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## Applied Ontology Engineering (703817, VU2)


### Unit 1

Dr. Martin Hepp


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## Profile Dr. Martin Hepp



2005 -	Senior Researcher, Digital Enterprise Research Institute (DERI), University of Innsbruck
2003-2005	Assistant Professor of Computer Information Systems, Florida Gulf Coast University, Fort Myers, Florida, USA
2000-2003	PhD in Management and Information Systems, University of Würzburg, Germany
1994-1999	Diplom-Kaufmann (M.B.A.), Business Administration and Management, University of Würzburg Majors: Information Systems, Operations Research, Law




**Office Hours:**


By appointment only

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<http://www.heppnetz.de>



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## Course Overview


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Building consensual representations of a domain of discourse is a prerequisite for Semantic Systems. In this course, students will learn the fundamental techniques of Ontology Engineering and get hands-on experience by developing non-toy ontologies for various domains.

- Fundamentals of Ontologies
- Ontology Engineering Methodologies
- Ontology Formalisms and Languages: RDF-S, OWL-DL, and WSML
- Ontology Design Patterns
- Hands-on exercises in the e-Business, Logistics, Tourism, and other domains

 <http://www.heppnetz.de/teaching/aoe/>

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## Overall Learning Goal

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Acquire the


- theoretical knowledge and
- practical skills

necessary to


- build,
- maintain, and
- review

real-world ontologies in various ontology formalisms (mainly WSML).

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## Attendance Policy




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- I need you ☺
- This is a graduate course; **assignments will require material discussed in class, not just what's on the slides or in the textbook!**



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## Course Logistics (1)




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**<http://www.heppnetz.de/teaching/aoe/>**

- Lecturer: Dr. Martin Hepp
- Lecture with Hands-on Sessions (VU2) for Master Students
- Classroom: **3W03 (Video conference room, TransIT building, level "02" (3rd floor in American counting))**
- Time: starting March 6th , Mon, 13:00 - 15:00 plus **one extra unit**  
**July 3, 12.00 noon – 6.00 p.m.**
- Registration:  
**<https://www.uibk.ac.at/zid/basicauth/validate.pl>**




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## Course Logistics (2)

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- **Classes**
  - **Mar 6:** Unit 1
  - **Mar 13:** **no classes** – *make-up on July 3*
  - **Mar 20:** **no classes** – *make-up on July 3*
  - **Mar 27:** Unit 2
  - **April 3:** **no classes** – *make-up on July 3*
  - **April 24:** Unit 3
  - **May 8:** Unit 4
  - **May 15:** Unit 5
  - **May 22:** Unit 6
  - **May 29:** Unit 7
  - **Jun 12:** **no classes** – *make-up on July 3*
  - **Jun 19:** Unit 8
  - **Jun 26:** Unit 9
  - **July 3:** Unit 10: Final Presentations (mandatory)  
**12.00 noon – 6.00 p.m.** (also make-up for missed classes)




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## Assignments and Grading

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- **Two Quizzes (25 %)**
  - Covers mandatory reading
  - Quiz 1: March 27
  - Quiz 2: to be announced
  - No make-up possible (except in case of absence due to medical reasons, to be certified by a medical doctor)
- **Individual Assignments (40 %)**
  - One or more (small) WSML ontology/ontologies plus documentation
- **Group Assignment (35 %)**
  - One (big) WSML ontology plus documentation plus presentation



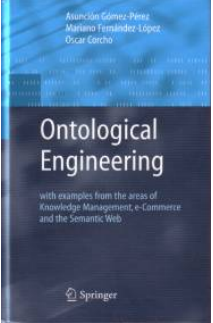
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## Resources

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- **Textbook (mandatory)**  
Gómez-Pérez/Fernández-López/Corcho:  
*Ontological Engineering*  
Springer 2004
- **Additional Materials (mandatory)**  
Will be made available or announced in class
- **Course Web Page**  
<http://www.heppnetz.de/teaching/aoe>



Slides will be made available on the Web page **after (!)** the respective unit.




