SOFTWARE ENGINEERING

CO3001

CHAPTER 8 – SOFTWARE IMPLEMENTATION

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WEEK 8

Adapted from https://iansommerville.com/software-engineering-book/slides/

TOPICS COVERED

- ✓ Implementation meaning
- ✓ Coding style & standards
- ✓ Code with correctness justification
- ✓ Integration meaning
- ✓ Integration process

IMPLEMENTATION

smallest part that will be separately maintained

✓ Implementation = Unit Implementation + Integration

put them all together

GOLDEN RULE (!?)

- ✓ Requirements to satisfy Customers
- ✓ Design again requirements only
- ✓ Implement again design only
- ✓ Test again design and requirements

IMPLEMENT CODE

One way to ...

- ✓ 1. Plan the structure and residual design for your code
- ✓ 2. Self-inspect your design and/or structure
- ✓ 3. Type your code
- ✓ 4. Self-inspect your code
- ✓ 5. Compile your code
- ✓ 6. Test your code

GENERAL PRINCIPLES IN PROGRAMMING PRACTICE

- ✓ 1. Try to re-use first
- ✓ 2. Enforce intentions
  - If your code is intended to be used in particular ways only, write it so that the code cannot be used in any other way.
  - If a member is not intended to be used by other functions, enforce this by making it private or protected etc.
  - Use qualifiers such as final and abstract etc. to enforce intentions

"THINK GLOBALLY, PROGRAM LOCALLY"

- ✓ Make all members
  - as local as possible
  - as invisible as possible
    - attributes private:
      - access them through more public accessor functions if required.
      - (Making attributes protected gives objects of subclasses access to members of their base classes -- not usually what you want)

EXCEPTIONS HANDLING

"If you must choice between throwing an exception and continuing the computation, continue if you can" (Cay Horstmann)

- ✓ Catch only those exceptions that you know how to handle
- ✓ Be reasonable about exceptions callers must handle
- ✓ Don't substitute the use of exceptions for issue that should be the subject of testing

NAMING CONVENTIONS

- ✓ Use concatenated words
  - e.g., cylinderLength
- ✓ Begin class names with capitals
- ✓ Variable names begin lower case
- ✓ Constants with capitals
  - as in MAX_N or use static final
- ✓ Data members of classes with an underscore
  - as in _timeOfDay
- ✓ Use get…, set…., and is… for accessor methods
- ✓ Additional getters and setters of collections
- ✓ And/or distinguish between instance variables, local variables and parameters

DOCUMENTING METHODS

- ✓ what the method does
- ✓ why it does so
- ✓ what parameters it must be passed (use @param tag)
- ✓ exceptions it throws (use @exception tag)
- ✓ reason for choice of visibility
- ✓ known bugs
- ✓ test description, describing whether the method has been tested, and the location of its test script
- ✓ history of changes if you are not using a sub-version system
- ✓ example of how the method works
- ✓ pre- and post-conditions
- ✓ special documentation on threaded and synchronized methods

```
/* Class Name            : EncounterCast
 * Version information   : Version 0.1
 * Date                  : 6/19/1999
 * Copyright Notice      : see below
 * Edit history:
 *   11 Feb
 *    8 Feb
 *   08 Jan
 */

/*
   Copyrig

   This pro
   "Softwa
   by Eric .
```

```
/** Facade class/object for the EncounterCharacters package. Used to
 * reference all characters of the Encounter game.
 * <p> Design: SDD 3.1 Module decomposition
 * <br> SDD 5.1.2 Interface to the EncounterCharacters package
 *
 * <p>Design issues:<ul>
 * <li> SDD 5.1.2.4 method engagePlayerWithForeignCharacter was
 *   not implemented, since engagements are handled more directly
 *   from the Engaging state object.
 * </u
 *
 * @a
 * @v
 */
public
{
   /** Name for human player */
   private static final String MAIN_PLAYER_NAME = "Elena";
```

```
/** Gets encounterCast, the one and only instance of EncounterCast.
  * <p> Requirement: SDD 5.1.2
  *
  * @return       The EncounterCast singleton.
  */
  public static EncounterCast getEncounterCast()
     { return encounterCastS; }
```

DOCUMENTING ATTRIBUTES

- ✓ Description -- what it's used for
- ✓ All applicable invariants
  - quantitative facts about the attribute,
    - such as "1 < _age < 130"
    - or " 36 < _length * _width < 193".

