FDA149
Software Engineering

Introduction to Design Patterns

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pelab

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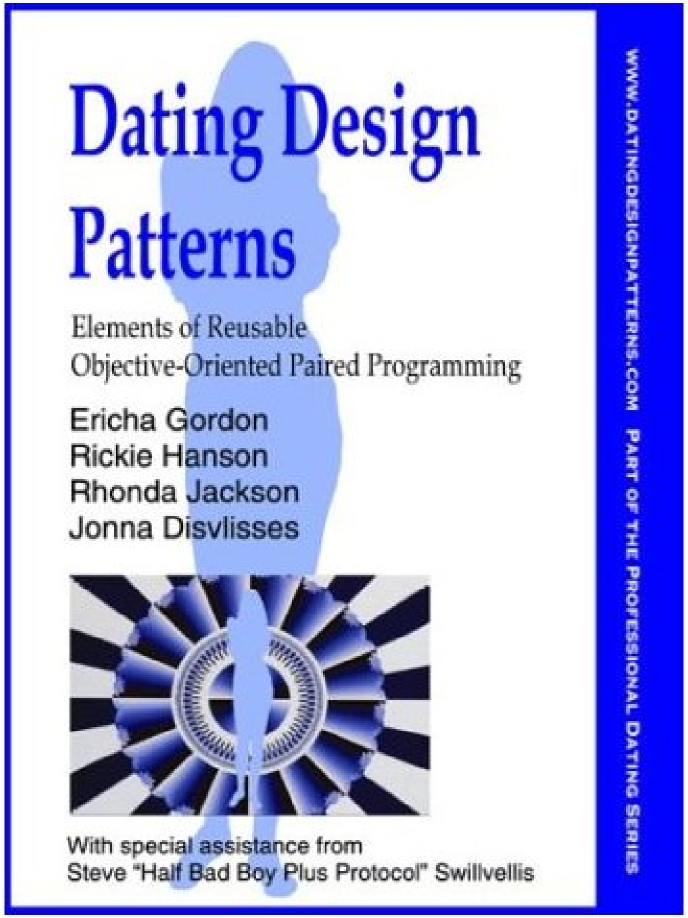
The Design Patterns Late Show



Dating Design Patterns

Elements of Reusable
Objective-Oriented Paired Programming

Ericha Gordon
Rickie Hanson
Rhonda Jackson
Jonna Disvlisses

With special assistance from
Steve "Half Bad Boy Plus Protocol" Swillvellis

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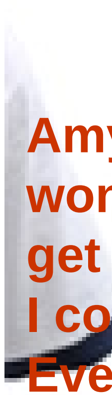
Top 10 Reasons to take a Design Pattern Course



1. Amy Diamond took this course but she is still wondering ”What’s in if for me ?”. Maybe I will get it an explain it to her.
2. I could get some easy points.
3. Everybody is talking about so it must to be cool.
4. If I master this I can added it to my CV.
5. Increase my salary at the company.
6. Applying patterns is easier than thinking
7. A great place to pick up ideas to plagiarize.
8. I bought this lousy T Shirt an I would like to understand the joke.
9. I thought that course is about Dating Design Patterns.
10. I failed the course last year so I’m trying again.

Seven Layers of Architecture

Enterprise-Architecture
Global-Architecture

System-Architecture

OO Architecture

Application-Architecture

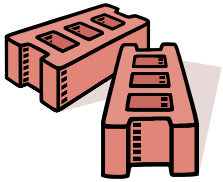
Subsystem

Macro-Architecture

Frameworks

Micro-Architecture

Design-Patterns



Objects

OO Programming

A Brief History of Design Patterns

- 1963 Ivan Edward Sutherland publishes his Ph.D Thesis at MIT: ” ***SketchPad, a Man-Machine Graphical Communication System***.

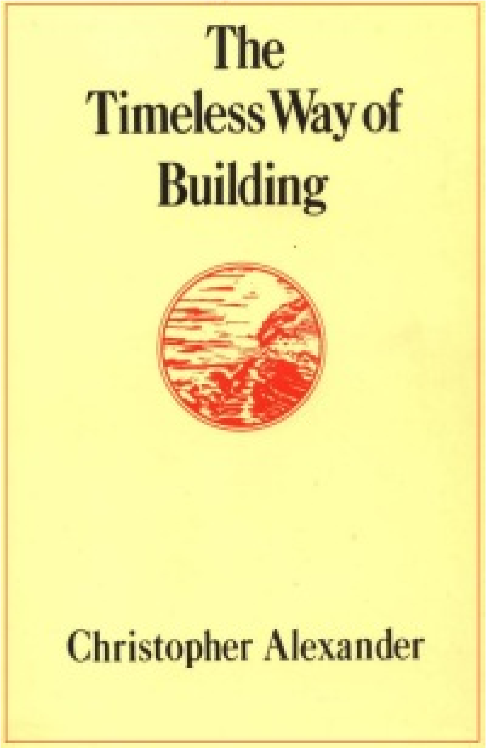
3-D computer modeling
visual simulations
computer aided design (CAD)
virtual reality
OO Programming

- 1970... - the window and desktop metaphors (conceptual patterns) are discovered by the Smalltalk group in Xerox Parc, Palo Alto

A Brief History of Design Patterns

- 1978/79: Goldberg and Reenskaug develop the MVC pattern for user Smalltalk interfaces at Xerox Parc

- 1979 Cristopher Alexander publishes: ”***The Timeless Way of Buildings***”



Introduces the notion of pattern and a pattern language

It is a architecture book and not a software book

Alexander sought to define step-by-step rules for solving common engineering problems relevant to the creation of buildings and communities.

A Brief History of Design Patterns

- 1987 OOPSLA - *Kent Beck and Ward Cunningham* at the OOPSLA-87 workshop on the Specification and Design for Object-Oriented Programming publish the paper: ***Using Pattern Languages for Object-Oriented Programs***
  - ☐ Discovered Alexander's work for software engineers by applying 5 patterns in Smalltalk

- 1991 Erich Gamma came up with an idea for a Ph.D. thesis about patterns, and by 1992, he had started collaborating with the other GOF members (Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides) on expanding this idea.
  - ☐ Erik come up with the idea while working on an object oriented application framework in C++ called "ET++".

- Bruce Anderson gives first Patterns Workshop at OOPSLA

A Brief History of Design Patterns

- 1993 GOF submitted a catalog of object-oriented software design patterns to the European Conference of Object-Oriented Programming (ECOOP) in 1993

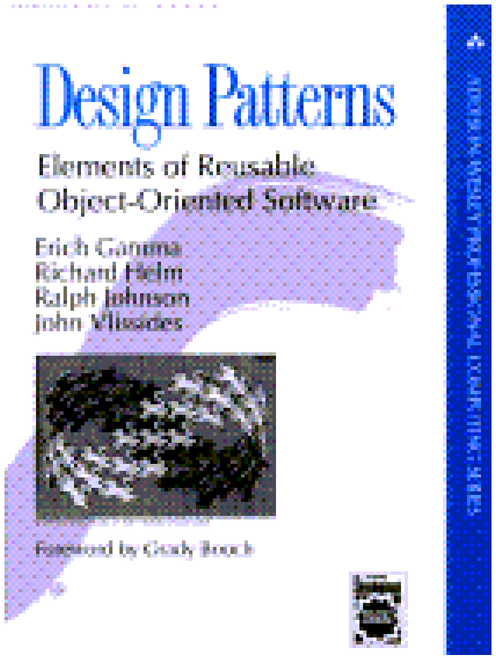
  E. Gamma, R. Helm, R. Johnson, J. Vlissides. Design Patterns: Abstraction and Reuse of Object-Oriented Design. ECOOP 97 LNCS 707, Springer, 1993

- 1993 Kent Beck and Grady Booch sponsor the first meeting of what is now known as the Hillside Group

- 1994 - First Pattern Languages of Programs (PLoP) conference

A Brief History of Design Patterns

1995 – GOF publishes : Design Patterns. Elements of Reusable Object-Oriented Software



the most popular computer book ever published

1 million copies sold

Are you bored?

