Knowledge Representation for the Semantic Web

Winter Quarter 2011

Slides 1 – 01/04/2011

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Today's Session

1. About me and my expectations for this course
2. About you and your expectations for this course
3. What is *Semantic Web*?
   Why does it need *Knowledge Representation*?
4. Course Project
5. Course contents overview
6. Organizational matters

About me

- 1998 Diplom (Master) in Mathematics, Tübingen, Germany
- 2001 PhD in Mathematics, Cork, Ireland
- 2001-2004 Postdoc in Artificial Intelligence, Dresden, Germany
- 10-12.2003 Research Associate CWRU Cleveland OH
- 2004-2009 Assistant Prof. in Appl. Comp. Sci., Karlsruhe, Germany
- since September 2009: Assistant Prof., Kno.e.sis Center at WSU

- Active Semantic Web researcher – this course is a basic introduction to my current core research area.

My expectations

- **PhD students beyond the Master do not require teaching through courses: If you're pursuing a PhD you should be able to learn all by yourself those things which you need to learn.**

- **Still, learning through courses can be helpful, and can in particular provide shortcuts to things you need.**

- **And it's rarely wrong to acquire broad knowledge.**

- **I expect:**
  That you take responsibility yourself, and decide for yourself how much work you want to put into this course.
  Regretfully, however, I will have to give grades at the end ...

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Who are you?

- **Which year?**
- **Master or PhD?**
- **Which specialization area?**
- **Why are you here?**
  - **topic relates to my specialization area;**
  - **topic sounds interesting;**
  - **need another course and it doesn't matter which;**
  - **not sure if I'll stay;**
  - **supervisor told me to come;**
  - **a friend dragged me along;**
  - **isn't this the Algebraic Topology class?**
  - **...**

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The WWW is penetrating our society

- Social contacts (social networking platforms, blogging, ...)
- Economics (buying, selling, advertising, ...)
- Administration (eGovernment)
- Education (eLearning, Web as information system, ...)
- Work life (information gathering and sharing)
- Recreation (games, role play, creativity, ...)

The current Web

- **Immensely successful.**
- **Huge amounts of data.**
- **Syntax standards for transfer of structured data.**
- **Machine-processable, human-readable documents.**

BUT:

- **Content/knowledge cannot be accessed by machines.**
  Meaning (semantics) of transferred data is not accessible.

Limitations of the current Web

- Too much information with too little structure
  and made for human consumption
  - Content search is very simplistic
  - future requires better methods
- Web content is heterogeneous
  in terms of content
  in terms of structure
  in terms of character encoding
  - future requires intelligent information integration
- Humans can derive new (implicit) information from given pieces of information
  but on the current Web we can only deal with syntax
  - requires automated reasoning techniques

Examples

- **Find that landmark article on data integration written by an Indian researcher in the 1990s.**
  [If you manage this without knowing the answer, let me know how you did it.]

- **Are lobsters spiders?**
  [This is getting easier these days, but was impossible a few years ago. It still needs finding and integrating over different websites, as well as some background knowledge.]

- **Which car is called a “duck” in German?**
  [This needs some intelligent integration of content from different websites plus background knowledge.]

Another example

“Identify congress members, who have voted “No” on pro environmental legislation in the past four years, with high-pollution industry in their congressional districts.”

In principle, all the required knowledge is on the Web – most of it even in machine-readable form.

However, without automated processing and reasoning we cannot obtain a useful answer.

Basic ingredients for the Semantic Web

- **Open Standards for describing information on the Web**
- **Methods for obtaining further information from such descriptions**

We'll talk about these matters in this course.

Basic ingredients for the Semantic Web

- **Methods for obtaining further information from such descriptions**

Main approach: Logical deduction (aka automated reasoning)

