The NetRexx Interpreter

http://www2.hursley.ibm.com/netrexx/

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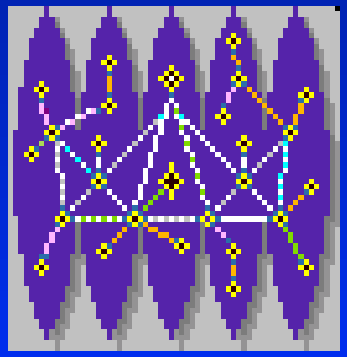


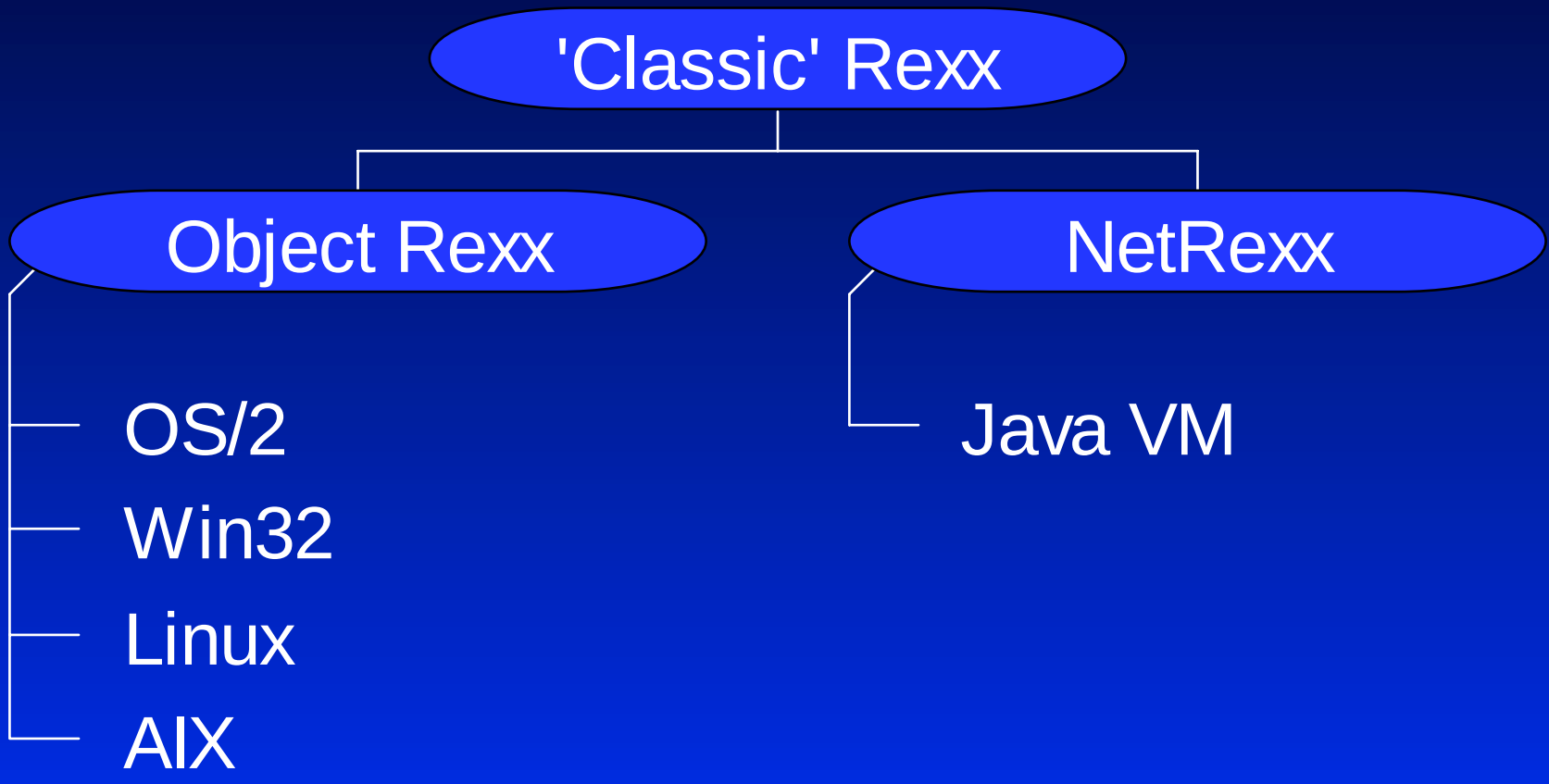
Overview

- Introduction to NetRexx
- Demo. -- compiling and interpreting NetRexx programs
- The compiler/interpreter implementation
- Questions?

What is NetRexx?

- A complete *alternative* to the Java language, for writing classes for the Java Virtual Machine
- Based on the simple syntax of Rexx, with Rexx decimal arithmetic
- Fully exploits the Java object model, exceptions, and binary arithmetic
- Automates type selection & declaration
- Removes many historical quirks

The Rexx language family



NetRexx Java implementation

- Current implementation first ***translates*** NetRexx to accessible Java source, or ***interprets*** it directly (or both)
- Runs on any Java platform
- Any class written in Java can be used
  - GUI, TCP/IP, I/O, DataBase, *etc.*
- Anything you could write in Java can be written in NetRexx

. . . and it's free.

NetRexx programs

toast.nrx

```
/* This wishes you good health. */
say 'Cheers!'
```

Control constructs

```
if  answer='yes'  then say 'OK!'
                  else say 'shucks'

loop  i=0  for  mystring.length
   say  i':'  mystring[i]
   end i
```

also **do..end** for simple grouping, with label for **leave**

Control constructs - select

```
select case i+1
  when 1, 2 then say 'small'
  when 3 then say 'medium'
  otherwise say 'large'
end
```

*(The usual Rexx **select** without case is also supported, and select may have a label)*

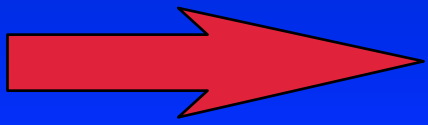
Strings - the base type

- Strings in NetRexx are of type *Rexx*
  - by default, data and numbers are strings
  - standard methods from Object Rexx
  - conversions
- Automatic inter-conversion with Java String class, char and char[ ] arrays, and numeric primitives (optional)

Arithmetic

- Preferred arithmetic is from ANSI Rexx
- Decimal, just one type of number
  - follows human rules (2 * 1.20 is 2.40)
  - gives exact results when expected (***e.g.***, for 0.1, 0.3)
  - no overflow at binary boundaries
  - arbitrary precision

```
numeric digits 300
say 1/7
```



numeric digits 300

0.14285714285714285714285714285714
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Binary classes and methods

- The **binary** keyword instructs the compiler to use native (binary) arithmetic types and operations (boolean, byte, int, long, float, *etc.*)
- Achieves the full speed of the Java Virtual Machine and JIT compilers
- No performance penalty for using NetRexx instead of Java

Explicit typing

- Casting/conversions use the ***blank*** (concatenation) ***operator***

```
number=int 7*y    -- number is an int
number2=int       -- variable declaration
```

- Consistently extends to method arguments

```
method size(x=int, y=int, depth=int 3)
```

Other features from Rexx

- Case-insensitivity
- Parse
- Trace (methods, all, results)

```
2 *=*   number=1/7
  >v> number "0.142857143"
3 *=*   parse number before '.' after
  >v> before "0"
  >v> after "142857143"
4 *=*   say after'.'before
  >>> "142857143.0"
```

Exceptions

- Semantics from Java
- Generalized and simplified syntax (extends all existing control constructs)

```
say 'Please enter a number:'
number=ask    -- read a line
do
  say 'reciprocal is:' 1/number
catch Exception
  say 'Sorry, could not divide'-
      '"'number'" into 1'
end
```

NetRexx JavaBean support

- JavaBean (indirect) properties

```
properties indirect
    filling=Color.red
```

generates (or checks):

```
method getFilling returns java.awt.Color
     return filling
method setFilling($1=java.awt.Color)
     filling=$1
```

