24. Trustworthy Framework Instantiation

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1)The framework instantiation problem
2)Remedies

Obligatory Literature

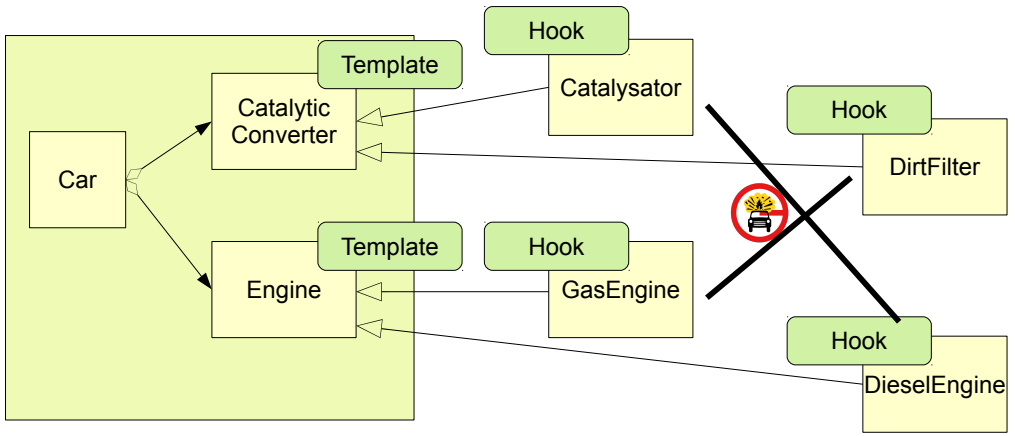
- Uwe Aßmann, Andreas Bartho, Falk Hartmann, Ilie Savga, Barbara Wittek. Trustworthy Instantiation of Frameworks. In *Trustworthy Components,* Reussner, Ralf and Szyperski, Clemens (ed.), Jan. 2006. LNCS 3938, Springer. Available at http://www.springerlink.com/index/104074p5h8581115.pdf

24.1 The Framework Instantation Problem

- Frameworks are often hard to instantiate, because they have many extension and variation points
  - and dependencies between them
- Whitebox frameworks are often instantiated with non-conformant subclasses
- Blackbox frameworks are often instantiated with non-fitting classes (multi-*point dependencies)*
- Some constraints cannot be checked statically

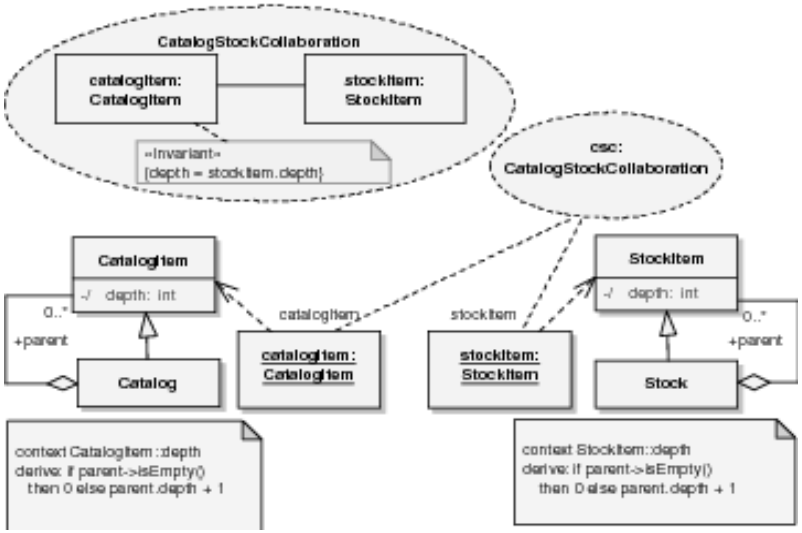
Problem 1: A Car Configurator

- How to instantiate two 1-T-H hooks, if there are dependencies between them (multi-*point constraints)?*
- Static constraint, domain-specific



