# Refactoring
# Lecture 5:
# Metrics

DAT159/H18

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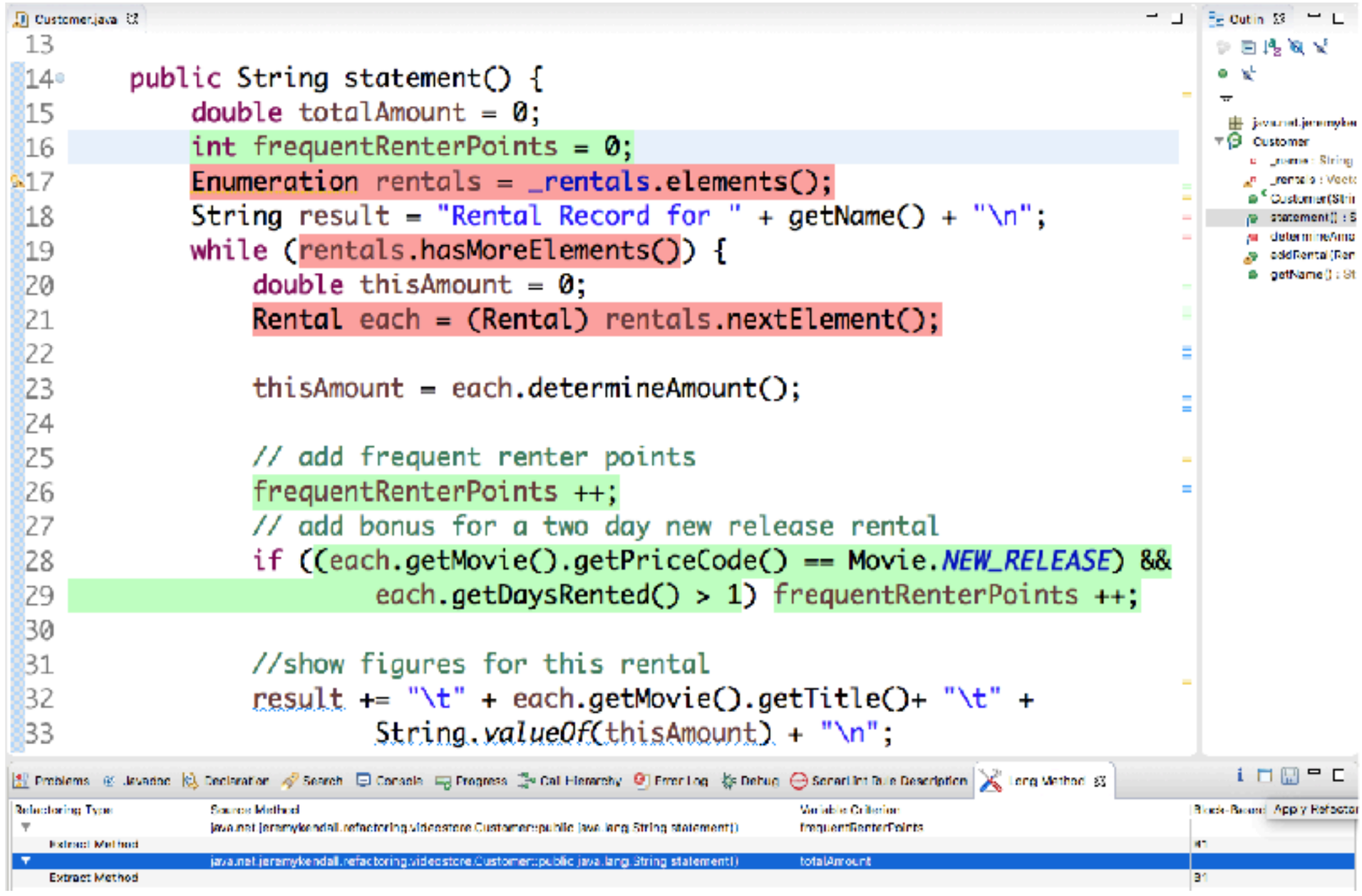
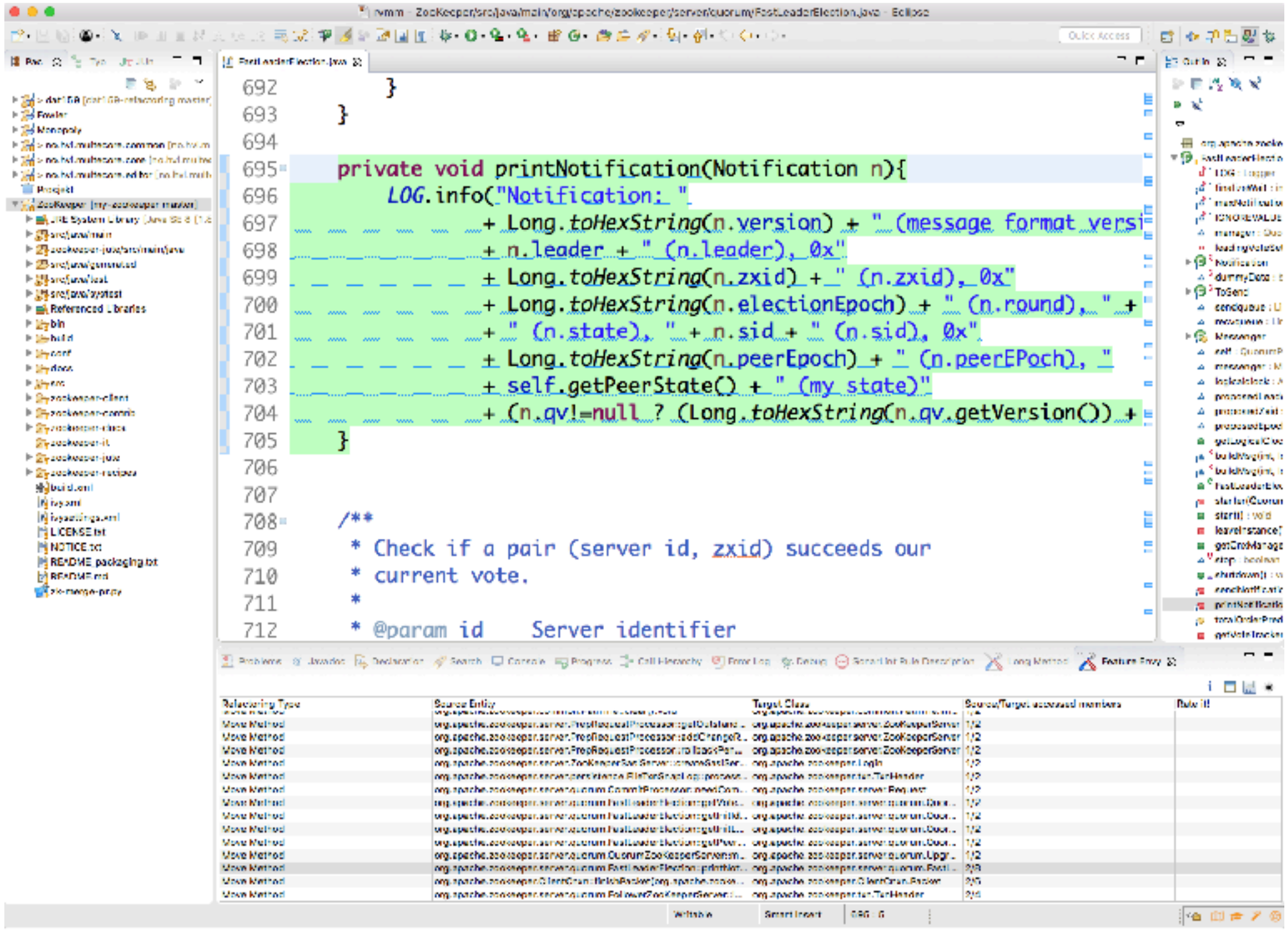
Høgskulen på Vestlandet

