CS628 Homework #2

Max marks: 50 **Due Mar 26, 2004**

- *You must take a printout of this homework, and fill in your answers in the spaces provided. You must turn in the sheets filled with your answers.*
- *You may work out the answers separately and then fill in* ***all*** *the steps and the final solution in the spaces provided.*
- *Be brief, complete and stick to what has been asked.*
- *If needed, you may cite results/proofs covered in class without reproducing them.*
- ***Do not copy solutions from others. Penalty for suspected copying: FR grade***

A four channel process, N, as shown in Fig. 1(a), is intended to be used for building interconnected token rings. An example of such interconnected rings is shown in Fig. 1(b). In general, two rings are said to be interconnected if they share at least one N process.

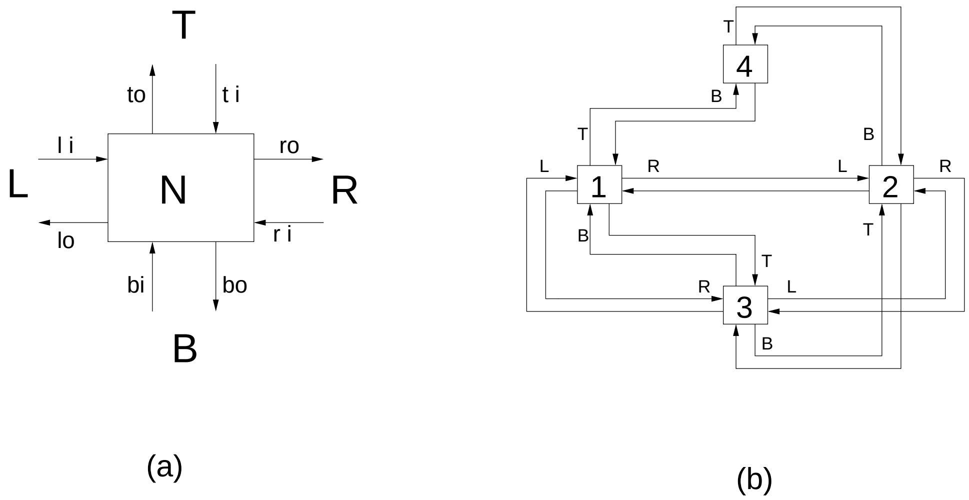

Figure 1: Interconnected token rings

For process N, channels L and B are passive, while channels R and T are active. Thus, a token is received either from L or B channels and forwarded either to R or T channels. The receipt of a token from a neighbouring N process or its forwarding to a neighbouring N process is accomplished through handshakes on the corresponding channels. As soon as process N receives an event signifying the start of a handshake on its L or B channel, the token is assumed to have been transferred to N. While the handshake on the channel must still be completed, the token is assumed to have been transferred as soon as N receives the first event of the handshake on its L or B channel. Similarly, after having the token, if process N wishes to transfer it to a neighbouring process, it initiates a handshake on its L or R channels. Process N is assumed to lose control of the token once it has initiated this handshake.

As an example, if N wishes to transfer a token to M, then N initiates a handshake on the corresponding channel; this signifies loss of control of the token by N. Process M assumes control of the token once it receives the first event of the handshake. Neither N nor M is said to control the token between the initiation of the handshake by N and its receipt by M.

Stated in other words, process N has control of the token after it has received an event that initiates a handshake on its L or B channels, and before it initiates the subsequent handshake on its T or R channels.

Each process N must transfer the token through one of its R or T channles sometime after it has received a token from a neighbour. In addition, we wish the following properties to be satisfied in any interconnected system of rings formed using the N processes.

P1 No process should receive a token while it is already in control of a token.

P2 All handshakes that are initiated must eventually be completed, and the sequence of events for each handshake must be respected.

P3 At any point of time, at most one process must be in control of the token. If no processes have the token, then it must be the case that one process has initiated the transfer of the token, while another (not necessarily distinct) process is ready to receive the token.

1. *[7 marks]* Suppose the behaviour of processes N_1 and N_2 are given by the Petri Nets shown in

