REFACTORING

Yuqun Zhang

CS 304

What is Refactoring?

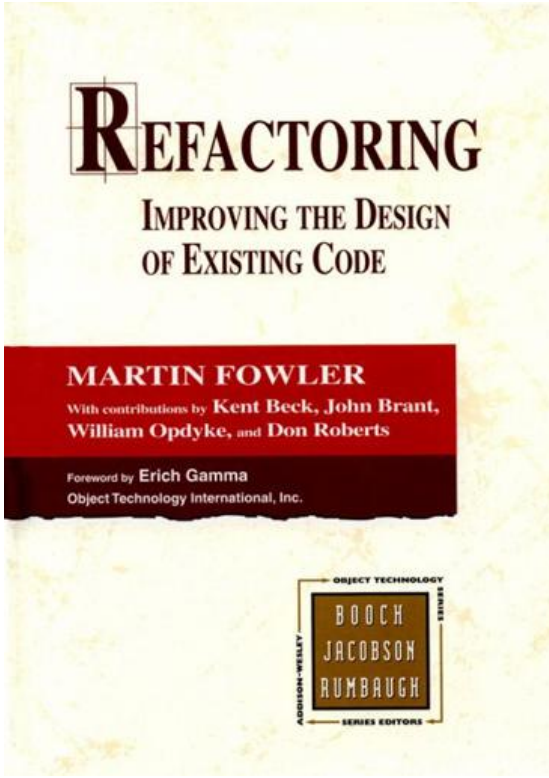
- Semantic-preserving program transformations
  - A change made to the internal structure of a program without modifying its observable behavior to make it
    - Easier to understand
    - Cheaper to modify
- **Refactoring patterns**
  - “Improving the design after the code has been written”
    - Seems a bit odd since we usually design first then code
    - Refactoring usually entails small changes with large cumulative effects

Why Refactor?

- Code degenerates under maintenance
- Code was poorly written to begin with

Bad Code Smells and Refactoring

- **Code smells**
  - Indicative of bad software design
  - List of bad smells: http://blog.codinghorror.com/code-smells/
  - Useful “catalog” of refactorings: http://www.refactoring.com/catalog/
  - Mapping of smells to refactorings: http://www.industriallogic.com/wp-content/uploads/2005/09/smellstorefactorings.pdf



Refactorings

- The book is basically a catalog of common refactoring patterns
  - Each includes a name, summary, motivation, mechanics, and examples
- Not formal (they can't be, since determining program equivalence is undecidable)
- Similar in nature to design patterns
  - Defining a shared vocabulary

EXAMPLES OF CODE SMELLS

And associated refactorings

#1: Duplicated Code

- You've done this before
- You know it's bad
- Examples
  - Same expression in two methods in the same class
  - Same expression in two methods in sibling classes
  - Same expression in two unrelated classes
- Explicit and subtle duplication
  - E.g., identical code (explicit) vs. structures or processing steps that appear different but are essentially the same (subtle)
- Potential useful refactorings:
  - **Extract method**, **Extract class**, **Template method pattern**, **Strategy pattern**

Extract Method

- Applies when you have a code fragment inside some code blocks where the lines of code should always be grouped together

✓ *Turn the fragment into a method whose name explains the purpose of the block of code*

Extract Method Refactoring Example

```
void printOwing() {
  printBanner();

  //print details
  System.out.println ("name:   " + _name);
  System.out.println ("amount " + getOutstanding());
}
```

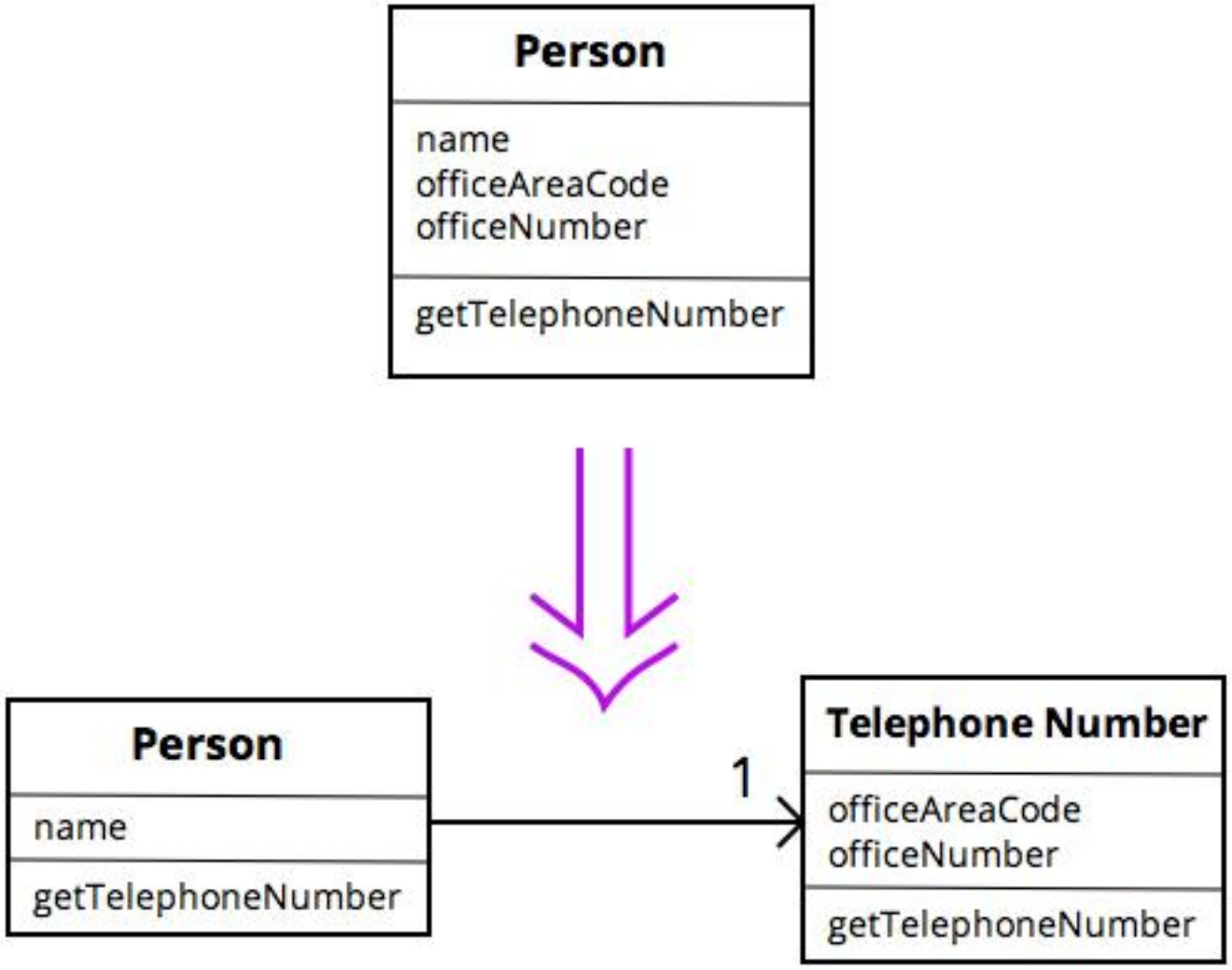
```
void printOwing() {
  printBanner();
  printDetails(getOutstanding());
}

void printDetails (double outstanding) {
  System.out.println ("name:   " + _name);
  System.out.println ("amount " + outstanding);
}
```

Extract Class

- You have one class doing work that should be done by two different classes

✓ *Create a new class and move the relevant fields and methods from the old class to the new class*

Extract Class Example



Some codes

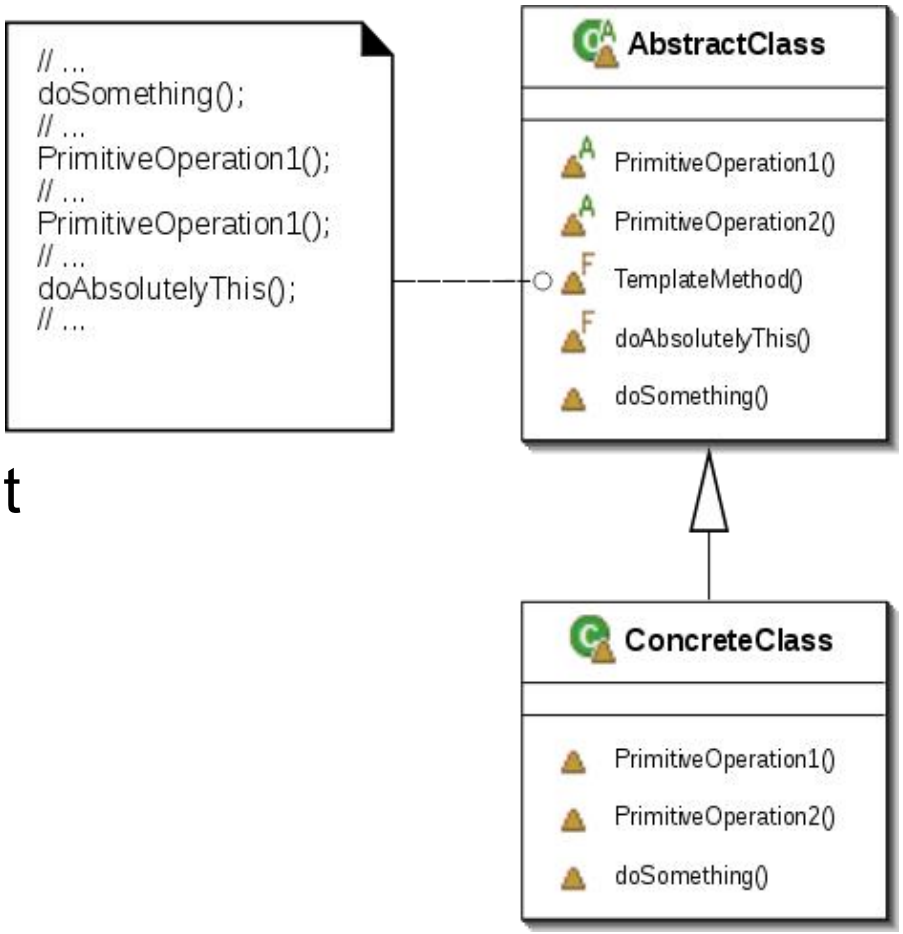
```
class Person...
  private String name;
  private TelephoneNumber officeTelephone = new TelephoneNumber();

  public String getName(){
        return name;
  }

  public String getTelephoneNumber(){
        return officeTelephone.getTelephoneNumber();
  }
```

