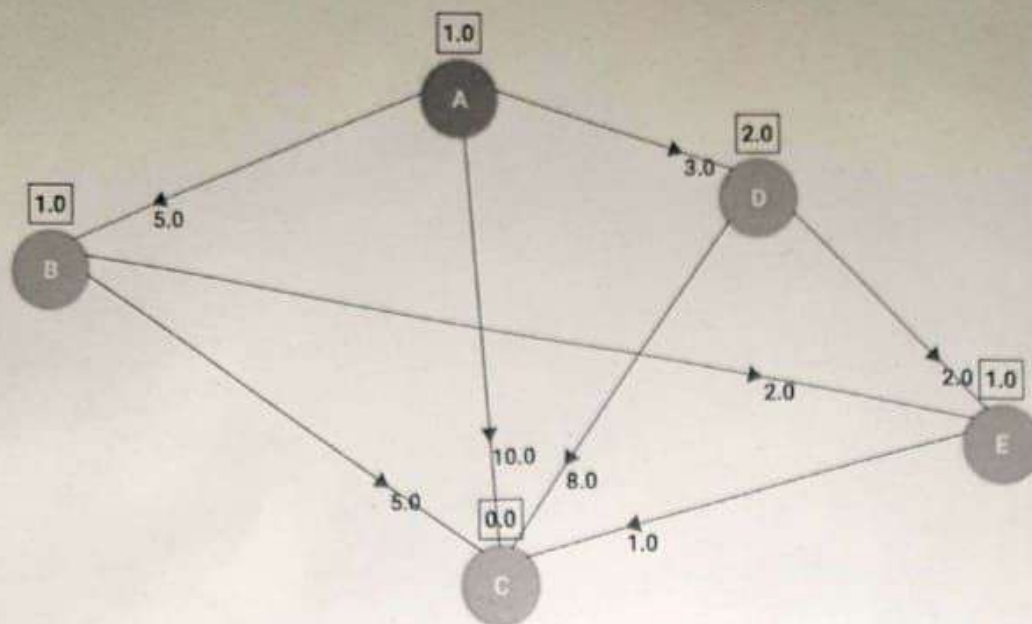


Consider the following graph, where A is the initial node and C the goal node, and the number associated with the arcs is the cost of the operator to go from the starting node to the arrival node of the arc. Next to each node, in a square, the heuristic estimate of its distance from the goal node is also indicated.



- a) Apply the depth-first search, and draw the developed search tree indicating for each node n the cost $g(n)$ and the expansion order; in case of non-determinism, choose the nodes to be expanded according to the alphabetical order.
- b) Apply the A* search, and draw the developed search tree indicating for each node n the function $f(n)$ and the expansion order. In the case of non-determinism, choose the nodes to be expanded according to the alphabetical order. Consider as heuristic $h(n)$ the one indicated in the square next to each node in the figure, that is:

$h(A) = 1$

$h(B) = 1$

$h(D) = 2$

$h(E) = 1$

$h(C) = 0$

Is the heuristic h defined in this way admissible?

What advantage is obtained by applying A*, compared to the outcome of the depth-first search?

Exercise 4

Consider the problem of moving an object initially on the table to room1 by using a robot. We have the following actions available:

Loading an object

load (X, Pos)

PREC: at (robot, Pos), at (X, Pos), robotfree

EFFECT: in (robot, X), \neg robotfree

Moving an object

carry (X, Pos1, Pos2)

PREC: at (robot, Pos1), in (robot, X)

EFFECT: at (robot, Pos2), \neg at (robot, Pos1)

Unloading an object

deliver (X, Pos)

PREC: at (robot, Pos), in (robot, X)

EFFECT: at (X, Pos), \neg in (robot, X)

Initial state: at (robot, table), in (robot, ogg)

Goal state: at (ogg, room1)

Show how the STRIPS algorithm finds a solution (only one successful path in the search tree should be shown).

Exercise 5

- 1) Model the action **load** (preconditions, effects and frame axioms), the initial state and the goal of the exercise 4 using the Kowalsky formulation
- 2) Show two levels of graph plan when applied to exercise 4.
- 3) What is hierarchical planning and explain the method presented during the course.
- 4) What is Particle Swarm Optimization and which are its main features?
- 5) What are non-informed search strategies? Describe the strategies that have been presented during the course.