Static Analysis for PHP

Semester Project
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PHP

- Weak & Dynamic Typing
- Compiler optimized for speed, not safety
- Large internal API (> 2500 functions)
- All kinds of dynamic features

  → "If it can be done, it usually can be done dynamically"

The problem

- Lot of room for run-time errors
  - Nearly all possible errors happen at run-time
- Most of those errors will be non-fatal
- Until recently, PHP was shipped to ignore lots of errors by default

→ Lots of broken or badly written scripts

Previous Work

- PHP-Sat
  - Mostly (only?) structure based
- PHPMD (PHP Mess Detector)
  - Program metrics
  - Some semantic checks
- Pixy
  - Taint-analysis, inter-procedural, for PHP4

This solution

- Structural checks
- Semantic checks
- Data/Type flow analysis
- Based on the grammar of PHP5.3

Why do types matter?

- PHP does type juggling
  - switch
  - What about ctype_digit ?

    → Relying on it is a problem waiting to happen: #50696, #49057, #34772, #25763, #24905, ...
- Non-scalar types

Analysis phases

- *Lexing (Jflex)*
- *Parsing (modified CUP)*
- *ST → AST*
- AST Transformations
- Structural checks
- API
- Semantic analysis
- *AST → CFG*
- Flow analysis

AST Transformations

- Allows to freely transform the AST
- Used for:
  - Include resolver
  - Annotations

Include Resolver

- Link ASTs
- Support some expressions:
  - dirname(), constants, string literals, concatenation

```
include dirname(__DIR__).'/path/to/file.php';
```

- One problem: include is an expression!

Annotations

- Comments preceding declarations
- Compatible with phpDocumentor

```
/**
 * My super concat function
 * @param string $foo
 * @param string $bar
 * @return string
 */
function concat ($foo, $bar) {
    return $foo.$bar;
}
```

Structural Checks

- Looks for common mistakes
  - Conditional class/functions declarations
  - Call-time pass by reference
  - Variable variables ($$a)

```
function foo($a) {
   return ++$a;
}
$b = 2;
foo(&$b);
echo $b;
```

API

- Support for API importation
  - e.g. defined(name: String): Boolean

```
<function name="defined">
  <return><type name="bool"></type></return>
  <args>
    <arg opt="0"><type name="string"></type></arg>
  </args>
</function>
```

Semantic analysis

- Attaches symbols to identifiers
  - Double declarations
  - Inheritance cycles
- Define variable scopes

Data types flow analysis

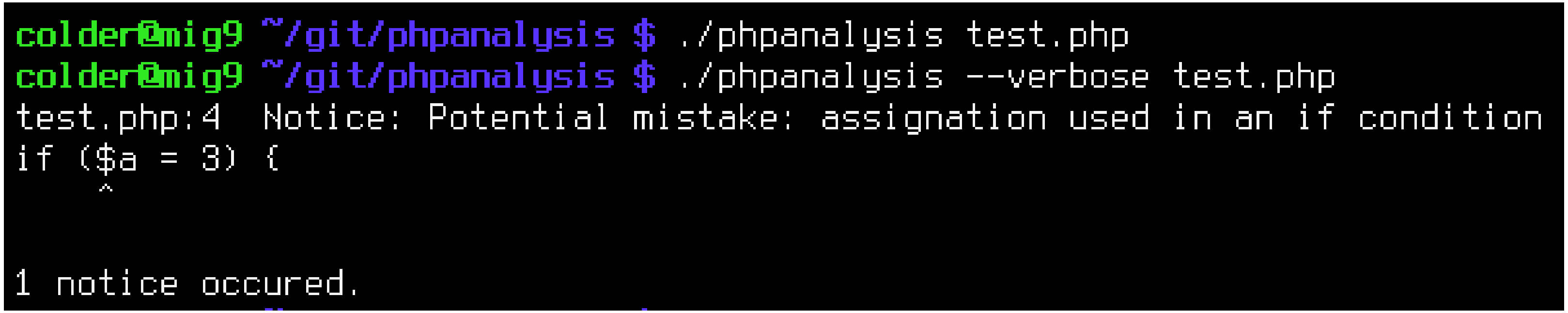
- Model the flow of types for each values in a series of statements
- The result is a model of the possible types for each values at each program point

