Hasso Plattner Institut

IT Systems Engineering | Universität Potsdam

Multiple Runtime Models and their Relations for Self-Managing Systems

HPI/SAP Workshop

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Thomas Vogel

HPI Research School

System Analysis & Modeling Group

Motivation

- **Continuous adaptation** of software to keep its value for the user (Laws of Software Evolution) [Lehman, 1996]
- (Increasing) **complexity** of software systems [Northrop et al., 2006]
- Maintenance & administration costs [Sterritt, 2005, Sommerville, 2007]

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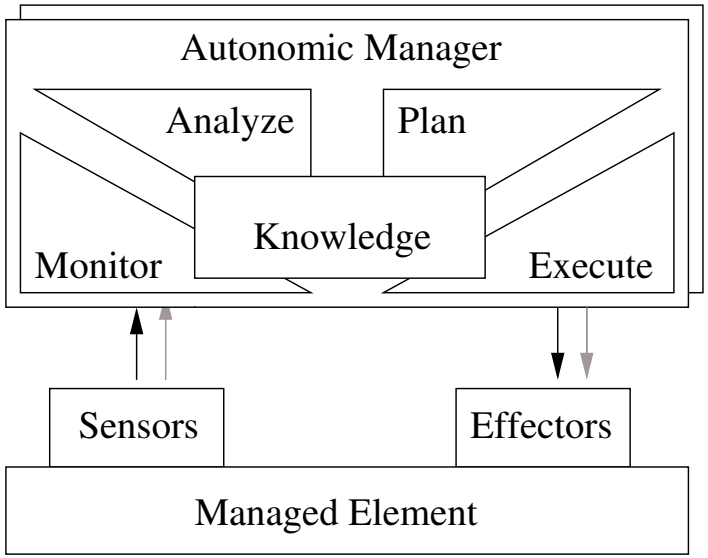
Self-Adaptive/-Managing Software [Cheng et al., 2009]

Systems that are able to adjust their behavior in response to their perception of the environment and the system itself.

$\rightsquigarrow$ Autonomic Computing

[Kephart and Chess, 2003]

Self-Managing Systems



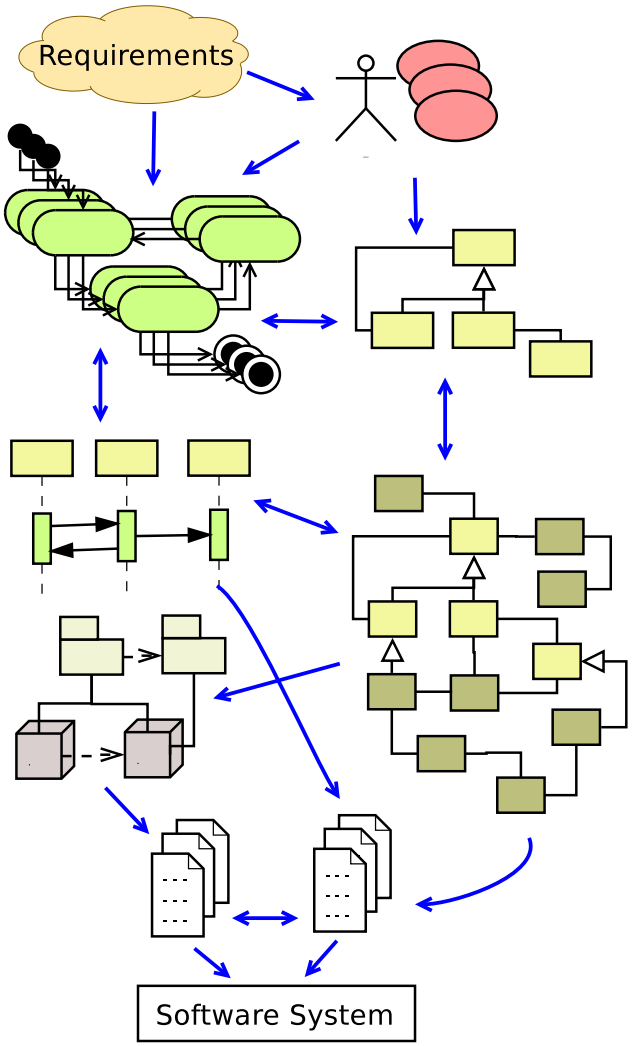
Feedback Loop [Kephart and Chess, 2003]

- Concepts originating from the control engineering discipline
  [Kokar et al., 1999, Diao et al., 2005]
- Self-healing/-optimization/-protection/-configuration [Lin et al., 2005]

Model-Driven Engineering

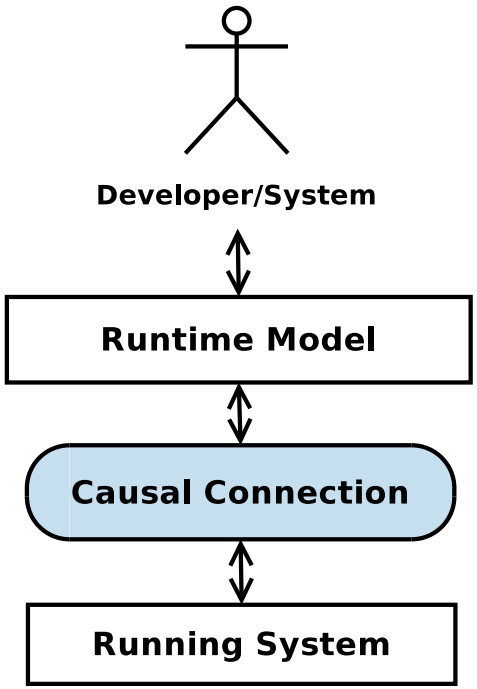
*The term Model-Driven Engineering (MDE) is **typically** used to describe **software development** approaches in which abstract models of software systems are created and systematically transformed to concrete implementations.*

[France and Rumpe, 2007]



MDE & Self-Managing Systems

- *In our broad vision of MDE, models [. . .] are also the **primary means by which developers and other systems understand, interact with, configure and modify the runtime behavior of software.*** [France and Rumpe, 2007]
- *Models@run.time* [Blair et al., 2009]



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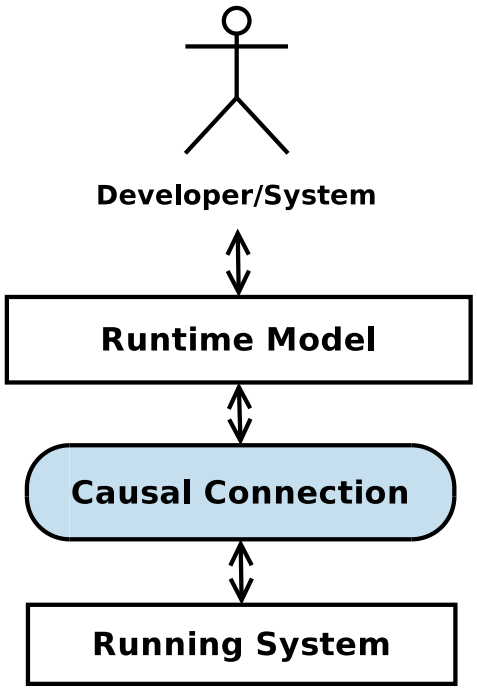
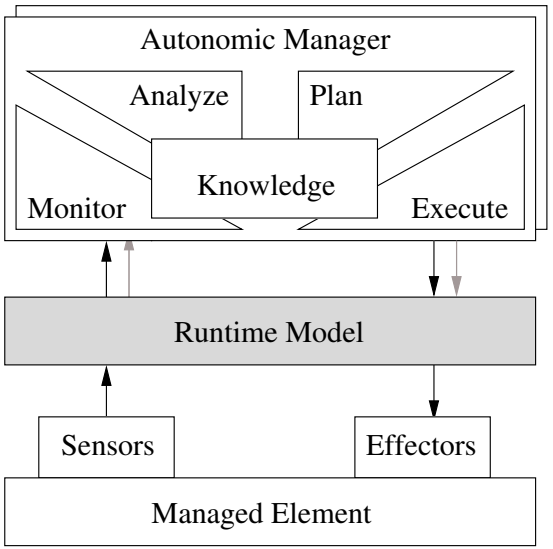
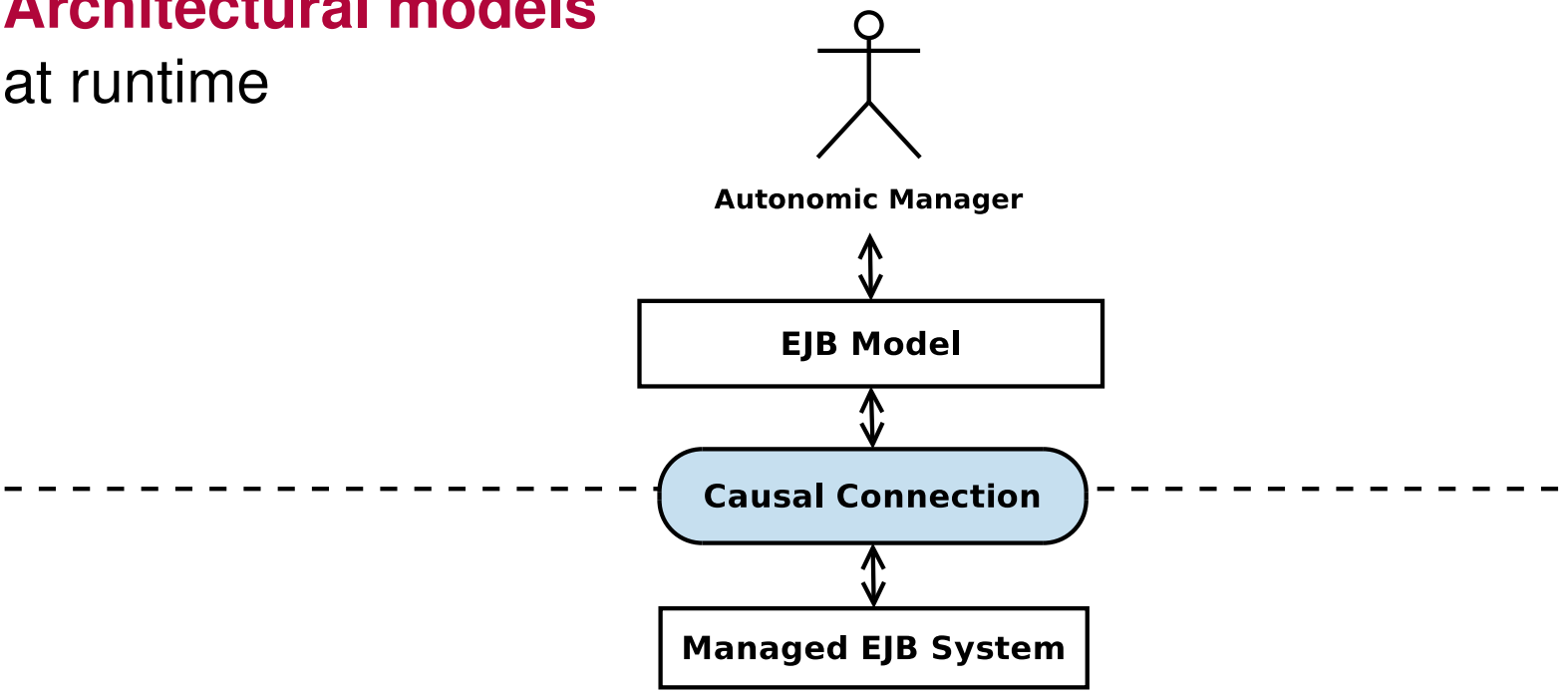




