SCHLOSS DAGSTUHL
Leibniz-Zentrum für Informatik

Dagstuhl Seminar 11441
Science and Engineering of Cyber-Physical Systems

Cyber-Physical Systems and Multi-Paradigm Modeling

ModHel'X

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Cyber-physical systems (CPSs)

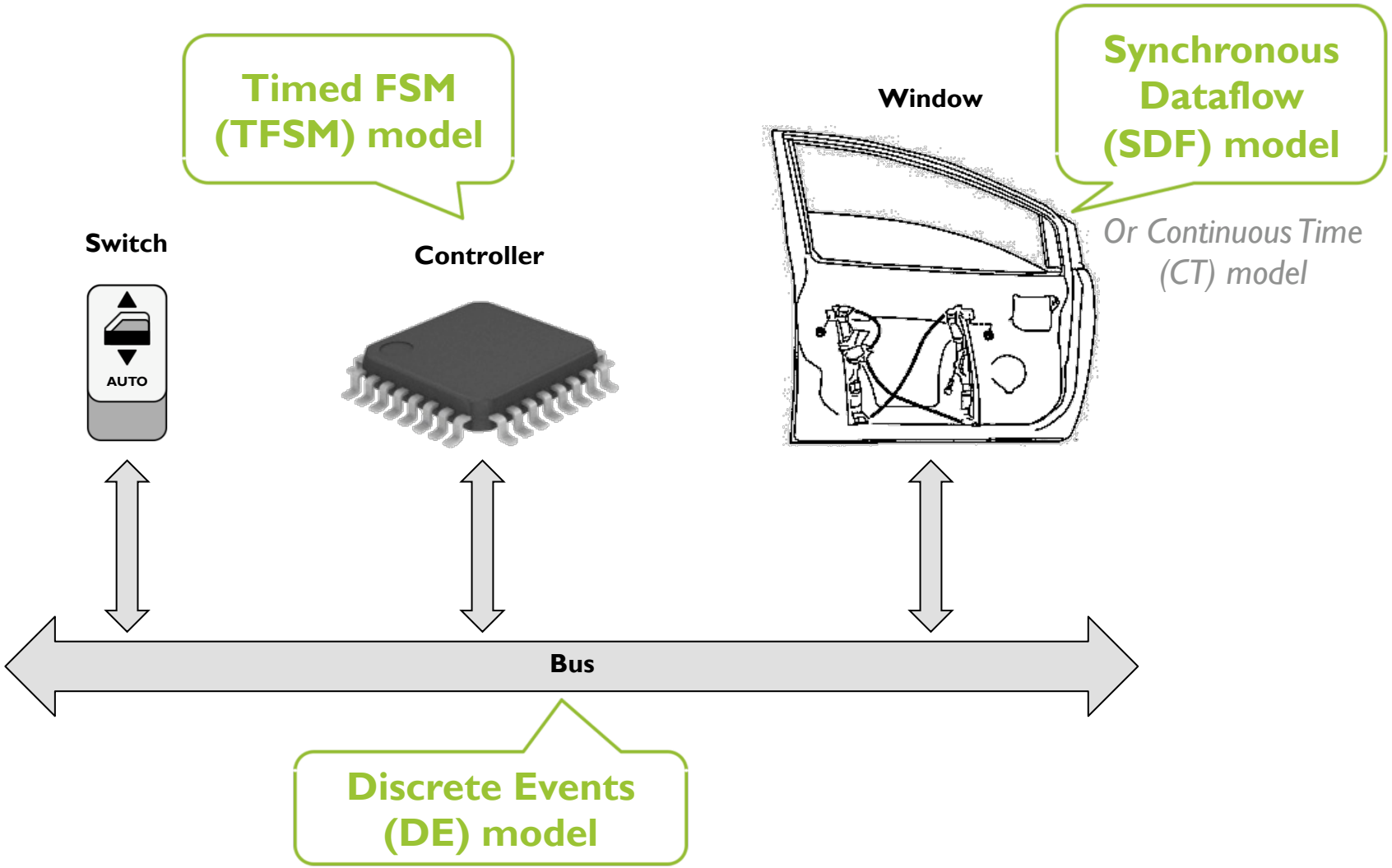
- CPSs =
  cyber (software-based) components
  + physical (sensors/actuators) components

