

OOP with Java

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OOP with Java

- 通知
 - Project 5: 11 月 24 日晚 9 点

- 复习
 - 继承
 - 代码复用
 - 向上转换，多态 (父类与子类的类型转换)
 - 接口
 - 代码复用
 - 向上转换，多态 (多个父接口)
 - 内部类
 - 代码复用
 - 向上转换，多态 (灵活实现多继承)

- 复习
 - 内部类
 - 定义在一个类的内部

```
class Outer{  
    ...  
    class Inner{  
        ...  
    }  
    ...  
}
```

```
public class Parcel{  
    class Contents{  
        private int i = 11;  
        public int value() {return i;}  
    }  
    class Destination{  
        private String label;  
        Destination(String r) {label = r;}  
        String readLabel() { return label;}  
    }  
    public Destination to(String s){  
        return new Destination(s);  
    }  
    public Contents contents(){  
        return new Contents();  
    }  
    public void ship(String dest){  
        Contents c = new Contents();  
        Destination d = new Destination(dest);  
        System.out.println(d.readLabel());  
    }  
  
    public static void main(String []args){  
        Parcel p = new Parcel();  
        Parcel.Destination d = p.to("Tasmania");  
        Parcel.Contents c = p.contents();  
    }  
}
```

- 复习
 - 内部类
 - 每个内部类对象包含的有一个外部类对象的引用
 - `OuterClassName.this`
 - 创建内部类
 - 在外部类的方法中：直接创建
 - 在其他地方：`OuterClassObject.new`

```
public class Parcel{
    class Contents{
        private int i = 11;
        public int value() {return i;}
    }
    class Destination{
        private String label;
        Destination(String r) {label = r;}
        String readLabel() { return label;}
    }

    public Destination to(String s){
        return new Destination(s);
    }
    public Contents contents(){
        return new Contents();
    }

    public static void main(String []args){
        Parcel p = new Parcel();
        Parcel.Destination d = p.new Destination("T");
        Parcel.Contents c = p.new Contents();
    }
}
```

- 复习

- 匿名内部类

- 没有名字的内部类
 - 必须继承某个类，或实现某个接口

```
public class Parcel{  
    public Contents contents(){  
        return new Contents() {  
            // anonymous inner class definition  
            private int i = 11;  
            public int value() {return i;}  
        };  
    }  
  
    public static void main(String []args){  
        Parcel p = new Parcel();  
        Contents c = p.contents();  
    }  
}
```



```
public class Parcel{  
    class PContents implements Contents{  
        private int i = 11;  
        public int value() {return i;}  
    }  
  
    public Contents contents(){  
        return new PContents();  
    }  
  
    public static void main(String []args){  
        Parcel p = new Parcel();  
        Contents c = p.contents();  
    }  
}
```

- 复习
 - 通过内部类灵活实现多继承

```
interface A {}
interface B {}
class X implements A, B {}

class Y implements A{
    B makeB() {
        return new B();
    }
}

public class Test{
    static void takeA(A a) {}
    static void takeB(B b) {}
    public static void main(String []args){
        X x = new X();
        Y y = new Y();
        takeA(x); takeB(x);
        takeA(y); takeB(b.makeB());
    }
}
```

```
class A {}
abstract class B {}
// class X implements A, B {}
// won't compile

class Y extends A{
    B makeB() {
        return new B();
    }
}

public class Test{
    static void takeA(A a) {}
    static void takeB(B b) {}
    public static void main(String []args){
        Y y = new Y();
        takeA(y); takeB(b.makeB());
    }
}
```


OOP with Java

- 容器简介
- Collection
 - List, Set, Queue
- Map
- Collection and Iterator

容器简介

- 如何将对象组织起来？

```
int a = 0;  
int b = 0;
```

```
...  
int z = 0;
```

```
MyType m_a = new MyType();  
MyType m_b = new MyType();
```

```
...  
MyType m_c = new MyType();
```

容器简介

- 数组

```
int [ ] a = new int[]{1,2,3};
```

```
MyType [ ] b = new MyType[3];
```

```
MyType [ ] c = new MyType[3] {  
    new MyType(),  
    new MyType(),  
    new MyType() };
```

长度不可变

1. 无法添加和删除数组元素
2. 数组元素之间的关系？(Set)

容器简介

- 容器
 - 提供更灵活的组织对象的方式
 - 动态添加，删除
 - 例如
 - List, Set, Queue
 - Map
 - 位于包 `java.util` 中

A diagram illustrating a list structure. It consists of a long yellow horizontal bar. Inside this bar, there are three blue rectangular boxes. The first box on the left is labeled 'Item1', the middle box is labeled 'Item2', and the last box on the right is labeled 'ItemN'.

Item1

Item2

ItemN

List: 一系列有序的对象
(数组 , 链表)

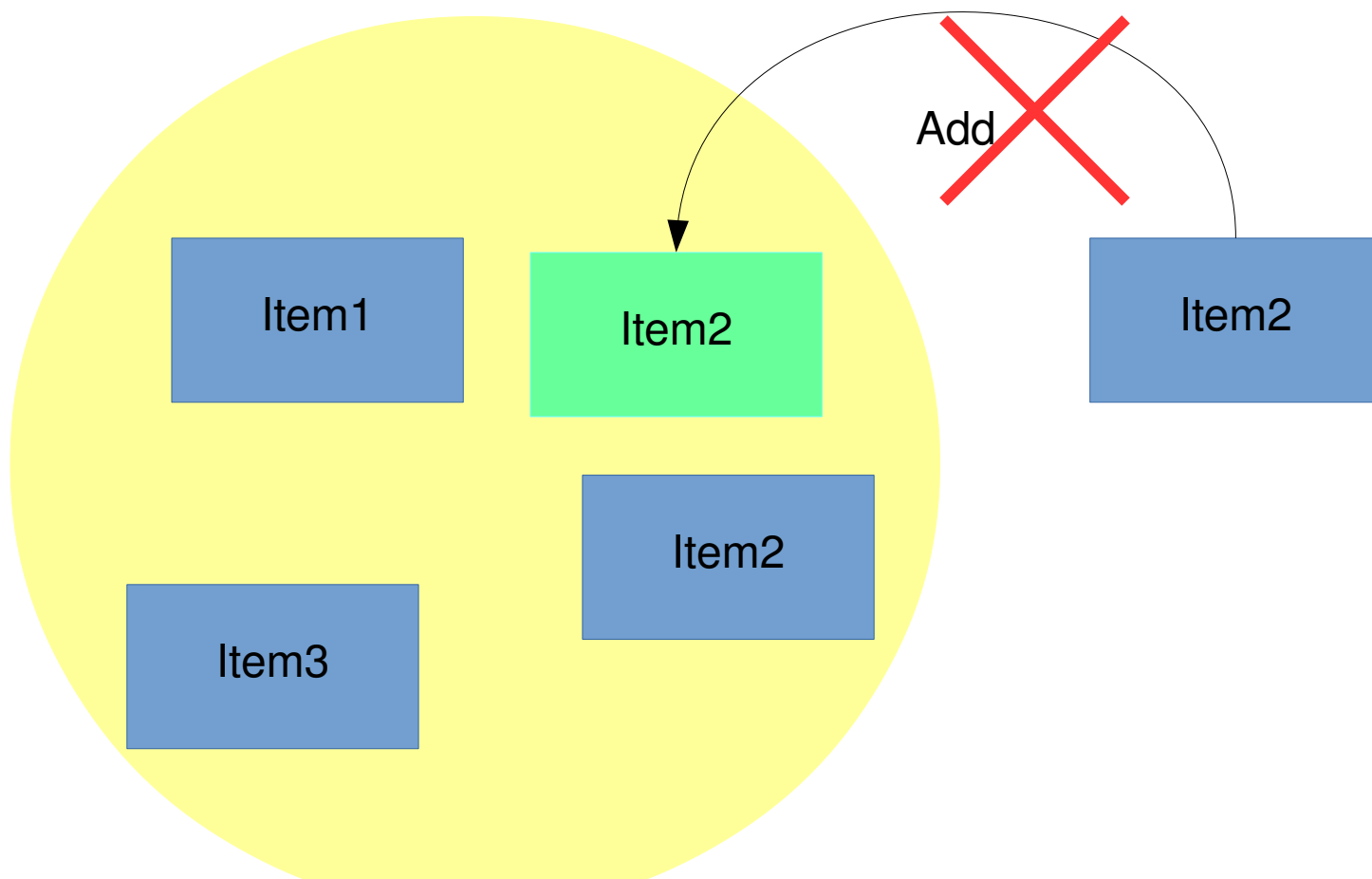
```
import java.util.*;
```

```
ArrayList a = new ArrayList();  
LinkedList b = new LinkedList();
```

```
//Implement List interface
```

```
List c = a;  
List d = b;
```

