Reactive Programming

Index

1. **Preliminary of Asynchronous Programming**

    - Preliminary
    - Aysnchronous Programming
    - When do we have to use Async?

2. **Reactive Programming**

    - Code Scalability
    - Reactive Programming (Reactive Extension)

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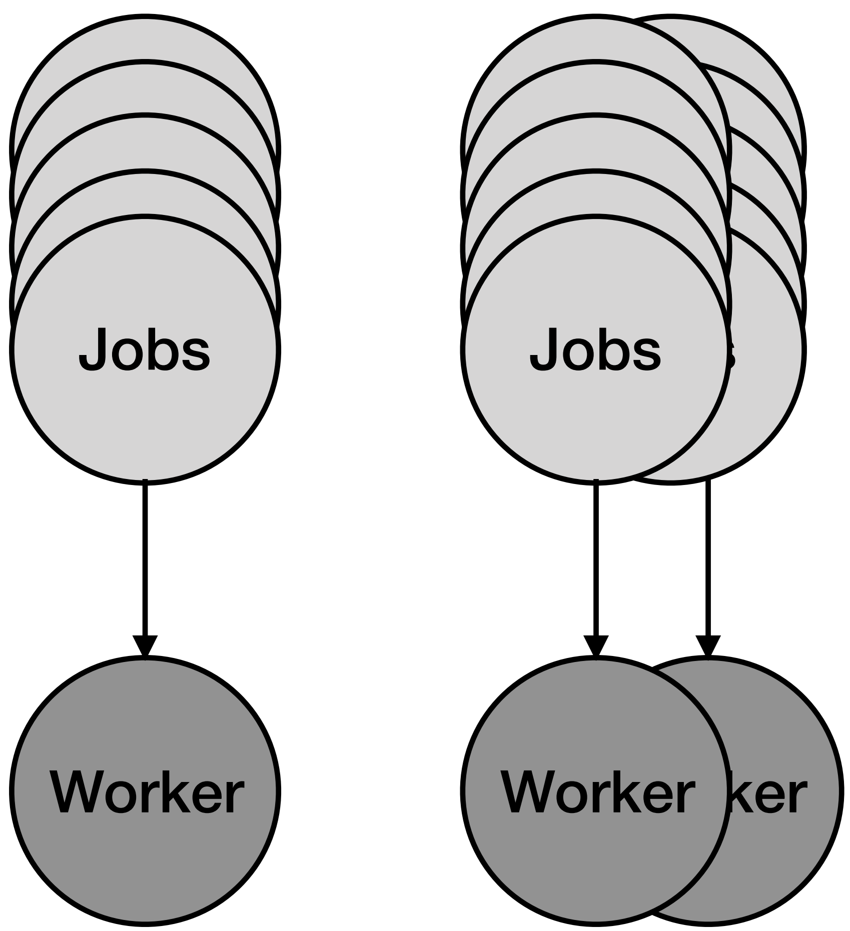
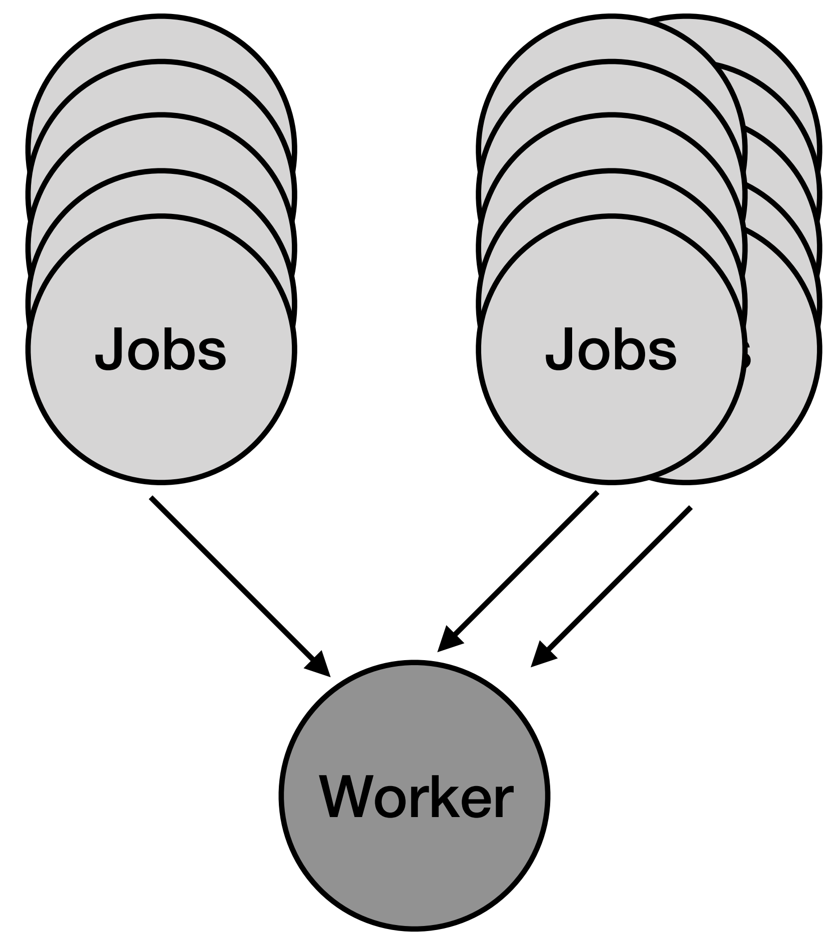
Preliminary

