(These slides are part of the course LINGI2252 “Software Maintenance and Evolution”, given by Prof. Kim Mens at UCL, Belgium)

LINGI2252 – PROF. KIM MENS

CODE REFACTORING*

* Slides mostly based on Martin Fowler’s book:
Refactoring: Improving the Design of Existing Code. ©Addison Wesley, 2000

Refactoring:
Improving the Design of Existing Code

One of the best references on software refactoring,
with illustrative examples in Java:

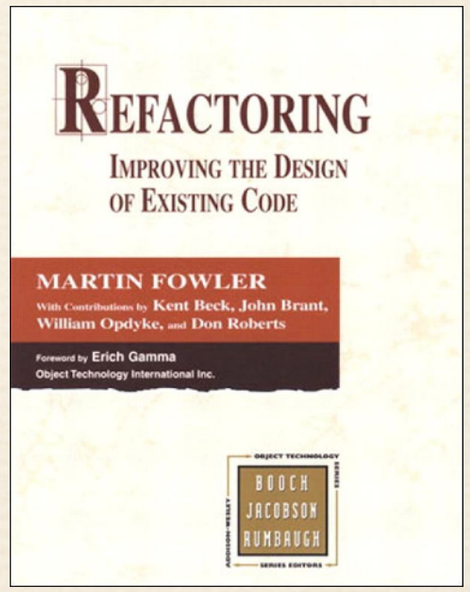
> *Refactoring: Improving the Design of Existing Code.*
> Martin Fowler. Addison Wesley, 2000. ISBN: 0201485672
>
> See also www.refactoring.com

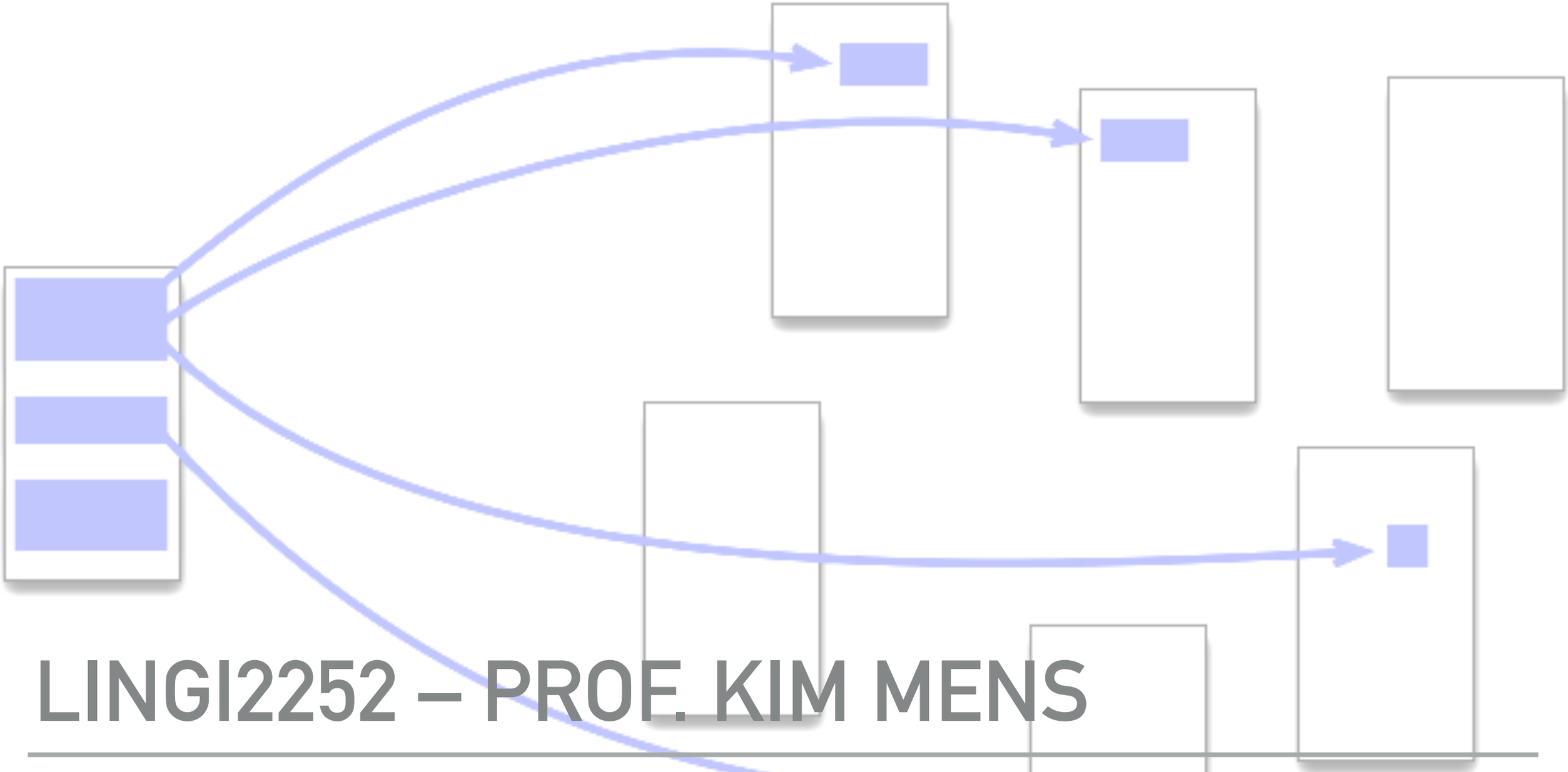
Overview of this presentation

A. Refactoring basics

B. Categories of refactoring

C. Words of warning





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A. REFACTORING BASICS*

* Based on Chapter 2 of Martin Fowler's book:
Refactoring: Improving the Design of Existing Code. ©Addison Wesley, 2000

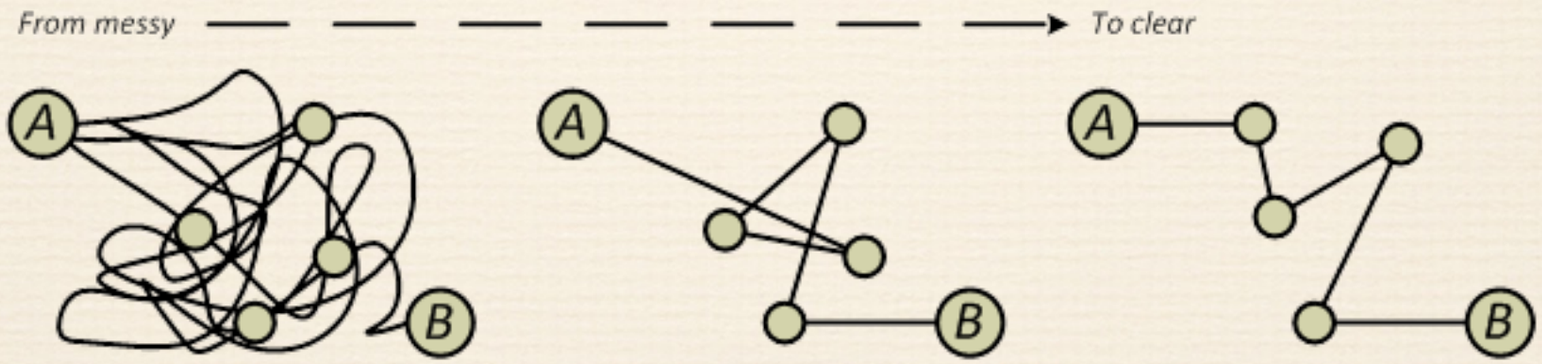
What is refactoring?

A **refactoring** is a software transformation that

preserves the external behaviour of the software;

improves the internal structure of the software.

It is a disciplined way to clean up code that minimises the chances of introducing bugs.



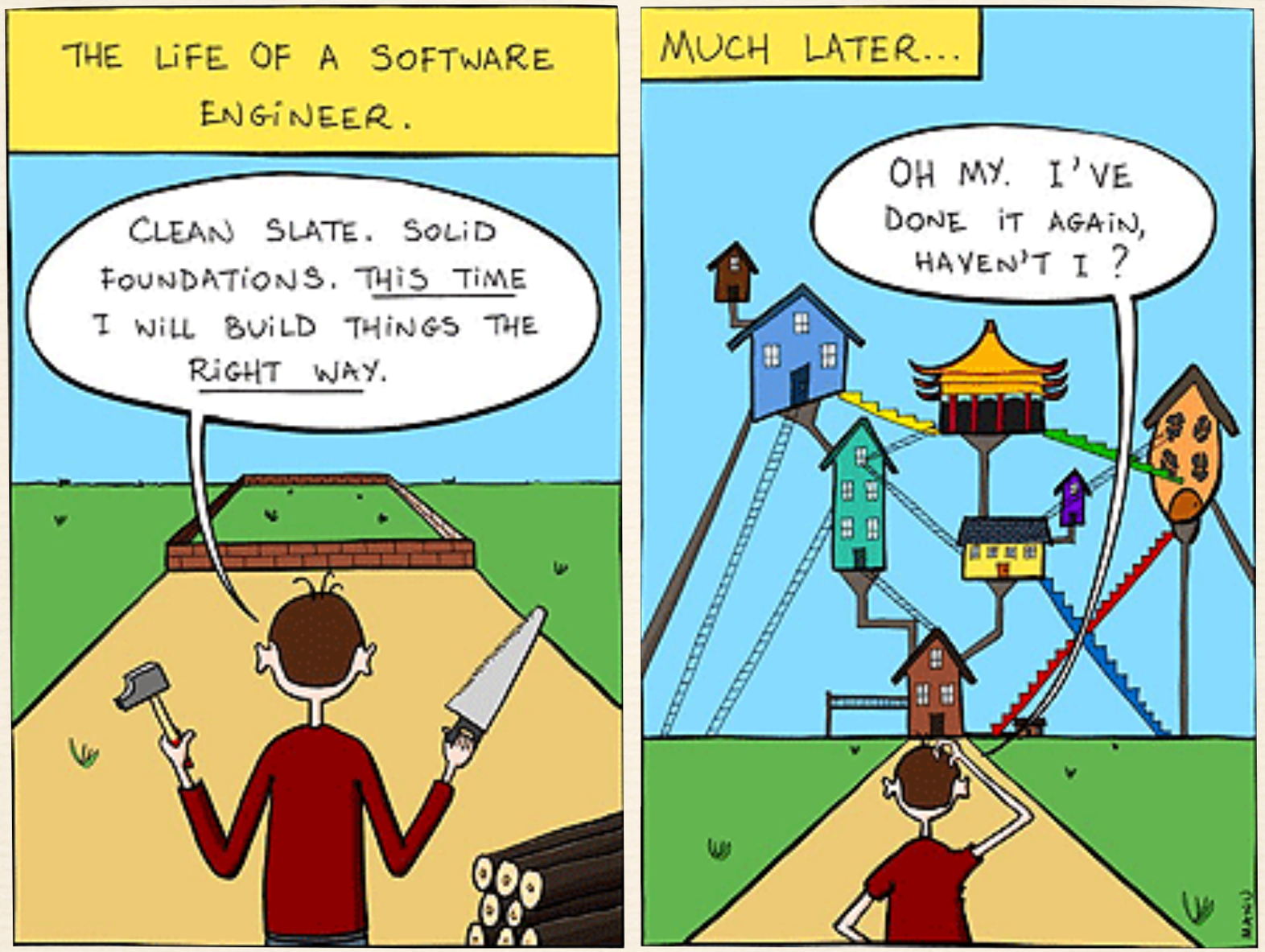
Definition of Refactoring [Fowler2000]

[noun] “a change made to the internal structure of software to make it easier to understand and cheaper to modify without changing its observable behaviour”

[verb] “to restructure software by applying a series of refactorings without changing its observable behaviour”

typically with the purpose of making the software easier to understand and modify

Why should you refactor?



Why should you refactor?

