Collections

Collections Framework

- Dikenalkan pada Java 2 SDK.
- Collection sudah ada sejak JDK 1.0
  - Hashtable
  - Vector

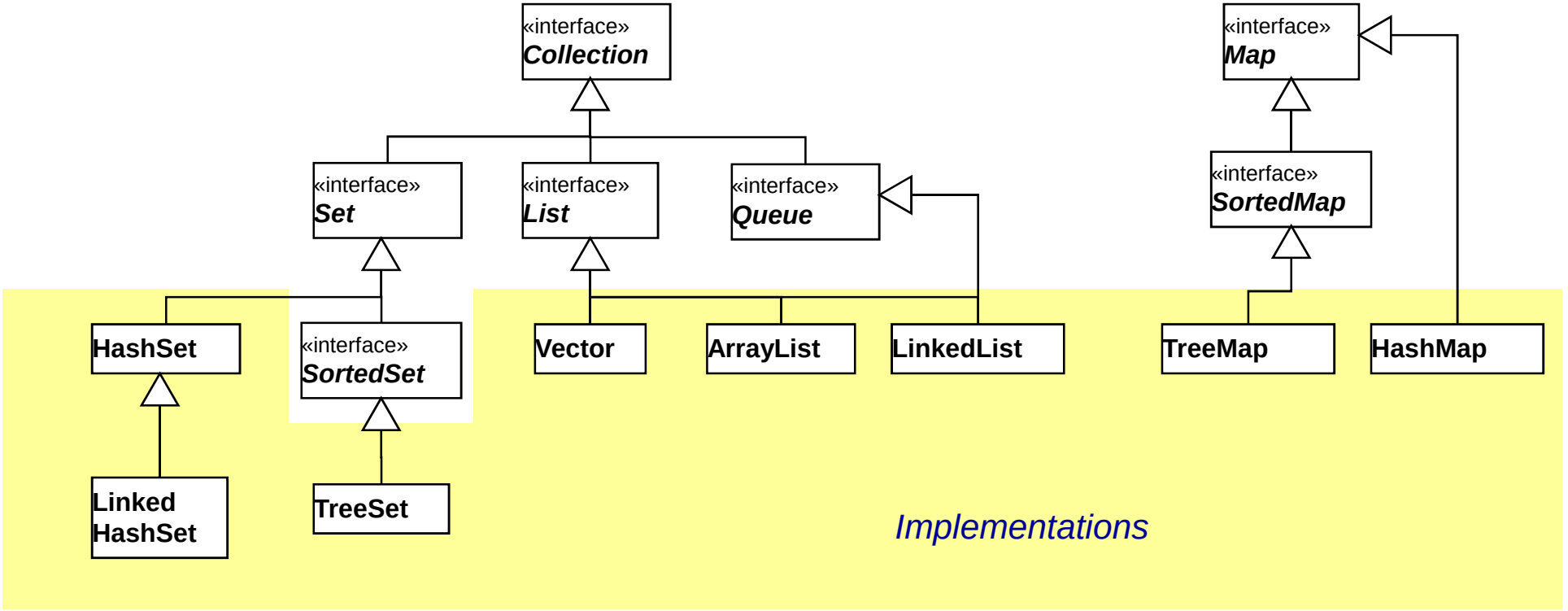
Collections

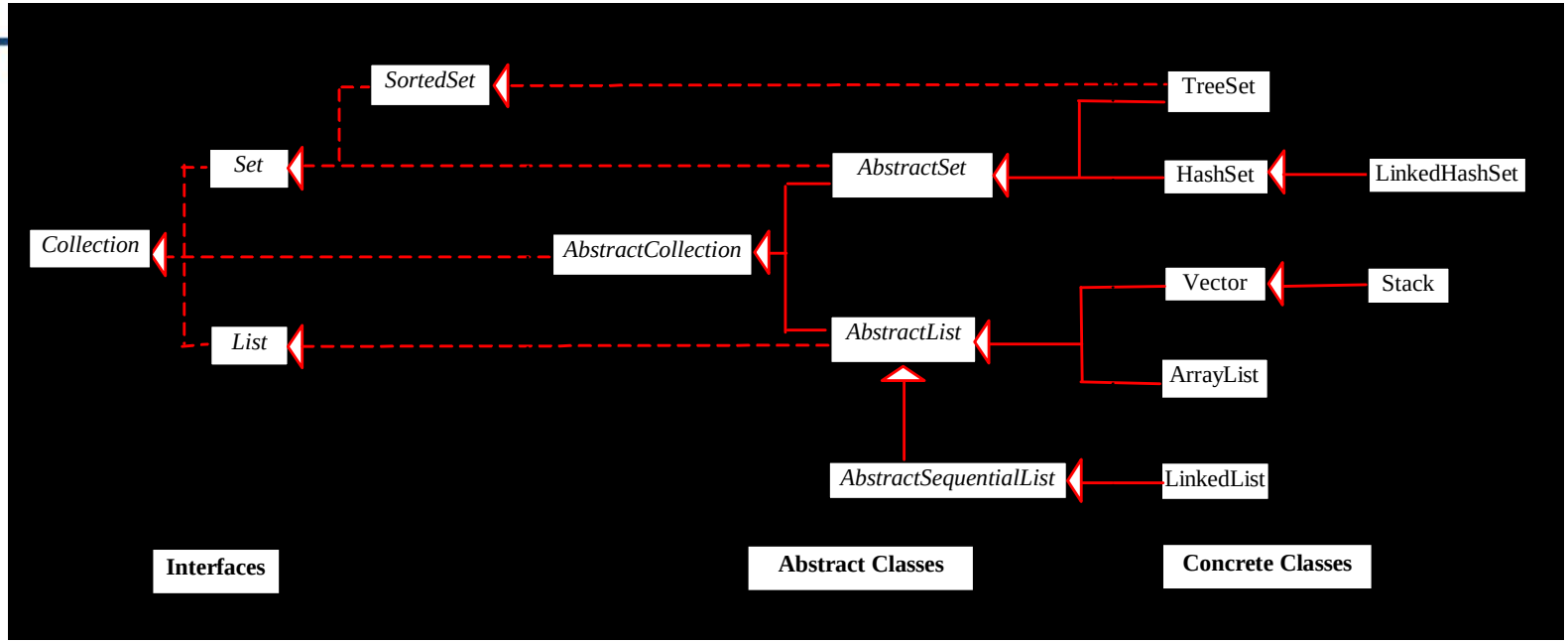
- Collection adalah suatu obyek yang bisa digunakan untuk menyimpan sekumpulan obyek
- Obyek yang ada dalam Collection disebut elemen
- Collection menyimpan elemen yang bertipe Object, sehingga berbagai tipe obyek bisa disimpan dalam Collection

