Adaptation and Abstract Runtime Models

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Self-Adaptive Systems

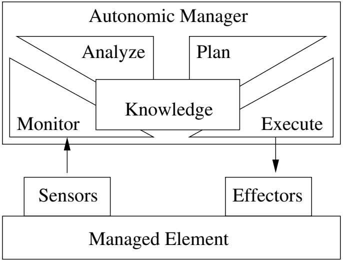


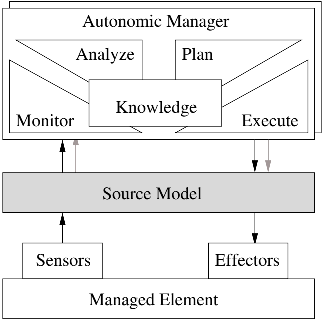
Figure: Feedback Loop [Kephart and Chess, 2003]

Separation of managing and managed elements
→ **Runtime representation of the running managed system**

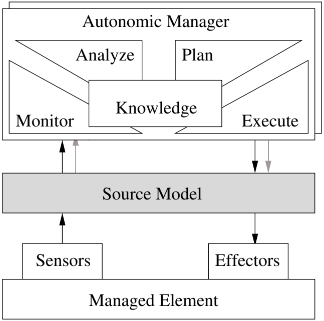
Motivation & Related Work

Architectural model as a runtime representation:

- One-to-one mapping between implementation classes and model elements [Oreizy et al., 1998]
- All concerns of interests like performance, costs, failures etc. [Garlan et al., 2004]



Motivation & Related Work



Pros

- Easing the connection between the model and the running system
- Avoiding the maintenance of several models

Cons

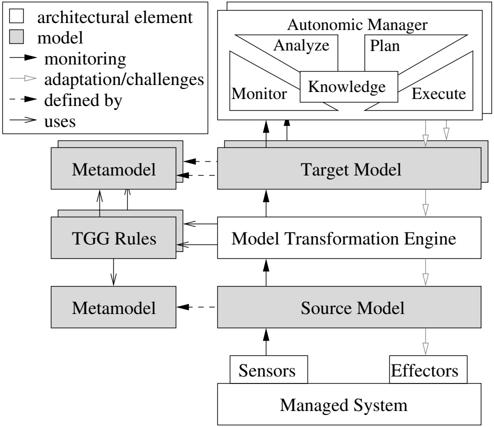
- Complexity of the model (all concerns + low level of abstraction)
- Platform- and implementation-specific model (solution space)
- Limited reusability of autonomic managers

Adaptation and Abstract Runtime Models

Multiple **Target Models**

- More abstract
- Focused on specific concerns

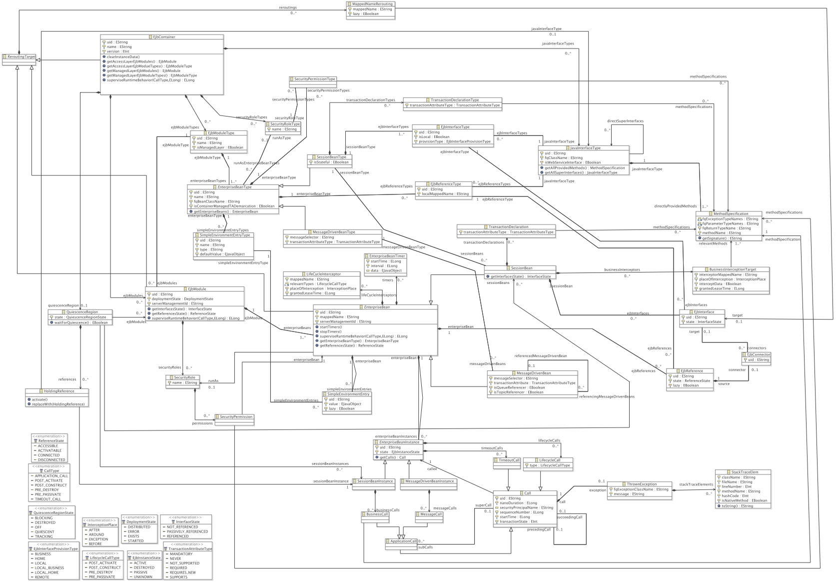
→ Reduced complexity
→ Problem space oriented
→ Leveraging reusability of models and managers across managed systems



