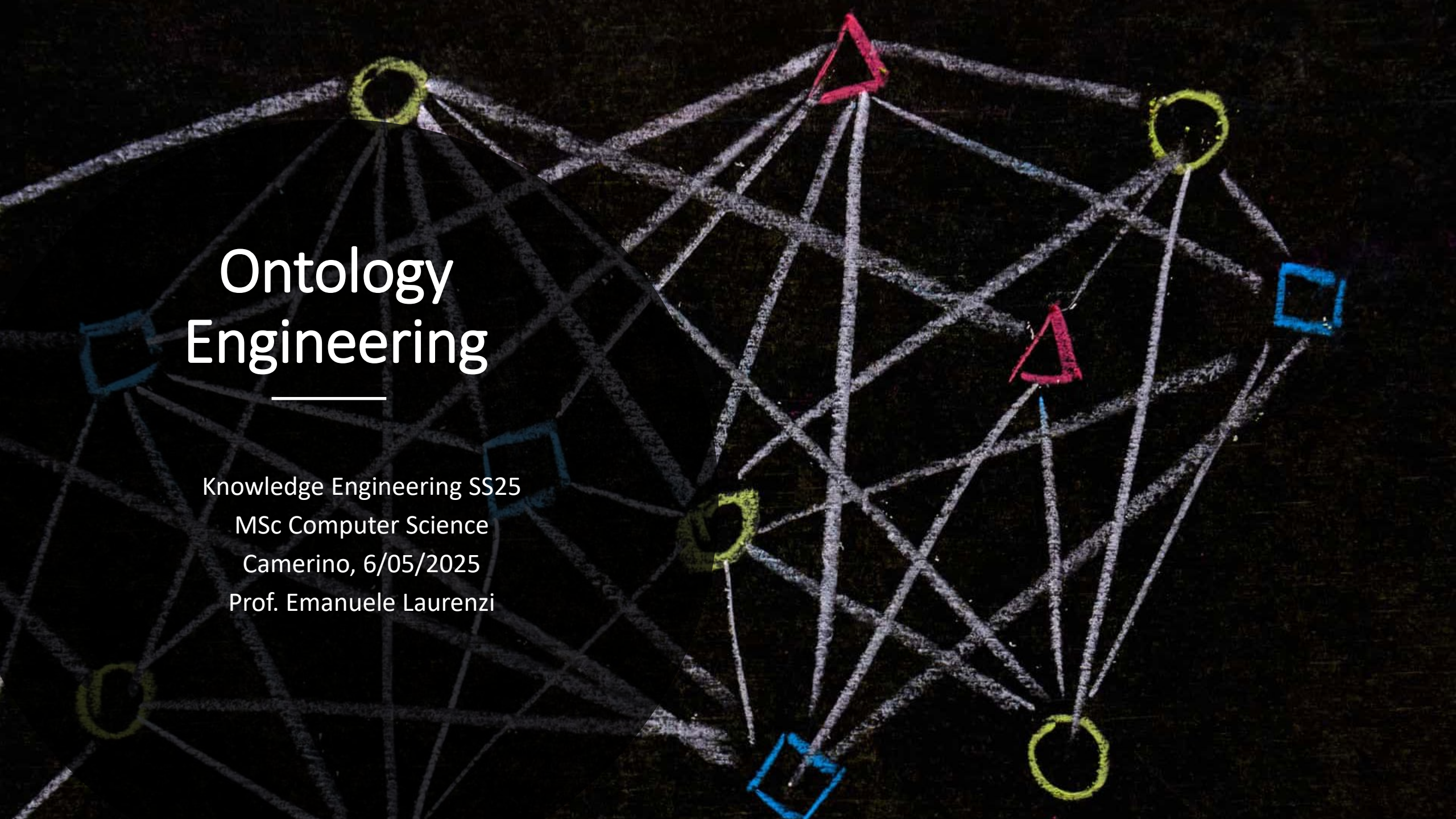


Ontology Engineering

Knowledge Engineering SS25

MSc Computer Science

Camerino, 6/05/2025

Prof. Emanuele Laurenzi

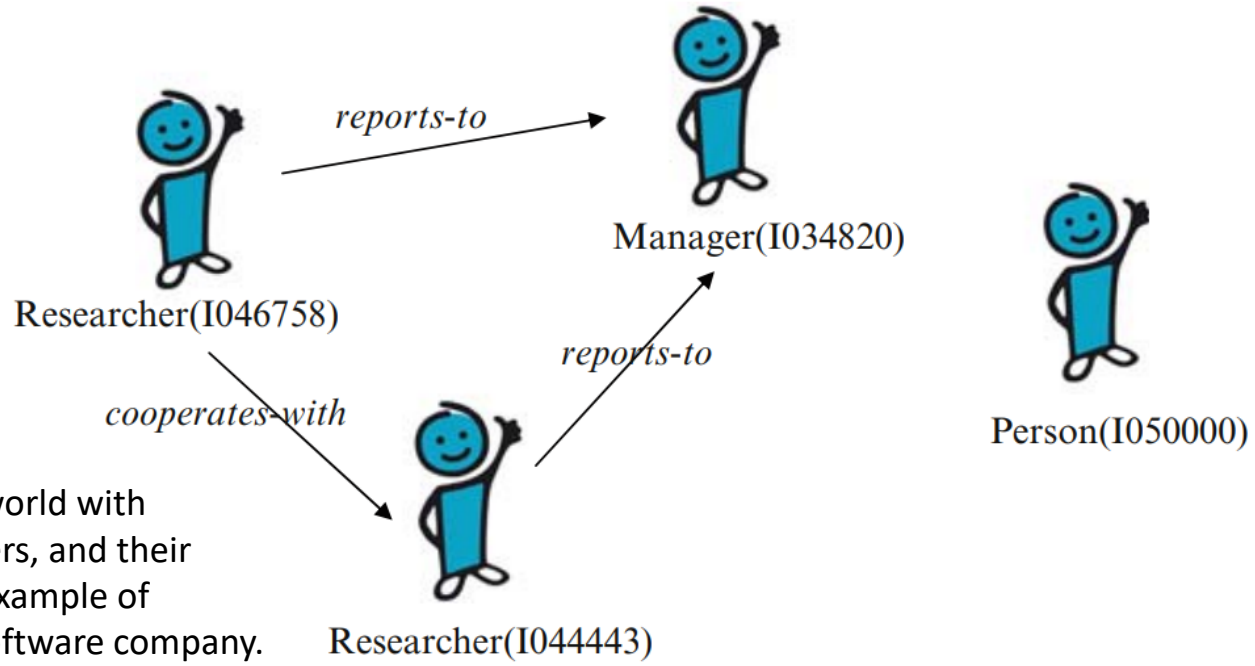
What is an Ontology? According to literature.

- Long history in Philosophy – the study of existence or investigating the nature of things.
  - Ontology is a part of metaphysics, a branch of philosophy that looks at the very nature of things, their being, cause, or identity.
- In the field of computer science and artificial intelligence:
- "An ontology is an "explicit specification of a conceptualization" (Gruber 1993)
- …
- "An ontology is a **formal**, **explicit specification** of a shared **conceptualization"** (Studer at all. 1998)
  - What is a conceptualization?
  - What is a formal, explicit specification?
  - How can we engineer an ontology?

http://www-ksl.stanford.edu/kst/what-is-an-ontology.html

Conceptualization

– "[…] A conceptualization is an abstract, simplified view of the world that we wish to represent for some purpose. […]" Nilsson (1987).

