

# Relative Thresholds: Case Study to Incorporate Metrics in the Detection of Bad Smells

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# Outline

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- State of the Art
- Previous Works
- Outlined Problem

## • Case Study

- Phase 1: Comparison between products
  - Partial conclusions
- Phase 2: Metric evolution between versions
  - Partial conclusions

## • Applying Relative Product Thresholds

- Example

## • Conclusions

## • Proposal and Future Work

*July, 3rd, 2006*

## Context

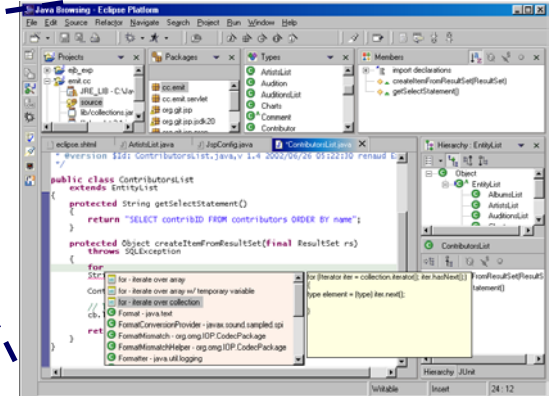
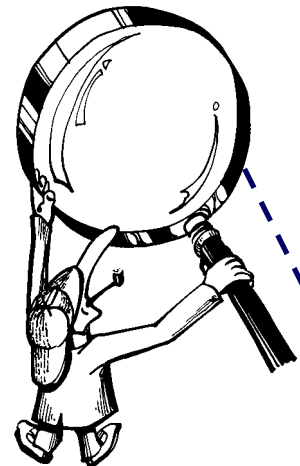
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### ■ When should we refactor?

- Visual inspection
  - Too much time!

### ■ Metric collection tools

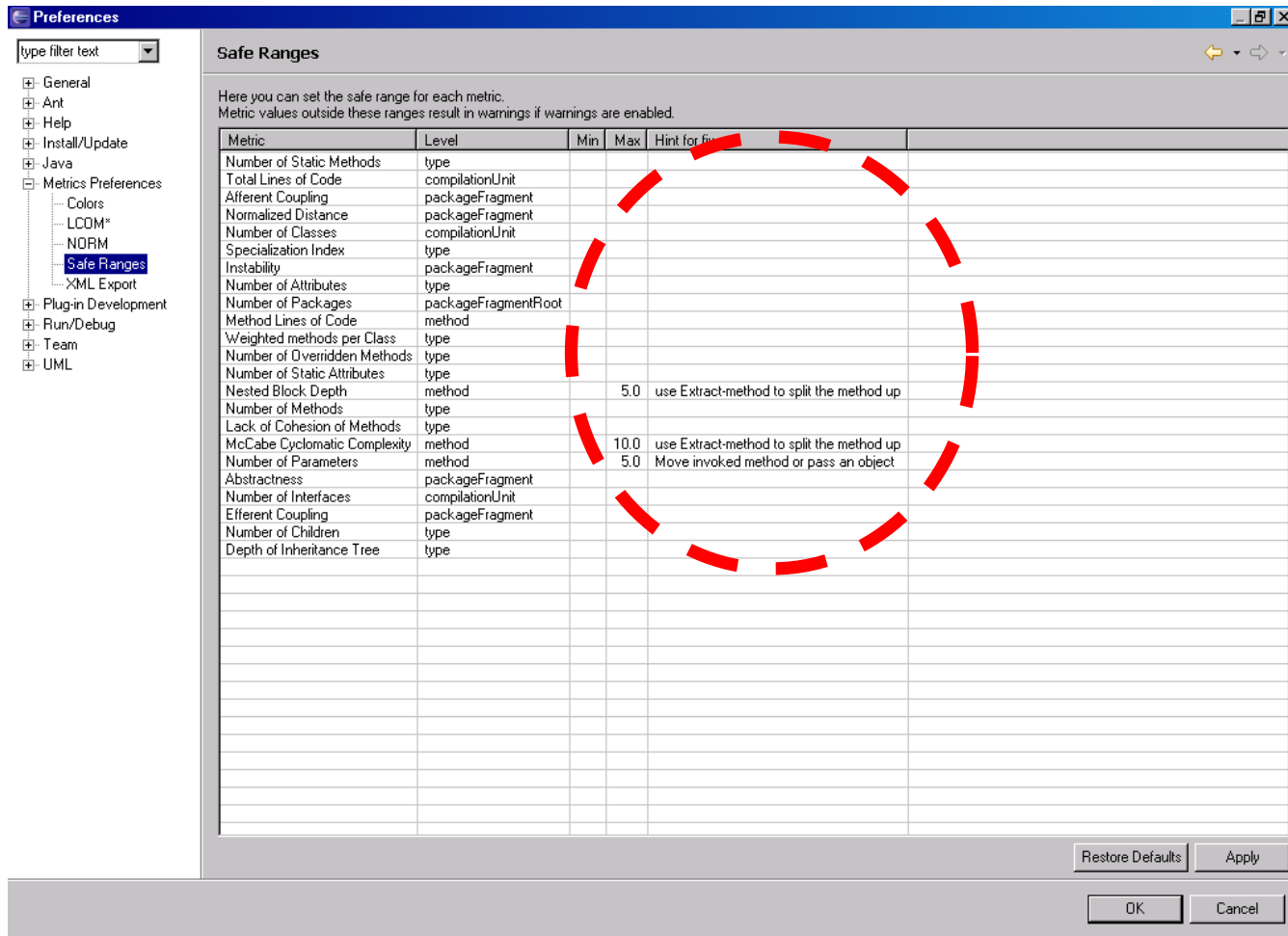
- Automatic process
- Using these values in smell detection
  - Thresholds helping to point out their presence
- Some research works but not included in most of the current IDEs



## Context    Current solutions in IDEs

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## ■ Example: Eclipse 3.1 &amp; Metrics 1.3.6 plug-in