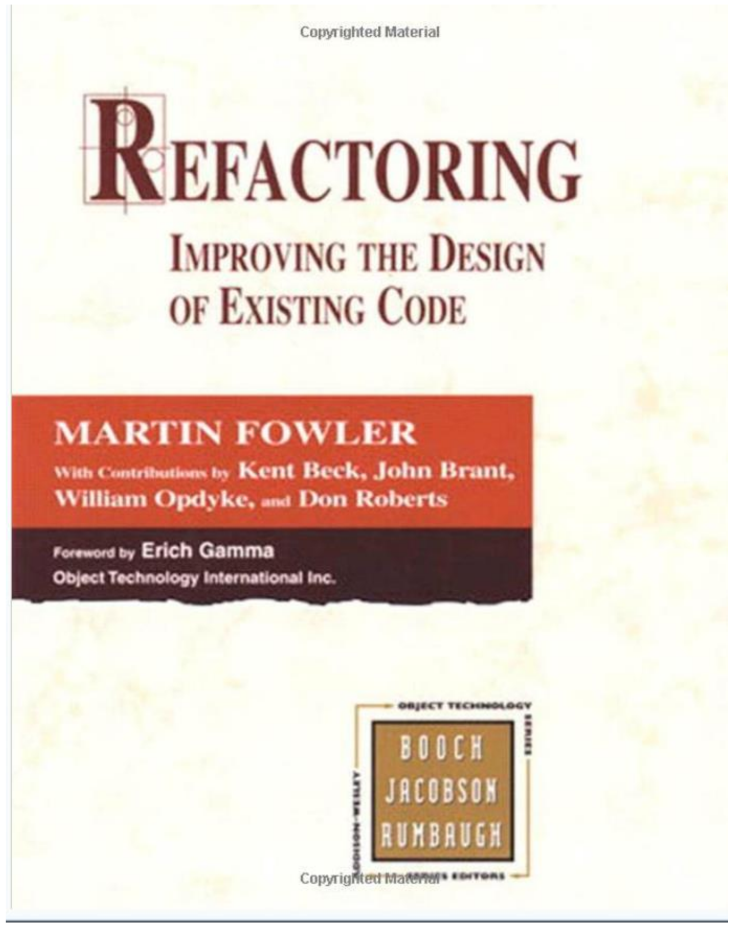
CONSTANTS

- ✓ Before designating a final variable, be sure that it is, indeed, final. You’re going to want to change "final" quantities in most cases. Consider using method instead.
- ✓ Ex:
  - instead of …
  - protected static final MAX_CHARS_IN_NAME;
  - consider using …
  - protected final static int getMaxCharsInName()
  - { return 20;
  - }

