UNIVERSITY OF MANCHESTER

DEPARTMENT OF COMPUTER SCIENCE

MSc IN ADVANCED COMPUTER SCIENCE

CS6461

The Semantic Web: Ontologies and OWL

Wednesday 28th January 2004

10.00 – 12.00

??Rubric??

1. **Ontology languages and description logic**

a) State three advantages of using a description logic as the basis for an ontology language. (3 marks)

b) Write down one or more DL axioms that express the same constraints that are expressed in each of the following OWL axioms (in abstract syntax):

i. DisjointClasses(Earth Wind Fire Water)
ii. ObjectProperty(father super(parent) functional domain(Person) range(Person))
iii. Class(Elephant partial super(animal) super(restriction(eats allValuesFrom(Plant))))
iv. Class(Person complete super(restriction(parent someValuesFrom(Person))))

(8 marks)

c) Consider the following interpretation consisting of a set (the domain) D and an interpretation function ext:

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D = {v, w, x, y, z}
ext(A) = {v, w, x}
ext(B) = {x, y}
ext(R) = {(v, w), (v, x), (y, x), (x, z)}
```

Show how ext can be extended to interpret the following class expressions (e.g., ext(A ⊓ B) = {x}):

i) ¬B
ii) B ⊔ ¬A
iii) ∃R.B
iv) ∀R.B
v) ∃R.(∃R.A)

(5 marks)

d) Fill in the blanks to complete the following statements about the relationship between interpretations and various inferences w.r.t. a knowledge base **K**, classes A and B, and an individual x.

i) A is a subclass of B w.r.t. **K** iff ..... in ..... interpretation I of **K**
ii) A is satisfiable w.r.t. **K** iff ..... in ..... interpretation I of **K**
iii) x is an instance of A w.r.t. **K** iff ..... in ..... interpretation I of **K**

(4 marks)

2. **Reasoning techniques**

a) When using a DL satisfiability/consistency reasoner, various reasoning problems are transformed into knowledge base satisfiability problems. Given a knowledge base **K**, show how:

i) determining if A is a subclass of B w.r.t. **K** can be transformed into a knowledge base satisfiability test.

ii) determining if x is an instance of A w.r.t. **K** can be transformed into a knowledge base satisfiability test. (2 marks)

b) Consider the following description logic knowledge base:

$$\mathbf{K} = \{ C \equiv A \sqcap \exists R.X,$$
$$D \equiv X \sqcap Y,$$
$$E \equiv \exists R.C\}$$

For each of the following expressions, say if it is satisfiable or not w.r.t. K, and show how a tableaux algorithm would use a sequence of expansion steps to prove the (un)satisfiability.

i) $C \sqcap (\forall R.Y)$

ii) $C \sqcap \forall R.(\neg D)$

iii) $C \sqcap (\forall R.Y) \sqcap (\forall R.\neg D)$

iv) $E \sqcap (\forall R.\neg X)$

v) $C \sqcap (\forall R.C)$

(10 marks)

c) Repeat iv) and v) above assuming that R is a transitive role. (4 marks)

d) What is the problem with tableaux algorithms that Blocking is designed to address. Why is blocking required with the SHIQ description logic but not with the ALC description logic? (4 marks)

3. **An ontology for a radio station**

a) Sketch a normalised ontology for use by a radio station which covers the items listed below and provides sufficient concepts to answer the questions in part b).

(10 marks)

Indicate the hierarchies for both concepts (classes and individuals) and properties (roles). For concepts, indicate clearly which are classes and which are individuals. For roles, indicate any properties – symmetric, unique, or transitive. Not any ambiguities. Note also key design decisions to 'normalise' the ontology.

To save space. Assume all primitives are disjoint.

You may draw the hierrchies either as diangrams out in outline style. There is no need to use OWL syntax.

Items to be represented: Programmes, Presenters, Pop Music, Soap Opera, Albums, News Bulletins, DJs, Rock Music, Time slots, Singles, Actors, Songs, Producers, Chat shows, CDs, The music library, Radio Stations, Classical music.

b) Define classes using your ontology for the items i) – v) below or explain why they cannot be expressed in OWL. Use owl abstract syntax (or a reasonable approximation). Be sure to distinguish *someValuesFrom* from *allValuesFrom.*

There may be some cases that cannot be represented in OWL form some reason or another. If so, indicate this and explain why.

If the definition in English is ambiguous, paraphrase it so it is unambiguous and then express the disambiguated notion in OWL.

i) Newsreader
ii) Programme directed by a woman
iii) Programme directed by its producer
iv) Classical music station
v) Programmes which have musical content but not classical music content.

(2 marks each)

4. **Ontological constructs**

a) **Time**

i) What issue is revealed by the following pair of sentences:

"John sat down at 18:30"
"While John was sitting down, his pants ripped"

ii) Represent the class of "sitting situations" in each of the above using a) a point based view of time b) an interval based view of time c) an interval based view of time graphically showing the relation from

Use the concepts: *Situation, Sitting, and Interval,*
use the properties: *hasProcess, occursOver, hasStartTime, has EndTime, occursAt.*
(4 marks)

b) **Part-whole relations**

i) Differentiate between: *components, subdivisions, members, constituents, members and contents* (6 marks)

ii) Identify the appropriate part-whole property/properties to link the following:

a) Motor_Car
b) Driver_car
c) Left_side_of_car
d) Steel_Body_of_car
e) Headlight_Electrical_system_of_car
f) Fish_School_of_fish (3 marks)

iii) How would you organise your ontology so that:

a) the defined class *"parts_of_car"* included *"motor"* and *"headlight"* but not *"Left_side_of_car", "Driver"* or *"Steel"*

but...

b) *"Rusting of the steel of the body of the car*", *"Damage to headlight", "Damage to Motor", "Damage to Left_side_of_car"* all were subsumed by *"Damage to Car"* but *"Damage to driver of car"* was not?
(6 marks)

c) **Important dichotomies**

i) What do Guarino and Welty mean by "endurant" and "perdurant"? Give an example of each. What is the characteristic relation between them. (2 marks)

ii) Explain why a "School of fish" is not a mathematical set. (2 marks)