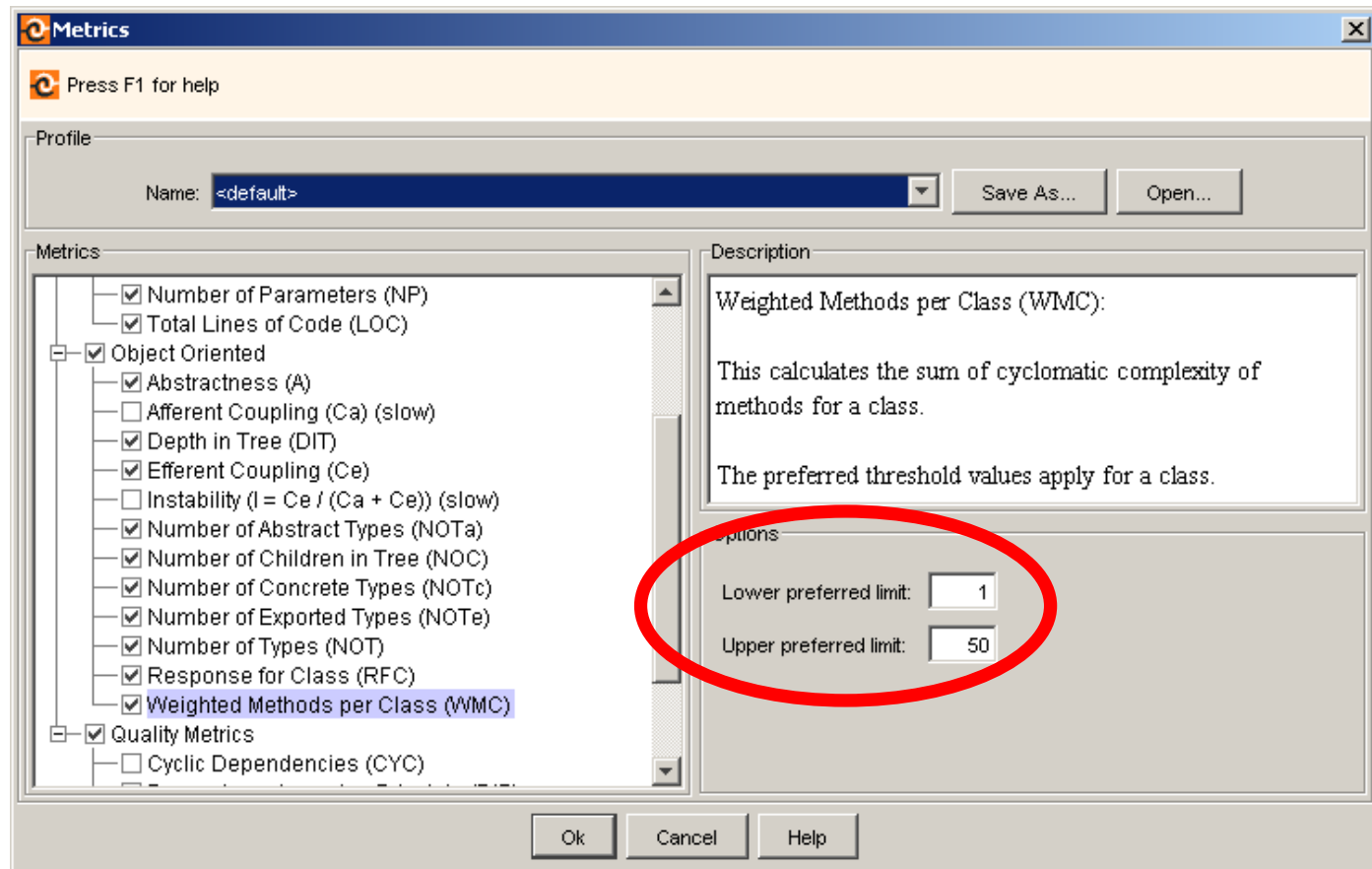


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## Context     Current solutions in IDEs

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### ■ Example: RefactorIt



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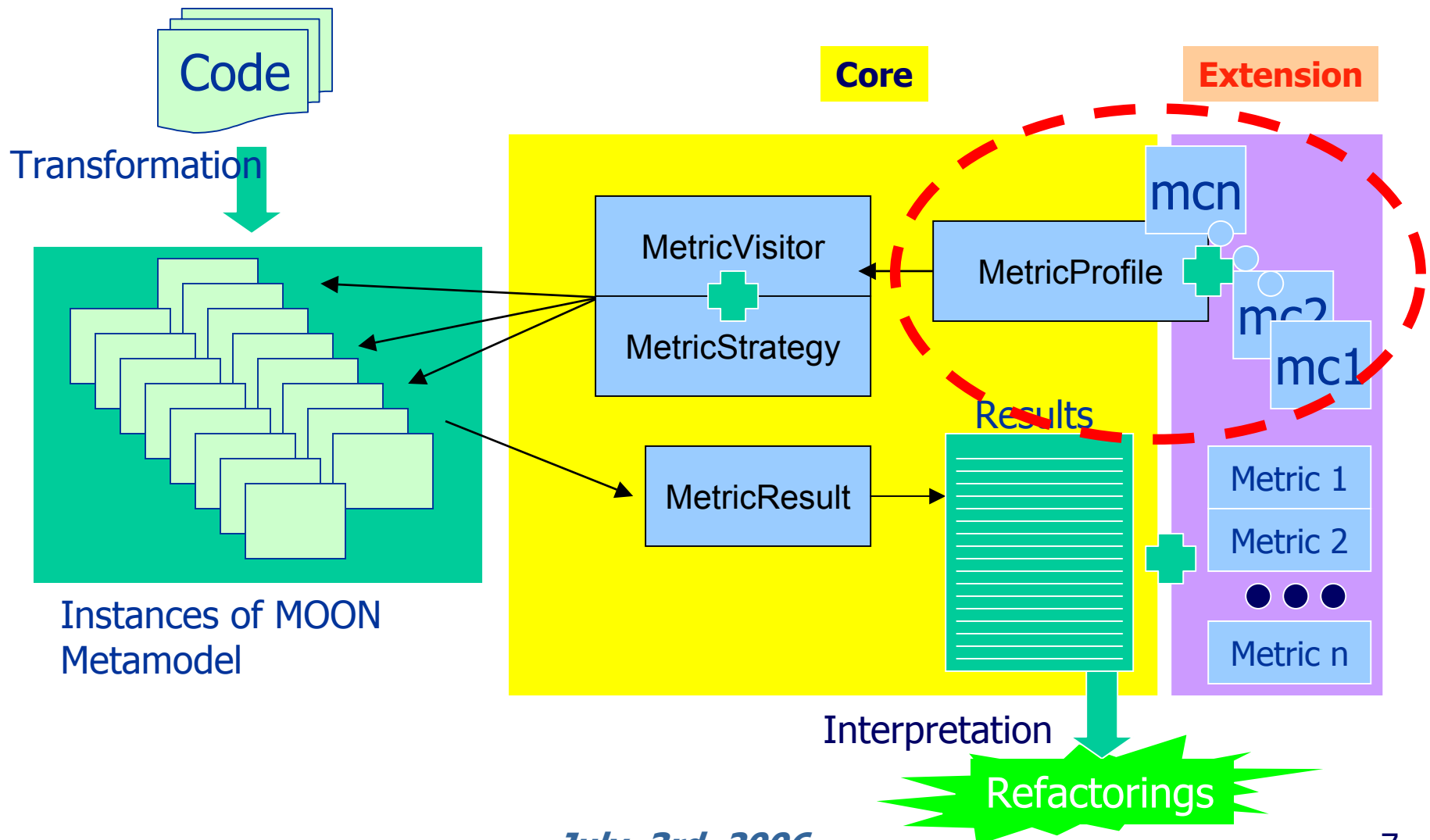
## State of the Art

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- **Establishing Software Metrics** [French, 1999]
  - Method to define relative thresholds
  - Neither working in refactoring nor bad smells
- **Bad Smells Taxonomy** [Mantyla, 2003]
  - Metrics suggest bad smells
  - Absolute values
- **Flaw Detection** [Marinescu, 2002]
  - Using metrics
  - Absolute and relative filters
- **SOUL** [Muñoz, 2003]
  - Logic predicates: metrics and heuristics
  - Generic thresholds

