61A Lecture 35

Monday, 28th November, 2011

Last time: sequential data and iterators

Sequences

- The sequence abstraction so far
  - Length
  - Element selection
- Lists and tuples
  - Store all elements up-front
  - can't deal with huge data
  - can't deal with infinite sequences

Iterators

- Store how to compute elements
- Compute one element at a time
- Delay evaluation

Last time: sequential data and iterators

Streams -- a unit of delayed evaluation.

- 2 elements, first and rest.
  - “first” is stored
  - “compute_rest” is stored
  - calculate “rest” on demand

Native python iterator interface

- __iter__()
- __next__()
- for-loops rely on these methods

Generator functions

- Functions that use yield to output values
- Creates a generator object
- __iter__() and __next__() automatically defined

Today: modularity, processing pipelines, and coroutines

Modularity in programs so far

- Helper functions a.k.a “subroutines”

Coroutines: what are they?

Coroutines in python

Types of coroutines

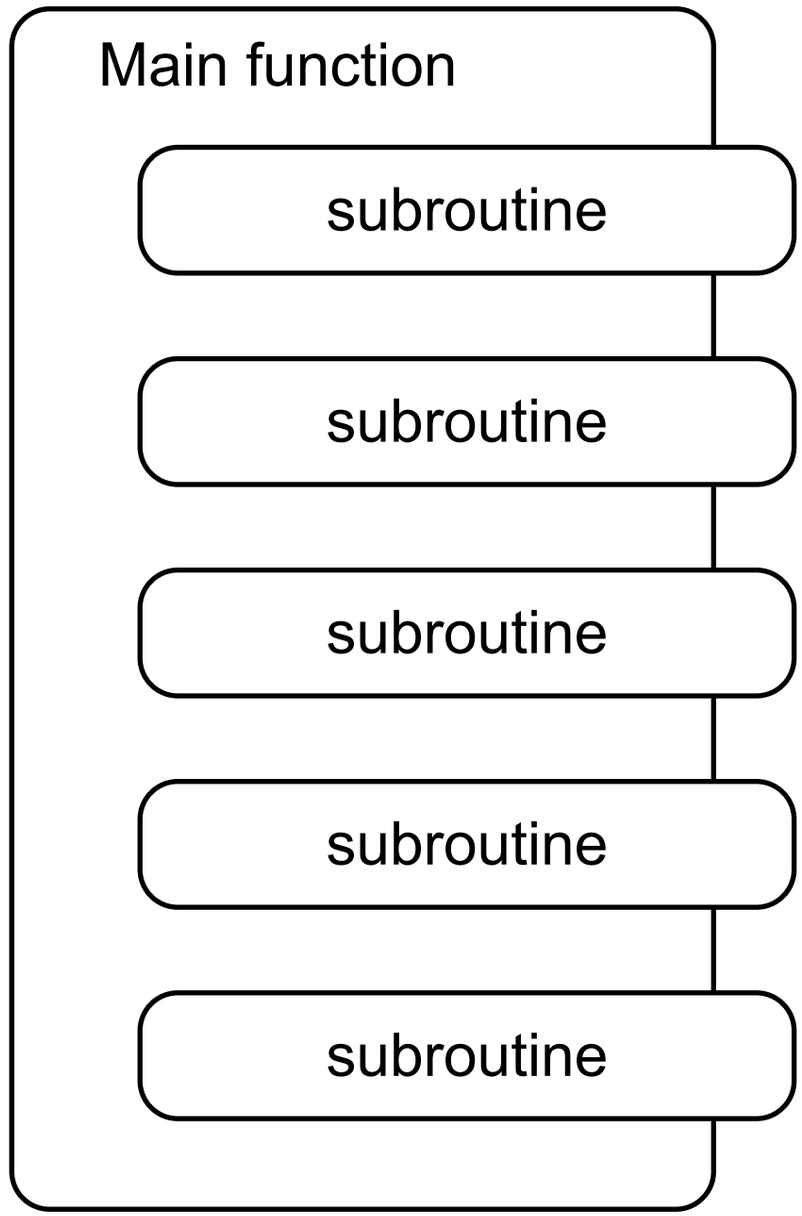
Multitasking

Modularity so far: helper functions

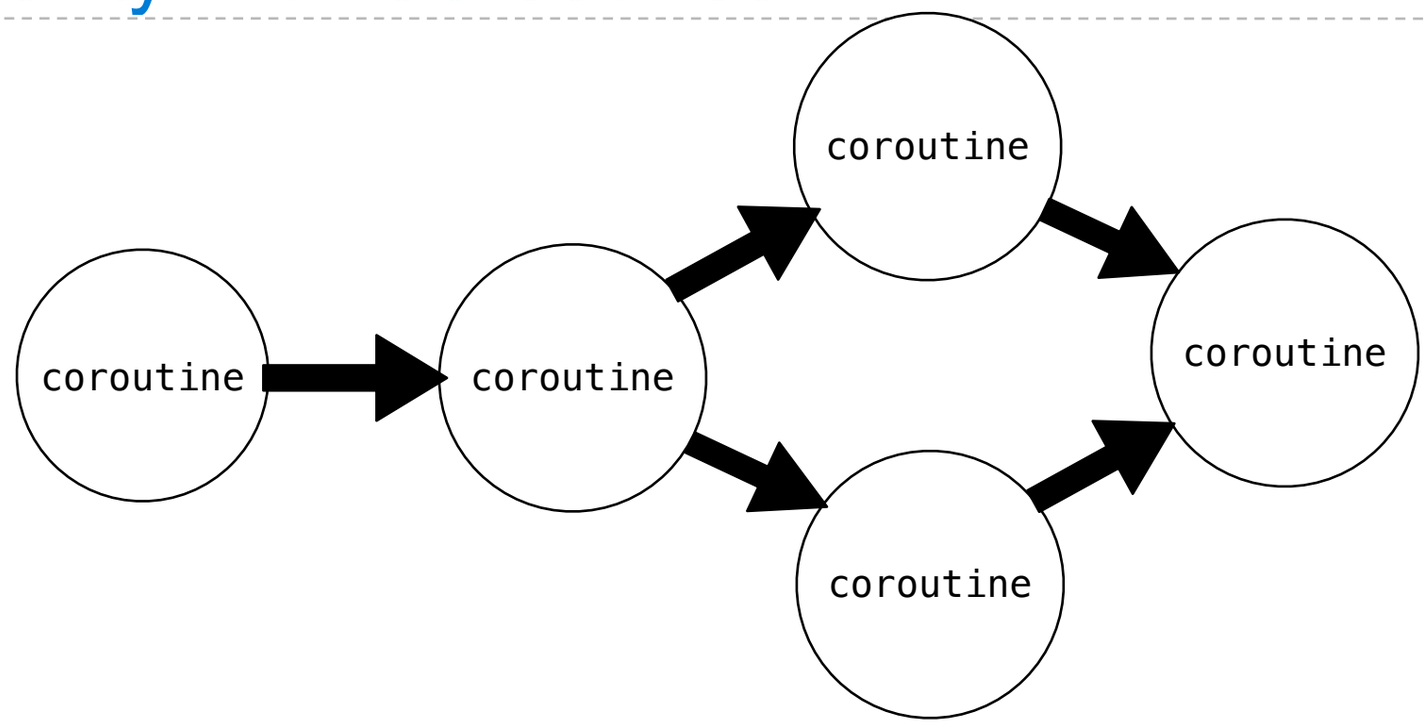
Modularity in programming?

