CS 61A Lecture 13

Wednesday, October 1

Announcements

- Homework 3 Due Wednesday 10/1 @ 11:59pm
- Optional Hog Contest Due Wednesday 10/1 @ 11:59pm
- Project 2 Due Thursday 10/9 @ 11:59pm
  - Project party Monday 10/6, 6pm-8pm in location TBD
- Special event on Tuesday 10/14 @ 7pm in Wheeler:
  Fireside chat with Founder & CEO of DropBox Drew Houston, hosted by John
- You can submit questions, and I'll ask them: http://goo.gl/HtkXFf

Dictionaries

```
{'Dem': 0}
```

Limitations on Dictionaries

Dictionaries are **unordered** collections of key-value pairs

Dictionary keys do have two restrictions:

- A key of a dictionary **cannot be** a list or a dictionary (or any *mutable type*)
- Two **keys cannot be equal;** There can be at most one value for a given key

This first restriction is tied to Python's underlying implementation of dictionaries

The second restriction is part of the dictionary abstraction

If you want to associate multiple values with a key, store them all in a sequence value

Linked Lists

Linked List Data Abstraction

Constructor:

```
def link(first, rest):
    """Construct a linked list from its first element and the rest."""
```

Selectors:

```
def first(s):
    """Return the first element of a linked list s."""
```

```
def rest(s):
    """Return the rest of the elements of a linked list s."""
```

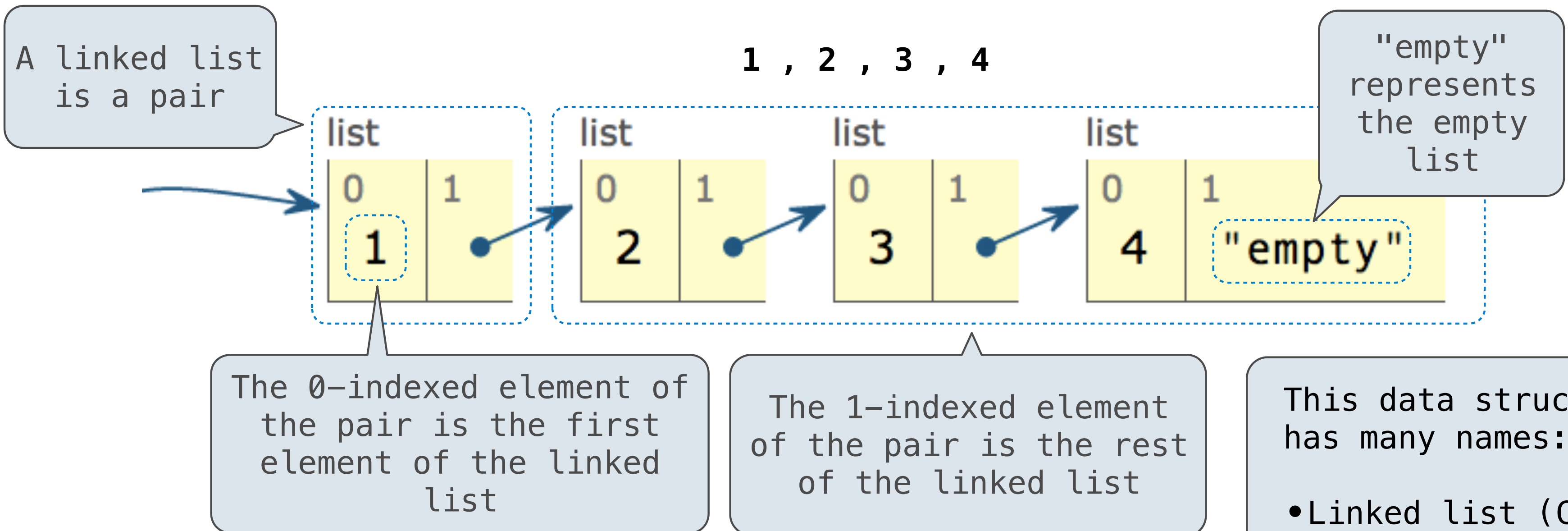
Behavior condition(s):

If a linked list s is constructed from a first element a and a linked list b, then

- first(s) returns a, which is an element of the sequence
- rest(s) returns b, which is a linked list

Implementing Recursive Lists with Pairs

We can implement linked lists as pairs. We'll use two-element lists to represent pairs.



This data structure has many names:

- Linked list (C, Java)
- List (Lisp)
- Forward list (C++)

(Demo)

Sequence Abstraction Implementation

Implementing the Sequence Abstraction

```
def len_link(s):
    """Return the length of linked list s."""
    length = 0
    while s != empty:
        s, length = rest(s), length + 1
    return length

def getitem_link(s, i):
    """Return the element at index i of linked list s."""
    while i > 0:
        s, i = rest(s), i - 1
    return first(s)
```

Length. A sequence has a finite length.

Element selection. A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0 for the first element.

