

Domain-Specific Languages

Plan

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

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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)

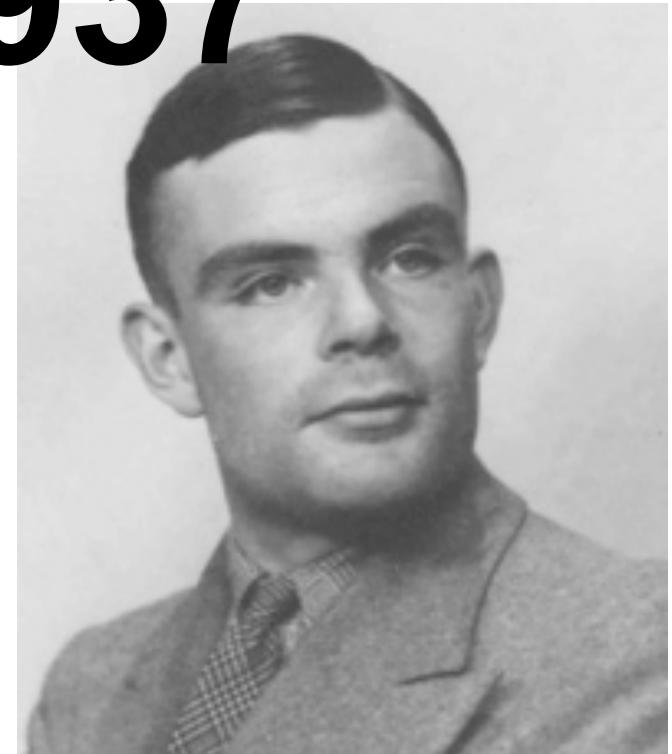
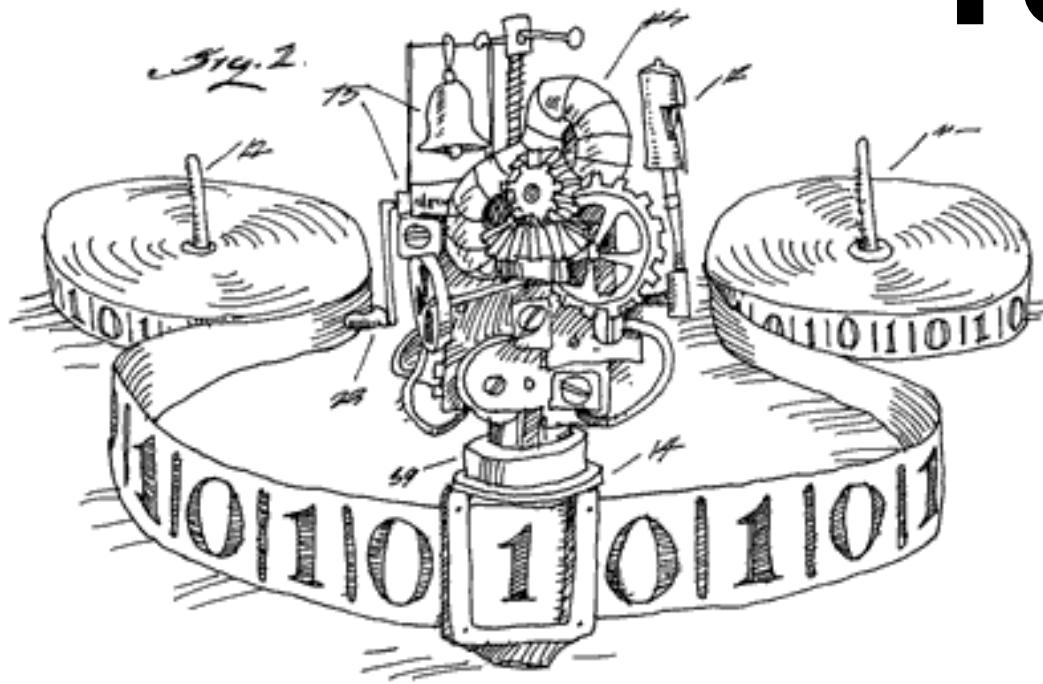
What are DSLs

Where are DSLs

Why DSLs (will) matter

The (Hi)Story of Software Engineering / Computer Science

1937

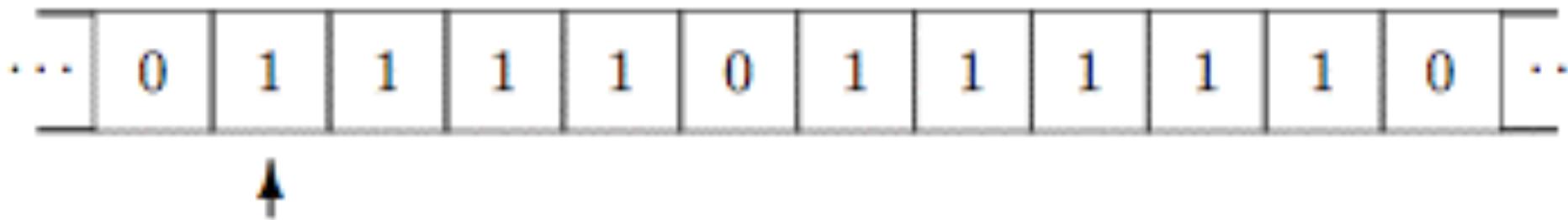


Turing Machine

- Infinite tape divided into Cells (0 or 1)
- Read-Write Head
- Transition rules

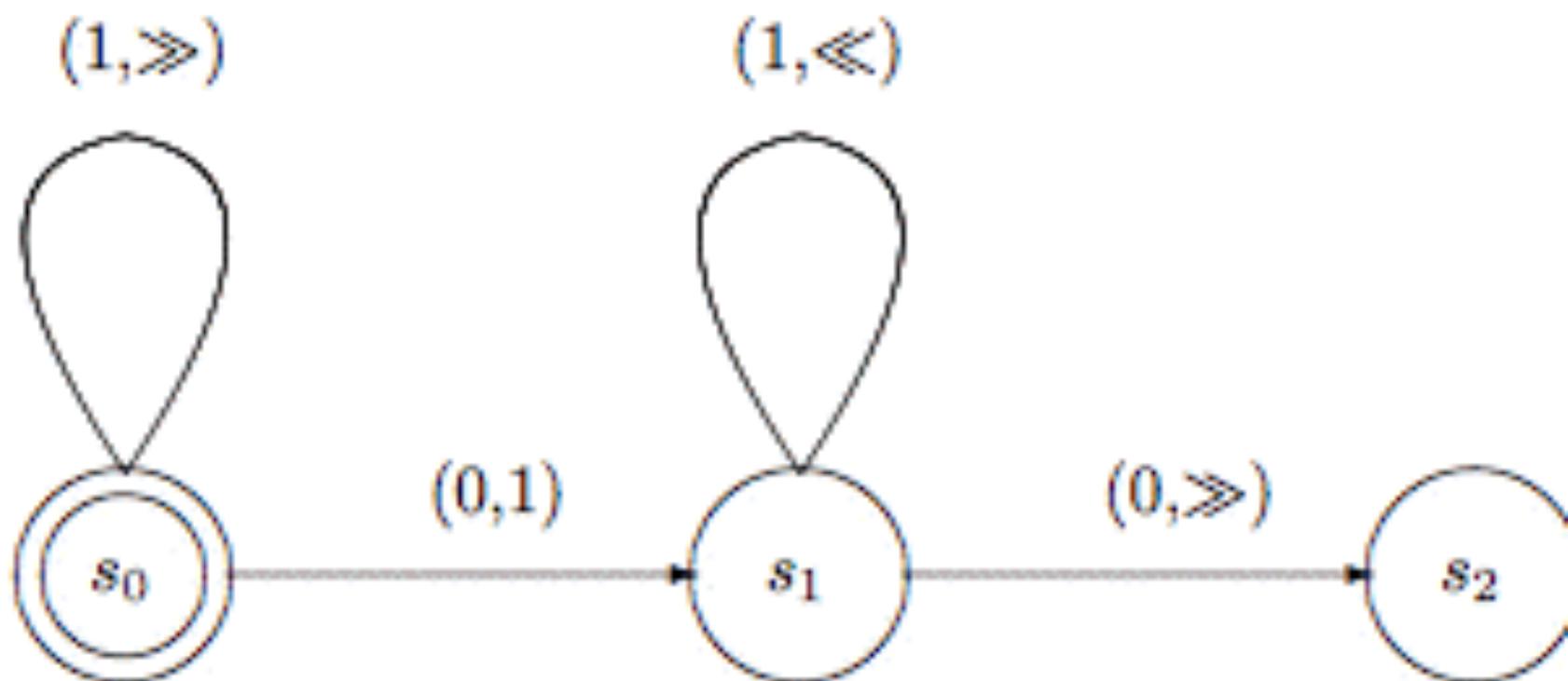
**Write a symbol
or move to left (>>) or right
(<<)**

< State_{current}, Symbol, State_{next}, Action >

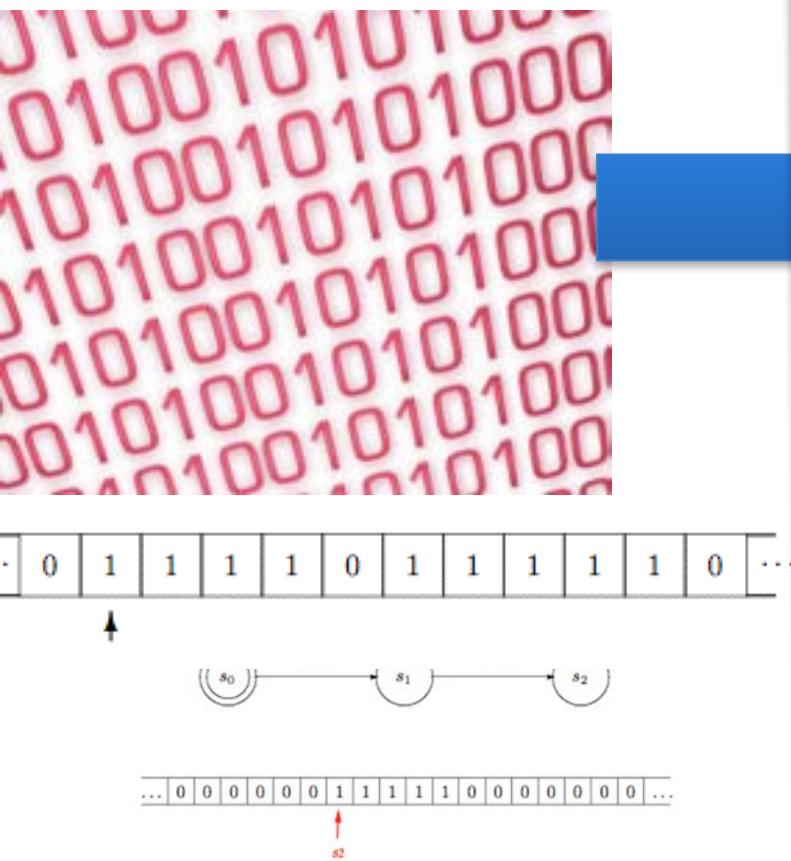


Turing Machine

~ kind of state machine



The (Hi)Story of Software Engineering / Computer Science

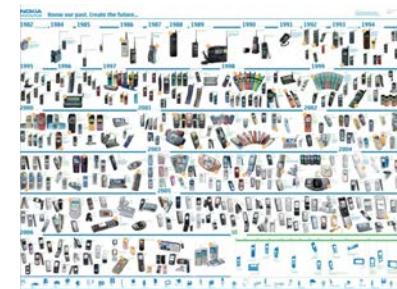
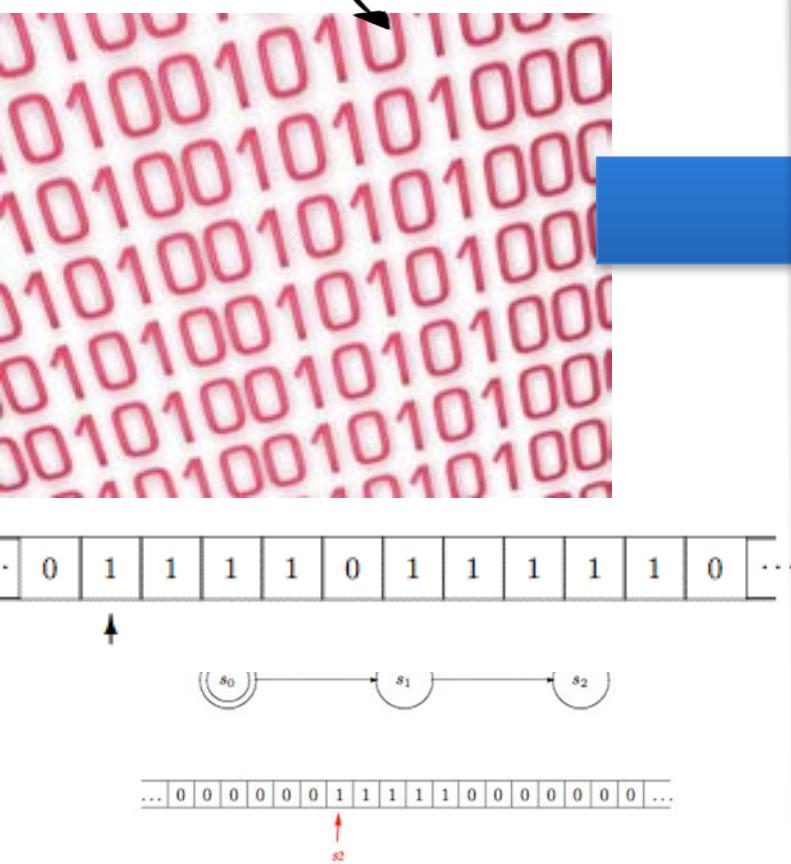


Google

twitter



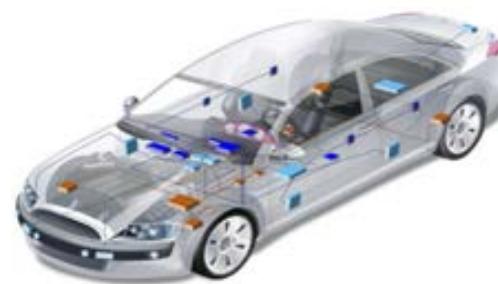
Software Languages



orange™



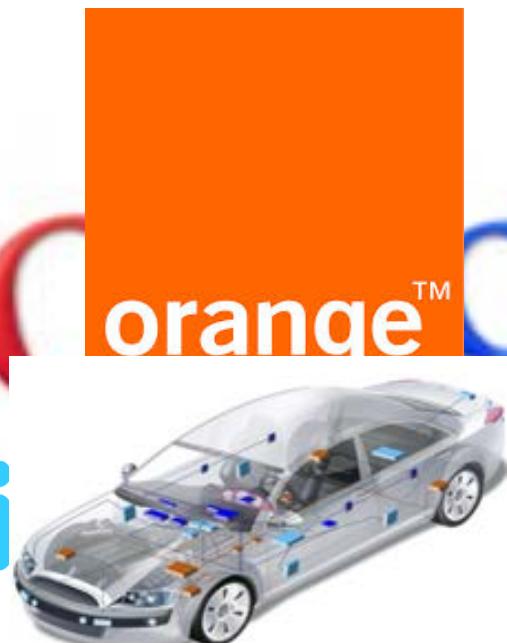
Google
twitter



Programming the Turing Machine

Why aren't we using tapes, states and transitions after all ?

Complex Systems



Distributed systems

Thousands of engineers/expertise

Web dev.

Large-scale systems

Critical Systems

Programming the Turing Machine

Why aren't we using tapes, states and transitions after all ?

You cannot be serious



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3CD LIMITED EDITION BOX SET • 2CD • 2LP • DOWN
AVAILABLE DECEMBER 10, 2013

Implementing a Turing machine in Excel

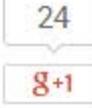
Cory Doctorow at 2:20 pm Fri, Sep 20, 2013



Like



142



24

The screenshot shows a Microsoft Excel spreadsheet titled "Turing Machine_Succesors.xlsx". The formula bar displays a complex formula involving VLOOKUP and INDEX functions. The main content of the spreadsheet consists of two columns of binary digits (0s and 1s) representing the state transitions of a Turing machine. The first column contains the initial state and the second column contains the successor state for each input.

	0	1
0	0 1	1 0
1	0 1	1 0
2	0 1	1 0
3	0 1	1 0
4	0 1	1 0
5	0 1	1 0
6	0 1	1 0
7	0 1	1 0
8	0 1	1 0
9	0 1	1 0
10	0 1	1 0
11	0 1	1 0
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Formulas are Turing complete

Turing Machine Successor.xlsx - Microsoft Excel																		
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Clipboard		Font				Alignment			Number			Styles			Cells		Editing	
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1		B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	
2		14		4	<---													
4	4 S1	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	
5	5 S1	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	
6	6 S1	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	
7	7 S1	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	
8	8 S2	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	
9	9 S2	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	
10	10 S2	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	
11	9 S3	-	-	-	-	1	1	1	1	1	-	-	-	-	-	-	-	
12	8 S3	-	-	-	-	1	1	1	1	1	1	-	-	-	-	-	-	
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14	6 S3	-	-	-	-	1	1	1	1	1	1	1	-	-	-	-	-	
15	7 S4	-	-	-	-	1	1	1	1	1	1	1	-	-	-	-	-	
16	7 S4	-	-	-	-	1	1	1	1	1	1	1	-	-	-	-	-	
17	7 S4	-	-	-	-	1	1	1	1	1	1	1	-	-	-	-	-	
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25	7 S4	-	-	-	-	1	1	1	1	1	1	1	-	-	-	-	-	
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29	7 S4	-	-	-	-	1	1	1	1	1	1	1	-	-	-	-	-	
30	7 S4	-	-	-	-	1	1	1	1	1	1	1	-	-	-	-	-	

Youtube video <https://t.co/RTfJAxX>

<http://fr.slideshare.net/Felienne/spreadsheets-are-code-online>

Esoteric programming languages

- Designed to test the boundaries of computer programming language design, as a proof of concept, as software art, or as a joke.
 - extreme paradigms and design decisions
 - Eg <https://esolangs.org/wiki/Brainfuck>
- Usually, an esolang's creators do not intend the language to be used for mainstream programming.

(brainfuck)

What does it compute?

```
+++++++[>+++++>++++++>+++<<<-  
]>++.>+.++++++  
.++,>++.<<+++++++.>,++,.----,.----,>+.
```

Quizz Time

- Why assembly language is not the mainstream language?
- Why spreadsheets are not used for building Google?
- Why esoteric languages are not used for mainstream programming?

Programming the Turing Machine

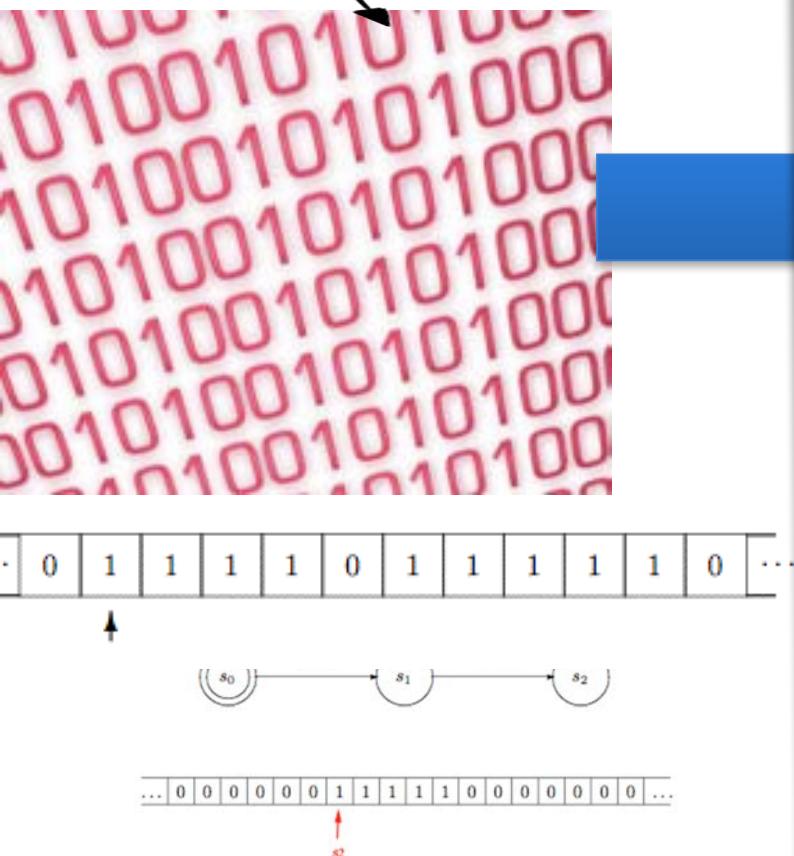
Why aren't we using tapes, states and transitions after all ?

Software Languages



Not fun. Over complicated.
Hard to write and
understand. No abstractions.
Poor language constructs.
Tooling Support?

Languages



Complex Systems



Google

twitter



Instagram



How Language Shapes Thought

The languages we speak affect our perceptions of the world

By Lera Boroditsky

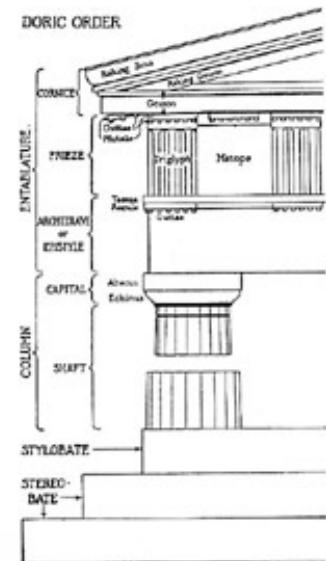
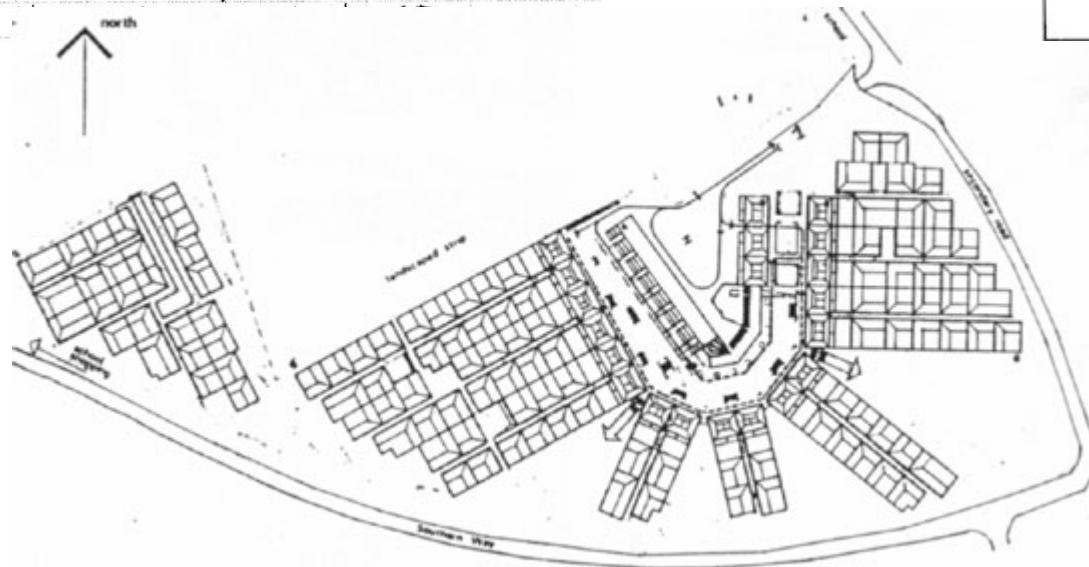
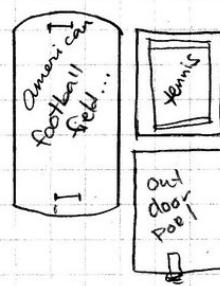
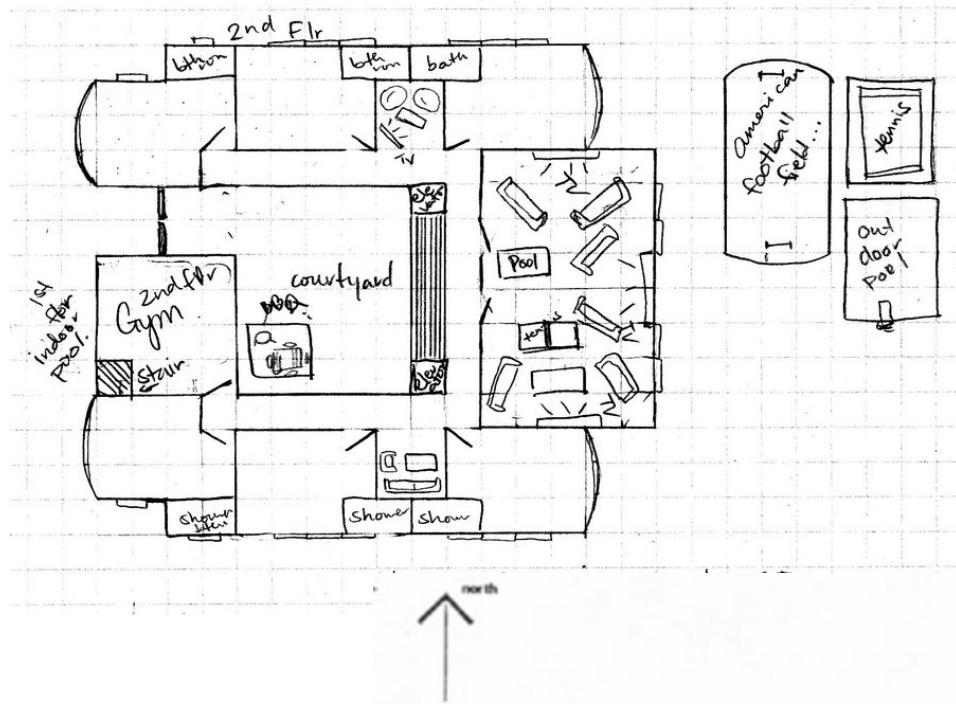
“Even variations in grammar can profoundly affect how we see the world.”

She's talking about real languages; **what about synthetic, programming languages?**

What is a language?

- « A system of signs, symbols, gestures, or rules used in **communicating** »
- « The **special** vocabulary and usages of a scientific, professional, or other group »
- « A system of symbols and rules used for communication with or between computers. »

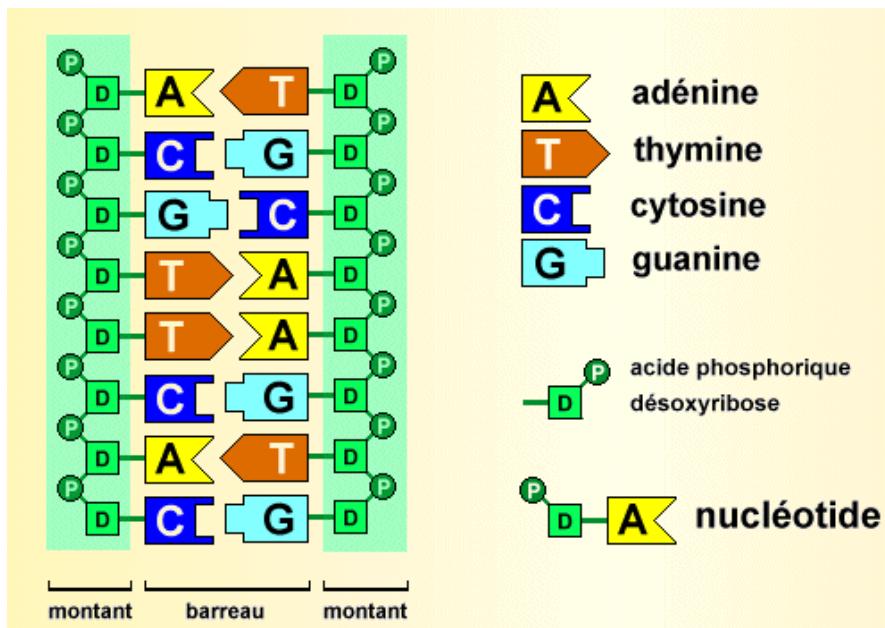
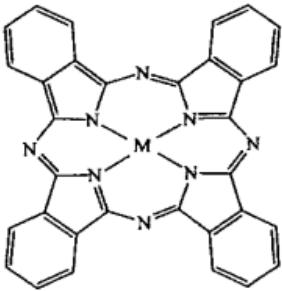
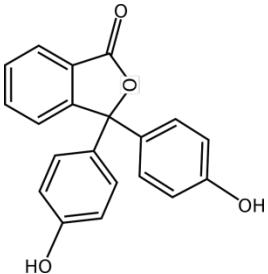
Architecture



Cartography



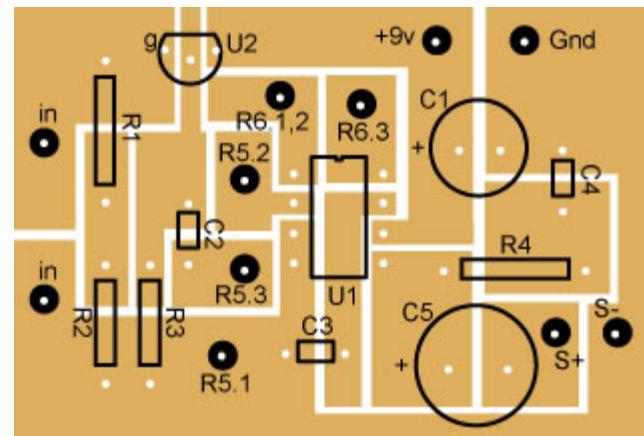
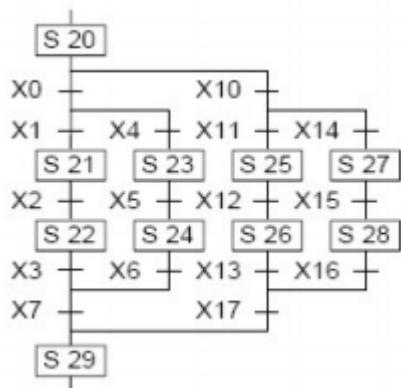
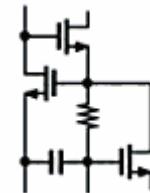
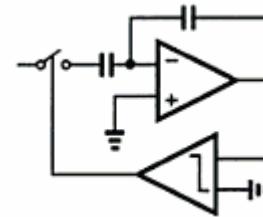
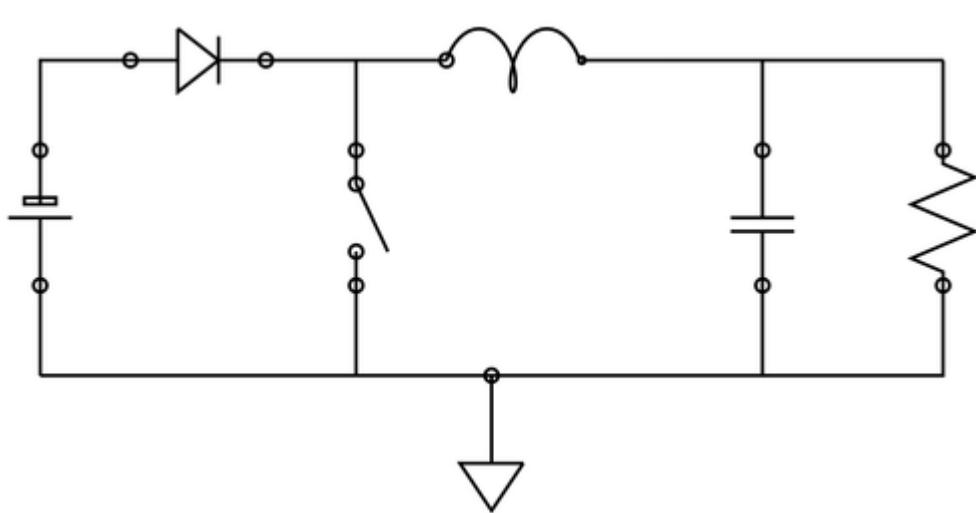
Biology



60	70	80	90	100
AGACCCCCAG	CAACCCCCGG	GGCCGTGCGG	CCTCGGTCGT	GTCGTGTGAT
160	170	180	190	200
AGACCCCGCG	TACGAATGCC	GGTCCACCAA	CAACCCGTGG	GCTTCGCAGC
260	270	280	290	300
CTGCCGGGCA	TGTACAGTC	TTGTCGGCAG	TTCTTCCACA	AGGAAGACAT
360	370	380	390	400
GGCTTGCTGG	GGCCCCCGCC	ACCAGCACTA	CAGACCTCCA	GTACGTCGTG
460	470	480	490	500
GGCCTATCCC	ACGCTCGCCG	CCAGCCACAG	AGTTATGCTT	GCCGAGTACA
560	570	580	590	600
GAAAGGGTGG	CGCCGATGAA	GAGACTATT	AAGCTGGAA	ACAAGGTGGT
660	670	680	690	700
ATAGTGGTTA	ACTTCACCTC	CAGACTCTTC	GCTGATGAAC	TGGCCGCCCT
760	770	780	790	800
AAAATATACA	GGCATTTGGC	CTGGGGTGCG	TATGCTCACG	TGAGACATCT
860	870	880	890	900
CCTGGAGGAG	GTTCGCCCCG	ACAGCCTGCG	CCTAACGCGG	ATGGATCCCT
960	970	980	990	1000
AGCAACACCC	AGCTAGCAGT	GCTACCCCCA	TTTTTTAGCC	GAAAGGATTC
1060	1070	Pvu II site	1090	1100
TGCCCGCAGCA	ACTGGGGCAC	GCTATTCTGC	AGCAGCTGTT	GGTGTACCA
1160	1170	1180	1190	1200
ACTTGATCTA	TATACCCACCA	ATGTGTCATT	TATGGGGCCGC	ACATATCGTC
1260	1270	1280	1290	1300
CTGTCATGT	ACCTTTGTAT	CCTATCAGCC	TTGGTTCCCA	GGGGGTGTCT
1360	1370	1380	1390	1400
TGTTTGAGGG	GGTGGTGCCA	GATGAGGTGA	CCAGGATAGA	TCTCGACCAG
1460	1470	1480	1490	1500
TCAGAGTCCTC	AGTTCTATAT	TTAACCTTGG	CCCCAGACTG	CACGTGTATG
1560	1570	1580	1590	1600
CGATTTGAAG	CGGGGGGGGT	ATGGCGTCAT	CTGATATTCT	GTGGGTTGCA
1660	1670	1680	1690	1700
AAAAACTTACC	GTCTACCTGC	CGGACACTGA	ACCCCTGGGTG	GTAGAGACCG
1760	1770	1780	1790	1800
AAGCTTCATC	GTGGTGCCT	GCCCTCAAAT	TCTCACAAAG	GCTTGAGGAT

CTG.

Electronics



In Software Engineering

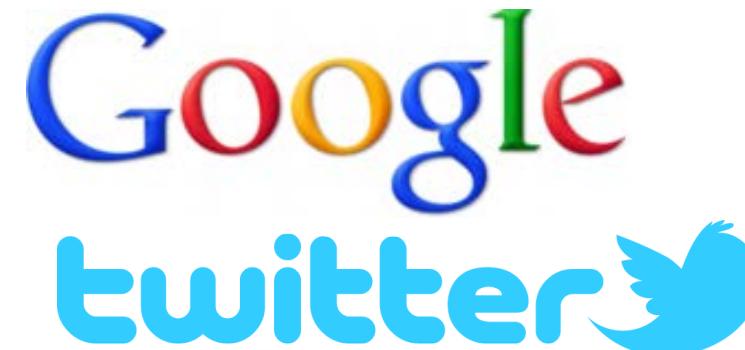
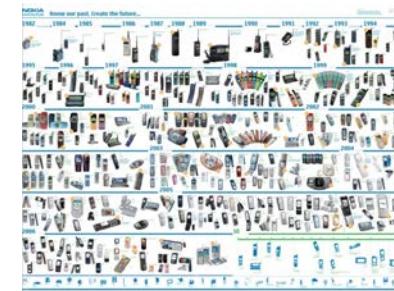
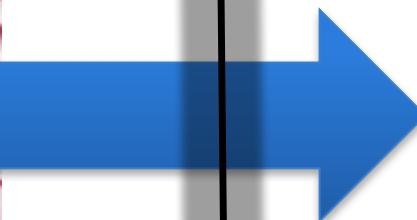
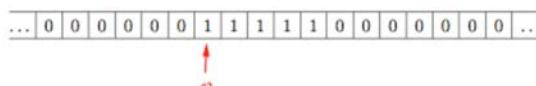
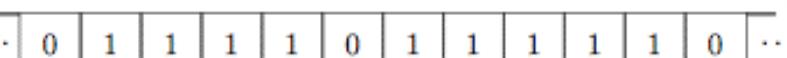
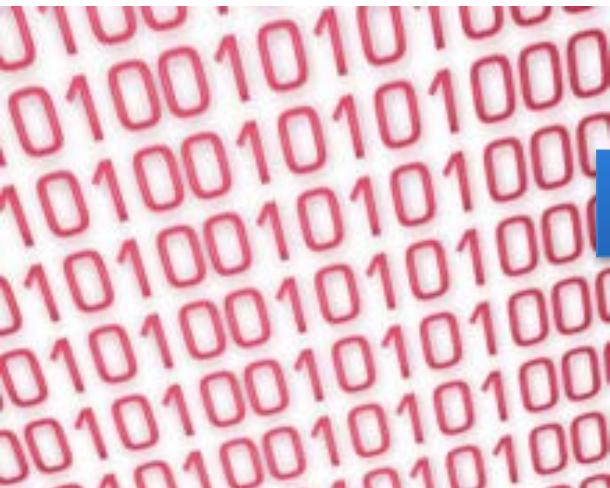
« Languages are the primary way in which system developers communicate, design and implement software systems »

General Purpose Languages

Assembly ?

