Proseminar work:
Investigation of Ontologies in Software-Engineering-(Meta-)Research

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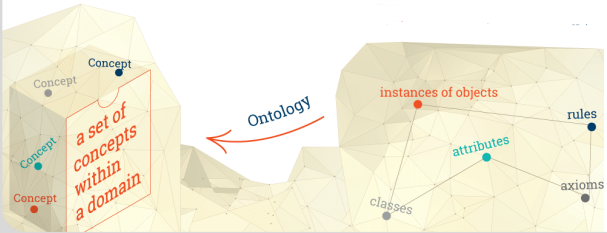
SOFTWARE DESIGN AND QUALITY, INSTITUTE FOR PROGRAM STRUCTURES AND DATA ORGANIZATION, KIT DEPARTMENT OF INFORMATICS



Outline

1 Motivation

2 Foundations
- Ontologies in Computer Science
- Meta-Research

3 Ontologies in Software-Engineering-Meta-Research
- Ontologies for Controlled Experiments on SE
- Ontology to support systematic reviews in SE

4 Conclusion

Motivation

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- Ontologies make Knowledge understandable for computers as well, that provides:
  - Supporting humans in Knowledge transferring process
  - Opportunity to analyze and generate new knowledge automatically by machines
- Useful for Software Engineering
  - Encapsulate the results of thousands Software Engineering experiments
  - Make possible to analyze them and find out the best Software Engineering practice

Ontology in Computer Science

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Def. Ontology in Computer Science

- “an explicit specification of a conceptualization” [Gruber 1993]
- Conceptualization: abstract model of some knowledge domain
- Explicit specification: classes, concepts, terms

Ontology languages

Well-known examples

- ER-Diagrams and UML-Diagrams
- Good for understanding and representing of Knowledge, but still made for humans

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Description Logic

The main feature: **separation** between **Terminology** and **Assertions**

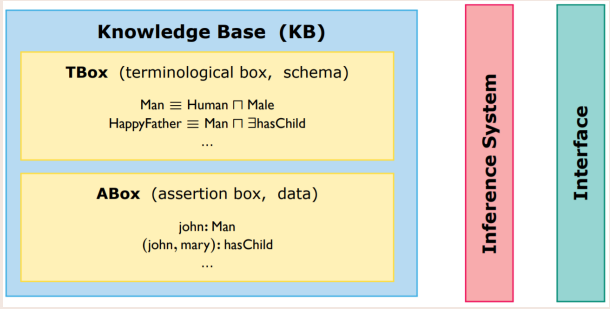

Figure: Architecture of DL [Konev 2010]

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Def. Meta-Research

The use of scientific methodology to study science itself

Meta-Research (2)

Areas of Meta-Research [Ioannidis et al. 2015]

1. **Methods**: practices for performing research (**e.g.** study design, methods, statistics).
2. **Reporting**: publications of standards and study registrations (**e.g.** study registration, information to patients, public and policy-makers)
3. **Reproducibility:** methods for verifying research (**e.g.** sharing data and methods, replicability)
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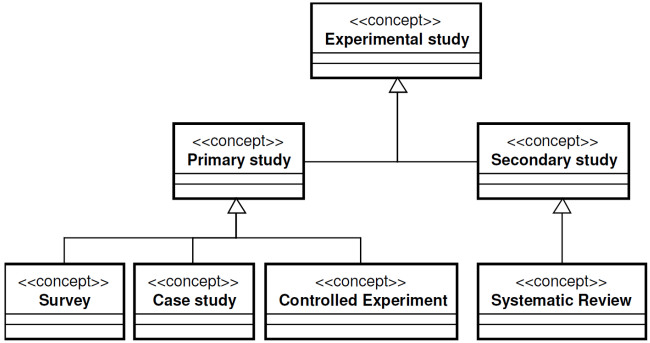

Figure: Classification of empirical studies [Garcia et al. 2008]

Ontology for Controlled Experiments on SE

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- Sharing of knowledge among research groups

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- Present an Ontology for experimental studies for knowledge transfer, assisting in designing, conducting and evaluating controlled experiments.
- Validate the ontology, whilst instantiating it to a controlled experiment.

