Property Testing with derived idempotents

Brian Zeligson

April 2020

Table of Contents

Table of Contents

What is Property Testing?

$$\exists \Longrightarrow \forall$$

What is Property Testing?

$$\exists \implies \forall$$

Unit tests on cartoon steroids.

What is Property Testing?

$\exists \implies \forall$

Unit tests on cartoon steroids.

Take from the source:

QuickCheck
Hypothesis
JSVerify

Property Testing - A closer look at the examples

You don't know what your inputs are.

Property Testing - A closer look at the examples

You don't know what your inputs are.

Your properties are meant to hold over a broad set of inputs, they must be general.

Property Testing - A closer look at the examples

You don't know what your inputs are.

Your properties are meant to hold over a broad set of inputs, they must be general.

How do you make meaningful assertions without re-implementing the code under test?

Property Testing - A closer look at the examples

You don't know what your inputs are.

Your properties are meant to hold over a broad set of inputs, they must be general.

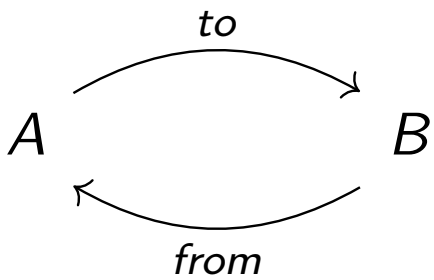
How do you make meaningful assertions without re-implementing the code under test?

Revisit:

QuickCheck
Hypothesis
JSVerify

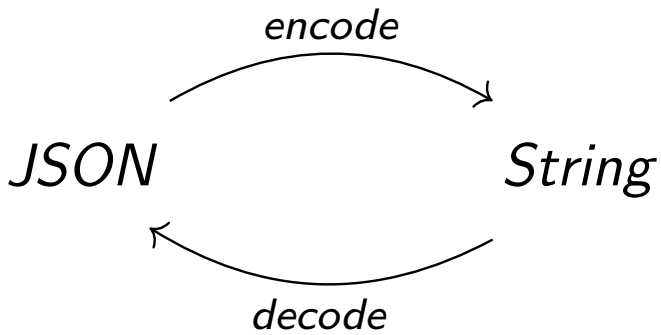
Table of Contents

Isomorphism Defined



$$\text{from}(\text{to}(\text{A})) = \mathit{from} \circ \mathit{to} = 1_A$$
$$\text{to}(\text{from}(\text{B})) = \mathit{to} \circ \mathit{from} = 1_B$$

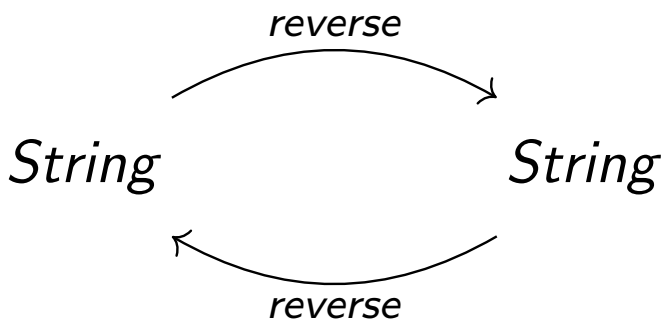
Isomorphism Example: encode $\iff$ decode



$$\text{decode}(\text{encode}(\text{JSON})) = \mathit{decode} \circ \mathit{encode} = 1_{\mathit{JSON}}$$

$$\text{encode}(\text{decode}(\text{String})) = \mathit{encode} \circ \mathit{decode} = 1_{\mathit{String}}$$

