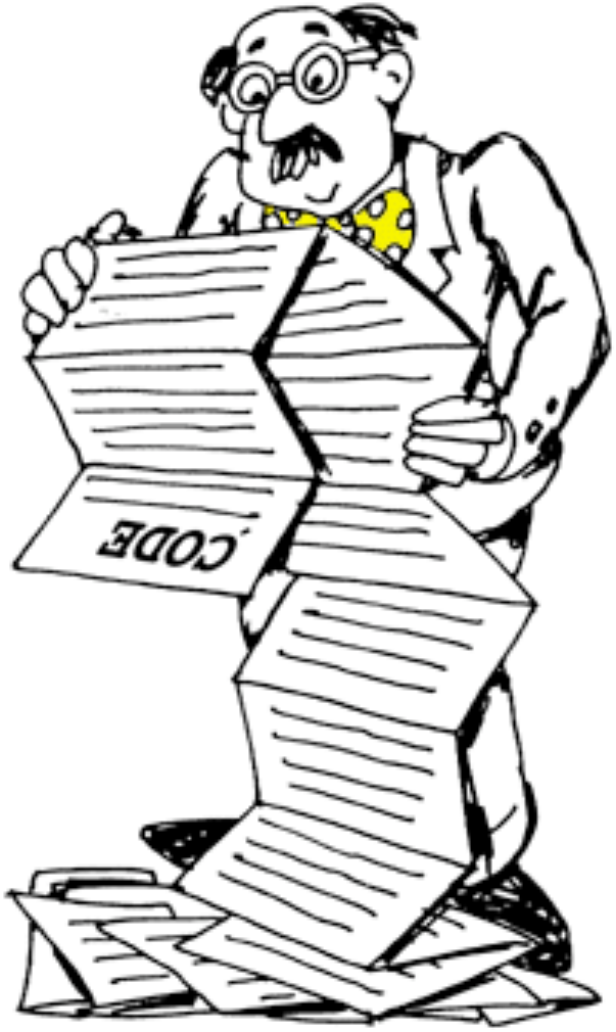
Computer Languages

`minijava` - Concrete & Abstract syntax

1. Parsing
2. Syntactic categories
3. Concrete syntax
4. Abstract syntax
5. Composite pattern

February 4

Overview of a compiler



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- Analyze the source code to understand what it means!
  - in the process of doing so it has to reject meaningless sources!
- Generate code in a language for which a machine exists.

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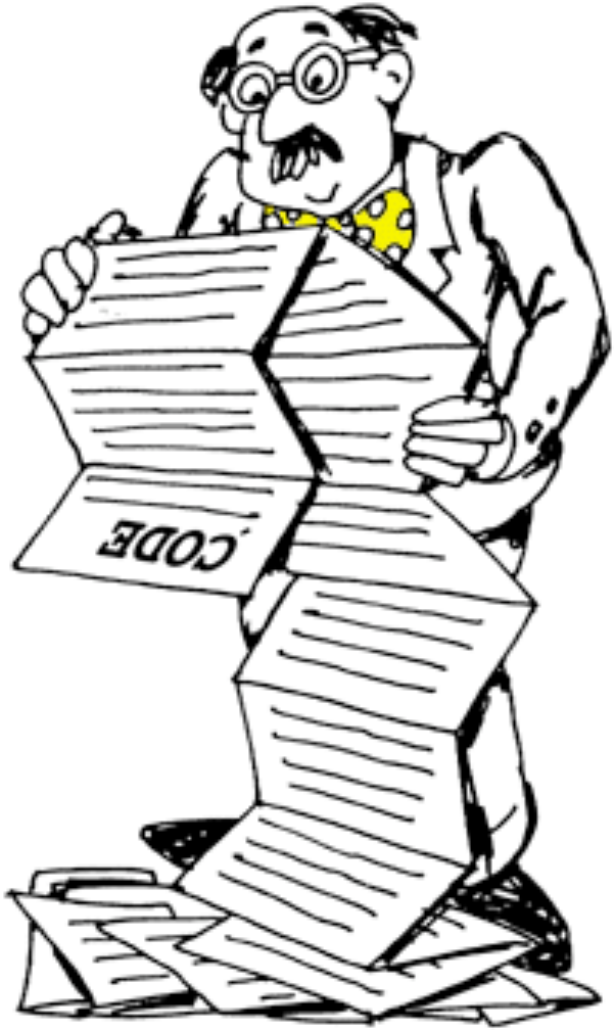