NetRexx Inner Class support

- Minor and Dependent classes

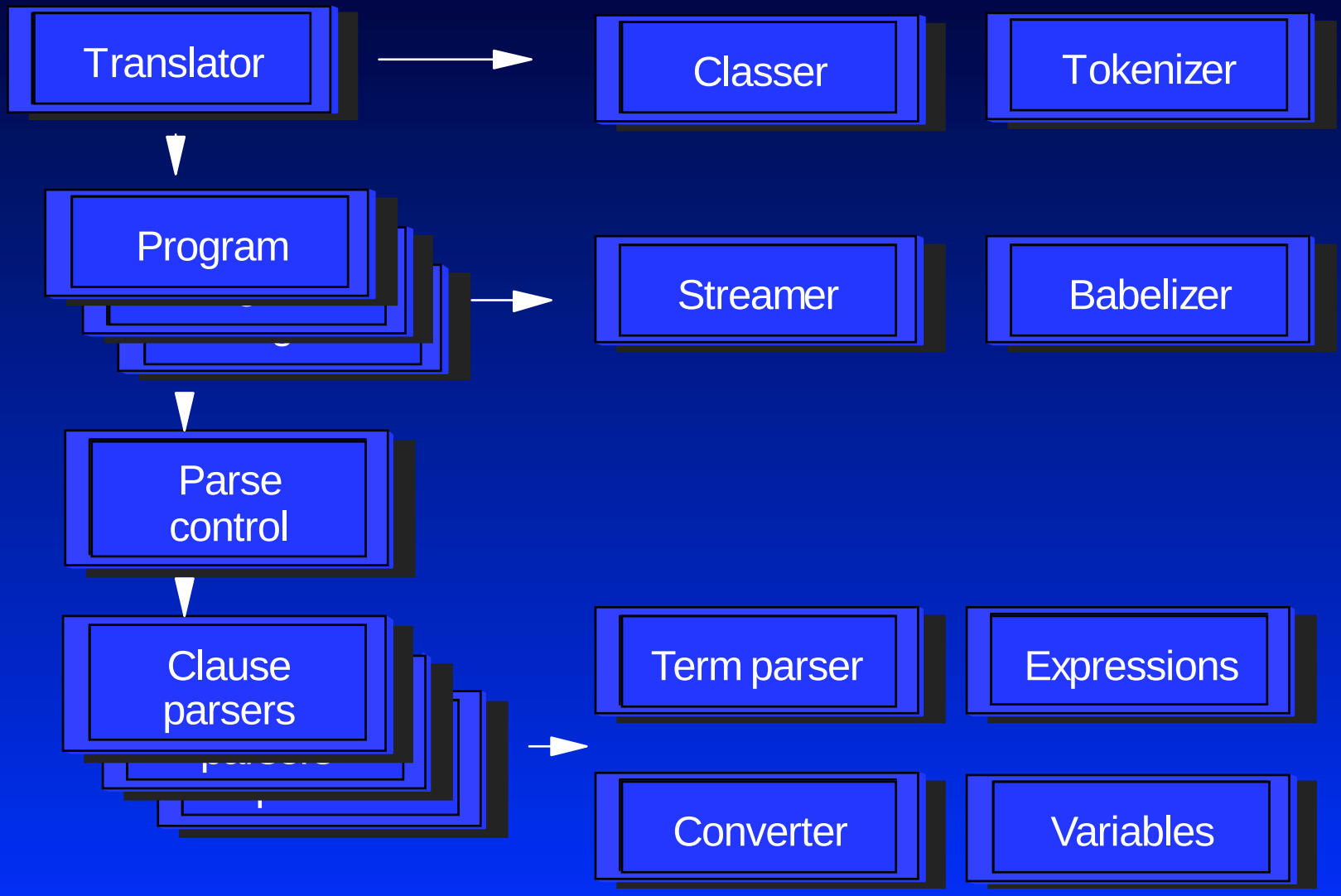
```
class Foo
   x=Bar()
   y=Foo.Bar null
   z='Hello'
   x.Counter

class Foo.Bar dependent extends AnOther
   method Counter
      say  parent.z
```

Demonstration ...

So how does it work?

- Unconventional organization
- Structured like an interpreter rather than a compiler
- Parsing is not carried out 'up front', but on demand
- Parsing is identical for translation to Java or for direct interpretation, with full error checking at the point of parsing

Overall translator organization



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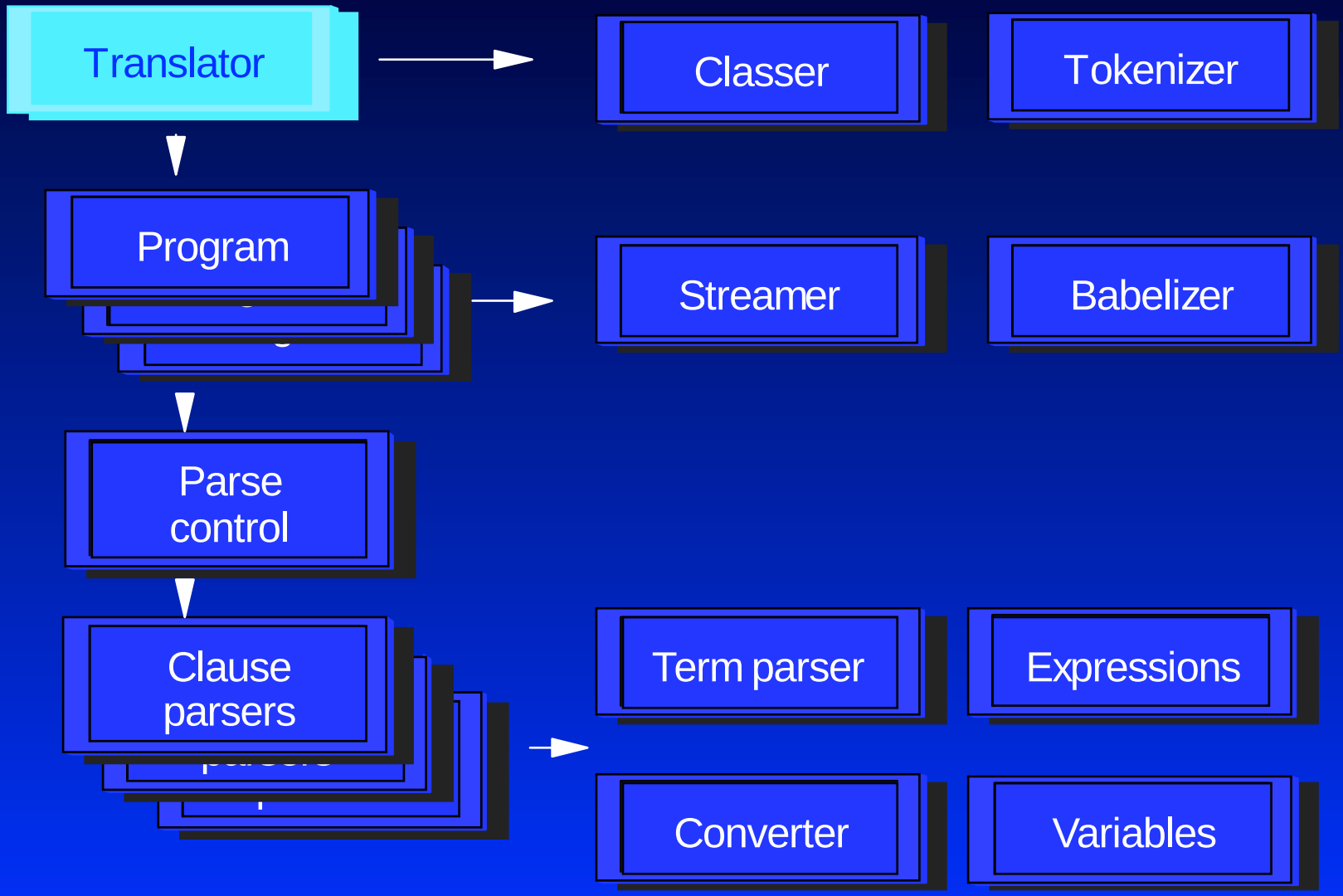

Translator

- Internal API for NetRexxC to use
- Factory, language, and programs setup
- Cross-program pass control (3 main passes)
- Manages compilation using javac
- Manages interpretation
- Top-level error handling

