MSDL
Modelling, Simulation and Design Lab

Co-simulation: Simulator Coupling Approaches

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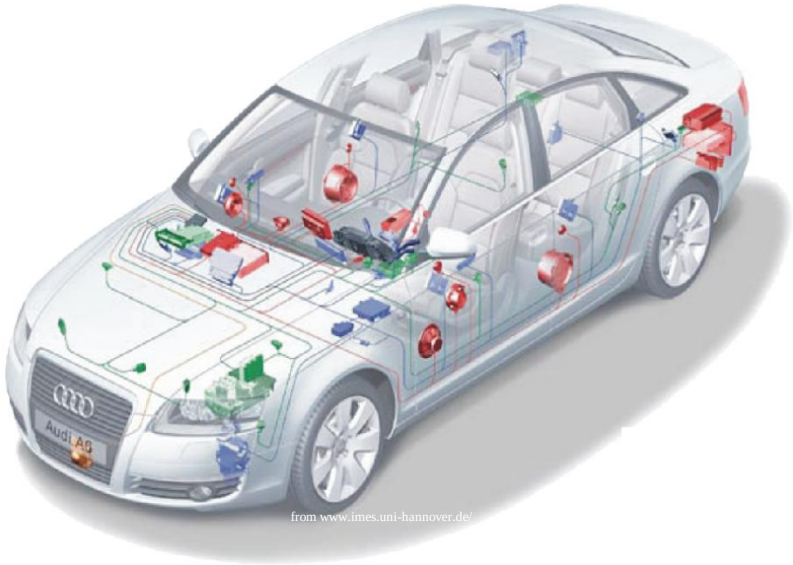
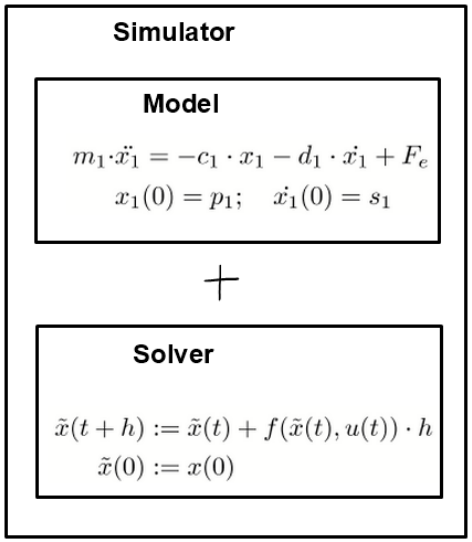
The modern car

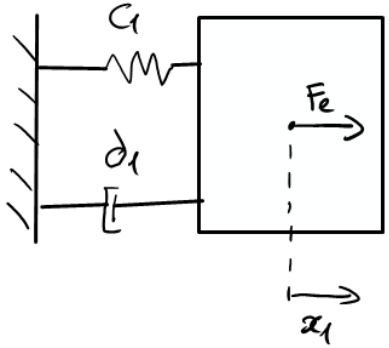
- Complexity
  - 40+ subsystems
- Competitive Market
- Concurrent Development
  - Late Integration Problems
- Distributed Development
  - Specialized suppliers
  - Late Integration (due to IP)



