Technische Universität Braunschweig

ISF

Engineering Delta Modeling Languages

Ina Schaefer

(joint work with Bernhard Rumpe, Arne Haber, Karsten Kolassa, Markus Look, Klaus Müller, Kathrin Hölldobler)

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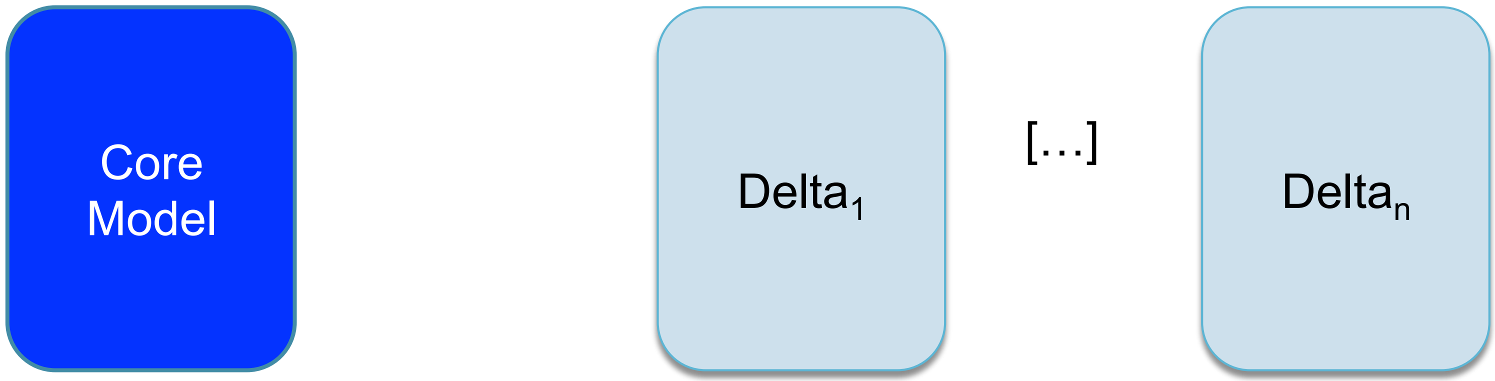
Delta Modeling



Core Model:

- A model for a complete variant
- Developed with standard techniques or an existing legacy application

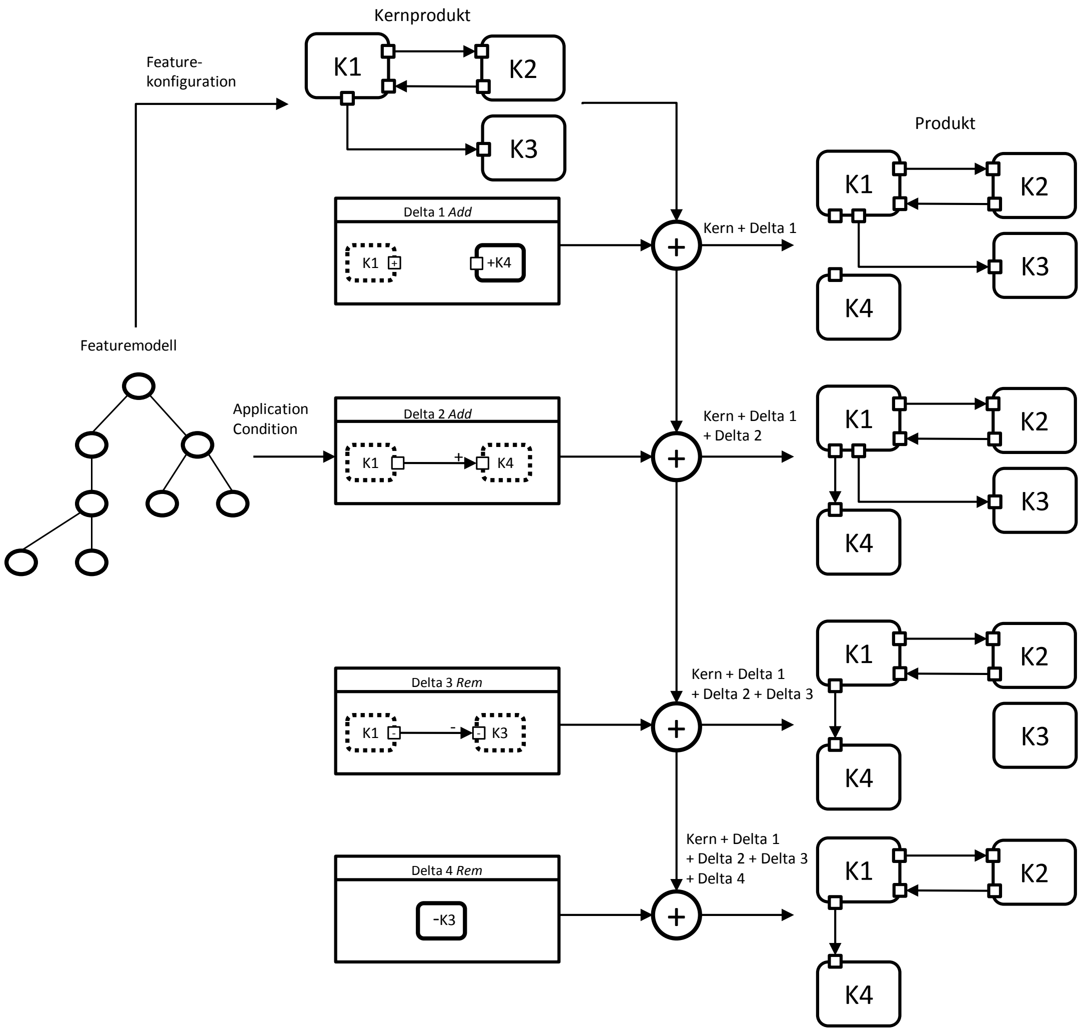
Deltas:

- Modifications of core model
- Selection of deltas for each model variant
- Ordering for conflict resolution

