TECHNISCHE UNIVERSITÄT DRESDEN

Refactory

Technical University Dresden Department of Computer Science Chair for Software Technology

31. Generic Refactoring for Programming and Modeling Languages

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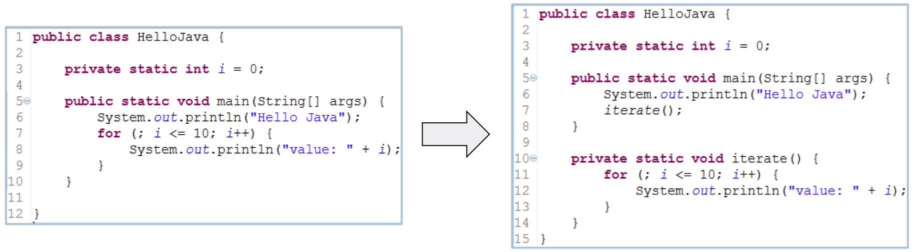
Version 11-1.1, 17.1.11

Obligatory Literature

- Sander Tichelaar, Stéphane Ducasse, Serge Demeyer, and Oscar Nierstrasz. A meta-model for language-independent refactoring. In Proceedings of International Symposium on Principles of Software Evolution (ISPSE '00), pages 157-167. IEEE Computer Society Press, 2000.
  - doi:10.1109/ISPSE.2000.913233,
- MOOSE framework http://www.moosetechnology.org/
- Jan Reimann, Mirko Seifert, and Uwe Aßmann. Role-based generic model refactoring. In Dorina C. Petriu, Nicolas Rouquette, and Øystein Haugen, editors, MoDELS (2), volume 6395 of Lecture Notes in Computer Science, pages 78-92. Springer, 2010. Best Paper Award.

An Example of Code Refactoring
Extract Method (Outlining)



```java
public class HelloJava {

    private static int i = 0;

    public static void main(String[] args) {
        System.out.println("Hello Java");
        for (; i <= 10; i++) {
            System.out.println("value: " + i);
        }
    }

}
```

```java
public class HelloJava {

    private static int i = 0;

    public static void main(String[] args) {
        System.out.println("Hello Java");
        iterate();
    }

    private static void iterate() {
        for (; i <= 10; i++) {
            System.out.println("value: " + i);
        }
    }
}
```

From Code to Models
Why is Refactoring needed for Models?

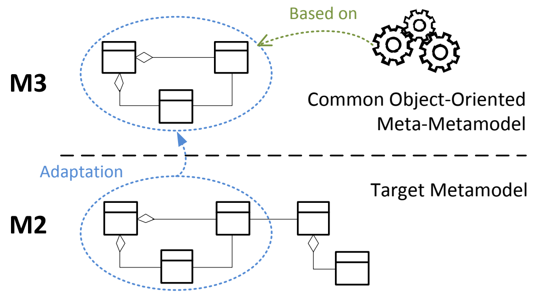
- Model-Driven Software Development:
  - Models are partial code
  - Models are primary artefacts in MDSD
  - Good model design is essential for understandability
  - Some models are domain-specific, and belong to **domain-specific languages (DSL)**

Why should it be generic?

- Known code refactorings are transferable to many DSLs
- Core steps of refactorings are equal for different metamodels
- A lot of additional effort to specify refactorings from scratch

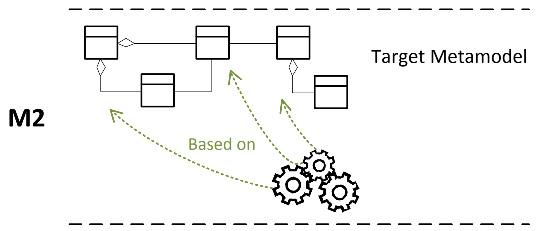
Related Work – Limitations
M3 layer specification

- Common meta-metamodel to static
- Lack of exact control of structures to be refactored



[Moha, Naouel, Vincent Mahé, Olivier Barais und Jean-Marc Jézéquel: *Generic Model Refactorings*, MODELS 2009]

