

CS 635 Advanced Object-Oriented Design & Programming
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Doc 10 Observer
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References

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Java API

Squeak API

VisualWorks Smalltalk API

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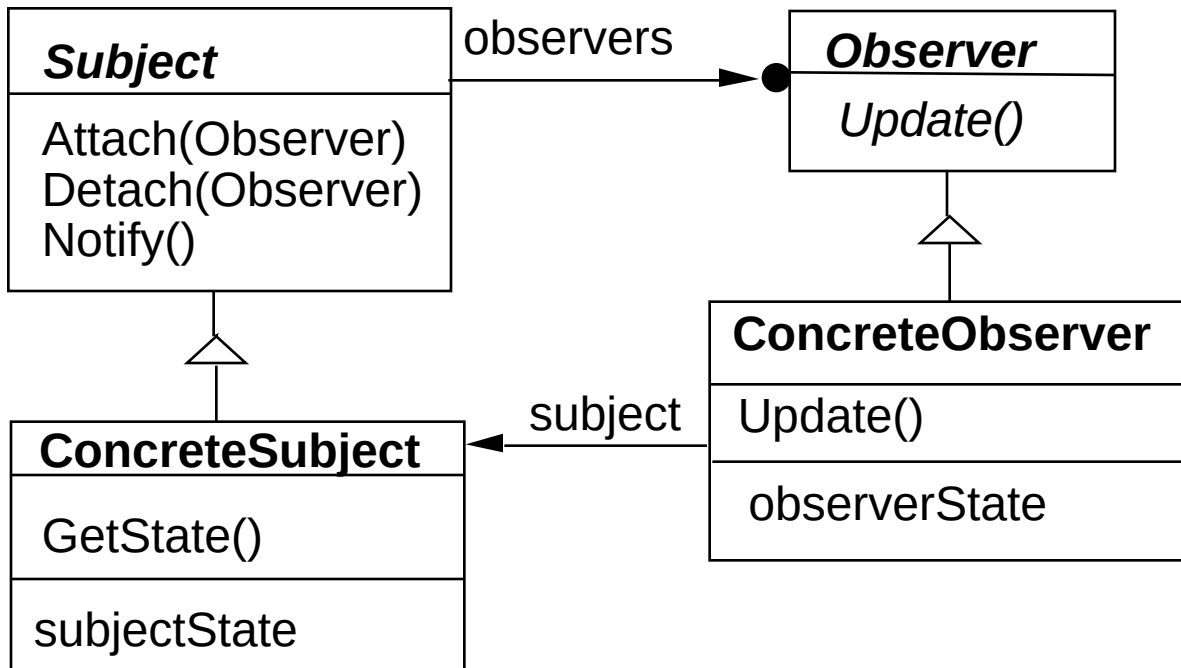
Observer

Defines a one-to-many dependency between objects so that when one object changes state, all its dependents are notified and updated automatically

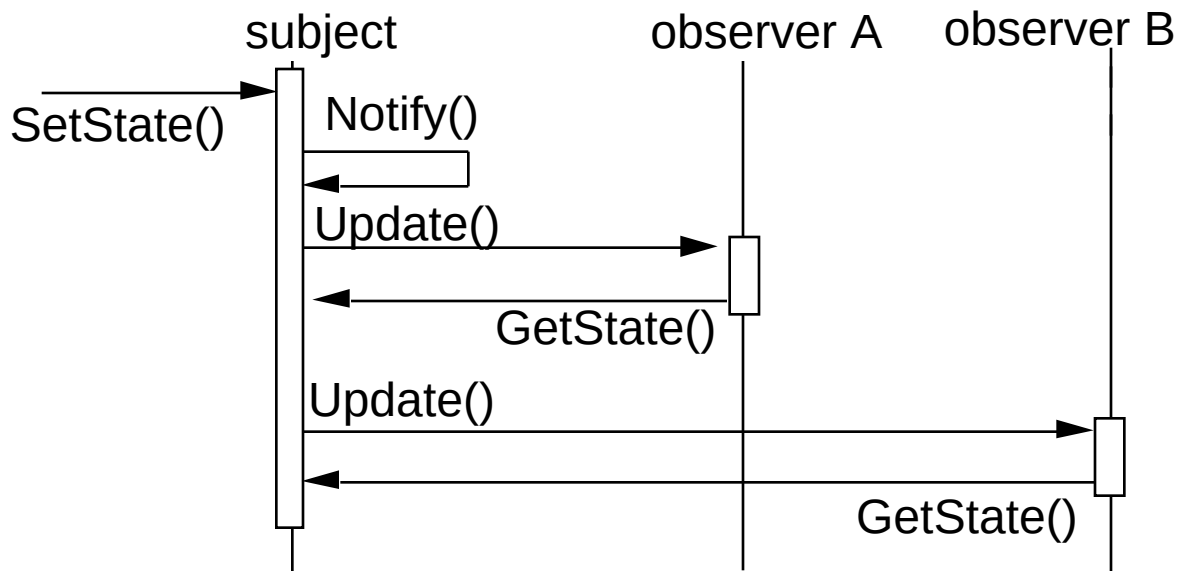
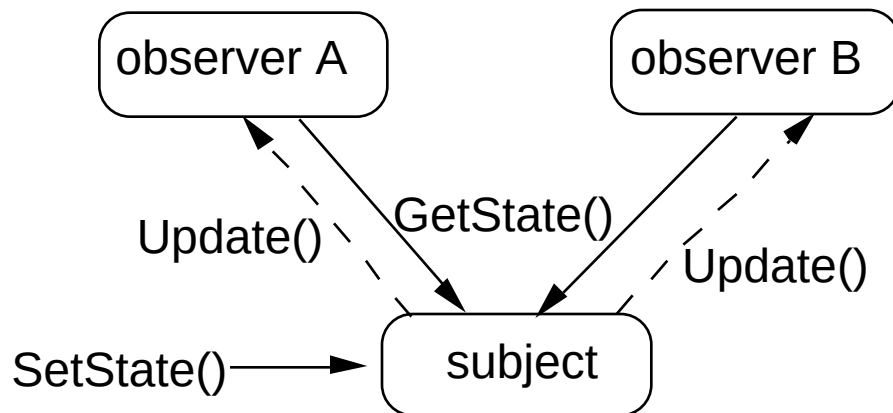
Use the Observer pattern:

- When an abstraction has two aspects, one dependent on the other.
- When a change to one object requires changing others, and you don't know how many objects need to be changed
- When an object should be able to notify other objects without making assumptions about who these objects are.

Structure



Collaborations



Java's Implementation

Java API implements a framework for this pattern

Java	Observer Pattern
Interface Observer	Abstract Observer class
Observable class	Subject class

Class `java.util.Observable`

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`

When implemented, this interface allows all classes to be
observable by instances of class `Observer`

java.util.Observable Methods

addObserver(Observer)

Adds an observer to the observer list.

clearChanged()

Clears an observable change.

countObservers()

Counts the number of observers.

deleteObserver(Observer)

Deletes an observer from the observer list.

deleteObservers()

Deletes observers from the observer list.

hasChanged()

Returns a true boolean if an observable change has occurred.

notifyObservers()

Notifies all observers if an observable change occurs.

notifyObservers(Object)

Notifies all observers of the specified observable change which occurred.

setChanged()

Sets a flag to note an observable change.

Interface java.util.Observer

update

Called when observers in the observable list need to be updated

A Java Example

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 );  
    }  
}
```



```
abstract class CounterButton extends Button
{
    protected Counter count;

    public CounterButton( String buttonName, Counter count )
    {
        super( buttonName );
        this.count = count;
    }

    public boolean action( Event processNow, Object argument )
    {
        changeCounter();
        return true;
    }

    abstract protected void changeCounter();
}

class IncreaseButton extends CounterButton
{
    public IncreaseButton( Counter count )
    {
        super( "Increase", count );
    }

    protected void changeCounter()
    {
        count.increase();
    }
}
```

```
class DecreaseButton extends CounterButton
```

```
{  
    public DecreaseButton( Counter count )  
    {  
        super( "Decrease", count );  
    }  
}
```

```
protected void changeCounter()  
{  
    count.decrease();  
}  
}
```

```
class ButtonController extends Frame
```

```
{  
    public ButtonController( Counter model, int x, int y,  
                             int width, int height )  
    {  
        setTitle( model.label() );  
        reshape(x, y, width, height );  
        setLayout( new FlowLayout() );  
  
        // buttons to change counter  
        add( new IncreaseButton( model ));  
        add( new DecreaseButton( model ));  
        show();  
    }  
}
```

Sample Program

```
class TestButton
{
    public static void main( String args[] ){
        Counter x = new Counter( "x" );
        Counter y = new Counter( "y" );