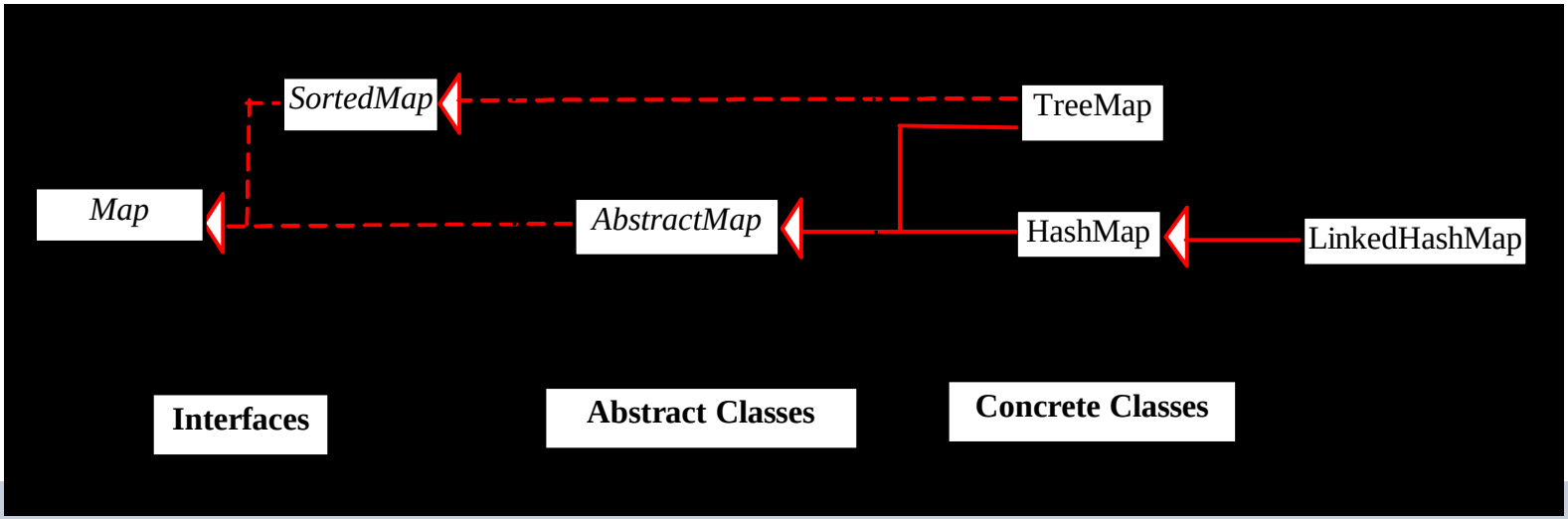
The Java Collections API

- Java Collections API terdiri dari interface:
  - **`Collection`** : sekumpulan obyek yang tidak mempunyai posisi yang tetap (no particular order) dan menerima duplikat.
  - **`List`**: sekumpulan obyek yang berdasarkan urutan (ordered) dan menerima duplikat.
  - **`Set`**: sekumpulan obyek yang tidak berdasarkan urutan (unordered) dan menolak duplikat.
  - **`Map`**: mendukung pencarian berdasarkan key, key ini harus unik. Has no particular order.

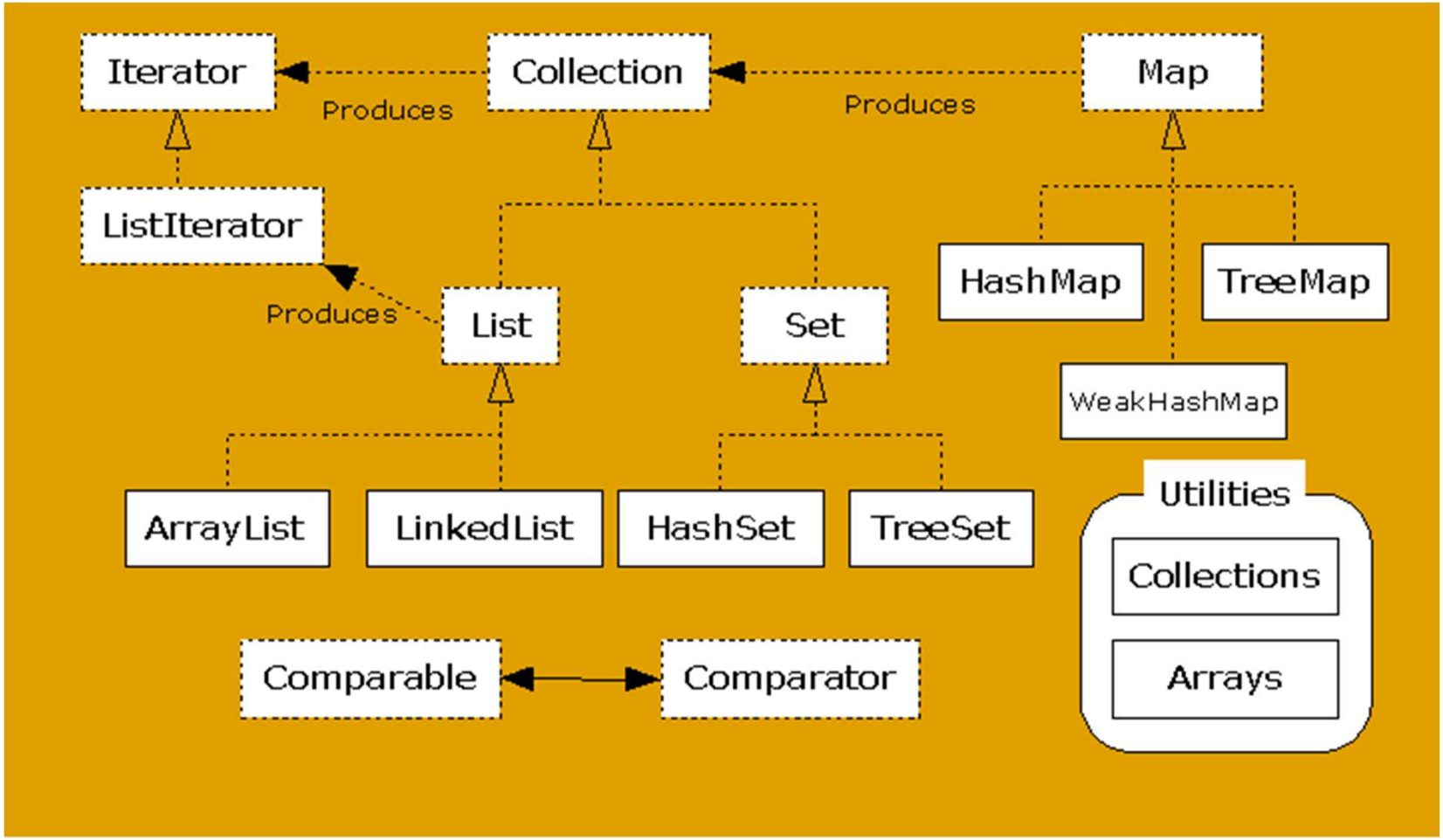
Interface Collection dan Hirarki Class




SortedSet
TreeSet
Set
AbstractSet
HashSet
LinkedHashSet
Collection
AbstractCollection
Vector
Stack
List
AbstractList
ArrayList
AbstractSequentialList
LinkedList
Interfaces
Abstract Classes
Concrete Classes