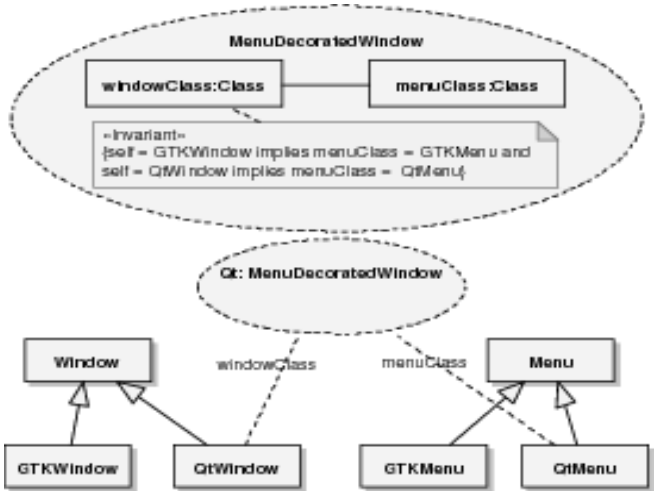
Problem 2: SalesPoint Framework

- Catalog and Stock hierarchies must be isomorphic
- Dynamic constraint; domain-specific



Problem 3: Parallel Hierarchies

- Window types must be varied parallely
- Static constraint, but technical



Problem 4: Dynamic Assumptions

- Other dynamic contract checks

Null-checks
Range checks
Sortedness of ordered collections

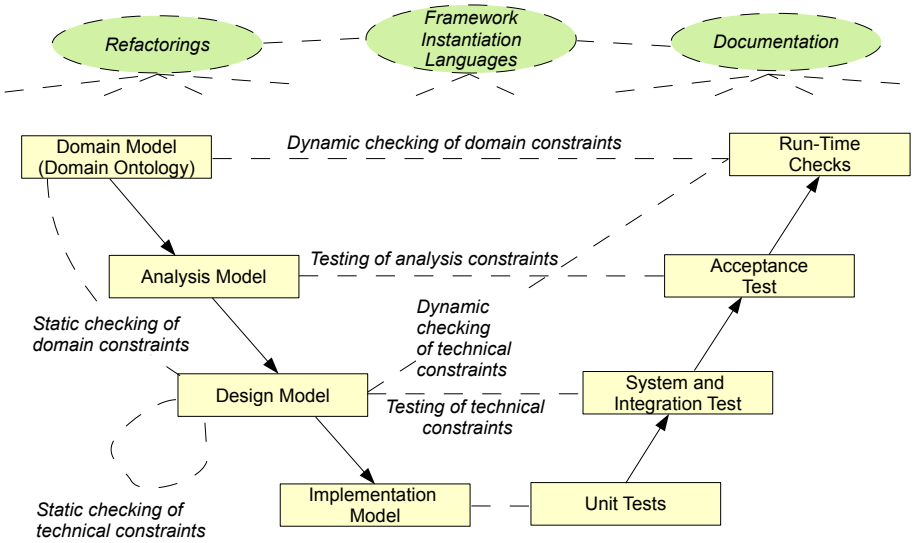
Dynamic technical constraints

Classification of Instantiation Constraints

Facet 2: Cause \ Facet 1: Stage	Static	Dynamic
Domain-specific (analysis-related)	Car configurator multi-point constraint	SalesPoint isomorphic hierarchies of Catalogs and Stocks
Technical (design-related)	Windows parallel hierarchies	Dynamic assumptions Dynamic contracts

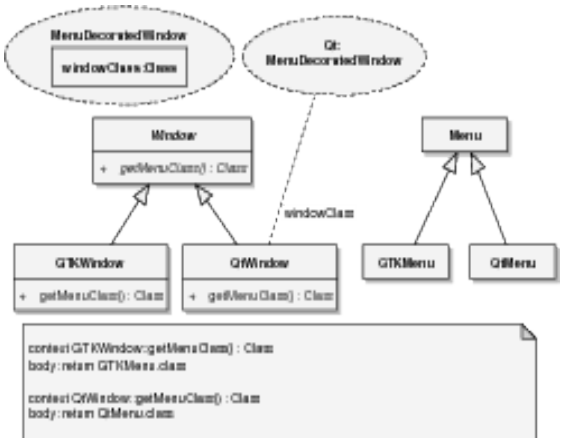
24.2 Remedies for Trustworthy Instantiation

Checking Mechanisms in All Phases of the Life Cycle



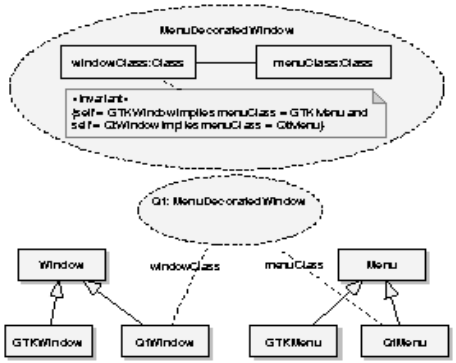
Remedy 1: Refactoring of Multi-Point Constraints