        IncreaseDetector plus = new IncreaseDetector( );
        x.addObserver( plus );
        y.addObserver( plus );

        new ButtonController( x, 30, 30, 150, 50 );
        new ButtonController( y, 30, 100, 150, 50 );
    }
}
```

Squeak Smalltalk Implementation¹

Squeak	Java	Observer Pattern
Object	Observer	Abstract Observer class
Model	Observable	Subject class

Object methods

update: aParameter

Receive an update message from a Model(Subject)

changed

Receiver changed in a general way; inform all the dependents by sending each dependent an update: message.

changed: aParameter

Receiver changed. The change is denoted by the argument aParameter. Inform all of the dependents.

addDependent: anObject

removeDependent: anObject

dependents

return collection of all dependents

Object implements methods for both Observer and Subject.

Actual Subjects should subclass Model

Model handles dependents better

¹ VisualWorks Smalltalk has a richer implementation of Observer methods, which would simplify the Squeak example

Squeak Example

```
Model subclass: #Counter
  instanceVariableNames: 'count '
  classVariableNames: ''
  poolDictionaries: ''
  category: 'Whitney-Examples'
```

Class Methods

```
new
  ^super new initialize
```

Instance Methods

```
printOn: aStream
  aStream nextPutAll: count printString
```

```
decrease
  count := count - 1.
  self changed: #Decreased
```

```
increase
  count := count + 1.
  self changed: #Increased
```

```
initialize
  count := 0
```

Squeak Example - Continued

Object subclass: #IncreaseDetector
instanceVariableNames: 'model '
classVariableNames: "
poolDictionaries: "
category: 'Whitney-Examples'

Class Methods

on: aCounter
^super new setModel: aCounter

Instance Methods

update: aSymbol
aSymbol = #Increased
ifTrue:
[Transcript
show: 'Count is now: ', model printString;
cr]

setModel: aCounter
model := aCounter.
aCounter addDependent: self

Squeak Example - Continued

```
| counter |  
counter := Counter new.  
IncreaseDetector on: counter.  
counter  
    increase;  
    decrease;  
    decrease;  
    increase
```

Consequences

- Abstract coupling between Subject and Observer
- Support for broadcast communication
- Unexpected updates

Simple change in subject can cause numerous updates, which can be expensive or distracting

- Updates can take too long

Subject can not perform any work until all observers are done

Implementation Issues

Mapping subjects(Observables) to observers

Use list in subject

Use hash table

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

Dangling references to Deleted Subjects

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 );
}
}
```

If there are several of changes at once, you may not want each change to trigger an update

It might be inefficient or cause too many screen updates

- 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.notifyObservers();
```

Make sure Subject is self-consistent before Notification

Here is an example of the problem

```
class ComplexObservable extends Observable
```

```
{  
    Widget frontPart = new Widget();  
    Gadget internalPart = new Gadget();
```

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

```
class MyBetterClass extends ComplexObservable
```

```
{  
    Gear backEnd = new Gear();  
  
    public void trickyChange()  
    {  
        super.trickyChange();  
        backEnd.yetAnotherChange();  
        setChanged();  
        notifyObservers( );  
    }  
}
```

A Template Method Solution to the Problem

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

    public void trickyChange()
    {
        doThisChangeWithFactoryMethod();
        setChanged();
        notifyObservers( );
    }

    private void doThisChangeWithTemplateMethod()
    {
        frontPart.widgetChange();
        internalpart.anotherChange();
    }
}

class MyBetterClass extends ComplexObservable
{
    Gear backEnd = new Gear();
    private void doThisChangeWithTemplateMethod()
    {
        backEnd.yetAnotherChange();
    }
}
```

Adding information about the change

push models - add parameters in the update method

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 );
```

```
}
```

```
}
```

pull model - observer asks Subject what happened

class IncreaseDetector extends Counter implements Observer

```
{ // stuff not shown
```

```
public void update( Observable whatChanged )
```

```
{
```

```
if ( whatChanged.didYouIncrease() )
```

```
    increase();
```

```
}
```

```
}
```

class Counter extends Observable

```
{ // some code removed
```

```
public void increase()
```

```
{
```

```
    count++;
```

```
    setChanged();
```

```
    notifyObservers( );
```

```
}
```

```
}
```

Scaling the Pattern

Java uses the Observer pattern in AWT and Swing

AWT & Swing components broadcast events(change) to Observers(Listeners)

In Java 1.0 AWT components broadcast each event to all its listeners

Usually each listener was interested in a particular type of event

As the number of AWT components & listeners grew programs slowed down

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 supports

 MouseListener

 MouseMotionListener

Each listener interface replaces update with multiple methods

MouseListener interface has:

 mouseClicked()

 mouseEntered()

 mousePressed()

 mouseReleased()

A mouse listener (observer) has to implement all 4 methods

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

Squeak 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

Adapting Observers

An observer implements an update method

A concrete observer represents an abstraction

Update() may be out of place in this abstraction

Use an adapter to map update() method to a different method in the concrete observer

VisualWorks Smalltalk has a built-in adapter
DependencyTransformer