Concrete Syntax for Objects

Domain-Specific Language Embedding and Assimilation without Restrictions

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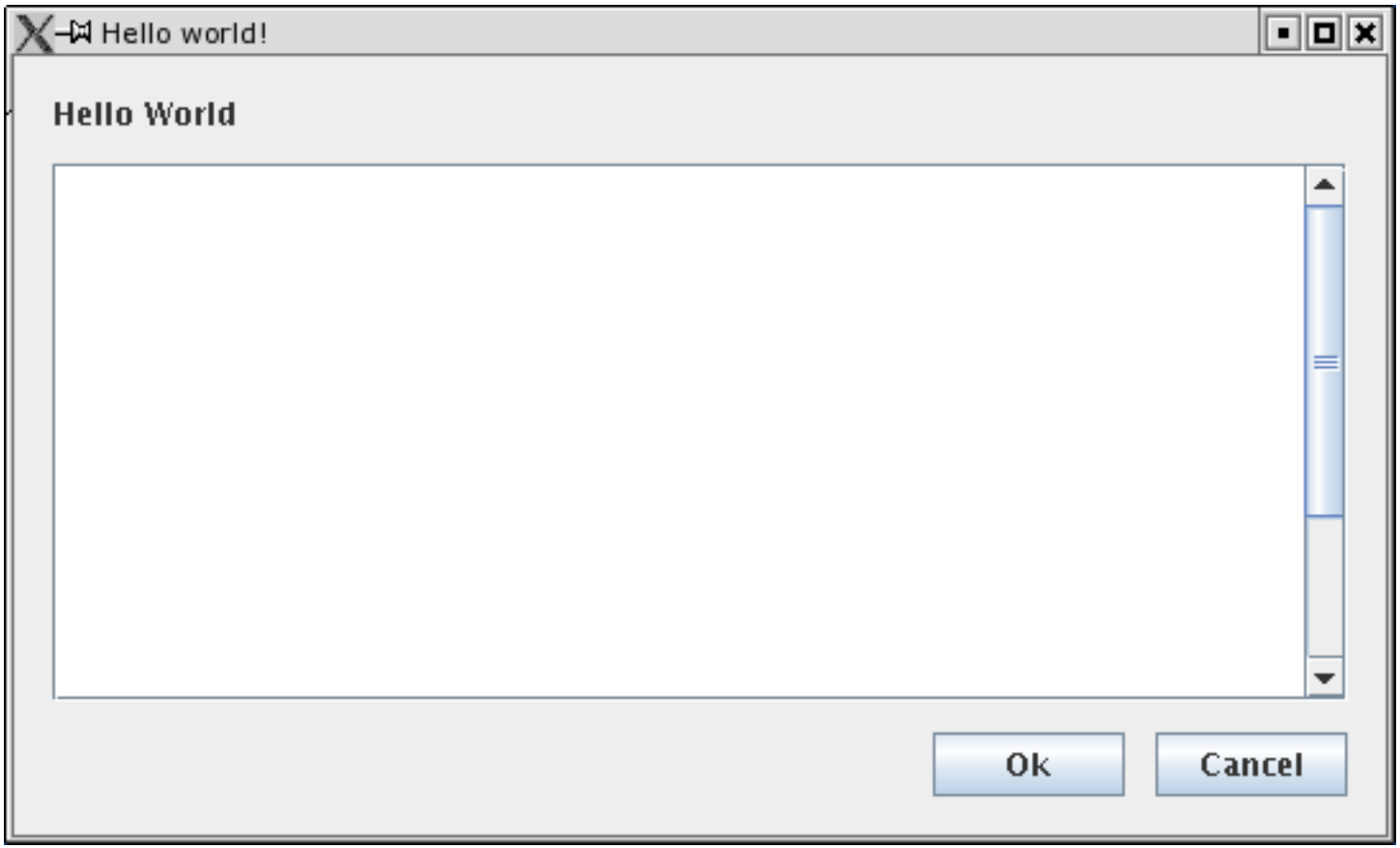
Outline

Simple Java/Swing GUI



GUI: Implementation in Java

```
JTextArea text = new JTextArea(20,40);

JPanel panel = new JPanel(new BorderLayout(12,12));
panel.add(BorderLayout.NORTH , new JLabel("Hello World"));
panel.add(BorderLayout.CENTER , new JScrollPane(text));

JPanel south = new JPanel(new BorderLayout(12,12));
JPanel buttons = new JPanel(new GridLayout(1, 2, 12, 12));
buttons.add(new JButton("Ok"));
buttons.add(new JButton("Cancel"));

south.add(BorderLayout.EAST, buttons);
panel.add(BorderLayout.SOUTH, south);
```