Some codes (continued.)

```
class TelephoneNumber...
  private String number;
  private String areacode;

  public String getTelephoneNumber(){
        return ("(" + areacode + ") " + number);
  }
```

Template Method Pattern

- A Template Method describes the skeleton behavior of a method
  - Defers some substeps to subclasses
- By defining the “primitive operations” comprising the template method, the subclasses provide different behaviors



Style Smells

- Comments
  - There's a fine line between comments that illuminate and comments that obscure
  - Make sure comments are actually needed; if possible, refactor the code so that the comments aren't required
    - Copious comments can be indicative of bad code
- Naming
  - Avoid placing types in method or variable names (because if you change the type, you'll have to change the name)
  - Make sure that the names of methods and variables succinctly describe what the purpose is
  - Pick a standard way of naming things and stick with it; make sure that analog functions have analog names (e.g., if you can open() you ought to be able to close())
- Dead code
  - Delete it. Use version control.

Long Method

- Two long methods are more likely to share duplicated code/logic
- Small methods help explain code
  - If you don't understand a long method, breaking it into smaller, well named methods helps readability
- Systems with smaller methods tend to be easier to extend and maintain
- Summary: all other things being equal, a shorter method is easier to read, easier to understand, and easier to troubleshoot
- Potential useful refactorings:
  - **Extract method** (vast majority of the time)

Large Class

- This often happens when we code before careful design or prototype a design and then keep building it
- Too many instance variables
  - A class is trying to do too much
  - The class has too many responsibilities
- Single Responsibility Principle: one class should be responsible for only one functional purpose
- Potential refactorings
  - **Extract class**, **Extract subclass**
    - Hint: look for common prefixes/suffixes in identifiers
  - **Observer**
    - Common for GUIs

Long Parameter List

- Long lists of parameters (common in procedural programming) are likely to be **volatile**
  - i.e., likely to change often and rapidly
- Consider which parameters are essential
  - Leave the rest to the object to track down as necessary
- Potential refactorings:
  - **Replace parameter with method**, **Introduce parameter object**, **Preserve whole object**

Replace Parameter with Method

- An object invokes a method then passes the result as a parameter for a method
  - The receiver can also invoke this method

✓*Why the indirection? Remove the parameter and let the receiver invoke the method.*

Replace Parameter with Method Example

```
int basePrice = _quantity * _itemPrice;
discountLevel = getDiscountLevel();
double finalPrice = discountedPrice (basePrice, discountLevel);
```

```
int basePrice = _quantity * _itemPrice;
double finalPrice = discountedPrice (basePrice);
```

Some codes (originally)

```
public double getPrice(){
    int basePrice = quantity * itemPrice;
    int discountLevel;
    if (quantity > 100) discountLevel = 2;
    else discountLevel = 1;
    double finalPrice = discoutedPrice (basePrice,
discountLevel);
    return finalPrice;
}

private double discountedPrice (int basePrice, int
discountLevel)  {
    if (discountLevel == 2) return basePrice * 0.1;
    else return basePrice * 0.05;
}
```

Some codes (originally)

```
public double getPrice(){
    int basePrice = quantity * itemPrice;
    int discountLevel;
    if (quantity > 100) discountLevel = 2;
    else discountLevel = 1;
    double finalPrice = discoutedPrice (basePrice,
discountLevel);
    return finalPrice;
}

private double discountedPrice (int basePrice, int
discountLevel)  {
    if (discountLevel == 2) return basePrice * 0.1;
    else return basePrice * 0.05;
}
```

Some codes (Initial modification)

```
public double getPrice(){
    int basePrice = quantity * itemPrice;
    int discountLevel = getDiscountLevel();
    double finalPrice = discoutedPrice (basePrice,
discountLevel);
    return finalPrice;
}

private int getDiscountLevel ()  {
    if (quantity > 100) discountLevel = 2;
    else discountLevel = 1;
}
```

Some codes (a little further)

```
private double discountedPrice (int basePrice, int discountLevel)  {
    if (getDiscountLevel() == 2) return basePrice * 0.1;
    else return basePrice * 0.05;
}
```

Some codes (Now what do we have)

```
public double getPrice(){
    int basePrice = quantity * itemPrice;
    int discountLevel = getDiscountLevel();
    double finalPrice = discoutedPrice
(basePrice);
    return finalPrice;
}

private double discountedPrice (int basePrice)
{
    if (getDiscountLevel() == 2) return
basePrice * 0.1;
    else return basePrice * 0.05;
}
```

Some codes (Something is not necessary)

```
public double getPrice(){
    int basePrice = quantity * itemPrice;
    int discountLevel = getDiscountLevel();
    double finalPrice = discoutedPrice
(basePrice);
    return finalPrice;
}

private double discountedPrice (int basePrice)
{
    if (getDiscountLevel() == 2) return
basePrice * 0.1;
    else return basePrice * 0.05;
}
```

Some codes (final version)

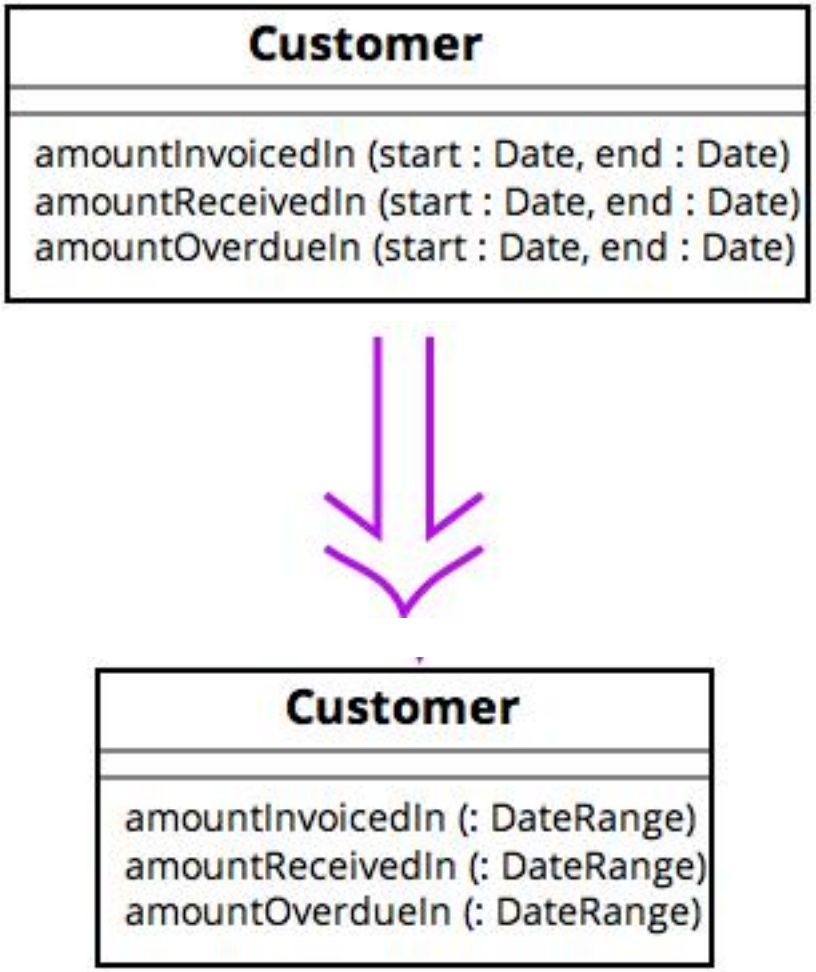
```
public double getPrice(){
    return discountedPrice();
}

private double discountedPrice ()  {
    if (getDiscountLevel() == 2) return
getBasePrice() * 0.1;
    else return getBasePrice() * 0.05;
}

private double getBasePrice(){
    return quantity * itemPrice;
}
```

Introduce Parameter Object

- You have a group of parameters that naturally (often) go together

✓*Replace them with a single object*

Introduce Parameter Object Example



Preserve Whole Object

- You get a bunch of values from an object but then pass those objects together to another method call

✓*Maybe you should just pass the whole object instead.*

Preserve Whole Object Example

```
int low = daysTempRange().getLow();
int high = daysTempRange().getHigh();
withinPlan = plan.withinRange(low, high);
```

```
withinPlan = plan.withinRange(daysTempRange());
```

Divergent Change

- Commonly change a particular class in different ways for different reasons
  - Separating divergent responsibilities decreases the chance that one change negatively affects a different function
  - E.g., in `class X`, change `mA()`, `mB()`, and `mC()` every time we add a new database; change `mD()`, `mE()`, and `mF()` every time we add a new financial instrument
- Potential refactoring:
  - **Extract class**

