

Domain-Specific Languages and Xtext

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Plan

- Domain-Specific Languages (DSLs)
 - Languages and abstraction gap
 - Examples and rationale
 - DSLs vs General purpose languages, taxonomy
- **External DSLs**
 - Grammar and parsing
 - Xtext

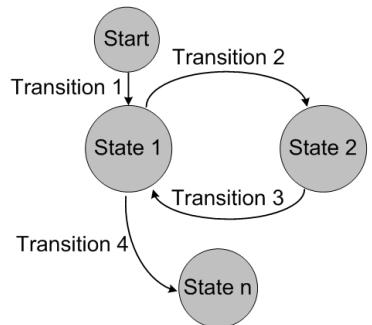
Contract

- Better understanding/source of inspiration of software languages and DSLs
 - Revisit of history and existing languages
- Foundations and practice of Xtext
 - State-of-the-art language workbench (Most Innovative Eclipse Project in 2010, mature and used in a variety of industries)

BIBTEX



Graphviz



**Finite State
Machine**



Domain-Specific Languages (DSLs)

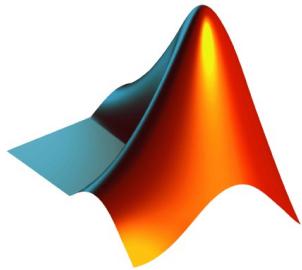
```
[Event "F/S Return Match"]
[Site "Belgrade, Serbia Yugoslavia[JUG]"]
[Date "1992.11.04"]
[Round "29"]
[White "Fischer, Robert J."]
[Black "Spassky, Boris V."]
[Result "1/2-1/2"]
```

```
1. e4 e5 2. Nf3 Nc6 3. Bb5 a6 4. c3 Bb7 5. O-O Be7 6. Bb5 Nf6 7. Bb7 Nc3 8. d4 Bf5 9. Nf1 0-0 10. Nxe4 11. c4 c6 12. c5 axb4 13. Nc3 Bh7 14. Nf1 Nc6 15. Nxe4 Nf6 16. Nf1 Nc6 17. Nxe4 Nf6 18. Bxe7 Qxe7 19. exd4 Qf6 20. Nf1 Nc6 21. Nxe4 Nf6 22. Ne5 Rae8 23. Nf1 Rxf7+ Rxf7 24. Nxe4 Nf6 25. Nf1 Nf6 26. Nxe4 Nf6 27. Nf1 Nf6 28. Nxe4 Nf6 29. b3 Ke6 30. a3 Kd6 31. axb4 cxb4 32. Ra5 Nd7 33. Ra7 g6 34. Ra6+ Kc5 35. Ke1 Nf4 36. g3 Nxh3 37. Ra5 Nf6 38. Kd2 Nf6 39. Ra7 g6 40. Ra6+ Kc5 41. Kd3 Nf6 42. Ra5 Nf6 43. Re6 1/2-1/2
```

PGN



Make



Matlab



DSL =

Syntax + Services

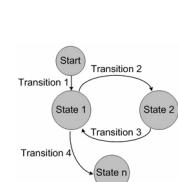
Specialized notation:

Textual or Graphical Specific Vocabulary Idiomatic constructs

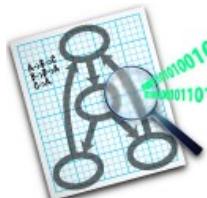
Specialized tools/IDE:

- Editor with auto-completion, syntax highlighting, etc.
- Compiler
- Interpreter
- Debugger
- Profiler
- Syntax/Type Checker

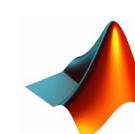
1



BIBTEX



The SQL logo icon consists of three stacked horizontal bars of increasing height from left to right, followed by the letters "SQL" in a bold, black, sans-serif font.



Language workbenches

- Tools for reducing the gap between the design and implementation of (external) domain-specific languages
- The Killer App for DSLs?
<http://www.martinfowler.com/articles/languageWorkbench.html>

Language Workbenches

Erdweg et al. SLE'13

		Ensō	Más	MetaEdit+	MPS	Onion	Rascal	Spoofax	SugarJ	Whole	Xtext
Notation	Textual	●	●		●	●	●	●	●	●	●
	Graphical	●	○	●			○			●	
	Tabular		●	●	●					●	
	Symbols			●	●					●	
Semantics	Model2Text		●	●	●	●	●	●	●	●	●
	Model2Model			●	●	●	●	●	●	●	●
	Concrete syntax			●	●	●	●	●	●		
	Interpretative	●		●	●		○	●		●	●
Validation	Structural	●	●	●	●	●	●	●	●	●	●
	Naming	○	●	●	●	●		●		●	○
	Types				●				●		●
	Programmatic	●			●	●	●	●	●		●
Testing	DSL testing				●		○	●		●	●
	DSL debugging	●		●	●		●			●	●
	DSL prog. debugging	●			●					●	●
Composability	Syntax/views	●		●	●	●	●	●	●	●	○
	Validation			●	●	●	●	●	●	●	●
	Semantics	●		●	●	●	●	●	●		●
	Editor services			●	●	●	●	●	●		●
Editing mode	Free-form	●		●		●	●	●	●		●
	Projectional		●		●	●				●	
Syntactic services	Highlighting	○	●	●	●	●	●	●	●	●	●
	Outline			●	●	●	●	●	●	●	●
	Folding	●	●	●	●	●	●	●	●	●	●
	Syntactic completion			●	●	●		●	●		●
	Diff	●		●	●	●	●	●	●		●
	Auto formatting	●	●	●	●	●	●	●		●	●
Semantic services	Reference resolution		●	●	●	●	●	●	●		●
	Semantic completion		●	●	●	●	●	●	●	●	●
	Refactoring	○	●	●	●		●	●		●	
	Error marking	●	●	●	●	●	●	●	●	●	●
	Quick fixes				●						●
	Origin tracking	●		●	●	●	●	●	●	●	●
	Live translation		●		●	●	○	●	●	●	●

Table 1: Language Workbench Features (● = full support, ○ = partial/limited support)

The screenshot shows the Eclipse IDE interface with the following details:

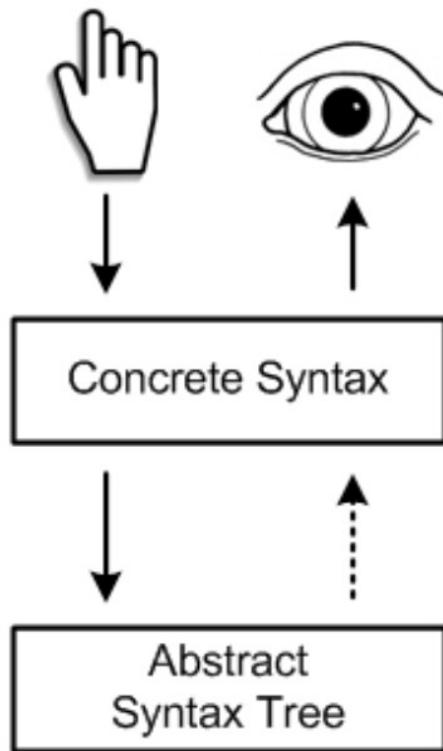
- Title Bar:** Java - strategoxt-sugar-papers/test/BookHandler.sugj - Eclipse - /Users/seba/tmp/ecli...
- Toolbar:** Includes icons for file operations, search, and transform.
- Left Margin:** Shows icons for errors (red), warnings (yellow), and information (green).
- Outline View (Outli):** Displays the XML schema structure:

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">
    <xs:element name="book">
        <xs:complexType>
            <xs:sequence>
                <xs:element name="author">
                    <xs:complexType>
                        <xs:sequence>
                            <xs:element name="name" type="xs:string"/>
                        </xs:sequence>
                    </xs:complexType>
                </xs:element>
                <xs:element name="editions">
                    <xs:complexType>
                        <xs:sequence>
                            <xs:element name="edition">
                                <xs:complexType>
                                    <xs:sequence>
                                        <xs:element name="year" type="xs:int"/>
                                        <xs:element name="publisher" type="xs:string"/>
                                    </xs:sequence>
                                </xs:complexType>
                            </xs:element>
                            <xs:element name="edit" type="xs:int"/>
                        </xs:sequence>
                    </xs:complexType>
                </xs:element>
            </xs:sequence>
        </xs:complexType>
    </xs:element>
</xs:schema>
```
- Problems View:** Shows 1 error and 1 warning.
 - Error:** expected element edition of namespace lib at line 18.
 - Warning:** skipping validation of quoted attribute value at line 14.
- Description View:** Provides detailed descriptions for the errors and warnings.
- Bottom Buttons:** Writable and Smart Insert.

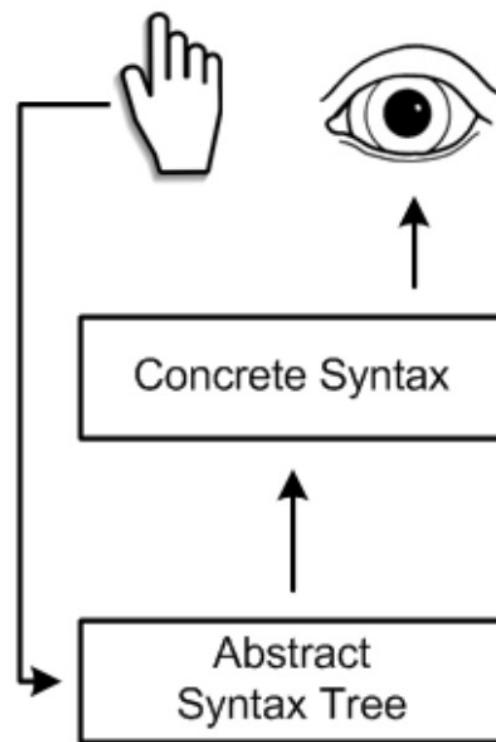
Sebastian Erdweg, Tillmann Rendel, Christian Kästner, and Klaus Ostermann. Sugarj: Library-based syntactic language extensibility. OOPSLA'11

Projectional editing

Parsing



Projection



Projectional editing

```
exported component Judge extends nothing {
    provides FlightJudger judger
    int16 points = 0;
    void judger_reset() <= op judger.reset {
        points = 0;
    } runnable judger_reset
    void judger_addTrackpoint(Trackpoint* tp) <= op judger.addTrackpoint {
        points += 0
        

|                      |                   |                   |
|----------------------|-------------------|-------------------|
|                      | tp->alt <= 2000 m | tp->alt >= 2000 m |
| tp->speed < 150 mps  | 0                 | 10                |
| tp->speed >= 150 mps | 5                 | 20                |


    } runnable judger_addTrackpoint
    int16 judger_getResult() <= op judger.getResult {
        return points;
    } runnable judger_getResult
} component Judge
```

Projectional Editing

```
exported statemachine FlightAnalyzer initial = beforeFlight {
    next(Trackpoint* tp)                                reset()
    beforeFlight [tp->alt == 0 m] -> airborne
    airborne   [tp->alt == 0 m && tp->speed == 0 mps] -> crashed
                [tp->alt == 0 m && tp->speed > 0 mps] -> landing
                [tp->speed > 200 mps && tp->alt == 0 m] -> airborne
                [tp->speed > 100 mps && tp->speed <= 200 mps &&
                 tp->alt == 0 m] -> airborne
    landing    [tp->speed == 0 mps] -> landed
                [tp->speed > 0 mps] -> landing
    landed     [ ] -> beforeFlight
    crashed    [ ] -> beforeFlight
}
```

```

SM.sdf3
System.Machine = [
  state machine [ID] [Extends]
  [{Element "\n"}*]
]

Extends.Extends =
[extends [ID]]

Extends.NoExtends = □

Element.State =
[state [ID]]

Element.Transition = [
transition from [StateRef] to
[Guard] [Actions]
]

names.nab
11 Machine(m, elems, extends) :
12   defines Machine m
13   scopes State, Variable
14
15 Extends(m) :
16   imports State, Variable from m
17
18 State(s) :
19   defines State s
20
21 StateRef(s) :
22   refers to State s
23
24 VarDef(x, c) :
25   defines Variable x of type t
26   where c has type t

types.ts
6 False() : BoolType()
7 True() : BoolType()
8
9 Var(x) : t
10 where definition of x : t
11
12 Or(e1, e2) + And(e1, e2) :
13   where e1 : BoolType()
14     else error "bool exp"
15     and e2 : BoolType()
16       else error "bool exp"
17
18 Eq(e1, e2) + Gt(e1, e2) :
19   where e1 : IntType()
20     else error "int exp"
21

generate.str
6 sm-to-java :
7   machine@Machine(m, exten
8   public class [m] [<ext
9     String current = [<
10      [vardefs]
11
12      String next(String e
13        [cond-stat*]
14        while(true) {
15          [uncond-stat*]
16        }
17      ]
18    ]
19  ]
20  where ...
21

VendingMachine.ATOML
state Vend_Drink
state Vend_Sweet
state Empty

transition from Waiting to Vend_Drink: V
[drinks > 0] / drinks := drinks - 1

transition from Vend_Drink to Waiting: V
[drinks > 0 or sweets > 0]

VendingMachine.aterm
1 Machine(
2   "VendingMachine"
3   , NoExtends()
4   , [ VarDef("drinks", Int("10"))
5   , VarDef("sweets", Int("20"))
6   , State("Waiting")

```

The Spoofax Language Workbench

Spoofax is a platform for developing textual domain-specific languages with full-featured [Eclipse](#) editor plugins.

With the Spoofax language workbench, you can write the grammar of your language using the high-level SDF grammar formalism. Based on this grammar, basic editor services such as syntax highlighting and code folding are automatically provided. Using high-level descriptor languages, these services can be customized. More sophisticated services such as error marking and content completion can be specified using rewrite rules in the Stratego language.

Meta Languages

Language definitions in Spoofax are constructed using the following meta-languages:

- The [SDF3](#) syntax definition formalism
- The [NaBL](#) name binding language
- The [TS](#) type specification language
- The [Stratego](#) transformation language

xtext

*Xtext, a popular, easy-to-use model-based tool
for developping DSLs*

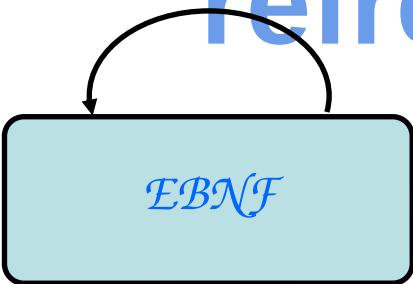
*Your DSL in 5' (incl. editors and
serializers)*

Your DSL in 5'

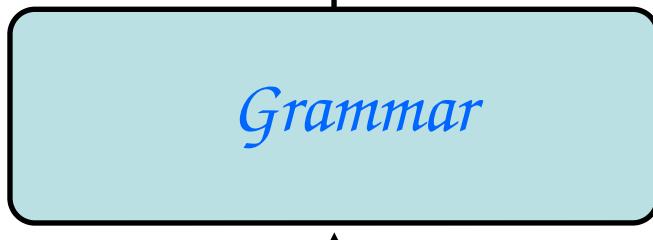
Short Demonstration

Foundations (or some course refresh)

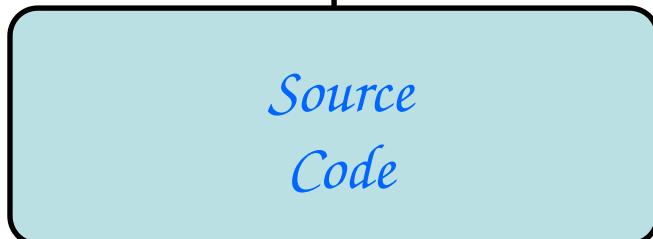
\mathcal{M}^3



\mathcal{M}^2



\mathcal{M}^1



Java Grammar