Simulators

Simulator = Solver + Model





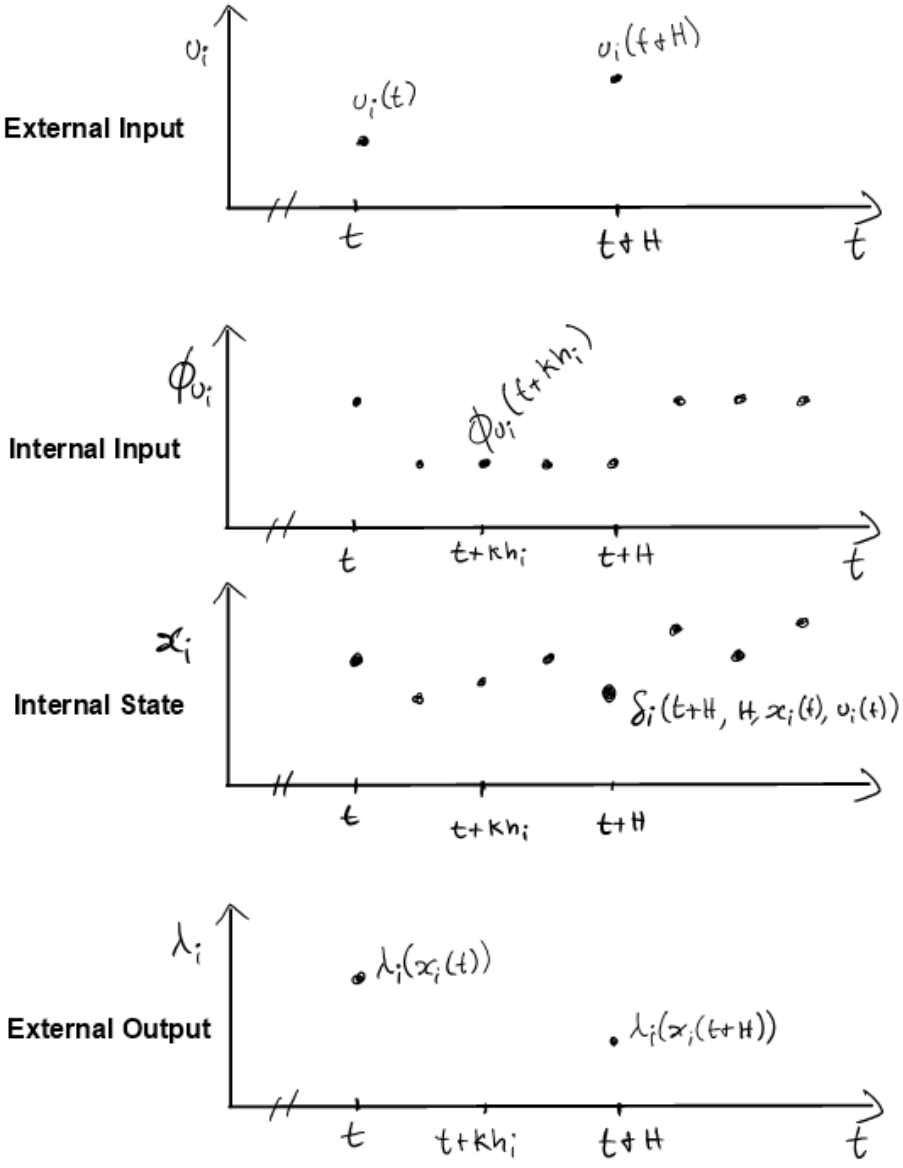
$$S_i = \langle X_i, U_i, Y_i, \delta_i, \lambda_i, x_i(0), \phi_{U_i} \rangle$$

$$\delta_i : \mathbb{R} \times \mathbb{R} \times X_i \times U_i \rightarrow X_i$$

$$\lambda_i : \mathbb{R} \times X_i \times U_i \rightarrow Y_i \text{ or } \mathbb{R} \times X_i \rightarrow Y_i$$

$$x_i(0) \in X_i$$

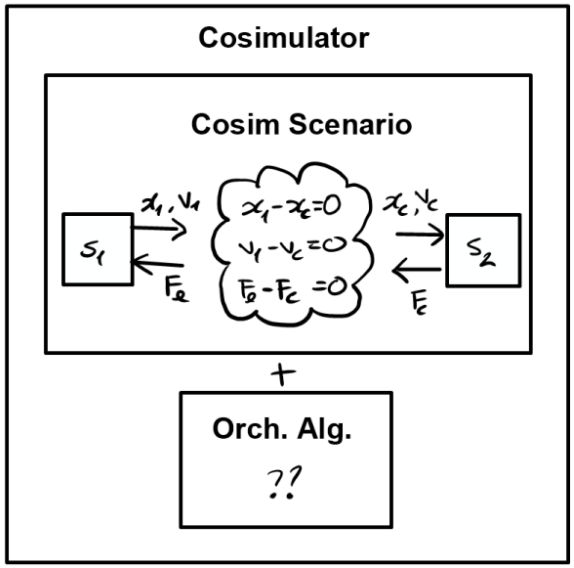
$$\phi_{U_i} : \mathbb{R} \times U_i \times \ldots \times U_i \rightarrow U_i$$



