COMP 250

Lecture 32

interfaces

(Comparable, Iterable & Iterator)

Nov. 22/23, 2017

Java `Comparable` interface

Suppose you want to define an ordering on objects of some class.

Sorted lists, binary search trees, priority queues all *require* that an ordering exists.
(Elements are “comparable”).

Comparable interface

```
interface  Comparable<T> {

     int   compareTo( T   t );

}
```

`Comparable` interface

T implements Comparable<T>

T   t1,   t2;

`Comparable` interface

T implements Comparable<T>

T t1, t2;

Java API *recommends* that t1.compareTo(t2) returns:

$$\begin{cases} \text{0,} & \text{if t1.equals(t2) returns true} \\ \text{positive number,} & \text{if t1 > t2} \\ \text{negative number,} & \text{if t1 < t2} \end{cases}$$

Some classes assume comparable generic types.
Their implementations call the compareTo( ) method.

e.g. PriorityQueue< E >

(uses a heap with comparable E)

TreeSet< E >

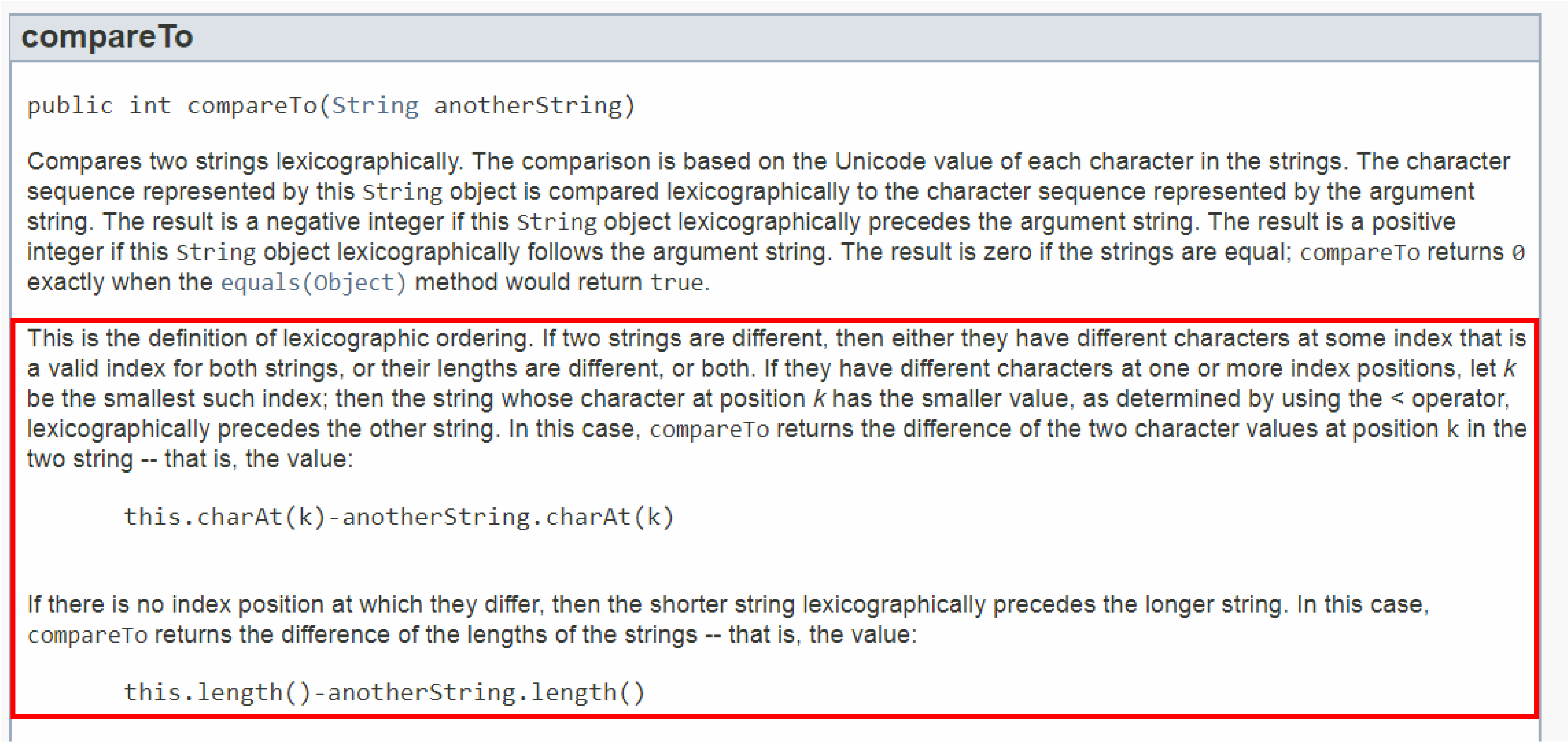
(uses a balanced binary search tree with comparable E)