```
CHARLITERAL
: '\'' 
| ``
| ~(`` | ``\n`` | ``\r`` | ``\n\r``)
| ``\\``;

STRINGLITERAL
: `"`
| ~(`` | ``\n`` | ``\r`` | ``\n\r``)
| ``*``;
| ``*``*``;

fragment
EscapeSequence
: ``\\`` (
| 'b'
| 't'
| 'n'
| 'r'
| ``\\``;
```

```
modifiers
: (
| annotation
| PUBLIC
| PROTECTED
| PRIVATE
| STATIC
| ABSTRACT
| FINAL
| NATIVE
| SYNCHRONIZED
| TRANSIENT
| VOLATILE
| STRICTFP
)*;

variableModifiers
: (
| annotation
)*;

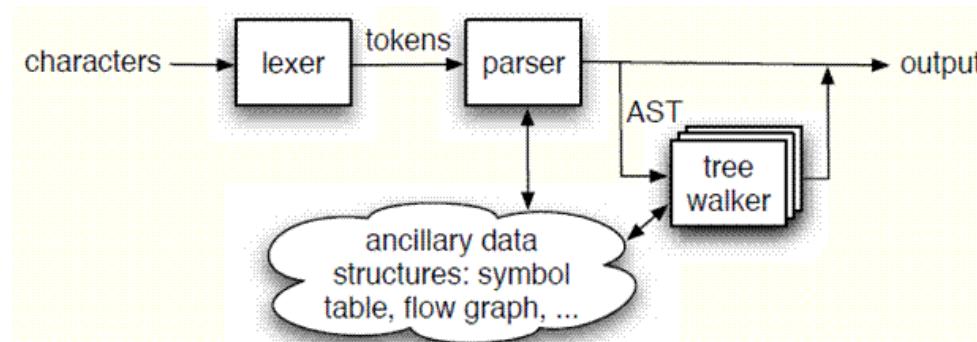
classDeclaration
: normalclassDeclaration
| enumDeclaration
```

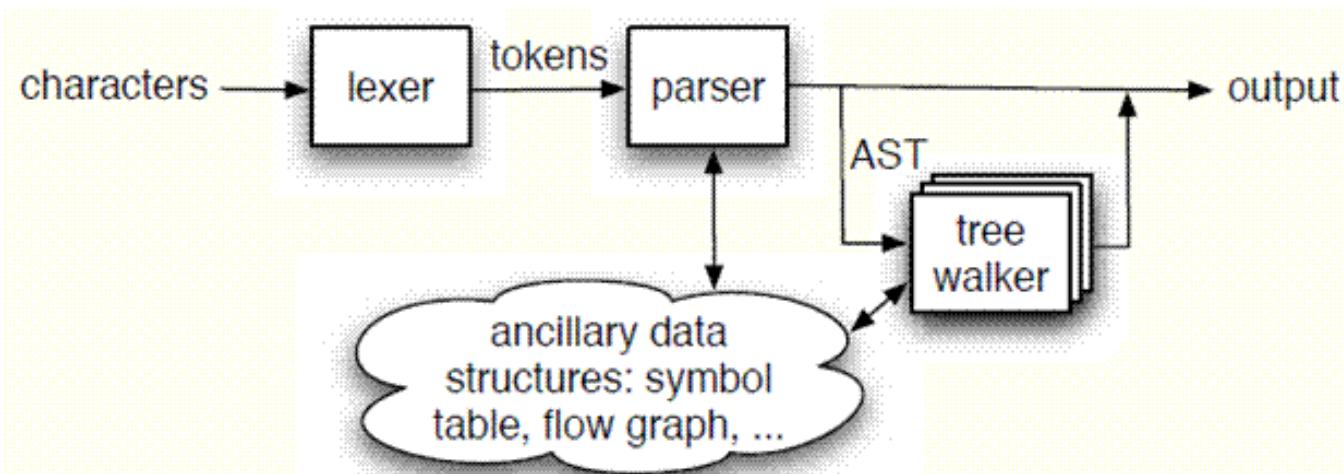
Java Program

```
/*
public class HelloWorld {
    public static void main(String[] args) {
        System.out.println("Hello, World");
    }
}
```

Compilation Process

- Source code
 - Concrete syntax used for specifying a program
 - Conformant to a grammar
- Lexical analysis
 - Converting a sequence of characters into a sequence of **tokens**
- Parsing (Syntactical analysis)
 - Abstract Syntax Tree (AST)





The Definitive
ANTLR
Reference

Building Domain-Specific Languages

Terence Parr

```

CHARLITERAL
:   '\\'
|   EscapeSequence
|   ~( '\\\\' | '\"' | '\\r' | '\\n' )
)
'\\'
;

STRINGLITERAL
:   """
|   EscapeSequence
|   ~( '\\\\' | '\"' | '\\r' | '\\n' )
"""
;

fragment
EscapeSequence
:   '\\\\' (
    'b'
|   't'
|   'n'
|   'f'
|   'r'
|   '\"'
|   '\\'
);

```

```

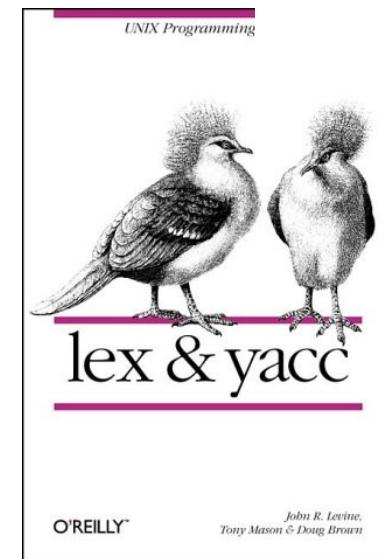
classOrInterfaceDeclaration
:   classDeclaration
|   interfaceDeclaration
;

modifiers
:   (
    annotation
|   PUBLIC
|   PROTECTED
|   PRIVATE
|   STATIC
|   ABSTRACT
|   FINAL
|   NATIVE
|   SYNCHRONIZED
|   TRANSIENT
|   VOLATILE
|   STRICTFP
)*
;

variableModifiers
:   (
    FINAL
|   annotation
)*
;

classDeclaration
:   normalClassDeclaration
|   enumDeclaration
;

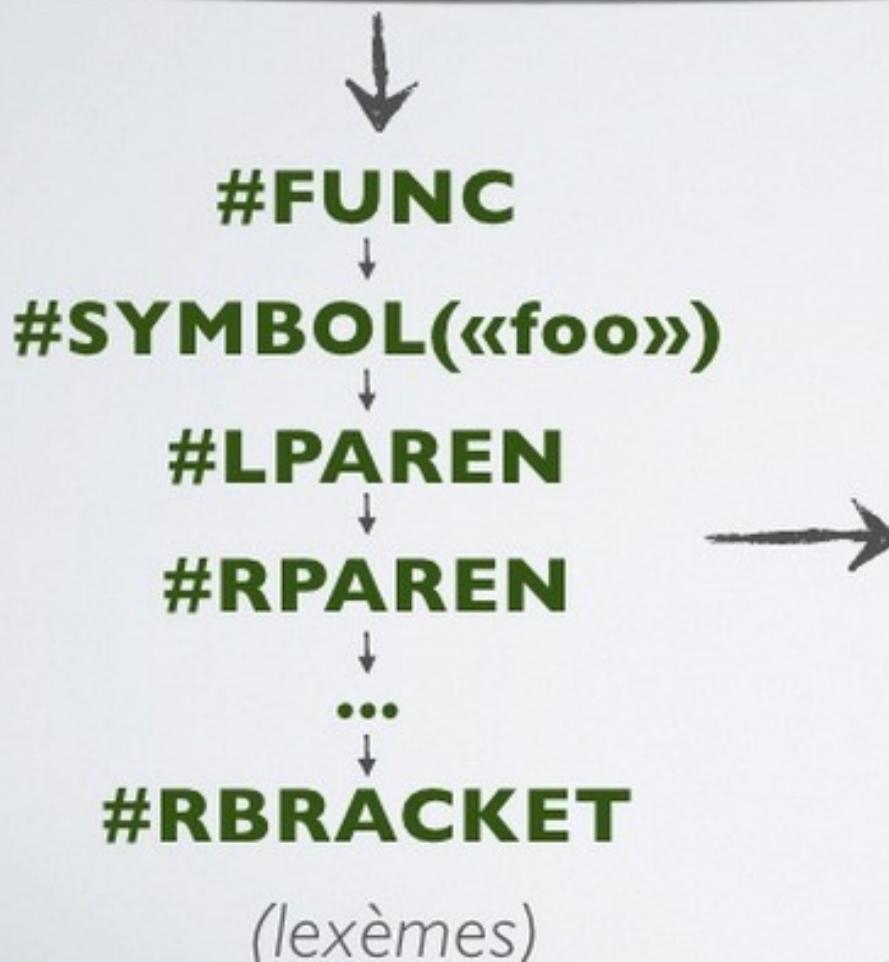
```



O'REILLY® John R. Levine,
Tony Mason & Doug Brown

EXEMPLE

```
function foo() {  
    echo «Hello, World !»;  
}  
(Syntaxe concrète)
```



```

class StringInterp {
    val int = 42
    val dbl = Math.PI
    val str = "My hovercraft is full of eels"

    println(s"String: $str Double: $dbl Int: $int Int Expr: ${int * 1.0}")
}

```

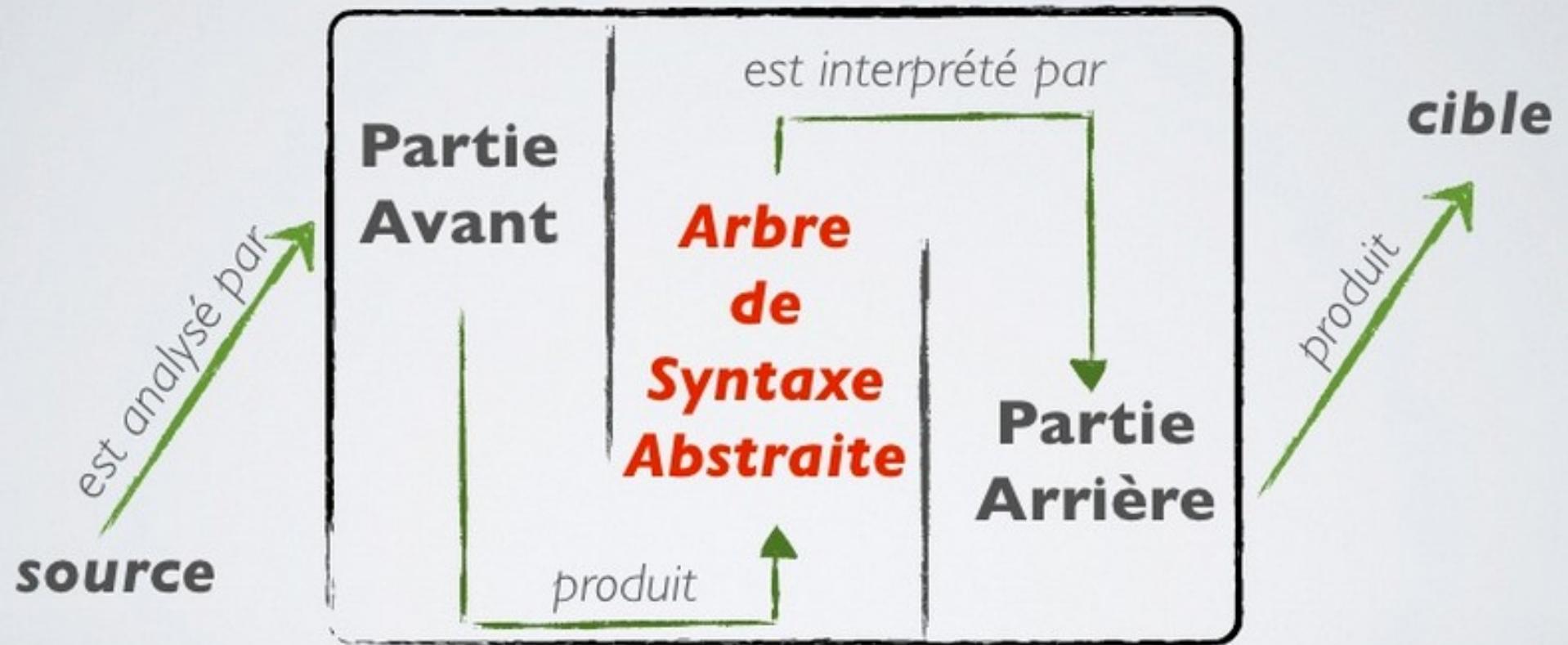
Scala AST (example)

```

Block(
  List(
    ClassDef(Modifiers(), TypeName("StringInterp"), List(), Template(
      List(Ident(TypeName("AnyRef"))), noSelfType, List(DefDef(Modifiers(), termNames.CONSTRUCTOR,
      List(),
      List(List())),
      TypeTree(), Block(List(Apply(Select(Super(This(typeNames.EMPTY), typeNames.EMPTY),
      termNames.CONSTRUCTOR), List()))), Literal(Constant(()))), ValDef(Modifiers(), TermName("int"),
      TypeTree(), Literal(Constant(42))), ValDef(Modifiers(), TermName("dbl"), TypeTree(),
      Literal(Constant(3.141592653589793))), ValDef(Modifiers(), TermName("str"), TypeTree(),
      Literal(Constant("My hovercraft is full of eels"))), Apply(Select(Ident(scala.Predef),
      TermName("println")), List(Apply(Select(Apply(Select(Ident(scala.StringContext), TermName("apply")),
      List(Literal(Constant("String: ")), Literal(Constant(" Double: ")), Literal(Constant(" Int: ")),
      Literal(Constant(" Int Expr: ")), Literal(Constant(""))))), TermName("s")),
      List(Select(This(TypeName("StringInterp")), TermName("str")), Select(This(TypeName("StringInterp")),
      TermName("dbl")), Select(This(TypeName("StringInterp")), TermName("int")),
      Apply(Select(Select(This(TypeName("StringInterp")), TermName("int")), TermName("$times")),
      List(Literal(Constant(1.0))))))), TermName("s"))
    )));
  )
)