# Smells Addendum

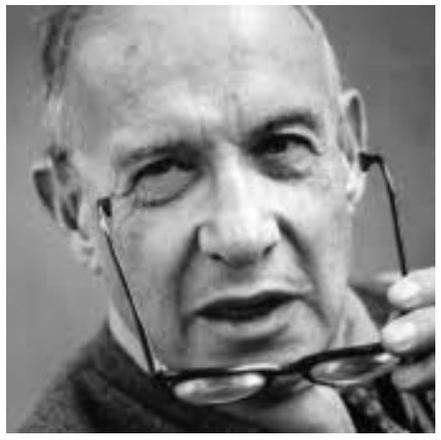
JDeodorant: https://marketplace.eclipse.org/content/jdeodorant



# JDeodorant: Feature Envy



# Metrics



“If you can't measure it, you can't improve it.” - Peter Drucker on management

“Measure what is measurable, and make measurable what is not so”
- Galileo(?)

# Metrics for Software Engineering?

**Code metrics:**

- (S)LOC
- Cyclomatic Complexity
- Depth of Inheritance
- Cohesion
- Coupling

**Object-oriented**

**Other metrics:**

- Performance
- Test coverage
- Bugs (per LOC)
- Function Point Analysis

# SLOC Measurement

- SLOC is the traditional and the most popular sizing metric
- Excludes comments and blanks
- Includes headers, declarations,…
- Counts individual lines; doesn't care about multiple statements/line
- LLOC: *logical* LOC (statements only)
- Boehm: *delivered source instructions* (DSI)
- Q: How do the refactorings affect this metric?

# SLOC vs. LLOC

Example:

- SLOC: 5
- LLOC: 2
  (`for, printf`)
- What about `++`?
- Neither cares about structure…

```
for (i = 0;
  i < 100;
     i ++) {
        printf(“hello");
    }

/* An important loop */
```

# McCabe's Cyclomatic Complexity (MCC)

"Program Control Graph" *G* (now Control Flow Graph):

- node = block of code without jumps (*N*)
  (*straight-line code, basic block)*
- edge = branches (*E*)
- connected components (*p*)

