CS 428/528 Lecture 16: Statecharts

March 7, 2024

Based on the SCP87 and LICS87 paper by Harel et al

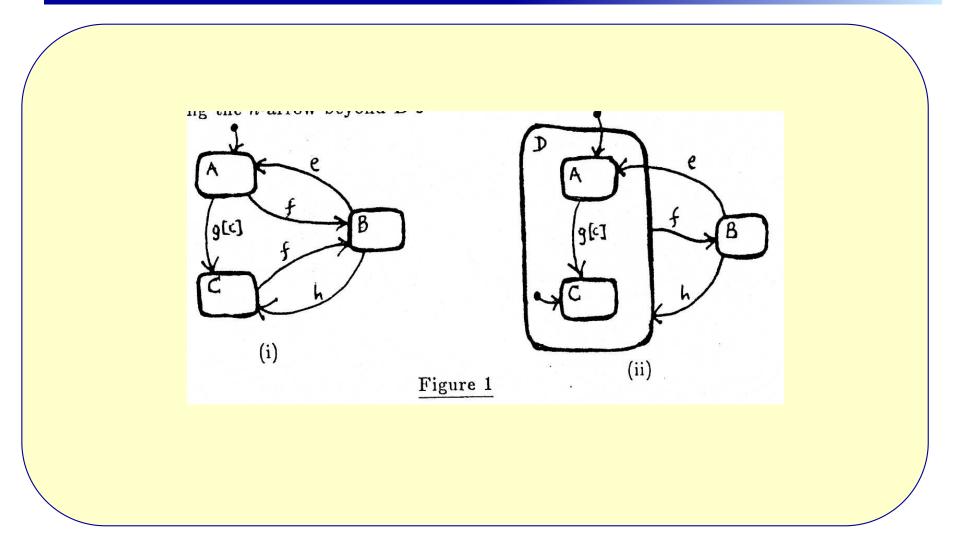
Limitations of State Machines

- » They are too flat (no depth, hierarchy, or modularity; no support for stepwise, topdown, or bottom-up development)
- » They are uneconomical when modeling transitions (e.g., high-level interrupt)
- » Infeasible because of too many states
- » No support for concurrency

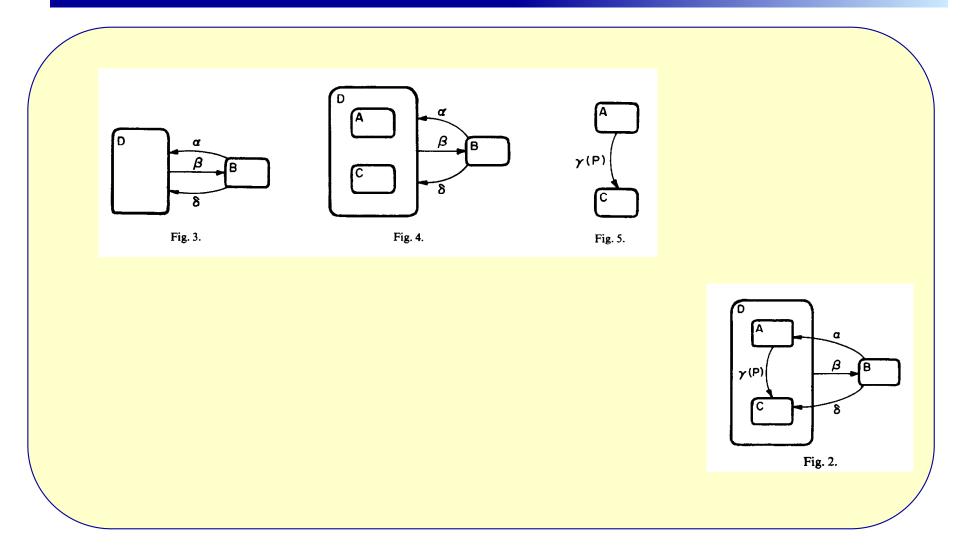
Statecharts

» Statecharts = state-diagrams + depth + orthogonality + broadcast communications

