Composite Pattern

This lesson discusses the composite pattern that lets us treat individual elements and group of elements as one.

What is it ?

Composite literally means ***made up of various elements or parts***. The pattern allows you to treat the whole and the individual parts as one. The closest analogy you can imagine is a tree. The tree is a *recursive* data-structure where each part itself is a sub-tree except for the leaf nodes. The root is the top-level composite and its children are either composites themselves or just leaf nodes. The leaf itself can be thought of as a tree with just a single node.

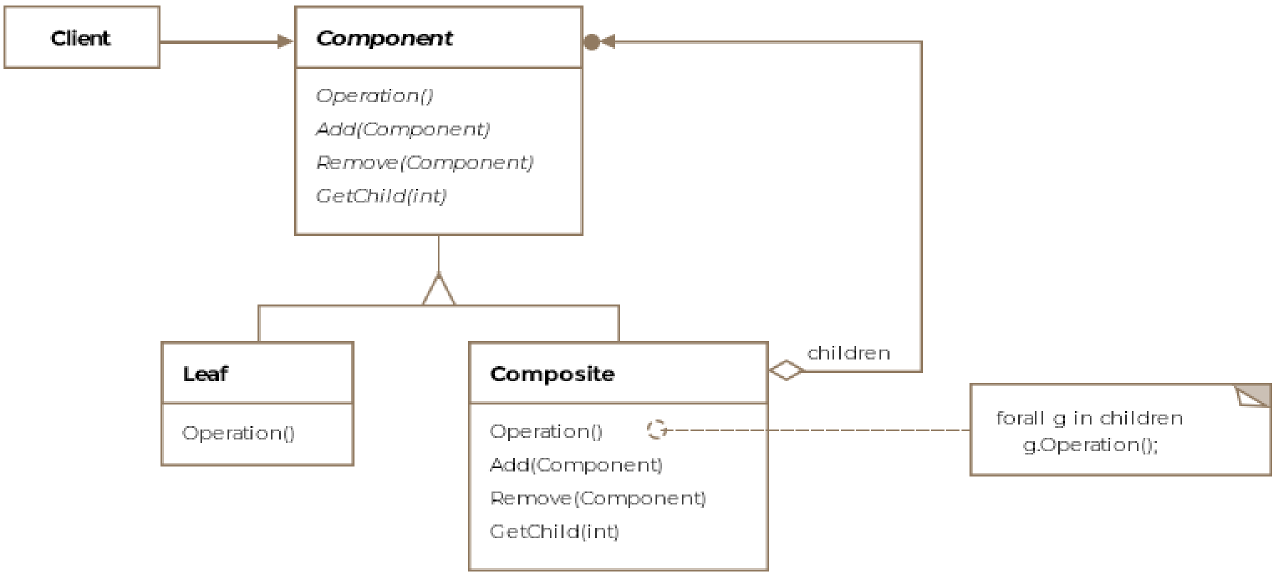
Formally, the composite pattern is defined as ***composing objects into tree structures to represent part-whole hierarchies, thus letting clients uniformly treat individual objects and composition of objects.***

The pattern allows the clients to ignore the differences between the whole and the part.

