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PHP OGO NFN MEM LDL KCK JBJ

Bring PHP to the Java-World
(well … actually it is Scala)

by Bodo Junglas

What we would like to cover today

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Agenda

- Motivation and goals
- Is converted code still readable?
- Compatibility and test suite
- Ugly features of PHP (Why is this so complicated)
- Overall project layout
- How to write an interpreter in Scala

Why do we even want to do this?

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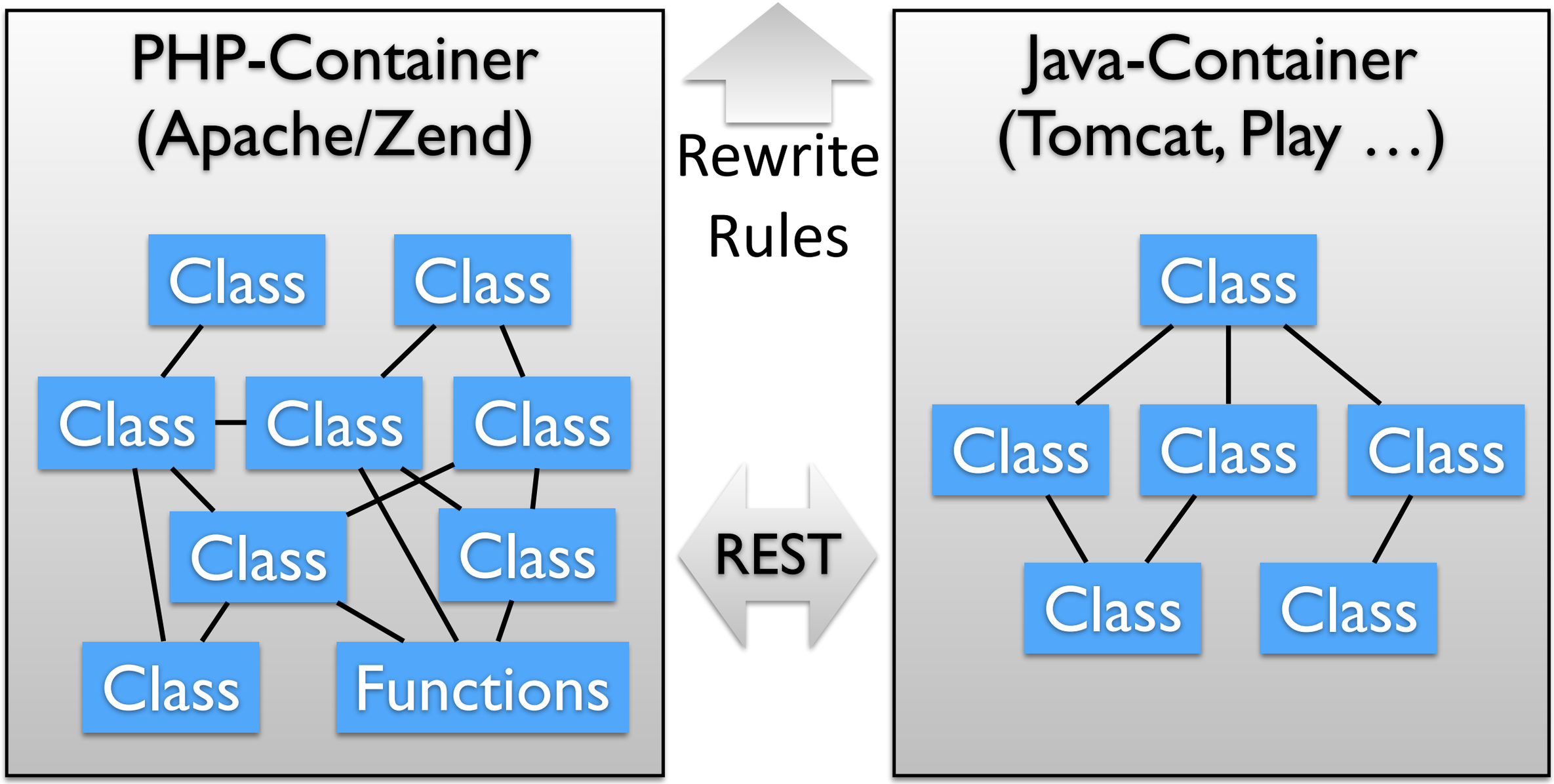
Real world example: Consider a large project with lots of legacy PHP code that wants to migrate to Java



Wouldn't it be much nicer, if ...

