CS134:
Sequences and Loops

Announcements & Logistics

- **Homework 3** is out on GLOW, due next Monday @ 11 pm
  - Covers materials through last lecture (conditionals)
- **Lab 1** graded feedback will be released today
  - Instructions on how to view feedback on course webpage under Resources
- **Lab 2** due today 11pm / tomorrow 11pm
- No class on Friday!
- **Lab 3** starter code pushed on Friday
  - Try to spend 30-60 minutes on it before your scheduled lab
  - Should be able to do #1-3 in Part 1 after today's class
- Tuesday late lab starts at 2:35 (not 2:25)

Do You Have Any Questions?

Last Time

- Looked at more complex decisions in Python
  - Used Boolean expressions with **and**, **or**, **not**
- Chose between many different options in our code
  - `If elif else` chained conditionals

Today's Plan

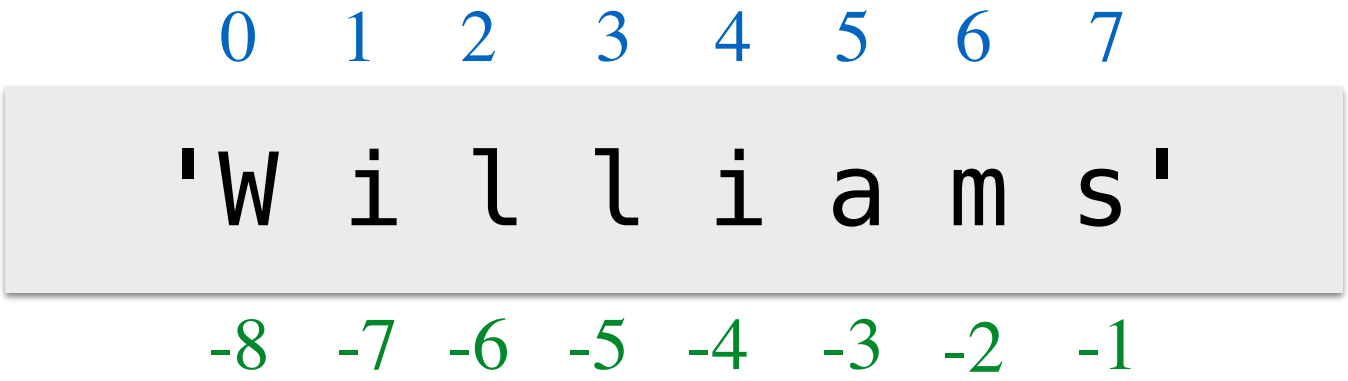
- Start discussing *sequences* in Python
  - Focus on **strings** today
  - Move on to **lists** on Monday
  - Lab 3 covers both!
- Discuss *slicing* and *indexing* of strings
- Introduce **for loops** as a mechanism to iterate over sequences

Sequences in Python: Strings

- **Sequences** are an abstract type in Python that represent **ordered collections of elements**: e.g., strings, lists, ranges, etc.
- Today we will focus on **strings** (type `str`) which are ordered sequences of individual characters
  - Consider for example: `word = "Hello"`
  - `'H'` is the first character of word, `'e'` is the second character, and so on
  - In Computer Science, it is convention to use **zero-indexing**, so we say that `'H'` is the zeroth character of word, `'e'` is the first character, and so on
- We can access each character of a string using these **indices**

How Do Indices Work?

- Can access elements of a sequence (such as a string) using its **index**
- Indices in Python are both positive and negative
- Everything outside of these values will cause an `IndexError`.




```
word = 'Williams'
```

Accessing Elements of Sequences

```
In [1]: word = 'Williams'

In [2]: word[0]  # character at 0th index?
Out[2]: 'W'

In [3]: word[3]  # character at 3rd index?
Out[3]: 'l'

In [4]: word[7] # character at 7th index?
Out[4]: 's'

In [5]: word[8] # will this work?
---------------------------------------
IndexError
```