  → We can typecheck the result

Examples

Multiple verbosities

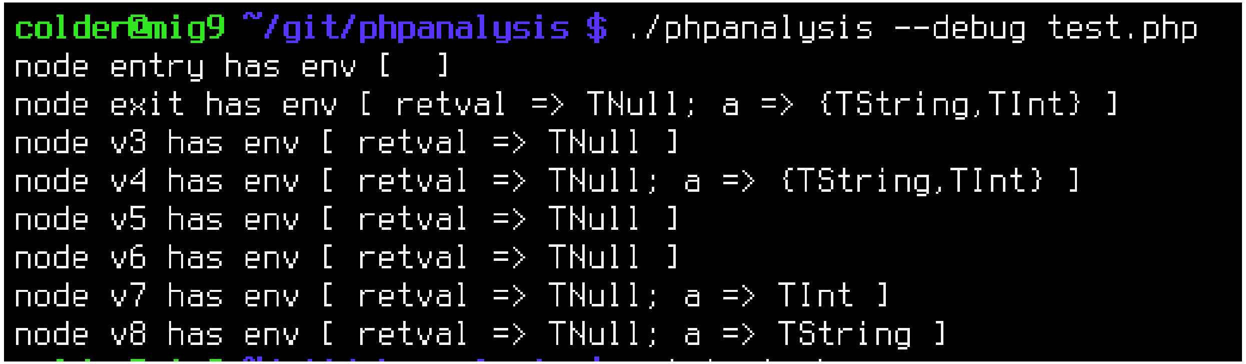
```
<?php
$a = 2;

if ($a = 3) {
    $b = 2;
}
```



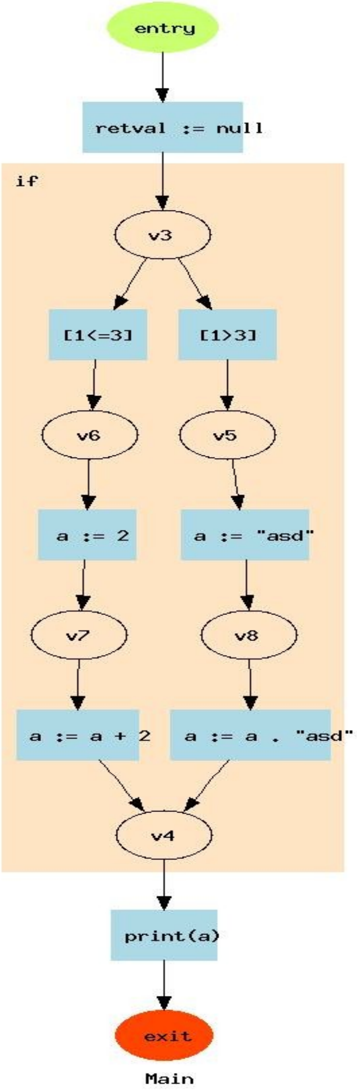
```
colder@mig9 ~/git/phpanalysis $ ./phpanalysis test.php
colder@mig9 ~/git/phpanalysis $ ./phpanalysis --verbose test.php
test.php:4  Notice: Potential mistake: assignation used in an if condition
if ($a = 3) {
    ^


1 notice occured.
```

Branches

```
<?php

if (1 > 3) {
    $a = "asd";
    $a = $a."asd";
} else {
    $a = 2;
    $a = $a+2;
}

echo $a;
```

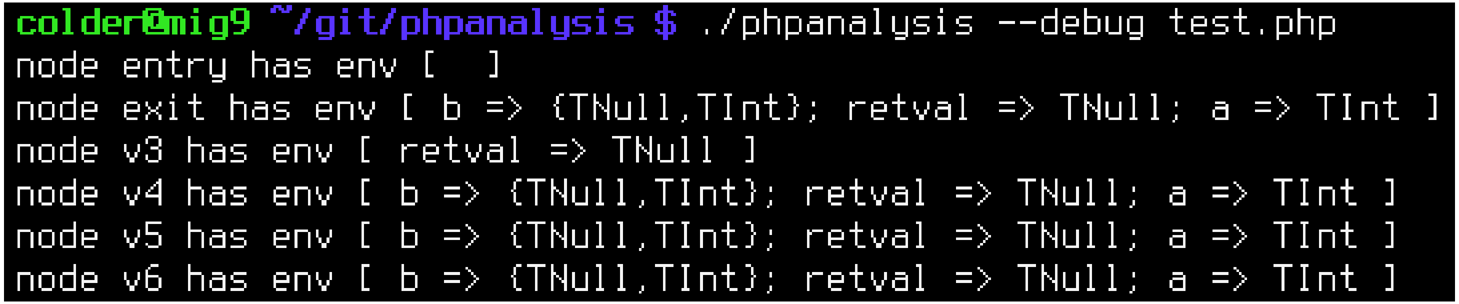


```
colder@mig9 ~/git/phpanalysis $ ./phpanalysis --debug test.php
node entry has env [  ]
node exit has env [ retval => TNull; a => {TString,TInt} ]
node v3 has env [ retval => TNull ]
node v4 has env [ retval => TNull; a => {TString,TInt} ]
node v5 has env [ retval => TNull ]
node v6 has env [ retval => TNull ]
node v7 has env [ retval => TNull; a => TInt ]
node v8 has env [ retval => TNull; a => TString ]
```

