CONSTRUCTOR UNIVERSITY

Design Patterns

Sommerville, Chapter 18

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CONGRESS.SYS Corrupted:
Re-boot Washington D.C. (Y/n)?

Introduction to Design Patterns

- Be a good programmer
  - …and an efficient one – *learn from others!*
- Similar patterns occur over and over
  - Do not reinvent the wheel
  - Sharing knowledge of problem solving
  - Facilitate communication between programmers
  - Write elegant and graceful code
- Computer programming as art [Donald Knuth]
  - See conceptual beauty

Semiotics: Aspects of Language Use

- Syntax -- how to write it (grammar)
  - Ex: if (condition) statement;
if [condition]; then statement; fi
- Semantics -- what to express (how it is evaluated)
  - Ex: conditional evaluation
- Pragmatics -- how to apply
  - Ex: "goto considered bad"
- Meta language -- describe the language of discourse
  - Ex: BNF grammars

www.cs.sfu.ca/~cameron/Teaching/383/syn-sem-prag-meta.html

Design Patterns

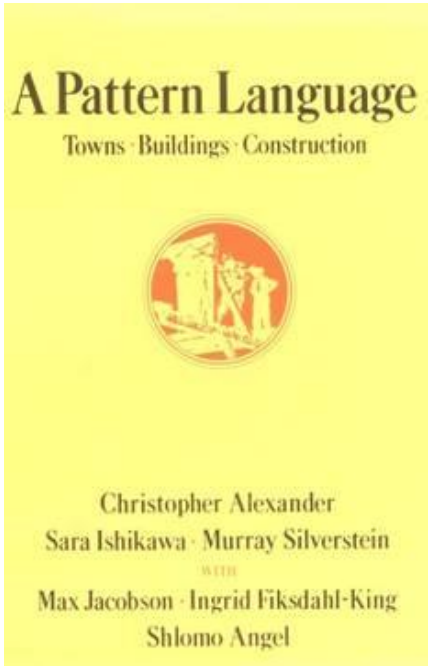
- pattern =
  description of the problem and the essence of its solution
  - should be sufficiently abstract to be reused in different settings
  - often rely on object characteristics such as inheritance and polymorphism
- design pattern =
  way of re-using abstract knowledge about a (sw) design problem and its solution

