Exercise 1

Consider the following search tree, where the initial state corresponds to node A and the only final states correspond to nodes O and S. The path leading to a target node with the lowest total path cost is optimal. Assume that the cost function for moving to a node from its parent is g = 1 for D, H, M, N and g = 3 for all other nodes (except the root). Also, Consider a heuristic function h defined as follows: h = 4 for B, h = 3 for E, F, K, L, h = 2 for A, C, M, N, P, Q, T , h = 1 for D, G, H, I, J and h = 0 for O, R, S. When a node is extended, the child nodes are created in order from left to right. In cases of parity in the priority queue, the node that entered last precedes.

a. Confirm that h is an acceptable heuristic function.

b. Give the node extension sequence for algorithm A *.

c. Accurately record the contents of the priority queue in each step of A*

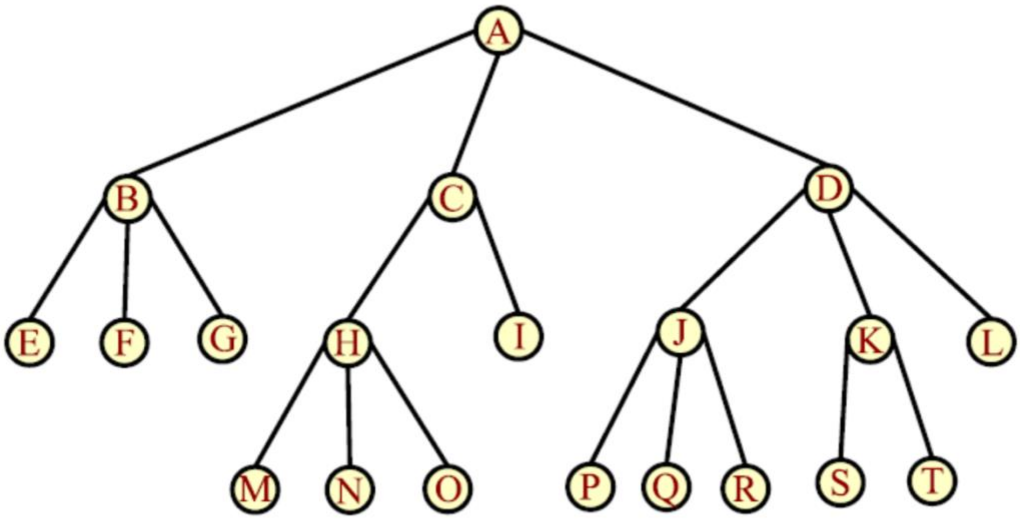
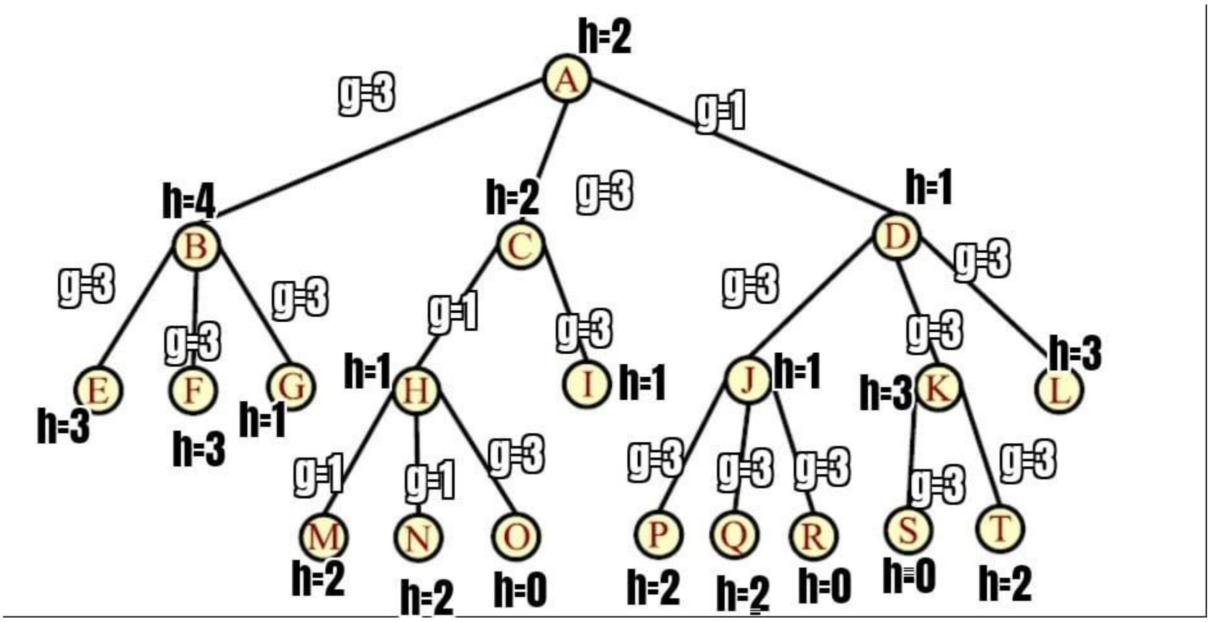