TreeMap< K, V >

(uses a balanced binary search tree with comparable K)

e.g. String implements Comparable<T>

https://docs.oracle.com/javase/7/docs/api/java/lang/String.html



compareTo

```
public int compareTo(String anotherString)
```

Compares two strings lexicographically. The comparison is based on the Unicode value of each character in the strings. The character sequence represented by this `String` object is compared lexicographically to the character sequence represented by the argument string. The result is a negative integer if this `String` object lexicographically precedes the argument string. The result is a positive integer if this `String` object lexicographically follows the argument string. The result is zero if the strings are equal; `compareTo` returns `0` exactly when the `equals(Object)` method would return `true`.

This is the definition of lexicographic ordering. If two strings are different, then either they have different characters at some index that is a valid index for both strings, or their lengths are different, or both. If they have different characters at one or more index positions, let *k* be the smallest such index; then the string whose character at position *k* has the smaller value, as determined by using the < operator, lexicographically precedes the other string. In this case, `compareTo` returns the difference of the two character values at position `k` in the two string -- that is, the value:

```
    this.charAt(k)-anotherString.charAt(k)
```

If there is no index position at which they differ, then the shorter string lexicographically precedes the longer string. In this case, `compareTo` returns the difference of the lengths of the strings -- that is, the value:

```
    this.length()-anotherString.length()
```

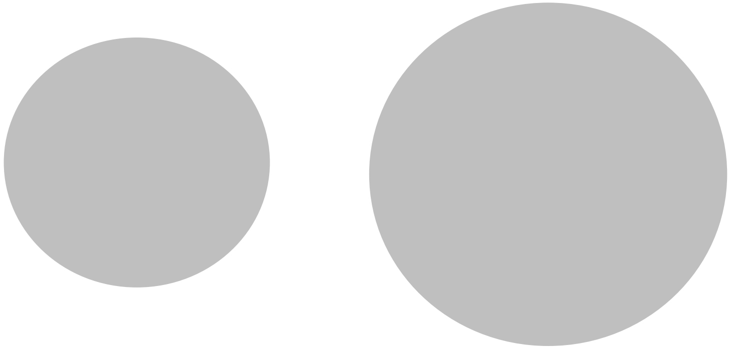
e.g. Character, Integer, Float, Double, BigInteger, etc

all implement Comparable<T>.

You cannot compare objects of these classes using the "<" operator. Instead use compareTo( ).

Example: Circle

Q: How can we define a compareTo(Circle) and equals(…) method for ordering Circle objects ?



A: Compare their radii or their areas.

Java recommends overriding equals(Object), rather than overloading.

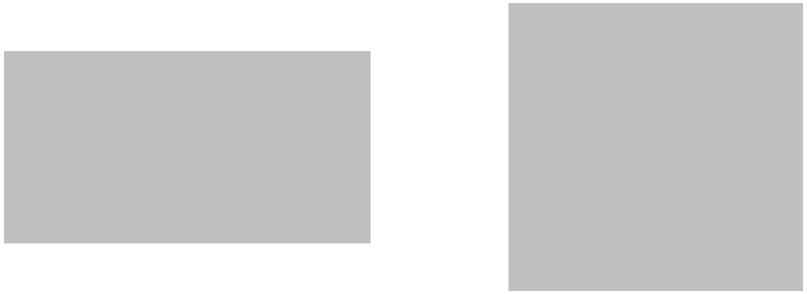
```
public class Circle implements Comparable<Circle>{
    private radius;

    public Circle(double radius){    // constructor
        this.radius = radius;
    }

    public boolean  equals(Circle c) {
        return   radius == c.getRadius();
    }

    public int  compareTo(Circle c) {
        return   radius - c.getRadius();
    }
}
```

Example: Rectangle

Q: When are two Rectangle objects equal ?

