

EmpAnADa Project

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Outline

- EmpAnADa introduction
- Part I
 - Completeness and consistency in detail
- Part II
 - Background
 - UML
 - Empirical research
 - Measurement
 - Directions of the project
 - Metrics
 - Refactoring and changes in an artifact
 - Completeness and Consistency
 - Visualization of Metrics
 - EmpAnADa and LaQuSo



EmpAnADa

- Empirical Analysis of Architecture and Design Quality
- Development of quantitative methods to predict attributes of early artifacts, mainly UML models
 - Quality (maintainability, changeability...)
 - Effort estimation
 - Identification of fault-prone elements
- Empirical studies to
 - Validate methods
 - Investigate UML usage and problems in practice



Part I

Empirical Assessment of Completeness in Industrial UML Designs



Overview of Part I

- Completeness
 - Decomposition
 - Consistency
- Techniques Developed
- Case Studies
- Observations
- Conclusions



Why Completeness?

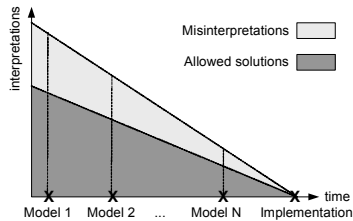
- Interviews and surveys investigating industrial use of UML
 - Uncertainty about precision and accuracy of design metrics for prediction of quality attributes
 - Miscommunication
 - Integration problems
 - Uncertainty about completeness of model



Completeness & Consistency

Problem:

- (Early) models allow several solutions/interpretations (dark grey)
 - Source code describes exactly one solution
- Misinterpretations amplified by (light grey)
 - lack of completeness
 - presence of conflicts
 - UML specific: overlapping diagram types, no formal semantics, degrees of freedom

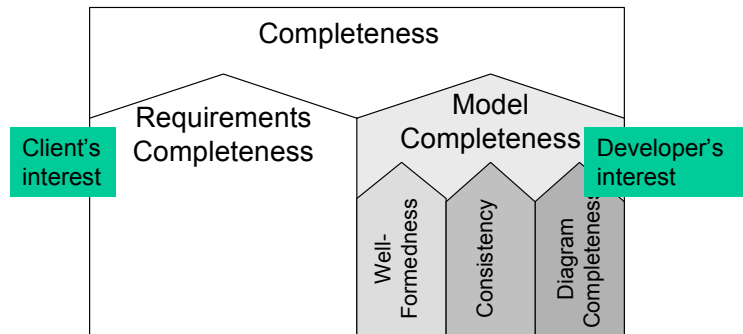


Goal:

Investigate the magnitude of completeness of UML models in industrial practice



Decomposition of Completeness

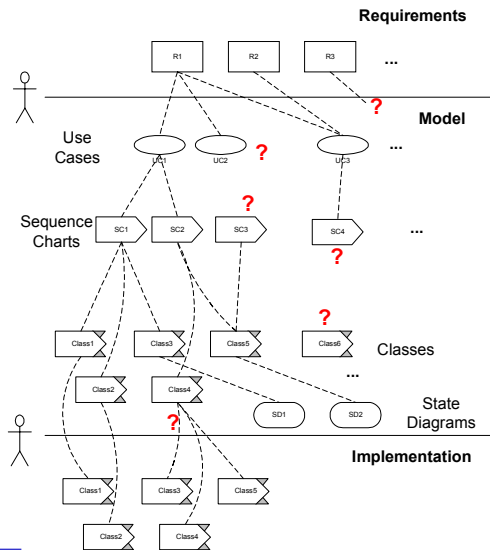


- Well-Formedness:
 - property of individual diagram
- Consistency and Diagram Completeness:
 - relation between different diagrams

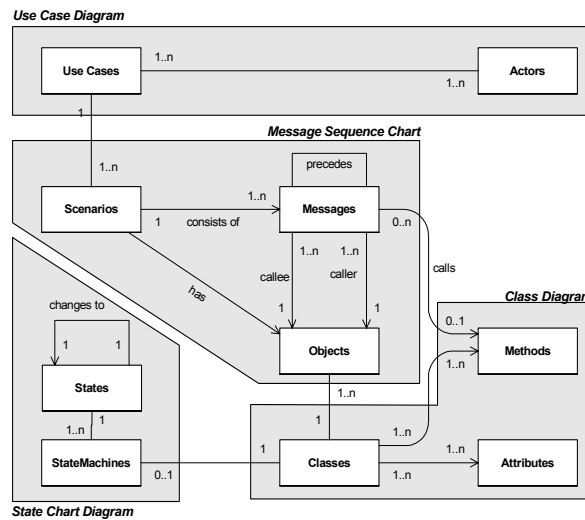


Scope of Analysis

- Requirements can be traced across multiple diagram types
- Examples of incompleteness
- Scope of analysis