Shotgun Surgery

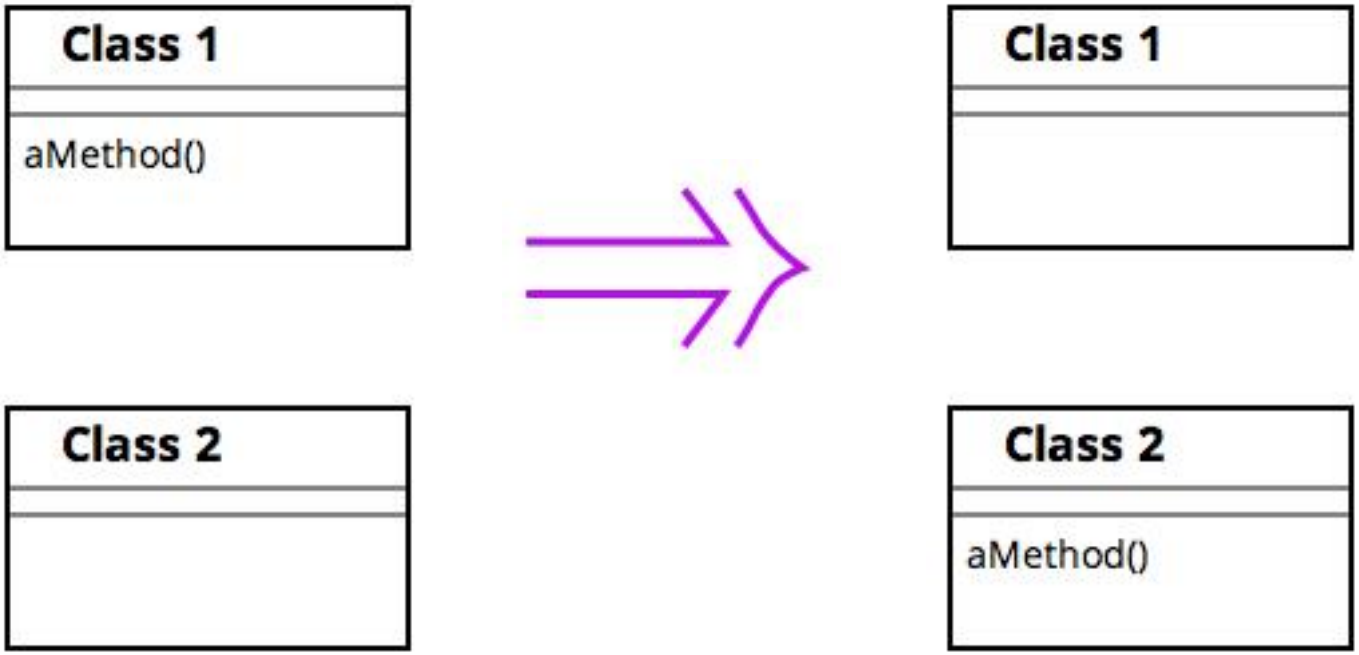
- Opposite of divergent change
- One change alters many classes; constantly making lots of little changes to a lot of different classes
  - It's easy to miss an important change
- Special case:
  - Parallel inheritance hierarchies – every time you make a subclass of one class, you have to make a subclass of another
- Potential refactorings:
  - **Move method**, **Move field**, **Inline class**

Move Method

- A method is, or will be, using or used by more features of a class other than the class within which it is defined

✓ *Well, then, move it. Create a new method with a similar body in the class it uses most. Turn the old method into a simple delegation or remove it altogether.*

Move Method Example



Move Method (another) Example

```
class Project {
  Person[] participants;
}

class Person {
  int id;
  boolean participate(Project p) {
    for(int i=0; i<p.participants.length; i++) {
          if (p.participants[i].id == id) return(true);
    }
    return(false);
  }
}

... if (x.participate(p)) ...
```

```
class Project {
  Person[] participants;
  boolean participate(Person x) {
    for(int i=0; i<participants.length; i++) {
          if (participants[i].id == x.id) return(true);
    }
    return(false);
  }
}

class Person {
  int id;
}

... if (p.participate(x)) ...
```

Feature Envy

- A method in a class seems more interest in some other class's internals than its own
  - The most common target of the envy is data
  - E.g., a class repeatedly calls getter and setter methods on some other class
- [Strategy pattern is an exception]
- Potential refactorings:
  - **Extract method**, **Move method**, **Move field**

Data Clumps

- Bunches of data that hang around together should be made into their own object
  - Fields in several classes, parameters that are always chained together, etc.
  - Ask yourself the question: are the others sensible when one is removed?
- Potential refactorings:
  - **Extract class**, **Preserve whole object**, **Introduce parameter object**

Primitive Obsession

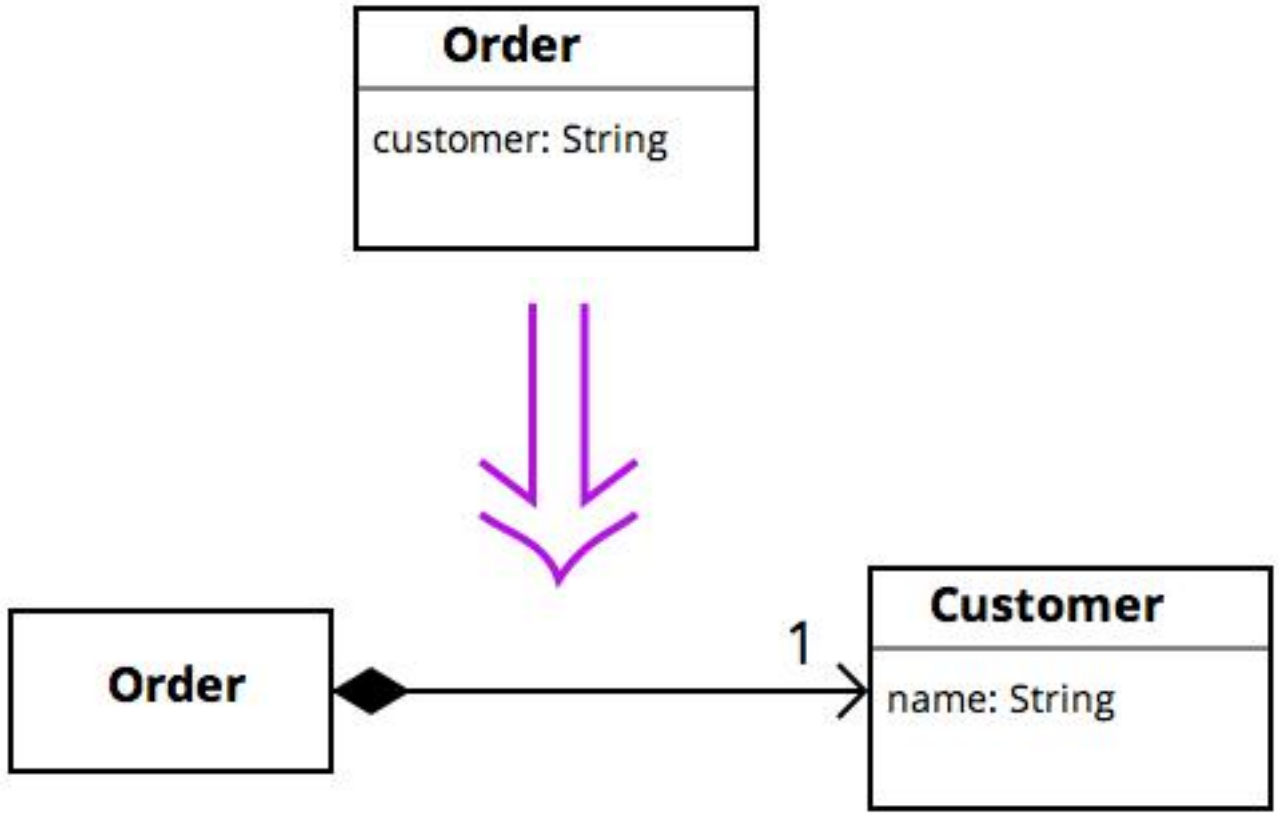
- Old-timers are reluctant to use small objects for money, strings, intervals, etc.
- Instead result in an over-emphasis on primitive objects (e.g., strings, arrays, integers, etc.)
- Classes generally provide a simpler and more natural way to directly model things than primitives do
  - Higher level abstractions clarify code
- Potential refactorings:
  - **Replace data value(s) with object**, **Replace type code with class**, **Replace type code with state/strategy**

Replace Data Value with Object

- You have a data item that needs additional data or behavior
  - Really, try not to start with primitives and add more and more primitives that are conceptually (but not concretely) linked

