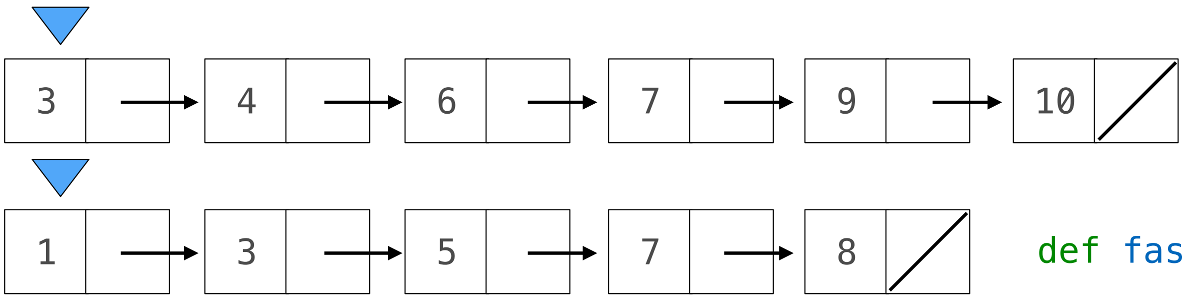
Decomposition (Linked List Practice)

Announcements

Discussion 8

Linear-Time Intersection of Sorted Linked Lists

Given two sorted **linked lists** with no repeats, return the number of elements that appear in both.




```
def fast_overlap(s, t):
    if s is Link.empty or t is Link.empty:
        return 0
    if s.first == t.first:
        return 1 + fast_overlap(s.rest, t.rest)
    elif s.first < t.first:
        return fast_overlap(s.rest, t)
    elif s.first > t.first:
        return fast_overlap(s, t.rest)
```

```
def fast_overlap(s, t):
    k = 0
    while s and t:
        if s.first == t.first:
            k, s, t, = k + 1, s.rest, t.rest
        elif s.first < t.first:
            s = s.rest
        elif s.first > t.first:
            t = t.rest
    return k
```

Slow Overlap

```
def count_if(f, s):
    if s is Link.empty:
        return 0
    else:
        if f(s.first):
            return 1+count_if(f, s.rest)
        else:
            return count_if(f, s.rest)

def contained_in(s):
    def f(s, x):
        if s is Link.empty:
            return False
        else:
            return s.first == x or f(s.rest, x)
    return lambda x: f(s, x)

def overlap(s, t):
    "For s and t with no repeats, count the numbers that appear in both."
   return count_if(contained_in(t), s)
```

Exponential growth. E.g., recursive fib

Incrementing *n* multiplies *time* by a constant

Quadratic growth.

Incrementing *n* increases *time* by *n* times a constant

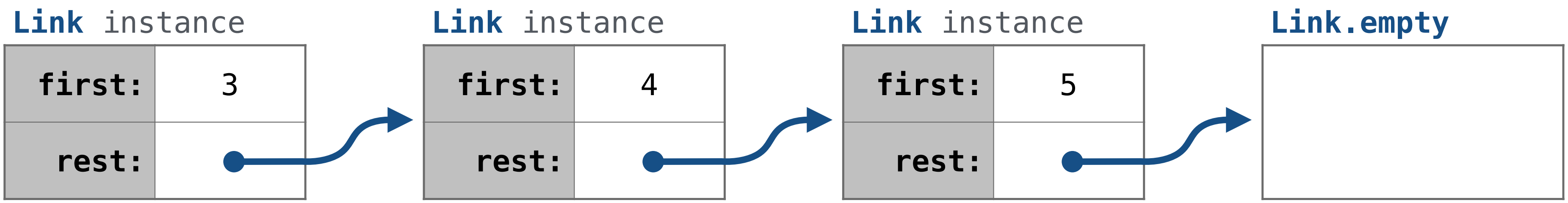
Linear growth.

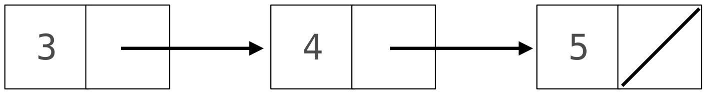
Incrementing *n* increases *time* by a constant

