Homework 4

Sean Papay 007323511

Dakota Polenz 007879664

Ryan Lichtig 007264348

Problem 9.10

The riddle can be expressed in first-order logic as:
$Male(m) \wedge$
$(\neg\exists s : Brother(s, I) \vee Sister(s, I)) \wedge (\exists f : Son(f, Father(I)) \wedge f = Father(m))$
Where I represents the speaker in the riddle, and m represents "that man". From this, we can use the axioms of the kinship domain to deduce the identity of "that man":

$$\begin{aligned} Male(m)\wedge \\ (\neg\exists s : Brother(s, I) \vee Sister(s, I))\wedge \\ (\exists f : Son(f, Father(I)) \wedge f = Father(m)) \end{aligned} \tag{1}$$

$$\begin{aligned} Male(m)\wedge \\ (\neg\exists s : (Sibling(s, I) \wedge Male(s)) \vee (Sibling(s, I) \wedge Female(s))\wedge \\ (\exists f : Son(f, Father(I)) \wedge f = Father(m)) \end{aligned} \tag{2}$$

$$\begin{aligned} Male(m)\wedge \\ (\neg\exists s : Sibling(s, I) \wedge (Male(s) \vee Female(s)))\wedge \\ (\exists f : Son(f, Father(I)) \wedge f = Father(m)) \end{aligned} \tag{3}$$

$$\begin{aligned} Male(m)\wedge \\ (\neg\exists s : Sibling(s, I))\wedge \\ (\exists f : Son(f, Father(I)) \wedge f = Father(m)) \end{aligned} \tag{4}$$

$$\begin{aligned} Male(m)\wedge \\ (\neg\exists s : Sibling(s, I))\wedge \\ (\exists f : Son(f, Father(I)) \wedge Parent(f, m) \wedge Male(f)) \end{aligned} \tag{5}$$

$$\begin{aligned}
&Male(m)\wedge \\
&(\neg\exists s : Sibling(s, I))\wedge \\
&(\exists f : Child(f, Father(I)) \wedge Parent(f, m) \wedge Male(f))
\end{aligned} \tag{6}$$

$$\begin{aligned}
&Male(m)\wedge \\
&(\neg\exists s : s \neq I \wedge (\exists p : Parent(p, s) \wedge Parent(p, I)))\wedge \\
&(\exists f : Child(f, Father(I)) \wedge Parent(f, m) \wedge Male(f))
\end{aligned} \tag{7}$$

$$\begin{aligned}
&Male(m)\wedge \\
&(\forall s : s = I \vee \neg(\exists p : Parent(p, s) \wedge Parent(p, I)))\wedge \\
&(\exists f : Child(f, Father(I)) \wedge Parent(f, m) \wedge Male(f))
\end{aligned} \tag{8}$$

$$\begin{aligned}
&Male(m)\wedge \\
&(\forall s : s = I \vee \neg(\exists p : Parent(p, s) \wedge Parent(p, I)))\wedge \\
&(\exists f, g : g = Father(I) \wedge Child(f, g) \wedge Parent(f, m) \wedge Male(f))
\end{aligned} \tag{9}$$

$$\begin{aligned}
&Male(m)\wedge \\
&(\forall s : s = I \vee \neg(\exists p : Parent(p, s) \wedge Parent(p, I)))\wedge \\
&(\exists f, g : Parent(g, I) \wedge Child(f, g) \wedge Parent(f, m) \wedge Male(f) \wedge Male(g))
\end{aligned} \tag{10}$$

$$\begin{aligned}
&Male(m)\wedge \\
&(\forall s : s = I \vee \neg(\exists p : Parent(p, s) \wedge Parent(p, I)))\wedge \\
&(\exists f, g : Parent(g, I) \wedge Parent(g, f) \wedge Parent(f, m) \wedge Male(f) \wedge Male(g))
\end{aligned} \tag{11}$$

$$\begin{aligned}
&Male(m)\wedge \\
&(\forall s : (\exists p : Parent(p, s) \wedge Parent(p, I)) \rightarrow s = I)\wedge \\
&(\exists f, g : Parent(g, I) \wedge Parent(g, f) \wedge Parent(f, m) \wedge Male(f) \wedge Male(g))
\end{aligned} \tag{12}$$