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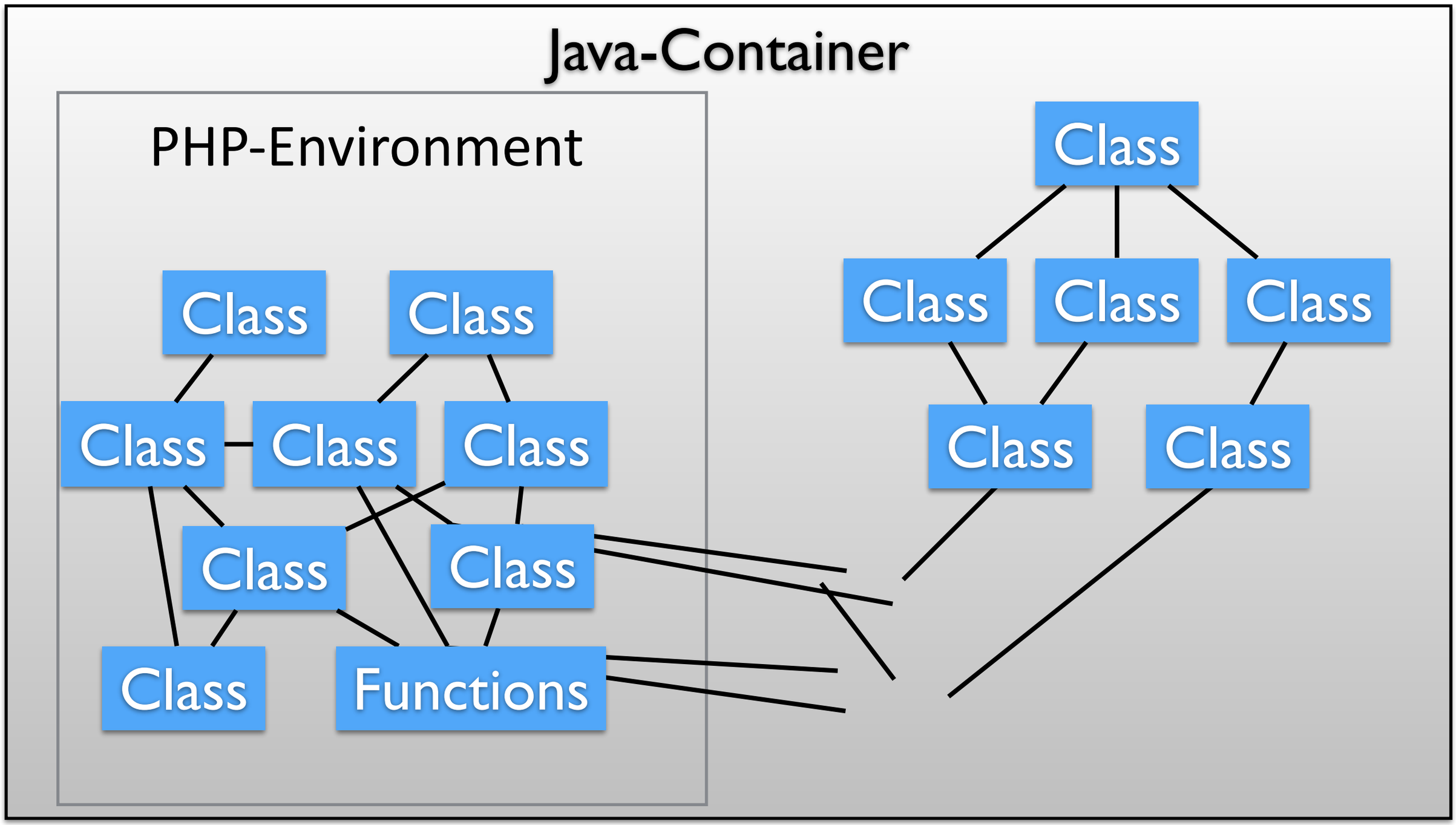
... we could use refactoring tools



Where do we see ourselves?

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The defining goals of JBJ

- Offer a way to run existing PHP code inside a Java VM (i.e. a PHP interpreter inside the Java-VM)
- Allow interaction between PHP and Java
- Automatic conversion of PHP code that …
  - … runs transparently with the remaining PHP code
  - … gives developers a starting point where to begin structured refactoring
  - … is still readable

… and pigs might just fly …

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Other projects with a similar direction:

- Quercus
  - Nearly complete PHP interpreter in Java
  - Part of Caucho/Resin, GPL license
  - Does not seem to be community driven
- JPHP
  - Compiles PHP Java-VM byte-code
  - Github project / Apache 2 license
- Project Zero/WebSphere sMesh
  - Probably dead by now

… and the other way round:

- PJP - PHP/Java Bridge
  - Tries to integrate the Java-VM into the PHP interpreter

… but non of them offers a real conversion.

What is next

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Very first roundtrip.

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```
1 This is before
2 <?php
3     print "Hello" . " " . "world";
4 ?>
5 This is after
```

March 7 2014 on a Train Berlin->Dortmund

»After gaining consciousness its first intent was to kill its creator.«

```
 1 package testunits
 2
 3 import de.leanovate.jbj.runtime.context.Context
 4 import de.leanovate.jbj.runtime.value._
 5 import de.leanovate.jbj.runtime.JbjCodeUnit
 6
 7 object hello_world extends JbjCodeUnit {
 8
 9   def exec(implicit ctx: Context) {
10
11     ctx.out.print("""This is before
12       |""".stripMargin)
13     ctx.out.print("")
14     ctx.out.print(((StringVal("""Hello""") !! StringVal(""" """)) !!
   StringVal("""world""")).toOutput)
15     ctx.out.print("""This is after
16       |""".stripMargin)
17   }
18 }
```

More recent examples (Hello world)

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```
1 This is before
2 <?php
3     print "Hello" . " " . "world";
4 ?>
5 This is after
```

```
1 trait hello_world extends JbjCodeUnit {
2
3   def exec(implicit ctx: Context) {
4
5     inline("This is before\n")
6     print(p("Hello") !! p(" ") !! p("world"))
7     inline("This is after\n")
8   }
9 }
```