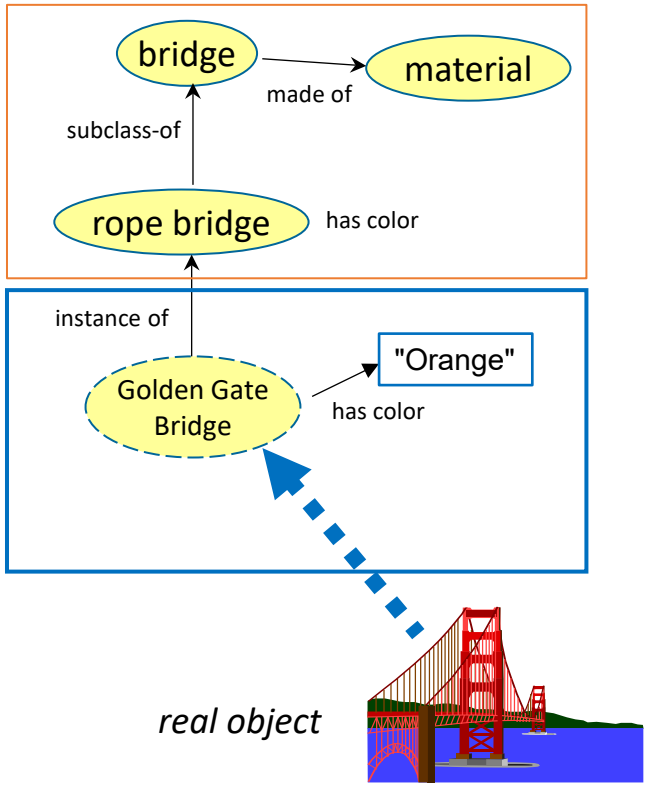


E.g., A tiny part of a specific world with persons, managers, researchers, and their relationships in the running example of human resources in a large software company.

Guarino (2009)

Basic aspects of an Ontology

– An *ontology* consists of
  – Concepts (Classes),
  – Relationships (Object Properties) between concepts,
  – Attributes (Data Properties) of concepts,
  – Constraints that hold between/for the concepts.
– An ontology together with a set of individual instances constitutes a *knowledge base.*



Adapted fromProf. Dr. Knut Hinkelmann

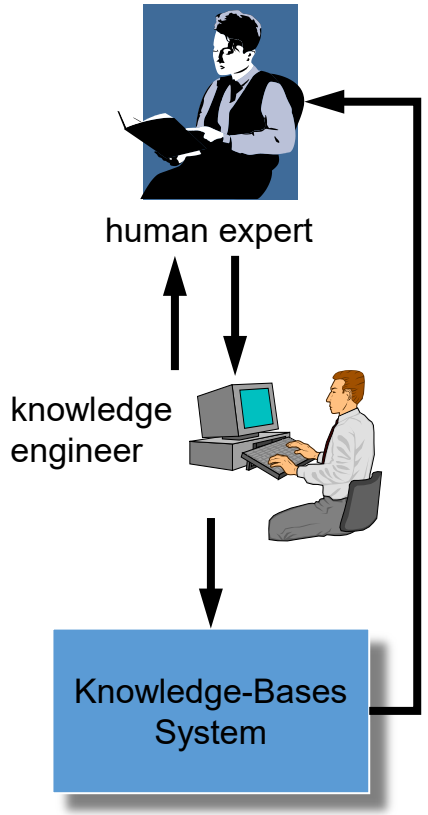
https://people.cs.uct.ac.za/~mkeet/OEbook/slides/L1IntroOE19.pptx

Ontology Engineering means Knowledge Engineering

Definition of Knowledge Engineering

- Knowledge Engineering is the process of
  - building and
  - maintaining

  knowledge-based systems or intelligent agents
- *"Knowledge Engineering is an engineering discipline that involves integrating knowledge into computer systems in order to solve complex problems normally requiring a high level of human expertise."*[1)]
- Sources of knowledge
  - Human experts
  - Documentation



1) Feigenbaum, E., and P. McCorduck. (1983). The Fifth Generation. Reading, MA: Addison-Wesley

Ontology Development 101

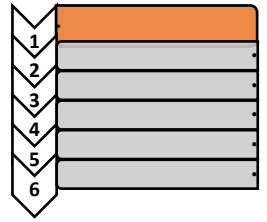
Methodology for ontology engineering

Methodology: Ontology Development 101

1. Determine the domain and scope of the ontology
2. Consider reusing existing ontologies
3. Enumerate important terms
4. Define classes and class hierarchy
5. Define the data and object properties of classes
6. Create instances

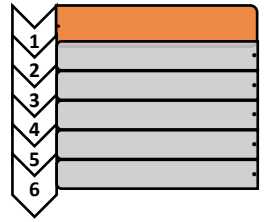
Adatped from OntologyDevelopment 101
https://perso.liris.cnrs.fr/alain.mille/enseignements/Ecole_Centrale/What%20is%20an%20ontology%20and%20why%20we%20need%20it.htm

Determine the domain and scope of the ontology



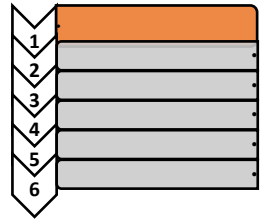
- What is the domain that the ontology will cover?
- For what we are going to use the ontology?
- For what types of questions the information in the ontology should provide answers? → Competency questions
- Who will use and maintain the ontology?