COBOL ? LISP ? C ? C++ ?

Java? PHP ? C# ? Ruby ?



Limits of General Purpose Languages (1)

- **Abstractions and notations** used are not natural/suitable for the stakeholders



```
if (newGame) resources.free();
s = FILENAME + 3;
setLocation(); load(s);
loadDialog.process();

try { setGamerColor(RED); }
catch(Exception e) { reset(); }
while (notReady) { objects.make();
if (resourceNotFound) break;

byte result; // сменить на int!
music();
System.out.print("");
```



Limits of General Purpose Languages (2)

- Not targeted to a **particular** kind of problem, but to any kinds of software problem.



Domain Specific Languages

- Targeted to a **particular** kind of problem, with dedicated notations (textual or graphical), support (editor, checkers, etc.)
- Promises: more « efficient » languages for resolving a set of specific problems in a domain



Domain Specific Languages (DSLs)

- Long history: used for almost as long as computing has been done.
- You're using DSLs in a daily basis
- You've learnt many DSLs in your curriculum
- Examples to come!

HTML

```
<?xml version="1.0" encoding="iso-8859-1"?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "DTD/xhtml1-transitional.dtd">
<html xml:lang="en" lang="en" xmlns="http://www.w3.org/1999/xhtml">
  <head>
    <title>Hello World</title>
  </head>
  <body>
    <p>My first Web page.</p>
  </body>
</html>
```

Domain: web (markup)

CSS

```
.CodeMirror {  
    line-height: 1;  
    position: relative;  
    overflow: hidden;  
}  
  
.CodeMirror-scroll {  
    /* 30px is the magic margin used to hide the element's real scrollbars */  
    /* See overflow: hidden in .CodeMirror, and the paddings in .CodeMirror-sizer */  
    margin-bottom: -30px; margin-right: -30px;  
    padding-bottom: 30px; padding-right: 30px;  
    height: 100%;  
    outline: none; /* Prevent dragging from highlighting the element */  
    position: relative;  
}  
.CodeMirror-sizer {  
    position: relative;  
}
```

Domain: web (styling)

SQL

```
SELECT Book.title AS Title,  
       COUNT(*) AS Authors  
  FROM Book  
 JOIN Book_author  
    ON Book.isbn = Book_author.isbn  
GROUP BY Book.title;
```

```
INSERT INTO example  
(field1, field2, field3)  
VALUES  
( 'test' , 'N' , NULL);
```

Domain: database (query)

Makefile

```
PACKAGE      = package
VERSION      = `date "+%Y.%m%d%" `
RELEASE_DIR  = ..
RELEASE_FILE = $(PACKAGE)-$(VERSION)

# Notice that the variable LOGNAME comes from the environment in
# POSIX shells.
#
# target: all - Default target. Does nothing.
all:
    echo "Hello $(LOGNAME), nothing to do by default"
    # sometimes: echo "Hello ${LOGNAME}, nothing to do by default"
    echo "Try 'make help'"

# target: help - Display callable targets.
help:
    egrep "^# target:" [Mm]akefile

# target: list - List source files
list:
    # Won't work. Each command is in separate shell
    cd src
    ls

    # Correct, continuation of the same shell
    cd src; \
    ls
```

Domain: software building

Lighttpd configuration file

```
server.document-root = "/var/www/servers/www.example.org/pages/"

server.port = 80

server.username = "www"
server.groupname = "www"

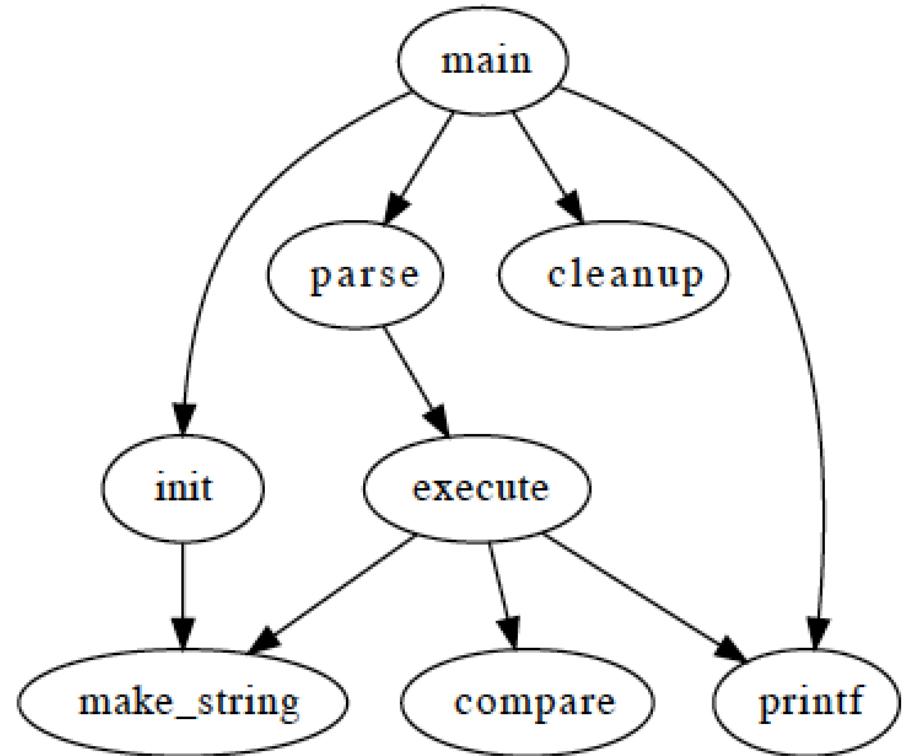
mimetype.assign = (
    ".html" => "text/html",
    ".txt" => "text/plain",
    ".jpg" => "image/jpeg",
    ".png" => "image/png"
)

static-file.exclude-extensions = ( ".fcgi", ".php", ".rb", "~", ".inc" )
index-file.names = ( "index.html" )
```

Domain: web server (configuration)

Graphviz

```
digraph G {  
    main -> parse -> execute;  
    main -> init;  
    main -> cleanup;  
    execute -> make_string;  
    execute -> printf  
    init -> make_string;  
    main -> printf;  
    execute -> compare;  
}
```



Domain: graph (drawing)

Regular expression

```
<TAG\b[^>]*>(.*)?</TAG>
```

Domain: strings (pattern matching)

OCL

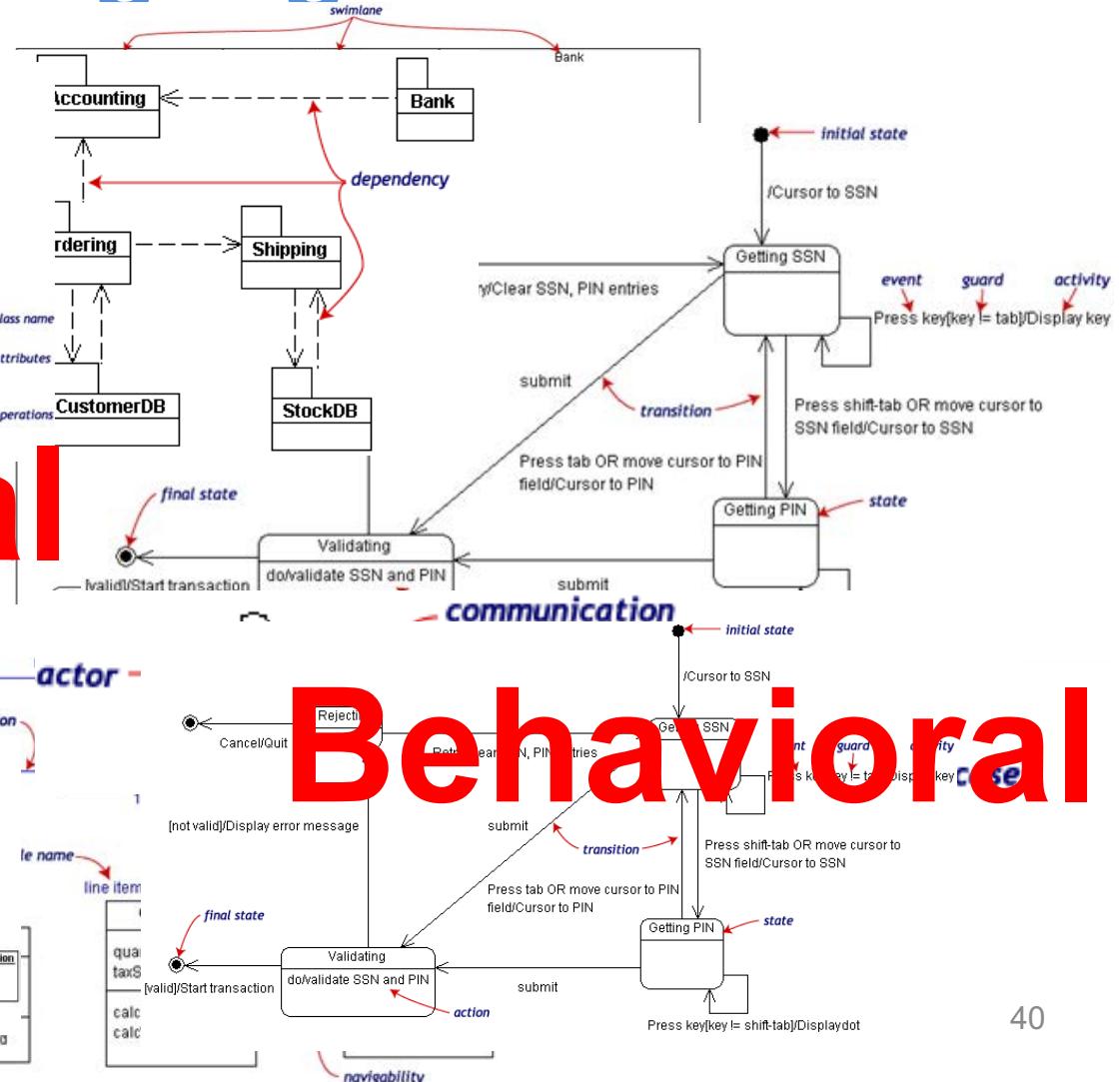
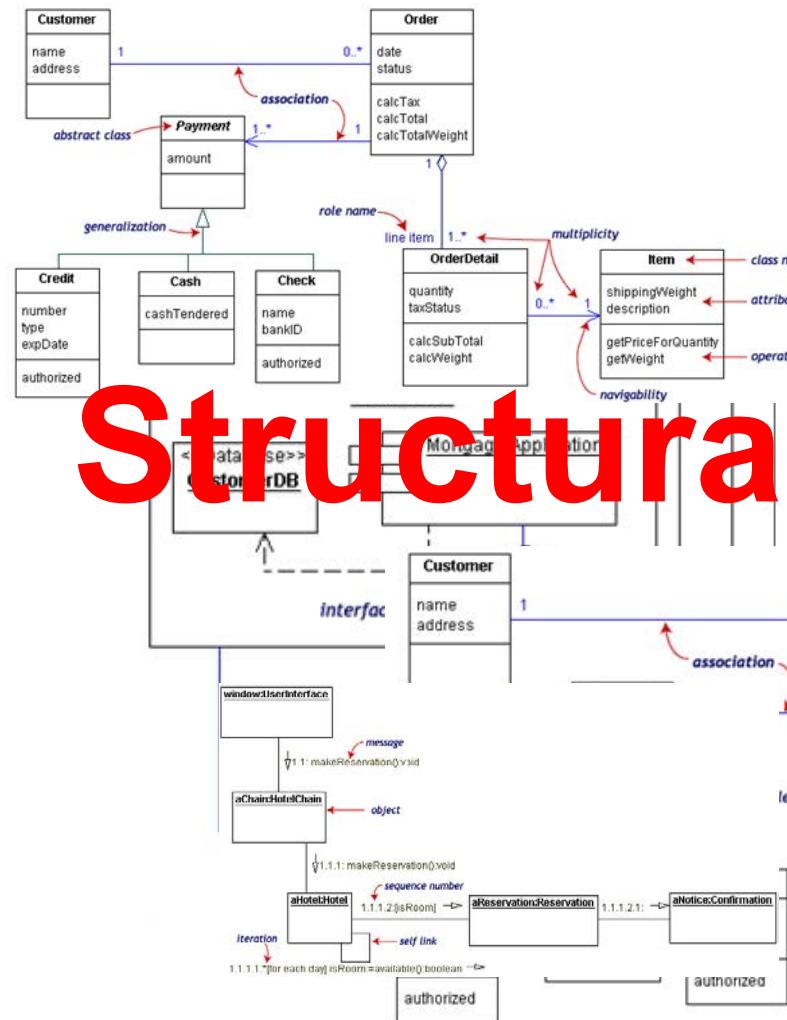
```
self.questions->size  
self.employer->size  
self.employee->select (v | v.wages>10000 )->size  
Student.allInstances  
->forAll( p1, p2 |  
    p1 <> p2 implies p1.name <> p2.name )
```

Domain: model management

**UML can be seen as a collection
of domain-specific modeling
languages**

Structural

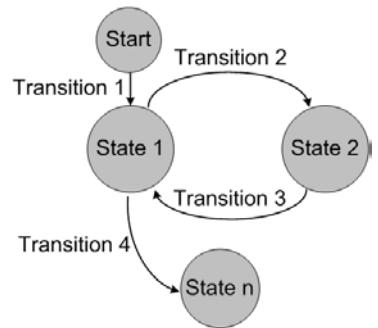
Behavioral



BIBTEX



Graphviz



Finite State Machine



Domain-Specific Languages (DSLs)

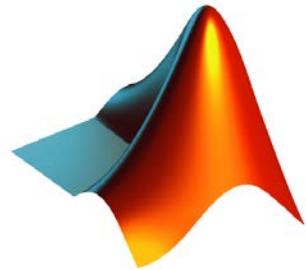
```
[Event "F/S Return Match"]
[Site "Belgrade, Serbia Yugoslavia[JUG]"]
[Date "1992.11.04"]
[Round "29"]
[White "Fischer, Robert J."]
[Black "Spassky, Boris V."]
[Result "1/2-1/2"]
```

```
1. e4 e5 2. Nf3 Bb5 3. c3 Nc6 4. d4 Bb7 5. O-O Be7 6. Bb5 7. Bb3 8. e3 0-0 9. Nc3 10. Nf6 11. c4 c6 12. c5 Nc6 13. Nf6 14. Nc3 15. Nf6 16. Nc3 17. Nf6 18. Nc3 19. exd5 20. Nf6 21. Nc3 22. Nf6 23. Ne5 Rae8 24. Rxf7+ Rxf7 25. Nf6 26. Nf6 27. Nf6 28. Qxf6 29. b3 Ke8 30. a3 Kd6 31. axb4 cxb4 32. Ra5 Nd5 33. Ra7 g6 34. Ra6+ Kc5 35. Ke1 Nf4 38. g3 Nxh3 39. Nf2 42. g4 Bd3 43. Re6 1/2-1/2
```

PGN



Make



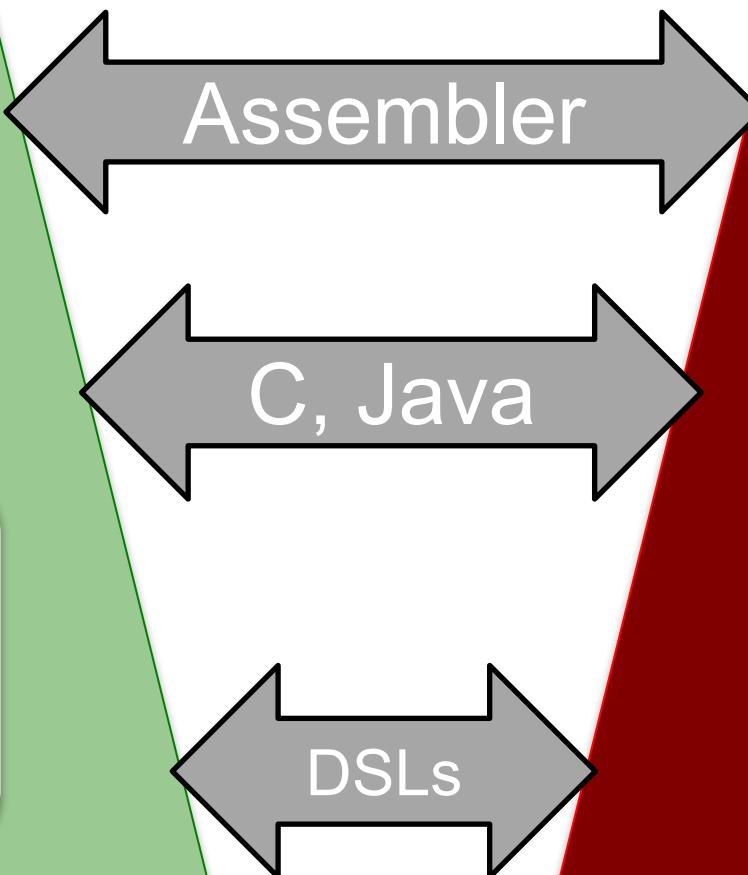
Matlab



Abstraction Gap

Problem
Space

Solution
Space



orange™



Google

twitter



« Another lesson we should have learned from the recent past is that the development of 'richer' or 'more powerful' programming languages was a mistake in the sense that these baroque monstrosities, these conglomerations of idiosyncrasies, are really unmanageable, both mechanically and mentally.

aka General-Purpose Languages

I see a great future for very systematic and very modest programming languages »

1972



aka Domain-Specific Languages

ACM Turing Lecture, « The Humble Programmer »
Edsger W. Dijkstra

Empirical Assessment of MDE in Industry

John Hutchinson, Jon Whittle, Mark Rouncefield

School of Computing and Communications
Lancaster University, UK
+44 1524 510492

{j.hutchinson, j.n.whittle,
m.rouncefield}@lancaster.ac.uk

Steinar Kristoffersen

Østfold University College and Møreforskning Molde AS
NO-1757 Halden
Norway
+47 6921 5000

steinar.kristoffersen@hiof.no

Model-Driven Engineering Practices in Industry

John Hutchinson
School of Computing and
Communications
Lancaster University, UK
+44 1524 510492

{j.hutchinson@lancaster.ac.uk}

Mark Rouncefield
School of Computing and
Communications
Lancaster University, UK
+44 1524 510492

{m.rouncefield@lancaster.ac.uk}

Jon Whittle
School of Computing and
Communications
Lancaster University, UK
+44 1524 510492

{j.n.whittle@lancaster.ac.uk}

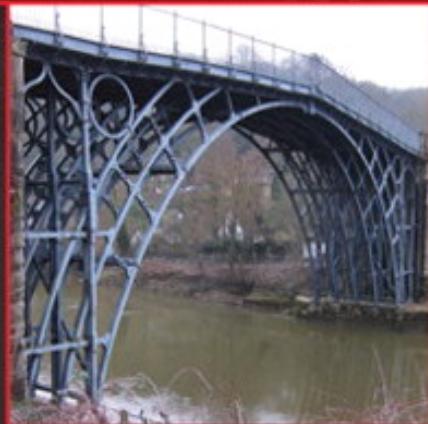
2011

**« Domain-specific
languages are far more
prevalent than
anticipated »**

The Addison-Wesley Signature Series

DOMAIN-SPECIFIC LANGUAGES

MARTIN FOWLER
WITH REBECCA PARSONS



A MARTIN FOWLER SIGNATURE
Book Martin Fowler



2011



What is a domain-specific language ?

- « Language **specially** designed to perform a task in a **certain domain** »
- « A formal processable language targeting at a **specific viewpoint or aspect** of a software system. Its **semantics and notation** is designed in order to support working with that viewpoint as good as possible »
- « A computer language that's targeted to a particular kind of problem, **rather than a general purpose language** that's aimed at any kind of software problem. »

GPL (General Purpose Language)

A *GPL* provides notations that are used to describe a computation in a human-readable form that can be translated into a machine-readable representation.

A *GPL* is a formal notation that can be used to describe problem solutions in a precise manner.

A *GPL* is a notation that can be used to write programs.

A *GPL* is a notation for expressing computation.

A *GPL* is a standardized communication technique for expressing instructions to a computer. It is a set of syntactic and semantic rules used to define computer programs.

Promises of domain-specific languages

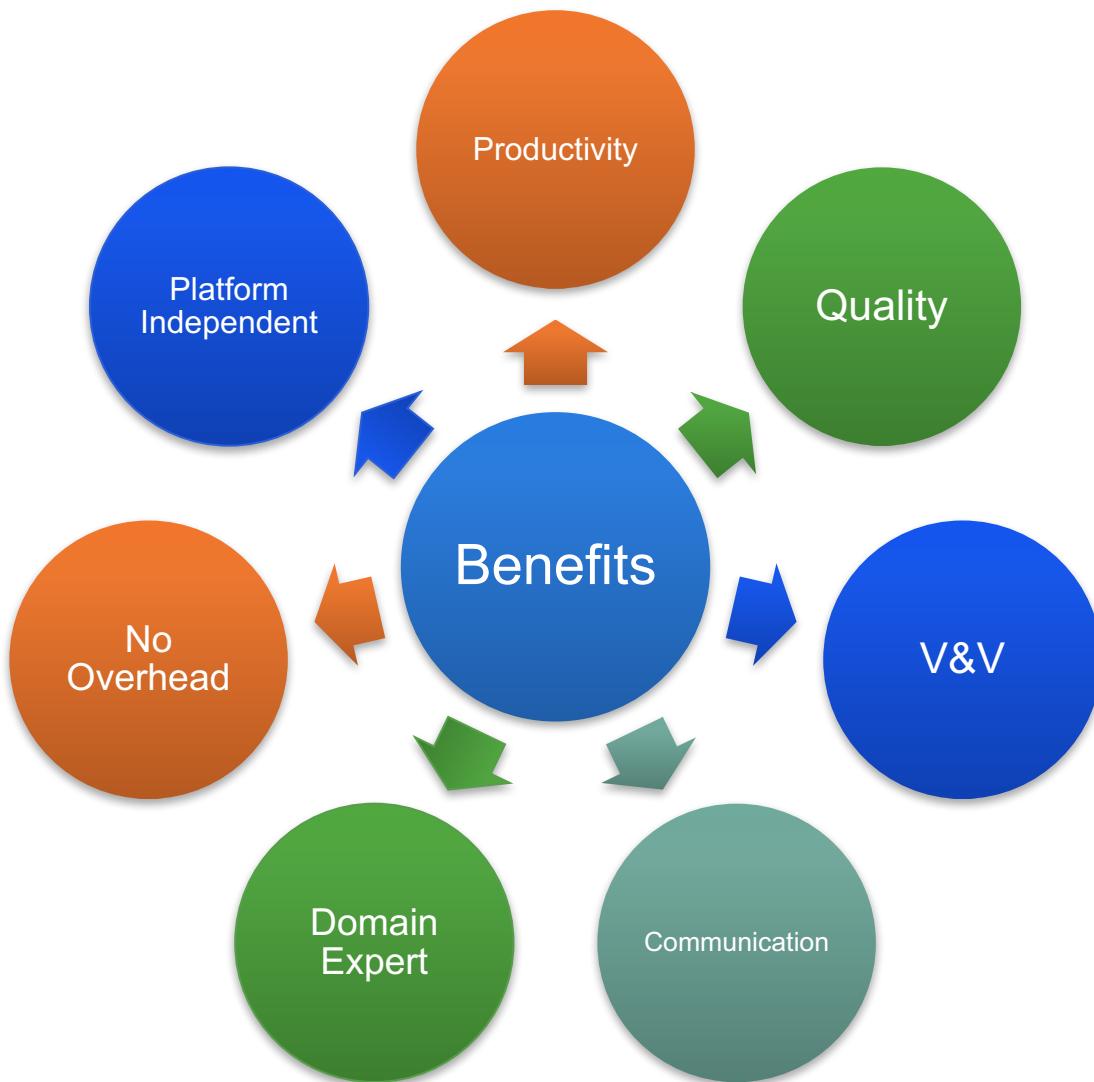
Higher abstractions

Avoid redundancy

Separation of concerns

Use domain concepts

Promises of domain-specific languages



GeneralPL vs DomainSL

The boundary isn't as clear as it could be. Domain-specificity is not black-and-white, but instead gradual: a language is more or less domain specific



	GPLs	DSLs
Domain	large and complex	smaller and well-defined
Language size	large	small
Turing completeness	always	often not
User-defined abstractions	sophisticated	limited
Execution	via intermediate GPL	native
Lifespan	years to decades	months to years (driven by context)
Designed by	guru or committee	a few engineers and domain experts
User community	large, anonymous and widespread	small, accessible and local
Evolution	slow, often standardized	fast-paced
Deprecation/incompatible changes	almost impossible	feasible

External DSLs vs Internal DSLs

- An **external** DSL is a completely separate language and has its own custom syntax/tooling support (e.g., editor)
- An internal DSL is more or less a set of APIs written on top of a host language (e.g., Java).
 - Fluent interfaces

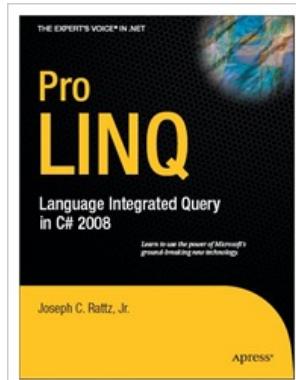
External vs Internal DSL (SQL example)

```
-- Select all books by authors born after 1920,  
-- named "Paulo" from a catalogue:  
SELECT *  
FROM t_author a  
JOIN t_book b ON a.id = b.author_id  
WHERE a.year_of_birth > 1920  
    AND a.first_name = 'Paulo'  
ORDER BY b.title
```

```
Result<Record> result =  
create.select()  
    .from(T_AUTHOR.as("a"))  
    .join(T_BOOK.as("b")).on(a.ID.equal(b.AUTHOR_ID))  
    .where(a.YEAR_OF_BIRTH.greaterThan(1920))  
    .and(a.FIRST_NAME.equal("Paulo")))  
    .orderBy(b.TITLE)  
    .fetch();
```

Internal DSL (LINQ/C# example)

```
// DataContext takes a connection string
DataContext db = new DataContext("c:\\northwind\\northwnd.mdf");
// Get a typed table to run queries
Table<Customer> Customers = db.GetTable<Customer>();
// Query for customers from London
var q =
    from c in Customers
    where c.City == "London"
    select c;
foreach (var cust in q)
    Console.WriteLine("id = {0}, City = {1}", cust.CustomerID, cust.City);
```



Internal DSL

- « Using a host language (e.g., Java) to give the host language the feel of a particular language. »
- Fluent Interfaces**
 - « The more the use of the API has that language like flow, the more fluent it is »

```
Result<Record> result =
    create.select()
        .from(T_AUTHOR.as("a"))
        .join(T_BOOK.as("b")).on(a.ID.equal(b.AUTHOR_ID))
        .where(a.YEAR_OF_BIRTH.greaterThan(1920))
        .and(a.FIRST_NAME.equal("Paulo")))
        .orderBy(b.TITLE)
        .fetch();
```

```
-- Select all books by authors born after 1920,
-- named "Paulo" from a catalogue:
SELECT *
FROM t_author a
JOIN t_book b ON a.id = b.author_id
WHERE a.year_of_birth > 1920
AND a.first_name = 'Paulo'
ORDER BY b.title
```

SQL in... Java

DSL in GPL

```
Connection con = null;

// create sql insert query
String query = "insert into user values(" + student.getId() + ","
    + student.getFirstName() + "','" + student.getLastName()
    + "','" + student.getEmail() + "','" + student.getPhone()
    + "')";

try {
    // get connection to db
    con = new CreateConnection().getConnection("checkjdbc", "root",
        "root");

    // get a statement to execute query
    stmt = con.createStatement();

    // executed insert query
    stmt.execute(query);
    System.out.println("Data inserted in table !");
}
```

Regular expression in...

Java

DSL in GPL

```
public class RegexTestStrings {  
    public static final String EXAMPLE_TEST = "This is my small example "  
        + "string which I'm going to " + "use for pattern matching.";  
  
    public static void main(String[] args) {  
        System.out.println(EXAMPLE_TEST.matches("\w.*"));  
        String[] splitString = (EXAMPLE_TEST.split("\\s+"));  
        System.out.println(splitString.length); // Should be 14  
        for (String string : splitString) {  
            System.out.println(string);  
        }  
        // Replace all whitespace with tabs  
        System.out.println(EXAMPLE_TEST.replaceAll("\\s+", "\t"));  
    }  
}
```

Terminology

- Traditional dichotomy between internal DSL and external DSL (Fowler et al., 2010)
 - Fluent APIs
 - Internal DSLs
 - (deeply) embedded DSLs
 - External DSLs
 - What's LINQ?
- Boundary between DSL and GPL is not that clear (Voelter et al., 2013)
 - What is and what is not a DSL is still a debate

Internal DSLs vs External DSL

- Both internal and external DSLs have strengths and weaknesses
 - learning curve,
 - cost of building,
 - programmer familiarity,
 - communication with domain experts,
 - mixing in the host language,
 - strong expressiveness boundary
- Focus of the course
 - **external DSL** a completely separate language with its own custom syntax and tooling support (e.g., editor)

Plan

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

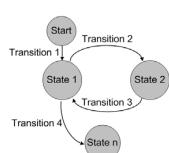
Contract

- 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)

DSL = Syntax + Services

Specialized notation:

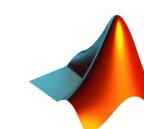
Textual or Graphical
Specific Vocabulary
Idiomatic constructs



BIBT_EX

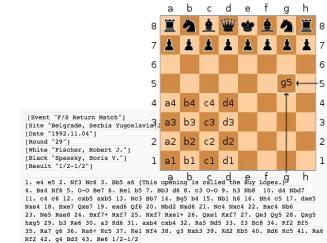


SQL



Specialized tools/IDE:

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



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 Panel:** Shows two tabs: BookSchema.sugj and *BookHandler.sugj. The *BookHandler.sugj tab is active, displaying Java code:

```
import xml.Sugar;
import xml.Editor;
import xml.schema.BookSchema;

public class BookHandler {
    public void appendBook(ContentHandler ch) throws SAXException {
        String title = "Sweetness and Power";
        @Validate
        ch.<{lib}book title="{new String(title)}">
            <{lib}author name="Sidney W. Mintz" />
            <{lib}editions>
                <{lib}edition year="1985" publisher="Viking Press" />
                <{lib}edit year="1986" publisher="Penguin Books" />
            </{lib}editions>
        </<{lib}author
        <{lib}book
        <{lib}edition
        <{lib}editions
```
- Right Panel:** Shows the Outliner view with the following tree structure:

```
BookHandler
  appendBook
    book
      author
      editions
      isPublished
      getLanguage
```
- Bottom Left:** Problems view showing 1 error and 1 warning.

Resource	Location
BookHandler.sugj	line 18
BookHandler.sugj	line 14

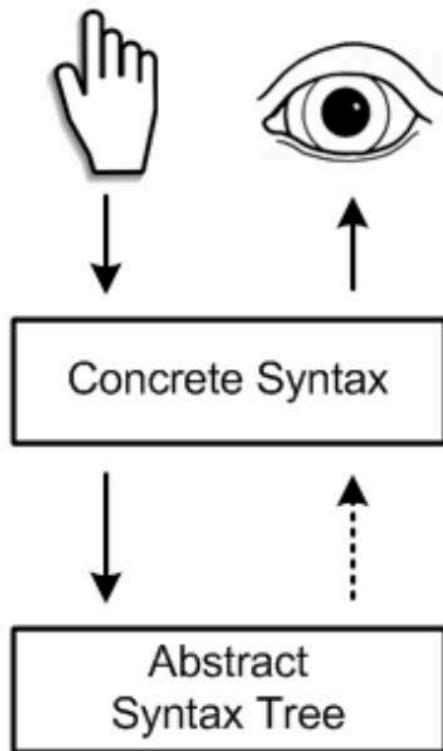
Description

 - Errors (1 item): expected element edition of namespace lib
 - Warnings (1 item): skipping validation of quoted attribute value
- Bottom:** Status bar with Writable and Smart Insert buttons.