E.g.,

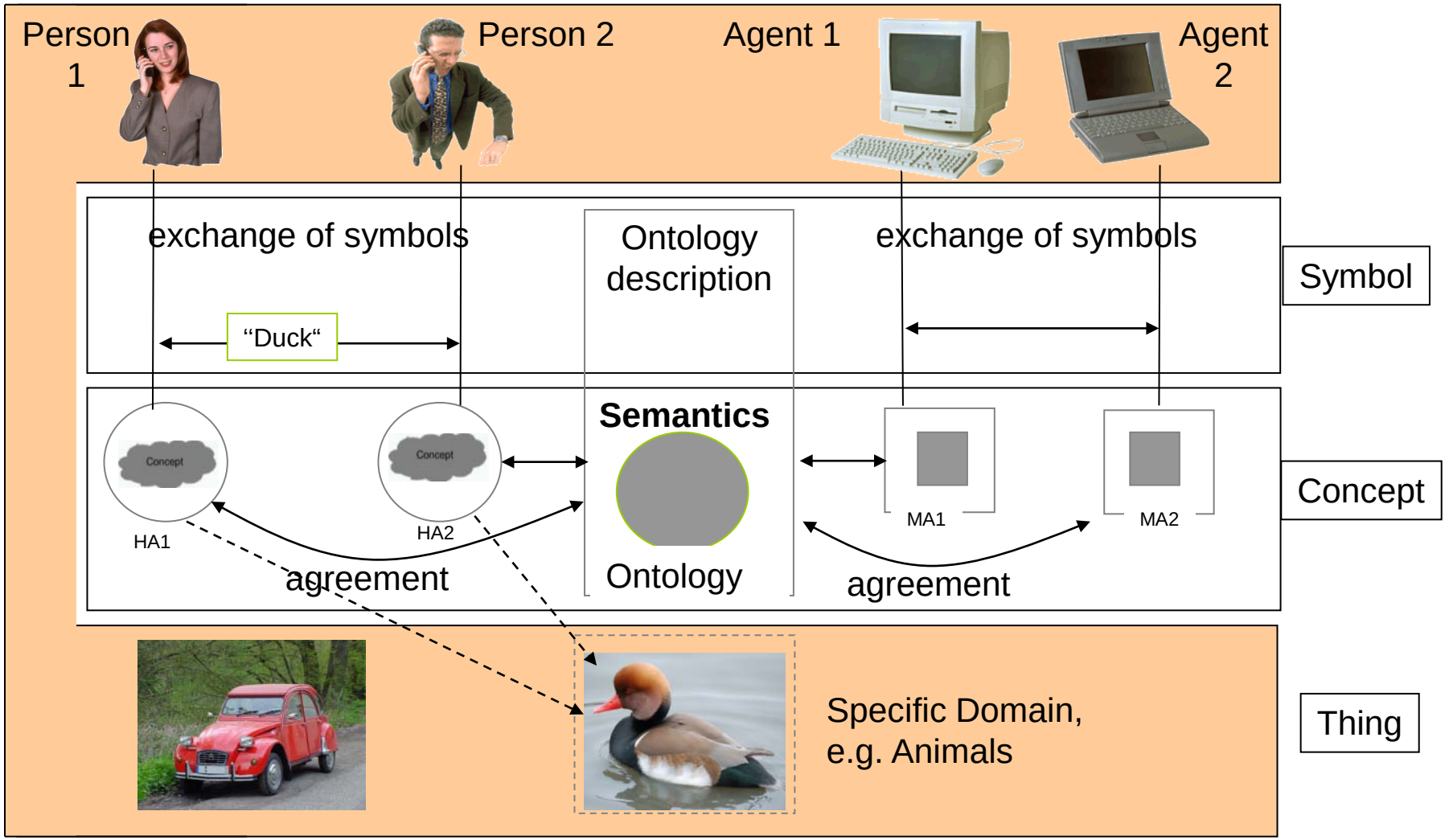
D.C. is a capital

Every capital is a city

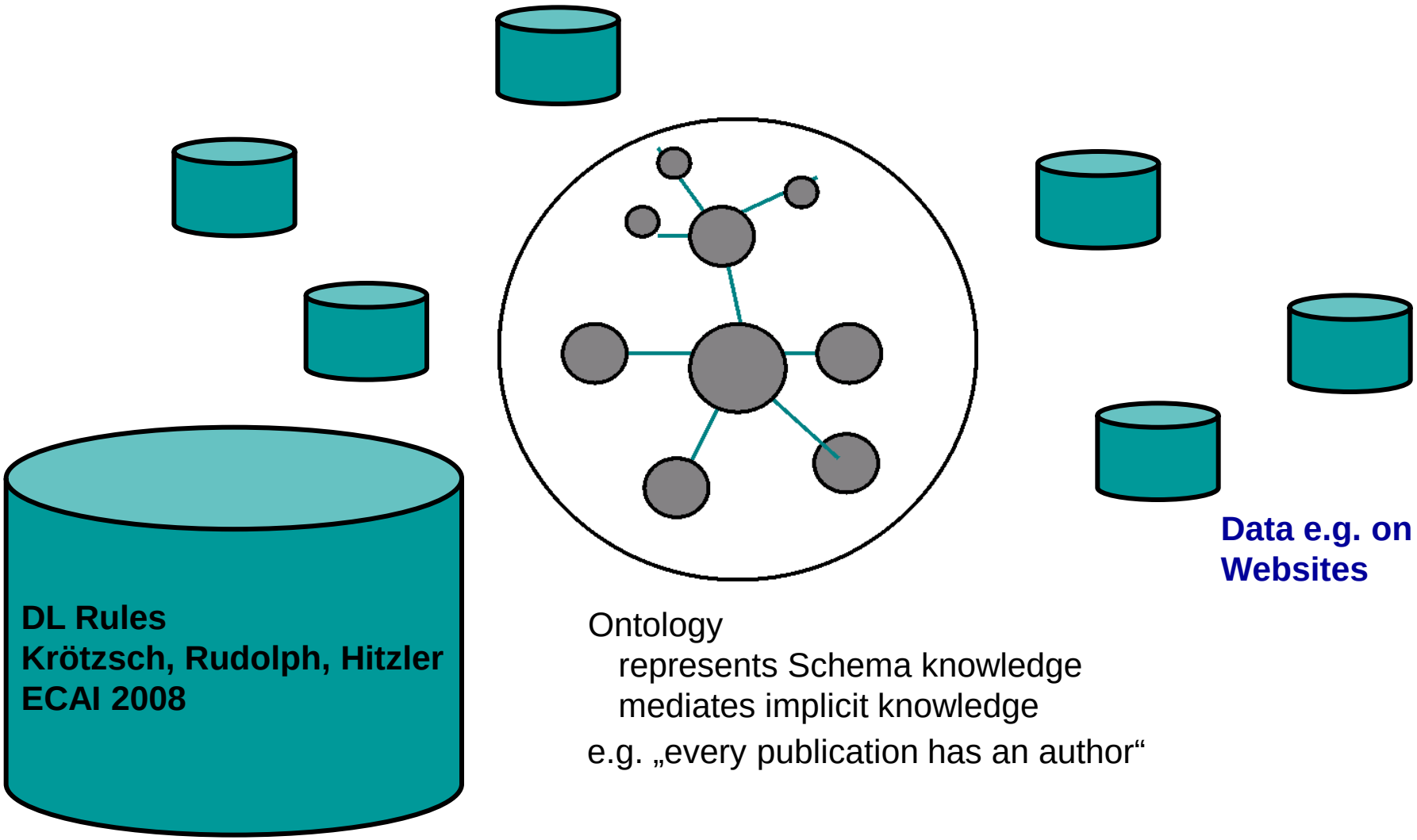
Hence: D.C. is a city

Based on predicate logic. – it needs to be specified which conclusions are valid. Plus, we need algorithms for these.