SortedMap
TreeMap
Map
AbstractMap
HashMap
LinkedHashMap
Interfaces
Abstract Classes
Concrete Classes

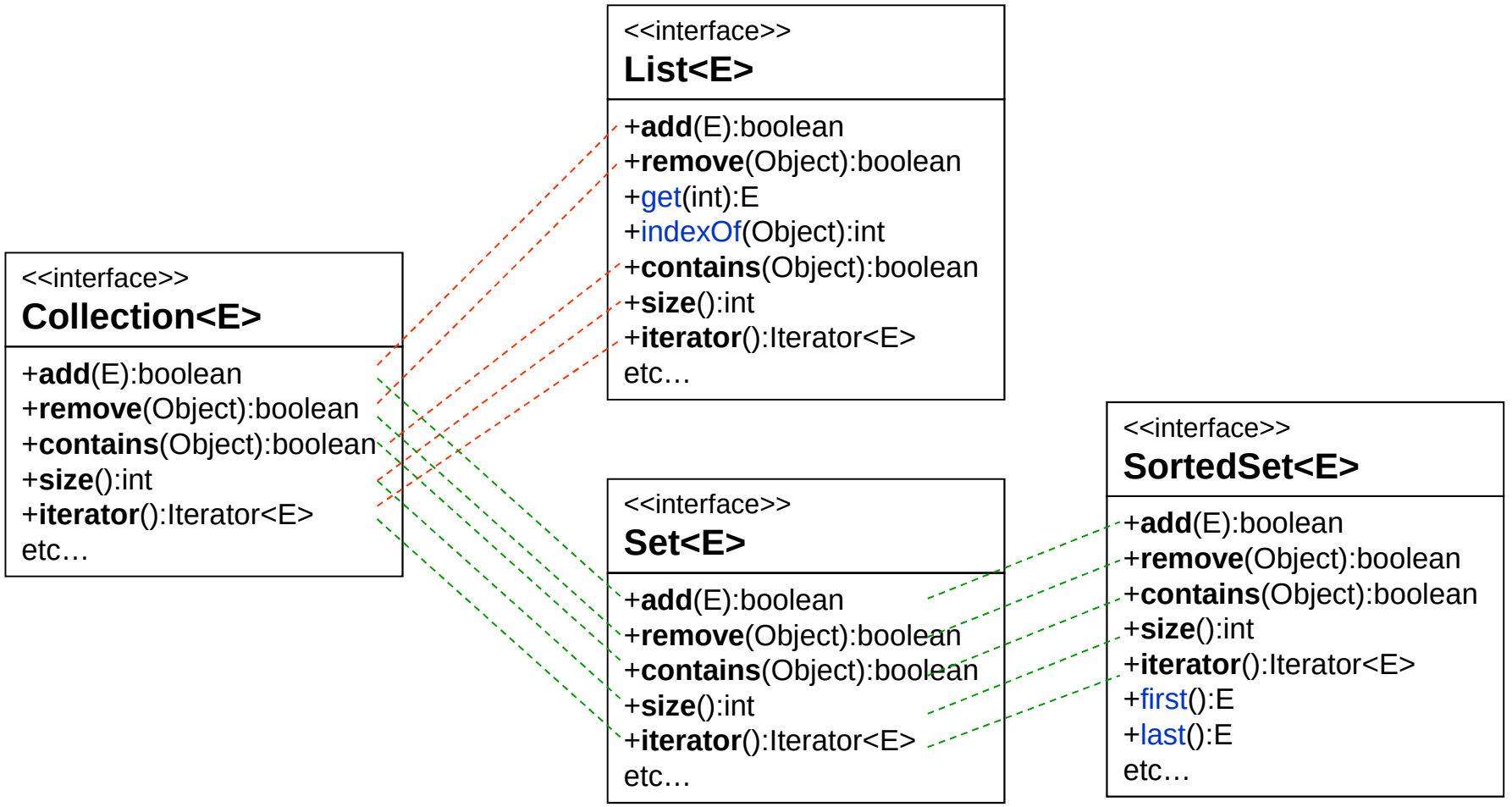
Collection Interfaces and Classes



Interface Collection

```
public interface Collection {
    // Basic Operations
    int size();
    boolean isEmpty();
    boolean contains(Object element);
    boolean add(Object element);    // Optional
    boolean remove(Object element); // Optional
    Iterator iterator();

    // Bulk Operations
    boolean containsAll(Collection c);
    boolean addAll(Collection c);    // Optional
    boolean removeAll(Collection c); // Optional
    boolean retainAll(Collection c); // Optional
    void clear();                    // Optional

    // Array Operations
    Object[] toArray();
    Object[] toArray(Object a[]);
}
```

Expansion of contracts



Set : HashSet

- Elemen pada Set selalu unik
- Set menolak duplikat
- Elemen yang tersimpan tidak berdasarkan urutan(unorder) dan tidak di sorting (unsorted)
- Berhubungan dengan definisi matematika mengenai himpunan.
- Interface Set merupakan subinterface dari interface Collection
- Class yang mengimplementasikan interface Set adalah HashSet

```
public interface Set {
    // Basic Operations
    int size();
    boolean isEmpty();
    boolean contains(Object element);
    boolean add(Object element);    // Optional
    boolean remove(Object element); // Optional
    Iterator iterator();

    // Bulk Operations
    boolean containsAll(Collection c);
    boolean addAll(Collection c);    // Optional
    boolean removeAll(Collection c); // Optional
    boolean retainAll(Collection c); // Optional
    void clear();                    // Optional

    // Array Operations
    Object[] toArray();
    Object[] toArray(Object a[]);
}
```

Set: HashSet

```
import java.util.*;

public class SetExample {
    public static void main(String[] args) {
        Set set = new HashSet();
        set.add("one");
        set.add("second");
        set.add("3rd");
        set.add(new Integer(4));
        set.add(new Float(5.0F));
        set.add("second"); // duplicate, not added
        set.add(new Integer(4)); // duplicate, not added
        System.out.println(set);
    }
}
```

