

# Artificial Intelligence

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## PART I – Search and Planning

October 28th, 2019

First Name and Last name

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The results of the exams of all the students will be posted in a single file in the Moodle web page. Each student will be identified only by his/her 'Matricola' code (Sapienza registration number). If you do not agree on having your grade listed in this file, please check this box:

NO-WEB [ ☐ ]

Maximum time is 75 minutes. You can use neither the text books nor your notes.

Students enrolled in the academic year 2019/20 in the Master Degree in Artificial Intelligence and Robotics, please check this box: [ ☐ ].

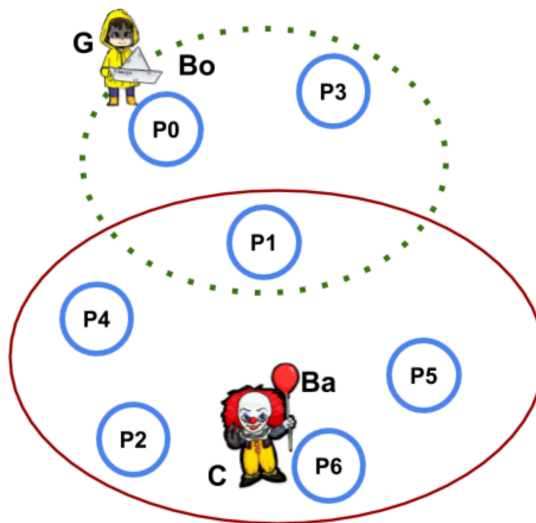
Students enrolled in the academic year 2018/19, 2017/18, 2016/17 in the Master Degree in Artificial Intelligence and Robotics, please specify year of enrolment:

Students enrolled in academic year 2019/20 in the Master Degree Engineering in Computer Science and any other curricula that include a 6 ECTS course in Artificial Intelligence, please check this box: [ ☐ ]

Students enrolled in academic year 2018/19 or earlier in the Master Degree Engineering in Computer Science and any other curricula that include a 6 ECTS course in Artificial Intelligence, please specify year of enrolment:

**Exercise 1 (8 points)**

*Group A.* A clown  $C$  and Georgie  $G$  are tired of playing with their toys and they want to exchange them.  $G$  wants to play with the balloon  $Ba$  while,  $C$  wants to play with the boat  $Bo$ . Unfortunately, they are both very shy and they never want to be at the same place  $P_i$ . Hence, they have to find a common place (for example  $P1$ ) where to drop and collect objects (they can drop an object in a place and move into another place).  $G$  and  $C$  cannot hold two objects at the same time. The environment is depicted in the figure,  $G$  can only move in places within the dotted line; while  $C$  can only move within the continuous line. Places within the same set are all connected (i.e.  $\{P0, P1, P3\}$  for the dotted set and  $\{P1, P2, P4, P5, P6\}$  for the other). The figure shows the initial state where  $G$  holds  $Bo$  and he is at  $P0$ , and  $C$  holds  $Ba$  and he is at  $P6$ . The goal state is represented by  $G$  at  $P3$  holding  $Ba$  and  $C$  at  $P5$  holding  $Bo$ .



- Define the problem and the domain file in PDDL
- Show one possible sequence of actions to a goal state including all the states in the sequence
- Draw the first 3 steps of the tree generated by forward search assuming a perfect heuristic (a heuristic choosing the move in the plan given above). Show all the actions applicable at each of the traversed states, and the state reached.

**Exercise 2 (4 points)**

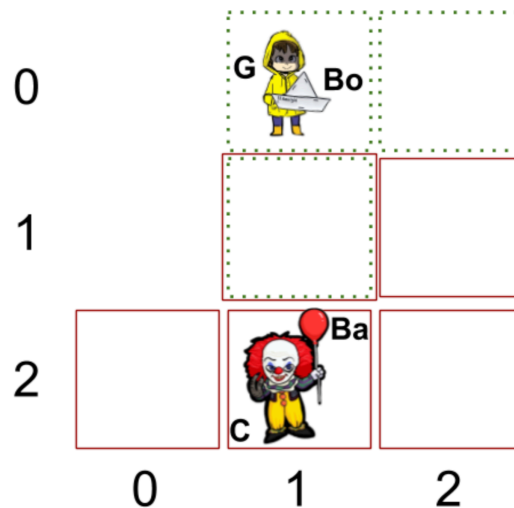
Describe the notion of HLA in HTN and provide examples, considering also the given problem.

**Exercise 3 (4 points)**

Discuss the approach to define heuristics for Heuristic search and provide examples, considering also the problem given.

**Exercise 1 (8 points)**

*Group B.* A clown  $C$  and Georgie  $G$  are tired of playing with their toys and they want to exchange them.  $G$  wants to play with the balloon  $Ba$  while,  $C$  wants to play with the boat  $Bo$ . They are both very friendly and they want to be at the same cell  $C_{ij}$  for exchanging them. Hence, they have to find a common place (for example Cell  $\langle 1, 1 \rangle$ ), where to drop and collect objects.  $G$  and  $C$  cannot hold two objects at the same time. Moreover, they cannot drop and collect objects, if they are not in the same cell simultaneously. The environment is depicted in the figure,  $G$  can only move within dotted cells; while  $C$  can only move within continuous perimeter cells. Cells of the same kind (i.e.  $\{C01, C11, C02\}$  for the dotted set and  $\{C11, C12, C20, C21, C22\}$  for the other) are connected only horizontally and vertically, in fact agents cannot move diagonally. The figure shows the initial state, where  $G$  holds  $Bo$  and he is at  $C01$ , and  $C$  holds  $Ba$  and he is at  $C21$ . The goal state is represented by  $G$  at  $C02$  holding  $Ba$  and  $C$  at  $C22$  holding  $Bo$ .



- Define the problem and the domain file in PDDL
- Show one possible sequence of actions to a goal state including all the states in the sequence
- Draw the first 3 steps of the tree generated by forward search assuming a perfect heuristic (a heuristic choosing the move in the plan given above). Show all the actions applicable at each of the traversed states, and the state reached.

**Exercise 2 (4 points)**

Describe the notion of *promotion* and *demotion* in the context of POP and provide examples, considering also the given problem.

**Exercise 3 (4 points)**

Discuss the properties and the limitations of  $A^*$ . Give a possible heuristic for the given problem.