Part III. Technical Spaces
20. Analysis and Model Management in the Technical Space Grammarware and Treeware (Context-Free Syntax Analysis)

Prof. Dr. rer. nat. Uwe Aßmann
Institut für Software- und Multimediatechnik
Lehrstuhl Softwaretechnologie
Fakultät für Informatik
TU Dresden
http://st.inf.tu-dresden.de
Version 21-1.2, 08.01.22

1) Parsing
2) Regular Tree Grammars
3) Tree Construction
4) Text Algebrae
5) Controlled Natural Languages (CNL)
6) Pseudocode and Markup Languages

Literature

- Obligatory:
  - http://www.antlr.org
- Optional:
  - Cocktail www.cocolab.de, die Compiler-Toolbox für die schnellsten Compiler der Welt (kommerziell, Demoversionen erhältlich)
  - TaTa Tree Grammars http://tata.gforge.inria.fr/ and all the tree theory
  - Oana Andrei, Helene Kirchner. A Port Graph Calculus for Autonomic Computing and Invariant Verification. A. Corradini. TERMGRAPH 2009, 5th International Workshop on Computing with Terms and Graphs, Satellite Event of ETAPS 2009, Mar 2009, York, United Kingdom. Electronic Notes in Theoretical Computer Science, Elsevier. Preprint <inria-00418560>, https://hal.inria.fr/inria-00418560

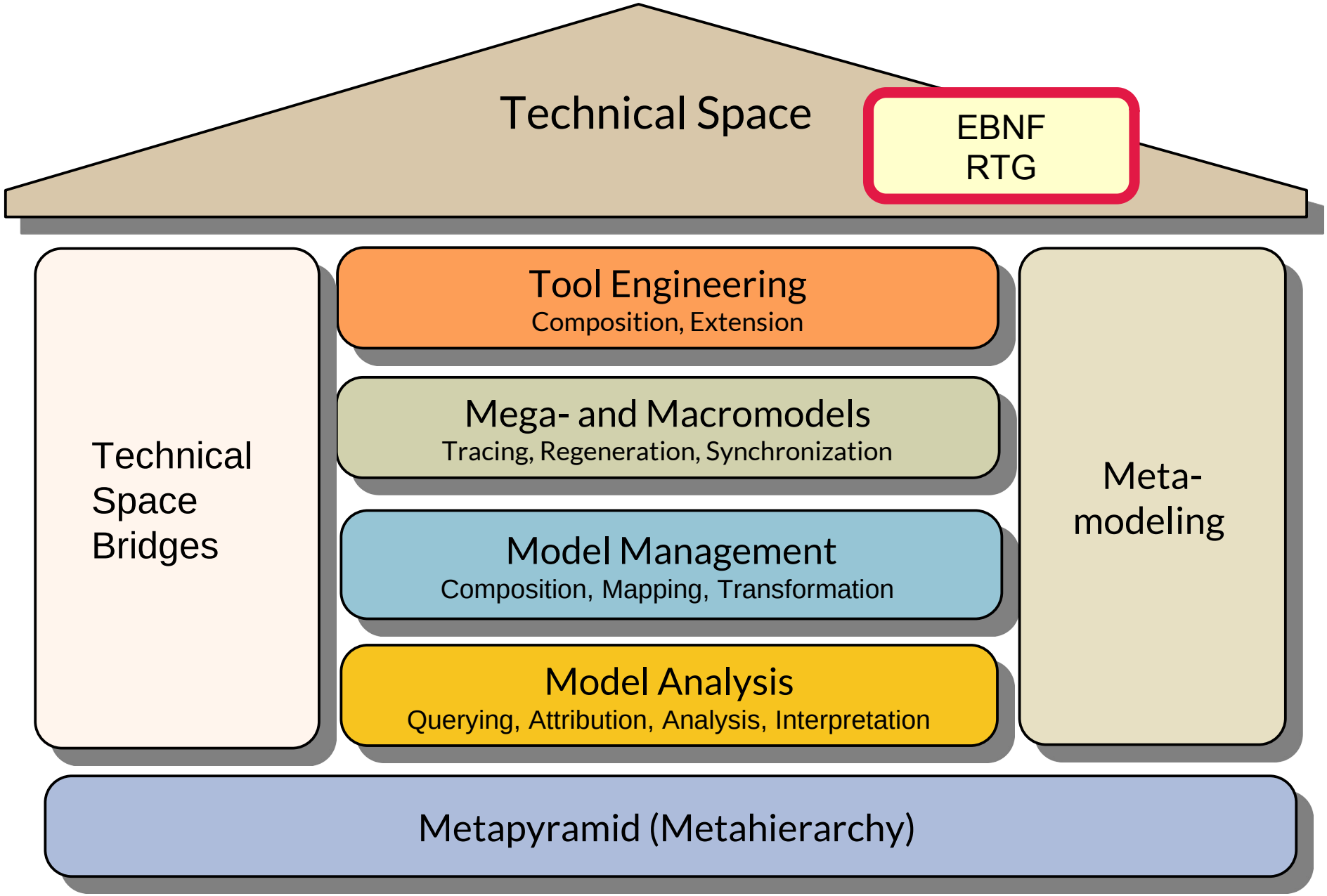
© Prof. U. Aßmann

20.1. Parser Generators in the Technical Space Grammarware

1) Parsing as checker for instance-of
2) Antlr as example
3) Example pocket computer

- Analyzing the structure of linear lists
- And transforming them to trees

Q10: The House of a Technical Space

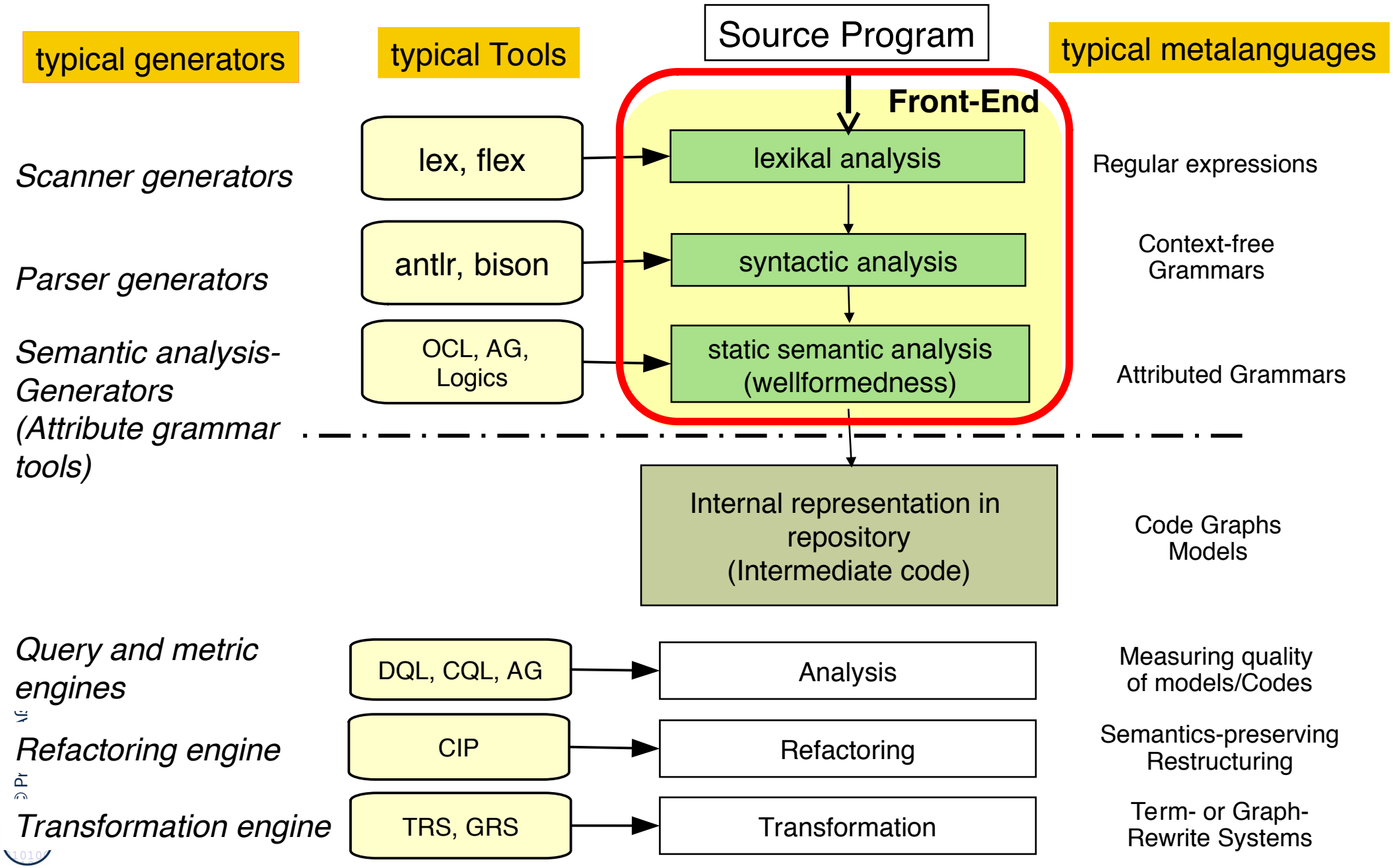


© Prof. U. Aßmann

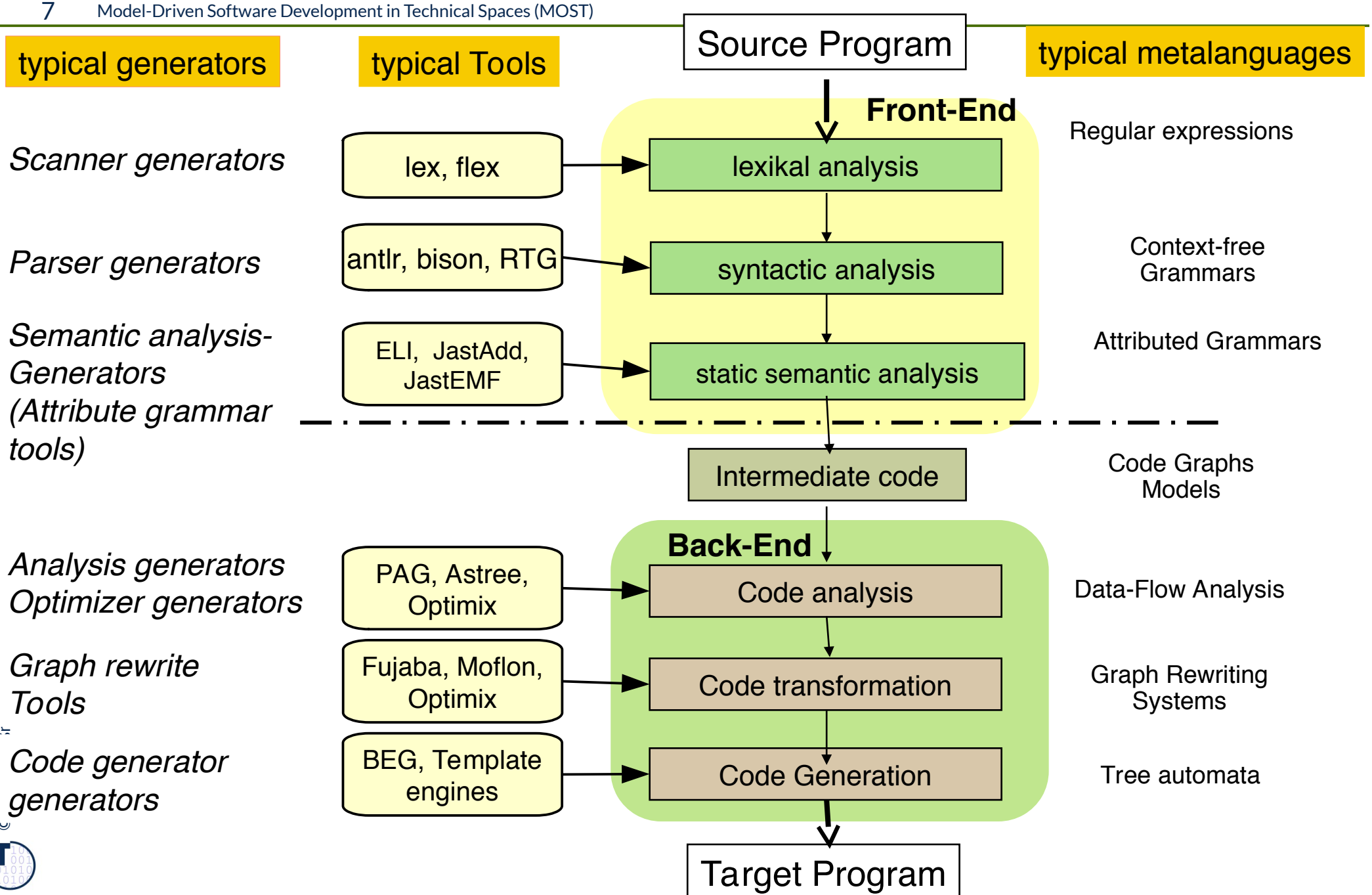
Q11: Overview of Technical Spaces in the Classical Metahierarchy

	Grammarware (Strings) today	Text-ware	Table-ware		Treeware (trees) today	Link-Tree-ware		Graphware/ Modelware			Role-Ware	CROM-Ware	Ontology-ware
	Strings	Text	Text-Table	Relational Algebra	NF2	XML	Link trees	MOF	Eclipse	CDIF	MetaEdit+	Context-role graphs	OWL-Ware
M3	EBNF	EBNF		CWM (common warehouse model)	NF2-language	XSD	JastAdd, Silver	MOF	Ecore, EMOF	ERD	GOPPR	CROM	RDFS OWL
M2	Grammar of a language	Grammar with line delimiters	csv-header	Relational Schema	NF2-Schema	XML Schema, e.g. xhtml	Specific RAG	UML-CD, -SC, OCL	UML, many others	CDIF-languages	UML, many others	CROM	HTML XML MOF UML DSL
M1	String, Program	Text in lines	csv Table	Relations	NF2-tree relation	XML-Documents	Link-Syntax-Trees	Classes, Programs	Classes, Programs	CDIF-Models	Classes, Programs	CROM models	Facts (T-Box)
M0	Objects	Sequences of lines	Sequences of rows	Sets of tuples	trees	dynamic semantics in browser		Object nets	Hierarchical graphs	Object nets	Object nets	Context-Object-Role Nets	A-Box (RDF-Graphs)

