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Chapter 4: Software Construction for Understandability

4.1 Construction for Understandability

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Outline

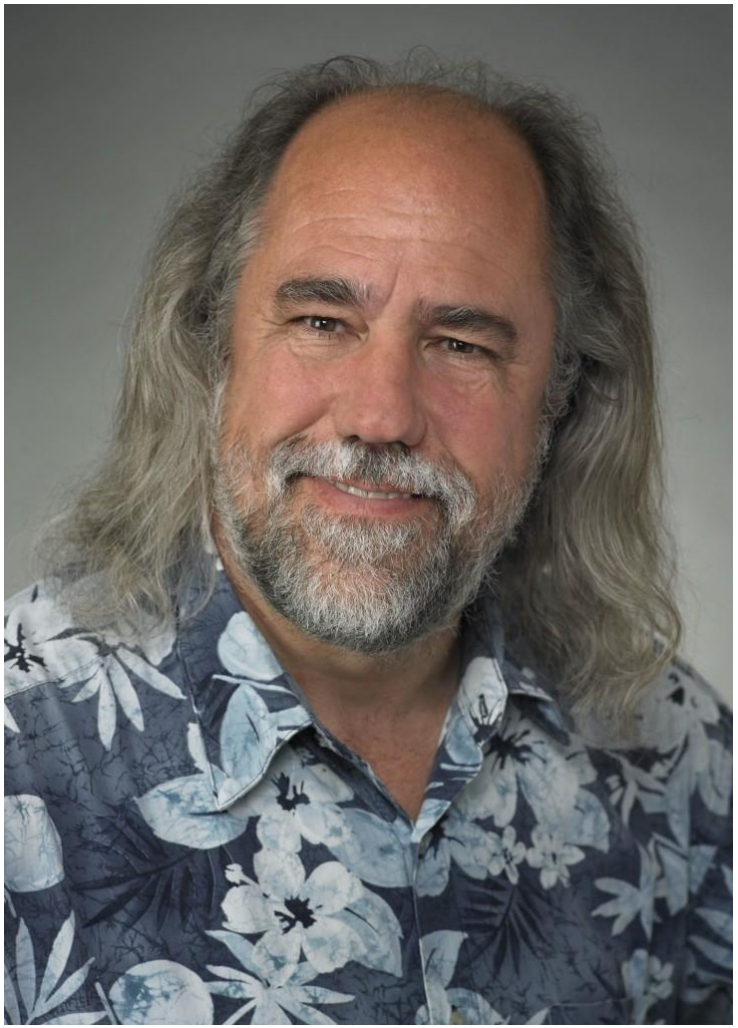
- **Metrics for Understandability**
- **Documenting in source code**
  - Specifications, Rep Invariants, Abstract Function, Safety from Rep Exposure, Testing Strategy, Thread-Safe, …
  - Comments
- **Pseudo-code before programming**
- **Coding conventions**
  - Naming
  - Formatting: Length, White lines, Spacing, Indentation
  - File organization
- **Summary**

What Stroustrup (inventor of C++) said

- **"I like my code to be elegant and efficient.**
  - The `logic` should be `straightforward` to make it hard for bugs to hide (This chapter)
  - The dependencies minimal to `ease` `maintenance` (Chapter 6)
  - `Error` `handling` complete according to an articulated strategy (Chapter 7)
  - `Performance` close to `optimal` so as not to tempt people to make the code messy with unprincipled optimizations (Chapter 8)
- **Clean code does one thing well."**

What Grady Booch said about code

- **Clean code is `simple` and `direct`.**
- **Clean code reads like `well-written` prose.**
- **Clean code never obscures the designer's intent but rather is full of crisp `abstractions` and `straightforward` lines of control.**



1 Metrics for Understandability

What is Understandability?

- **Understandability – the readability of the code**
- **For example:**
  - Are naming conventions followed?
  - Is it self-descriptive and/or well commented?
  - Are things (e.g., classes) doing only one thing or many things at once?
  - Are the methods really long or short and can their intent be understood in a single pass of reading or does it take a good deal of screen staring and whiteboard analysis?
- Why do we need understandable code: source code with low understandability are error-prone and hard to maintain!

An alias: Readability

- **Readability refers to the ease with which a human reader can comprehend the purpose, control flow, and operation of source code.**
  - It affects the aspects of quality above, including portability, usability and most importantly maintainability.
- **Readability is important because programmers spend the majority of their time reading, trying to understand and modifying existing source code, rather than writing new source code.**
  - Unreadable code often leads to bugs, inefficiencies, and duplicated code.

Code Readability Example

Example #a

```
z = ((3*x^2) + (4*x) – 5) – ((2*y^2) – (7*y) + 11) / ((3*x^2) + (4*x) – 5)
```

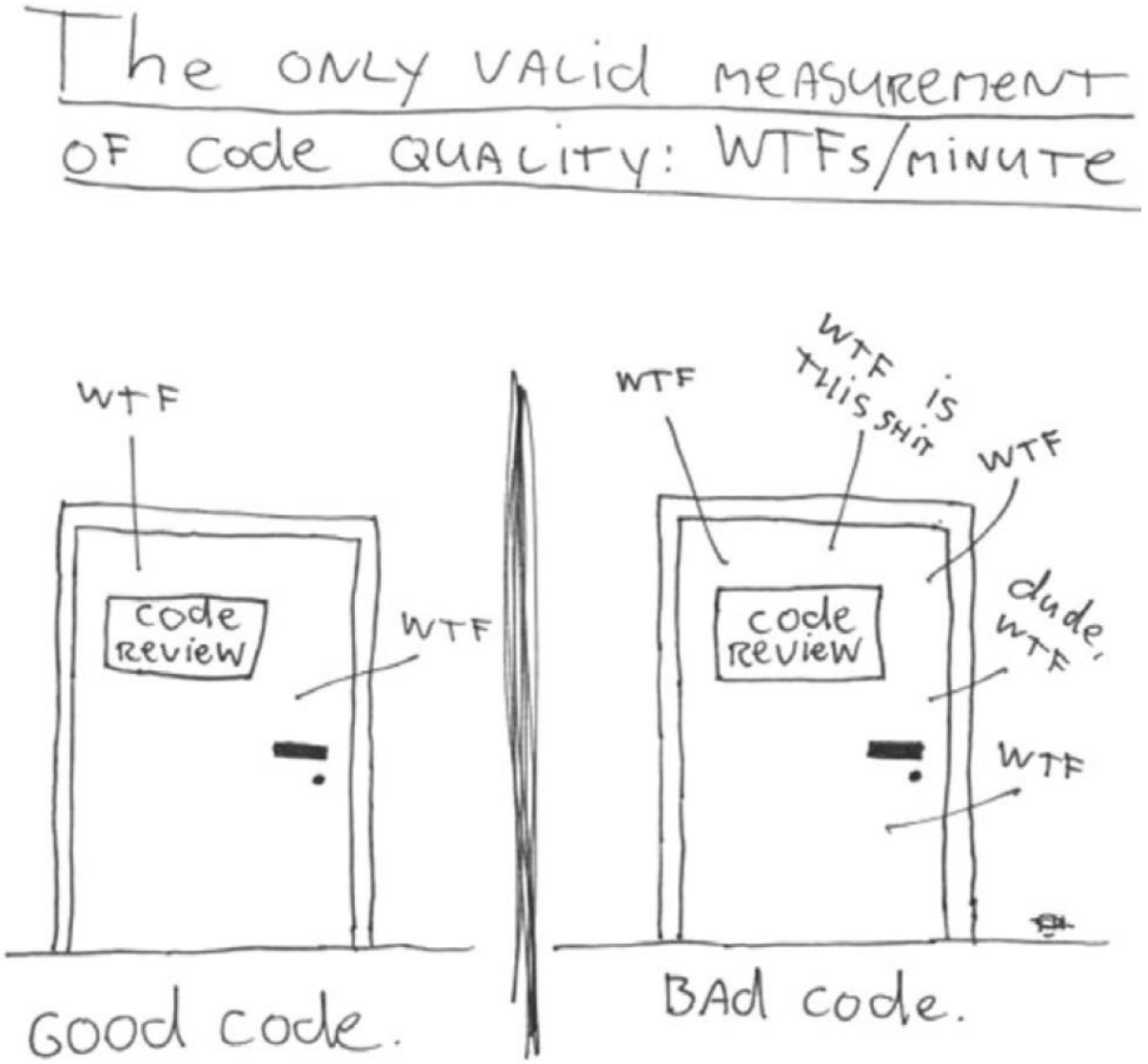
vs.

Example #b

```
a = ((3*x^2) + (4*x) – 5)
b = ((2*y^2) – (7*y) + 11)
z = (a – b) / a
```

"Although both examples are comprehensible, example b is comprehensible with greater ease (i.e., more readable) than example a."

Code quality measurement: WTFs/min ☺



Length of names

- The longer the names of classes, variables, methods, etc., the more descriptive they probably are**, to accurately reflect the purpose of the entity.**
  - Names should be descriptive. The longer the name, the more descriptive it is likely to be.
  - Names should also be succinct. The longer the name, the less efficient it is likely to be.
  - `a` is not a good variable name, `Age` is better, but `EmployeeAge` seems much more descriptive.
  - Generally, names consisting of 1 or 2 letters are not good. What is enough depends on your language and the application you're making.
- **Metrics: Average length of *all* names**

➔ Good naming conventions

Name Uniqueness Ratio (UNIQ)

- **Name Uniqueness Ratio (UNIQ)**
  - When two entities have the same name, it's possible that they get mixed. UNIQ measures the uniqueness of all names.
  - It's acceptable to use the same name at many locations. However, the name should refer to the same logical thing.
- For example, variable `userName` should always contain the same type of username in the same data type (`string`). If `userName` can mean one thing in one procedure and another thing somewhere else, the likelihood of confusion increases.

Complexity and LoC

- **Complexity**
  - Complex code isn't likely to be understandable. (details are to be discussed in Chapter 5 Maintainability-Oriented Construction)
- **Lines of code (LoC)**
  - The longer a method gets, the harder it probably is to understand.

Comment density (MCOMM%)

- **The more comments in your code, the easier it is to read - and understand.**
  - Whitespace lines are also important for legibility.
- **Note: Not all comments contain a description of what's happening.** Some comments are simply separators, such '----------. So, it's more sensible to pay attention to meaningful comments and not just any comments.
  - A profusion of comments provides an easy-to-follow natural-language narrative.
- **Measurement:** how many meaningful comments there are per each logical line of code.