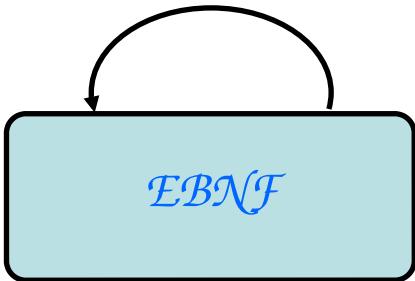
```

Compilation (en français)



DSL? The same!

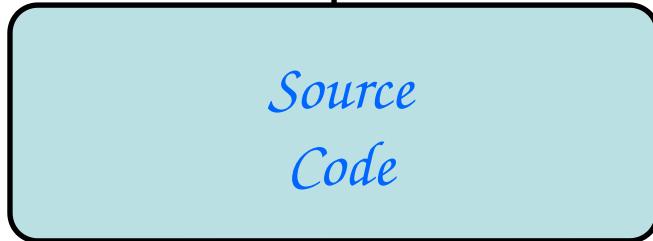
\mathcal{M}^3



\mathcal{M}^2



\mathcal{M}^1



DSL Grammar

DSL specification/program

UNIX Programming Tools



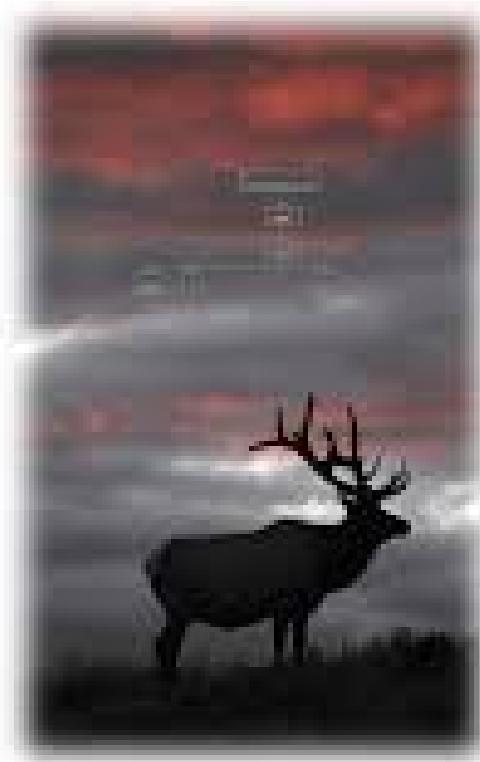
O'REILLY™

*John R. Levine,
Tony Mason & Doug Brown*



The Definitive **ANTLR** Reference

Building Domain-
Specific Languages

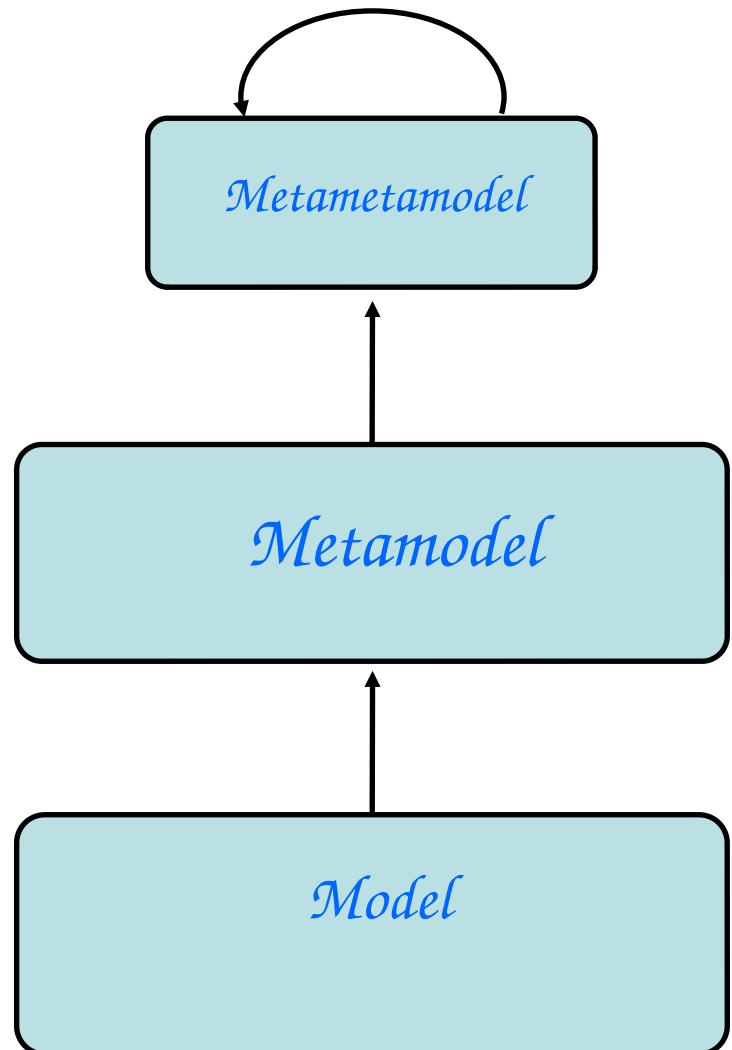
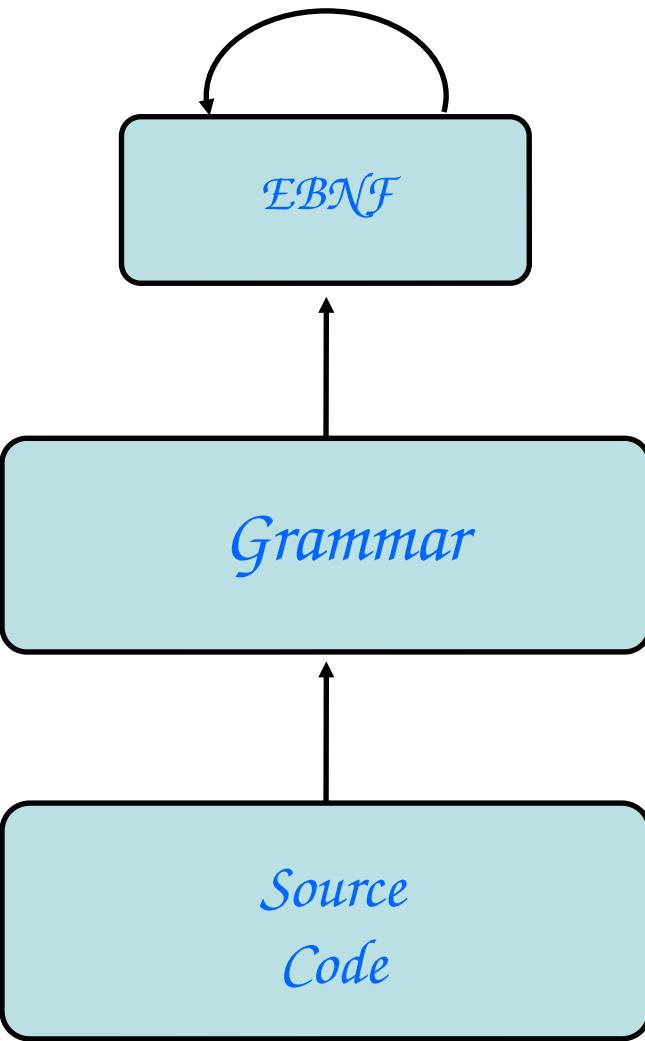


Reference Part

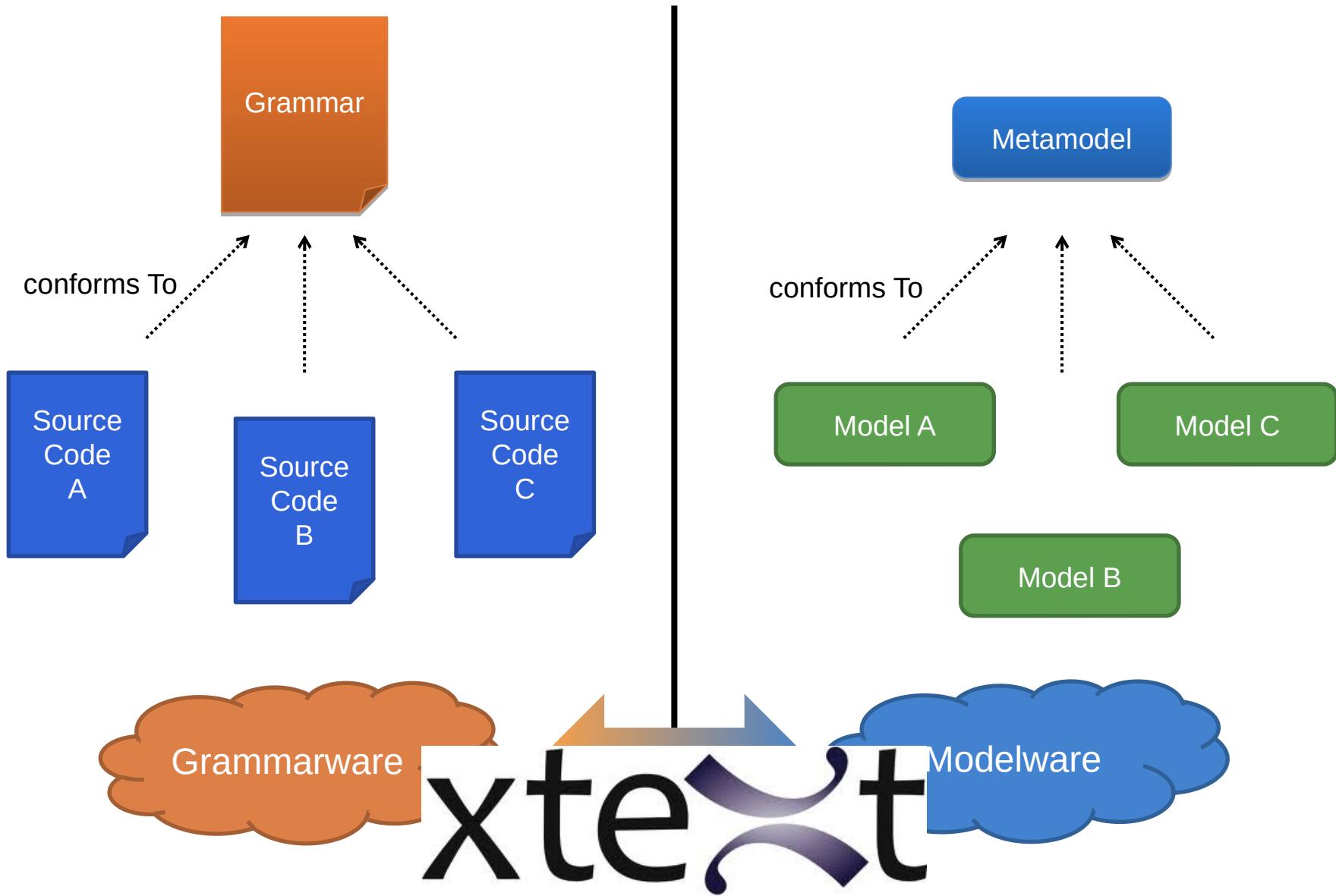
\mathcal{M}^3

\mathcal{M}^2

\mathcal{M}^1



Language and MDE

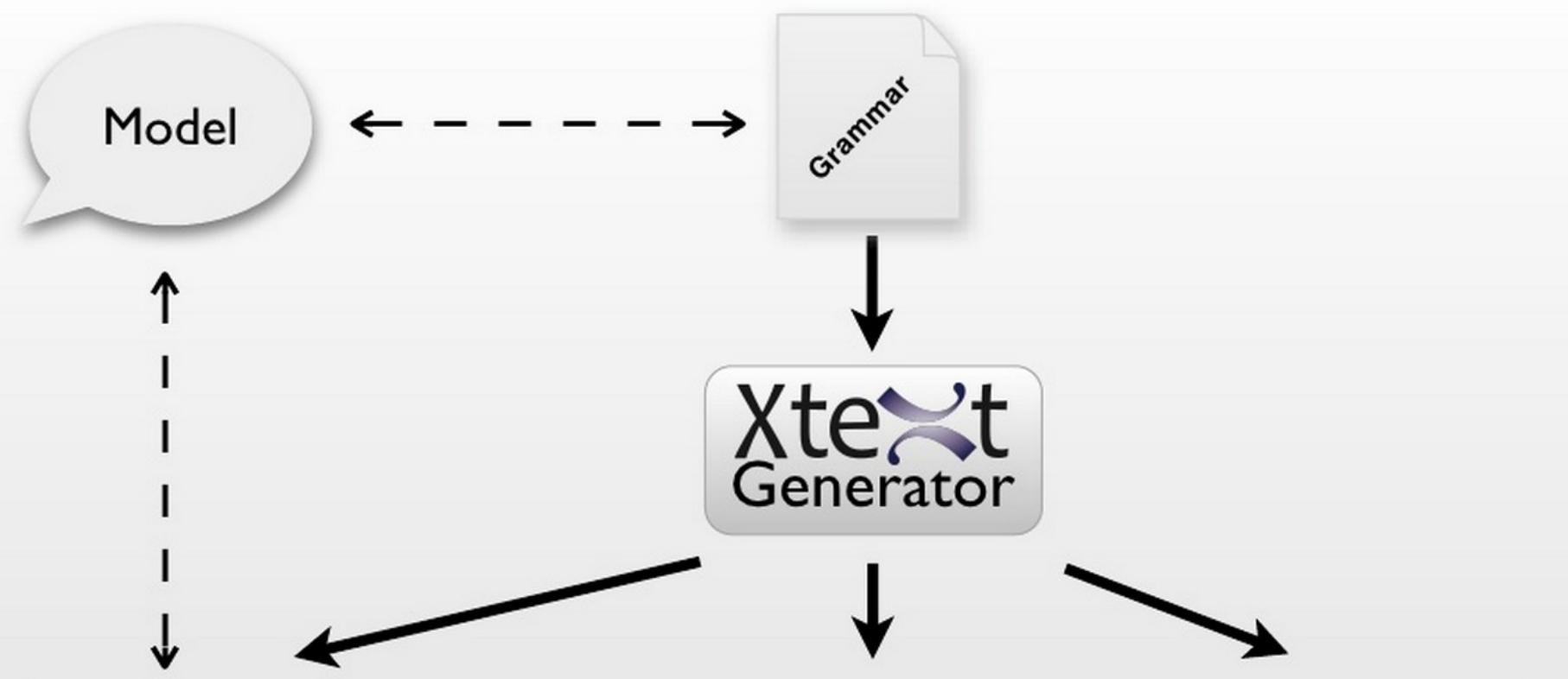




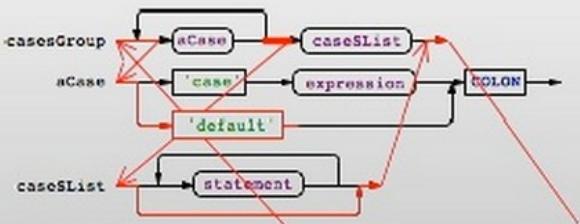
Give me a **grammar**,

I'll give you (for free)

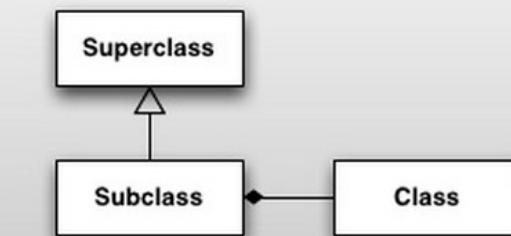
- * a comprehensive editor (auto-completion, syntax highlighting, etc.) in Eclipse
- * an Ecore metamodel and facilities to load/serialize/visit conformant models (Java ecosystem)
- * extension to override/extend « default » facilities (e.g., checker)



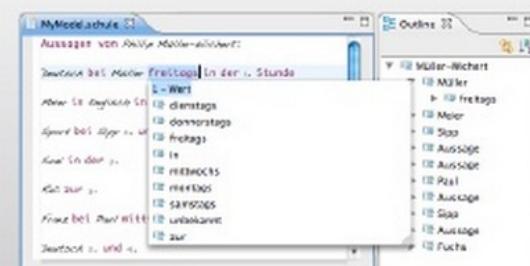
Xtext Runtime



LL(*) Parser

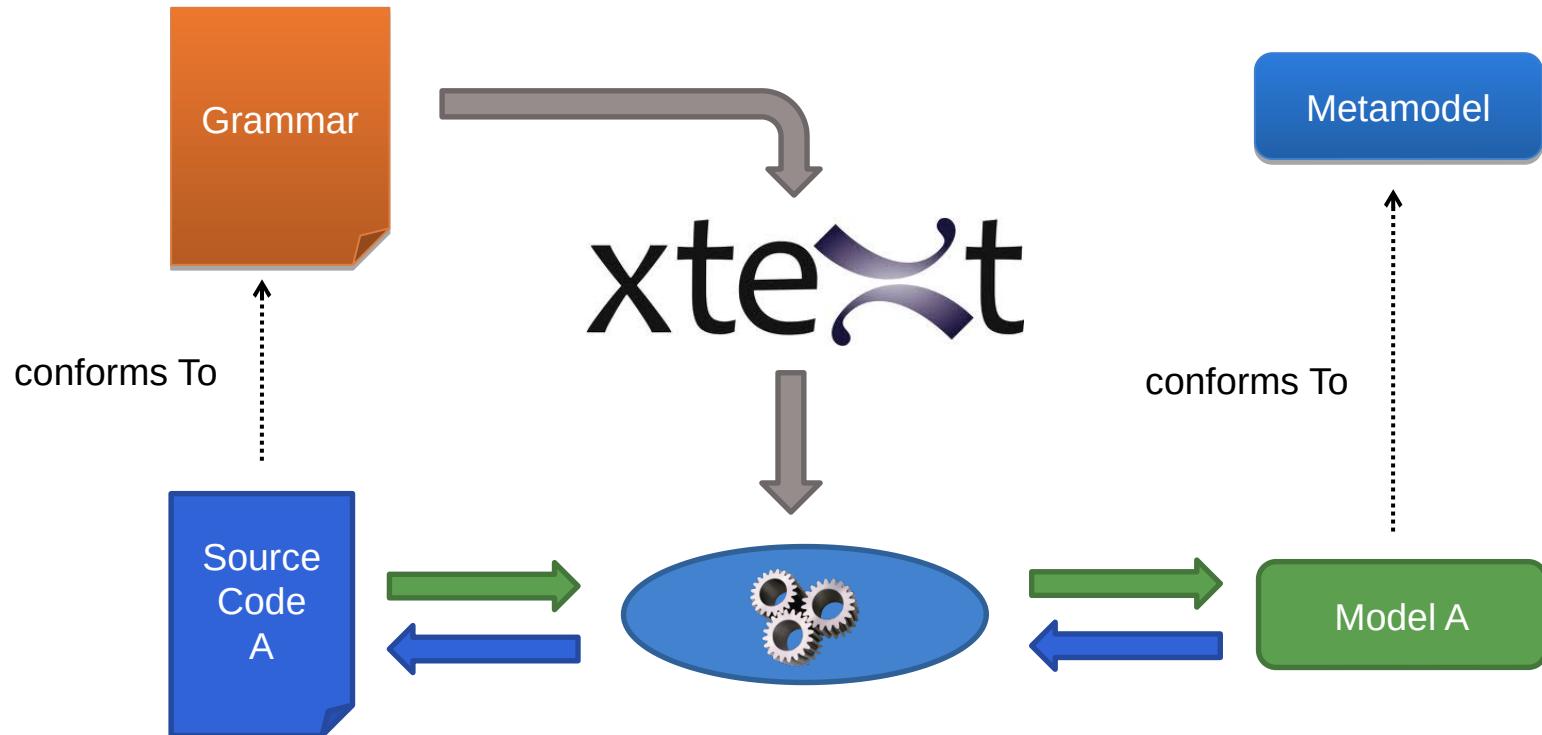


ecore meta model



editor

Xtext, Grammar, Metamodel

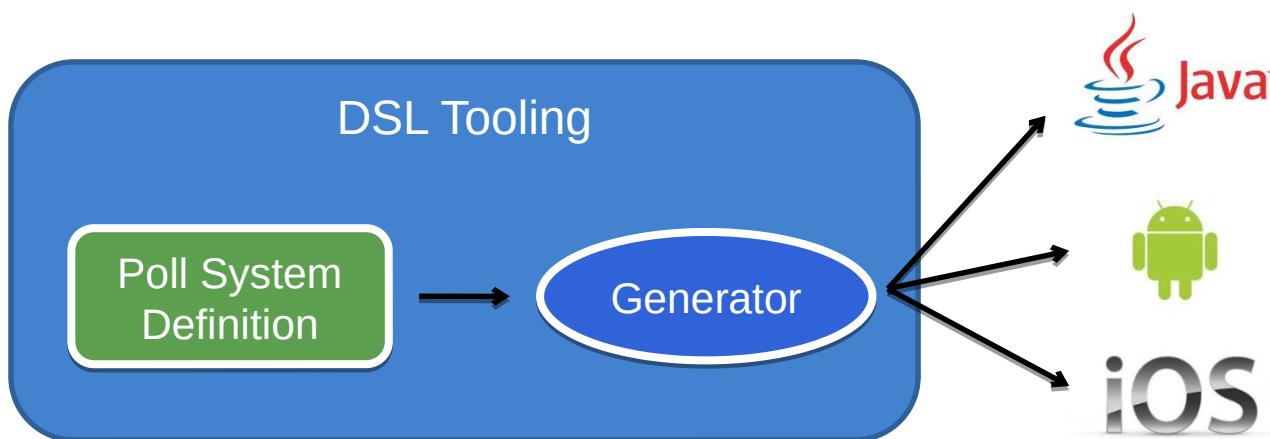


The Grammar Language of Xtext

- Corner-stone of Xtext
- A... DSL to define textual languages
 - Describe the concrete syntax
 - Specify the mapping between concrete syntax and domain model
- From the grammar, it is generated:
 - The domain model
 - The parser
 - The tooling

A first example

- Poll System application
 - Define a Poll with the corresponding questions
 - Each question has a text and a set of options
 - Each option has a text
- Generate the application in different platforms



Something like...

DSL Tooling

