ICS 271
Fall 2016
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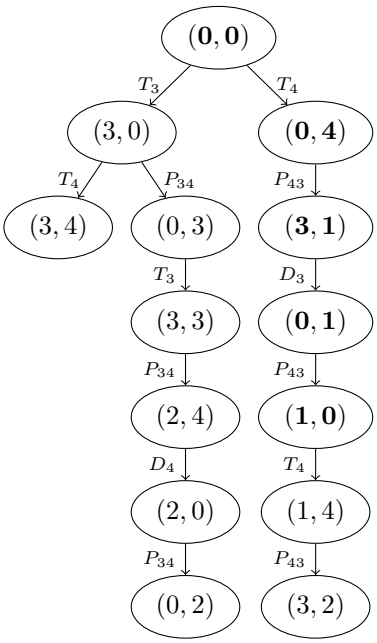
Homework Assignment 1
Due Tuesday, 10/11

1. (a) i. Initial state: $(0, 0)$
   Left 0 means initial water in *Three* is 0 Liter;
   Right 0 means initial water in *Four* is also 0 Liter.
   ii. Whole state: (a, b)
   $a(a \in [0, 3])$ is current mount of water in *Three*;
   $b(b \in [0, 4])$ is current mount of water in *Four*.
   iii. Goal state: $(1, x)$
   x could be any valid number.
   iv. Operators:
   T_3: if $a < 3$, $(a, b) \rightarrow (3, b)$
   T_4: if $b < 4$, $(a, b) \rightarrow (a, 4)$
   D_3: if $a > 0$, $(a, b) \rightarrow (0, b)$
   D_4: if $b > 0$, $(a, b) \rightarrow (a, 0)$
   P_{34}: if $a > 0 \,\&\, b < 4$, $(a, b) \rightarrow (\max(a - (4 - b), 0), \min(a + b, 4))$
   P_{43}: if $b > 0 \,\&\, a < 3$, $(a, b) \rightarrow (\min(a + b, 3), \max(b - (3 - a), 0))$

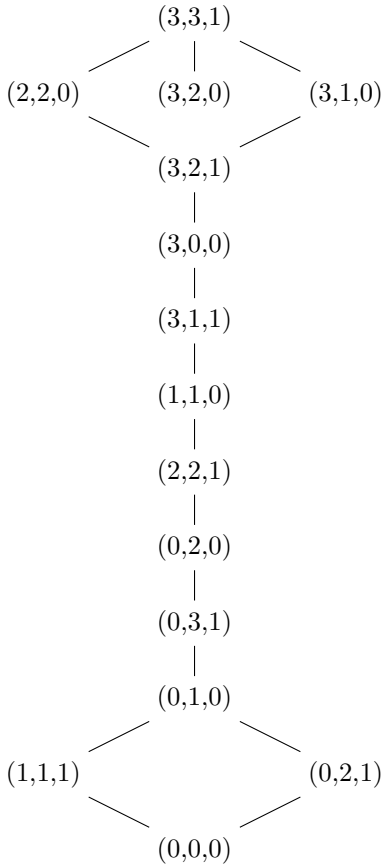
   (b) Graph of all the state space nodes (same state only appear once)

