East Carolina UNIVERSITY

Supporting PHP Dynamic Analysis in PHP AiR

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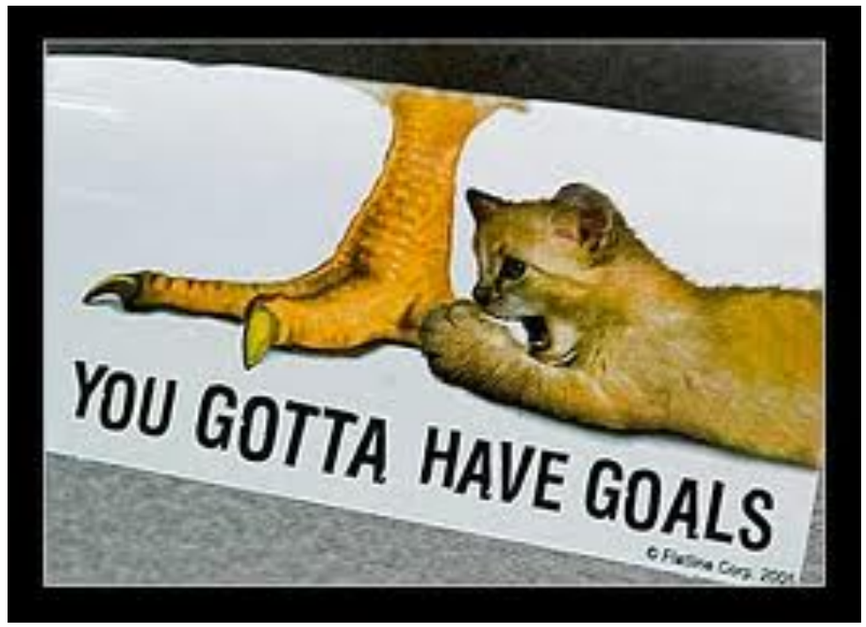
http://www.rascal-mpl.org

PHP AiR: PHP Analysis in Rascal

- PHP AiR: a framework for PHP source code analysis
- Domains:
  - Program analysis (static/dynamic)
  - Software metrics
  - Empirical software engineering



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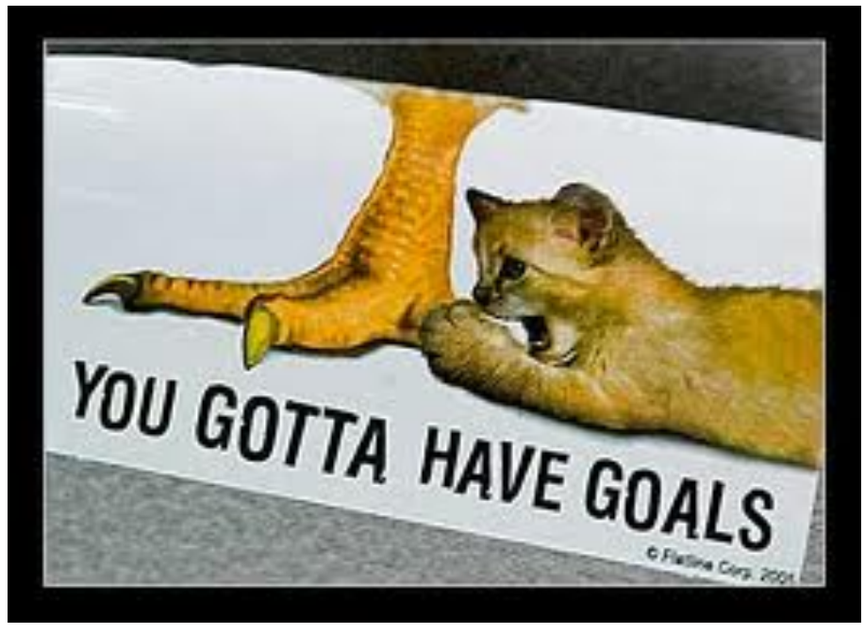

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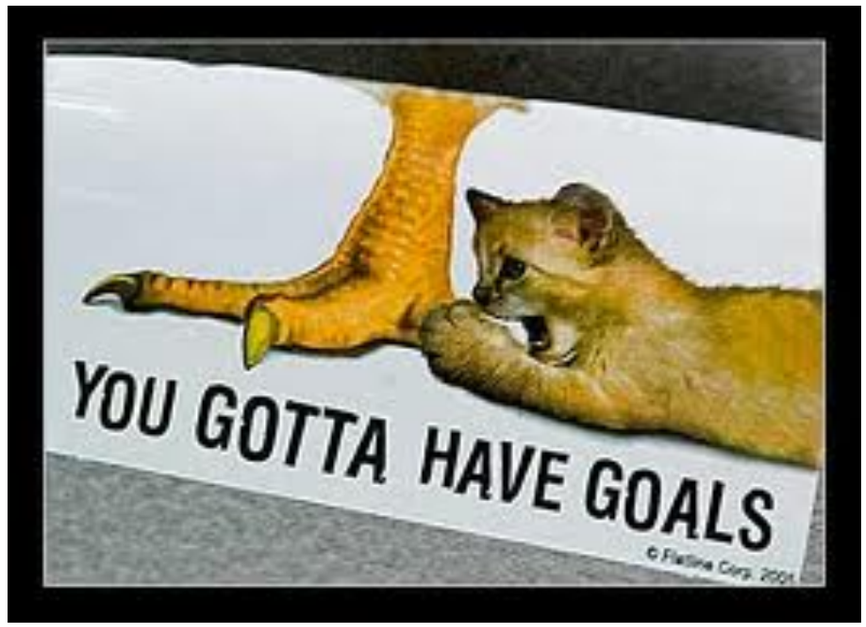


A quick note on Rascal

- “Rascal is a domain specific language for source code analysis and manipulation a.k.a. meta-programming.” (http://www.rascal-mpl.org/)

- Language focus: **program analysis**, program transformation, domain-specific language creation

- Current projects across large numbers of domains, both outside and within academia (including this one!)