✓*Instead, turn the data item into an object*

Replace Data Value with Object Example

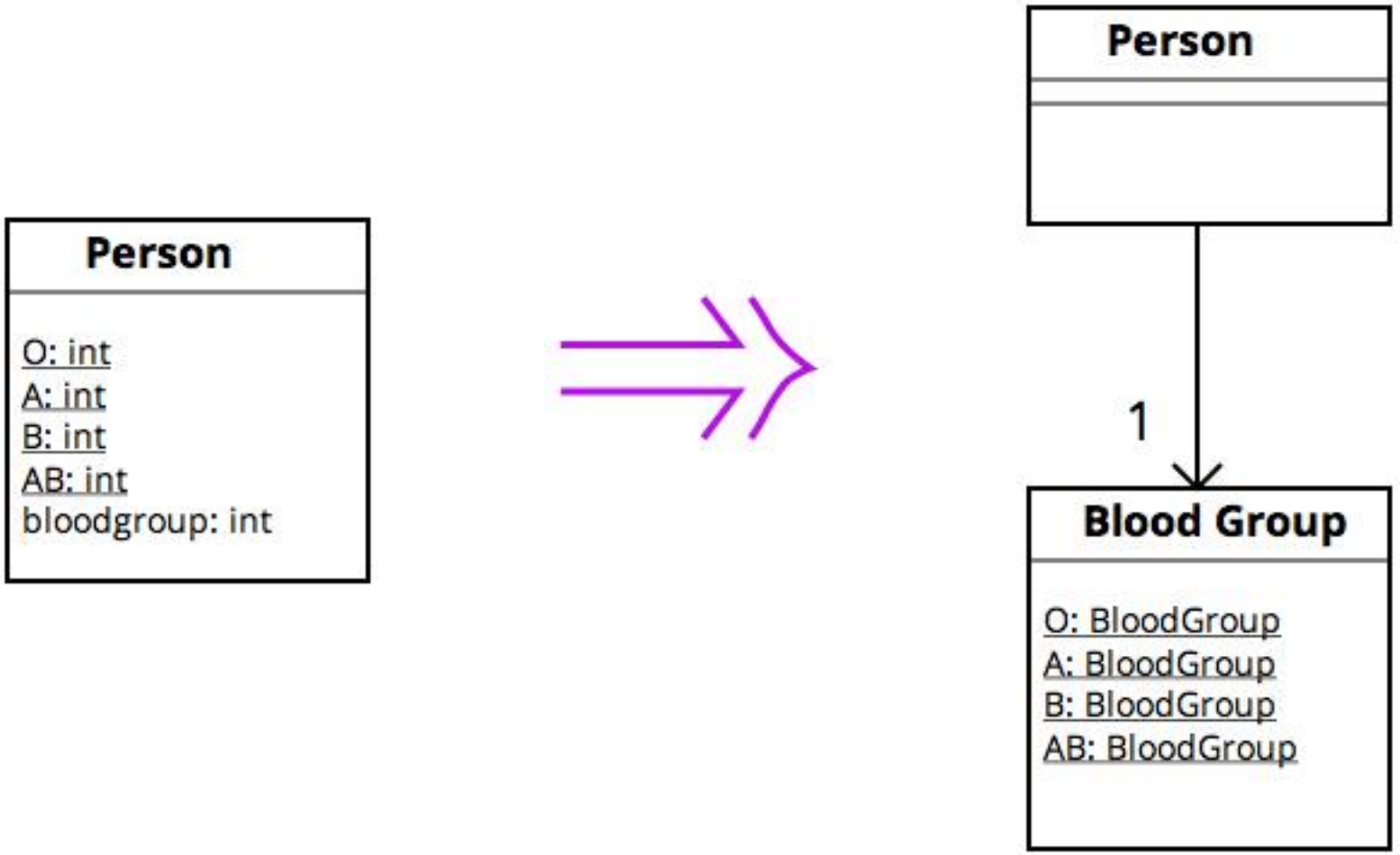


Replace Type Code with Class

- A class has a (numeric) type code that does not affect its behavior

✓*Replace the number with a new class*

Replace Type Code with Class Example



Replace Type with Class: Code Examples

```
class Person {
  public static final int O = 0;
  public static final int A = 1;
  public static final int B = 2;
  public static final int AB = 3;

  private int _bloodGroup;

  public Person (int bloodGroup) {
      _bloodGroup = bloodGroup;
  }

  public void setBloodGroup(int arg) {
      _bloodGroup = arg;
  }

  public int getBloodGroup() {
      return _bloodGroup;
  }
}
```

Replace Type with Class: Code Examples (cont.)

```
class BloodGroup {
  public static final BloodGroup O = new BloodGroup(0);
  public static final BloodGroup A = new BloodGroup(1);
  public static final BloodGroup B = new BloodGroup(2);
  public static final BloodGroup AB = new BloodGroup(3);
  private static final BloodGroup[] _values = {O, A, B, AB};

  private final int _code;

  private BloodGroup (int code ) {
      _code = code;
  }

  public int getCode() {
      return _code;
  }

  public static BloodGroup code(int arg) {
      return _values[arg];
  }
}
```

Replace Type with Class: Code Examples (cont.)

```
class Person {
    public static final int O = BloodGroup.O.getCode();
    public static final int A = BloodGroup.A.getCode();
    public static final int B = BloodGroup.B.getCode();
    public static final int AB = BloodGroup.AB.getCode();

    private BloodGroup _bloodGroup;

    public Person (int bloodGroup) {
        _bloodGroup = BloodGroup.code(bloodGroup);
    }

    public int getBloodGroup() {
        return _bloodGroup.getCode();
    }

    public void setBloodGroup(int arg) {
        _bloodGroup = BloodGroup.code (arg);
    }
  }
```

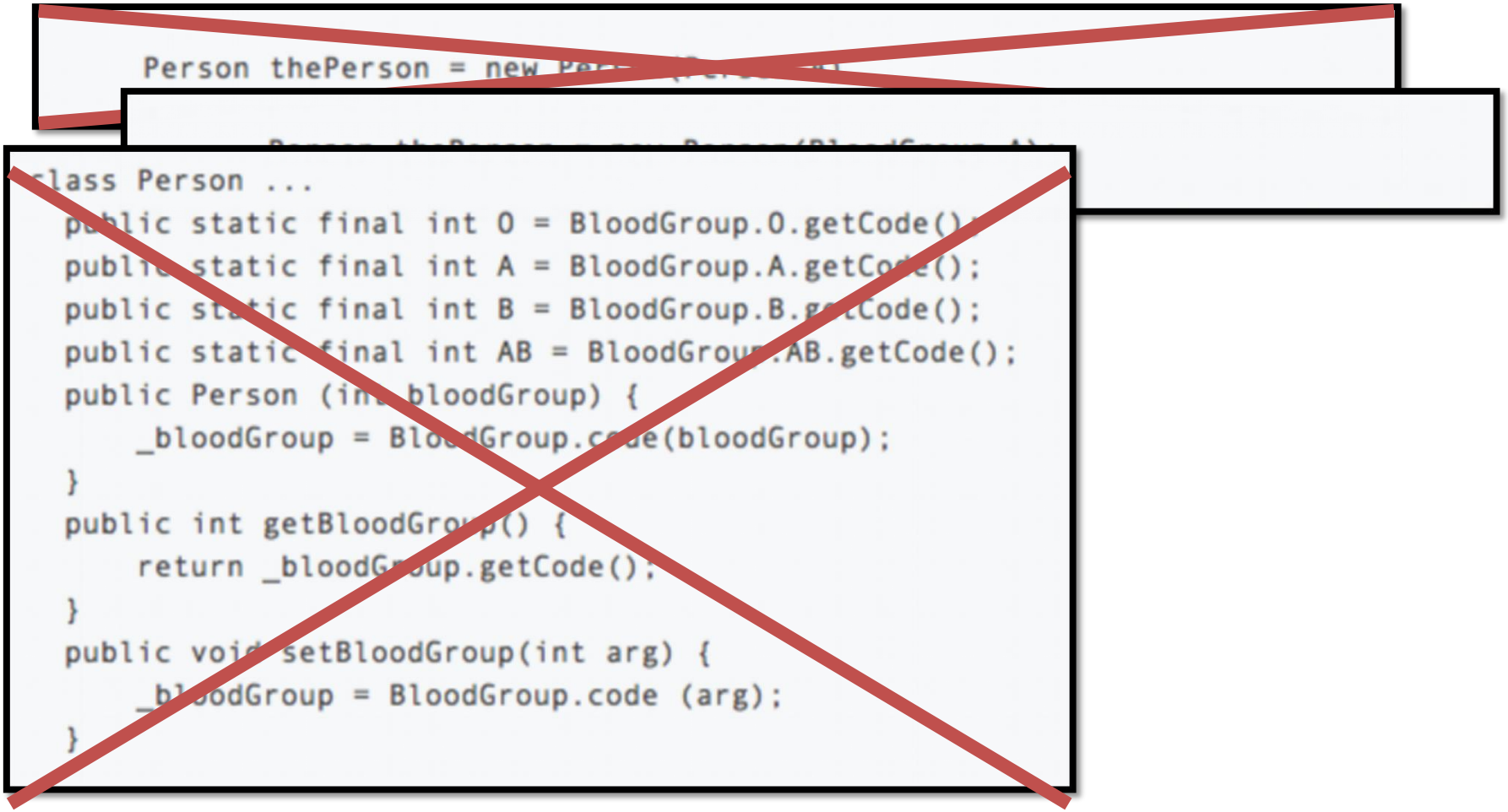
Replace Type with Class: Code Examples (cont.)

```
class Person {
    ...

    pub
    }

    pub
    }
}
```

```
class Person {
    ...

    public Person (int bloodGroup) {
    }

    publ
    }
}
```

```
class Person {
    ...

    public void setBloodGroup(int arg) {
        _bloodGroup = BloodGroup.code (arg);
    }

    public void setBloodGroup(BloodGroup arg) {
        _bloodGroup = arg;
    }
}
```

Replace Type with Class: Code Examples (cont.)



```
Person thePerson = new Person(...);
```

```
class Person ...
  public static final int O = BloodGroup.O.getCode();
  public static final int A = BloodGroup.A.getCode();
  public static final int B = BloodGroup.B.getCode();
  public static final int AB = BloodGroup.AB.getCode();
  public Person (int bloodGroup) {
      _bloodGroup = BloodGroup.code(bloodGroup);
  }
  public int getBloodGroup() {
      return _bloodGroup.getCode();
  }
  public void setBloodGroup(int arg) {
      _bloodGroup = BloodGroup.code (arg);
  }
```

Replace Type with Class: Code Examples (cont.)