0	1	2	3	4	5	6	7
'W	i	l	l	i	a	m	s'
-8	-7	-6	-5	-4	-3	-2	-1

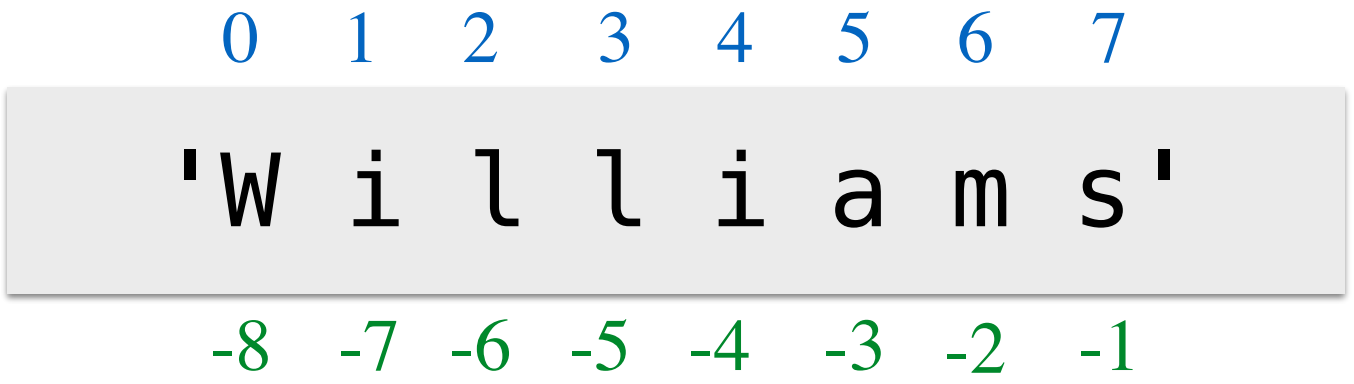
Length of a Sequence

- Python has a built-in `len()` function that computes the length of a sequence such as a string (or a list, which we will see in next lecture)
- For a string, `len()` simply returns the number of characters
- Thus, a string `word` has (positive) indices
  `0, 1, 2, ..., len(word)-1`

```
In [6]: len("Williams")

Out[6]: 8

In [7]: len("pneumonoultramicroscopicsilicovolcanoconiosis")

Out[7]: 45
```

Negative Indexing

- Negative indexing starts from -1, and provides a handy way to access the last character of a non-empty sequence without knowing its length




```
>>> word = 'Williams'
>>> word[-1]
's'
```

Note: Most other languages do not support negative indexing!

Slicing Sequences

- We can **extract subsequences** of a sequence using the **slicing** operator `[:]`
- For a given sequence `var`, `var[start:end:step]` returns a new sequence starting at index '`start`' (inclusive), ending at index '`end`' (exclusive), using an increment of '`step`'
  - Example: Suppose we want to extract the substring `'Williams'` from `'Williamstown'` using slicing operator `[:]`
  - Note: Many more examples in Jupyter notebook!

```
In [1]: place = "Williamstown"

In [2]: # return the sequence from 0th index up to (not including) 8th
        place[0:8:1]

Out[2]: 'Williams'
```

Slicing Sequences: Using Step

- The (optional) third `step` parameter to the slicing operator determines in what direction to traverse, and whether to skip any elements while traversing and creating the subsequence
- By default, `start = 0, end = len(), step = +1` (which means move left to right in increments of one)
- We can pass other `step` parameters to obtain new sliced sequences

```
In [3]: place = "Williamstown"

In [4]: place[:8:1] # start is 0, end is 8, step is +1
Out[4]: 'Williams'

In [5]: place[:8:2] # start is 0, end is 8, step is +2
Out[5]: 'Wlim'

In [6]: place[::2] # start is 0, end is 12, step is +2
Out[6]: 'Wlimtw'
```

Slicing Sequences: Optional Step

- When the step parameter is set to a negative value it gives a nifty way to reverse sequences
- Note: `start` and `end` are interpreted "backwards" when using a negative step!

```
In [15]: place[::-1] # reverse the sequence
Out[15]: 'nwotsmailliW'

In [16]: place[::-2]
Out[16]: 'nosali'

In [17]: place[8:0:-1]
Out[17]: 'tsmailli'
```