Competency Questions



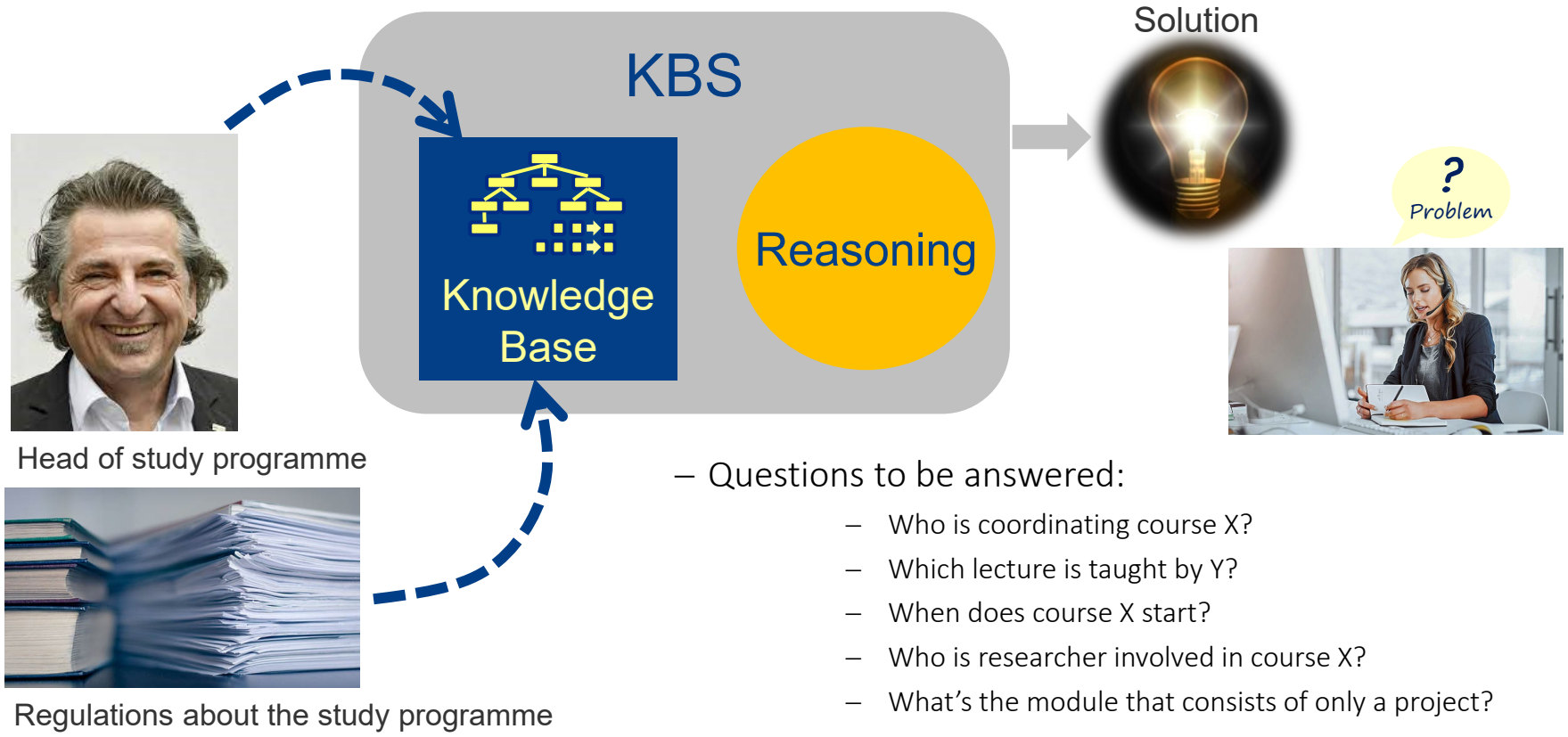
- One of the ways to determine the scope of the ontology is to sketch a list of questions that a knowledge base based on the ontology should be able to answer (Gruninger and Fox 1995)
  - Does the ontology contain enough information to answer these types of questions?
  - Do the answers require a particular level of detail or representation of a particular area?

