Paradigm Independent Software Complexity Metrics

Dr. Zoltán Porkoláb
Department of Programming Languages and Compilers
Eötvös Loránd University, Faculty of Informatics

e-mail: gsd@elte.hu

The structure of the presentation

- The role of software metrics
- Metrics: an overview
- Object-oriented software metrics
- Multiparadigm programming
- The AV-graph
- Results

Role of software metrics

- Cost of the software
  - Specification
  - Design
  - Implementation
  - Testing & Bug-fixing
  - Maintenance
- More than 70% of cost is for testing and maintenance (Zuse 1998)
- Software quality

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Software metrics

- Software metrics:
  - Measuring the development process (process metrics)
  - Measuring the product (product metrics)
- Product metrics:
  - External metrics:
    - Reliability metrics
    - Functional metrics
    - Efficiency metrics
  - Internal product metrics:
    - Size
    - Complexity
    - Style

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Product metrics

- Size metrics:
  - LOC, eLOC
  - Ignore the semantic

Structural metrics:

- McCabe 1976
  - Motivation: predict testing efforts
  - For structured programs: V(G) = p + 1
- Howatt and Baker 1989
  - Motivation: involve nesting level
  - SN(G) = |N|+ND(G)

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Object-oriented metrics in theory

- Chidamber-Kemerer (1994) OO metrics suite:
  - WMC (Weighted Methods per Class)
  - DIT (Depth of Inheritance Tree, DIT)
  - NOC (Number of Child Classes)
  - CBO (Coupling Between Object Classes) fan-in and fan out
  - RFC (Response for Class)
  - LCOM (Lack of Cohesion in Methods)
    - Chidamber - Kemerer
    - Henderson - Sellers

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Object-Oriented metrics in practice

- Eclipse (www.eclipse.org)
  - McCabe cyclomatic complexity
  - Efferent coupling (≠ fan out!)
  - Lack of Cohesion
  - LOC (Lines of Code)
  - Number of Fields in Classes
  - Nesting Depth
  - Number of Method Parameters
  - Number of Statements
  - Weighted Methods per Class

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Software paradigm

- Evolution of Software paradigm
  - Structured programming
  - Object-oriented programming
    - Classes, inheritance, virtual function
  - Generative programming
    - Aspect-Oriented (Kitzales 1994)
    - Intentional (Simonyi 1995)
    - Template metaprogramming (Veldhuizen 1994)
- Multiparadigm programming (Coplien 1998)
  - Simultaneous usage of paradigms

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Paradigm-independent Software Metrics

Applicable for programs written in different paradigms or in mixed-paradigm environment

Based on general programming language features which are paradigm- and language-independent. The paradigm-dependent attributes are derived from these features.

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Components

- Control Structure of Program
  - Most of the programs share the same control statements
- Complexity of Data Types
  - Reflects the complexity of data types used (like classes)
- Complexity of Data Access
  - Connection between control structure and data
    - Direction of data flow
    - Nesting depth

