Performing Magic with PHP

Metaprogramming and Reflection

Gregor Gabrysiak Stefan Marr Falko Menge

Hasso Plattner Institute
University of Potsdam

15 January 2008

We all know what PHP is...

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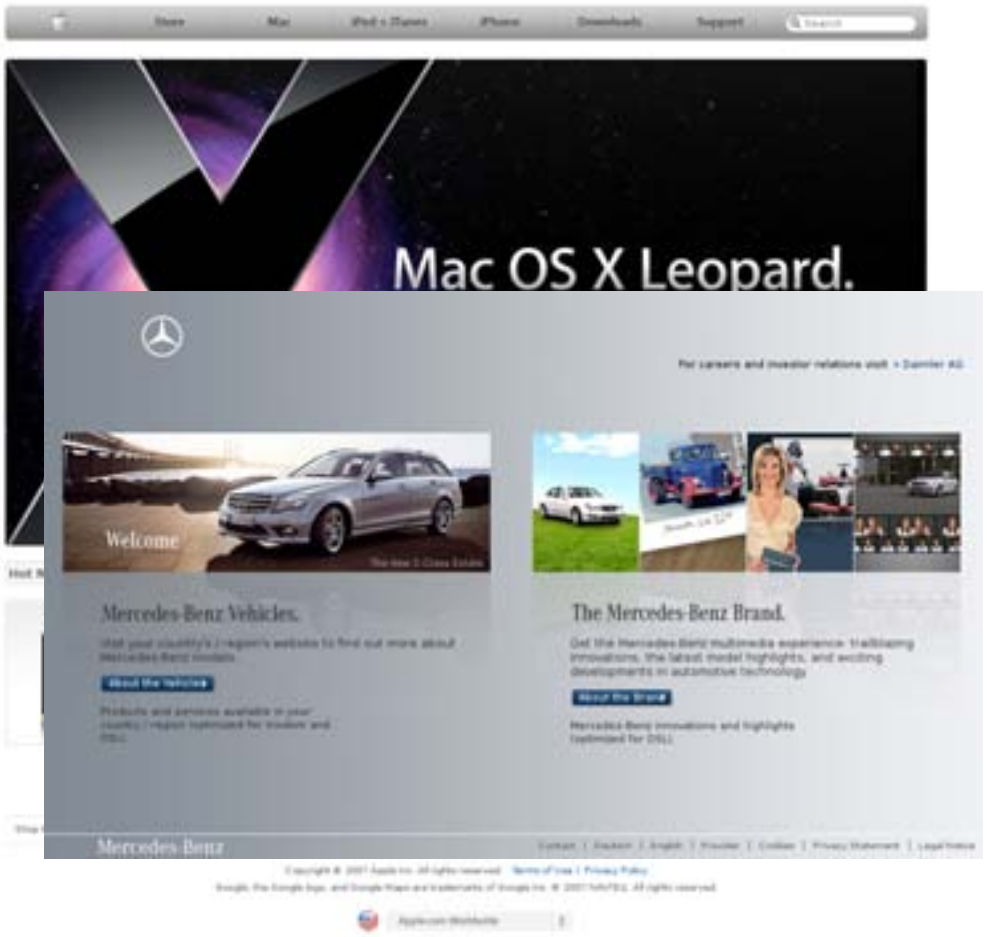

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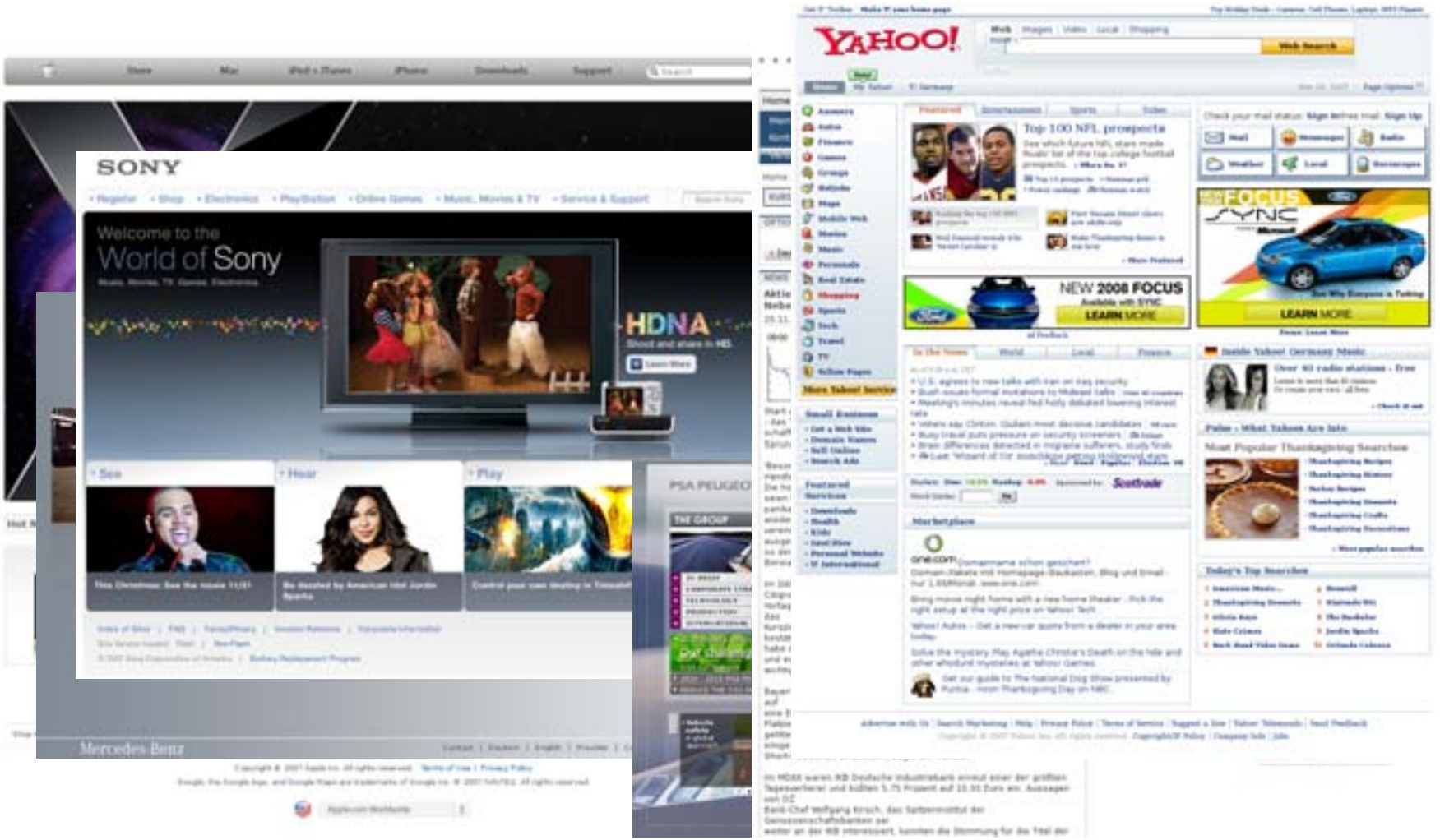


