TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Informatik Institut für Software- und Multimediatechnik, Lehrstuhl für Softwaretechnologie

Towards Well-formed Fragment Composition with Reference Attribute Grammars

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DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

Background and Motivation

Basic Terminology[Kristensen+87, Aßmann 03]

Fragment Composition: methodology for *syntax-safe* source code composition according to the language grammar or metamodel.

- ❑ a Basic implementation technique for syntax-safe templates, code generation, aspect-oriented programming systems,….

Fragment: partial or under-specified piece of *source code* of a program or model (e.g., method, field declaration, class, expression…)

Slot: Explicitly declared variation point in a fragment.

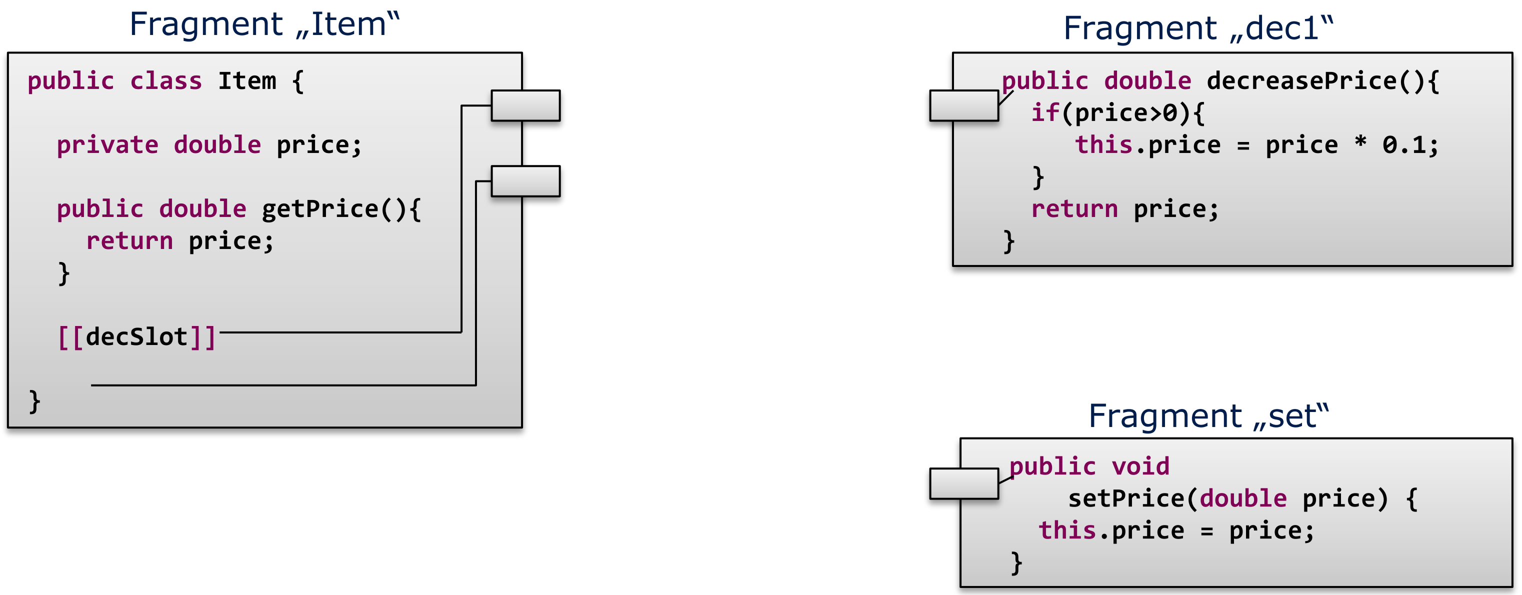
- ❑ can be bound to a syntactically compatible fragment

Hook: Implicit extension point in a fragment.

- ❑ can be extended with syntactically compatible fragments

Background and Motivation

Fragment Composition Example



Fragment „Item“

```
public class Item {

  private double price;

  public double getPrice(){
    return price;
  }

  [[decSlot]]

}
```