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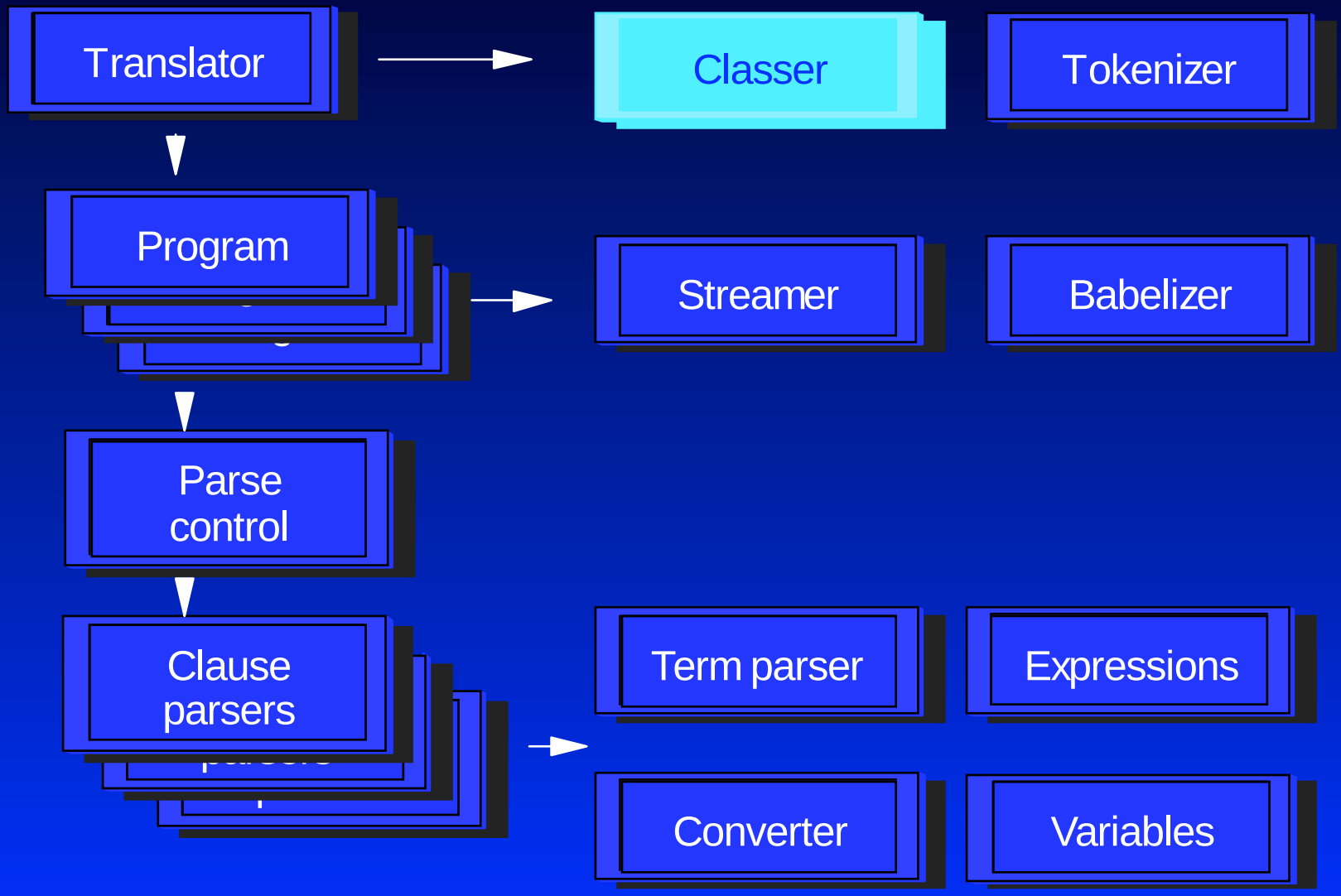

Classer

- Most difficult area of translation, due to changes in Java core over time
- In general 'owns' the external namespace
- Manages class path, ambiguous classes, *etc.*
- Locates, reads, and parses class images
- Locates methods and properties, based on costing algorithm

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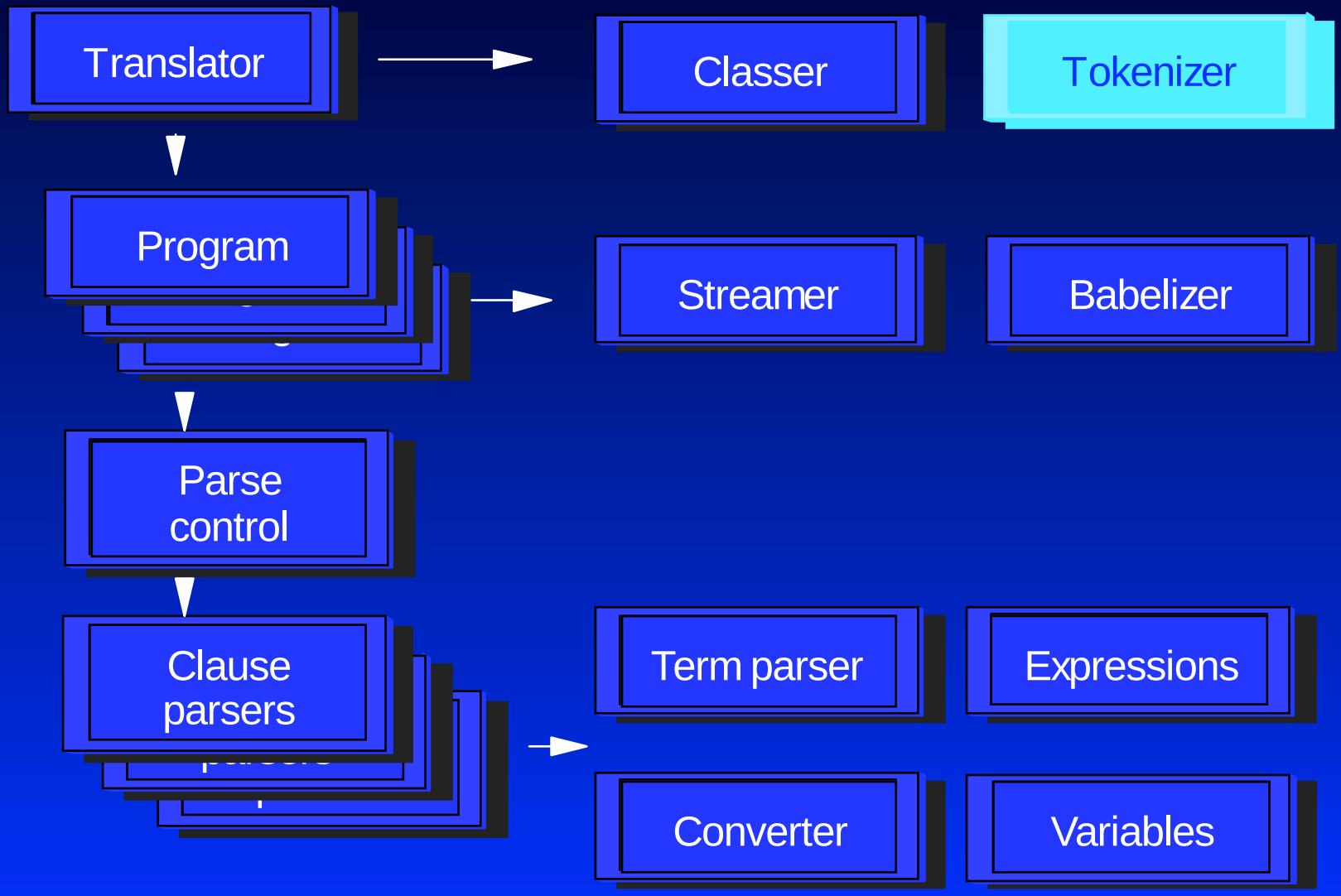

Tokenizer

- One of several shared resources
- Language-independent tokenizing of an input stream or array of character arrays
- Other shared resources include:
  - error message editor
  - base internal types (Tokens, Flags, Types, *etc.*)
  - trace code generator
  - interfaces (ClauseParser, ProgramSource, *etc.*)

