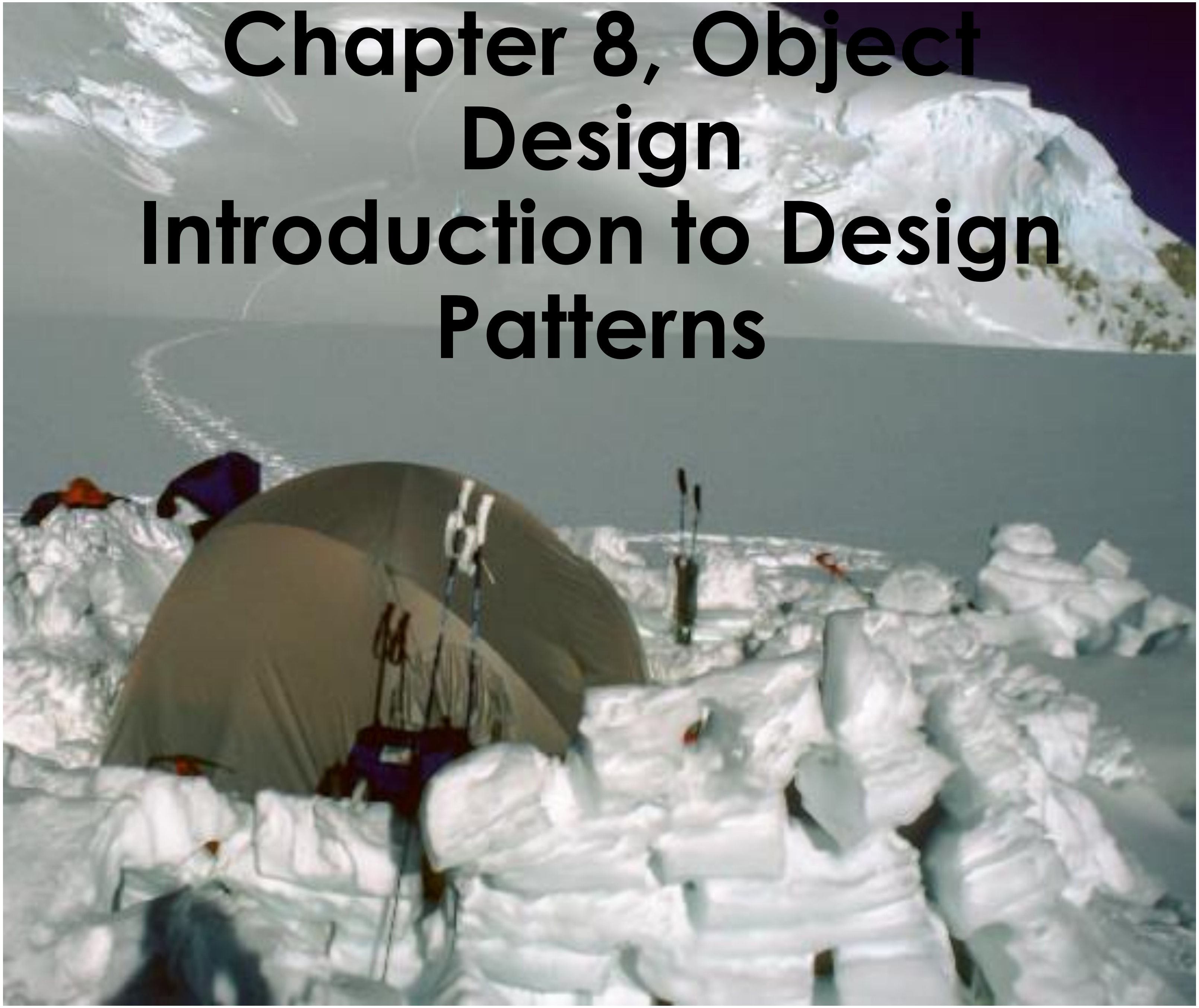
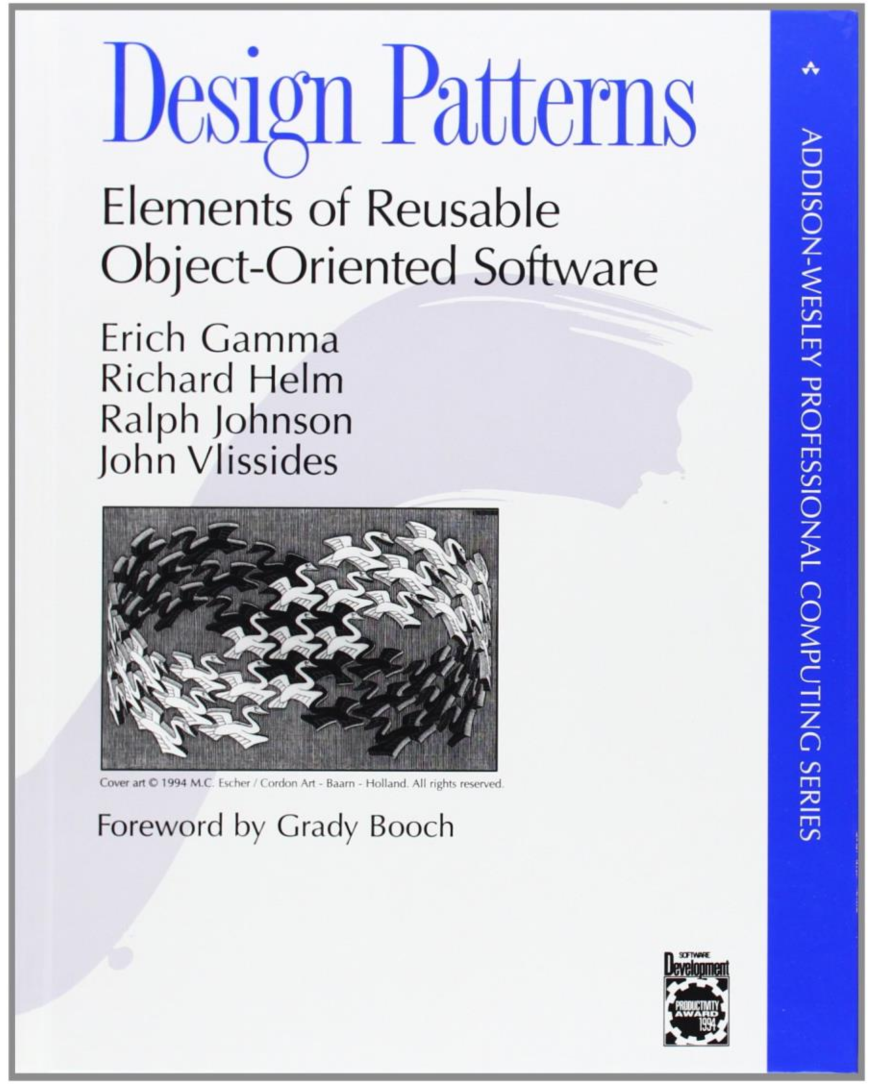
Chapter 8, Object Design Introduction to Design Patterns



Object-Oriented Software Engineering

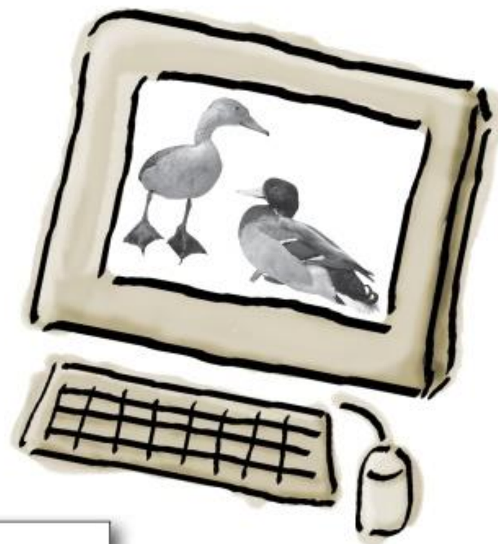
Using UML, Patterns, and Java

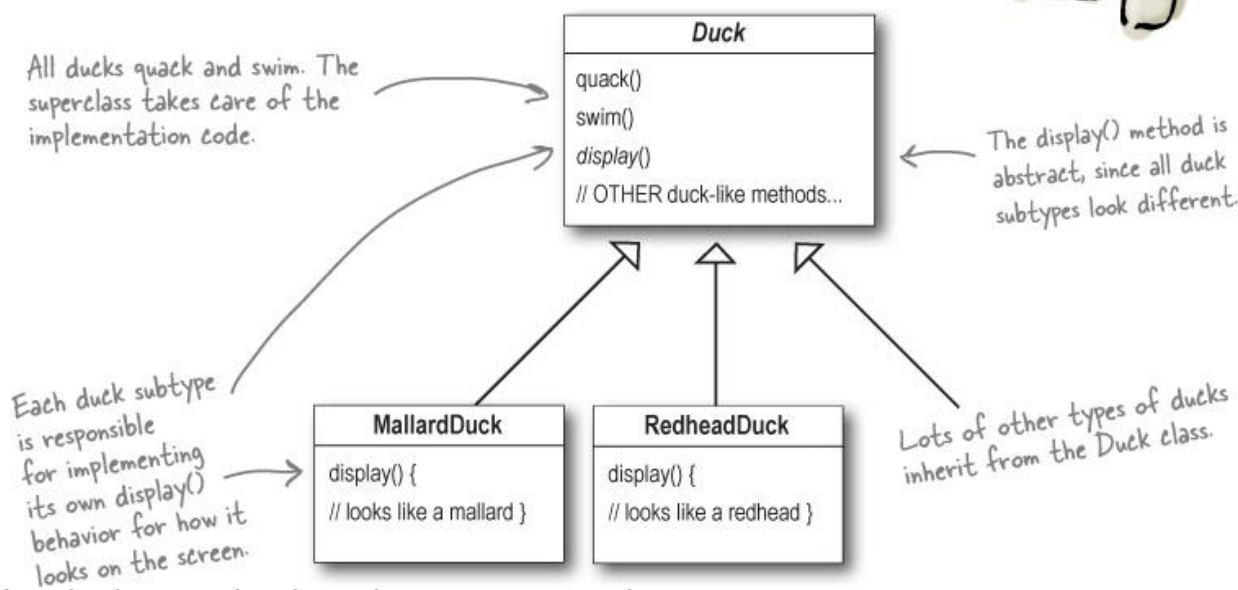
Learning Design Patterns



Example OO application

Joe works for a company that makes a highly successful duck pond simulation game, *SimUDuck*. The game can show a large variety of duck species swimming and making quacking sounds. The initial designers of the system used standard OO techniques and created one Duck superclass from which all other duck types inherit.

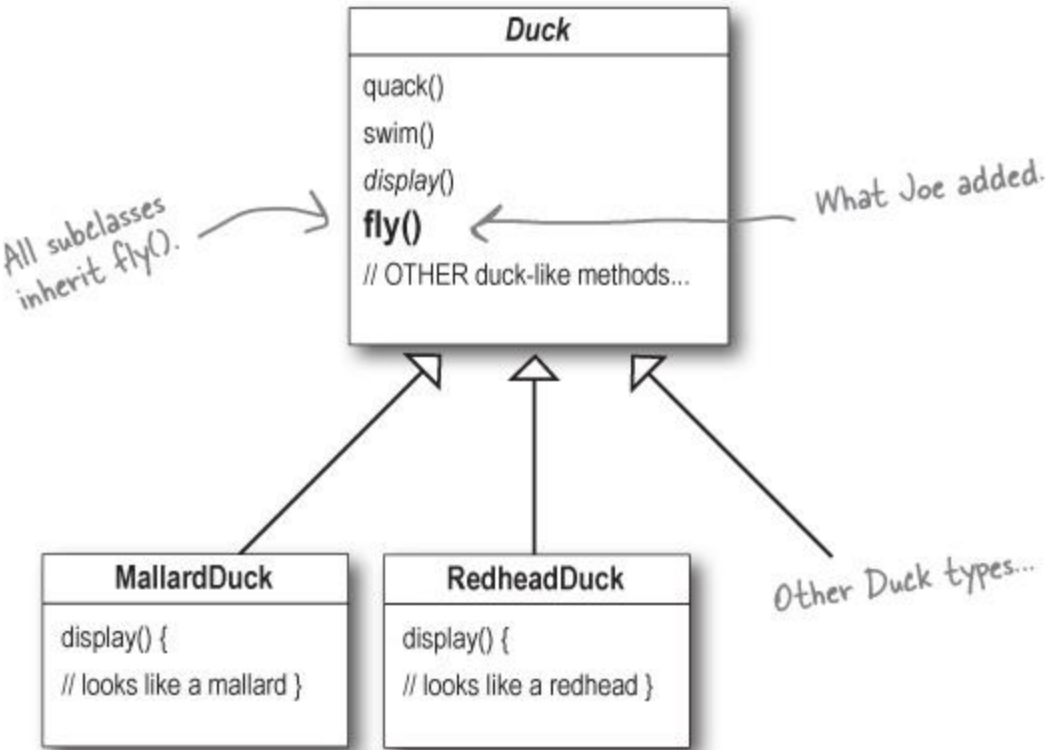




Change Request Comes in

- In the last year, the company has been under increasing pressure from competitors... They need something *really* impressive to show at the upcoming shareholders meeting in Maui *next week*.
- The executives decided that flying ducks is just what the simulator needs to blow away the other duck sim competitors. And of course Joe’s manager told them it’ll be no problem for Joe to just whip something up in a week. “After all,” said Joe’s boss, “he’s an OO programmer... *how hard can it be?”*

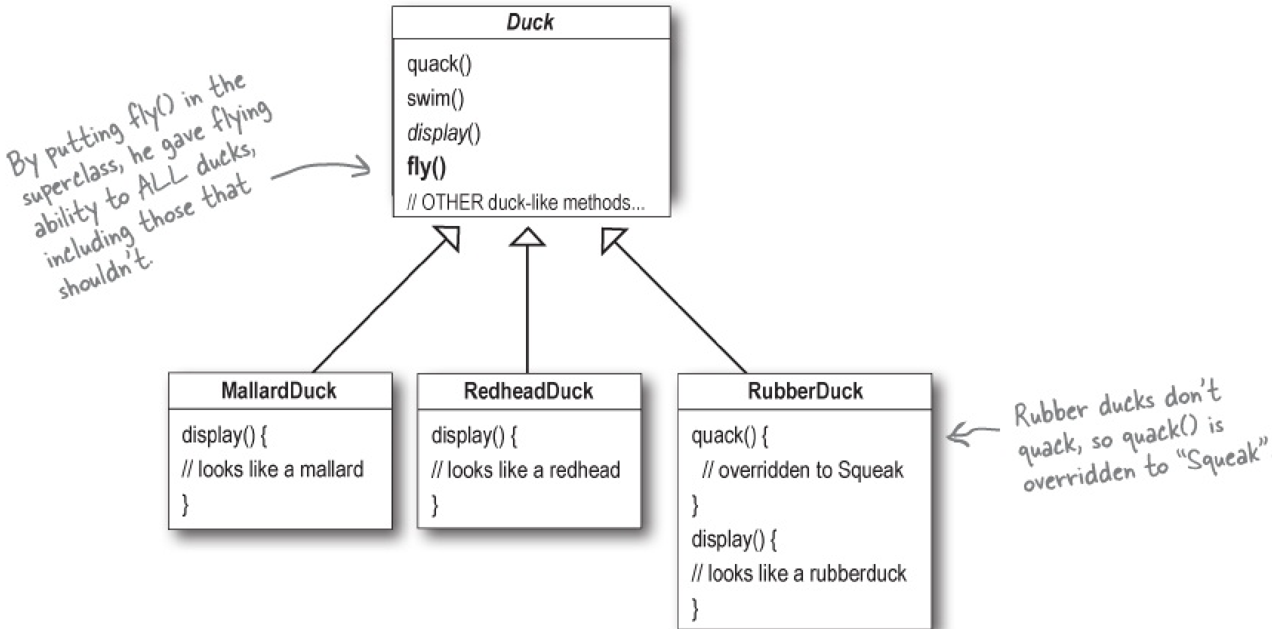
Implementing Change Request



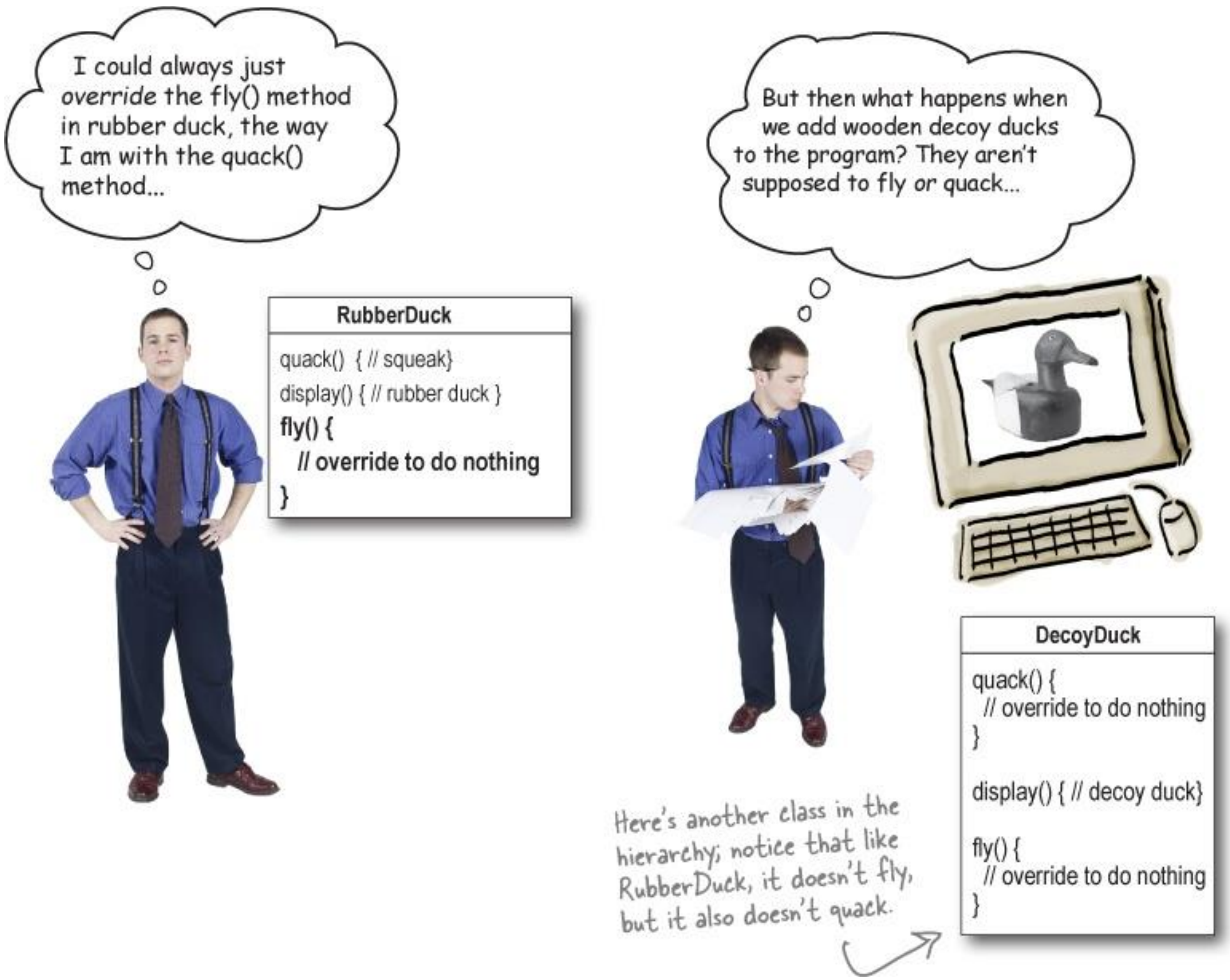
Problem

Joe failed to notice that not *all* subclasses of Duck should *fly*. When Joe added new behavior to the Duck superclass, he was also adding behavior that was *not* appropriate for some Duck subclasses. He now has flying inanimate objects in the SimUDuck program.

A localized update to the code caused a nonlocal side effect (flying rubber ducks)!

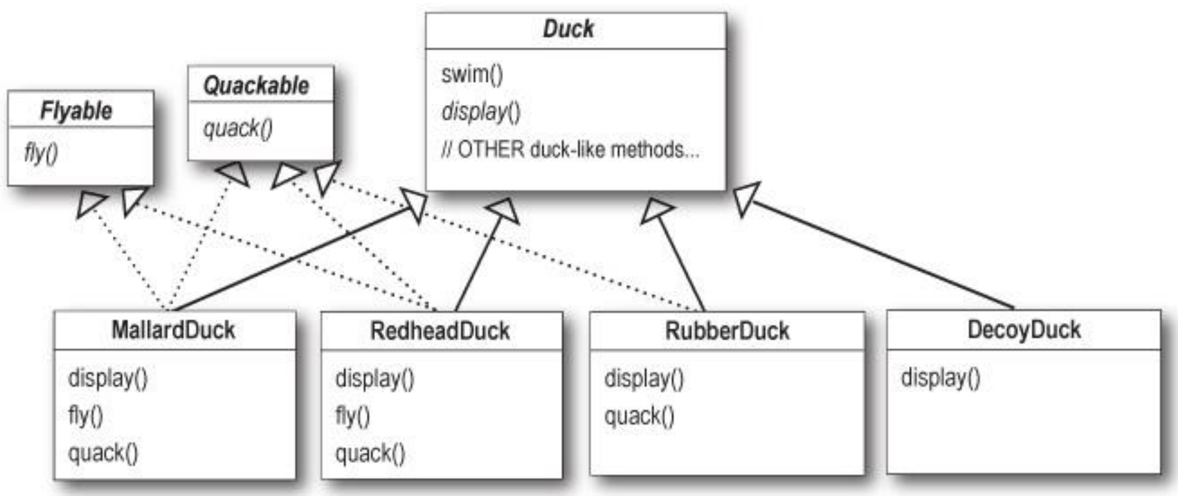


Easy Fix?



I could always just override the fly() method in rubber duck, the way I am with the quack() method...
RubberDuck
quack() { // squeak}
display() { // rubber duck }
fly() {
// override to do nothing
}
But then what happens when we add wooden decoy ducks to the program? They aren't supposed to fly or quack...
DecoyDuck
quack() {
// override to do nothing
}
display() { // decoy duck}
fly() {
// override to do nothing
}
Here's another class in the hierarchy; notice that like RubberDuck, it doesn't fly, but it also doesn't quack.

Interfaces?



What do you think about this design?

Interfaces

We know that not *all* of the subclasses should have flying or quacking behavior, so inheritance isn't the right answer. But while having the subclasses implement Flyable and/or Quackable solves *part* of the problem (no inappropriately flying rubber ducks), it completely destroys code reuse for those behaviors, so it just creates a *different* maintenance nightmare. And of course there might be more than one kind of flying behavior even among the ducks that *do* fly.

WHAT WOULD YOU DO IF YOU WERE JOE?

We have to deal with CHANGE

The one constant in software development

Okay, what's the one thing you can always count on in software development?

No matter where you work, what you're building, or what language you are programming in, what's the one true constant that will be with you always?

(use a mirror to see the answer)

No matter how well you design an application, over time an application must grow and change or it will *die*.