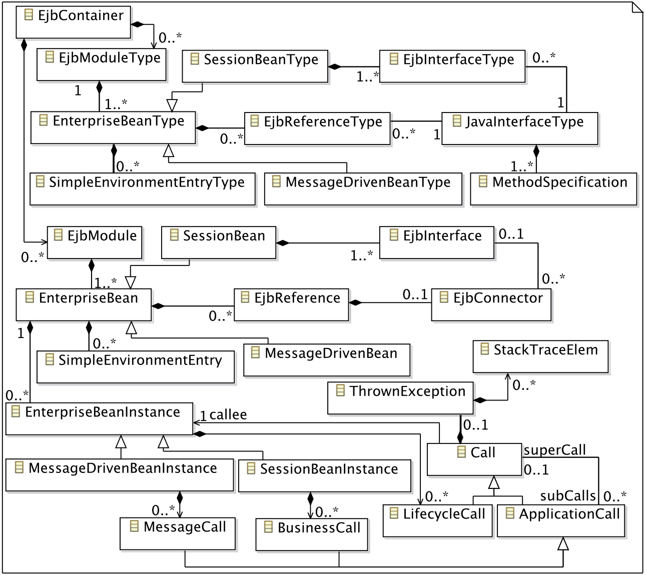
[Vogel et al., 2009]

- Maintenance of target models by a model transformation engine
- Incremental, bidirectional model synchronization

Case Study for EJB: Source Metamodel



Source Metamodel (simplified)