Characteristics of Delta Modeling

- Modular and flexible description of change
- Automatic variant generation
- Easily integrates variability and evolution
- Paves way for efficient testing, analysis and verification
- Support for proactive, reactive and extractive SPLE

Deltas on Software Architectures



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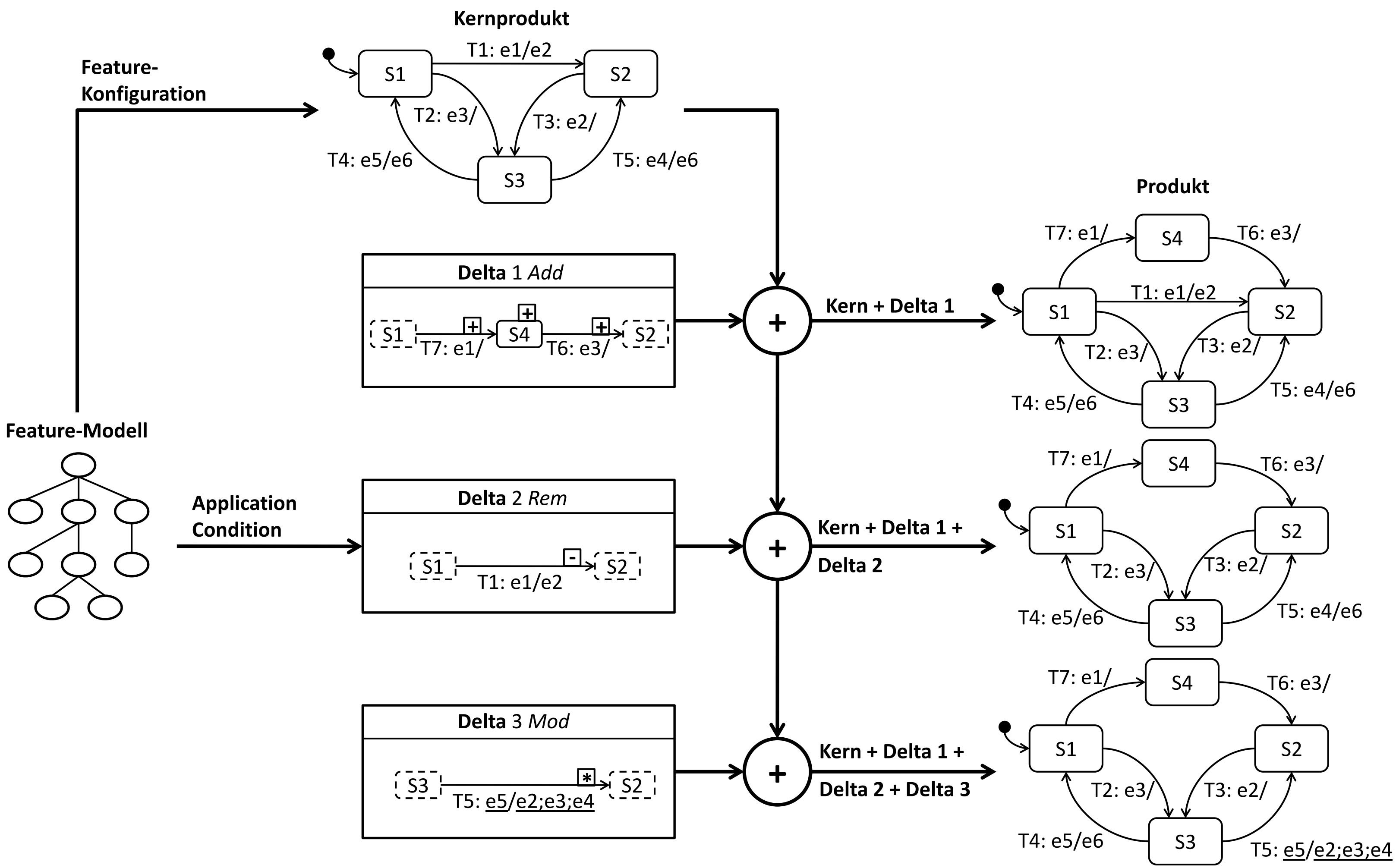
Deltas on State Machines



Deltas in Java

Core Modul: Java-Programs

```
core Interval, Vehicle_Speed {

class IntervalCmdProcessor {
  int intervalSelection;
  int vehicleSpeed;
  int wipeCmd;

  void computeWipeCmd() {
    [...]
  }
}
```

