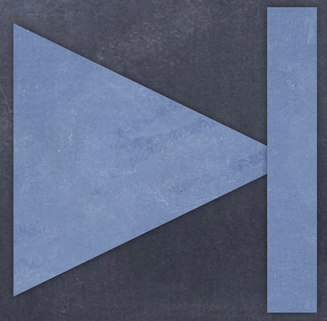
迭代器和生成器



迭代器（Iterator）

可迭代（Iterables）

- 列表、元组、字典、Ranges、字符串（还有集合）都是可迭代的对象

```
my_order = ["Yuca Shepherds Pie", "Pão de queijo", "Guaraná"]

ranked_chocolates = ("Dark", "Milk", "White")

prices = {"pineapple": 9.99, "pen": 2.99, "pineapple-pen": 19.99}

best_topping = "pineapple"
```

迭代

我们可以对可迭代的对象迭代：

```
my_order = ["Yuca Shepherds Pie", "Pão de queijo", "Guaraná"]
for item in my_order:
    print(item)
lowered = [item.lower() for item in my_order]

ranked_chocolates = ("Dark", "Milk", "White")
for chocolate in ranked_chocolates:
    print(chocolate)

prices = {"pineapple": 9.99, "pen": 2.99, "pineapple-pen": 19.99}
for product in prices:
    print(product, " costs ", prices[product])
discounted = { item: prices[item] * 0.75 for item in prices }

best_topping = "pineapple"
for letter in best_topping:
    print(letter)
```

迭代子

- 一个迭代子是一个可以提供序列化访问值的对象，其一次访问一个值！
  - iter(iterable) 返回一个在iterable对象之上的迭代器
  - next(iterator) 返回迭代器的下一个元素

迭代子

```
toppings = ["pineapple", "pepper", "mushroom", "roasted red pepper"]

topperator = iter(toppings)
next(iter) # 'pineapple'
next(iter) # 'pepper'
next(iter) # 'mushroom'
next(iter) # 'roasted red pepper'
next(iter) # ❌ StopIteration exception
```

迭代子是可变的吗？🤔

demo

处理 StopIteration

- StopIteration是一个会终止程序正常运行的"异常"（Exception）
- 处理异常应该使用 try/except

处理 StopIteration

```
ranked_chocolates = ("Dark", "Milk", "White")

chocolaterator = iter(ranked_chocolates)
print(next(chocolaterator))
print(next(chocolaterator))
print(next(chocolaterator))

try:
    print(next(chocolaterator))
except StopIteration:
    print("No more left!")
```

demo

处理 StopIteration

- 配合while来处理迭代

```
ranked_chocolates = ("Dark", "Milk", "White")
chocolaterator = iter(ranked_chocolates)

try:
    while True:
        choco = next(chocolaterator)
        print(choco)
except StopIteration:
    print("No more left!")
```

demo

Iterators vs. For loops

```
ranked_chocolates = ("Dark", "Milk", "White")
chocorator = iter(ranked_chocolates)

try:
    while True:
        choco = next(chocorator)
        print(choco)
except StopIteration:
    print("No more left!")
```

```
ranked_chocolates = ("Dark", "Milk", "White")
for chocolate in ranked_chocolates:
    print(chocolate)
```

Actually, a for loop is just syntactic sugar! 🍬

再次回顾for语句

```
for <name> in <expression>:
    <suite>
```

- 语义：
  - 1. Python 首先求值头部的<expression>，确保其产生一个Iterable的对象
  - 2. Python 得到iterable对象的迭代器
  - 3. Python 利用iterable得到其next value，#绑定到当前帧的name
  - 4. Python 执行<suite>中的语句
  - 5. Python 重复上述操作直到 StopIteration error

```
iterator = iter(<expression>)
try:
    while True:
        <name> = next(iterator)
        <suite>
except StopIteration:
    pass
```

内部的__next__()和__iter__()

- iter()函数本质上调用该对象"自己"的__iter__()

```
ranked_chocolates = ("Dark", "Milk", "White")
chocorator1 = iter(ranked_chocolates)
chocorator2 = ranked_chocolates.__iter__()
```

什么叫自己的？

- next()函数本质上调用该迭代器"自己"的__next__()

```
ranked_chocolates = ("Dark", "Milk", "White")
chocolate1 = next(chocorator1)
chocolate2 = chocorator2.__next__()
```

demo

比较两种迭代

for

```
ranked_chocolates = ("Dark", "Milk", "White")
for chocolate in ranked_chocolates:
    print(chocolate)
```

Iterator

```
ranked_chocolates = ("Dark", "Milk", "White")
chocorator = iter(ranked_chocolates)
try:
    while True:
        print(next(chocorator))
except StopIteration:
    pass
```