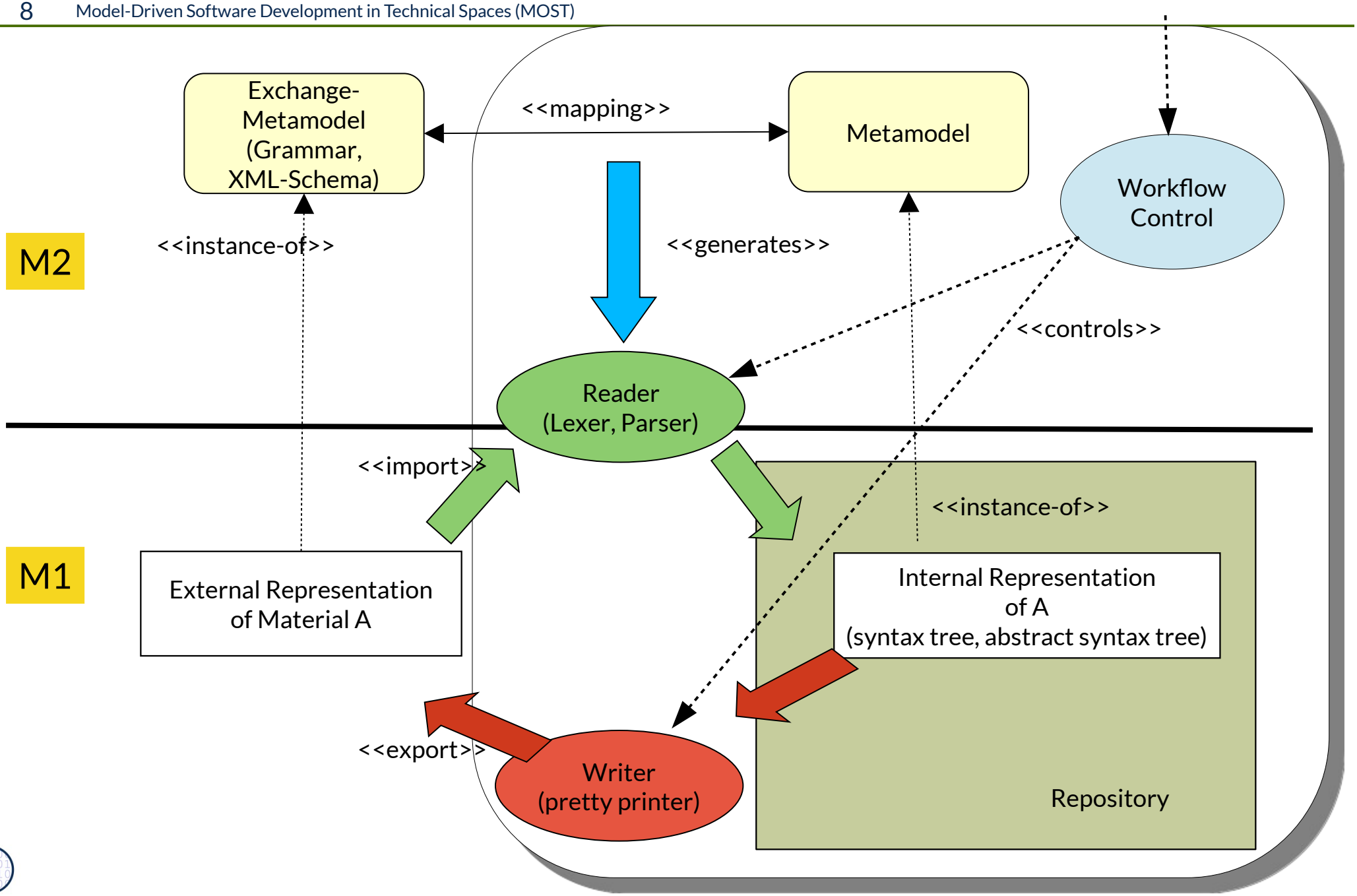
Q7: Phases of a Source Code Importers into a Repository and the Generating Tools



Q9: Phases of Compilers and Software Tools and Generators



Rpt.: Use of Generated Importers and Exporters in Modelling Tools



© Prof. U. Aßmann

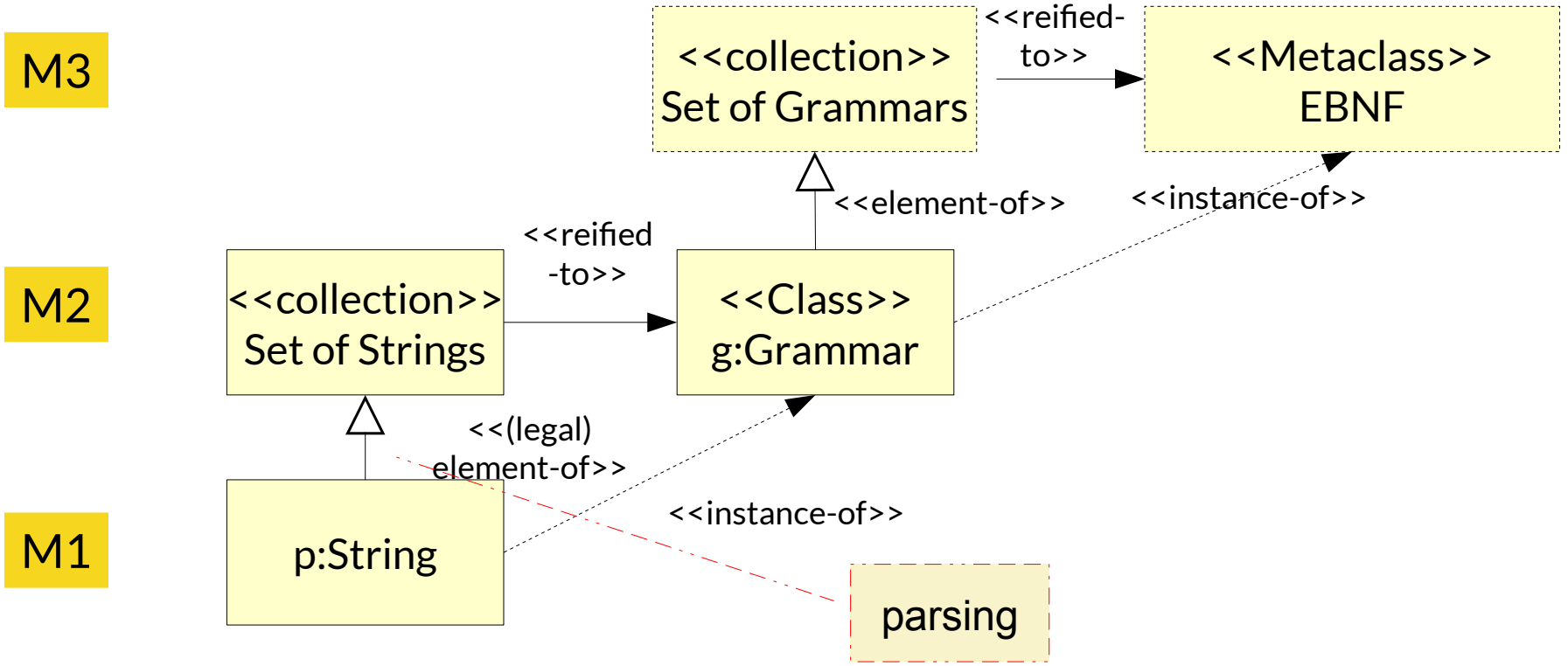
Problem 1 of Parsing

- Parsing a program, model or document, or a material means to **recognize its context-free structure in the linear stream of characters**
  - Parsers are usually the first phases of a tool when it *imports a material*
- Parsers parse according to the *concrete syntax grammar* containing
  - Whitespace handling
  - Block handling (brackets)
  - Comment handling
- From a context-free grammar, a **parse automaton with parse rules** can be derived:
  - Address ::= Streetname StreetNumber Location
  - Location ::= Postcode Town Country
- Generates the parse rules
  - Streetname StreetNumber Location → Address
  - Postcode Town Country → Location
- The parser reads in all tokens until it can decide which rule to reduce

© Prof. U. Aßmann

String/Text Parsing with Grammars

- A grammar can be used to generate a parser for strings (texts) that tests the legality of a string with the grammar
- The parser checks <<instance-of>> for the string p with regard to the grammar g



© Prof. U. Aßmann

EBNF Rules for String Grammars

Symbol	Meaning	Example
Name (Nonterminal)	Identifier (for type or variable)	A = B + C
"text"	Token (text terminal)	B ::= "Town" + R
=, ::=	Consists of	X ::= X1 + X2 + X3
+, also juxtaposition	Sequence	X ::= X1 X2 X3
@	Key (unique identifier)	P = @PersonNr + N + Address
[...|...]	Selection (alternative)	P = [P1 | P2]
n { ... } m	Iteration, at least n upto m times	B = 1 { C } 10
n *	Iteration of n - arbitrarily many times	Children ::= Name *
n +	Iteration of n at least once	PastEmployers ::= Name +
(...)	Optional	Address ::= Street + (PostBox)
A // “,”	Sequence of A with intermittend ','	C = D // “,”
* ... *	Comment	X = B + C *text*
< a > b	Modifier (Kommentar)	< old > A < new > A
SYN	Synonym für Name	SecondName SYN SurName

© Prof. U. Aßmann

Example: Address Grammar

- "::=" means "is-composed-of" or "is-decomposed-to"
- Every rule declares a whole-part decomposition
- Grammar declares the structure of a part list

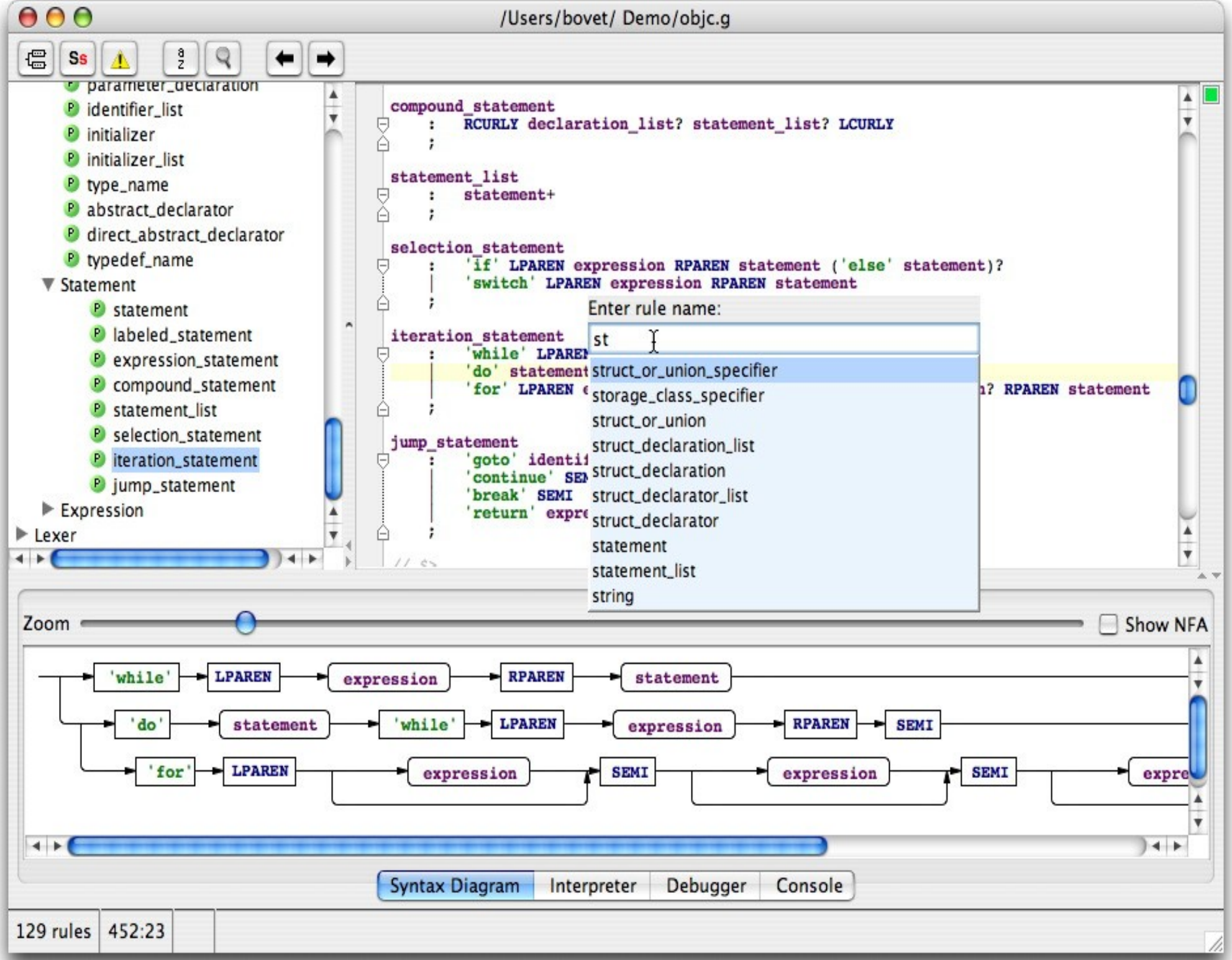
```
Address       ::= Person Company Location.
Person        ::= Title Name
Title         ::= „Dr.“ | „Prof. Dr.“ | „Mr.“ | „Ms.“
Name          ::= FirstName* LastName
Company       ::= String
Location      ::= Street StreetNumber Postcode Town
FirstName     ::= String
LastName      ::= String
Postcode      ::= 5{Digit}5
Street        ::= String
StreetNumber        ::= Integer [ String ]
Town          ::= String
```