```
PollSystem {  
    Poll Quality {  
        Question q1 {  
            "Value the user experience"  
            options {  
                A : "Bad"  
                B : "Fair"  
                C : "Good"  
            }  
        }  
        Question q2 {  
            "Value the layout"  
            options {  
                A : "It was not easy to locate elements"  
                B : "I didn't realize"  
                C : "It was easy to locate elements"  
            }  
        }  
    }  
    Poll Performance {  
        Question q1 {  
            "Value the time response"  
            options {  
                A : "Bad"  
                B : "Fair"  
                C : "Good"  
            }  
        }  
    }  
}
```

Generator



Xtext Grammar

Grammar
definition

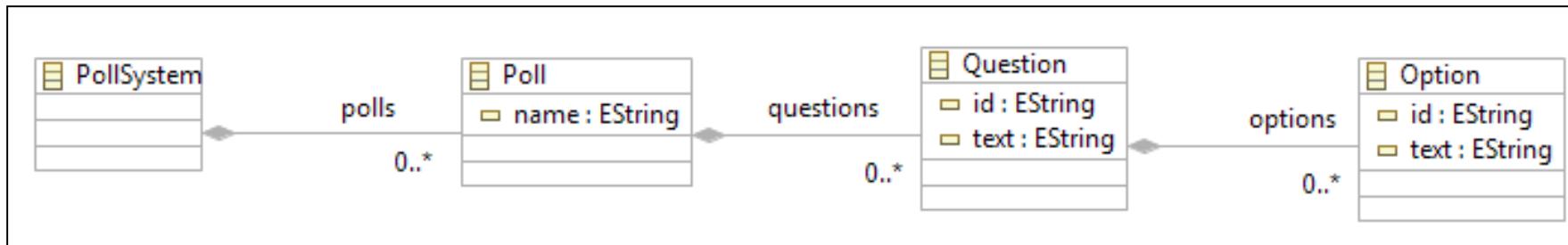
```
grammar fr.miage.xtext.Poll with org.eclipse.xtext.common.Terminals

generate poll "http://www.miage.fr/xtext/Poll"

PollSystem:
    'PollSystem' '{' polls+=Poll+ '}';
    
Poll:
    'Poll' name=ID '{' questions+=Question+'}'';

Question:
    'Question' id=ID '{' text=STRING 'options' '{' options+=Option+ '}'
    '}';

Option:
    id=ID ':' text=STRING;
```



Xtext Grammar

Grammar
reuse

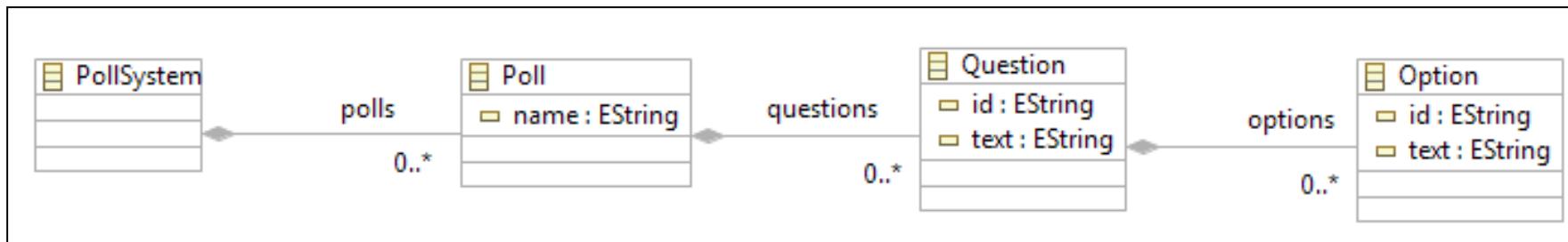
```
grammar fr.miage.xtext.Poll with org.eclipse.xtext.common.Terminals

generate poll "http://www.miage.fr/xtext/Poll"

PollSystem:
    'PollSystem' '{' polls+=Poll+ '}';
    
Poll:
    'Poll' name=ID '{' questions+=Question+'}'';

Question:
    'Question' id=ID '{' text=STRING 'options' '{' options+=Option+ '}'
        '}';

Option:
    id=ID ':' text=STRING;
```



Xtext Grammar

```
grammar fr.miage.xtext.Poll with org.eclipse.xtext.common.Terminals

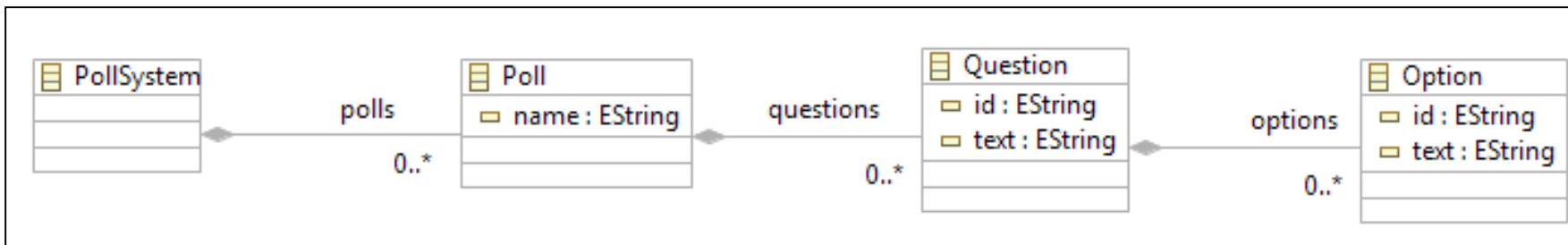
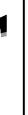
generate poll "http://www.miage.fr/xtext/Poll"

PollSystem:
    'PollSystem' '{' polls+=Poll+ '}';
    
Poll:
    'Poll' name=ID '{' questions+=Question+'}'';

Question:
    'Question' id=ID '{' text=STRING 'options' '{' options+=Option+ '}'
        '}';

Option:
    id=ID ':' text=STRING;
```

Derived
metamodel



Xtext Grammar

Parser Rules

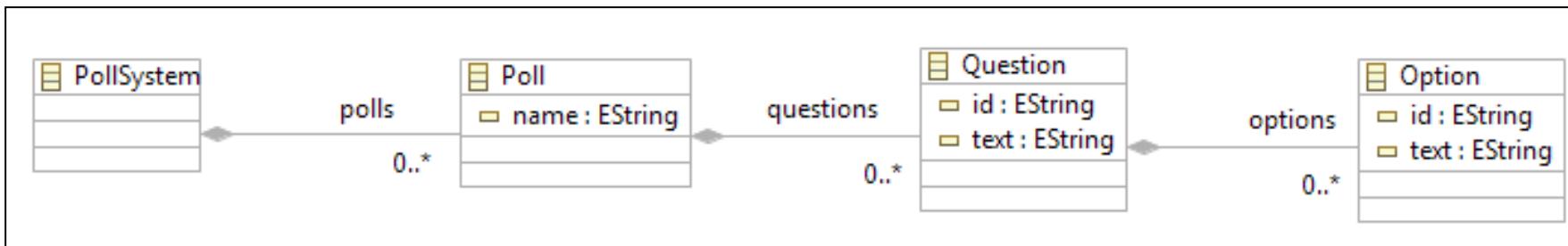
```
grammar fr.miage.xtext.Poll with org.eclipse.xtext.common.Terminals

generate poll "http://www.miage.fr/xtext/Poll"

PollSystem:
    'PollSystem' '{' polls+=Poll+ '}';
    
Poll:
    'Poll' name=ID '{' questions+=Question+ '}';

Question:
    'Question' id=ID '{' text=STRING 'options' '{' options+=Option+ '}'}';

Option:
    id=ID ':' text=STRING;
```



Xtext Grammar

```
grammar fr.miage.xtext.Poll with org.eclipse.xtext.common.Terminals

generate poll "http://www.miage.fr/xtext/Poll"
```

PollSystem:

```
→ 'PollSystem' '{' polls+=Poll+ '}';

```

Poll:

```
→ 'Poll' name=ID '{' questions+=Question+ '}';

```

Question:

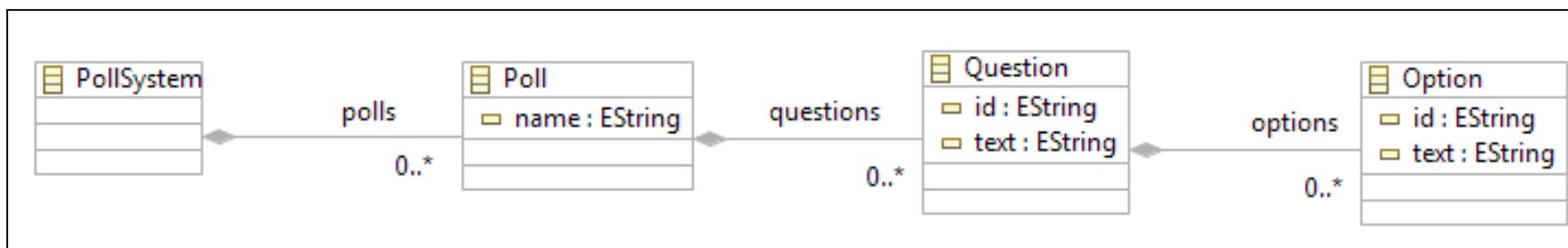
```
→ 'Question' id=ID '{' text=STRING 'options' '{' options+=Option+ '}'} '}';

```

Option:

```
id=ID ':' text=STRING;
```

Keywords



Xtext Grammar

```
grammar fr.miage.xtext.Poll with org.eclipse.xtext.common.Terminals

generate poll "http://www.miage.fr/xtext/Poll"

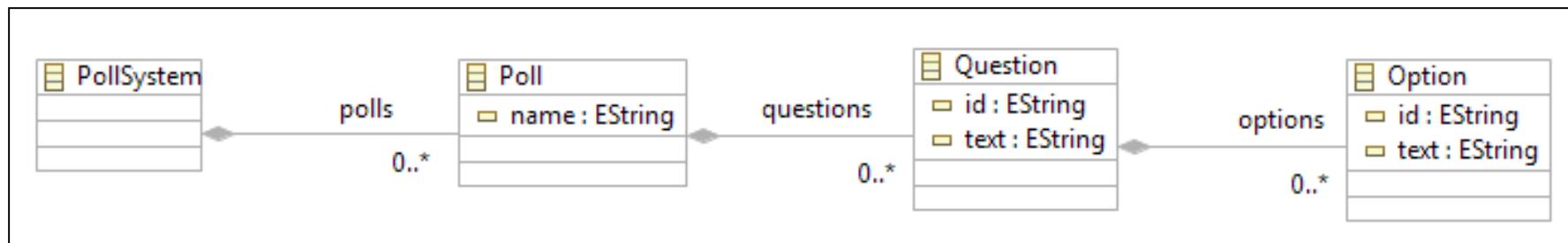
PollSystem:
    'PollSystem' '{' polls+=Poll+ '}';
    ^ Multivalue assignment

Poll:
    'Poll' name=ID '{' questions+=Question+ '}';
    ^ Simple assignment

Question:
    'Question' id=ID '{' text=STRING 'options' '{' options+=Option+ '}'} ';
    ^ Simple assignment

Option:
    id=ID ':' text=STRING;
```

(not here Boolean assignment)



Xtext Grammar

```
grammar fr.miage.xtext.Poll with org.eclipse.xtext.common.Terminals
```

```
generate poll "http://www.miage.fr/xtext/Poll"
```

```
PollSystem:
```

```
    'PollSystem' '{' polls+=Poll+ '}';

```

Cardinality (others: * ?)



```
Poll:
```

```
    'Poll' name=ID '{' questions+=Question+ '}';

```

```
Question:
```

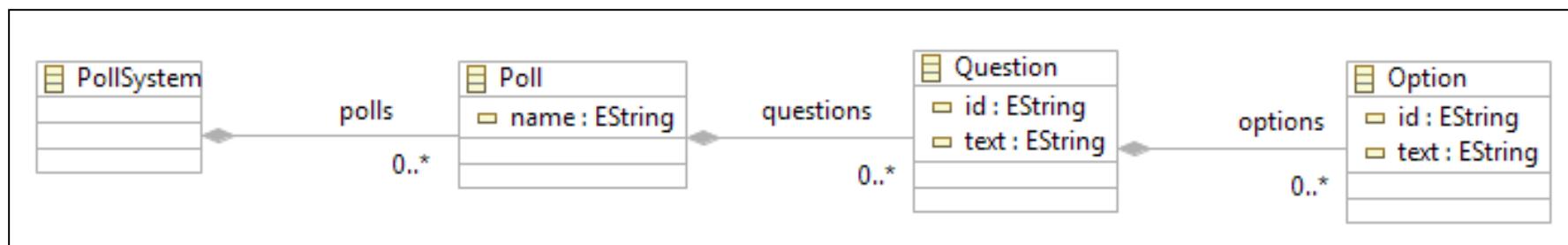
```
    'Question' id=ID '{' text=STRING 'options' '{' options+=Option+ '}'
        '}';

```

```
Option:
```

```
    id=ID ':' text=STRING;

```



Xtext Grammar

```
grammar fr.miage.xtext.Poll with org.eclipse.xtext.common.Terminals
```

```
generate poll "http://www.miage.fr/xtext/Poll"
```

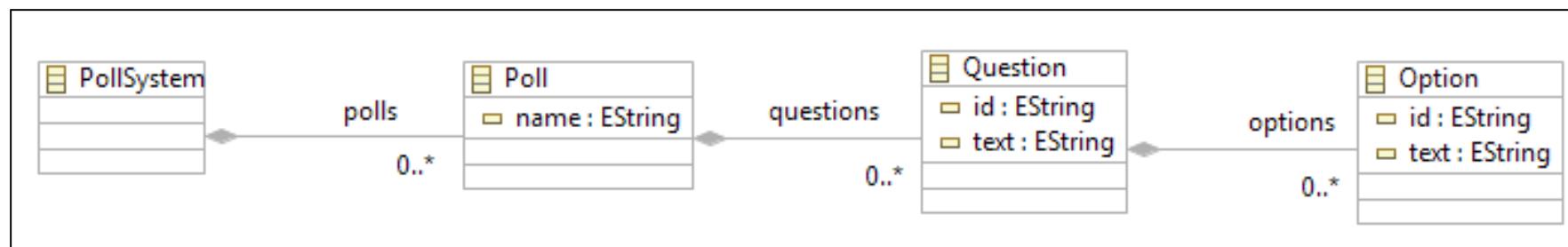
```
PollSystem:  
    'PollSystem' '{' polls+=Poll+ '}';
    
```

```
Poll:  
    'Poll' name=ID '{' questions+=Question+ '}';
    
```

```
Question:  
    'Question' id=ID '{' text=STRING 'options' '{' options+=Option+ '}'}';
    
```

```
Option:  
    id=ID ':' text=STRING;
    
```

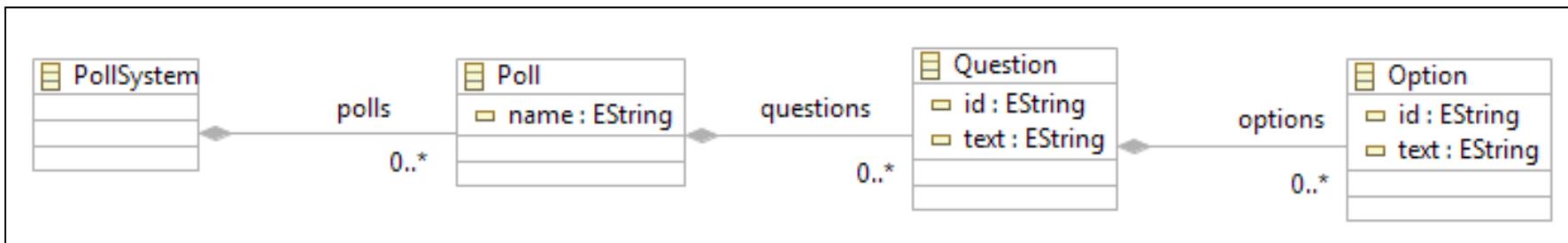
Containment



Grammar and Programs/Specifications/Models

```
grammar fr.miage.xtext.Poll with org.eclipse.xtext.common.Terminals
generate poll "http://www.miage.fr/xtext/Poll"
PollSystem:
    'PollSystem' '{' polls+=Poll+ '}';
Poll:
    'Poll' name=ID '{' questions+=Question+'}';
Question:
    'Question' id=ID '{' text=STRING 'options' '{' options+=Option+ '}'} '}';
Option:
    id=ID ':' text=STRING;
```

```
PollSystem {
    Poll Quality {
        Question q1 {
            "Value the user experience"
            options {
                A : "Bad"
                B : "Fair"
                C : "Good"
            }
        }
        Question q2 {
            "Value the layout"
            options {
                A : "It was not easy to locate elements"
                B : "I didn't realize"
                C : "It was easy to locate elements"
            }
        }
    }
    Poll Performance {
        Question q1 {
            "Value the time response"
            options {
                A : "Bad"
                B : "Fair"
                C : "Good"
            }
        }
    }
}
```



Grammar and Programs/Specifications/Models

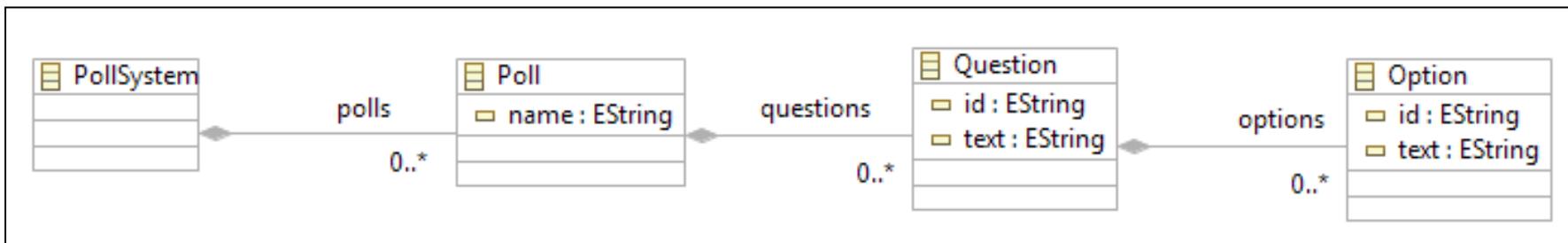
```
grammar fr.miage.xtext.Poll with org.eclipse.xtext.common.Terminals

generate poll "http://www.miage.fr/xtext/Poll"

PollSystem:
    'PollSystem' '{' polls+=Poll+ '}';
    
Poll:
    'Poll' name=ID '{' questions+=Question+'}'';

Question:
    'Question' id=ID '{' text=STRING 'options' '{' options+=Option+ '}';
    
Option:
    id=ID ':' text=STRING;
```

```
PollSystem {
    Poll Quality {
        Question q1 {
            "Value the user experience"
            options {
                A : "Bad"
                B : "Fair"
                C : "Good"
            }
        }
        Question q2 {
            "Value the layout"
            options {
                A : "It was not easy to locate elements"
                B : "I didn't realize"
                C : "It was easy to locate elements"
            }
        }
    }
    Poll Performance {
        Question q1 {
            "Value the time response"
            options {
                A : "Bad"
                B : "Fair"
                C : "Good"
            }
        }
    }
}
```



Grammar and Programs/Specifications/Models

```
grammar fr.miage.xtext.Poll with org.eclipse.xtext.common.Terminals

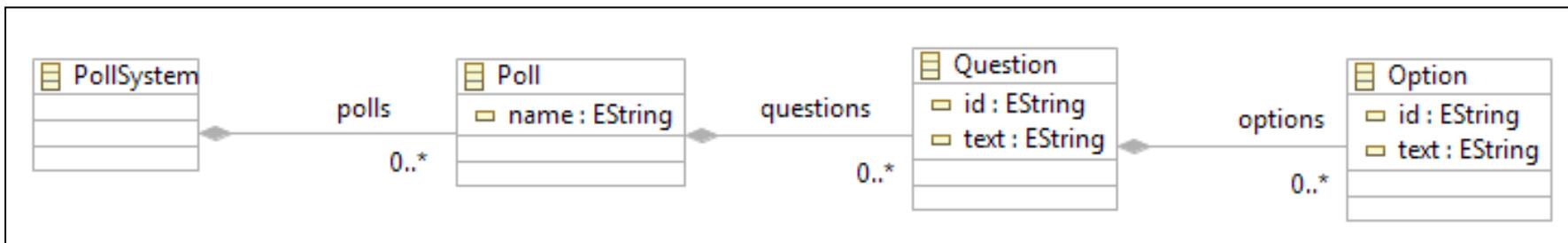
generate poll "http://www.miage.fr/xtext/Poll"

PollSystem:
    'PollSystem' '{' polls+=Poll+ '}';
    
Poll:
    'Poll' name=ID '{' questions+=Question+'}'';

Question:
    'Question' id=ID '{' text=STRING 'options' '{' options+=Option+ '}'}';

Option:
    id=ID ':' text=STRING;
```

```
PollSystem {
    Poll Quality {
        Question q1 {
            "Value the user experience"
            options {
                A : "Bad"
                B : "Fair"
                C : "Good"
            }
        }
        Question q2 {
            "Value the layout"
            options {
                A : "It was not easy to locate elements"
                B : "I didn't realize"
                C : "It was easy to locate elements"
            }
        }
    }
    Poll Performance {
        Question q1 {
            "Value the time response"
            options {
                A : "Bad"
                B : "Fair"
                C : "Good"
            }
        }
    }
}
```



Grammar and Programs/Specifications/Models

```
grammar fr.miage.xtext.Poll with org.eclipse.xtext.common.Terminals

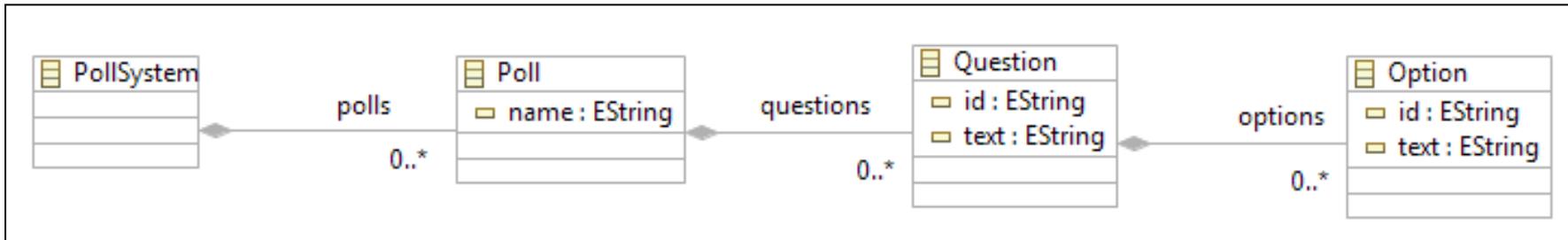
generate poll "http://www.miage.fr/xtext/Poll"

PollSystem:
    'PollSystem' '{' polls+=Poll+ '}';
    
Poll:
    'Poll' name=ID '{' questions+=Question+'}'';

Question:
    'Question' id=ID '{' text=STRING options='{' options+=Option+ '}'}';

Option:
    id=ID ':' text=STRING;
```

```
PollSystem {
    Poll Quality {
        Question q1 {
            "Value the user experience"
            options {
                A : "Bad"
                B : "Fair"
                C : "Good"
            }
        }
        Question q2 {
            "Value the layout"
            options {
                A : "It was not easy to locate elements"
                B : "I didn't realize"
                C : "It was easy to locate elements"
            }
        }
    }
    Poll Performance {
        Question q1 {
            "Value the time response"
            options {
                A : "Bad"
                B : "Fair"
                C : "Good"
            }
        }
    }
}
```



Quizz Time

```
Quetionnaire.xtext ✎
1 grammar org.xtext.example.mydsl.Quetionnaire with org.eclipse.xtext.common.Terminals
2
3 generate questionnaire "http://www.xtext.org/example/mydsl/Questionnaire"
4
5 @PollSystem:
6   'PollSystem' '{' polls+=Poll+ '}';
7
8 @Poll:
9   'Poll' name=ID '{' questions+=Question+ '}';
10
11 Question : 'Question' ID? '{' text=STRING 'options' options+=Option+ '}';
12
13 Option : id=ID ':' text=STRING ;
```

Est-ce que le fichier vide .q est correct vis-à-vis de la grammaire Xtext? Pourquoi?

Quizz Time

```
grammar org.xtext.example.mydsl.Questionnaire with org.eclipse.xtext.common.Terminals

generate questionnaire "http://www.xtext.org/example/mydsl/Questionnaire"

PollSystem:
    {PollSystem} 'PollSystem' '{' polls+=Poll* '}';

Poll:
    'Poll' name=ID '{' questions+=Question+ '}';

Question : 'Question' ID? '{' text=STRING 'options' options+=Option+ '}';

Option : id=ID ':' text=STRING ;
```

Est-ce que le fichier .q suivant est correct vis-à-vis de la grammaire Xtext?
Pourquoi?

PollSystem {



Quizz Time

Quetionnaire.xtext

```
1 grammar org.xtext.example.mydsl.Quetionnaire with org.eclipse.xtext.common.Terminals
2
3 generate questionnaire "http://www.xtext.org/example/mydsl/Questionnaire"
4
5@PollSystem:
6     'PollSystem' '{' polls+=Poll+ '}';
7
8@Poll:
9     'Poll' name=ID '{' questions+=Question+ '}';
10
11 Question : 'Question' ID '{' text=STRING 'options' options+=Option+ '}';
12
13 Option : id=ID ':' text=STRING ;
```

Est-ce que le fichier .q suivant est correct vis-à-vis de la grammaire Xtext? Pourquoi?

