

Iterators

Motivation

- We often want to access every item in a data structure or collection in turn
 - We call this *traversing* or *iterating over* or *stepping through* or *visiting every item in* the data structure or collection
- Example with a data structure (array):

```
for (int i = 0; i < arr.length(); i++)  
    /* do something to arr[i] */
```
- This is straightforward because we know exactly how an array works!

Motivation

- What if we want to traverse a *collection* of objects?
 - A list, a stack, a queue ...
 - Its underlying implementation may not be known to us
- Java provides a *common scheme* for stepping through all elements in *any* collection, called an *iterator*

What is an Iterator?

- An *iterator* is a mechanism used to step through the elements of a collection one by one
 - Each element is “*delivered*” exactly once
- *Example*
 - Iterate through an ordered list and print each element in turn

5

9

23

34

Iterator Interface

- The Java API has a generic **interface** called **Iterator<T>** that specifies what methods are required of an iterator
 - **public boolean hasNext();**
returns true if there are more elements in the iteration
 - **public T next();**
returns the next element in the iteration
 - **public void remove();**
removes the last element returned by the iterator
(*optional operation*)
- It is in the java.util package of the Java API

Array Iterator

- If we had a collection with an array implementation, we would need an ***array implementation*** of the ***Iterator*** interface
 - See ***ArrayIterator.java***:
 - Its attributes
 - Its constructor
 - The code for the methods **hasNext** and **next**
 - In what order does it deliver the items?
- **Note:** ***ArrayIterator.java*** can be used by an array implementation of ***any*** collection!

// Represents an iterator over the elements of an array

import java.util.*;

public class Arraylterator<T> implements Iterator<T> {

// Attributes

private int count; // number of elements in collection

private int current; // current position in the iteration

private T[] items; // items in the collection

// Constructor: sets up this iterator using the
// specified items

public Arraylterator (T[] collection, int size) {

items = collection;

count = size;

current = 0;

}

// cont'd..

Arraylterator.java

// cont'd..

**// Returns true if this iterator has at least one
// more element to deliver in the iteration**

```
public boolean hasNext( ) {  
    return (current < count);  
}
```

**// Returns the next element in the iteration.
// If there are no more elements in this iteration,
// throws an exception.**

```
public T next( ) {  
    if (! hasNext( ))  
        throw new NoSuchElementException( );  
    current++;  
    return items[current - 1];  
}  
}
```

ArrayIterator.java (cont'd)

Linked Iterator

- If we had a collection with a linked implementation, we would need a ***linked implementation*** of the **Iterator** interface
 - See ***LinkedListIterator.java***
 - Its attributes
 - Its constructor
 - The code for the methods **hasNext** and **next**
 - In what order does it deliver the items?
- **Note:** ***LinkedListIterator.java*** can be used by a linked implementation of **any** collection!

```
import java.util.*;
public class LinkedIterator<T> implements Iterator<T> {

    // Attributes
    private int count;           // number of elements in collection
    private LinearNode<T> current; // current position

    // Constructor: Sets up this iterator using the specified items
    public LinkedIterator (LinearNode<T> collection, int size){
        current = collection;
        count = size;
    } //cont'd..
```

LinkedIterator.java

// ..cont'd..

*// Returns true if this iterator has at least one more element
// to deliver in the iteration.*

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

*// Returns the next element in the iteration. If there are no
// more elements in this iteration, throws an exception.*

```
public T next( ) {  
    if (! hasNext( ))  
        throw new NoSuchElementException( );  
    T result = current.getElement( );  
    current = current.getNext( );  
    return result;  
}  
}
```

**LinkedListIterator.java
(cont'd)**

Iterators for a Collection

How do we set up an iterator for a collection?

- Recall that the ListADT interface has an ***operation*** called **iterator** :

```
// Returns an iterator for the elements in this list  
public Iterator<T> iterator( );
```

- (In fact, any of our collections could have had an **iterator** operation ... *later*)

The **iterator** Operation in the ListADT

- Note that the **return type** of the **iterator** operation is **Iterator<T>**
 - But **Iterator<T>** is an interface, not a class!
 - When the return type of a method is an *interface name*, the method actually returns an object from *a class that implements the interface*
 - The **iterator** operation in **ArrayList** will use the class **ArrayIterator**
 - The **iterator** operation in **LinkedList** will use the class **LinkedListIterator**

iterator method for ArrayList

```
/**
 * Returns an iterator for the elements currently in this list.
 *
 * @return an iterator for the elements in this list
 */
public Iterator<T> iterator()
{
    return new ArrayIterator<T> (list, rear);
}
```

iterator method for LinkedList

```
/**
 * Returns an iterator for the elements currently in this list.
 *
 * @return an iterator for the elements in this list
 */
public Iterator<T> iterator( )
{
    return new LinkedListIterator<T> (contents, count);
}
```

The only difference from the **iterator** method in **ArrayList** is the **class** from which the iterator object is being created!

Using an Iterator

- When the `iterator()` method in a collection is invoked, it returns an “iterator object”
- We can then invoke the methods `hasNext()` and `next()` on that object, to iterate through the collection
 - (Those are the methods that are specified in the `Iterator<T>` interface)

Using an Iterator in an Application

Example: Suppose we had an unordered list that was created by

```
ArrayUnorderedList<Person> myList =  
    new ArrayUnorderedList<Person>();
```

and then had items added to it...

```
// Use iterator to display contents of list  
Iterator<Person> iter = myList.iterator();  
while(iter.hasNext() )  
{  
    System.out.println(iter.next());  
}
```

// cont' d

Using an Iterator in an Application

// Print just the email addresses now

// Note that we have to start a new iteration!

```
iter = myList.iterator(); // start new iteration
while(iter.hasNext() )
{
    System.out.println(iter.next().getEmail());
}
```

Example: Using an Iterator within a Class Definition

- Rewrite the toString() method of ArrayList using its iterator:

```
public String toString() {  
    String result = "";  
  
    Iterator<T> iter = this.iterator();  
  
    while ( iter.hasNext() )  
        result = result + iter.next().toString() + "\n";  
  
    return result;  
}
```

Discussion

- Could we use the *very same code* from the previous slide for the `toString()` method of `LinkedList`?
- If we had an `iterator` operation in the `StackADT`, could we use this very same code for the `toString()` methods of the `StackADT` implementations?

Exercises

- Add an **iterator** operation to the StackADT
 - Implement it in **ArrayStack**
 - In what order will it deliver the items if we use `ArrayIterator.java` to implement the `Iterator<T>` interface?
 - Implement it in **LinkedStack**
 - In what order will it deliver the items if we use `LinkedListIterator.java` to implement the `Iterator<T>` interface?
 - Rewrite the **toString** method of the StackADT implementations to use its iterator
- Ditto for the QueueADT

Discussion

- Note that the order of the iteration is determined by the design of the class that implements the `Iterator<T>` interface
- If we wanted an iterator that delivered the items in a stack in the opposite order from `ArrayIterator`, what would we have to do?

Why use Iterators?

- Traversing through the elements of a collection is very common in programming, and iterators provide a *uniform* way of doing so
- Advantage? Using an iterator, we don't need to know how the collection is implemented!