Isomorphism Example: reverse $\Longleftrightarrow$ reverse

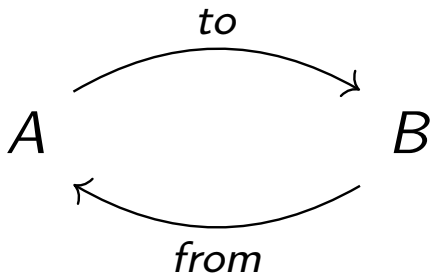


$$\text{reverse}(\text{reverse}(\text{String})) = \mathit{reverse} \circ \mathit{reverse} = 1_{\mathit{String}}$$

$$\text{reverse}(\text{reverse}(\text{String})) = \mathit{reverse} \circ \mathit{reverse} = 1_{\mathit{String}}$$

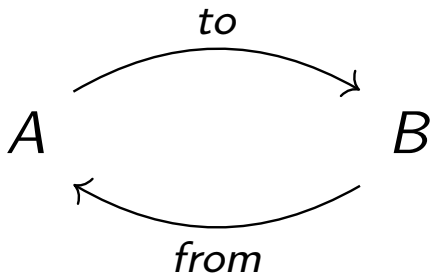
Table of Contents

Idempotent Defined



$$\text{to}(\text{from}(\text{B})) = to \circ from = 1_B$$

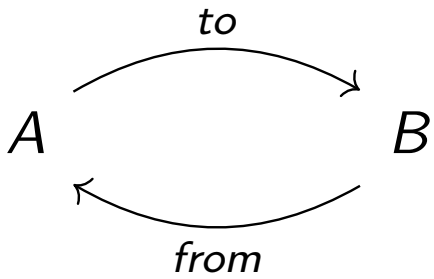
Idempotent Defined



$$\text{to}(\text{from}(\text{B})) = \mathit{to} \circ \mathit{from} = 1_B$$

$$\text{from}(\text{to}(\text{from}(\text{to}(\text{A})))) =$$

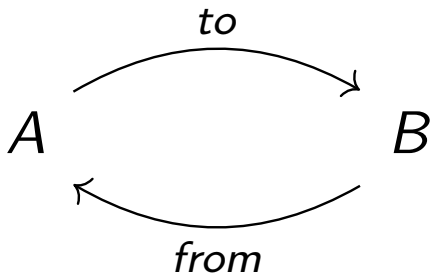
Idempotent Defined



$$\text{to}(\text{from}(\text{B})) = \mathit{to} \circ \mathit{from} = 1_B$$

$$\text{from}(\text{to}(\text{from}(\text{to}(\text{A})))) =$$
$$\mathit{from} \circ \mathit{to} \circ \mathit{from} \circ \mathit{to} =$$

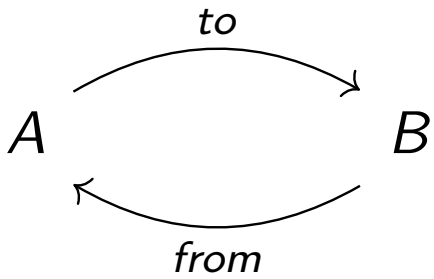
Idempotent Defined



$$\text{to}(\text{from}(\text{B})) = to \circ from = 1_B$$

$$\text{from}(\text{to}(\text{from}(\text{to}(\text{A})))) =$$
$$from \circ to \circ from \circ to =$$
$$from \circ (to \circ from) \circ to =$$

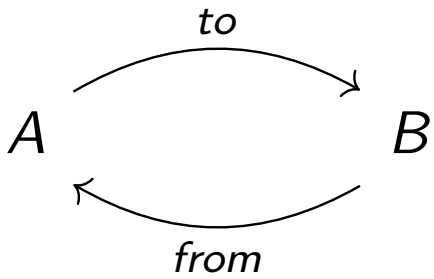
Idempotent Defined



$$\text{to}(\text{from}(\text{B})) = to \circ from = 1_B$$

$$\text{from}(\text{to}(\text{from}(\text{to}(\text{A})))) =$$
$$from \circ to \circ from \circ to =$$
$$from \circ (to \circ from) \circ to =$$
$$from \circ 1_B \circ to =$$

