Homework #5: Chapters 11-12

The following exercises are due at the beginning of class on Monday, March 30. Note, this homework is continued on the reverse side of the paper.
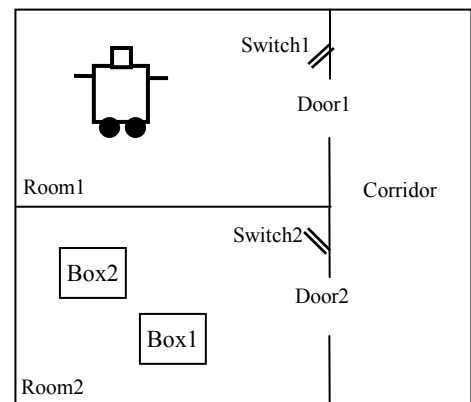
1. *[30 points]* Consider the STRIPS actions defined for the air cargo problem in Figure 11.2 on page 380 of the book, and the problem instance described below:

   Initial State: At(P1,SFO) ∧ At(P2,JFK) ∧ At(C1,SFO) ∧ In(C2,P2) ∧ Plane(P1) ∧ Plane(P2) ∧ Cargo(C1) ∧ Cargo(C2) ∧ Airport(JFK) ∧ Airport(SFO) ∧ Airport(ORD)
   Goal: At(P1,SFO) ∧ At(P2,SFO) ∧ At(C1,JFK) ∧ In(C2,P1)

   a) *[15 points]* Do the first level of a breadth-first forward state-space search on this problem. You should show all actions that are applicable in the initial state, as well as the successor states that result from these actions. For convenience, your state descriptions may omit literals that use the Plane, Airport, and Cargo predicates. Note, some of the applicable actions may be spurious, but you should show them anyway.
   b) *[15 points]* Do the first level of a breadth-first backward state-space search on this problem. You should show all actions that are relevant and consistent with the given goal, and show the predecessor states for these actions. In addition to omitting literals that use the Plane, Airport, and Cargo predicates as above, you may use variables as parameters for the actions.

2. *[40 points]* Consider the world of Shakey the robot, as shown to the right below. Shakey has the following six actions available:
   - *Go(x,y),* which moves Shakey from *x* to *y*. It requires Shakey to be at *x* and that *x* and *y* are locations in the same room. By convention a door between two rooms is in both of them, and the corridor counts as a room.
   - *Push(b,x,y),* which allows Shakey to push a box *b* from location *x* to location *y*. Both Shakey and the box must be at the same location before this action can be used.
   - *ClimbUp(b,x),* which allows Shakey to climb onto a box *b* at location *x*. Both Shakey and the box must be at the same location before this action can be used. Also Shakey must be on the *Floor.*

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

   - *ClimbDown(b,x),* which allows Shakey to climb down from a box *b* at location *x*. Shakey must be on the box and the box must be in location *x* before this action can be used.
   - *TurnOn(s,x),* which allows Shakey to turn on switch *s* which is located at location *x*. Shakey must be on top of a box at the switch's location before this action can be used.

- *TurnOff(s,x)*, which allows Shakey to turn off switch *s* which is located at location *x*. Shakey must be on top of a box at the switch's location before this action can be used.

a) *[20 points]* Using STRIPS syntax, define the six actions from above. In your action definitions, use only the following 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*, *ShakeyOn(x)* to mean that Shakey 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. You may also use the constants *Shakey* and *Floor* in the action definitions.

b) *[10 points]* Using STRIPS, define the initial state depicted on the previous page. Use only the predicates from part (a) and the constants *Box1, Box2, Switch1, Switch2, Floor, Shakey, Room1, Room2, Corridor, L_{Door1}, L_{Door2}, $L_{ShakeyStart}$, $L_{Switch1}$, $L_{Box1Start}$, $L_{Box2Start}$, $L_{Switch2}$*. The L_x constants are intended to represent the locations of *x*, Hint: You should have 20 conjuncts in the initial state definition.

c) *[10 points]* Provide a totally ordered plan for Shakey 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.

3. *[20 points]* Consider the inconsistent partially ordered plan below. Identify the conflicts in this plan and show all ways of resolving them that follow the principle of least commitment. For each solution, draw the new partially ordered plan, and list all of its linearizations.
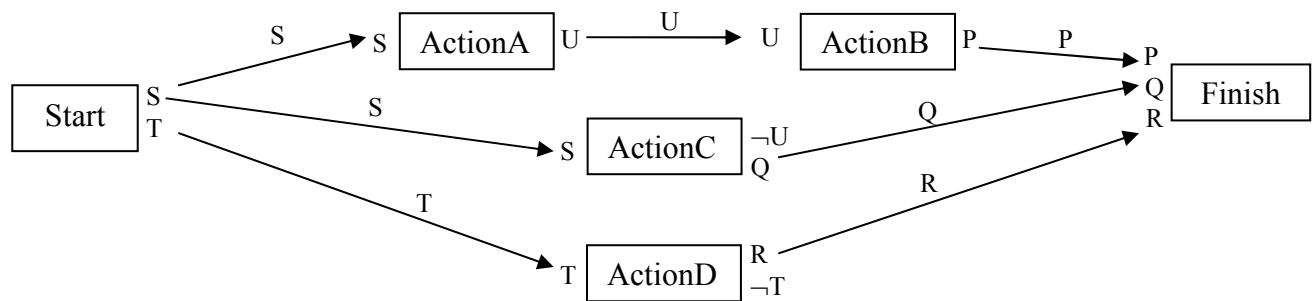
4. *[10 points]* Give a real-world example of bounded indeterminacy. Give one of unbounded indeterminacy. Do not repeat the examples from the book or class. Explain your answers.