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laziness as a virtue

GENERATOR POWER

True iterators for efficient data processing in Python

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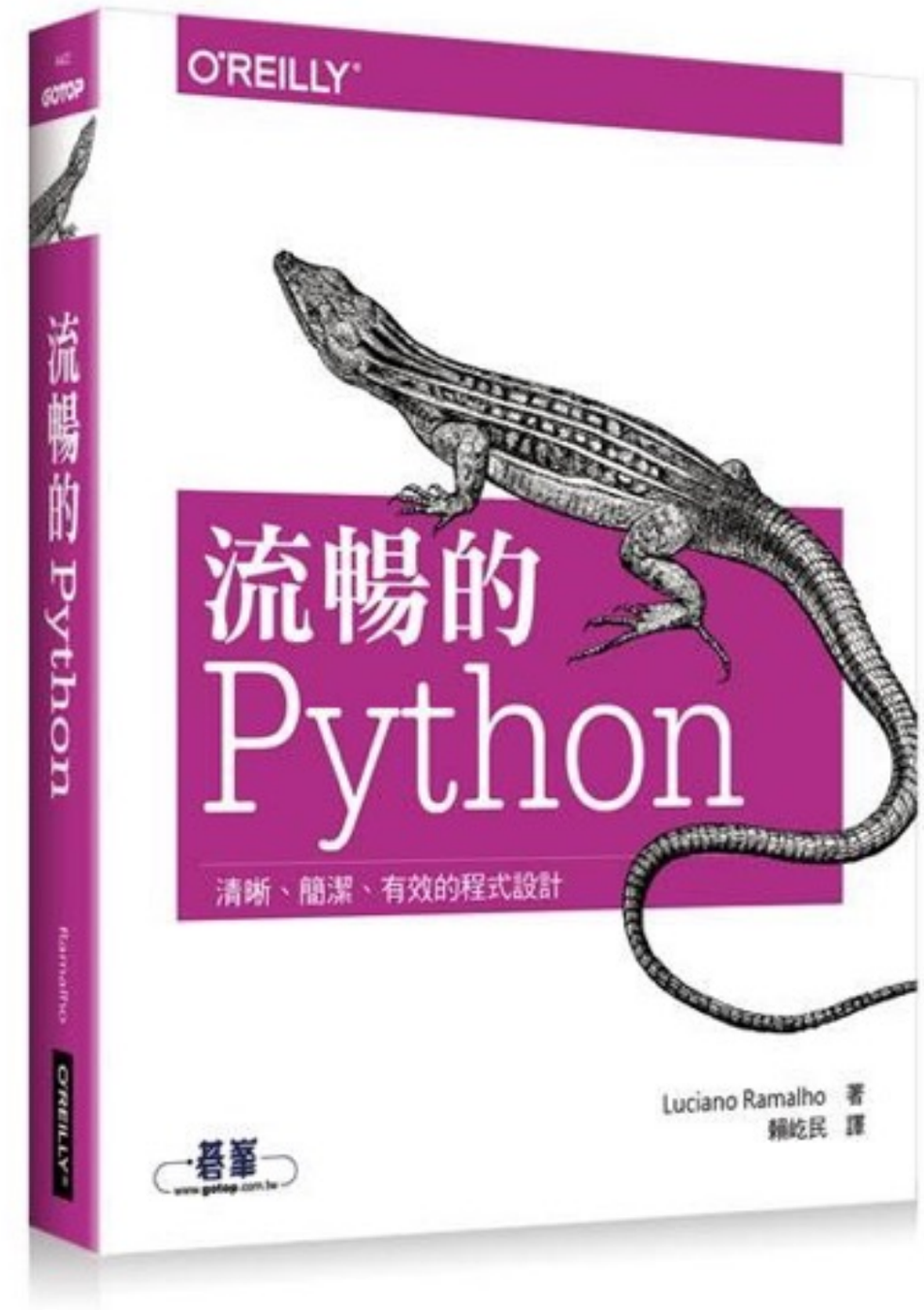
FLUENT PYTHON, MY FIRST BOOK



Fluent Python (O'Reilly, 2015)

Python Fluente (Novatec, 2015)

Python к вершинам мастерства* (DMK, 2015)

流暢的 Python† (Gotop, 2016)

also in **Polish, Korean...**

** Python. To the heights of excellence*
† Smooth Python

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ITERATION

That's what computers are for

ITERATION: C LANGUAGE

```c
#include <stdio.h>

int main(int argc, char *argv[]) {
    for(int i = 0; i < argc; i++)
        printf("%s\n", argv[i]);
    return 0;
}
```

```
$ ./args alpha bravo charlie
./args
alpha
bravo
charlie
```

ITERATION: C VERSUS PYTHON

```c
#include <stdio.h>

int main(int argc, char *argv[]) {
    for(int i = 0; i < argc; i++)
        printf("%s\n", argv[i]);
    return 0;
}
```

```python
import sys

for arg in sys.argv:
    print arg
```

ITERATION: X86 INSTRUCTION SET

Loop Instructions [edit]

The `loop` instruction decrements ECX and jumps to the address specified by `arg` unless decrementing ECX caused its value to become zero. For example:

```
mov ecx, 5
start_loop:
; the code here would be executed 5 times
loop start_loop
```

source: *x86 Assembly* wikibook
https://en.wikibooks.org/wiki/X86_Assembly

ITERATION: BEFORE JAVA 5

```
class Arguments {
    public static void main(String[] args) {
        for (int i=0; i < args.length; i++)
            System.out.println(args[i]);
    }
}
```

```
$ java Arguments alpha bravo charlie
alpha
bravo
charlie
```

FOREACH: SINCE JAVA 5

The official name of the *foreach* syntax is *"enhanced for"*

```
class Arguments2 {
    public static void main(String[] args) {
        for (String arg : args)
            System.out.println(arg);
    }
}
```

```
$ java Arguments2 alpha bravo charlie
alpha
bravo
charlie
```

FOREACH: SINCE JAVA 5

The official name of the *foreach* syntax is *"enhanced for"*

year: 2004

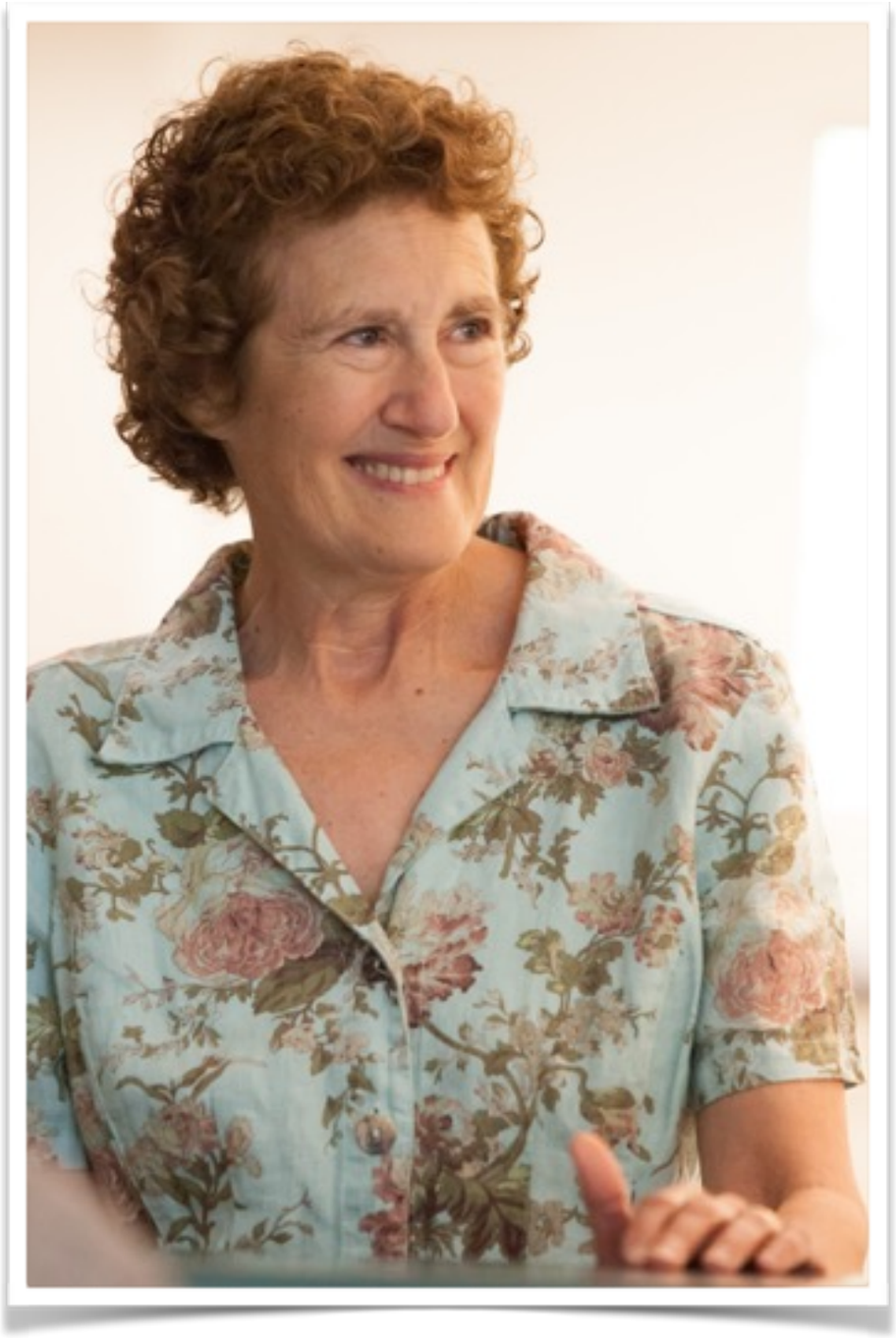
```
class Arguments2 {
    public static void main(String[] args) {
        for (String arg : args)
            System.out.println(arg);
    }
}
```

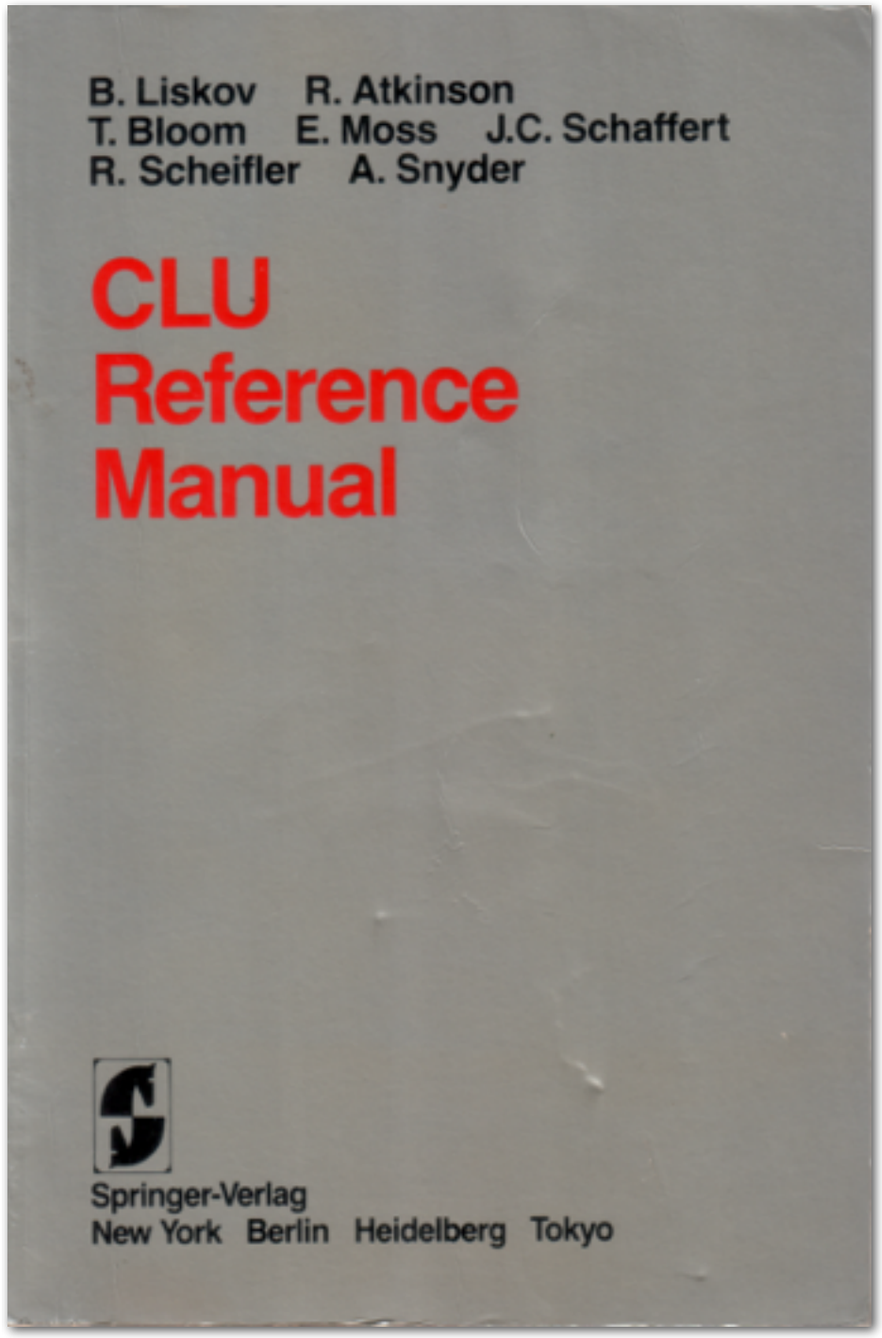
year: 1991

```
import sys

for arg in sys.argv:
    print arg
```

FOREACH IN BARBARA LISKOV'S CLU





CLU Reference Manual — B. Liskov et. al. — © 1981 Springer-Verlag — also available online from MIT: http://publications.csail.mit.edu/lcs/pubs/pdf/MIT-LCS-TR-225.pdf

FOREACH IN CLU

year: 1975

types of results can be returned in the exceptional conditions. All information about the names of conditions, and the number and types of arguments and results is described in the *iterator heading*. For example,

```
leaves = iter (t: tree) yields (node)
```

is the heading for an iterator that produces all leaf nodes of a tree object. This iterator might be used in a **for** statement as follows:

```
for leaf: node in leaves(x) do
    ... examine(leaf) ...
end
```

1.3 Clusters

A *cluster* implements a data abstraction, which is a

operations to create and manipulate those objects. The

or control abstractions. The *cluster heading* states what operations are available, e.g.,

CLU Reference Manual, p. 2
B. Liskov et. al. — © 1981 Springer-Verlag

ITERABLE OBJECTS: THE KEY TO FOREACH

- Python, Java & CLU let programmers define **iterable** objects

```
for item in an_iterable:
    process(item)
```

- Some languages don't offer this flexibility
  - C has no concept of iterables
  - In Go, only some built-in types are iterable and can be used with foreach (written as the **for … range** special form)

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ITERABLES

For loop data sources

avoidable
belieavable
extensible
fixable
iterable
movable
readable
playable
washable

iterable, adj. — Capable of being iterated.