0	1	2	3	4	5	6	7	8	9	10	11
'W	i	l	l	i	a	m	s	t	o	w	n'
-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1

Testing Membership: `in` Operator

- The `in` operator in Python is used to test if a given sequence is a subsequence of another sequence; returns `True` or `False`

```
In [25]: 'Williams' in 'Williamstown'
Out[25]: True

In [26]: 'W' in 'Williams'
Out[26]: True

In [27]: 'w' in 'Williams' # capitization matters
Out[27]: False

In [28]: 'liam' in 'WiLLiams' # will this work?
Out[28]: False
```

String Methods: upper(), lower()

- Python provides several convenient **methods** for manipulating **strings**
  - Methods are like functions, but are applied to specific variables using **dot notation**: `var.method()` (more info on methods coming soon!)
- Example: The `upper()` and `lower()` string **methods** convert a string to upper or lowercase respectively; these methods **return a new string**

```
In [29]: message = "HELLLOOOO...!!!"

In [30]: message.lower() # leaves non-alphabets the same
Out[30]: 'helllooo...!!!'

In [31]: song = "$$ la la la laaa la $$..."

In [32]: song.upper()
Out[32]: '$$ LA LA LA LAAA LA $$...'
```

`isVowel()` function

- Consider two versions of an `isVowel()` function that takes a character (a string) as input and returns whether or not it is a vowel
  - Ignore case by converting to lowercase using `str.lower()` method
  - Use `in` operator to simplify code (fewer boolean expressions)

In [33]:
```
def oldIsVowel(char):
    """Old isVowel function"""
    c = char.lower() # convert to lower case first
    return (c == 'a' or c == 'e' or
            c == 'i' or c == 'o' or c == 'u')
```

In [34]:
```
def isVowel(char):
    """Simpler isVowel function"""
    c = char.lower() # convert to lower case first
    return c in 'aeiou'
```

Iteration Motivation: Counting Vowels

- **Problem:** Write a function `countVowels()` that takes a string `word` as input and returns the number of vowels in the string (an int)
- We can use our `isVowel()` function to help us

```
def countVowels(word):
    '''Returns number of vowels in the word'''
    pass

>>> countVowels('Williamstown')
4
>>> countVowels('Ephelia')
4
```

First Attempt with Conditionals

- Using conditionals as shown is repetitive and does not generalize to arbitrary length words
- Note that `val += 1` is shorthand for `val = val + 1`
- We need something else that allows us to "loop" over the characters in an arbitrary input string

In [35]:
```
word = 'Williams'
counter = 0
if isVowel(word[0]):
    counter += 1
if isVowel(word[1]):
    counter += 1
if isVowel(word[2]):
    counter += 1
if isVowel(word[3]):
    counter += 1
if isVowel(word[4]):
    counter += 1
if isVowel(word[5]):
    counter += 1
if isVowel(word[6]):
    counter += 1
if isVowel(word[7]):
    counter += 1
print(counter)
```

```
3
```

Iterating with `for` Loops

- One of the most common ways to manipulate a sequence is to perform some action **for each element** in the sequence
- This is called **looping** or **iterating** over the elements of a sequence
- Syntax of a for loop:

var is called the loop variable

```
for var in seq:
    # body of loop
    (do something)
```

seq is a sequence (for example, a string)

Iterating with `for` Loops

- As the loop executes, the loop variable (`char` in this example) takes on the value of each of the elements of the sequence one by one

```
In [37]: # simple example of for loop

word = "Williams"

for char in word:
    print(char)
```

```
W
i
l
l
i
a
m
s
```

Counting Vowels

- We can use a for loop to implement our `countVowels()` function
- Notice how `count` "accumulates" values in the loop
- We call `count` an **accumulation variable**