© Prof. U. Aßmann

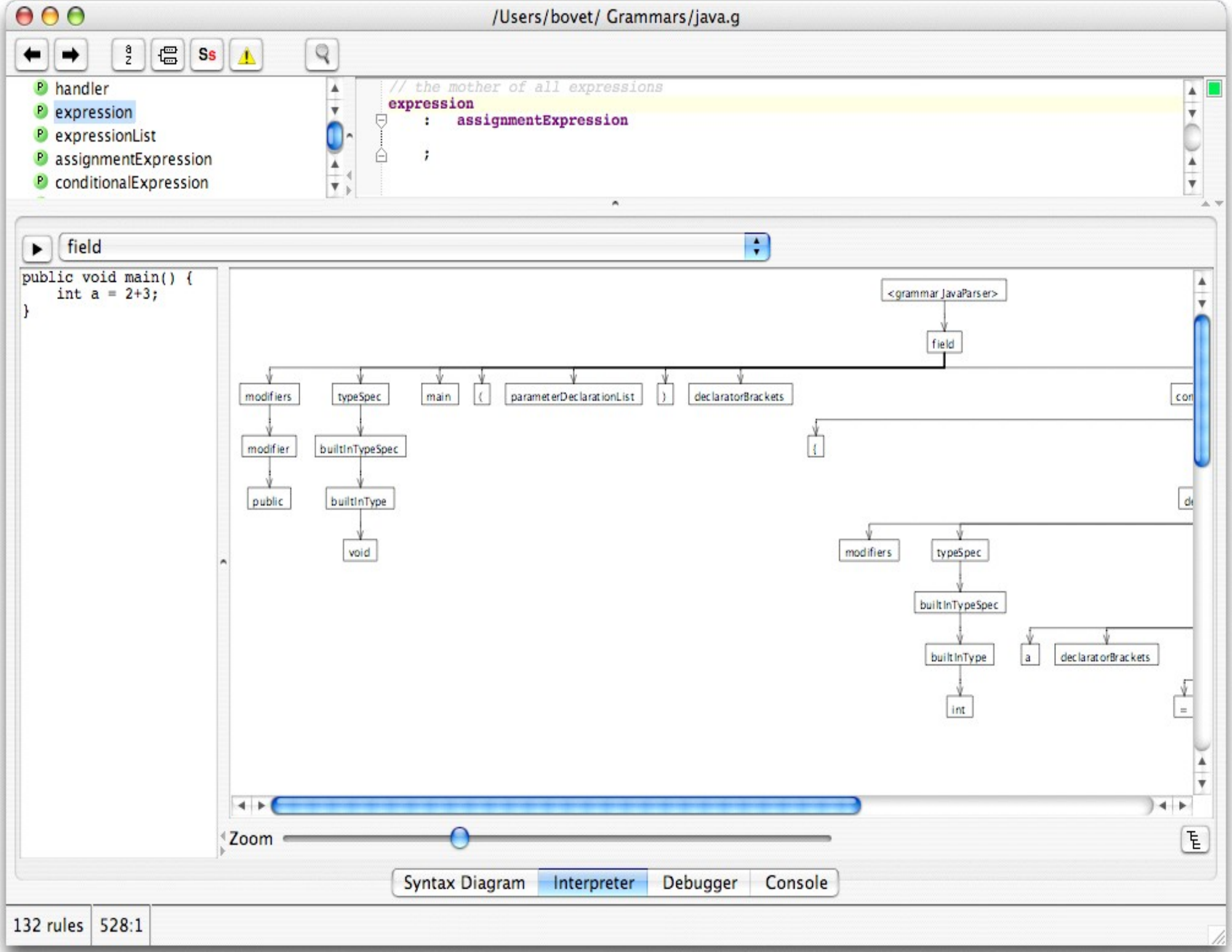
Example: ANTLR www.antlr.org

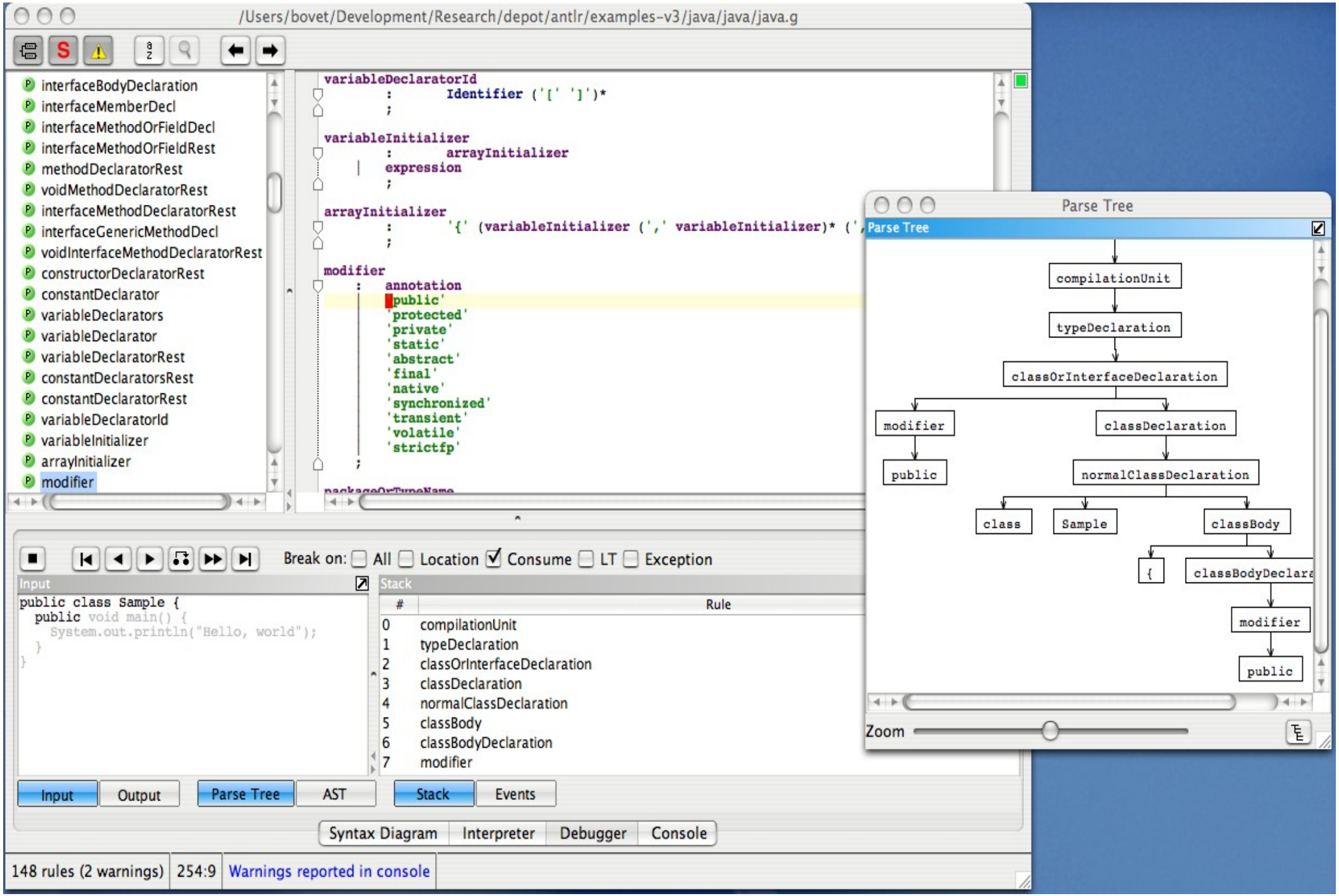
- Since the 90s, many parser generators have been built for C/C++
  - Cocktail's lalr, ell, lark www.cocolab.de
  - Fnc2 (INRIA)
  - flex und bison (GNU)
  - Eli is a fast compiler generator toolset http://eli.sf.net
- For Java, ANTLR is popular
  - Parser class LL(k): Left-recursive grammar rules, k-lookahead for decisions
  - Generated Parser with algorithm “recursive descent”
  - http://www.bearcave.com/software/antlr/antlr_expr.html

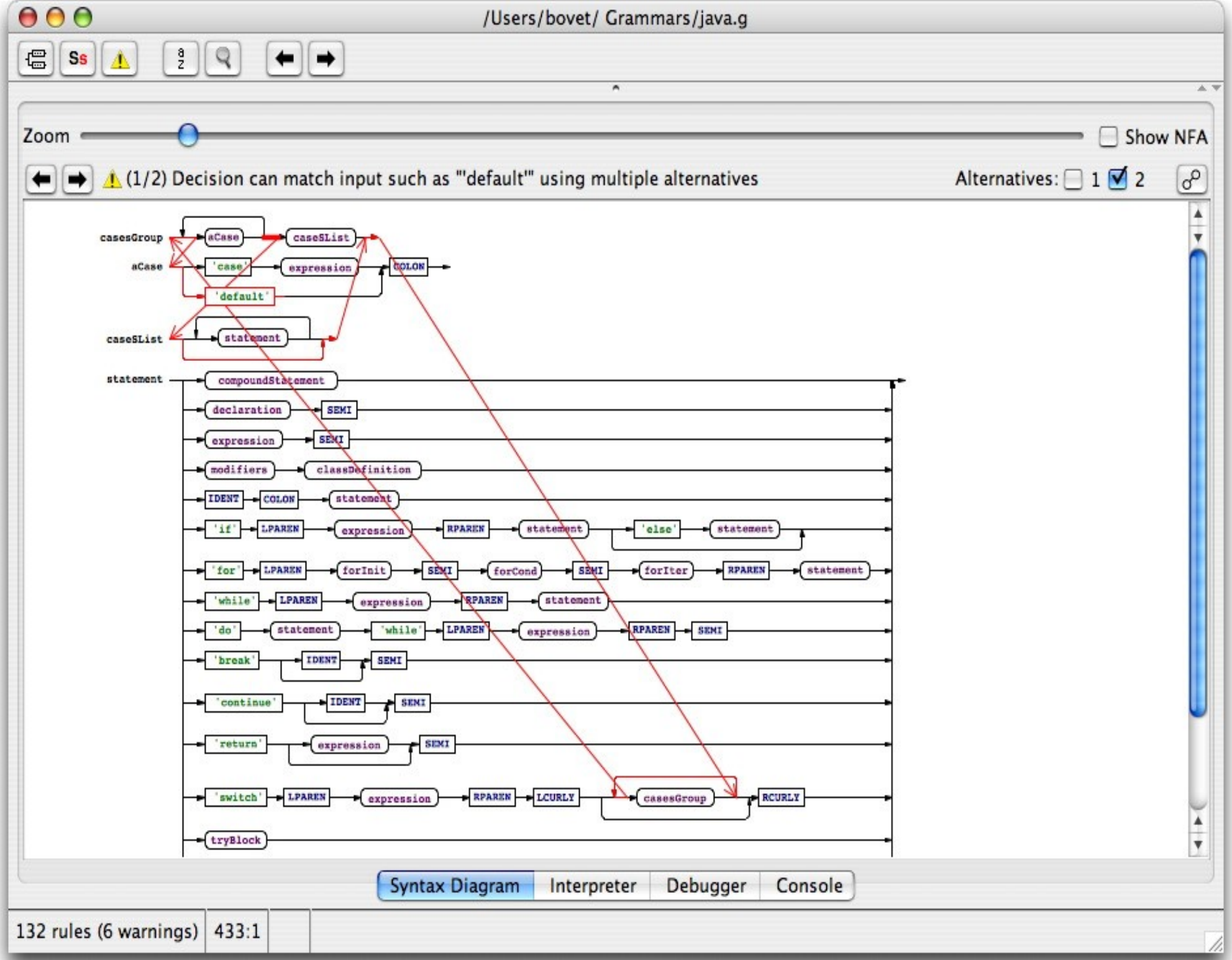
© Prof. U. Aßmann



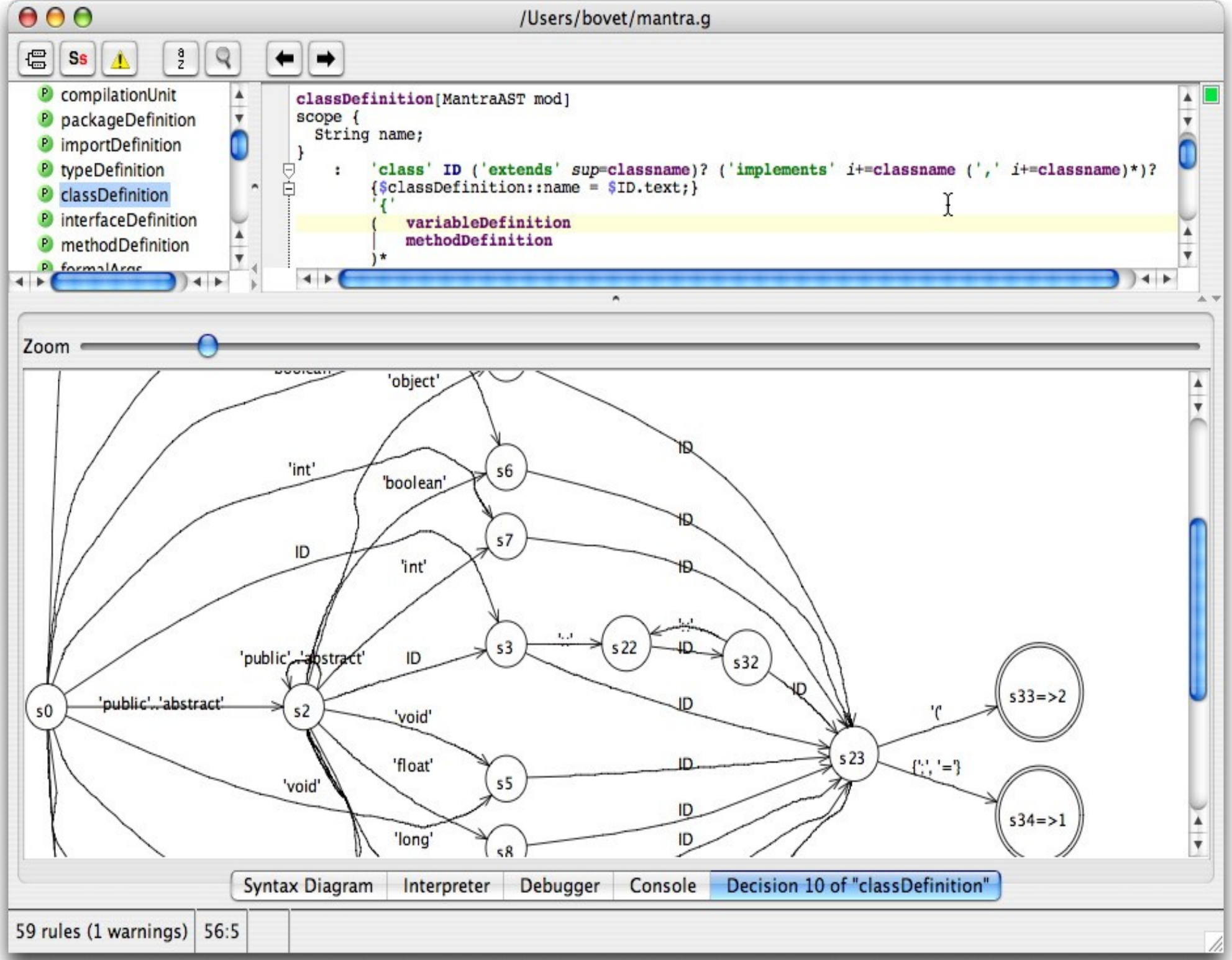
© Prof. U. Aßmann


/Users/bovet/ Grammars/java.g
handler
expression
expressionList
assignmentExpression
conditionalExpression
// the mother of all expressions
expression
: assignmentExpression
;
field
public void main() {
int a = 2+3;
}
<grammar JavaParser>
field
modifiers
typeSpec
main
(
parameterDeclarationList
)
declaratorBrackets
modifier
builtInTypeSpec
public
builtInType
void
{
modifiers
typeSpec
builtInTypeSpec
builtInType
int
a
declaratorBrackets
Zoom
Syntax Diagram
Interpreter
Debugger
Console
132 rules
528:1


/Users/bovet/Development/Research/depot/antlr/examples-v3/java/java/java.g
interfaceBodyDeclaration
interfaceMemberDecl
interfaceMethodOrFieldDecl
interfaceMethodOrFieldRest
methodDeclaratorRest
voidMethodDeclaratorRest
interfaceMethodDeclaratorRest
interfaceGenericMethodDecl
voidInterfaceMethodDeclaratorRest
constructorDeclaratorRest
constantDeclarator
variableDeclarators
variableDeclarator
variableDeclaratorRest
constantDeclaratorsRest
constantDeclaratorRest
variableDeclaratorId
variableInitializer
arrayInitializer
modifier
variableDeclaratorId
: Identifier ('[' ']')*
;
variableInitializer
: arrayInitializer
| expression
;
arrayInitializer
: '{' (variableInitializer (',' variableInitializer)* (',
;
modifier
: annotation
| 'public'
| 'protected'
| 'private'
| 'static'
| 'abstract'
| 'final'
| 'native'
| 'synchronized'
| 'transient'
| 'volatile'
| 'strictfp'
;
Break on: All Location Consume LT Exception
Input
public class Sample {
public void main() {
System.out.println("Hello, world");
}
}
Stack
Rule
0 compilationUnit
1 typeDeclaration
2 classOrInterfaceDeclaration
3 classDeclaration
4 normalClassDeclaration
5 classBody
6 classBodyDeclaration
7 modifier
Input Output Parse Tree AST Stack Events
Syntax Diagram Interpreter Debugger Console
148 rules (2 warnings) 254:9 Warnings reported in console
Parse Tree
Parse Tree
compilationUnit
typeDeclaration
classOrInterfaceDeclaration
modifier
classDeclaration
public
normalClassDeclaration
class
Sample
classBody
{
modifier
public
Zoom



© Prof. U. Aßmann



© Prof. U. Aßmann

20.1.2 Program Interpretation While Parsing

An ANTLR Grammar for the Input Language of Pocket Calculator

- ANTLR knows several *actions (snippets, fragments)* in a rule
  - *semantic actions:* modifying attributes of nodes or temporary values
  - *emissions:* emitting tokes of an output alphabet, e.g., for code generation
  - *motions*: emitting an action on a shared environment ("motion grammars")
    - e.g., for controlling a robot
    - Motion grammars usually influence parsing also!

