Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Knowledge Representation

Thursday 17\textsuperscript{th} January 2008

Time: 09:45 – 11:45

Please answer any THREE Questions from the FIVE questions provided

This is a CLOSED book examination

The use of electronic calculators is NOT permitted
1. **Knowledge Acquisition and Modelling**

You have been asked to build an ontology in order to build an application that supports management of an agricultural institute. The first stage of a Knowledge Acquisition process has identified the following list of terms. Explanations of some of the terms are given below.

<table>
<thead>
<tr>
<th>Term</th>
<th>Term</th>
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</thead>
<tbody>
<tr>
<td>Animal</td>
<td>Battery Chicken *</td>
</tr>
<tr>
<td>Bird</td>
<td>Building</td>
</tr>
<tr>
<td>Bull</td>
<td>Carnivore</td>
</tr>
<tr>
<td>Cheese</td>
<td>Chicken</td>
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<tr>
<td>Cow</td>
<td>Domestic</td>
</tr>
<tr>
<td>Duck</td>
<td>Egg</td>
</tr>
<tr>
<td>Female</td>
<td>Field</td>
</tr>
<tr>
<td>Fox</td>
<td>Free Range Chicken *</td>
</tr>
<tr>
<td>Goat</td>
<td>Goatherd *</td>
</tr>
<tr>
<td>Goose</td>
<td>Grass</td>
</tr>
<tr>
<td>Herbivore</td>
<td>Horse</td>
</tr>
<tr>
<td>Lake</td>
<td>Male</td>
</tr>
<tr>
<td>Meat</td>
<td>Milk</td>
</tr>
<tr>
<td>Omnivore</td>
<td>Pig</td>
</tr>
<tr>
<td>Plant</td>
<td>Pond</td>
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<tr>
<td>Predator</td>
<td>Pest</td>
</tr>
<tr>
<td>Rabbit</td>
<td>Ram</td>
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<tr>
<td>Rat</td>
<td>River</td>
</tr>
<tr>
<td>Shed</td>
<td>Sheep</td>
</tr>
<tr>
<td>Shepherd *</td>
<td>Waterfowl *</td>
</tr>
<tr>
<td>Wheat</td>
<td>Wild</td>
</tr>
<tr>
<td>Wolf</td>
<td></td>
</tr>
</tbody>
</table>

* Free Range: Refers to animals (usually poultry) that are not confined and can thus range freely for food rather than being confined in an enclosure.

* Battery Chickens: Chickens kept confined in cages, usually for intensive egg production.

* Goatherd: Someone who looks after goats

* Shepherd: Someone who looks after sheep

* Waterfowl: A general term used to describe birds that live around water.

Question 1 continues on the following page.
Question 1 continues from the previous page.

a) i) Describe two techniques you could use in order to help in constructing a concept hierarchy from this list of terms. (4 marks)

ii) For each of the techniques chosen, give an example of a situation where the technique is more appropriate, and one where the technique is less appropriate. (2 marks)

b) i) Sketch out a basic hierarchy of the terms. For each term in your hierarchy indicate whether the concept is:

- Self-standing (S)
- Modifier (M)
- Definable (D)

Introduce abstractions into the hierarchy where necessary. If concepts are definable, provide some brief natural language definitions, with discussion of any points you feel are particularly interesting or contentious. You should also introduce any relations that are used within the definitions. (14 marks)

2. Logic

a) In First Order Logic, what do we mean by:

i) a valid formula;

ii) a satisfiable formula;

iii) an unsatisfiable formula. (3 marks)

iv) What do soundness and completeness results tell us about first order logic? (2 marks)

b) Describe two key reasoning services, and discuss why they are important in the context of supporting conceptual modelling. (4 marks)

c) What do we mean by extra-logical services? Describe two extra-logical services that we might expect to find in tools and discuss why they are useful. (3 marks)

d) For each of the concept expressions below, say whether or not they are satisfiable, and sketch out how a tableaux algorithm would be applied in order to prove the (un)satisfiability.

i) (some R (some R (not C))) and (all R C)

ii) not ((some R (C or D)) or (all R (not (C and D))))

Assume that this is being done in the context of an empty TBox. (8 marks)
3. **Ontology Engineering**

a) Ontology Matching and Alignment are concerned with determining correspondences or relationships between concepts in different ontologies.

i) Why do we need matching and alignment? (3 marks)

ii) What are some of the key issues in performing matching? (3 marks)

Your answers should include specific reference to issues relating to the Semantic Web. You may also wish to illustrate your answer with a concrete example.

b) What is the difference between a concept definition and constraint? (2 marks)

c) For each of the following natural language descriptions, formalize the concept description using Manchester OWL syntax. Assume that the ontology contains the following terms:

- **Classes**
  - Person
  - FootballPlayer
  - Musician

- **Modifiers**
  - Male
  - Female

- **Properties**
  - hasChild
  - hasFriend
  - hasSex

i) Musicians who are not childless, but only have daughters. (2 marks)

ii) People who are either FootballPlayers or are friends of FootballPlayers (2 marks)

d) i) The OntoClean methodology introduces properties of classes including Identity and Rigidity. For each of these properties, provide a brief description of the property. (4 marks)

ii) Violation of OntoClean’s constraints does not necessarily produce logical inconsistency. Discuss why this is the case (4 marks)
4. **Conceptual Foundations**

a) What are the five roles of a knowledge representation? Give a consequence or characteristic effect of each role on KR. (5 marks)

b) Why is a knowledge representation not a data structure? Illustrate this point with a contrasting example. (3 marks)

c) Give a brief description of a mid-size commonsense representation problem (no more than 80 words or so; 80 words would be very long). (Note: do not use the Surprise Birthday Problem. You are otherwise free to either reuse the basic spirit of examples from the Common Sense problems page, or invent one entirely) (2 marks)

i) What are the domains touched by this problem? (2 marks)

ii) Give 3 elaborations that a successful representation of this problem should tolerate. For each elaboration, (briefly) explicate what it tests about the representation and why that is significant. (6 marks)

iii) Give an elaboration that is not necessary for a successful representation of this problem to handle, and explain why. (2 marks)

5. **Logic Engineering**

a) Explain the trade off between complexity and expressiveness in logics. How does this affect the success of a formalism? What are the drawbacks of each? Give an example of trading expressiveness for lower complexity and its consequences. (6 marks)

b) Explain how one can improve the effective expressiveness of a logic without increasing its strict expressiveness. (4 marks)

c) What does it mean for a logic to be *decidable*? Why is decidability an important or useful property? (2 marks)

d) i) What is the Semantic Web? (2 marks)

ii) What are the issues facing KR formalisms for the Semantic Web? How are some of these issues resolved (or not resolved) in current Semantic Web Languages? (6 marks)

**END OF EXAMINATION**