25) Invasive Software Composition (ISC)

Prof. Dr. Uwe Aßmann
Florian Heidenreich
Technische Universität Dresden
Institut für Software- und Multimediatechnik
http://st.inf.tu-dresden.de

Version 11-0.5, Juli 6, 2011

Obligatory Literature

- ISC book Chap 4
- www.the-compost-system.org
- www.reuseware.org

Other References

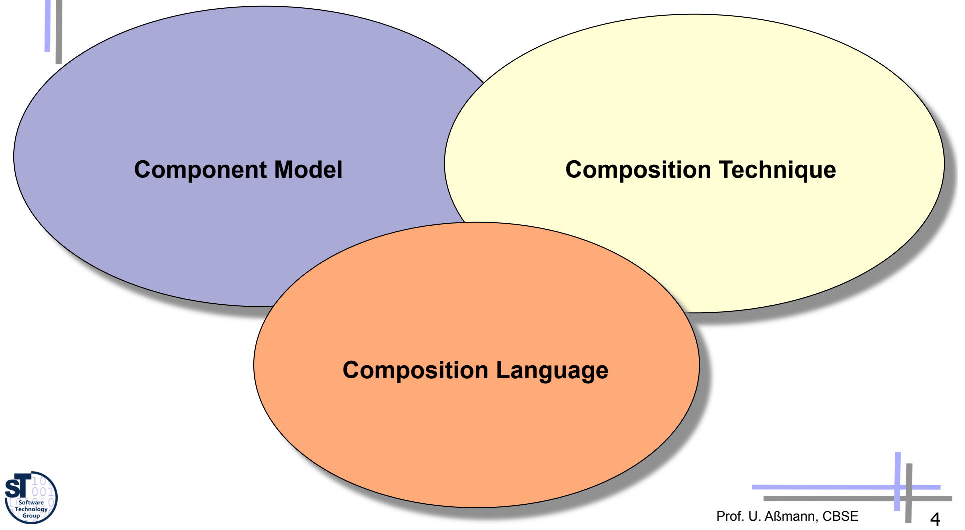
Jakob Henriksson. A Lightweight Framework for Universal Fragment Composition. Technische Universität Dresden, Dec. 2008
http://nbn-resolving.de/urn:nbn:de:bsz:14-ds-1231251831567-11763

Jendrik Johannes. Component-Based Model-Driven Software Development. Technische Universität Dresden, Dec. 2010
http://nbn-resolving.de/urn:nbn:de:bsz:14-qucosa-63986

Jendrik Johannes and Uwe Aßmann, Concern-Based (de)composition of Model-Driven Software Development Processes. Model Driven Engineering Languages and Systems - 13th International Conference, MODELS 2010, 2010,Part II, Springer, 2010, LNCS 6395, URL = http://dx.doi.org/10.1007/978-3-642-16129-2

Falk Hartmann. Safe Template Processing of XML Documents. PhD thesis. Technische Universität Dresden, July 2011.

Software Composition

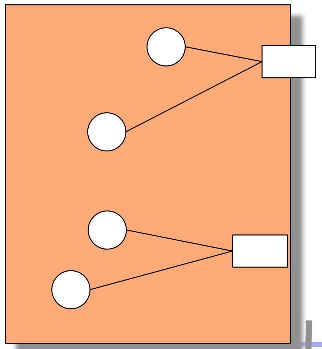


25.1) Invasive Software Composition - A Fragment-Based Composition Technique

Invasive Software Composition

Invasive software composition parameterizes and extends fragment components at hooks by transformation

- A **fragment component** is a fragment group (fragment container, fragment component, fragment box)
  - a set of fragments or fragment forms
- Uniform representation for
  - a fragment
    - a class, a package, a method
  - a fragment group
    - an advice or an aspect
    - some metadata
    - a composition program
  - A generic fragment (group)



The Component Model of Invasive Composition

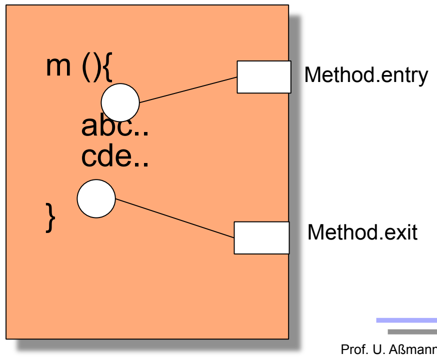
Hooks are *change points* of a fragment component:

fragments or positions, which are subject to change

- Fragment components have hooks (change points)
- A *change point* can be
  - An *extension point (hook)*
  - A *variation point (slot)*
- Example:
  - Extension point: method entries/exits
  - Variation point: Generic parameters