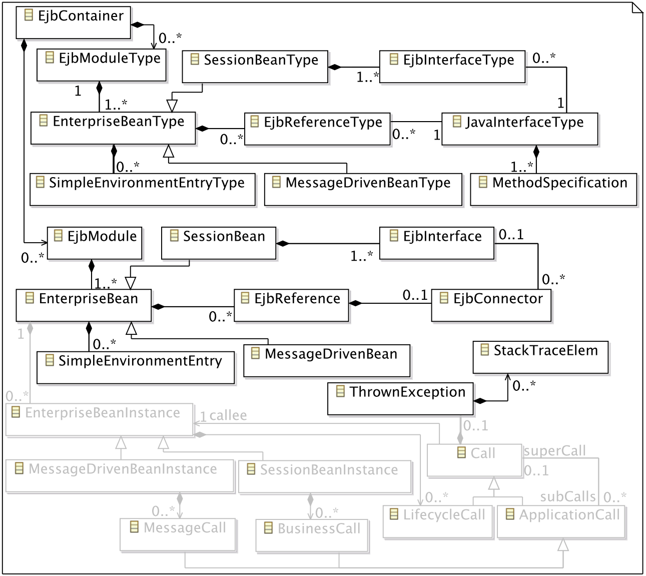
Types

Deployment

Instances

HPI

Form Source to Target Metamodel

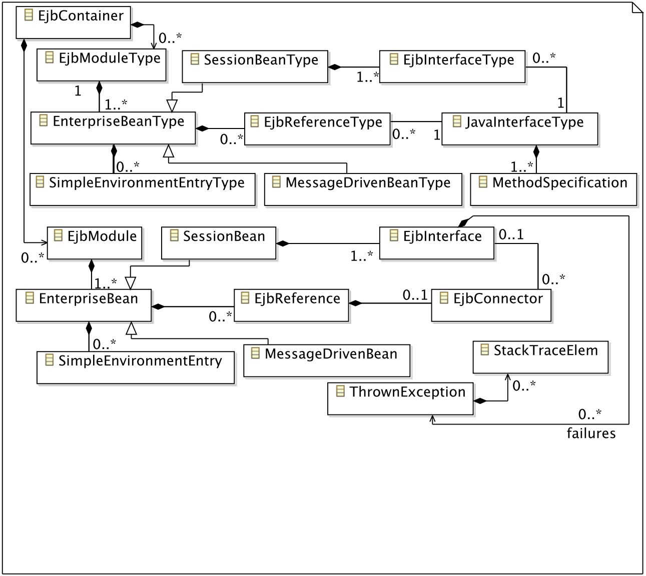


Types

Deployment

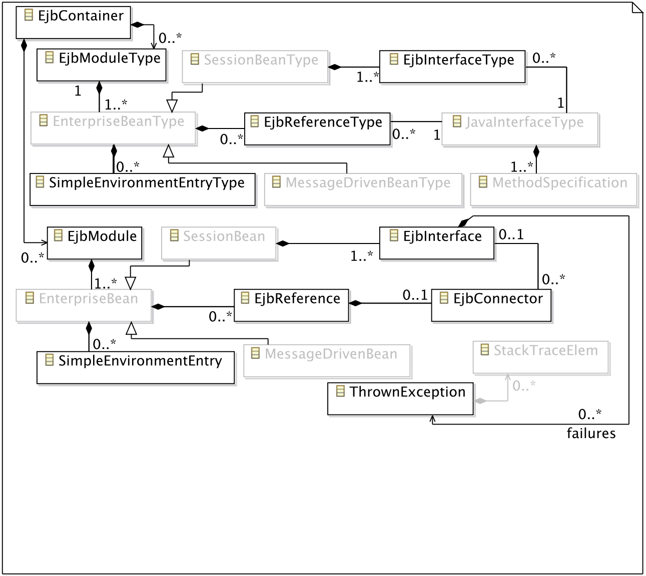
Abstract from Instances

Form Source to Target Metamodel



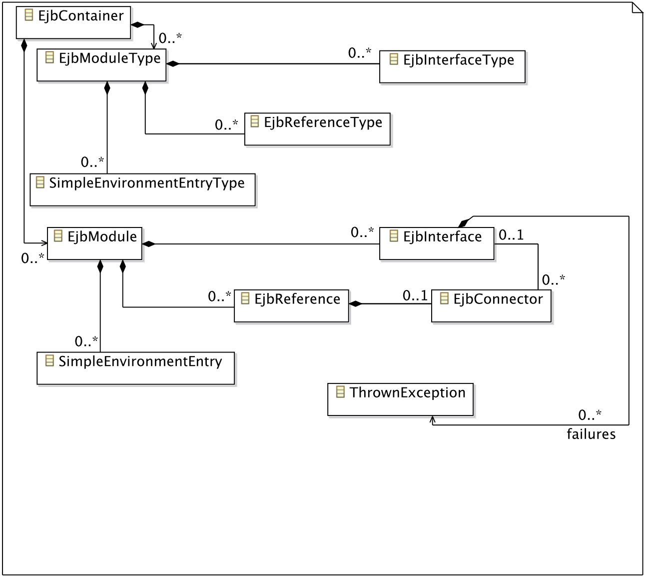
White box views

Form Source to Target Metamodel



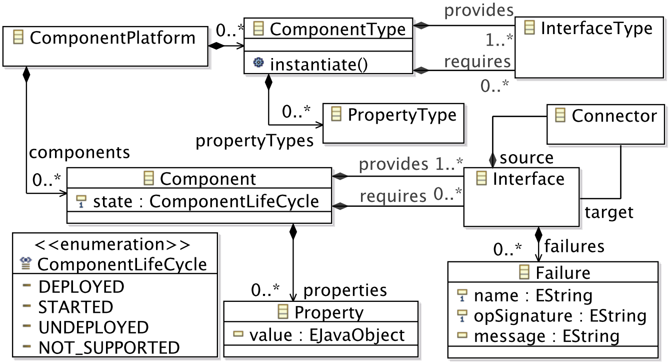
Black box views

Form Source to Target Metamodel



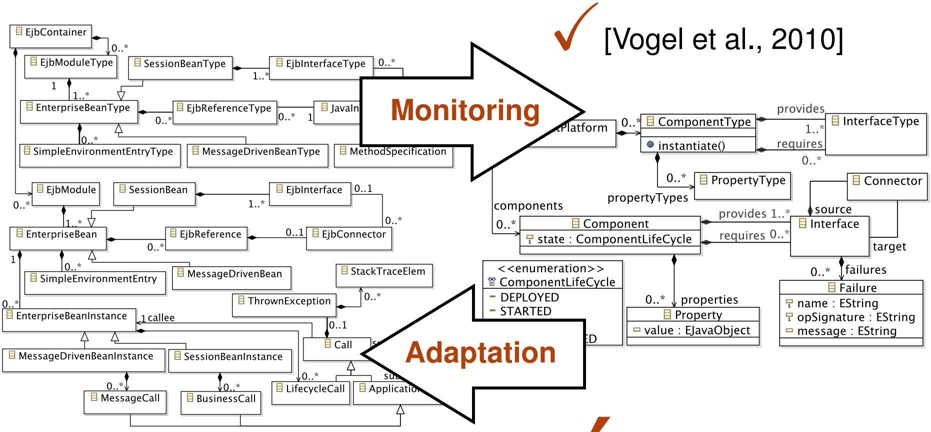
Platform-specific view

Target Metamodel (simplified)



- Black-box view on component types and components
- Abstract and platform-independent model
- Focused on one problem space: architecture + occurred failures