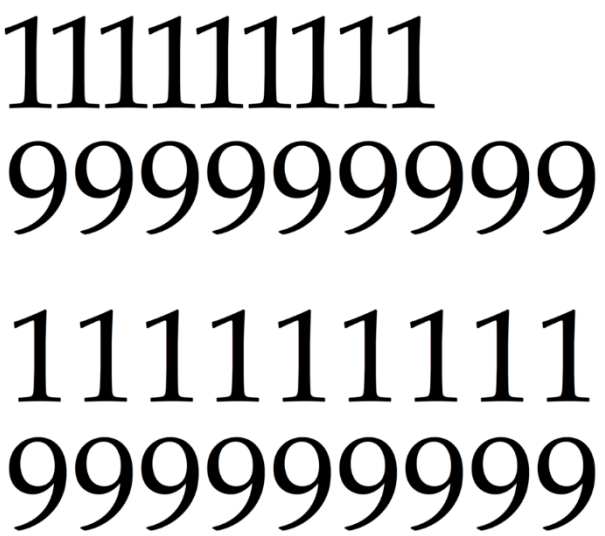
```
MCOMM% = MCOMM / LOC
```

How to do in writing understable code?

- **Many many considerations:**
  - Naming conventions (consisting naming scheme)
  - Limit line length and file length
  - Enough necessary comments
  - Code format such as Consistent Indentation, White space before and after names and operators, Code alignment, Separating blocks of code with space lines between them, etc
  - Avoid deep nesting (simple structural complexity)
  - File and folder organization
  - …

Question: why monospaced font for code?

- **If we display and print our programs in, say, Times Roman font, we can squeeze more characters onto a line.**
- **The disadvantage of a variable width font is that the programmer no longer controls alignment of corresponding elements of a series of lines. That can make errors harder to spot. Even indentation may be less clear.**
- **Sticking with a monospaced font for displaying and printing your source code is highly recommended.**
- **List of monospaced typefaces**
  - https://en.wikipedia.org/wiki/List_of_monospaced_typefaces



Remember

- **Code understandability/readability is usually more important than efficiency and performance.**
- **Always start with well-written code, and tune at the end**

2 Documenting in source code

Documenting in code by comments

- **Code should be self-descriptive (self-documented).**
- **Thus, it is not necessary to use formal external documents (e.g., .doc) to help understand the code.**
- **In good, self-documented code, you don't have to explain every single line because every identifier (variable, method, class) has a clear *semantic* name.**
- **If not, try documenting in your code with comments.**
- **Comments should describe the "why"**

```
float a, b, c; a=9.81; b=5; c= .5*a*(b^2);
/* compute displacement with Newton's equation x = v₀t + ½at² */
float gravitationalForce = 9.81;
float timeInSeconds = 5;
float displacement = (1 / 2) * gravitationalForce * (timeInSeconds ^ 2)
```

Four types of comments in code

- **Good programmers use commentary in four places:**
  - Title comments introduce a class definition, an important function, a package of macro definitions, some other nontrivial module, or an entire source-code file. For proprietary programs, the title comment often includes a copyright notice.
  - Introductory comments describe the purpose and usage of a class, function, or other module.
  - Block comments describe the purpose and strategy of a group of related statements.
  - Single-Line / Trailing / End-Of-Line comments explain an individual statement or even a part of a statement.

Title and Introductory comments

- **Doc comments describe the whole file, Java classes, interfaces, constructors, methods, and fields.**
- **Each doc comment is set inside the comment delimiters /**...*/, with one comment per class, interface, or member.**
- **This comment should appear just before the declaration:**

```
/**
 * The Example class provides ...
 */
public class Example { ...
```

- **They are also called Documentation Comments, because JavaDoc can be automatically generated from these comments.**

Title and Introductory comments

```
/**
 * Returns the element at the specified position of this list.
 *
 * <p>This method is <i>not</i> guaranteed to run in constant time.
 * In some implementations, it may run in time proportional to the
 * element position.
 *
 * @param index position of element to return; must be non-negative and
 *              less than the size of this list.
 * @return the element at the specified position of this list
 * @throws IndexOutOfBoundsException if the index is out of range
 *         ({@code index < 0 || index >= this.size()})
 */
E get(int index);
```

Block Comments

- **Block comments are used to provide descriptions of files, methods, data structures and algorithms.**
  - Block comments may be used at the beginning of each file and before each method.
  - They can also be used in other places, such as within methods. Block comments inside a function or method should be indented to the same level as the code they describe.

```
/*
 * Here is a block comment.
 */

/*
 *    one
 *        two
 *            three
 */
```

Single-Line / Trailing / End-Of-Line comments

- **Single-line comment:** very short comments can appear on the same line as the code they describe, but should be shifted far enough to separate them from the statements.
- **Trailing comments:** Short comments can appear on a single line indented to the level of the code that follows. A single-line comment should be preceded by a blank line.
- **End-Of-Line Comments** the // delimiter can comment out a complete line or only a partial line.

```
if (condition) {

    /* Handle the condition. */
    ...
}

if (a == 2) {
    return TRUE;            /* special case */
} else {
    return isPrime(a);      /* works only for odd a */

if (foo > 1) {
    ...                     // Explain why here
}
else {
    return false;           // Explain why here.
}
```

Comment is an integral part of the code

- **Program documentation is an integral part of code, not separately.**
  - Title and introductory comments are best written *before* the code. That helps you to clarify your thoughts and usually saves time.
  - Line-by-line and block comments can be written before, during, or after the code. In complicated logic, block comments are often useful to explain the state of data items at that point.
- **Comments should avoid stating what's obvious from the code.**
  - Describe *what* is being done, not *how*.
  - Comments should not provide information that can be easily inferred from the code.

```
Not: weight*=2.2;     //Multiply by conversion factor
But: weight*=2.2;     //Convert to pounds
Not: while(count>0)   //Loop until count exhausted
But: while(count>0)   //Examine all work orders
```

Commenting conventions

- **At the beginning of each file there should be a comment explaining the purpose of this file in the project.**
- **Each class declaration should have a comment explaining what the class is for.**
- **Each method or function should have comments explaining what it does and how it works, as well as what is the purpose of its parameters.**
- **All variables declarations, most importantly class data members, should be appended with a comment describing its role, unless its name makes it obvious.**
- **In cases where an elaborated algorithm is used in a long function, inline comments should be used to highlight and explain all the important steps of the algorithm.**

Special comments for design

- **For the code of an ADT, all the following are mandatory comments:**
  - Specifications: pre-condition and post-condition (section 3.2)
  - Rep Invariants (RI) (section 3.3)
  - Abstract Function (AF) (section 3.3)
  - Safety from Rep Exposure (section 3.3)
  - Testing Strategy (to be discussed in Chapter 7)
  - How to ensure thread-safe (to be discussed in Chapter 10)
  - …

Documenting Specifications by comments

- **Specification: pre-condition and post-condition**

```
/**
 * Find a value in an array.
 * @param arr array to search, requires that val occurs exactly once
 *            in arr
 * @param val value to search for
 * @return index i such that arr[i] = val
 */
static int find(int[] arr, int val)
```

```
/**
 * Returns the element at the specified position of this list.
 *
 * <p>This method is <i>not</i> guaranteed to run in constant time.
 * In some implementations, it may run in time proportional to the
 * element position.
 *
 * @param index position of element to return; must be non-negative and
 *              less than the size of this list.
 * @return the element at the specified position of this list
 * @throws IndexOutOfBoundsException if the index is out of range
 *         ({@code index < 0 || index >= this.size()})
 */
E get(int index);
```

postcondition

precondition

Rep Invariants (RI) and Abstract Function (AF)

```
// Immutable type representing a tweet.
public class Tweet {

    private final String author;
    private final String text;
    private final Date timestamp;

    // Rep invariant:
    //   author is a Twitter username (a nonempty string of letters, digits, underscore
s)
    //   text.length <= 140
    // Abstraction Function:
    //   represents a tweet posted by author, with content text, at time timestamp
    // Safety from rep exposure:
    //   All fields are private;
    //   author and text are Strings, so are guaranteed immutable;
    //   timestamp is a mutable Date, so Tweet() constructor and getTimestamp()
    //        make defensive copies to avoid sharing the rep's Date object with client
s.

    // Operations (specs and method bodies omitted to save space)
    public Tweet(String author, String text, Date timestamp) { ... }
    public String getAuthor() { ... }
    public String getText() { ... }
    public Date getTimestamp() { ... }
}
```

Documenting how to ensure thread-safe

```
/** SimpleBuffer is a threadsafe EditBuffer with a simple rep. */
public class SimpleBuffer implements EditBuffer {
    private String text;
    // Rep invariant:
    //   text != null
    // Abstraction function:
    //   represents the sequence text[0],...,text[text.length()-1]
    // Thread safety argument:
    //   all accesses to text happen within SimpleBuffer methods,
    //   which are all guarded by SimpleBuffer's lock
```

Documenting testing strategy

```
/**
 * Reverses the end of a string.
 *
 * For example:
 *   reverseEnd("Hello, world", 5)
 *   returns "Hellodlrow ,"
 *
 * With start == 0, reverses the entire text.
 * With start == text.length(), reverses nothing.
 *
 * @param text    non-null String that will have
 *                its end reversed
 * @param start   the index at which the
 *                remainder of the input is
 *                reversed, requires 0 <=
 *                start <= text.length()
 * @return input text with the substring from
 *               start to the end of the string
 *               reversed
 */
static String reverseEnd(String text, int start)
```

Document the strategy at the top of the test class:

```
/*
 * Testing strategy
 *
 * Partition the inputs as follows:
 * text.length(): 0, 1, > 1
 * start:         0, 1, 1 < start < text.length(),
 *                text.length() - 1, text.length()
 * text.length()-start: 0, 1, even > 1, odd > 1
 *
 * Include even- and odd-length reversals because
 * only odd has a middle element that doesn't move.
 *
 * Exhaustive Cartesian coverage of partitions.
 */
```

Each test method should have a comment above it saying how its test case was chosen, i.e. which parts of the partitions it covers:

```
// covers test.length() = 0,
//        start = 0 = text.length(),
//        text.length()-start = 0
@Test public void testEmpty() {
    assertEquals("", reverseEnd("", 0));
}
```

3 Pseudo-code before programming

What is Pseudocode?