SOME ITERABLE OBJECTS & THE ITEMS THEY YIELD

str: Unicode characters

bytes: integers 0…255

tuple: individual fields

dict: keys

set: elements

```
>>> with open('1.txt') as text:
...     for line in text:
...         print(line.rstrip())
...
alpha
beta
gamma
delta
```

io.TextIOWrapper:

(text file) Unicode lines

models.query.QuerySet

(Django ORM) DB rows

numpy.ndarray

(NumPy multidimensional array) elements, rows…

```
>>> d = {'α': 3, 'β': 4, 'γ': 5}
>>> list(d)
['γ', 'β', 'α']
>>> list(d.values())
[5, 4, 3]
>>> list(d.items())
[('γ', 5), ('β', 4), ('α', 3)]
```

OPERATIONS WITH ITERABLES

- Parallel assignment (a.k.a. tuple unpacking)

```
>>> a, b, c = 'XYZ'
>>> a
'X'
>>> b
'Y'
>>> c
'Z'
>>> g = (n*10 for n in [1, 2, 3])
>>> a, b, c = g
>>> a
10
>>> b
20
>>> c
30
```

ITERATING OVER ITERABLES OF ITERABLES

- Parallel assignment in **for** loops

```
>>> pairs = [('A', 10), ('B', 20), ('C', 30)]

>>> for label, size in pairs:
...     print(label, '->', size)
...
A -> 10
B -> 20
C -> 30
```

ONE ITERABLE PROVIDING MULTIPLE ARGUMENTS

- Function argument unpacking (a.k.a. *splat*)

```
>>> def area(a, b, c):
...     """Heron's formula"""
...     a, b, c = sorted([a, b, c], reverse=True)
...     return ((a+(b+c)) * (c-(a-b)) * (c+(a-b)) * (a+(b-c))) ** .5 / 4
...
>>> area(3, 4, 5)
6.0
>>> t = (3, 4, 5)
>>> area(*t)
6.0
```

expand iterable into multiple arguments

REDUCTION FUNCTIONS

Reduction functions: consume a finite iterable and return a scalar value (e.g. the sum, the largest value etc.)

- **all**
- **any**
- **max**
- **min**
- **sum**

```
>>> L = [5, 7, 8, 1, 4, 6, 2, 9, 0, 3]
>>> all(L)
False
>>> any(L)
True
>>> max(L)
9
>>> min(L)
0
>>> sum(L)
45
```

SORT X SORTED

- **.sort():** a **list** method, sorts the list in-place (e.g. my_list.sort())
- **sorted():** a built-in function, consumes an **iterable** and returns a new sorted **list**

```
>>> L = ['grape', 'Cherry', 'strawberry', 'date', 'banana']
>>> sorted(L)
['Cherry', 'banana', 'date', 'grape', 'strawberry']

>>> sorted(L, key=str.lower)  # case insensitive
['banana', 'Cherry', 'date', 'grape', 'strawberry']

>>> sorted(L, key=len)  # sort by word length
['date', 'grape', 'Cherry', 'banana', 'strawberry']

>>> sorted(L, key=lambda s:list(reversed(s)))  # reverse word
['banana', 'grape', 'date', 'strawberry', 'Cherry']
```

```
>>> from django.db import connection
>>> q = connection.queries
>>> q
[]
```

Django ORM queryset demo

```
>>> from django.db import connection
>>> q = connection.queries
>>> q
[]
>>> from census.models import *
>>> res = County.objects.all()[:5]
>>> q
[]
```

this proves
that queryset
is a lazy iterable

```
>>> from django.db import connection
>>> q = connection.queries
>>> q
[]
>>> from census.models import *
>>> res = County.objects.all()[:5]
>>> q
[]
>>> for m in res: print m.state, m.name
...
GO Abadia de Goiás
MG Abadia dos Dourados
GO Abadiânia
MG Abaeté
PA Abaetetuba
>>> q
[{'time': '0.000', 'sql': u'SELECT "census_county"."id",
"census_county"."state", "census_county"."name",
"census_county"."name_ascii",
"census_county"."meso_region_id", "census_county"."capital",
"census_county"."latitude", "census_county"."longitude",
"census_county"."geohash" FROM "census_county"
ORDER BY "census_county"."name_ascii" ASC LIMIT 5'}]
```

the database is hit only when the for loop consumes the results

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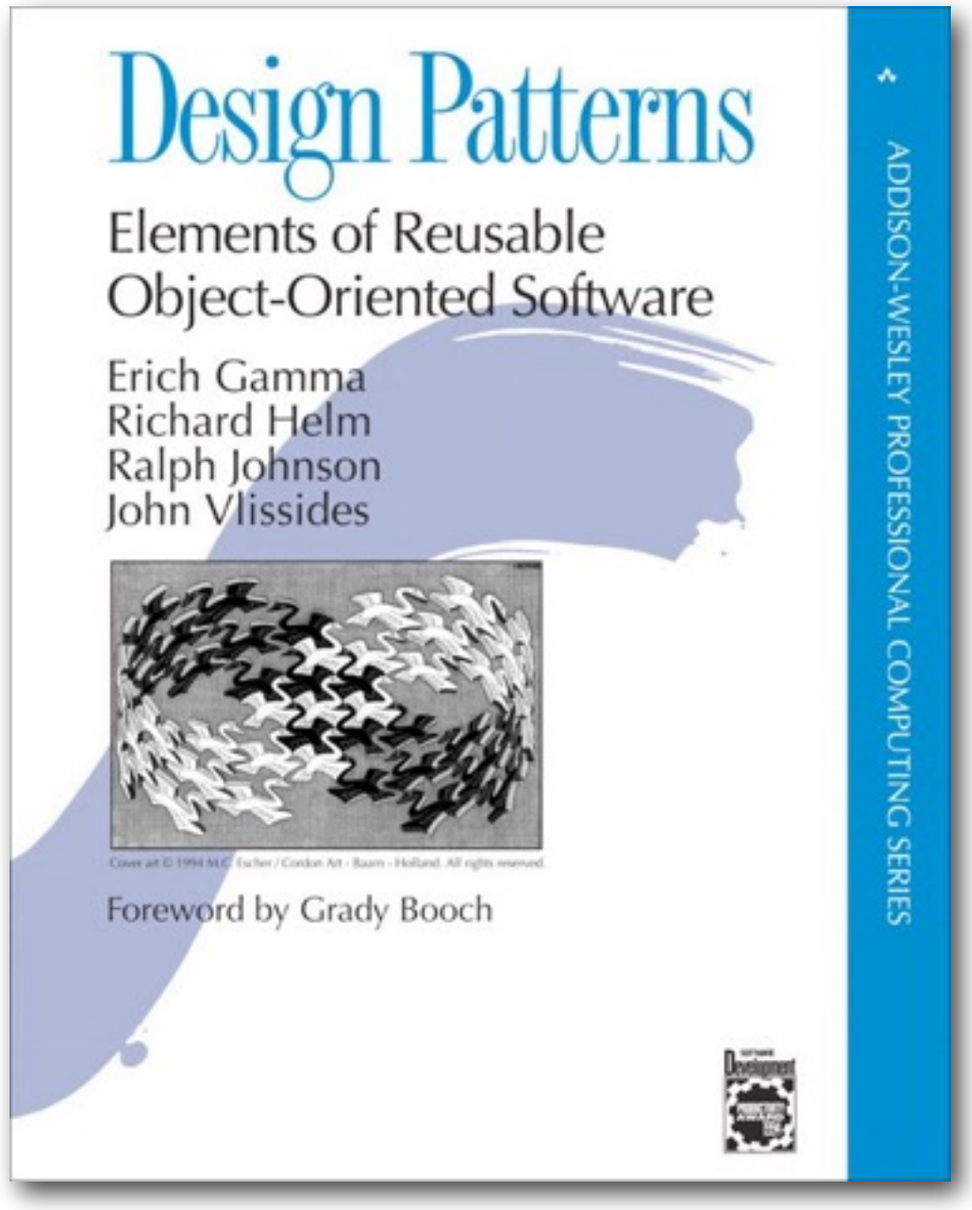
THE ITERATOR PATTERN

