osnap! Painless and massive regression test generation for OCaml

Valentin Chaboche

Nomadic Labs, Paris, France valentin.chaboche@lambda-coins.com

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- Bill arrives as the saviour of the camel worshippers: he has to optimise the software to allow more camel worshippers to exchange their non-fungible tokens.
- The problem is that if Bill makes a mistake, the blockchain collapses.

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He manages to isolate a certain function `sum`:

```
type t =
  | Leaf of int
  | Node of t * t

(** /!\ Do not modify /!\ *)
let rec sum = function
  | Leaf x -> x
  | Node (a, b) -> sum a + sum b
```

He then decided to optimise the function using his extensive knowledge of OCaml:

```
let sum tree =
  let rec sum tree cont = match tree with
    | Leaf x -> cont x
    | Node (a, b) ->
      sum a (fun sum_a ->
        sum b (fun sum_a ->
          cont (sum_a + sum_a)))
  in sum tree (fun x -> x)
```

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```
let test_sum =
  let tree1 = Node (Leaf 0, Leaf 0) in
  assert (sum tree1 = 0);
  let tree2 = Node (Leaf 1, Leaf 1) in
  assert (sum tree2 = 2);
  (* By induction other cases will work. *)
  ()
```

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  assert (sum tree2 = 2);
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  ()
```

And the code is added in production.

However, Bill's modification is obviously wrong, and Bill will not pass his trial period. But how could he have done better?

- Write more unit tests: would he have found the inputs needed to detect the error case?
- Use random input generators to write property-based tests: which properties to test?

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- Get inspiration from the property-based testing to randomly generate k scenarios.
- Store the results of these scenarios to create regression tests.
- Re-run the test cases on new versions of the function to detect unwanted changes in results.

In order to generate `k` scenarios, we need to be able to generate a value for each parameter of a function.

```
type 'a spec = {
  gen : 'a gen;
    (** Generate random values for ['a]. *)
  printer : 'a printer option
    (** Optional printer to observe generated values. *)
}
```

Then, we consider the textual representation of the result to display it to the user.

```
type 'a result = 'a printer
```

Finally, we build the global specification from the parameter specs.

```
type ('fn, 'r) t =
  | Arrow : 'a spec * ('fn, 'r) t -> ('a -> 'fn, 'r) t
  | Result : 'r result -> ('r, 'r) t
```

Finally, we build the global specification from the parameter specs.

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let repeat n c = String.make n c

let spec_repeat : (int -> char -> string, string) t =
  Spec.(int ^> char ^>> Printer.string)
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val ( ^> ) : 'a spec -> ('b, 'c) t -> ('a -> 'b, 'c) t
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let repeat n c = String.make n c

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val ( ^> ) : 'a spec -> ('b, 'c) t -> ('a -> 'b, 'c) t
val ( ^>> ) : 'a spec -> 'b result -> ('a -> 'b, 'b) t
```

We can then define a specification for the sum function.

```
let gen_tree = ... and printer_tree = ...

let spec_tree = Spec.{ gen = gen_tree; printer = Some printer_tree}

let spec_sum : (tree -> int, int) Spec.t =
  Spec.(spec_tree ^>> Printer.int)
```

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let spec_sum : (tree -> int, int) Spec.t =
  Spec.(spec_tree ^>> Printer.int)
```

Then, we can generate the regression tests.

```
let _ =
  let test = Test.make ~spec:spec_sum sum in
  Runner.(run_tests ~encoding:Marshal [ test ])
```

```
+ {
+  name = sum;
+  scenarios = [
+    N (N (N (N (N (L 2, L 87), N (L 4000, L 7)), L 6), L 0), L 63)    =  4165
+    N (L 4, N (L 217, L 97))    =    318
+    N (L 6, L 505)    =    511
+    N (L 2, L 8)    =    10
+    N (L 80, N (L 7, L 69))    =    156
+    L 83    =    83
+    L 4    =    4
+    N (N (N (L 2, L 674), N (L 42, L 456)), L 90)    =    1264
+    L 7    =    7
+    L 504    =    504
+  ]
+ }

Do you want to promote this new snapshot? [Y\n]
```

```
+ {
+  name = sum;
+  scenarios = [
+    N (N (N (N (N (L 2, L 87), N (L 4000, L 7)), L 6), L 0), L 63)    =  4165
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+    L 4    =    4
+    N (N (N (L 2, L 674), N (L 42, L 456)), L 90)    =    1264
+    L 7    =    7
+    L 504    =    504
+  ]
+ }
```

```
Do you want to promote this new snapshot? [Y\n]
```

We now have the regression tests.

