SE SOFTWARE ENGINEERING

RWTH AACHEN UNIVERSITY

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

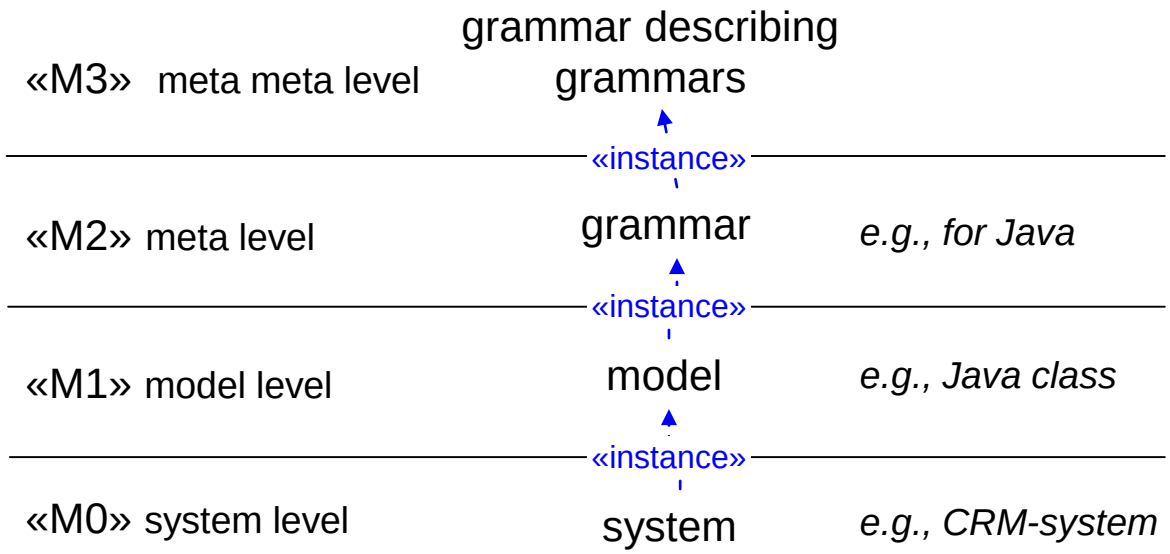
Symbol Tables

- 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

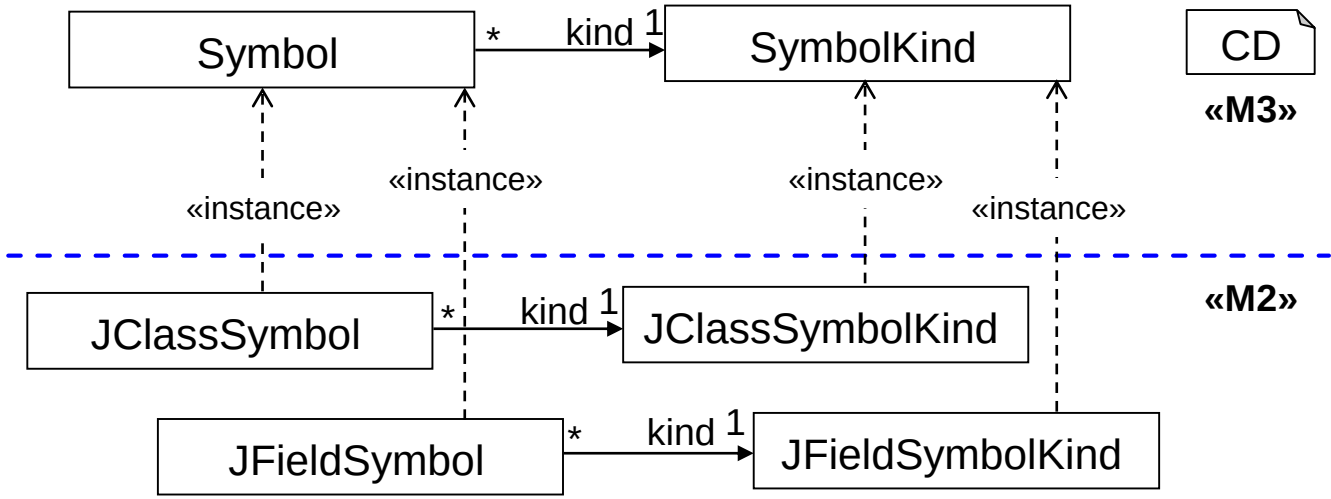
- Language-independent meta model (M3) for symbol tables which is basis for language-specific symbol tables (M2)
- An integration of the symbol table M3 model and the grammar M3 model, which allows to switch between both models as needed
- The generation of the language specific symbol table and automatically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