© Prof. U. Aßmann

Actions Calculating Attributes

- Pocket calculator interpretes the program to calculate one attribute `$value`
  - Interpretation needs non-terminal attributes, which are stored on the stack of the parser
- Usually, the parse automaton with the parse rules is not shown, because it is rather complex
- Debugging a generated parser is no fun

```
grammar Expr;
@header {
package test;
import java.util.HashMap;
}
@lexer::header {package test;}
@members {
/** Map variable name to Integer object holding value */
HashMap memory = new HashMap();
}
prog:   stat+ ;

stat:   expr NEWLINE {System.out.println($expr.value);}
    |   ID '=' expr NEWLINE
        {memory.put($ID.text, new Integer($expr.value));}
    |   NEWLINE
    ;
expr returns [int value]
    :   e=multExpr {$value = $e.value;}
        (   '+' e=multExpr {$value += $e.value;}
        |   '-' e=multExpr {$value -= $e.value;}
        )*
    ;
multExpr returns [int value]
    :   e=atom {$value = $e.value;} ('*' e=atom {$value *=
$e.value;})*
    ;
atom returns [int value]
    :   INT {$value = Integer.parseInt($INT.text);}
    |   ID
        {
        Integer v = (Integer)memory.get($ID.text);
        if ( v!=null ) $value = v.intValue();
        else System.err.println("undefined variable "+$ID.text);
        }
    |   '(' e=expr ')' {$value = $e.value;}
    ;
// lexical rules
ID  :   ('a'..'z'|'A'..'Z')+ ;
INT :   '0'..'9'+ ;
NEWLINE:'\r'? '\n' ;
WS  :   (' '|'\t')+ {skip();} ;
```

© Prof. U. Aßmann

Control of a Generated Java Parser


```
import org.antlr.runtime.*;
public class Test {
    public static void main(String[] args) throws Exception {
        ANTLRInputStream input = new ANTLRInputStream(System.in);
        ExprLexer lexer = new ExprLexer(input);
        CommonTokenStream tokens = new CommonTokenStream(lexer);
        // Link lexer tokens with parser parser
        ExprParser parser = new ExprParser(tokens);
        // rune the parser parser
        parser.prog();
    }
}
```

© Prof. U. Aßmann

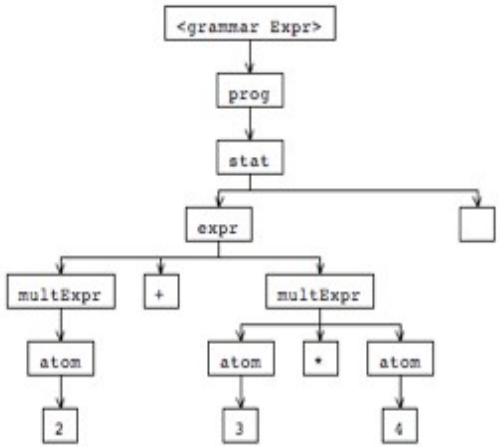
/Users/bovet/ Grammars/Demo/Expr.g

prog
stat
expr
multExpr
atom
ID
INT
NEWLINE
WS

```
grammar Expr;

@header {
package test;
import java.util.HashMap;
}

@lexer::header {package test;}

@members {
/** Map variable name to Integer object holding value */
HashMap memory = new HashMap();
}

prog:   stat+ ;

stat:   expr NEWLINE {System.out.println($expr.value);}
    |   ID '=' expr NEWLINE
        {memory.put($ID.text, new Integer($expr.value));}
    |   NEWLINE
    ;

expr returns [int value]
    :   e=multExpr {$value = $e.value;}
        (   '+' e=multExpr {$value += $e.value;}
        |   '-' e=multExpr {$value -= $e.value;}
        )*
```

prog | Line Endings: Unix (LF) | Ignore rules: WS | Guess

2+3*4

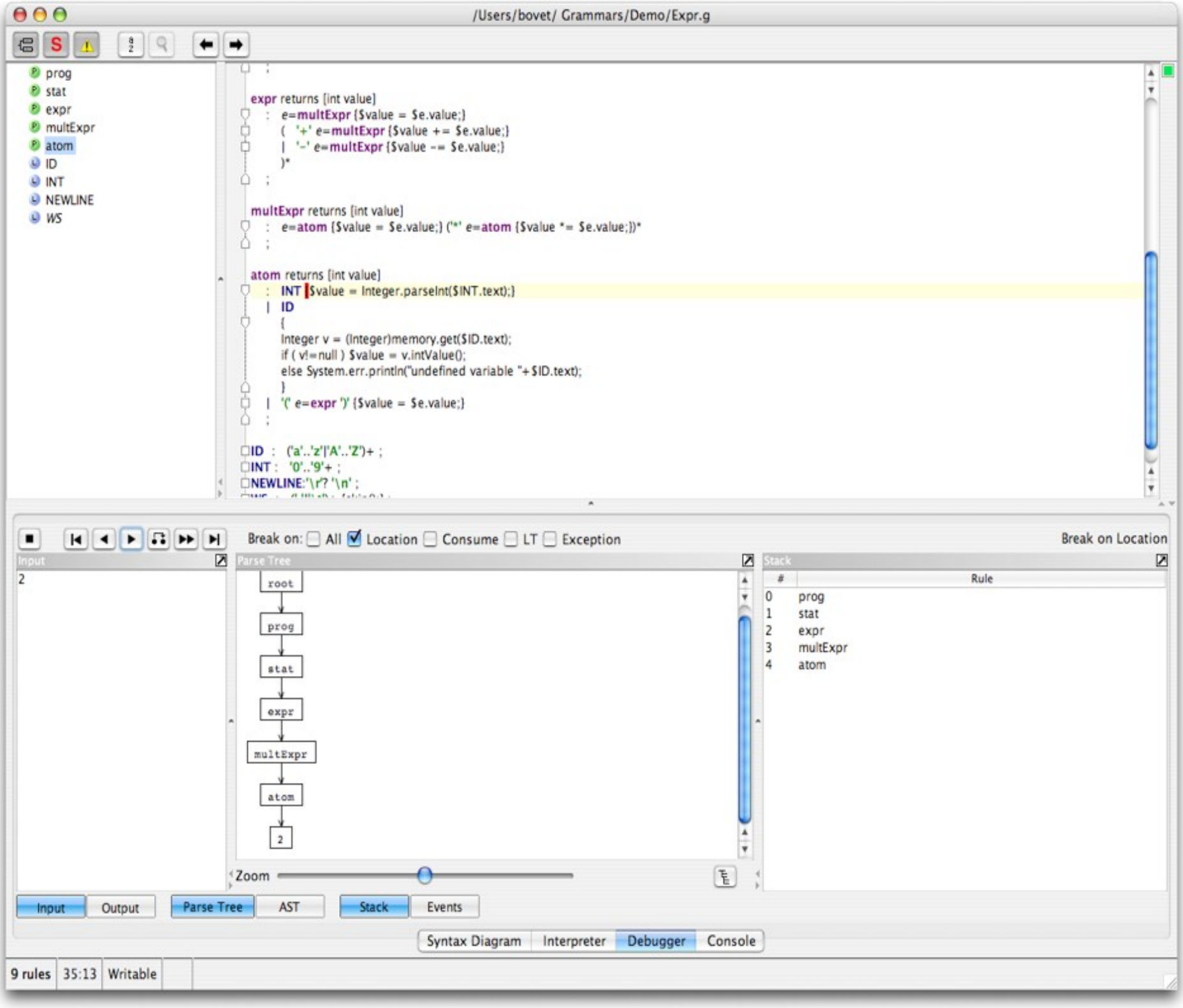


Zoom

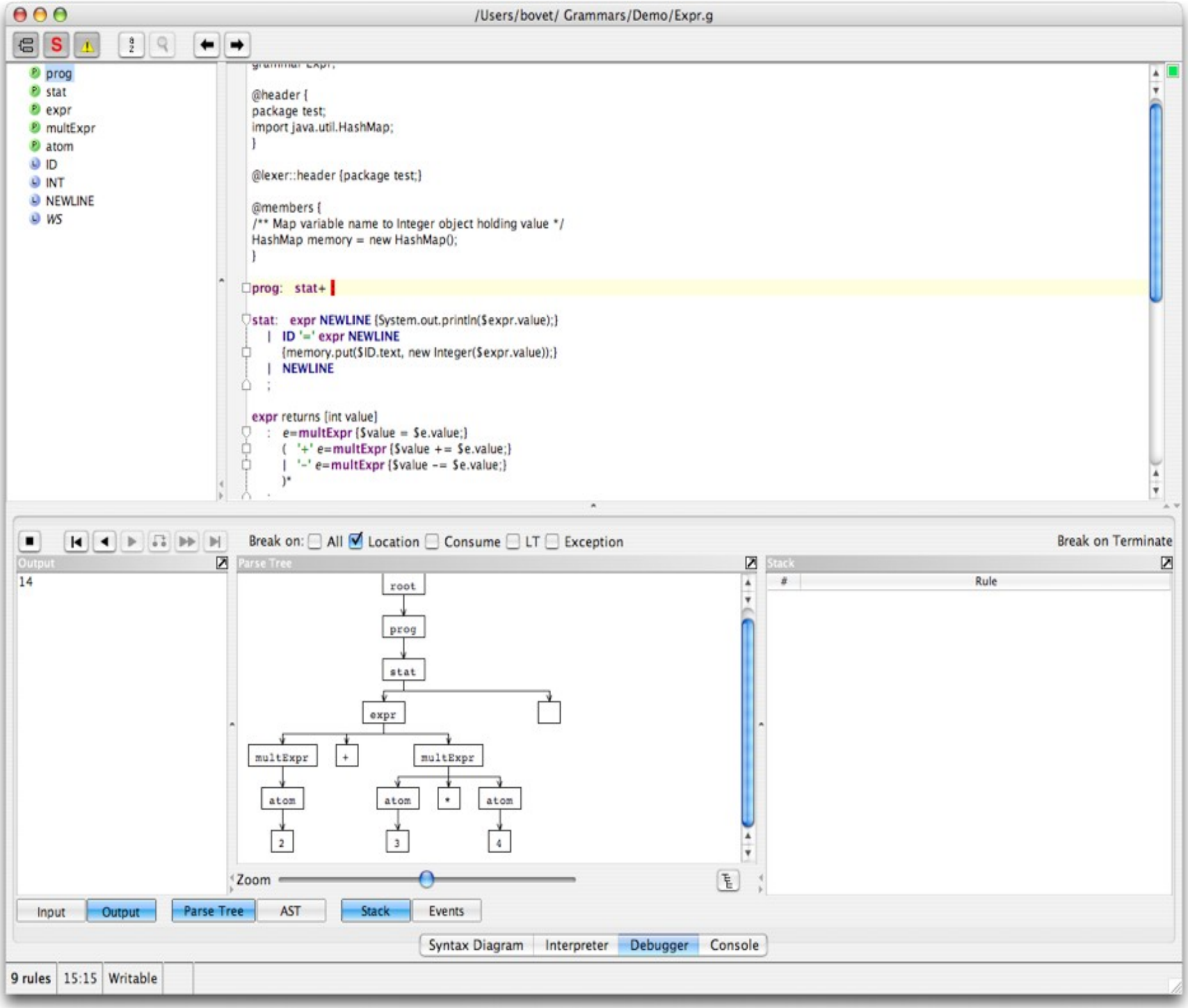
Syntax Diagram | Interpreter | Debugger | Console

9 rules | 1:1 | Writable

© Prof. U. Aßmann



© Prof. U. Aßmann



© Prof. U. Aßmann

Applications of String Grammars

Applications can be everything that has to do with *ordered strings*:

- Protocol checking in component-based systems (protocol automata and grammars)
- Document processing
- Matching text patterns and data mining in files, emails, streams
- Communication in multi-agent systems

© Prof. U. Aßmann

20.2 Regular Tree Grammars (RTG)

- String grammars are for structuring sequences
- RTG are for specifying trees, syntax trees and abstract syntax trees
- A RTG does not care about concrete syntax

Regular Tree Grammars

http://hydra.nixos.org/build/23332578/download/1/manual/chunk-chapter/demo-sdf.html#idm140737305321888

- String Grammars assume:
  - Sequence of words
  - Implicit syntax tree, because non-terminals specify it implicitly
- ***Regular Tree Grammars*** specify the tree **explicitly**, with tree node constructors
- ENBF-rule for Tree Grammar Rule:

TreeNode → constructor '(' Treenode // ',' ')'

- Example:

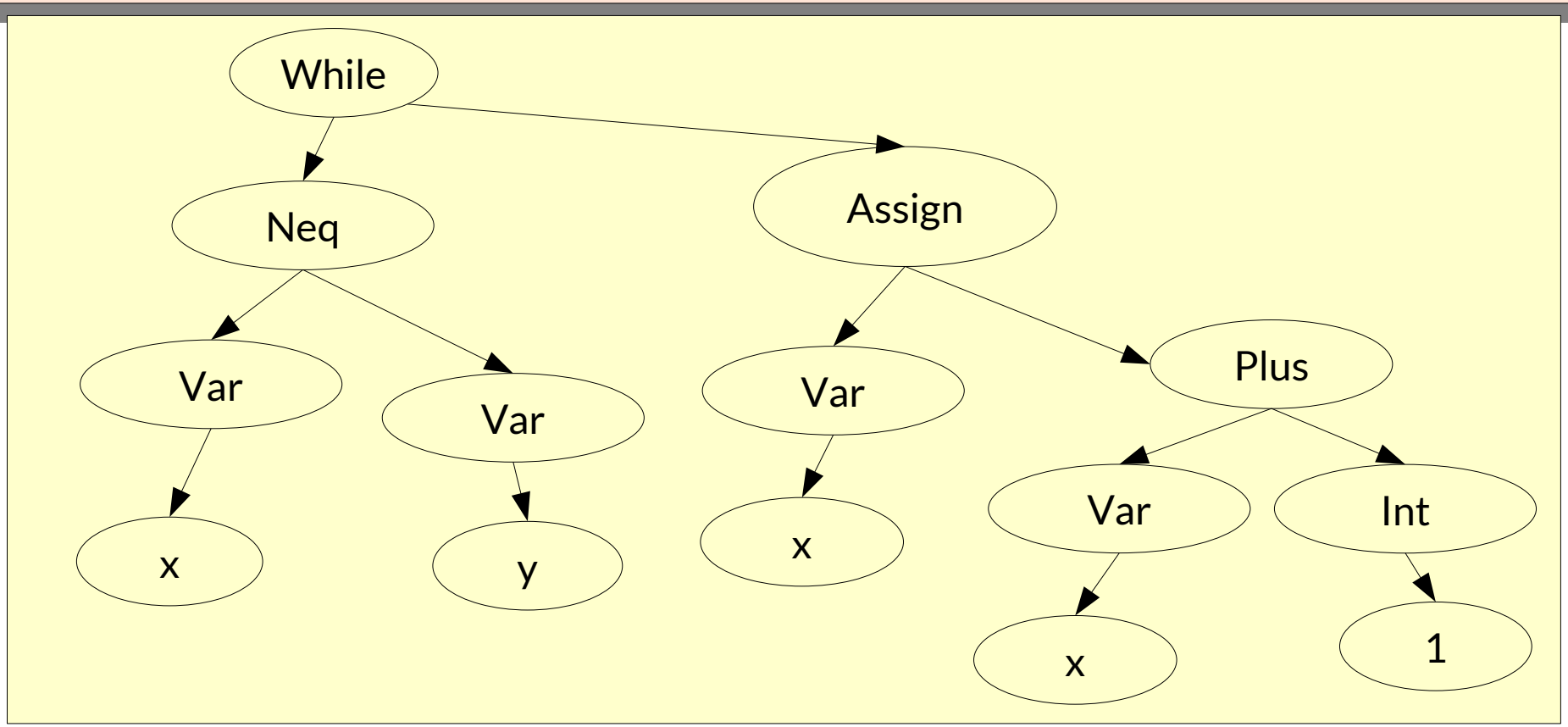
Model → ModelElements *

```
// Regular Tree Grammar from Stratego
regular tree grammar TIL
  start Program
  productions
    Program       -> Program(ListStar0fStat0)
    Stat          -> ProcCall(Id,ListStar0fExp0)
    Exp           -> FunCall(Id,ListStar0fExp0)
    Stat          -> For(Id,Exp,Exp,ListStar0fStat0)
    Stat          -> While(Exp,ListStar0fStat0)
    Stat          -> IfElse(Exp,ListStar0fStat0,ListStar0fStat0)
    Stat          -> IfThen(Exp,ListStar0fStat0)
    Stat          -> Block(ListStar0fStat0)
    Stat          -> Assign(Id,Exp)
    Stat          -> DeclarationTyped(Id,Type)
    Stat          -> Declaration(Id)
    ListStar0fStat1 → Stat // „'
    ListStar0fStat0 → Stat *
     Type          -> TypeName(Id)
    Exp           -> Or(Exp,Exp)  | And(Exp,Exp)
    Exp           -> Geq(Exp,Exp)   |  Eq(Exp,Exp) |  Neq(Exp,Exp)
    Exp           -> Gt(Exp,Exp)     |  Lt(Exp,Exp) |  Leq(Exp,Exp)
    Exp           -> Sub(Exp,Exp)   |  Add(Exp,Exp)
    Exp           -> Mod(Exp,Exp)  | Div(Exp,Exp) |  Mul(Exp,Exp)
    Exp           -> String(String)
    Exp           -> Int(Int) |  Var(Id)
    Exp           -> False()  |  True()
    StrChar        -> <string>
    String         -> <string>
    Int           -> <string>
    Id            -> <string>
```

© Prof. U. Aßmann

Correct Instance?