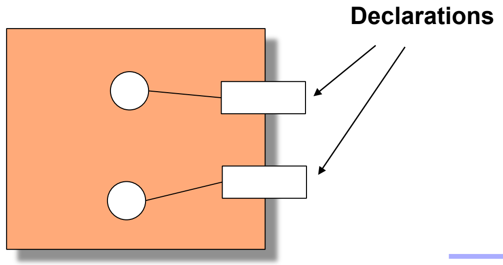
Implicit Hooks

- A **hook (extension point)** is given by the component's language
- Hooks can be *implicit* or *explicit (declared)*
  - We draw implicit hooks *inside* the component, at the border
- Example: Method Entry/Exit



Slots (Declared Hooks)

- A **slot** is a variation point (a code parameter)
- Slots are always *declared,* i.e., declared or explicit hooks
  - They are never implicit, i.e., must be declared by the component writer
  - We draw slots as crossing the border of the component



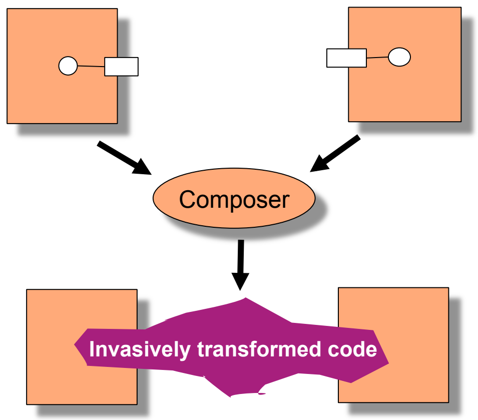
The Composition Technique of Invasive Composition

Invasive Software Composition
parameterizes and extends
fragment components
at implicit and declared hooks
by transformation

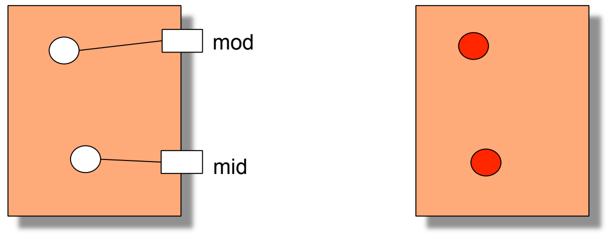
An invasive composition operator treats declared and implicit hooks uniformly

The Composition Technique of Invasive Composition

- A *composer (composition operator)* is a static metaprogram (program transformer)



Bind Composer Parameterizes Fragment Components

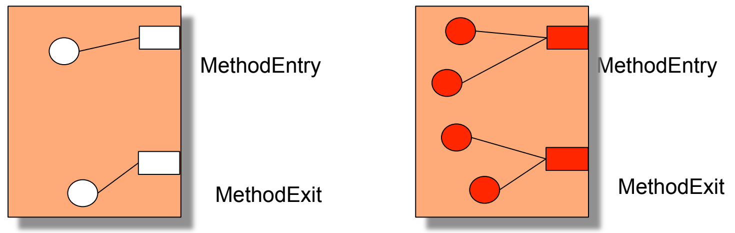


```
<<mod:Modifier>>
m (){

    abc..
    <<mid:Statement>>
    cde..

}
```

```
synchronized m (){
    abc..
    f();
    cde..
}
```

```
component.findHook(„mod“).bind(“synchronized”);
component.findHook(„mid“).bind(“f();”);
```

Extend Operator Extends the Fragment Components



```
m (){

    abc..
    cde..

}
```

```
m (){
    print("enter m");
    abc..
    cde..
    print("exit m");
}
```

```
component.findHook(„MethodEntry").extend("print(\"enter m\");");
component.findHook(„MethodExit").extend("print(\"exit m\");");
```

Merge Operator

merge(Component C1, Component C2) :=

    extend(C1.list, C2.list)

where list is a list of inner components, inner fragments, etc.

