Time: 60 mins   Total marks: 15

- **The exam is open book and notes.**

- **Results/proofs covered in class/problem sessions/assignments may simply be cited, unless specifically asked for.**

- **Unnecessarily lengthy solutions will be penalized.**

- **If you need to make any assumptions, state them clearly.**

- **Do not copy solutions from others or indulge in unfair means.**

You are the Chief Technical Officer of AllAsync, Inc. So far, your company has developed only one product: P, which has two input ports and two output ports, as shown in Fig. 1a. The company division that produced this product has made available an automaton describing the behaviour of this product, as shown in Fig. 1b.
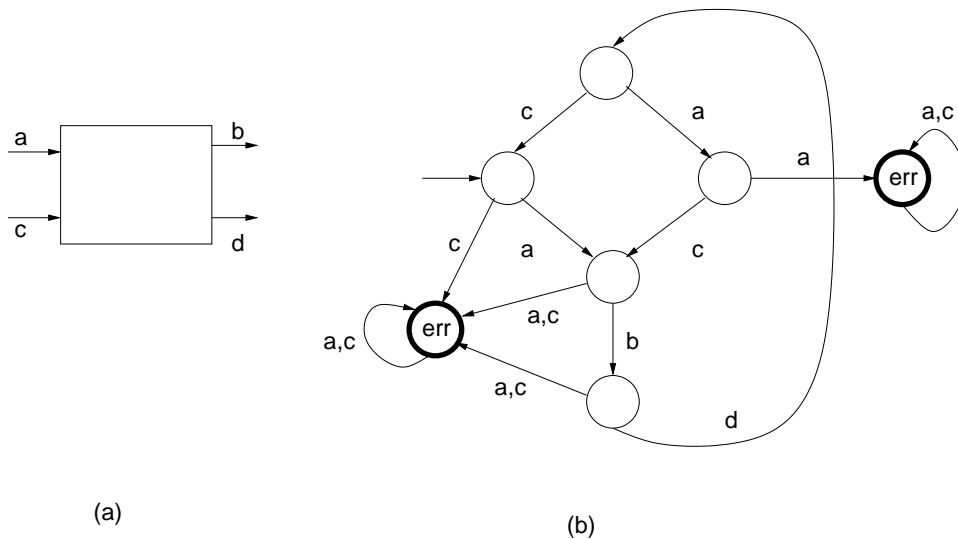

(a)   (b)

Figure 1: Product catalogue of AllAsync, Inc.

An important client, AsyncUsers Ltd., calls you and asks for a custom product, Q, also with two input ports and two output ports, but whose behaviour is given by the automaton in Fig. 2b. The cost of designing this product from scratch is way too high for AllAsync to afford. At the same time, AllAsync would not like to lose AsyncUsers' order. So, as CTO of AllAsync, you first try to see if P can be sold as Q. Unfortunately, the behaviour of P is not the same as that of Q. Already in panic mode, you must now see if two units of product P can be composed to obtain the behaviour of Q. If this fails, AllAsync stands to lose AsyncUsers' order, so the stakes are really high!

1. *[15 marks]* Is it possible to compose two units of P to obtain a product that works properly as Q? More specifically, we wish to know if it is possible to connect two units of P, such that (i) none of the P units malfunction if the environment obeys the protocol described in Fig. 2b, and (ii) the

Protocol with environment: P = x? –> y? –> P1
                            P1 = z! –> (x? –> y? || w!) –> P1
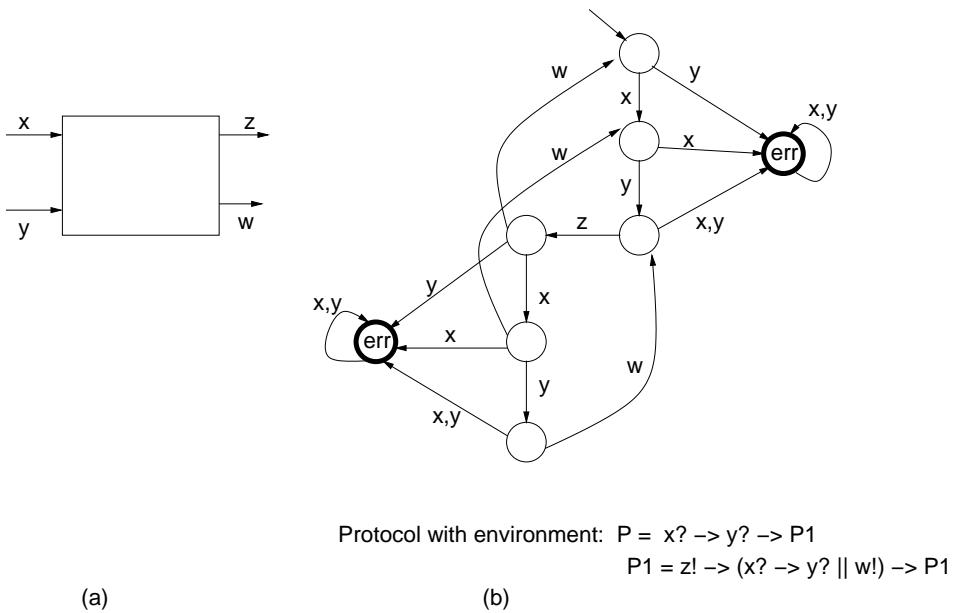
(a)   (b)

Figure 2: Requirement from AsyncUsers Ltd.

composed unit never produces output events in violation of the protocol. Note that we require none of the P units to malfunction (i.e., enter into its error state).

Regardless of whether your answer is in the affirmative or negative, you must show how you wish to connect the two units of P (which input of which unit to which output of which unit). You must also draw the automaton representing the behaviour of the composed system. In the automaton, you need not hide internal signals. Indicate which state transitions in the composed automaton are never taken because of the protocol described in Fig. 2b.

A simple "Yes" or "No" answer will fetch no marks.

Hint: Spend a few minutes trying to understand what could be a meaningful way of connecting two P units to realize the desired behaviour of Q. It pays to obtain some intuition about the problem before plunging into it. Problem solving is not always a mechanical procedure.