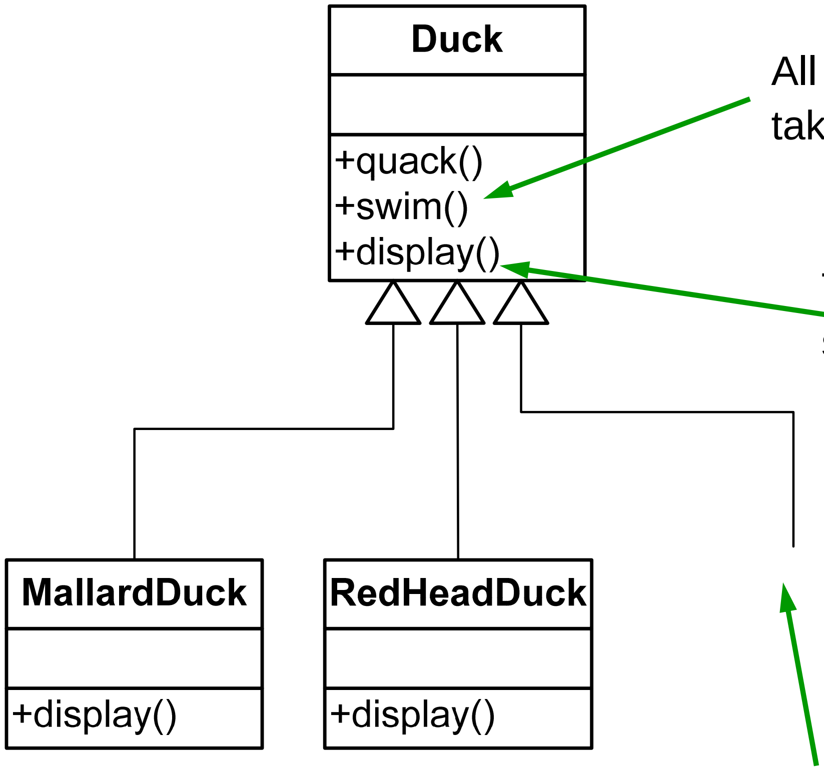
Let’s do some programming!!!!

The Job

- Joe works at a company that produces a simulation game called *SimUDuck.* He is an OO Programmer and his duty is to implement the necessary functionality for the game.

- The game should have the following specifications:
  - A variety of different ducks should be integrated into the game
  - The ducks should swim
  - The duck should quake

A First Design for the Duck Simulator Game

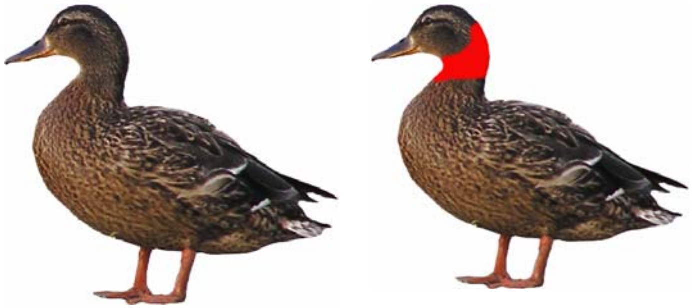


All ducks **`quack()`** and **`swim()`**. The superclass takes care of the implementation

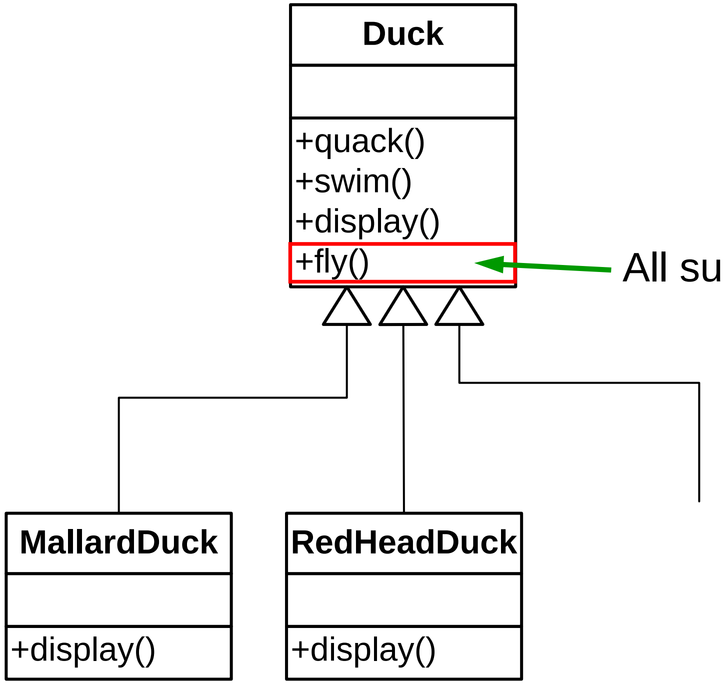
The **`display()`** method is abstract since all the duck subtypes look different

Each duck subtype is responsible for implementing its own **`display()`** behavior for how it looks on the screen

Lots of other types of ducks inherit from the Duck type



Ducks that Fly



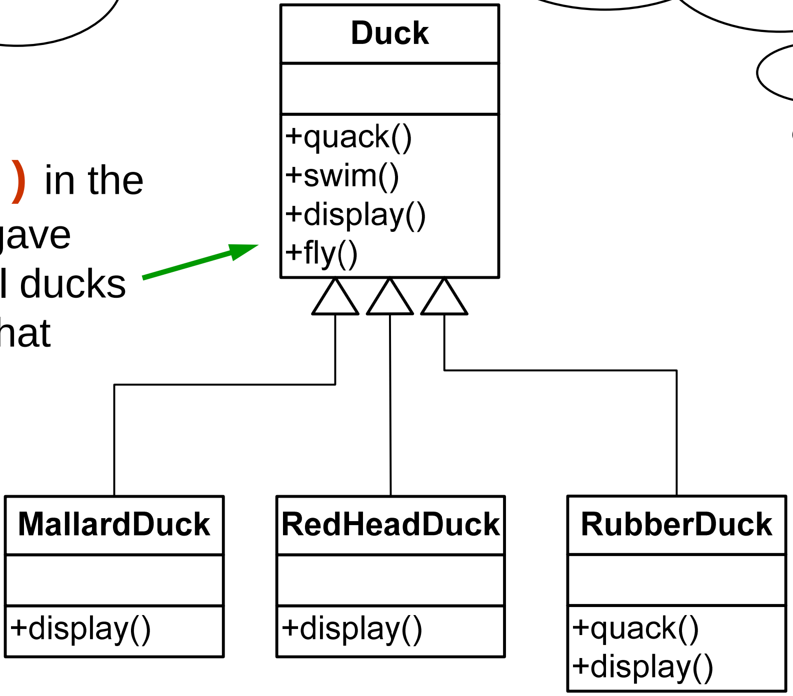
All subclasses inherit `fly()`

But Something Went Wrong

Joe, I’m at the shareholder’s meeting. They just gave a demo and there were rubber duckies flying around the screen. Is this a joke or what?

By putting **fly()** in the superclass Joe gave flying ability to all ducks including those that shouldn’t

OK, so there’s a slight flaw in my design. I don’t see why they can’t just call it a “feature”. It’s kind of cute



Duck

+quack()
+swim()
+display()
+fly()

MallardDuck

+display()

