Programming and Data Structures
Active Learning Activity 7: Array Based and Linked Lists

Activity Objectives

At the end of this activity, students should be able to:

1. Add new methods to the implementation of the generic data structures **`ArrayList`** and **`LinkedList`**
2. Instantiate the two generic data structures in a test program
3. Store an animal list in the two instantiated data structures
4. Compare the performance of the search, add, and remove operations for the two data structures

Activity

1. Use the implementation of the class **`ArrayList`** as seen in class.
2. Use the implementation of the class **`LinkedList`** as seen in class.
3. Add the following methods to the two classes **`ArrayList`** and **`LinkedList`**:
    a. A search method: **`public int contains(E item)`**. The method returns the number of iterations performed by the linear search algorithm to determine if **`item`** is found in the list or not. **`contains()`** uses an iterator object to visit the elements in the array list and the linked list. Determine the time complexity of the method and write the Big-O notation as a comment before the method header.
    b. A removal method: **`public int remove(E item)`**. The method returns the number of iterations performed to find **`item`** and remove it from the list. Determine the time complexity of the method and write the Big-O notation as a comment before the method header. Comment out the method **`boolean remove(Object o)`** from the class **`ArrayList`** to avoid compiler errors.
    c. An insertion method: **`public int add(int index, E item)`**. The method returns the number of iterations performed to add **`item`** at the given position **`index`**. Determine the time complexity of the method and write the Big-

O notation as a comment before the method header. Comment out the method **boolean add(int index, E item)** from the class **ArrayList** to avoid compiler errors.

4. Create a test program named **AnimalList** to do the following:
    a. Instantiate **ArrayList** and **LinkedList** classes for the type **String** and name the two instances **animalAL** and **animalLL** respectively.
    b. Read the file "**animals.txt**" and add each line from the file to **animalAL** and **animalLL** using the method **add(E)**. The file contains about 500 names of animals.
    c. Test the performance of the three methods added to the two data structures. For each method do the following:
        i. generate a random integer between 0 and the size of the two lists. Use the random number as an index to get an animal name from **animalAL**.
        ii. Search/remove/add the name in the two lists and display the number of iterations for each list.
        iii. Repeat ***steps i and ii*** 20 times to generate 20 random animal names, search/remove/add the names in the two lists and display the number of iterations for each list.
        iv. Display the average number of iterations for the search/remove/add methods in the two lists.
        v. Explain why the number of iterations is different in the two lists for the same animal, but the average numbers of iterations are of the same order.
        vi. Discuss the results you obtained for the average number of iterations against the time complexity analysis you performed when you defined the methods.

5. Submit the following files on Github:

    LinkedList.java, **ArrayList.java**, and **AnimalDB.java**.

Here is a sample output of the program for the search/remove/add 20 random animal names:

```
Comparing the methods contains(E item)
======================================
Animal name              Iterations(AL)           Iterations(LL)
Krill                    272                      216
Coral                    244                      244
Opossum                  27                       461
Harrier                  100                      388
Damselfly                249                      239
Donkey                   78                       163
Great white shark        479                      9
Sugar glider             478                      10
Box jellyfish            237                      251
Hare                     182                      306
Reptile                  441                      47
Angelfish                389                      99
Cattle                   97                       62
Spider monkey            429                      59
Bali cattle              342                      146
Fancy rat                260                      228
Elephant                 150                      338
Cat                      110                      133
Loon                     179                      309
Domestic guinea fowl     293                      195
Average # iterations     251                      195

Comparing the methods remove(E item)
====================================
Animal name              Iterations(AL)           Iterations(LL)
Turkey                   487                      136
Orca                     486                      127
Locust                   485                      242
Pilot whale              484                      120
Alligator                483                      65
Gayal                    482                      434
Tree frog                481                      314
Swallow                  480                      153
African buffalo          479                      168
Orangutan                478                      436
Sparrow                  477                      359
Fancy mouse              476                      371
Domestic duck            475                      275
Albatross                474                      433
Right whale              473                      176
```

```
Cephalopod               472                      156
Trout                    471                      43
Chicken breeds           470                      180
Shark                    469                      42
Arabian leopard          468                      261
Average  # iterations    477                      224

Comparing the methods add(int index, E item)
============================================
Animal name              Iterations(AL)           Iterations(LL)
Stingray                 398                      69
Hare                     293                      175
Cockroach                337                      132
Black widow spider       147                      323
Crawdad                  258                      213
Bug                      132                      340
Bug                      133                      340
Booby                    250                      224
Cockroach                342                      133
Fancy rat                224                      252
Domestic turkey          69                       408
Salamander               198                      280
Orangutan                440                      39
Hare                     302                      178
Lark                     318                      163
Irukandji jellyfish      408                      74
Boar                     76                       407
Macaw                    406                      78
Junglefowl               159                      326
Stoat                    218                      268
Average                  255                      221
```