References

Design Patterns: Elements of Reusable Object-Oriented Software, Gamma, Helm, Johnson, Vlissides, 1995, pp. 293-303, 117-126

Java API

VisualWorks Smalltalk API

Prototype-based Languages
  http://en.wikipedia.org/wiki/Prototype-based_programming
  JavaScript The Definite Guide 4'th Ed, Flanagan, O'Reilly Press, 2002
Observer

One-to-many dependency between objects

When one object changes state,
    all its dependents are notified and updated automatically
Pseudo Java Example

public class Subject {
    Window display;
    public void someMethod() {
        this.modifyMyStateSomeHow();
        display.addText( this.text() );
    }
}

public class Subject {
    ArrayList observers = new ArrayList();
    public void someMethod() {
        this.modifyMyStateSomeHow();
        changed();
    }

    private void changed() {
        Iterator needsUpdate = observers.iterator();
        while (needsUpdate.hasNext() )
            needsUpdate.next().update( this );
    }
}

public class SampleWindow {
    public void update(Object subject) {
        text = ((Subject) subject).getText();
        Thread.sleep(10000).
    }
}

Abstract coupling - Subject and Observer

Broadcast communication

Updates can take too long
### Some Language Support

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**Smalltalk Implementation**

Object implements methods for both Observer and Subject.

Actual Subjects should subclass Model
Java's Observer

Class java.util.Observable

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void addObserver(Observer o)
void clearChanged()
int countObservers()
void deleteObserver(Observer o)
void deleteObservers()
boolean hasChanged()
void notifyObservers()
void notifyObservers(Object arg)
void setChanged()

Observable object may have any number of Observers

Whenever the Observable instance changes, it notifies all of its observers

Notification is done by calling the update() method on all observers.

Interface java.util.Observer

Allows all classes to be observable by instances of class Observer
class Counter extends Observable {
    public static final String INCREASE = "increase";
    public static final String DECREASE = "decrease";
    private int count = 0;
    private String label;

    public Counter( String label ) { this.label = label; }

    public String label() { return label; }
    public int value() { return count; }
    public String toString() { return String.valueOf( count );}

    public void increase() {
        count++;
        setChanged();
        notifyObservers( INCREASE );
    }

    public void decrease() {
        count--;
        setChanged();
        notifyObservers( DECREASE );
    }
}
class IncreaseDetector implements Observer {
    public void update( java.util.Observable whatChanged,
            java.lang.Object message) {
        if ( message.equals( Counter.INCREASE) ) {
            Counter increased = (Counter) whatChanged;
            System.out.println( increased.label() + " changed to " +
                    increased.value());
        }
    }
}

public static void main(String[] args) {
    Counter test = new Counter();
    IncreaseDetector adding = new IncreaseDetector();
    test.addObserver(adding);
    test.increase();
}
require 'observer'

class Counter
  include Observable

  attr_reader :count

  def initialize
    @count = 0
  end

  def increase
    @count += 1
    changed
    notify_observers(:INCREASE)
  end

  def decrease
    @count -= 1
    changed
    notify_observers(:DECREASE)
  end
end

class IncreaseDetector
  def update(type)
    if type == :INCREASE
      puts('Increase')
    end
  end
end

count = Counter.new()
presolve count
puts count
puts count
puts count
puts count
Implementation Issues
Mapping subjects (Observables) to observers

Use list in subject
Use hash table

```java
public class Observable {
    private boolean changed = false;
    private Vector obs;

    public Observable() {
        obs = new Vector();
    }

    public synchronized void addObserver(Observer o) {
        if (!obs.contains(o)) {
            obs.addElement(o);
        }
    }

    public synchronized void addObserver(Observer o) {
        if (!obs.contains(o)) {
            obs.addElement(o);
        }
    }
}
```
Observing more than one subject

If an observer has more than one subject how does it know which one changed?

Pass information in the update method
Deleting Subjects

In C++ the subject may no longer exist

Java/Smalltalk observer may prevent subject from garbage collection
Who Triggers the update?

