CS5270 Assignment 3 (the final assessment)

March 16, 2007

NOTES:

1. This assignment is due on 9th April 6:30pm. You can pass it to me beforehand - slipping under the door is fine. No extensions. Submissions should be typed (not hand-written), and you should work on this assignment on your own.

1 Problem1 (5 marks)

In the notes for CTL, the assertion is made that all ten base CTL temporal expressions may be expressed in terms of **EX**, **AU** and **EU** (from the language CTL-). In addition, on page 76, I give two of these, expressing **AX** and **EG**. Define all five other CTL temporal expressions in terms of the CTL- operators **EX**, **AU** and/or **EU**.

2 Problem2 (4 marks)

In the notes for TCTL, again we use a subset of the language (TCTL-), using only **EU** and **AU**. Define **AF**, **AG**, **EF** and **EG** in terms of the TCTL- temporal operators **in**, **AU** and/or **EU**.

3 Problem3 (4 marks)

Consider the arbiter example repeated various times in the notes. Write CTL expressions which assert (as closely as you can) that:

1. It is not possible for both processes to be using the resource at the same time.
2. A process which requests for a resource will eventually be granted the resource.

Describe in words any variation in the meaning of the expression given in words above, and the CTL expression you have given.

4 Problem4 (5 marks)

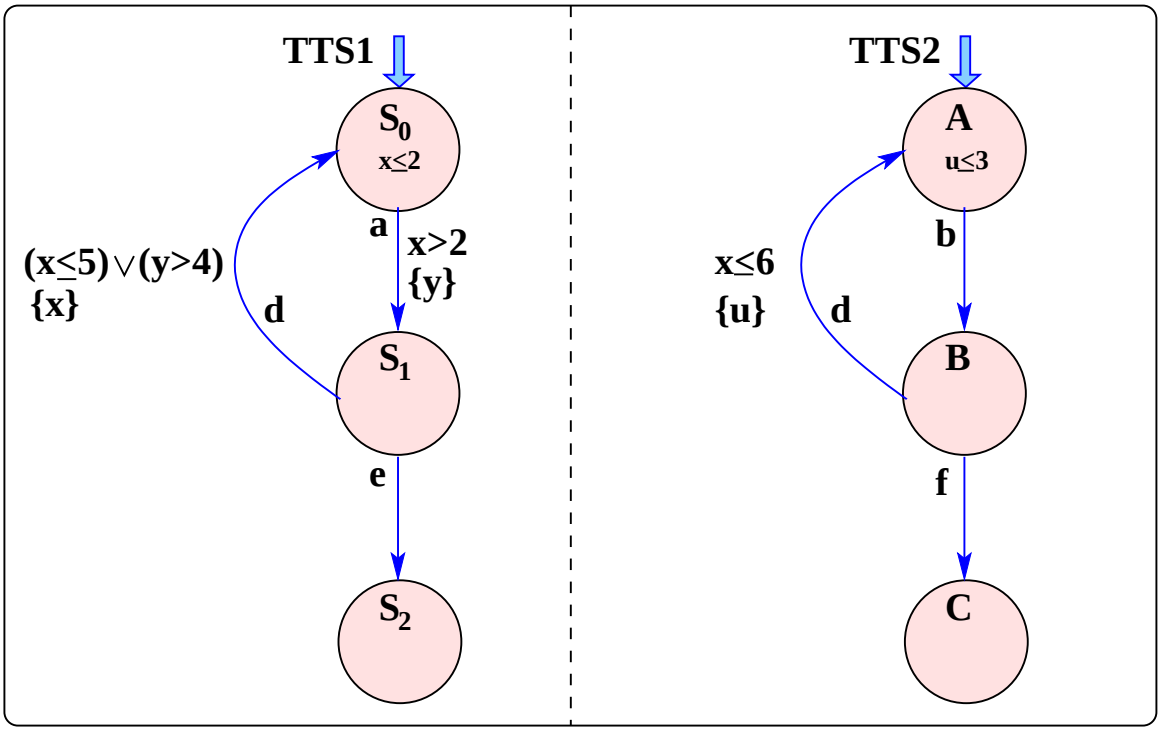
Modify the arbiter so that a process which requests for a resource will eventually be granted the resource (assuming that the resource eventually becomes free). Show on the diagram the states that will be labelled with the assertion given above in problem 3.2.