Ontology for Controlled Experiments on SE

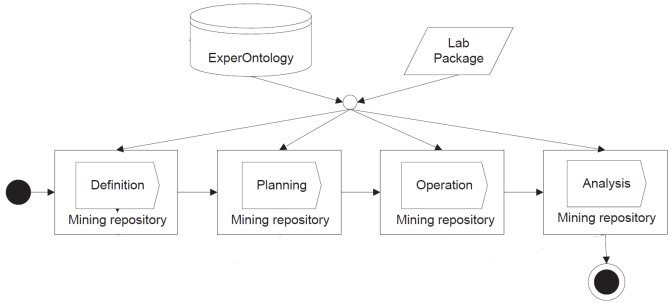

Figure: Controlled Experiments phases [Scatalon, Garcia, and Correia 2011]

Ontology for Controlled Experiments on SE

Suggested Ontology (main concepts)

1. *Lab Package* from *Original Experiment* is used for *Replication* and generation of a new *Lab Package*.
2. *Experimenter Profile*: negative - lack of experience, positive - high experience
3. *Original Experiment* and *Replication* evaluated regarding to *Validity*

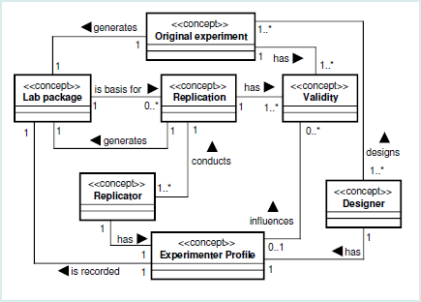

Figure: Ontology for Controlled Experiments [Garcia et al. 2008]

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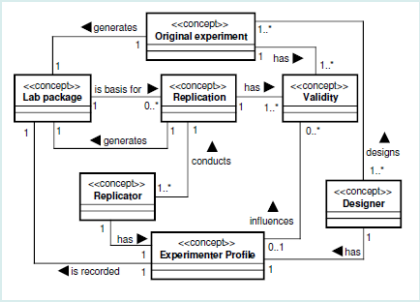

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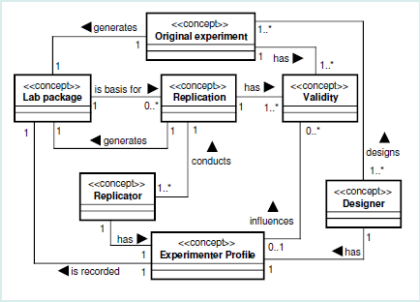

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Ontology for Controlled Experiments on SE

Evaluation

- Experiments [Basili and Selby 1987] encapsulated in Lab Package
- Comparing 3 testing techniques
- 32 Subjects in **3 groups** with **3 testing techniques** for **3 types software**

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Results

- After instanciation of experiment into the ontology observe the missing values on the predicate
- After look into experiment: indeed
- Ontology: mechanism to improve the obtained data set from the Lab Package

Ontology to support systematic reviews in SE

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Evidence-based Software Engineering [Kitchenham, Dyba, and Jorgensen 2004]

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Evidence-based Software Engineering [Kitchenham, Dyba, and Jorgensen 2004]

- Originates from Evidence-based Medicine
- Purpose: determine what SE practice works, when, where and which tools and standards needed
- The main instrument: Systematic Reviews (SRs)

Ontology to support systematic reviews in SE

Problem

- Major challenge to strengthen the foundations of SE:
  produce knowledge that can be based on scientific methodology

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Objectives

- Present a template designed to support systematic reviews in SE

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Problem

- Major challenge to strengthen the foundations of SE:
  produce knowledge that can be based on scientific methodology