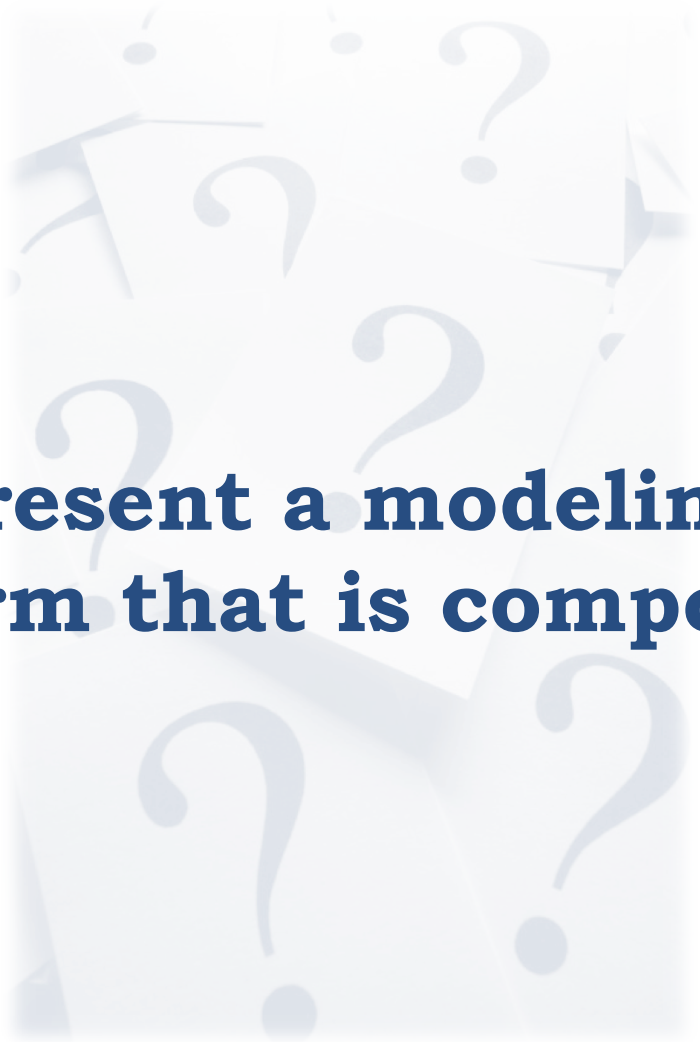
- CPSs design challenges =
  - Heterogeneous components ➡ Heterogeneous design paradigms
  - Tight interaction cyber+physical ➡ Model composition

- The problem we try to address = how to compose models that are written using different modeling languages in order to be able to reason globally on a CPS under design?

- Experimental platform = ModHel'X

The power window example

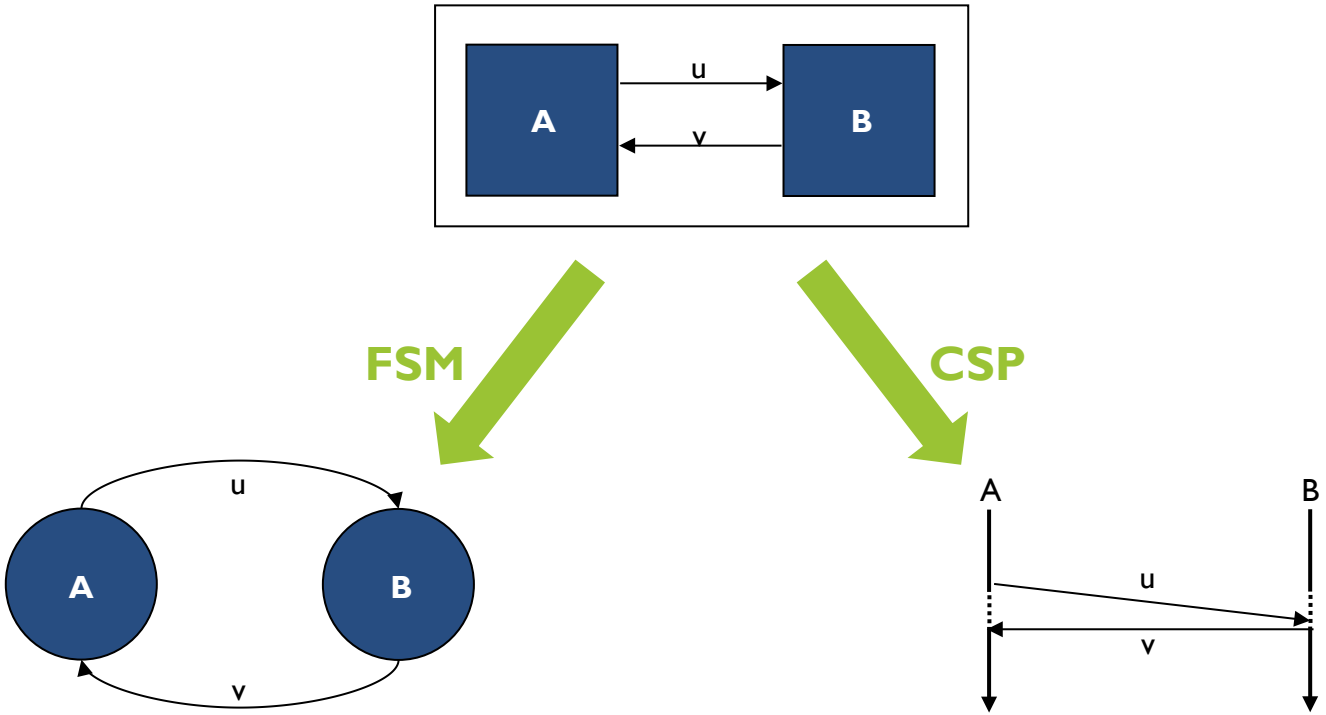




How to represent a modeling paradigm in a form that is composable?

