UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

BSc Examination 2008

COMPUTING & INFORMATION SYSTEMS

IS53024A (CIS341)
Artificial Intelligence

Duration: 2 hours and 15 minutes

Date and Time:

You should answer three questions in this paper. There are five questions in total. All questions are worth 25 marks. The marks for each part of a question are indicated at the end of the part in [.] brackets.

No calculators should be used.

THIS PAPER MUST NOT BE REMOVED FROM THE EXAMINATION ROOM

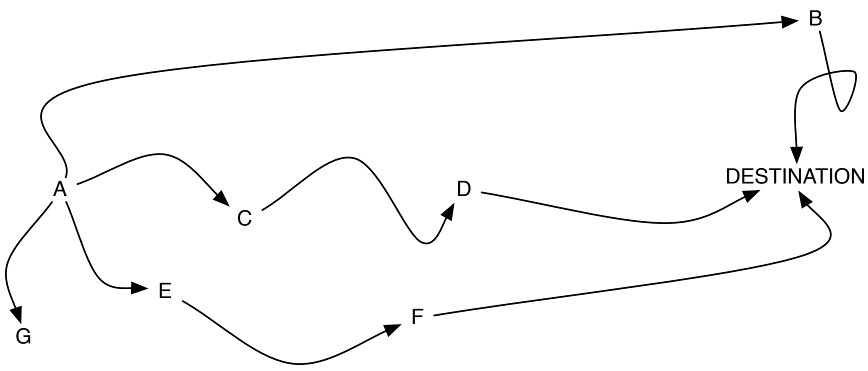

Figure 1: A Map of routes and locations (not to scale)

1. **This question is about search**

(a) What is the difference between informed and uninformed search? [2]

(b) Explain the functions $g(n)$, $h(n)$ and $f(n)$ in the context of informed search. [3]

(c) Describe greedy search and A* search. [4]

(d) Is greedy search optimal? What must be true of $h(n)$ for A* to be optimal? [2]

Consider the map in Figure 1.

The distances along the roads are given in the following table.

From	To	distance
A	B	360
B	Destination	120
A	C	180
C	D	130
D	Destination	70
A	E	100
E	F	140
F	Destination	220
A	G	60

We are also provided with a table of the distance of all towns to the destination, as the crow flies. This will always underestimate the actual distance using roads.

From	To	distance
A	Destination	400
B	Destination	80
C	Destination	240
D	Destination	120
E	Destination	340
F	Destination	200
G	Destination	440

(e) Calculate $h(n)$ and $g(n)$ for each of the nodes A, B, C, D, E, F and G. [4]

(f) Describe what happens when greedy search is used. [4]

(g) Describe what happens when A* search is used. [4]

(h) Suppose you ran greedy search with $g(n) = -h(n)$. Describe how this would operate. [2]

2. **This question is about designing agents and agent communication**

   (a) Outline with examples the advantages and disadvantages of reactive, deliberative and hybrid agent architectures. [9]

   (b) Explain what is meant by an agent communication language and what is meant by the semantics of a language. [3]

   (c) Describe the FIPA initiative. [3]

   (d) With reference to your own examples of human communication, and with reference to FIPA, discuss some of the difficulties of trying to define the semantics of an agent communication language. [10]

3. **This question is about logical agents**

(a) Explain what is a knowledge base and what is an inference engine. [4]

(b) Outline the limitations of propositional logic to build a logical agent. [2]

(c) Consider an example of the wumpus world as shown in the table below.

			PIT
PIT	PIT	GOLD	
Agent			wumpus

It has a wumpus at square (4,1) and pits at (1,3) and (2,3) and (4,4) and there is gold at (3,3). (The bottom left square is labelled (1,1), the square to its right is labelled (2,1) and so on.) The rules of the environment are as follows.

- EnvRule 1: *Squares adjacent to pits are breezy.*
- EndRule 2: *Squares adjacent to the wumpus, and the squares containing the wumpus have a stench.*

Copy and complete the picture and include information about where an agent could sense a breeze or a stench. Note each such square with a B to represent there is a breeze, and an S to represent a stench. [2]

(d) State, with explanation, whether the following properties are true of the Wumpus World. [5]

i. Fully Observable.
ii. Deterministic.
iii. Episodic.
iv. Static
v. Discrete.

