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Enhancing the Academic Portfolio – SE Research and Teaching for Academia

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Are there still engineering focused universities without SE?

- Many universities across the globe offer well established Systems Engineering (SE) courses and academic degrees (undergraduate and postgraduate, including research degrees at master and doctorate levels), as well as continuous professional development programs (for both industry and public sectors).
- Some universities even have world-class reputation for the excellence they demonstrate in SE research & teaching.
- However, there are **still many universities worldwide** that offer courses in traditional fields of Engineering but **not yet in SE**, let alone specific SE degrees or qualifications.
- Given that SE is essential for the development and in-life support of systems, even more so with the increasing levels of complexity of today's and tomorrow's systems and Systems of Systems (SoS), it seems **urgent and important** for such universities **to consider an extension of their academic portfolio**.

Why should they include SE in their portfolio?

Attract good academics and students – enhanced by comprehensive research and teaching portfolio including SE, professional certifications and course accreditations

High ranking (research and teaching) and funding – only possible with good academics & students

Good career choices and high employability – enhanced by good range of engineering subjects including SE and professional certification

Research funding and opportunities – enhanced by being part of a leading university that offers a comprehensive range of courses including SE

University

- Engineering department
  - Academics
  - Students

Successful bidding process and systems – enabled by sound SE and SE certified resources

Soundness of proposals and academic strength of the participating universities – SE aspects must be appropriately addressed

Employers
(industry, public sector and academia)

Funding bodies
(industrial, governmental and international)

Some key challenges to including SE

- **Lack of strategic SE vision** => unwillingness to invest
- Lack of suitable SE academics and interested students (short term)
- Therefore no immediate research funding and study fees (short term)
- **Culture of little cooperation among different disciplines and faculties**
- **Lack of visibility of the intended SE domain portfolio**
- **Employability of students** for SE jobs (knowledge alone not sufficient)
- Quickly evolving **body of knowledge and state of the art**

What is ontology and how can it help address these challenges?

An ontology defines a 'common vocabulary for researchers who need to share information in a domain. It includes machine-interpretable definitions of basic concepts in the domain and relations among them' (Noy & McGuinness, 2000).

In order to build the SE domain ontology presented in this paper, the open source ontology editor **Protégé** and the **OWL** (Ontology Web Language) notation were selected. Protégé was developed by the Stanford Center for Biomedical Informatics Research at the Stanford University School of Medicine, and has since become the world's leading open source ontology editor with over 300,000 registered users from a large variety of industrial and academic domains worldwide (Stanford University, 2014).

What is ontology and how can it help address these challenges?

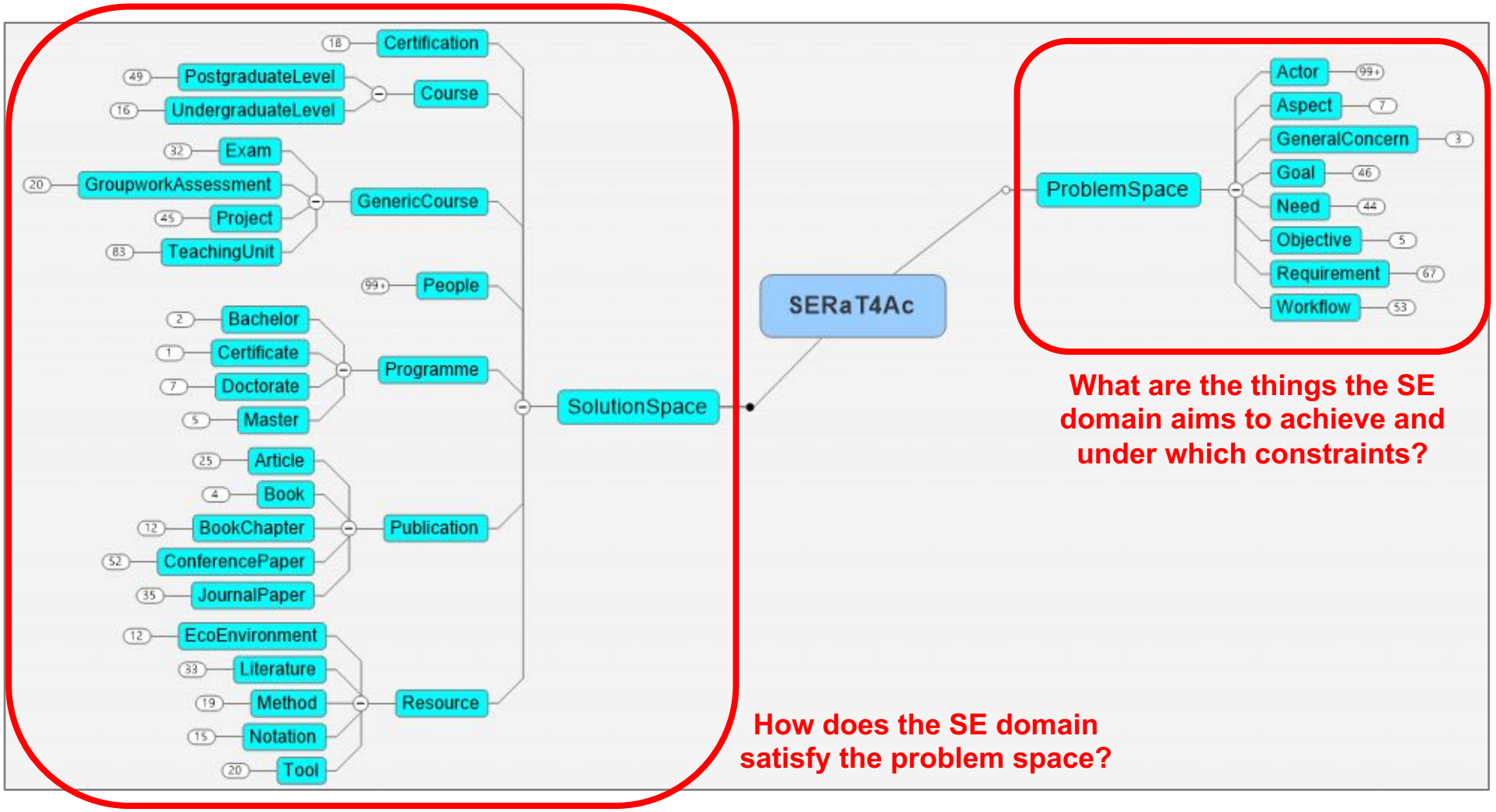
The **SE domain** of a university as the System of Interest (SoI) can be specified in terms of its problem and solution spaces, not to:

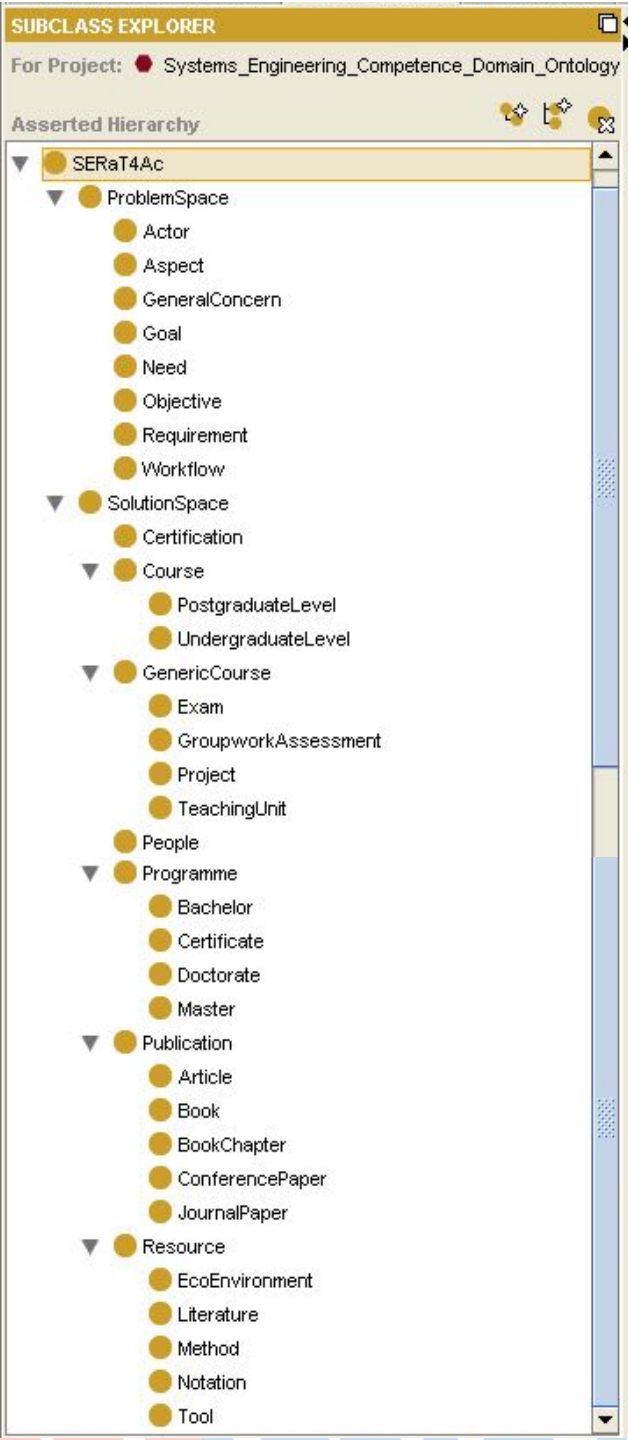
- Replace the Human Resource Management tools of the university;
- Manage content of books, papers or other documents;

But rather to:

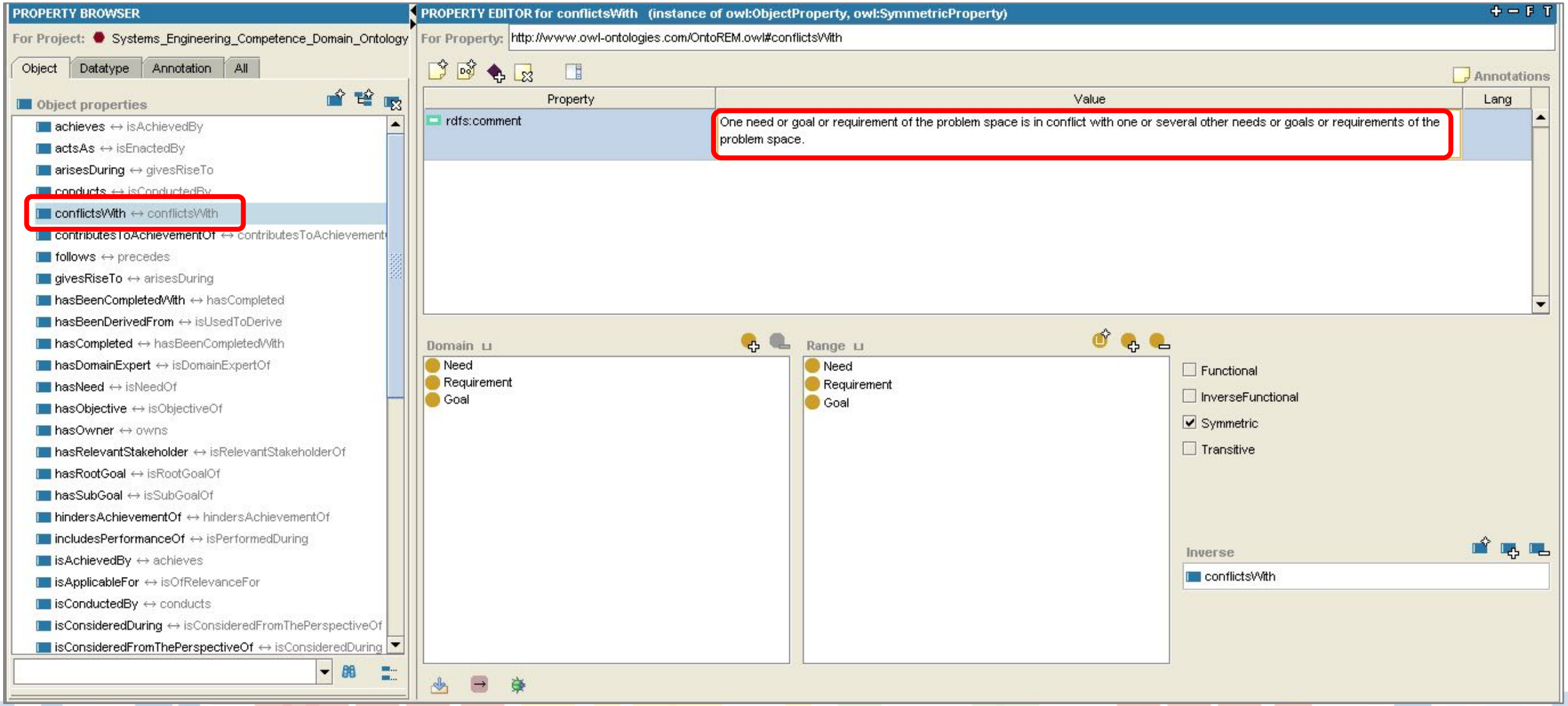
- ✓ Enhance the **decision-making** by the leadership of the university and the new SE domain;
- ✓ Enhance both **strategic planning and operational management** of the SE domain;
- ✓ Make the relevant **meta-knowledge explicit and re-usable**;
- ✓ **Avoid misunderstandings**;
- ✓ **Increase resilience** by reducing dependency on key individual staff members;
- ✓ Enable **continuous improvement**, **change management** and **training** of new staff members.