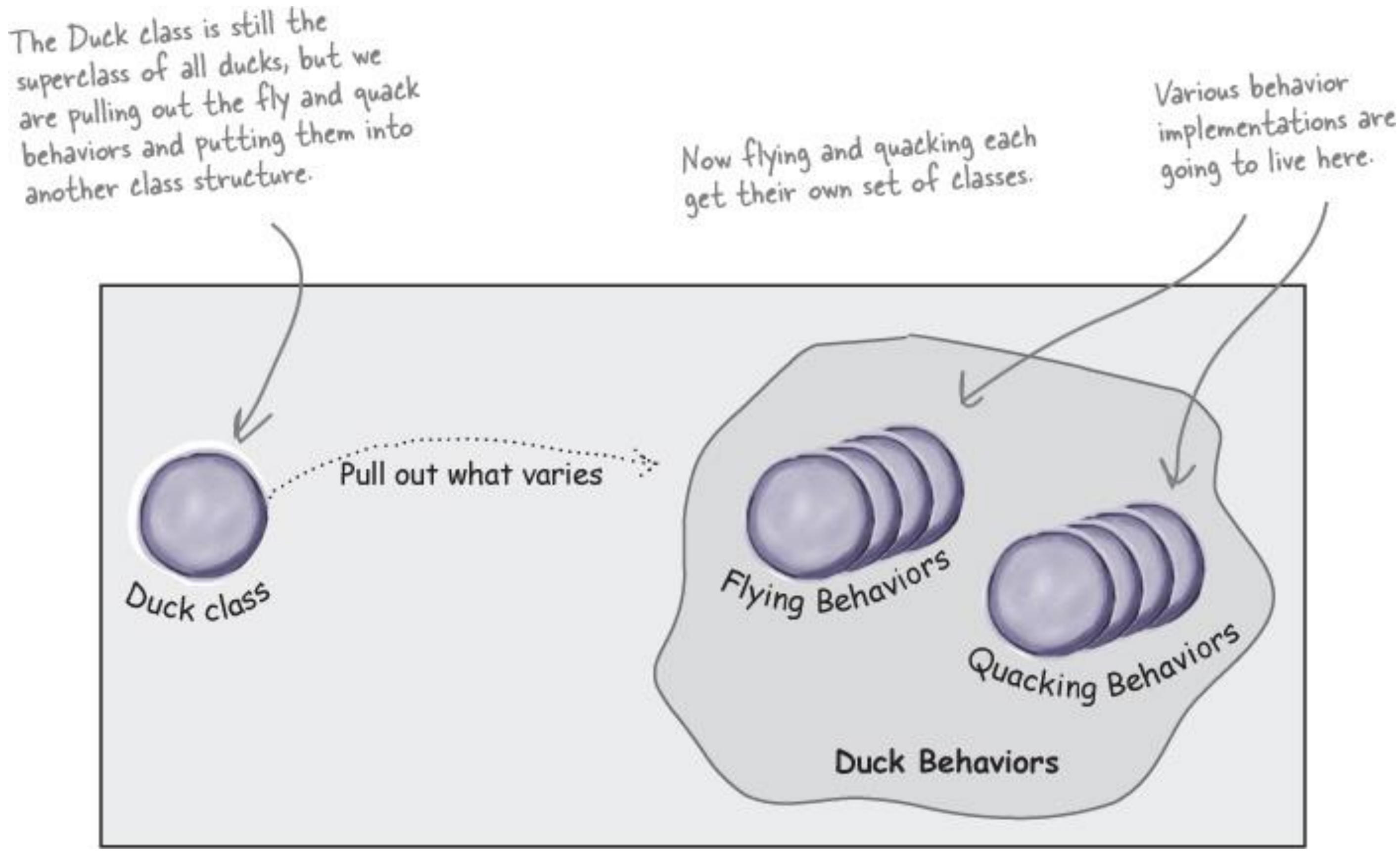
Design Principle

DESIGN PRINCIPLE

Identify the aspects of your application that vary and separate them from what stays the same.

The first of many design principles. We'll spend more time on these throughout the book.

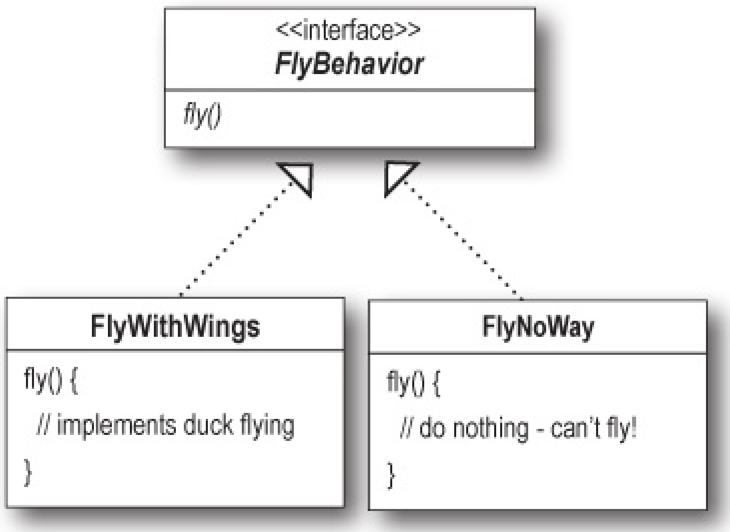
Separating behaviors



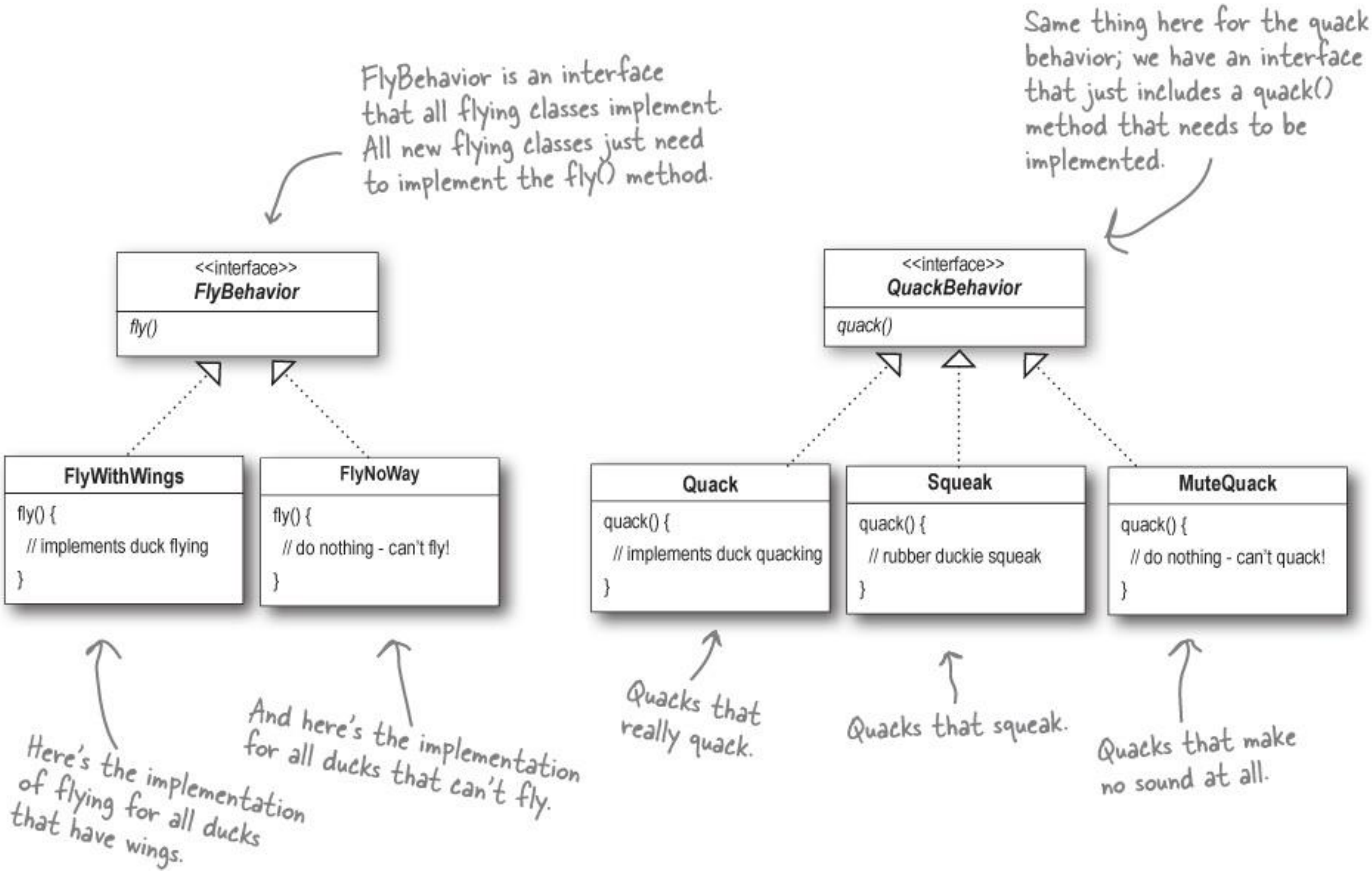
Separating Behaviours

DESIGN PRINCIPLE

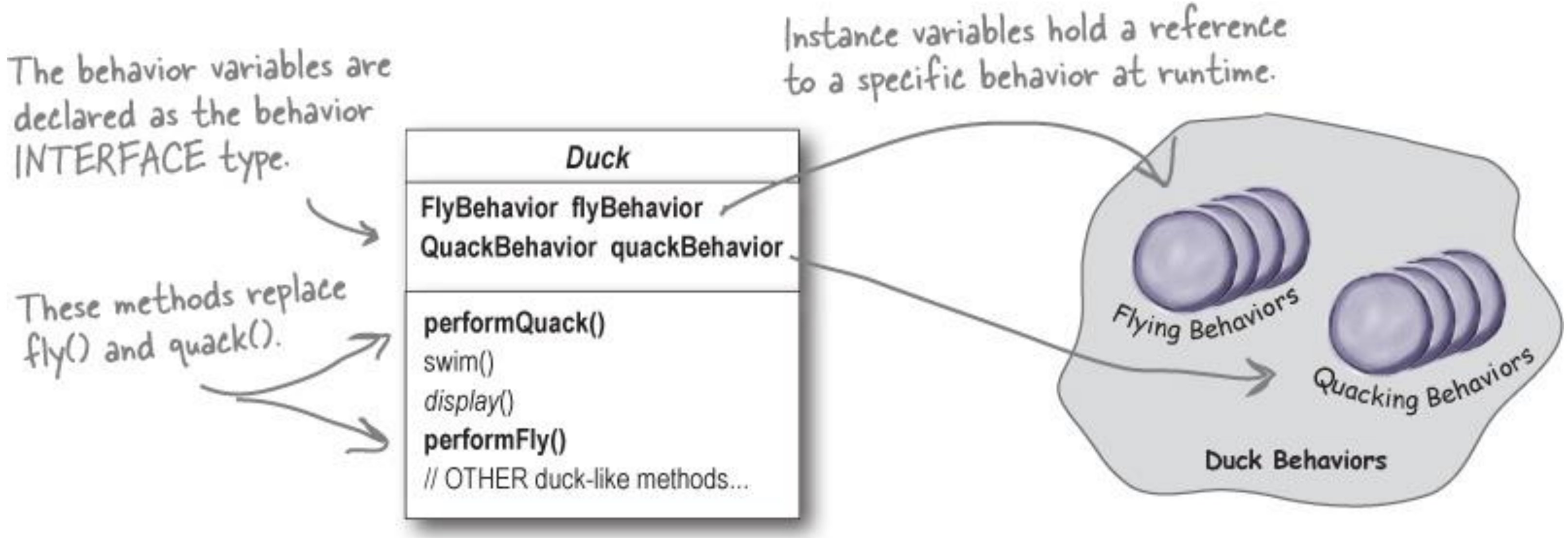
Program to an interface, not an implementation.



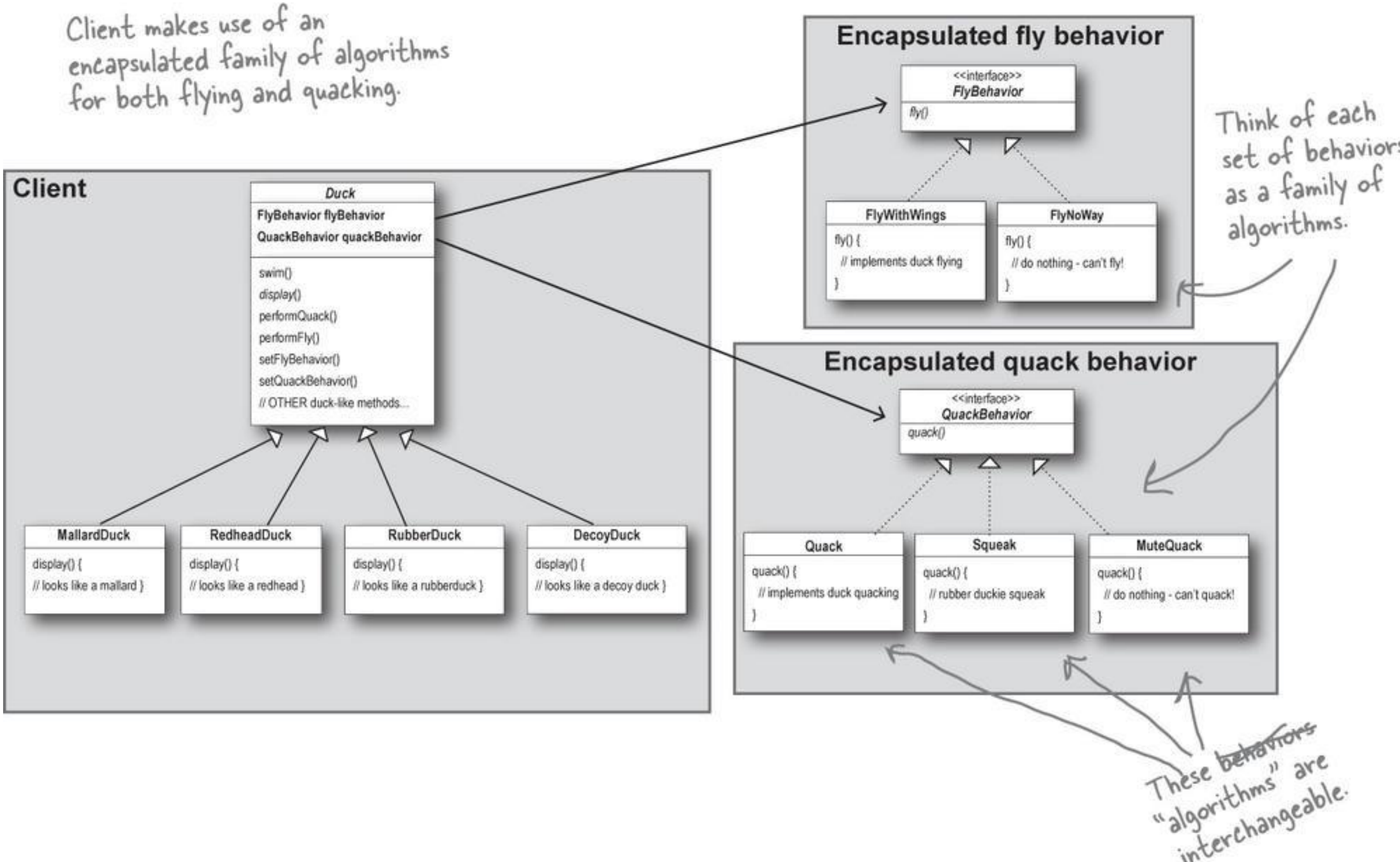
Implementing Duck Behavior



Combining behaviors with the duck



The Big Picture



Implementation

NOTE

With this design, other types of objects can reuse our fly and quack behaviors because these behaviors are no longer hidden away in our Duck classes!

And we can add new behaviors without modifying any of our existing behavior classes or touching any of the Duck classes that use flying behaviors.

So we get the benefit of REUSE without all the baggage that comes along with inheritance.

```
public class Duck {
    QuackBehavior quackBehavior;
    // more

    public void performQuack() {
        quackBehavior.quack();
    }
}
```

Each Duck has a reference to something that implements the QuackBehavior interface.

Rather than handling the quack behavior itself, the Duck object delegates that behavior to the object referenced by quackBehavior.

Duck Class

```
public abstract class Duck {

    FlyBehavior flyBehavior;
    QuackBehavior quackBehavior;
    public Duck() {
    }

    public abstract void display();

    public void performFly() {
        flyBehavior.fly();
    }

    public void performQuack() {
        quackBehavior.quack();
    }

    public void swim() {
        System.out.println("All ducks float, even decoys!");
    }
}
```

Declare two reference variables for the behavior interface types. All duck subclasses (in the same package) inherit these.

Delegate to the behavior class.

```
public interface FlyBehavior {
    public void fly();
}
```

The interface that all flying behavior classes implement.

```
public class FlyWithWings implements FlyBehavior {
    public void fly() {
        System.out.println("I'm flying!!");
    }
}
```

Flying behavior implementation for ducks that DO fly...

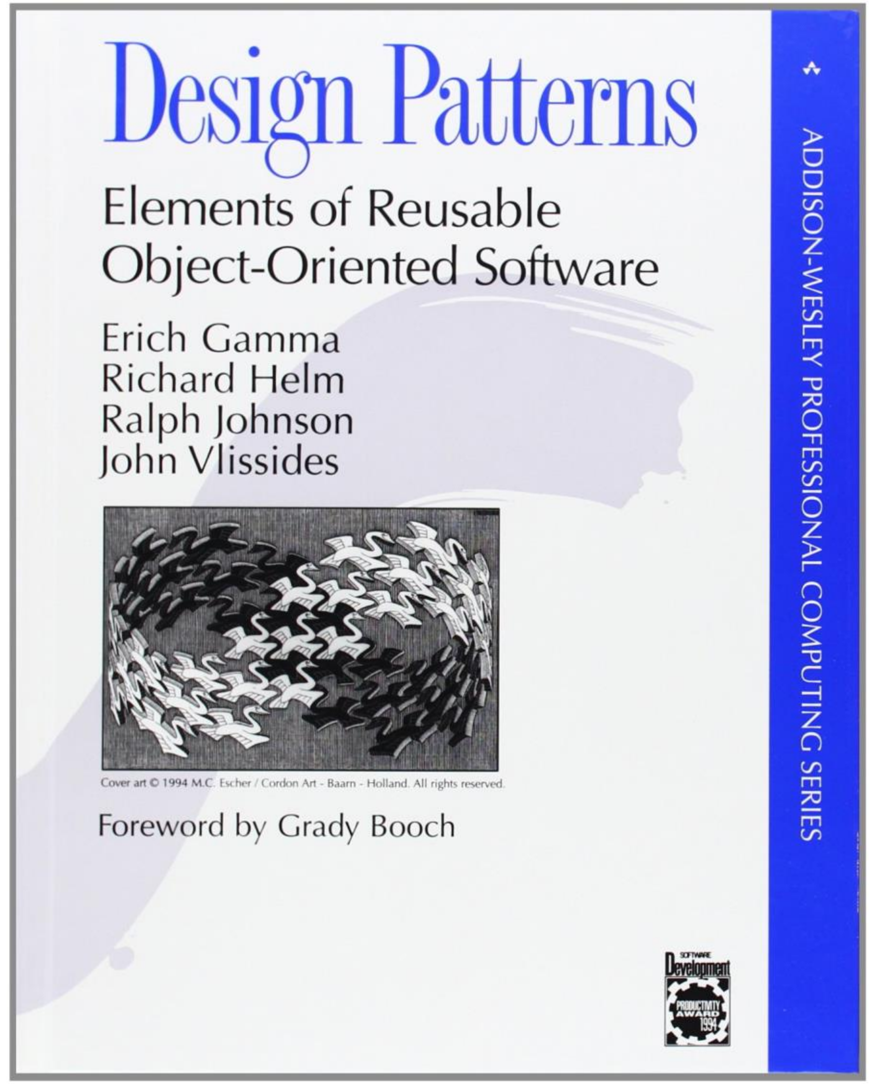
```
public class FlyNoWay implements FlyBehavior {
    public void fly() {
        System.out.println("I can't fly");
    }
}
```

Flying behavior implementation for ducks that do NOT fly (like rubber ducks and decoy ducks).

Additional Design Heuristics

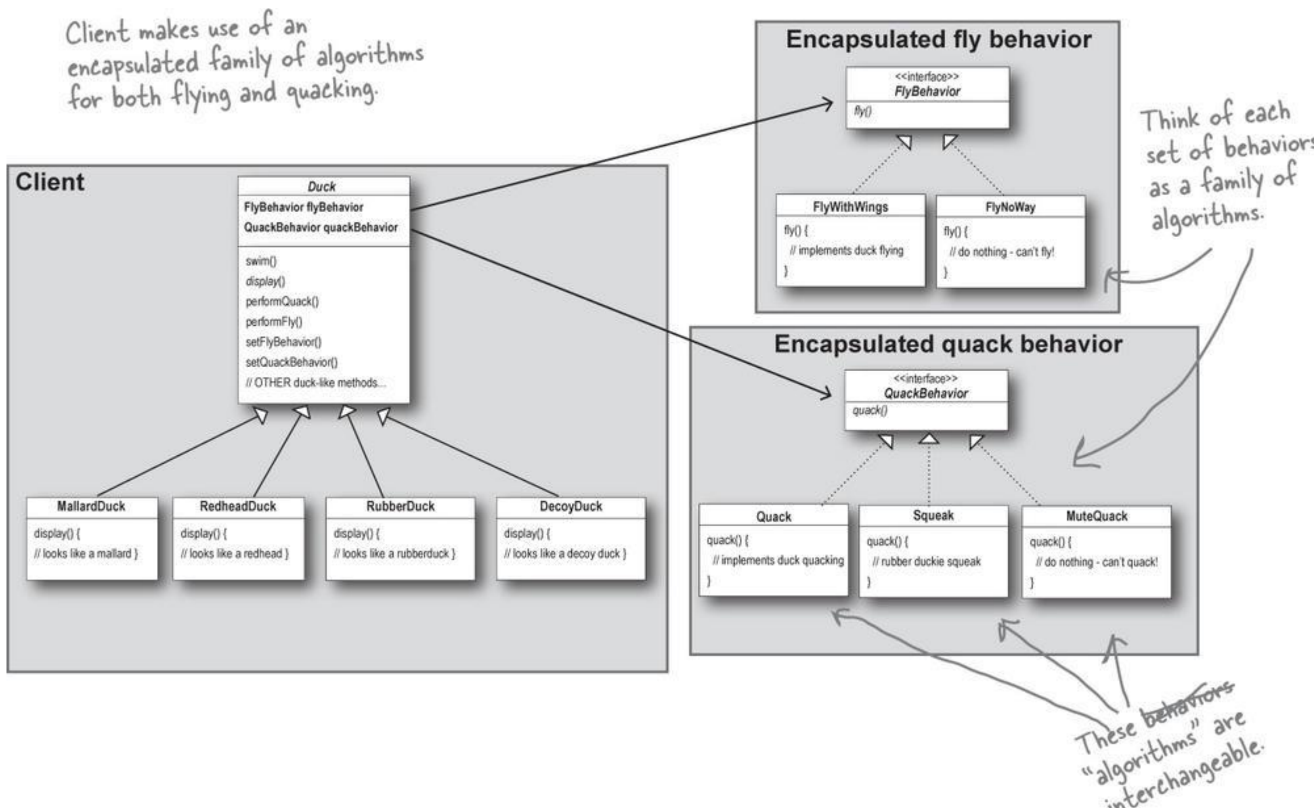
- Never use implementation inheritance, always use interface inheritance
- A subclass should never hide operations implemented in a superclass
- If you are tempted to use implementation inheritance, use delegation instead

Learning Design Patterns



Strategy Pattern

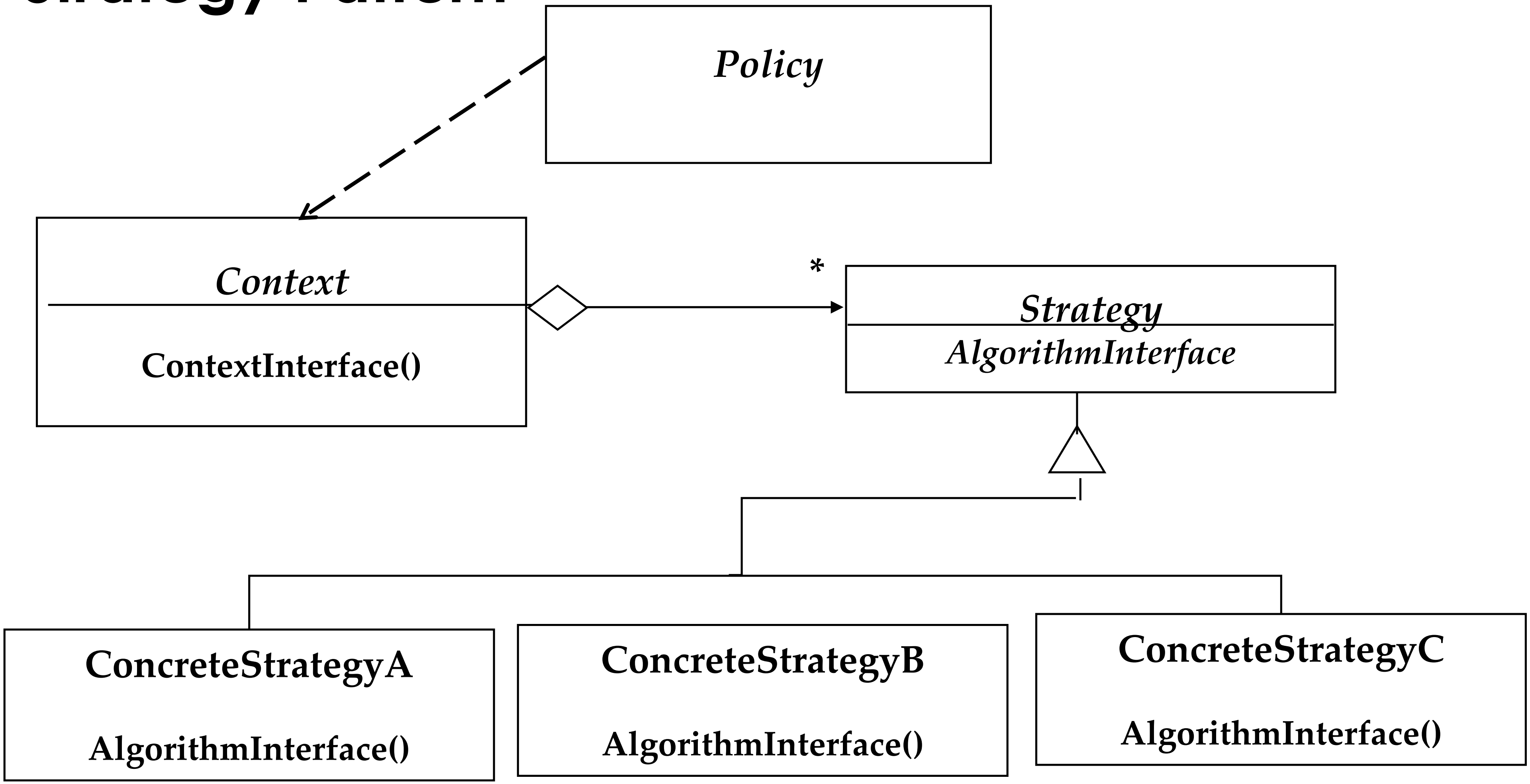
- **The Strategy Pattern** defines a family of algorithms, encapsulates each one, and makes them interchangeable. Strategy lets the algorithm vary independently from clients that use it.