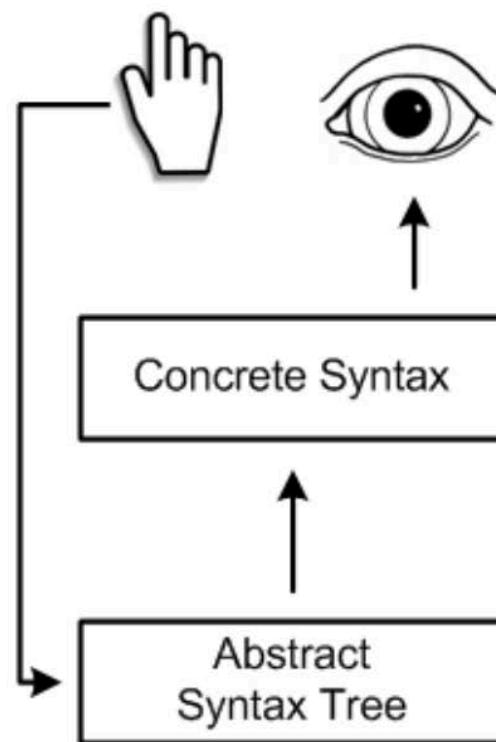
Sebastian Erdweg, Tillmann Rendel, Christian Kästner, and Klaus Ostermann. Sugarj: Library-based syntactic language extensibility. OOPSLA'11

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 {		reset()
beforeFlight	next(Trackpoint* tp) [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	[] -> beforeFlight
landing	[tp->speed == 0 mps] -> landed [tp->speed > 0 mps] -> landing	[] -> beforeFlight
landed		[] -> beforeFlight
crashed		
}		

```

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 A
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
21 where ...

VendingMachine.ATOM
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:

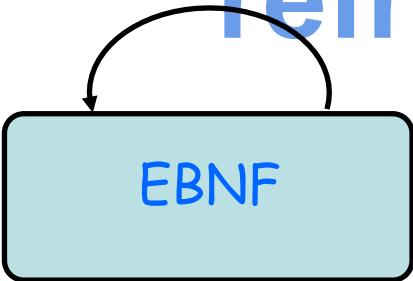
- The [SDF3](#) syntax definition formalism
- The [NaBL](#) name binding language
- The [TS](#) type specification language
- The [Stratego](#) transformation language

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

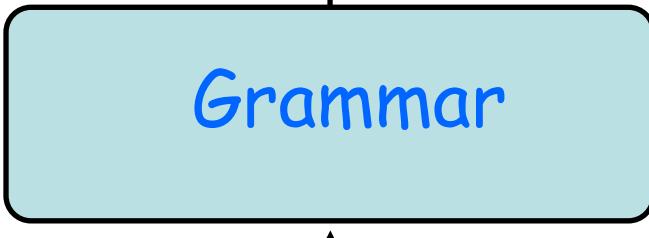
Your DSL in 5' (incl.
editors and serializers)

Foundations (or some course refresh)

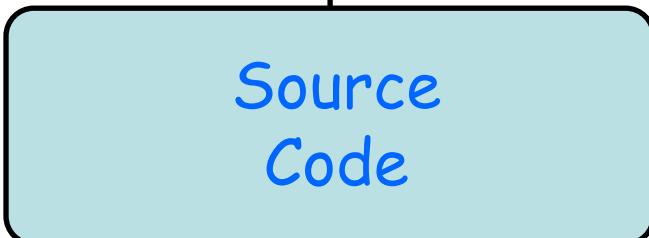
M³



M²



M¹



Java Grammar

```
CHARLITERAL
: '\\''
| {
  EscapeSequence
}
'\\'
;

STRINGLITERAL
: '\"'
| {
  EscapeSequence
}
\"*
;

fragment
EscapeSequence
: '\\\\' (
  'b'
| 't'
| 'n'
| 'r'
| '\"'
| '\''
| '/'
| '\\'
| '?'
| 'x' hexDigit hexDigit
| 'u' hexDigit hexDigit hexDigit hexDigit
| 'U' hexDigit hexDigit hexDigit hexDigit hexDigit hexDigit hexDigit hexDigit
);

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

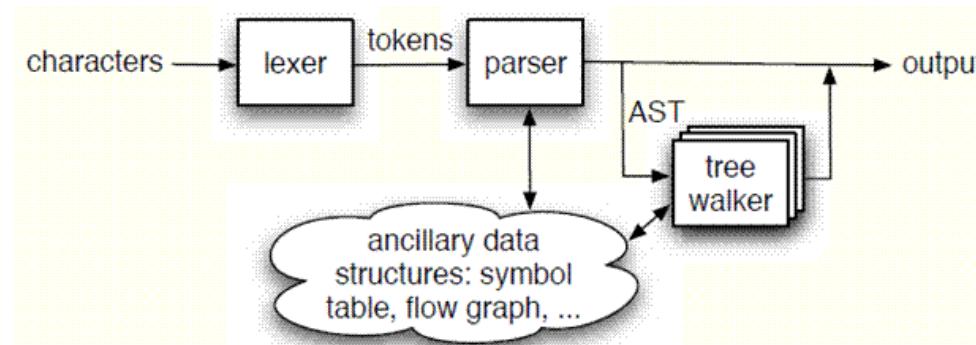
classDeclaration
: normalClassDeclaration
| enumDeclaration
```

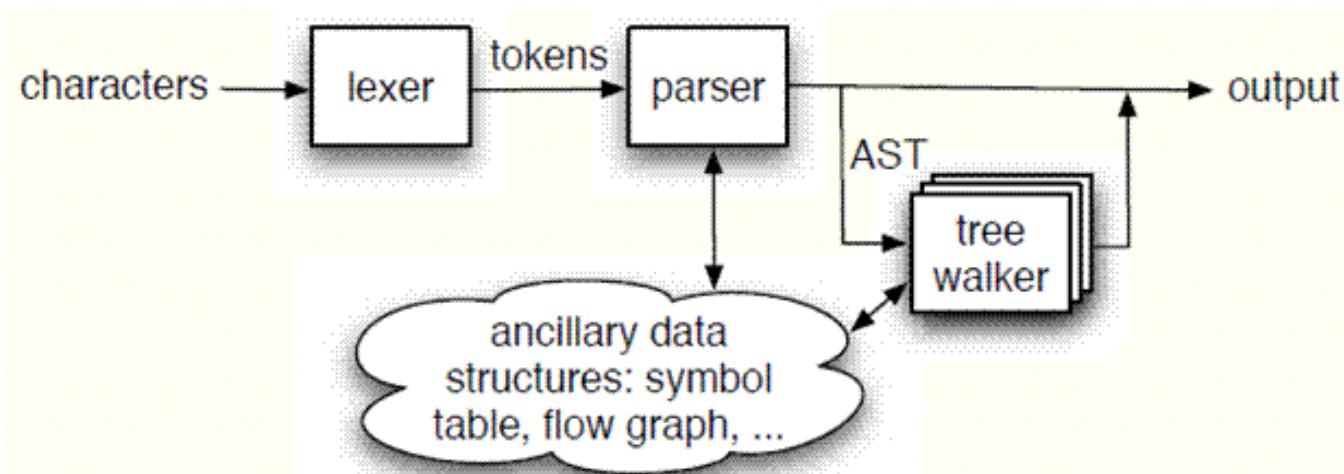
Java Program

```
/*
 ****
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'
|   '\"'
)
;

```

```

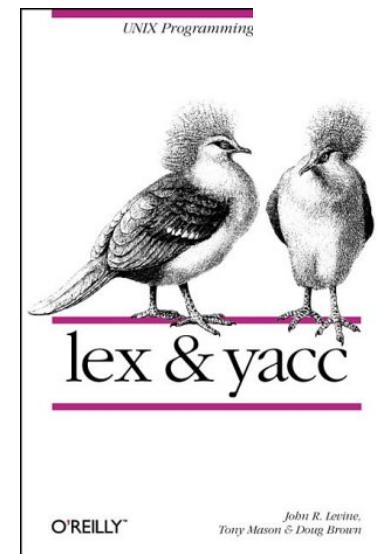
classOrInterfaceDeclaration
:   classDeclaration
|   interfaceDeclaration
;

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

variableModifiers
:   (
    FINAL
|   annotation
)*
;

classDeclaration
:   normalClassDeclaration
|   enumDeclaration
;

```



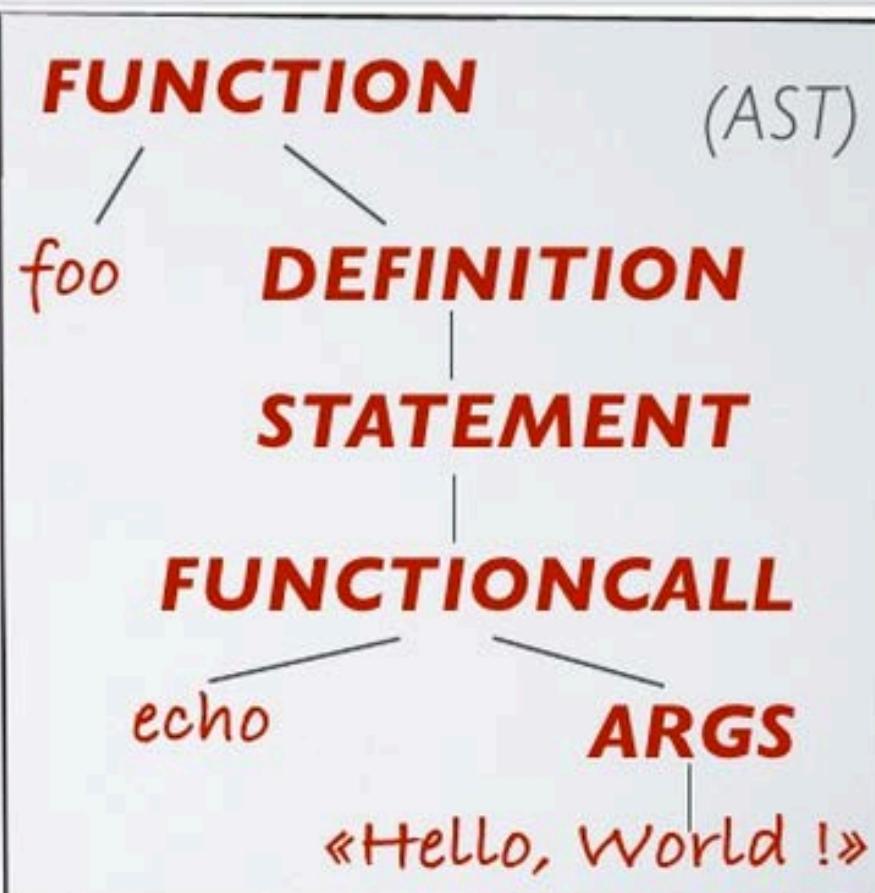
O'REILLY®

John R. Levine,
Tony Mason & Doug Brown

EXEMPLE

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

↓
#FUNC
↓
#SYMBOL(«foo»)
↓
#LPAREN
↓
#RPAREN
↓
...
↓
#RBRACKET
(lexèmes)



```

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}")
}

```

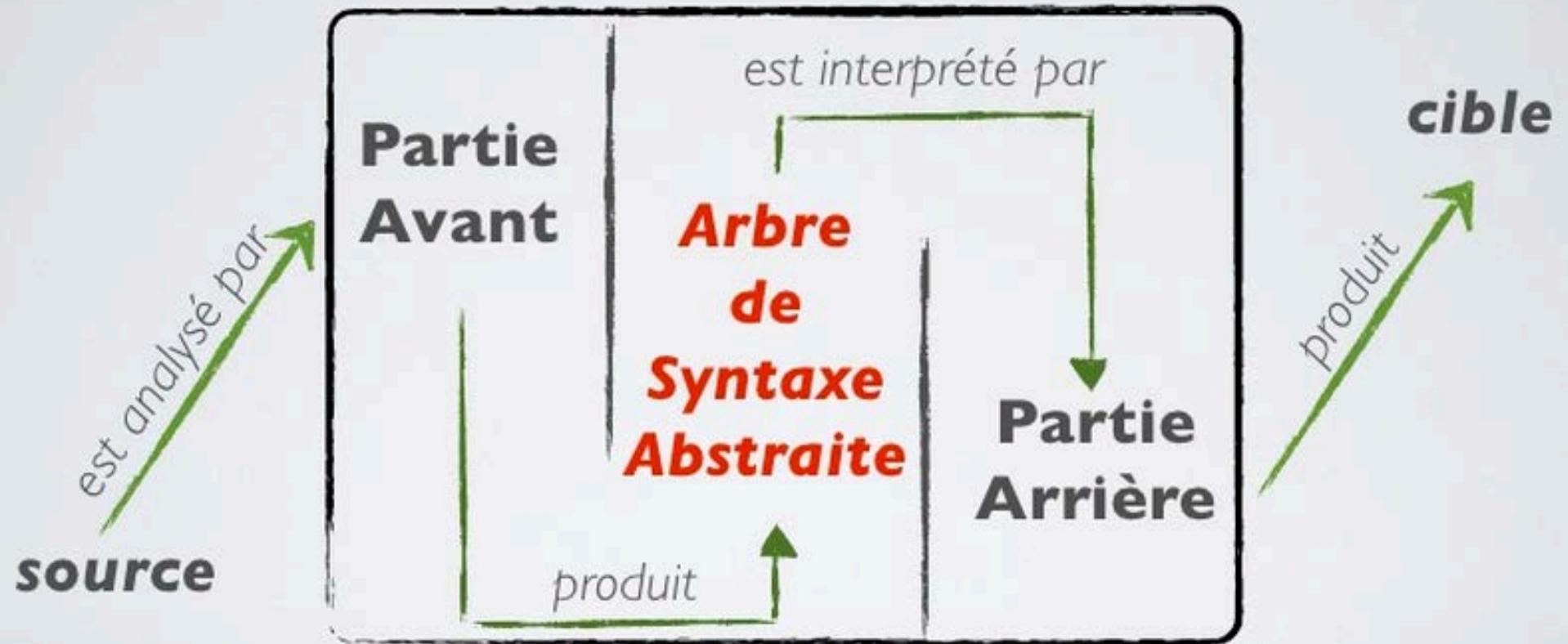
Scala AST (example)

```

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"))
    )));
  )
)

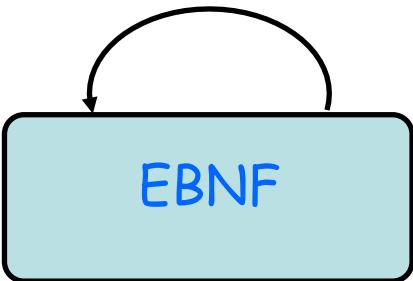
```

Compilation (en français)



DSL? The same!

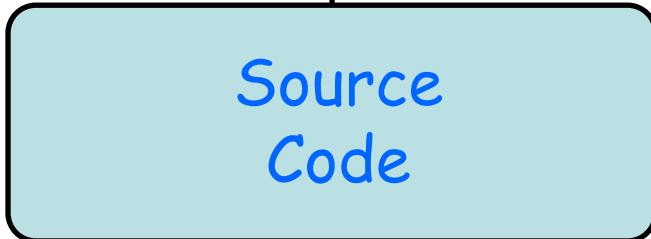
M³



M²



M¹



DSL
specification/program

UNIX Programming Tools



O'REILLY™

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

The
Pragmatic
Programmers

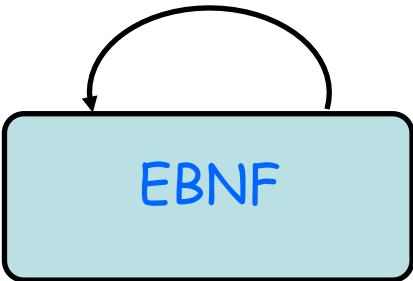
The Definitive
ANTLR
Reference

Building Domain-
Specific Languages

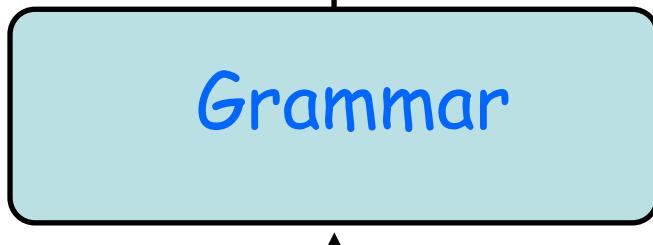


Terence Parr

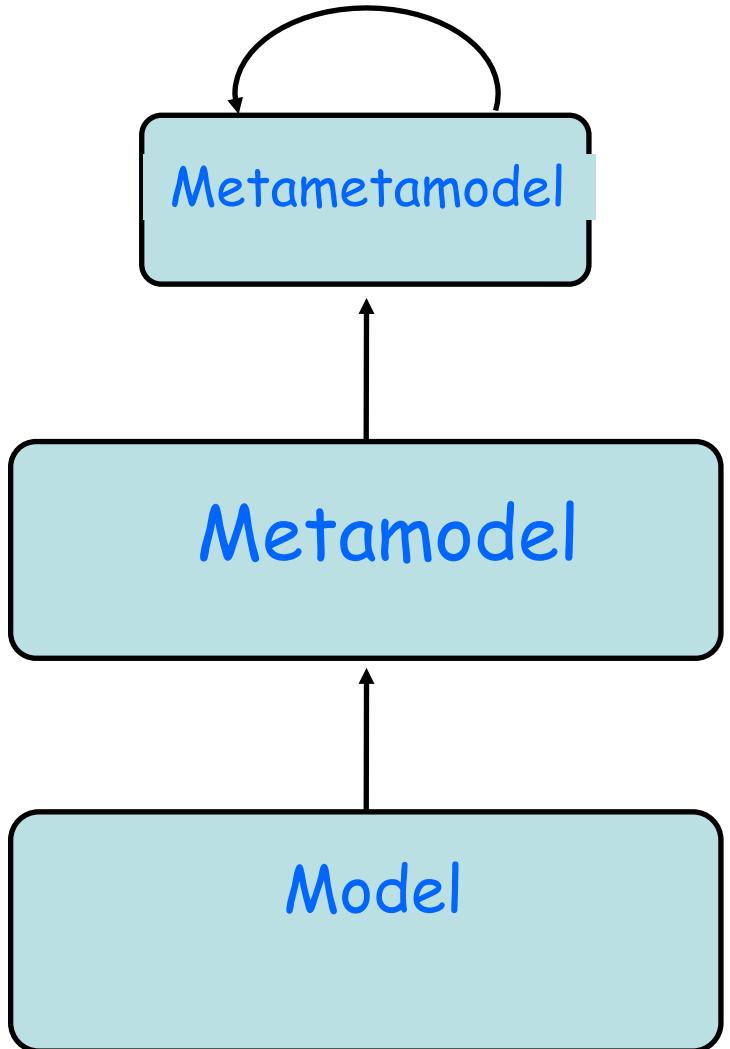
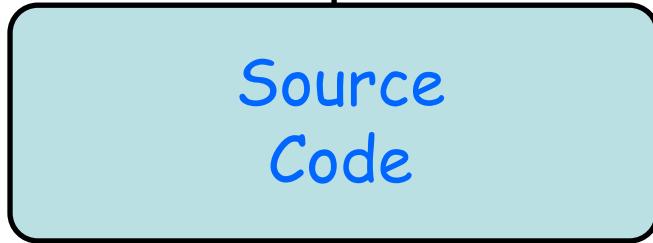
M³



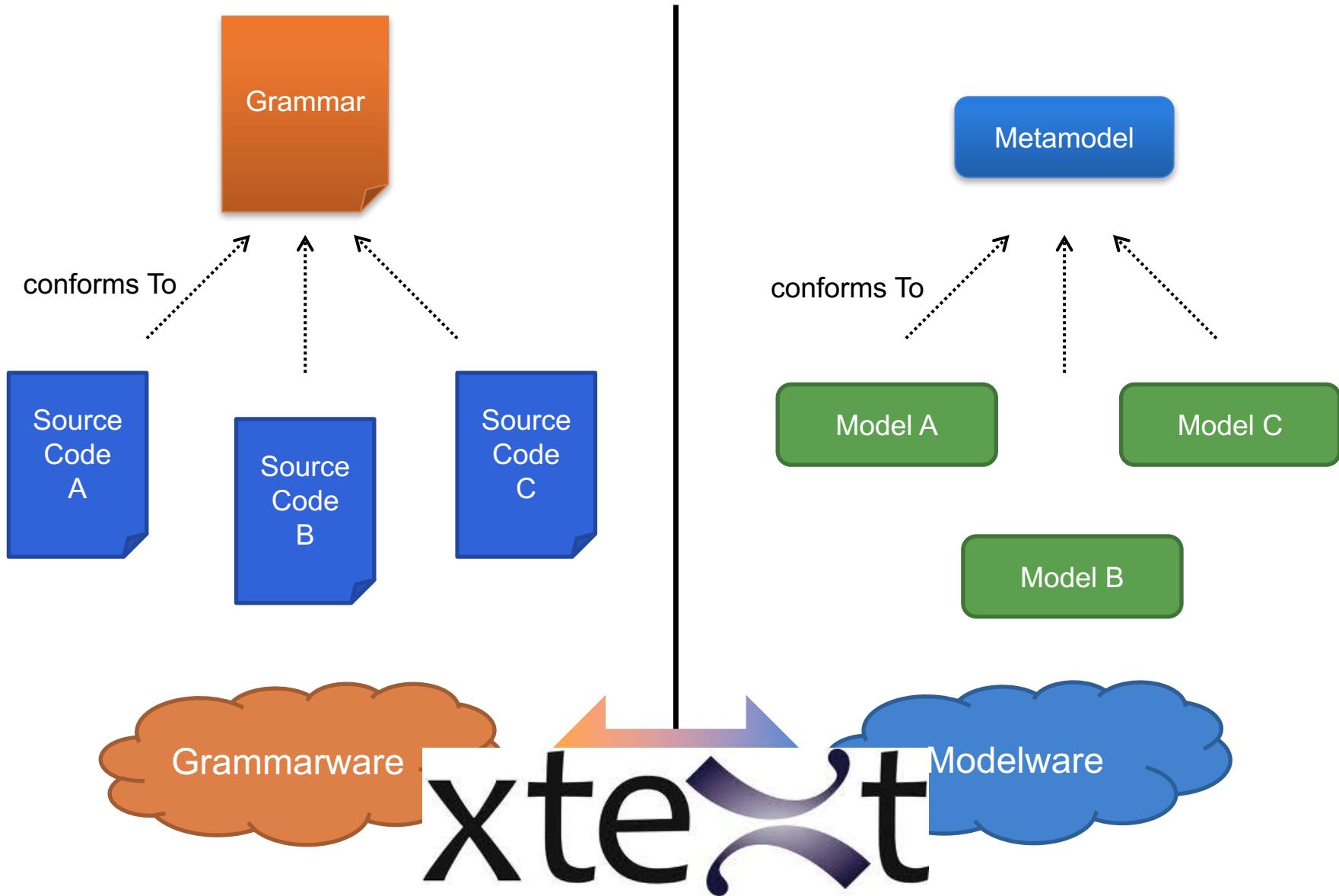
M²



M¹



Language and MDE

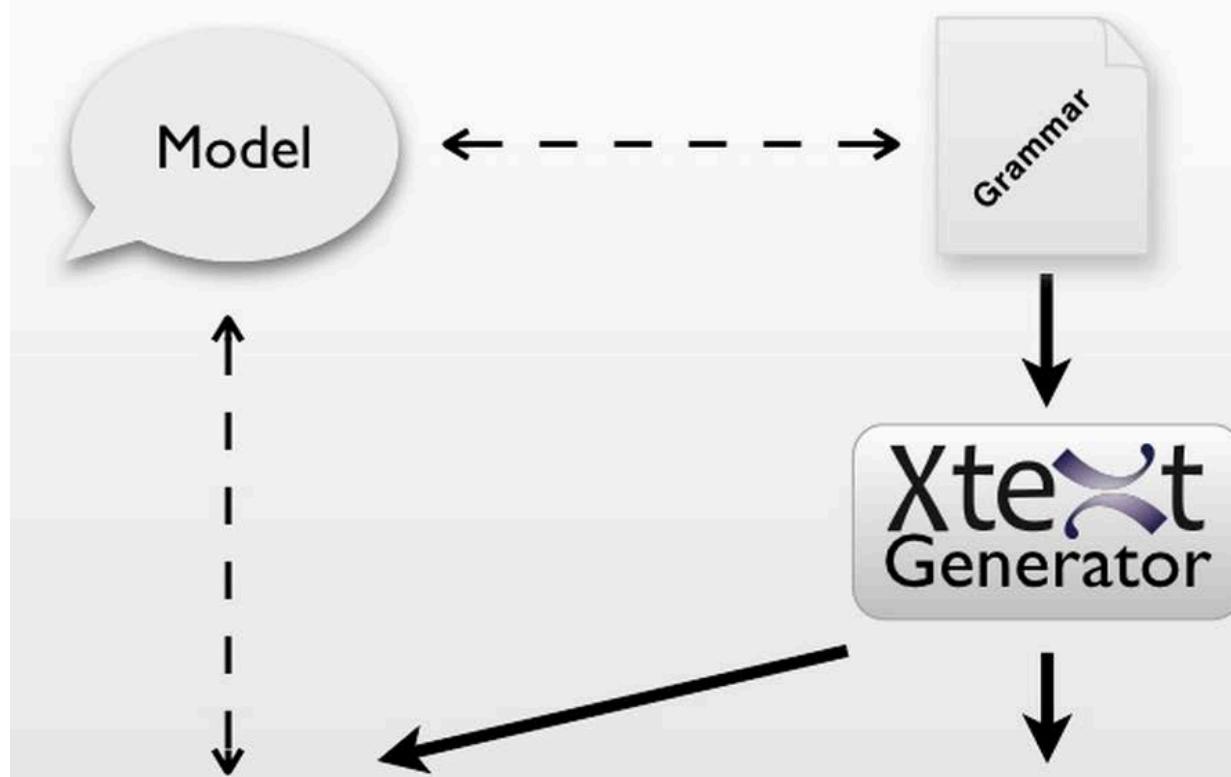




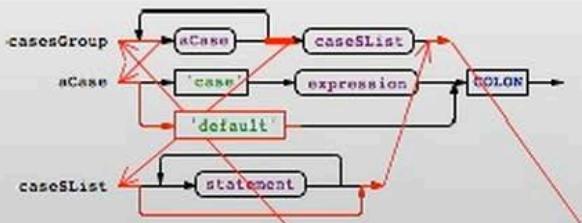
Give me a **grammar**,

I'll give you (for free)

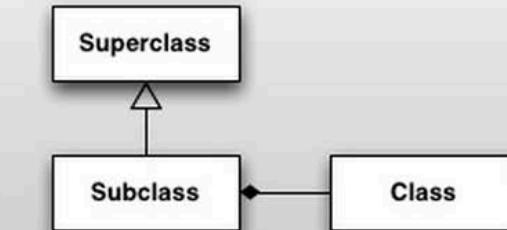
- * a comprehensive editor (auto-completion, syntax highlighting, etc.) in Eclipse
- * an Ecore metamodel and facilities to load/serialize/visit conformant models (Java ecosystem)
- * extension to override/extend « default » facilities (e.g., checker)



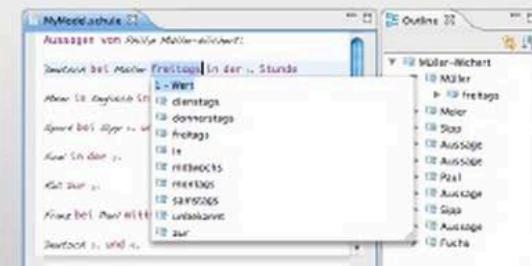
Xtext Runtime



LL(*) Parser

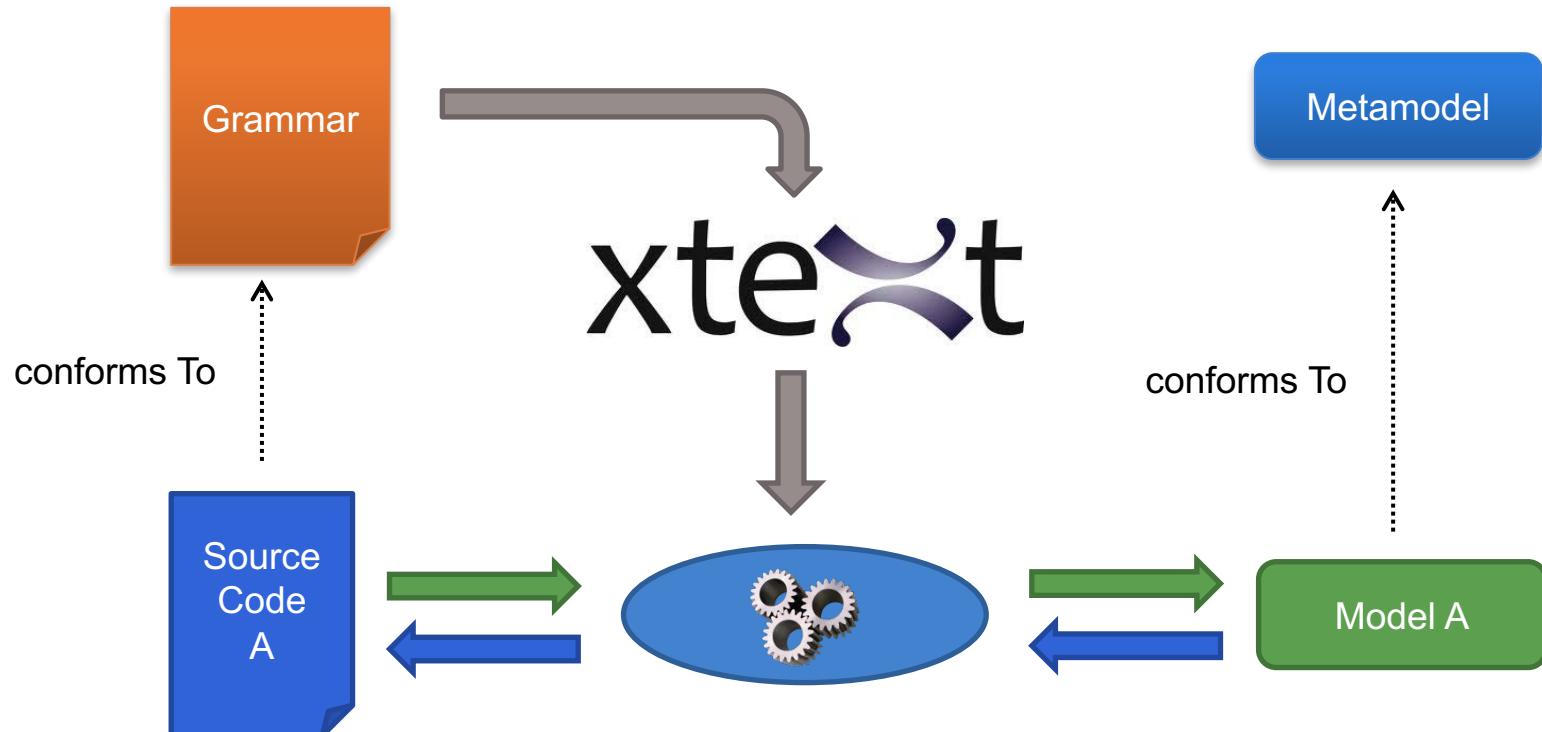


ecore meta model



editor

Xtext, Grammar, Metamodel

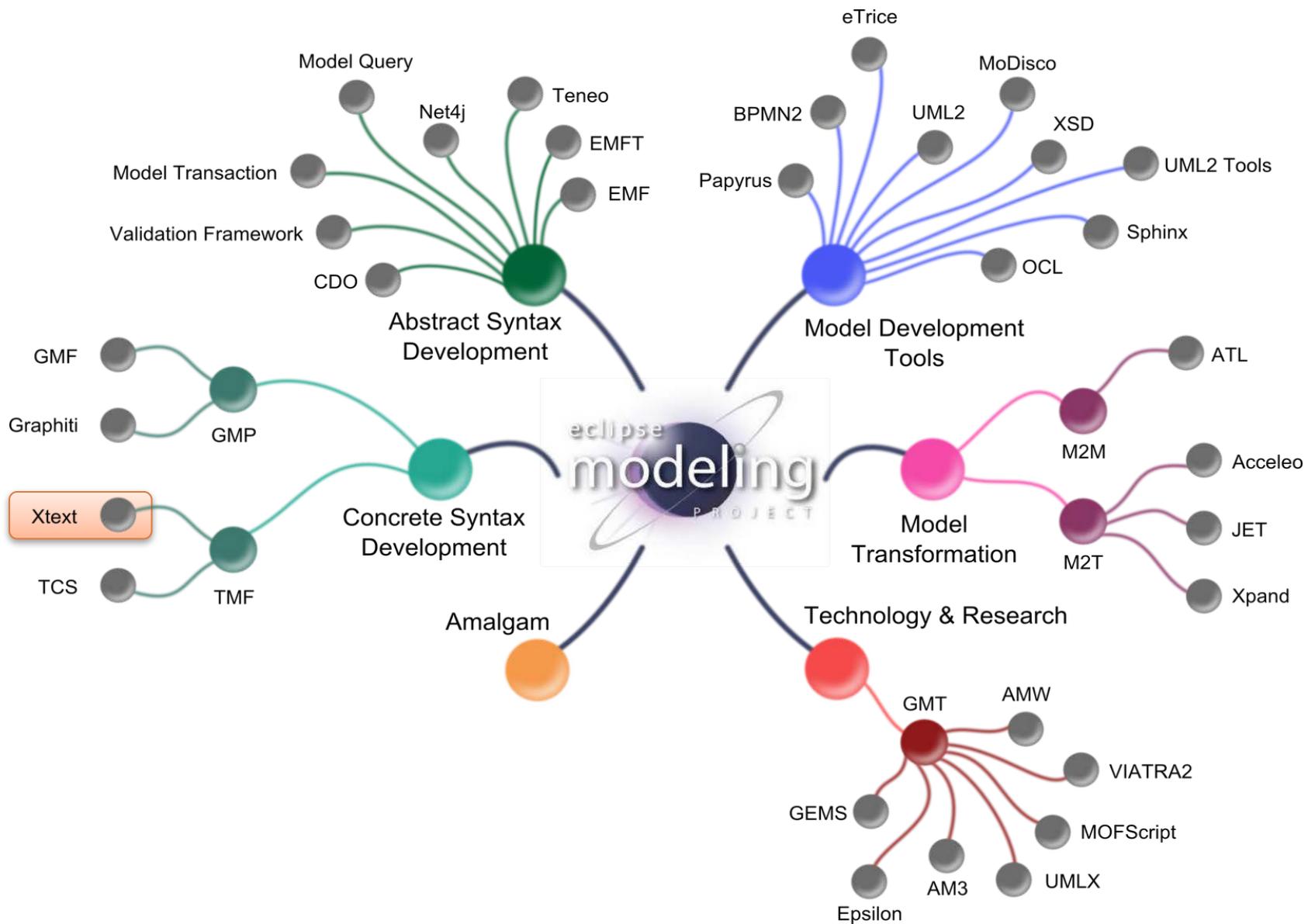


Xtext Project

- Eclipse Project
 - Part of Eclipse Modeling
 - Part of Open Architecture Ware
- Model-driven development of Textual DSLs
- Part of a family of languages
 - **Xtext**
 - Xtend
 - Xbase
 - Xpand
 - Xcore



Eclipse Modeling Project



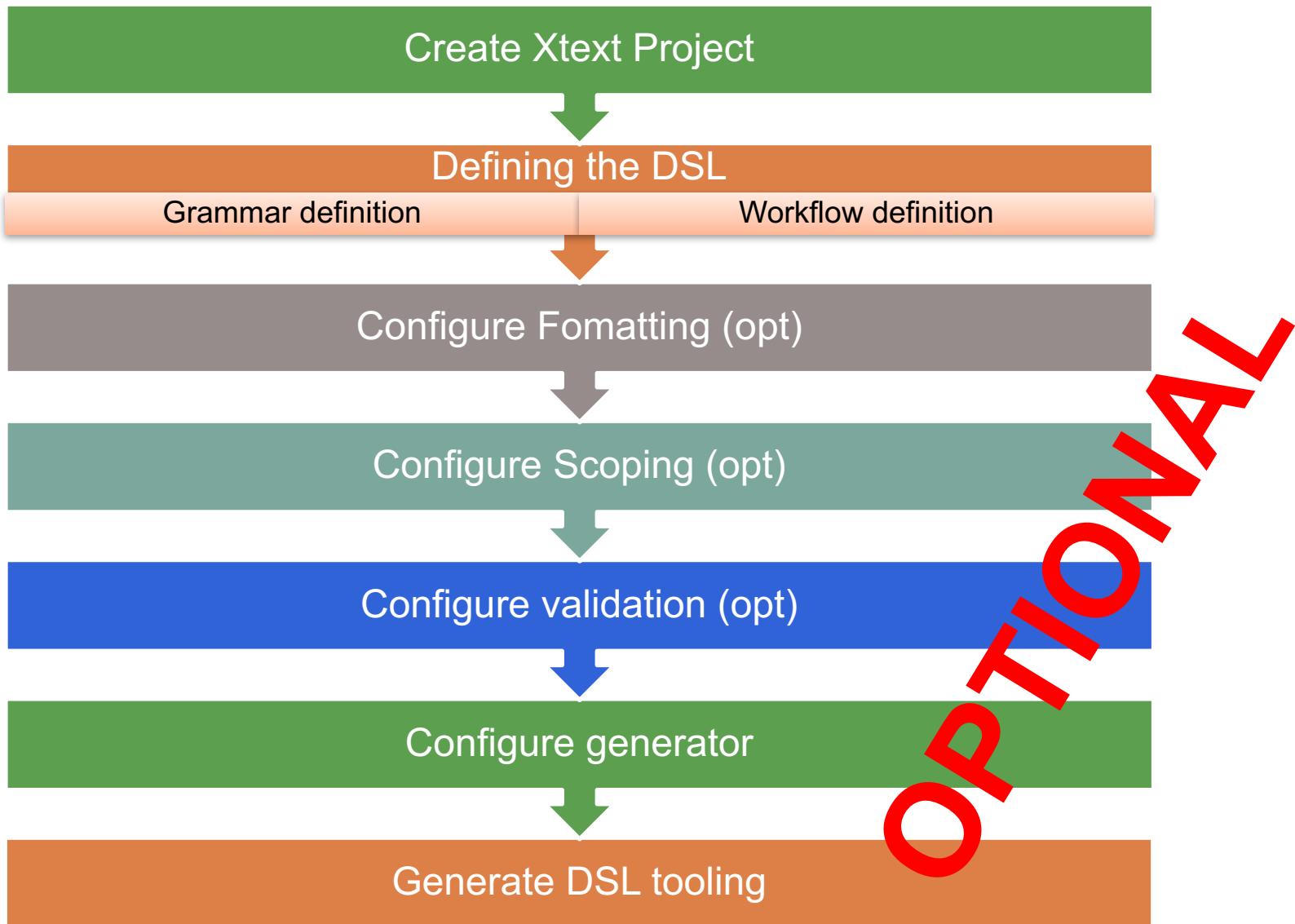
The Grammar Language of Xtext

- 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

Main Advantages

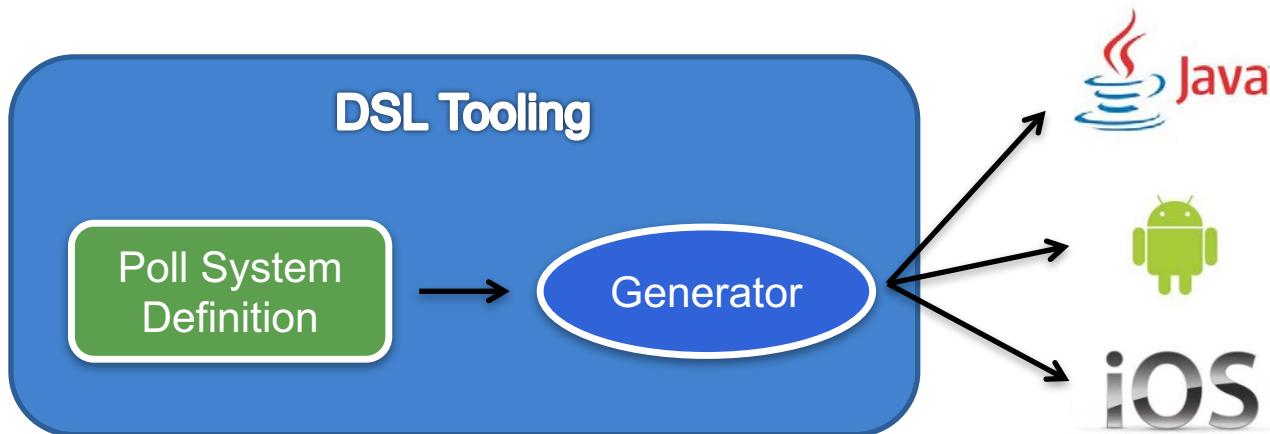
- Consistent look and feel
- Textual DSLs are a resource in Eclipse
- Open editors can be extended
- Complete framework to develop DSLs
- Easy to connect to any Java-based language

Development Process



Motivating Scenario

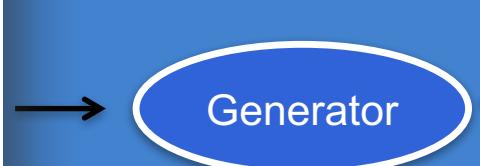
- Poll System application
 - Define a Poll with the corresponding questions
 - Each question has a text and a set of options
 - Each option has a text
- Generate the application in different platforms



Motivating Scenario (2)

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"  
            }  
        }  
    }  
}
```