Building the class hierarchy





Defining object and datatype properties



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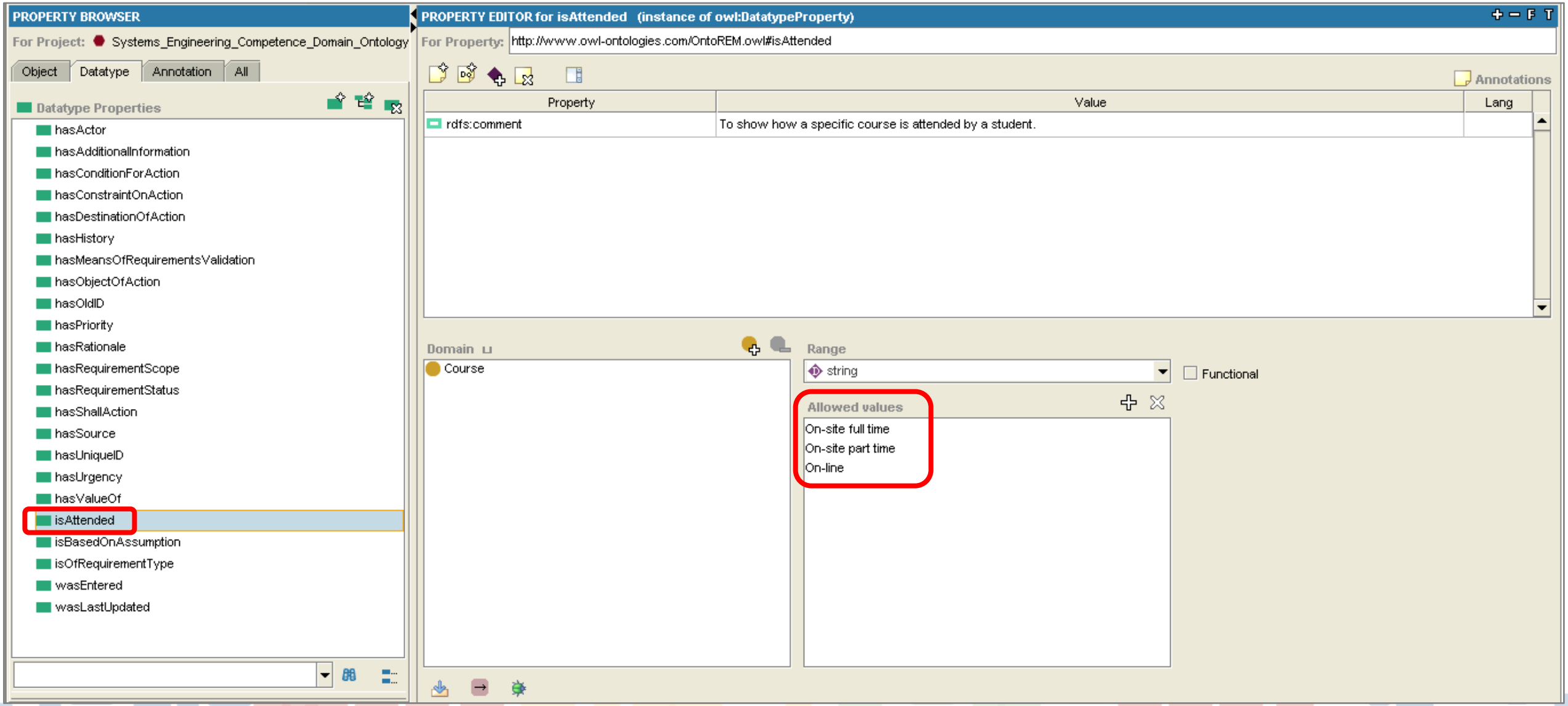
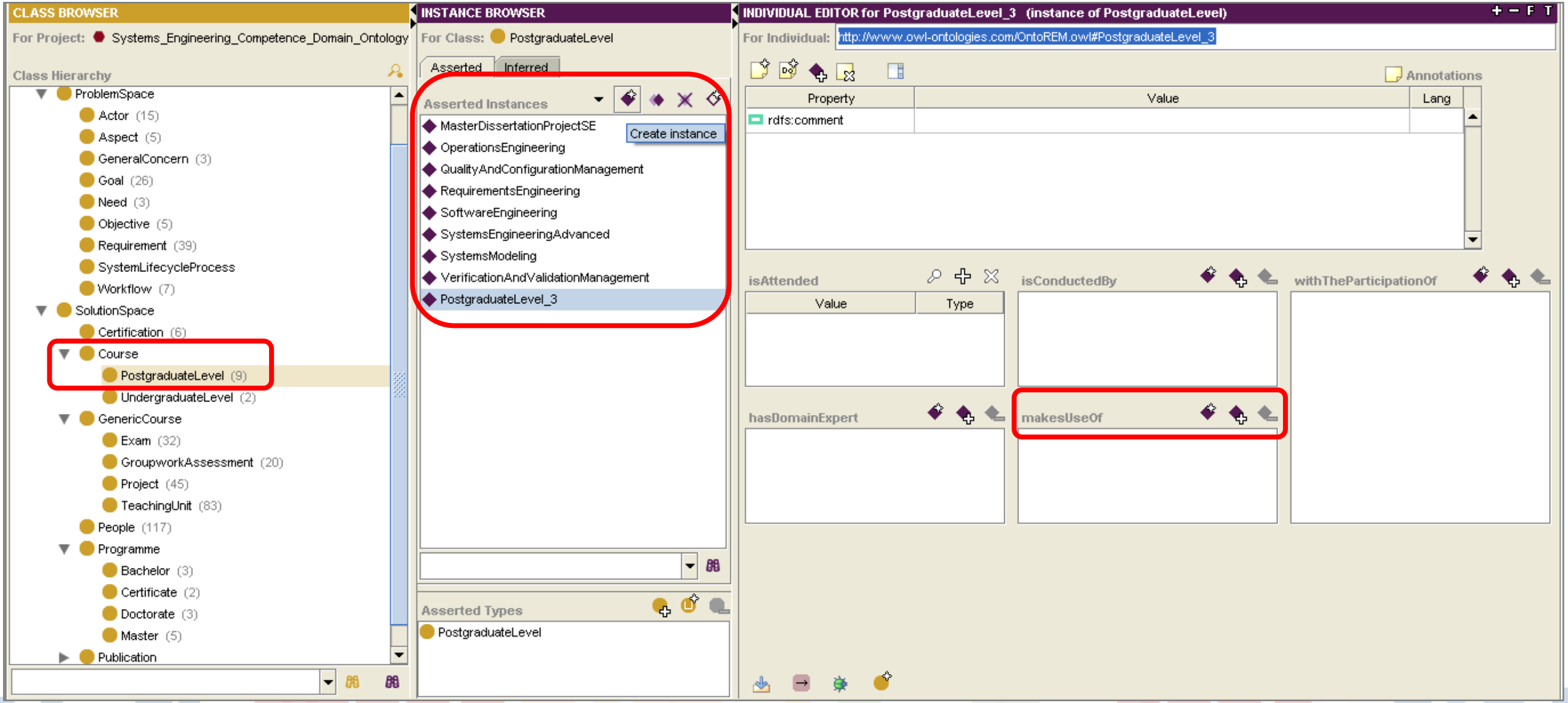
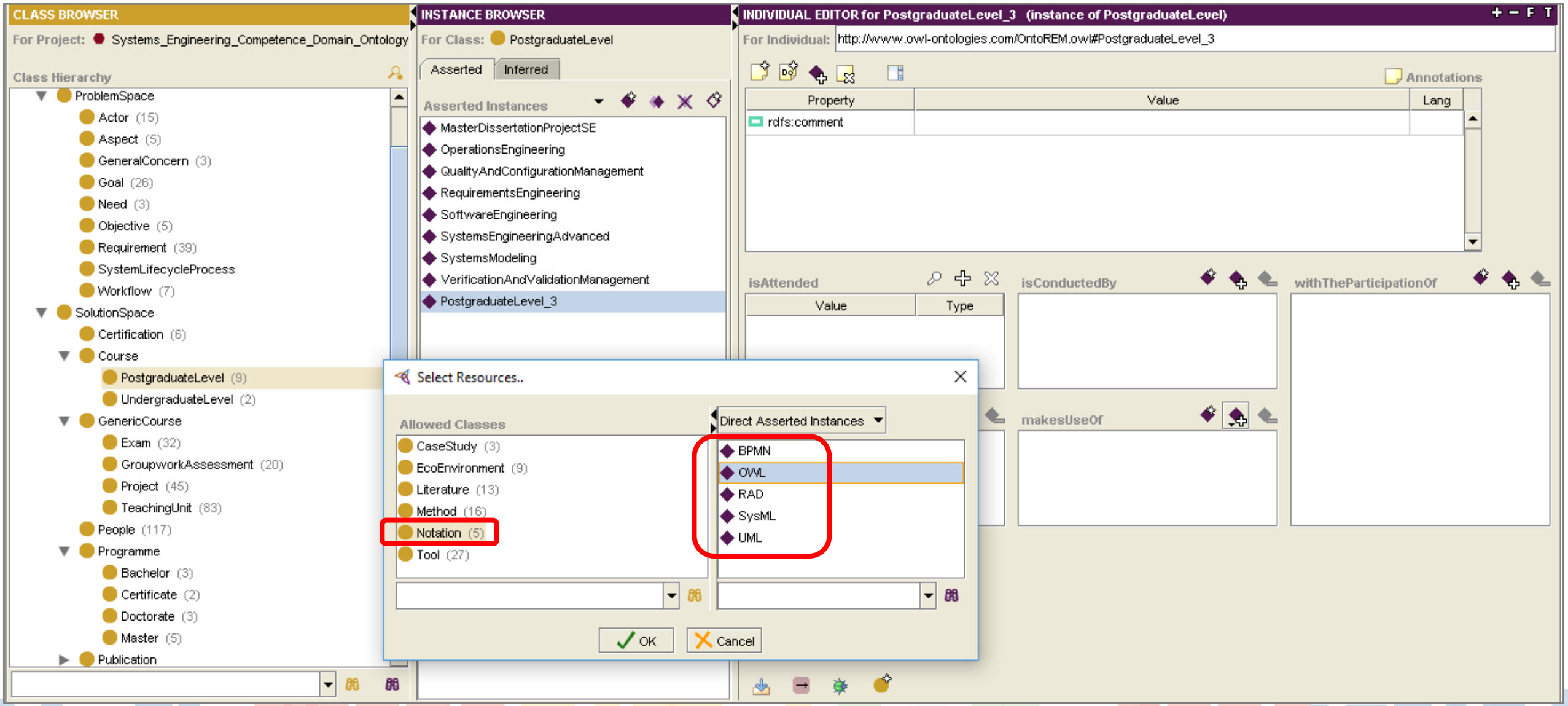


