COMP 4475 *Assignment Three*

Due: April 5^{th}, Before Class (10AM)

1. (**30 marks**) (Ex.1 in Ch9 of the book KRR) In this chapter, we considered the semantics of a description logic language that includes concept-forming operators such as **FILLS** and **EXISTS** but no role-forming operators. In this question, we extend the language with new concept-forming operators and role-forming operators.

   (a) Present a formal semantics in the style of Section 9.3.1 for the following concept-forming operators:
   - [**SOME** r] Role existence. Something with at least 1 r.
   - [**AT-MOST** n r] Maximum role cardinality. Something with at most n r's.

   (b) Do the same for the following role-forming operators:
   - [**INVERSE** r] Role inverse. So the :Child role could be defined as
     [**INVERSE** :Parent].
   - [**COMPOSE** r_1 ... r_{n-1} r_n] Role composition. The r_n's of the r_{n-1}'s ... of the r_1's. So
     [**ALL**[**COMPOSE** :Parent:BrotherInLaw]Rich]
     would mean something all of whose uncles are rich (where an uncle is a brother-in-law of a parent).

   (c) Use this semantic specification to show that for any roles r, s, and t, the concept
   [**ALL**[**COMPOSE** r s][**SOME** t]]
   subsumes the concept
   [**ALL** r [**AND**[**ALL** s [**EXISTS** 2 t]][**ALL** s [**AT-MOST** 2 t]]]]
   by showing that the extension of the latter concept is always a subset of the extension of the former.

2. (**30 marks**) (Ex.3 from 3.a to 3.c in Ch12 of the book KRR) Consider the following example:
   The fire alarm in a building can go off if there is a fire in the building or if the alarm is tampered with by vandals. If the fire alarm goes off, this can cause crowds to gather at the front of the building and fire trucks to arrive.

   (a) Represent these causal links in a belief network. Let a stand for "alarm sounds," c for "crowd gathers", f for "fire exists", t for "fire truck arrives", and v for "vandalism exists".
   (b) Give an example of an independence assumption that is implicit in this network.
   (c) What are the 10 conditional probabilities that need to be specified to fully determine the joint probability distribution? Suppose that there is a crowd in front of the building one day but that no fire trucks arrive. What is the chance that there is a fire, expressed as some function of the 10 given conditional probabilities?

3. (**40 marks**) (Ex.1 in Ch14 of the book KRR) **Blocks World** Imagine that we have a collection of blocks on a table and a robot arm that is capable of picking up blocks and putting them elsewhere, as shown in Figure 1.

   We assume that the robot arm can hold at most one block at a time. We also assume that the robot can only pick up a block if there is no other block on top of it. Finally, we assume that a block can only support or be supported by at most one other block, but that the table surface is large enough that all blocks can be directly on the table. There are only two actions available:

   puton(x, y) which picks up block x and moves it onto block y, and

   putonTable(x) which moves block x onto the table.

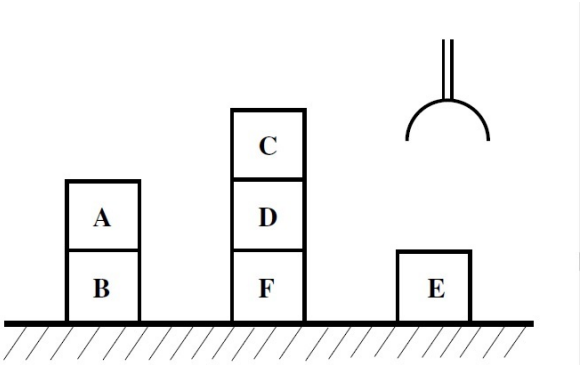

Figure 1: The Blocks World

Similarly, we have only two fluents:

On(x, y, s) which holds when block x is on block y, and
OnTable(x, s) which holds when block x is on the table.

Answer the following questions:

- Write the precondition axioms for the actions.
- Write the effect axioms for the actions.
- Show how successor state axioms for the fluents would be derived from these effect axioms. Argue that the successor state axioms are not logically entailed by the effect axioms by briefly describing an interpretation where the effect axioms are satisfied but the successor state ones are not.
- Show how frame axioms are logically entailed by the successor state axioms.