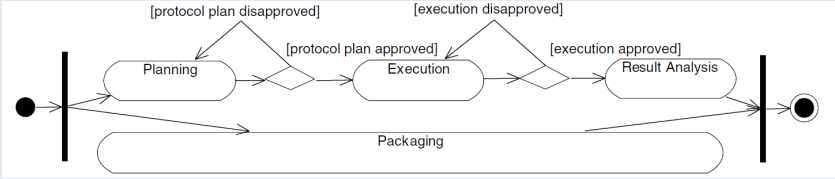
Objectives

- Present a template designed to support systematic reviews in SE
- Introduce development of ontologies to describe knowledge regarding such experimental studies

Ontology to support systematic reviews in SE

Systematic Review conduction process

1. **Planning**: research objectives and SR protocol
2. **Execution**: identify, select and evaluate primary studies
3. **Result Analysis**: extract and synthesize data from the the articles



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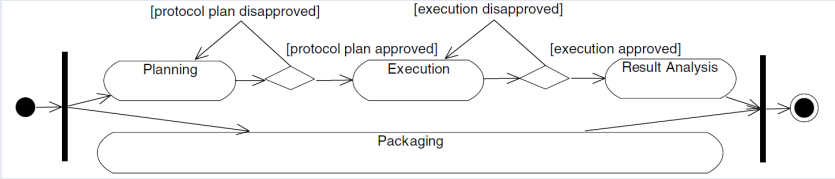

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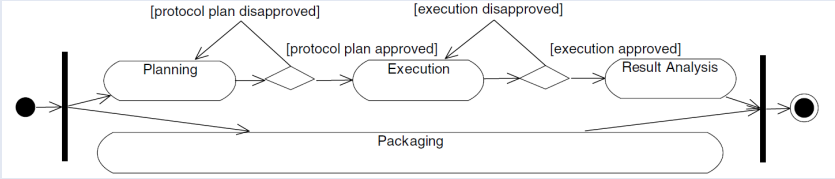

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Systematic Review

1. Question Formularization
   - 1.1. Question Focus
   - 1.2. Question Quality and Amplitude
     - Problem
     - Question.
     - Keywords and Synonyms
     - Intervention
     - Control
     - Effect
     - Outcome Measure
     - Population.
     - Application
     - Experimental Design
2. Sources Selection
   - 2.1. Sources Selection Criteria Definition
   - 2.2. Studies Languages
   - 2.3. Sources Identification
     - Sources Search Methods
     - Search String
     - Sources List
   - 2.4. Sources Selection after Evaluation
   - 2.5. References Checking
3. Studies Selection
   - 3.1. Studies Definition
     - Studies Inclusion and Exclusion Criteria Definition
     - Studies Types Definition
   - 3.2. Procedures for Studies Selection
   - 3.3. Selection Execution
     - Initial Studies Selection
     - Studies Quality Evaluation
     - Selection Review
4. Information Extraction
   - 4.1. Information Inclusion and Exclusion Criteria Definition
   - 4.2. Data Extraction Forms
   - 4.3. Extraction Execution
     - Objective Results Extraction
       - i) Study Identification
       - ii) Study Methodology
       - iii) Study Results
       - iv) Study Problems
     - Subjective Results Extraction
       - i) Information through Authors
       - ii) General Impressions and Abstractions
   - 4.4. Resolution of divergences among reviewers
5. Results Summarization
   - 5.1. Results Statistical Calculus
   - 5.2. Results Presentation in Tables
   - 5.3. Sensitivity Analysis
   - 5.4. Plotting
   - 5.5. Final Comments
     - Number of Studies
     - Search, Selection and Extraction Bias
     - Publication Bias
     - Inter-Reviewers Variation.
     - Results Application
     - Recommendations

Figure: Systematic Review protocol template [Almeida Biolchini et al. 2007]

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Scientific Ontology

Suggested Ontology features

- Based on SR protocol template
- Level-structured
- Both taxonomic *is_a* and meronymic *has* relations
- Level 0: *Experimental Method*, *Primary Research* and *Research Synthesis*
- Next: only *Primary Research*
- But: similar for *Experimental Method* and *Research Synthesis*