- p(…) converts a scala Int, String, … to its PHP-counterpart (might become an implicit conversion)
- inline(…) encapsulates everything outside <?php ?>
- »!!« is a replacement for PHP's ».«

More recent examples (Variables)

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```php
<?php
$a = "Hello";
$b = "world";
$c = $a . " " . $b;

echo $c;

$d = $c + 42;

echo $d;
?>
```

```
trait hello_world2 extends JbjCodeUnit {

  def exec(implicit ctx: Context) {
    val a = lvar("a")
    val b = lvar("b")
    val c = lvar("c")
    val d = lvar("d")

    a := p("Hello")
    b := p("world")
    c := a !! p(" ") !! b
    echo(c)
    d := c + p(42L)
    echo(d)
  }
}
```

- Variables have to be declared with lvar(…) helper
- Assignment is done with »:=«

More recent examples (Arrays, Loops)


```php
<?php
 $a = array("Hello", "World", 42);

 for($i=0; $i<count($a); $i++) {
   echo $a[$i];
   $a[$i] = ($i + 2) * $i + 1;
   echo "\n";
 }

 for($i=0; $i<count($a); $i++) {
   echo $a[$i];
   echo "\n";
 }
?>
```

```
trait hello_world3 extends JbjCodeUnit {
 def exec(implicit ctx: Context) {
  val a = lvar("a")
  val i = lvar("i")

  a := array(p("Hello"), p("World"), p(42L))
  pFor(i := p(0L), i < p(count(a)), i.++) {
   echo(a.dim(i))
   a.dim(i) := (i + p(2L)) * i + p(1L)
   echo(p("\n"))
  }
  pFor(i := p(0L), i < p(count(a)), i.++) {
   echo(a.dim(i))
   echo(p("\n"))
  }
 }
}
```

- array(…) helper to create PHP-style arrays
- pFor(…,…,…) helper to create PHP-style for-loops

What is next

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Agenda

- Motivation and goals
- Is converted code still readable?
- **Compatibility and test suite**
- Ugly features of PHP (Why is this so complicated)
- Overall project layout
- How to write an interpreter in Scala

How to test an interpreter?

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How to ensure compatibility

- Run lots of PHP scripts focussing on different aspects of the language
- See that all of them run smoothly (i.e. without any unexpected runtime exceptions)
- Compare the output with the expected output generated by the »real« PHP interpreter

… luckily there already is a test suite.

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The test suite of the PHP interpreter itself operates just like this. Look out for "*.phpt" files

lang/008.phpt

```
--TEST--
Testing recursive function
--FILE--
<?php

function Test()
{
        static $a=1;
        echo "$a ";
        $a++;
        if($a<10): Test(); endif;
}

Test();

?>
--EXPECT--
1 2 3 4 5 6 7 8 9
```

… which can be easily reused.

de.leanovate.jbj.core.tests.lang.Lang1Spec.scala

```
1 "Testing recursive function" in {
2   // lang/008
3   script(
4     """<?php
5       |
6       |function Test()
7       |{
8       | static $a=1;
9       | echo "$a ";
10      | $a++;
11      | if($a<10): Test(); endif;
12      |}
13      |
14      |Test();
15      |
16      |?>""".stripMargin
17  ).result must haveOutput(
18    """1 2 3 4 5 6 7 8 9 """.stripMargin
19  )
20 }
```

Where we are at the moment

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Raw test count:

- PHP's tests are split up:
  - 761 legacy tests
  - 1414 Zend engine tests
  - I.e. 2175 core interpreter tests
- JBJ: >820 core tests

But:

- This is just the core interpreter
- Every PHP extension has its own set of tests
  - Total sum: 12729

What is next

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Why not just Copy&Paste

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PHP is not easily converted:

- PHP is around since 1995 and has been influenced by several languages and concepts. Some of its features do not translate well to the Scala-world
- Even though some features could be considered »legacy« now, only developers can decide if a certain feature is relevant for some existing code or not

Hurdle 1: Implicit type conversions

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Concatenation operator

```
"Hello " . "42"     ---> (string) "Hello 42"

"Hello " . 42       ---> (string) "Hello 42"
```

Arithmetic operators

```
"Hello " + "42"     --->  ???

" 1e5 " + 42        --->  ???
```

Hurdle 1: Implicit type conversions

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Logical operators

```
"Hello " && true        --->  ???

"false" && true         --->  ???

"" && true              --->  ???

0 && true               --->  ???
```

Bitwise operators

```
"Hello" | "abcde"       --->  ???

"Hello" | 10            --->  ???

"13" | 10               --->  ???
```

Hurdle 1: Implicit type conversions

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Comparison operator

```
"42" < "10000"          --->  ???

"42a" < "10000"         --->  ???

42 < "10000"            --->  ???

42 < "10000a"           --->  ???

