An Exploration of Sustainability Thinking in Research Software Engineering

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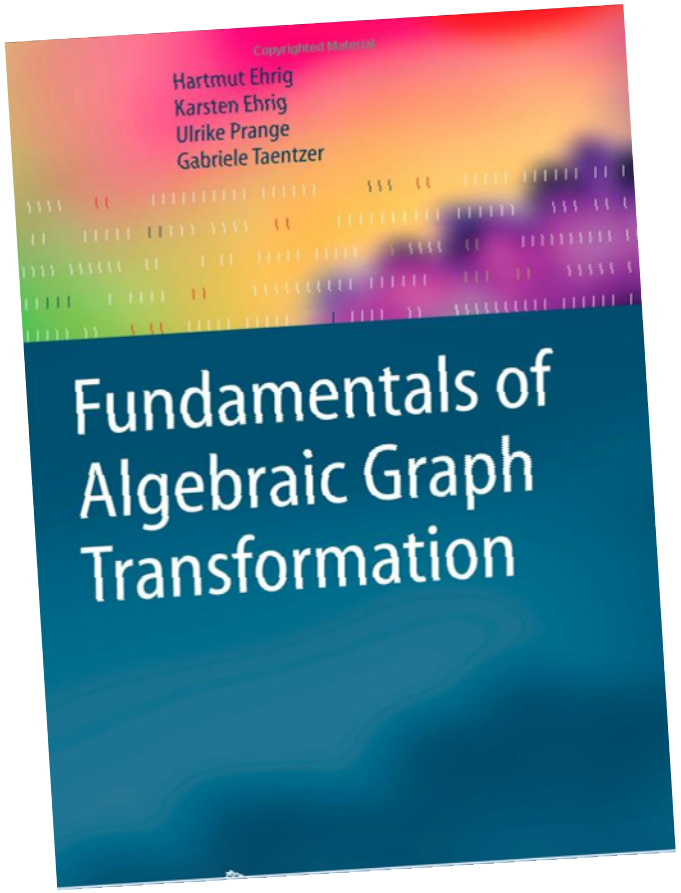
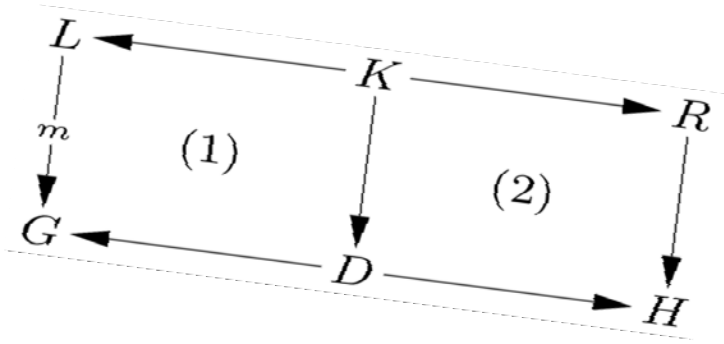
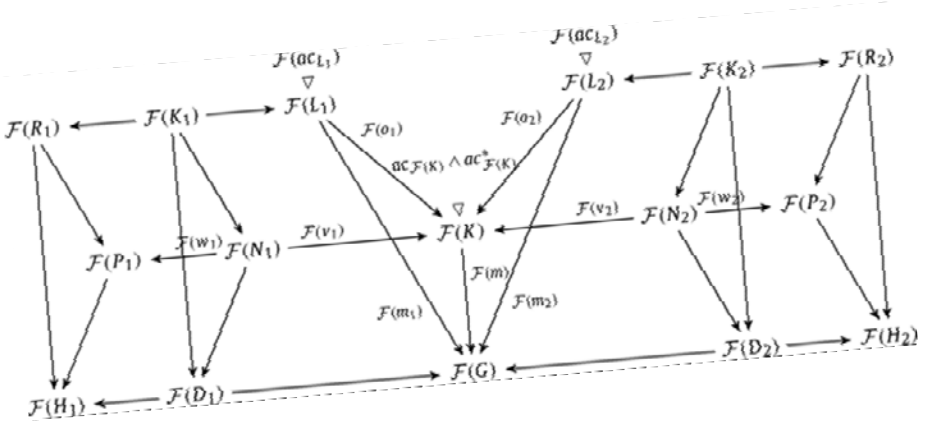
7th Intl. Workshop on Requirements Engineering for Sustainable Systems (RE4SuSy)
August 20th, 2018, Banff, Canada, at RE'18