A: Their heights are equal and their widths are equal.

These are not equal:



Q: How can we define a compareTo() and equals(…) method for ordering Rectangle objects ?

class Rectangle implements Comparable<Rectangle>

Rectangle t1, t2;

Java API *recommends* that t1.compareTo(t2) returns:

$$
\begin{cases}
0, & \text{if } t1.\text{equals}(t2) \text{ returns true} \\
\text{positive number}, & \text{if } t1 > t2 \\
\text{negative number}, & \text{if } t1 < t2
\end{cases}
$$

```
class   Rectangle  implements  Comparable<Rectangle>{

     …      //  constructor
      ….     //    getArea method

    boolean  equals(  Rectangle  other ) {
         return  (this.height ==  other.height) && (this.width == other.width);
    }

     int   compareTo(  Rectangle r ){
          return   this.getArea()  - other.getArea();
     }
}
```

This is <u>not</u> consistent with Java API recommendation on the previous slide.   Why not ?

```
class   Rectangle  implements  Comparable<Rectangle>{

    ...      //  constructor

   ....     //     getArea method

    boolean  equals(  Rectangle  other ) {
          return  this.getArea() == other.getArea();
    }

     int   compareTo(  Rectangle r ){
            return   this.getArea()  - other.getArea();
     }
}
```

This is consistent with Java API recommendation.

But it is maybe not such a natural way to order rectangles.

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Java `Iterator` interface

Motivation 1: we often want to visit *all* the objects in some collection.

e.g. linked list, binary search tree, hash map entries,
vertices in a graph

Java `Iterator` interface

Motivation 2: We sometimes want to have multiple "iterators".

Analogy: Multiple TA's grading a collection of exams.

Java `Iterator` interface

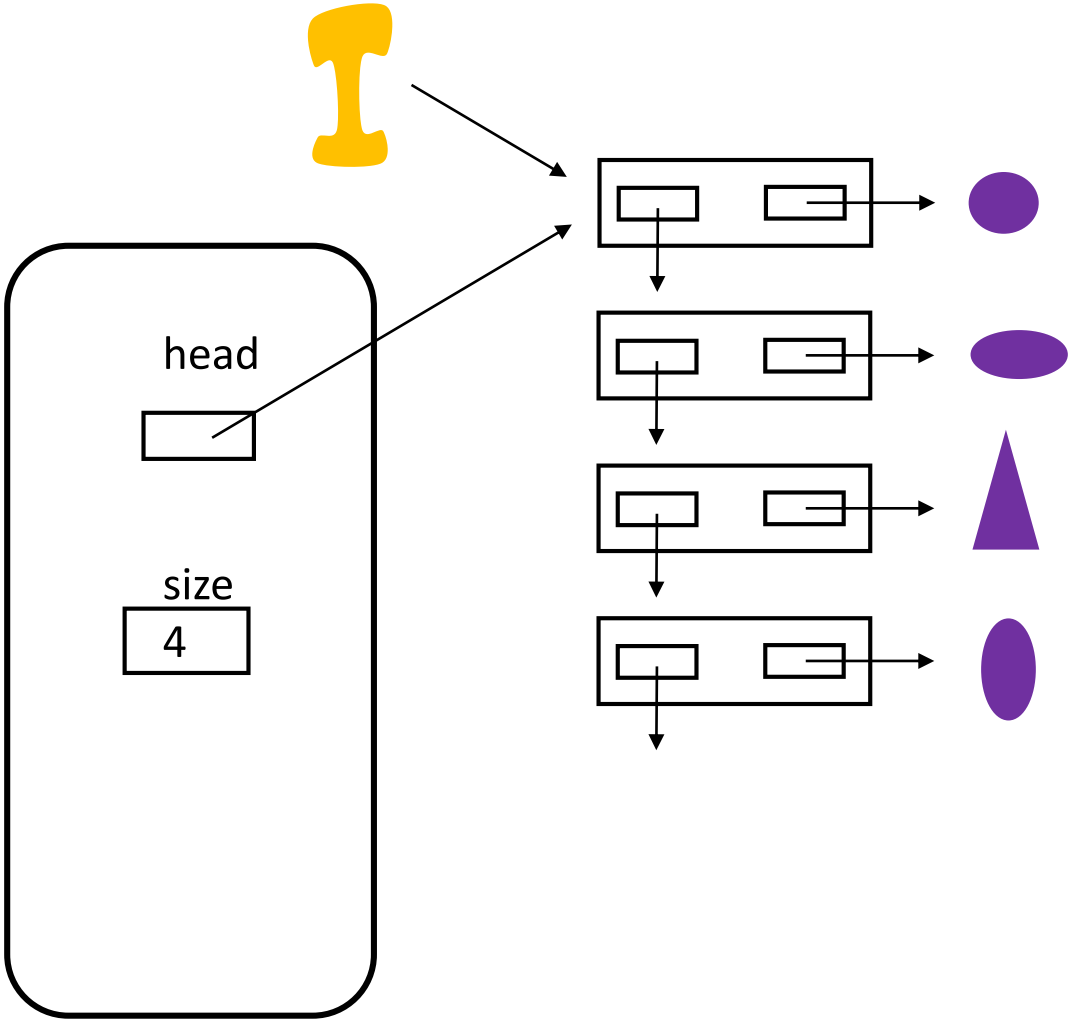
```
interface  Iterator<T> {
        boolean   hasNext();
        T              next();          // returns current, and
                                        //  advances to next

        void         remove();    // optional;   ignore it
}
```