Relational Meta Model



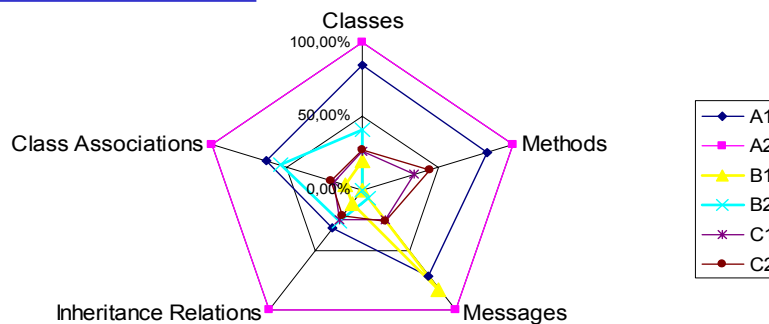
Examples of Rules

- Well-formedness
 - Objects in SD must have a role name
 - Classes must have methods
- Consistency
 - Messages in SD must correspond to method in class diagram
- Completeness
 - Interaction of classes must be described in SD
 - Methods must be called in SD



Rule-checking is implemented in a tool

Case Studies



A1, A2

- Image processing
- Subsystems, same version
- 168 classes, 853 messages
- >100 man years
- Real-world

B1, B2

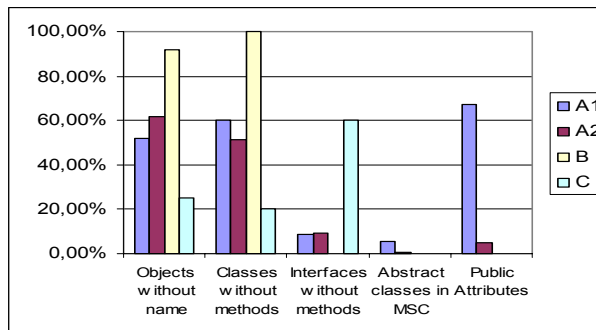
- Embedded Controller
- Subsequent versions, redesign
- 69 classes, 705 messages
- >100 man years
- Real-world

C1, C2

- Embedded Controller
- Subsequent version, inspection in between
- 46 classes, 219 messages
- 1,5 man years
- Post-grad students

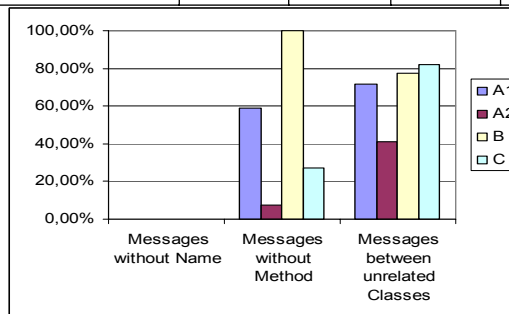
Results: Well-formedness Rules

	A1	A2	B	C
Objects without name	52.00%	61.58%	91.92%	25.24%
Classes without methods	60.19%	51.19%	100.00%	20.00%
Interfaces without methods	8.82%	9.38%	N/A	60.00%
Abstract classes in MSC	5.56%	0.60%	0.00%	0.00%
Public Attributes	67.23%	5.08%	0.00%	0.00%



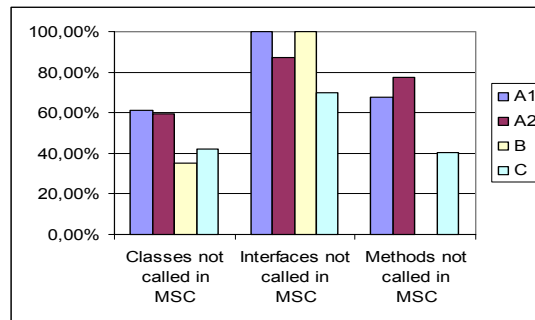
Results: Consistency Rules

	A1	A2	B	C
Messages Without Name	0.00%	0.00%	0.28%	0.00%
Messages without Method	58.73%	7.62%	100.00%	27.14%
Messages between unrelated Classes	71.94%	41.03%	77.73%	81.90%



