Algebraic component composition in the UML

Master's thesis presentation

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Master's thesis topic

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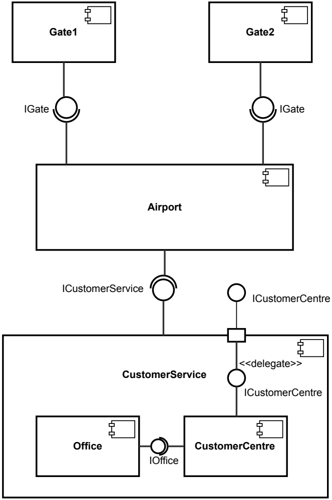
Algebraic component composition in the UML

What are software components?

- Software entity which encapsulates functionality
- A set of provided and required methods described by interfaces
- Major point: composable
- Composition by attaching required and provided interfaces

What are software components?

Component diagram



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Algebraic component composition in the UML

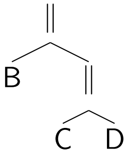
Algebraic component composition

$$\texttt{TextFieldWithButton} = \texttt{TextField} \parallel \texttt{Button}$$

- Define atomic components
- Compose them using an algebraic composition expression
- The result is *always a new composite component* with derived information

Algebraic component composition

The expression: $A = B \parallel C \parallel D$ is represented like this;



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Algebraic component composition in the UML

The Unified Modeling Language

- *De facto* standard for OO modeling
- Provides numerous different types of diagrams
- Extension mechanism: UML profile with stereotypes

Forms of UML models

- Two representations of an UML model
- A semantic model and a graphical model
- We say that the graphical model draws the semantic model
- Both will be demonstrated later

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Algebraic component composition in the UML

Component models

- Defines a standard and rules for composition
- Ensures compatibility
- Examples: OSGi, CORBA Component Model, rCOS and many others
- My prototype features: algebraic composition, UML modeling, model validation

Why?

Motivation

- The UML supports component modeling in the traditional sense
- Algebraic modeling approach: "take one or two components and apply a composition operator to get a new component"
- Problem: The UML does not support such compositions

The UML problem

- No bookkeeping details, does not store derived information
- "Plain" UML is not enough
- We want to know *which* components were used in a composition (i.e. the left and (right) operand and other arguments

Problem statements

1. How can the Unified Modeling Language (UML), extended with a UML profile, be used to support and represent models of textual algebraic component specifications?
2. What are the benefits of the algebraic component composition approach in component-based modeling?

Methods

- Literature studies
  - Algebraic composition proposed in *rCOS: Defining Meanings of Component-Based Software Architectures* by Dong *et al*.
- Prototype development
- Evaluation
  - Design decisions
  - Modeling examples (airport)
  - Comparing traditional and algebraic approach

The composition operators

The binary operators

- Parallel ($\|$)
- Disjoint ($\otimes$)
- Plugging ($\ll$)

- Variations of taking the union of the methods and the variables of the operands

The composition operators

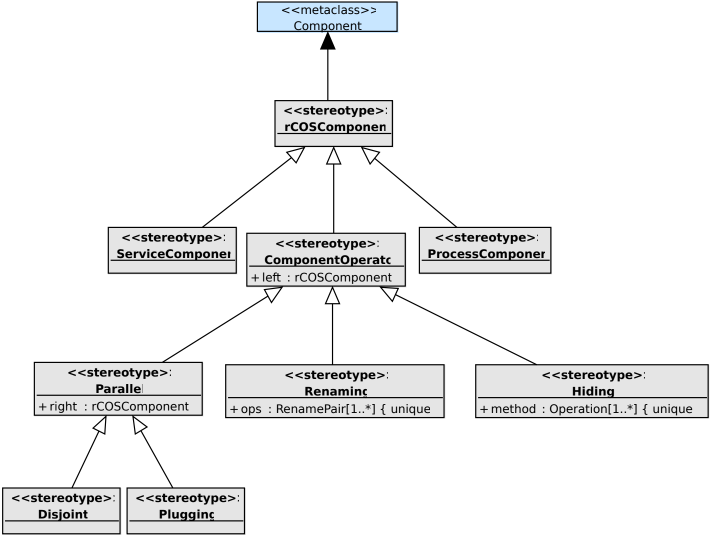
The unary operators

- Renaming ($C[oldname \leftarrow newname]$)
- Restriction/hiding ($C \backslash \{foo, bar\}$)

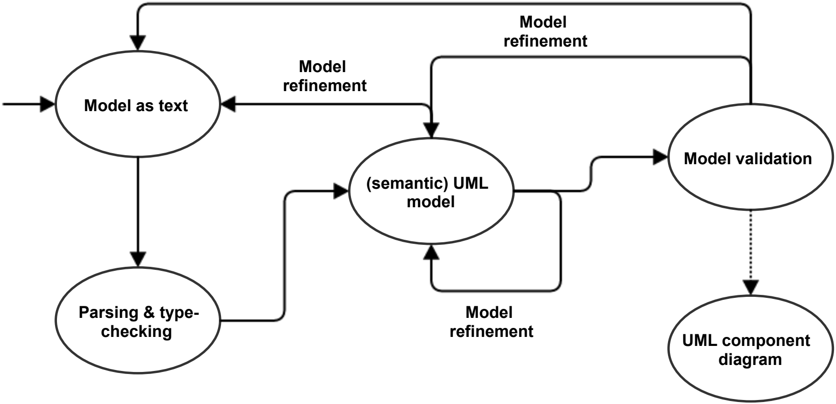
The prototype

- Extension of the rCOS tool
- Defines a DSL, called rCOSPN
- Defines a UML profile
- Can validate UML models using the OCL
- Plug-in for the Eclipse platform