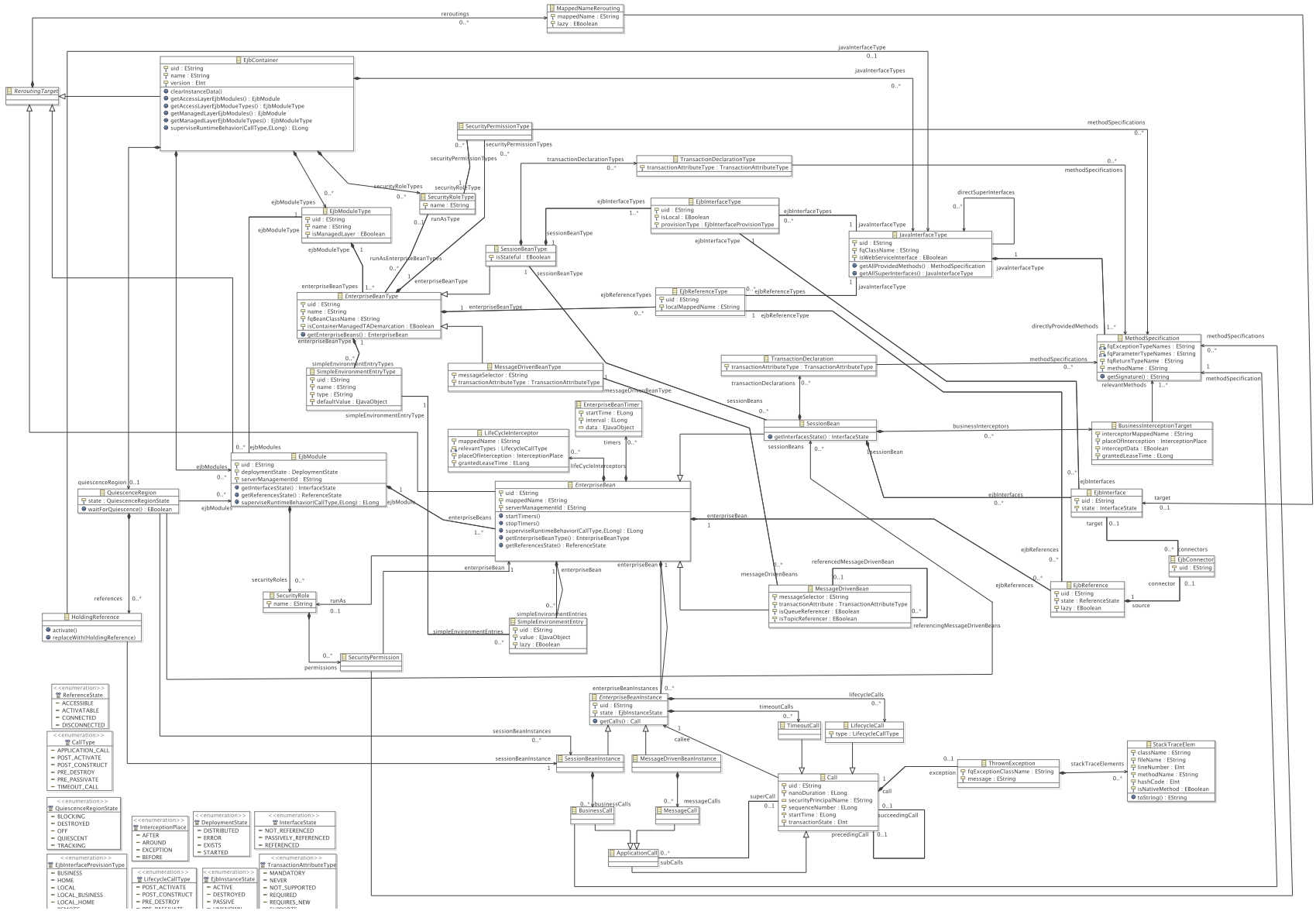
Self-Managing Systems

Self-Managing EJB Systems

- Component-based software systems
  - *Enterprise Java Beans 3* (EJB)
- **Architectural monitoring and adaptation**
  - components and connectors, above the level of *Java* objects
- **Architectural models**
  at runtime



EJB (Runtime) Metamodel



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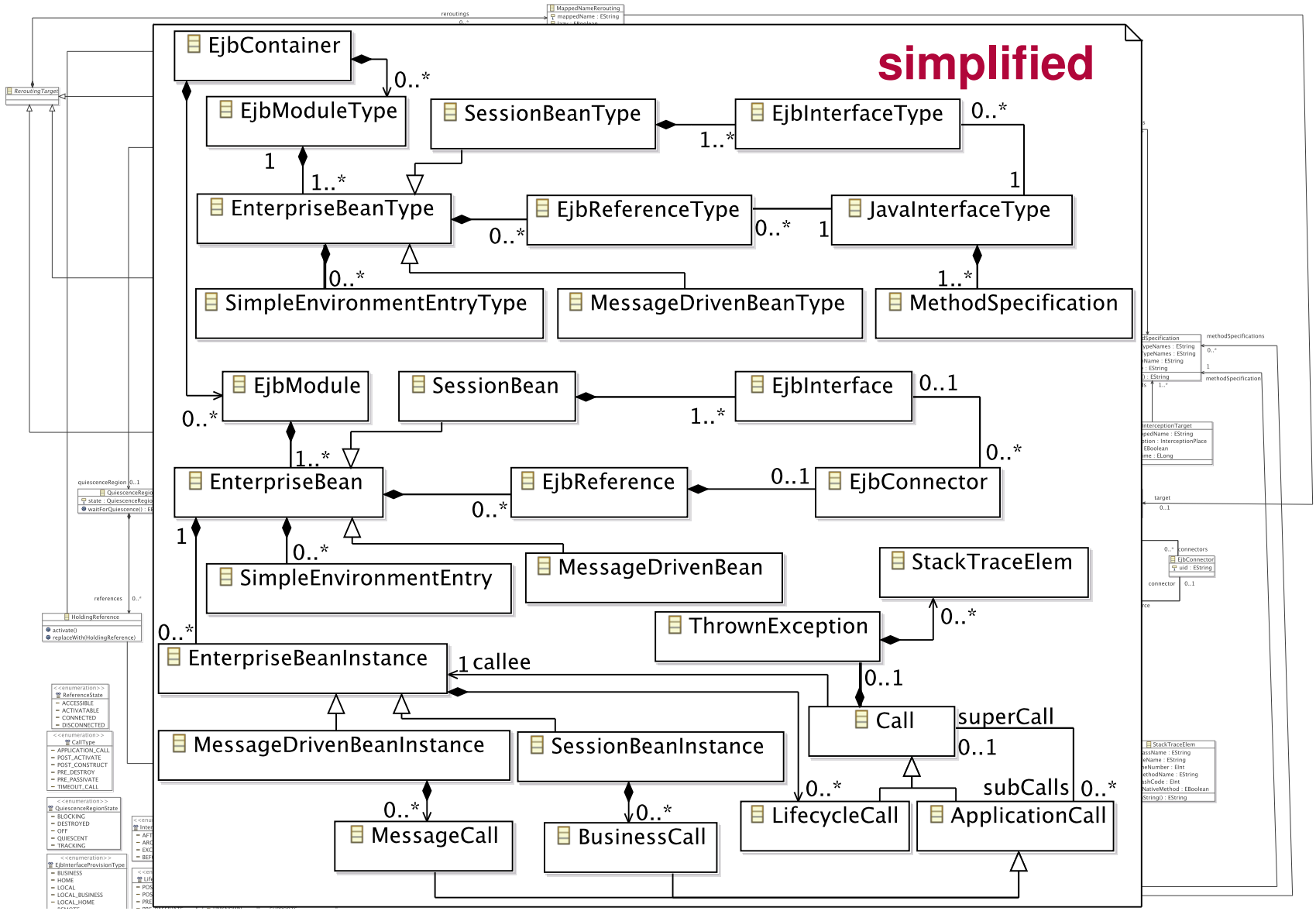
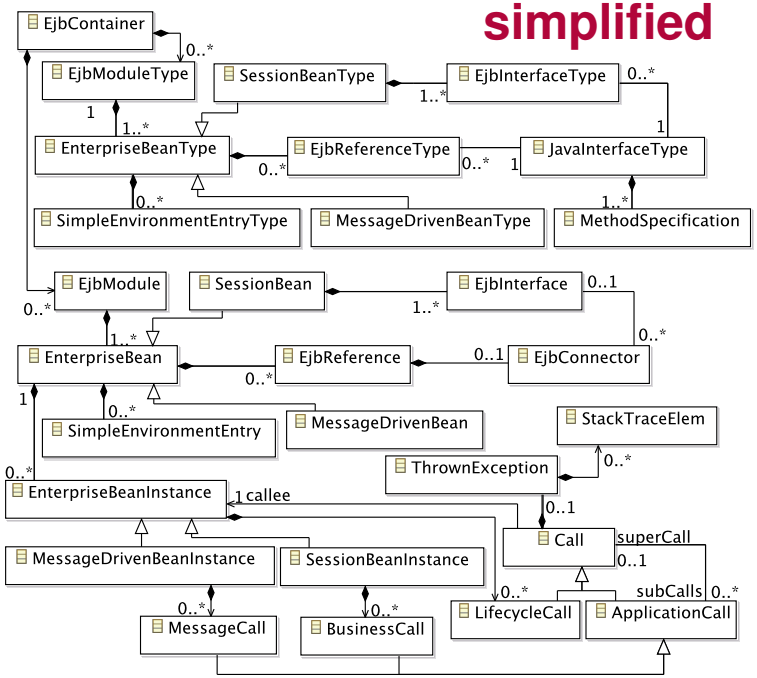