History of PHP

Timeline

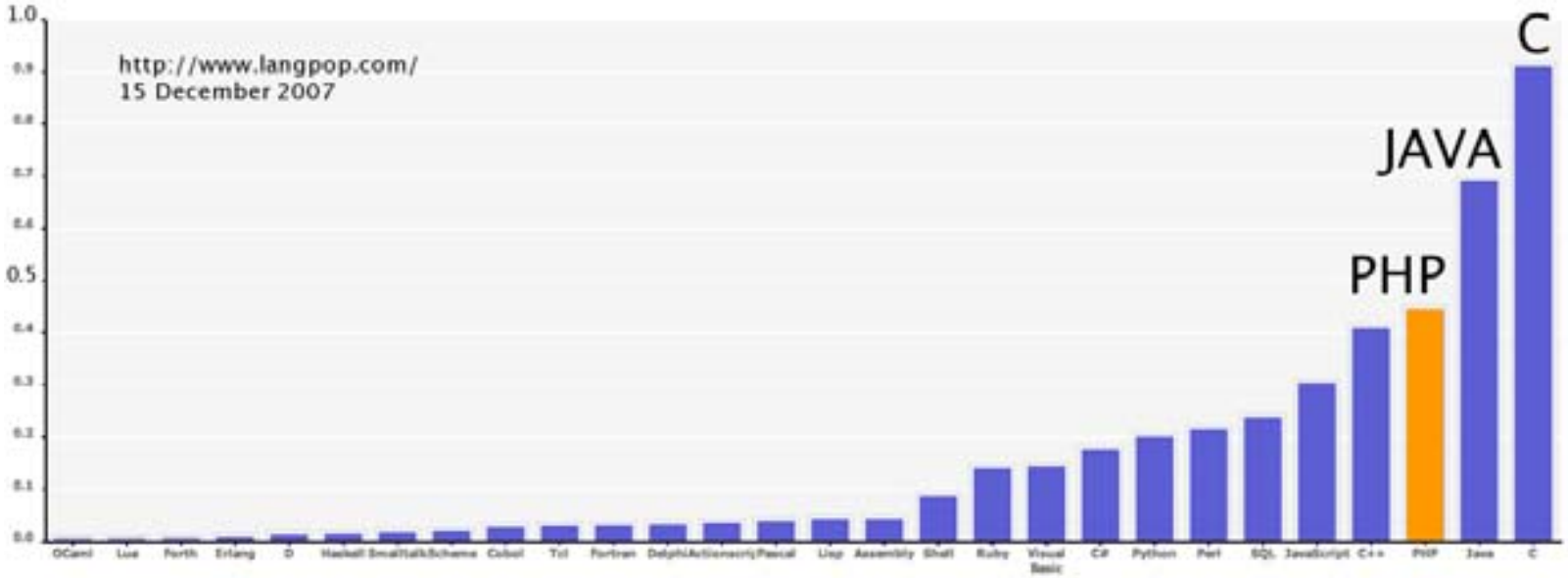
- 1995 "Personal Home Page Tools"
  - Developed by Rasmus Lerdorf
- 1996 PHP: Hypertext Preprocessor Version 2
  - Already used by approx. 1% of all domains (in 1997)
- 1998 PHP 3
  - Available on 10% of all Web servers (1998)
- 2000 PHP 4
  - Zend Engine released, first rudimentary object model
- 2004 PHP 5
  - New object model, improved XML, database abstraction
- PHP 6 is on the way
  - Unicode support, legacy features dropped

Application Domains of PHP

- Server-side scripting - Traditional domain of PHP
- Command-line scripting, partly replacing Perl, Python, awk, or shell scripting

```
php -r "sleep(7*60); echo chr(7);"
```

- Bindings to GUI libraries, such as GTK+, Qt and Win32



Outline

Language Features of PHP

Object Model

- Dynamically typed
- PHP4 has already offered an object model
  - Objects were handled like primitive types
  - Passed by value
- PHP5 has reintroduced classes and interfaces
  - Objects are passed by reference
  - Visibilities
  - Modifiers: `static`, `final`, `abstract`
- Garbage collection basically using reference counting
- Type hinting

```php
interface iDog {
    public function setName($name);
    public function sit();
}
abstract class Dog implements iDog {
    protected $name = "unnamed dog";
    public function setName($name) {
        $this->name = $name;
    }
    final public function sit() {
        echo "$this->name sat down, barking: ";
        echo  $this->bark();
    }
    protected function bark() {
        print "WOOF";
    }
}
class Poodle extends Dog implements iDog {
    final protected function bark() {
        echo " wiif ";
    }
}
$b = new Poodle();
$b->setName("small poodle");
$b->sit();
```

Magic Methods

Dynamic Object Properties

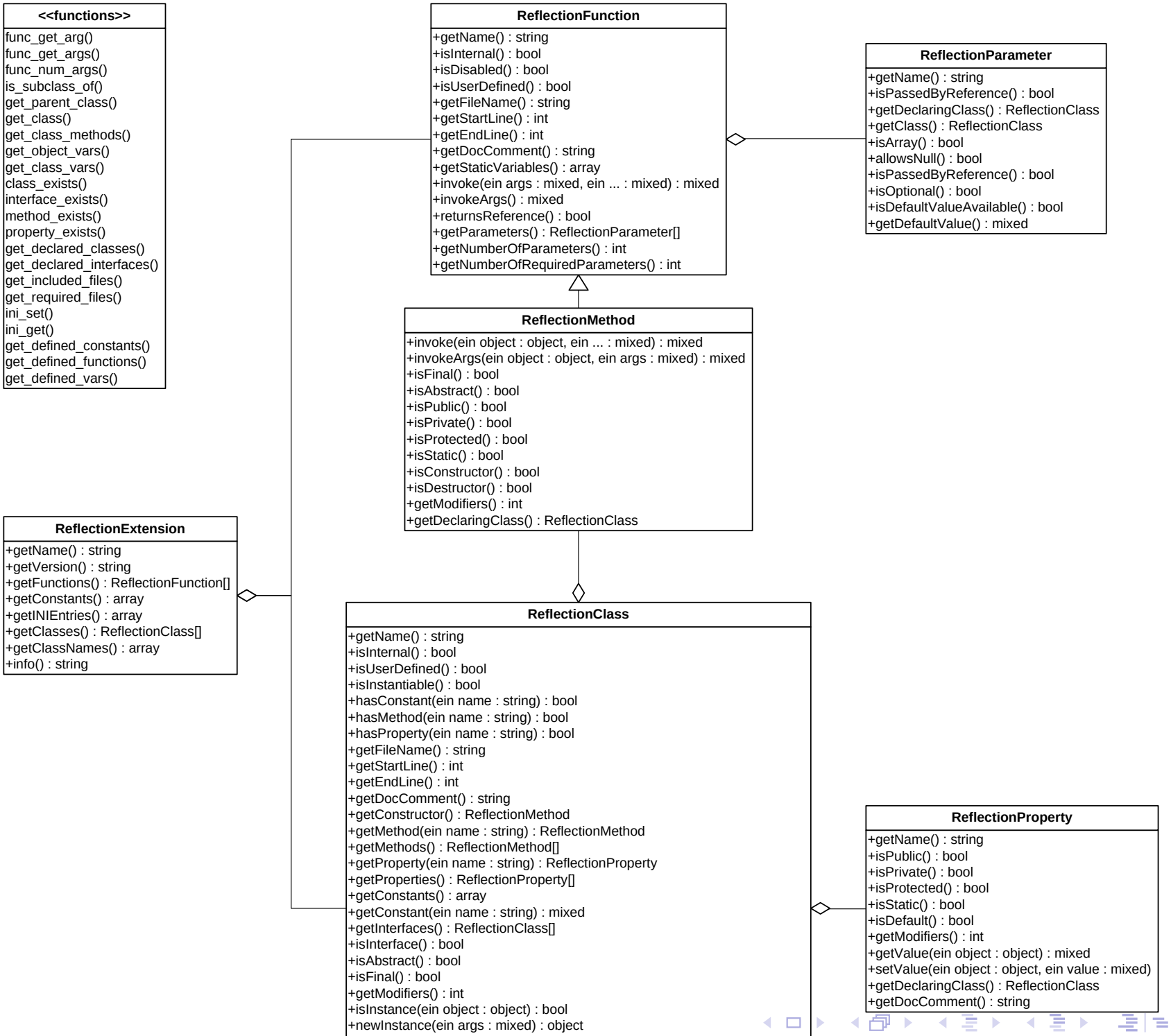
- `__get()`, `__set()`
  - Called when property to get or to set is not available
  - May be overloaded to enforce different behavior
- `__isset()`: tests whether a variable is set or nil
- `__unset()`: destroys the values of certain properties
- `__clone()`: defines how an instance is to be duplicated

