UNIVERSITY OF LONDON

IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 1999

BEng Honours Degree in Computing Part II
MEng Honours Degrees in Computing Part II
BSc Honours Degree in Mathematics and Computer Science Part II
MSci Honours Degree in Mathematics and Computer Science Part II
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 Royal College of Science
Associateship of the City and Guilds of London Institute

PAPER 2.13 / MC 2.13

CONCURRENT PROGRAMMING

Monday, April 26th 1999, 2.00 – 3.30

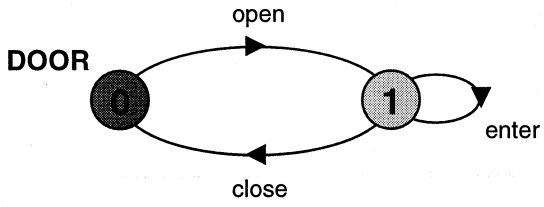
Answer THREE questions

For admin. only:
paper contains 4 questions

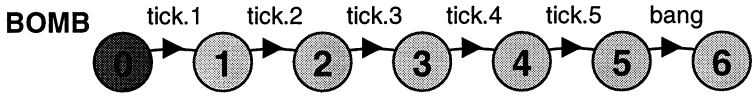
1a Explain how *non-deterministic choice* is expressed in the Finite State Processes (FSP) modelling notation. Briefly explain why non-deterministic choice is useful in modelling systems.

b For each of the following Labelled Transition Systems (LTS), give an equivalent FSP specification.

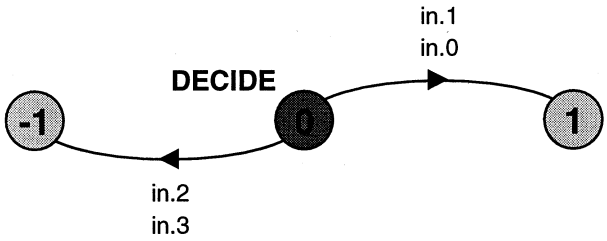
i)



ii)



iii)



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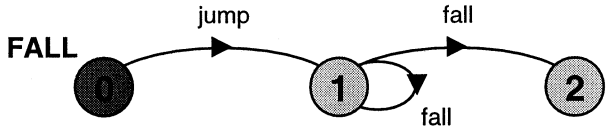


c For each of the following FSP specifications, give an equivalent LTS.

i)
```
EVENS    = (in[i:0..3] -> STATE[i%2]),  // % is modulus
STATE[0] = (even -> EVENS),
STATE[1] = (odd  -> EVENS).
```

ii)
```
CLOCK          = CLOCK[0],
CLOCK[i:0..4]  = (tick->CLOCK[i+1]).
```

iii)
```
COUNT          = COUNT[0],
COUNT[i:0..3]  = (when(i<3) inc -> COUNT[i+1]
                 |when(i>0) dec -> COUNT[i-1]
                 ).
```

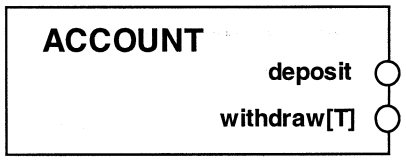
iv)
```
PERSON = (walk -> meet -> PERSON).
||MEET = (alice:PERSON || bob:PERSON)
         /{meet/{alice,bob}.meet}.      // draw LTS for MEET
```

The three parts carry, respectively, 20%, 40% , 40% of the marks.

2a Briefly explain how a *guarded action* in an FSP specification is translated into part of a Java program that implements that specification.

b A Special Savings Building Society Account is permitted to have a maximum balance of **M** hundred pounds. Savers may deposit one hundred pounds at a time into the account up to the maximum. They may withdraw money in multiple units of a hundred pounds so long as the account is not overdrawn.

The alphabet of the process that models the savings account is depicted below, together with a definition of the meaning of each action.



range T = 1..M

deposit - deposit one hundred pounds.
This action is blocked if the balance would exceed **M** hundred pounds.

withdraw[T] - withdraw an amount in the range **T** hundred pounds.
This action is blocked if sufficient funds are not available.