Figure 1

a)



In order for a heuristic function to be admissible, h(x) <= g(x) for every x.

As we can see, the nodes leading to our goals have h<g

- h(A) < g(A) ➔ 2 < 7
- h(C) < g(C) ➔ 2 < 4
- h(H) < g(H) ➔ 1 < 3
- h(D) < g(D) ➔ 1 < 6
- h(K) = g(K) ➔ 3 = 3

b)

1. f(A) = 2 ← ROOT
   1.1. f(D) = 1+1 = 2
   1.2. f(C) = 3 + 2 = 5
      1.2.1. f(H) = 4 + 1 = 5
   1.3. f(J) = 4 + 1 = 5
   1.4. f(B) = 3 + 4 = 7
      1.4.1. f(G) = 6 + 1 = 7
   1.5. f(M) = 5 + 2 = 7
   1.6. f(N) = 5 + 2 = 7
   1.7. f(O) = 7 + 0 = 7 ← GOAL

So the path is A->C->H->O

c)

- {A:2}
- {B:7, C:5, D:2}
- {B:7, C:5, L:7, K:7, J:5}
- {B:7, H:5, I:7, L:7, K:7, J:5}
- {B:7, M:7, N:7, O:7, L:7, K:7, J:5}
- {B:7, M:7, N:7, O:7, L:7, K:7, P:9, Q:9, R:7}
- {E:9, F:9, G:7, M:7, N:7, O:7, L:7, K:7, P:9, Q:9, R:7}
- {E:9, F:9, M:7, N:7, O:7, L:7, K:7, P:9, Q:9, R:7}
- {E:9, F:9, N:7, O:7, L:7, K:7, P:9, Q:9, R:7}
- {E:9, F:9, O:7, L:7, K:7, P:9, Q:9, R:7}

Exercise 2

Suppose the problem of coloring the 5 areas with the limitation that in each square we assign a color different from its neighbors horizontally and vertically (not necessarily diagonally), as shown in Figure 2. The available colors are Red and Blue. We represent the problem as a constraint satisfaction problem with one variable for each region and corresponding binary constraints for the colors. The value fields of the variables are the set {R, B} that corresponds to the two colors.

a. If we assign the value R to variable 1, show the result of the forward checking algorithm (i.e. how the value fields of the variables will end up).

b. If initially each variable has both values in its value field, except for the variable 5 which has only B, then what is the result of the Arc Consistency algorithm?

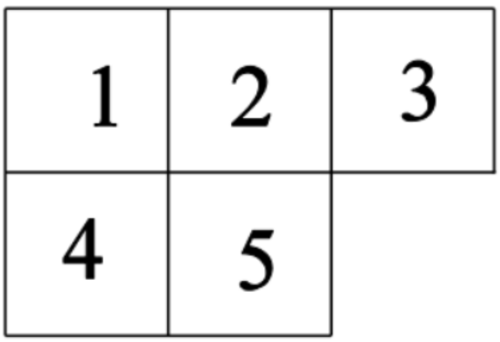


Figure 2

a)

1 = {R}
2 = {B}
3 = {R,B}
4 = {B}
5 = {R,B}

b)

1 = {B}
2 = {R}
3 = {B}
4 = {R}
5 = {B}

Arc Examined	Values Deleted	Field of Values
5 - 2	2(B)	1(R,B) – 2(R,B) – 3(R,B) – 4(R,B) – 5(B)
5 – 4	4(B)	1(R,B) – 2(R) – 3(R,B) – 4(R,B) – 5(B)
2 – 3	3(R)	1(R,B) – 2(B) – 3(R,B) – 4(R) – 5(B)
2 – 1	1(R)	1(R,B) – 2(R) – 3(B) – 4(R) – 5(B)
4 – 1	None	1(B) – 2(R) – 3(B) – 4(R) – 5(B)
5 – 2	None	1(B) – 2(R) – 3(B) – 4(R) – 5(B)
5 – 4	None	1(B) – 2(R) – 3(B) – 4(R) – 5(B)