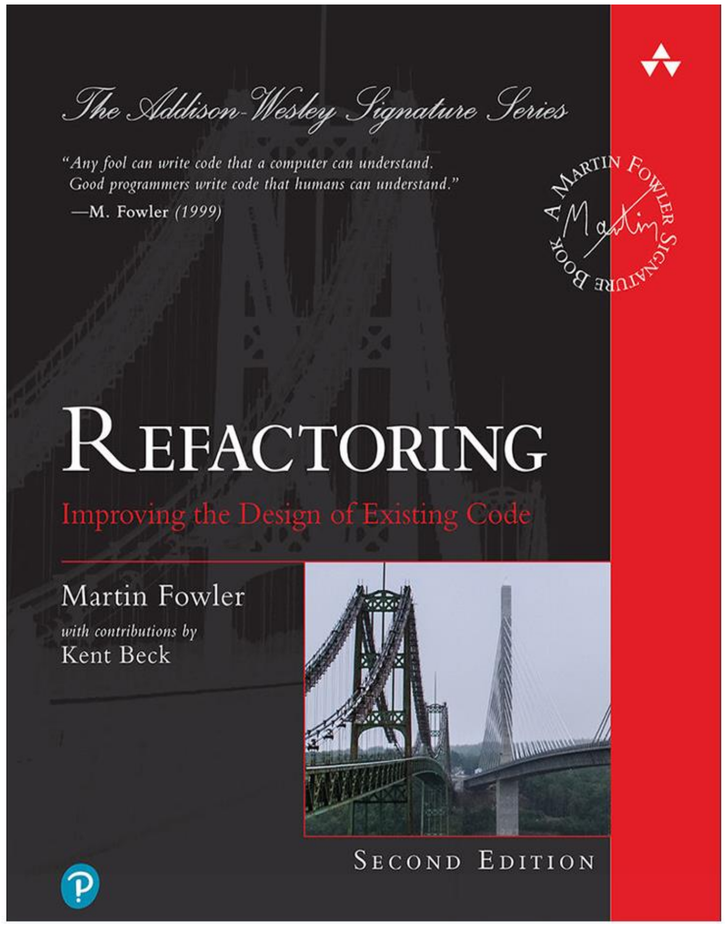
INITIALIZING ATTRIBUTES

- ✓ Attributes should be always be initialized, think of
  - private float _balance = 0;
- ✓ Attribute may be an object of another class, as in
  - private Customer _customer;
- ✓ Traditionally done using the constructor, as in
  - private Customer _customer = new Customer("Edward", "Jones");
- ✓ Problem is maintainability. When new attributes added to Customer, all have to be updated. Also accessing persistent storage unnecessarily.

RELEVANT BOOKS



Old edition, available online at NTNU lib.



New edition

BAD SMELLS IN CODE (CODE SMELLS)

- ✓ Code smells are any violation of fundamental design principles that decrease the overall quality of the code.
- ✓ Not bugs or errors
- ✓ Can certainly add to the chance of bugs and failures down the line.

CODE SMELLS CATEGORIES

- ✓ Duplicated Code
- ✓ Long Method
- ✓ Large Class
- ✓ Long Parameter List

- ✓ Divergent Change
- ✓ Shotgun Surgery

- ✓ Feature Envy
- ✓ Data Clumps
- ✓ Primitive Obsession

- Switch Statements
- Lazy Element
- Speculative Generality
- Temporary Field

- Message Chains
- Middle Man

- Data Class
- Refused Bequest

COD REFACTORING GOALS AND PROPERTIES

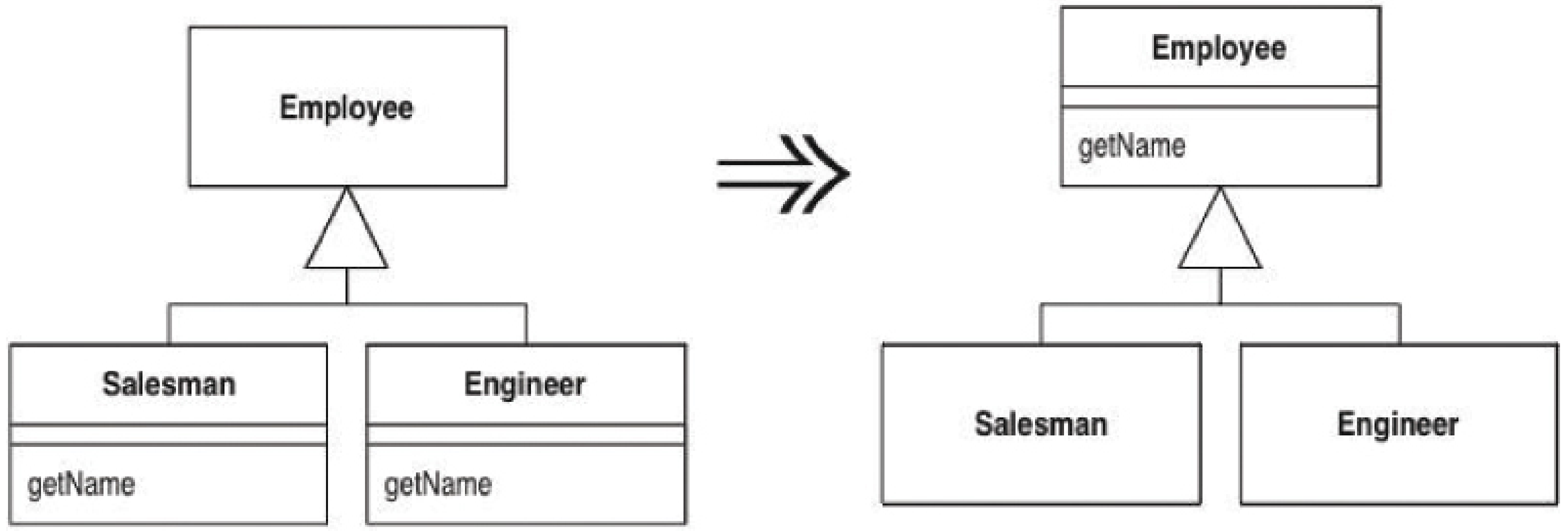
- ✓ Change the internal structure without changing external behavior
- ✓ Eliminate code smells for
  - Readability
  - Consistency
  - Maintainability
- ✓ Properties
  - Preserve correctness
  - One step at a time
  - Frequent testing

CODE REFACTORING STEPS

- ✓ Designing solid tests for the section to be refactored
- ✓ Reviewing the code to identify bad smells of code
- ✓ Introducing refactoring and running tests (One step at a time)

REMOVE DUPLICATED CODE – PULL UP METHOD (DON'T REPEAT YOURSELF (DRY))

- ✓ You have methods with identical results on subclasses.



