Model-Driven Software Engineering using Specialization Patterns

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History of Abstraction and Modeling in SE

- Languages

  solution space (implementation technology)

  - machine code → assembly → C → OO
- Platforms
  - OS APIs → middleware and frameworks

- Modeling

  problem space (application domain)

  - structured modeling → UML → domain-specific modeling languages → cross-cutting concerns
- Modeling tools
  - CASE → round-trip engineering → MDE

Current Challenges *[Schmidt, 2006]*

- Modeling
  - Model interchange format standardization
  - Model evolution
  - Support for arbitrary application domains
- Engineering and implementation
  - Multiple target platforms & their complexity and evolution
  - Deployment and configuration using XML
    - semantic gap between design intent and language
  - Round-trip engineering
    - most code still written manually
    - model and produced code should be kept in sync

What Kind of Modeling is MDE?

- Modeling is essential in SE, but…
- Great variety in what the models represent and how they are used
  - *"If I create a visualization of some part of a system, am I practicing MDE?"*

Domain-Specific Modeling

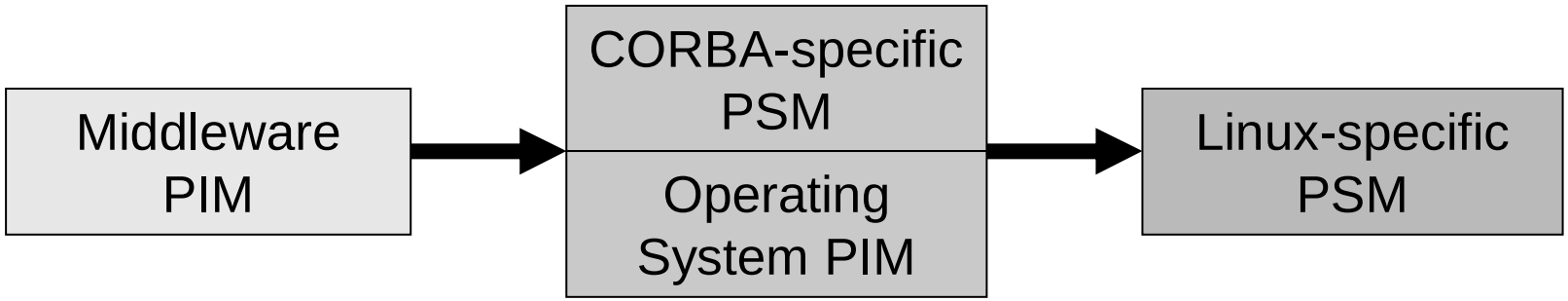
- Standard specification languages for describing the models
- Models can be tailored to accurately match the domain's vocabulary
- Metamodels
  - domain concepts and their relationships
  - semantics and constraints associated with the concepts

MDE Tools

- Are a unifying vehicle to document, analyze, and transform information systematically at many phases
- Generate code or a more specific model (semi-) automatically from a more abstract model
  - transformation generators analyze & synthesize models
- Impose domain-specific constraints and perform checks that can prevent errors early in the lifecycle
- Need not be complicated
  - they target higher-level systems (frameworks) instead of lower-level systems as in the past (e.g. OS APIs)

