CODE BEAM EUROPE

STOCKHOLM

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Improve your tests with Makina

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#CodeBEAM

The problem

files	blank	comment	code
4	760	383	4513

files	blank	comment	code
18	500	408	1692

Introduction to PBT

Writing unit-tests is hard and time-consuming:

```
reverse([]) == []
reverse([1]) == [1]
reverse([1 ,2]) == [2 ,1]
...
```

Property-Based Testing (PBT) philosophy:

Don't write tests, generate them.

A test execution in PBT consists of:

1. Data generation.
2. Property checking.
3. An shrinking strategy (if the property doesn't hold).

A property:

```
forall list <- list() do
  list == reverse(reverse(list))
end
```

In each test:

1. `list()` generates a random list:

   `[8 ,10 ,6] ...`

2. Checks the property:

   `[8, 10, 6] == reverse(reverse([8, 10, 6]))`

3. If the property doesn't hold returns a counter-example.

Testing *stateful* programs

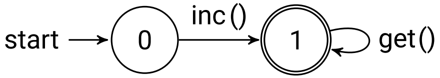
Imagine a simple counter:

Command	Returns
`start/1`	`:ok` | `:error`
`stop/0`	`:ok` | `:error`
`inc/0`	`:ok`
`get/0`	`integer()`

Unit test:

```
:ok = start(0)
:ok = inc()
1   = get()
:ok = stop()
```

This test can be represented:



To successfully test this program we need to:

- Generate sequences of commands.
- An internal state to track the changes in the program.
- A way to interact with the program under test.

PBT of *stateful* programs

Basic property of *stateful* programs:

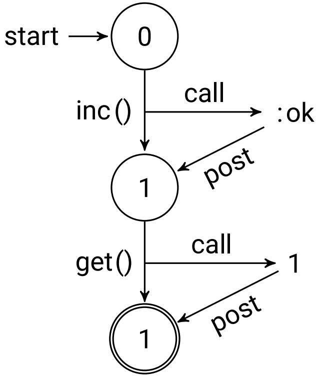
```
forall cmds <- commands(Counter) do
  :ok == run_commands(Counter, cmds)
end
```

where:

- `commands/1` generates sequences commands:

  ```
  [start(0), inc(), get(), stop()]
  ...
  ```

- `run_commands` executes the generated sequence.



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PBT state machines

Introduced by `Erlang QuickCheck`.

Adopted by other PBT libraries such as `Proper`.

These libraries provide a DSL to model the system.

Proven effectiveness.

Very slow adoption.

Why?

Problems:

- Hard to write.
- Cryptic errors.
- Usually buggy.
- Code reuse is very hard.
- Hard to maintain.

Makina

`Makina` is a DSL to write PBT state machines.

- Fully compatible with `Erlang QuickCheck` and `PropEr`.
- Improved usability.
- Better error messages.
- Improved error detection in models.

A Makina model contains:

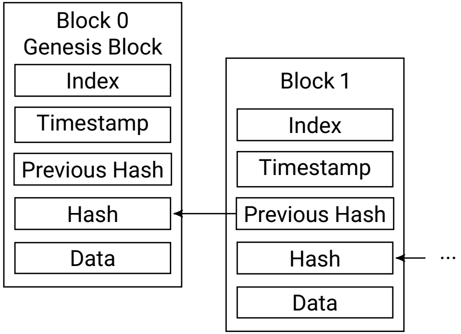
- `state`
- `command`
- `invariants`

Provides code reuse mechanisms:

- imports
- `extends`
- composition

Ethereum Blockchain

A blockchain is a distributed ledger that enables peer-to-peer transactions.



Ethereum is one of the largest blockchains.

Introduced smart-contracts.

`etherex` a library to interact with Ethereum using Elixir.

