HLA-based Logistic Simulation

Project experiences

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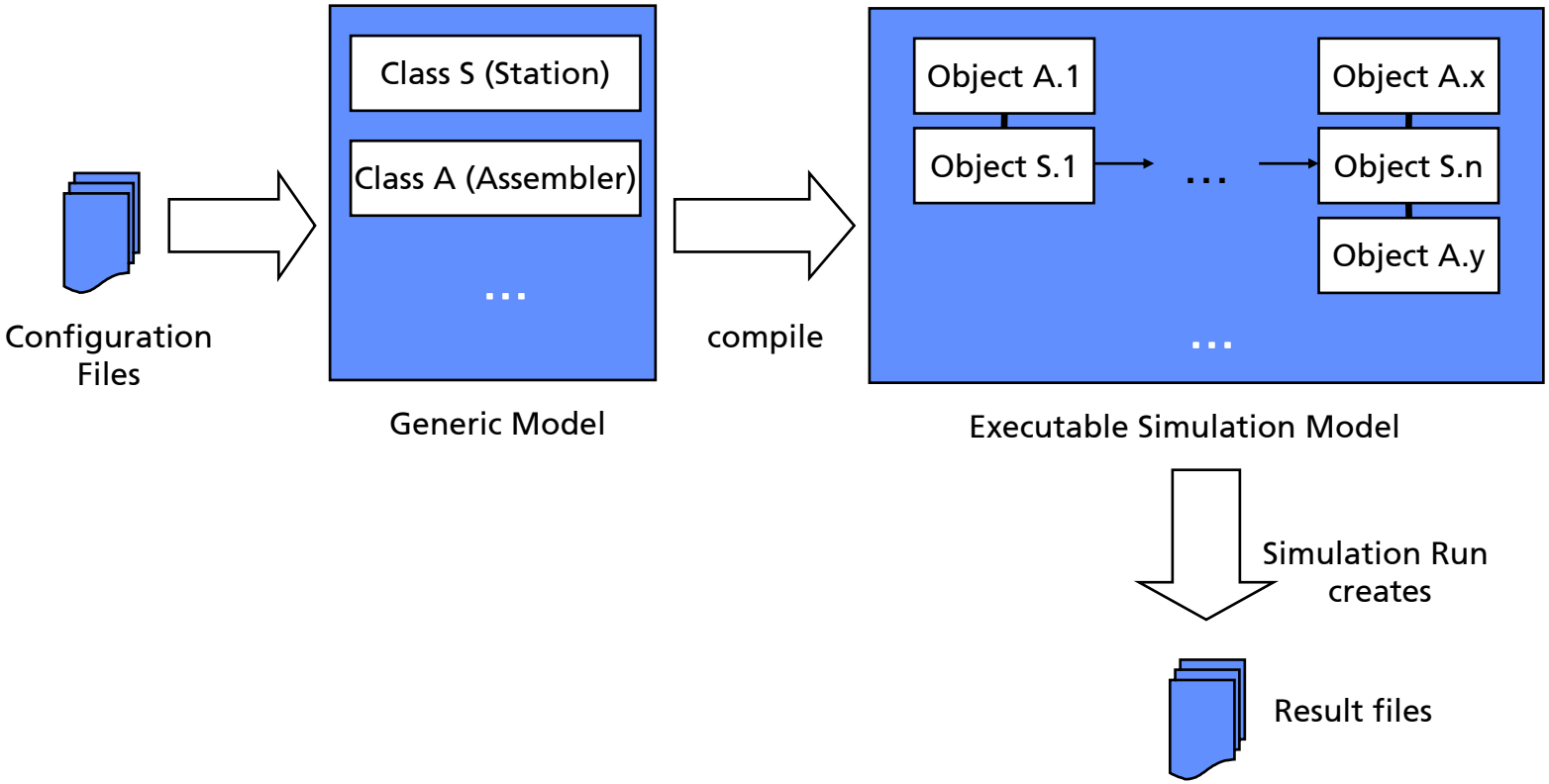
Preconditions