Strategy Pattern

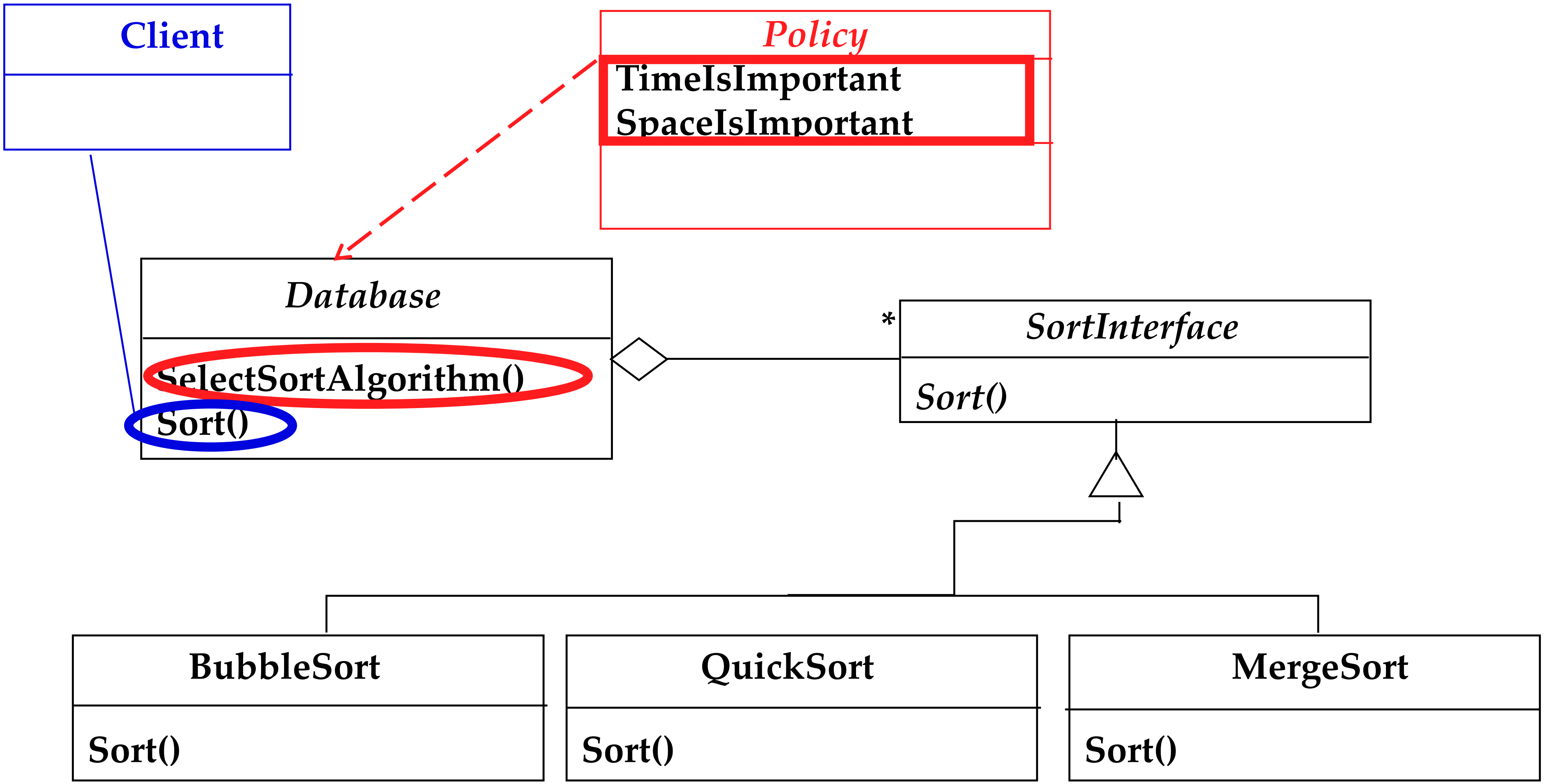
- Different algorithms exists for a specific task
  - We can switch between the algorithms at run time
- Examples of tasks:
  - Different collision strategies for objects in video games
  - Parsing a set of tokens into an abstract syntax tree (Bottom up, top down)
  - Sorting a list of customers (Bubble sort, mergesort, quicksort)
- Different algorithms will be appropriate at different times
  - First build, testing the system, delivering the final product
- If we need a new algorithm, we can add it without disturbing the application or the other algorithms.

Strategy Pattern

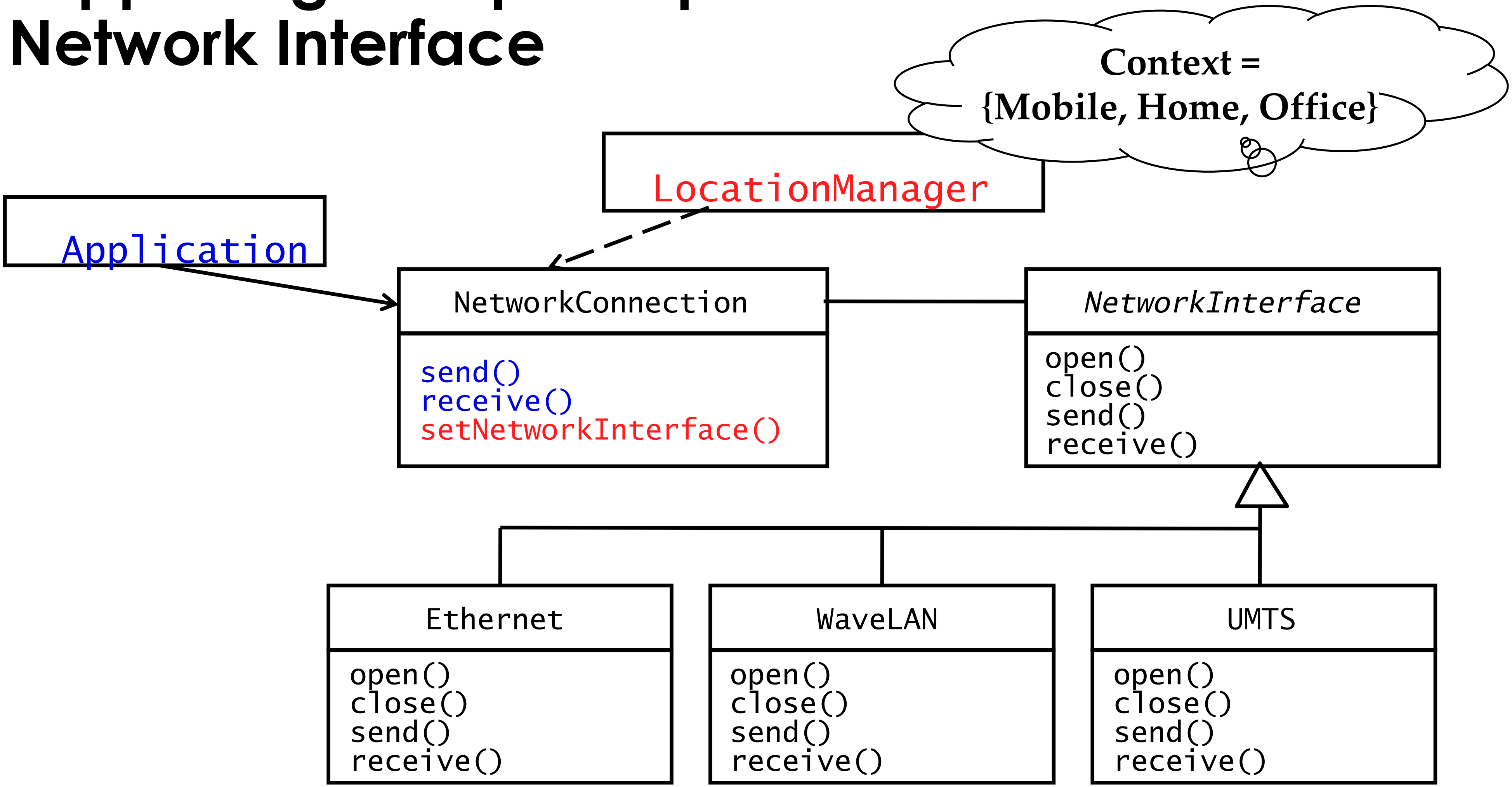


Policy decides which ConcreteStrategy is best in the current Context.

Using a Strategy Pattern to Decide between Algorithms at Runtime



Supporting Multiple implementations of a Network Interface



A Game: Get-15

- Start with the nine numbers 1,2,3,4, 5, 6, 7, 8 and 9.
- You and your opponent take alternate turns, each taking a number
- Each number can be taken only once: If you opponent has selected a number, you cannot also take it.
- The first person to have any three numbers that total 15 wins the game.
- Example:

You:	**1**	**5**	**3**	**8**	
Opponent:	**6**	**9**	**7**	**2**	**Opponent Wins!**

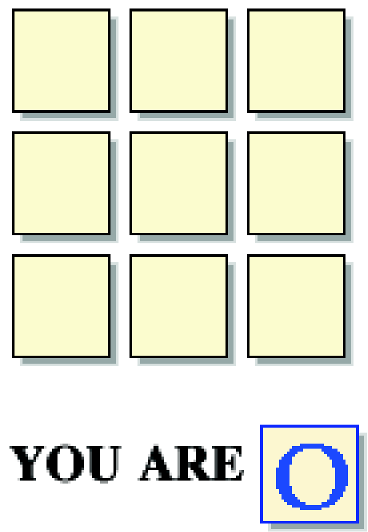
Characteristics of Get-15

- Hard to play,
- The game is especially hard, if you are not allowed to write anything done.

- Why?
  - All the numbers need to be scanned to see if you have won/lost
  - It is hard to see what the opponent will take if you take a certain number
  - The choice of the number depends on all the previous numbers

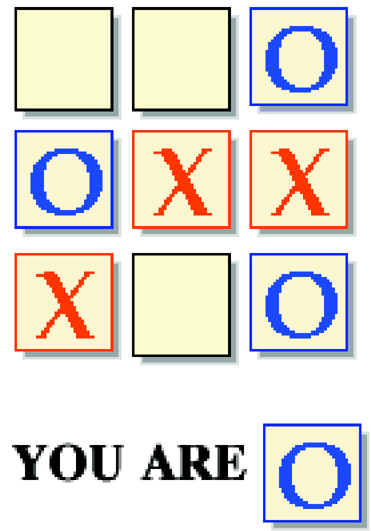
  - Not easy to devise an simple strategy

Another Game: Tic-Tac-Toe

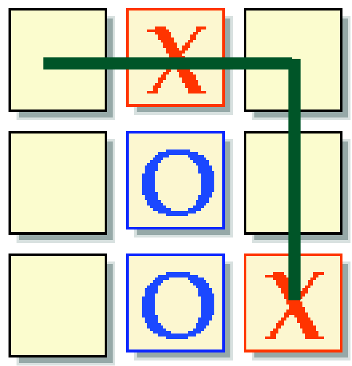


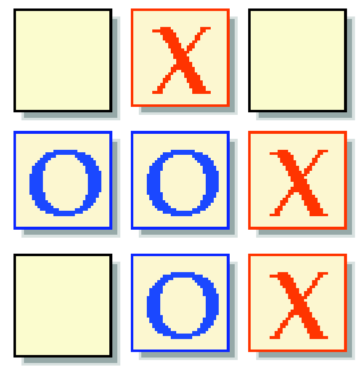
Source: http://boulter.com/ttt/index.cgi

A Draw Sitation

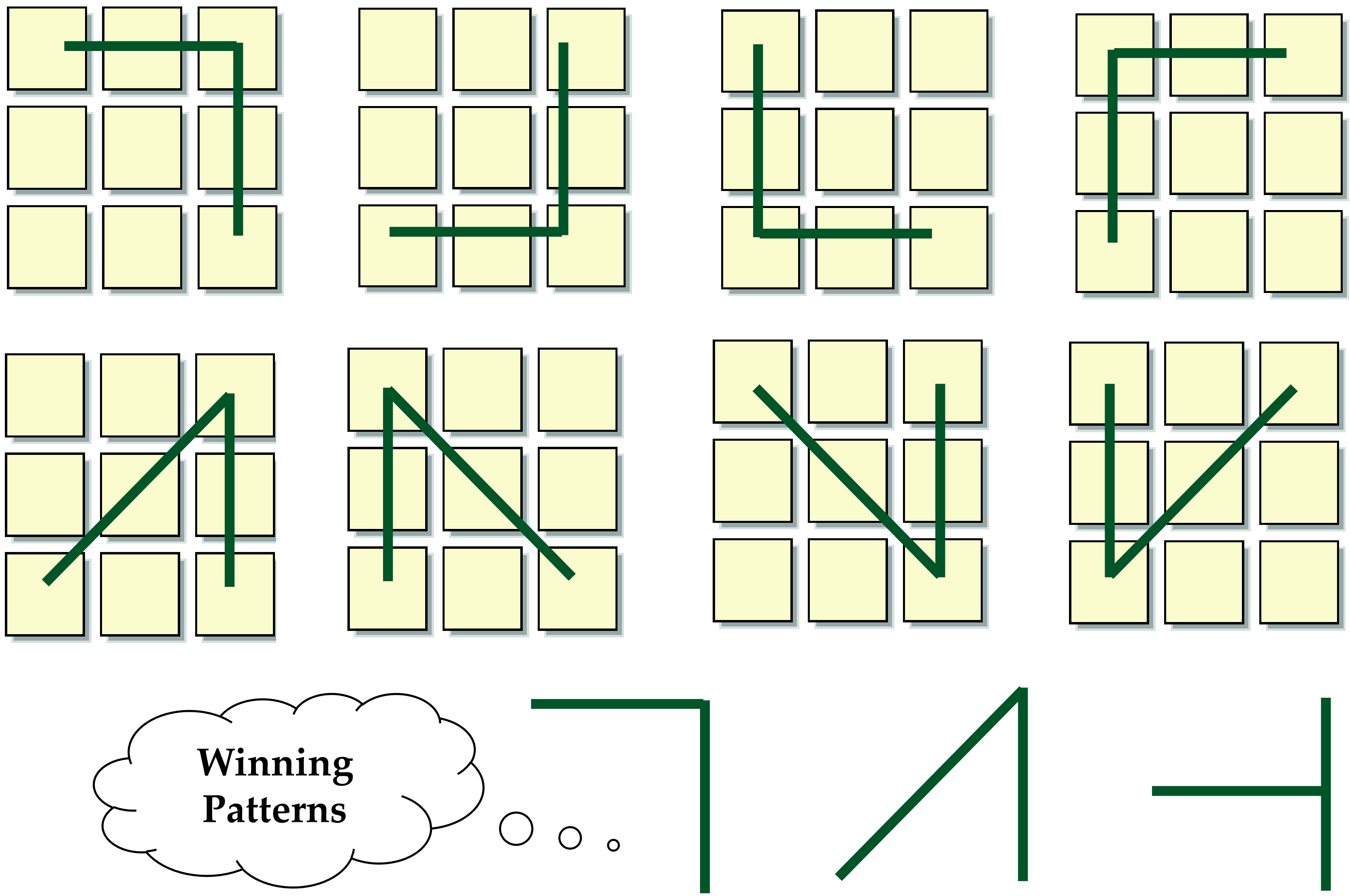


Strategy for determining a winning move





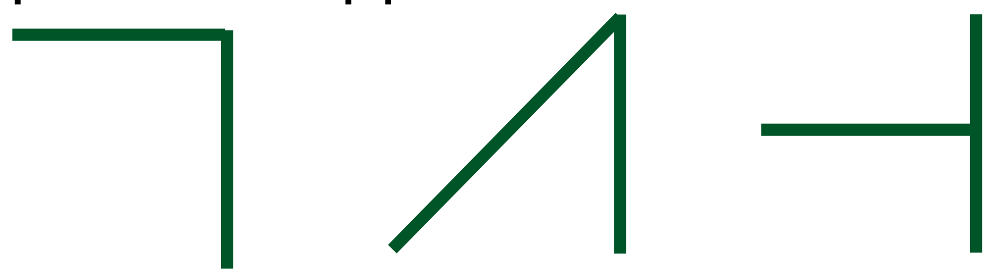
Winning Situations for Tic-Tac-Toe



Tic-Tac-Toe is "Easy"

Why? Reduction of complexity through patterns and symmetries.

Patterns: Knowing the following three patterns, the player can anticipate the opponents move.



Symmetries:

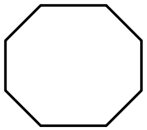
The player needs to remember only these three patterns to deal with 8 different game situations

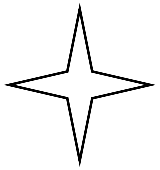
The player needs to memorize only 3 opening moves and their responses.

Get-15 and Tic-Tac-Toe are identical problems

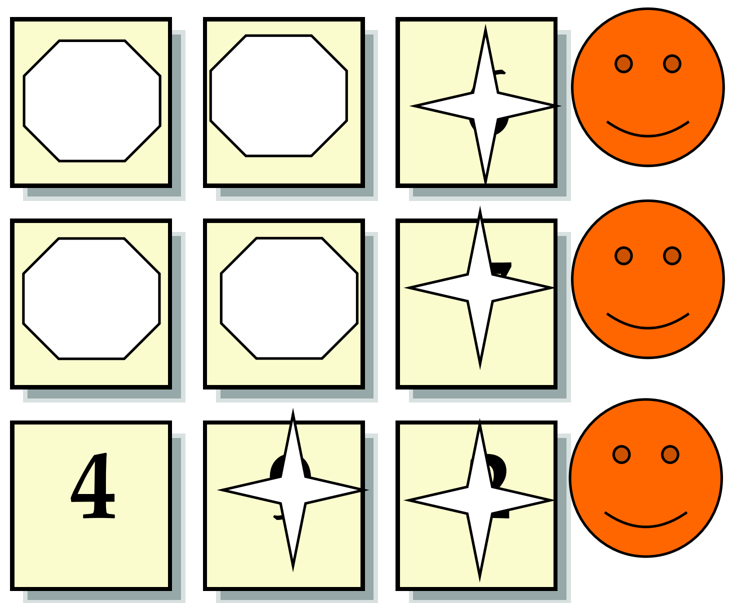
- Any three numbers that solve the 15 problem also solve tic-tac-toe.
- Any tic-tac-toe solution is also a solution the 15 problem
- To see the relationship between the two games, we simply arrange the 9 digits into the following pattern

8	1	6
3	5	7
4	9	2

 **You:** 1 5 3 8

 **Opponent:** 6 9 7 2

8	1	6
3	5	7
4	9	2



What is this?

1.Nf3 d5 2.c4 c6 3.b3 Bf5 4.g3 Nf6 5.Bg2 Nbd7 6.Bb2 e6 7.O-O Bd6 8.d3 O-O 9.Nbd2 e5 10.cxd5 cxd5 11.Rc1 Qe7 12.Rc2 a5 13.a4 h6 14.Qa1 Rfe8 15.Rfc1

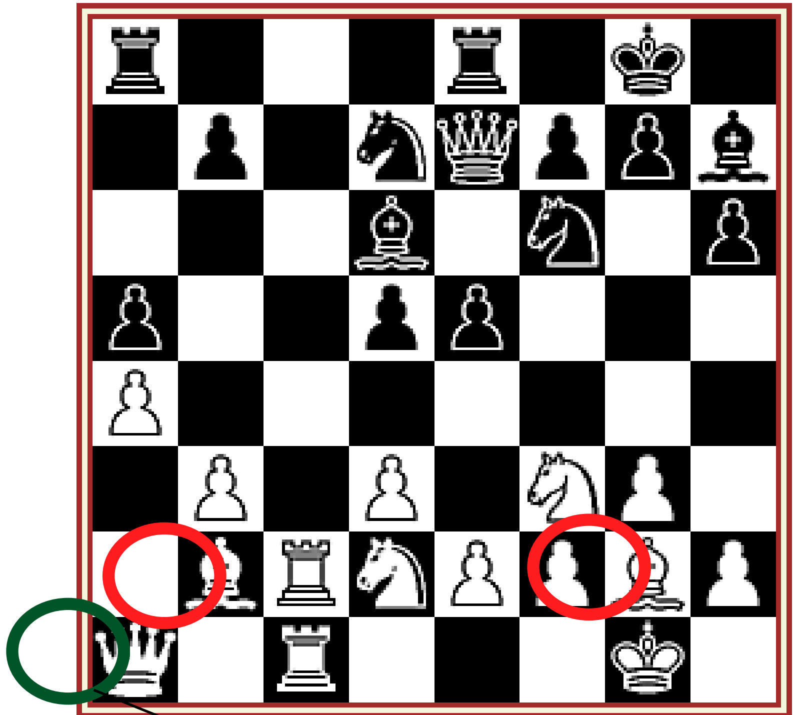
This is a **fianchetto**!

