Gang of Four
Object Oriented Design Patterns

Motivation

Object Oriented Analysis (OOA)

- domain problem designed as (domain) objects
  - addresses the functional challenges
  - what a system does
  - provides guidance for implementation

Object Oriented Design (OOD)

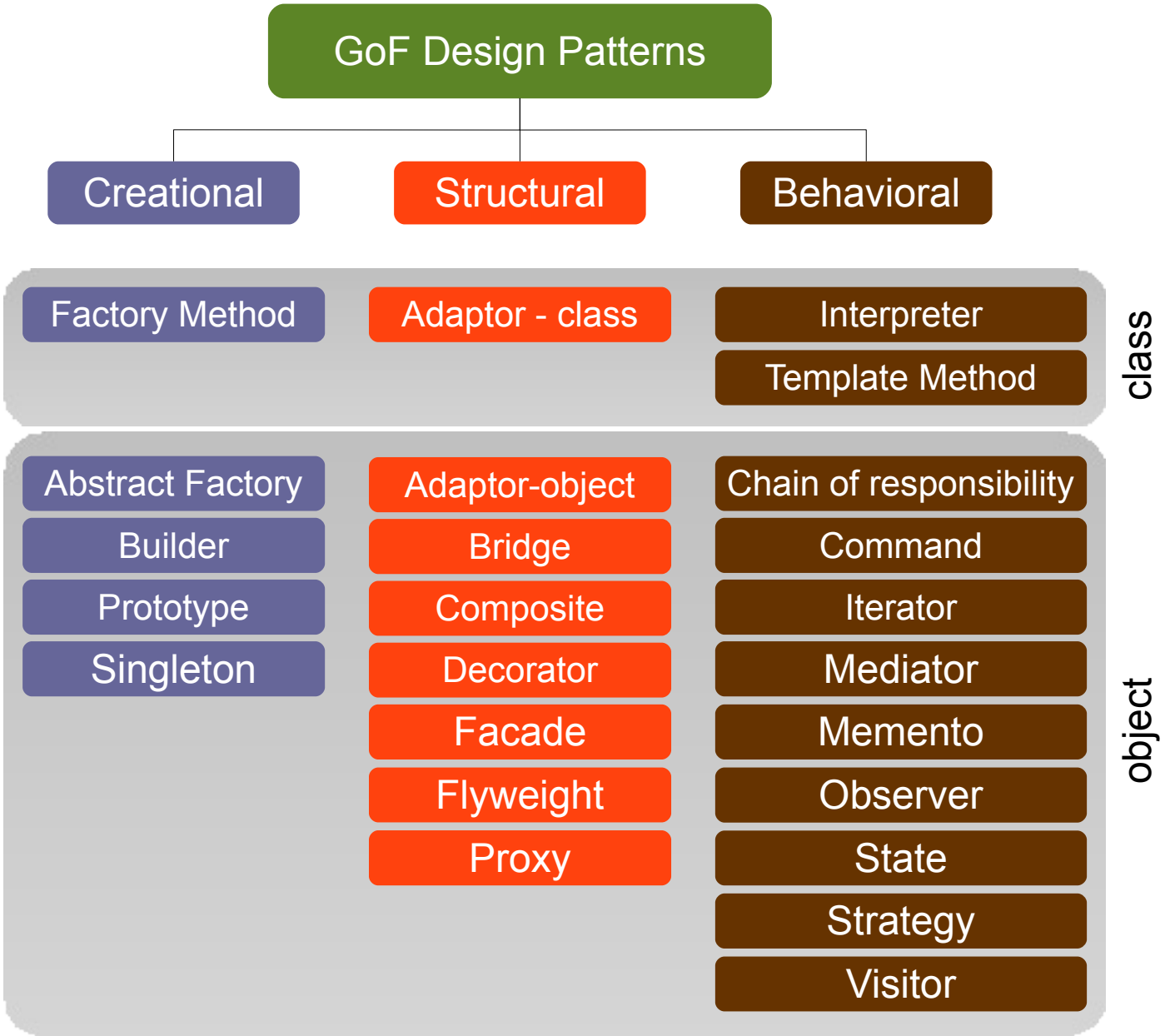
- domain problem solved as (implementation) objects
  - addresses the implementation challenges
  - how a system realizes OOA