- **One of the popular representation of Algorithm**
- **Widely choosen because:**
  - Easy to read and write
  - Allow the programmer to concentrate on the logic of the problem
  - Structured in natural language

Pseudocode Convention

- **Statements are written in simple English**
- **Each instruction is written on a separate line**
- **Keywords and indentation are used to signify particular control structures.**
- **Each set of instructions is written from top to bottom, with only one entry and one exit.**
- **Groups of statements may be formed into modules, and that group given a name.**

Six Basic Computer Operations

1. **Receive information from outside:** `Read, Get`
2. **Put out information to outside:** `Print, Write, Output, Display`, **etc**
3. **Perform arithmetic/computation:** `Compute, Calculate`
4. **Assign value to a variable or memory location:** `Set, Save, Store, ←`
5. **Compare and select alternate actions:** `If-Then-Else`
6. **Repeat a group of actions:** `For, While, Do/Until`

(1) Receive Info. from outside: Read/Get

- **Read → used when the algorithm is to receive the input from a record on a file**
- **Get → used when the algorithm is to receive input from the keyboard.**

```
Read student name
Get system date
Read number_1, number_2
Get tax_code
```

(2) Put out information to outside

- **Print → used when the output is to be sent to the printer**
- **Write → used when the output is to be written to a file**
- **Put, Output, Display → used when the output is to be written to the screen**
- **Prompt → required before an input instruction Get, cause the message to be sent to the screen which requires the user responds, usually by providing input.**

```
Print `Program Completed´
Write customer record to master file
Put out name, address and postcode
Output total_tax
Display ´End of data´


Prompt for student_mark
Get student_mark
```

(3) Perform arithmetic/computation

- **Verb used:**
  - Compute
  - Calculate
- **Symbols used:**
  - +, -, *, /, ()

```
Add number to total
Total = total + number


Divide total_marks by student_count
Sales_tax = cost_price * 0.10
Compute C = (F – 32) * 5/9
```

(4) Assign value to a variable or memory

- **Three cases :**
  - To give data an initial value in pseudocode, the verbs Initialise or Set are used
  - To assign a value as a result of some processing, the symbols ′=′ or ′←′ are written
  - To keep a variable for later use, the verbs Save or Store are used.

```
Initialize total_price to zero
Set student_count to 0
Total_price = cost_price + sales_tax
Total_price ← cost_price + sales_tax
Store customer_num in last_customer_num
```

(5) Compare and select alternate actions

```
IF student_attendance_status is part_time THEN
    add 1 to part_time_count
  ELSE
    Add 1 to full_time_count
  ENDIF
```

(6) Repeat a group of actions

```
WHILE student_total < 50
  Read student record
  Print student name, address to report
  Add 1 to student_total
ENDWHILE
```

Pseudocode Guidelines

- **High-level description:**
  - Begin with an English description of how the algorithm works.
  - Include a general overview of the approach and goals.
  - You may want to include examples and diagrams of the data structures that help make the operation of the algorithm more clear.
  - For recursive algorithms it is often useful to clearly describe the base and inductive cases that make the algorithm correct.
  - About one or two paragraphs of text is usually enough.

Writing pseudocode

- **Given two sorted lists, L1 and L2, write a function to compute L1 ∪ L2 (the union of the two lists). The resulting list should be sorted as well.**
- **Provide a recursive algorithm that given a binary tree determines the number of leaves in the tree.**

4 Coding conventions

Coding conventions

- **Coding conventions are a set of prescriptive rules that pertain to how code is to be written, such as:**
  - **Naming**: how to give names to various named entities in a program as to convey meaning embedded into the names.
  - **Layout and Indentation**: how particular syntactical elements are to be indented in order to maximize readability.
  - **Declarations**: what particular syntax to use to declare variables, data structures, classes, etc. in order to maximize code readability.
  - **File organization**: how code is distributed between files, and organized within each file.

Coding conventions

- **Who does it?**
  - Coding conventions are only applicable to the original programmers and peer reviewers, and eventually the maintainers of a software system.
  - Other workers that are using the code are also likely to be affected, such as testers involved in unit or integration testing.
- **Why do it?**
  - Coding conventions only improve internal qualities of the software and generally do not affect any externally visible quality.
  - Coding conventions aim at maximizing the productivity of the coding process by making code more readable and understandable.
  - Using coding conventions makes it easier to develop further code in a project and eventually aims at increasing the sustainability of the development by decreasing the cost of adding code to an existing code base.

Coding conventions

- **How to do it?**
  - Conventions may be formalized in a documented set of rules that an entire team or company follows, or may be as informal as the habitual coding practices of an individual or a group of coders.
  - Can be verified and enforced by a peer review mechanism.
  - Coding conventions are not enforced by compilers, though some IDEs may provide a "pretty printer" feature that will implement some aspects of coding conventions such as indentation.
  - Some code refactoring activities can be used to implement some code changes that are related to coding conventions, such as renaming or breaking larger functions into smaller ones.
  - Another related tool/activity is the use of an automated API documentation tool, which uses specially formatted code comments to provide automatically generated documentation for the code, which also improves software understandability.

Coding conventions

- **Code conventions are important to programmers for a number of reasons:**
  - 80% of the lifetime cost of a piece of software goes to maintenance.
  - Hardly any software is maintained for its whole life by the original author.
  - Code conventions improve the readability of the software, allowing engineers to understand new code more quickly and thoroughly.
  - If you ship your source code as a product, you need to make sure it is as well packaged and clean as any other product you create.

Various coding conventions

- **Indentation and Alignment**
- **Braces and Parentheses**
- **White Space and Blank Lines**
- **New Lines and Line Wrapping**
- **Control Statements**
- **Comments**
- **Naming**
- **File Organization**
- **…**

(1) Naming

Use Intention-Revealing Names

- **The name of a variable, function, or class, should tell you why it exists, what it does, and how it is used.**
- **If a name needs a comment, then the name does not reveal intent.**
  - `int d; // elapsed time in days`
  - `int elapsedTimeInDays;`
  - `int daysSinceCreation;`
  - `int fileAgeInDays;`

```
public List<int[]> getThem() {
  List<int[]> list1 = new ArrayList<int[]>();
  for (int[] x : theList)
    if (x[0] == 4)
      list1.add(x);
  return list1;
}
```

```
public List<Cell> getFlaggedCells() {
  List<Cell> flaggedCells = new ArrayList<Cell>();
  for (Cell cell : gameBoard)
     if (cell.isFlagged())
        flaggedCells.add(cell);
   return flaggedCells;
}
```

Use Intention-Revealing Names

- **Avoid disinformation:** avoid leaving false clues that obscure the meaning of code.
  - `1` and `l`, `0` and `o`
  - Use `accountList` only if it is implemented by a `List`; `accounts` seems better.
- **Make Meaningful Distinctions**
- **Use Pronounceable Names**
- **Use Searchable Names**

```
for (int j=0; j<34; j++) {
   s += (t[j]*4)/5;
}
```

```
int realDaysPerIdealDay = 4;
const int WORK_DAYS_PER_WEEK = 5;
int sum = 0;
for (int j=0; j < NUMBER_OF_TASKS; j++) {
  int realTaskDays = taskEstimate[j] * realDaysPerIdealDay;
  int realTaskWeeks = (realdays / WORK_DAYS_PER_WEEK);
  sum += realTaskWeeks;
}
```

Package/Class/Interface Naming

- **Packages should be lower case:**
- **This:**
  - `package java.util;`
  - `package com.myapp.mypackage;`
- **Not This:**
  - `package javax.MyPackage`
  - `package Com.MyPackage`
- **Classes and Interfaces should be nouns and upper case**
- **This:**
  - `Object`
  - `Customer`
- **Not This:**
  - `myClass`
  - `My_Class`
  - `MYCLASS`

Method and Variable Naming

- **Methods should be verbs and start as lower case (Camel Case)**
- **This:**
  - `getX()`
  - `createX()`
- **Not This:**
  - `Log()`
  - `CREATE_X()`
- **Use camel case for variable naming**
- **This:**
  - `customerId`
  - `carSpeed`
  - `size`
- **Not This:**
  - `Customer_id`
  - `CarSpeed`
  - `Size`

Constant and Parameter Naming

- **Constant naming: all upper case with underscores between words**
- **This:**
  - `MAIL_SERVER_URL`
  - `MAX_SIZE`
- **Not This:**
  - `mailServerUrl`
  - `Mail_server_url`

- **Parameter naming: Make sure your parameters mean something**
- **This:**
  - `public double calculate(double totalPrice, double units)`
- **Not This:**
  - `public double calculate(double a, double b)`

- **Actually, all your variables should have meaningful names!**

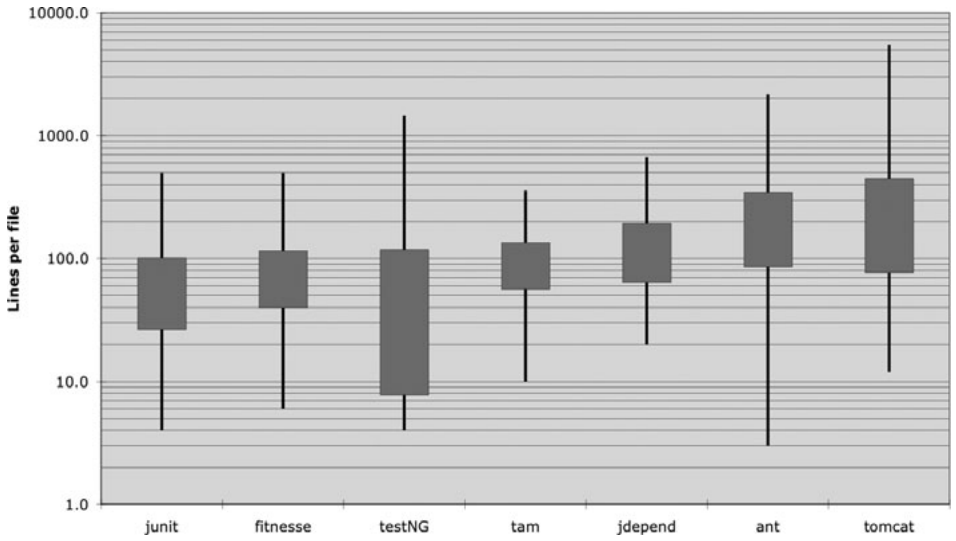
A short summary

- **The hardest thing about choosing good names is that it requires good descriptive skills and a shared cultural background.**
- **Good naming in your code is for good understandability, good readability, and ultimately, good communication with other programmers who will read your code in the future.**
- **Even, with your own in the future!**