Runtime Model Synchronization



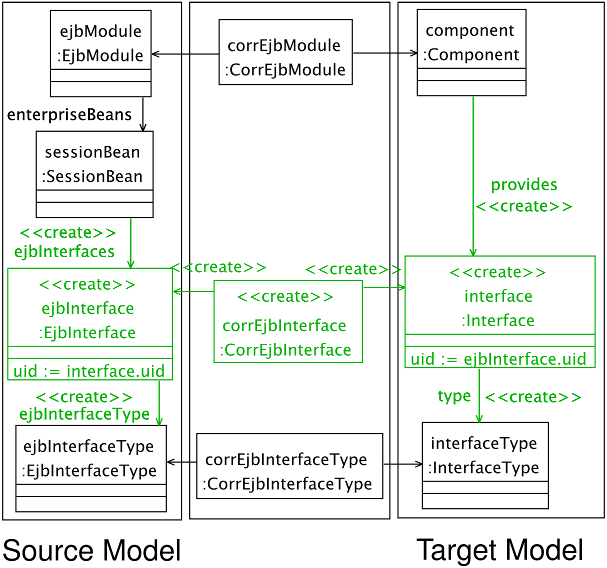
Challenges

(1) Refinement for Adaptation

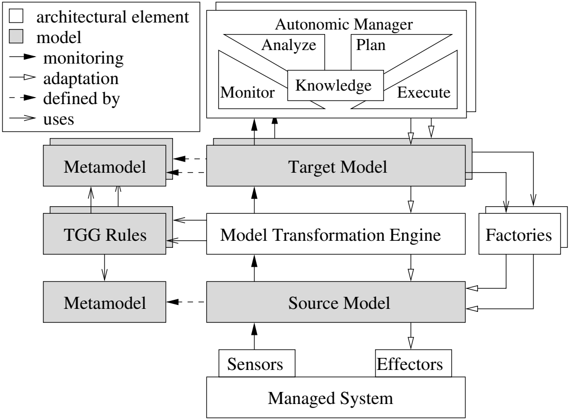
Challenge

- Desired abstraction gap between source and target model impedes the bidirectional model synchronization [Hettel et al., 2008, Stevens, 2010]
- Refinement of abstract target model changes to source model changes
  $\rightsquigarrow$ architecture refinement [Moriconi et al., 1995, Garlan, 1996]
- Case study: white box (source model) vs. black box (target model) views on component types and components

(1) Refinement for Adaptation



(1) Refinement for Adaptation



Solution: Factories (cf. [Gamma et al., 1995])

- Operating on the source model (no abstraction gap)
- Invoked on target models
- Pragmatically extends the transformation engine

(2) Restrictions to Adaptation

Challenge

- Interfacing autonomic managers with target models
  $\rightarrow$ **How** changes are performed on a model?
- Definition of allowed changes on abstract target models
  $\rightarrow$ **What** changes can be performed on a model?

Solution

- Solution similar to **adaptation operators** in *Rainbow* [Garlan et al., 2004]
- For each target metamodel: specification of specific actions a manager can perform on a target model for adapting the system

HPI

(3) Ordering of Adaptation Steps

Challenge

- Structural adaptation involving a set of atomic changes/steps
- **Synchronizing a set of target model changes in one run to the source model, and then in one run to the system** $\rightsquigarrow$ transaction
- Interactions esp. dependencies among different steps
- Different orders for target model, source model or system changes
- Overwriting of changes and losing of intermediate changes
- **Consistency** of the system affected by not suitable orders

(3) Ordering of Adaptation Steps

Solution: 3 options

1. **Target Model Usage**
   - Triggering of intermediate synchronizations by managers at runtime
   - Example: c_1, *sync*, c_2, *sync*
2. **Transformation Engine**
   - Design of rules using application contexts or constraints
   - Example: $c_1 || c_2$ on target model, but constraint/context of rule for c_2 is not fulfilled until rule for c_1 has been applied $\rightarrow$ c_1 before c_2 on source model
3. **Causal Connection between Source Model and System**
   - Generic ordering of changes for executing them on the system depending on the types of changes
   - Example: stop comp, remove conn and comp, deploy comp, create conn, set parameter values, start comp

Conclusion & Future Work

Conclusion

- Multiple and abstract models for **monitoring** and **adaptation**
- Reusability of models and managers across managed systems
- Runtime model synchronization to maintain multiple models

Future Work

- Concurrent adaptations by different managers on different models

→ Coordination to balance competing adaptations and concerns

- Distributed setting

→ Distributed, generic, and incremental model synchronization

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