Class Diagram

The class diagram consists of the following entities

- **Component**
- **Leaf**
- **Composite**
- **Client**



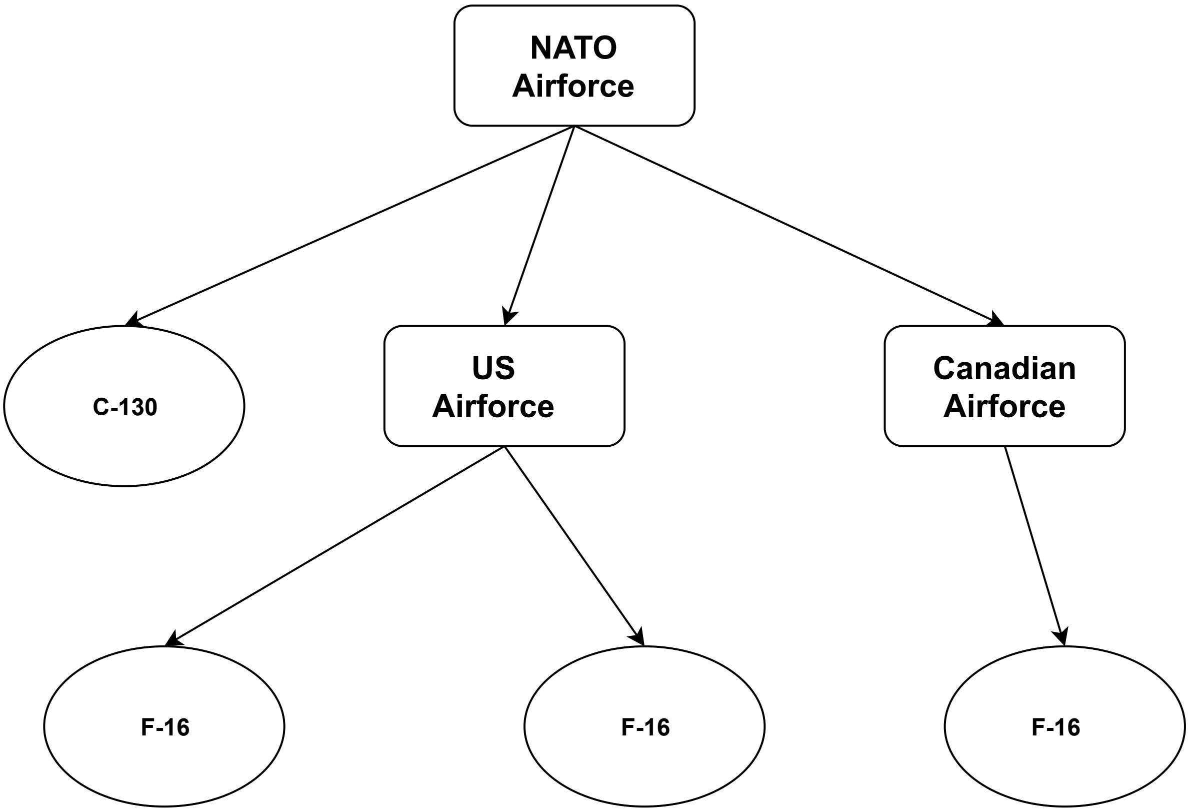
Class Diagram

Example

Assume, that we now want to represent all the aircraft in the combined air forces of the NATO alliance. An air force is primarily made up of several aircraft but it can also have sub-air forces. For instance, the US has the 1st Air Force, 2nd Air Force so on and so forth. Our NATO alliance can consist of air forces from multiple countries including individual planes.

If we want to treat the composite and each part as the same, we would need both the *part* (the aircraft) and the *whole* (the airforce) to implement the same interface. In our scenario we'll create three classes:

- `Airforce`
- `F16`
- `C130Hercules`



Tree Depiction of Composite

The class `Airforce` will represent the **composite** and the other two classes the **part**. Furthermore, we'll create an interface `IAlliancePart` that will allow us to treat the objects from each of the three classes as one type.

Each aircraft requires some number of pilots to operate and maybe peripheral staff for maintainance. The classes would implement the funtionality to return the number of personnel required for the aircraft to operate. The `Airforce` class should return the total number of personnel required to operate all the aircraft composed of the airforce.

```
public interface IAlliancePart {

    // Any implementing class should return the
    // the number of personnel or staff required
    // to operate the aircraft or the airfoce
    int getPersonnel();
}
```

The classes implementing the above interface appear below:

```java
public class F16 implements IAircraft, IAlliancePart {

    @Override
    public int getPersonnel() {
        // We need 2 pilots for F-16
        return 2;
    }
}

public class C130Hercules implements IAircraft, IAlliancePart {

    @Override
    public int getPersonnel() {
        // This cargo plane, needs 5 people
        return 5;
    }
}
```

The above two classes act as parts, now we'll write the composite class `Airforce`.

```java
public class Airforce implements IAlliancePart {

    ArrayList<IAlliancePart> planes = new ArrayList<>();

    public void add(IAlliancePart alliancePart) {
        planes.add(alliancePart);
    }

    @Override
    public int getPersonnel() {

        // We iterator over the entire air force which can
        // contain leaf nodes (planes) or other composites
        // (air forces). This iteration is an example of an
        // internal iterator.
        Iterator<IAlliancePart> itr = planes.iterator();
        int staff = 0;

        while (itr.hasNext()) {
            staff += itr.next().getPersonnel();
        }
```

```
        return staff;

    }
}
```

Pay attention to the `getPersonnel` method for the `Airforce` class. It is an example of an ***internal iterator***. It is called internal because the `Airforce` assumes the responsibility of iterating over itself and its subparts. The iteration can also be extracted out into a separate class and would make an example of an ***external iterator***.

The internal iterator will recursively call the `getPersonnel` method on the nested air force objects. The leaves would actually be the planes and will return a number. The personnel count for the root air force object will be the sum of all the people required to operate all the planes.

The client can invoke the `getPersonnel` method on the root object and get a total count. Note how transparency is created by treating the composite and the part as same. The client code or the internal iterator code doesn't need conditional if-else statements to check for the type of the object and then call the appropriate method on it. The client code appears below:

```
public class Client {

    public void main() {

        Airforce NatoAllaiance = new Airforce();

        // The nested methods aren't listed for brevity's sake
        NatoAllaiance.add(createCanadaAirForce());
        NatoAllaiance.add(createUSAAirForce());

        F16 frenchF16 = new F16();
        C130Hercules germanCargo = new C130Hercules();

        NatoAllaiance.add(frenchF16);
        NatoAllaiance.add(germanCargo);

        System.out.println(NatoAllaiance.getPersonnel());
    }
```

```
    }
}
```

Note ours is a simple example with a single method and we chose an `interface` instead of an `abstract class` to represent the whole and the part. If we opted for the latter, we could have provided default implementations for some methods.

The composite pattern allows a client to work seamlessly with a composite object. The client doesn't need to distinguish between the composite and the part. To make this happen, the composite, as well as, the part needs to implement a common interface or inherit from a common abstract class. This will let the client invoke common methods on both. However, it is possible that the common super-type has methods which make sense for the part and not for the composite or vice versa. Say our interface `IAlliancePart` could have a method `fire()` which would be applicable to the part, i.e. the plane but not to the composite, i.e. the air force. In such a scenario, it is ok to put in a default implementation or throw an `UnSupportedOperationException`.

Other Examples

- In Java, the class `javax.faces.component.UIComponent` is an example of the composite.
- Imagine a UI Menu widget which can have sub-menus and menu items that perform some action when clicked on by the user. The menus would form the composite while the menu-items would form the part.

Caveats

- references to parents: Since the composite is a tree structure, one may or may not need to store references to the parent.
- ordering of children in a composite: In some scenarios, it might be required to store or traverse the children in a certain order within the composite.
- cacheing part of the composite for traversal: For complex composites, it may make sense to cache part of the composite object to speed up traversal or search.