# Previous Work Support Based on Frameworks [QA00SE'05]

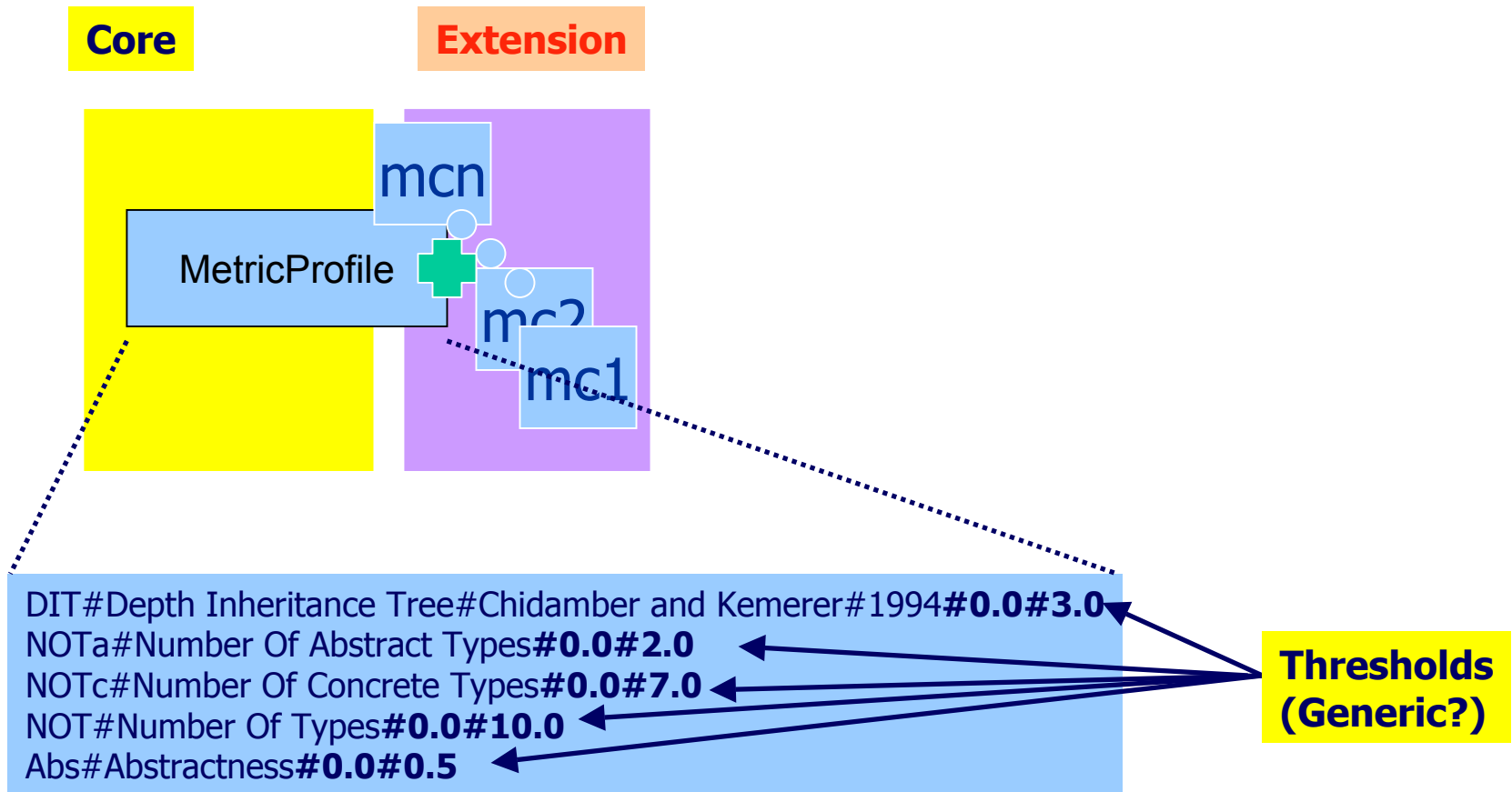
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## Previous Work Support Based on Frameworks [QA00SE'05]

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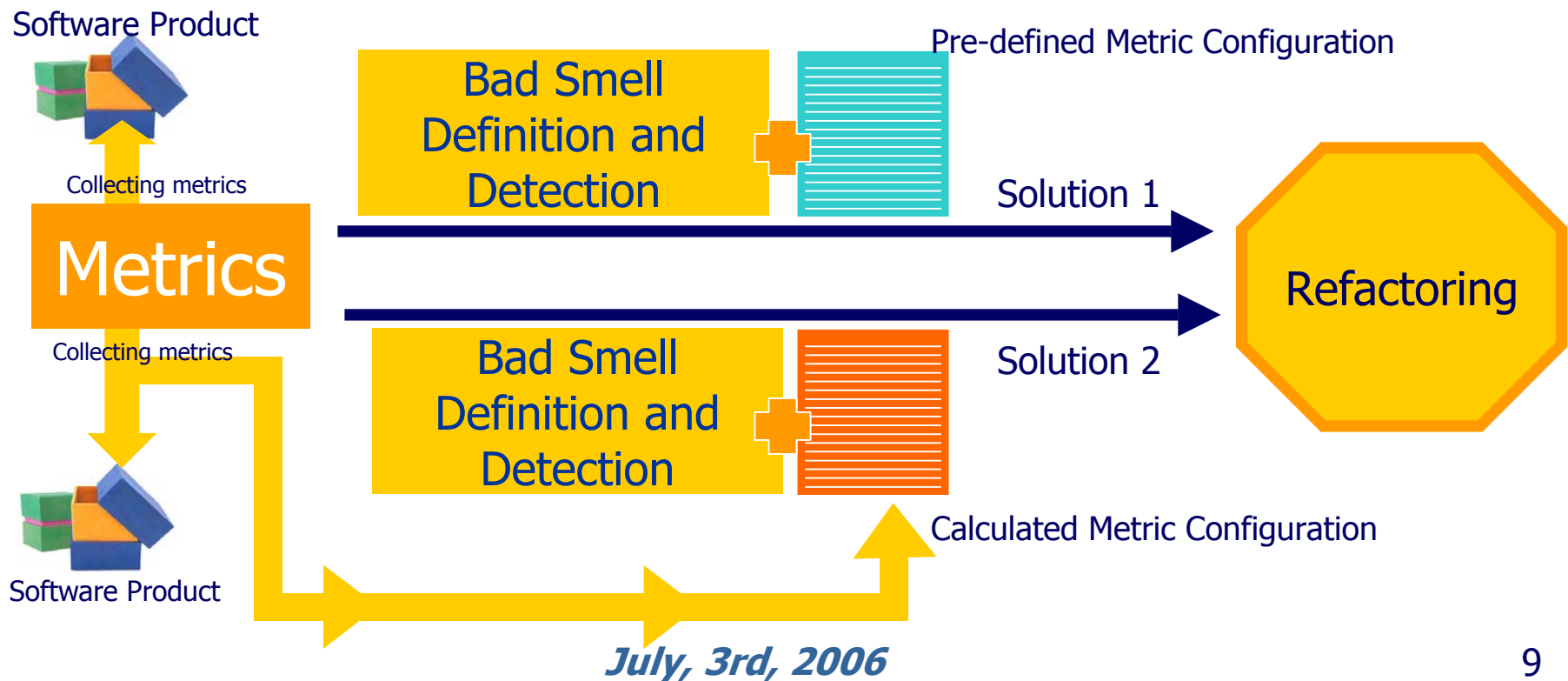






## Outlined Problem

- Should we use generic or relative product thresholds to detect bad smells?
- And then... refactor the code



## Case Study

### Phase 1: Comparison between products

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#### ■ Phase 1: Comparison between products

##### ■ Six software products – stable - medium size

- jfreechart-1.0.0.pre2 (629 classes)
- jhotdraw-6.0b1 (496 classes)
- struts-1.2.8 (273 classes)
- jcoverage-1.0.5 (90 classes)
- easymock-1.0.5 (47 classes)
- junit-3.8.1 (46 classes)