In chess, the fianchetto (Italian: [fjaŋˈkɛtto] "little flank") is a pattern of development wherein a bishop is developed to the second rank of the adjacent knight fil

The fianchetto is a staple of many "hypermodern" openings, whose philosophy is to delay direct occupation of the center with the plan of undermining and destroying the opponent's central outpost.

The fianchetto is one of the basic building-blocks of chess thinking.

Fianchetto (Reti-Lasker)



The diagram is from Reti-Lasker, New York 1924. We can see that Reti has allowed Lasker to occupy the centre but Rtei has fianchettoed both Bishops to hit back at this, and has even backed up his Bb2 with a Queen on a1!

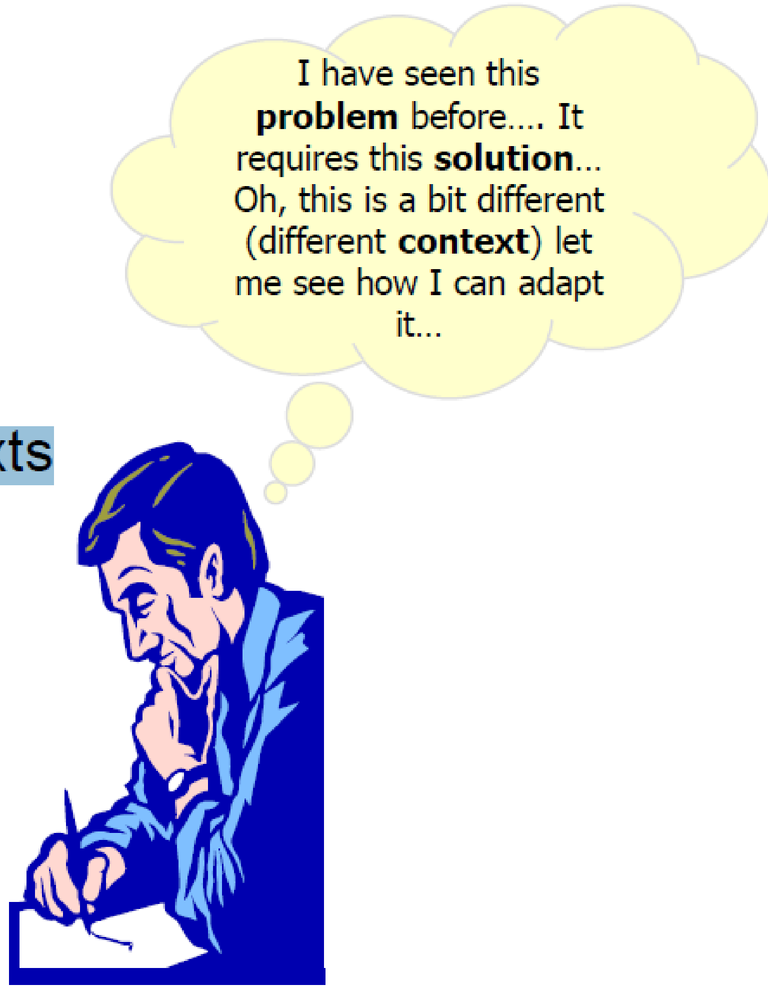
Observations

- Many *problems recur*.
- Many problems have the *same solution structure.*
- Exact solution is dependent on the *context*
- A more experienced person can solve new problems faster and better.

Problem Solving - Expert

- Knows many problems.
- Knows solutions to these problems.
- recalls generic solution when encountering new problems
- Knows various different contexts
- Knows how to apply this knowledge

In short: Expert knows many *patterns*…



Making Patterns – Reusable

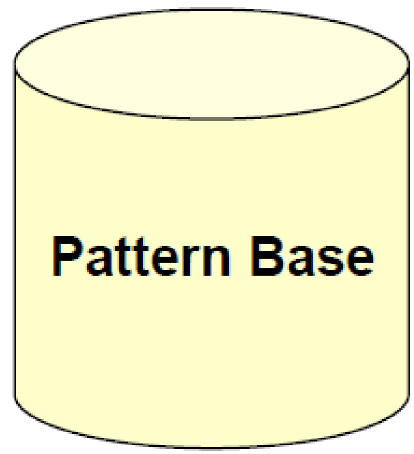
Engineers should aim to capture this valuable *pattern* knowledge

and make this reusable in a catalog

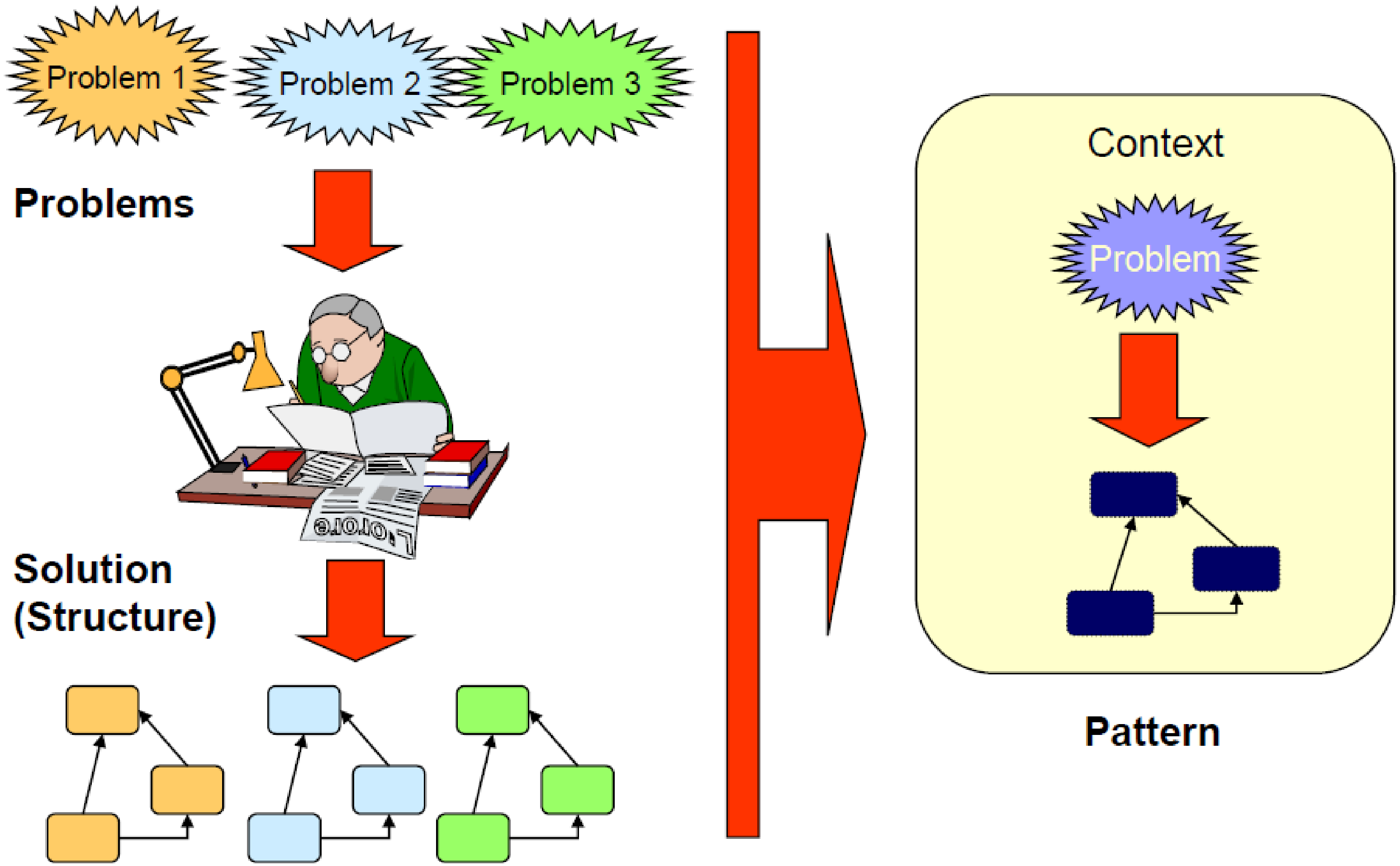
so that other engineers/designers can (re)use these patterns to

build systems

faster and *with quality*



Discovering Patterns



Describing Patterns

Name
- meaningful name

Problem
- statement of the intent/goal

Context
- preconditions and the pattern’s applicability

Forces
- description of relevant forces and constraints

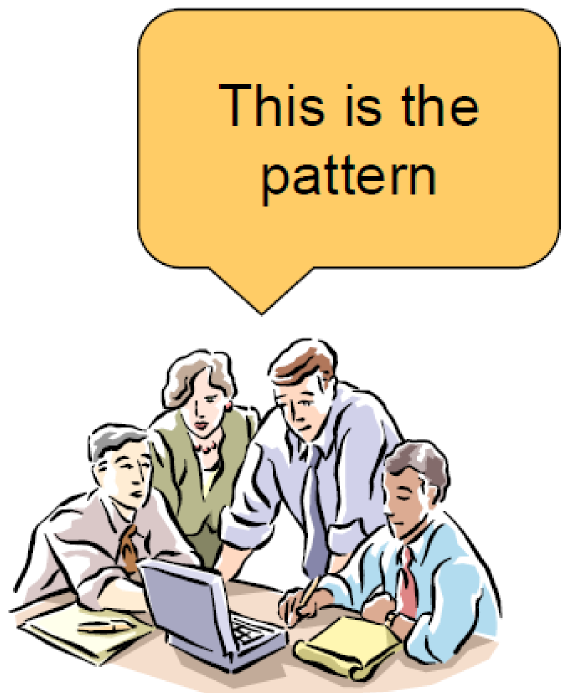
Solution
- a structure

Example
- sample application of the pattern

Consequences
- state of the system after applying the pattern

Rationale

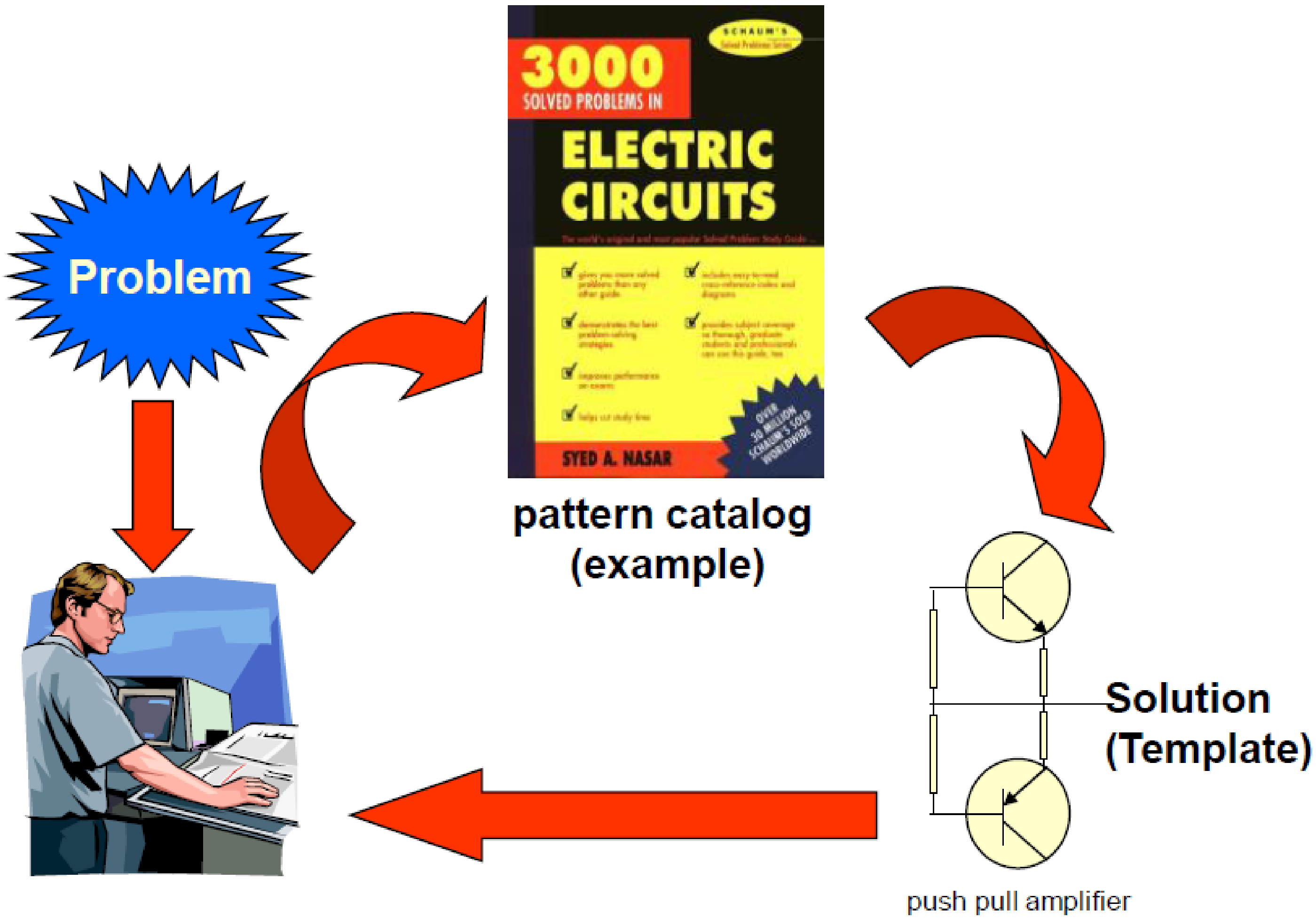
Related Patterns
- static and dynamic relations to other patterns



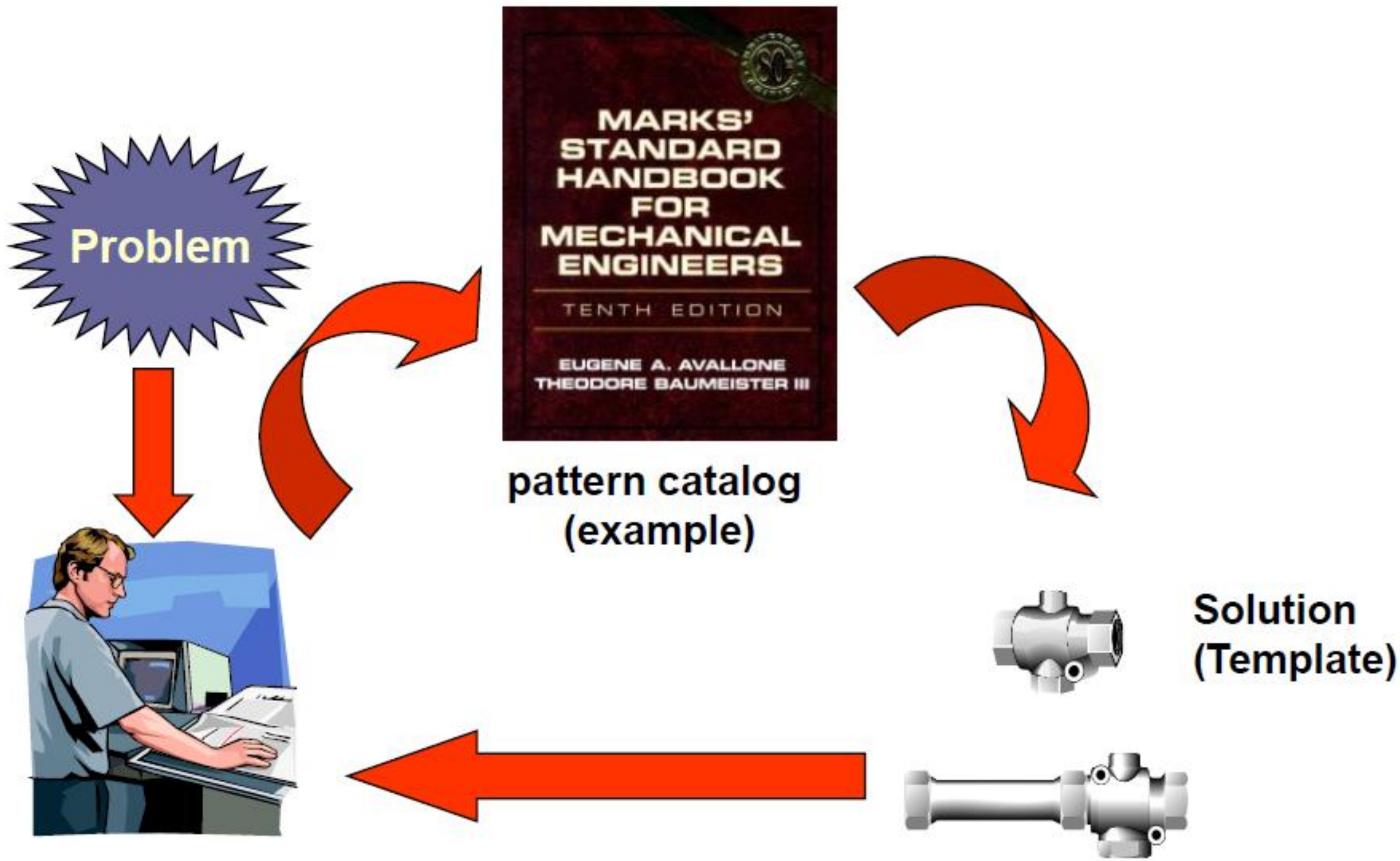
Patterns are not designs

- Pattern is a template/blueprint
- Must be instantiated
  - make design decisions
  - evaluate tradeoffs
- combined with other patterns
- Patterns are reusable abstractions providing solutions for recurring problems
- Patterns are applied in mature engineering
- Patterns can be applied at various abstractions levels
  - architectural
  - design
  - programming

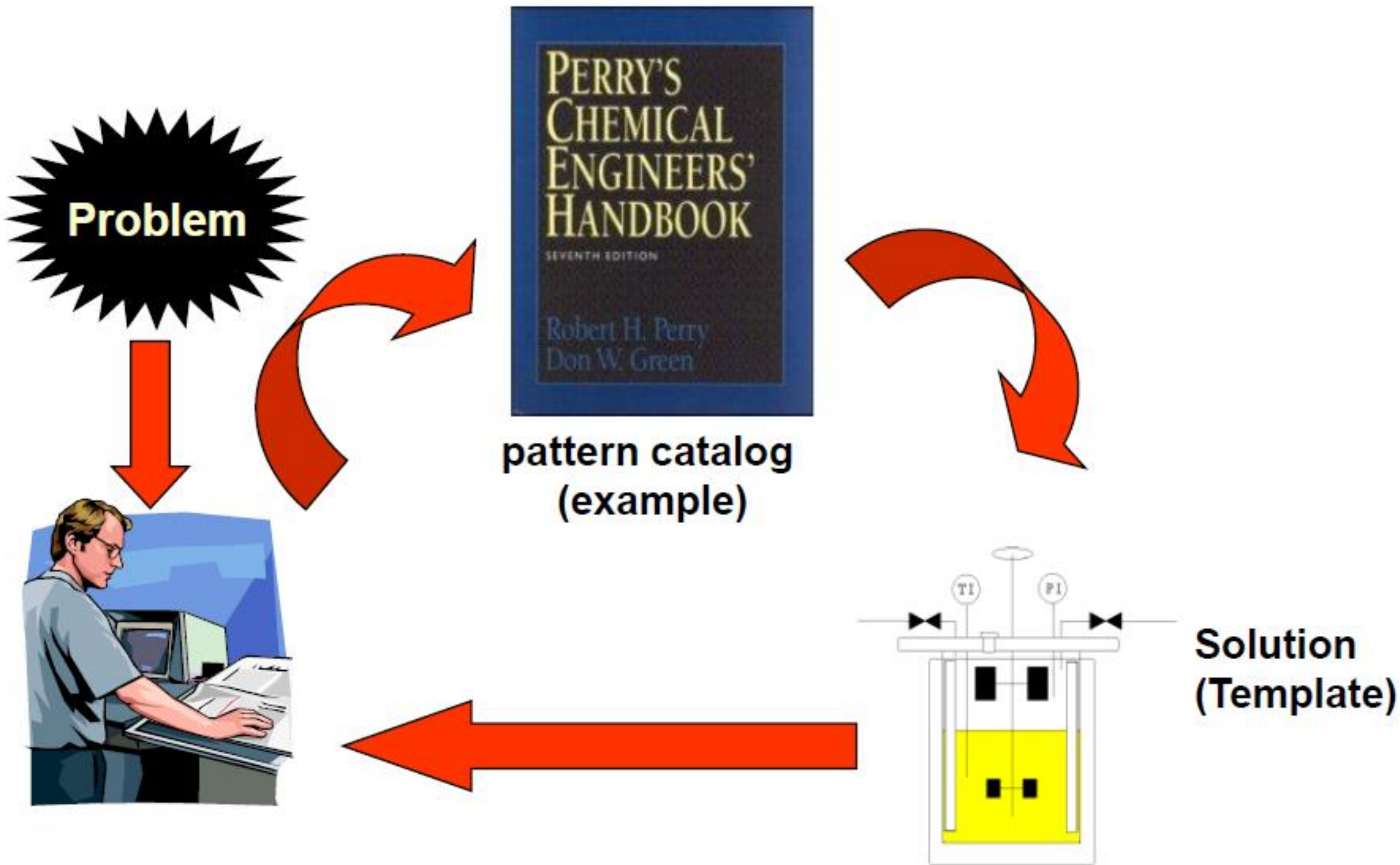
Electrical Engineering Patterns



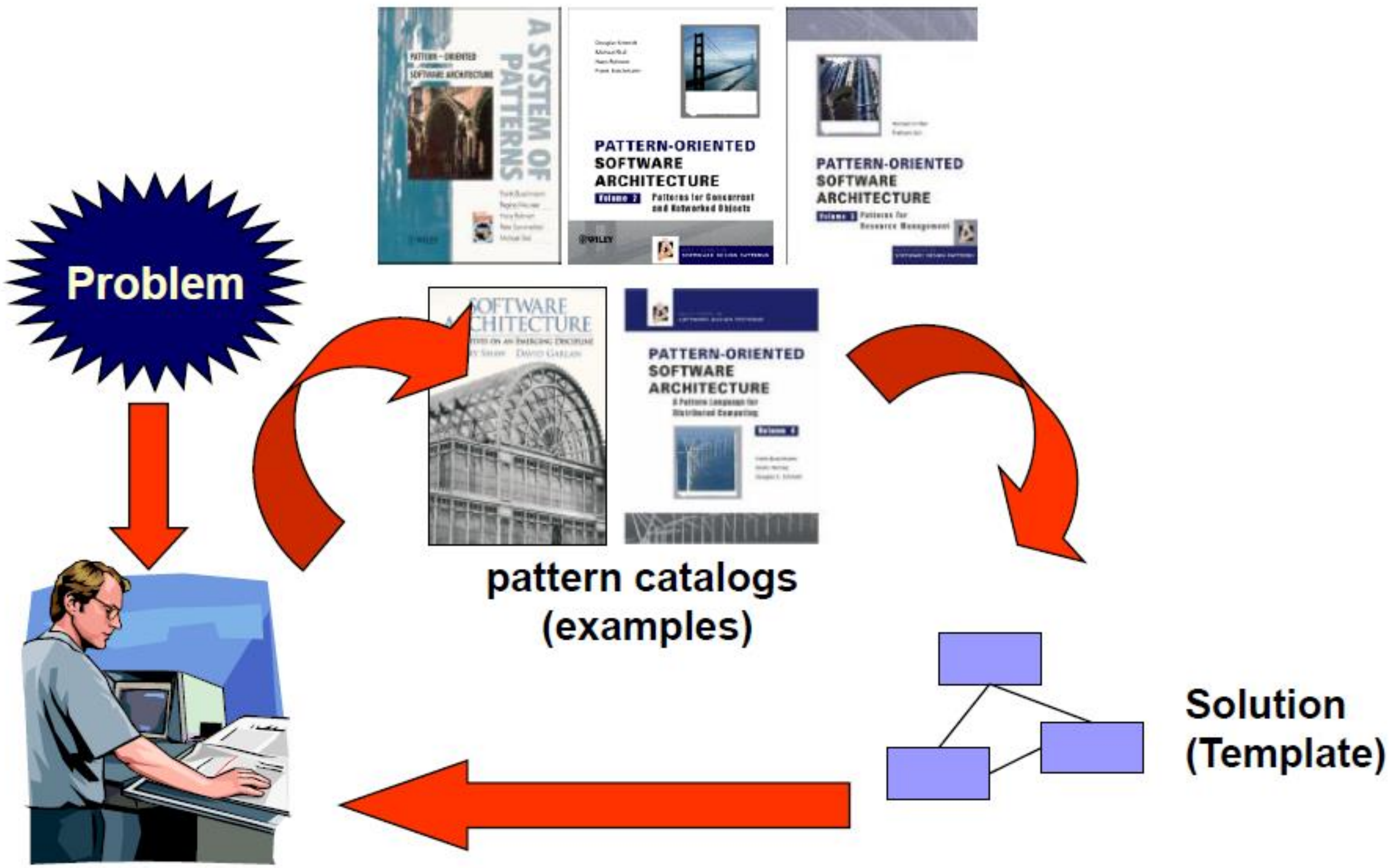
Mechanical Engineering Patterns



Chemical Engineering Patterns



Software Engineering Patterns



Categorization of Software Patterns

- Architectural Patterns (Styles)
- Design Patterns
  - provides schemes for **refining** the architecture.
- Programming Patterns (Idioms)
  - provides schemes for mapping the design to a specific programming language

(Other: Organizational, Analysis, UI Design etc.)