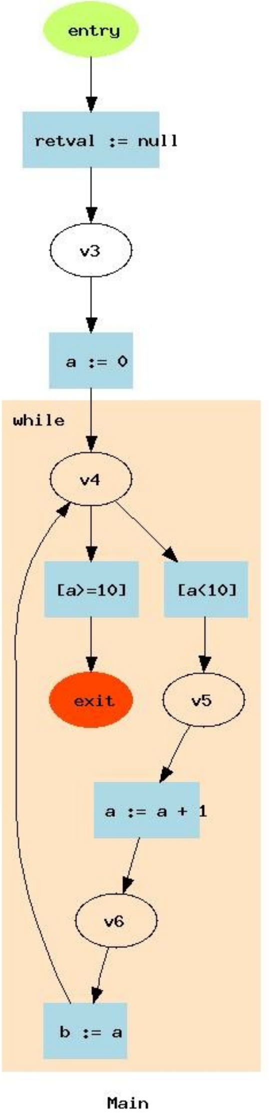


Loops

```
<?php
$a = 0;
while($a < 10) {
    $a = $a + 1;
    $b = $a;
}
```



```
colder@mig9 ~/git/phpanalysis $ ./phpanalysis --debug test.php
node entry has env [  ]
node exit has env [ b => {TNull,TInt}; retval => TNull; a => TInt ]
node v3 has env [ retval => TNull ]
node v4 has env [ b => {TNull,TInt}; retval => TNull; a => TInt ]
node v5 has env [ b => {TNull,TInt}; retval => TNull; a => TInt ]
node v6 has env [ b => {TNull,TInt}; retval => TNull; a => TInt ]
```



Conditional types filtering

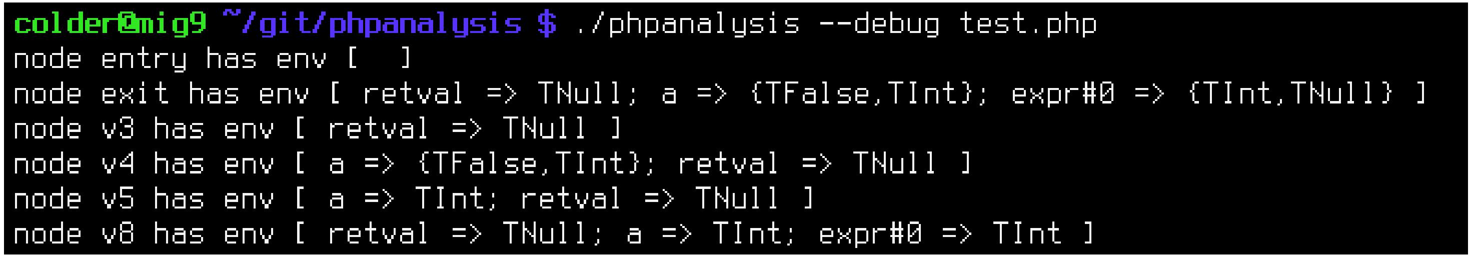
- “remembering” checks
- Every values have a boolean value:

TRUE	FALSE
Arrays, integers, floats, strings, **resources**, **objects**, **true**	Arrays, integers, floats, strings, **false**, **null**

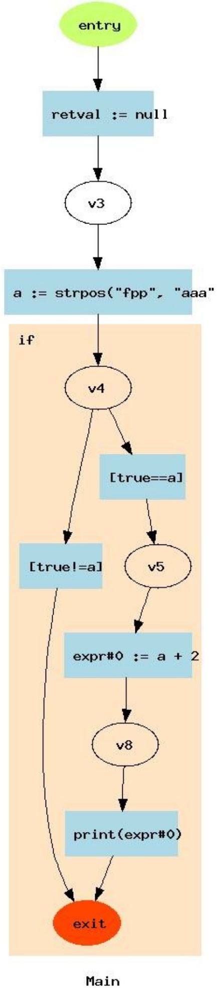
- Lots of functions possibly return *false* on error
- We don't want *false* to pollute our results, if properly checked!