Parallelism - Concurrency



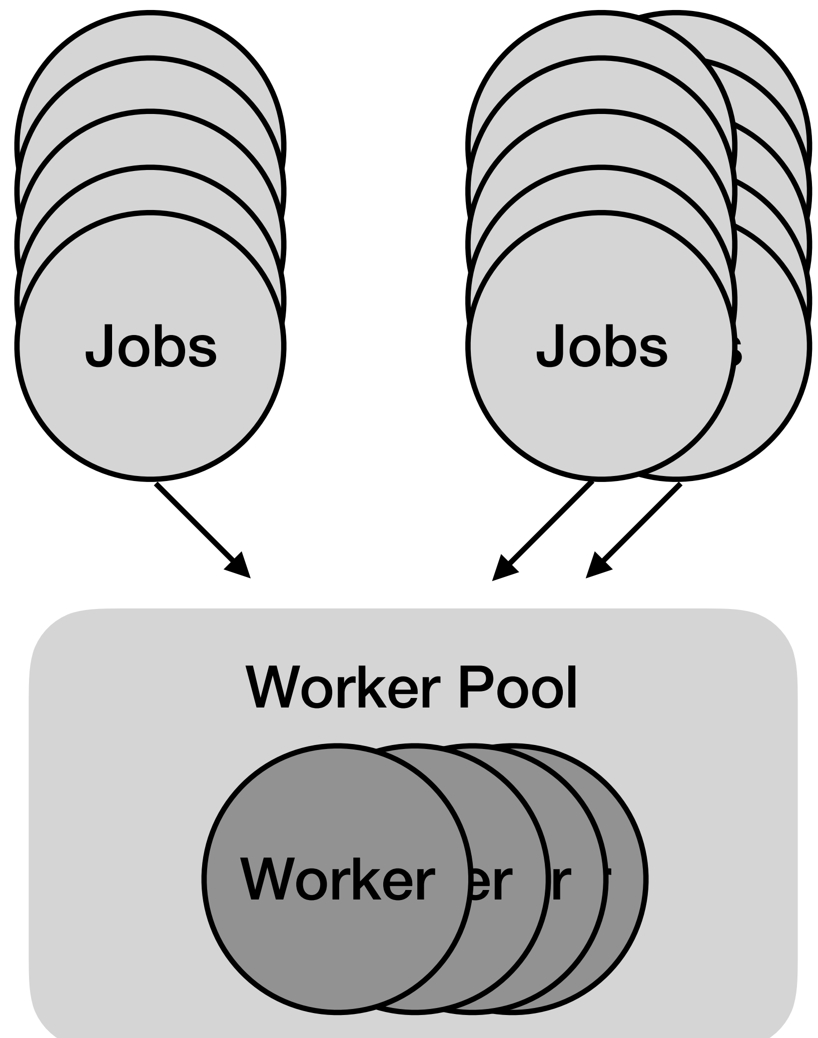
일꾼이 여러개
여러개 일꾼이 “동시에” 일을 하면서 처리



일꾼 갯수 상관 X
일을 스케줄링을 통해 처리하면서
마치 동시에 하는 것처럼 처리

Preliminary

Parallelism + Concurrency



당연히 2가지 다 확보가능

Preliminary

Blocking I/O - Non Blocking I/O

```
while not_finished:
    data = socket.recv(buf_size)
    do_something(data)
```

소켓에서 데이터를 받고 로직을 진행 (Imperative 하게)

Preliminary

Blocking I/O - Non Blocking I/O

```
while not_finished:
    try:
        data = socket.recv(buf_size)
        do_something(data)
    except socket.error as e:
        if e.args[0] in _ERRNO_WOULDBLOCK:
            # Do something else
```

데이터를 읽거나 쓰는 과정에서 기다리지 않음

Preliminary

Asynchronous Programming

```
data = yield tornado.iostream.read_until('\r\n')
```

Implementation Details

Blocking or Non-Blocking socket I/O

Asynchronous programming 의 Implementation detail 를
Non-blocking i/o 든지 blocking i/o 이든지 상관 X

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Asynchronous Programming

Providing Concurrency by Scheduling Events

이벤트를 스케줄링하면서 동시성을 제공하는 것이 목적

Asynchronous Programming

How communicate with a scheduler?

Callback, Future, Promise, Await