Basic Idea of the Semantic Web



Basic Idea of the Semantic Web



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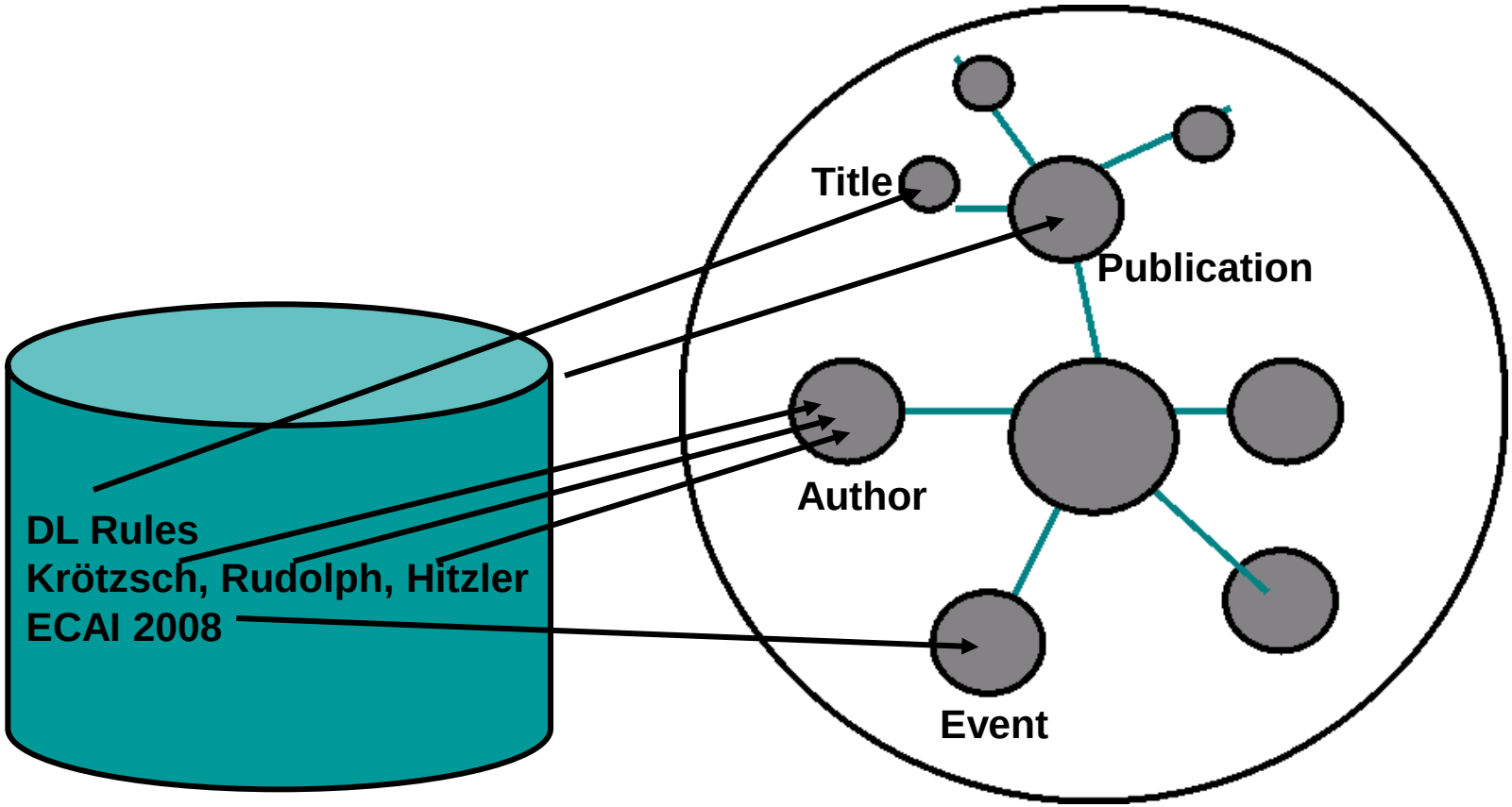
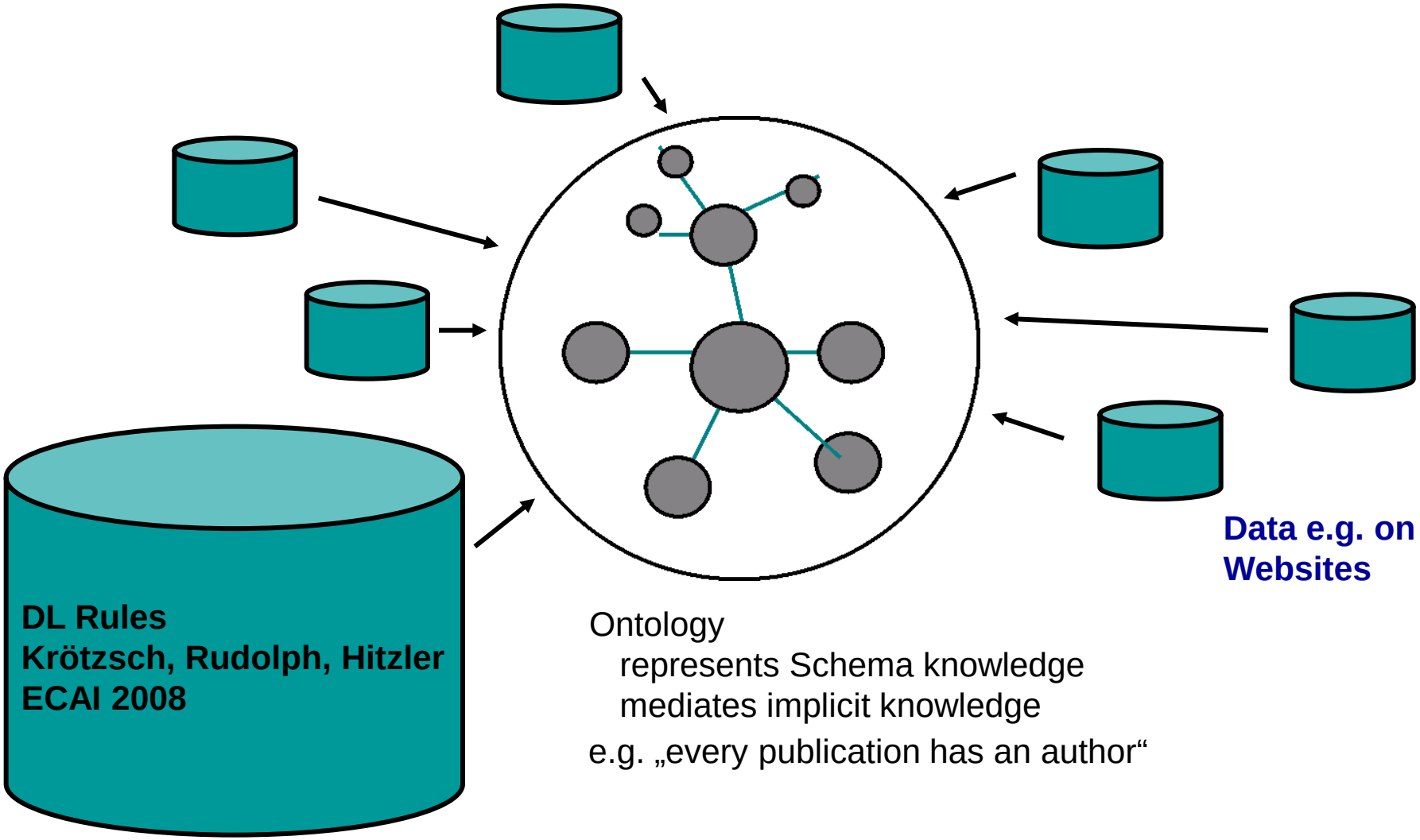


