The Observer Pattern

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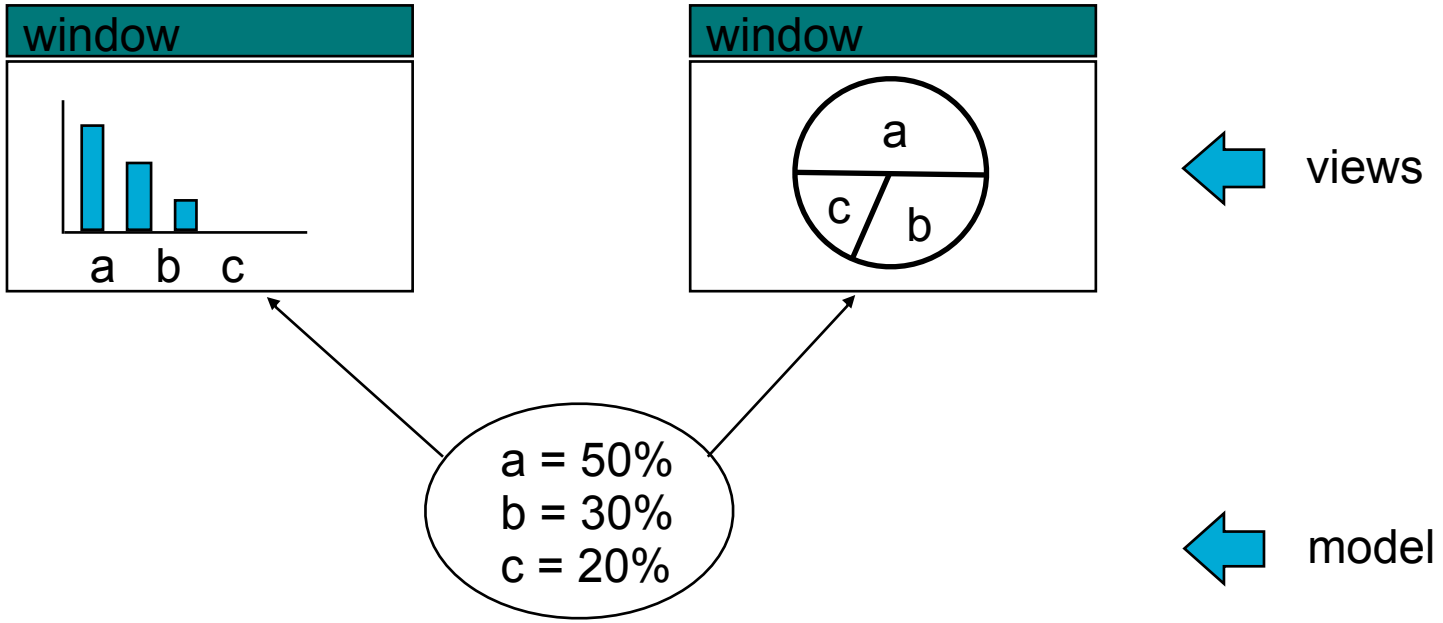
Introduction to the Observer Pattern

- Intent
  - Define a one-to-many dependency between objects so that when one object changes state, all its dependants are notified and updated accordingly.

- Examples
  - Examples of this pattern abound, both in the real world and in the software domain.
  - To motivate this pattern, we consider the “classic” example on the next slide.

Observer -- Motivation

- In a spreadsheet application, several views of the same essential data are to be displayed on the screen simultaneously, e.g.,