- `__toString()`: describes a class' string representation
- `__sleep()`, `__wakeup()`, `__set_state()`

Magic Methods

- `__autoload()`
  - Used to load all necessary classes once
  - Saves parse time and memory
- `__call()`
  - Captures the invocation of non-existing methods
  - Behavior can be adjusted for every class
  - Similar to Smalltalk's `#doesNotUnderstand: aMessage`

```
class s {
  private $default = "default answer";
  public function __call($name, $arguments) {
    echo "Method $name called:\n";
    var_dump($arguments);
    return $this->default;
  }
}
```


<<functions>>
func_get_arg()
func_get_args()
func_num_args()
is_subclass_of()
get_parent_class()
get_class()
get_class_methods()
get_object_vars()
get_class_vars()
class_exists()
interface_exists()
method_exists()
property_exists()
get_declared_classes()
get_declared_interfaces()
get_included_files()
get_required_files()
ini_set()
ini_get()
get_defined_constants()
get_defined_functions()
get_defined_vars()
ReflectionFunction
+getName() : string
+isInternal() : bool
+isDisabled() : bool
+isUserDefined() : bool
+getFileName() : string
+getStartLine() : int
+getEndLine() : int
+getDocComment() : string
+getStaticVariables() : array
+invoke(ein args : mixed, ein ... : mixed) : mixed
+invokeArgs() : mixed
+returnsReference() : bool
+getParameters() : ReflectionParameter[]
+getNumberOfParameters() : int
+getNumberOfRequiredParameters() : int
ReflectionParameter
+getName() : string
+isPassedByReference() : bool
+getDeclaringClass() : ReflectionClass
+getClass() : ReflectionClass
+isArray() : bool
+allowsNull() : bool
+isPassedByReference() : bool
+isOptional() : bool
+isDefaultValueAvailable() : bool
+getDefaultValue() : mixed
ReflectionMethod
+invoke(ein object : object, ein ... : mixed) : mixed
+invokeArgs(ein object : object, ein args : mixed) : mixed
+isFinal() : bool
+isAbstract() : bool
+isPublic() : bool
+isPrivate() : bool
+isProtected() : bool
+isStatic() : bool
+isConstructor() : bool
+isDestructor() : bool
+getModifiers() : int
+getDeclaringClass() : ReflectionClass
ReflectionExtension
+getName() : string
+getVersion() : string
+getFunctions() : ReflectionFunction[]
+getConstants() : array
+getINIEntries() : array
+getClasses() : ReflectionClass[]
+getClassNames() : array
+info() : string
ReflectionClass
+getName() : string
+isInternal() : bool
+isUserDefined() : bool
+isInstantiable() : bool
+hasConstant(ein name : string) : bool
+hasMethod(ein name : string) : bool
+hasProperty(ein name : string) : bool
+getFileName() : string
+getStartLine() : int
+getEndLine() : int
+getDocComment() : string
+getConstructor() : ReflectionMethod
+getMethod(ein name : string) : ReflectionMethod
+getMethods() : ReflectionMethod[]
+getProperty(ein name : string) : ReflectionProperty
+getProperties() : ReflectionProperty[]
+getConstants() : array
+getConstant(ein name : string) : mixed
+getInterfaces() : ReflectionClass[]
+isInterface() : bool
+isAbstract() : bool
+isFinal() : bool
+getModifiers() : int
+isInstance(ein object : object) : bool
+newInstance(ein args : mixed) : object
ReflectionProperty
+getName() : string
+isPublic() : bool
+isPrivate() : bool
+isProtected() : bool
+isStatic() : bool
+isDefault() : bool
+getModifiers() : int
+getValue(ein object : object) : mixed
+setValue(ein object : object, ein value : mixed)
+getDeclaringClass() : ReflectionClass
+getDocComment() : string