Linked Lists Mutation

Linked List Notation

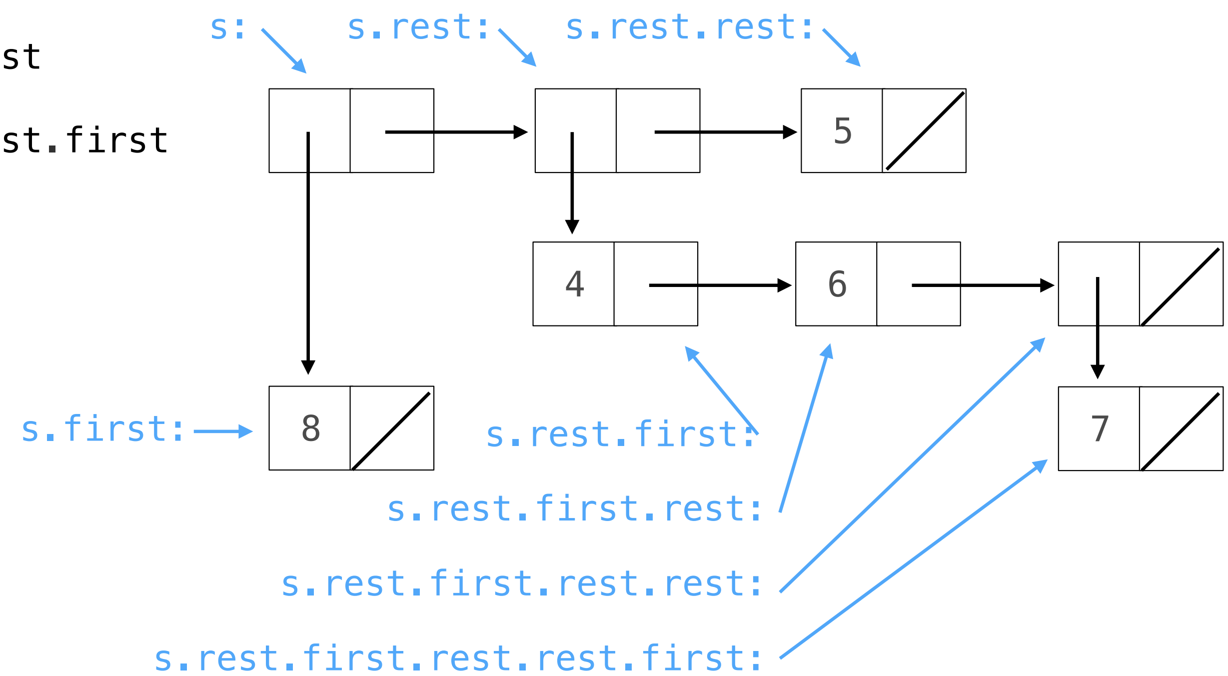
```
s = Link(3, Link(4, Link(5)))
```





Nested Linked Lists

```
>>> s = Link(Link(8), Link(Link(4, Link(6, Link(Link(7)))), Link(5)))
>>> print(s)
<<8> <4 6 <7>> 5>
>>> s.first.first
8
>>> s.rest.first.rest.rest.first
Link(7)
>>> s.rest.first.rest.rest.first.first
7
```



Recursion and Iteration

Many linked list processing functions can be written both iteratively and recursively

Recursive approach:

- What recursive call do you make?
- What does this recursive call do/return?
- How is this result useful in solving the problem?

```
def length(s):
    """The number of elements in s.

    >>> length(Link(3, Link(4, Link(5))))
    3
    """

    if s is Link.empty:

        return 0

    else:

        return 1 + length(s.rest)
```

Iterative approach:

- Describe a process that solves the problem.
- Figure out what additional names you need to carry out this process.
- Implement the process using those names.

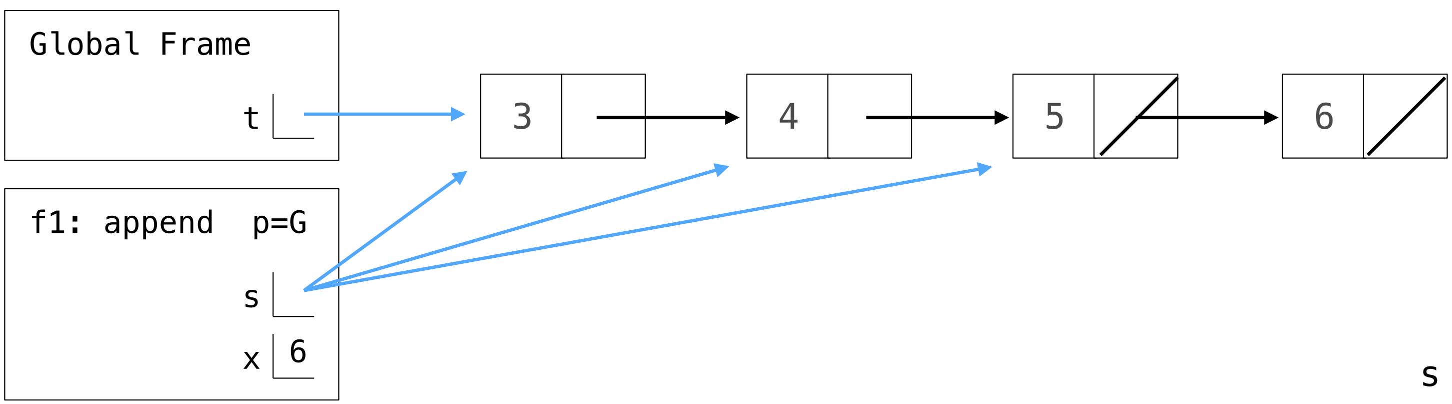
```
def length(s):
    """The number of elements in s.

    >>> length(Link(3, Link(4, Link(5))))
    3
    """

    k = 0

    while s is not Link.empty:

        s, k = s.rest, k + 1

    return k
```

