Coding Example: Modifying the list

This coding example will help you go through a simple and straightforward solution to add, delete, and set items in a list.

We'll cover the following

- setitem
- delitem
- insert
- Complete Solution:

Modification of the list is a little complicated, because it requires managing the memory properly. The solution is pretty straightforward as it poses no real difficulty. You can have a look at the code below (the comments are added at each step to help you understand what's happening).

> **Note:** Always be careful with negative steps, key range and array expansion. When the underlying array needs to be expanded, it's better to expand it more than necessary in order to avoid future expansion.

setitem

```
L[1] = 1,1,1

 | 0 | 0 || 1 | 1 || 2 | 2 |
  item 1    item 2    item 3

OUTPUT
 | 0 | 0 || 1 | 1 | 1 || 2 | 2 |
  item 1    item 2        item 3
```

delitem

```
L = TypedList([[0,0], [1,1], [0,0]])
del L[1]

 | 0 | 0 || 1 | 1 || 2 | 2 |
  item 1    item 2    item 3

OUTPUT
 | 0 | 0 || 2 | 2 |
  item 1    item 2
```

insert

```
L = TypedList([[0,0], [1,1], [0,0]])
L.insert(1, [3,3])

 | 0 | 0 || 1 | 1 || 2 | 2 |
  item 1    item 2    item 3

OUTPUT
 | 0 | 0 || 3 | 3 || 1 | 1 || 2 | 2 |
  item 1    item 2    item 3    item 4
```

Complete Solution:

Here's the complete implementation of the list with all the methods added in the code:

```python
# -*- coding: utf-8 -*-
# -----------------------------------------------------------------------------
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# -----------------------------------------------------------------------------

import numpy as np

class ArrayList(object):
    """
    An ArrayList is a strongly typed list whose type can be anything that can be
    interpreted as a numpy data type.
    """

    def __init__(self, data=None, sizes=None, dtype=float, sizeable=True, writeable=True):
        """ Create a new buffer using given data and sizes or dtype

        Parameters
        ----------

        data : array_like
            An array, any object exposing the array interface, an object
            whose __array__ method returns an array, or any (nested) sequence.

        sizes:  int or 1-D array
            If `itemsize is an integer, N, the array will be divided
            into elements of size N. If such partition is not possible,
            an error is raised.

            If `itemsize` is 1-D array, the array will be divided into
            elements whose successive sizes will be picked from itemsize.
            If the sum of itemsize values is different from array size,
            an error is raised.

        dtype: np.dtype
            Any object that can be interpreted as a numpy data type.

        sizeable : boolean
            Indicate whether item can be appended/inserted/deleted

        writeable : boolean
            Indicate whether content can be changed
        """

        self._sizeable = sizeable
        self._writeable = writeable

        if data is not None:
            if type(data) in [list,tuple]:
                if type(data[0]) in [list,tuple]:
                    sizes = [len(l) for l in data]
                    data = [item for sublist in data for item in sublist]
            self._data = np.array(data, copy=False)
            self._size = self._data.size

            # Default is one group with all data inside
            _sizes = np.ones(1)*self._data.size

            # Check item sizes and get items count
            if sizes is not None:
                if type(sizes) is int:
                    if (self._size % sizes) != 0:
                        raise ValueError("Cannot partition data as requested")
                    self._count = self._size//sizes
                    _sizes = np.ones(self._count,dtype=int)*(self._size//self._count)
                else:
                    _sizes = np.array(sizes, copy=False)
                    self._count = len(sizes)
                    if _sizes.sum() != self._size:
                        raise ValueError("Cannot partition data as requested")
            else:
                self._count = 1

            # Store items
            self._items = np.zeros((self._count,2),int)
            C = _sizes.cumsum()
            self._items[1:,0] += C[:-1]
            self._items[0:,1] += C

        else:
            self._data = np.zeros(512, dtype=dtype)
            self._items = np.zeros((64,2), dtype=int)
            self._size = 0
            self._count = 0


    @property
    def data(self):
        """ The array's elements, in memory. """
        return self._data[:self._size]



    @property
    def itemsize(self):
        """ Individual item sizes """
        return self._items[:self._count,1] - self._items[:self._count,0]



    @property
    def size(self):
        """ Number of base elements, in memory. """
        return self._size



    @property
    def dtype(self):
        """ Describes the format of the elements in the buffer. """
        return self._data.dtype



    def __len__(self):
        """ x.__len__() <==> len(x) """
        return self._count



    def __str__(self):
        s = '[ '
        for item in self: s += str(item) + ' '
        s += ']'
        return s



    def __getitem__(self, key):
        """ x.__getitem__(y) <==> x[y] """

        if type(key) is int:
            if key < 0:
                key += len(self)
            if key < 0 or key >= len(self):
                raise IndexError("Tuple index out of range")
            dstart = self._items[key][0]
            dstop  = self._items[key][1]
            return self._data[dstart:dstop]

        elif type(key) is slice:
            istart, istop, step = key.indices(len(self))
            if istart > istop:
                istart,istop = istop,istart
            dstart = self._items[istart][0]
            if istart == istop:
                dstop = dstart
            else:
                dstop  = self._items[istop-1][1]
            return self._data[dstart:dstop]

        elif isinstance(key,str):
            return self._data[key][:self._size]

        elif key is Ellipsis:
            return self.data

        else:
            raise TypeError("List indices must be integers")


    def __setitem__(self, key, data):
        """ x.__setitem__(i, y) <==> x[i]=y """

        if not self._writeable:
            raise AttributeError("List is not sizeable")

        if type(key) is int:
            if key < 0:
                key += len(self)
            if key < 0 or key > len(self):
                raise IndexError("List assignment index out of range")
            dstart = self._items[key][0]
            dstop  = self._items[key][1]
            self._data[dstart:dstop] = data

        elif type(key) is slice:
            istart, istop, step = key.indices(len(self))
            if istart > istop:
                istart,istop = istop,istart
            if istart == istop:
                dstart = self._items[key][0]
                dstop  = self._items[key][1]
                self._data[dstart:dstop] = data
            else:
                if istart > len(self) or istop > len(self):
                    raise IndexError("Can only assign iterable")
                dstart = self._items[istart][0]
                if istart == istop:
                    dstop = dstart
                else:
                    dstop  = self._items[istop-1][1]
                self._data[dstart:dstop] = data

        elif key is Ellipsis:
            self.data[...] = data

        elif type(key) is str:
            self._data[key][:self._size] = data

        else:
            raise TypeError("List assignment indices must be integers")



    def __delitem__(self, key):
        """ x.__delitem__(y) <==> del x[y] """

        if not self._sizeable:
            raise AttributeError("List is not sizeable")

        # Deleting a single item
        if type(key) is int:
            if key < 0:
                key += len(self)
