UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2003

BEng Honours Degree in Computing Part III
MEng Honours Degree in Information Systems Engineering Part IV
MEng Honours Degrees in Computing Part IV
MSc in Advanced Computing
PhD
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute

PAPER C474=I4.8

MULTI-AGENT SYSTEMS

Tuesday 13 May 2003, 14:00
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators not required

1a Briefly explain Russell and Norvig's P.A.G.E. characterisation of an agent.

b Let S be the set of all environment states, P the set of percepts of the state of the environment available to an agent, and A the set of the actions it can perform on the environment:

i) Suppose the response of the environment to an action performed by the agent is characterised by a relation:
env: AxSxS
i.e. env(a,s,s') holds if s' is a possible next state of the environment given that the agent performs action a in state s.

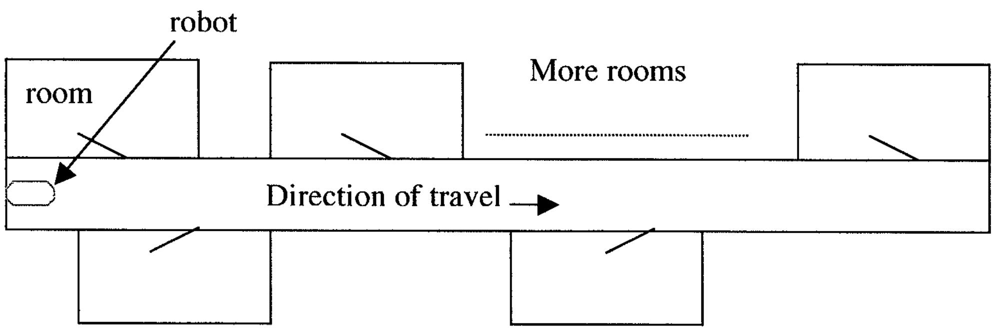
Assume that an agent has a function:
see: S -> P
that maps any state of the environment to an element of P, and an action function:
action: PxP -> A
that maps two percept values into an action.

Define an interaction history for the agent assuming that all but its first action are determined by its current and immediately preceding perceptions of the environment. The first action is computed using just the first perception.

ii) Give an alternative functional characterisations of the agent described in part i) as an hysteretic in which the action is determined by the current perception and the value held in some internal memory M. Say what set of values must be stored in M.

iii) Give code for the initialisation and the subsequent execution cycle of the agent as characterised in part ii).

c A security robotic agent has to move down a corridor on the left and right of which there are a series of rooms with doors off the corridor as depicted in the following picture. Doors are never opposite one another. The robot does not know how many rooms there are. It always starts at the left end of the corridor. Its task is to move down the corridor in the direction indicated by the arrow



looking for unlocked doors. When it finds an unlocked door it opens the door to see if anyone is in the room. If it there is someone in the room, it leaves the room and continues down the corridor. If there is no one in the room, it leaves but locks the door before continuing. It stops when it comes to the end of the corridor.

Assume that the agent has the following set of perceptual capabilities:

wall_front	there is (or not) a wall immediately in front of it
unlocked_door(left)	there is (or not) an unlocked door immediately on its left
unlocked_door(right)	there is (or not) an unlocked door immediately on its right
person-in-room	there is (or not) a person in a room

And the following action repertoire:

move-forward	move a short distance down the corridor
open	open an unlocked door
move-into-room	move through an unlocked door
lock	close and lock an unlocked door
move-out-of-room	move out of a room into the corridor, still facing the opposite wall
turn(left)	turn to left 90 degrees
turn(right)	turn to right 90 degrees
stop	stop wherever it is

You can assume that its actions always succeed. The agent also has three internal states: in_corridor, in_room_on(left), in_room_on(right). The last two enable it to remember whether it has entered a room on the left or on the right of the cirridor. Define the required behaviour of this agent by:

either defining a suitable response function which, for each internal state, and each possible set of percept values for that state, returns the next internal state and the required action,
or by drawing a finite state machine for the agent.

Indicate a negative value for a percept test, such as door-left, by not(door-left). An action response can be a sequence of up to three actions.

The three parts of this question carry respectively 10%, 40%, and 50% of the marks.

2a AGENT0 implements a simple model of a communicating agent that can be asked to commit to do things on behalf of other agents.

i) What are the types of action can such an agent be requested to do?

ii) What type of messages can it be sent? Briefly explain how it responds to each type of message.

iii) Sometimes a AGENT0 agent drops a commitment. When and why does it do this?

iv) How is time measured by an AGENT0 agent?

b BDI agents are practical reasoning agents that exhibit both reactive and goal orientated behaviour.

i) What are the main dynamic components of a BDI agent? How do they change?

ii) Describe how plans are represented in such an agent. Give an example of a plan to achieve a goal.

iii) How does a BDI agent respond to a new goal? Explain any difference between the response to an internally generated goal and an externally given goal?

iv) In what way are BDI agents reactive?

The two parts of this question carry equal marks.

3a Suggest four mental state modalities that might be used to give a semantics to an agent communication language. Using them, give mental state preconditions, *for the sender* S *only*, which characterize when it is suitable for S to send the following KQML messages to a receiver R:

i) *ask-one*

ii) *tell*

b Briefly explain, the role of the KQML facilitator related performatives:

i) *advertise*

ii) *recommend-one*

iii) *recruit-all*

iv) *broker-all*

You do *not* need to give examples.

c i) Describe the general structure of a KQML message. Suggest a representation of KQML messages in Prolog.

Using this representation, give the Prolog version of the KQML message that would be sent when:

ii) an agent book_ag wants a facilitator agent fac_ag to know that it can respond to KQML messages that ask it to return, as a stream, all answers to queries expressed in Prolog using a book_data ontology.

iii) agent mob_ag wants the facilitator fac_ag to let it know the identity of any agent that advertises to the faciliator that it can be asked to find all answers to queries expressed in prolog using the book_data ontology returning the answers as a stream of messages.

iv) agent mob_ag, wants the facilitator fac_ag to forward to a suitable agent, a request to have all solutions to a Prolog query:

price(Title,'Joe Soap',Price),Price<20

which uses the ontology book_data, sent to it as a stream of tell messages. The answers are to come from the agent that receives the forwarded message.

The three parts of this question carry respectively 40%, 30%, and 30% of the marks

4a The Contract Net protocol is primarily a broadcast mechanism for allocating tasks to task executing agents.

i) How does an agent, as a task manager, find another agent to whom to allocate a task if it has no prior knowledge of the capabilities of the other agents but knows what capabilities are required to do the task?

ii) If a manager gets no response to a task announcement, what can it do?

iii) Suppose a network of task executing agents had access to a facilitator or matchmaker agent. Suggest how the facilitator might be used instead if a general broadcast mechanism.

iv) How might an agent, as a potential contractor, try to find tasks to execute?

v) Are the roles of manager and contractor fixed?

b

i) What are the key advantages and disadvantages to using mobile agents? How might the disadvantages be overcome?

ii) What support software is needed in a mobile agent system?

iii) How might a mobile agent be moved?

iv) Usually a mobile agent moves from one host to another, but an agent may also be mobile because its host computer, such as hand-held computer, moves location. If the host computer has the ability to join new local networks as it moves, the agent on the host is effectively moved to a new environment in much the same way as a mobile agent that hops from host to host. What components of the mobile agent support software might be needed if the agent on a mobile host is to take advantage of the new environment in which it finds itself?

The two parts of this question carry equal marks

[End of paper