Exercise Sheet 7
Due: Friday, December 7th, 2018

Send your solution to drexlerd@tf.uni-freiburg.de or submit a hardcopy before the lecture.

Exercise 7.1 (Relaxed planning graph and heuristics, 2+2 points)
Consider the relaxed planning task $\Pi^+$ with variables $A = \{a, b, c, d, e\}$, operators $O = \{o_1, o_2, o_3\}$, $o_1 = \langle d, c \land (c \triangleright e) \rangle$, $o_2 = \langle c, a \rangle$, $o_3 = \langle a, b \rangle$, goal $\gamma = b \land e$ and initial state $s = \{a \mapsto 0, b \mapsto 0, c \mapsto 0, d \mapsto 1, e \mapsto 0\}$. Solve the following exercises by drawing the relaxed planning graph for the lowest depth $k$ that is necessary to extract a solution.

(a) Calculate $h_{sa}(s)$ for $\Pi^+$.

(b) Calculate $h_{FF}(s)$ for $\Pi^+$.

Exercise 7.2 (Finite-domain representation, 2+2+2 points)
Consider the propositional Blocksworld planning task $\Pi = \langle A, I, O, \gamma \rangle$, with

- the set of variables
  
  \[ A = \{A\text{-}clear, B\text{-}clear, C\text{-}clear, A\text{-}on-B, A\text{-}on-C, A\text{-}on-T, B\text{-}on-A, B\text{-}on-C, B\text{-}on-T, C\text{-}on-A, C\text{-}on-B, C\text{-}on-T\} \]

- $I(a) = 1$ for $a \in \{B\text{-}on-T, A\text{-}on-B, A\text{-}clear, C\text{-}on-T, C\text{-}clear\}$, $I(a) = 0$, else.

- $O$ contains the actions
  
  $move-X-Y-Z = \langle X\text{-}on-Y \land X\text{-}clear \land Z\text{-}clear, \neg X\text{-}on-Y \land Y\text{-}clear \land X\text{-}on-Z \land \neg Z\text{-}clear \rangle$

  $move-X\text{-}Table-Z = \langle X\text{-}on-T \land X\text{-}clear \land Z\text{-}clear, \neg X\text{-}on-T \land X\text{-}on-Z \land \neg Z\text{-}clear \rangle$

  $move-X-Y\text{-}Table = \langle X\text{-}on-Y \land X\text{-}clear, \neg X\text{-}on-Y \land Y\text{-}clear \land X\text{-}on-T \rangle$

  for pair-wise distinct $X, Y, Z \in \{A, B, C\}$

- $\gamma = B\text{-}on-C \land C\text{-}on-A$.

(a) The following mutex groups can be found for $\Pi$:

\[ L_1 = \{B\text{-}on-A, C\text{-}on-A, A\text{-}clear\} \]
\[ L_2 = \{A\text{-}on-B, C\text{-}on-B, B\text{-}clear\} \]
\[ L_3 = \{A\text{-}on-C, B\text{-}on-C, C\text{-}clear\} \]
\[ L_4 = \{A\text{-}on-B, A\text{-}on-C, A\text{-}on-T\} \]
\[ L_5 = \{B\text{-}on-A, B\text{-}on-C, B\text{-}on-T\} \]
\[ L_6 = \{C\text{-}on-A, C\text{-}on-B, C\text{-}on-T\} \]
Specify a planning task $\Pi'$ that is equivalent to $\Pi$ and in finite-domain representation by using these mutex groups. Please name the variables in a reasonable way (e.g., analogously to the examples given in the lecture).

(b) Specify the propositional planning task $\Pi''$ that is induced by $\Pi'$.

(c) How are both planning tasks $\Pi$ and $\Pi''$ related? Is a plan for $\Pi$ always a plan for $\Pi''$ and vice versa?

You may and should solve the exercise sheets in groups of two. Please state both names on your solution.