Fragment „dec1“

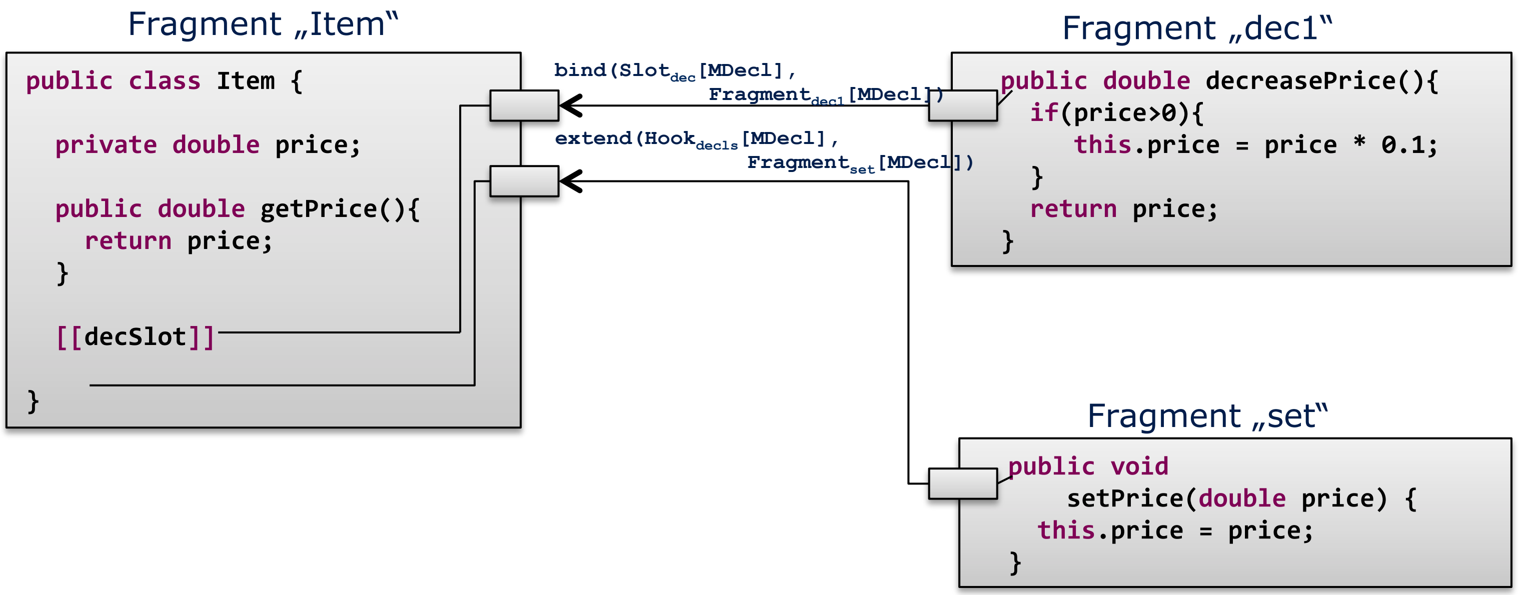
```
public double decreasePrice(){
  if(price>0){
     this.price = price * 0.1;
  }
  return price;
}
```

Fragment „set“

```
public void
     setPrice(double price) {
   this.price = price;
 }
```

Background and Motivation

Fragment Composition Example



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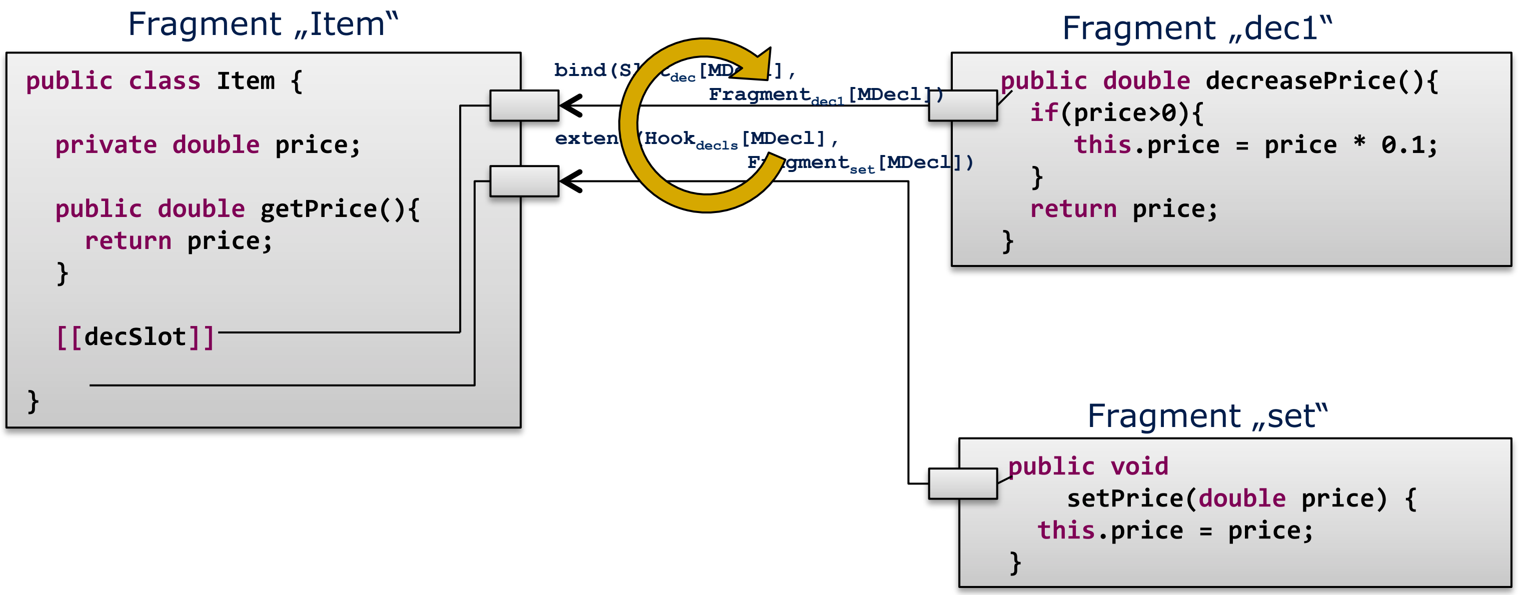
bind(Slot$_{dec}$[MDecl], Fragment$_{dec1}$[MDecl])

extend(Hook$_{decls}$[MDecl], Fragment$_{set}$[MDecl])

