Design Patterns

CSC207 – Software Design

Design Patterns

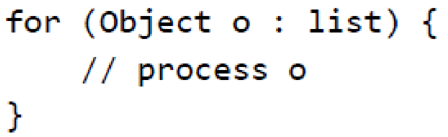
- Design pattern:
  - A general description of the solution to a well-established problem using an arrangement of classes and objects.
- Patterns describe the shape of code rather than the details.
  - There are lots of them in CSC 301 and 302.

Loop patterns from first year

- Loop pattern:
  - A general description of an algorithm for processing items in a collection.
- All of you (hopefully) have some loop patterns in your heads.
- You don't really need to think about these any more; you just use them, and you should be able to discuss them with your fellow students.
- Some first-year patterns:
  - Process List
  - Counted Loop
  - Accumulator
  - Sentinel

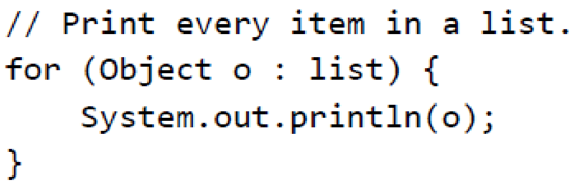
Process list pattern

- **Purpose**: to process every item in a collection where you don't care about order or context; you don't need to remember previous items.
- **Outline**:



```
for (Object o : list) {
    // process o
}
```

- **Example**:

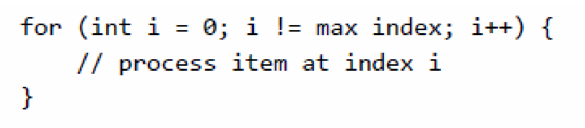


```
// Print every item in a list.
for (Object o : list) {
    System.out.println(o);
}
```

- **Other example**: darken every pixel in a picture

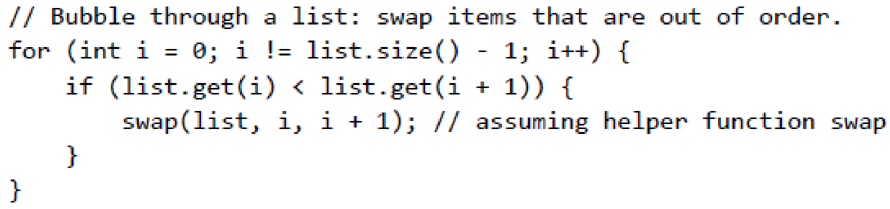
Counted loop pattern

- **Purpose**: to process a range of indices in a collection.
- **Outline**:



```
for (int i = 0; i != max index; i++) {
    // process item at index i
}
```

- **Example**:

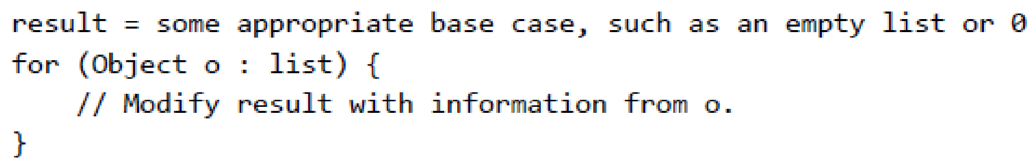


```
// Bubble through a list: swap items that are out of order.
for (int i = 0; i != list.size() - 1; i++) {
    if (list.get(i) < list.get(i + 1)) {
        swap(list, i, i + 1); // assuming helper function swap
    }
}
```

- **Other example**: print indices of even-length string

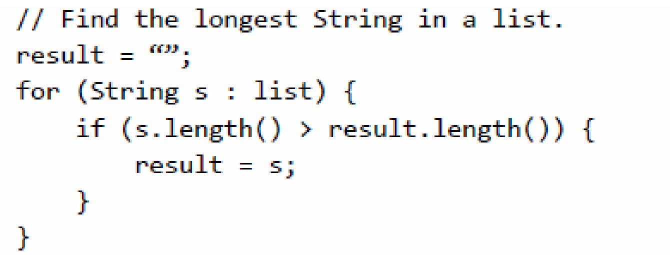
Accumulator pattern

- **Purpose**: to accumulate information about items in a collection.
- **Outline**:



```
result = some appropriate base case, such as an empty list or 0
for (Object o : list) {
    // Modify result with information from o.
}
```