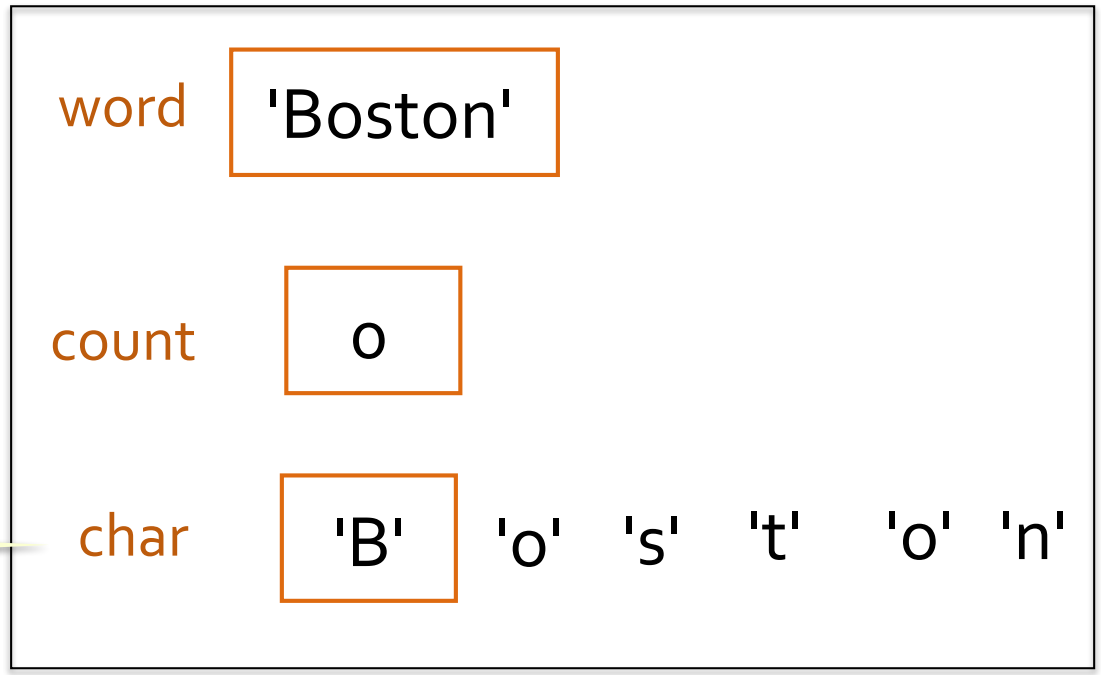
```
def countVowels(word):
    '''Takes a string as input and returns
    the number of vowels in it'''

    count = 0 # initialize the counter

    # iterate over the word one character at a time
    for char in word:
        if isVowel(char): # call helper function
            count += 1
    return count
```

Counting Vowels: Tracing the Loop

- How are the local variables updated as the loop runs?

```
def countVowels(word):
    '''Returns number of vowels in the word'''
    count = 0
    for char in word:
        if isVowel(char):
            count += 1
    return count
```

countVowels('Boston')



Loop variable

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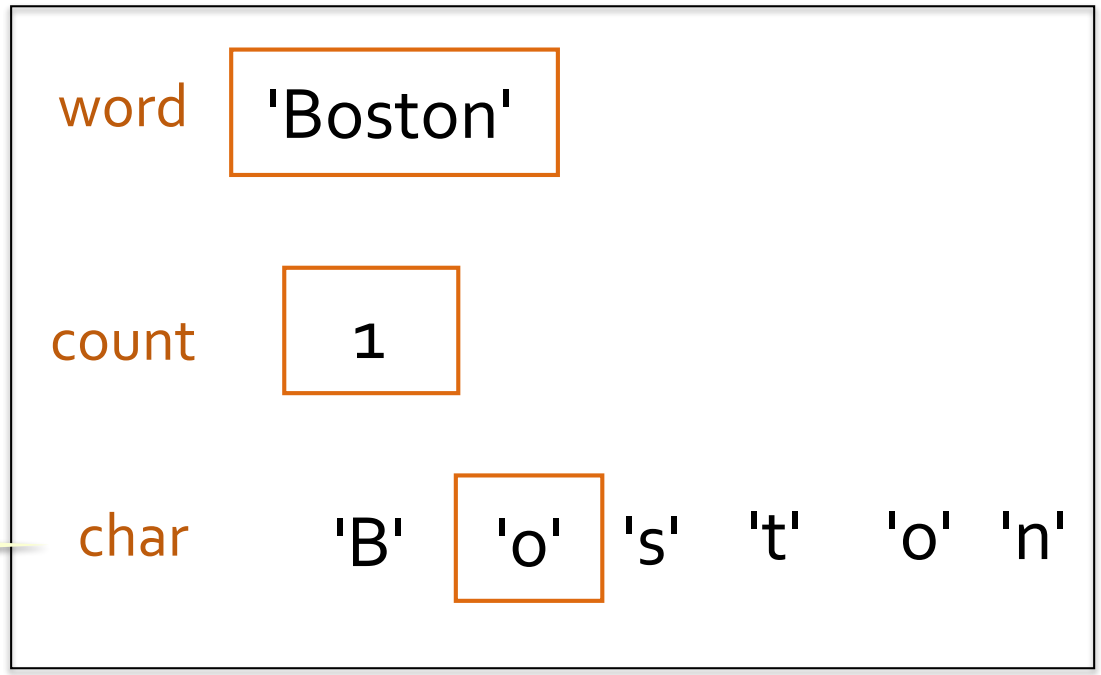

