The Linked List

CS 214, Fall 2019
A problem with vectors

What if we want to add 6 between 5 and 7?
No can do! Elements 7, 8, 9, 10, and 11 are all in the way, and the vector is full.

Need to create a new, bigger vector, and copy everything over…
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Books on a string

The Art of Computer Programming

VOLUME 1
Fundamental Algorithms
Third Edition

DONALD E. KNUTH

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- The Art of Computer Programming
  - Volume 1: Fundamental Algorithms
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  - Donald E. Knuth

- The Art of Computer Programming
  - Volume 2: Seminumerical Algorithms
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- Concrete Mathematics
  - A Foundation for Computer Science
  - Second Edition
  - Graham, Knuth, Patashnik
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Nodes and pointers

You saw cons in 111.

- car holds the *first* element, and
- cdr holds a pointer to the *rest* of the list.
Nodes and pointers

Inserting in the middle? No problem!

Just change the pointers

![Diagram showing a linked list with nodes and pointers](image)
Nodes and pointers

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[Diagram showing node structures with arrows indicating car and cdr connections]
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Nodes and pointers

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Inserting at the beginning
Inserting at the beginning
Inserting at the beginning
Inserting at the beginning
Inserting at the beginning
Indirection
Indirection
Indirection
Now in DSSL2
Linked lists in DSSL2

# Link is one of:
# - node { data: Number, next: Link }
# - None

struct node:
    let data
    let next

class SLL:
    let head

    def __init__(self):
        self.head = None
Linked lists in DSSL

# Link is one of:
# - node { data: Number, next: Link }
# - None

```python
struct node:
    let data
    let next
```

```python
class SLL:
    let head

    def __init__(self):
        self.head = None

    def push_front(self, data):
        self.head = node(data, self.head)
```

List operations in DSSL2

class SLL:
    ...

    def get_front(self):
        if node?(self.head): self.head.data
        else: error('SLL.get_front: empty list')
List operations in DSSL2

class SLL:
    ...

def get_front(self):
    if node?(self.head): self.head.data
    else: error('SLL.get_front: empty list')

def get_nth(self, n):
    curr = self.head
    while n > 0:
        if curr is None:
            error('SLL.get_nth: too short')
            curr = curr.next
        n = n - 1
    curr.data
More DSSL2 list operations

A (re)factoring:

class SLL:
  ...

  def _find_nth_node(self, n):
    curr = self.head
    while n > 0:
      if curr is None: error('too short')
      curr = curr.next
      n = n - 1
    curr

  def get_nth(self, n):
    self._find_nth_node(n).data

  def set_nth(self, n, val):
    self._find_nth_node(n).data = val
What else might we want to do?
What else might we want to do?

- Insert or remove at the given position or the end.
- Split a list in two or splice two into one.
- Know how long the list is without counting.
Keeping the length

How can we make sure the len field is always right?
How can we make sure the `len` field is always right?
Quick access to the tail

Which operations are simple now? Which are still more work?
Quick access to the tail

Which operations are simple now? Which are still more work?
Doubly-linked

head

tail

len

6

1

data

prev

next

2

data

prev

next

3

data

prev

next

4

data

prev

next

5

data

prev

next

6

data

prev

next

len

6
Circular, doubly-linked with sentinel

len 6
Empty (circular, doubly-linked w/sentinel)
Let’s look at a singly-linked list class in DSSL2.
Next time: abstract data types