- Helper functions!
  - a.k.a. “subroutines”
- A sub-program responsible for a small piece of computation

A main function is responsible for calling all the subroutines



Modularity with Coroutines

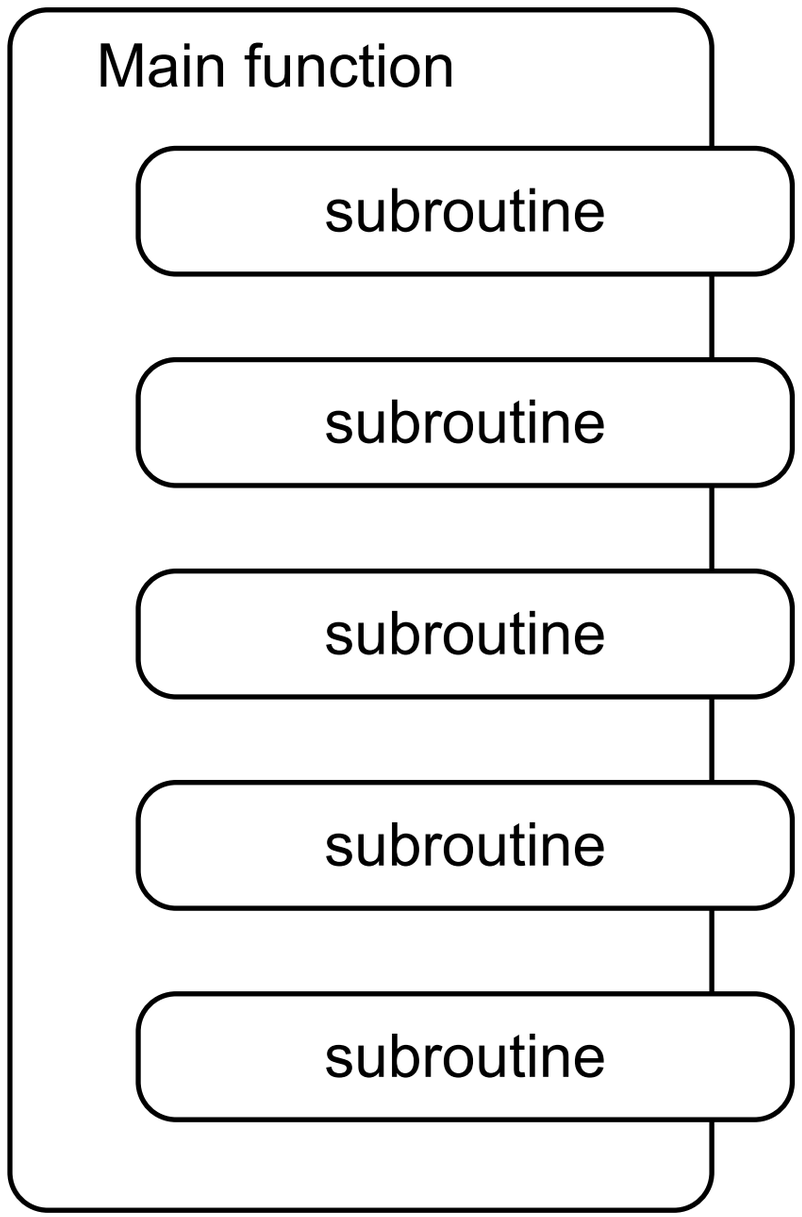


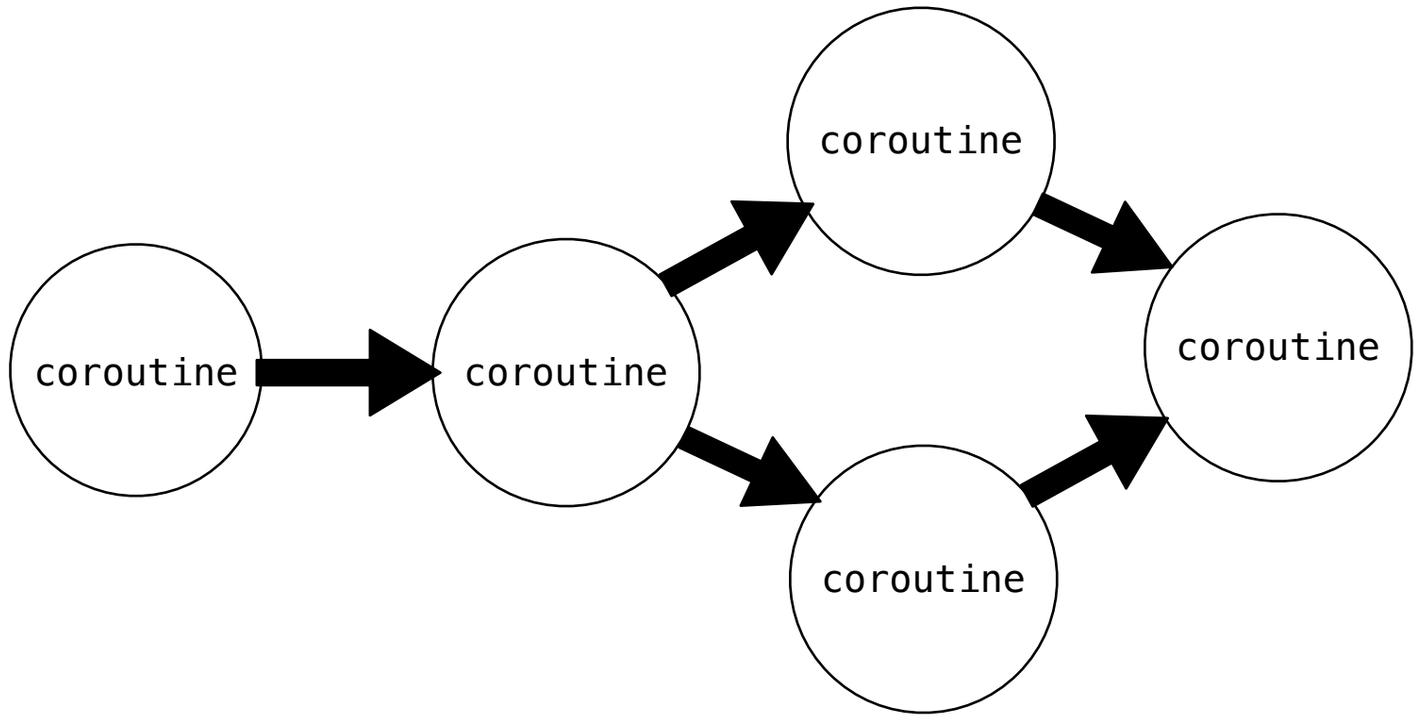
Coroutines are *also* sub-computations

The difference: no main function

Separate coroutines link together to form a complete pipeline

Coroutines vs. subroutines: a conceptual difference





colleagues that **co**operate

subordinate to a main function

Coroutines in python, or, the many faces of “yield”

Previously: generator functions

- ***Produce*** data with yield

```
def letters_generator():
        current = 'a'
        while current <= 'd':
            yield current
            current = chr(ord(current)+1)
```

pauses execution
local variables preserved
resumes when **.__next__** is called
returns the yielded value

Now: coroutines

- ***Consume*** data with yield

```
    value = (yield)
```

pauses execution
local variables preserved
resumes when **.send(data)** is called
assigns value to yielded data

```
                value = (yield)
send(data)
```

