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## Exercises 3 : Processos e Concorrência

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### Exercise I.1

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Let  $A(a) \triangleq a.A$  and  $B(b) \triangleq \bar{b}.B$ . Compute the first derivatives of the following processes:

1.  $A + B$
  2.  $A + B\langle a \rangle$
  3.  $A | B$
  4.  $A | B\langle a \rangle$
  5.  $\{a/b\} (A | B)$
  6.  $\text{new } \{a\} (A | B\langle a \rangle)$
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### Exercise I.2

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Let  $A(a, b, c, d) \triangleq \bar{a}.b.A + \bar{c}.d.A$ . Draw the transition graphs of the following processes

1.  $A$
  2.  $\text{new } \{a\} A$
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### Exercise I.3

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Consider the following description of a two-position *buffer* with acknowledgements. Note the process is built from copies of a 1-position *buffer* also with acknowledgements: it acknowledges in  $\bar{r}$  the reception of a message and waits in  $t$  the confirmation that a message sent was arrived to its destination.

$$Bs \triangleq \text{new } \{mo, mi\} (B(in, mo, mi, r) | B(mo, out, t, mi))$$
$$B(in, out, t, r) \triangleq in.\overline{out}.t.\bar{r}.B$$

1. Draw the synchronisation graph of  $Bs$ .
  2. Check whether the behaviour of  $Bs$  is the intended one (drawing, for this purpose, the corresponding transition graph)
  3. Find a solution to the problem detected (if any) and draw the corresponding transition graph.
  4. Explain how the specification given (or your new solution) can be adapted to describe *buffers* with an arbitrary, but fixed number of positions.
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### Exercise I.4

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Consider the following description of a 1-position bidirectional buffer, *i.e.*, able to transmit and receive messages in any direction.

$$BT(in_1, in_2, out_1, out_2) \triangleq in_1(x).\overline{out_1}\langle x \rangle.BT + in_2(x).\overline{out_2}\langle x \rangle.BT$$

1. Specify a 2-position bidirectional buffer by parallel composition of two instances of process  $BT$ .
2. Draw its synchronisation diagram and the transition graph.

#### Exercise I.5

Consider the following specification of a control system for a crossing between a road and a railway. Events  $car$  and  $train$  modelled, respectively, a car or a train approaching the cross. Actions  $up$  e  $dw$  stand for the opening and closing of the protection bar to prevent cars to cross. Similarly,  $green$  and  $red$  model the semaphore for trains. Finally, events  $\overline{ccross}$  and  $\overline{tcross}$  come from sensors which register the actual cross of a car or a train, respectively.

$$\begin{aligned}
 Road &\triangleq car.up.\overline{ccross}.dw.Road \\
 Rail &\triangleq train.green.\overline{tcross}.red.Rail \\
 Signal &\triangleq \overline{green}.red.Signal + \overline{up}.dw.Signal
 \end{aligned}$$

$$C \triangleq \text{new } \{green, red, up, dw\} (Road \mid Rail \mid Signal)$$

1. Explain the behaviour of this process and sketch its synchronisation diagram.
2. Compute the transition graph corresponding to process  $C$

#### Exercise I.6

An  $n$ -trigger, for  $n > 1$ , is used in electronic voting to detect that a fixed number of votes have been received along its  $n$  input ports, numbered from  $a_1$  to  $a_n$ . As soon votes have been received in half of the input ports a signal is sent through its output port  $\bar{s}$  and the process terminates. Each port  $a_i$  receives only a single input. Inputs, however, may arrive in any order to the different ports.

1. Specify a 3-trigger.
2. Specify a  $n$ -trigger, for  $n$  arbitrary.

#### Exercise I.7

Draw the transition graph of  $T \triangleq a.(b.0 \mid T)$  ?