To improve the design of software

To counter code decay (software ageing)

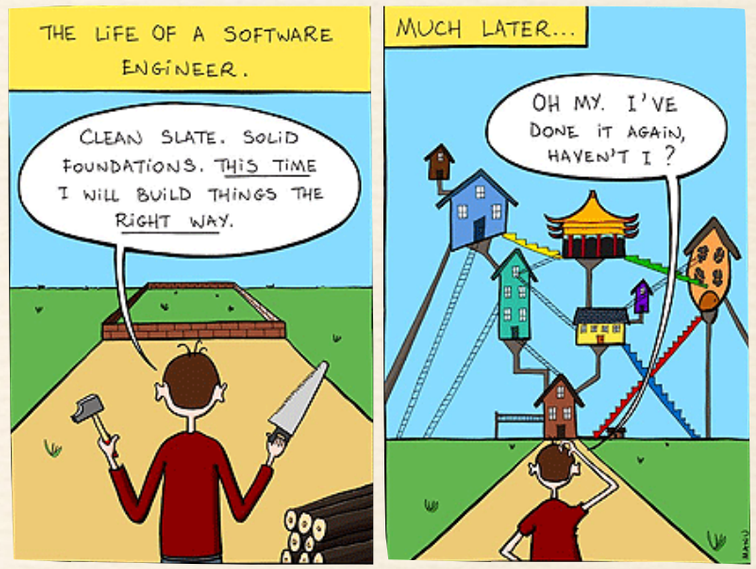
refactoring helps code to remain in shape

To increase software comprehensibility

To find bugs and write more robust code

To increase productivity (program faster)

on a long term basis, not on a short term basis



Why should you refactor?

To reduce costs of software maintenance

To reduce testing

- automatic refactorings are guaranteed to be behaviour preserving

To prepare for / facilitate future customisations

To turn an OO application into a framework

To introduce design patterns in a behaviourally preserving way

When should you refactor?

Whenever you see the need for it

Do it all the time in little bursts

Not on a pre-set periodical basis

Apply the rule of three

1st time : implement from scratch

2nd time : implement something similar by code duplication

3rd time : do not implement similar things again, but refactor

When should you refactor?

Refactor when adding new features or functions

- Especially if feature is difficult to integrate with the existing code

Refactor during bug fixing

- If a bug is very hard to trace, refactor first to make the code more understandable, so that you can understand better where the bug is located

Refactor during code reviews

When should you refactor?

Refactoring also fits naturally in the *agile methods* philosophy

Is needed to address the principle "Maintain simplicity"

> Wherever possible, actively work to eliminate complexity from the system
>
> By refactoring the code

What do you tell the manager?

When (s)he's technically aware (s)he'll understand why refactoring is important.

When (s)he's interested in quality, (s)he'll understand that refactoring will improve software quality.

When (s)he's only interested in the schedule, don't tell that you're doing refactoring, just do it anyway.

In the end refactoring will make you more productive.

When shouldn't you refactor?

When the existing code is such a mess that although you could refactor it, it would be easier to rewrite everything from scratch instead.

When you are too close to a deadline.

The productivity gain would appear after the deadline and thus be too late.

However, when you are *not* close to a deadline you should *never* put off refactoring because you don't have the time.

Not having enough time usually is a sign that refactoring is needed.

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B. CATEGORIES OF REFACTORINGS*

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Categories of refactorings

Small refactorings

(de)composing methods

moving features between objects

organizing data

simplifying conditional expressions

dealing with generalisation

simplifying method calls

Big refactorings

Tease apart inheritance

Extract hierarchy

Convert procedural design to objects

Separate domain from presentation

Small refactorings

(de)composing methods [9 refactorings]

moving features between objects [8 refactorings]

organizing data [16 refactorings]

simplifying conditional expressions [8 refactorings]

dealing with generalisation [12 refactorings]

simplifying method calls [15 refactorings]

Small Refactorings : (de)composing methods

1. Extract Method
2. Inline Method
3. Inline Temp
4. Replace Temp With Query
5. Introduce Explaining Variable
6. Split Temporary Variable
7. Remove Assignments to Parameter
8. Replace Method With Method Object
9. Substitute Algorithm

Legend:

= we will zoom in on these

= home reading

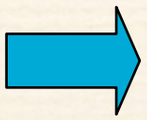
(De)composing methods: 1. Extract Method

What? When you have a fragment of code that can be grouped together, turn it into a method with a name that explains the purpose of the method

Why? improves clarity, removes redundancy

Example:

```
public void accept(Packet p) {
 if ((p.getAddressee() == this) &&
      (this.isASCII(p.getContents())))
   this.print(p);
 else
   super.accept(p); }
```



```
public void accept(Packet p) {
 if this.isDestFor(p) this.print(p);
 else super.accept(p); }
public boolean isDestFor(Packet p) {
 return
  ((p.getAddressee() == this) &&
   (this.isASCII(p.getContents()))); }
```

Beware of local variables !

(De)composing methods : 2. Inline Method

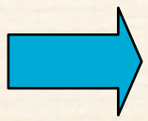
(Opposite of Extract Method)

What? When a method's body is just as clear as its name, put the method's body into the body of its caller and remove the method

Why? To remove too much indirection and delegation

Example:

```
int getRating(){
    return moreThanFiveLateDeliveries();
}

boolean moreThanFiveLateDeliveries(){
    return _numberOfLateDeliveries > 5;
}
```



```
int getRating(){
return (_numberOfLateDeliveries > 5);
}
```

(De)composing methods :
3. Inline Temp

What? When you have a temp that is assigned once with a simple expression, and the temp is getting in the way of refactorings, replace all references to that temp with the expression.

Why? (Part of ***Replace Temp with Query*** refactoring)

Example:

```
double basePrice = anOrder.basePrice();
return (basePrice > 100)
```

```
return (anOrder. basePrice() > 100)
```

(De)composing methods : 4. Replace Temp with Query

What? When you use a temporary variable to hold the result of an expression, extract the expression into a method and replace all references to the temp with a method call

Why? Cleaner code

Example:

```
double basePrice = _quantity * _itemPrice;
if (basePrice > 1000)
     return basePrice * 0.95;
else
     return basePrice * 0.98;
```

```
if (basePrice() > 1000)
     return basePrice() * 0.95;
else
     return basePrice() * 0.98;
…
double basePrice(){
      return _quantity * _itemPrice;
}
```

(De)composing methods : 5. Introduce Explaining Variable

What? When you have a complex expression, put the result of the (parts of the) expression in a temporary variable with a name that explains the purpose

Why? Breaking down complex expressions for clarity

Example:

```
if ( (platform.toUpperCase().indexOf("MAC") > -1) &&
     (browser.toUpperCase().indexOf("IE") > -1) &&
     wasInitialized() && resize > 0 )
{
//ACTION
}
```

```
     final boolean isMacOs     = platform.toUpperCase().indexOf("MAC") > -1;
     final boolean isIEBrowser = browser.toUpperCase().indexOf("IE") > -1;
     final boolean wasResized = resize > 0;

     if (isMacOs && isIEBrowser && wasInitialized() && wasResized){
     //ACTION
     }
```

(De)composing methods : 6. Split Temporary Variable

What? When you assign a temporary variable more than once, but it is not a loop variable nor a collecting temporary variable, make a separate temporary variable for each assignment

Why? Using temps more than once is confusing

Example:

```
double temp = 2 * (_height + _width);
System.out.println (temp);
temp = _height * _width;
System.out.println (temp);
```

```
final double perimeter =
                    2 * (_height + _width);
System.out.println (perimeter);
final double area = _height * _width;
System.out.println (area);
```

(De)composing methods :
7. Remove Assignments To Parameters

What? When the code assigns to a parameter,
use a temporary variable instead

Why? Lack of clarity and confusion between "pass by value"
and "pass by reference"

Example:

```
int discount (int inputVal, int quantity,
int yearToDate){
   if (inputVal > 50) inputVal -= 2;
   ... MORE CODE HERE ...
```

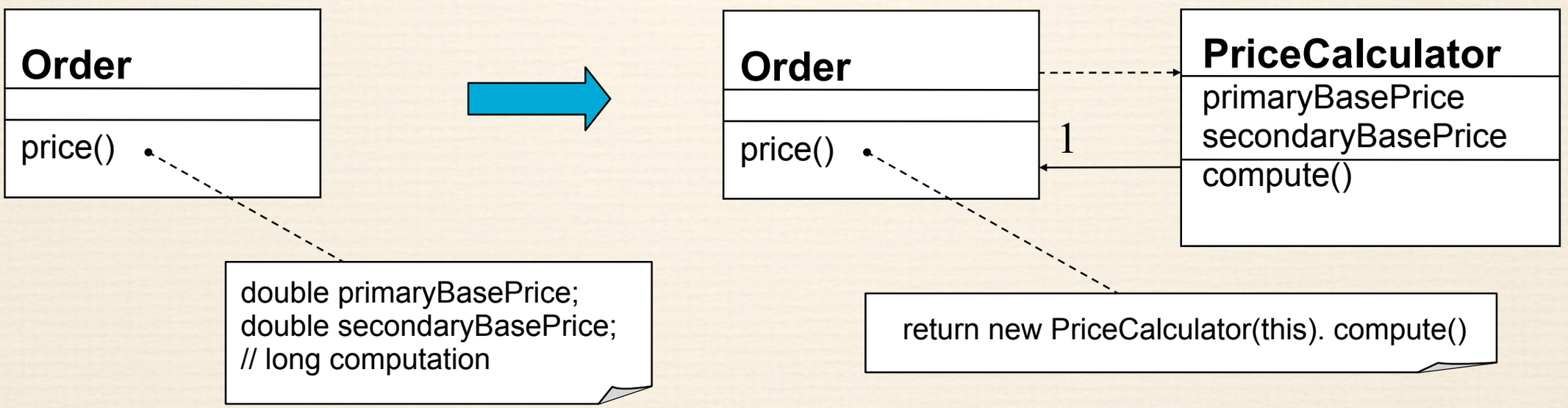
```
int discount (int inputVal, int quantity,
int yearToDate){
   int result = inputVal;
   if (inputVal > 50) result -= 2;
 ... MORE CODE HERE ...
```

(De)composing methods :
8. Replace Method with Method Object

What? When you have local variables but cannot use **extract method**, turn the method into its own object, with the local variables as its fields

Why? Extracting pieces out of large methods makes things more comprehensible

Example:



(De)composing methods : 9. Substitute Algorithm

What? When you want to replace an algorithm with a clearer alternative, replace the body of the method with the new algorithm

Why? To replace complicated algorithms with clearer ones

Example:

```
String foundPerson(String[] people){
   for (int i = 0; i < people.length; i++){
         if (people[i]. equals (“John”) ) {
             return “John”;
          }
 if (people[i]. equals (“Jack”) ) {
             return “Jack”;
          }
    }
}
```

```
String foundPerson(String[] people){
   List candidates = Array.asList(new String[] {“John”, “Jack”})
   for (int i = 0; i < people.length; i++)
         if (candidates[i]. contains (people[i]))
             return people[i];
}
```

Small refactorings

(de)composing methods [9 refactorings]

moving features between objects [8 refactorings]

organizing data [16 refactorings]

simplifying conditional expressions [8 refactorings]

dealing with generalisation [12 refactorings]

simplifying method calls [15 refactorings]

Small Refactorings : moving features between objects

1. Move Method
2. Move Field
3. Extract Class
4. Inline Class
5. Hide Delegate
6. Remove Middle Man
7. Introduce Foreign Method
8. Introduce Local Extension

Legend:

= we will zoom in on these

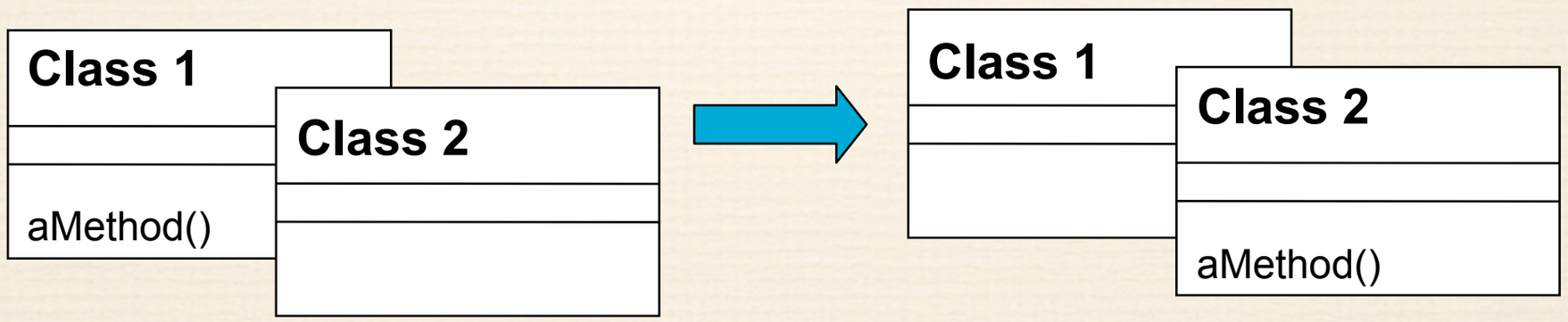
= home reading

Moving features between objects : 1,2. Move Method / Field

What? When a method (resp. field) is used by or uses more features of another class than its own, create a similar method (resp. field) in the other class; remove or delegate original method (resp. field) and redirect all references to it.