Background and Motivation

Fragment Composition Example



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Background and Motivation

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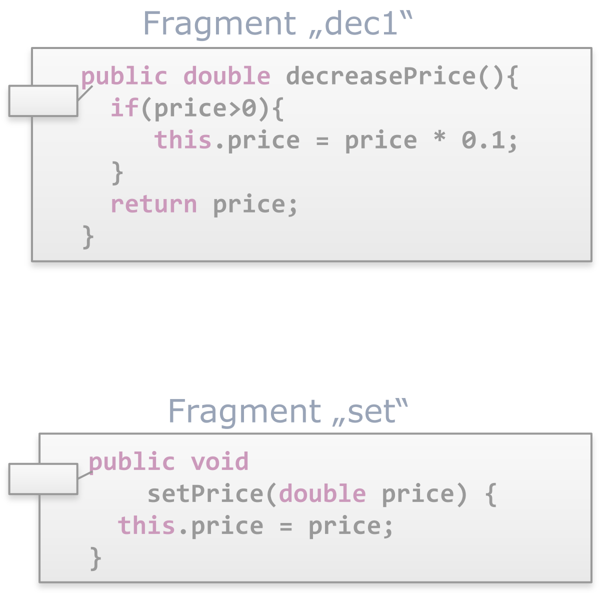

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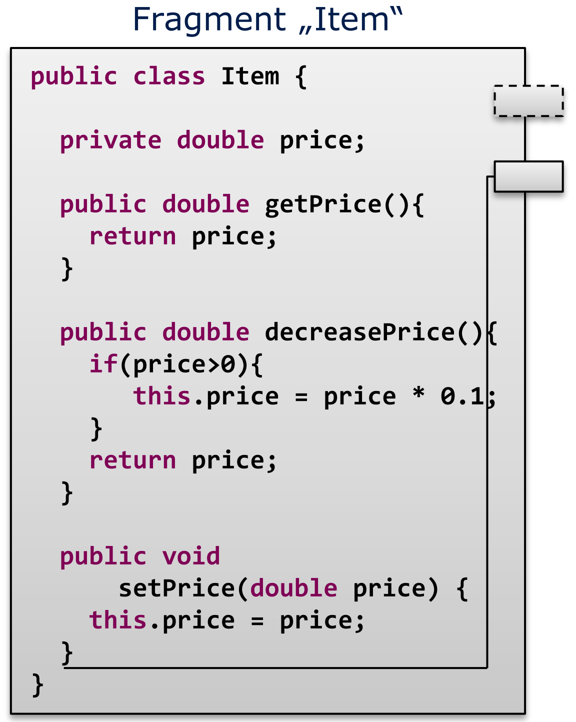
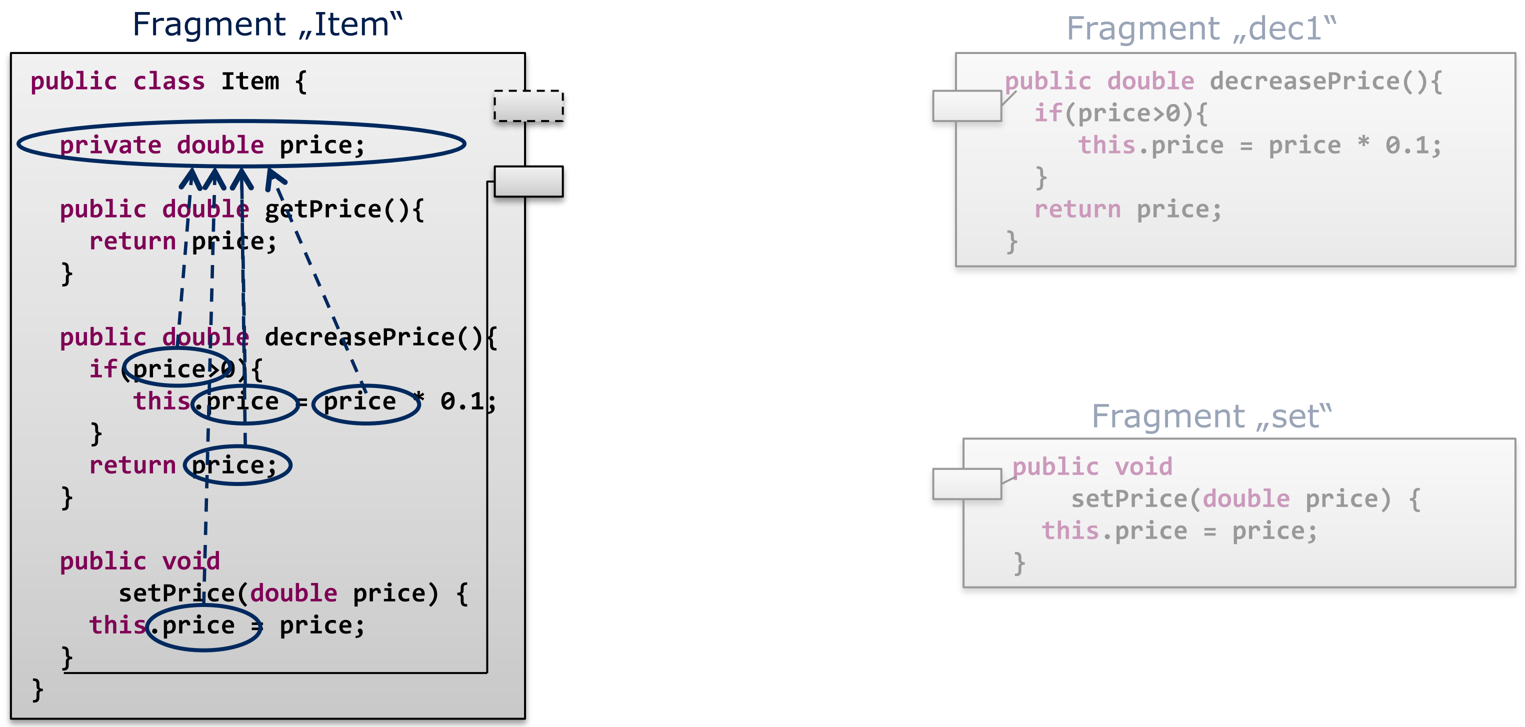