Asynchronous framework 를 사용할 때 중요한건 이 프레임워크가
어떻게 유저 코드랑 스케줄링 해주는 스케줄러랑 통신을 하느냐이다

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When do we have to use Async?

Massive I/O

CPU bound job 에서는 쓸모 X

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Code Scalability

Everything must be compositional

Code Scalability

Remind

Asynchronous Frameworks (tornado, asyncio)

```
data = yield tornado.iostream.read_until('\r\n')
```

much more compositional

Non-Blocking I/O

```
while not_finished:
    try:
        data = socket.recv(buf_size)
        do_something(data)
    except socket.error as e:
        if e.args[0] in _ERRNO_WOULDBLOCK:
            # Do something else
```

Code Scalability

Asynchronous Frameworks (tornado, asyncio)

```
data = yield tornado.iostream.read_until('\r\n')
```

Is It enough?

NO !

Code Scalability

Multiple Async HTTP Calls
Multiple Async HTTP Calls and Take Fastest Response

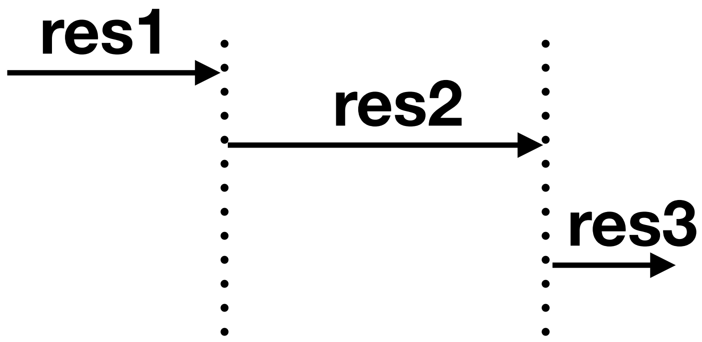
Code Scalability

Multiple Async HTTP Calls - Asynchronous Frameworks

```
res1 = yield service1_api_call()
res2 = yield service2_api_call()
res3 = yield service3_api_call()

data = res1 + res2 + res3
```

Must be refactored !

