Project demo on Dec 12!

28: Modeling
FSM-based design for software

- Incorporates reasoning about state into design
- Translates pretty easily to code
- Guides unit testing

Can we formalize how we talk about FSMS to help prove properties about the system?

Can we incorporate hardware/physics into our state-based model?
Formal verification

Does the model of the system meet the requirements?

- Formal definition of model (today/next week)
- Formal definition of requirements (later)

Required or recommended by some safety standards at high SILs
FSMs as models

FSM describes behavior of the system
Abstracts away some aspects of the system
What do you think when you hear “all models are wrong, some models are useful”?
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
Back to the formal definition

(Lee/Seshia 3.3.3)

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

- States is a finite set of states
- Inputs is a set of input valuations
- Outputs is a set of output valuations
- update: States x Inputs → States x Outputs is an update function
- initialState is the initial state
FSM for system with indicator light - TT

System with two switches and indicator light

On/off switch: if off, no response to light switch and light is off

Light switch: if system is on, light is on if switch is on and vice versa

FSM = (States, Inputs, Outputs, update, initial State)

States = {OFF, LIGHT ON, LIGHT OFF}

Inputs = OF in {true, false}
   LS in {true, false}

Outputs = LT in {true, false}

update(OFF, true, true) -> (LIGHT ON, true)
...
update(OFF, false, false) -> (OFF, false)

initial State = OFF
Valuation

(Lee/Seshia 3.3.3)

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Valuation: a set of values that a signal can take on or the assertion that the value is absent

**Numerical** signals: R U {absent} or N U {absent}
**Pure** signals: {present, absent}
**Categorical** signals: examples {1, 2, 3, ... 8, absent} or {true, false, absent}
Present vs. Absent

For a discrete system, events for an input:

- Are discrete (separate, individual events)
- Happen in sequence

absent means “absence of an event,” while a value means “we received/sent this value”

changes depending on assumptions/implementation of model

Light switch: moment where it gets flipped to on or off

Push button as pure signal: event is the push of a button
FSM for system with indicator light - ET

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**Light switch:** if system is on, light is on if switch is on and vice versa

**OF =** {true, false, absent}

**LS =** {true, false, absent}

**LT =** {on, off, absent}
Time/event triggered design

**Purely time-triggered**
(Our implementations are time-triggered)
We call updateFSM with all inputs periodically
All inputs are present for every update (event is the action of polling input)

**Event-triggered**
(Would get complicated to implement using our template)
Transition the FSM based on a change in input (e.g. interrupt)
Not all inputs may be present for every update