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## Preliminary Syllabus

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- Unit 1:** Ontology Engineering Fundamentals
- Unit 2:** Ontology Formalisms: RDF-S and WSML / Ontology Tools: WSMT and SWEDE
- Unit 3:** Ontology Engineering Methodologies
- Unit 4:** OntoClean including Exercises
- Unit 5:** Introduction to Description Logics / Pitfalls – The OWL Pizza Experiments
- Unit 6:** Ontology Mapping, Merging, Alignment, and Exercises
- Unit 7:** Ontology Engineering Exercises 1
- Unit 8:** Ontology Engineering Exercises 2
- Unit 9:** Ontology Engineering Exercises 3
- Unit 10:** Group Presentations



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## The need for a shared understanding




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- People, organizations, and software systems must communicate between and among themselves
- However, due to different needs and background contexts, there can be widely varying viewpoints and assumptions regarding what is essentially the same subject matter; each may have differing, overlapping and or mis-matched concepts
- The consequent lack of a shared understanding leads to poor communication within and between people, organizations, and systems.
- It limits interoperability and re-use of data and program code.




from: Uschold/Gruninger: Ontologies: Principles, Methods and Applications, 1996

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## Natural language is very ambiguous...




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- „I saw him standing near the **bank**.“
- „The **jaguar** was much faster than we we all had expected.“
- „The unknown species was very **tall**.“


Only the amount of contextual information (e.g. was had been said before, the speaker's identity and background,...) helps us restrict all possible interpretations of a statement to the most likely intended one.



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## What is an ontology?




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- **Ontology:** A shared understanding of some domain of interest.
- An ontology necessarily entails or embodies some sort of world view with respect to a given domain.
- Often in the form of a set of
  - concepts (entities, attributes, processes),
  - their definitions, and
  - their inter-relationships.
- This is called a „conceptualization“.




from: Uschold/Gruninger: Ontologies: Principles, Methods and Applications, 1996

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## Varying degree of formality




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- **highly informal:** expressed loosely in natural language
- **semi-informal:** expressed in a restricted and structured form of natural language
- **semi-formal:** expressed in an artificial, formally defined language
- **rigorously formal:** meticulously defined terms with formal semantics, theorems and proofs of such properties as soundness and completeness



from: Uschold/Gruninger: Ontologies: Principles, Methods and Applications, 1996


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## Higher degree of formality: Costs and benefits

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- The more formal an ontology is, the more does it exclude unwanted interpretations.
- Also, it includes the amount of inferences that can be drawn.
- However, it is more costly in terms of labor and engineering delay to create a more formal conceptualization.
- Also, achieving consensus is more difficult and time-consuming for a higher degree of formality.
- A higher degree of formality also imposes high entry barriers on the ones who are to model the respective domains and thus excludes potential contributors.



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## Main categories of uses for ontologies

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**COMMUNICATION**

between people  
and organizations

**INTEROPERABILITY**


between systems

**SYSTEMS ENGINEERING**

Reusable Components    Reliability

Specification

from: Uschold/Gruninger: Ontologies: Principles, Methods and Applications, 1996



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## The contractual dimension of ontologies in business settings

- Ontologies allow to make explicit what is agreed **and what is not agreed**.
- This avoids misunderstandings about how narrow or broad a given term is meant in a business relationship.

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## Ontologies as a hub for meaning

$2 \cdot n$  more translators for each additional node


2 more translators for each additional node

from: Uschold/Gruninger: Ontologies: Principles, Methods and Applications, 1996

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## What is Ontology Engineering?




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- The art and science of building, maintaining, and evaluating consensual representations of a domain of interest.



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## Skeletal methodology for building ontologies




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- Identify Purpose and Scope
- Building the Ontology
  - ontology capture
  - ontology coding
  - integrating existing ontologies
- Evaluation
- Documentation


from: Uschold/Gruninger: Ontologies: Principles, Methods and Applications, 1996



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## Initial guidelines for designing ontologies




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- **Clarity:** Communicate effectively the intended meaning to humans who use the ontology
  - Natural language definitions
  - Give examples
  - Motivate distinctions
  - Formal axioms, if possible
- **Coherence:** The ontology should be internally consistent
  - Axioms
  - Definitions
- **Extensibility:** Crafted so that one can extend and specialize the ontology monotonically
- **Minimal ontological commitment**
  - Make as few claims as possible about the world being modeled
  - Too many (usage restricted) vs. too few (compatible with unintended models)


from: Uschold/Gruninger: Ontologies: Principles, Methods and Applications, 1996



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## Step 1: Purpose and Scope