##### ■ Collecting metrics over different features:

- NOF number of fields
- NOM number of methods
- WMC cyclomatic complexity
- LCOM lack of cohesion of methods
- DIT depth in the inheritance tree
- NSC number of children
- SIX specialization index
- NORM number of overridden methods

## Case Study

### Phase 1: Comparison between products

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## Results

|                            | NOF         | NOM          | WMC          | LCOM | DIT  | NSC   | SIX  | NORM  |
|----------------------------|-------------|--------------|--------------|------|------|-------|------|-------|
| Mean JFreeChart 1.0.0-pre2 | 2,40        | 10,08        | 22,98        | 0,21 | 2,55 | 0,36  | 0,16 | 0,69  |
| Bounded mean (15%)         | 1,41        | 7,45         | 15,87        | 0,17 | 2,47 | 0,04  | 0,08 | 0,46  |
| Q3                         | <b>3,00</b> | <b>11,00</b> | <b>25,00</b> | 0,50 | 3,00 | 0,00  | 0,14 | 1,00  |
| Q2 Median                  | 1,00        | 5,00         | 9,00         | 0,00 | 3,00 | 0,00  | 0,00 | 0,00  |
| Q1                         | <b>0,00</b> | <b>3,00</b>  | <b>6,00</b>  | 0,00 | 2,00 | 0,00  | 0,00 | 0,00  |
| Standard Deviation         | 5,05        | 15,01        | 38,82        | 0,32 | 1,14 | 1,48  | 0,37 | 1,23  |
| Minimum                    | 0,00        | 0,00         | 0,00         | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Maximum                    | 48,00       | 166,00       | 490,00       | 1,00 | 7,00 | 16,00 | 3,20 | 9,00  |
|                            | NOF         | NOM          | WMC          | LCOM | DIT  | NSC   | SIX  | NORM  |
| Mean Junit-3.8.1           | 2,17        | 8,13         | 15,70        | 0,21 | 2,70 | 0,28  | 0,18 | 0,35  |
| Bounded mean (15%)         | 1,50        | 6,53         | 12,33        | 0,18 | 2,58 | 0,15  | 0,09 | 0,28  |
| Q3                         | <b>2,00</b> | <b>9,75</b>  | <b>15,75</b> | 0,50 | 3,75 | 0,00  | 0,12 | 1,00  |
| Q2 Median                  | 1,00        | 4,50         | 8,00         | 0,00 | 2,00 | 0,00  | 0,00 | 0,00  |
| Q1                         | <b>0,00</b> | <b>2,00</b>  | <b>4,00</b>  | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Standard Deviation         | 3,59        | 10,35        | 20,42        | 0,33 | 1,84 | 0,72  | 0,45 | 0,60  |
| Minimum                    | 0,00        | 0,00         | 1,00         | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Maximum                    | 18,00       | 62,00        | 106,00       | 0,91 | 6,00 | 3,00  | 2,00 | 3,00  |
|                            | NOF         | NOM          | WMC          | LCOM | DIT  | NSC   | SIX  | NORM  |
| Mean Jcoverage-1.0.5       | 1,49        | 4,35         | 9,56         | 0,24 | 1,78 | 0,39  | 0,81 | 0,28  |
| Bounded mean (15%)         | 1,23        | 3,70         | 8,17         | 0,20 | 1,62 | 0,19  | 0,10 | 0,21  |
| Q3                         | <b>2,00</b> | <b>5,00</b>  | <b>14,00</b> | 0,50 | 2,00 | 0,00  | 0,00 | 0,00  |
| Q2 Median                  | 1,00        | 3,00         | 5,00         | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Q1                         | <b>0,00</b> | <b>2,00</b>  | <b>3,00</b>  | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Standard Deviation         | 1,87        | 4,46         | 9,59         | 0,34 | 1,05 | 0,96  | 0,37 | 0,52  |
| Minimum                    | 0,00        | 0,00         | 1,00         | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Maximum                    | 7,00        | 25,00        | 46,00        | 1,00 | 5,00 | 4,00  | 1,67 | 2,00  |
|                            | NOF         | NOM          | WMC          | LCOM | DIT  | NSC   | SIX  | NORM  |
| Mean easymock-2.0          | 1,41        | 5,83         | 12,54        | 0,15 | 1,24 | 0,09  | 0,12 | 0,33  |
| Bounded mean (15%)         | 1,24        | 4,13         | 8,32         | 0,11 | 1,08 | 0,00  | 0,02 | 0,16  |
| Q3                         | <b>2,00</b> | <b>5,00</b>  | <b>13,50</b> | 0,33 | 1,00 | 0,00  | 0,00 | 0,00  |
| Q2 Median                  | 1,00        | 3,00         | 3,50         | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Q1                         | <b>1,00</b> | <b>3,00</b>  | <b>3,00</b>  | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Standard Deviation         | 1,34        | 7,51         | 19,25        | 0,24 | 0,67 | 0,46  | 0,41 | 0,73  |
| Minimum                    | 0,00        | 0,00         | 0,00         | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Maximum                    | 6,00        | 38,00        | 105,00       | 0,85 | 4,00 | 3,00  | 2,00 | 3,00  |
|                            | NOF         | NOM          | WMC          | LCOM | DIT  | NSC   | SIX  | NORM  |
| Mean struts-1.2.8          | 2,91        | 8,60         | 18,84        | 0,28 | 2,59 | 0,46  | 0,51 | 0,96  |
| Bounded mean (15%)         | 2,09        | 6,66         | 13,21        | 0,25 | 2,45 | 0,24  | 0,33 | 0,67  |
| Q3                         | <b>4,00</b> | <b>11,00</b> | <b>22,00</b> | 0,67 | 4,00 | 1,00  | 0,60 | 1,00  |
| Q2 Median                  | 2,00        | 4,00         | 8,00         | 0,00 | 2,00 | 0,00  | 0,00 | 0,00  |
| Q1                         | <b>0,00</b> | <b>2,00</b>  | <b>3,00</b>  | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Standard Deviation         | 4,56        | 11,02        | 29,13        | 0,36 | 1,48 | 1,13  | 0,95 | 2,04  |
| Minimum                    | 0,00        | 0,00         | 0,00         | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Maximum                    | 40,00       | 82,00        | 260,00       | 0,98 | 7,00 | 10,00 | 5,00 | 28,00 |
|                            | NOF         | NOM          | WMC          | LCOM | DIT  | NSC   | SIX  | NORM  |
| Mean JHotDraw60b1          | 1,40        | 9,51         | 13,36        | 0,16 | 2,84 | 0,57  | 0,31 | 0,73  |
| Bounded mean (15%)         | 1,09        | 7,72         | 10,31        | 0,11 | 2,68 | 0,07  | 0,16 | 0,38  |
| Q3                         | <b>2,00</b> | <b>11,00</b> | <b>14,00</b> | 0,00 | 4,00 | 0,00  | 0,32 | 1,00  |
| Q2 Median                  | 1,00        | 7,00         | 9,00         | 0,00 | 3,00 | 0,00  | 0,00 | 0,00  |
| Q1                         | <b>0,00</b> | <b>4,00</b>  | <b>5,00</b>  | 0,00 | 2,00 | 0,00  | 0,00 | 0,00  |
| Standard Deviation         | 1,86        | 10,40        | 16,76        | 0,30 | 1,49 | 3,84  | 0,74 | 1,70  |
| Minimum                    | 0,00        | 0,00         | 0,00         | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Maximum                    | 19,00       | 90,00        | 158,00       | 1,50 | 9,00 | 71,00 | 8,00 | 19,00 |