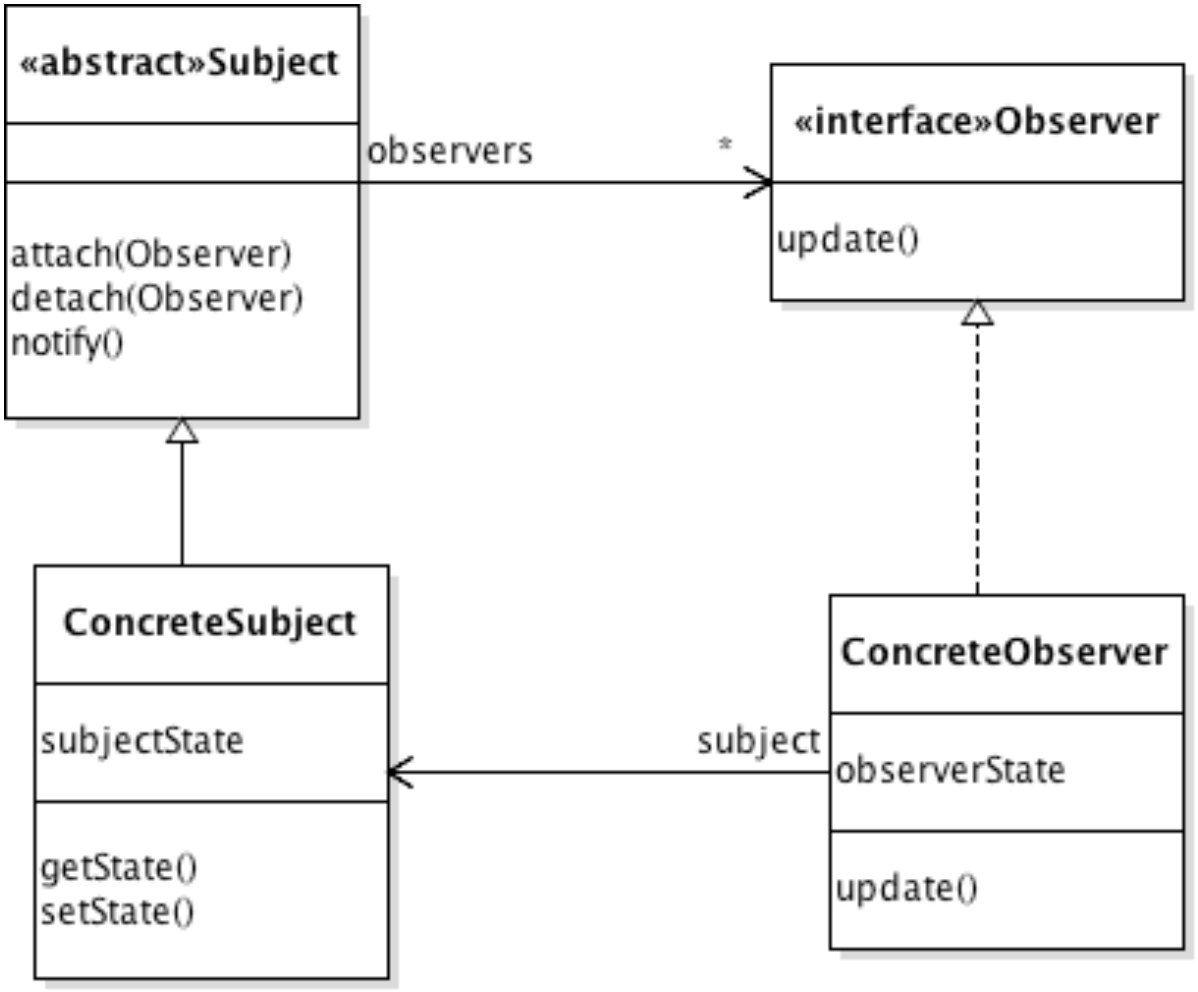


- How best to design this in software?

Observer -- Applicability

- Use the Observer pattern when:
  - An abstraction has two aspects, one dependent on the other, and it is necessary to model them as separate objects;
  - A change to one object requires changing others, and you don't know how many objects need to be changed;
  - An object should be able to notify other objects, without making assumptions about who these objects are (loose coupling).