REMOVE DUPLICATED CODE - SUBSTITUTE ALGORITHM

✓ You want to replace an algorithm with one that is clearer.

```
String foundPerson(String[] people){

  for (int i = 0; i < people.length; i++) {
      if (people[i].equals ("Don"))
      { return "Don"; }

       if (people[i].equals ("John"))
       { return "John"; }

       if (people[i].equals ("Kent"))
       { return "Kent";  }
    }
    return "";
}
```

```
String foundPerson(String[] people){
     List candidates = Arrays.asList(new
String[] {"Don", "John", "Kent"});

  for (int i=0; i<people.length; i++)
       if (candidates.contains(people[i]))
                return people[i];

    return "";

}
```

REDUCE SIZE – SHORTEN METHOD/CLASS

- ✓ **Long Method**
  - E.g., Extract method
- ✓ **Large Class**
  - E.g., Extract class, subclass, interface

EXTRACT METHOD EXAMPLE

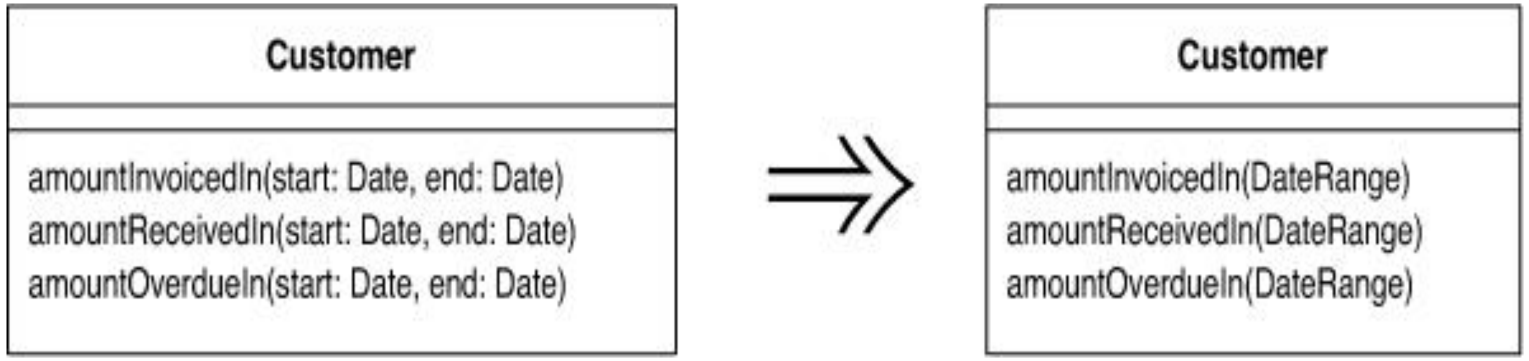
If you have to spend effort looking at a fragment of code and figure out what it is doing, then you should extract it into a function/method and name it after "*what*."

```
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);
}
```

REDUCE SIZE – SHORTEN PARAMETER LIST

- ✓ **Long Parameter List**
  - E.g., Introduce Parameter Object


Customer
amountInvoicedIn(start: Date, end: Date)
amountReceivedIn(start: Date, end: Date)
amountOverdueIn(start: Date, end: Date)
Customer
amountInvoicedIn(DateRange)
amountReceivedIn(DateRange)
amountOverdueIn(DateRange)

DIVERGENT CHANGE

✓ **Code smell**

- One module is often changed in different ways for different reasons.
- Classes have more than distinct responsibilities that it has more than one reason to change
- Violation of single responsibility design principle