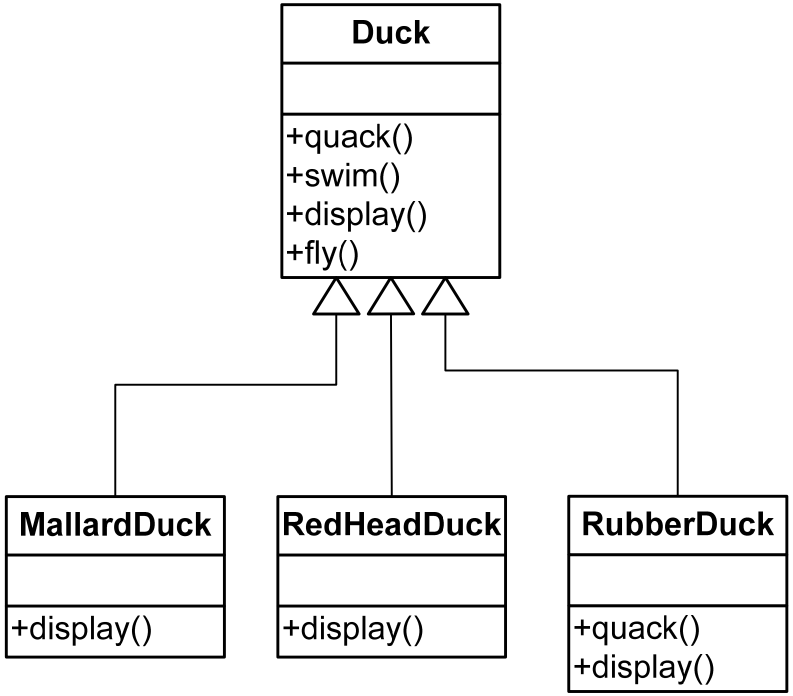
RedHeadDuck

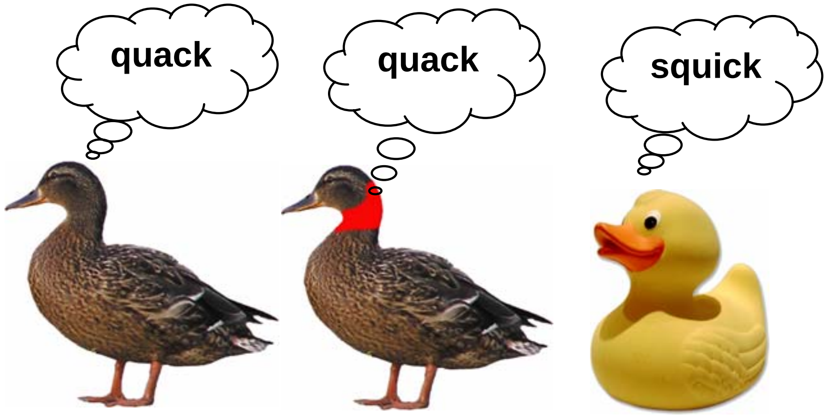
+display()

RubberDuck

+quack()
+display()

Inheritance at Work



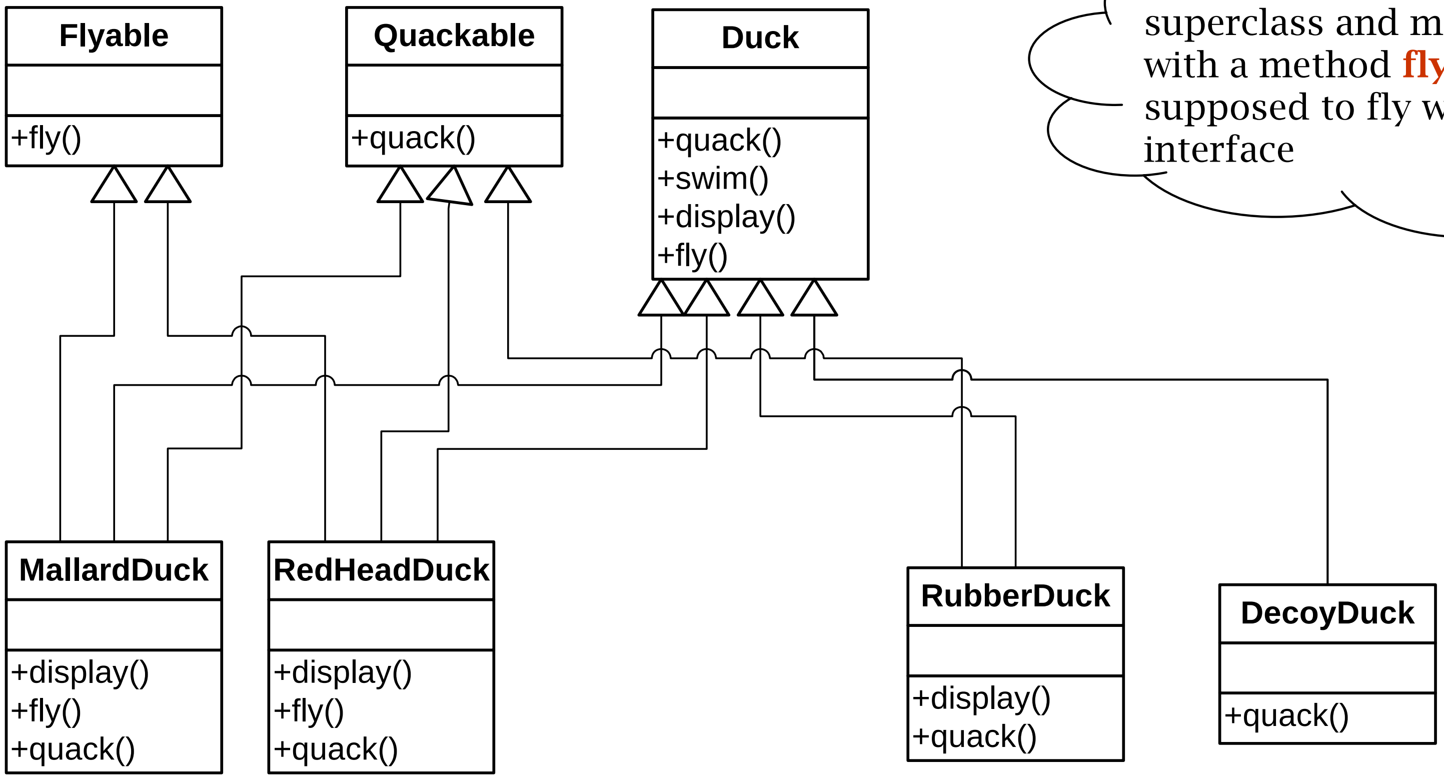


```
void Duck::quack(){
  cout << ”quack, quack” << endl;
}

void RubberDuck::quack(){
  cout << ”squick, squick” << endl;
}
```

We can override the `fly()` method in the rubber duck in a similar way that we override the `quack()` method

```
void Duck::fly(){
  // fly implementation
}

void RubberDuck::fly(){
  // do nothing
}
```

How About an Interface



Flyable
+fly()

Quackable
+quack()

Duck
+quack()
+swim()
+display()
+fly()

MallardDuck
+display()
+fly()
+quack()

RedHeadDuck
+display()
+fly()
+quack()

RubberDuck
+display()
+quack()

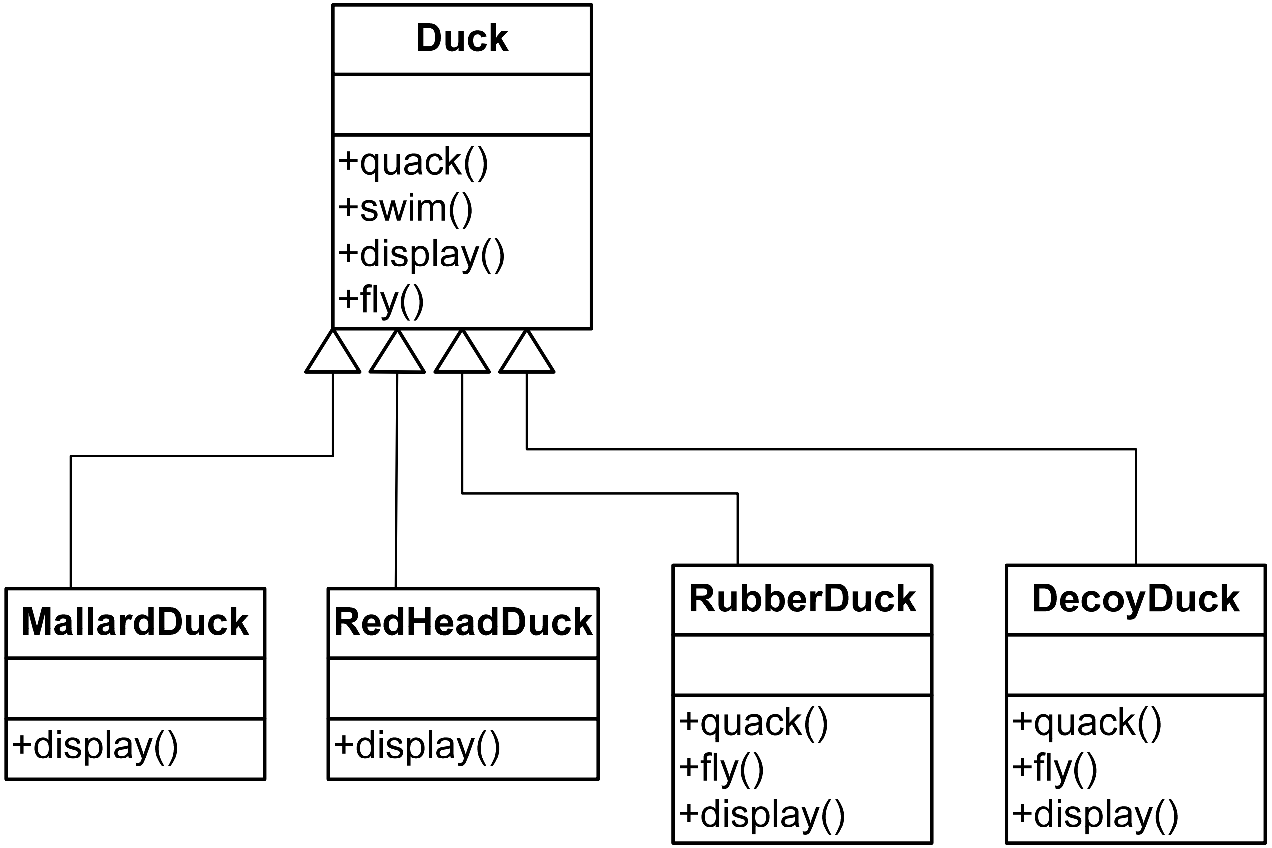
DecoyDuck
+quack()