Results: Completeness Rule

	A1	A2	B	C
Classes not called in MSC	61.11%	59.52%	35.29%	42.22%
Interfaces not called in MSC	100.00%	87.50%	100.00%	70.00%
Methods not called in MSC	67.65%	77.59%	N/A	40.14%



Observations in Case Studies

- Strong differences in the habits of designers
 - even within a single project
 - miscommunication may be reduced by modeling standards
- Degradation between C1 and C2 wrt. SD completeness: rules helped identify missing SD's
- Odd results for SD-rules in B2: identified that wrong version of model was in project repository.
- Case C has best scores: off critical-path project (?)
- Results of assessments can be used for
 - focusing of improvements
 - monitoring progress
 - benchmarking: comparison between different models (versions, sub-models, processes)



Contributions & Conclusions

- Industrial-strenght techniques for quantitative assessment of incompletenesses and inconsistencies.
- Case studies provided insight into use of the UML
 - Absolute number of rule violations quite large
 - Industrial projects move into implementation while there are still many incompletenesses
- Incomplete spots identified by tool were confirmed by designers and led to improvements in the design



Future Work

- Which degree of completeness is needed?
 - for high accuracy and precision of estimates
 - to reduce miscommunication
- Do incompleteness and inconsistencies of the model result in flaws in the implementation?
- Can “Modeling standards” (enforced by tooling) improve completeness?



Part II

Background Topics & Future Directions



Background - UML

- Unified Modeling Language
 - Booch, Rumbaugh, Jacobson : 1997
- Purpose: visual modelling of different aspects of the system
 - Higher abstraction level than programming
- Diagrams are views on the model
- 9 diagram types

Structural

Class diagram
Package diagram
Object diagram
Use case diagram
Deployment diagram

Behavioral

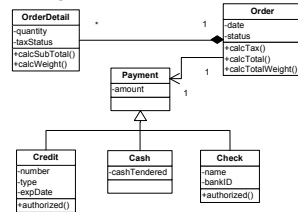
Sequence diagram
Collaboration diagram
State diagram
Activity diagram

- Extensible by stereotypes, tagged values, meta-model changes
- Lack of formal semantics

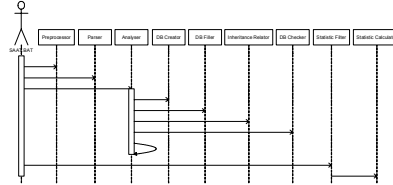


Background – UML

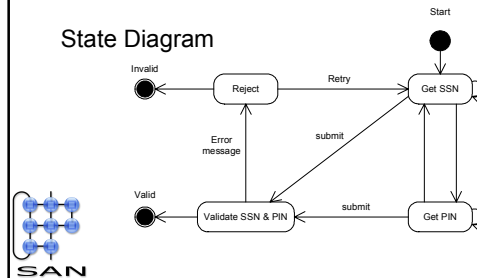
Class Diagram



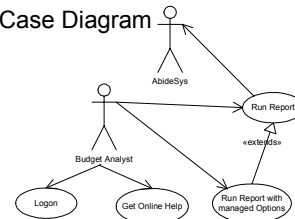
Sequence Diagram



State Diagram



Use Case Diagram



Background – Empirical Research

- SW engineering is cross-disciplinary
 - Technical issues
 - Networks, databases, operating systems...
 - Language issues
 - Syntax, semantics
 - Social issues and psychology
 - Why empirical SW engineering research?
 - Quantitative studies give objective and statistically significant results regarding
 - Understanding
 - Controlling
 - Predicting
 - Improving
- } Of the SW Development process
- Empirical strategies
 - Surveys
 - Experiments
 - Case Studies



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Background – Empirical Research Strategies

Factor	Survey	Experiment	Case study
Execution control	No	Yes	No
Measurement control	No	Yes	Yes
Investigation cost	Low	High	Medium
Ease of replication	High	High	Low

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Empirical Research in EmpAnADa

- Survey
 - Web-questionnaire about UML usage
- Experiment
 - Classroom experiment is planned
- Case Studies
 - Always looking for case studies
 - Currently contacts to
 - Philips (PMS, Optical Storage)
 - Siemens Corporate Research
 - LogicaCMG / Thales
 - Océ
 - CGE&Y
 - CBS

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Background - Measurement

- “*Measurement is a mapping from the empirical world to the formal, relational world*” (Fenton)
- Types of metrics
 - Product
 - Lines of Code (LOC), Depth of Inheritance, number of defects...
 - Process
 - Cost per number of errors found, coverage of a test...
 - Resource
 - Team size, experience of staff, age of staff...
- Most product metrics research is about finished products