Software Architecture Patterns

Ex: Layers Pattern

Problem: A large system, which is characterized with a mix of low and high level issues, where high-level operations rely on low-level issues:

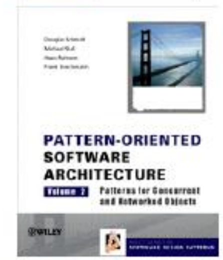
Solution: Structure your system into an appropriate number of layers and place them on top of each other;

express a **fundamental structural organization** schemes for software systems.

provide a set of predefined subsystems

specify their responsibilities

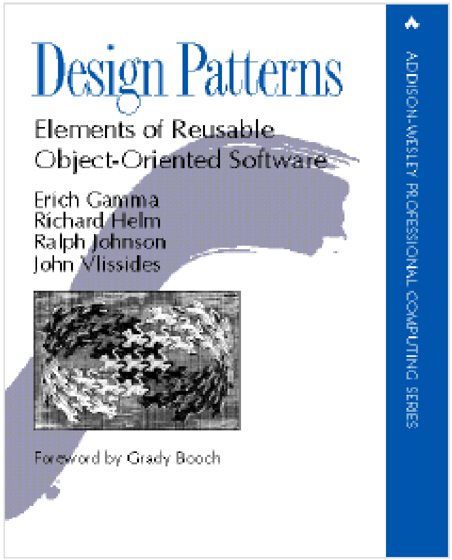
and include rules and guidelines for organizing the relationships between them



Software Design Patterns

Design Patterns: Elements of Reusable Object-Oriented Software, Gamma et al., 1995

A *design pattern* provides a scheme for refining the architectural entities of a software system. It describes commonly recurring structure of communicating components that solves a general design problem within a particular context.



23 object-oriented design patterns

Design pattern community

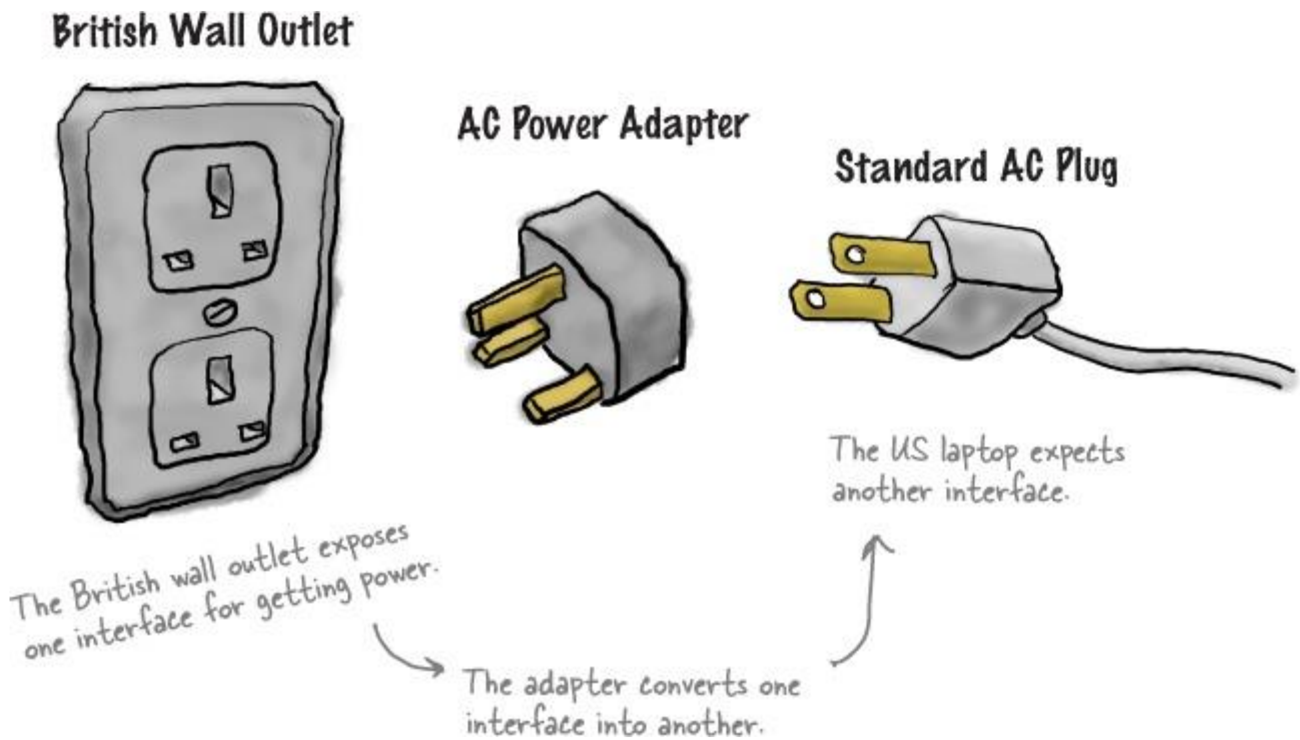
- http://hillside.net/patterns/

PLOP conferences/workshops

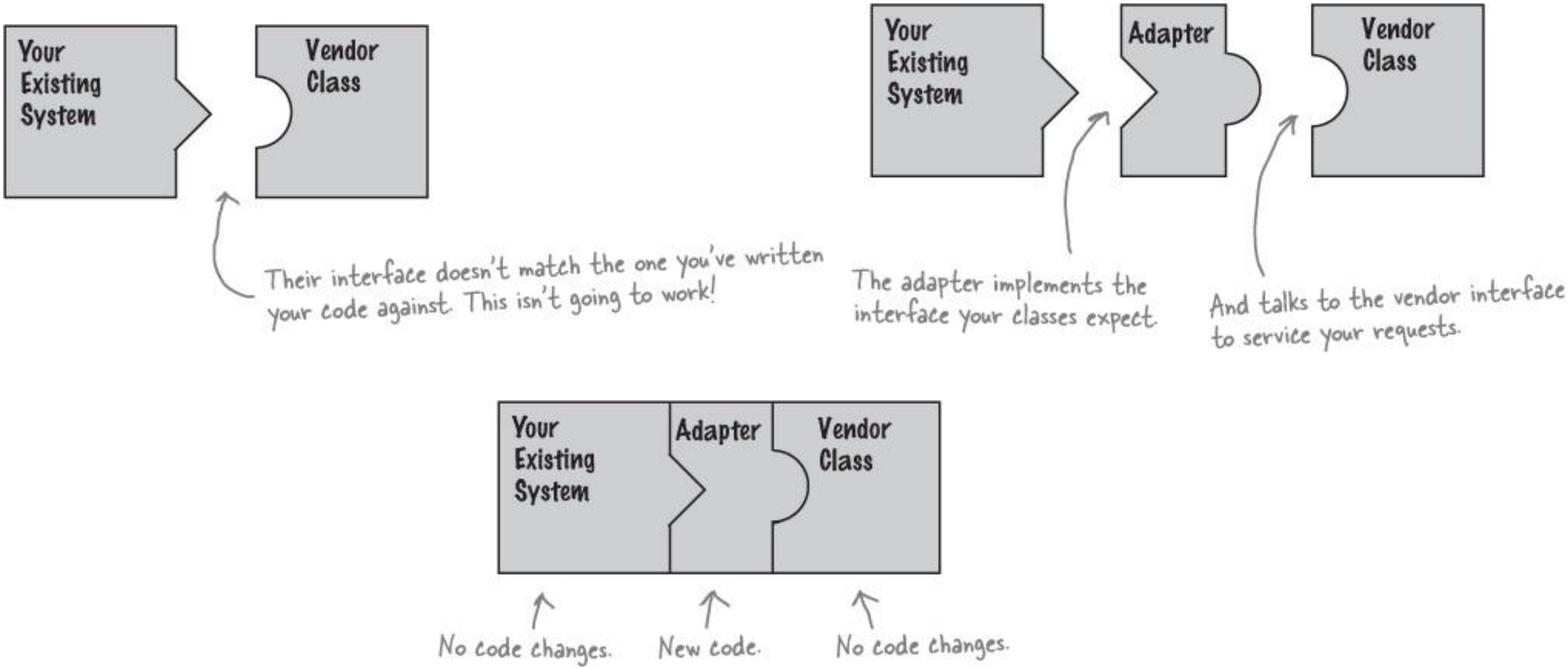
THE 23 GANG OF FOUR DESIGN PATTERNS

C	Abstract Factory
S	Adapter
S	Bridge
C	Builder
B	Chain of Responsibility
B	Command
S	Composite
S	Decorator
S	Facade
C	Factory Method
S	Flyweight
B	Interpreter
B	Iterator
B	Mediator
B	Memento
C	Prototype
S	Proxy
B	Observer
C	Singleton
B	State
B	Strategy
B	Template Method
B	Visitor

Adapter Pattern

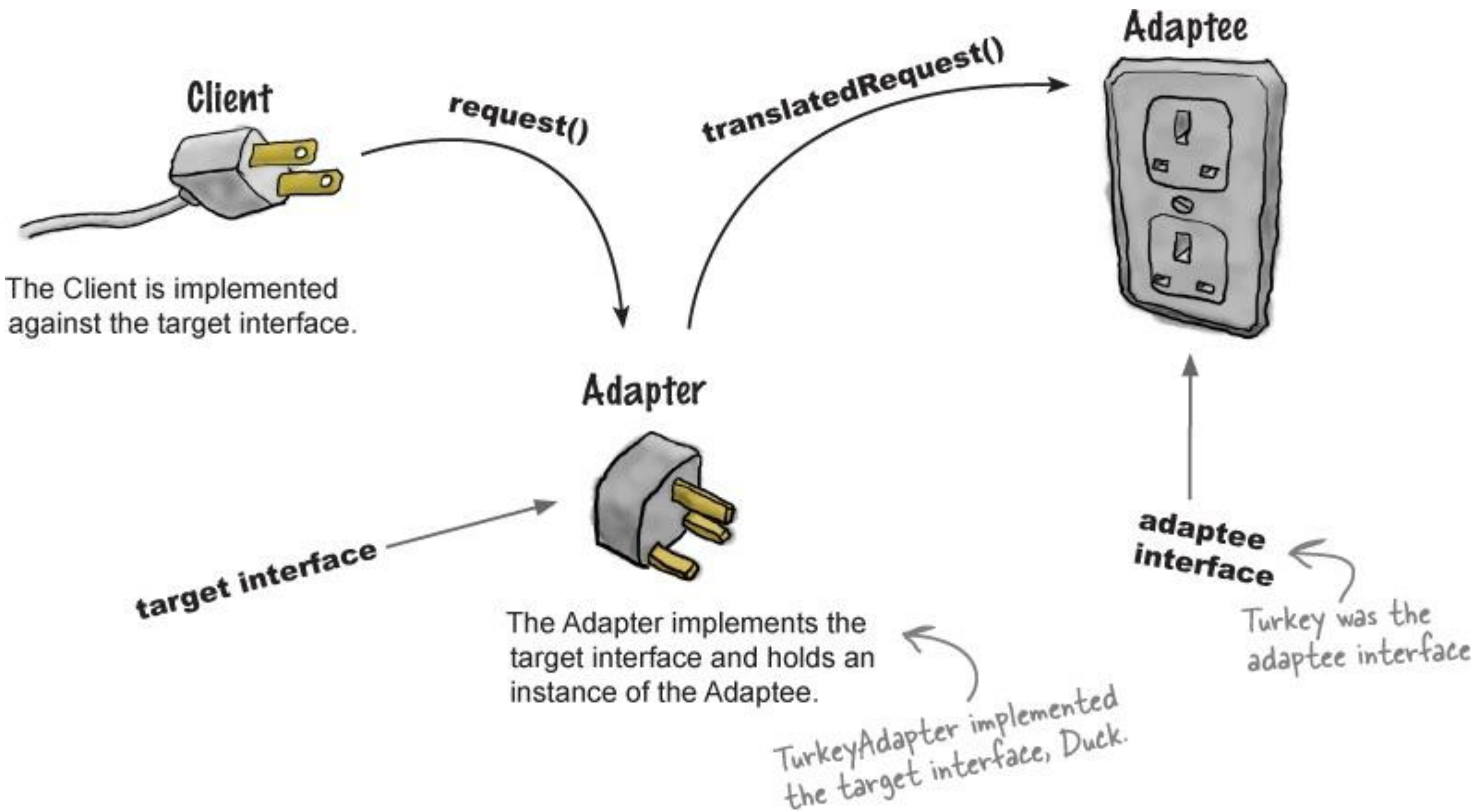


Object Oriented Adapters



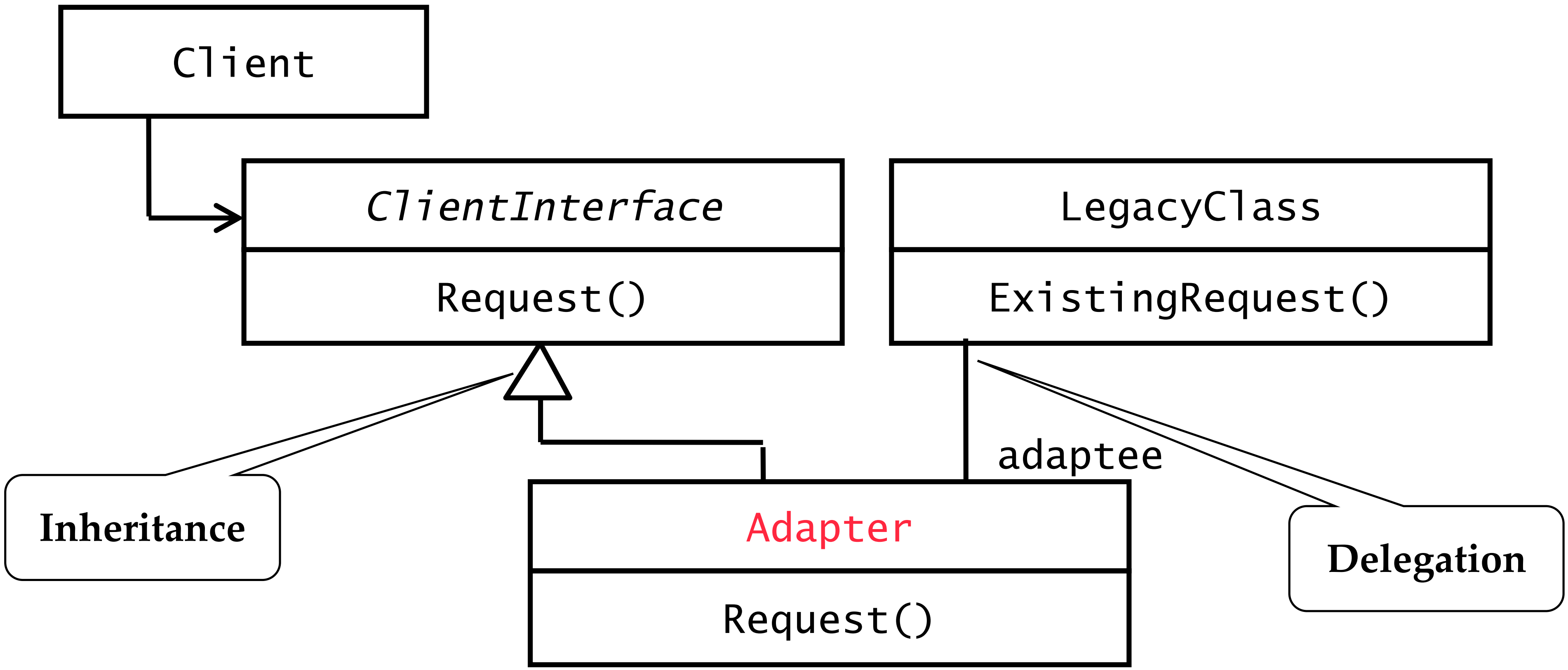
Can you think of a solution that doesn't require YOU to write ANY additional code to integrate the new vendor classes? How about making the vendor supply the adapter class?

The Adapter Pattern Explained



① The client makes a request to the adapter by calling a method on it using the target interface.
② The adapter translates the request into one or more calls on the adaptee using the adaptee interface.
③ The client receives the results of the call and never knows there is an adapter doing the translation.

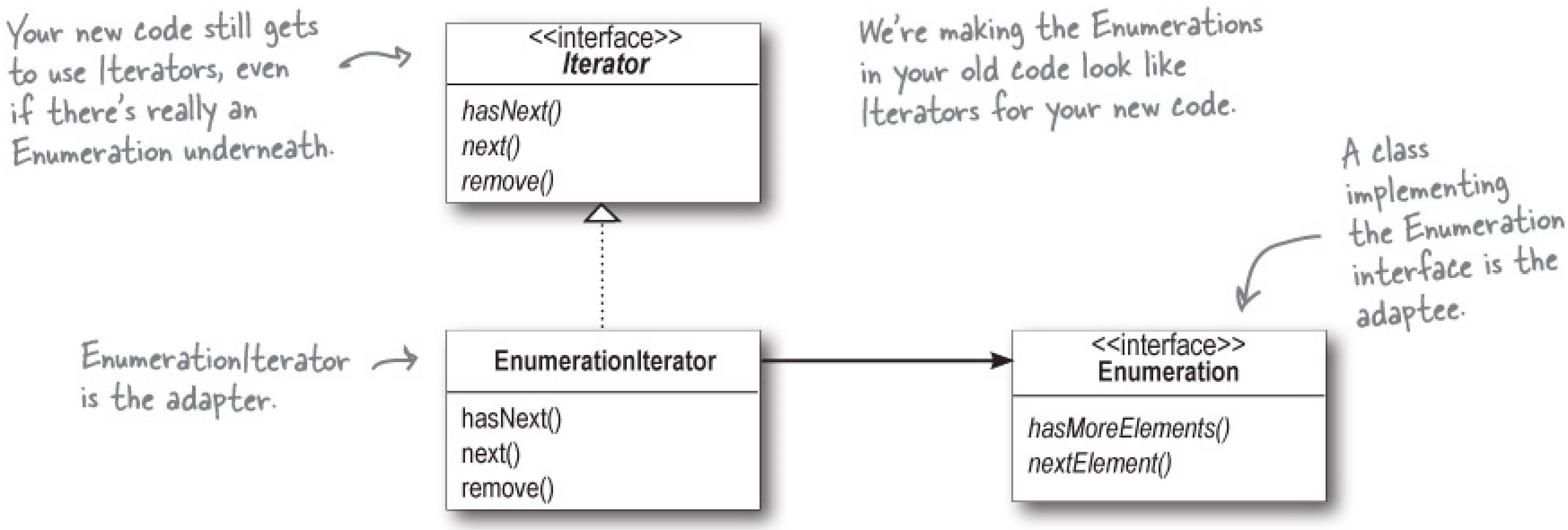
Adapter Pattern



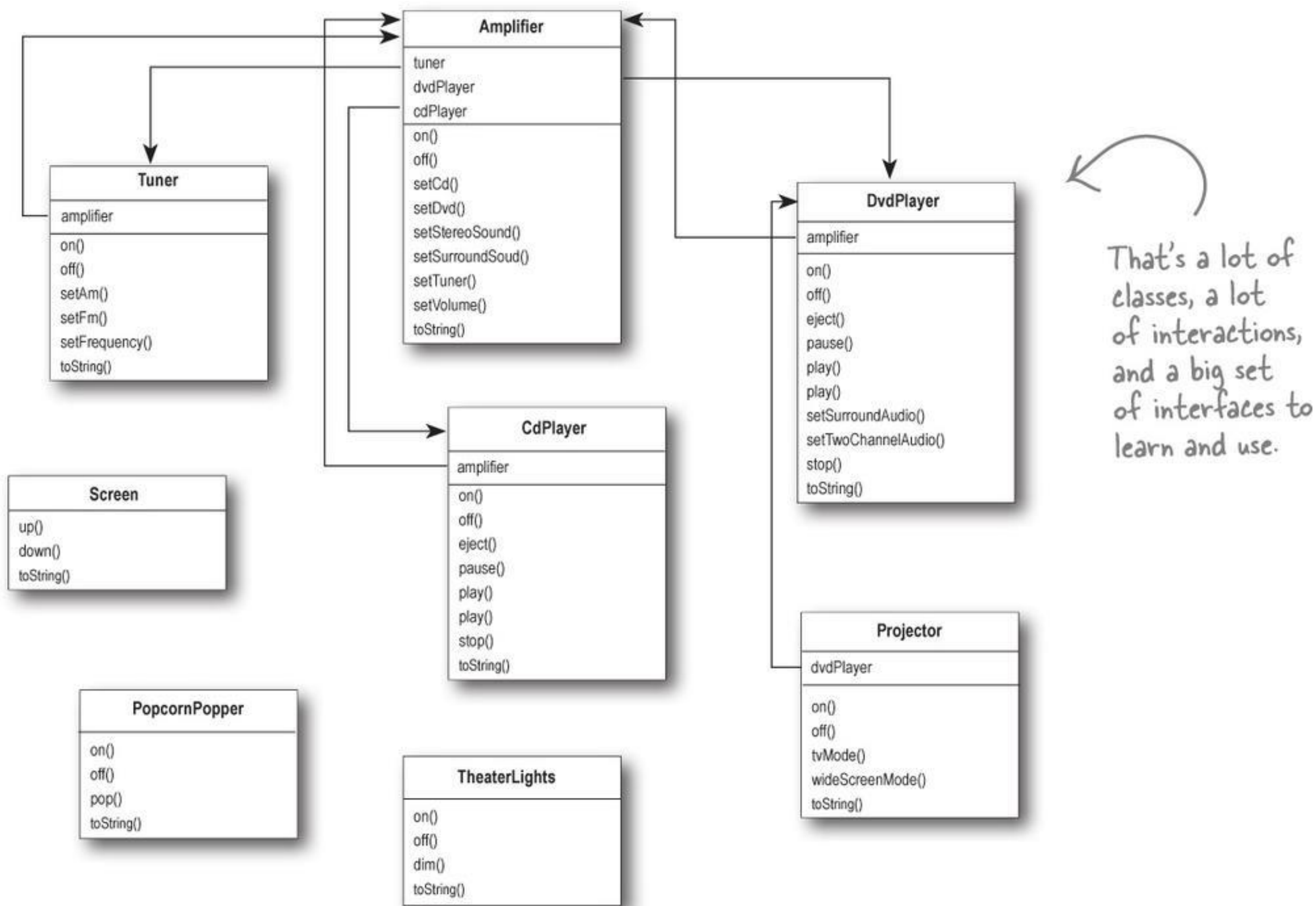
The adapter pattern uses inheritance as well as delegation:

- **Interface inheritance is used to specify the interface of the Adapter class.**
- **Delegation is used to bind the Adapter and the Adaptee**

Real life adapter in Java



Another Example



Watch a Movie

Pick out a DVD, relax, and get ready for movie magic. Oh, there's just one thing—to watch the movie, you need to perform a few tasks:

① Turn on the popcorn popper

② Start the popper popping

③ Dim the lights

④ Put the screen down

⑤ Turn the projector on

⑥ Set the projector input to DVD

⑦ Put the projector on wide-screen mode

⑧ Turn the sound amplifier on

⑨ Set the amplifier to DVD input

⑩ Set the amplifier to surround sound

⑪ Set the amplifier volume to medium (5)

⑫ Turn the DVD player on

⑬ Start the DVD player playing

Watch a Movie

Six different classes involved!

```
popper.on();
popper.pop();

lights.dim(10);

screen.down();

projector.on();
projector.setInput(dvd);
projector.wideScreenMode();

amp.on();
amp.setDvd(dvd);
amp.setSurroundSound();
amp.setVolume(5);

dvd.on();
dvd.play(movie);
```

Turn on the popcorn popper and start popping...