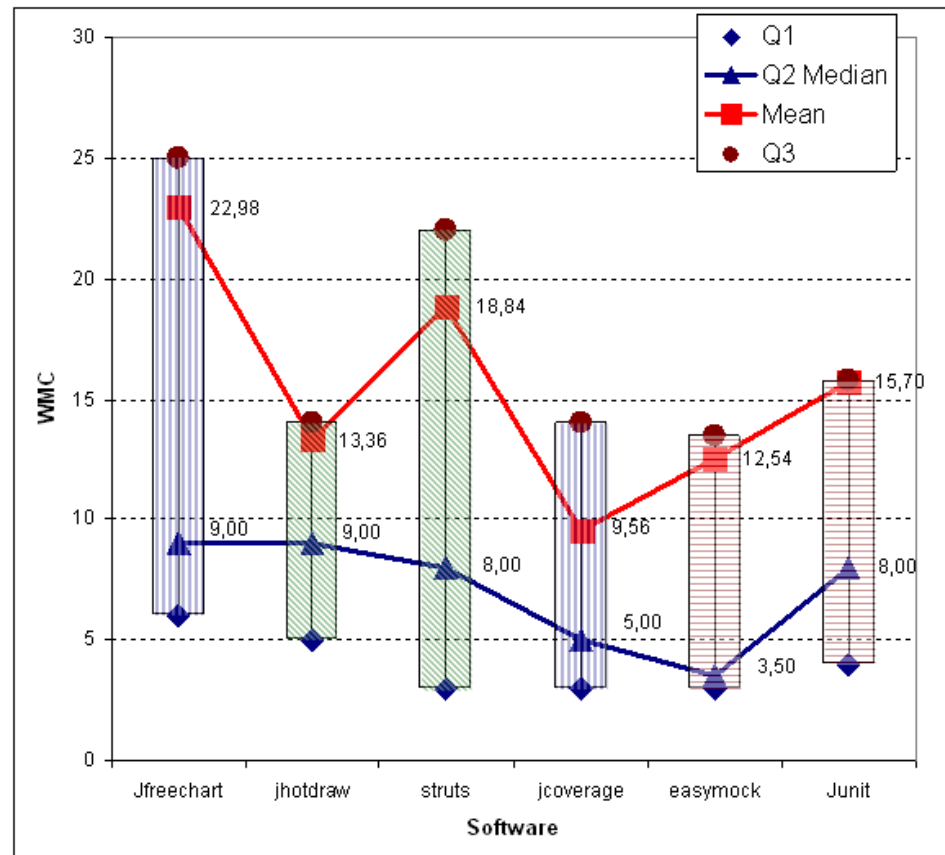
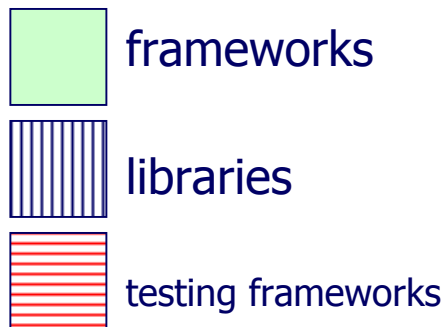
## Partial Conclusions

Phase 1: Comparison between products

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### ■ Example: WMC

- box plot removing “whiskers”
- different values between distributions



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## Partial Conclusions

### Phase 1: Comparison between products

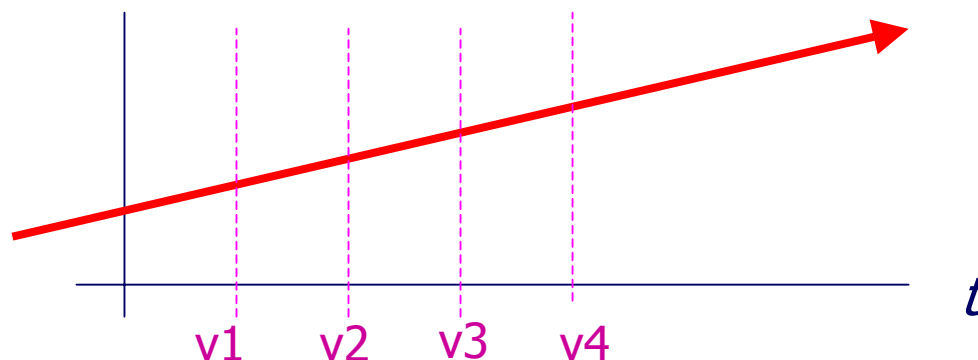
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#### ■ Initial observations and conclusions

- Distributions are not symmetrical with positive asymmetry
- Certain correlation of some metrics with size product
- Dispersed data
  - Differences between minimum and maximum values are large
  - Very different between products
- Kind of product does not determine distribution size

#### ■ Question

- Does absence of generic thresholds generate large metric changes between versions?



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## Case Study

### Phase 2: Metric evolution between versions

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#### ■ Phase 2: Metric evolution between versions

- Taking different versions of three products collecting the same metrics
  - along several years, even duplicating the number of classes from initial versions



- jfreechart-1.0.1 (691 classes, 2006-01-27)
- jfreechart-1.0.0-pre2 (629 classes, 2005-03-10)
- jfreechart-0.9.21 (570 classes, 2004-09-10)
- jfreechart-0.9.7 (492 classes, 2003-04-17)
- jfreechart-0.9.4 (326 classes, 2002-10-18)

#### JHotDraw

- jhotdraw-6.0b1 (497 classes, 2004-02-01)
- jhotdraw-5.4b2 (478 classes, 2004-01-31)
- jhotdraw-5.3 (208 classes, 2002-01-20)
- jhotdraw-5.2 (149 classes, 2001-02-18)



- junit-3.8.1 (47 classes)
- junit-3.2 (32 classes)
- junit-2.1 (19 classes)

