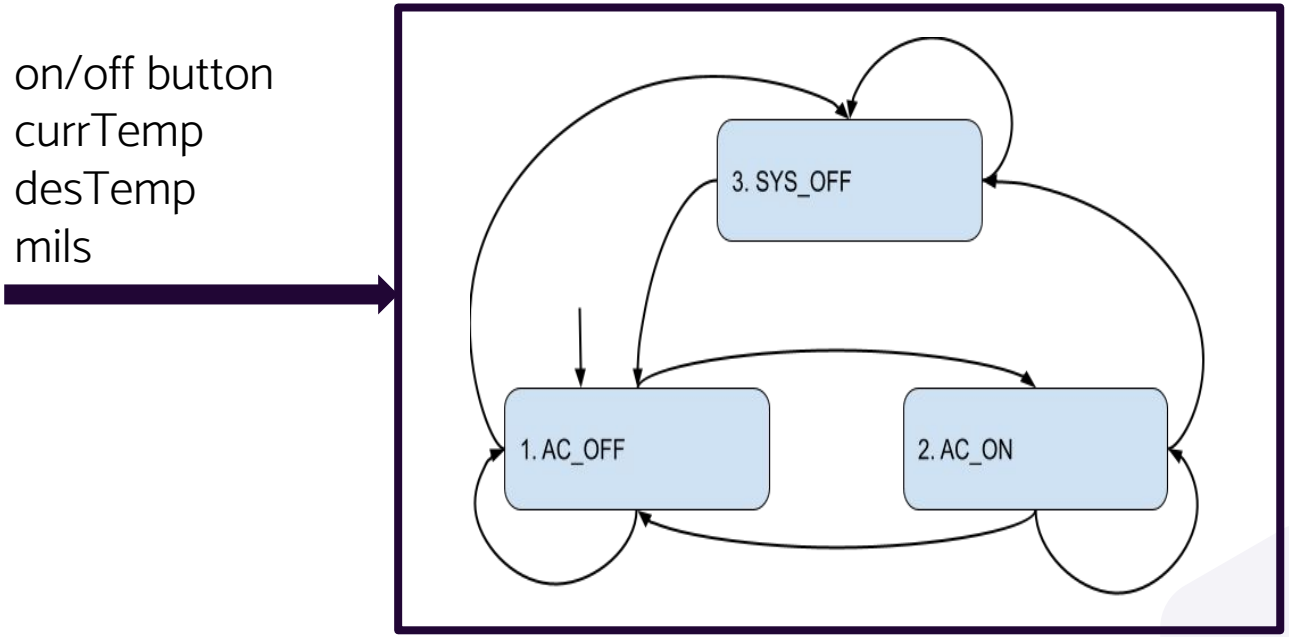
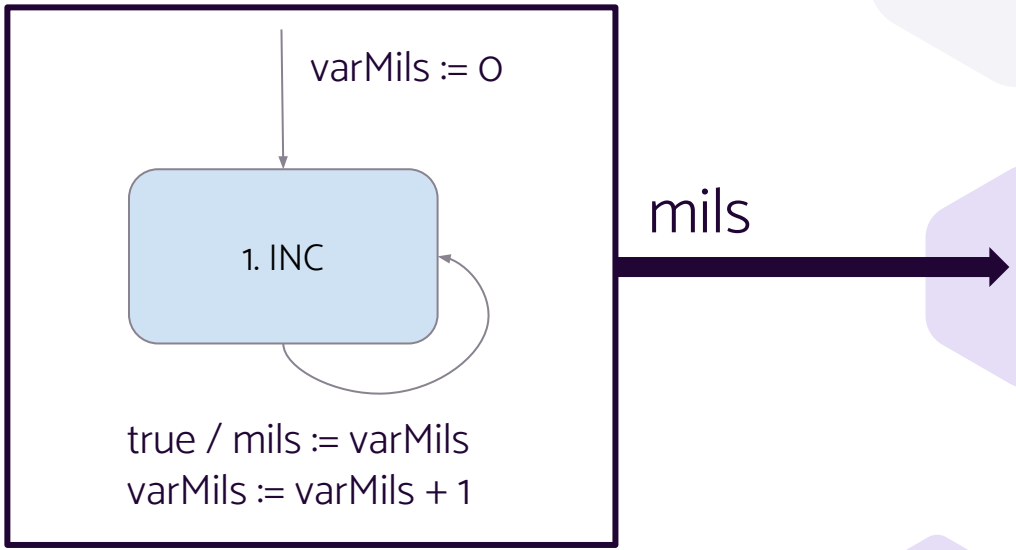
30: Hybrid systems