Motivation

How can we improve OOD

- identify common characteristics
  - creation, structure, behaviour, interactions
- design patterns
  - generic blueprints (micro architecture)
  - language and implementation independent
  - two main catalogues
    - GoF
      - Gang of Four (Gamma, Helm, Johnson, Vlissides, 1995)
    - POSA
      - Pattern Oriented Software Architecture (Buschmann, et al.; Wiley, 1996)

Design Patterns



Singleton

Intent

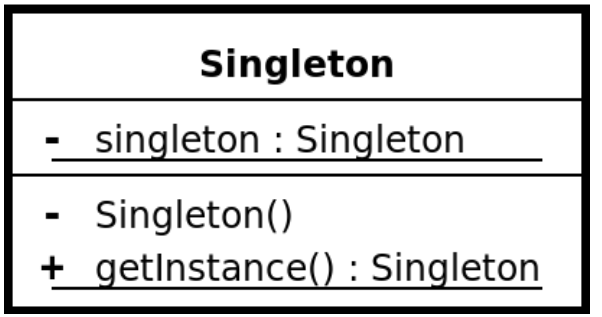
- *"ensure a class only has one instance, and provide a global point of access to it."*

Construction

```
public class Singleton {
  private static final Singleton INSTANCE = new Singleton();

  // Private constructor prevents
  // instantiation from other classes
  private Singleton() {}

  public static Singleton getInstance() {
     return INSTANCE;
  }
}
```



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Singleton

Advantages

- controlled access
- refinement of functionality
  - via inheritance/subclass
- variable number of instances
  - only the *getInstance* method needs modification

Singleton

A closer look

- reuse
- separation of concerns
- global presence
- stateful vs. stateless
- multiple instances
- life cycle

Singleton – A Closer Look

Reuse

- coupling
  - results in tighter coupling
    - couples with the exact type of the singleton object
  - pass by reference to reduce coupling
- inheritance
  - easy to extend functionality in subclasses
  - not easy to override the object instance in subclasses

Singleton – A Closer Look

Separation of concerns

- singleton class responsible for creation
  - acts as a builder/factory
- what if we were to separate the two concerns
  - example
    - Database connection as a singleton
    - System 1 uses a singleton to ensure only a single database connection
    - System 2 needs to connection pool of 10 databases connections

Singleton – A Closer Look

Global presence

- provides a global access point to a service
  - aren't global variables bad?
  - can be accessed from anywhere
  - violation of layered access
- not part of method signature
  - dependency is not obvious
  - requires code inspection
- a large system may require many singletons
  - use a registry/repository

Singleton – A Closer Look

Stateful singleton

- same as a global variable in principle
  - aren't global variables bad?
- access concerns
  - synchronization
  - concurrency – multiple threaded using a singleton
- mutable vs. immutable state

Stateless singleton

- better then stateful
- can we have a stateless singleton?

Singleton – A Closer Look

Multiple instances

- distributed systems
  - is it possible to have a true singleton in a distributed system?
  - global registries/repositories
- language (Java) specific concerns
  - initialization – has to be thread safe
  - serialization
  - class loaders

Singleton – A Closer Look

Life-cycle & life span

- creation
  - lazy initialization
- singletons are long lived
  - as long as an application's life span
  - registries can outlive applications
  - unit testing requires short lived state
- language (Java) specific concern
  - reloading singleton class (servlets)
  - loss of state

Singleton

When can I use a singleton

- considerations[1]
  - will every user use this class exactly the same way?
  - will every applications ever need only one instance?
  - should the clients be unaware of the application
- examples
  - Java Math class (stateless – static class)
  - top level GUI (window/frame)
  - logging