Background and Motivation

Fragment Composition Example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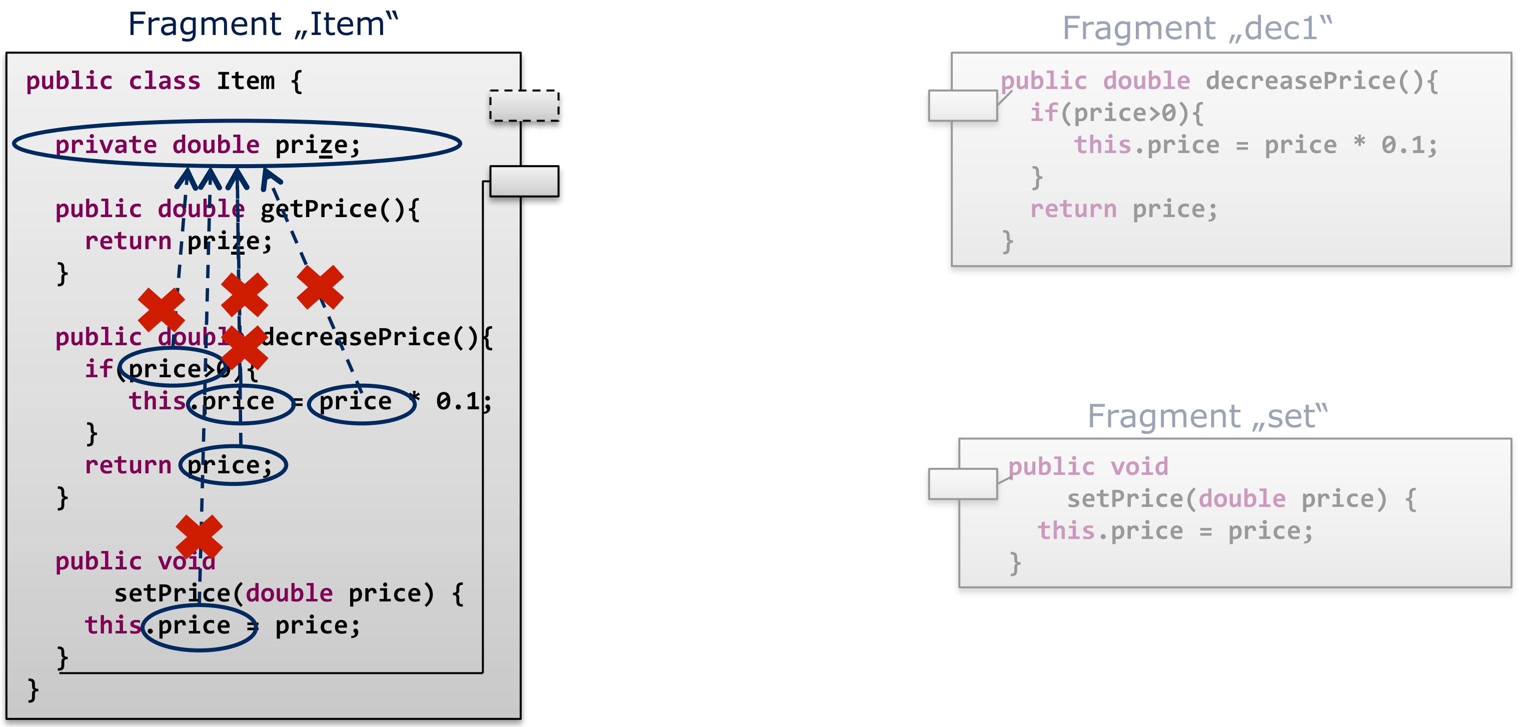
Background and Motivation