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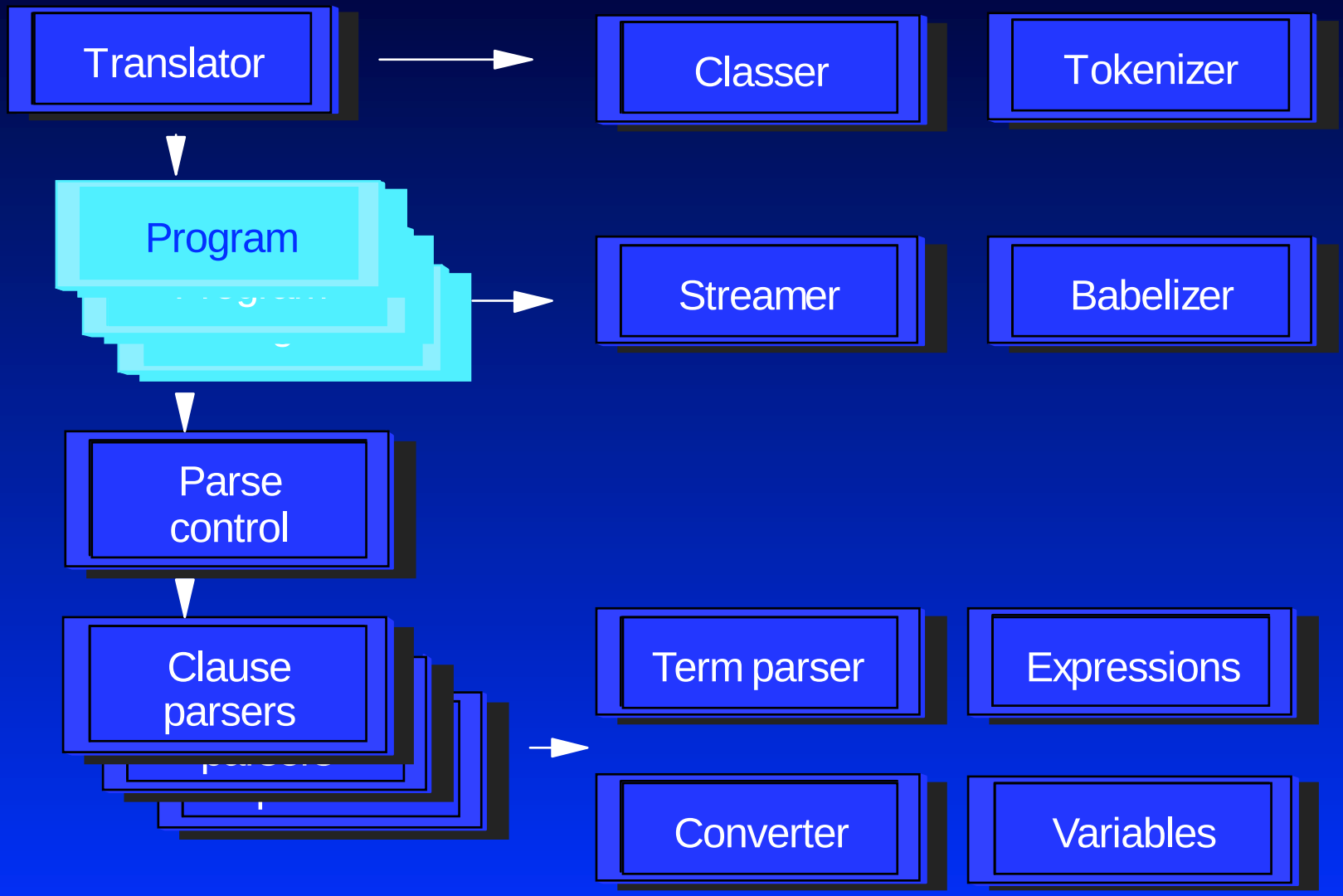

Program

- Represents exactly one of the programs being translated
- Each program may be in a different language, with different syntax (and different semantics at the statement level)
- Holds program-level objects (streamer, package information, imports, options, *etc.*)

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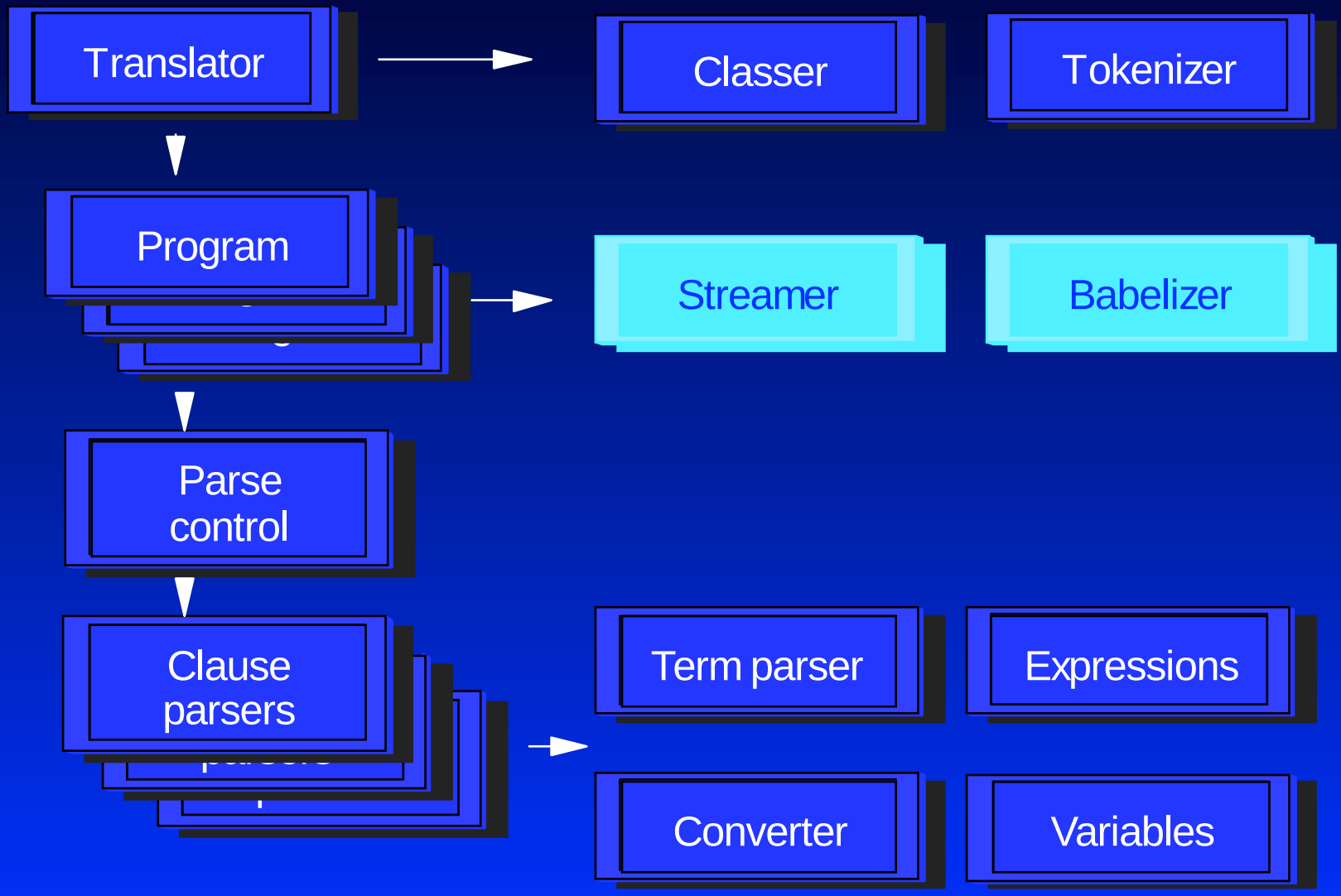
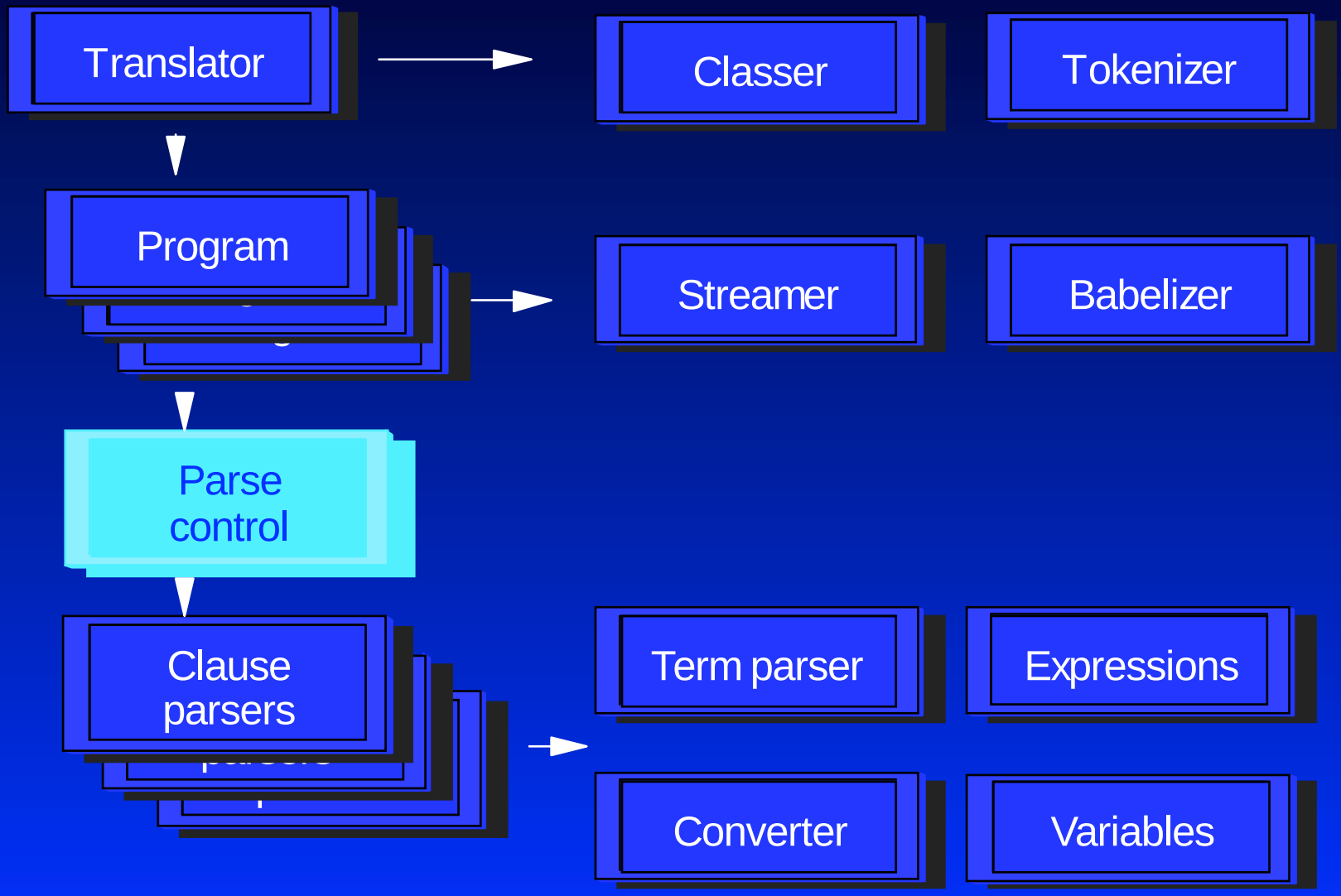


