Practice Questions on FSM Testing

Answer the following questions for FSM M in Figure 1.

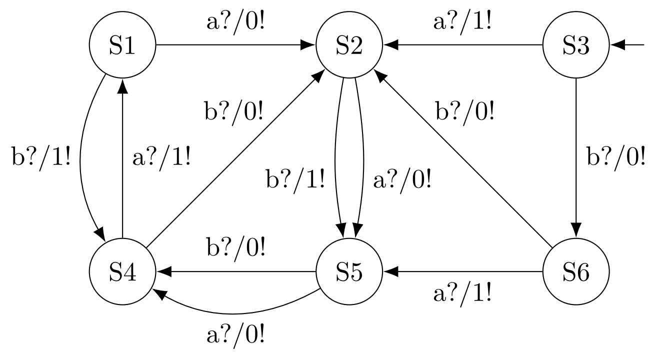

Figure 1: FSM M

1. Calculate λ^* (S3, a? a? a? b? a? a? b?).

> **Solution:** λ^*(S3, a? a? a? b? a? a? b?) = 1! 0! 0! 0! 0! 0! 0!

2. Provide a state tour (i.e., a sequence that reaches all states), or explain why it does not exist.

> **Solution:** b? a? b? a? a?

3. Provide a transition tour (i.e., a sequence that reaches all transitions), or explain why it does not exist.

> **Solution:** A transition tour does not exist as: a) you cannot reach state $S3$ after leaving it, and b) from $S3$, you have to choose either a? or b?. From the above two observations, one can conclude that one of the transitions of $S3$ will never be reached (in the context of a transition tour!).
>
> Other answers are also possible (state $S6$, for instance).

4. Provide a synchronising sequence to each state.

> **Solution:** A synchronising sequence for $S3$ does not exist as this state does not have any incoming transition. Similarly, a synchronizing sequence for $S6$ does not exist: you cannot reach $S6$ after leaving it.
>
> The sequence $\sigma =$ b? b? a? b? a? b? is a synchronizing sequence for state $S4$. By extending this sequence, we obtain synchronizing sequence σ a? for $S1$, synchronizing sequence σ a? a? for $S2$, and synchronizing sequence σ a? a? a? for $S5$.

5. Provide a distinguishing sequence, or explain why it does not exist.

Solution: a? b? a? b?

State	Output
S1	0 1 0 0
S2	0 0 1 1
S3	1 1 0 0
S4	1 1 1 1
S5	0 0 1 0
S6	1 0 1 1

6. Provide Unique Input/Output sequence(s) for each state.

Solution: The distinguishing sequence is also a UIO for every state.

7. A *homing sequence* is a sequence of input symbols such that the final state after applying it can be determined by looking at the outputs.[1] Formally, a sequence $x \in I^*$ is *homing* if, for every pair of states q, q', $\delta^*(q,x) \neq \delta^*(q',x) \;\Rightarrow\; \lambda^*(q,x) \neq \lambda^*(q',x)$. Like synchronising sequences, homing sequences are used for constructing test suites for FSMs without reset. Show that every synchronising sequence is a homing sequence, but that the converse is not true. Provide a homing sequence for FSM M containing at most 4 input symbols.

Solution: A sequence $x \in I^*$ is synchronising if, for every pair of states q, q', $\delta^*(q,x) = \delta^*(q',x)$. Thus trivially any synchronising sequence is homing. Sequence a? b? b? b? is homing for M but it is clearly not synchronising, since after x we can be in $S2, S4\ and\ S5$.

Output	State
0 0 0 0	S2
0 0 1 0	S4
0 1 0 1	S5
1 0 0 1	S5
1 1 0 0	S2
1 1 0 1	S5

If σ is a distinguishing sequence then for all distinct states q and q', $\lambda^*(q,x) \neq \lambda^*(q',x)$. Thus trivially also any distinguishing sequence is homing, and in particular the sequence a? b? a? b? is a homing sequence for M.

8. Make tests for state S3, and explain why these tests test S3.

Solution: The lecture slides do not define precisely how to 'test a state', but a straightforward way is to go to S3, and execute a characterisation set to check that we are in the right state. An access sequence to S3 is ϵ, and a characterisation set is {a? b? a? b?} (because this is a distinguishing sequence). So a test suite for S3 would be {a? b? a? b?}.

[1] In contrast, a distinguishing sequence is a sequence of input symbols such that the state *before* applying it can be determined by looking at the outputs.

9. Make tests for transition S4 $\xrightarrow{b?/0!}$ S2.

Solution: Again, the lecture slides do not define precisely how to 'test a transition', but a transition should have the correct output and the correct destination state, so we

a) make a test to observe the output, and

b) add tests for the destination state, using a characterisation set.

We can take the transition S4 $\xrightarrow{b?/0!}$ S2 with input sequence b? a? b? b?, and a characterisation set is {a? b? a? b?} (because this is a distinguishing sequence), so the set {b? a? b? b?, b? a? b? b? a? b? a? b?} would test the transition (or, optimised, {b? a? b? b? a? b? a? b?}).

10. Consider an implementation i which passes all tests (as made above) for all states and transitions in the FSM. Under which conditions can we conclude that i is correct with respect to the FSM?

Solution: Testing all states as above yields $A \cdot C$, and testing all transitions yields $A \cdot I \cdot C$, so together this makes a 0-complete test suite. Thus, i has at most 6 states and passes all the tests then it conforms to specification M.