```
PollSystem {
    Poll p1 {
        Question {
            "Q1"
            options o1 : "R1"
        }
    }
}
```

*Xtext, your DSL in 5' (incl. editors
and serializers)*

Live Demonstration

The screenshot shows the Eclipse IDE interface with the Package Explorer and a code editor.

Package Explorer:

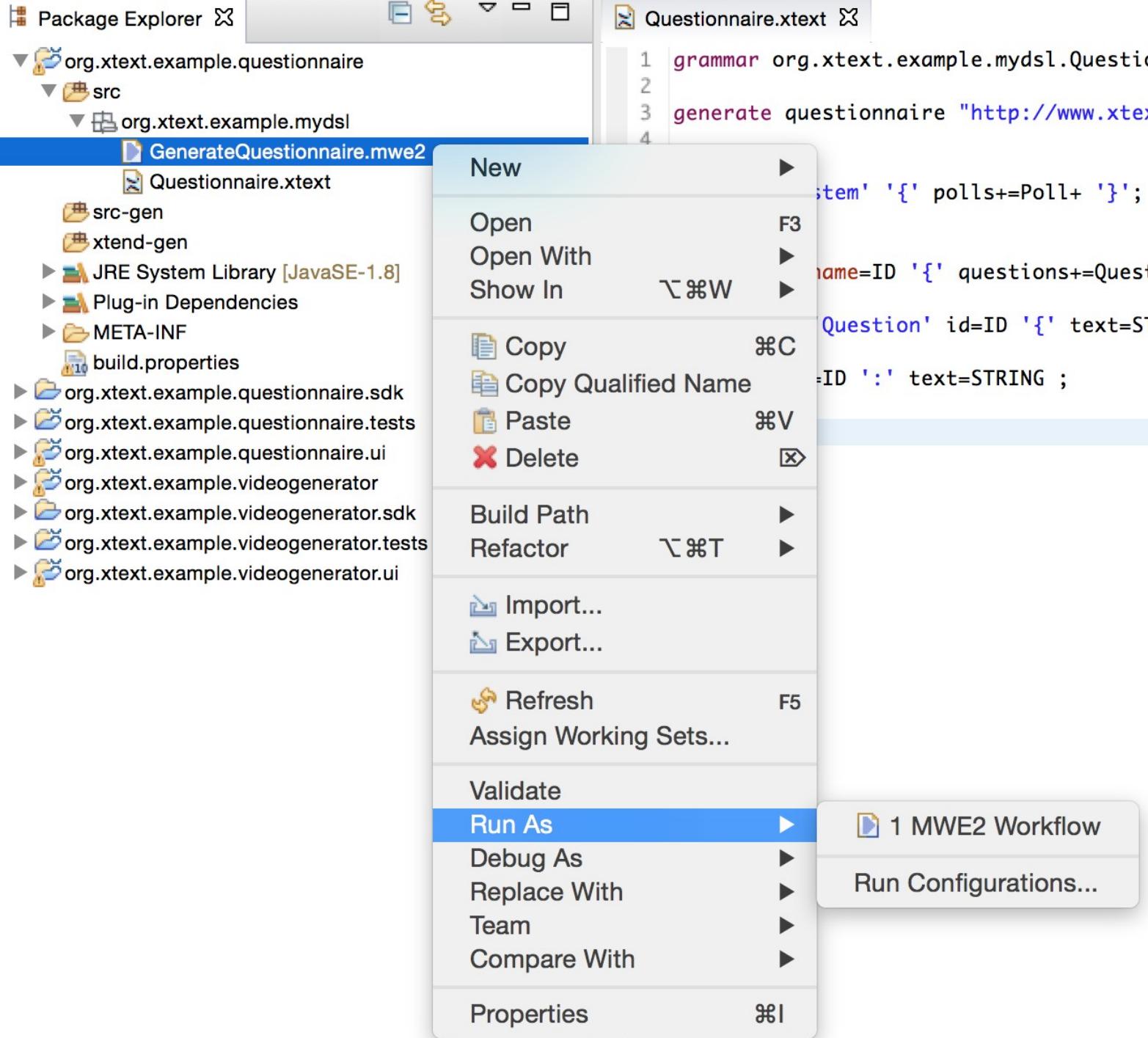
- org.xtext.example.questionnaire
 - src
 - org.xtext.example.mydsl
 - GenerateQuestionnaire.mwe2
 - Questionnaire.xtext
 - src-gen
 - xtend-gen

JRE System Library [JavaSE-1.8]
Plug-in Dependencies
META-INF
build.properties

org.xtext.example.questionnaire.sdk
org.xtext.example.questionnaire.tests
org.xtext.example.questionnaire.ui

Code Editor (Questionnaire.xtext):

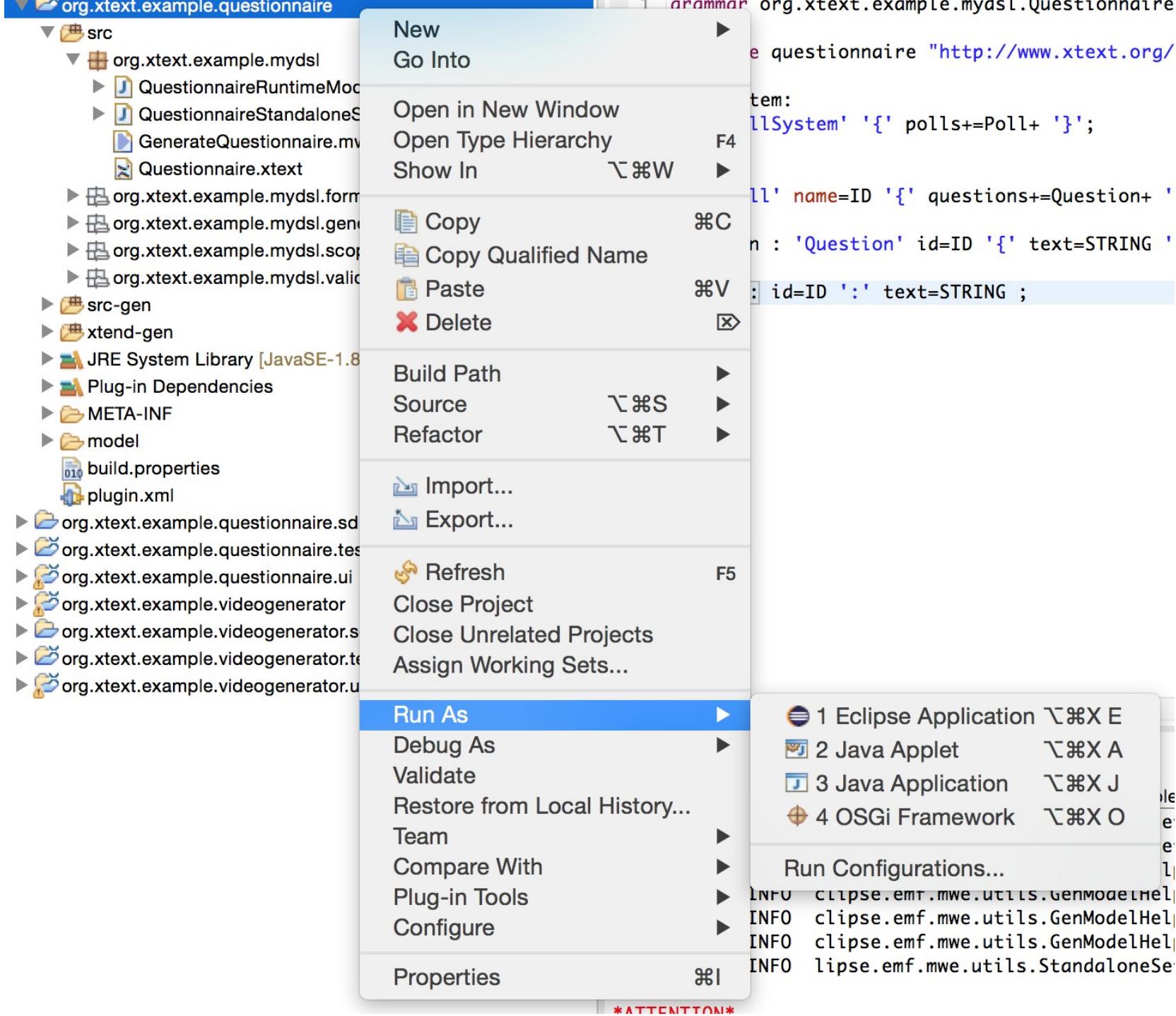
```
1 grammar org.xtext.example.mydsl.Questionnaire with org.eclipse.xtext.common.Terminals
2
3 generate questionnaire "http://www.xtext.org/example/mydsl/Questionnaire"
4
5 @PollSystem:
6     'PollSystem' '{' polls+=Poll+ '}';
7
8 @Poll:
9     'Poll' name=ID '{' questions+=Question+ '}';
10
11 Question : 'Question' id=ID '{' text=STRING 'options' '{' options+=Option+ '}' '}';
12
13 Option : id=ID ':' text=STRING ;
```





```
<terminated> Generate Language Infrastructure (org.xtext.example.questionnaire) [Mwe2 Launch] /Library/Java/JavaVirtualMachines/jdk1.8.0_31.jdk/Contents/Home/bin/java (28 sept. 2014)
0 [main] INFO lipse.emf.mwe.utils.StandaloneSetup - Registering platform uri '/Users/macher1/Documents/workspaceIDM1516'
127 [main] INFO lipse.emf.mwe.utils.StandaloneSetup - Adding generated EPackage 'org.eclipse.xtext.Xbase.XbasePackage'
408 [main] INFO clipse.emf.mwe.utils.GenModelHelper - Registered GenModel 'http://www.eclipse.org/Xtext/Xbase/XAnnotations' from 'platform:/resource/Questionnaire/XAnnotations.genmodel'
413 [main] INFO clipse.emf.mwe.utils.GenModelHelper - Registered GenModel 'http://www.eclipse.org/xtext/xbase/Xtype' from 'platform:/resource/Questionnaire/Xtype.genmodel'
436 [main] INFO clipse.emf.mwe.utils.GenModelHelper - Registered GenModel 'http://www.eclipse.org/xtext/xbase/Xbase' from 'platform:/resource/Questionnaire/Xbase.genmodel'
436 [main] INFO clipse.emf.mwe.utils.GenModelHelper - Registered GenModel 'http://www.eclipse.org/xtext/common/JavaVMTypes' from 'platform:/resource/Questionnaire/JavaVMTypes.genmodel'
1005 [main] INFO lipse.emf.mwe.utils.StandaloneSetup - Adding generated EPackage 'org.eclipse.xtext.common.types.TypesPackage'

