dippy_gram: Grammar-Aware, Coverage-Guided Differential Fuzzing (WIP)

Ben Kallus, Sean W. Smith, James Utley

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Overview

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Dippygram is a differential fuzzer that uses coverage information, grammar-based mutations, and a novel bug minimization scheme to detect crashing and non-crashing bugs.

We apply dippygram to a suite of URL parsers, and have discovered numerous parser differentials, both crashing and non-crashing.
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- Uses AFL instrumentation, and is thus compatible with many interpreted languages through python-afl, Kelinci, and ruby-afl.
- Pretty simple; ~500 loc (10x fewer than NEZHA)
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- For example, RFC 3986 permits a URL parser to ignore or reject password fields from URLs, because their use is deprecated.
- We use configurable program output comparators to ensure that the fuzzer does not report these uninteresting differences.
- This allows us to choose an equivalence that suits our target specification. For example, we can specify that a portion of program output is to be considered case insensitively when determining whether a meaningful difference has been observed.
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- The minimized input’s trace is recorded, and future inputs with the same trace after minimization are ignored.
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Too-permissive scheme validation

.://example.com

<table>
<thead>
<tr>
<th>Parser</th>
<th>Scheme</th>
<th>Host</th>
<th>Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPython</td>
<td>.</td>
<td>example.com</td>
<td>.://example.com</td>
</tr>
<tr>
<td>rfc3986</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>urllib3</td>
<td></td>
<td></td>
<td>//example.com</td>
</tr>
</tbody>
</table>
Bad IPv6 hostname validation

http://[::1]example.com

<table>
<thead>
<tr>
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<tr>
<td>CPython</td>
<td>::1</td>
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<tr>
<td>CPython</td>
<td>::1</td>
</tr>
<tr>
<td>everything else</td>
<td>rejects</td>
</tr>
</tbody>
</table>
Bad scheme validation
evil.com://good.com

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<tbody>
<tr>
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<td>evil.com</td>
<td>good.com</td>
<td>//good.com</td>
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Bad port validation

http://example.com:  +8_0

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<tbody>
<tr>
<td>CPython</td>
<td>http</td>
<td>example.com</td>
<td>80</td>
</tr>
<tr>
<td>Hyperlink</td>
<td>http</td>
<td>example.com</td>
<td>80</td>
</tr>
<tr>
<td>rfc3986</td>
<td>http</td>
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Improper Unicode handling
http://example.com:1\u06F0

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Detecting bug composition

If we have encountered bugs \( A \) and \( B \), the presence of both at once should not be considered a new bug. We currently solve this by ensuring that mutations are small enough that multiple bugs are not likely to be introduced in the same mutation step.

Experiments

We have a lot of experiments left to run, including:

- Evaluation of different mutation combinations.
- Evaluation of differential fuzzing across programming language boundaries.
- Comparison to symbolic execution-based approaches.
- Extending our approach to other formats:
  - HTTP (ongoing)
  - Fuzzing to enumerate differences between standards.
  - Differential fuzzing across architecture-specific code using AFL’s QEMU mode.

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Thank You.

Contact me! (benjamin.p.kallus.gr@dartmouth.edu)

This work was funded by the DARPA GAPS and SafeDocs programs.

https://github.com/kenballus/url_differential_fuzzing