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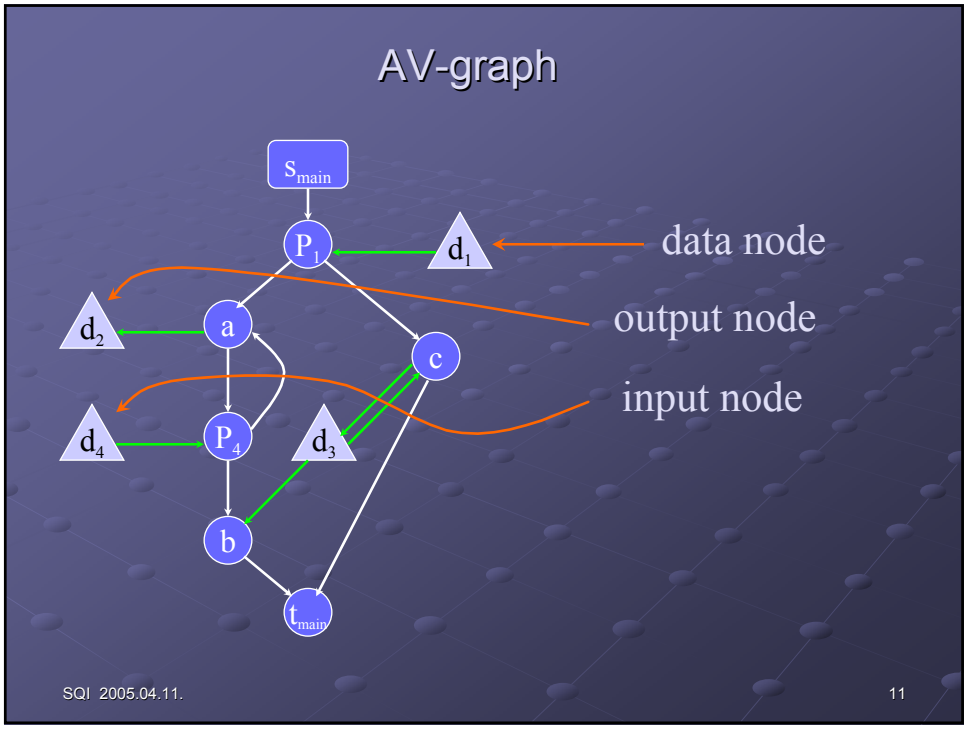
AV-graph
s_{main}
P_1
d_1
data node
d_2
a
c
output node
d_4
P_4
d_3
input node
b
t_{main}
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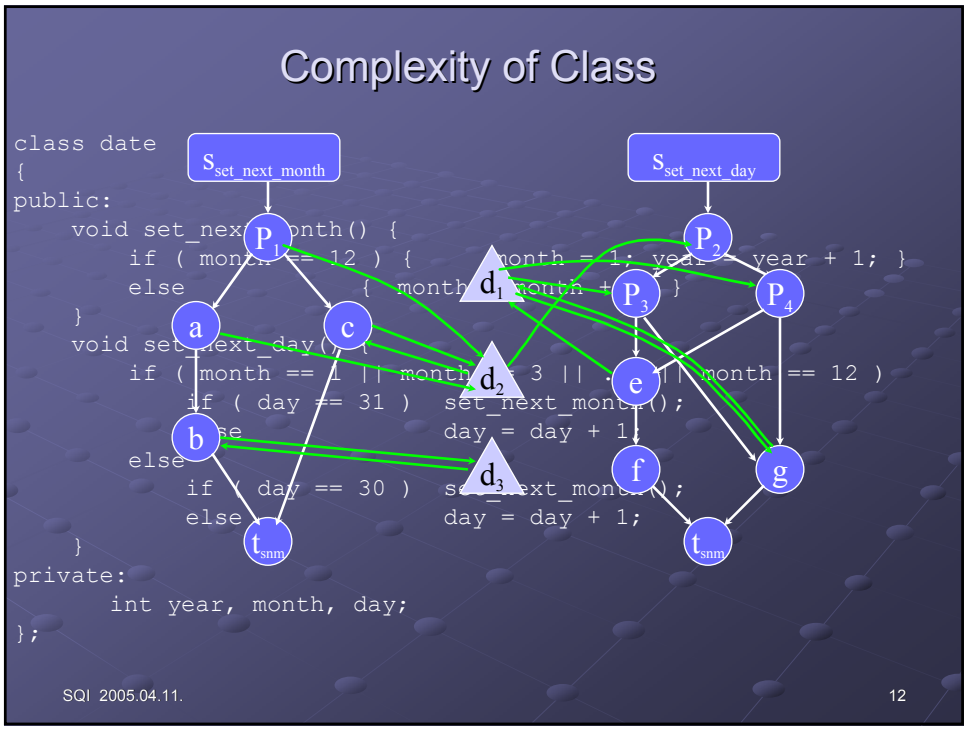
Complexity of Class
class date
{
public:
void set_next_month() {
if (month == 12) {
else
}
void set_next_day() {
if (month == 1 || month == 3 || month == 12)
if (day == 31)
else
if (day == 30)
else
}
private:
int year, month, day;
};
$s_{set\_next\_month}$
$s_{set\_next\_day}$
P_1
P_2
P_3
P_4
d_1
d_2
d_3
a
c
b
e
f
g
t_{snm}
t_{snm}
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Our Measuring tool

- Supported languages
  - Java 1.3
  - Java 1.4 (assert)
  - Java 5 (generics)
- Implementation
  - standalone application and Eclipse Plug-in
- Ouput
  - CSV
  - XML

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Test Data

- Java Standard Library 1.4.2
  - 367.000 eLOC
- jBOSS 3.2.3
  - 300.000 eLOC
- Omg.org.CORBA
  - 5.000 eLOC
- The measure tool (with mostly generated parser)
  - 7.000 eLOC
- Eclipse 3.0M6
  - 900.000 eLOC
- **17.000 class – more than 1.5 million lines**

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Results

- No statistical correlation between the OO and multi paradigm metrics:
  - OO metrics only measure the big picture
  - MPM consider more properties: higher density
  - The structural complexity of methods are extremely increase the overall complexity.

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