Symbols: Named Model Elements

```
class C {
  int f;
  C c;

  void m() {
    int f = g;

    while(…) {
      int f;
    }
  }
}
```

named 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

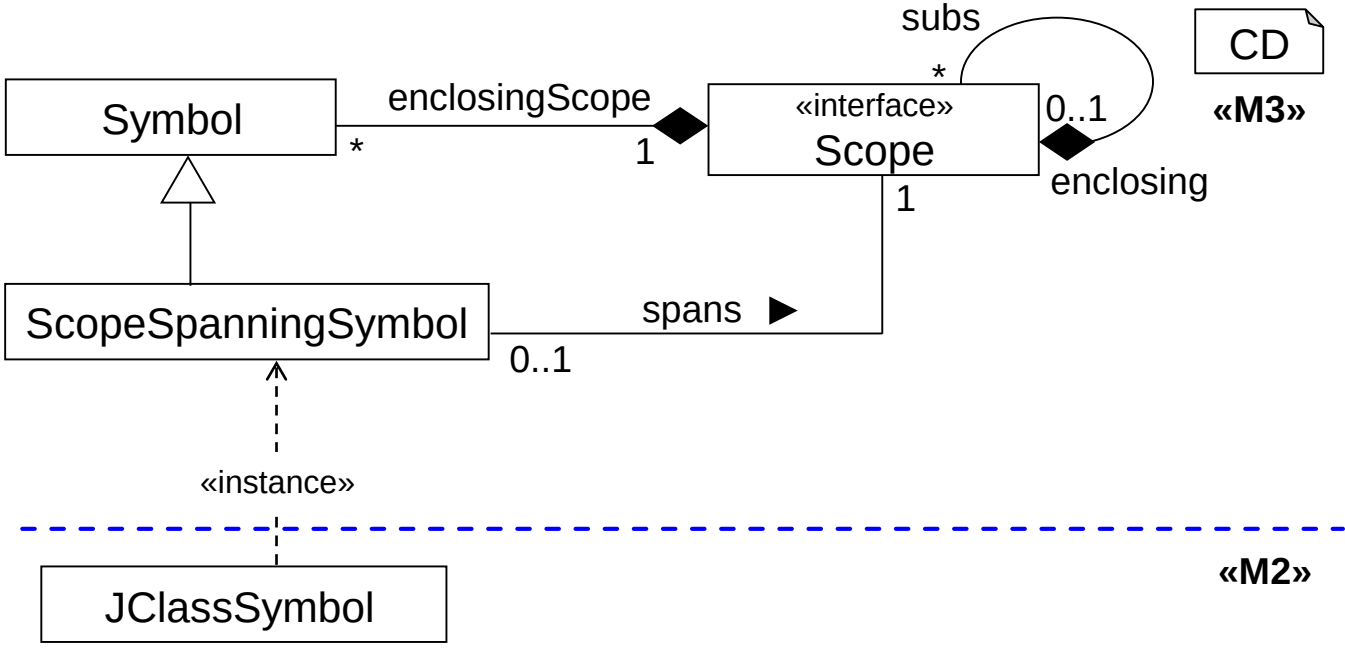
Scopes: Containers for Symbols

```
class C {
   int f;
   C c;

   void m() {
      int f = g;

      while(...) {
         int f;
      }
   }
}
```