(e) Assume that the agent's knowledge base includes the following inference rules. [3]

- (A1) If there is no stench at (1,1) then it implies that there is no wumpus at (1,1) and no wumpus at (1,2) and no wumpus at (2,1)
- (A2) If there is no stench at (2,1) then it implies that there is no wumpus at (1,1) and no wumpus at (2,1) and no wumpus at (2,2) and no wumpus at (3,1)
- (A3) If there is a stench at (3,1) then it implies that there is a wumpus at (2,1) or a wumpus at (3,1) or a wumpus at (3,2) or a wumpus at (4,1)

Using propositions of the form $W_{(i,j)}$ and $\neg W_{(i,j)}$ which assert that there is a wumpus at (i,j) and no wumpus at (i,j), respectively, write these three rules using first order propositional logic.

(f) An agent can perceive a breeze and/or a stench if it is in a square where these events are happening. This perception is simply in the form of a tuple. For example, the tuple (yes,no) would state that the agent could sense a breeze and no stench. Assume it is known to the agent that it is in a 4x4 grid, that there is only 1 wumpus, that the agent starts from (1,1). (Please note that adjacent does not include diagonals and that an agent can only move into adjacent squares.)

Suppose the agent moves from (1,1) to (2,1) to (2,2) to (2,1) to (3,1). Record the perceptions that the agent would have in its knowledge base. [3]

(g) Prove, using the knowledge base and the seven rules of logical inference given below, that the agent can infer that there is a wumpus is at (4,1). [6]

The seven inference rules for propositional logic

- Rule1 (MP)

$$\frac{\alpha \Rightarrow \beta, \qquad \alpha}{\beta}$$

- Rule2 (AE)

$$\frac{\alpha_1 \wedge \alpha_2 \wedge \ldots \wedge \alpha_n}{\alpha_i}$$

- Rule3 (AI)

$$\frac{\alpha_1, \alpha_2, \ldots \alpha_n}{\alpha_1 \wedge \alpha_2 \wedge \ldots \wedge \alpha_n}$$

- Rule4 (OI)

$$\frac{\alpha_i}{\alpha_1 \vee \alpha_2 \vee \ldots \alpha_i \ldots \vee \alpha_n}$$

- Rule5 (DNE)

$$\frac{\neg \neg \alpha}{\alpha}$$

- Rule6 (UR)

$$\frac{\alpha \vee \beta, \qquad \neg \beta}{\alpha}$$

- Rule7 (R)

$$\frac{\alpha \vee \beta, \qquad \neg \beta \vee \gamma}{\alpha \vee \gamma}$$

4. **This question is concerned with negotiation in task-oriented domains.**

Consider the following scenario. Agent Ag_1 has been assigned the tasks $\{t_1, t_2\}$ and agent Ag_2 has been assigned the tasks $\{t_3, t_4\}$.

The costs to agent Ag_1 are as follows.

$$c_1(t_1) = 20$$
$$c_1(t_2) = 10$$
$$c_1(t_3) = 3$$
$$c_1(t_4) = 0$$

The costs to agent Ag_2 are as follows

$$c_2(t_1) = 8$$
$$c_2(t_2) = 10$$
$$c_2(t_3) = 2$$
$$c_2(t_4) = 24$$

The agents might be better off if they decide to negotiate and swap their tasks and make a *deal*. The only proviso is that in any deal they must still complete 2 tasks. The agents agree to use the *monotonic concession protocol* for negotiation.

(a) Describe the *monotonic concession protocol* for negotiation. [2]

(b) Describe what is meant by the utility of a deal, what the conflict deal is, and what an individually rational deal is. [3]

(c) Describe what is meant by the risk of an agent pulling out of a deal. Write down a mathematical formula which defines the risk. [4]

(d) Describe the Zeuthen strategy. [3]

(e) Show what will happen when agents Ag_1 and Ag_2 both use the Zeuthen strategy and the monotonic concession protocol. What is the final utility to both agents in the resulting deal? [4]

(f) Consider the following scenario.

Agent Ag_1 has been assigned the tasks $\{t_1, t_2, t_3\}$ and agent Ag_2 has been assigned the tasks $\{t_4, t_5, t_6\}$.