(yield) returns the sent data.
Execution resumes

Coroutines in Python

Consuming data with yield:

- value = (yield)
- Execution pauses waiting for data to be sent

Send a coroutine data using send(...)

Start a coroutine using ___next__()

Signal the end of a computation using close()

- Raises GeneratorExit exception inside coroutine

Example: print out strings that match a pattern

```
def match(pattern):
        print('Looking for ' + pattern)
        try:
            while True:
                s = (yield)
                if pattern in s:
                    print(s)
        except GeneratorExit:
            print("=== Done ===")
```

execution starts

resumes here, waiting for data

s = "the Jabberwock ..."

match found

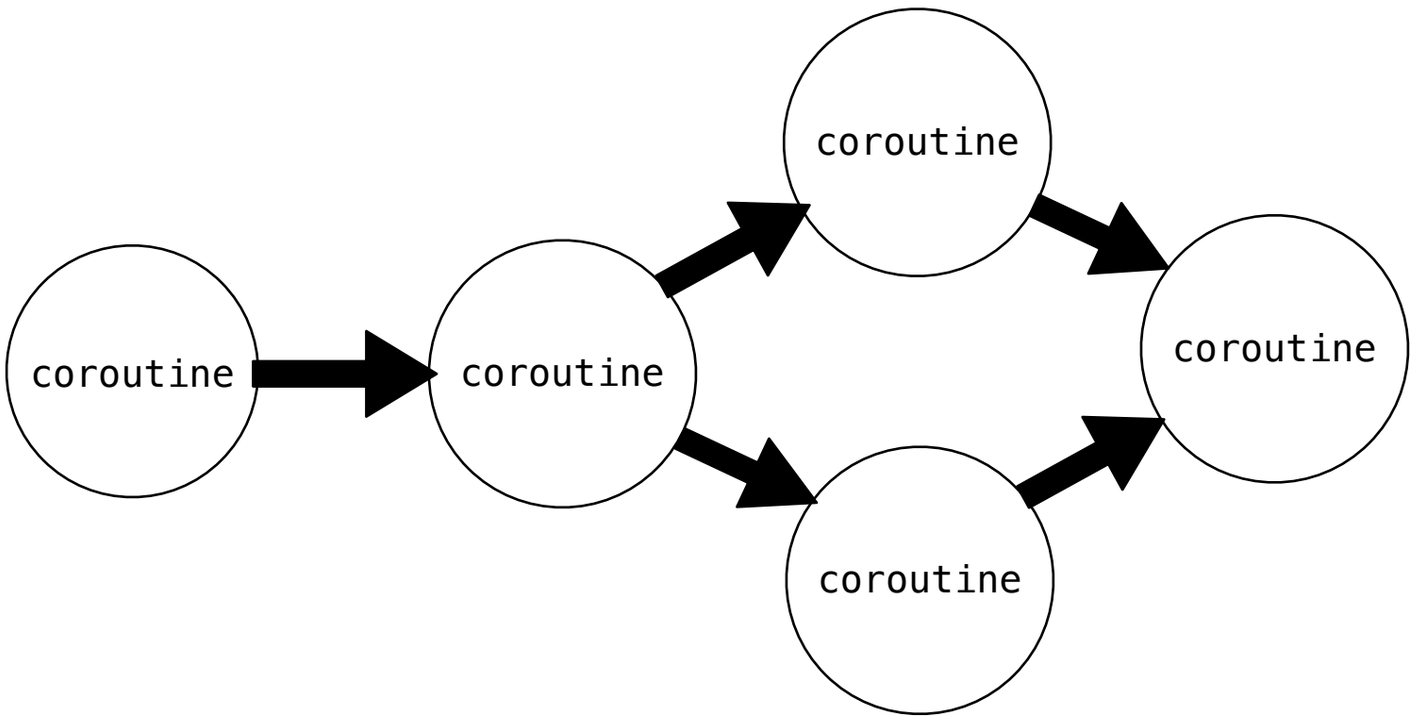
catch exception

```
Step 1: Initialize
>>> m = match("Jabberwock")
```

does nothing
creates a new object

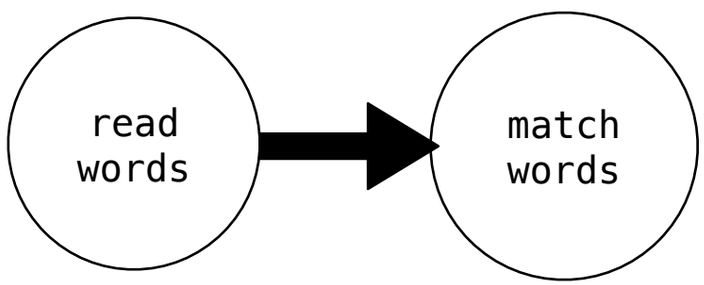
```
Step 2: Start with __next__()
>>> m.__next__()
'Looking for Jabberwock'
Step 3: Send data
>>> m.send("the Jabberwock with eyes of flame")
'the Jabberwock with eyes of flame'
Step 4: close the coroutine
>>> m.close()
'=== Done ==='
```