if scope

method scope

class scope



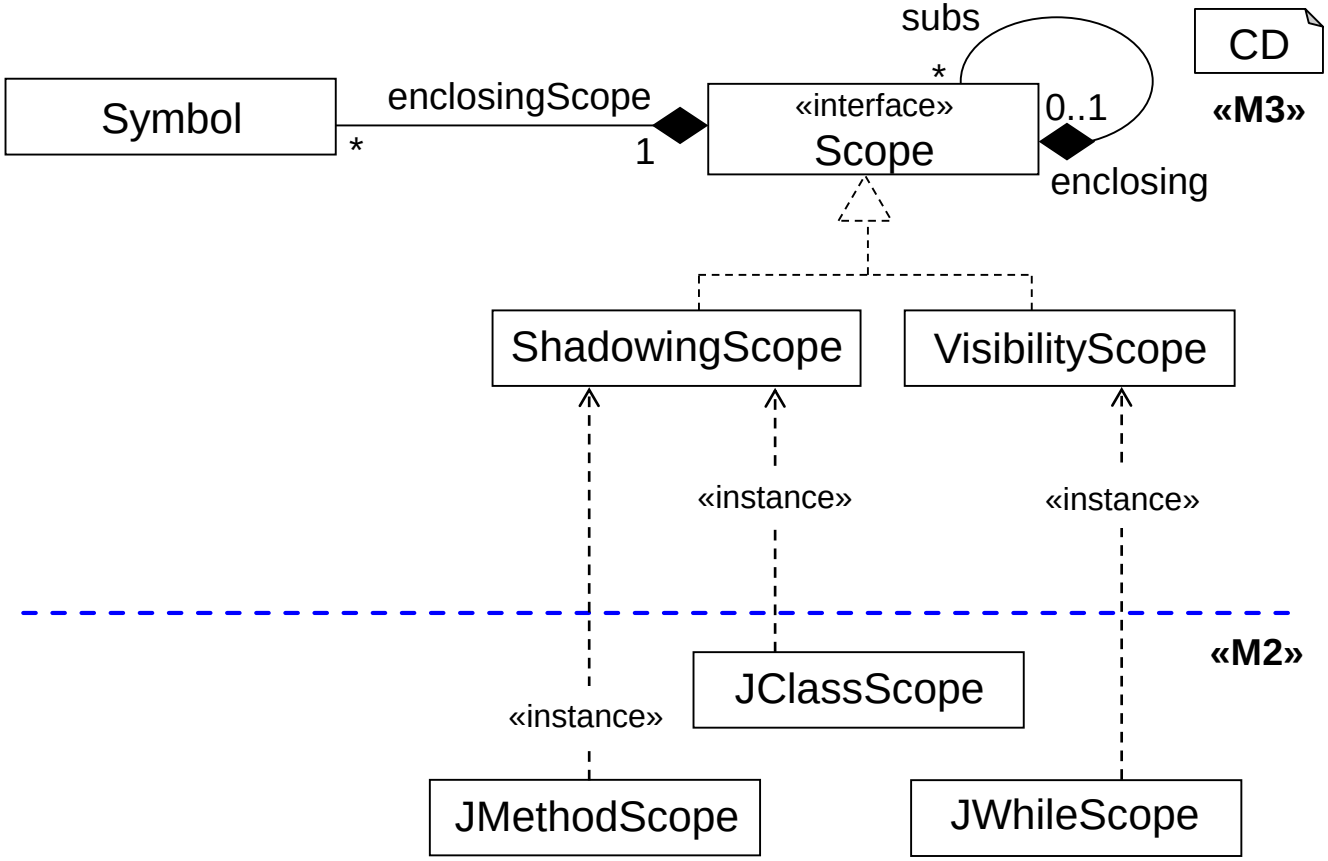
- A scope holds a collection of symbol definitions
- Structured hierarchically
- Limits visibility of a symbol
- Some symbols span a scope (scope spanning symbols)

Shadowing and Visibility Scopes

```
class C {
  int f;
  C c;

  void m() {
    int f;

    while(...) {
      int f;
    }
  }
}
```

