Introduction to Design Patterns

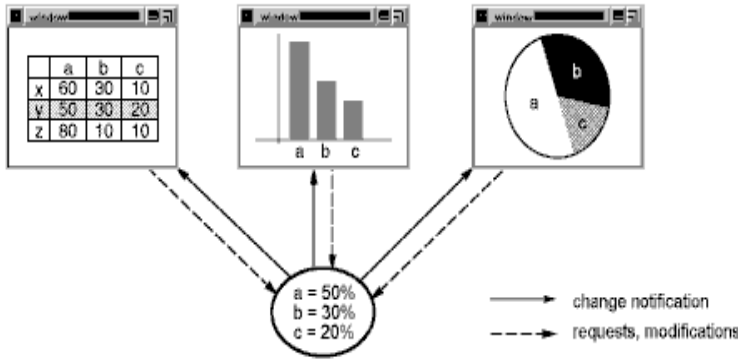
Origins of Patterns in Architecture

- C. Alexander: problem of objective quality
  - by making observations of buildings, towns, streets, gardens,
    - he discovered that high quality constructs had things in common
    - architectural structures differed from each others, even it they were of the same type solving the same problem. Yet different solutions were of high quality.
- Conclusion: structures could not be separated from the problem they are solving
  - ...so he looked at different structures yielding a high quality solution to same problem and extracted the core of the solution, i.e. the **patterns**.
- Alexanders patterns
  - **solutions** to a **problem** in a **context**
  - 253 patterns covering regions, towns, transportations, homes offices, rooms, lighting, gardens, ...
  - a generative pattern language

Design Patterns

- Design patterns represent solutions to problems that arise when developing software within a particular context
  - Patterns = **Problem/Solution** pair in **Context**
- Capture static and dynamic structure and collaboration among key participants in software designs
  - key participant – major abstraction that occur in a design problem
  - useful for articulating the ***how*** and ***why*** to solve *non-functional forces*.
- Facilitate reuse of successful software architectures and design
  - i.e. the "*design of masters*"… ;)

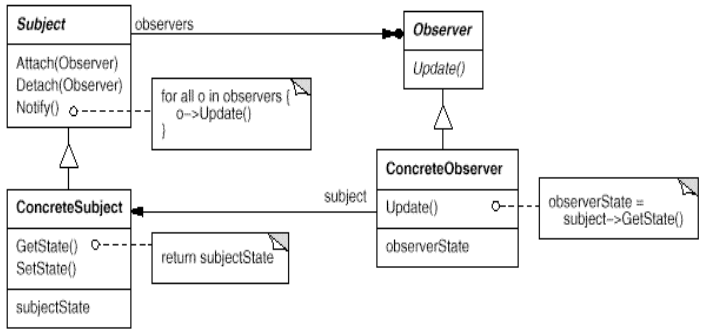
Example: Data-Views Consistency Problem



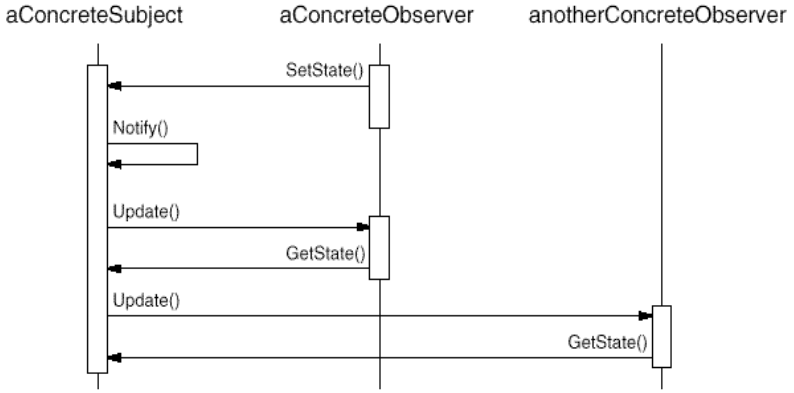
Example: The Observer Pattern

- Intent
  - Define a one-to-many dependency between objects so that when one object changes state, all its dependencies are notified and updated automatically
- Forces
  - There may be many observers
  - Each observer may react differently to the same notification
  - The data-source (subject) should be as decoupled as possible from the observer
    - to allow observers to change independently of the subject

Structure of the Observer Pattern



Collaboration in the Observer Pattern



What Makes it a Pattern ?

A pattern must...

- ...solve a problem
  - i.e. it must be useful
- ...have a context
  - it must describe where the solution can be used
- ...recur
  - must be relevant in other situations
- ... teach
  - provide sufficient understanding to tailor the solution
- ... have a name
  - referred consistently

GoF Form of a Design Pattern

Pattern name and classification

Intent
what does pattern do

Also known as
other known names of pattern (if any)

Motivation
the design problem

Applicability
situations where pattern can be applied

Structure
a graphical representation of classes in the pattern

Participants
the classes/objects participating and their responsibilities

Collaborations
of the participants to carry out responsibilities

GoF Form of a Design Pattern (contd.)