On the Difference of Declared and Implicit Hooks

- Invasive composition unifies generic programming (BETA) and view-based programming (merge composition operators)
  - By providing *bind* (parameterization) and *extend* for all language constructs

```
Hook h = methodComponent.findHook("MY");
if (parallel)
     h.bind("synchronized");
else
     h.bind(" ");
methodComponent.findHook("MethodEntry").bind("");
methodComponent.findHook("MethodExit").bind("");
```

```
/* @genericMYModifier */ public print() {
   // <<MethodEntry>>
   if (1 == 2)
        System.out.println("Hello World");
        // <<MethodExit>>
        return;
   else
        System.out.println("Bye World");
        // <<MethodExit>>
        return;
}
```

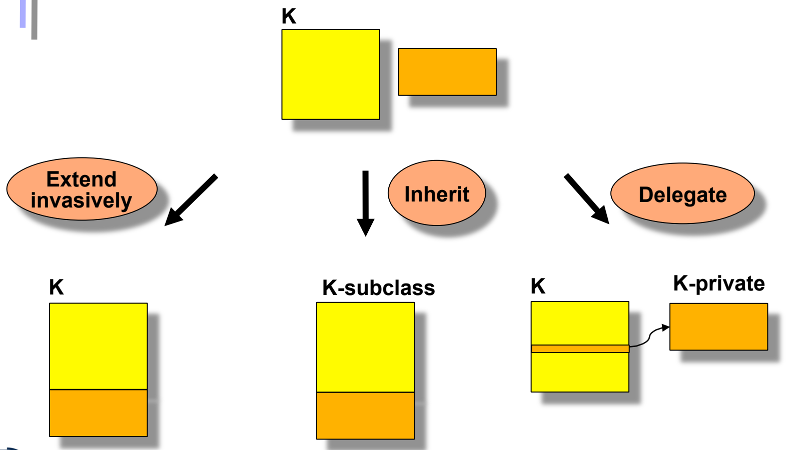
```
synchronized public print () {
    if (1 == 2)
         System.out.println("Hello World");
         return;
    else
         System.out.println("Bye World");
         return;
}
```

When Do you Need Invasive Composition

- When static relations have to be adapted
  - Inheritance relationship: multiple and mixin inheritance
  - Delegation relationship:;When delegation pointers have to be inserted
  - Import relationship
  - Definition/use relationships (adding a definition for a use)
- When physical unity of logical objects is desired
  - No splitting of roles, but integration into one class
- When the resulting system should be highly integrated

Invasive Extension Integrates Feature Groups

- ... and roles, because a feature group can play a role
- The invasive extension lies between inheritance and delegation



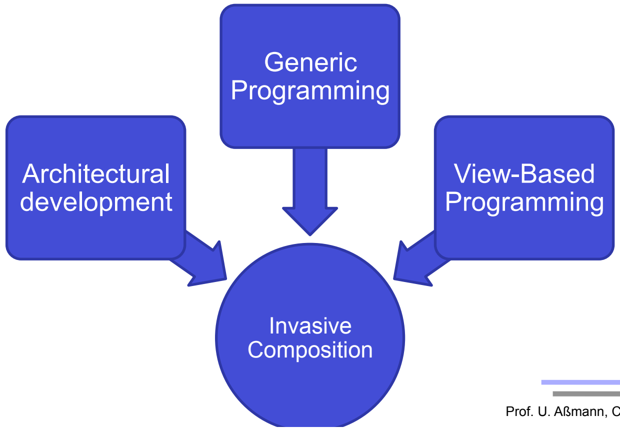
When To Use What?

- Deploy Inheritance
  - for consistent side-effect free composition
- Deploy Delegation
  - for dynamic variation
  - Suffers from object schizophrenia
- Deploy Invasive Extension
  - for non-foreseen extensions that should be *integrated*
  - to develop aspect-orientedly
  - to adapt without delegation

Invasive Composition

Adds a full-fledged composition language to generic and view-based programming

Combines architectural systems, generic, view-based and aspect-oriented programming



Composition Programs

Basically, every language may act as a composition language, if its basic operators are *bind* and *extend*.

Imperative languages: Java (used in COMPOST), C, ..

Graphical languages: boxes and lines (used in Reuseware)

Functional languages: Haskell

Scripting languages: TCL, Groovy, ...

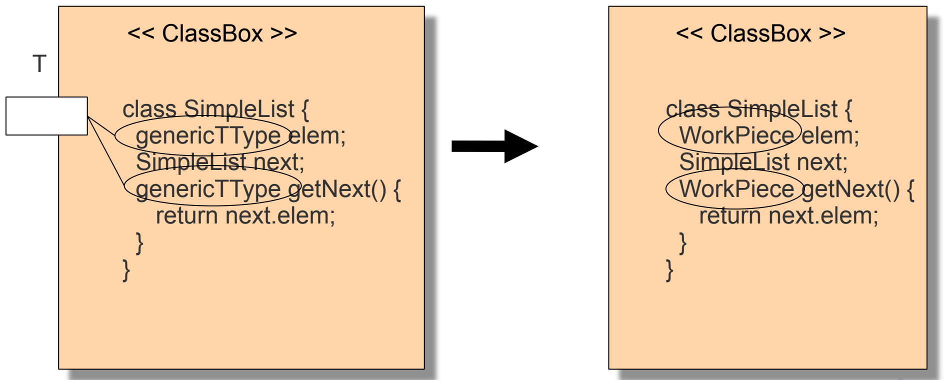
Logic languages: Prolog, Datalog, F-Datalog

Declarative Languages: Attribute Grammars, Rewrite Systems

25.2) What Can You Do With Invasive Composition?