e.g. „every publication has an author“

Basic Idea of the Semantic Web



Ontology
- represents Schema knowledge
- mediates implicit knowledge

e.g. „every publication has an author“

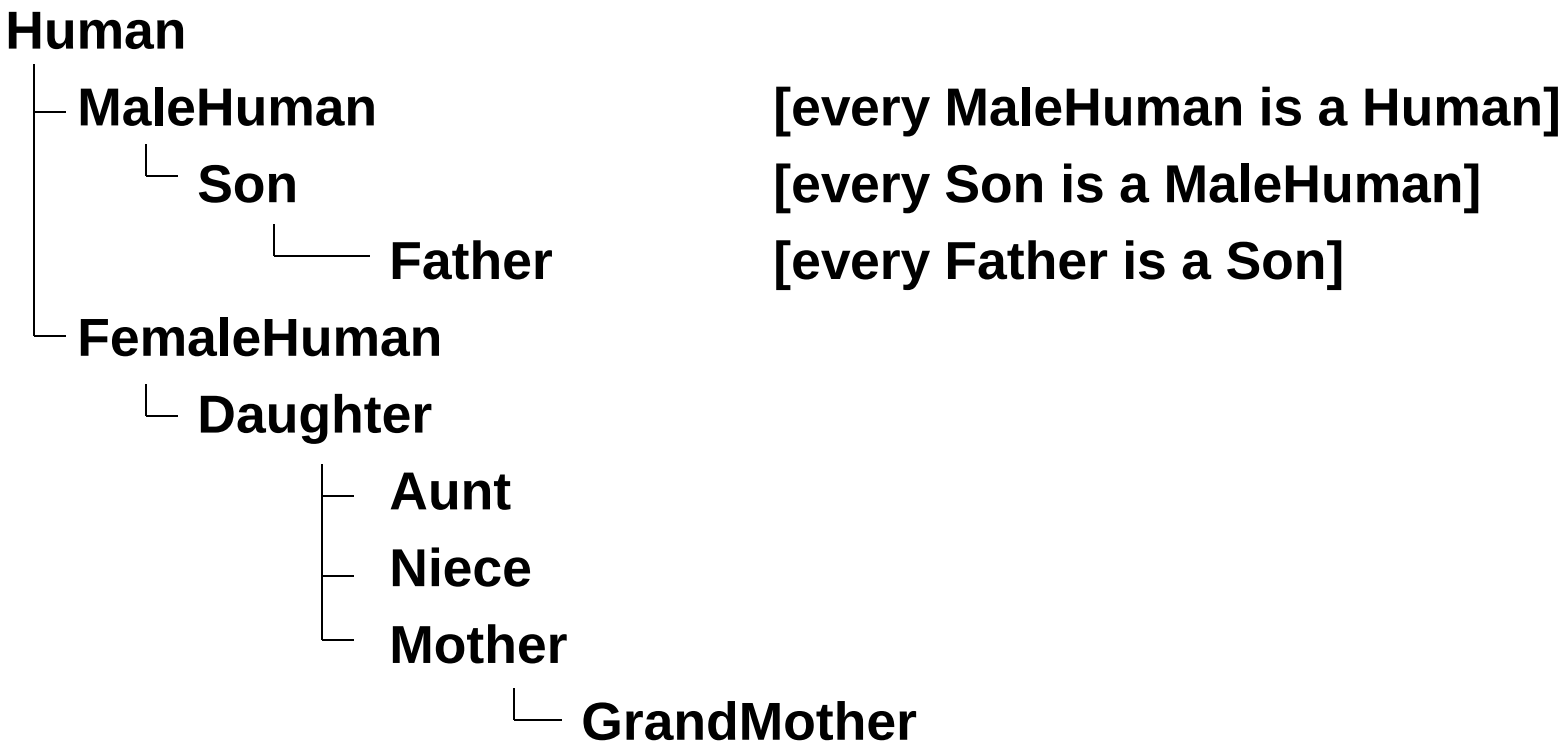
Ontology languages

- **Of central importance for the realisation of Semantic Technologies are suitable representation languages.**
- **Meaning (semantics) provided via logic and deduction algorithms (automated reasoning).**
- **Scalability is a challenge.**

Expressivity Scalability

Ontologies

- **The core of an ontology is usually a *taxonomy*:**
  - **classes of things, arranged in a hierarchy**



Ontologies

- **We will talk more (in fact, a lot) about ontologies**

- **For now, let's focus on taxonomies**

Partonomy vs. Taxonomy

- The following is a *partonomy* (and *not* a taxonomy):
  - classes of things, arranged in a hierarchy of "part-of" relationships

America
- LatinAmerica
  - SouthAmerica
    - Brazil

[Brazil is *part of* South America]

- NorthAmerica
  - USA
    - Indiana
    - Florida
    - Ohio
      - GreeneCounty

Partonomy vs. Taxonomy

- **Partonomy:**

  A *is part of* B

  hand is part of body
  Germany is part of Europe
  Wing is part of aircraft
  Engine is part of car

- **Taxonomy**

  ***every* A *is a* B**

  every father is a man
  every dog is a mammal
  every bottle is a container
  every arm is a limb

Very brief history of the Semantic Web

- invented ca. 1989.
- 1990s: W3C metadata activity (lead to RDF(S))
- W3C semantic web activity: chartered 2001.

- USA: DAML-Programme 2000-2005
  approx. $90M.
- Many large scale EU projects since 2002 and ongoing.
  → FP6/FP7
- Major IT companies and
  venture capital now investing.