Abstract Runtime Metamodels

simplified



complex

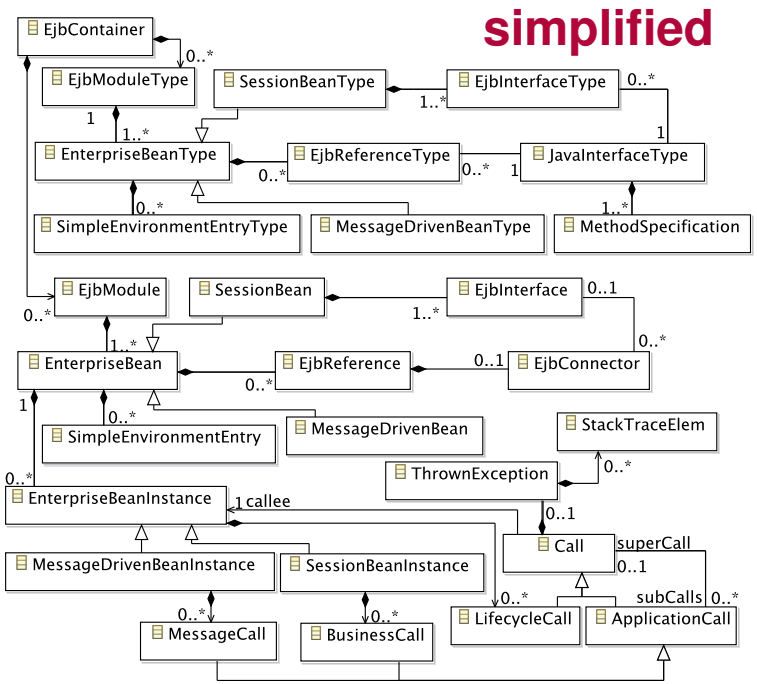
detailed

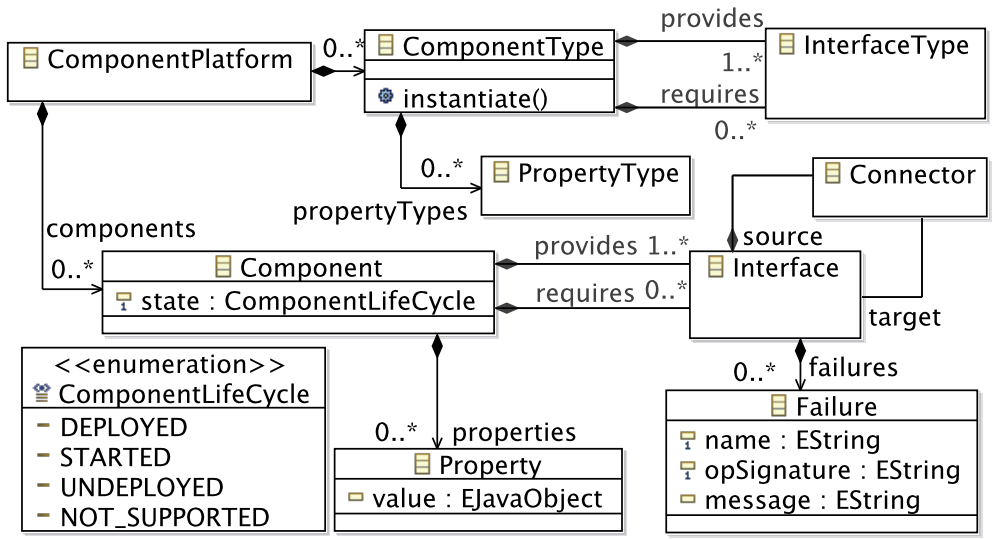
multiple concerns

platform-specific

solution space

Abstract Runtime Metamodels



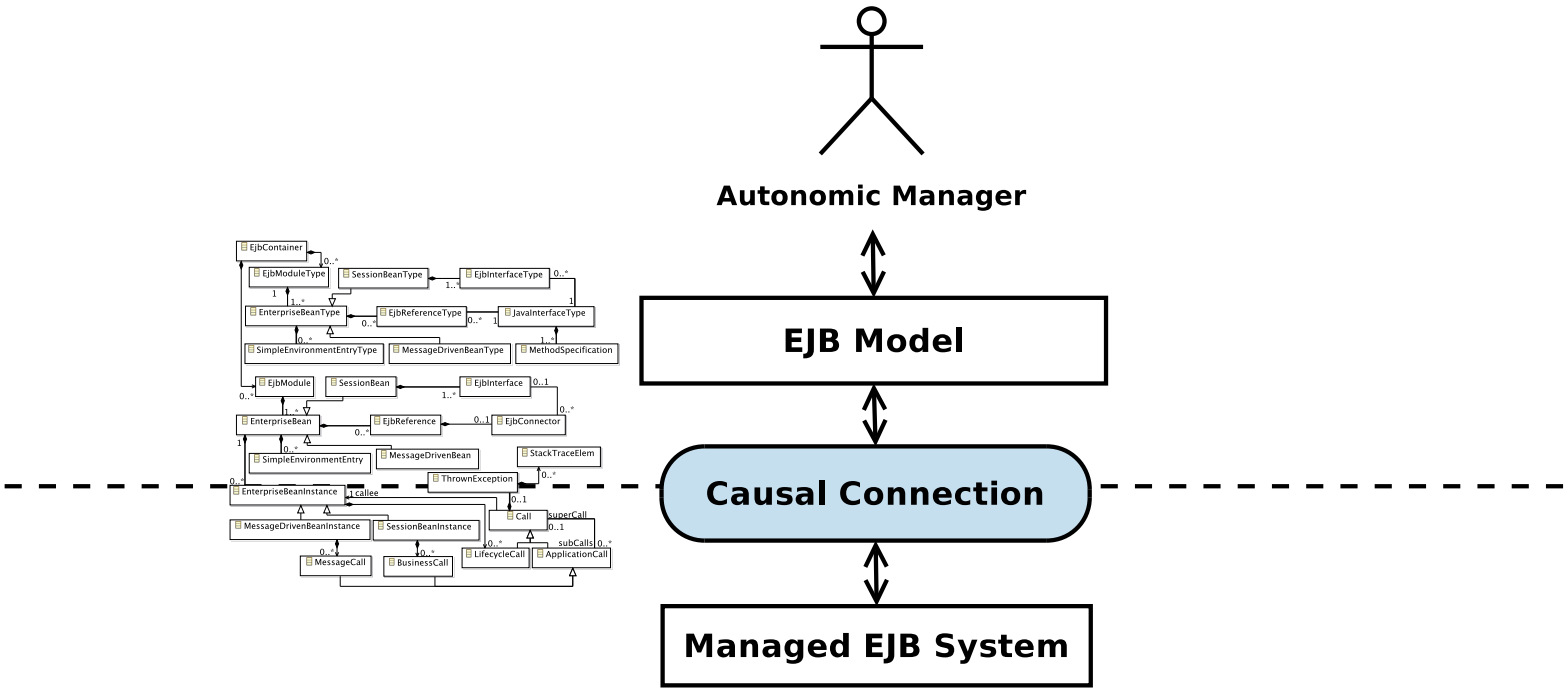


complex
detailed
multiple concerns
platform-specific
solution space

vs.

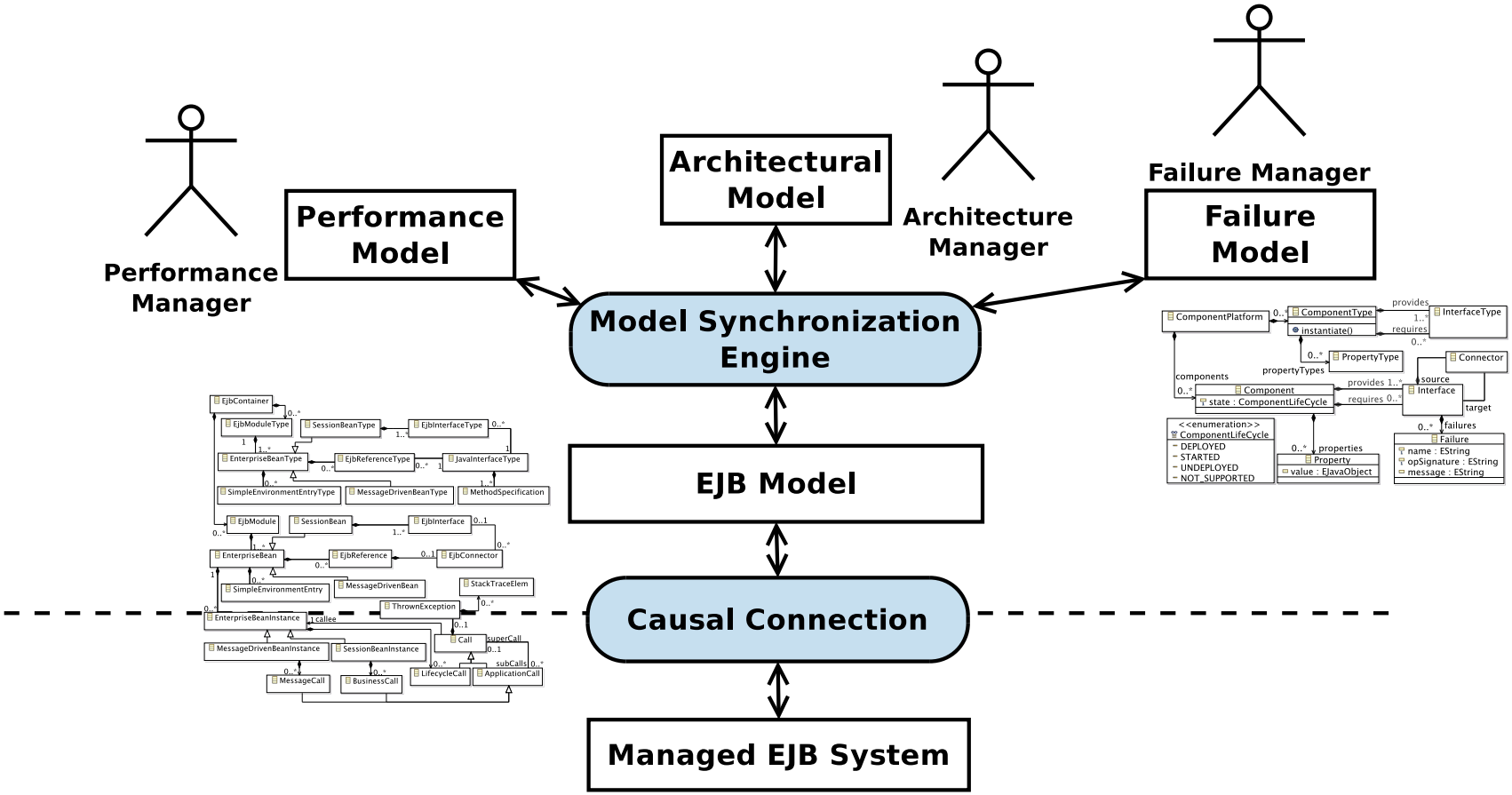
less complex
abstract
one concern
platform-independent
problem space