Why? Essence of refactoring

Example:

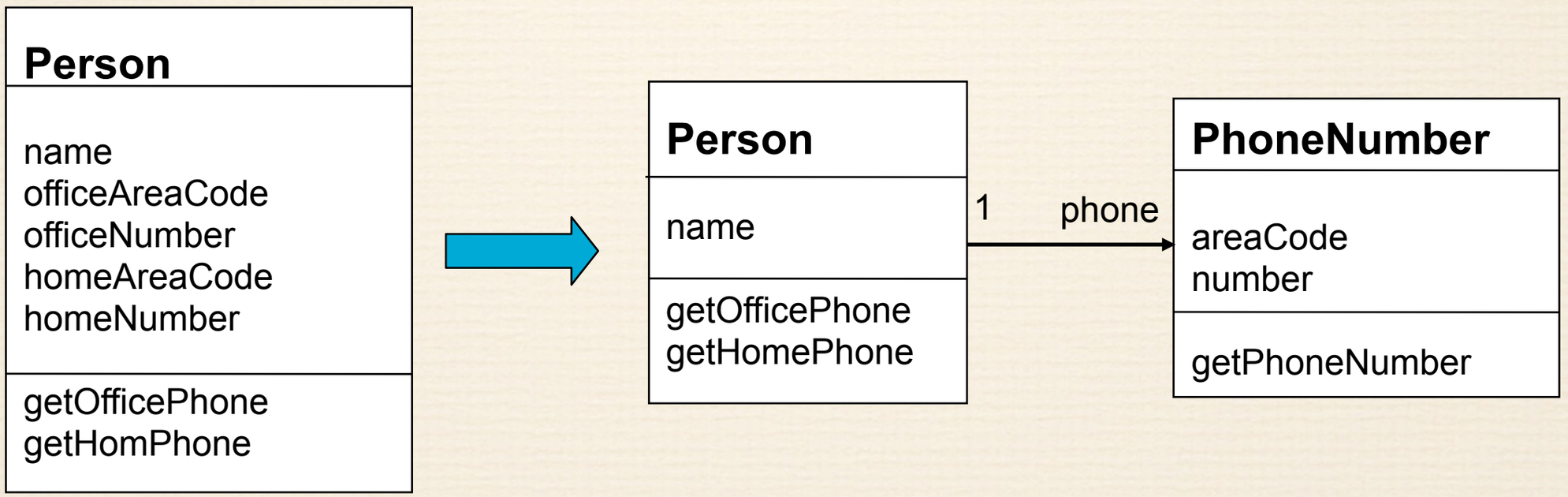


Moving features between objects : 3. Extract Class

What? When you have a class doing work that should be done by two, create a new class and move the relevant fields and methods to the new class

Why? Large classes are hard to understand

Example:

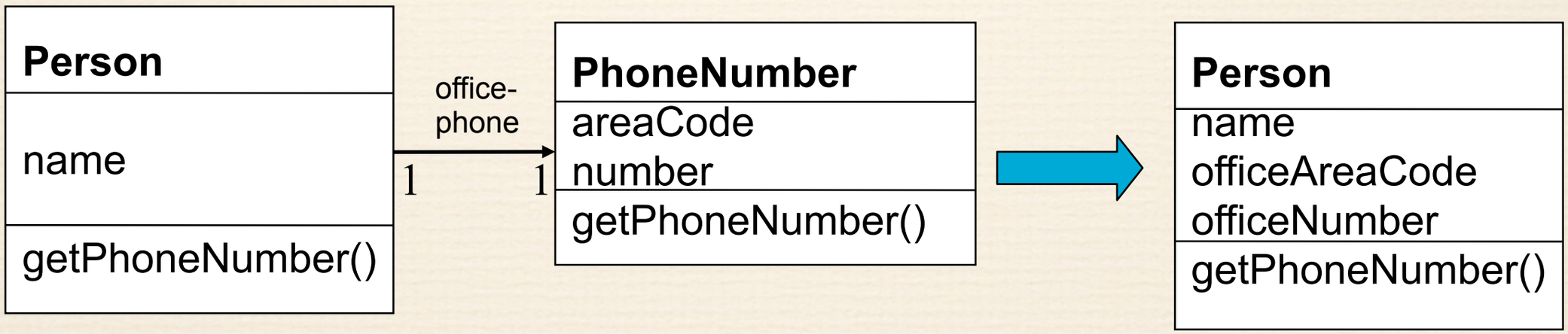


Moving features between objects : 4. Inline Class

What? When you have a class that does not do very much, move all its features into another class and delete it

Why? To remove useless classes (as a result of other refactorings)

Example:

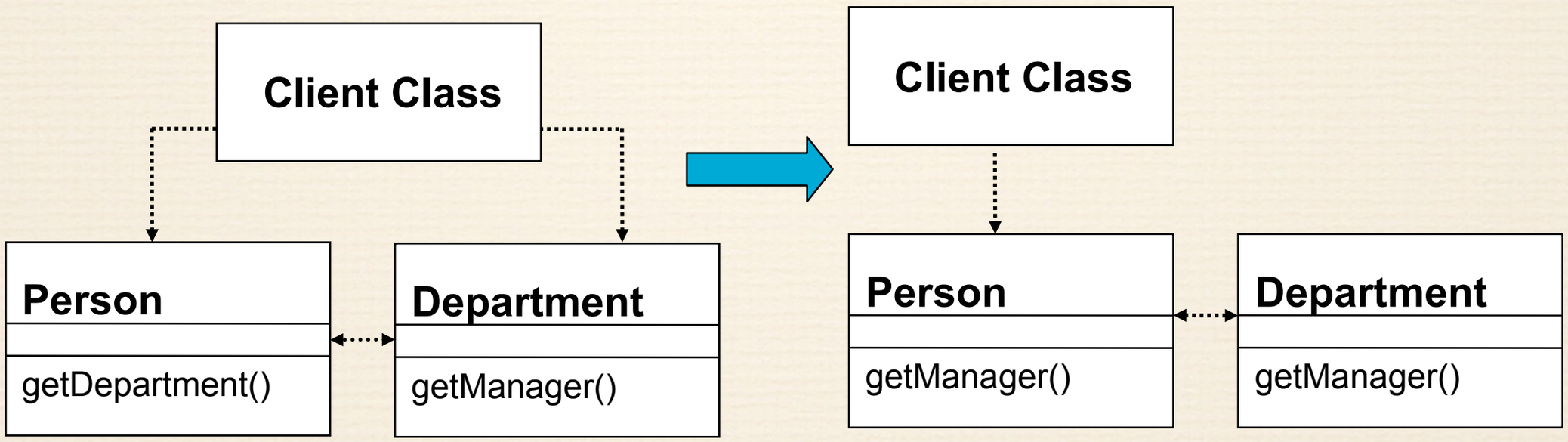


Moving features between objects : 5. Hide Delegate

What? When you have a client calling a delegate class of an object, create methods on the server to hide the delegate

Why? Increase encapsulation

Example:

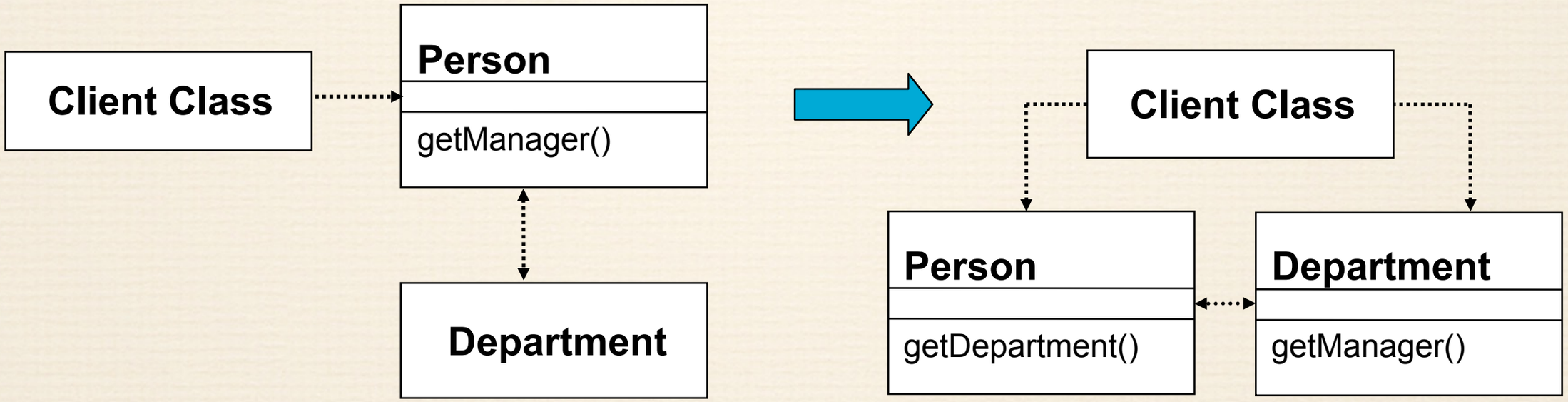


Moving features between objects : 6. Remove Middle Man

What? When a class is doing too much simple delegation, get the client to call the delegate directly

Why? To remove too much indirection (as a result of other refactorings)

Example:



Moving features between objects : 7. Introduce Foreign Method

What? When a server class needs an additional method, but you cannot modify the class, create a method in the client class with an instance of the server class as its first argument

Why? To introduce one additional service

Example:

```
Date newStart = new Date (previousEnd.getYear(),
     previousEnd.getMonth(), previousEnd.getDate() + 1);
```

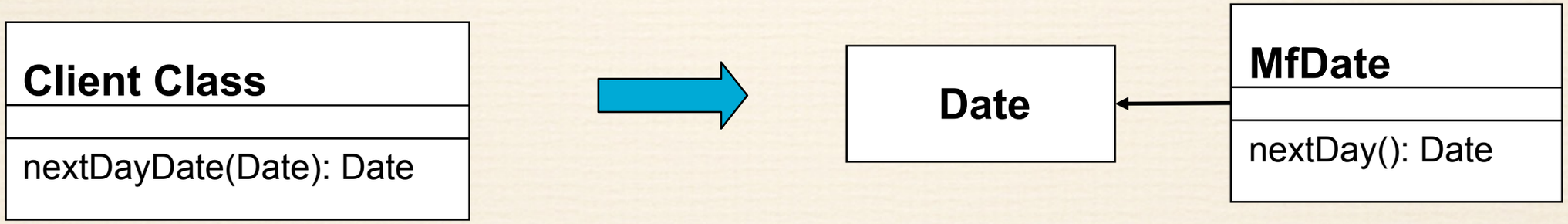
```
Date newStart = nextDay(previousEnd);

private static Date nextDay(Date arg) {
  return new Date (arg.getYear(),
     arg.getMonth(), arg.getDate() + 1);
}
```

Moving features between objects : 8. Introduce Local Extension

What? When a server class needs several additional methods but you cannot modify the class, create a new class containing the extra methods; make the extension class a subclass or wrapper

Why? To introduce several additional services

Example:



Small refactorings

(de)composing methods [9 refactorings]

moving features between objects [8 refactorings]

organizing data [16 refactorings]

simplifying conditional expressions [8 refactorings]

dealing with generalisation [12 refactorings]

simplifying method calls [15 refactorings]

Small Refactorings : organizing data

1. Encapsulate field
2. Replace data value with object
3. Change value to reference
4. Change reference to value
5. Replace array with object
6. Duplicate observed data
7. Change unidirectional association to bidirectional
8. Change bidirectional association to unidirectional
9. Replace magic number with symbolic constant
10. Encapsulate collection
11. Replace record with data class
12. Replace subclass with fields
13-16. Replace type code with class / subclass / state / strategy

Organizing Data : 1. Encapsulate Field

What? There is a public field. Make it private and provide accessors.

