Exercise 10.1 (Merge-and-Shrink abstractions, 2+3+4+1 points)

Consider the (SAS\textsuperscript{+}) Gripper planning task $\Pi = \langle V, I, O, \gamma \rangle$ with two balls $B_1$ and $B_2$:

- $V = \{ \text{pos}_{B_1}, \text{pos}_{B_2}, \text{pos}_{\text{Robby}}, \text{status}_{G_1}, \text{status}_{G_2} \}$
  $D_{\text{pos}_{B_1}} = D_{\text{pos}_{B_2}} = \{ L, R, G_1, G_2 \}$
  $D_{\text{pos}_{\text{Robby}}} = \{ L, R \}$
  $D_{\text{status}_{G_1}} = D_{\text{status}_{G_2}} = \{ E, F \}$ (empty and full)

- $I(\text{pos}_{B_1}) = I(\text{pos}_{B_2}) = I(\text{pos}_{\text{Robby}}) = L, I(\text{status}_{G_1}) = I(\text{status}_{G_2}) = E$

- $O = \{ ML, MR \} \cup \{ ABXG | A \in \{ P, D \}, B \in \{ B_1, B_2 \}, X \in \{ L, R \}, G \in \{ G_1, G_2 \} \}$
  - $ML = \langle \text{pos}_{\text{Robby}} = R, \text{pos}_{\text{Robby}} := L \rangle$ (move left)
  - $MR = \langle \text{pos}_{\text{Robby}} = L, \text{pos}_{\text{Robby}} := R \rangle$ (move right)
  - $PBXG = \langle \text{pos}_{\text{Robby}} = X \land \text{pos}_B = X \land \text{status}_G = E, \text{pos}_B := G \land \text{status}_G := F \rangle$
    for $B \in \{ B_1, B_2 \}, G \in \{ G_1, G_2 \}, X \in \{ L, R \}$ (pick ball $B$ with gripper $G$ in room $X$)
  - $DBXG = \langle \text{pos}_{\text{Robby}} = X \land \text{pos}_B = G, \text{pos}_B := X \land \text{status}_G := E \rangle$
    for $B \in \{ B_1, B_2 \}, G \in \{ G_1, G_2 \}, X \in \{ L, R \}$ (drop ball $B$ from gripper $G$ in room $X$)

- $\gamma = \langle \text{pos}_{B_1} = R \land \text{pos}_{B_2} = R \rangle$

(a) Visualize $T^{\pi(\text{pos}_{B_1})}, T^{\pi(\text{pos}_{\text{Robby}})}$ and $T^{\pi(\text{status}_{G_1})}$ and specify the according one-dimensional tables.

(b) Visualize $T^{\pi(\text{pos}_{B_1})} \otimes T^{\pi(\text{status}_{G_1})}$ and specify the according two-dimensional table.

(c) Shrink the graph from (b) by collapsing all nodes with identical $g$ and $h$ values. Use linked lists to renumber the nodes. Visualize the resulting graph, and specify the resulting new two-dimensional table and the final status of the linked list.

(d) Which heuristic value do we get for $s = \{ \text{pos}_{B_1} \mapsto L, \text{pos}_{B_2} \mapsto G_1, \text{pos}_{\text{Robby}} \mapsto R, \text{status}_{G_1} \mapsto F, \text{status}_{G_2} \mapsto E \}$ and how is the look-up of the value performed?

Note: The exercise sheets may and should be worked on in groups of two students. Please state both names on your solution (this also holds for submissions by e-mail).