[1] http://www.ibm.com/developerworks/library/co-single.html

Adapter

Intent

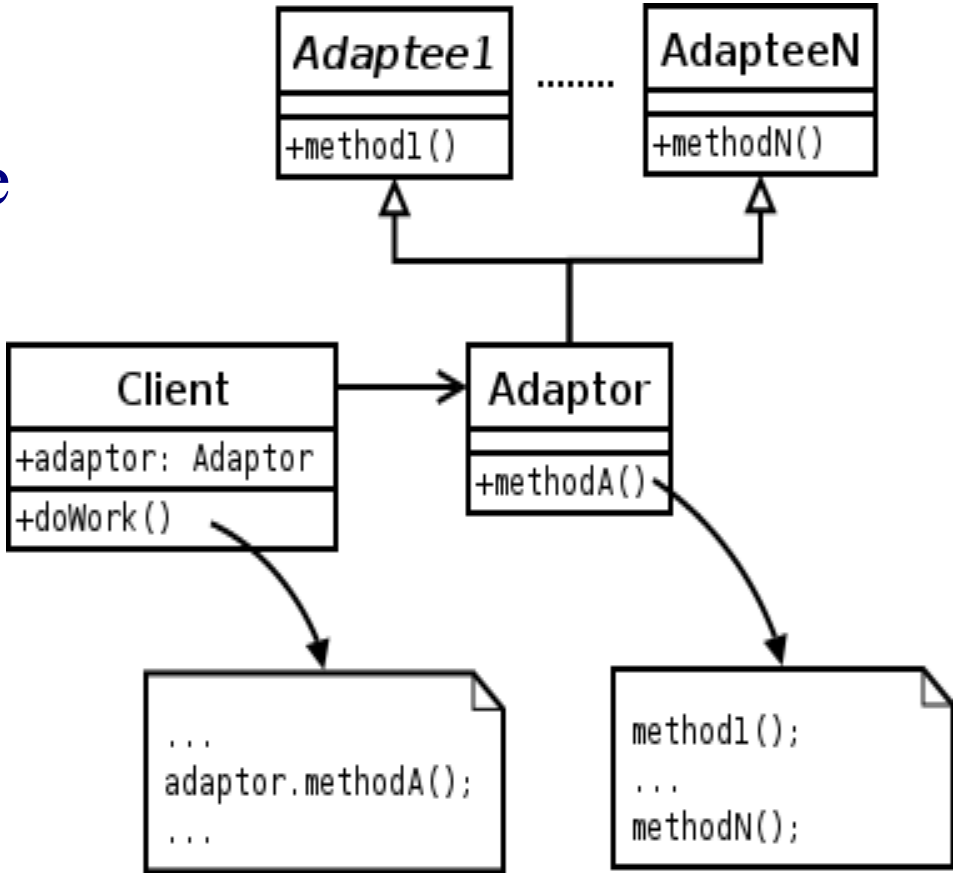
- *"convert the interface of a class into another interface... Adapter lets classes work together that couldn't otherwise because of incompatible interface"*

- also known as wrapper
- example
  - boolean values can be represented by
    - {1,0}, {true, false}, {yes, no}

Adapter – Class

Requirement

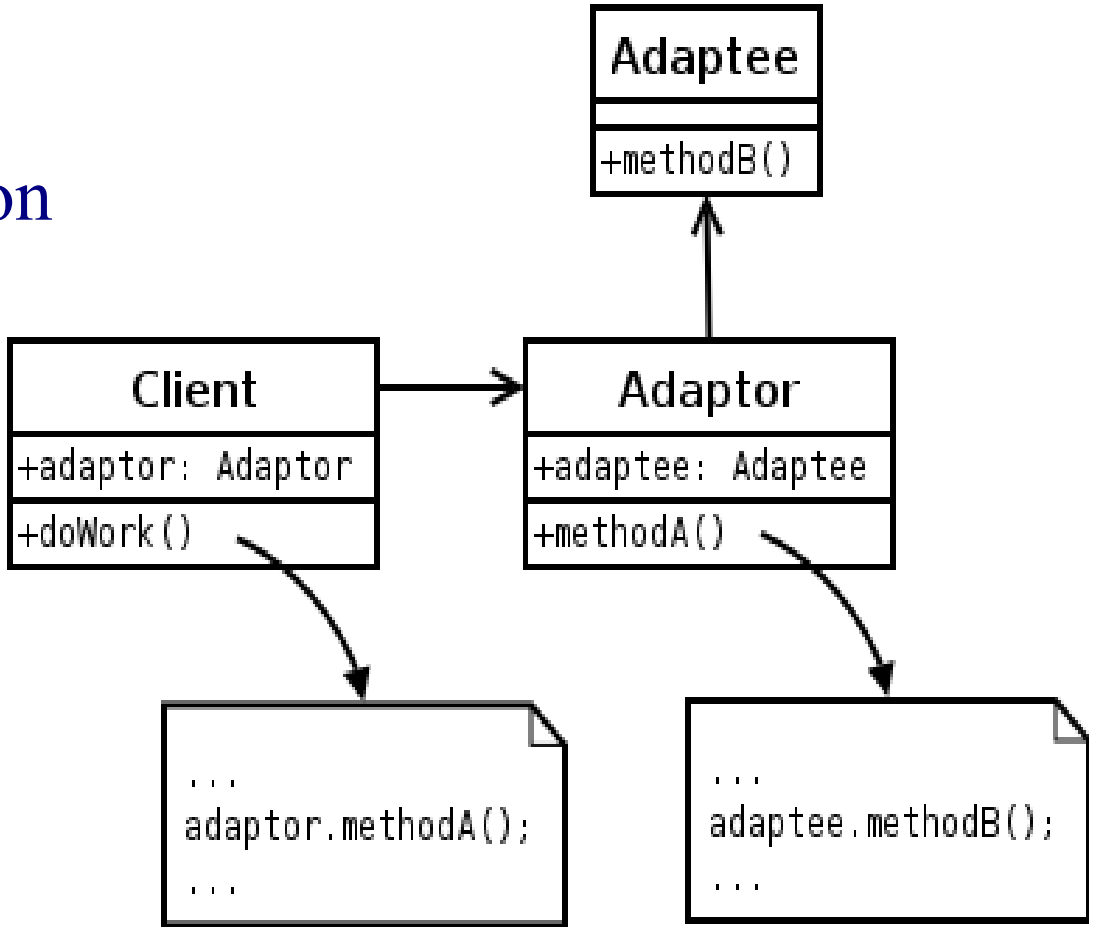
- requires multiple inheritance
- what about implementations that do not support multiple inheritance (Java)?