next() is a method, not a field like in the linked list class.

Recall lecture 5 and Exercises 3

```
class   SLinkedList<E> {

     SNode<E>   head;

      :

      private   class   SNode<E> {

                    SNode<E>   next;
                    E              element;
                     ....
      }

      private   class  SLL_Iterator<E>    implements   Iterator<E>{
                     .....
      }
}
```

As we will see, the iterator object will reference a node in the list.



```
private class  SLL_Iterator<E>   implements   Iterator<E>{

        private SNode<E>    cur;

        SLL_Iterator( SLinkedList<E>     list){           //   constructor
                cur = list.getHead();
        }

        public   boolean   hasNext() {
                return (cur != null);
        }

        public   E   next() {
                E    element  =  cur.getElement;
                cur = cur.getNext();
                return element;
        }
}
```

Java `Iterator` interface

Q: Who constructs the Iterator object for a collection class such as LinkedList, ArrayList, HashMap, … ?

A:

Java `Iterator` interface

Q: Who constructs the Iterator object for a collection class such as LinkedList, ArrayList, HashMap, … ?

A: The class itself does it .

How ?

A collection class is “iterable” if the class is able to make an iterator object that iterates over the elements.

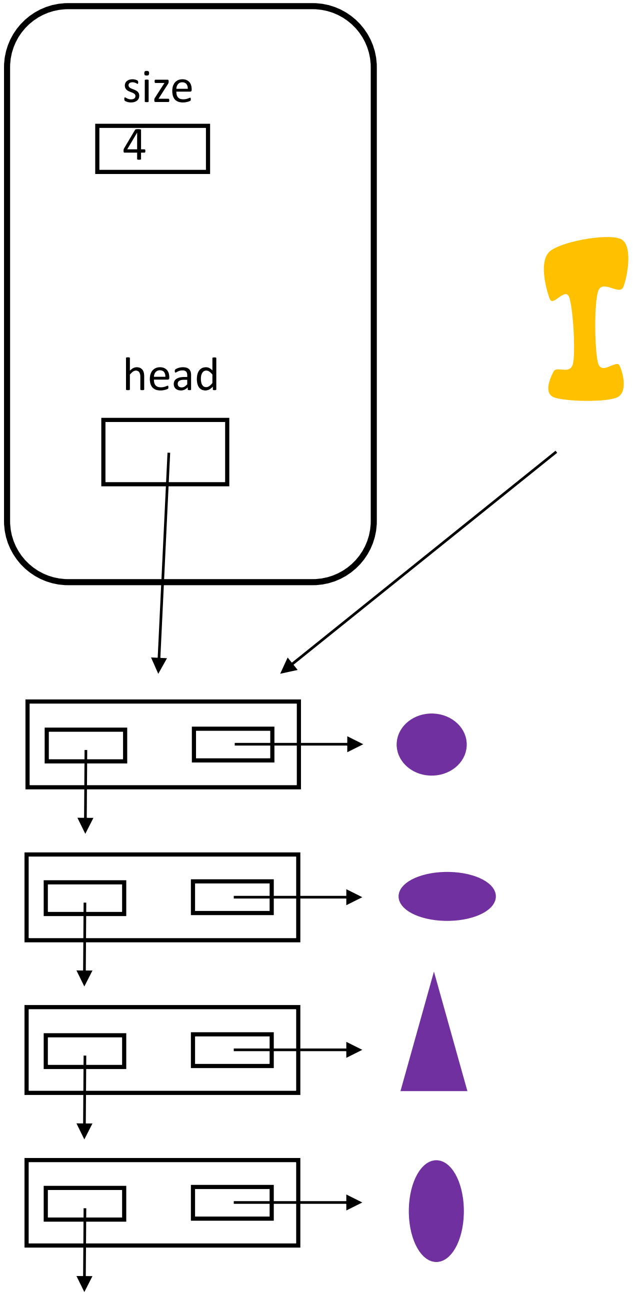
Java Iterable interface

```
interface  Iterable<T> {
        Iterator<T>    iterator();
}
```