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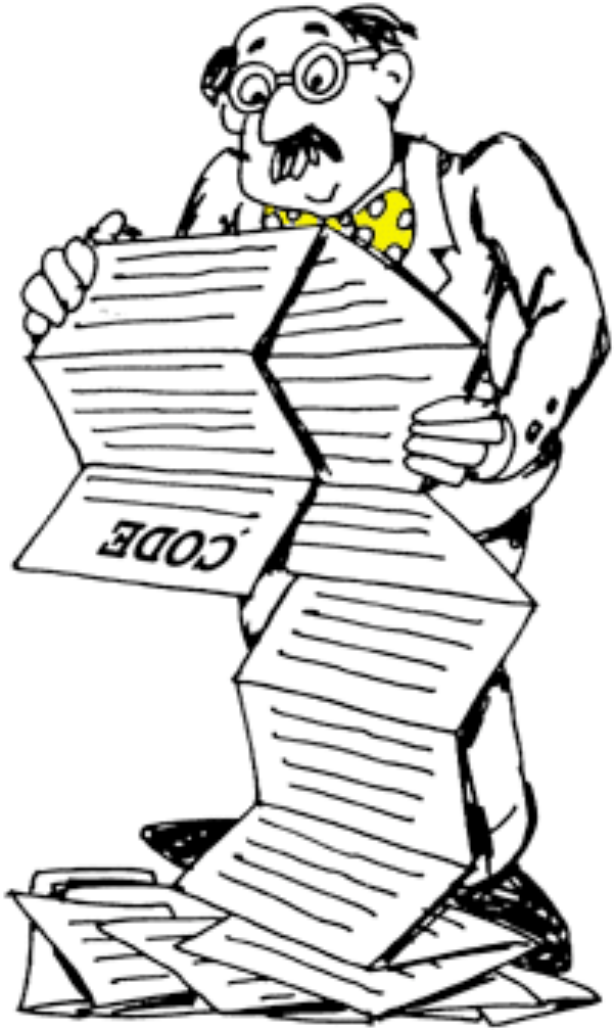

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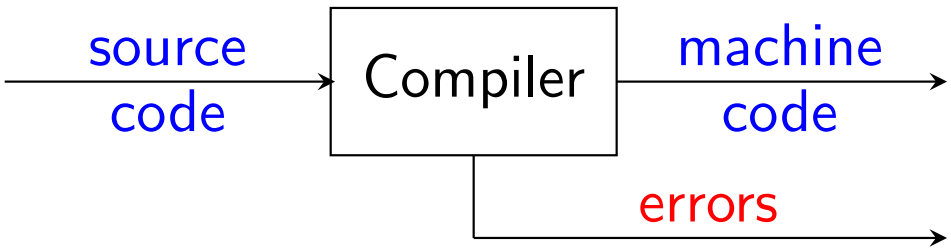

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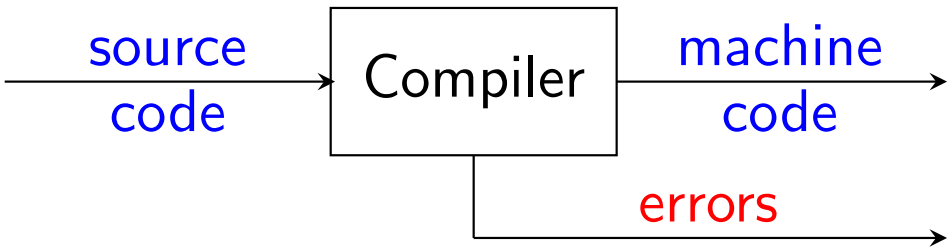