Why? Encapsulating state increases modularity, and facilitates code reuse and maintenance.
When the state of an object is represented as a collection of private variables, the internal representation can be changed without modifying the external interface

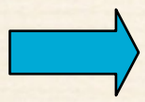
Example:

```
public String name;
```

```
private String name;
public String getName() {
  return this.name; }
public void setName(String s) {
  this.name = s; }
```

Organizing Data :
2. Replace Data Value with Object

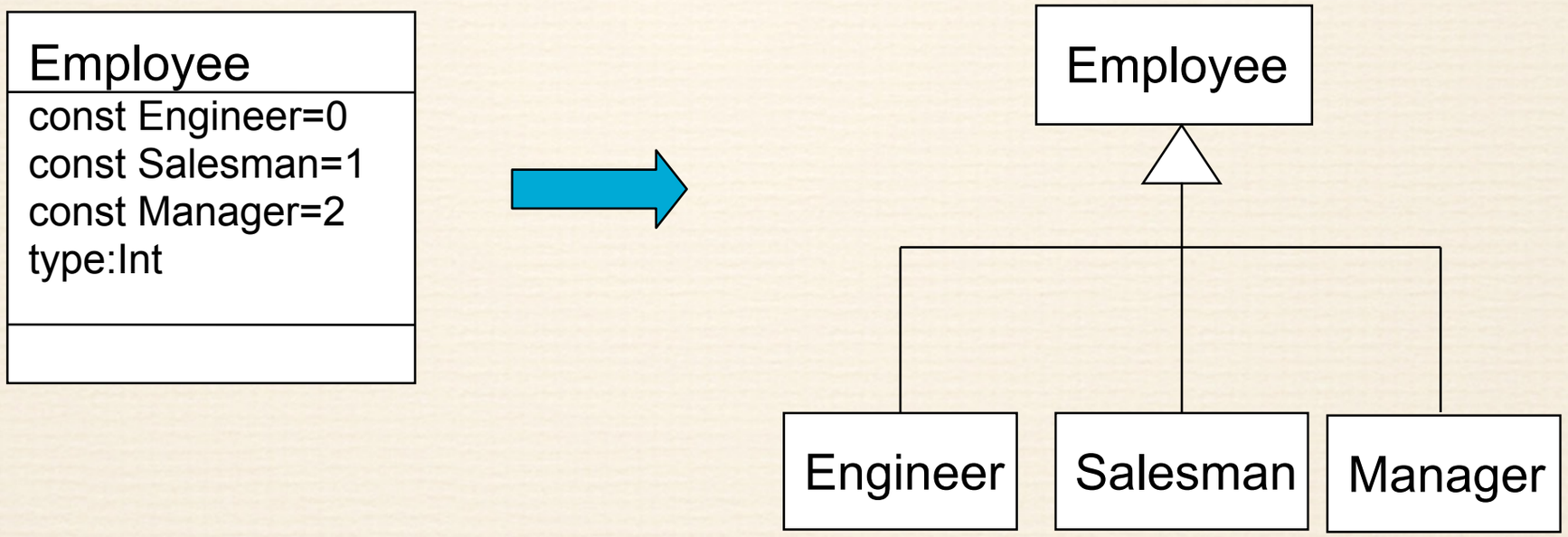
```
private String contents;
public String getContents() {
  return this.contents; }
public void setContents(String s) {
  this.contents = s; }
```



```
private Document doc;
public String getContents() {
  return this.doc.getContents(); }
public void setContents(String s) {
  this.doc.setContents(s); }

public class Document {
  private String contents;

  public String getContents() {
    return this.contents; }
  public void setContents(String s) {

    this.contents = s; }

}
```

Organizing Data :
13. Replace Type Code with Subclass

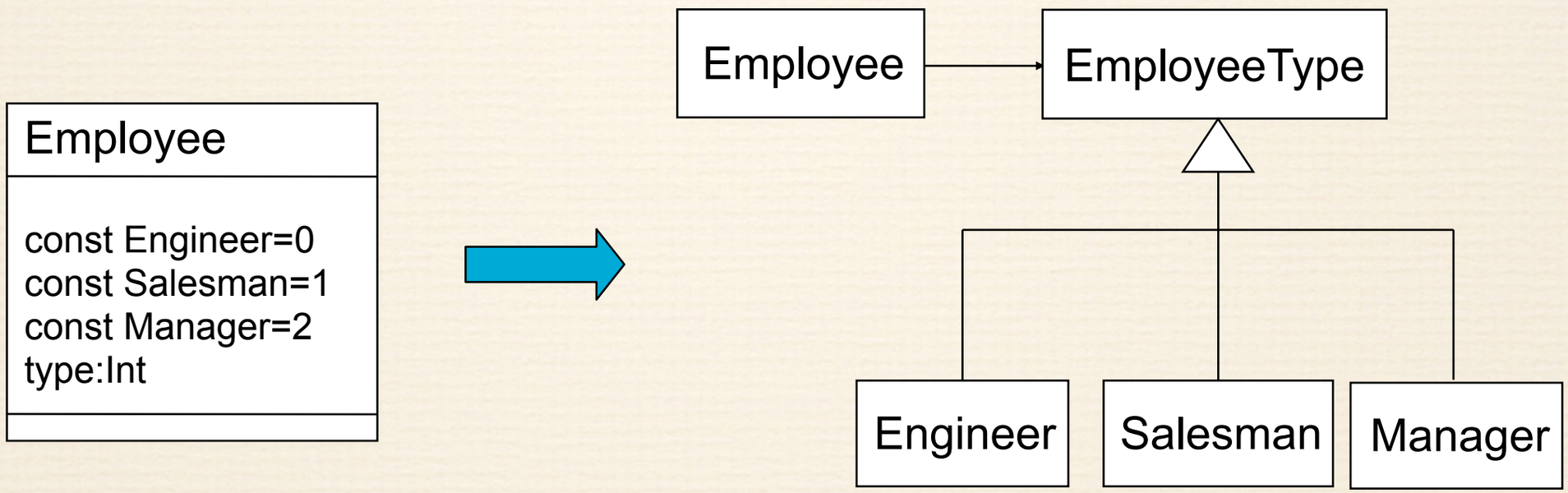
What? An immutable type code affects the behaviour of a class
Example:



Organizing Data :
15,16. Replace Type Code with State/Strategy

When? If subclassing cannot be used, e.g. because of dynamic type changes during object lifetime (e.g. promotion of employees)

Example:



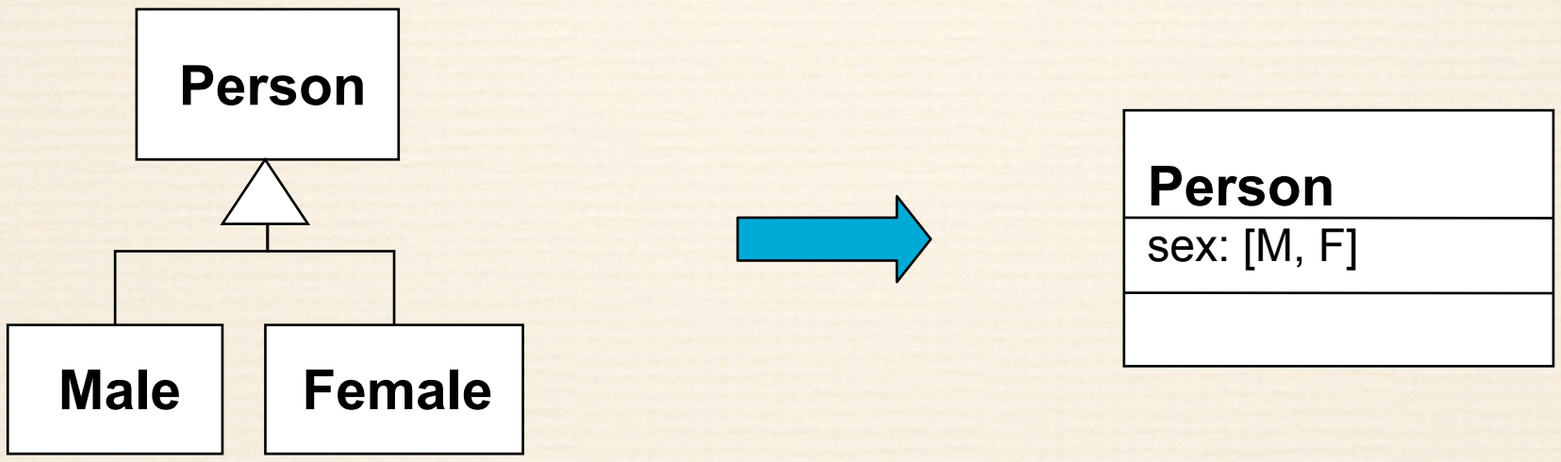
Makes use of **state pattern** or **strategy design pattern**

Organizing Data :
12. Replace Subclass with Fields

What? Subclasses vary only in methods that return constant data

Solution: Change methods to superclass fields and eliminate subclasses

Example:



Similar to **replace inheritance with aggregation**

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simplifying method calls [15 refactorings]

Small Refactorings : simplifying conditional expressions

1. Decompose conditional
2. Consolidate conditional expression
3. Consolidate duplicate conditional fragments
4. Remove control flag
5. Replace nested conditional with guard clauses
6. Replace conditional with polymorphism
7. Introduce null objects
8. Introduce assertion

Small refactorings

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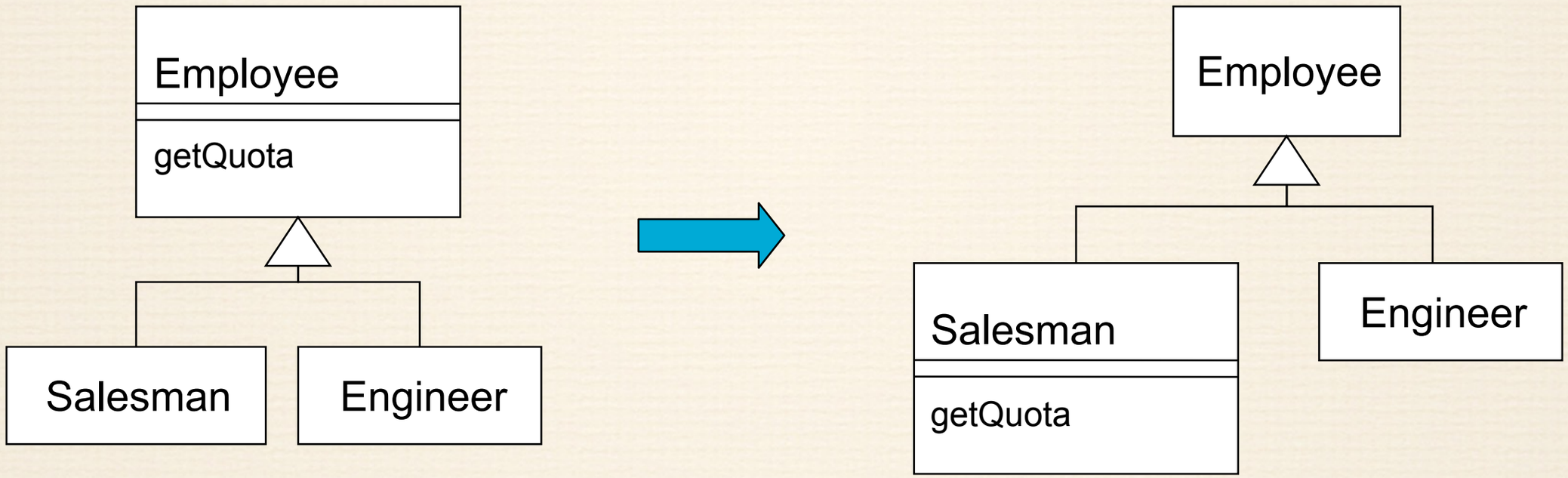
Small Refactorings : dealing with generalisation