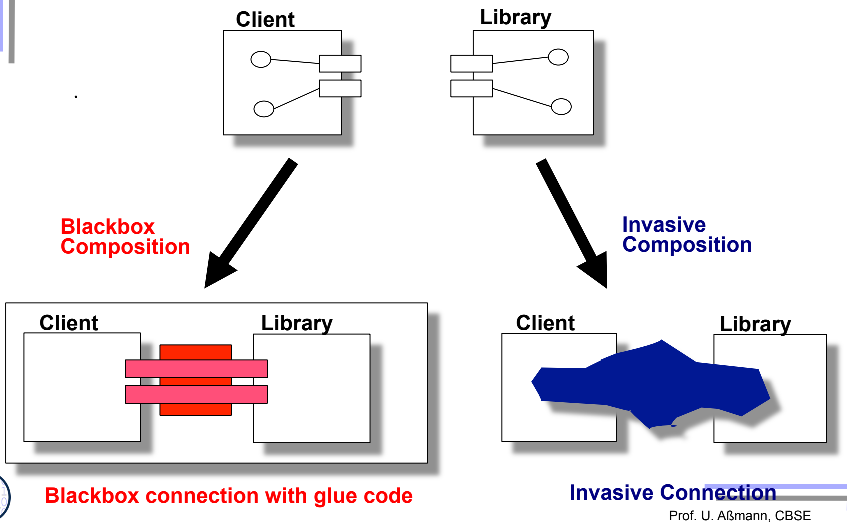
Universally Generic Programming

In contrast to BETA, ISC offers a full-fledged composition language



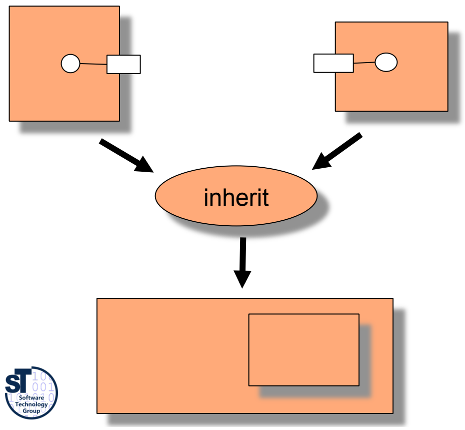
Invasive Connections

In contrast to ADL, ISC offers invasive connections



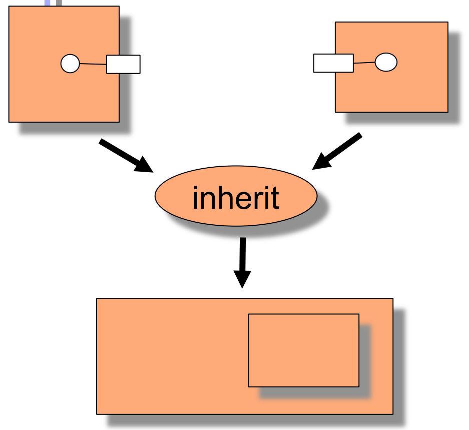
Mixin Inheritance

- Extension can be used for inheritance (mixins)
- In contrast to OO languages, ISC offers tailored inheritance operations, based on the extend operator



- **inheritance :=**
  - copy first super class
  - extend with second super class

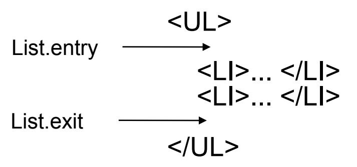
Mixin Inheritance Works Uniformly for Languages that don't have it

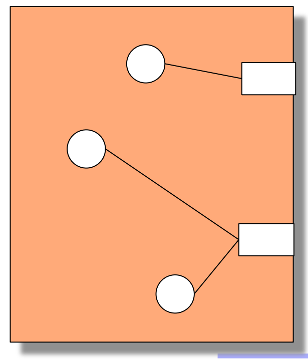


- Invasive composition can model mixin inheritance uniformly for all languages
- e.g., for XML
- inheritance :=
  - copy first super document
  - extend with second super document