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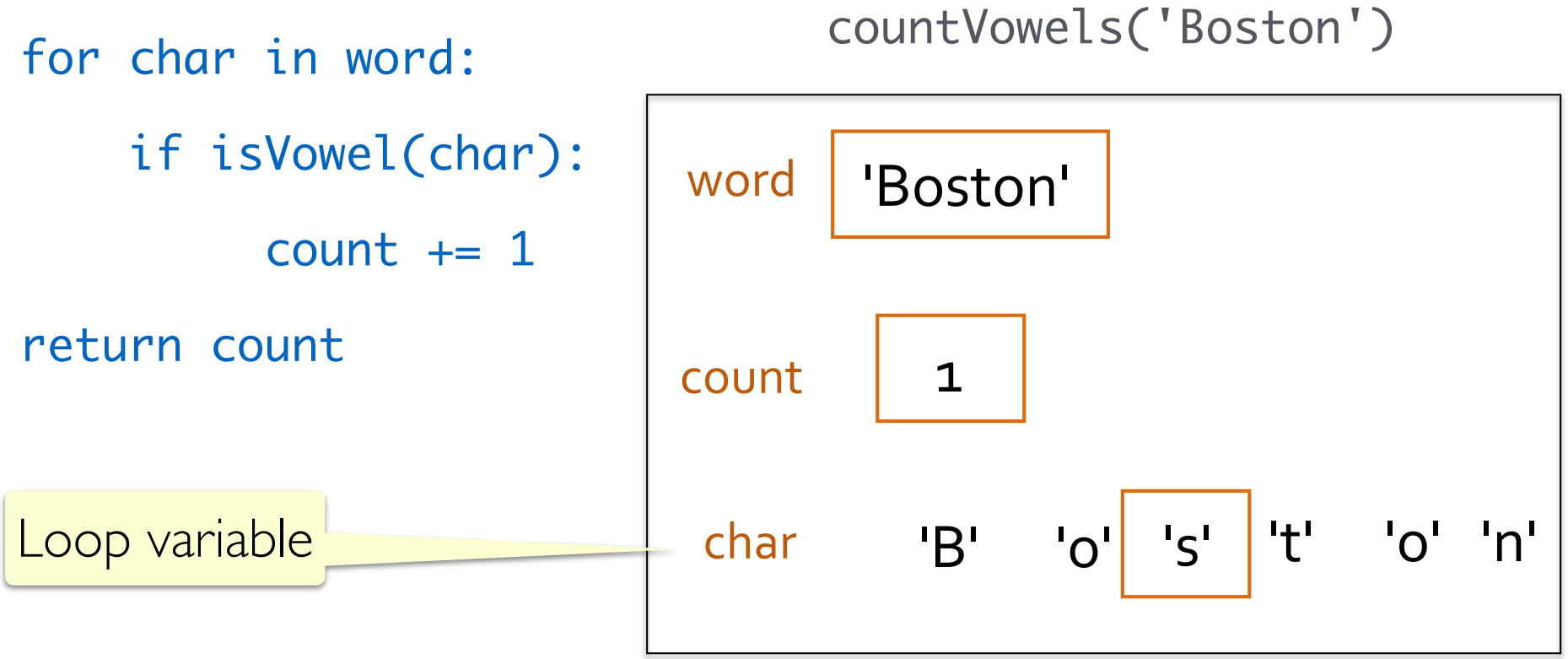