We can take the **fly()** out of the Duck superclass and make a Flyable interface with a method **fly()**. Each duck that is supposed to fly will implement that interface

Really? I don't think so !!!

Brilliant

Yet Another Duck is Added to the Application



```
void DecoyDuck::quack(){
  // do nothing;
}

void DecoyDuck::fly(){
  // do nothing
}
```

Embracing Change

- In SOFTWARE projects you can count on one thing that is constant:

CHANGE

- **Solution**
  - Deal with it.
    - Make CHANGE part of your design.
    - Identify what vary and separate from the rest.

- Let’s shoot some ducks!

Design Principle

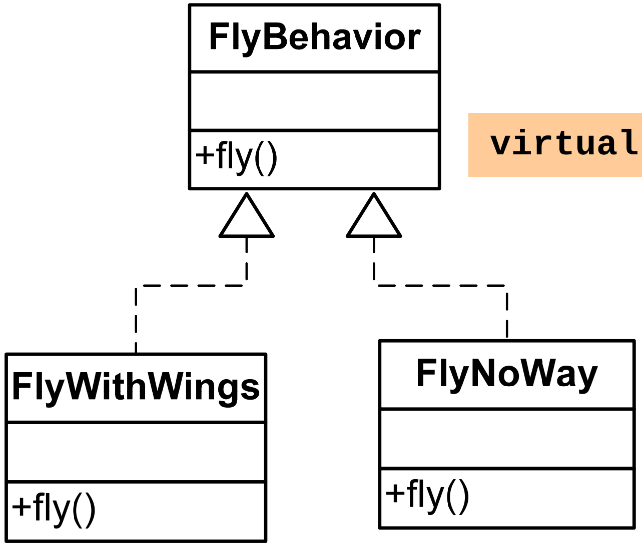
Encapsulate that vary

The Constitution of Software Architects

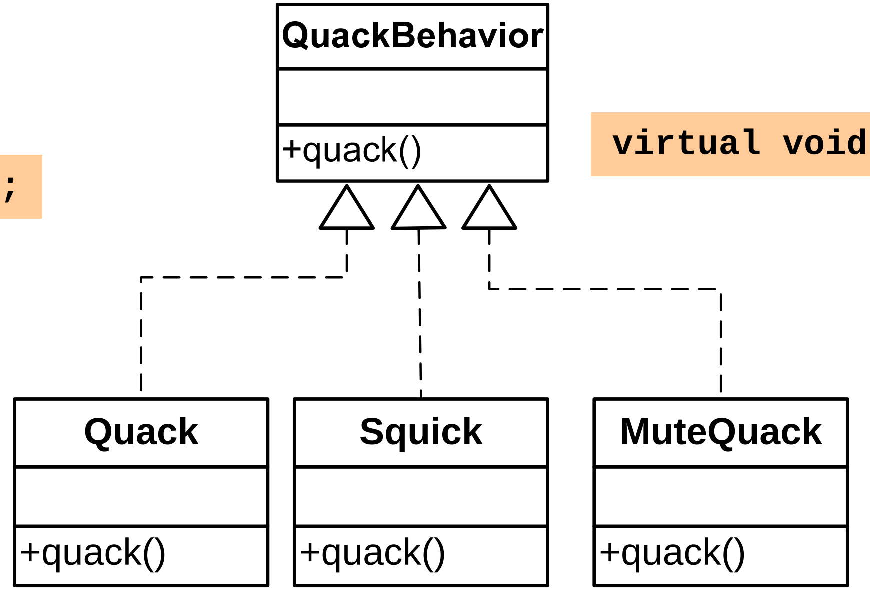
- Encapsulate that vary.
- ?????????
- ?????????
- ?????????
- ?????????
- ?????????
- ?????????
- ?????????
- ?????????

Embracing Change in Ducks

- `fly()` and `quack()` are the parts that vary
- We create a new set of classes to represent each behavior



```
virtual void fly()=0;
```



```
virtual void quack()=0;
```

```
void FlyWithWings::fly(){
  cout << "I'm flying!" << endl;
};
```

```
void Quack::quack(){
  cout << "Quack" << endl;
};
```

```
void Squeak::quack(){
  cout << "Squeak" << endl;
};
```

```
void FlyNoWay::fly(){
  cout << "I can't fly." << endl;
};
```

```
void MuteQuack::quack(){
   cout << "....." << endl;
};
```