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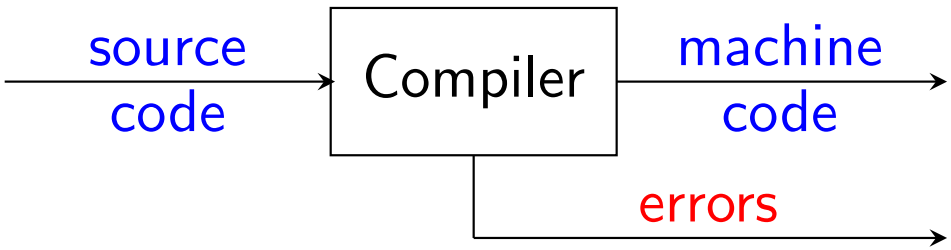

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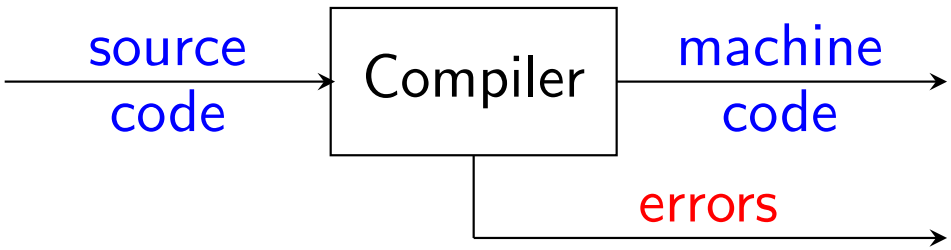

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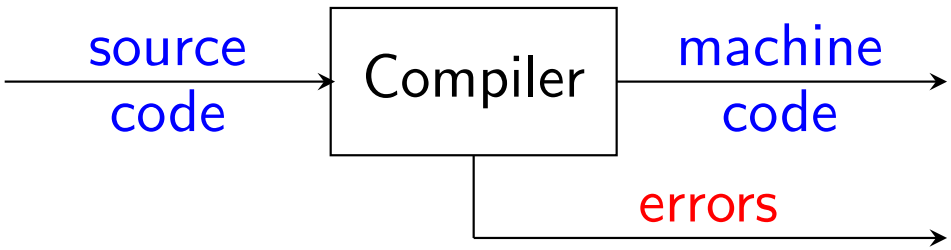

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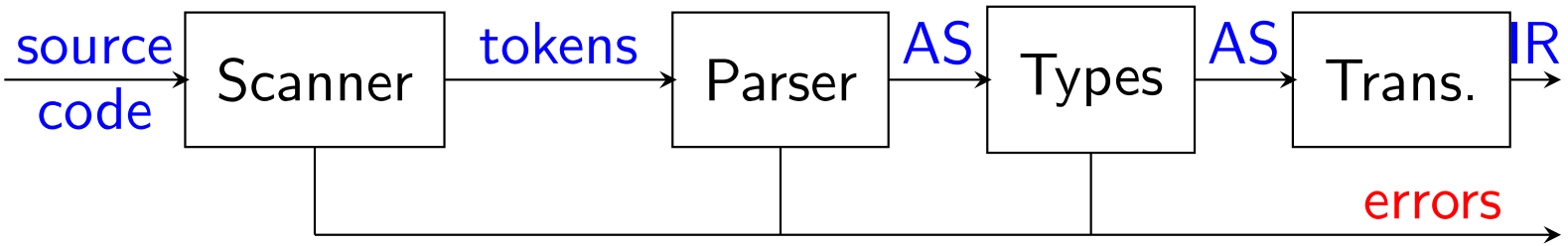

- The Scanner (lexical analyzer) transforms a sequence of characters (source code) into a sequence of tokens: a representation of the *lexemes* of the language.
- The Parser (syntactical analyzer) takes the sequence of tokens and generates a tree representation, the Abstract Syntax.
- This tree is analyzed by the type checker and is then used to generate the intermediate representation.