42 < "a10000"           --->  ???
```

Hurdle 1: Implicit type conversions

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pre/post-fix operators

```
$a = 1
$a++                    ---> (int) 2

$a = 10
$a--                    ---> (int) 9

$a = "Hello"
$a++                    --->  ???

$a = "Hello"
$a--                    --->  ???
```

Hurdle 2: By-Reference

By-reference parameters

```php
<?php

function squareIt(&$x) {
    $x = $x * $x;
}

$a = 2;
squareIt($a);
print "Result: $a\n";
?>
```

```
Result: 4
```

Hurdle 2: By-Reference

By-reference variables

```php
<?php
$a = 4;
$b = array(1, 2, 3, &$a);
$c = &$a;

echo "1. b[3] = ${b[3]}  a = $a\n";
$c = 1;
echo "2. b[3] = ${b[3]}  a = $a\n";
$b[3] = 8;
echo "3. c = $c   a = $a\n";
?>
```

```
1. b[3] = 4  a = 4
2. b[3] = 1  a = 1
3. c = 8   a = 8
```

Hurdle 3: Generators

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A hint of Python

```php
<?php
function generateNums() {
    for ( $i = 1; $i < 5; $i++ ) {
        yield $i;
    }
};
$generator = generateNums(); // this is a Generator class
                             // implementing the Iterator
                             // interface
foreach ($generator as $value) {
    print "Value: $value\n";
}
?>
```

Since PHP 5.5

Hurdle 4: Classes, interfaces … traits

Some Java, some C++

```php
<?php

class A {
    function __construct() {
        print "constructor\n";
    }

    function __destruct() {
        print "destructor\n";
    }
}

print "start\n";
$a = new A();
print "middle\n";
$a = NULL;
print "end\n";
?>
```

```
start
constructor
middle
destructor
end
```

Hurdle 5: Lambda expressions

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A hint of Javascript

```php
<?php
$result = 0;

$one = function()
{ var_dump($result); };

$two = function() use ($result)
{ var_dump($result); };

$three = function() use (&$result)
{ var_dump($result); };

$result++;

$one();
$two();
$three();
?>
```

```
PHP Notice:  Undefined variable

NULL
int(0)
int(1)
```

Since PHP 5.3

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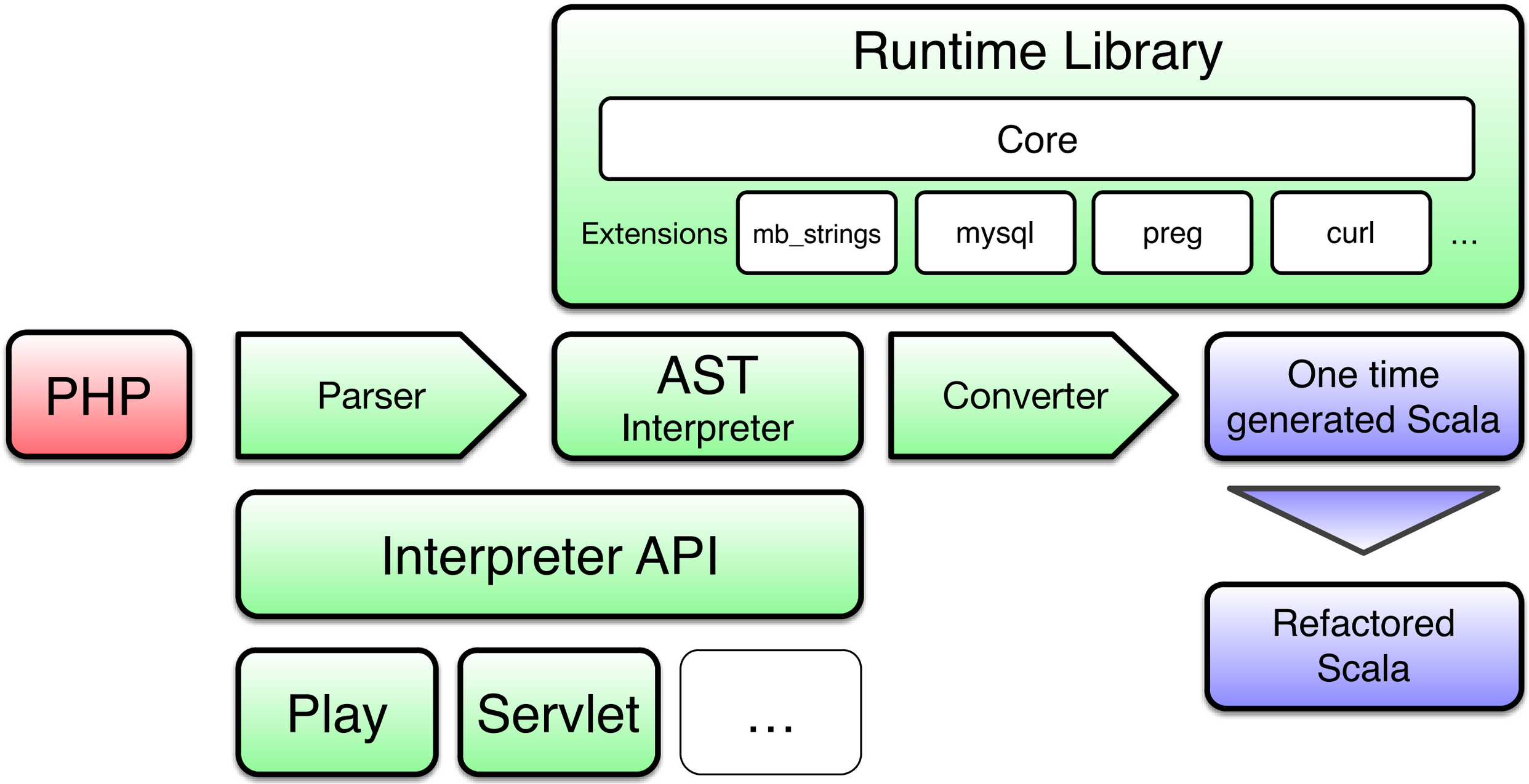
Its good to have a plan

Project structure



How PHP is running it

Classical lexer/parser

- Lexical analyzer generated by »flex« (traditionally by »lex« as part of the POSIX standard)
- Parser generated by »bison« (traditionally by »yacc« as part of the POSIX standard)
- PHP’s parser compiles the source-code to a sequence of Op-Codes that a run by the Zend-Engine (i.e. Zend-Engine is the VM of PHP)

Its nice to have a choice

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Alternatives in Java

- JavaCC: lexer + parser
- AntLR: lexer + parser
- JLex/JFlex: lexer
- CUP: parser
- byacc/J: parser
- jay: parser
- …

Many of these generate codes that exceeds the 64kb method size limit of Java

What is next

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Scala has its own toolset for parsers

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Scala combinators: Parsers for free

