UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

Department of Computing

B. Sc. Examination 2018

IS53024B
Artificial Intelligence

Duration: 2 hours 15 minutes

Date and time:

This paper is in two parts: part A and part B. You should answer ALL questions from part A and TWO questions from part B. Part A carries 40 marks, and each question from part B carries 30 marks. The marks for each part of a question are indicated at the end of the part in [.] *brackets.*

There are 100 marks available on this paper.

No calculators should be used.

THIS PAPER MUST NOT BE REMOVED FROM THE EXAMINATION ROOM

Part A

Question 1

(a) Define *rational agent*. [6]

(b) Suppose that a room thermostat turns the heating on if the room is too cold, and otherwise turns the heating off. Argue that the thermostat is a rational agent. [6]

(c) Write an agent function for the thermostat in part (b) above. [8]

Question 2

(a) Consider the following facts and rules for rule-based system inference:

```
(FACT 1 ( E ))
(FACT 2 ( F ))
(FACT 3 ( C ))
(FACT 4 ( H ))
(RULE 1 (IF (( A ) and ( C ) and ( E )) (THEN ( D )))
(RULE 2 (IF (( H )) (THEN ( A )))
(RULE 3 (IF (( D ) and ( F )) (THEN ( B )))
```

Prove that the goal (B) is true and give the sequences of backward rule firings using the rules and facts in the order in which they are given. [15]

(b) Explain briefly what is the relationship between the sequences of firing the rules during forward chaining and backward chaining in for rule-based system inference. [5]

Part B

Question 3

(a) Write, in pseudocode, a *Simple Tree Search* algorithm. Your answer should not specify how a node is chosen for expansion. [7]

(b) Modify your answer to (a) so that the pseudocode implements *depth-first search*. [7]

(c) Compare depth-limited search to depth-first search. [8]

(d) *Iterative deepening search* launches a series of depth-limited searches of increasing limit and terminates when the goal is found. Explain how iterative-deepening avoids the disadvantages of depth-limited search. [8]

Question 4

(a) Explain briefly the forward chaining algorithm for rule-based production systems. [6]

(b) Explain briefly the backward chaining algorithm for rule-based production systems. [6]

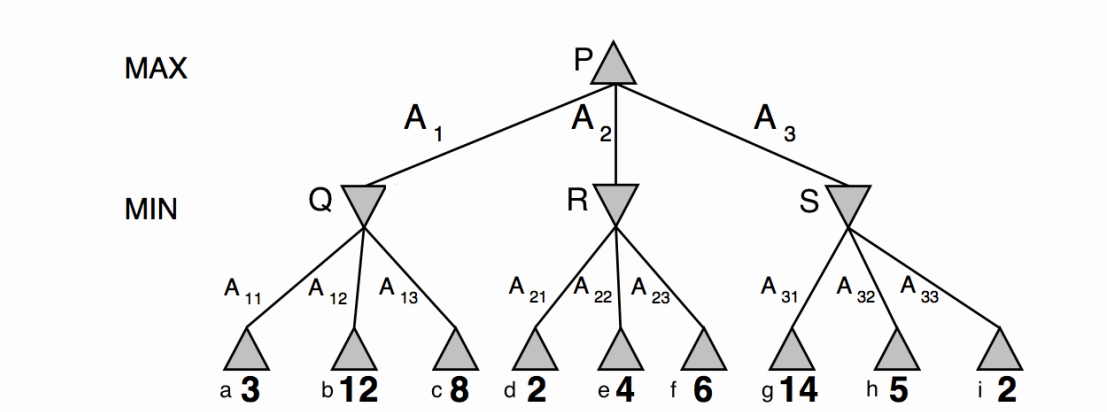
(c) Demonstrate the operation of the forward chaining algorithm for rule-based systems using the following first-order rules and facts:

```
(RULE 1  (IF   (Dog ?x)
         (THEN (Animal ?x)))

(RULE 2  (IF   (AnimalLover ?x) (Animal ?y))
     (THEN (Feeds ?x ?y)))

(RULE 3  (IF   (Dog ?x) (Owns ?y ?x))
         (THEN (AnimalLover ?y)))

(FACT 1 (Dog Dany)
(FACT 2 (Owns Jack Dany)
```

Give the variable bindings at each step of the forward chaining algorithm. Use the rules and facts in the given order. [18]

Question 5

(a) The diagram below shows a game tree for a 2 ply game. Use the *minimax* algorithm to calculate the utilities at nodes P, Q, R and S. [7]



(b) Assume the terminal nodes are evaluated from left to right, i.e. a, then b, then c etc. Can any of the terminal nodes be pruned? Explain your answer. [8]

(c) Let a concept description language with 3 attributes be given for symbolic machine learning. Assume that these attributes take the following values:

```
  a1            a2          a3
 ----       ---------      -----
|    |     |    |    |    |     |
b    g     c    d    e    a     f
```

Interpret the behaviour of the candidate elimination algorithm using the following positive and negative training examples:

```
1. ( b d a ) +)
2. ( g e f ) -)
3. ( b c a ) +)
```

- Illustrate the changes of the boundary sets after the first example. [5]
- Illustrate the changes of the boundary sets after the second example. [5]
- Illustrate the changes of the boundary sets after the third example. [5]