Processing Sequential Data

Many data sets can be viewed and processed sequentially:
- The set of all Twitter posts
- Votes cast in a presidential election
- Sensor readings of an airplane
- The set of all positive integers

However, the sequence interface we developed previously does not always apply.
- A sequence has a finite, known length
- A sequence support element selection for any element

In most cases, satisfying the sequence interface requires storing the entire sequence in a computer's memory.

Today: Efficient representations of sequential data
Implicit Sequences

An implicit sequence is a representation of sequential data that does not explicitly store each element.

Example: The range class represents consecutive integers.
- The range is represented by two values: start and end.
- The length and elements are computed on demand.
- Constant space for arbitrarily large sequences.
The Iterator Interface

An iterator is an object that can provide the next element of a (possibly implicit) sequence.

The iterator interface has two methods:

• __next__(self) returns the next element in the sequence
• __iter__(self) returns an equivalent iterator (Why?)

The next function invokes the __next__ method on its argument.

If there is no next element, then the __next__ method of an iterator should raise a StopIteration exception.
The For Statement

\[
\text{for <name> in <expression>:} \\
\text{<suite>}
\]

1. Evaluate the header <expression>, which yields an iterable object.
2. For each element in that sequence, in order:
   A. Bind <name> to that element in the first frame of the current environment.
   B. Execute the <suite>.

An iterable object has a method \_iter\_ that returns an iterator.

```python
>>> counts = [1, 2, 3]
>>> for item in counts:
    print(item)
1
2
3
>>> counts = [1, 2, 3]
>>> items = counts.__iter__()  # use the iterator
>>> try:
    while True:
        item = items.__next__()  # fetch the next item
        print(item)
    except StopIteration:
        pass
1
2
3
```
Generators and Generator Functions

A generator is an iterator backed by a generator function.

A generator function is a function that yields values.

When a generator function is called, it returns a generator.

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

>>> for letter in letters_generator():
    print(letter)

a
b
c
d
```
Streams

A stream is a recursive list with an explicit first element and an implicit rest of the list.

class Stream(object):
    """A lazily computed recursive list."""

class empty(object):
    def __repr__(self):
        return 'Stream.empty'

empty = empty()

def __init__(self, first, compute_rest=lambda: empty):
    assert callable(compute_rest), 'compute_rest must be callable.'
    self.first = first
    self._compute_rest = compute_rest
    self._rest = None

@property
def rest(self):
    """Return the rest of the stream, computing it if necessary."""
    if self._compute_rest is not None:
        self._rest = self._compute_rest()
        self._compute_rest = None
    return self._rest
Integer Streams

An integer stream is a stream of consecutive integers.

An integer stream starting at k consists of k and a function that returns the integer stream starting at k+1.

def make_integer_stream(first=1):
    """Return a stream of consecutive integers, starting with first."

    >>> s = make_integer_stream(3)
    >>> s.first
    3
    >>> s.rest.first
    4
    """
    def compute_rest():
        return make_integer_stream(first+1)
    return Stream(first, compute_rest)
Mapping a Function over a Stream

Mapping a function over a stream applies a function only to the first element at first, but computes the rest lazily.

```python
def map_stream(fn, s):
    """Map a function fn over the elements of a stream s."""
    if s is Stream.empty:
        return s
    def compute_rest():
        return map_stream(fn, s.rest)
    return Stream(fn(s.first), compute_rest)

Demo
Filtering a Stream

When filtering a stream, processing continues until an element is kept in the output.

```python
def filter_stream(fn, s):
    """Filter stream s with predicate function fn."""
    if s is Stream.empty:
        return s
    def compute_rest():
        return filter_stream(fn, s.rest)
    if fn(s.first):
        return Stream(s.first, compute_rest)
    else:
        return compute_rest()
```
A Stream of Primes

The stream of integers not divisible by any $k \leq n$ is:

- The stream of integers not divisible by any $k < n$,
- Filtered to remove any element divisible by $n$.
- Called the Sieve of Eratosthenes.

2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13

Demo