Exercise 3

Consider the problem of creating crossword puzzles, that is, matching words to a rectangular grid. The grid is provided as part of the problem and defines which squares are empty and which are shaded. A list of allowed words (dictionary) is also provided. The goal is to fill in all the blanks using a subset of words in the list, so that each (maximum) row of consecutive squares (horizontal or vertical) contains exactly one word in the dictionary (repetitions are allowed). Formulate the problem of constructing crossword puzzles as a problem of constraint satisfaction. Describe the variables, value ranges, and constraints of the problem. Give a possible solution to a 3x3 grid, where only the middle square is shaded, which satisfies your description and contains words from the word list {AND, ART, TOP, DIP, END, POT, DOE, PIT, PAT}.

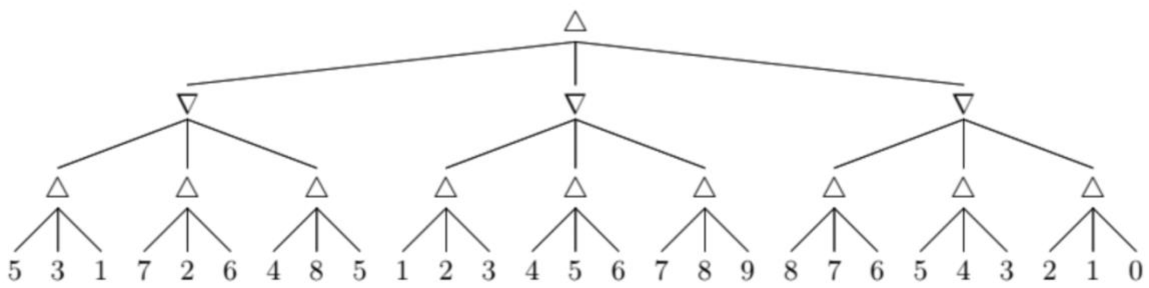
ANSWER

The variables are the empty clusters where we can put a word. The value range of those clusters are the words included in our dictionary. The constraints we have are that in case that some squares of those clusters overlap with another clusters, the words we can use should have common letters in those squares. Also the word should have exactly the length of the corresponding cluster.

P	**A**	**T**
I		**O**
T	**O**	**P**

Exercise 4

Arrange the following tree of a game and assume that the MAX player uses MINIMAX search with a-b pruning and the extension sequence is from left to right.



a. Enter the value of the game at the root and note the move that MAX will choose.

b. Mark on the tree all the branches that will be pruned during the search.

c. Is there a better root extension (MAX) order to prune more nodes?

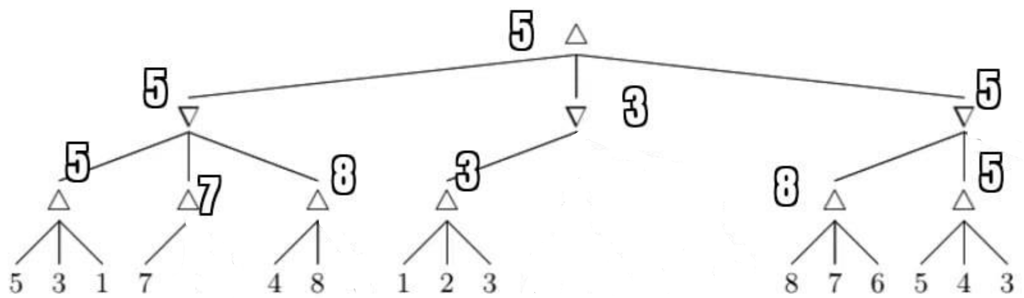
d. If we knew that the MIN chooses equally random moves, what would be the MAX's best move?

a)

MAX will choose to move to the left child and will take a value of 5, since it has to choose between 3 children with values from left to right 5,3,2.

b)

The tree after the pruning will be:



c)

There is no other way because we found very fast the value of MAX, and we pruned according to that. If the root extension was from right to left we would found this value last.

d)

For the left child: 5 * 1/3 + 7 * 1/3 + 8 * 1/3 = 20/3
For the middle child: 3 * 1/3 + 6 * 1/3 + 9 * 1/3 = 18/3
For the right child: 8 * 1/3 + 5 * 1/3 + 2 * 1/3 = 15/3

So MAX would still choose the left child