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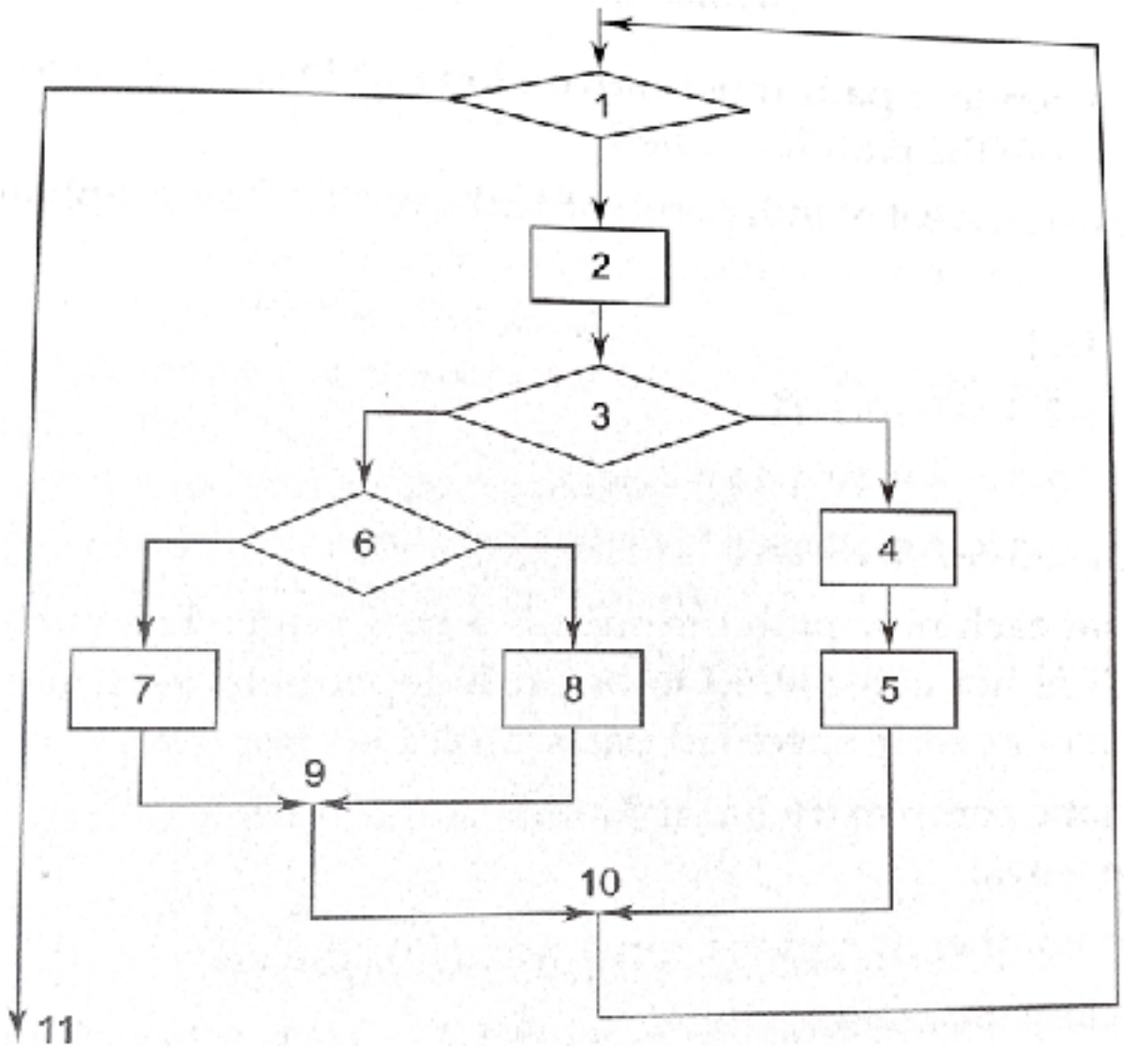
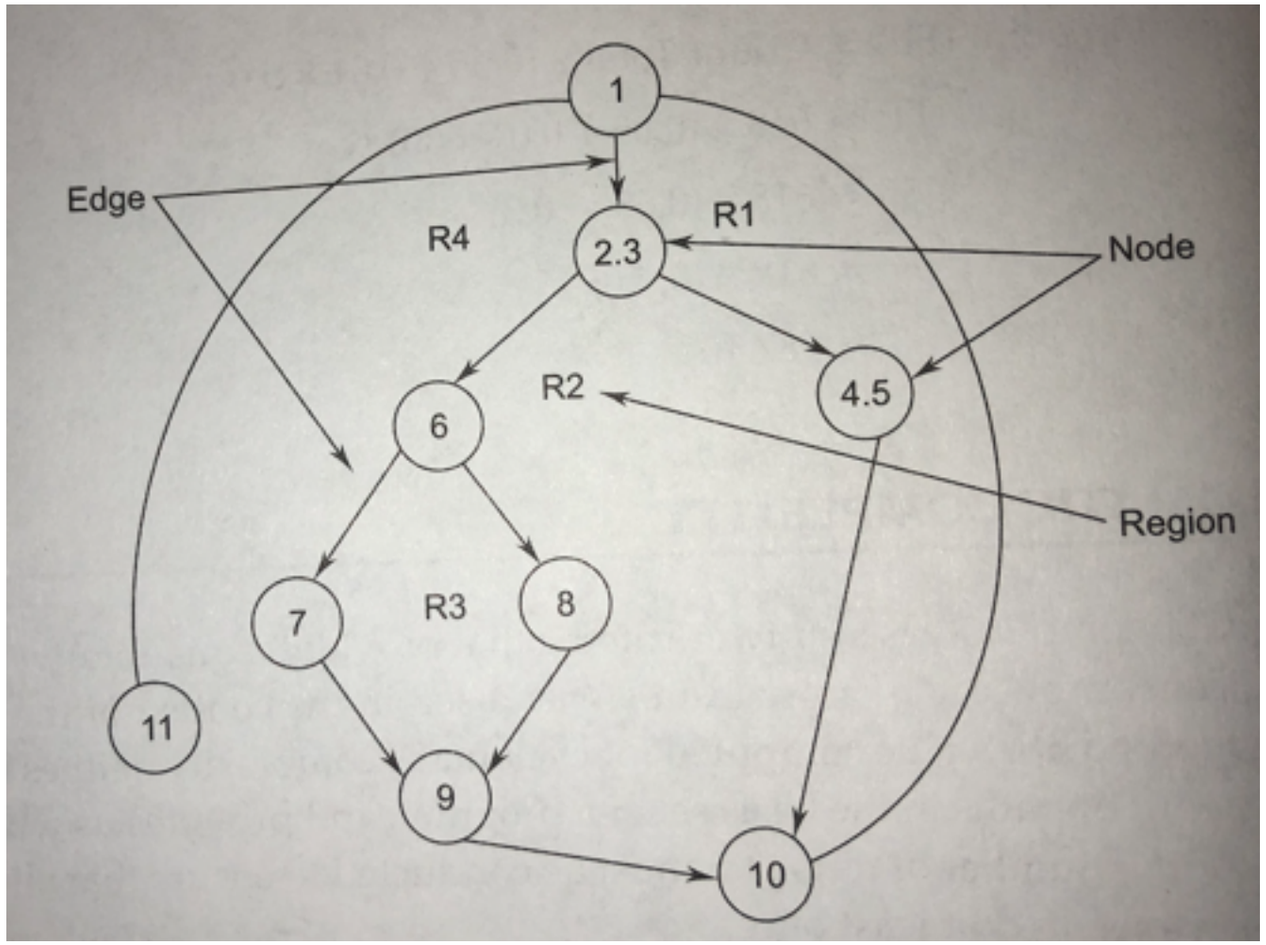
- *V(G)* = *E* - *N* + *p* (variation: +2*p*; *p* usually 1, hence: +2)
- Relation to number of *paths* to tests

