SENG 350
- Software Architecture & Design

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Design Patterns

Fall 2024

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Web programming

- The non-design bits
- Developing web applications of all scales

  "In software engineering, a Web application or webapp is an application accessed with a Web browser over a network such as the Internet or an intranet. Web applications are popular due to the ubiquity of the browser as a client, sometimes called a thin client. The ability to update and maintain Web applications without distributing and installing software on potentially thousands of client computers is a key reason for their popularity. Web applications implement Webmail, online retail sales, online auctions, wikis, discussion boards, Weblogs, MMORPGs, and many other functions."

Webapps summary

- Accessed with a Web Browser (client)
- Over a network

- Code is mainly run on server
- Exception: Javascript (also: Java, Flash,..)

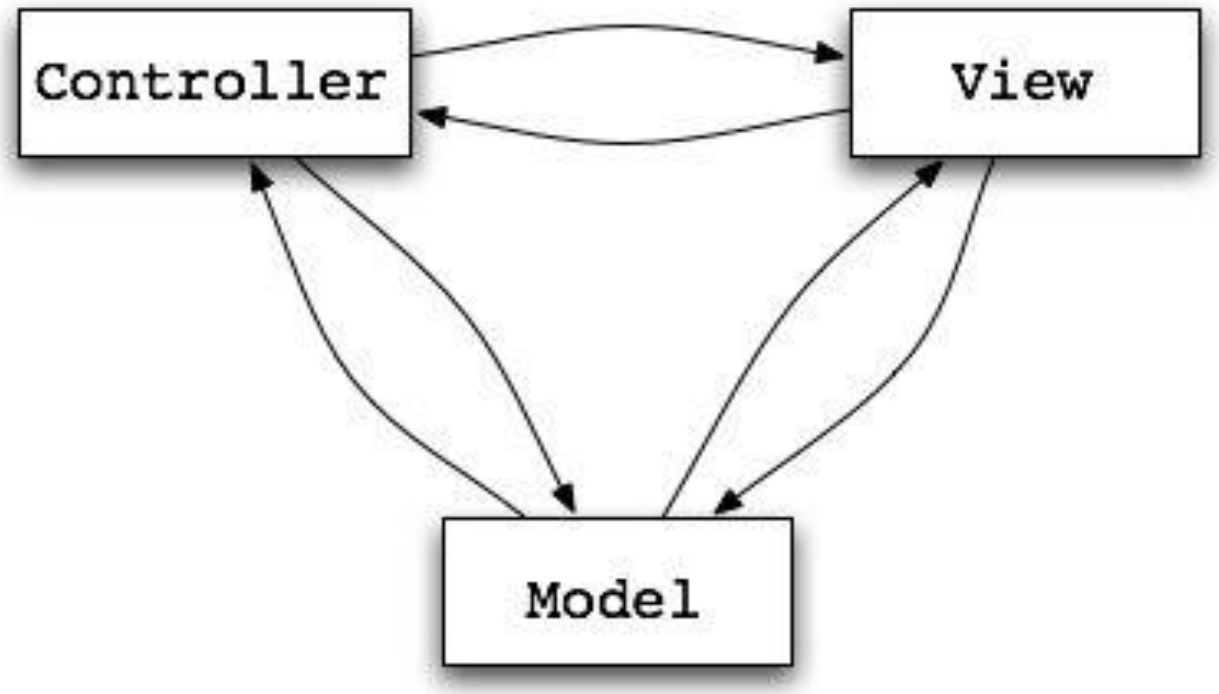
- Code is loaded from server
- Data is mainly stored on server

- Webapps can be updated easily…
  ..without updating the clients!

General 3 tiered structure

- First tier: client side code (web-browser), e.g. (X)HTML, Javascript, Java, Flash
- Second tier: server side code, e.g. C/C++, Perl, PHP, Java, Ruby, Python
- Third tier: server side database

Model View Controller



- Architectural Pattern from Smalltalk
- Decouples data and presentation
- Eases the development

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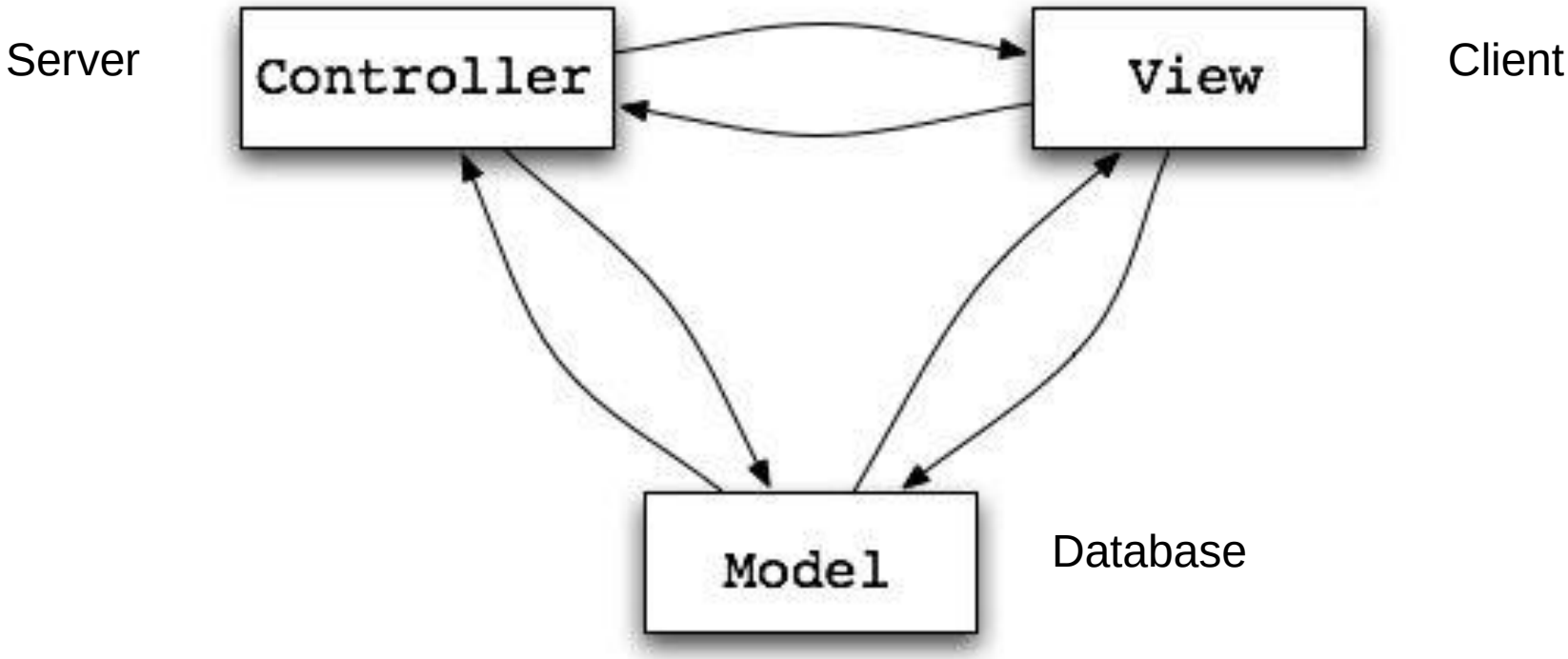