(Demo)

Interactive Diagram

Recursive implementations

`(Demo)`

Linked List Processing

```
extend
reverse
apply_to_all_link
join_link
partitions
print_partitions
```

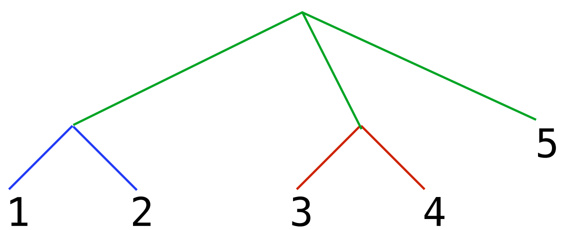
(Demo)

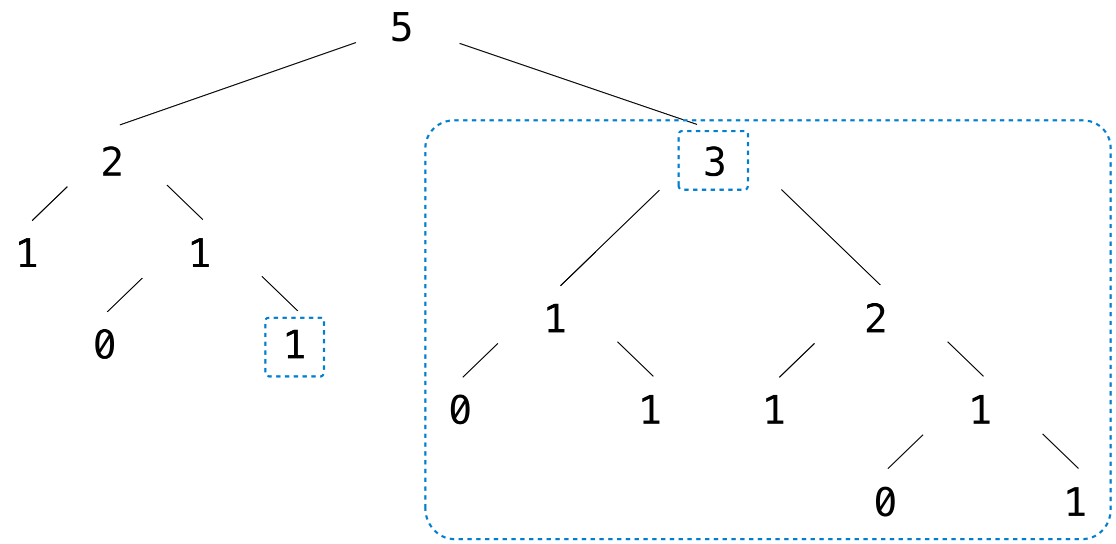
Rooted Trees

Rooted Trees Have a Value at the Root of Every Tree

Previously, trees ***either*** had branches ***or*** they were a leaf value; Rooted trees have **both**

[[1, 2], [3, 4], 5]





A rooted tree has a root value and a sequence of branches, which are rooted trees

A rooted tree with zero branches is called a leaf

The root values of sub-trees within a rooted tree are often called node values or nodes

Implementing the Rooted Tree Abstraction

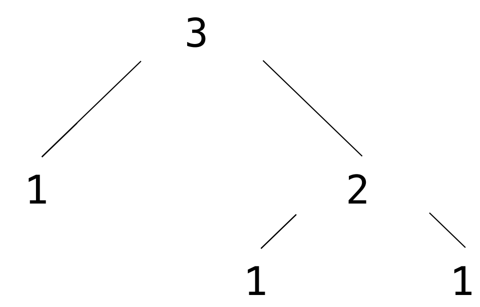
```
def rooted(value, branches):
    for branch in branches:
        assert is_rooted(branch)
    return [value] + list(branches)

def root(tree):
    return tree[0]

def branches(tree):
    return tree[1:]

def is_rooted(tree):
    if type(tree) != list or len(tree) < 1:
        return False
    for branch in branches(tree):
        if not is_rooted(branch):
            return False
    return True
```

A rooted tree has a root value and a sequence of branches, which are each rooted trees




```
>>> rooted(3, [rooted(1, []),
...            rooted(2, [rooted(1, []),
...                       rooted(1, [])])])
[3, [1], [2, [1], [1]]]
```

(Demo)

Encoding Strings

(Bonus Material)

Representing Strings: the ASCII Standard

American Standard Code for Information Interchange

"Bell" (\a)

"Line feed" (\n)

ASCII Code Chart

8 rows: 3 bits

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	HT	LF	VT	FF	CR	SO	SI
1	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	DEL

16 columns: 4 bits

- Layout was chosen to support sorting by character code
- Rows indexed 2-5 are a useful 6-bit (64 element) subset
- Control characters were designed for transmission

(Demo)

Representing Strings: the Unicode Standard

- 109,000 characters
- 93 scripts (organized)
- Enumeration of character properties, such as case
- Supports bidirectional display order
- A canonical name for every character

http://ian-albert.com/unicode_chart/unichart-chinese.jpg

U+0058 LATIN CAPITAL LETTER X

U+263a WHITE SMILING FACE

U+2639 WHITE FROWNING FACE

'☺'   '☹'

(Demo)

Representing Strings: UTF-8 Encoding

UTF (UCS (Universal Character Set) Transformation Format)

Unicode: Correspondence between characters and integers

UTF-8: Correspondence between those integers and bytes

A byte is 8 bits and can encode any integer 0-255.

bytes			integers
	00000000	0	
	00000001	1	
	00000010	2	
	00000011	3	

Variable-length encoding: integers vary in the number of bytes required to encode them.

In Python: string length is measured in characters, bytes length in bytes.

(Demo)