Fragment Composition Example



Fragment „Item"

```
public class Item {
  private double prize;

  public double getPrice(){
    return prize;
  }

  public double decreasePrice(){
    if(price>0){
       this.price = price * 0.1;
    }
    return price;
  }

  public void
      setPrice(double price) {
    this.price = price;
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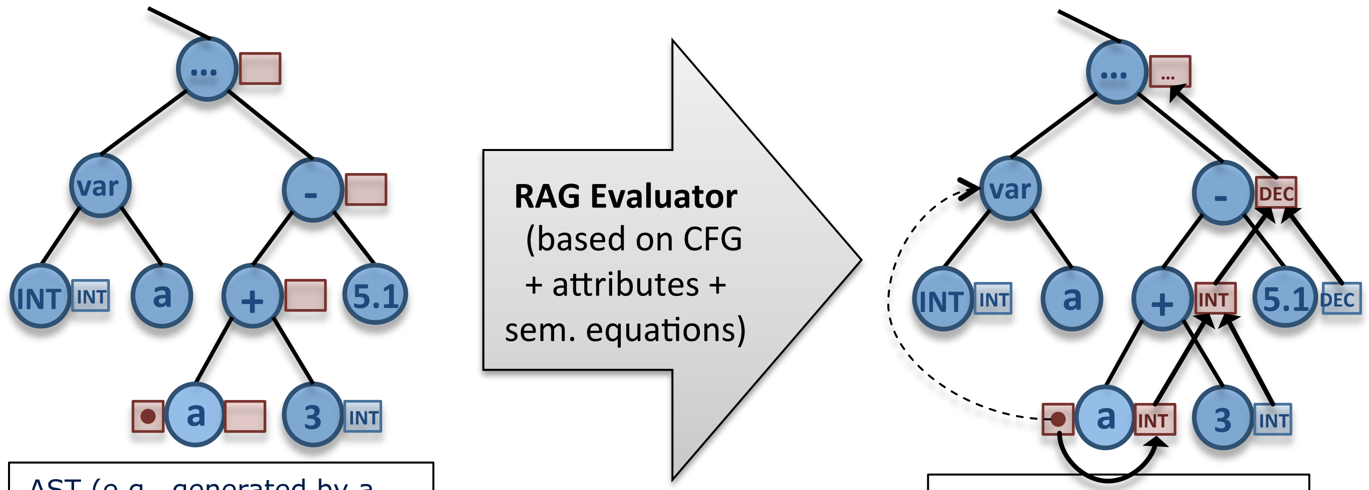
Background and Motivation

Solution Idea: Use Reference Attribute Grammars (RAGs) to specify fragment component models

- Formalism for specifying static semantics of programming languages and generating compiler frontends.