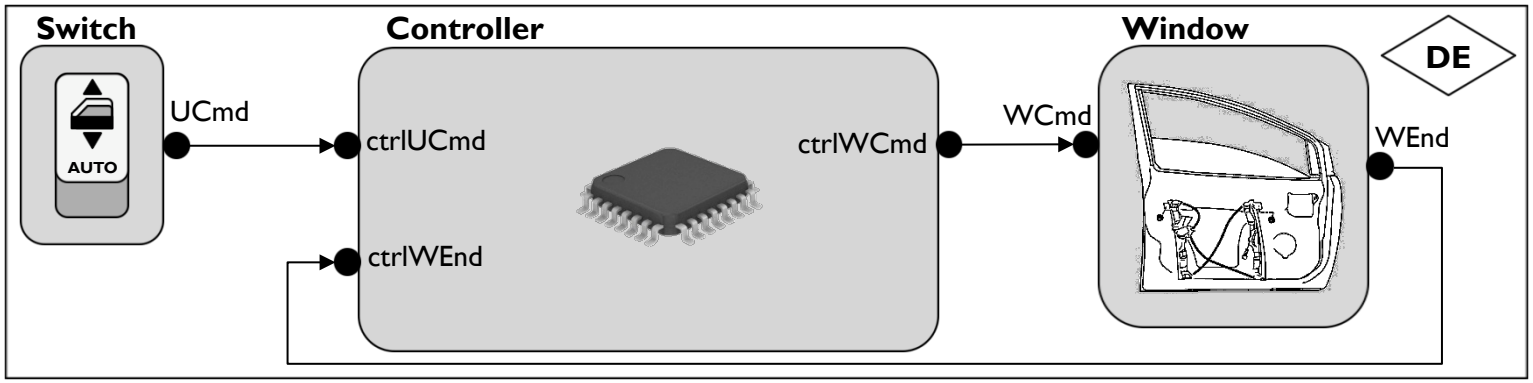
Model of Computation

- Represents the semantics of a modeling language
- Provides the rules for interpreting a model



Model = structure + MoC

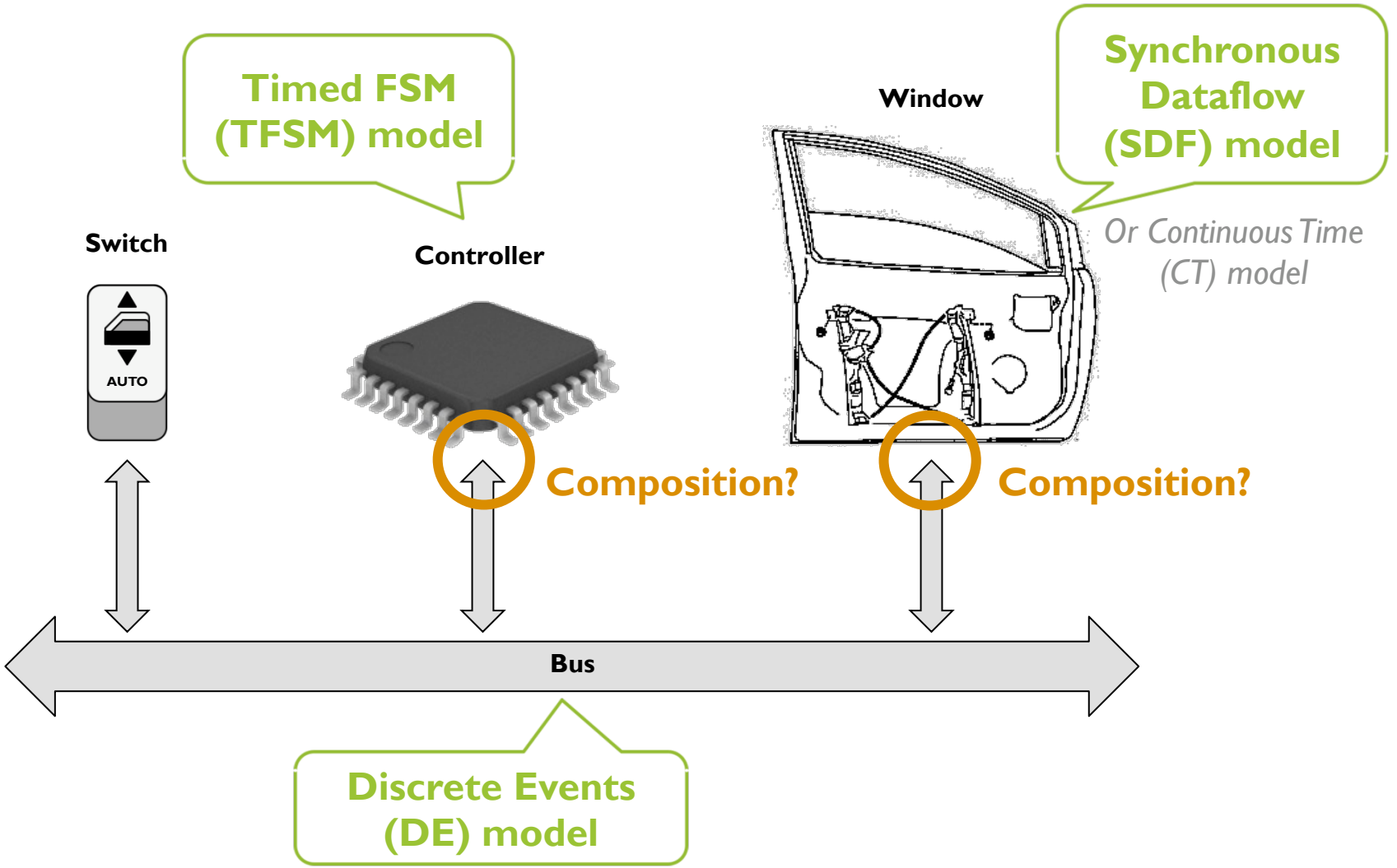
- The structure of a model is a set of interconnected blocks (black boxes)
- A MoC is used to provide an interpretation (semantics) of that structure