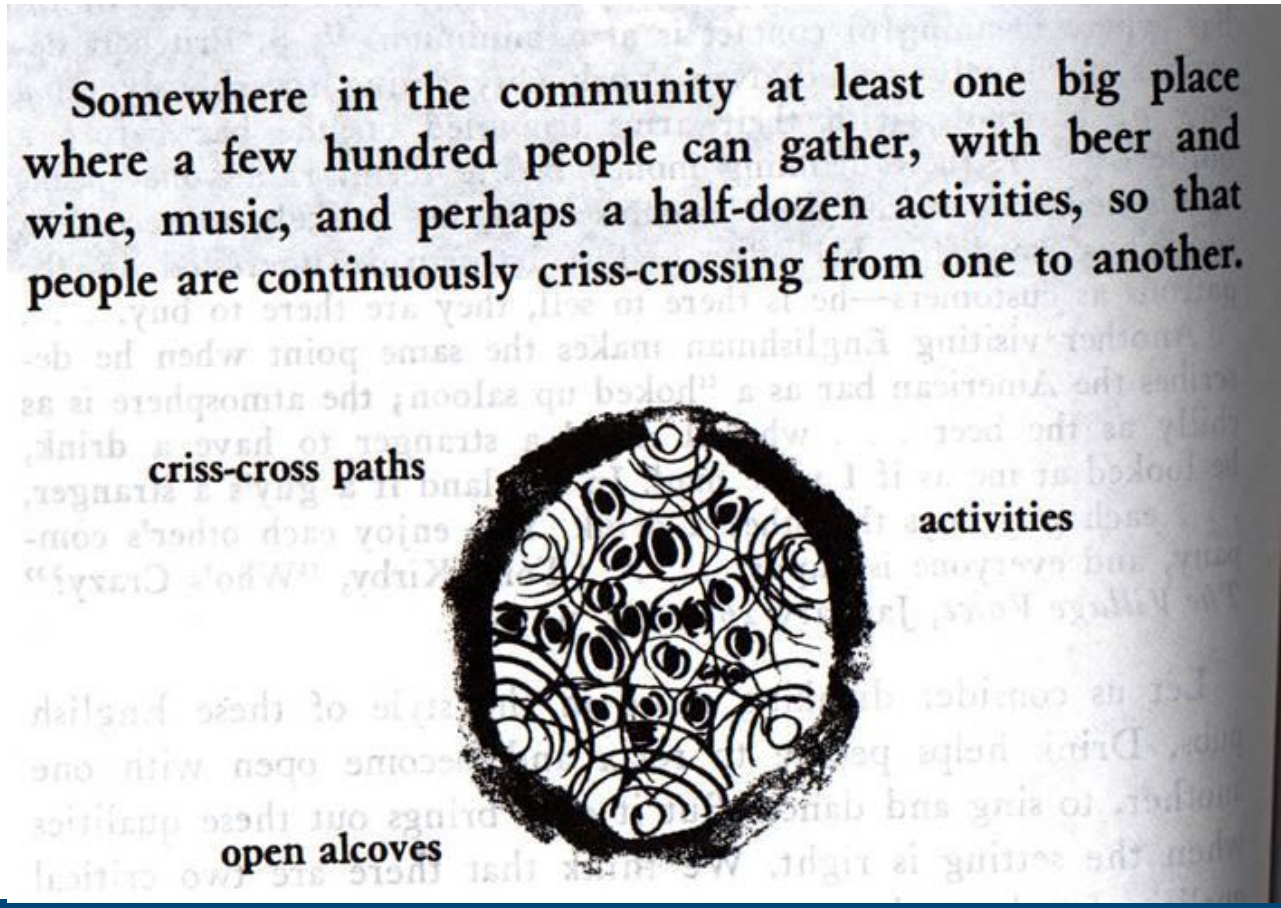
History of Design Patterns

- Architect: Christopher Alexander
  - *A Pattern Language* (1977)
  - *A Timeless Way of Building* (1979)
- "Gang of four"
  - Erich Gamma
  - Richard Helm
  - Ralph Johnson
  - John Vlissides
- *Design Patterns: Elements of Reusable Object-Oriented Software* (1995)