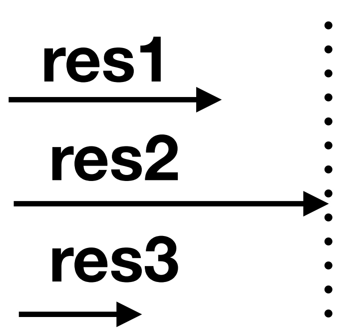


Code Scalability

Multiple Async HTTP Calls - Asynchronous Frameworks

```
futures = [service1_api_call(),
           service2_api_call(),
           service3_api_call()]

data = []
for future in futures:
    data.append((yield future))
```



Code Scalability

Multiple Async HTTP Calls - Rx

```
Observable.merge(service1_api_call(),
                 service2_api_call(),
                 service3_api_call())
         .map(lambda data: ...)
```

Code Scalability

Multiple Async HTTP Calls and Take Fastest Response
- Asynchronous Frameworks

…. ???

Code Scalability

Multiple Async HTTP Calls and Take Fastest Response - Rx

```
Observable.merge(service1_api_call(),
                 service2_api_call(),
                 service3_api_call())
          .take(1)
          .map(lambda data: ...)
```

Code Scalability

Reactive Programming (Rx)

↑ **much more compositional**

Asynchronous Frameworks (tornado, asyncio)

```
data = yield tornado.iostream.read_until('\r\n')
```

↑ **much more compositional**

Non-Blocking I/O

```
while not_finished:
    try:
        data = socket.recv(buf_size)
        do_something(data)
    except socket.error as e:
        if e.args[0] in _ERRNO_WOULDBLOCK:
            # Do something else
```

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   - Code Scalability
   - **Reactive Programming (Reactive Extension)**

Reactive Programming

Async 한 상황에서 Async 한 데이터를 어떻게 처리할 것인지에 대한 아이디어
Async 한 작업을 Functional 하게 처리하는 아이디어

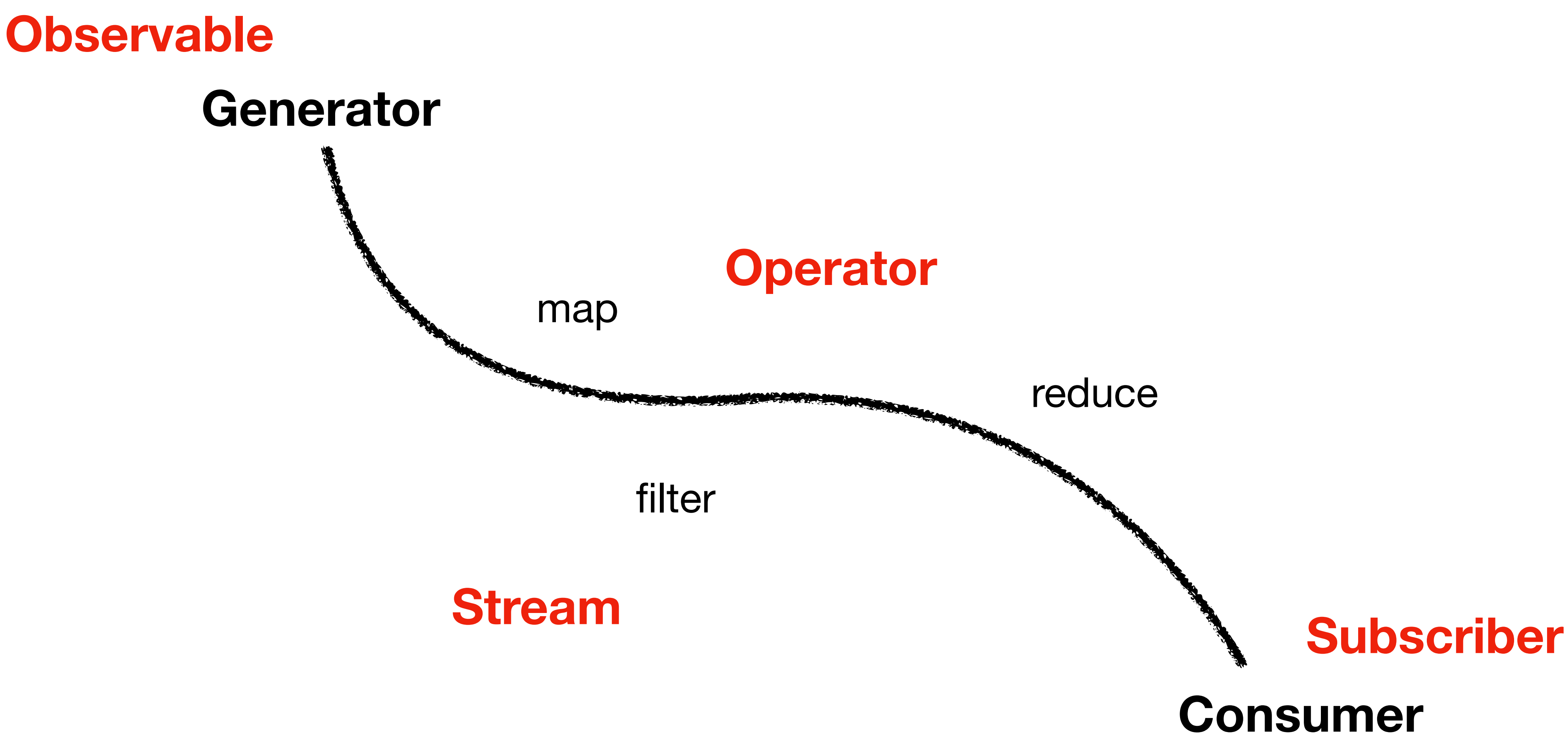
아이디어 => Stream 이라는 것으로 연결하고 그 Stream 에 데이터를 흘려보내라