Example for a scope and domain



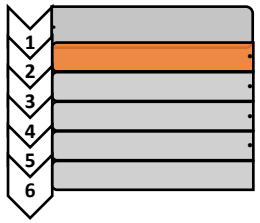
- We want to represent knowledge about
  - the courses in the MSc in Business Information Systems,
  - responsibilities for and contribution to these courses.
- Constraints from the underlying reality:
  - A module consists of a project or a course.
  - Members of the research staff can be involved in modules of the MSc BIS, he or she can teach a course but can't coordinate them.
  - A lecturer or professor are part of the didactic staff and can coordinate a module in the MSc BIS.
  - Both research and didactic staff are considered academic staff.
- Competency Questions:
  - Who is coordinating course X?
  - Which lecture is taught by Y?
  - When does course X start?
  - Who is researcher involved in course X?
  - What's the module that consists of only a project?

Example



- Questions to be answered:
  - Who is coordinating course X?
  - Which lecture is taught by Y?
  - When does course X start?
  - Who is researcher involved in course X?
  - What's the module that consists of only a project?

Consider reusing existing ontologies



- It is always worth considering what others have done, and check if their work can be refined and extended for our particular domain and task.
- Mandatory if the system needs to interact with other applications that have already committed to particular ontologies or controlled vocabularies.

An example of re-used ontology from the literature

ArchiMEO: A Standardized Enterprise Ontology based on the ArchiMate Conceptual Model

Knut Hinkelmann[a], Emanuele Laurenzi[b], Andreas Martin[c], Devid Montecchiari[d], Maja Spahic[e] and Barbara Thönssen[f]
School of Business, FHNW University of Applied Sciences and Arts Northwestern Switzerland, 4600 Olten, Switzerland

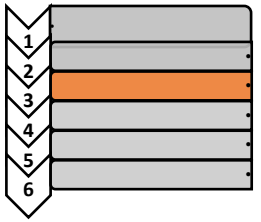
Keywords: Enterprise Ontology, Enterprise Architecture, ArchiMate, Enterprise Modeling.

Abstract: Many enterprises face the increasing challenge of sharing and exchanging data from multiple heterogeneous sources. Enterprise Ontologies can be used to effectively address such challenge. In this paper, we present an Enterprise Ontology called ArchiMEO, which is based on an ontological representation of the ArchiMate standard for modeling Enterprise Architectures. ArchiMEO has been extended to cover various application domains such as supply risk management, experience management, workplace learning and business process as a service. Such extensions have successfully proven that our Enterprise Ontology is beneficial for enterprise applications integration purposes.

https://www.scitepress.org/Papers/2020/90002/90002.pdf

Exercise:
Enumerate important terms in the ontology

- What are the terms we would like to talk about?
- What are their properties?
- What would we like to say about those terms?

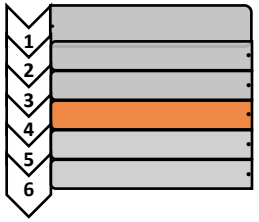


Important Terms

Given the focus and the competency questions, important terms are:

- module, project, course, MSc BIS course, professor, lecturer, researcher, research staff, didactic staff, academic staff.