```
1 package scala.util.parsing.combinator
2
3 trait Parsers {
4     type Elem
5
6     trait Parser {
7         def apply(input: Reader[Elem]) : ParseResult[T]
8     ...
9     }
10
11    sealed abstract class ParseResult[+T]
12
13    case class Success[+T](...) extends ParseResult[T]
14    case class Failure(...) extends ParseResult[Nothing]
15    case class Error(...) extends ParseResult[Nothing]
16 ...
17 }
```

- There is no distinction between lexer and parser

Getting started with combinators

»Hello World« for parsers: Calculator

```
1 class Calculator1 extends Parsers {
2   type Elem = Char
3
4   def expr: Parser[Int] = addition | subtraction | number
5
6   def addition: Parser[Int] =
7     number ~ '+' ~ number ^^ { case left ~ _ ~ right => left + right }
8
9   def subtraction: Parser[Int] =
10    number ~ '-' ~ number ^^ { case left ~ _ ~ right => left - right }
11
12  def number: Parser[Int] =
13    digit.+ ^^ { digits => digits.mkString("").toInt }
14
15  def digit: Parser[Char] = elem("digit", ch => ch.isDigit)
16
17  def parse(str: String):Int = expr(new CharSequenceReader(str)) match {
18    case Success(result, remain) if remain.atEnd => result
19 ... error handling
20  }
21 }
```

How to combine

Combinator operators

```
15    def digit: Parser[Char] = elem("digit", ch => ch.isDigit)
```

»elem(kind: String, condition: Elem => Boolean«
creates a parser that consumes a single element if a condition is met

```
12    def number: Parser[Int] =
13      digit.+ ^^ { digits => digits.mkString("").toInt }
```

»rep1(p: => Parser[T]): Parser[List[T]]« (or »+« postfix) creates a parser by repeating a given parser at least once.

»^^« maps the result of a parser

How to combine

Combinator operators

```
 6   def addition: Parser[Int] =
 7     number ~ '+' ~ number ^^ { case left ~ _ ~ right => left + right }
 8
 9   def subtraction: Parser[Int] =
10     number ~ '-' ~ number ^^ { case left ~ _ ~ right => left - right }
```

»~« combines two parsers to a new one that is only successful if both parsers are successful in sequence.

```
4   def expr: Parser[Int] = addition | subtraction | number
```

»|« combines two parsers to a new one that is successful if one of the given ones is successful

How to parse

Using the parser

```
14   def parse(str: String):Int = expr(new CharSequenceReader(str)) match {
15     case Success(result, remain) if remain.atEnd => result
16     case Success(_, remain) =>
17       throw new RuntimeException(s"Unparsed input at ${remain.pos}")
18     case NoSuccess(msg, remain) =>
19       throw new RuntimeException(s"Parse error $msg at ${remain.pos}")
20   }
```

Examples

```
"42"          ---> 42
"42+54"       ---> 96
"42-54"       ---> -12
"42-54+12"    ---> "Unparsed input" exception
```

Pitfall 1: Longest match selection

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Order of combinations is important

What if

```
4   def expr: Parser[Int] = addition | subtraction | number
```

… is this

```
4   def expr: Parser[Int] = number | addition | subtraction
```

```
"42"          ---> 42
"42+54"       ---> "Unparsed input" exception
"42-54"       ---> "Unparsed input" exception
"42-54+12"    ---> "Unparsed input" exception
```

May be solved by

