Structural Design Pattern

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Outline

1. Structural Pattern Overview

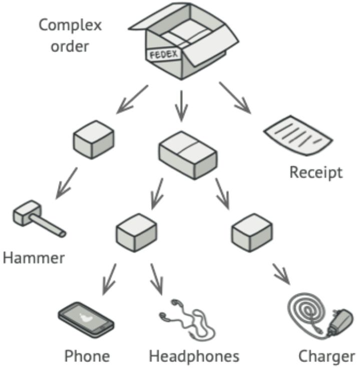
2. Composite design pattern

Structural Pattern Overview

How classes and objects are composed to form larger structure.

- **Adapter**: Convert the interface of a class into another interface.
- **Bridge**: Decouple an abstraction from its implementation.
- **Composite**: Compose objects into tree structure.
- **Decorator**: Attach additional responsibilities to an object dynamically.
- **Facade**: Provide a unified interface to a set of interfaces.
- **Flyweight**: Use sharing to support large numbers of fine-grained objects efficiently.
- **Proxy**: Provide a surrogate or placeholder for another object to control access to it.

Problem Statement



- Imagine that you have two types of objects: **Products** and **Boxes**
- A Box can contain several Products as well as a number of smaller Boxes.
- These little Boxes can also hold some Products or even smaller Boxes, and so on.

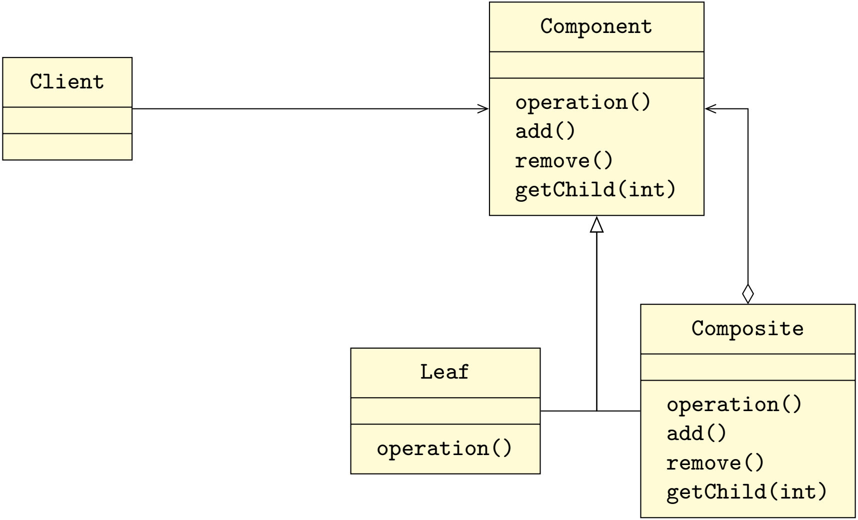
Problem Statement

- Create an ordering system that uses these classes
- Orders could contain simple products without any wrapping, as well as boxes stuffed with products...and other boxes.
- How would you determine the total price of such an order?
- You could try the direct approach: unwrap all the boxes, go over all the products and then calculate the total.
- That would be doable in the real world; but in a program, it's not as simple as running a loop.
- You have to know the classes of Products and Boxes you're going through, the nesting level of the boxes and other nasty details beforehand.
- All of this makes the direct approach either too awkward or even impossible.

The Intent of Composite Design Pattern

Compose objects into tree structures to represent part-whole hierarchies. Composite lets clients treat individual objects and compositions of objects uniformly.

Structure of Bridge Pattern: Object adapter



Tree implementation

component.h

```cpp
#ifndef _COMPONENT_H_
#define _COMPONENT_H_
#include <algorithm>
#include <string>
class Component {
protected:
  Component* _parent;
public:
  virtual ~Component();
  void setParent(Component* parent);
  Component* getParent() const;
  virtual void add(Component* component);
  virtual void remove(Component* component);
  virtual bool isComposite() const;
  virtual std::string operation() const = 0;
};
#endif // _COMPONENT_H_
```

component.cpp

```cpp
#include "component.h"

Component::~Component() {
}

void Component::setParent(Component* parent) {
  this->_parent = parent;
}

void Component::add(Component* component) {
}

void Component::remove(Component* component) {
}

Component* Component::getParent() const {
  return this->_parent;
}

bool Component::isComposite() const {
  return false;
}
```

Tree implementation

leaf.h

```cpp
#ifndef _LEAF_H_
#define _LEAF_H_
#include "component.h"

class Leaf : public Component {
public:
  std::string operation() const override;
};
#endif
```

leaf.cpp

```cpp
#include "leaf.h"

std::string Leaf::operation() const {
  return "Leaf";
}
```

Tree implementation

composite.h

```cpp
#ifndef _COMPOSITE_H_
#define _COMPOSITE_H_
#include "component.h"
#include <list>

class Composite : public Component {
protected:
  std::list<Component*> _children;
public:
  void add(Component* component) override;
  void remove(Component* component) override;
  bool isComposite() const override;
  std::string operation() const override;
};
#endif // _COMPOSITE_H_
```

composite.cpp

```cpp
#include "composite.h"

void Composite::add(Component* component) {
  this->_children.push_back(component);
  component->setParent(this);
}

void Composite::remove(Component* component) {
  _children.remove(component);
  component->setParent(nullptr);
}

bool Composite::isComposite() const {
  return true;
}

std::string Composite::operation() const {
  std::string result;
  for(const Component* c : _children) {
    if(c == _children.back()) {
      result += c->operation();
    }
    else {
      result += c->operation() + "+";
    }
```

Applicability

- Make sure that the core model of your app can be represented as a tree structure. Try to break it down into simple elements and containers. Remember that containers must be able to contain both simple elements and other containers.
- Declare the component interface with a list of methods that make sense for both simple and complex components.
- Create a leaf class to represent simple elements. A program may have multiple different leaf classes.
- Create a container class to represent complex elements. In this class, provide an array field for storing references to sub-elements. The array must be able to store both leaves and containers, so make sure it's declared with the component interface type.
- Finally, define the methods for adding and removal of child elements in the container.

How to implement

- Use the Composite pattern when you have to implement a tree-like object structure.
- The Composite pattern provides you with two basic element types that share a common interface: simple leaves and complex containers. A container can be composed of both leaves and other containers. This lets you construct a nested recursive object structure that resembles a tree.
- Use the pattern when you want the client code to treat both simple and complex elements uniformly.
- All elements defined by the Composite pattern share a common interface. Using this interface, the client doesn't have to worry about the concrete class of the objects it works with.

Pros and Cons

- You can work with complex tree structures more conveniently: use polymorphism and recursion to your advantage.
- Open/Closed Principle. You can introduce new element types into the app without breaking the existing code, which now works with the object tree.

- It might be difficult to provide a common interface for classes whose functionality differs too much. In certain scenarios, you'd need to overgeneralize the component interface, making it harder to comprehend.

Relations with Other Patterns

- You can use Builder when creating complex Composite trees because you can program its construction steps to work recursively.
- Chain of Responsibility is often used in conjunction with Composite. In this case, when a leaf component gets a request, it may pass it through the chain of all of the parent components down to the root of the object tree.
- You can use Iterators to traverse Composite trees.
- You can use Visitor to execute an operation over an entire Composite tree.
- You can implement shared leaf nodes of the Composite tree as Flyweights to save some RAM.
- Composite and Decorator have similar structure diagrams since both rely on recursive composition to organize an open-ended number of objects.
- Designs that make heavy use of Composite and Decorator can often benefit from using Prototype.

Thank You!