PHP5 Reflection API

<<functions>>
func_get_arg()
func_get_args()
func_num_args()
is_subclass_of()
get_parent_class()
get_class()
get_class_methods()
get_object_vars()
get_class_vars()
class_exists()
interface_exists()
method_exists()
property_exists()
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ini_set()
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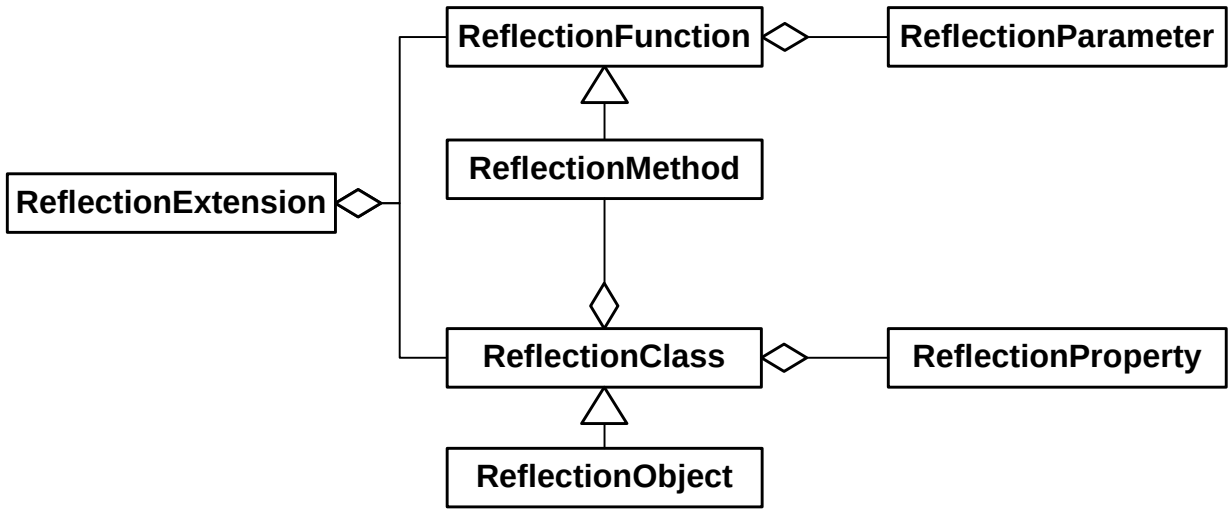
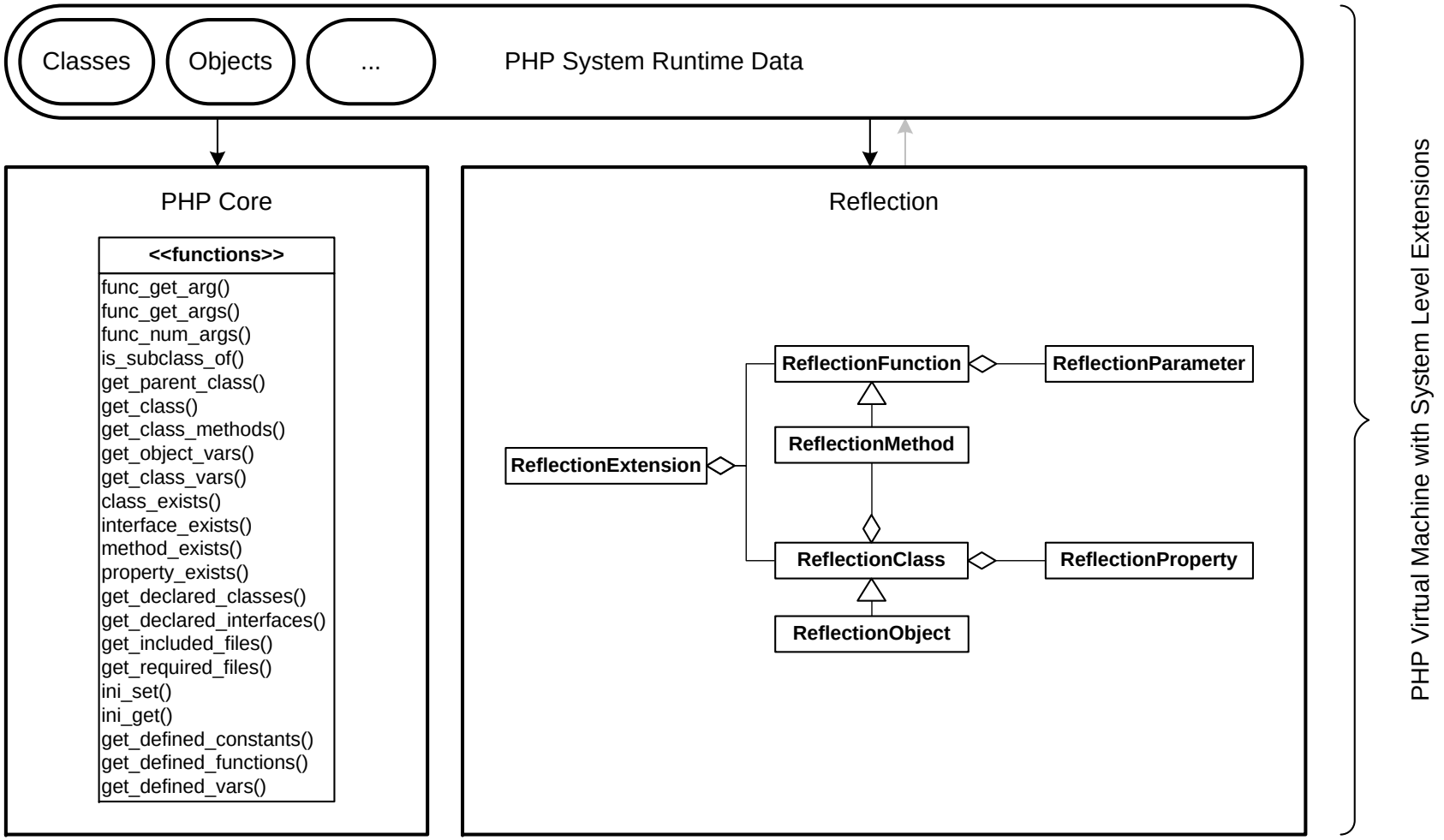
get_defined_constants()
get_defined_functions()
get_defined_vars()

