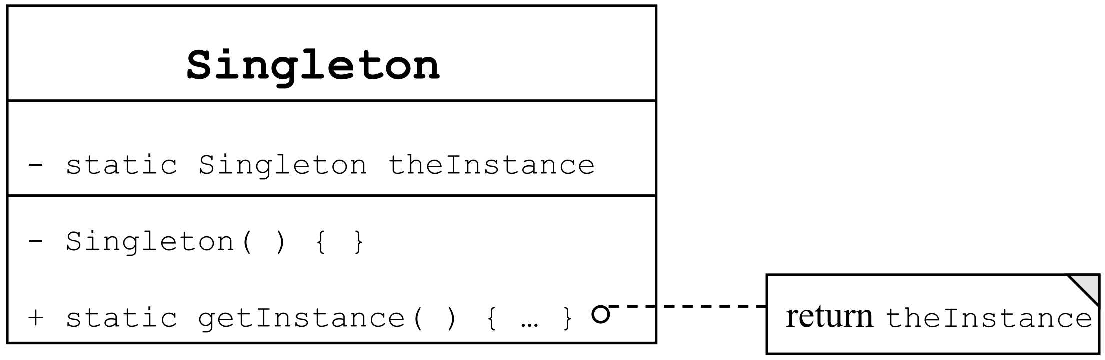
CS 213 Spring 2016

Lecture 19: March 29

Design Patterns – 2
Iterator

Previously - Singleton: Creational

- Ensure that a class has only one object (instance) and provide a global point of access to this single instance

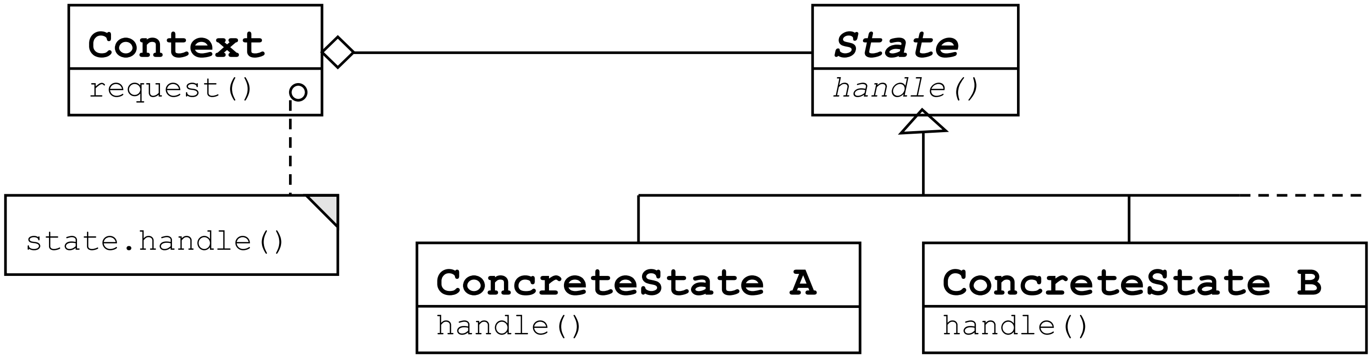


- The single private constructor ensures that an instance of Singleton cannot be created using `new`

- Example: State classes `CalcClearState`, `CalcEqualsState`, etc. in the state-based calculator application

Previously - State: Behavioral

- Allow an object to change its behavior when its internal state changes – the "object" is a subclass of an abstract class, thus polymorphism



- Context (client code) has a state object that is one of the concrete instances: the request method executes `handle` on this concrete instance dynamically binding the appropriate concrete class method – neat use of polymorphism

- Example: State classes CalcState (abstract) and `CalcClearState`, `CalcEqualsState`, etc. (concrete) in the state-based calculator application. The context is the `CalcController` class.

Iterator: Behavioral

```
public class LinkedList<T> {
   public static class Node<E> {
      public E data;
      public Node<E> next;
   }
   public Node<T> front;
   . . .
}
```

Solution 1: Iterate by directly accessing nodes

```
LinkedList<String> list =
                     new LinkedList<String>();
. . .
for (LinkedList.Node<String> ptr = list.front;
    ptr != null; ptr = ptr.next) {
    System.out.println(ptr.data);
}
```

Only works if `Node` class and `front` are accessible to clients, which means they must be made public, which is not a good design idea

Need something like this instead

```
public class LinkedList<T> {
   static protected class Node<E> {
      protected E data;
      protected Node<E> next;
   }
   protected Node<T> front;
   . . .
}
```

Iterator: Behavioral

Solution 2: Iterate via method invocation

```
public class LinkedList<T> {
   . . .
   protected Node<T> curr;

   public void reset() {
      curr = front;
   }

   public T next() {
      T ret = null;
      if (curr != null) {
          ret = curr.data;
          curr = curr.next;
      }
      return ret;
   }

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

Basic Iteration using solution 2

```
LinkedList<String> list = new LinkedList<String>();
. . .
for (list.reset(); list.hasNext();) {
    System.out.println(list.next());
}
```

E.g. Print #links from each web page to all other web pages

```
LinkedList<URL> list = new LinkedList<URL>();

// populate with web pages . . .

