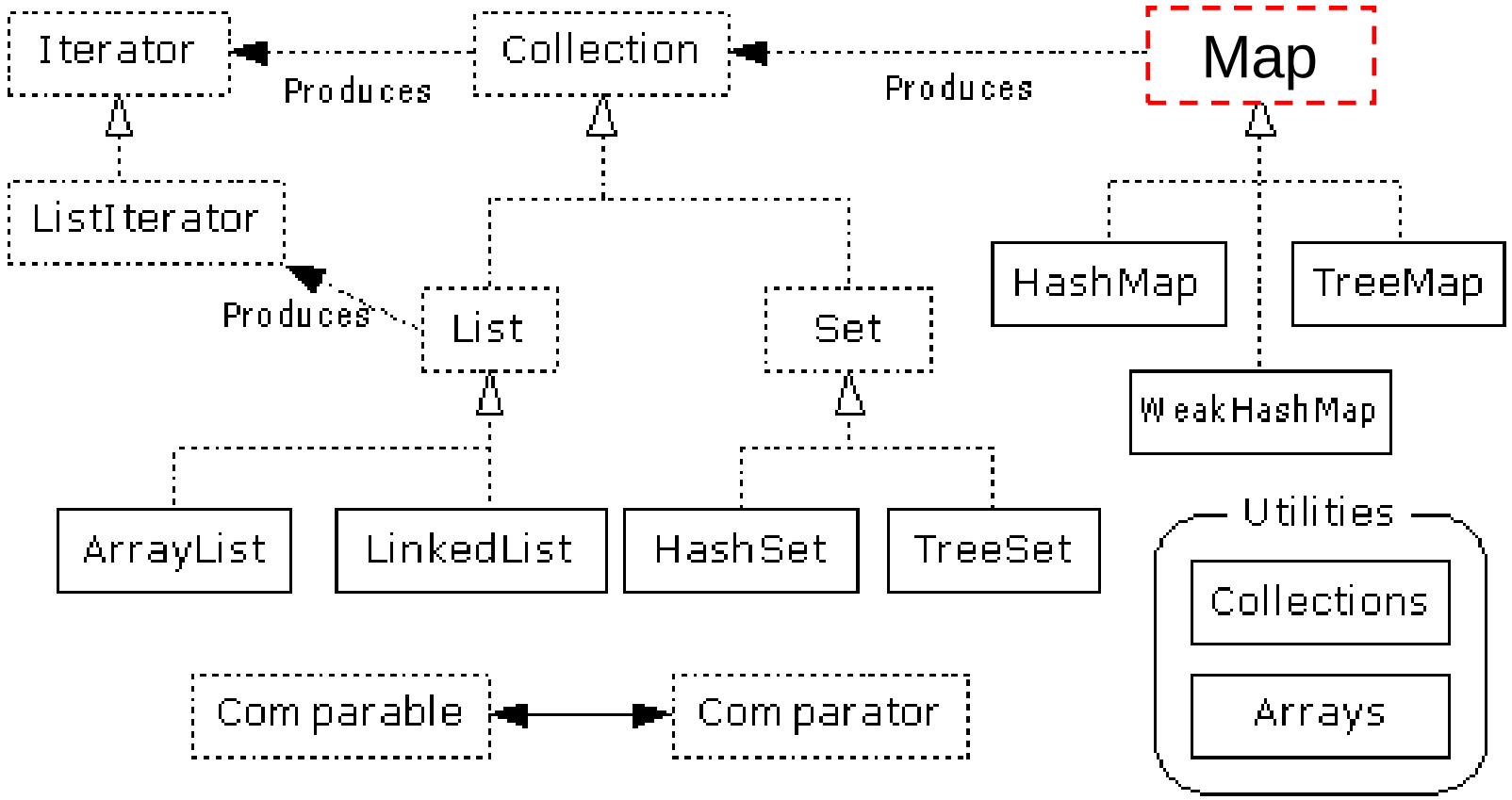
HashSet

- Prevent duplicates in the collection
- Can find and add that elements in the collections very quickly
- 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
- The `hashCode()` method and the `equals()` method must be compatible
  - if two objects are equal, they must have the same `hashCode()` value

TreeSet

- Prevent duplicates in the collections
- Keep the element sorted
- 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

c. Map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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