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## Case Study

## Phase 2: Metric evolution between versions

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## Results

### JFreeChart

|                            | NOF   | NOM    | VMC    | LCOM | DIT  | NSC   | SIX  | NORM |
|----------------------------|-------|--------|--------|------|------|-------|------|------|
| Mean jfreechart-1.0.1      | 2,22  | 9,94   | 22,42  | 0,19 | 2,53 | 0,33  | 0,16 | 0,69 |
| Bounded mean (15%)         | 1,27  | 7,27   | 15,25  | 0,15 | 2,46 | 0,03  | 0,09 | 0,48 |
| Q3                         | 2,00  | 11,00  | 23,00  | 0,40 | 3,00 | 0,00  | 0,17 | 1,00 |
| Q2 Median                  | 1,00  | 5,00   | 9,00   | 0,00 | 3,00 | 0,00  | 0,00 | 0,00 |
| Q1                         | 0,00  | 4,00   | 7,00   | 0,00 | 2,00 | 0,00  | 0,00 | 0,00 |
| Standard Deviation         | 4,86  | 15,18  | 39,39  | 0,31 | 1,12 | 1,41  | 0,35 | 1,18 |
| Minimum                    | 0,00  | 0,00   | 0,00   | 0,00 | 1,00 | 0,00  | 0,00 | 0,00 |
| Maximum                    | 46,00 | 173,00 | 513,00 | 1,00 | 7,00 | 14,00 | 3,33 | 8,00 |
|                            | NOF   | NOM    | VMC    | LCOM | DIT  | NSC   | SIX  | NORM |
| Mean jfreeChart-1.0.0-pre2 | 2,40  | 10,08  | 22,98  | 0,21 | 2,55 | 0,36  | 0,16 | 0,69 |
| Bounded mean (15%)         | 1,41  | 7,45   | 15,87  | 0,17 | 2,47 | 0,04  | 0,08 | 0,46 |
| Q3                         | 3,00  | 11,00  | 25,00  | 0,50 | 3,00 | 0,00  | 0,14 | 1,00 |
| Q2 Median                  | 1,00  | 5,00   | 9,00   | 0,00 | 3,00 | 0,00  | 0,00 | 0,00 |
| Q1                         | 0,00  | 3,00   | 6,00   | 0,00 | 2,00 | 0,00  | 0,00 | 0,00 |
| Standard Deviation         | 5,05  | 15,01  | 38,82  | 0,32 | 1,14 | 1,48  | 0,37 | 1,23 |
| Minimum                    | 0,00  | 0,00   | 0,00   | 0,00 | 1,00 | 0,00  | 0,00 | 0,00 |
| Maximum                    | 48,00 | 166,00 | 490,00 | 1,00 | 7,00 | 16,00 | 3,20 | 9,00 |
|                            | NOF   | NOM    | VMC    | LCOM | DIT  | NSC   | SIX  | NORM |
| Mean jfreechart-0.9.21     | 2,38  | 9,99   | 22,47  | 0,21 | 2,52 | 0,36  | 0,16 | 0,66 |
| Bounded mean (15%)         | 1,41  | 7,33   | 15,44  | 0,17 | 2,45 | 0,05  | 0,08 | 0,44 |
| Q3                         | 2,00  | 12,75  | 26,00  | 0,50 | 3,00 | 0,00  | 0,16 | 1,00 |
| Q2 Median                  | 1,00  | 5,00   | 9,00   | 0,00 | 3,00 | 0,00  | 0,00 | 0,00 |
| Q1                         | 0,00  | 3,00   | 6,00   | 0,00 | 2,00 | 0,00  | 0,00 | 0,00 |
| Standard Deviation         | 4,93  | 15,20  | 38,66  | 0,32 | 1,12 | 1,47  | 0,37 | 1,20 |
| Minimum                    | 0,00  | 0,00   | 0,00   | 0,00 | 1,00 | 0,00  | 0,00 | 0,00 |
| Maximum                    | 47,00 | 155,00 | 473,00 | 0,96 | 7,00 | 16,00 | 3,00 | 8,00 |
|                            | NOF   | NOM    | VMC    | LCOM | DIT  | NSC   | SIX  | NORM |
| Mean jfreechart-0.9.7      | 2,14  | 7,03   | 15,63  | 0,20 | 3,21 | 0,31  | 0,17 | 0,49 |
| Bounded mean (15%)         | 1,22  | 5,06   | 11,08  | 0,15 | 3,07 | 0,04  | 0,07 | 0,28 |
| Q3                         | 2,00  | 9,00   | 19,00  | 0,50 | 4,00 | 0,00  | 0,09 | 1,00 |
| Q2 Median                  | 0,00  | 3,00   | 6,00   | 0,00 | 3,00 | 0,00  | 0,00 | 0,00 |
| Q1                         | 0,00  | 1,00   | 3,00   | 0,00 | 2,00 | 0,00  | 0,00 | 0,00 |
| Standard Deviation         | 4,55  | 10,65  | 24,45  | 0,32 | 1,97 | 1,34  | 0,44 | 1,02 |
| Minimum                    | 0,00  | 0,00   | 0,00   | 0,00 | 1,00 | 0,00  | 0,00 | 0,00 |
| Maximum                    | 39,00 | 87,00  | 203,00 | 1,00 | 7,00 | 15,00 | 3,00 | 7,00 |
|                            | NOF   | NOM    | VMC    | LCOM | DIT  | NSC   | SIX  | NORM |
| Mean jfreechart-0.9.4      | 2,69  | 7,77   | 18,00  | 0,26 | 3,02 | 0,40  | 0,27 | 0,61 |
| Bounded mean (15%)         | 1,71  | 6,13   | 13,51  | 0,22 | 2,85 | 0,08  | 0,11 | 0,32 |
| Q3                         | 3,00  | 11,00  | 24,00  | 0,62 | 4,00 | 0,00  | 0,16 | 1,00 |
| Q2 Median                  | 1,00  | 4,00   | 8,00   | 0,00 | 3,00 | 0,00  | 0,00 | 0,00 |
| Q1                         | 0,00  | 1,00   | 3,00   | 0,00 | 1,00 | 0,00  | 0,00 | 0,00 |
| Standard Deviation         | 4,87  | 9,70   | 25,11  | 0,35 | 1,95 | 1,49  | 0,70 | 1,34 |
| Minimum                    | 0,00  | 0,00   | 1,00   | 0,00 | 1,00 | 0,00  | 0,00 | 0,00 |
| Maximum                    | 39,00 | 60,00  | 195,00 | 1,00 | 7,00 | 16,00 | 6,00 | 8,00 |

## Case Study

## Phase 2: Metric evolution between versions

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## ■ Results

## ■ JHotDraw

|                    | NOF   | NOM   | WMC    | LCOM | DIT  | NSC   | SIX  | NORM  |
|--------------------|-------|-------|--------|------|------|-------|------|-------|
| Mean JHotDraw60b1  | 1,40  | 9,51  | 13,36  | 0,16 | 2,84 | 0,57  | 0,31 | 0,73  |
| Bounded mean (15%) | 1,09  | 7,72  | 10,31  | 0,11 | 2,68 | 0,07  | 0,16 | 0,38  |
| Q3                 | 2,00  | 11,00 | 14,00  | 0,00 | 4,00 | 0,00  | 0,32 | 1,00  |
| Q2 Median          | 1,00  | 7,00  | 9,00   | 0,00 | 3,00 | 0,00  | 0,00 | 0,00  |
| Q1                 | 0,00  | 4,00  | 5,00   | 0,00 | 2,00 | 0,00  | 0,00 | 0,00  |
| Standard Deviation | 1,86  | 10,40 | 16,76  | 0,30 | 1,49 | 3,84  | 0,74 | 1,70  |
| Minimum            | 0,00  | 0,00  | 0,00   | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Maximum            | 19,00 | 90,00 | 158,00 | 1,50 | 9,00 | 71,00 | 8,00 | 19,00 |
|                    | NOF   | NOM   | WMC    | LCOM | DIT  | NSC   | SIX  | NORM  |
| Mean jhotdraw54b1  | 1,41  | 9,67  | 13,89  | 0,16 | 2,90 | 0,58  | 0,32 | 0,73  |
| Bounded mean (15%) | 1,12  | 7,85  | 10,80  | 0,11 | 2,75 | 0,08  | 0,17 | 0,39  |
| Q3                 | 2,00  | 11,00 | 15,00  | 0,00 | 4,00 | 0,00  | 0,33 | 1,00  |
| Q2 Median          | 1,00  | 7,00  | 9,00   | 0,00 | 3,00 | 0,00  | 0,00 | 0,00  |
| Q1                 | 1,00  | 4,00  | 6,00   | 0,00 | 2,00 | 0,00  | 0,00 | 0,00  |
| Standard Deviation | 1,81  | 10,33 | 16,88  | 0,30 | 1,48 | 3,89  | 0,75 | 1,71  |
| Minimum            | 0,00  | 0,00  | 0,00   | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Maximum            | 16,00 | 88,00 | 148,00 | 1,50 | 9,00 | 71,00 | 8,00 | 19,00 |
|                    | NOF   | NOM   | WMC    | LCOM | DIT  | NSC   | SIX  | NORM  |
| Mean jhotdraw53    | 1,83  | 9,12  | 15,51  | 0,27 | 2,65 | 0,86  | 0,51 | 1,21  |
| Bounded mean (15%) | 1,46  | 7,07  | 11,60  | 0,23 | 2,43 | 0,20  | 0,41 | 0,97  |
| Q3                 | 3,00  | 10,00 | 18,00  | 0,63 | 3,00 | 0,00  | 0,75 | 2,00  |
| Q2 Median          | 1,50  | 6,50  | 12,50  | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Q1                 | 0,00  | 3,00  | 4,75   | 0,00 | 2,00 | 0,00  | 0,00 | 0,00  |
| Standard Deviation | 2,38  | 10,87 | 20,54  | 0,35 | 1,66 | 3,53  | 0,66 | 1,66  |
| Minimum            | 0,00  | 0,00  | 1,00   | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Maximum            | 17,00 | 72,00 | 146,00 | 1,50 | 8,00 | 40,00 | 3,00 | 12,00 |
|                    | NOF   | NOM   | WMC    | LCOM | DIT  | NSC   | SIX  | NORM  |
| Mean jhotdraw52    | 1,83  | 8,30  | 13,53  | 0,26 | 2,81 | 0,68  | 0,56 | 1,28  |
| Bounded mean (15%) | 1,52  | 6,37  | 10,25  | 0,23 | 2,60 | 0,24  | 0,48 | 1,06  |
| Q3                 | 3,00  | 10,00 | 15,25  | 0,60 | 3,00 | 0,00  | 1,00 | 2,00  |
| Q2 Median          | 1,00  | 5,00  | 8,00   | 0,00 | 2,00 | 0,00  | 0,28 | 1,00  |
| Q1                 | 0,00  | 3,00  | 4,00   | 0,00 | 2,00 | 0,00  | 0,00 | 0,00  |
| Standard Deviation | 2,19  | 9,82  | 16,84  | 0,33 | 1,70 | 1,91  | 0,66 | 1,69  |
| Minimum            | 0,00  | 0,00  | 1,00   | 0,00 | 1,00 | 0,00  | 0,00 | 0,00  |
| Maximum            | 14,00 | 61,00 | 108,00 | 1,50 | 8,00 | 12,00 | 3,11 | 12,00 |