Pipelines: the power of coroutines

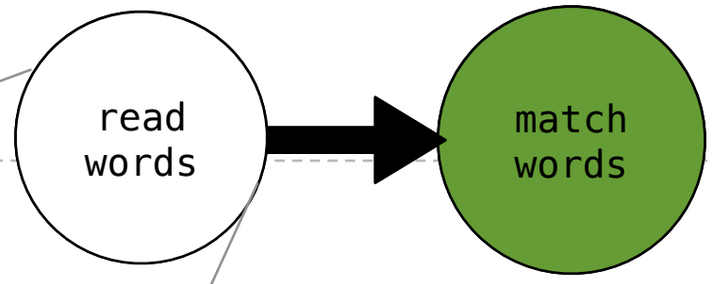


We can chain coroutines together to achieve complex behaviors
Create a pipeline
Coroutines send data to others downstream

A simple pipeline

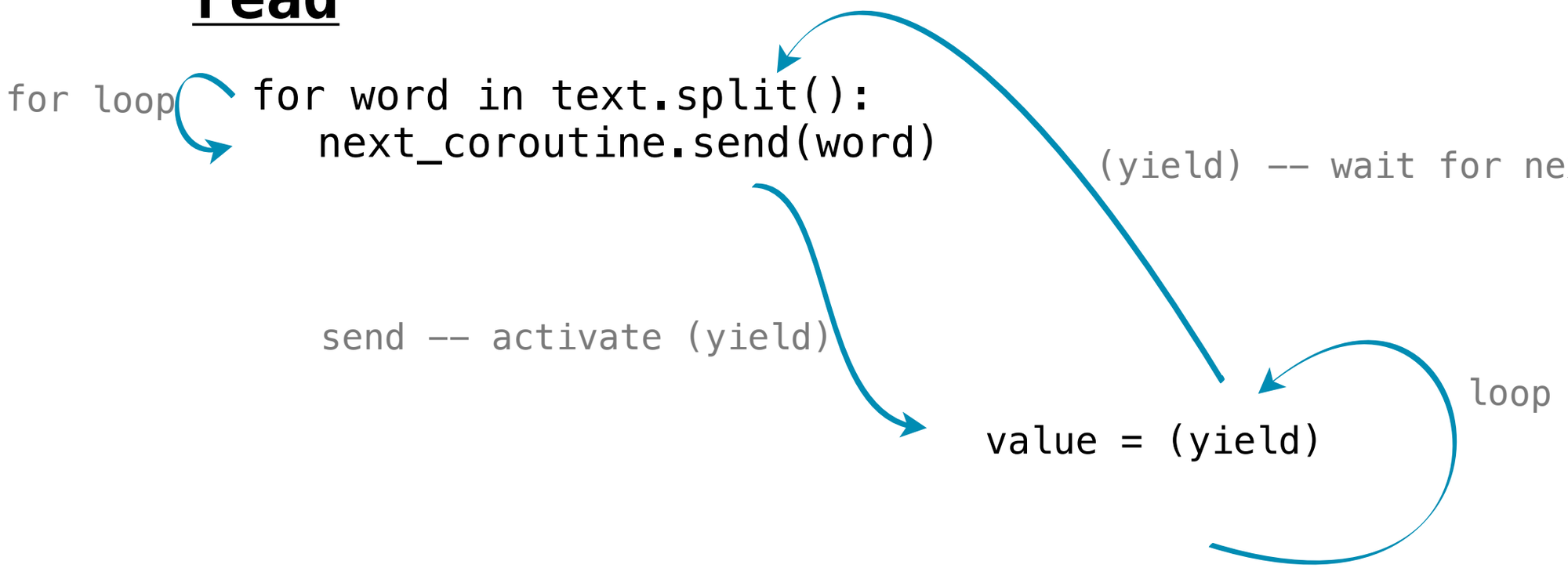


A simple pipeline: reading words



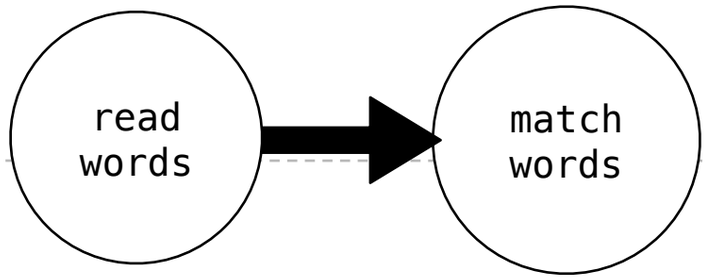

```
def read(text, next_coroutine):needs to know where to send()
    for word in text.split():
        next_coroutine.send(word)
    next_coroutine.close()
```

read



next_coroutine

A simple pipeline



read

for loop

```
for word in text.split():
    next_coroutine.send(word)
```

send -- activate (yield)

(yield) -- wait for next send

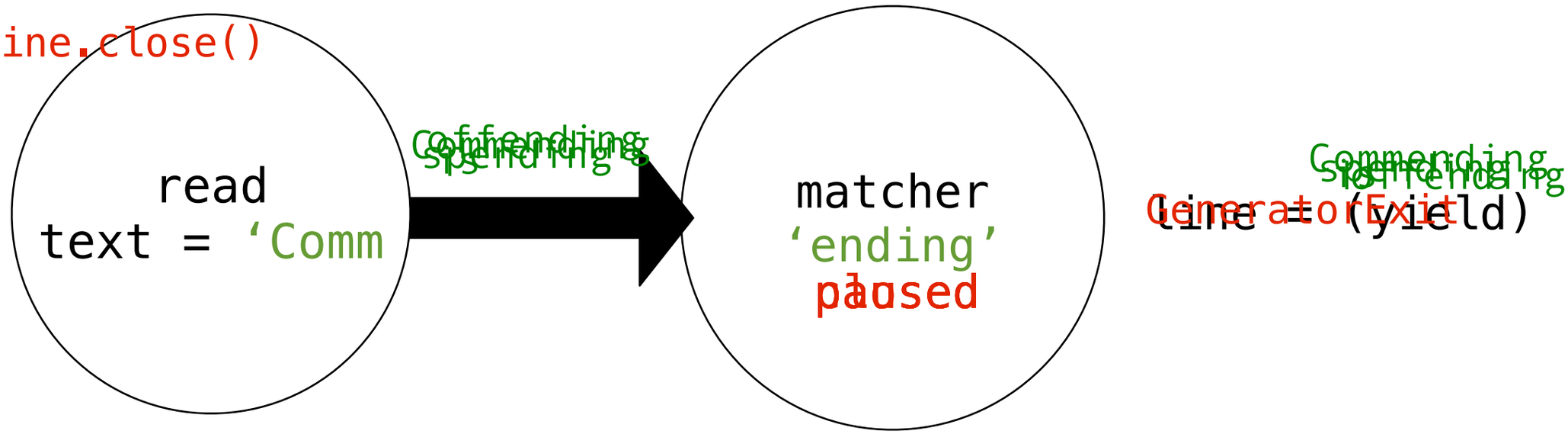
```
while True:
  line = (yield)
  if pattern in line:
    print(line)
```