(2) Vertical formatting by blank lines

Length Limits

- **Limit the Number of Java Statements per Line to 1**
  - Multiple statement can hide code to the casual observer
  - Makes stepping through code difficult
  - Long lines cannot be handled well by many terminals and tools.
- **Limit the Length of Methods**
  - A method should be about a "page of code"
  - Around 30 lines of code
- **Limit the Length of Source Files:** in Java, file size is closely related to class size.
  - Typically 200 lines long, with an upper limit of 500
  - Small files are easier to understand



Vertical Openness Between Concepts

```
package fitnesse.wikitext.widgets;

import java.util.regex.*;

public class BoldWidget extends ParentWidget {
  public static final String REGEXP = "'''.+?'''";
  private static final Pattern pattern = Pattern.compile("'''(.+?)'''",
    Pattern.MULTILINE + Pattern.DOTALL
  );

  public BoldWidget(ParentWidget parent, String text) throws Exception {
    super(parent);
    Matcher match = pattern.matcher(text);
    match.find();
    addChildWidgets(match.group(1));
  }

  public String render() throws Exception
    StringBuffer html = new StringBuffer("
    html.append(childHtml()).append("</b>"
    return html.toString();
  }
}
```

```
package fitnesse.wikitext.widgets;
import java.util.regex.*;
public class BoldWidget extends ParentWidget {
  public static final String REGEXP = "'''.+?'''";
  private static final Pattern pattern = Pattern.compile("'''(.+?)'''",
    Pattern.MULTILINE + Pattern.DOTALL);
  public BoldWidget(ParentWidget parent, String text) throws Exception {
    super(parent);
    Matcher match = pattern.matcher(text);
    match.find();
    addChildWidgets(match.group(1));}
  public String render() throws Exception {
    StringBuffer html = new StringBuffer("<b>");
    html.append(childHtml()).append("</b>");
    return html.toString();
  }
}
```

Use Blank Lines to Organize Code

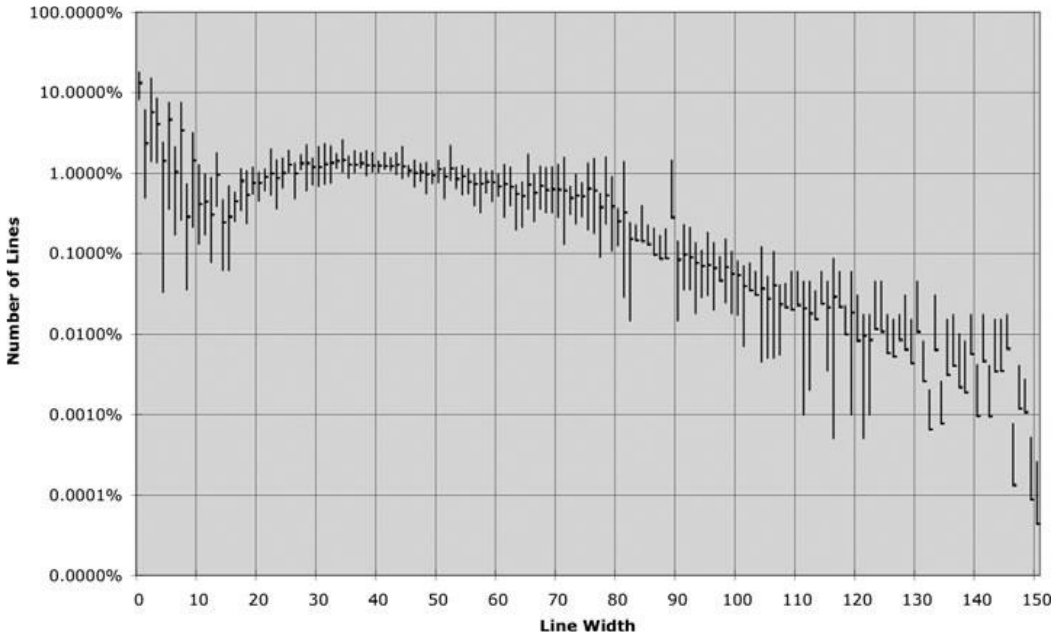
- **Vertical density implies close association, so lines of code that are tightly related should appear vertically dense.**
  - Single blank lines
    - Between local variable declarations and the first code in a method
    - Before a block comment
    - Between logical sections of code to improve readability
  - Double blank lines
    - Between methods
    - Between class and interface definitions
    - Between any other sections of a source file

- **Concepts that are closely related should be kept vertically close to each other.** Their vertical separation should be a measure of how important each is to the understandability of the other.

(3) Horizontal Formatting: White Spacing

How wide should a line be?

- **We should strive to keep our lines short.**
- **The old Hollerith limit of 80 is a bit arbitrary.**



Horizontal Openness and Density

- We use horizontal white space to associate things that are strongly related and disassociate things that are more weakly related to accentuate them.
  - Before and after the assignment operators
  - Between the function names and the opening parenthesis

```
public class Quadratic {
  public static double root1(double a, double b, double c) {
    double determinant = determinant(a, b, c);
    return (-b + Math.sqrt(determinant)) / (2*a);
  }
  public static double root2(int a, int b, int c) {
    double determinant = determinant(a, b, c);
    return (-b - Math.sqrt(determinant)) / (2*a);
  }
  private static double determinant(double a, double b, double c) {
    return b*b - 4*a*c;
  }
}
```

(4) Horizontal Formatting: Indentation

Horizontal Formatting: Indentation

- **Code must be indented according to its nesting level.**
  - The body of a function must be indented with respect to its header;
  - the body of a for, while, or switch statement must be indented with respect to its first line, and similarly for if statements and other nested structures.
- **You can choose the amount of indentation but you should be consistent.**
  - A default tab character (eight spaces) is too much: three or four spaces is sufficient.
  - Most editors and programming environments allow you to set the width of a tab character appropriately.
- **Bad indentation makes a program harder to read and can also be a source of obscure bugs.**

```
while (p)
  obj.update(p);
  p++;
```

Indentation Levels

- **Use a consistent number of spaces for an indent such as 2, 3, 4, or 8**
- **Just pick one and stick to it!**
- **Don't use hard tabs for indentation!**

```
private static void findJavaFiles(File parentDirectory, List<File> files) {

   for (File file : parentDirectory.listFiles()) {
      if (file.getName().endsWith(".java"))
         files.add(file);
      else if (file.isDirectory())
         findJavaFiles(file, files);
   }
}
```

(5) Horizontal Formatting: Line Wrapping

Wrapping Lines

- **When an expression will not fit on a single line, break it according to these general principles:**
  - Break after a comma.
  - Break before an operator.
  - Prefer higher-level breaks to lower-level breaks.
  - Align the new line with the beginning of the expression at the same level on the previous line.

- **For method signatures, double the indentation of the next line**

```
public void doSomething(String arg1,
        String arg2, String arg3) {
//Stuff goes here
}
```

Examples of Wrapping Lines

```
someMethod(longExpression1, longExpression2, longExpression3,
        longExpression4, longExpression5);

var = someMethod1(longExpression1,
                  someMethod2(longExpression2,
                          longExpression3));

longName1 = longName2 * (longName3 + longName4 - longName5)
           + 4 * longname6; // PREFER

longName1 = longName2 * (longName3 + longName4
                         - longName5) + 4 * longname6; // AVOID

//DON'T USE THIS INDENTATION
if ((condition1 && condition2)
    || (condition3 && condition4)
    ||!(condition5 && condition6)) { //BAD WRAPS
    doSomethingAboutIt();           //MAKE THIS LINE EASY TO MISS
}

//USE THIS INDENTATION INSTEAD
if ((condition1 && condition2)
        || (condition3 && condition4)
        ||!(condition5 && condition6)) {
    doSomethingAboutIt();
}

//OR USE THIS
if ((condition1 && condition2) || (condition3 && condition4)
        ||!(condition5 && condition6)) {
    doSomethingAboutIt();
}
```

(6) File organization

Order Sections Within a Source File Consistently

- **For a source file:**
  - 1. Package or file level comments
  - 2. Package and import statements
  - 3. Public class or interface declaration
  - 4. Private class and interface declarations

Ordering of Import Statements

- **Orders:**
  - 1. Standard packages (`java.io, java.util`, etc.)
  - 2.Third party packages such as `com.ibm.xml.parser`
  - 3. Your own packages
- **Within each group order the packages in alphabetic order**
- **Use the wildcard (*) to reduce the import**
  - `java.util.*;`
- **Or do individual imports**
  - `java.util.Date;`
  - `java.util.Vector;`

Ordering of Class Parts

- **1. Javadoc comments**
- **2. Class declaration statement**
- **3. Class-wide comments**
- **4. Class static variable declarations (public, protected, package, private)**
- **5. Class instance variable declarations (public, protected, package, private)**
- **6. Methods declarations**
  - Constructors first
  - Functional or alphabetical ordering