1. Push down method / field
2. Pull up method / field / constructor body
3. Extract subclass / superclass / interface
4. Collapse hierarchy
5. Form template method
6. Replace inheritance with delegation (and vice versa)

Dealing with Generalisation: 1. Push Down Method

When behaviour on a superclass is relevant only for some of its subclasses, move it to those subclasses

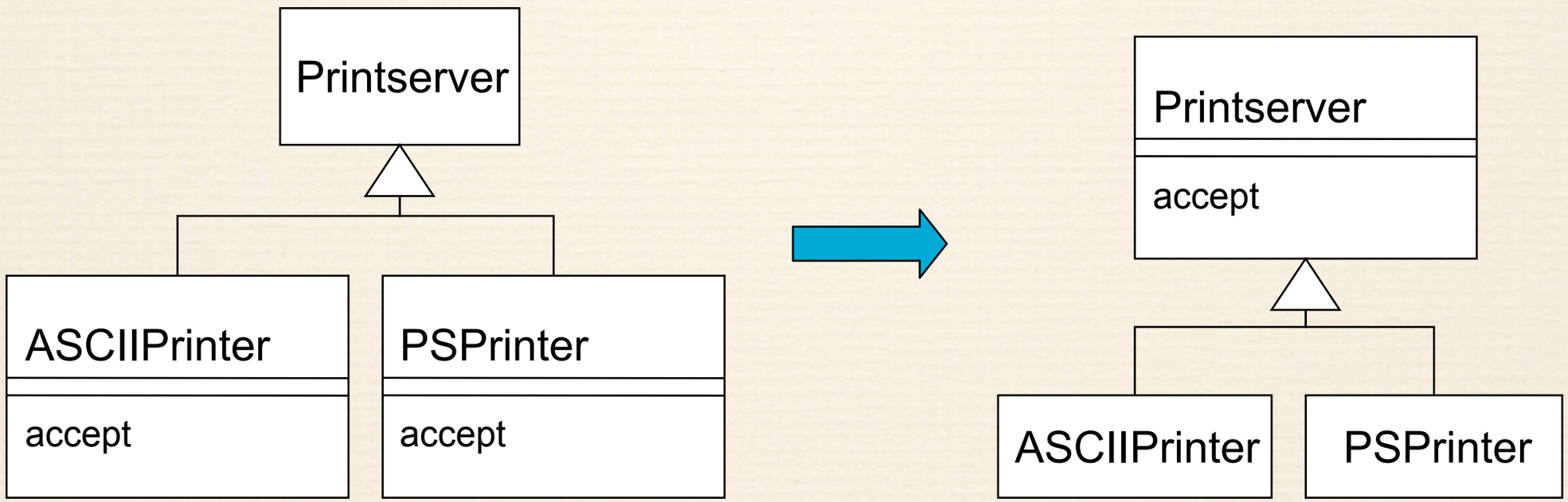


Dealing with Generalisation:
2. Pull Up Method

Simple variant: look for methods with same name in subclasses that do not appear in superclass

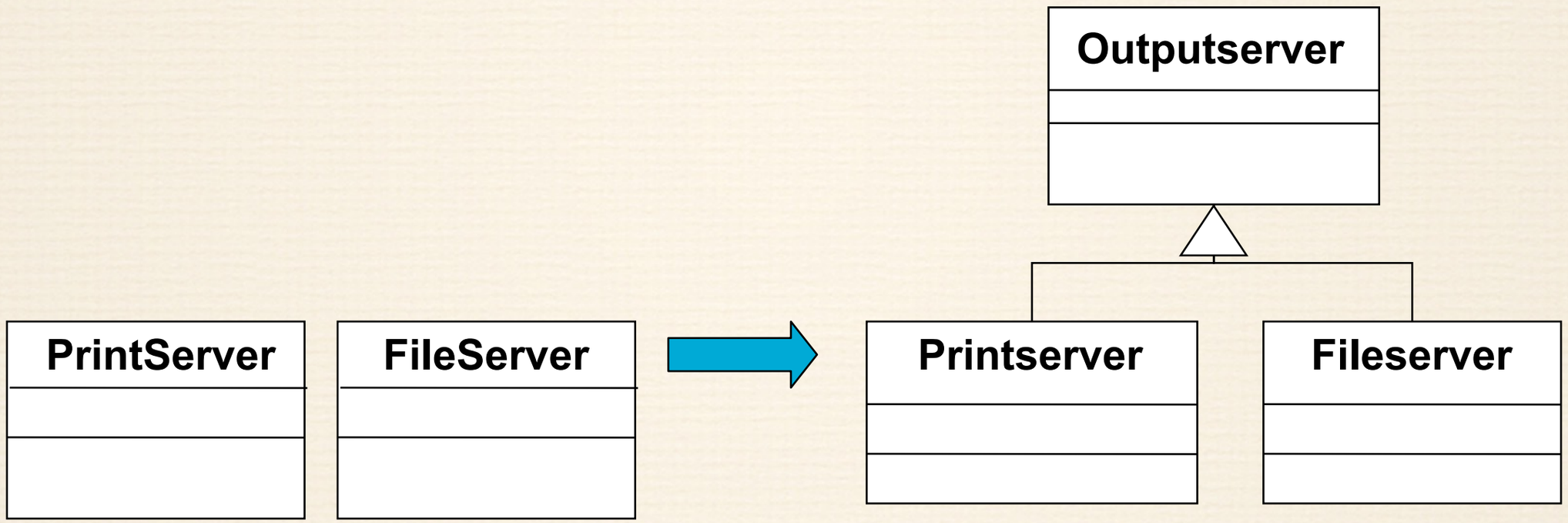
More complex variant: do not look at the name but at the behaviour of the method

If the method that is being pulled up already exists in the superclass as an abstract method, make it concrete with the common behaviour



Dealing with Generalisation:
3. Extract Superclass

When you have 2 classes with similar features



Small refactorings

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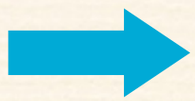
Small Refactorings : simplifying method calls

1. Rename method
2. Add parameter
3. Remove parameter
4. Separate query from modifier
5. Parameterize method
6. Replace parameter with method
7. Replace parameter with explicit methods
8. Preserve whole object
9. Introduce parameter object
10. Remove setting method
11. Hide method
12. Replace constructor with factory method
13. Encapsulate downcast
14. Replace error code with exception
15. Replace exception with test

Simplifying method calls : 9. Introduce Parameter Object

Group parameters that belong together in a separate object

Customer
amountInvoicedIn(from:Date,to:Date) amountReceivedIn(from:Date,to:Date) amountOverdueIn(from:Date,to:Date)



Customer
amountInvoicedIn(r:DateRange) amountReceivedIn(r:DateRange) amountOverdueIn(r:DateRange)

DataRange
from : Date to : Date

Simplifying method calls:
14. Replace Error Code with Exception

What? When a method returns a special code to indicate an error, throw an exception instead

Why? Clearly separate normal processing from error processing

Example:

```
int withdraw(int amount) {
  if (amount > balance)
    return -1
else
  {balance -= amount;
   return 0}
}
```

```
void withdraw(int amount) throws BalanceException {
  if (amount > balance) throw new BalanceException();
  balance -= amount;
}
```

Categories of refactorings (according to [Fowler2000])

Small refactorings

(de)composing methods [9]

moving features between objects [8]

organizing data [16]

simplifying conditional expressions [8]

dealing with generalisation [12]

simplifying method calls [15]

Big refactorings

Tease apart inheritance

Extract hierarchy

Convert procedural design to objects

Separate domain from presentation

Big refactorings

Require a large amount of time (> 1 month)

Require a degree of agreement among the development team

No instant satisfaction, no visible progress

Big Refactorings

1. Tease apart inheritance
2. Extract hierarchy
3. Convert procedural design to objects
4. Separate domain from presentation

Big refactorings:
1. Tease apart inheritance

Problem

A tangled inheritance hierarchy that is doing 2 jobs at once

Solution

Create 2 separate hierarchies and use delegation to invoke one from the other

Big refactorings:
1. Tease apart inheritance

Approach

Identify the different jobs done by the hierarchy.

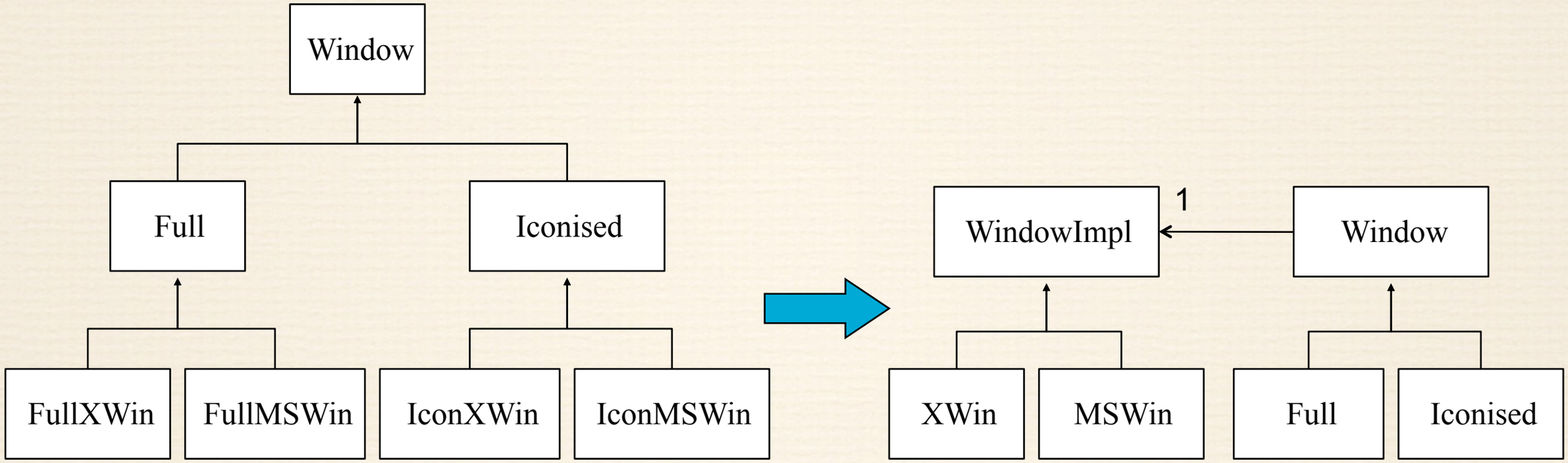
Extract least important job into a separate hierarchy.

Use extract class to create common parent of new hierarchy.

Create appropriate subclasses.

Use move method to move part of the behaviour from the old hierarchy to the new one.

