Ejercicios

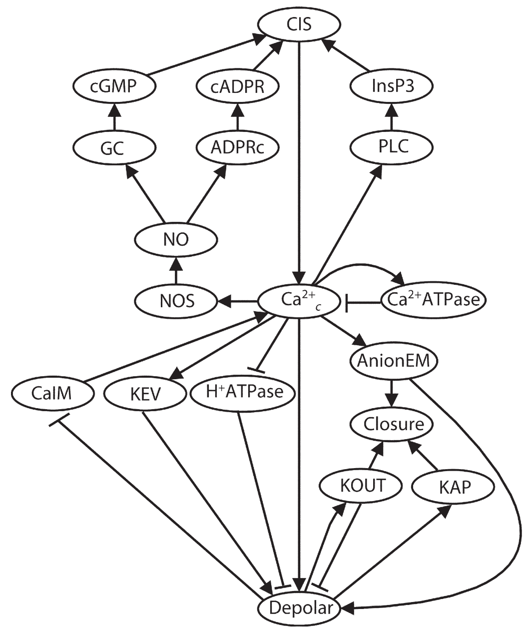
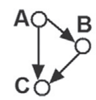


FIGURE 4.3 Figure for Exercise 4.1. The network is a part of a plant signal transduction network whose signal is the drought hormone abscisic acid and whose outcome is the closure of the stomata (microscopic pores on the leaves) [15, 16]. An arrowhead or a short perpendicular bar at the end of an edge indicates activation or inhibition, respectively. The full names of the nodes can be found in [15, 16]. Figure reprinted from Ref. [17] with permission from Elsevier.

Exercise 4.1. Consider the network depicted in Figure 4.3.

1. Is the network strongly connected? Explain your answer.
2. If the network is not strongly connected, identify its strongly connected components.
3. Does the network contain loops? If so, identify them.
4. Does the network contain cycles? If so, identify all cycles.
5. Are there any feed-forward loops? If so, identify them as positive, negative, or incoherent.
6. Are there any feedback loops? Identify them. Identify their sign as positive or negative.

Network



(a)

Transition functions

$$f_A = x_A$$
$$f_B = x_A$$
$$f_C = x_A \text{ AND } x_B$$

(b)

Truth tables

x_A	f_A, f_B
0	0
1	1

x_A	x_B	f_C
0	0	0
0	1	0
1	0	0
1	1	1

(c)

FIGURE 4.4 A Boolean model of a simple signal transduction network. (a) The signal transduction network. The edges with arrows represent positive effects. Note that the network does not uniquely determine the Boolean updating function for node *C*. (b) The Boolean transition functions in the model. The first transition function indicates that the state variable of node *A* does not change. The second transition function indicates that the state variable of node *B* follows the state of node *A* with a delay. The third transition function indicates that the condition for the ON state of node *C* is that both *A* and *B* are on. (c) The truth tables of the Boolean updating functions given in (b).

Exercise 4.2. Construct the transition function and truth table for the networks in Figure 4.5. Consider both the AND and OR possibilities for the transition function of *C* for the network in Figure 4.5a and for the transition function of the node *B* for the network in Figure 4.5b. □

Exercise 4.3. Show that the truth table of a Boolean function with k variables has 2^k rows and $k + 1$ columns. *Hint*: Determine the number of different sequences of length k that can be formed from 0s and 1s. □

Exercise 4.4. Can you guess the attractor(s) of the Boolean model in Example 4.1? Consider the cases $x_A = 0$ and $x_A = 1$ separately. □

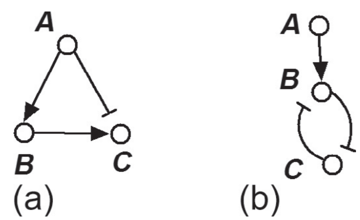


FIGURE 4.5 Figure for Exercise 4.2 and several of the follow-up exercises. Two simple signal transduction networks. For both networks, A is the source node (signal).

Exercise 4.5. Determine the state transition graph of the model in Figure 4.4 in the presence of a signal ($x_A = 1$) when using synchronous update. Compare with Figure 4.6a (right panel). □

Exercise 4.6. Determine the state transition graphs for the networks in Figure 4.5, assuming synchronous update. Consider both the AND and OR possibilities for the transition function of C for the network in panel (a) and for the transition function of B for the network in panel (b). Consider both the sustained absence ($x_A = 0$) and presence ($x_A = 1$) of node A. □

Example 4.1. (continued). Let us consider again the network from Figure 4.4 with the absence of signal ($x_A = 0$) but use general asynchronous update, when one node is updated at any given time step.

Exercise 4.7. Determine the state transition graph of the model in Figure 4.4 in the presence of signal ($x_A = 1$) when using general asynchronous update. Compare with Figure 4.6b (right panel). □

Exercise 4.8. Determine the state transition graphs for the networks in Figure 4.5 when using general asynchronous update. Consider both the AND and OR possibilities for the transition function of C for the network in Figure 4.5a and for the transition function of B for the network in Figure 4.5b. Consider both the sustained absence ($x_A = 0$) and presence ($x_A = 1$) of node A. □

Exercise 4.9. For each of the cases considered in Exercises 4.6 and 4.8, compare the steady states obtained when using synchronous update and general asynchronous update. Are the steady states the same? □

Exercise 4.10. Consider the network in Figure 4.7. Determine the state transition graph of the network, using first synchronous update and then general asynchronous update. For the case $x_I = 0$, compare your graphs with those in Figure 4.7. □

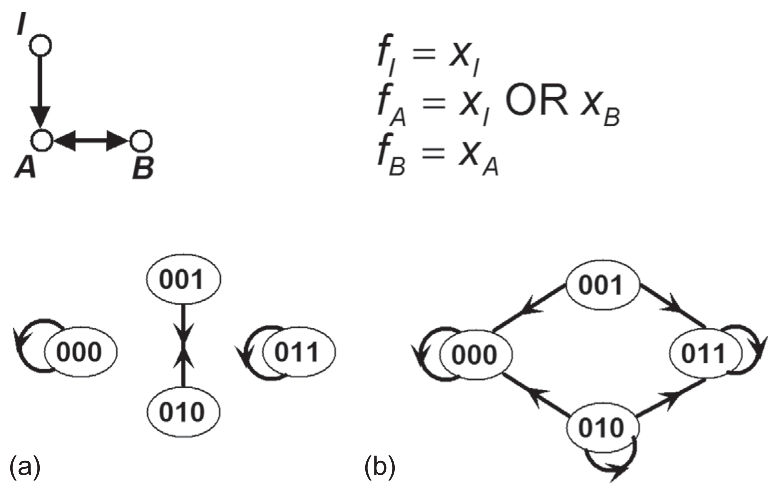


FIGURE 4.7 A simple signal transduction network composed of a source node I and two nodes, A and B, which form a mutual activation loop. It is assumed that the positive inputs from I and B are independently sufficient to activate node A. (a) The network's state transition graph corresponding to synchronous update, when the signal is OFF ($x_I = 0$). The states are specified in the node order I, A, B. (b) The state transition graph corresponding to general asynchronous update, when the signal is OFF ($x_I = 0$).