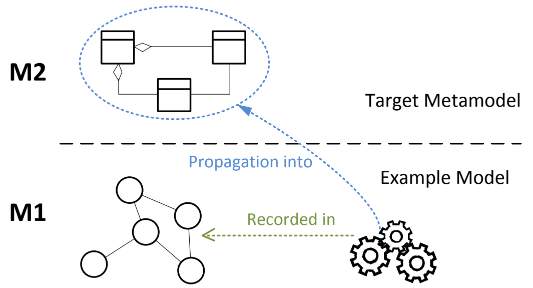
Related Work – Limitations
M2 layer specification



- No genericity
- No reuse

[Taentzer, Gabriele, Dirk Müller and Tom Mens: Specifying Domain-Specific Refactorings for AndroMDA Based on Graph Transformation, AGTIVE 2007]

Related Work – Limitations
M1 layer specification

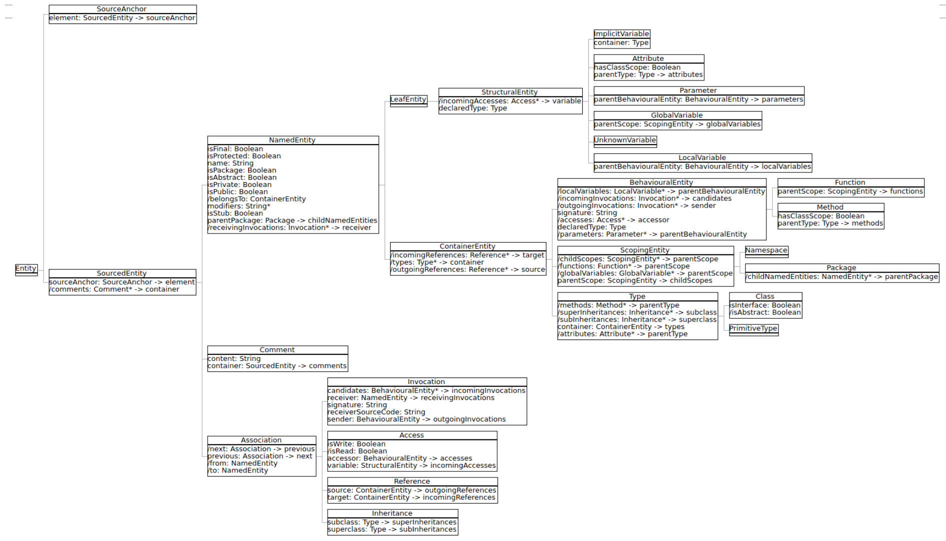


- No genericity
- No reuse

[Brosch, Petra, Philip Langer, Martina Seidl, Konrad Wieland, Manuel Wimmer, Gerti Kappel, Werner Retschitzegger and Wieland Schwinger: *An Example is Worth a Thousand Words: Composite Operation Modeling By-Example*, MODELS 2009]