Big refactorings:
1. Tease apart inheritance



Big refactorings:
1. Tease apart inheritance

Related design patterns

Bridge

decouples an abstraction from its implementation so that the two can vary independently

Strategy / Visitor / Iterator / State

Big refactorings:
2. Extract hierarchy

Problem

An overly-complex class that is doing too much work, at least in part through many conditional statements.

Solution

Turn class into a hierarchy where each subclass represents a special case.

Big refactorings:
2. Extract hierarchy

Approach

Create a subclass for each special case.

Use one of the following refactorings to return the appropriate subclass for each variation:

replace constructor with factory method

replace type code with subclasses

replace type code with state/strategy

Take methods with conditional logic and apply:

replace conditional with polymorphism

Big refactorings:
2. Extract hierarchy (example)

Calculating electricity bills.

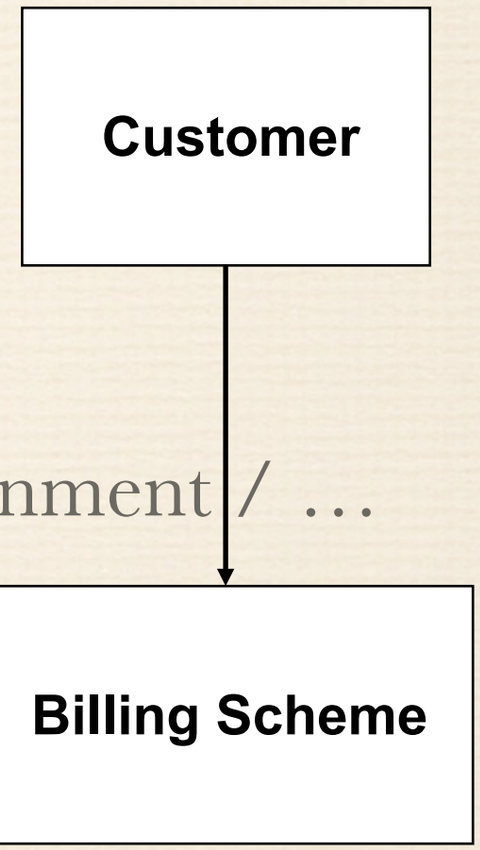
Lots of conditional logic needed to cover many different cases:

different charges for summer/winter

different tax rates

different billing plans for personal / business / government / …

reduced rates for persons with
disabilities or social security



Big refactorings:
3. Convert procedural design into objects

Problem

You have code written in a procedural style.

Solution

Turn the data records into objects, break up the behaviour, and move the behaviour to the objects.

Smaller refactorings used

extract method, move method, …

Big refactorings:
4. Separate domain from presentation

Goal

Change a two-tier design (user interface/database) into a a three-tier one (UI/business logic/database).

Solution

Separate domain logic into separate domain classes.

Smaller refactorings used

extract method, move method/field, duplicate observed data, …

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C. REFACTORING TOOLS

AUTOMATED CODE REFACTORING TOOLS

Available for all major programming languages
(and OO programming languages in particular)

Java : IntelliJ IDEA, Eclipse, NetBeans, JDeveloper, …

JavaScript : WebStorm, Eclipse, …

C++ : VisualStudio, Eclipse, …

ObjectiveC and **SWIFT** : XCode

.NET : VisualStudio

Smalltalk, **PHP**, **Ruby**, **Python**, **C#**, **Delphi**, …

LIMITATIONS OF MOST REFACTORING TOOLS

Only support for primitive refactorings

- class refactorings
  - add (sub)class to hierarchy, rename class, remove class
- method refactorings
  - add to class, rename, remove, push down, pull up, add parameter, move to component, extract code
- variable refactorings
  - add to class, rename, remove, push down, pull up, create accessors, abstract variable

Often no support for higher-level refactorings

REFACTORING IN ECLIPSE

The refactoring tool in Eclipse supports a number of transformations described in Martin Fowler's book

Refactoring can be accessed via the Refactor menu.

Refactoring commands are also available from the context menus in many views or appear as quick assists.

SUPPORTED REFACTORING ACTIONS IN ECLIPSE (2016)

Rename, Move, Change Method Signature

Extract Method, Extract Local Variable, Extract Constant

Inline, Move Type to New File, Use Supertype Where Possible

Convert Anonymous Class to Nested, Convert Local Variable to Field

Extract Superclass, Extract Interface, Extract Class

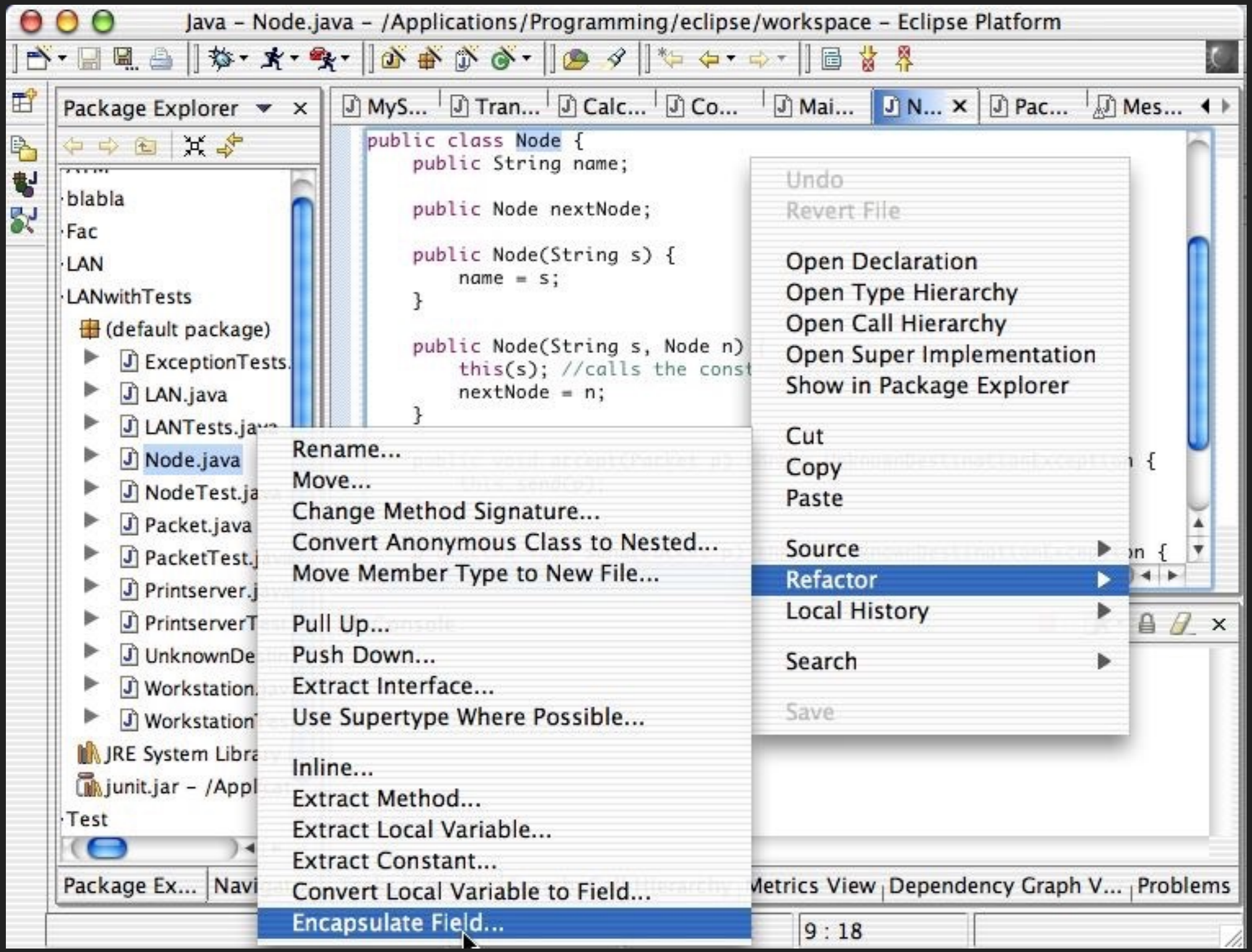
Push Down, Pull Up, Encapsulate Field

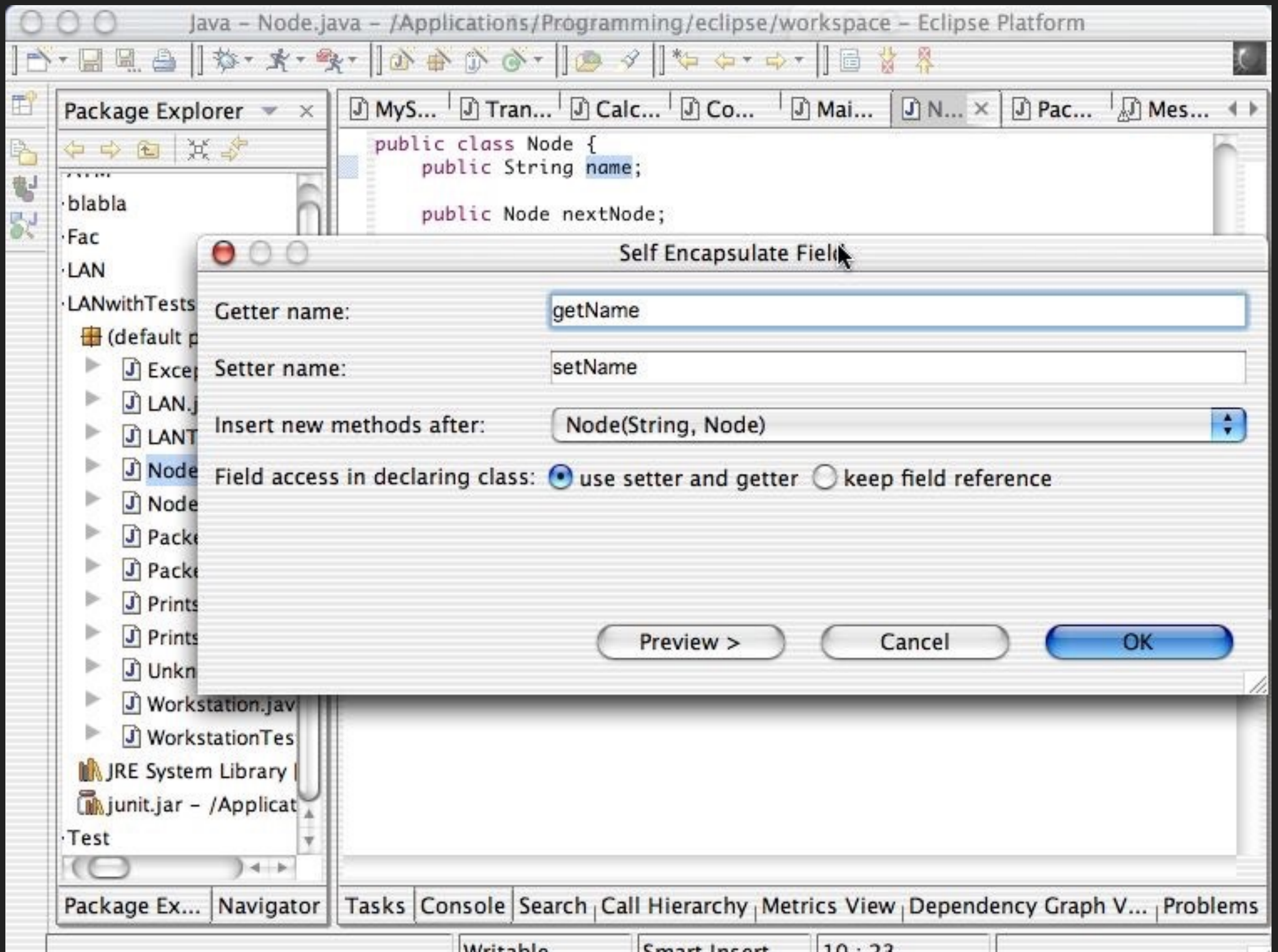
Introduce Parameter Object, Introduce Indirection