Abstract Runtime Models



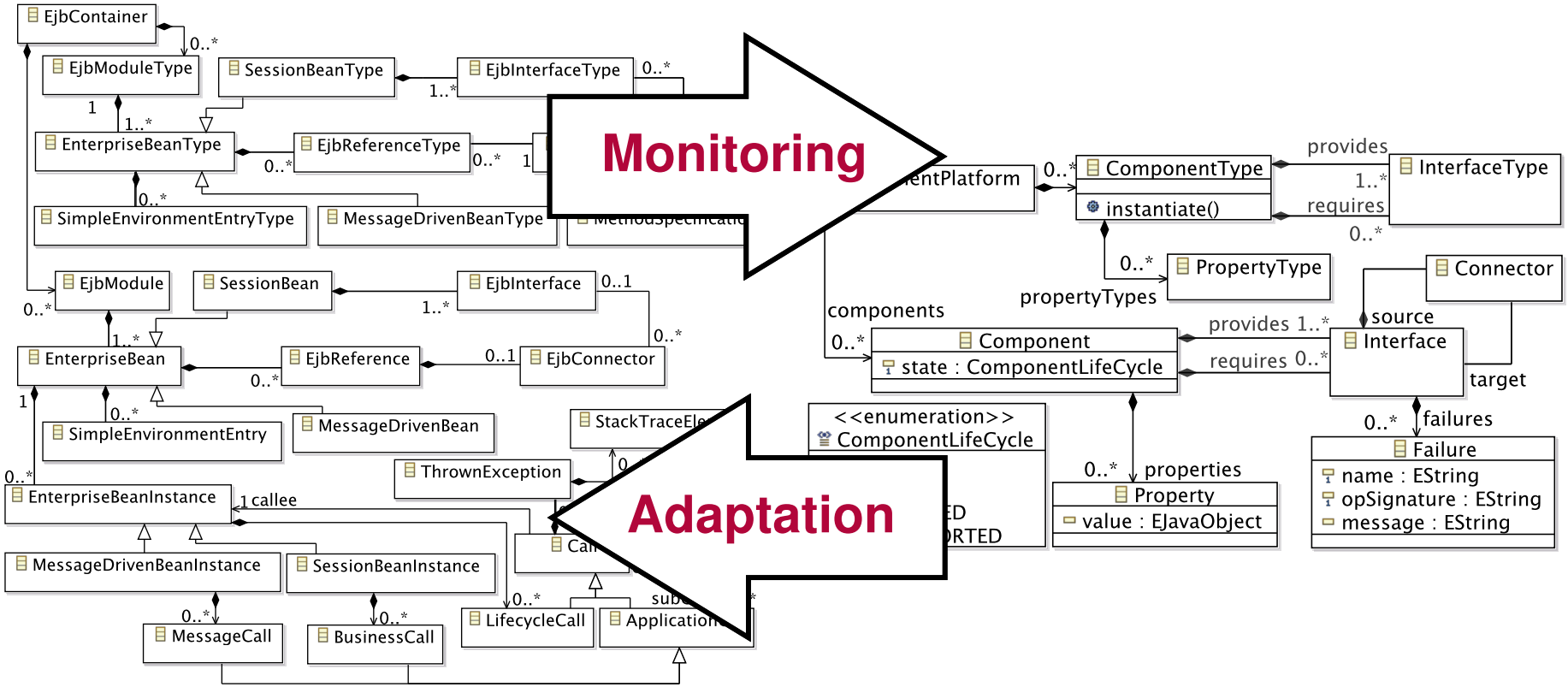
Abstract Runtime Models

- Concern-specific, platform-independent models and managers
- **Model Synchronization** to maintain the runtime models



Runtime Model Synchronization

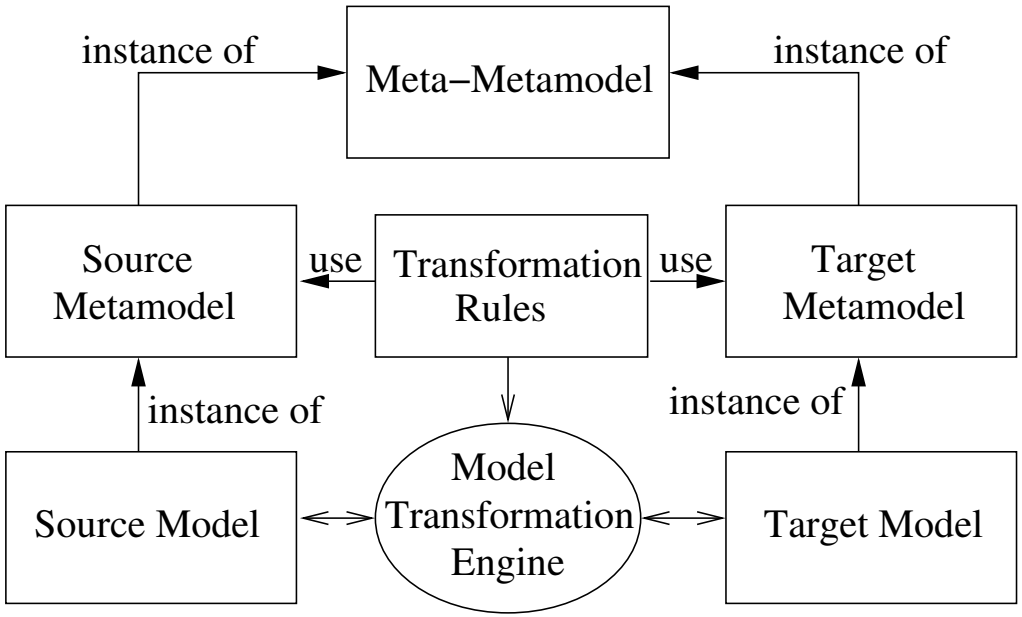
- Abstraction (monitoring) and refinement (adaptation)



Simplified **EJB Metamodel**
(Source Metamodel)

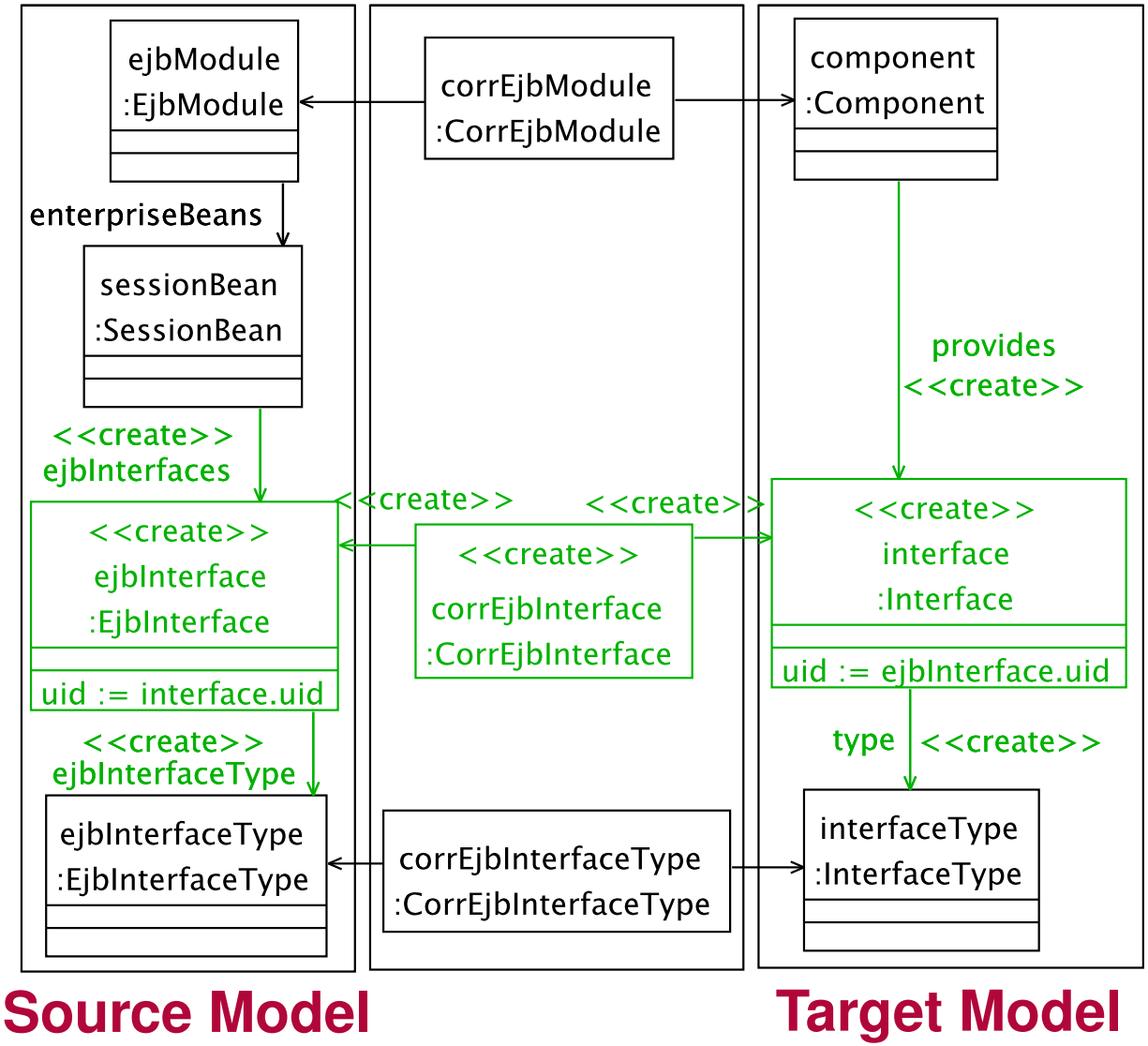
Failure Metamodel
(Target Metamodel)

Model Transformation Engine

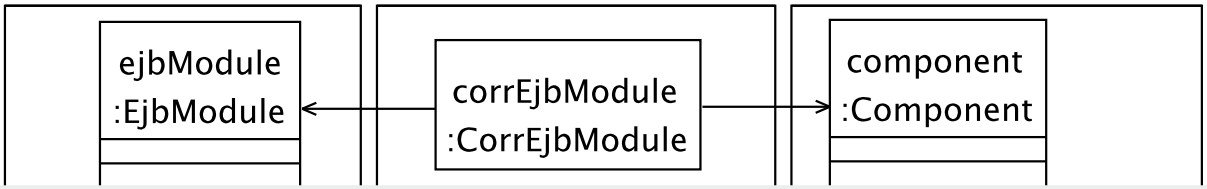


- Unidirectional vs. Bidirectional
- Transformation vs. Synchronization
- Bidirectional synchronization based on **Triple Graph Grammars** (TGG) [Giese and Wagner, 2009, Giese and Hildebrandt, 2008]
- **Incremental** and event-driven solution applicable at runtime