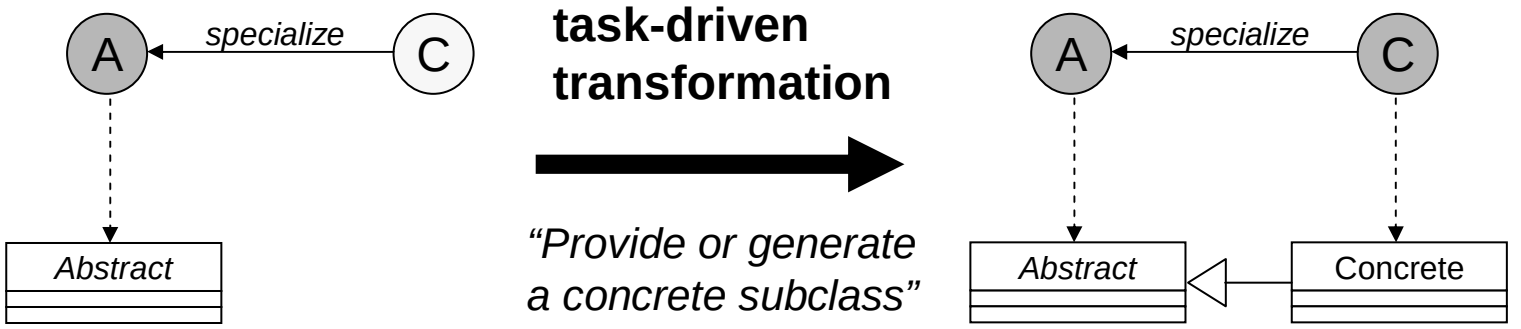
OMG's MDA Vocabulary

- Four kinds of models
  - ~~Computation Independent Model (CIM)~~
  - Platform Independent Model (PIM)
  - Platform Specific Model (PSM) described by a Platform Model (PM)
  - ~~Implementation Specific Model (ISM)~~
- Note: "platform" is always relative to a particular point of view



Specialization Patterns

- Descriptions of structural configurations of (modeling) elements
- Provide a mechanism to implement MDE
  - can be thought of as catalysts or specifications of transformations from a PIM to a PSM
- Consist of roles
  - *input roles* bound to source model before transformation
  - *output roles* depend on input roles and generate the target model during the transformation