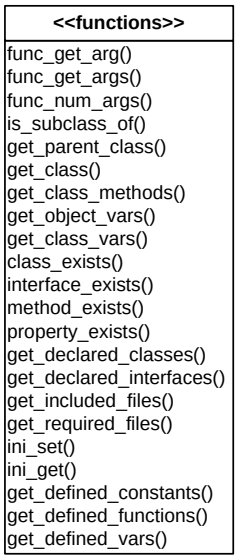


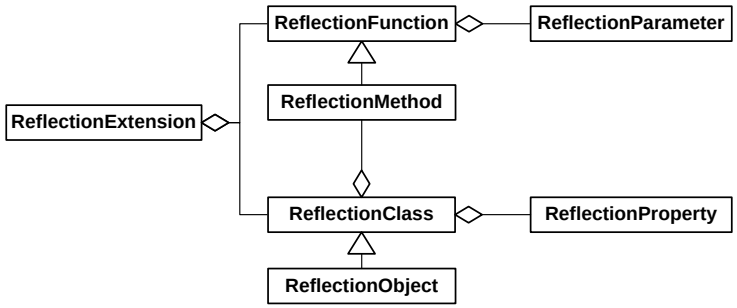
PHP5 Reflection API



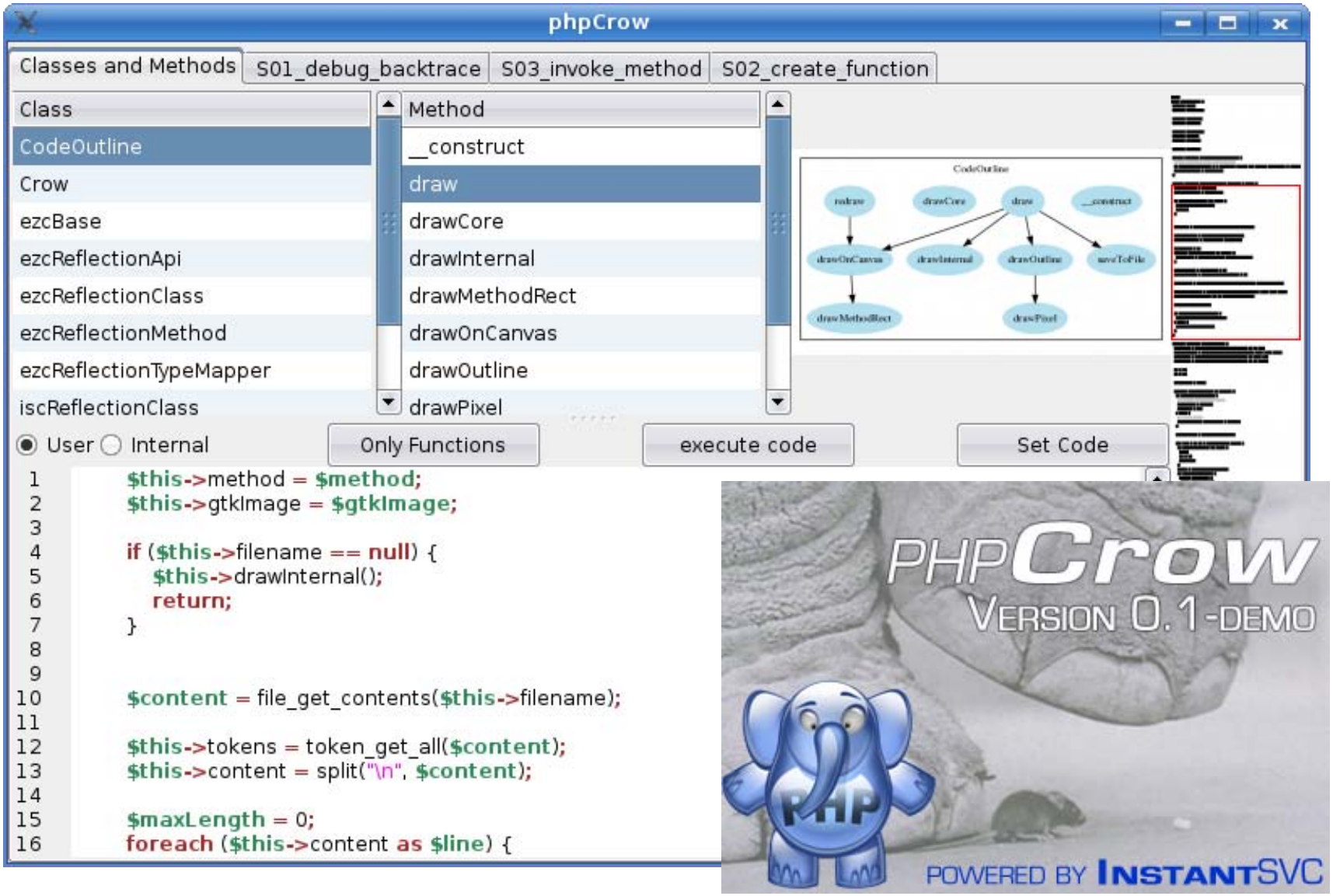
PHP5 Reflection API

- Wraps underlying VM data structures
- Provides introspection and method/function invocation capabilities
- Can be deactivated (to reduce VM memory footprint)
- Respects the *Mirrors* design principle [1] to a high degree





Reflection in Action



Reflection in Action: debug_backtrace

```
class DebugBacktrace {
    public function callee() {
        echo 'Caller of this Function was ',
            DebugBacktrace::getCaller(), ".\n";
    }
    public static function getCaller() {
        $trace = debug_backtrace();
        return $trace[2]['class'] . $trace[2]['type']
            . $trace[2]['function'];
    }
    public function test1() {
        $this->callee();
    }
    public static function test2($t) {
        $t->callee();
    }
}

$d = new DebugBacktrace();
$d->test1(1, 2, 3);
DebugBacktrace::test2($d);
```

Common Usage of Reflection in PHP

- XML/JSON to PHP mapping
- Frameworks for dependency injection and AOP
- PHPCallGraph –> visualization
- PHPUnit: Mockup objects, generation of test skeletons, code metrics

Example for Annotations

```
class Calculator {
    /**
     * @assert (0, 0) == 0
     * @assert (0, 1) == 1
     * @assert (1, 1) == 2
     */
    public function add($a, $b) { return $a + $b; }
}
```

Basic Intercession

Execute Generated Code

- `eval()`
- `create_function()`

Dynamically Call a Method or Function

- `call_user_function()`
- `call_user_function_array()`
- `call_user_method()`
- `call_user_method_array()`
- `$functionName($a, $b);`

Basic Intercession: `create_function`

`create_function`

```
$func = create_function('$foo,$bar', 'echo "CreatedFunction:
    $foo $bar\n";');
$func('Hello', 'World!');
var_dump(addslashes($func));

call_user_func($func, 'FOO', 'baz');

//common usage example
$av = array("the ", "a ", "that ", "this ");
array_walk($av, create_function('&$v,$k', '$v = $v . "mango";'))
    ;
print_r($av);
```

Basic Intercession: Invoke Methods

Invoke Methods

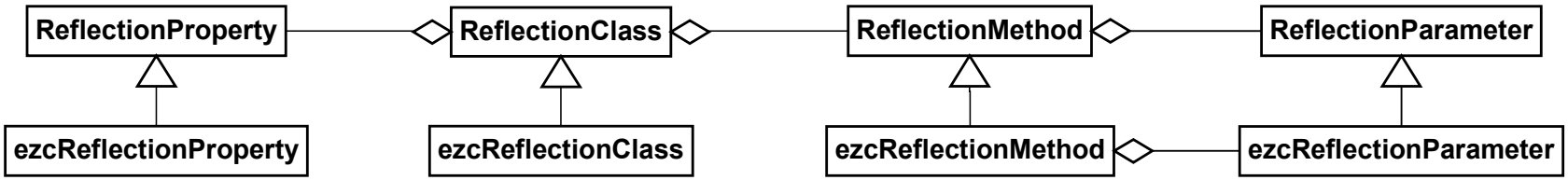
```
class InvokeTest {
  public function callMe() {
    echo "Yeah, you called me!\n";
  }
}

$o = new InvokeTest();
$class = new ReflectionClass($o);
$method = $class->getMethod('callMe');
$method->invoke($o, 'callMe');

function fooFunc($bar) {
   echo "$bar\n";
}

$func = 'fooFunc';
$func('Hello World');
```