Specify the behaviour of ACCOUNT in FSP.

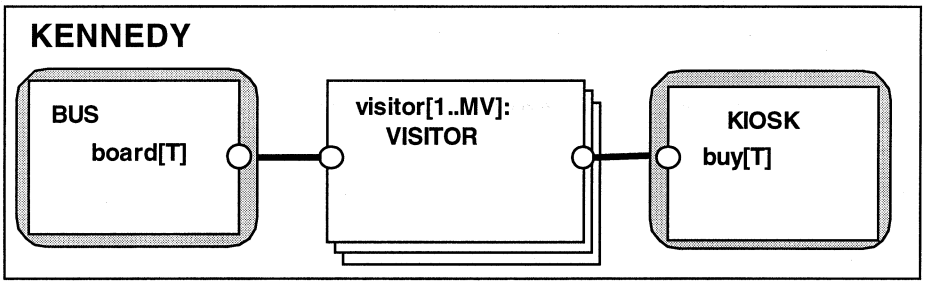
c Implement the ACCOUNT specification from part b with the two actions as monitor methods programmed in Java.

The three parts carry, respectively, 20%, 35%, 45% of the marks.

turn over .....

3a Briefly outline the two different ways of creating a new thread in Java.

b Visitors to the Kennedy Space Center in Florida buy a numbered ticket from a kiosk. Tickets are numbered in the range **T = 1..MT**. When ticket **MT** has been issued, the next ticket to be issued will be ticket numbered 1, i.e. the ticket vendor installs a new ticket roll. After buying a ticket, the visitor proceeds to the bus stop to board the bus that tours the center. The visitor may only board a bus when his/her ticket number appears on a large display. The structure diagram for a model of this system with **MV** visitors is shown below:



Given that the behaviour of VISITOR is defined by:

```
VISITOR = (buy[t:T] -> board[t] -> STOP).
```

specify the behaviour of each of the processes (BUS, KIOSK) and the composite process KENNEDY in FSP.

c Implement the specifications for each of the model entities (BUS, KIOSK, VISITOR) in Java. Include the definition of a method `void build(int MV)` which creates the objects required for KENNEDY.

The three parts carry, respectively, 20%, 30%, 50% of the marks.

4a Explain the terms *safety property* and *liveness property* with respect to concurrent programs.

Draw the Labelled Transition System for the following safety property:

```
property
TIMELY=(arrive      ->TIMELY | begin_lecture->LATE),
LATE  =(end_lecture->TIMELY | begin_lecture->LATE).
```

and give an example of a trace that violates the property.

b A reservoir has a maximum capacity of **N** cubic metres of water. The action **fill[*x*]** fills the reservoir with ***x*** cubic metres where ***x*** is in the range **T = 1..N.** Similarly the action **empty[*x*]** empties the reservoir of ***x*** cubic metres where ***x*** is in the range **T**. Specify a safety property that asserts that a model of the reservoir does not overflow or underflow.

c Define the meaning of a *progress property* in FSP.

d Given the process:

```
ROTATE  = (move -> LEFT | move -> RIGHT),
LEFT    = (up -> left -> LEFT | down -> left -> LEFT),
RIGHT   = (up -> right ->RIGHT| down -> right -> RIGHT).
```

State which of the follow progress properties:

```
progress VERTICAL    = {up,down}
progress HORIZONTAL  = {left,right}
progress UP          = {up}
progress DOWN        = {down}
progress LEFT        = {left}
progress RIGHT       = {right}
```

are satisfied/violated in each of the following systems:

i) `||ONE   = (ROTATE).`
ii) `||TWO   = (ROTATE)>>{up}.`
iii) `||THREE = (ROTATE)<<{up}.`

Give brief reasons for your answers with respect to the LTS for each system.

The four parts carry, respectively, 20%, 20%, 10%, 50% of the marks.

End of paper