- **Example**:

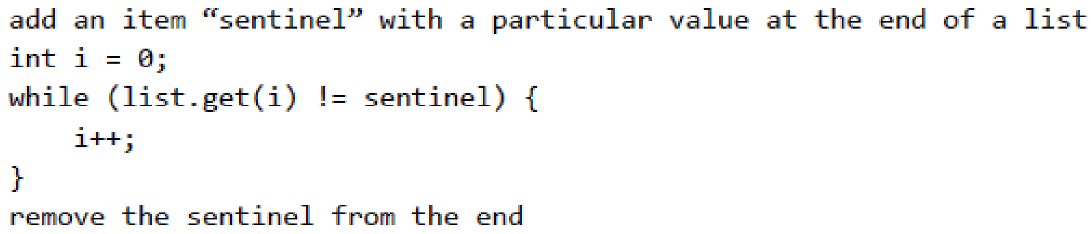


```
// Find the longest String in a list.
result = “”;
for (String s : list) {
    if (s.length() > result.length()) {
        result = s;
    }
}
```

- **Other examples**: sum, min, accumulate a list of items meeting a particular criterion.

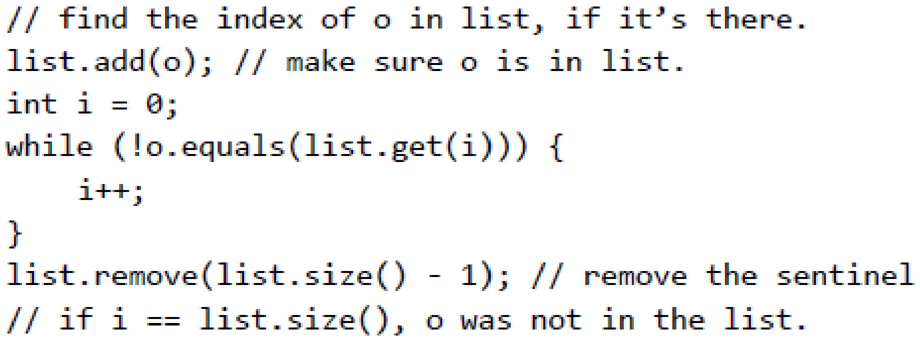
Sentinel pattern

- **Purpose**: to remove a condition in a loop guard.
- **Outline**:



```
add an item “sentinel” with a particular value at the end of a list
int i = 0;
while (list.get(i) != sentinel) {
    i++;
}
remove the sentinel from the end
```

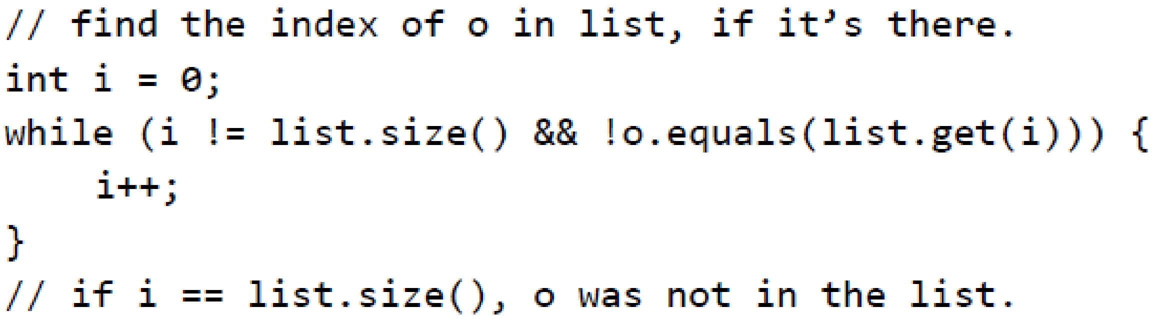
- **Example**:



```
// find the index of o in list, if it’s there.
list.add(o); // make sure o is in list.
int i = 0;
while (!o.equals(list.get(i))) {
    i++;
}
list.remove(list.size() - 1); // remove the sentinel
// if i == list.size(), o was not in the list.
```