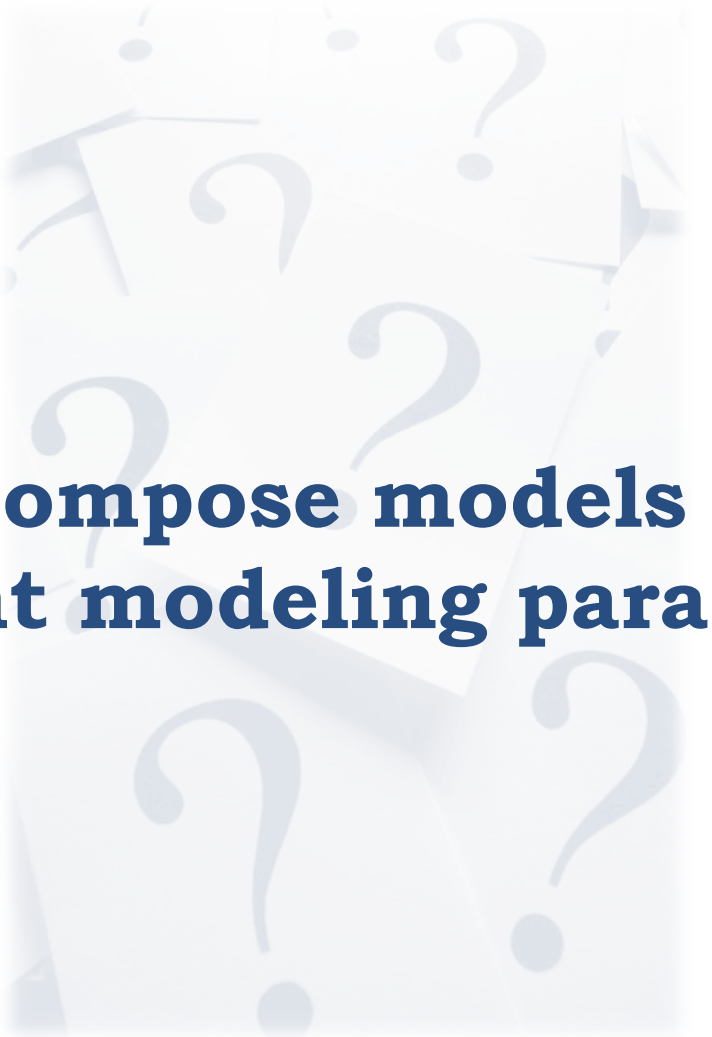


MoCs currently available in ModHel'X

- Discrete Events (DE)
  - Exchange of events ⟨value, date⟩
  - ≈ Network messages
- Synchronous Data Flow (SDF)
  - Flows of sampled data
  - Multi sample rate
  - ≈ Simulink block diagrams
- Timed Finite State Machines (TFSM) [+ FSM + *Charts]
  - Timed transitions: "after(T)"
  - ≈ very simplified UML's Stateflow
- Petrinets

