CODE BEAM EUROPE

STOCKHOLM

HYBRID CONFERENCE

Improve your tests with Makina

Luis Eduardo Bueso de Barrio

May 20 | 2022

#CodeBEAM

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

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Imagine a simple counter:

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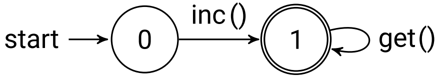

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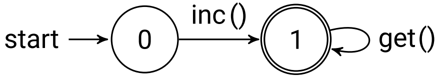

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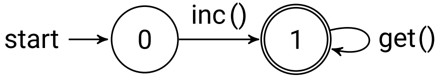
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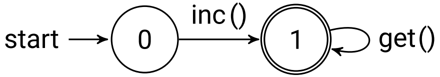

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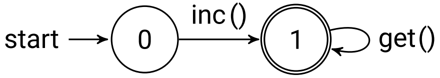

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Basic property of *stateful* programs:

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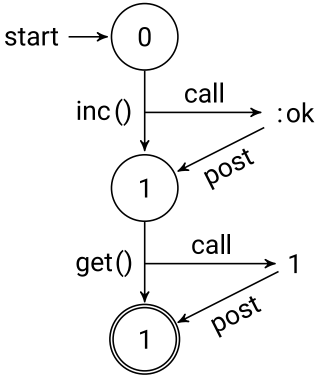

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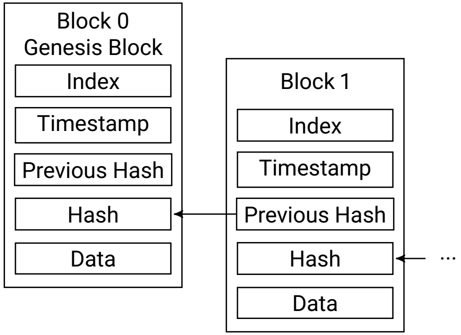

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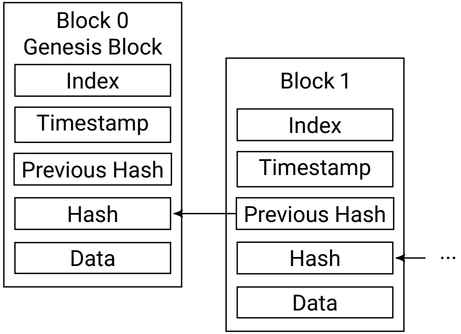

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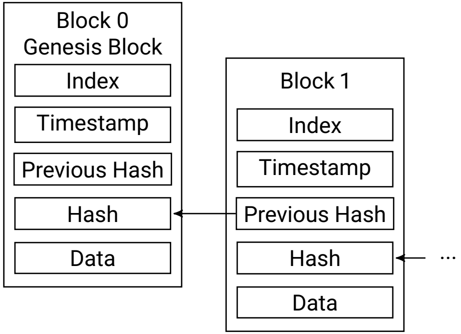

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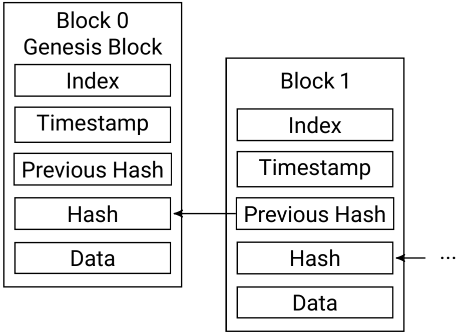

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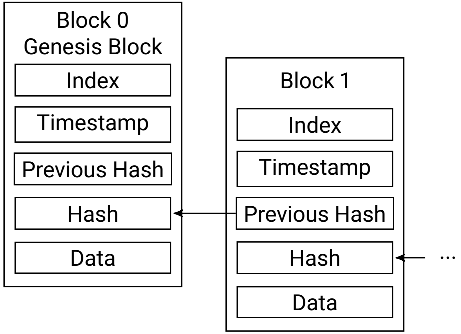

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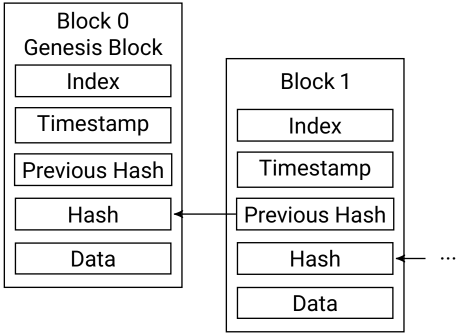