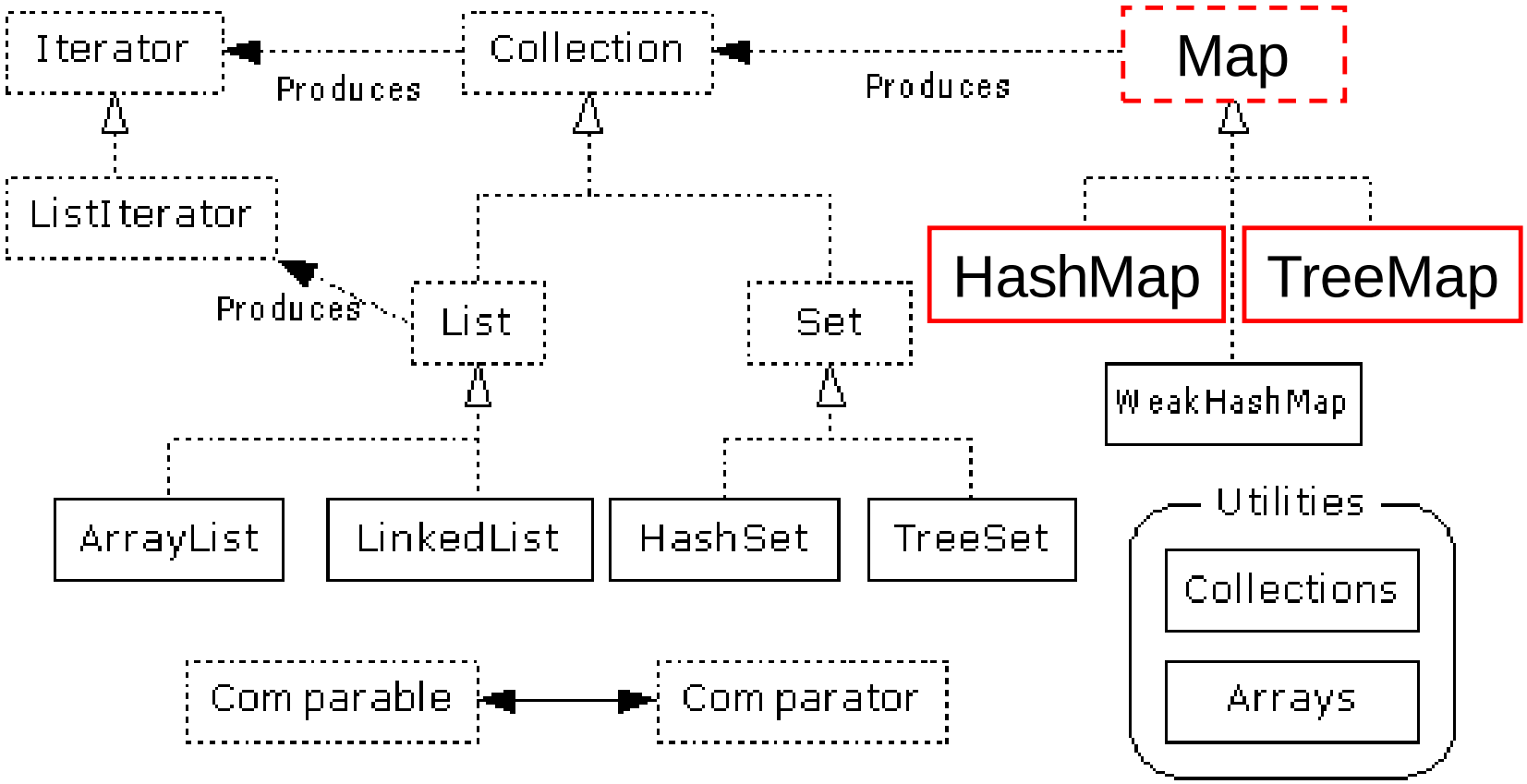
Map methods

```
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()
```


Map views

- A means of 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. The Map interface provides a small nested interface called Map.Entry that is the type of the elements in this Set.

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))*

Bulk Operations

- In addition to the basic operations, a Collection may provide "bulk" operations

```
boolean containsAll(Collection c);
boolean addAll(Collection c);     // Optional
boolean removeAll(Collection c); // Optional
boolean retainAll(Collection c); // Optional
void clear();                     // Optional
Object[] toArray();
Object[] toArray(Object a[]);
```


Kesimpulan

- Java Collection Framework mencakup : List, Set, Map
- List digunakan ketika urutan (sequences) menjadi pertimbangan.
- Set digunakan ketika keunikan (uniqueness) menjadi pertimbangan.
- Map digunakan ketika pencarian berdasarkan kunci (key) menjadi pertimbangan

Referensi

- Head first java 2nd Edition. Chapter 16 : Collections and Generic
- Java Collections. URL [http://www.cs.washington.edu/education/courses/403/03wi/]
- Oracle Academy, Section 3 – Data structures : Generic and Collections.