Personal experience with research software development I: Henshin

» Turning graph transformation concepts and theory…

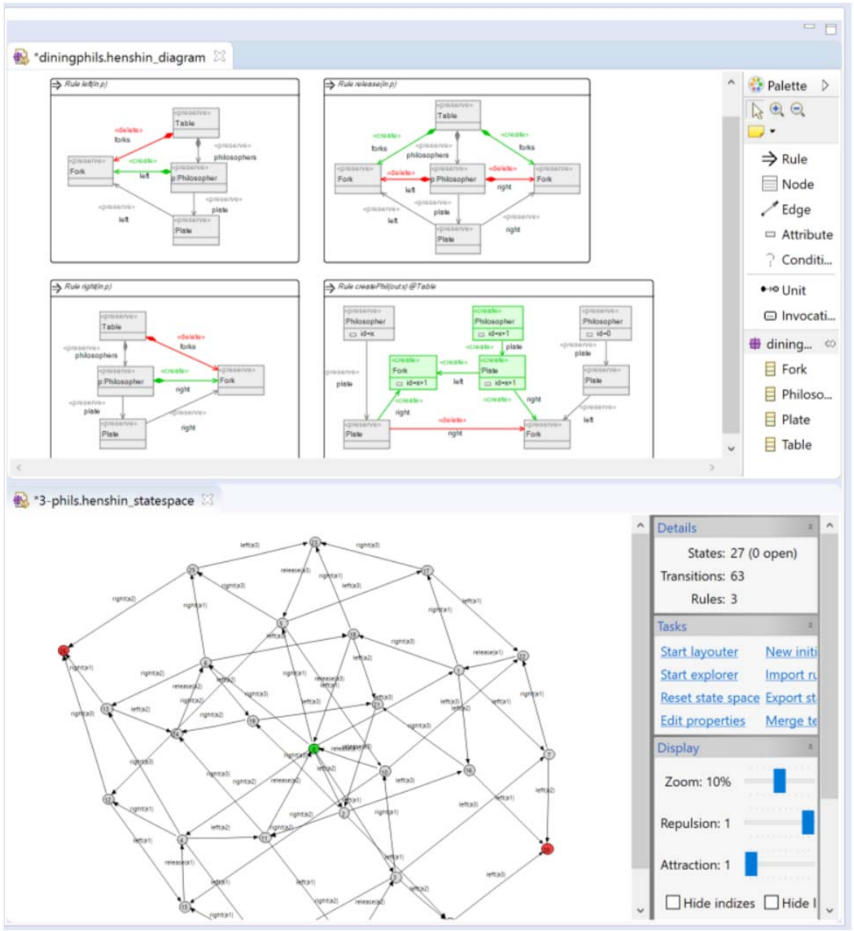






Personal experience with research software development I: Henshin

» … into and experimental tool suite for Model-Driven Software Engineering

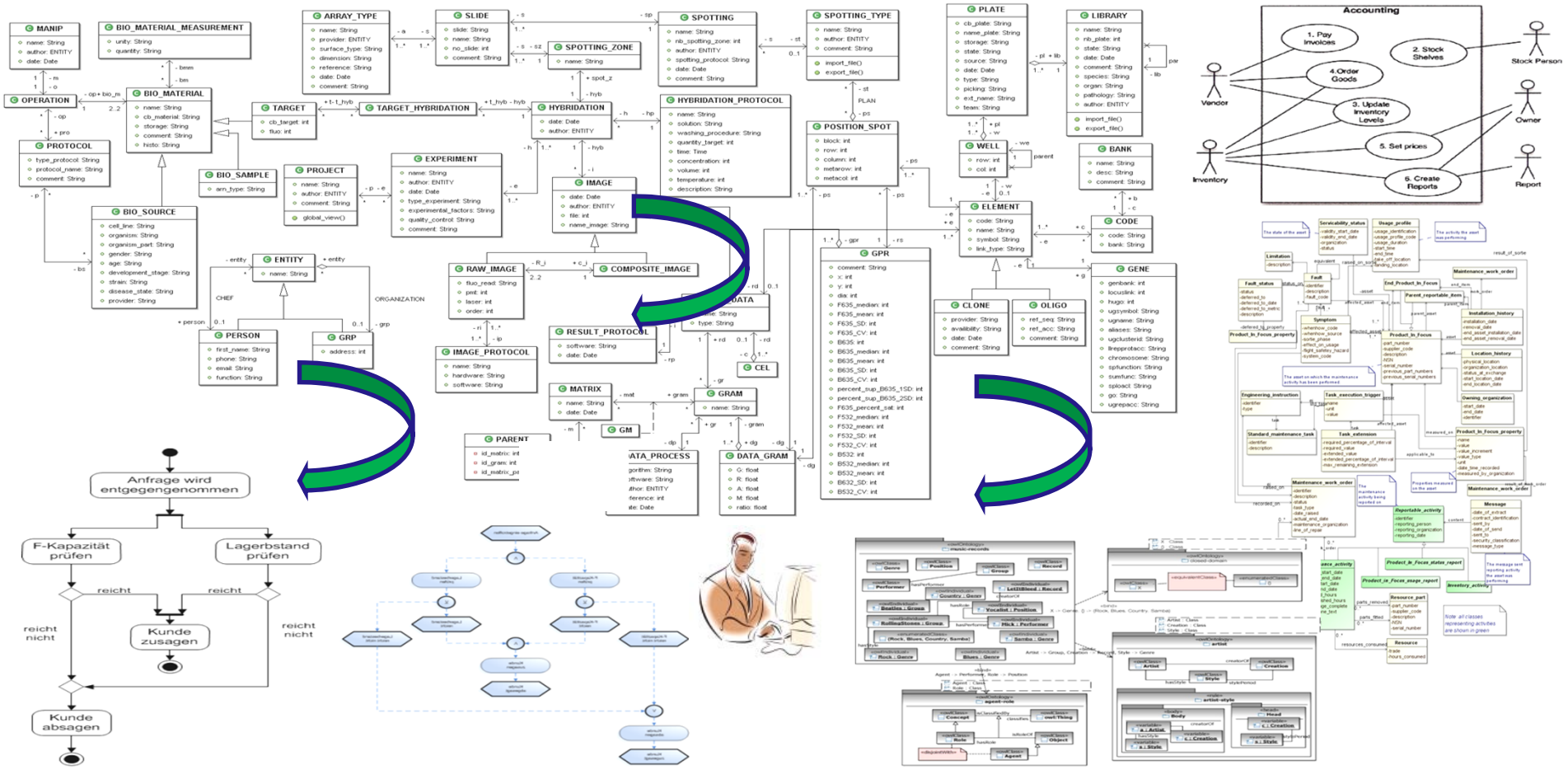


- Expressive transformation language with a graphical syntax
- Control-flow constructs with parameter passing
- Support for endogenous and exogenous transformations
- Arbitrary mixing of different graph transformation styles (DPO/SPO)
- Efficient interpreter engine based on constraint solving
- Verification using state space tools
- Code generator for Apache Giraph