Triple Graph Grammar Rule

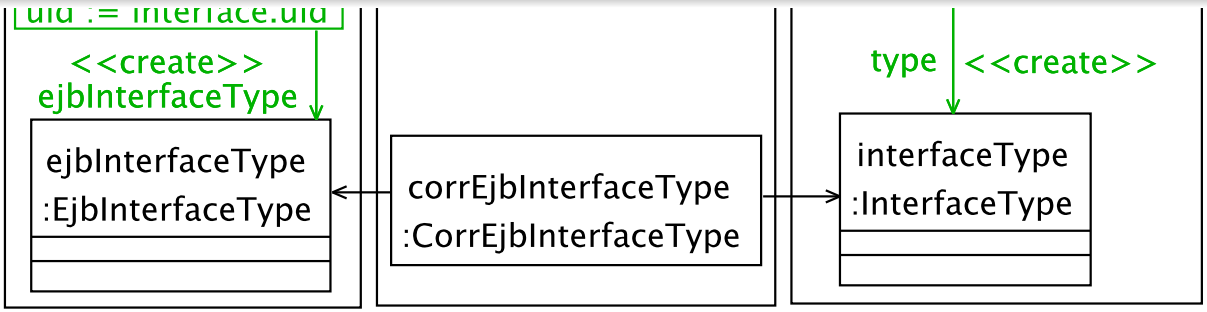


Triple Graph Grammar Rule



- Declarative rules
- Automatic generation of operational rules
- Abstraction gap between models: manually written code “extending” the rules for adaptation

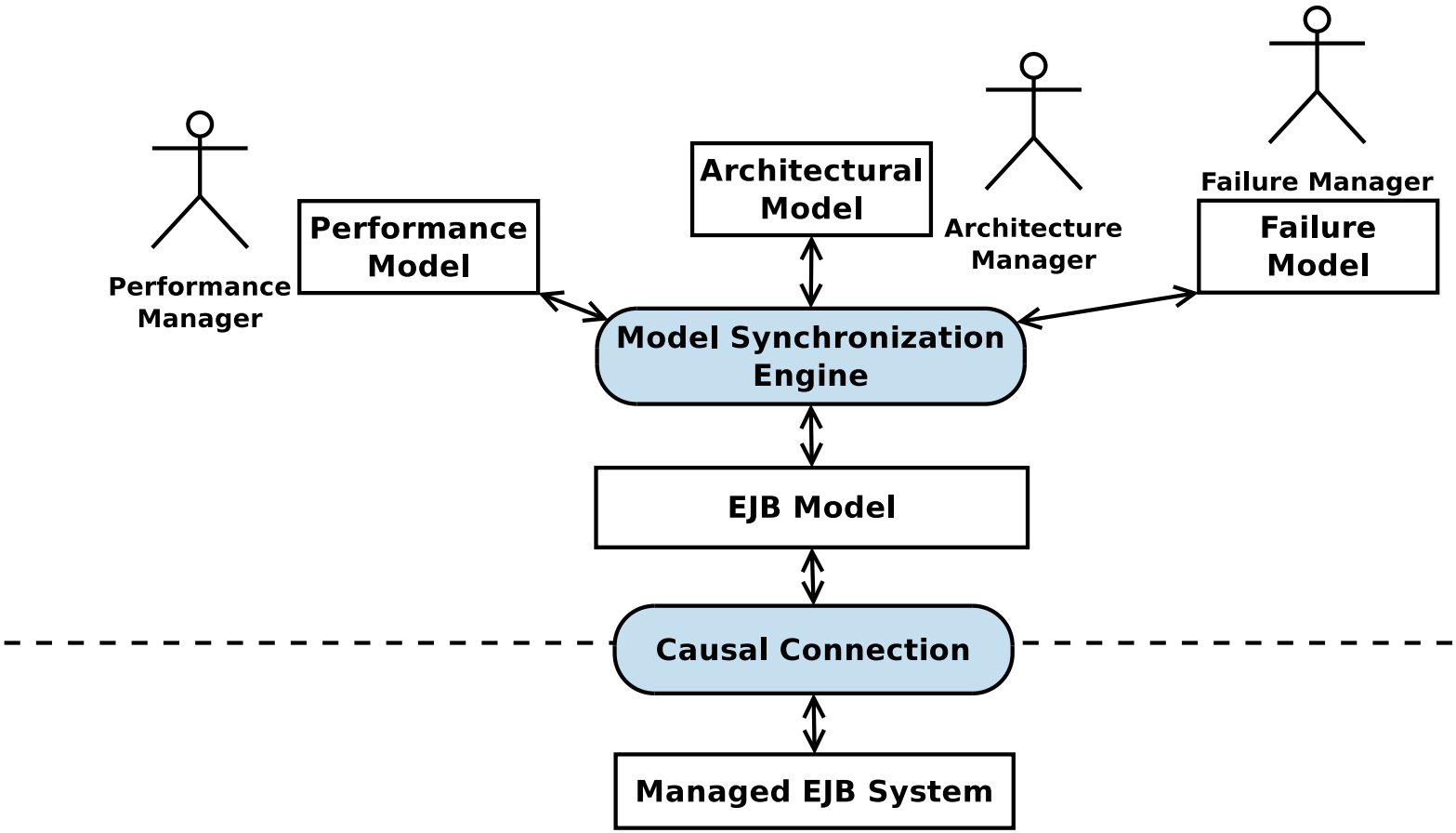
→ **MDE simplifies the development of maintaining multiple runtime models**



Source Model **Target Model**

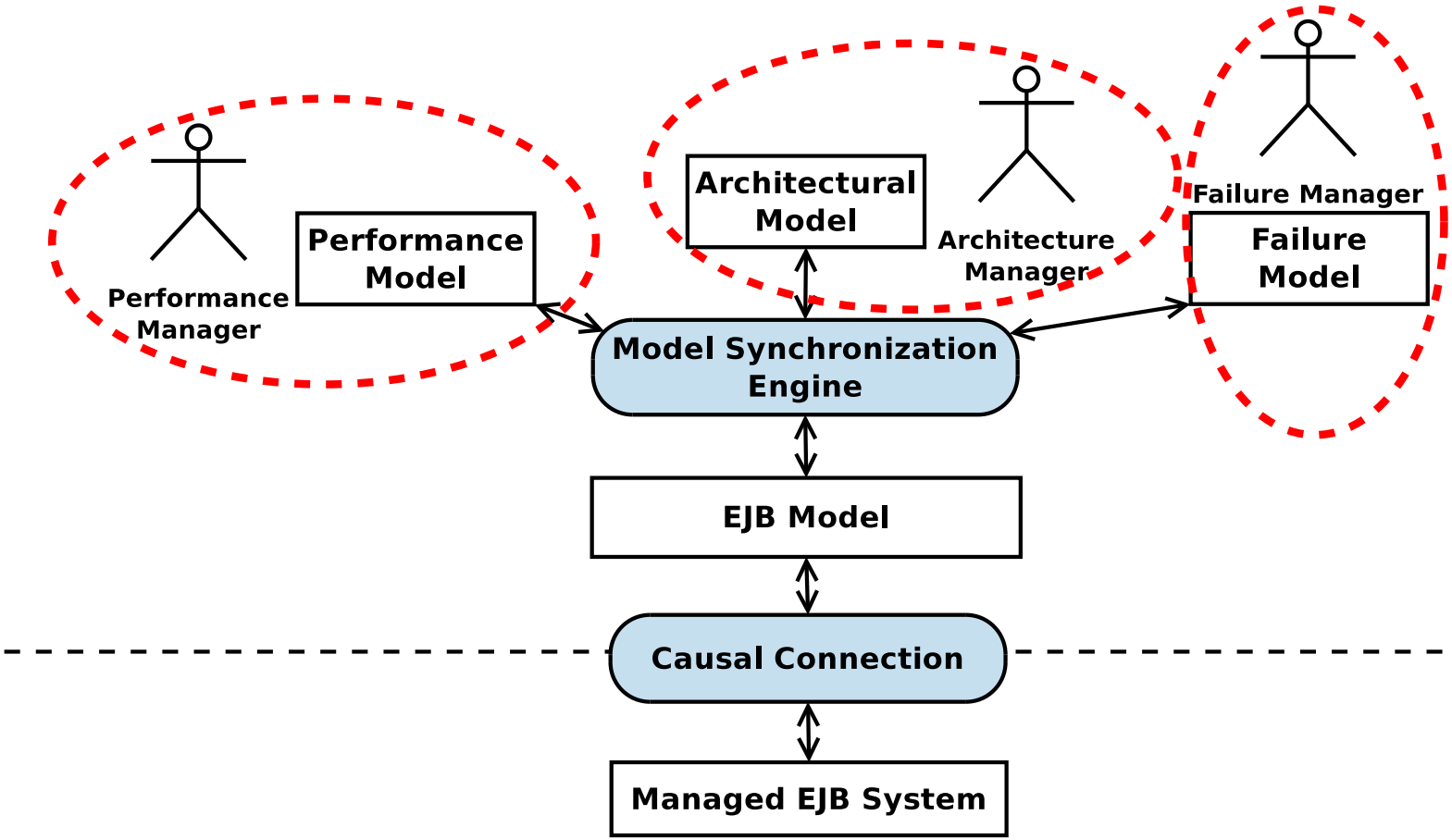
Multiple Runtime Models...

...but how they are **related**?



Multiple Runtime Models...

