Building an IDE with Rascal

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Outline

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Building on Past Work

- GIPE and GIPE II: Centaur (LeLisp, Prolog)
- ASF+SDF (Lisp, then C, with Java front-end)
- Rascal (C and Java, now completely in Java), building on the Eclipse IDE Meta-Tooling Platform (Eclipse IMP) for language IDE support

Running Example: Oberon-0

- A subset of Oberon, a successor to Pascal and Modula-2
- Developed as part of a language workbench competition
- Includes common, basic features from many languages: variables, constants, procedures, arrays, records, simple control flow constructs
- Goal was to develop a number of language tools: editor, type checker, compiler, etc

A Swap Procedure in Oberon-0

```
PROCEDURE Swap(VAR x, y: INTEGER);
VAR
  temp: INTEGER;
BEGIN
  temp := x;
  x := y;
  y := temp
END Swap;
```

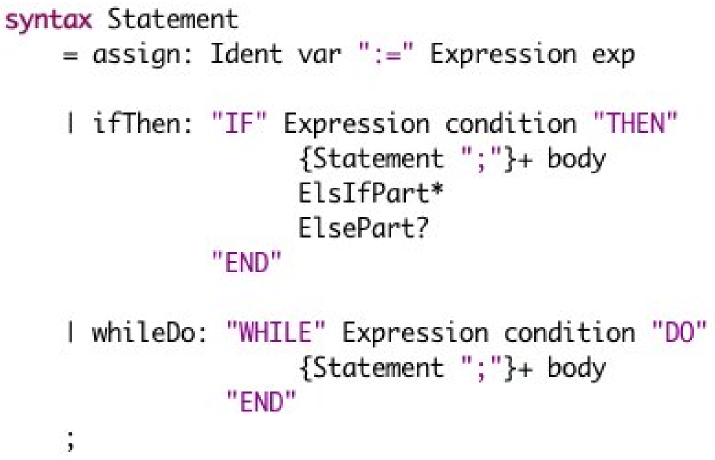
Arrays and Procedures in Oberon-0

```
MODULE testL4;
VAR
  x: ARRAY 4 OF INTEGER;
  i: INTEGER;

PROCEDURE f(i: INTEGER; z: ARRAY 4 OF INTEGER);
BEGIN
  Write(z[i]); WriteLn()
END f;

BEGIN
  i := 0;
  WHILE i < 4 DO
    x[i] := i; f(i,x);
    i := i + 1
  END
END testL4.
```

Parsing in Rascal

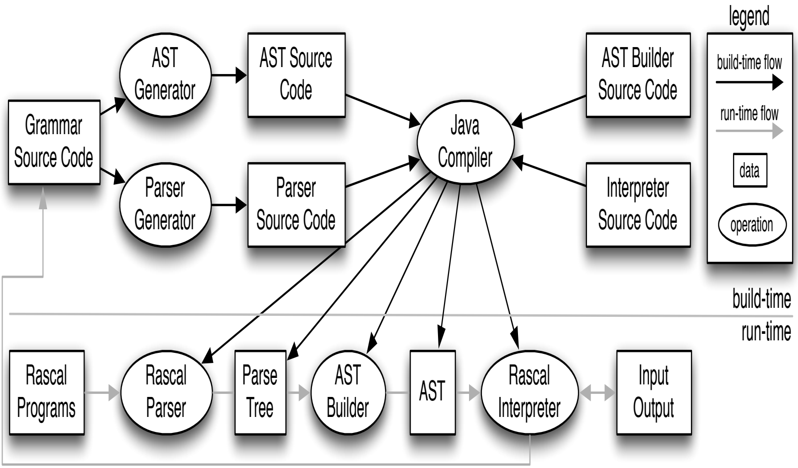
- Grammars defined using Rascal grammar definition notation
- A Rascal program then builds a Java-based parser for the grammar
- Parser is GLL – filtering rules used to remove ambiguities

Example: Oberon-0 Grammar



```
syntax Statement
    = assign: Ident var ":=" Expression exp

    | ifThen: "IF" Expression condition "THEN"
                    {Statement ";"}+ body
                    ElsIfPart*
                    ElsePart?
              "END"

    | whileDo: "WHILE" Expression condition "DO"
                    {Statement ";"}+ body
               "END"
    ;
```

