Foundations of Agents Exam, 19.10.2015

1 Markov Decision Process

Consider a POMDP (partially observable MDP) with the following properties:

States	$S = \{s_1, s_2\}$
Initial belief function	$b(s_1) = 0.6$
	$b(s_2) = 0.4$
Observation model	$\omega(s_1, o_1) = 0.8$
	$\omega(s_2, o_1) = 0.2$
	$\omega(s_1, o_2) = 0.2$
	$\omega(s_2, o_2) = 0.8$
Transition function	$t(s_1, a, s_1) = t(s_2, a, s_2) = 0$
	$t(s_1, a, s_2) = t(s_2, a, s_1) = 1$

1. Determine the belief function b' after the agent executes action a followed by observation o_1.
Determine the belief function b'' after the agent executes action a followed by observation o_2.

2. Determine the transition function $\tau(b, a, b')$

2 Dynamic Logic

Using different methods, prove the following axiom:

$$\models [\psi?]\varphi \rightarrow (\psi \rightarrow \varphi)$$

1. Prove that the above axiom holds using a semantic tableaux.

2. Prove that the above axiom holds using the definitions of the semantics of dynamic logic.

3 Modelling the World

Consider the following simple real-life logistics problem: A truck T must move a package P from location A to location B. In our world, we have 3 types of actions:

$$load, unload, drive$$

Furthermore we have the following 5 atomic propositions:

$$at(T, A), at(T, B), at(P, A), at(P, B), in(P, T)$$

Applied to our problem, there are 4 atomic actions possible:

$$drive(A, B), drive(B, A), load(P, T), unload(P, T)$$

Given the 5 atomic propositions, there are $2^5 = 32$ possible states. However, only 6 out of them are meaningful.
Note, that P is no longer at A once loaded into the truck. Loading and unloading does not change the location of the truck, though.

1. Give a graphical representation of the problem. Specify all meaningful states and specify all legal state transitions. Use a Kripke structure $\mathcal{I} = (S, I, R^A)$ for the graphical representation.

2. Using dynamic logic, describe the preconditions and effects of each atomic action. You can use variables for the location, package and the truck to give a general description of each type of action. If you do not wish to use variables, note, that you will need two separate definitions for each location of the actions $load(P, T)$ and $unload(P, T)$.

4 BDI Logic

Give a specification of the Beliefs, Desires and Intentions of an *irrational* agent using Bratman's BDI model. This agent intends to do action a while believing it will never be able to execute action a. Draw a Kripke structure to represent the Beliefs, Desires and Intentions you specified.

5 Bonus (for extra points)

Formally prove that a *realistic* agent cannot choose an intention that violates the **no-intention-belief-inconsistency** principle.