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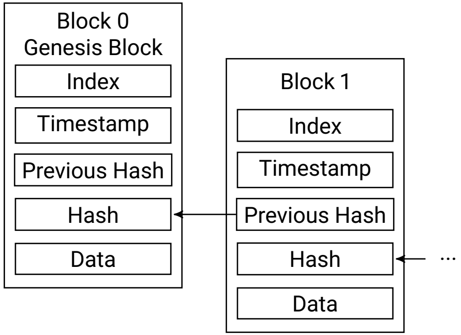

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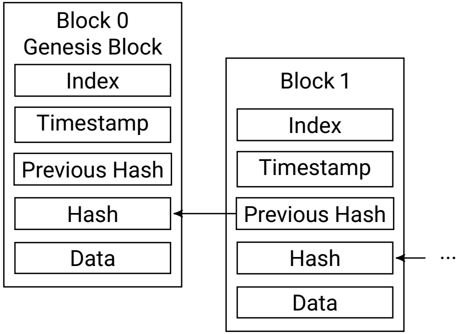

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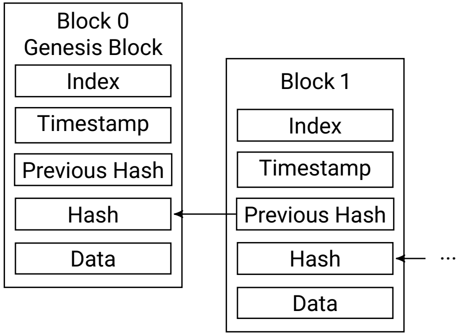

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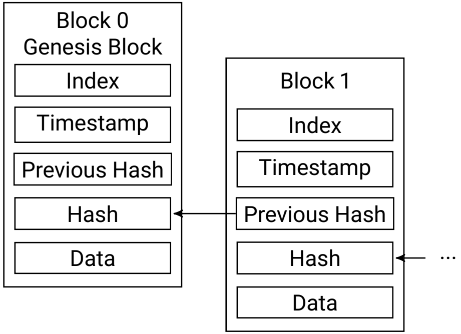

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  state height: 0

  invariants non_neg_height: height > 0

  command block_number() do
    pre true
```

Mining blocks

The API:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`

1. create module.
2. import `Makina`.
3. define state.
4. define invariants.
5. define commands.
6. introduce the callbacks.

```elixir
defmodule Blocks do
  use Makina

  state height: 0

  invariants non_neg_height: height > 0

  command block_number() do
    pre true
    args []
```

Mining blocks

The API:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`

1. create module.
2. import `Makina`.
3. define state.
4. define invariants.
5. define commands.
6. introduce the callbacks.

```
defmodule Blocks do
  use Makina

  state height: 0

  invariants non_neg_height: height > 0

  command block_number() do
    pre true
    args []
    valid_args true
```

Mining blocks

The API:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`

1. create module.
2. import `Makina`.
3. define state.
4. define invariants.
5. define commands.
6. introduce the callbacks.

```
defmodule Blocks do
  use Makina

  state height: 0

  invariants non_neg_height: height > 0

  command block_number() do
    pre true
    args []
    valid_args true
    call Etherex.block_number
```

Mining blocks

The API:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`

1. create module.
2. import `Makina`.
3. define state.
4. define invariants.
5. define commands.
6. introduce the callbacks.

```
defmodule Blocks do
  use Makina

  state height: 0

  invariants non_neg_height: height > 0

  command block_number() do
    pre true
    args []
    valid_args true
    call Etherex.block_number
    next []
```

Mining blocks

The API:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`

1. create module.
2. import `Makina`.
3. define state.
4. define invariants.
5. define commands.
6. introduce the callbacks.

```
defmodule Blocks do
  use Makina

  state height: 0

  invariants non_neg_height: height > 0

  command block_number() do
    pre true
    args []
    valid_args true
    call Etherex.block_number
    next []
    post {:ok, height} == result
```

#CodeBEAM

Mining blocks

The API:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`

1. create module.
2. import `Makina`.
3. define state.
4. define invariants.
5. define commands.
6. introduce the callbacks.

