6.825 Recitation Problems: Lec. 11

Solutions
December 13, 2001

1 Book Problem 11.2

a. Buy($x$, store)
   - Pre: $\text{At}(\text{store}), \text{Sells}(\text{store}, x), \text{Have(CC)}$
   - Eff: $\text{Have}(x)$

b. PickUp($x$)
   - Pre: $\text{At}(y), \text{At}(x, y), \text{Portable}(x)$
   - Eff: $\text{Have}(x)$
   Note: We have implicitly added another version of $\text{At}$ that takes 2 arguments. $\text{At}(x, y)$ means object $x$ is at location $y$. In the original 1-argument version, $\text{At}(y)$ means the agent is at location $y$.

c. For this, I won’t draw the plan but explain how you would change the original plan (lecture slide 11-8) to incorporate the changes.

   First, we’ve changed the Buy action to include the precondition of Have(CC). So we need to add the action $\text{PickUp(CC)}$ to the plan. The preconditions for $\text{PickUp(CC)}$ are $\text{At(CC, y), At(y), and Portable(CC)}$. They are all effects of the Start action if we instantiate $y = \text{Home}$. So then the Go actions threaten $\text{PickUp(CC)}$ action, so we put in the ordering constraint that the $\text{PickUp(CC)}$ action come before the Go actions.

   So the modified plan is

   (1) Start
   (2) $\text{PickUp(CC)}$
   (3) $\text{Go(SM)}$
   (4) $\text{Buy(Banana)}, \text{Buy(Milk)}$
   (5) $\text{Go(HDW)}$
   (6) $\text{Buy(Drill)}$
   (7) Finish

d. In a plan in which the agent leaves home without the card, the agent cannot do the Buy action because a precondition of Buy is Have(CC), and the only way to achieve Have(CC) is to do the action PickUp(CCC). But the preconditions of PickUp, At(CCC, y) and At(y), cannot be satisfied at the same time because CC is at Home, and after the Go action, the agent is not at Home anymore. So the agent must go back home to be able to do the PickUp(CCC) action.

2 Book Problem 11.7

a. $\forall x, y, r, s. \text{At}(\text{Shakey}, x, s) \land \text{In}(x, r) \land \text{In}(y, r) \land \text{On}(\text{Shakey, Floor, s}) \Rightarrow \text{At}(\text{Shakey, y, Result}(\text{Go(y)}))$

b. $\forall b, x, y, r, s. \text{At}(\text{Shakey, x, s}) \land \text{In}(x, r) \land \text{In}(y, r) \land \text{Pushable(b)}$
   $\text{edgeOn(Shakey, Floor, s, RightarrowAt(Shakey, y, Result(\text{Go(y)}))} \land \text{At}(b, y, Result(\text{Go(y)}))$

c. $\forall b, x, s. \text{At}(\text{Shakey, x, s}) \land \text{At}(b, x, s) \land \text{Climbable(x)} \Rightarrow \text{On(Shakey, b, Result(Climb(b))}$
4. ∀b,x.\(\text{On(Shakey, } b, s) \land \text{Climbable(b)} \Rightarrow \text{On(Shakey, } b, \text{Result(Down(b)))}\)

5. ∀ls,b,x,s.\(\text{On(Shakey, } b, s) \land \text{At(b, } x, s) \land \text{At(ls, } x) \land \text{TurnedOff(ls)} \Rightarrow \text{TurnedOn(ls, Result(TurnOn(ls)))}\)

6. ∀ls,b,x,s.\(\text{On(Shakey, } b, s) \land \text{At(b, } x, s) \land \text{At(ls, } x) \land \text{TurnedOff(ls)} \Rightarrow \text{TurnedOff(ls, Result(TurnOff(ls)))}\)

b. 1. Go(y)
   -Pre: \(\text{At(Shakey, } x), \text{In(y, } r), \text{In(x, } r), \text{On(Shakey, Floor)}\)
   -Eff: \(\text{At(Shakey, } y), \neg\text{At(Shakey, } x), \text{On(Shakey, Floor)}\)

2. Push(b, x, y)
   -Pre: \(\text{At(Shakey, } x), \text{At(b, } x), \text{In(y, } r), \text{In(x, } r), \text{Pushable(b), On(Shakey, Floor)}\)
   -Eff: \(\text{At(Shakey, } y), \neg\text{At(Shakey, } x), \text{At(b, } y), \neg\text{At(b, } x), \text{On(Shakey, Floor)}\)

3. Climb(b)
   -Pre: \(\text{At(Shakey, } x), \text{At(b, } x), \text{Climbable(b)}\)
   -Eff: \(\text{On(Shakey, } b), \neg\text{On(Shakey, Floor)}\)

4. Down(b)
   -Pre: \(\text{On(Shakey, } b)\)
   -Eff: \(\text{On(Shakey, Floor), } \neg\text{On(Shakey, } b)\)

5. TurnOn(ls)
   -Pre: \(\text{On(Shakey, } b), \text{TurnedOff(ls), At(b, } x), \text{At(ls, } x)\)
   -Eff: \(\text{TurnedOn(ls)}\)

6. TurnOff(ls)
   -Pre: \(\text{On(Shakey, } b), \text{TurnedOff(ls), At(b, } x), \text{At(ls, } x)\)
   -Eff: \(\text{TurnedOff(ls)}\)

c. Assume Box2 is at Loc1, and we’re pushing it to the location Loc2 in Room2.

1. Go(Door3)
2. Go(Corridor)
3. Go(Door1)
4. Go(Loc2)
5. Push(Box2, Loc1, Door1)
6. Push(Box2, Door1, Corridor)
7. Push(Box2, Corridor, Door2)
8. Push(Box2, Door2, Loc2)

3 Book Problem 11.9

a. \(\text{At(Monkey, A)} \land \text{At(Banana, B)} \land \text{At(Box, C)} \land \text{Height(Monkey, Low)} \land \text{Height(Box, Low)} \land \text{Height(Banana, High)}\)

b. 1. Go(x, y)
   -Pre: \(\text{At(Monkey, } x)\)
   -Eff: \(\text{At(Monkey, } y), \neg\text{At(Monkey, } x)\)

2. Push(a, x, y)
   -Pre: \(\text{At(Monkey, } x), \text{At(a, } x)\)
   -Eff: \(\text{At(Monkey, } y), \neg\text{At(Money, } x), \text{At(a, } y), \neg\text{At(a, } x)\)

3. Climb(a)
   -Pre: \(\text{At(Monkey, } x), \text{At(a, } x), \text{Height(Monkey, Low), Height(a, Low)}\)
   -Eff: \(\text{Height(Monkey, High)}\)

4. Grasp(a)
   -Pre: \(\text{At(Monkey, } x), \text{At(Monkey, a), Height(Monkey, y), Height(a, y)}\)
   -Eff: \(\text{Holding(a)}\)
c. \( At(Monkey, x, S_0) \land At(Box, y, S_0) \land At(Banana, z, S_0) \land At(Box, y, S_1) \land Holding(Banana, S_1) \)

d. qualification problem