Sentinel pattern, continued

- Here is the code that Sentinal replaces; note that `i != list.size()` is evaluated every time through the loop, even though it is false only once.



```
// find the index of o in list, if it’s there.
int i = 0;
while (i != list.size() && !o.equals(list.get(i))) {
    i++;
}
// if i == list.size(), o was not in the list.
```

Design Pattern Categories

- Creational
  - **Purpose**: control the way objects are created
  - **Examples**: Singleton, Abstract Factory, Prototype

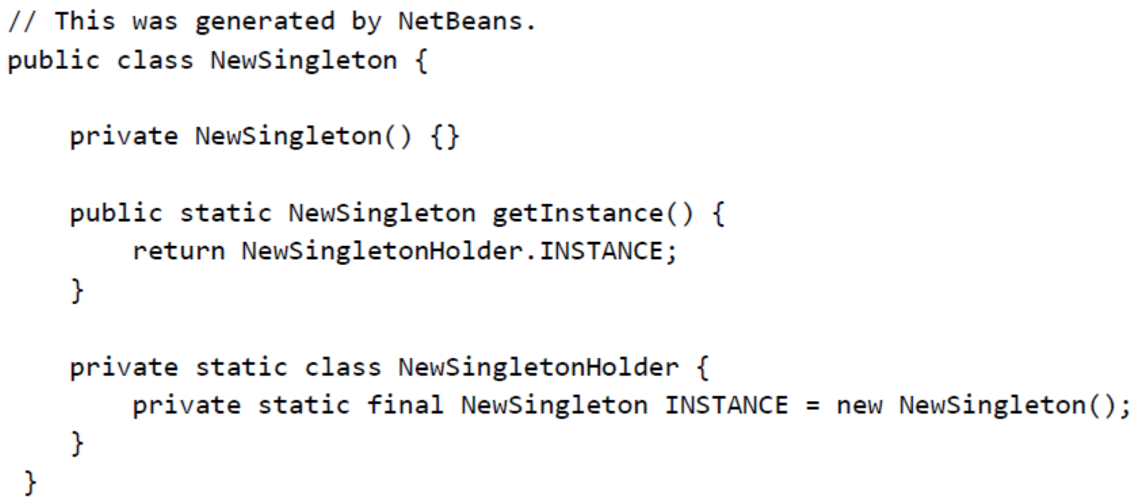
- Behavioural
  - **Purpose**: process a collection of items
  - **Examples**: Iterator, Visitor

- Structural
  - **Purpose**: store data in a particular way
  - **Examples**: Composite, Adapter

Creational	Structural	Behavioural	Architecture
Factory method Abstract Factory Builder Lazy instantiation Object pool Prototype **Singleton** Multiton Resource acquisition is initialization	**Adapter** Bridge Composite Decorator Façade Flyweight Proxy	Null Object Null Object Command Interpreter **Iterator** Mediator Memento **Observer** State Chain of responsibility Strategy Specification Template method Visitor	Layers Presentation-abstraction-control Three-tier Pipeline Implicit invocation Blackboard system Peer-to-peer Model-View-Controller Service-oriented architecture Naked objects

Singleton Pattern

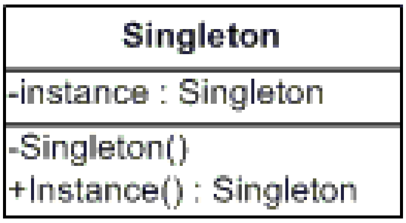
- **Purpose**: to ensure there is exactly one instance of a class.
- **Outline**:



```
// This was generated by NetBeans.
public class NewSingleton {

    private NewSingleton() {}

    public static NewSingleton getInstance() {
        return NewSingletonHolder.INSTANCE;
    }

    private static class NewSingletonHolder {
        private static final NewSingleton INSTANCE = new NewSingleton();
    }
 }
```

Uses: password verifier for a website, logger object for tracking events.
There are other options for an implementation. What are they? Why might there be an inner class here?