Dim the lights to 10%...

Put the screen down...

Turn on the projector and put it in wide screen mode for the movie...

Turn on the amp, set it to DVD, put it in surround sound mode and set the volume to 5...

Turn on the DVD player... and FINALLY, play the movie!

But there's more...

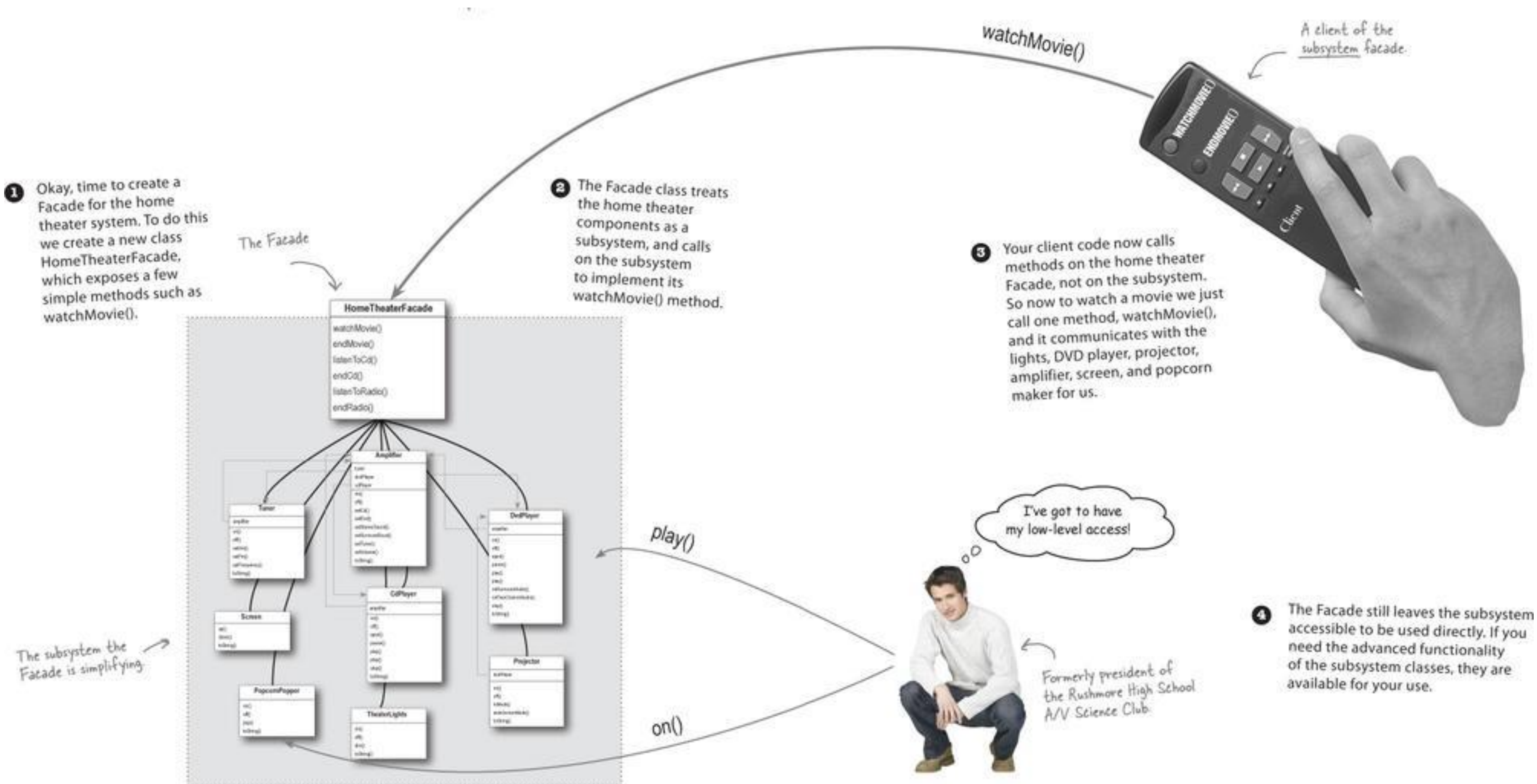
When the movie is over, how do you turn everything off? Wouldn't you have to do all of this over again, in reverse?

Wouldn't it be as complex to listen to a CD or the radio?

If you decide to upgrade your system, you're probably going to have to learn a slightly different procedure.

So what to do? The complexity of using your home theater is becoming apparent!

Façade


watchMovie()
A client of the subsystem facade.
WATCHMOVIE()
ENDMOVIE()
Client
1 Okay, time to create a Facade for the home theater system. To do this we create a new class HomeTheaterFacade, which exposes a few simple methods such as watchMovie().
The Facade
2 The Facade class treats the home theater components as a subsystem, and calls on the subsystem to implement its watchMovie() method.
3 Your client code now calls methods on the home theater Facade, not on the subsystem. So now to watch a movie we just call one method, watchMovie(), and it communicates with the lights, DVD player, projector, amplifier, screen, and popcorn maker for us.
HomeTheaterFacade
watchMovie()
endMovie()
listenToCd()
endCd()
listenToRadio()
endRadio()
Amplifier
Tuner
DvdPlayer
CdPlayer
Screen
Projector
PopcornPopper
TheaterLights
I've got to have my low-level access!
play()
on()
The subsystem the Facade is simplifying.
Formerly president of the Rushmore High School A/V Science Club.
4 The Facade still leaves the subsystem accessible to be used directly. If you need the advanced functionality of the subsystem classes, they are available for your use.

```java
public class HomeTheaterFacade {
    Amplifier amp;
    Tuner tuner;
    DvdPlayer dvd;
    CdPlayer cd;
    Projector projector;
    TheaterLights lights;
    Screen screen;
    PopcornPopper popper;

    public HomeTheaterFacade(Amplifier amp,
                 Tuner tuner,
                 DvdPlayer dvd,
                 CdPlayer cd,
                 Projector projector,
                 Screen screen,
                 TheaterLights lights,
                 PopcornPopper popper) {

        this.amp = amp;
        this.tuner = tuner;
        this.dvd = dvd;
        this.cd = cd;
        this.projector = projector;
        this.screen = screen;
        this.lights = lights;
        this.popper = popper;
    }

        // other methods here

}
```

Here's the composition; these are all the components of the subsystem we are going to use.

The facade is passed a reference to each component of the subsystem in its constructor. The facade then assigns each to the corresponding instance variable.

We're just about to fill these in...

```java
public void watchMovie(String movie) {
    System.out.println("Get ready to watch a movie...");
    popper.on();
    popper.pop();
    lights.dim(10);
    screen.down();
    projector.on();
    projector.wideScreenMode();
    amp.on();
    amp.setDvd(dvd);
    amp.setSurroundSound();
    amp.setVolume(5);
    dvd.on();
    dvd.play(movie);
}

public void endMovie() {
    System.out.println("Shutting movie theater down...");
    popper.off();
    lights.on();
    screen.up();
    projector.off();
    amp.off();
    dvd.stop();
    dvd.eject();
    dvd.off();
}
```

watchMovie() follows the same sequence we had to do by hand before, but wraps it up in a handy method that does all the work. Notice that for each task we are delegating the responsibility to the corresponding component in the subsystem.

And endMovie() takes care of shutting everything down for us. Again, each task is delegated to the appropriate component in the subsystem.

Watch a Movie (The easy way)

```
public class HomeTheaterTestDrive {
    public static void main(String[] args) {
        // instantiate components here

        HomeTheaterFacade homeTheater =
                new HomeTheaterFacade(amp, tuner, dvd, cd,
                        projector, screen, lights, popper);

        homeTheater.watchMovie("Raiders of the Lost Ark");
        homeTheater.endMovie();
    }
}
```

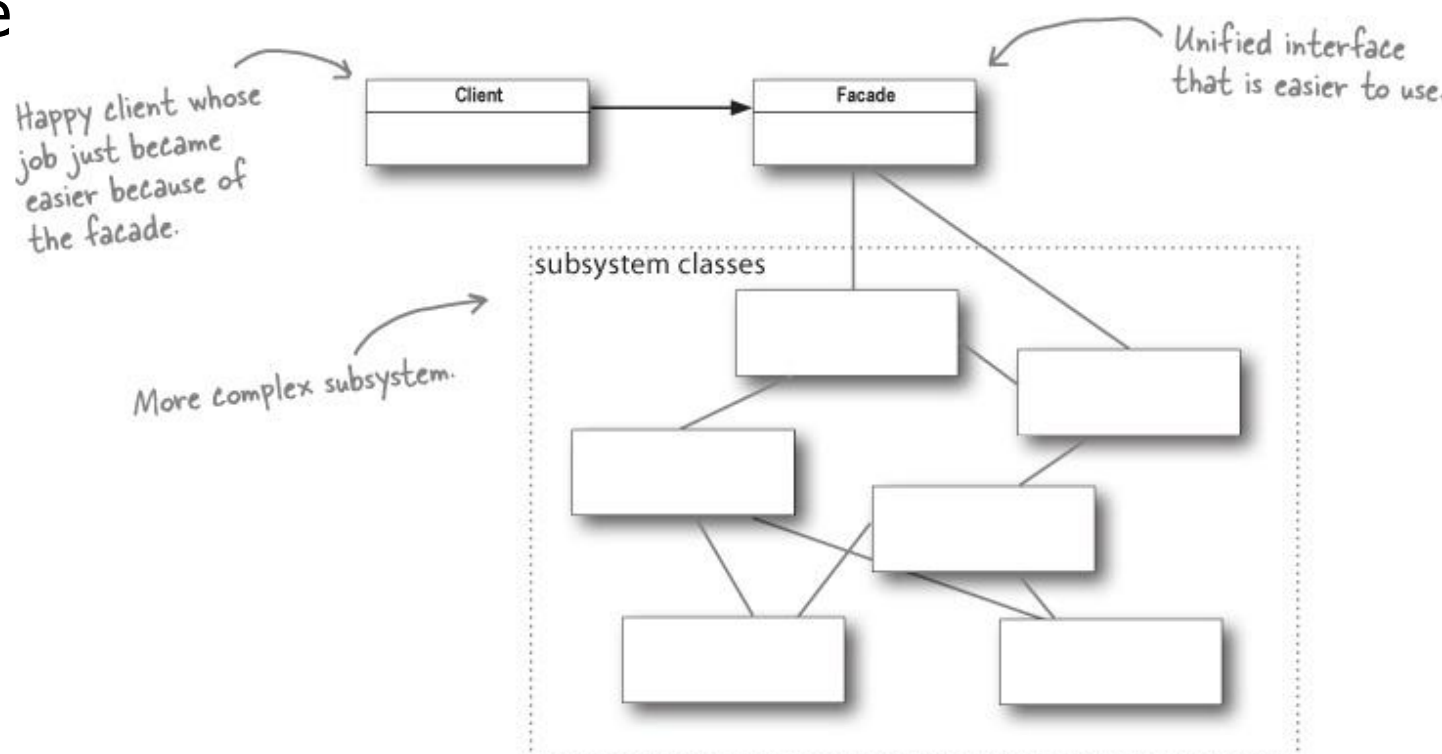
Here we're creating the components right in the test drive. Normally the client is given a facade; it doesn't have to construct one itself.

First you instantiate the Facade with all the components in the subsystem.

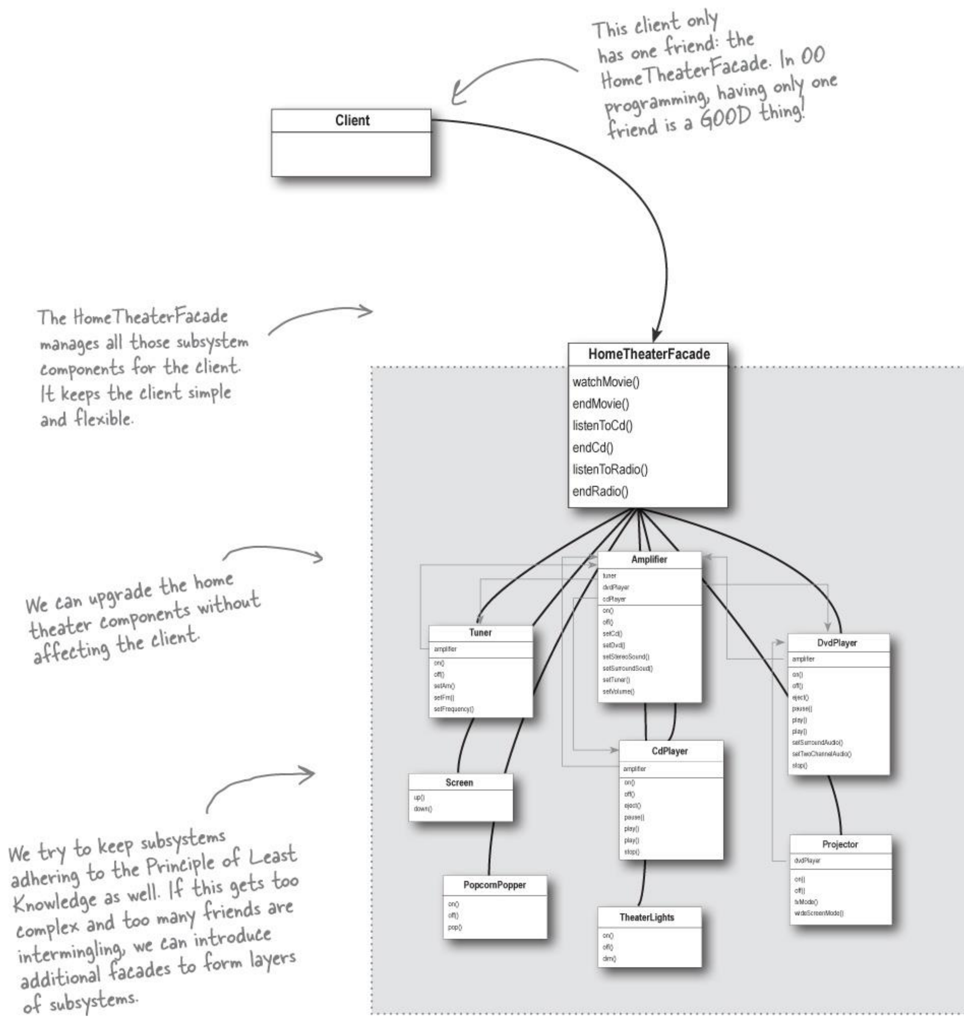
Use the simplified interface to first start the movie up, and then shut it down.

Façade Pattern

The Facade Pattern provides a unified interface to a set of interfaces in a subsystem. Facade defines a higher-level interface that makes the subsystem easier to use

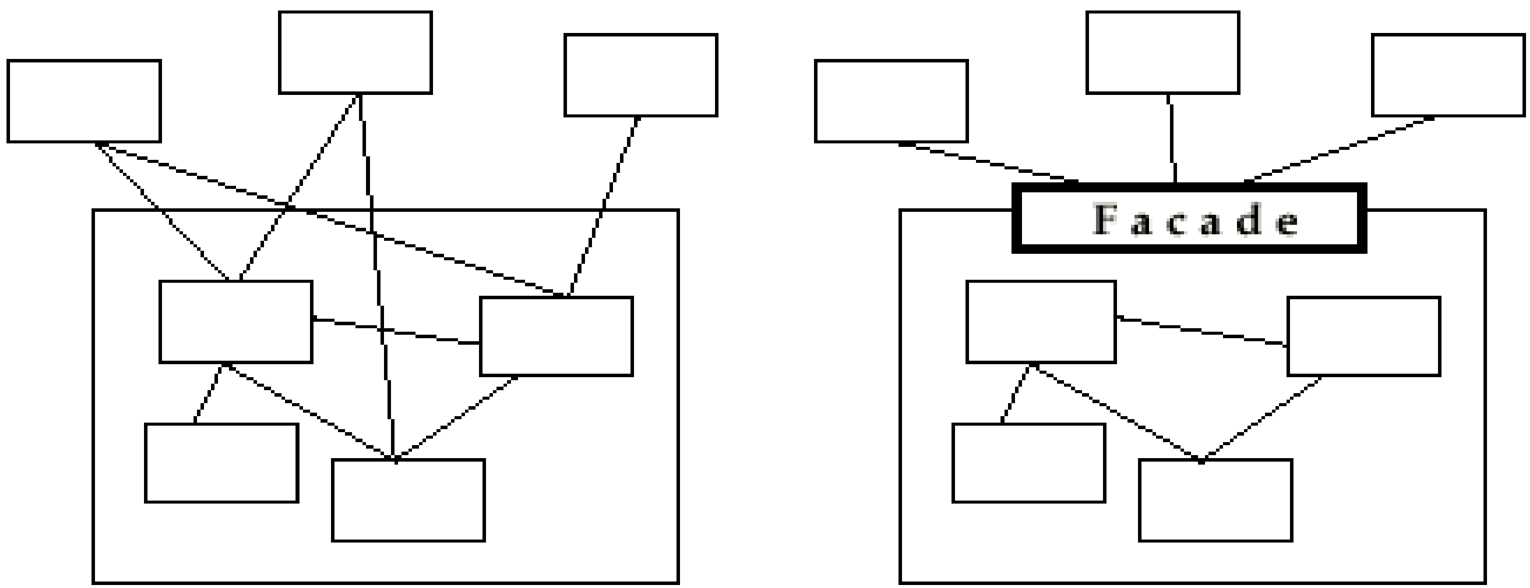


Façade and Principle of Least Knowledge



Facade Pattern

- Provides a unified interface to a set of objects in a subsystem.
- A facade defines a higher-level interface that makes the subsystem easier to use (i.e. it abstracts out the gory details)
-

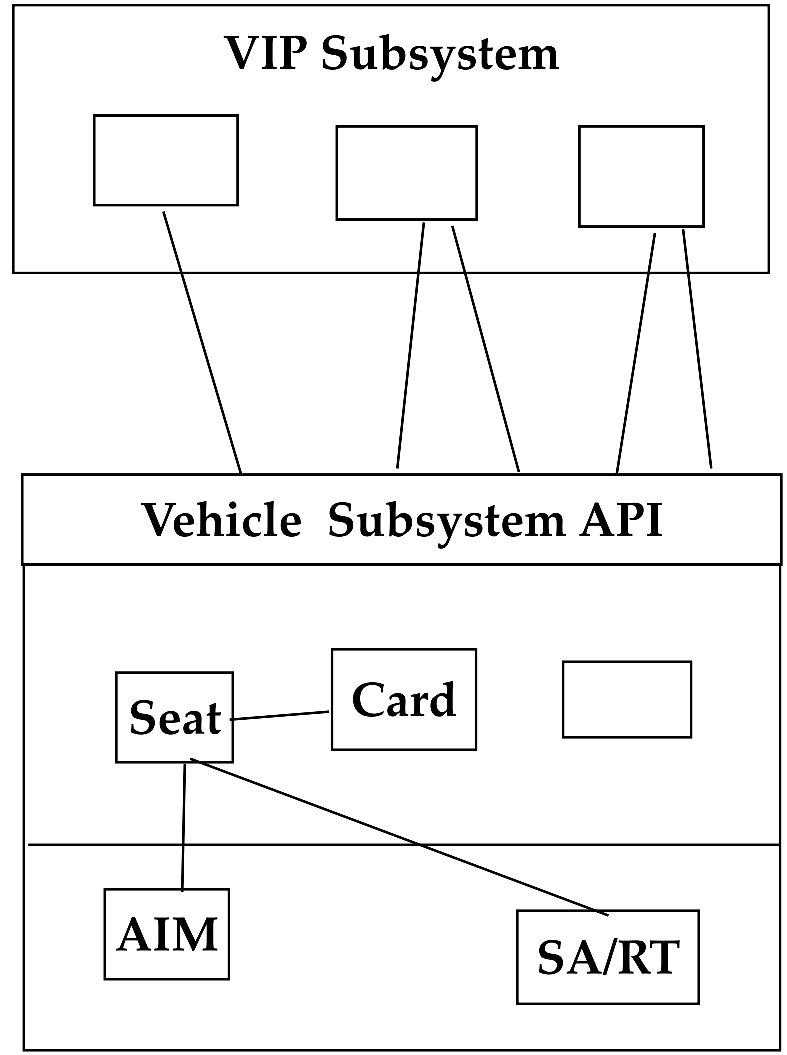


When should you use these Design Patterns?

- A façade should be offered by all subsystems in a software system who a services
  - The façade delegates requests to the appropriate components within the subsystem. The façade usually does not have to be changed, when the components are changed
- The adapter design pattern should be used to interface to existing components
  - Example: A smart card software system should use an adapter for a smart card reader from a specific manufacturer

Realizing an Opaque Architecture with a Facade

- The subsystem decides exactly how it is accessed.
- No need to worry about misuse by callers
- If a façade is used the subsystem can be used in an early integration test
  - We need to write only a driver



Adapter / Façade Summary

- When you need to use an existing class and its interface is not the one you need, use an adapter.
- When you need to simplify and unify a large interface or complex set of interfaces, use a facade.
- An adapter changes an interface into one a client expects.
- A facade decouples a client from a complex subsystem.
- Implementing an adapter may require little work or a great deal of work depending on the size and complexity of the target interface.
- Implementing a facade requires that we compose the facade with its subsystem and use delegation to perform the work of the facade.
- You can implement more than one facade for a subsystem.