Annotations in PHP

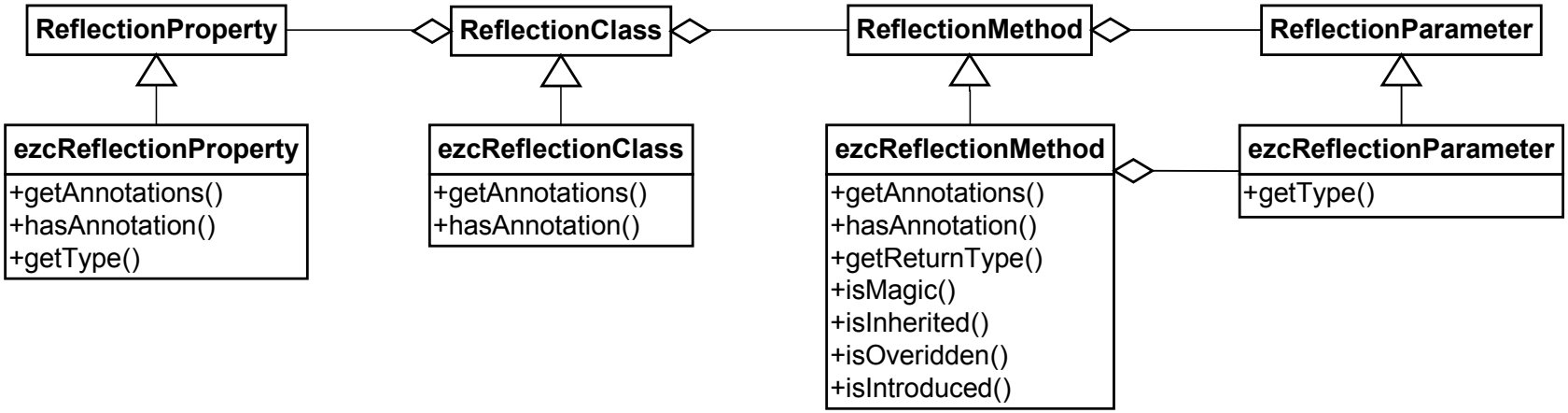
Class with Type Annotations

```
class HelloWorld {

    /**
     * @var string
     */
    private $hello = 'Hello';

    /**
     * @param string $name
     * @return string
     */
    public function getGreeting($name) {
        return "$this->hello $name!";
    }

}
```

