Knowledge Representation and Reasoning Systems

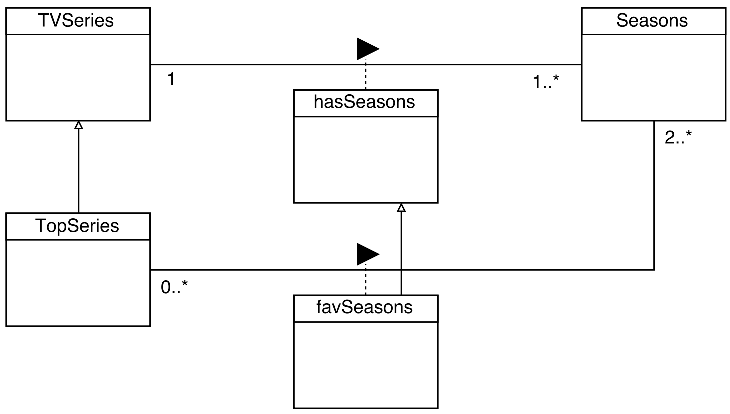
Final Exam

3 hours / closed book

Group I (Ontologies)

Question 1:

Consider the following UML class diagram representing part of a data model of a TV series web site.



1a) Translate the UML class diagram into an appropriate Description Logic.

1b) Express in Description Logic (in the fragment you think is more appropriate) the following knowledge about the TV series domains. You must use the roles **hasCharacter** (domain TVSeries), **hasDirector** (domain TVSeries), and **hasParticipant** (domain TVSeries). If necessary new concepts and roles may be introduced:

i. All kid's TV series are series and non violent;
ii. All episodes of TV series have characters, and have exactly one director;
iii. All participants in TV series are Actors, Backgrounds or Doubles;
iv. All Novelas are TV series that only have characters that speak (at least) portuguese.

Question 2:

Consider the following TBox T of an ontology

$\mathrm{Zombies} \sqsubseteq \mathrm{Walking} \sqcap \mathrm{Dead}$
$\mathrm{Walking} \sqsubseteq (\exists \mathrm{hasPart}.(\mathrm{Arm} \sqcup \mathrm{Leg})) \sqcap (\forall \mathrm{hasPart}.\mathrm{Alive})$
$\exists \mathrm{hasPart}.\mathrm{Alive} \sqsubseteq \mathrm{Alive}$

2a) Translate the above TBox into first-order logic.

2b) Suppose that furthermore the ontology has the ABox containing the following assertions

fury: $\mathrm{Zombie} \sqcap (\forall \mathrm{bites}.\mathrm{Alive})$
rich: (=2 hasPart Leg)
(fury,rich):eats

Present a model of the given TBox and ABox (don't forget to define the domain and corresponding interpretation of individuals, atomic classes and roles), if possible, and show the result of interpreting the $(\exists \mathrm{hasPart}.(\mathrm{Arm} \sqcup \mathrm{Leg})) \sqcap (\forall \mathrm{hasPart}.\mathrm{Alive})$ in the model you've defined.

2c) Using tableaux algorithms check if it is possible to exist zombies from the given TBox T plus the axiom that all dead things are not alive $\mathrm{Dead} \sqsubseteq \neg \mathrm{Alive}$, i.e. that { z:Zombie } has no models.

Group II (Answer set Programming)

Question 3 (Answer set computation):

1) Present all the stable models of the following program:

```
a :- not b.
b :- not a.
c :- not d.
d :- not c.
a :- d.

{e;f} :- b.

:- c, not f.
```

2) Translate the following program into a normal logic program:

```
1 {a;b} 1 :- c.      c :- 1 {d;e;f;g} 3.      f.      {g}.
```

3) Use the approximation algorithm to determine one stable model of the program, and show by definition that it is indeed a stable model:

```
a :- not b, not c.
b :- not a.
c :- a.
```

EXTRA QUESTION FOR EMCL STUDENTS:

4) Check if {a,c} is a stable model of the next disjunctive logic program:

```
a ; b  :- c.
    a  :- not b.
b ; c  :- not a.
b ; c  :- a.
```

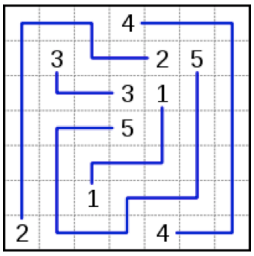
Question 3 (ASP modelling):

The Numberlink puzzle is a grid puzzle with the following simple rules:

1. Connect pairs of the same numbers with a continuous line.
2. Lines go through the center of the cells, horizontally, vertically, or changing direction, and never twice through the same cell.
3. Lines cannot cross, branch off, or go through the cells with numbers.

Consider the following puzzle (left) and its solution (right). It is already defined a coordinate system to facilitate the resolution of this problem.

7				4			
6		3			2	5	
5				3	1		
4				5			
3							
2			1				
1	2				4		
	1	2	3	4	5	6	7



Using answer set programming, produce a program for CLINGO system that will allow you to solve this kind of puzzles. Consider the following instance, capturing some of the information set forth:

```
h(1..7).      number(1,1,2).    number(5,5,1).
v(1..7).      number(5,1,4).    number(2,6,3).
n(1..5).      number(3,2,1).    number(5,6,2).
              number(4,4,5).    number(6,6,5).
              number(4,5,3).    number(4,7,4).
```

An instance of predicate **number(X, Y, N)** represents that square (X,Y) has number N. You should use the predicate **line(X,Y,N)** to represent that square(X,Y) is numbered N or that contains a segment of a line connecting pair of numbers N. The coordinates of the board are given by predicates **h/1** and **v/1**.

It is suggested that you use in your implementation the following auxiliary predicates:
1. numbered(X,Y) to represent that square (X,Y) is numbered;
2. adjacent(X1,Y1,X2,Y2) to represent that squares (X1,Y1) are adjacent to each other.

A simple solution to the problem can be constructed from the following observations:
1. All squares must belong to a single line;
2. Numbered squares belong to the corresponding lines;
3. A numbered square has exactly one adjacent square belonging to the line;
4. A non-numbered square of a line has exactly two adjacent squares belonging to the same line.
5. That's all!

EXTRA TASK FOR EMCL STUDENTS:

Add a predicate which is true whenever the given instance of the Numberlink puzzle is well constructed, i.e. that each board has for any given N exactly two numbered squares with N, that all number fact instances are inside the board, and that all numbered squares have at least one adjacent non-numbered square. You are suggested to use auxiliary predicates to implement this predicate (NOTE: these are not constraints).

THE END