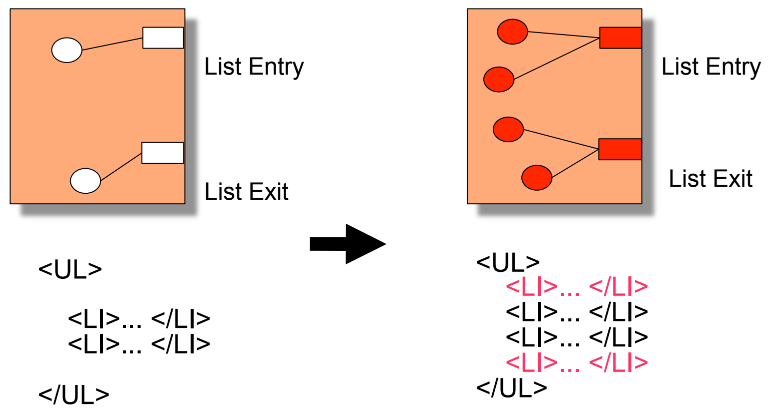
Invasive Document Composition for XML

- Invasive composition can be used for document languages, too [Hartmann2011]
- Example List Entry/Exit of an XML list
- Hooks are given by the Xschema



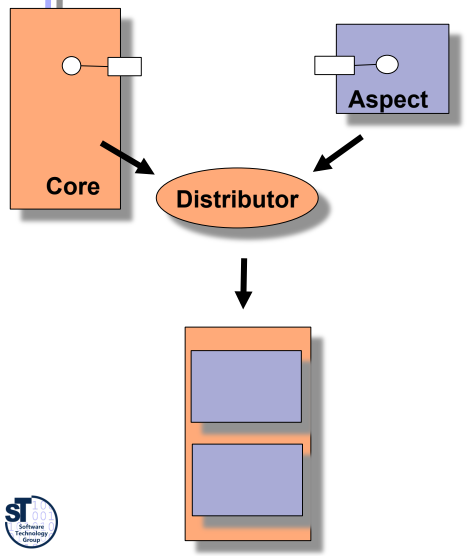


Hook Manipulation for XML



```
XMLcomponent.findHook(„ListEntry“).extend(„<LI>... </LI>”);
XMLcomponent.findHook(„ListExit“).extend(“<LI>... </LI>”);
```

Composers can be Used as Weavers in AOP (Core and Aspect Components)



- Complex composers distribute aspect fragments over core fragments
- *Distributors* extend the core
- Distributors are more complex operators, defined from basic ones
- Static aspect weaving can be described by distributors

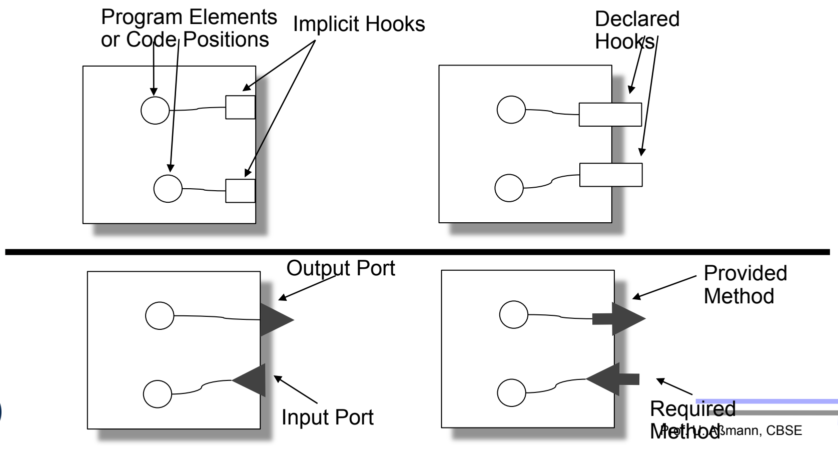
Invasive Model Composition with Reuseware

25.3) Composition and Functional Interfaces

Composition vs Functional Interfaces

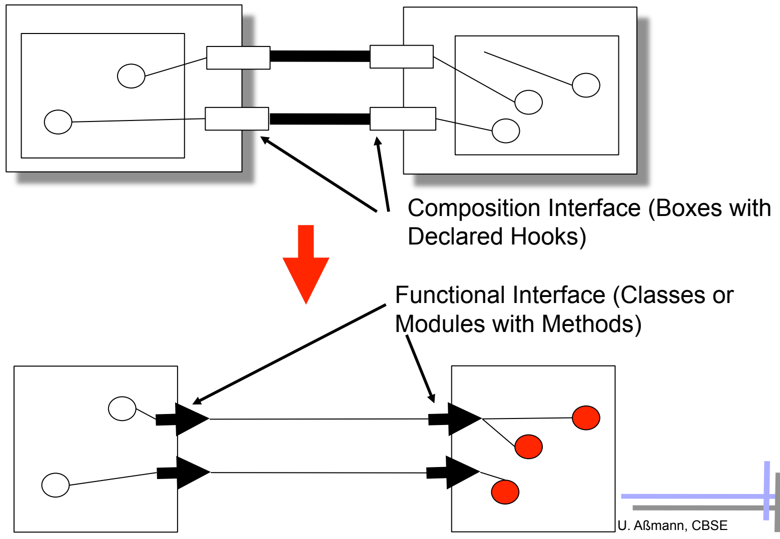
Composition interfaces contain hooks and slots
- static, based on the component model at design time