First thought (ok, but not far enough):

- Tier 1: View (Client)
- Tier 2: Controller (Server)
- Tier 3: Model (Database)

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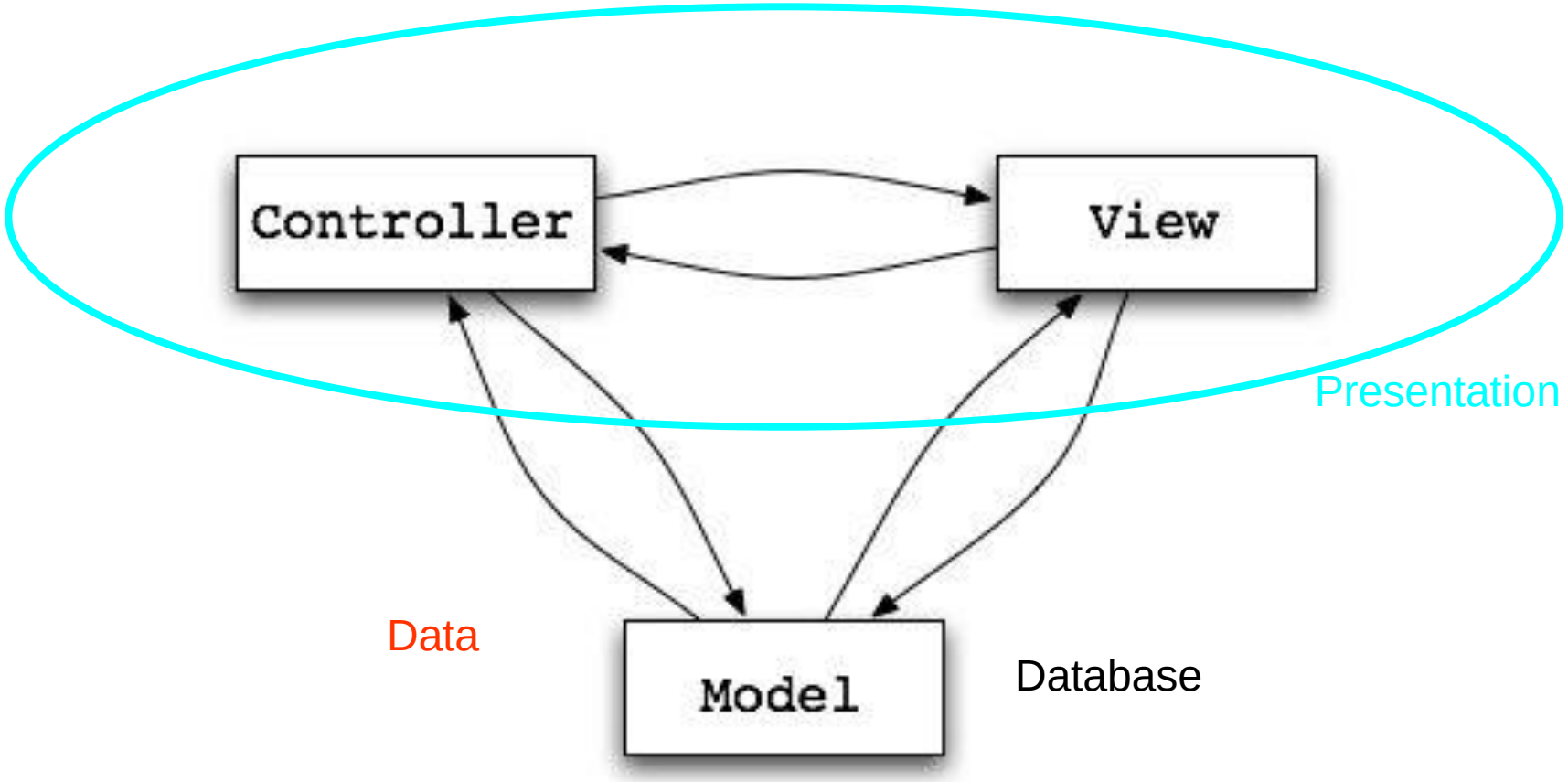

Presentation:

View is the user interface (e.g. button)

Controller is the code (e.g. callback for button)

Data:

Model is the database

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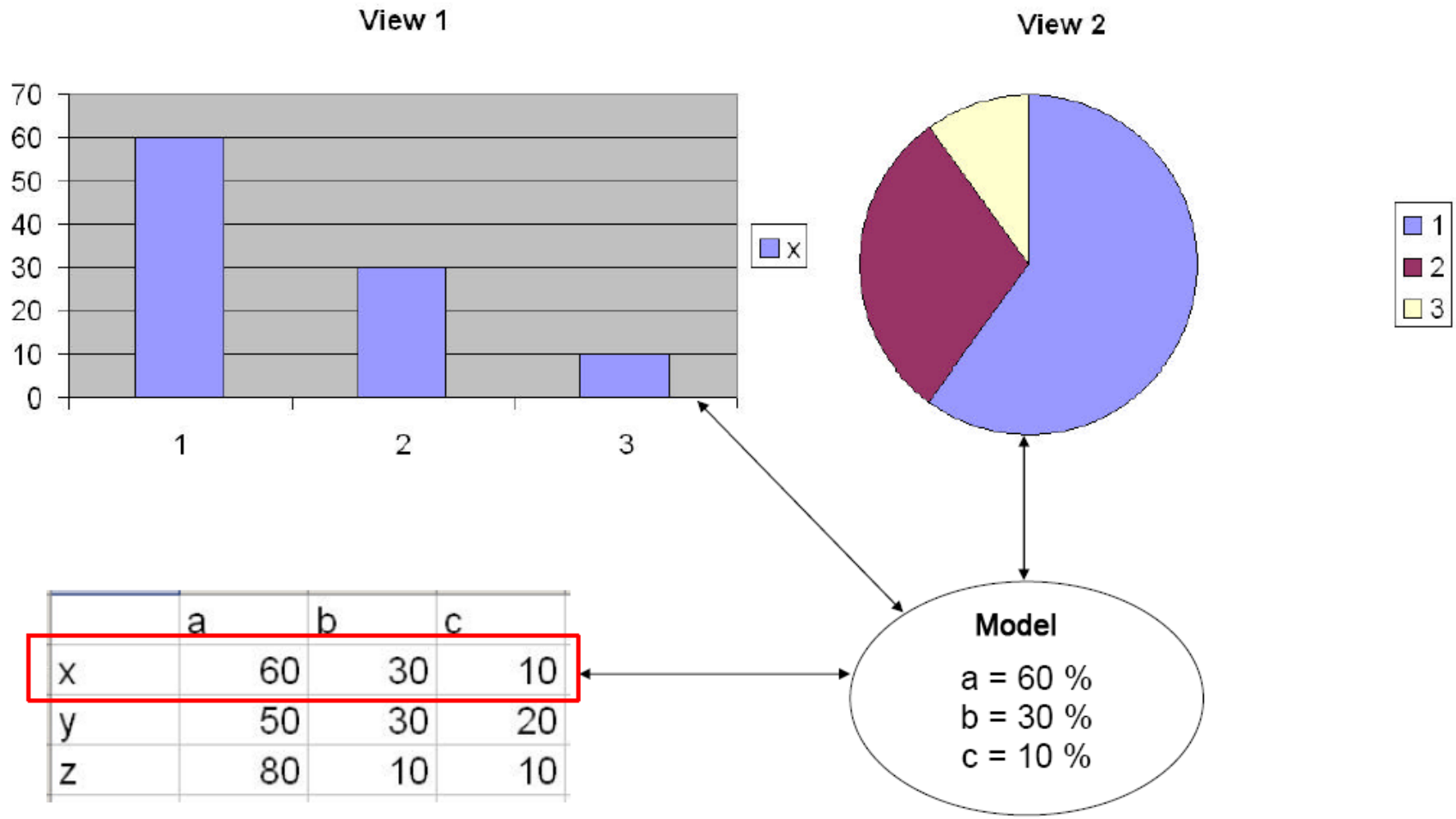
Example Control Flow in MVC