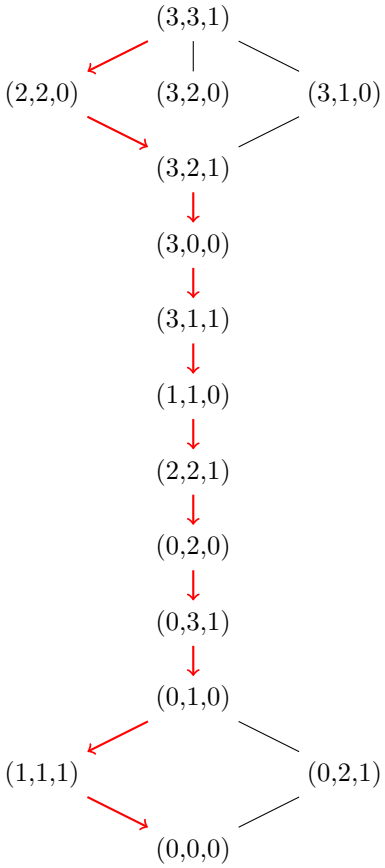


2. (a) • State description: (m, c, f)
   - $m :=$ No. of missionaries on this side;
   - $c :=$ No. of cannibals on other side;
   - $f :=$ flag to show where the boat is locate, 1 := on this side; 0 := on other side.
   • Initial State: $(3, 3, 1)$
   • Goal State: $(0, 0, 0)$
   • Total No. of valid States: $2 \times |\{(3, 2), (3, 1), (3, 0), (2, 2), (1, 1), (0, 1), (0, 2), (0, 3)\}| + |\{(3, 3), (0, 0)\}| = 18$

(b) Operators:
T_{10}: if $f == 1 \,\&\, m > 0$, $(m, c, f) \rightarrow (m-1, c, f-1)$
T_{01}: if $f == 1 \,\&\, c > 0$, $(m, c, f) \rightarrow (m, c-1, f-1)$
T_{20}: if $f == 1 \,\&\, m > 1$, $(m, c, f) \rightarrow (m-2, c, f-1)$
T_{02}: if $f == 1 \,\&\, c > 1$, $(m, c, f) \rightarrow (m, c-2, f-1)$
T_{11}: if $f == 1 \,\&\, m > 0 \,\&\, c > 0$, $(m, c, f) \rightarrow (m-1, c-1, f-1)$
P_{10}: if $f == 0 \,\&\, m < 3$, $(m, c, f) \rightarrow (m+1, c, f+1)$
P_{01}: if $f == 0 \,\&\, c < 3$, $(m, c, f) \rightarrow (m, c+1, f+1)$
P_{20}: if $f == 0 \,\&\, m < 2$, $(m, c, f) \rightarrow (m+2, c, f+1)$
P_{02}: if $f == 0 \,\&\, c < 2$, $(m, c, f) \rightarrow (m, c+2, f+1)$
P_{11}: if $f == 0 \,\&\, m < 3 \,\&\, c < 3$, $(m, c, f) \rightarrow (m+1, c+1, f+1)$

(c) State space graph: (the graph below on the left)





(d) DFS trace leading to a solution: (the graph above on the right)

3. (a) Uniform Cost Search:
S B A F D C H E J L K G

(b) Depth-First Search:
S A D E J G K G L G B F L G M G C H I

(c) (Depth-First) Iterative-Deepening Search:
Iter 0: S
Iter 1: S A B C
Iter 2: S A D E B F C H I
Iter 3: S A D E J K L B F L M C H I
Iter 4: S A D E J G K G L G B F L G M G C H I

4. (a) BFS:
   Minimum No. of nodes (including root node):

$$\sum_{i=0}^{g} b^i - b^g + 1$$

   Maximum No. of nodes (including root node):

$$\sum_{i=0}^{g} b^i$$

   (b) DFS:
   Minimum No. of nodes (including root node):

$$g + 1$$

   Maximum No. of nodes (including root node):

$$\sum_{i=0}^{d} b^i - \sum_{j=0}^{d-g} b^j + 1$$

   (c) DF-IDS:
   Minimum No. of nodes (including root node):

$$\sum_{k=0}^{g-1}(\sum_{i=0}^{k} b^i) - b^g + 1 \quad (if\ g \geqslant 1)$$

$$1 \quad (if\ g = 0)$$

   Maximum No. of nodes (including root node):

$$\sum_{k=0}^{g}(\sum_{i=0}^{k} b^i)$$

5. If hash table is $O(1)$, No. of comparisons is $O(b^d)$.
   If hash table is $O(n)$, No. of comparisons is $O(b^{2d})$.

The end!