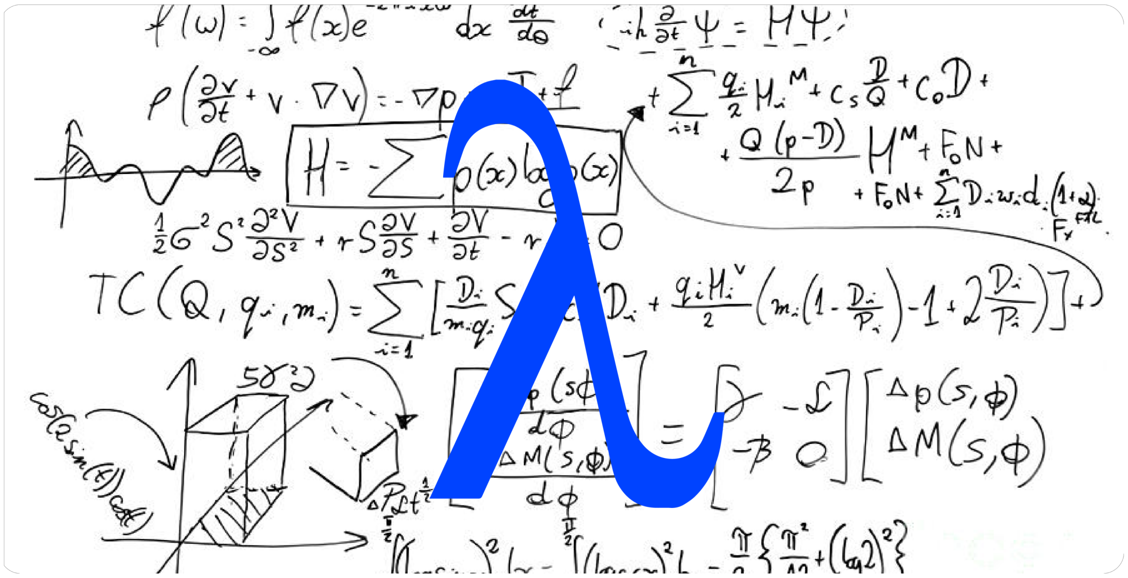
functional-python

April 10, 2022

0.1 Functional Programming in Python

By Vic Kumar | https://github.com/vickumar1981/functional_python



Salt Lake City, UT | PyCon 2022

0.2 About Me

Software Developer at Excella, Inc.