- Now class “person” is like...

```
class person...
     public int getBloodGroupCode(){
         return _bloodGroup.getCode();
      }

    public BloodGroup getBloodGroup(){
         return _bloodGroup;
    }

    public Person (BloodGroup bloodGroup){
         _bloodGroup = bloodGroup;
    }

    public boid setBloodGroup(BloodGroup arg){
        _bloodGroup = arg;
    }
```

Replace Type with Class: Code Examples (cont.)

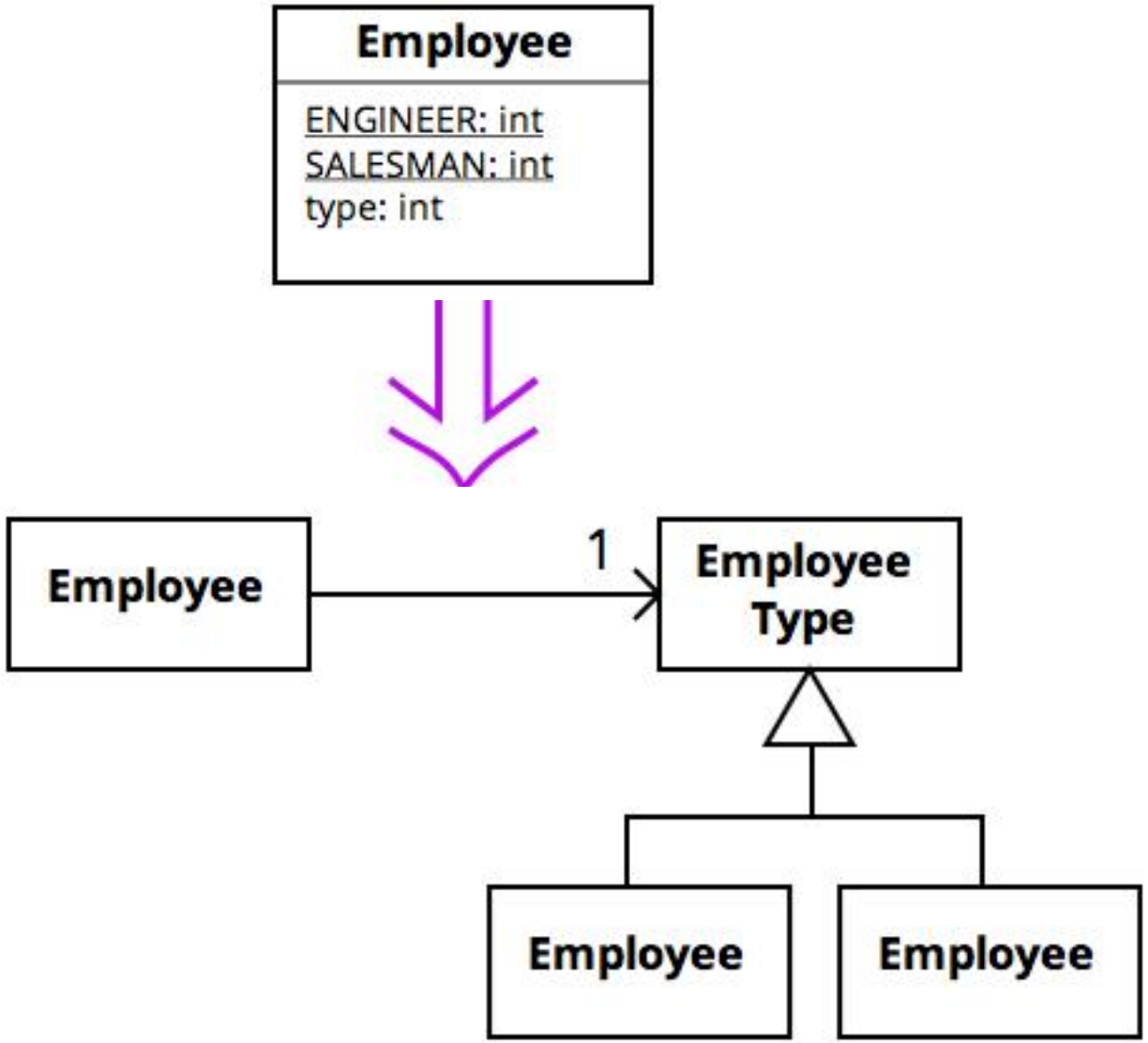
- Any more improvements for class “BloodGroup”?

Replace Type Code with State/Strategy

- You have a type code that affects the behavior of the class, but you cannot use subclassing

✓*Replace the type code with a state/strategy object*

Replace Type Code with State/Strategy Example



Replace Type Code with State/Strategy Example

```
class Employee {
    private EmployeeType type;
    private float salary;
    private float commission;
    ...
    public void setEmployeeType(EmployeeType type) {
        this.type = type;
    }
    public float salary() {
        return salary;
    }
    ...
    public float pay() {
        return type.pay(this);
    }
}
```

```
class Engineer extends EmployeeType {
    float pay(Employee employee) {
        return employee.salary();
    }
}

class Salesman extends EmployeeType {
    float pay(Employee employee) {
        return employee.salary() +
               employee.commission();
    }
}
```

Replace Type Code with State/Strategy Example

```
class Employee {
    private EmployeeType type;
    private float salary;
    private float commission;
    ...
    public void setEmployeeType(EmployeeType type) {
        this.type = type;
    }
    public float salary() {
        return salary;
    }
    ...
    public float pay() {
        return type.pay(this);
    }
}
```

```
enum EmployeeType {
    ENGINEER {
        float pay(Employee employee) {
            return employee.salary();
        }
    },
    SALESMAN {
        float pay(Employee employee) {
            return employee.salary() +
                   employee.commission();
        }
    };
    abstract float pay(Employee employee);
}
```

Switch statements

- Ugh.
- Switch statements often end up duplicated across the system
- Indicative of lack of OO style and underuse of polymorphism
- Special case: a conditional that chooses different behavior based on the type of an object
- Potential refactorings:
  - **Extract method**, **Move method**, **Replace type code with subclasses**, **Replace type code with state/strategy**, **Replace conditional with polymorphism**

Replace Conditional with Polymorphism

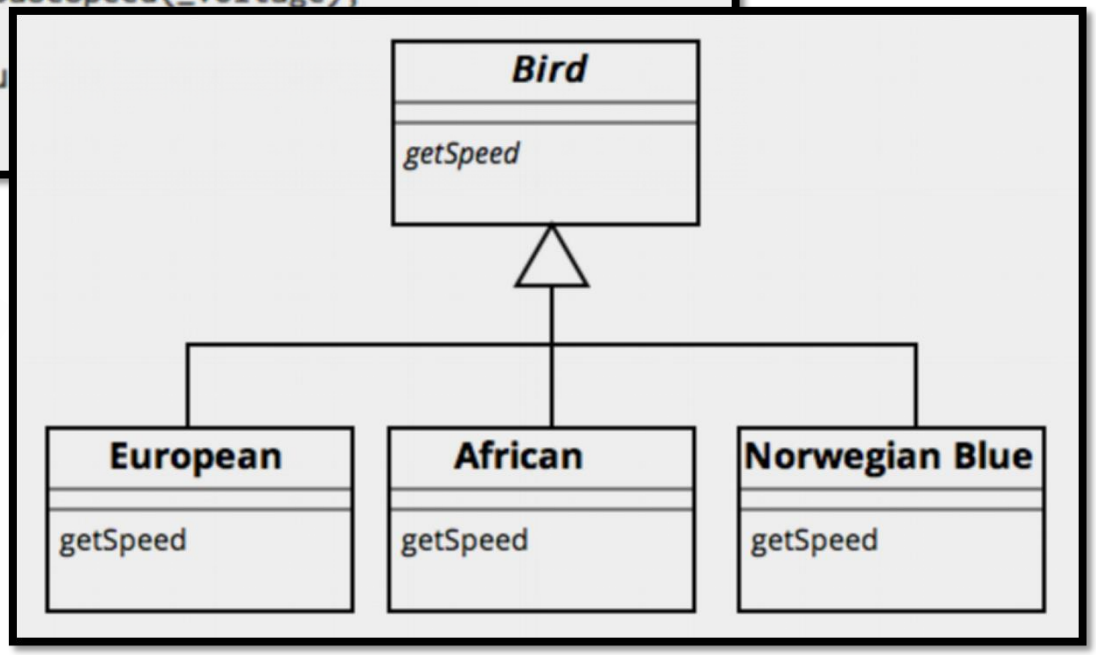
- You have a condition that chooses different behavior depending on the type of object

✓*Move each leg of the conditional to an overriding method in a subclass*

- Make the original method abstract (why?)
  - Otherwise, you're introducing an instance of the **Refused Request** smell… coming up

