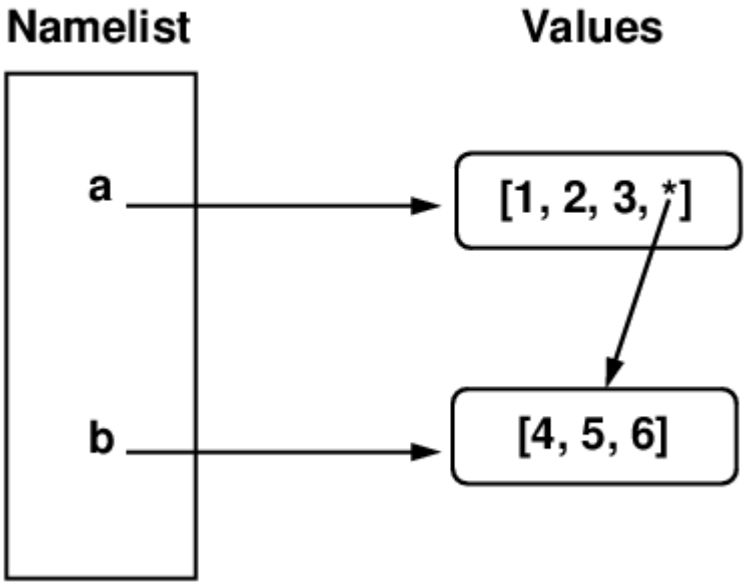
Lecture 3.1 : Shallow and deep copies¶

Introduction

- We continue our exploration of the relation between variables, references and immutable/mutable objects with another example.

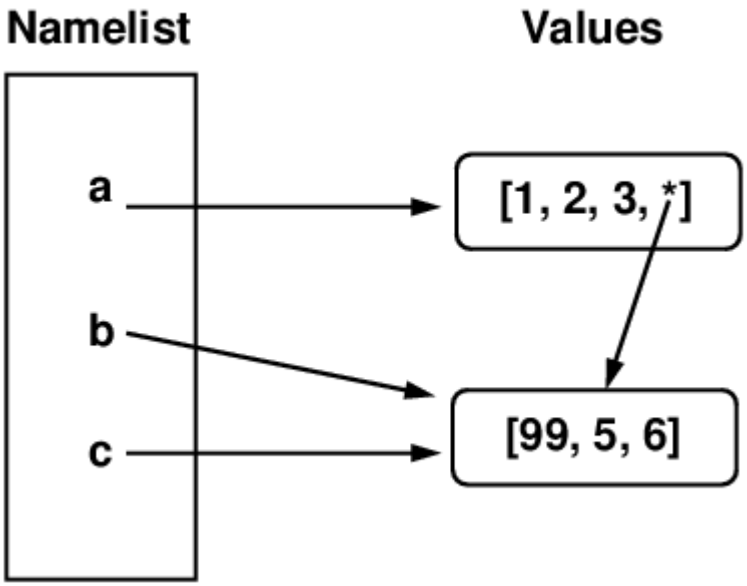
```
>>> a = [1, 2, 3]
>>> b = [4, 5, 6]
>>> a.append(b)
>>> a
[1, 2, 3, [4, 5, 6]]
```

- What is going on here? The diagram below depicts the situation.



- As we can see, when we `a.append(b)` we append a *reference* to `b` to `a`. (To join list `b` to list `a` we would write `a.extend(b)`.) Thus after the append operation, `a` contains three integers and a reference to the list referenced by `b`. The list `[4, 5, 6]` is thus shared by `a` and `b`. Any change to `b` affects `a` as the following example demonstrates.

```
>>> c = b
>>> c[0] = 99
>>> c
[99, 5, 6]
>>> b
[99, 5, 6]
>>> a
[1, 2, 3, [99, 5, 6]]
```



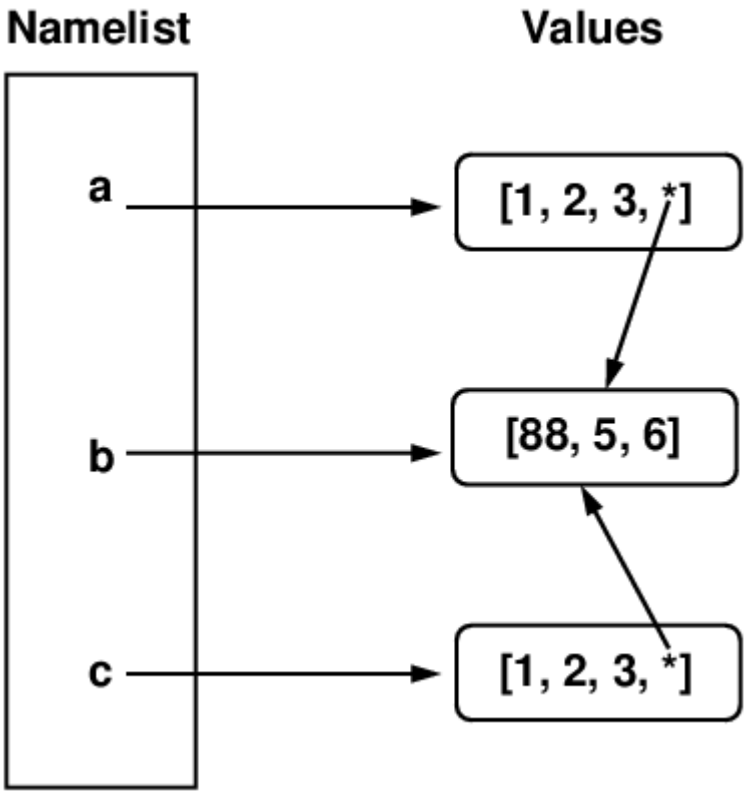
- It is crucial to note that `a.append(b)` adds a reference to `b` to `a`. It does *not* append a *new copy* of the object referenced by `b` to `a`.