The properties:

1. Mining blocks.
2. Account access.
3. Transfers between accounts.

Mining blocks

The API:

Command	Returns
`block_number()`	`{:ok, integer()}`
`mine()`	`:ok`

1. state?
2. invariants?

```elixir
defmodule Blocks do
  use Makina, implemented_by: Etherex

  state height: 0

  invariants non_neg_height: height >= 0

  command block_number() do
    post {:ok, height} == result
  end

  command mine() do
    call Etherex.Time.mine()
    next height: height + 1
  end
end
```

Consulting callback documentation

```
iex> h Blocks.Command.Mine.post

# def post(state, arguments, result)

@spec post(dynamic_state(), arguments(), result()) :: boolean()

This callback contains a predicate that should be true after the execution of
mine

## Available variables

### State

- state contains the complete dynamic state of the model.
- height attribute defined in the state declaration.

### Arguments

- arguments contains all the generated arguments of the command.

### Result

- result variable that contains the result of the command execution.
```

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Adding type information

```
 1  defmodule Blocks do
 2    use Makina, implemented_by: Etherex
 3
 4    state height: 0 :: integer()
 5
 6    invariants non_neg_height: height >= 0
 7
 8    command block_number() :: {:ok, integer()} do
 9      post {:ok, height} == result
10    end
11
12    command mine() :: :ok do
13      call Etherex.Time.mine()
14      next height: height + 1
15    end
16  end
```

```
$ mix gradient

The function call Etherex.block_number() on line 8 is expected
to have type result() but it has type {:ok, quantity()} | {:error, error()}
```

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Adding documentation

```elixir
defmodule Blocks do
  use Makina, implemented_by: Etherex

  @moduledoc """
  Specifies the mining facilities of the blockchain.
  """

  state height: Etherex.block_number!() :: non_neg_integer()

  invariants non_genesis_block: height >= 0

  command block_number() :: {:ok, non_neg_integer()} do
    @moduledoc "Retrieves the block number from the blockchain."
    post {:ok, height} == result
  end

  command mine() :: :ok do
    @moduledoc "Mines a new block."
    call Etherex.Time.mine()
    next height: height + 1
  end
end
```

Consulting module documentation

```
iex> h Blocks

# Blocks

Contains a Makina model called Blocks.

Specifies the mining facilities of the blockchain.

## Commands

- mine stored at Blocks.Command.Mine
- block_number stored at Blocks.Command.BlockNumber

Detailed information about each command can be accessed inside the interpreter:

iex> h Blocks.Command.NAME

## State attributes

- height

...
```

Running the test

```
$ mix test
Starting Quviq QuickCheck version 1.45.1

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ignoring property options [:long_result, :quiet, :verbose]
....................................................................................................
OK, passed 100 tests

51.5 Blocks.mine()
48.5 Blocks.block_number()

Finished in 8.6 seconds (0.00s async, 8.6s sync)
```

Account access

```
defmodule Accounts do
  use Makina, implemented_by: Etherex

  alias Etherex.Type

  state accounts: Etherex.accounts!(), :: [Type.address()],
        balances: get_accounts() :: %{Type.address() => integer()}

  command get_balance(account :: Type.address()) ::
    {:ok, Type.quantity()} | {:error, Type.error()} do
    pre accounts != []
    valid_args account in accounts
    post {:ok, balances[account]} == result
  end

  @spec get_accounts :: %{Type.address() => integer()}
  def get_accounts do
    Etherex.accounts!()
    |> Enum.map(fn a -> {a, Etherex.get_balance!(a)} end)
    |> Enum.into(%{})
  end
end
```

Running the tests

```
Starting Quviq QuickCheck version 1.45.1

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  1) property Accounts (ExamplesTest)
     test/examples_test.exs:12
     ** (Makina.Error) argument ‘account‘ missing in command get_balance
     stacktrace:
       (makina 0.1.0) lib/makina/error.ex:9: Makina.Error.throw_error/1
       (examples 0.1.0) lib/accounts.ex:13: Accounts.Command.GetBalance.check_args/1
       (examples 0.1.0) lib/accounts.ex:1: Accounts.Behaviour.next_state/3
     Finished in 0.1 seconds (0.00s async, 0.1s sync)

1 properties, 1 failure

Randomized with seed 763550
```

Generating transactions

An abstract model for contracts

A basic model to test a contract