            if key < 0 or key > len(self):
                raise IndexError("List deletion index out of range")
            istart, istop = key, key+1
            dstart,dstop = self._items[key]

        # Deleting several items
        elif type(key) is slice:
            istart, istop, step = key.indices(len(self))
            if istart > istop:
                istart,istop = istop,istart
            if istart == istop:
                return
            dstart = self._items[istart][0]
            dstop  = self._items[istop-1][1]

        # Ellipsis
        elif key is Ellipsis:
            istart,istop = 0, len(self)
            dstart, dstop = 0, self.size
        # Error
        else:
            raise TypeError("List deletion indices must be integers")

        # Remove data
        size = self._size - (dstop-dstart)
        self._data[dstart:dstart+size] = self._data[dstop:dstop+size]
        self._size -= dstop-dstart

        # Remove corresponding items
        size = self._count - istop
        self._items[istart:istart+size] = self._items[istop:istop+size]

        # Update other items
        size = dstop-dstart
        self._items[istart:istop+size+1] -= size, size
        self._count -= istop-istart



    def insert(self, index, data, sizes=None):
        """ Insert data before index

        Parameters
        ----------

        index : int
            Index before which data will be inserted.

        data : array_like
            An array, any object exposing the array interface, an object
            whose __array__ method returns an array, or any (nested) sequence.

        sizes:  int or 1-D array
            If `itemsize is an integer, N, the array will be divided
            into elements of size N. If such partition is not possible,
            an error is raised.

            If `itemsize` is 1-D array, the array will be divided into
            elements whose successive sizes will be picked from itemsize.
            If the sum of itemsize values is different from array size,
            an error is raised.
        """

        if not self._sizeable:
            raise RuntimeError("List is not sizeable")

        if type(data) in [list,tuple] and type(data[0]) in [list,tuple]:
            sizes = [len(l) for l in data]
            data = [item for sublist in data for item in sublist]

        data = np.array(data,copy=False).ravel()
        size = data.size

        # Check item size and get item number
        if sizes is not None:
            if type(sizes) is int:
                if (size % sizes) != 0:
                    raise ValueError("Cannot partition data as requested")
                _count = size//sizes
                _sizes = np.ones(_count,dtype=int)*(size//_count)
            else:
                _sizes = np.array(sizes,copy=False)
                _count = len(sizes)
                if _sizes.sum() != size:
                    raise ValueError("Cannot partition data as requested")
        else:
            _count = 1

        # Check if data array is big enough and resize it if necessary
        if self._size + size  >= self._data.size:
            capacity = int(2**np.ceil(np.log2(self._size + size)))
            self._data = np.resize(self._data, capacity)

        # Check if item array is big enough and resize it if necessary
        if self._count + _count  >= len(self._items):
            capacity = int(2**np.ceil(np.log2(self._count + _count)))
            self._items = np.resize(self._items, (capacity, 2))

        # Check index
        if index < 0:
            index += len(self)
        if index < 0 or index > len(self):
            raise IndexError("List insertion index out of range")

        # Inserting
        if index < self._count:
            istart = index
            dstart = self._items[istart][0]
            dstop  = self._items[istart][1]
            # Move data
            self._data[dstart+size:self._size+size] = self._data[dstart:self._size]
            # Update moved items
            I = self._items[istart:self._count]+size
            self._items[istart+_count:self._count+_count] = I

        # Appending
        else:
            dstart = self._size
            istart = self._count

        # Only one item (faster)
        if _count == 1:
            # Store data
            self._data[dstart:dstart+size] = data
            self._size += size
            # Store data location (= item)
            self._items[istart][0] = dstart
            self._items[istart][1] = dstart+size
            self._count += 1

        # Several items
        else:
            # Store data
            dstop = dstart + size
            self._data[dstart:dstop] = data
            self._size += size

            # Store items
            items = np.ones((_count,2),int)*dstart
            C = _sizes.cumsum()
            items[1:,0] += C[:-1]
            items[0:,1] += C
            istop = istart + _count
            self._items[istart:istop] = items
            self._count += _count


    def append(self, data, sizes=None):
        """
        Append data to the end.

        Parameters
        ----------

        data : array_like
            An array, any object exposing the array interface, an object
            whose __array__ method returns an array, or any (nested) sequence.

        sizes:  int or 1-D array
            If `itemsize is an integer, N, the array will be divided
            into elements of size N. If such partition is not possible,
            an error is raised.

            If `itemsize` is 1-D array, the array will be divided into
            elements whose successive sizes will be picked from itemsize.
            If the sum of itemsize values is different from array size,
            an error is raised.
        """

        self.insert(len(self), data, sizes)

L = ArrayList( np.arange(10), [3,3,4])
print("L")
print (L)
#[ [0 1 2] [3 4 5] [6 7 8 9]]
print("L.data")
print (L.data)
#[0 1 2 3 4 5 6 7 8 9]

# Set an item
print("L[0]=3,3,3")
L[0] = 3,3,3
print (L)
#[3 3 3] [3 4 5] [6 7 8 9]]

# Delete an item
print("del L[0]")
del L[0]
print (L)
#[[3 4 5][6 7 8 9]]

# Insert an item
print("L.insert(1, [3,3])")
L.insert(1, [3,3])
print (L)
#[[3 4 5] [3 3] [6 7 8 9]]
```

RUN SAVE RESET

Output 1.647s

```
L
[ [0 1 2] [3 4 5] [6 7 8 9] ]
L.data
[0 1 2 3 4 5 6 7 8 9]
L[0]=3,3,3
[ [3 3 3] [3 4 5] [6 7 8 9] ]
del L[0]
[ [3 4 5] [6 7 8 9] ]
L.insert(1, [3,3])
```

> **Note:** You can also add several items at once by specifying common or individual size: a single scalar means all items are the same size while a list of sizes is used to specify individual item sizes.

In the next lesson, we will discuss another interesting type called the *Memory-aware* array!