while loop

match

A simple pipeline

```
for word in text.split():
   next_coroutine.send(word)
next_coroutine.close()
```

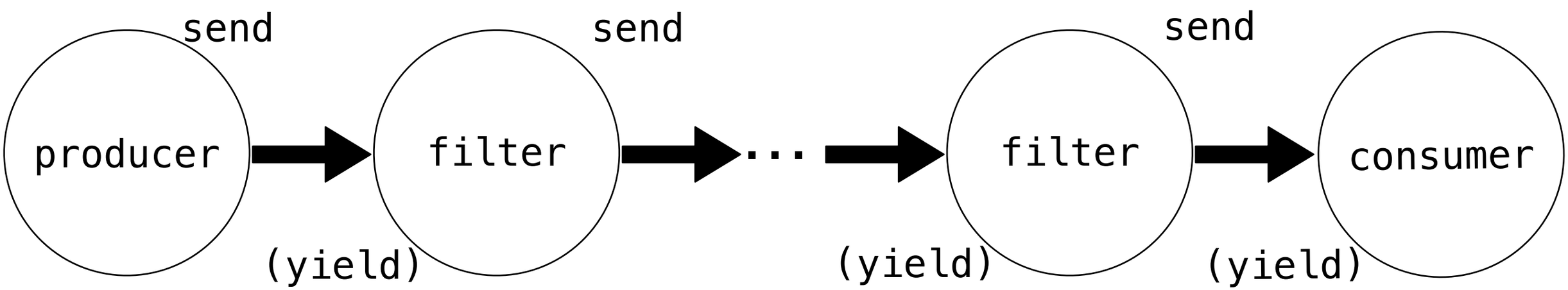



```
>>> matcher = match('ending')
>>> matcher.__next__()
‘Looking for ending’
>>> text = 'Commending spending is offending to people pending lending!'
>>> read(text, matcher)
‘Commending’
‘spending’
‘offending’
‘pending’
‘lending!’
‘=== Done ===’
```

last word!

Produce, Filter, Consume

Coroutines can have different roles in a pipeline
Based on how they use send() and yield