...but how they are **related**? **dependencies, trade-offs,...?**



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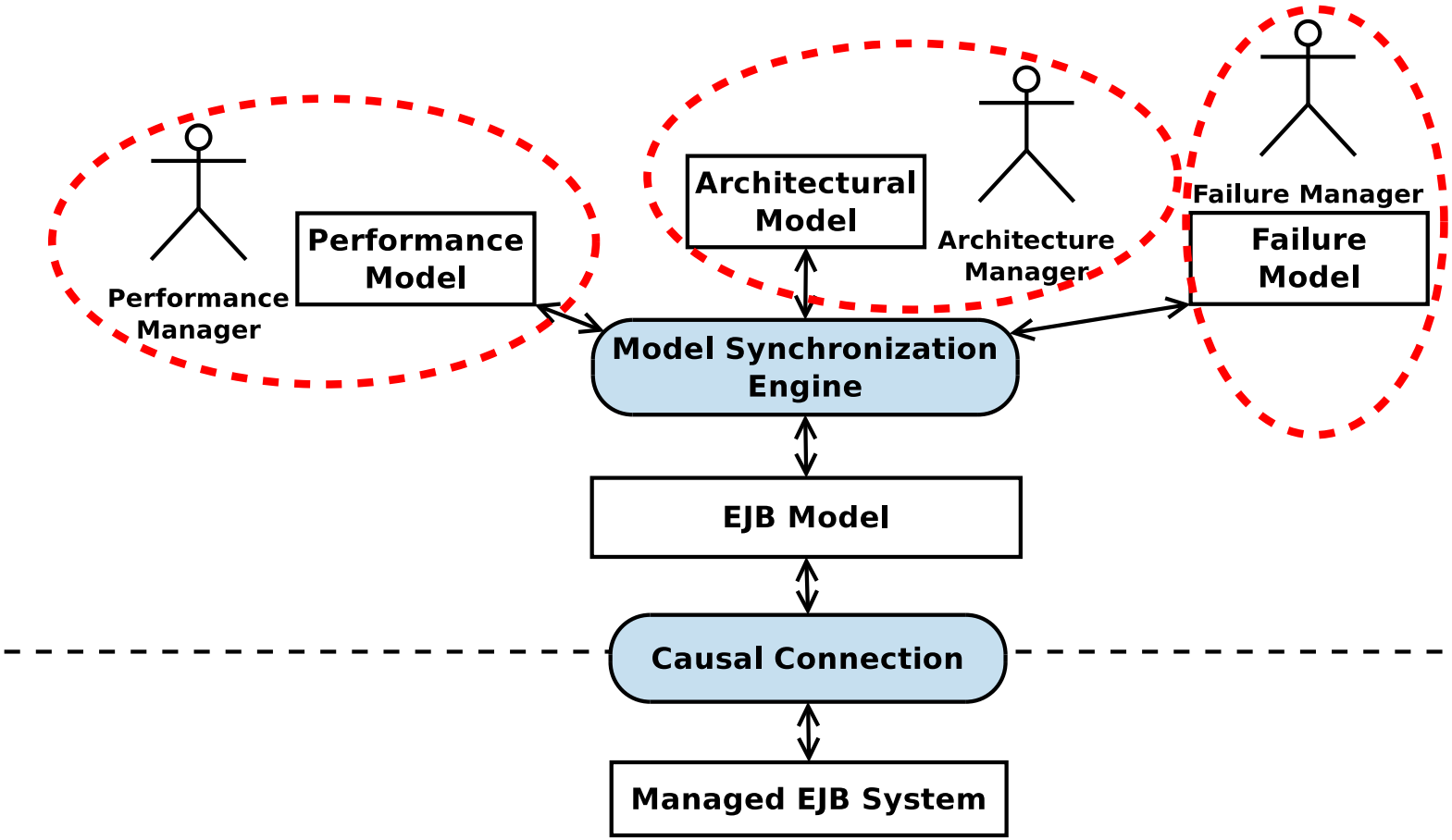
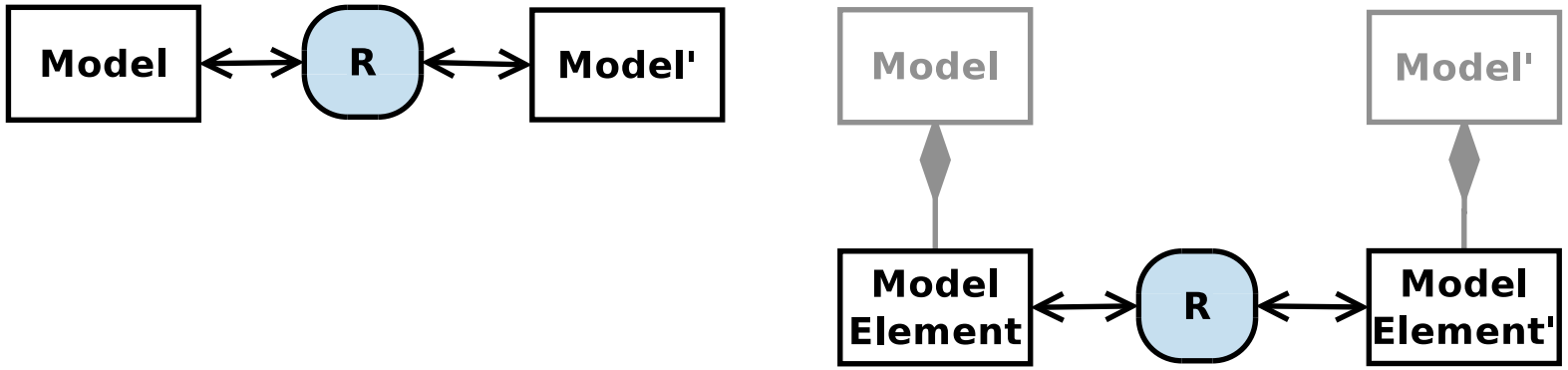


…and how to describe and utilize relations?

Megamodels

"Good enough" Definition (Megamodel)

A *megamodel* is a model that contains models and relations between those models or between elements of those models.



- Makes relations explicit
- Basis for **model-driven** management of models and relations
- Research by Favre [Favre, 2005] and Bézivin et al. [Bézivin et al., 2003, Bézivin et al., 2004, Barbero et al., 2007]

Megamodel Concepts

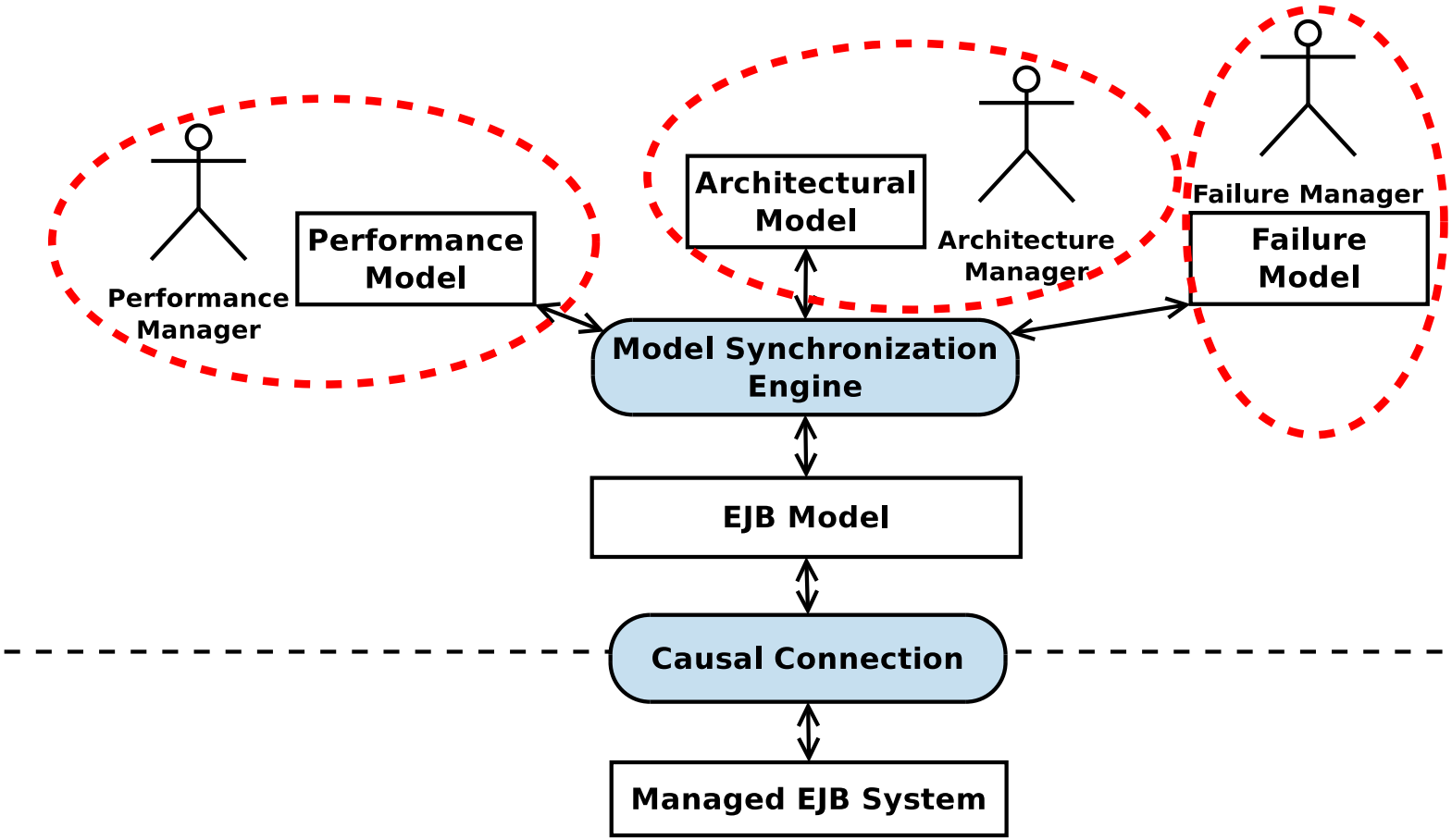
Organizational Purposes:

- Organizing and structuring models and relations
- Registry for models and their relations

Utilization Purposes:

- Navigation through different models in a model-driven manner
- Operational relations by means of executable units

Self-Managing EJB System



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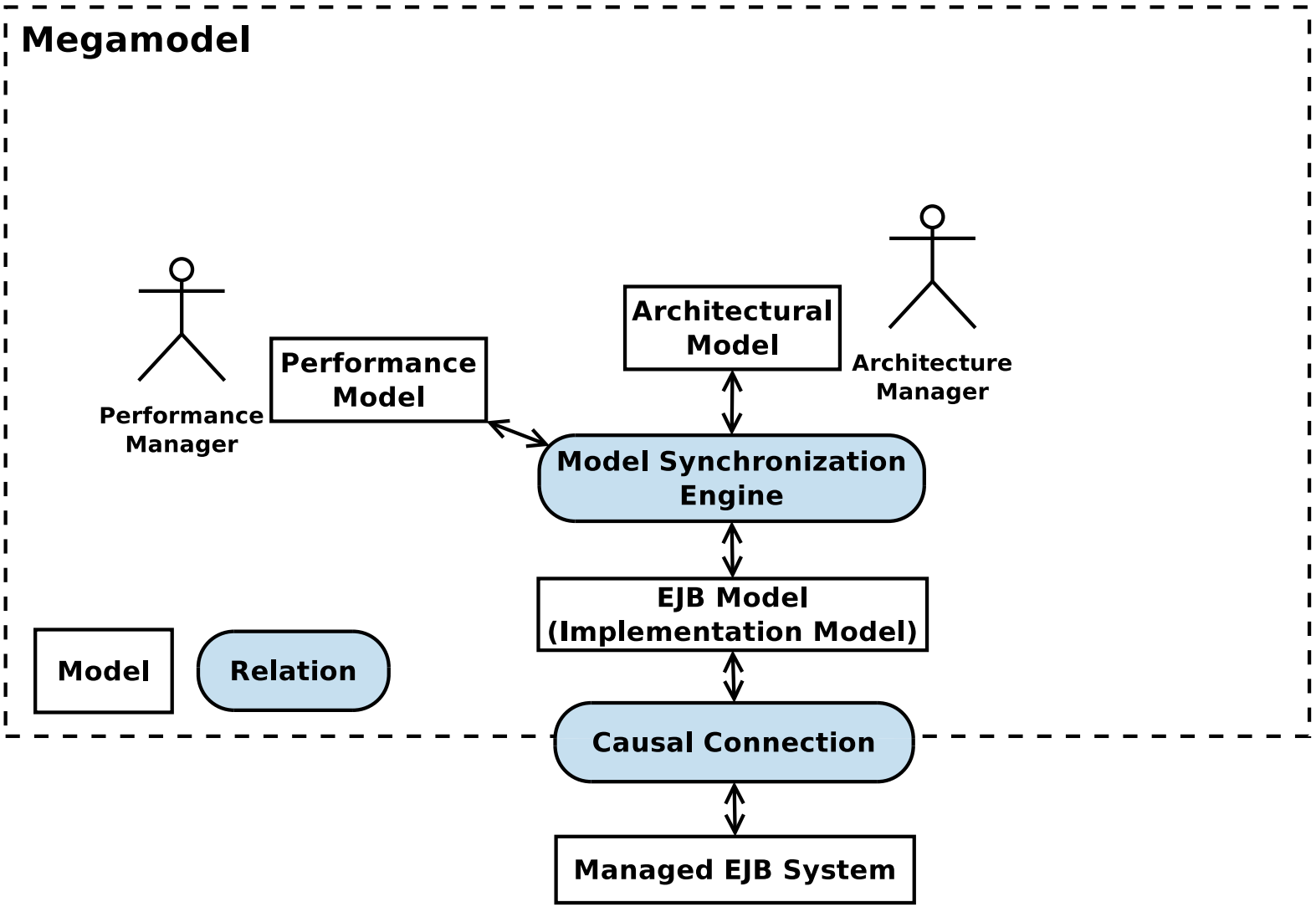