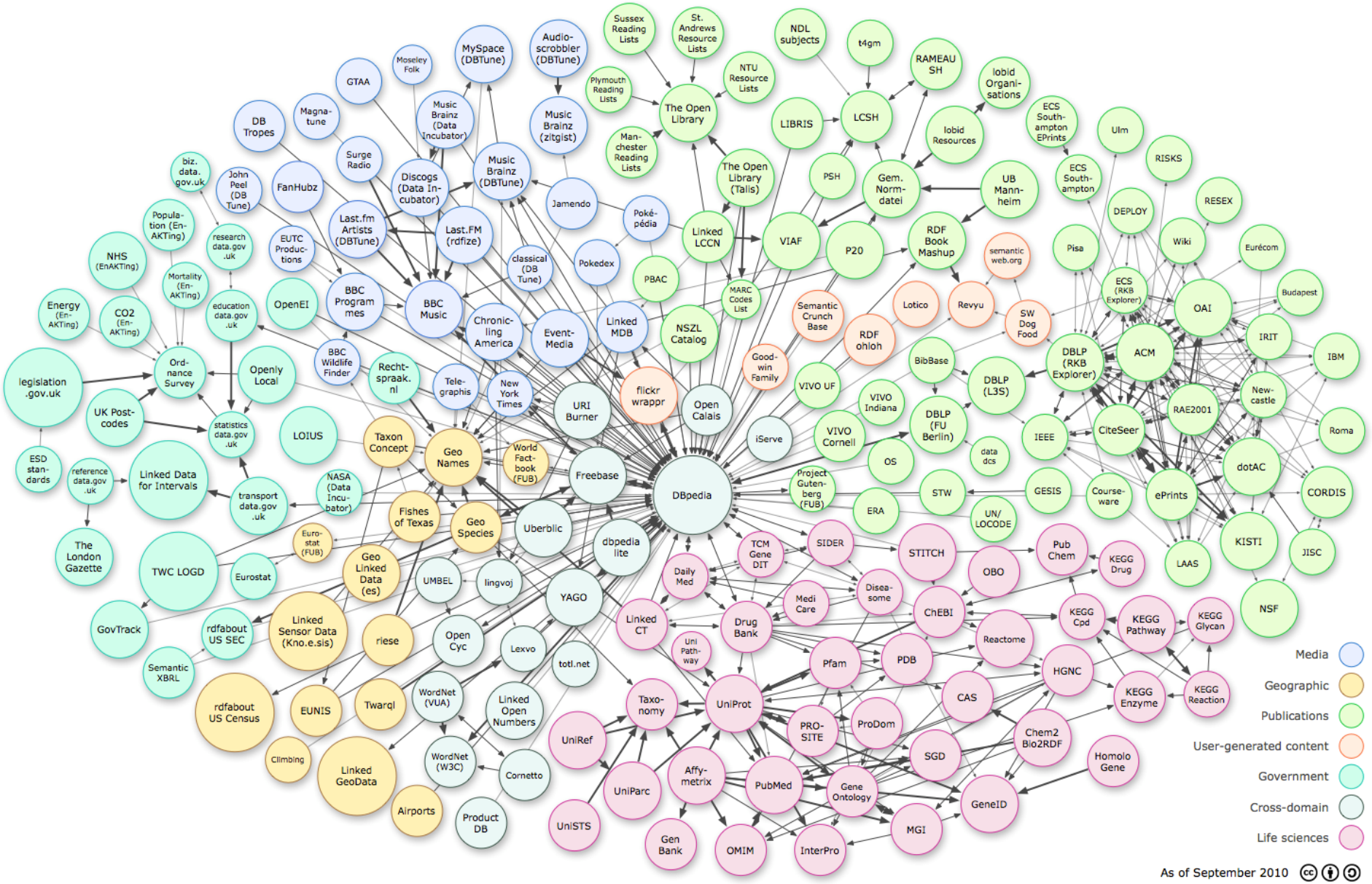
Semantic Technologies in the US

- Funding available e.g. via
  - NIH
  - NSF
  - DoD, DoE, AFRL
  - IARPA, DARPA
  - ...

- Considerable industrial take-up
  - Annual Semantic Technology Conference in CA
    Taylored towards industry
  - Major IT players (Oracle, IBM, HP, Accenture, Siemens) invest
  - Major government contractors (BBN, Lockheed, ...)
  - Venture capital (e.g. Vulcan, Inc.).
  - Structured data on the Web (BBC, nytimes.com, data.gov,...)

Linked Open Data

kno.e.sis



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Course Project

- Throughout the course, each of you will create an ontology
- We'll do this step by step

- The goal of the project is to learn "hands-on" about ontology modeling

- You'll be given incremental assignments to work on your ontology.

First project assignment

- Select a domain which you want to model (e.g., “family”).
  - use a domain you have good knowledge about
  - use a domain which is accessible for others (e.g. do not choose Algebraic Topology)
  - you will be stuck with this domain until the end of the project!
  - send name of the domain to me by 01/05/2010.
- Select approx. 20 class names for an initial taxonomy.
  - Taxonomy must be at least 3 nodes deep.
- Create the taxonomy and write it up.
  - choose your own representation method – but it must be generally understandable (or give an explanation)
  - send taxonomy to me by 01/9/2010
- Write a few sentences why you chose this domain.
  - send this to me by 01/9/2010

Course Project

- **Deadlines are hard.**
- **The more "difficult" domains are the more interesting ones ;)**
- **You will be able to revise your taxonomy later.**
- **Do this first part without discussion with other students.**
- **Expect that, at some stage, other students will have access to your ontology. I may also discuss examples explicitly in class or on slides. So whatever you write up will be "public."**
- **Don't worry (yet!) too much about "correctness" of your modeling.**

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Course contents overview

- Resource Description Framework (RDF)
  - Syntax
  - Semantics
  - Automated Reasoning
- Web Ontology Language (OWL)
  - Syntax
  - Semantics
  - Automated Reasoning

If time permits:

- SPARQL
- OWL and Rules
- Applications

Course contents discussion

- **What's your knowledge about XML?**
- **What's your knowledge about predicate logic?**

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Organizational matters

- **Course Website:**
  http://www.semantic-web-book.org/page/KR4SW-11
  When do you want me to put up the slides?
- **If you have not yet received a class email from me, let me know asap.**
- **Class meetings:**
  - **Tuesday 2:15pm to 3:55pm in Russ 355**
  - **Thursday 2:15pm to 3:55pm in Russ 355**
  - **Class starts 4th of January 2011 and ends 10th of March 2011**
- **"Office hours:**
  - **Thursdays 1pm to 2pm and by appointment.**
    I usually have to leave right after class.
  - **Please use email as main means of communication with me (besides talking with me in or after class).**

