Adaptable Symbol Table Management by Meta Modeling and Generation of Symbol Table Infrastructures

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Motivation

- Many textual software languages share common concepts
  - Define model elements
  - Refer to model elements defined in the same model as well as in another model (including loading of models)
  - Shadow names that are already defined

- Mechanisms behind those concepts usually are complex and must be fully understood by language engineer in order to apply them

- Therefore, language workbenches provide mechanisms to implement those concepts

- The MontiCore language workbench uses so-called symbol tables
Symbol Tables

- A symbol table is a data structure that maps names to their associated information.

- In MontiCore, a symbol table may also represent the semantic meta model and contain information not directly defined in the model
  - e.g., all non-private fields of a Java class including fields of the super class
Contribution

- **Language-independent meta model** (M3) for symbol tables which is basis for language-specific symbol tables (M2)
- An **integration** of the symbol table M3 model and the grammar M3 model, which allows to switch between both models as needed
- The **generation** of the language specific symbol table and automatically integration with the grammar model

```
  «M3»  meta meta level  grammar describing  grammars
  ┌────────────────────────────────────────────┐
  │ «instance» ┌──────────────────────────────┐
  └─────────┘  «M2»  meta level  grammar  e.g., for Java
  ┌────────────────────────────────────────────┐
  │ «instance» ┌──────────────────────────────┐
  └─────────┘  «M1»  model level  model  e.g., Java class
  ┌────────────────────────────────────────────┐
  │ «instance» ┌──────────────────────────────┐
  └─────────┘  «M0»  system level  system  e.g., CRM-system
```
Symbols: Named Model Elements

- A symbol represents a named model element and its associated information
- It may provide information that is not (directly) contained in the model element
  - e.g., all non-private methods of the super class
A scope holds a collection of symbol definitions
- Structured hierarchically
- Limits visibility of a symbol
- Some symbols span a scope (scope spanning symbols)
class C {
    int f;
    C c;
}

void m() {
    int f;
    while (...) {
        int f;
    }
}

- Shadowing scopes may shadow names of enclosing scopes, visibility scopes may not
A symbol reference refers to a symbol defined elsewhere either in the same model or another.
Simplified Grammar M3 Model

- Textual software languages are described by grammars
- Abstract syntax tree is the meta-model

```plaintext
JClass@Ann = "class" Name "{" (JField | JMethod)* "}";
JField = type:Name Name ";" ;
```

Diagram:
- **Production**
  - definedBy 1
  - `*`
- **Terminal**
  - `*`
- **Nonterminal**
  - `*`
- **Annotation**
  - `*`
Composing Grammar and Symbol Table M3 Models

- Language engineer (LE) usually needs both M2 models
- To enable this, we compose the M3 models
- LE can switch between these structures as needed
Generating Language-Specific Symbol Table (M2)

- Language-specific symbol table depends on the language’s semantic

- Composition of the two M2 models is affected both the grammar design as well as the symbol table design
- Hence, composition must be conducted manually

- Generative support
  - Prerequisite: limit cardinalities to 0..1
  - Automatically derive the language-specific symbol table infrastructure (or parts of it) from the grammar
  - Simultaneously integrate it with language-specific grammar model
  - Using annotation mechanism of MontiCore’s grammar
Generating Language-Specific Symbol Table

- Mapping via naming convention
  - production `Prod` is mapped to symbol `ProdSymbol`

```
JClass@! = "class" Name "{" (JField | JMethod)* "}";
JField@! = type:Name@JClass Name ";" ;
JWhile = "while" "(" ... ")" "{" JField* ... "}";
```
Conclusion

- Textual software languages share some common concepts, such as defining and referencing model elements, and name shadowing.

- Language-independent meta model for symbol tables first-level classes, which serves as basis for language-specific symbol tables.

- Integration of this the symbol table meta model and the grammar meta model.

- Generating language-specific symbol table infrastructure (or parts of it) and directly integrating it with the corresponding grammar model.