GUI: Implementation in Java/Swul

```
JPanel panel = panel of border layout {
  north = label "Hello World"

  center = scrollpane of textarea {
    rows    = 20
    columns = 40
  }

  south = panel of border layout {
    east = panel of grid layout {
      row = {
        button "Ok"
        button "Cancel"
      }
    }
  }
};
```

XML fragment (Cocoon)

```
<html>
  <body>
    <p>Some text here</p>
  </body>
</html>
```

XML Generation in Java (Cocoon)

```
out.startDocument();
out.startElement("", "html", "html", noAttrs);
out.startElement("", "body", "body", noAttrs);
out.startElement("", "p", "p", noAttrs);
out.characters(text.toCharArray(), 0, text.length());
out.endElement("", "p", "p");
out.endElement("", "body", "body");
out.endElement("", "html", "html");
out.endDocument();
```

XML Generation in Java/XML

```
out.write document %>
    <html>
      <body>
        <p><%  text :: cdata %></p>
      </body>
    </html>
  <%;
```

Java code (Castor)

```
if(propertyChangeListeners == null)
  return;

PropertyChangeEvent event =
  new PropertyChangeEvent(this, fieldName, oldValue, newValue);

for(int c=0; c < propertyChangeListeners.size(); c++) {
  ((PropertyChangeListener)
      propertyChangeListeners.elementAt(c)).propertyChange(event);
}
```

Java Generation in Java (Castor)

```
jsc.add("if (");
jsc.append(vName);
jsc.append(" == null) return;");
jsc.add("PropertyChangeEvent event = new ");
jsc.append("PropertyChangeEvent");
jsc.append("(this, fieldName, oldValue, newValue);");
jsc.add("");
jsc.add("for (int i = 0; i < ");
jsc.append(vName);
jsc.append(".size(); i++) {");
jsc.indent();
jsc.add("((PropertyChangeListener) ");
jsc.append(vName);
jsc.append(".elementAt(i)).");
jsc.append("propertyChange(event);");
jsc.unindent();
jsc.add("}");
```

Java Generation in JavaJava

```
ATerm stm = bstm |[ {
    if(x == null)
     return;

    PropertyChangeEvent event =
      new PropertyChangeEvent(this, fieldName, oldValue, newValue);

    for(int c=0; c < x.size(); c++) {
      ((PropertyChangeListener)
        x.elementAt(c)).propertyChange(event);
    }
  } ]|;
```

Philosophy of MetaBorg

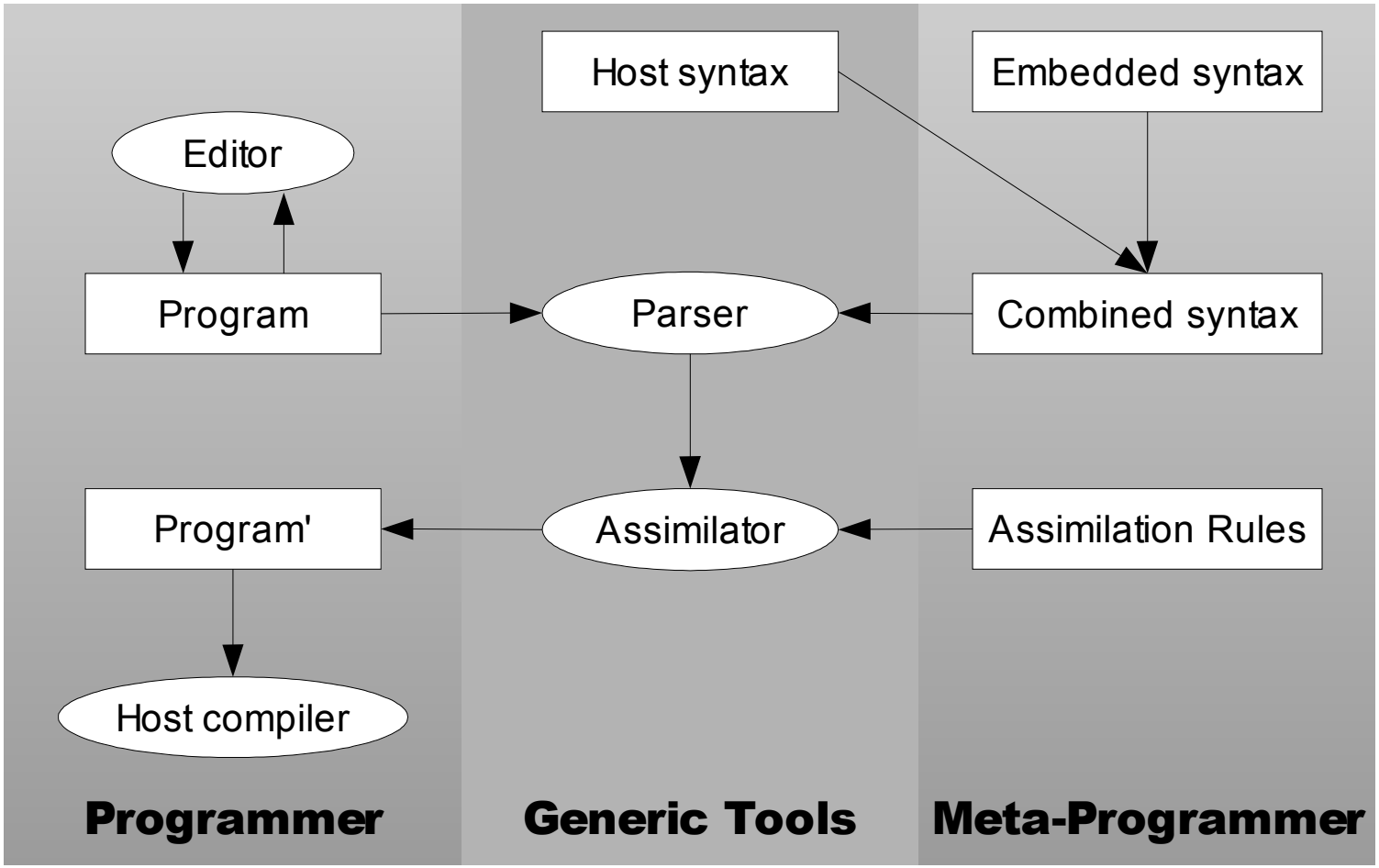
General purpose languages:

1. Designed for extensibility and reuse
   $\Rightarrow$ Sufficient *semantic* domain abstraction
2. API: Generic syntax of method invocations
   $\Rightarrow$ Poor *syntactic* domain abstractions

MetaBorg: Concrete syntax for domain abstractions

- *Embedding* of domain-specific language
- *Assimilating* embedded domain code

Architecture of MetaBorg



Java/Tuples

Syntactic abstraction:

```
(Integer, String) t = (1, "Hello world!");
```

API:

```
public class Tuple<F, S> {
  public Tuple(F first, S second) ...
  public static <F1, S1> Tuple<F1, S1> construct(F1 f, S1 s)  ...

  public F getFirst()  ...
  public void setFirst(F value)  ...
}
```

After assimilation:

```
Tuple<Integer, String> t = Tuple.construct(1 , "Hello world!");
```

Realizing Java/Tuples

Embed syntax of Tuples in Java

```
module Java-Tuple imports Generic-Java
exports
  context-free syntax
    "(" Expr "," Expr ")" -> Expr {cons("NewTuple")}
    "(" Type "," Type ")" -> Type {cons("TupleType")}
```

Assimilate Tuples to Tuple API

```
module Java-Tuple-Assimilate imports Generic-Java
rules
  AssimilateTuple :
    expr |[ (e1, e2) ]| -> expr |[ Tuple.construct(e1, e2) ]|

  AssimilateTuple :
    type |[ (t1, t2) ]| -> type |[ Tuple<t1, t2> ]|
```

Realizing Java/Tuples

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  AssimilateTuple :
    type |[ (t1, t2) ]| -> type |[ Tuple<t1, t2> ]|
```

SDF Syntax Definition of Swul

```
module Swul imports Swul-Layout
exports
  context-free syntax
    "panel" "of" Layout          -> Component {cons("Panel")}
    "panel" "{" PanelProp* "}" -> Component {cons("Panel")}
    "layout" "=" Layout          -> PanelProp {cons("Layout")}
    "border" "=" Border          -> PanelProp {cons("Border")}

  context-free syntax
    "button" String                 -> Component {cons("ButtonText")}
    "button" "for" Action           -> Component {cons("Button")}
    "button" "{" ButtonProp* "}"  -> Component {cons("Button")}

  context-free syntax
    Id ":="  Component -> Component {cons("Assign")}
    Id ":"   Component -> Component {cons("Declare")}

  lexical syntax
    [a-zA-Z][a-zA-Z0-9]+ -> Id
```

Syntax Definition of Java/Swul

Embedding Swul in Java:

- Swul constructs as Java expressions
- Java expressions as Swul constructs

```
module Java-Swul
imports Java-Prefixed Swul-Prefixed
exports
  context-free syntax
    SwulComponent -> JavaExpr {cons("ToExpr")}
    SwulLayout    -> JavaExpr {cons("ToExpr")}