List 接口



Set: 集合 (没有重复元素)

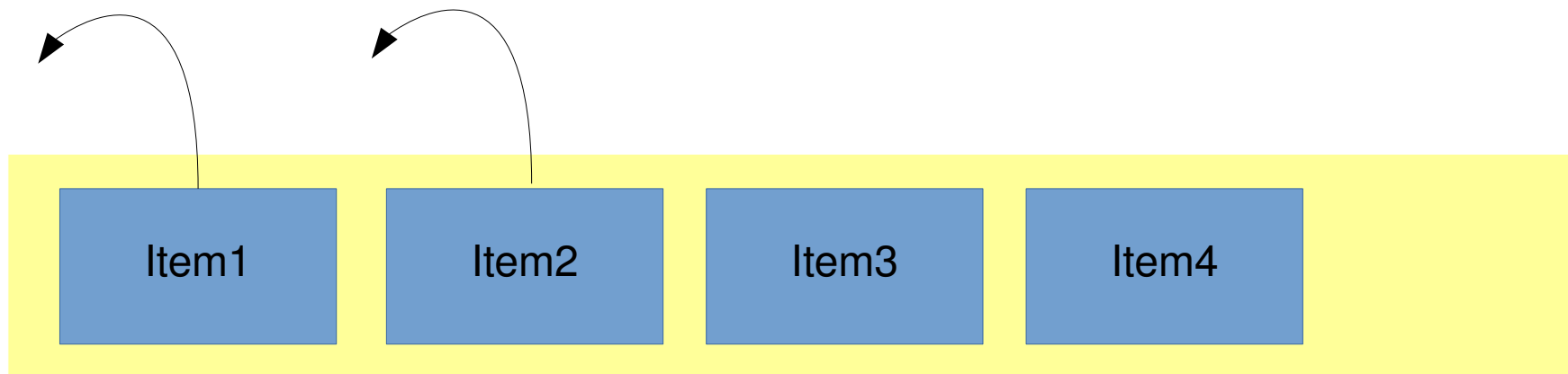
```
import java.util.*;
```

```
HashSet a = new HashSet();  
TreeSet b = new TreeSet();
```

```
//implement Set interface
```

```
Set c = a;  
Set d = b;
```

Set 接口



Queue: 队列

- enqueue (进队)
- dequeue (出队)
- 先进先出
- 应用：任务调度

```
import java.util.*;
```

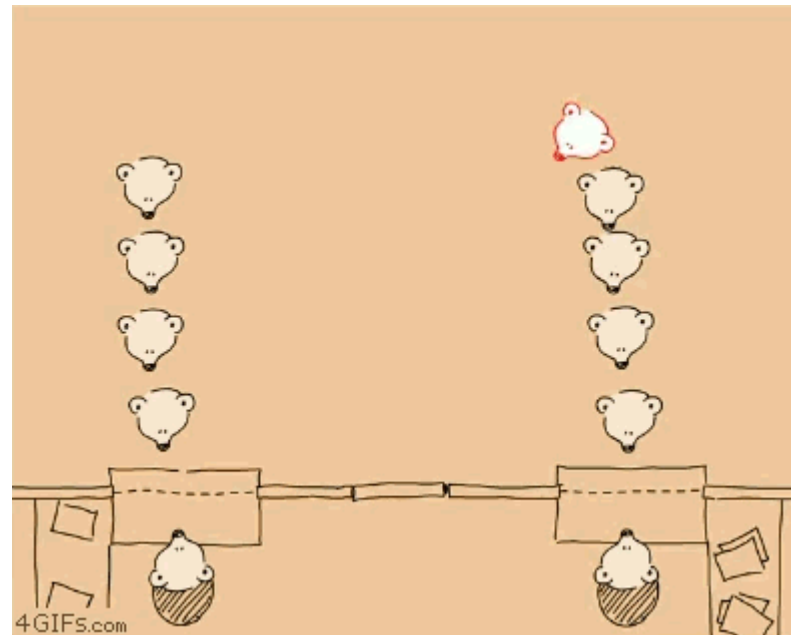
```
LinkedList a = new LinkedList();  
PriorityQueue b = new PriorityQueue();
```