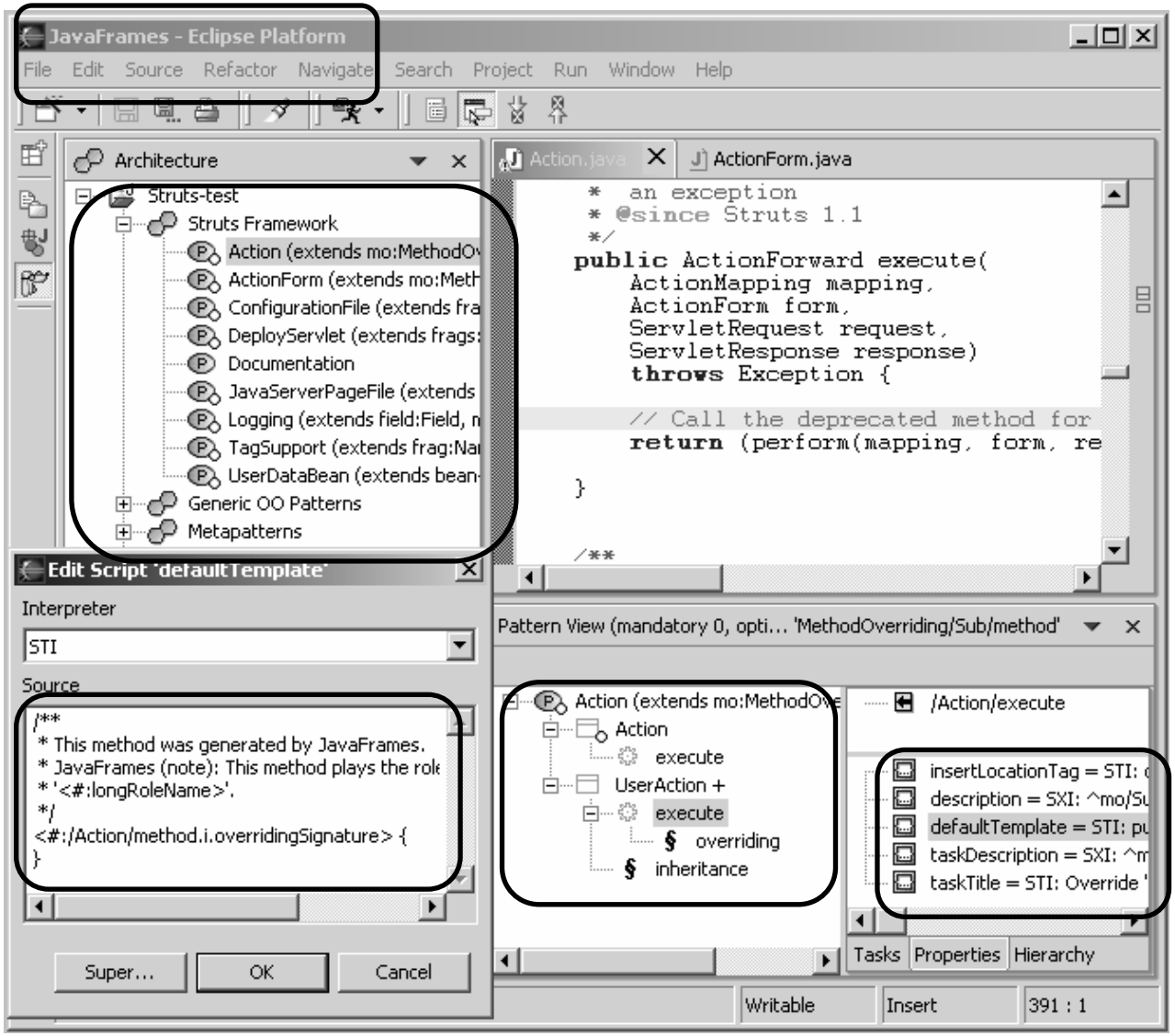


Roles, Role Instances, Tasks

- Roles are bound to concrete software systems (e.g. UML model or source code) through *role instances*
- A role has
  - a *type* that determines the kind of elements they can be bound to (e.g. UML class role or Java operation role)
  - a set of *constraints* (depending on type), constraints can also refer to other roles
  - a set of *scripts* to enable code generation
- Interactive role binding through *tasks*
  - unbound role instances & constraint violations generate tasks

