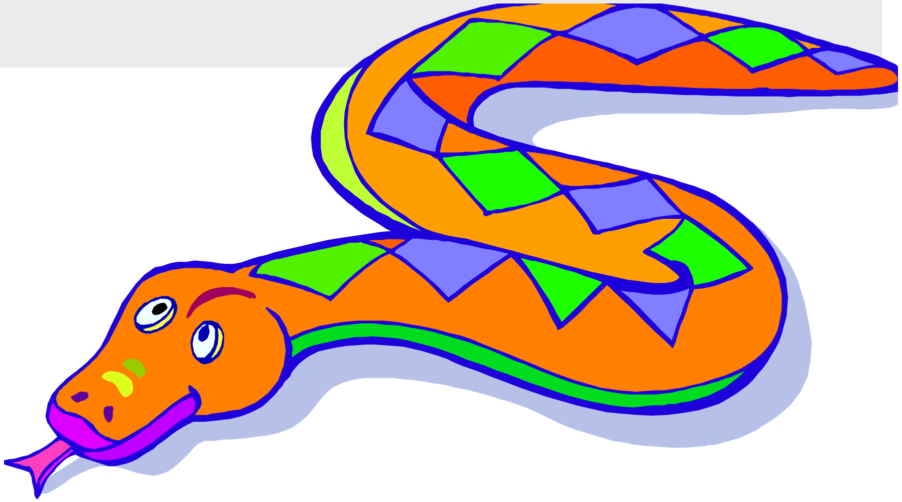
List Comprehensions



Python’s higher-order functions

- Python supports higher-order functions that operate on lists similar to Scheme’s

```
>>> def square(x):
        return x*x
>>> def even(x):
        return 0 == x % 2
>>> map(square, range(10,20))
[100, 121, 144, 169, 196, 225, 256, 289, 324, 361]
>>> filter(even, range(10,20))
[10, 12, 14, 16, 18]
>>> map(square, filter(even, range(10,20)))
[100, 144, 196, 256, 324]
```

- But many Python programmers prefer to use list comprehensions, instead

List Comprehensions

- A *list comprehension* is a programming language construct for creating a list based on existing lists
  - Haskell, Erlang, Scala and Python have them
- Why "comprehension"? The term is borrowed from math's *set comprehension* notation for defining sets in terms of other sets
- A powerful and popular feature in Python
  - Generate a new list by applying a function to every member of an original list
- Python's notation:
  [expression for name in list]

List Comprehensions

- The syntax of a *list comprehension* is somewhat tricky

```
[x-10 for x in grades if x>0]
```

- Syntax suggests that of a *for*-loop, an *in* operation, or an *if* statement
- All three of these keywords ('*for*', '*in*', and '*if*') are also used in the syntax of forms of list comprehensions

[expression for name in list]

List Comprehensions

```
>>> li = [3, 6, 2, 7]
>>> [elem*2 for elem in li]
[6, 12, 4, 14]
```

Note: Non-standard colors on next few slides clarify the list comprehension syntax.

[expression for name in list]

- Where expression is some calculation or operation acting upon the variable name.
- For each member of the list, the list comprehension
  1. sets name equal to that member,
  2. calculates a new value using expression,
- It then collects these new values into a list which is the return value of the list comprehension.

List Comprehensions

- If list contains elements of different types, then expression must operate correctly on the types of all of list members.
- If the elements of list are other containers, then name can consist of a container of names matching the type and "shape" of the list members.

```
>>> li = [('a', 1), ('b', 2), ('c', 7)]
>>> [ n * 3 for (x, n) in li]
[3, 6, 21]
```

- Containers are objects that contain references to other objects (e.g., lists, types, dictionaries)

[expression for name in list]

List Comprehensions

- expression can also contain user-defined functions.

```
>>> def subtract(a, b):
        return a - b

>>> oplist = [(6, 3), (1, 7), (5, 5)]
>>> [subtract(y, x) for (x, y) in oplist]
[-3, 6, 0]
```

[expression for name in list]

Syntactic sugar

List comprehensions can be viewed as syntactic sugar for a typical higher-order functions

```
[ expression for name in list ]
```

```
map( lambda name: expression, list )
```

```
[ 2*x+1 for x in [10, 20, 30] ]
```

```
map( lambda x: 2*x+1, [10, 20, 30] )
```

Filtered List Comprehension

- Filter determines whether expression is performed on each member of the list.

- For each element of list, checks if it satisfies the filter condition.

- If the filter condition returns *False*, that element is omitted from the list before the list comprehension is evaluated.

[expression for name in list if filter]

Filtered List Comprehension

```
>>> li = [3, 6, 2, 7, 1, 9]
>>> [elem*2 for elem in li if elem > 4]
[12, 14, 18]
```

- Only 6, 7, and 9 satisfy the filter condition
- So, only 12, 14, and 18 are produce.

[expression for name in list if filter]

More syntactic sugar

Including an if clause begins to show the benefits of the sweetened form

[expression for name in list if filt]

map(lambda name . expression, filter(filt, list))

`[` 2*x+1 `for` x `in` [10, 20, 30] if x > 0 `]`

map(lambda x: 2*x+1,

filter(lambda x: x > 0 , [10, 20, 30])

Nested List Comprehensions

- Since list comprehensions take a list as input and produce a list as output, they are easily nested

```
>>> li = [3, 2, 4, 1]
>>> [elem*2 for elem in
        [item+1 for item in li] ]
[8, 6, 10, 4]
```

- The inner comprehension produces: [4, 3, 5, 2]
- So, the outer one produces: [8, 6, 10, 4]

[expression for name in list]

Syntactic sugar

[e1 for n1 in [e1 for n1 list]]

map(lambda n1: e1,

map(lambda n2: e2, list))

[2*x+1 for x in [y*y for y in [10, 20, 30]]]

map(lambda x: 2*x+1,

map(lambda y: y*y, [10, 20, 30]))