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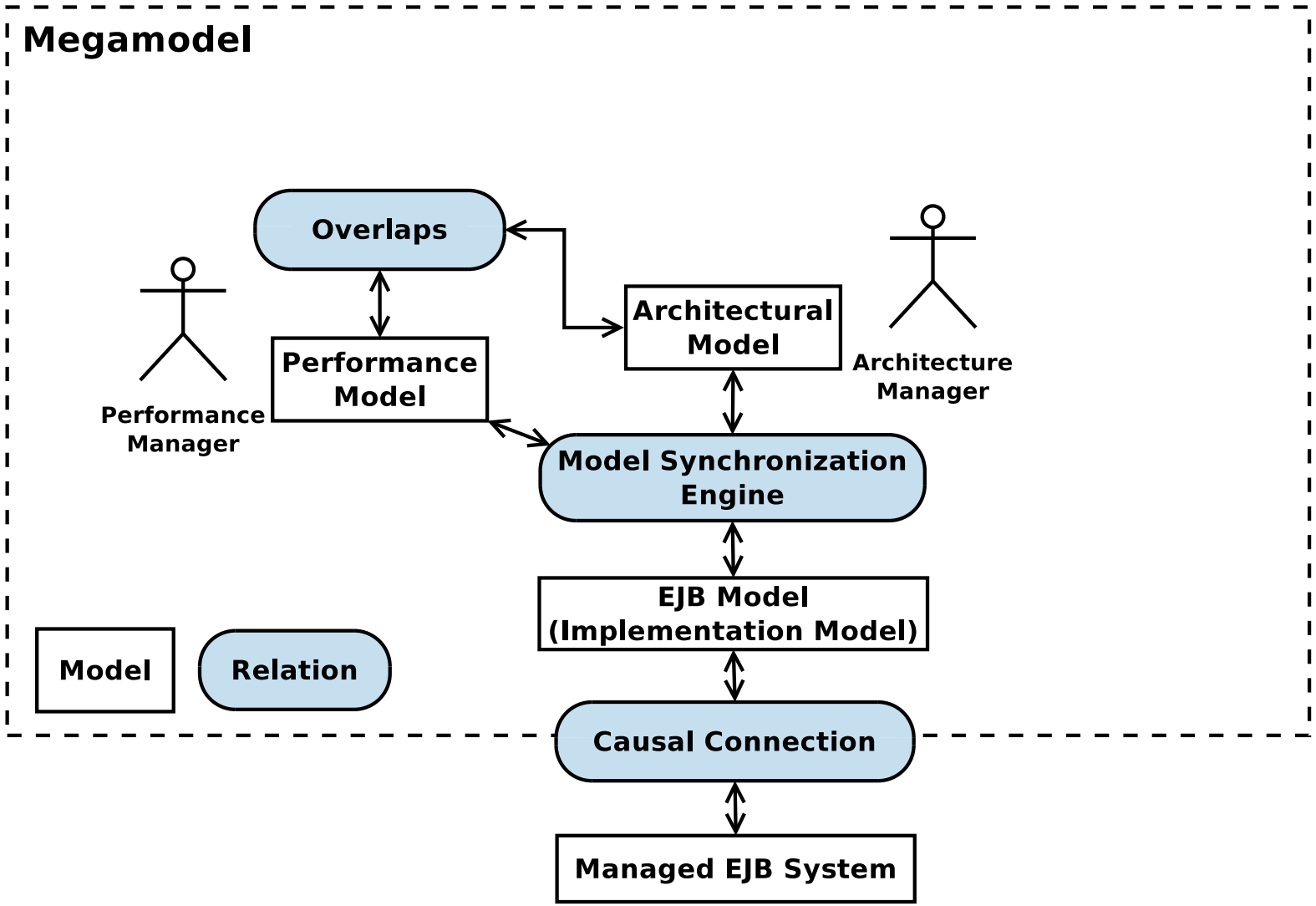

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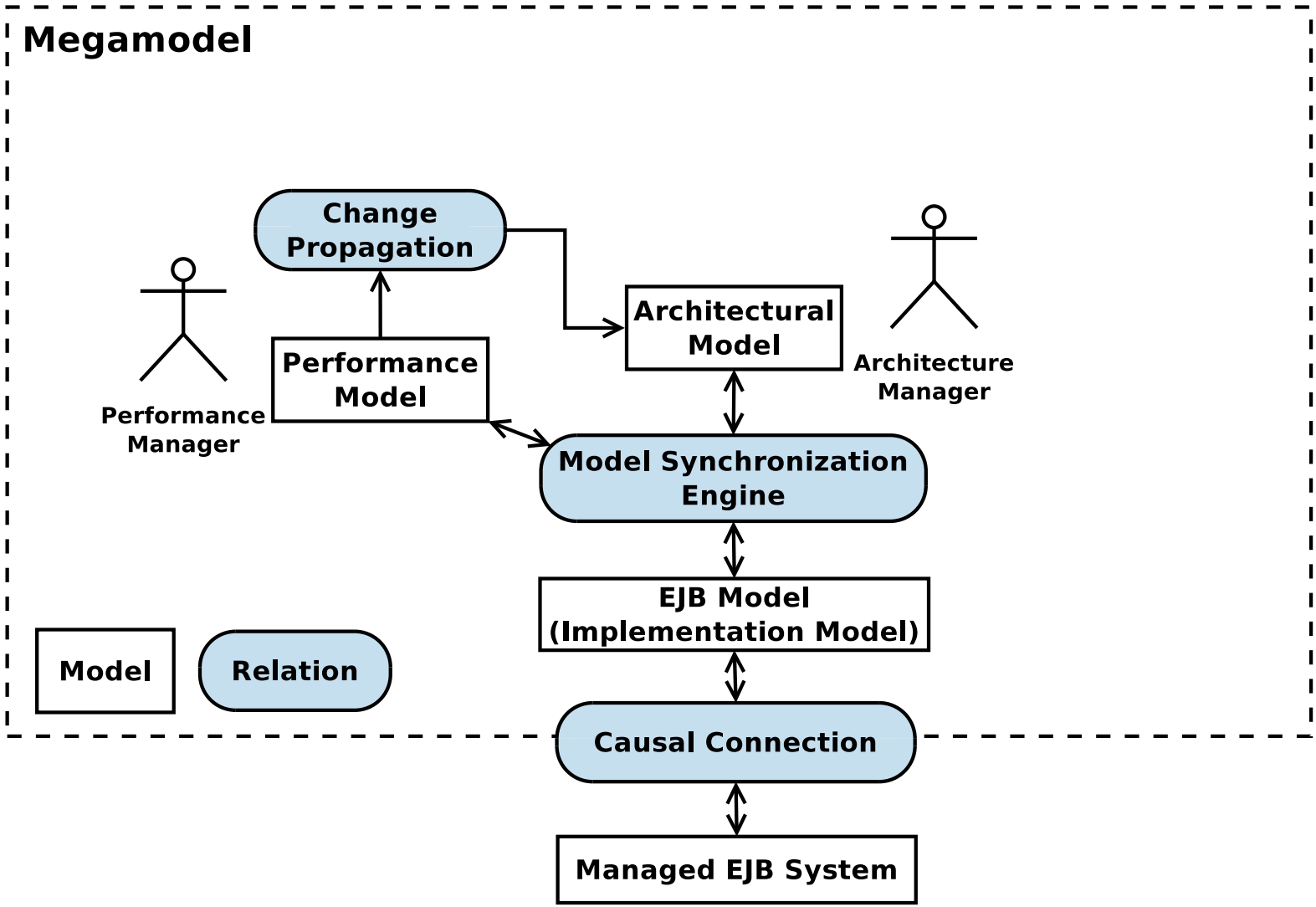