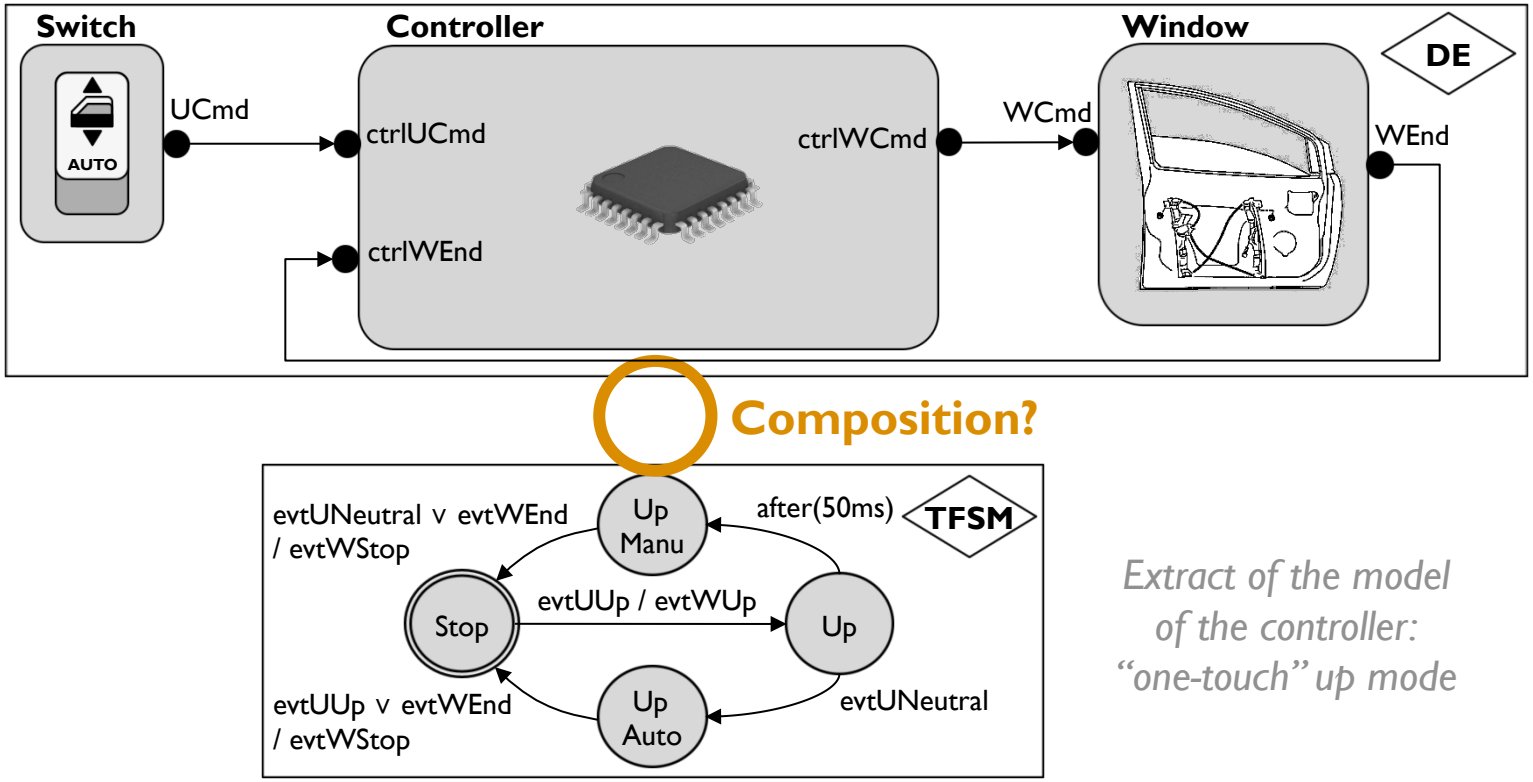
The power window example (again)





How to compose models that use different modeling paradigms?

