Sharif University of Technology
Department of Computer Engineering

# Embedded System Design

## StateCharts (Cont.) (8)

A. Ejlali

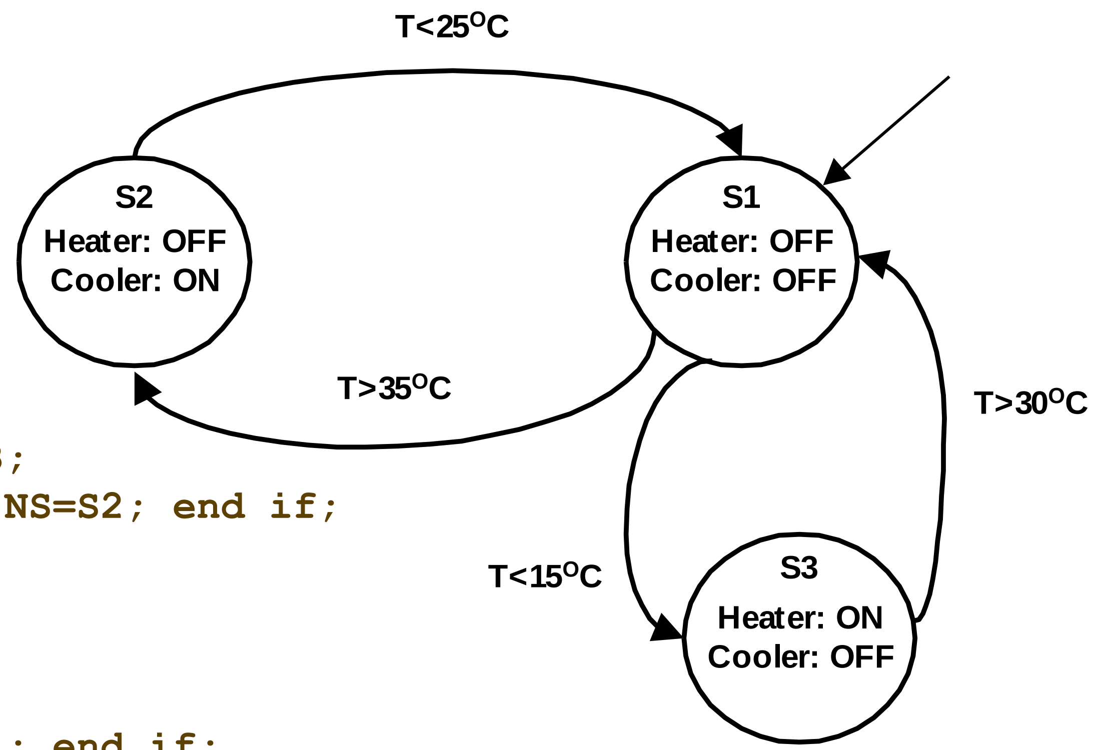
# Moore and Mealy Automata

- Moore:
  - Output reactions are assigned to the nodes of an automaton
- Mealy:
  - Output reactions are assigned to the arcs of an automaton

  - Mixed Moore-Mealy automata are also possible.