# MCC: Flowchart vs. Flowgraph



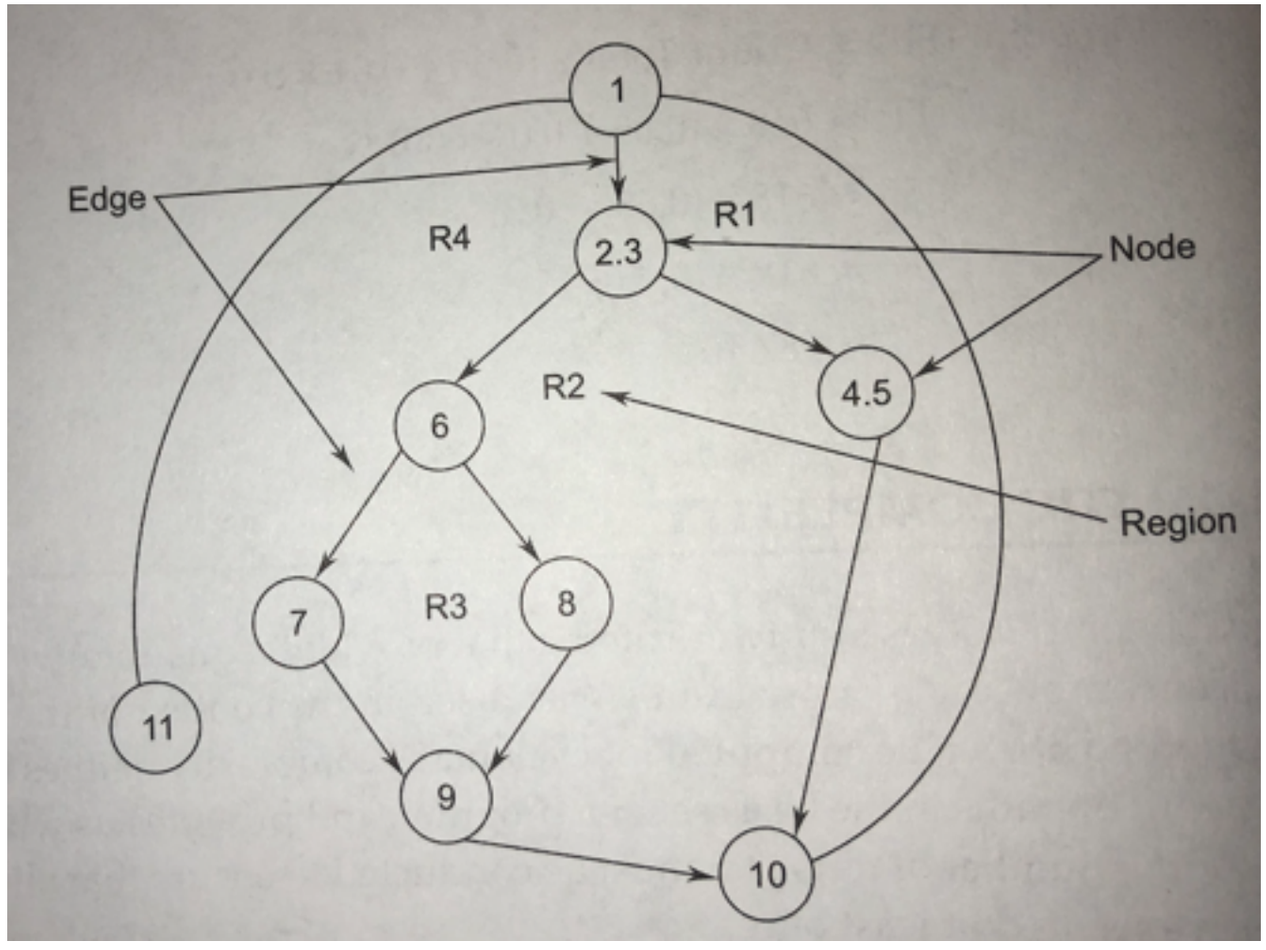




**Flowchart** **Flowgraph**

[Agarwal, Tayal, Gupta: “Software Engineering & Testing”]

# MCC Example

**How many independent paths?**




- Set of *independent* paths:
  - 1-11
  - 1-2-3-4-5-10-1-11
  - 1-2-3-6-8-9-10-1-11
  - 1-2-3-6-7-9-10-1-11
- **V(G) = 11 edges - 9 nodes + 2 = 4 (regions)**
  **Alternative: V(G) = 3 predicate nodes + 1 = 4**

# Control Flow Graphs

Exercise — draw CFGs for Java's constructs:

- `if-then-else`
- `while() {}`
- `do {} while ()`
- `for() {}`

(Bonus question: what about exceptions?)