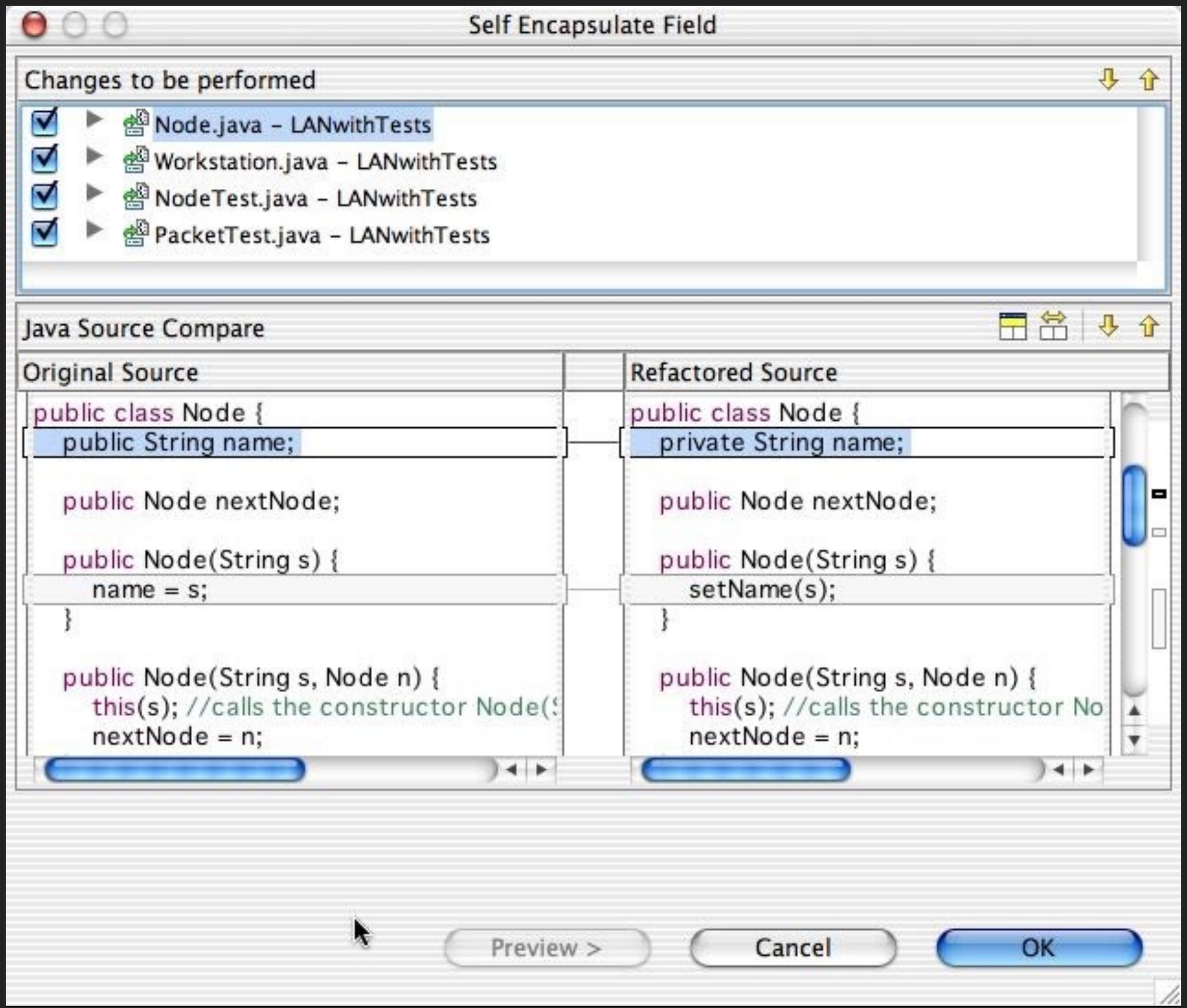
Introduce Factory, Introduce Parameter

Generalize Declared Type , Infer Generic Type Arguments

(and more)


Java – Node.java – /Applications/Programming/eclipse/workspace – Eclipse Platform
Package Explorer
blabla
Fac
LAN
LANwithTests
(default package)
ExceptionTests.
LAN.java
LANTests.ja
Node.java
NodeTest.ja
Packet.java
PacketTest.j
Printserver.j
PrintserverT
UnknownDe
Workstation.
Workstation
JRE System Libra
junit.jar – /Appl
Test
MyS...
Tran...
Calc...
Co...
Mai...
N...
Pac...
Mes...
public class Node {
public String name;
public Node nextNode;
public Node(String s) {
name = s;
}
public Node(String s, Node n)
this(s); //calls the const
nextNode = n;
}
Undo
Revert File
Open Declaration
Open Type Hierarchy
Open Call Hierarchy
Open Super Implementation
Show in Package Explorer
Cut
Copy
Paste
Source
Refactor
Local History
Search
Save
Rename...
Move...
Change Method Signature...
Convert Anonymous Class to Nested...
Move Member Type to New File...
Pull Up...
Push Down...
Extract Interface...
Use Supertype Where Possible...
Inline...
Extract Method...
Extract Local Variable...
Extract Constant...
Convert Local Variable to Field...
Encapsulate Field...
Package Ex...
Navi
Metrics View
Dependency Graph V...
Problems
9 : 18


Java – Node.java – /Applications/Programming/eclipse/workspace – Eclipse Platform
Package Explorer
MyS...
Tran...
Calc...
Co...
Mai...
N...
Pac...
Mes...
public class Node {
public String name;
public Node nextNode;
blabla
Fac
LAN
LANwithTests
Self Encapsulate Field
Getter name:
getName
Setter name:
setName
Insert new methods after:
Node(String, Node)
Field access in declaring class:
use setter and getter
keep field reference
Preview >
Cancel
OK
JRE System Library
junit.jar – /Applicat
Test
Package Ex...
Navigator
Tasks
Console
Search
Call Hierarchy
Metrics View
Dependency Graph V...
Problems


Self Encapsulate Field
Changes to be performed
Node.java - LANwithTests
Workstation.java - LANwithTests
NodeTest.java - LANwithTests
PacketTest.java - LANwithTests
Java Source Compare
Original Source
Refactored Source
public class Node {
public String name;
public Node nextNode;
public Node(String s) {
name = s;
}
public Node(String s, Node n) {
this(s); //calls the constructor Node(
nextNode = n;
public class Node {
private String name;
public Node nextNode;
public Node(String s) {
setName(s);
}
public Node(String s, Node n) {
this(s); //calls the constructor No
nextNode = n;
Preview >
Cancel
OK

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D. WORDS OF WARNING

A WORD OF WARNING (1)

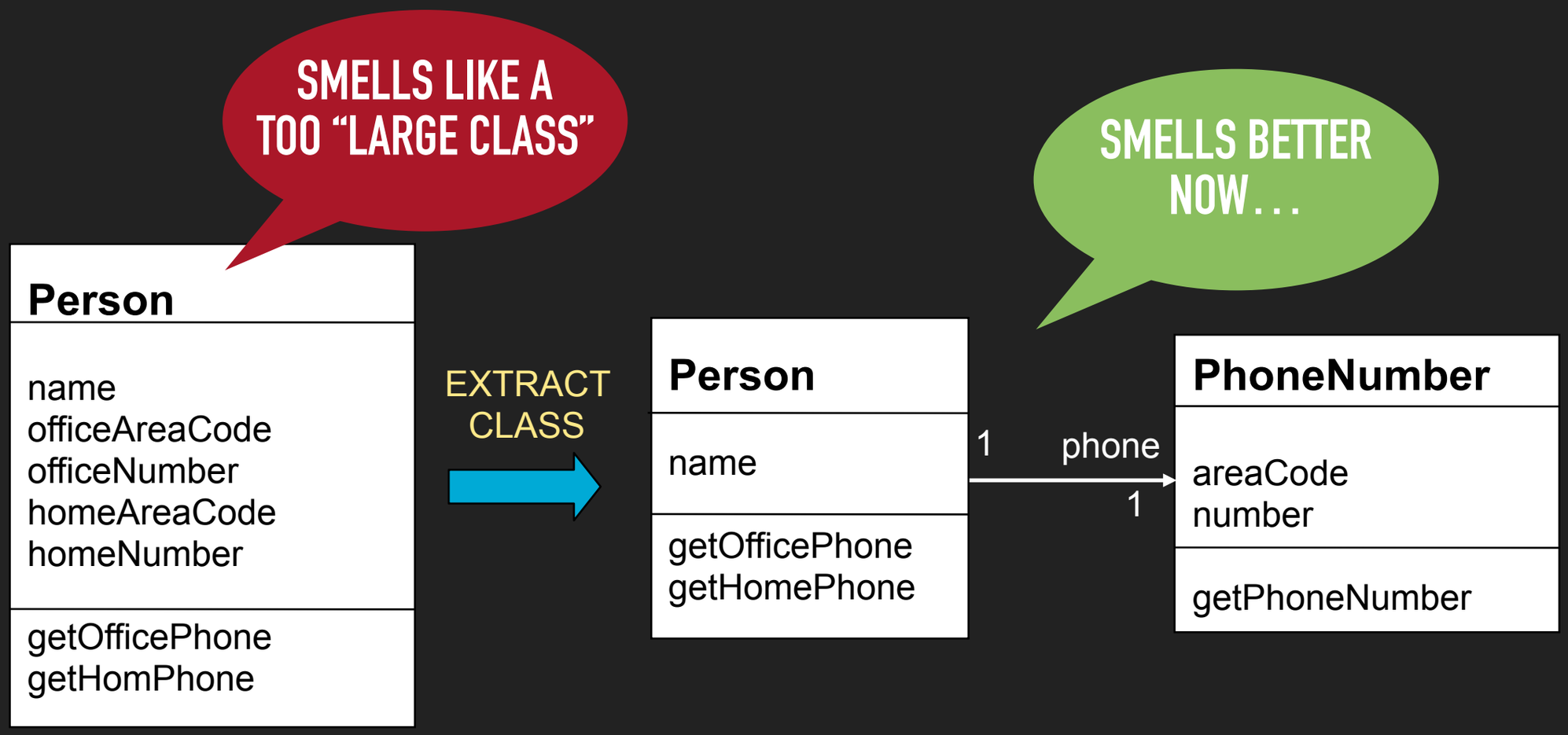
Know what you are doing

If not applied well, refactoring may *decrease* quality rather than improve it

A WORD OF WARNING (1)