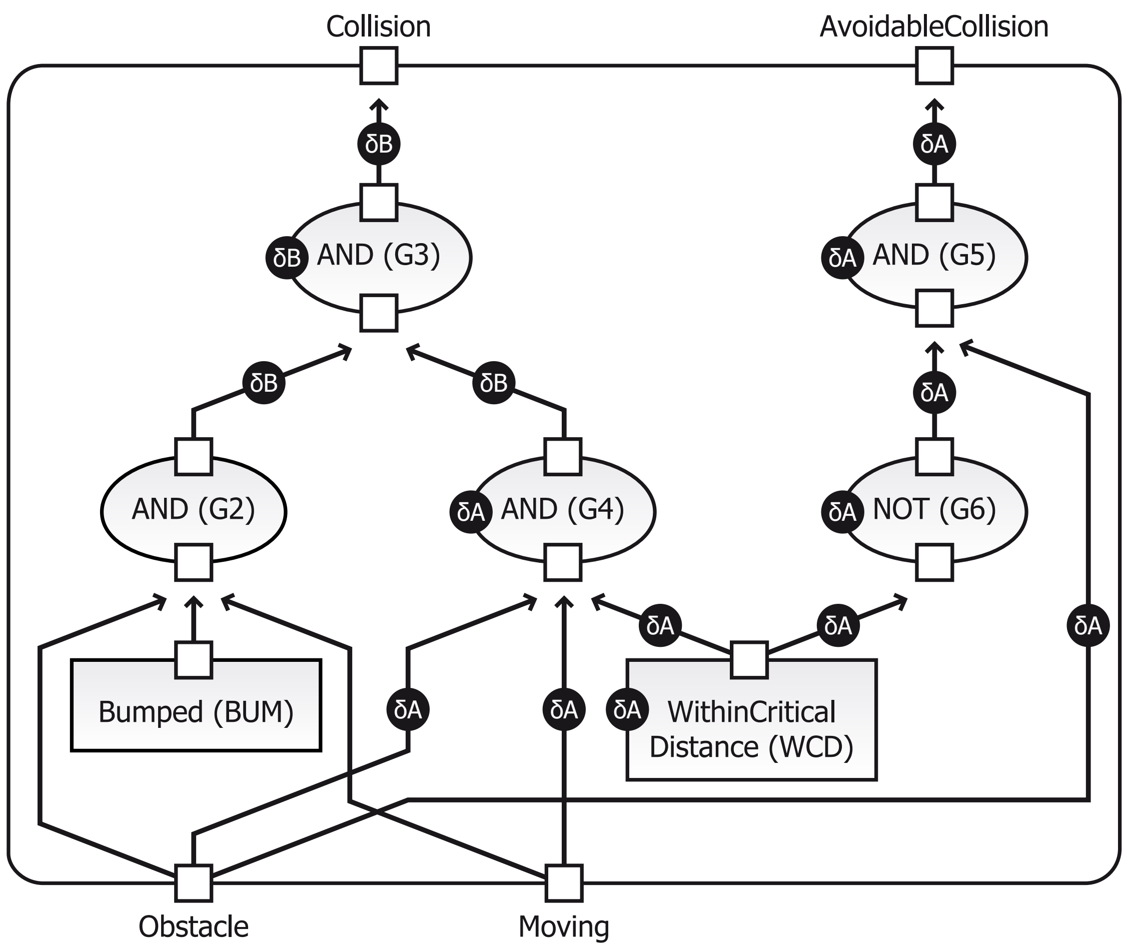
Delta-Modul: Changes to Programs

```
delta DRainEval when Rain_Sensor {

 modifies class IntervalCmdProcessor {

  adds int rainIntensity;

  modifies computeWipeCmd() {
    [...]
  }
 }
}
```

Type system guarantees syntactic correctness of generated variants:

$$\frac{\forall i \in 1..n, \quad \vdash \mathtt{DC}_i : dcc_i}{\vdash \mathtt{delta}\ \delta\ \cdots\ \{\mathtt{DC}_1 \ldots \mathtt{DC}_n\} : \{dcc_1, \ldots, dcc_n\}} \quad (\text{CT-DELTA})$$

Deltas on Component Fault Diagrams



Agenda

- Language Workbench MontiCore
- Engineering Delta Modeling Languages with MontiCore
- Discussion

MontiCore

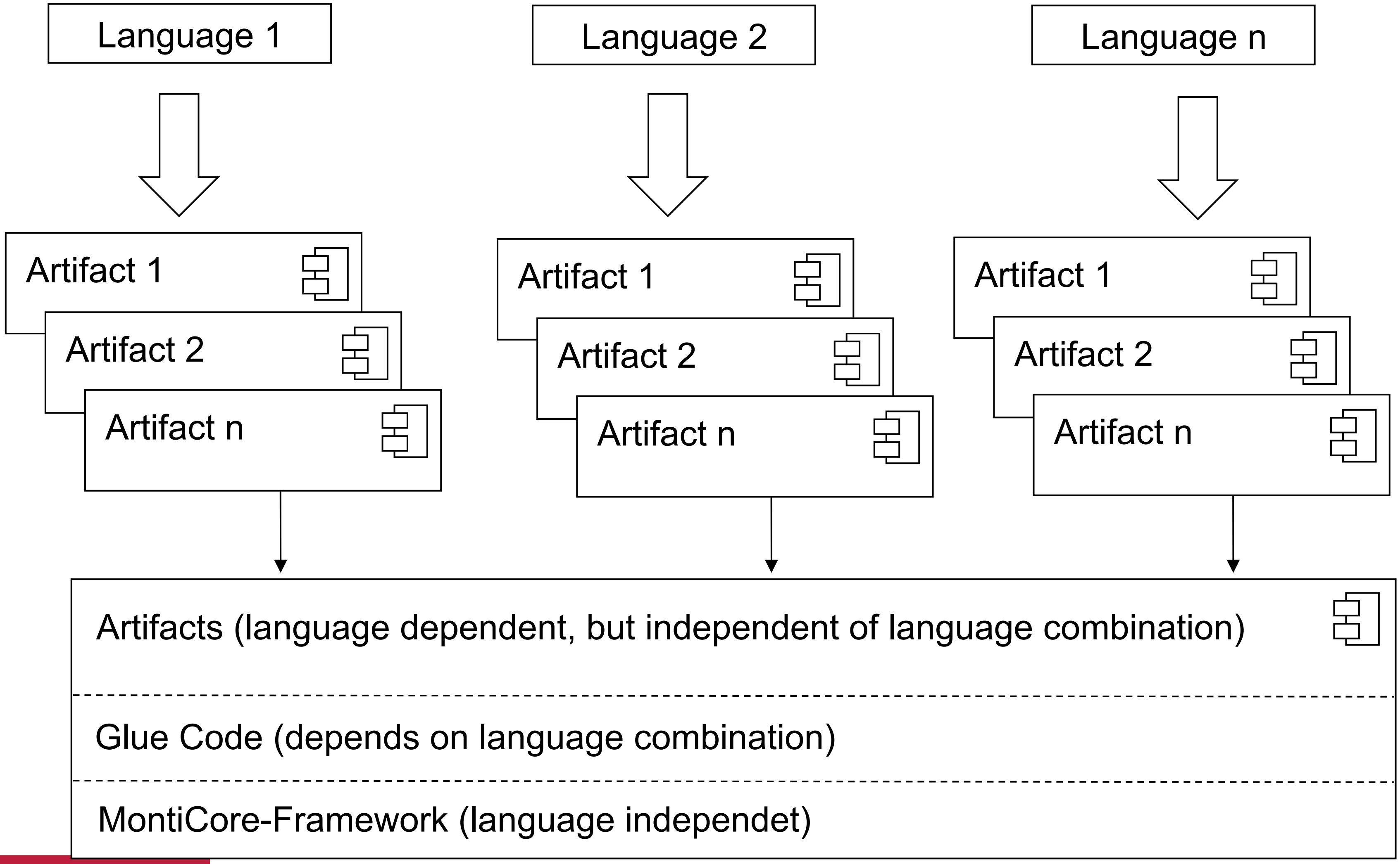
Framework for development and processing of domain-specific languages