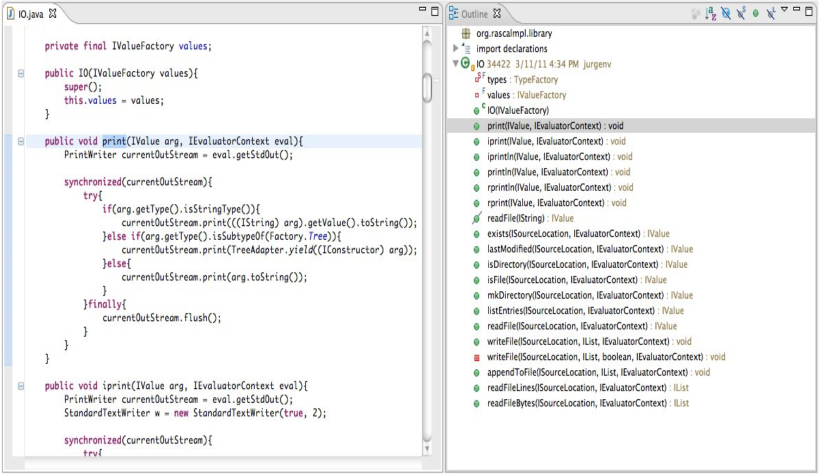
Rascal Meta-Programming Architecture



Outliners in IDEs

- Outlines provide a quick overview of code, indicating which constructs (classes, methods, functions, variables, etc) have been defined
- Outlines also provide a way to browse the code quickly – selecting an element in the outline takes the programmer to the appropriate part of the code

Code Outlining Example: Java in Eclipse



```
    private final IValueFactory values;

    public IO(IValueFactory values){
        super();
        this.values = values;
    }

    public void print(IValue arg, IEvaluatorContext eval){
        PrintWriter currentOutStream = eval.getStdOut();

        synchronized(currentOutStream){
            try{
                if(arg.getType().isStringType()){
                    currentOutStream.print(((IString) arg).getValue().toString());
                }else if(arg.getType().isSubtypeOf(Factory.Tree)){
                    currentOutStream.print(TreeAdapter.yield((IConstructor) arg));
                }else{
                    currentOutStream.print(arg.toString());
                }
            }finally{
                currentOutStream.flush();
            }
        }
    }

    public void iprint(IValue arg, IEvaluatorContext eval){
        PrintWriter currentOutStream = eval.getStdOut();
        StandardTextWriter w = new StandardTextWriter(true, 2);

        synchronized(currentOutStream){
            try{
```

```
org.rascalmpl.library
  import declarations
  IO 34422 3/11/11 4:34 PM jurgenv
    types : TypeFactory
    values : IValueFactory
    IO(IValueFactory)
    print(IValue, IEvaluatorContext) : void
    iprint(IValue, IEvaluatorContext) : void
    iprintln(IValue, IEvaluatorContext) : void
    println(IValue, IEvaluatorContext) : void
    rprintln(IValue, IEvaluatorContext) : void
    rprint(IValue, IEvaluatorContext) : void
    readFile(IString) : IValue
    exists(ISourceLocation, IEvaluatorContext) : IValue
    lastModified(ISourceLocation, IEvaluatorContext) : IValue
    isDirectory(ISourceLocation, IEvaluatorContext) : IValue
    isFile(ISourceLocation, IEvaluatorContext) : IValue
    mkDirectory(ISourceLocation, IEvaluatorContext) : IValue
    listEntries(ISourceLocation, IEvaluatorContext) : IValue
    readFile(ISourceLocation, IEvaluatorContext) : IValue
    writeFile(ISourceLocation, IList, IEvaluatorContext) : void
    writeFile(ISourceLocation, IList, boolean, IEvaluatorContext) : void
    appendToFile(ISourceLocation, IList, IEvaluatorContext) : void
    readFileLines(ISourceLocation, IEvaluatorContext) : IList
    readFileBytes(ISourceLocation, IEvaluatorContext) : IList
```

Outlining Support in Rascal: Building the Outline

- Outlines are built over the concrete syntax of a language
- Labels indicate the display name in the outline view
- Locations allow the user to jump to the outlined item