UML : Singleton Pattern

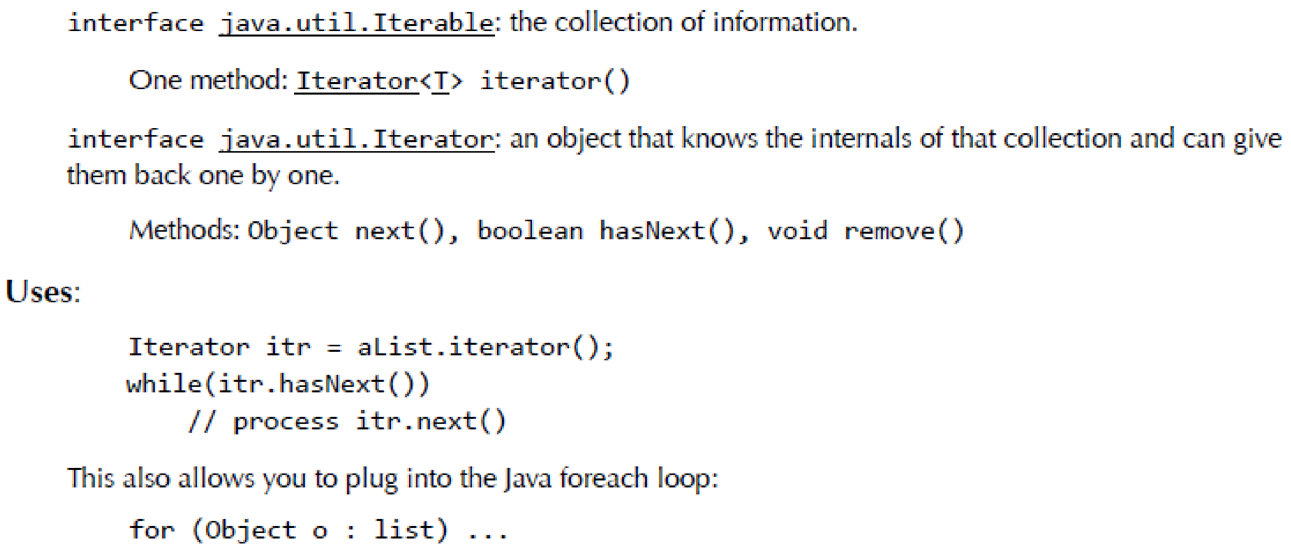


- “-” means private
- “+” means public
- Only one is ever created.

- Examples:
  - interface to a database
  - logging system

Iterator Pattern

- **Purpose**: to separate the list contents from the object that iterates over them so that multiple iterators can be used.
- **Outline**:



`interface` java.util.Iterable: the collection of information.

One method: `Iterator<T> iterator()`

`interface` java.util.Iterator: an object that knows the internals of that collection and can give them back one by one.

Methods: `Object next(), boolean hasNext(), void remove()`

Uses:

```
Iterator itr = aList.iterator();
while(itr.hasNext())
    // process itr.next()
```

This also allows you to plug into the Java foreach loop:

```
for (Object o : list) ...
```

Implementing the Iterator Pattern

```
public class MyCollection<T> implements Iterable<T> {
    private int size;
    private T[] list = ...;
    public Iterator<T> iterator() {
        return new MyIterator<T>();
    }

    private class MyIterator<T> implements Iterator<T> {
        int current = 0;
        public boolean hasNext() {  return current < list.size();  }
        public T next() {
            T res = list[current];
            current++;
            return res;
        }
        // optional operation; what are the difficulties?
        public void remove() {}
    }
}
```