https://www.eclipse.org/henshin/

Personal experience with research software development II: SiDiff/SiLift

» Model management operators supporting model evolution in MDE



Personal experience with research software development II: SiDiff/SiLift

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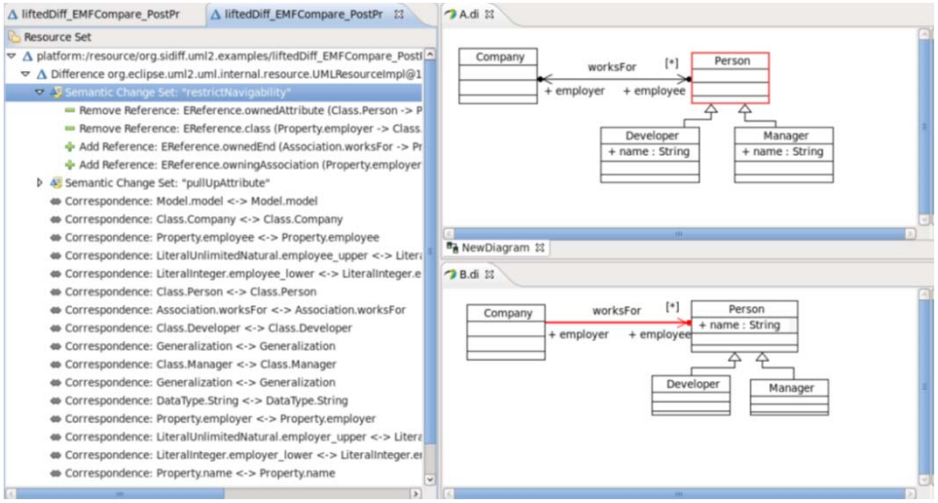
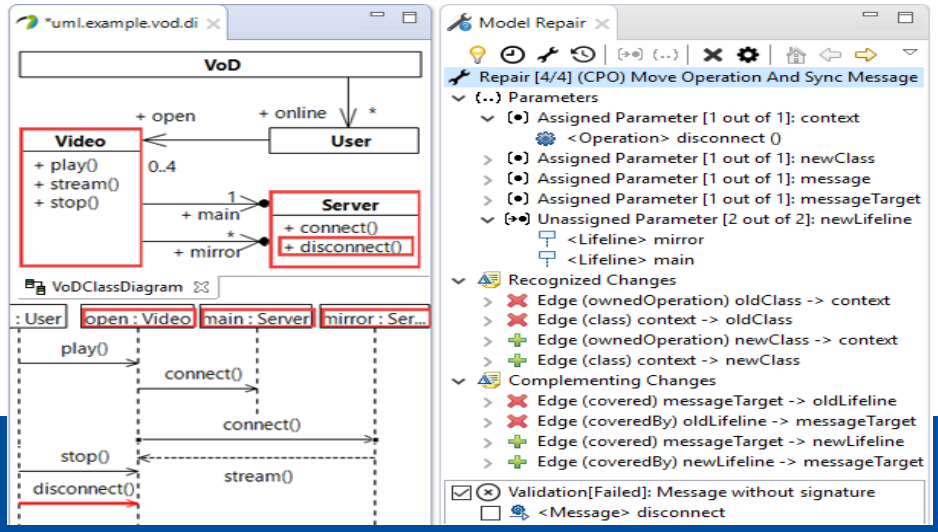




- Model matching and differencing
- Semantic lifting of low-level differences
- Consistency-preserving patching and merging
- Model refactoring and restructuring
- Semi-automated model repair
- Change impact analyses
- ...

siDiff see the difference SiLift lift me up

http://pi.informatik.uni-siegen.de/Projekte/SiLift/

More generally: Research software in (Software) Engineering

- In SE, empirical validation of new methods and techniques requires prototypical implementations and tools (the research software).
- These tools are being developed for the sake of gaining scientific insights.

Table 2. Types of research questions represented in ICSE 2002 submissions and acceptances

Type of question	Submitted	Accepted	Ratio Acc/Sub
Method or means of development	142(48%)	18 (42%)	(13%)
Method for analysis or evaluation	95 (32%)	19 (44%)	(20%)
Design, evaluation, or analysis of a particular instance	43 (14%)	5 (12%)	(12%)
Generalization or characterization	18 (6%)	1 (2%)	(6%)
Feasibility study or exploration	0 (0%)	0 (0 %)	(0%)
TOTAL	298(100.0%)	43 (100.0%)	(14%)

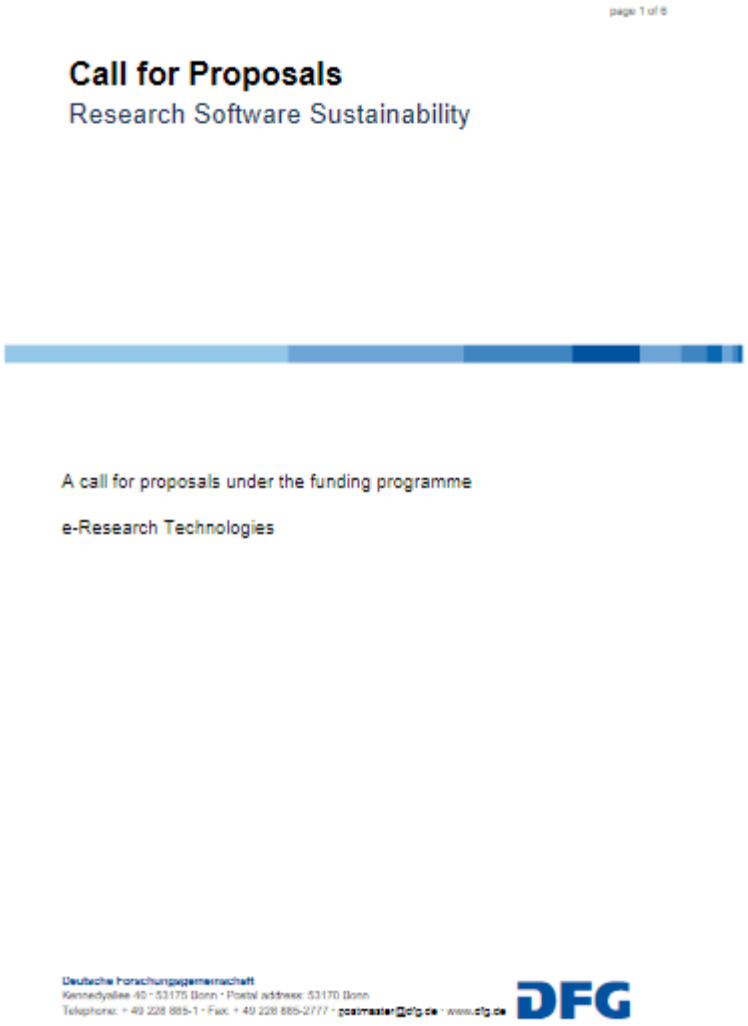
[Mary Shaw: What Makes Good Research in Software Engineering? J. of Software Tools for Technology Transfer (2002)]

- Also applies to other engineering sciences, at least to those which heavily rely on computer-aided analysis and design principles.

Recurring problems with research software

- **Distinguishing characteristics**
  - **Short educational cycles (BSc, MSc and PhD projects)**
  - **Intermediate academic funding structures (grants)**
  - **Driven by academic recognition incentives (papers)**
  - **Extremely distributed development (silos and geographically)**
- **Rapid research software aging vs. long-term research progress**
  - **design knowledge gets lost quickly**
  - **repeated re-implementation of legacy software components**
  - **research results are often irreproducible**
- **Actual usage often limited to individual projects**

The quest for sustainable (research) software



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Call for Proposals

Research Software Sustainability

A call for proposals under the funding programme

e-Research Technologies

Deutsche Forschungsgemeinschaft
Kennedyallee 40 · 53175 Bonn · Postal address: 53170 Bonn
Telephone: + 49 228 885-1 · Fax: + 49 228 885-2777 · postmaster@dfg.de · www.dfg.de