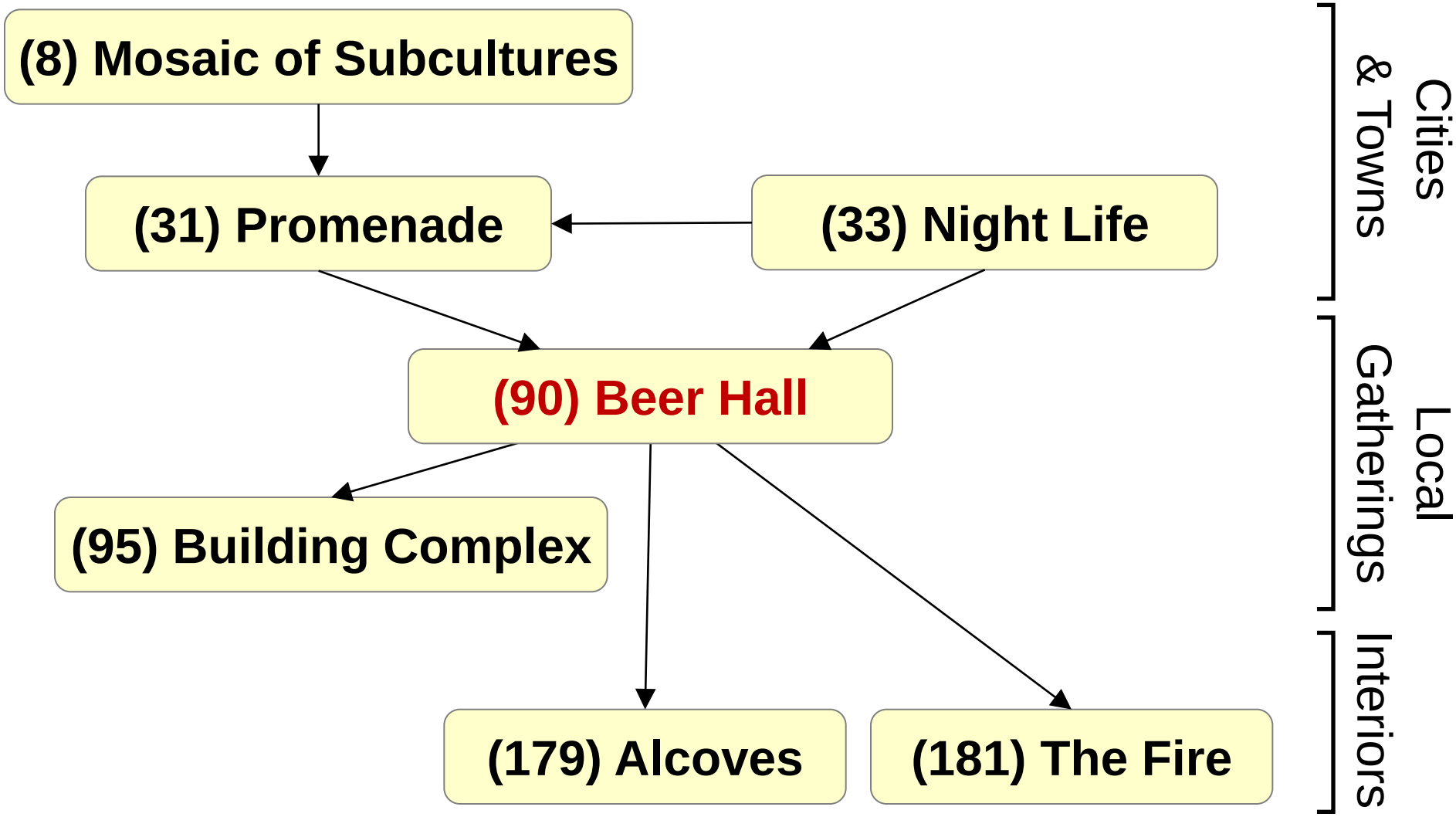
Design Patterns in Architecture

- First used in architecture [C. Alexander]
  - Ex. How to create a beer hall where people socialize?





Design Patterns in Architecture



Pattern Elements

- Name
  - A meaningful pattern identifier
- Description
- Problem / Applicability description
- Solution description
  - Not concrete design but template for design solution that can be instantiated in different ways
- Consequences
  - The results and trade-offs of applying the pattern

Patterns by Example: Singleton

- Name
  - Singleton
- Description
  - Ensure a class has only one instance and provide a global point of access to it
- Problem / Applicability
  - Used when only one object of a kind may exist in the system
- Solution
  - defines an Instance operation that lets clients access its unique instance
  - Instance is a class operation
  - responsible for creating and maintaining its own unique instance

Singleton Code

```
// Singleton pattern -- Structural example

class Singleton
{
public:
    static Singleton* Instance()
    {
        static Singleton instance;
        return &instance;
    }
private:
  Singleton() {}
}
```

```
int main()
{
    // Constructor is protected, cannot use new
    Singleton *s1 = Singleton::Instance();
    Singleton *s2 = Singleton::Instance();
    Singleton *s3 = s1->Instance();
    Singleton &s4 = *Singleton::Instance();

    if( s1 == s2 )
        cout << "same instance"  << endl;
}
```

Singleton Application

```
class LoadBalancer
{
private:
    LoadBalancer()
    {
        add_all_servers;
    }
public:
    static LoadBalancer *GetLoadBalancer()
    {
        // thread-safe in C++ 11
        static LoadBalancer balancer;
        return &balancer;
    }
…
}
```

```
//  SingletonApp test

LoadBalancer *b1 = LoadBalancer::GetLoadBalancer();
LoadBalancer *b2 = LoadBalancer::GetLoadBalancer();

if( b1 == b2 )
    cout << "same instance"  << endl;
```