```
4   def expr: Parser[Int] = number ||| addition ||| subtraction
```

»|||« combines two parsers to a new one that is successful if one of the given ones is successful. If both are successful, the one which consumes more wins.

Pitfall 2: Recursion is not your friend

Do not repeat the yacc-way

```
 5   def expr: Parser[Int] = addition | subtraction | number
 5
 6   def addition: Parser[Int] =
 7     number ~ '+' ~ number ^^ { case left ~ _ ~ right => left + right }
 8
 9   def subtraction: Parser[Int] =
10     number ~ '-' ~ number ^^ { case left ~ _ ~ right => left - right }
```

```
 5   def expr: Parser[Int] = addition | subtraction | number
 5
 6   def addition: Parser[Int] =
 7     expr ~ '+' ~ expr ^^ { case left ~ _ ~ right => left + right }
 8
 9   def subtraction: Parser[Int] =
10     expr ~ '-' ~ expr ^^ { case left ~ _ ~ right => left - right }
```

Fails with Stack-overflow.

The correct way to do it

Parse elements delimited by operators

```
 4    def expr = addSub
 5
 6    def addSub: Parser[Int] = mulDiv * (
 7        '+' ^^^ { (left: Int, right: Int) => left + right}
 8      | '-' ^^^ { (left: Int, right: Int) => left - right} )
 9
10    def mulDiv = number * (
11        '*' ^^^ { (left: Int, right: Int) => left * right }
12      | '/' ^^^ { (left: Int, right: Int) => left / right } )
```

»*« repeats the left parser by using the right parser to parse the delimiters. The result of the right parser has to be a function to combine the results of the left parser.

»^^^« simply replaces the result of a parser

Pitfall 3: Pollution of the grammar

Potential way to handle whitespaces

```
13   def number: Parser[Int] =
14     whitespace.* ~> digit.+ <~ whitespace.* ^^ { digits =>
14                                                  digits.mkString("").toInt }
15
16   def digit: Parser[Char] = elem("digit", ch => ch.isDigit)
17
18   def whitespace: Parser[Char] =
19                                    elem("ws", ch => ch == ' ' || ch == '\t')
```

»<~« and »~>« are just like »~« but ignore the results of the parser to the left resp. right.

»*« postfix is just like the »+« postfix but succeeds even if there is no match at all.

Separate code into lexer and parser


```
 1 class Calculator3 extends StdTokenParsers {
 2   override type Tokens = StdLexical
 3
 4   override val lexical = new StdLexical
 5
 6   lexical.delimiters ++= List("(", ")", "+", "-", "*", "/")
 7
 8   def expr: Parser[Int] = addSub
 9
10   def addSub: Parser[Int] = mulDiv * (
11       '+' ^^^ { (left: Int, right: Int) => left + right}
12     | '-' ^^^ { (left: Int, right: Int) => left - right} )
13
14   def mulDiv = number * (
15       '*' ^^^ { (left: Int, right: Int) => left * right }
16     | '/' ^^^ { (left: Int, right: Int) => left / right } )
17
18   def term: Parser[Int] = "(" ~> expr <~ ")" | numericLit ^^ (_.toInt)
19
20   def parse(str: String) = expr(new lexical.Scanner(str)) match {
21 ...
24   }
25 }
```

Separate code into lexer and parser

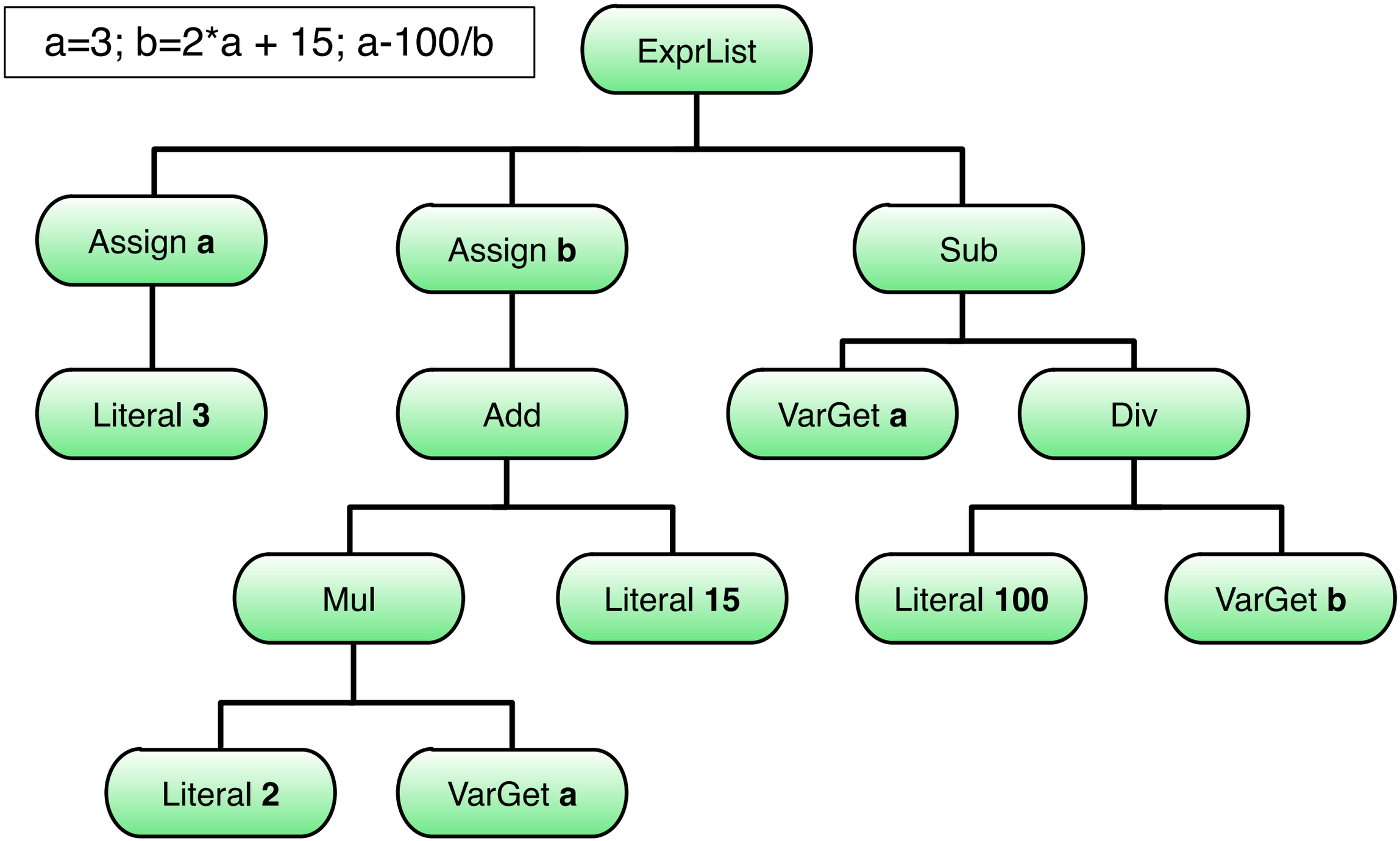
Examples