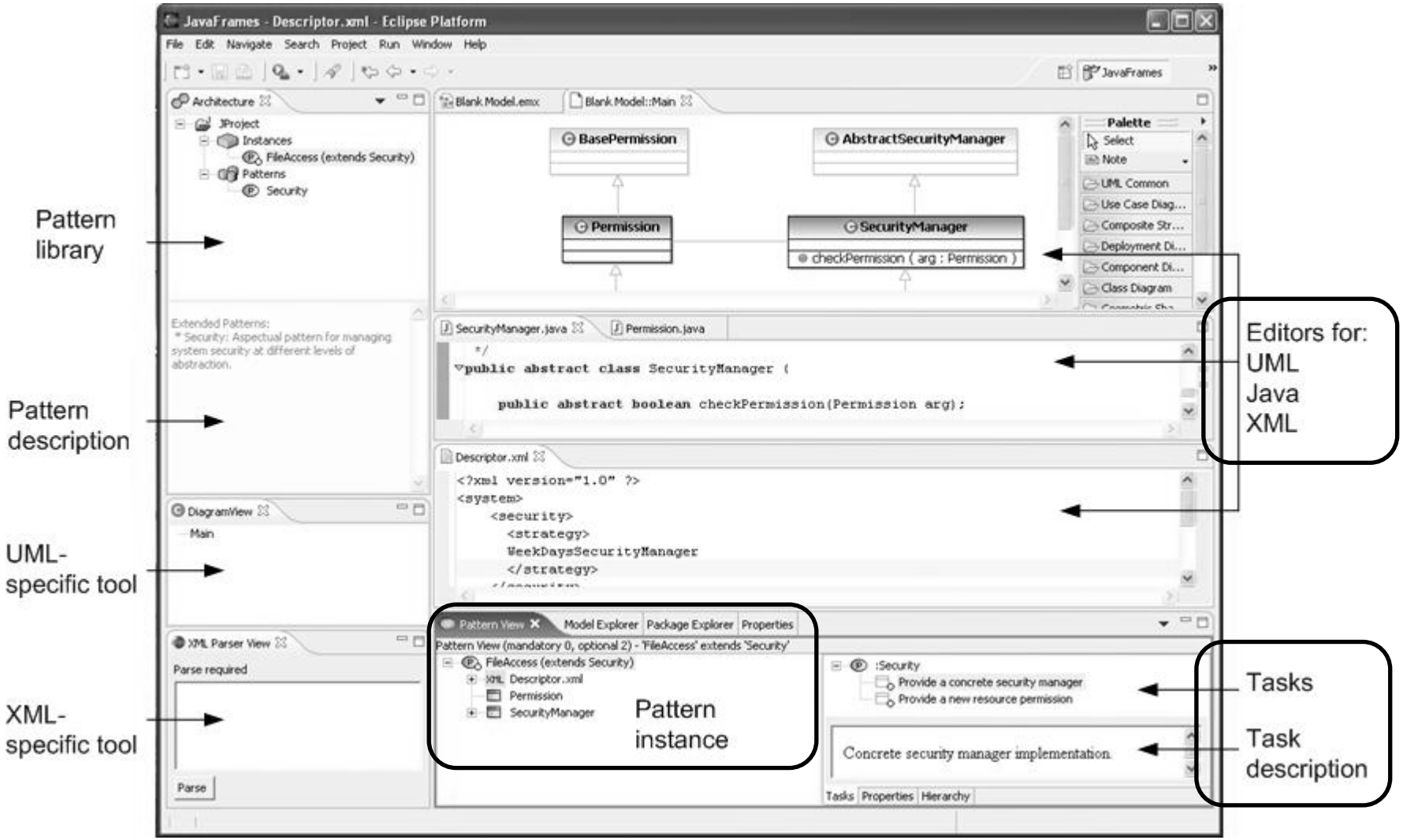
Specialization Patterns

Tool Support: JavaFrames



Specialization Patterns

Tool Support (cont'd): MADE



Applications

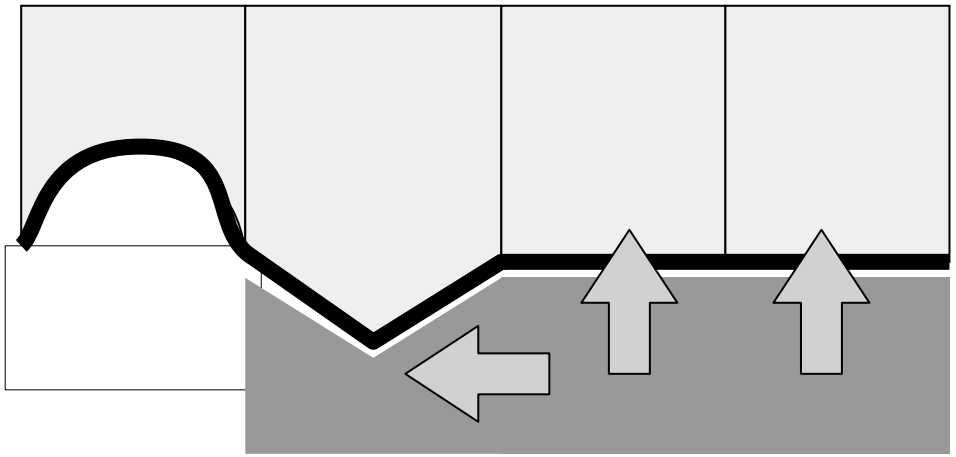
- UML model transformations
  - from UML to UML & from UML to code
  - MADE & INARI *[Hammouda et al., 2004]*
- Framework usage
  - from abstract code (FW) to concrete (app) code
  - JavaFrames *[Hakala et al., 2001], [Viljamaa, 2004 & 2006]*
  - Design fragments *[Fairbanks, Garlan, Scherlis, 2006]*
    - an approach very similar to specialization patterns
- Web service development
  - JavaFrames & MADE *[Jiang, Ruokonen, Systä, 2005]*

Example 1 *[Viljamaa, 2004] & [Viljamaa, 2005]*

Framework-Based SW Development

FW

App

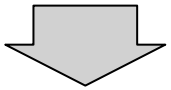


reuse interface = a collection of hot spots or variation points that enable specialization of FW, e.g. by subclassing (*white-box reuse*) or by combining and customizing ready-made components (*black-box reuse*)

Example 1 (cont'd)

Framework Usage Problems

- FWs are abstract, complex, large systems
- Implementation languages don't fully support FW-based development
- Typical FW documentation consists only of informal descriptions and small sample apps



- Locating hot spots & understanding dependencies?
- Steep learning curve, high training costs