# Cyclomatic Complexity: Example

```
public static void bubbleSort(int[] numArray) {

    int n = numArray.length;
    int temp = 0;

    for (int i = 0; i < n; i++) {
        for (int j = 1; j < (n - i); j++) {

            if (numArray[j - 1] > numArray[j]) {
                temp = numArray[j - 1];
                numArray[j - 1] = numArray[j];
                numArray[j] = temp;
            }

        }
    }
}
```

```
int partition(int arr[], int left, int right)
{
      int i = left, j = right;
      int tmp;
      int pivot = arr[(left + right) / 2];

      while (i <= j) {
            while (arr[i] < pivot)
                  i++;
            while (arr[j] > pivot)
                  j--;
            if (i <= j) {
                  tmp = arr[i];
                  arr[i] = arr[j];
                  arr[j] = tmp;
                  i++;
                  j--;
            }
      };
      return i;
}

void quickSort(int arr[], int left, int right) {
      int index = partition(arr, left, right);
      if (left < index - 1)
            quickSort(arr, left, index - 1);
      if (index < right)
            quickSort(arr, index, right);
}
```

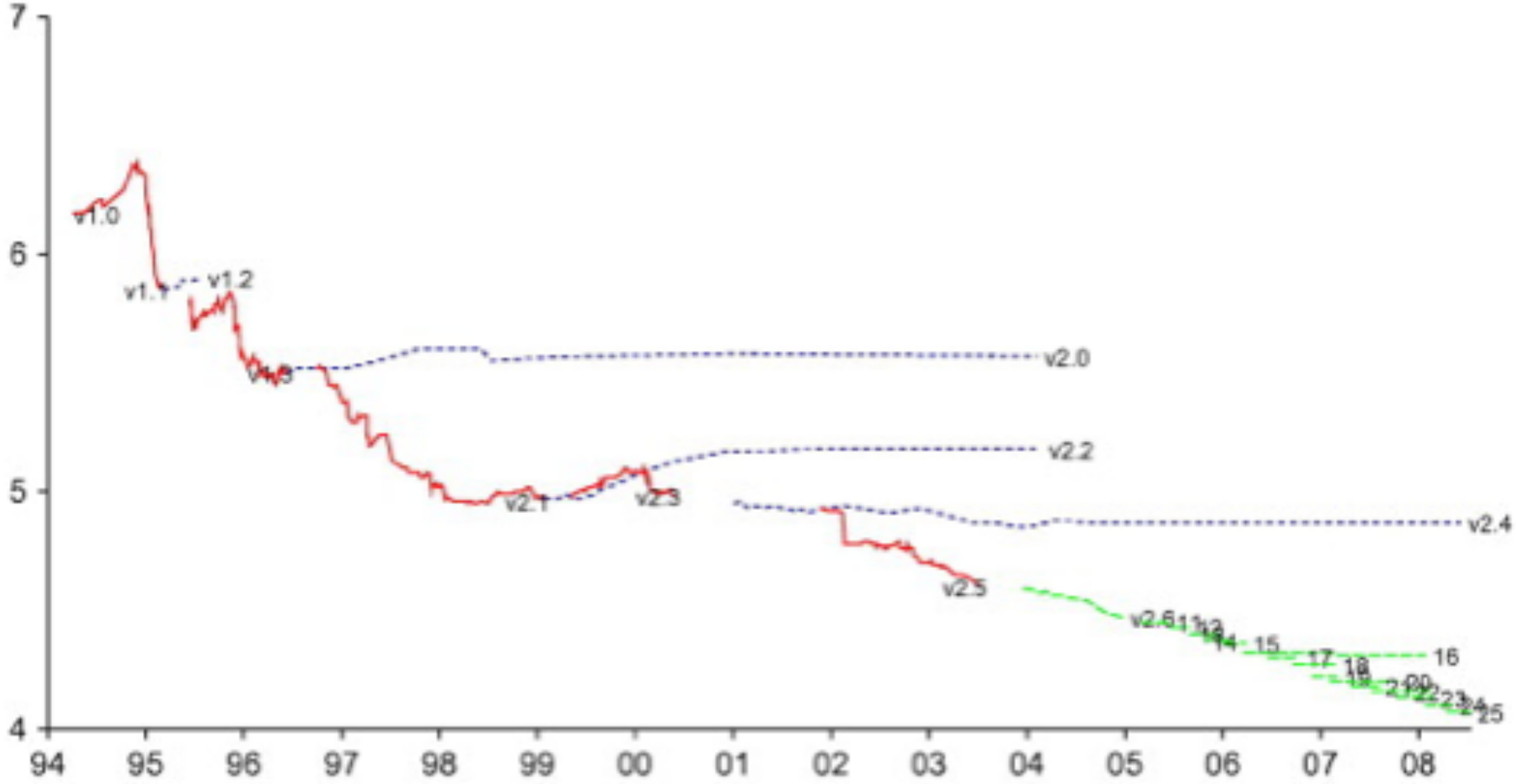
# Cyclomatic Complexity (3)