Reactive Programming

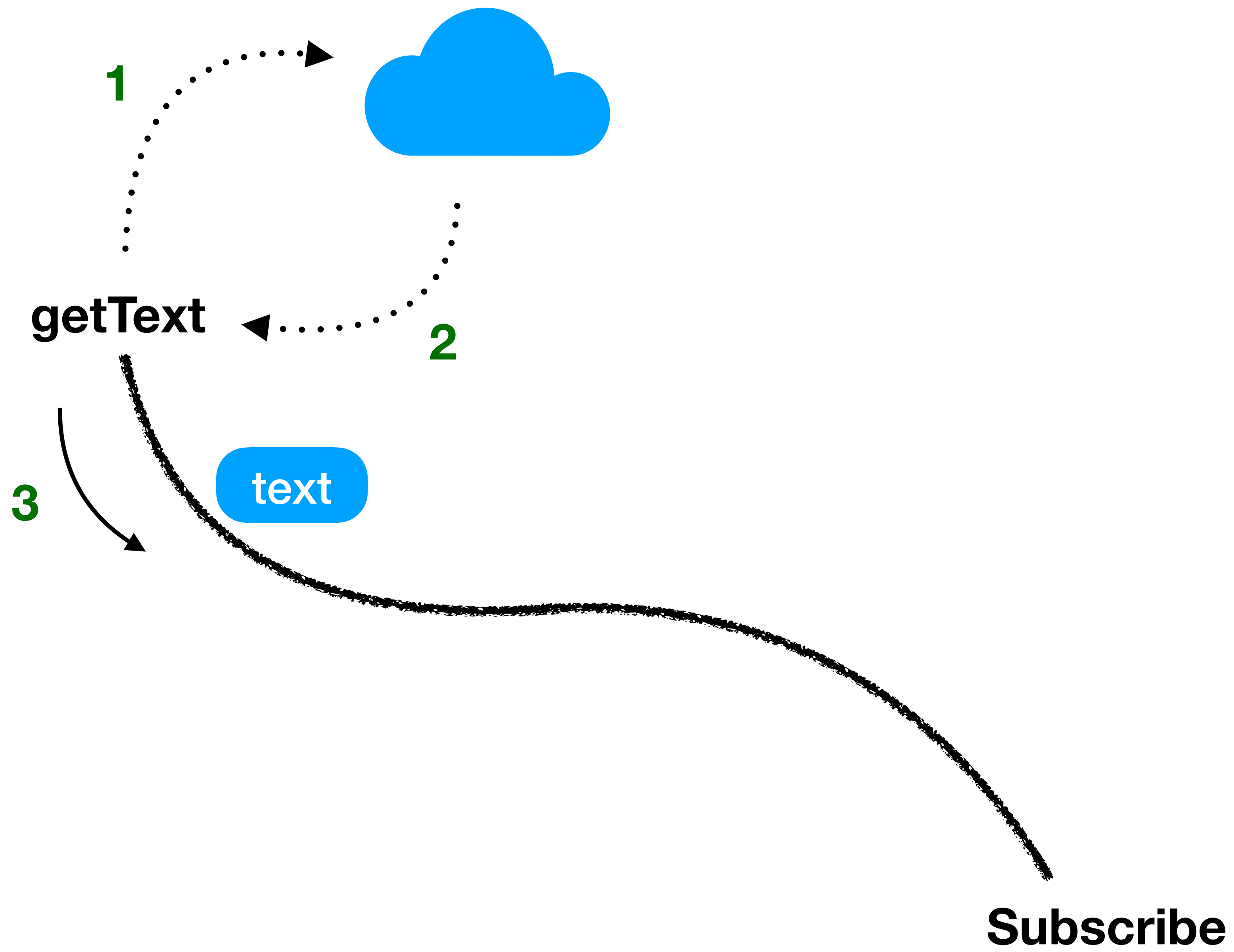
Reactive Libraries

Reactive Extension, Sodium, ReactiveCocoa …

Reactive Programming



Reactive Programming



Reactive Programming

Async 한 처리를 Functional 하게 처리하자

리턴값 Stream 은 Observable 을 반환하자

Stream 에 흐르는 Data/Event 를 Operator 로 처리하자

Stream 과 Stream 을 연결하자

Reactive Programming

Providing Concurrency by Scheduling Events

\+ Asynchronous framework 가 해주는일

Providing Operators by Calling Functions

Reduce Complexity using functional programming patterns, disciplines

Reactive Programming

Rx Operators

Observable<Data>

+

Operator

timer, defer, interval, repeat,
map, flat_map, filter, zip,
merge, delay, timeout
...

시간 관련 operator

데이터를 다루는 operator

Reactive Programming

Essence of Observable

Stream<Optional<Async<Data>>>

lazy execution

data 가 있는지

Fork-Join, asyncio, tornado

Reactive Programming

Essence of Observable

Rx : Stream<Optional<Async<Data>>>
→ (Data → Stream<Optional<Async<Data>>>)
→ Stream<Optional<Async<Data>>>

Reactive Programming

Essence of Observable

Rx : Stream<Optional<Async<Data>>>
→ (Data → Stream<Optional<Async<Data>>>)
→ (Data → Stream<Optional<Async<Data>>>)
→ (Data → Stream<Optional<Async<Data>>>)
→ Stream<Optional<Async<Data>>>

Reactive Programming

Essence of Observable

Rx : Stream<Optional<Async<Data>>>
→ (Data → Stream<Optional<Async<Data>>>)