Organizing multiple files into package

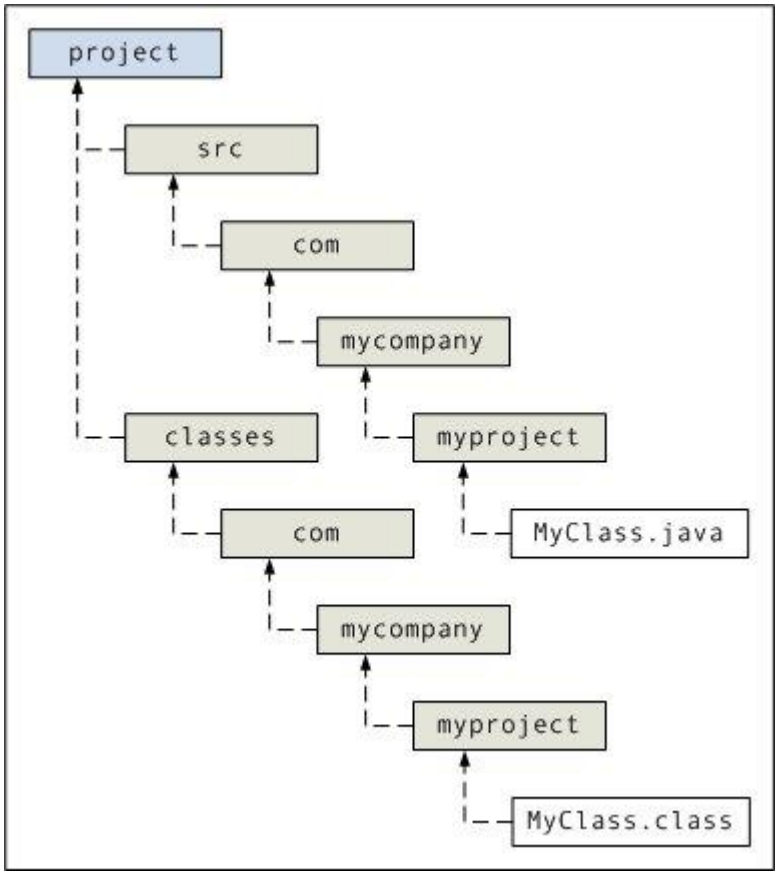
- **A package is a collection of classes and interfaces.**
- **Each package has its own name and organizes its top-level (that is, nonnested) classes and interfaces into a separate namespace, or name collection.**
  - Although same-named classes and interfaces cannot appear in the same package, they can appear in different packages because a separate namespace assigns to each package.
- **From an implementation perspective, equating a package with a directory proves helpful, as does equating a package's classes and interfaces with a directory's classfiles.**

JDK is organized by packages

- **For examples:**
  - `java.lang`: A collection of language-related classes, such as `Object` and `String`, organized in the java package's `lang` subpackage
  - `java.lang.ref`: A collection of reference-related language classes, such as `SoftReference` and `ReferenceQueue`, organized in the `ref` sub-subpackage of the java package's `lang` subpackage
  - `javax.swing`: A collection of Swing-related component classes, such as `JButton`, and interfaces, such as `ButtonModel`, organized in the `javax` package's `swing` subpackage

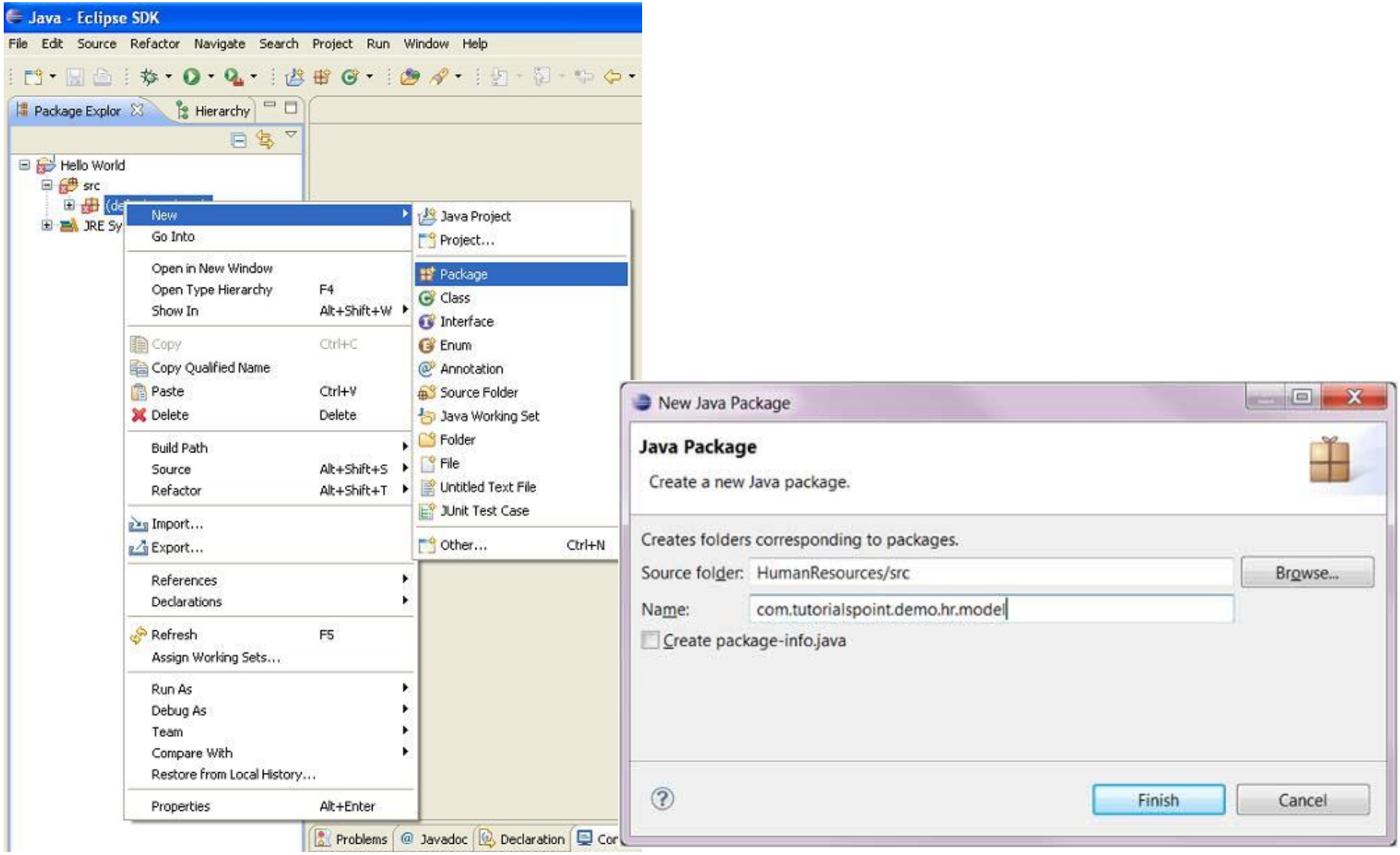
Create a package of classes and interfaces

- **Every source file's classes and interfaces organize into a package.**
- **In the package directive's absence, those classes and interfaces belong to the unnamed package (the directory the JVM regards as the current directory—the directory where a Java program begins its execution.**
- **If the package directive appears in a source file, that directive names the package for those classes and interfaces.**




```
package packageName [ . subpackageName ... ]
package game;
package game.devices;
```

Create a package of classes and interfaces



Principles of Package

- **(REP) The Reuse/Release Equivalency Principle**

  复用/发布等价原则

- **(CCP) The Common Closure Principle**

  共同封闭原则

- **(CRP) The Common Reuse Principle**

  共同复用原则

(REP) The Reuse/Release Equivalency Principle

- **The granule of reuse is the granule of release. (复用的粒度应等价于发布的粒度)**
  - Single Classes are seldom reusable
  - Unreleased modules cannot be reused
  - So the granularity of reuse is the granularity of release

(CCP) The Common Closure Principle

- The classes in a package should be closed together against the same kinds of changes. (一个包中的所有类针对同一种变化是封闭的)
- A change that affects a closed package affects all the classes in that package and no other packages. (一个包的变化将会影响包里所有的类，而不会影响到其他的包)
- If two classes are so tightly bound together, either physically or conceptually, such that the almost always change together; then they should belong to the same package. (如果两个类紧密耦合在一起，即二者总是同时发生变化，那么它们就应属于同一个包)

(CRP) The Common Reuse Principle

- **The classes in a package are reused together. (一个包里的所有类应被一起复用)**
- **If you reuse one of the classes in the package, you reuse them all. (如果复用了其中一个类，那么就应复用所有的类)**

Principles of Package Coupling

- **(ADP) The Acyclic Dependencies Principle**

  无圈依赖原则

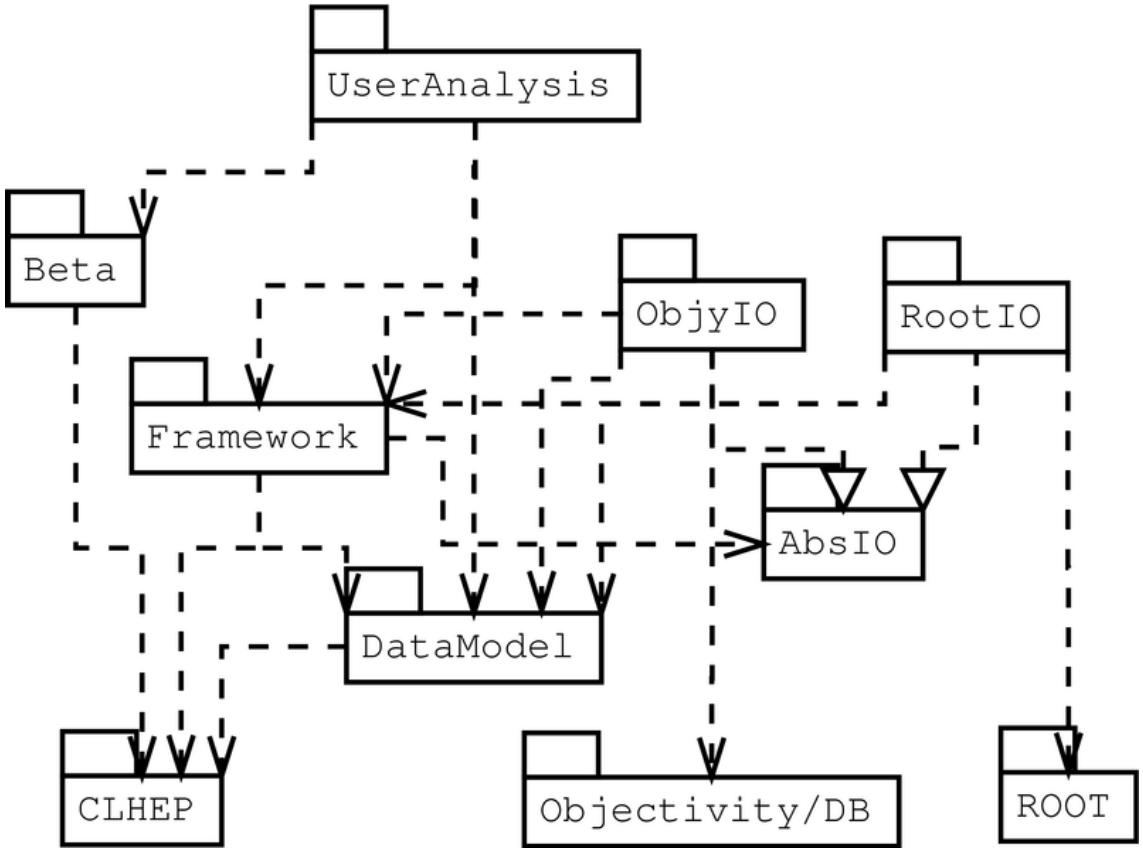
- **(SDP) The Stable Dependencies Principle**