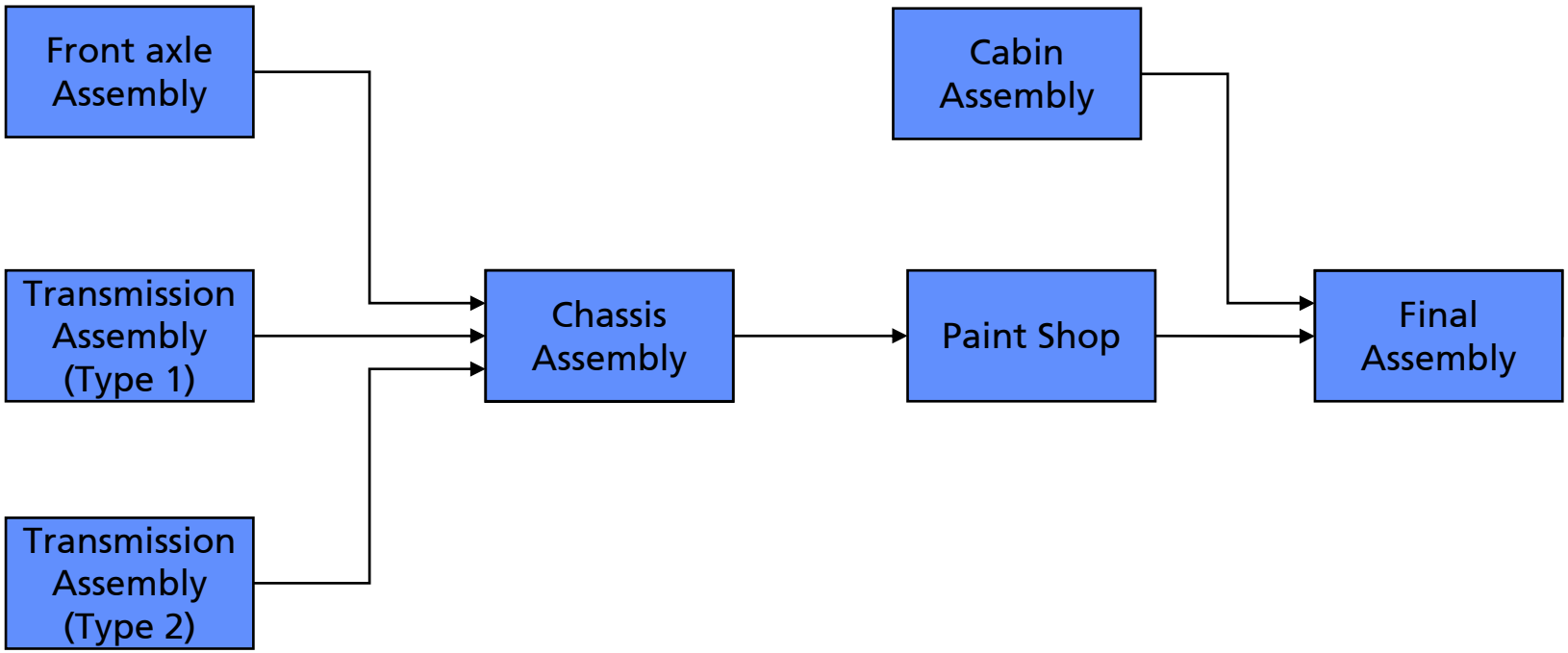
- Production of vehicles
- Preexisting SLX simulation models, level of detail very high
  - To simulate assembly and paint processes
  - Originally developed to support factory design
  - Also been used to support factory operations
- One model can be used to simulate exactly one sub area of the entire factory, e.g. transmission assembly, paint shop, …
- Interrelationships are not modeled and can't be investigated
- Preexisting models are generic → can be adapted to a special use case by editing a set of configuration data

Existing generic models



Original Layout of the factory

Production system



Project objectives

- Simulate the complex system
  - Investigate the dependencies between the different sub models
    - Dimensioning of buffers between the sub areas
    - Coordination of production schedules
    - Detection of bottlenecks in the complex system regarding the required throughput
- Reuse the existing simulation models
- Using the HLA as middleware for the distributed simulation
  - RTI 1.3NG
  - Expert knowledge from previous projects
  - Existing HLA-SLX Wrapper library

Requirements (1)

1. Simulation Management

- Prepare the existing models to be connected using the HLA
- Support the user in creating the Federation
  - Which model should be coupled? What's their relation?
- Encapsulation of RTI-Services against the user
- Start & Manage all Federates (Simulations) automatically

2. Extension of the existing models

- Creation of a "consistent" solution for all models

  - Utilization for both monolithic und distributed simulation runs

Requirements (2)

