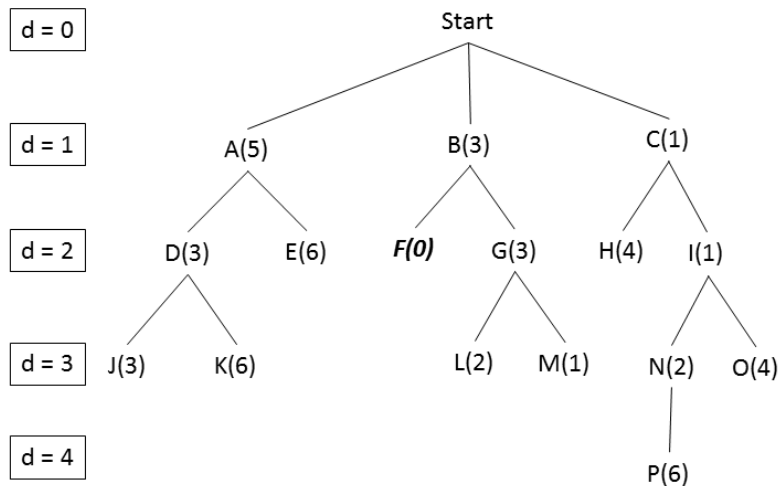


1. a) The following diagram shows a search tree with four **depth** levels, from depth $d = 0$ to 4. The nodes are labelled alphabetically from A to P and the number in brackets is the output of an evaluation function rating the cost for choosing that node: LOWER ratings mean the node is a BETTER choice for visiting next. The goal state is F, which is shown in bold italics, and has a zero cost.



- i) Show the nodes visited by **breadth-first** search, including the **open** and **closed** queues at each step. (5 marks)
- ii) Show the nodes visited by **depth-first** search, including the **open** and **closed** queues at each step. (5 marks)
- iii) Show the nodes visited by **best-first** search, including the **open** and **closed** queues at each step. (5 marks)
- iv) Show the nodes visited by **A*** search, including the **open** and **closed** queues at each step. Use the depth, d , as the additional input for the A* evaluation function because it measures the distance of a state from the start. (5 marks)
- v) Explain why A* search will always produce an optimal (i.e. the most efficient) path but this is not true for best-first search. (5 marks)

2. Assume that the following statements are used by a financial advisor and you wish to build a rule-based expert system based on them:

Rule 1: If the client has ADEQUATE SAVINGS and HIGH INCOME then they should INVEST in the stock market.

Rule 2: If the client does NOT have ADEQUATE SAVINGS then they should INCREASE SAVINGS.

Rule 3: If the client has SAVINGS and their DEPENDANTS ARE WELL SUPPORTED then the client has ADEQUATE SAVINGS.

Known facts: The client has HIGH INCOME, has SAVINGS, and the client's DEPENDANTS ARE WELL SUPPORTED.

- a) Explain what each of the following terms mean for a rule: **triggered**, **fired**, **true**, and **false**. (4 marks)
- b) Show how the rule-based system will advise a person to invest in the stock market using **forward chaining** (also known as **forward reasoning**). For each step of the process, your answer should show the contents of the **working memory**, the **conflict resolution** set, and the rule that is **fired**. (6 marks)
- c) Show how **backward chaining** (also known as **backward reasoning**) can prove that the advice to invest in the stock market is correct. For each step of the process, your answer should show the proof list and choices between rules, if any. (6 marks)

(question continues on next page...)

(Question 2 continued. . .)

- d) How do backward chaining and forward chaining provide rule-based expert systems with a natural way of explaining advice? (5 marks)
- e) Convert Rule 1 of the rule list at the beginning of this question (on the previous page) into a suitable **Lisp list** representation that has two members, the rule conclusion first and then an **association** list of the rule conditions and their values. (4 marks)
- f) Write a Lisp function called `get-conditions` that takes a rule as a parameter and returns the list of conditions, where the rule has the list structure you gave for Part (e) above. (4 marks)
- g) Write a suitable Lisp list representation for the known facts given after Rule 3 of the rule list on the previous page. (3 marks)
- h) Write the Lisp code for a function called `condition-true` that takes a single rule condition as a parameter and returns the condition if it is in the known facts with the same value (i.e. the animal is known to have the property or known not to have it). If the condition does not match the facts, then the function should return `nil`. Your function should assume the same list structures for rules and facts you defined earlier in this question. (6 marks)
- i) In the laboratory classes, you created a hierarchical knowledge base for a program that advises on choosing a house. Hierarchical knowledge was also used in the GRiST and ADVANCE intelligent knowledge-base systems (IKBSs). Explain how a Lisp program would need different types of functions for hierarchical knowledge-based systems compared to rule-based systems. Answers will gain marks if illustrated by example Lisp functions. (7 marks)

3. a) Define the terms **stigmergy** and **pheromone** in the context of **swarm intelligence**. (4 marks)
- b) Explain how pheromones help ants find the shortest paths between their nest and a food source. (5 marks)
- c) Explain how **Ant Colony Optimisation** can be used to find clusters in data. Your answer does not need to define stigmergy and pheromones again but should focus on how the individual behaviour of ants leads to the overall population providing information about how data objects are clustered into groups. (5 marks)
- d) The GRiST mental-health risk and safety decision support system (DSS) differs from swarm intelligence by being based on human classification expertise.
- i) Give TWO reasons why a particular problem domain would be suitable for a DSS based on human classification expertise. (4 marks)
- ii) Give TWO reasons why a particular problem domain would be suitable for a DSS based on swarm intelligence such as ant colony optimisation. (4 marks)
- iii) Explain how mind maps can play a useful role in creating a DSS based on human expertise. You may find it helpful to illustrate your answer using the GRiST or ADVANCE research projects. (8 marks)

END OF EXAMINATION PAPER