Iterator Pattern

This lesson discusses how the underlying elements that make up an aggregate object can be looped through without exposing implementation details to clients.

What is it ?

Iterate literally means to perform repeatedly. A *for* loop iterates over an array i.e. it accesses the array repeatedly. If you are familiar with Java then you would already have come across this pattern while working with Java Collections. A brief demonstration is below.

```
    ArrayList<String> companiesIWantToInterviewFor = new ArrayList<>
();
    companiesIWantToInterviewFor.add("SnapChat");
    companiesIWantToInterviewFor.add("Twitter");
    companiesIWantToInterviewFor.add("Tesla");

    Iterator<String> it = companiesIWantToInterviewFor.iterator();
    while (it.hasNext()) {
        System.out.println(it.next());
    }
```

The iterator allows a consumer to go over the elements of a collection without knowing how the collection is implemented. A collection can be a list, array, arraylist, hashmap or any other fancy datastructure. A collection signifies a bunch of objects. It doesn't specify any ordering or properties about the objects it holds. An iterator is formally defined as *a pattern that allows traversing the elements of an aggregate or a collection sequentially without exposing the underlying implementation*.
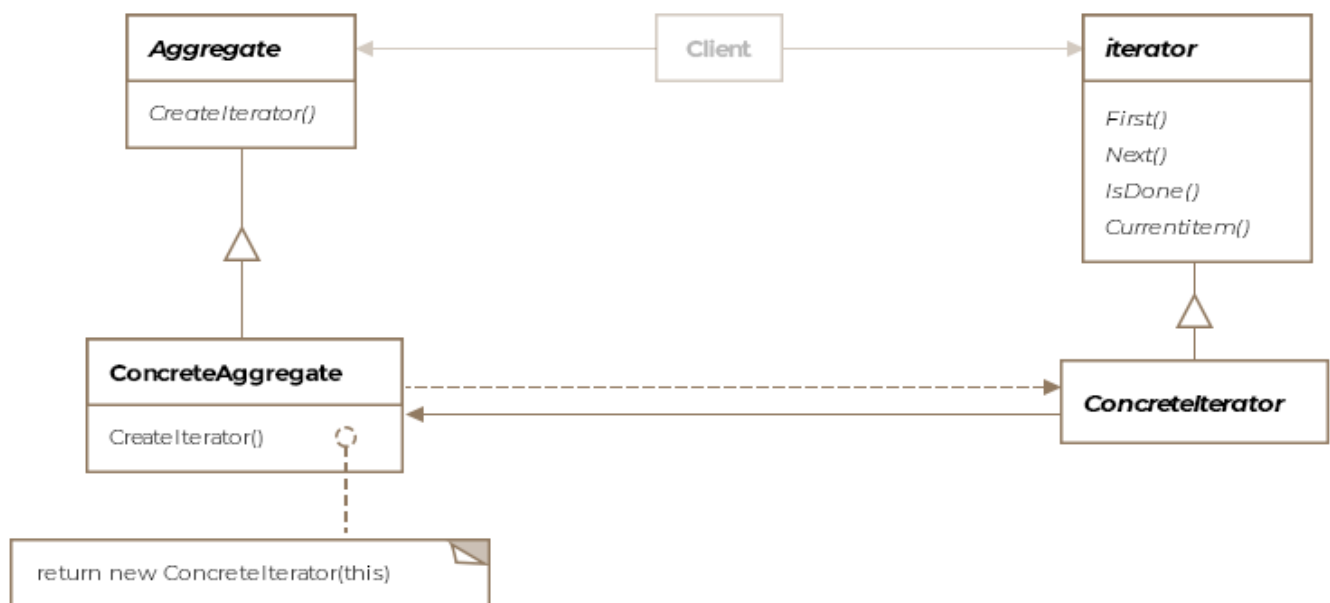
The iterator pattern extracts out the responsibility of traversing over an aggregate out of the aggregate's interface and encapsulates it in the iterator class, thereby simplifying the aggregate's interface.

Class Diagram

The class diagram consists of the following entities

- **Iterator**

- **Concrete Iterator**

- **Aggregate**

- **Concrete Aggregate**

Example

Java already has an interface `Iterator` but for the purposes of learning, we'll create it from scratch. Our interface will expose only two methods `next()` and `hasNext()`. It'll look something like below:

```
public interface Iterator {

    void next();

    boolean hasNext();
}
```