- Multi-point constraints can be refactored such that the constraint moves inside the framework
  - One point is removed
- Advantage: Framework can control itself



Remedy 2: Static Verification of Static Constraints

- *UML collaborations* are appropriate to describe static (technical and domain-specific) instantiation constraints.
  - OCL specifies static invariants of the framework, instantiation preconditions and postconditions
  - OCL can reason over types, hence, instantiations or extensions of the framework can be analyzed and verified

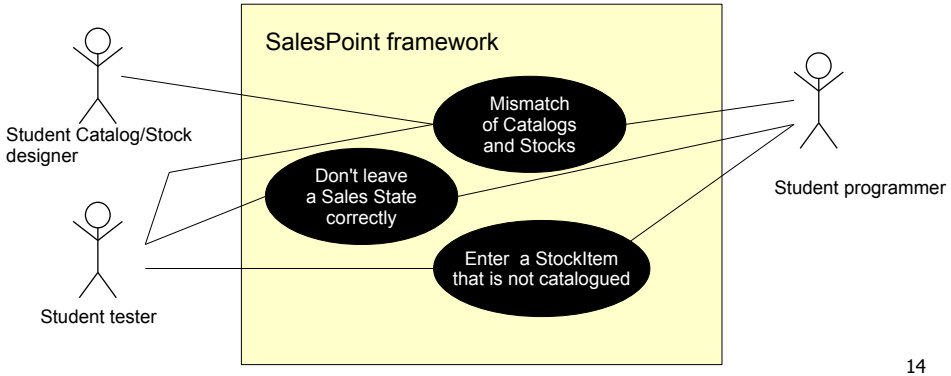


Remedy 3: Framework Testing

- Frameworks must be *negatively tested*
  - Beyond functional tests (positive tests), censorious negative tests for the behavior in case of misinstantiiaton must be conducted
  - Negative test cases have to be derived
    - specifying ill instantiation conditions
    - and the behavior of the framework
  - Framework must react reasonably
    - NOT dump core
    - Handle exceptions appropriately
    - Emit comprehensible error messages, also to the end user

Misuse Diagrams

- *Misuse diagrams* specify *misuse cases,* dually to use case diagrams, which specify functional use cases
- [Sindre, G., Opdahl, A.L. Eliciting security requirements with misuse cases. Requirements Engineering 10 (2005) 34–44]
- Used to describe system abuse (intrusion, fraud, security attacks)
- Coarse-grain technique to specify also *framework misuse*



Negative Test Table Entries

- From use case diagrams, usually test tables are derived
  - A test table contains test case entries, describing one test case
    - Class of test case (positive, negative)
    - Onput parameters of method
    - Output parameters
    - Reaction, state afterwards

Testcase	Testclass	Input		Output			Reaction
		String date		Date d1			
				day	month	year	
1	positive	1. Januar 2006		1	1	2006	
2	positive	05/12/2008		5	12	2008	
3	positive	January 23, 2007		23	1	2007	
4	negative	Mak 44, 2007					failure
5	negative	March 44, 2007					failure

Negative Test Case Entries for Misuse of Frameworks

- Input parameters must be refined
  - Dynamic constraints are tested as usual negative test cases, with input and output parameter specification
  - Static constraints, however, work on types. Hence, their test case entries are different. Negative test cases specify ill instantiations, framework error messages and exception handling

Testcase	Testclass	Input		Reaction	
		hook 1	hook 2		
1	pos. static	QtMenu	QtButton		
2	pos. static	GtkMenu	GtkButton		
3	neg. static	QtMenu	GtkButton	error „for multi-point, use parallel classes“	
4	neg. static	GtkMenu	QtButton	error „for multi-point, use parallel classes“	