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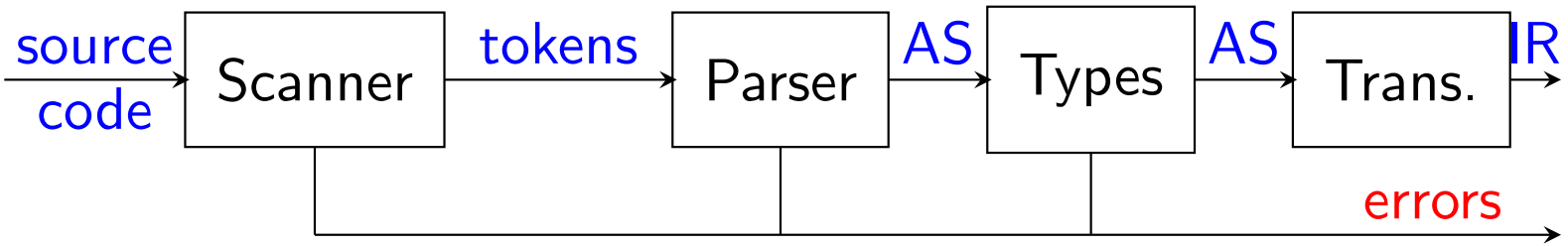

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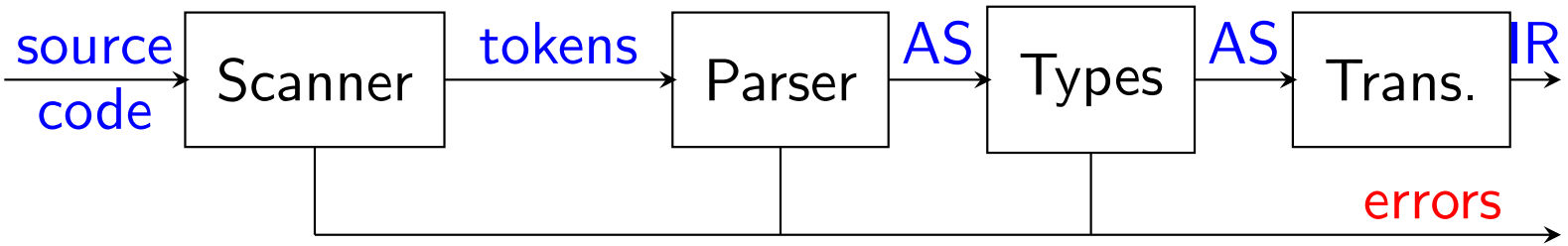

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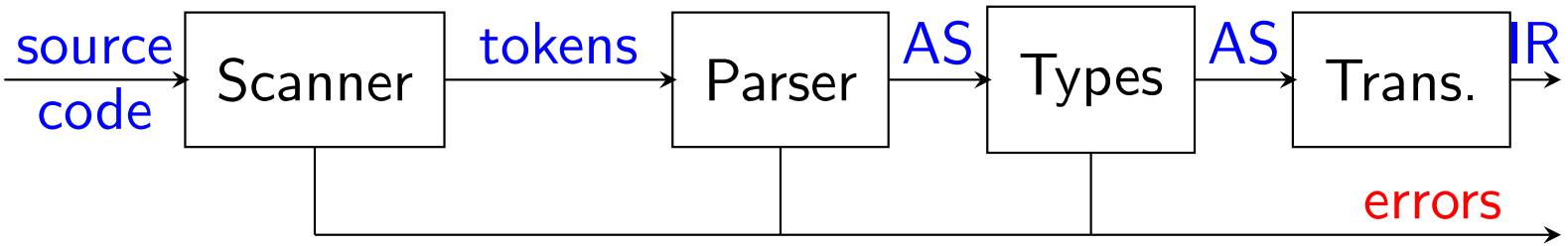

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Syntactic categories

What kind of phrases are used in a programming language? What components do they have?