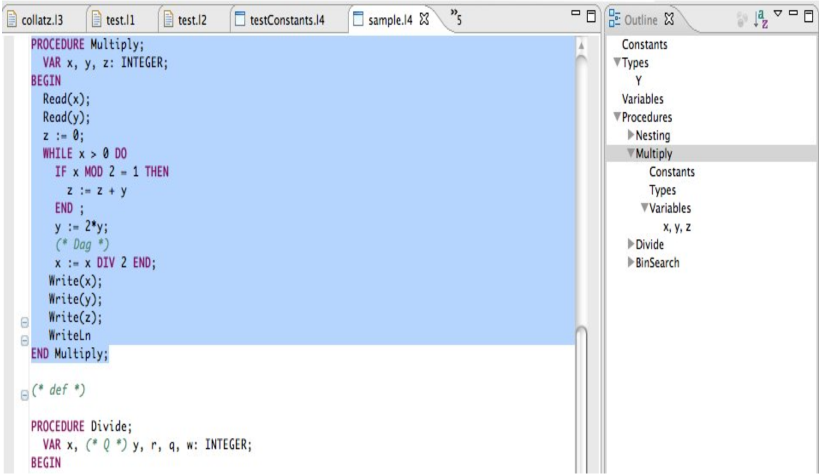
```
public node outlineModule(Module x) {
  return outlineDecls(x.decls)[@label="<x.name>"];
}

Node outlineDecls(Declarations decls) {
  cds = outline([ constDecl()[@label="<cd.name>"][@\loc=cd@\loc] |
                 /ConstDecl cd := decls.consts ])[@label="Constants"];
  tds = outline([ typeDecl()[@label="<td.name>"][@\loc=td@\loc] |
                 /TypeDecl td := decls.types ])[@label="Types"];
  vds = outline([ varDecl()[@label="<vd.names>"][@\loc=vd@\loc] |
                 /VarDecl vd := decls.vars ])[@label="Variables"];
  return outline([cds, tds, vds]);
}
```

Outlining Support in Rascal: Registering the Outliner

- `registerOutliner` registers an outliner function with the IDE
- The IDE then calls this function to build the outline automatically as the file changes
- The IDE also provides the outline view, using the location and name info to build the view content

```
registerOutliner("l4", outlineModule);
```

Code Outlining Example: Oberon-0 in Rascal



```
PROCEDURE Multiply;
  VAR x, y, z: INTEGER;
BEGIN
  Read(x);
  Read(y);
  z := 0;
  WHILE x > 0 DO
    IF x MOD 2 = 1 THEN
      z := z + y
    END ;
    y := 2*y;
    (* Dag *)
    x := x DIV 2 END;
   Write(x);
   Write(y);
   Write(z);
   WriteLn
END Multiply;

(* def *)

PROCEDURE Divide;
  VAR x, (* Q *) y, r, q, w: INTEGER;
BEGIN
```

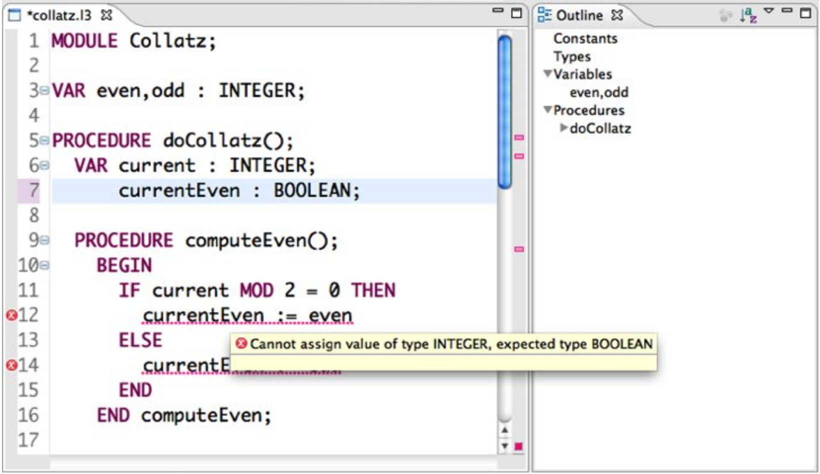
```
Constants
▼Types
   Y
Variables
▼Procedures
  ▶Nesting
  ▼Multiply
     Constants
     Types
    ▼Variables
       x, y, z
  ▶Divide
  ▶BinSearch
```