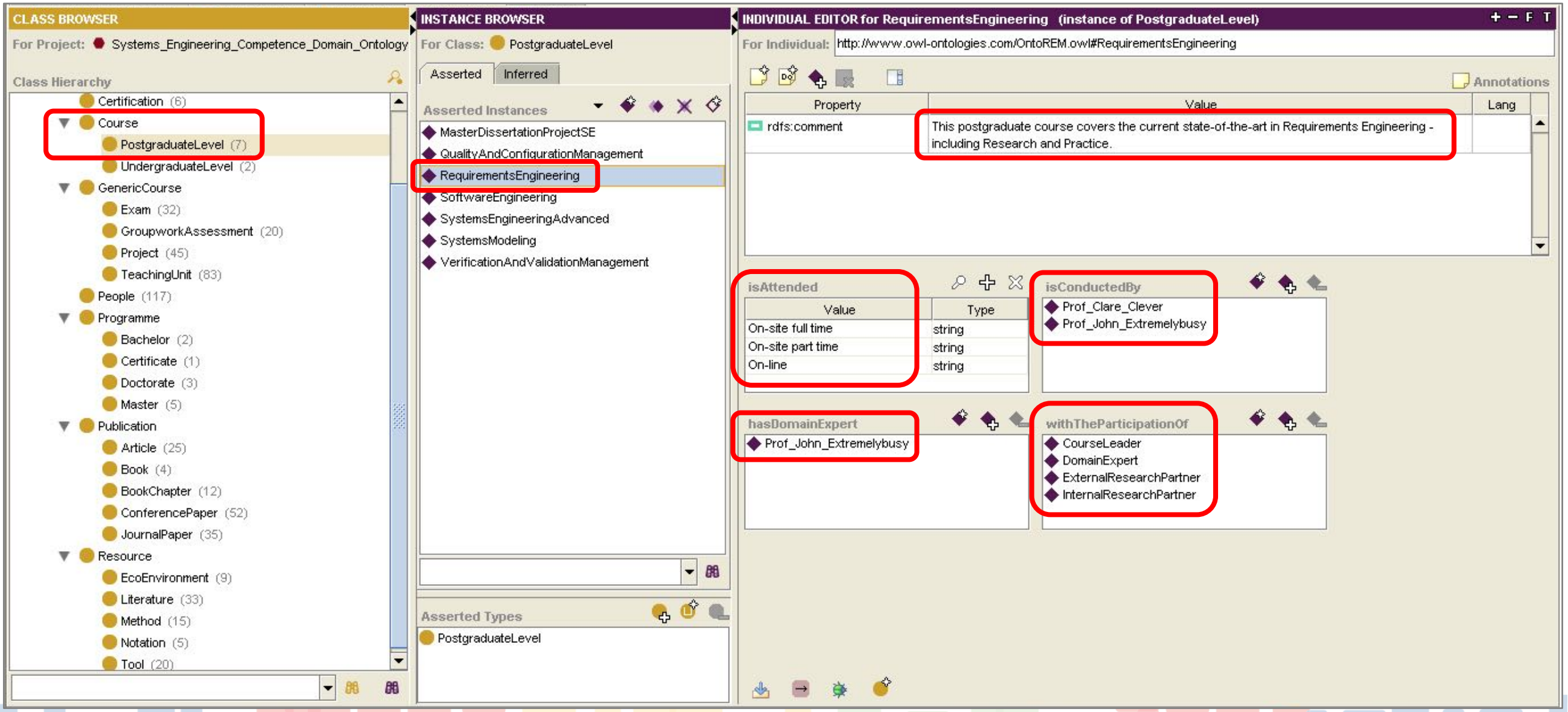
Creating instances of classes



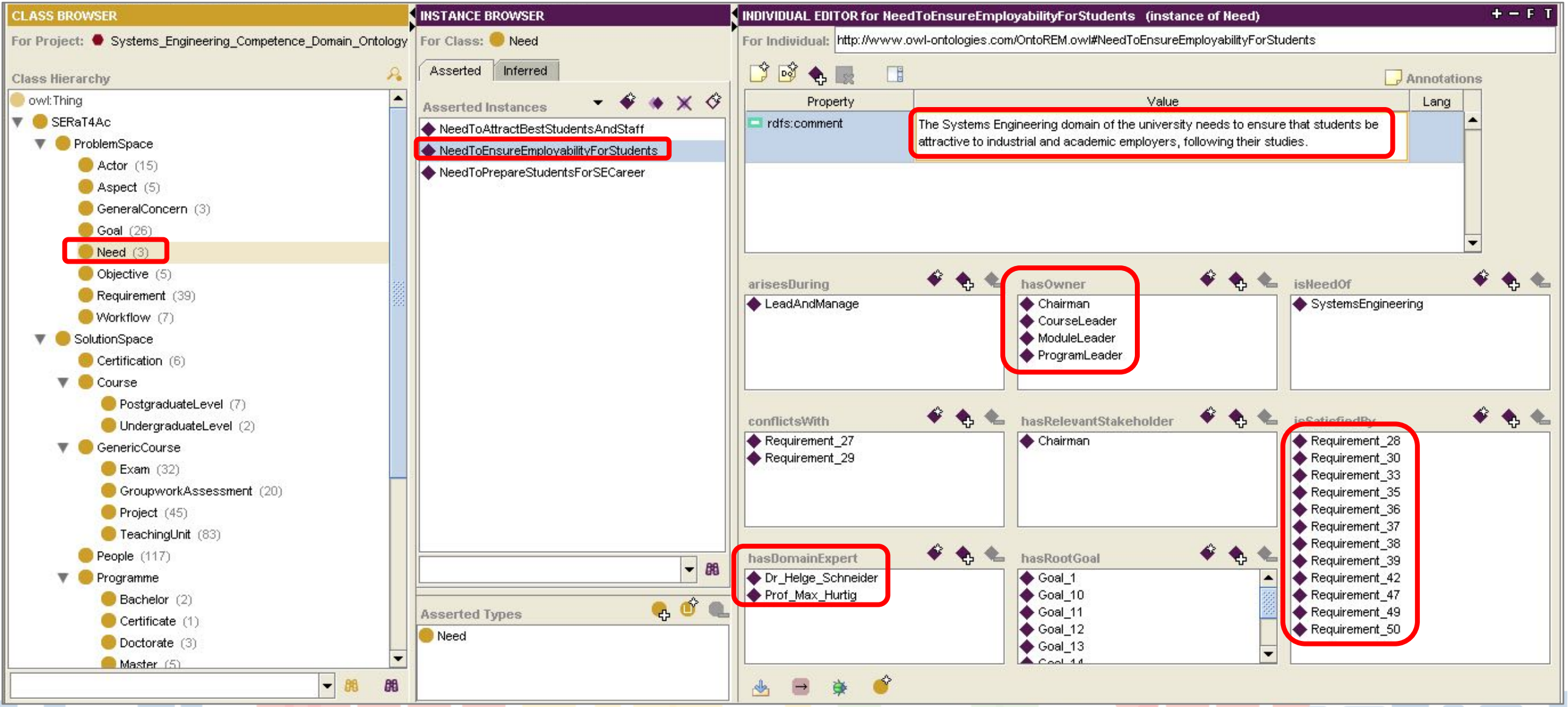
Establishing traceability by linking instances