Hasil:

```
[one, second, 5.0, 3rd, 4]
```

Set: HashSet

```
import java.util.*;

public class FindDups {
    public static void main(String args[]) {
        Set s = new HashSet();
        for (int i=0; i<args.length; i++)
            if (!s.add(args[i]))
                System.out.println("Duplicate detected: "+args[i]);

        System.out.println(s.size()+" distinct words detected: "+s);
    }
}
```

```
% java FindDups i came i saw i left

Duplicate detected: i
Duplicate detected: i
4 distinct words detected: [came, left, saw, i]
```

Set: HashSet

```
import java.util.*;

public class FindDups2 {
    public static void main(String args[]) {
        Set uniques = new HashSet();
        Set dups = new HashSet();

        for (int i=0; i<args.length; i++)
            if (!uniques.add(args[i]))
                dups.add(args[i]);

        uniques.removeAll(dups);  // Destructive set-difference

        System.out.println("Unique words:    " + uniques);
        System.out.println("Duplicate words: " + dups);
    }
}
```

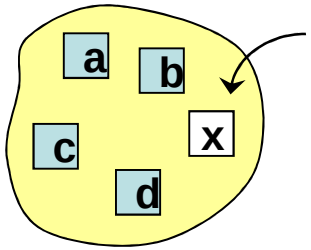
```
% java FindDups2 i came i saw i left

Unique words:    [came, left, saw]
Duplicate words: [i]
```

Set<E>

- Mathematical Set abstraction – contains **no duplicate** elements
  - i.e. no two elements e1 and e2 such that e1.equals(e2)

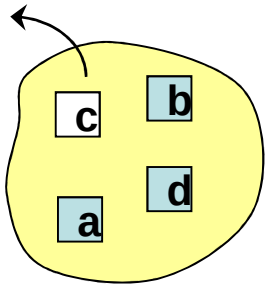
add(x)
→*true*

add(b)
→*false*



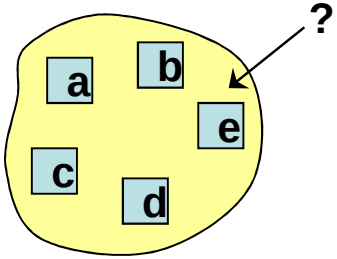
remove(c)
→*true*

remove(x)
→*false*



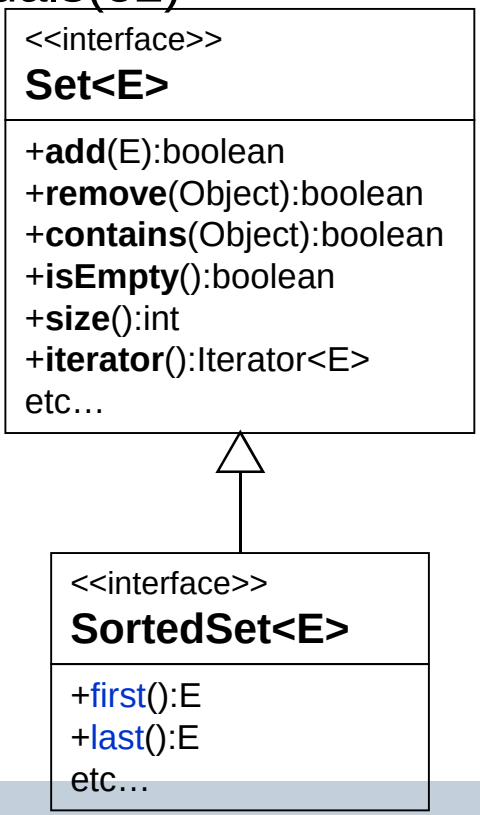
contains(e)
→true

contains(x)
→*false*



isEmpty()
→*false*

size()
→*5*



Operasi Besar (Bulk operations) pada Set: HashSet

Merupakan operasi pada Himpunan

- s1.containsAll(s2)
  mengembalikan nilai true jika s2 adalah subset s1. (Set s2 adalah subset s1 apabila s1 berisi semua anggota s2)
- s1 = s1 U s2
  s1.addAll(s2)
  hasil dari s1 adalah gabungan (union) dari s1 dan s2
- s1 = s1 ∩ s2
  s1.retainAll(s2)
  hasil dari s1 adalah irisan(intersection) dari s1 dan s2.
- s1 = s1 – s2
  s1.removeAll(s2)
  hasil dari s1 adalah selisih dari s1 dengan s2
  Selisih (s1 - s2) adalah set yang berisi semua elemen yang ada pada s1 tetapi tidak ada pada s2.

```
import java.util.*;

public class Sets{
    public static void main(String args[]){
        Set s1 = new HashSet();
        Set s2 = new HashSet();

        for(int i=0;i<5;i++)
            s1.add(new Integer(i));

        for (int i=3; i<7; i++)
            s2.add(new Integer(i));
        System.out.println("s1 = " + s1);
        System.out.println("s2 = " + s2);

        System.out.println(s1.containsAll(s2));

        s1.retainAll(s2);
        System.out.println(s1);

        s1.removeAll(s2);
        System.out.println(s1);
    }
}
```

```
C:\j2sdk1.4.1_01\bin\j
s1 = [2, 4, 1, 3, 0]
s2 = [4, 6, 3, 5]
false
[4, 3]
[]
Finished executing
```

SortedSet:TreeSet

- Aturan sama dengan interface Set → menolak duplikat.
- Ingat → SortedSet adalah subinterface Set.
- Beda: elemen tersimpan dalam urutan ascending → sorted.
- Contoh SortedSet: TreeSet.

SortedSet: TreeSet

```
import java.util.*;
class SortedSetTest{
    public static void main(String [] arg){
        SortedSet set = new TreeSet();
        set.add("Chess");
        set.add("Whist");
        set.add("Checkers");
        set.add("BlackJack");
        set.add("Chess");
        System.out.println(set);
    }
}
```

Output: [BlackJack, Checkers, Chess, Whist]

Class HashSet and TreeSet

- **HashSet and TreeSet mengimplementasikan interface Set.**

HashSet

- Diimplementasikan menggunakan hash table
- Element tidak terurut
- **Method add, remove, and contains, kompleksitas waktu** *O(c).*

TreeSet

- Diimplementasikan menggunakan struktur pohon.
- Dijamin elemen dalam keadaan terurut.
- **Method add, remove, and contains kompleksitas waktu logarithmic** *O(log (n)),*
  dimana n adalah jumlah elemen pada set.