```
defmodule Blocks do
  use Makina

  state height: 0

  invariants non_neg_height: height > 0

  command block_number() do
    pre true
    args []
    valid_args true
    call Etherex.block_number
    next []
    post {:ok, height} == result
  end
```

Mining blocks

The API:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`

1. create module.
2. import `Makina`.
3. define state.
4. define invariants.
5. define commands.
6. introduce the callbacks.

```
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
```

Mining blocks

The API:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`

1. create module.
2. import `Makina`.
3. define state.
4. define invariants.
5. define commands.
6. introduce the callbacks.

```
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() :: :ok do
    next height: height + 1
  end
end
```

Auto generated documentation

Auto generated documentation

When a model is compiled automatically generates documentation.

Auto generated documentation

When a model is compiled automatically generates documentation.

```
iex> h Blocks
```

Auto generated documentation

When a model is compiled automatically generates 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

...
```

Auto generated documentation

When a model is compiled automatically generates documentation.

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

Auto generated documentation

When a model is compiled automatically generates documentation.

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

...
## 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.
```

Running the test

Running the test

```
$ mix test
```

Running the test

```
$ mix test
Starting Quviq QuickCheck version 1.45.1
```

Running the test

```
$ mix test
Starting Quviq QuickCheck version 1.45.1

Failed! After 1 tests.
[
    Blocks.block_number/0,
    Blocks.mine/0,
]

================================================================================
Postcondition crashed:
** (Makina.Error) invariant "non_neg_height" check failed

Shrinking x.(1 times)
[
    Blocks.block_number/0
]

Last state: %{height: 0}

Finished in 0.1 seconds (0.00s async, 0.1s sync)
1 properties, 1 failure
```

#CodeBEAM

Fixing the model

Fixing the model

```
Postcondition crashed:
** invariant "non_neg_height" check failed

Shrinking x.(1 times)
[
    Blocks.block_number/0
]

Last state: %{height: 0}
```

```
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
    next height: height + 1
  end
end
```

Fixing the model

```
Postcondition crashed:
** invariant "non_neg_height" check failed

Shrinking x.(1 times)
[
    Blocks.block_number/0
]

Last state: %{height: 0}
```

What happened?

```
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
    next height: height + 1
  end
end
```

#CodeBEAM

Fixing the model

```
Postcondition crashed:
** invariant "non_neg_height" check failed

Shrinking x.(1 times)
[
    Blocks.block_number/0
]

Last state: %{height: 0}
```

What happened?

Invariant doesn’t hold even on the initial state!

```
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
    next height: height + 1
  end
end
```

Fixing the model

```
Postcondition crashed:
** invariant "non_neg_height" check failed

Shrinking x.(1 times)
[
    Blocks.block_number/0
]

Last state: %{height: 0}
```

What happened?

Invariant doesn’t hold even on the initial state!

```
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
    next height: height + 1
  end
end
```

Running the test

Running the test

```
$ mix test
```

Running the test

```
$ mix test
Starting Quviq QuickCheck version 1.45.1
```

Running the test

```
$ mix test
Starting Quviq QuickCheck version 1.45.1

....................................................................................................
OK, passed 100 tests

51.5 Blocks.mine/0
48.5 Blocks.block_number/0

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

Adding documentation

Adding documentation

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




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

  invariants non_genesis_block: height >= 0

  command block_number() :: {:ok, non_neg_integer()} do

    post {:ok, height} == result
  end

  command mine() :: :ok do

    next height: height + 1
  end
end
```

Adding documentation

```
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."
    next height: height + 1
  end
end
```

Adding type information

Adding type information

```
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
```

Adding type information

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

  state height: 0 :: integer()

  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
```

#CodeBEAM

Adding type information

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

  state height: 0 :: integer()

  invariants non_neg_height: height >= 0

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

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

#CodeBEAM

Adding type information

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

  state height: 0 :: integer()

  invariants non_neg_height: height >= 0

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

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

```
$ mix gradient
```

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 {:ok, quantity()}
but it has type {:ok, quantity()} | {:error, error()}
```

Account access

Account access

The API:

Command	Returns
`get_balance/1`	`:ok`

Account access

The API:

```
defmodule Accounts do
```

Command	Returns
`get_balance/1`	`:ok`

1. create module.

Account access

The API:

Command	Returns
`get_balance/1`	`:ok`

1. create module.
2. import `Makina`.

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

  alias Etherex.Type









end
```

Account access

The API:

Command	Returns
`get_balance/1`	`:ok`

1. create module.
2. import `Makina`.
3. define state.