- Independent of number of lines per function
  (number of blocks and branches, not size of a block)
- Does not depend on format/coding style
- Let’s ignore *p* for now!
- Reasonable values? 5? 10? More than 10?
- Q: How do the refactorings affect this metric?
- Applies to C and Java (no OO)
- Compare with Sonar’s *Cognitive Complexity*

# MCC in the Linux Kernel

**Average cyclomatic complexity per function over time**

*Ayelet Israeli, Dror G. Feitelson: The Linux kernel as a case study in software evolution. Journal of Systems and Software 83(3): 485-501 (2010)*



# Depth of Inheritance

- Obvious [Chidamber & Kemerer], distance from superclass
- Effect on program understanding?
  “The deeper a class [..], the greater the number of methods it is likely to inherit”
- Also: breadth of tree (“*top-heavy*”/“*bottom-heavy*”; former can indicate lack of reuse)

# Lack of Cohesion

- Cohesion promotes encapsulation
- Lack of cohesion can recommend splitting classes
- LCOM1-4 (LCOM5?)
  - LCOM1 [Chidamber & Kemerer]
    Number of pairs of methods that **do not share** attributes (higher = worse) — getters/setters?
  - LCOM4 [Hitz & Montazeri 1995]: number of "connected components" in a class. A connected component is a set of related methods (and class-level variables). There should be only one such a component in each class. If there are 2 or more components, the class should be split [..]

