CMSC421 Fall 2005 Homework 3

December 6, 2005

1 *Problem 1: Resolution Theorem Proving (15 pts)*

(a)
i. $\forall x\ smart(x) \wedge study(x) \wedge attend(x) \Rightarrow prepared(x)$.
ii. $\forall x, t\ fair(t) \wedge prepared(x) \Rightarrow pass(x, t)$.
iii. $\forall x\ umdstudent(x) \Rightarrow smart(x)$.
iv. $\forall t \sim fair(t) \Rightarrow \sim (\exists x\ pass(x, t))$.
v. $umdstudent(Chris)$.
vi. $\exists x\ pass(x, 421exam)$.
vii. $attend(Chris)$.
(b)
i. $\sim smart(x) \vee \sim study(x) \vee \sim attend(x) \vee prepared(x)$.
ii. $\sim fair(t) \vee \sim prepared(x_1) \vee pass(x_1, t)$.
iii. $\sim umdstudent(x_2) \vee smart(x_2)$.
iv. $fair(t_1) \vee \sim pass(x_3, t_1)$.
v. $umdstudent(Chris)$.
vi. $pass(someone, 421exam)$. (someone is Skolem constant)
vii. $attend(Chris)$
(c)

1. $\sim smart(x) \vee \sim study(x) \vee \sim attend(x) \vee prepared(x)$
2. $\sim fair(t) \vee \sim prepared(x_1) \vee pass(x_1, t)$
3. $\sim umdstudent(x_2) \vee smart(x_2)$
4. $fair(t_1) \vee \sim pass(x_3, t_1)$
5. $umdstudent(Chris)$.
6. $pass(someone, 421exam)$. (someone is Skolem constant)
7. $attend(Chris)$
8. $study(Chris) \wedge \sim pass(Chris, 421exam)$ *negated goal*
9. $study(Chris)$ *8*

Table 1: Truth Table

	t = 0	t = 1	t = 2
Action(t)	Action(0) = Load(...)	Action(1) = Drive(...)	
At(Truck,Depot,t)	T	?	?
At(Truck,AVW,t)	?	?	T
At(Machine1,Depot,t)	?	?	?
At(Machine1,AVW,t)	?	?	?
On(Machine1,Truck,t)	T	?	?
At(Machine2,Depot,t)	T	?	?
At(Machine2,AVW,t)	?	?	?
On(Machine2,Truck,t)	F	T	?

10. $\sim pass(Chris, 421exam)$ *8*

11. $\sim smart(Chris) \lor \sim attend(Chris) \lor prepared(Chris)$ *1, 9* $x/Chris$

12. $\sim smart(Chris) \lor prepared(Chris)$ *7, 11*

13. $smart(Chris)$ *3, 5* $x_2/Chris$

14. $prepared(Chris)$ *12, 13*

15. $\sim fair(t) \lor pass(Chris, t)$ *2, 14* $x_1/Chris$

16. $\sim fair(421exam)$ *10, 15* $t/421exam$

17. $\sim pass(x_3, 421exam)$ *4, 16* $t_1/421exam$

18. $false$ *6, 17* $x_3/someone$

Therefore, proved.

2 *Problem 2: Reasoning About Action And Change (15 pts)*

(a)
See Table 1.
(b)
i. Things can only be in one place at a time.
$At(x, Depot, t) \Rightarrow \sim At(x, AVW, t)$
$At(x, AVW, t) \Rightarrow \sim At(x, Depot, t)$
ii. Whatever is on the truck is at where the truck is located.
$On(x, Truck, t) \land At(Truck, l, t) \Rightarrow At(x, l, t)$
(c)

$Moving(x, l, t) \Rightarrow (Drivable(x) \wedge Action(t) = Drive(x, l)) \vee \exists y(On(x, y, t) \wedge Drivable(y) \wedge Action(t) = Drive(y, l))$

(d)

$Moving(x, l, t) \Rightarrow At(x, l, t + 1)$

$At(x, l1, t) \wedge \sim \exists l2(Moving(x, l2, t)) \Rightarrow At(x, l1, t + 1)$

$On(x, y, t) \Rightarrow On(x, y, t + 1)$

3 *Problem 3: STRIPS Russell & Norvig exercise 11.4 (15 pts)*

(a) The initial state is:

$At(Monkey, A) \wedge At(Bananas, B) \wedge At(Box, C) \wedge Height(Monkey, Low) \wedge Height(Box, Low) \wedge Height(Bananas, High) \wedge Pushable(Box) \wedge Climbable(Box)$

(b) The actions are: (this is not the only way)