Scheduler → (Data → Stream<Optional<Async<Data>>>) User
→ (Data → Stream<Optional<Async<Data>>>)
→ Stream<Optional<Async<Data>>>

Reactive Programming

Reduce Complexity using functional programming patterns, disciplines

1. Stream (based on Co-induction)

```
Observable.from(get_obj)
          .filter(is_a)
          .map(...)
          .flat_map(...)
          .map(...)
          .subscription(success, error, complete)
```

Reactive Programming

Reduce Complexity using functional programming patterns, disciplines

2. Compositionality

```
Observable.from(get_obj)
          .filter(is_b)
          .map(...)
          .flat_map(...)
          .map(...)
          .subscription(success, error, complete)
```

이렇게 바꾸더라도 로직에 영향 X
짝만 맞추면 됨

Reactive Programming

Reduce Complexity using functional programming patterns, disciplines

3. Compositionality of Operators

```
operator = some_other_operator : Observable<a> -> * -> Observable<b>

feature_a = Observable.from(get_obj)
                      .filter(is_b)
                      .map(...)
                      .flat_map(...)
                      .map(...)
                      .some_other_operator(...)

feature_b = Observable.from(get_obj)
                      .flat_map(feature_a)
                      .map(...)
                      .some_other_operator(...)
                      .subscription(success, error, complete)
```