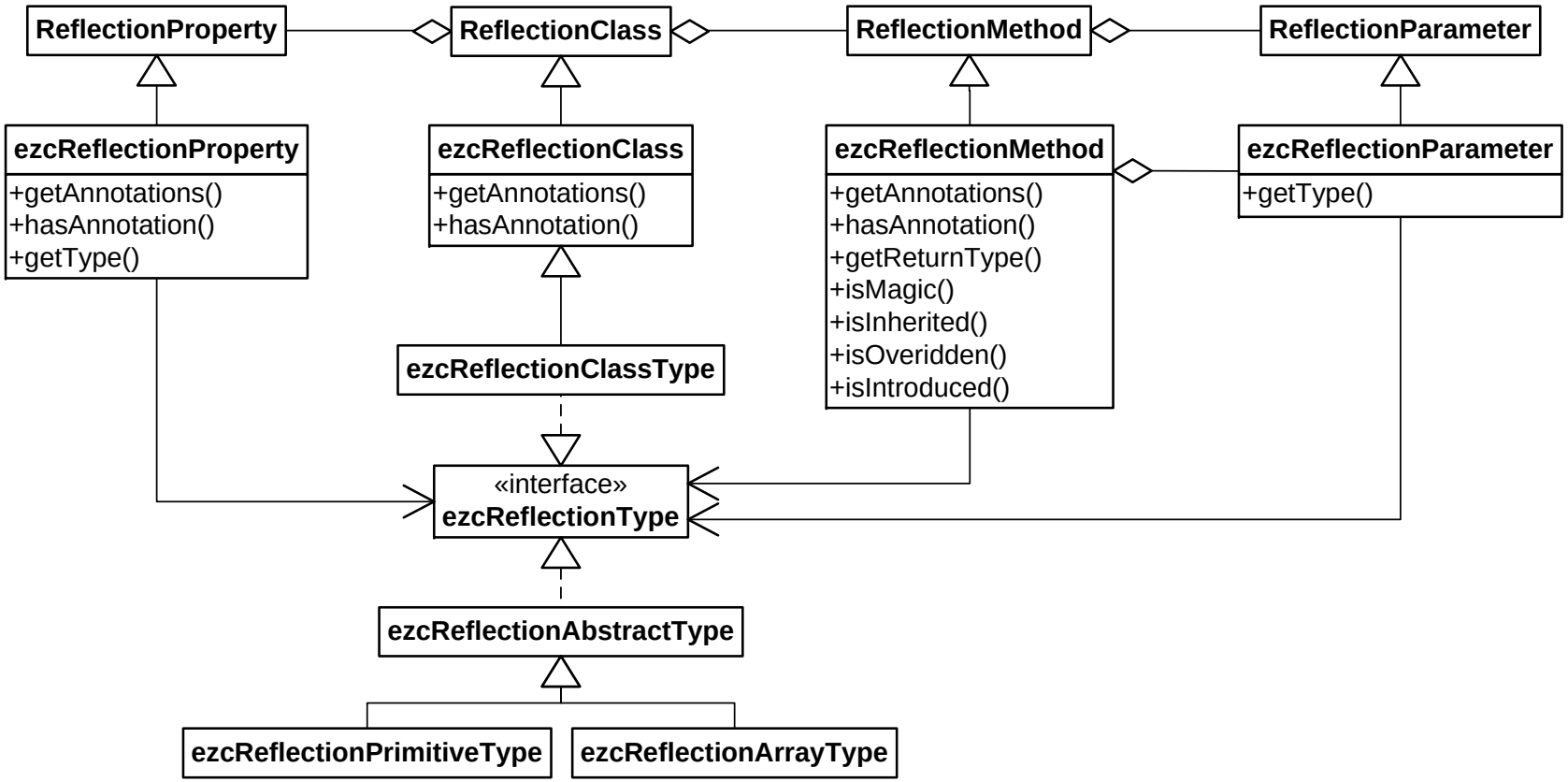
eZ Components: Reflection Component



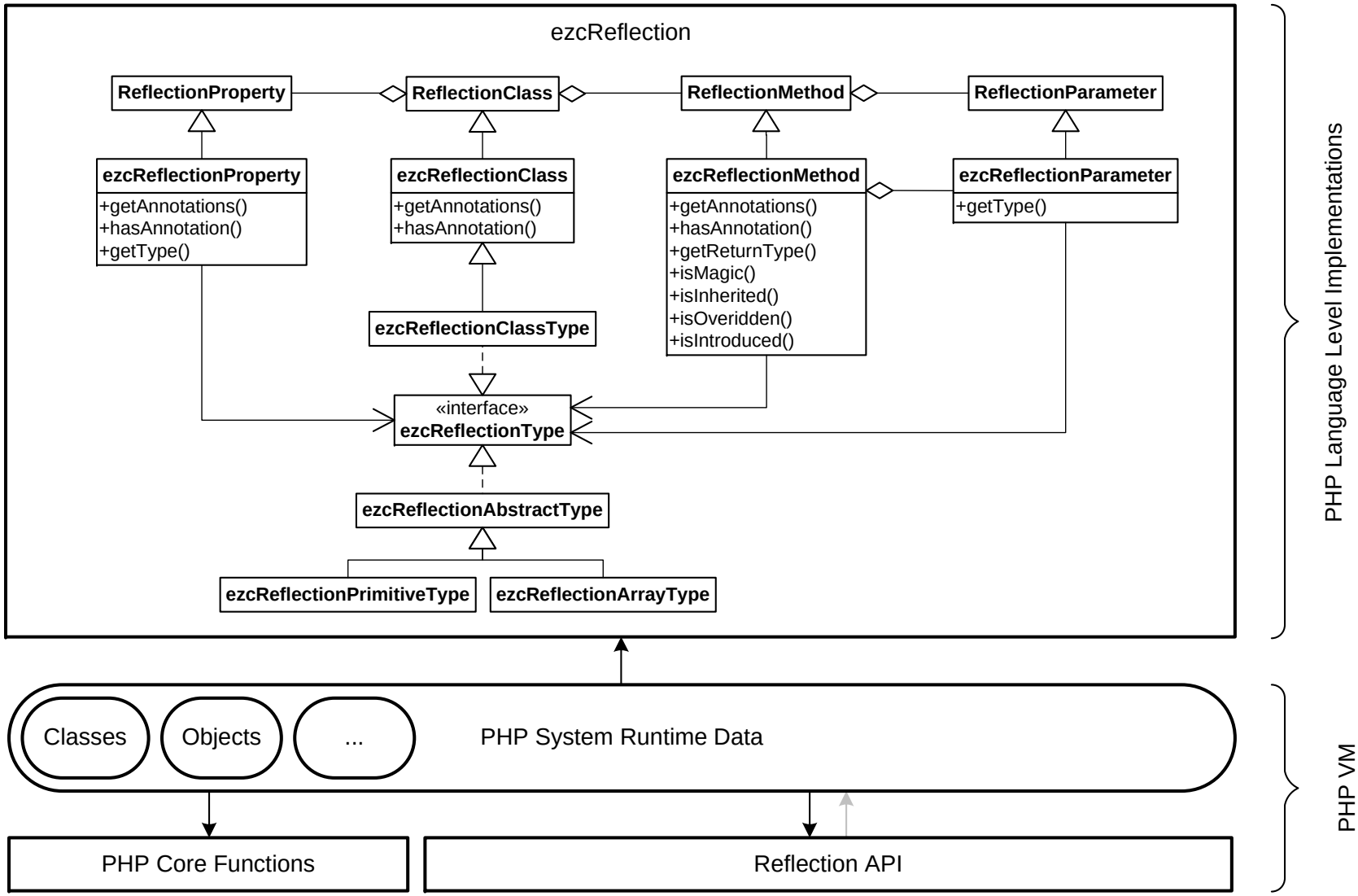
eZ Components: Reflection Component



eZ Components: Reflection Component



eZ Components: Reflection Component



eZ Components: Reflection Component

Feature Summary

- Introduces support for PHPDoc-style annotations
- Type annotations are accessible at runtime for introspection
- No runtime constraints
- Can leverage other reflection implementations as a data source, e.g. StaticReflection
- Used e.g. for WSDL generation

Annotations for WSDL Generation

Hello World Web Service

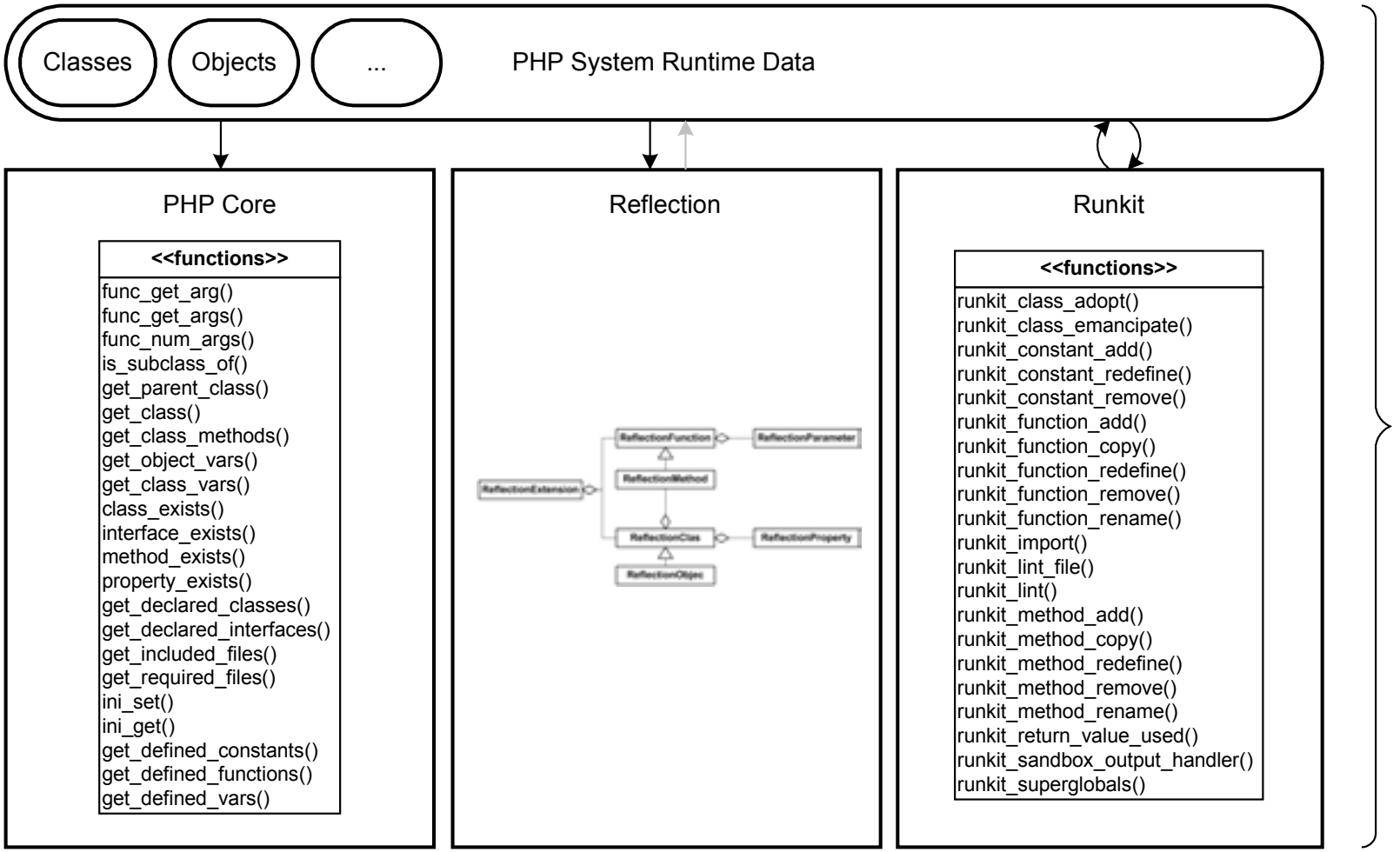
```
/**
 * @webservice
 */
class HelloWorld {

    /**
     * @param string $name
     * @return string
     * @webmethod
     */
    public function getGreeting($name) {
        return "Hello $name!";
    }

}
```