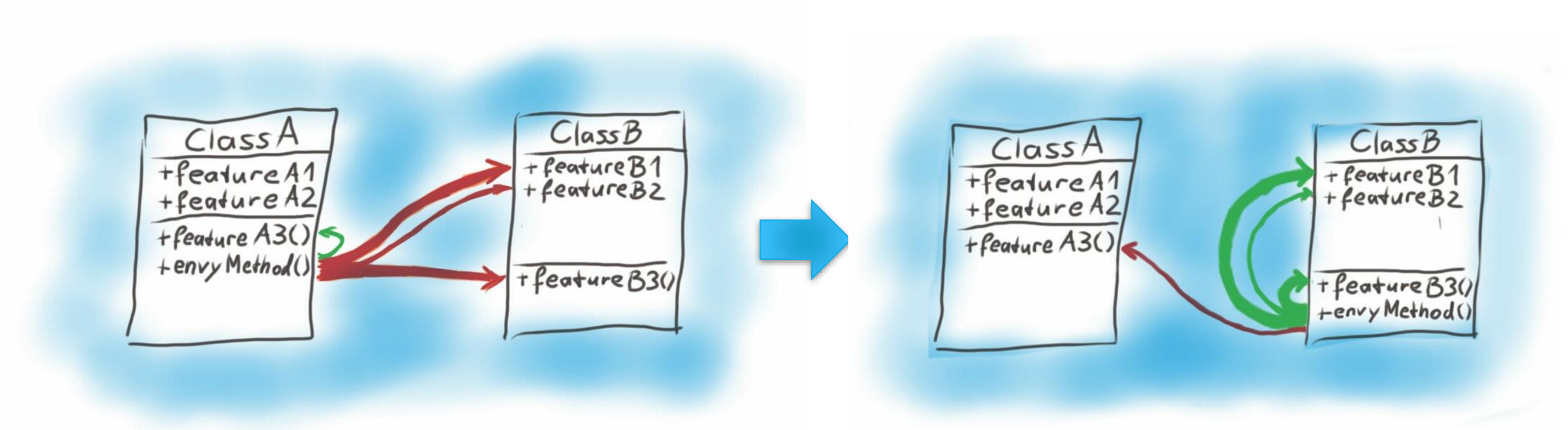
✓ **Refactoring**

- You identify everything that changes for a particular cause and put them all together

INCREASE COHESION

✓ **Feature envy**

- A function in one module spends more time communicating with functions or data inside another module than it does within its own module.
- Move function to give it a dream home



https://waog.wordpress.com/2014/08/25/code-smell-feature-envy/

INCREASE COHESION (CONT')

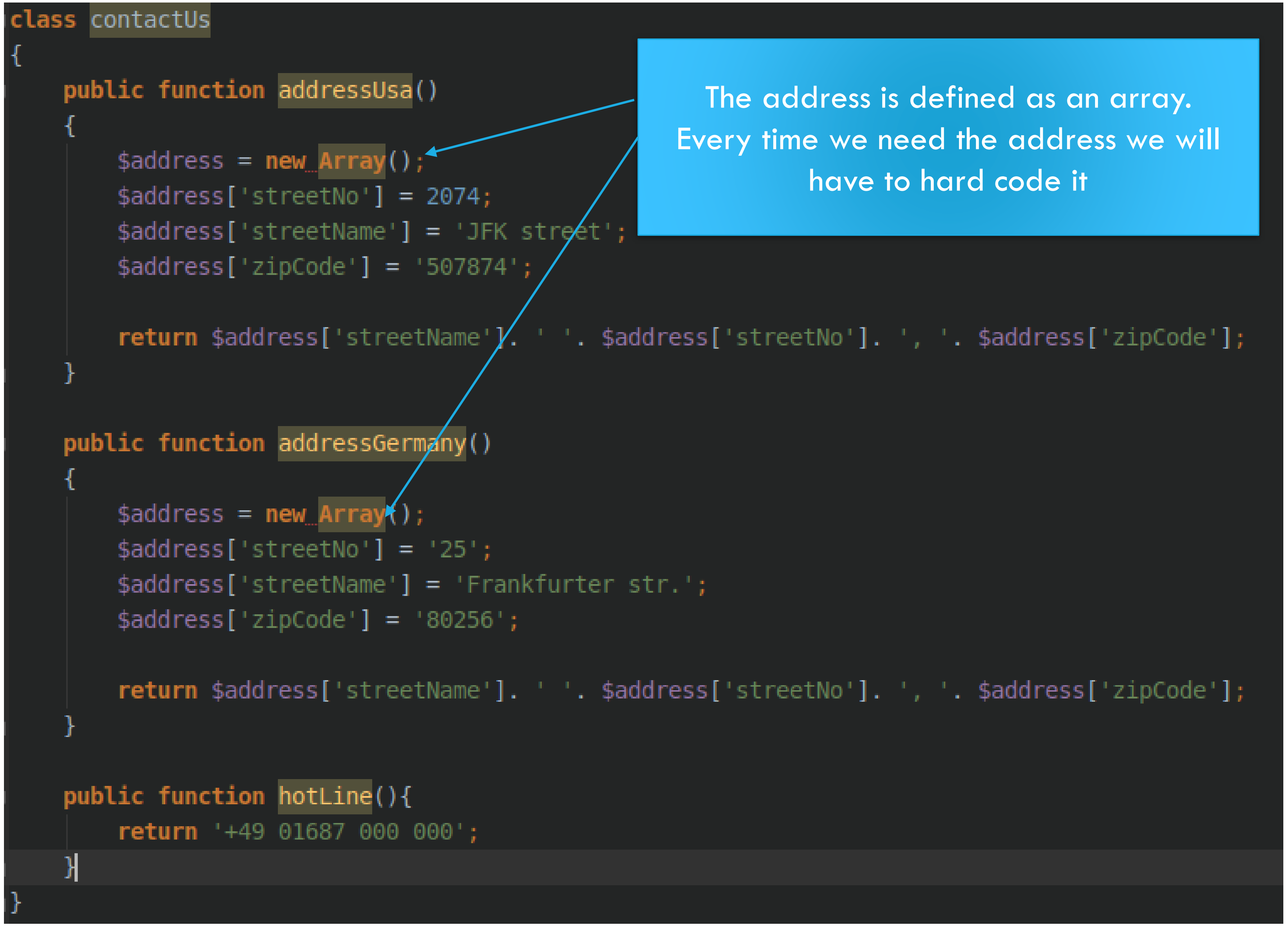
- **Data clumps**
  - Bunches of data often hang around together
  - Consolidate the data together, e.g., Introduce Parameter Object or Preserve Whole Object