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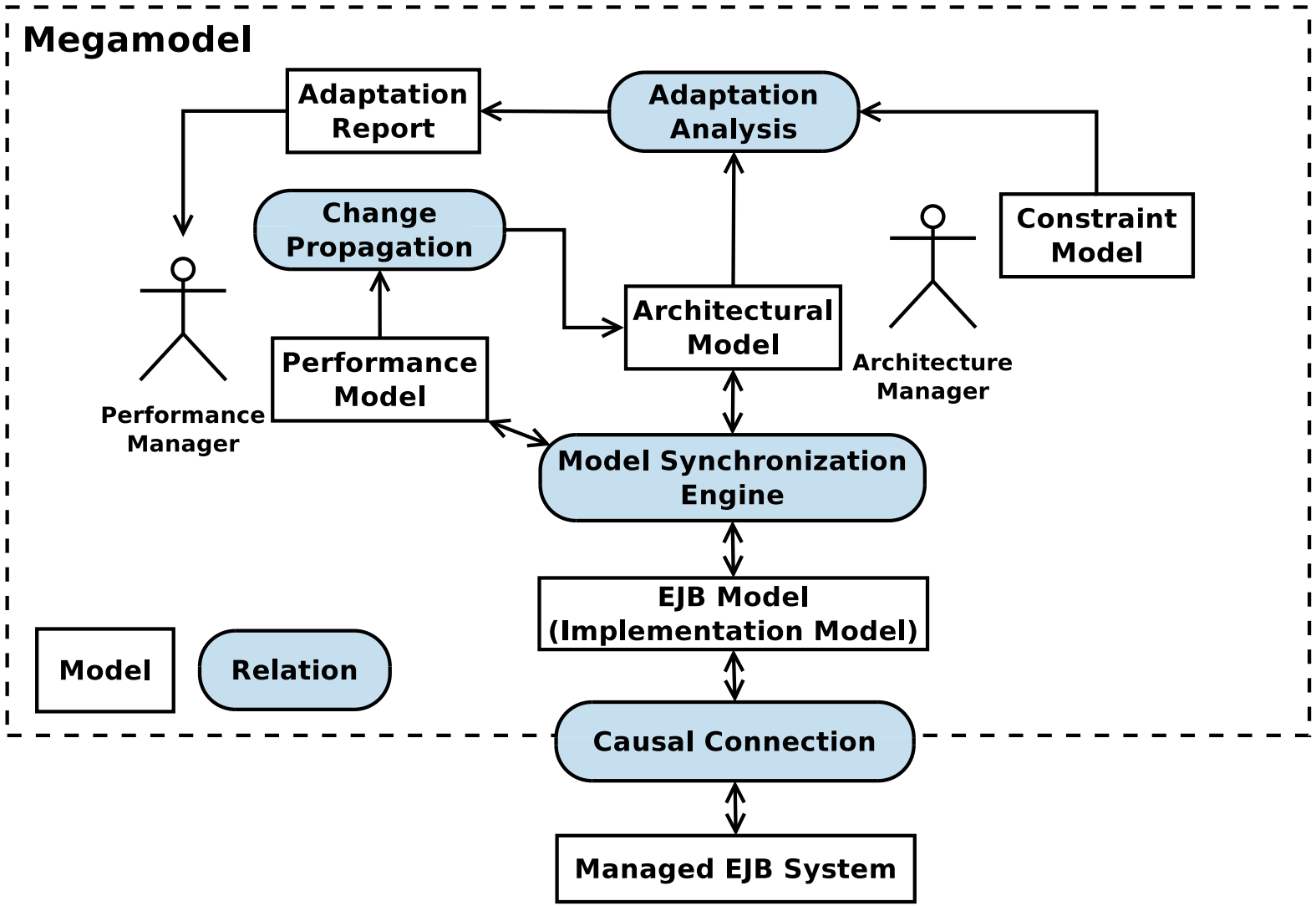
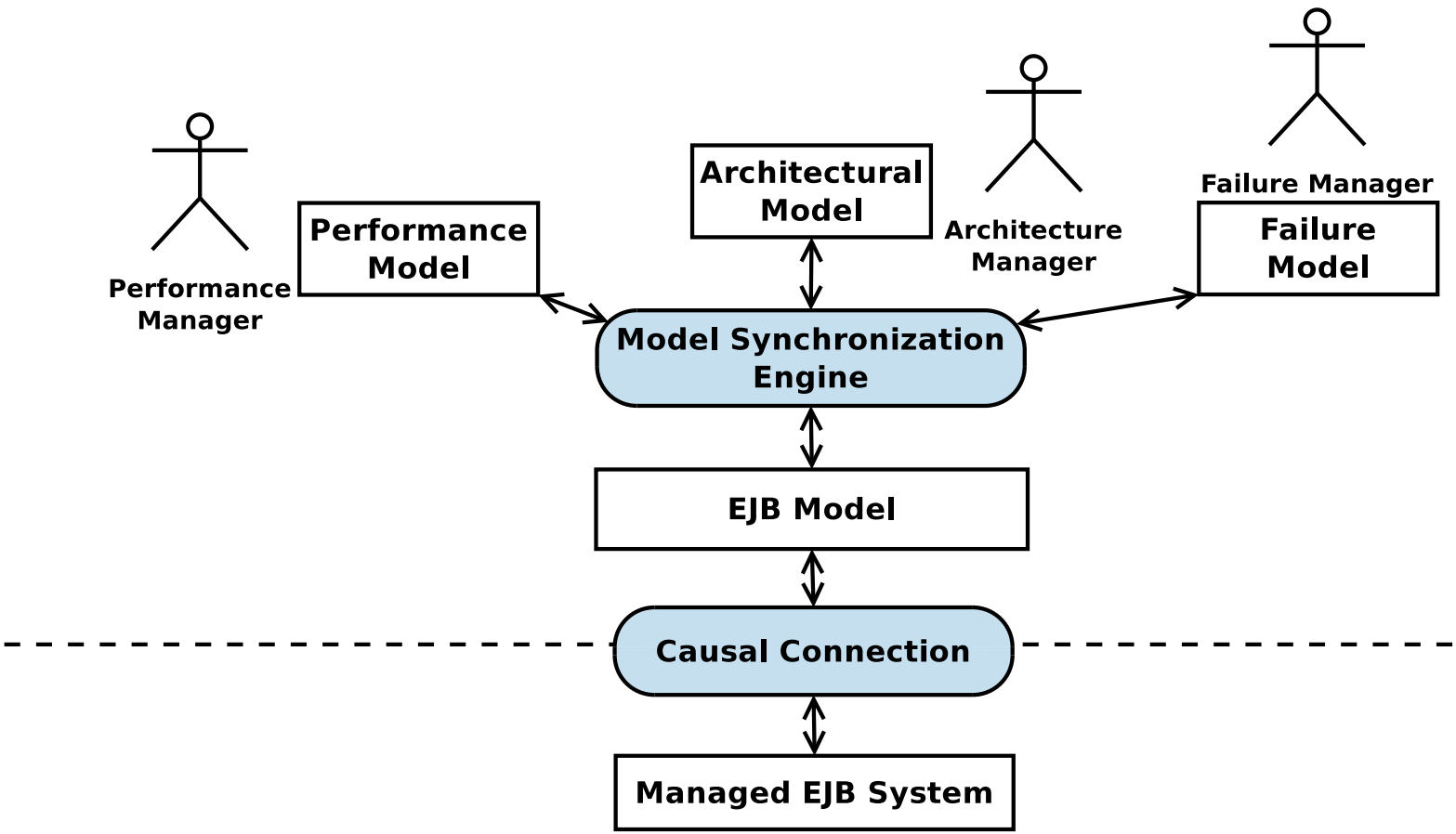


Implementation



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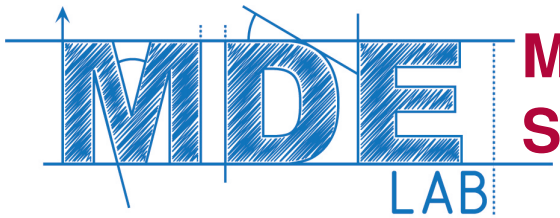
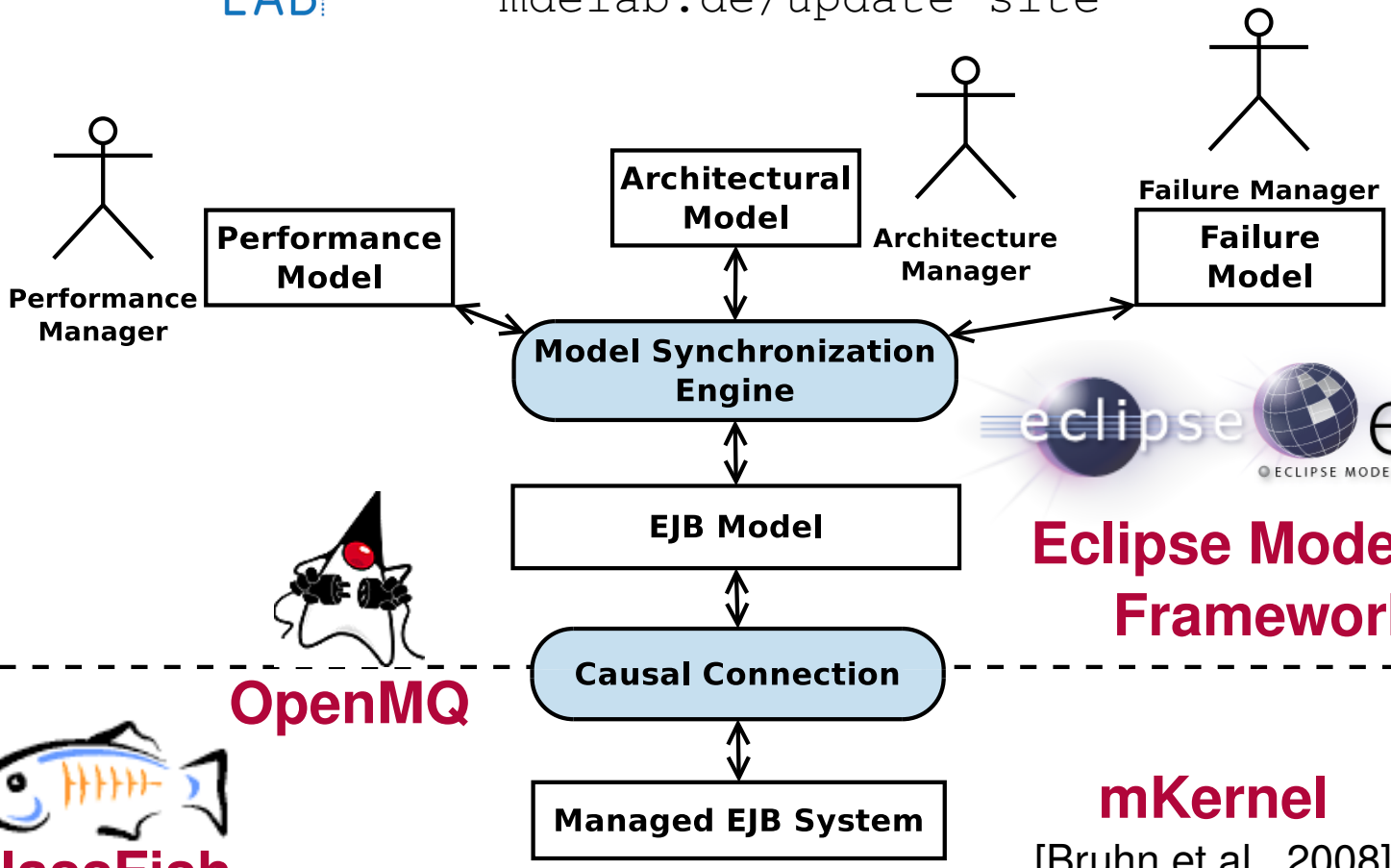


Model Transformation Engine (MoTE)
Story Diagram Modeling (SDM) Tools

mdelab.de/update-site



Conclusion and Future Work

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- Working approach using **multiple runtime models** for architectural monitoring and adaptation
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- Semantics of models and model operations
- Describing and utilizing relations at runtime

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Thank You!

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