Singleton, Revisited

Problems:
- Subclassing
- Copy constructor
- Destructor: when?
- Static vs. heap

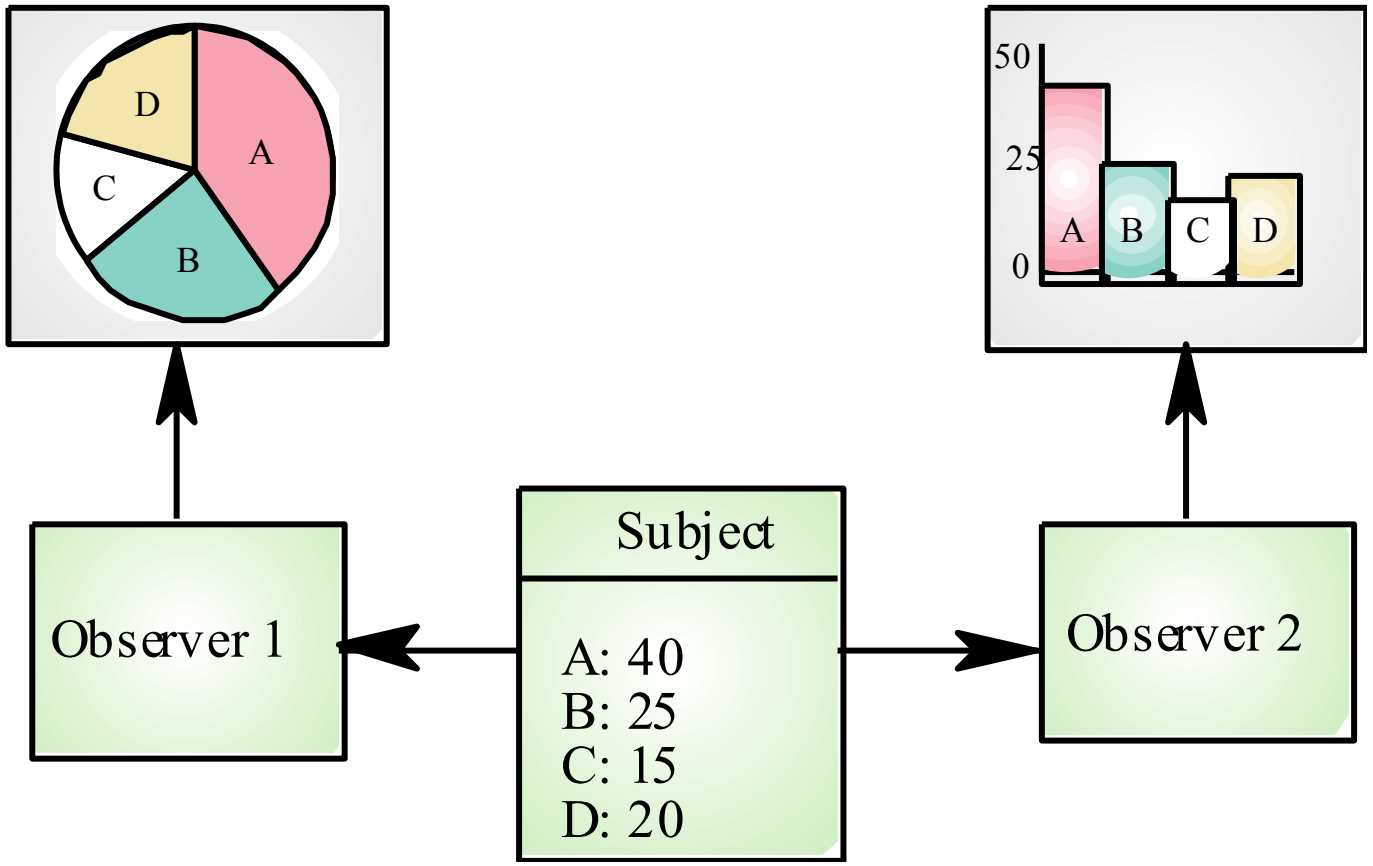
```
// Singleton pattern

class Singleton
{
public:
    static Singleton* Instance()
    {
        static Singleton instance;
        return &instance;
    }
private:
  Singleton() {}
}
```

```
// Singleton -- modified example

class Singleton
{
public:
    static Singleton* Instance()
    {
        static Singleton instance;
        return &instance;
    }
private:
    Singleton() {}
    Singleton(const Singleton&);
    Singleton& operator=(const Singleton&);
}
```