Annotators

- Annotators allow annotations to be added to language constructs and displayed in the editor
- Typical examples: name resolution, type checking – want errors to be displayed graphically to users, marking error locations

```
public Module checkModule(Module x) {
  m = implode(x);
  <m, st> = resolve(m);
  errors = { error(l, s) | <l, s> <- st.scopeErrors };
  if (errors == {}) {
    errors = check(m, st.symbolTable);
  }
  return x[@messages = errors];
}

registerAnnotator("l4", checkModule);
```

Annotator Example: Type Checking Oberon-0



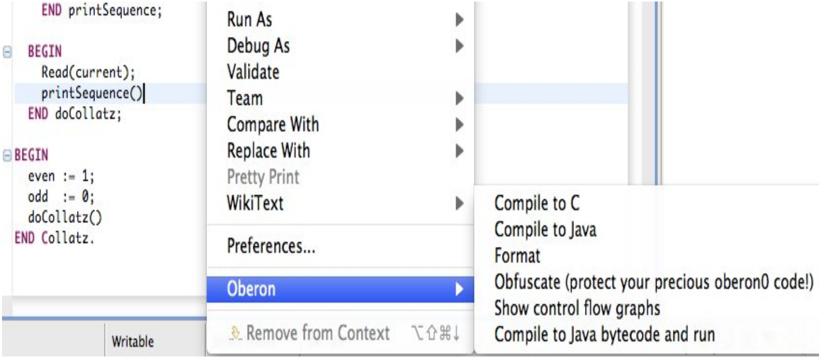
```
MODULE Collatz;

VAR even,odd : INTEGER;

PROCEDURE doCollatz();
  VAR current : INTEGER;
      currentEven : BOOLEAN;

  PROCEDURE computeEven();
    BEGIN
      IF current MOD 2 = 0 THEN
        currentEven := even
      ELSE
        currentE
      END
    END computeEven;

```

Cannot assign value of type INTEGER, expected type BOOLEAN

Contributors

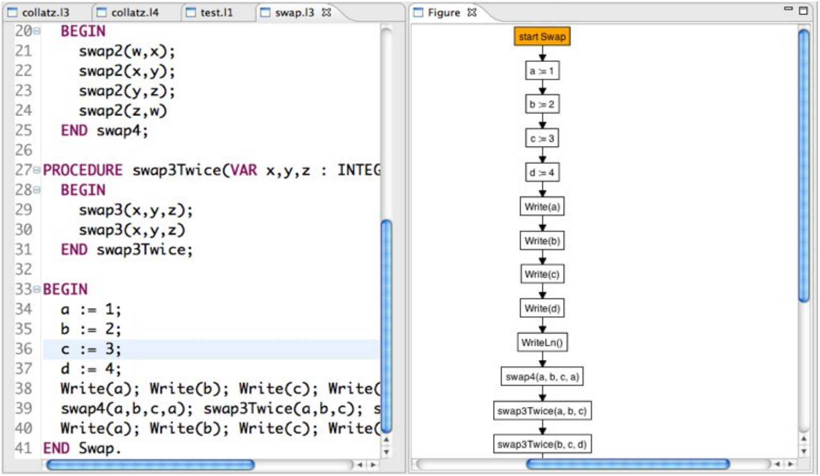
- Contributors provide a way to add more advanced functionality
- Each contribution is a menu item – execution is triggered by the user
- Examples: interaction with external tools, compilation, visualization

An Example Contributors Menu



```
    END printSequence;

  BEGIN
    Read(current);
    printSequence()
  END doCollatz;

BEGIN
  even := 1;
  odd  := 0;
  doCollatz()
END Collatz.
```

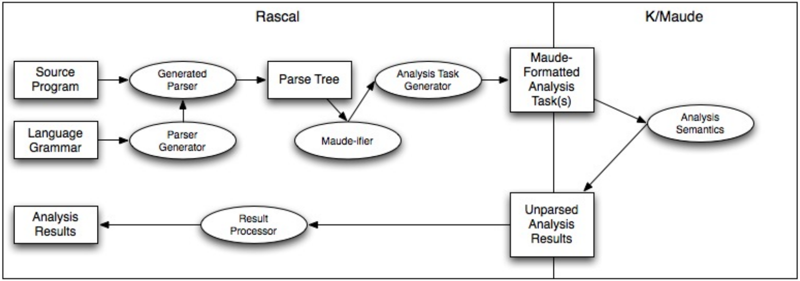
Visualization Contribution: Control Flow Graph



```
  BEGIN
    swap2(w,x);
    swap2(x,y);
    swap2(y,z);
    swap2(z,w)
  END swap4;

PROCEDURE swap3Twice(VAR x,y,z : INTEG
  BEGIN
    swap3(x,y,z);
    swap3(x,y,z)
  END swap3Twice;

BEGIN
  a := 1;
  b := 2;
  c := 3;
  d := 4;
  Write(a); Write(b); Write(c); Write(
  swap4(a,b,c,a); swap3Twice(a,b,c); s
  Write(a); Write(b); Write(c); Write(
END Swap.
```