Co-simulation

Co-sim. Scenario = Simulators + Coupling Conditions

Co-Simulator = Co-sim. Scenario + Orch. Algorithm

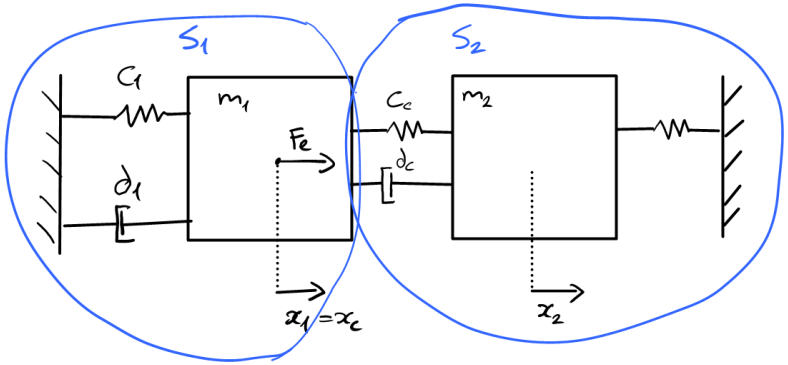


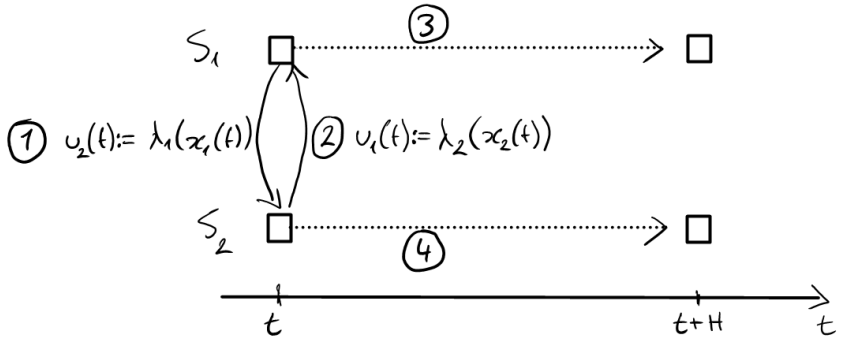
$$CS = \langle S, L \rangle$$

$$S = (S_1, \ldots S_n)$$

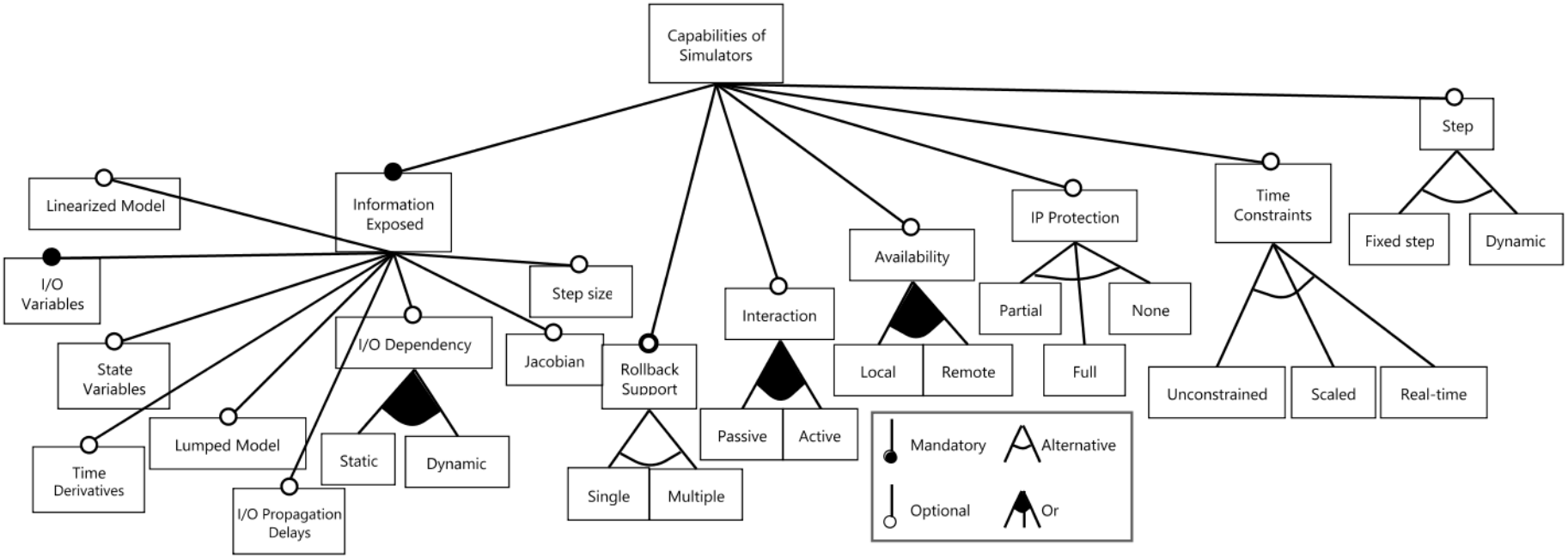
$$L : Y_1 \times \ldots \times Y_n \times U_1 \times \ldots \times U_n \rightarrow \mathbb{R}^n$$

