29: Extended state machines, non-determinism and composition
Formalizing FSMs

We handwaved some aspects of FSMs

✔ Role and behavior of inputs and outputs
✔ Presence/absence of self-loops

Distinction between FSMs and extended SMs

Why non-determinism might be useful

How to compose systems
Keeping track of data

An FSM is a 5-tuple: (States, Inputs, Outputs, update, initialState)

How do we keep track of internal data?

Example: system with yes/no vote buttons, keep track of difference in votes (board example)
Vote counter

Inputs:
Yes : pure (present, absent)
No : pure

Output:
Diff : integer

Variables:
voteDiff : integer
FSM vs Extended SM

Figure 3.3: Visual notation for a finite state machine.

Figure 3.9: Notation for extended state machines.

Lee/Seshia chapter 3
Review: Embedded systems as distributed systems
Composition of automata

Figure 5.2: Side-by-side composition of two actors.

Figure 5.7: Cascade composition of two actors.

Lee/Seshia chapter 5
Figure 5.8: Example of a cascade composition of two FSMs.

Figure 5.9: Semantics of the cascade composition of Figure 5.8, assuming synchronous composition.
Feedback loops in automata

Really powerful concept: if we can model the environment and compose it with the model of the software, now we have a closed system and proofs about the system only depend on transitions between states.

Figure 6.1: Any interconnection of actors can be modeled as a single (side-by-side composite) actor with feedback.

Figure 15.1: Open and closed systems.
AC model from prelab

on/off button
currTemp
desTemp
mils
Modeling mils

1. INC

```plaintext
varMils := 0
true / mils := varMils
varMils := varMils + 1
```
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

inputs: sigR, sigG, sigY : pure
outputs: pedestrian : pure
true /

true / pedestrian

none

waiting

sigG /

sigR /

crossing

Lee/Seshia fig. 3.11