- User interacts with the VIEW UI
- CONTROLLER handles the user input (often a callback function attached to UI elements)
- CONTROLLER updates the MODEL
- VIEW uses MODEL to generate new UI
- UI waits for user interaction

MVC – general example



Design Patterns

By Purpose				
		Creational	**Structural**	**Behavioral**
By Scope	**Class**	• Factory Method	• Adapter (class)	• Interpreter • Template Method
	Object	• Abstract Factory • Builder • Prototype • Singleton	• Adapter (object) • Bridge • Composite • Decorator • Façade • Flyweight • Proxy	• Chain of Responsibility • Command • Iterator • Mediator • Memento • Observer • State • Strategy • Visitor

Singleton Pattern

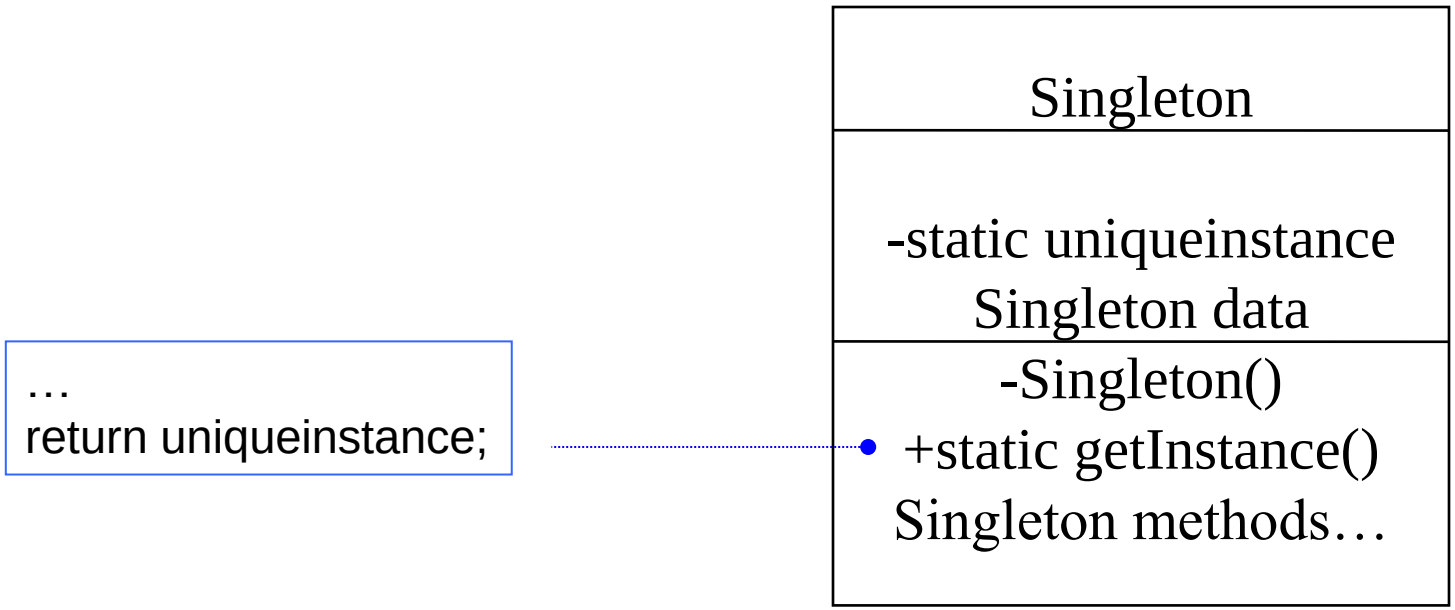
Singleton

- Intent
  - Ensure a class has only one instance, and provide a global point of access to it
- Motivation
  - Important for some classes to have exactly one instance.
  - Ensure only one instance is available and easily accessible
    - global variables give access, but don’t keep you from instantiating many objects
  - Give class responsibility for keeping track of its sole instance

Design Solution

Defines a getInstance() operation that lets clients access its unique instance

May be responsible for creating its own unique instance



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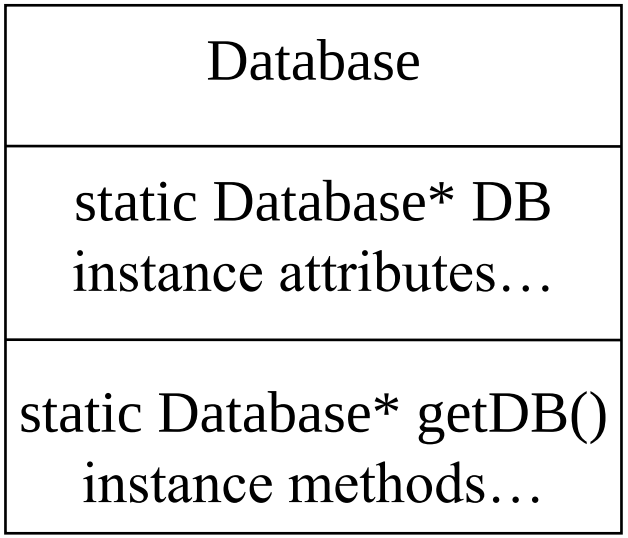
Singleton Example (Java)

Database




```
public class Database {
private static Database DB;
   ...
private Database() { ... }
public static Database getDB() {
   if (DB == null)
     DB = new Database();
   return DB;
}
   ...
}
```

