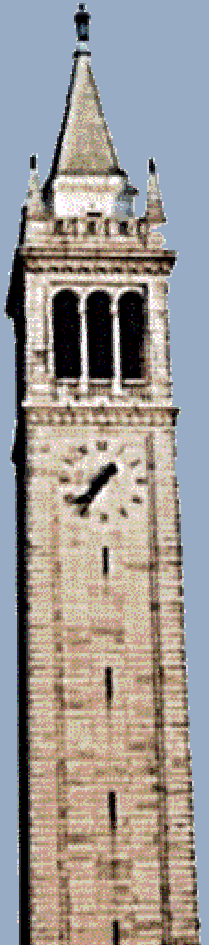# Modal Models in Vehicle-Vehicle Coordination Control

Xiaojun Liu

The Ptolemy Group

EECS Department, UC Berkeley

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Vehicle-Vehicle Coordination Control

- **Part of the MoBIES Automotive Open Experimental Platform (OEP)**
- **Used on vehicles in an intelligent vehicle highway system**
  - **Platoon formation**
- **Goals**
  - **Maintain safety**
  - **Reduce traffic delay**
  - **Maximize fuel efficiency**
  - **Give passengers a comfortable ride**

Picture obtained from http://vehicle.me.berkeley.edu/mobies/vehicle/

Control Modes in Vehicle-Vehicle Coordination

- **The controller works in different modes due to**
  - **Operational requirements**
    - **Tracking**
    - **Collision avoidance**
  - **Quality of communication among vehicles**
    - **Reliable real-time update of speed/distance among neighboring vehicles**
    - **Complete loss of inter-vehicle communication**
  - **Various failure conditions, etc.**
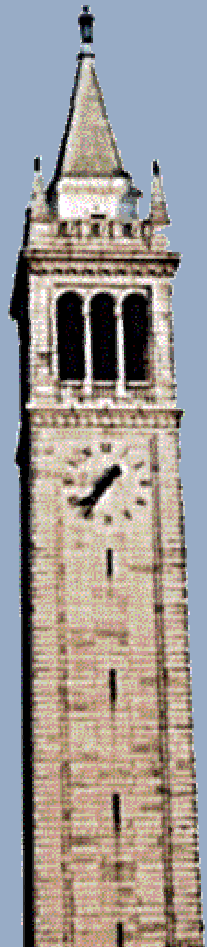- **A modeling paradigm is needed for designing and validating modal controllers**
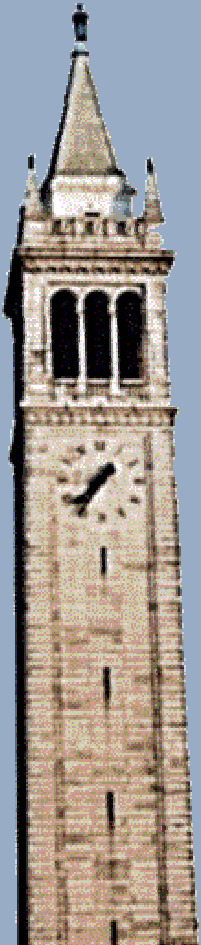
Motivation of Modal Models

■ **Finite state machines (FSM) are used extensively to describe modes and transitions**