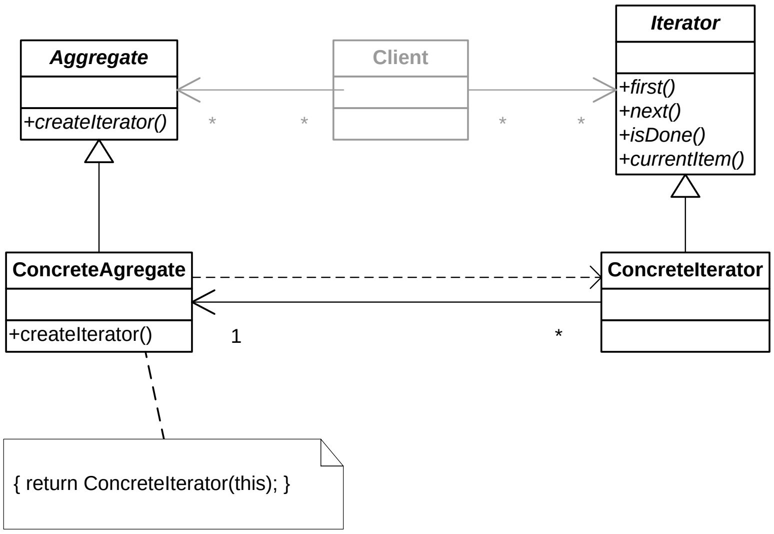
Use:

```
// Given m, a variable of
// type MyCollection<String>.
Iterator itr = m.iterator();
while(itr.hasNext()) {
   String s = itr.next();
}
```

Use:

```
for (String s : m) {
    // do something with s
}
```

UML: Iterator Pattern



Aggregate

+createIterator()

Client

Iterator

+first()
+next()
+isDone()
+currentItem()

ConcreteAgregate

+createIterator()

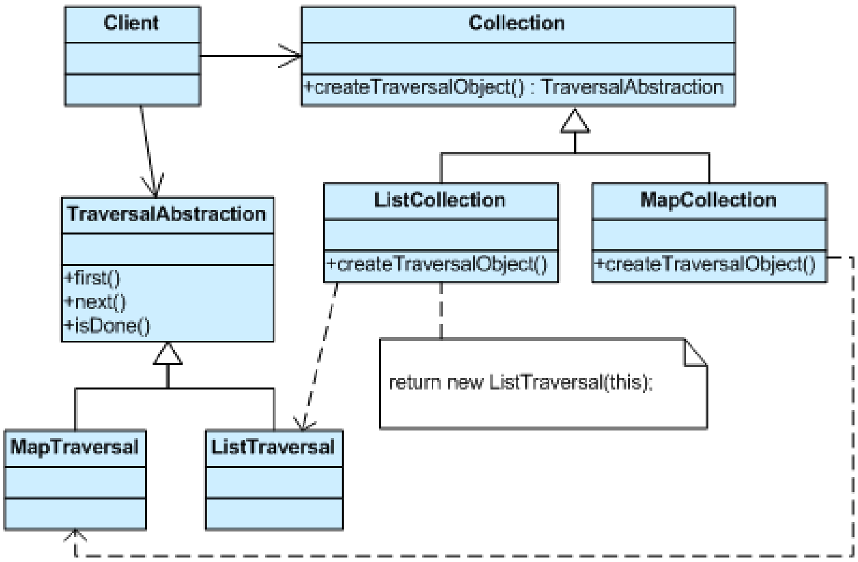
ConcreteIterator

1

*

{ return ConcreteIterator(this); }

UML: Iterator Pattern



Client

Collection

+createTraversalObject() : TraversalAbstraction

ListCollection

+createTraversalObject()

MapCollection

+createTraversalObject()

TraversalAbstraction

+first()
+next()
+isDone()