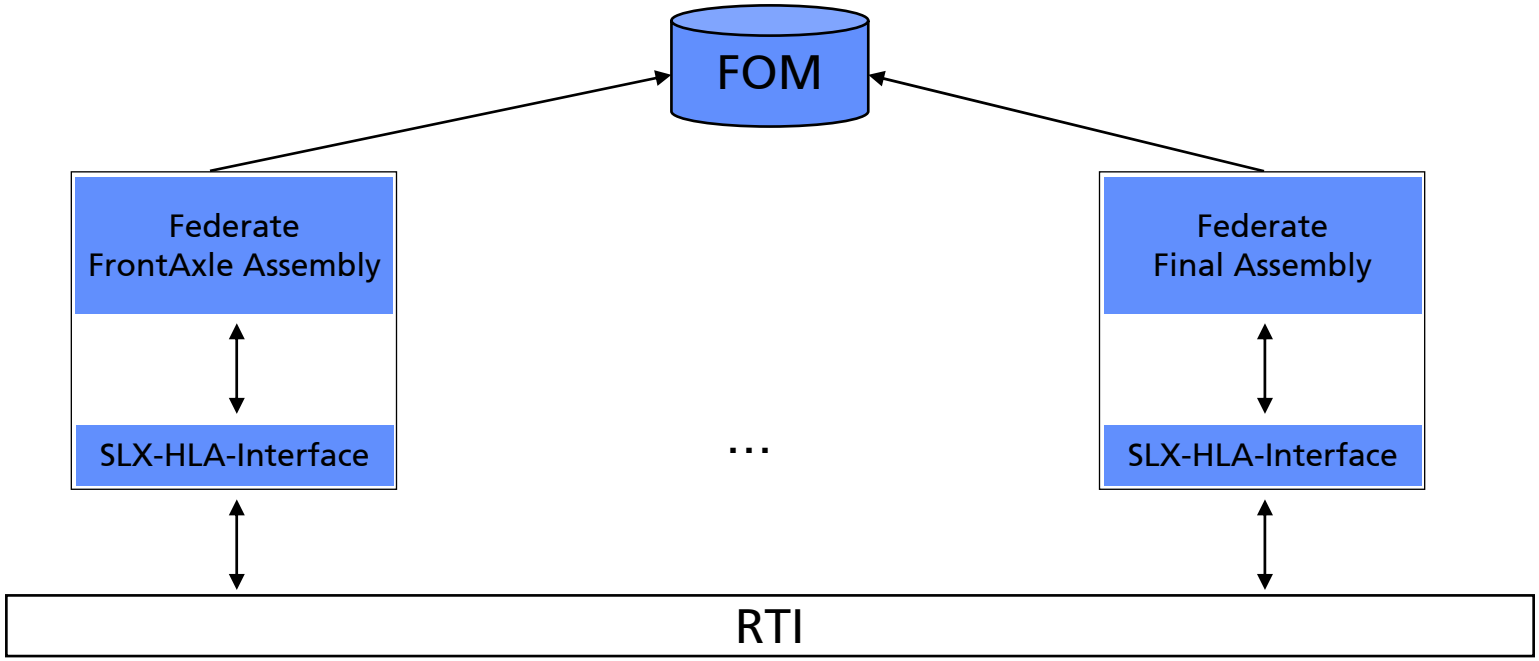
3. Modeling the flow of material and information

- Exchange of produced assembly parts between the different sub models
- Ensuring the access to relevant information which belong to other sub models (e.g. buffer fill level)

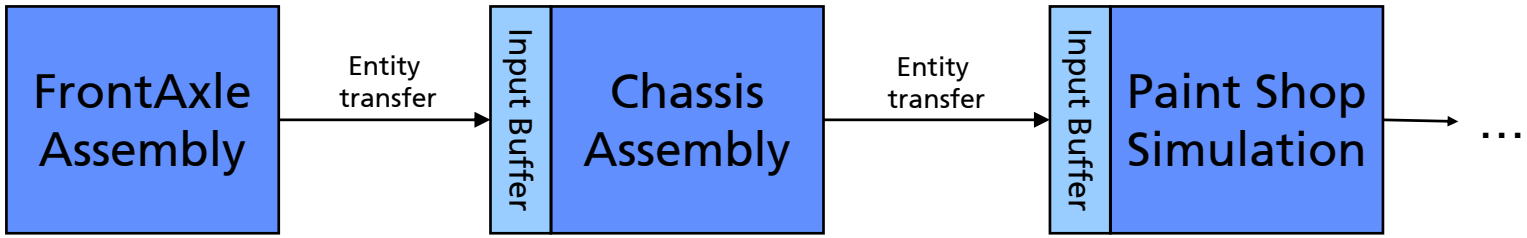
4. Carry out simulation experiments

- Parameterize the complex model
- Collect data about the complex model
- Calculate results (e.g. progress of the buffer fill level, waiting times)
- Visualization of the simulation processes