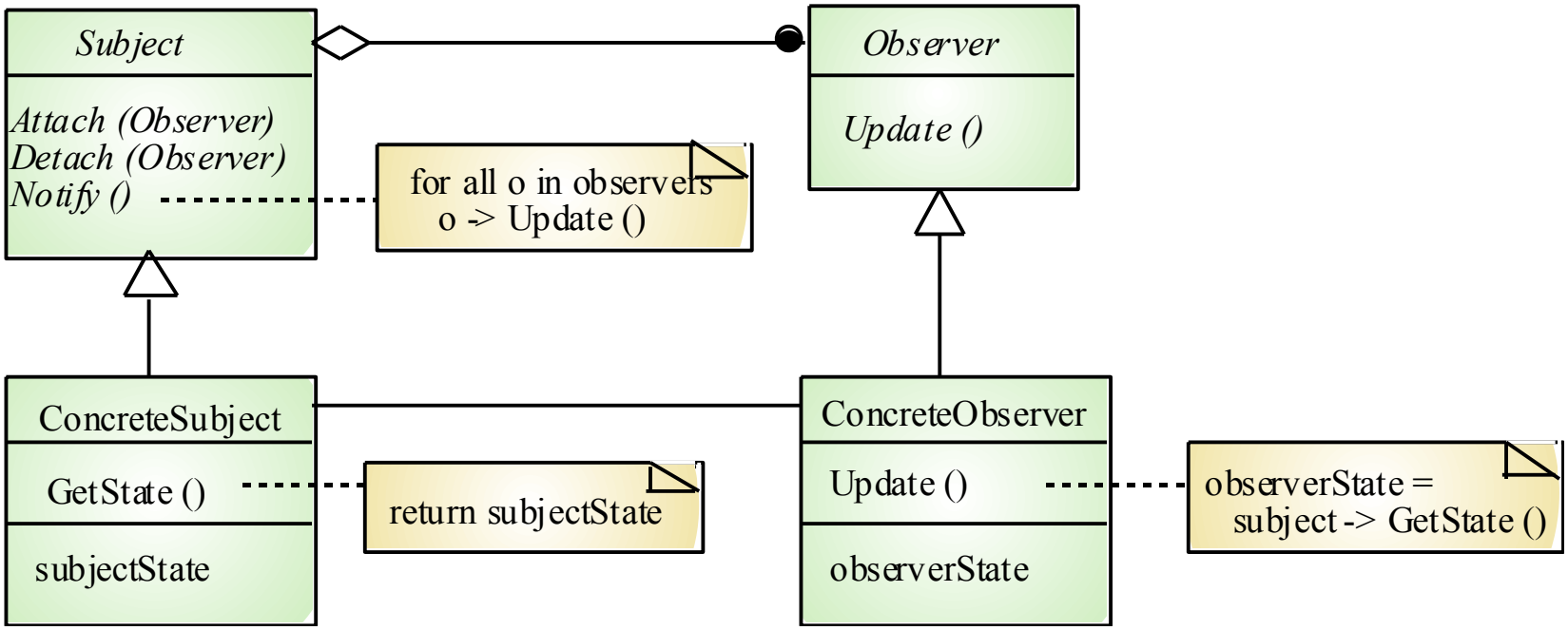
Multiple displays enabled by Observer



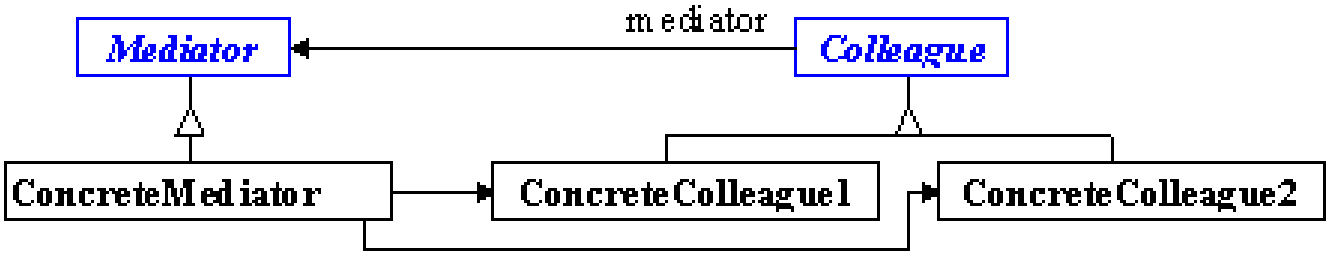
The Observer Pattern

- Name
  - Observer
- Description
  - Separates the display of object state from the object itself
- Problem / Applicability
  - Used when multiple displays of state are needed
- Solution
  - See slide with UML description
- Consequences
  - Optimizations to enhance display performance are impractical

The Observer pattern



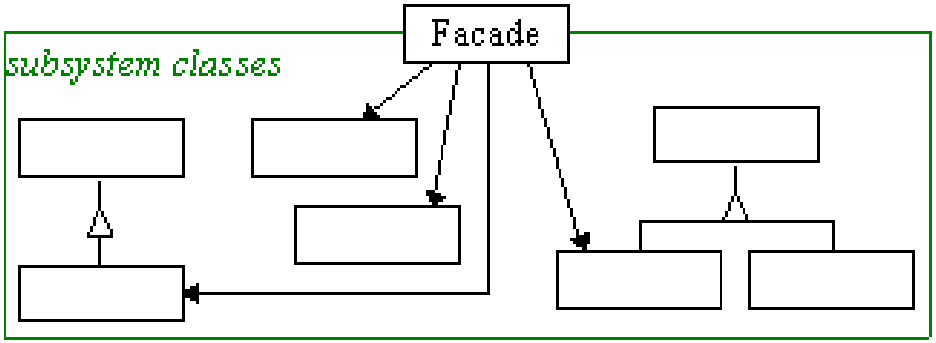
The Mediator Pattern



- Description
  - Define an object that encapsulates how a set of objects interact
  - Mediator promotes loose coupling by keeping objects from referring to each other explicitly
- Problem / Applicability
  - Complex interaction exists
- Consequences
  - Limits subclassing; Decouples colleagues; Simplifies object protocols; Abstracts how objects cooperate; Centralizes control