```
"42 - 3*3*3*2 + 24/2"                                  ---> 0
"2 * (3 /* blah blah */ +4) / 2 + 7 * 5"    ---> 42
```

- Even though this works quite nicely, all the »work« is done by the parser itself.
- Parser rules might become quickly polluted for more complex functionality: Type-conversion, variables, functions …

Go abstract … tree-like

Abstract syntax tree



Just a bunch of one-liners

Define an AST in Scala

```
1 trait Node { }
2
3 trait Expr extends Node { }
4
5 case class ExprListExpr(exprs: List[Expr]) extends Expr
6
7 case class LiteralExpr(value: Int) extends Expr
8
9 case class AddExpr(left: Expr, right: Expr) extends Expr
10
11 case class SubExpr(left: Expr, right: Expr) extends Expr
12
13 case class MulExpr(left: Expr, right: Expr) extends Expr
14
15 case class DivExpr(left: Expr, right: Expr) extends Expr
16
17 case class VarGetExpr(name: String) extends Expr
18
19 case class AssignExpr(name: String, expr: Expr) extends Expr
```

Case classes are their own factory

Parse to an AST

```
1 object ASTParser extends StdTokenParsers {
2   override type Tokens = StdLexical
3
4   override val lexical = new StdLexical
5
6   lexical.delimiters ++= List("(", ")", "+", "-", "*", "/", "=", ";")
7
8   def exprs: Parser[Expr] = repsep(expr, ";") ^^ ExprListExpr
9
10  def expr: Parser[Expr] = assign | addSub
11
12  def assign: Parser[Expr] = ident ~ "=" ~ addSub ^^ {
13                case name ~ _ ~ valueExpr => AssignExpr(name, valueExpr) }
14
15  def addSub: Parser[Expr] = mulDiv * ("+" ^^^ AddExpr | "-" ^^^ SubExpr)
16
17  def mulDiv: Parser[Expr] = term * ("*" ^^^ MulExpr | "/" ^^^ DivExpr)
18
19  def term: Parser[Expr] =
20    "(" ~> expr <~ ")" | ident ^^ VarGetExpr |
21    numericLit ^^ (str => LiteralExpr(str.toInt))
22 ...
23 }
```

Interpret: Just some more one-liners

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Add interpreter

```
1 trait Expr extends Node {
2   def eval(implicit context: CalculatorContext): Int
3 }
```