List

- Elemen tersimpan berdasarkan urutan masukan (ordered).
- Menerima duplikat.
- Contoh List:
  - LinkedList : elemen dalam LinkedList masuk dari awal dan dihapus dari akhir.
  - Vector : a growable array of object.
  - ArrayList: mirip vector, bersifat unsyncronized (jika multiple threads mengakses object ArrayList, object ini harus syncronized secara eksternal)

List

- Pengembangan dari Interface Collection.
  - Pengaksesan elemen melalui indeks seperti array
    add (int, Object), get(int), remove(int), set(int, Object)
  - Pencarian element
    indexOf(Object), lastIndexOf(Object)
  - Menggunakan Iterator tertentu disebut **ListIterator**
  - Dapat mengambil subList

    subList(int fromIndex, int toIndex)

List

- **add(Object) :** menambahkan elemen diakhir list
- **remove(Object) :** menghapus di awal list
- **list1.equals(list2) :** dikatakan sama dengan memperhatikan urutan elemen

List

```
public interface List extends Collection {
    // Positional Access
    Object get(int index);
    Object set(int index, Object element);             // Optional
    void add(int index, Object element);               // Optional
    Object remove(int index);                          // Optional
    abstract boolean addAll(int index, Collection c); // Optional

    // Search
    int indexOf(Object o);
    int lastIndexOf(Object o);

    // Iteration
    ListIterator listIterator();
    ListIterator listIterator(int index);

    // Range-view
    List subList(int from, int to);
}
```

Class ArrayList dan LinkedList

- Class **ArrayList dan LinkedList** mengimplementasikan interface List.
- **ArrayList** adalah sebuah implementasi array dimana elemen-elemennya dapat diakses secara langsung menggunakan **get and set methods.**

  Biasanya ArrayList untuk urutan sederhana (simple sequence).
- **LinkedList** menggunakan **double linked list**
- Memberikan performance yang lebih baik untuk **method add dan remove** dibandingkan **ArrayList.**
- Memberikan performance yang lebih jelek untuk method **get and set** dibandingkan **ArrayList.**

List : ArrayList

```
1   import java.util.*
2
3   public class ListExample {
4     public static void main(String[] args) {
5       List list = new ArrayList();
6       list.add("one");
7       list.add("second");
8       list.add("3rd");
9       list.add(new Integer(4));
10      list.add(new Float(5.0F));
11      list.add("second");          // duplicate, is added
12      list.add(new Integer(4));    // duplicate, is added
13      System.out.println(list);
14    }
15  }
```

```
[one, second, 3rd, 4, 5.0, second, 4]
```

List: Vector

```
import java.util.*;
class VectorTest{
    public static void main(String [] arg){
        Vector v = new Vector();
        v.add("Zak");
        v.add("Gordon");
        v.add(0 ,"Duke");
        v.add("Lara");
        v.add("Zak");
        System.out.println(v);
        String name = (String) v.get(2);
        System.out.println(name);
    }
}
```

Output: [Duke, Zak, Gordon, Lara, Zak]

Gordon

```
import java.util.*;

public class TestVector{
    private static void swap(List a, int i, int j) {
        Object tmp = a.get(i);
        a.set(i, a.get(j));
        a.set(j, tmp);
    }
    public static void shuffle(List list, Random rnd) {
        for (int i=list.size(); i>1; i--)
            swap(list, i-1, rnd.nextInt(i));
    }
    public static void main(String args[]){
        Vector v = new Vector();

        for(int i=0;i<10;i++)
            v.add(new Integer(i));
        System.out.println(v);
        v.setElementAt("Andi",1);
        System.out.println(v);
        v.set(5,"Rita");
        System.out.println(v);

        swap(v,2,5) ;
        System.out.println(v);

        shuffle(v,new Random());
        System.out.println(v);
    }
}
```

```
C:\j2sdk1.4.1_01\bin\java.exe  -class
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
[0, Andi, 2, 3, 4, 5, 6, 7, 8, 9]
[0, Andi, 2, 3, 4, Rita, 6, 7, 8, 9]
[0, Andi, Rita, 3, 4, 2, 6, 7, 8, 9]
[3, 7, 8, 9, Andi, 0, 2, 6, Rita, 4]
Finished executing
```

List

- Collection menyediakan method untuk merandom isi dari Collection

```
import java.util.*;

public class Shuffle {
    public static void main(String args[]) {
        List l = new ArrayList();
        for (int i=0; i<args.length; i++)
            l.add(args[i]);
        Collections.shuffle(l, new Random());
        System.out.println(l);
    }
}
```

List

- Output program sama dengan sebelumnya tapi lebih singkat

```
import java.util.*;

public class Shuffle {
    public static void main(String args[]) {
        List l = Arrays.asList(args);
        Collections.shuffle(l);
        System.out.println(l);
    }
}
```

List

```
import java.util.*;

public class TestList{
    public static void main(String args[]){
        List list = new ArrayList();
        list.add("Anis");
        list.add("Budi");
        list.add("Candra");
        list.add("Dewi");
        int i = list.indexOf("Candra");
        System.out.println(i);
    }
}
```

Output

2

```
import java.util.*;

public class TestList{

    public static void replace(List l, Object val, Object newVal) {
    for (ListIterator i = l.listIterator(); i.hasNext(); )
        if (val==null ? i.next()==null : val.equals(i.next()))
            i.set(newVal);
    }

    public static void replace(List l, Object val, List newVals) {
        for (ListIterator i = l.listIterator(); i.hasNext(); ) {
            if (val==null ? i.next()==null : val.equals(i.next())) {
               i.remove();
               for (Iterator j = newVals.iterator(); j.hasNext(); )
                i.add(j.next());
            }
        }
    }

    public static void main(String args[]){
        List list = new ArrayList();
        List list2 = new ArrayList();

        list.add("Anis");
        list.add("Budi");
        list.add("Candra");
        list.add("Dewi");
        System.out.println(list);
        replace(list,"Anis","Rika");
        System.out.println(list);

        list2.add("Intan");
        list2.add("Imam");
        replace(list,"Budi", list2);
        System.out.println(list);
    }
}
```

```
C:\j2sdkl.4.l_Ol\bin\java.exe  -cl:
[Anis, Budi, Candra, Dewi]
[Rika, Budi, Candra, Dewi]
[Rika, Intan, Imam, Candra, Dewi]
Finished executing
```

