COMP718: Ontologies and Knowledge Bases
2012, semester 1
Module outline

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1 Aims and Synopsis

The principal aim of this module is to provide the participant with a comprehensive overview of ontology engineering and its usage in ontology-driven information systems and knowledge bases. A secondary aim is to provide hands-on experience in ontology development and Semantic Web Technologies that illustrate the theory, such as language features, automated reasoning, querying ontologies, and top-down and bottom-up ontology development.
This module covers material such that, upon completion, the student:

(i) has a general understanding of the notion of what ontologies and knowledge bases are, what they can be used for, how, and when not;
(ii) has obtained a good understanding of the, currently, main ontology languages—OWL and its underlying Description Logics languages—in order to represent the knowledge in ontologies formally and to reason over them, and have a basic understanding of what the automated reasoner does;
(iii) can confidently use methods and methodologies to develop ontologies, including the top-down approach with foundational ontologies and bottom-up using non-ontological resources such as relational databases, natural language or thesauri; and
(iv) has become acquainted with several major applications and application scenarios, such as the Semantic Web, ontology-based data access, and ontologies for the life sciences and other domains, and has had a taste of the research trends in the field.

Interwoven in the module's aims is skills development for the students' BSc(honours) project. The students will become familiar with reading scientific literature and will gain experience in report writing and presenting their work to their peers.

2 Module assessment

The final mark for the module will be based on three categories of assessment:

- A written assignment at the end of the course [50 %]
- One intermediate practical assignment [20 %]
  The assignment will be introduced in week 3 and handed in by the end of week 8
- Mini-project (including a presentation) at the end of the course [30 %]
  The topics you can choose from will be communicated in week 6

Note: Something has to be submitted for each of the three categories in order to have a chance to pass the course.
Note: This is a 16 credit module; one credit amounts to a workload of about 10 hours (on average, for an average student).

3 Module material

The course material consists of:

- The printed and bound lecture notes;
- Lecture slides posted on the module's Moodle page;
- Reading material for the lectures: papers, book chapters, standardization documentation, which are listed at the end of each chapter in the lecture notes.
- Material for the chosen mini-project (some are already listed in the bibliography, and additional ones or will be made available depending on the chosen project topic).

The slides and reading material will be made available through the module's Moodle page.

4 Module content

1. *Lecture 1: Introduction.* The introductory lecture addresses differences between databases and knowledge bases, conceptual data models and ontologies, what an ontology is (and is not), and a prominent application area, being the Semantic Web.

2. **Block 1: Logic foundations for ontologies**

   (a) *Lecture 2: FOL recap and Description Logics.* After a quick recap of first order predicate logic, the basics of Description Logics (DL) will be introduced. DLs are a family of languages that are decidable fragments of FOL and lie at the basis of most 'species' of the World Wide Web consortium's standardised Web Ontology Language OWL.

   (b) *Lecture 3: The Web Ontology Language OWL.* This lecture is devoted to the, thus far most widely used family of Web Ontology Languages, OWL, and its design rationale.

   (c) *Lecture 4: OWL 2 and Reasoning.* The successor of OWL, called OWL 2, will be discussed. In addition, we take a look at the principal automated reasoning services for (OWL) ontologies, such as satisfiability checking and classification.

3. **Block 2: Ontology engineering**

   (a) *Lecture 5: Top-down Ontology Development I.* One step of ontology development is the use of foundational ontologies and their formalisations (on paper in FOL, in OWL DL, Isabelle). In particular, we shall look at the DOLCE and BFO foundational ontologies, and commence with a core relation in ontology development, being part-whole relations.

   (b) *Lecture 6: Top-down Ontology Development II.* We continue with part-whole relations and add the notions ontology design patterns and ontology reuse.

   (c) *Lecture 7: Bottom-up Ontology Development.* In addition to starting from 'above', one can reusing legacy material to generate candidate classes and relations to speed

up populating an ontology. In particular, we will look at relational databases, thesauri (including SKOS), and natural language processing.

(d) *Lecture 8: Methods and Methodologies.* This lecture takes a closer look at parameters for ontology design, methods (such as OntoClean, glassbox reasoning), and more comprehensive methodologies (Methontology, MoKi, NeOn methodology).

4. **Block 3: Advanced Topics**

   (a) *Lectures 9 and 10: 'Ontology'/Conceptual Model-based Data Access.* Due to various usage scenarios, there is a need to maintain the link between the data and the knowledge, such as in scientific workflows or *in silico* biology and enhanced user and content management in e-learning applications. This can be done in one knowledge base or to connect a database to an ontology (or vv.) so that one can query the database 'intelligently' through the ontology by availing of its classes, object properties and axioms. In these two lectures, we will start with a motivation and an overview of one such system (WONDER), which relies on the DL-Lite family of DL languages (roughly OWL 2 QL), a mapping layer, and a relational database. We then shall look at its technical details as well as the principal options for reaslising such a system.

   (b) *Lecture 11: Temporal ontologies.* There are various extensions to the 'basic' ontology languages and reasoning services, such as vagueness, uncertainly, and the temporal dimension. In this lecture we cover a temporal DL and some of the modelling issues it solves.

5. **Block 4: Recap and Research Trends**

   (a) *Lecture 12: Research trends.* We take a look as some research trends, where we will take a selection from any of the following topics: modularization, dealing with imprecise knowledge (fuzzy/rough), interaction with conceptual data modelling, or 'debugging' ontologies (glass-box reasoning).

   (b) *Lecture 13: Mini-project Presentations.* Each group will present the outcome of their chosen mini-project and discussed in class. Everyone must attend the lecture and participate in the presentation and discussions.