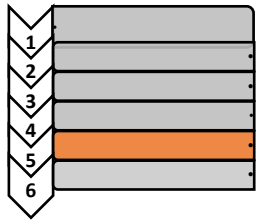
Exercise:
Define Classes and Class Hierarchy

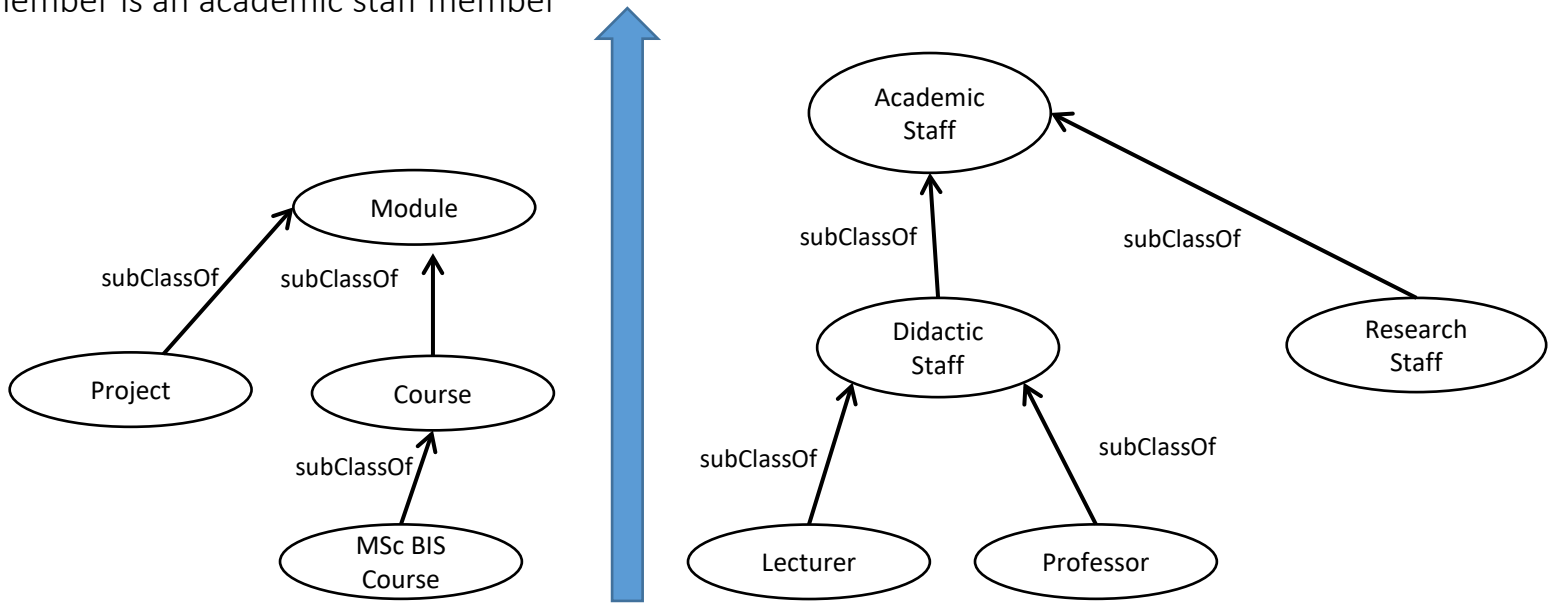


- Several possible approaches in developing a class hierarchy:
  - Top-down: General to specific concepts
  - Bottom-up: Specific to general concepts
  - Combination: Salient to general and specific concepts
- Classes for
  - Modeling Objects
  - Relations

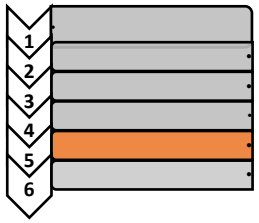
Class Hierarchy

- Bottom-up approach:
  - A MSc BIS course is a course
  - A course is a module
  - A project is a module
  - A professor is a didactic staff member
  - A didactic staff member is an academic staff member
  - Etc.