Textual, grammar-based definition of languages and tools

- AST classes
- lexer/parser
- pretty printer
- editor

Modular and compositional language development

Language Composition



MontiCore Grammar Format

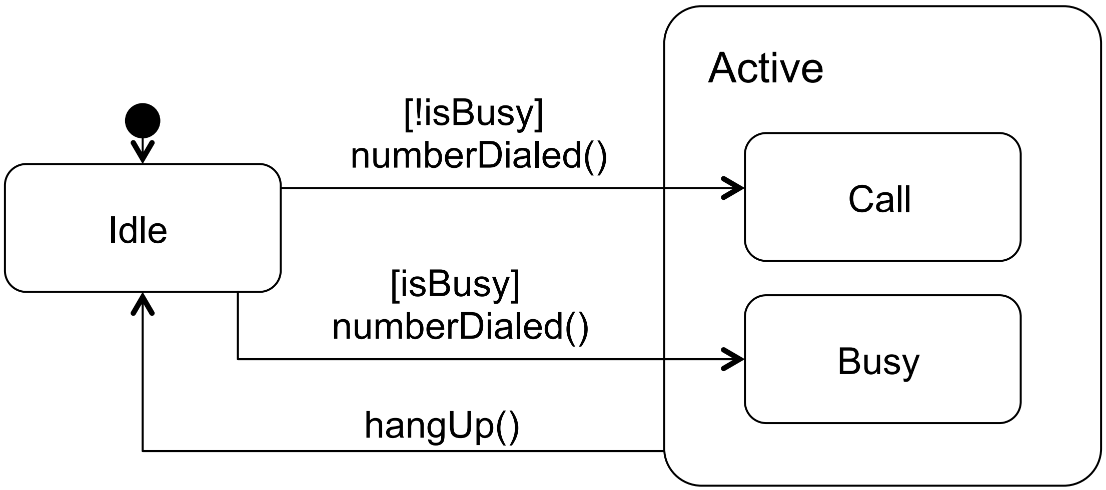
Integrated definition of lexer and parser productions, abstract and concrete syntax.

```
grammar Statechart extends Common {
  SCDefinition =
    "statechart" Name
    "{" Element* "}";

  interface Element;

  Transition implements Element =
    source:Name "->" target:Name
    ( (":" TransitionBody) | ";" );

  State implements Element = "state" Name ...;
   ...
}
```

Interface non-terminal: Set of Alternatives

Statechart Example

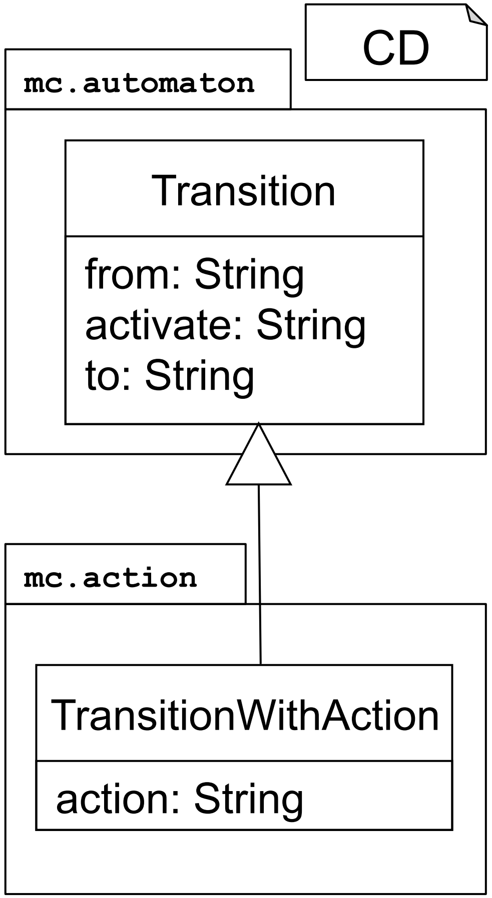
```
statechart Telephone {
   initial state Idle;
   state Active {
      state Busy;
      state Call;
   }
   Idle -> Call :  [!isBusy] numberDialed() ;
   Idle -> Busy : [ isBusy] numberDialed() ;
   Active -> Idle : hangUp();
}
```



Modularity and Reusability: Inheritance

```
package mc.automaton;

grammar Automaton {

  Transition =
    From:IDENT "-" Activate:IDENT ">" To:IDENT ";" ;

}
```

```
package mc.action;

grammar ActionAutomaton extends Automaton {

  TransitionWithAction extends Transition =
    From:IDENT "-" Activate:IDENT
    "[" Action:IDENT "]" ">" To:IDENT ";" ;

}
```