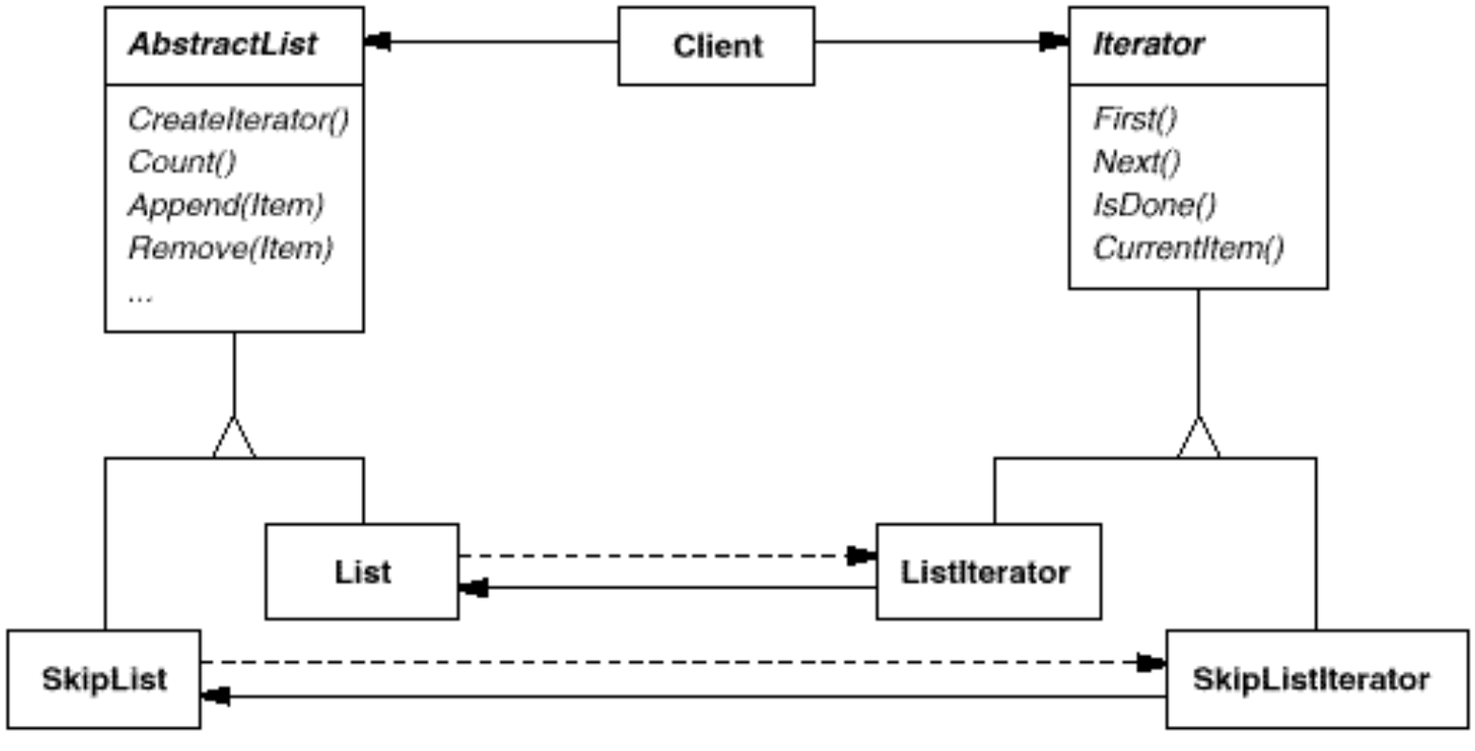
The classic recipe

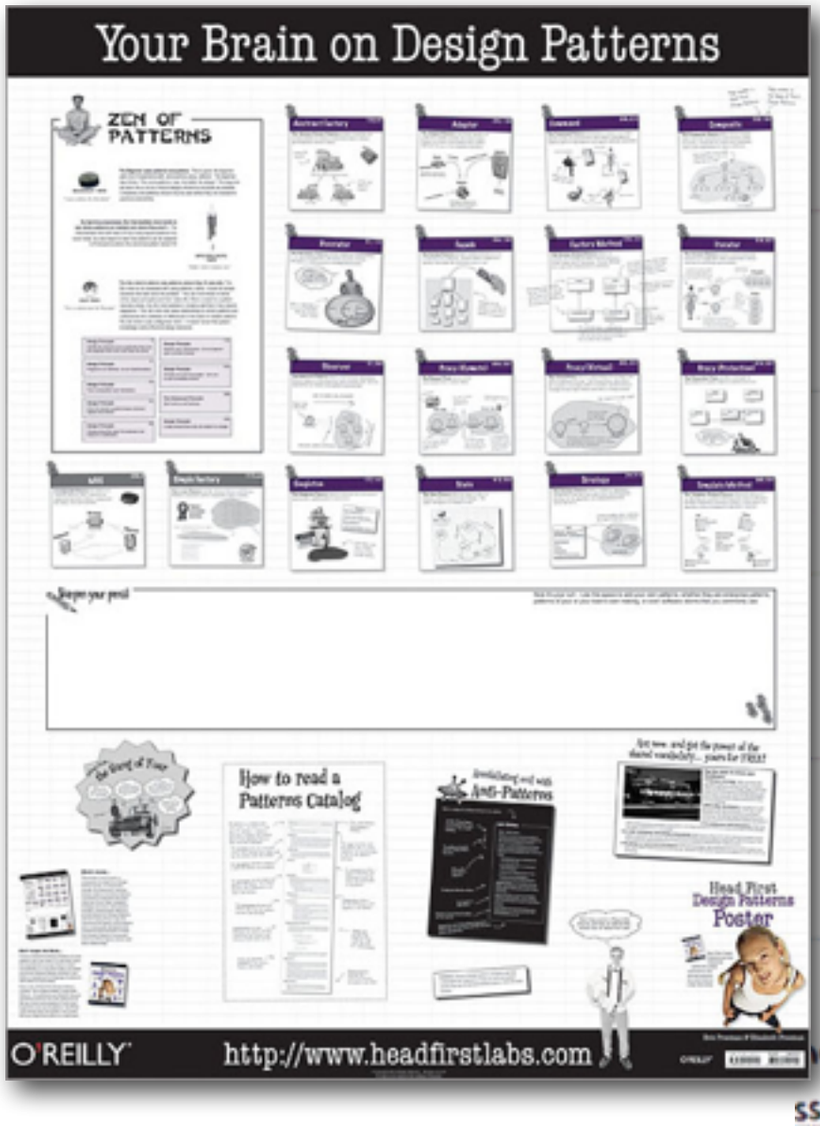
THE ITERATOR FROM THE GANG OF FOUR

Design Patterns

Gamma, Helm, Johnson & Vlissides

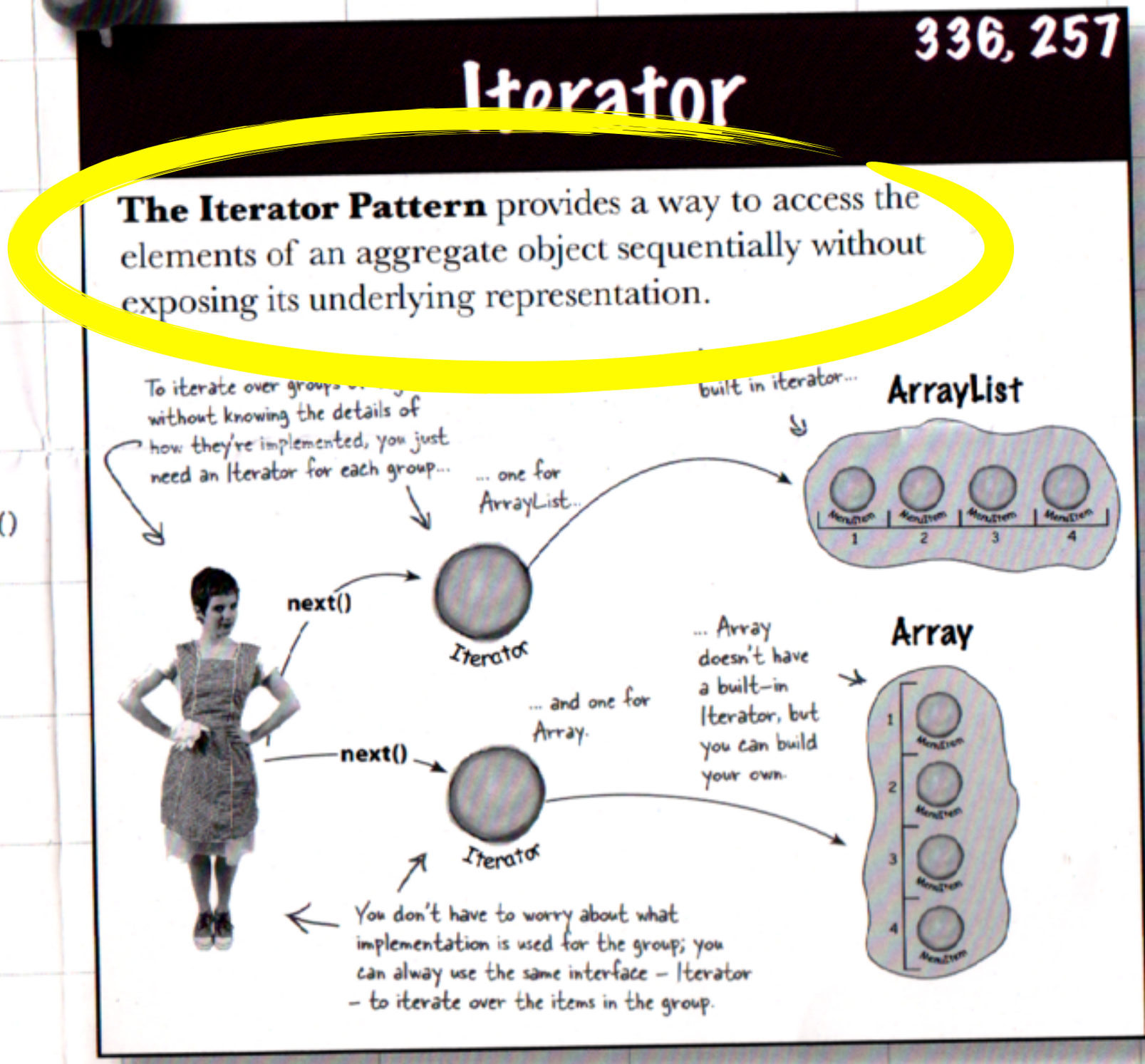






Head First Design Patterns Poster

O'Reilly
ISBN 0-596-10214-3



THE FOR LOOP MACHINERY

- In Python, the **for** loop, automatically:
  - Obtains an **iterator** from the **iterable**
  - Repeatedly invokes **next()** on the **iterator**, retrieving one item at a time
  - Assigns the item to the loop variable(s)

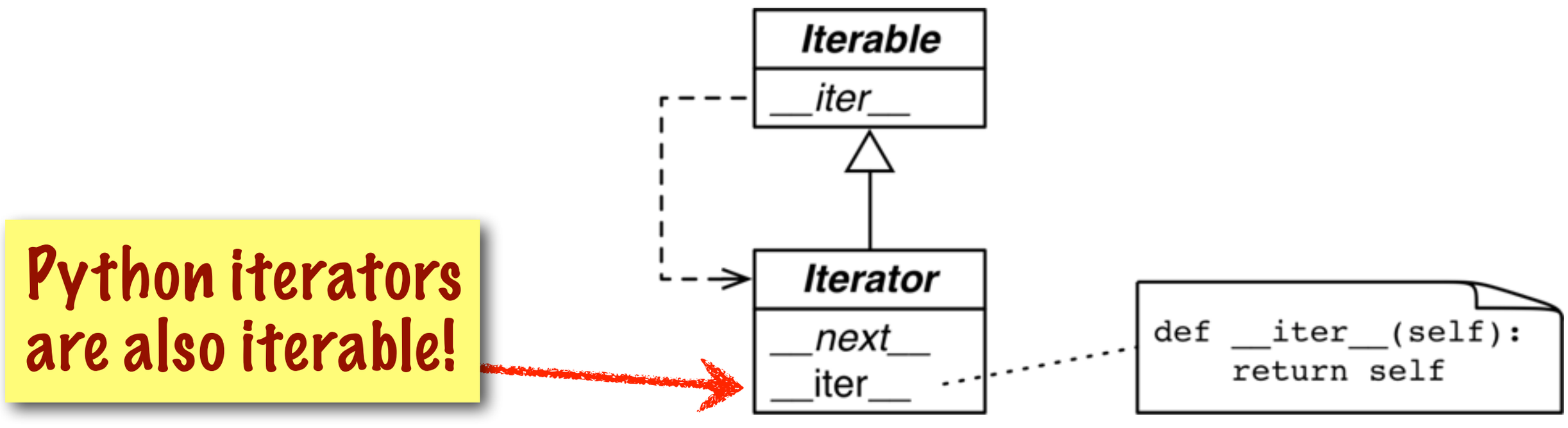
```
for item in an_iterable:
    process(item)
```

- Terminates when a call to **next()** raises **StopIteration**.

ITERABLE VERSUS ITERATOR

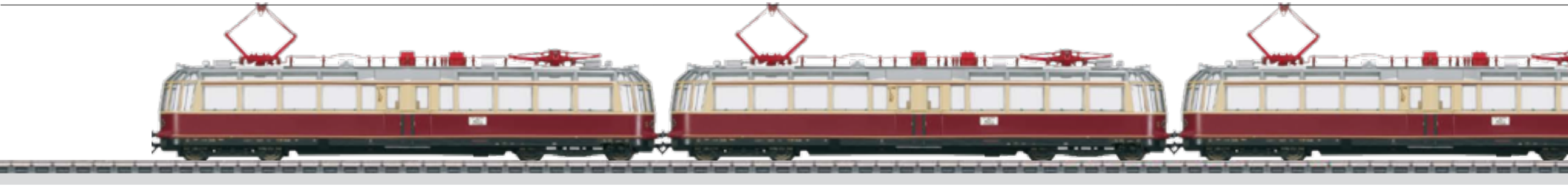
- **iterable**: implements **Iterable** interface (**__iter__** method)
  - **__iter__** method returns an **Iterator**

- **iterator**: implements **Iterator** interface (**__next__** method)
  - **__next__** method returns next item in series and
  - raises **StopIteration** to signal end of the series



AN ITERABLE TRAIN

An instance of **Train** can be iterated, car by car



```
>>> t = Train(3)
>>> for car in t:
...     print(car)
car #1
car #2
car #3
>>>
```

CLASSIC ITERATOR IMPLEMENTATION

The pattern as described by Gamma et. al.

```
class Train:

    def __init__(self, cars):
        self.cars = cars

    def __iter__(self):
        return TrainIterator(self.cars)

class TrainIterator:

    def __init__(self, cars):
        self.next = 0
        self.last = cars - 1

    def __next__(self):
        if self.next <= self.last:
            self.next += 1
            return 'car #%s' % (self.next)
        else:
            raise StopIteration()
```

```
>>> t = Train(4)
>>> for car in t:
...     print(car)
car #1
car #2
car #3
car #4
```

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GENERATOR FUNCTION

Michael Scott's "true iterators"

A VERY SIMPLE GENERATOR FUNCTION

Any function that has the **yield** keyword in its body is a generator function.

When invoked, generator function returns a generator object

```
>>> def gen_123():
...     yield 1
...     yield 2
...     yield 3
...
>>> for i in gen_123(): print(i)
1
2
3
>>> g = gen_123()
>>> g
<generator object gen_123 at ...>
>>> next(g)
1
>>> next(g)
2
>>> next(g)
3
>>> next(g)
Traceback (most recent call last):
...
StopIteration
```

Note:

The **gen** keyword was proposed to replace **def** in generator function headers, but Guido van Rossum rejected it.

```
>>> def gen_ab():
...     print('starting...')
...     yield 'A'
...     print('continuing...')
...     yield 'B'
...     print('The End.')
...
>>> for s in gen_ab(): print(s)
starting...
A
continuing...
B
The End.
>>> g = gen_ab()
>>> g
<generator object gen_ab at 0x...>
>>> next(g)
starting...
'A'
>>> next(g)
continuing...
'B'
>>> next(g)
The End.
Traceback (most recent call last):
...
StopIteration
```

HOW IT WORKS

- Invoking the generator function builds a **generator object**
- The body of the function only starts when **next(g)** is called.
- At each **next(g)** call, the function resumes, runs to the next **yield,** and is suspended again.

THE WORLD FAMOUS FIBONACCI GENERATOR

fibonacci yields an infinite series of integers.

```
def fibonacci():
    a, b = 0, 1
    while True:
        yield a
        a, b = b, a + b
```

```
>>> fib = fibonacci()
>>> for i in range(10):
...     print(next(fib))
...
0
1
1
2
3
5
8
13
21
34
```

FIBONACCI GENERATOR BOUND TO N ITEMS

Easier to use

```
def fibonacci(n):
    a, b = 0, 1
    for _ in range(n):
        yield a
        a, b = b, a + b
```

```
>>> for x in fibonacci(10):
...     print(x)
...
0
1
1
2
3
5
8
13
21
34
>>> list(fibonacci(10))
[0, 1, 1, 2, 3, 5, 8, 13, 21, 34]
```

ARITHMETIC PROGRESSION GENERATOR

```
def arithmetic_progression(increment, *, start=0, end=None):
    index = 0
    result = start + increment * index
    while end is None or result < end:
        yield result
        index += 1
        result = start + increment * index
```

```
>>> ap = arithmetic_progression(.1)
>>> next(ap), next(ap), next(ap), next(ap), next(ap)
(0.0, 0.1, 0.2, 0.30000000000000004, 0.4)

>>> from decimal import Decimal
>>> apd = arithmetic_progression(Decimal('.1'))
>>> [next(apd) for i in range(4)]
[Decimal('0.0'), Decimal('0.1'), Decimal('0.2'), Decimal('0.3')]

>>> list(arithmetic_progression(.5, start=1, end=5))
[1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5]

>>> list(arithmetic_progression(1/3, end=1))
[0.0, 0.3333333333333333, 0.6666666666666666]
```

ITERABLE TRAIN WITH A GENERATOR METHOD

The **Iterator** pattern as a language feature:

```
class Train:

    def __init__(self, cars):
        self.cars = cars

    def __iter__(self):
        for i in range(self.cars):
            yield 'car #%s' % (i+1)
```

Train is now iterable because __iter__ returns a generator!

```
>>> t = Train(3)
>>> it = iter(t)
>>> it
<generator object __iter__ at 0x…>
>>> next(it), next(it), next(it)
('car #1', 'car #2', 'car #3')
```

COMPARE: CLASSIC ITERATOR × GENERATOR METHOD

The classic Iterator recipe is obsolete in Python since v.2.2 (2001)

```
class Train:

    def __init__(self, cars):
        self.cars = cars

    def __iter__(self):
        return IteratorTrem(self.cars)

class TrainIterator:

    def __init__(self, cars):
        self.next = 0
        self.last = cars - 1

    def __next__(self):
        if self.next <= self.last:
            self.next += 1
            return 'car #%s' % (self.next)
        else:
            raise StopIteration()
```

```
class Train:

    def __init__(self, cars):
        self.cars = cars

    def __iter__(self):
        for i in range(self.cars):
            yield 'car #%s' % (i+1)
```

Generator function handles the state of the iteration

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BUILT-IN GENERATORS

Common in Python 2, widespread in Python 3

BUILT-IN GENERATOR FUNCTIONS

Consume any iterable object and return generator objects:

enumerate

filter

map

reversed

zip

ZIP, MAP & FILTER IN PYTHON 2

```
>>> L = [0, 1, 2]
>>> zip('ABC', L)
[('A', 0), ('B', 1), ('C', 2)]

>>> map(lambda x: x*10, L)
[0, 10, 20]

>>> filter(None, L)
[1, 2]
```

not generators!

zip:

consumes N **iterables** in parallel, yielding **list** of tuples

map:

applies function to each item in **iterable**, returns **list** with results

filter:

returns **list** with items from **iterable** for which predicate results *truthy*

ZIP, MAP & FILTER: PYTHON 2 × PYTHON 3

Python 2

```
>>> L = [0, 1, 2]
>>> zip('ABC', L)
[('A', 0), ('B', 1), ('C', 2)]

>>> map(lambda x: x*10, L)
[0, 10, 20]

>>> filter(None, L)
[1, 2]
```

In Python 3, **zip**, **map**, **filter** and many other functions in the standard library return **generators**.