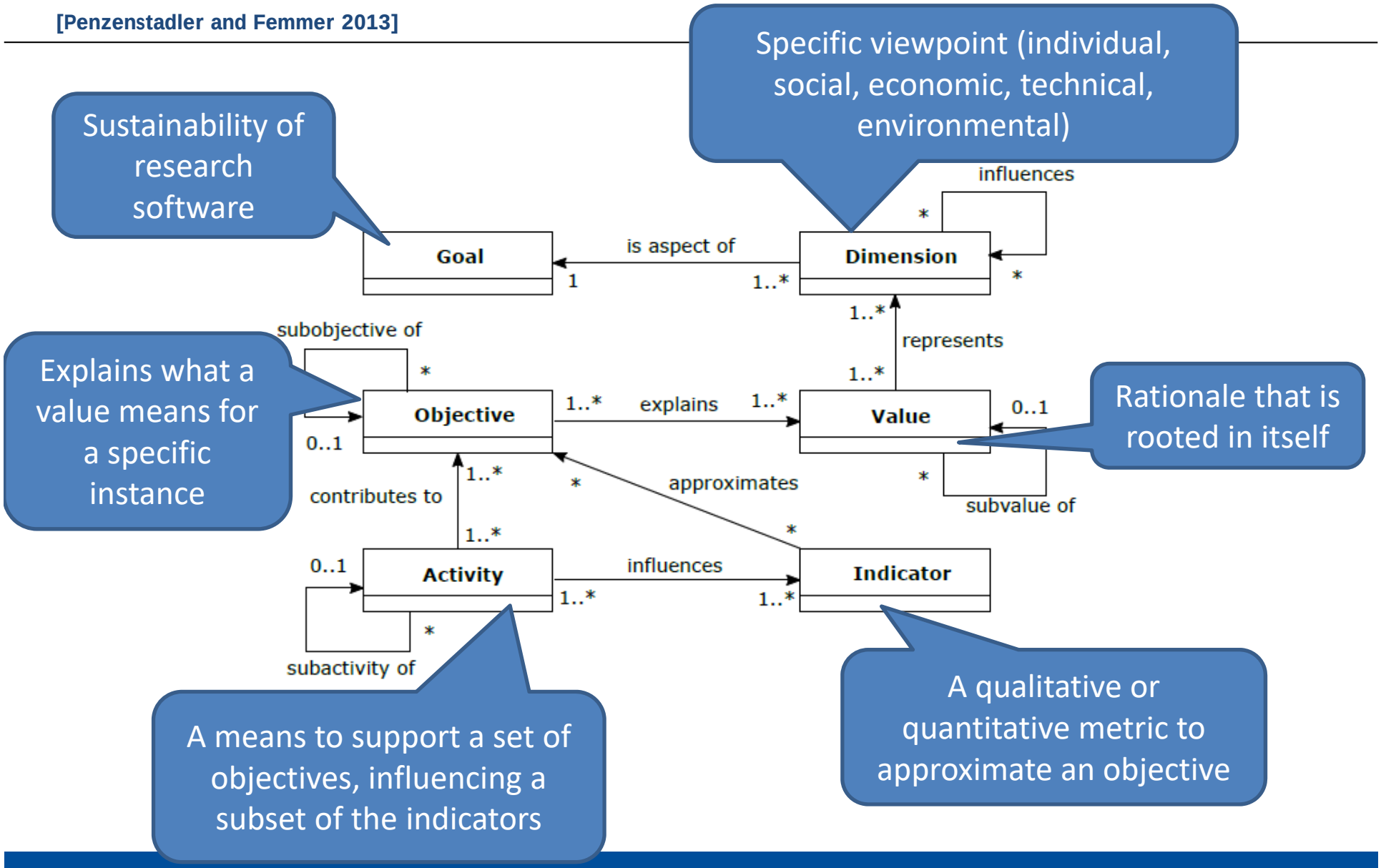
DFG

Existing initiatives and related work:

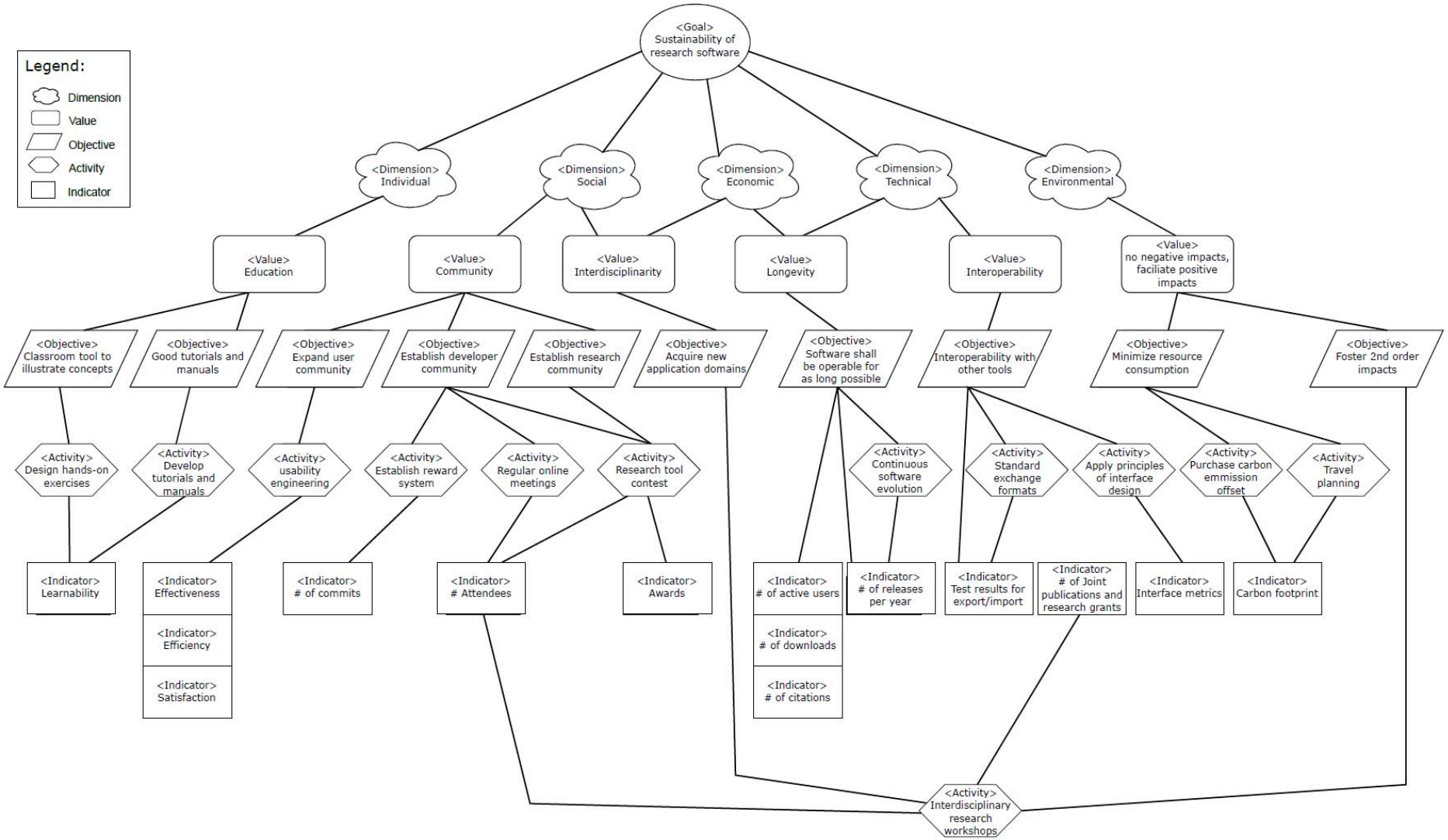
- Software maintenance and evolution (e.g., ICSME but also prominent at ICSE, ESEC/FSE, ASE, …)
- Software engineering for sustainability (e.g., guiding theme of ICSE'12)
- Scientific software engineering (e.g., 2016 Dagstuhl perspectives workshop on engineering scientific software)
- Sustainable software for science (e.g., WSSSPE workshop series)
- …