   ■ **Formal analysis and verification methods available**
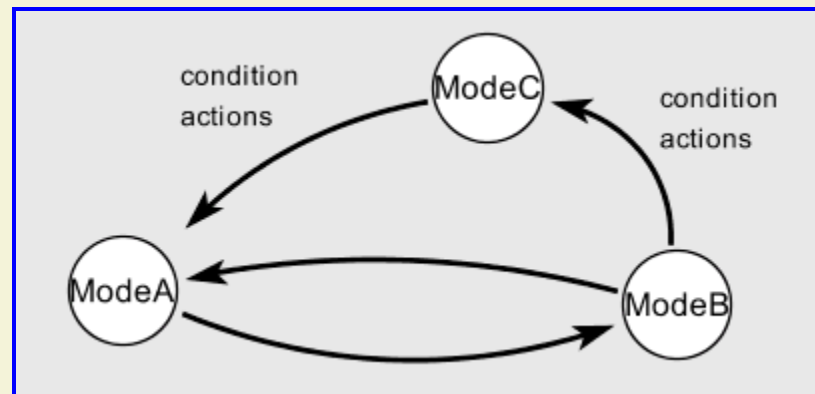
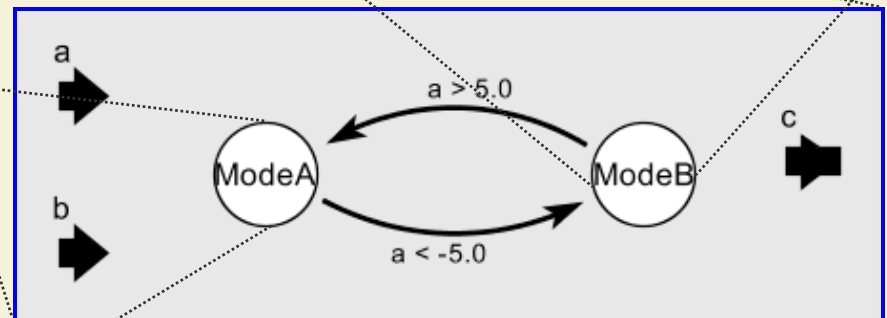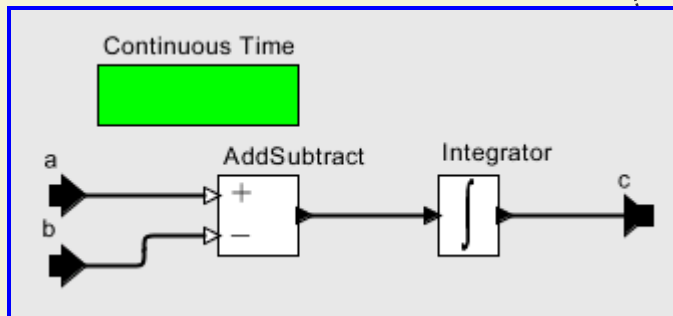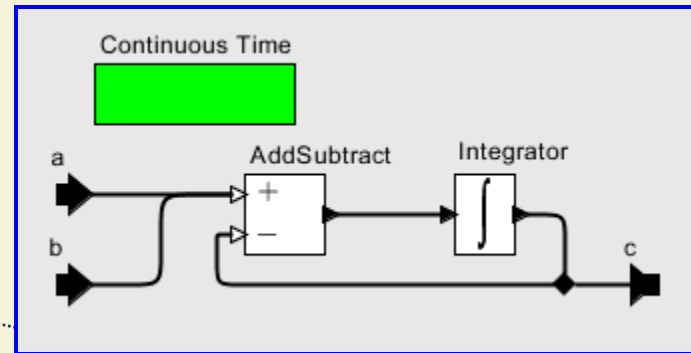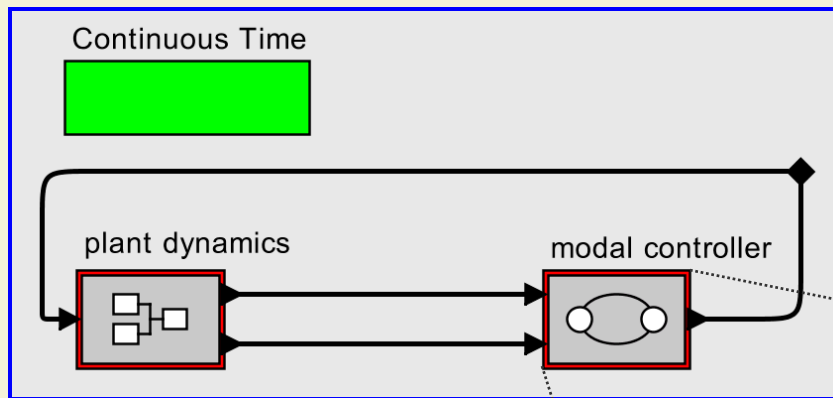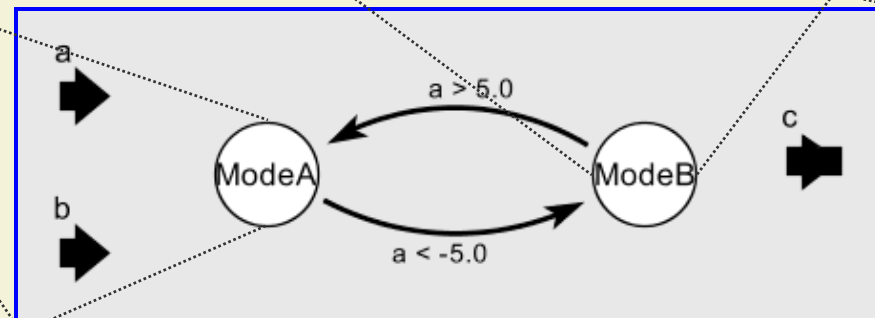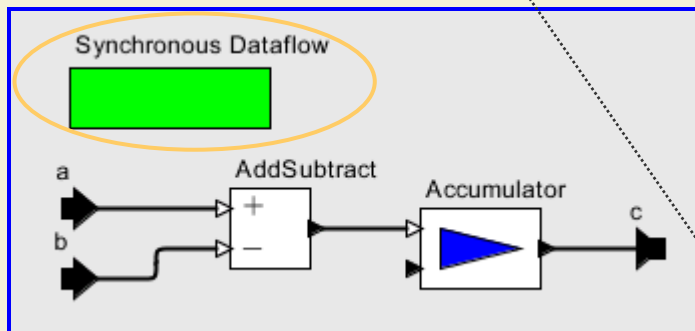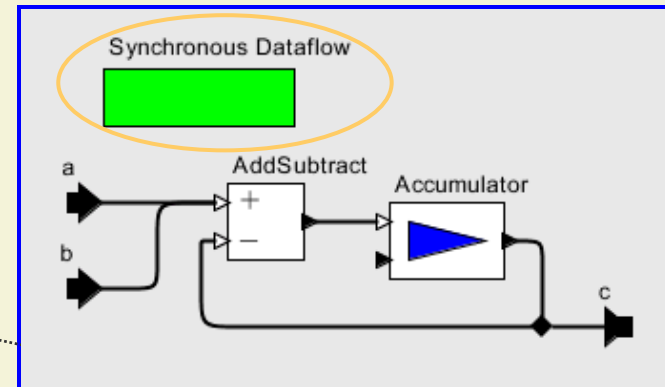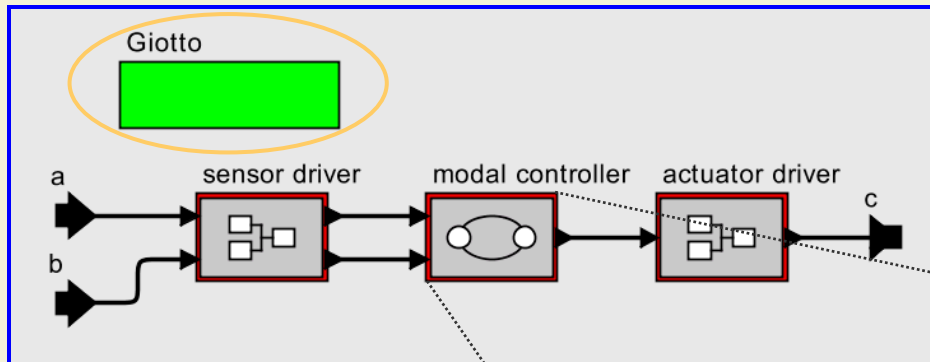■ **FSMs are in general not practical to describe the control algorithms**