Python 3

```
>>> L = [0, 1, 2]
>>> zip('ABC', L)
<zip object at 0x102218408>

>>> map(lambda x: x*10, L)
<map object at 0x102215a90>

>>> filter(None, L)
<filter object at 0x102215b00>
```

GENERATORS ARE ITERATORS

Generators are iterators, which are also iterable:

```
>>> L = [0, 1, 2]
>>> for pair in zip('ABC', L):
...     print(pair)
...
('A', 0)
('B', 1)
('C', 2)
```

Build the list explicitly to get what Python 2 used to give:

```
>>> list(zip('ABC', L))
[('A', 0), ('B', 1), ('C', 2)]
```

Most collection constructors consume suitable generators:

```
>>> dict(zip('ABC', L))
{'C': 2, 'B': 1, 'A': 0}
```

THE ITERTOOLS STANDARD MODULE

- "infinite" generators
  - **count(), cycle(), repeat()**
- generators that consume multiple iterables
  - **chain(), tee(), izip(), imap(), product(), compress()...**
- generators that filter or bundle items
  - **compress(), dropwhile(), groupby(), ifilter(), islice()...**
- generators that rearrange items
  - **product(), permutations(), combinations()...**

Note:
Many of these functions were inspired by the Haskell language

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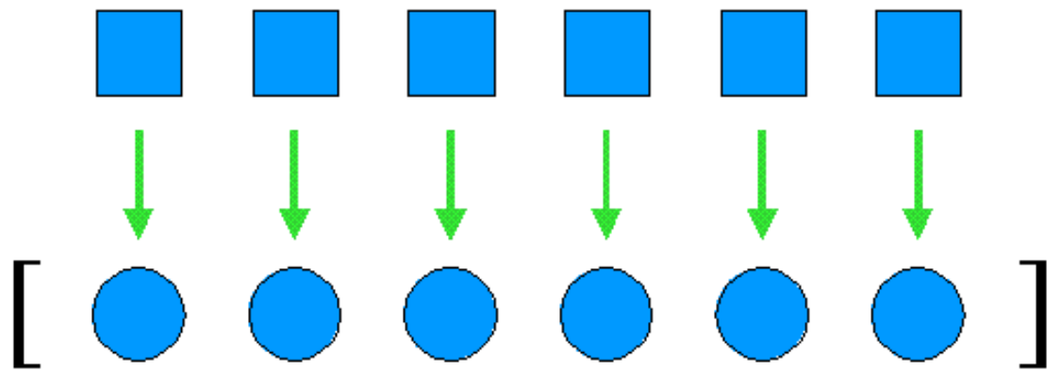
GENEXPS

Syntax shortcut for building generators

LIST COMPREHENSION

Syntax to build a list from any finite iterable — limited only by available memory.



input: any iterable

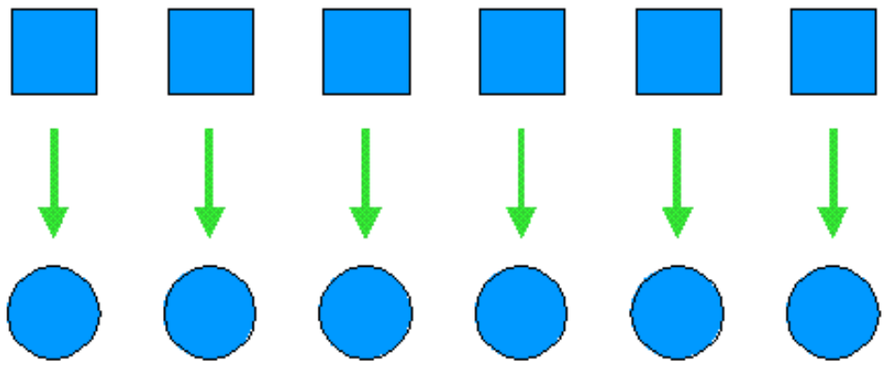
output: always a list

```
>>> s = 'abracadabra'
>>> l = [ord(c) for c in s]
>>> [ord(c) for c in s]
[97, 98, 114, 97, 99, 97, 100, 97, 98, 114, 97]
```

* syntax borrowed from Haskell and set builder notation

GENERATOR EXPRESSION

Syntax to build an generator from any iterable.
Evaluated *lazily*: input is consumed one item at a time



input: any iterable

output: a generator

```
>>> s = 'abracadabra'
>>> g = (ord(c) for c in s)
>>> g
<generator object <genexpr> at 0x102610620>
>>> list(g)
[97, 98, 114, 97, 99, 97, 100, 97, 98, 114, 97]
```

TRAIN WITH GENERATOR EXPRESSION

__iter__ as a plain method returning a generator expression:

```
class Train:

    def __init__(self, cars):
        self.cars = cars

    def __iter__(self):
        return ('car #%s' % (i+1) for i in range(self.cars))
```

__iter__ as a generator method:

```
class Train:

    def __init__(self, cars):
        self.cars = cars

    def __iter__(self):
        for i in range(self.cars):
            yield 'car #%s' % (i+1)
```

THE PYTHONIC DEFINITION OF ITERABLE

iterable, adj. — (Python) An object from which the **iter()** function can build an **iterator**.

iter(iterable)

Returns iterator for iterable, invoking **__iter__** (if available) or building an iterator to fetch items via **__getitem__** with 0-based indices (seq[0], seq[1], etc...)

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CASE STUDY

Using generator functions to convert database dumps

CONVERSION OF LARGE DATA SETS

Context

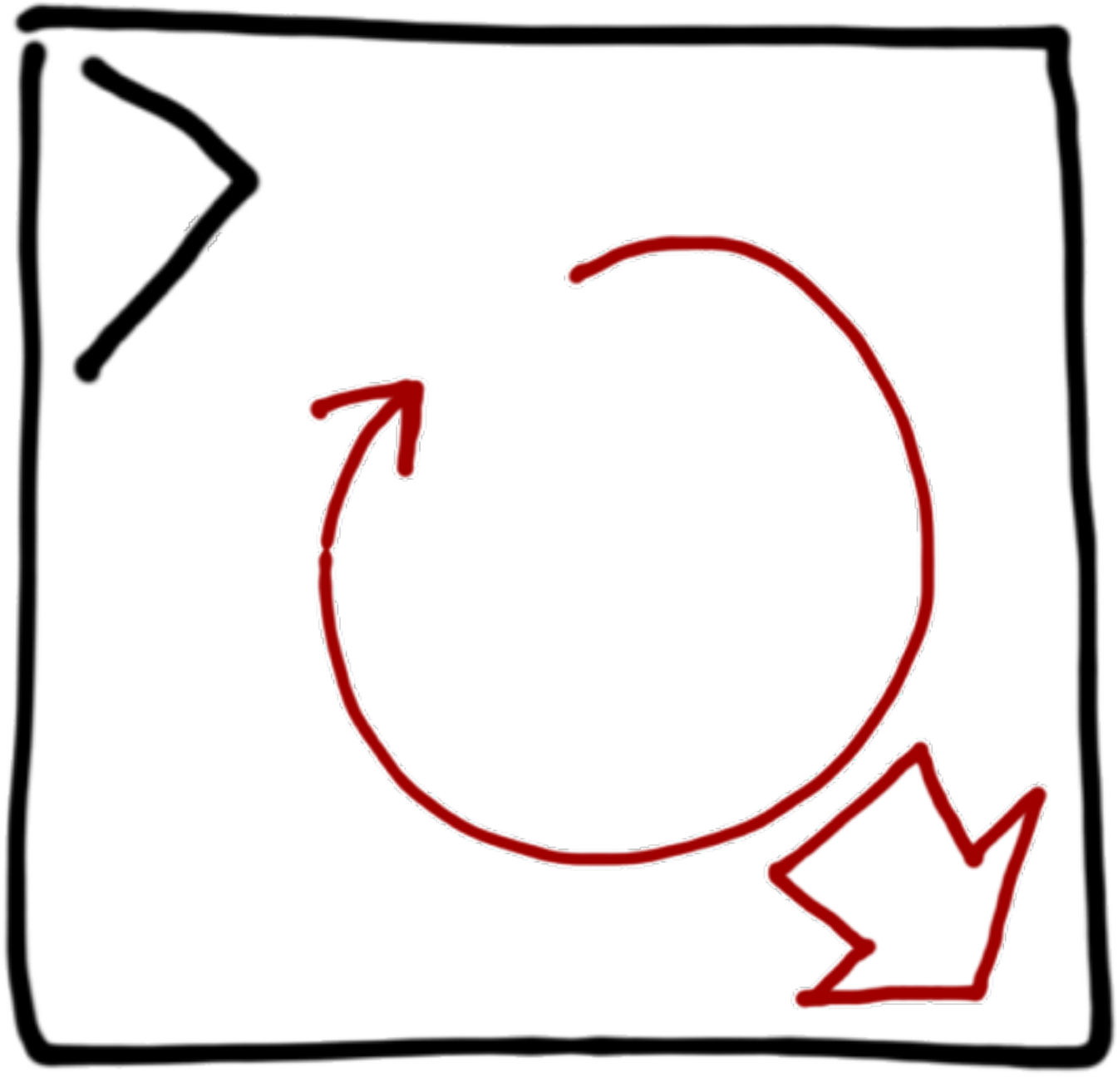
`isis2json`, a command-line tool to convert and refactor semi-structured database dumps; written in **Python 2.7**.

Usage

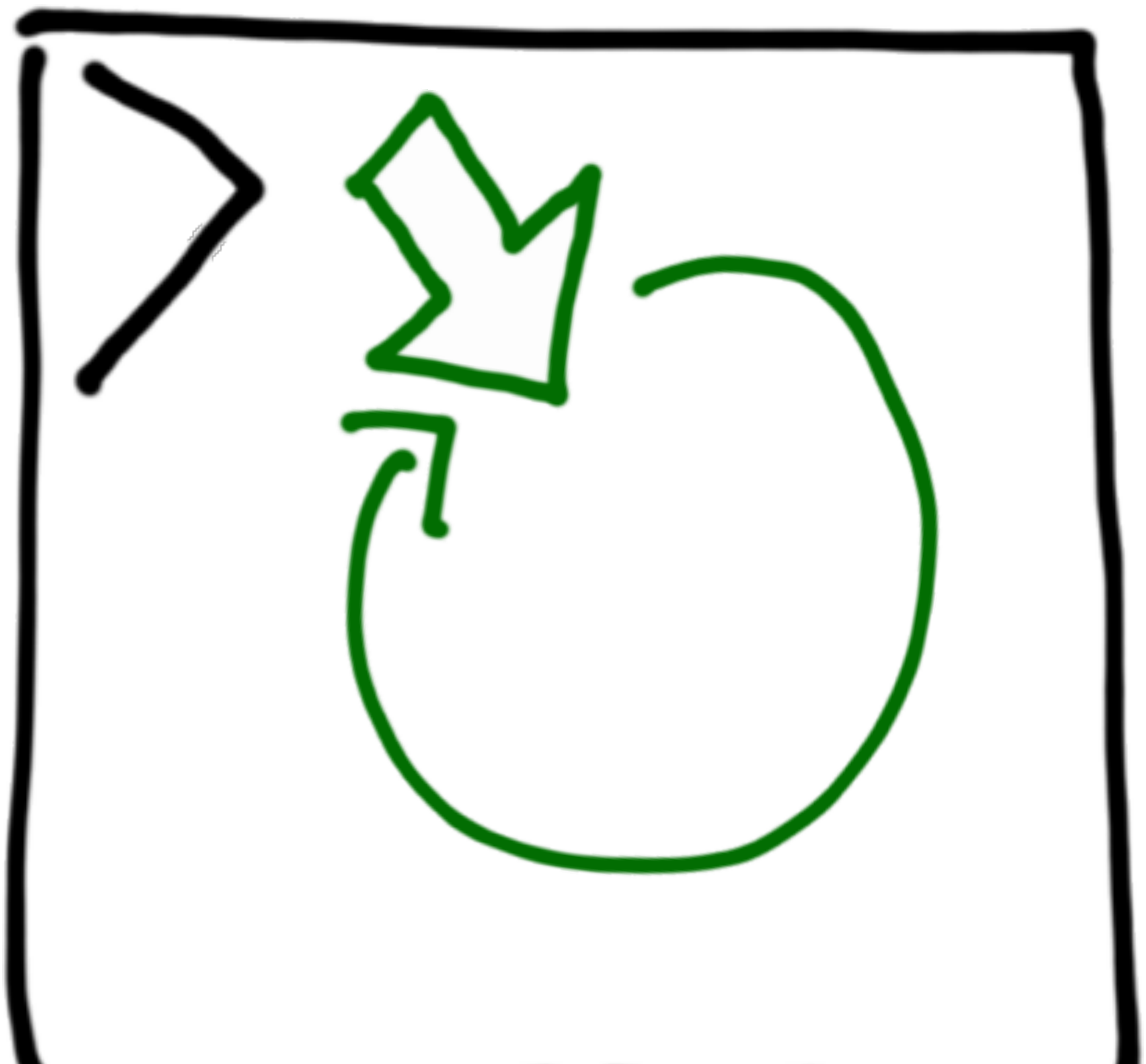
Generator functions to decouple reading from writing logic.

