Iterator interface, Iteratorable interface

Two very useful Interfaces
Need for Iterators:

to simplify the step of processing all the elements of a collection

- Very often we need to have a method that accesses ALL the **elements** in a collection. E.g.,
  - All the elements on a Stack, or on a Queue, or on a Graph

- The user could write code to access each element in a collection, but it would be slightly different for each collection. E.g., going through
  - All the elements on a Stack, or on a Queue, or on a Graph

- An *iterator* is an object that allows the user to **acquire** and **use** each element in a collection

- It **works with** a collection, but is a **separate** object
Example of an Iterator use

1. Suppose WCDorms is an LinkedList of String objects

    ```java
    LinkedList<String> WCDorms = new LinkedList<>();
    
    Iterator<String> itr = WCDorms.iterator();
    
    while (itr.hasNext()) {
        System.out.println(itr.next());
    }
    ```

2. The first line obtains the iterator, then the loop uses hasNext and next to access and print each dorm
9.3 – The Iterator Interface

An iterator is an object that provides a means of processing a collection of objects, one at a time.

By implementing the `Iterator` interface, a class formally establishes that objects of that type are iterators.

Now, the `for-each` version of the `for` loop can be used to process the items in the iterator.
Iterators work with “for-each” loops

- A for-each loop can be used for the same goal:

```java
for (String dorm : WCDorms)
    System.out.println(dorm);
```

- The for-each loop uses an iterator behind the scenes

- The for-each loop can be used on any object that is `Iterable`
Different Data Structure, same way of processing all elements

```java
import java.util.LinkedList;
import java.util.Iterator;
import java.util.Vector;

/**
 * Example on how to use iterator of a LinkedList.
 * @author (TM)
 * @version (2022.11.09)
 */
public class LinkedListIteratorExample
{
    public static void main(String[] args)
    {
        LinkedList<String> dorms = new LinkedList<String>();
        dorms.add("Beebe");
        dorms.add("Clafflin");
        dorms.add("Stone-Davis");

        Iterator<String> it = dorms.iterator();  // Let's see what's in LL
        System.out.println("LinkedList elements:");
        while(it.hasNext())
        {
            System.out.println(it.next());
        }

        dorms.add("Science Center ;");
        dorms.add("Casa Cervantes");
        dorms.add("Tower Court");

        it = dorms.iterator();
        System.out.println("\nNew LinkedList iterator: ");
        while(it.hasNext())
        {
            System.out.println(it.next());
        }
    }
}
```

```java
import java.util.Iterator;
import java.util.Vector;

/**
 * Example on how to use iterator of a Vector.
 * @author (TM)
 * @version (2022.11.09)
 */
public class VectorIteratorExample
{
    public static void main(String args[])
    {
        Vector<String> dorms = new Vector<String>();
        dorms.add("Beebe");
        dorms.add("Clafflin");

        Iterator<String> it = dorms.iterator();
        System.out.println("Vector elements:");
        while(it.hasNext())
        {
            String obj = it.next();
            System.out.println(obj);
        }

        dorms.add("Stone-Davis");
        dorms.add("Science Center ;");
        dorms.add("Casa Cervantes");
        dorms.add("Tower Court");

        it = dorms.iterator();
        System.out.println("\nNew Vector iterator: ");
        while(it.hasNext())
        {
            System.out.println(it.next());
        }
    }
}
```
Iterators

- You may want to use an iterator explicitly if you don't want to process all elements
  - i.e., searching for a particular element
- You may also use an explicit iterator if you want to call the remove method
- The for-each loop does not give access to the iterator, so remove cannot be called
Iterators

- You shouldn't assume that an iterator will deliver the elements in any particular order unless the documentation explicitly says you can.
- Also, remember that an iterator is accessing the elements stored in the collection.
- The structure of the underlying collection should not be changed while an iterator is being used.
- Most iterators in the Java API are fail-fast, meaning they throw an exception if the collection is modified while the iterator is active.
Iterators and Iterable

- There are two key interfaces in the Java API related to iterators:
  - `Iterator` – used to define an iterator
  - `Iterable` – used to define a collection that provides an iterator

- When we call a collection `Iterable`, it means it will provide an `Iterator` when requested

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td><code>Iterator&lt;E&gt; iterator()</code></td>
<td>Returns an iterator over a set of elements of type E.</td>
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</tbody>
</table>
Using Java Foundations’ ArrayIterator

It is a little different; it is more flexible:
It can remember where was the next() element
Using JavaFoundation's `ArrayIterator`

```java
import javafoundations.ArrayIterator;

/**
 * Client program for testing ArrayIterator.
 *
 * @author CS230 (TM)
 * @version 2020.03.29
 */

public class IteratorTest {
    public static void main(String args[]){
        ArrayIterator<String> dormsIter = new ArrayIterator<String>();
        dormsIter.add("Beebe");
        dormsIter.add("Claflin");
        dormsIter.add("Stone-Davis");

        while (dormsIter.hasNext())
            System.out.println(dormsIter.next());

        dormsIter.add("Dower");
        dormsIter.add("Casa Cervantes");
        dormsIter.add("Tower Court");

        while (dormsIter.hasNext())
            System.out.println(dormsIter.next());
    }
}
```
Implementing JF’s Iterator

It uses an array to store and access the elements. We could also have another implementation that uses a LinkedList.
Implementing an iterator using array

```java
import java.util.*;

generic class ArrayIterator<T> implements Iterator<T> {
    private int DEFAULT_CAPACITY = 10;
    private int count;    // the number of elements in the iterator
    private int current;  // the current position in the iteration
    private T[] items;    // the iterator's storage for elements

    // Sets up this iterator.
    public ArrayIterator() {
        items = (T[]) (new Object[DEFAULT_CAPACITY]);
        count = 0;
        current = 0;
    }

    (more...)
```
Implementing an iterator using array

```java
// Adds the specified item to this iterator.
public void add (T item)
{
    if (count == items.length)
        expandCapacity();
    items[count] = item;
    count++;
}

// Expands the capacity of the storage array
private void expandCapacity()
{
    T[] larger = (T []) (new Object[items.length*2]);
    int location = 0;
    for (T element : items)
        larger[location++] = element;

    items = larger;
}

// (more...)
```
Implementing an iterator using array

// --------------------------------------------------------------------------------------------------
// 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, a NoSuchElementException is thrown.
// --------------------------------------------------------------------------------------------------
public T next() {
    if (! hasNext())
        throw new NoSuchElementException();
    current++;
    return items[current - 1];
}

// --------------------------------------------------------------------------------------------------
// The remove operation is not supported in this collection.
// --------------------------------------------------------------------------------------------------
public void remove() throws UnsupportedOperationException {
    throw new UnsupportedOperationException();
}