Functional interfaces are based on the component model at run time and contain slots and hooks of it



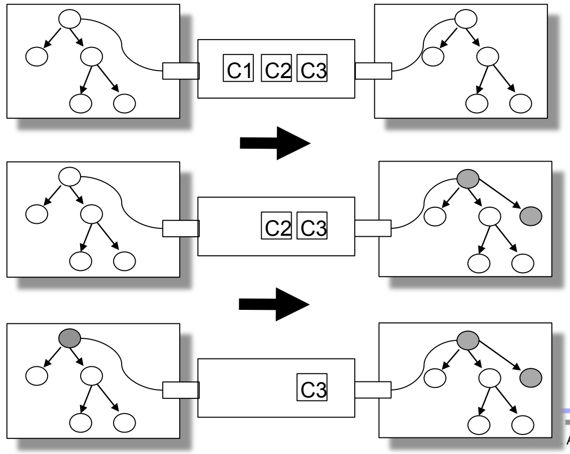
Functional Interfaces are Generated from Composition Interfaces

2-stage process


Composition Interface (Boxes with Declared Hooks)
Functional Interface (Classes or Modules with Methods)

Execution of a Composition Program

- transforms a set of fragment components step by step, binding their composition interfaces (filling their slots and hooks), resulting in an integrated program with functional interfaces



25.4) Different Forms of Greyboxes (Shades of Grey)

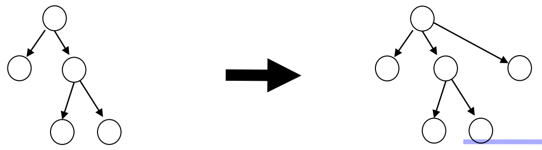
Invasive Composition and Information Hiding

- Invasive Composition modifies components at well-defined places during composition
  - There is less information hiding than in blackbox approaches
  - But there is...
  - ... that leads to greybox components

Refactoring is a Whitebox Operation

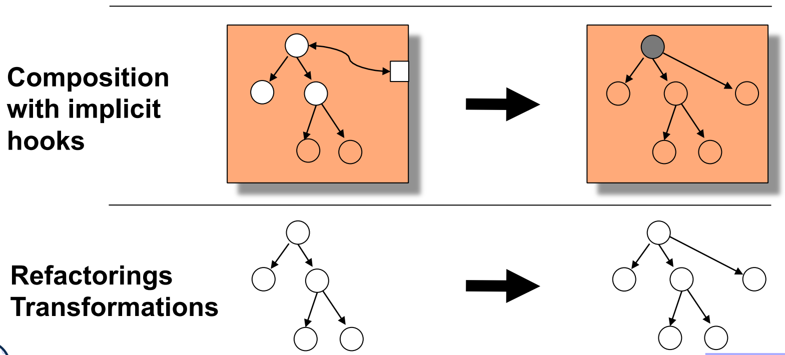
- Refactoring works directly on the AST/ASG
- Attaching/removing/replacing fragments
- Whitebox reuse

Refactorings Transformations



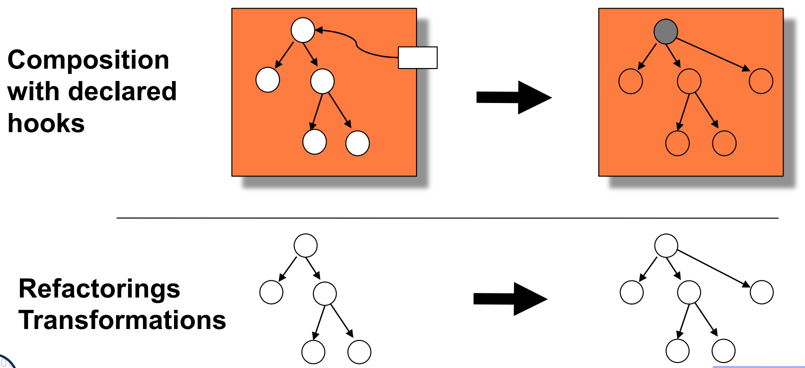
Modifying Implicit Hooks is a Light-Grey Operation

