Practical Computing for Scientists

Armin Sobhani

CSCI 2000U

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UNIVERSITY OF ONTARIO
INSTITUTE OF TECHNOLOGY

Python
Slicing

by Greg Wilson

UNIVERSITY OF ONTARIO
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Lists, strings, and tuples are all *sequences*

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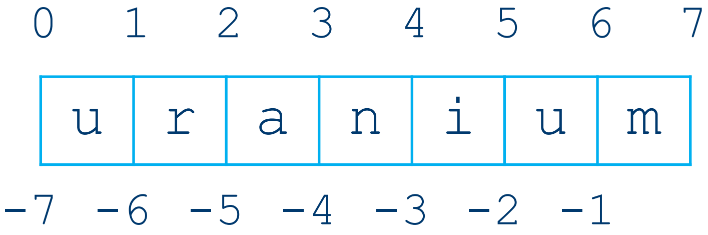
```
>>> element = 'uranium'
>>>
```



```
 0   1   2   3   4   5   6   7
   u   r   a   n   i   u   m
-7  -6  -5  -4  -3  -2  -1
```

Lists, strings, and tuples are all *sequences*

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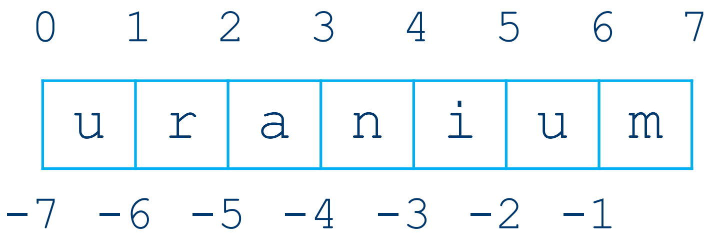
```
>>> element = 'uranium'
>>> print(element[1:4])
ran
>>>
```



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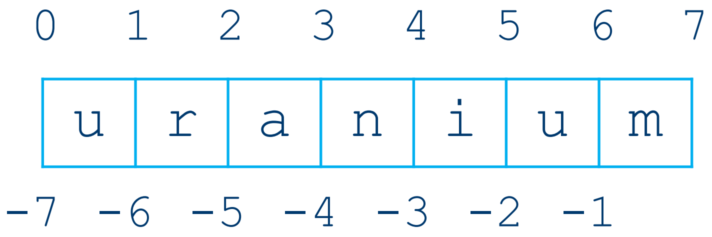
>>> element = 'uranium'
>>> print(element[1:4])
ran
>>> print(element[:4])
uran
>>>
```



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>>> element = 'uranium'
>>> print(element[1:4])
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>>> print(element[:4])
uran
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ium
>>>
```