Modularity and Reusability: Embedding

- Production may contain symbols defined in a different grammar

```
grammar... {

  Value = STRING
     | Number
     | IDENT
     | "(" Expression ")"
     | ...

}
```

```
grammar OD extends mc.umlp.common.Common {

   external Value;

   ODAttribute =
         Modifier
         Type?
         name:IDENT
         ("=" Value)? ";";
...
```

import of external nonterminal

usage in production

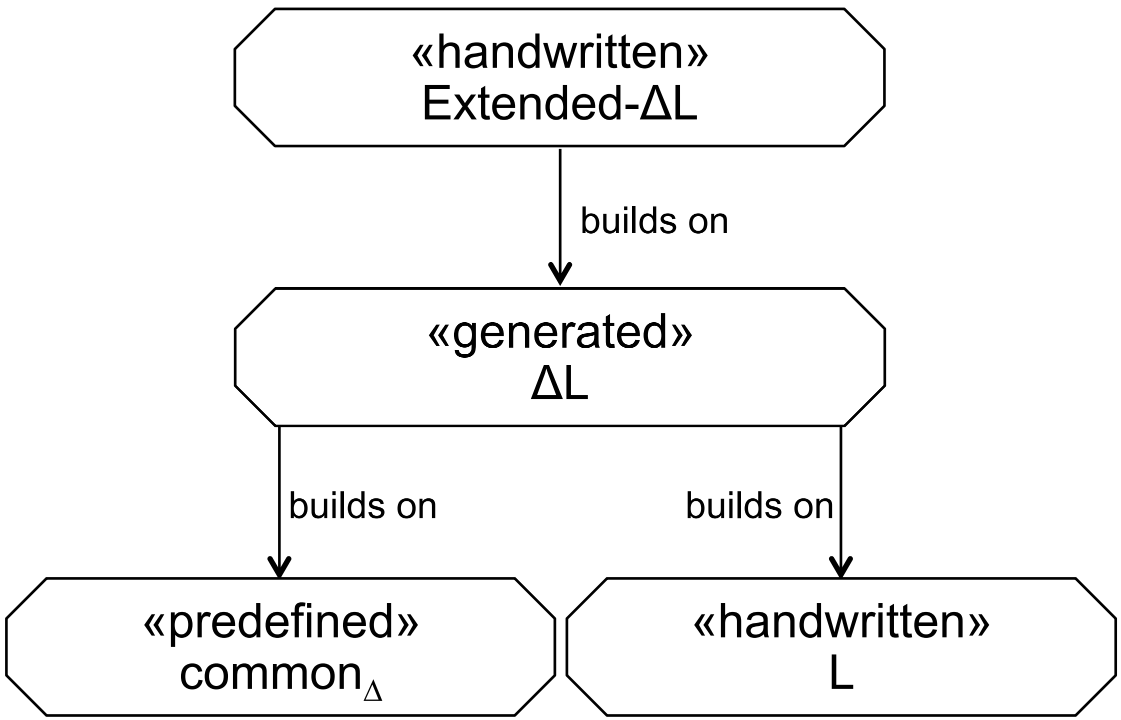
A Delta Language for Statecharts

```
statechart Telephone {
   initial state Idle;
   state Active {
      state Busy;
      state Call;
    }
    Idle -> Call :  [!isBusy] numberDialed() ;
    Idle -> Busy : [ isBusy] numberDialed() ;
   Active -> Idle : hangUp();
}
```

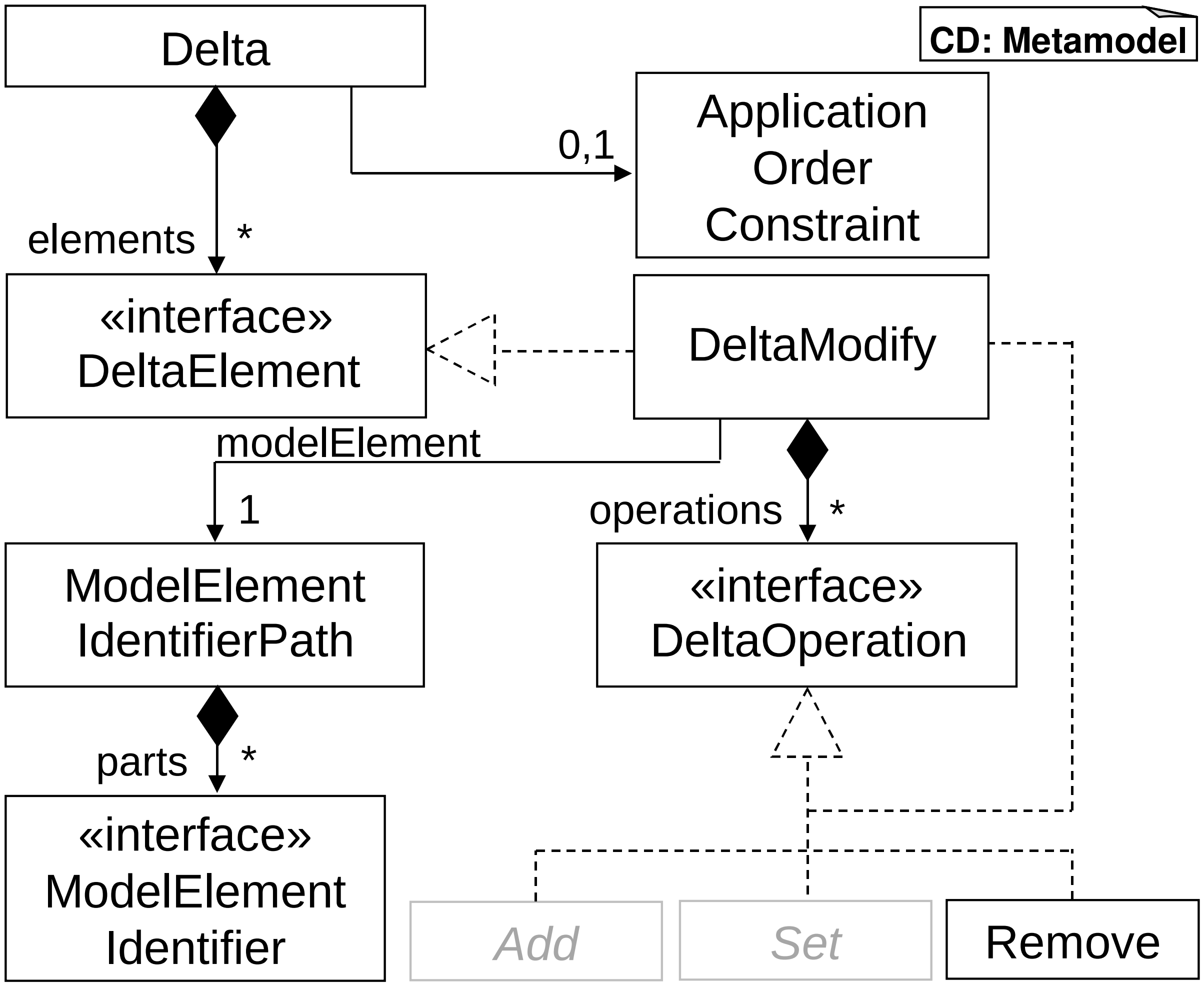
```
statechart Telephone {
   initial state Idle;
   state Active {
      state Voicemail;
      state Call;
   }
   state Dialing;
   Dialing -> Call : [!isBusy] numberDialed();
   Dialing -> Voicemail : [isBusy]
   numberDialed();
   Dialing -> Voicemail : [waited5seconds]
   numberDialed();
   Idle -> Dialing: openLine();
   Active -> Idle : hangUp();}
```

```
delta Voicemail {
  modify statechart Telephone {
    add state Dialing;

    add transition Idle -> Dialing: openLine();

    modify transition [Idle -> Call;]{
      set source Dialing;
    }

    modify transition [Idle -> Busy;]{
      set source Dialing;
    }

    modify state Active.Busy {
      set name Voicemail;
    }

    add transition Dialing -> Voicemail:
      [waited5seconds] numberDialed();
  }
}
```