Motivation of Modal Models, Continued

■ **FSMs need to be hierarchically composed with other computational models**

Motivation of Modal Models, Continued

- **The composition may involve multiple computational models**

Modal Models in Ptolemy II

- **Leverage the Ptolemy II infrastructure that supports hierarchical heterogeneity**
- **Capable of modeling modal systems that involve various models of computation, such as continuous time (CT), discrete event (DE), Giotto, and synchronous dataflow (SDF)**
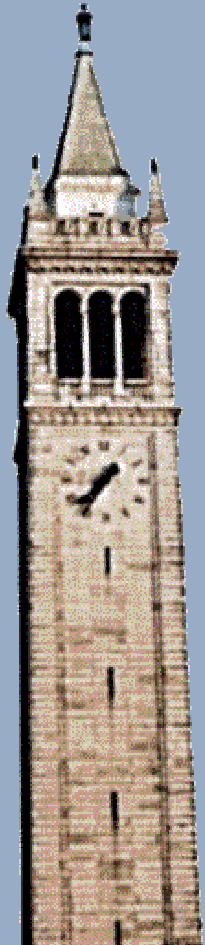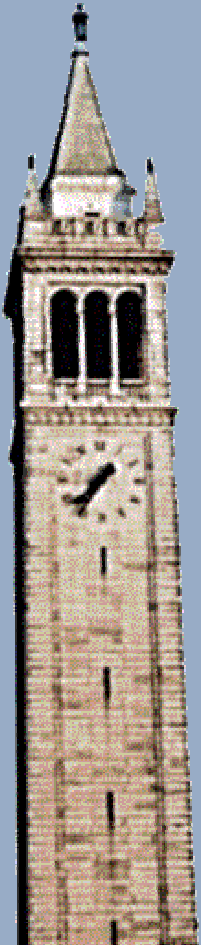
A Modal Model of the MoBIES Vehicle-Vehicle Automotive OEP Problem