It could have been called makeIterator().

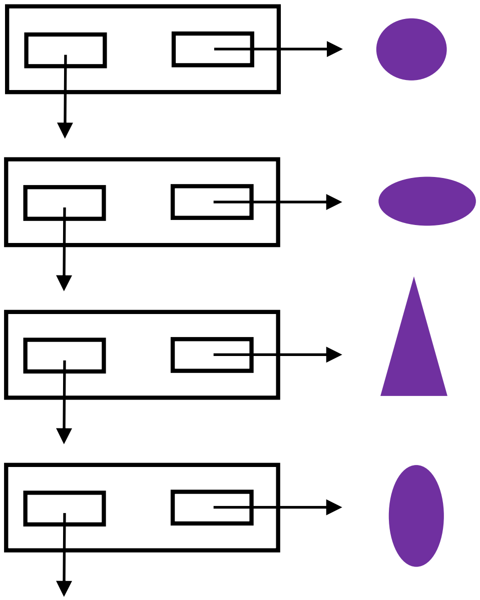
If a class implements Iterable, then the class has an iterator() method, which constructs an Iterator object.

```
class   SLinkedList<E> implements Iterable<E> {

    SNode<E>   head;

     private   class   SNode<E> {
                    SNode<E>   next;
                    E              element;
                     ….
      }

      private   class  SLL_Iterator<E>    implements   Iterator<E>{
                     …..
     }

      SLL_Iterator<E>   iterator()   {
           return  new SLL_Iterator( this );
      } ;
}
```

