Resit Protocol Validation

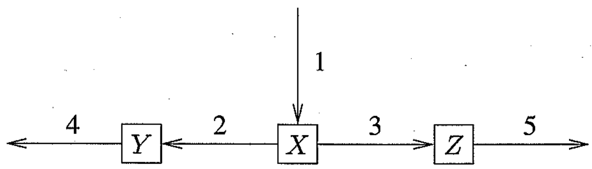
VU University Amsterdam, 15 February 2012, 18:30-21:15

(At this exam, you may use copies of the slides without handwritten comments. Answers can be given in English or Dutch.)

(The exercises in this exam sum up to 90 points; each student gets 10 points bonus.)

1. Give algebraic specifications over the natural numbers of 'greater than or equal' $\geq$: $Nat \times Nat \to Bool$, the cut-off minus function $\dot{-}$: $Nat \times Nat \to Nat$ (with $n \dot{-} m = 0$ if $n \leq m$), and the function *divides* : $Nat \times Nat \to Bool$ (where $divides(m, n)$ returns T if and only if m divides n). (10 pts)

2. Data elements from a set Δ can be received by X via channel 1 (by $r_1(d)$), after which they are *alternernatingly* sent on to Y via channel 2 (by $s_2(d)$) or to Z via channel 3 (by $s_3(d)$). So the first received datum is sent to Y, the second to Z, the third to Y, etc. Y sends on received data elements via channel 4, while Z sends on received data elements via channel 5.



   (a) Specify the parallel processes X, Y and Z in μCRL, including the action (**act**), communication (**comm**) and initial (**init**) declarations. (The data types that you use do not have to be specified.) (8 pnts)

   (b) Let $\Delta = \{0\}$. Draw the state space of $\partial_{\{r_2, s_2, r_3, s_3\}}(X \| Y \| Z)$. (6 pnts)

   (c) Draw the state space of $\tau_{\{c_2, c_3\}}(\partial_{\{r_2, s_2, r_3, s_3\}}(X \| Y \| Z))$ after minimization modulo branching bisimilarity. (4 pnts)

3. (a) Linearize, using the algorithm underlying `mcrl -regular`, the μCRL specification

$$\begin{aligned} Y(m{:}Nat) &= a(m) \cdot Z(S(m)) \cdot Y(S(m)) \\ Z(m{:}Nat) &= b(m) \cdot Z(m) + c(S(m)) \end{aligned}$$

(8 pts)

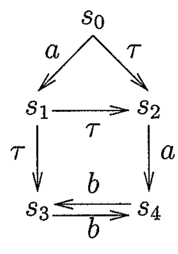
   (b) Linearize, using the algorithm underlying `mcrl`, the μCRL specification

$$\begin{aligned} Y(m{:}Nat) &= a(m) \cdot Z(S(m)) \cdot Y(m) \\ Z(m{:}Nat) &= b(m) \cdot Z(S(m)) + c(m) \end{aligned}$$

   with initial state $Y(0)$.

   Would the algorithm underlying `mcrl -regular` terminate on this specification? Explain your answer. (12 pts)

4. Consider the following state space.



(a) What is the maximal collection of confluent τ-transitions in this state space? Explain your answer. (6 pnts)

(b) Apply the minimization algorithm modulo branching bisimilarity to this state space. Describe the subsequent splits that you perform, and the results of those splits. Also draw the resulting minimized state space. (10 pnts)

(c) Compare a reduction based on confluent τ-transitions with applying the minimization algorithm modulo branching bisimilarity. What are the advantages and disadvantages of both approaches? (4 pnts)

5. Consider the data base approach to distributed state space generation, whereby states are represented as lists of indices, and are stored in a binary tree. Let a processor first store the list of indices 11010100, then 11011011, then 00100100, and finally 00101011. Show how the binary tree at this processor evolves. (10 pts)

6. Specify $even : Nat \to Bool$ such that $even(n) = \mathsf{T}$ if and only if n is an even number.

Consider the following LPE:

$$\begin{array}{rcl} X(n:Nat) & = & \tau{\cdot}X(n) \lhd even(n) \rhd \delta \\ & + & a(n){\cdot}X(S(S(n))) \lhd \mathsf{T} \rhd \delta \end{array}$$

Give the confluence formula for the τ-summand, and argue that it is true, meaning that the τ-transitions generated by this summand are confluent. (12 pnts)