Concrete syntax

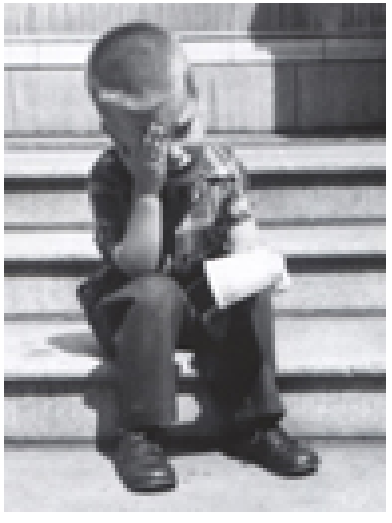
How do the phrases look like? What words, separators, punctuations are used?

Abstract syntax

What data structure can be used to store the program so that the structure is evident?

Composite pattern

How can we implement this data structure in Java?



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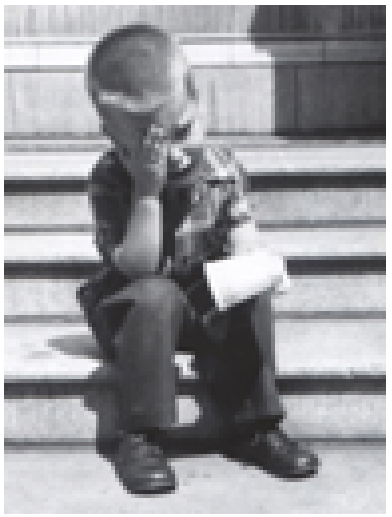

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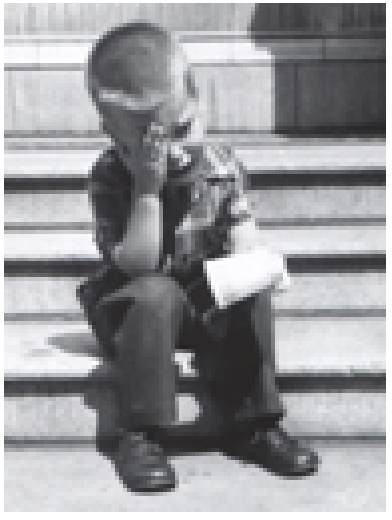

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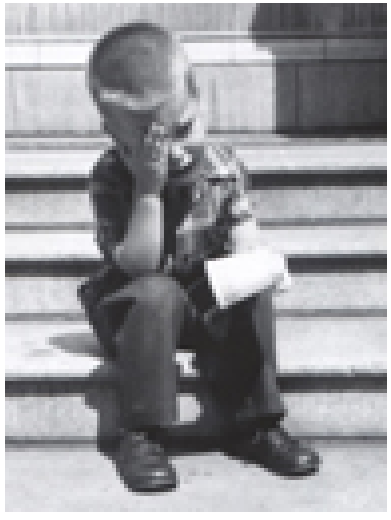

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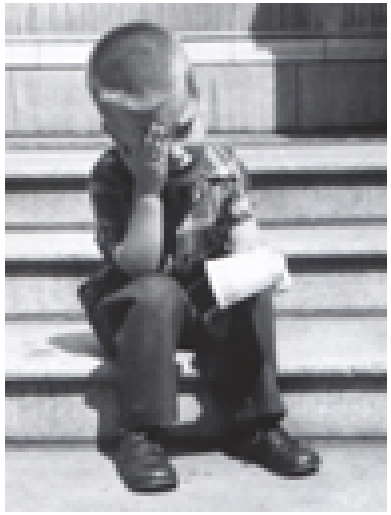

Syntactic categories in programming languages

Example

```
class Small{
    public static void main(String args[]){
        System.out.println("Hello "+args[0]);
    }
}
```

Example

```
resource small()
  string[10] user
  getarg(1,user)
  write("Hello",user)
end
```

Example

```
import System


main =
   do (user:_) <- getArgs
      print("Hello " ++ user)
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  - and some class declarations!
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Syntactic categories in programming languages

Declarations

What we use to build abstractions: we give names to entities.

Expressions

Entities that have a value. Expressions usually have an associated type.

Statements

Entities that change state.

Some programming languages have no statements (*Haskell*). In some languages statements and expressions are mixed up (*C*). Different programming paradigms support different kinds of values and abstractions.

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Syntactic categories in `minijava` - declarations

```
class A {
  int x;
  ...

  public int f(){
    int y;
    ...
  }

  ...