*ATTENTION*
It is recommended to use the ANTLR 3 parser generator (BSD licence - http://www.antlr.org/license.html).
Do you agree to download it (size 1MB) from 'http://download.itemis.com/antlr-generator-3.2.0-patch.jar'? (type 'y' or 'n' and hit enter)y
11812 [main] INFO erator.parser.antlr.AntlrToolFacade - downloading file from 'http://download.itemis.com/antlr-generator-3.2.0-patch.jar' ...
108842 [main] INFO erator.parser.antlr.AntlrToolFacade - finished downloading.
108848 [main] INFO ipse.emf.mwe.utils.DirectoryCleaner - Cleaning /Users/macher1/Documents/workspaceIDM1516/org.xtext.example.questionnaire
108849 [main] INFO ipse.emf.mwe.utils.DirectoryCleaner - Cleaning /Users/macher1/Documents/workspaceIDM1516/org.xtext.example.questionnaire
108849 [main] INFO ipse.emf.mwe.utils.DirectoryCleaner - Cleaning /Users/macher1/Documents/workspaceIDM1516/org.xtext.example.questionnaire
110353 [main] INFO clipse.emf.mwe.utils.GenModelHelper - Registered GenModel 'http://www.xtext.org/example/mydsl/Questionnaire' from 'platform:/resource/Questionnaire/Questionnaire.genmodel'
113410 [main] INFO text.generator.junit.Junit4Fragment - generating Junit4 Test support classes
113428 [main] INFO text.generator.junit.Junit4Fragment - generating Compare Framework infrastructure
113584 [main] INFO .emf.mwe2.runtime.workflow.Workflow - Done.
```



**File**

Create a new file resource.



Enter or select the parent folder:

FooQuestionnaire



FooQuestionnaire

VideoGen1

File name:

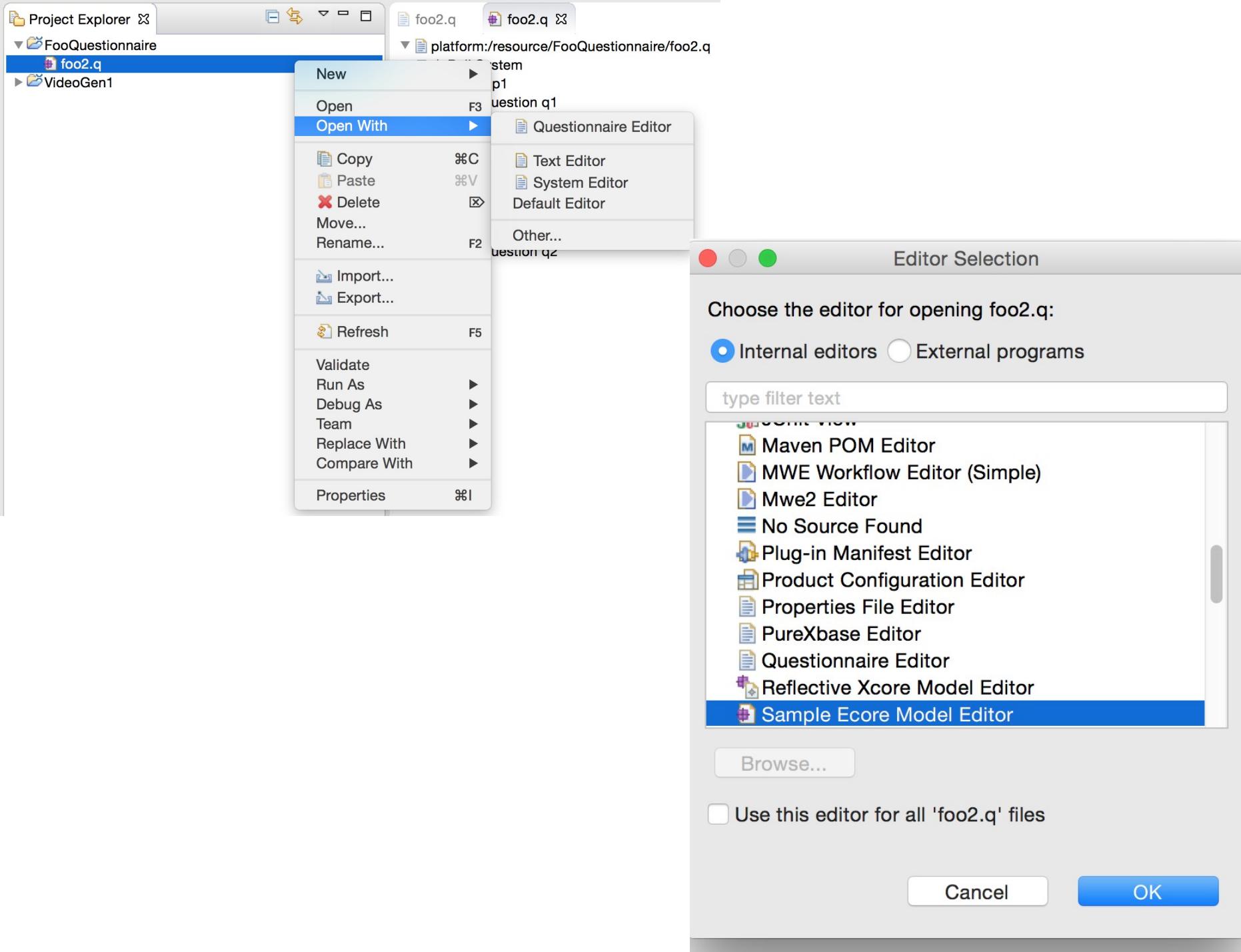
Advanced >>



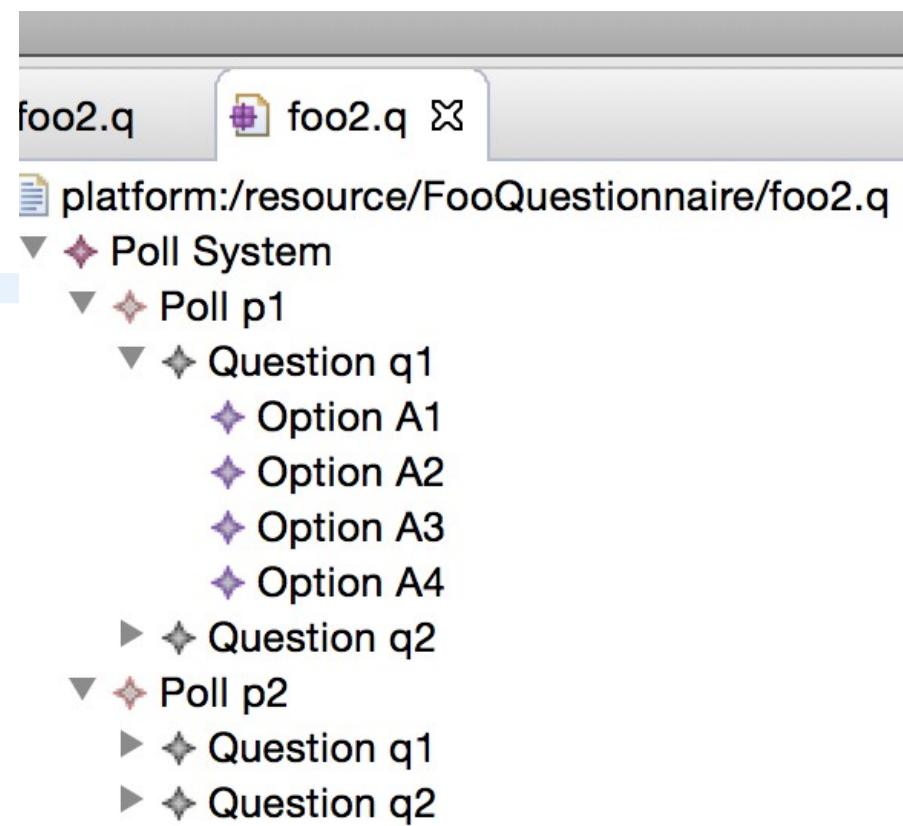
Cancel

Finish

```
PollSystem {  
    Poll p1 {  
        Question q1 {  
            "What is the best JavaScript framework for testing?"  
            options [  
                A1: "PhantomJS"  
                A2: "Jasmine"  
                A3: "Mocha"  
                A4: "I prefer to develop my own framework"  
            ]  
        }  
  
        Question q2 {  
            "What is the best CSS preprocessor?"  
            options [  
                A1: "Less.js"  
                A2: "Sass"  
                A3: "Stylus"  
                A4: "I don't care about preprocessing CSS"  
            ]  
        }  
    }  
  
    Poll p2 {  
        Question q1 {  
            "What is the best Java framework for testing?"  
            options [  
                A1: "JUnit"  
                A2: "Jasmine"  
                A3: "I prefer to develop my own framework"  
            ]  
        }  
  
        Question q2 {  
            "What is the best Java library for logging?"  
            options [  
                A1: "Log4J"  
                A2: "java.util.logging"  
                A3: "I don't care about logging"  
            ]  
        }  
    }  
}
```



```
2.q ✎  
ollSystem {  
  
    Poll p1 {  
        Question q1 {  
            "What is the best JavaScript framework for testing?"  
            options [  
                A1: "PhantomJS"  
                A2: "Jasmine"  
                A3: "Mocha"  
                A4: "I prefer to develop my own framework"  
            ]  
        }  
  
        Question q2 {  
            "What is the best CSS preprocessor?"  
            options {  
                A1: "Less.js"  
                A2: "Sass"  
                A3: "Stylus"  
                A4: "I don't care about preprocessing CSS"  
            }  
        }  
  
    Poll p2 {  
        Question q1 {  
            "What is the best Java framework for testing?"  
            options {  
                A1: "JUnit"  
                A2: "Jasmine"  
                A3: "I prefer to develop my own framework"  
            }  
        }  
  
        Question q2 {  
            "What is the best Java library for logging?"  
            options {  
                A1: "Log4J"  
                A2: "java.util.logging"  
                A3: "I don't care about logging"  
            }  
        }  
    }  
}
```



```
2.q X

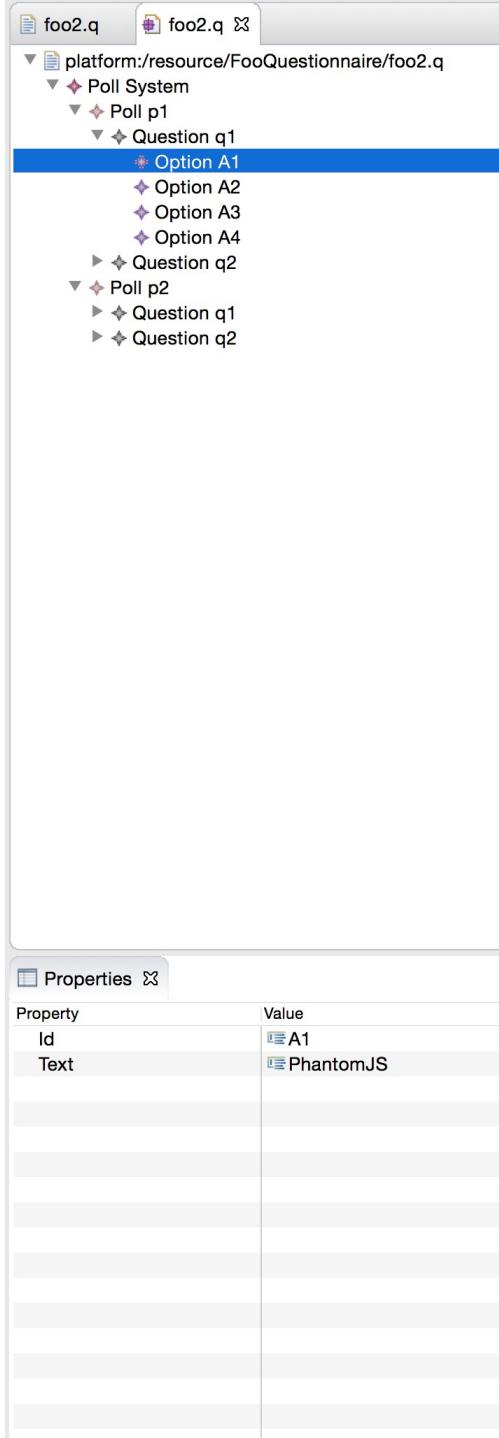
ollSystem {

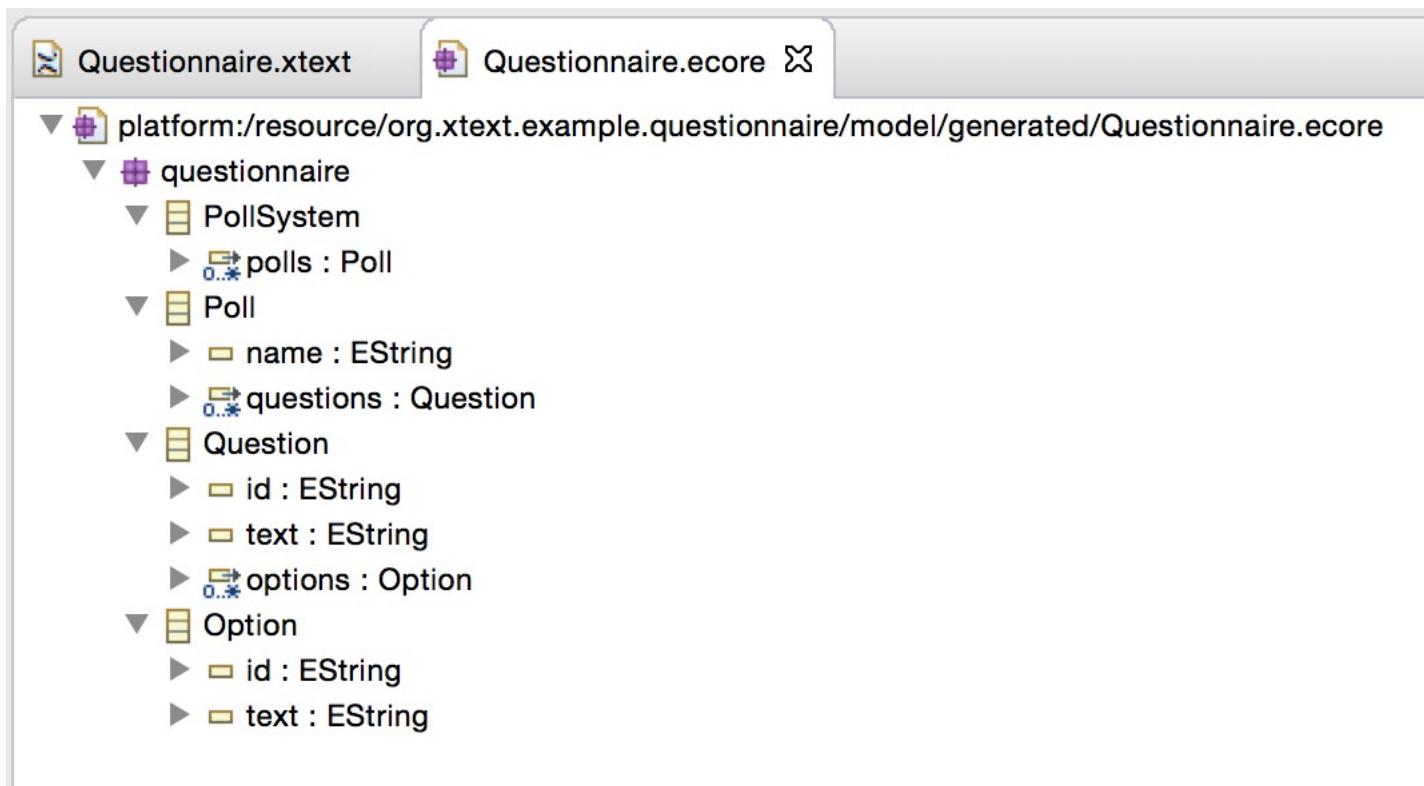
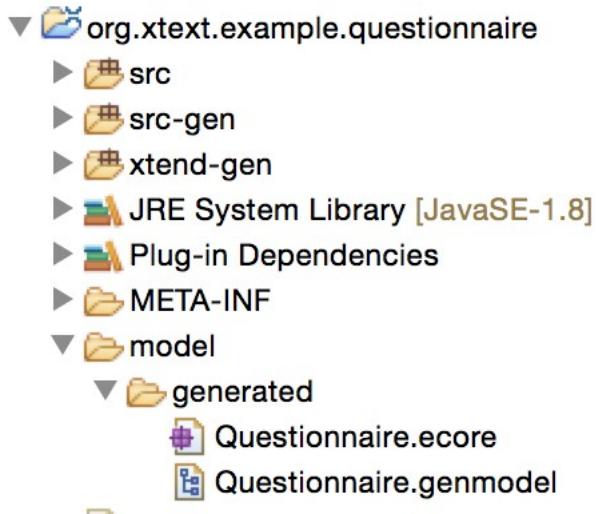
    Poll p1 {
        Question q1 {
            "What is the best JavaScript framework for testing?"
            options [
                A1: "PhantomJS"
                A2: "Jasmine"
                A3: "Mocha"
                A4: "I prefer to develop my own framework"
            ]
        }

        Question q2 {
            "What is the best CSS preprocessor?"
            options [
                A1: "Less.js"
                A2: "Sass"
                A3: "Stylus"
                A4: "I don't care about preprocessing CSS"
            ]
        }
    }

    Poll p2 {
        Question q1 {
            "What is the best Java framework for testing?"
            options [
                A1: "JUnit"
                A2: "Jasmine"
                A3: "I prefer to develop my own framework"
            ]
        }