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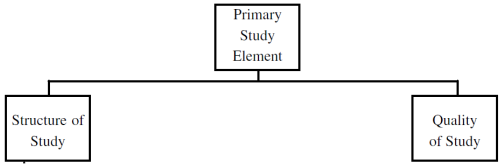

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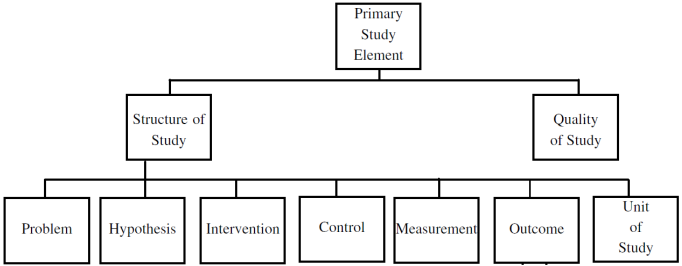

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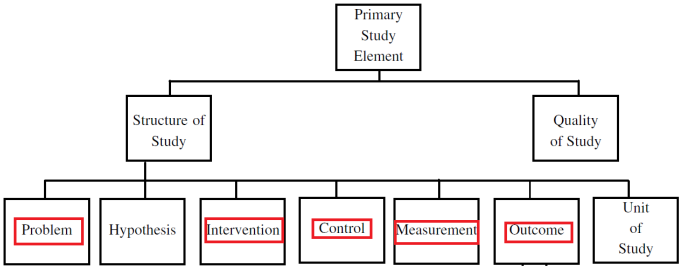

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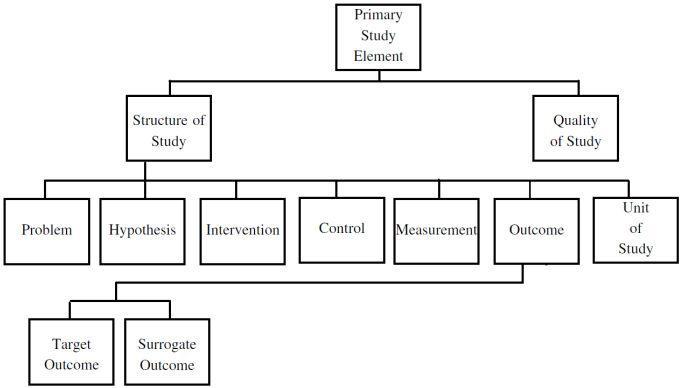

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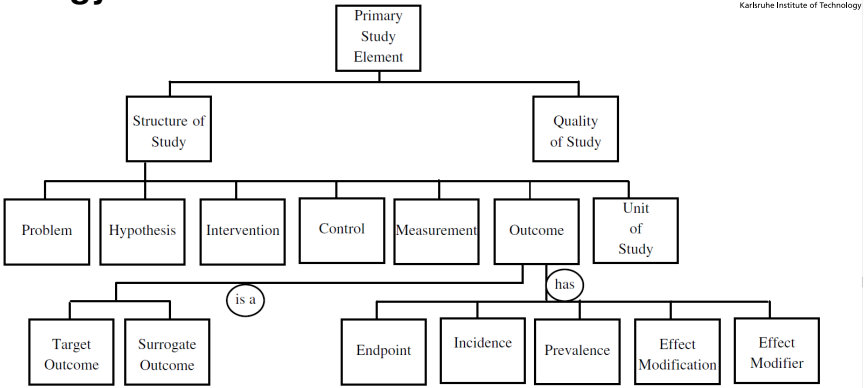

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- Here only the small part. The full ontology conceptualizes on all roles in SR template
- Powerful, comprehensive and covers all SR needs

Comparison

Similarities

- Adoption of ontologies: best for accumulate knowledge and formalize it
- Not a silver bullet: **but**, still enough for fulfilling a lot of objectives
- In Development: towards a comprehensive ontologies for all purposes

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Meta-Research

- Research on research
- How researches should be conducted, what practices effective and in what fields
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