Lets say we have a class `AirForce` and it contains different kinds of aircraft, some are cargo airplanes, others are fighter jets and a few helicopters. Objects for each of these aircraft types are stored in different collection types. Take a minute to go over the `Airforce` class listing below:

```java
public class AirForce {

    List<IAircraft> jets = new ArrayList<>();
    IAircraft[] helis = new IAircraft[1];
    LinkedList<Boeing747> cargo = new LinkedList<>();

    public List<IAircraft> getJets() {
        return jets;
    }

    public IAircraft[] getHelis() {
        return helis;
    }

    public LinkedList<Boeing747> getCargo() {
        return cargo;
    }

    public AirForce() {
        jets.add(new F16());
        helis[0] = new CobraGunship();
        cargo.add(new Boeing747());
    }

    // This method returns a concrete iterator that
    // traverses over the entire airforce planes.
    public Iterator createIterator() {
        return new AirForceIterator(this);

    }

    // This method returns a different concerete iterator
    // that traverses over only the jets in the airforce.
    public Iterator createJetsIterator() {
        return new JetsIterator(jets);

    }
}
```

Note the methods `createIterator()` and `createJetsIterator()` return objects that implement the `Iterator` interface. Notice how each kind of aircraft is stored in a different type of collection. If a client needs to list all the aircraft in an airforce object, it'll have a hard time invoking getters and then going over

each individual collection. We mask this complexity by creating an iterator class whose sole job is to list all the aircraft held by the airforce. Look at the implementation below:

```java
public class AirForceIterator implements Iterator {

    List<IAircraft> jets;
    IAircraft[] helis;
    LinkedList<Boeing747> cargo;
    int jetsPosition = 0;
    int helisPosition = 0;
    int cargoPosition = 0;

    /**
     * The iterator is composed with the object it'll be iterating over
     */
    public AirForceIterator(AirForce airForce) {
        jets = airForce.getJets();
        helis = airForce.getHelis();
        cargo = airForce.getCargo();

    }


    @Override
    /**
     * We provide our own custom logic of returning aircraft in a
     * sequence. Note we are returning IAircraft interface object which
     * every plane in our airforce implements. We also design the function
     * to throw a runtime exception if next is invoked when no more elements
     * are left to iterate over
     */
    public IAircraft next() {

        // return helis first
        if (helisPosition < helis.length) {
            return helis[helisPosition++];
        }

        // return jets second
        if (jetsPosition < jets.size()) {
            return jets.get(jetsPosition++);
        }

        // return cargos last
        if (cargoPosition < cargo.size()) {
            return cargo.get(cargoPosition++);
        }
```

```
            throw new RuntimeException("No more elements");


    }


    @Override
    public boolean hasNext() {

        return helis.length > helisPosition ||
                jets.size() > jetsPosition ||
                cargo.size() > cargoPosition;
    }
}
```

Let's look at how the client uses the iterator

```
public class Client {

    public void main() {

        AirForce airForce = new AirForce();

        Iterator jets = airForce.createJetsIterator();

        while (jets.hasNext()) {
            jets.next();
        }

        Iterator allPlanes = airForce.createIterator();

        while (allPlanes.hasNext()) {
            allPlanes.next();
        }
    }
}
```

Notice, the client has no idea about how the different airplane types are held in the airforce object nor does it know what type of aircraft they are. It simply gets to work with the `IAircraft` interface.

The Java API has its own iterator interface which also includes `remove()` and `forEachRemaining()` methods that we have not included in our in-house iterator.

Internal vs External Iterator

When the iteration control rests with the client using the iterator, that is, the client is responsible for advancing the traversal and explicitly requesting the next element from the iterator, it is an example of an ***external iterator***. Iterators in our aircraft example are external iterators. On the other hand, when the client hands the iterator an operation to perform and the iterator performs the operation on each element of the aggregate, it is an example of an ***internal iterator***.

Other Examples

- In Java several classes directly or indirectly implement the `Iterator` interface. By indirect implemenation, it is implied that a class implements an interface that extends the `Iterator` interface.

- Another example one can think of is in case of tree datastructure. One can parametrize the `createIterator()` method to yield iterators which traverse the tree in preorder, inorder or postorder.

- `java.util.Scanner` class is another example of the iterator pattern.

- `java.util.Enumeration` interface although deprecated but is an early example of the iterator pattern in Java.

Caveats

- Note that there could be more than one pending traversals on the aggregate. Each iterator would store its own traversal state. The iterator

can apply the memento pattern to store the traversal state.

- By moving the traversal outside of the aggregate, it's easier to provide variations on the traversal algorithm to the client.

- Special care needs to be taken care when insertions or deletions are allowed to an aggregate amidst an on-going traversal. The iterator can either skip over a new element or iterate over the same element twice.

- For composites as described in the *Composite Pattern*, it might make sense to create internal iterators instead of external ones, reason being that the composite can have several levels of aggregate structures and its easier for the composite to internally keep track of the traversal position by calling itself recursively and implicitly storing the traversal path in the call stack.

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