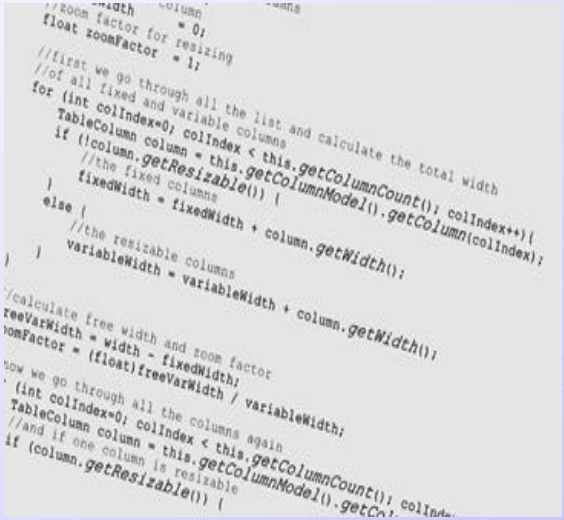

Software Quality Workshop @ NetObjectDays2004

Assessing and interpreting object-oriented software complexity with structured and independent metrics

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Structure

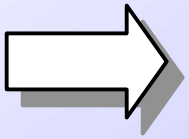
1. Introduction
2. Preparing data
3. Removing metrics correlation
4. Interpreting complexity results
5. Praxis example
6. Prospects

Why assessing complexity as a fault source

- Complexity from a cognition view

Difficulty to understand system behaviour even when all system parts are understood

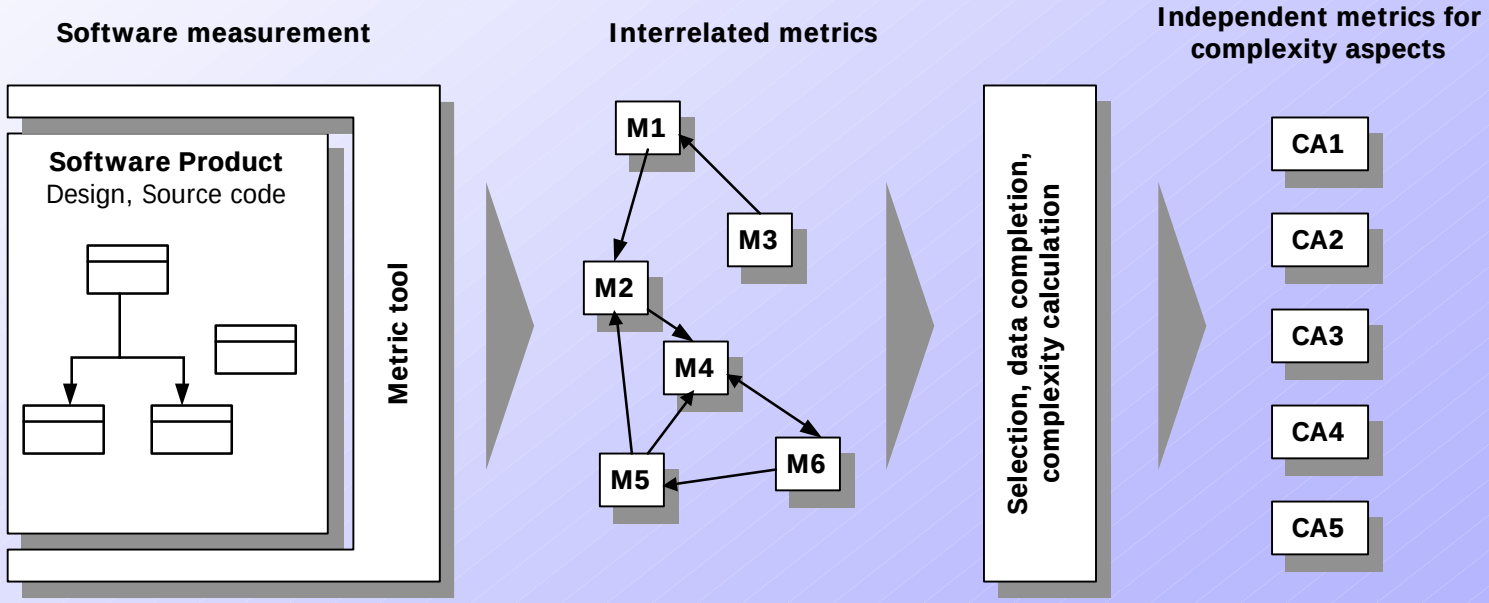
- Complicates overview on side effects
  - Cross-references from invocation and inheritance
- Overlooked side effects can cause faults



Complexity aspects need to be surveyed

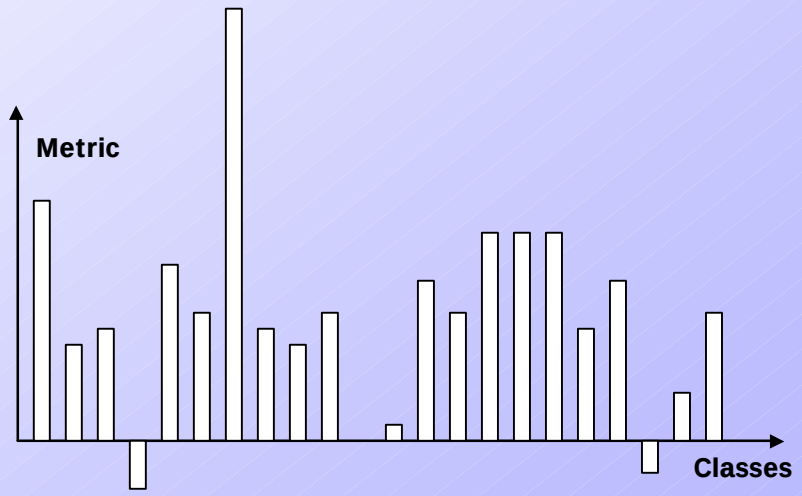
Complexity measurement process

- Metrics based software product assessment
- Inspection of raw data for missing or outlier values
- Metrics selection with a classification structure



