Composing Configurable (Java) Components

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Introduction

Project Deliver:

- Intelligent Knowledge Management for Software Delivery
- Focus on release and delivery for product lines

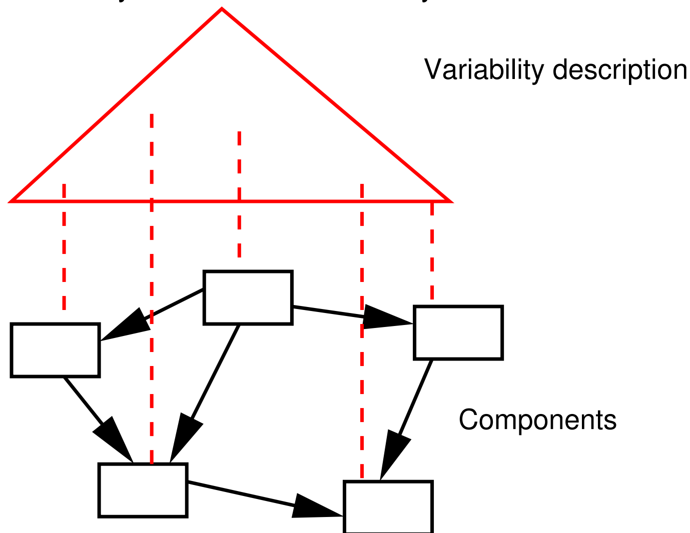
This talk:

- Composing Configurable (Java) Components
- *How to automatically deliver systems composed of configurable java components?*

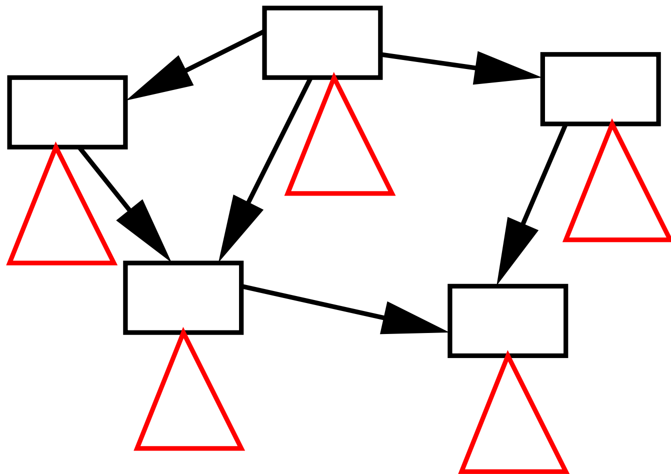
Outline

- Configurable components
  - Component variability vs. system variability
  - Example Java component: `tree`
  - Implementing variability with AOP
- Automating composition
  - Specification of variability
  - Relating features to implementation
  - Deriving configured compositions

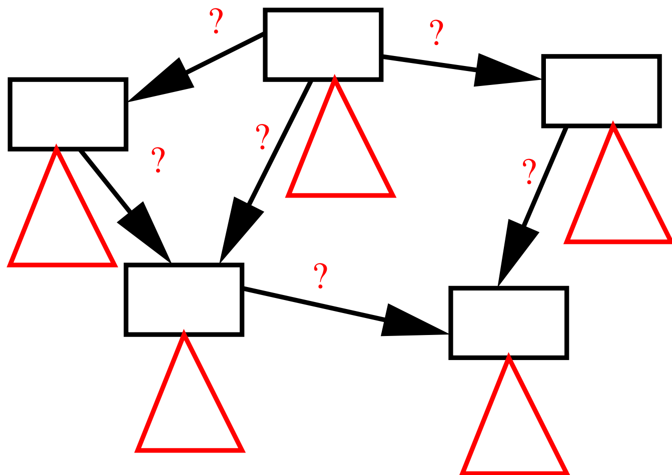
Variability described at level of system



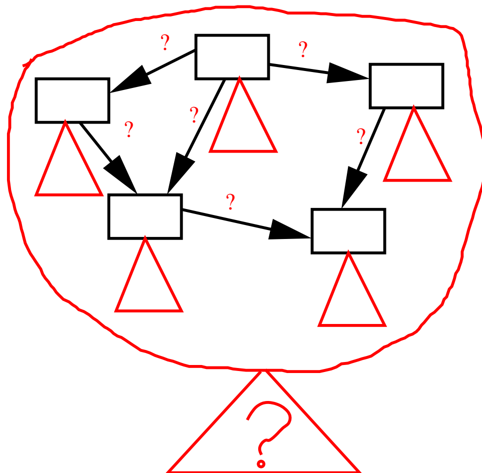
Variability described per component



What happens at these junctures?



How to configure a composition?



A `tree` component with two implementations: array and list, and optional visiting functionality.

visitors
tree
list
TreeFactory
«aspect»
Visitability
«Interface»
TreeFactory
«aspect»
Visitability
array
TreeFactory
«aspect»
Visitability

Implementing variability

Programming language imposes restrictions on variation mechanisms

Aspect-Oriented Programming (AOP) very popular for implementing variability.