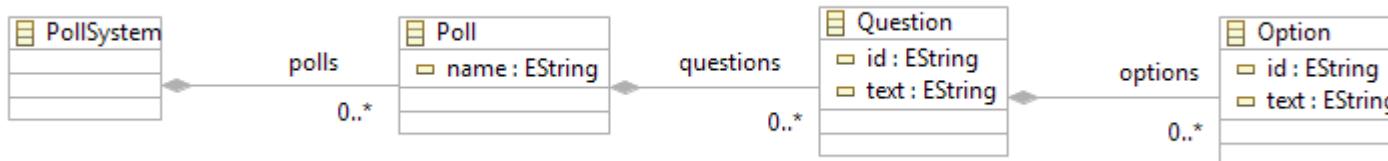


Grammar Definition

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;
```



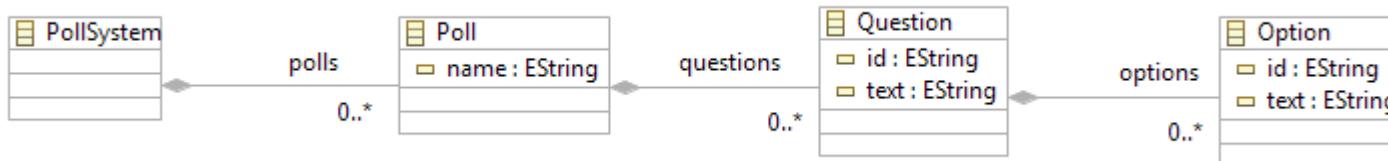
Grammar Definition

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;
```

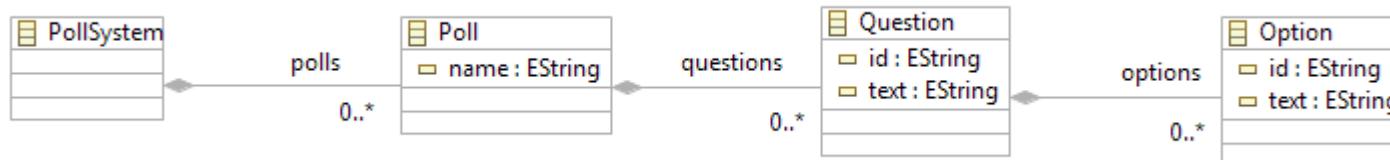


Grammar Definition

Derived
metamodel

```
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;
```

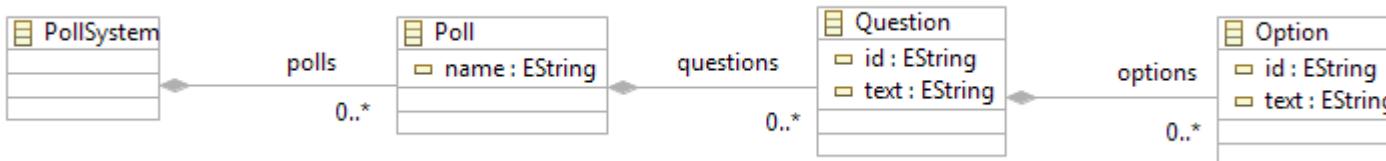


Grammar Definition

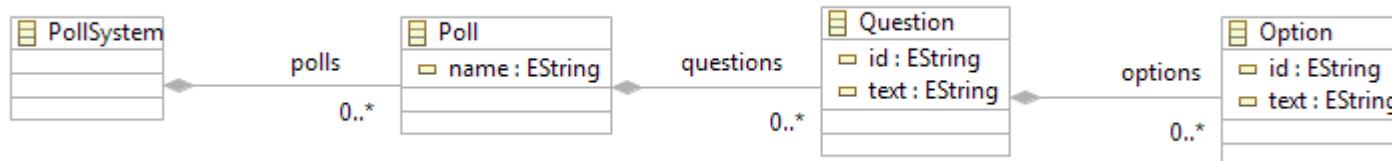
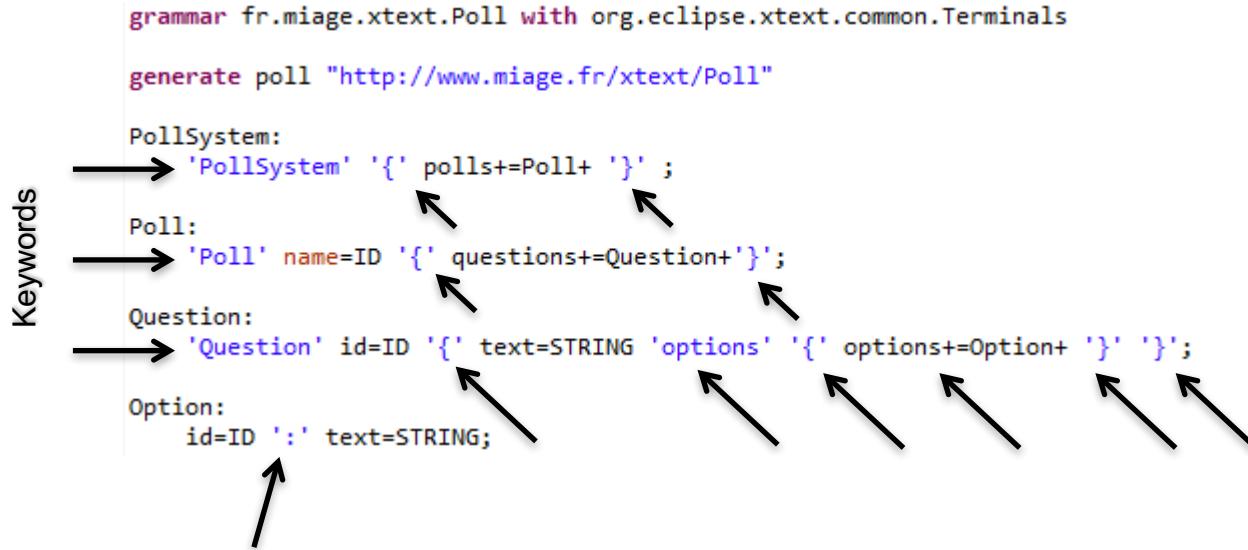
grammar fr.miage.xtext.Poll with org.eclipse.xtext.common.Terminals

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;



Grammar Definition



Grammar Definition

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

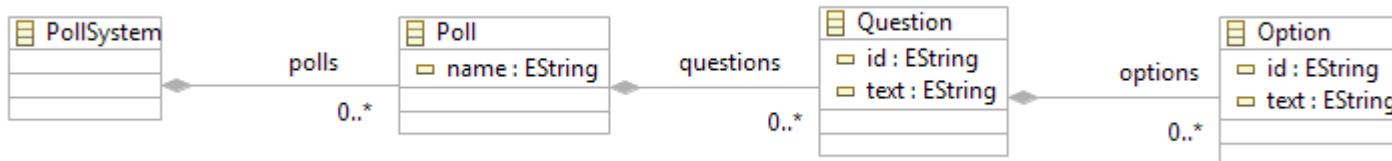
generate poll "http://www.miage.fr/xtext/Poll"

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

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

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

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



Grammar Definition

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

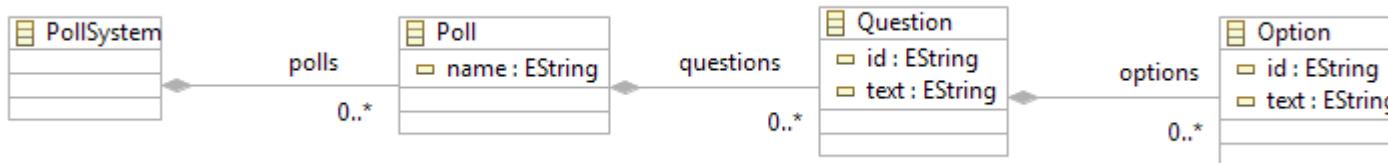
generate poll "http://www.miage.fr/xtext/Poll"

PollSystem:
    'PollSystem' '{' polls+=Poll+ '}';
    ^ Cardinality (others: * ?)

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

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

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



Grammar Definition

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

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

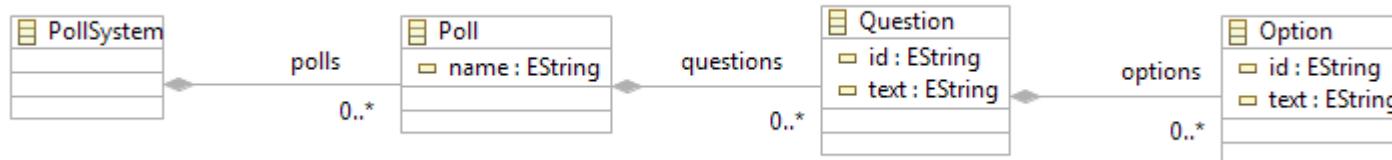
PollSystem:
    'PollSystem' '{' polls+=Poll+ '}';
    ^

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

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

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

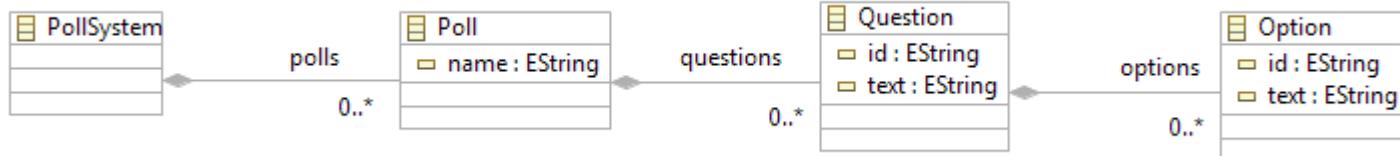
Containment



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;
```

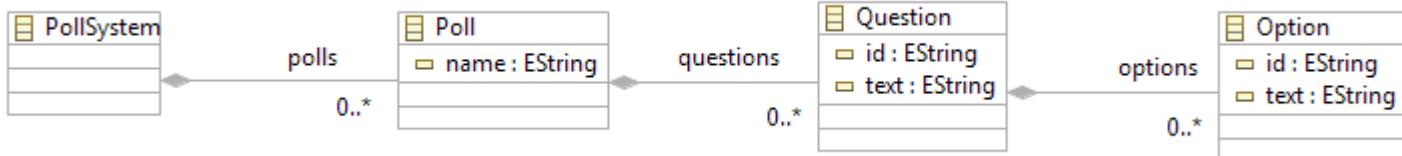
```
PollSystem {  
    Poll Quality {  
        Question q1 {  
            "Value the user experience"  
            options {  
                A : "Bad"  
                B : "Fair"  
                C : "Good"  
            }  
        }  
        Question q2 {  
            "Value the layout"  
            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 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;
```

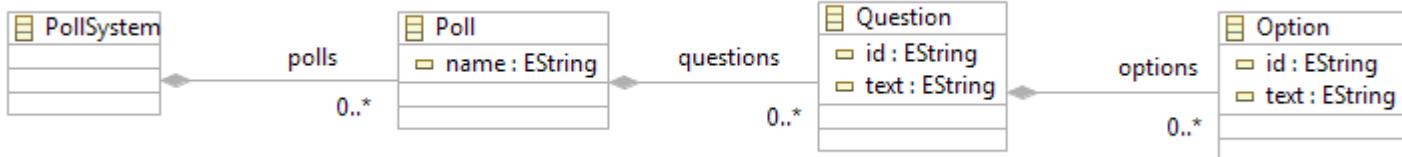
```
PollSystem {  
    Poll Quality {  
        Question q1 {  
            "Value the user experience"  
            options {  
                A : "Bad"  
                B : "Fair"  
                C : "Good"  
            }  
        }  
        Question q2 {  
            "Value the layout"  
            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 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;
```

```
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"
      }
    }
  }
}
```



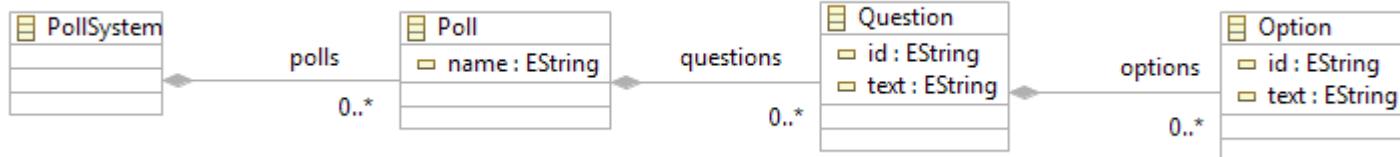
Grammar Definition

```
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;
```

```
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"
            }
        }
    }
}
```

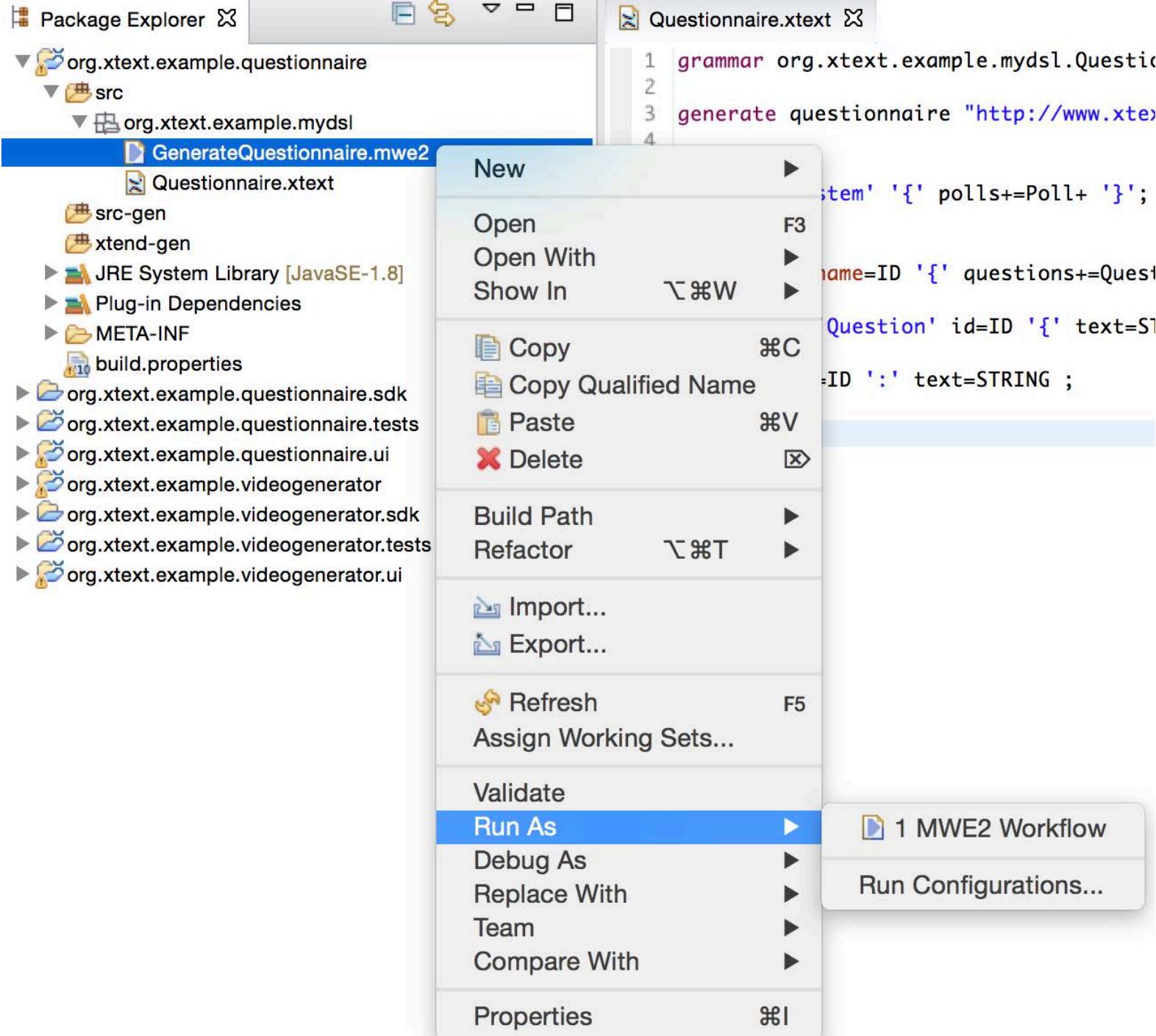


Xtext, your DSL in 5'
(incl. editors and
serializers)

Live Demonstration

The screenshot shows the Eclipse IDE interface with two main panes. On the left is the 'Package Explorer' view, which displays the project structure for 'org.xtext.example.questionnaire'. The 'src' folder contains 'org.xtext.example.mydsl' with files 'GenerateQuestionnaire.mwe2' and 'Questionnaire.xtext'. Other visible files include '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', and 'org.xtext.example.questionnaire.ui'. The 'Questionnaire.xtext' file is currently selected and open in the right-hand code editor. The code editor displays the following Xtext grammar:

```
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 ;
```

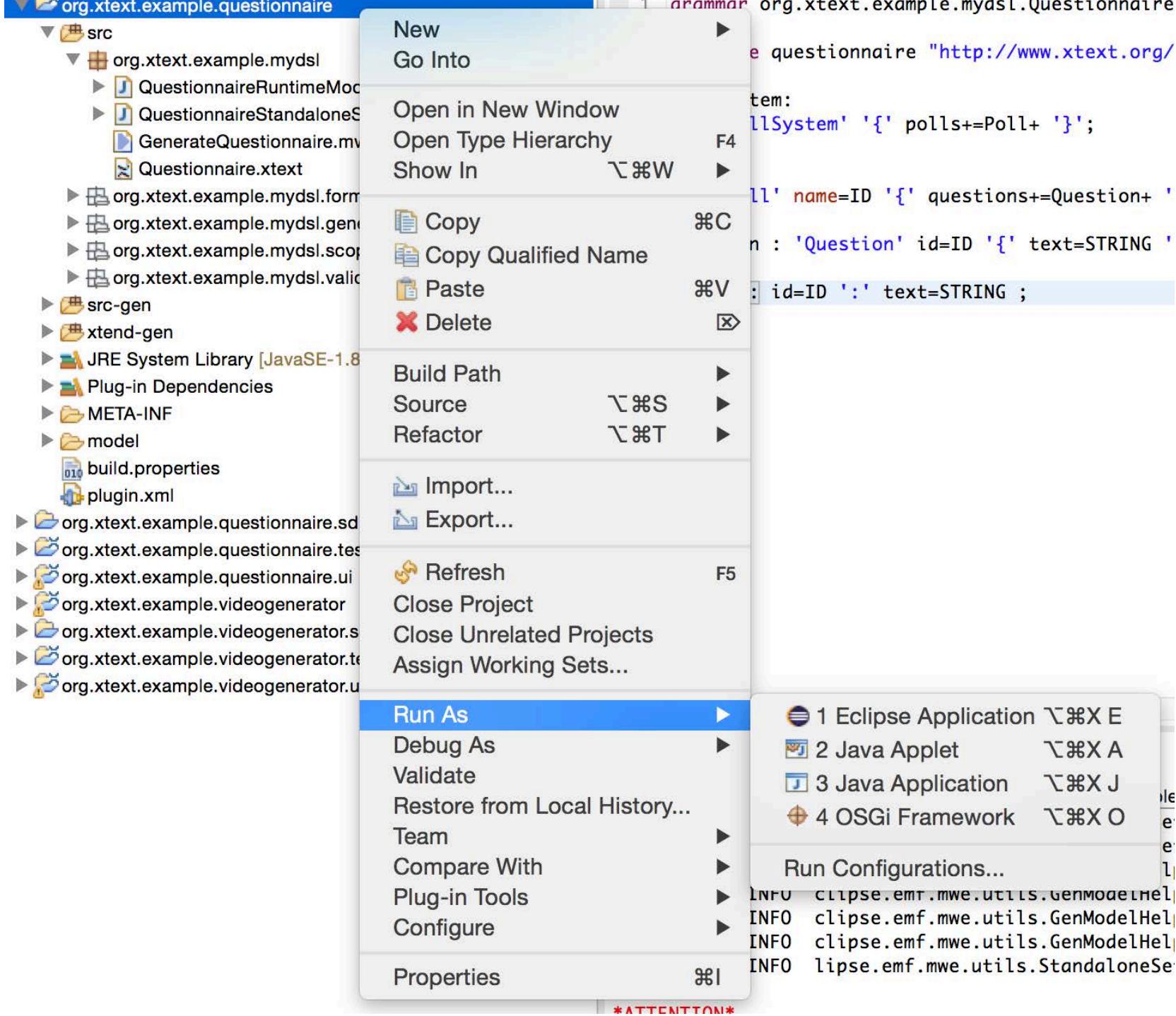


Problems Javadoc Declaration Console

<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.
```



ATTENTION

**File**

Create a new file resource.



Enter or select the parent folder:

FooQuestionnaire



FooQuestionnaire

VideoGen1

File name:

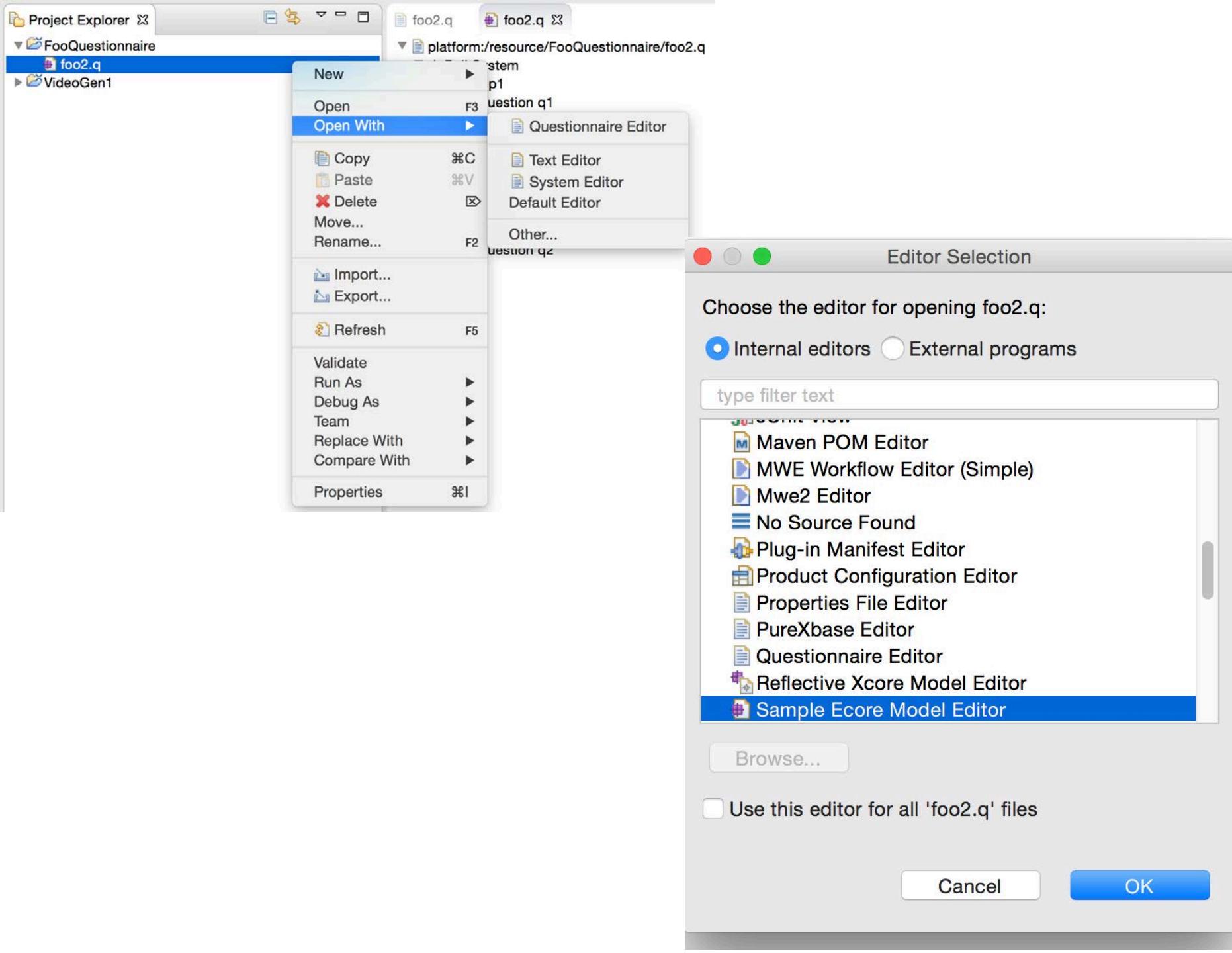
Advanced >>



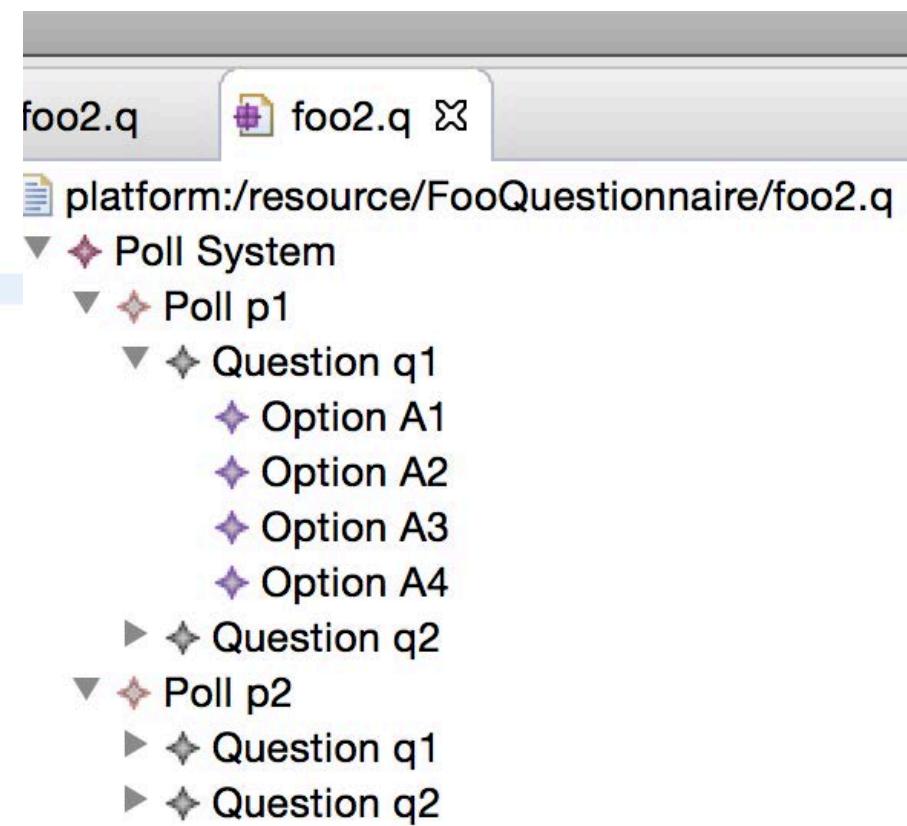
Cancel

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"  
            }  
        }  
    }  
}
```



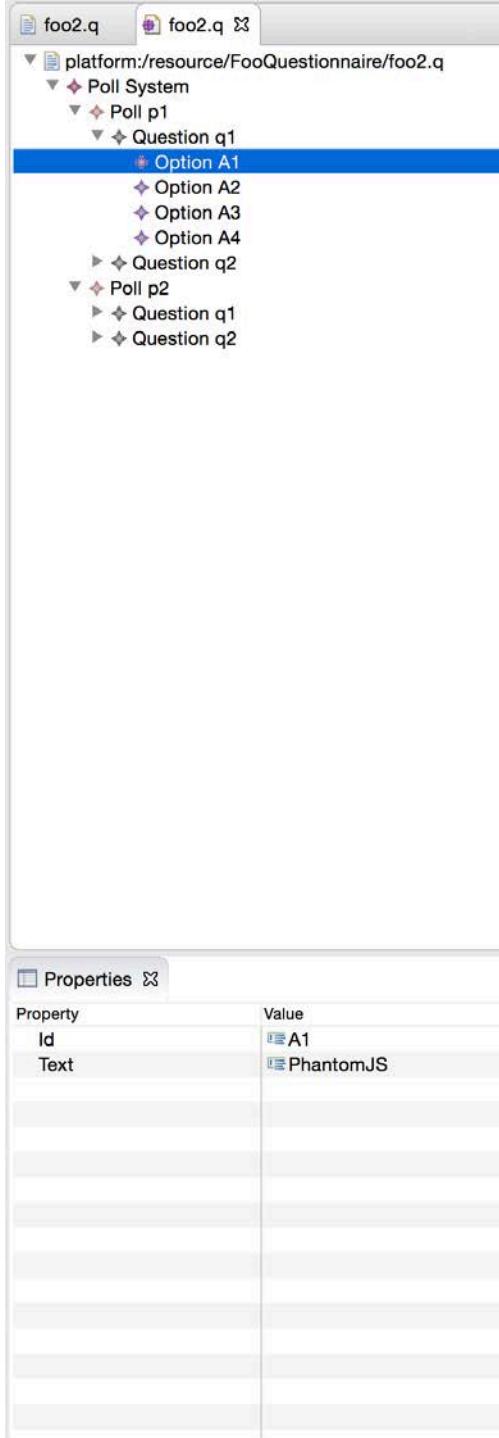
```
2.q ✎
ollSystem {

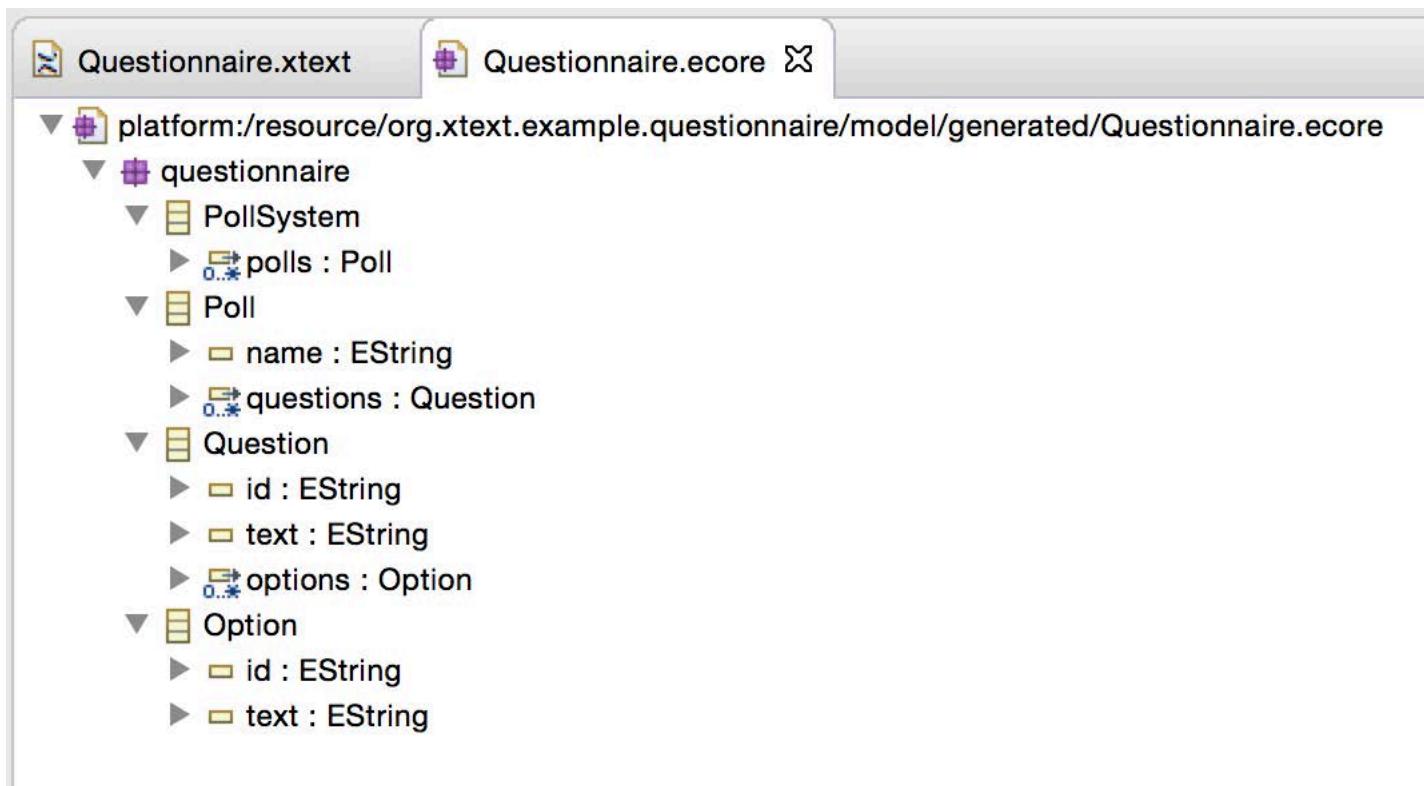
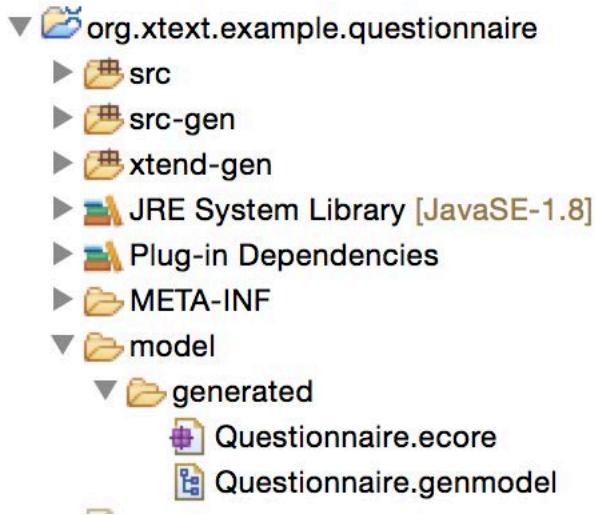
    Poll p1 {
        Question q1 {
            "What is the best JavaScript framework for testing?"
            options [
                A1: "PhantomJS"
                A2: "Jasmine"
                A3: "Mocha"
                A4: "I prefer to develop my own framework"
            ]
        }