行为相同不等于实现相同

- For循环和迭代器的语义是一样的，但是Python对这两者具体的实现是不同的

	10,000 runs	1,000,000 runs
For loop	3.2 milliseconds	336 milliseconds
Iterator	8.3 milliseconds	798 milliseconds

具体实现的不同

用dis模块来查看具体的不同:

```
import dis
def for_version():
    y = 0
    for x in [1, 2, 3]:
        y += x * 2

def iter_version():
    _gen_ = iter([1, 2, 3])
    y = 0
    try:
        while True:
            y += next(_gen_) * 2
    except StopIteration:
        pass
```

```
dis.dis(for_version)
dis.dis(iter_version)
```

```
1           8 FOR_ITER                16 (to 26)
2          10 STORE_FAST               1 (x)
3      7   12 LOAD_FAST                0 (y)
4          14 LOAD_FAST                1 (x)
5          16 LOAD_CONST               3 (2)
6          18 BINARY_MULTIPLY
7          20 INPLACE_ADD
8          22 STORE_FAST               0 (y)
9          24 JUMP_ABSOLUTE            8
```

```
1     15   20 LOAD_FAST                1 (y)
2          22 LOAD_GLOBAL              1 (next)
3          24 LOAD_FAST                0 (_gen_)
4          26 CALL_FUNCTION            1
5          28 LOAD_CONST               2 (2)
6          30 BINARY_MULTIPLY
7          32 INPLACE_ADD
8          34 STORE_FAST               1 (y)
9          36 JUMP_ABSOLUTE           20
```

语义等价不等于实现等价

demo

一些返回迭代子的函数

函数	描述
reversed(sequence)	返回sequence的一个逆向的迭代子
zip(*iterables)	返回一个迭代器，其元素是一个个元组，每个元组中的元素是每个iterable的元素。
map(func, iterable,…)	返回一个迭代器，每个元素是func(x)，其中x是iterable中的元素
filter(func, iterable)	返回iterable的一个迭代器，但是过滤掉其中使得func返回为False的元素

一个有用的小细节

- 对一个迭代器上调用iter()会返回该迭代器

```
numbers = ["一", "二", "三"]
num_iter = iter(numbers)
num_iter2 = iter(num_iter)
num_iter is num_iter2
```

- 这也是为什么下面代码能够运行的原因

```
nums = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
for num in filter(lambda x: x % 2 == 0, nums):
    print(num)
```

demo

一些返回可迭代对象的函数

函数	描述
list(iterable)	返回一个list包含iterable里的所有元素
tuple(iterable)	返回一个tuple包含iterable里的所有元素
sorted(iterable)	返回一个排序好的list，包含iterable里的所有元素

生成器（Generator）

生成器（Generator）

- 一个生成器就是一种迭代器，其产生由生成器函数决定的元素
- 一个生成器函数使用 **yield** 而不是 **return**：

generator function

```
def evens():
    num = 0
    while num < 10:
        yield num
        num += 2
```

generator

```
evengen = evens()
next(evengen)   # 0
next(evengen)   # 2
next(evengen)   # 4
next(evengen)   # 6
next(evengen)   # 8
next(evengen)   # ❌ StopIteration exception
```

python tutor

生成器工作流程

```
def evens():
    num = 0
    while num < 2:
        yield num
        num += 2

gen = evens()

next(gen)
next(gen)
```

- 当生成器函数被调用时，其直接返回一个迭代器（没有进入函数体）。
- 当next()被调用时，其进入函数体，从上一次的终止点（初始就是函数体的第一句），运行到下一次的 yield 语句 。
- 如果找到了yield语句，那么其在下一句停止（这一次的终止点，作为下一次的起点），并返回yield语句中的表达式的值。
- 如果找不到yield语句，则在函数的末端终止，并产生一个 StopIteration 的异常。

对生成器进行循环

- 我们可以对生成器进行循环，因为其本质也是一个迭代器

```
def evens(start, end):
    num = start + (start % 2)
    while num < end:
        yield num
        num += 2

for num in evens(12, 60):
    print(num)
```

对生成器进行循环

```
def evens(start, end):
    num = start + (start % 2)
    while num < end:
        yield num
        num += 2
for num in evens(12, 60):
    print(num)
```

对比

```
evens = [num for num in range(12, 60) if num % 2 == 0]
# Or  = filter(lambda x: x % 2 == 0, range(12, 60))
for num in evens:
    print(num)
```

为什么需要生成器

- 生成器是惰性的（lazy）：他们只在需要时才产生下一个项
- 很多时候你不需要一次生成整个序列，而是只需要部分。

为什么需要生成器

```
def find_matches(filename, match):
    for line in open(filename):
        if line.find(match) > -1:
            yield line

line_iter = find_matches('frankenstein.txt', "!")
next(line_iter)
next(line_iter)
```

```
def find_matches(filename, match):
    matched = []
    for line in open(filename):
        if line.find(match) > -1:
            matched.append(line)
    return matched

matched_lines = find_matches('frankenstein.txt', "!")
matched_lines[0]
matched_lines[1]
```

有了generator，可以在使用时才获得想要的项。而很多时候并不事先知道到底要使用"多少"，因此如果没有generator的话，需要整个都生成，这显然是低效的！而且会ran out of memeroy!