## Case Study

## Phase 2: Metric evolution between versions

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## Results

### JUnit

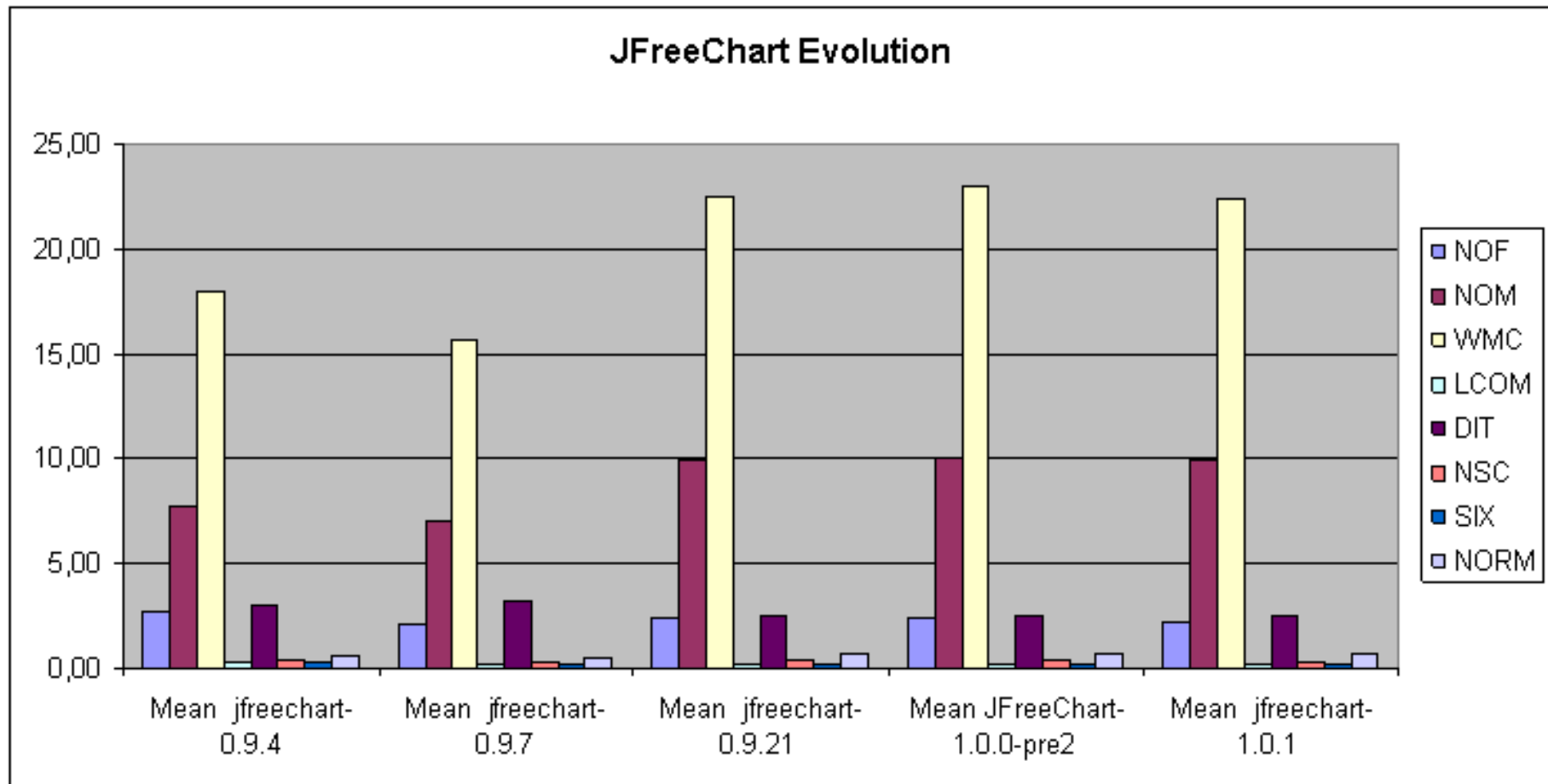
|                    | NOF   | NOM   | WMC    | LCOM | DIT  | NSC  | SIX  | NORM |
|--------------------|-------|-------|--------|------|------|------|------|------|
| Mean JUnit 3.8.1   | 2,17  | 8,13  | 15,70  | 0,21 | 2,70 | 0,28 | 0,18 | 0,35 |
| Bounded mean (15%) | 1,50  | 6,53  | 12,33  | 0,18 | 2,58 | 0,15 | 0,09 | 0,28 |
| Q3                 | 2,00  | 9,75  | 15,75  | 0,50 | 3,75 | 0,00 | 0,12 | 1,00 |
| Q2 Median          | 1,00  | 4,50  | 8,00   | 0,00 | 2,00 | 0,00 | 0,00 | 0,00 |
| Q1                 | 0,00  | 2,00  | 4,00   | 0,00 | 1,00 | 0,00 | 0,00 | 0,00 |
| Standard Deviation | 3,59  | 10,35 | 20,42  | 0,33 | 1,84 | 0,72 | 0,45 | 0,60 |
| Minimum            | 0,00  | 0,00  | 1,00   | 0,00 | 1,00 | 0,00 | 0,00 | 0,00 |
| Maximum            | 18,00 | 62,00 | 106,00 | 0,91 | 6,00 | 3,00 | 2,00 | 3,00 |
|                    | NOF   | NOM   | WMC    | LCOM | DIT  | NSC  | SIX  | NORM |
| Mean JUnit 3.2     | 2,72  | 7,94  | 14,75  | 0,25 | 2,56 | 0,19 | 0,13 | 0,34 |
| Bounded mean (15%) | 1,68  | 5,96  | 11,29  | 0,22 | 2,43 | 0,04 | 0,09 | 0,25 |
| Q3                 | 3,00  | 11,00 | 18,50  | 0,50 | 3,50 | 0,00 | 0,19 | 1,00 |
| Q2 Median          | 1,00  | 3,50  | 5,50   | 0,00 | 2,00 | 0,00 | 0,00 | 0,00 |
| Q1                 | 0,00  | 2,00  | 2,00   | 0,00 | 1,00 | 0,00 | 0,00 | 0,00 |
| Standard Deviation | 4,85  | 11,65 | 21,05  | 0,34 | 1,93 | 0,64 | 0,24 | 0,65 |
| Minimum            | 0,00  | 0,00  | 1,00   | 0,00 | 1,00 | 0,00 | 0,00 | 0,00 |
| Maximum            | 20,00 | 60,00 | 103,00 | 0,92 | 6,00 | 3,00 | 0,75 | 3,00 |
|                    | NOF   | NOM   | WMC    | LCOM | DIT  | NSC  | SIX  | NORM |
| Mean JUnit 2.1     | 2,16  | 8,11  | 14,05  | 0,22 | 2,53 | 0,32 | 0,31 | 0,58 |
| Bounded mean (15%) | 1,35  | 7,18  | 12,41  | 0,19 | 2,41 | 0,18 | 0,17 | 0,47 |
| Q3                 | 2,00  | 8,50  | 18,00  | 0,50 | 3,00 | 0,00 | 0,26 | 1,00 |
| Q2 Median          | 1,00  | 4,00  | 6,00   | 0,00 | 2,00 | 0,00 | 0,00 | 0,00 |
| Q1                 | 0,00  | 4,00  | 4,00   | 0,00 | 1,00 | 0,00 | 0,00 | 0,00 |
| Standard Deviation | 4,06  | 8,52  | 15,30  | 0,31 | 1,61 | 0,82 | 0,70 | 0,84 |
| Minimum            | 0,00  | 1,00  | 1,00   | 0,00 | 1,00 | 0,00 | 0,00 | 0,00 |
| Maximum            | 18,00 | 31,00 | 55,00  | 0,89 | 6,00 | 3,00 | 3,00 | 3,00 |