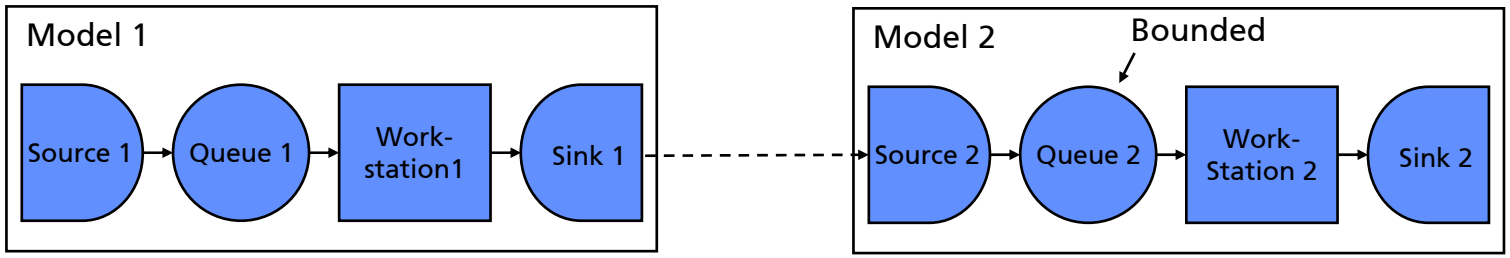
Federation Overview



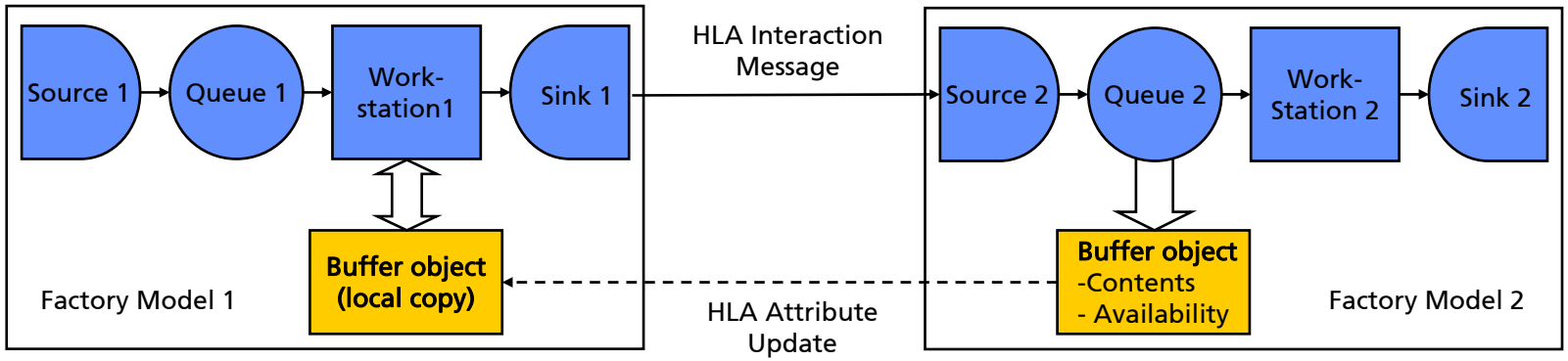
Modeling the flow of material and information



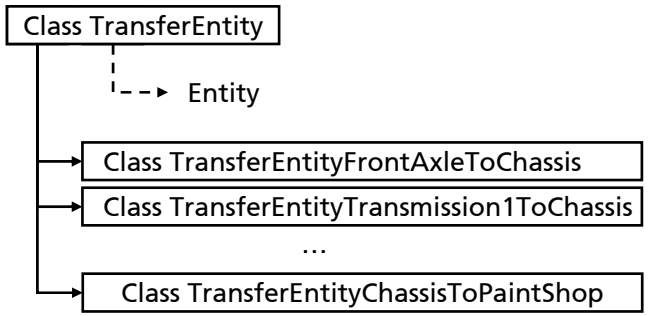
- Problem to solve can be mapped on a standardized interoperability model (see WSC2007, Taylor et. al)
  - Type A.2 → Synchronous entity passing using a bounded buffer