Conditional type filtering

```
<?php
$a = strpos("fpp", "aaa");

if ($a) {
    echo $a+2;
}
```

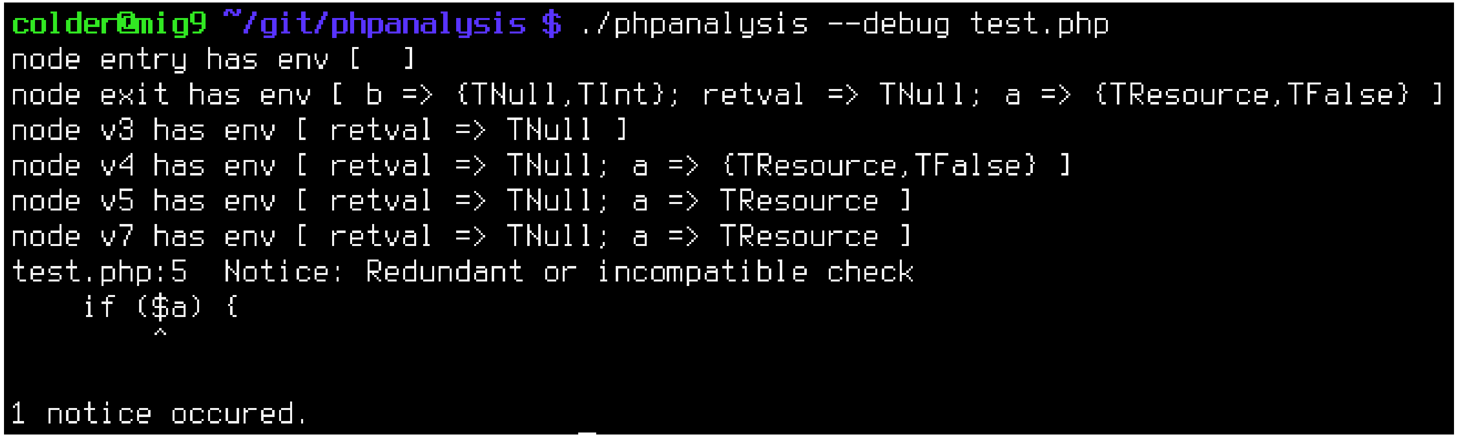


```
colder@mig9 ~/git/phpanalysis $ ./phpanalysis --debug test.php
node entry has env [  ]
node exit has env [ retval => TNull; a => {TFalse,TInt}; expr#0 => {TInt,TNull} ]
node v3 has env [ retval => TNull ]
node v4 has env [ a => {TFalse,TInt}; retval => TNull ]
node v5 has env [ a => TInt; retval => TNull ]
node v8 has env [ retval => TNull; a => TInt; expr#0 => TInt ]
```

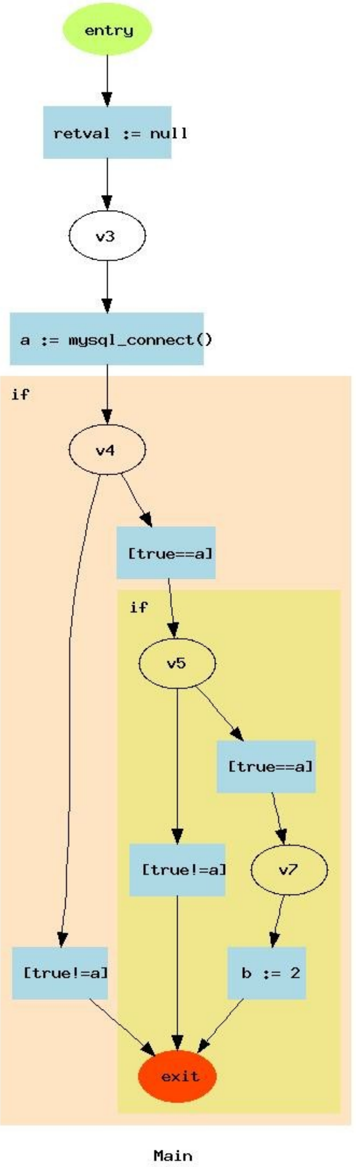


Redundant tests

```
<?php
$a = mysql_connect();

if ($a) {
    if ($a) {
        $b = 2;
    }
}
```



```
colder@mig9 ~/git/phpanalysis $ ./phpanalysis --debug test.php
node entry has env [  ]
node exit has env [ b => {TNull,TInt}; retval => TNull; a => {TResource,TFalse} ]
node v3 has env [ retval => TNull ]
node v4 has env [ retval => TNull; a => {TResource,TFalse} ]
node v5 has env [ retval => TNull; a => TResource ]
node v7 has env [ retval => TNull; a => TResource ]
test.php:5  Notice: Redundant or incompatible check
    if ($a) {
        ^


1 notice occured.
```



Tests on real code

- Used to find 4 mistakes in 2 scripts written by a colleague!
- Too many false positives in complex, modular, OOP code.
  - 134 false notices found in a 370 lines class containing 9 methods

    → Increasing the signal-to-noise ratio is the next challenge!

Future Work

- Stabilize the support for every PHP5.3 features
- Provide a decent model for references
- Improve annotations for complex arrays
- Add support for in-code annotations?
- ...