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

  alias Etherex.Type

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




end
```

Account access

The API:

Command	Returns
`get_balance/1`	`:ok`

1. create module.
2. import `Makina`.
3. define state.
4. define invariants.

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

  alias Etherex.Type

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








end
```

Account access

The API:

Command	Returns
`get_balance/1`	`:ok`

1. create module.
2. import `Makina`.
3. define state.
4. define invariants.
5. define commands.

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

  alias Etherex.Type

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

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

Running the test

Running the test

```
$ mix test
```

Running the test

```
$ mix test
Starting Quviq QuickCheck version 1.45.1
```

Running the test

```
$ mix test
Starting Quviq QuickCheck version 1.45.1

1) property Accounts (ExamplesTest)
   ** (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
```

Fixing the model

Fixing the model

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

  alias Etherex.Type

  state accounts: Etherex.accounts!() :: [Type.address()],
        balances: Etherex.balances!() :: %{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
end
```

Fixing the model

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

  alias Etherex.Type

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

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

Running the test

Running the test

```
$ mix test
```

Running the test

```
$ mix test
Starting Quviq QuickCheck version 1.45.1
```

#CodeBEAM

Running the test

```
$ mix test
Starting Quviq QuickCheck version 1.45.1

....................................................................................................
OK, passed 100 tests

'100.0 Accounts.get_balance/1

Finished in 4.6 seconds (0.00s async, 4.6s sync)
1 properties, 0 failures
```

Generating transactions

#CodeBEAM

Generating transactions

The API to generate and check transactions:

Generating transactions

The API to generate and check transactions:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`
`get_balance/1`	`{:ok, integer()}`
`transfer/3`	`{:ok, hash()}`

Generating transactions

The API to generate and check transactions:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`
`get_balance/1`	`{:ok, integer()}`
`transfer/3`	`{:ok, hash()}`

We can compose `Blocks` and `Accounts`!

Generating transactions

The API to generate and check transactions:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`
`get_balance/1`	`{:ok, integer()}`
`transfer/3`	`{:ok, hash()}`

We can compose `Blocks` and `Accounts`!

```
defmodule Transactions do
  use Makina,
    extends: [Blocks, Accounts],
    implemented_by: Etherex
end
```

Generating transactions

The API to generate and check transactions:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`
`get_balance/1`	`{:ok, integer()}`
`transfer/3`	`{:ok, hash()}`

We can compose `Blocks` and `Accounts`!

```
defmodule Transactions do
  use Makina,
    extends: [Blocks, Accounts],
    implemented_by: Etherex
end
```

Generates a model `Transactions.Composed`.

Generating transactions

```
iex(1)> h Transactions.Composed
```

The API to generate and check transactions:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`
`get_balance/1`	`{:ok, integer()}`
`transfer/3`	`{:ok, hash()}`

We can compose `Blocks` and `Accounts`!

```elixir
defmodule Transactions do
  use Makina,
    extends: [Blocks, Accounts],
    implemented_by: Etherex
end
```

Generates a model `Transactions.Composed`.

Generating transactions

The API to generate and check transactions:

Command	Returns
`mine/0`	`:ok`
`block_number/0`	`{:ok, integer()}`
`get_balance/1`	`{:ok, integer()}`
`transfer/3`	`{:ok, hash()}`

We can compose `Blocks` and `Accounts`!

```elixir
defmodule Transactions do
  use Makina,
    extends: [Blocks, Accounts],
    implemented_by: Etherex
end
```

Generates a model `Transactions.Composed`.

```
iex(1)> h Transactions.Composed

# Transactions.Composed

Contains a Makina model called Transactions.Compose

## Commands

 - mine stored
 - get_balance
 - block_number

## State attributes

 - height
 - balances
 - accounts

## Invariants

 - non_neg_height
```

#CodeBEAM

Generating transactions

Generating transactions