}
```

- classes
  - A class can be used as the type of an object.
- fields
  - A field is a global variable inside a class, stands for a place in memory.
- methods
  - A method can be used instead of a statement or an expression.
- local variables
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```
3 true false
x
x+98*y<x*y*y
a.f()
new A()
arr[39]
```

- constants
- identifiers
- using operators
- calling a method
- object creation
- array element

What are the values of these expressions?

What are the values of identifiers? Are the expressions meaningful?

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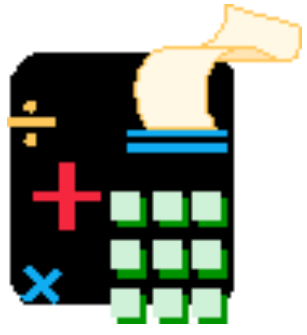

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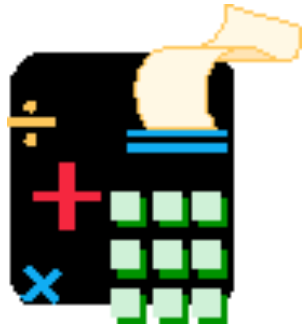

Syntactic categories in `minijava` - statements

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arr[38]=x;
System.out.println(x);
if (x<y) max=y;
   else  max=x;
while(x<y)
   x=x+y;
```

assignment

array assign

output

conditional

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Overview of the grammar for `minijava`

goal → *mainClass classDeclarationList*

mainClass → `CLASS ID '{' PUBLIC STATIC VOID MAIN '('`
`STRING '[' ']' ID ')' '{'` *statement* `'}'`

classDeclarationList → *classDeclarationList classDeclaration*
| ∈

classDeclaration → `CLASS ID '{'` *varDeclarationList*
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Overview of the grammar

metDeclaration → PUBLIC *type* ID '(' *parameters* ')' '{'
varDeclarationList statementList
RETURN *exp* '}'

statement → '{' *statementList* '}'
| IF '(' *exp* ')' *statement* ELSE *statement*
| WHILE '(' *exp* ')' *statement*
| SYSTEMOUT '(' *exp* ')' ';'
| ID '=' *exp* ';'
| ID '[' *exp* ']' '=' *exp* ';'

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Remarks

The grammar in the appendix of the book describes a small subset of Java called minijava. Do not add things to it! We will compile minijava!

When understanding the grammar, start from the goal. But when implementing it in jacc start with expressions, then statements and then the declarations!