https://github.com/fluentpython/isis2json

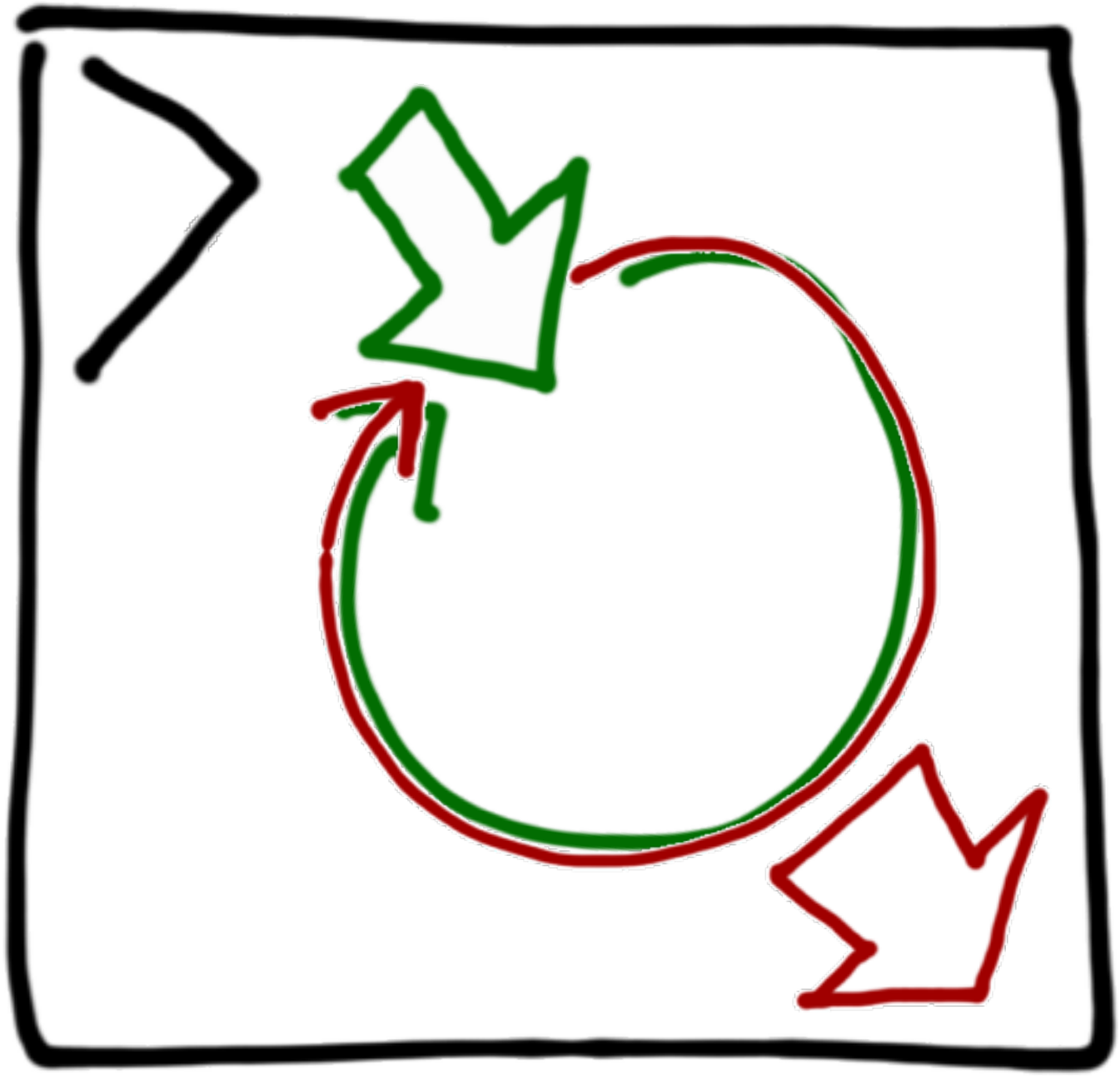
MAIN LOOP: OUTPUTS JSON FILE



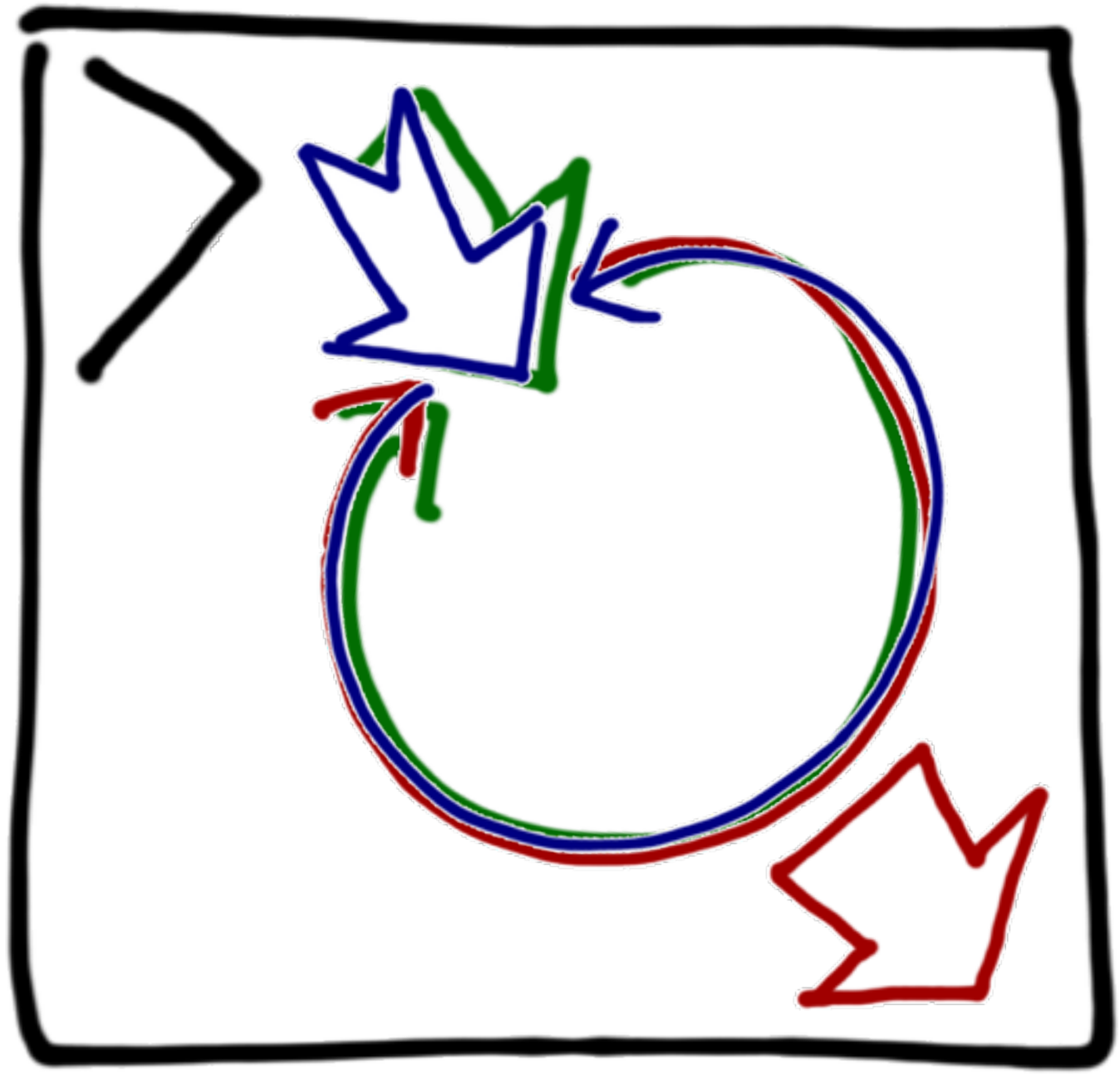
ANOTHER LOOP READS RECORDS TO CONVERT



ONE SOLUTION: SAME LOOP READS AND WRITES



HOW TO SUPPORT A NEW INPUT FORMAT?



SOLUTION: GENERATOR FUNCTIONS

iterMstRecords

generator function: yields MST records

iterIsoRecords

generator function: yields ISO-2709 records

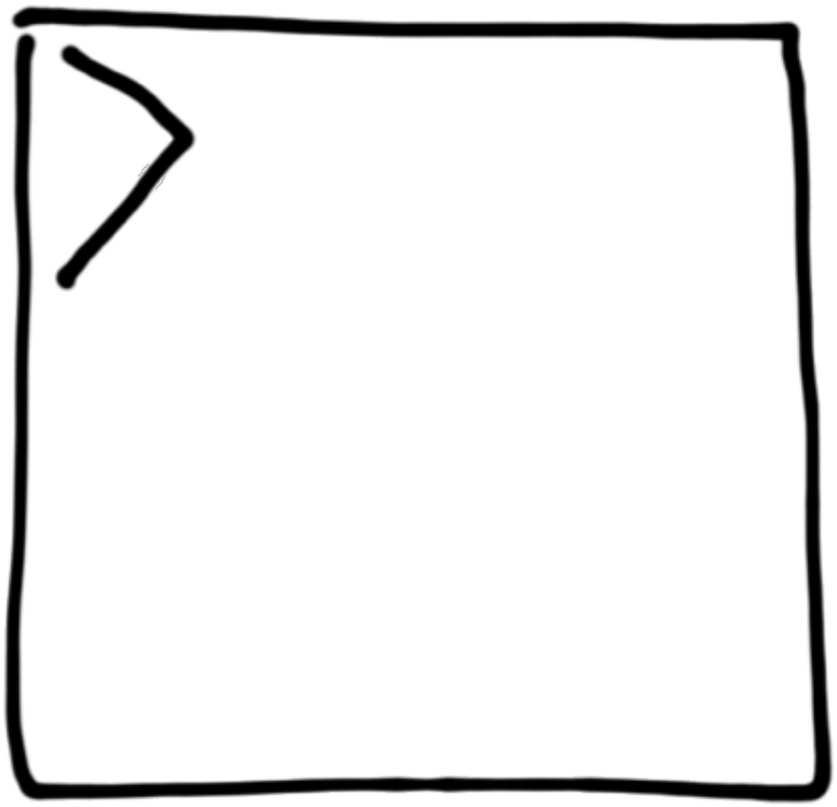
writeJsonArray

consumes and outputs records

main

parses command-line arguments

MAIN: PARSE COMMAND-LINE



```
def main():
    # create the parser
    parser = argparse.ArgumentParser(
        description='Convert an ISIS .mst or .iso file to a JSON array')

    # add the arguments
    parser.add_argument(
        'file_name', metavar='INPUT.(mst|iso)',
        help='.mst or .iso file to read')
    parser.add_argument(
        '-o', '--out', type=argparse.FileType('w'), default=sys.stdout,
        metavar='OUTPUT.json',
        help='the file where the JSON output should be written'
             ' (default: write to stdout)')
    parser.add_argument(
        '-c', '--couch', action='store_true',
        help='output array within a "docs" item in a JSON document'
             ' for bulk insert to CouchDB via POST to db/_bulk_docs')
    parser.add_argument(
        '-m', '--mongo', action='store_true',
        help='output individual records as separate JSON dictionaries,'
             ' one per line for bulk insert to MongoDB via mongoimport utility')
    parser.add_argument(
        '-t', '--type', type=int, metavar='ISIS_JSON_TYPE', default=1,
        help='ISIS-JSON type, sets field structure: 1=string, 2=alist, 3=dict '
             '(default=1)')
    parser.add_argument(
        '-q', '--qty', type=int, default=DEFAULT_QTY,
        help='maximum quantity of records to read (default=ALL)')
    parser.add_argument(
        '-s', '--skip', type=int, default=0,
        help='records to skip from start of .mst (default=0)')
    parser.add_argument(
        '-i', '--id', type=int, metavar='TAG_NUMBER', default=0,
        help='generate an "_id" from the given unique TAG field number'
             ' for each record')
    parser.add_argument(
        '-u', '--uuid', action='store_true',
        help='generate an "_id" with a random UUID for each record')
    parser.add_argument(
        '-p', '--prefix', type=str, metavar='PREFIX', default='',
        help='concatenate prefix to every numeric field tag '
             '(ex. 99 becomes "v99")')
    parser.add_argument(
        '-n', '--mfn', action='store_true',
        help='generate an "_id" from the MFN of each record'
             ' (available only for .mst input)')
    parser.add_argument(
        '-k', '--constant', type=str, metavar='TAG:VALUE', default='',
        help='Include a constant tag:value in every record (ex. -k type:AS)')

    '''
    # TODO: implement this to export large quantities of records to CouchDB
    parser.add_argument(
        '-r', '--repeat', type=int, default=1,
        help='repeat operation, saving multiple JSON files'
             ' (default=1, use -r 0 to repeat until end of input)')
    '''
    # parse the command line
    args = parser.parse_args()
    if args.file_name.lower().endswith('.mst'):
        iterRecords = iterMstRecords
    else:
        if args.mfn:
            print('UNSUPORTED: -n/--mfn option only available for .mst input.')
            raise SystemExit
        iterRecords = iterIsoRecords
    if args.couch:
        args.out.write('{ "docs" : ')
    writeJsonArray(iterRecords, args.file_name, args.out, args.qty, args.skip,
        args.id, args.uuid, args.mongo, args.mfn, args.type, args.prefix,
        args.constant)
    if args.couch:
        args.out.write('}\n')
    args.out.close()

if __name__ == '__main__':
    main()
```