Use AOP to:

- influence Tree factory creation; either array or list factory
- add Visitor design pattern; Trees should implement Visitable interface

Implementing optional visitor functionality

```
package tree;
import visitors.*;
public aspect Visitability {
  declare parents: Tree extends Visitable;
  public void Tree.accept(Visitor v) {
    v.visit(this);
  }
  public Visitable[] getKids() { ... }
}
```

Questions

Tree component has 4 variants:

- array with visiting, array without visiting
- list with visiting, list without visiting

How to configure this component family?

- How to prevent invalid configurations?
- Do we call AspectJ by hand?
- Which components go into the final `jar` when?

Moreover: propagation of variability

- What if `visitors` component is configurable as well?
- How to verify inter-component configuration?

Towards automatic delivery of compositions

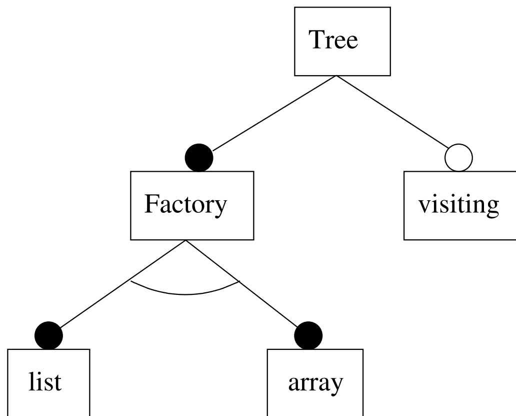
Goals:

- configuration user interface
- checking consistency of configuration
- automatically derive compositions

Component Description Language (CDL):

- configuration interfaces: specification of variability
- binding interfaces: mapping of variability to implementation

Feature diagrams



Configuration interfaces

Feature description:

- Composite features (e.g. `Factory`)
- Atomic features (e.g. `visiting`)
- Connectives: **`all`**, **`one-of`**, **`more-of`**, **`?`**
- Constraints: `a` **`requires`** `b`, **`include`** `a`

Feature description for Tree

```
Tree: all(Factory, visiting?)
Factory: one-of(list, array)
```

Binding interfaces

The interface between configuration and variation

- If-statements:
  - conditionals on atomic features
- Binding statements, e.g.:
  - set a property
  - generate code
  - weave an aspect
- Composition statements:
  - require another component

Example binding interface

Binding interface for `tree`

```
if (array) weave(UseArrayTrees);
if (list) weave(UseListTrees);
if (visiting) {
  require(visitors);
  weave(Visitability);
  if (list) weave(list.Visitability);
  if (array) weave(array.Visitability);
}
```

Dependency configuration

Dependencies may be passed atomic features.

Example

Assume `visitors` had alternative features `top-down` and `bottom-up`.

```
require(visitors, [top-down]);
```

Require only the top-down variant of the visitors component.

Variability inheritance

Dependencies may be configured partially.

Example

Assume `visitors` had an optional `logging` feature.

```
if (visiting) {
  require(visitors, [top-down]);
}
```

Now, `tree` inherits an optional `logging` feature *iff* the `visiting` feature is enabled.

NB: composition is recursively dependent on configuration.

Deriving compositions

A composition follows from the configuration of composed configuration interfaces:

- Union of configuration interfaces
- Constraints to respect `requires` relation

After configuring:

- Atomic features induce bindings
- Top composite features induce the composition

Example composition

- Union of configuration interfaces:

```
Tree: all(Factory, visiting?)
Factory: one-of(array, list)
Visitors: all(Strategy, logging?)
Strategy: one-of(top-down, bottom-up)
```

- Composition constraints:

```
visiting requires Visitors
visiting requires top-down
```

Consistency checking

Check composed configuration interface as boolean formula:

Features	Logic
feature description	boolean formula
atomic and composite features	atoms
configurability	satisfiability
configuration	valuation
validity of a configuration	satisfaction

Binary Decision Diagrams (BDDs) used to check satisfiability.

Valid configurations

Configuration	Composition
top-down	Visitors
top-down, logging	Visitors
bottom-up	Visitors
bottom-up, logging	Visitors
array	Tree
list	Tree
array, visiting, top-down	Tree, Visitors
list, visiting, top-down	Tree, Visitors
array, visiting, top-down, logging	Tree, Visitors
list, visiting, top-down, logging	Tree, Visitors

Component description language (CDL)

```
package tree {
  Tree: all(Factory, visiting?)
  Factory: one-of(list, array)
  if (array) weave(UseArrayTrees);
  if (list) weave(UseListTrees);
  if (visiting) {
    require(visitors);
    weave(Visitability);
    if (list) weave(list.Visitability);
    if (array) weave(array.Visitability);
  }
}
```

Summary

- Configurable Java Components
- Composition becomes complex:
  - Configuration correctness
  - Binding of features
- CDL for automation:
  - Feature descriptions
  - Binding actions

End

- Deliver project:
  `http://www.cwi.nl/projects/deliver`
- Technical report available
- More info: `http://www.cwi.nl/~storm`

Thank you!