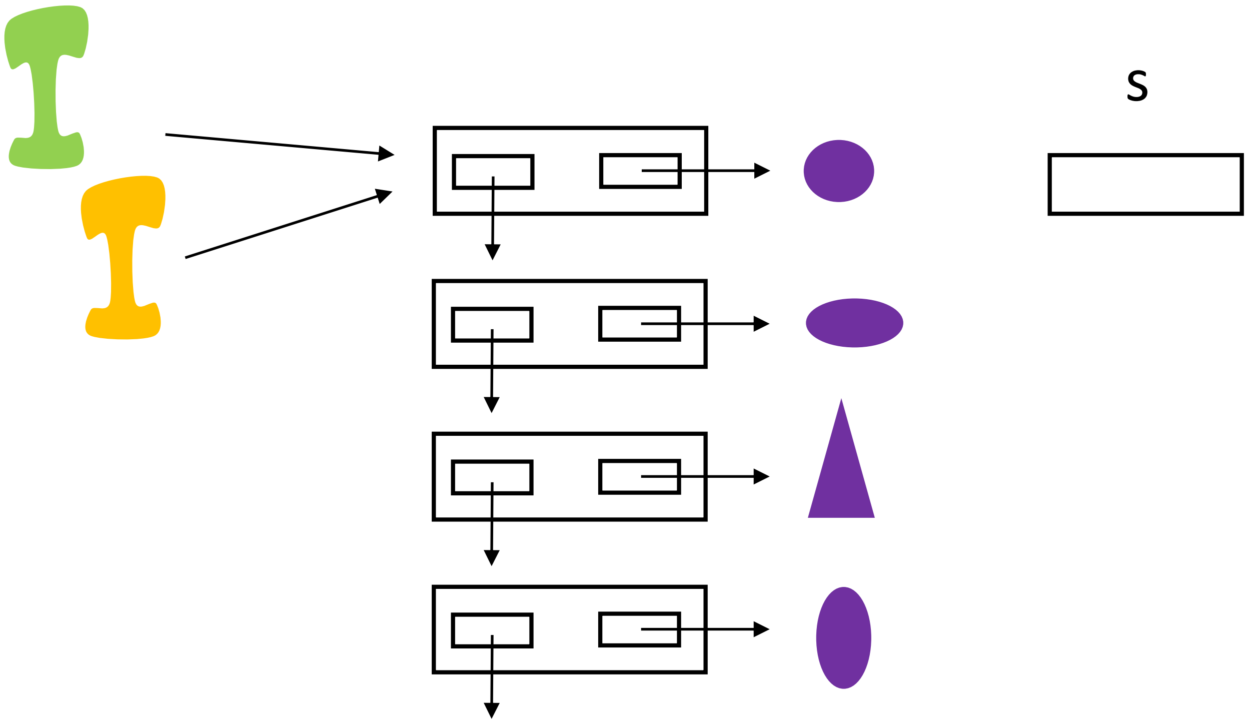


```
private class  SLL_Iterator<E>   implements   Iterator<E>{

            private SNode<E>    cur;

            SLL_Iterator( SLinkedList<E>     list){
                        cur = list.getHead();
            }
            public   boolean   hasNext() {
                        return (cur != null);
            }

            public   E   next() {
                        E    element  =  cur.getElement;
                        cur = cur.getNext();
                        return element;
            }

}
```

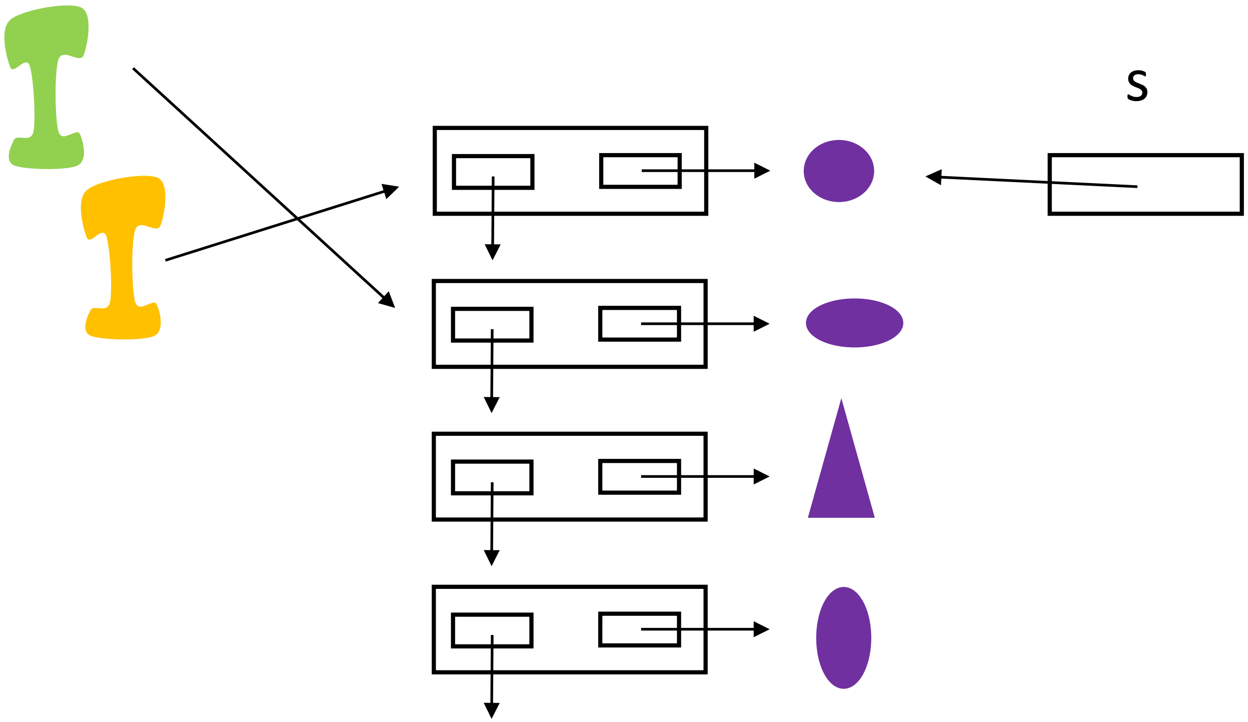
```
LinkedList<Shape>   list;
Shape   s;
```



```
LinkedList<Shape>   list;
Shape   s;
      :
Iterator<Shape>   iter1  =  list.iterator();
Iterator<Shape>   iter2  =  list.iterator();
```