Replace Conditional with Polymorphism Example

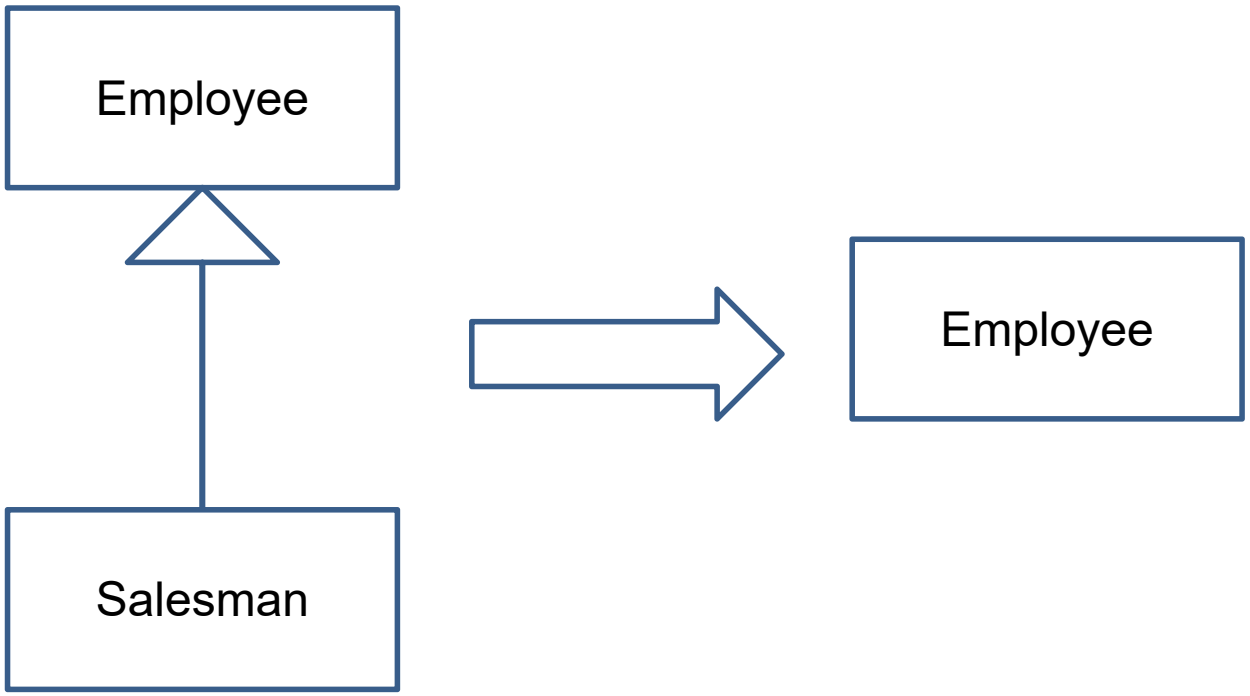
```
double getSpeed() {
  switch (_type) {
    case EUROPEAN:
      return getBaseSpeed();
    case AFRICAN:
      return getBaseSpeed() - getLoadFactor() * _numberOfCoconuts;
    case NORWEGIAN_BLUE:
      return (_isNailed) ? 0 : getBaseSpeed(_voltage);
  }
  throw new RuntimeException ("Shou
}
```



Lazy Class

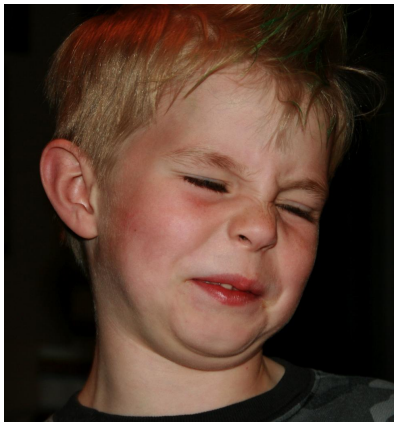
- Each class costs something to maintain and understand
  - We don't often intentionally make lazy classes, but it can commonly result from downsizing or adding things speculatively
- Potential refactorings:
  - **Collapse hierarchy**, **Inline class**

Collapse Hierarchy

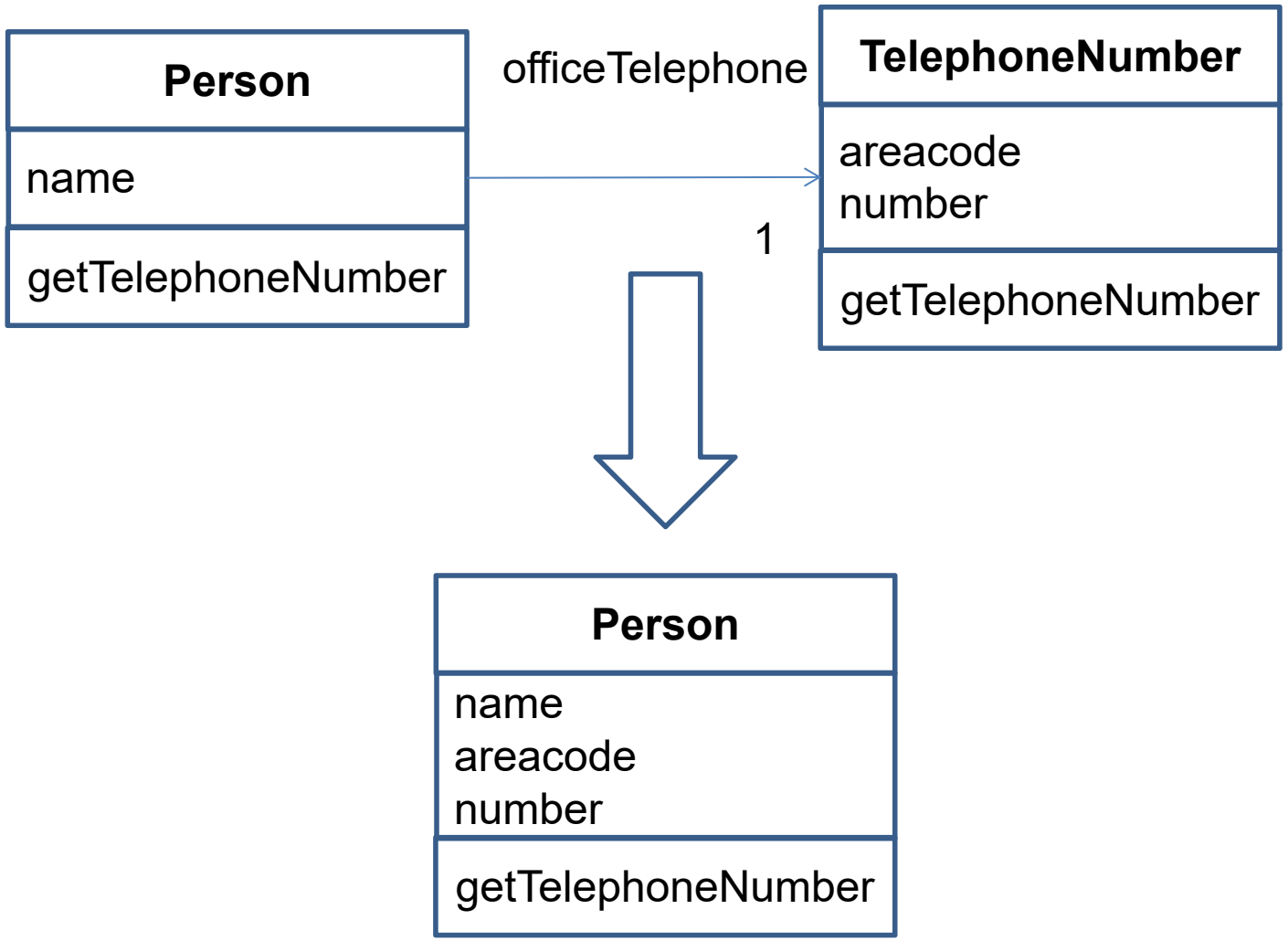


Speculative Generality

- We sometimes create hooks and special cases to handle things that aren't required
  - E.g., "we might need a method to do X some day"
  - This is evident when you have generic or abstract code that is not actually needed (at least not yet)
- Potential refactorings:
  - **Collapse hierarchy**, **Rename method**, **Remove parameter**, **Inline class**



Inline class



Temporary Field

- The inclusion of an instance variable that is only set in some instances
- The rest of the time, the field is empty or (worse) contains irrelevant data
  - This hampers understandability and can lead to accidental errors based on context
- Potential refactorings
  - **Extract class**, **Introduce null object**

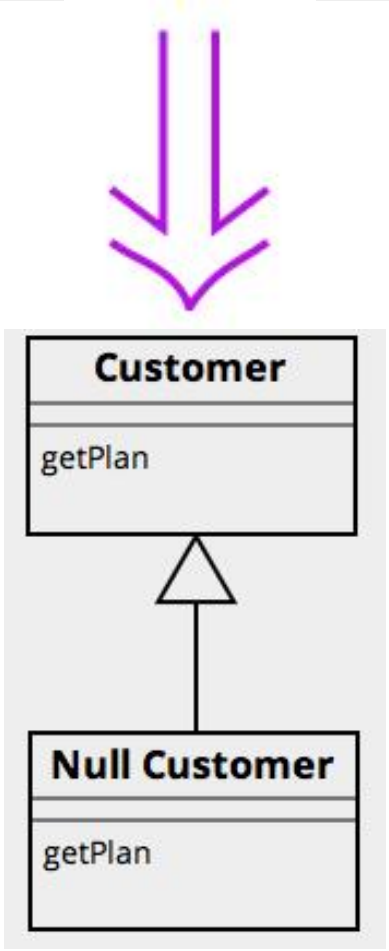
Introduce Null Object

- You have repeated checks for a null values
  - Ugh. It's ugly and hard to read.