31.2 MOOSE

FAMIX Upper Metamodel


SourceAnchor
element: SourcedEntity -> sourceAnchor
Entity
SourcedEntity
sourceAnchor: SourceAnchor -> element
/comments: Comment* -> container
NamedEntity
isFinal: Boolean
isProtected: Boolean
name: String
isPackage: Boolean
isAbstract: Boolean
isPrivate: Boolean
isPublic: Boolean
/belongsTo: ContainerEntity
modifiers: String*
isStub: Boolean
parentPackage: Package -> childNamedEntities
/receivingInvocations: Invocation* -> receiver
LeafEntity
StructuralEntity
/incomingAccesses: Access* -> variable
declaredType: Type
ImplicitVariable
container: Type
Attribute
hasClassScope: Boolean
parentType: Type -> attributes
Parameter
parentBehaviouralEntity: BehaviouralEntity -> parameters
GlobalVariable
parentScope: ScopingEntity -> globalVariables
UnknownVariable
LocalVariable
parentBehaviouralEntity: BehaviouralEntity -> localVariables
ContainerEntity
/incomingReferences: Reference* -> target
/types: Type* -> container
/outgoingReferences: Reference* -> source
BehaviouralEntity
/localVariables: LocalVariable* -> parentBehaviouralEntity
/incomingInvocations: Invocation* -> candidates
/outgoingInvocations: Invocation* -> sender
signature: String
/accesses: Access* -> accessor
declaredType: Type
/parameters: Parameter* -> parentBehaviouralEntity
Function
parentScope: ScopingEntity -> functions
Method
hasClassScope: Boolean
parentType: Type -> methods
ScopingEntity
/childScopes: ScopingEntity* -> parentScope
/functions: Function* -> parentScope
/globalVariables: GlobalVariable* -> parentScope
parentScope: ScopingEntity -> childScopes
Namespace
Package
/childNamedEntities: NamedEntity* -> parentPackage
Type
/methods: Method* -> parentType
/superInheritances: Inheritance* -> subclass
/subInheritances: Inheritance* -> superclass
container: ContainerEntity -> types
/attributes: Attribute* -> parentType
Class
isInterface: Boolean
/isAbstract: Boolean
PrimitiveType
Comment
content: String
container: SourcedEntity -> comments
Invocation
candidates: BehaviouralEntity* -> incomingInvocations
receiver: NamedEntity -> receivingInvocations
signature: String
receiverSourceCode: String
sender: BehaviouralEntity -> outgoingInvocations
Association
/next: Association -> previous
previous: Association -> next
/from: NamedEntity
/to: NamedEntity
Access
isWrite: Boolean
/isRead: Boolean
accessor: BehaviouralEntity -> accesses
variable: StructuralEntity -> incomingAccesses
Reference
source: ContainerEntity -> outgoingReferences
target: ContainerEntity -> incomingReferences
Inheritance
subclass: Type -> superInheritances
superclass: Type -> subInheritances

http://www.moosetechnology.org/?_s=5k2-x-GDJjdd2YIX

- The FAMIX upper metamodel
  - Enables generic refactoring for all entities *above methods*, class restructurings, etc.
- The MOOSE framework supplies basic graph algorithms for reengineering and refactoring:
  - Strongly connected components
  - Dominance
  - Kruskal spanning trees
- Concept recognition in texts
- Formal concept analysis

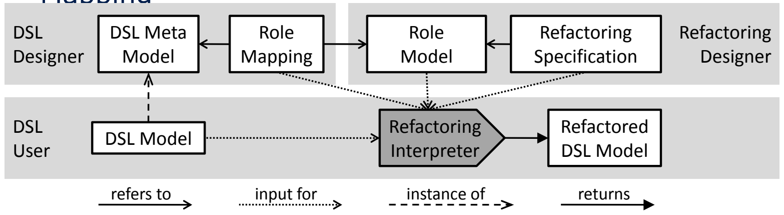
31.2 Refactory

The generic refactorer of TU Dresden
Jan Reimann

Role-based Generic Model Refactoring

Role-based Design (Reenskaug, Riehle & Gross)

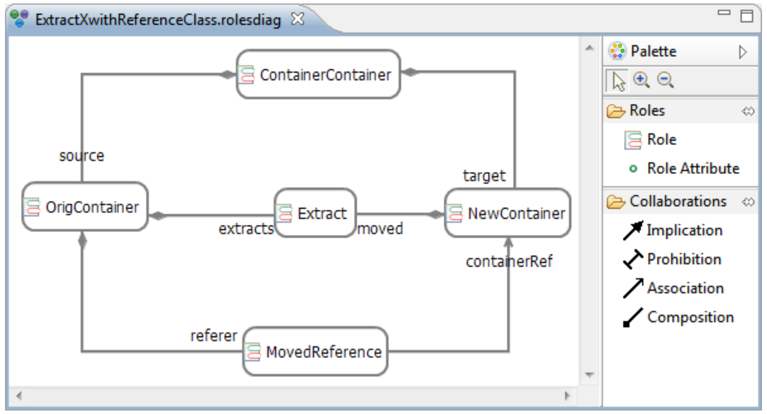
- Definition of collaborations of objects in different contexts
- Here: Context = model refactoring
- Participants play role in concrete refactoring → Role Model
- Role-based transformation → Refactoring Specification
- Application to desired parts of metamodel → Role Mapping