Observer -- typical class structure

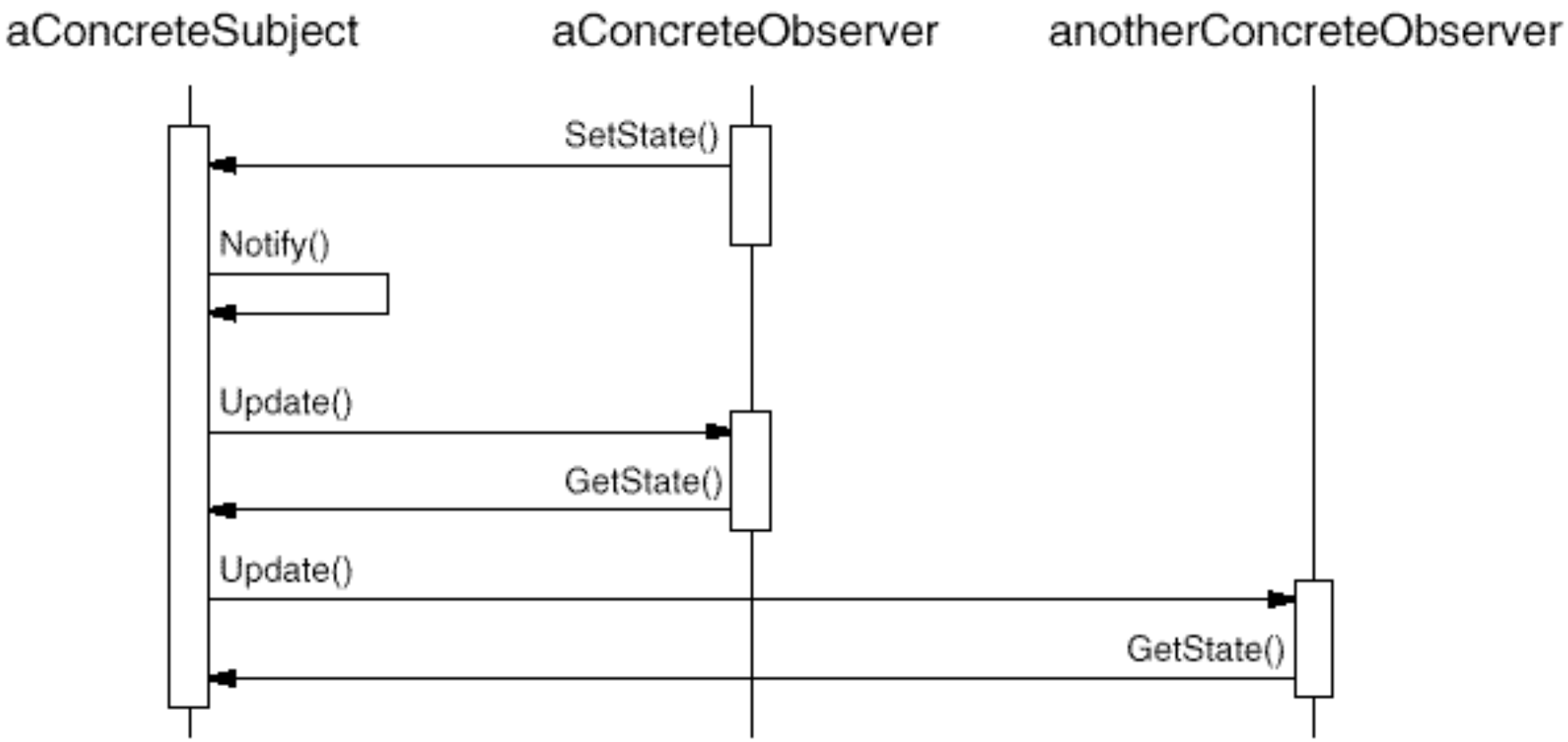


notify() invokes **update()** on all observers

getState() returns the contents of **subjectState**

update() invokes **getState()** on **subject** and stores result in **observerState**.

Observer -- Collaborations



Observer -- Consequences

- Benefits and liabilities of Observer include:
  - *Abstract coupling from Subject to Observer*. (The binding is tighter in the opposite direction… why couldn't it be weakened?)
  - *Support for broadcast communication*. Sending a single **`notify`** request results in multiple `update` messages being sent (known as *multicasting*).
  - *Unexpected updates*. A single change to the subject may cause a cascade of updates to observers and their dependants.
    - can be a big challenge in a complicated system

Observer Implementation – Triggering the Updates

- *Who triggers the update?* When a client updates the subject, the subject must be sent a **`notify`** message in order for the update messages to be sent to the observers.
- Who sends the subject the **`notify`** message? Two possibilities:
  - All state-setting operations on the subject call **`notify`** after they change the subject state (less efficient but safe).
  - Clients that update the subject state call **`notify`** at the appropriate time (more efficient, but also more error-prone).

Observer Implementation – Push and Pull Models

- **Pull Model**: the observer is notified that a change has occurred and must find out itself what changes have occurred.
- **Push Model**: the subject sends observers detailed information about the change that has occurred (in the simplest case, the entire new state itself).
- The Pull model is simple, but leads to further requests from the observer to the subject.
- The dumb Push model is simplest, but may be inefficient; trying to make it smarter on a per-observer basis increases subject→observer coupling.
- Extending the Subject registration interface is also possible.

Observer – Other Implementation Issues

- Issues related to the implementation of Observer include:
  - *Mapping Subjects to Observers*. Simplest is to store a list of references to observers in the subject.
    - A central look-up table to store the Subject->Observer mapping is another possibility.
  - *Observing multiple subjects*. In this case the observer can receive updates from several subjects, so it needs to know the source of any **`update`** message. Simplest solution is for the subject to pass a reference to itself with the **`update`** message.
  - *Garbage Collection*. The reference the Subject holds to an Observer may prevent the Observer from ever being garbage collected. Either Observers must detach from Subject, or a **weak reference** should be used.

Observer Implementation – Java

- Java explicitly support the Observer pattern through `java.util.Observer` and `java.util.Observable`.
- The **`Observer`** interface contains the method update
  - public void update(Observable o, Object arg)
- The **`Observable`** class provide a full implementation of Subject behaviour including:
  - addObserver(Observer o)
  - deleteObserver(Observer o)
  - notifyObservers()

Uses of Observer

- First and best-known use is as part of the MVC (Model/View/Controller) framework in Smalltalk.
- Observer is a very commonly-occurring pattern:
  - Java Listeners are essentially a specialisation of the Observer pattern.
  - Language support in Java, C#, Ruby and others.
- An example of non-GUI use of this pattern is interprocess messaging, e.g., when a central control panel is used to change state across a whole cluster of servers.