Adapter – Object

Requirement

- via object composition



Adapter – Class vs. Object

Class

- commitment to a concrete adaptee class
  - can not use a class hierarchy
- allows for specialization
- static in nature

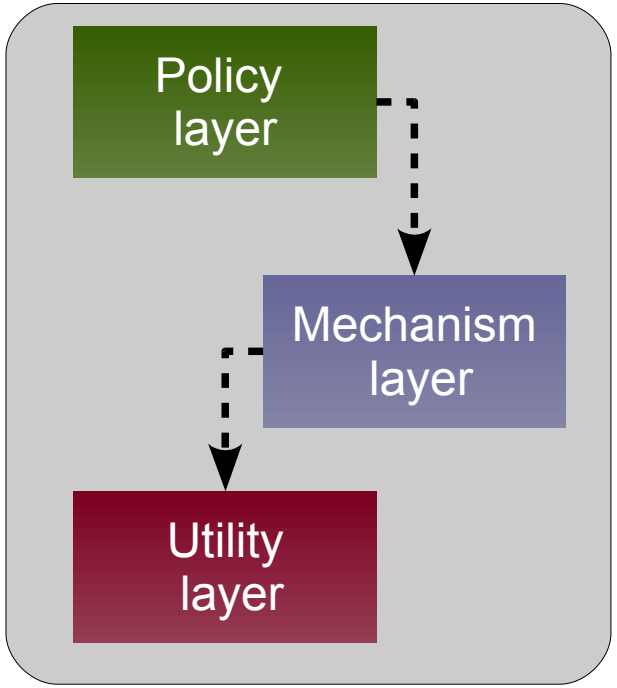
Object

- can use many adaptees
- harder to override the adaptee behavior