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

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

PRIMITIVE OBSESSION

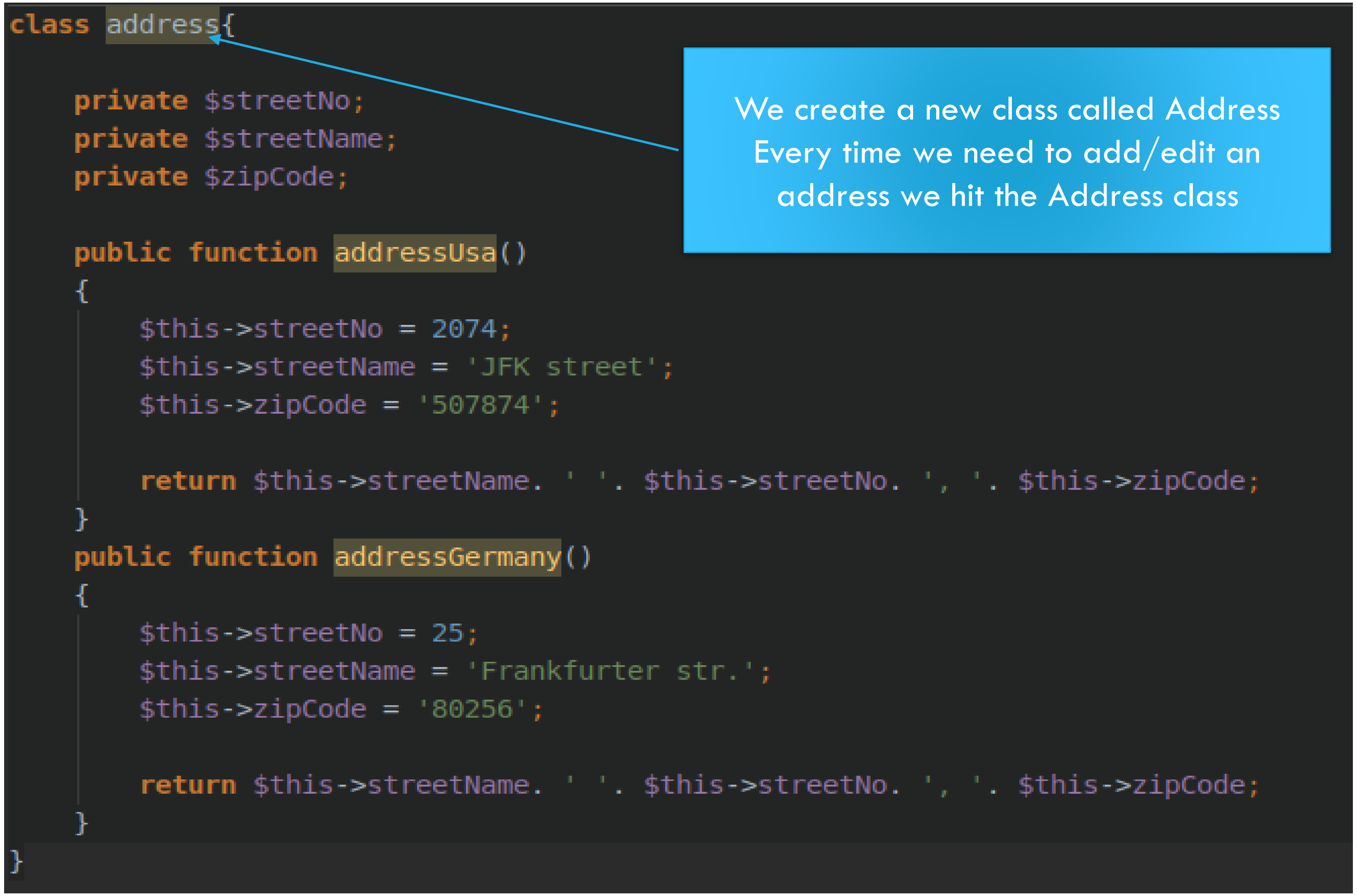
- ✓ Primitive fields are basic built-in building blocks of a language, e.g., int, string, or constants
- ✓ Primitive Obsession is when the code relies too much on primitives and when uses primitive types to represent an object in a domain



```
class contactUs
{
    public function addressUsa()
    {
        $address = new Array();
        $address['streetNo'] = 2074;
        $address['streetName'] = 'JFK street';
        $address['zipCode'] = '507874';

        return $address['streetName']. ' '. $address['streetNo']. ', '. $address['zipCode'];
    }

    public function addressGermany()
    {
        $address = new Array();
        $address['streetNo'] = '25';
        $address['streetName'] = 'Frankfurter str.';
        $address['zipCode'] = '80256';

        return $address['streetName']. ' '. $address['streetNo']. ', '. $address['zipCode'];
    }

    public function hotLine(){
        return '+49 01687 000 000';
    }
}
```