Linked List Mutation

To change the contents of a linked list, assign to first and rest attributes

Example: Append x to the end of non-empty s

```
>>> t = Link(3, Link(4, Link(5)))
>>> append(t, 6)
>>> t
Link(3, Link(4, Link(5, Link(6))))
```




```
s = s.rest

s.rest = Link(x)
```

Recursion and Iteration

Many linked list processing functions can be written both iteratively and recursively

Recursive approach:

- What recursive call do you make?
- What does this recursive call do/return?
- How is this result useful in solving the problem?

```
def append(s, x):
    """Append x to the end of non-empty s.
    >>> append(s, 6)  # returns None!
    >>> print(s)
    <3 4 5 6>
    """
    if  s.rest is not Link.empty :
        append( s.rest , x )
    else:
        s.rest = Link(x)
```

Iterative approach:

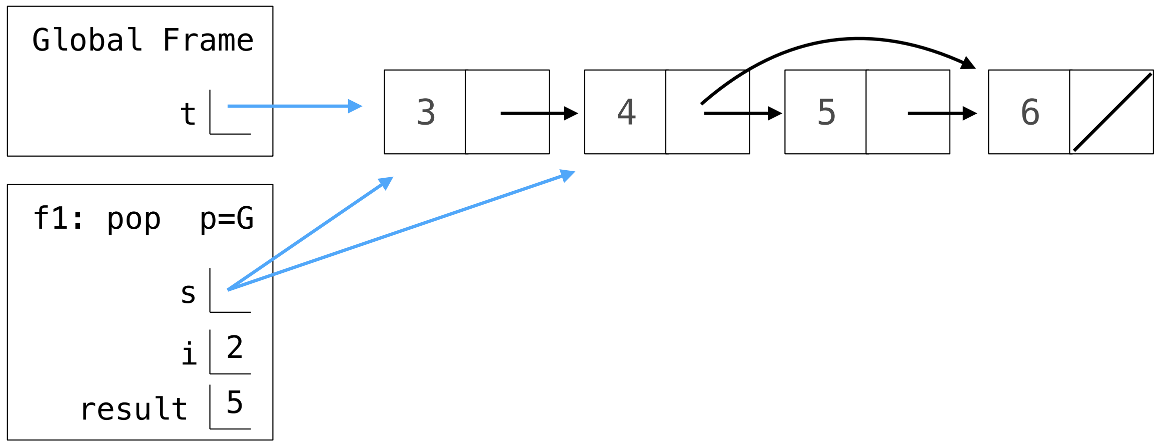
- Describe a process that solves the problem.
- Figure out what additional names you need to carry out this process.
- Implement the process using those names.

```
def append(s, x):
    """Append x to the end of non-empty s.
    >>> append(s, 6)  # returns None!
    >>> print(s)
    <3 4 5 6>
    """
    while  s.rest is not Link.empty :
        s = s.rest
    s.rest = Link(x)
```

Example: Pop

Implement pop, which takes a linked list s and positive integer i. It removes and returns the element at index i of s (assuming s.first has index 0).

```
def pop(s, i):
    """Remove and return element i from linked list s for positive i.
    >>> t = Link(3, Link(4, Link(5, Link(6))))
    >>> pop(t, 2)
    5
    >>> pop(t, 2)
    6
    >>> pop(t, 1)
    4
    >>> t
    Link(3)
    """
    assert i > 0 and i < length(s)
    for x in range(_i - 1_):
        s = s.rest
    result = s.rest.first
    s.rest = s.rest.rest
    return ___result___
```

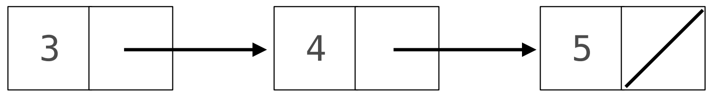


Linked List Construction

Constructing a Linked List

Build the rest of the linked list, then combine it with the first element.

```
s = Link.empty
s = Link(5, s)
s = Link(4, s)
s = Link(3, s)
```




```
def range_link(start, end):
    """Return a Link containing consecutive
    integers from start up to end.

    >>> range_link(3, 6)
    Link(3, Link(4, Link(5)))
    """

    if start >= end:

        return Link.empty

    else:

        return Link(start, range_link(start + 1, end))
```

```
def range_link(start, end):
    """Return a Link containing consecutive
    integers from start to end.

    >>> range_link(3, 6)
    Link(3, Link(4, Link(5)))
    """

    s = Link.empty

    k = end - 1

    while k >= start:

        s = Link(k, s)
        k -= 1

    return s
```