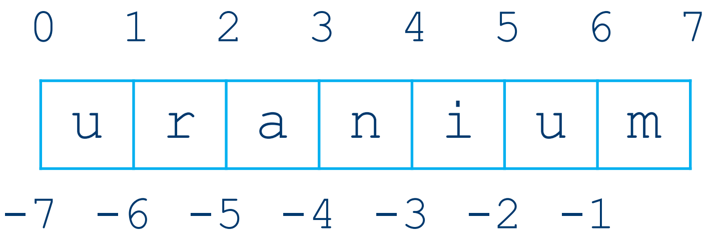

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 | u | r | a | n | i | u | m |
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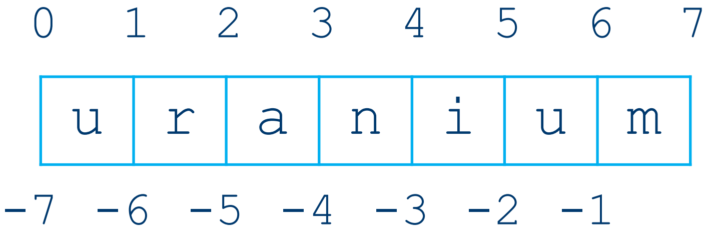
>>> element = 'uranium'
>>> print(element[1:4])
ran
>>> print(element[:4])
uran
>>> print(element[4:])
ium
>>> print(element[-4:])
nium
>>>
```



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Python checks bounds when indexing

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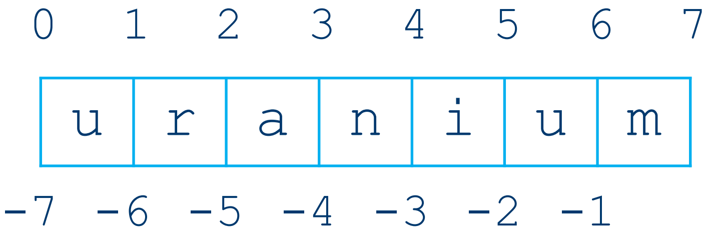

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   u   r   a   n   i   u   m
-7  -6  -5  -4  -3  -2  -1
```

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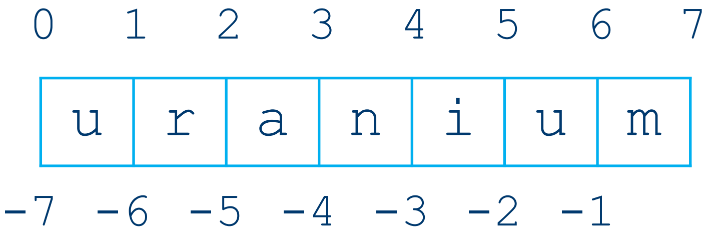
```
>>> element = 'uranium'
>>> print(element[400])
```



0 1 2 3 4 5 6 7

u r a n i u m

-7 -6 -5 -4 -3 -2 -1

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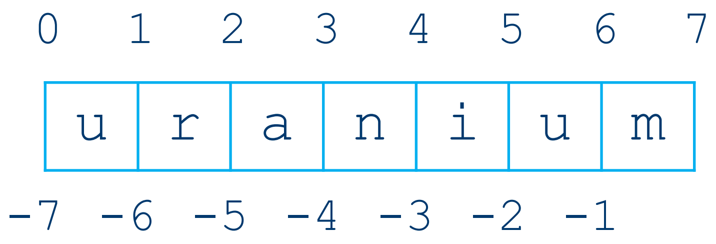
But truncates when slicing

```
>>> element = 'uranium'
>>> print(element[400])
IndexError: string index out of range
>>>
```



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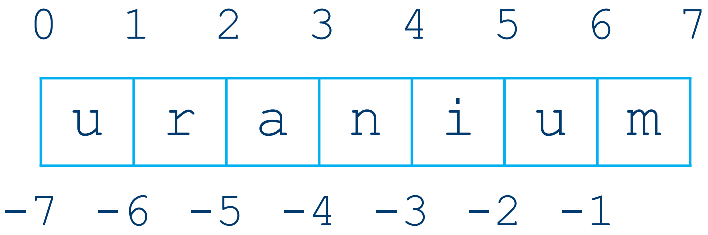
-7   -6   -5   -4   -3   -2   -1
```

Python checks bounds when indexing

But truncates when slicing