Data Preparation

- Missing data tampers statistics (e.g. average with no values)
- Techniques for treating missing data
  - List Deletion – deleting data row
  - Mean Imputation – replacing with metric mean
  - Regression Imputation – fitting curve, for time based metrics
  - Siminar Response Pattern Imputation – for multidimensional data
  - Multiple Imputation – filling with values of random other classes



De – correlation of metrics

- Interrelations between metrics complicate drawing conclusions
  - Metrics are high correlated
  - Linear factors of high correlatey metrics are variable – constant sum
  - A large class cannot be separated without increasing inheritance / coupling

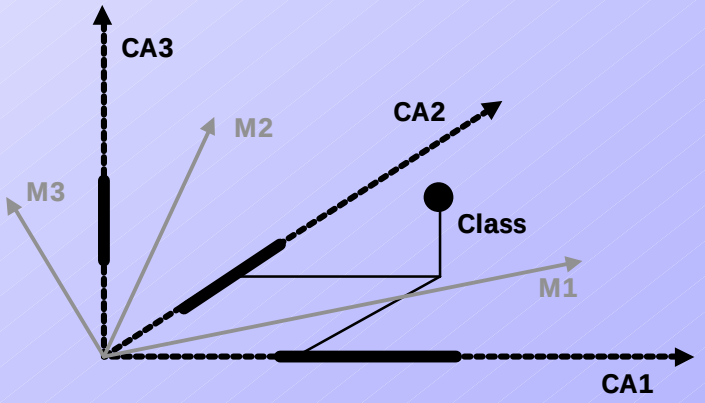
- Principal Components Analysis removes Interrelations
  - Basis technique for generating independent variables
  - Every Principal Component is a linear combination of metrics
  - Factors of linear combination make Principal Components interpretable
  - Eigenvalues of Principal Components describing importance (data variance)

Principal Components Analysis

- Multivariate technique for independent metrics
  - Each Principal Component is a linear combination of metrics

$$y_1 = \sum_{i=1}^{n} a_{1i} * x_i ; \qquad \sum_{i=1}^{n} a_{1i}^2 = 1$$

  - Principal Components describing decreasing data variance
  - Rotation and orthogonalisation in n-dim. Space
  - Axis points to maximum variance



- Interpretable transformation to independent interpretable ‘virtual metrics’

From Principal components to complexity aspects

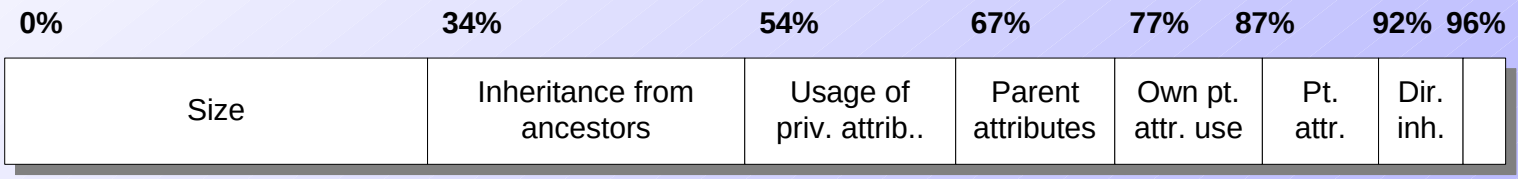
- Results of PCA technique describe aspects and importance
  - Metric factors for linear combination indicate meaning of the Principal Component
  - Eigenvalue indicates importance in the data set

PC / Metric	LOC	DIT	NOM	CBO
1: Factor loading	1.1	0.2	0.9	0.4
1: Contribution	40%	5%	30%	15%
2: Factor loading	-0.1	0.1	0.3	0.5
2: Constribution	5%	5%	30%	40%

- Example for interpretation
  - PC1 size related
  - PC2 coupling related independent to size

Praxis example: technical software

- Component of railway operation system surveyed
  - Language C++
  - Approx. 800 classes, 15 metrics
  - Outlier and missing values inspected
  - Only components with Eigenvalue >0.5 selected



- Toplists for all classes and all complexity aspects
  - Basis for selection of reengineered classes

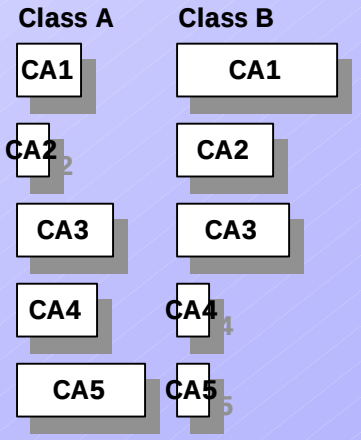
Usage and prospects

Characteristics

- Overview on complexity aspects of object-oriented Software
- Interpretation through descriptive vectors and metrics
- Improved system view with independent aspects
- Usable for object oriented source code and (shortened) UML-Design

Further usage

- Independent ‘virtual metrics’ for empirical modeling techniques
- Reduced calculation number



Complexity comparision between system classes for test, integration order or reengineering

Discussion