Language Engineering Tools

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Overview

- Parsing and pretty-printing
  - *parse-unit*
    - syntax definition testing
  - *StrategoBox*
    - advanced pretty-printers

- Applications of abstract syntax definitions
  - *sdf2rtg* and *rtg2sig*
  - *rtg2typematch* and *wf-checker*
  - *xml-interpret*
    - interoperability of xml and aterm tools

parse-unit

Testing Syntax Definitions for Fun

Syntax Defi nition is Software Engineering

- configuration management
  - build management
  - version management
  - deployment
- process
  - extreme syntax definition
- validation and verification
  - inspection and *testing*
- evolution
- metrics

Importance of Syntax Defi nition Testing

- usual arguments: deployment, build management, evolution
- conventional parsing techniques:
  - definition is not a definition
  - undo grammar hacking
  - implicit disambiguation
- documentation for language implementers and users
- large, modular syntax definitions
  - ambiguities not obvious
  - unexpected results (e.g. embeddings)

Current Techniques for Syntax Definition Testing

1) by hand: waste of time

2) some larger inputs
   - no checking of results
   - poor error-reporting

$\Rightarrow$ apply unit-testing techniques!

- verification of results
- excellent error reports
- documentation

Unit-Testing without Tool Support

from build system

1) files for input and output
   - poor overview
   - discourages a lot of atomic tests
2) automake tests: programs that succeed or fail
3) application from build system requires work/experience

from Stratego or shell-script:

1) *escape* special (?!) characters
2) *no reuse* for different purposes:
   - documentation
   - different parsing tools
   - testsuite analysis, such as coverage

Example parse-testsuite

```
testsuite Expressions
topsort Exp

test simple addition
  "2 + 3" -> Plus(Int("2"), Int("3"))

test addition is left associative
  "1 + 2 + 3" -> Plus(Plus(_, _), _)

test for lazy people
  "1 + 2 + 3" succeeds

test
  file large.exp succeeds

test
  "x1" fails
```

SGLR Implementation and Invocation

```
parse-parse-testsuite -i Exp.testsuite |
  parse-unit -p Exp.tbl --verbose 1


-----------------------------------------------------------------------
executing testsuite Expressions with 5 tests
-----------------------------------------------------------------------
* OK   : test 1 (simple addition)
* OK   : test 2 (addition is left associative)
* OK   : test 3 (for lazy people)
* OK   : test 4 (large.exp)
sglr: error in d_0.tmp, line 1, col 2: character ‘1’ (\x31) unexpected
* OK   : test 5 (x1)
-----------------------------------------------------------------------
results testsuite Expressions
successes : 5
failures  : 0
-----------------------------------------------------------------------
```

Parse-unit is the Silver Bullet

- concise *overview* of input and expected result
- check results at different *levels of detail*
- *no escaping* of ‘special’ characters required
- *file* and *inline* input
- *reusable* for different parser implementations
- enables *reasoning* about testsuites

Future Work

- *coverage* of parse-testsuites
  - rule coverage
  - context-based branch coverage (work of Ralf Lämmel)
- *import* mechanism for modular testsuites
- different parsers
  - bison/glr producing aterms
- sglr specific features (attributes)
  - ambiguities
  - statistics
- *apath* based result checking

StrategoBox

Stratego Rules, also for Pretty-Printing

GPP: Generic Pretty Printer

- *pretty-printing* of parse and abstract syntax trees
- *box*
  - text layout language
  - output format independent
    - abox2text, abox2html, abox2latex
- *pretty-print table*
  - map constructor names to box templates
  - applied by ast2abox
  - can be generated from SDF2 syntax definition

Pretty-Print Table Example

```
Module -- V[H[KW["module"] _1] _2],
Module.2:iter-star -- _1,

Constructors -- V is=2 [H [KW["constructors"]]
                  A (l hs=1, l hs=1, l hs=1) [_1]],
Constructors.1:iter-star -- _1,

OpDecl    -- R [_1 KW[":"] H hs=1 [_2]],
OpDeclInj -- R ["" KW[":"] H hs=1 [_1]],

Match -- H hs=0[KW["?"] _1],
Build -- H hs=0[KW["!"] _1],

ScopeDefault -- H hs=0[KW["{"] _1 KW["}"]],
Scope -- H hs=0[KW["{"] V[H[_1 KW[":"]] _2] KW["}"]],
Scope.1:iter-star-sep -- H hs=0[_1 KW[","]],
```

Problem

```
if(bar)
{
  foo
}
else if(bar)
{
  foo
} ...
```

```
if(bar)
{
  foo
}
else
if(bar)
{
  foo
} ...
```

Pretty print rule for `If`:

```
If  -- V vs=0 [
         H hs=0 [KW["if"] "(" _1 ")"]
         _2
         KW["else"]
         _3
       ]
```