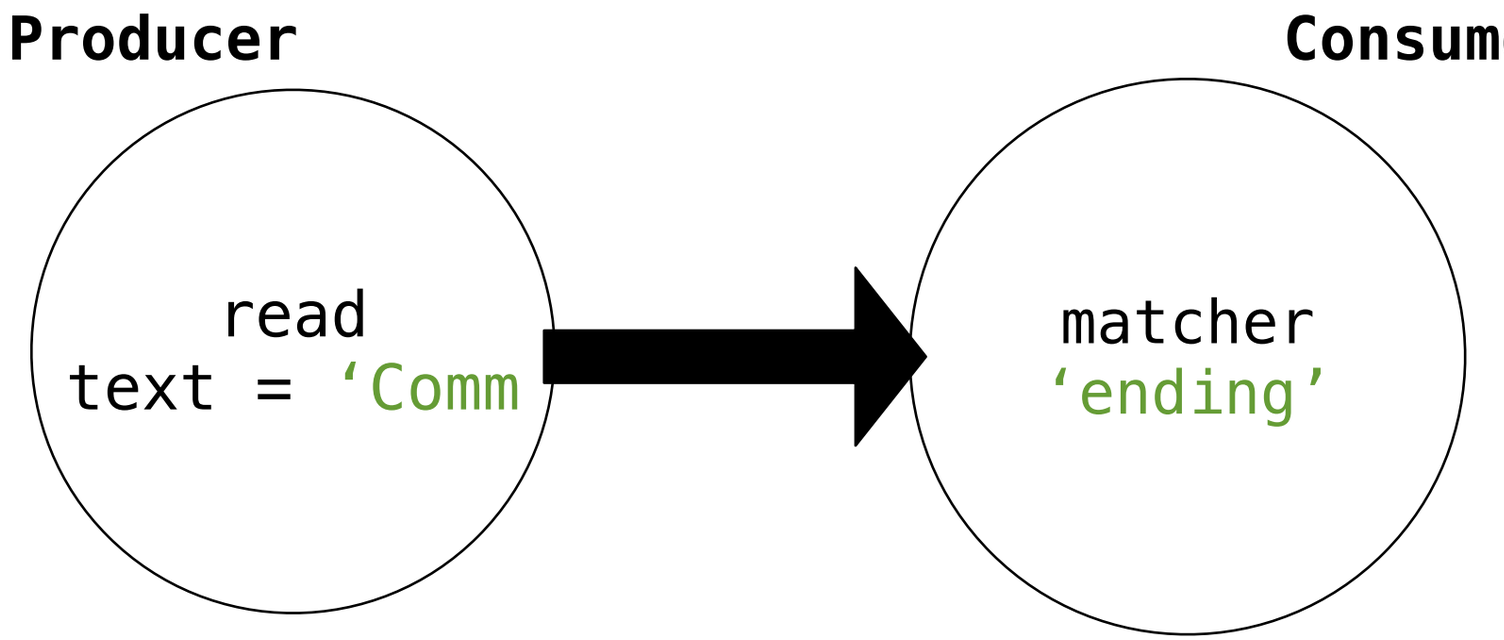
The **producer**
only sends data

The **filter**
consumes with (yield)
and sends results
downstream

There can be many
layers of filters

The **consumer**
only consumes data

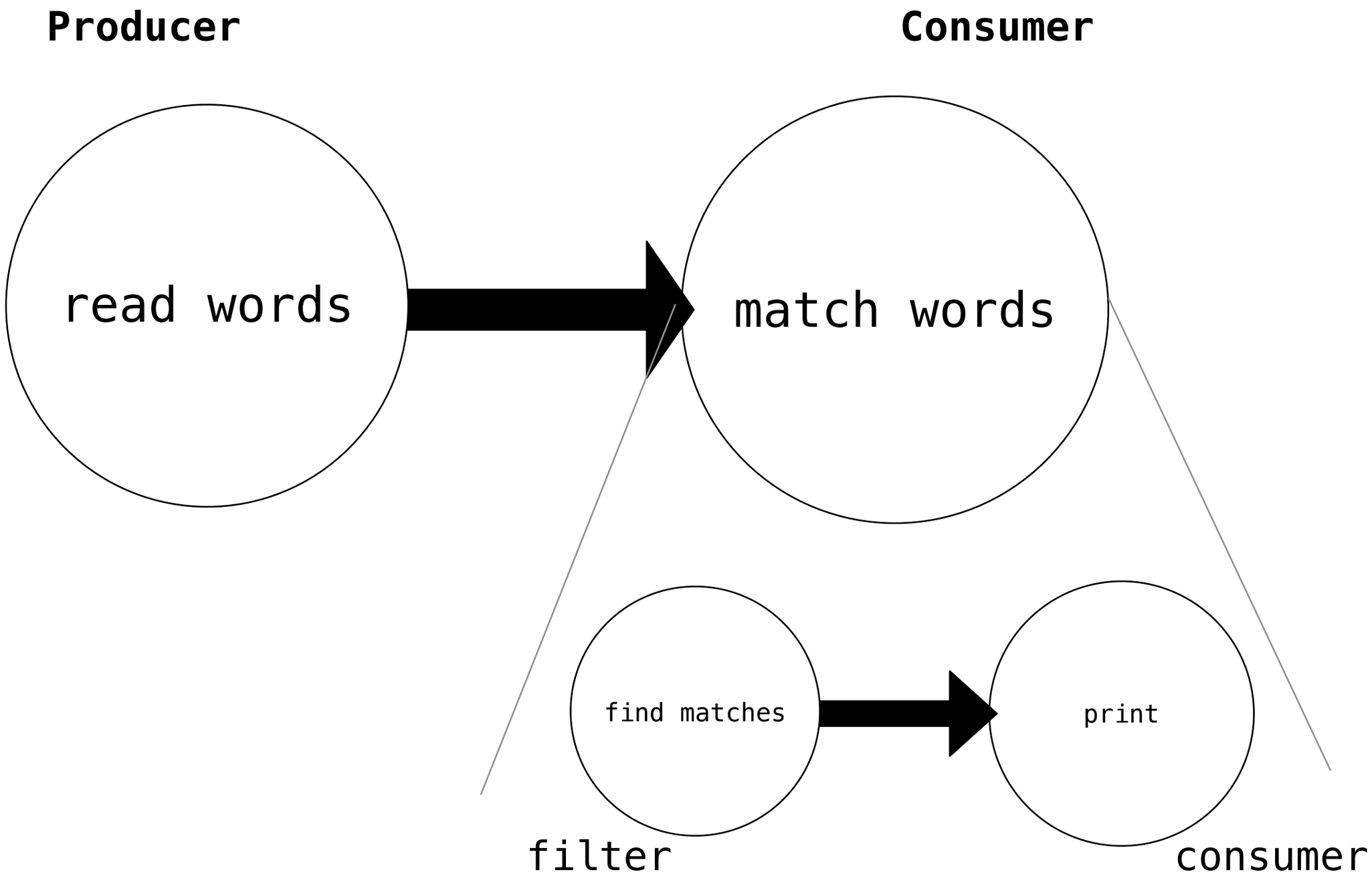
Example: simple pipeline



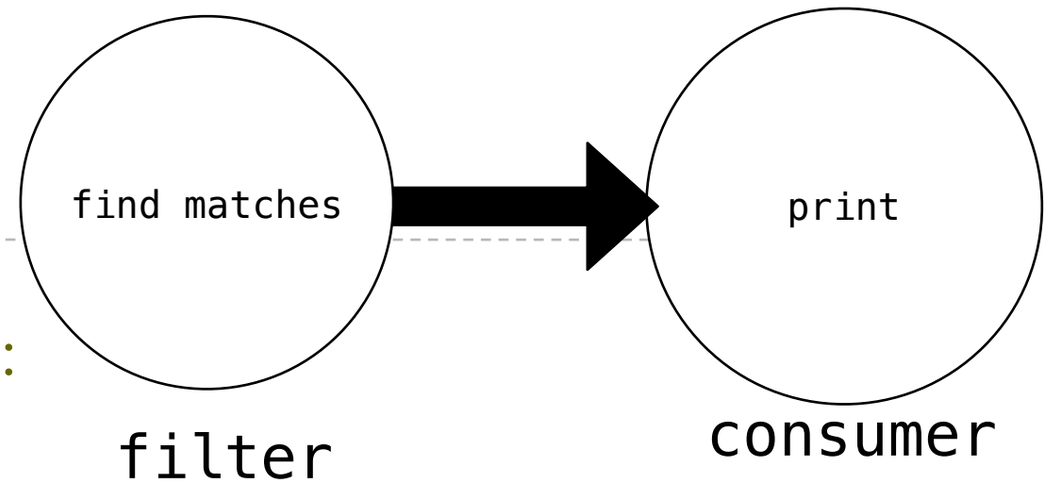

```
def read(text, next_coroutine):
    for word in text.split():
        next_coroutine.send(word)
    next_coroutine.close()
```

```
def match(pattern):
    print('Looking for ' + pattern)
    try:
        while True:
            s = (yield)
            if pattern in s:
                print(s)
    except GeneratorExit:
        print("=== Done ===")
```