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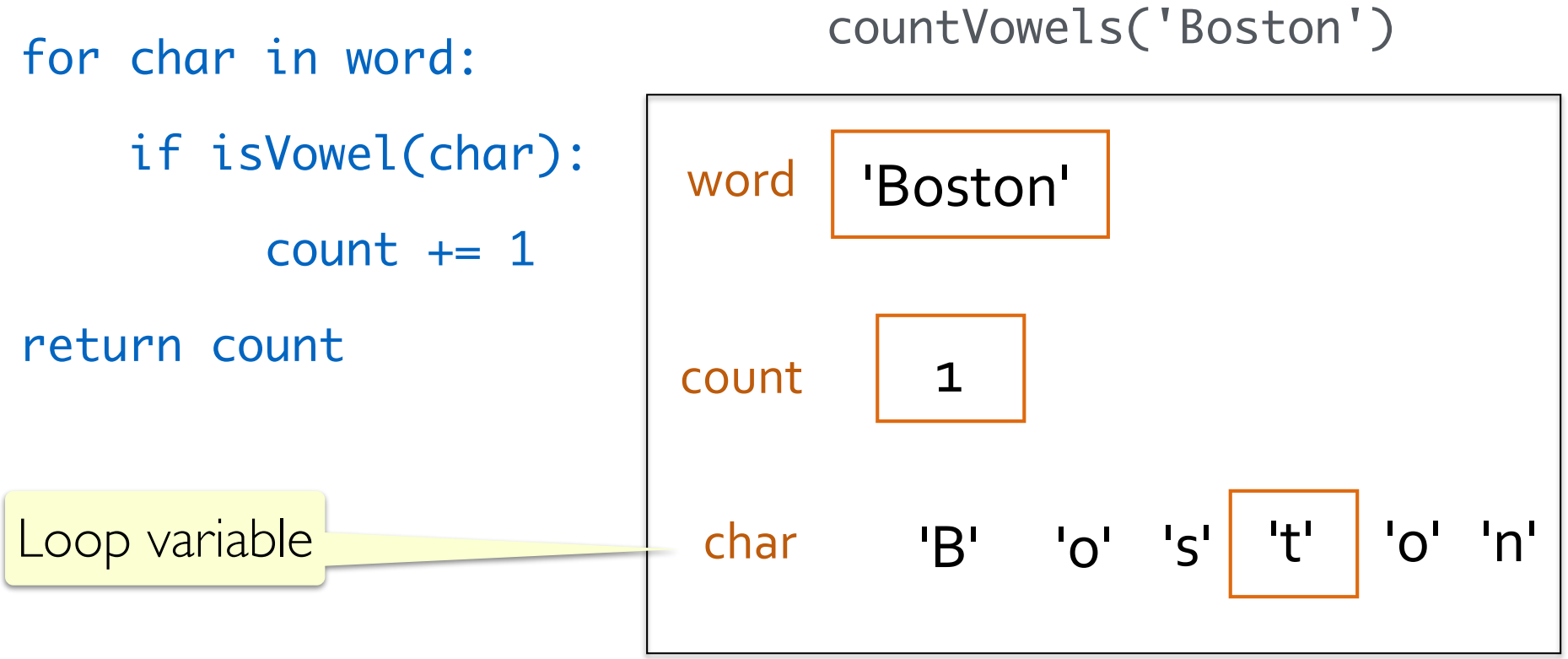