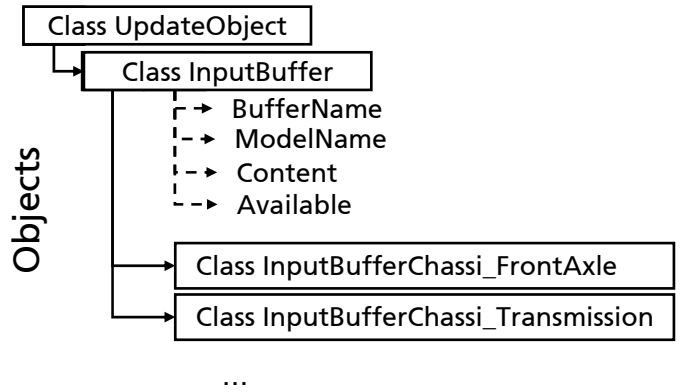
Realizing the flow of material and information



Interactions



Objects



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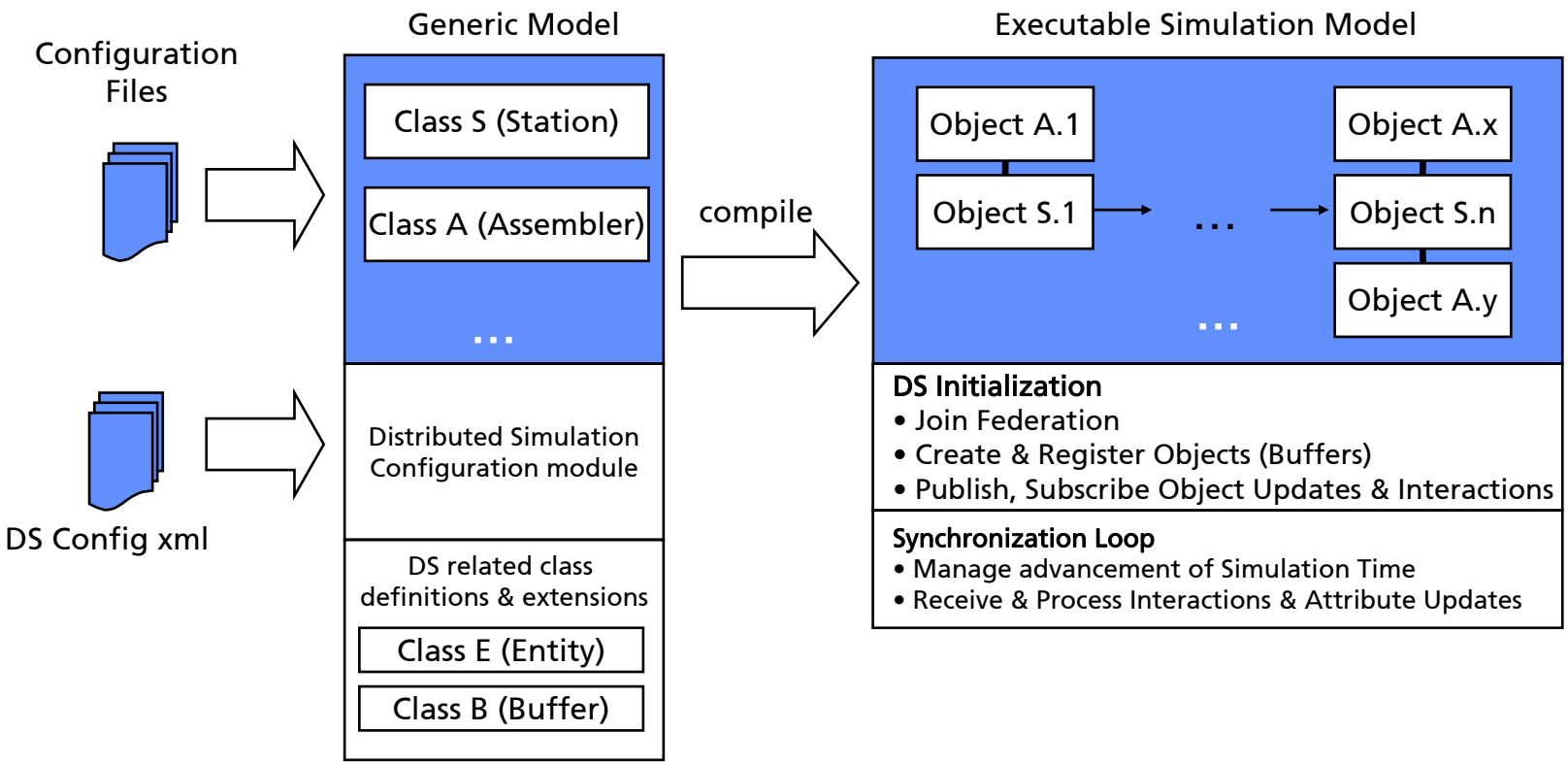
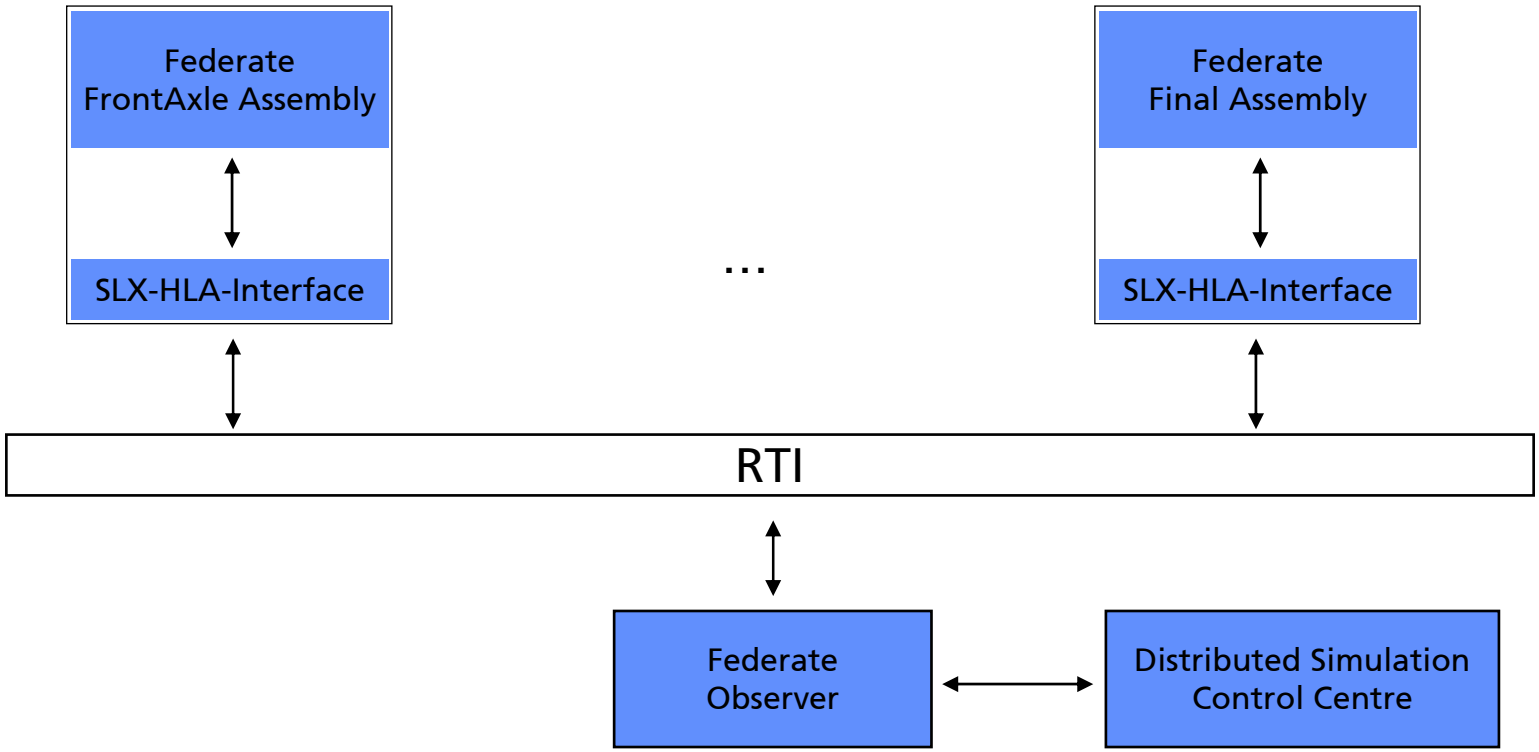
Extending the existing generic models