AC model from prelab

on/off button
currTemp
desTemp
mils



Modeling mils



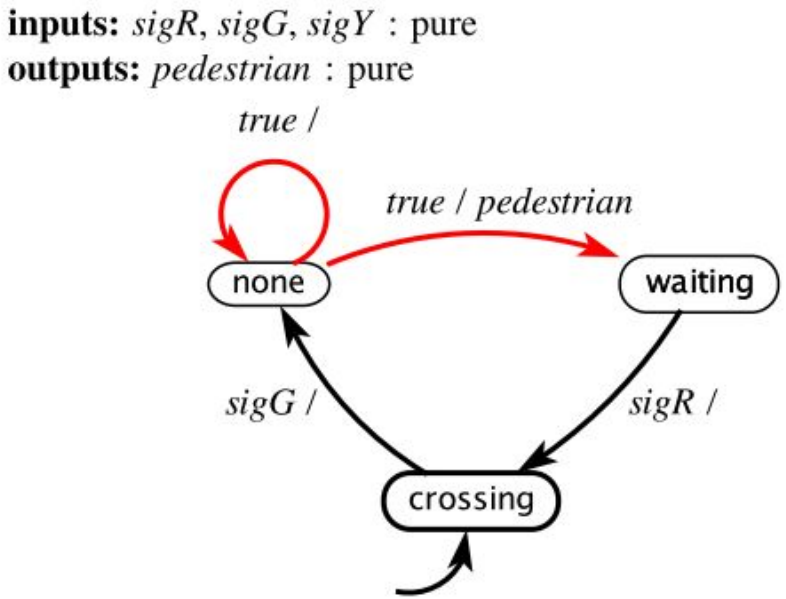
How do we model:

- *Current temp*
- *Desired temp*
- *Button push*

Nondeterminism

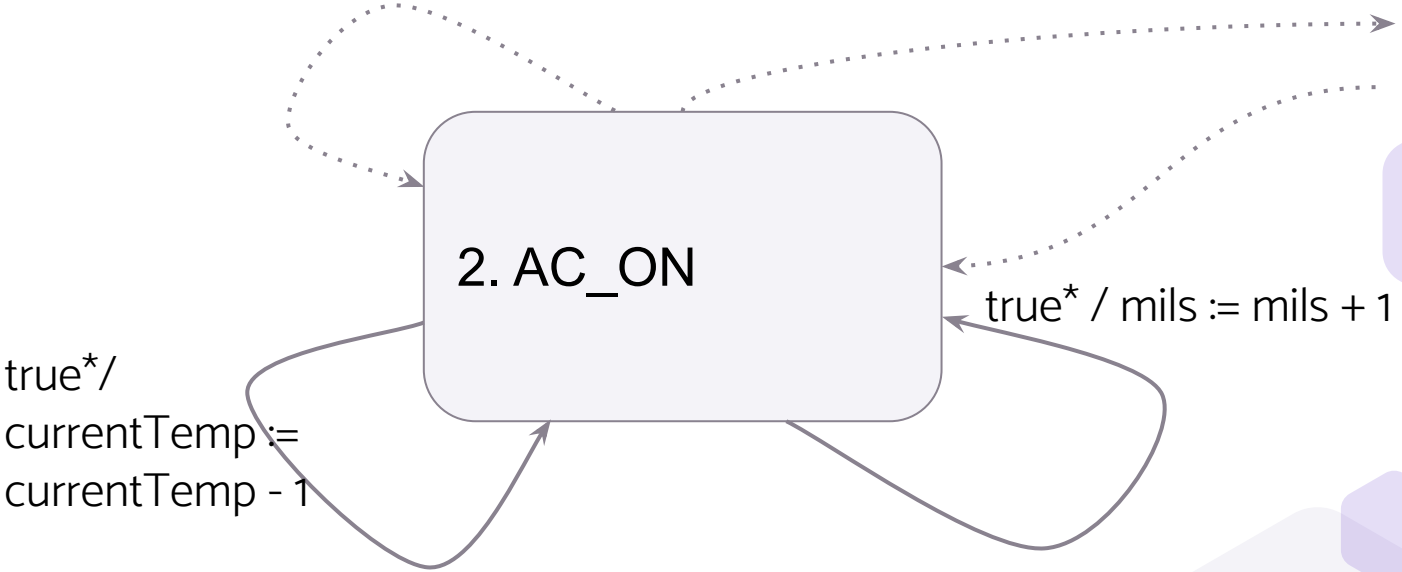
Guards out of a state are not mutually exclusive