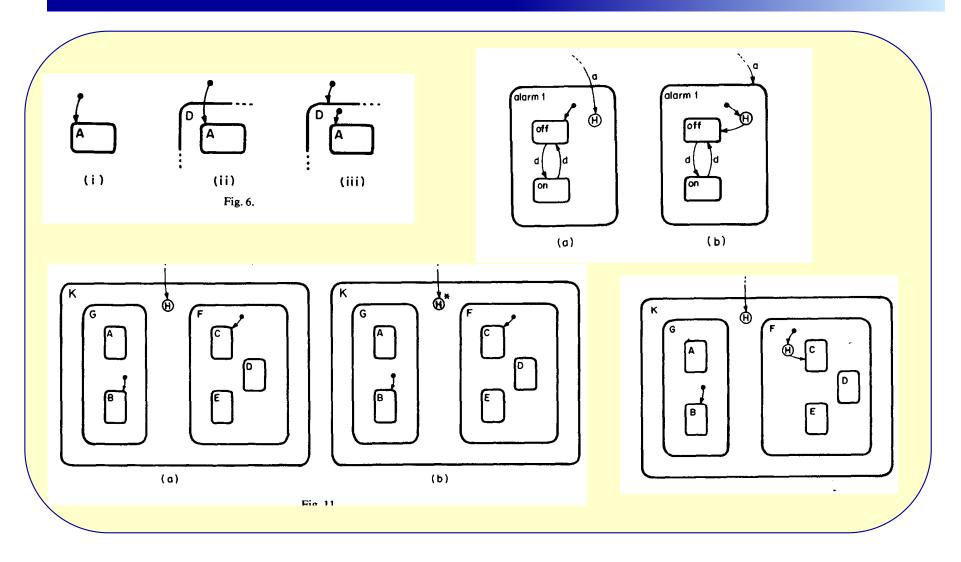




Depth + Stepwise Refinement



Depth: Default State & Enter-by-History

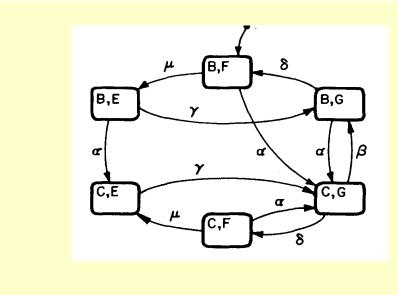


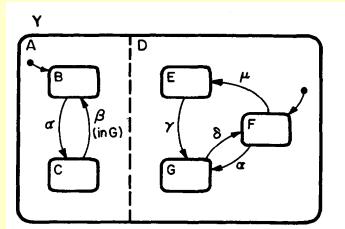
is in B or in C in its A component. Both behaviors are part of the *orthogonality* of A and D, which is the term we use to describe the AND decomposition.

Figure 20 is the conventional AND-free equivalent of Fig. 19. The reader will no doubt realize that Fig. 20 contains six states because the components of Fig. 19 contained two and three. Clearly, two components with one thousand states each would result in one *million* states in the product. This, of course, is root of the exponential blow-up in the number of states, which occurs when classical finite-state automata or state diagrams are used, and orthogonality is our way of avoiding it.

Note that the β -transition from C to B has the condition "in G" attached to it, with the obvious consequences, shown explicitly in Fig. 20. Thus, while Y has indeed been split into two orthogonal components, there will in general be some dependence. The "in G" condition causes A to depend somewhat on D, and indeed to 'know' something about the inner states of D. Formally, orthogonal product is a generalization of the usual product of automata, the difference being that the latter is usually required to be a *disjoint* product, whereas here some dependence between components can be introduced, by common events or "in G"-like conditions.

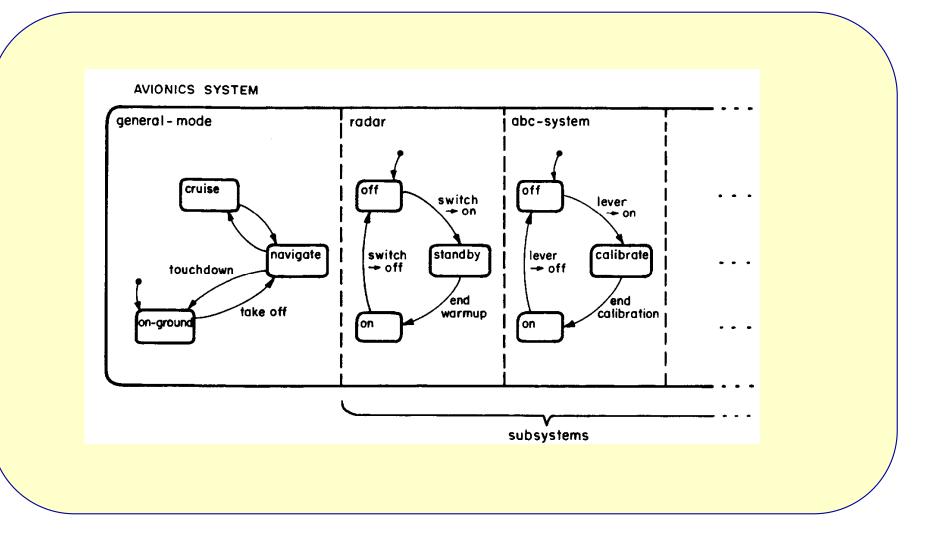
irrency)