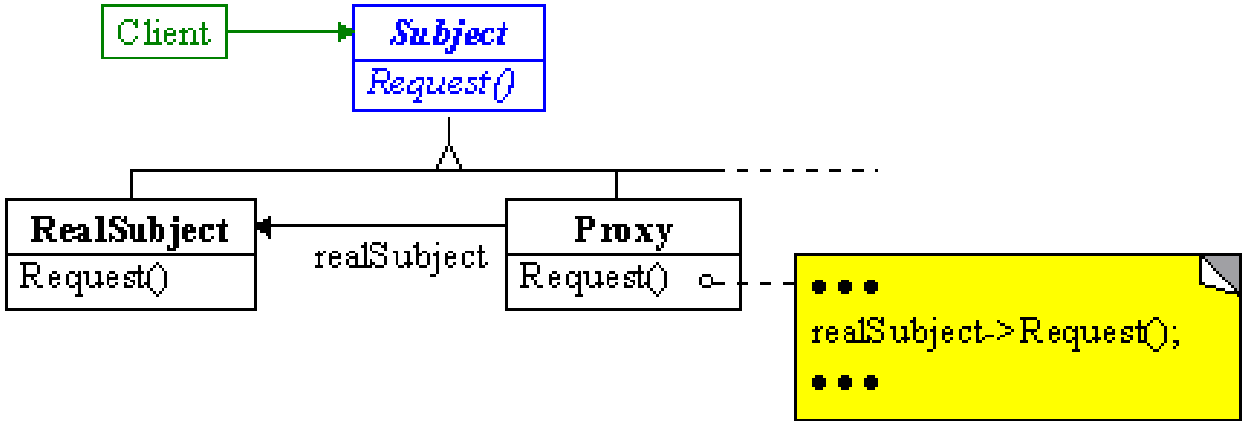
The Façade Pattern

- Description
  - Provides a unified interface to a set of interfaces in a subsystem
  - Defines a higher-level interface that makes subsystem easier to use



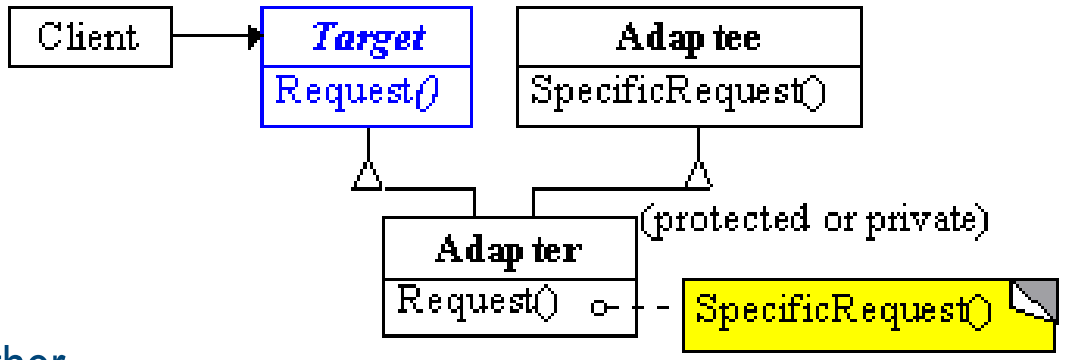
- Applicability
  - Need to provide a simple interface to a complex system
  - Need to decouple a subsystem from its clients
  - Need to provide an interface to a software layer
- Consequences
  - Shields clients from subsystem components
  - Promotes weak coupling between the subsystem and its clients