Run Experiments



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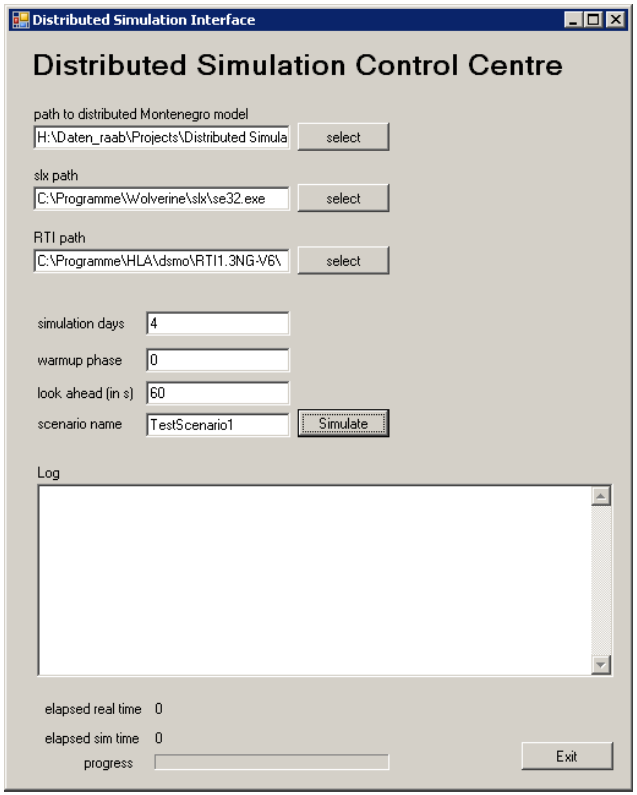
Distributed Simulation Control Centre



- written in C++ .Net
- Usage:
  - Start RTI
  - Load & Distribute Configuration
  - Start Simulation Models
  - Monitor Experiment at Runtime
  - Produce Simulation Results
    - Reports
    - Animations

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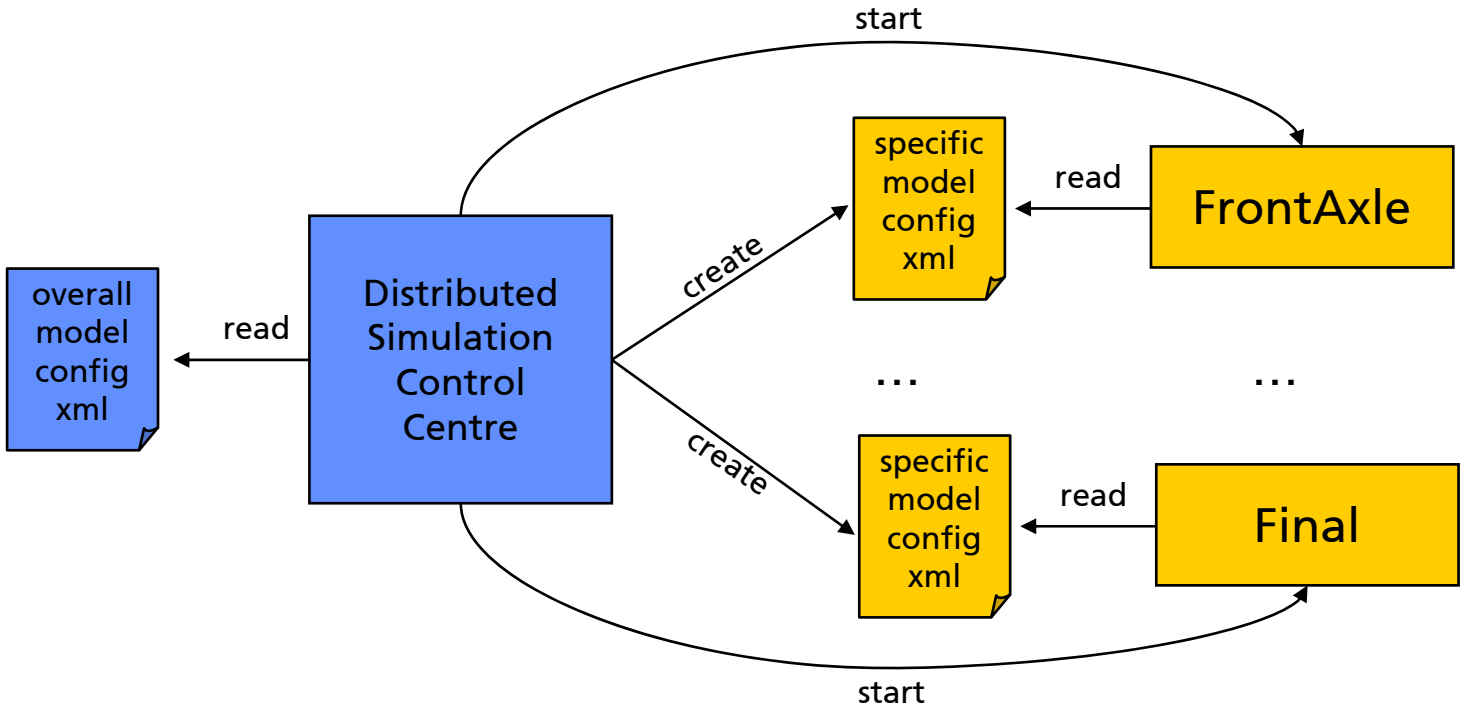
Configuration & Start