对可迭代对象直接yield

```
def a_then_b(a, b):
    for item in a:
        yield item
    for item in b:
        yield item

list(a_then_b(["Apples", "Aardvarks"], ["Bananas", "BEARS"]))
```

对比

another syntactic sugar! 🍬

```
def a_then_b(a, b):
    yield from a
    yield from b

list(a_then_b(["Apples", "Aardvarks"], ["Bananas", "BEARS"]))
```

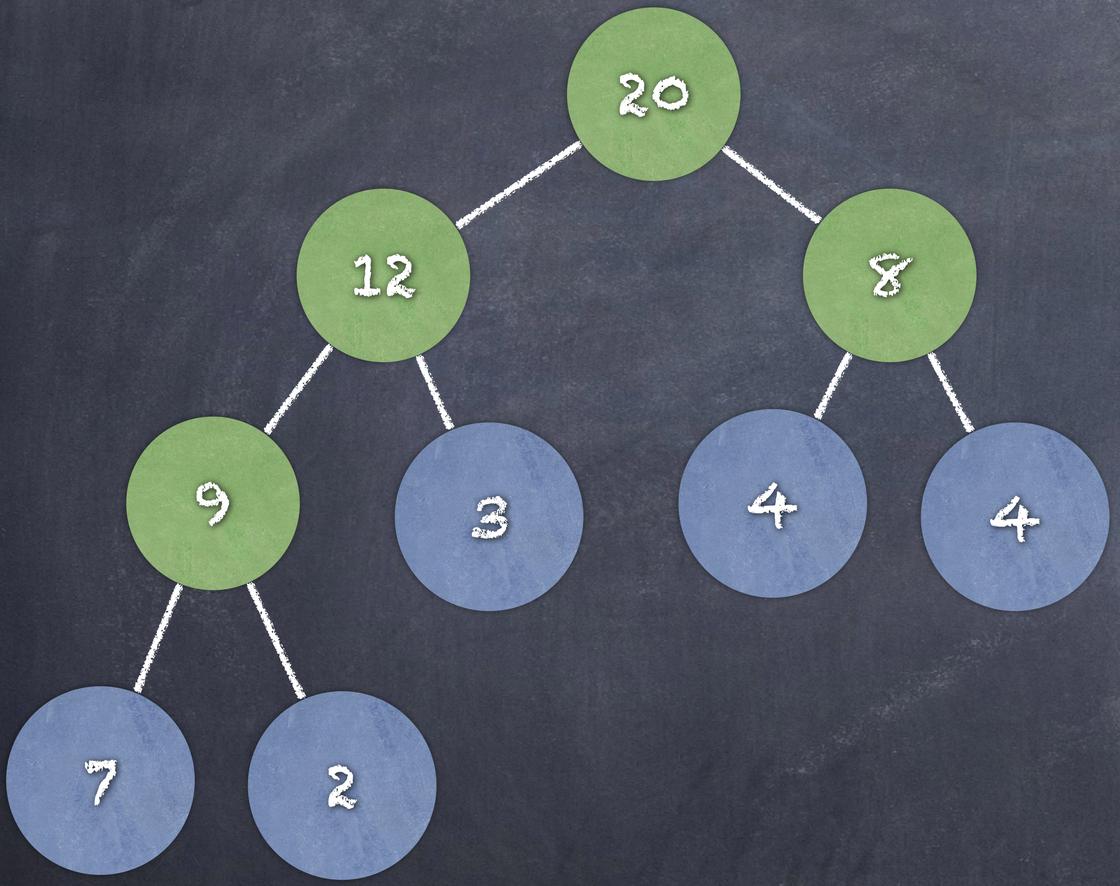
递归的yield

```
def factorial(n, accum):
    if n == 0:
        yield accum
    else:
        for result in factorial(n - 1, n * accum):
            yield result

for num in factorial(3, 1):
    print(num)
```

yield from还可以从generator function中获得generator:

```
def factorial(n, accum):
    if n == 0:
        yield accum
    else:
        yield from factorial(n - 1, n * accum)

for num in factorial(3, 1):
    print(num)
```

树的递归生成器



A pre-order traversal of the tree:

```
def nodes(t):
    yield label(t)
    for c in branches(t):
        yield from nodes(c)

t = tree(20, [tree(12,
                   [tree(9,
                         [tree(7), tree(2)]),
                    tree(3)]),
              tree(8,
                   [tree(4), tree(4)])])

node_gen = nodes(t)
next(node_gen)
```

Any questions ?