```
>>> element = 'uranium'
>>> print(element[400])
IndexError: string index out of range
>>> print(element[1:400])
>>> ranium
>>>
```



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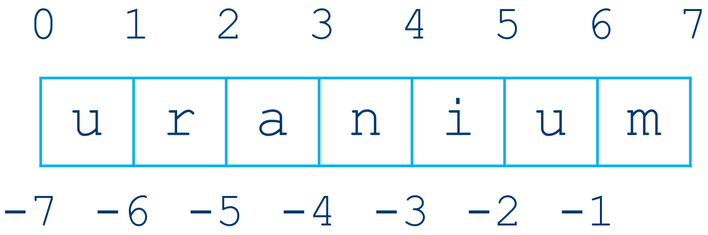

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"A foolish consistency is
the hobgoblin of little minds."

— *Ralph Waldo Emerson*

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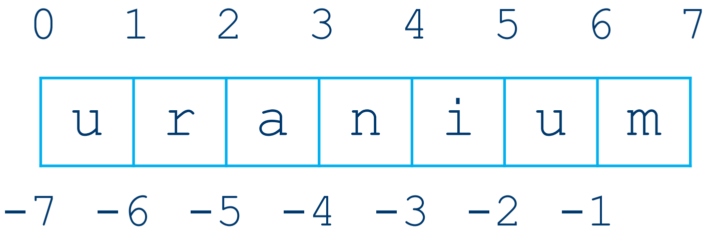

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```

"A foolish consistency is
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"Aw, you're kidding me!"

— *programmers*

So `text[1:3]` is `0`, `1`, or `2` characters long

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`''`	`''`
`'a'`	`''`
`'ab'`	`'b'`
`'abc'`	`'bc'`
`'abcdef'`	`'bc'`

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- From index 1 up to (but not including) index 1

And `text[3:1]` is always the empty string

- *Not* the reverse of `text[1:3]`

But `text[1:-1]` is everything except the first and last characters

Slicing always creates a new collection

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Beware of aliasing

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```
>>> points = [[10, 10], [20, 20], [30, 30], [40, 40]]
>>>
```

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```
>>> points = [[10, 10], [20, 20], [30, 30], [40, 40]]
>>> middle = points[1:-1]
>>>
```

Slicing always creates a new collection

Beware of aliasing

```
>>> points = [[10, 10], [20, 20], [30, 30], [40, 40]]
>>> middle = points[1:-1]
>>> middle[0][0] = 'whoops'
>>>
```

Slicing always creates a new collection

Beware of aliasing