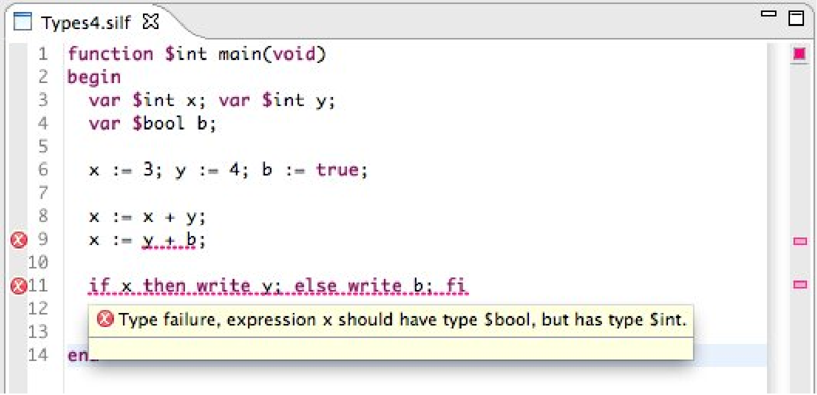
Contributors: Integration with External Tools

- Contributors in Rascal-based IDEs are not limited to those written in Rascal
- Example: linking a Rascal-based front-end with a Maude-based analysis framework



Contributors: Integration with External Tools

Information from the external tool can be used to set up annotations...

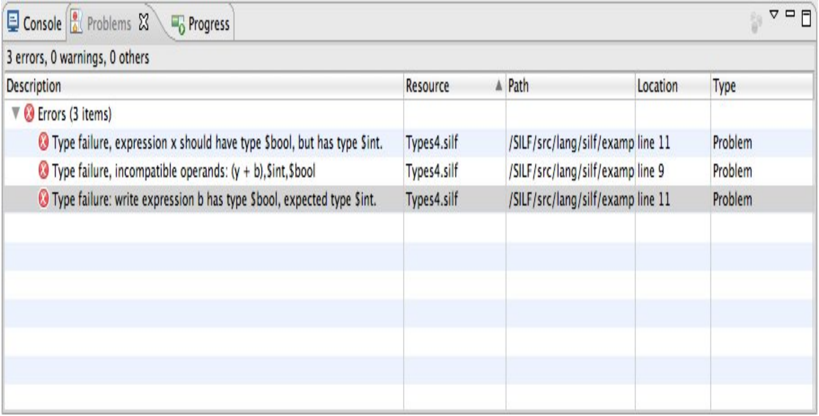


```
function $int main(void)
begin
  var $int x; var $int y;
  var $bool b;

  x := 3; y := 4; b := true;

  x := x + y;
  x := y + b;

  if x then write y; else write b; fi


en
```

Type failure, expression x should have type $bool, but has type $int.

Contributors: Integration with External Tools

... and to add other information, such as entries in an Eclipse Problems view.



3 errors, 0 warnings, 0 others

Description	Resource	Path	Location	Type
Errors (3 items)				
Type failure, expression x should have type $bool, but has type $int.	Types4.silf	/SILF/src/lang/silf/examp	line 11	Problem
Type failure, incompatible operands: (y + b),$int,$bool	Types4.silf	/SILF/src/lang/silf/examp	line 9	Problem
Type failure: write expression b has type $bool, expected type $int.	Types4.silf	/SILF/src/lang/silf/examp	line 11	Problem

Conclusions

- Building on IMP, Rascal provides a number of hooks to add support for language IDEs
- Support based on higher-level constructs in Rascal: instead of generating from a language specification, Rascal provides abstractions for working with programming languages and programs, providing high degree of customizability
- Bridge to Java allows IDE features to be based on tools written in Rascal and/or Java and on external tools