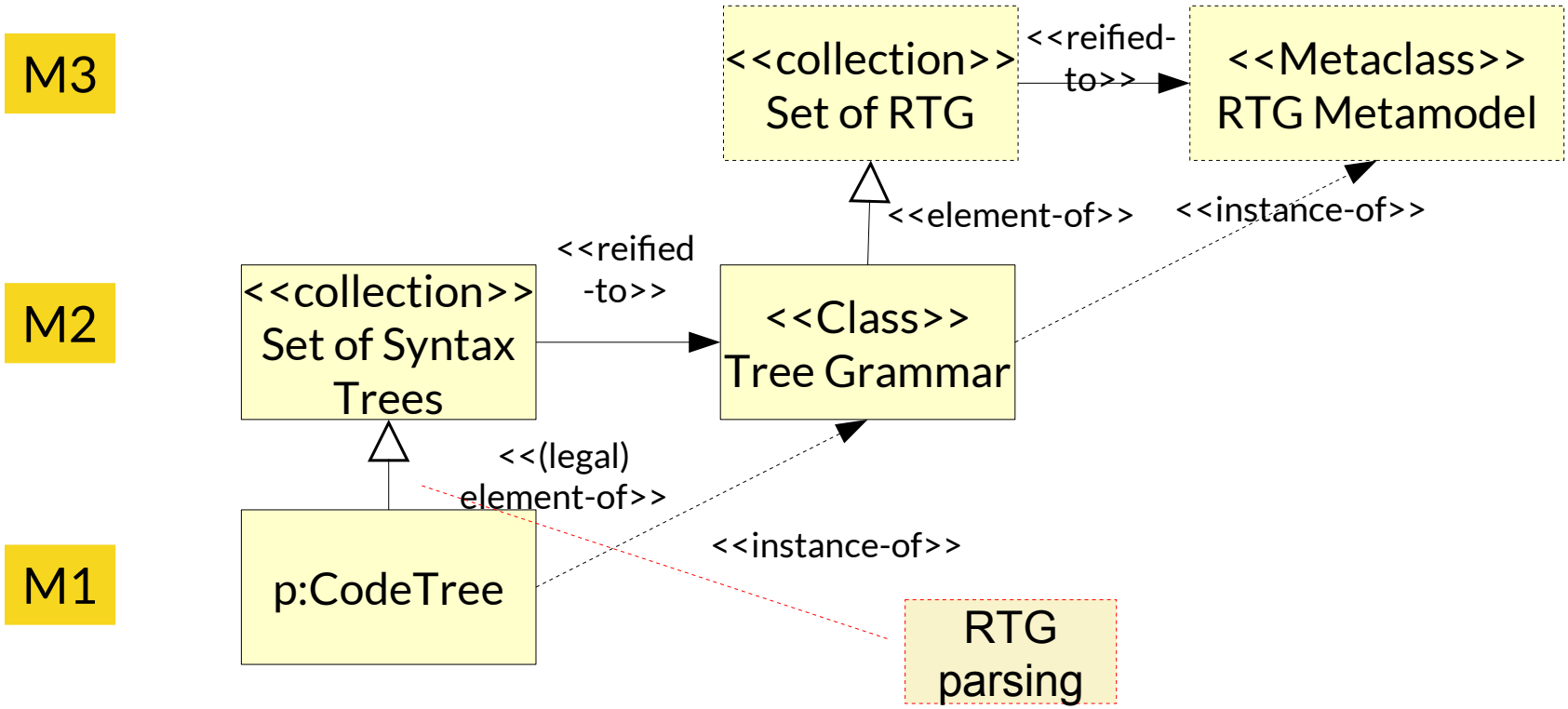

```
// Example: applying TIL grammar to a fragment
ExecuteGrammar(TIL,
    While(Neq(Var(x),Var(y)), Assign(Var(x),Plus(Var(x),Int(1) ) )
)
```



© Prof. U. Aßmann

Tree Parsing with RTG

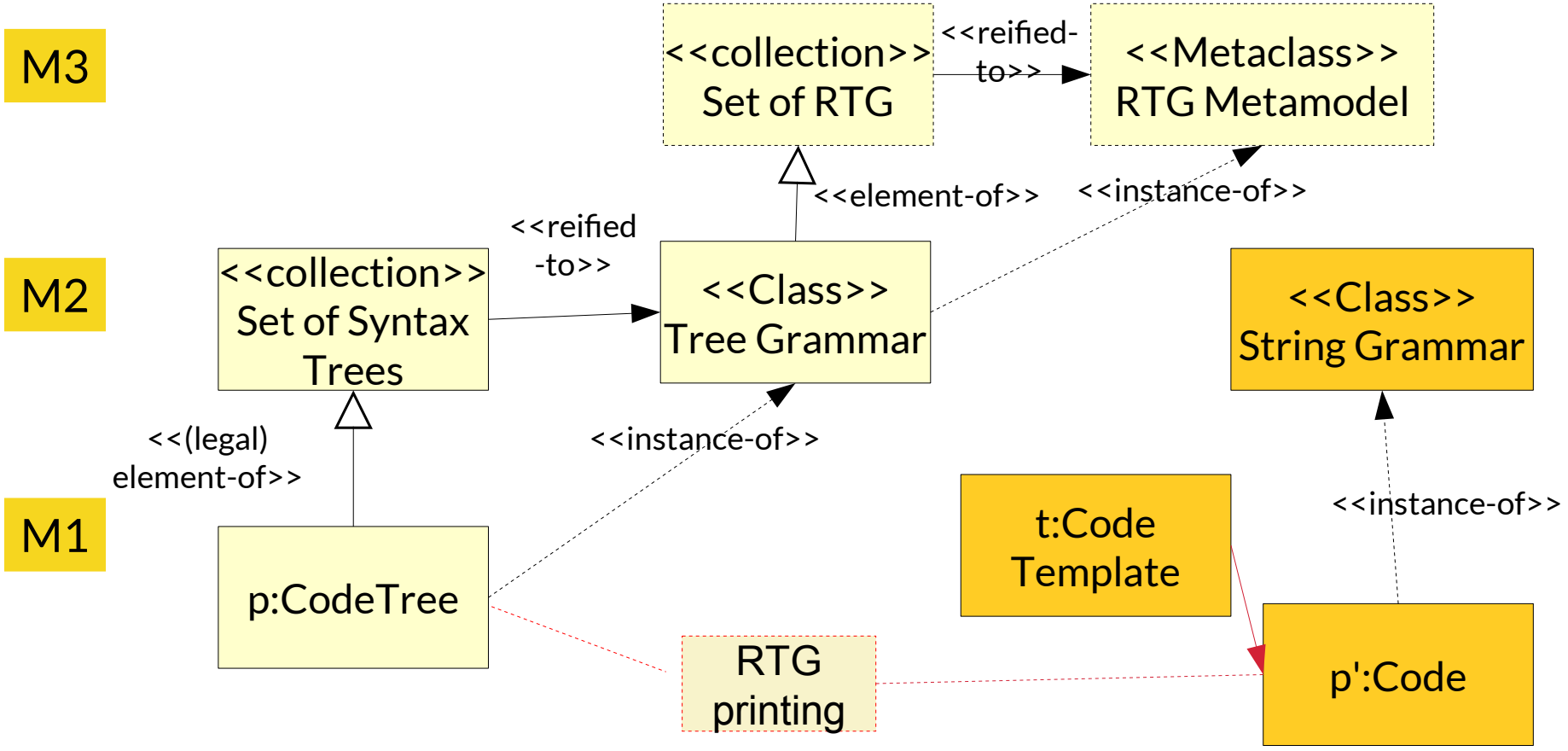
- An RTG can be used to generate a **tree parser** that tests the legality of a code tree with a tree grammar



© Prof. U. Aßmann

Tree Pretty-Printing with RTG

- An RTG can be used to generate a **tree pretty-printer** that prints the nodes of a tree recursively
- If p is a code tree, p' can be its pretty-printed copy, derived of a code template t
- Exercise: write a pretty-printer for the RTG TIL



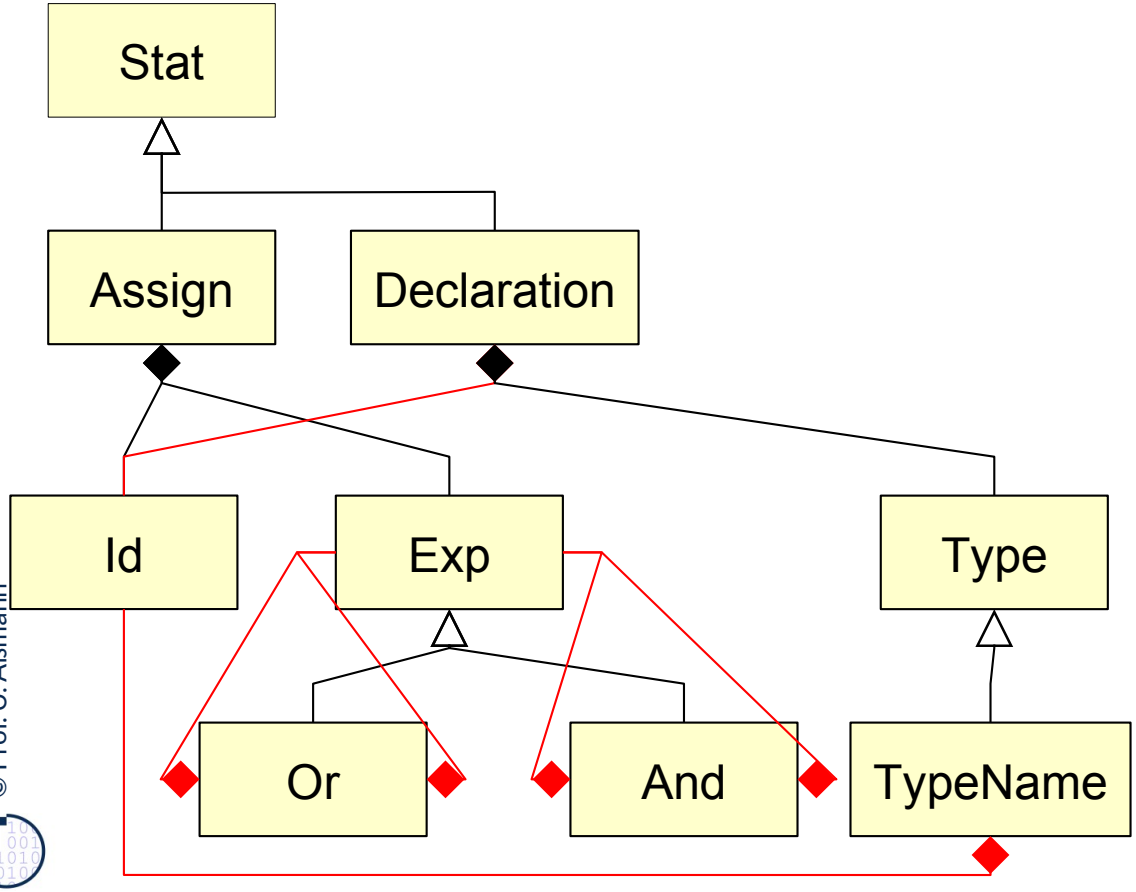
© Prof. U. Aßmann

20.2.2. Metamodels and Tree Grammars

- Foll parser also build syntax trees – Design Pattern Builder

Grammars and Metamodels are Very Similar

- The nonterminals of a grammar form the *name space* of the grammar
- Definition of a nonterminal (on left side)
- Use of a nonterminal (on right side) induces relation to definition
- Metamodels are graphs (including the red edges); grammars are *link trees* (red edges are overlaid)




```
Stat      -> Assign(Id,Exp)
Stat      -> Declaration(Id,Type)
Type      -> TypeName(Id)
Exp       -> Or(Exp,Exp)  | And(Exp,Exp)
Id        -> String
```

© Prof. U. Aßmann

20.3. Tree Construction as a Mapping between Parse Grammar and Tree Grammar

- Foll parser also build syntax trees – Design Pattern Builder

Tree Construction While Parsing

- Parsing recognizes the tree structure of a text (concrete syntax, CS)
  - **However, the syntax tree must be built as "action" while parsing**
- After parsing, the parser creates an **(abstract)** ***syntax tree (AST)***, i.e., builds up a tree with regard to a ***regular tree grammar of the abstract syntax (AS)***
  - Recognized nonterminals have to be mapped
  - Tokens, keywords, comments, layouts have to be omitted
  - **Tree building:** Treenodes have to be allocated and composed
- This **CS-AS mapping (from concrete to abstract syntax)** is created by hand in *side actions* of the parser
  - as action snippet in the rules
- For simple languages, parsers and tree constructors are no longer written by hand, but generated from *grammars in EBNF*
  - **Parser** recognizes the structure of the text ("Zerteiler des Textes")
  - **Tree builder** generates an abstract syntax tree
  - **CS-AS-mapping** creates AS nodes after recognition of CS nonterminals

© Prof. U. Aßmann

Constructing a Tree Grammar fitting to the String Grammar of Office DSL


```
//*******************************************************************************
// Copyright (c) 2006-2010
// Software Technology Group, Dresden University of Technology
//
// All rights reserved. This program and the accompanying materials
// are made available under the terms of the Eclipse Public License v1.0
// which accompanies this distribution, and is available at
// http://www.eclipse.org/legal/epl-v10.html
//
// Contributors:
//   Software Technology Group - TU Dresden, Germany
//      - initial API and implementation
// *******************************************************************************/
SYNTAXDEF office
FOR <http://emftext.org/office>
START OfficeModel
OPTIONS {
        licenceHeader ="../../org.dropsbox/licence.txt";
        generateCodeFromGeneratorModel = "true";
        disableLaunchSupport = "true";
        disableDebugSupport = "true";
}
RULES {
    OfficeModel ::= "officemodel" name[] "{" elements:Element* "}" ;

    Elements ::= Office | Employee;
    Office ::= "office" name[];

    Employee ::= "employee" name[]
                                "works" "in" worksIn[]
                                "works" "with"
                                worksWith[] ("," worksWith[])* ;
}
```

© Prof. U. Aßmann

.CS Grammar Plus Mapping to RTG (Abstract Syntax Tree)

- CS-AS mapping works via side actions of the grammar rules (“transducer”)
- Tree is built while returning from recursive descent

```
//*********************************************************
// Copyright (c) 2006-2015 under EPL
// Software Technology Group, Dresden University of Technology
// http://www.eclipse.org/legal/epl-v10.html
//
//*********************************************************/
SYNTAXDEF office  FOR <http://emftext.org/office>
TREENODES { // RTG
      START NodeOfficeModel
      NodeOfficeModel →
NodeOfficeModel(name:String,elements:Element *)
      Element → Office(name:String) |
                Employee(name:String, worksIn:String,
worksWith:String *)
}
START OfficeModel
RULES {
    OfficeModel returns [NodeOfficeModel root]
      ::= "officemodel" name[] "{" elements:Element * "}"
    {  root = NodeOfficeModel()
       root.name = name; root.elements = assemble elements; };
    Elements returns [Element retval]
      ::= Office  { retval = Office.val;  }
      | Employee  { retval = Employee.val;  };
    Office returns [Element retval]
      ::= "office" name[] { retval = Office(name);  };
    Employee returns [Element retval]
      ::= "employee" name[] "works" "in" worksIn[]
                                    "works" "with"
                                    worksWith[] ("," worksWith[])*
    { retval = Employee(name,worksIn,assemble worksWith);
    };
}
```

© Prof. U. Aßmann

Modeling Tools need Several Languages and DSL

- Bidirektional mapping between technical space “Grammarware” and another one, e.g., “Treeware”, “Link-TreeWare”, “XMLWare”, or “Modelware”

How can an MDSD Tool work flexibly
with several *textual* languages?

Generating parsers and tree builders from string grammars and RTG

… and generate from the RTG ..