The costs to agent Ag_1 are as follows.

$$c_1(t_1) = 5$$
$$c_1(t_2) = 7$$
$$c_1(t_3) = 3$$
$$c_1(t_4) = 4$$
$$c_1(t_5) = 2$$
$$c_1(t_6) = 1$$

The costs to agent Ag_2 are as follows

$c_2(t_1) = 1$
$c_2(t_2) = 2$
$c_2(t_3) = 3$
$c_2(t_4) = 7$
$c_2(t_5) = 5$
$c_1(t_6) = 8$

Sketch what would happen if the same strategy was repeated and write down the final deal. (Note, that agents must always offer a deal where there are 3 tasks.) [5]

(g) Would the Zeuthen strategy still provide an optimal solution if agents could offer an arbitrary (rather than fixed) numbers of tasks? What would be the advantages and disadvantages of this approach? [4]

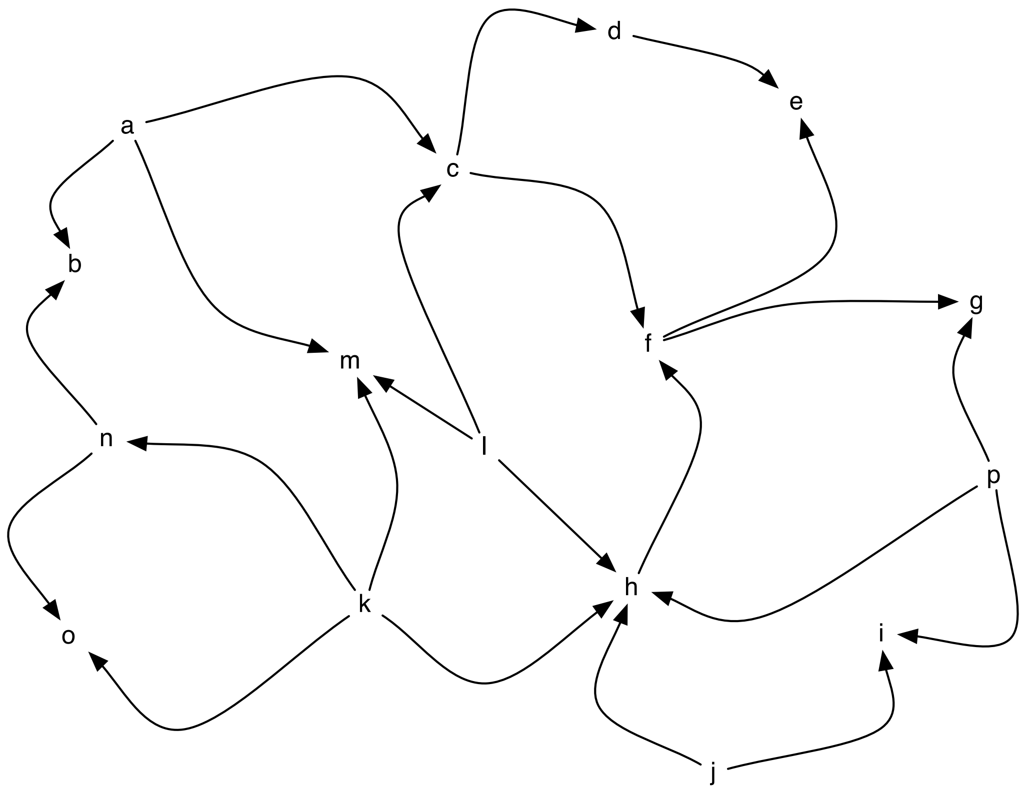

Figure 2: An abstract argument system

5. **This question is about Agents and Argumentation Systems**

(a) This part is about agents

i. Provide a characterisation of an agent and why it is distinct from more traditional approaches to building software. [5]

ii. What trends in technology and human computer interaction suggest an agent approach is appropriate to designing software? [5]

(b) This part is about argumentation

Define what it means when we talk about

i. one argument *attacking* another; [1]

ii. an *acceptable* argument. [1]

iii. Explain the status of the following arguments in Figure 2, justifying your answer in each case: [13]

- a
- b

- c
- d
- e
- f
- g
- h
- i
- j
- k
- l
- m
- n
- o
- p