Role-based Generic Model Refactoring

Role-based Metamodeling

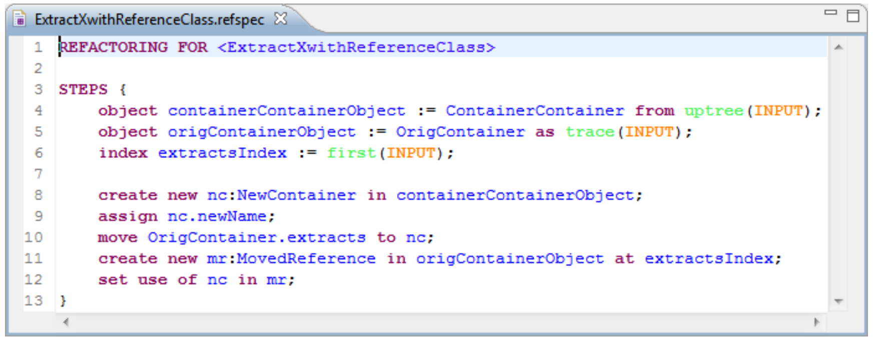
- Refactory sees a role model (a view) of the metamodel



Role-based Generic Model Refactoring

Refactoring Specification on Role Model

- The roles of this role-metamodel can be used to write refactoring scripts and operators

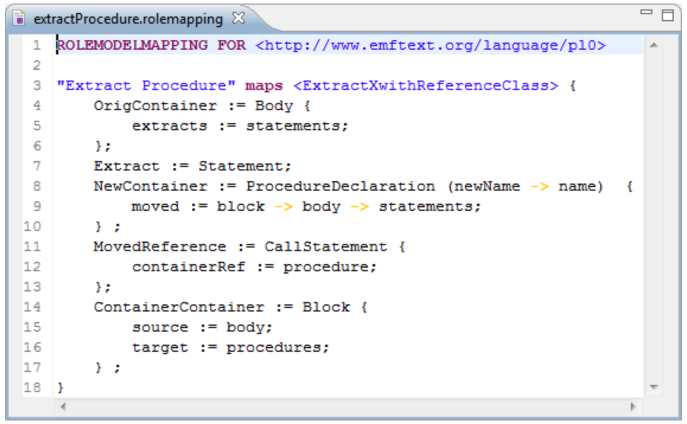

ExtractXwithReferenceClass.refspec

```
REFACTORING FOR <ExtractXwithReferenceClass>

STEPS {
    object containerContainerObject := ContainerContainer from uptree(INPUT);
    object origContainerObject := OrigContainer as trace(INPUT);
    index extractsIndex := first(INPUT);

    create new nc:NewContainer in containerContainerObject;
    assign nc.newName;
    move OrigContainer.extracts to nc;
    create new mr:MovedReference in origContainerObject at extractsIndex;
    set use of nc in mr;
}
```

Role-based Generic Model Refactoring

Role Mapping to Specific DDL

- A **mapping** maps roles to metaclasses in a concrete metamodel


extractProcedure.rolemapping

```
ROLEMODELMAPPING FOR <http://www.emftext.org/language/pl0>

"Extract Procedure" maps <ExtractXwithReferenceClass> {
    OrigContainer := Body {
        extracts := statements;
    };
    Extract := Statement;
    NewContainer := ProcedureDeclaration (newName -> name)  {
        moved := block -> body -> statements;
    } ;
    MovedReference := CallStatement {
        containerRef := procedure;
    };
    ContainerContainer := Block {
        source := body;
        target := procedures;
    } ;
}
```