In application code…

```
Database db = Database.getDB();
db.someMethod();
```

Singleton Example (C++)

```
class Database
{
private:
   static Database *DB;
   ...
   private Database() { ... }
public:
   static Database *getDB()
   { if (DB == NULL)
       DB = new Database());
     return DB;
   }
   ...
}
Database *Database::DB=NULL;
```

In application code…

```
Database *db =
       Database.getDB();
Db->someMethod();
```

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Implementation

- Declare all of class's constructors private
  - prevent other classes from directly creating an instance of this class
- Hide the operation that creates the instance behind a class operation (getInstance)
- Variation: Since creation policy is encapsulated in getInstance, it is possible to vary the creation policy

Singleton Consequences

- Ensures only one (e.g., Database) instance exists in the system
- Can maintain a pointer (need to create object on first get call) or an actual object
- Can also use this pattern to control fixed multiple instances
- Much better than the alternative: global variables

By Purpose				
		Creational	**Structural**	**Behavioral**
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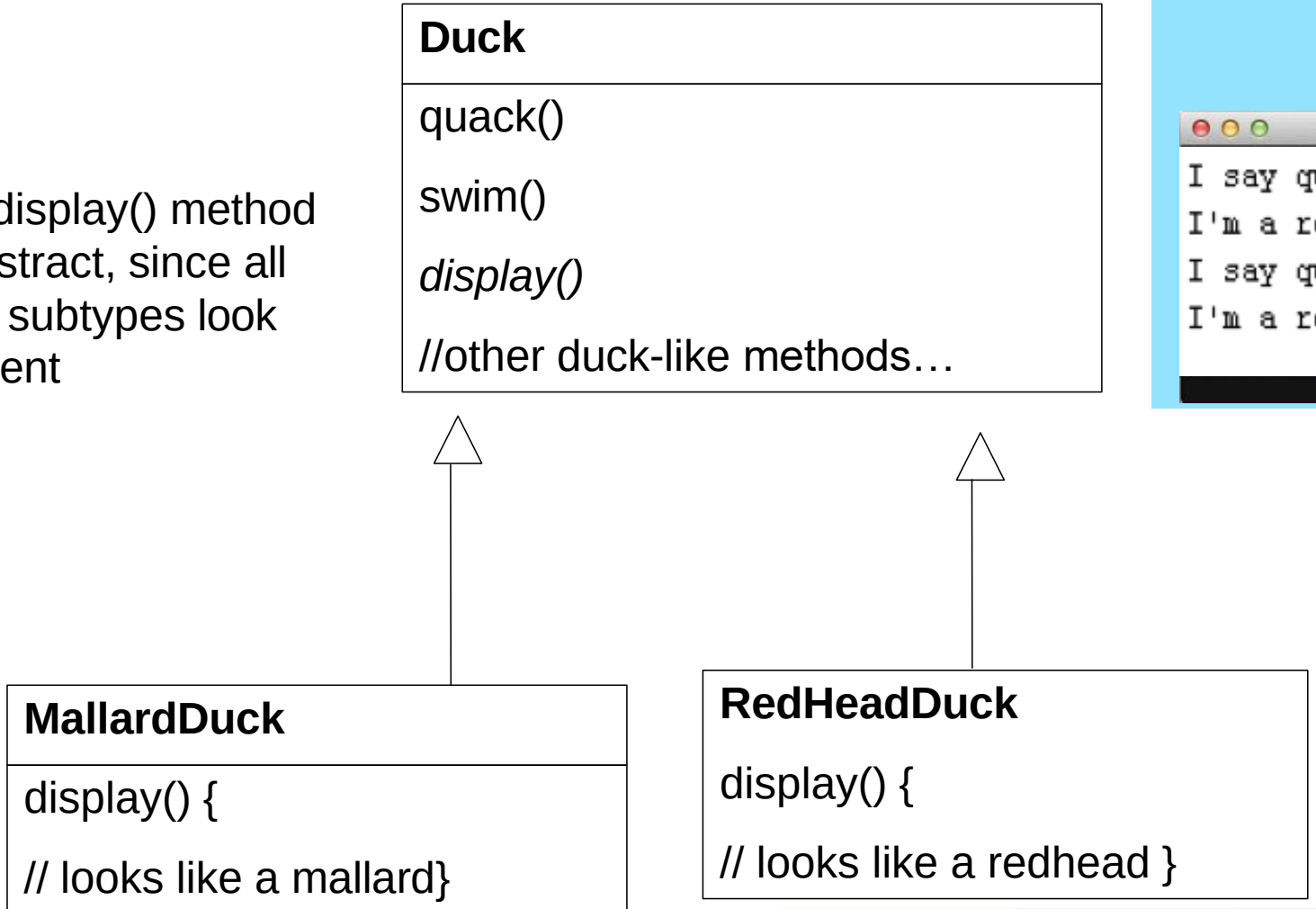
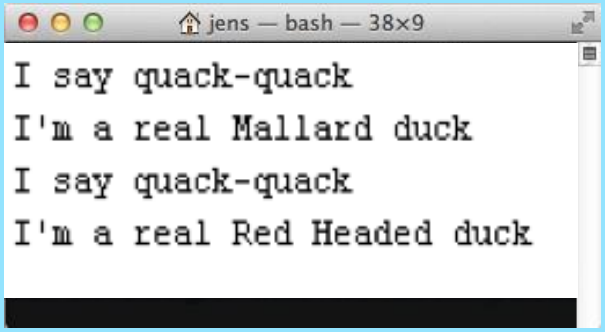
The Strategy Pattern

Introductory Example: (OO) Duck application

The display() method is abstract, since all duck subtypes look different



Test run:



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But Executives want to introduce fly capability quickly

How to do it in a short time, like 2 days?

