CMU 15-671	Models of Software Systems	Fall 1997

State Machines 2 & Statecharts

Garlan	Homework 5	Due: 29 September 1997

Problem 1.

The following problem description, very slightly modified, is sometimes referred to as "Kemmerer's library problem."

> Consider a small library system with the following actions:
>
> 1. Check out a copy of a book. Return a copy of a book.
> 2. Add a copy of a book to the library. Remove a copy of a book from the library.
> 3. Get the list of books by a particular author or in a particular subject area.
> 4. Find out the list of books currently checked out by a particular borrower.
> 5. Find out what borrower last checked out a particular copy of a book.
>
> There are two types of users: staff users and ordinary borrowers. Actions listed in 2, 4, and 5 are restricted to staff users, except that ordinary borrowers can perform action 4 to find out the list of books currently borrowed by themselves.
>
> The library system must satisfy the following invariants:
>
> 1. All copies in the library must be available for checkout or be checked out.
> 2. No copy of a book may be both available and checked out at the same time.
> 3. A borrower may not have more than a predefined number of books checked out at one time.
> 4. A borrower may not have more than one copy of the same book checked out at one time.

Since the above description is written in English, there are some natural ambiguities and you will need to resolve them in your formalization below. Thus, you may find that in doing Parts A-C, you iterate through different solutions for Part A. This is perfectly normal and in fact, expected!

Part A. Write a state machine description of the library system. This will require you to define the state space (i.e., the set of state variables and their types), the initial states, the actions, and the transition relation. Use pre- and post-conditions to specify the behavior of actions. Use a balance of both pre-conditions and exceptional termination conditions to best characterize the behavior of a library in real life. See the middle of p. 9 of Handout 6 for the template to use to describe your actions.

Part B. Given your formalization of the library in Part A, answer the following questions and explain your answer by referring to your state machine description.

1. Is there a difference between a book and a copy of a book?
2. Can a user be both a staff person and an ordinary borrower?
3. Can two different users have different copies of the same book?
4. What assumptions do you need to make about the initial state of the library?

Part C. Formally characterize each of the second and third invariants as an predicate. For each, show that your actions preserve it.

Problem 2.

For these questions, use the following system description of the OfficePhone2000:

> The OfficePhone2000 will be available when the phone is on the hook, and busy otherwise.
>
> When the phone receives an incoming call, it will determine whether the phone is busy or available. If the phone is busy, the incoming call will be forwarded to the voice mail unit; if the phone is not busy, then the phone will ring. The phone will stop ringing if the caller hangs up; if the phone is still ringing after 10 seconds, the call will be sent to the voice mail unit and the phone will stop ringing.
>
> The voicemail part of the OfficePhone2000 will wait for calls to be forwarded to it. When a call is forwarded to it, it will play the recording. When the end of the recording is reached, the voicemail unit will begin recording, indicating this with a "beep". If the caller hangs up at any time after being forwarded to the voicemail unit, the voicemail unit will stop whatever it is doing and resume waiting for another call to be forwarded to it. If the recording had begun, the voicemail indicator on the phone will start flashing; when messages are cleared, the indicator will stop flashing.
>
> If the user of the phone presses the "supervisor" button on the phone, the voicemail unit will be deactivated; if there are any callers in the voicemail system and the phone is available, the phone will ring until the phone is either busy or the caller hangs up. If the phone is busy when this happens, the caller will be disconnected. No calls will be forwarded to the voicemail unit and the indicator will not flash until the voicemail unit is reactivated; reactivating the voicemail unit will resume flashing the indicator as appropriate. While the voicemail is inactive, incoming calls will be held until the phone is available. Voicemail can be reactivated by pressing the "supervisor" button again.

1. Draw the statechart.
2. For what events and under which conditions is the behavior of this system undefined, if any? I.e., are there events that cannot happen in our interpretation of labels, but which should be defined?
3. If drawn as a state machine, approximately how many states would be needed to draw your statechart?