UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2007

BEng Honours Degree in Computing Part II
MEng Honours Degrees in Computing Part II
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 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 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 C223=MC223=I3.27

CONCURRENCY

Tuesday 24 April 2007, 10:00
Duration: 120 minutes

Answer THREE questions

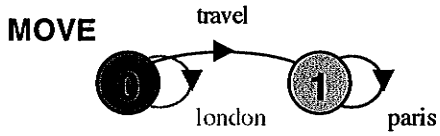
Paper contains 4 questions
Calculators not required

Section A (Use a separate answer book for this Section)

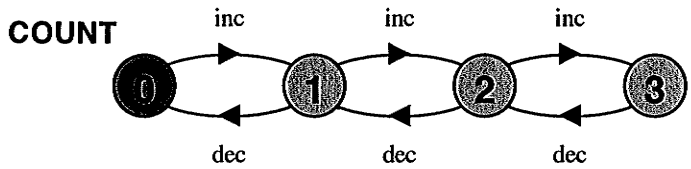
1a Processes modelled in FSP are assumed to execute asynchronously. Briefly explain how parallel composition accounts for this fact.

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

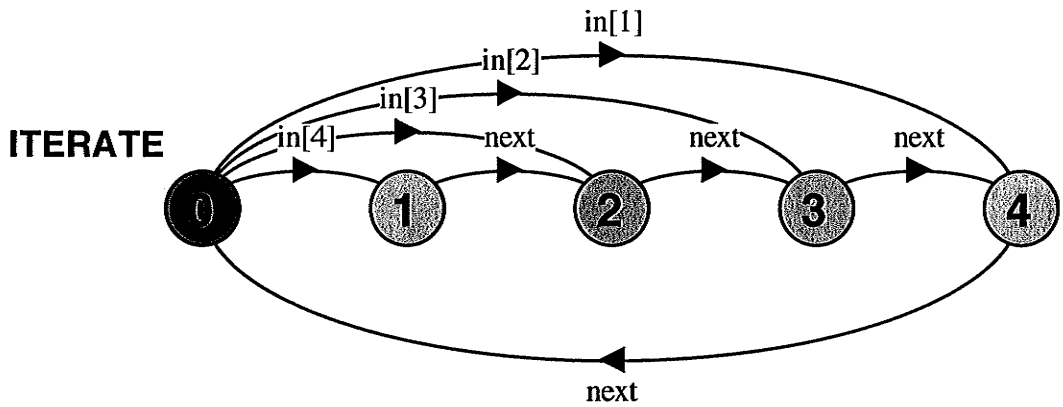
i)



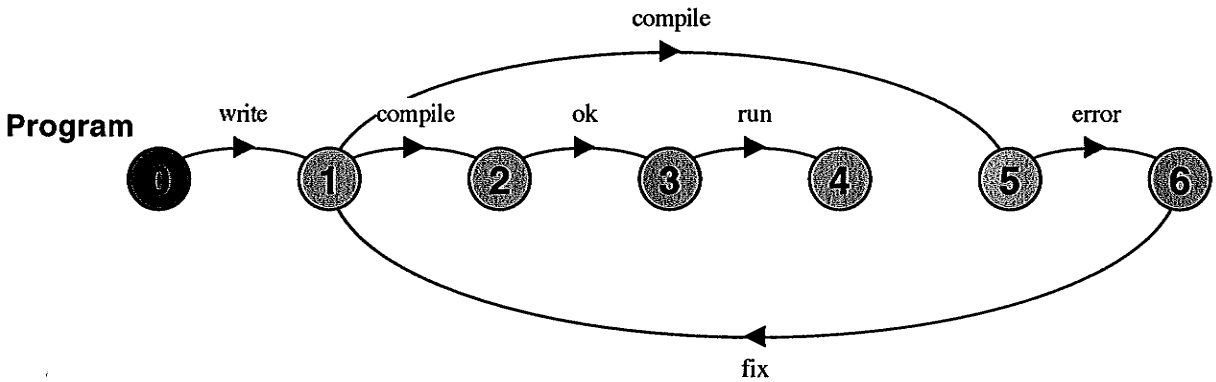
ii)



iii)



iv)



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

i)
```
DICE = (throw[i:1..6]->(when (i==6)again->DICE)).
```

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

USER = (open-> enter -> close -> USER |
        open -> close -> enter -> USER).

||SAFE = (USER || CHECKSAFE). // draw LTS for SAFE
```

iii)
```
DOG    = (bark -> attack -> DOG).
||DOGS = (fido:DOG || rover:DOG)
         /{bark/{fido,rover}.bark}. // draw LTS for DOGS
```

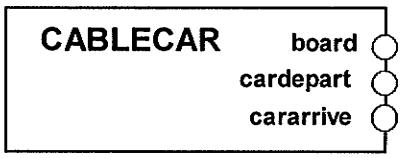
iv)
```
BROKEN  = STOP + {tick[2]}.
||ENDOFTIME = (CLOCK(20) || BROKEN).