Design Principle

Program to an interface not to an implementation

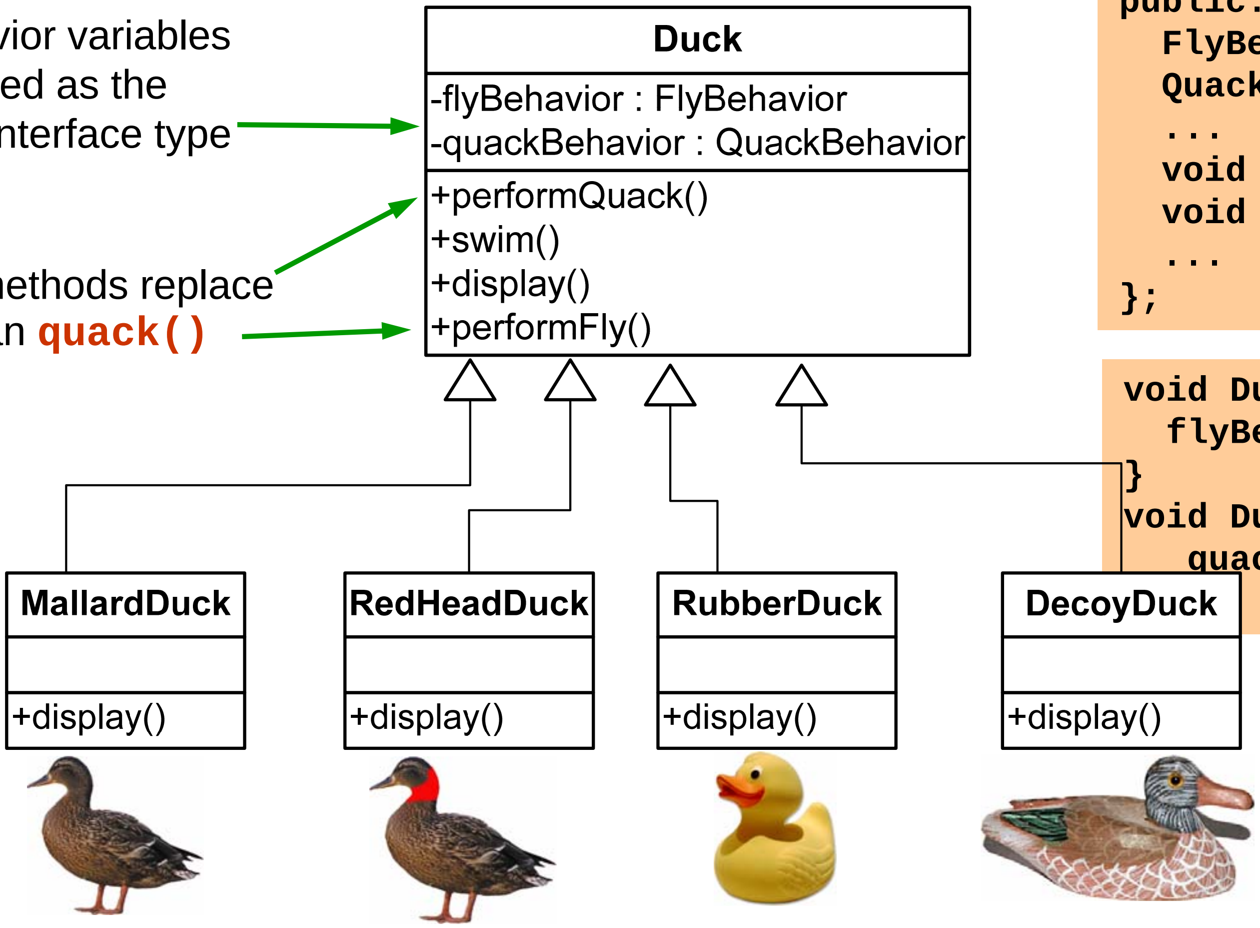
The Constitution of Software Architects

- Encapsulate that vary.
- Program to an interface not to an implementation.
- ?????????
- ?????????
- ?????????
- ?????????
- ?????????
- ?????????
- ?????????

Integrating the Duck Behavior

The behavior variables are declared as the behavior interface type

These methods replace **fly()** an **quack()**



Duck

-flyBehavior : FlyBehavior
-quackBehavior : QuackBehavior

+performQuack()
+swim()
+display()
+performFly()

MallardDuck

+display()

RedHeadDuck

+display()

RubberDuck

+display()

DecoyDuck

+display()

```
class Duck{
public:
  FlyBehavior *flyBehavior;
  QuackBehavior *quackBehavior;
  ...
  void performFly();
  void performQuack();
  ...
};
```

```
void Duck::performFly(){
  flyBehavior->fly();
}
void Duck::performQuack(){
   quackBehavior->quack();
```

```
MallardDuck::MallardDuck(){
  flyBehavior = new FlyWithWings();
  quackBehavior = new Quack();
}
```

```
RubberDuck::RubberDuck(){
  flyBehavior = new FlyNoWay();
  quackBehavior = new Squick();
}
```

Design Principle Ahead

Duck

-flyBehavior : FlyBehavior
-quackBehavior : QuackBehavior

+performQuack()
+swim()
+display()
+performFly()

Each Duck **HAS A** FlyingBehavior and a QuackBehavior to which it delegates flying an quacking

Composition

Instead of inheriting behavior, the duck get their behavior by being composed with the right behavior object

Design Principle

Favor Composition over Inheritance

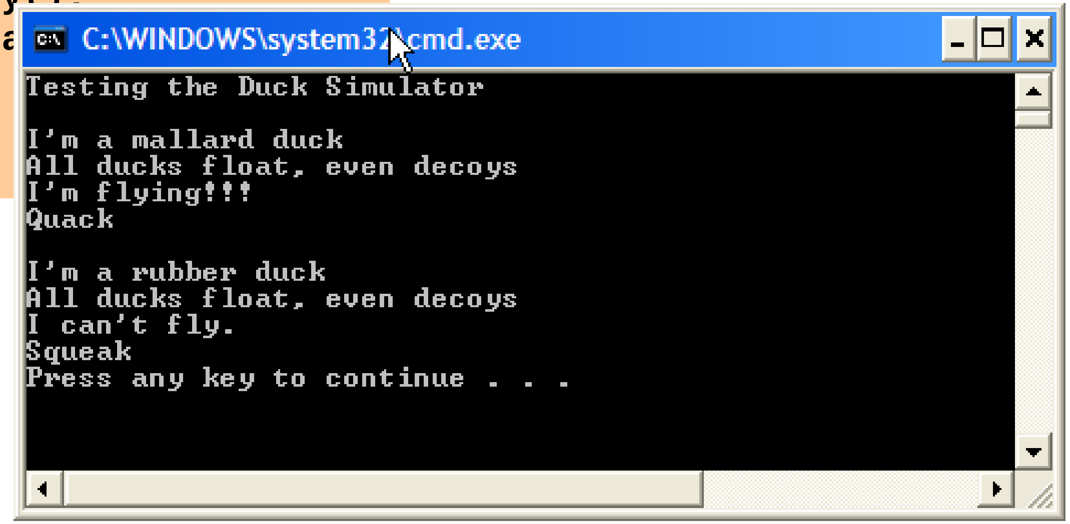
The Constitution of Software Architectcts

- Encapsulate that vary.
- Program to an interface not to an implementation.
- Favor Composition over Inheritance.
- ?????????
- ?????????
- ?????????
- ?????????
- ?????????
- ?????????

Testing the Duck Simulator

```
int main(){
  cout << "Testing the Duck Simulator”
  << endl << endl;

  Duck *mallard = new MallardDuck();
  mallard->display();
  mallard->swim();
  mallard->performFly();
  mallard->performQuack();

  cout << endl;

  Duck *rubberduck = new RubberDuck();
  rubberduck->display();
  rubberduck->swim();
  rubberduck->performFly();
  rubberduck->performQua

  return 0;
}
```

The mallard duck inherited **`performQuack()`** method which delegates to the object **`QuackBehavior`** (calls **`quack()`**) on the duck’s inherited **`quackBehavior`** reference



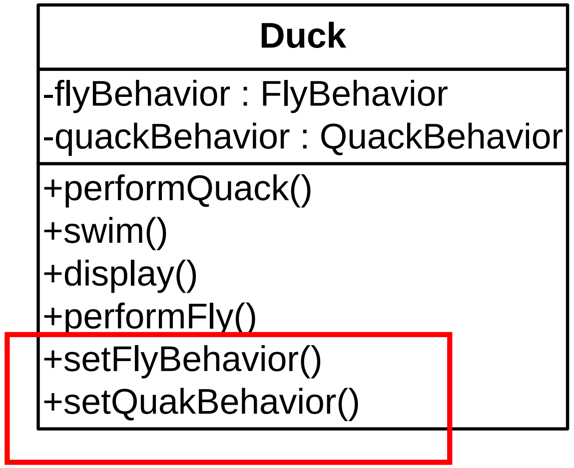
```
Testing the Duck Simulator

I’m a mallard duck
All ducks float, even decoys
I’m flying!!!
Quack

I’m a rubber duck
All ducks float, even decoys
I can’t fly.
Squeak
Press any key to continue . . .
```

Shooting Ducks Dynamicaly

Joe, I'm at the shareholder's meeting. The competitors are ahead us. They just released a new version of DOOM. Do something! It should be possible to shoot those damned ducks.

No problem boss. I can fix this. I will transform our Simulator into a duck shooting game

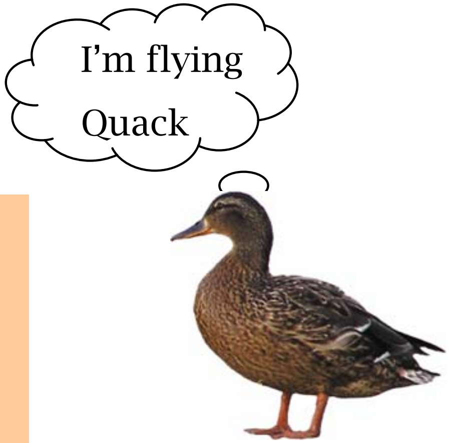
Shooting Ducks Dynamicaly

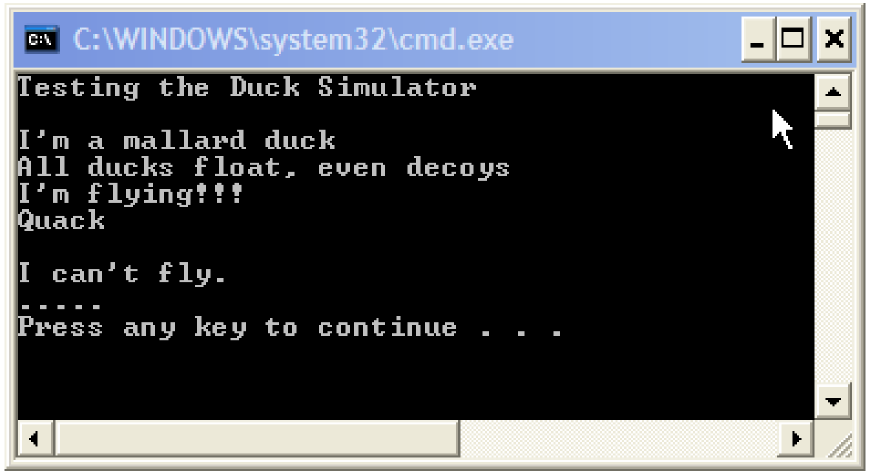


Duck
-flyBehavior : FlyBehavior -quackBehavior : QuackBehavior
+performQuack() +swim() +display() +performFly() +setFlyBehavior() +setQuakBehavior()

```
void Duck::setFlyBehavior(FlyBehavior *fb){
  flyBehavior = fb;
}
void Duck::setQuackBehavior(QuackBehavior *qb){
  quackBehavior = qb;
}
```