shadows field f

not allowed, local variable already defined



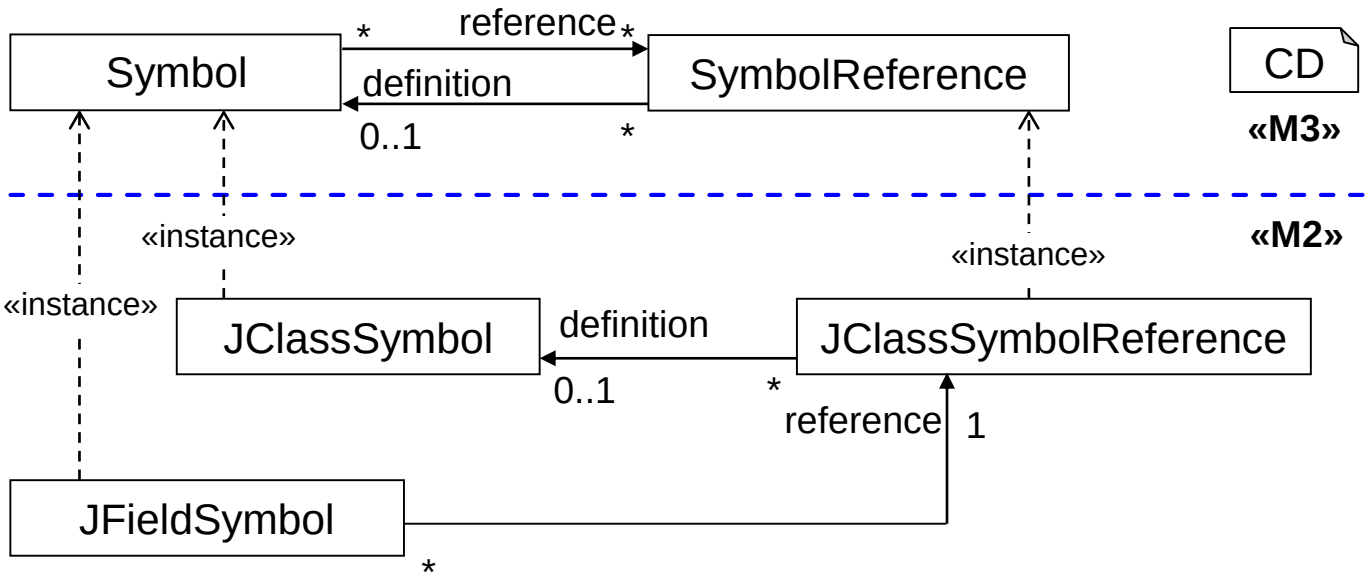
- Shadowing scopes may shadow names of enclosing scopes, visibility scopes may not

Symbol References

```
class C {
   int f;
   C c;
   void m() {
      int f;
      while(...) {
         int f;
      }
   }
}
```

refers to class "C"

refers to built-in type "int"