Reactive Programming

Reduce Complexity using functional programming patterns, disciplines

4. ROP, First Class Effect

```
Observable.from(get_obj)
          .filter(is_b)
          .map(...)
          .flat_map(...)
          .map(...)
          .subscription(success, error, complete)
```

Reactive Programming

Reduce Complexity using functional programming patterns, disciplines

5. Abstracted Data Type based on Type Theory - First Class Effect

```
Observable.from(get_obj)
          .filter(is_b)
          .map(...)
          .flat_map(...)
          .map(...)
          .subscription(success, error, complete)
```

Reactive Programming

Reduce Complexity using functional programming patterns, disciplines

5. Abstracted Data Type based on Type Theory - First Class Effect

```
Observable.from(get_obj)
          .filter(is_b)
          .map(...)
          .flat_map(...)
          .map(...)
          .subscription(success, error, complete)
```

```
   from : a -> Observable<a>
 filter : Observable<a> -> (a -> bool) -> Observable<a>
    map : Observable<a> -> (a -> b) -> Observable<b>
flat_map : Observable<a> -> (a -> Observable<b>) -> Observable<b>
```

```
operators : Observable<a> -> * -> Observable<b>  =>  flat_map
```

Reactive Programming

Reduce Complexity using functional programming patterns, disciplines

5. Abstracted Data Type based on Type Theory - First Class Effect

```
Observable.from(get_obj)
          .flat_map(filter_is_a)
          .flat_map(...)
          .flat_map(...)
          .flat_map(...)
          .subscription(success, error, complete)
```

```
    from : a -> Observable<a>
flat_map : Observable<a> -> (a -> Observable<b>) -> Observable<b>
```

Rx : Stream<Optional<Async<Data>>>
→ (Data → Stream<Optional<Async<Data>>>)
→ (Data → Stream<Optional<Async<Data>>>)
→ (Data → Stream<Optional<Async<Data>>>)
→ Stream<Optional<Async<Data>>>

Reactive Programming

Reduce Complexity using functional programming patterns, disciplines

5. Abstracted Data Type based on Type Theory - First Class Effect

```
Stream.from(Optional.from(Async.from(get_obj)))
      .flat_map(Optional.flat_map(Async.flat_map(filter_is_a)))
      .flat_map(Optional.flat_map(Async.flat_map(...)))
      .flat_map(Optional.flat_map(Async.flat_map(...)))
      .flat_map(Optional.flat_map(Async.flat_map(...)))
```

```
    from : a -> Stream<Optional<Async<a>>>
flat_map : Stream<Optional<Async<a>>>
            -> (a -> Stream<Optional<Async<b>>>
            -> Stream<Optional<Async<b>>>
```

Rx : Stream<Optional<Async<Data>>>
→ (Data → Stream<Optional<Async<Data>>>)
→ (Data → Stream<Optional<Async<Data>>>)
→ (Data → Stream<Optional<Async<Data>>>)
→ Stream<Optional<Async<Data>>>

Reactive Programming

Reduce Complexity using functional programming patterns, disciplines

5. Abstracted Data Type based on Type Theory - First Class Effect

```
Observable.from(get_obj)
          .flat_map(filter_is_a)
          .flat_map(...)
          .flat_map(...)
          .flat_map(...)
          .subscription(success, error, complete)
```

이런식으로 쭉 연결된 형태가 Rx 의 본질
Asynchronous Programming 을 한단계 래핑을 하여
이런식으로 프로그램을 짜서 돌릴 수 있도록 하겠다하는 규칙

SUMMARY

Code Scalability

Reactive Programming (Rx)

↑ **much more compositional**

Asynchronous Frameworks (tornado, asyncio)

```
data = yield tornado.iostream.read_until('\r\n')
```