List

- Tambahkan program sebelumnya

```
System.out.println(list.subList(0,5).indexOf("Dewi"));
list.add(2,"Dewi");
System.out.println(list);
System.out.println(list.subList(2,list.size()).indexOf("Dewi"));
System.out.println(list.subList(2,list.size()).lastIndexOf("Dewi"));
```

```
4
[Rika, Intan, Dewi, Imam, Candra, Dewi]
0
3
Finished executing
```

```
public static List dealHand(List deck, int n) {
    int deckSize = deck.size();
    List handView = deck.subList(deckSize-n, deckSize);
    List hand = new ArrayList(handView);
    handView.clear();
    return hand;
}
class Deal {
    public static void main(String args[]) {
        int numHands = Integer.parseInt(args[0]);
        int cardsPerHand = Integer.parseInt(args[1]);

       // Make a normal 52-card deck
        String[] suit = new String[] {"spades", "hearts",
                                      "diamonds", "clubs"};
        String[] rank = new String[]
            {"ace","2","3","4","5","6","7","8",
             "9","10","jack","queen","king"};
        List deck = new ArrayList();
        for (int i=0; i<suit.length; i++)
            for (int j=0; j<rank.length; j++)
                deck.add(rank[j] + " of " + suit[i]);

        Collections.shuffle(deck);

        for (int i=0; i<numHands; i++)
            System.out.println(dealHand(deck, cardsPerHand));
    }
}
```

Output

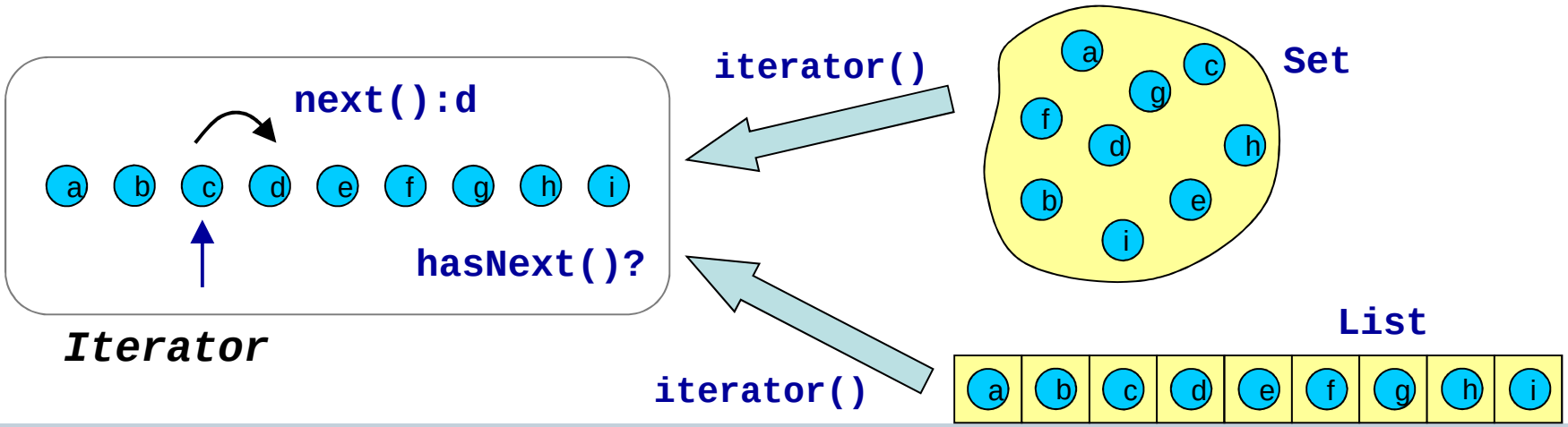
```
% java Deal 4 5

[8 of hearts, jack of spades, 3 of spades, 4 of spades, king of diamonds]
[4 of diamonds, ace of clubs, 6 of clubs, jack of hearts, queen of hearts]
[7 of spades, 5 of spades, 2 of diamonds, queen of diamonds, 9 of clubs]
[8 of spades, 6 of diamonds, ace of spades, 3 of hearts, ace of hearts]
```

List

- Sebagian besar algoritma(method) pada class Collections diaplikasikan ke List. Sehingga dengan algoritma ini memudahkan untuk memanipulasi data pada List.
- sort(List)
  mengurutkan List dengan algoritma merge sort
- shuffle(List)
  Permutasi secara random pada List
- reverse(List)
  membalik urutan elemen pada List
- fill(List, Object)
  Mengganti setiap elemen pada List dengan value yang ditentukan
- copy(List dest, List src)
  Mengkopikan source List ke destination List.
- binarySearch(List, Object)
  Mencari sebuah element pada List dengan algoritma binary Search

java.util.Iterator<E>

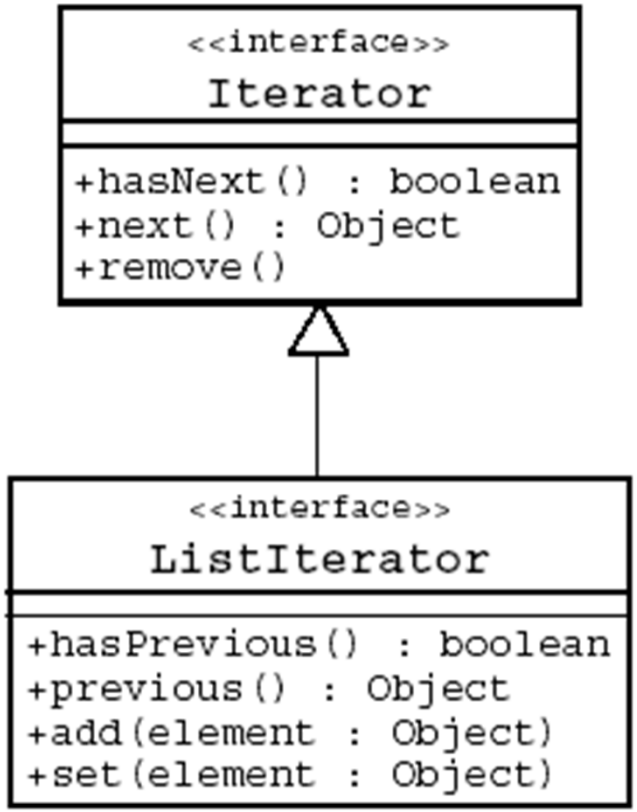
- Think about typical usage scenarios for Collections
  - **Retrieve** the list of all patients
  - **Search** for the lowest priced item
- More often than not you would have to traverse every element in the collection – be it a List, Set, or your own datastructure
- Iterators provide a generic way to traverse through a collection regardless of its implementation



ListIterator

- `ListIterator` adalah subinterface dari `Iterator`.
- Dengan menggunakan ListIterator pada List, maka elemen dapat diambil secara backward.
- Gunakan method `next` atau `previous` sebagai navigasi.