$$\begin{aligned} Male(m)\wedge \\ (\forall s : (\exists p : Parent(p, s) \wedge Parent(p, I)) \rightarrow s = I)\wedge \\ (\exists f : f = I \wedge Parent(f, m) \wedge Male(f)) \end{aligned} \tag{13}$$

$$Male(m) \wedge Parent(I, m) \wedge Male(I) \tag{14}$$

$$Male(m) \wedge Child(m, I) \tag{15}$$

$$Son(m, I) \tag{16}$$

From this, we can conclude that "that man" is, in fact, the speaker's son.

In prenex normal form, the original riddle can be expressed as follows:

$\exists f : \forall s : (\neg Brother(s, I) \vee \neg Son(f, Father(I)) \vee \neg f = Father(m) \vee \neg Male(m)) \wedge (\neg Sister(s, I) \vee \neg Son(f, Father(I)) \vee \neg f = Father(m) \vee \neg Male(m))$

Problem 9.23

a. Premise: $\forall h : Horse(h) \rightarrow Animal(h)$
Conclusion: $\forall c, q : (HeadOf(c, q) \wedge Horse(q)) \rightarrow \exists a : (HeadOf(c, a) \wedge Animal(a))$

b. Premise: $\neg Horse(h) \vee Animal(h)$
Conclusion: $HeadOf(C, Q) \wedge Horse(Q) \wedge (\neg HeadOf(C, a) \vee \neg Animal(a))$

c. $\frac{(\neg HeadOf(C,Q) \vee \neg Animal(Q)), HeadOf(C,Q)}{\neg Animal(Q)}$

$\frac{\neg Animal(Q), (\neg Horse(h) \vee Animal(h))}{\neg Horse(Q)}$

$\frac{\neg Horse(Q), Horse(Q)}{\perp}$

Additional Problem 1 For information about our intial state and our actions, refer to the files $\{aditional1.n.jpeg|n \in \{1,2\}\}$.

See the file planninggraph.pdf for a visual representation of our planning graph. The execution of graphplan on this problem would procede as follows: The planning graph would initially contain only the initial fluents, those that appear in column S0. Graphplan would populate the planning graph up to time step 3, at which point our goal state appears among our fluents. At this point, we perfom a backward search, but find no valid plan to reach our goal. We continue to time step 4, and notice our fluents have leveled off. We perform a second backward search, and still find no goal; however, our no-goods have not yet leveled off, so we continue. We do the same for time step 5, and again find no valid plan. At time step 6, however, our backward search yields a valid plan, at which point graphplan terminates succesfully.

Additional Problem 2 To solve the frame problem, PDDL specifies the result of an action in terms of what changes .while everything that stays the same is left unmentioned.

Disadvantages to formulating problems in PDDL is that PDDL does not have a universal quantifier, which means that objects that are similar but originally defined separately need to be individually quantified when envoking actions on the objects.

Additional Problem 3

$Republican(Nixion) \wedge Quaker(Nixion) \wedge Californian(Nixion) \wedge Hippie(x) \rightarrow Pacifist(x)$

1. $Republican(x) : \neg Pacifist(x) / \neg Pacifist(x)$

2. $Quaker(x) : Pacifist(x) / Pacifist(x)$

3. $Californian(x) : Hippie(x) / Hippie(x)$

4. $Republican(x) : \neg Hippie(x) / \neg Hippie(x)$

In our example we state that being a hippie implies that one is also a pacifist. This precludes the possibility of Nixon being simultaneously a hippie and not a pacifist, leaving 3 possible combinations of pacifism and hippyism. We intend to show each of these combinations is an extension of our system. In the case that Nixon is a pacifist hippy, he abides by exactly two default rules, those for Quakers and Californians.

In the case that he is a Pacifist, but not a hippy, he abides by the default rules for Quakers and one of the default rules for Republicans. In the case that he is neither a pacifist or a hippie, he abides by both default rules for Republicans. Since each of these cases is maximal, there exist exactly three extensions to our system.