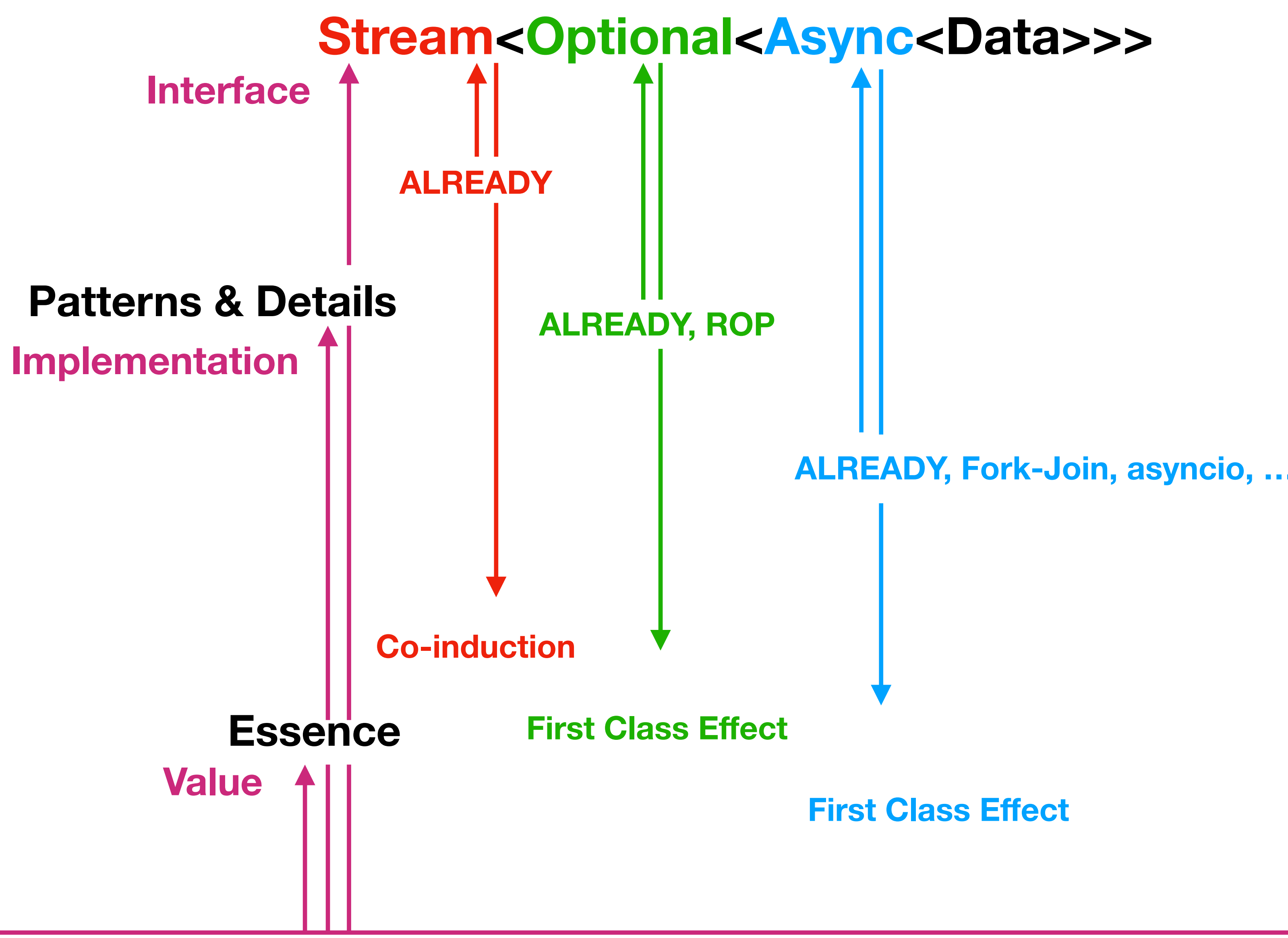
↑ **much more compositional**

Non-Blocking I/O

```
while not_finished:
    try:
        data = socket.recv(buf_size)
        do_something(data)
    except socket.error as e:
        if e.args[0] in _ERRNO_WOULDBLOCK:
            # Do something else
```

Reactive Programming

Essence of Observable



what we can obtain by following the principles can be explained based on mathematics.

Reference

<u>Salt Stack 과 RxPY 로 살펴보는 파이썬 비동기 프로그래밍</u>

<u>Functional Reactive Programming 패러다임</u>