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- Be clear about why the ontology is being built and what its intended usages are
- E.g.
  - interoperability between systems
  - systems engineering
  - communication between people and organizations
- Recommended: Written document


from: Uschold/Gruninger: Ontologies: Principles, Methods and Applications, 1996



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## Motivating Scenarios




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- Define one or more motivating scenarios
- Should justify the need for a new ontology
- Should clarify the context of usage of the new ontology




from: Uschold/Gruninger: Ontologies: Principles, Methods and Applications, 1996

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## Competency Questions




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- A set of queries which place demands on the underlying ontology.
- Ontology must be able to represent the questions using its terminology and the answers based on the axioms
- Ideally, in a staged manner, where consequent questions require the input from the preceding ones.
- A rationale for each competency question should be given.




from: Uschold/Gruninger: Ontologies: Principles, Methods and Applications, 1996

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## Step 2: Building the ontology




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- Step 2a: Ontology capture
  - Identify key concepts and relationships
  - produce clear text definitions for these
  - identification of terms that refer to these
  - Consensus
- Step 2b: Ontology coding
  - Explicit representation of the conceptualization in some formal language




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## Ontology Capture: Scoping




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- Brainstorming
  - Produce all potentially relevant terms and phrases
  - People involved must have substantial domain expertise
- Grouping: Structure terms loosely into work areas
  - Provisionally categorize them for inclusion or exclusion (-> purpose and scope)
  - Keep notes of these decisions
  - Group similar terms and potential synonyms together




from: Uschold/Gruninger: Ontologies: Principles, Methods and Applications, 1996

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## Ontology Capture: Produce Definitions




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- Determine suitable **meta-ontology**
  - especially: use words and modeling primitives in a consistent manner (e.g. role, entity, relationship, instance,...)
- **Work areas:** Start with those the have the most semantic overlap with others
  - must be right in the first place, otherwise lot of redundant re-working
- **Terms:** Produce definitions in a middle-out fashion rather than top-down or bottom up.
  - see next slide




from: Uschold/Gruninger: Ontologies: Principles, Methods and Applications, 1996

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## Produce Definitions: The Middle-out Approach




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- Define the most basic (i.e. important) terms first in each work area before moving to more abstract or more specific terms
- **Example:**
  - Dog – fundamental
  - Spaniel – specific
  - Mammal – abstract
- **Guideline:** Basic is what is the same for most people




from: Uschold/Gruninger: Ontologies: Principles, Methods and Applications, 1996

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## Advantages of the Middle-out Approach




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- A bottom-up approach results in a high degree of detail
  - increases overall effort
  - makes it difficult to spot commonality between related concepts
  - increases risk of inconsistencies and re-work
- Top-down allow better control of degree of detail
  - risk of arbitrary high-level categories
  - risk of limited stability
- Middle-out strikes a balance in terms of the level of detail
- The higher level categories naturally arise and are thus more likely to be stable.




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## Reaching Agreement: Some suggestions




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- Produce a natural language text definitions
- Ensure consistency with terms already in use
  - use existing thesauri and dictionaries
  - avoid introducing new terms in the definitions
- Indicate relationships with other commonly used terms
  - synonyms, variants, broader / narrower terms, such referring to different dimensions
- Give examples




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## Step 3: Integrating Existing Ontologies




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- Check overlap with existing ontologies
- Establish formal links
  - Produce mappings to existing concept definitions
  - Import and extend existing ontologies
- **Avoid re-inventing the wheel!**




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## Step 4: Ontology Evaluation




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- Validate whether the ontology produced is consistent and meets the requirements specification
  - Intended scope and usages
  - Competency questions




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## Step 5: Documentation




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- Give natural text definitions for each element of the ontology,
- Ideal: retrievable resources at the very same URI, if URIs are used as ontology element identifiers
- Use multi-media elements, if feasible



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## Most Popular Modeling Primitives




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- Class/Concept
- Is-A Relationships
  - InstanceOf / rdf:type
  - subclassOf / rdfs:subclassOf
- Generic Relationship/Property
  - Object Property
  - Datatype Property
- Individual/Instance



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## Assignment for Next Class




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- Read Uschold & Gruninger: *Ontologies: Principles, Methods and Applications*, 1996
  - link available on the course homepage
  - <http://www.heppnetz.de/teaching/aoe>
- Read chapter 1 in the textbook (p. 1 – 45)
  - Gómez-Pérez/Fernández-López/Corcho: *Ontological Engineering*, Springer 2004
- Build a small ontology for the domain of a university library in the form of a semantic network.
- **Be prepared: Quiz** at the beginning of unit 2 (March 27)



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## Modeling Examples



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- Peter loves Frieda, a brown-eyed Spaniel.
- Peter loves Frieda, his friend Paul's Spaniel.
- Peter wrote down a poem by Shakespeare.



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**Thank you!**

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