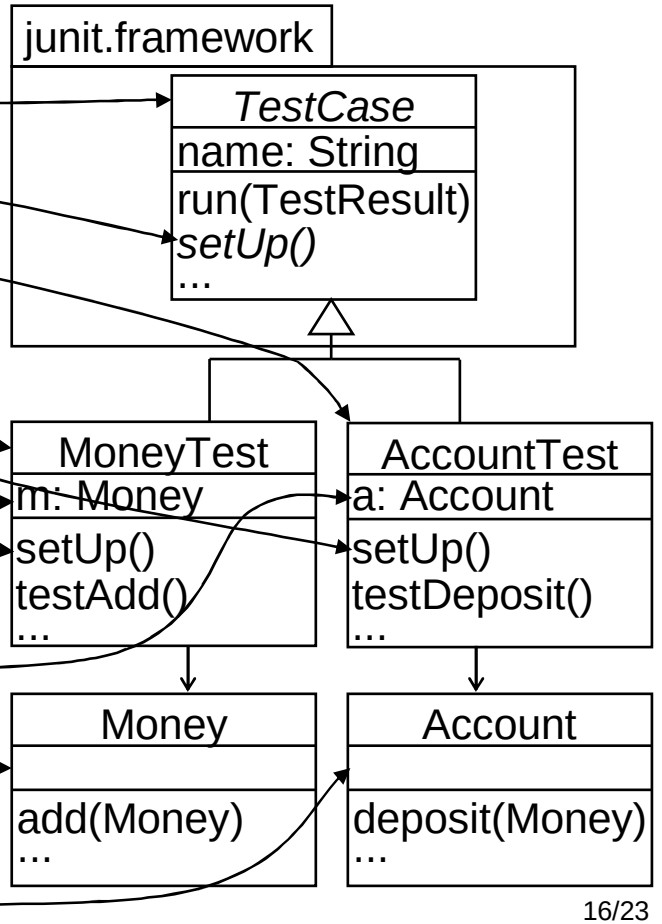
Example 1 (cont'd)

Task-Driven FW Usage Assistance

specialization pattern

```
class TestCase {
  method setUp{}
}
class UserTestCase* {
  inherits TestCase;
  method setUp {
    overrides TestCase.setUp;
    fragment fixtureCreation {
      sets fixtureAttr;
    }
  }
  field fixtureAttr* {
    isTypeOf FixtureClass;
  }
}
class FixtureClass* {}
```

UML, Java, etc.



Example 1 (cont'd)

JavaFrames

- Provides
  - context-sensitive and adjusting documentation
  - parameterized code generation
  - validation of app code against the FW requirements
- Implemented as an Eclipse perspective

Example 2 *[Jiang, Ruokonen, Systä, 2005]*

Reuse in Web Service Development

- Traditionally
  - reuse as web service composition (building services from other services)
  - e.g. choreography languages
- Our approach adds to this
  - reuse of WSDL descriptions
  - validation of rules defined for WSDL descriptions (e.g. Basic Profile 1.1)
  - Reuse in service implementations

Example 2 (cont'd)

Modeling Variation in WS Development

	Variation points	**Variation mechanisms**
WSDL document	• Service name & address • SOAP action string • WSDL character encoding • Namespaces • Array declarations • Binding to transportation • …	*WSDL2Code* • Parameterized WSDL template *Code2WSDL* • Parameterized code generation
Service endpoint	• Names and types of operations and their parameters	*WSDL2Code* • Managed in WSDL design *Code2WSDL* • Tool guides framework specialization
Business logic	• Depends on the service framework in question	• A framework and tool support for its specialization

Example 2 (cont'd)

Solution: Tool-Assisted WS Development

- JavaFrames & MADE provide
  - context-sensitive and adjusting documentation
  - parameterized UML model and Java code generation
  - validation against WSDL & Basic Profile 1.1 specifications
- Integrated to Eclipse, Rational Rose & Rational Software Architect

Conclusion

- MDE (automatic model transformations and code generation) is becoming increasingly important in SE
- Specialization patterns provide a viable way to implement task-driven transformations
- Empirical evidence shows the benefits of tool support (at least in the context of framework specialization) *[Fairbanks, Garlan, Scherlis, 2006]*

Questions?

- Thank you!
- http://practise.cs.tut.fi (downloads)

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