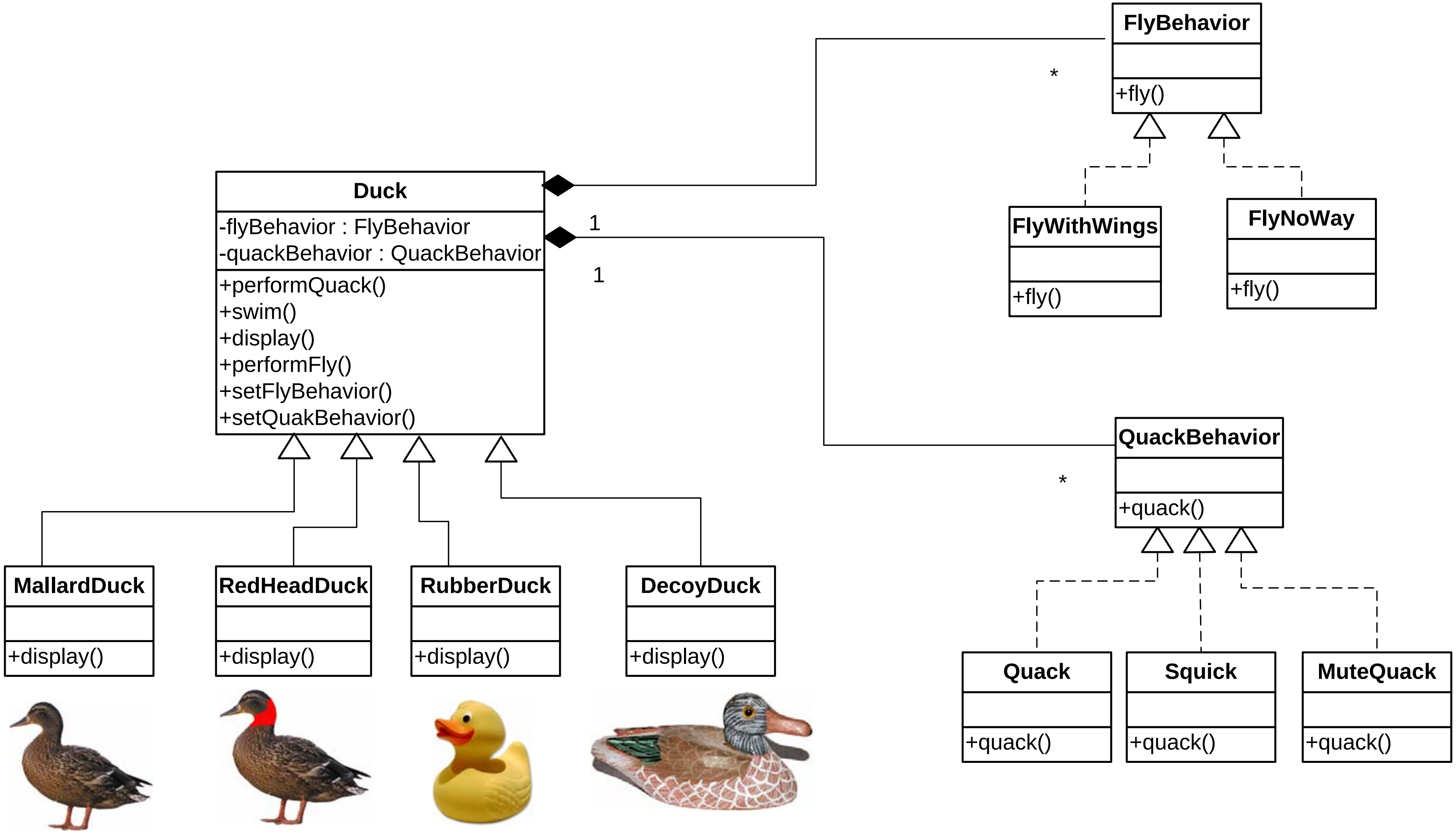
```
int main(){

  Duck *mallard = new MallardDuck();
  mallard->display();
  mallard->swim();
  mallard->performFly();
  mallard->performQuack();

  cout << endl;

  mallard->setFlyBehavior(new FlyNoWay());
  mallard->setQuackBehavior(new MuteQuack());
  mallard->performFly();
  mallard->performQuack();

  return 0;
}
```





```
Testing the Duck Simulator

I'm a mallard duck
All ducks float, even decoys
I'm flying!!!
Quack

I can't fly.
.....
Press any key to continue . . .
```

The Big Picture



Duck
-flyBehavior : FlyBehavior
-quackBehavior : QuackBehavior
+performQuack()
+swim()
+display()
+performFly()
+setFlyBehavior()
+setQuakBehavior()

FlyBehavior
+fly()

FlyWithWings
+fly()

FlyNoWay
+fly()

QuackBehavior
+quack()

Quack
+quack()

Squick
+quack()

MuteQuack
+quack()

MallardDuck
+display()

RedHeadDuck
+display()

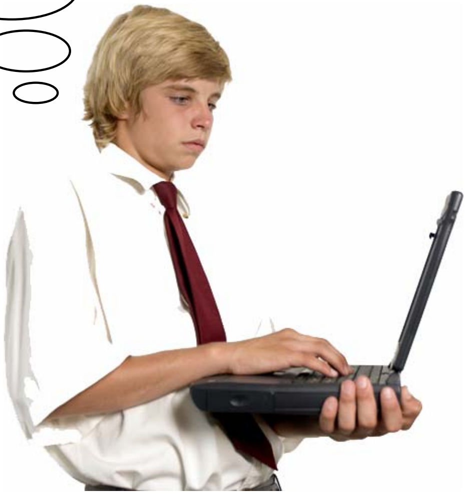
RubberDuck
+display()

DecoyDuck
+display()