  稳定依赖原则

- **(SAP) The Stable Abstraction Principle**

  稳定抽象原则

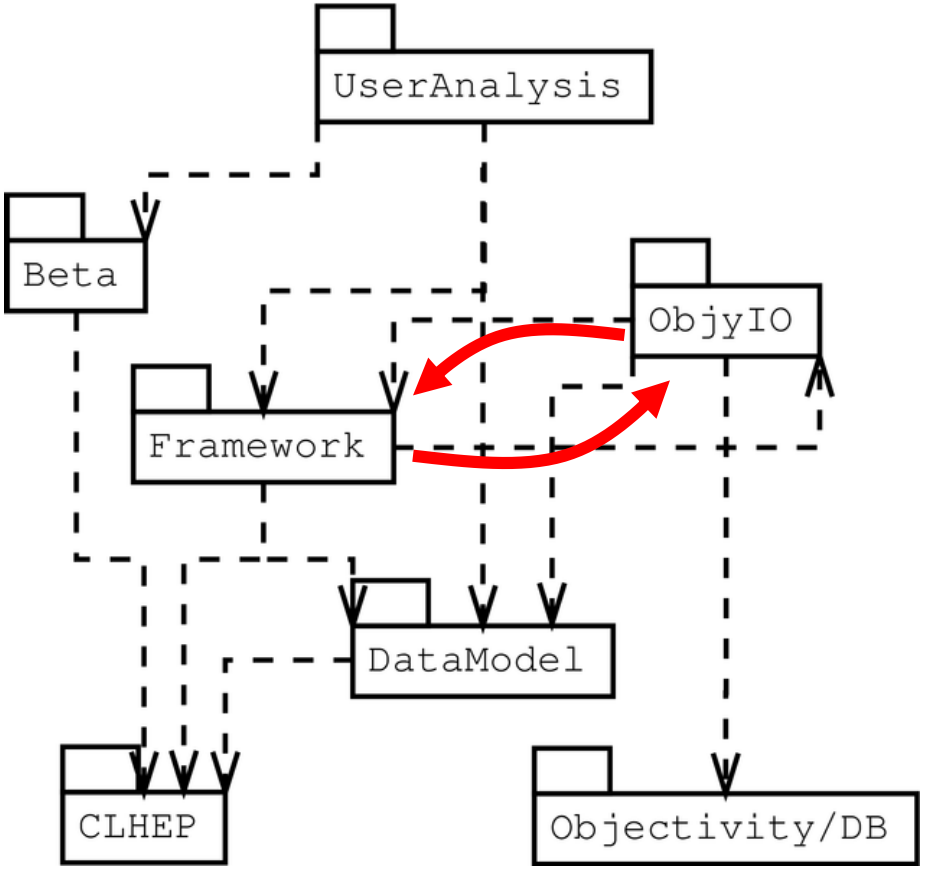
Dependency graph between packages



(ADP) The Acyclic Dependencies Principle

- Allow no cycles in the package dependency graph. (不允许在包依赖图中出现任何圈/回路)
- Packages that adhere to the acyclic dependency principle are typically easier to unit test, maintain and understand. (无圈将容易进行测试、维护与理解)
- Cyclic dependencies make it more difficult to predict what the effect of changes in a package are to the rest of the system. (若存在回路依赖，很难预测该包的变化将会如何影响其他包)

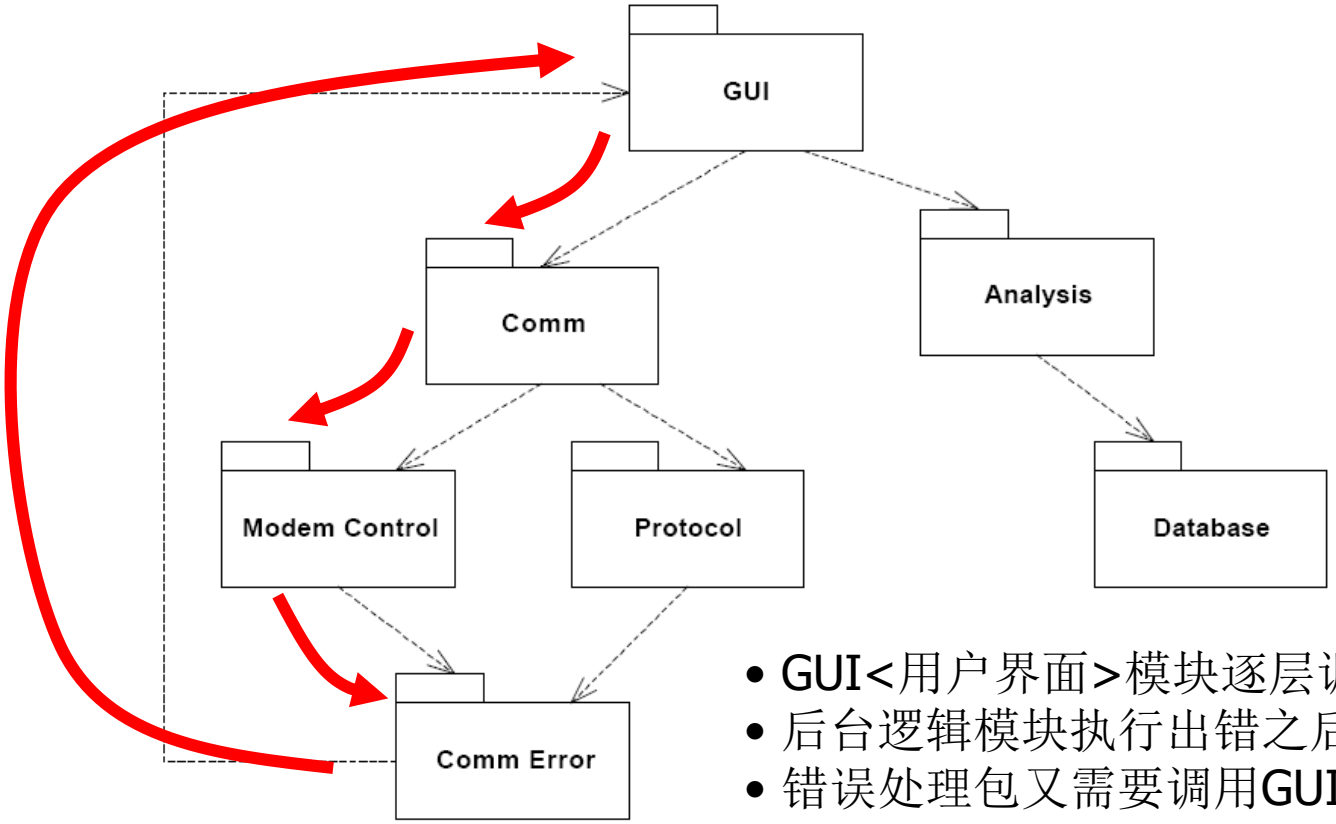
Dependency Cycles



Breaking a Cycle

- **Cycles can be broken in two ways (消除圈的两种方式)**
  - creating a new package (创建新包)
  - makes use of the DIP and ISP (利用DIP<依赖倒置原则>和ISP<接口隔离原则>)