        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"
            ]
        }
    }
}
```



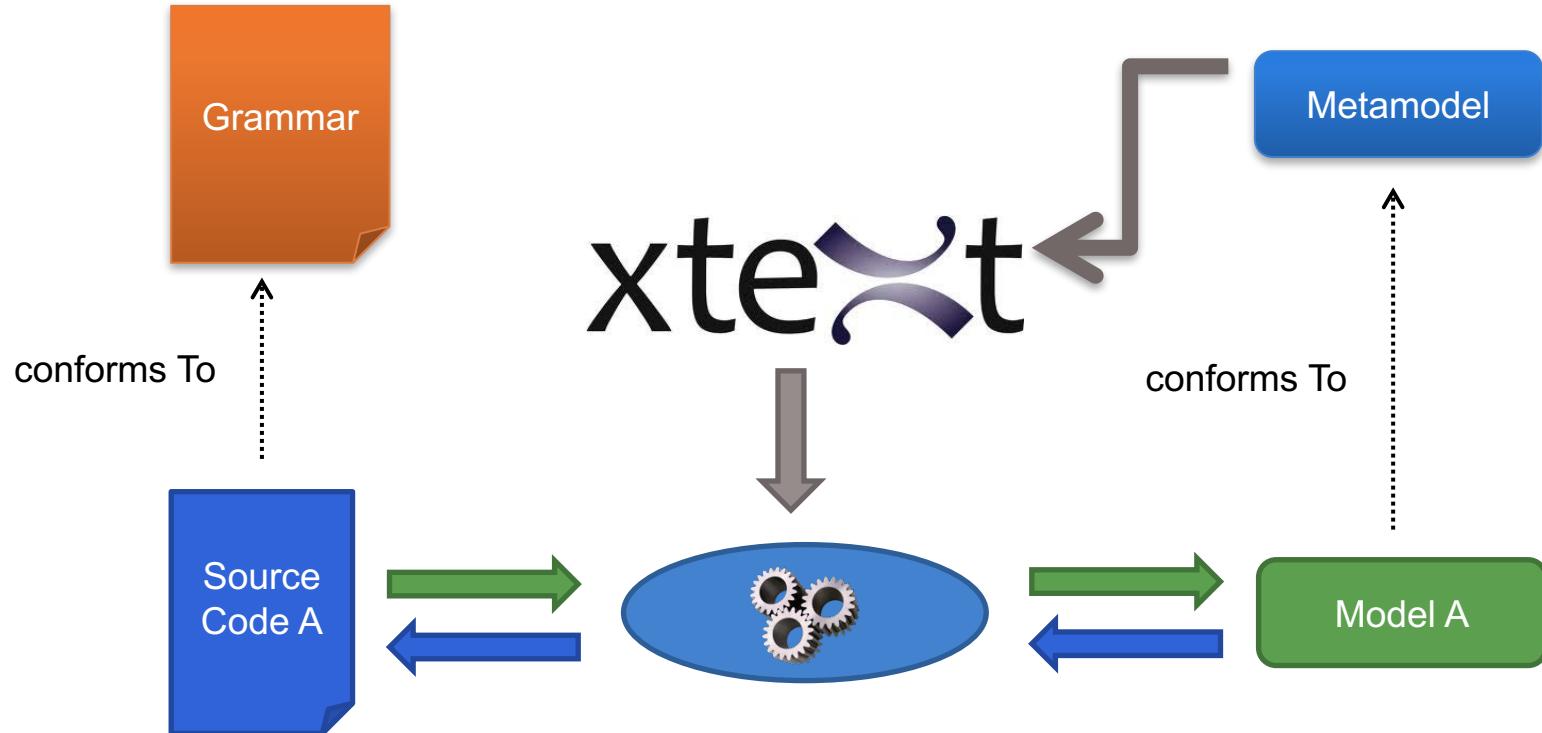


From Metamodel

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)

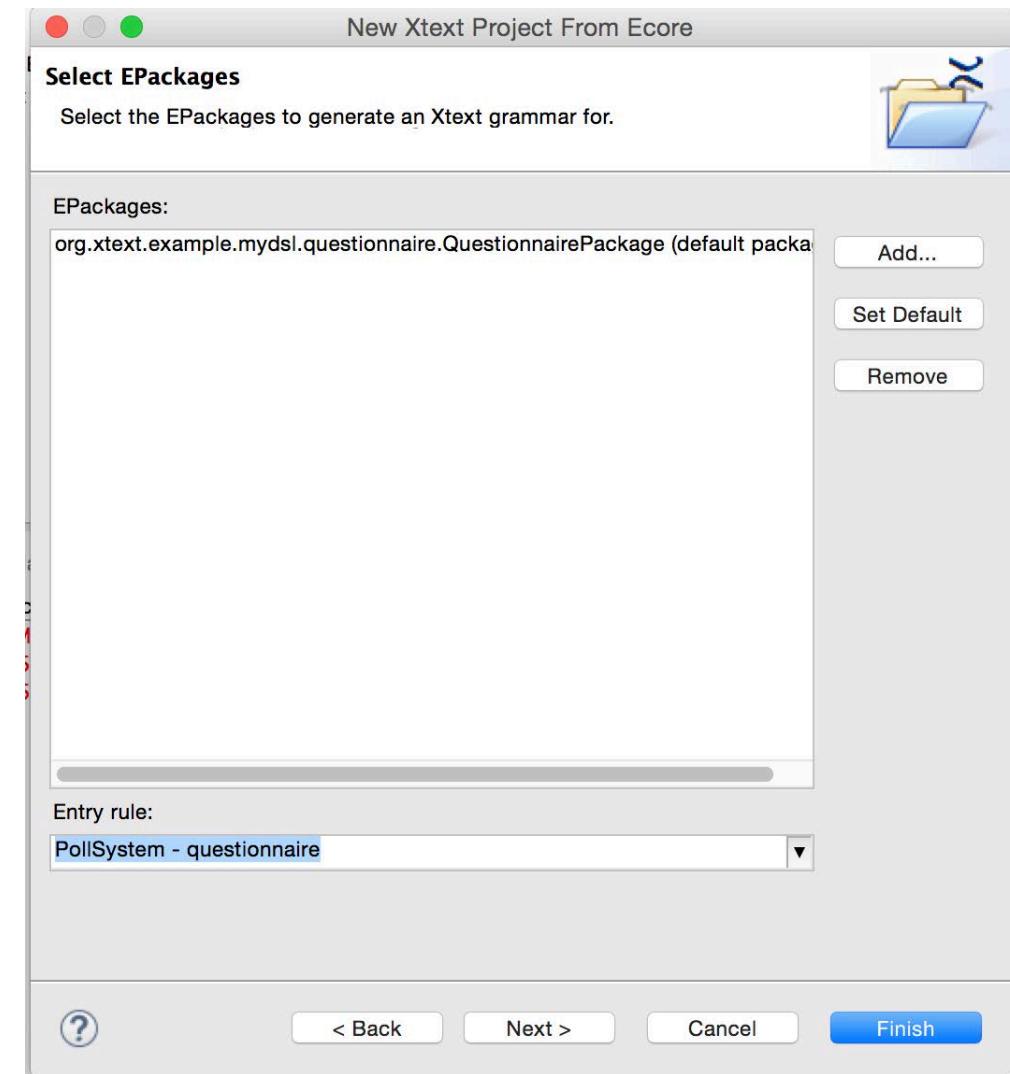
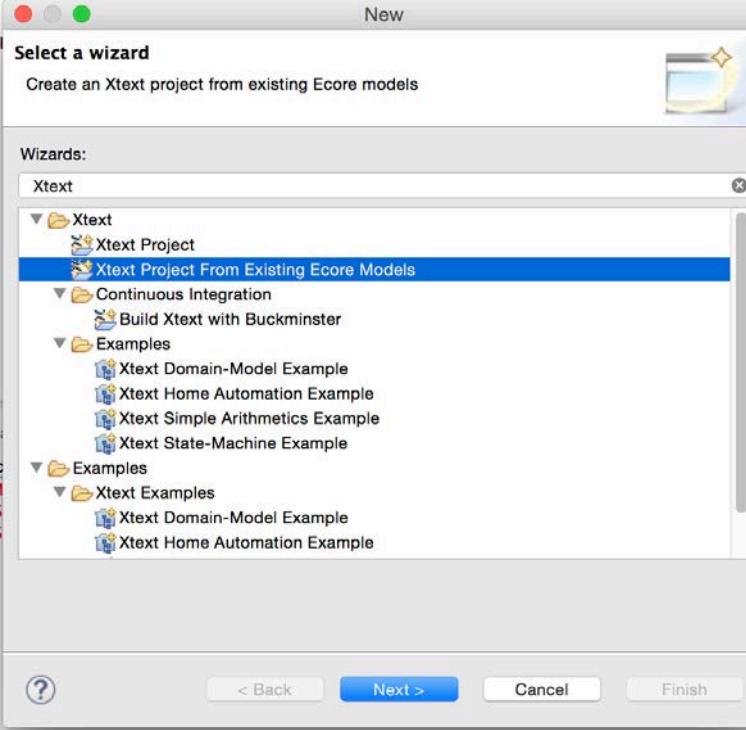


Give me a **metamodel**,

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



```
// 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
```

Graphical DSL

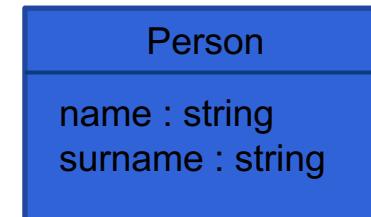
(vs Textual DSL)

Graphical vs Textual DSLs

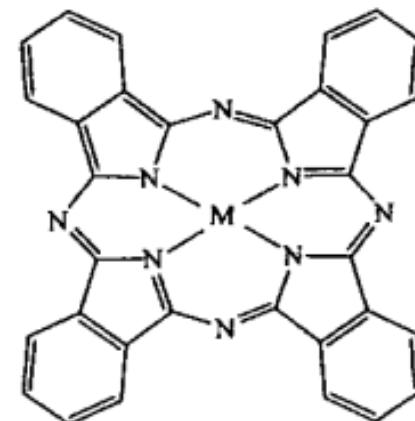
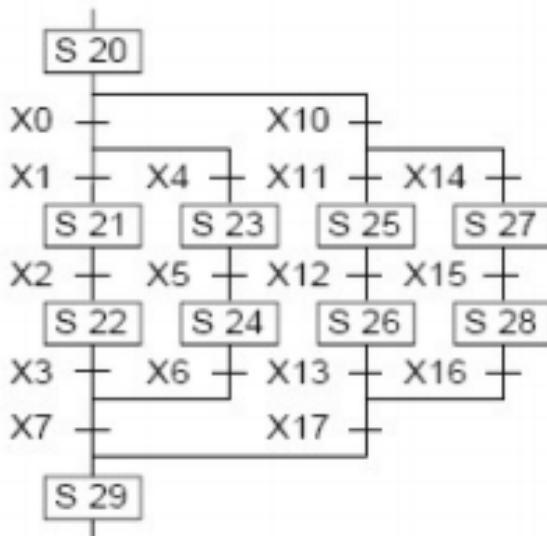
- Success depends on how the notation fits the domain