```
>>> points = [[10, 10], [20, 20], [30, 30], [40, 40]]
>>> middle = points[1:-1]
>>> middle[0][0] = 'whoops'
>>> middle[1][0] = 'aliasing'
>>>
```

Slicing always creates a new collection

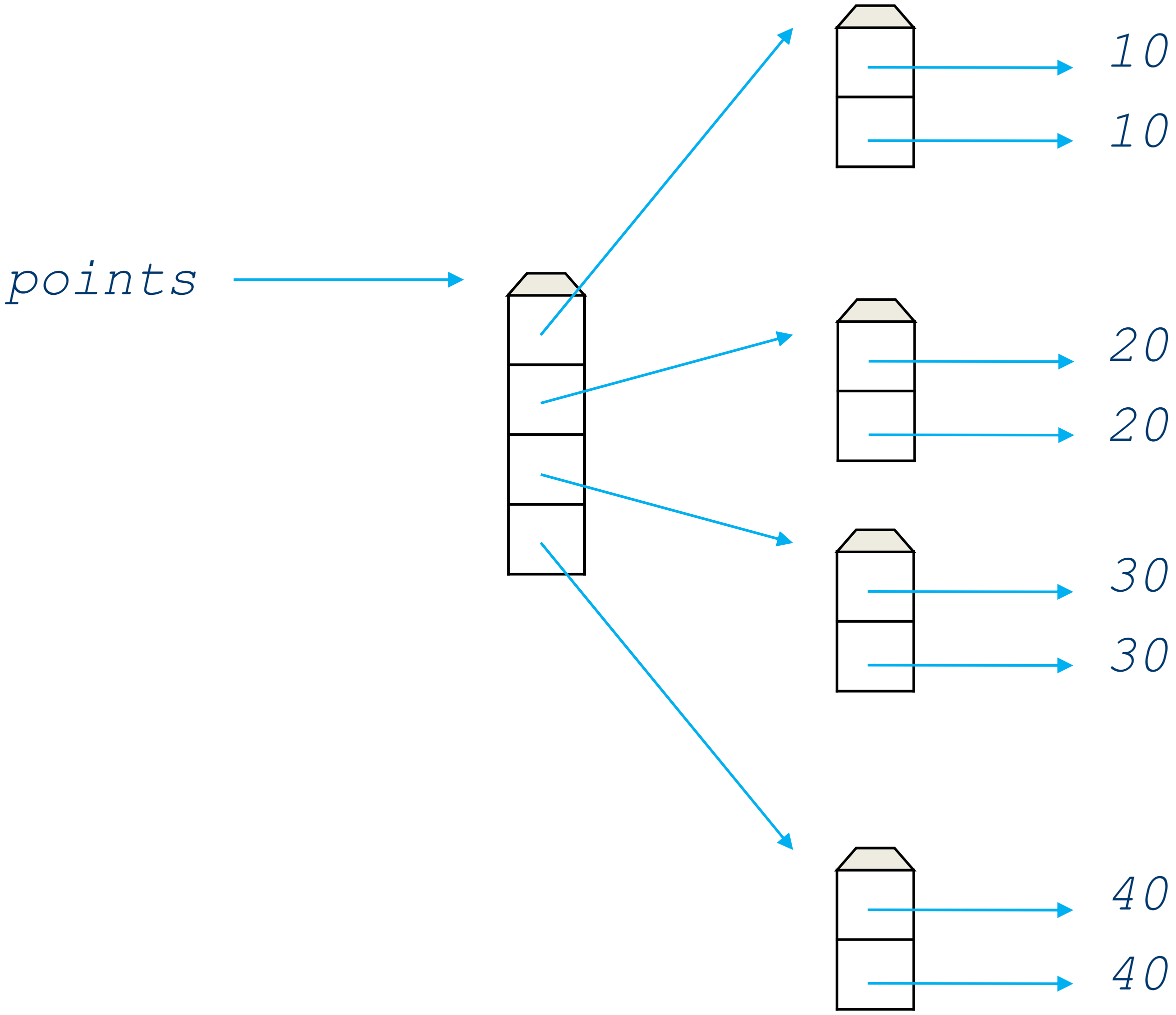
Beware of aliasing

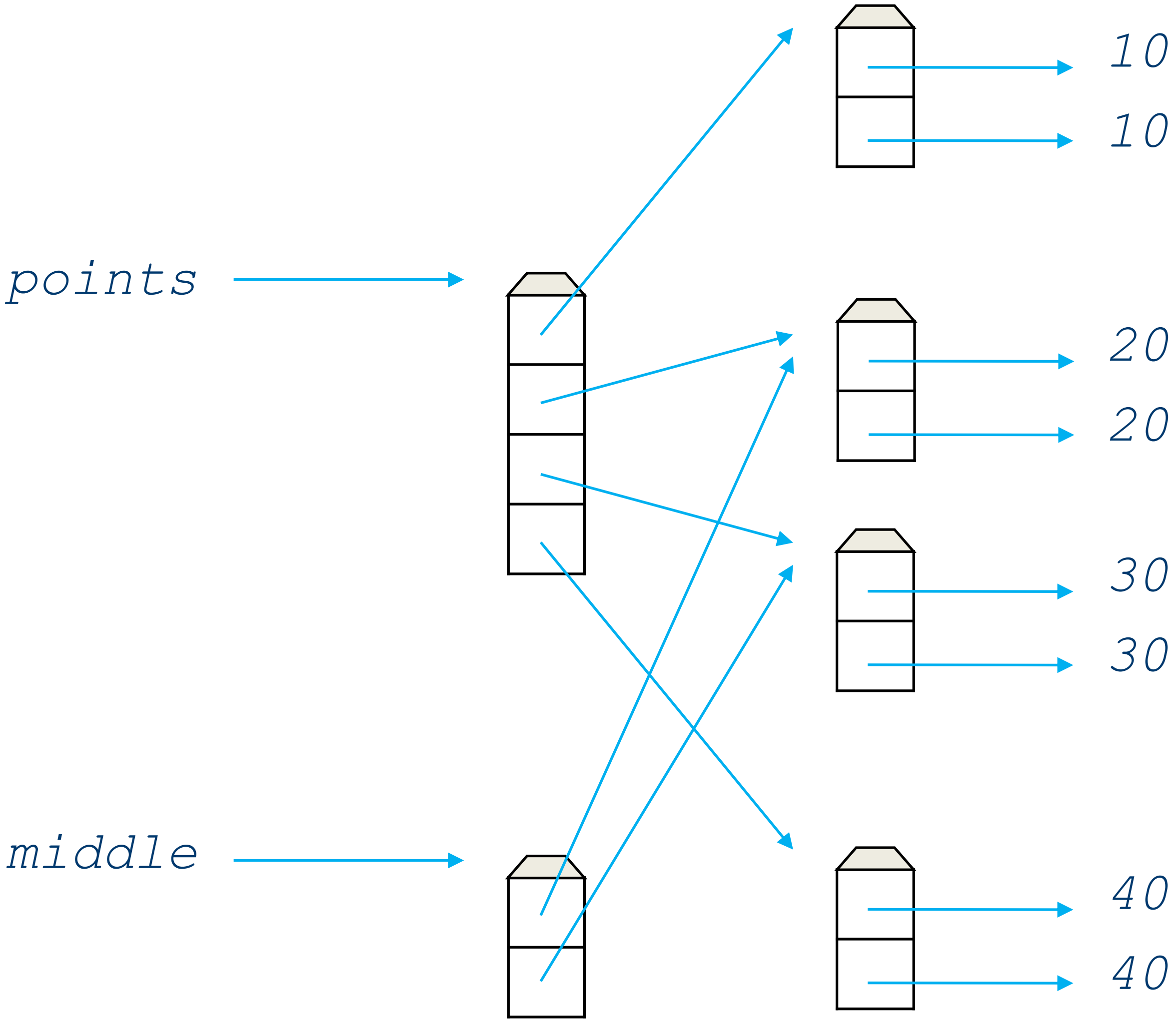
```
>>> points = [[10, 10], [20, 20], [30, 30], [40, 40]]
>>> middle = points[1:-1]
>>> middle[0][0] = 'whoops'
>>> middle[1][0] = 'aliasing'
>>> print(middle)
>>> [['whoops', 20], ['aliasing', 30]]
>>>
```

Slicing always creates a new collection

Beware of aliasing

