FuzzChick

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We'll come back to this...

QuickChick: A Brief Review

QuickChick is a properties based testing framework for Coq.

- You build (or derive) generators for data types.
- Using those generators you can feed data into test cases.
- These test cases can be any arbitrary predicate.

QuickChick: Pros and Cons

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What's not so great about QuickChick?

- Getting *good* generators can be hard!

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In general you want good coverage. How can you achieve that with minimal work?

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Why is this good?

FuzzChick Intuition

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Maybe we can utilize AFL's smarts to achieve better test coverage.

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Maintainer fixed this issue promptly, which was *awesome*!

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- QuickChick generates "random" files for each test, and the names aren't all that useful
  - Modified QuickChick to include test case in name, but still not ideal.

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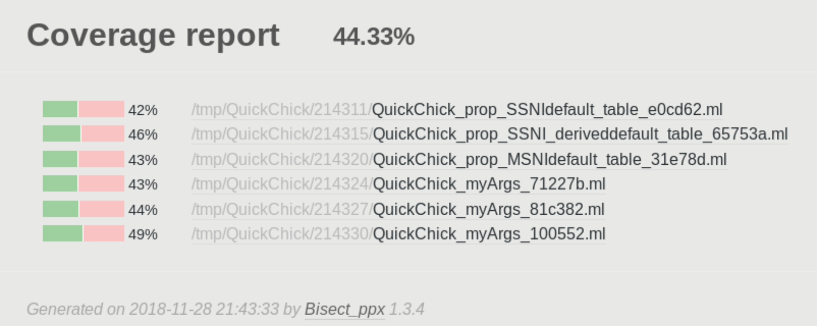
It works! We can measure stuff!

QuickChick Coverage: ifc-basic

Coverage with QuickChick in the ifc-basic example:



QuickChick vs FuzzChick: ifc-basic

QuickChick:

42% /tmp/QuickChick/214311/QuickChick_prop_SSNIdefault_table_e0cd62.ml

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QuickChick:

42% /tmp/QuickChick/214311/QuickChick_prop_SSNIdefault_table_e0cd62.ml

FuzzChick:

39% /tmp/QuickChick/225637/QuickChick_prop_SSNIdefault_table_732ea6.ml

For some reason it seems that FuzzChick actually gets worse coverage than QuickChick on this test case... At least in the time I let it run (I'm not terribly patient)

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  - Hard to tell what "good coverage" is due to the extraneous code extracted by QuickChick.
- Something's not instrumented correctly?
- This test case, for whatever reason, is fuzzer unfriendly?
  - Maybe extracted Coq could be fuzzer unfriendly? Lots of inefficient data types like like `nat` (basically a linked list whose length represents a number).
  - Could result in excessively long paths and hard to solve predicates for DSE?
  - Not sure that having pointers everywhere would be AFL's strength...

Some Further Coverage Testing...

Test case:

```
Extract Constant unlikely_branch =>
" fun i ->
  if (0 < i)
  then if (i mod 100 == 0)
       then if (i mod 1000 == 0)
            then if (i mod 10000 == 0)
                 then if (i mod 100000 == 0)
                      then if (i mod 1000000 == 0)
                           then if (i < 1000001)
                                then 42
                                else 0
                           else 0
                      else 0
                 else 0
            else 0
       else 0
  else 0
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Definition always_zero := forAll (choose (0%Z, 9999999%Z)) (fun n =>
     unlikely_branch n =? 0).
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Trying to give AFL a good chance to find the failing branch...

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then if (i mod 1000000 == 0)                    then if (i < 1000001)
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FuzzChick:

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    then if (i mod 10000 == 0)                    then if (i mod 100000 == 0)                    then if (i mod 1
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Suggests maybe the extracted OCaml is harder for AFL to analyze? The C branches were discovered very quickly by AFL.

Performance

- Fuzzing is an order of magnitude slower than random testing.
- Performance bottleneck: disk access.
- Experiments to see whether the instrumentation overhead is worth it are still in preliminary stages.

Fuzzing a Large Project

How do QuickChick and FuzzChick perform on a large scale project?

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And unfortunately they performed not so well...

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coq $\xrightarrow{???}$ C (Apache)

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$\text{Coq} \xrightarrow{\textit{Extract}} \text{OCaml} \xrightarrow{\textit{Unixcall}} \text{C (Apache)}$

Fuzzing a Large Project

Target:

I want the fuzzers to help me capture what is a string that will make the patched Apache run successfully (exit with 0).

Fuzzing a Large Project

Quickchick:

- **Pros:** Quickchick runs pretty fast at generating test cases.
- **Cons:** Quickchick fails to capture the successful case I want when we generate 10000 random strings. (That sounds natural I guess).

Fuzzing a Large Project

FuzzChick:

- **Pros:** FuzzChick runs AFL and AFL does not generate random string, but it can cheat on having some test script that people wrote.
- **Cons:** It runs pretty slowly (1.2s per test case). Maybe the string it comes up with is meaningful to the server.

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Aborted.

Fuzzing a Large Project

Takeaway:

It is not yet very practical to fuzz large real world project with Coq and OCaml.

Honourable Mentions: Some Other Stuff We Did

- Honggfuzz!
- Plain AFL!

Future Work for QuickChick

- Better support for external program
  QuickChick was originally designed to compile OCaml code extracted from Coq. It used system calls to run external programs. To have AFL to analyze the instance under test (IUT), we need to link the checker and IUT into one instrumented executable.
- Rich path coverage analysis
  There are branches in generator, IUT, and checker. We are specifically interested in the edge coverage of IUT. However, under current framework, the IUT is opaque to analysis.

Conclusion! Questions?

Whew! Questions?

References

- Calvin Beck, Jiani Huang, and Yishuai Li. *Quick700*. 2018. URL: https://github.com/Quick700/Quick700 (visited on 11/29/2018).
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- Leonidas Lampropoulos, Zoe Paraskevopoulou, and Benjamin C Pierce. "Generating Good Generators for Inductive Relations". In: ().
- Michal Zalewski. *AFL*. URL: http://lcamtuf.coredump.cx/afl/ (visited on 11/29/2018).

These are all good resources! You should look at them!