```
 1 case class LiteralExpr(value: Int) extends Expr {
 2   def eval(implicit context: CalculatorContext) = value
 3 }
 4
 5 case class AddExpr(left: Expr, right: Expr) extends Expr {
 6   def eval(implicit ctx: CalculatorContext) = left.eval + right.eval
 7 }
 8
 9 case class VarGetExpr(name: String) extends Expr {
10   def eval(implicit ctx: CalculatorContext) =
11     context.getVariable(name).getOrElse {
12       throw new RuntimeException(s"Variable $name not defined")
13     }
14 }
15 ...
```

… and just go on from here

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Outlook

- JBJ's parser and interpreter is just a calculator in its n-th iteration.
- Conversion is based on the abstract syntax tree.
- It contains a way to integrate pre-defined Scala-functions in PHP utilizing Scala-macros.
- Runtime-library already contains all the building blocks to write PHP extensions in Scala
  - … but: Many extensions are still missing
  - … considering that ~12000 tests are still open: Any help is welcome

Where to read on

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Links

http://bedcon2014.leanovate.de

https://github.com/leanovate/jbj

Unused pages

How to test a converter

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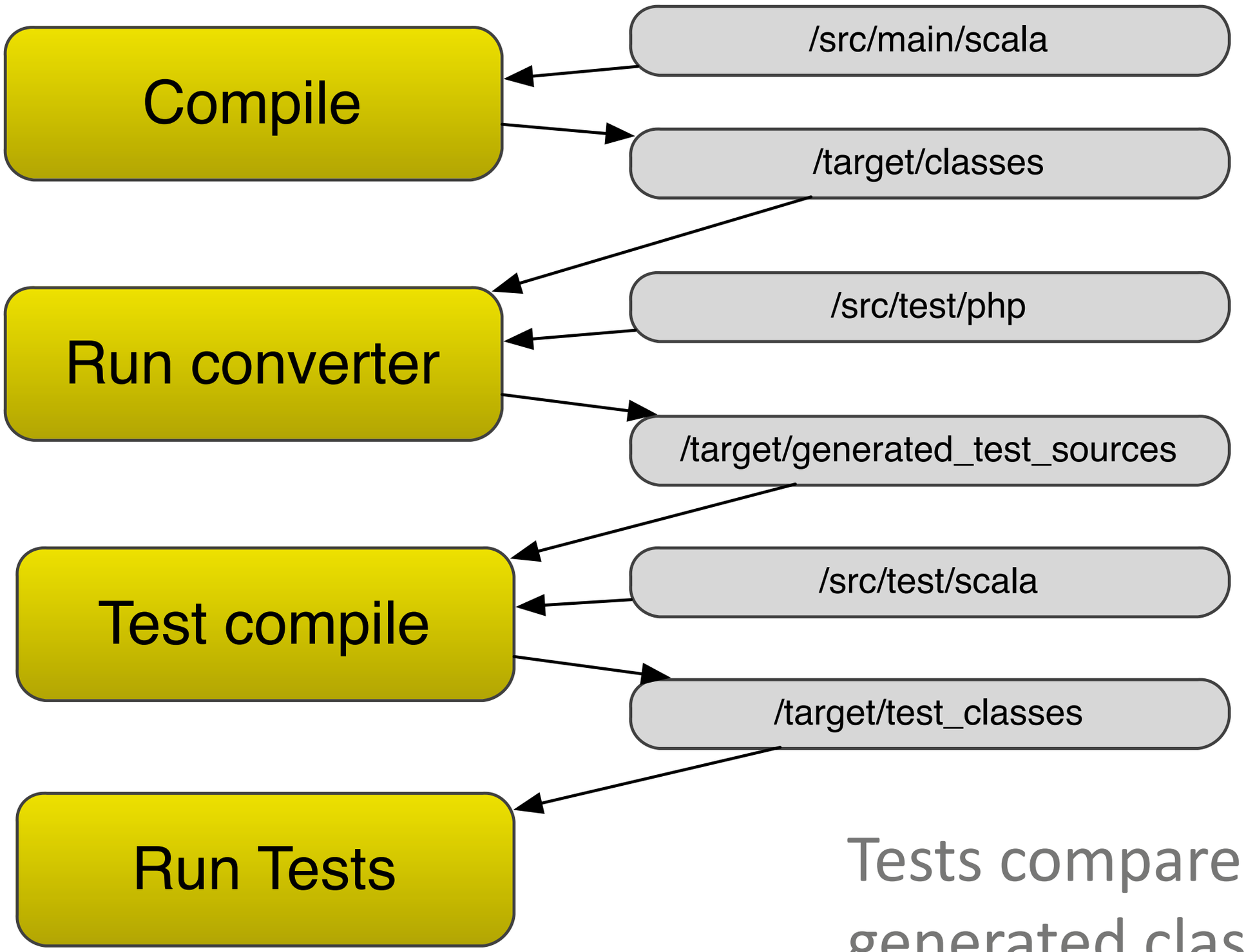

Tests compare output of generated classes.

Hurdle 5: Implicit array/class creation

Assignments may create arrays/classes

```php
<?php

$a[][][] = 3;

var_dump($a);

$b[1][2]->bla = "Hello";

var_dump($b);
?>
```

```
array(1) {
  [0] =>
  array(1) {
    [0] =>
    array(1) {
      [0] =>
      int(3)
    }
  }
}
PHP Strict standards:
   Creating default object from empty value
array(1) {
  [1] =>
  array(1) {
    [2] =>
    class stdClass#1 (1) {
      public $bla =>
      string(5) "Hello"
    }
  }
}
```

Hurdle 7: Lots of extensions

leanovate
beyond product

1001

PHP ships with lots of buildin functionality

- mb_string: Basic multi-byte string support
- iconv: Deeper charset/unicode support
- curl: HTTP/FTP client
- preg: Regular expressions
- bcmath: Arbitrary length arithmetics
- mysql: MySql database driver
- gd: »libgd« wrapper to create images (e.g. CAPCHA)
- …