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FuzzChick is an experiment to improve QuickChick using ideas from fuzzing. This combines QuickChick with AFL [3].

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FuzzChick is an experiment to improve QuickChick using ideas from fuzzing. This combines QuickChick with AFL [3].

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?

# Finally, FuzzChick!

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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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Compiling with absolute paths cause an infinite loop #180



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

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



But...

# It works! We can measure stuff!

# QuickChick Coverage: ifc-basic

Coverage with QuickChick in the ifc-basic example:

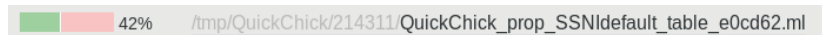
## Coverage report 44.33%

		42%	<a href="#">/tmp/QuickChick/214311/QuickChick_prop_SSNldefault_table_e0cd62.ml</a>
		46%	<a href="#">/tmp/QuickChick/214315/QuickChick_prop_SSNl_deriveddefault_table_65753a.ml</a>
		43%	<a href="#">/tmp/QuickChick/214320/QuickChick_prop_MSNIdefault_table_31e78d.ml</a>
		43%	<a href="#">/tmp/QuickChick/214324/QuickChick_myArgs_71227b.ml</a>
		44%	<a href="#">/tmp/QuickChick/214327/QuickChick_myArgs_81c382.ml</a>
		49%	<a href="#">/tmp/QuickChick/214330/QuickChick_myArgs_100552.ml</a>

Generated on 2018-11-28 21:43:33 by [Bisect\\_ppx 1.3.4](#)

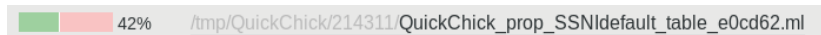
# QuickChick vs FuzzChick: ifc-basic

QuickChick:

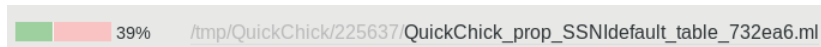


# QuickChick vs FuzzChick: ifc-basic

QuickChick:



FuzzChick:



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 `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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In the equivalent C code AFL does quite well...

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QuickChick:

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then if (i mod 1000000 == 0)                then if (i < 10000001)
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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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Well, in fairness, it does eventually, but it takes a good 30 minutes. QuickChick was much faster.

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.



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We tried them on Apache's httpd,

And unfortunately they performed not so well...

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$\text{coq} \xrightarrow{???} \text{C (apache)}$

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$\text{coq} \xrightarrow{???} \text{C (apache)}$

$\text{coq} \xrightarrow{\text{Extract}} \text{Ocaml} \xrightarrow{\text{Unixcall}} \text{C (apache)}$

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## Good news:

- Both Quickchick and FuzzChick successfully run on the apache server.

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- Both Quickchick and FuzzChick successfully run on the apache server.

## Bad news:

- We failed to go deeper than the client side on the server.

# Fuzzing a Large Project

Since I don't know what is the string that will make Apache run normally. (Thanks to the lack of documentation and the pthread function the patch is using.) 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 testscript that people wrote.
- **Cons:** It runs pretty slowly ( 1.2s per testcase). 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



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## ■ Honggfuzz!

- ▶ Finally got this working...
- ▶ Didn't really work out because it takes a long time to find bugs by fuzzing.
- ▶ Decided it wasn't really a great comparison to FuzzChick which is a properties based testing tool anyway.
- ▶ Some useful scripts / documentation to get this running in our git repo. [1]

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## ■ Plain AFL!

- ▶ Similar story to Honggfuzz.

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).
-  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!