```
class Person {  
    private String name;  
    private String name;  
}
```

```
Person has (name, surname)
```

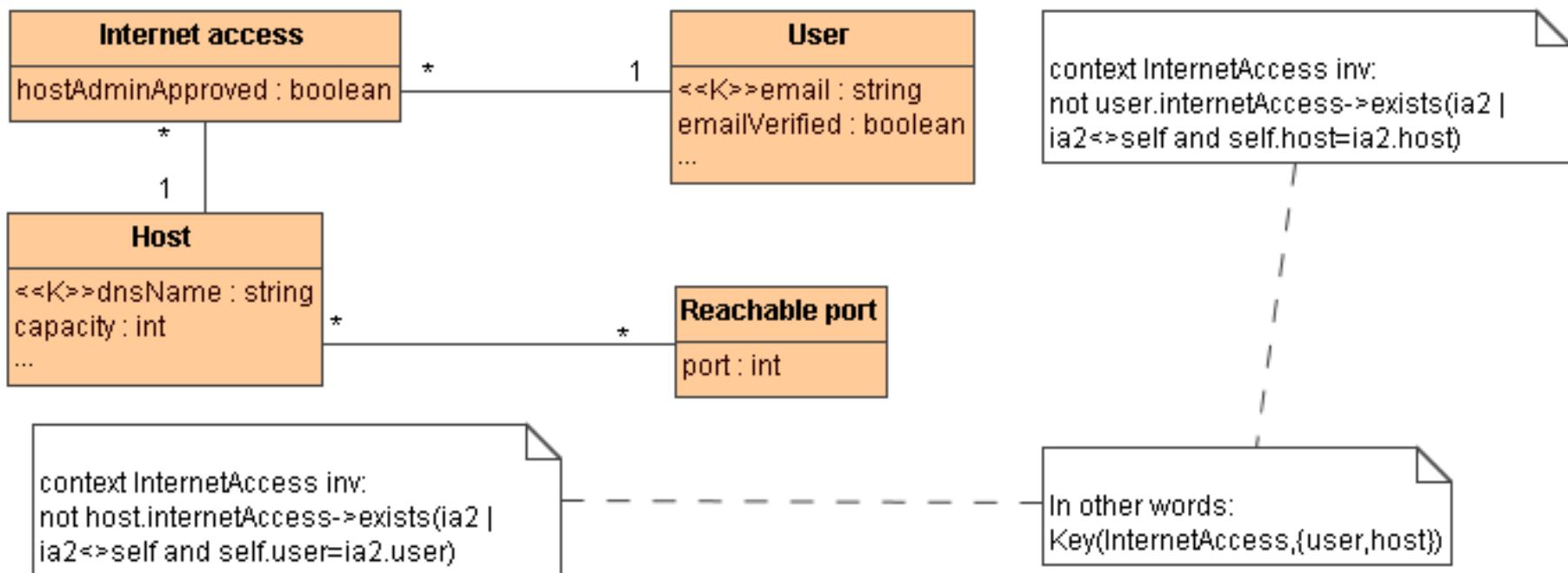


- Graphical DSLs are not always easier to understand



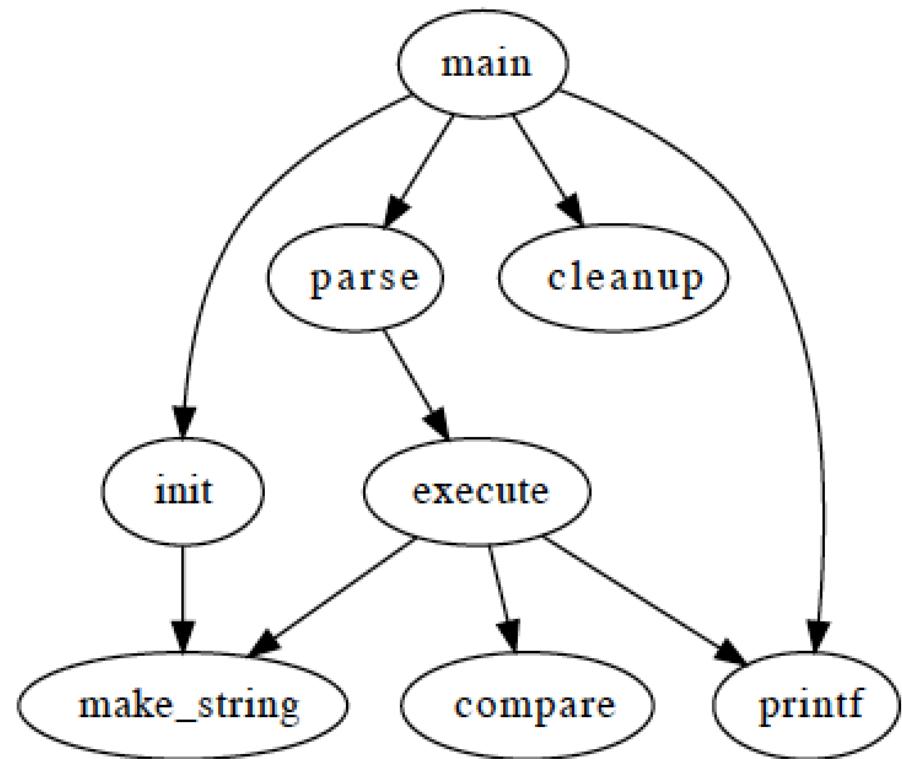
phthalocyanine

A language can be graphical and textual

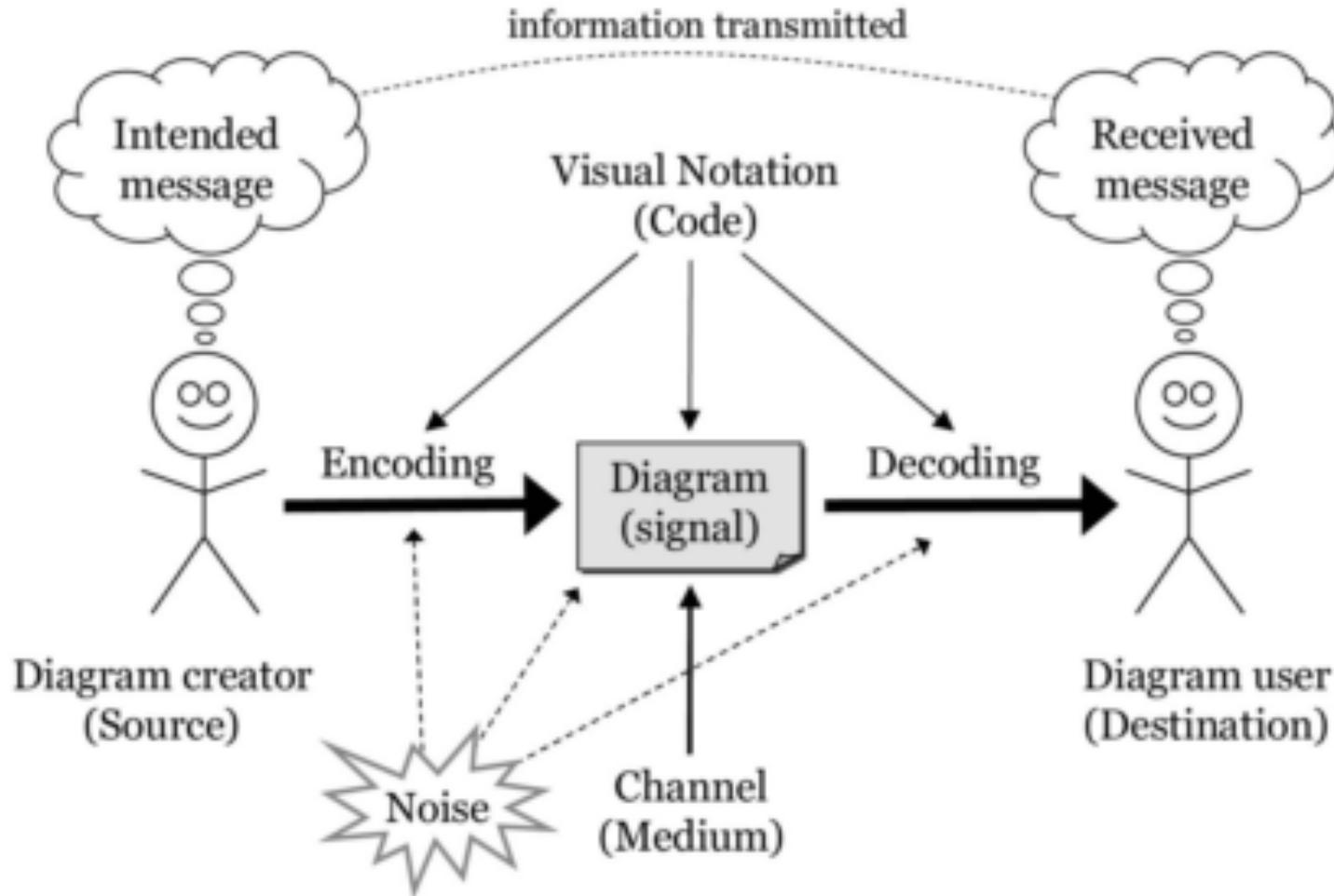


Alternative representation

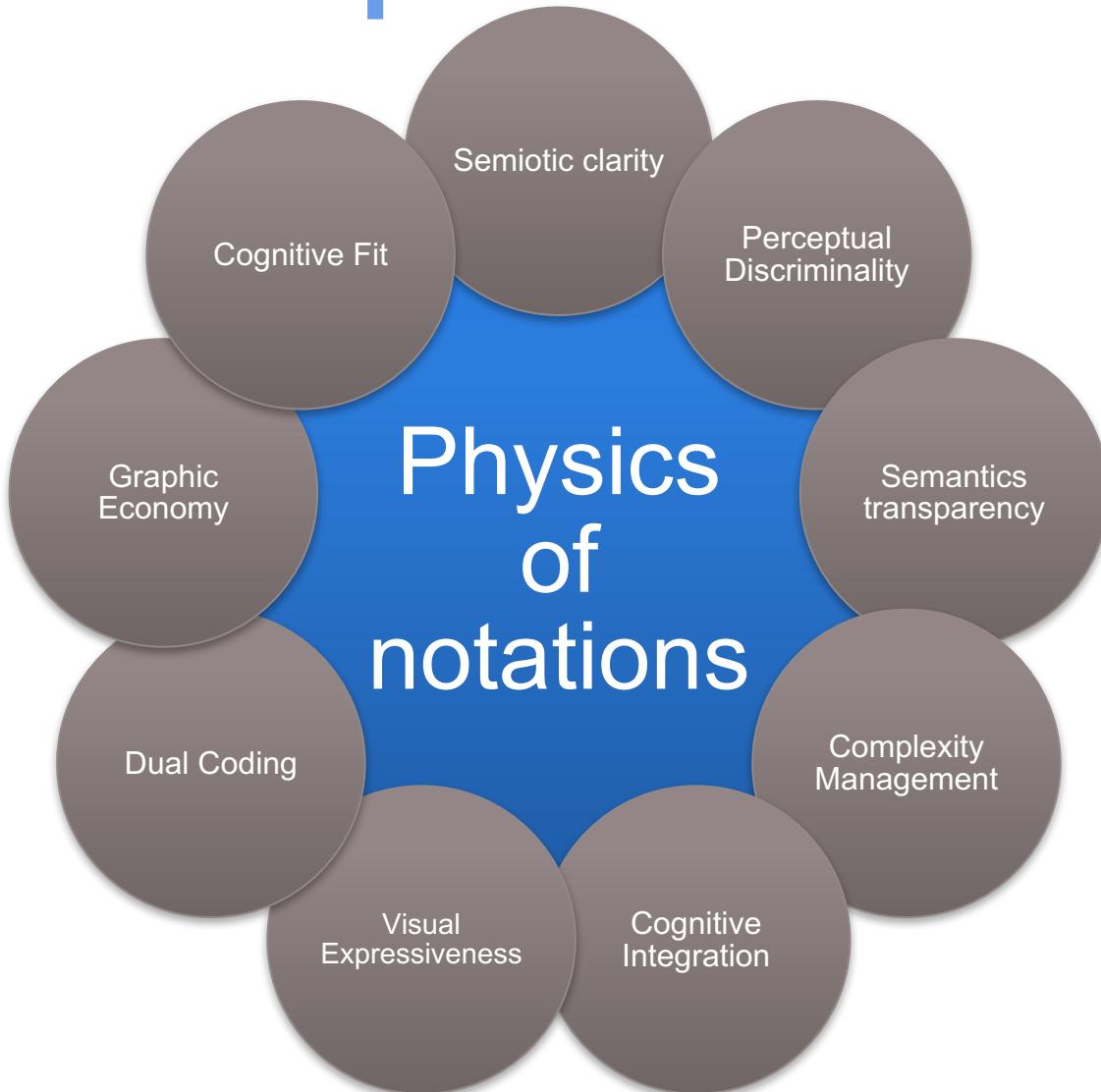
```
digraph G {  
    main -> parse -> execute;  
    main -> init;  
    main -> cleanup;  
    execute -> make_string;  
    execute -> printf  
    init -> make_string;  
    main -> printf;  
    execute -> compare;  
}
```



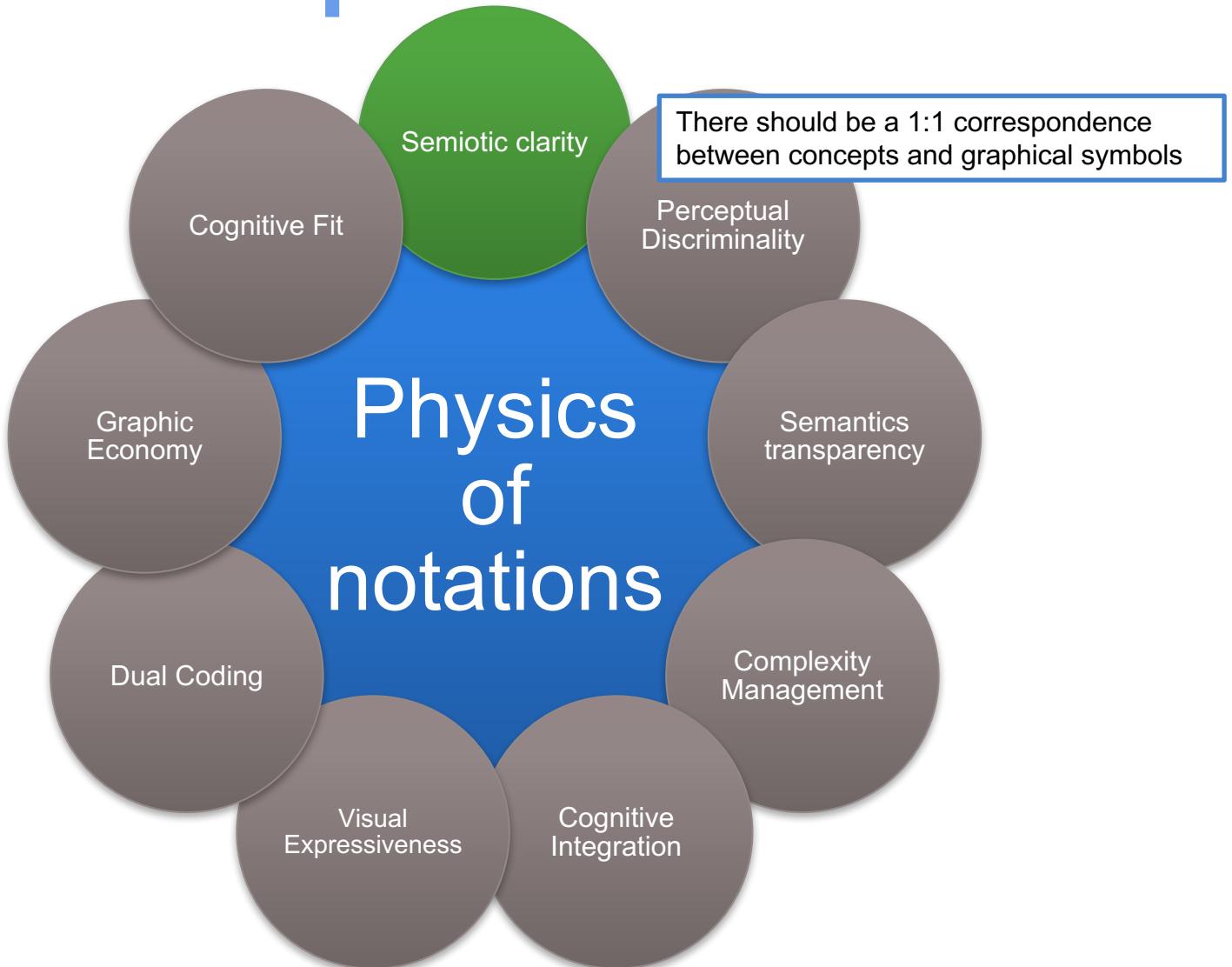
Recommendations for Graphical DSLs



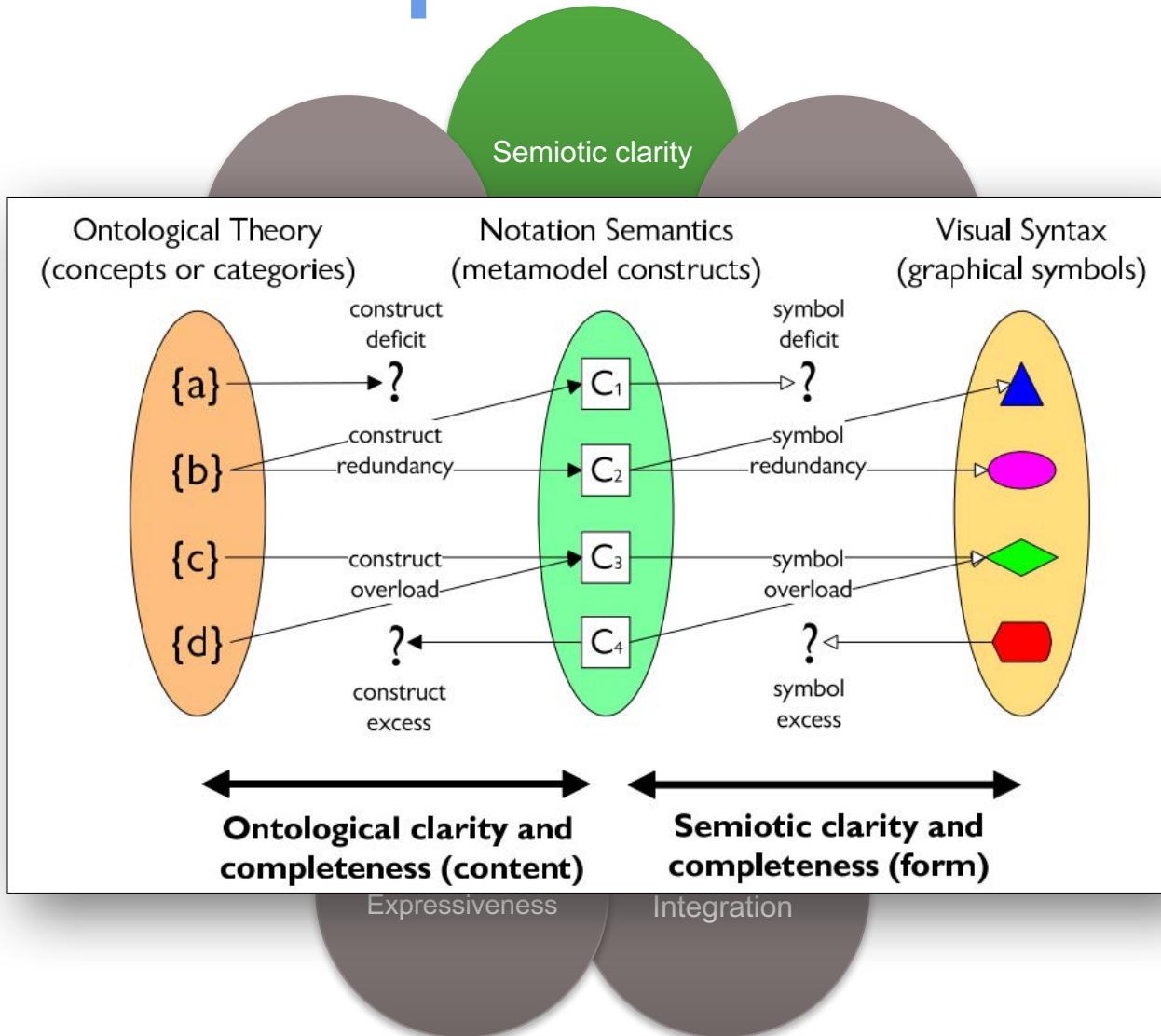
Recommendations for Graphical DSLs



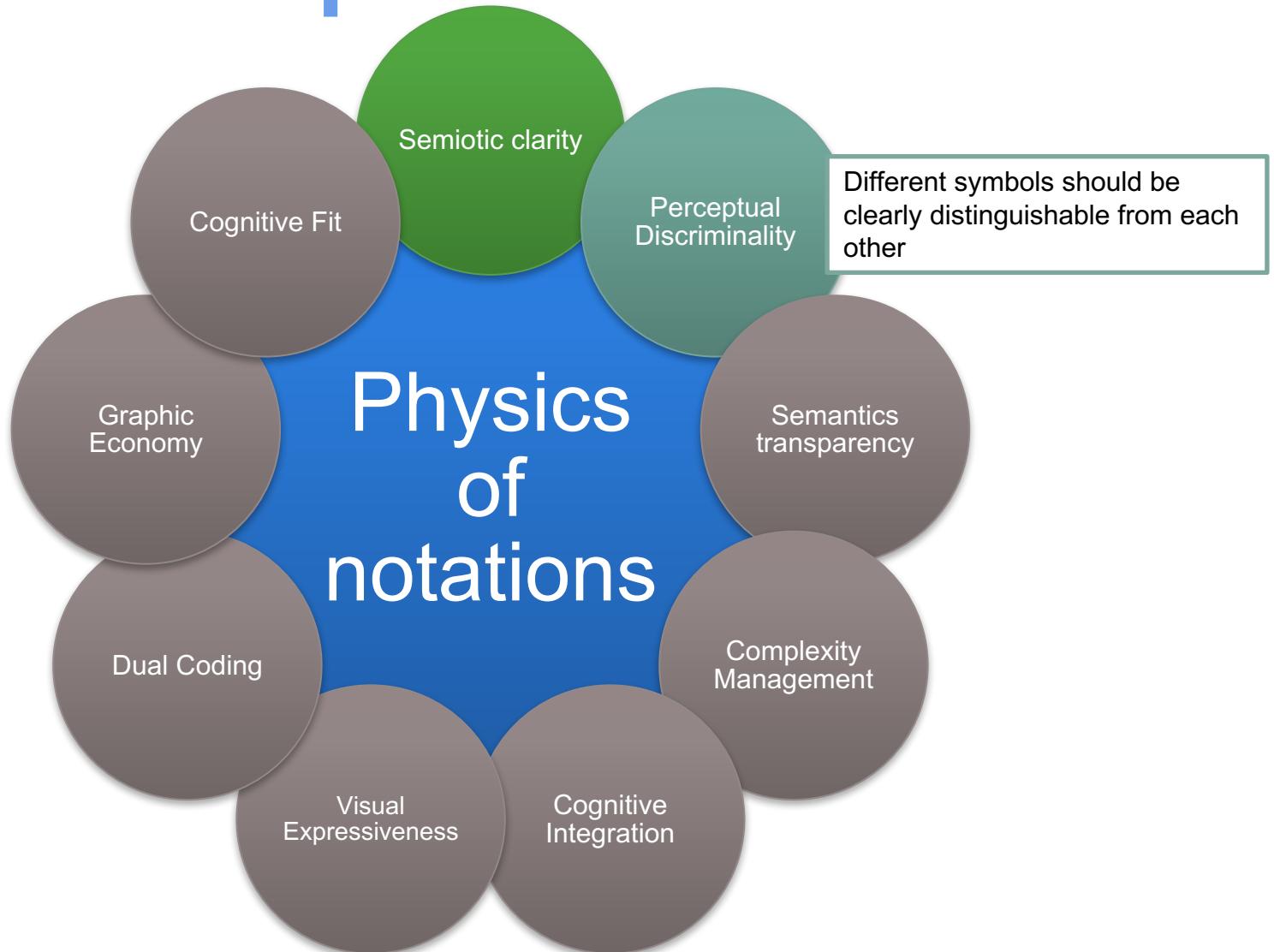
Recommendations for Graphical DSLs



Recommendations for Graphical DSLs



Recommendations for Graphical DSLs



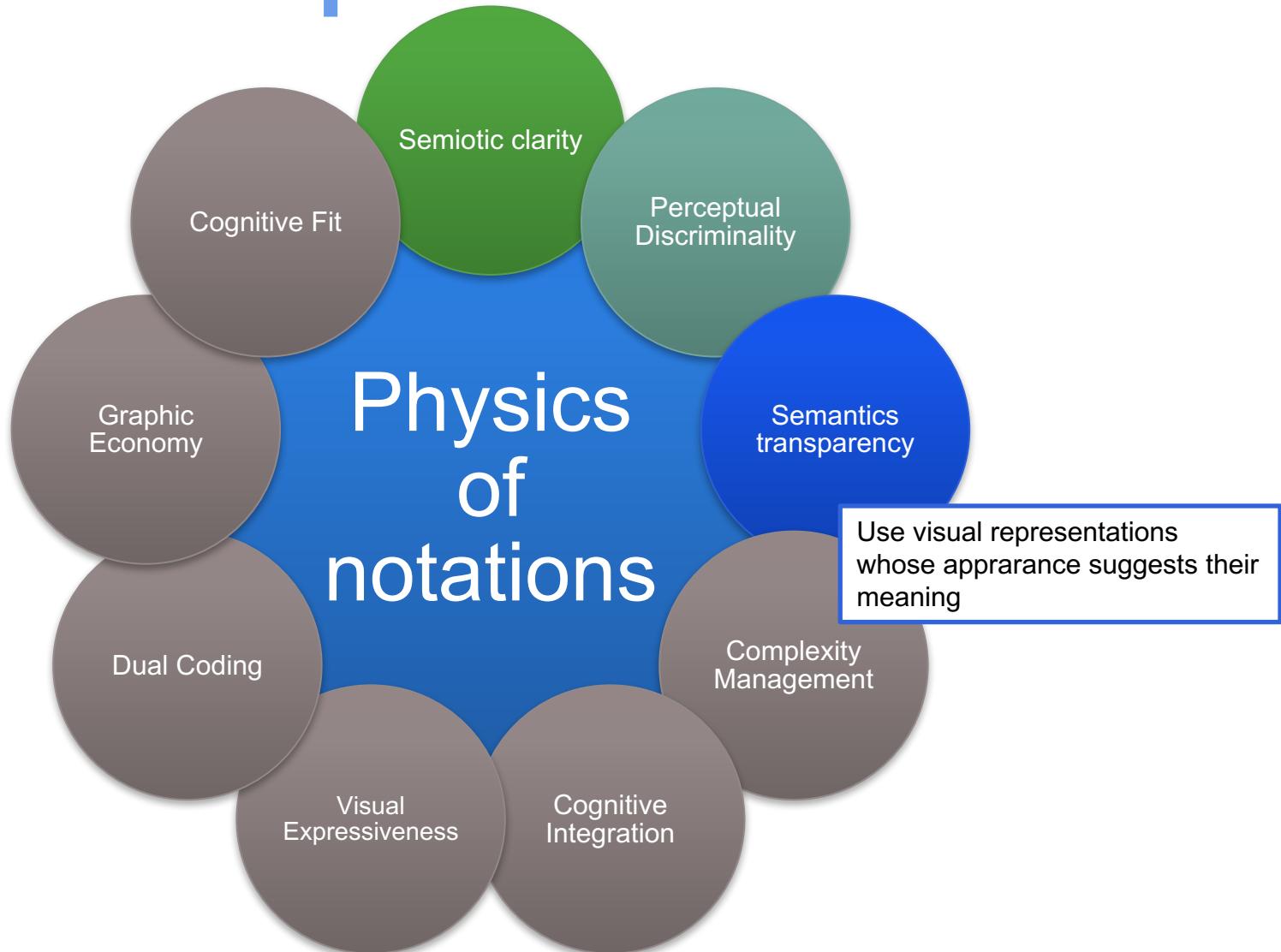
Recommendations for Graphical DSLs

Aggregation	Association (navigable)	Association (non-navigable)	Association class relationship	Composition
Constraint	Dependency	Generalisation	Generalisation set	Interface (provided)
Interface (required)	N-ary association	Note reference	Package containment	Package import (public)
Package import (private)	Package merge	Realisation	Substitution	Usage

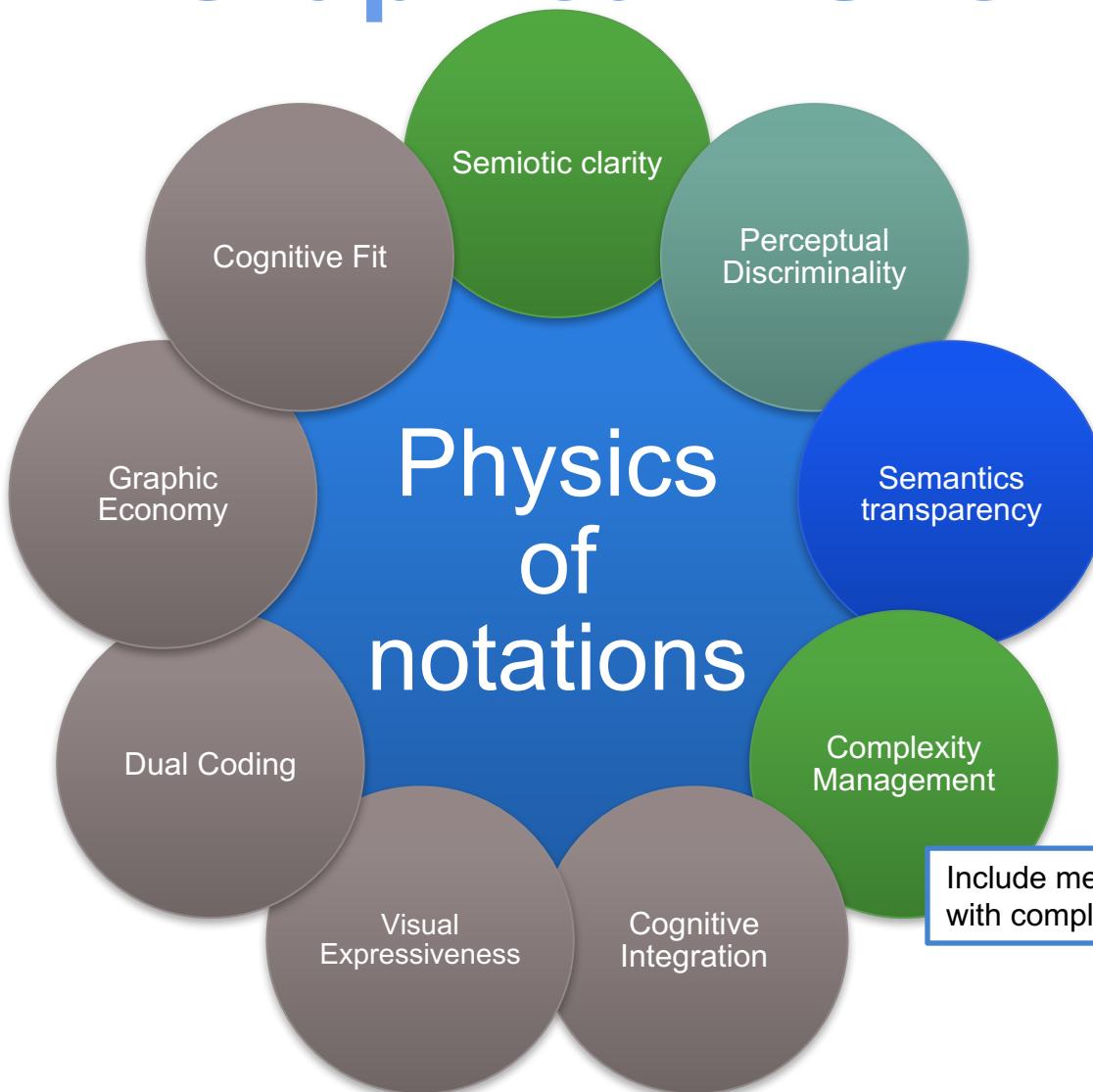
Visual Expressiveness

Cognitive Integration

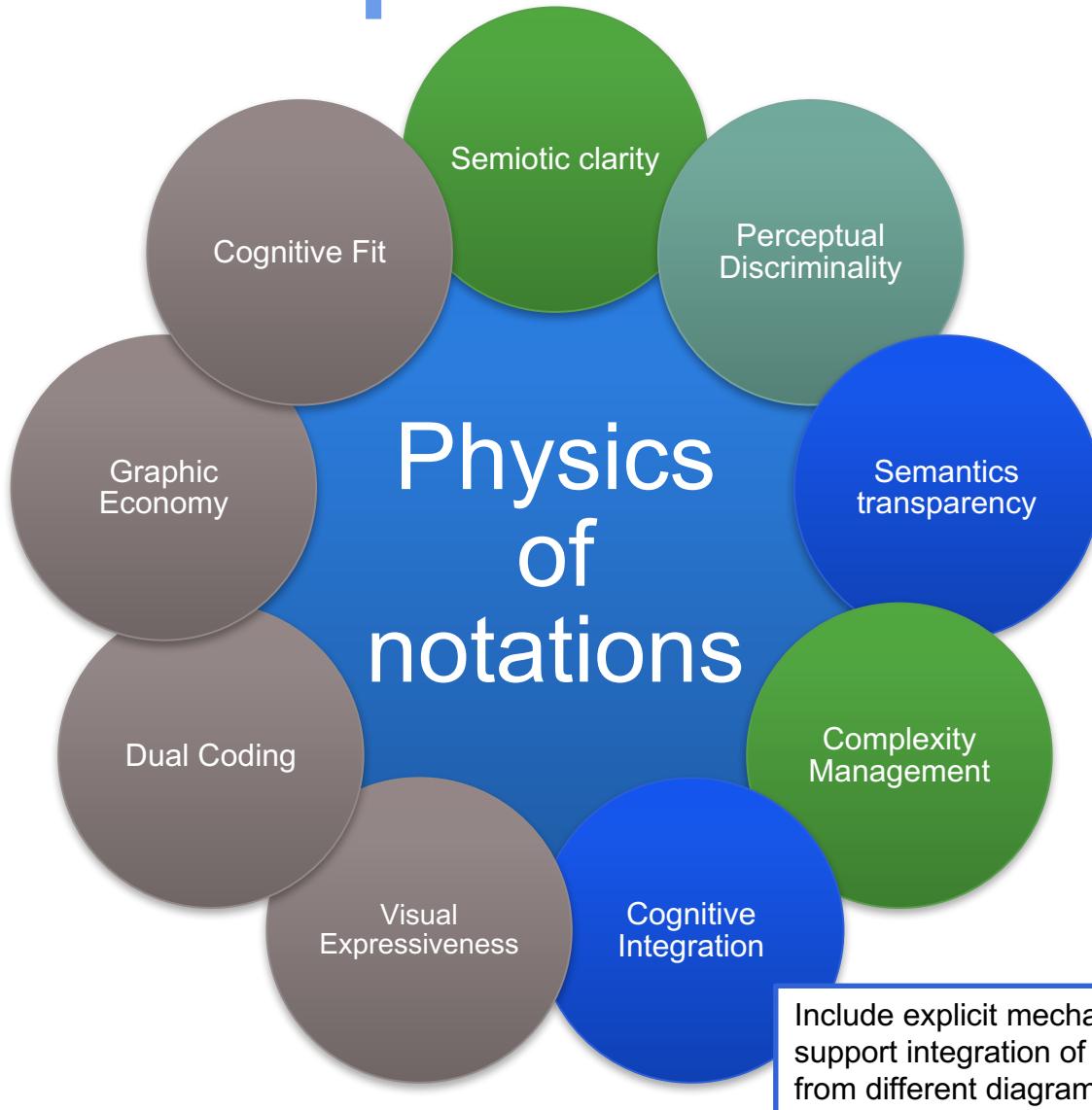
Recommendations for Graphical DSLs



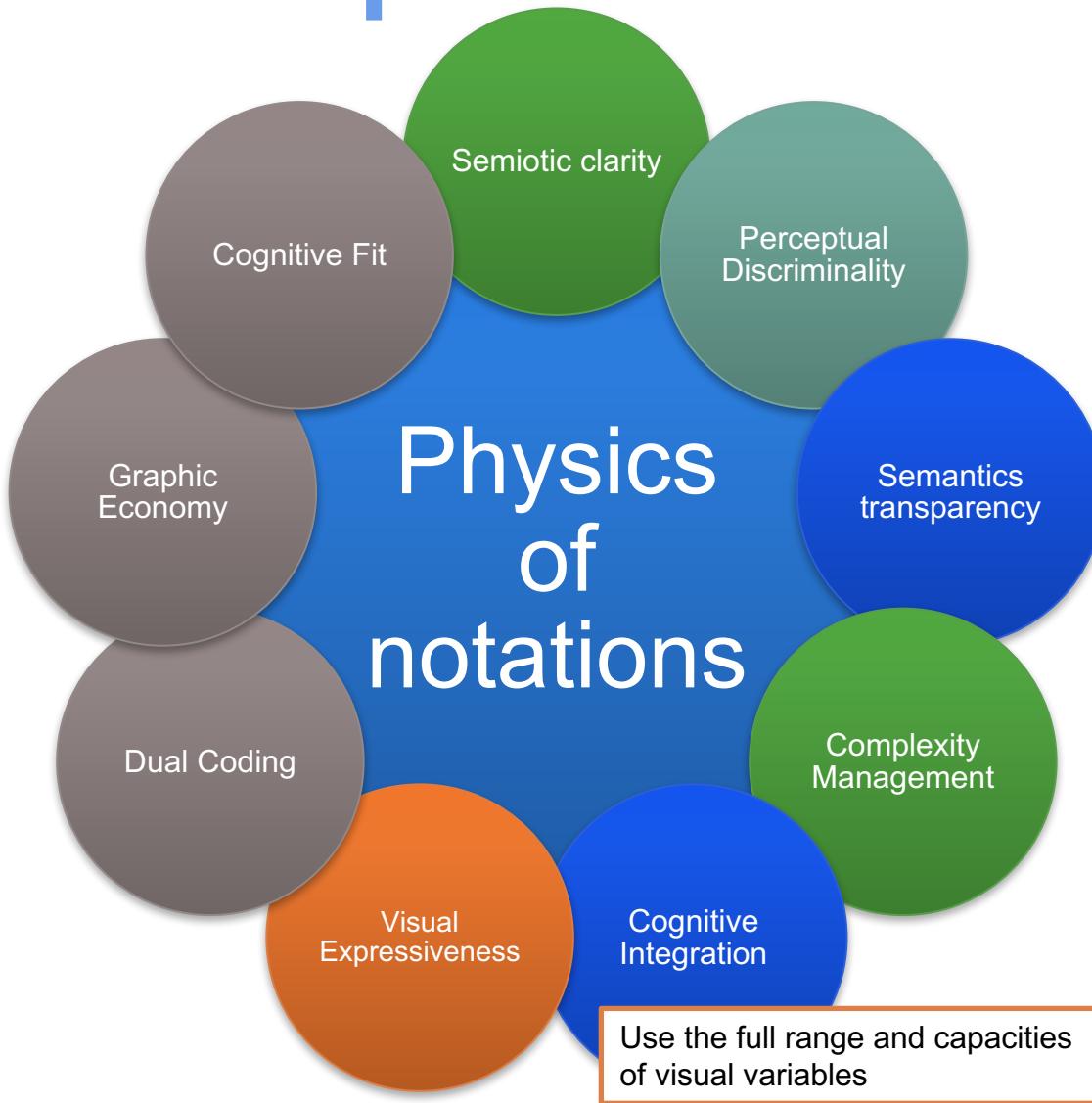
Recommendations for Graphical DSLs



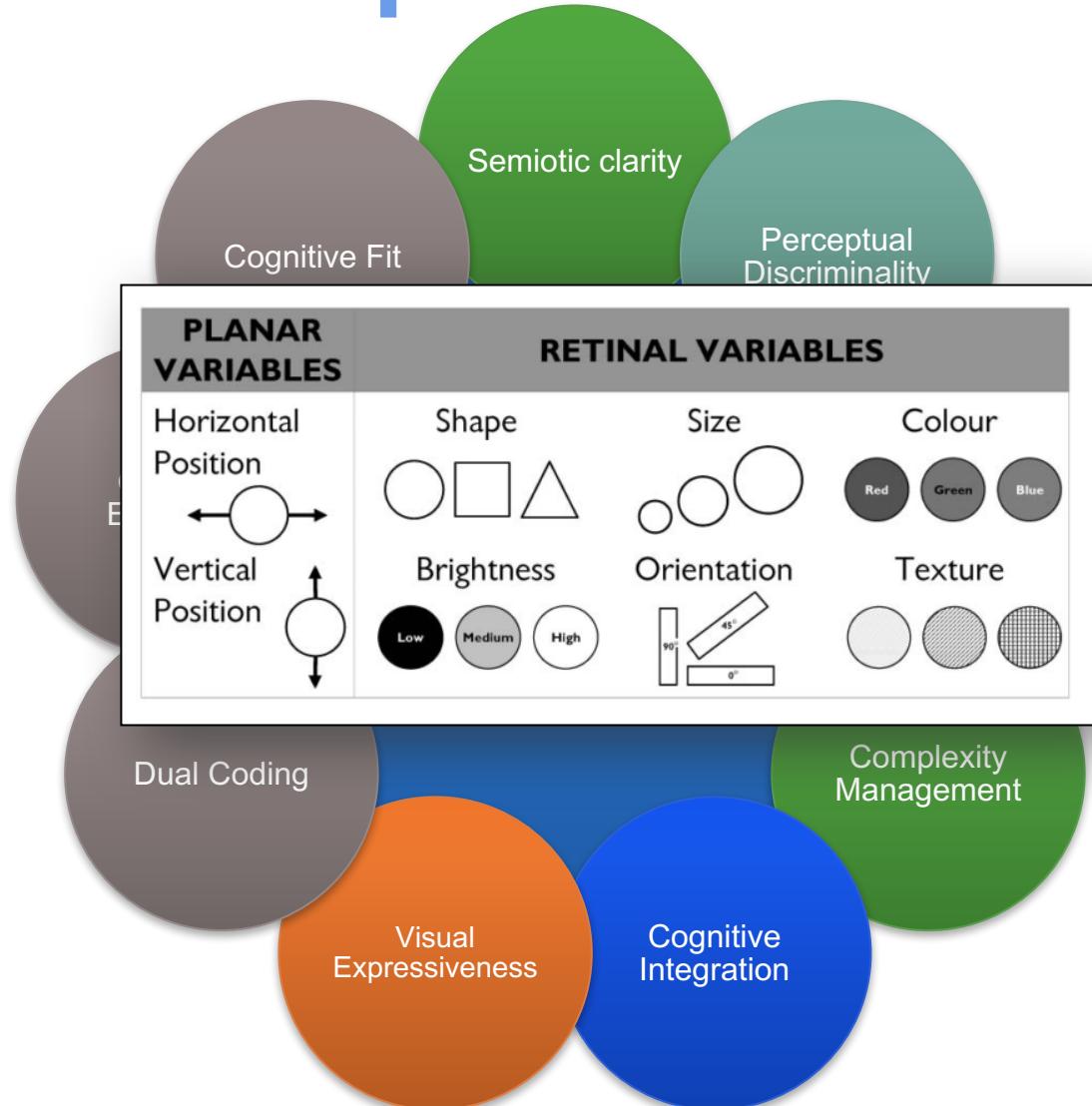
Recommendations for Graphical DSLs



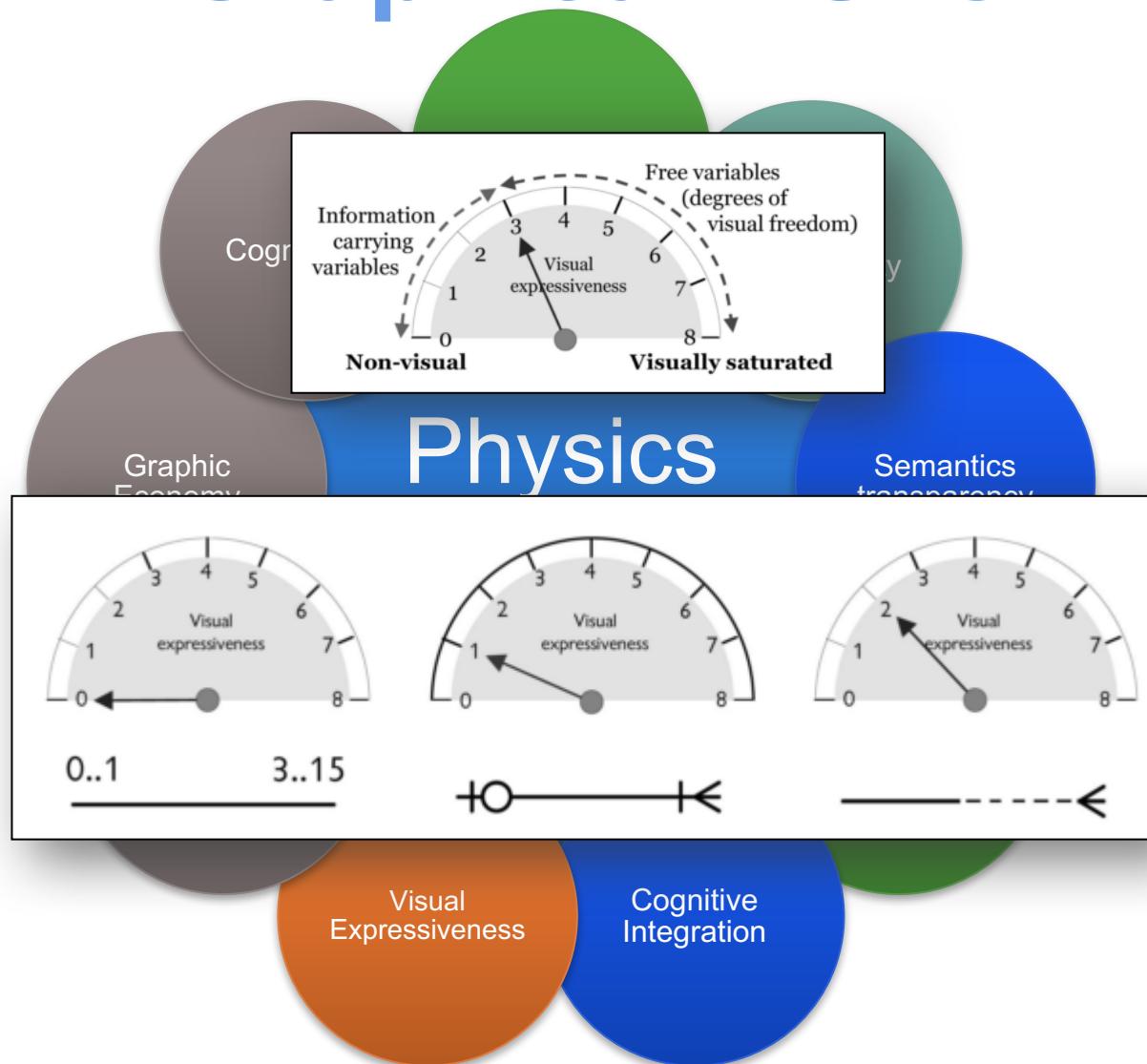
Recommendations for Graphical DSLs



Recommendations for Graphical DSLs



Recommendations for Graphical DSLs



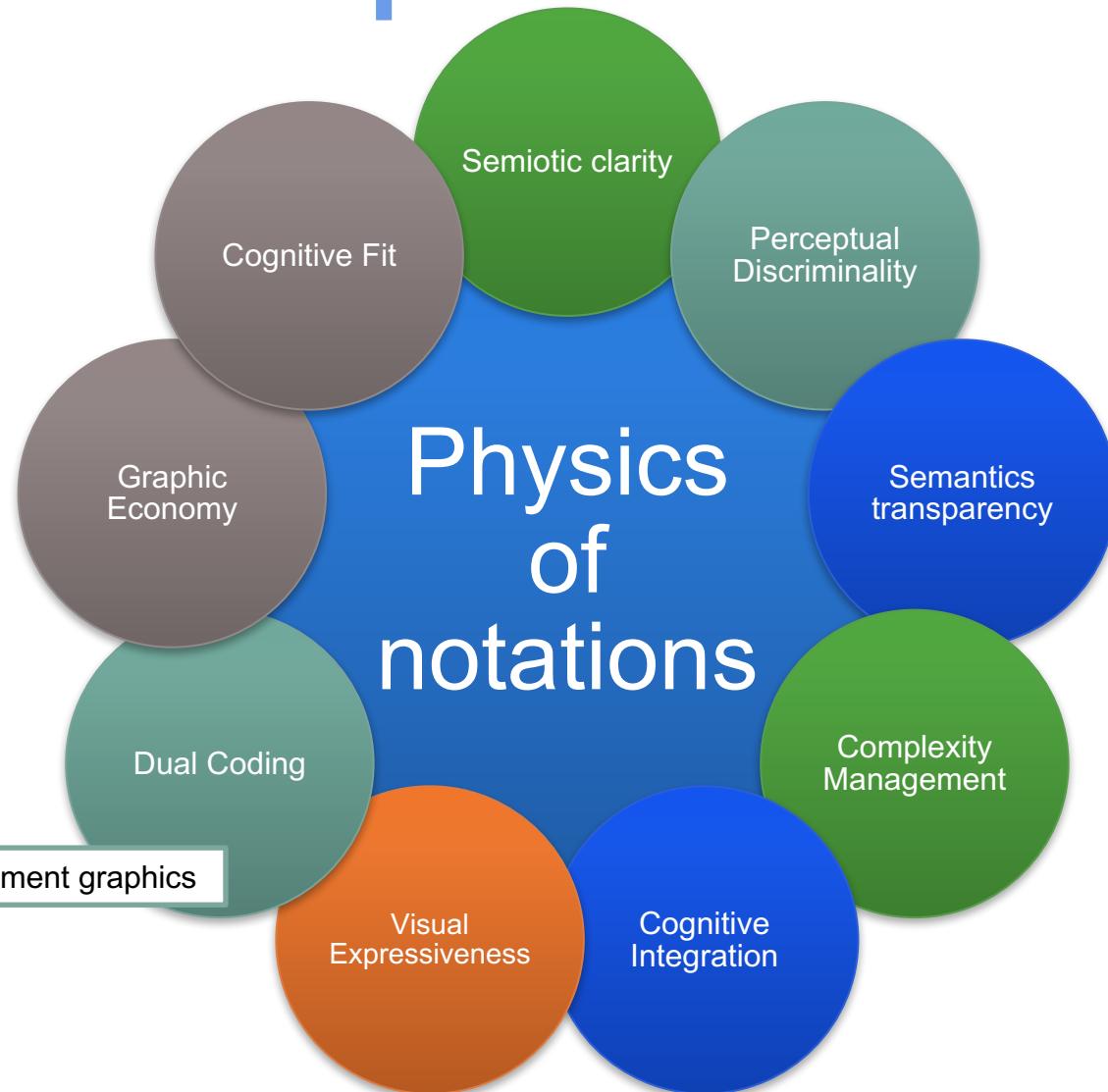
Recommendations for Graphical DSLs

Diagram Type	X	Y	Size	Brightness	Colour	Shape	Texture	Orientation
Activity	●	●		●		●		
Class				●		●		
Communication				●		●		
Component				●		●		
Composite structure				●		●		
Deployment				●		●		
Interaction overview				●		●		
Object				●		●		
Package				●		●		
Sequence	●					●		
State machine				●		●		
Timing	●	●				●		
Use case	●					●		

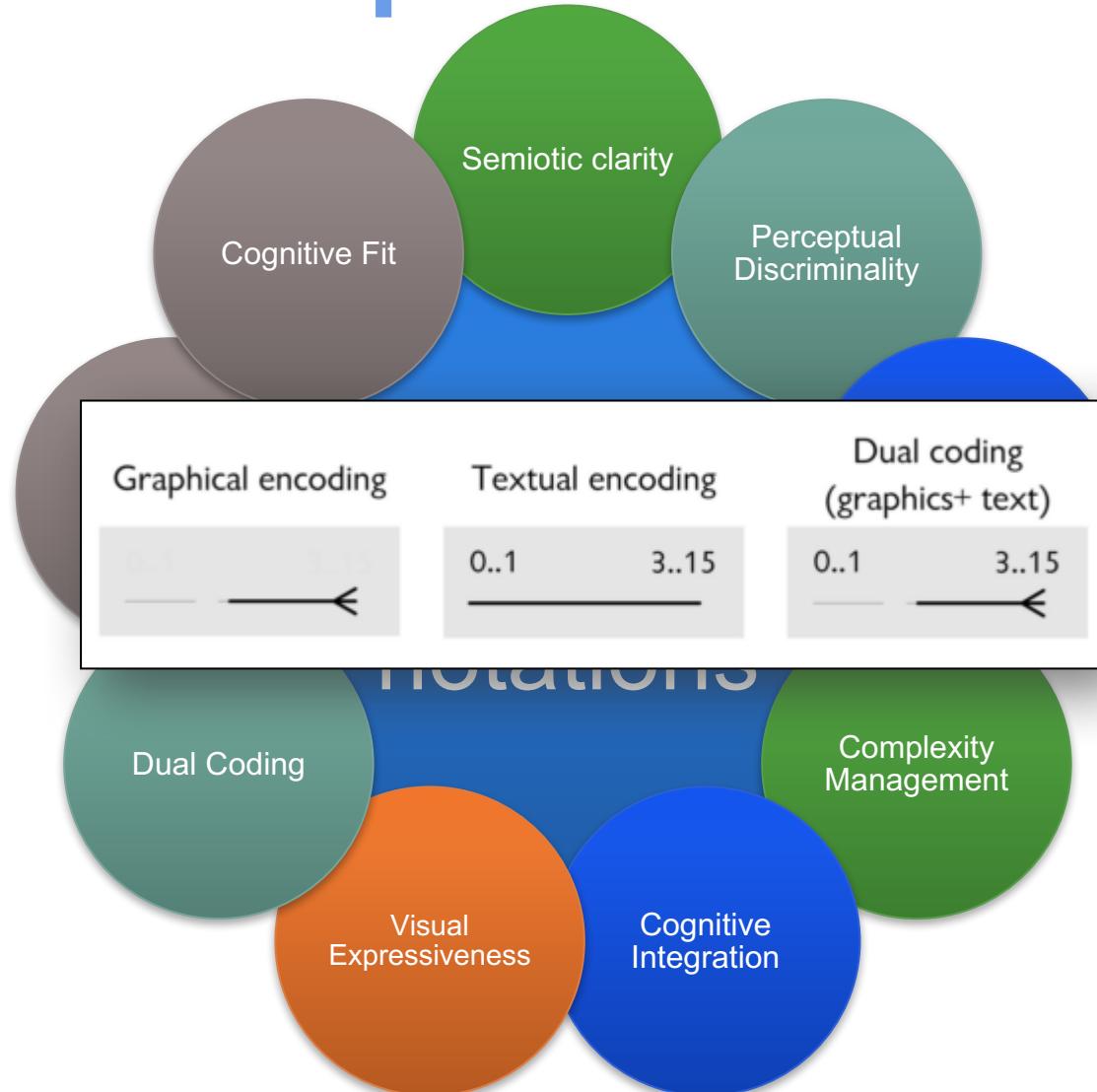
Visual Expressiveness

Cognitive Integration

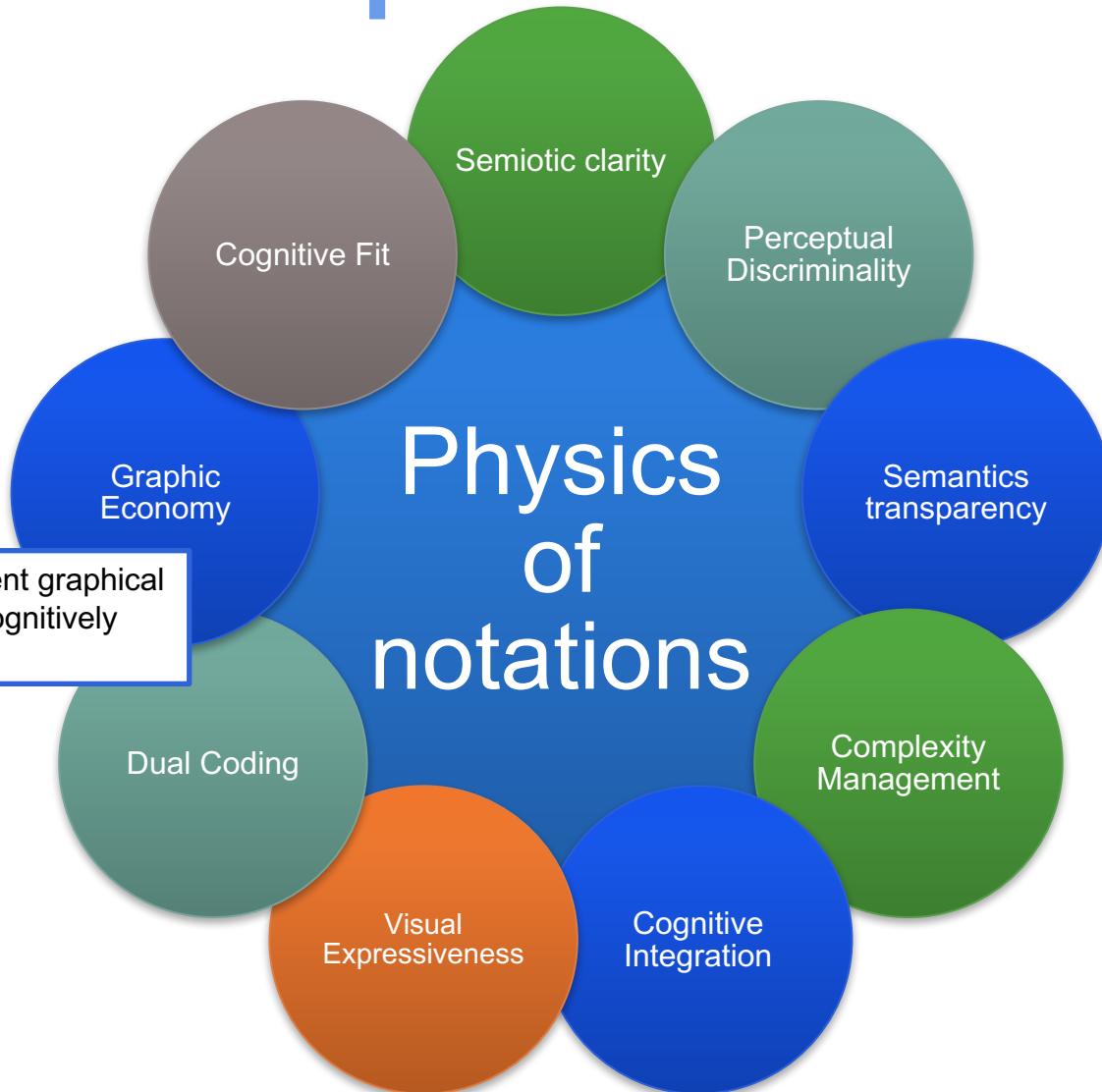
Recommendations for Graphical DSLs



Recommendations for Graphical DSLs

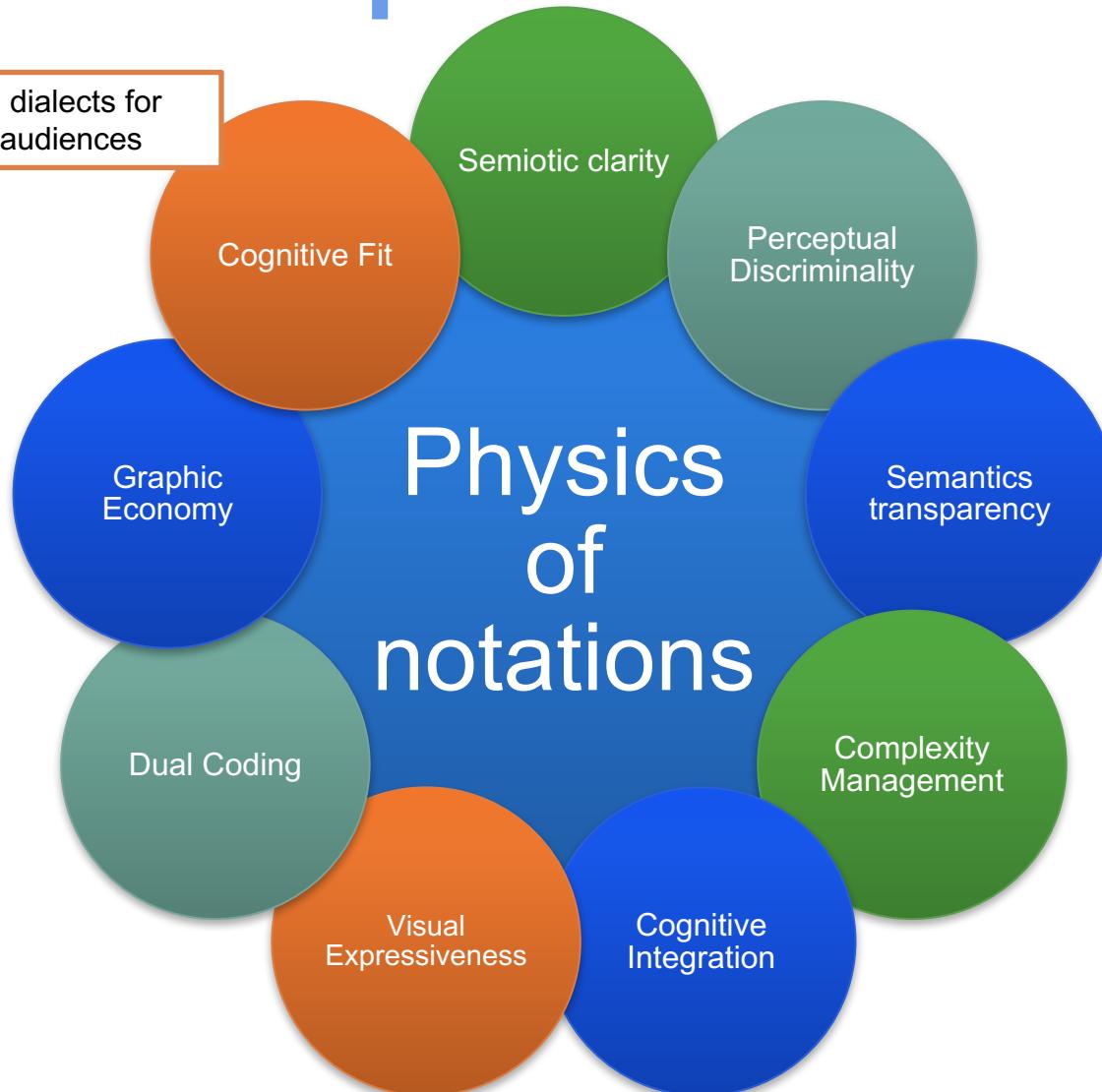


Recommendations for Graphical DSLs



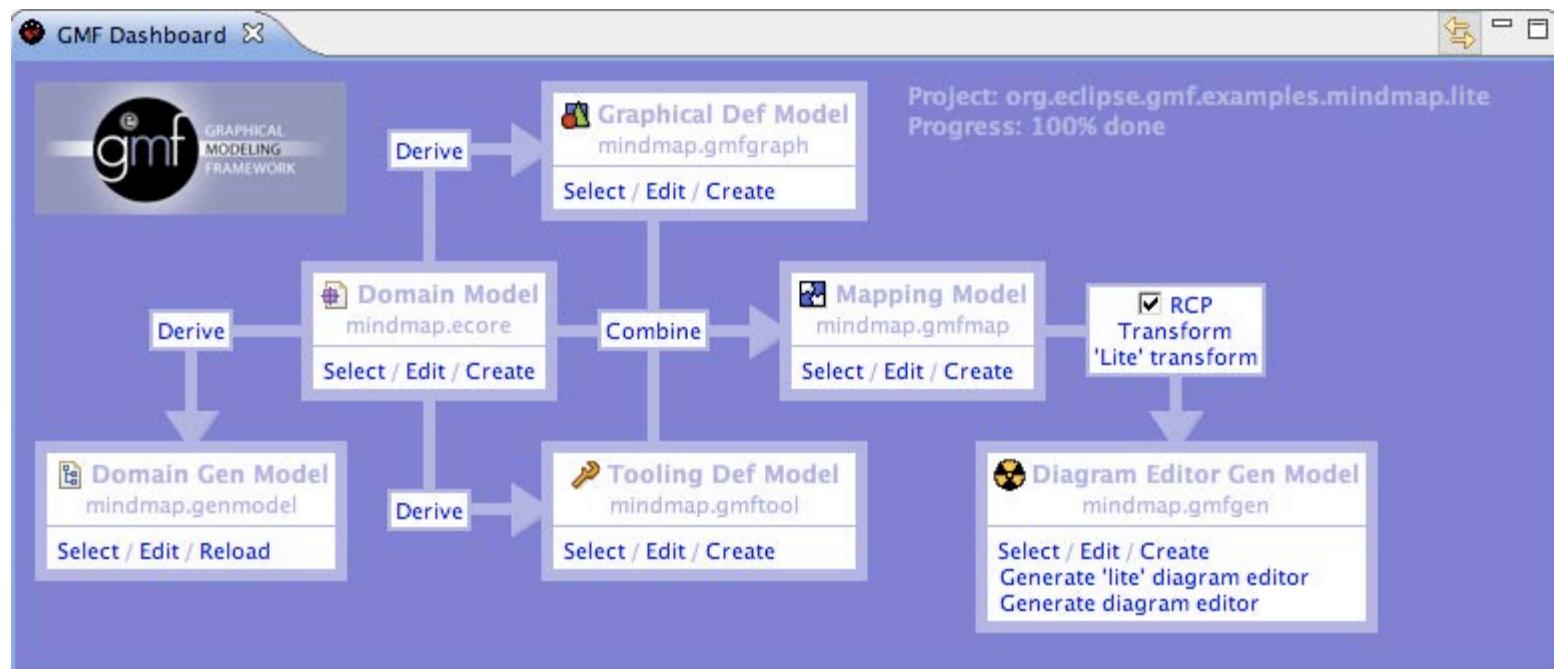
Recommendations for Graphical DSLs

Use different visual dialects for different tasks and audiences



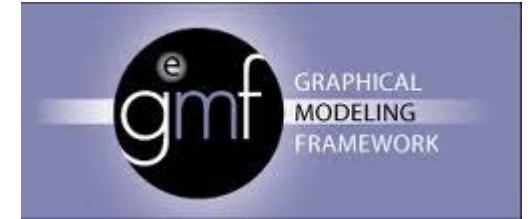
Graphical Modeling Framework (GMF)

- Model-Driven Framework to develop graphical editors based on EMF and GEF
- GMF is part of Eclipse Modeling Project
- Provides a generative component to create the DSL tooling
- Provides a runtime infrastructure to facilitate the development of graphical DSLs

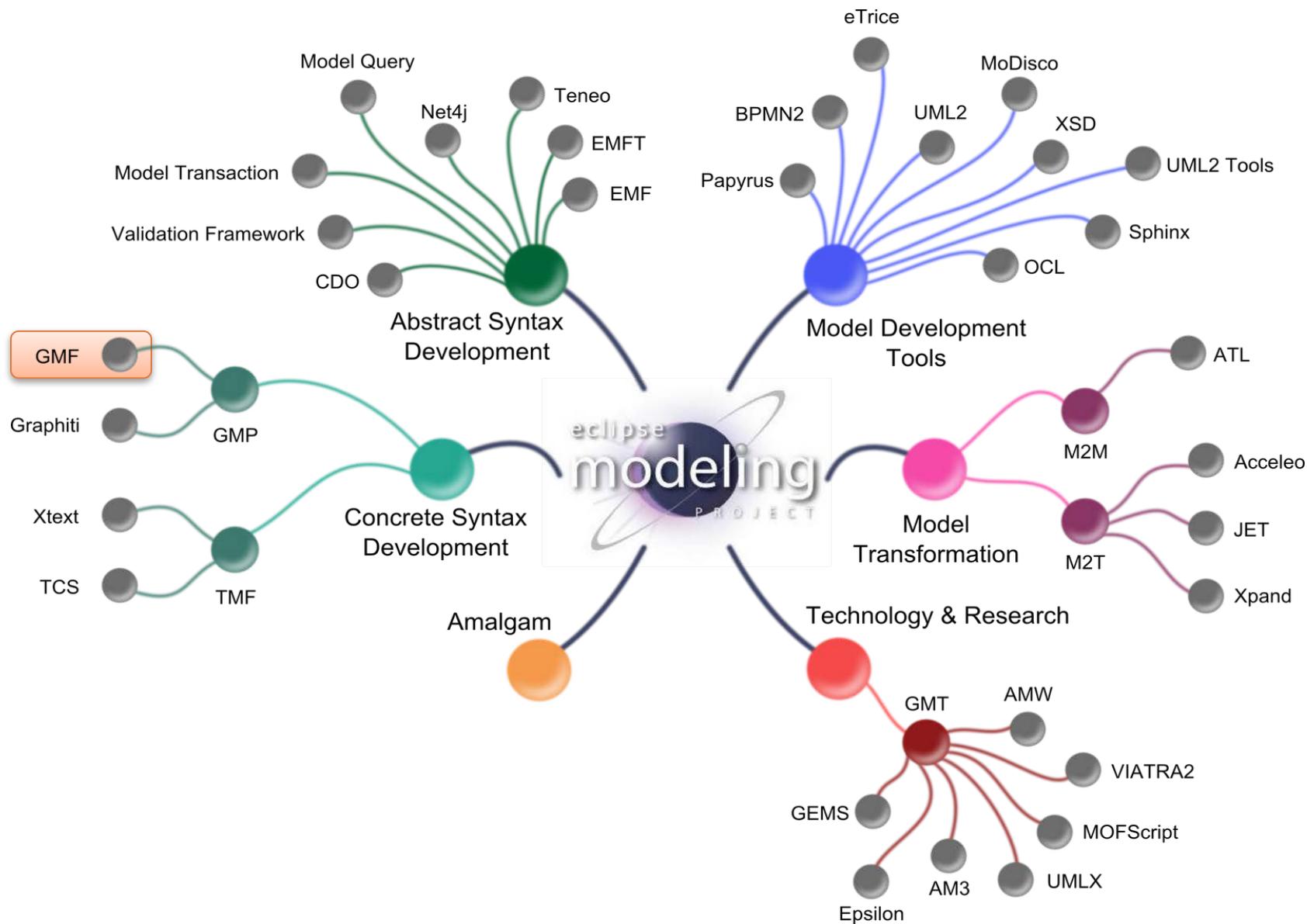


GMF

- Eclipse project
 - Eclipse Modelling components
 - Uses
 - EMF (Eclipse Modeling Framework)
 - GEF (Graphical Editing Framework)
- Model-driven framework for Graphical DSLs
 - Everything is a model
- DSL definition easy, tweaking hard



Eclipse Modeling Project



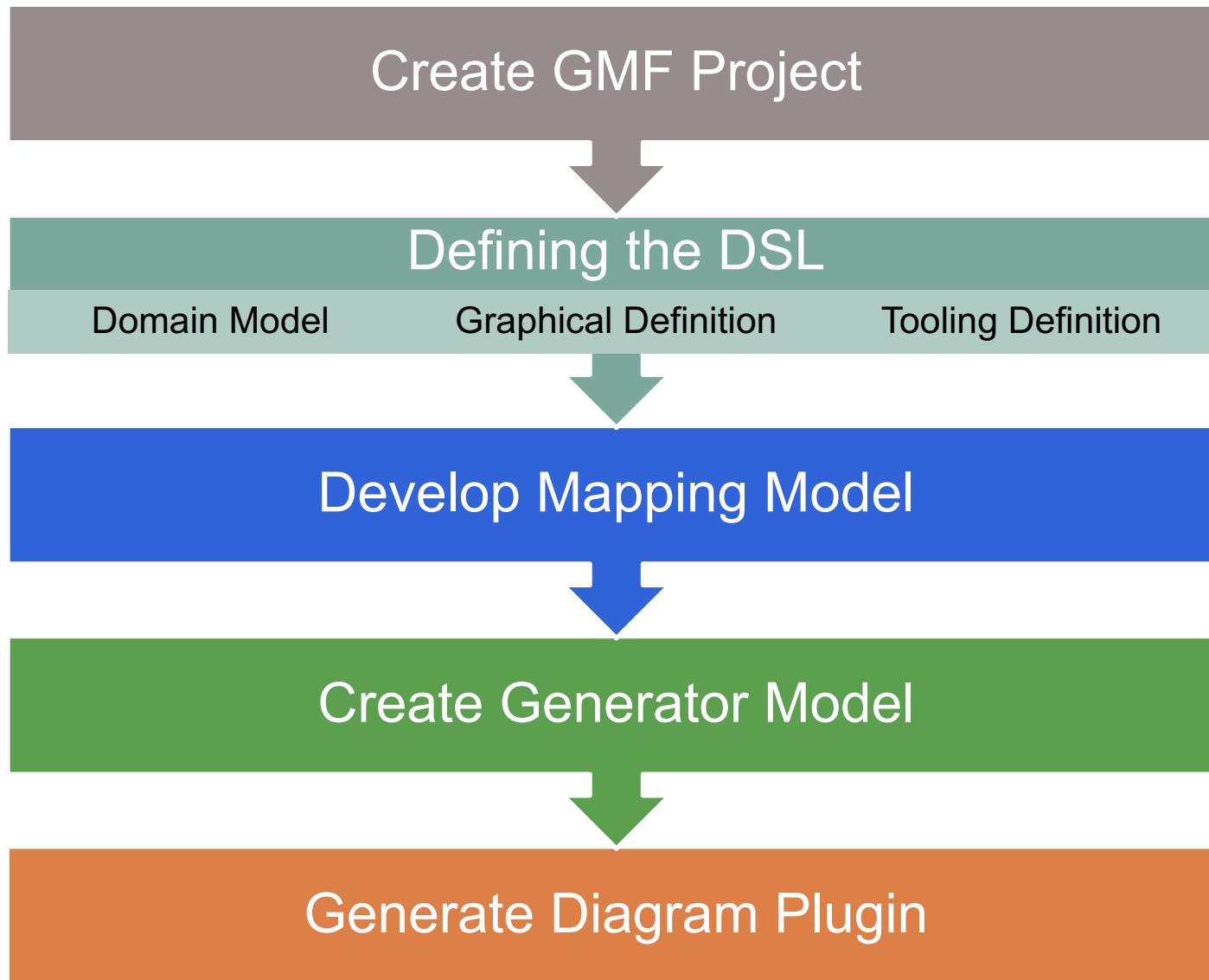
GMF features

- Tooling
 - Editors for notation, semantic and tooling
 - GMF Dashboard
 - Generator to produce the DSL implementation
- Runtime
 - Generated DSLs depend on the GMF Runtime to produce an extensible graphical editor

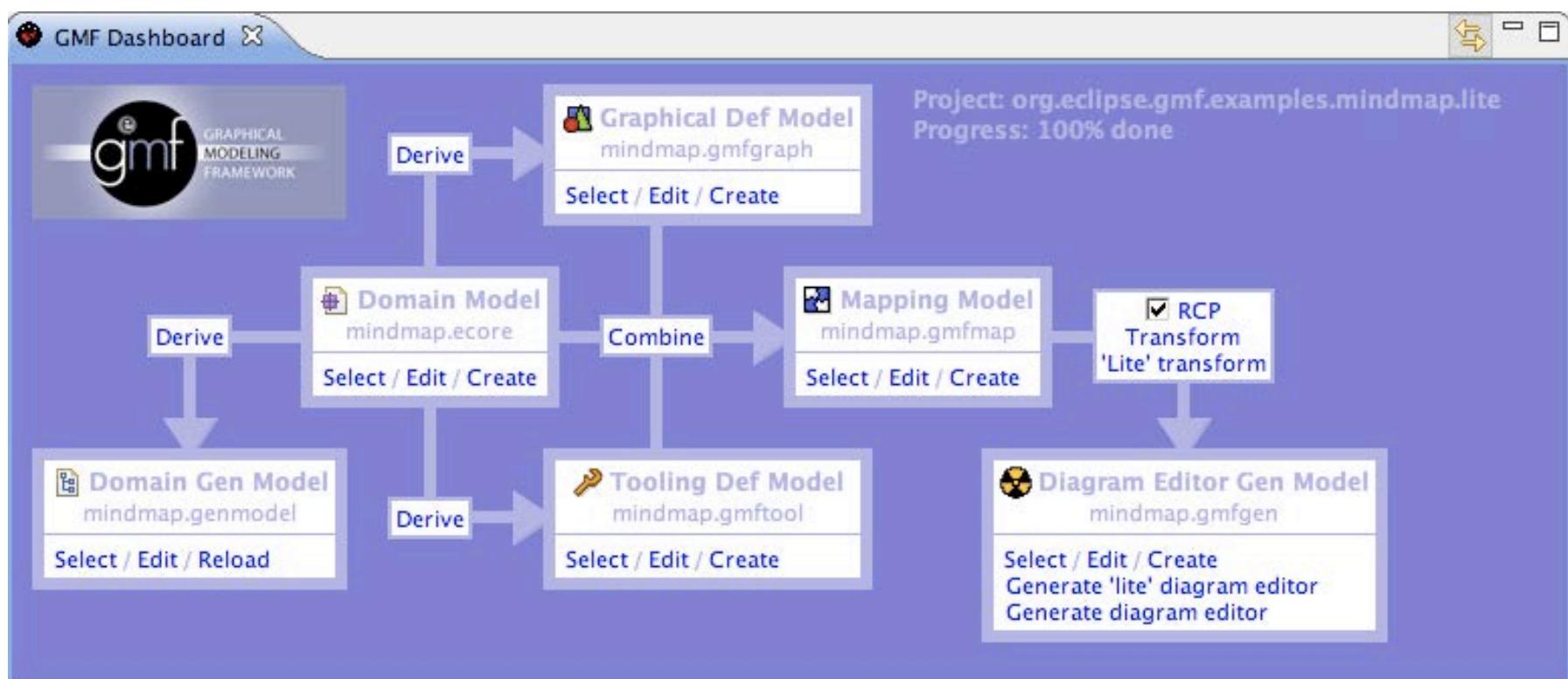
Main Advantages

- Consistent look and feel
- Diagram persistence
- Open editors can be extended by third-parties
- Already integrated with various Eclipse components
- Extensible notation metamodel to enable the isolation of notation from semantic concerns
- Future community enhancements will easily be integrated

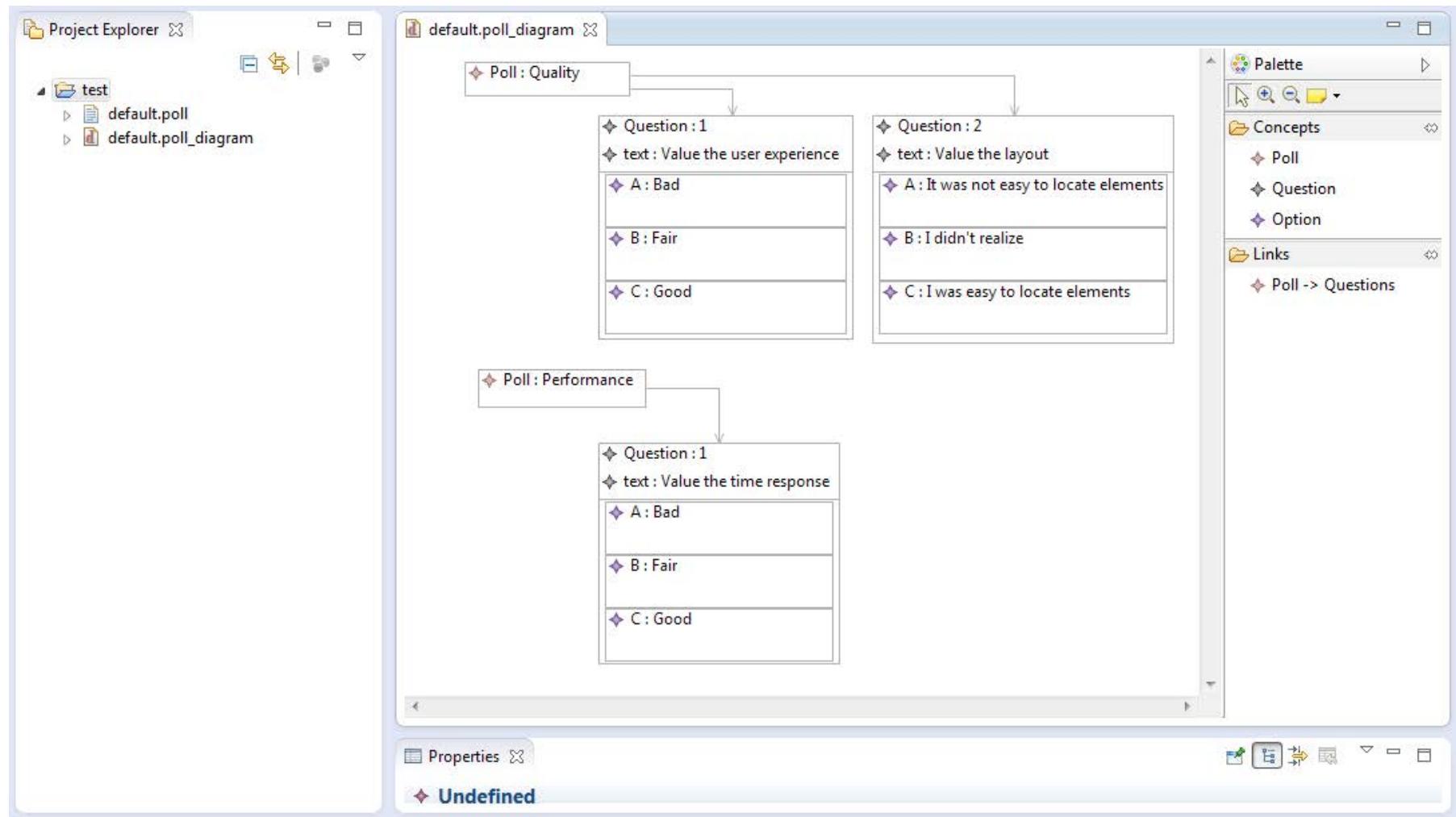
Development Process



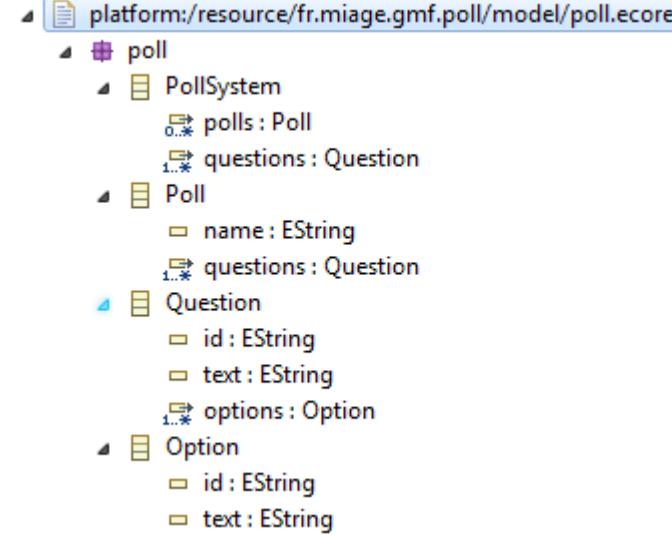
Development Process



Example (Graphical Notation)

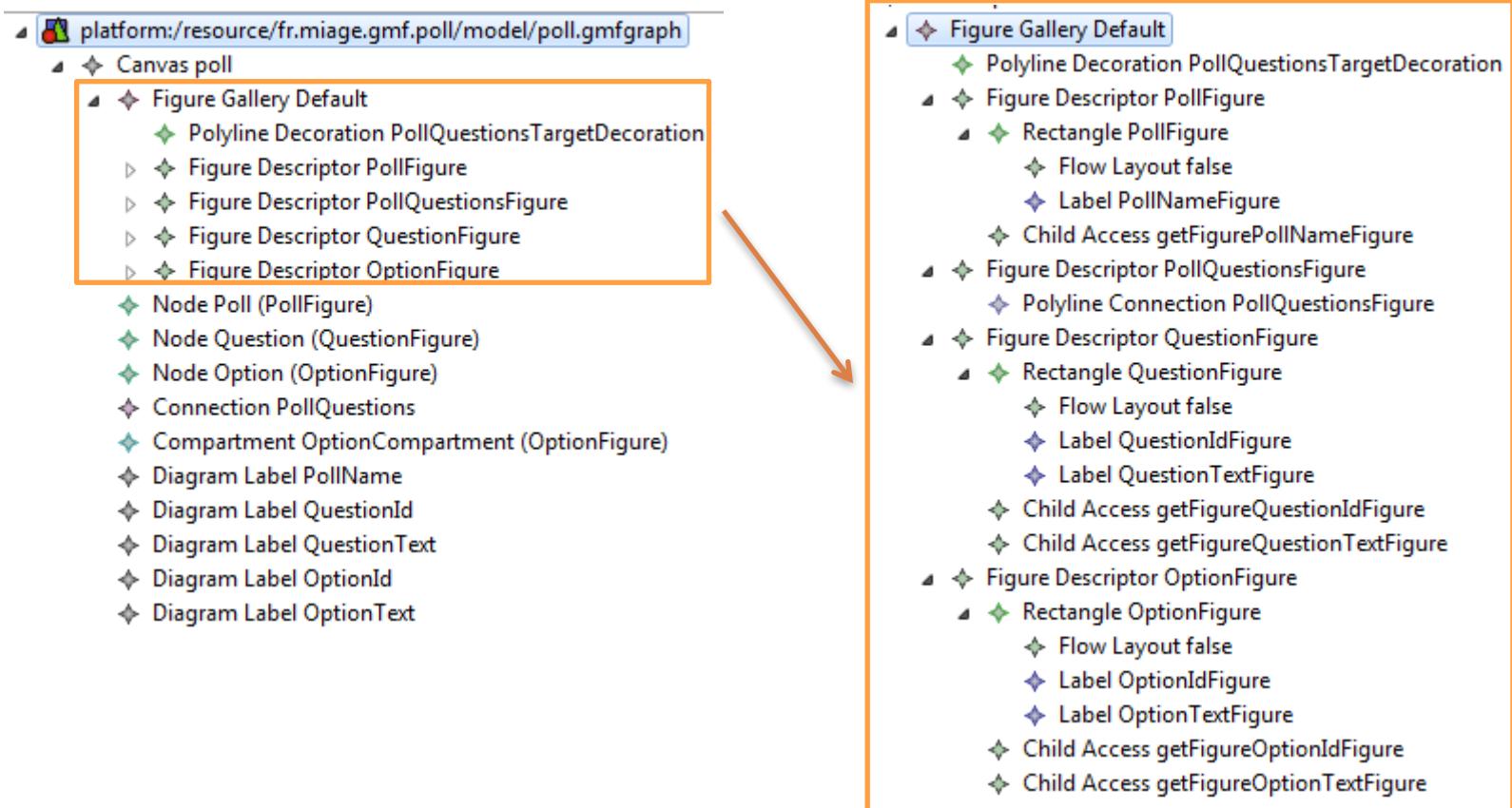


Poll System Metamodel

- Concepts
 - PollSystem
 - Poll
 - Question
 - Option
 - Attributes
 - A Poll has a name
 - A Question has an identifier and a descriptive text
 - An Option has an identifier and a descriptive text
 - Relationships
 - PollSystem is composed of polls and questions
 - Question has a set of options
- 
- ```
platform:/resource/fr.miage.gmf.poll/model/poll.ecore
 package poll {
 class PollSystem {
 <--> Poll polls
 <--> Question questions
 }
 class Poll {
 name : EString
 <--> Question questions
 }
 class Question {
 id : EString
 text : EString
 <--> Option options
 }
 class Option {
 id : EString
 text : EString
 }
 }
```

# Graphical Definition

- A model will represent a PollSystem
- A Poll will be a node
- A Question will be a rectangular node
- An Option will be a rectangular node included in the Question node



# Plan

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

# 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)
- Models and Languages
  - Perhaps a more concrete way to see models, metamodels and MDE (IDM in french)

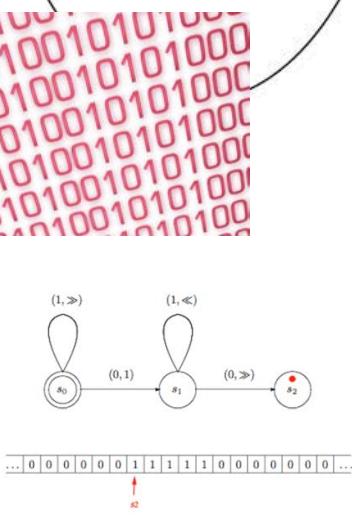
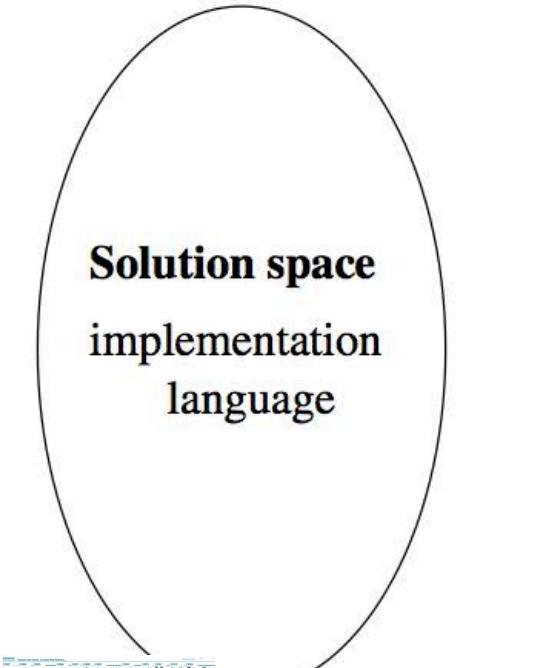
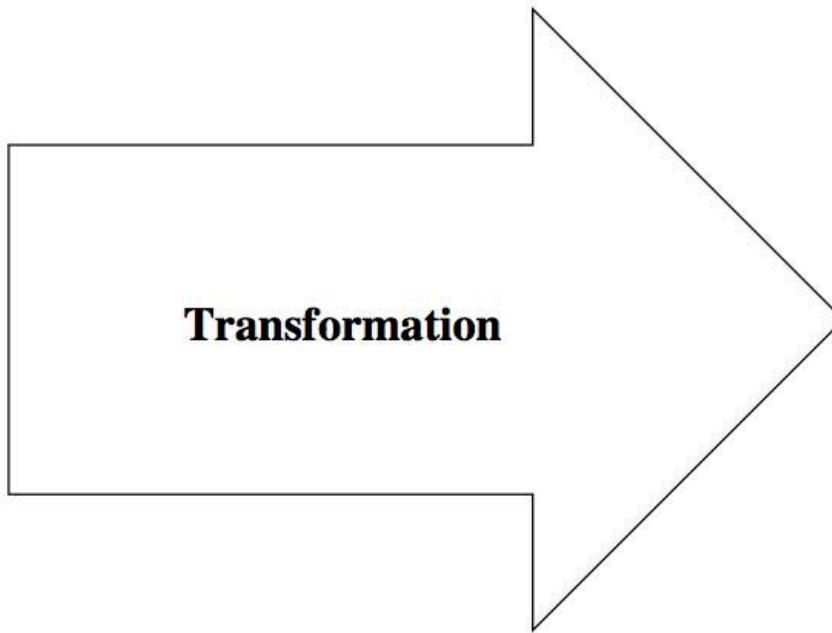
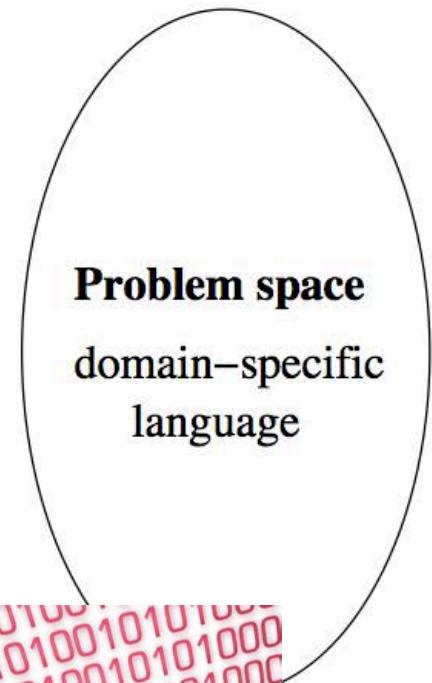
DSL,

Model,

Metamodel,

Summary

# Abstraction Gap



# Models/MDE

- In essence, a model is an **abstraction** of some aspect of a system under study.
- Some details are hidden or removed to **simplify** and focus attention.
- A model is an abstraction since **general** concepts can be formulated by abstracting common properties of instances or by extracting common features from specific examples
- **(Domain-specific) Languages** enable the specification or execution of models

# Generative approach

- Programming the generation of programs
  - Very old practice
  - Metaprogramming: generative language and target language are the same
    - Reflection capabilities
- Generalization of this idea:
  - from a specification written in one or more textual or graphical domain-specific languages
  - you generate customized variants

# Grammar