The UML profile



The workflow



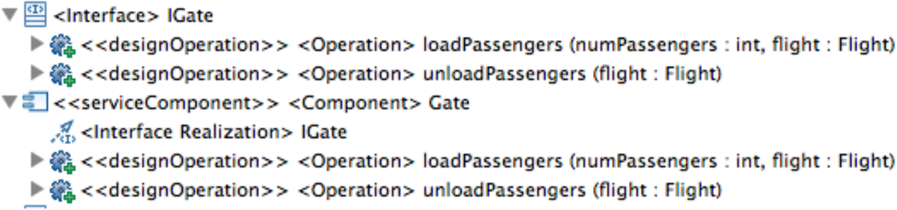
Prototype demonstration

Demonstration

Prototype demonstration

```
interface IGate {
    public loadPassengers(int numPassengers, Flight flight);
    public unloadPassengers(Flight flight);
}
component Gate {
    provided IGate {
        public loadPassengers(int numPassengers, Flight flight) {
            /* Method body */
        }

        public unloadPassengers(Flight flight) {
            /* Method body */
        }
    }
}
```

Prototype demonstration



```
▼ <Interface> IGate
    ▶ <<designOperation>> <Operation> loadPassengers (numPassengers : int, flight : Flight)
    ▶ <<designOperation>> <Operation> unloadPassengers (flight : Flight)
▼ <<serviceComponent>> <Component> Gate
      <Interface Realization> IGate
    ▶ <<designOperation>> <Operation> loadPassengers (numPassengers : int, flight : Flight)
    ▶ <<designOperation>> <Operation> unloadPassengers (flight : Flight)
```

Prototype demonstration

```
interface IOffice {
    public provideEmployee(;string employee);
}

component Office {
    provided IOffice {
        public provideEmployee(;string employee) {
            /* Method Body*/
        }
    }
}
```

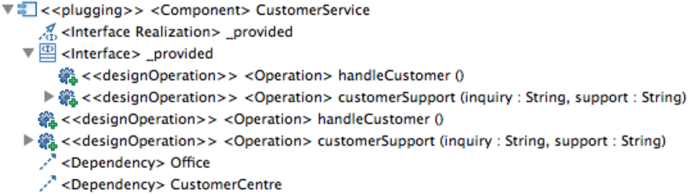
Prototype demonstration

```
component CustomerCentre {

    provided ICustomerService {
        public handleCustomer() {
            /* Method body */
        }
    }

    provided ICustomerCentre {
        public customerSupport(string inquiry; string support) {
            /* Method body */
        }
    }
    required IOffice;
}
```

Prototype demonstration

```
CustomerService = Office << CustomerCentre;
```

Prototype demonstration

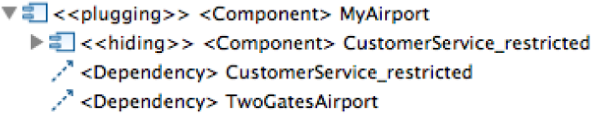


```
▼ <<plugging>> <Component> CustomerService
     <Interface Realization> _provided
  ▼  <Interface> _provided
        <<designOperation>> <Operation> handleCustomer ()
     ▶  <<designOperation>> <Operation> customerSupport (inquiry : String, support : String)
     <<designOperation>> <Operation> handleCustomer ()
  ▶  <<designOperation>> <Operation> customerSupport (inquiry : String, support : String)
     <Dependency> Office
     <Dependency> CustomerCentre
```

Prototype demonstration

```
component Airport {
    required ICustomerService;
    required IGate[2];
}

// COMPOSITIONS ---------------------------------------------------
GateRenamed = Gate[unloadPassengers <- unloadPassengers2, loadPassengers <- loadPassengers2];
OneGateAirport = GateRenamed << Airport;
TwoGatesAirport = Gate << OneGateAirport;
MyAirport = CustomerService \ {customerSupport} << TwoGatesAirport ;
```

Prototype demonstration



```
▼ <<plugging>> <Component> MyAirport
    ▶ <<hiding>> <Component> CustomerService_restricted
      <Dependency> CustomerService_restricted
      <Dependency> TwoGatesAirport
```

Discussion and conclusion

Recall the problem statements

1. How can the Unified Modeling Language (UML), extended with a UML profile, be used to support and represent models of textual algebraic component specifications?
2. What are the benefits of the algebraic component composition approach in component-based modeling?

Discussion

What are the alternatives to profiles?

- Sticking to plain UML
- Creating a new metamodel for UML

Discussion

- The UML profile provides a good solution for our modeling domain
- Simple
- Keeps track of what we need
- Able to interchange industry standard (the UML)
- Was able to build on the rCOS tool

Recall the problem statements

1. How can the Unified Modeling Language (UML), extended with a UML profile, be used to support and represent models of textual algebraic component specifications?
2. What are the benefits of the algebraic component composition approach in component-based modeling?

Discussion

- The algebraic approach is quite different from the traditional approach
- Everything is composable (if it conforms to the rules)
- Emphasizes small, reusable components
- Build composite components from these small building blocks
- The result is always a new independent component computed automatically

Limitations

- Composing two components with the same variable
- No explicit showing of methods that are “attached”

Conclusion

- The algebraic approach have several strengths
- Can be supported by the UML
- Unfortunately also some limitations
- Most people probably want graphical diagrams

Future work

- Extending the tool to graphical modeling
- Method bodies
- Code generation

Thanks for listening!