# Case Study

## Phase 2: Metric evolution between versions

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### ■ Example: Evolution in JFreeChart during 4 years

*July, 3rd, 2006*

## Partial Conclusions

Phase 2: Metric evolution between versions

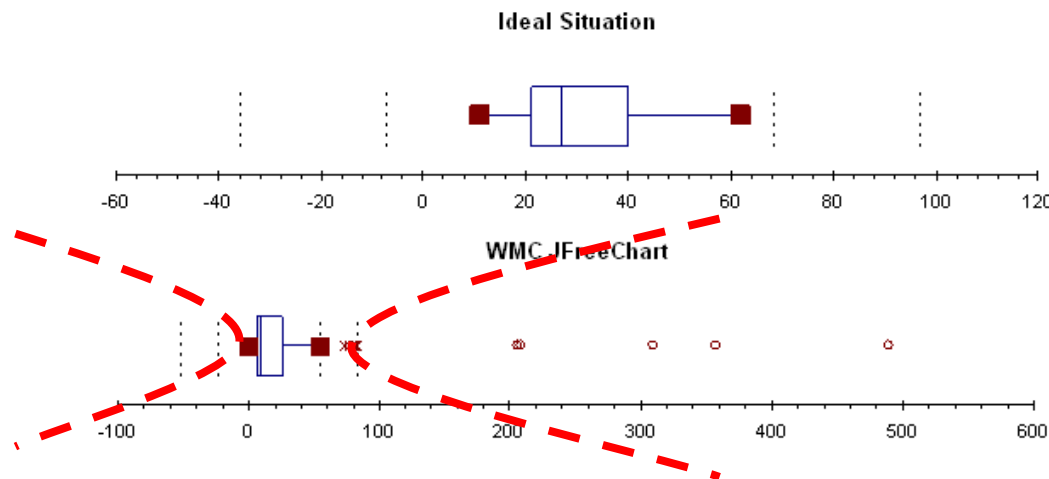
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- For each product, its relative threshold is stable between versions
- Thresholds should be defined depending on the product
  - can be fixed between stable versions
- Problem: *How can we fix thresholds in first versions?*
  - estimation from similar products (functionality, size, ...)

# Applying Relative Product Thresholds

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- Many *bad smells* are defined as
  - “high” or “low” values (of metrics)
- Based on previous definition:
  - high and low values could be identified as outliers in distributions

*July, 3rd, 2006*

# Applying Relative Product Thresholds

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## ■ Example

### ■ Lazy Class

- *"Classes are not doing enough..."*

- Used criterion:

  - $\text{NOF} \leq Q1_{\text{NOF}} \text{ AND } \text{NOM} \leq Q1_{\text{NOM}} \text{ AND } \text{WMC} \leq Q1_{\text{WMC}}$

### ■ Large Class

- *"Classes too large..."*

- Used criterion:

  - $\text{NOF} \geq Q3_{\text{NOF}} \text{ AND } \text{NOM} \geq Q3_{\text{NOM}} \text{ AND } \text{WMC} \geq Q3_{\text{WMC}}$

# Applying Relative Product Thresholds

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- For example:
  - *"What happens if we apply same criteria used with Junit on JFreechart?"*
  - Number of suspicious classes is very different
- **Lazy Class**
  - 63 suspicious classes
    - $Q1_{NOF}=0$ ,  $Q1_{NOM}=2$ ,  $Q1_{WMC}=4$ , with JUnit values
  - 97 suspicious classes
    - $Q1_{NOF}=0$ ,  $Q1_{NOM}=3$ ,  $Q1_{WMC}=6$ , with JFreeChart new calculated value
- **Large Class**
  - 148 suspicious classes
    - $Q3_{NOF}=2$ ,  $Q3_{NOM}=9.75$ ,  $Q3_{WMC}=15.75$ , with JUnit values
  - 108 suspicious classes
    - $Q3_{NOF}=3$ ,  $Q3_{NOM}=11$ ,  $Q3_{WMC}=25$ , with JFreeChart new calculated values

# Conclusions

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- Use of generic thresholds with metric collection
- Not the best solution to detect bad smells
- We give an approach using relative thresholds in bad smell detection
  - has been pointed their suitability
  - intended process
    - iteratively calculate metrics, detect bad smells, correct through refactorings, recalculate metrics and check outliers
    - absence (small number) of bad smells stops the process

# Proposal and Future Work

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- Relative product thresholds should be integrated in our current proposal of bad smell detection
  - Step towards tools that support metric collection and bad smells



- Need of more examples:
  - What happens with other languages?
  - What happens with other kind of products?
  - Does programmer experience, background, culture, ... have any effect?





### Relative Thresholds: Case Study to Incorporate Metrics in the Detection of Bad Smells



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