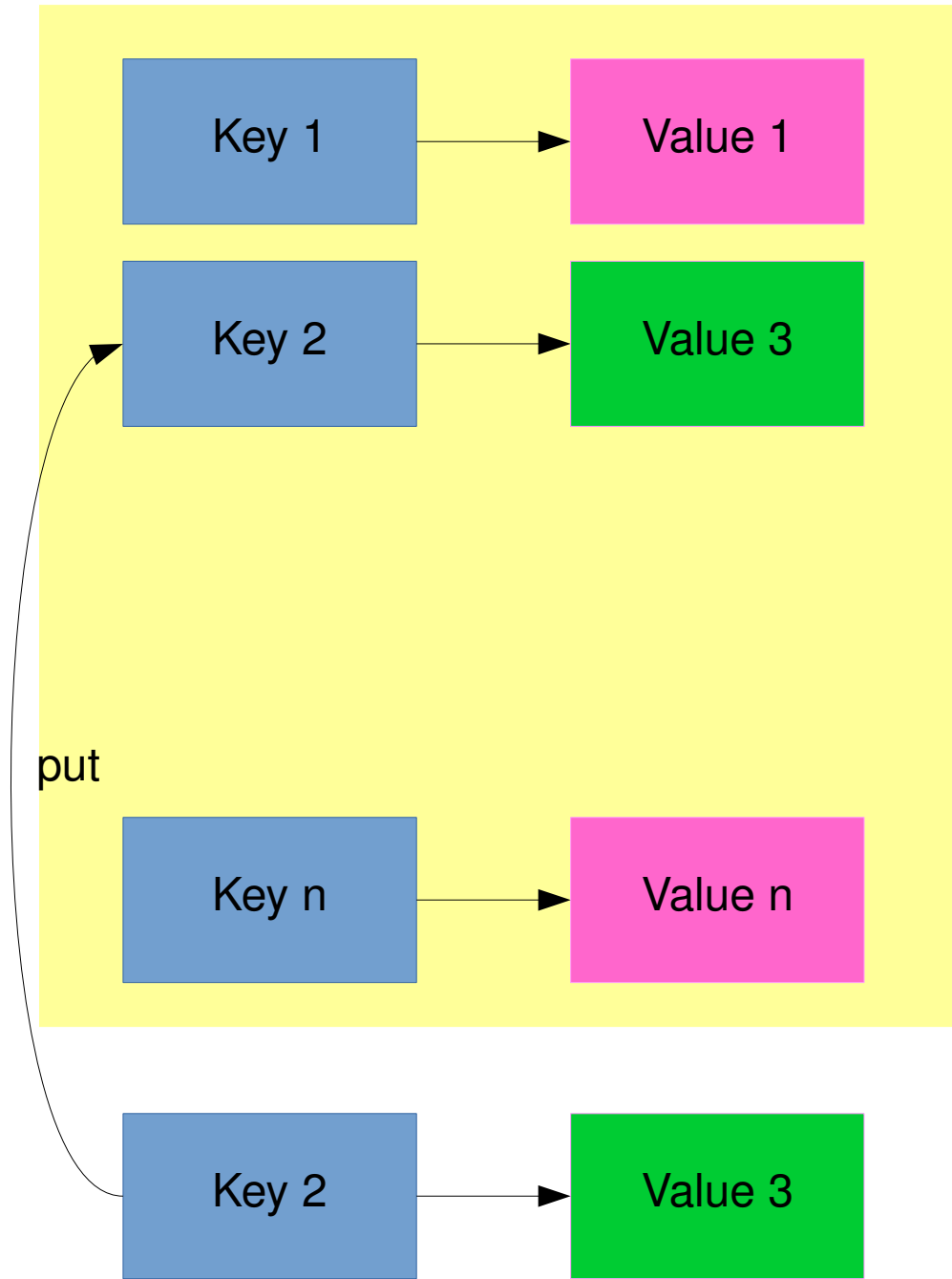
```
//Implement Queue interface
```

```
Queue c = a;  
Queue d = b;
```

Queue 接口

- 队列
 - 先进先出 (First in, first out)
 - 先来先服务 (First come, first serve)





Map:

- Key-value 对
- Key 不重复
- value 可以重复
- 应用：单词出现次数

```
import java.util.*;
```

```
//Implement Map interface  
HashMap a = new HashMap();
```

Map 接口

容器简介

- 泛型 (generic) 与类型安全的容器
 - 容器可以存放的类型为 Object
 - 任何类型的对象都能放入容器
 - 容器的类型只能在运行时确定

```
class Apple {  
    private static long counter;  
    private final long id = counter++;  
    public long id() { return id; }  
}  
class Orange { }
```

```
public class ApplesAndOrangesWithoutGenerics {  
    public static void main(String[] args) {  
        ArrayList apples = new ArrayList();  
        for(int i = 0; i < 3; i++)  
            apples.add(new Apple());  
  
        // Not prevented from adding an Orange to apples:  
        apples.add(new Orange());  
        for(int i = 0; i < apples.size(); i++)  
            ((Apple)apples.get(i)).id();  
        // Orange is detected only at run time  
    }  
}
```

容器简介

- 类型安全的容器
 - 定义容器为只能存放某种类型的对象
 - 编译时确定类型
- 泛型编程 (generic)

```
class Apple {  
    private static long counter;  
    private final long id = counter++;  
    public long id() { return id; }  
}  
class Orange { }
```

```
public class ApplesAndOrangesWithGenerics {  
    public static void main(String[] args) {  
        ArrayList<Apple> apples = new ArrayList<Apple>();  
        for(int i = 0; i < 3; i++)  
            apples.add(new Apple());  
  
        // Compile error!  
        // apples.add(new Orange());  
        for(int i = 0; i < apples.size(); i++)  
            apples.get(i).id();  
        for(Apple c: apples)  
            System.out.println(c.id());  
    }  
}
```

容器简介

- 类型安全的容器
 - Upcasting 适用

```
class GrannySmith extends Apple {}  
class Gala extends Apple {}  
class Fuji extends Apple {}  
class Braeburn extends Apple {}
```

```
public class GenericsAndUpcasting {  
    public static void main(String[] args) {  
        ArrayList<Apple> apples = new ArrayList<Apple>();  
  
        apples.add(new GrannySmith());  
        apples.add(new Gala());  
        apples.add(new Fuji());  
        apples.add(new Braeburn());  
        for(Apple c : apples)  
            System.out.println(c);  
    }  
}
```

容器简介

- 类型安全的容器
 - 不能指定基本类型
 - 使用基本类型的 wrapper
 - Autoboxing and unboxing

```
import java.util.*;  
  
// compile error  
// ArrayList<int> a = new ArrayList<int>();  
ArrayList<Integer> a = new ArrayList<Integer>();  
For (int i = 0; i < 10; ++i)  
    a.add(i); //autoboxing
```


容器简介

- 容器接口
 - Collection 接口：用于存放一组对象
 - List 接口：对象按照插入顺序排列容器中的对象
 - Set 接口：容器中不能有重复的对象
 - Queue 接口：按 " 队列 " 规则插入 / 删除对象
 - Map 接口
 - 用于存放一组 “键 - 值对” (key-value pair)
 - key 的类型, value 的类型
 - 按照 key 查找对应的 value
 - 也称为 dictionary, associative array

容器简介

```
import java.util.*;  
  
//List is an interface  
List<Apple> a = new ArrayList<Apple>();  
List<Apple> b = new LinkedList<Apple>();  
  
//Collection is an interface  
Collection<Apple> c = new ArrayList<Apple>();
```

容器简介

- 容器重写了 `toString()` 方法，可以帮助可视化容器的内容

```
import java.util.*;  
  
ArrayList<String> a = new ArrayList<String>();  
a.add("rat");  
a.add("cat");  
a.add("dog");  
a.add("dog");  
System.out.println(a);
```

```

public class PrintContainers{
    static Collection fill(Collection<String> c){
        c.add("rat");
        c.add("cat");
        c.add("dog");
        c.add("dog");
    }
    static Map fill(Map<String, String> m){
        m.put("rat", "Fuzzy");
        m.put("cat", "Rags");
        m.put("dog", "Bosco");
        m.put("dog", "Spot");
    }
    public static void main(String [] args){
        System.out.println(fill(new ArrayList<String>()));
        System.out.println(fill(new LinkedList<String>()));

        System.out.println(fill(new HashSet<String>()));
        System.out.println(fill(new TreeSet<String>()));
        System.out.println(fill(new LinkedHashSet<String>()));

        System.out.println(fill(new HashMap<String, String>()));
        System.out.println(fill(new TreeMap<String, String>()));
        System.out.println(fill(new LinkedHashMap<String, String>()));
    }
}

```

```

[rat, cat, dog, dog] //ArrayList
[rat, cat, dog, dog] //LinkedList
[cat, dog, rat] // HashSet
[cat, dog, rat] // TreeSet
[rat, cat, dog] // LinkedHashSet
{cat=Fuzzy, dog=Spot, rat=Fuzzy} //HashMap
{cat=Fuzzy, dog=Spot, rat=Fuzzy} //TreeMap
{rat=Fuzzy, cat=Fuzzy, dog=Spot}
//LinkedHashMap