```
>>> points = [[10, 10], [20, 20], [30, 30], [40, 40]]
>>> middle = points[1:-1]
>>> middle[0][0] = 'whoops'
>>> middle[1][0] = 'aliasing'
>>> print(middle)
>>> [['whoops', 20], ['aliasing', 30]]
>>> print(points)
[[10, 10], ['whoops', 20], ['aliasing', 30], [40, 40]]
>>>
```


points
10
10
20
20
30
30
40
40


points
middle
10
10
20
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40
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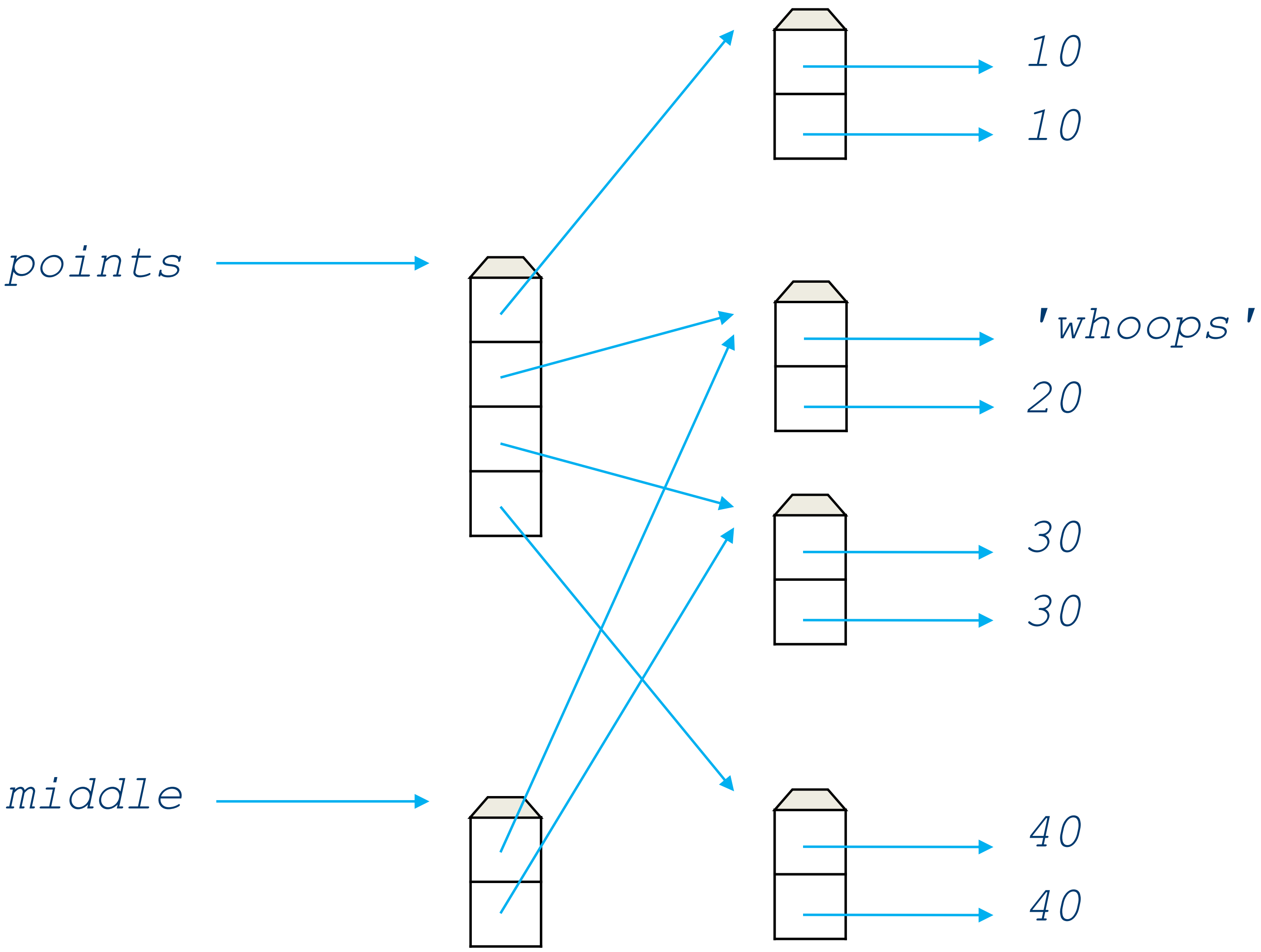


points

middle

10

10

'whoops'