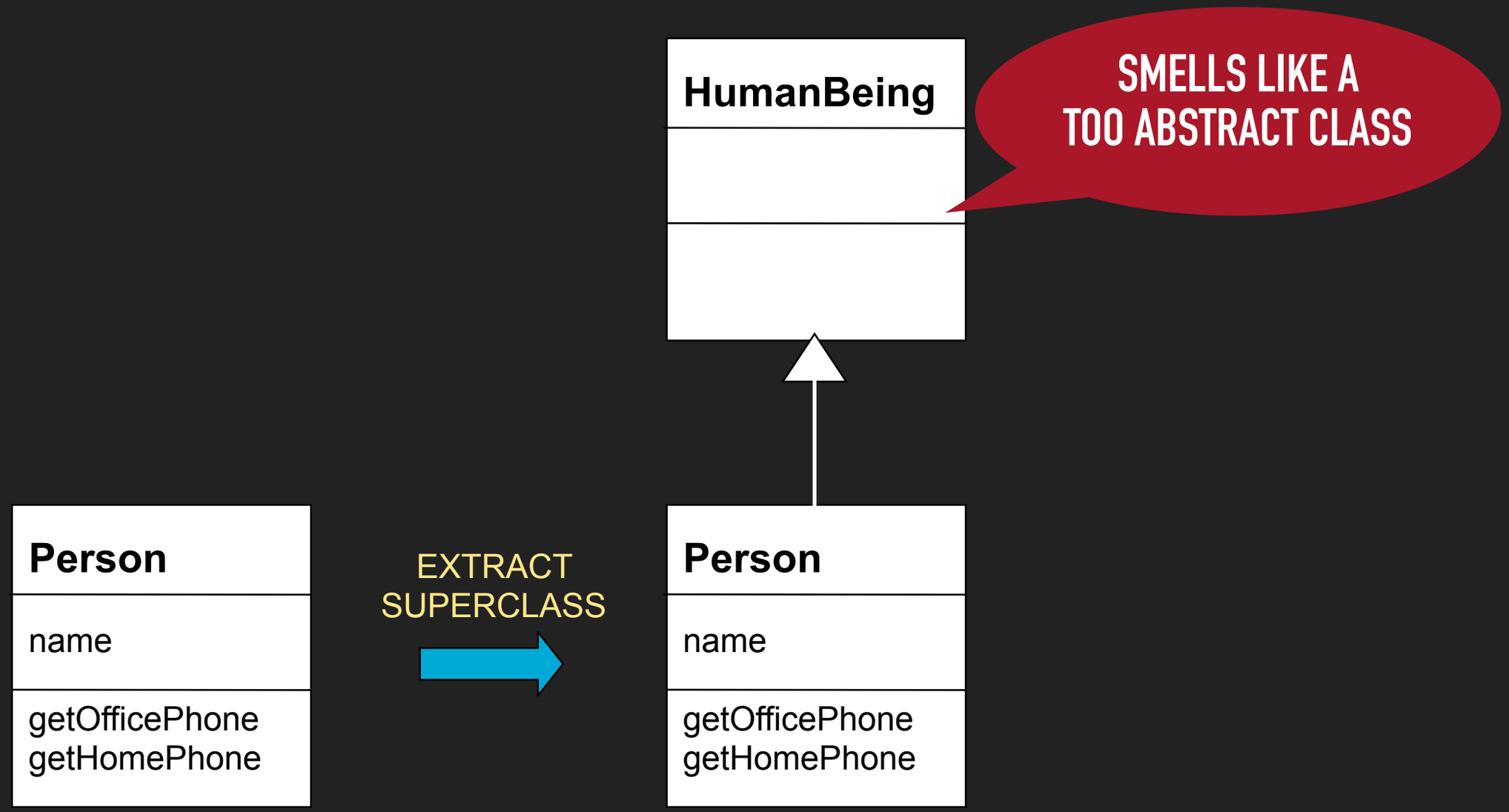
"Bad smells" are symptoms that something is wrong

Refactoring are supposed to remove "bad smells"



A WORD OF WARNING (1)

Refactoring should not introduce new smells



NEXT SESSION: INTRODUCTION TO "BAD SMELLS"

Bad code smells

- indicate that your code is ripe for refactoring

Refactoring is about

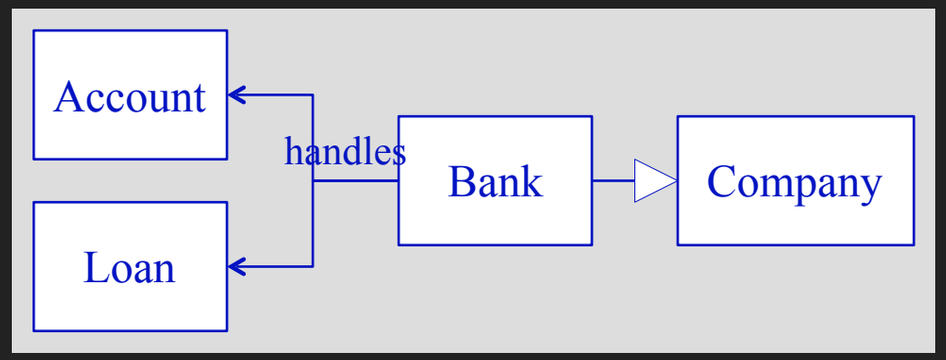
- *how* to change code

Bad smells are about

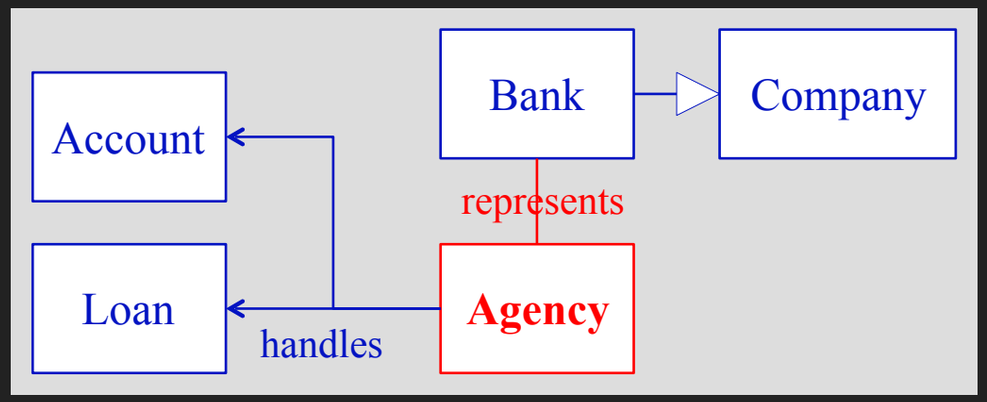
- *when* to modify it

A WORD OF WARNING (2)

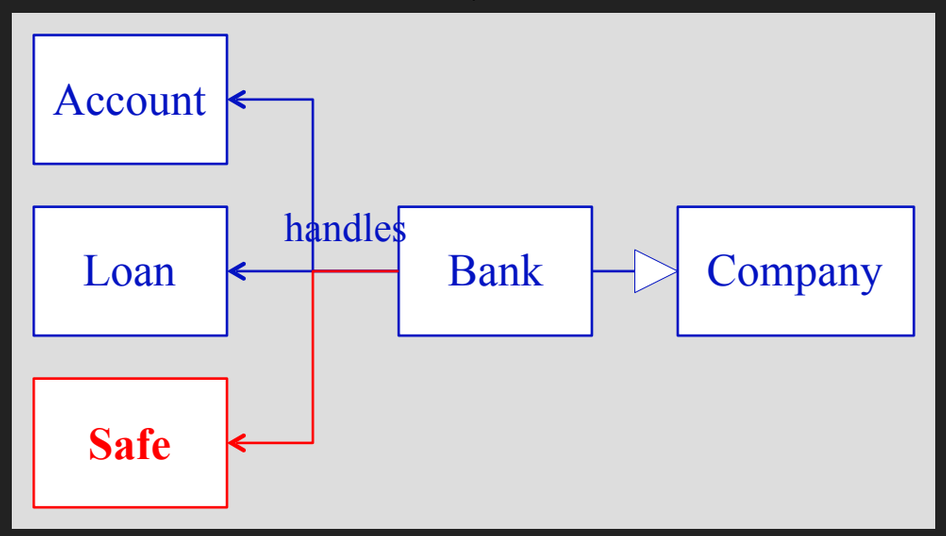
Independently applied refactorings can introduce subtle merge conflicts



EXTRACT CLASS

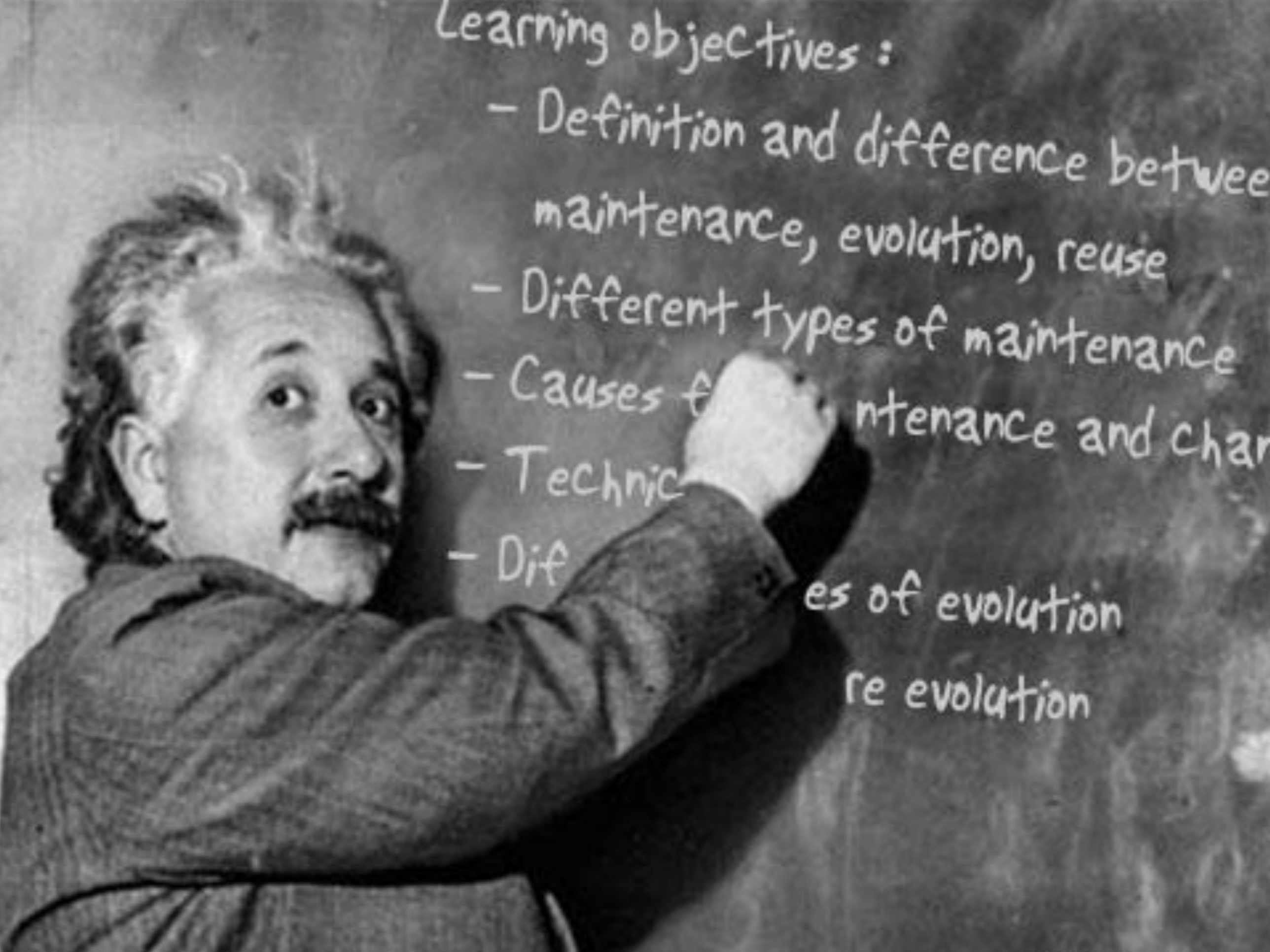


CREATE SUBCLASS



REFACTORING CONFLICT :

In the new version, Safe should not be handled by Bank, but by Agency


Learning objectives :
- Definition and difference betwee
maintenance, evolution, reuse
- Different types of maintenance
- Causes f ntenance and char
- Technic es of evolution
- Dif re evolution

POSSIBLE QUESTIONS

- Give a definition of **refactoring** in your own words and illustrate it with a concrete example of a refactoring.
- Explain **why** you should refactor.
- Explain **when** (= at what moment) refactoring should (or should not) be performed.
- Like refactoring, **performance optimisation** does not usually change the behaviour of code (other than its speed); it only alters the internal structure. So how does it differ from refactoring?
- Explain and illustrate one of the following refactorings in detail:
  - Extract Method, Move Method, Extract Class, Replace Type Code with Subclass, Replace Subclass with Fields, Pull Up Method, Introduce Parameter Object
- Give a concrete example of how a refactoring could accidentally **reduce quality**.
- Give a concrete example of how to independently applied refactorings could accidentally introduce a subtle **merge conflict**.