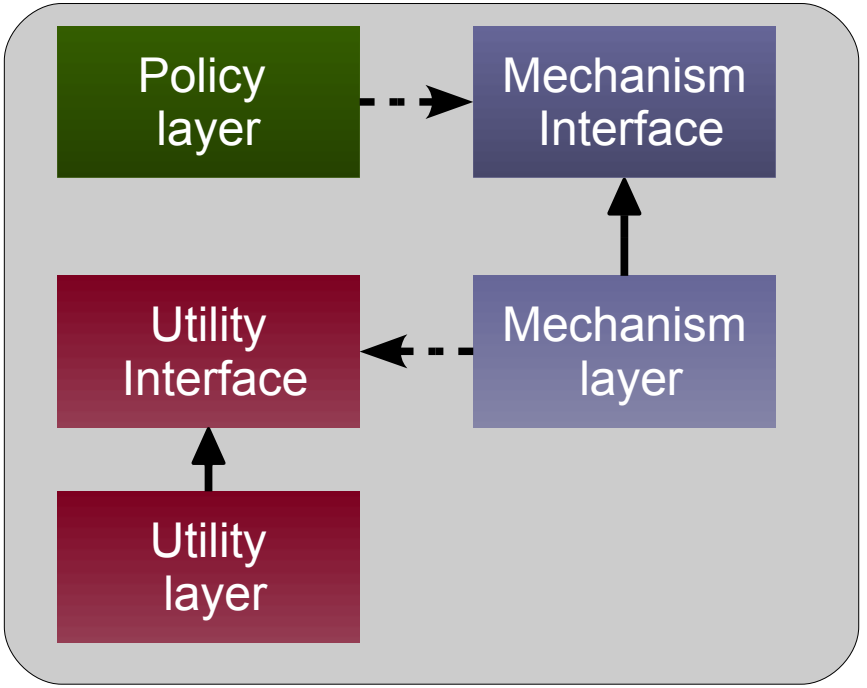
Adapter & Dependency Inversion

Dependency Inversion (DI)

- decouple high level layer from lower level layer(s)



Simple Layers



Abstract Layers

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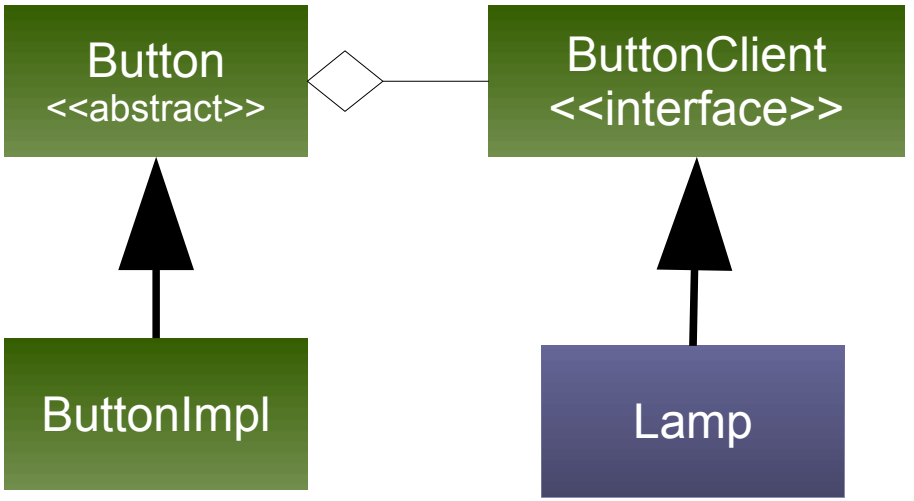
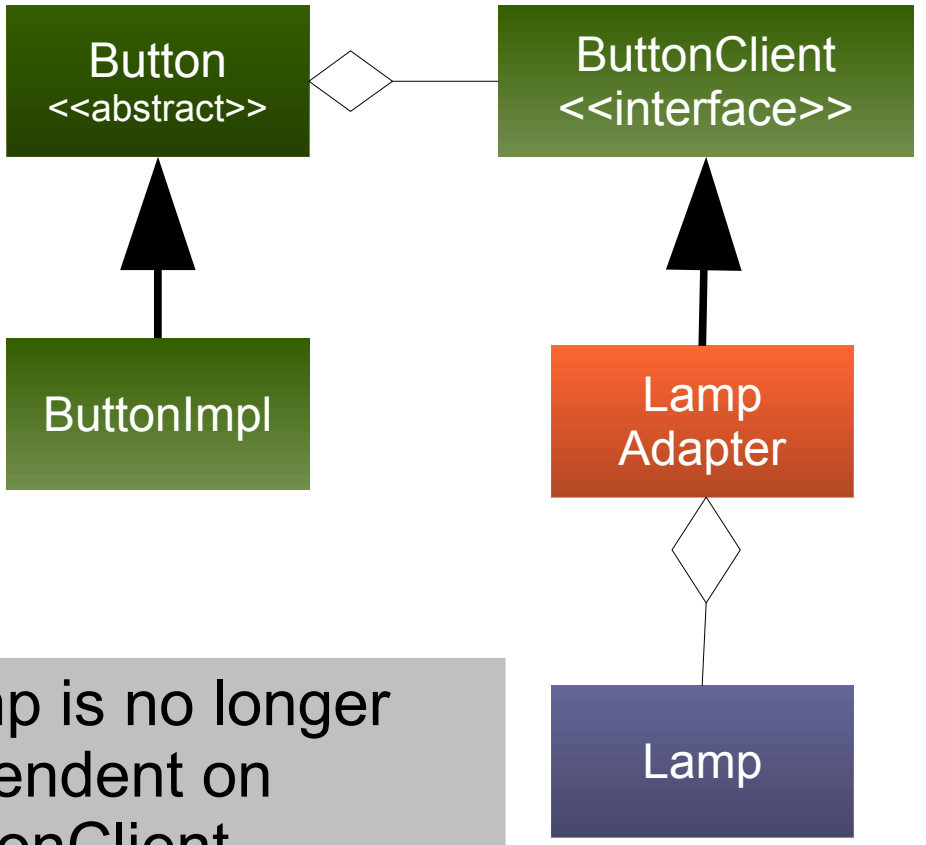
Adapter & Dependency Inversion