```
machineDefinition:
 MACHINE OPEN_SEP stateList
 transitionList CLOSE_SEP;

stateList:
 state (COMMA state)*;

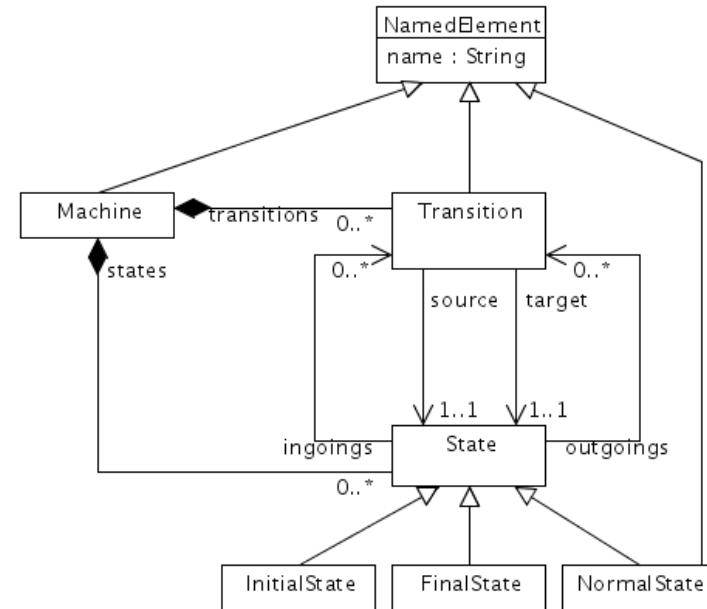
state:
 ID_STATE;

transitionList:
 transition (COMMA transition)*;

transition:
 ID_TRANSITION OPEN_SEP
 state state CLOSE_SEP;

MACHINE: 'machine';
OPEN_SEP: '{';
CLOSE_SEP: '}';
COMMA: ',';
ID_STATE: 'S' ID;
ID_TRANSITION: 'T' (0..9)+;
ID: (a..zA..Z_) (a..zA..Z0..9)*;
```

# MetaModel



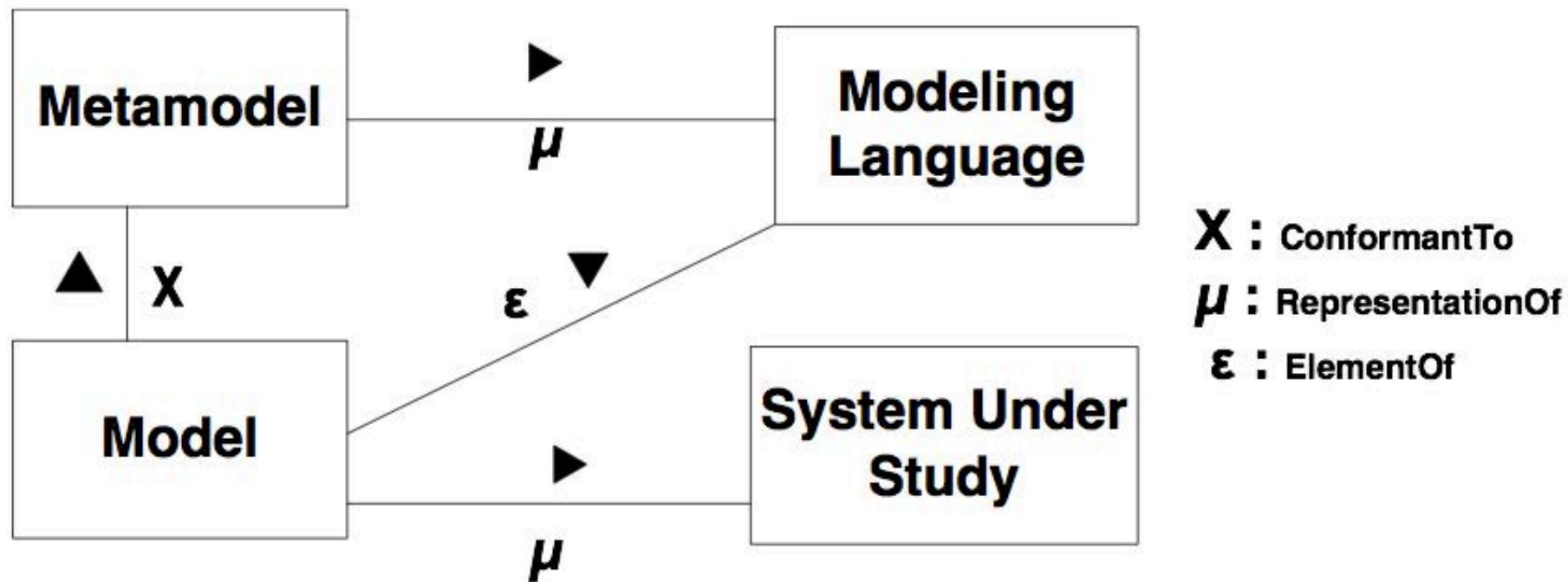
conforms To