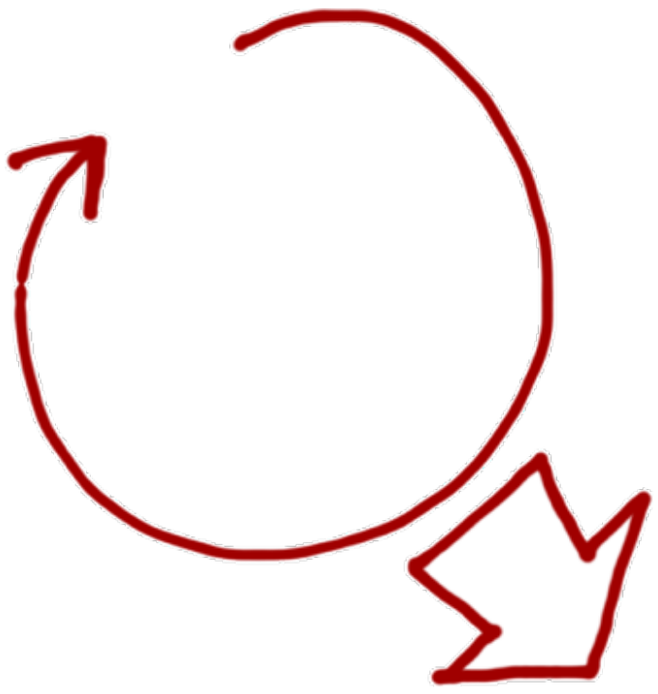
MAIN: SELECTING INPUT GENERATOR FUNCTION

pick generator function depending on input file extension

```
    args = parser.parse_args()
    if args.file_name.lower().endswith('.mst'):
        iterRecords = iterMstRecords
    else:
        if args.mfn:
            print('UNSUPORTED: -n/--mfn option only available for .mst input.')
            raise SystemExit
        iterRecords = iterIsoRecords
    if args.couch:
        args.out.write('{ "docs" : ')
    writeJsonArray(iterRecords, args.file_name, args.out, args.qty, args.skip,
        args.id, args.uuid, args.mongo, args.mfn, args.type, args.prefix,
        args.constant)
    if args.couch:
        args.out.write('}\n')
    args.out.close()

if __name__ == '__main__':
    main()
```

chosen generator function passed as argument

WRITING JSON RECORDS



```
def writeJsonArray(iterRecords, file_name, output, qty, skip, id_tag,
                   gen_uuid, mongo, mfn, isis_json_type, prefix, constant):
    start = skip
    end = start + qty
    if not mongo:
        output.write('[')
    if id_tag:
        id_tag = str(id_tag)
        ids = set()
    else:
        id_tag = ''
    for i, record in enumerate(iterRecords(file_name, isis_json_type)):
        if i >= end:
            break
        if i > start and not mongo:
            output.write(',')
        output.write('\n')
        if start <= i < end:
            if id_tag:
                occurrences = record.get(id_tag, None)
                if occurrences is None:
                    msg = 'id tag #%s not found in record %s'
                    if ISIS_MFN_KEY in record:
                        msg = msg + (' (mfn=%s)' % record[ISIS_MFN_KEY])
                    raise KeyError(msg % (id_tag, i))
                if len(occurrences) > 1:
                    msg = 'multiple id tags #%s found in record %s'
                    if ISIS_MFN_KEY in record:
                        msg = msg + (' (mfn=%s)' % record[ISIS_MFN_KEY])
                    raise TypeError(msg % (id_tag, i))
                else: # ok, we have one and only one id field
                    if isis_json_type == 1:
                        id = occurrences[0]
                    elif isis_json_type == 2:
                        id = occurrences[0][0][1]
                    elif isis_json_type == 3:
                        id = occurrences[0]['_']
                    if id in ids:
                        msg = 'duplicate id %s in tag #%s, record %s'
                        if ISIS_MFN_KEY in record:
                            msg = msg + (' (mfn=%s)' % record[ISIS_MFN_KEY])
                        raise TypeError(msg % (id, id_tag, i))
                    record['_id'] = id
                    ids.add(id)
            elif gen_uuid:
                record['_id'] = unicode(uuid4())
            elif mfn:
                record['_id'] = record[ISIS_MFN_KEY]
            if prefix:
                # iterate over a fixed sequence of tags
                for tag in tuple(record):
                    if str(tag).isdigit():
                        record[prefix+tag] = record[tag]
                        del record[tag] # this is why we iterate over a tuple
                        # with the tags, and not directly on the record dict
            if constant:
                constant_key, constant_value = constant.split(':')
                record[constant_key] = constant_value
            output.write(json.dumps(record).encode('utf-8'))
    if not mongo:
        output.write('\n]')
    output.write('\n')
```

WRITING JSON RECORDS

writeJsonArray gets generator function as first argument, then uses a **for** loop to consume that generator.

```
def writeJsonArray(iterRecords, file_name, output, qty, skip, id_tag,
                   gen_uuid, mongo, mfn, isis_json_type, prefix, constant):
    start = skip
    end = start + qty
    if not mongo:
        output.write('[')
    if id_tag:
        id_tag = str(id_tag)
        ids = set()
    else:
        id_tag = ''
    for i, record in enumerate(iterRecords(file_name, isis_json_type)):
        if i >= end:
            break
        if i > start and not mongo:
            output.write(',')
        output.write('\n')
        if start <= i < end:
            if id_tag:
                occurrences = record.get(id_tag, None)
```

READING ISO-2709 RECORDS

Input **for** loop reads each ISO-2709 record, populates a dict with its fields, and yields the dict.

```
def iterIsoRecords(iso_file_name, isis_json_type):
    from iso2709 import IsoFile
    from subfield import expand

    iso = IsoFile(iso_file_name)
    for record in iso:
        fields = {}
        for field in record.directory:
            field_key = str(int(field.tag)) # remove leading zeroes
            field_occurrences = fields.setdefault(field_key,[])
            content = field.value.decode(INPUT_ENCODING,'replace')
            if isis_json_type == 1:
                field_occurrences.append(content)
            elif isis_json_type == 2:
                field_occurrences.append(expand(content))
            elif isis_json_type == 3:
                field_occurrences.append(dict(expand(content)))
            else:
                raise NotImplementedError(
                    'ISIS-JSON type %s conversion not yet '
                    'implemented for .iso input' % isis_json_type)

        yield fields
    iso.close()
```

generator function!

READING ISO-2709 RECORDS

```
def iterIsoRecords(iso_file_name, isis_json_type):
    from iso2709 import IsoFile
    from subfield import expand

    iso = IsoFile(iso_file_name)
    for record in iso:
        fields = {}
        for field in record.directory:
            field_key = str(int(field.tag)) # remove leading zeroes
            field_occurrences = fields.setdefault(field_key,[])
            content = field.value.decode(INPUT_ENCODING,'replace')
            if isis_json_type == 1:
                field_occurrences.append(content)
            elif isis_json_type == 2:
                field_occurrences.append(expand(content))
            elif isis_json_type == 3:
                field_occurrences.append(dict(expand(content)))
            else:
                raise NotImplementedError(
                    'ISIS-JSON type %s conversion not yet '
                    'implemented for .iso input' % isis_json_type)

        yield fields
    iso.close()
```

creates new dict at each iteration

yields dict populated with record fields

READING .MST RECORDS

Input **for** loop reads each .MST record, populates a dict with its fields, and yields the dict.

another generator function!

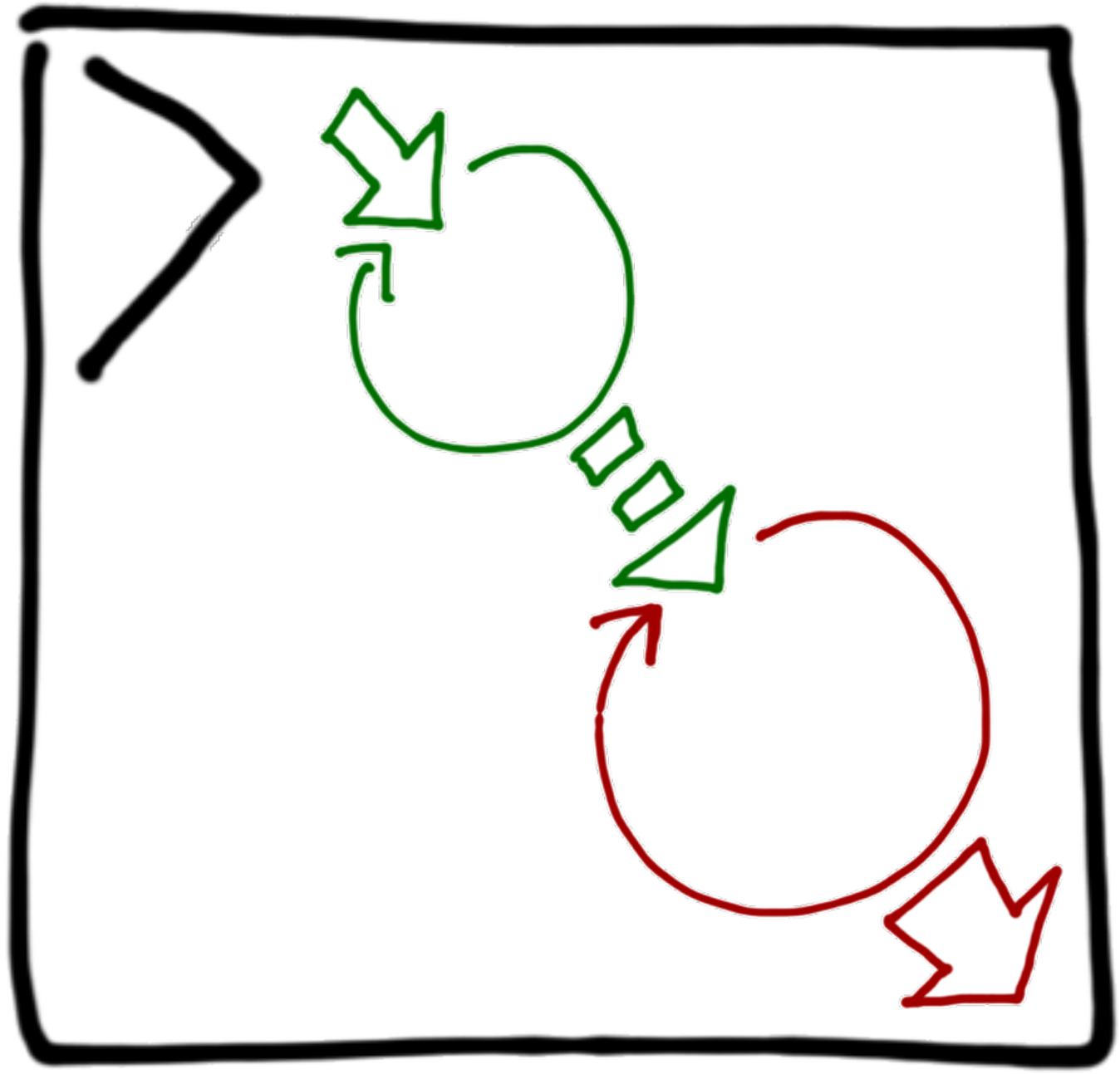
```
def iterMstRecords(master_file_name, isis_json_type):
    try:
        from bruma.master import MasterFactory, Record
    except ImportError:
        print('IMPORT ERROR: Jython 2.5 and Bruma.jar are required '
              'to read .mst files')
        raise SystemExit
    mst = MasterFactory.getInstance(master_file_name).open()
    for record in mst:
        fields = {}
        if SKIP_INACTIVE:
            if record.getStatus() != Record.Status.ACTIVE:
                continue
        else: # save status only there are non-active records
            fields[ISIS_ACTIVE_KEY] = record.getStatus() == Record.Status.ACTIVE
        fields[ISIS_MFN_KEY] = record.getMfn()
        for field in record.getFields():
            field_key = str(field.getId())
            field_occurrences = fields.setdefault(field_key,[])
            if isis_json_type == 3:
                content = {}
                for subfield in field.getSubfields():
                    subfield_key = subfield.getId()
                    if subfield_key == '*':
                        content['_'] = subfield.getContent()
                    else:
                        subfield_occurrences = content.setdefault(subfield_key,[])
                        subfield_occurrences.append(subfield.getContent())
                field_occurrences.append(content)
            elif isis_json_type == 1:
                content = []
                for subfield in field.getSubfields():
                    subfield_key = subfield.getId()
                    if subfield_key == '*':
                        content.insert(0, subfield.getContent())
                    else:
                        content.append(SUBFIELD_DELIMITER+subfield_key+
                                       subfield.getContent())
                field_occurrences.append(''.join(content))
            else:
                raise NotImplementedError(
                    'ISIS-JSON type %s conversion not yet '
                    'implemented for .mst input' % isis_json_type)
        yield fields
    mst.close()
```

```
def iterMstRecords(master_file_name, isis_json_type):
    try:
        from bruma.master import MasterFactory, Record
    except ImportError:
        print('IMPORT ERROR: Jython 2.5 and Bruma.jar are required '
              'to read .mst files')
        raise SystemExit
    mst = MasterFactory.getInstance(master_file_name).open()
    for record in mst:
        fields = {}
        if SKIP_INACTIVE:
            if record.getStatus() != Record.Status.ACTIVE:
                continue
        else: # save status only there are non-active records
            fields[ISIS_ACTIVE_KEY] = record.getStatus() == Record.Status.ACTIVE
        fields[ISIS_MFN_KEY] = record.getMfn()
        for field in record.getFields():
            field_key = str(field.getId())
            field_occurrences = fields.setdefault(field_key,[])
            if isis_json_type == 3:
                content = {}
                for subfield in field.getSubfields():
                    subfield_key = subfield.getId()
                    if subfield_key == '*':
                        content['_'] = subfield.getContent()
                    else:
                        subfield_occurrences = content.setdefault(subfield_key,[])
                        subfield_occurrences.append(subfield.getContent())
                field_occurrences.append(content)
            elif isis_json_type == 1:
                content = []
                for subfield in field.getSubfields():
                    subfield_key = subfield.getId()
                    if subfield_key == '*':
                        content.insert(0, subfield.getContent())
                    else:
                        content.append(SUBFIELD_DELIMITER+subfield_key+
                                       subfield.getContent())
                field_occurrences.append(''.join(content))
            else:
                raise NotImplementedError(
                    'ISIS-JSON type %s conversion not yet '
                    'implemented for .mst input' % isis_json_type)
        yield fields
    mst.close()
```