Hirarki Interface Iterator



ListIterator

```
public interface ListIterator extends Iterator {
    boolean hasNext();
    Object next();

    boolean hasPrevious();
    Object previous();

    int nextIndex();
    int previousIndex();

    void remove();          // Optional
    void set(Object o);     // Optional
    void add(Object o);     // Optional
}
```

Map

- Menyimpan elemen dengan key unik.
- Satu key untuk satu elemen.
- Key disimpan dalam bentuk object.
- Map tidak bisa menyimpan duplicate key.
- Map bisa menyimpan duplicate element.
- Has no particular order.
- Contoh:
  - Hashtable
  - HashMap
    - not syncronized for threads
    - permits null values to be stored

Map

- Map dapat dipandang sebagai Collection dengan 3 cara:
  - keySet
    menghasilkan Set key yang ada pada Map
  - Values
    Collection values yang ada pada Map. Collection disini bukan Set karena multiple key dapat mempunyai nilai yang sama.
  - entrySet
    Hasil disimpan pada Set, pasangan key-value yang ada pada Map

Map

- **Map** adalah object yang memetakan key dengan value. Disebut juga dengan *associative array atau dictionary.*
- Method untuk menambah dan menghapus
  - **put(Object key, Object value)**
  - **remove (Object key)**
- Method untuk mengambil object.
  - **get (Object key)**
- Method untuk mengambil key, value dan pasangan (key, value)
  - **keySet() // returns a Set**
  - **values() // returns a Collection,**
  - **entrySet() // returns a set**

Map

```
public interface Map {
    // Basic 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();

    // Bulk Operations
    void putAll(Map t);
    void clear();

    // Collection Views
    public Set keySet();
    public Collection values();
    public Set entrySet();

    // Interface for entrySet elements
    public interface Entry {
        Object getKey();
        Object getValue();
        Object setValue(Object value);
    }
}
```

```
import java.util.*;

public class Freq {
    private static final Integer ONE = new Integer(1);

    public static void main(String args[]) {
        Map m = new HashMap();

        // Initialize frequency table from command line
        for (int i=0; i<args.length; i++) {
            Integer freq = (Integer) m.get(args[i]);
            m.put(args[i], (freq==null ? ONE :
                            new Integer(freq.intValue() + 1)));
        }

        System.out.println(m.size()+" distinct words detected:");
        System.out.println(m);
    }
}
```

```
% java Freq if it is to be it is up to me to delegate

8 distinct words detected:
{to=3, me=1, delegate=1, it=2, is=2, if=1, be=1, up=1}
```

Map: Hashtable

```
class CollectionTest{
    public static void main(String [] arg){
        Hashtable ht = new Hashtable();
        ht.put("key1", new Integer(12));
    }
}
```

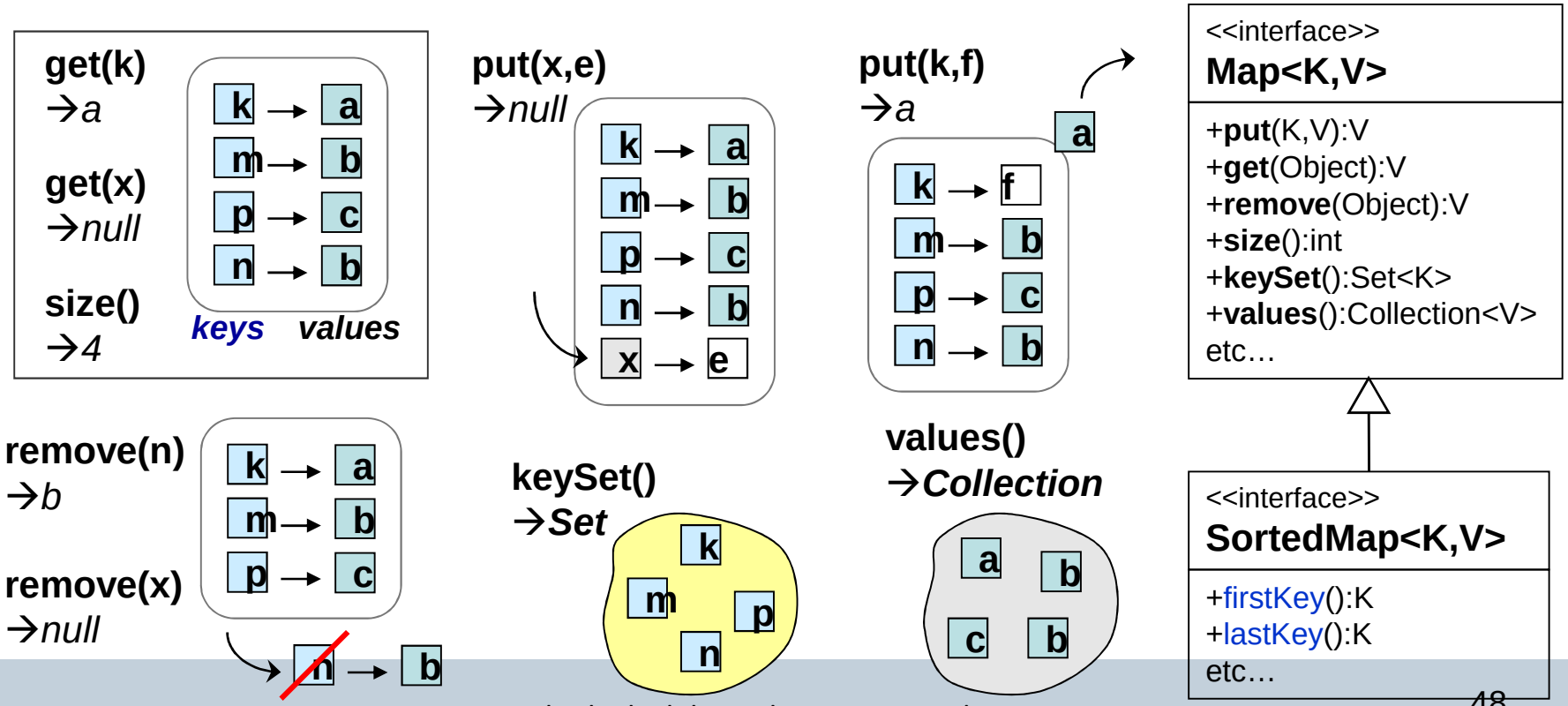
Map: HashMap

```
import java.util.*;
class HashMapTest{
    public static void main(String [] arg){
        HashMap hm = new HashMap();
        hm.put("Game1", "Hearts");
        hm.put(null, "Chess");
        hm.put("game3", "Checkers");
        hm.put("game3", "Whist");
        hm.put("game4", "Chess");
        System.out.println(hm);
    }
}
```