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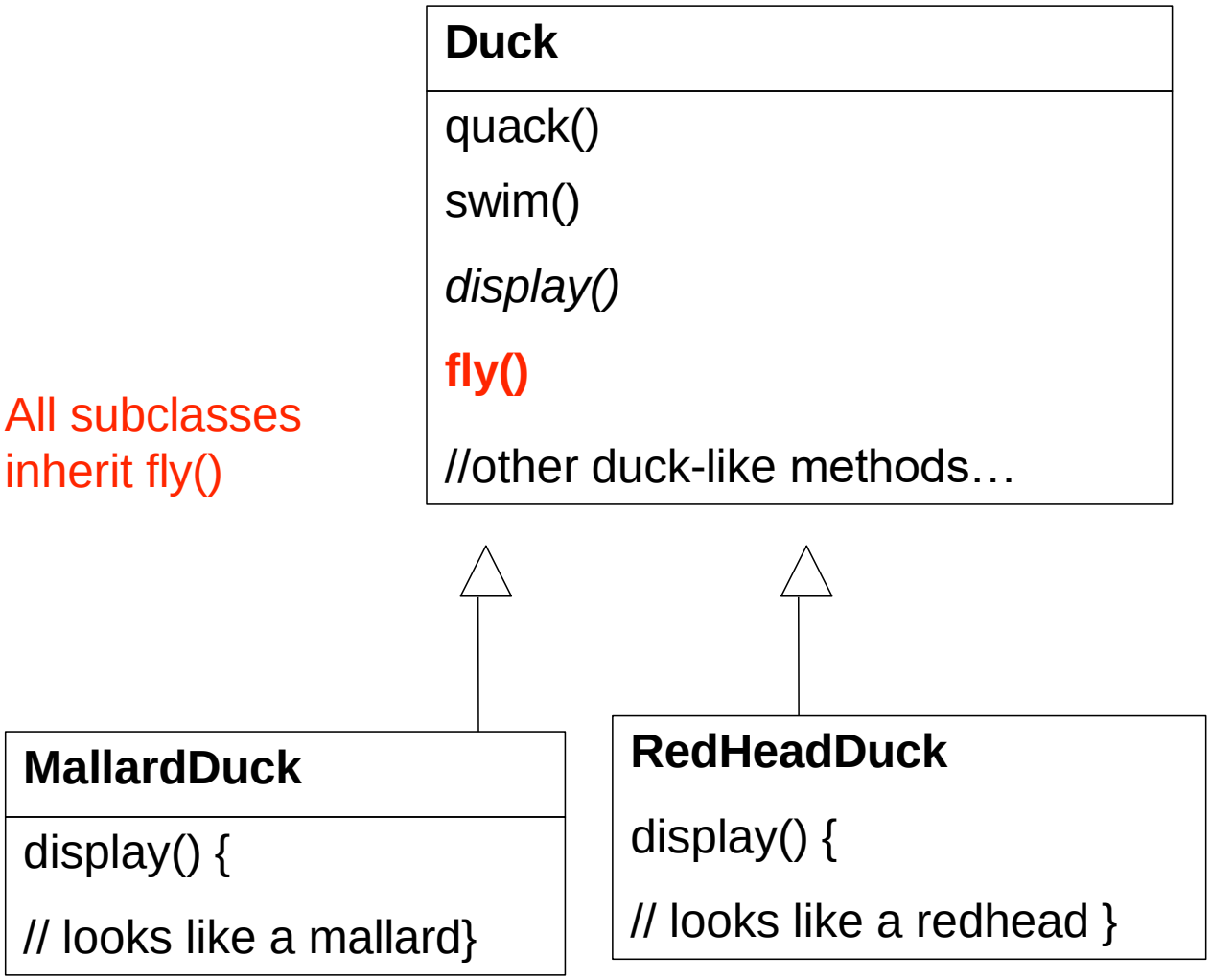
Solution #1: add a method fly() in Duck

All subclasses inherit fly()



Later it turns out that there are exceptions.
Not all ducks can fly!!!!

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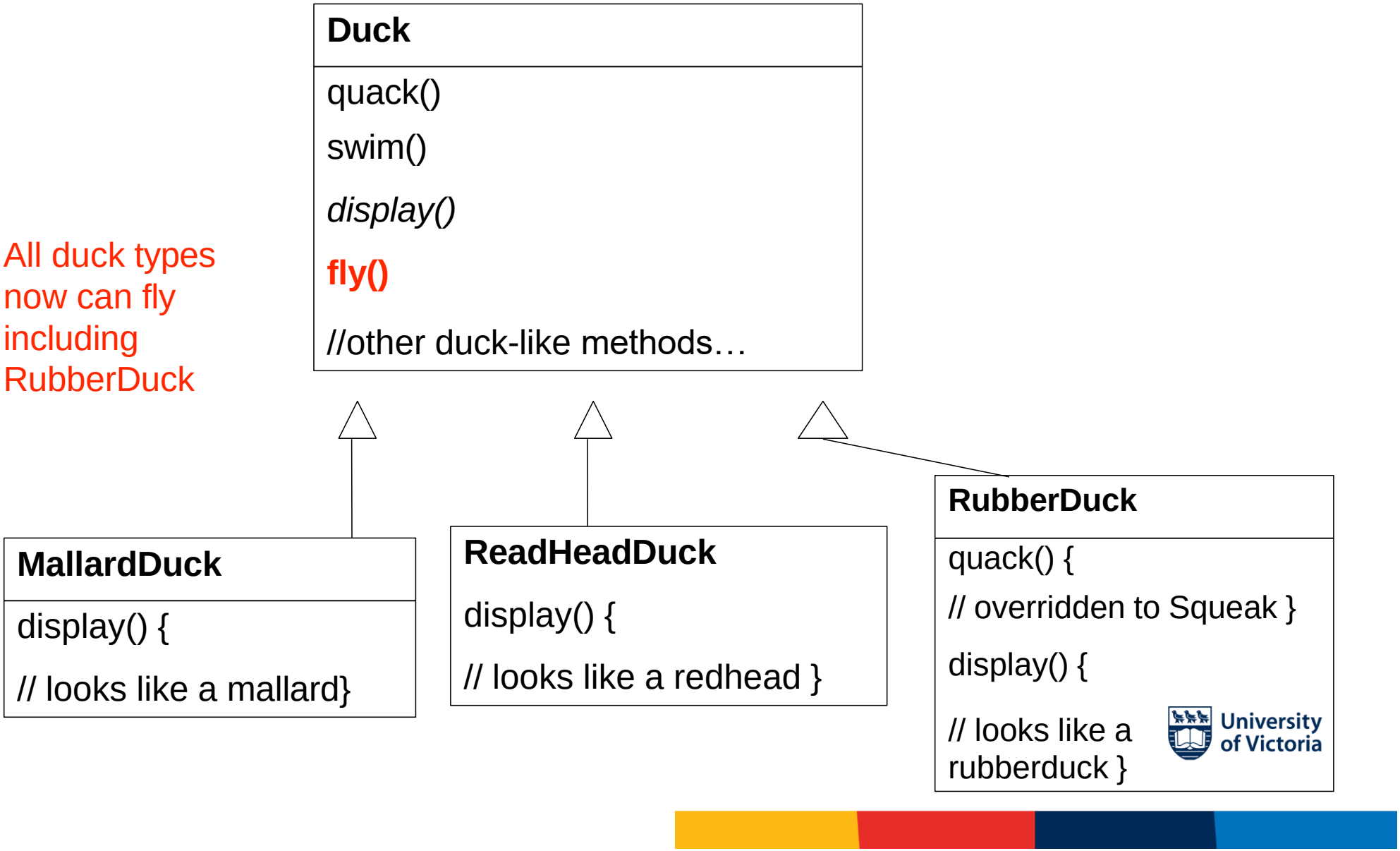
Something's wrong

All duck types now can fly including RubberDuck



How do we fix this?

How do we fix this? (in OO)

- Using inheritance as before
  - –Override the fly() method in rubber duck as in quack()

Wait a minute

- How about new duck types?
  - –Decoy duck?
    - Can’t quack
    - Can’t fly

How else could we model the "variability"?