Streamer and Babelizer

- Streamer handles input and output streams
  - locates input files
  - names and creates output files
  - checks for conflicts
  - reads files on demand
- Babelizer converts internal representations to viewable strings, depending on the language
  - associates file extensions with languages
  - arrays shown as **[ ][ ]** or **[,]** or **(,)**
  - attributes spelled as appropriate for the language; *e.g.*, **shared** or **Friend**

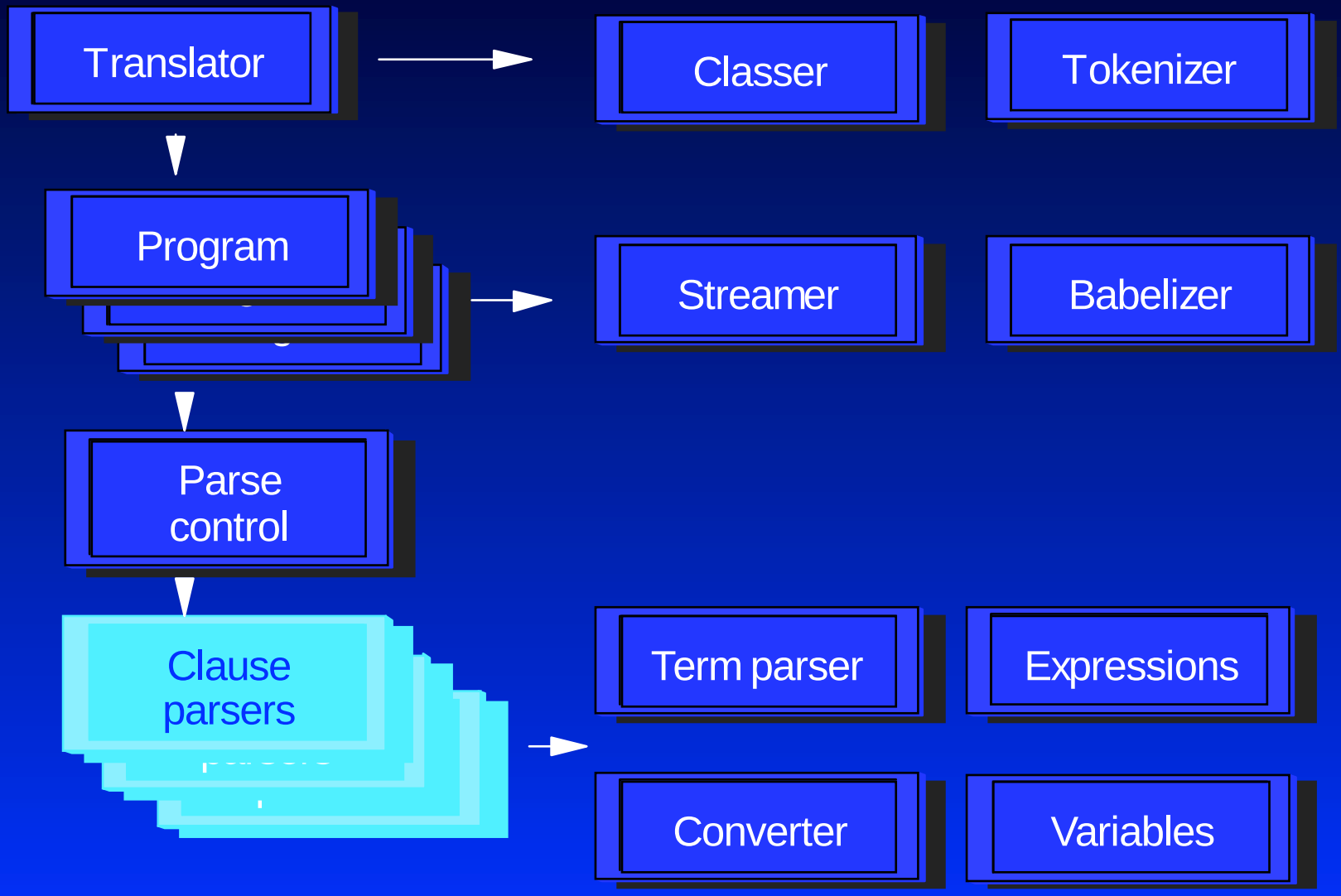
Overall translator organization



Parse control

- State machine for static parsing
- Language-dependent (hence one instance per program)
- Three levels of parsing, deferred where possible:
  - parseProgram
  - parseClassBody
  - parseMethodBody
- Parsing-related utilities (pushLevel, popLevel, *etc*.)