```

List:

- ArrayList 实现为数组
- LinkedList 实现为链表

Set/Map

- Hash: 实现为 hash 表，查询较快
- Tree: 实现为查询树，按顺序排列
- LinkedHash: 按照插入顺序排列

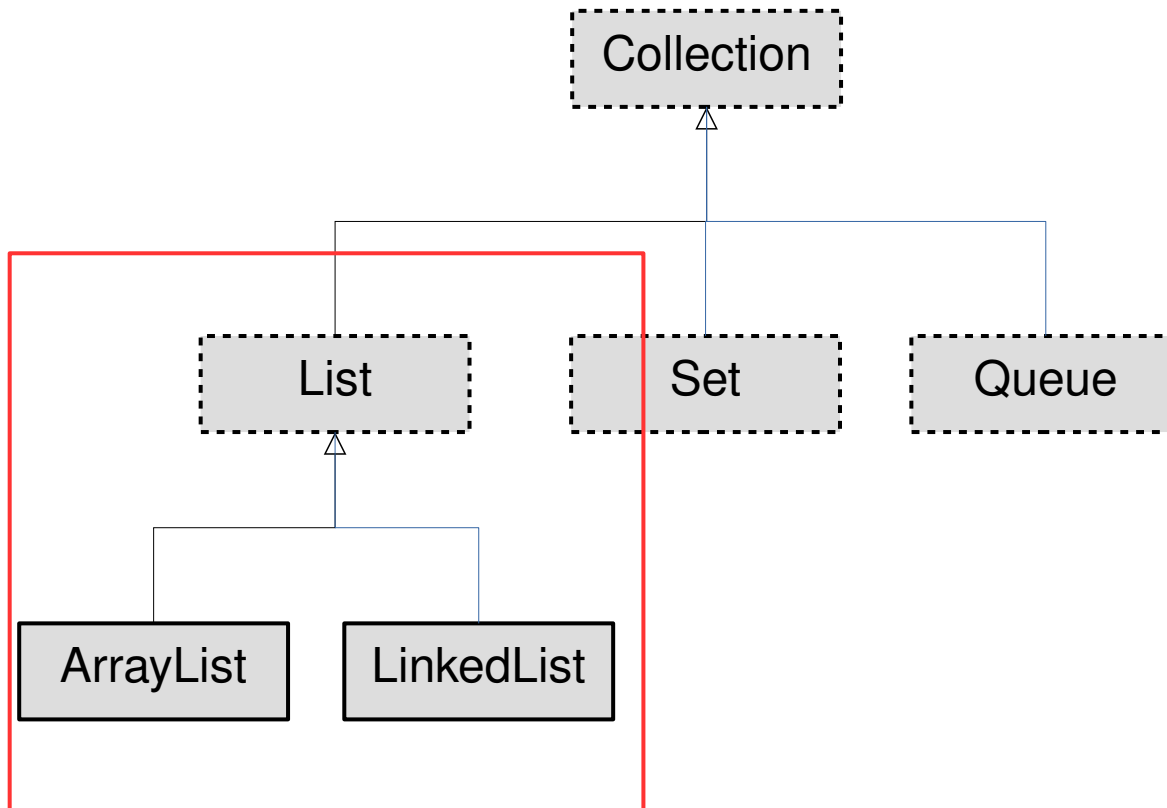
容器简介

- 总结
 - 容器类型
 - Collection: List, Set, Queue
 - Map
 - 类型安全的容器
 - `ArrayList<T> a = new ArrayList<T>();`
 - Upcasting and Autoboxing

List

- 两种类型的 List
 - ArrayList
 - “可扩展数组”
 - 适用于随机访问，插入删除较慢
 - LinkedList
 - 双向链表
 - 适用于顺序访问，插入删除较快
 - 实现了 Queue 接口

List



List

- List 接口
 - add(): 添加元素
 - remove(): 删除元素
 - get(): 返回第 i 个位置的元素
 - size(): 返回元素数量
 - ...

List

- 构造函数
 - ArrayList

```
ArrayList<E>();  
ArrayList<E>(int initialCapacity);  
ArrayList<E>(Collection<E> c);
```

- LinkedList

```
LinkedList<E>();  
LinkedList<E>(Collection<E> c);
```

• ArrayList

```
import java.util.*;

ArrayList<String> a = new ArrayList<String>();
// 插入 add(Object o)
a.add("rat"); a.add("cat"); a.add("dog"); a.add("dog");

// 查询 contains (Object o)
System.out.println(a.contains("cat"));

// 删除 remove(Object o) ( 若不在 List 中 , 返回 false, 否则返回 true)
a.remove("dog"); a.remove("dag");

// 访问第 i 个元素 : get(int)
a.get(0);

// 对象的数量 : size()
a.size();

// 序号 indexOf
a.indexOf("cat");
```

```
import java.util.*;

ArrayList<String> a = new ArrayList<String>();
// 插入 add(Object o)
a.add("rat"); a.add("cat"); a.add("dog"); a.add("dog");

// 子表 subList(int fromIndex, int toIndex)
List<String> sub = a.subList(2, 3);

// 是否为空 isEmpty()
System.out.println(a.isEmpty());

// 返回迭代器 iterator()
Iterator it = a.iterator();

// 返回 List 迭代器 listIterator()
ListIterator lit = a.listIterator();

// 转为数组
String [] aarray = a.toArray();

....
```

List

- Iterator (迭代器)
 - 通常需要访问 / 遍历 Collection 中的元素

```
ArrayList<String> a = new ArrayList<String>();  
.....  
a.get(i);  
  
LinkedList<String> b = new LinkedList<String>();  
.....  
b.get(i);  
  
Static void visit(List<String> ls) {  
    ls.get(i);  
    ....  
}
```

- 缺点
 - 依赖于 Collection 接口
 - 其他没有实现 Collection 接口的类无法使用函数 visit
- 解决方法 iterator, 包含方法
 - next()
 - hasNext()
 - remove()
- Collection 接口
 - iterator()
 - 返回该 List 的迭代器

List

- iterator()

```
Import java.util.*
public class SimpleIteration {
    ArrayList<String> a = new ArrayList<String>();
    a.add("rat");a.add("cat");a.add("dog");a.add("dog");
    Iterator<String> it = a.iterator();
    while(it.hasNext()){
        String s = it.next();
        System.out.println(s);
    }

    // identical to
    for(String i: a)
        System.out.println(i);
}
```

List

- iterator

```
Import java.util.*
public class Iteration {
    public static void display(Iterator<String> it)
    while(it.hasNext()){
        String s = it.next();
        System.out.println(s);
    }
    public static void main(String[]args){
        ArrayList<String> a = new ArrayList<String>();
        a.add("rat");a.add("cat");a.add("dog");a.add("dog");

        LinkedList<String> b = new LinkedList<String>(a);
        HashSet<String> c = new HashSet<String>(a);
        TreeSet<String> d = new TreeSet<String>(a);

        display(a.iterator());
        display(b.iterator());
        display(c.iterator());
        display(d.iterator());
    }
}
```

List

- ListIterator
 - List 接口提供
 - 扩展了 Iterator
 - 双向遍历
 - hasNext(), hasPrevious()
 - next(), previous()