Measurement in EmpAnADa

- Metrics are objective and automatically collectable
- Implementation metrics
 - Measure the exact product
 - Rather late
- Design Metrics
 - Early feedback in the analysis and design phase
 - Not all implementation metrics can be used
 - Opportunity for new metrics (multi-view)



Measurement in EmpAnADa II

- Relation between design metrics and properties of product
 - Quality properties
 - Maintainability
 - Comprehensibility
 - Changeability
 - ...
 - Defects
 - Finding relationships between metrics and test data, bugreports
 - Metrics to predict fault-prone classes
 - Prediction of process data
 - Development effort
 - Resource usage
- Design metrics as predictions: Accuracy and Precision
 - Depend on
 - Correspondence of model and source code
 - Completeness and Consistency of model



Completeness and Consistency

- Define completeness and consistency for UML models
- Assess the magnitude of violations in industrial practice
- What are the effects of C&C violations for the implementation?
- Which degree of C&C is needed for precise and accurate predictions based on UML models?

Part I



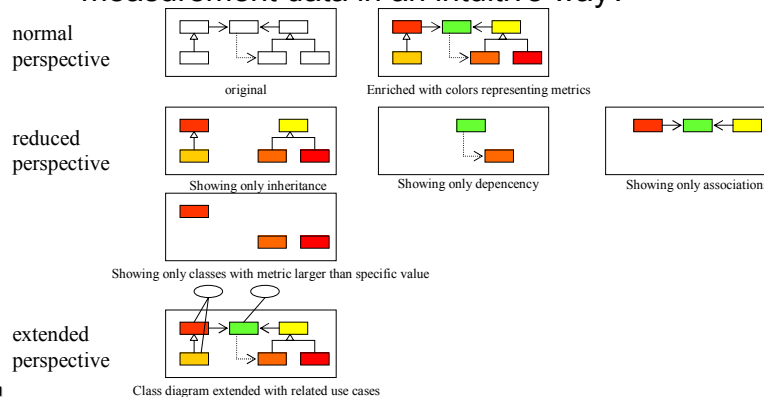
Refactoring and Evolution

- Refactoring:
 - “*Changing a SW system to improve its structure without altering the external behavior*” (Fowler)
 - Most literature considers source code refactorings
 - Approaches:
 - Defining higher level refactorings (architecture, design)
 - Investigating the role of metrics as “design smells”
- Evolution
 - How does the quality of designs change over subsequent versions?

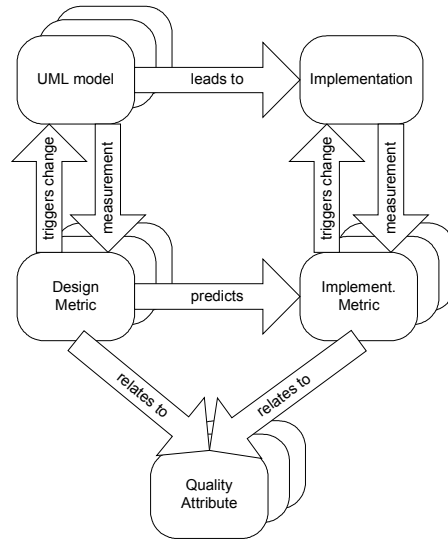


Visualization of Metrics and Artifacts

- For large systems metrics tools produce large amount of data
- Which techniques are useful to present the measurement data in an intuitive way?

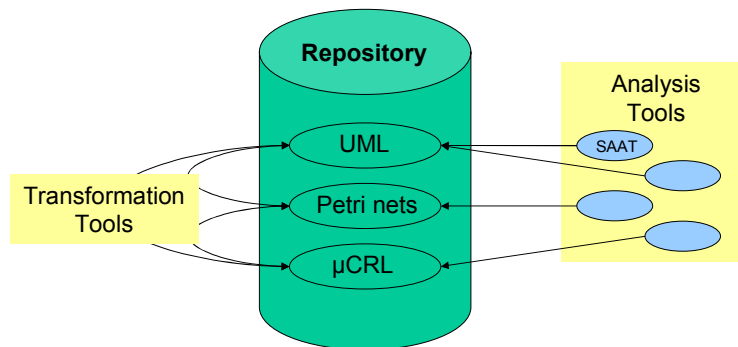


Summary of topics



Activity within LaQuSo

- Architecture Repository Group
 - Developing a repository to store SW architectures and designs in different formalisms



Discussion

