Homework #3: Chapters 9-11

The following exercises are due at the beginning of class on Friday, March 26.

You must use SWI-Prolog (version 5.2.13) to answer part of exercise 1. SWI-Prolog is free software and can be downloaded from http://www.swi-prolog.org/. Both Linux and Windows versions are available. You should install it in your home directory or on a personal computer. In either case, you will need approximately 5 megabytes of free disk space to install the software.

1. [30 points] Consider a zoology domain where only the following information is available. All objects in the domain are an Animal of one sort or another. There are 3 sub-classes of animals, Mammal, Bird, and Fish, which are distinguished by their covering and by the number of legs that they have. Mammals are covered in fur, birds are covered in feathers, and fish are covered in scales. Mammals have 4 legs, birds have 2 legs, and fish have 0 legs. There are 3 sub-classes of mammals: Cat, Dog, and Primate. Cats and dogs make specific sounds: cats make a purr sound and dogs make a bark sound. Sylvester and Felix are examples of cats. Spike and Fido are examples of dogs. George and KingKong are examples of primates. All birds can fly. Tweety is an example of a bird. There is a single sub-class of birds: Hawk. Tony is an example of a hawk. The only known example of a fish is Nemo.

a) [10 points] Construct a semantic network using only the information provided above. See Figure 10.9 on page 351 of the book for an example.
b) [10 points] Create a Prolog program to reason with the zoology information provided. There should only be 9 facts in your program: one for each individual animal (Sylvester, Felix, Spike, Fido, etc.). Attach a printout of the program (you do not need to submit it electronically). Hint: The Prolog program will be easier to write if you use unary predicates to represent categories.
c) [5 points] Test your Prolog program by asking it the following questions: Is Felix covered in fur? How many legs does Fido have? Is Spike a bird? Can Tony fly? Who are all of the individual animals? Include a printout that shows your queries and the program's responses (you may simply copy this from SWI-Prolog's main window and paste it into a file for printing).
d) [5 points] Now ask your program how many legs George has. If you followed the instructions to the letter, then the answer will seem incorrect. Despite being mammals, primates have only 2 legs. Show how you would change the semantic network and the Prolog program to account for this new information while retaining the assertion that mammals have 4 legs by default. Provide output from your Prolog program showing how many legs each individual mammal has.

2. [20 points] Use the rules and knowledge base defined on the right.

a) [10 points] Use backward chaining to find **ALL** answers for the query R(Red,y,z). You must construct a proof tree.

b) [10 points] Use forward chaining to find all atomic sentences entailed by the KB. Number them starting from 15. For each answer, indicated the numbers of the rules used to arrive at the answer. No proof tree is necessary.

1) $\forall x,y\ P(x,y) \rightarrow T(x,y)$
2) $\forall x,y\ P(x,y) \rightarrow T(y,x)$
3) $\forall x,y,z\ T(x,y) \wedge Q(y,z) \wedge S(z,x) \rightarrow R(x,y,z)$
4) P(Red,Blue)
5) P(Green,Red)
6) Q(Blue,Green)
7) Q(Green,Blue)
8) Q(Red,Green)
9) Q(Blue,Red)
10) Q(Green,Red)
11) S(Blue,Red)
12) S(Green,Red)
13) S(Green,Green)
14) S(Green,Blue)

3. [10 points] Use the STRIPS actions defined for the air cargo problem in Figure 11.2 on page 380 of the book and the states specified to the right.

a) [5 points] List the concrete actions that are applicable in the specified initial state if a forward state-space search is being used. Give the successor state(s) for the applicable Unload action(s).

b) [5 points] List the concrete actions that are relevant and consistent in the specified goal state if a backward state-space search is being used. Give the predecessor state(s) for the relevant Unload action(s).