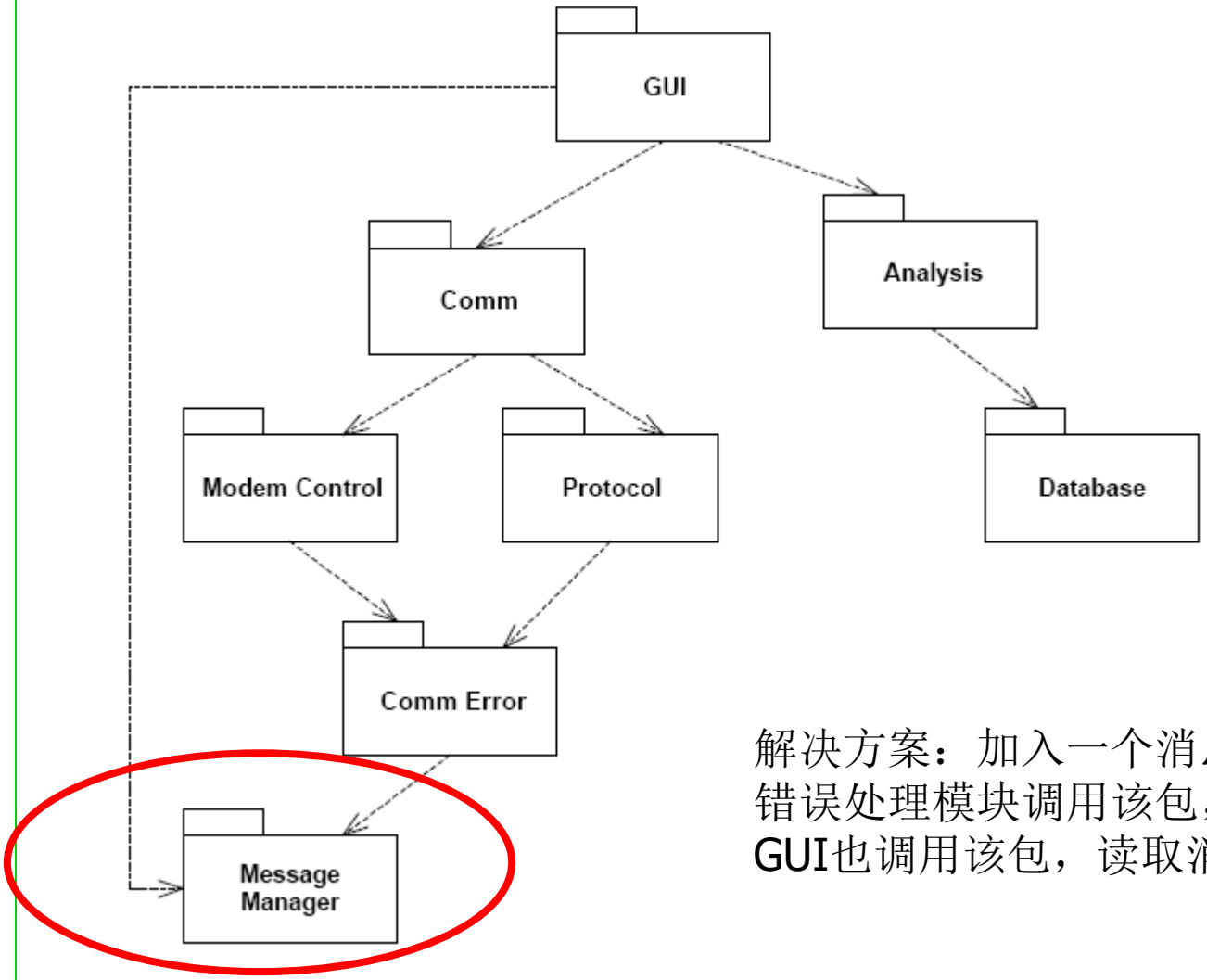
Approach (1): creating new packages



- GUI<用户界面>模块逐层调用后台逻辑模块；
- 后台逻辑模块执行出错之后，调用错误处理模块；
- 错误处理包又需要调用GUI，显示错误消息；

——从而形成包依赖图中的“圈”

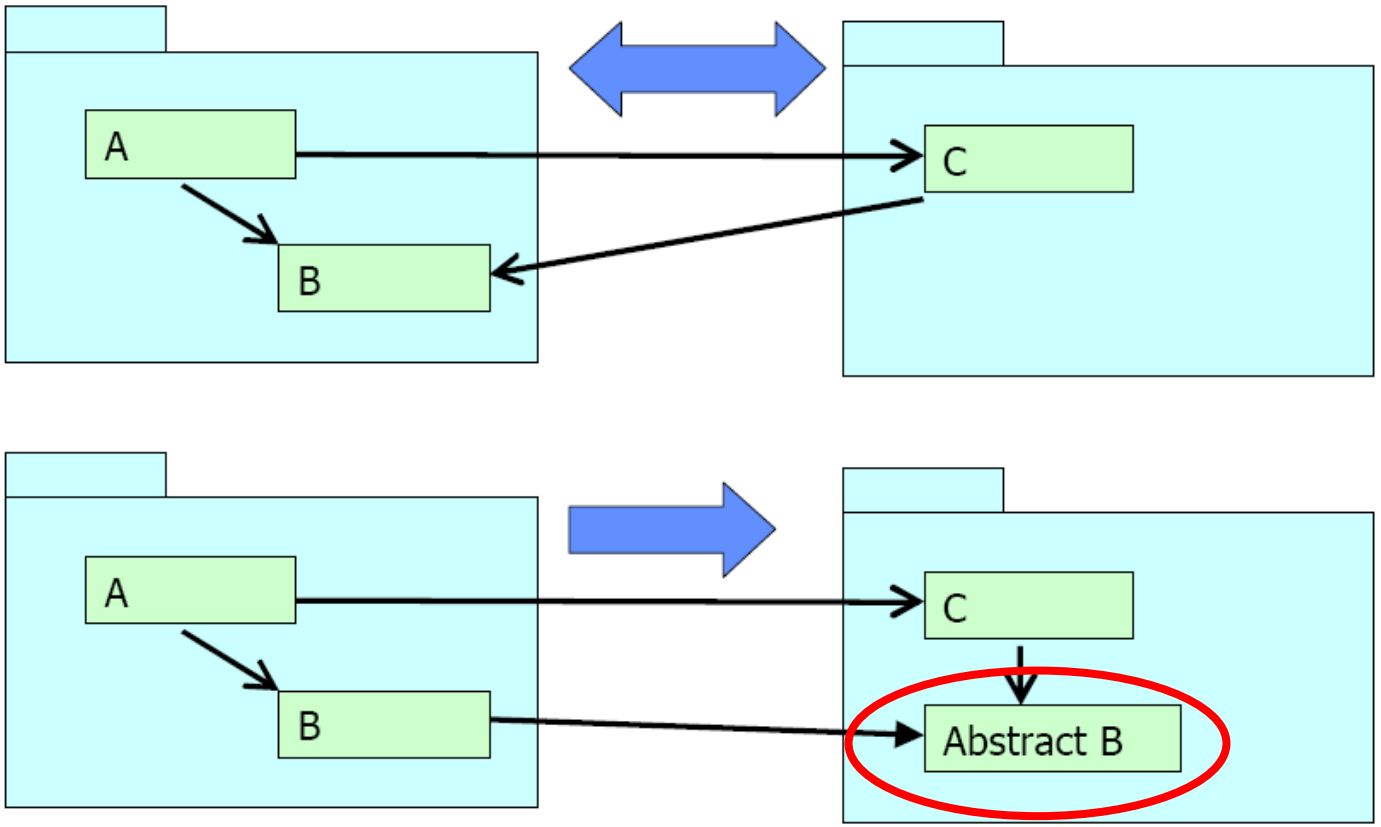
Approach (1): creating new packages



解决方案：加入一个消息管理的包，
错误处理模块调用该包，将错误消息发送过去；
GUI也调用该包，读取消息，并在UI上显示。

Approach (2): Using DIP and ISP

双向依赖→形成圈



创建抽象类，将依赖的方向加以翻转，从而消除圈

(SDP) The Stable Dependencies Principle

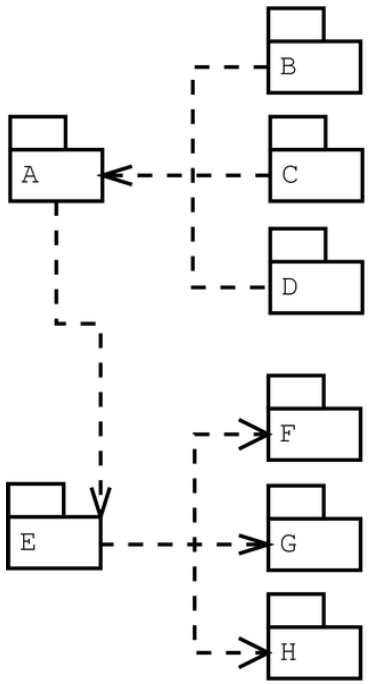
- Dependencies between released packages must run in the direction of stability. (包之间的依赖关系只能指向稳定的方向)
- The dependee must be more stable than the depender. (被依赖者应更稳定于依赖者)
- Stable packages are packages that are difficult to change. (稳定的包较难发生改变)
- Unstable packages that are used a lot by other packages are potential problem areas in a design. (如果不稳定的包却被很多其他包依赖，会导致潜在的问题)

An example

Bad

A is responsible for B, C and D. It depends on E, → irresponsible

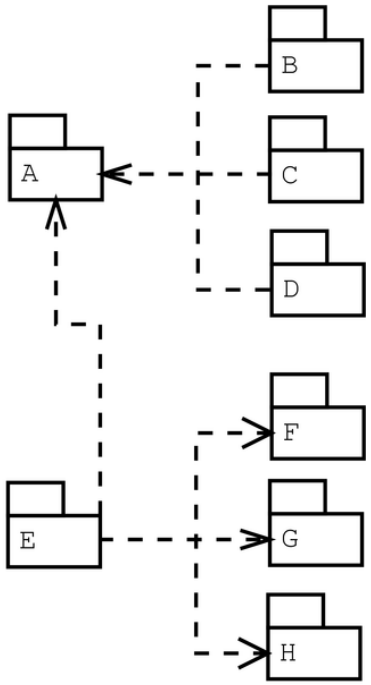
E depends on F, G and E. A depends on it. E is responsible and irresponsible.



Good

A is responsible for B, C, D and E. It will be hard to change

E depends on A, F, G and H. It is irresponsible and will be easy to modify.



(SAP) The Stable Abstraction Principle

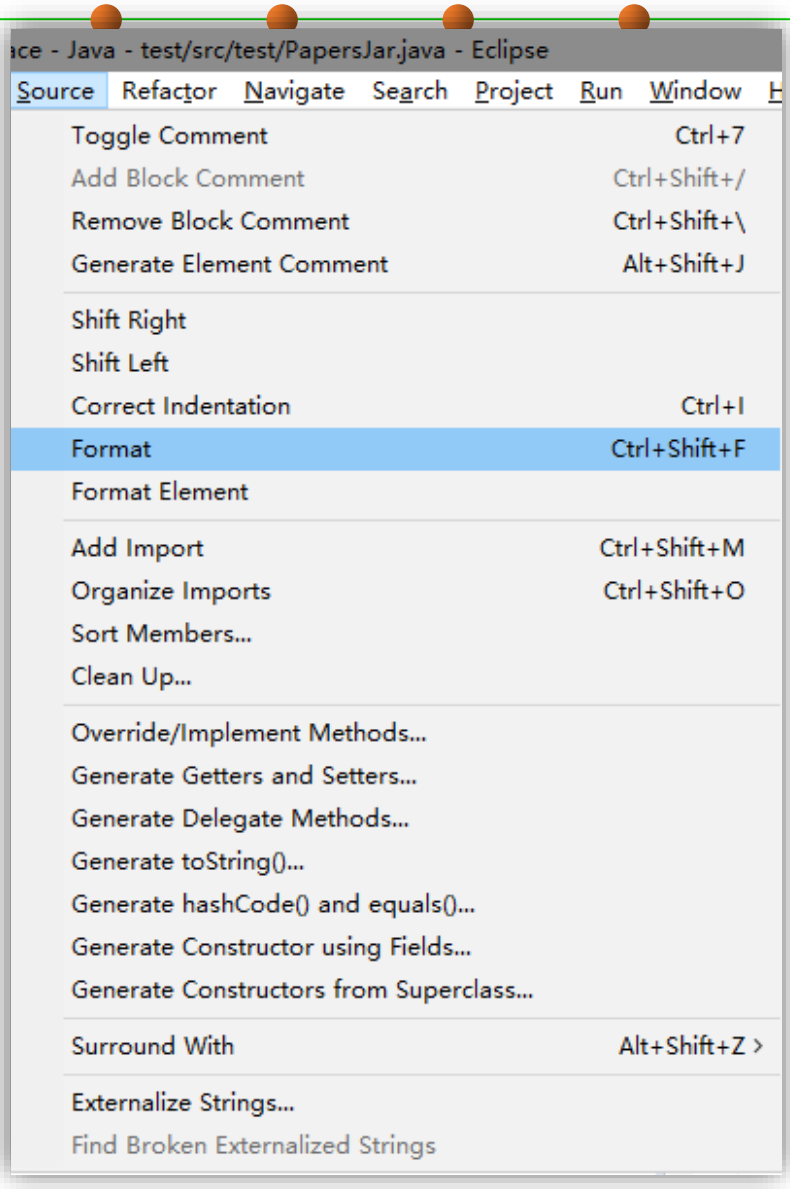
- **This principle sets up a relationship between stability and abstractness. (在稳定性与抽象度之间建立关联)**
  - A package should be as abstract as it is stable. (一个包是稳定的，那么它就应该尽可能抽象)
  - A completely stable package should consist of nothing but abstract classes (一个完全稳定的包中只应包含抽象类)
  - An instable package should be concrete since it its instability allows the concrete code within it to be easily changed. (不稳定的包应是具体的，以便于容易的进行修改)