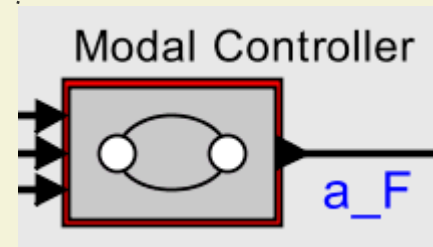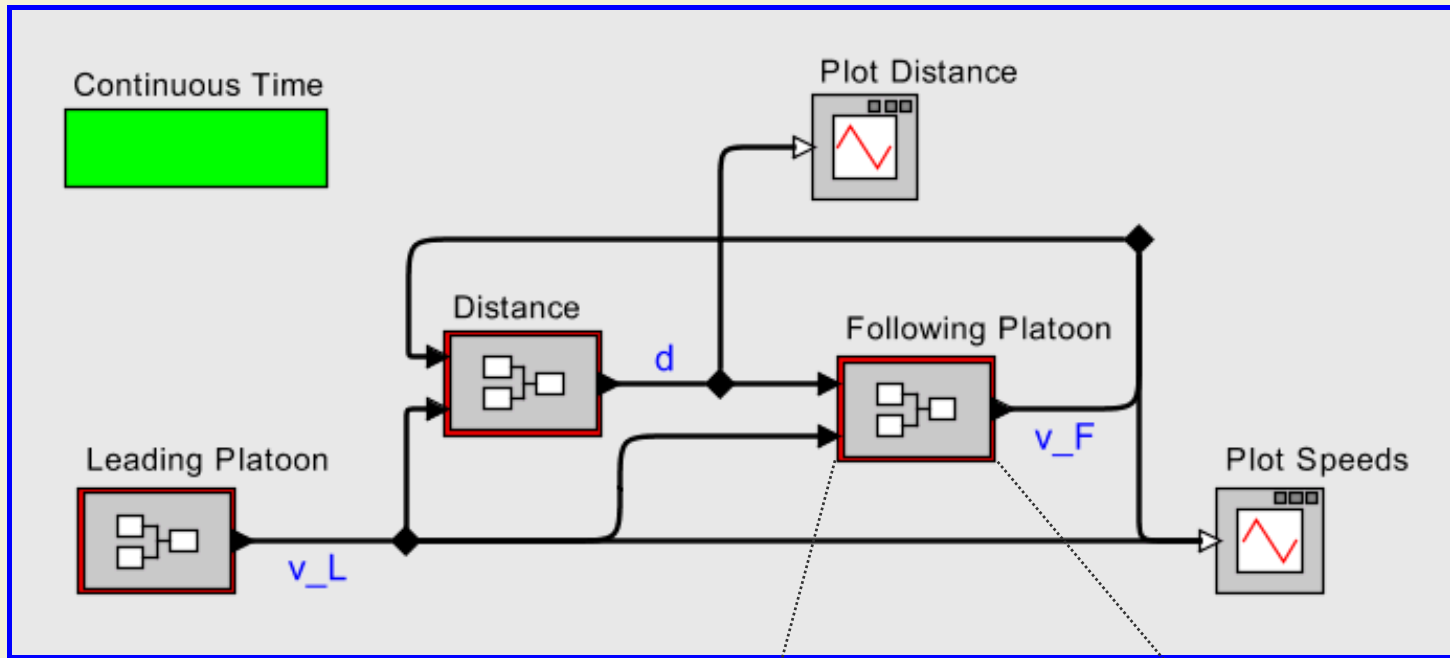- **Created by Professor Edward A. Lee, based on a formulation from the U-Penn MoBIES team**