Evaluation of Refactory

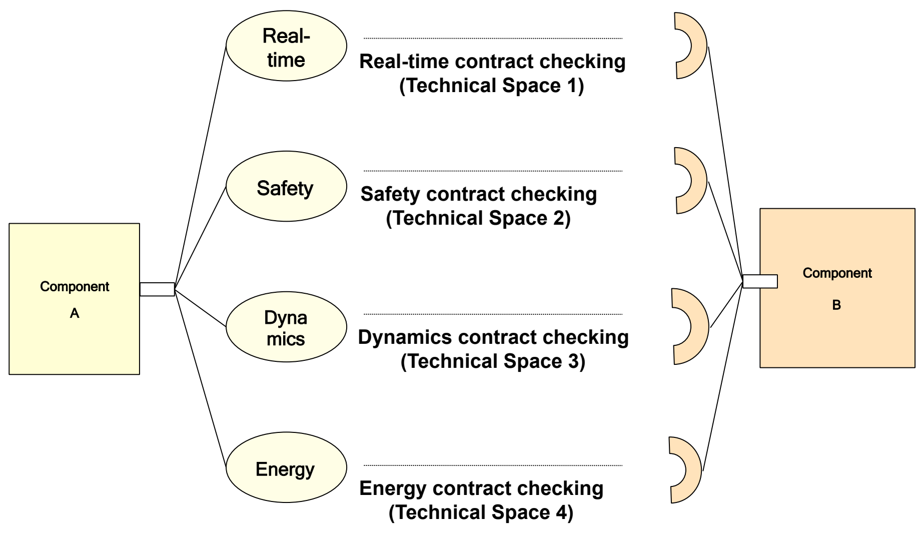
Starting point

- 16 target metamodels of different complexity (Java, UML, Ecore…)
- 53 concrete model refactorings

Result

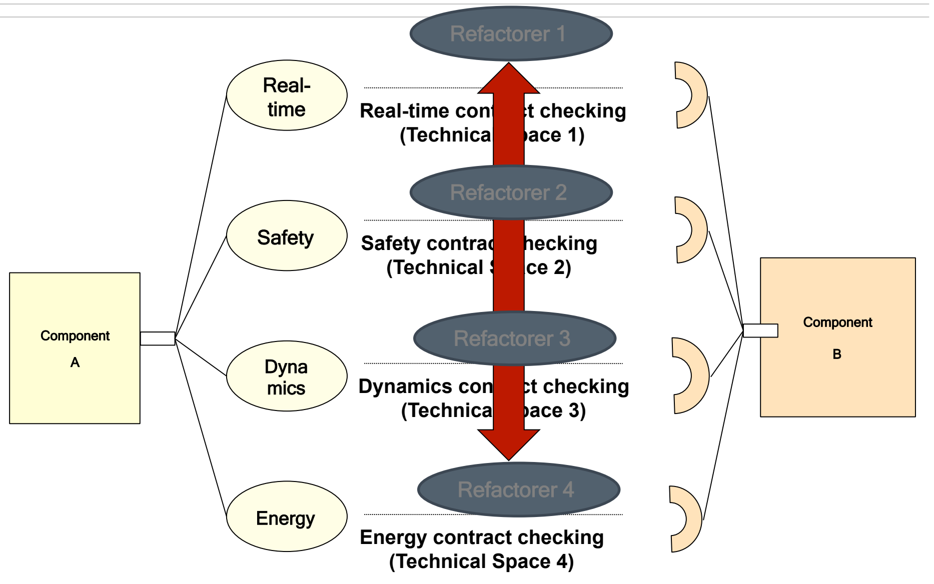
- 9 generic model refactorings
- 6 metamodel specific extensions were needed
- 7 metamodels are multiple target of same model refactoring
- 2 metamodels are at least target of every model refactoring

New: Multi-Quality Contracts in CPS (Multi-Technical Spaces)