https://excella.com

Technology Consulting firm based in Arlington, VA

Modern Software Delivery, AI and Data Analytics, Agile Transformation

0.3 Projects

0.3.1 Goto Code | https://gotocode.io

Remote interviews, coding problems, hackathons, and code katas

0.3.2 HBCU Digital | https://hbcudigital.com

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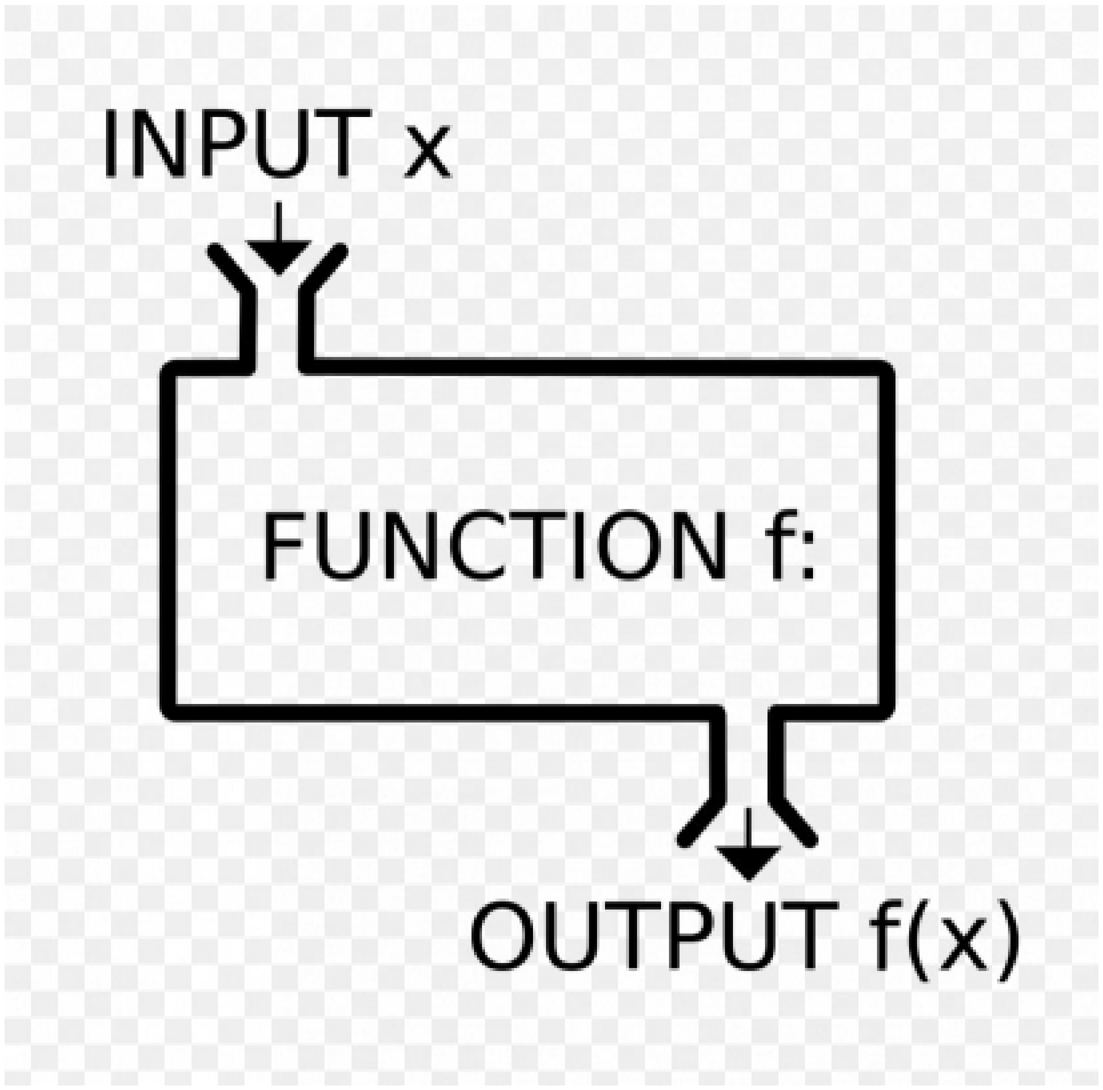
0.4 What is functional programming?

Functional programming (FP) is based on a simple premise with far-reaching implications: we construct our programs using only pure functions—in other words, functions that have no side effects.



What are side effects? A function has a side effect if it does something other than simply return a result, for example:

- Modifying a variable
- Modifying a data structure in place
- Setting a field on an object
- Throwing an exception or halting with an error
- Printing to the console or reading user input
- Reading from or writing to a file
- Drawing on the screen

0.5 What is referential transparency?

An expression e is referentially transparent if, for all programs p, all occurrences of e in p can be replaced by the result of evaluating e without affecting the meaning of p. A function f is pure if the expression f(x) is referentially transparent for all referentially transparent x.

[1]:
```
from typing import List

def add_numbers(numbers: List[int]) -> int:
    sum = 0
    for n in numbers:
        sum = sum + n
    return sum

add_numbers([1, 5, 6, 8])
```

[1]:
```
20
```

[2]:
```
from typing import List

def add_numbers(numbers: List[int]) -> int:
    # if sum = 0, we should be able to replace sum on the RHS with 0 and get␣
 ↪the same result
    sum = 0
    for n in numbers:
        sum = 0 + n
    return sum

add_numbers([1, 5, 6, 8])
```

[2]: 8

[3]:
```python
# Let's use recursion

def add_numbers2(numbers: List[int]) -> int:
    return numbers[0] if len(numbers) == 1 else numbers[0] +␣
 ↪add_numbers2(numbers[1:])

add_numbers2([1, 5, 6, 8])
```