The Proxy Pattern



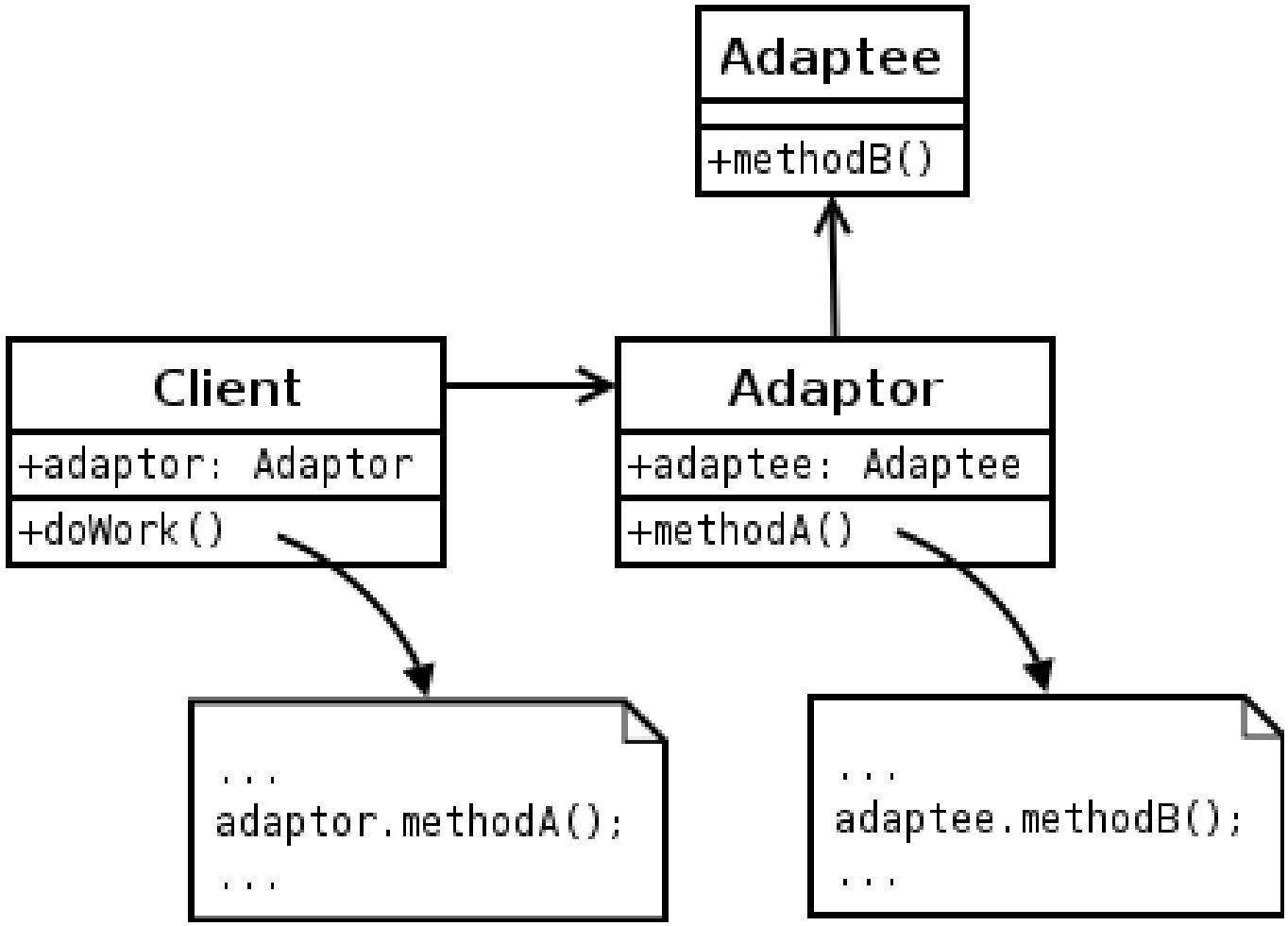
- Description
  - Provide a surrogate or placeholder for another object to control access to it
- Problem / Applicability
  - Remote proxies can hide the fact that a real object is in another address space
  - Virtual proxies can create expensive objects on demand
  - Protection proxies can control access to an object
  - Smart references can perform additional action above a simple pointer

The Adapter Pattern



- Description
  - Adapter lets classes work together
    that could not otherwise because of incompatible interfaces
- Problem / Applicability
  - Need to use an existing class whose interface does not match
  - Need to make use of incompatible classes
- Consequences
  - Class adapter commits to the concrete Adapter class