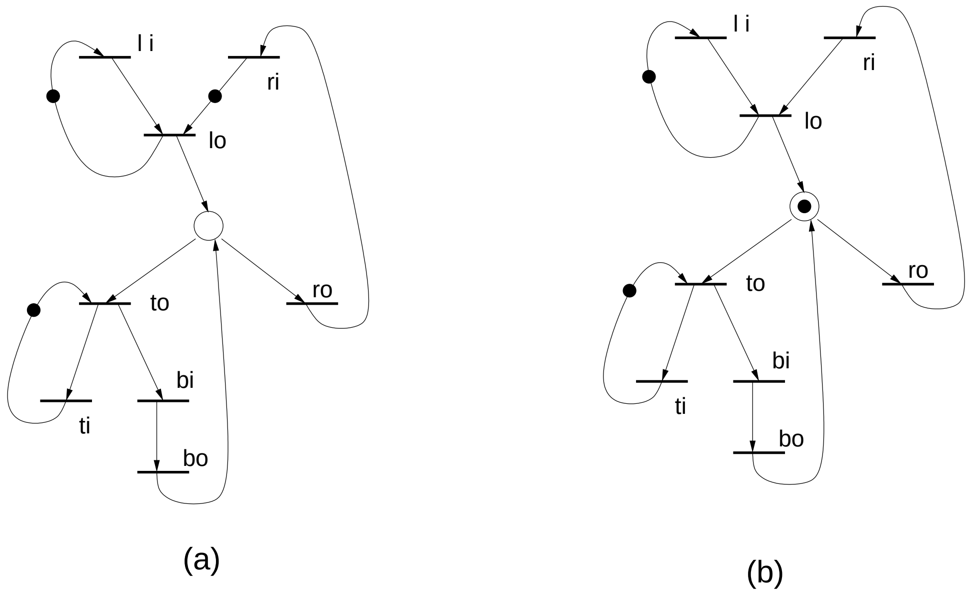

Figure 2: Petri Nets with obvious places omitted

Fig. 2a and b (obvious places betweeen transitions have been omitted for clarity). Note that the only difference between these two PNs is in the initial marking. This is necessary to ensure that at least one process has the token initially. Note also that we have labeled the transitions of the PNs with l_i, t_o etc. These denote events on the corresponding signals, without specifying the value assigned (unlike in STGs). Show how you would connect N_1 and N_2 to form a token ring that satisfies properties P1,‘ P2, P3 listed above. You are not allowed to use any component other than N_1 and N_2. You must give justification for your claim that your design satisfies P1, P2 and P3.

2. *[8 marks]* Consider the following description of N, in which $e?$ denoted the arrival *and* receipt of an event on e.

$N = ((l_i? \rightarrow P \rightarrow l_o!)[](b_i? \rightarrow P \rightarrow b_o?)) \rightarrow N$
$P = (r_o! \rightarrow r_i?)[](t_o! \rightarrow t_i?)$

We wish to form interconnected rings using these N processes, and one N_0 process that has the initial token. The behaviour of N_0 is given by:

$N_0 = (r_o! \rightarrow r_i?) \rightarrow N$

Indicate with justification whether interconnected rings formed with one N_0 and one or more N processes violate any of the properties P1, P2, P3. Answers without justification will fetch no marks.

3. *[8 + 2 marks]* For purposes of this question, a ring is a sequence of N processes $(N_0, N_1, \ldots N_{k-1})$ such that

   - $N_{i+1 \; mod \; k}$ is the R neighbour (neighbour connected to R channel) of N_i for all $i \in \{0, \ldots k-1\}$, or
   - $N_{i+1 \; mod \; k}$ is the T neighbour (neighbour connected to T channel) of N_i for all $i \in \{0, \ldots k-1\}$.

   For example, there are two rings in Fig. 1b, namely (N_1, N_2, N_3) and (N_1, N_4, N_2, N_3). We wish to form interconnected rings such that

   - Every ring has at least two processes.
   - Every pair of distinct rings have at most one N process in common.
   - Regardless of which process has the token, it should be possible for any other process in the system of interconnected rings to assume control of the token.
   - Every process has a R-neighbour, a L-neighbour, a T-neighbour and a B-neihbour.

   (a) Draw a Petri Net describing the behaviour of an N process that can be used to build such rings. Your design should be such that properties P1, P2 and P3 are satisfied. You may label the transitions of your PN by l_i, t_o etc, instead of l_i+, t_o-, etc. Indicate your initial marking using blue or black pen.

   (b) As indicated in Question 1 above, the initial marking of one N process in the interconnected system of rings must be made different to ensure that at least one process has the token to begin with. For the PN in part (a) above, show how would change the initial token marking for one

N process in the rings to ensure the presence of a token. You can use a red pen to indicate the token marking in the PN of part (a).

4. *[10 + 8 + 7 marks]* Suppose we modified the description of process N to say that whenever N receives a token from its L-neighbour, it non-deterministically chooses to forward it to its R-neighbour or T neighbour. However, whenever N receives a token from its B-neighbour, it forwards it to its R-neighbour. In addition, suppose we further said that all handshakes on channels are 4-phase. We now wish to form interconnected rings as in Question 3 above using these modified N processes.

   (a) Draw a PN with transitions labeled by l_i+, t_o- etc. describing the behaviour of the modified N process. You need not show the PN for the N process that has the initial token.

(b) Draw the STD for the PN in part (a) above.

(c) Are there any CSC conflicts in the STD of part (b)? You must give justification for your answer.

i. If your answer is in the affirmative, you must show where to insert state variable changes in the STD to resolve CSC conflicts.

ii. If your answer is in the negative, you must give the Boolean function implementation of any one output.