The address is defined as an array. Every time we need the address we will have to hard code it

https://codeburst.io/write-clean-code-and-get-rid-of-code-smells-aea271f30318



```
class address{

    private $streetNo;
    private $streetName;
    private $zipCode;

    public function addressUsa()
    {
        $this->streetNo = 2074;
        $this->streetName = 'JFK street';
        $this->zipCode = '507874';

        return $this->streetName. ' '. $this->streetNo. ', '. $this->zipCode;
    }
    public function addressGermany()
    {
        $this->streetNo = 25;
        $this->streetName = 'Frankfurter str.';
        $this->zipCode = '80256';

        return $this->streetName. ' '. $this->streetNo. ', '. $this->zipCode;
    }
}
```

We create a new class called Address
Every time we need to add/edit an address we hit the Address class

https://codeburst.io/write-clean-code-and-get-rid-of-code-smells-aea271f30318

INSPECTION AND CODE REVIEW

WHAT IS INSPECTION?

- ✓ Visual examination of software product

- ✓ Identify software anomalies
  - Errors
  - Code smells
  - Deviations from specifications
  - Deviations from standards
    - E.g., Java code conventions

      www.oracle.com/technetwork/java/codeconventions-150003.pdf

WHY DO WE NEED INSPECTION?

- ✓ Many software artifacts cannot be verified by running tests, e.g.,
  - Requirement specification
  - Design
  - Pseudocode
  - User manual

- ✓ Inspection reduces defect rates
- ✓ Inspection complements testing
- ✓ Inspection identifies code smells
- ✓ Inspection provides additional benefits

INSPECTION FINDS TYPES OF DEFECTS DIFFERENT FROM TESTING

Number of different types of defects detected by testing vs. inspection [1]

Some defect types	Testing	Inspection
Uninitialized variables	1	4
Illegal behavior, e.g., division by zero	49	20
Incorrectly formulated branch conditions	2	13
Missing branches, including both conditionals and their embedded statements	4	10