CLOCK(N=4) = S[0],
S[i:0..3]  = (tick[i] -> S[(i+1)%N]). // % is modulus

//draw LTS for ENDOFTIME.
```

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 In an automatic cable car system, each cable car has its own controller. The function of this controller is to ensure that a cable car only leaves the terminus when it is full of passengers. A cable car can hold a maximum of N passengers. After departure, the cable car arrives at the other end, all the passengers leave the cable car and new passengers may then board for another trip.

The alphabet of the cable car is depicted below, together with a definition of the meaning of each action.



board - a passenger boards the cable car.
cardepart - the cable car departs.
This action is delayed until the cable car is full.
cararrive - the cable car arrives at the other end.
This action is delayed until after departure.

Specify the behaviour of CABLECAR in FSP.

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

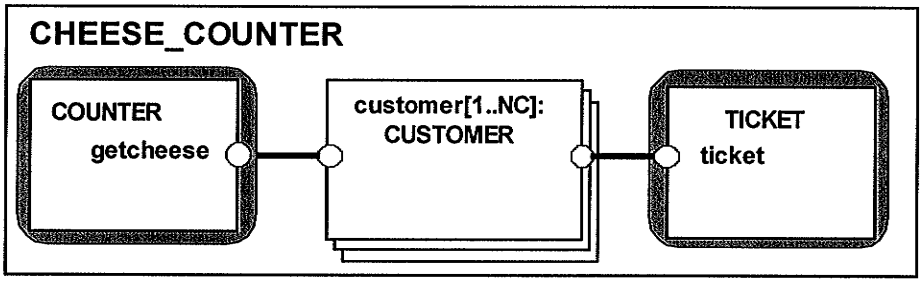
d Give the invariant for the number of passengers in the CABLECAR.

The four parts carry, respectively, 20%, 30%, 45%, 5% of the marks.

Section B (Use a separate answer book for this Section)

3a Briefly explain what is meant by the following statement: Safety properties as described in FSP using the `property` keyword are transparent.

b The cheese counter in a supermarket is continuously mobbed by hungry customers. To restore order, the management installs a ticket machine which issues tickets to customers. Tickets are numbered in the range 1..*MT*. When ticket *MT* has been issued, the next ticket to be issued will be ticket numbered 1, i.e. the management install a new ticket roll. The cheese counter has a display which indicates the ticket number of the customer currently being served. The customer with the ticket with the same number as the counter display then goes to the counter and is served. When the service is finished, the number is incremented (modulo MT). Given the structure diagram depicted below for the cheese counter system, specify in FSP the behaviour of each of the processes (CUSTOMER, TICKET, COUNTER) and the composite process CHEESE_COUNTER.



c Implement the specifications for COUNTER and TICKET in Java. Briefly justify your use of `notify` or `notifyAll`in COUNTER.

The three parts carry, respectively, 30%, 40%, 30% of the marks.

4a Explain what is meant by the statement given below. In addition, explain if it is a true statement or not.

'progress properties are compositional'.

b A university department of computing consists of a systems research group and a theory research group. Due to constraints on space, these groups share a meeting room. Due to mutual antagonism between the groups, to avoid conflict, the head of the department has decreed that the meeting room can contain only systems group members or theory group members but not both at the same time. Given the following definitions:

```
const M    = 3        //maximum number of people allowed in meeting room
const Max  = 7
set Hackers    = {hack[1..Max]}  //members of the systems group
set Eggheads   = {egg [1..Max]}  //members of the theory group

ACADEMIC =      (enter -> meet -> exit -> ACADEMIC).
||DEPARTMENT = (Hackers:ACADEMIC || Eggheads:ACADEMIC).
```

Specify a process **MEETINGROOM** in *FSP* that ensures that a maximum of M people are allowed into the meeting room at any one time and that the meeting room cannot be occupied by both hackers and eggheads at the same time.

c Specify the following safety properties in *FSP*:

i) **NOCONFLICT** checks that the meeting room is occupied either by hackers or eggheads, but not both simultaneously.

ii) **OVERFLOW** checks that more than M people do not occupy the meeting room at the same time.

Give the *FSP* composition for the system that combines the department, meeting room and the safety properties.

d Explain what is meant by recursive locking in Java.

The four parts carry, respectively, 20%, 30% 30%, and 20% of the marks