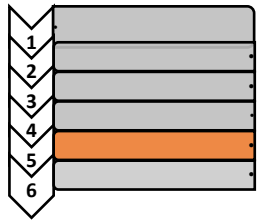


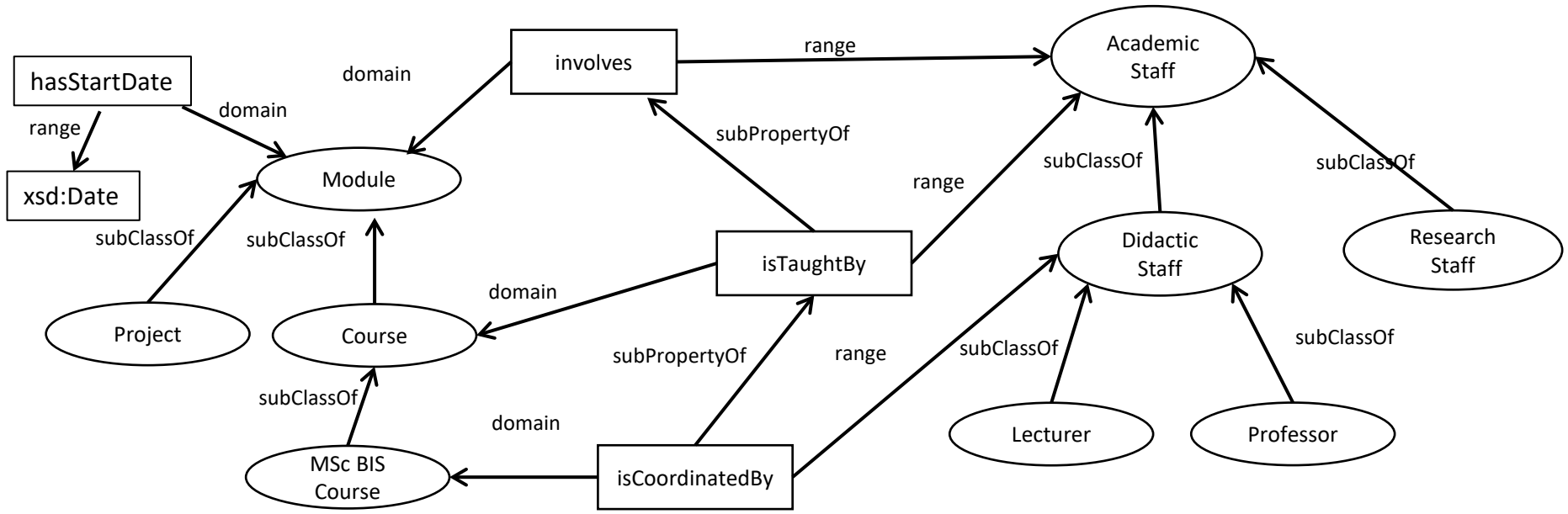
Exercise:
Define the properties of classes



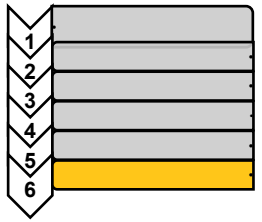
- Describe the internal structure of concepts
  - Data Type Properties: Attributes
    - Range are data types like String, Integer, …
  - Object Properties: Relations to other concepts
    - Range are classes
- Inheritance to Sub-classes