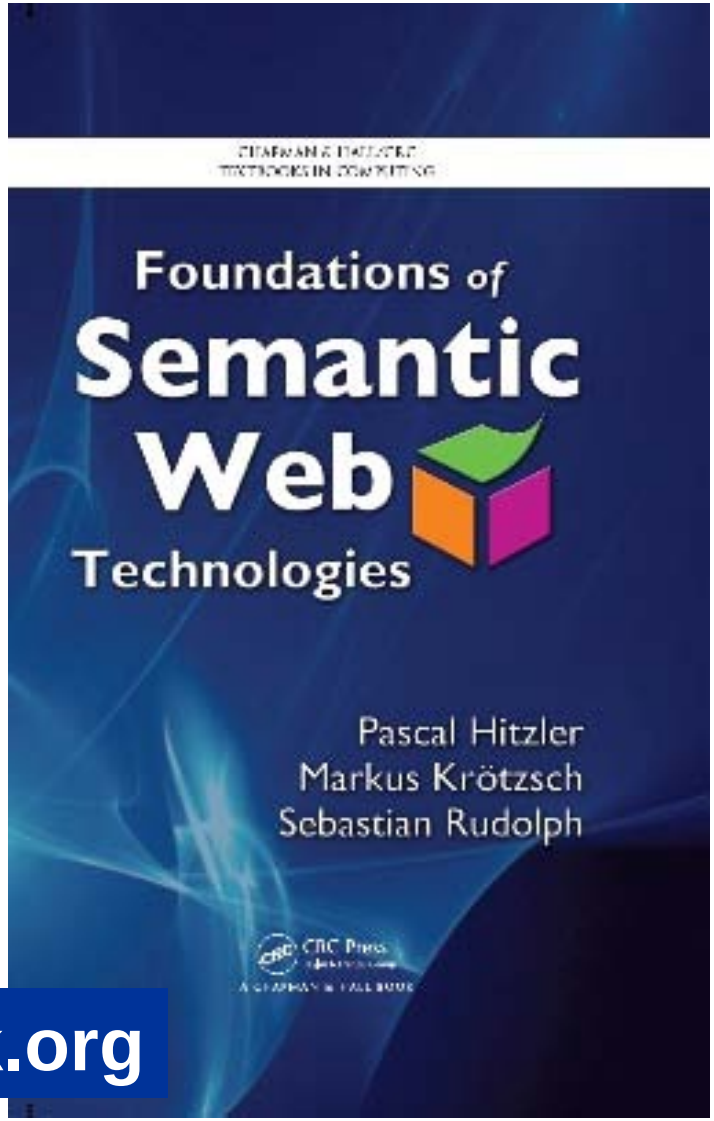
Textbook (required)

Pascal Hitzler, Markus Krötzsch, Sebastian Rudolph

Foundations of Semantic Web Technologies

Chapman & Hall/CRC, 2010

Choice Magazine Outstanding Academic Title 2010 (one out of seven in Information & Computer Science)



http://www.semantic-web-book.org

Textbook (Chinese translation)

Pascal Hitzler, Markus Krötzsch, Sebastian Rudolph

语义Web技术基础

Tsinghua University Press (清华大学出版社)，2011，to appear

Translators:
Yong Yu, Haofeng Wang, Guilin Qi (俞勇，王昊奋，漆桂林)

http://www.semantic-web-book.org

Grading

Homework 10%, Project 30%, Class Presentation 30%, Final Exam 30%

- **Homework: Students will take turns in presenting completed homework in class, and grading will be done by evaluating the participation in the tutorial sessions.**
- **Project: The project will be an ontology modeling project which will have several parts and run over the whole quarter. Students are expected to write an experience report on each part.**
- **Class Presentations: The class presentations will consist of original research papers.**
- **Final Exam: The final exam will be oral, i.e. in the form of a short interview (20 minutes), with the examiner asking questions and the student answering.**

Class Presentations

- **Presentations of original research papers extending beyond the material covered in this lecture.**
- **They will all be concerned with issues related to ontology reasoning/formal semantics.**
- **If you know a paper which you'd like to present, please let me know asap.**
- **I'll make some suggestions later in the class.**

Any further questions or open issues?

Topic next Thursday: XML primer

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