Pretty-Print Rules

- pretty-print table: *selection* of pp rules by constructor name
  - no number of children
  - no patterns
  - no conditions
  - no context

- solution: StrategoBox
  - *embed box* in Stratego
    $\Rightarrow$ meta-programming with concrete object syntax

- advantages
  - *pattern-matching* and *conditions*
  - *strategy* controls the application of pp rules

No Problem

```
UglyPrint :
  If(b1, b2, b3) ->
    V vs=0 [
      H hs=0 [KW["if"] "(" b1 ")"]
      b2
      KW["else"] b3
    ]

PrettyPrint :
  If(b1, b2, If(b3, b4, b5)) ->
    V vs=0 [
      H hs=0 [KW["if"] "(" b1 ")"]
      b2
      H hs=1 [KW["else"] H hs=0 [KW["if"] "(" b3 ")"]]
      b4
      KW["else"] b5
    ]
```

Quick Introduction: Compiling

```
module pretty-print
imports Box ...
```

pretty-print.meta

```
Meta([Syntax("Stratego-Box")])
```

by hand

```
strc -i pretty-print.str -I ${GPP}/share/sdf/gpp \
   -I ${GPP}/share/gpp
```

using Makefile.xt

```
STRINCLUDES = -I $(GPP)/share/sdf/gpp -I $(GPP)/share/gpp
```

Quick Introduction: Implementation

- *quotation* of Stratego to Box: choose
- *anti-quotation* of Box to Stratego: ~ or ~*

```
expr-to-box: Plus(e1, e2) ->        H hs=1 [~e1 "+" ~e2]
expr-to-box: Plus(e1, e2) ->     |[ H hs=1 [~e1 "+" ~e2] ]|
expr-to-box: Plus(e1, e2) -> box |[ H hs=1 [~e1 "+" ~e2] ]|

java-to-box:
  Try(block, catches, finally)
    ->
  V vs=0 [KW["try"] ~block ~*catches KW["finally"] ~finally]
```

Quick Introduction: Implementation

```
expr-to-box:
  Plus(b1, b2) -> H hs=1 [ b1 "+"  b2]

java-to-box:
  Try(b1, b2*, b3)
    ->
  V vs=0 [KW["try"] b1 b2* KW["finally"] b3]

java-to-box:
  SuperField(s) -> H hs=0 [KW["super"] "." s]
```

More examples:

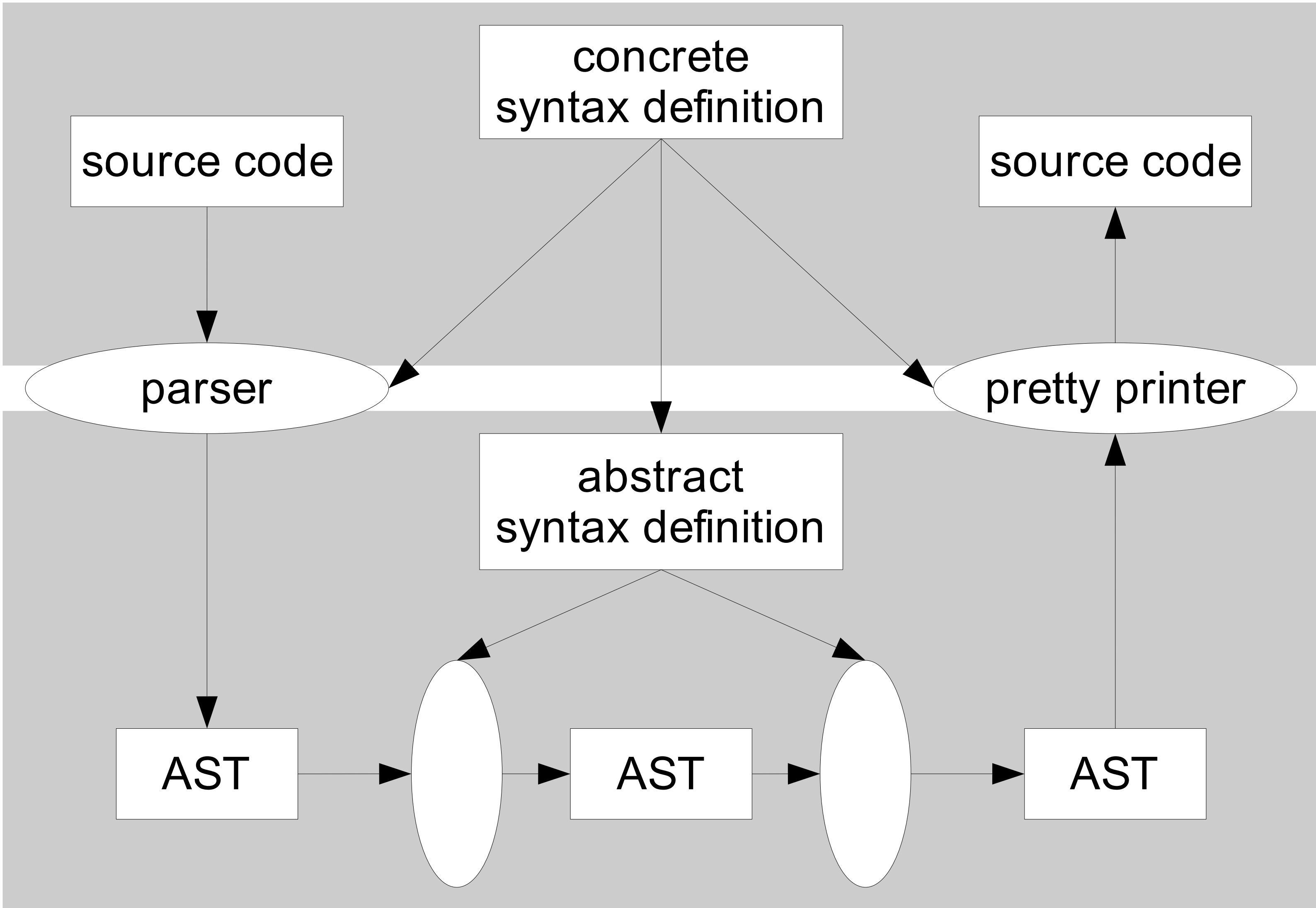
- *jtree2abox* in java-front/pp
- *xml-doc2abox* in xml-tools/pp
- *pp-aterm* in aterm-tools/pp