- Context-sensitive extension to context-free grammars/tree grammars:
  - ❑ non-terminals are assigned with (**inh**erited or **syn**thesized) *attributes*
  - ❑ for each context of an attribute (=grammar rule) a semantic equation specifies the attribute value

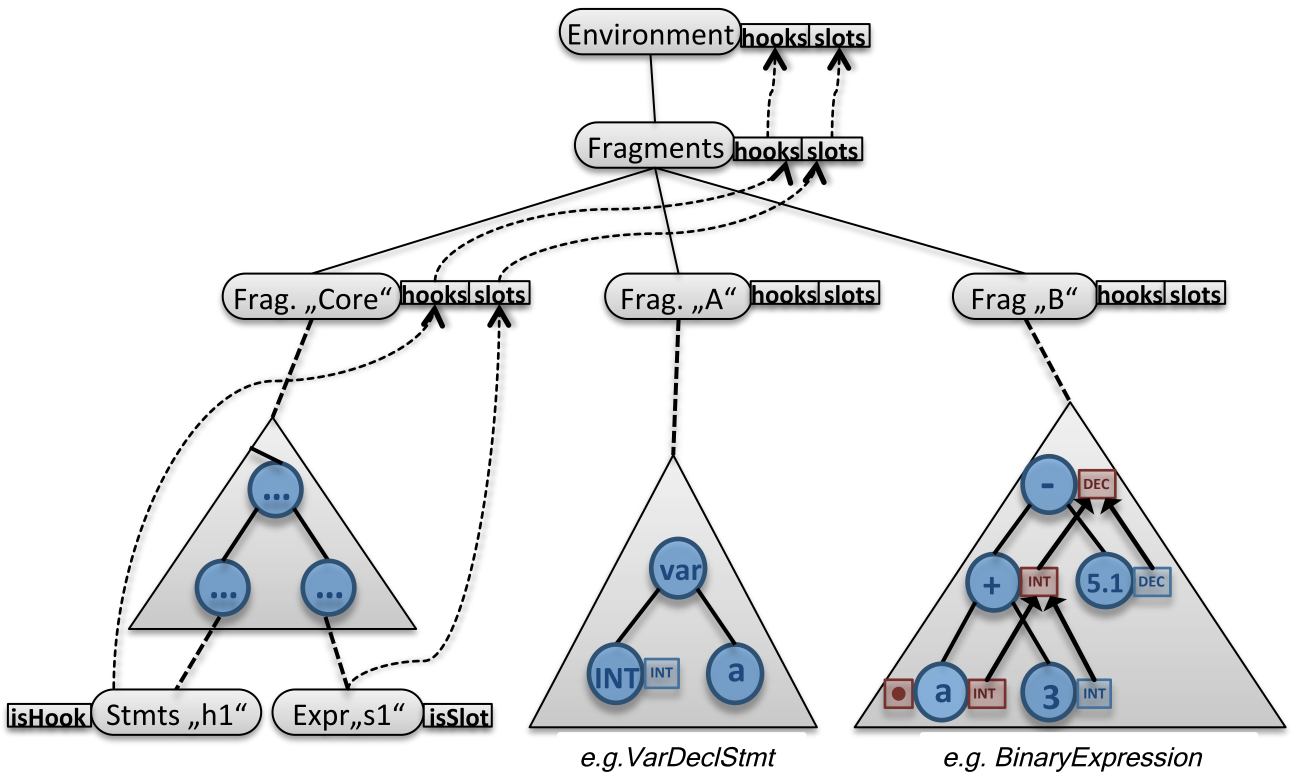


AST (e.g., generated by a parser from Java/C/.. code)

ASG (spanning tree with reference edges)

RAG-based Fragment Component Models

Example instance of a fragment component model



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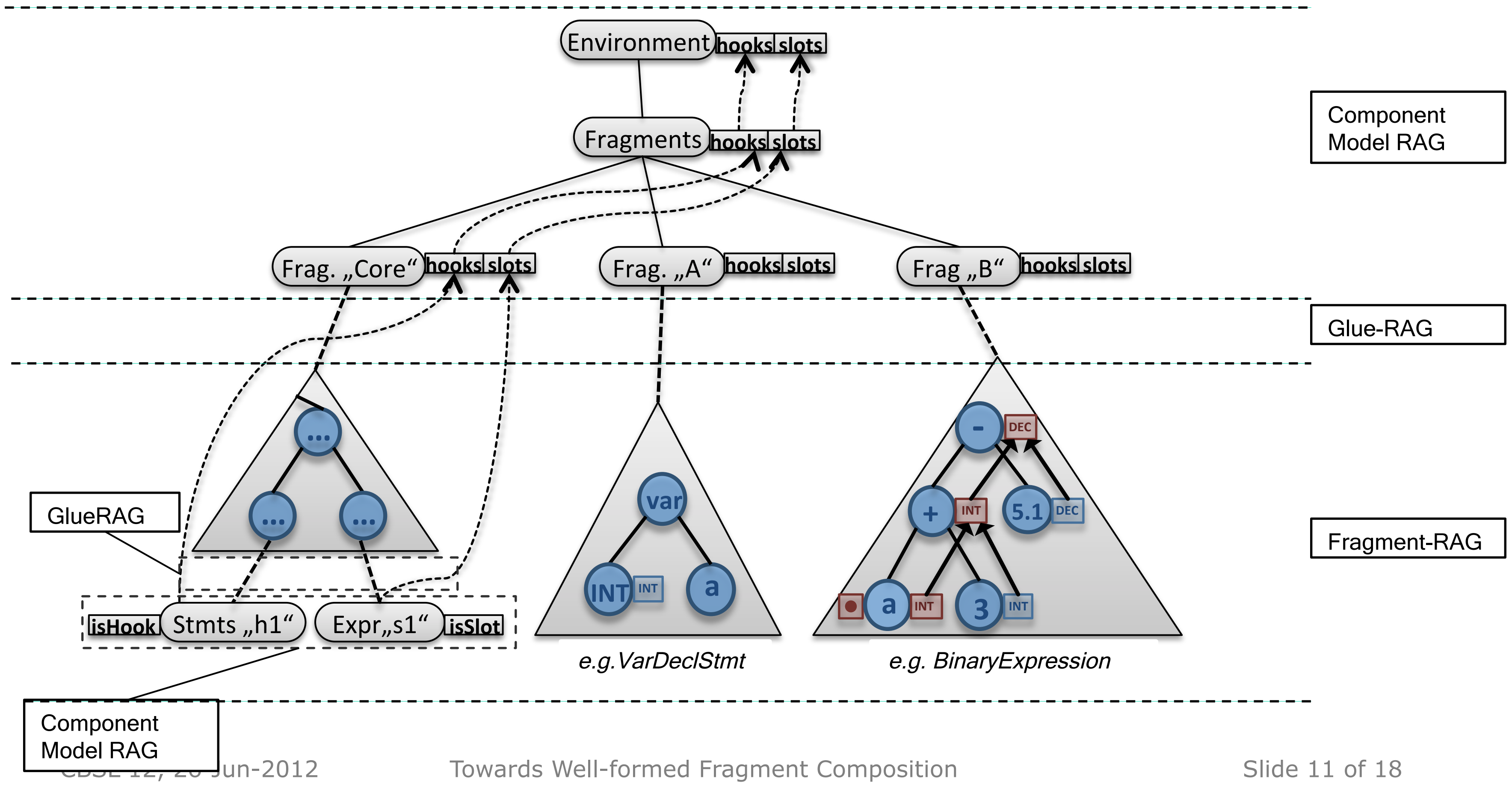
RAG-based Fragment Component Models