Have methods that change the state trigger update

class Counter extends Observable { // some code removed
    public void increase() {
        count++;
        setChanged();
        notifyObservers(INCREASE);
    }
}

Have clients call Notify at the right time

class Counter extends Observable { // some code removed
    public void increase() { count++;
}
}

Counter pageHits = new Counter();
pageHits.increase();
pageHits.increase();
pageHits.increase();
pageHits.increase();
pageHits.notifyObservers();
Subject is self-consistent before Notification

class ComplexObservable extends Observable {
    Widget frontPart = new Widget();
    Gadget internalPart = new Gadget();

    public void trickyChange() {
        frontPart.widgetChange();
        internalPart.anotherChange();
        setChanged();
        notifyObservers();
    }
}

class MySubclass extends ComplexObservable {
    Gear backEnd = new Gear();

    public void trickyChange() {
        super.trickyChange();
        backEnd.yetAnotherChange();
        setChanged();
        notifyObservers();
    }
}
Adding information about the change

push models - add parameters in the update method

```java
class IncreaseDetector extends Counter implements Observer {
    // stuff not shown
    public void update( Observable whatChanged, Object message) {
        if ( message.equals( INCREASE) )
            increase();
    }
}

class Counter extends Observable {
    // some code removed
    public void increase() {
        count++;
        setChanged();
        notifyObservers( INCREASE );
    }
}
```
Adding information about the change

pull model - observer asks Subject what happened

class IncreaseDetector extends Counter implements Observer {
    public void update( Observable whatChanged ) {
        if ( whatChanged.didYouIncrease() )
            increase();
    }
}

class Counter extends Observable {
    public void increase() {
        count++;
        setChanged();
        notifyObservers();
    }
}
Scaling the Pattern
Java Event Model

AWT/Swing components broadcast events to Listeners

JDK1.0 AWT components broadcast an event to all its listeners

A listener normally not interested all events

Broadcasting to all listeners was too slow with many listeners
Java 1.1+ Event Model

Each component supports different types of events:

Component supports
  ComponentEvent  FocusEvent
  KeyEvent        MouseEvent

Each event type supports one or more listener types:

  MouseEvent
  MouseListener  MouseMotionListener

Each listener interface replaces update with multiple methods

  MouseListener
    mouseClicked()  mouseEntered()
    mousePressed()   mouseReleased() 

Listeners
  Only register for events of interest
  Don't need case statements to determine what happened
Small Models

Often an object has a number of fields (aspects) of interest to observers.

Rather than make the object a subject make the individual fields subjects:
  - Simplifies the main object
  - Observers can register for only the data they are interested in

**VisualWorks ValueHolder**

Subject for one value

ValueHolder allows you to:

  - Set/get the value
    - Setting the value notifies the observers of the change
  - Add/Remove dependents
Prototype

Specify the kinds of objects to create using a prototypical instance, and create new objects by copying this prototype

Applicability

Use the Prototype pattern when

A system should be independent of how its products are created, composed, and represented; and

When the classes to instantiate are specified at run-time; or

To avoid building a class hierarchy of factories that parallels the class hierarchy of products; or

When instances of a class can have one of only a few different combinations of state.
Insurance Example

Insurance agents start with a standard policy and customize it.

Two basic strategies:

- Copy the original and edit the copy
- Store only the differences between original and the customize version in a decorator
Copying Issues

Shallow Copy Verse Deep Copy

Original Objects

Shallow Copy
Shallow Copy Verse Deep Copy

Original Objects

Deep Copy

Deeper Copy
class Door {
    public:
        Door();
        Door( const Door&);
        virtual Door* clone() const;

        virtual void Initialize( Room*, Room* );
        // stuff not shown
    private:
        Room* room1;
        Room* room2;
    }

Door::Door ( const Door& other ) //Copy constructor {
    room1 = other.room1;
    room2 = other.room2;
}

Door* Door::clone() const {
    return new Door( *this );
}
Cloning Issues - Java Clone

Shallow Copy

class Door implements Cloneable {
    private Room room1;
    private Room room2;

    public Object clone() throws CloneNotSupportedException {
        return super.clone();
    }
}

Deep Copy

public class Door implements Cloneable {
    private Room room1;
    private Room room2;

    public Object clone() throws CloneNotSupportedException {
        Door thisCloned = (Door) super.clone();
        thisCloned.room1 = (Room) room1.clone();
        thisCloned.room2 = (Room) room2.clone();
        return thisCloned;
    }
}
Prototype-based Languages

No classes

Behaviour reuse (inheritance)
   Cloning existing objects which serve as prototypes

Some Prototype-based languages

Self
JavaScript
Squeak (eToys)
Perl with Class::Prototyped module