✓*So replace the null value with a null object!*

Introduce Null Object Example

```
if (customer == null) plan = BillingPlan.basic();
else plan = customer.getPlan();
```



Message Chains

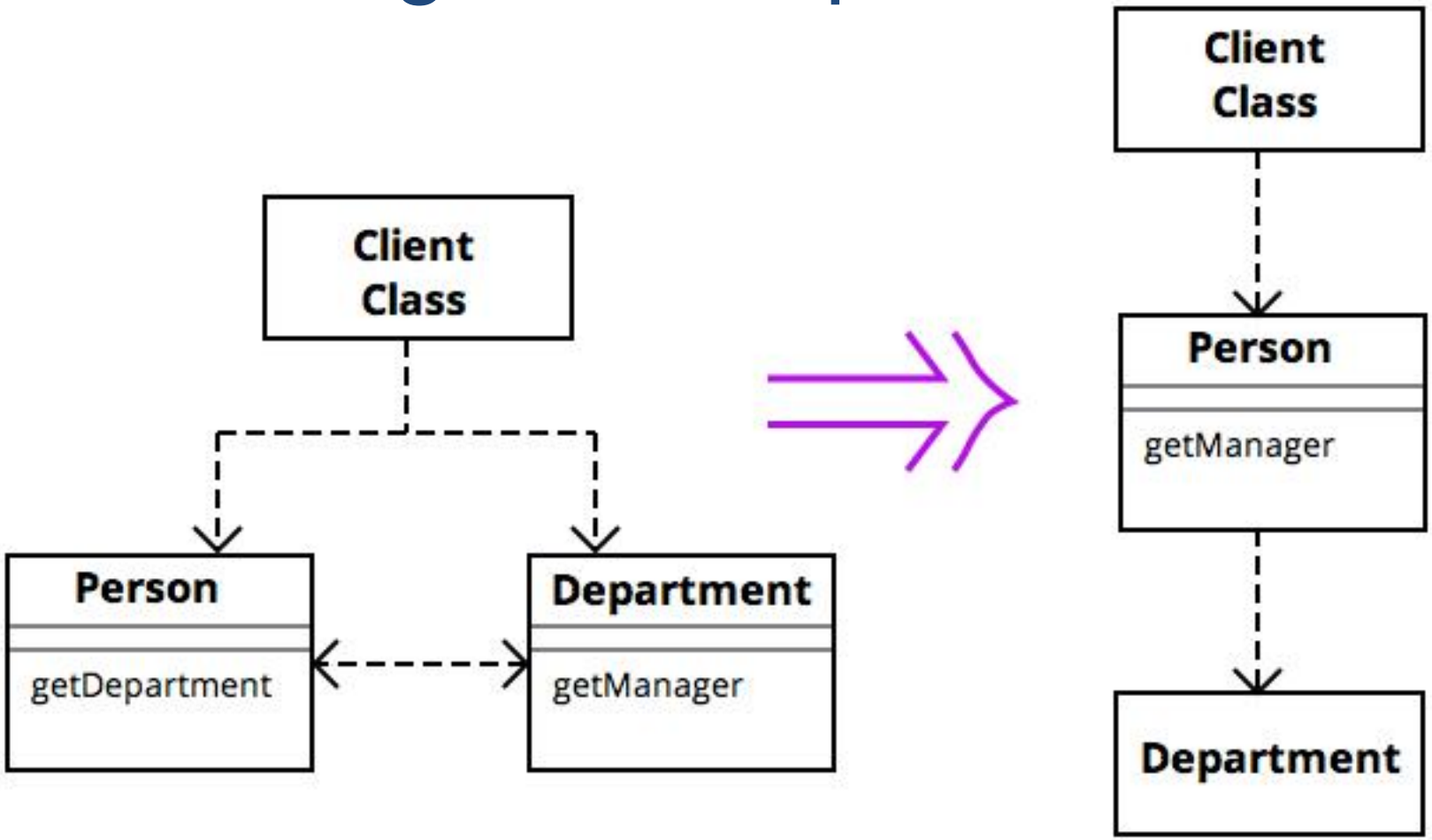
- Occur when you see a long line of method calls or temporary variables to get some data
  - E.g., long string of `getThis().getThat().getSomething()`
- Makes the code dependent on the algorithm for navigating the relationships between components
  - Failure to shelter outside objects from the implementation details
- Potential refactorings:
  - **Hide delegate**, **Extract method**, **Move method**

Hide Delegate

- A client is calling a delegate class of an object

✓*Create methods on the server to hide the delegate*

Hide Delegate Example



Some codes

```
class person{
    Department _department;

    public Department getDepartment(){
        return _department;
    }

    public void setDepartment(Department arg){
        _department = arg;
    }
}
```

Some codes (continued.)

```
class Department {
    private String _chargeCode;
    private Person _manager;

    public Department (Person manager){
        _manager = manager;
    }

    public Person getManager(){
        return _manager;
    }

...
```

Some codes (continued.)

- If you want to obtain a manager:
- manager = john.getDepartment().getManager();

- modification:
- public Person getManager(){
- return _department.getManager();
- }

Middle Man

- Delegation is good, and that's why we make objects
- But sometimes, we end up with a design that all an object is doing is passing along calls to another object
  - For no apparent reason (e.g., an Adapter would be an exception)
- There is a fine line between information hiding and delegation overhead.
- Potential refactorings:
  - **Remove middle man** (duh!), **Inline method**, **Replace delegation with inheritance**

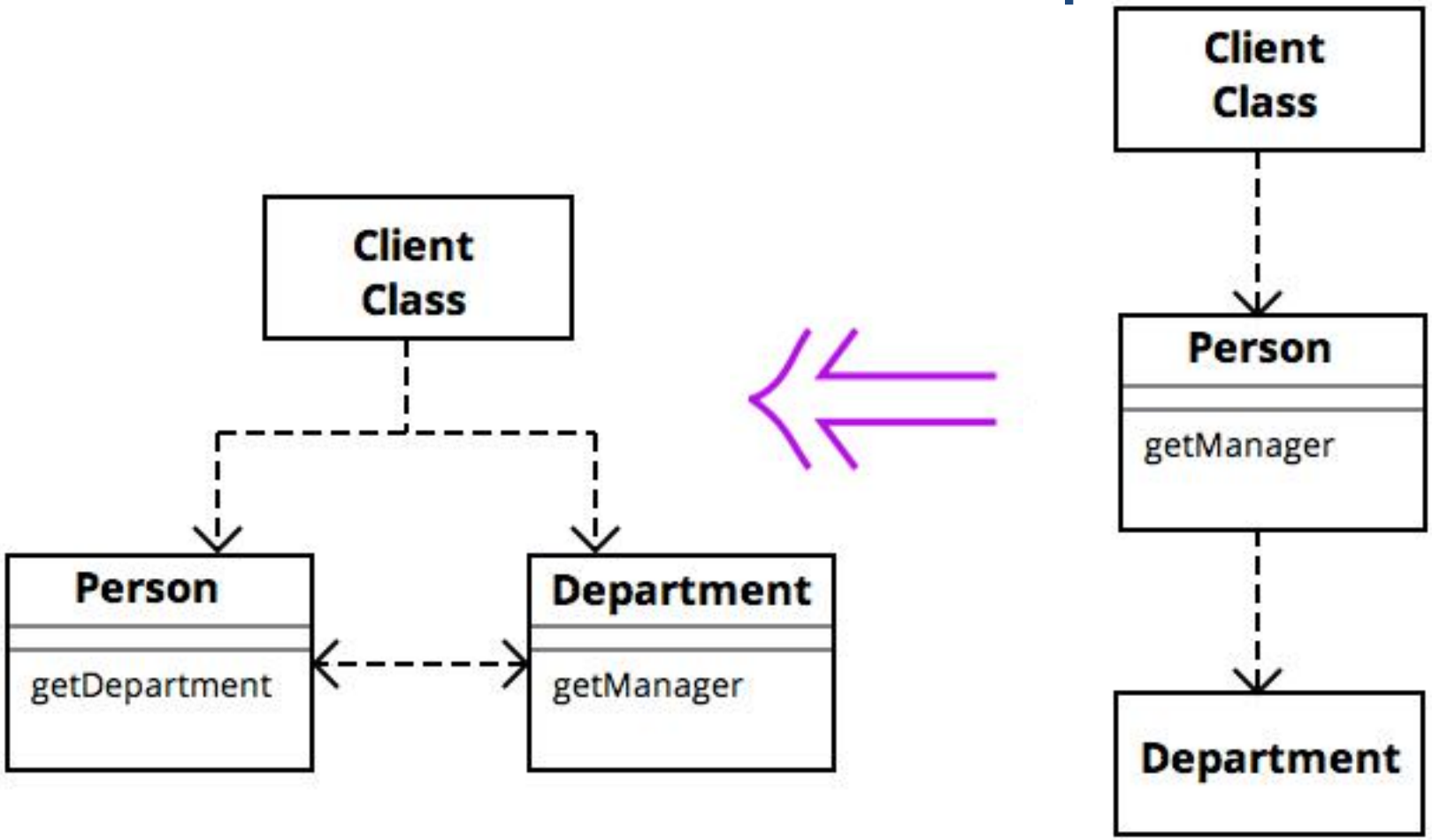
Remove Middleman

- A class is doing too much simple delegation

✓*Get the client to call the delegate directly*

- This is the exact dual for **Hide Delegate**

Remove Middleman Example



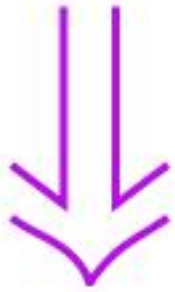
Inline Method

- A method's body is just as clear as its name

✓ *So put the method's body into the body of its callers and remove the method*

Inline Method Example

```
int getRating() {
  return (moreThanFiveLateDeliveries()) ? 2 : 1;
}
boolean moreThanFiveLateDeliveries() {
  return _numberOfLateDeliveries > 5;
}
```



```
int getRating() {
  return (_numberOfLateDeliveries > 5) ? 2 : 1;
}
```