- Reason about the “possible set of states” a system can be in
- Useful for modeling environment



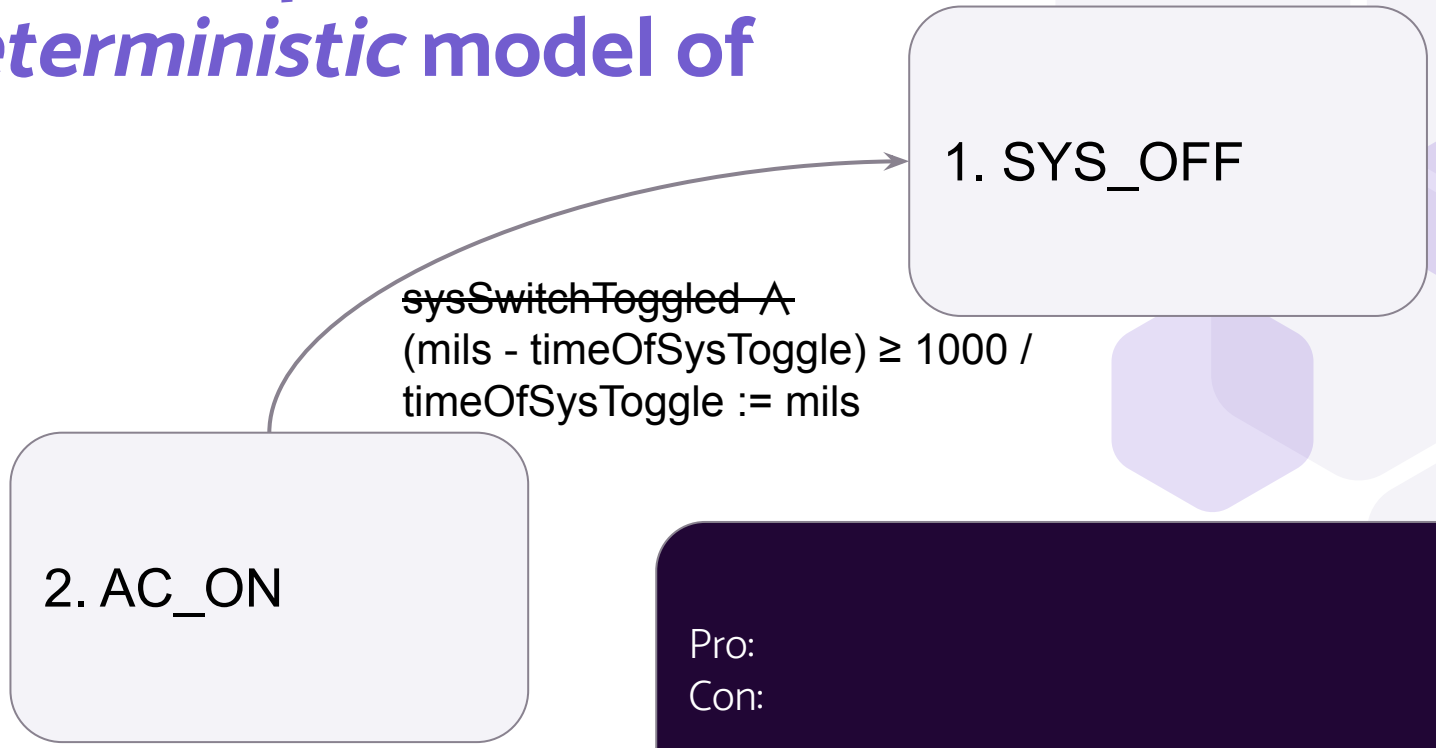
Lee/Seshia fig. 3.11

AC model composed with very simplified, *non-deterministic* model of current temp and time