DI



DI with Adapter



Lamp is no longer dependent on ButtonClient

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Adapter

How much adaptation is reasonable?

Bridge

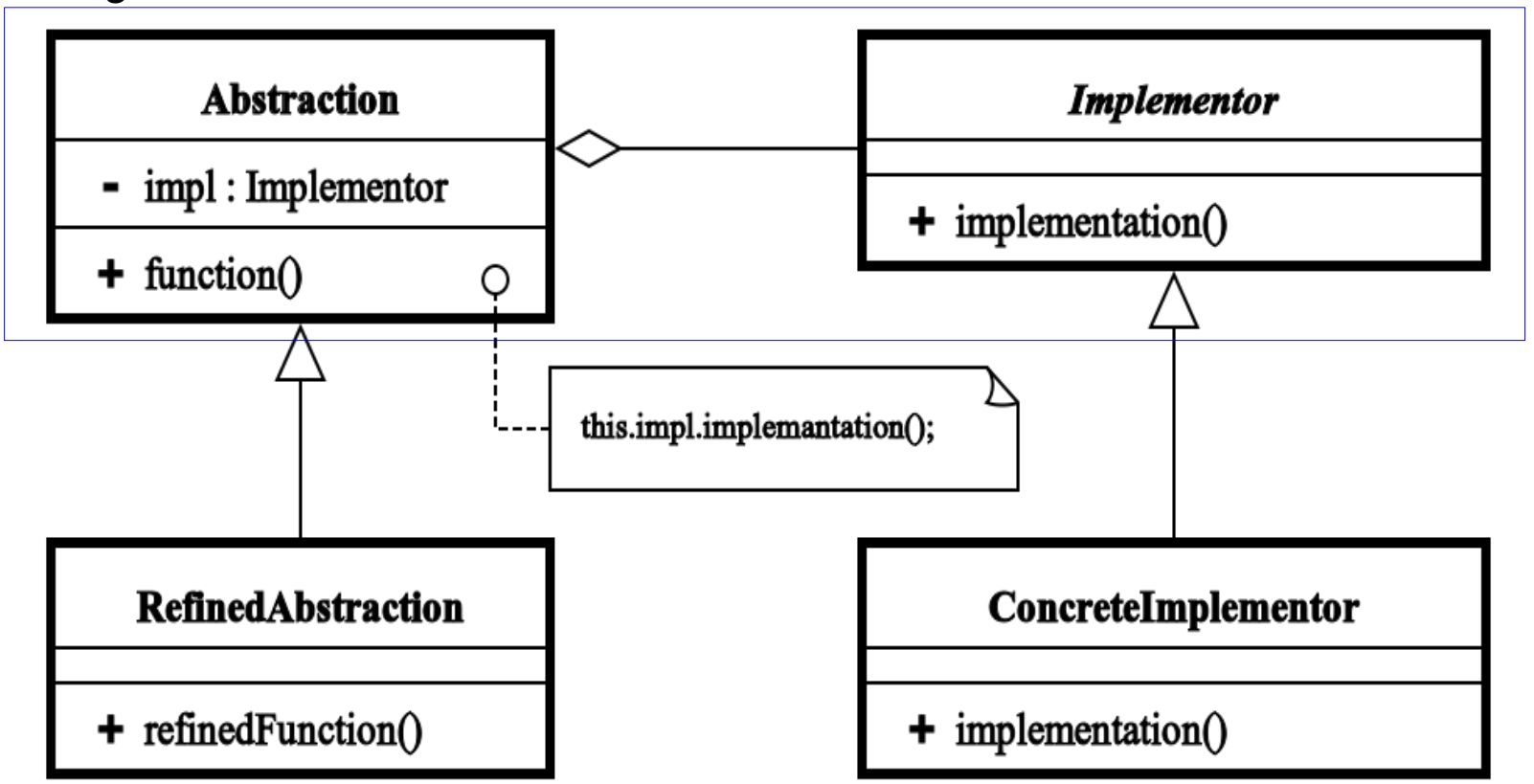
Intent

- *"decouples an abstraction from its implementation so the two can vary independently"*