- 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

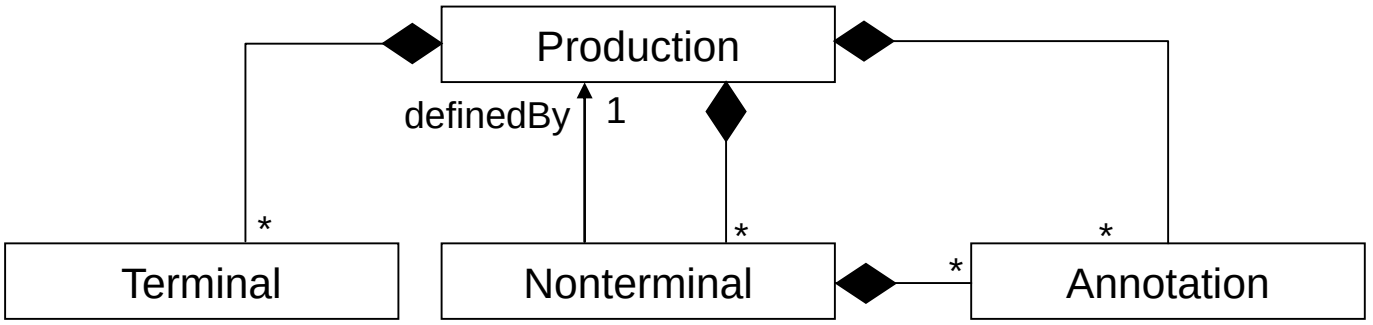
(instance of)
Annotation

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

(instance of)
Production

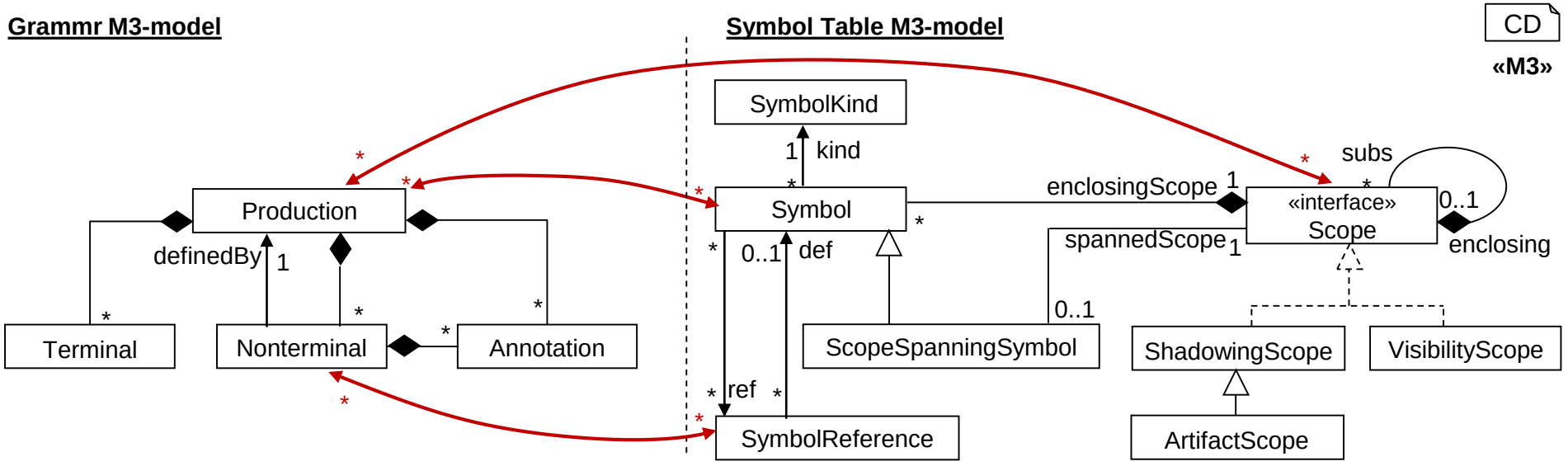
(instance of)
Terminal

(instance of)
Nonterminal



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

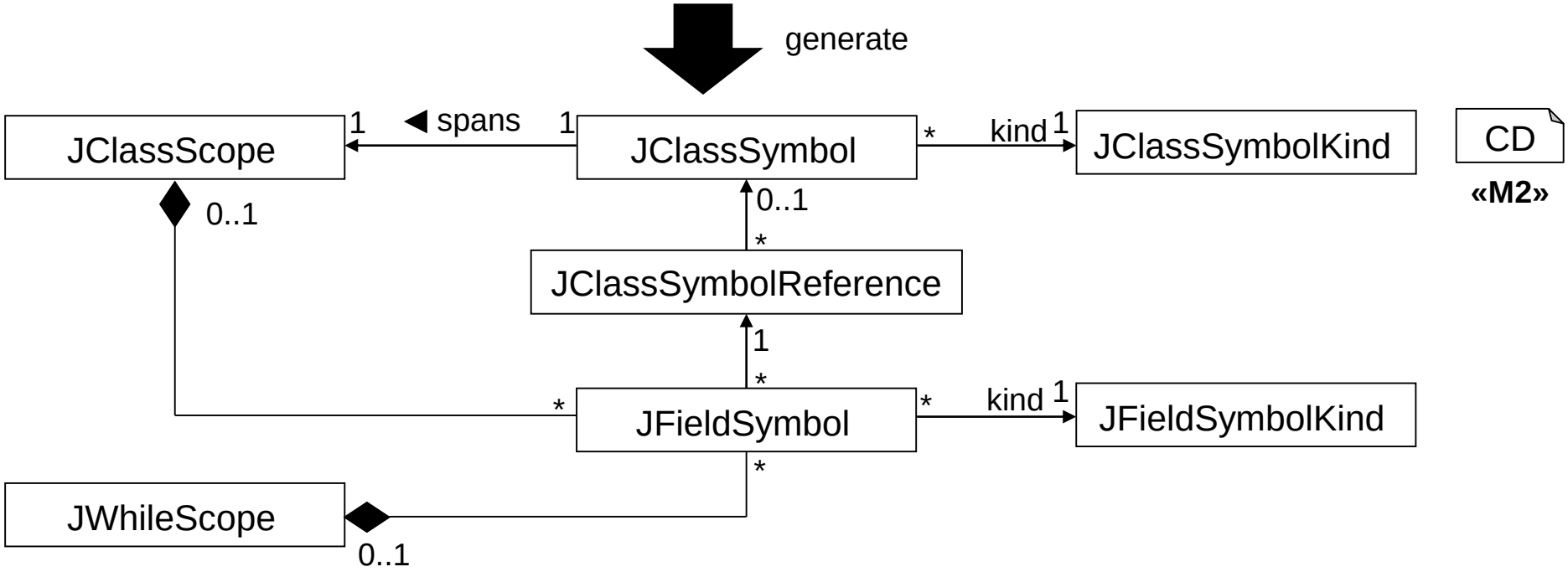
- Composition of the two M2 models is affected both the grammar design as well as the symbol table design
- Hence, composition must be conducted manually

- 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 **`Prod`*`Symbol`***

```
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