Initial State:
Plane(P1) ∧ Airport(JFK) ∧ Airport(NWK) ∧ Airport(SFO) ∧ Cargo(C1) ∧ Cargo(C2) ∧ Cargo(C3) ∧ Cargo(C4) ∧ Cargo(C5) ∧ In(C1,P1) ∧ At(P1,SFO) ∧ At(C2,SFO) ∧ At(C3,SFO) ∧ At(C4,JFK) ∧ At(C5,NWK)

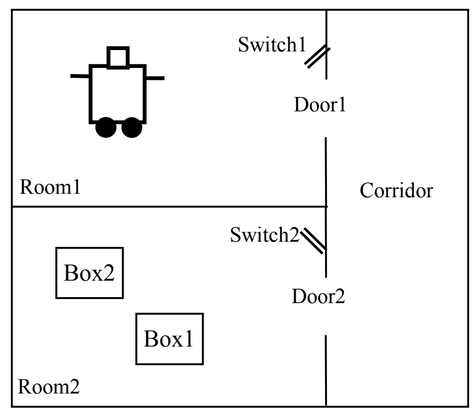
Goal State:
In(C1,P1) ∧ In(C2,P1) ∧ At(C3,NWK) ∧ At(P1,NWK)

4. [25 points] Consider the world of Shaky the robot, as described in problem 11.13 on page 414 of the book.

a) [10 points]Using STRIPS syntax, define the 6 actions described in the book (Go(x,y), Push(b,x,y), ClimbUp(b), ClimbDown(b), TurnOn(s), and TurnOff(s)). In your action definitions, use only the predicates Box(b) to mean that b is a box, In(x,r) to mean that location x is in room r, At(x,y) to mean that the object x is at location y, ShakyOn(x) to mean that Shaky is on the object x, Switch(s) to mean that s is a switch, and SwitchOn(s) to mean that the switch s is on. Only the constants Shaky and Floor should be used in the action definitions.

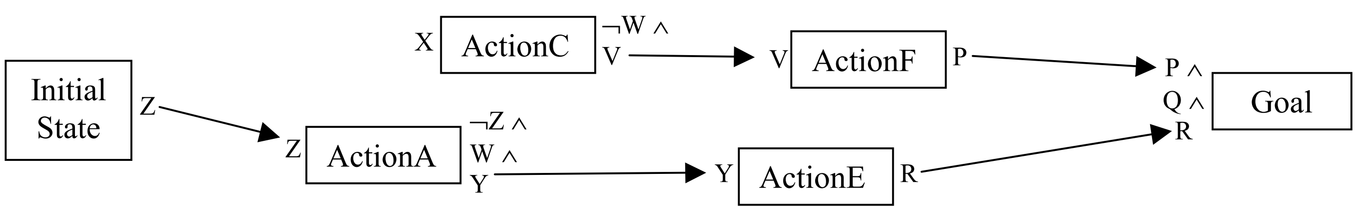
b) [5 points]Define the initial state depicted to the right. Use only the constants Box1, Box2, Switch1, Switch2, Floor, Shaky, Room1, Room2, Corridor, L_{Door1}, L_{Door2}, $L_{ShakyStart}$, $L_{Switch1}$, $L_{Box1Start}$, $L_{Box2Start}$, $L_{Switch2}$. Hint: You should have 20 conjuncts in the initial state definition.

c) [10 points]Provide a totally ordered plan for Shaky to turn off Switch2 using the actions defined in part a and the initial state defined in part b. You do not need to use an algorithm to find the plan.



NOTE: The intended interpretation of the switches drawn is that Switch1 is in the <u>off</u> position and Switch2 is in the <u>on</u> position.

5. [15 points] Consider the unfinished partially ordered plan given below. It is your task to finish the plan by adding actions as specified. In the end, you should have a plan that is a solution to the problem.



a) [6 points] Consider the open precondition X for ActionC. Use the STRIPS action Action(ActionB, PRECOND:Z, EFFECT: X) to achieve the precondition. Add a causal link to achieve the precondition of ActionB (without adding any new actions) and (if needed) add any ordering constraints to make the plan consistent.

b) [6 points] Consider the open precondition Q for the Goal. Use the STRIPS action Action(ActionD, PRECOND:W, EFFECT: Q) to achieve the precondition. Add a causal link to achieve the precondition of ActionB and add any ordering constraints needed to make the plan consistent.

c) [3 points] How many possible linearizations does your final plan have?