List

- LinkedList
 - 实现 List 接口
 - 实现 Queue 接口
 - add(), remove(), element()
 - offer(), poll(), peek()
 - 提供更多的方法

List

- LinkedList 方法

```
import java.util.*;
```

```
LinkedList<String> a = new LinkedList<String>();  
a.add("rat"); a.add("cat"); a.add("dog"); a.add("dog");
```

```
// 返回链表首元素  getFirst(), element(), 若链表为空则抛出异常  
a.getFirst(); a.element();
```

```
// 返回链表首元素  peek(), 若链表为空则返回 null  
a.peek();
```

```
// 删除并返回链表首元素  removeFirst(), remove(), 若链表为空则抛出异常  
String s = a.remove();
```

```
// 删除并返回链表首元素  poll, 若链表为空则返回 null  
String s = a.poll();
```

List

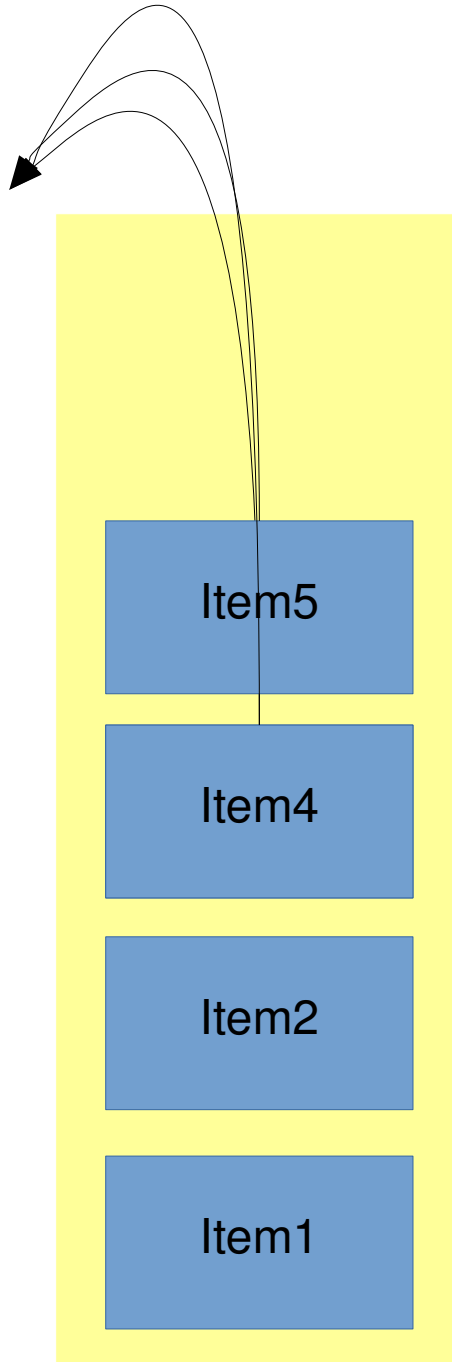
- LinkedList 方法

```
import java.util.*;  
  
LinkedList<String> a = new LinkedList<String>();  
a.add("rat"); a.add("cat"); a.add("dog"); a.add("dog");  
  
// 在链表头添加对象 addFirst()  
a.addFirst("tiger");  
  
// 在链表尾添加对象 add(), addLast(), offer()  
a.add("cow"); a.addLast("cow");
```

List

- **LinkedList 应用 : Stack**
 - 后进先出 (Last In First Out, LIFO)
 - push: 将一个对象入栈
 - pop: 从栈中取出一个元素 : 按照 LIFO 原则

List



```
LinkedList<Item> s = new LinkedList<Item>();
```

```
s.push(item1);  
s.push(item2);  
s.push(item3);  
s.pop();  
s.push(item4);  
s.push(item5);  
s.pop();  
s.pop();
```

List

```
import java.util.LinkedList;
public class Stack<T> {
    private LinkedList<T> storage = new LinkedList<T>();
    public void push(T v) { storage.addFirst(v); }
    public T peek() { return storage.getFirst(); }
    public T pop() { return storage.removeFirst(); }
    public boolean empty() { return storage.isEmpty(); }
    public String toString() { return storage.toString(); }
}
```

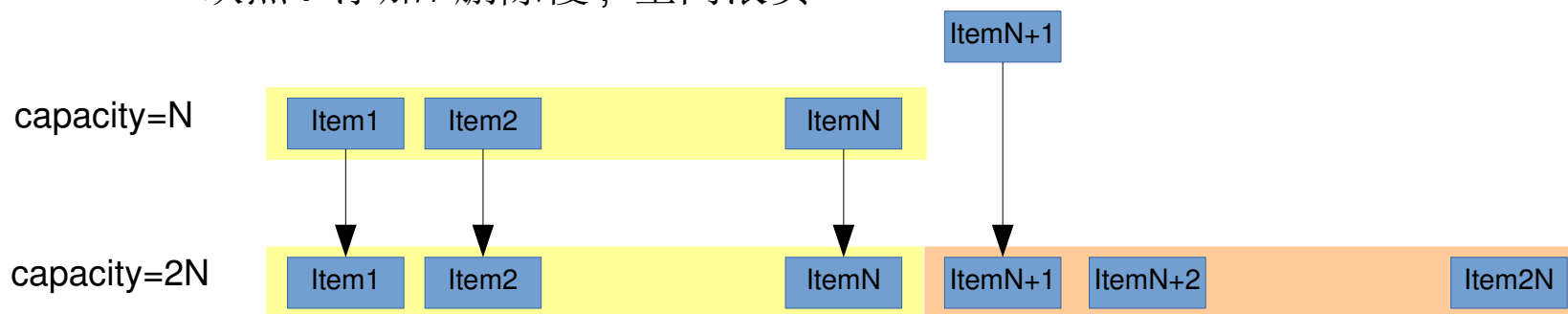
```
public class StackTest {
    public static void main(String[] args) {
        Stack<String> stack = new Stack<String>();
        for(String s : "My dog has fleas".split(" "))
            stack.push(s);
        while(!stack.empty())
            System.out.print(stack.pop() + " ");
    }
}
```