Example instance of a fragment component model



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Fragment Contracts

Terminology

Fragment assertions are (automatically) derived static properties of a given (code) fragment.

Fragment contracts are composition (pre-)conditions over fragment assertions.

- ❑ Ensure fragment compatibility w.r.t. static semantics and additional constraints
- ❑ Locate errors in composition programs
- ❑ Automatically select a compatible fragment component from a fragment repository

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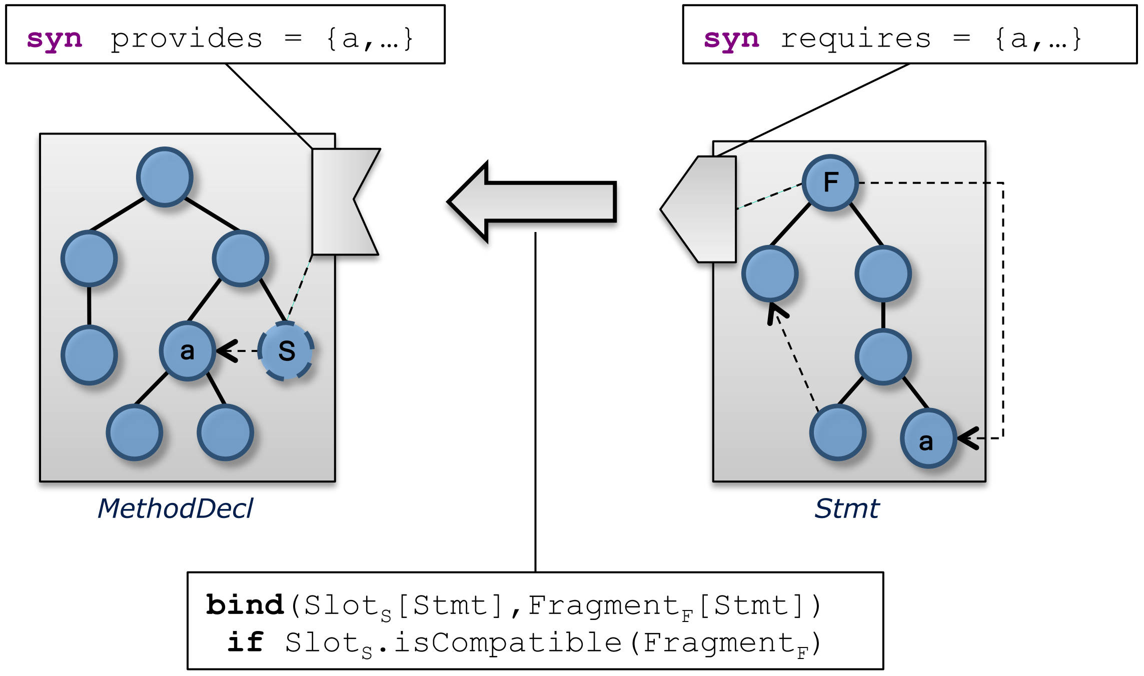
Fragment Contracts

Example: Def-Use Relation