Breaking down match



Breaking down match

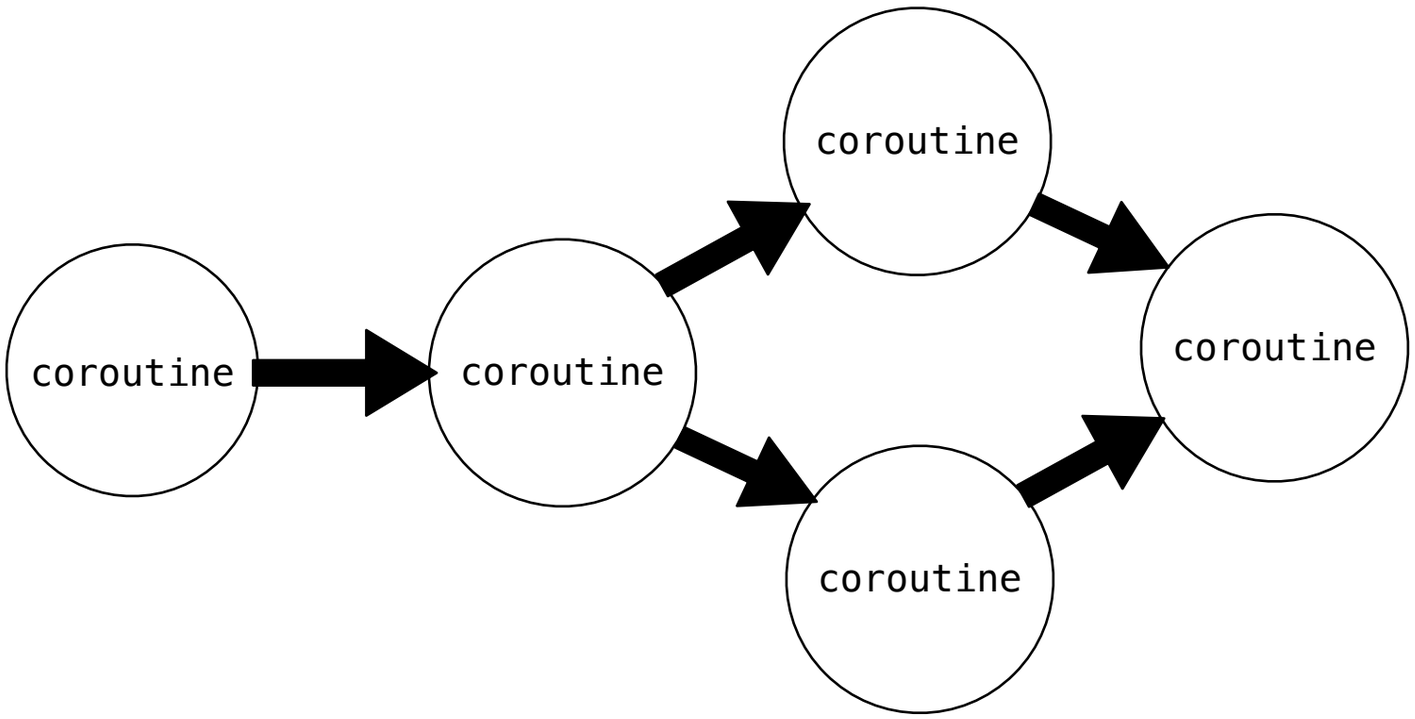



```
def match_filter(pattern, next_coroutine):
    print('Looking for ' + pattern)
    try:
        while True:
            s = (yield)
            if pattern in s:
                next_coroutine.send(s)
    except GeneratorExit:
        next_coroutine.close()
```

```
>>> printer = print_consumer()
>>> printer.__next__()
‘Preparing to print’
>>> matcher = match_filter('pend', printer)
>>> matcher.__next__()
‘Looking for pend’
>>> text = 'Commending spending is offending'
>>> read(text, matcher)
‘spending’
‘=== Done ===’
```

```
def print_consumer():
    print('Preparing to print')
    try:
        while True:
            line = (yield)
            print(line)
    except GeneratorExit:
        print("=== Done ===")
```

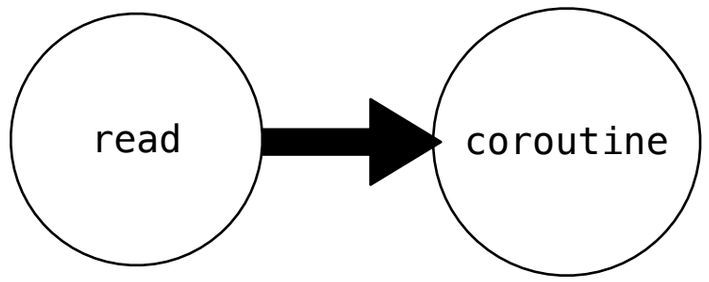
Multitasking



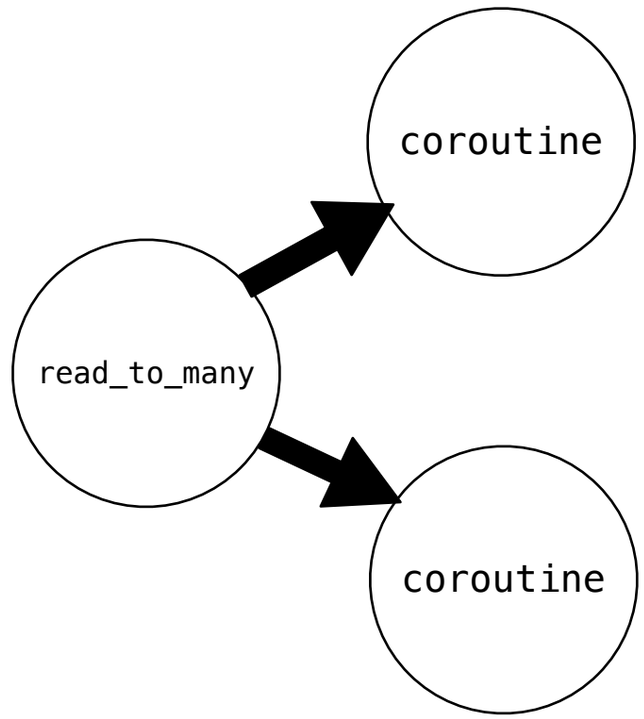
We do not need to be restricted to just one next step