- Aspect weaving and view composition works on implicit hooks *(join points)*
- *Implicit composition interface*

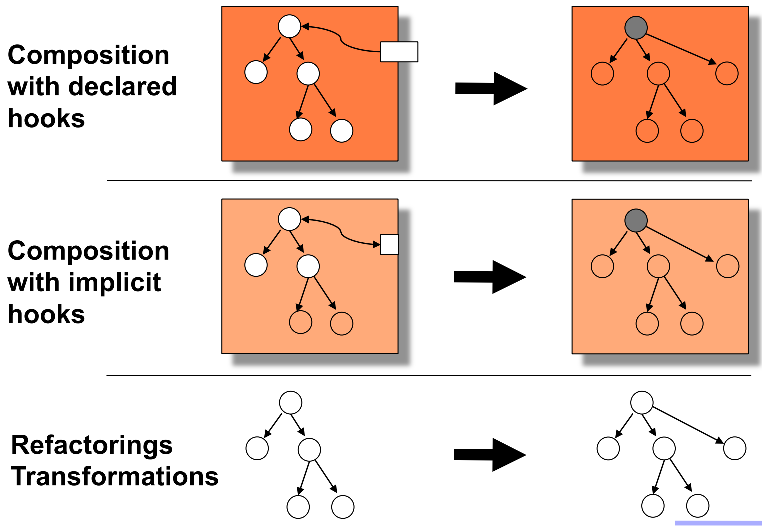


Parameterization as Darker-Grey Operation

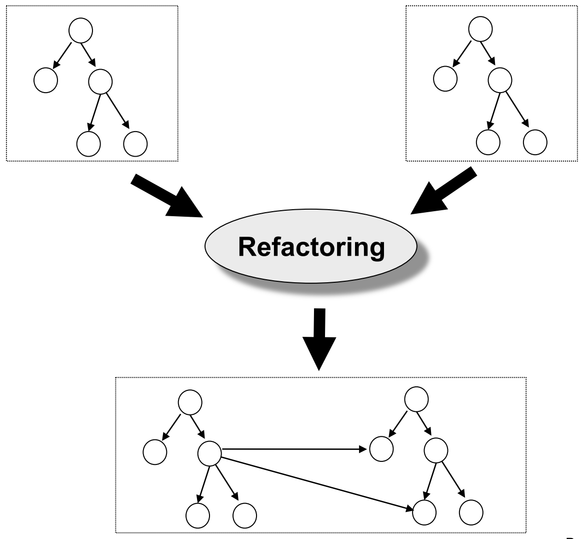
- Templates work on *declared hooks*
- *Declared composition interface*



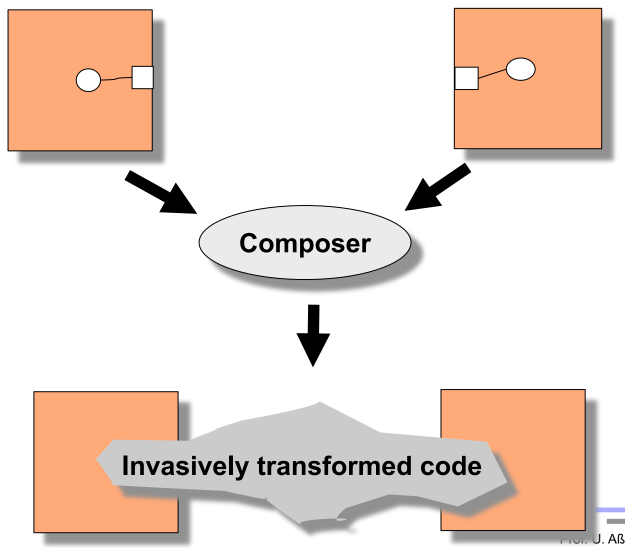
Systematization Towards Greybox Component Models


Composition with declared hooks
Composition with implicit hooks
Refactorings Transformations