Shallow and deep copies

- Suppose we wish to copy the list `a` above such that we create new copies of the objects it references rather than duplicating them. Let's try to do it with the slice operator:

```
>>> a = [1, 2, 3]
>>> b = [4, 5, 6]
>>> a.append(b)
>>> c = a[:]
>>> a
[1, 2, 3, [4, 5, 6]]
>>> c
[1, 2, 3, [4, 5, 6]]
>>> b[0] = 88
>>> a
[1, 2, 3, [88, 5, 6]]
>>> c
[1, 2, 3, [88, 5, 6]]
```

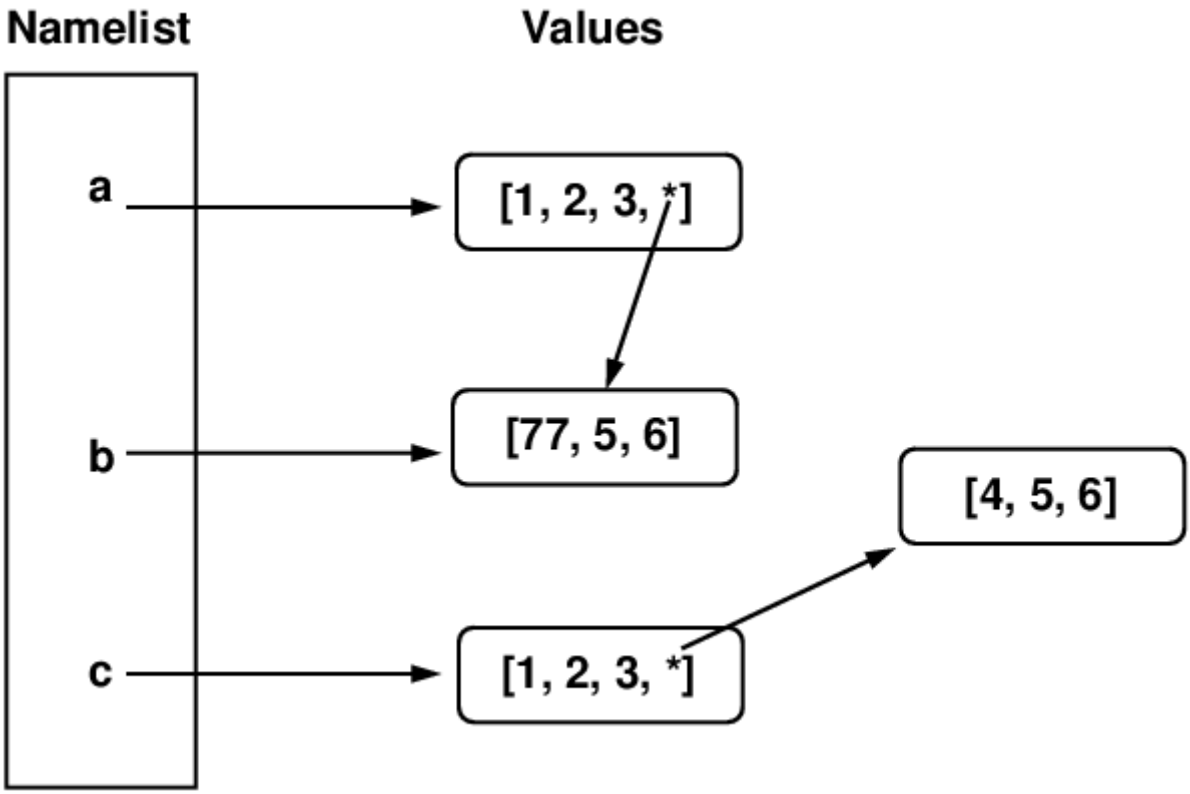
- That didn't work. When we wrote `c = a[:]` the reference to `b` in `a` was copied to `c`. Thus the subsequent change to `b` affected both `a` and `c`.



- When we copy an object where we copy only references it contains and not the referenced objects themselves we are making a *shallow copy*. When we write `c = a[:]` we are making a shallow copy.

- Suppose we want to copy not the references but the actual objects referenced? How can we do that? When we do so we are making a *deep copy*. In the `copy` module there is a `deepcopy()` function that allows us to do just that. Below we illustrate it in action.

```
>>> a = [1, 2, 3]
>>> b = [4, 5, 6]
>>> a.append(b)
>>> import copy
>>> c = copy.deepcopy(a)
>>> b[0] = 77
>>> a
[1, 2, 3, [77, 5, 6]]
>>> c
[1, 2, 3, [4, 5, 6]]
```



- Above we see that the list referenced by `c` does *not* contain a reference to `b` (it is unaffected by `b[0] = 77`). Instead `c` contains a reference to a new and separate copy of the list referenced from `a`. Note this form of copying is slower than the usual approach since it involves following all references in an object and creating new copies of the referenced objects. However, where independence from the source object is required in the copied object, it is a deep copy that must be implemented.