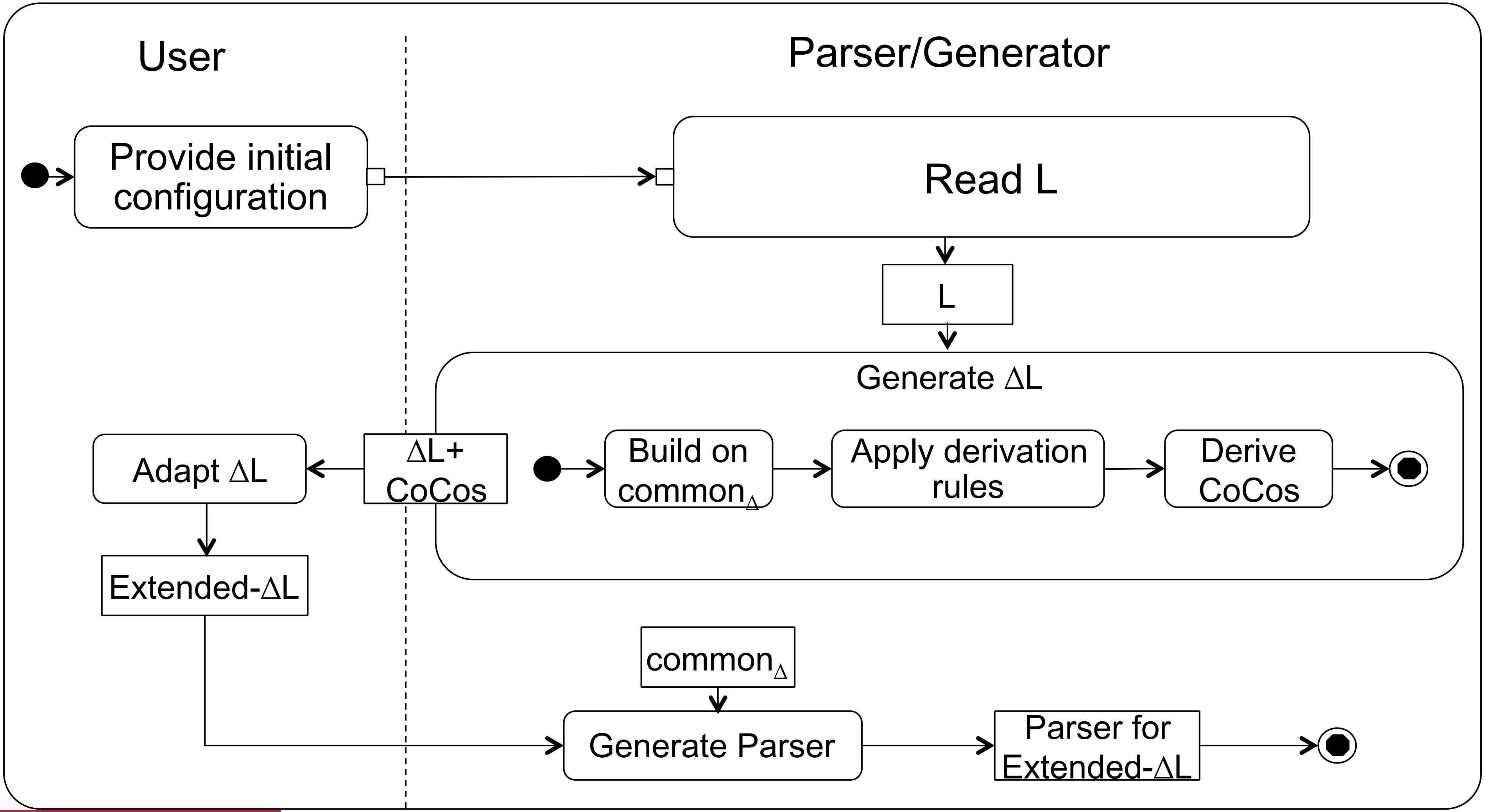
Language Hierarchy



Common-Delta Constructs



Delta Modeling Procedure



Common-Delta as MontiCore Grammar

```
// Elements that may be used directly within a
// delta model.
interface DeltaElement;

// Adds concrete syntax to modifies.
interface ScopeIdentifier;

Delta =
  "delta" Name
  ("after" ApplicationOrderConstraint)?
  "{"
    elements:DeltaElement*
  "}";

DeltaModify implements
      DeltaOperation, DeltaElement =
  "modify" ScopeIdentifier
  modelElement:ModelElementIdentifierPath "{"
  DeltaOperation*
  "}";

// To identify model elements.
interface ModelElementIdentifier;

// Hierarchical path of MEIs.
ModelElementIdentifierPath =
  parts:ModelElementIdentifier
  ("." parts:ModelElementIdentifier)*;