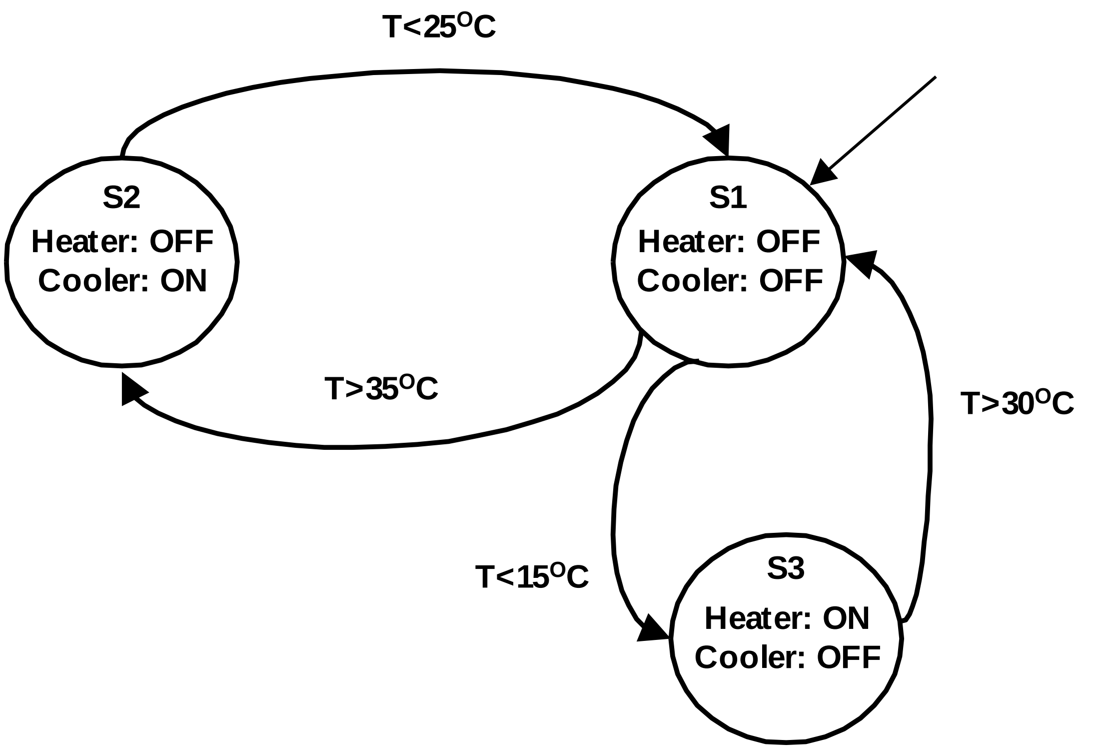
# Example: Moore

```
State PS=S1,NS;
Event e;

while(1){
  case(PS){
    S1:
      Turn_off(Heater);
      Turn_off(Cooler);
      e=Wait_for_event();
      if(e=='T<15') NS=S3;
      else if(e=='T>35') NS=S2; end if;
    S2:
      Turn_off(Heater);
      Turn_on(Cooler);
      e=Wait_for_event();
      if(e=='T<25') NS=S1; end if;
    S3:
      Turn_on(Heater);
      Turn_off(Cooler);
      e=Wait_for_event();
      if(e=='T>30') NS=S1; end if;
  }
  PS=NS;
}
```