[3]: 20

[4]:
```python
# Let's use a higher-order function

from functools import reduce

def add_numbers3(numbers: List[int]) -> int:
    return reduce(lambda a, b: a + b, numbers)

add_numbers3([1, 5, 6, 8])
```

[4]: 20

0.5.1 pyEffects: Let's add some classes to deal with common behaviors

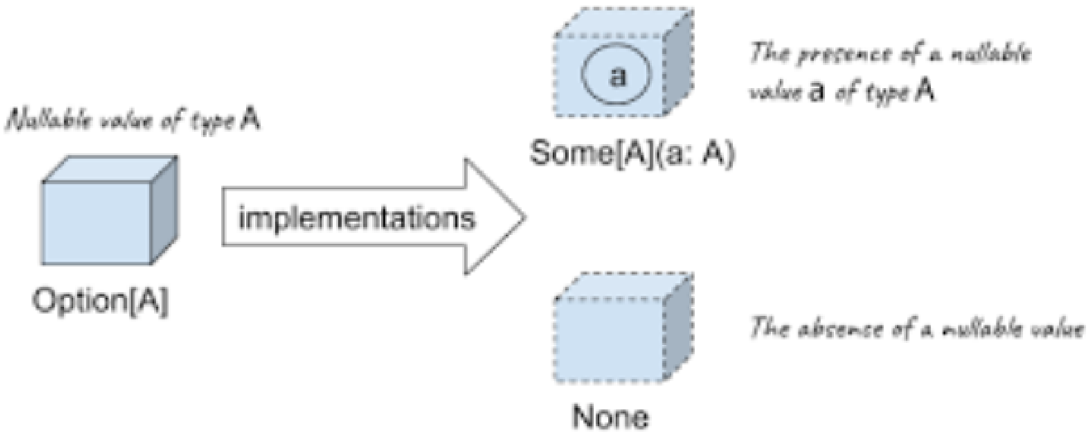
Classes: Option, Try, Either, and Future https://github.com/vickumar1981/pyeffects/

Read the Docs

[5]:
```
!pip install pyeffects
```

```
Requirement already satisfied: pyeffects in
/home/vic/anaconda3/lib/python3.9/site-packages (1.0.5)
```

0.6 Dealing with Emptiness: Option


Nullable value of type A
Option[A]
implementations
Some[A](a: A)
a
The presence of a nullable value a of type A
None
The absence of a nullable value

0.6.1 An Example Data Model

[6]:
```python
from dataclasses import dataclass
from pyeffects.Option import *

@dataclass
class Name:
    first_name: str = None
    last_name: str = None

    def get_last_name(self) -> Option[str]:
        return Option.of(self.last_name)

    def get_first_name(self) -> Option[str]:
        return Option.of(self.first_name)

@dataclass
class Contact:
    name: Name = None
    relationship: str = "primary contact"

    def get_name(self) -> Option[Name]:
        return Option.of(self.name)

@dataclass
class Person:
    name: Name = None
    contact1: Contact = None
    contact2: Contact = None

    def get_name(self) -> Option[Name]:
        return Option.of(self.name)

    def get_contact1(self) -> Option[Contact]:
        return Option.of(self.contact1)

    def get_contact2(self) -> Option[Contact]:
        return Option.of(self.contact2)
```

[7]:
```
def get_contact_first_name(person: Person) -> str:
    if person and person.contact1 and person.contact1.name:
        return person.contact1.name.first_name
    else:
        return None

p = Person("Person 1", Contact(Name("Bob", "Smith"), "grandfather"),␣
 ↪Contact(Name("Mary", "Smith"), "mother"))

get_contact_first_name(p)
```