Pretty printers (Code generators)

© Prof. U. Aßmann

Example: EMFText: EMOF and RTG

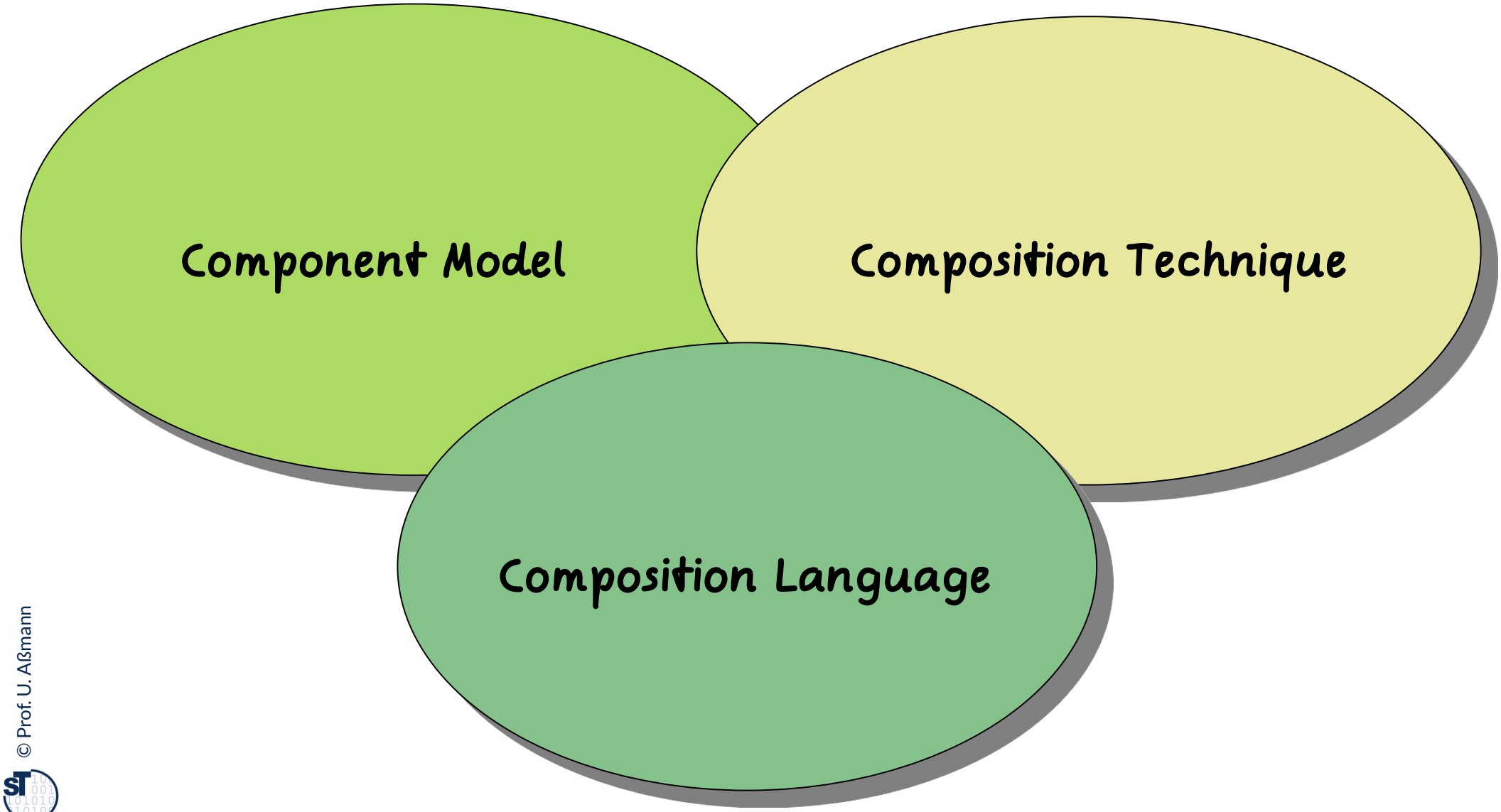
- EMFText uses the parser generator ANTLR to generate parsers
- The EMOF metamodels have a primary tree that can be written down as RTG
- Mapping concrete to abstracte syntax:
  - EBNF Grammar and the (implicit) RTG of the corresponding EMF metamodel are mapped *automatically* to each other (language mapping)
- For pretty printer generation, EMFText uses template-based code generation for the (implicit) RTG

© Prof. U. Aßmann

10.4 Text and Tree Algebrae

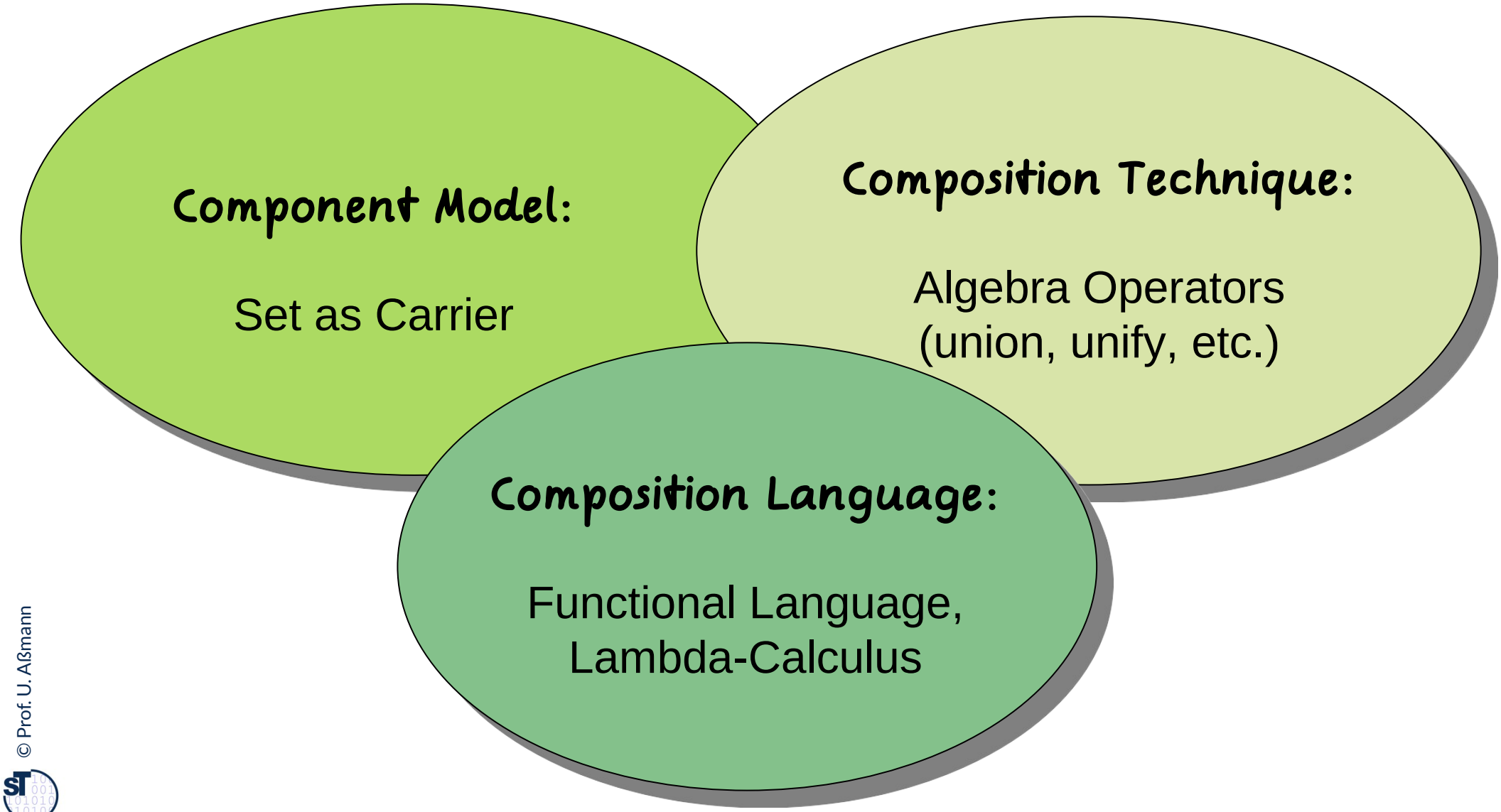
for composition of texts and trees

Composition with Composition Systems



© Prof. U. Aßmann

Composition with Algebrae in Mathematics



© Prof. U. Aßmann

One-sorted Algebra on Texts

- A **one-sorted algebra** is a set of operators on a carrier set (Trägermenge) of a type (a sort). Example: Texts, sequences of lines of characters
- Operations
  - E.g., the parser `splits` texts into lines, separated by newline characters
  - A text template is `expanded` by a padding (Füllsel)
- The UNIX Programmers Workbench is built on an algebra on texts:
  - `diff:  Text x Text → edit-sequence` (for a transformation)
  - `cmp:  Text x Text → Boolean`
  - `patch:  Text x edit-sequence → Text`
  - `diff3:  mine:Text x older:Text x yours:Text → edit-sequence`
  - `split:  Text x Split-char → Text*`
  - `match/grep:  Text x Pattern → Text*`
  - `check-property:  Text x Pattern → Boolean`
  - `is-consistent:  Text x Text → Boolean`
  - `format: Text → Text`
  - `expand: Text-template x padding:Text* → Text`

© Prof. U. Aßmann

CSV: A One-Sorted Algebra on Ascii-Tables

- Tables consist of sequences of lines, split into columns by a column-separator (TAB , COMMA, |)
  - .csv-tables (comma separated values)
  - html-tables, tex-tables
- `rdb` is a command tool suite on an algebra on tables:
  - `Diff: table x table → edit-sequence`
  - `Cmp: File x File → Boolean`
  - `Patch: table x edit-sequence → table`
  - `Diff3: mine:table x older:table x yours:table → edit-sequence`
  - `split: table x Splitzeichen → table*`
  - `match: table x Pattern → table*`
  - `check-property: table x Pattern → Boolean`
  - `is-consistent: table x table → Boolean`
  - `join, sort, group-by...`
  - `format: table → table`
  - `expand: table-template x table* → table`

© Prof. U. Aßmann

Excursion: CSV and Digital Preservation

- https://digital-preservation.github.io/
- Digital preservation “Bewahrung des digitalen Kulturerbes”
- csv schema language
  https://digital-preservation.github.io/csv-schema/csv-schema-1.1.html
- https://jsonformatter.org/xml-parser online xml parser

© Prof. U. Aßmann

Tree Algebra

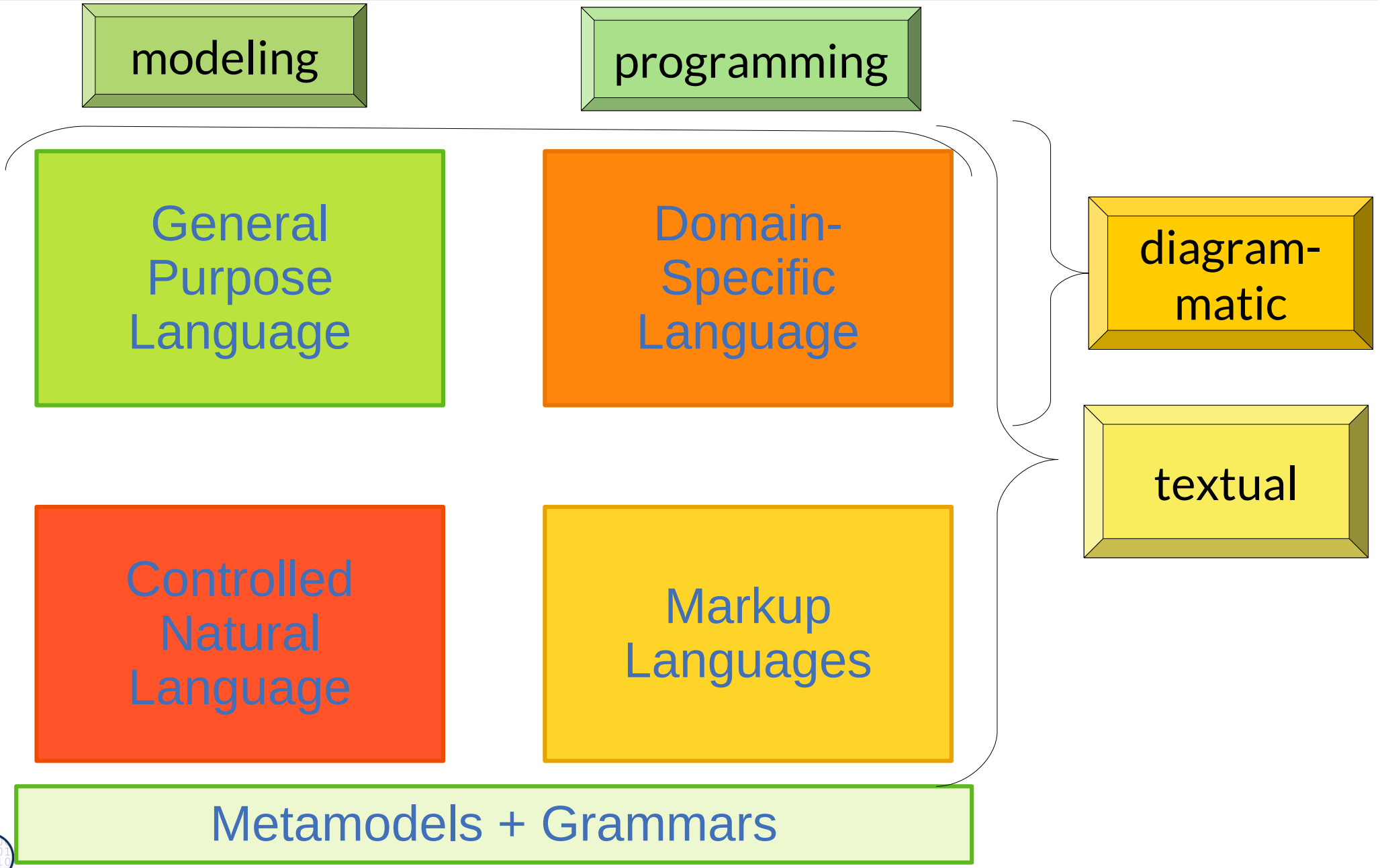
- Operations in a simple algebra on trees:
  - `Diff: tree x tree → edit-sequence`
  - `Cmp: File x File → Boolean`
  - `Patch: tree x edit-sequence → tree`
  - `Diff3: mine:tree x older:tree x yours:tree → edit-sequence`
  - `split: tree x node → upper:tree x lower:tree`
  - `match: tree x Pattern → tree*`
  - `check-property: tree x Pattern → Boolean`
  - `is-consistent: tree x tree → Boolean`
  - `Unify: tree x tree → tree`
  - `format: tree → tree`
  - `expand: tree-template x padding:tree* → tree`

© Prof. U. Aßmann

20.5 Controlled Natural Languages (CNL)

- Tobias Kuhn. A survey and classification of controlled natural languages. Comput. Linguistics, 40(1):121--170, 2014.
- Anne Cregan, Rolf Schwitter, and Thomas Meyer. Sydney owl syntax - towards a controlled natural language syntax for owl 1.1. In Proceedings of the OWLED 2007 Workshop on OWL: Experiences and Directions, volume 258. CEUR-WS, 2007.