List

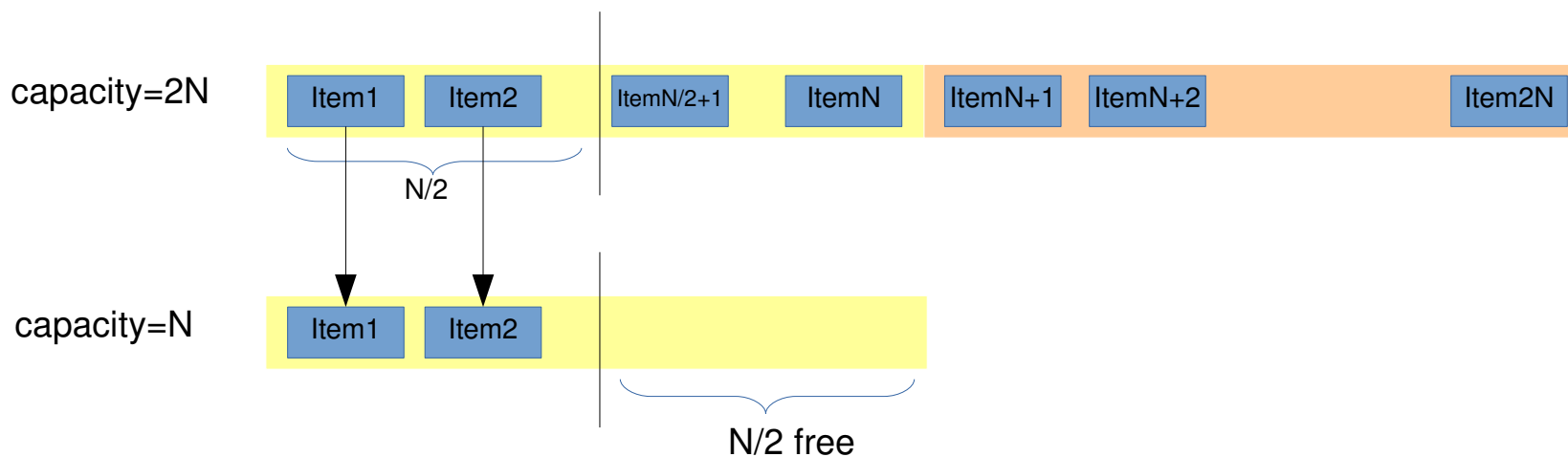
- Stack 的应用
 - 上下文无关文法

- ArrayList

- 对象存储在数组中 (可变长数组)
- 优点：随机访问快
- 缺点：添加 / 删除慢，空间浪费



扩张

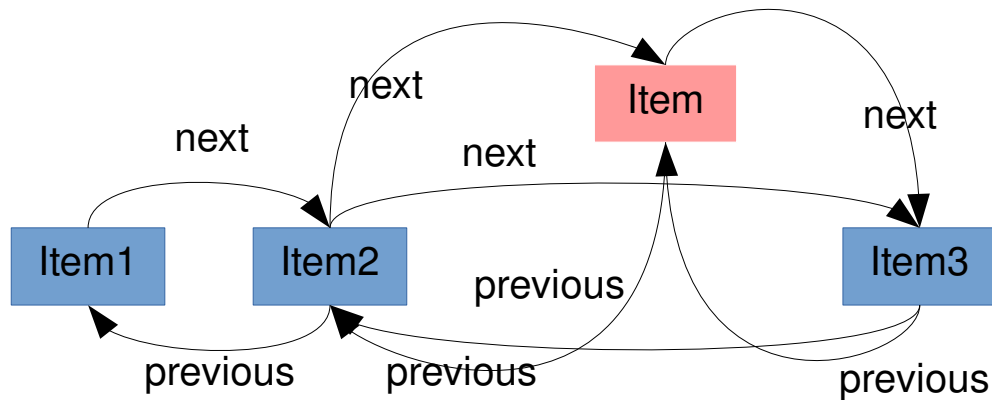
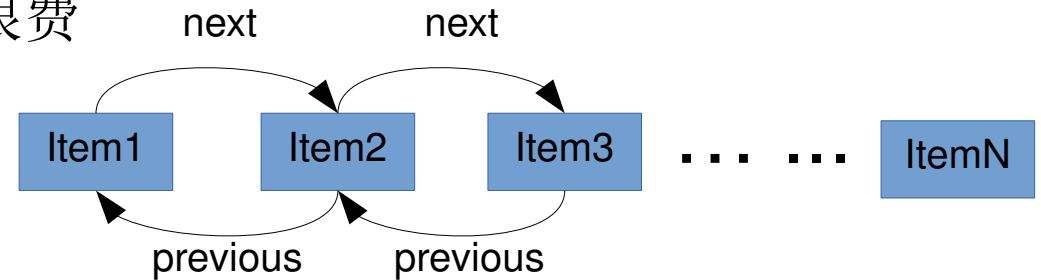