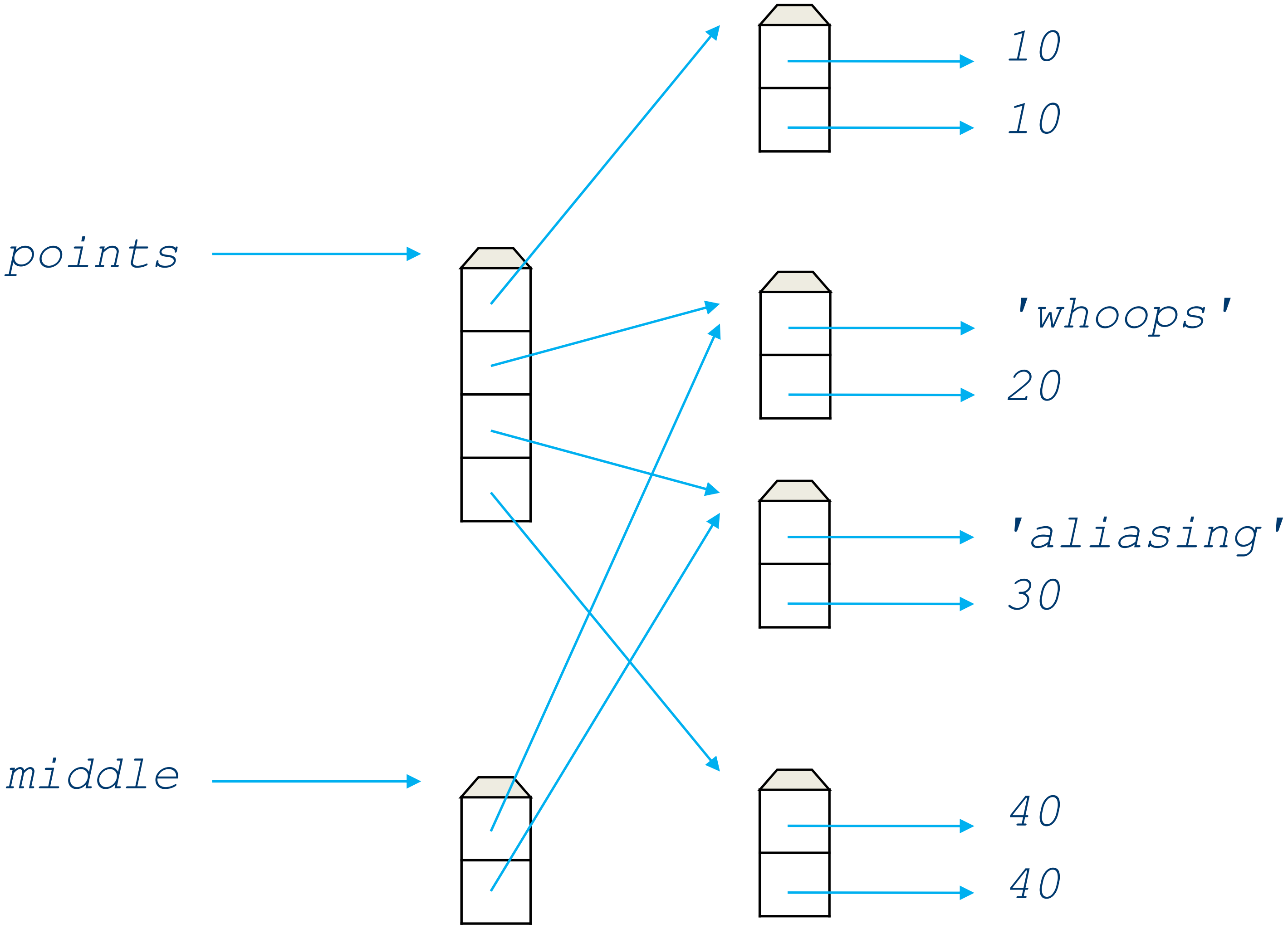
20

30

30

40

40



points

middle

10

10

'whoops'

20

'aliasing'

30

40

40

Python

NumPy

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NumPy

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the fundamental package for scientific computing with Python:

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- N-dimensional array object

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- linear algebra
- Fourier transform
- random number capabilities

Importing the NumPy Module