Doing Real Intercession: The Runkit Extension

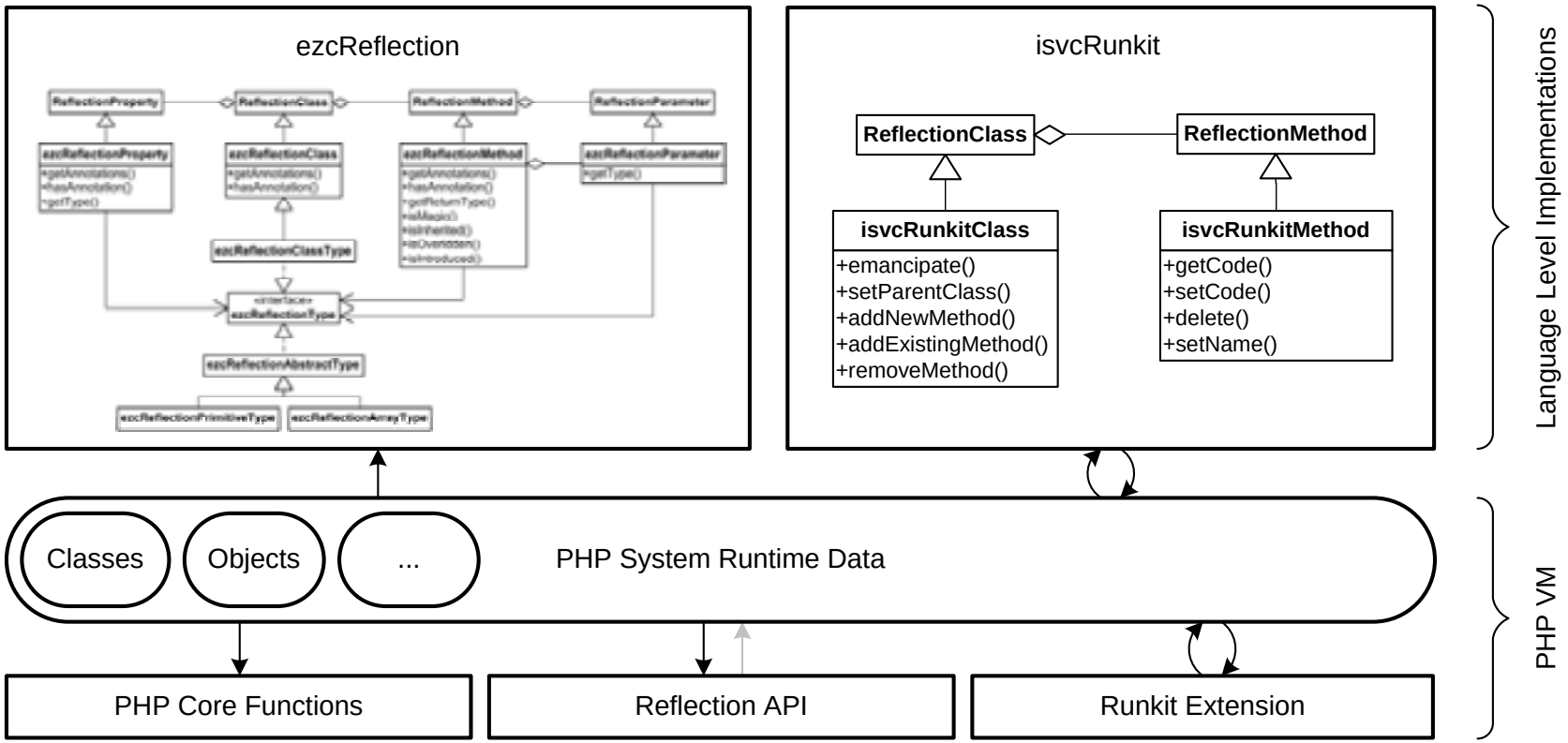
Features of Runkit

- Modify functions and methods
  - add, copy, redefine, rename and remove
- Modify constants and class constants
  - add, redefine and remove
- Modify the inheritance structure
  - adopt and emancipate classes
- Check if a return value will be used
- Sandbox classes
- Lint functions

Doing Real Intercession: The Runkit Extension



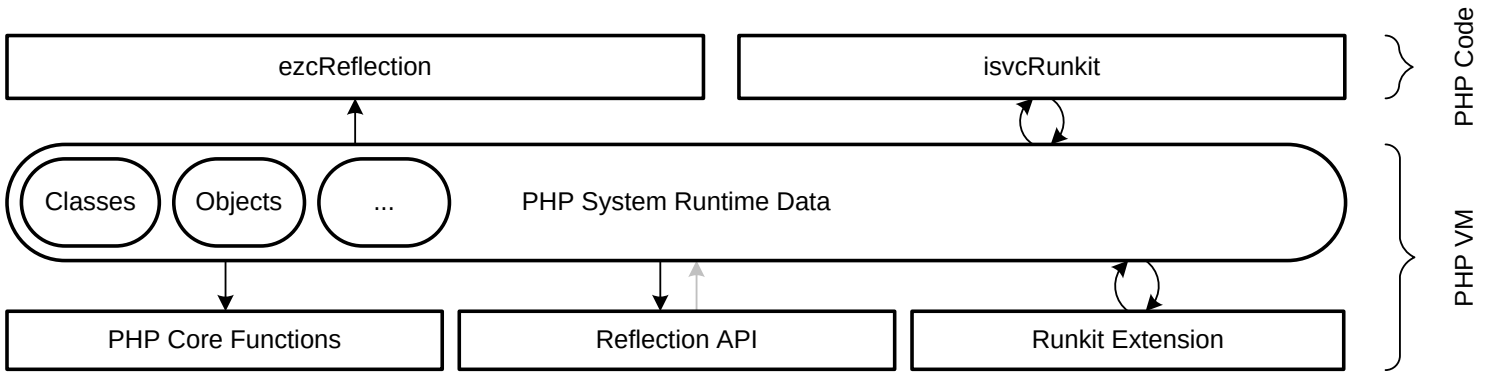
Object-oriented Runkit



Other Metaprogramming Extensions for PHP

- Advanced PHP Debugger (APD)
  - `override_function()`
  - `rename_function()`
  - Similar features provided by Runkit
- Tokenizer and `parse_tree`
  - Not reflective but very helpful for metaprogramming
- Several aspect-oriented programming (AOP) frameworks
  - Static aspect weaving
  - Using PHPDoc-style annotations and sometimes XML

Conclusion



- PHP has many reflective features
  - MOP divided into object-oriented and procedural API
  - Additional features provided by extensions
- Main use case: Web applications
  - Extensive intercession makes not much sense for the usual PHP execution model
  - In general more useful in long running programs, e.g. GTK+, QT, MFC or command line applications

For Further Reading I


Gilad Bracha and David Ungar.
Mirrors: design principles for meta-level facilities of object-oriented programming languages.
In *OOPSLA '04: Proceedings of the 19th annual ACM SIGPLAN conference on Object-oriented programming, systems, languages, and applications*, pages 331–344, New York, NY, USA, 2004. ACM.


Sara Golemon.
Runkit.
PHP Extension, The PHP Group, January 2008.
`http://pecl.php.net/package/runkit`.

For Further Reading II


Stefan Marr and Falko Menge.
ezcReflection.
SVN Repository, eZ Components, January 2008.
http://svn.ez.no/svn/ezcomponents/experimental/Reflection.


PHP Documentation Group.
PHP Manual.
Documentation, November 2007.
http://www.php.net/manual/en/language.oop5.reflection.php.

For Further Reading III

The PHP Group.
PHP Extension Community Library.
Project Site, January 2008.
http://pecl.php.net/.

David Welton.
Programming Language Popularity.
Web Site, DedaSys LLC, 2008.
http://www.langpop.com/.