[7]:
```
'Bob'
```

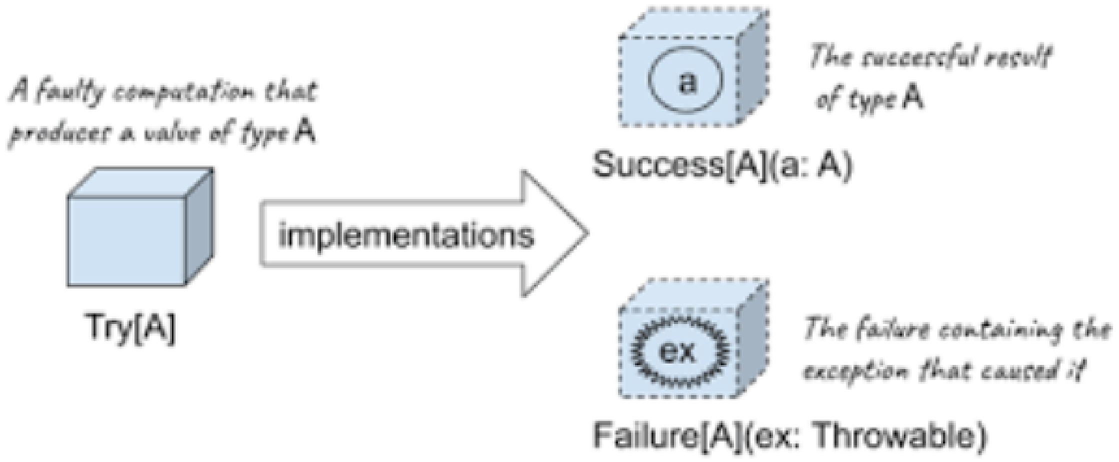
[8]:
```
def get_contact_first_name2(person: Person) -> Option[str]:
    return person.get_contact1()\
        .flat_map(Contact.get_name)\
        .flat_map(Name.get_first_name)

get_contact_first_name2(p)
```

[8]:
```
Some(Bob)
```

[9]:
```
person_with_no_contacts = Person("Person 2")
get_contact_first_name2(person_with_no_contacts).get_or_else("No contact name")
```

[9]:
```
'No contact name'
```

0.7 Dealing with Exceptions: Try


A faulty computation that produces a value of type A
Try[A]
implementations
The successful result of type A
a
Success[A](a: A)
The failure containing the exception that caused it
ex
Failure[A](ex: Throwable)

[10]:
```
person1_str = """
{
  "name": {
      "first_name": "1st",
      "last_name": "Person"
  },
  "contact1": {
      "name": {
          "first_name": "Alice",
          "last_name": "Jones"
      }
  }
}
"""

person2_str = """
{
  "name": {
      "first_name": "2nd",
      "last_name": "Person"
  },
  "contact1": {
      "name": {
          "first_name_is_wrong": "Mary",
          "last_name": "Jones"
      }
  }
}
"""
```

```
[11]: import json

      def parse_name(name_dict: dict) -> Name:
          try:
              n = Name(**name_dict)
              return n
          except TypeError as te:
              raise TypeError("Couldn't deserialize Name: " + str(te))

      def parse_contact(contact_dict: dict, relationship: str) -> Contact:
          n = None
          if 'name' in contact_dict:
              n = parse_name(contact_dict['name'])
          return Contact(name = n, relationship = relationship)

      def parse_person(json_str: str) -> Person:
          attributes = json.loads(json_str)
          n, contact1, contact2 = (None, None, None)
          if 'name' in attributes:
              n = parse_name(attributes['name'])
          if 'contact1' in attributes:
              contact1 = parse_contact(attributes['contact1'], 'contact1')
          if 'contact2' in attributes:
              contact2 = parse_contact(attributes['contact2'], 'contact2')
          return Person(n, contact1, contact2)

      person1 = parse_person(person1_str)
      person1.contact1.name.first_name
```

```
[11]: 'Alice'
```

```
[12]: person2 = parse_person(person2_str)
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
/tmp/ipykernel_1818/2680335701.py in parse_name(name_dict)
      4     try:
----> 5         n = Name(**name_dict)
      6         return n

TypeError: __init__() got an unexpected keyword argument 'first_name_is_wrong'

During handling of the above exception, another exception occurred:

TypeError                                 Traceback (most recent call last)
/tmp/ipykernel_1818/1474534612.py in <module>
----> 1 person2 = parse_person(person2_str)
```

```
/tmp/ipykernel_1818/2680335701.py in parse_person(json_str)
     20         n = parse_name(attributes['name'])
     21     if 'contact1' in attributes:
---> 22         contact1 = parse_contact(attributes['contact1'], 'contact1')
     23     if 'contact2' in attributes:
     24         contact2 = parse_contact(attributes['contact2'], 'contact2')

/tmp/ipykernel_1818/2680335701.py in parse_contact(contact_dict, relationship)
     11     n = None
     12     if 'name' in contact_dict:
---> 13         n = parse_name(contact_dict['name'])
     14     return Contact(name = n, relationship = relationship)
     15

/tmp/ipykernel_1818/2680335701.py in parse_name(name_dict)
      6         return n
      7     except TypeError as te:
----> 8         raise TypeError("Couldn't deserialize Name: " + str(te))
      9
     10 def parse_contact(contact_dict: dict, relationship: str) -> Contact:

TypeError: Couldn't deserialize Name: __init__() got an unexpected keyword␣
 ↪argument 'first_name_is_wrong'
```