- Open source, committers worldwide

Original motivation: dynamic invocations

- Reflective capability in PHP for invoking functions and methods
- Runtime target given as PHP *callable*, not as regular identifier
  - Function name
  - Object instance and method name
  - Class name and method name
  - Closures (in newer versions, not common yet)
- Parameters passed as var-args or as array

Dynamic invocations: two quick examples

```
// From MediaWiki 1.19.1
if ($this->mPage->getID() != $this->mRev->getPage())
{
   $fun = array(get_class($this->mPage),'newFromID');
   $this->mPage =
     call_user_func($fun, $this->mRev->getPage());
}
```

```
// From WordPress 3.4
$args = wp_list_widget_controls_dynamic_sidebar(
          array(0 => $args,
                1 => $widget['params'][0]));
call_user_func_array('wp_widget_control', $args);
```

What are they used for? Why study them?

- Often used for plugin systems and user extensions
- Presence makes it hard to analyze the program
  - How do we build a call graph?
  - How do we compute types? aliases? taint?
- Indirection also slows execution (observational, no figures yet)
- Not uncommon, so cannot just ignore: 94 in WordPress 3.4, 149 in MediaWiki 1.19.1 (see our ISSTA 2013 paper for details)

Possible solution: code specialization

- Idea based on work by Furr, An, and Foster: *Profile-Guided Static Typing for Dynamic Scripting Languages* (OOPSLA 2009)
  - Trace executions of system, execute using test scripts
  - Replace dynamic features with static variants and “catch-all”
- Original work used Ruby, Mulder applied technique to PHP and WordPress (see thesis *Reducing Dynamic Feature Usage in PHP Code*)
- Results installation-specific, based on specific plugins used

Why not just use the existing solution?

- Earlier work had a complex tool chain, hard to set up and reuse
- Very scenario-specific, targeted specifically at dynamic invocations, we need a generic tracing framework
- No support for figuring out where strings come from, useful for analysis and empirical studies

Supporting dynamic analysis in PHP AiR

- Now: Support function trace analysis directly in PHP AiR
  - Flexible parsing and filtering capabilities
  - Directly in Rascal, easy to extend, share, replicate
- Future: support execution of tests from within Rascal
  - Initial support for driving xdebug exists, needs further work
- Early stage: Instrument interpreter to track origins of strings

Function trace analysis in action: PHP defines

- First, generate trace/traces (currently outside of PHP AiR)
- Parsing, stage 1: Read in line from trace file, determine the record type, apply initial filtering
- Parsing, stage 2: parse function parameters, apply additional filtering
- Major bottleneck is speed of parser
- Further challenge: location information in not precise, line-based

String origins

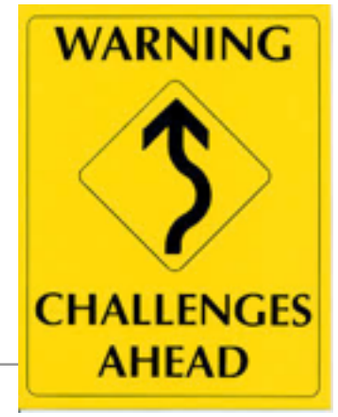
- Based on origin tracking (van Deursen, Klint, and Tip) and string origins (Inostroza, van der Storm, and Erdweg)

- Goal: figure out where strings come from, track transformations of strings through program execution

- Origins tracked using source locations of literals, info on external inputs, transformation functions; origin types based on how string is created

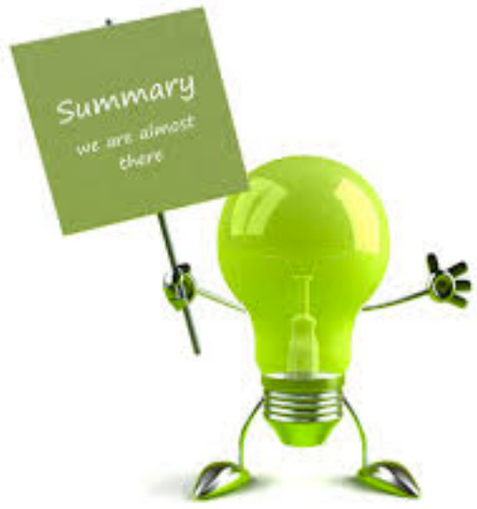
- Still very early in implementation

String origins: challenges



- PHPs main goal in life: generate strings
- String-handling code is often optimized, we need to undo this
- Looking into HHVM, changes may be less disruptive, Quercus may be an implementation dead-end (supports PHP 5.4, nothing newer)
- Also looking into K, instrument existing PHP semantics (e.g., *An Executable Formal Semantics of PHP* by Filaretti & Maffeis, ECOOP 2014), simplicity of interpreter may allow us to be more precise

Summary



- Dynamic analysis for PHP is needed to properly analyze and study dynamic language features

- We are extending PHP AiR to enable flexible dynamic analysis for PHP

- Trace parsing and filtering works well, adapting to handle undocumented xdebug outputs

- String origins work is still ongoing, reevaluating choice of platform, looking for interested students

Discussion

Thank you!
Any Questions?

- Rascal: http://www.rascal-mpl.org
- Me: http://www.cs.ecu.edu/hillsma

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