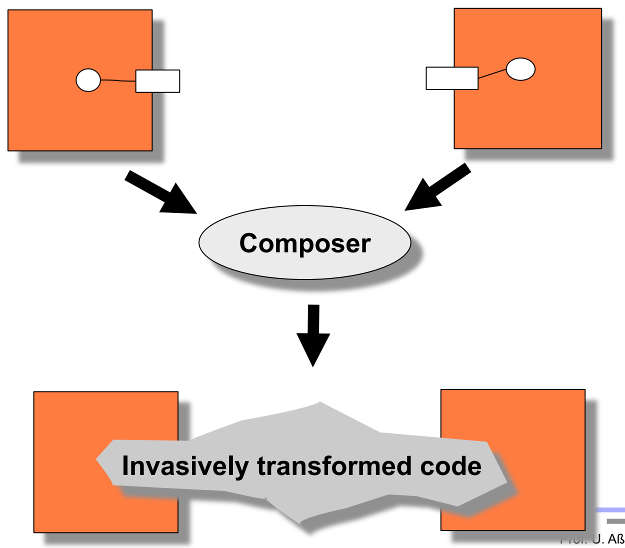
Refactoring Builds On Transformation Of Abstract Syntax



Invasive Composition Builds On Transformation Of Implicit Hooks



Invasive Composition Builds On Transformation on Declared Hooks



25.5 Invasive Software Composition as Composition Technique

Invasive Composition: Component Model

- Fragment components are graybox components
  - Composition interfaces with declared hooks
  - Implicit composition interfaces with implicit hooks
  - The composition programs produce the functional interfaces
    - Resulting in efficient systems, because superfluous functional interfaces are removed from the system
  - Content: source code
    - binary components also possible, poorer metamodel
- Aspects are just a special type of component
- Fragment-based parameterisation a la BETA
  - Type-safe parameterization on all kinds of fragments

Invasive Composition: Composition Technique

- Adaptation and glue code: good, composers are program transformers and generators
- Aspect weaving
  - Parties may write their own weavers
  - No special languages
- Extensions:
  - Hooks can be extended
  - Soundness criteria of lambdaN still apply
  - Metamodelling employed
- Not yet scalable to run time

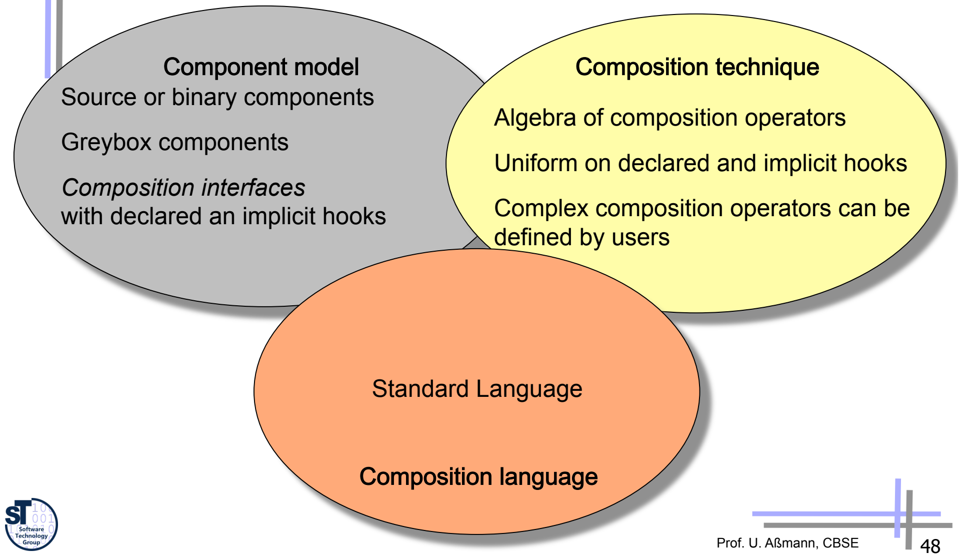
Composition Language

- Various languages can be used
- Product quality improved by metamodel-based typing of compositions
- Metacomposition possible
  - Architectures can be described in a standard object-oriented language and reused
- An *assembler* for composition
  - Other, more adequate composition languages can be compiled

Conclusions for ISC

- Fragment-based composition technology
  - Graybox components
  - Producing tightly integrated systems
- Components have *composition interface*
  - From the composition interface, the functional interface is derived
  - Composition interface is different from functional interface
  - Overlaying of classes (role model composition)
- COMPOST framework showed applicability of ISC for Java
  - (ISC book)
- Reuseware Composition Framework extends these ideas
  - For arbitrary grammar-based languages
  - For metamodel-based languages
- http://reuseware.org

Invasive Composition as Composition System


Component model
Source or binary components
Greybox components
Composition interfaces
with declared an implicit hooks
Composition technique
Algebra of composition operators
Uniform on declared and implicit hooks
Complex composition operators can be defined by users
Standard Language
Composition language

What Have We Learned

- With the uniform treatment of declared and implicit hooks, several technologies can be unified:
  - Generic programming
  - Connector-based programming
  - Refactorings
  - Inheritance-based programming
  - View-based programming
  - Aspect-based programming

The End