INSPECTION REDUCES DEFECT RATES

Removal Step	Lowest Rate	Modal Rate	Highest Rate
Informal design reviews	25%	35%	40%
Formal design inspections	45%	55%	65%
Informal code reviews	20%	25%	35%
Formal code inspections	45%	60%	70%
Modeling or prototyping	35%	65%	80%
Personal desk-checking of code	20%	40%	60%
Unit test	15%	30%	50%
New function (component) test	20%	30%	35%
Integration test	25%	35%	40%
Regression test	15%	25%	30%
System test	25%	40%	55%
Low-volume beta test (<10 sites)	25%	35%	40%
High-volume beta test (>1,000 sites)	60%	75%	85%

Source: Adapted from *Programming Productivity* (Jones 1986a), "Software Defect-Removal Efficiency" (Jones 1996), and "What We Have Learned About Fighting Defects" (Shull et al. 2002).

TESTING VS. INSPECTION

	Testing	Inspection
Pros	• Can, at least partly, be automated • Can consistently repeat several actions • Fast and high volume	• Can be used on all types of documents, not just code • Can see the complete picture, not only a spot check • Can uses all information in the team • Can be innovative and inductive
Cons	• Is only a spot check • Can only be used for code • May need several stubs and drivers	• Is difficult to use on complex, dynamic situations • Unreliable (people can get tired) • Slow and low volume

CODE REVIEW AT GOOGLE [3]

- ✓ "All code that gets submitted needs to be reviewed by at least one other person, and either the code writer or the reviewer needs to have readability in that language. Most people use Mondrian to do code reviews, and obviously, we spend a good chunk of our time reviewing code."

--Amanda Camp, Software Engineer, Google

EXAMPLE OF A CODE REVIEW CHECKLIST

INSPECT CODE 1 OF 5: CLASSES OVERALL

One way to ...

- ✓ C1. Is its (the class') name appropriate?
- ✓ C2. Could it be abstract (to be used only as a base)?
- ✓ C3. Does its header describe its purpose?
- ✓ C4. Does its header reference the requirements and/or design element to which it corresponds?
- ✓ C5. Does it state the package to which it belongs?
- ✓ C6. Is it as private as it can be?
- ✓ C7. Should it be final (Java)
- ✓ C8. Have the documentation standards been applied?

INSPECT CODE 2 OF 5 : ATTRIBUTES

One way to ...

- ✓ A1. Is it (the attribute) necessary?
- ✓ A2. Could it be static?
- ✓ A3. Should it be final?
- ✓ A4. Are the naming conventions properly applied?
- ✓ A5. Is it as private as possible?
- ✓ A6. Are the attributes as independent as possible?
- ✓ A7. Is there a comprehensive initialization strategy?

INSPECT CODE 3 OF 5 : CONSTRUCTORS

One way to ...

- ✓ CO1. Is it (the constructor) necessary?
- ✓ CO2. Does it leverage existing constructors?
- ✓ CO3. Does it initialize of all the attributes?
- ✓ CO4. Is it as private as possible?
- ✓ CO5. Does it execute the inherited constructor(s) where necessary?

INSPECT CODE 4 OF 5: METHOD HEADERS

One way to ...

- ✓ MH1. Is the method appropriately named?
- ✓ MH2. Is it as private as possible?
- ✓ MH3. Could it be static?
- ✓ MH4. Should it be final?
- ✓ MH5. Does the header describe method’s purpose?
- ✓ MH6. Does the method header reference the requirements and/or design section that it satisfies?
- ✓ MH7. Does it state all necessary invariants?
- ✓ MH8. Does it state all pre-conditions?
- ✓ MH9. Does it state all post-conditions?
- ✓ MH10.Does it apply documentation standards?
- ✓ MH11.Are the parameter types restricted?

INSPECT CODE 5 OF 5: METHOD BODIES

One way to ...

- ✓ MB1. Is the algorithm consistent with the detailed design pseudocode and/or flowchart?
- ✓ MB2. Does the code assume no more than the stated preconditions?
- ✓ MB3. Does the code produce every one of the postconditions?
- ✓ MB4. Does the code respect the required invariant?
- ✓ MB5. Does every loop terminate?
- ✓ MB6. Are required notational standards observed?
- ✓ MB7. Has every line been thoroughly checked?
- ✓ MB8. Are all braces balanced?
- ✓ MB9. Are illegal parameters considered?
- ✓ MB10. Does the code return the correct type?
- ✓ MB11. Is the code thoroughly commented?