```
>>> import numpy
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```
>>> import numpy
>>> import numpy as np
```

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```
>>> import numpy
>>> import numpy as np
>>> from numpy import *
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>>> import numpy as np
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NumPy Arrays

```
>>> a = np.array([1, 4, 5, 8], float)
```

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>>> a = np.array([1, 4, 5, 8], float)
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>>> a = np.array([1, 4, 5, 8], float)
```

arrays are similar to lists in Python except that every element of an array must be of the same type

typically a numeric type like **`float`** or **`int`**

NumPy Arrays

```
>>> a = np.array([1, 4, 5, 8], float)
>>> a
```

NumPy Arrays

```
>>> a = np.array([1, 4, 5, 8], float)
>>> a
array([ 1., 4., 5., 8.])
```

NumPy Arrays

```
>>> a = np.array([1, 4, 5, 8], float)
>>> a
array([ 1., 4., 5., 8.])
>>> type(a)
```

NumPy Arrays

```
>>> a = np.array([1, 4, 5, 8], float)
>>> a
array([ 1.,  4.,  5.,  8.])
>>> type(a)
<type 'numpy.ndarray'>
```

Accessed and Sliced Like Lists

```
>>> a = np.array([1, 4, 5, 8], float)
```

Accessed and Sliced Like Lists

```
>>> a = np.array([1, 4, 5, 8], float)
>>> a[:2]
```

Accessed and Sliced Like Lists

```
>>> a = np.array([1, 4, 5, 8], float)
>>> a[:2]
array([ 1., 4.])
```