Collecting data

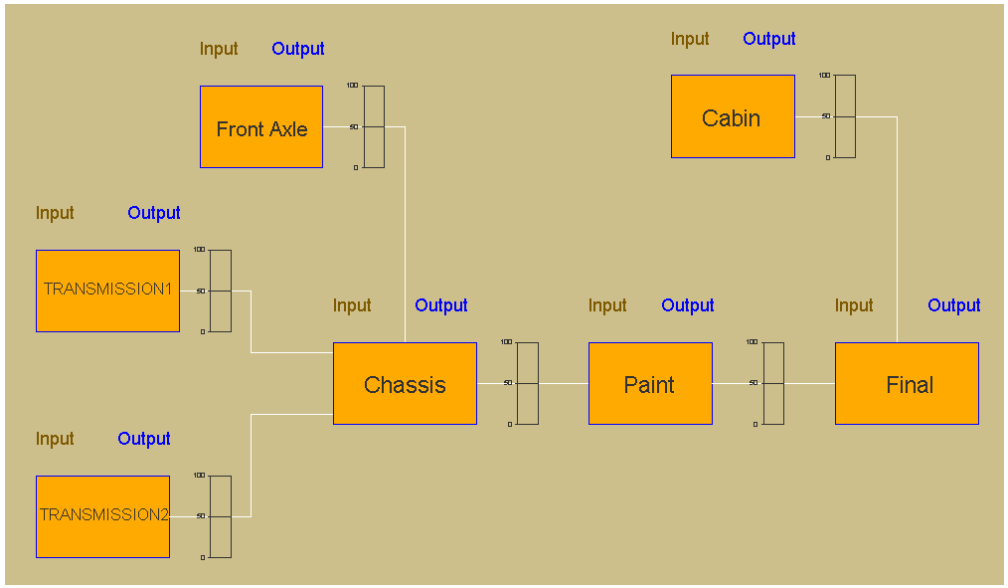
- Observer Federate is used to monitor the progress of the distributed simulation
- Preexisting information like:
  - Transfer of produced vehicle parts (Interaction)
  - Update of Buffer fill level (Attribute update)
- Additional data using HLA-Interactions:
  - Waiting times
    - Blocking due to overfull buffers
    - Due to assembly part deficits
  - Daily production statistics (e.g. Demand vs. Production)

Calculate & display simulation results

- Sub model related results:
  - Demand vs. Production
- Buffer related results:
  - Fill level (average, max, progress), throughput
- Relation Model-Buffer:
  - e.g. model waiting times due to full buffers of successor models
- Relation Model-Model:
  - Waiting times due to assembly part deficits (e.g. caused by a predecessor model which produces to slow)
- Simulation results are automatically generated, in form of html reports und MS Excel Charts

Visualize Simulation Progress

- Proof Animation
  - Production progress (started parts vs. finished parts)
  - Buffer (throughput, content)



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Outlook

- Improvement of user-interface
  - Experiment configuration (define model structure & relationships)
  - Optimization with distributed models
  - Model administration
- Validation of complex distributed models
- Improvement of run-time performance
  - Investigating dynamic Lookaheads

Modellierung des Material- & Informationsflusses (1) - backup