```
machine {
 SOne STwo
 T1 { SOne STwo }
}
```

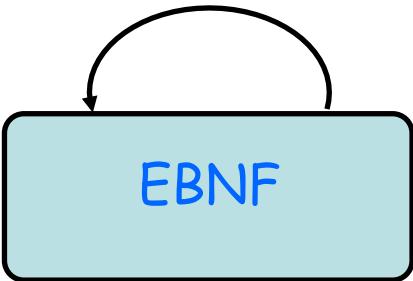
conforms To

Source Code/Model

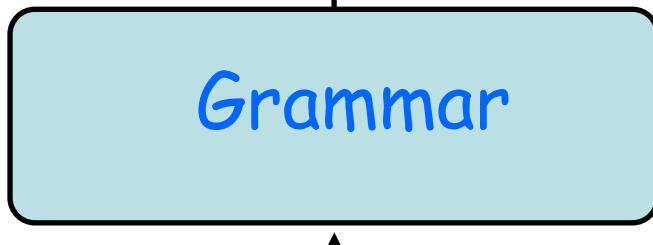
# Model, Metamodel, Metametamodel, DSML



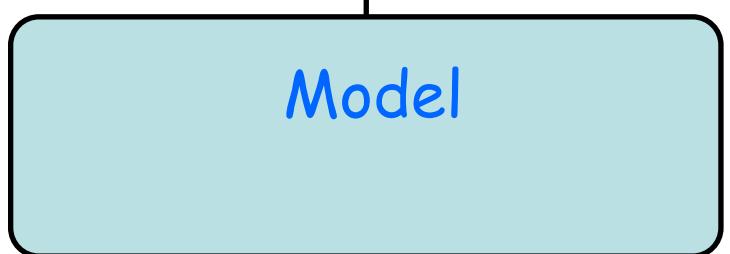
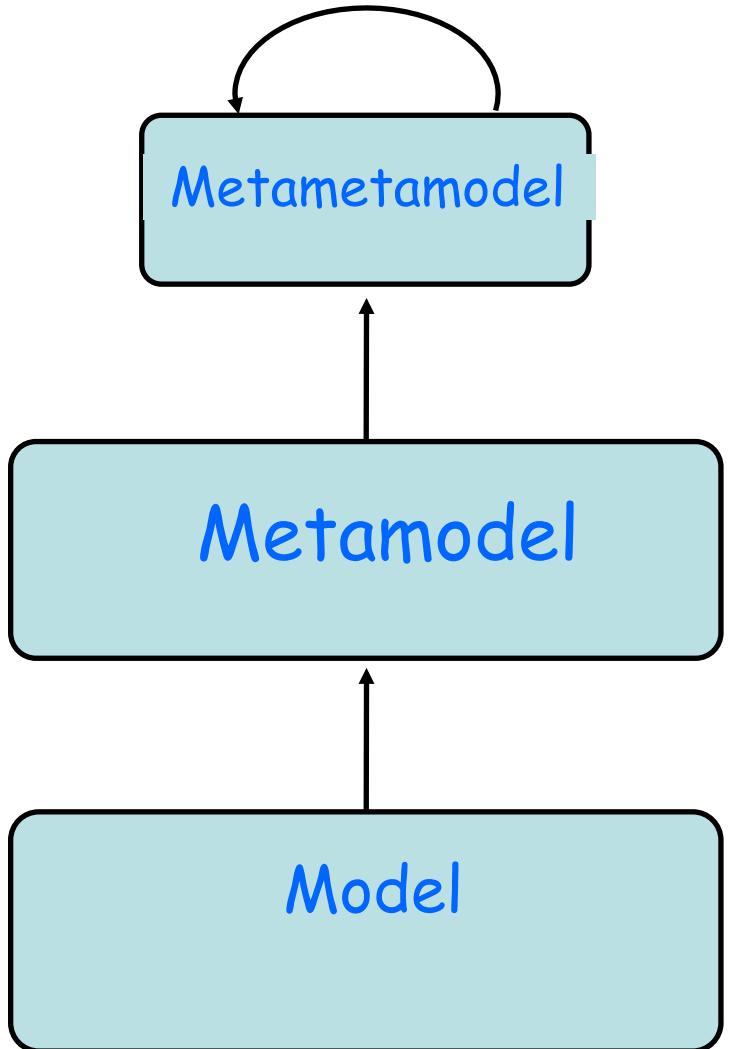
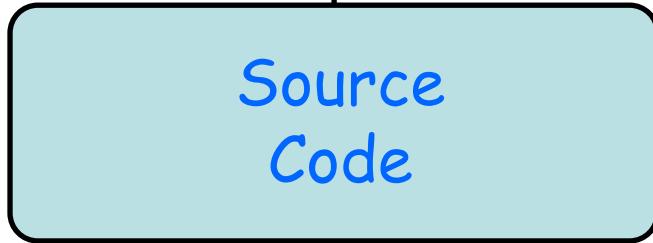
M<sup>3</sup>



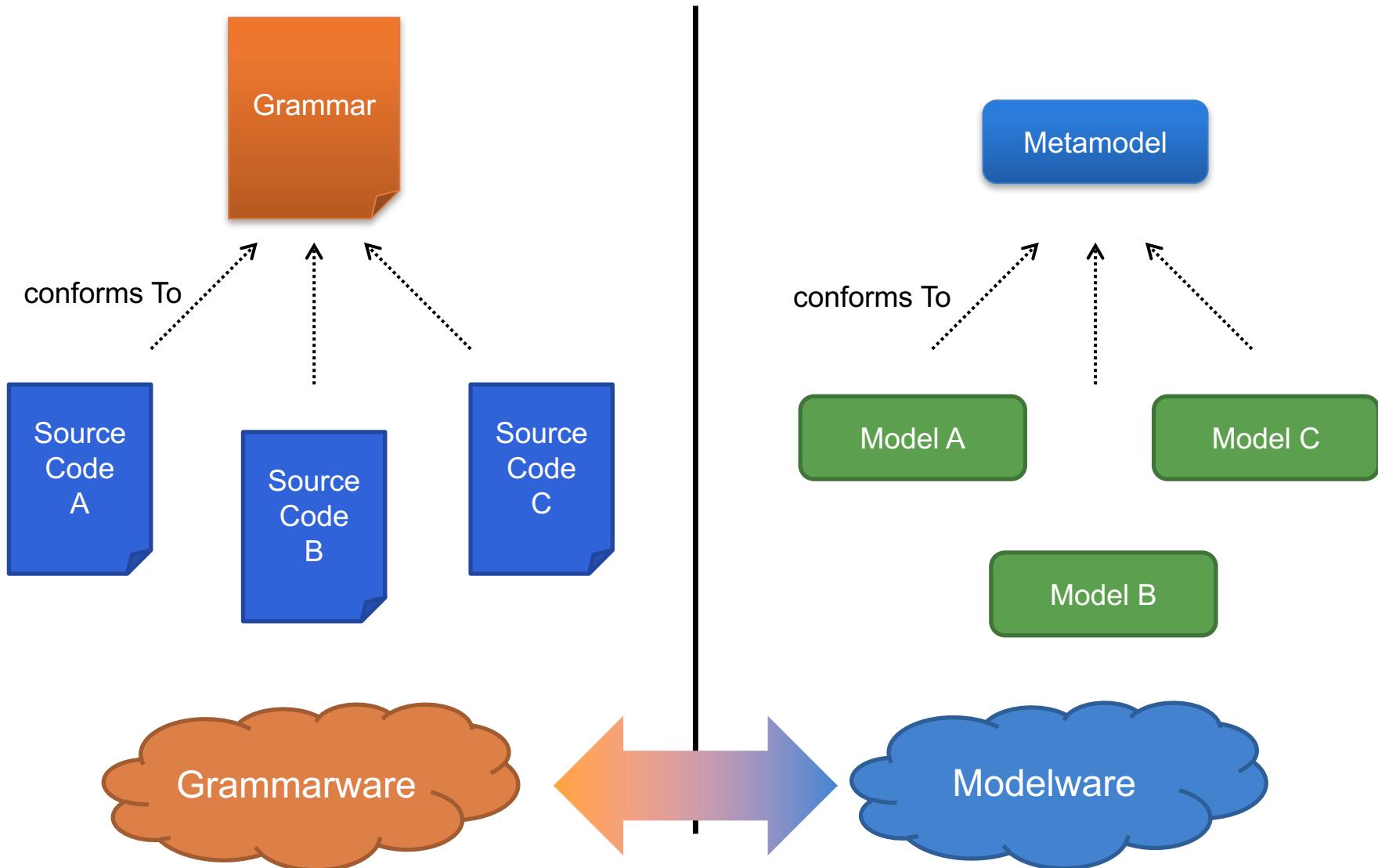
M<sup>2</sup>



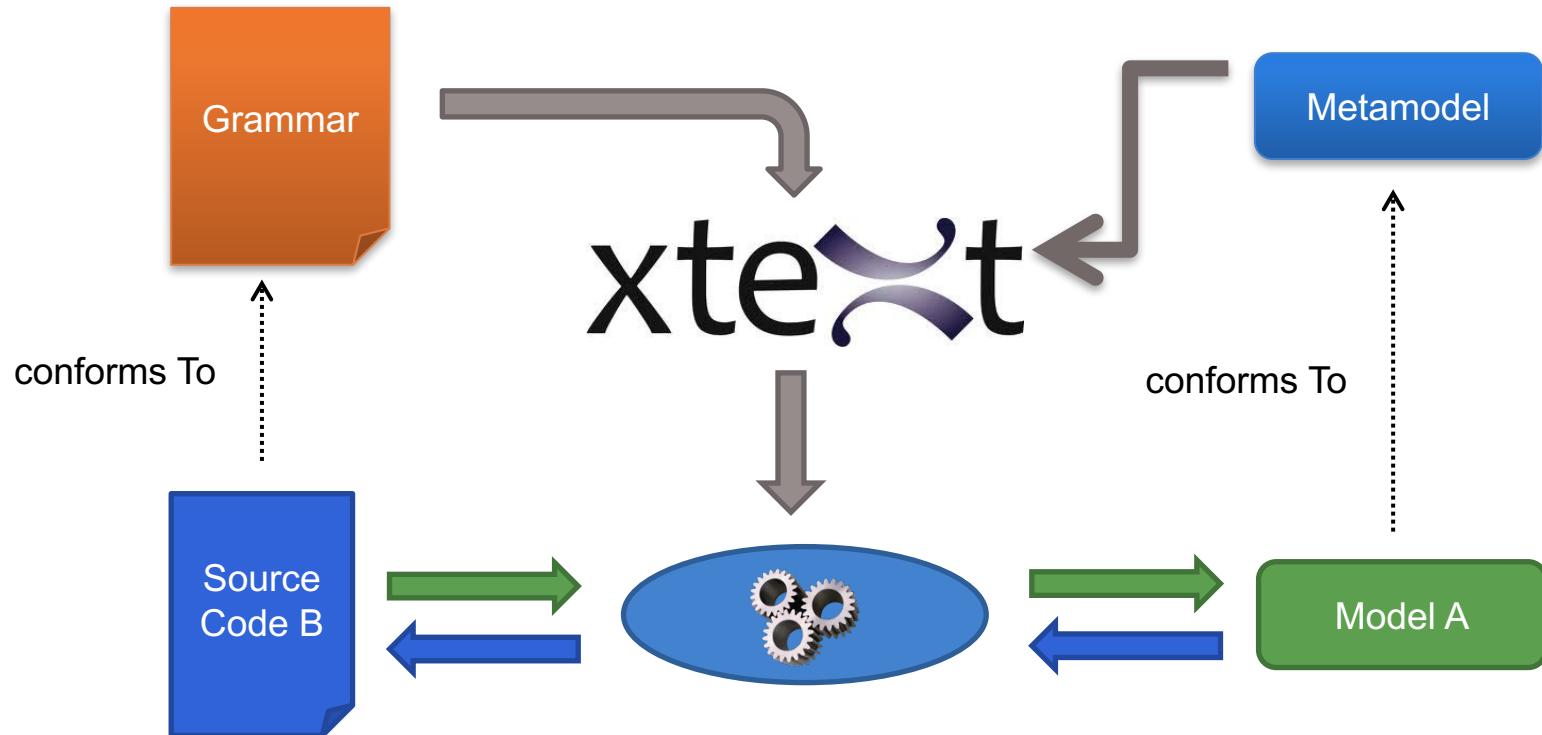
M<sup>1</sup>



# Language and MDE



# MDE, Grammar: there and back again



# **Empirical Assessment of MDE in Industry**

John Hutchinson, Jon Whittle, Mark Rouncefield

School of Computing and Communications  
Lancaster University, UK  
+44 1524 510492

{j.hutchinson, j.n.whittle,  
m.rouncefield}@lancaster.ac.uk

Steinar Kristoffersen

Østfold University College and Møreforskning Molde AS  
NO-1757 Halden  
Norway  
+47 6921 5000

steinar.kristoffersen@hiof.no

## **Model-Driven Engineering Practices in Industry**

John Hutchinson  
School of Computing and  
Communications  
Lancaster University, UK  
+44 1524 510492

{j.hutchinson@lancaster.ac.uk}

Mark Rouncefield  
School of Computing and  
Communications  
Lancaster University, UK  
+44 1524 510492

{m.rouncefield@lancaster.ac.uk}

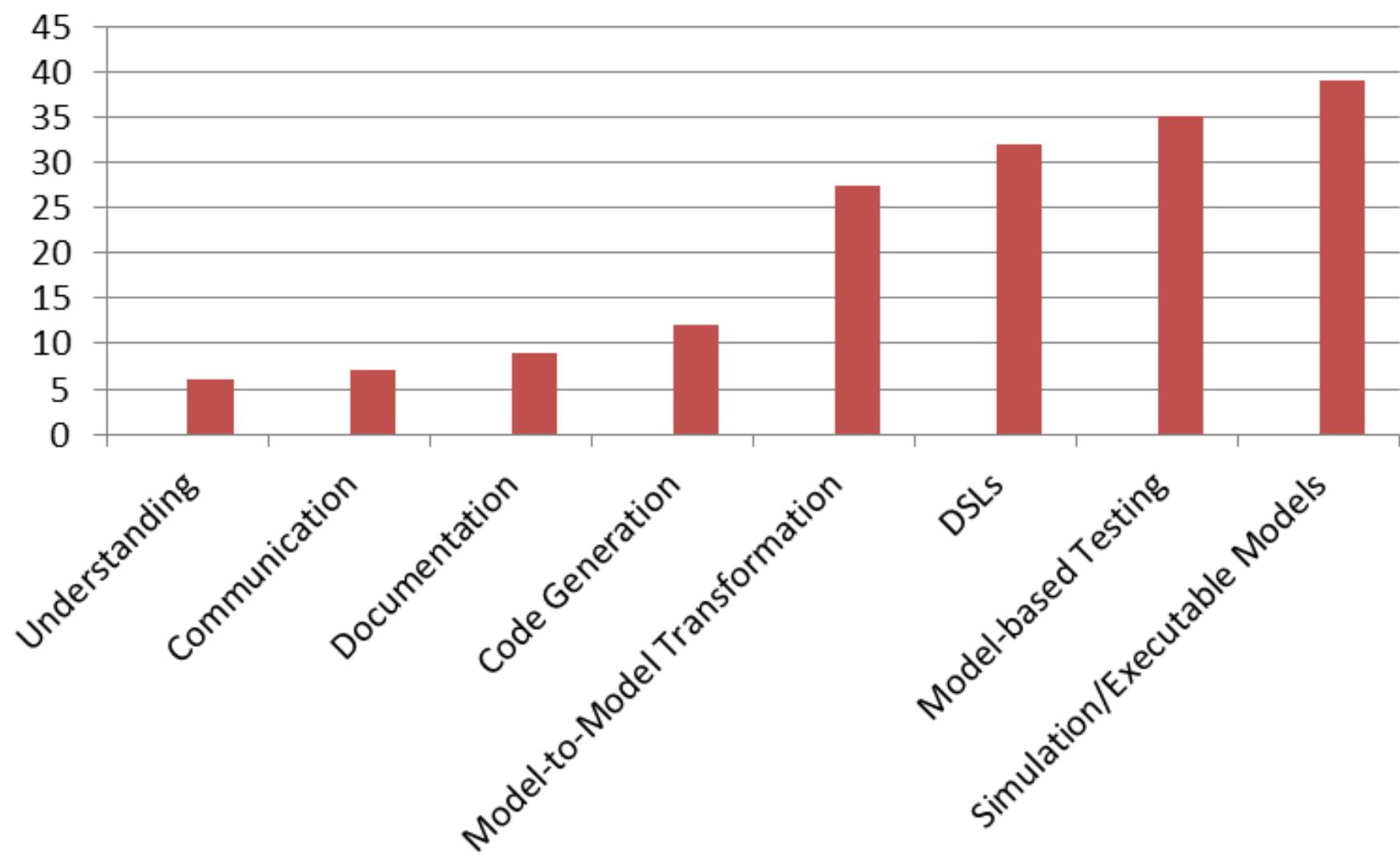
Jon Whittle  
School of Computing and  
Communications  
Lancaster University, UK  
+44 1524 510492

{j.n.whittle@lancaster.ac.uk}

**2011**

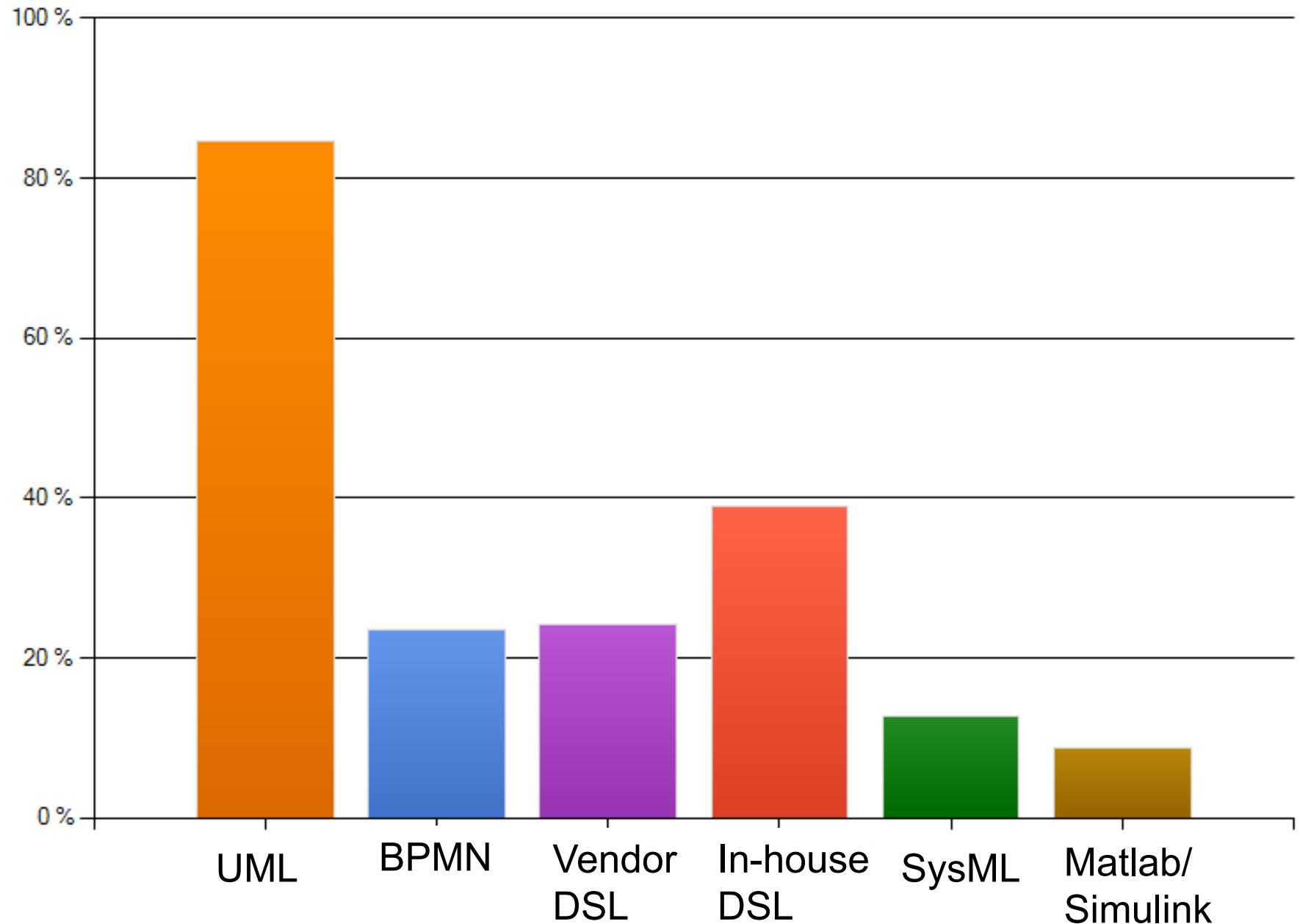
**« Domain-specific  
languages are far more  
prevalent than  
anticipated »**

# What are models used for?

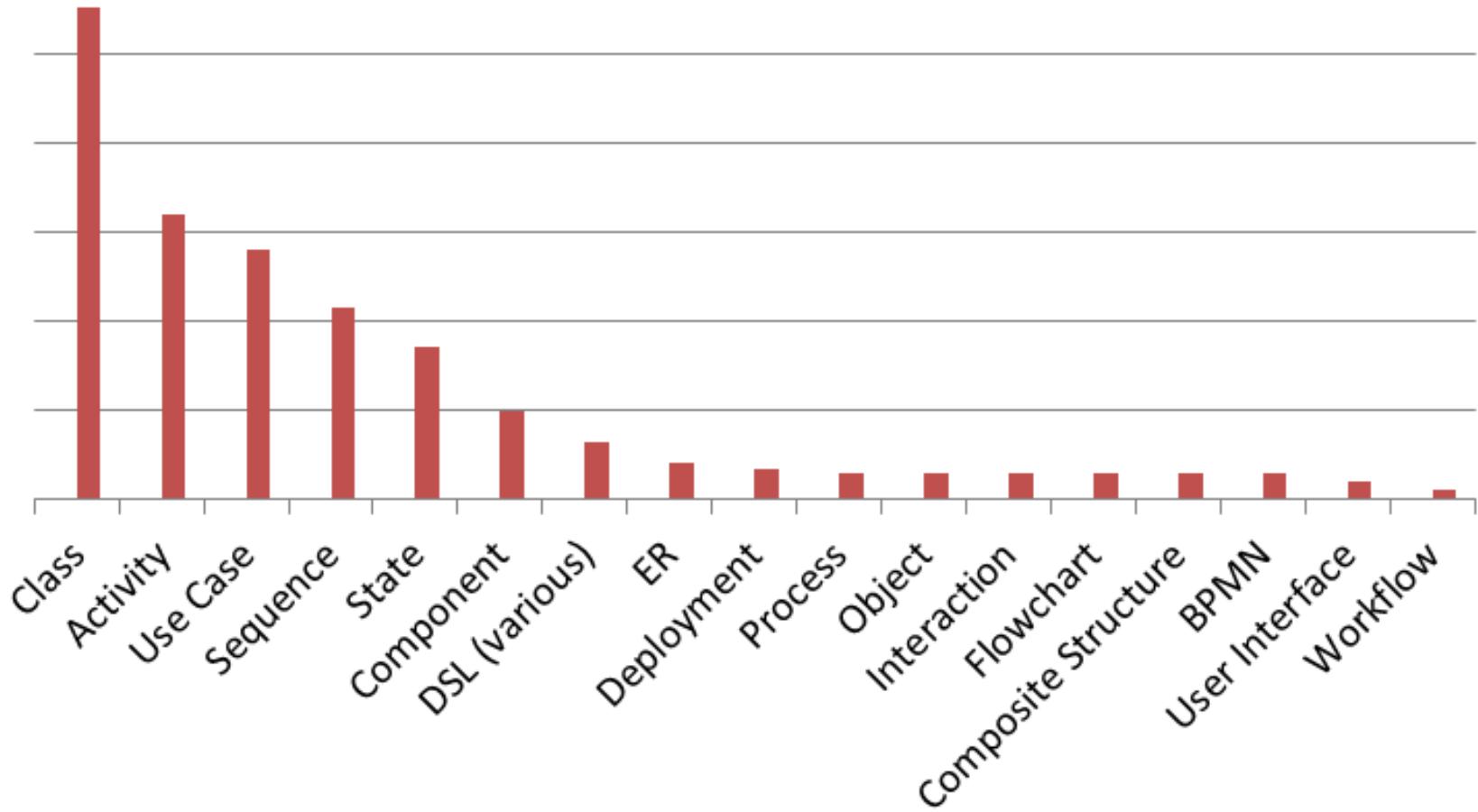


"Do not use" percentages for MDE activities

# Which modeling languages do you use?



# Which diagrams are used?



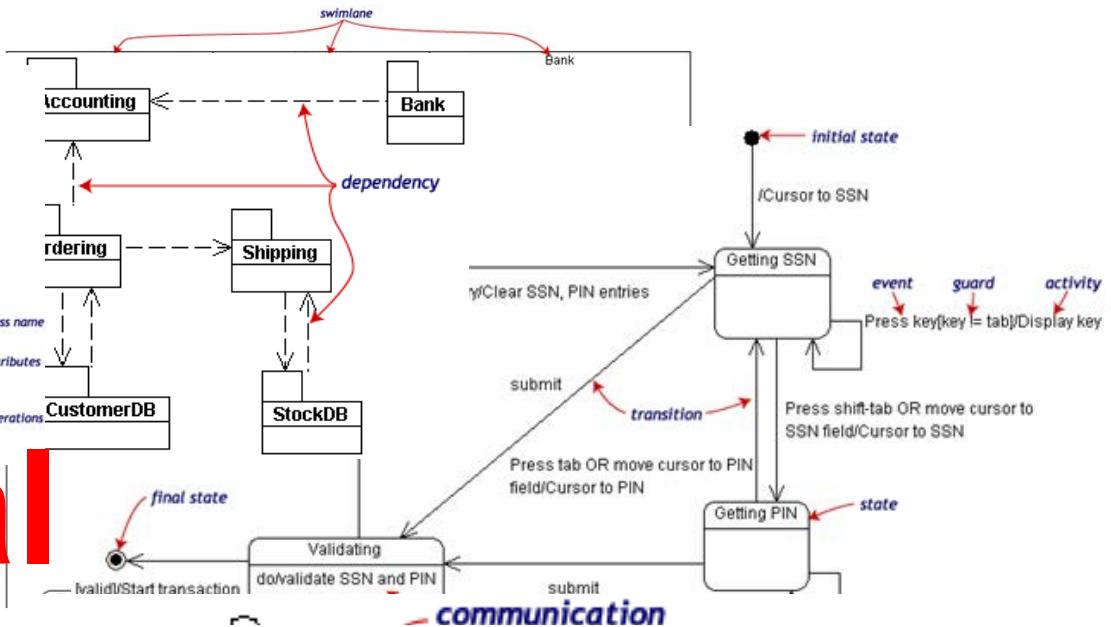
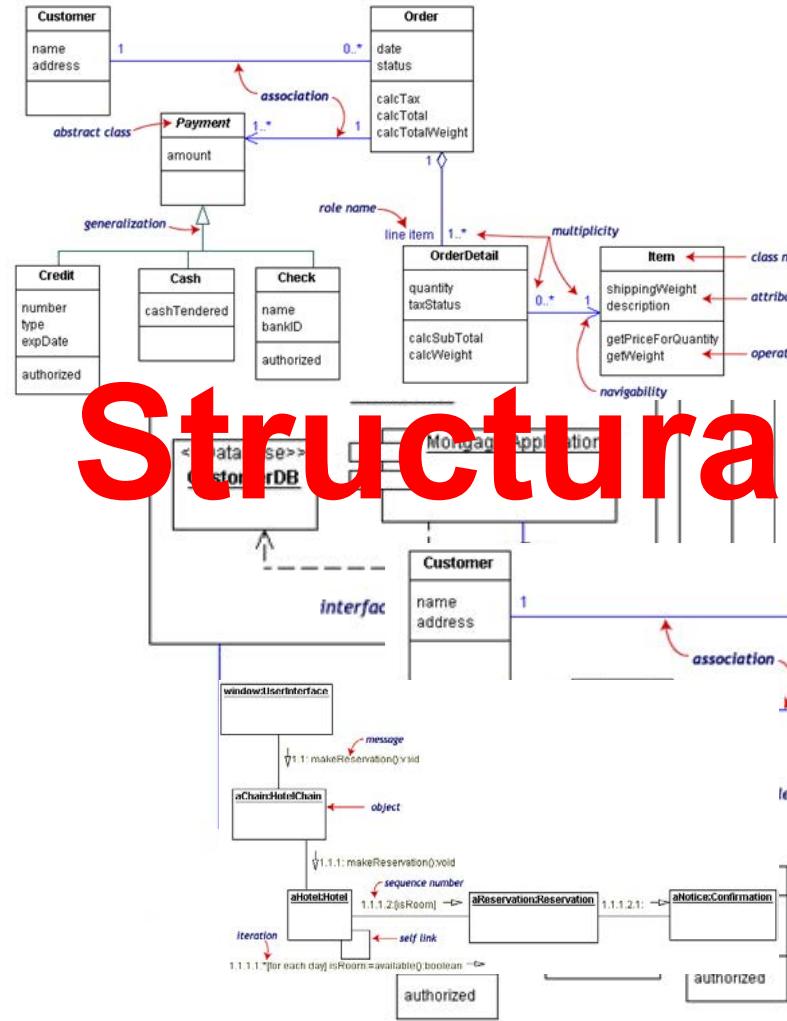
19 different diagram types are used regularly

## Use of multiple languages (DSLs)

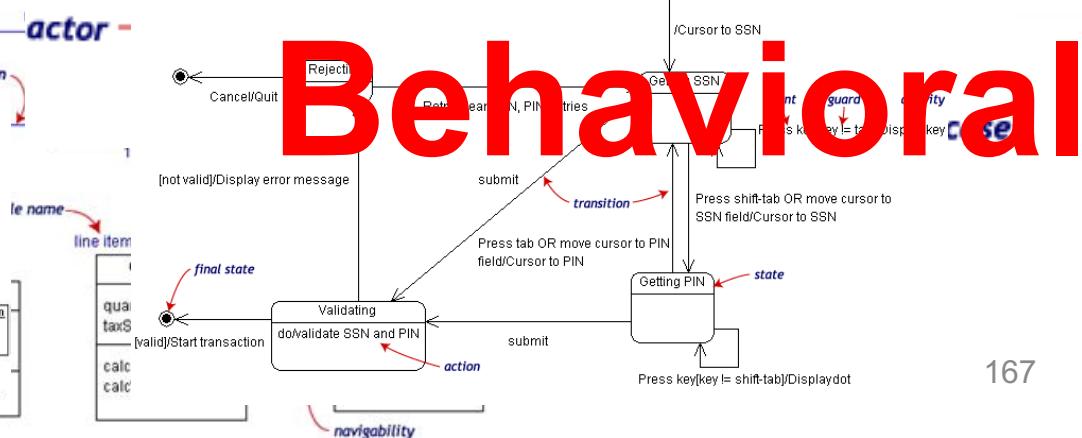
- 62% of those using custom DSLs also use UML
- Almost all users of SysML and BPMN also use UML
- UML is the most popular ‘single use’ language
  - 38% of all respondents
- UML used in combination with just about every combination of modeling languages
  - 14% of UML users combine with vendor DSL
  - 6% with both custom and vendor DSL

# UML can be seen as a collection of domain-specific modeling languages

**Structural**



**Behavioral**



# Xtext is built using MDE technologies



The Definitive  
ANTLR  
Reference



Xtext (and alternatives) democratize DSL development

# 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

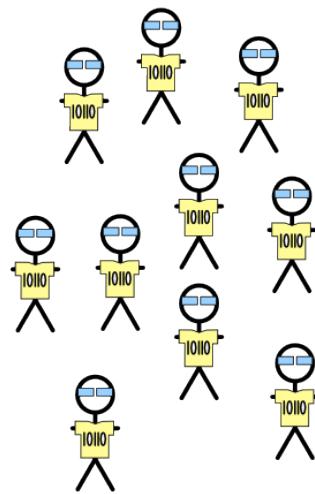
But my take away  
message is NOT

That DSLs should be used  
systematically, in every  
situations

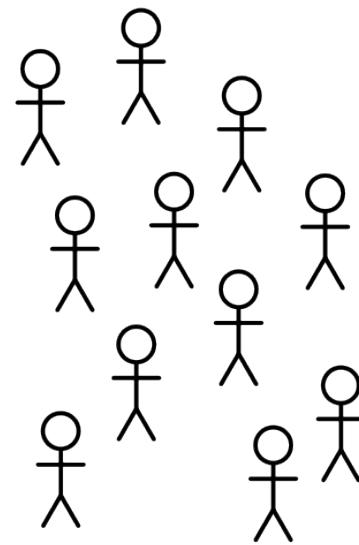
# When Developing DSLs?

- Tradeoff cost/time of development versus productivity gained for solving problems
  - If you use your DSL for resolving one problem, just one time, hum...
  - DSL: reusable, systematic means to resolve a specific task in a given domain
- DSL development can pay off quickly
  - 5' you can get a DSL
- But DSL development can be time-consuming and numerous worst practices exists

# Actors

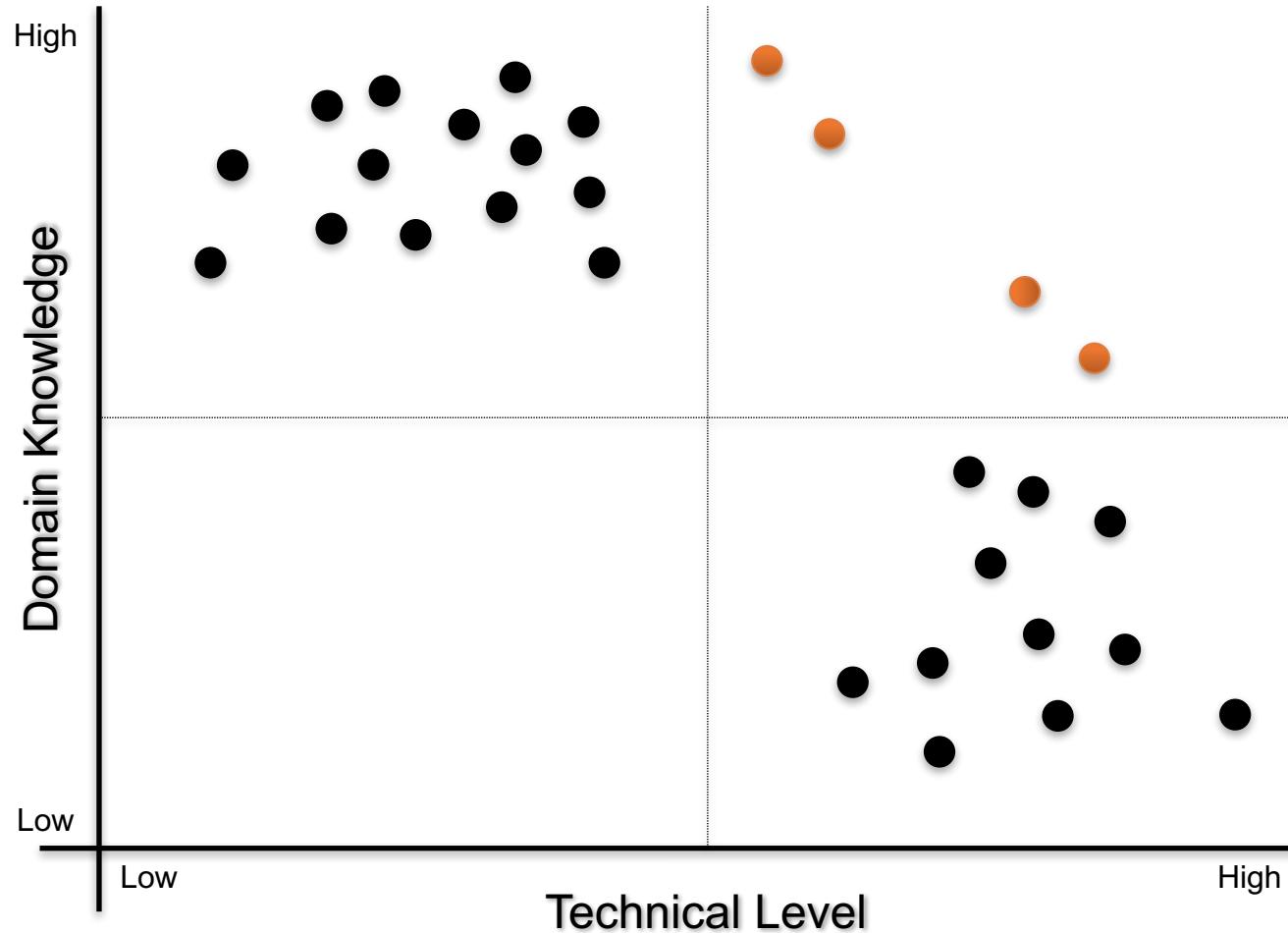


Developers



End-Users

# Actors



# Best Practices

Limit  
Expressiveness

Viewpoints

Evolution

Learn from  
GPLs

Support

Tooling

# Worst Practices

- Initial conditions
  - Only Gurus allowed
    - Believe that only gurus can build languages or that “I’m smart and don’t need help”
  - Lack of Domain Understanding
    - Insufficiently understanding the problem domain or the solution domain
  - Analysis paralysis
    - Wanting the language to be theoretically complete, with its implementation assured

# Worst Practices

- The source for Language Concepts
  - UML: New Wine in Old Wineskins
    - Extending a large, general-purpose modeling language
  - 3GL Visual Programming
    - Duplicating the concepts and semantics of traditional programming languages
  - Code: The Library is the Language
    - Focusing the language on the current code's technical details
  - Tool: if you have a hammer
    - Letting the tool's technical limitations dictate language development

# Worst Practices

- The resulting language
  - Too Generic / Too Specific
    - Creating a language with a few generic concepts or too many specific concepts, or a language that can create only a few models
  - Misplaced Emphasis
    - Too strongly emphasizing a particular domain feature
  - Sacred at Birth
    - Viewing the initial language version as unalterable

# Worst Practices

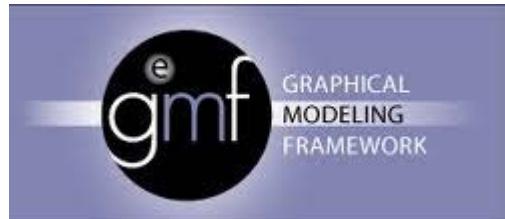
- Language Notation
  - Predetermined Paradigm
    - Choosing the wrong representational paradigm or the basis of a blinkered view
  - Simplistic Symbols
    - Using symbols that are too simple or similar or downright ugly

# Worst Practices

- Language Use
  - Ignoring the use process
    - Failing to consider the language's real-life usage
  - No training
    - Assuming everyone understands the language like its creator
  - Pre-adoption Stagnation
    - Letting the language stagnate after successful adoption

# Questions ?

<http://martinfowler.com/bliki/DomainSpecificLanguage.html>



## Empirical Assessment of MDE in Industry

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{j.hutchinson, j.n.whittle,  
m.rouncefield}@lancaster.ac.uk

Steinar Kristoffersen  
Østfold University College and Møreforskning Molde AS  
NO-1757 Halden  
Norway  
+47 6921 5000  
steinar.kristoffersen@hiof.no