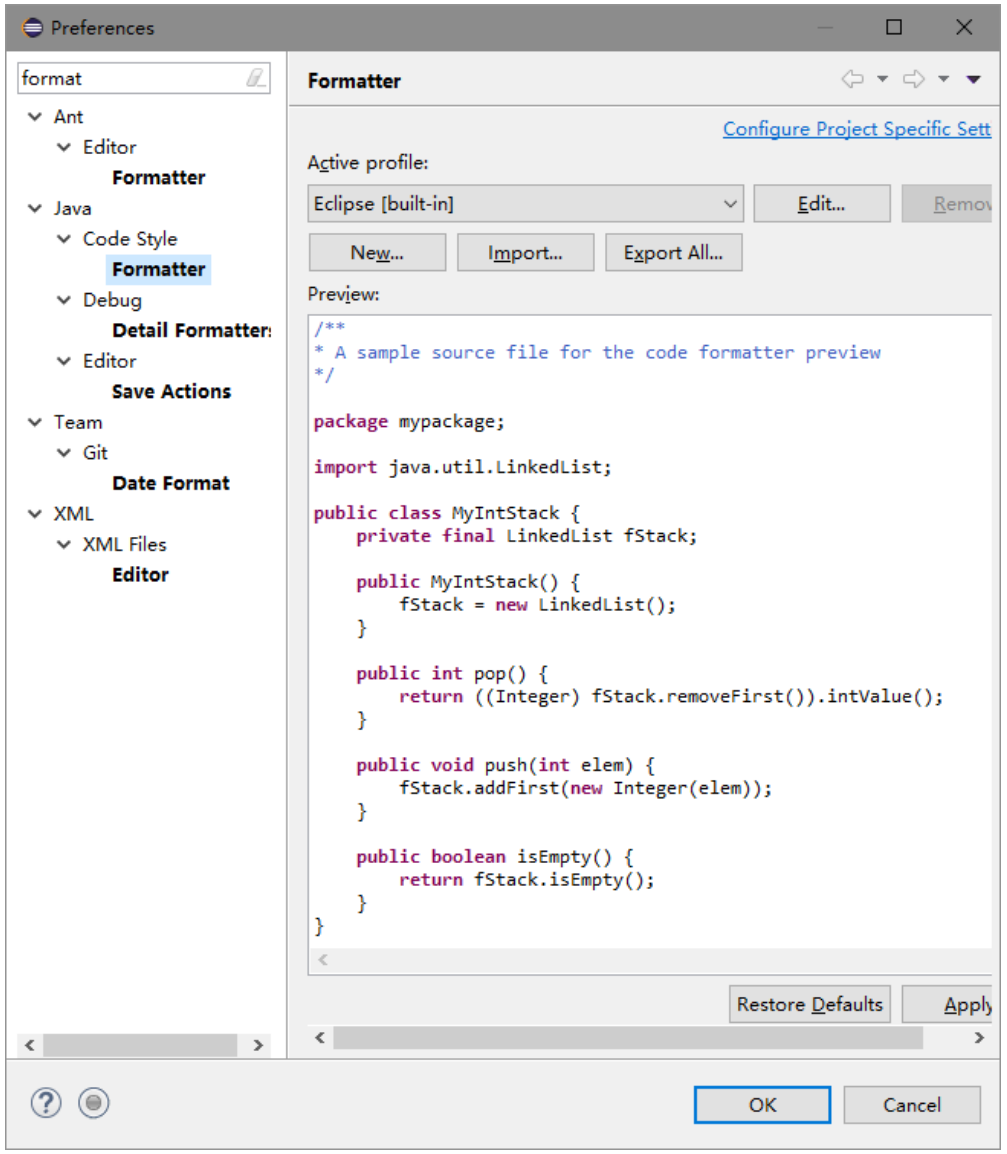
SAP and SDP

- The SAP and the SDP combined amount to the Dependency Inversion Principle for Packages. (SAP和SDP共同构成了包之间的“依赖倒置原则DIP”)
- SDP says that dependencies should run in the direction of stability, and the SAP says that stability implies abstraction. (SDP: 依赖应指向稳定的方向，SAP: 稳定性隐含着抽象)
- Thus, dependencies run in the direction of abstraction (因此，依赖应指向抽象的方向)

(8) Automatic Code Formatting in IDE

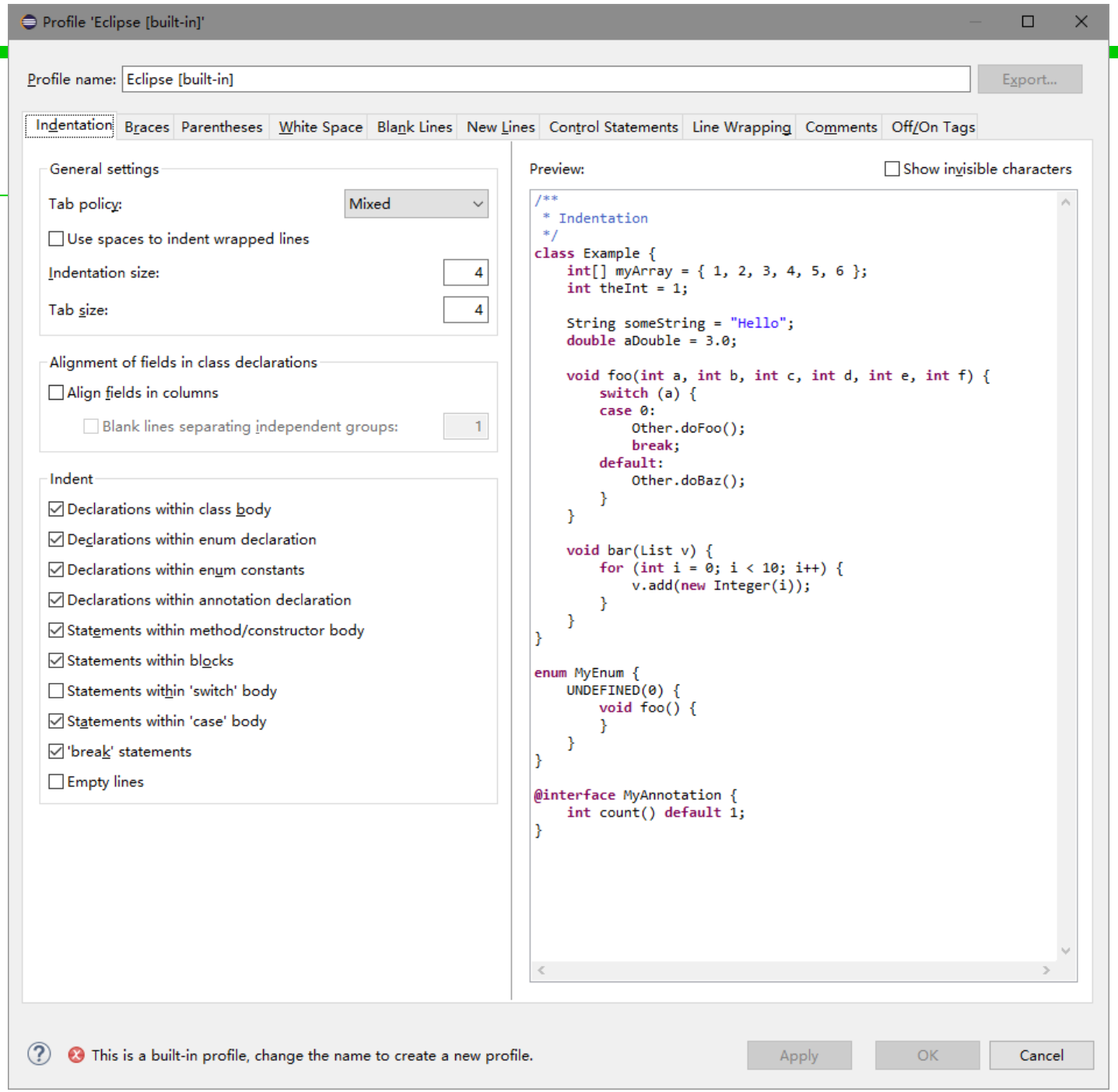
Formatting code in Eclipse IDE





Formatting code in Eclipse IDE

(demo)



(9) Following a standard coding styles/conventions

Standard code conventions

- **Oracle's Java code conventions**
  - http://www.oracle.com/technetwork/java/codeconventions-150003.pdf
- **Google's Java style guide**
  - https://google.github.io/styleguide/javaguide.html
- **Many others:**
  - http://geosoft.no/development/javastyle.html
  - https://dmoztools.net/Computers/Programming/Languages/Java/Coding_Standards/
  - http://www.huihoo.org/code/java_code_conventions.html
- **And for other languages:**
  - https://en.wikipedia.org/wiki/Coding_conventions#Coding_conventions_for_languages

Summary

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HARBIN INSTITUTE OF TECHNOLOGY

The end

April 7, 2019