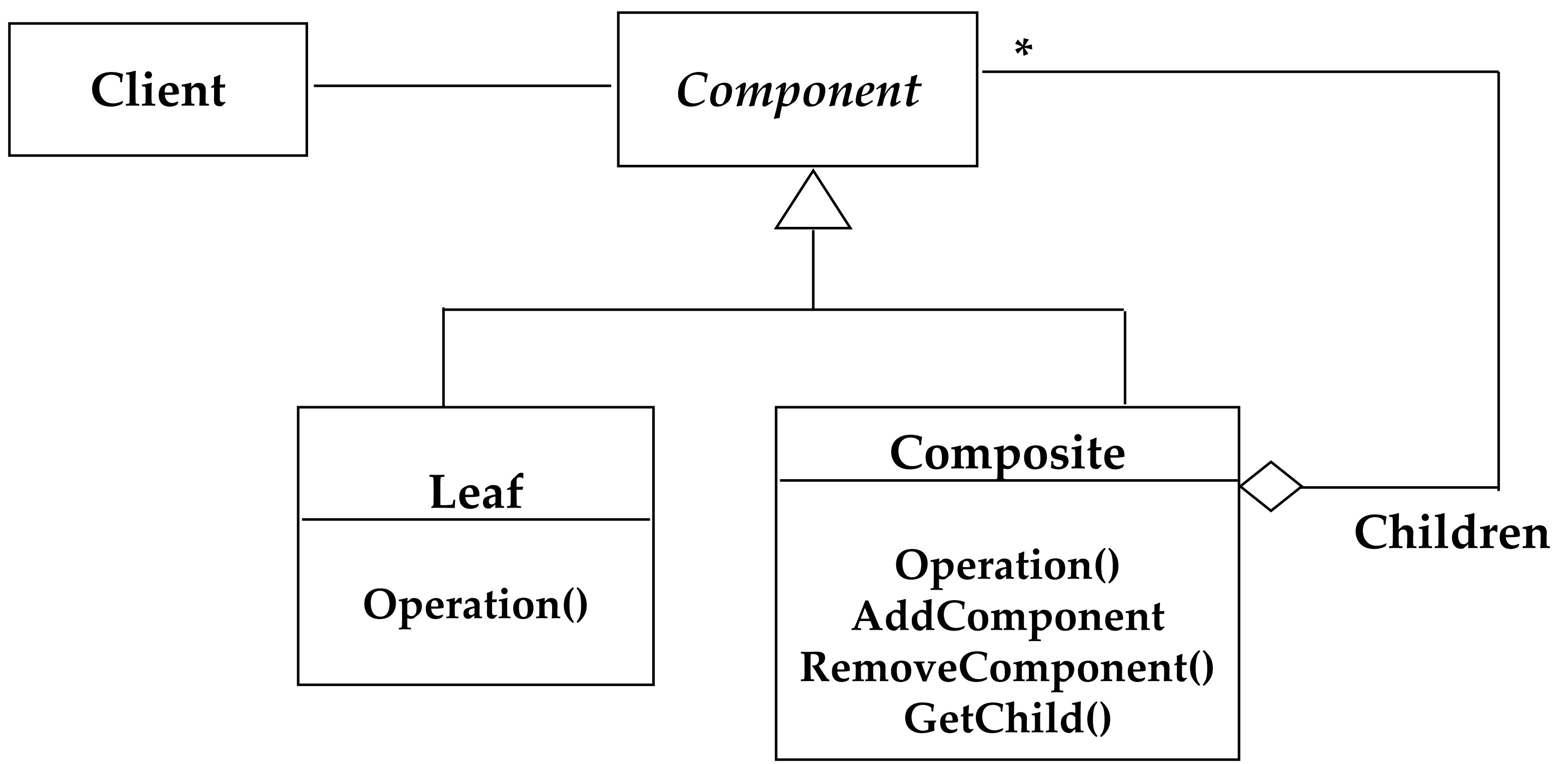
What is common between these definitions?

- Definition Software System
  - A software system consists of subsystems which are either other subsystems or collection of classes

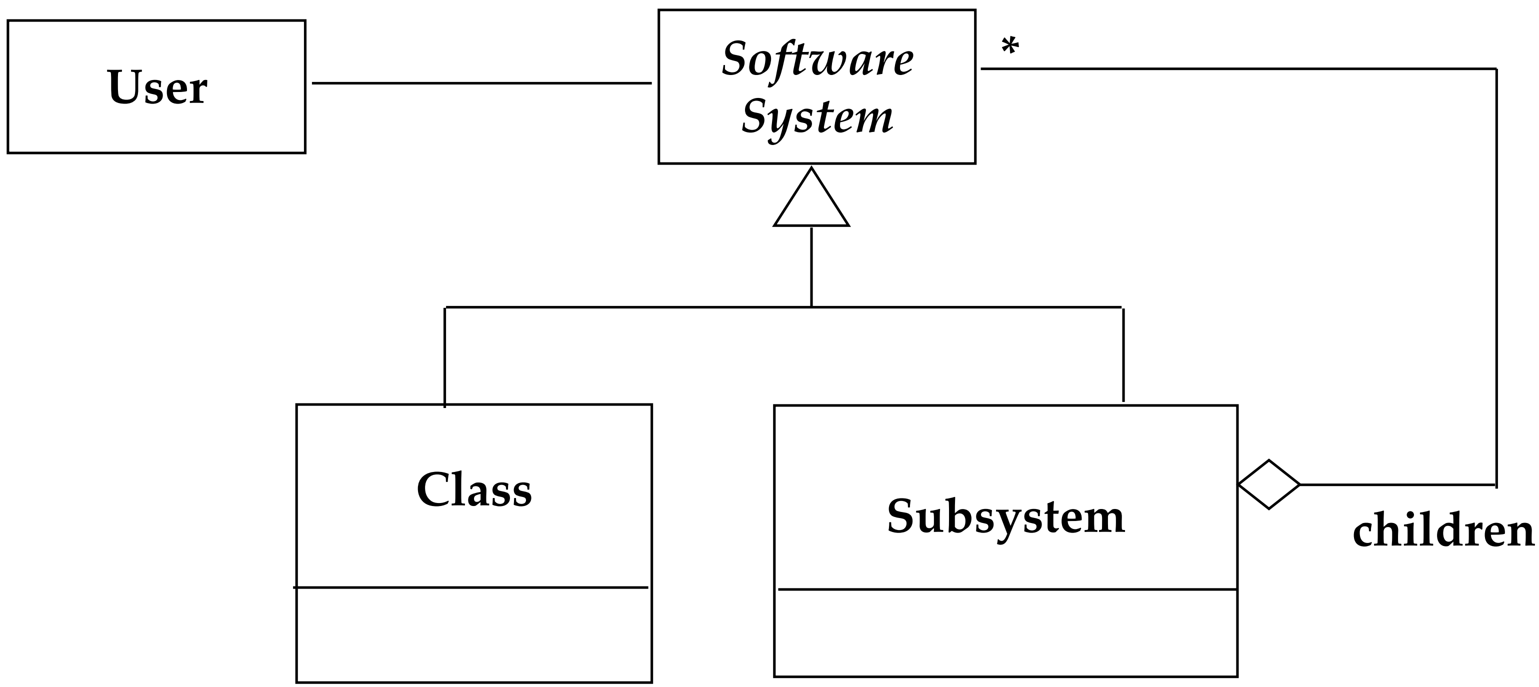
- Definition Software Lifecycle:
  - The software lifecycle consists of a set of development activities which are either other actitivies or collection of tasks

Introducing the Composite Pattern

- Models tree structures that represent part-whole hierarchies with arbitrary depth and width.
- The Composite Pattern lets client treat individual objects and compositions of these objects uniformly

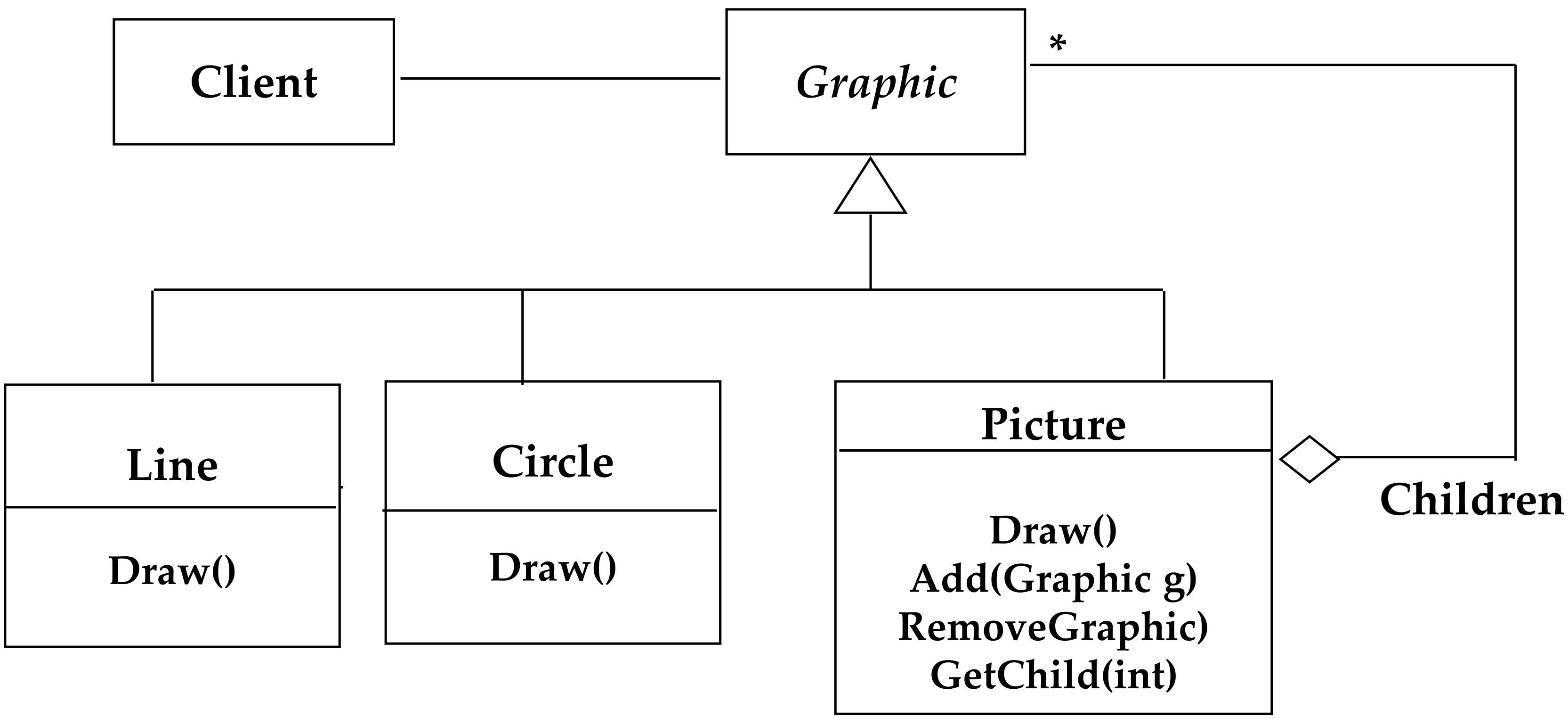


Modeling a Software System with a Composite Pattern



Graphic Applications also use Composite Patterns

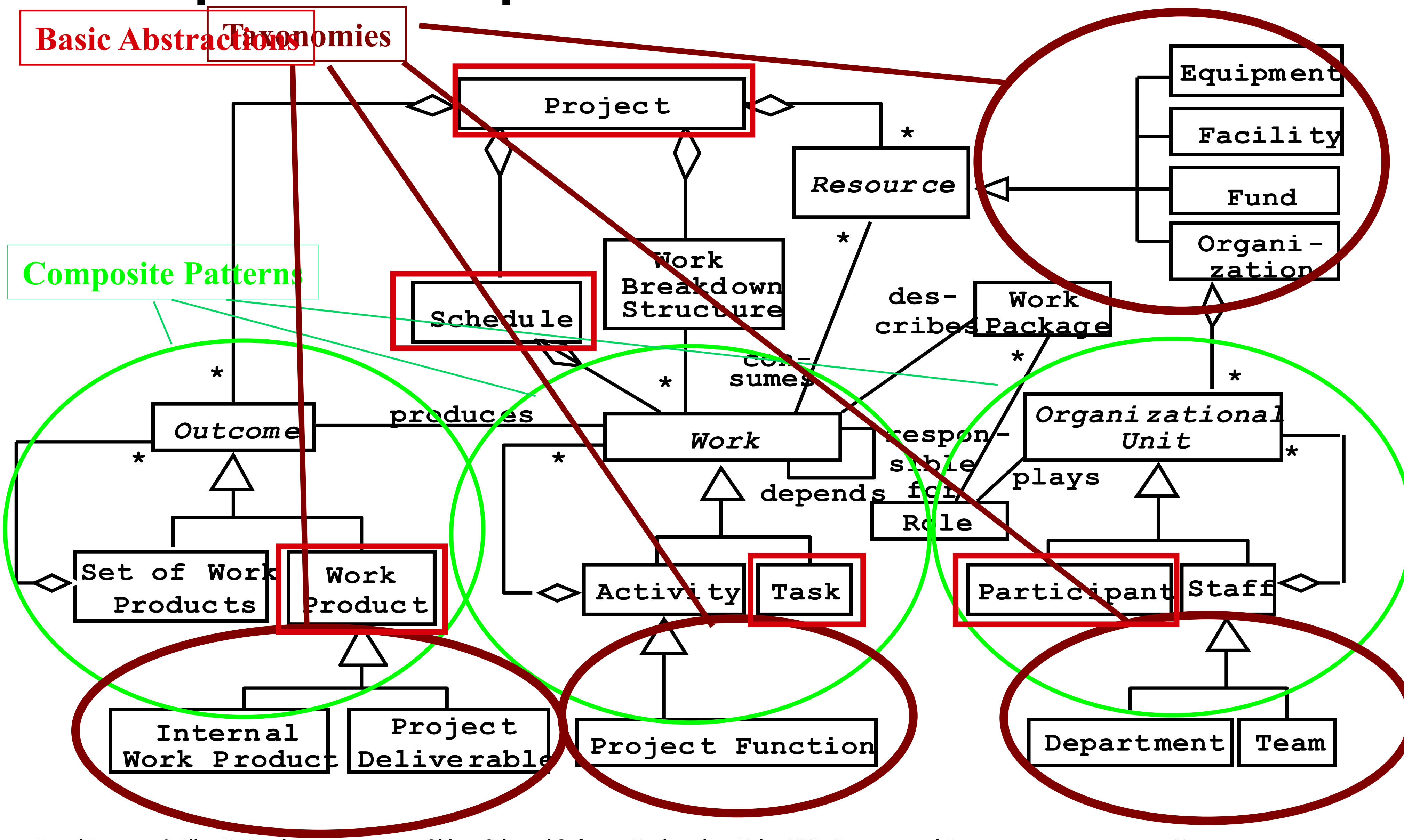
- The *Graphic* Class represents both primitives (Line, Circle) and their containers (Picture)



Reducing the Complexity of Models

- To communicate a complex model we use navigation and reduction of complexity
  - We do not simply use a picture from the CASE tool and dump it in front of the user
  - The key is to navigate through the model so the user can follow it
- We start with a very simple model
  - Start with the key abstractions
  - Then decorate the model with additional classes
- To reduce the complexity of the model further, we
  - Look for inheritance (taxonomies)
    - If the model is still too complex, we show subclasses on a separate slide
  - Then we identify or introduce patterns in the model
    - We make sure to use the name of the patterns.

Example: A Complex Model



Summary

- Composite, Adapter, Bridge, Façade, Proxy (Structural Patterns)
  - Focus: Composing objects to form larger structures
    - Realize new functionality from old functionality,
    - Provide flexibility and extensibility
- Command, Observer, Strategy, Template (Behavioral Patterns)
  - Focus: Algorithms and assignment of responsibilities to objects
    - Avoid tight coupling to a particular solution
- Abstract Factory, Builder (Creational Patterns)
  - Focus: Creation of complex objects
    - Hide how complex objects are created and put together

Conclusion

Design patterns

- provide solutions to common problems
- lead to extensible models and code
- can be used as is or as examples of interface inheritance and delegation
- apply the same principles to structure and to behavior

- Design patterns solve a lot of your software development problems
  - Pattern-oriented development

Chapter 8, Object Design: Design Patterns II

Object-Oriented Software Engineering
Using UML, Patterns, and Java

Object-Oriented Software Engineering
Using UML, Patterns, and Java

Recall: Why reusable Designs?

A design…

…enables flexibility to change (reusability)

…minimizes the introduction of new problems when fixing old ones (maintainability)

…allows the delivery of more functionality after an initial delivery (extensibility).

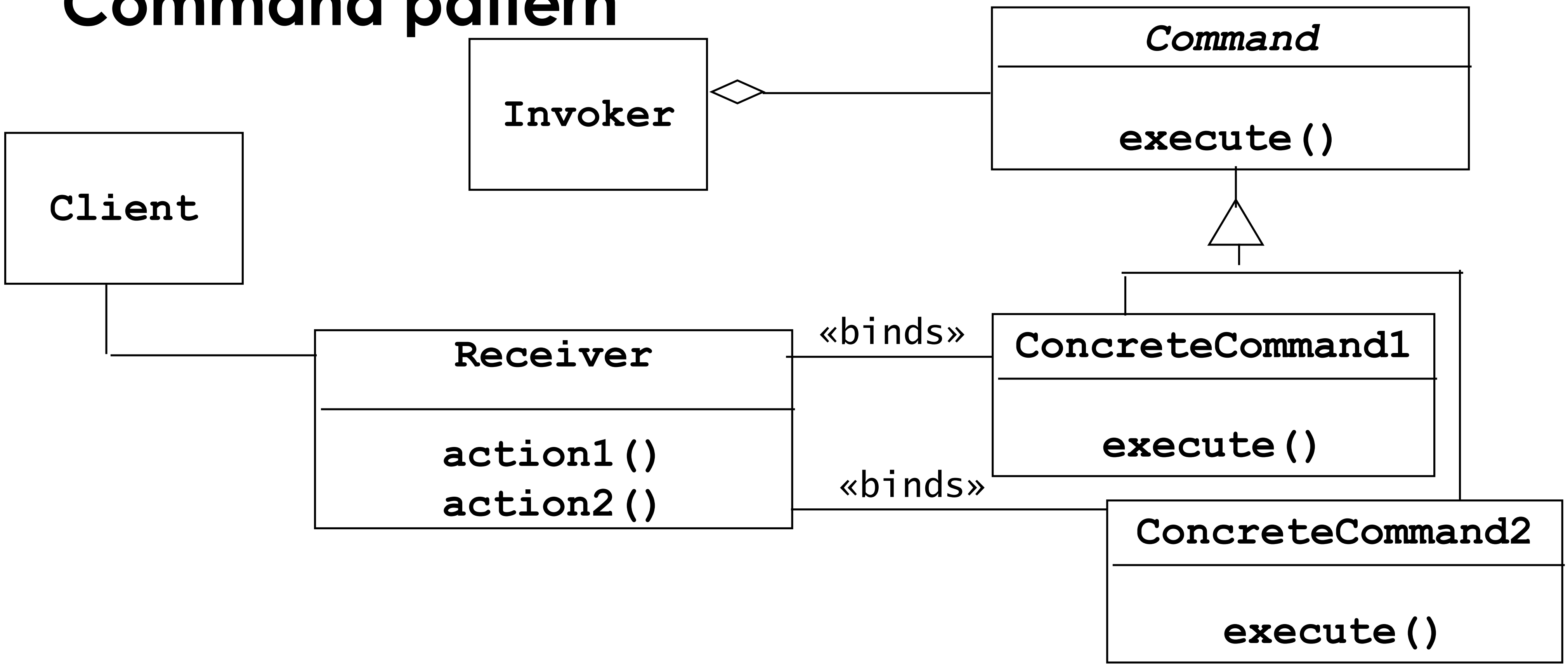
Definitions

- Extensibility (Expandibility)
  - A system is extensible, if new functional requirements can easily be added to the existing system
- Customizability
  - A system is customizable, if new nonfunctional requirements can be addressed in the existing system
- Scalability
  - A system is scalable, if existing components can easily be multiplied in the system
- Reusability
  - A system is reusable, if it can be used by another system without requiring major changes in the existing system model (design reuse) or code base (code reuse).

Command Pattern: Motivation

- You want to build a user interface
- You want to provide menus
- You want to make the menus reusable across many applications
  - The applications only know what has to be done when a command from the menu is selected
  - You don't want to hardcode the menu commands for the various applications
- Such a user interface can easily be implemented with the Command Pattern.

Command pattern



- Client (in this case a user interface builder) creates a ConcreteCommand and binds it to an action operation in Receiver
- Client hands the ConcreteCommand over to the Invoker which stores it (for example in a menu)
- The Invoker has the responsibility to execute or undo a command (based on a string entered by the user)

Comments to the Command Pattern

- The Command abstract class declares the interface supported by all ConcreteCommands.
- The client is a class in a user interface builder or in a class executing during startup of the application to build the user interface.
- The client creates concreteCommands and binds them to specific Receivers, this can be strings like "commit", "execute", "undo".
  - So all user-visible commands are sub classes of the Command abstract class.
- The invoker - the class in the application program offering the menu of commands or buttons - invokes theconcreteCommand based on the string entered and the binding between action and ConcreteCommand.

Decouples boundary objects from control objects

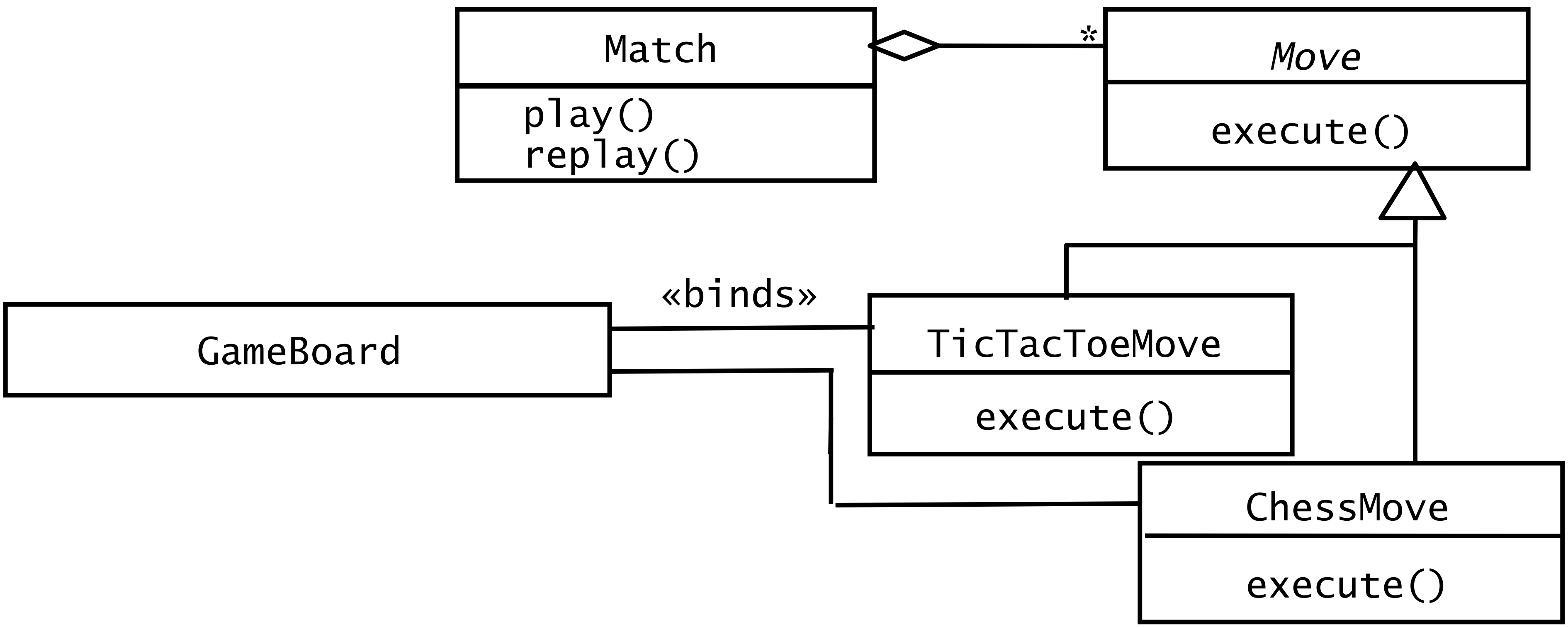
- The command pattern can be nicely used to decouple boundary objects from control objects:
  - Boundary objects such as menu items and buttons, send messages to the command objects (I.e. the control objects)
  - Only the command objects modify entity objects
- When the user interface is changed (for example, a menu bar is replaced by a tool bar), only the boundary objects are modified.

