**All** of these problems count as bonus problems, i.e. they do not count towards the maximum possible homework problems, but if you solve them they count towards your score.

1. **Belief Quality:** Given the epistemic state shown in Figure 1, what is the quality of $B$'s belief that at least one of the cards is spades? How would you express this as a formula, using left and right as the predicates for the left and right card, and $Q[\alpha]_B$ as the modal operator for "$B$'s weighted quality of belief is $\alpha$?

2. **Belief Quality:** Given the epistemic state shown in Figure 1, for each of the following sentences, determine if the state is a model for that sentence (and why). Note that left and right refer to the left and right card, respectively, which may either be clubs (♣) or spades (♠)

- $Q[> 0.2]_A$ left(♣)
- $Q[> 0.4]_A$ left(♣)
- $Q[> 0.99]_A$ left(♣)
- $Q[> 0.2]_B$ right(♣)
- $Q[> 0.4]_B$ right(♣)
- $Q[> 0.99]_B$ right(♣)

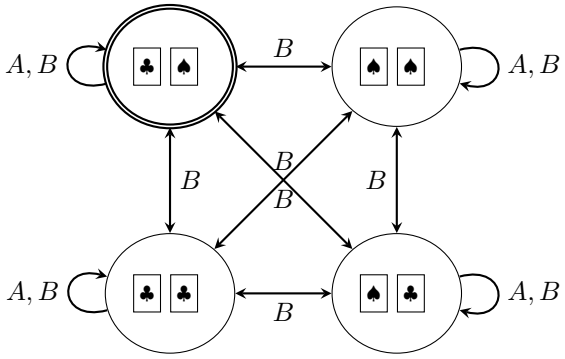


Figure 1: An Epistemic State.

3. **Weighted Belief Quality:** Given the epistemic state shown in Figure 1, assign weights to each world, such that the resulting state is a model for the sentence
$(W[> 0.7]_B \text{ left}(♠)) \wedge (\neg W[> 0.9]_B \text{ left}(♠))$

4. **Planning with DEL:** Assume you, $A$, have one possible operator, `claim(c,s)`, which is to claim that one of the cards $c$ (can be `left` or `right`) has a particular suit (♠ or ♣). When you use an action defined by this operator, agent $B$ will increase the weight of all worlds which are inconsistent with your statement by 1 (i.e. they count lies). Find a plan that causes $B$ to believe that the left card is a spades with a weighted quality of at least 0.7.

5. **Planning with DEL:** Assume you, $A$, have one possible operator, `claim(c,s)`, which is to claim that one of the cards $c$ (can be `left` or `right`) has a particular suit (♠ or ♣). When you use an action defined by this operator, agent $B$ will increase the weight of all worlds which are inconsistent with your statement by 1 (i.e. they count lies). Find a plan that causes $B$ to believe that the the two cards are the same with a weighted quality of at least 0.8.