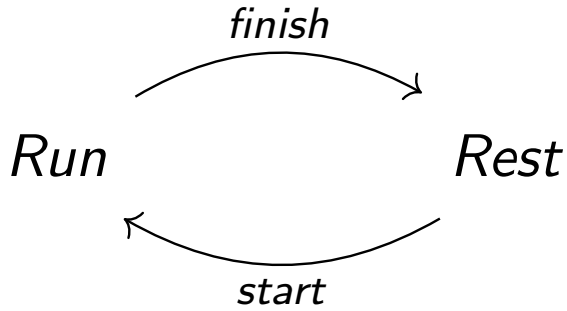
Idempotent Defined



$$\text{to}(\text{from}(\text{B})) = to \circ from = 1_B$$

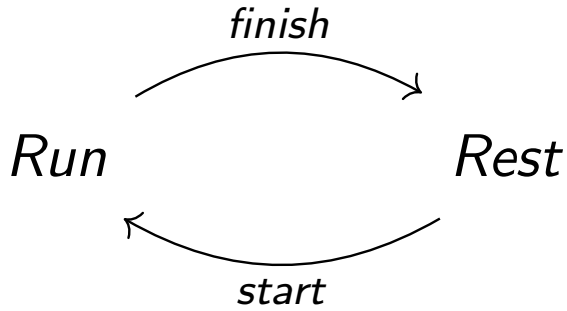
$$\text{from}(\text{to}(\text{from}(\text{to}(\text{A})))) =$$
$$from \circ to \circ from \circ to =$$
$$from \circ (to \circ from) \circ to =$$
$$from \circ 1_B \circ to =$$
$$from \circ to$$

Idempotent Example: Run $\hookrightarrow$ Rest



$$\text{start}(\text{finish}(\text{Run})) = \textit{start} \circ \textit{finish} = 1_{\textit{Run}}$$

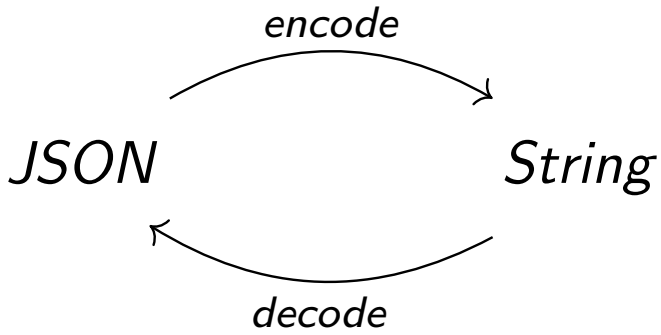
Idempotent Example: Run $\hookrightarrow$ Rest



$$\text{start}(\text{finish}(\text{Run})) = \mathit{start} \circ \mathit{finish} = 1_{\mathit{Run}}$$

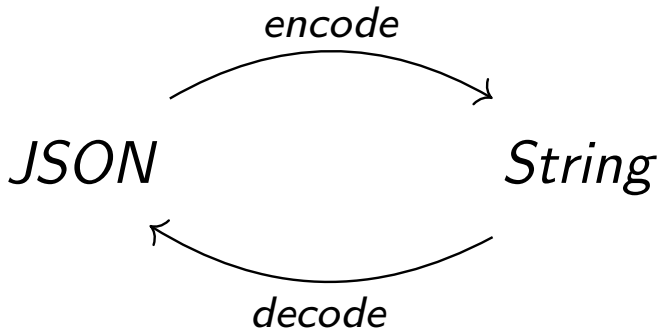
$$\text{finish}(\text{start}(\text{finish}(\text{start}(\text{Rest})))) =$$
$$\mathit{finish} \circ \mathit{start} \circ \mathit{finish} \circ \mathit{start} =$$
$$\mathit{finish} \circ (\mathit{start} \circ \mathit{finish}) \circ \mathit{start} =$$
$$\mathit{finish} \circ (1_{\mathit{Run}}) \circ \mathit{start} =$$
$$\mathit{finish} \circ \mathit{start}$$