```

```
// Default identifier: qualified name.
DefaultModelElementIdentifier implements
  ModelElementIdentifier =
  QualifiedModelElementName;

interface DeltaOperation;

// Operand of a delta operation.
interface DeltaOperand;

DeltaAdd implements DeltaOperand = "add";
DeltaSet implements DeltaOperand = "set";
DeltaRemove implements DeltaOperand = "remove";

// Default remove operation.
DeltaRemoveOperation implements
    DeltaOperation =
  DeltaRemove target:ModelElementIdentifierPath
  ";";
```

Delta Language Derivation I

1. We need to address every element to define a delta.
   - For every nonterminal `N` that can be identified by a qualifiied name, use the default implementation to address it.
   - For every other nonterminal `N`, square brackets are used to address it. We introduce a new nonterminal:

     Δ`N`$_{MEI}$ `implements ModelElementIdentifier= "[" N "]„`

2. We need to define the scope.
   - For every nonterminal `N` $\in$ L, we introduce a new nonterminal `N`$_{SI}$ and generate a production of the form:

     Δ `N`$_{SI}$ `implements ScopeIdentifier = "N"`

Delta Language Derivation II

3. We need rules to specify the delta operation we want to apply.
   - For every nonterminal $N \in L$, we introduce a new nonterminal N_{DO} and generate an operation production of the form:

     Δ `N`$_{DO}$ `implements DeltaOperation = DeltaOperand N`

4. We need to consider that nonterminals can be used more than once on the RHS of a production.
   - For every nonterminal $N \in L$ and for each identier $\mathbf{n}_i$ of **N**, we introduce a new nonterminal **n**DOi and generate a production of the form:

     Δ $\mathbf{n}_{DOi}$ `implements DeltaOperation = DeltaOperand "`$\mathbf{n}_i$`" N`

5. We need to add delimiters.
   - For every nonterminal $N \in L$ that is neither a block statement nor a single line statement with a line delimiter, we modify the operation production and append a delimiter.

Context Conditions

In addition to the derivation rules to create ΔL, we generate context conditions that provide semantic.

The context conditions can check that,

1. the `ModelElementIdentifier` is referencing an existing element.
2. the `ModelElementIdentifier` references a model element that corresponds to its type.
3. a `ModelElementIdentifierPath` is valid in terms of its single concatenated elements.
4. the `DeltaOperation` is applicable within the scope of its surrounding modify statement.
5. a `DeltaOperand` is applicable for its element.
6. an element which should be added does not exist yet.
7. an element which should be remove exists.

Case Study

```
grammar Statechart extends Common {
    SCDefinition =
        "statechart" Name
        "{" Element* "}";

    interface Element;

    Transition implements Element =
        source:Name "->" target:Name
        ( (":" TransitionBody) | ";" );

        State implements Element = state
Name ... ;
...
```

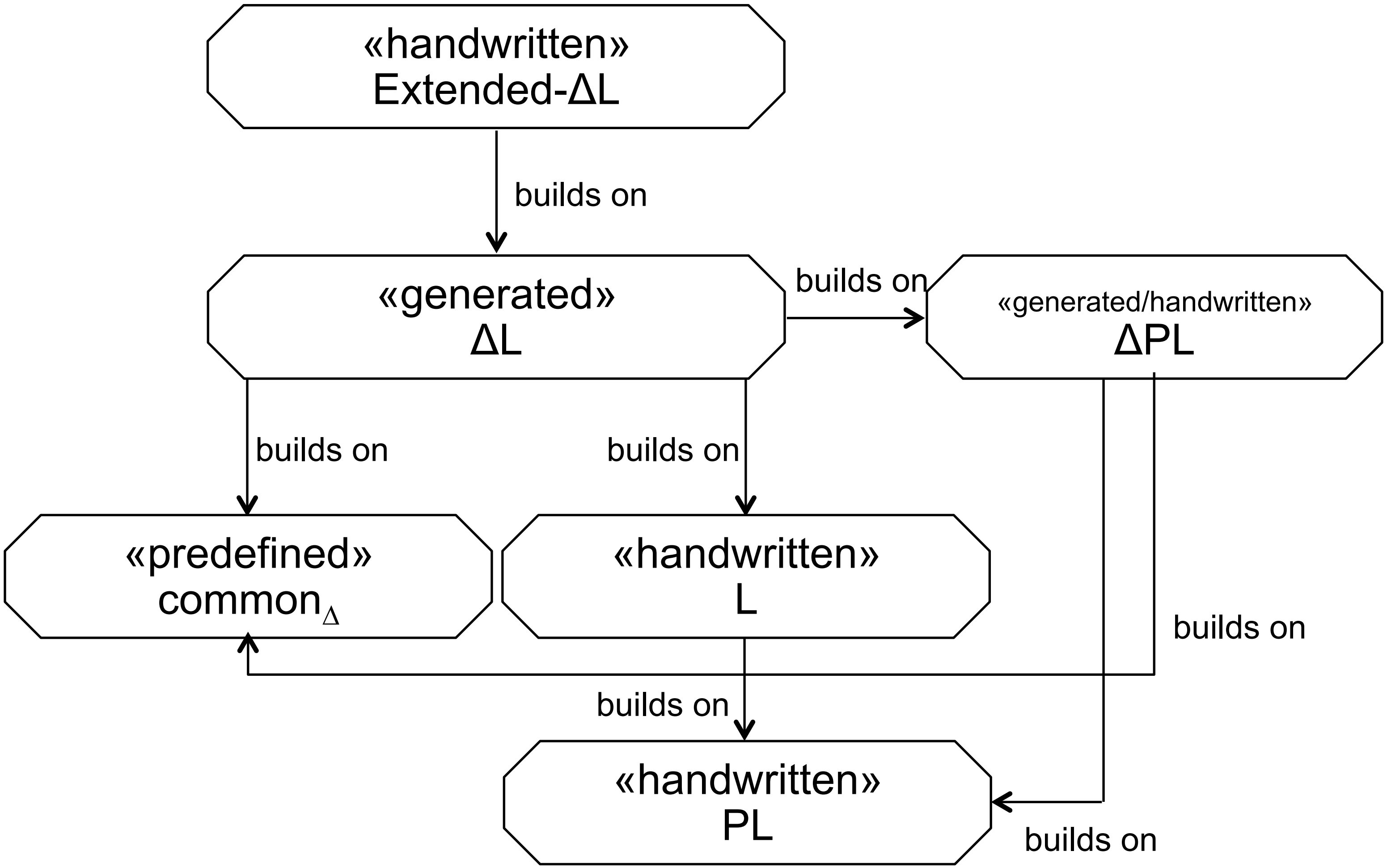
```
grammar DeltaStatechart extends CommonDelta,
Statechart {
  DeltaSCDefinition = Delta;

SCTransitionIdentifier implements
("[" SCTransition "]")=>
ModelElementIdentifier = "[" SCTransition "]";

DeltaSCStateScopeIdentifier implements
ScopeIdentifier = "state";
}
```