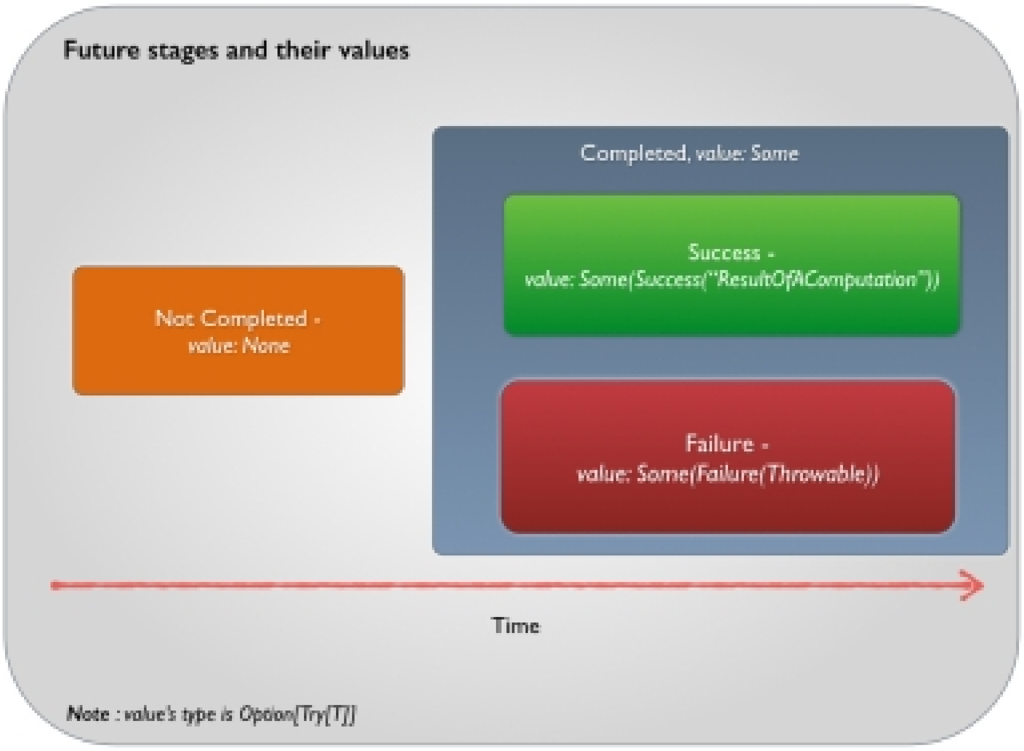
[13]:
```python
import json
from pyeffects.Try import *

def parse_name(name_dict: dict) -> Try[Person]:
    return Try.of(lambda: Name(**name_dict['name']))

def handle_parse_error(relationship: str) -> Contact:
    print(f"Error parsing contact: {relationship} (relationship)")
    return Contact(relationship = relationship)

def parse_contact(contact_dict: dict, relationship: str) -> Contact:
    return parse_name(contact_dict)\
        .map(lambda n: Contact(name = n, relationship = relationship))\
        .or_else_supply(lambda: handle_parse_error(relationship))

def parse_person(json_str: str) -> Person:
    attributes = json.loads(json_str)
    n = parse_name(attributes).get_or_else(None)
    contact1 = Try.of(lambda: parse_contact(attributes['contact1'],␣
 ↪'contact1')).get_or_else(None)
    contact2 = Try.of(lambda: parse_contact(attributes['contact2'],␣
 ↪'contact2')).get_or_else(None)
```

```
    return Person(n, contact1, contact2)
```