creates new dict at each iteration

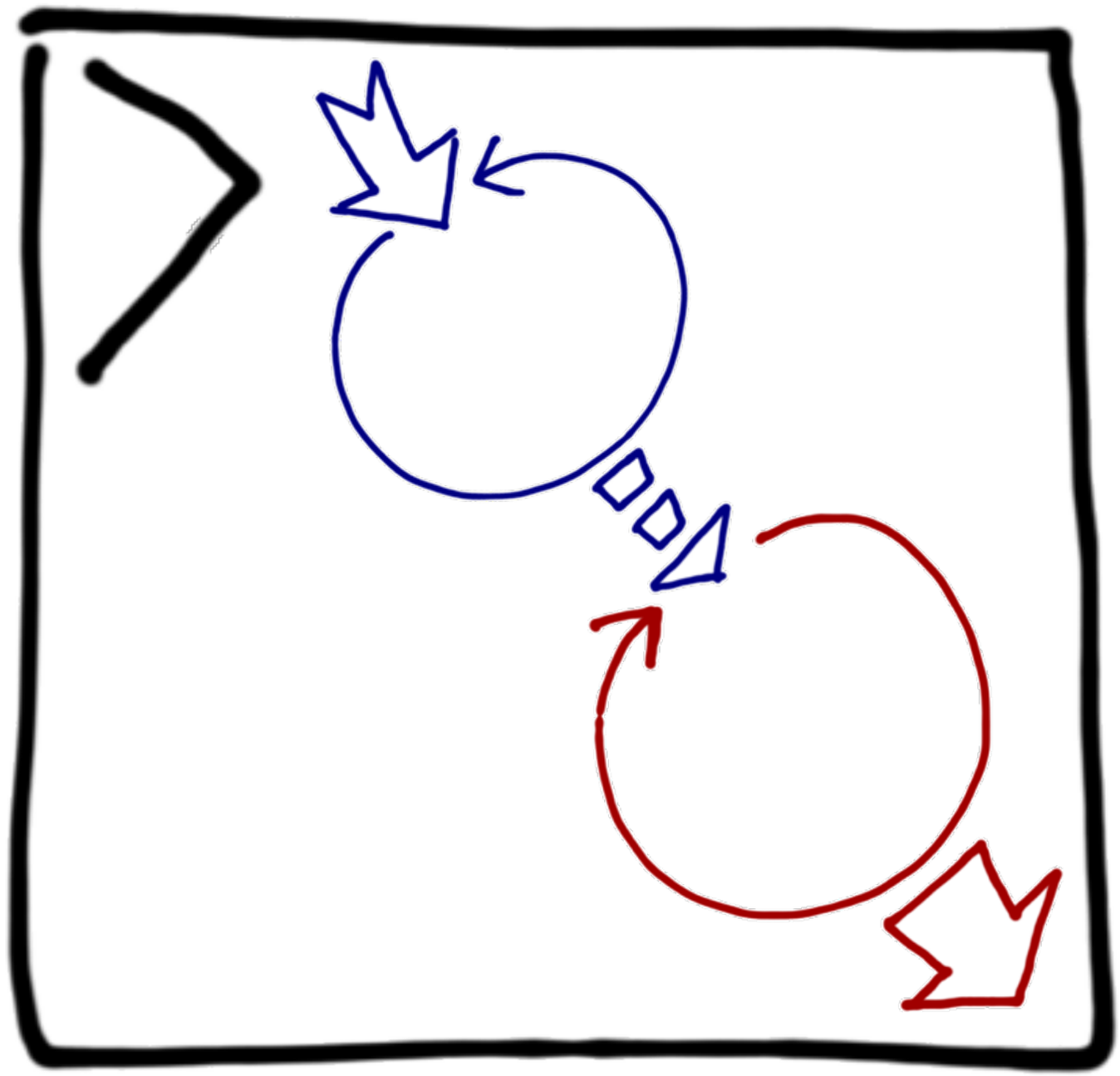
yields dict populated with record fields

PROBLEM SOLVED



```
import sys
import argparse
from uuid import uuid4
import os

try:
    import json
except ImportError:
    if os.name == 'java': # running Jython
        from com.xhaus.jyson import JysonCodec as json
    else:
        import simplejson as json

SKIP_INACTIVE = True
DEFAULT_QTY = 2**31
ISIS_MFN_KEY = 'mfn'
ISIS_ACTIVE_KEY = 'active'
SUBFIELD_DELIMITER = '^'
INPUT_ENCODING = 'cp1252'

def iterMstRecords(master_file_name, isis_json_type):
    try:
        from bruma.master import MasterFactory, Record
    except ImportError:
        print('IMPORT ERROR: Jython 2.5 and Bruma.jar are required '
              'to read .mst files')
        raise SystemExit
    mst = MasterFactory.getInstance(master_file_name).open()
    for record in mst:
        fields = {}
        if SKIP_INACTIVE:
            if record.getStatus() != Record.Status.ACTIVE:
                continue
        else: # save status only there are non-active records
            fields[ISIS_ACTIVE_KEY] = record.getStatus() == Record.Status.ACTIVE
        fields[ISIS_MFN_KEY] = record.getMfn()
        for field in record.getFields():
            field_key = str(field.getId())
            field_occurrences = fields.setdefault(field_key,[])
            if isis_json_type == 3:
                content = {}
                for subfield in field.getSubfields():
                    subfield_key = subfield.getId()
                    if subfield_key == '*':
                        content['_'] = subfield.getContent()
                    else:
                        subfield_occurrences = content.setdefault(subfield_key,[])
                        subfield_occurrences.append(subfield.getContent())
                field_occurrences.append(content)
            elif isis_json_type == 1:
                content = []
                for subfield in field.getSubfields():
                    subfield_key = subfield.getId()
                    if subfield_key == '*':
                        content.insert(0, subfield.getContent())
                    else:
                        content.append(SUBFIELD_DELIMITER+subfield_key+
                                       subfield.getContent())
                field_occurrences.append(''.join(content))
            else:
                raise NotImplementedError(
                    'ISIS-JSON type %s conversion not yet '
                    'implemented for .mst input' % isis_json_type)
        yield fields
    mst.close()

def iterIsoRecords(iso_file_name, isis_json_type):
    from iso2709 import IsoFile
    from subfield import expand

    iso = IsoFile(iso_file_name)
    for record in iso:
        fields = {}
        for field in record.directory:
            field_key = str(int(field.tag)) # remove leading zeroes
            field_occurrences = fields.setdefault(field_key,[])
            content = field.value.decode(INPUT_ENCODING,'replace')
            if isis_json_type == 1:
                field_occurrences.append(content)
            elif isis_json_type == 2:
                field_occurrences.append(expand(content))
            elif isis_json_type == 3:
                field_occurrences.append(dict(expand(content)))
            else:
                raise NotImplementedError(
                    'ISIS-JSON type %s conversion not yet '
                    'implemented for .iso input' % isis_json_type)
        yield fields
    iso.close()

def writeJsonArray(iterRecords, file_name, output, qty, skip, id_tag,
                   gen_uuid, mongo, mfn, isis_json_type, prefix, constant):
    start = skip
    end = start + qty
    if not mongo:
        output.write('[')
    if id_tag:
        id_tag = str(id_tag)
        ids = set()
    else:
        id_tag = ''
    for i, record in enumerate(iterRecords(file_name, isis_json_type)):
        if i >= end:
            break
        if i > start and not mongo:
            output.write(',')
        output.write('\n')
        if start <= i < end:
            if id_tag:
                occurrences = record.get(id_tag, None)
                if occurrences is None:
                    msg = 'id tag #%s not found in record %s'
                    if ISIS_MFN_KEY in record:
                        msg = msg + (' (mfn=%s)' % record[ISIS_MFN_KEY])
                    raise KeyError(msg % (id_tag, i))
                if len(occurrences) > 1:
                    msg = 'multiple id tags #%s found in record %s'
                    if ISIS_MFN_KEY in record:
                        msg = msg + (' (mfn=%s)' % record[ISIS_MFN_KEY])
                    raise TypeError(msg % (id_tag, i))
                else: # ok, we have one and only one id field
                    if isis_json_type == 1:
                        id = occurrences[0]
                    elif isis_json_type == 2:
                        id = occurrences[0][0][1]
                    elif isis_json_type == 3:
                        id = occurrences[0]['_']
                    if id in ids:
                        msg = 'duplicate id %s in tag #%s, record %s'
                        if ISIS_MFN_KEY in record:
                            msg = msg + (' (mfn=%s)' % record[ISIS_MFN_KEY])
                        raise TypeError(msg % (id, id_tag, i))
                    record['_id'] = id
                    ids.add(id)
            elif gen_uuid:
                record['_id'] = unicode(uuid4())
            elif mfn:
                record['_id'] = record[ISIS_MFN_KEY]
            if prefix:
                # iterate over a fixed sequence of tags
                for tag in tuple(record):
                    if str(tag).isdigit():
                        record[prefix+tag] = record[tag]
                        del record[tag] # this is why we iterate over a tuple
                        # with the tags, and not directly on the record dict
            if constant:
                constant_key, constant_value = constant.split(':')
                record[constant_key] = constant_value
            output.write(json.dumps(record).encode('utf-8'))
    if not mongo:
        output.write('\n]')
    output.write('\n')

def main():
    # create the parser
    parser = argparse.ArgumentParser(
        description='Convert an ISIS .mst or .iso file to a JSON array')

    # add the arguments
    parser.add_argument(
        'file_name', metavar='INPUT.(mst|iso)',
        help='.mst or .iso file to read')
    parser.add_argument(
        '-o', '--out', type=argparse.FileType('w'), default=sys.stdout,
        metavar='OUTPUT.json',
        help='the file where the JSON output should be written'
             ' (default: write to stdout)')
    parser.add_argument(
        '-c', '--couch', action='store_true',
        help='output array within a "docs" item in a JSON document'
             ' for bulk insert to CouchDB via POST to db/_bulk_docs')
    parser.add_argument(
        '-m', '--mongo', action='store_true',
        help='output individual records as separate JSON dictionaries,'
             ' one per line for bulk insert to MongoDB via mongoimport utility')
    parser.add_argument(
        '-t', '--type', type=int, metavar='ISIS_JSON_TYPE', default=1,
        help='ISIS-JSON type, sets field structure: 1=string, 2=alist, 3=dict '
             '(default=1)')
    parser.add_argument(
        '-q', '--qty', type=int, default=DEFAULT_QTY,
        help='maximum quantity of records to read (default=ALL)')
    parser.add_argument(
        '-s', '--skip', type=int, default=0,
        help='records to skip from start of .mst (default=0)')
    parser.add_argument(
        '-i', '--id', type=int, metavar='TAG_NUMBER', default=0,
        help='generate an "_id" from the given unique TAG field number'
             ' for each record')
    parser.add_argument(
        '-u', '--uuid', action='store_true',
        help='generate an "_id" with a random UUID for each record')
    parser.add_argument(
        '-p', '--prefix', type=str, metavar='PREFIX', default='',
        help='concatenate prefix to every numeric field tag '
             '(ex. 99 becomes "v99")')
    parser.add_argument(
        '-n', '--mfn', action='store_true',
        help='generate an "_id" from the MFN of each record'
             ' (available only for .mst input)')
    parser.add_argument(
        '-k', '--constant', type=str, metavar='TAG:VALUE', default='',
        help='Include a constant tag:value in every record (ex. -k type:AS)')
    '''
    # TODO: implement this to export large quantities of records to CouchDB
    parser.add_argument(
        '-r', '--repeat', type=int, default=1,
        help='repeat operation, saving multiple JSON files'
             ' (default=1, use -r 0 to repeat until end of input)')
    '''
    # parse the command line
    args = parser.parse_args()
    if args.file_name.lower().endswith('.mst'):
        iterRecords = iterMstRecords
    else:
        if args.mfn:
            print('UNSUPORTED: -n/--mfn option only available for .mst input.')
            raise SystemExit
        iterRecords = iterIsoRecords
    if args.couch:
        args.out.write('{ "docs" : ')
    writeJsonArray(iterRecords, args.file_name, args.out, args.qty, args.skip,
        args.id, args.uuid, args.mongo, args.mfn, args.type, args.prefix,
        args.constant)
    if args.couch:
        args.out.write('}\n')
    args.out.close()

if __name__ == '__main__':
    main()
```