1. We start using the Statechart grammar
2. We create our new grammar
3. We implement the `ModelElementIdentifier` production for every nonterminal N ∊ L.
4. We derive the productions for the modify statements, which are used to denote which Statechart grammar construct we want to modify.
5. …

```
DeltaSCStateChartScopeIdentifier
implements ScopeIdentifier =
"statechart";

DeltaSCTransitionScopeIdentifier
implements
ScopeIdentifier = "Transition";
```

```
DeltaStateOperation implements
(DeltaOperand Transition)=> DeltaOperation
= operand:DeltaOperand Transition;

DeltaStateOperation implements
(DeltaOperand State)=> DeltaOperation =
operand:DeltaOperand State;
```

Extensions


«handwritten»
Extended-ΔL
builds on
«generated»
ΔL
builds on
«generated/handwritten»
ΔPL
builds on
builds on
«predefined»
common$_\Delta$
«handwritten»
L
builds on
builds on
«handwritten»
PL
builds on

Conclusion

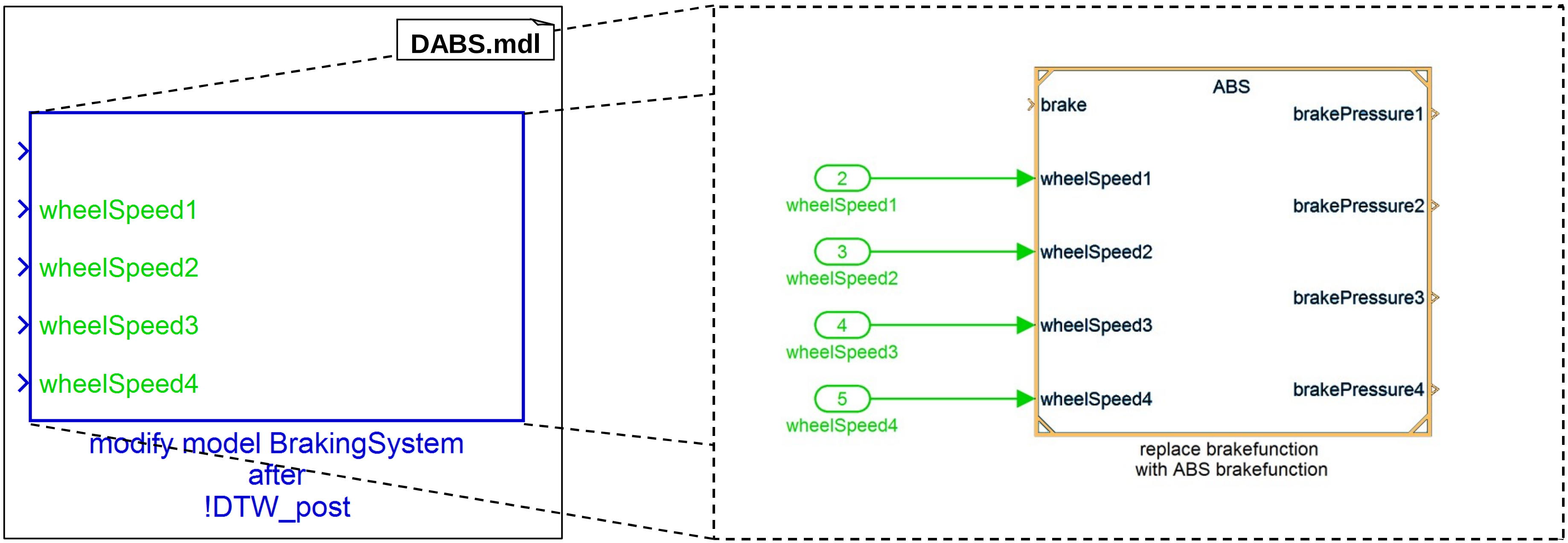
Summary:

- Delta modeling is a flexible approach to represent variability and evolution of models.
- Delta modeling languages can be generated for textual modeling languages.

Future Work:

- Perform larger case studies on various modeling languages
- Generating delta modeling languages for visual modeling languages?
- Development of a pluggable delta type system

Visual Delta Modeling in Simulink



Related Work

Comparison with Model transformation languages:

(D1) Addressing elements to be modified:

- Delta models refer to concrete model.
- Graph transformation rules describe general patterns.

(D2) Negative application conditions:

- Delta languages deliberately don’t offer constructs to define NACs.
- In order to avoid invalid models after transformation, NACs are used in transformative approaches.

(D3) Different scope:

- Delta languages provide a restricted amount of delta operations for model-specific modifications.
- In contrast, graph transformation rules are capable of modeling arbitrary modifications.