```elixir
defmodule Transactions do
  use Makina, implemented_by: Etherex, extends: [Accounts, Blocks]
  alias Etherex.Type









end
```

#CodeBEAM

Generating transactions

```elixir
defmodule Transactions do
  use Makina, implemented_by: Etherex, extends: [Accounts, Blocks]
  alias Etherex.Type

  command transfer(
    from :: Type.address(),
    to :: Type.address(),
    value :: Type.quantity()
  ) :: {:ok, Type.hash()} do




  end






end
```

Generating transactions

```elixir
defmodule Transactions do
  use Makina, implemented_by: Etherex, extends: [Accounts, Blocks]
  alias Etherex.Type

  command transfer(
    from :: Type.address(),
    to :: Type.address(),
    value :: Type.quantity()
  ) :: {:ok, Type.hash()} do
    pre accounts != []



  end






end
```

#CodeBEAM

Generating transactions

```
defmodule Transactions do
  use Makina, implemented_by: Etherex, extends: [Accounts, Blocks]
  alias Etherex.Type

  command transfer(
    from :: Type.address(),
    to :: Type.address(),
    value :: Type.quantity()
  ) :: {:ok, Type.hash()} do
    pre accounts != []
    args from: oneof(accounts), to: oneof(accounts), value: pos_integer()


  end






end
```

Generating transactions

```elixir
defmodule Transactions do
  use Makina, implemented_by: Etherex, extends: [Accounts, Blocks]
  alias Etherex.Type

  command transfer(
    from :: Type.address(),
    to :: Type.address(),
    value :: Type.quantity()
  ) :: {:ok, Type.hash()} do
    pre accounts != []
    args from: oneof(accounts), to: oneof(accounts), value: pos_integer()
    valid_args from in accounts and to in accounts

  end







end
```

Generating transactions

```
defmodule Transactions do
  use Makina, implemented_by: Etherex, extends: [Accounts, Blocks]
  alias Etherex.Type

  command transfer(
    from :: Type.address(),
    to :: Type.address(),
    value :: Type.quantity()
  ) :: {:ok, Type.hash()} do
    pre accounts != []
    args from: oneof(accounts), to: oneof(accounts), value: pos_integer()
    valid_args from in accounts and to in accounts
    next balances: update_balances(balances, from, to, value)
  end







end
```

Generating transactions

```elixir
defmodule Transactions do
  use Makina, implemented_by: Etherex, extends: [Accounts, Blocks]
  alias Etherex.Type

  command transfer(
    from :: Type.address(),
    to :: Type.address(),
    value :: Type.quantity()
  ) :: {:ok, Type.hash()} do
    pre accounts != []
    args from: oneof(accounts), to: oneof(accounts), value: pos_integer()
    valid_args from in accounts and to in accounts
    next balances: update_balances(balances, from, to, value)
  end

  def update_balances(balances, from, to, value) do
    balances
    |> Map.update!(from, fn balance - value end)
    |> Map.update!(to, fn balance + value end)
  end
end
```

Running the test

Running the test

```
$ mix test
```

Running the test

```
$ mix test
Starting Quviq QuickCheck version 1.45.1
```

Running the test

```
$ mix test
Starting Quviq QuickCheck version 1.45.1

Failed! After 1 tests.
[
    Transactions.transfer("0xffcf8fdee72ac11b5c542428b35eef5769c409f0",
                          "0x90f8bf6a479f320ead074411a4b0e7944ea8c9c1",
                          423319221061516289),
    Transactions.get_balance("0x90f8bf6a479f320ead074411a4b0e7944ea8c9c1"),
    Transactions.mine(),
    Transactions.mine(),
    Transactions.block_number()
]

================================================================================
Postcondition failed.

...
```

Running the test

```
Shrinking xxx.xx.x.x.x(4 times)
```

Running the test

```
Shrinking xxx.xx.x.x.x(4 times)

[
    Transaction.transfer("0xffcf8fdee72ac11b5c542428b35eef5769c409f0",
                         "0x90f8bf6a479f320ead074411a4b0e7944ea8c9c1",
                         1),
    Transactions.block_number()
]

================================================================================
Postcondition failed.

...