PROBLEM SOLVED



```
import sys
import argparse
from uuid import uuid4
import os

try:
    import json
except ImportError:
    if os.name == 'java': # running Jython
        from com.xhaus.jyson import JysonCodec as json
    else:
        import simplejson as json

SKIP_INACTIVE = True
DEFAULT_QTY = 2**31
ISIS_MFN_KEY = 'mfn'
ISIS_ACTIVE_KEY = 'active'
SUBFIELD_DELIMITER = '^'
INPUT_ENCODING = 'cp1252'

def iterMstRecords(master_file_name, isis_json_type):
    try:
        from bruma.master import MasterFactory, Record
    except ImportError:
        print('IMPORT ERROR: Jython 2.5 and Bruma.jar are required '
              'to read .mst files')
        raise SystemExit
    mst = MasterFactory.getInstance(master_file_name).open()
    for record in mst:
        fields = {}
        if SKIP_INACTIVE:
            if record.getStatus() != Record.Status.ACTIVE:
                continue
        else: # save status only there are non-active records
            fields[ISIS_ACTIVE_KEY] = record.getStatus() == Record.Status.ACTIVE
        fields[ISIS_MFN_KEY] = record.getMfn()
        for field in record.getFields():
            field_key = str(field.getId())
            field_occurrences = fields.setdefault(field_key,[])
            if isis_json_type == 3:
                content = {}
                for subfield in field.getSubfields():
                    subfield_key = subfield.getId()
                    if subfield_key == '*':
                        content['_'] = subfield.getContent()
                    else:
                        subfield_occurrences = content.setdefault(subfield_key,[])
                        subfield_occurrences.append(subfield.getContent())
                field_occurrences.append(content)
            elif isis_json_type == 1:
                content = []
                for subfield in field.getSubfields():
                    subfield_key = subfield.getId()
                    if subfield_key == '*':
                        content.insert(0, subfield.getContent())
                    else:
                        content.append(SUBFIELD_DELIMITER+subfield_key+
                                       subfield.getContent())
                field_occurrences.append(''.join(content))
            else:
                raise NotImplementedError(
                    'ISIS-JSON type %s conversion not yet '
                    'implemented for .mst input' % isis_json_type)
        yield fields
    mst.close()

def iterIsoRecords(iso_file_name, isis_json_type):
    from iso2709 import IsoFile
    from subfield import expand

    iso = IsoFile(iso_file_name)
    for record in iso:
        fields = {}
        for field in record.directory:
            field_key = str(int(field.tag)) # remove leading zeroes
            field_occurrences = fields.setdefault(field_key,[])
            content = field.value.decode(INPUT_ENCODING,'replace')
            if isis_json_type == 1:
                field_occurrences.append(content)
            elif isis_json_type == 2:
                field_occurrences.append(expand(content))
            elif isis_json_type == 3:
                field_occurrences.append(dict(expand(content)))
            else:
                raise NotImplementedError(
                    'ISIS-JSON type %s conversion not yet '
                    'implemented for .iso input' % isis_json_type)
        yield fields
    iso.close()

def writeJsonArray(iterRecords, file_name, output, qty, skip, id_tag,
                   gen_uuid, mongo, mfn, isis_json_type, prefix, constant):
    start = skip
    end = start + qty
    if not mongo:
        output.write('[')
    if id_tag:
        id_tag = str(id_tag)
        ids = set()
    else:
        id_tag = ''
    for i, record in enumerate(iterRecords(file_name, isis_json_type)):
        if i >= end:
            break
        if i > start and not mongo:
            output.write(',')
        output.write('\n')
        if start <= i < end:
            if id_tag:
                occurrences = record.get(id_tag, None)
                if occurrences is None:
                    msg = 'id tag #%s not found in record %s'
                    if ISIS_MFN_KEY in record:
                        msg = msg + ' (mfn=%s)' % record[ISIS_MFN_KEY])
                    raise KeyError(msg % (id_tag, i))
                if len(occurrences) > 1:
                    msg = 'multiple id tags #%s found in record %s'
                    if ISIS_MFN_KEY in record:
                        msg = msg + ' (mfn=%s)' % record[ISIS_MFN_KEY])
                    raise TypeError(msg % (id_tag, i))
                else: # ok, we have one and only one id field
                    if isis_json_type == 1:
                        id = occurrences[0]
                    elif isis_json_type == 2:
                        id = occurrences[0][0][1]
                    elif isis_json_type == 3:
                        id = occurrences[0]['_']
                    if id in ids:
                        msg = 'duplicate id %s in tag #%s, record %s'
                        if ISIS_MFN_KEY in record:
                            msg = msg + ' (mfn=%s)' % record[ISIS_MFN_KEY])
                        raise TypeError(msg % (id, id_tag, i))
                    record['_id'] = id
                    ids.add(id)
            elif gen_uuid:
                record['_id'] = unicode(uuid4())
            elif mfn:
                record['_id'] = record[ISIS_MFN_KEY]
            if prefix:
                # iterate over a fixed sequence of tags
                for tag in tuple(record):
                    if str(tag).isdigit():
                        record[prefix+tag] = record[tag]
                        del record[tag] # this is why we iterate over a tuple
                        # with the tags, and not directly on the record dict
            if constant:
                constant_key, constant_value = constant.split(':')
                record[constant_key] = constant_value
            output.write(json.dumps(record).encode('utf-8'))
    if not mongo:
        output.write('\n]')
    output.write('\n')

def main():
    # create the parser
    parser = argparse.ArgumentParser(
        description="Convert an ISIS .mst or .iso file to a JSON array")

    # add the arguments
    parser.add_argument(
        'file_name', metavar='INPUT.(mst|iso)',
        help='.mst or .iso file to read')
    parser.add_argument(
        '-o', '--out', type=argparse.FileType('w'), default=sys.stdout,
        metavar='OUTPUT.json',
        help='the file where the JSON output should be written'
             '(default: write to stdout)')
    parser.add_argument(
        '-c', '--couch', action='store_true',
        help='output array within a "docs" item in a JSON document'
             ' for bulk insert to CouchDB via POST to db/_bulk_docs')
    parser.add_argument(
        '-m', '--mongo', action='store_true',
        help='output individual records as separate JSON dictionaries,'
             ' one per line for bulk insert to MongoDB via mongoimport utility')
    parser.add_argument(
        '-t', '--type', type=int, metavar='ISIS_JSON_TYPE', default=1,
        help='ISIS-JSON type, sets field structure: 1=string, 2=alist, 3=dict '
             '(default=1)')
    parser.add_argument(
        '-q', '--qty', type=int, default=DEFAULT_QTY,
        help='maximum quantity of records to read (default=ALL)')
    parser.add_argument(
        '-s', '--skip', type=int, default=0,
        help='records to skip from start of .mst (default=0)')
    parser.add_argument(
        '-i', '--id', type=int, metavar='TAG_NUMBER', default=0,
        help='generate an "_id" from the given unique TAG field number'
             ' for each record')
    parser.add_argument(
        '-u', '--uuid', action='store_true',
        help='generate an "_id" with a random UUID for each record')
    parser.add_argument(
        '-p', '--prefix', type=str, metavar='PREFIX', default='',
        help='concatenate prefix to every numeric field tag '
             '(ex. 99 becomes "v99")')
    parser.add_argument(
        '-n', '--mfn', action='store_true',
        help='generate an "_id" from the MFN of each record'
             '(available only for .mst input)')
    parser.add_argument(
        '-k', '--constant', type=str, metavar='TAG:VALUE', default='',
        help='Include a constant tag:value in every record (ex. -k type:AS)')
    '''
    # TODO: implement this to export large quantities of records to CouchDB
    parser.add_argument(
        '-r', '--repeat', type=int, default=1,
        help='repeat operation, saving multiple JSON files'
             '(default=1, use -r 0 to repeat until end of input)')
    '''
    # parse the command line
    args = parser.parse_args()
    if args.file_name.lower().endswith('.mst'):
        iterRecords = iterMstRecords
    else:
        if args.mfn:
            print('UNSUPORTED: -n/--mfn option only available for .mst input.')
            raise SystemExit
        iterRecords = iterIsoRecords
    if args.couch:
        args.out.write('{ "docs" : ')
    writeJsonArray(iterRecords, args.file_name, args.out, args.qty, args.skip,
        args.id, args.uuid, args.mongo, args.mfn, args.type, args.prefix,
        args.constant)
    if args.couch:
        args.out.write('}\n')
    args.out.close()

if __name__ == '__main__':
    main()
```

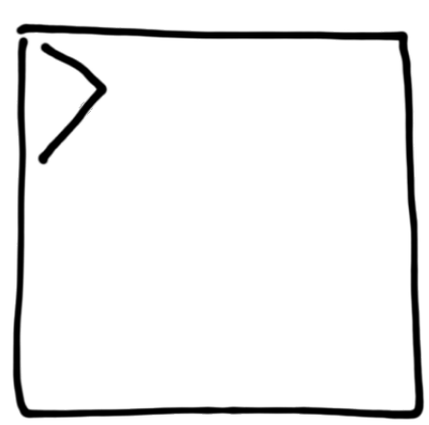
SOLUTION INSIGHT

- Generator functions to yield records from input formats.
- To support new input format, write new generator!

```
def iterMstRecords(master_file_name, isis_json_type):
    try:
        from bruma.master import MasterFactory, Record
    except ImportError:
        print('IMPORT ERROR: Jython 2.5 and Bruma.jar are required '
              'to read .mst files')
        raise SystemExit
    mst = MasterFactory.getInstance(master_file_name).open()
    for record in mst:
        fields = {}
        if SKIP_INACTIVE:
            if record.getStatus() != Record.Status.ACTIVE:
                continue
        else: # save status only there are non-active records
            fields[ISIS_ACTIVE_KEY] = record.getStatus() == Record.Status.ACTIVE
        fields[ISIS_MFN_KEY] = record.getMfn()
        for field in record.getFields():
            field_key = str(field.getId())
            field_occurrences = fields.setdefault(field_key,[])
            if isis_json_type == 3:
                content = {}
                for subfield in field.getSubfields():
                    subfield_key = subfield.getId()
                    if subfield_key == '*':
                        content['_'] = subfield.getContent()
                    else:
                        subfield_occurrences = content.setdefault(subfield_key,[])
                        subfield_occurrences.append(subfield.getContent())
                field_occurrences.append(content)
            elif isis_json_type == 1:
                content = []
                for subfield in field.getSubfields():
                    subfield_key = subfield.getId()
                    if subfield_key == '*':
                        content.insert(0, subfield.getContent())
                    else:
                        content.append(SUBFIELD_DELIMITER+subfield_key+
                                       subfield.getContent())
                field_occurrences.append(''.join(content))
            else:
                raise NotImplementedError(
                  'ISIS-JSON type %s conversion not yet '
                  'implemented for .mst input' % isis_json_type)
        yield fields
    mst.close()
```

```
def iterIsoRecords(iso_file_name, isis_json_type):
    from iso2709 import IsoFile
    from subfield import expand

    iso = IsoFile(iso_file_name)
    for record in iso:
        fields = {}
        for field in record.directory:
            field_key = str(int(field.tag)) # remove leading zeroes
            field_occurrences = fields.setdefault(field_key,[])
            content = field.value.decode(INPUT_ENCODING,'replace')
            if isis_json_type == 1:
                field_occurrences.append(content)
            elif isis_json_type == 2:
                field_occurrences.append(expand(content))
            elif isis_json_type == 3:
                field_occurrences.append(dict(expand(content)))
            else:
                raise NotImplementedError(
                  'ISIS-JSON type %s conversion not yet '
                  'implemented for .iso input' % isis_json_type)

        yield fields
    iso.close()
```

```
def writeJsonArray(iterRecords, file_name, output, qty, skip, id_tag,
                   gen_uuid, mongo, mfn, isis_json_type, prefix, constant):

    start = skip
    end = start + qty
    if not mongo:
        output.write('[')
    if id_tag:
        id_tag = str(id_tag)
        ids = set()
    else:
        id_tag = ''
    for i, record in enumerate(iterRecords(file_name, isis_json_type)):
        if i >= end:
            break
        if i > start and not mongo:
            output.write(',')
        output.write('\n')
        if start <= i < end:
            if id_tag:
                occurrences = record.get(id_tag, None)
                if occurrences is None:
                    msg = 'id tag #%s not found in record %s'
                    if ISIS_MFN_KEY in record:
                        msg = msg + (' (mfn=%s)' % record[ISIS_MFN_KEY])
                    raise KeyError(msg % (id_tag, i))
                if len(occurrences) > 1:
                    msg = 'multiple id tags #%s found in record %s'
                    if ISIS_MFN_KEY in record:
                        msg = msg + (' (mfn=%s)' % record[ISIS_MFN_KEY])
                    raise TypeError(msg % (id_tag, i))
                else: # ok, we have one and only one id field
                    if isis_json_type == 1:
                        id = occurrences[0]
                    elif isis_json_type == 2:
                        id = occurrences[0][0][1]
                    elif isis_json_type == 3:
                        id = occurrences[0]['_']
                    if id in ids:
                        msg = 'duplicate id %s in tag #%s, record %s'
                        if ISIS_MFN_KEY in record:
                            msg = msg + (' (mfn=%s)' % record[ISIS_MFN_KEY])
                        raise TypeError(msg % (id, id_tag, i))
                    record['_id'] = id
                    ids.add(id)
            elif gen_uuid:
                record['_id'] = unicode(uuid4())
            elif mfn:
                record['_id'] = record[ISIS_MFN_KEY]
            if prefix:
                # iterate over a fixed sequence of tags
                for tag in tuple(record):
                    if str(tag).isdigit():
                        record[prefix+tag] = record[tag]
                        del record[tag] # this is why we iterate over a tuple
                                        # with the tags, and not directly on the record dict
            if constant:
                constant_key, constant_value = constant.split(':')
                record[constant_key] = constant_value
            output.write(json.dumps(record).encode('utf-8'))
    if not mongo:
        output.write('\n]')
    output.write('\n')
```



```
def main():
    # create the parser
    parser = argparse.ArgumentParser(
        description='Convert an ISIS .mst or .iso file to a JSON array')

    # add the arguments
    parser.add_argument(
        'file_name', metavar='INPUT.(mst|iso)',
        help='.mst or .iso file to read')
    parser.add_argument(
        '-o', '--out', type=argparse.FileType('w'), default=sys.stdout,
        metavar='OUTPUT.json',
        help='the file where the JSON output should be written'
             ' (default: write to stdout)')
    parser.add_argument(
        '-c', '--couch', action='store_true',
        help='output array within a "docs" item in a JSON document'
             ' for bulk insert to CouchDB via POST to db/_bulk_docs')
    parser.add_argument(
        '-m', '--mongo', action='store_true',
        help='output individual records as separate JSON dictionaries,'
             ' one per line for bulk insert to MongoDB via mongoimport utility')
    parser.add_argument(
        '-t', '--type', type=int, metavar='ISIS_JSON_TYPE', default=1,
        help='ISIS-JSON type, sets field structure: 1=string, 2=alist, 3=dict '
             '(default=1)')
    parser.add_argument(
        '-q', '--qty', type=int, default=DEFAULT_QTY,
        help='maximum quantity of records to read (default=ALL)')
    parser.add_argument(
        '-s', '--skip', type=int, default=0,
        help='records to skip from start of .mst (default=0)')
    parser.add_argument(
        '-i', '--id', type=int, metavar='TAG_NUMBER', default=0,
        help='generate an "_id" from the given unique TAG field number'
             ' for each record')
    parser.add_argument(
        '-u', '--uuid', action='store_true',
        help='generate an "_id" with a random UUID for each record')
    parser.add_argument(
        '-p', '--prefix', type=str, metavar='PREFIX', default='',
        help='concatenate prefix to every numeric field tag '
             '(ex. 99 becomes "v99")')
    parser.add_argument(
        '-n', '--mfn', action='store_true',
        help='generate an "_id" from the MFN of each record'
             ' (available only for .mst input)')
    parser.add_argument(
        '-k', '--constant', type=str, metavar='TAG:VALUE', default='',
        help='Include a constant tag:value in every record (ex. -k type:AS)')

    '''
    # TODO: implement this to export large quantities of records to CouchDB
    parser.add_argument(
        '-r', '--repeat', type=int, default=1,
        help='repeat operation, saving multiple JSON files'
             ' (default=1, use -r 0 to repeat until end of input)')
    '''
    # parse the command line
    args = parser.parse_args()
    if args.file_name.lower().endswith('.mst'):
        iterRecords = iterMstRecords
    else:
        if args.mfn:
            print('UNSUPORTED: -n/--mfn option only available for .mst input.')
            raise SystemExit
        iterRecords = iterIsoRecords
    if args.couch:
        args.out.write('{ "docs" : ')
    writeJsonArray(iterRecords, args.file_name, args.out, args.qty, args.skip,
        args.id, args.uuid, args.mongo, args.mfn, args.type, args.prefix,
        args.constant)
    if args.couch:
        args.out.write('}\n')
    args.out.close()

if __name__ == '__main__':
    main()
```

SUBJECTS FOR ANOTHER DAY...

- Use of generator functions as coroutines.

"Coroutines are not related to iteration"

David Beazley

- Sending data to a generator through the **.send()** method.

.send() is used in pipelines, where coroutines are *data consumers*

- Using yield on the right-hand side of an assignment, to get data from a **.send()** call.

coroutines are better expressed with the new **async def** & **await** syntax in Python ≥ 3.5

Q & A

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