Q16: Languages in Software Factories



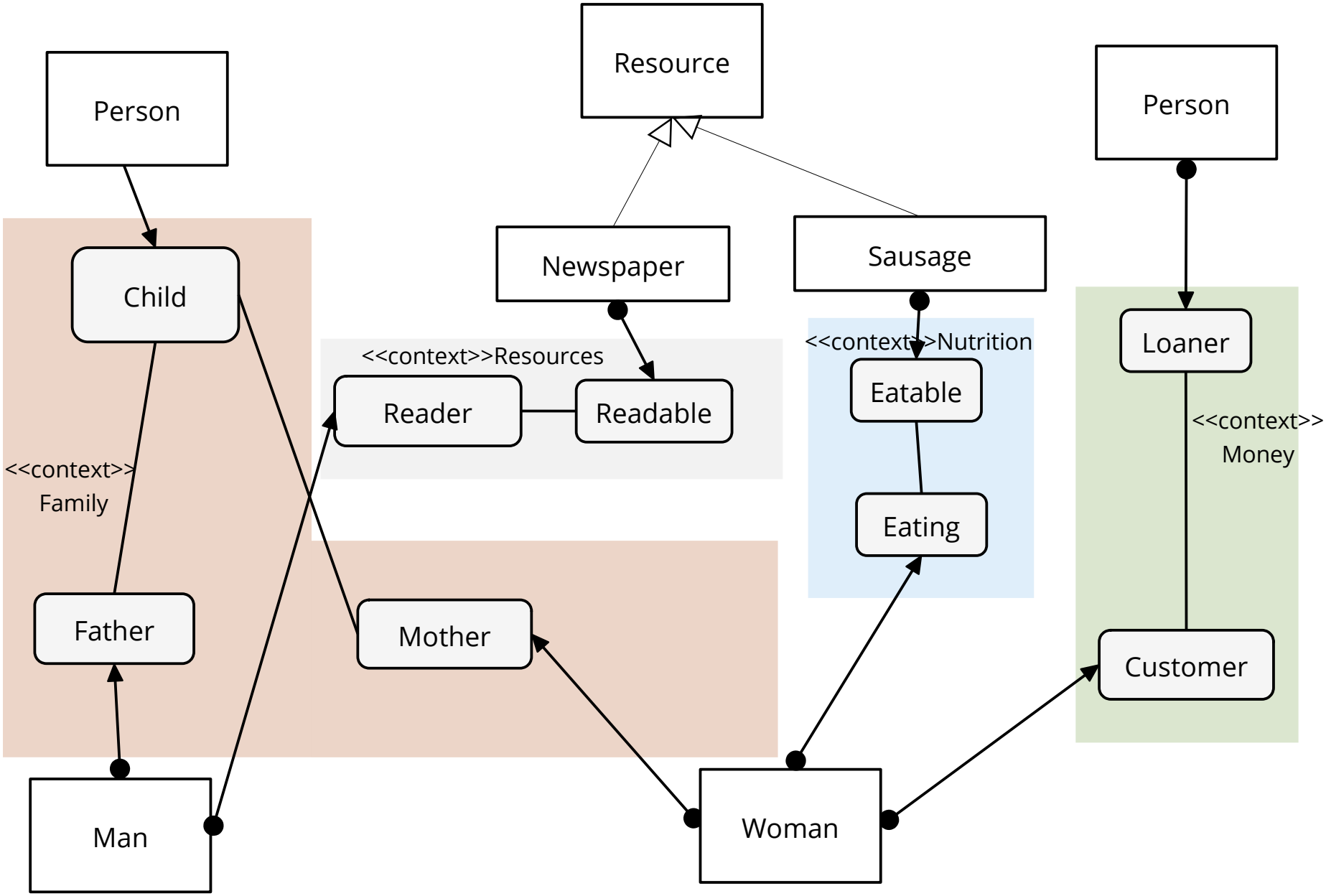
© Prof. U. Aßmann

Controlled Natural Languages (CNL)

- Def.: A ***controlled natural language*** is a restricted natural language that can be described by a formal grammar, either a
  - context-free grammar (e.g., specified by ANTLR)
  - regular tree grammar (e.g., specified by Spoofax)
  - context-sensitive grammar or attributed grammar (e.g., specified by JastAdd, see later).
- Advantages:
  - Simple, comprehensive syntax
  - In contrast to a natural language, a CNL can be processed easily by tools, because syntax trees for naturally looking texts can be built

© Prof. U. Aßmann

Families and Banks in Natural and Role Types (CROM)

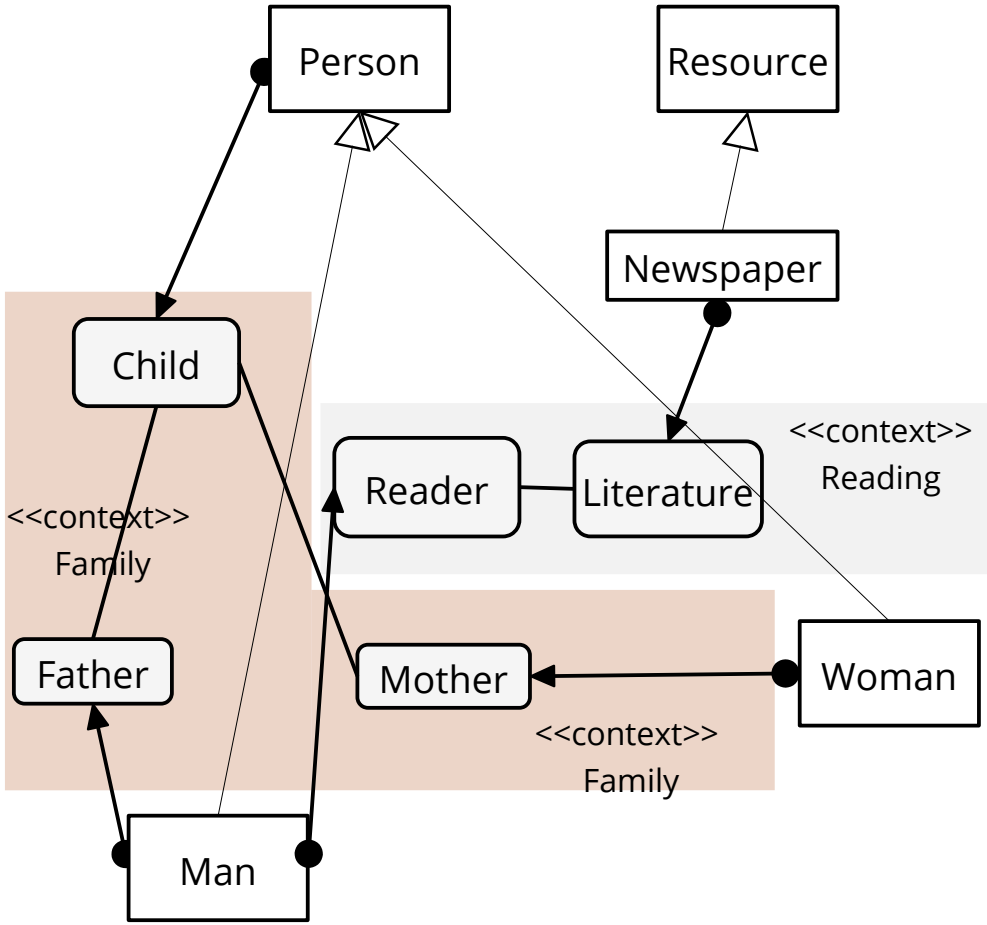


© Prof. U. Aßmann

Families and Banks in Natural and Role Types, Specified in Sydney OWL Syntax

- Models can be read or specified in controlled natural language
- [Cregan] introduces a CNL for OWL ontologies, also useful for CROM
- Example: Families in CROM:

```
Every Man is a Person.
Every Woman is a Person.
Every Person may play a Child (in a Family).
Every man:Man may play a Father (in a
Family).
Every Child is related to a Mother in a
Family
Every Child is related to a Father in a
Family.
A man:Main may play a Reader (in Reading).
Every Reader is related to a Literature in
Reading.
Every Newspaper is a Resource.
Every Newspaper may play a Literature (in
Reading).
```



PENS Classification

- [Kuhn] Languages can be classified with regard to 4 criteria and school grades.
- E.g., English is $S^2E^5N^5S^2$.

	Precision	Expressiveness	Naturalness	Simpliicty
English	1	5	5	1
Controlled English	4	3	5	4
Domain-specific language	4	3	5	4
UML Class diagrams	3	3	4	4

© Prof. U. Aßmann

20.6 Markup Languages and Pseudocode

http://en.wikipedia.org/wiki/Pseudocode
Languages used for documentation

Pseudocode

- **Pseudocode** consists of *structured text with keywords and blocks*, z. B. **seq, endseq, if, then, else, endif, while, endwhile, call, action, stop**,...
  - Natural text is enclosed as comment, but ignored
- For pseudocode, grammars can be constructed:
  - Syntax checking with ***island parsing***
  - An ***island grammar*** contains
    - "islands" for the keywords and structure
    - "water" for the free-form text
- Tool support:
  - Code generation (code templates and comments)
  - Documentation generation (structograms, LaTeX document generation)

© Prof. U. Aßmann

Examples for Pseudocode

- In pseudocode, structure can be recognized (as islands in the free-form water)
- Pseudocode can recognize names and do a name analysis:
  - Title of procedures, classes, and processes
  - Types from the data dictionary, Local names
- Pseudocode can define macros

```
process empfangen_Patient 1.3.1
for &Patient
      with >Bestelldatum = Datum in &Termine und >Beschwerden
       if Name*des Patienten* in &Patient
      else "aktualisieren_Patient 1.1"
      if keine >Beschwerden und >Bestelldatum ungueltig
              then „vergeben_Termin 1.2“
      else Uebernahme Patientendaten aus &Patient
      alle Unterlagen fuer Arzt aufbereiten
      <Aufnahme Name*des Patienten* in &Warteliste
      if @Bestdat+Zeit = Kalenderdatum + Uhrzeit
       then Terminpatient Platz m+1*
              vorhergehender Terminpatient m*
       else Platz n+1*n Anzahl aller Patienten im Wartezimmer*
```

© Prof. U. Aßmann

Structural Skelecon of Pseudocode (2)


```
action empfangen_Patient
        while (Patienten oder Praxisoeffnung)
        seq Eingabe >Bestelldatum, >Beschwerden
        if (@Bestdat+Uhrzeit enth. &Termine)
        then Bestellpatient
        else if (@Gebdatum+Name enth. &Patient)
                then ziehen Patientenakte
                else call aktualisieren_Patientendaten
             endif
             if (>Beschwerden <> 0*vorhanden*)
                then Unbestellter_Patient
                else call vergeben_Termin
             endif endif
      Aufbereiten aller Unterlagen fuer Arzt endseq
        if (Bestellpatient)
                then <Aufnahme Platz m+1 in &Warteliste
                else <Aufnahme Platz n+1 in &Warteliste
        endif endwhile
stop
```

© Prof. U. Aßmann

LATEX, XML and Pseudocode

- Markup languages structure pseudocode with **markup tags.**

```
\documentclass{article}

\title{My first Document}
\author{John Doe}
\usepackage[english]{babel}

\begin{document}

\maketitle

Hello World! My name is John Doe.

\emph{Next paragraph has to be written.}

\end{document}
```

© Prof. U. Aßmann

Support for Pseudocode

- LaTeX-distributions have good style packages for pseudocode:
  - algorithms.sty
  - \usepackage{algpseudocode}
  - \usepackage{algorithmicx}
  - listings.sty
- See also ELAN, the semi-natural programming language
  - http://de.wikipedia.org/wiki/ELAN
  - Part of OS L3, predecessor of L4

```
PACKET stack handling DEFINES push,pop,init
stack:
  LET max = 1000;
  ROW max INT VAR stack;
  INT VAR stack pointer;
  PROC init stack:
    stack pointer := 0
  END PROC init stack;
  PROC push (INT CONST dazu wert):
    stack pointer INCR 1;
    IF stack pointer > max
      THEN errorstop ("stack overflow")
      ELSE stack [stack pointer] := dazu wert
    END IF
  END PROC push;

  PROC pop (INT VAR von wert):
    IF stack pointer = 0
      THEN errorstop ("stack empty")
      ELSE von wert := stack [stack pointer];
           stack pointer DECR 1
    END IF
  END PROC pop

END PACKET stack handling;
```

- http://os.inf.tu-dresden.de/L3/usrman/node10.html

© Prof. U. Aßmann

Summary

- Parser generators belong to the tool set of a software engineer
- Parsers can parse
  - Texts (lines of rows)
  - CSV relations (lines of delimiter-separated tuples)
  - Pseudocode with island grammars
- The parser only parses the context-free structure of the programms, document, or model;
- Syntax trees are built from a mapping of concrete to abstract syntax
- Context conditions, integrity and wellformedness constraints are delayed to the *static semantic analysis* on the syntax tree

© Prof. U. Aßmann

The End

- Why is a parser often delivering several results (parses)?
- How can you disambiguate ambiguate rules?
- Why is string parsing not the same as tree parsing? What is the difference of concrete and abstract syntax trees?
- Explain the difference of
  - A string grammar vs a tree grammar
  - A concrete syntax grammar (CS grammar) vs an abstract syntax grammar (AS grammar)

© Prof. U. Aßmann

20.A.1 Port-Graph Algebrae on Fragments

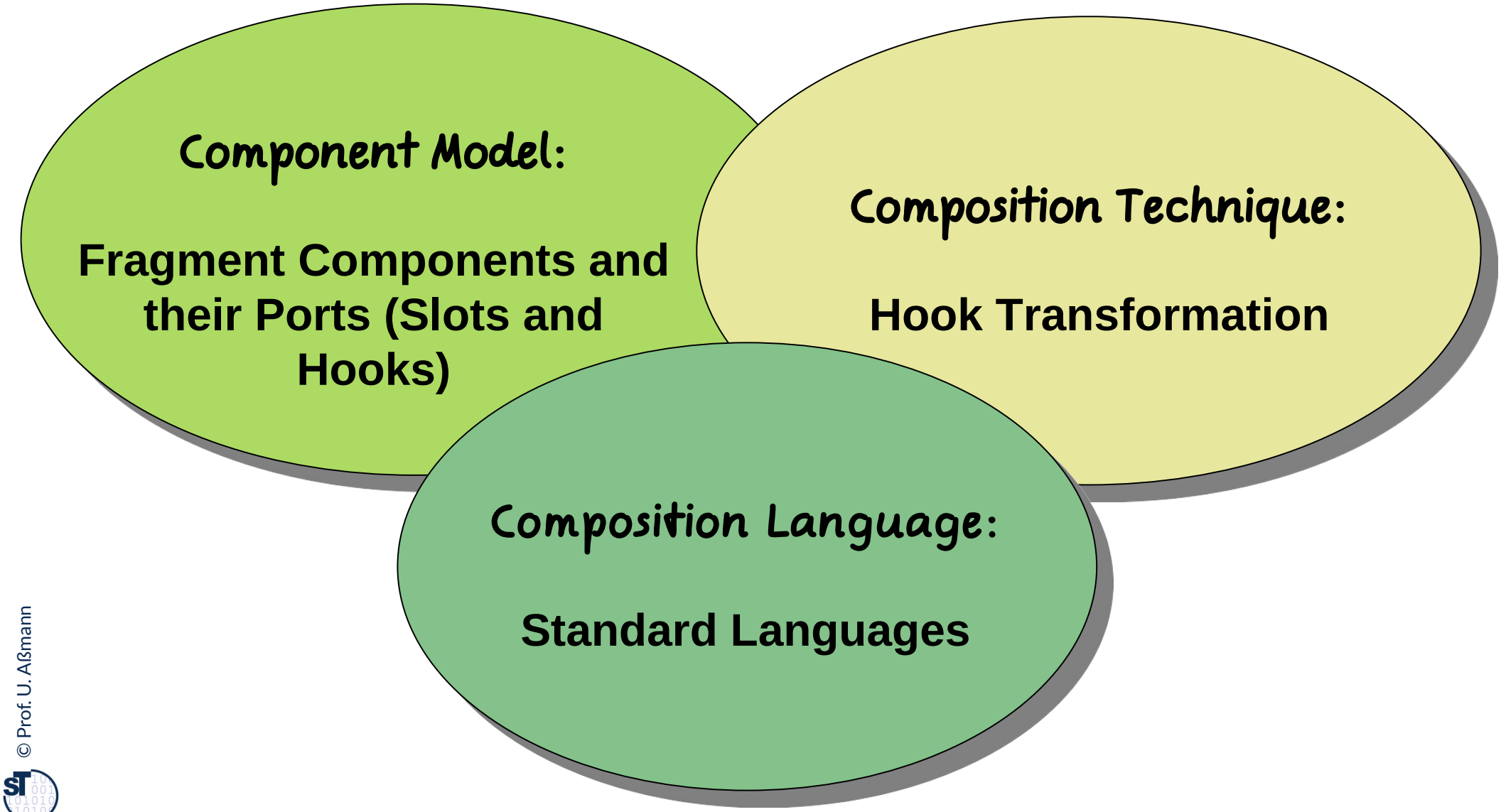
Invasive Software Composition is a general, typed templating technique for all languages