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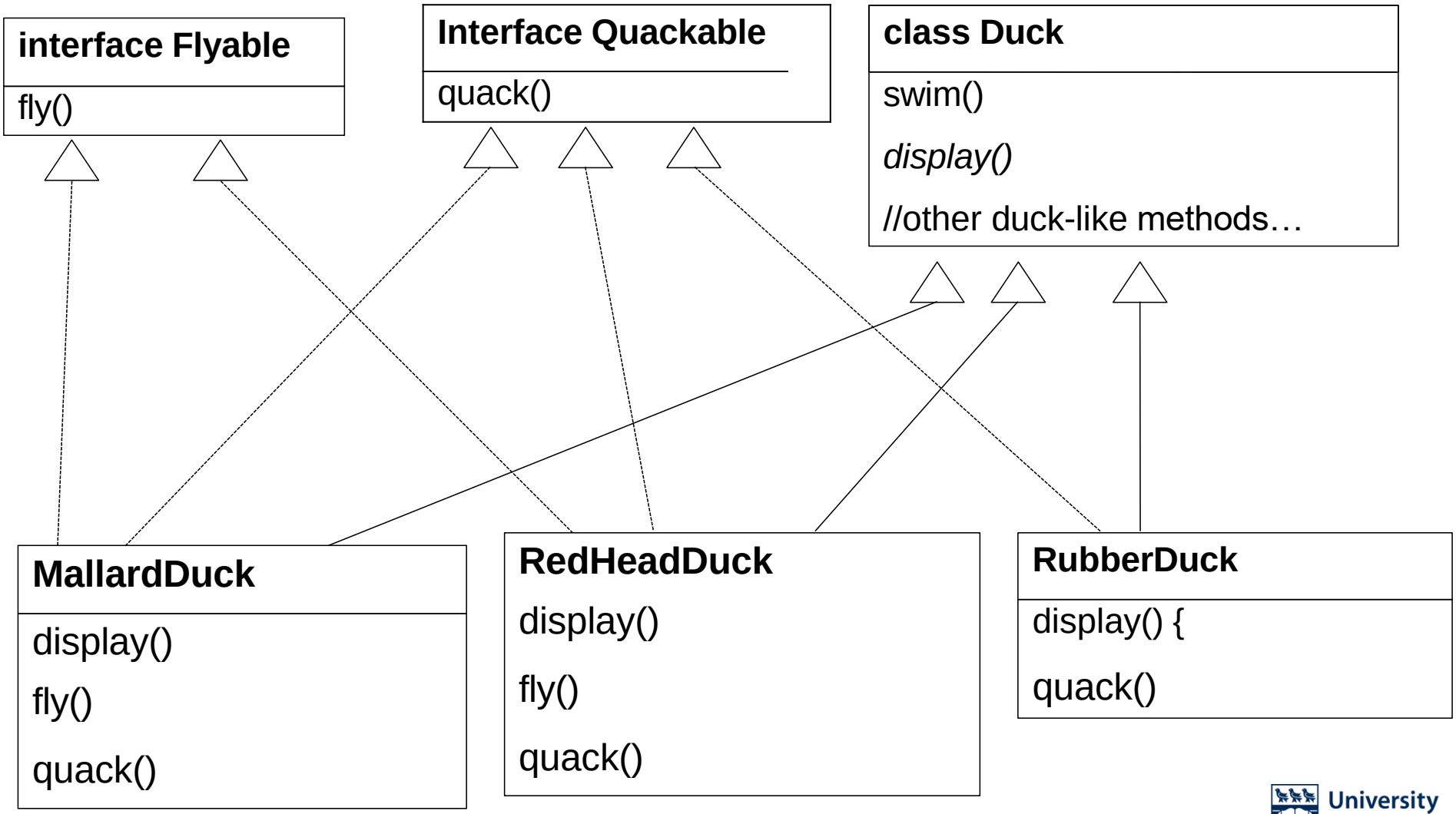
How about Interface?

- Take the fly() method out of Duck superclass
- And make a Flyable() interface
  - –Only those ducks that fly are required to implement the interface
- Make a Quackable interface too



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But…

- You shoot yourself in the foot by duplicating code for every duck type that can fly and quack!
- And we have a lot of duck types
- We have to be careful about the properties – we cannot just call the methods blindly
- *We have created a maintenance nightmare!*

Re-thinking:

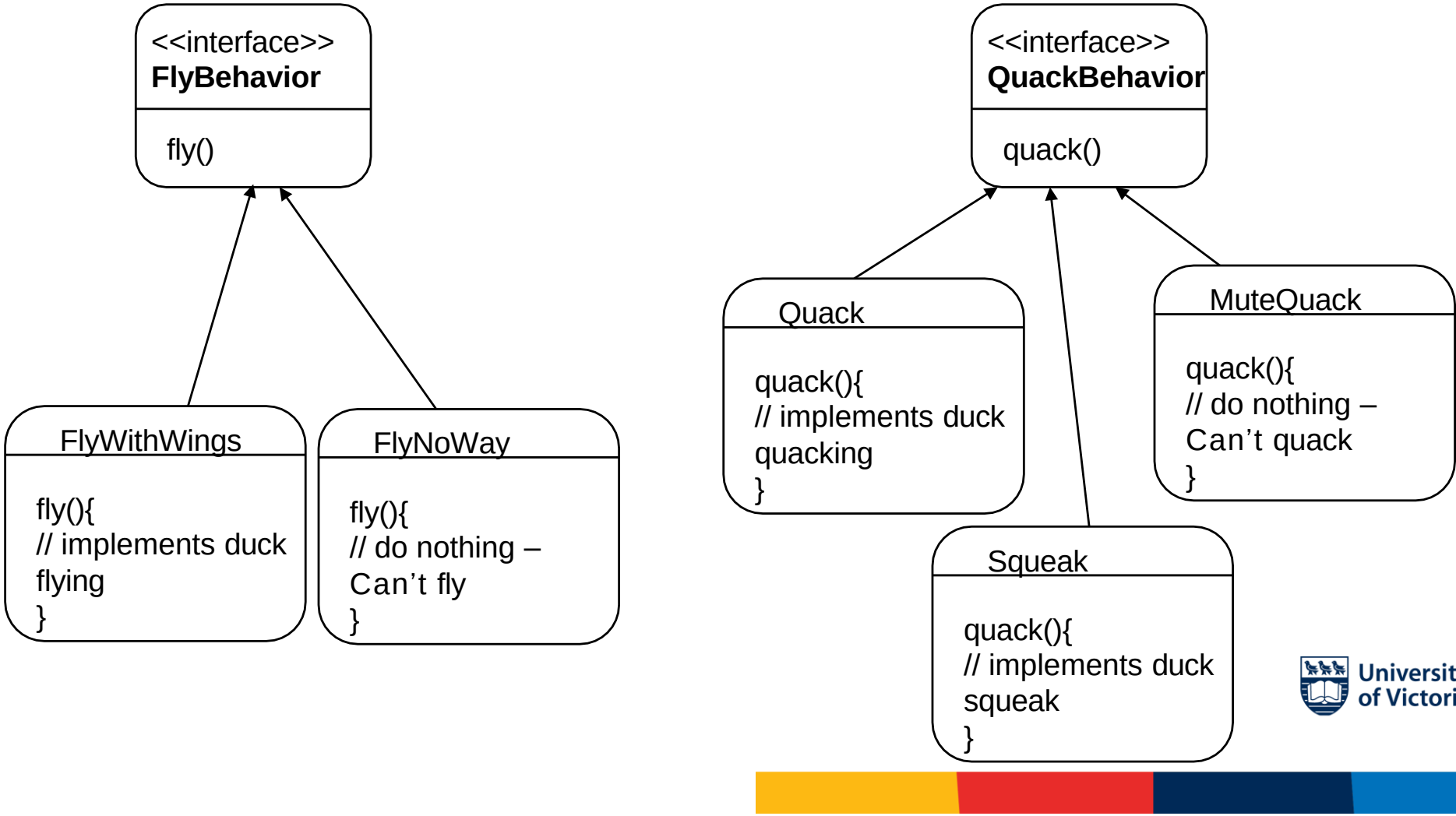
- Inheritance has not worked well because
  - Duck behaviour keeps changing
  - Not suitable for all subclasses to have those properties
- Interface was at first promising, *but*
  - No code re-use
  - Tedious
    - Every time a behaviour is changed, you must track down and change it in all the subclasses where it is defined
  - Error prone