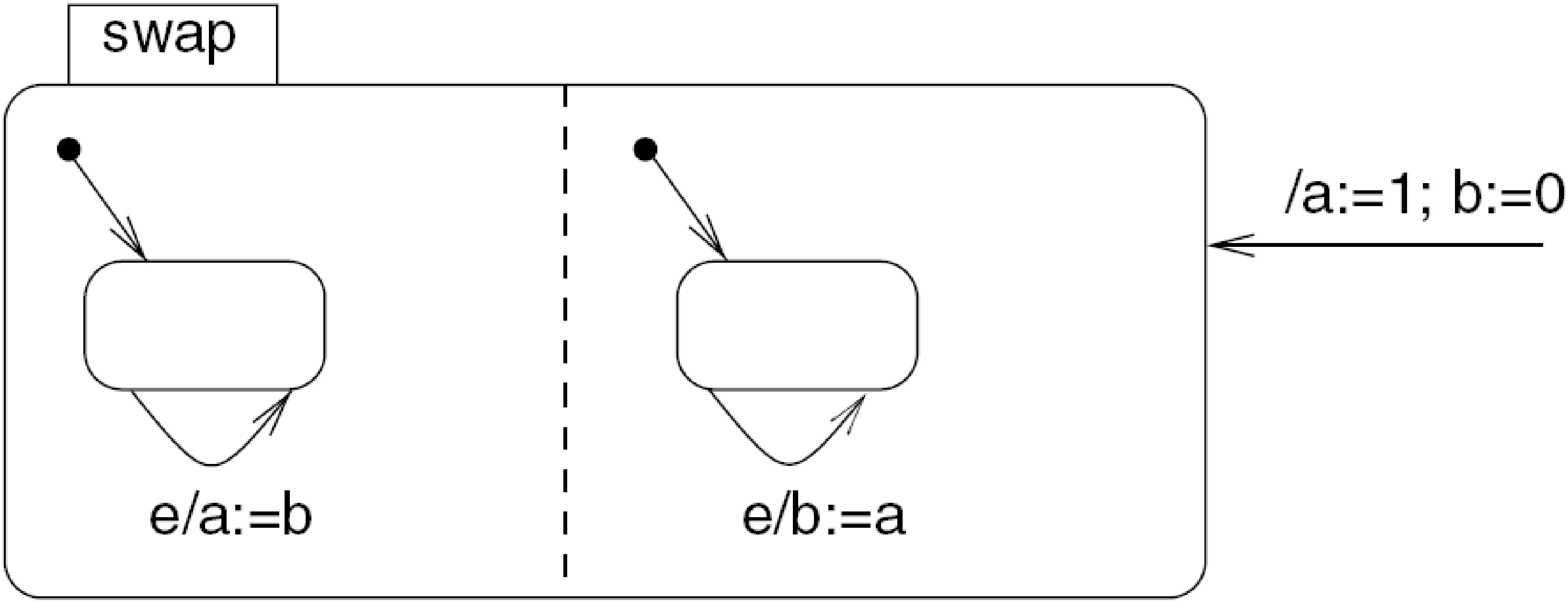


# Example: Mealy

```
State PS=S1,NS;
Event e;

while(1){
  case(PS){
    S1:
      e=Wait_for_event();
      if(e=='T<15')
        NS=S3;
        Turn_on(Heater);
        Turn_off(Cooler);
      else if(e=='T>35')
        NS=S2;
        Turn_off(Heater);
        Turn_on(Cooler);
     end if;
    S2:
      ...
    S3:
      ...
  }
  PS=NS;
}
```

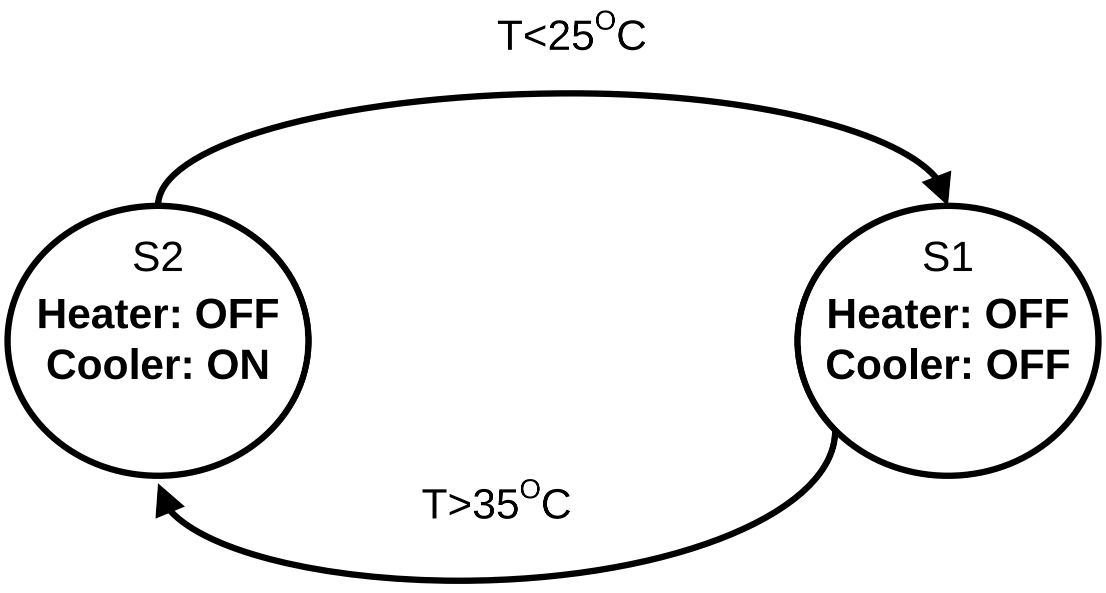


# Mutually Dependent Assignments



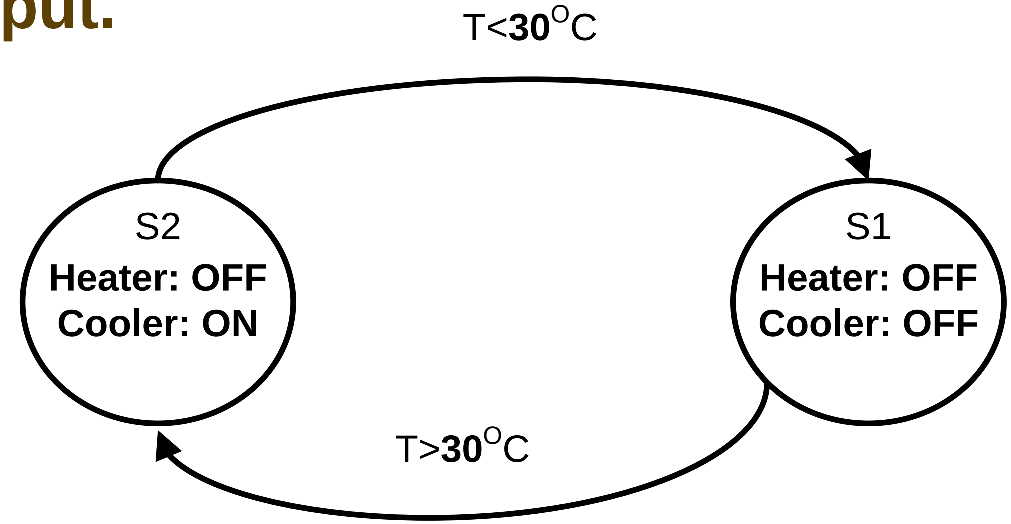
# Hysteresis

- **Hysteresis is used to prevent chattering where the system would have rapid state transitions when the sensor input is close to the setpoint.**