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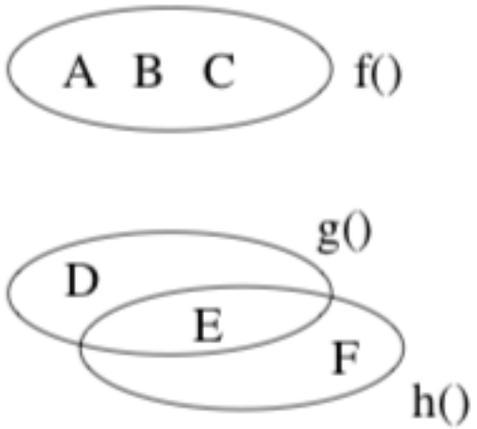
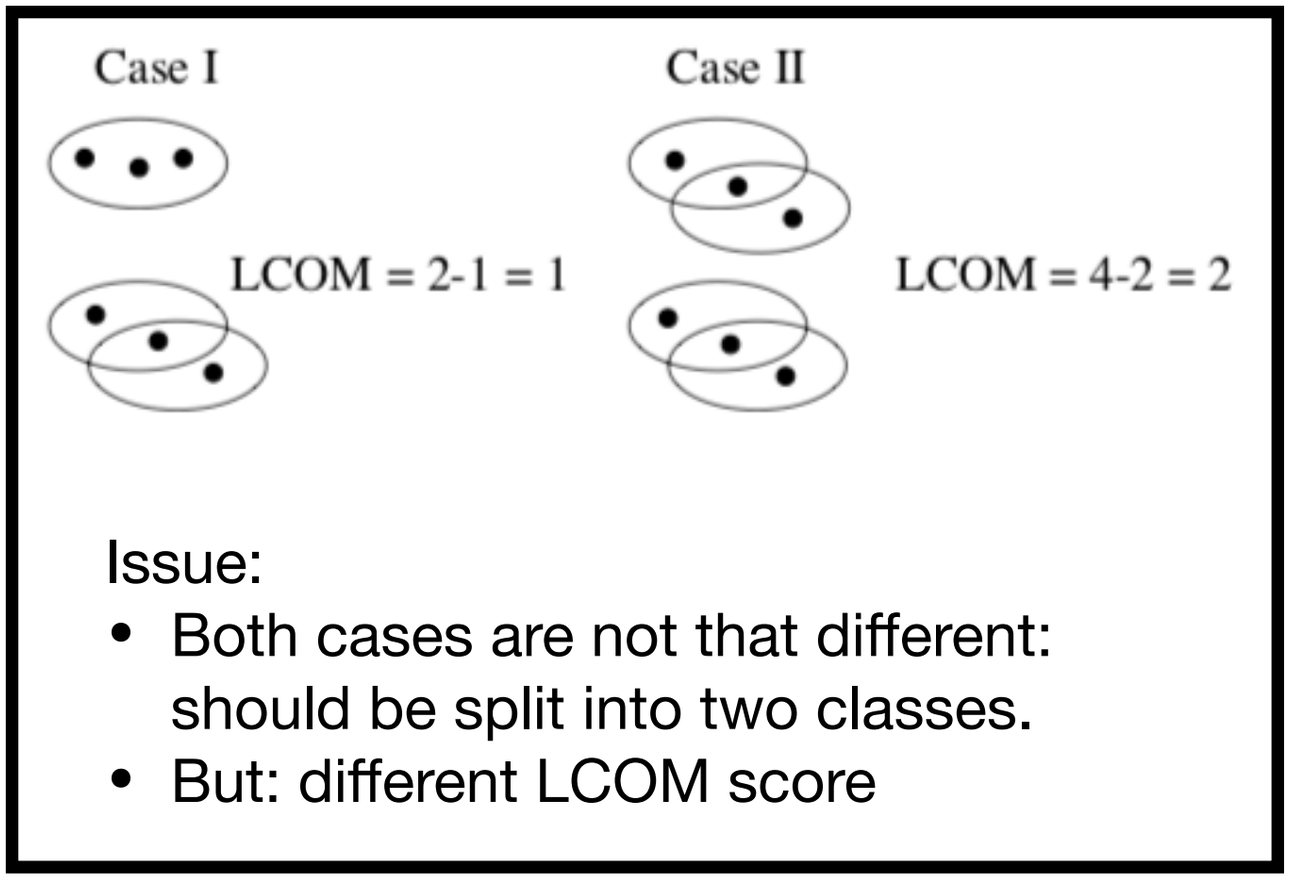
- Maybe you want to *Extract Method* first?

# LCOM Example




```
class X {
        int A, B, C, D, E, F;
        void f () { ... uses A, B, C ... }
        void g() { ... uses D, E ... }
        void h() { ... uses E, F ... }
};
```

**[Hitz/Montazeri]**




Issue:

- Both cases are not that different: should be split into two classes.
- But: different LCOM score

# Coupling/CBO

- **C**oupling **B**etween **O**bject classes [Chidamber & Kemerer]
- Number of other classes to which a class is coupled
- Objects *coupled*, if methods of one use methods or attributes of another
- High coupling = bad for reuse

# Example CBO (1)

- CBO for classes A/B/C?
- What about A→B→C, is CBO associative? Should it be?

```
1  package dat159.metrics;
2
3  public class CBO {
4
5      class A {
6          B b;
7      }
8
9      class B {
10         A a1;
11         A a2;
12         C c;
13     }
14
15     class C {}
16 }
```

# Example CBO (2)

```
1  package dat159.metrics;
2
3  public class CBO {
4
5      class A {
6          B b;
7      }
8
9      class B {
10         A a1;
11         A a2;
12         C c;
13     }
14
15     class C {}
16 }
```

```
5      class A {
6          B b;
7
8          void f() {
9              b.c.x = 42;
0          }
```

?

# Tools for Metrics

- Install *Metrics* plugin from
  - ~~Eclipse Marketplace~~
  - ~~State-of-flow update site~~
  - `https://github.com/qxo/eclipse-metrics-plugin/raw/master/updatesite/`

# References:


- Thomas J. McCabe:
  “A Complexity Measure”. IEEE Trans. Software Eng. 2(4): 308-320 (1976)

- Shyam R. Chidamber, Chris F. Kemerer:
  “A Metrics Suite for Object Oriented Design”. IEEE Trans. Software Eng. 20(6): 476-493 (1994)

- Agarwal, Tayal, Gupta: “Software Engineering & Testing”, Jones and Bartlett Publishers, 2010, Ch. “Software Measurement and Metrics”