Accessed and Sliced Like Lists

```
>>> a = np.array([1, 4, 5, 8], float)
>>> a[:2]
array([ 1., 4.])
>>> a[3]
```

Accessed and Sliced Like Lists

```
>>> a = np.array([1, 4, 5, 8], float)
>>> a[:2]
array([ 1., 4.])
>>> a[3]
8.0
```

Accessed and Sliced Like Lists

```
>>> a = np.array([1, 4, 5, 8], float)
>>> a[:2]
array([ 1.,  4.])
>>> a[3]
8.0
>>> a[0] = 5.
```

Accessed and Sliced Like Lists

```
>>> a = np.array([1, 4, 5, 8], float)
>>> a[:2]
array([ 1., 4.])
>>> a[3]
8.0
>>> a[0] = 5.
>>> a
array([ 5., 4., 5., 8.])
```

Multidimensional Arrays

```
>>> a = np.array([[1, 2, 3], [4, 5, 6]], float)
```

Multidimensional Arrays

```
>>> a = np.array([[1, 2, 3], [4, 5, 6]], float)
>>> a
array([[ 1., 2., 3.],
       [ 4., 5., 6.]])
```

Multidimensional Arrays

```
>>> a = np.array([[1, 2, 3], [4, 5, 6]], float)
>>> a
array([[ 1.,  2.,  3.],
       [ 4.,  5.,  6.]])
>>> a[0,0]
1.0
```

Multidimensional Arrays

```
>>> a = np.array([[1, 2, 3], [4, 5, 6]], float)
>>> a
array([[ 1., 2., 3.],
       [ 4., 5., 6.]])
>>> a[0,0]
1.0
>>> a[0,1]
2.0
```

Slicing of Multidimensional Arrays

```
>>> a = np.array([[1, 2, 3], [4, 5, 6]], float)
```

Slicing of Multidimensional Arrays

```
>>> a = np.array([[1, 2, 3], [4, 5, 6]], float)
>>> a[1,:]
array([ 4., 5., 6.])
```

Slicing of Multidimensional Arrays

```
>>> a = np.array([[1, 2, 3], [4, 5, 6]], float)
>>> a[1,:]
array([ 4., 5., 6.])
```

in a dimension indicates the use of everything along that dimension

Slicing of Multidimensional Arrays

```
>>> a = np.array([[1, 2, 3], [4, 5, 6]], float)
>>> a[1,:]
array([ 4., 5., 6.])
>>> a[:,2]
array([ 3., 6.])
```

Slicing of Multidimensional Arrays

```
>>> a = np.array([[1, 2, 3], [4, 5, 6]], float)
>>> a[1,:]
array([ 4., 5., 6.])
>>> a[:,2]
array([ 3., 6.])
>>> a[-1:,-2:]
array([[ 5., 6.]])
```

Methods of Arrays

```
>>> X = np.zeros((2, 3))
```

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```
>>> X = np.zeros((2, 3))
>>> X
array([[ 0.,  0.,  0.],
       [ 0.,  0.,  0.]])
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Methods of Arrays

```
>>> X = np.zeros((2, 3))
>>> X
array([[ 0.,  0.,  0.],
       [ 0.,  0.,  0.]])
>>> a.shape
(2, 3)
```

Methods of Arrays

```
>>> X = np.zeros((2, 3))
>>> X
array([[ 0.,  0.,  0.],
       [ 0.,  0.,  0.]])
>>> a.shape
(2, 3)
>>> a.dtype
dtype('float64')
```

Random Numbers

```
>>> np.random.seed(293423)
```

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```
>>> np.random.seed(293423)
>>> np.random.rand(5)
array([ 0.33677247,  0.52693437,  0.79529578])
```

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```
>>> np.random.seed(293423)
>>> np.random.rand(5)
array([ 0.33677247,  0.52693437,  0.79529578])
>>> np.random.rand(2,3)
array([[ 0.78867702,  0.02147624,  0.84612516],
       [ 0.0704939 ,  0.1526965 ,  0.77831701]])
```