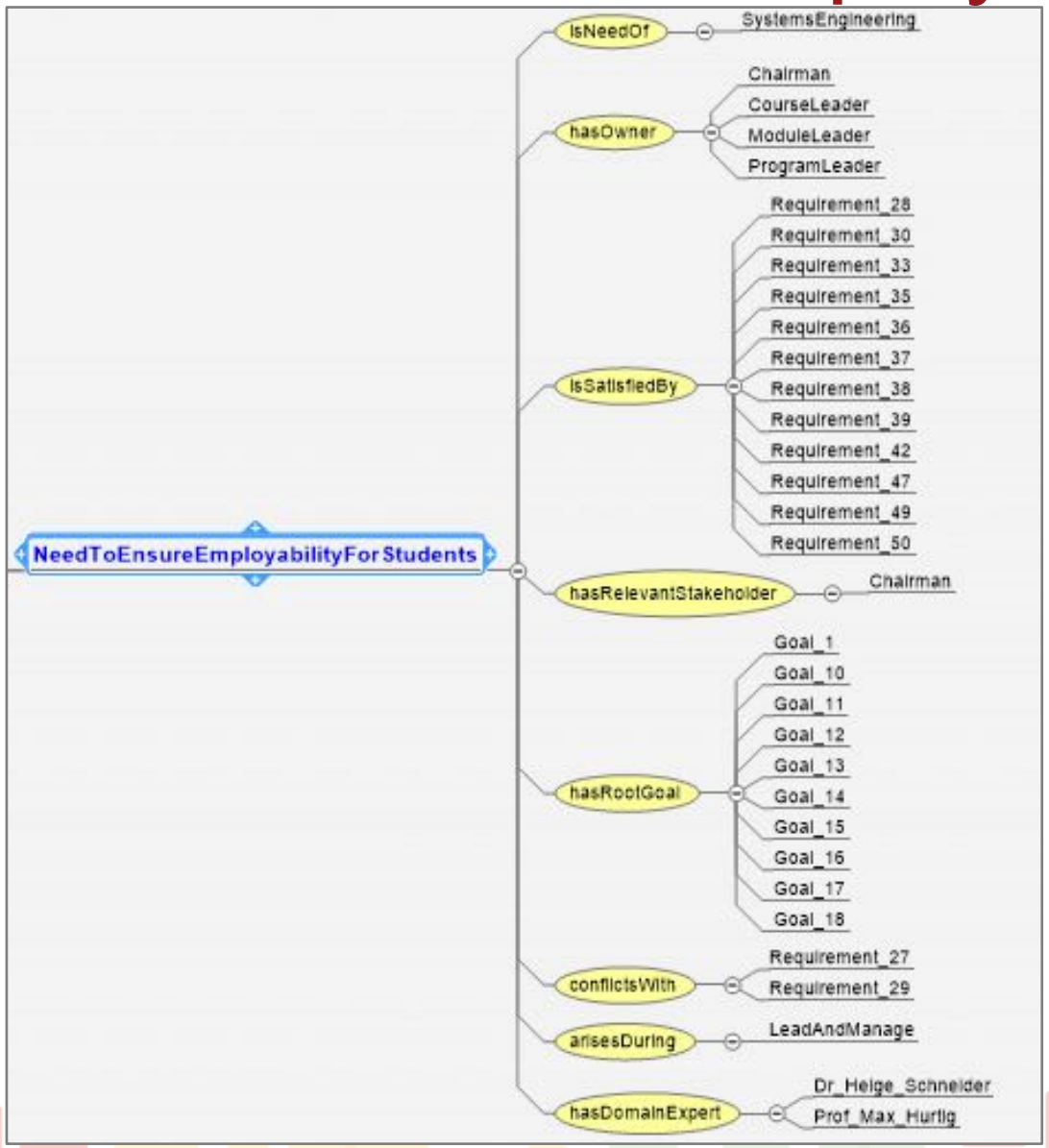
Example – SE courses



Example – Need to ensure employability

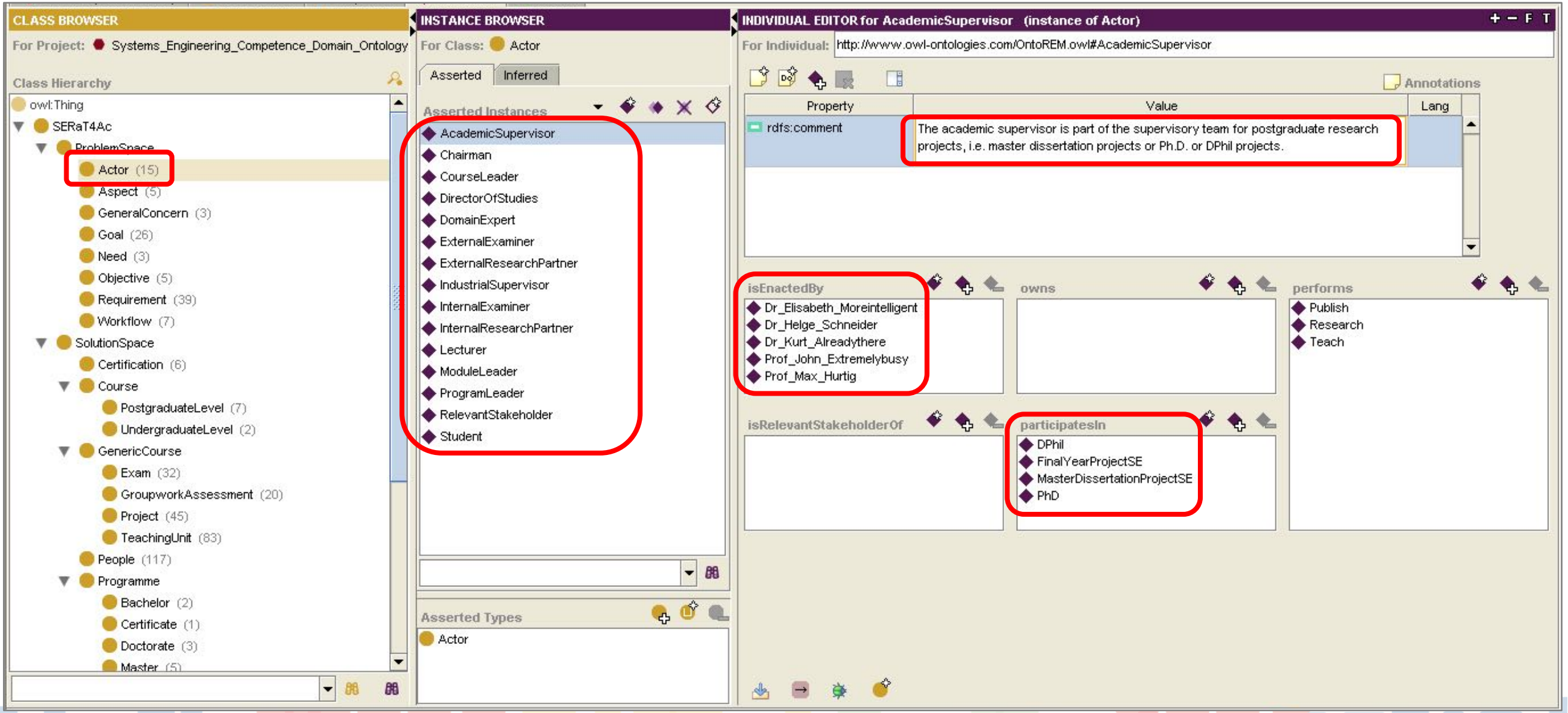


Example – Need to ensure employability

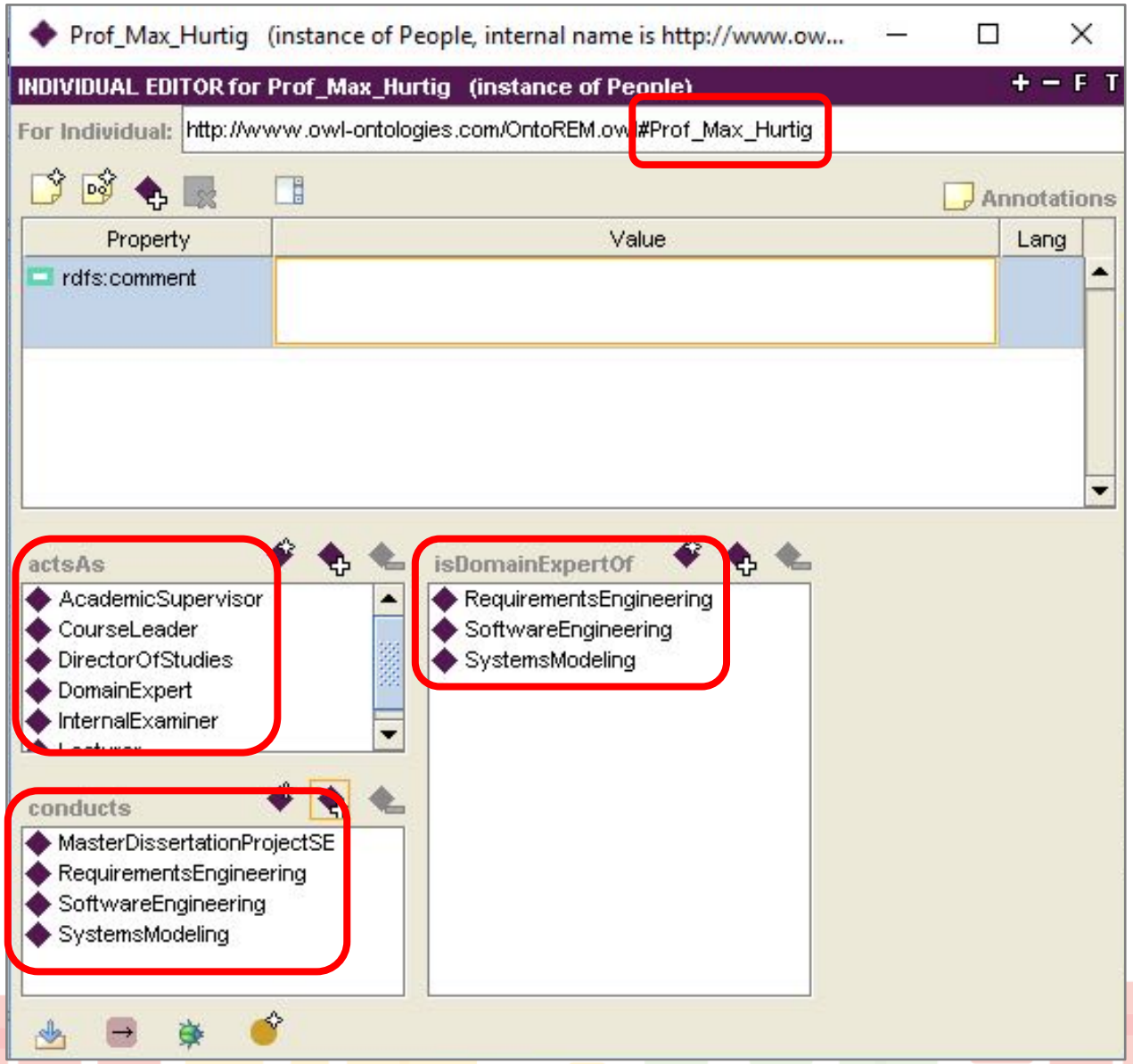


Alternative mind map view

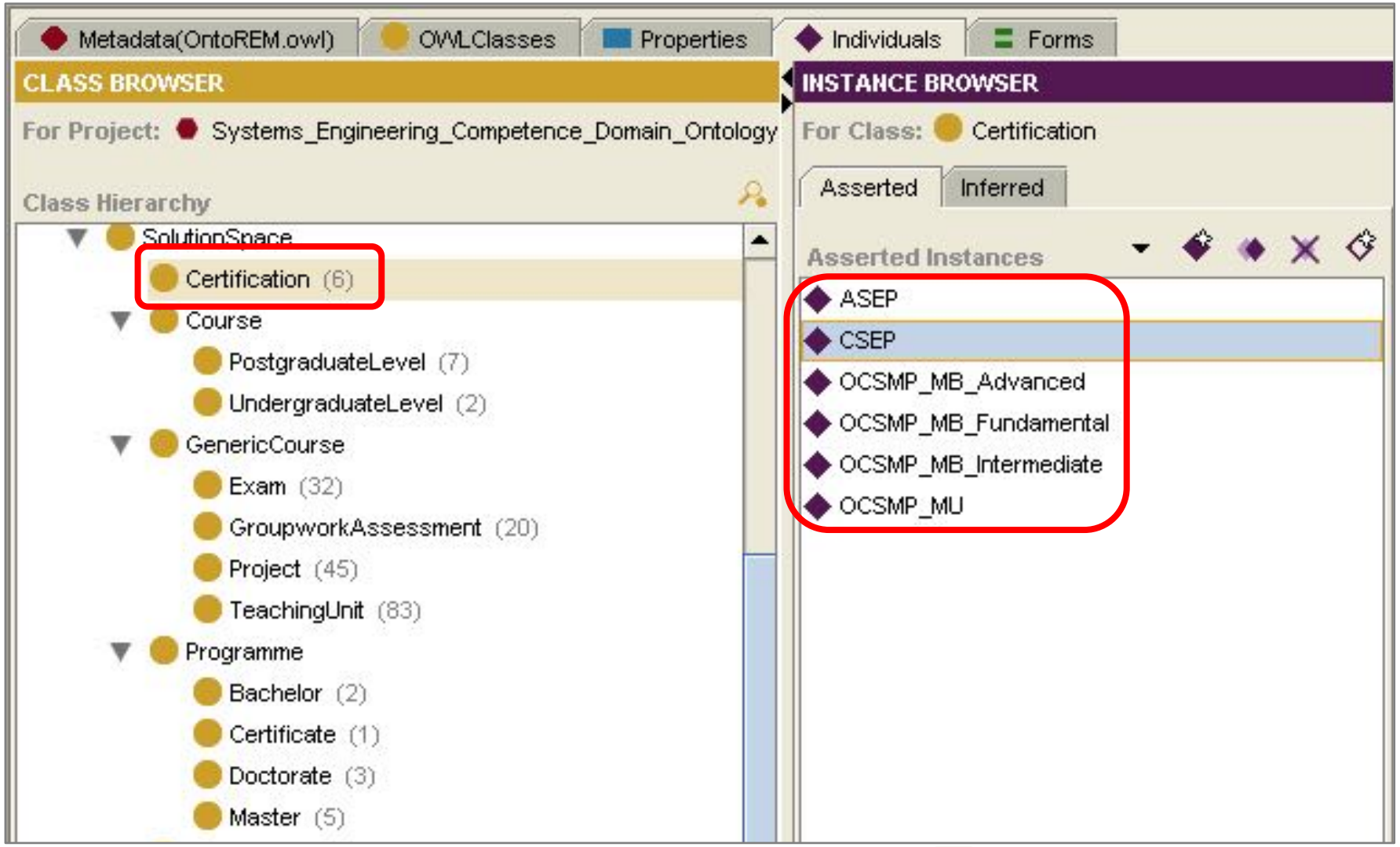
Example – Academic staff member



Example – Academic staff member



Example – Professional SE certifications



Conclusions

- ✓Given that SE is essential for the development and in-life support of increasingly complex systems and SoS, it seems **urgent and important** for engineering based universities to include SE in their academic portfolio.
- ✓One possible **enabler** of the successful establishment of SE as part of the academic portfolio is to develop and maintain an **SE domain ontology** that helps to manage the complexity of the SE domain knowledge.
- ✓The generic SE domain ontology '**SERaT4Ac**' (SE Research and Teaching for Academia) was developed using the leading open source ontology editor Protégé and the OWL notation; the applied, iterative ontology development process was presented, using typical examples.
- ✓'SERaT4Ac' is intended to serve as a **useful starting point** for universities who wish to follow the proposed approach, which of course would have to be adjusted to a specific university's existing infrastructure and ways of working; so that the new SE domain of the university would be fully aligned with the university's context in terms of its vision, strategy, policies, directives, and overall terminology.
- ✓As part of **future research**, it would seem interesting to conduct one or several comprehensive case studies using the proposed, generic SE domain ontology to critically evaluate the suggested use of ontology, including the re-use of existing ontologies.

Thank you

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