… based on port-graph algebrae

… with Graybox Components

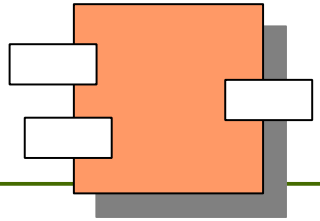
... preview onto the summer (CBSE course)

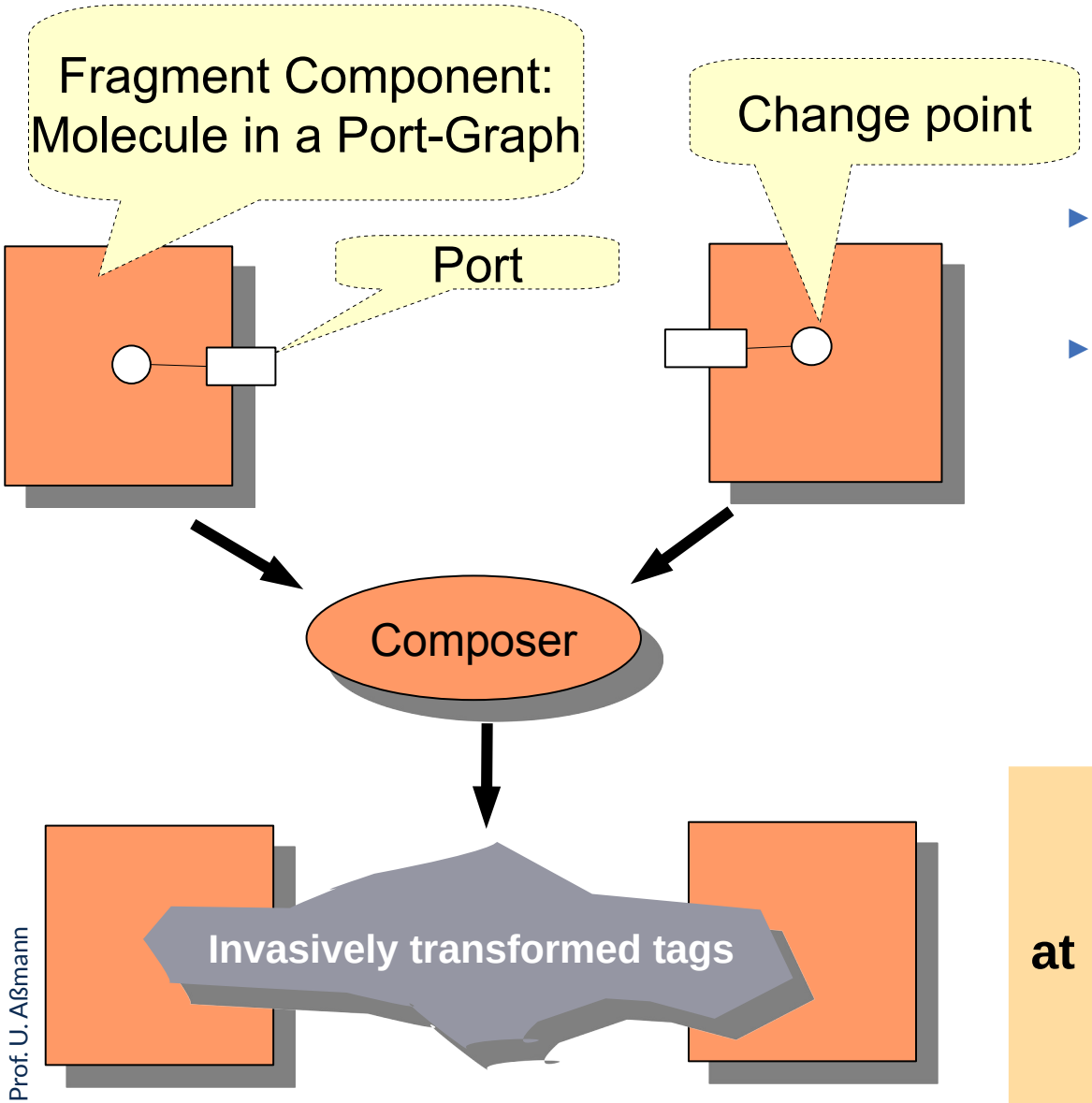
“Invasive” Composition (Typed Templating) with Port-Graph Algebrae



© Prof. U. Aßmann

Invasive Composition as Hook Transformations



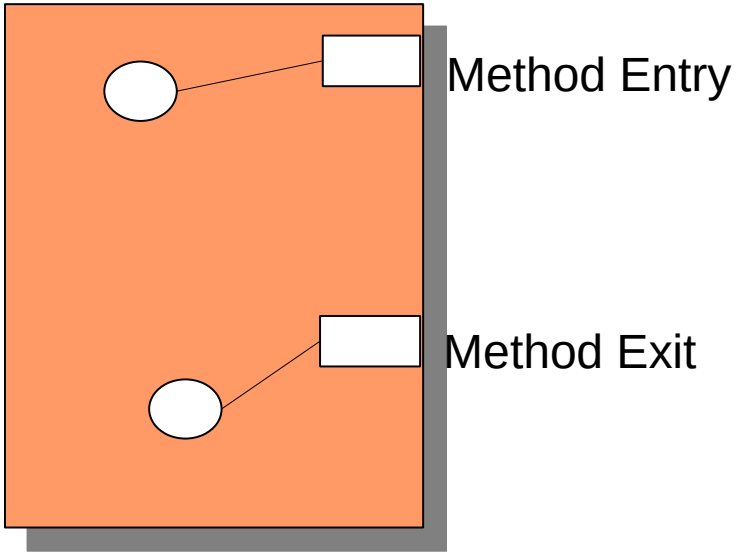


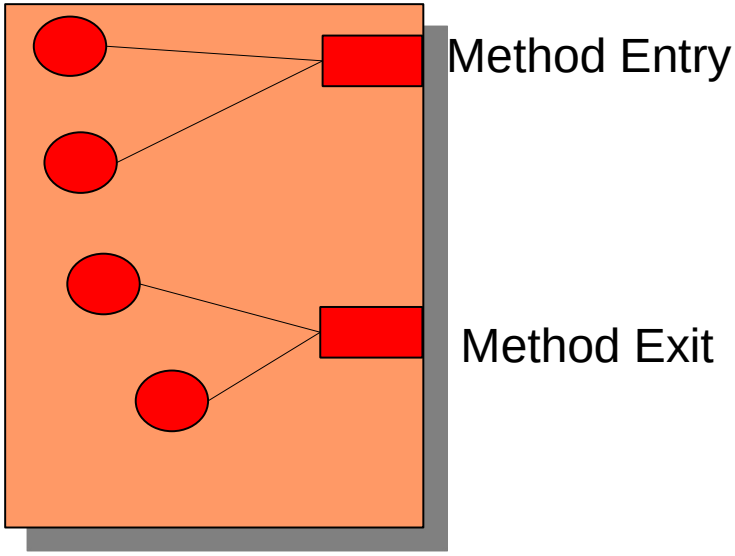
- A **port graph** is a graph in which each node (**molecule**) has a set of *ports*
- A **fragment component** is a molecule with ports (slots, hooks, query points) related to change points

Invasive Composition
adapts and extends
fragment components
at ports (slots, hooks, query-points)
by composition operators

© Prof. U. Aßmann

Binding Implicit Hooks with Fragments





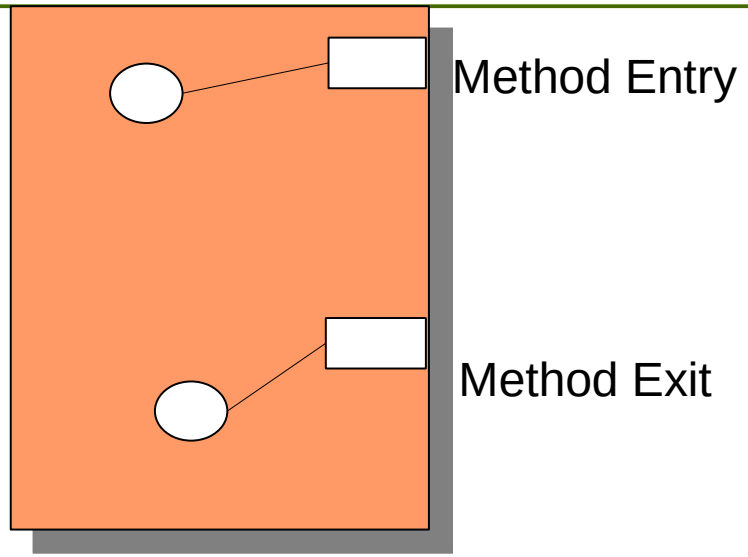

```
m (){

    abc..
    cde..

}
```

```
m (){
    print("enter m");
    abc..
    cde..
    print("exit m");
}
```

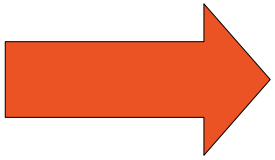
```
component.findHook(„.MethodEntry").extend("print(\"enter m\");");

component.findHook(„MethodExit").extend("print(\"exit m\");");
```

© Prof. U. Aßmann

Partial Parsing of Fragment Components




```
m (){

    abc..
    cde..

}
```

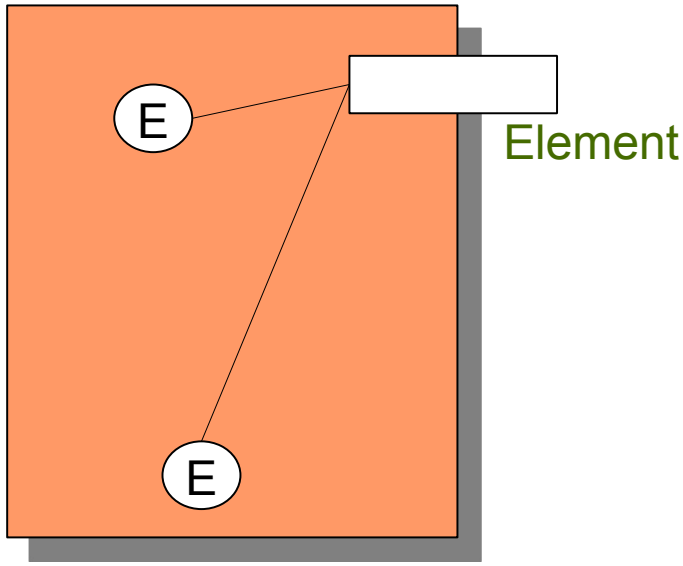


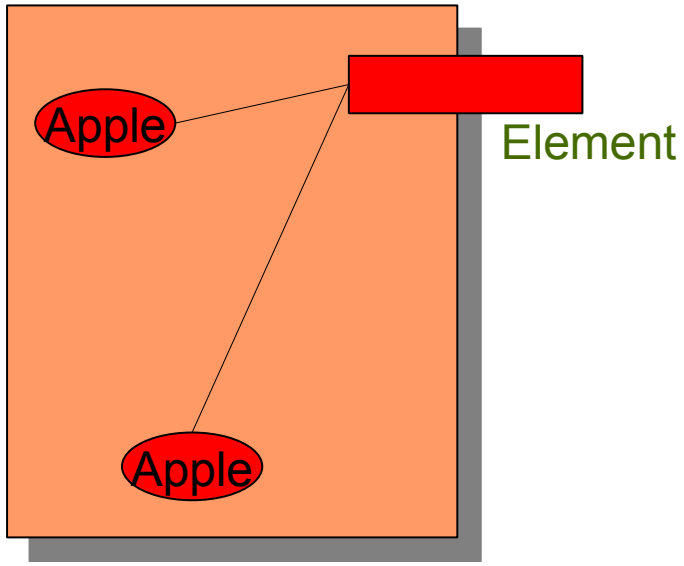
```
m (){
    // Method Entry
    abc..
    cde..
    // Method Exit
}
```

```
Component = compositionSystem.partialParser(„m (){ abc.. cde.. }“);
```

© Prof. U. Aßmann

Binding Declared Hooks with Fragments





List(E) list;

....
list.add(new E());

...

List(Apple) list;

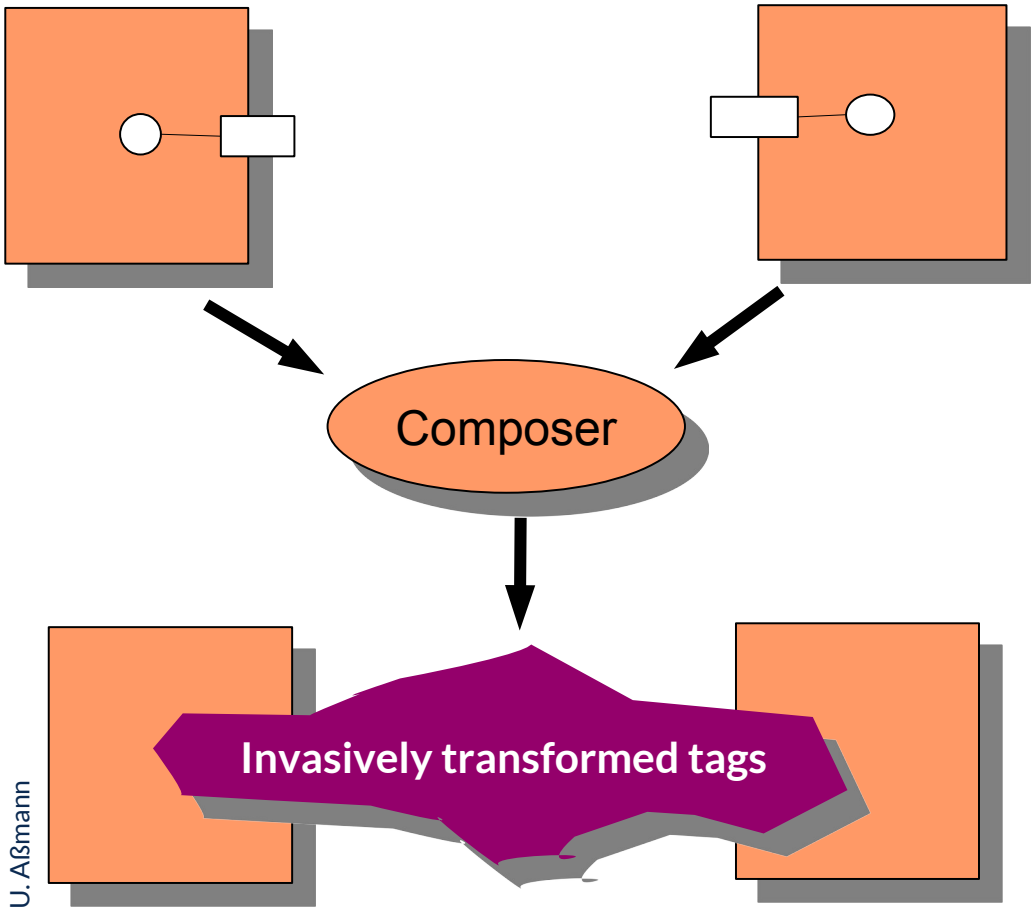
....
list.add(new Apple());

...

box.findHook(„Element“).bind(“Apple”);

© Prof. U. Aßmann

Invasive Composition as Hook Transformations



- Invasive Composition works uniformly on
  - For all languages
  - For declared hooks and implicit hooks
- Allows for unification of
  - Inheritance
  - Views
  - Aspect weaving
  - Parameterization
  - Role model merging

© Prof. U. Aßmann

Operators in a Port-Graph Algebra

Simple composition operators

- **bind** hook (parameterize)
  - For generic programming
- **rename** component, rename hook
- **remove** value from hook (unbind)
- **extend** component or hook extensions
- **copy** fragment component

Compound composition operators

- **inheritance** from component
  - For object-oriented programming
- **view** of component
  - view-based programming
- **connect** hook 1 and 2
  - For connector-based programming
- **distribute** component over other component
  - For aspect weaving

© Prof. U. Aßmann