UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2002

MSc in Computing Science
BEng Honours Degree in Information Systems Engineering Part III
MEng Honours Degree in Information Systems Engineering Part III
BSc Honours Degree in Mathematics and Computer Science Part III
MSci Honours Degree in Mathematics and Computer Science Part III
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
This paper is also taken for the relevant examinations for the Associateship of the Royal College of Science

PAPER M335=I3.27

CONCURRENT AND DISTRIBUTED PROGRAMMING

Tuesday 7 May 2002, 14:00
Duration: 120 minutes

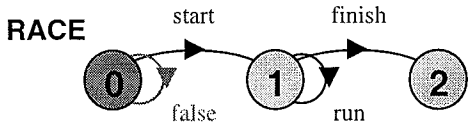
Answer THREE questions

Paper contains 4 questions
Calculators not required

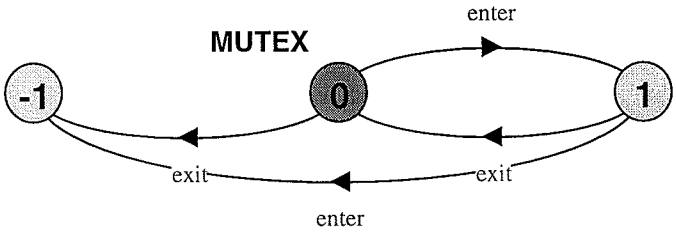
1a Processes modeled in FSP are said to execute *asynchronously*. Briefly explain what *asynchronous* execution means in this context.

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

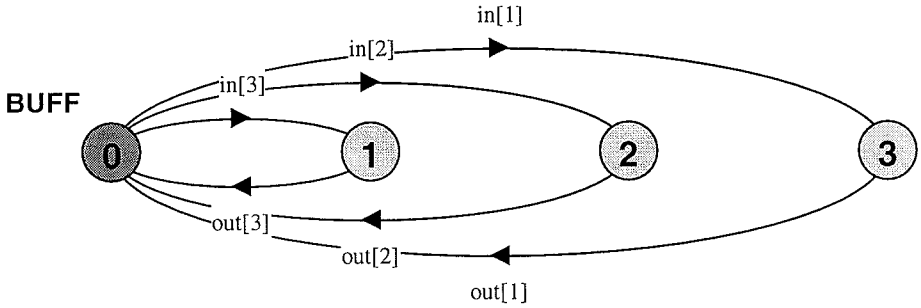
i)



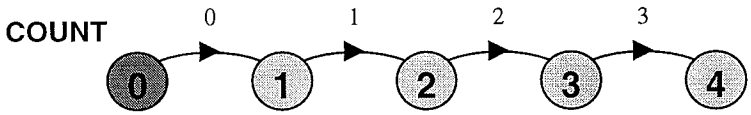
ii)



iii)



iv)



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

i)
```
OVERFLOW = CAPACITY[0],
CAPACITY[i:0..3] = (drip->CAPACITY[i+1]).
```

ii)
```
property SAFE = (open->OPEN),
OPEN = ( enter->OPEN | close->SAFE).
```

iii)
```
CONSTRAIN = STOP + {north}.
TURTLE  = (north->move->TURTLE | south->move->TURTLE).
||SYS = (CONSTRAIN || TURTLE).   //draw LTS for SYS
```

iv)
```
GATE  = (in->out->GATE).
||AND = (a:GATE || b:GATE)/{out/{a.out,b.out}}.
```
//draw LTS for AND

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

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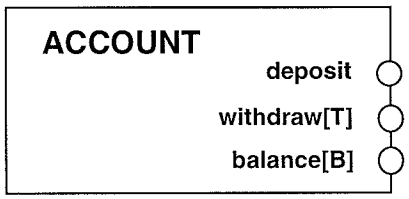
2a Briefly describe the operation of the **`notify()`**, **`notifyAll()`** and **`wait()`** methods used in Java for condition synchronisation in monitors.

b A Special Euro Savings Society Account is permitted to have a maximum balance of **M** hundred Euros. Savers may deposit one hundred Euros at a time into the account up to the maximum. They may withdraw money in multiple units of a hundred Euros 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
range B= 0..M

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

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

balance[B] - returns the balance in the range **B** hundred Euros.

Specify the behaviour of ACCOUNT in FSP.

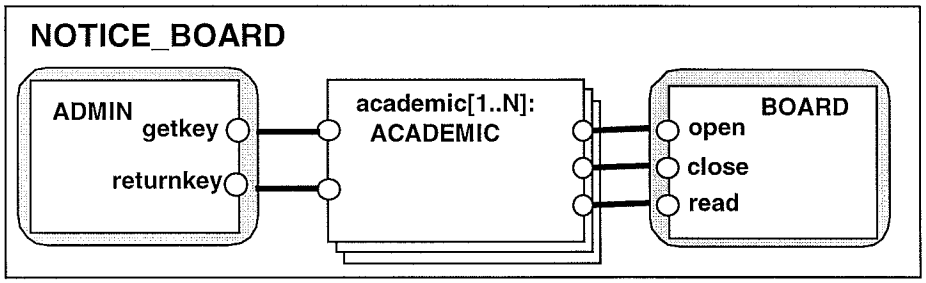
c Implement the ACCOUNT specification from part b with the three actions as monitor methods programmed in Java.

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

turn over .....

3a Explain briefly how a resource, shared by a set of processes can be modelled in FSP.

b A notice board is shared by a department of academics. The notice board has a glass cover that may only be opened with the aid of a key obtained from the administrator. To change a notice, an academic must obtain the key, open the glass cover, change the notice, close the cover and return the key. Other academics can read the notice board when it is closed (i.e. not opened for a change). The structure diagram for an FSP model of the system with *N* academics is shown below:



Given that the behaviour of **ACADEMIC** is defined by:

```
ACADEMIC = (getkey ->open ->close ->returnkey ->ACADEMIC
           |read   ->ACADEMIC).
```

specify the behaviour of each of the processes (**ADMIN, BOARD**) and the composite process **NOTICE_BOARD** in FSP.

c Implement the specifications for each of the entities (**ADMIN, ACADEMIC, BOARD**) in Java. Include the definition of a method **void build(int N)** which creates the objects required for **NOTICE_BOARD**.

(Hint: Use the method **Math.random()** which randomly returns a floating point value between zero and one to decide whether an academic chooses to change a notice or simply read the notice board. Ignore details of data representations for keys, notices etc. and use **void** methods with no parameters to implement model actions.)

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 following 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.