Read-to-many

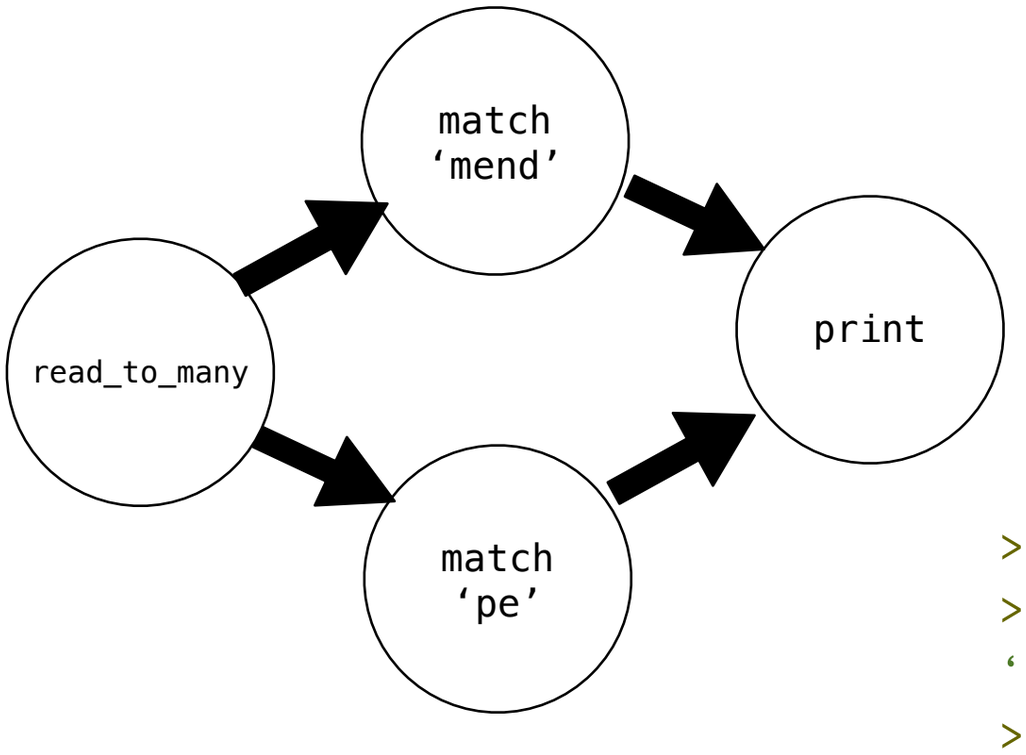
```
def read(text, next_coroutine):
    for word in text.split():
        next_coroutine.send(word)
    next_coroutine.close()
```




```
def read_to_many(text, coroutines):
    for word in text.split():
        for coroutine in coroutines:
            coroutine.send(word)
    for coroutine in coroutines:
        coroutine.close()
```

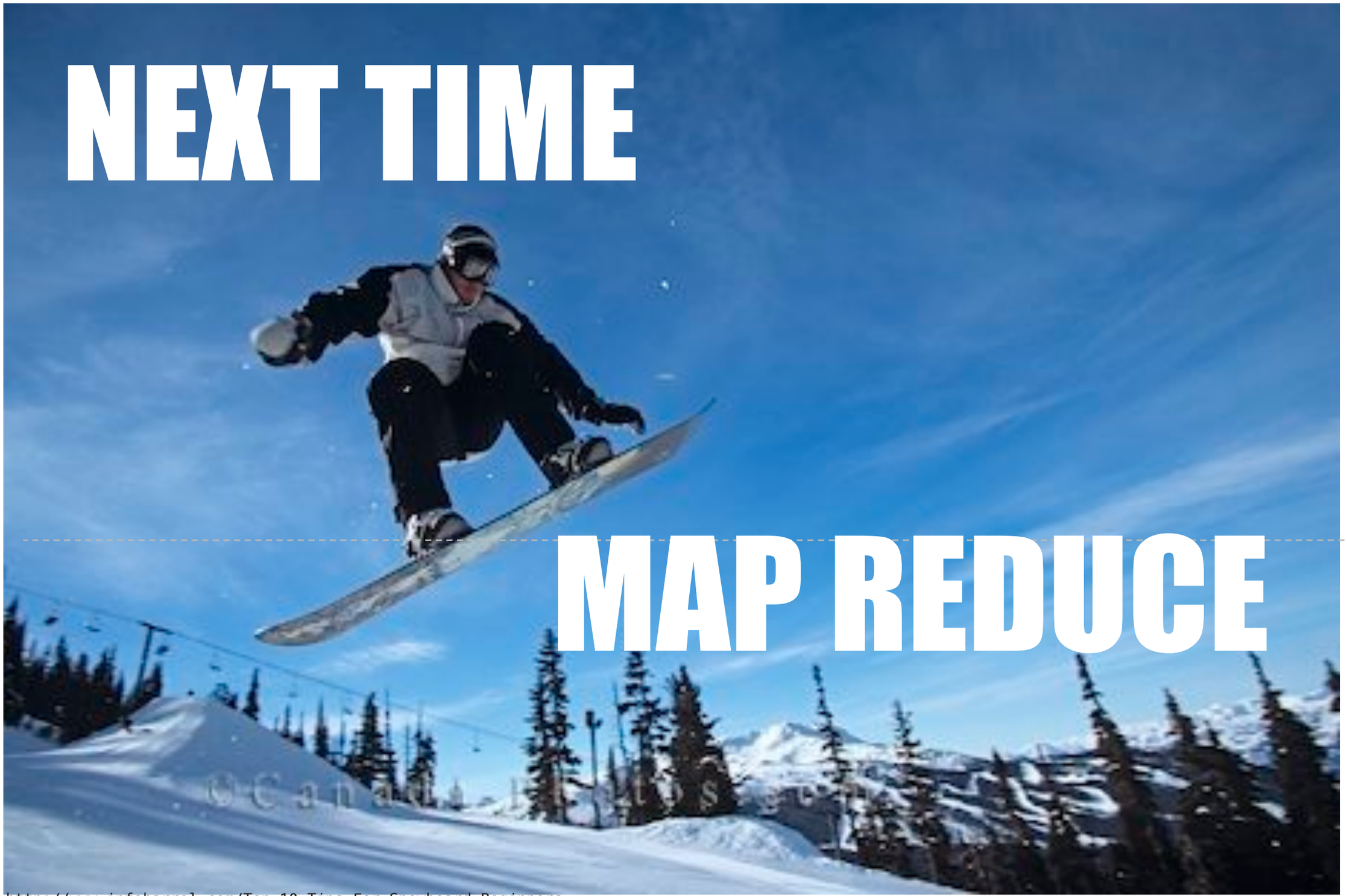


Matching multiple patterns



Any questions?

```
>>> printer = print_consumer()
>>> printer.__next__()
‘Preparing to print’
>>> m = match_filter('mend', printer)
>>> m.__next__()
‘Looking for mend’
>>> p = match_filter("pe", printer)
>>> p.__next__()
‘Looking for pe’
>>> read_to_many(text, [m, p])
‘Commending’
‘spending’
‘people’
‘pending’
‘=== Done ===’
```



http://www.infobarrel.com/Top_10_Tips_For_Snowboard_Beginners