Our approach: A generic sustainability goal model…

[Penzenstadler and Femmer 2013]



… and its instantiation for research software (in MDE)



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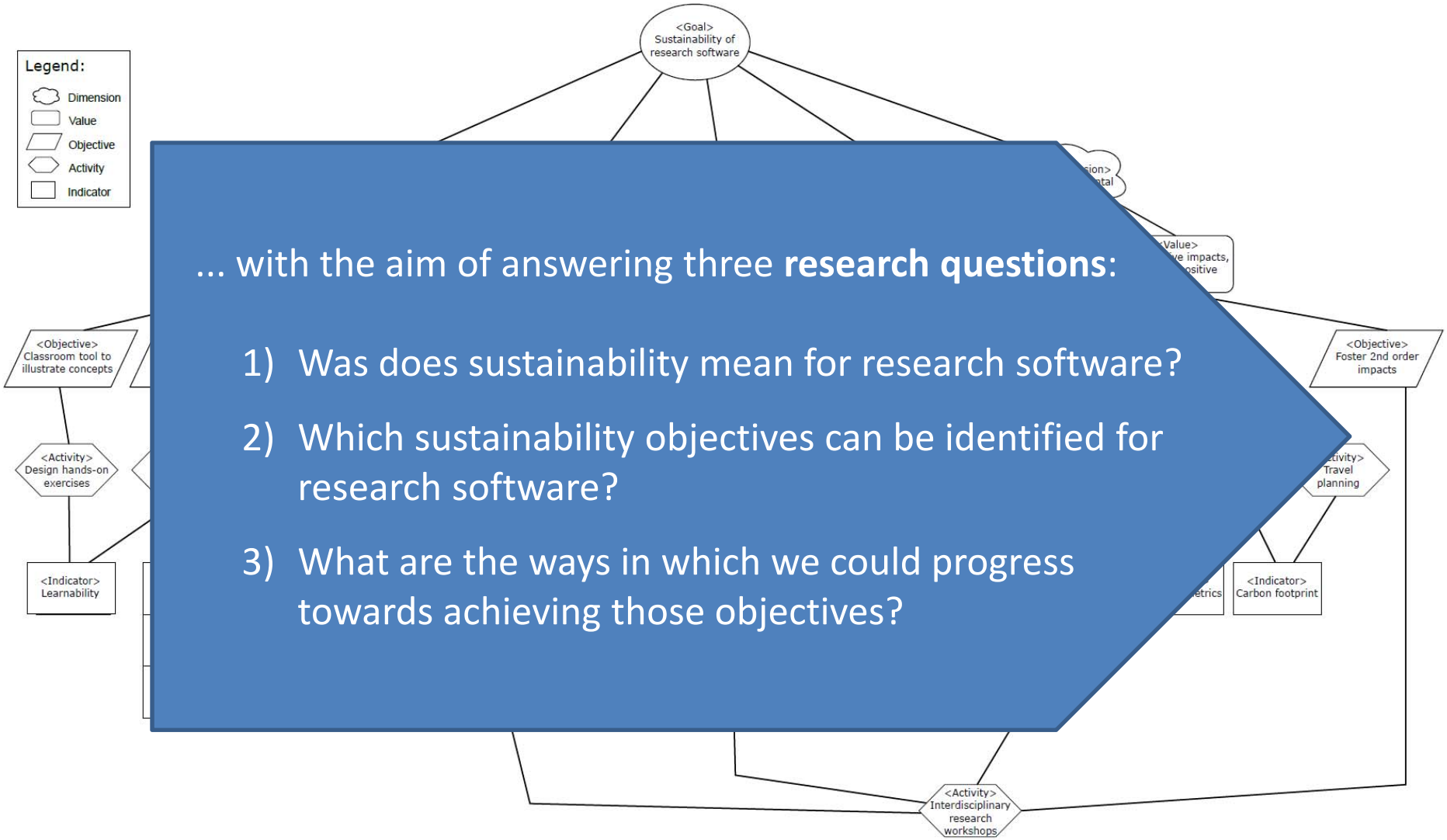
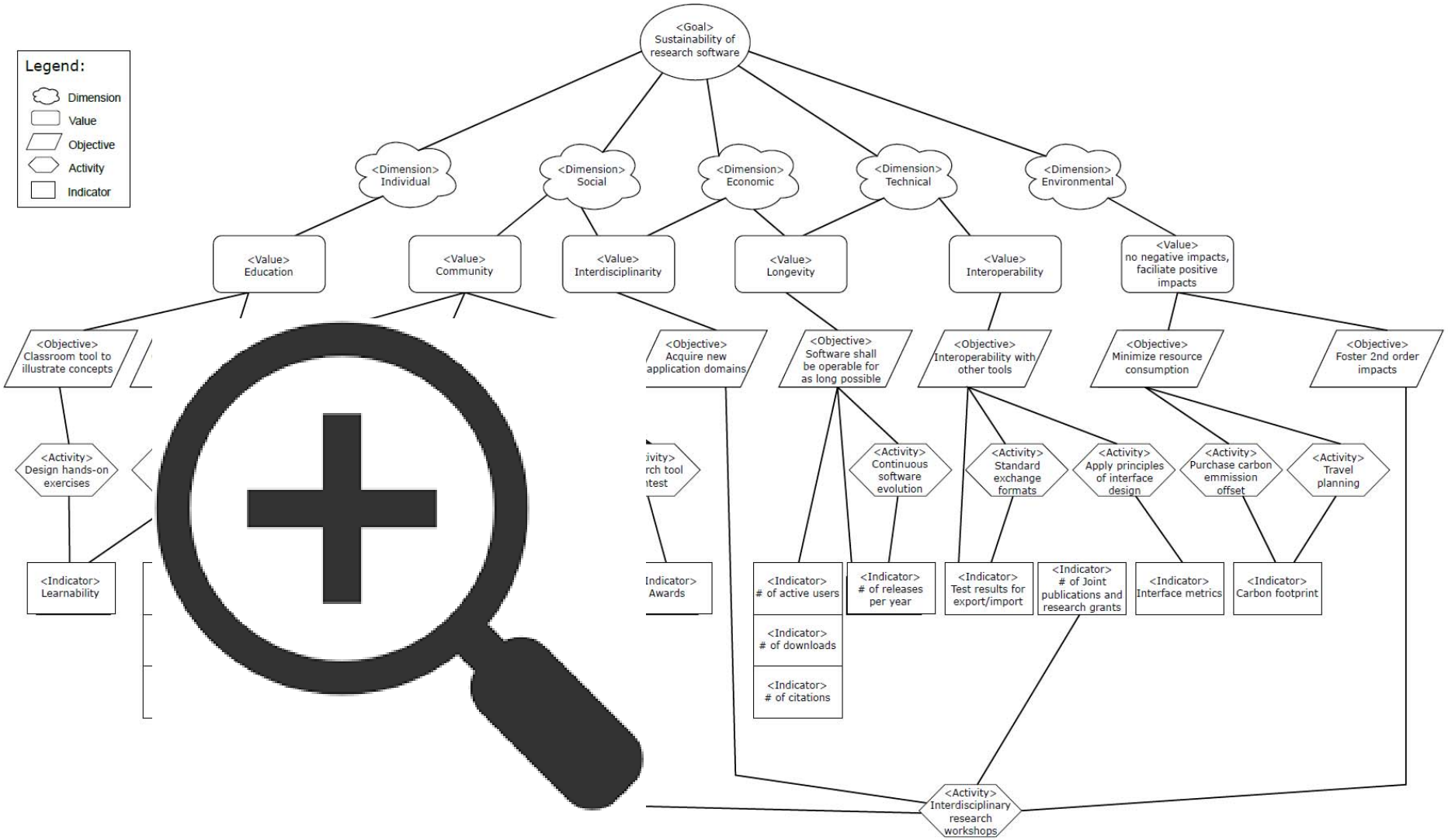
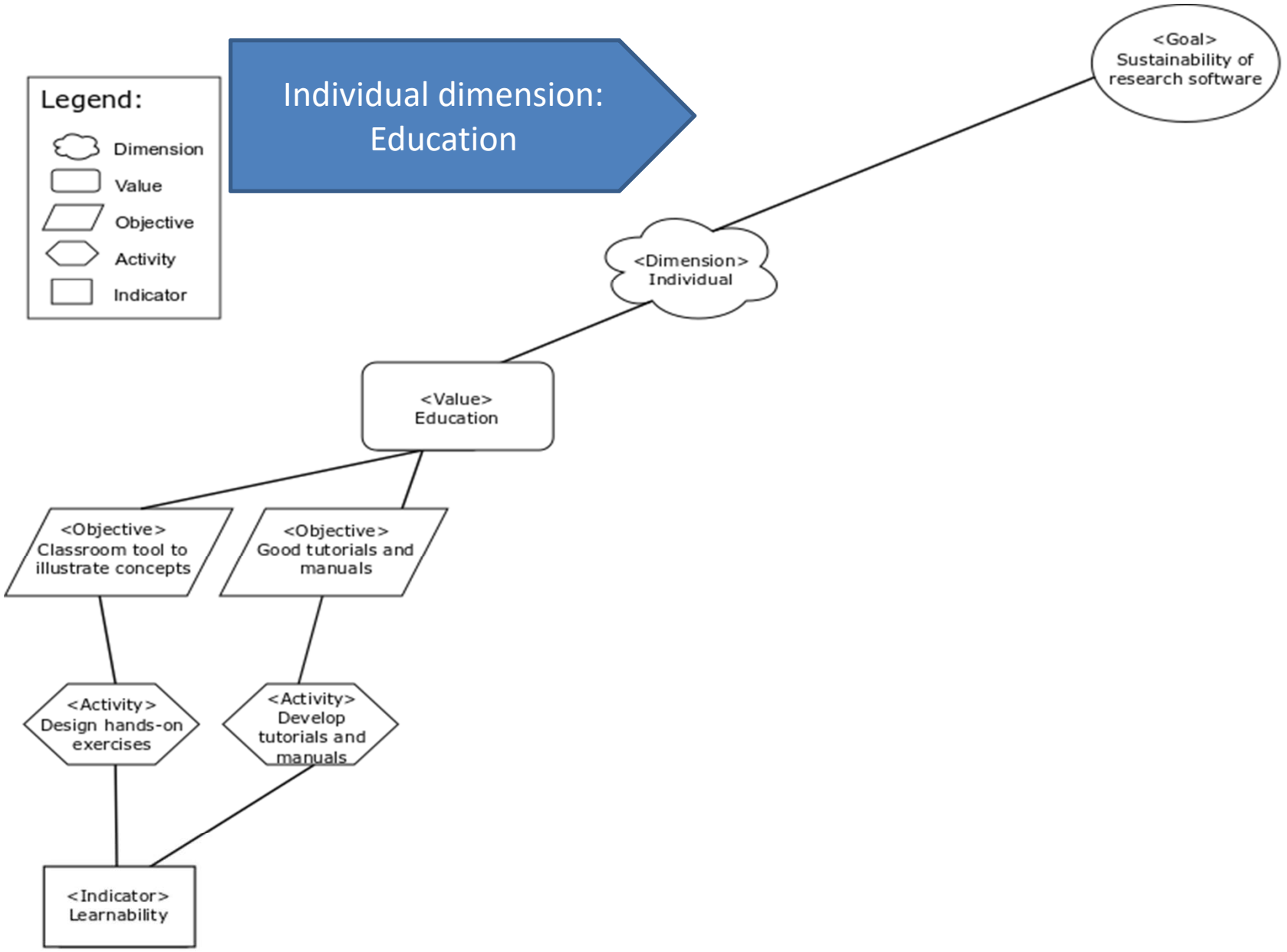