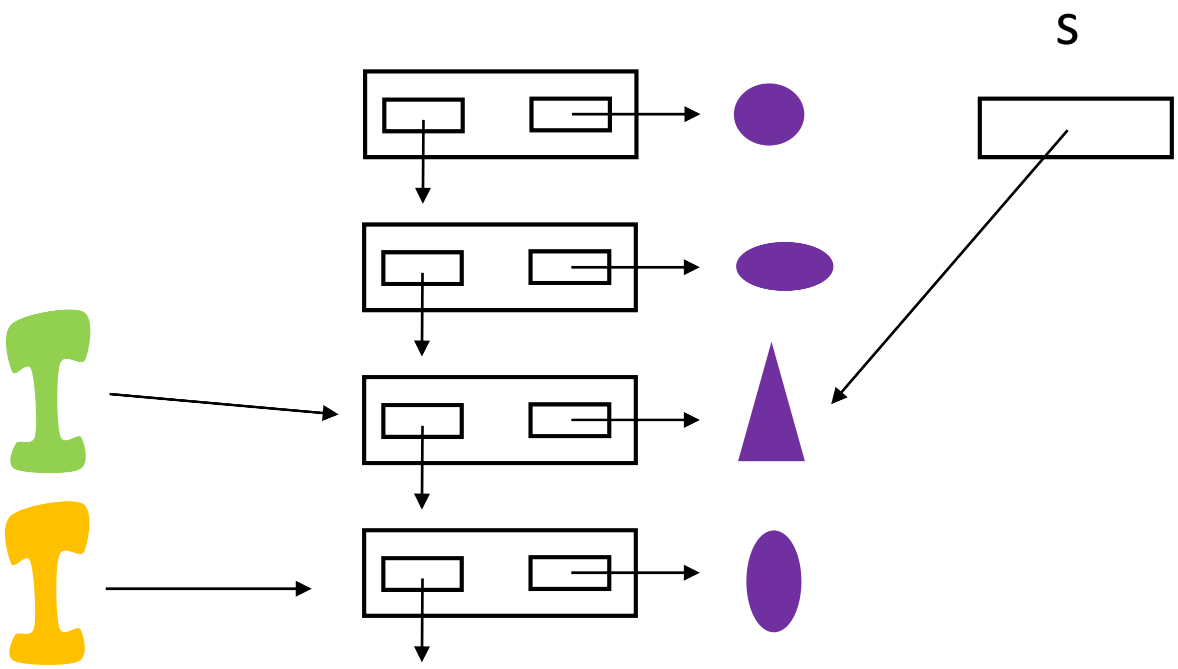


```
LinkedList<Shape>   list;
Shape   s;
      :
Iterator<Shape>   iter1  =  list.iterator();
Iterator<Shape>   iter2  =  list.iterator();

s = iter1.next()
```

