halcheck

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December 22, 2023

`halcheck` — Overview

Overview

Summary

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Why `halcheck`?

1. Clearer API
2. Support for custom test-case generation strategies
3. Better space complexity

`halcheck` — Overview — API

All PBT frameworks are direct ports or descendants of QuickCheck. These frameworks all consist of:

A central generator data type:

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data Gen a = Gen (Random → a)
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choose    :: (Int, Int) → Gen Int
suchThat  :: (a → Bool) → Gen a → Gen a
frequency :: [(Int, Gen a)] → Gen a
...
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- Users must be comfortable reasoning about higher-order functions.
- Users must ensure generators are only invoked in the correct context.

`halcheck` — Overview — API

Example: *Write a generator combinator that produces `std::vector`s shorter than a given length.*

```
// RapidCheck
Gen<std::vector<int>> example(int N) {
  return gen::container<std::vector<int>>(
    *gen::inRange(0, N),
    gen::arbitrary<int>);
}

-- QuickCheck
example n = vectorOf (choose (0, n - 1)) arbitrary
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```
// RapidCheck
Gen<std::vector<int>> example(int N) {
  return gen::container<std::vector<int>>(
    *gen::inRange(0, N), // WRONG (no compiler error)
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Example: *Write a generator combinator that produces `std::vector`s shorter than a given length.*

```
// RapidCheck
Gen<std::vector<int>> example(int N) {
  // WRONG: n is computed once, all generated values have the same size!
  auto n = *gen::inRange(0, N);
  return gen::container<std::vector<int>>(n, gen::arbitrary<int>());
}
```

```
-- QuickCheck          ↓ WRONG: choose :: (Int, Int) → Gen Int
example n = vectorOf (choose (0, n - 1)) arbitrary
--          ↑ WRONG: vectorOf :: Int → Gen Int → Gen [Int]
```

`halcheck` — Overview — API

Example: *Write a generator combinator that produces `std::vector`s shorter than a given length.*

Solution: Delay computation of `*gen::inRange(0, N)` using `gen::exec`.

```
// RapidCheck
Gen<std::vector<int>> example(int N) {
  return gen::exec([=] {
    return *gen::container<std::vector<int>>(
      *gen::inRange(0, N),
      gen::arbitrary<int>);
  });
}
```

```
-- QuickCheck
example n = do
  i ← choose (0, n - 1)
  vectorOf i arbitrary
```

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  - Haskell's type system ensures this always happens.
  - C++'s type system can provide no such guarantee!
- **Solution:** Get rid of the generator type!
  - All code is written in the generator context.
  - Bonus: fewer higher-order functions.

```
// halcheck
std::vector<int> example(int N) {
  return gen::container<std::vector<int>>(
    gen::range(0, N),
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`halcheck` — Overview — Strategies

There are various desirable strategies for generating data:

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Most PBT frameworks (and all C++ PBT frameworks) use a fixed strategy.

halcheck — Overview — Strategies

halcheck provides combinators for specifying strategies:

```
//   random(int) → strategy
// ↓ Executes random test cases forever or until a bug is found.
test::random(seed)([] { /* test code */ });
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(Intended for advanced users.)

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`halcheck` — Overview — Space Complexity

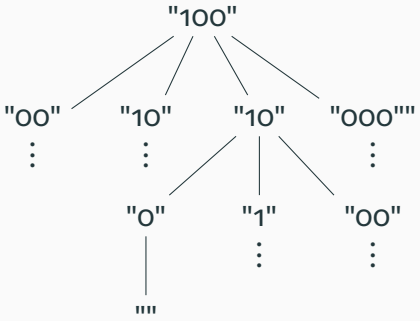
How does shrinking work?

Internally, every generator is a function returning a “shrink tree” of values.

```
data Gen a = Gen (Random → Tree a)
```

Shrink trees can be very large so they must be computed lazily.

Shrink tree for a list:



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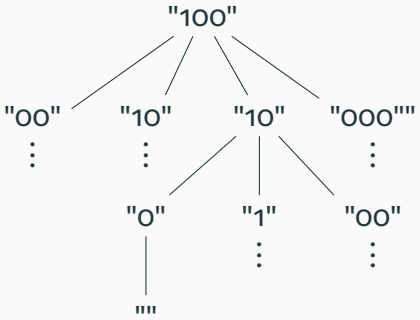

This implementation strategy does not work for C++!

halcheck — Overview — Space Complexity

Example:

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auto xs = *gen::arbitrary<std::vector<int>>();
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Conclusion: all combinators (with shrinking behaviour) must make copies of their arguments!

Problem: by default, copies in C++ are deep ($\mathcal{O}(n)$ instead of $\mathcal{O}(1)$).

halcheck — Overview — Space Complexity

Generators cannot return references:

```
// Generates a random reference
// to an element of xs.
rc::Gen<int &> referenceOf(??? xs);
//          What goes here? ↑

// Example: assign a
// random element to 0.
*referenceOf(xs) = 0;
```

What type should `referenceOf` have?

`halcheck` — Overview — Space Complexity

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- Motto: shrink inputs, not outputs!
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Note: `halcheck` does not use internal shrinking.

- Users have full control over shrinking.

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`halcheck` — In Progress

New strategies:

- `ordered` (SmallCheck/LeanCheck)
- Coverage-guided (fuzztest)
  - Requires support for mutations.
- Learning-based (RLCheck)
- Reproducing test-cases

Test framework integration:

- Google Test
- CUnit
- doctest (partially done)