Idempotent Example: JSON $\hookrightarrow$ String



$$\text{decode}(\text{encode}(\text{JSON})) = \mathit{decode} \circ \mathit{encode} = 1_{\mathit{JSON}}$$

Idempotent Example: JSON $\hookrightarrow$ String



$$\text{decode}(\text{encode}(\text{JSON})) = \mathit{decode} \circ \mathit{encode} = 1_{\mathit{JSON}}$$

$$\text{encode}(\text{decode}(\text{encode}(\text{decode}(\text{String})))) =$$
$$\mathit{encode} \circ \mathit{decode} \circ \mathit{encode} \circ \mathit{decode} =$$
$$\mathit{encode} \circ (\mathit{decode} \circ \mathit{encode}) \circ \mathit{decode} =$$
$$\mathit{encode} \circ (1_{\mathit{JSON}}) \circ \mathit{decode} =$$
$$\mathit{encode} \circ \mathit{decode}$$

Table of Contents

Making Properties Easy

We know that properties are easy and effective when we have an isomorphism.

```
prop_RevRev xs = reverse (reverse xs) == xs
  where types = xs::[Int]
```

Making Properties Easy

We know that properties are easy and effective when we have an isomorphism.

```
prop_RevRev xs = reverse (reverse xs) == xs
  where types = xs::[Int]
```

What about when we don't have an isomorphism?

Making Properties Easy

We know that properties are easy and effective when we have an isomorphism.

```
prop_RevRev xs = reverse (reverse xs) == xs
  where types = xs::[Int]
```

What about when we don't have an isomorphism?

Can we *find* an isomorphism?

Finding an isomorphism

FizzBuzz does not belong to an isomorphism.

```
object FizzBuzz {
  def apply(nums: List[Int]): List[String] =
    nums.map(n => (n, n % 3, n % 5) match {
      case (0, _, _) => "0"
      case (_, 0, 0) => "FizzBuzz"
      case (_, 0, _) => "Fizz"
      case (_, _, 0) => "Buzz"
      case _ => n.toString
    })
}
```

Finding an isomorphism

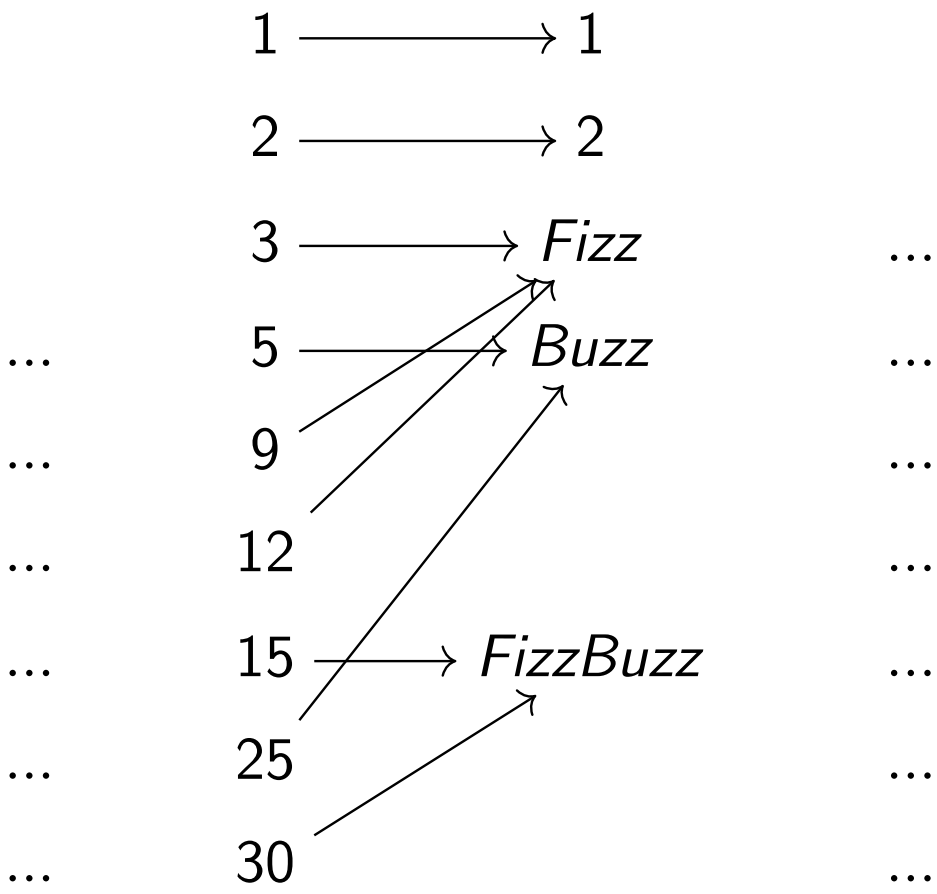
FizzBuzz does not belong to an isomorphism.

```
object FizzBuzz {
  def apply(nums: List[Int]): List[String] =
    nums.map(n => (n, n % 3, n % 5) match {
      case (0, _, _) => "0"
      case (_, 0, 0) => "FizzBuzz"
      case (_, 0, _) => "Fizz"
      case (_, _, 0) => "Buzz"
      case _ => n.toString
    })
}
```