    JavaExpr      -> SwulBorder    {cons("FromExpr")}
    JavaExpr      -> SwulComponent {cons("FromExpr")}
```

Assimilation Rules for Java/Swul

```
Swulc-Component :
  swul |[ button e ]| -> expr |[ new JButton(e) ]|

Swulc-Layout :
  swul |[ grid layout {ps*} ]| -> expr |[ new GridLayout(i,j) ]|
    where <nr-of-rows> ps* => i
        ; <nr-of-columns> ps* => j

Swulc-AddComponent(|x) :
  swul |[ south = c ]| -> bstm |[ x.add(BorderLayout.SOUTH, e); ]|
    where <Swulc-Component> c => e

Swulc-Component :
  swul |[ x := c ]| -> expr |[ {| x = e; | x |} ]|
     where <Swulc-Component> c => e

Swulc-Component :
  swul |[ x : c ]| -> expr |[ {| t x = e; | x |} ]|
     where <java-type-of> c => t
         ; <Swulc-Component> c => e
```

Assimilation Rules for Java/Swul

```
Swulc-Component :
  swul |[ button e ]| -> expr |[ new JButton(e) ]|

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Swulc-Component :
  swul |[ x : c ]| -> expr |[ {| t x = e; | x |} ]|
     where <java-type-of> c => t
         ; <Swulc-Component> c => e
```

Why is MetaBorg this Easy?

MetaBorg is based on the right tools for the job.

- SDF
  Modular syntax definition
- SGLR
  Scannerless Generalized LR parsing
- Stratego
  Rewriting rules with concrete syntax

Modular Syntax Definition

Modularity:

$\Rightarrow$ requires full class of context-free grammars.

$\Rightarrow$ requires disambiguation

SDF: Modular to the core.

- defines complete (lexical and context-free) syntax
- allows full class of context-free grammars
- allows ambiguities
- declarative disambiguation
- modules, renamings, parameterization

SDF: Disambiguation

Associativity:

```
Exp "+" Exp -> Exp {left, cons("Plus")}
```

Relative priorities and group associativity:

```
context-free priorities
    Exp "." Id  "(" {Exp ","}* ")" -> Exp
  > {left:
      Exp "/" Exp -> Exp
      Exp "*" Exp -> Exp }
  > {left:
      Exp "+" Exp -> Exp
      Exp "-" Exp -> Exp }
```

Parsing with Separate Lexical Analysis

Lexical Analyzer:

- Input string to sequence of tokens
- Often generated from regular expressions

JPanel	north	=	panel	of	border	layout	{	north	=
id	kwd	=	kwd	kwd	kwd	kwd	{	kwd	=

Scannerless Parsing

Embedding languages:

- *Context* of token must be considered
- Longest-match might be too greedy
- Separate lexers are not composable.

Solution:

- no separate lexical analysis: *scannerless*
- complete definition of syntax
- optional specification of longest-match:

```
lexical restrictions
  Id       -/- [A-Za-z0-9]
  IntConst -/- [0-9]
```

Structured Tokens

A lexer produces tokens: plain sequence of characters.

```
href="http://www.cs.uu.nl/staff/<% name %>.html"
```

SGLR parses this without any further processing to:

```
Attribute(
  QName(None, "href")
, DoubleQuoted(
    [ Literal("http://www.cs.uu.nl/staff/")
    , Literal(FromMetaExpr(ExprName(Id("name"))))
    , Literal(".html")
    ]
  )
)
```

Assimilation: Rewrite Rules

Stratego's rewrite rules:

- Implement *basic assimilation* steps
- Application is controlled by a *strategy*.
- Many assimilations can reuse *generic traversal strategies*.
- Dynamically defined rewrite rules for *context-sensitive* assimilation.
- Expressed in concrete syntax for embedded domain-specific language and host language: MetaBorg!

Distinguishing Characteristics

- Syntactic
- No restrictions on syntax definition
- Not restricted to a single host language
- Interaction with host language
- No restrictions on assimilation

Conclusion: Overview

MetaBorg method

- Domain abstractions at syntactic level
- Embedding of domain-specific languages
- Assimilation of domain code

MetaBorg application prospect

- The growth of a language is restricted by its general application area.

$\Rightarrow$ Extension for domain-specific applications.

Excited?

Related courses

- Seminar: Software Generation and Configuration
- Course: Program Transformation

Master projects

- Linguistic reflection
- Strategic Java
- ...

More information

- http://www.metaborg.org (paper and code)
- http://www.syntax-definition.org
- http://www.stratego-language.org