5 Problem5 (8 marks)

The LTL formula $\mathrm{A}(\mathrm{F}\,(p \wedge \mathrm{X}\,p))$ is in LTL, but no equivalent formula is found in CTL. Give a CTL formula that seems likely to be similar to the formula, and then show a counter-example in the same way that was done for the LTL formula $\mathrm{A}(\mathrm{FG}\,p)$.

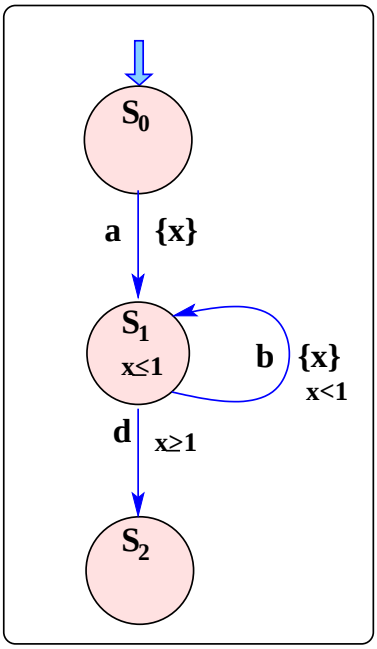
6 Problem6 (5 marks - from old exam)

Construct the parallel composition TS of TS1 and TS2, and give a timed computation in which action **d** occurs.



7 Problem7 (4 marks - from old exam)

Construct the regional transition system for this timed transition system. Give your answer in both formal and graphical forms:



8 Problem8 (5 marks)

Describe (in words) the relationship between a zone transition system and a regional transition system, which are representing the same system. Give an example of a regional transition system with its corresponding zone transition system.

9 Problem9 (60 marks)

You are to use Uppaal to model a communication system with five components, each one of which should be modelled separately (i.e. a separate diagram for each):

Sender: The Sender can transmit messages at any time. It does this by using a transmission protocol component (which may retransmit failed messages). The sender is only able to transmit if the transmission protocol component is ready.

TransmitterProtocol: The transmission protocol to use is a simple one described below. All messages must go through the media.

Media: The media models either a *perfect* media (in which each message that leaves the TransmitterProtocol arrives at the ReceiverProtocol, and vice-versa), or an *erratic* media (in which case messages are sometimes not delivered). When a message is delivered, the delay from the media will always be less than 2 time units. The perfect and erratic media models are to be demonstrated in two separate Uppaal systems, where all other components are unchanged.

ReceiverProtocol: The receiver protocol is to match the transmission protocol described below.

Receiver: The Receiver receives messages, and acknowledges this to the ReceiverProtocol.

Note that it is also easily possible to model this system as *one* thing, or as *three* things, but I want you to model it as *five* co-operating transition systems in Uppaal.

9.1 Informal description of the protocol

You are to model a simple-minded timeout protocol which is informally described like this:

When the TransmitterProtocol receives a message from the Sender, it sends a message to the Media, sets a timer (say 6 time units), and then waits for an acknowledgement from the Media, before telling the Sender it is ready for the next message. If the timer times out, the TransmitterProtocol should re-send the message (and keep doing this until it gets an acknowledgement).

When the ReceiverProtocol receives a message from the Media, it sends an acknowledgement back to the Media, and then it sends the message on to the Receiver, before waiting for the Receiver to tell it that it is OK to get the next message.

It is possible for this simple protocol to result in an error in transmission - in particular it is possible for the Receiver to get duplicate messages when the media is erratic.

9.2 Deliverables

In your written documentation, you are to describe your model clearly, and then test and improve it:

1. Describe how all the components of your composite system tie together, and
2. for each component, describe in words (and with diagrams) how your component works, and what choices you made.
3. Define what it means for your system to be *correct*. This definition should identify the *duplicate message* situation.
4. Show a sequence of messages which result in the duplicate message situation.
5. Construct at least 3 Uppaal queries that verify that your system is *incorrect*. Give the results of the queries in the absence of media errors, and also when you have a media which corrupts messages.
6. With a minimum number of changes, modify your transmission and receiver protocols to correct the error. Use similar Uppaal queries to verify that your system is *correct*. Give the results of the queries in the absence of media errors, and also when you have the media which corrupts messages.

A good writeup may include a progression from a model that has some form of incorrect behaviour, through to a revised model which no longer exhibits the incorrect behaviour. You should clarify any extra timing constraints that you have put into your systems.

In addition to your writeup, including the (graphical) transition systems and brief descriptions, you must submit the Uppaal code electronically in the `Assignment3` folder in the IVLE. Your submission should be a zipped folder containing the documentation in PDF format, and the four Uppaal systems.