[14]:
```
person1 = parse_person(person1_str)
print(f"{person1.name.first_name} {person1.name.last_name}")
print(person1.contact1.name.first_name)

person2 = parse_person(person2_str)
print(f"{person2.name.first_name} {person2.name.last_name}")
print(person2.contact1.name)
```

```
1st Person
Alice
Error parsing contact: contact1 (relationship)
2nd Person
None
```

0.8 Dealing with Concurrency: Future


Future stages and their values
Completed, value: Some
Success -
value: Some(Success("ResultOfAComputation"))
Not Completed -
value: None
Failure -
value: Some(Failure(Throwable))
Time
Note : value's type is Option[Try[T]]

0.8.1 Running in Function a New Thread

[15]:
```
from pyeffects.Future import *
import time

def delayed_result() -> int:
    time.sleep(3)
    return 100

start_time = time.time()
result = Future.run(delayed_result).map(lambda v: v + 1)
print(f"Done: {result.is_done()}")
time.sleep(4)
print(f"Done: {result.is_done()}")
print(f"Result: {result.get()}")
execution_time = (time.time() - start_time)
print(f"Execution time: {execution_time} s")
```

```
Done: False
Done: True
Result: 101
Execution time: 4.003849029541016 s
```

0.8.2 Combining Futures using `flat_map`

[16]:
```
def delayed_result1() -> int:
    time.sleep(3)
    return 100

def delayed_result2() -> int:
    time.sleep(5)
    return 50

def handle_result(result: Try[int], start_time: int) -> None:
    print(f"Result: {result.get()}")
    execution_time = (time.time() - start_time)
    print(f"Execution time: {execution_time} s")


start_time = time.time()
result1 = Future.run(delayed_result1)
result2 = Future.run(delayed_result2)
result1.flat_map(lambda v1: result2.map(lambda v2: v1 + v2))\
    .on_complete(lambda v: handle_result(v, start_time))
```

```
Result: 150
```

```
Execution time: 5.007669448852539 s
```

0.8.3 Dealing with an Asynchronous Errors

[17]:
```
def delayed_result1() -> int:
    time.sleep(3)
    raise Exception("Error getting result")

def delayed_result2() -> int:
    time.sleep(5)
    return 50

def handle_result(result: Try[int], start_time: int) -> None:
    if result.is_failure():
        print("Unable to compute result due to exception")
        print(result.error())
    else:
        print(f"Result: {result.get()}")
    execution_time = (time.time() - start_time)
    print(f"Execution time: {execution_time} s")


start_time = time.time()
result1 = Future.run(delayed_result1)
result2 = Future.run(delayed_result2)
result1.flat_map(lambda v1: result2.map(lambda v2: v1 + v2))\
    .on_complete(lambda v: handle_result(v, start_time))
```

```
Unable to compute result due to exception
Error getting result
Execution time: 3.003845453262329 s
```

0.8.4 Using Future.traverse

[18]:
```
def delayed_result1() -> List[int]:
    time.sleep(3)
    return 100

def delayed_result2() -> List[int]:
    time.sleep(5)
    return 50

def handle_result(results: List[int], start_time: int) -> None:
    print(f"Result: {sum(results)}")
    execution_time = (time.time() - start_time)
    print(f"Execution time: {execution_time} s")
```

```python
start_time = time.time()
result1 = Future.run(delayed_result1)
result2 = Future.run(delayed_result2)

# Convert List[Future[int]] -> Future[List[int]]
Future.traverse([result1, result2])\
    .on_complete(lambda v: handle_result(v.get(), start_time))
```

```
Result: 150
Execution time: 5.003130674362183 s
```

0.9 Take aways

- Using side-effects can make code harder to reason about
- If functions are referentially transparent, it becomes easier to use localized reasoning
- Can use abstractions: Try, Future, Option, Either to replace common behaviors
- Fluent API style: reads left to right

0.9.1 Twitter: @vickumar1981

0.9.2 Github: https://github.com/vickumar1981