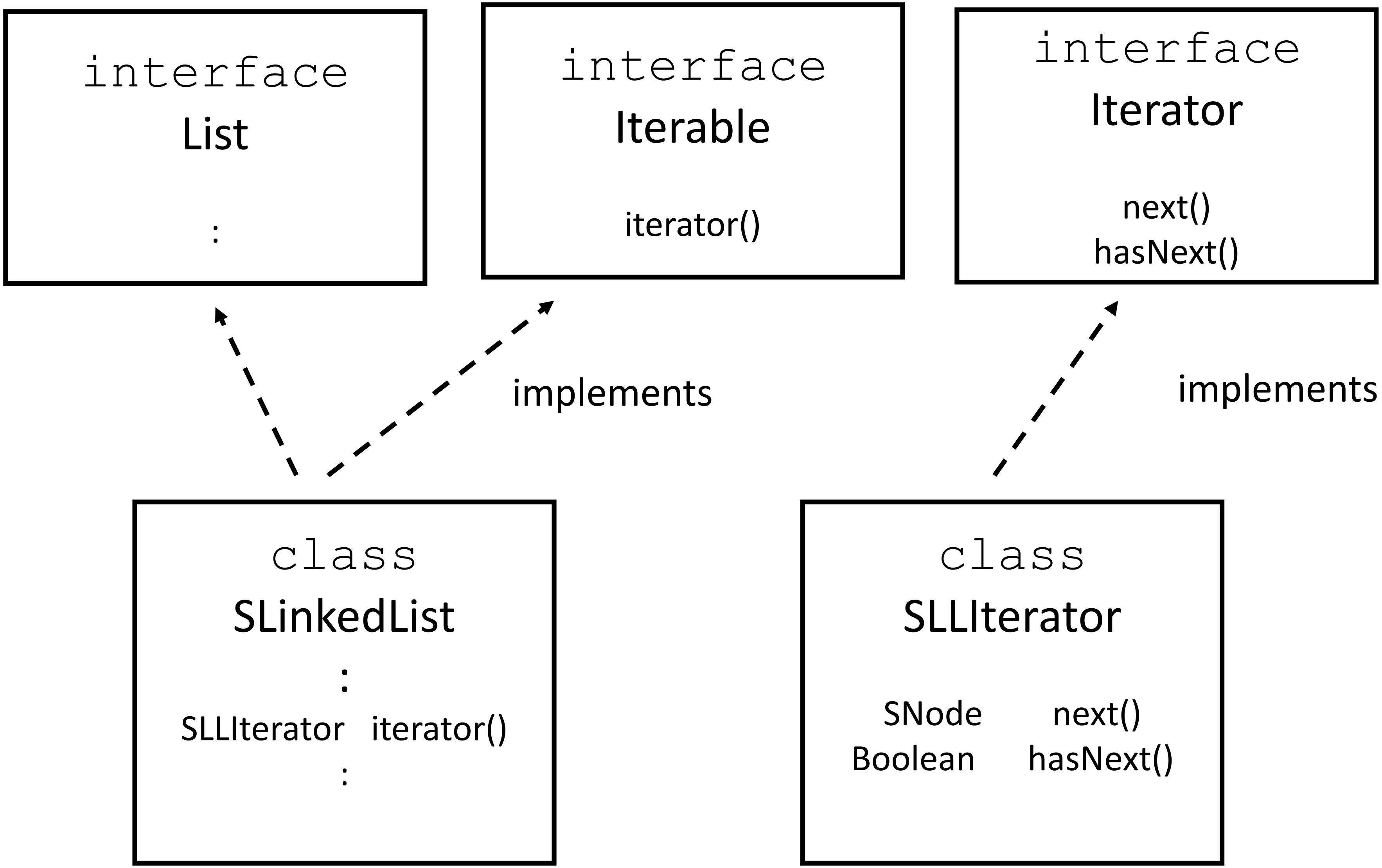


The iterators iterate over LinkedList nodes,   not Shapes.
The next() method returns Shapes.

```
LinkedList<Shape>   list;
Shape   s;
       :
Iterator<Shape>   iter1  =  list.iterator();
Iterator<Shape>   iter2  =  list.iterator();

s = iter1.next()

s = iter2.next()

s = iter1.next()

s = iter2.next()

s = iter2.next()
```



The iterators iterate over LinkedList nodes,   not Shapes.
The next() method returns Shapes.



SLLIterator might be an inner class of SLinkedList.
The iterator() method calls the constructor of the SLLIterator class.

Assignment 4: `MyHashTable`

You will implement a hashtable (or hashmap).

You will use the `SLinkedList` class from Exercises 4 to implement a `HashLinkedList` class which you will use for the buckets.

You will implement a `HashIterator` class for your hash table.

ASIDE: Java enhanced for loop

It can be used for any class that implements Iterable.

Example:

```
LinkedList<String>      list  =  new  LinkedList<String>();
        ....

for (String   s   :   list)  {
     System.out.println( s );
}
```