Future Work

- make using multiple embeddings more easy
- separate reusable parts in pp library
  - block structure
  - lists and separators
  - Box specific traversals
- configuration of pretty-printers
- derive Box expressions from ‘example’
- applications
  - pretty-print concrete object syntax fragments

Application of Abstract Syntax Definitions

Grammars as Contracts



Abstract Syntax Definitions in Stratego/XT

Stratego/XT: abstract syntax trees

- Stratego signature: abstract syntax definition
- generated from SDF2 concrete syntax definition

Do we use it?

- No, even format checkers are written by hand!

Why not?

- every generated signature is incorrect!
  - lexical syntax, injections, aliases, renamings
- no separate language

Solution: stratego-regular

ATerm: Tree Languages and Grammars

- tree language – subset of terms over *ranked alphabet*
- aterm application – *fixed number* of children

```
regular tree grammar
  start Section
  productions
    Section -> section (Title?, {Para})
    Title   -> title   (<string>)
    Para    -> para    (<string>)
```

```
regular tree grammar
  start Exp
  productions
    Exp -> Plus (Exp, Exp)
    Exp -> Call (Var, {Exp})
    Exp -> Var
    Var -> Var  (<string>)
```

XML: Hedge Languages and Grammars

- *hedge* – sequence of trees
- children of xml element – sequence of *varying length*

```
regular hedge grammar
  start Section
  productions
    Section -> section (Title? Para*)
    Title   -> title   (<string>)
    Para    -> para    (<string>)
```

```
regular hedge grammar
  start Exp
  productions
    Exp -> Plus (Exp Exp)
    Exp -> Call (Var Exp*)
    Exp -> Var
    Var -> Var  (<string>)
```

Application: Code Generation

- *sdf2rtg* – generate rtg from SDF

```
sdf2rtg -i Example.def -m Example
```

- *rtg2sig* – generate Stratego Signature from rtg

```
rtg2sig -i Example.rtg --module Example
```

- *rtg2typematch* – generate type predicate strategies

```
parse-rtg|rtg2typematch --module Example
```

widely used: java-front, sdf-front, stratego-shell, xml-tools

Application: Validation

history:

- developed *fc-gen* in 2002
- Stratego signature input $\Rightarrow$ nobody uses it

stratego-regular:

- *wf-checker:* aterm in the language of an rhg
- no need to write a format checker by hand
- to do
  - rename to format-checker
  - define subsets of an rtg?
  - generate code by partial evaluation?

Application: Exchange

exchange

$\longrightarrow$ from *xml* systems invoke *aterm* tools

$\longleftarrow$ invoke *xml* tools from *aterm* systems

problem: differences between xml and aterm

- aterm has a more explicit structure
- aterm has pritimive data types
- aterm has structured annotations

solution: use same abstract syntax definition for xml and aterm

- rtg for aterm
- rhg for xml

Application: Exchange

aterm to xml

- drop explicit structure
- `data2xml-doc | pp-xml-doc`

xml to aterm

- add explicit structure
- `xml-interpret --rhg Example.rhg`

interoperability

$\longrightarrow$ *aterm* tools as *xml* tools using generic *data2xml-doc*

$\longleftarrow$ *xml* tools as *aterm* tools using *xml-interpret*