*we would actually have to make sure that these transitions aren't taken if we need to leave state 2, e.g. ¬(sysSwitchToggled ∧ (mils - timeOfSysToggle) ≥ 1000)

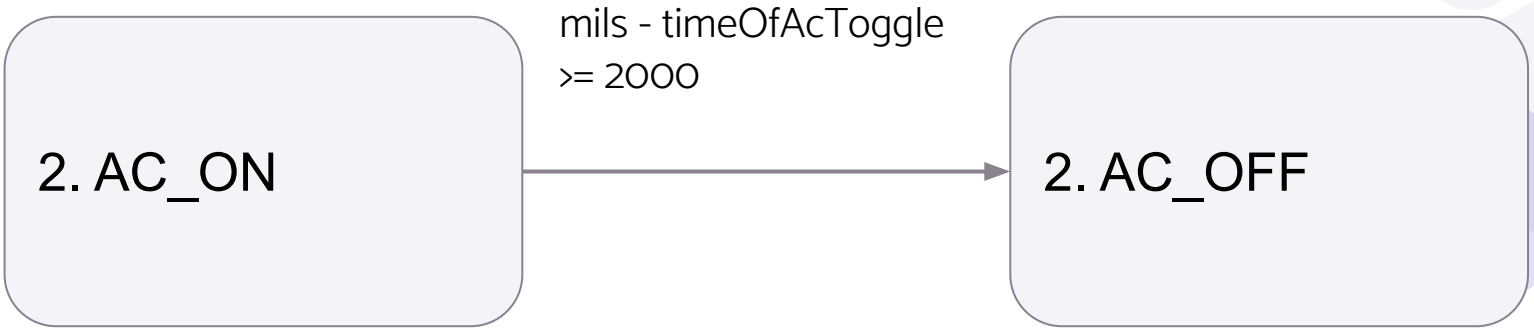
AC model composed with *non-deterministic* model of button



Pro:

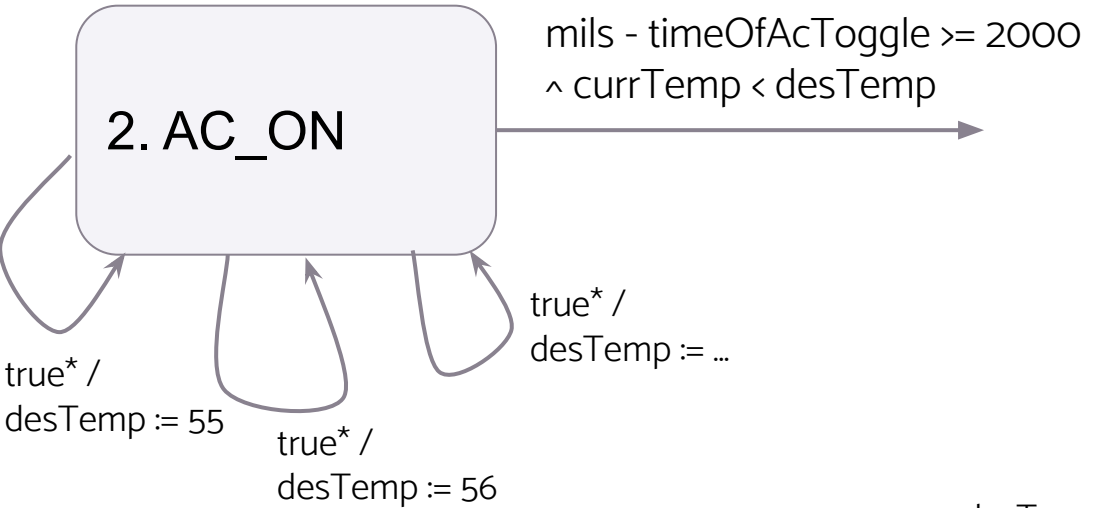
Con:

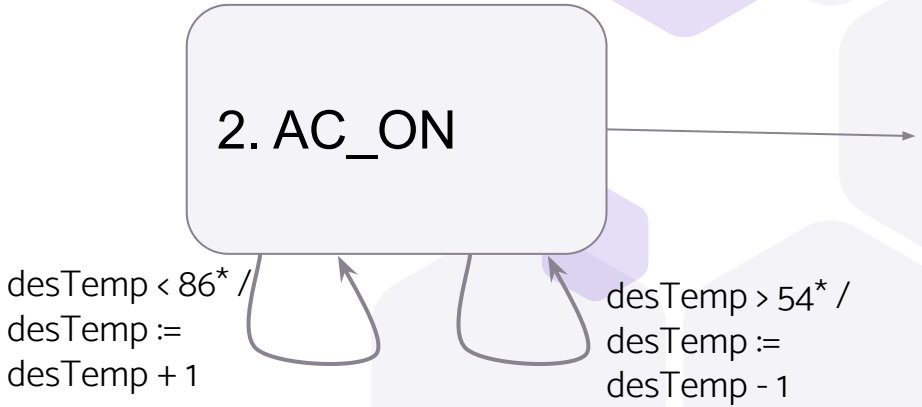
Composing with model of desired temp: option 1



We lose ability to prove things like:
(desTemp > curTemp ⟶ eventually AC_ON)

Composing with model of desired temp: options 2 and 3





What are we missing out on when we tell time by using “mils” as an input?

ODEs

Sometimes it is more desirable to describe a variable in terms of how it changes rather than its explicit form

Useful for: modeling, reasoning

Define a function in terms of its derivative and possibly initial conditions

Ordinary Differential Equation, or ODE

Solving general ODEs is beyond the scope of the class, but we will discuss some patterns here

Example: falling ball

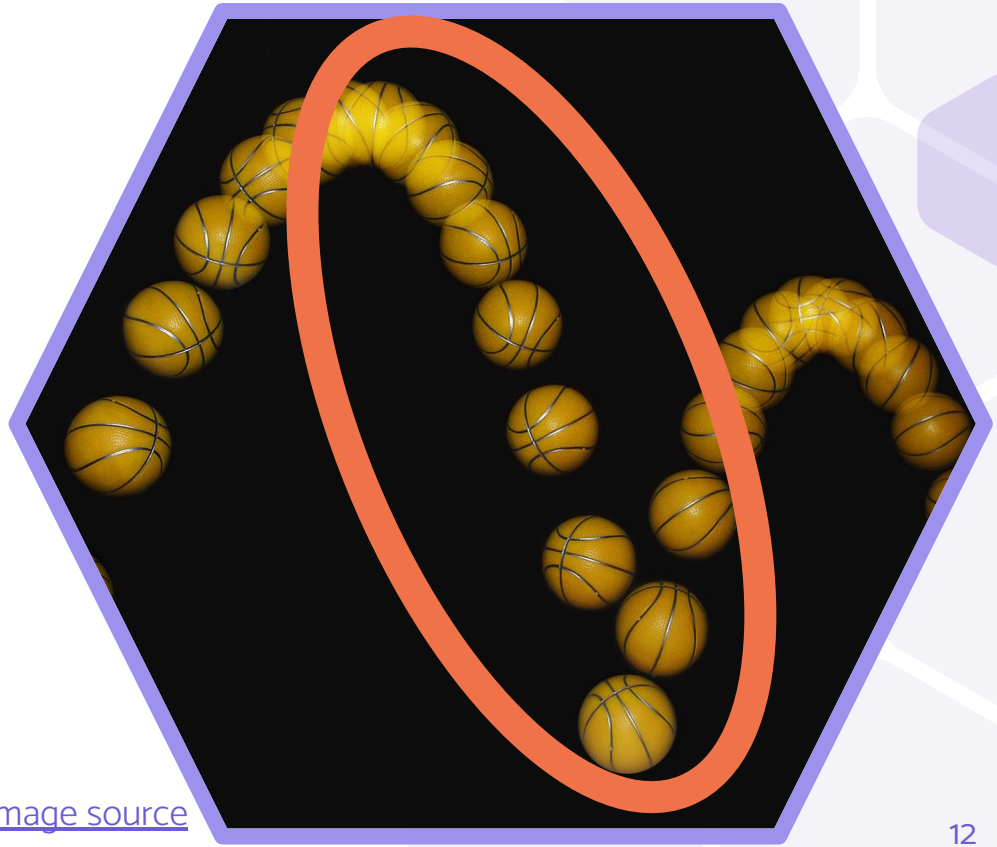
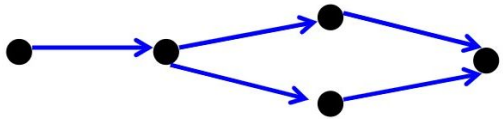