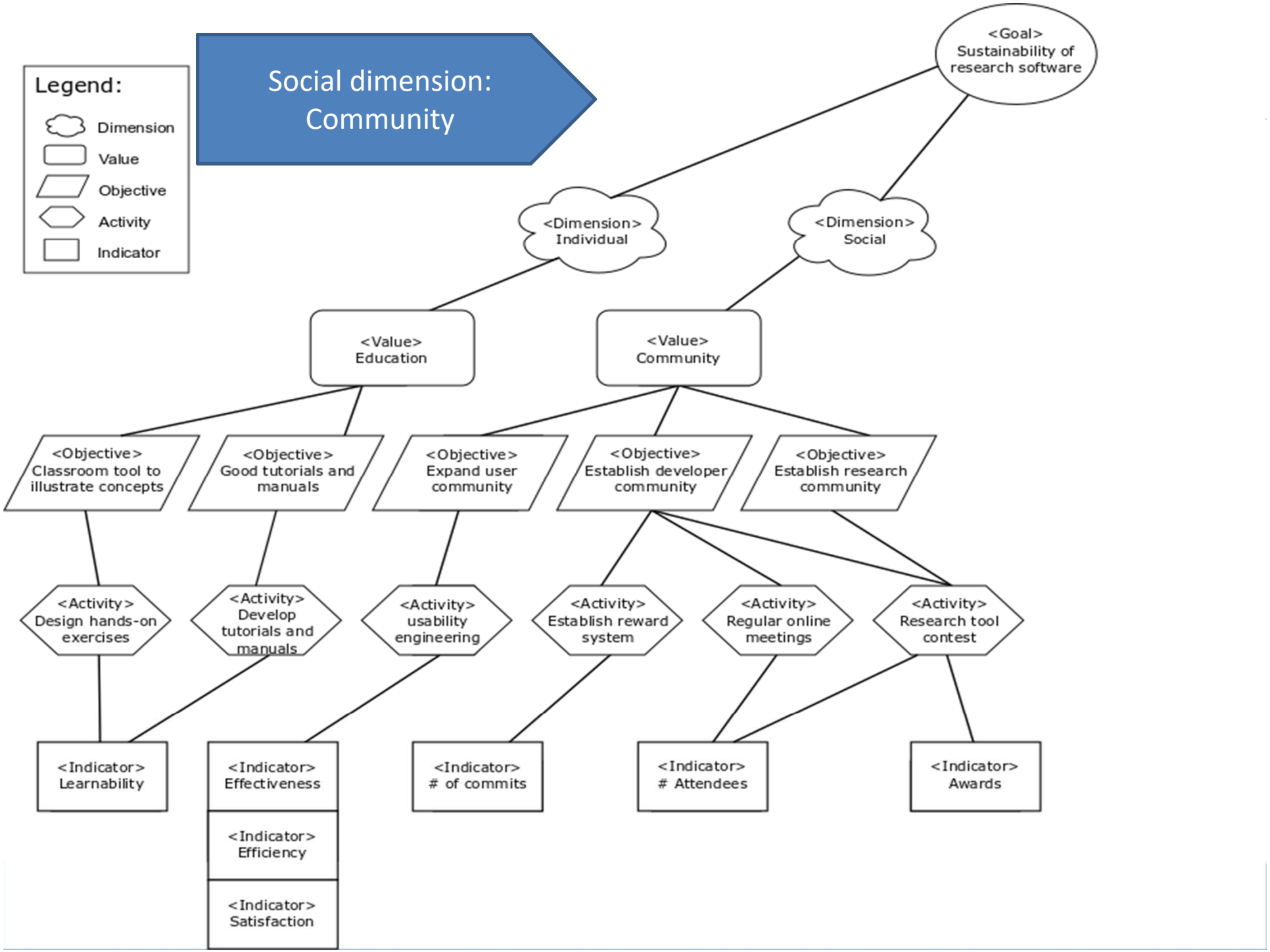
… with the aim of answering three **research questions**:

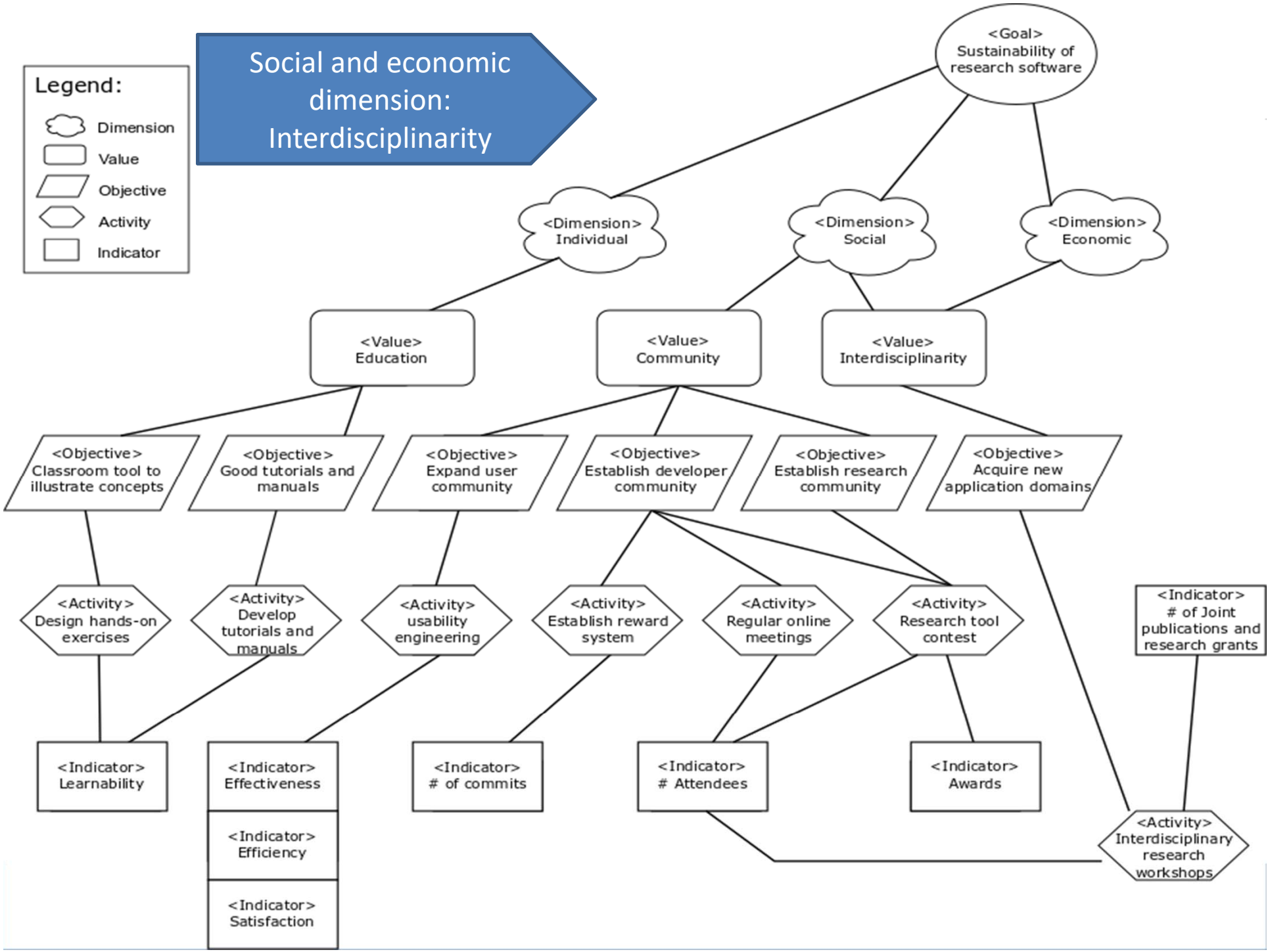
1) Was does sustainability mean for research software?
2) Which sustainability objectives can be identified for research software?
3) What are the ways in which we could progress towards achieving those objectives?