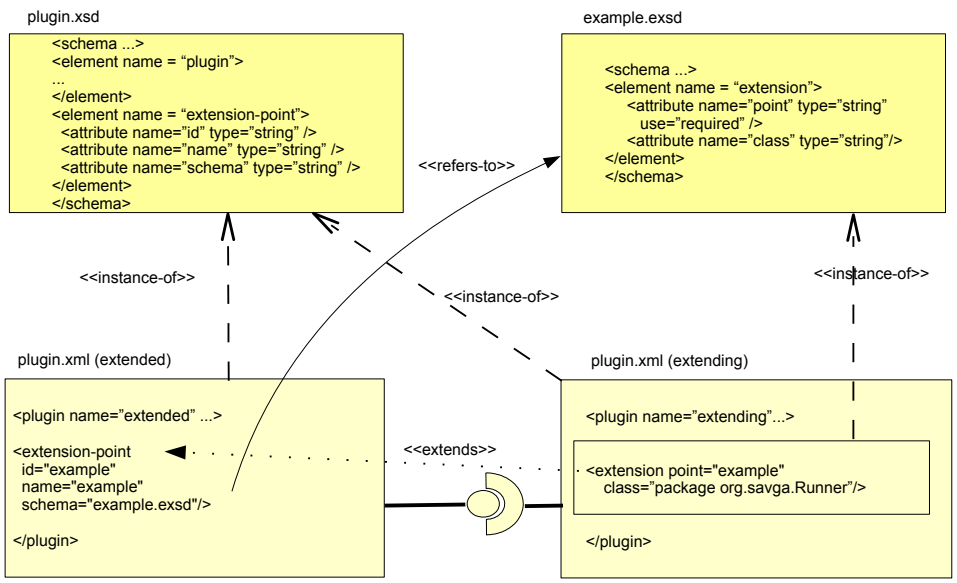
Derivation of JUnit Test Cases

- From every test table entry dealing with a dynamic constraint, a JUnit test case is derived (www.junit.org)
  - Test method or test class with test method, deriving from class *TestCase*
- From every test table entry dealing with a static constraint, a compilation test suite case is derived
  - Stored in a database
  - Sold with the framework to the customer of the framework
  - Helps the customer to instantiate right
- See course Softwaretechnologie II, summer semester

Remedy 4: Framework Instantiation Languages

- Eclipse has demonstrated that a framework extension (instantiation) language can be beneficial
  - to type variability and extension points
  - to describe not only extension points for code, but also for other resources, such as GUI elements, business objects, etc.
- Eclipse language is based on XML, thus restricted on:
  - XML tree specifications
  - XML base types

Eclipse Extension Specs



Why A Framework Extension Language Should Be Based on Logic

- Beyond XML, logic can capture context-sensitive static constraints
  - also static multi-point framework instantiation constraints
- However, the logic must be enriched with domain-specific concepts, such as framework, hook, variation point, extension point, instantiation, etc.
- Good candidates are *typed logic languages*
  - Ontology languages OWL, SWRL
  - Frame logic (F-logic, on top of XSB)
  - OCL on UML class diagrams (UML collaborations)

Remedy 5: Dynamic Contract Checking

- Dynamic multi-point constraints must be checked at run-time
  - Mainly, this amounts to *contract checking* of the framework
- Two best practices can be applied:
  - Framework contract layers
  - Contract aspects

Framework Contract Layers

- Best practice is to check a dynamic constraint (single- or multi-point) in a separate layer, encapsulating the *contract concern*
- The checking layer is called from outside (the application), but the inner layer from inside the framework. This is much faster than checking always!
  - When composing the framework with others, the contract layer can be

```
class Collection {
  public boolean sorted() { ... /* sortedness predicate */ }
  public Element searchBinary(ElementKey key){
    // contract checking
    if(!sorted())
      sort();
    // calling the inner layer
    return searchBinaryInternal(key);
  }
  // inner layer
  protected Element searchBinaryInternal(ElementKey key){
    .. binary search algorithm ...
  }
}
```


Remedy 6: Contract Aspects

- Once encapsulated in a layer, contract checks can be moved into a *contract aspect*
  - Tools such as Aspect/J can weave the contract in
  - Here: methods of package *framework* that have a parameter of type *Menu* are checked on null value
- Advantage: the aspect can easily be exchanged
  - Reduces effort, in particular when the aspect is *crosscutting*

```
before(Menu m): call(* framework.*.*(Menu)) && args(m) {
      if (m == null) {
         throw new Exception ("Null Menu parameter passed when " +
              thisJoinPoint.getThis() + " was called ");
      }
   }
```


What Have We Learned?

- Framework instantiation and extension is hard, because there are many constraints, both domain-specific and technical, to obey
- Multi-point constraints describe dependencies between two or several framework hooks
- Appropriate remedies against misinstantiations are:
  - Thorough documentation (well, of course with the pyramid principle)
  - Refactoring (removal) of multi-point constraints
  - Negative testing with misuse diagrams and negative test table entries
  - Using logic to verify static constraints
  - Use contract layers and contract aspects to facilitate checking of dynamic constraints

The End