Operator	Preconditions	Add effects	Delete effects
Go(x,y)	At(Monkey,x)	At(Monkey,y)	At(Monkey,x)
Push(b,x,y)	At(Monkey,x) At(b,x) Pushable(b)	At(b,y) At(Monkey,y)	At(b,x) At(Monkey,x)
ClimbUp(b,x)	At(Monkey,x) At(b,x) Climbable(b)	On(Monkey,b) Height(Monkey,High)	Height(Monkey,Low)
ClimbDown(b)	On(Monkey, b) Climbable(b)	Height(Monkey,Low)	Height(Monkey, High) On(Monkey,b)
Grasp(o,h,x)	Height(Monkey,h) Height(o,h) At(Monkey,x) At(o,x)	Have(Monkey,o)	
UnGrasp(o, h, x)	Have(Monkey, o) At(Monkey, x)	At(o, x) Height(o, h)	Have(Monkey, o)

(c)

In situation calculus, the goal is a state s such that: $Have(Monkey, Bananas, s) \wedge (\exists x At(Box, x, s_0) \wedge At(Box, x, s))$. In STRIPS, we can only talk about the goal state; there is no way of representing the fact that there must be some relation (such as equality of location of an object) between two states within the plan. So there is no way to represent this goal.

(d)

Actually, we did include the *Pushable* precondition. This is an example of the qualification problem.

4 *Problem 4: POP (15 pts)*

See Figure 1.

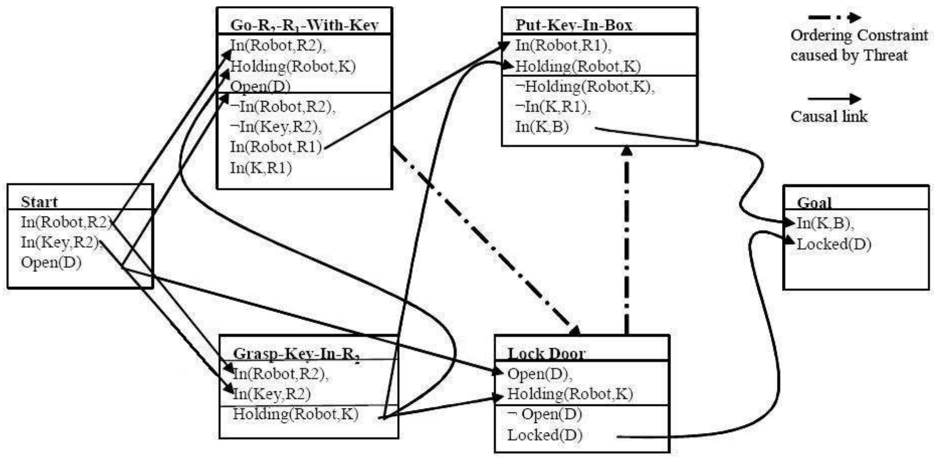

Figure 1: POP

5 *Problem 5: GraphPlan (15 pts)*

See Figure 2.

6 *Problem 6: Design Your Own Planning Problem (25 pts)*

Answer varies.

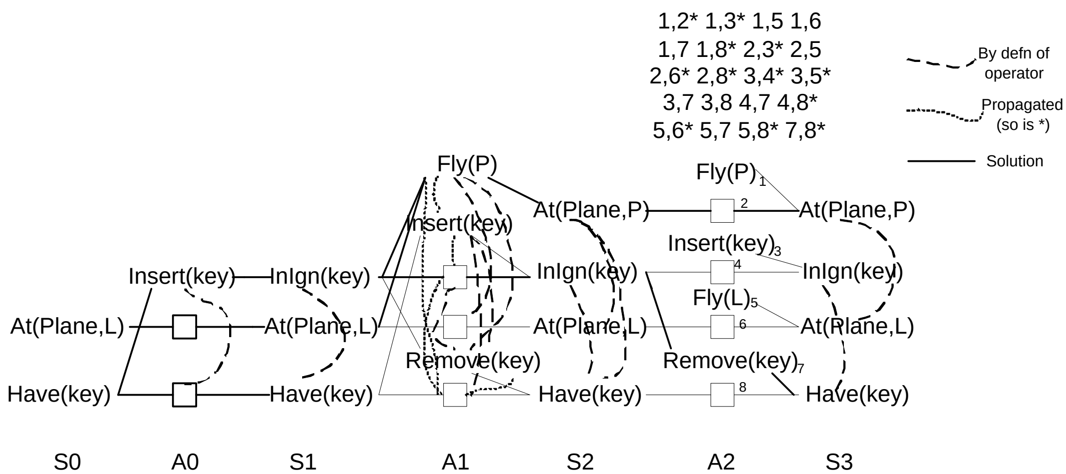

Figure 2: GraphPlan