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We forget about connecting terminals and about the derivation and concentrate in the other syntactic categories that are used!

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What do we need?

Main class

We only need the name and the statement!

Class Declaration

We only need the name, the list of variable declarations and the list of method declarations.

Method declaration

We only need the result type, the name, the list of parameters, the list of variable declarations, the statement list and the returned expression.

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Assign

We need the identifier and the expression.

Array element assign

We need the identifier, the indexing expression and the right hand side expression.

If

We need the expression and two statements!

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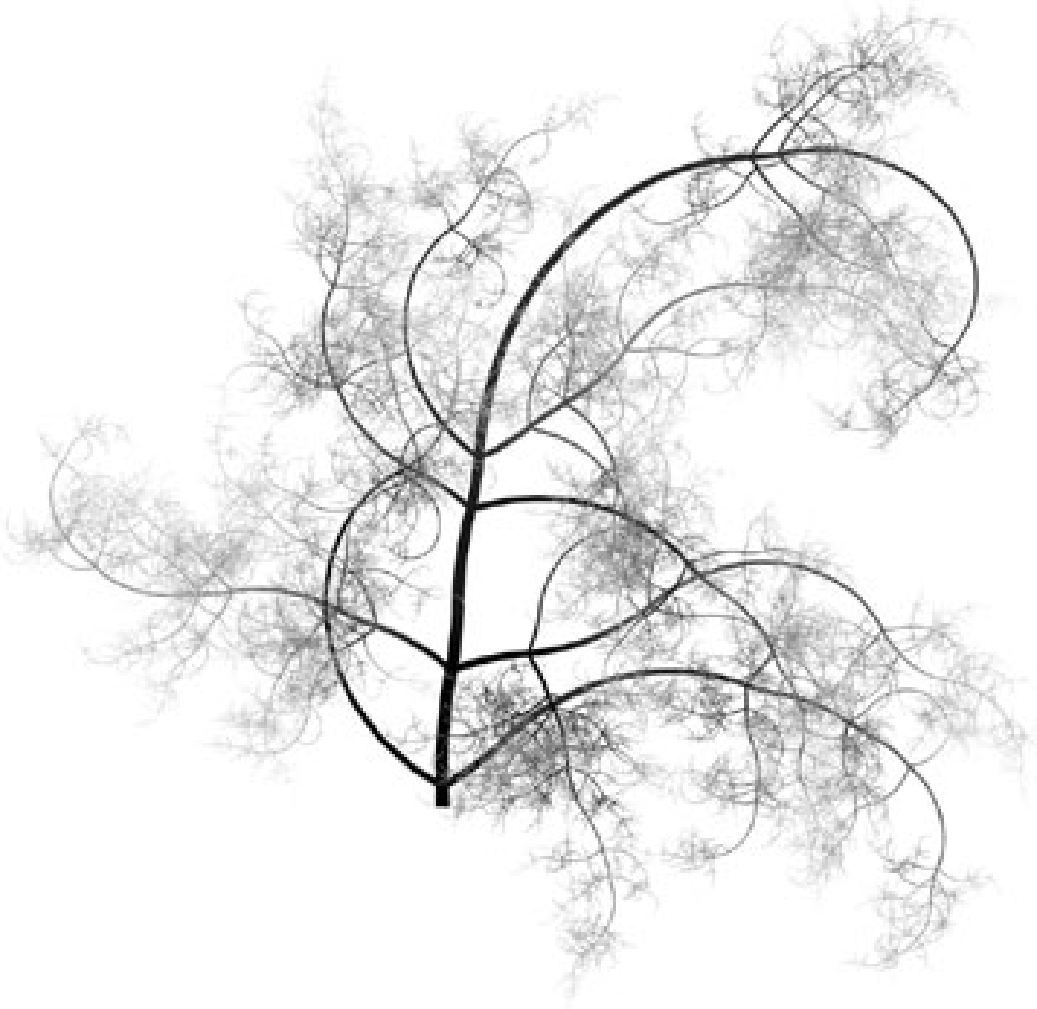
Trees

All this looks very much like trees with diferent type and number of children for different types of nodes!



Abstract syntax in Java

We need a datastructure in Java for the abstract syntax trees.

Problem

There will be a class for each type of node. But we want that all types of statement nodes can be used where a statement is needed! (and the same for expressions by the way.)

Containers and components

Bricks are used as components, contained in a construction. But the construction can be used as a component in a larger construction!

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Node for IF

```
public class If {
  public Exp e;
  public Statement s1,s2;

  public If(Exp ae, Statement as1, Statement as2) {
    e=ae; s1=as1; s2=as2;
  }
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How do we see that this builds a statement, that can be used where a statement is required?

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Building syntax trees

As the parser recognizes sentences of the different forms, it will build the abstract syntax trees.