v_F

d

v_L
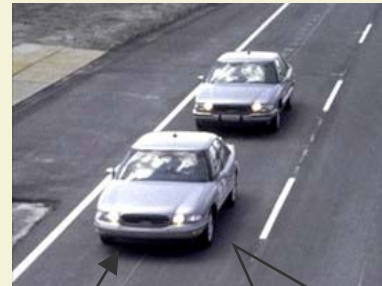
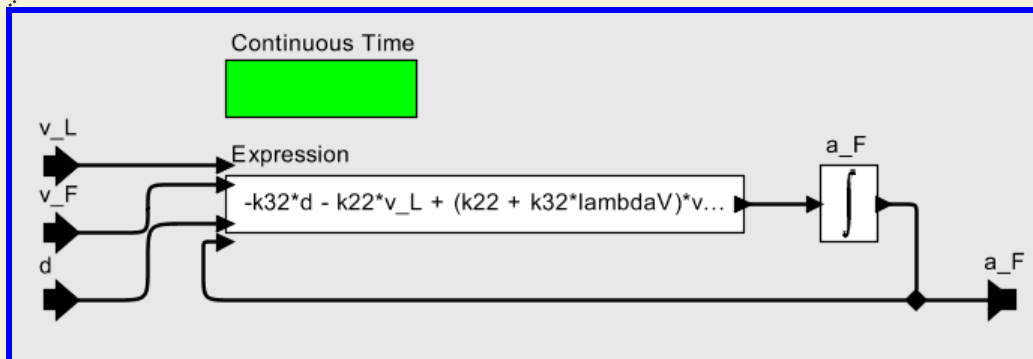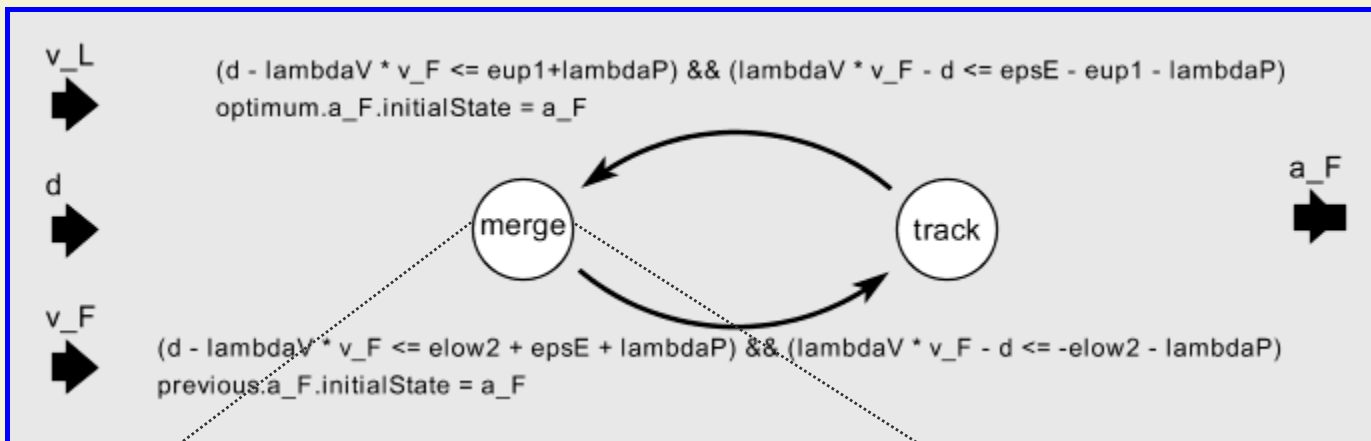The leading car has a modal controller with two modes: merge and track.

Vehicle-Vehicle Model, Continued

Vehicle-Vehicle Model, Continued

$(d - lambdaV * v\_F <= eup1 + lambdaP)$ && $(lambdaV * v\_F - d <= epsE - eup1 - lambdaP)$

optimum.a_F.initialState = a_F

$(d - lambdaV * v\_F <= elow2 + epsE + lambdaP)$ && $(lambdaV * v\_F - d <= -elow2 - lambdaP)$

previous.a_F.initialState = a_F

Continuous Time

Expression

$-k32*d - k22*v\_L + (k22 + k32*lambdaV)*v...$

For the track mode, the model is similar but with different parameters.