Let's now come back to Bill's optimisation.

```
let sum tree =
  let rec sum tree cont = match tree with
    | Leaf x -> cont x
    | Node (a, b) ->
      sum a (fun sum_a ->
        sum b (fun sum_a ->
          cont (sum_a + sum_a)))
  in sum tree (fun x -> x)
```

Let's now re-run the regression tests.

```
--- failure -------------------------------------------------------------

@@ -1,14 +1,14 @@
 {
   name = sum;
   scenarios = [
-    N (N (N (N (N (L 2, L 87), N (L 4000, L 7)), L 6), L 0), L 63)    =    4165
-    N (L 4, N (L 217, L 97))    =    318
-    N (L 6, L 505)    =    511
-    N (L 2, L 8)    =    10
-    N (L 80, N (L 7, L 69))    =    156
+    N (N (N (N (N (L 2, L 87), N (L 4000, L 7)), L 6), L 0), L 63)    =    126
+    N (L 4, N (L 217, L 97))    =    388
+    N (L 6, L 505)    =    1010
+    N (L 2, L 8)    =    16
+    N (L 80, N (L 7, L 69))    =    276
     L 83    =    83
     L 4    =    4
-    N (N (N (L 2, L 674), N (L 42, L 456)), L 90)    =    1264
+    N (N (N (L 2, L 674), N (L 42, L 456)), L 90)    =    180
     L 7    =    7
     L 504    =    504
   ]


-------------------------------------------------------------------------------
failure: ran 1 test (1 error(s))
```

Now, Bill can use the regression tests of the sum function until he converges to a correction of his optimisation.

```
@@ -12,6 +12,6 @@ let sum tree =
     | Leaf x -> cont x
     | Node (a, b) ->
       sum a (fun sum_a ->
-          sum b (fun sum_a ->
-              cont (sum_a + sum_a)))
+          sum b (fun sum_b ->
+              cont (sum_a + sum_b)))
   in sum tree (fun x -> x)
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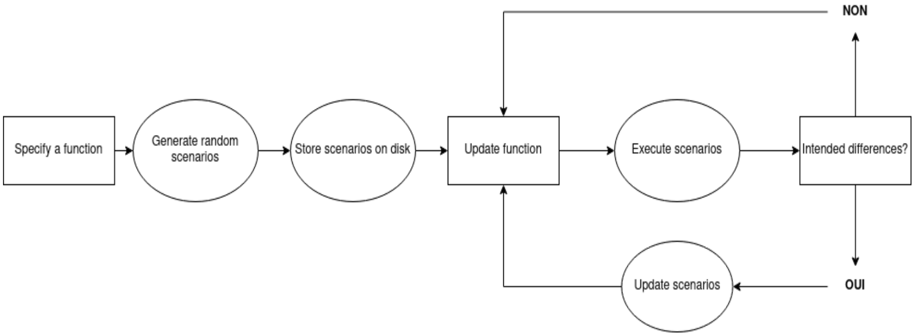
     | Leaf x -> cont x
     | Node (a, b) ->
       sum a (fun sum_a ->
-          sum b (fun sum_a ->
-              cont (sum_a + sum_a))
+          sum b (fun sum_b ->
+              cont (sum_a + sum_b)))
   in sum tree (fun x -> x)
```

The tests will now prove him right.

```
---------------------------------------------------------------
success: ran 1 test (1 passed)
```


NON
Specify a function
Generate random scenarios
Store scenarios on disk
Update function
Execute scenarios
Intended differences?
Update scenarios
OUI

Conclusion

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Inspired by unit tests and property-based testing, we were able to:

- Automatically generate `k` scenarios using random generators
- Abstract the expertise needed to extract properties from the code.
- Save and version the state of a function to prevent unwanted changes in the future.

Future works

We have several ways to improve the tool.

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- Better integration with the development environment, notably by connecting the tool to existing framework such as `QCheck` or `ppx_expect`.
- Regression tests are not very resilient to change: old scenarios cannot be re-applied to a function if its signature changes.

Future works

We have several ways to improve the tool.

- Better integration with the development environment, notably by connecting the tool to existing framework such as `QCheck` or `ppx_expect`.
- Regression tests are not very resilient to change: old scenarios cannot be re-applied to a function if its signature changes.
- Generating a large number of scenarios does not ensure a large coverage of generators. We would then like to incrementally improve the code's coverage of the scenarios, for example, by using coverage tools such as `bisect_ppx`.

Thanks for listening!

https://github.com/vch9/osnap

Références

- Code coverage for OCaml and ReScript.
  https://github.com/aantron/bisect_ppx
- Marshaling of data structures.
  https://ocaml.org/api/Marshal.html
- QuickCheck inspired property-based testing for OCaml.
  https://github.com/c-cube/qcheck
- Expect-test - a cram like framework for OCaml.
  https://github.com/janestreet/ppx_expect

Example of tree generator's implementation using QCheck.

```
let gen_tree : tree QCheck.Gen.t =
  let open QCheck.Gen in
  sized @@ fix (fun self -> function
    | 0 -> map (fun x -> Leaf x) nat
    | n ->
      oneof [
        map (fun x -> Leaf x) nat;
        map2 (fun x y -> Node (x, y))
          (self (n / 2)) (self (n / 2));
      ])
```