Transactions.block_number() -> {:ok, 1}


Last state: %{height: 0, ...}

Finished in 0.8 seconds (0.00s async, 0.8s sync)
1 properties, 1 failure
```

Fixing the transactions model

Fixing the transactions model

```elixir
defmodule Transactions do
  use Makina, implemented_by: Etherex, extends: [Accounts, Blocks]
  alias Etherex.Type

  command transfer(
    from :: Type.address(),
    to :: Type.address(),
    value :: Type.quantity()
  ) :: {:ok, Type.hash()} do
    pre accounts != []
    args from: oneof(accounts), to: oneof(accounts), value: pos_integer()
    valid_args from in accounts and to in accounts

    next balances: update_balances(balances, from, to, value),

  end

  def update_balances(balances, from, to, value) do
    balances |> Map.update!(from, &(&1 - value)) |> Map.update!(to, &(&1 + value))
  end
end
```

Fixing the transactions model

```elixir
defmodule Transactions do
  use Makina, implemented_by: Etherex, extends: [Accounts, Blocks]
  alias Etherex.Type

  command transfer(
    from :: Type.address(),
    to :: Type.address(),
    value :: Type.quantity()
  ) :: {:ok, Type.hash()} do
    pre accounts != []
    args from: oneof(accounts), to: oneof(accounts), value: pos_integer()
    valid_args from in accounts and to in accounts

    next balances: update_balances(balances, from, to, value),
         height: height + 1
  end

  def update_balances(balances, from, to, value) do
    balances |> Map.update!(from, &(&1 - value)) |> Map.update!(to, &(&1 + value))
  end
end
```

Running the test

Running the test

```
$ mix test
```

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$ mix test
Starting Quviq QuickCheck version 1.45.1
```

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..Failed! After 2 tests.
[
    ...
]

================================================================================
Postcondition failed.

...
```

Running the tests

```
Shrinking xxxx.x.x.x.x.xx.x(6 times)
```

Running the tests

```
Shrinking xxxx.x.x.x.x.xx.x(6 times)

[
    Transactions.transfer("0x90f8bf6a479f320ead074411a4b0e7944ea8c9c1",
                          "0x90f8bf6a479f320ead074411a4b0e7944ea8c9c1",
                          1),
    Transactions.get_balance("0x90f8bf6a479f320ead074411a4b0e7944ea8c9c1")
]

================================================================================
Postcondition failed.

Transactions.get_balance("0x90f8bf6a479f320ead074411a4b0e7944ea8c9c1")
-> {:ok, 999999999999999999999979000}

Last state:
%{ balances: %{ "0x90f8bf6a479f320ead074411a4b0e7944ea8c9c1" => 1000000000000000000000000000000,
        ...
    },
    ...
}
Finished in 1.1 seconds (0.00s async, 1.1s sync)
1 properties, 1 failure
```

#CodeBEAM

Fixing the transactions model

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Our model does not consider gas consumption.

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1. A symbolic attribute to store transactions.
2. `balances` needs to be symbolic.
3. `get_balance/0` precondition.

Fixing the transactions model

Our model does not consider gas consumption.

We need to change:

1. A symbolic attribute to store transactions.
2. `balances` needs to be symbolic.
3. `get_balance/0` precondition.

```
defmodule Transactions do
  ...
  state transactions: [] :: [symbolic(Type.hash())]
        balances: super()
          :: symbolic(%{Type.address() => integer()})

  command get_balance() do
    pre transactions == []
  end

  command transfer(...) do
    ...
    next transactions: [symbolic(elem(result, 1))
                        | transactions],
         ...
  end
```

Fixing the transactions model

Fixing the transactions model

`gas_cost/1` consults the consumed command and computes the new balances.

```
command gas_cost(hash :: Type.hash()) :: {Type.address(), Type.quantity()} do
  pre transactions != []
  args hash: oneof(transactions)
  valid_args hash in transactions
  next do
    from = symbolic(elem(result, 0))
    gas = symbolic(elem(result, 1))
    [
      transactions: List.delete(transactions, hash),
      balances: discount_gas(balances, from, gas) |> symbolic()
    ]
  end
end
```

Running the tests

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Starting Quviq QuickCheck version 1.45.1
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....................................................................................................
OK, passed 100 tests

'25.5 Transactions.mine/0
'24.9 Transactions.block_number/0
'23.6 Transactions.transfer/3
'14.3 Transactions.gas_cost/1
'11.8 Transactions.get_balance/1

Finished in 15.8 seconds (0.00s async, 15.8s sync)
1 properties, 0 failures
```

Results and conclussions

Before Makina:

files	blank	comment	code
4	760	383	4513

After Makina:

files	blank	comment	code
18	500	408	1692

Libraries:

- `https://gitlab.com/babel-upm/makina/makina`
- `https://://gitlab.com/babel-upm/blockchain/etherex`

Slides and code:

- `https://gitlab.com/babel-upm/makina/code_beam_2022`