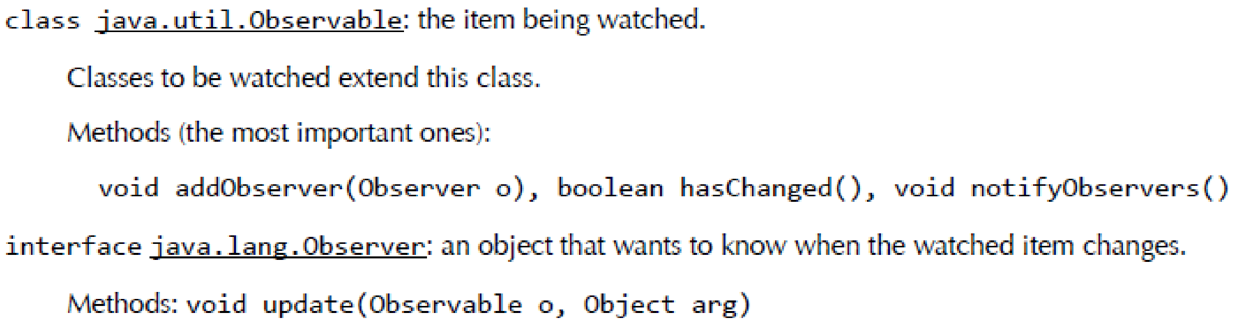
return new ListTraversal(this);

MapTraversal

ListTraversal

Observer Pattern

- **Purpose**: to allow multiple objects to observe when another object changes.
- **Outline**:



`class java.util.Observable`: the item being watched.

Classes to be watched extend this class.

Methods (the most important ones):

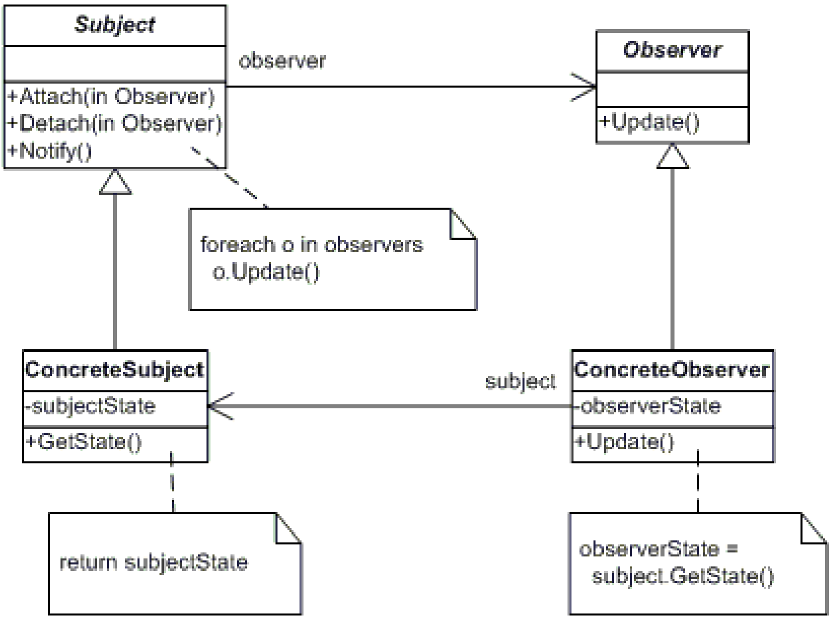
`void addObserver(Observer o), boolean hasChanged(), void notifyObservers()`

`interface java.lang.Observer`: an object that wants to know when the watched item changes.

Methods: `void update(Observable o, Object arg)`

- **Uses**:
  - As an alternative (or enhancement) to MVC, where each view observes the model.
  - RSS

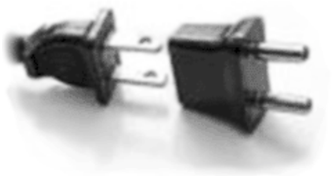
UML: Observer



Sample Code

- How can the ***Observer pattern*** improve the design of ***Fraud Detection*** system?