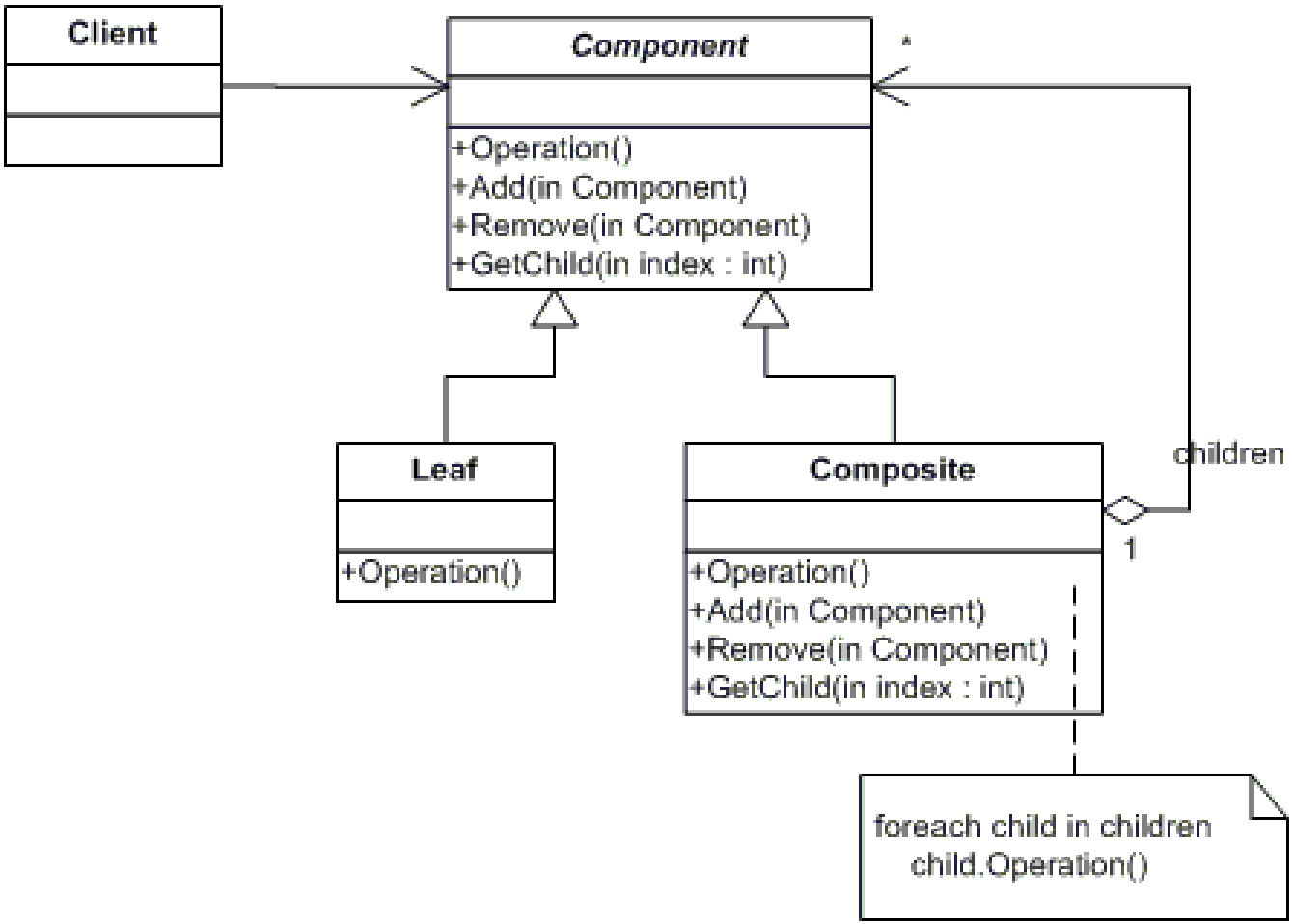
Adapter: Another View [Wikipedia]



Composite Pattern

- Definition
  - Compose objects into tree structures to represent part-whole hierarchies
  - Composite lets clients treat individual objects and compositions of objects uniformly
- Problem / Applicability
  - Any time there is partial overlap in the capabilities of objects

Composite Pattern UML Diagram



Types of Patterns

- Creational
  - Abstract Factory — Creates an instance of several families of classes
  - Builder — Separates object construction from its representation
  - Factory Method — Creates an instance of several derived classes
  - Prototype — A fully initialized instance to be copied or cloned
  - Singleton — A class of which only a single instance can exist
- Structural Patterns
  - Adapter — Match interfaces of different classes
  - Bridge — Separates an object's interface from its implementation
  - Composite — A tree structure of simple and composite objects
  - Decorator — Add responsibilities to objects dynamically
  - Façade — A single class that represents an entire subsystem
  - Flyweight — A fine-grained instance used for efficient sharing
  - Proxy — An object representing another object

Types of Patterns (contd.)

- Behavioral Patterns
  - Chain of Resp. — A way of passing a request between a chain of objects
  - Command — Encapsulate a command request as an object
  - Interpreter — A way to include language elements in a program
  - Iterator — Sequentially access the elements of a collection
  - Mediator — Defines simplified communication between classes
  - Memento — Capture and restore an object's internal state
  - Observer — A way of notifying change to a number of classes
  - State — Alter an object's behavior when its state changes
  - Strategy — Encapsulates an algorithm inside a class
  - Template Method — Defer the exact steps of an algorithm to a subclass
  - Visitor — Defines a new operation to a class without change

Summary

- Design patterns = generic, re-usable design templates for OOP
  - Code templates, to be adapted by programmer
  - Faster, safer implementation through re-use
- three types of patterns: creational, structural, and behavioral
- Design pattern catalog
  - http://www.dofactory.com/net/design-patterns#list
- *It's practice – show it in interviews!*