50.021 Artificial Intelligence
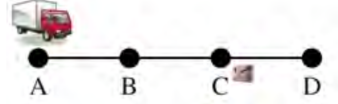
Quiz 6

Student Name: **Student ID:**

[Q1]. **(10p)** Recall the logistics problem in the lecture notes, shown in fig 1.

Another Example: "Logistics"

- Facts P: $\{truck(x) \mid x \in \{A, B, C, D\}\} \cup pack(x) \mid x \in \{A, B, C, D, T\}\}$.
- Initial state I: $\{truck(A), pack(A)\}$.
- Goal G: $\{truck(B), pack(B)\}$.
- Actions A: (Notated as "precondition $\Rightarrow$ adds, $\neg$ deletes")
    - $drive(x, y)$, where x, y have a road:
      "$truck(x) \Rightarrow truck(y), \neg truck(x)$".
    - $load(x)$: "$truck(x), pack(x) \Rightarrow pack(T), \neg pack(x)$".
    - $unload(x)$: "$truck(x), pack(T) \Rightarrow pack(x), \neg pack(T)$".

Figure 1: Logistics Problem

The static facts also include the roads: `road(A, B), road(B, A), road(B, C), road(C, B)`

1. **(1p)** Write action *drive* in PDDL format by filling in the template below. Recall in PDDL you need parameters, precondition, and effects.
   Solution

   ```
   (:action drive
       :parameters  (?x ?y)

       :precondition (and (truck ?x) (road?x ?y))

       :effects (and (truck ?y) (not truck ?x))
       )
   ```

2. **(1p)** Rewrite the `actions` such that they become delete-relaxed actions.
   Solution

   - $drive(x, y)$: "$truck(x) \implies truck(y)$", where x, y have a road.
   - $load(x)$: "$truck(x), pack(x) \implies pack(T)$"
   - $unload(x)$: "$truck(x), pack(T) \implies pack(x)$"

3. **(3p)** Fill in the states and actions below. If you find the goal facts earlier than the ith iteration, then fill all the states and action afterwards as None.

   $F_0 = $ _____

   $A_0 = $ _____

   $F_1 = $ _____

   $A_1 = $ _____

1

$F_2 =$ _____

$A_2 =$ _____

$F_3 =$ _____

$A_3 =$ _____

Solution $F_0 = \{(truckA), (packA), road(A, B), road(B, A), road(B, C), road(C, B)\}$
$A_0 = \{load(A), drive(A, B)\}$ (preconditions are in F_0)
$F_1 = F_0 + \{pack(T), truck(B)\}$
$A_1 = \{unload(A), unload(B), drive(B, A), drive(B, C)\}$ (preconditions are in F_1)
$F_2 = F_1 + \{pack(B), truck(C)\}$
$A_2 = $ None
$F_3 = $ None
$A_3 = $ None

4. **(2p)** What is the value of h_{max} and h_{add}?

Solution h_{add} is the sum of the levels of the goals $= 1 + 2 = 3$
h_{max} is the max level of the goal $= 2$.

5. **(3p)** Let G_t be the set of goal facts used in $h_F F$. Fill in the blanks below following the backward pass rule to get $h_F F$. Note that if you already find the goal node earlier than i^{th} iteration, then fill the corresponding G_i as None. Begin backward pass at the correct iteration k where your goal node is found. What is the value of $h_F F$?

At the start of $t = 3$ loop,
$G_0 =$ $G_1 =$

$G_2 =$ $G_3 =$

$G_4 =$ $selected =$

At the end of $t = 3$ loop,
$G_0 =$ $G_1 =$

$G_2 =$ $G_3 =$

$G_4 =$ $selected =$

At the end of $t = 2$ loop,
$G_0 =$ $G_1 =$

$G_2 =$ $G_3 =$

$G_4 =$ $selected =$

At the end of $t = 1$ loop,
$G_0 =$ $G_1 =$

$G_2 =$ $G_3 =$

$G_4 =$ $selected =$

Solution
At the start of $t = 2$ loop,
$G_0 = \{(\}, G_1 = \{(truckB)\}, G_2 = \{(packB)\}, selected = \{\}$

At the end of $t = 2$ loop,
$G_0 = \{truckA\}, G_1 = \{(truck(B), pack(T)\}, G_2 = \{(packB)\}, selected = \{drive(A, B), unload(B)\}$

At the end of $t = 1$ loop, (ignoring G_2)
$G_0 = \{(truckA, packA)\}, G_1 = \{(truck(B), pack(T)\},$
$G_2 = \{(packB)\}, selected = \{load(A), drive(A, B), unload(B)\}$

The value of h_{FF} is the length of $selected$ set which is 3

3

[Q2]. **(6p)** Refer to the Bayes network in figure 2 and answer whether the following statements are True/False, using d-separation algorithm. **Show your steps**. Answers without explanation only get a maximum of half of the total marks.
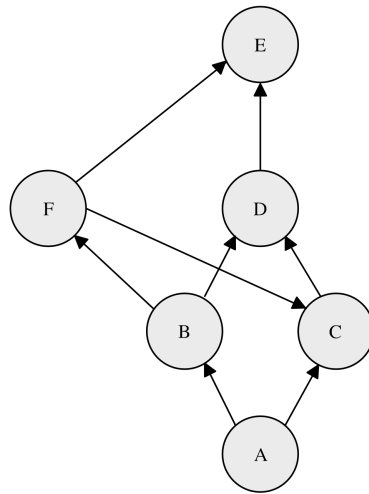

Figure 2: Bayes Network

Hint: keep cool, and enumerate all paths. Then check all paths whether all are inactive, or one of them is active. Write for us down what paths you checked and whether they are inactive or active. Check also for common effects with children of common effects. Example: A and F have a common effect C, and it has D,E as a child

1. D and F are independent given B, C
   Solution: True. F and D are d-separated.

2. A and F are independent given B,D
   Solution: True. A and F are d-separated.

3. B is independent of C given A
   Solution: False. $B-> F-> C$ is an active path

[Q3] Answer the following multiple choice questions.

1 Consider a Bayesian network B with boolean variables, Answer following questions.
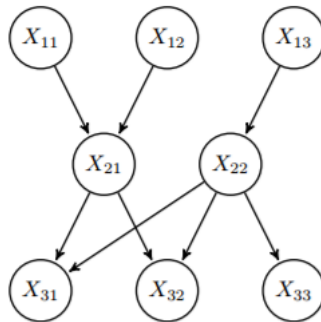
    a From the rule we covered in lecture, choose the variable(s) conditionally independent of x_{33} given x_{11} and x_{12}

    A. x_{21}

    B. x_{31} and x_{21}

    C. x_{31} , x_{32} and x_{21}

    D. None

    b From the rule we covered in lecture, choose the variable(s) conditionally independent of x_{33} given x_{22}.

    A. x_{21}

    B. x_{11}, x_{12} and x_{13}

    C. x_{31} , x_{32} and x_{21}

    D. Everything but x_{22} and x_{33}

2 Consider the figure shown below. Determine which independency is not true.
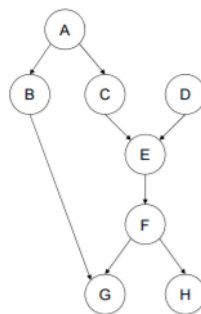
    A. $(B \perp C | A)$

    B. $(A \perp F | E)$

    C. $(C \perp D | F)$

    D. $(A \perp G | \{B, F\})$

Answer: 1. A,D 2. C **Template for Q1 part 1**:

```
(:action drive
    :parameters _____

    :precondition _____

    :effects _____
    )
```