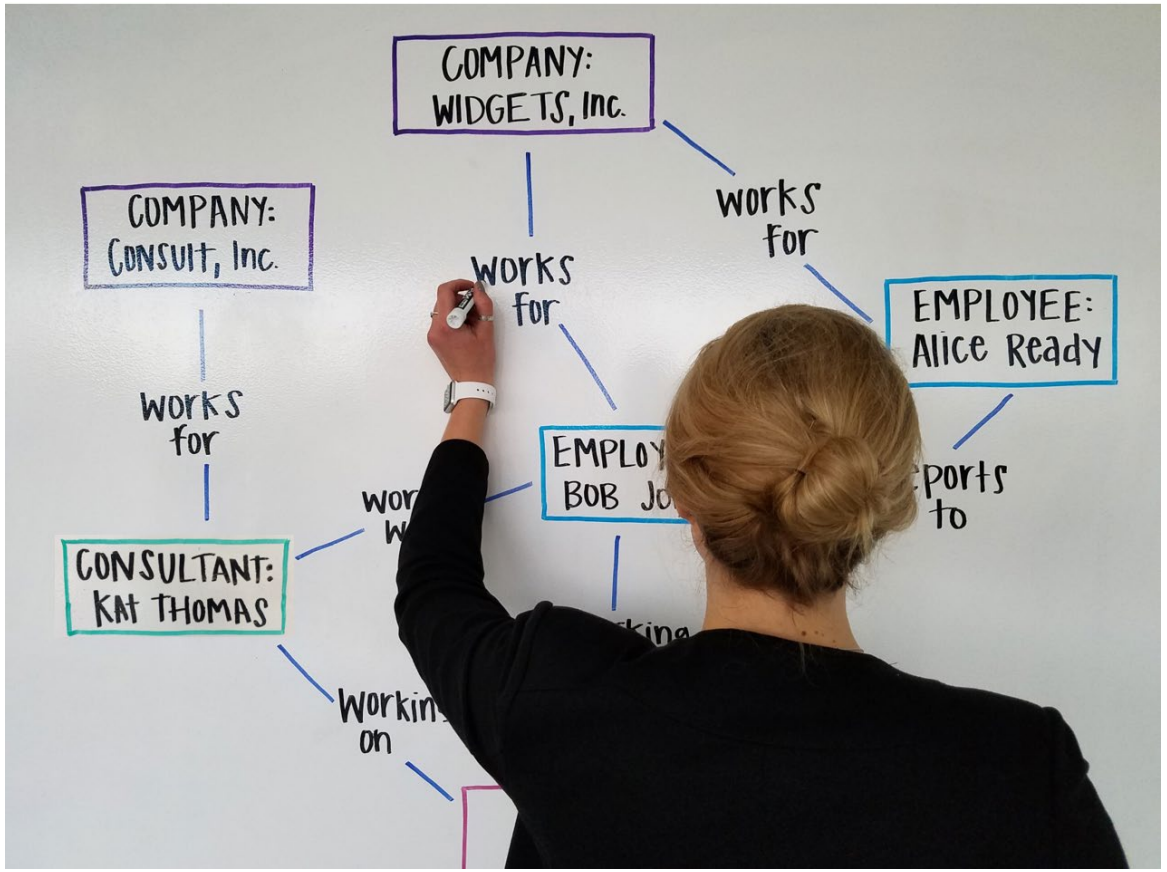
A possible result





Exercise: Create Instances



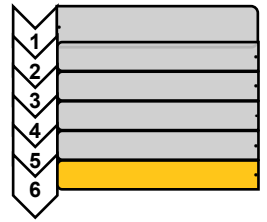


Create Instances

- Holger Wache is a professor
- KP_DM is taught by Holger Wache
- KP_DM is a MSc BIS course
- Emanuele Laurenzi is a lecturer
- KP_DM is taught by Holger Wache
- KP_DM is coordinated by Holger Wache
- KP_DM has start date 26.02.2022

- Knut Hinkelmann is a Professor
- ABIT is taught by Knut Hinkelmann
- ABIT is coordinated by Knut Hinkelmann
- ABIT is a course of MSc BIS
- Devid Montecchiari is a research staff member
- Devid Montecchiari is involved in ABIT
- ABIT has startdate 24.02.2022

- Manager's Shadow Project is a project (i.e., a module but not a course)



Test Your Ontology

– Turn the competency questions into SPARQL queries and fire the queries against your ontology.

- Who is coordinating course X?
- Which lecture is taught by Y?
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Test Your Ontology

– Turn the competency questions into SPARQL queries and fire the queries against your ontology.

- Who is coordinating course X?
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```
SELECT ?project
WHERE {
  ?project rdf:type teaching:Project .
}
```

teaching:MSP

Query Editor | Query Library

```
SELECT ?module ?coordinator
WHERE {
  ?module teaching:isCoordinatedBy ?coordinator .
}
```

[module]	coordinator
teaching:ABIT	teaching:Knut123
teaching:KP_DM	teaching:Holger123

Query Editor | Query Library

```
SELECT ?lecture ?teacher
WHERE {
  ?lecture  teaching:isTaughtBy ?teacher .
}
```

[lecture]	teacher
teaching:ABIT	teaching:Knut123
teaching:KP_DM	teaching:Holger123
teaching:KP_DM	teaching:Emanuele123

Query Editor | Query Library

```
SELECT ?course ?start
WHERE {
  ?course teaching:hasStartDate ?start .
}
```

[course]	start
teaching:ABIT	2022-02-24
teaching:KP_DM	2022-02-26

Query Editor | Query Library

```
SELECT  ?course ?researcher
WHERE {
  ?course teaching:involves ?researcher .
}
```

[course]	researcher
teaching:ABIT	teaching:Devid123

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