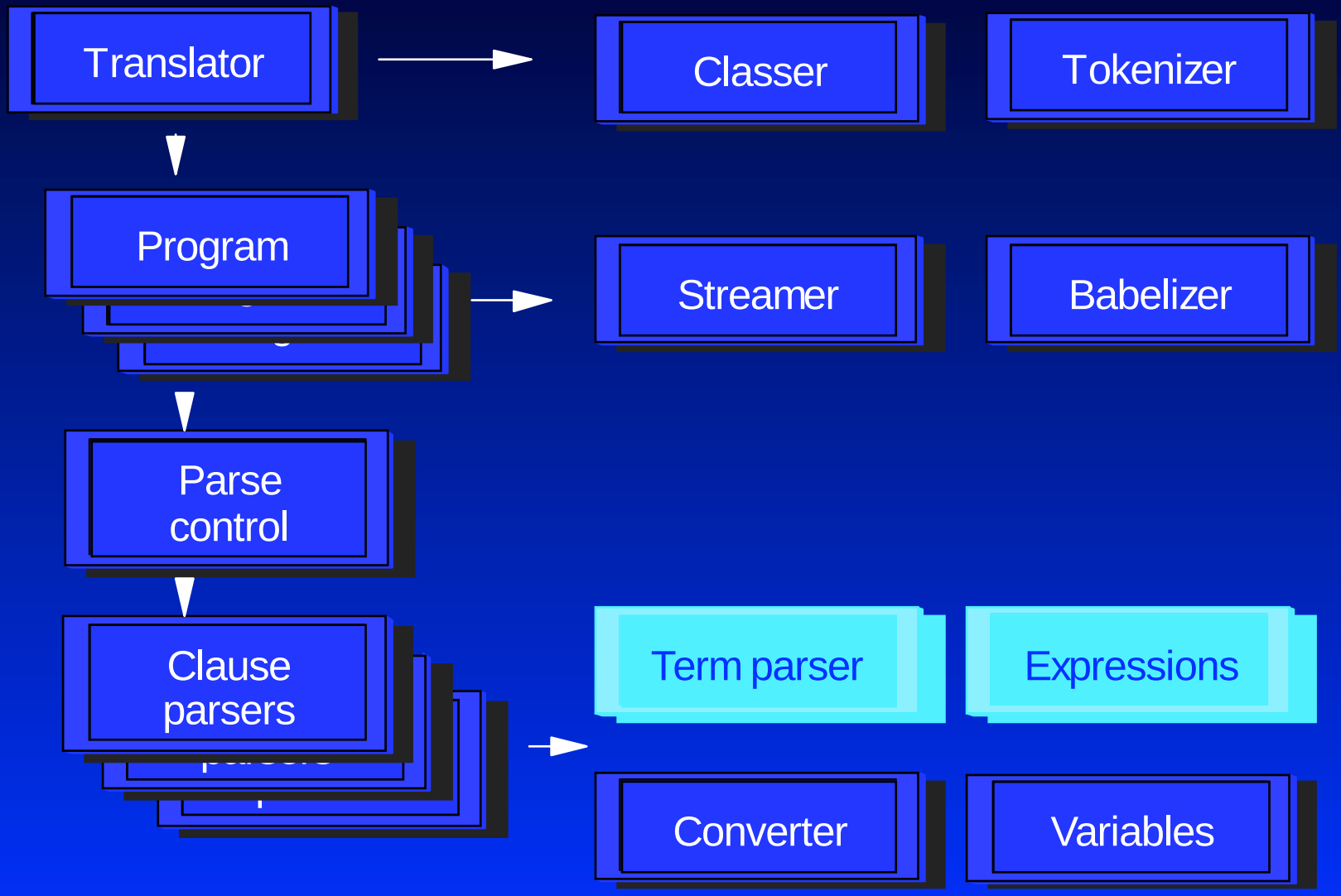
Overall translator organization



Clause parsers

- Each knows about a single clause in one language (Do, Catch, End, Nop, Say, *etc.*)
- Each has a scan method (lexical parse)
- Each has a generate method, for Java code
- Each has an interpret method
- generate and interpret share information gleaned during scan (which may have been multi-pass)

Overall translator organization



Term and Expression parsers

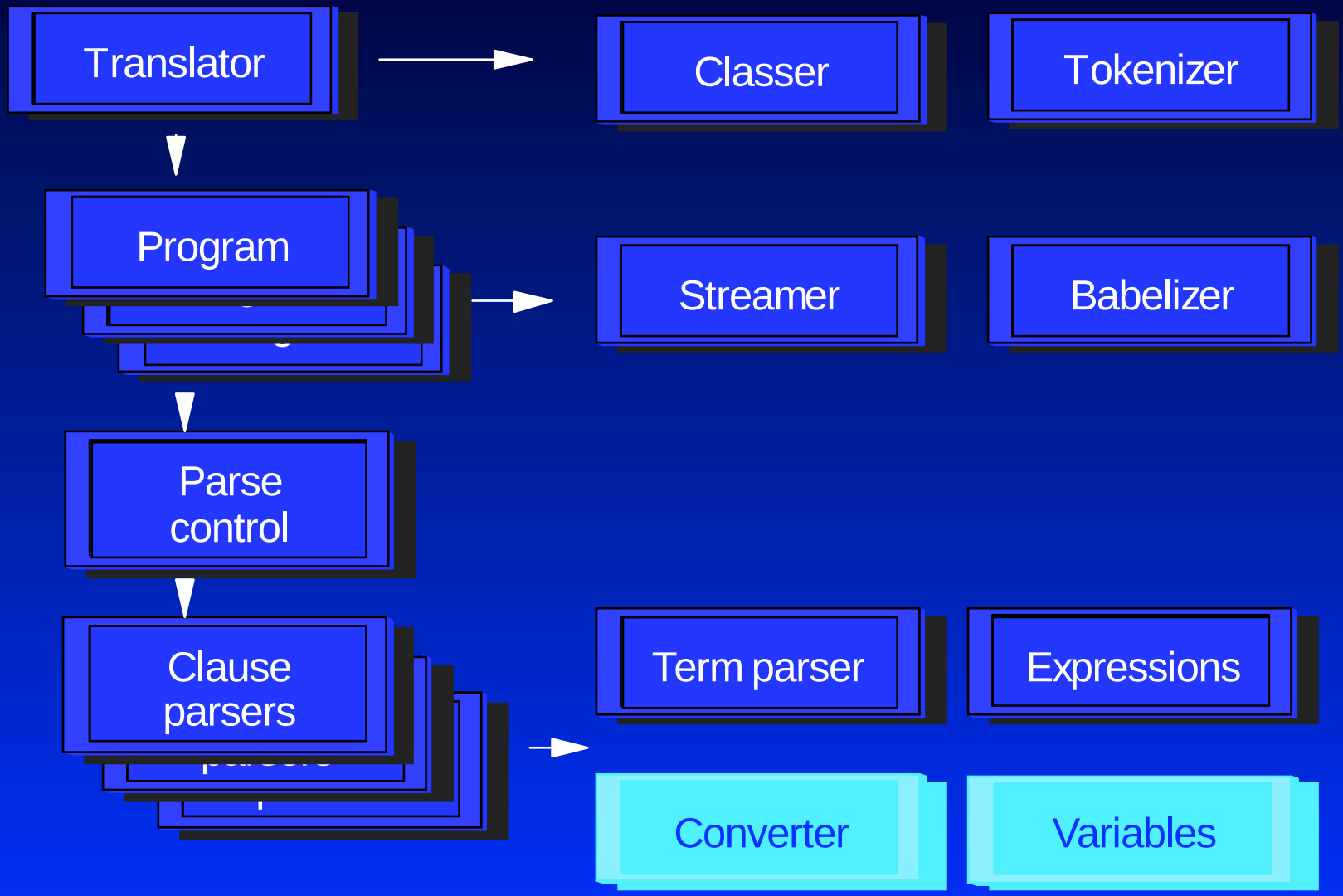
- Recursively call each other to parse terms and expressions. For example:

```
(Rexx vector.get('key')).substr(i+1, j)
```

- Term parser is more complicated than Expression parser, and is easily the largest class in the translator (100K characters, including comments)

- Like clause parsers, both can emit Java code or execute (interpret) the term or expression