What is the closest isomorphism we can find?

It helps to take a different perspective.

FizzBuzz as a Set Function



We cannot have an isomorphism because inputs *collapse* onto outputs.
This prevents construction of an inverse.

FizzBuzz as a Set Function, Partitioned Domain

$$\{1\} \longrightarrow 1$$

$$\{2\} \longrightarrow 2$$

$$\{3, 6, 9, 12, ...\} \longrightarrow \textit{Fizz}$$

$$\{4\} \longrightarrow 4$$

$$\{5, 10, 20, 25, ...\} \longrightarrow \textit{Buzz}$$

$$\{7\} \longrightarrow 7 \qquad ...$$

$$... \qquad \{15, 30, ...\} \longrightarrow \textit{FizzBuzz}$$

$$\{16\} \longrightarrow 16$$

We have an isomorphism, can we fix the input type?

FizzBuzz as a Set Function, Partitioned Domain

$$\{1\} \longrightarrow 1$$

$$\{2\} \longrightarrow 2$$

$$\{3, 6, 9, 12, ...\} \longrightarrow \textit{Fizz}$$

$$\{4\} \longrightarrow 4$$

$$\{5, 10, 20, 25, ...\} \longrightarrow \textit{Buzz}$$

$$\{7\} \longrightarrow 7 \qquad ...$$

$$... \qquad \{15, 30, ...\} \longrightarrow \textit{FizzBuzz}$$

$$\{16\} \longrightarrow 16$$

We have an isomorphism, can we fix the input type?

With an idempotent.

FizzBuzz^{-1} as a Set Function, Idempotent

We just pick one value from each input set.

$$1 \leftarrow \{1\} \leftarrow 1$$

$$2 \leftarrow \{2\} \leftarrow 2$$

$$3 \leftarrow \{3, 6, 9, 12, ...\} \leftarrow \textit{Fizz}$$

$$4 \leftarrow \{4\} \leftarrow 4$$

$$5 \leftarrow \{5, 10, 20, 25, ...\} \leftarrow \textit{Buzz}$$

$$7 \leftarrow \{7\} \leftarrow 7 \qquad ...$$

$$... \qquad 15 \leftarrow \{15, 30, ...\} \leftarrow \textit{FizzBuzz}$$

$$16 \leftarrow \{16\} \leftarrow 16$$

This can be pre-composed with FizzBuzz to create an identity on the output set.
This means we have an idempotent on the input set.

Table of Contents