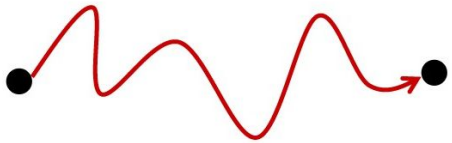
Image source

Hybrid systems

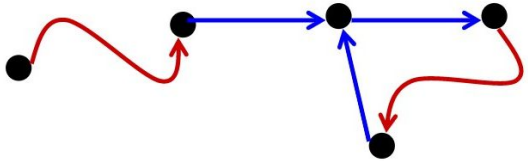
Discrete System (FSM)

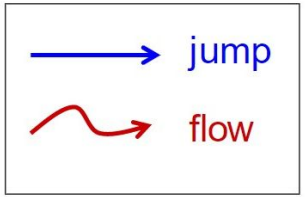


Continuous System



Hybrid System





Slide from Prabal Dutta and Sanjal A. Seshia, 2019

Timed automata

Distinction between discrete and continuous variables

Continuous behavior defined in “states”

Now called “modes”

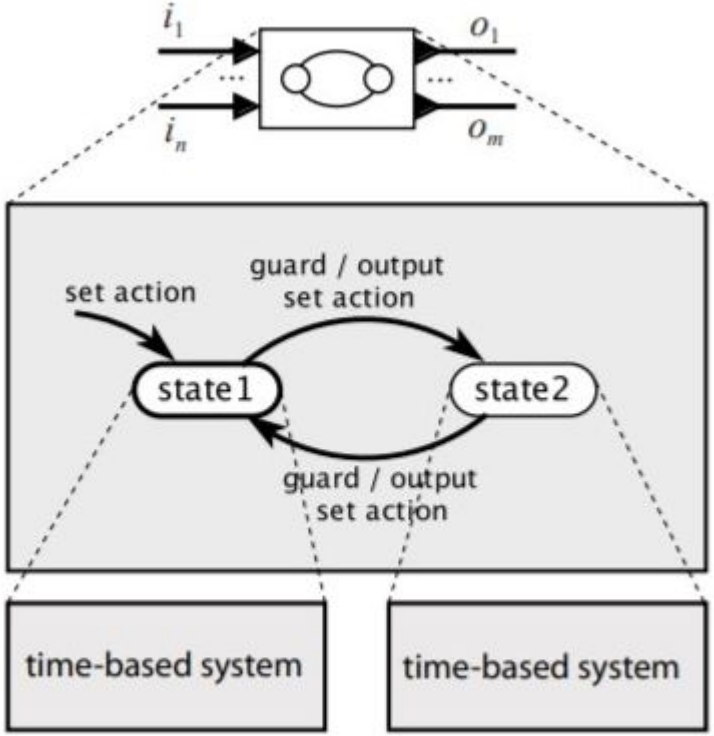


Figure 4.4: Notation for hybrid systems.

Lee/Seshia chapter 4

Example: bouncing ball

Board discussion

Image source

Discussion of homework problems