```
bind(Slot_S[Stmt],Fragment_F[Stmt])
 if Slot_S.isCompatible(Fragment_F)
```

Java Case Study

- Java-Fragments based on the RAG tool **JastAdd2** and the **JastAddJ** extensible Java compiler by Hedin/Ekman

- JastAdd2 (www.jastadd.org)
  - ❑ Supports reference, higher-order and collection attributes, and rewrites
  - ❑ Supports OO ASTs and is implemented in Java
  - ❑ Supports extensible compiler construction approaches [Ekman06]
  - ❑ Generates Deman-driven evaluators with cached attributes

- JastAddJ
  - ❑ RAG based extensible Java compiler
  - ❑ Fully compliant with Java2 1.5
  - ❑ Modular Name + type analysis for Java
  - ❑ Bytecode reader + generator
  - ❑ Modular Java Grammar (basically LALR)
  - ❑ PrettyPrinter

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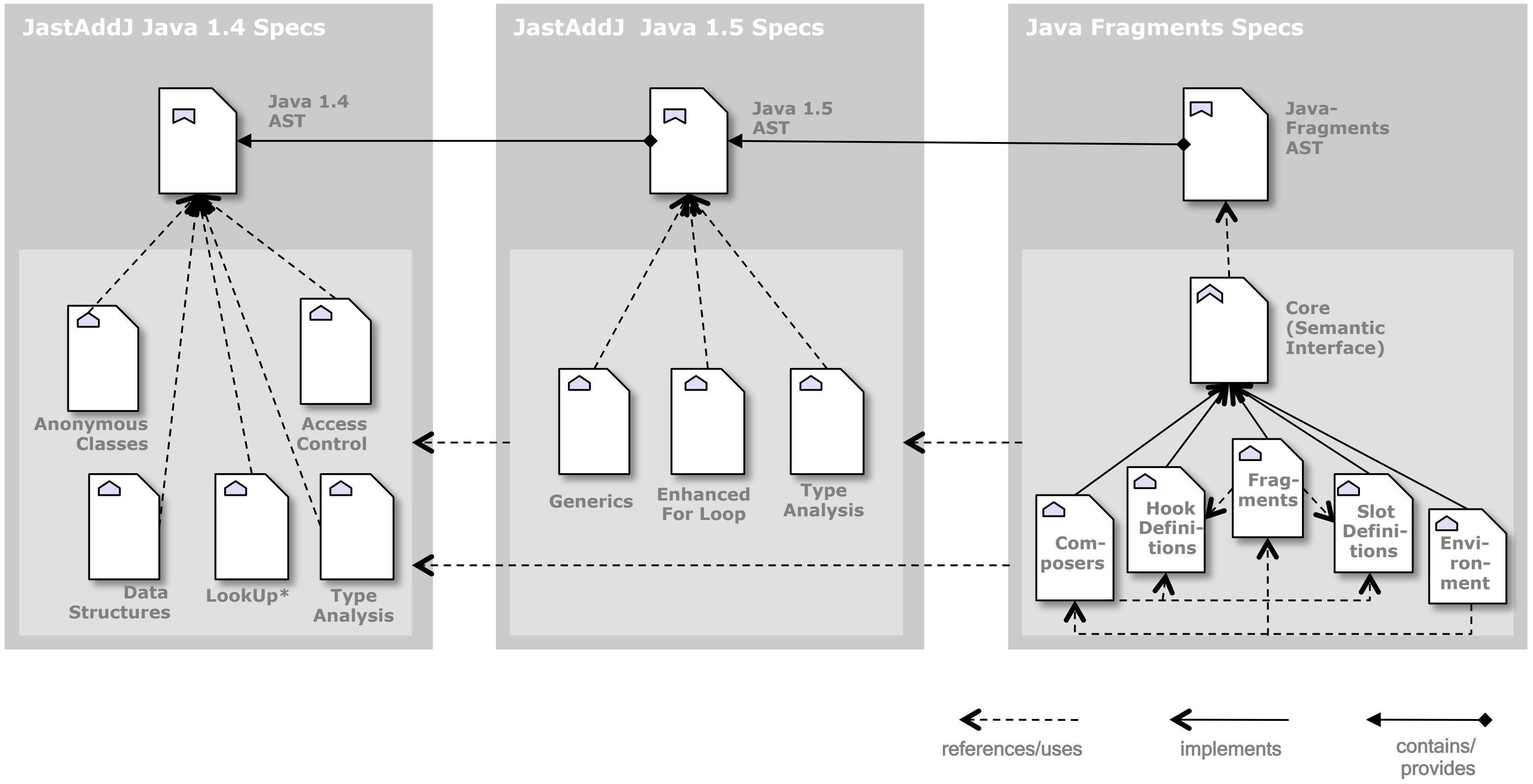
Java Case Study

Overview of the involved RAG specifications



Java Case Study

Fragment Composition Features

- Extended Java 1.5 Specification and parser
  - ❑ Slot Markup (types, expressions, statements, literals, methods, variable declarations)
  - ❑ Addressable Hooks (class-members, method hooks, block hooks in different classes, parameter lists)
  - ❑ According fragment types
  - ❑ RAG API for *fragment contracts*
  - ❑ Java API for creating composition programs (staged composition possible)
  - ❑ Implementation of composition operators with conditional AST rewrites (not shown in the paper)

Conclusion and Outlook

Benefits

- First approach for well-formed fragment composition
  - ❑ e.g., for generating safe template engines, AOP systems
- Universal approach that can be transferred to any language
  - ❑ like an “add-on”, if RAG frontend exists
- Founded in the RAG formalism

Open Issues/Outlook

- Complex usage/more industrial scenarios
  - ❑ we have a first prototype on architectural skeletons
- Transfer to model-based languages/ web languages
- Safe-C implementation
- (Non)confluency of composition steps
- Connection with composition languages / ADLs

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»Wissen schafft Brücken.«