缩减

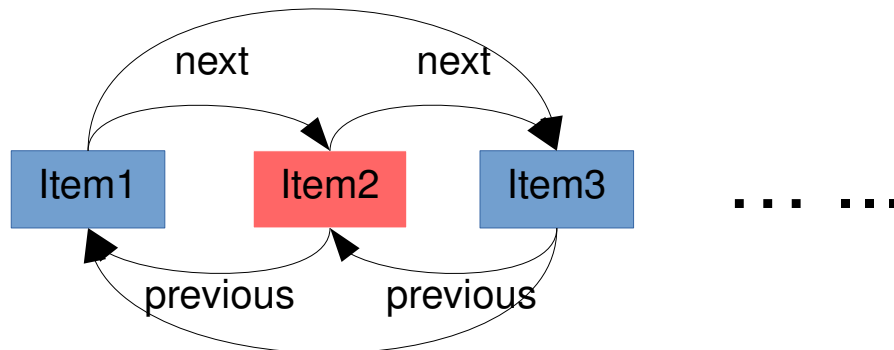
每次扩张或缩减数组长度时，保证新的数组有一半的可用空间

• LinkedList

- 双向链表
- 优点：添加 / 删除较快，无空间浪费
- 缺点：随机访问慢



插入

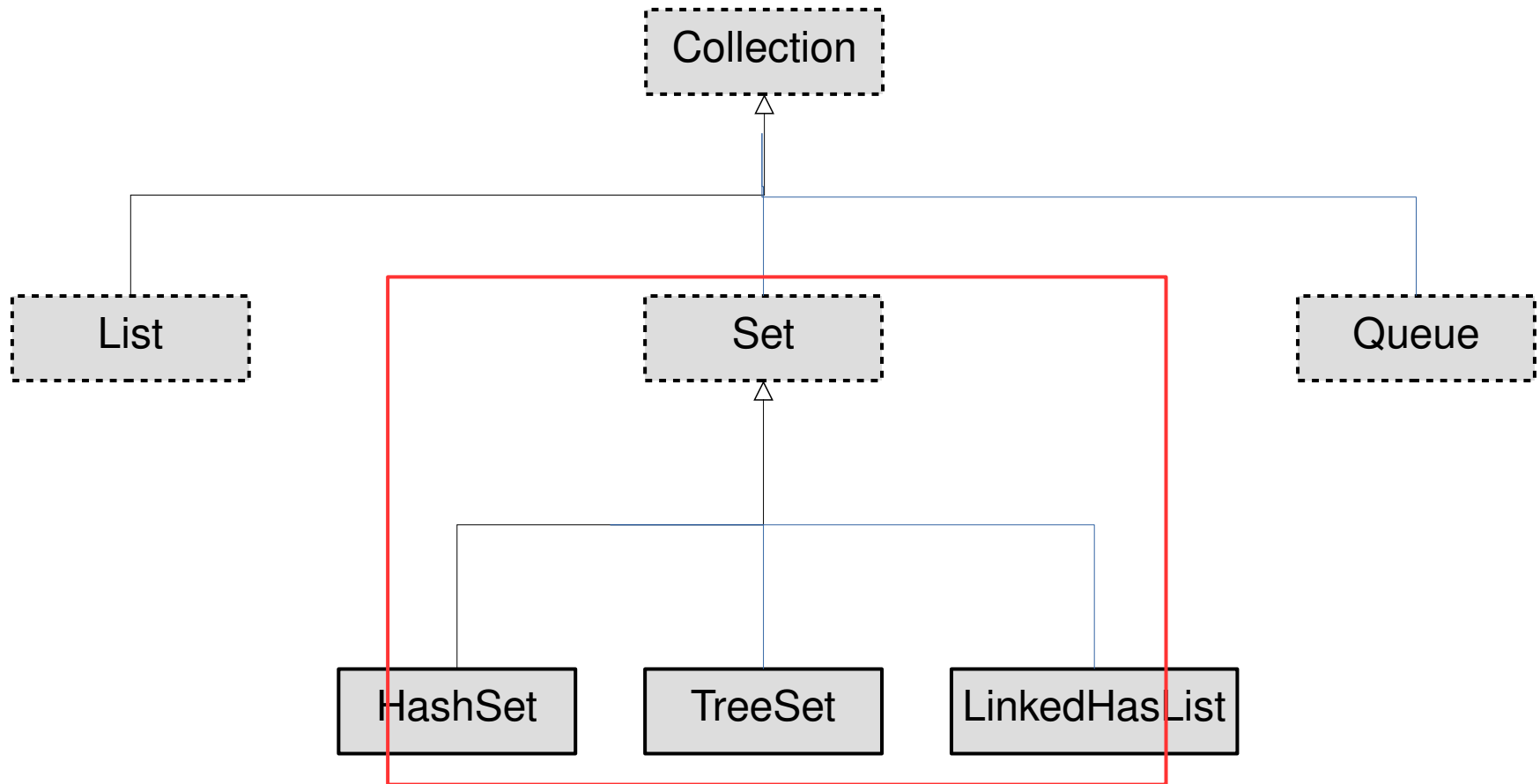


删除

List

- 总结
 - List 接口
 - add(), remove(), get(), size(), indexOf()
 - ArrayList
 - 可变长度数组
 - LinkedList
 - 链表
 - 实现 Queue 接口
 - 迭代器 Iterator

Set



Set

- Set 接口
 - 容器中不能出现重复的元素
 - 没有对 **Collection** 接口扩展
 - 三种主要实现
 - HashSet
 - TreeSet
 - LinkedHashSet

Set

- Set 接口
 - add(Object o), addAll(Collection<E> c)
 - remove(Object o), removeAll(Collection<E> c)
 - contains(Object o)
 - iterator()
 - size()
 - toArray()
 - ...

Set

- HashSet

- 特点：快速（插入，删除，查找），无序

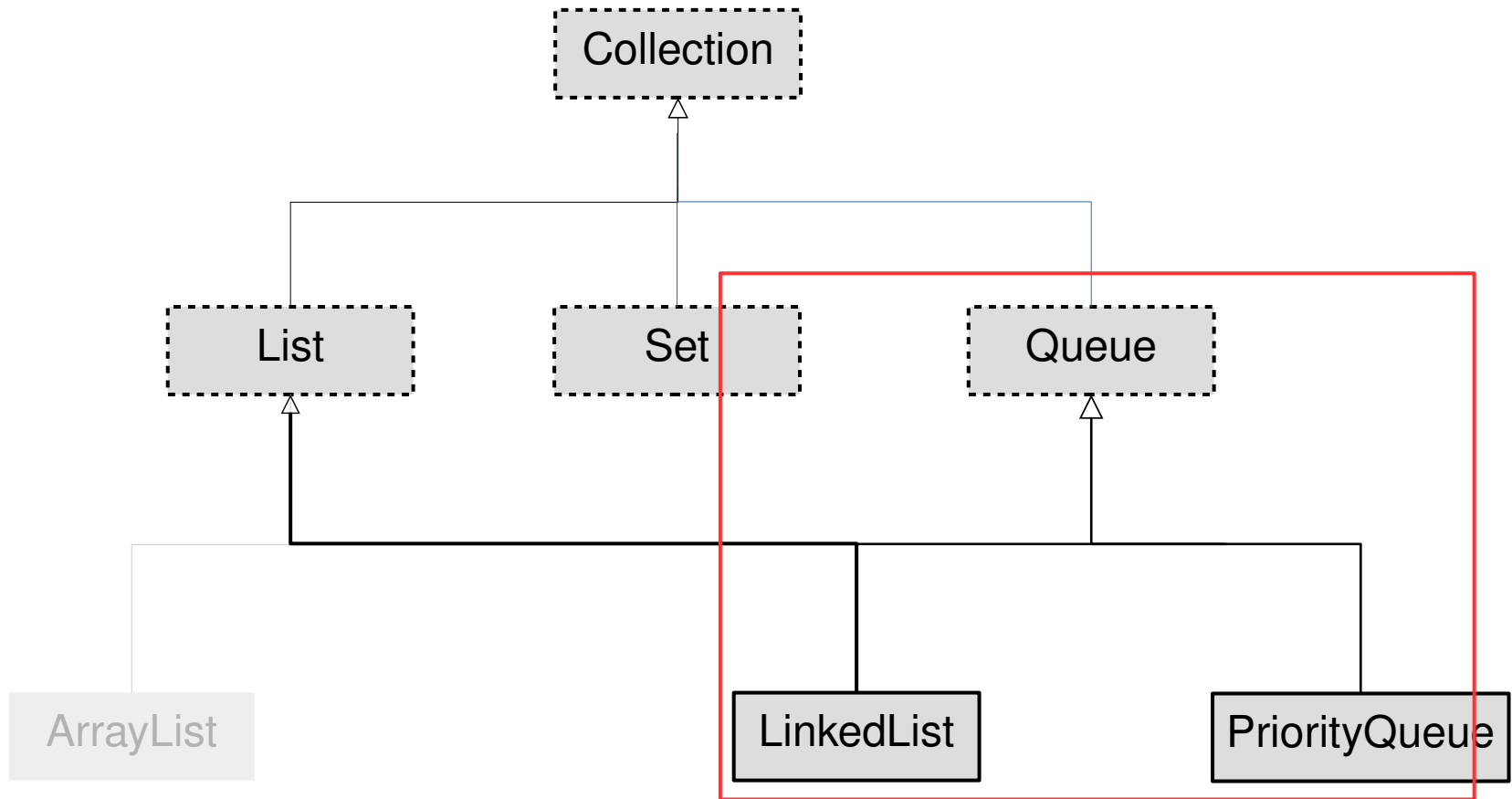
```
import java.util.*

public class SetOfInteger {
    public static void main(String[] args) {
        Random rand = new Random(47);
        Set<Integer> intset = new HashSet<Integer>();
        for (int i = 0; i < 10000; i++)
            intset.add(rand.nextInt(30));
        System.out.println(intset);
    }
}
```

Set

- TreeSet
 - 特点：速度较慢 (插入，删除，查找)，有序
- LinkedHashSet
 - 特点：速度快，按插入顺序排列

Queue



Queue

- Queue 接口
 - 队列规则：先进先出 (First in, First out)
 - 接口
 - offer(Object o), add(Object o): 将对象加入队列尾部
 - poll(), remove(): 弹出位于队首的对象
 - peek(), element(): 返回位于队首的对象，并不删除
 - LinkedList
 - PriorityQueue


```
import java.util.*

public class QueueTest {
    public static void printQ(Queue queue) {
        while(queue.peek() != null)
            System.out.print(queue.remove() + " ");
        System.out.println();
    }
    public static void main(String[] args) {
        Queue<Integer> queue = new LinkedList<Integer>();
        Random rand = new Random(47);
        for(int i = 0; i < 10; i++)
            queue.offer(rand.nextInt(i + 10));
        printQ(queue);

        Queue<Character> qc = new LinkedList<Character>();
        for(char c : "Brontosaurus".toCharArray())
            qc.offer(c);
        printQ(qc);
    }
}
```

