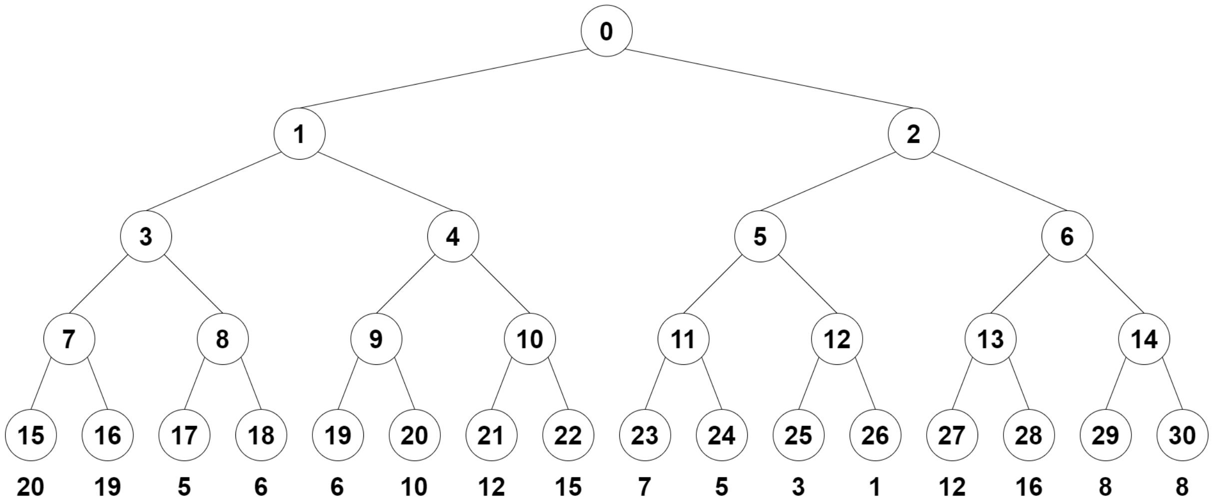
1 Adversarial Search



Consider an adversarial game with **two** players acting independently and the winner is unique. Suppose we have an AI agent using the min-max algorithm to play this game and it has produced a search tree shown in the figure above. In this search tree,

- the first level (node 0) is the **maximizing** level;
- the second level (node 1 and 2) is the ***minimizing*** level;
- the third level (node 3, 4, 5, and 6) is the **maximizing** level;
- the fourth level (node 7 to 14) is the ***minimizing*** level;
- the fifth level (node 15 to 30) is the leaf level and the number beneath each node is the static evaluator score of the corresponding game state.

Your tasks are the following:

1. Apply the min-max algorithm without pruning. Show the returned value for each non-leaf node (node 0 to 14).

node	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
value															

2. Indicate the optimal path as a linked list of nodes (e.g., 0 - 1 - 3 - 7 - 15) the agent will choose.
3. Apply the min-max algorithm with alpha-beta pruning. List all of the nodes in ascending order that will be pruned.

2 Constraint Satisfaction Problem

A degree program has the following nine courses: $C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8$ and C_9. These courses fall into the following area of knowledge: A student is required to complete at least one course from each of the areas to obtain the

Area	Courses
1	C_1, C_2, C_3, C_4, C_6
2	C_3, C_4, C_5
3	C_6, C_7, C_8
4	C_3, C_9

degree. Further, there are five restriction on choosing the courses:

1. For A_1 only, the courses must be taken in pair specified as follows: (C_1, C_2), (C_1, C_3), and (C_4, C_6).
2. A student can only choose one from C_3, C_4, C_9.
3. A student can only choose one between C_1 and C_7.
4. A student can only choose one between C_6 and C_8.
5. A course can only be used to count in one area and can only be taken at most once. For example, if a student takes C_3 for A_1, then they cannot use it or retake it for A_2 or A_4.

Please answer the following questions.

1. Model the situation as a CSP. Specifically,
   - define variables (hint: use the area of knowledge requirements),
   - list their domains, and
   - list the constraints (just for convention, use $R_1, R_2, \ldots$ to denote them).
2. Use DFS with backtracking to find a solution to complete the degree while obeying all of the restrictions. When exploring, select variable/value based on the index order (e.g., C_i goes before C_{i+1}). If backtracking occurs, specify the constraint that is violated. Please show your work in a figure.
3. Suppose a student has already taken C_8 for area 3 and C_9 for area 4, what courses should they take for the remaining areas in order to obtain the degree?