# State Inertia

- **Alternative solution is state inertia: a single threshold + state holding for at least $T_{min}$.**
- **Problem:**
  - **It does not have time-scale invariance**
  - **Time-Scale Invariance: time scaling at the input results in the same time scaling at the output.**



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## The MoC of Differential Equations (9)

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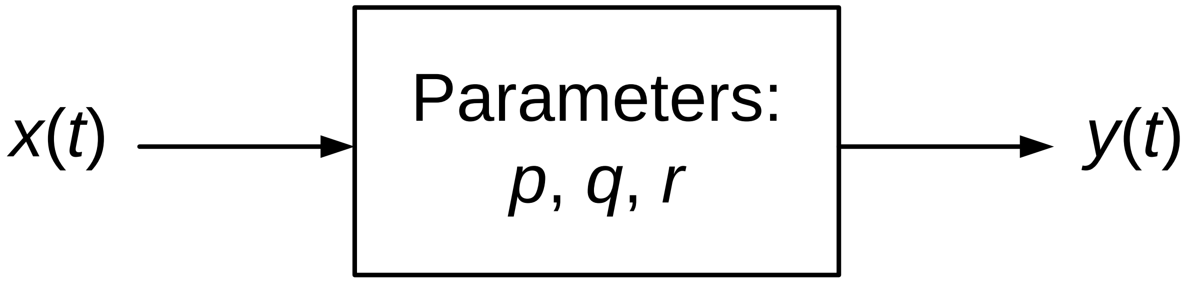
# Actor Models




- **Actor: A box like that above, where the inputs are functions and the outputs are functions, is called an actor.**

# Actors

- Closely related to the concept of functional in mathematics.
- Can be used to model sensors, actuators, computation, and plant.

# Example 1

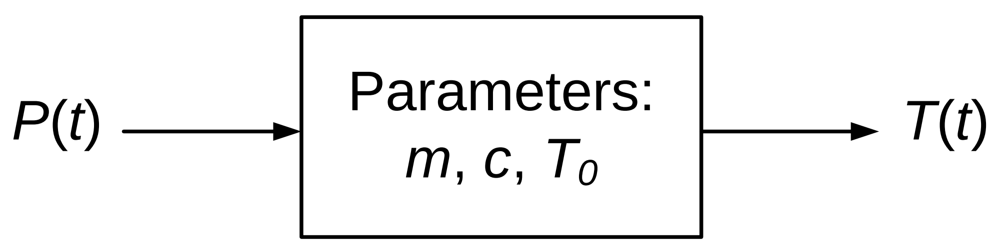
- **Actor model of the plant in the air conditioning system.**

$$dE = mc\,dT$$

$$dT = \frac{1}{mc}\,dE$$

$$T = \frac{1}{mc}\int_{E_0}^{E_1} dE + T_0$$

$$T = \frac{1}{mc}\int_{t_0}^{t_1} P(t)dt + T_0$$



# Example 2

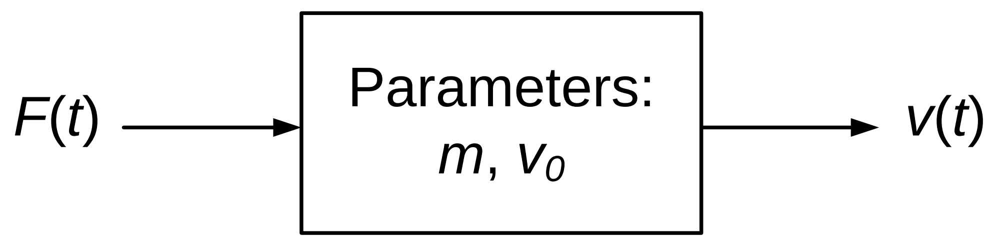
- **Actor model of the plant in one dimensional velocity control.**

$$F = ma$$

$$F = m\,\frac{dv}{dt}$$

$$dv = \frac{1}{m} F dt$$

$$v = \frac{1}{m}\int_{t_0}^{t_1} F(t)dt + v_0$$



# Key Point in Modeling a Plant

- The most important point in modelling a plant as an actor is to correctly determine the input(s) and output(s).
  - **Output** is what you desire to control.
  - **Input** is what you really give (apply) to the system from the viewpoint of the controller.