Design Principle

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

- So what are variable in the Duck class?
  - –Flying behaviour
  - –Quacking behaviour
- Pull these duck behaviours out of the Duck class
  - –Create new classes for these behaviours

Implementing duck behaviours in separate strategy classes



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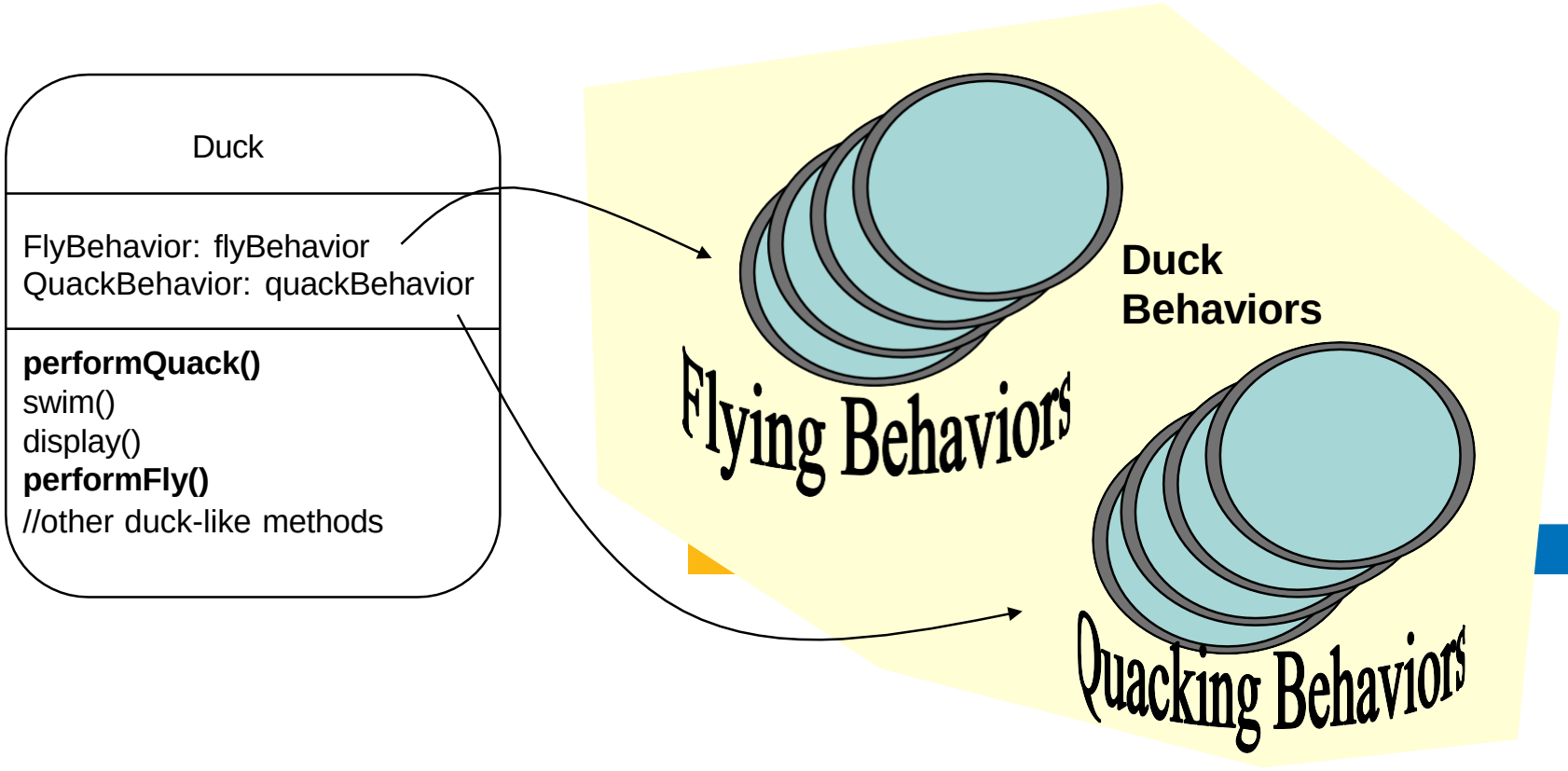
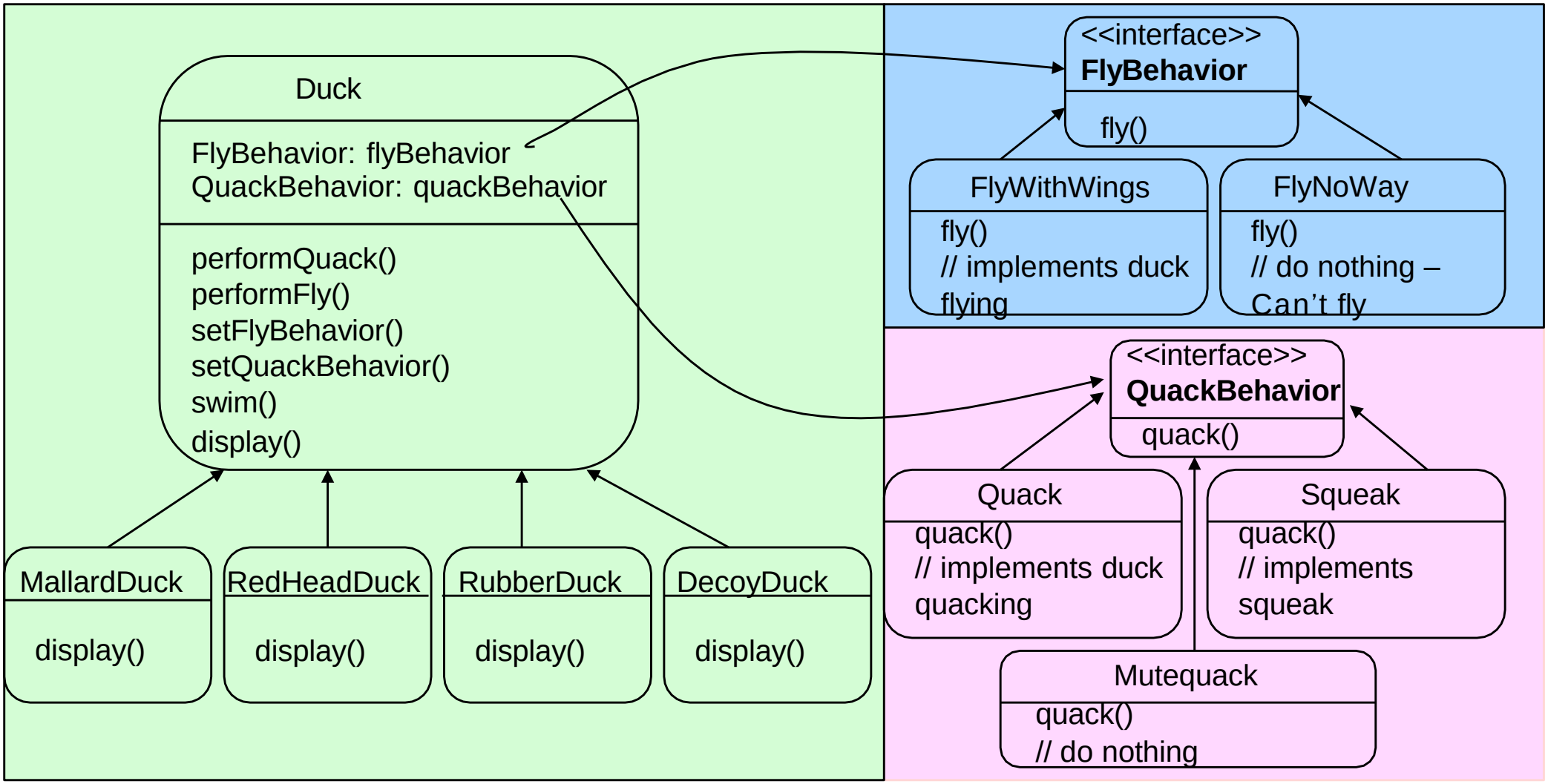
Integrating the behaviours into the Duck class