for (list.reset(); list.hasNext();) {
    URL wp1 = list.next();
    for (list.reset(); list.hasNext();) {
        URL wp2 = list.next();
        int n = numLinks(wp1, wp2);
        System.out.println(“#links from “ + wp1 +
                           “ to “ + wp2 + “ = “ + n);
    }
}
```

This won’t work – the inner loop thrashes the state of the outer!

Iterator: Behavioral

Solution 3: Separate the Iterator from the LinkedList

```
// in same package as LinkedList
public class LinkedListIterator<T> {

   protected LinkedList.Node<T> curr;

   public LinkedListIterator(
                LinkedList<T> list) {
      curr = list.front;
   }

   public T next() {
      T ret = null
      if (curr != null) {
          ret = curr.data;
          curr = curr.next;
      }
      return ret;
   }

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

Print #links from each web page to all other web pages

```
LinkedList<URL> list =
            new LinkedList<URL>();

// populate with web pages . . .

LinkedListIterator<URL> iter1 =
    new LinkedListIterator<URL>(list);
LinkedListIterator<URL> iter2 =
    new LinkedListIterator<URL>(list);

while (iter1.hasNext()) {
   URL wp1 = iter1.next();
   while (iter2.hasNext()) {
        URL wp2 = iter2.next();
        int n = numLinks(wp1, wp2);
        . . .
    }
}
```

Iterator: Behavioral

Solution 4: Generalization with Interface

java.util

```
public interface Iterator<T> {
   boolean hasNext();
   T next();
   void remove();
}
```

```
class LinkedListIterator<T>
             implements Iterator<T> {
   protected LinkedList<T> list;
   protected LinkedList.Node<T> curr;

   LinkedListIterator(LinkedList<T> list) {
      this.list = list;
      curr = list.front;
   }
   public T next() {
      T ret = null
      if (curr != null) {
          ret = curr.data;
          curr = curr.next;
      }
      return ret;
   }
   public boolean hasNext() {
      return curr != null;
   }
   public void remove() {
      throw new
        UnsupportedOperationException();
   }
}
```

This is a default method in the Java 8 version of the `Iterator` interface, which throws this exception. So this particular Implementation need not be coded since it is the same as the default

Iterator: Behavioral

Solution 4: Generalization with Interface

```
public class LinkedList<T> {
   . . .
   public Iterator<T> iterator() {
      return new
      LinkedListIterator<T>(this);
   }
   . . .
}
```

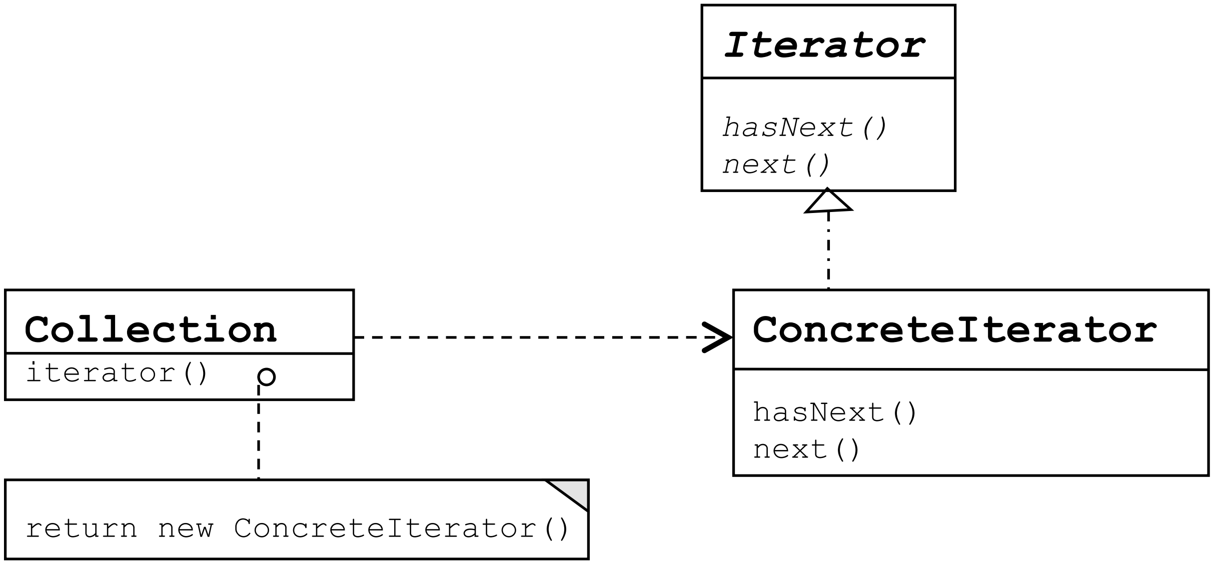
```
LinkedList<URL> list =
    new LinkedList<URL>();
// populate with web pages . . .

Iterator<URL> iter1 = list.iterator();

while (iter1.hasNext()) {
   URL wp1 = iter1.next();
   Iterator<URL> iter2 = list.iterator();
   while (iter2.hasNext()) {
        URL wp2 = iter2.next();
        int n = numLinks(wp1, wp2);
        . . .
    }
}
```

Iterator: Behavioral

- Access the contents of a collection without exposing its internal representation
- Support overlapping multiple traversals
- Provide a uniform interface for traversing different collections – support polymorphic iteration


Iterator
hasNext()
next()
Collection
iterator()
ConcreteIterator
hasNext()
next()
return new ConcreteIterator()