Zooming in (individual, social and economic dimension)




Legend:
Dimension
Value
Objective
Activity
Indicator
Individual dimension: Education
<Goal> Sustainability of research software
<Dimension> Individual
<Value> Education
<Objective> Classroom tool to illustrate concepts
<Objective> Good tutorials and manuals
<Activity> Design hands-on exercises
<Activity> Develop tutorials and manuals
<Indicator> Learnability


Legend:
Dimension
Value
Objective
Activity
Indicator
Social dimension: Community
<Goal> Sustainability of research software
<Dimension> Individual
<Dimension> Social
<Value> Education
<Value> Community
<Objective> Classroom tool to illustrate concepts
<Objective> Good tutorials and manuals
<Objective> Expand user community
<Objective> Establish developer community
<Objective> Establish research community
<Activity> Design hands-on exercises
<Activity> Develop tutorials and manuals
<Activity> usability engineering
<Activity> Establish reward system
<Activity> Regular online meetings
<Activity> Research tool contest
<Indicator> Learnability
<Indicator> Effectiveness
<Indicator> Efficiency
<Indicator> Satisfaction
<Indicator> # of commits
<Indicator> # Attendees
<Indicator> Awards


Social and economic dimension: Interdisciplinarity
Legend:
Dimension
Value
Objective
Activity
Indicator
<Goal> Sustainability of research software
<Dimension> Individual
<Dimension> Social
<Dimension> Economic
<Value> Education
<Value> Community
<Value> Interdisciplinarity
<Objective> Classroom tool to illustrate concepts
<Objective> Good tutorials and manuals
<Objective> Expand user community
<Objective> Establish developer community
<Objective> Establish research community
<Objective> Acquire new application domains
<Activity> Design hands-on exercises
<Activity> Develop tutorials and manuals
<Activity> usability engineering
<Activity> Establish reward system
<Activity> Regular online meetings
<Activity> Research tool contest
<Indicator> # of Joint publications and research grants
<Indicator> Learnability
<Indicator> Effectiveness
<Indicator> Efficiency
<Indicator> Satisfaction
<Indicator> # of commits
<Indicator> # Attendees
<Indicator> Awards
<Activity> Interdisciplinary research workshops

Limitations

- **Evidence w.r.t. applicability and effectiveness of the model**
  - **Applicability in practice?**
  - Validation of objectives and activities?

- **Generalizability of the model**
  - What about other research software from
    - the field of Model-Driven Engineering
    - the broader field of software engineering
    - other engineering sciences
    - the computational sciences (e.g., natural, economic, social and life sciences)

- **Completeness of the model**
  - Important values (and according objectives, activities and indicators) may be missing, e.g., in the data-driven sciences:
    - Reproducibility of research results, long after initial publication
    - Continuous evolution and maintenance of computational research software

Limitations and future work

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  - **Applicability in practice?**
  - Validation of objectives and activities?

Application and assessment

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Transfer to other kinds of research software and scientific domains

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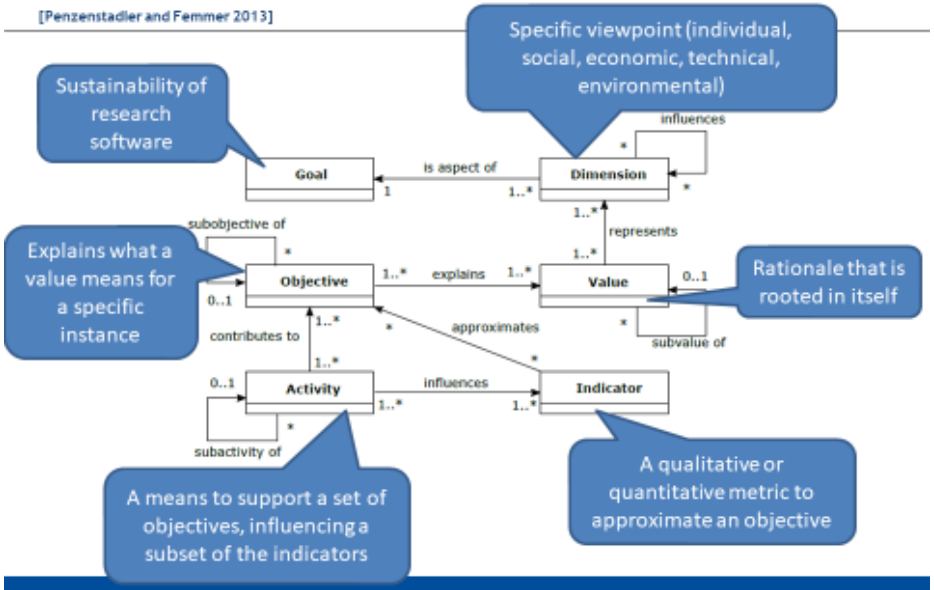

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