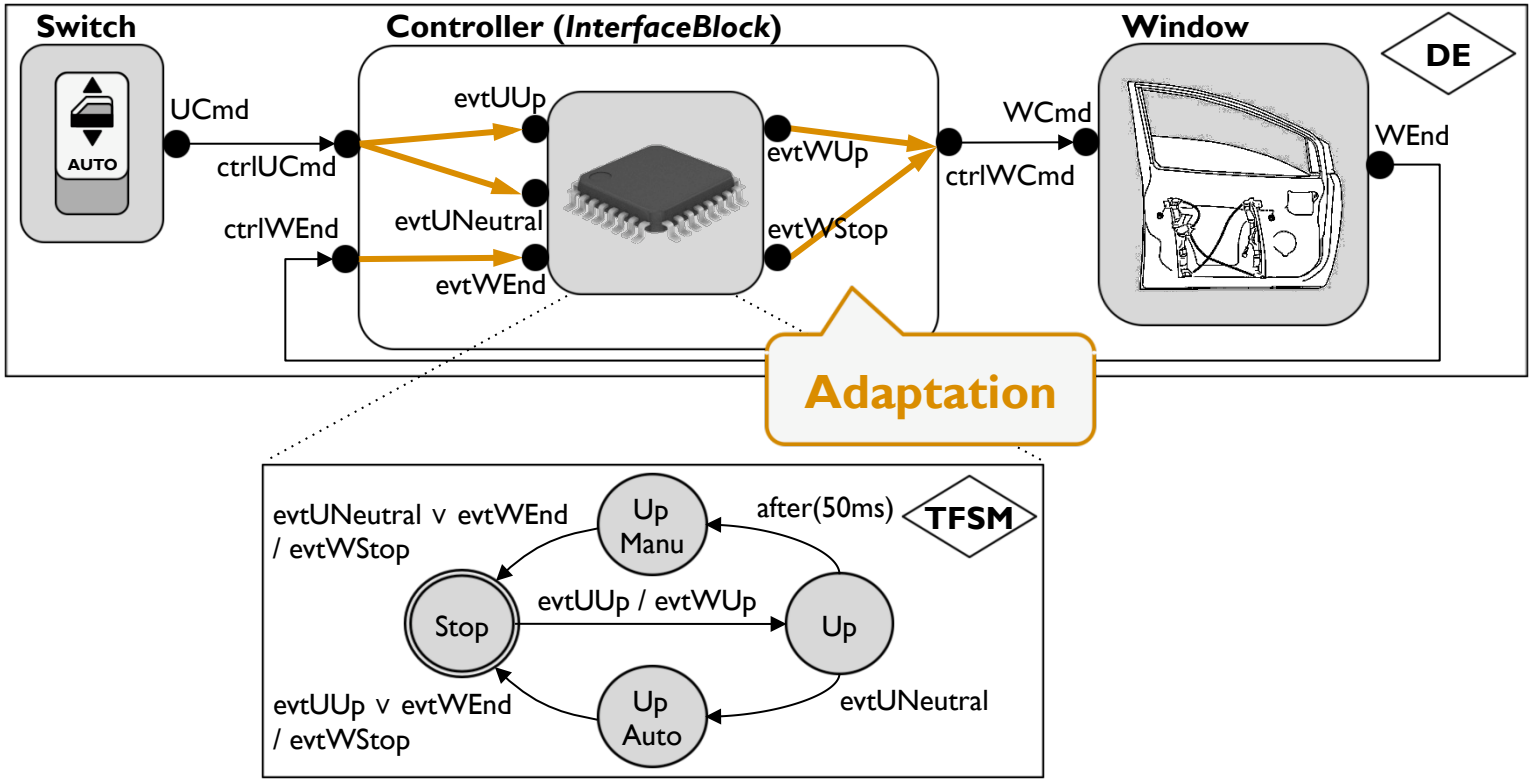
Composition of heterogeneous models



Extract of the model of the controller: "one-touch" up mode

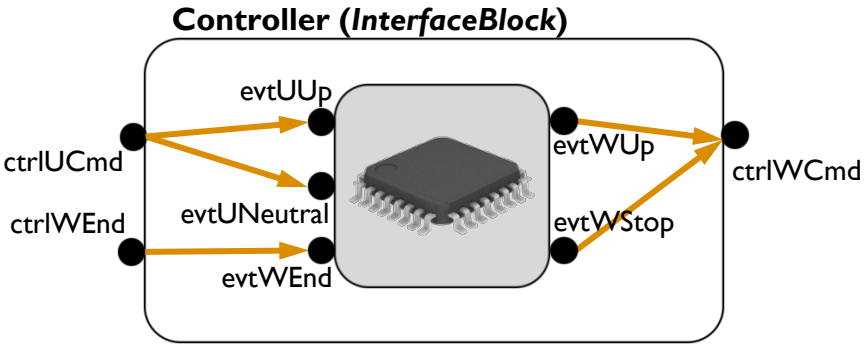
Composition of heterogeneous models

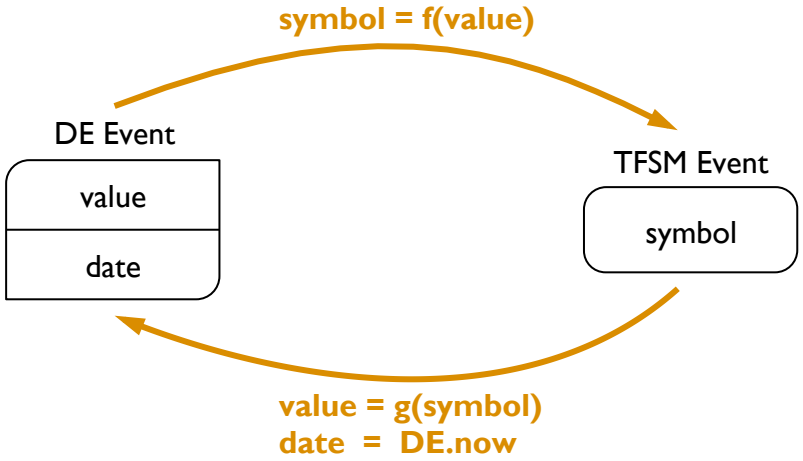
- "Interface blocks" are used to embed a model into a block
  - ➡ Support for heterogeneity through hierarchy