Example

```
statement   :  IF '(' exp ')' statement ELSE statement
            { $$ = new If($3, $5, $7); }
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There is an abstract class for the syntactic category *statement* and one class inheriting from it for each production for *statement*!

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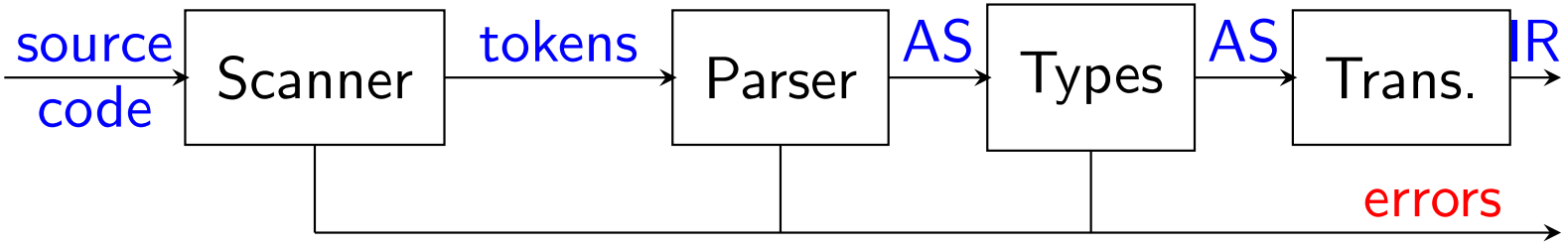

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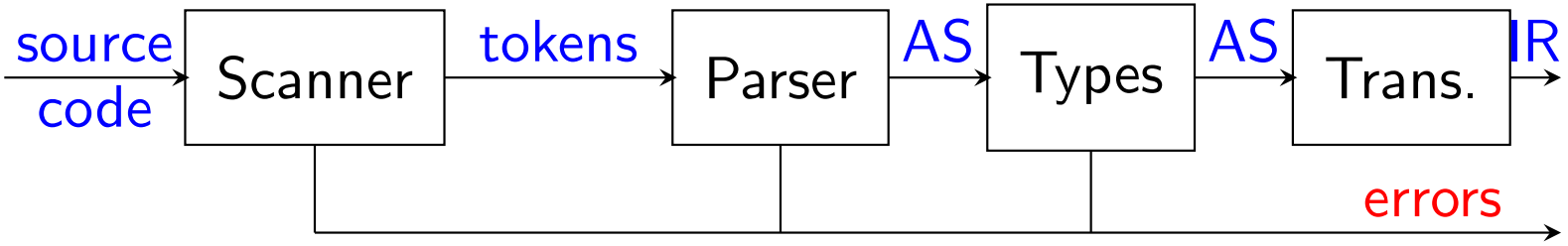

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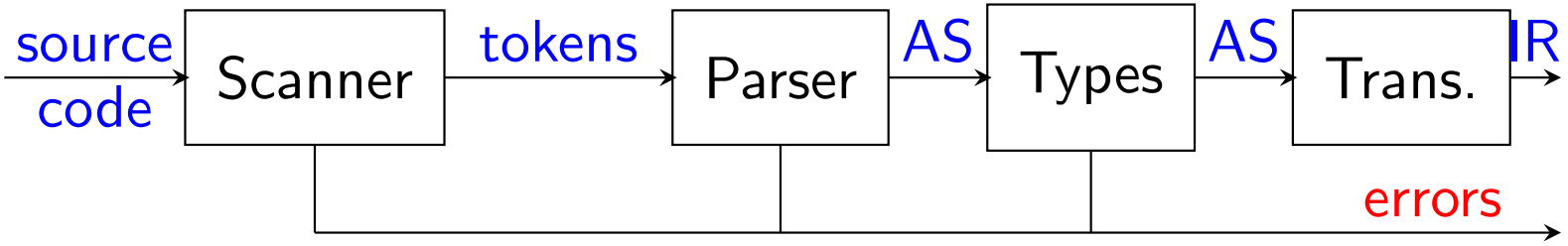

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