Command Pattern Applicability

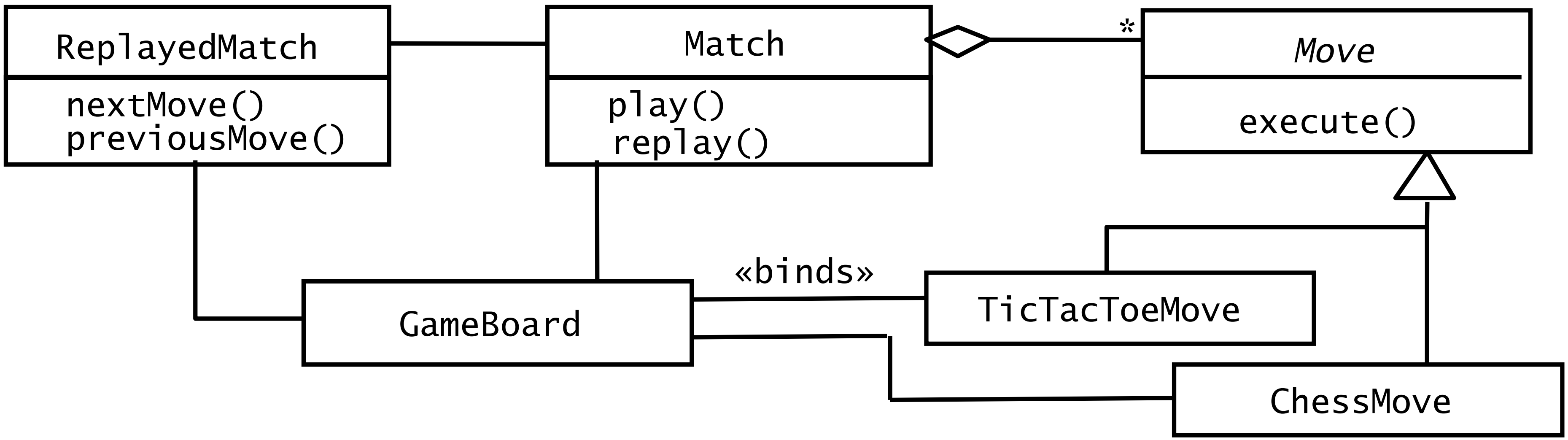
- Parameterize clients with different requests
- Queue or log requests
- Support undoable operations

- Uses:
  - Undo queues
  - Database transaction buffering

Applying the Command Pattern to Command Sets



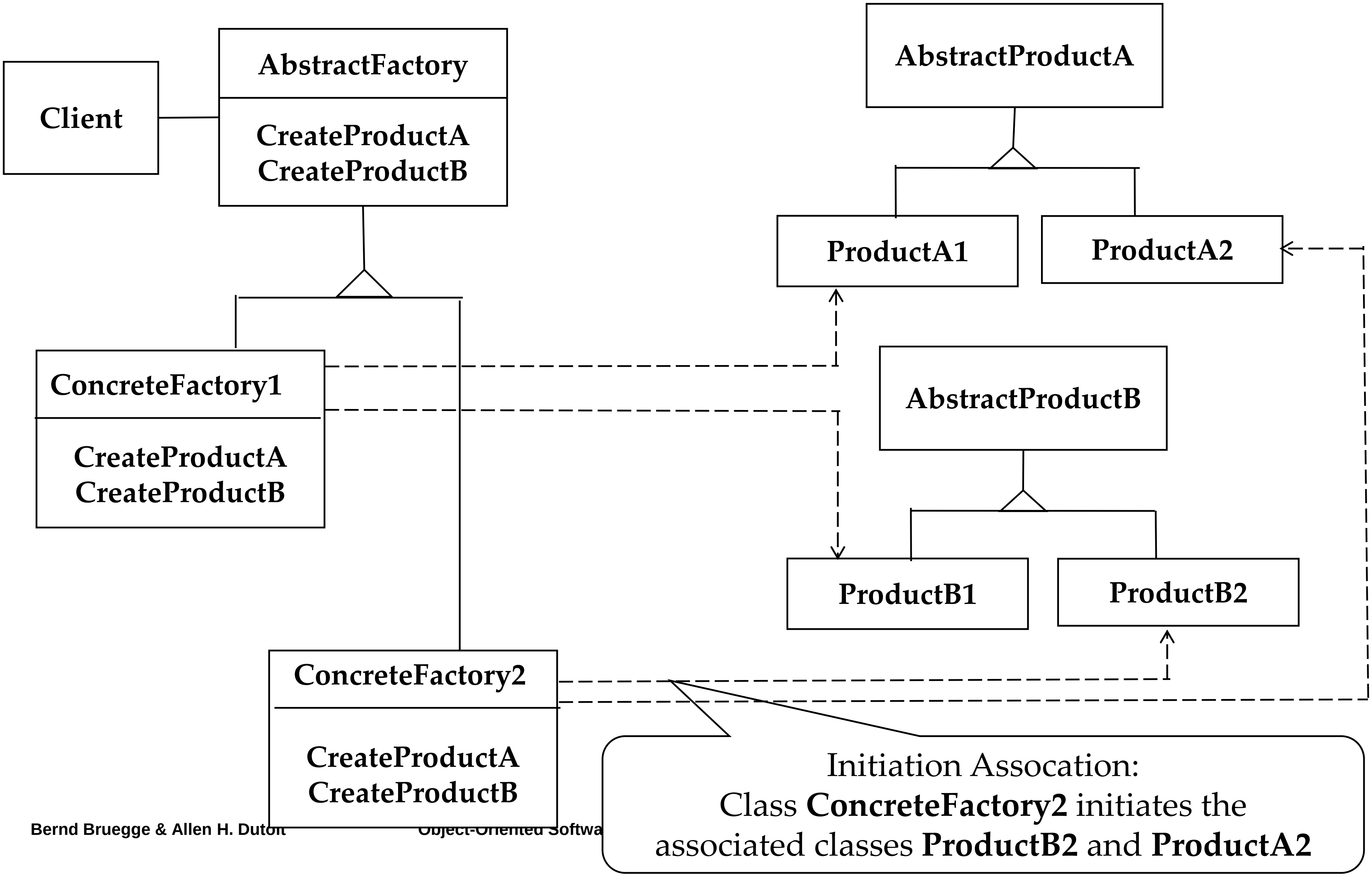
Applying the Command design pattern to Replay Matches in ARENA



Abstract Factory Pattern Motivation

- Consider a user interface toolkit that supports multiple looks and feel standards for different operating systems:
  - How can you write a single user interface and make it portable across the different look and feel standards for these window managers?
- Consider a facility management system for an intelligent house that supports different control systems:
  - How can you write a single control system that is independent from the manufacturer?

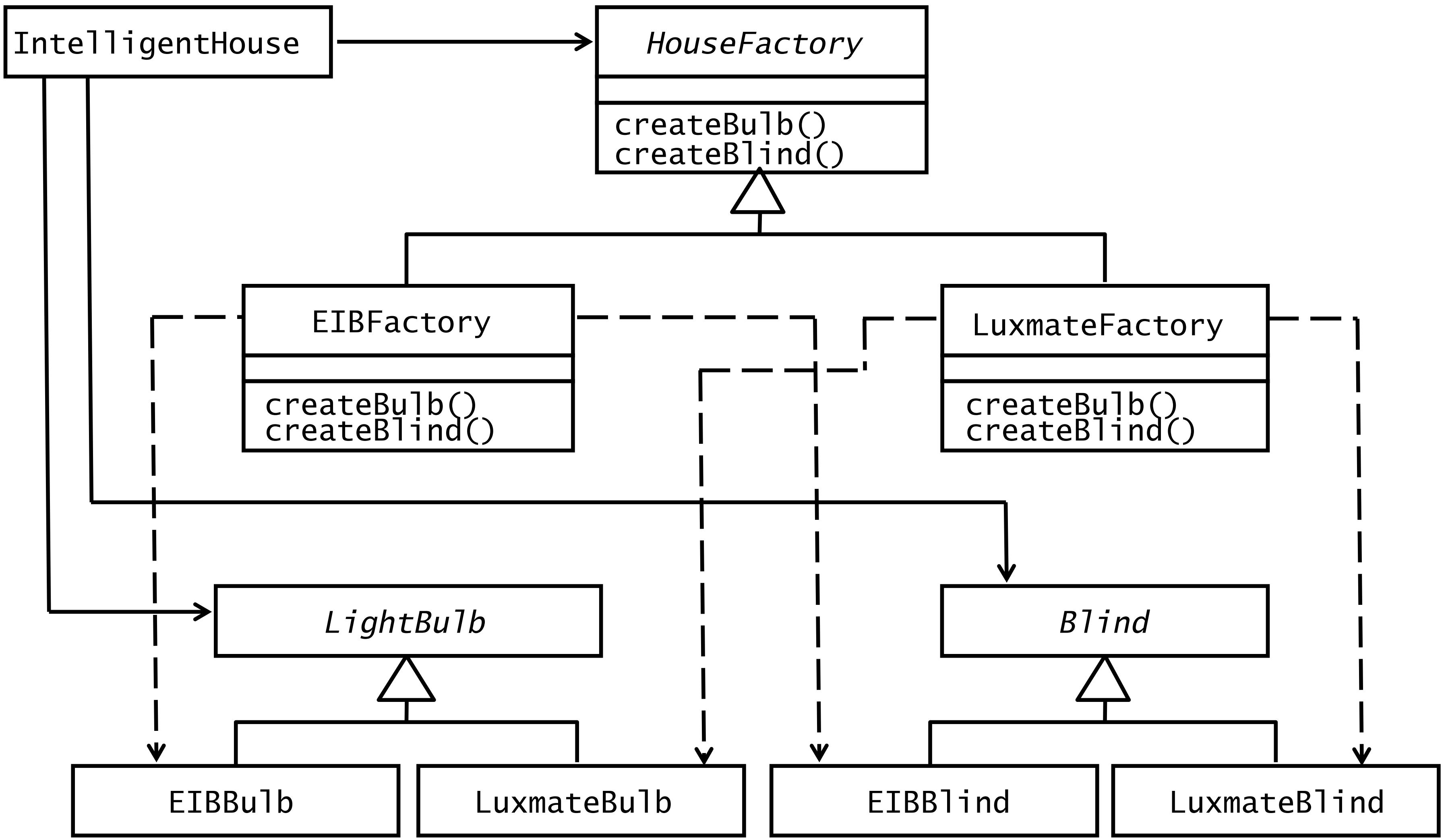
Abstract Factory



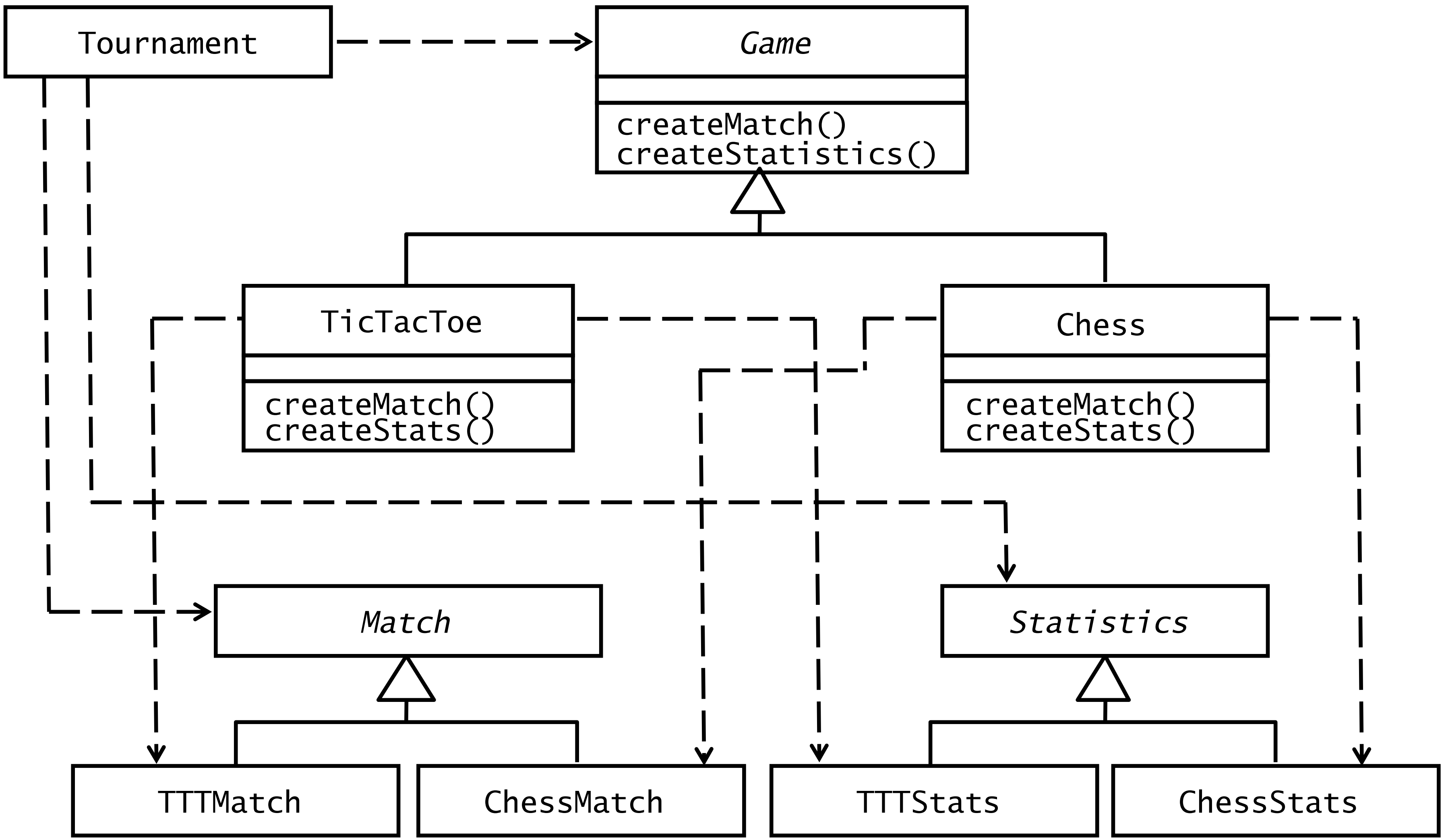
Applicability for Abstract Factory Pattern

- Independence from Initialization or Representation
- Manufacturer Independence
- Constraints on related products
- Cope with upcoming change

Example: A Facility Management System for a House



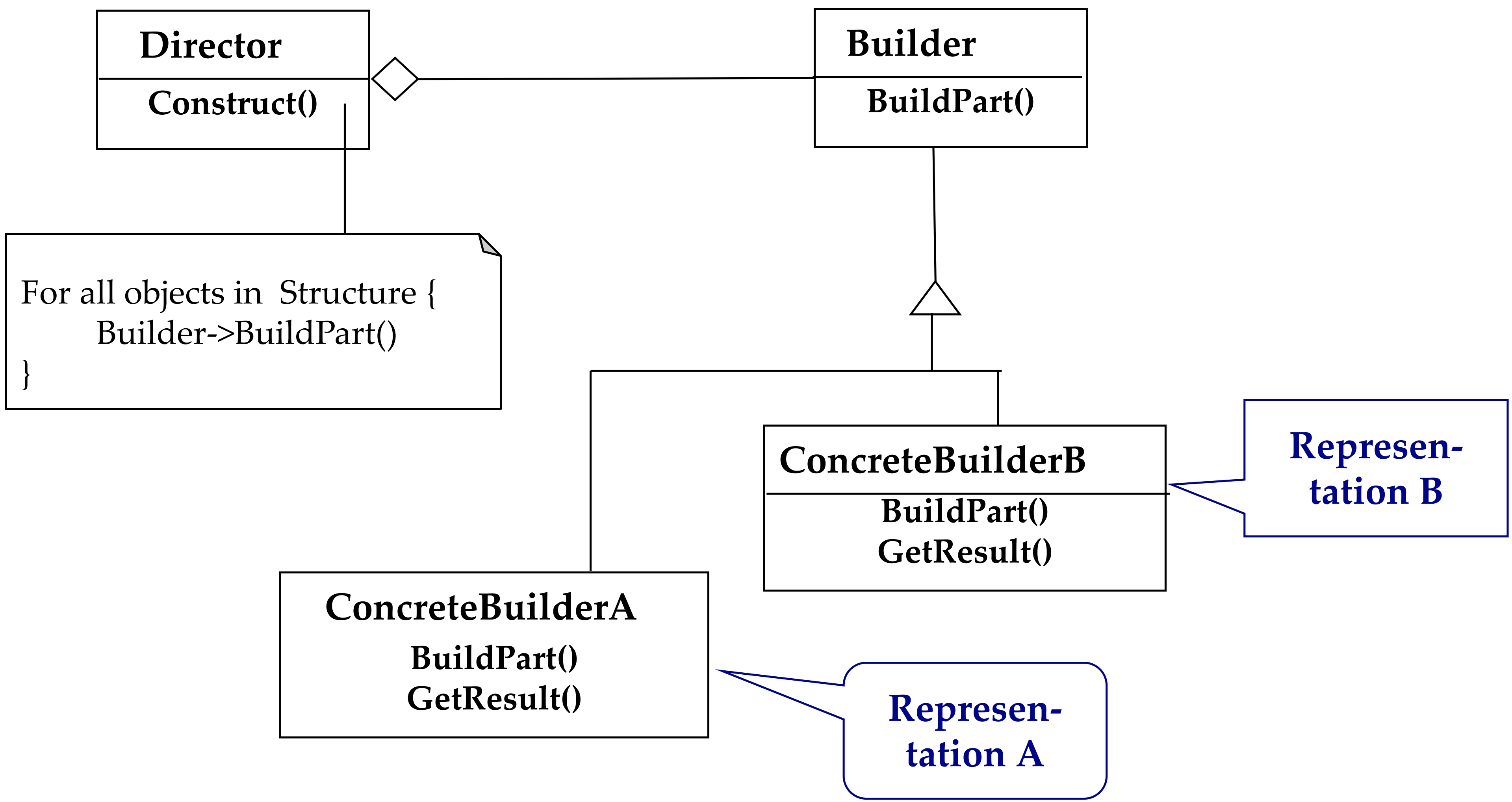
Applying the Abstract Factory Pattern to Games



Builder Pattern Motivation

- The construction of a complex object is common across several representations
- Example
  - Converting a document to a number of different formats
    - the steps for writing out a document are the same
    - the specifics of each step depend on the format
- Approach
  - The construction algorithm is specified by a single class (the "director")
  - The abstract steps of the algorithm (one for each part) are specified by an interface (the "builder")
  - Each representation provides a concrete implementation of the interface (the "concrete builders")

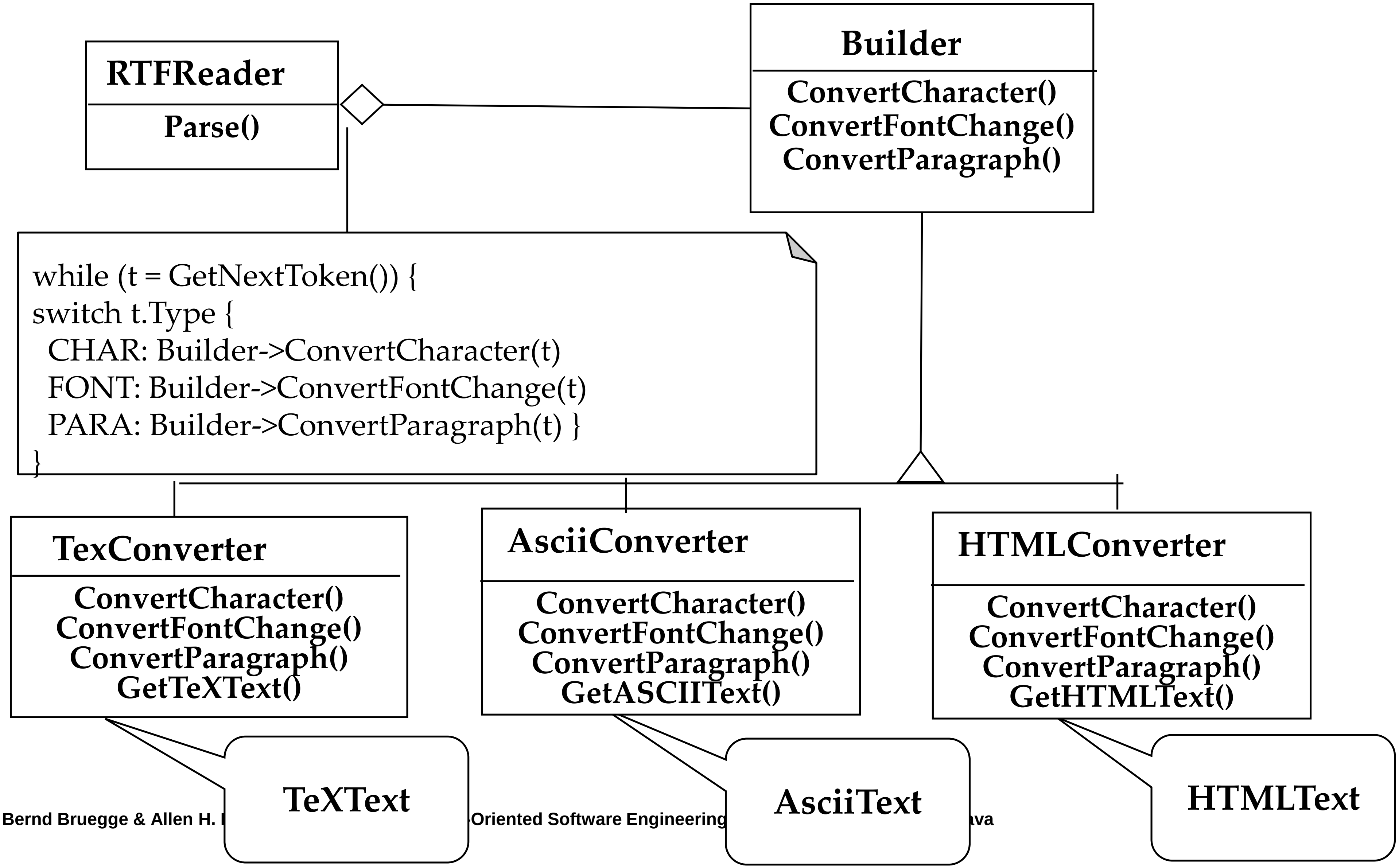
Builder Pattern



Applicability of Builder Pattern

- The creation of a complex product must be independent of the particular parts that make up the product
- The creation process must allow different representations for the object that is constructed.

Example: Converting an RTF Document into different representations



Comparison: Abstract Factory vs Builder

- Abstract Factory
  - Focuses on product family
  - Does not hide the creation process
- Builder
  - The underlying product needs to be constructed as part of the system, but the creation is very complex
  - The construction of the complex product changes from time to time
  - Hides the creation process from the user
- Abstract Factory and Builder work well together for a family of multiple complex products

Clues in Nonfunctional Requirements for the Use of Design Patterns

- *Text:* "manufacturer independent",
  "device independent",
  "must support a family of products"

  => Abstract Factory Pattern
- *Text:* "must interface with an existing object"

  => Adapter Pattern
- *Text:* "must interface to several systems, some of them to be developed in the future",
  " an early prototype must be demonstrated"

  =>Bridge Pattern
- *Text:* "must interface to existing set of objects"

  => Façade Pattern

Clues in Nonfunctional Requirements for use of Design Patterns (2)

- *Text:* “complex structure”,
  “must have variable depth and width”

  => Composite Pattern
- *Text:* “must be location transparent”

  => Proxy Pattern
- *Text:* “must be extensible”,
  “must be scalable”

  => Observer Pattern
- *Text:* “must provide a policy independent from the mechanism”

  => Strategy Pattern

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