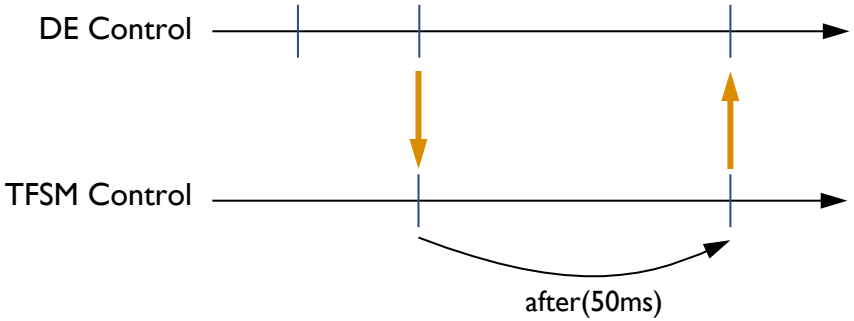


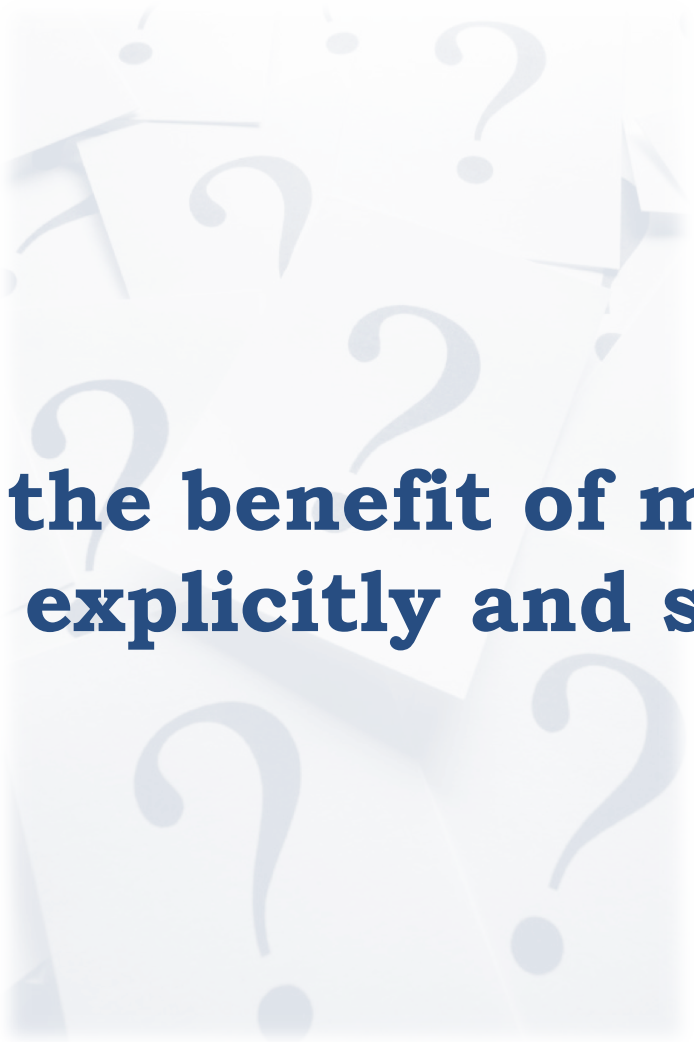
What is adaptation?

- Adaptation of data
  - Forms
  - Values
- Adaptation of time notions
  - Time scales
  - Time forms (seconds, revolutions, centimeters…)
- Adaptation of control flow
  - "Moments" at which "things" happen



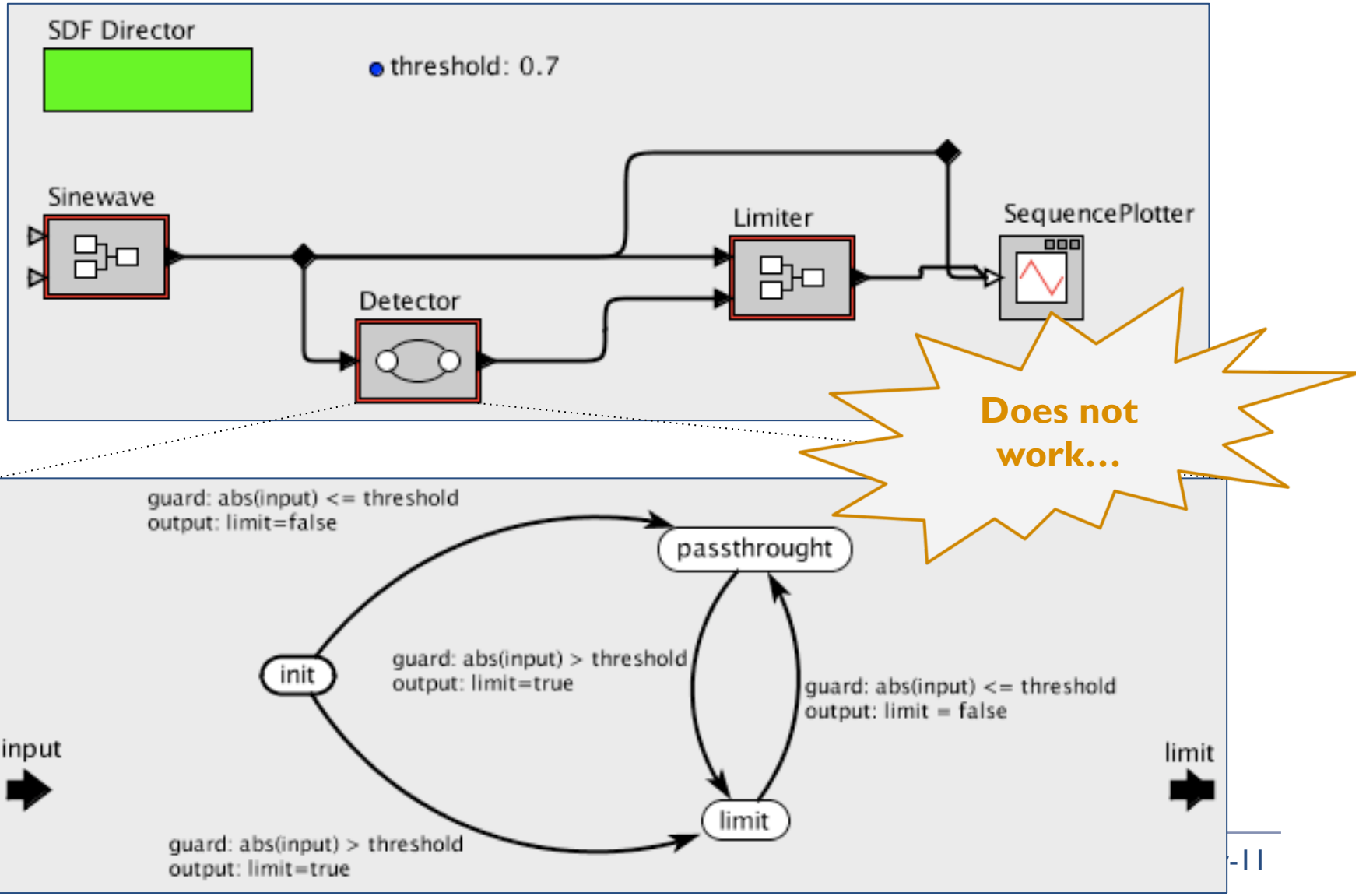






What is the benefit of modeling adaptation explicitly and separately?