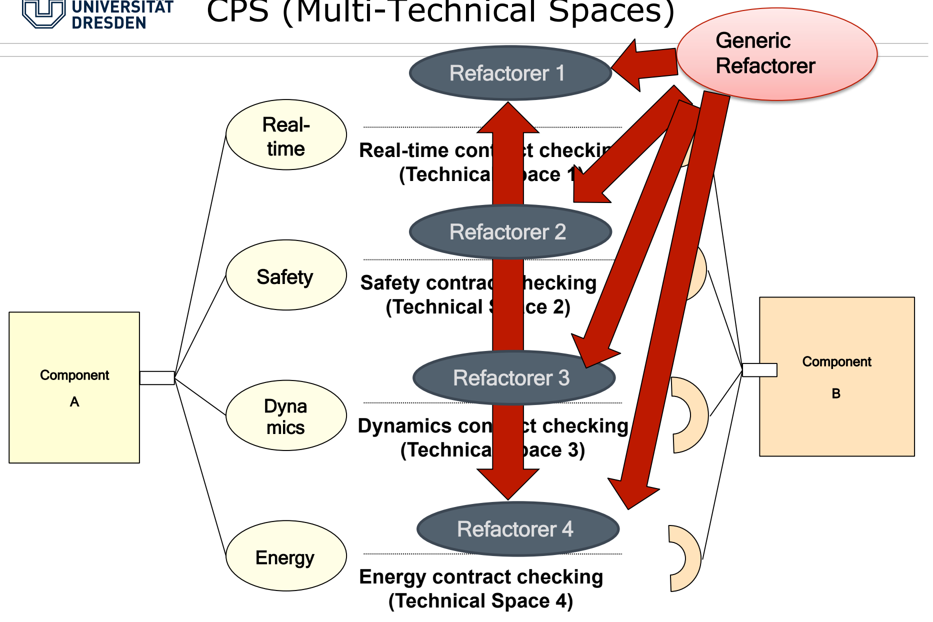
Real-time
Real-time contract checking (Technical Space 1)
Safety
Safety contract checking (Technical Space 2)
Component A
Component B
Dyna mics
Dynamics contract checking (Technical Space 3)
Energy
Energy contract checking (Technical Space 4)

New: Multi-Quality Contracts in CPS (Multi-Technical Spaces)



Refactorer 1
Real-time
Real-time contract checking (Technical Space 1)
Refactorer 2
Safety
Safety contract checking (Technical Space 2)
Refactorer 3
Component A
Component B
Dyna mics
Dynamics contract checking (Technical Space 3)
Refactorer 4
Energy
Energy contract checking (Technical Space 4)

New: Multi-Quality Contracts in CPS (Multi-Technical Spaces)



Generic Refactorer
Refactorer 1
Real-time
Real-time contract checking (Technical Space 1)
Refactorer 2
Safety
Safety contract checking (Technical Space 2)
Refactorer 3
Component A
Component B
Dyna mics
Dynamics contract checking (Technical Space 3)
Refactorer 4
Energy
Energy contract checking (Technical Space 4)

Lessons Learned

- Refactorings generically specifiable if abstractable and structurally transferable
- Metamodel-specific refactorings possible
- Design decisions
  - ”Specific” generic refactoring
  - Metamodel-specific extension or
  - Implementation of metamodel-specific refactoring (Java)
- Reuse beneficial if model refactoring appliable to at least two metamodels

Contributions

- Generic refactoring works!!
- Definition of generic model refactorings based on roles
  - Role models form a dedicated context for every model refactoring
- Approach allows both for genericity and control of the structures to be refactored
- Control is achieved by mapping of role models into arbitrary sections of the target metamodel
- Interpretation by resolving roles and collaborations into the target metamodel

Contributions

Outlook

- Pre- and postconditions with role-based OCL interpreter
- Preservation of behavior with formalization of semantics
- Specification of model smells
- Co-Refactoring
- Automatic mapping to metamodels

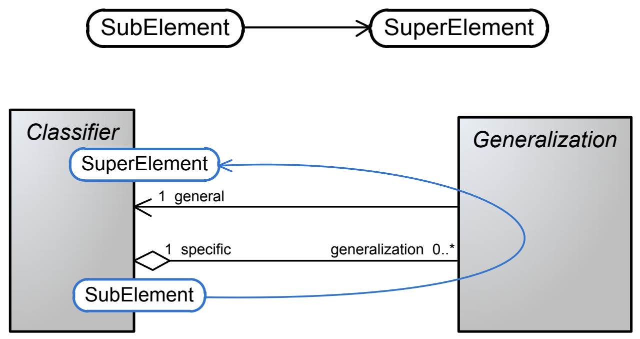
Students looked for in Resubic Lab
Co-Refactoring of mulit-quality specificatios
http://resubic.inf.tu-dresden.de

Refactory

http://www.emftext.org/refactoring

jan.reimann@tu-dresden.de

Mapping to Paths


SubElement
SuperElement
Classifier
SuperElement
1 general
1 specific
generalization 0..*
SubElement
Generalization