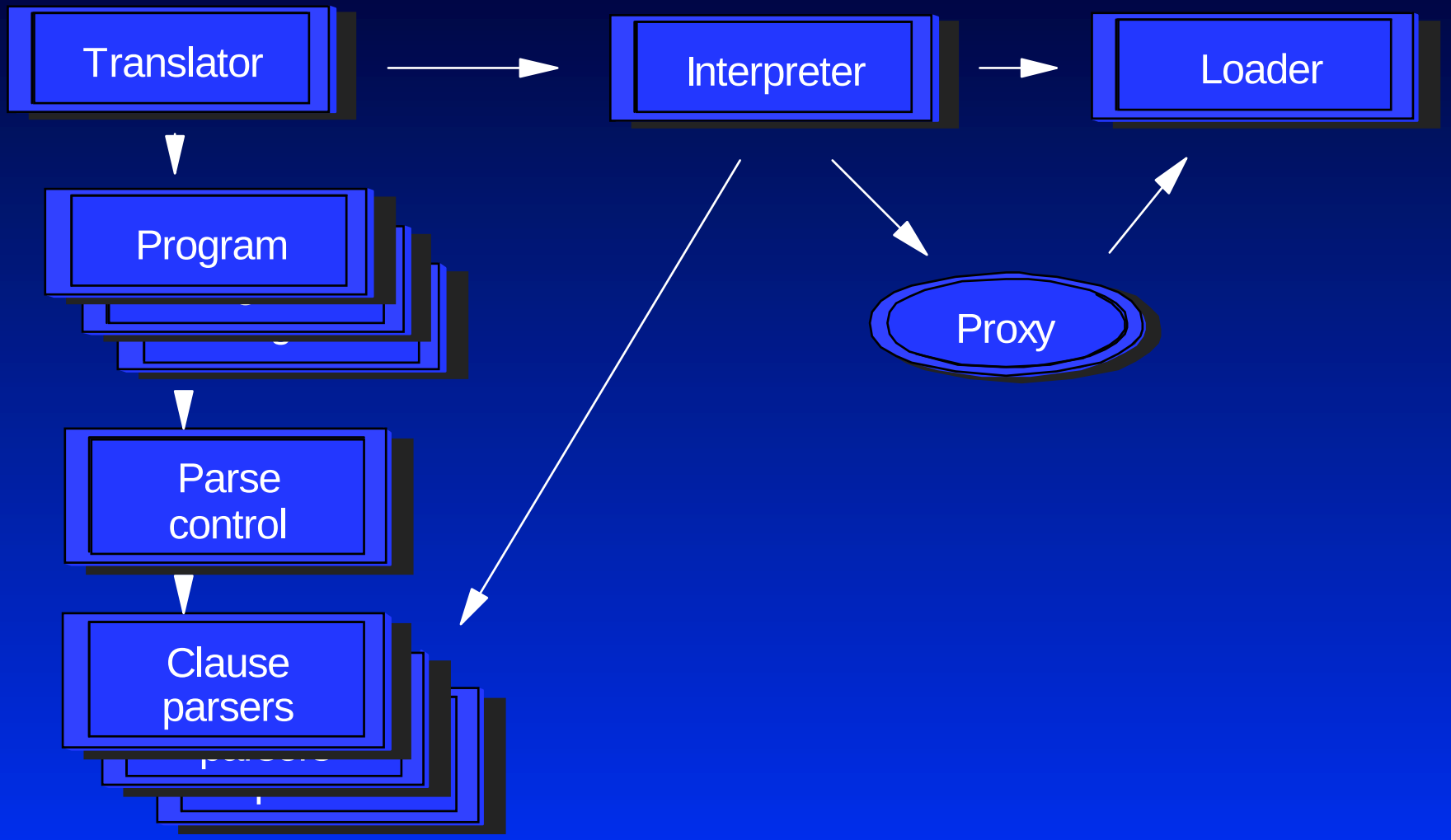
Overall translator organization



Converter and Variable manager

- Converter understands type inferences
  - costs conversions (used for method finding and error checking)
  - effects conversions (emits Java code or interprets)
- Variable manager handles both class and method variables
  - All properties and local variables during scan passes
  - Only static (Class) properties and local variables during interpretation - instance properties are held in a real object

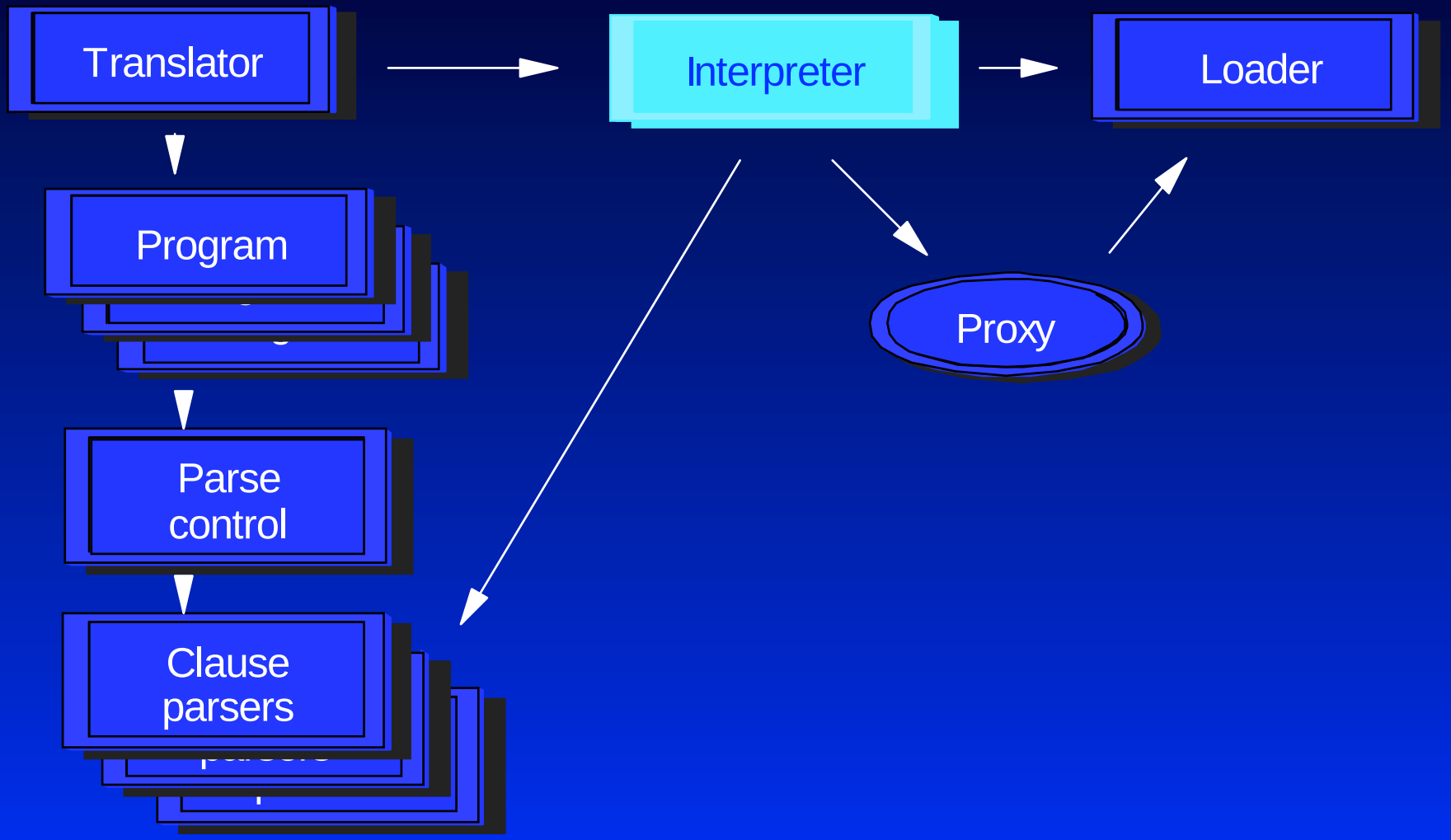
Interpretation



General principle

- First, programs are parsed (to determine classes, properties, and methods with their signatures)
- For each class, a *proxy* (stub) class is created
  - this has all the properties just as in a 'real' class
  - for each method, it has only the definition and return
  - when a method is invoked through Java reflection, it immediately calls the interpreter, which interprets the method body
- Real instances are created, so interpreted classes are visible to the JVM for callbacks, *etc*.