Another heterogeneous example



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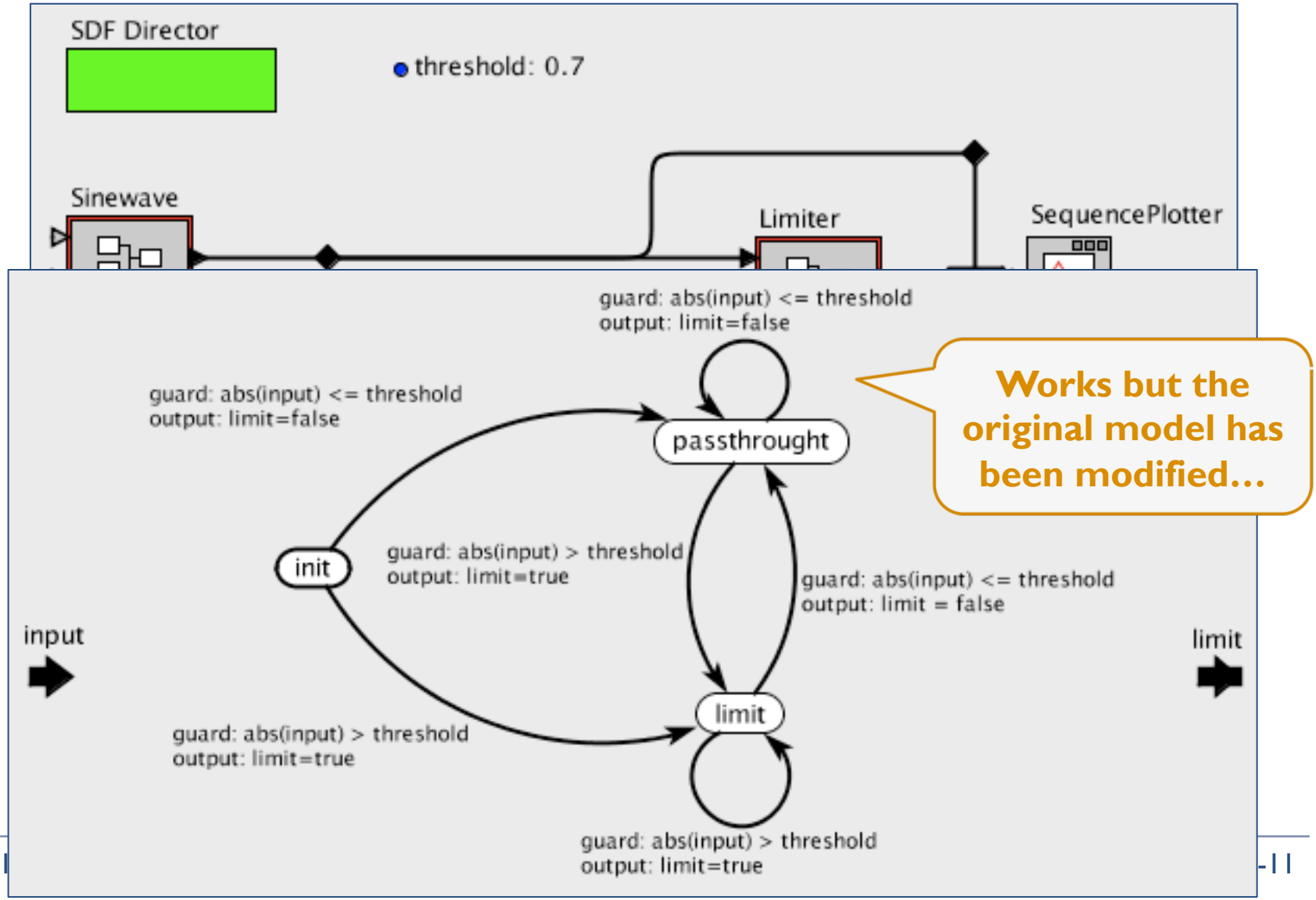

Conclusion?

Key points

- Our approach:
  - Models of Computation (MoCs) for representing the semantics of design paradigms
  - Semantic adaptation for composing heterogeneous models using hierarchy

- Goals of ModHel'X:
  - Extensible set of MoCs
  - Explicit, customizable and modular semantic adaptation

Current research directions

- Modeling MoCs
  - Imperative form ➡ execution
  - Declarative form ➡ verification & validation
  - Variants of a MoC? Reusability of (parts of) a model of a MoC?
- Modeling Semantic Adaptation
  - Declarative form using CCSL constraints (time and control)
  - Components with heterogeneous "ports" (data)
  - Patterns of adaptation
- Multi-view modeling
- Heterogeneous model testing


MERCI!
THANK YOU!
FRAPAR.