- Duck class will ***delegate*** its flying and quacking behavior instead of implementing these itself

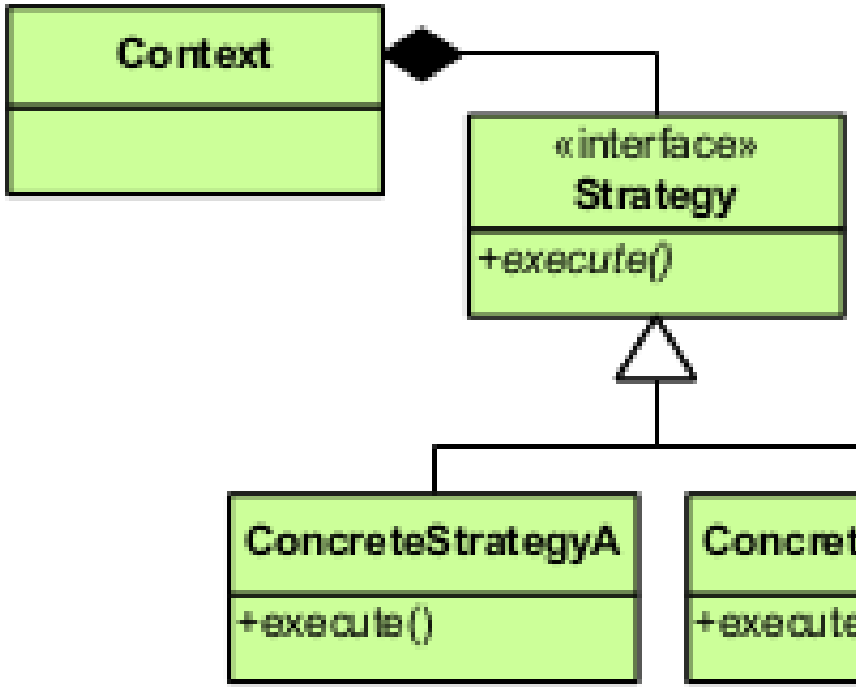


Using UML


Duck
FlyBehavior: flyBehavior
QuackBehavior: quackBehavior
performQuack()
performFly()
setFlyBehavior()
setQuackBehavior()
swim()
display()
MallardDuck
display()
RedHeadDuck
display()
RubberDuck
display()
DecoyDuck
display()
<<interface>>
FlyBehavior
fly()
FlyWithWings
fly()
// implements duck flying
FlyNoWay
fly()
// do nothing – Can't fly
<<interface>>
QuackBehavior
quack()
Quack
quack()
// implements duck quacking
Squeak
quack()
// implements squeak
Mutequack
quack()
// do nothing

Strategy Pattern Defined

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.



Specific behaviours by implementing interface QuackBehavior

```
public class Quack implements QuackBehavior { public void quack() {
        System.out.println("Quack");
    }
}
```

```
public class Squeak implements QuackBehavior { public void quack() {
        System.out.println("Squeak");
    }
}
```

```
public class MuteQuack implements QuackBehavior { public void quack() {
        System.out.println("<< Silence >>");
    }
}
```


2. Implement performQuack()

```
public abstract class Duck {
    // Declare two reference variables for the behavior interface types
    FlyBehavior flyBehavior;
    QuackBehavior quackBehavior; // All duck subclasses inherit these
    // etc

    public Duck() {
    }


    public void performQuack() {
        quackBehavior.quack();   // Delegate to the behavior class
    }
```


3. How to set the quackBehavior variable & flyBehavior variable

```
public class MallardDuck extends Duck {


    public MallardDuck() {


      quackBehavior = new Quack();
                    // A MallardDuck uses the Quack class to handle its quack,
                    // so when performQuack is called, the responsibility for the quack
                    // is delegated to the Quack object and we get a real quack


      flyBehavior = new FlyWithWings();
                    // And it uses flyWithWings as its flyBehavior type

    }

    public void display() {
          System.out.println("I'm a real Mallard duck");
    }
```

How to set behaviour dynamically?

Add new methods to the Duck class

```
public void setFlyBehavior (FlyBehavior fb) {
    flyBehavior = fb;
}

public void setQuackBehavior(QuackBehavior qb) {
    quackBehavior = qb;
}
```

Strategy Pattern in Game Dev (example)

https://youtu.be/MOEsKHqLiBM?feature=shared

In-class activity

- Find another “manifestation” of the Strategy pattern in the wild
- Submit to Week 5
- 15 minutes