        Question q2 {
            "What is the best Java library for logging?"
            options [
                A1: "Log4J"
                A2: "java.util.logging"
                A3: "I don't care about logging"
            ]
        }
    }
}
```





Another example:

Chess

**“Queen to c7.
Check.”**



**“Rd2-c2,
rook at d2 moves to c2”**

Moves in Chess:

Rook at a1 moves to a5.

Piece Square Action Destination

Bishop at c8 captures knight at h3.

Piece Square Action Destination

N b1 x c3

Piece Square Action Destination

g2 - g4

Square Action Destination

Bishop at c8 captures knight at h3

$\mathbb{B} \text{ c8 x h3}$



P e2 – e4

p g7 – g5

Knight at b2 moves to c3

pawn at f7 moves to f5

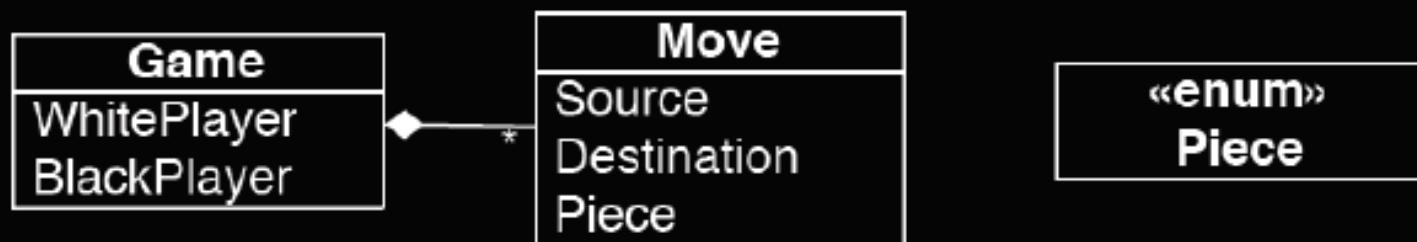
Q d1 – h5

1-0

Concrete Syntax

Constraints !!!

Abstract Syntax



Chess Example - Grammar

Game:

```
"White:" whitePlayer=STRING  
"Black:" blackPlayer=STRING  
(moves+=Move)+;
```

Move:

```
AlgebraicMove | SpokenMove;
```

AlgebraicMove:

```
(piece=Piece)? source=Square (captures?='x' | '-') dest=Square;
```

SpokenMove:

```
piece=Piece 'at' source=Square  
(captures?='captures' capturedPiece=Piece 'at' | 'moves to')  
dest=Square;
```

terminal Square:

```
('a'..'h')('1'..'8');
```

enum Piece:

```
pawn    = 'P' | pawn = 'pawn' |  
knight  = 'N' | knight = 'knight' |  
bishop  = 'B' | bishop = 'bishop' |  
rook    = 'R' | rook = 'rook' |  
queen   = 'Q' | queen = 'queen' |  
king    = 'K' | king = 'king';
```

Chess Example - Model

White: "Mayfield"

Black: "Trinks"

pawn at e2 moves to e4

pawn at f7 moves to g5

K b1 - c3

f7 - f5

queen at d1 moves to h5

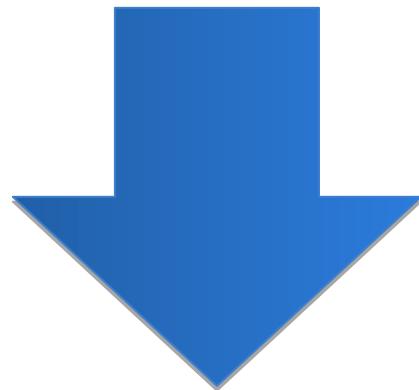
// 1-0



```
foo1.videogen ✘

mandatory videoseq v1 "https://www.youtube.com/watch?v=PjNi1uYhV5w"
optional videoseq v2 "v2Folder/v2.mp4"
alternatives v3 {
    videoseq v31 "v3/seq1.mp4"
    videoseq v32 "v3/seq1.mp4"
    videoseq v33 "v3/seq1.mp4"
}

alternatives v4 {
    videoseq v41 "v4/seq1.mp4"
    videoseq v42 "v4/seq1.mp4"
}
mandatory videoseq v5 "https://www.youtube.com/watch?v=ezKx-S0LiNQ"
```



 FFmpeg

foo1.videoogen

```
mandatory videoseq v1 "https://www.youtube.com/watch?v=PjNi1uYhV5w"
optional videoseq v2 "v2Folder/v2.mp4"
@alternatives v3 {
    videoseq v31 "v3/seq1.mp4"
    videoseq v32 "v3/seq1.mp4"
    videoseq v33 "v3/seq1.mp4"
}

@alternatives v4 {
    videoseq v41 "v4/seq1.mp4"
    videoseq v42 "v4/seq1.mp4"
}
mandatory videoseq v5 "https://www.youtube.com/watch?v=ezKx-S0LiNQ"
```

Quizz Time

Write a Xtext grammar so that the specification below is conformant

foo1.videogen

```
mandatory videoseq v1 "https://www.youtube.com/watch?v=PJNi1uYhV5w"
optional videoseq v2 "v2folder/v2.mp4"
@alternatives v3 {
    videoseq v31 "v3/seq1.mp4"
    videoseq v32 "v3/seq1.mp4"
    videoseq v33 "v3/seq1.mp4"
}

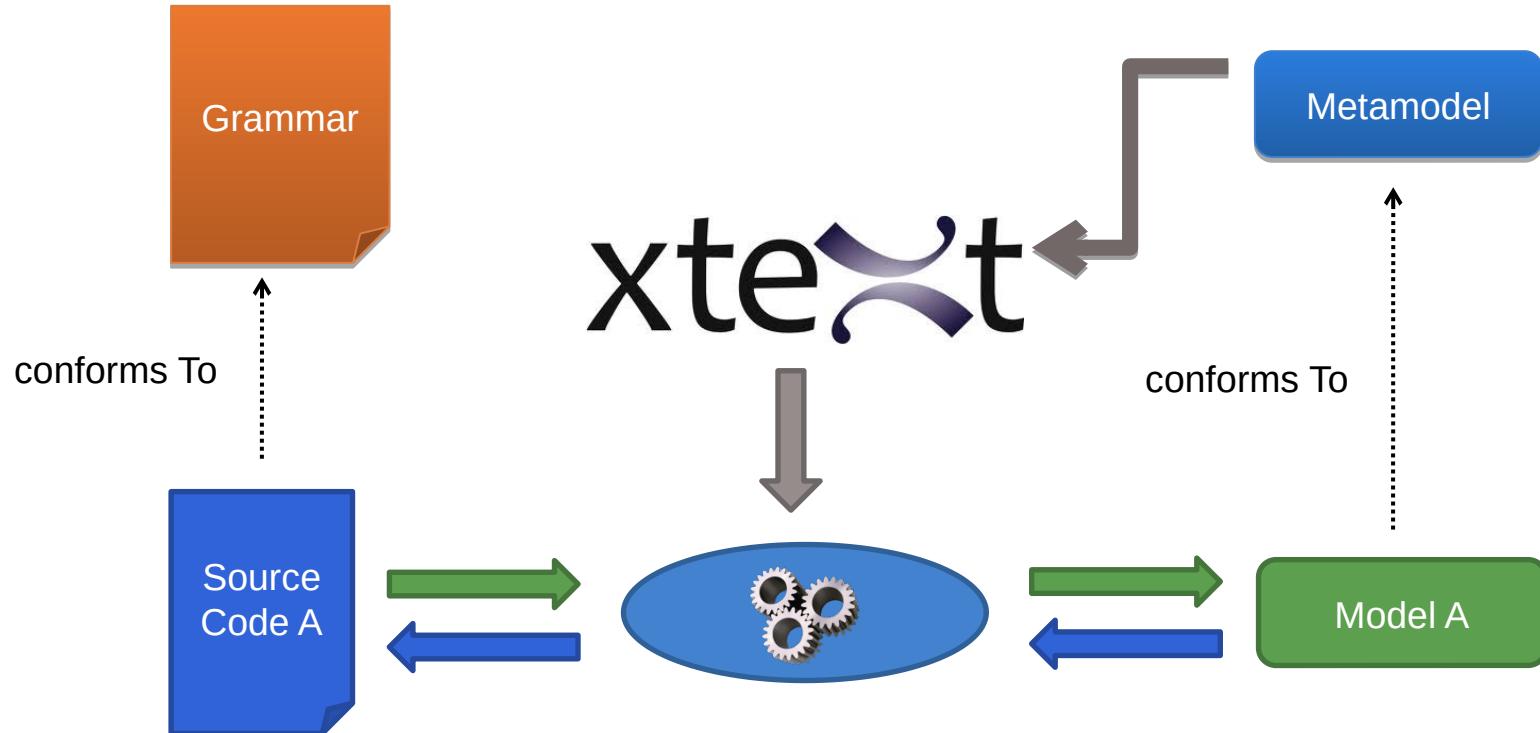
@alternatives v4 {
    videoseq v41 "v4/seq1.mp4"
    videoseq v42 "v4/seq1.mp4"
}
mandatory videoseq v5 "https://www.youtube.com/watch?v=ezKx-S0LiNQ"
```

From Metamodel

To

Grammar (other side)

From Metamodel to Grammar





Give me a **metamodel**,

I'll give you (for free)

- * a comprehensive editor (auto-completion, syntax highlighting, etc.) in Eclipse
- * a grammar and facilities to load/serialize/visit conformant models (Java ecosystem)
- * extension to override/extend « default » facilities (e.g., checker)



Give me a **metamodel**,

The grammar can be « weird » (i.e., not as concise and as comprehensible than if you made it manually)

[Same observation actually applies to the other side: generated metamodels (from grammar) can be weird as well, but you have at least some control in Xtext-based grammar]
[We will experiment in the lab sessions]

Live

Demonstration

New

Select a wizard

Create an Xtext project from existing Ecore models

Wizards:

Xtext

- ▼ Xtext
 - Xtext Project
 - Xtext Project From Existing Ecore Models**
- ▼ Continuous Integration
 - Build Xtext with Buckminster
- ▼ Examples
 - Xtext Domain-Model Example
 - Xtext Home Automation Example
 - Xtext Simple Arithmetics Example
 - Xtext State-Machine Example
- ▼ Examples
 - Xtext Examples
 - Xtext Domain-Model Example
 - Xtext Home Automation Example

?

< Back Next > Cancel Finish

New Xtext Project From Ecore

Select EPackages

Select the EPackages to generate an Xtext grammar for.

EPackages:

org.xtext.example.mydsl.questionnaire.QuestionnairePackage (default package)

Add... Set Default Remove

Entry rule:

PollSystem - questionnaire

?

< Back Next > Cancel Finish

```
// automatically generated by Xtext
grammar org.xtext.example.mydsl.Questionnaire2 with org.eclipse.xtext.common.Terminal

import "http://www.xtext.org/example/mydsl/Questionnaire"
import "http://www.eclipse.org/emf/2002/Ecore" as ecore

PollSystem returns PollSystem:
    {PollSystem}
    'PollSystem'
    '{'
        ('polls' '{' polls+=Poll ( "," polls+=Poll)* '}' )?
    '}';
    13
    14
    15
    16

Poll returns Poll:
    {Poll}
    'Poll'
    name=EString
    '{'
        ('questions' '{' questions+=Question ( "," questions+=Question)* '}' )?
    '}';
    24

EString returns ecore::EString:
    STRING | ID;
    27

Question returns Question:
    {Question}
    'Question'
    '{'
        ('id' id=EString)?
        ('text' text=EString)?
        ('options' '{' options+=Option ( "," options+=Option)* '}' )?
    '}';
    36

Option returns Option:
    {Option}
    'Option'
    '{'
        ('id' id=EString)?
        ('text' text=EString)?
    '}';
    44
```

Quizz Time

**Explain (roughly) the
« algorithm » of Xtext to
generate a grammar from an
ecore Metamodel**

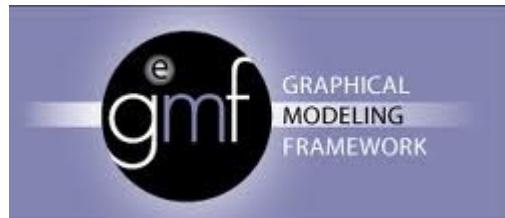
My 3 take away messages

- #1 *DSLs are important (as intuited for a long time – it will become more and more apparent)*
- #2 *DSL technology is here (no excuse)*
- #3 *MDE meets language engineering*

Questions ?

(see also resources and lab sessions)

[http://martinfowler.com/
bliki/DomainSpecificLanguage.html](http://martinfowler.com/bliki/DomainSpecificLanguage.html)

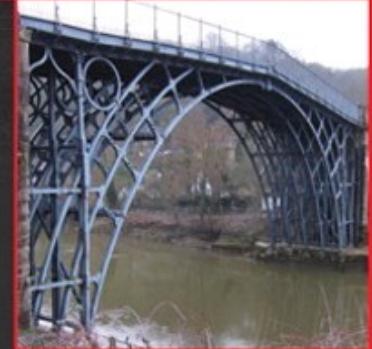
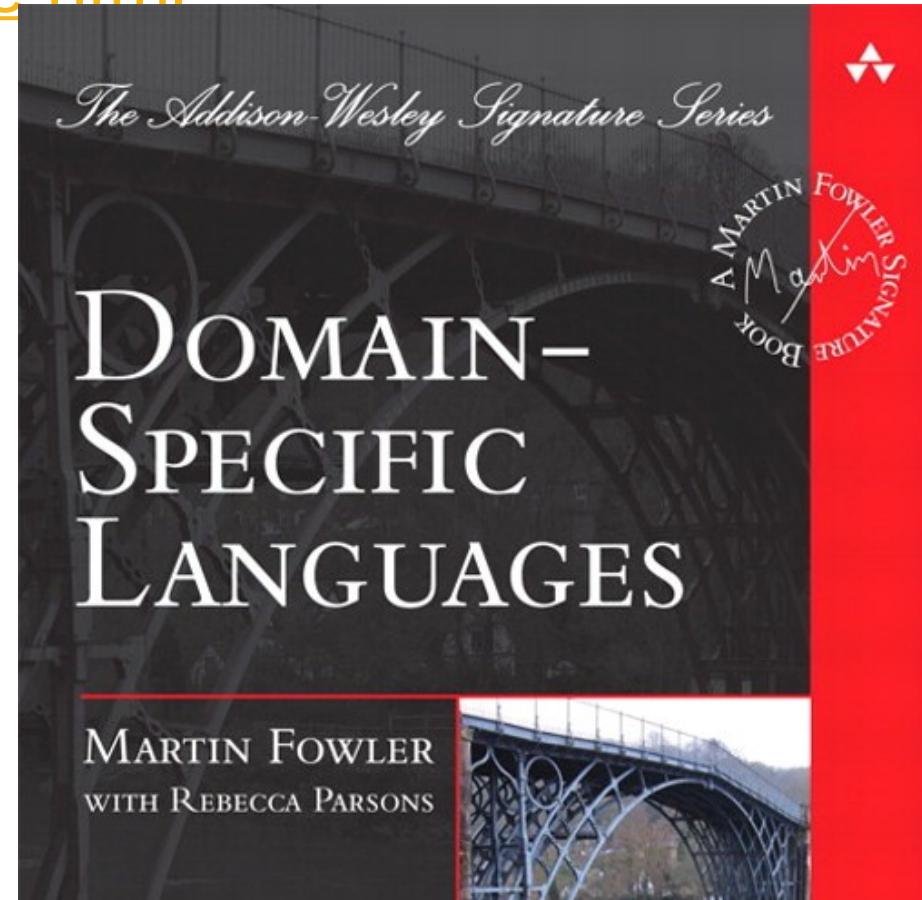


Empirical Assessment of MDE in Industry

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