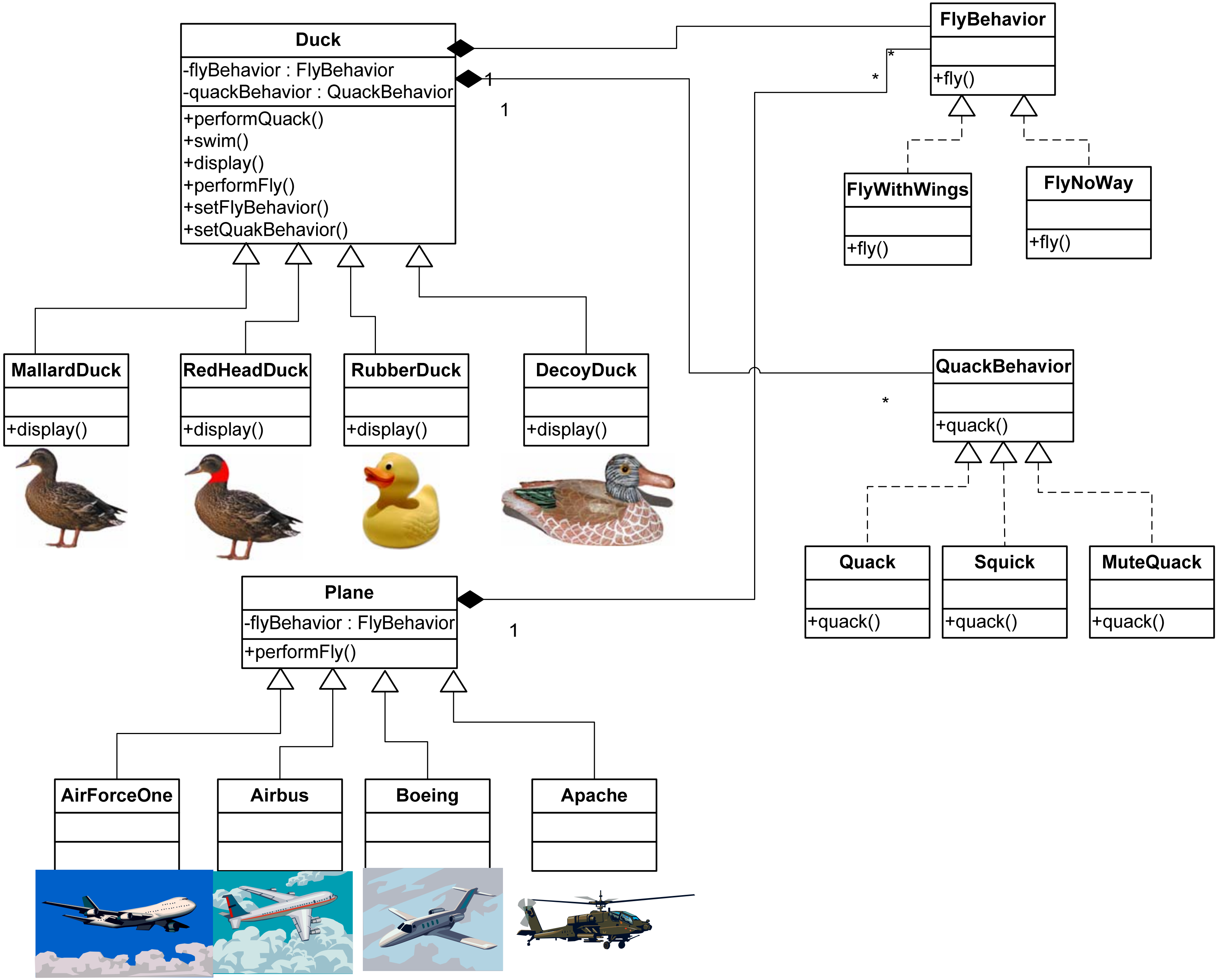
Yet another Change

Joe, I'm at the movie theater. I just saw Star Wars. Great movie. I was just thinking maybe we should put some nice planes into a our simulator. This will destroy our competitors.

OK, Ok… I will do that. But I need a raise.



Behavior Reuse



Duck

-flyBehavior : FlyBehavior
-quackBehavior : QuackBehavior

+performQuack()
+swim()
+display()
+performFly()
+setFlyBehavior()
+setQuakBehavior()

FlyBehavior

+fly()

FlyWithWings

+fly()

FlyNoWay

+fly()

MallardDuck

+display()

RedHeadDuck

+display()

RubberDuck

+display()

DecoyDuck

+display()

QuackBehavior

+quack()

Quack

+quack()

Squick

+quack()

MuteQuack

+quack()

Plane

-flyBehavior : FlyBehavior

+performFly()

AirForceOne

Airbus

Boeing

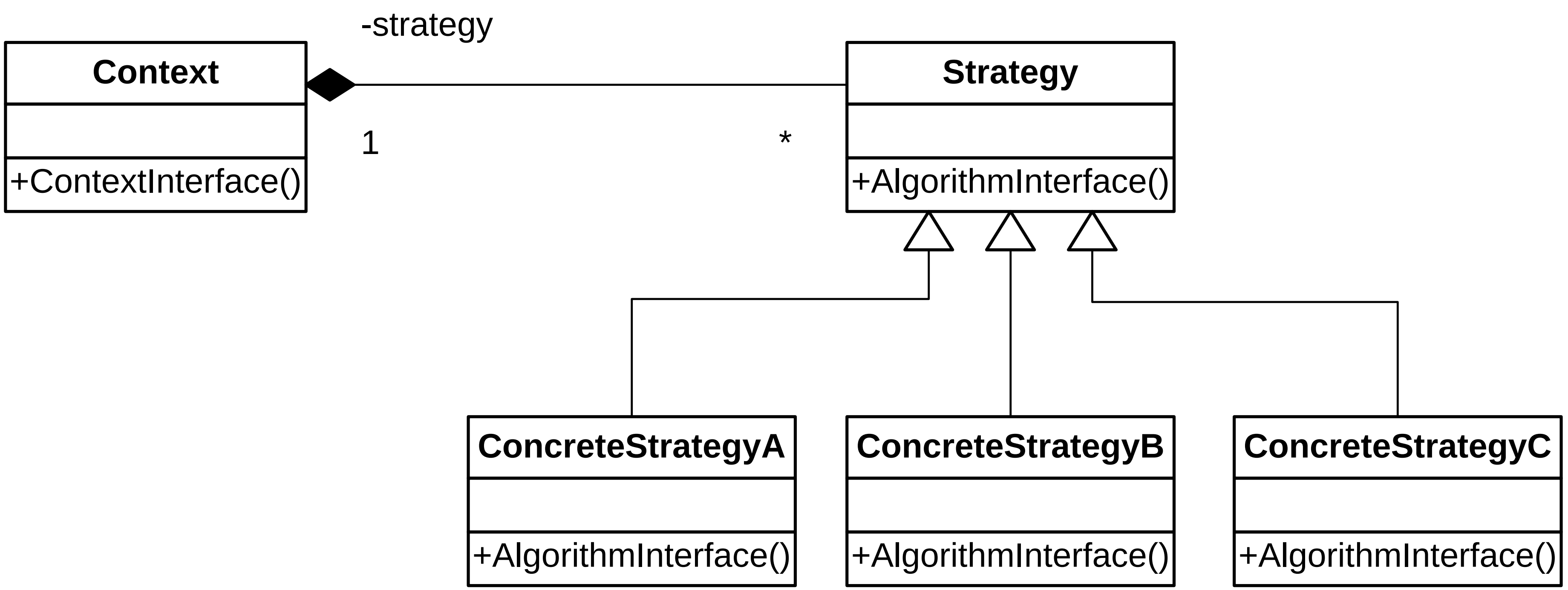
Apache

Congratulations

Congratulations !!!

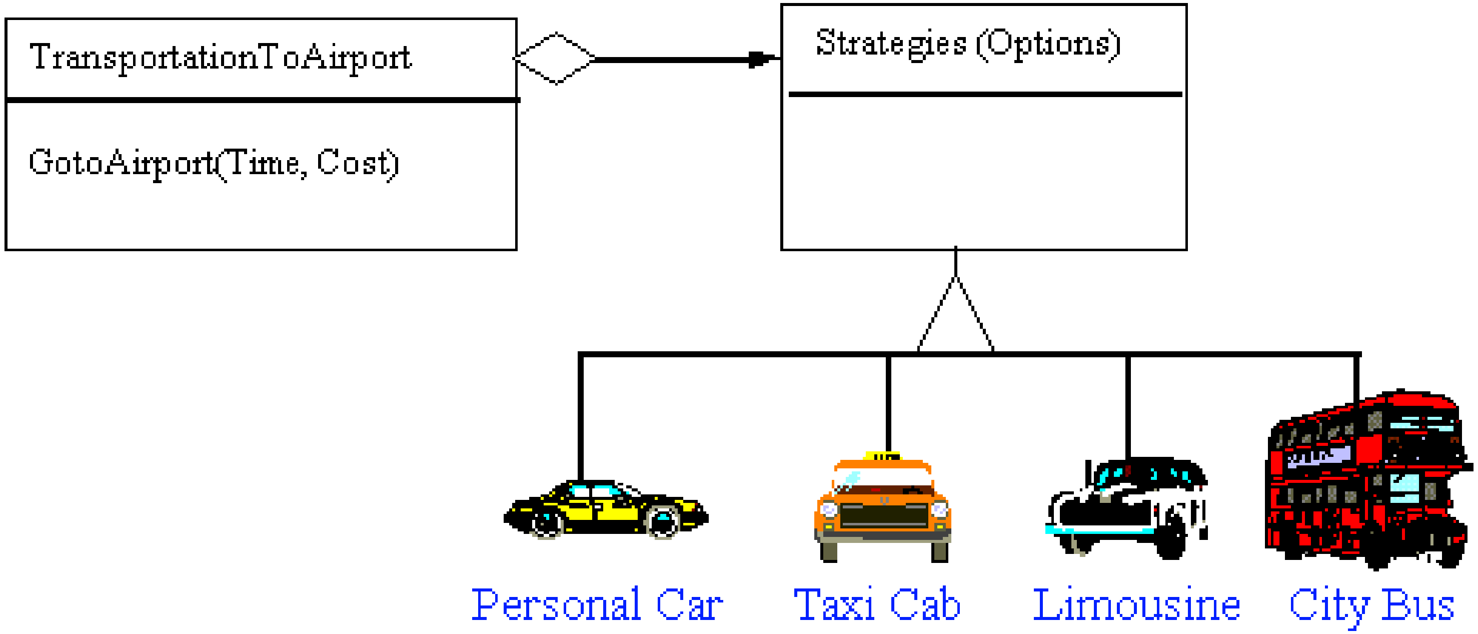
This is your first pattern called STRATEGY

Strategy Pattern Diagram



Strategy – defines a family of algorithms, encapsulate each one, and makes them interchangeable. Strategy lets the algorithm vary independently from the clients that use it.