Interpretation



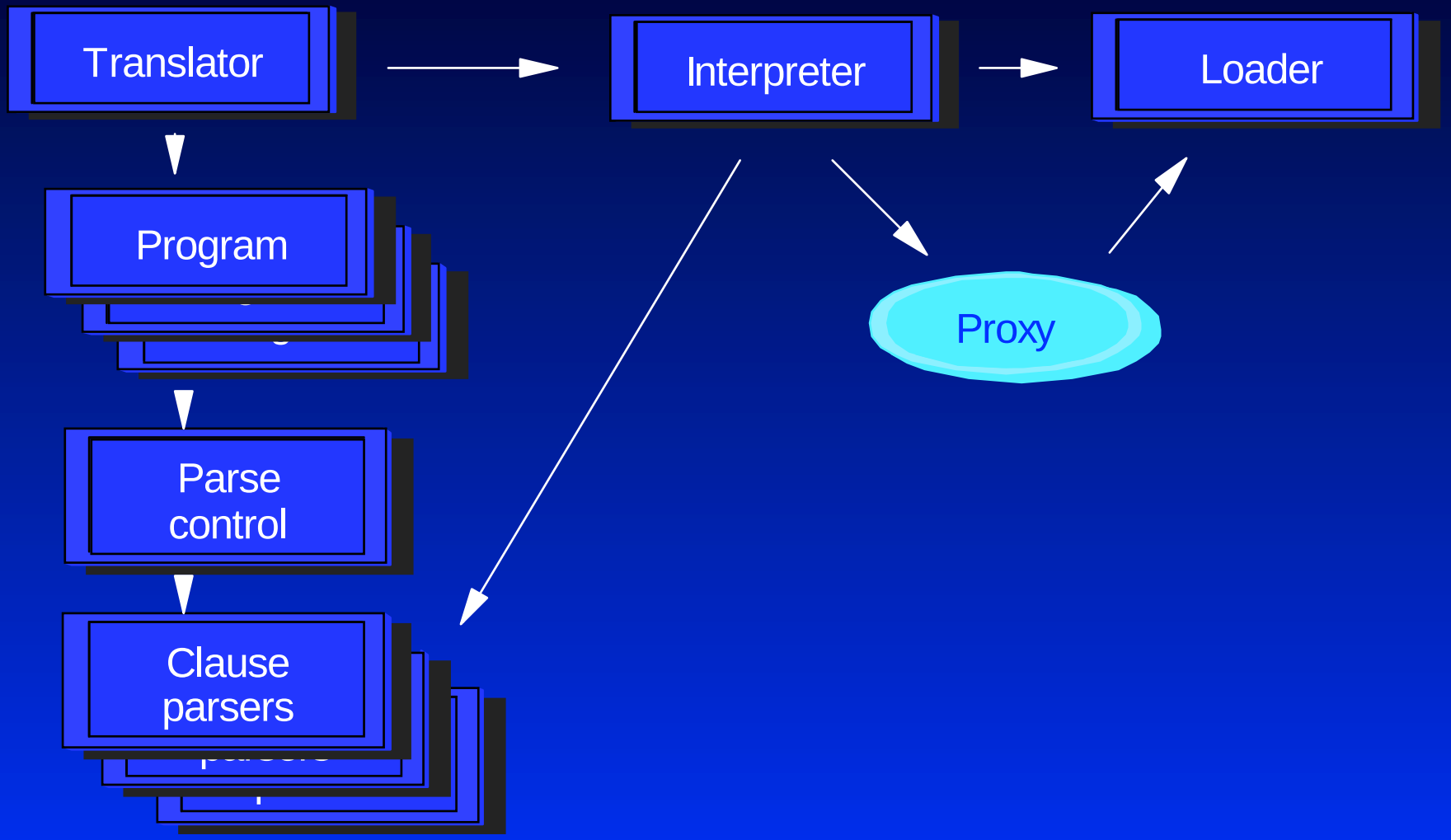
Interpreter

- Primary task is interpreting method bodies, by finding each clause in turn and invoking its interpret method
- When class first used or instance constructed, interprets initialization code (properties, *etc.*)
- Handles Java reflection (access to real properties, instances of objects, arrays, *etc.*)

Interpreter complications

- Signals - have to be wrapped, and cannot be passed through a reflection call
- Constructors - arguments to super(x, y) call must be interpreted, then the super(x, y) call must be made by the proxy class, and only then can the constructor method body be interpreted
- Protected (synchronized) blocks of code must truly be protected to be thread-safe

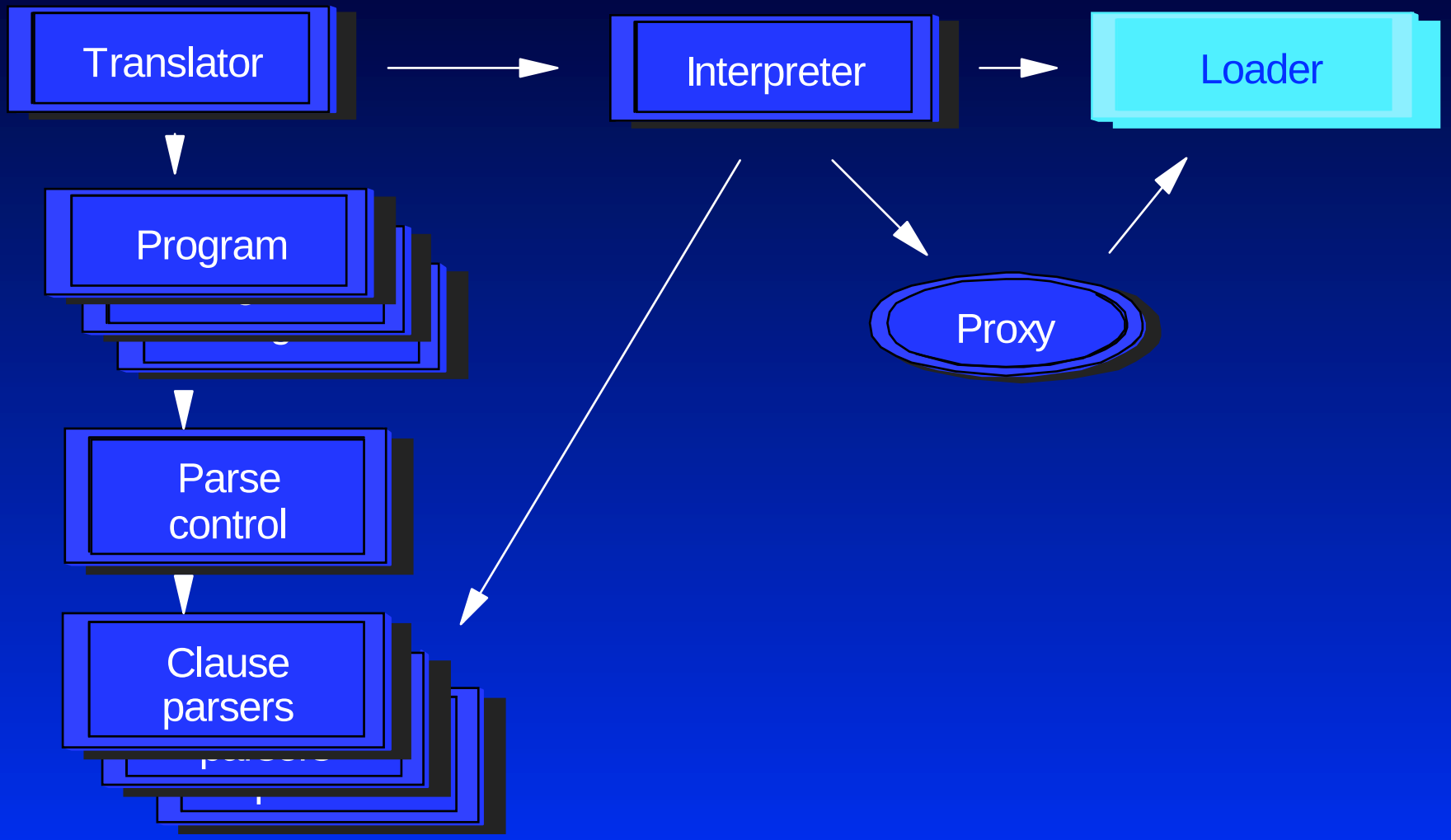
Interpretation



Proxy class

- Builds a binary class image (in a byte array) for a class that is to be interpreted
- Tedious but relatively straightforward - the code for every method is essentially the same
  - collect arguments (wrapped if necessary) into an Object array
  - invoke the interpreter to interpret the method body
  - get the returned Object; unwrap or cast it as required, and return it

Interpretation



Proxy class Loader

- A Java classloader is needed to actually load a class into the JVM
- If the built-in one were used then a class could never be redefined; classes are only unloaded when the object that loaded them is unloaded
- Complication: we also have to load any external (compiled) private classes, as otherwise they appear to be in a different package and hence would not be accessible when they should be

Summary

- A blend of Rexx and Java
  - scripting ***and*** application development
  - a truly general-purpose language
- Both decimal and binary arithmetic
- High productivity and simplicity
  - Java source is typically 35% bigger
  - Interpreter greatly speeds development
- Designed for ***users***, not compilers.

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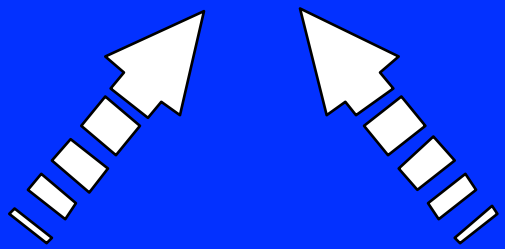
NetRexx



Rexx + Java

Strong typing doesn't need extra typing