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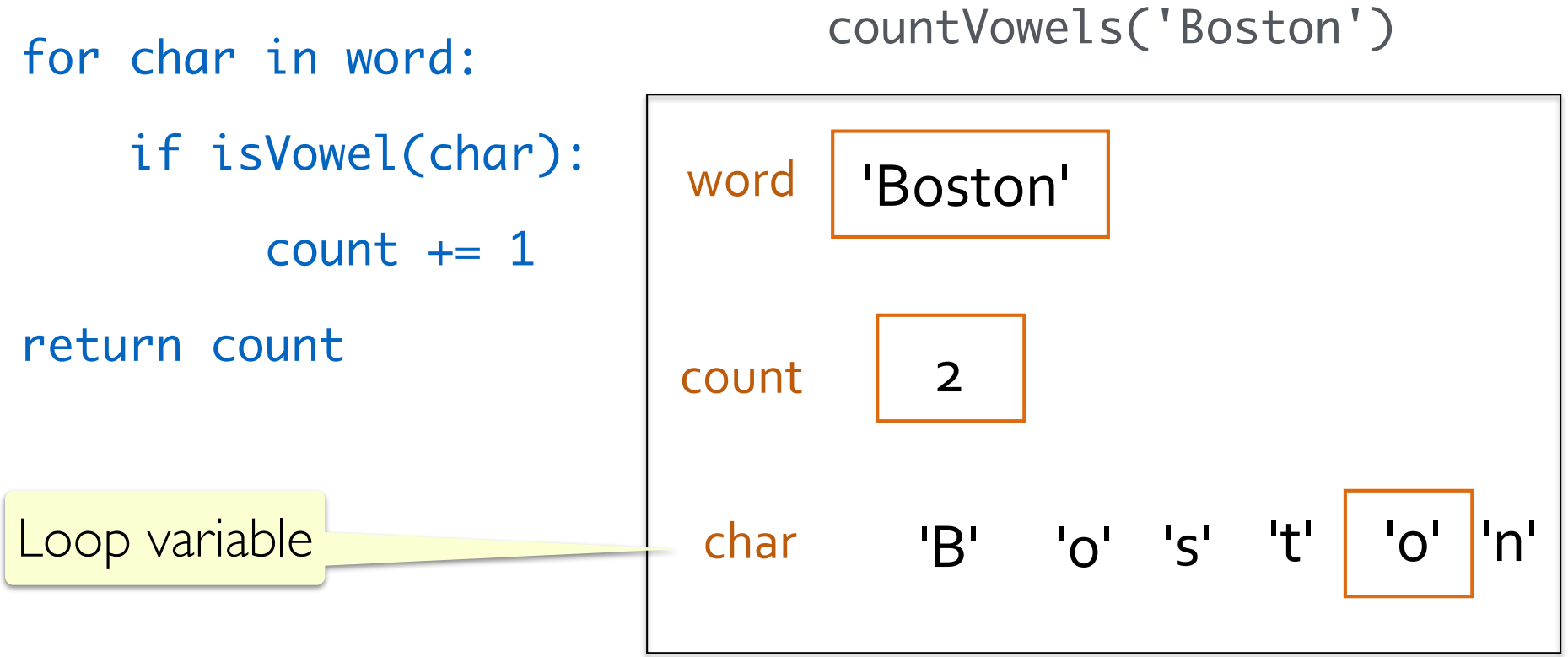