Adapter Pattern



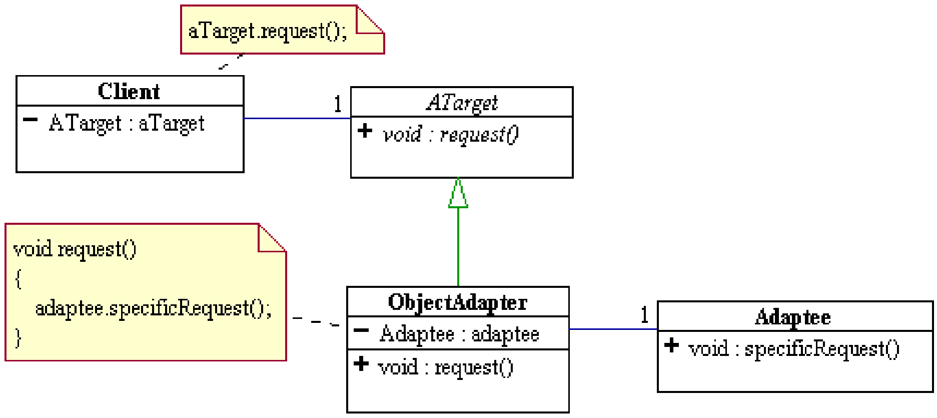
- Intent:
  - implement an interface known to one set of classes so that they can communicate with other objects that don't know about the interface
- Context:
  - want to use a class in a way that its original author didn't anticipate
    - E.g. write data to a string instead of to a file
    - Or apply regular expressions to streams instead of to strings

Adapter (cont'd)

- Motivation:
  - You want to use a class as though it implemented an interface that it doesn't actually implement
  - You do not want to modify or extend that class
  - You can translate the operations you want to perform to the ones the class actually implements

- **Solution:** create an adapter that implements the interface you want, and calls the methods the class has

UML: Adapter Pattern

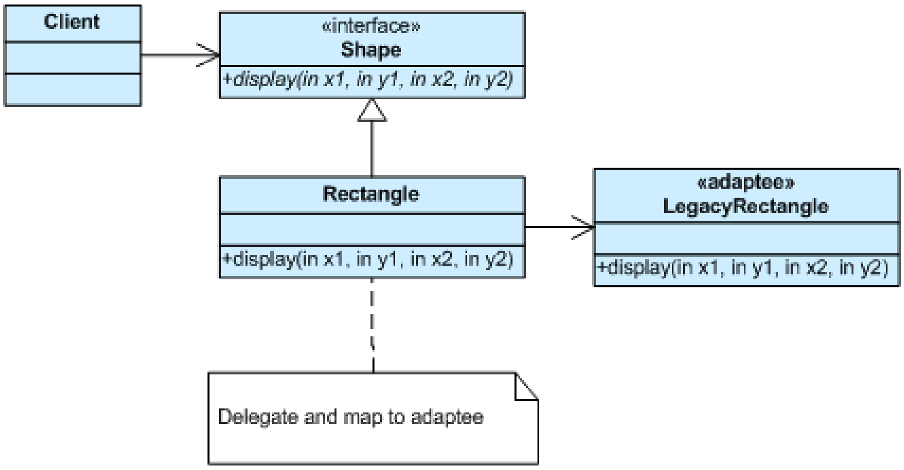


```
aTarget.request();
```

```
void request()
{
   adaptee.specificRequest();
}
```

Adapter examples

a legacy Rectangle component's display() method expects to receive "x, y, w, h" parameters. But the client wants to pass "upper left x and y" and "lower right x and y". This incongruity can be reconciled by adding an additional level of indirection – i.e. an Adapter object.


Client
«interface»
Shape
+display(in x1, in y1, in x2, in y2)
Rectangle
+display(in x1, in y1, in x2, in y2)
«adaptee»
LegacyRectangle
+display(in x1, in y1, in x2, in y2)
Delegate and map to adaptee