Strategy – Non Software Example



What are Patterns

- *A pattern is a named nugget of insight that conveys the essence of a proven solution to a recurring problem within a certain context amidst competing concerns.“* (D. Riehle/H. Zullighoven)
- *The pattern is at the same time a thing, which happens in the world, and the rule which tells us how to create that thing, and when we must create it.*
(R. Gabriel)
- *A pattern involves a general discription of a recurring solution to a recurring problem with various goals and constraints.It identify more than a solution, it also explains why the solution is needed.“* (J. Coplien)
- ... describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice **[Alexander]**

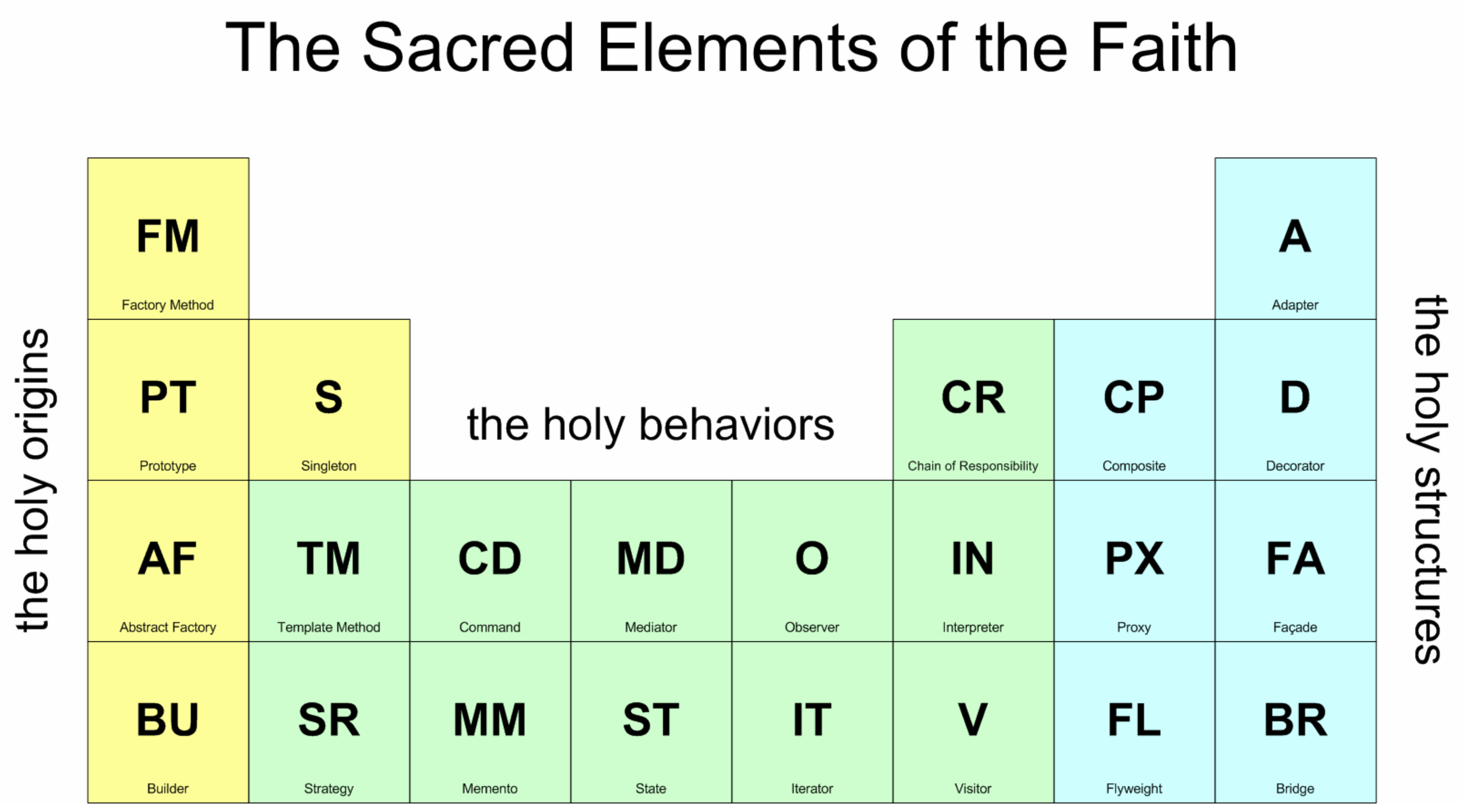
Design Pattern Space

- Creational patterns
  - Deal with initializing and configuring of classes and objects
- Structural patterns
  - Deal with decoupling interface and implementation of classes and objects
- Behavioral patterns
  - Deal with dynamic interactions among societies of classes and objects

Design Pattern Space

		Purpose		
		Creational	Structural	Behavioral
Scope	Class	• Factory Method	• Adapter	• Interperter
	Object	• Abstract Factory • Builder • Prototype • Singleton	• Adapter • Bridge • Composite • Decorator • Facade • Flyweight • Proxy	• Chain of Responsibility • Command • Iterator • Mediator • Momento • Observer • State • Strategy • Vistor

Design Pattern Space



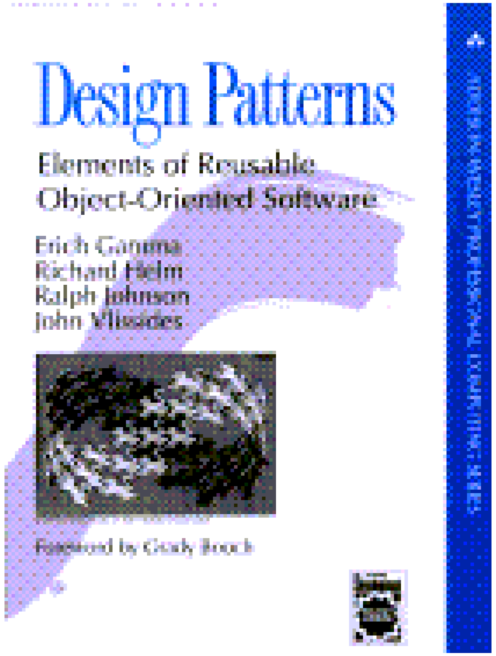
The Sacred Elements of the Faith

the holy origins

FM Factory Method							**A** Adapter
PT Prototype	**S** Singleton	the holy behaviors			**CR** Chain of Responsibility	**CP** Composite	**D** Decorator
AF Abstract Factory	**TM** Template Method	**CD** Command	**MD** Mediator	**O** Observer	**IN** Interpreter	**PX** Proxy	**FA** Façade
BU Builder	**SR** Strategy	**MM** Memento	**ST** State	**IT** Iterator	**V** Visitor	**FL** Flyweight	**BR** Bridge

the holy structures

What’s In a Design Pattern--1994



- The GoF book describes a pattern using the following four attributes:
  - The ***name*** to describes the pattern, its solutions and consequences in a word or two
  - The ***problem*** describes when to apply the pattern
  - The ***solution*** describes the elements that make up the design, their relationships, responsibilities, and collaborations
  - The ***consequences*** are the results and trade-offs in applying the pattern
- All examples in C++ and Smalltalk

Closing remarks

- No Real Ducks have been harmed during this lecture.