Inappropriate Intimacy

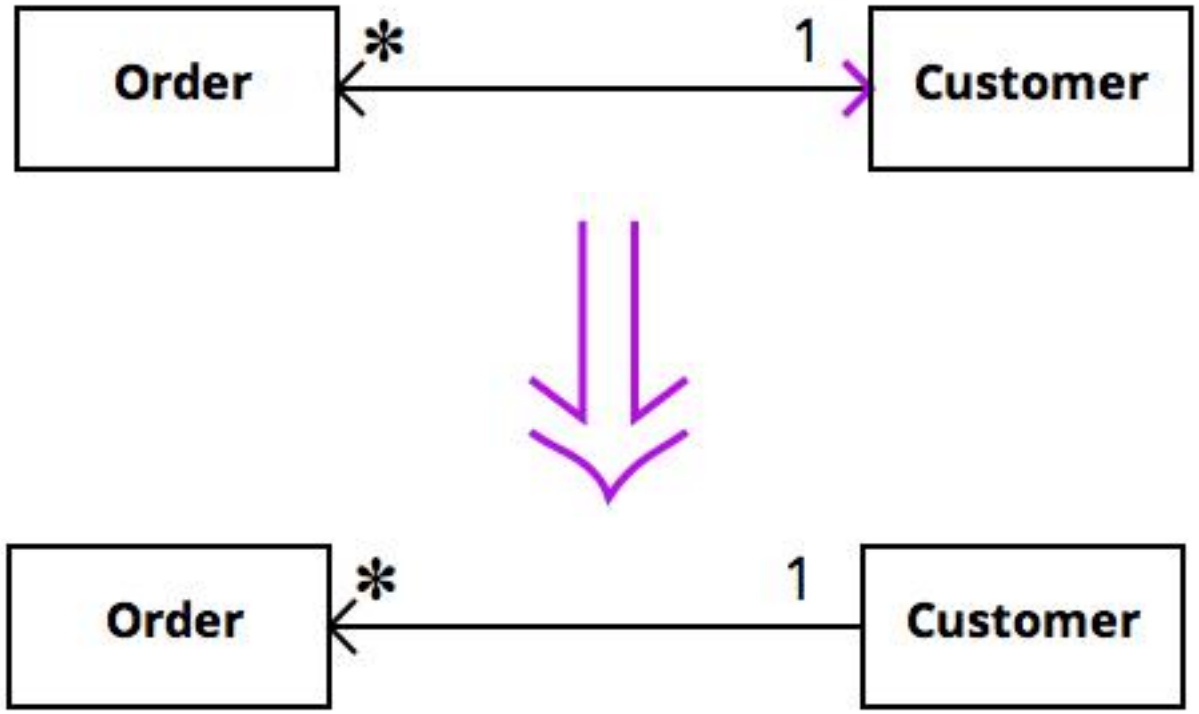
- Classes sometimes end up delving too much into each others' private methods and fields
- Related: *Data Class* – classes that have fields and getters and setters but nothing else
  - Almost assuredly being manipulated in far too much detail by others
- Potential refactorings:
  - **Move method**, **Move field**, **Change bidirectional association to unidirectional association**, **Extract class** (if classes do in fact have common interests), **Hide delegate** (allow another class to act as a go-between), **Encapsulate collection** (for Data Class)

Change Bidirectional Association to Unidirectional

- You have a two-way association but one class no longer needs access to the other

✓*So drop the unneeded end of the association*

Change Bidirectional Association to Unidirectional

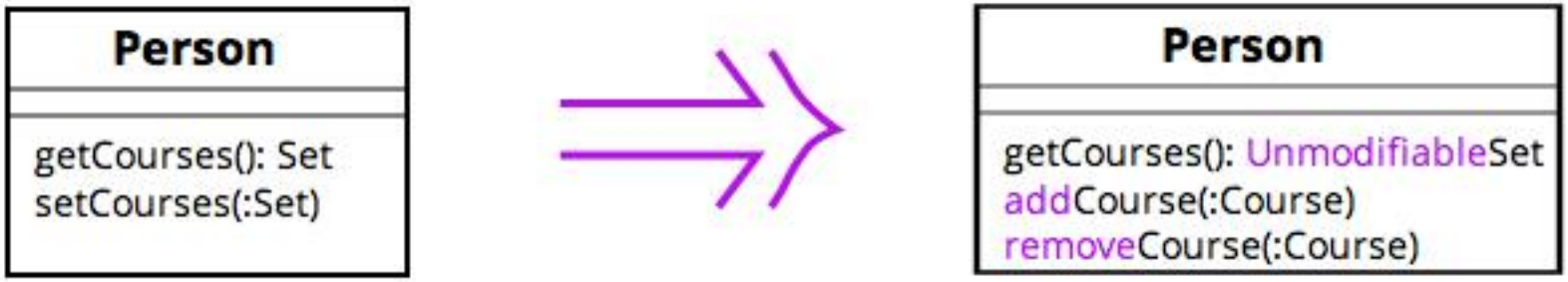


Encapsulate Collection

- A method returns a collection
  - This can be confusing because it may seem to the caller that he can make changes to the collection

✓ *Make it return a read-only view and provide add/remove methods*

Encapsulate Collection Example



Alternative Classes with Different Interfaces

- Classes can be completely different on the outside but end up being the same internally
- Basically, you should find the similarities in the two classes, the refactor them to share a common interface
- Potential refactorings:
  - **Extract superclass**, **Unify interfaces with adapter**

Refused Bequest

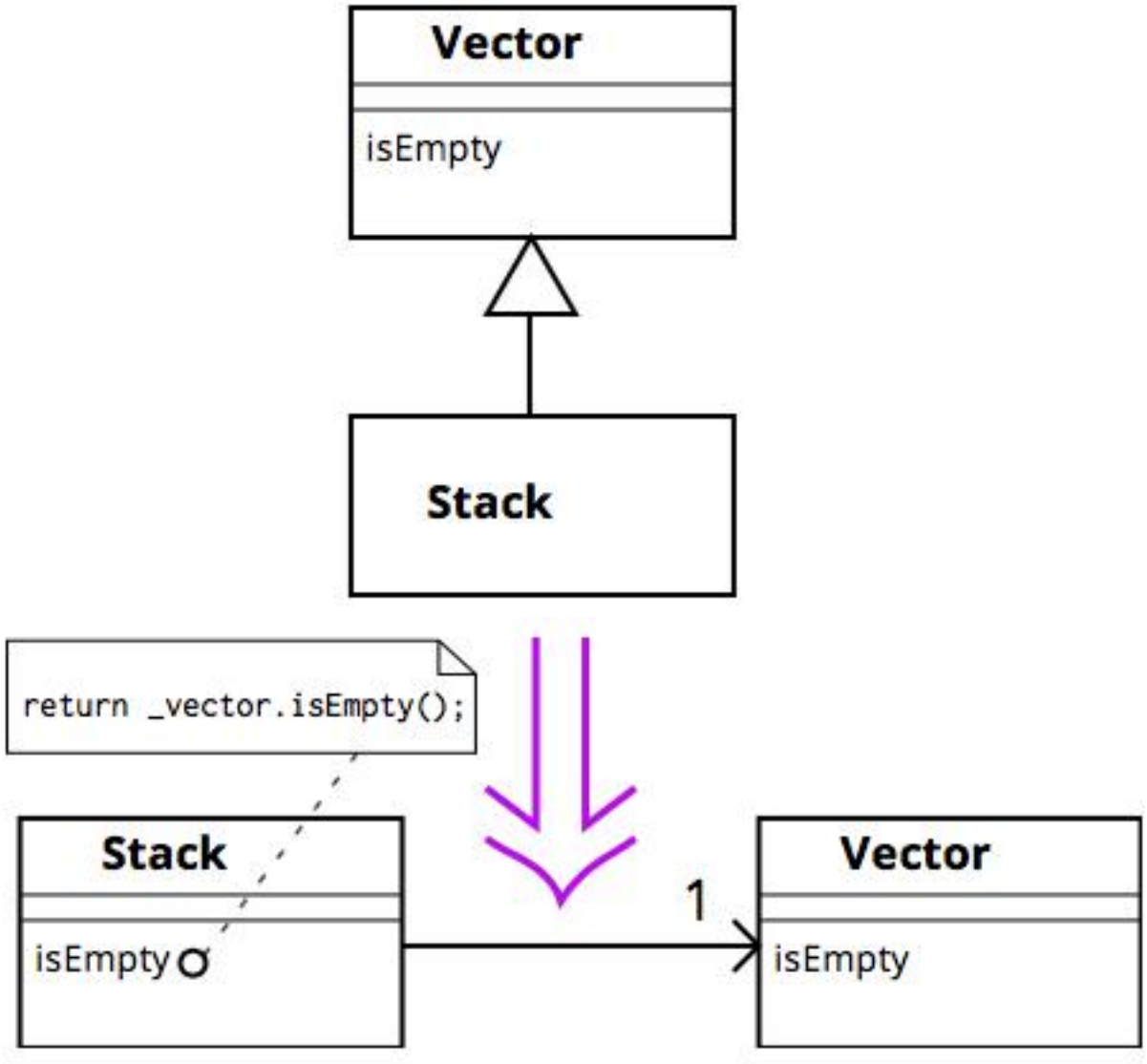
- Happens when you inherit code you don't want
  - i.e., a child class uses very little of the functionality of some parent (base) class
- The worst (strongest smell) here is when the child reimplements the behavior from the parent class
- Potential refactorings:
  - **Push down field**, **Push down method**, **Replace inheritance with delegation**

Replace Inheritance with Delegation

- A subclass uses only part of a superclass's interface or does not want to inherit data

✓ *Create a field for the superclass, adjust methods to delegate to the superclass, and remove the subclassing*

Replace Inheritance with Delegation Example



QUESTIONS?