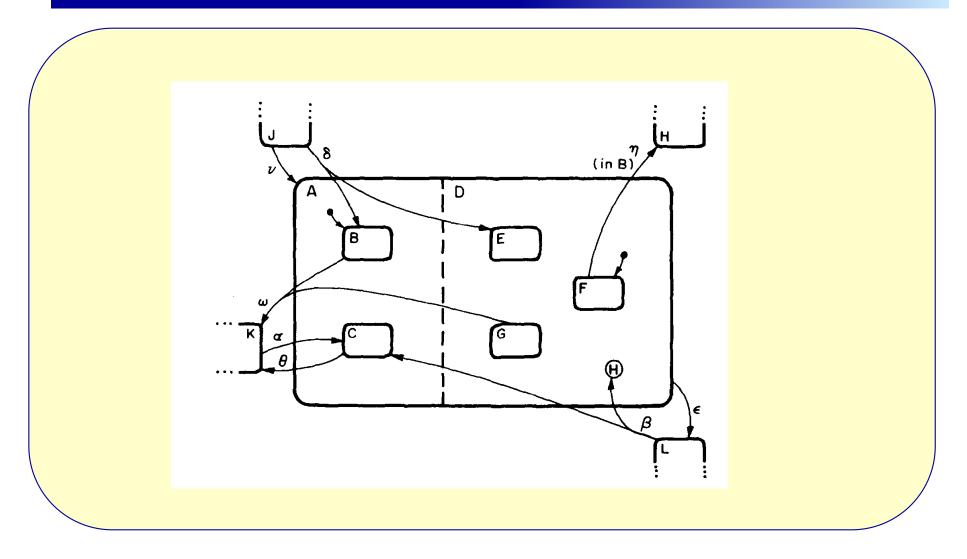


One slightly bothersome notational problem is the lack of an appropriate location for the name "Y". The product state Y will, in general, lie within some superstate Z, to which the area outside the borderline of the (A, D) box 'belongs'. Of course, it is possible to use an additional box as in Fig. 21(a). We prefer to try managing without the name Y or simply to attach it to the outside as in Fig. 21(b).

Orthogonality (or Concurrency)



Orthogonality (or Concurrency)



Broadcast Communication

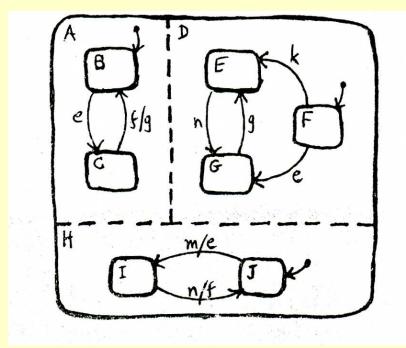


Fig. 4 shows a simple example of this. If we are in (B, F, J) and along comes the external event m, the next configuration should be (C, G, I), by virtue of e being generated in H and triggering the two transitions in components A and D. This is a *chain reaction* of length 2. If now external event n occurs, the new configuration will be (B, E, J), by virtue of a similar chain reaction of length 3.

D. Harel

D is default among D and B, and A zooming in and out the latter has c halogous to the start states of finite-s ow introduce our running example. T a main display area and four smalle ttons denoted here a, b, c and d. See Fig.

> a CITIZEN CITIZEN 12:31^{AM} 12:31^{AM} Fig. 7.

24 hour time modes) or the date (d me (beeps on the hour if enabled), tv nd regular display modes, and a 1/10 tery blinking indication, and a beep ain functions of these are known, an weakens' to denote certain events of c ngs complete one would have to tie the sical parts of the system, or to specieparately specified, components.

n external events will be the depressing and releasing of t denotes button a being depressed, and " \hat{a} " denotes it beinwill be certain internal ones too. The distinction is sharpene

hark here that while the description of the watch presented herein is to be as faithful to its actual workings as possible, there are some very erences that are not worth dwelling upon here, and that most likely will acted in normal use of the watch. The point is, however, that the statechart th (cf. Fig. 31) was obtained by the author using the obviously inapproprid of observation from the final product; had it been the basis for the

am/pm or 24 hour time modes) or the date (day of month, month, day of week), it has a chime (beeps on the hour if enabled), two independent alarms, a stopwatch (with lap and regular display modes, and a 1/100 s display), a light for illumination, a weak battery blinking indication, and a beeper test. We shall assume throughout that the main functions of these are known, and will use liberal terminology, such as 'power weakens' to denote certain events of obvious meaning, though, of course, to make things complete one would have to tie these events up with actual happenings in the physical parts of the system, or to specify them as output events produced

The main external events will be the depressing and releasing of buttons (e.g., event "a" denotes button a being depressed, and " \hat{a} " denotes it being released),

intended to be as faithful to its actual workings as possible, there are some very minor differences that are not worth dwelling upon here, and that most likely will not be detected in normal use of the watch. The point is, however, that the statechart of the watch (cf. Fig. 31) was obtained by the author using the obviously inappropriate method of observation from the final product; had it been the basis for the initial specification and design of that final product, in the spirit of the gradual development presented below, the undescribed anomalies might have been avoided.