Output: {Game4=Chess, Game3=Whist, Game1=Hearts, null=Chess}

Map<K,V>

- Stores mappings from (unique) keys (type **K**) to values (type **V**)
  - See, you can have more than one type parameters!
- Think of them as “arrays” but with objects (keys) as indexes
  - Or as “directories”: e.g. **"Bob" → 021999887**



```
import java.util.*;

public class TestMap {
    public static void main(String args[]) {
        Map m1 = new HashMap();
        m1.put(new Integer(1),"abc");
        m1.put(new Integer(2),"abc");
        m1.put(new Integer(3),"def");

        Map m2 = new HashMap();
        m2.put(new Integer(1),"klm");
        m2.put(new Integer(2),"abc");
        m2.put(new Integer(3),"def");
        m2.put(new Integer(4),"klm");
        m2.put(new Integer(5),"abc");

        m1.putAll(m2);
        System.out.println(m1);

        Set set = m1.keySet();
        System.out.println(set);

        System.out.println(m1.values());

        System.out.println(m1.entrySet());

        for (Iterator i=m1.entrySet().iterator(); i.hasNext(); ) {
            Map.Entry e = (Map.Entry) i.next();
            System.out.println(e.getKey() + ": " + e.getValue());
        }
    }
}
```

```
C:\j2sdk1.4.1_01\bin\java.exe  -clas
{2=abc, 4=klm, 1=klm, 3=def, 5=abc}
[2, 4, 1, 3, 5]
[abc, klm, klm, def, abc]
[2=abc, 4=klm, 1=klm, 3=def, 5=abc]
2: abc
4: klm
1: klm
3: def
5: abc
Finished executing
```

MultiMap

```
import java.util.*;

public class MultiMap {
    public static void main(String[] args) {
            Map m = new HashMap() ;

            String str[] ={"Andi","Ani","Anisa"};
            List l = Arrays.asList(str);

            m.put(new Integer(1),l);

            String str2[]= {"Budi","Badu","Bina"} ;
            l = Arrays.asList(str2);

            m.put(new Integer(2),l);

            System.out.println(m);
    }
}
```

```
C:\j2sdk1.4.1_01\bin\java.exe  -classpath "D:
{2=[Budi, Badu, Bina], 1=[Andi, Ani, Anisa]}
Finished executing
```

SortedMap: TreeMap

- Aturan mirip Map
- Beda: obyek tersimpan secara sorted berdasarkan key.
- No duplicate key.
- Elements may be duplicate.
- Key tidak boleh null value.

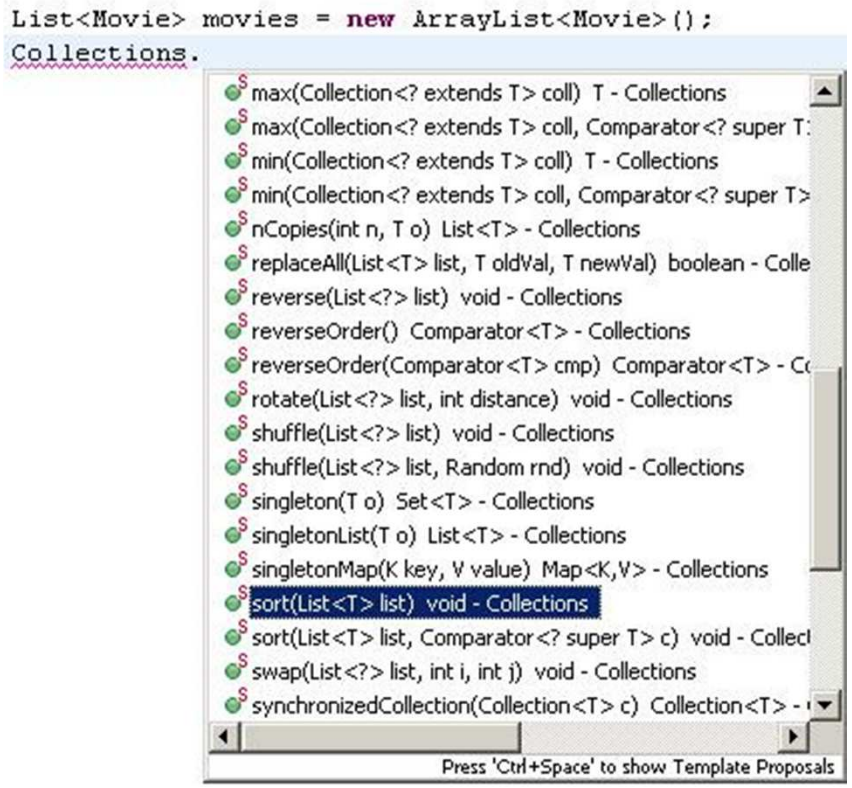
SortedMap: TreeMap

```
import java.util.*;
class TreeMapTest{
    public static void main(String [] args){
        SortedMap title = new TreeMap();
        title.put(new Integer(3), "Checkers");
        title.put(new Integer(1), "Euchre");
        title.put(new Integer(4), "Chess");
        title.put(new Integer(2), "Tic Tac Toe");
        System.out.println(title);
    }
}
```

Output: {1=Euchre, 2=Tic Tac Toe, 3=Checkers, 4=Chess}

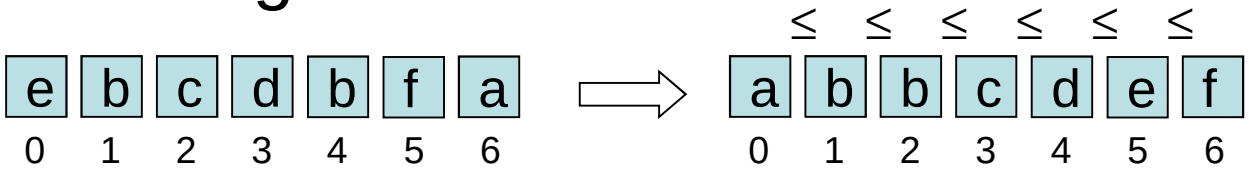
java.util.Collections

- Offers many very useful utilities and algorithms for manipulating and creating collections
  - **Sorting** lists
  - Index searching
  - Finding min/max
  - Reversing elements of a list
  - Swapping elements of a list
  - Replacing elements in a list
  - Other nifty tricks
- Saves you having to implement them yourself
  → **reuse**



Collections.sort()

- Java's implementation of merge sort – ascending order



- What types of objects can you sort? Anything that has an **ordering**
- Two sort() methods: sort a given List according to either 1) *natural ordering* of elements or an 2) externally defined ordering.

1)
```
public static <T extends Comparable<? super T>> void sort(List<T> list)
```

2)
```
public static <T> void sort(List<T> list, Comparator<? super T> c)
```

- Translation:
  1. Only accepts a List parameterised with type implementing Comparable
  2. Accepts a List parameterised with any type as long as you also give it a Comparator implementation that defines the ordering for that type