$$L(y_1, \ldots, y_n, u_1, \ldots, u_n) = \bar{0}$$





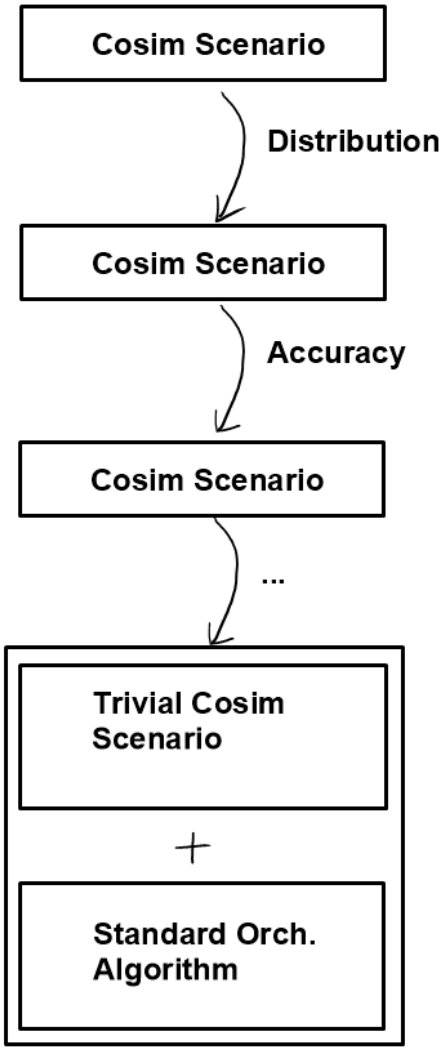
Orchestration Algorithm Concerns



- Heterogeneous Capabilities of Simulators
  - Accuracy
  - Algebraic Loops
  - Distribution
  - Modularity

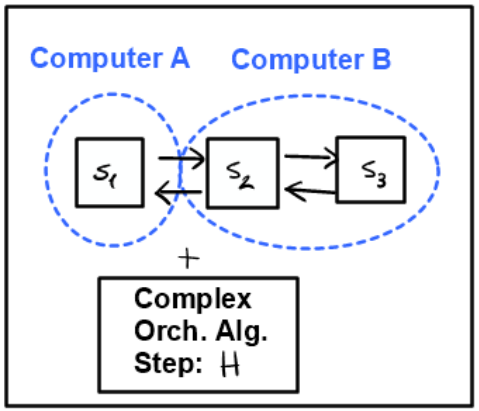
Separation of Concerns via MDE

- Objective: Deal with Complex Orchestration Alg.
- How?
  - Transform Co-sim scenario to address each concern separately;
  - Reduce to a trivial form;
  - Add standard Orchestration Alg;

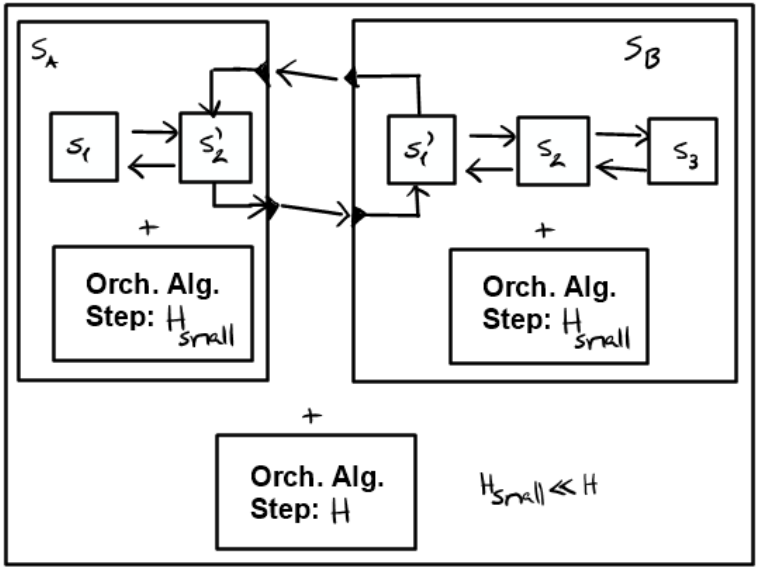


Example: Distribution Concern

- Across computers, small H incurs network communication cost.
- Large H leads to accuracy problem.
- Extrapolation made by simulators is inappropriate to the scenario.
- Complex orchestration mechanism required to deal with distribution correctly.



Distribution



Thank you!