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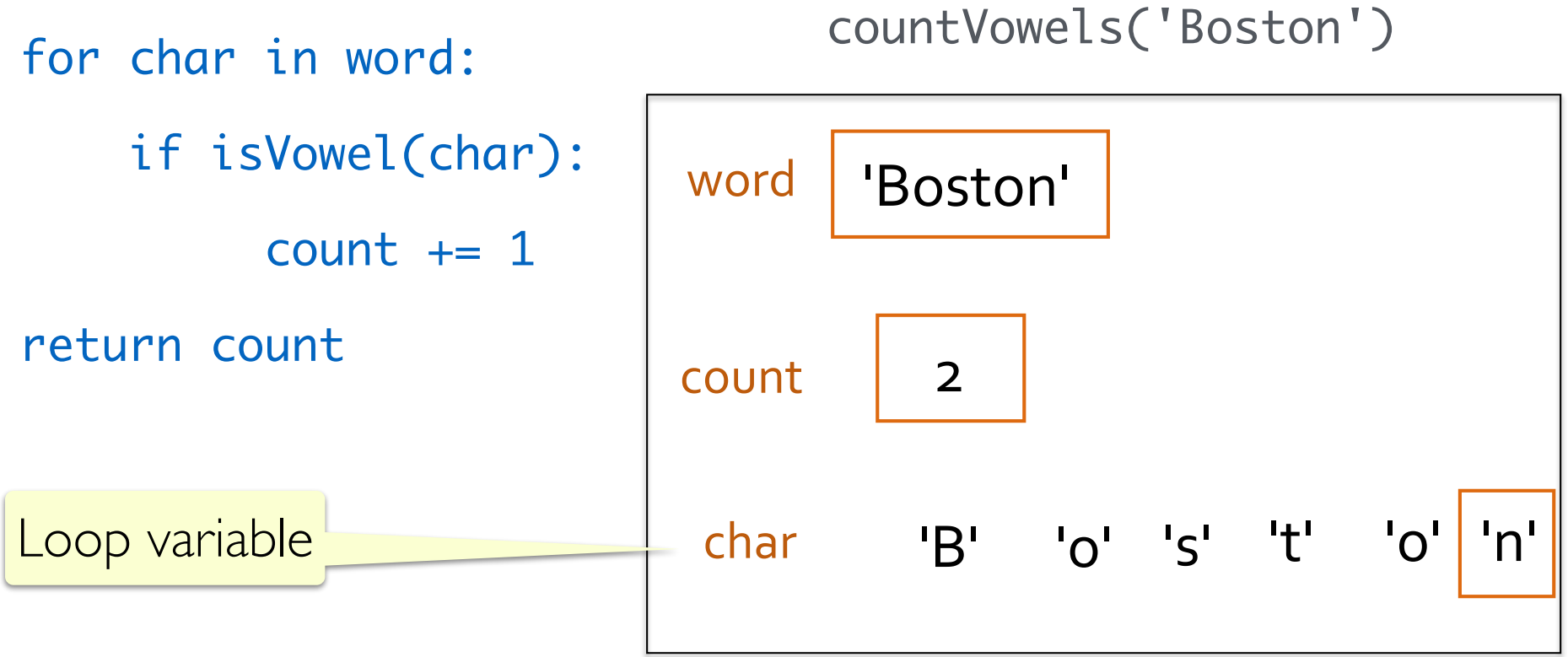

Exercise: Count Characters

- Define a function `countChar()` that takes two arguments, a character and a word (both strings), and returns the number of times (int) that character appears in the word (ignoring case).

```
def countChar(char, word):
    '''Counts # of times char appears in word'''
     pass
>>> countChar('m', 'ammonia')
2
>>> countChar('a', 'Alabama')
4
>>> countChar('a', 'rhythm')
0
```

Exercise: Count Characters

- Define a function **`countChar()`** that takes two arguments, a character and a word (both strings), and returns the number of times (int) that character appears in the word (ignoring case).

```
def countChar(char, word):
    '''Counts # of times char appears in word'''
    count = 0                  # initialize accumulation var
    for letter in word: # letter is the loop variable
        if char.lower() == letter.lower():
            count += 1         # increment count (accumulate)
    return count
```

Exercise: Vowel Sequences

- Define a function `vowelSeq()` that takes a string `word` as input and returns a string containing all the vowels in word in the same order as they appear.

```
def vowelSeq(word):
    '''Returns the vowel subsequence in word'''
     pass
>>> vowelSeq("Chicago")
"iao"
>>> vowelSeq("protein")
"oei"
>>> vowelSeq("rhythm")
""
```

Exercise: Vowel Sequences

- Define a function `vowelSeq()` that takes a string `word` as input and returns a string containing all the vowels in word in the same order as they appear.
- Accumulation variables don't have to be counters! Can accumulate strings as well

```
def vowelSeq(word):
    '''returns the vowel subsequence in word'''
    vowels = ""              # accumulation variable
    for char in word:        # char is loop variable
        if isVowel(char):    # if char is a vowel
            vowels += char # accumulate
    return vowels
```