Consequences
trade-offs, concerns

Implementation
hints, techniques

Sample code
code fragment showing possible implementation

Known uses
patterns found in real systems

Related patterns
closely related patterns

Classification of Design Patterns

- Creational Patterns
  - deal with initializing and configuring classes and objects
  - *how am I going to create my objects?*
- Structural Patterns
  - deal with decoupling the interface and implementation of classes and objects
  - *how classes and objects are composed to build larger structures*
- Behavioral Patterns
  - deal with dynamic interactions among societies of classes and objects
  - *how to manage complex control flows (communications)*

Drawbacks of Design Patterns

- Patterns do not lead to direct code reuse
- Patterns are deceptively simple
- Teams may suffer from patterns overload

Key Mechanisms in Design Patterns

GoF Design Principle no. 1

Program to an interface, not an implementation

- Use interfaces to define common interfaces
  - and/or abstract classes in C++
- Declare variables to be instances of the abstract class
  - not instances of particular classes
- Use *Creational patterns*
  - to associate interfaces with implementations

Benefits

- Greatly reduces the implementation dependencies
- Client objects remain unaware of the classes that implement the objects they use.
- Clients know only about the abstract classes (or interfaces) that define the interface.

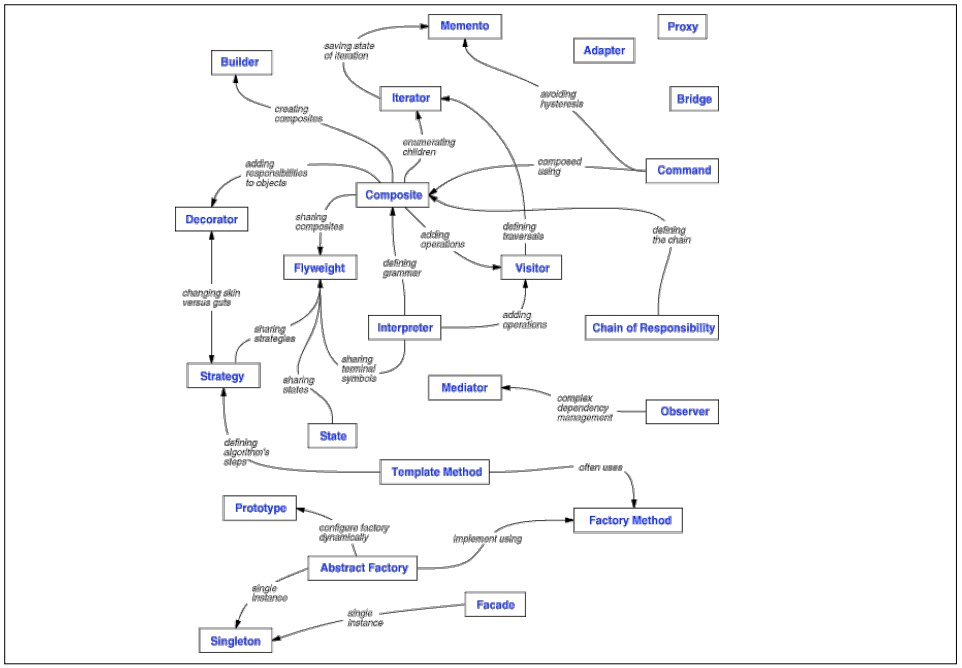
Class vs. Object Patterns

- Mechanisms of reuse
  - White-box vs. Black-box
- Class Inheritance
  - easy to use; easy to modify
    - implementation being reused;
  - language-supported
  - static bound ⇒ can't change at run-time;
  - mixture of physical data representation ⇒ breaks encapsulation
    - change in parent ⇒ change in subclass
- Object Composition
  - objects are accessed solely through their interfaces
    - no break of encapsulation
  - any object can be replaced by another at runtime
    - as long as they are the same type

Design Principle no. 2

Favor composition over class inheritance

- Keeps classes focused on one task
- Inheritance and Composition Work Together!
  - ideally no need to create new components to achieve reuse
  - this is rarely the case!
  - reuse by inheritance makes it easier to make new components
    - modifying old components
- Tendency to overuse inheritance as code-reuse technique
- Designs – more reusable by depending more on object composition


Memento
Proxy
saving state of iteration
Adapter
Builder
Iterator
avoiding hysteresis
Bridge
creating composites
enumerating children
adding responsibilities to objects
composed using
Command
Composite
Decorator
sharing composites
defining traversals
defining the chain
adding operations
Flyweight
defining grammar
Visitor
changing skin versus guts
sharing strategies
Interpreter
adding operations
Chain of Responsibility
Strategy
sharing terminal symbols
sharing states
Mediator
complex dependency management
Observer
State
defining algorithm's steps
Template Method
often uses
Prototype
configure factory dynamically
Factory Method
implement using
Abstract Factory
single instance
Facade
single instance
Singleton