- does this not sounds like an adapter?
  - will take a closer look later

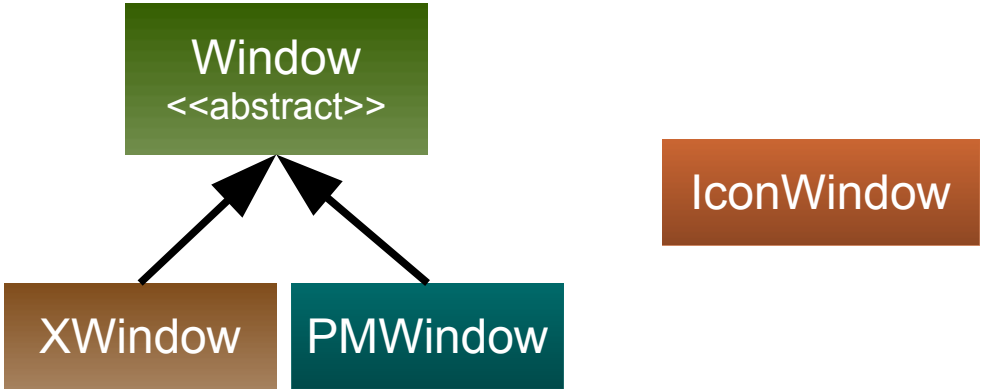
Bridge

Bridge

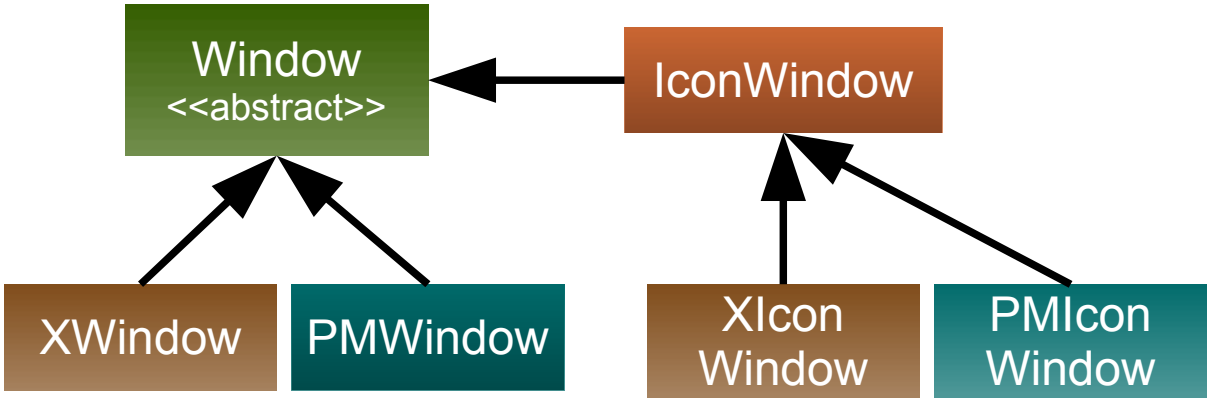


Bridge Example

Problem



Solution via inheritance

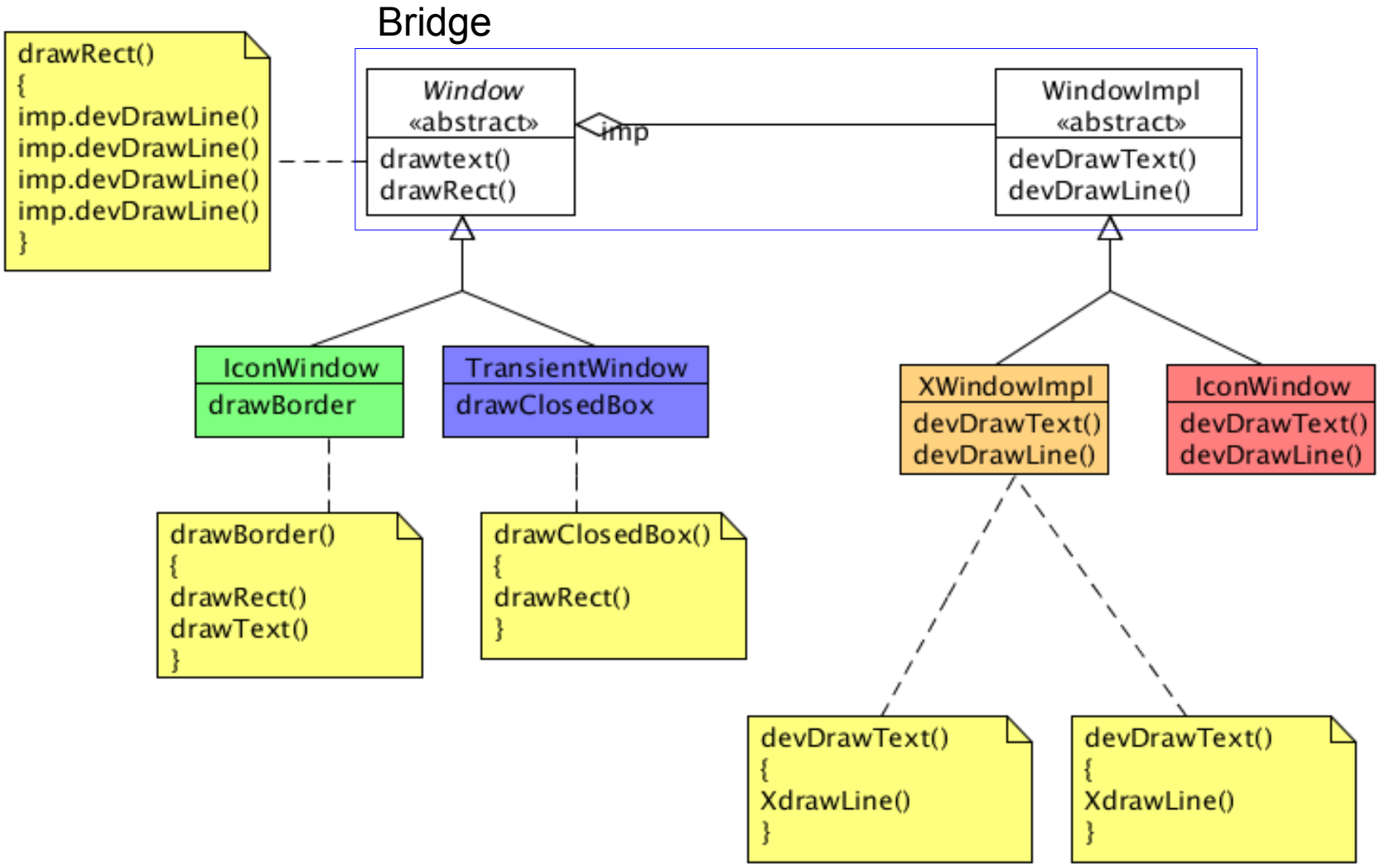


problem1: what if we have to support another platform?

problem2: client code is tied to an implementation. For portable code, the client should not refer to an implementation

Bridge Example

Solution: Use bridge pattern to place abstraction and implementation in two different hierarchies



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Bridge

Features

- flexible binding between abstraction & implementation
- two class hierarchies
- clients are decoupled

Adapter & Bridge

Common elements

- flexibility via indirection
- request forwarding

Adapter & Bridge

Difference in intent

- adapter
  - resolves incompatibilities between two existing interfaces
  - two interfaces are independent and can evolve separately
  - coupling is unforeseen
  - adapts components after they have been designed
- bridge
  - connects an abstraction and its many implementations
  - evolution is in accordance with the base abstraction
  - coupling between the abstraction and the implementations are known