Queue

- **PriorityQueue**

- 优先级队列

- 每次出队时，选择优先级最高的对象
 - 队列中的对象可以比较优先级
 - 普通队列也可看成优先级队列：优先级为加入队列的时间

```
import java.util.*;
public class PriorityQueueTest {
    public static void main(String[] args) {
        PriorityQueue<Integer> qi = new PriorityQueue<Integer>();
        int [ ] iarray = {25, 22, 20, 18, 14, 9, 3, 1, 1, 2, 3, 9, 14, 18, 21, 23, 25};
        for (int i: iarray)
            qi.offer(i);
        printQ(qi);

        PriorityQueue<Character> qc = new PriorityQueue<Character>();
        for(char c : "Brontosaurus".toCharArray())
            qc.offer(c);
        printQ(qc);
    }
}
```

Queue

- 自定义优先级
 - 构造函数

```
PriorityQueue<E>(int initialCapacity, Comparator<E> comparator)
```

- Comparator 接口
 - 定义两个元素的优先级关系
 - 包含方法 `compare(E e1, E e2)`
 - Compare 返回负数当 e1 优先级低于 e2
 - Compare 返回正数当 e1 优先级高于 e2
 - Compare 返回 0 当 e1 优先级等于 e2

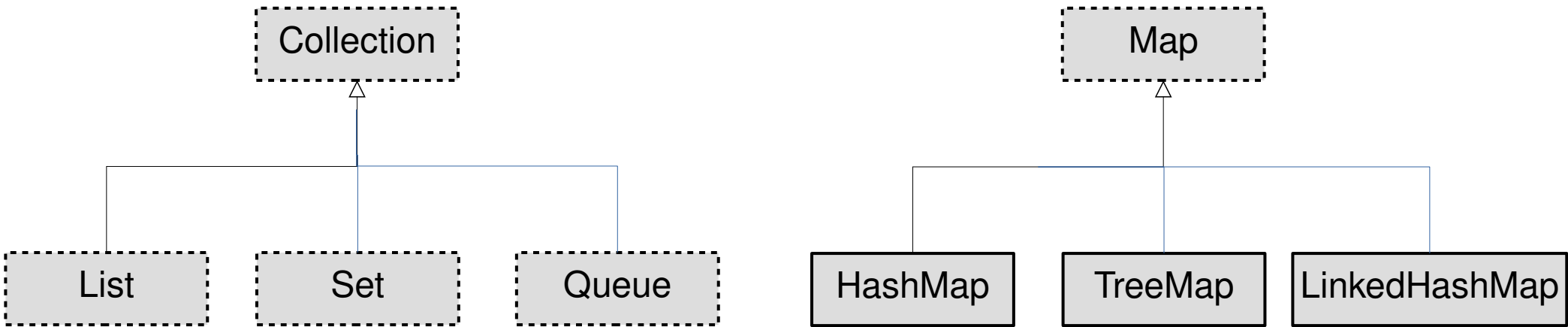
```

public class PriorityQueueTest {
    public static void main(String[] args) {
        PriorityQueue<Character> qc = new PriorityQueue<Character>();
        for(char c : "Brontosaurus".toCharArray())
            qc.offer(c);
        printQ(qc);

        PriorityQueue<Character> rqc = new PriorityQueue<Character>(10,
            new Comparator<Character>(){
                public int compare(Character c1, Character c2){
                    if (c1 > c2)
                        return -1;
                    else if (c1 < c2)
                        return 1;
                    else
                        return 0;
                }
            });
        for(char c : "Brontosaurus".toCharArray())
            rqc.offer(c);
        printQ(rqc);
    }
}

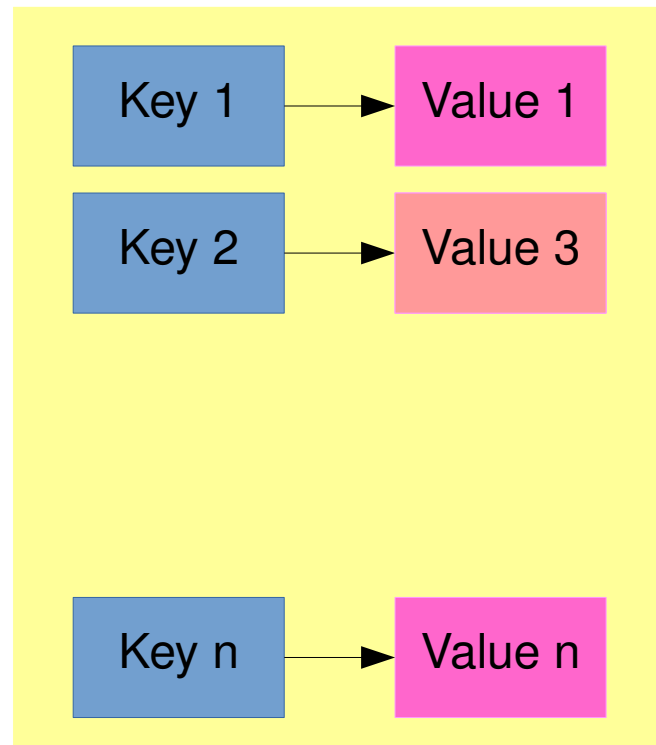
```

Map



Map

- Map
 - Key-value pair



Map

- Map 接口
 - 存入键值对 : `put(K key, V value)`
 - 返回键对应的值 : `get(K key)`
 - 是否包含键 `key`: `containsKey(Object key)`
 - 是否包含值 `value`: `containsValue(Object value)`
 - 返回键组成的 Set: `keySet()`
 - 返回值组成的 Collection: `values()`


```
import java.util.*
```

```
public class MapTest {  
    public static void main(String[] args) {  
        HashMap<String, String>m = new HashMap<String, String>()  
        m.put("rat", "Fuzzy");  
        m.put("cat", "Rags");  
        m.put("dog", "Bosco");  
        m.put("dog", "Spot");  
        System.out.println(m.get("dog"));  
        System.out.println(m.containsKey("dog"));  
        System.out.println(m.containsValue("dog"));  
        System.out.println(m.keySet());  
        System.out.println(m.values());  
    }  
}
```

```
import java.util.*

public class MapTest {
    public static void main(String[] args) {
        HashMap<String, ArrayList<Integer>>m = new HashMap<>()
        m.put("rat", new ArrayList<Integer>(Array.asList(1,2,3)));
        m.put("cat", new ArrayList<Integer>(Array.asList(4,5,6)));
        m.put("dog", new ArrayList<Integer>(Array.asList(7,8,9)));
        m.put("dog", new ArrayList<Integer>(Array.asList(10,11,12)));
        System.out.println(m.get("dog"));
        System.out.println(m.containsKey("dog"));
        System.out.println(m.keySet());
        System.out.println(m.values());

        HashMap<String, HashMap<String, Integer>>n = new HashMap<>();
        ...
    }
}
```

Map

- Map
 - 建议 : Immutable key

迭代器与 foreach

- Iterable 接口
 - 提供 `iterator()`: 返回迭代器
- Collection 扩展了 Iterable 接口
- foreach 语句
 - 对所有实现 Iterable 接口的类
 - 数组

