# Practical 4: City Databases using Linked List

## Aim

Implement a **city database** using **unordered lists**. Each database record contains the name of the city (a string of arbitrary length) and the coordinates of the city expressed as integer x and y coordinates. Your program should allow following functionalities:

a) Insert a record
b) Delete a record by name or coordinate
c) Search a record by name or coordinate
d) Point all records within a given distance of a specified point.

Implement the database using an **array-based list** implementation, and then a **linked list** implementation

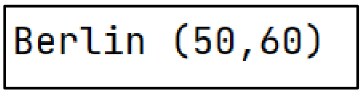
## Program

### a. Array based Implementation

```
public class CityDatabaseArray {

    private static final int INITIAL_CAPACITY = 10;
    private String[] cityNames;
    private int[] xCoords;
    private int[] yCoords;
    private int size;

    public CityDatabaseArray() {
        cityNames = new String[INITIAL_CAPACITY];
        xCoords = new int[INITIAL_CAPACITY];
        yCoords = new int[INITIAL_CAPACITY];
        size = 0;
    }

    // Inserts a record with the given name and coordinates
    public void insert(String name, int x, int y) {
        if (size >= cityNames.length) {
            resize();
        }
        cityNames[size] = name;
        xCoords[size] = x;
        yCoords[size] = y;
        size++;
    }

    // Deletes a record with the given name or coordinates
    public void delete(String nameOrCoord) {
        for (int i = 0; i < size; i++) {
            if (cityNames[i].equals(nameOrCoord) || (xCoords[i] + "," + yCoords[i]).equals(nameOrCoord)) {
                cityNames[i] = cityNames[size - 1];
                xCoords[i] = xCoords[size - 1];
                yCoords[i] = yCoords[size - 1];
                size--;
                return;
            }
        }
    }

    // Searches for a record with the given name or coordinates and returns its index, or -1 if not found
    public int search(String nameOrCoord) {
        for (int i = 0; i < size; i++) {
            if (cityNames[i].equals(nameOrCoord) || (xCoords[i] + "," + yCoords[i]).equals(nameOrCoord)) {
                return i;
            }
        }
        System.out.println("City is:");
        return -1;
    }

    // Prints all records within the given distance of the specified point
    public void printNearby(int x, int y, double distance) {
        for (int i = 0; i < size; i++) {
            double dx = xCoords[i] - x;
            double dy = yCoords[i] - y;
            double dist = Math.sqrt(dx*dx + dy*dy);
            if (dist <= distance) {
                System.out.println(cityNames[i] + " (" + xCoords[i] + "," + yCoords[i] + ")");
            }
        }
    }

    // Resizes the arrays to twice their current capacity
    private void resize() {
        int newCapacity = 2 * cityNames.length;
        String[] newCityNames = new String[newCapacity];
        int[] newXCoords = new int[newCapacity];
        int[] newYCoords = new int[newCapacity];
        for (int i = 0; i < size; i++) {
            newCityNames[i] = cityNames[i];
            newXCoords[i] = xCoords[i];
            newYCoords[i] = yCoords[i];
        }
        cityNames = newCityNames;
        xCoords = newXCoords;
        yCoords = newYCoords;
    }
```

```
    public static void main(String[] args) {
        CityDatabaseArray db = new CityDatabaseArray();

            db.insert("Berlin",50,60);
            db.insert("Tokyo",40 ,70);
            db.insert("Berlin",50,90);
            db.insert("Delhi",20 ,70);
            db.search("Berlin");
            db.printNearby(50,40,20);

    }
}
```

**Output:**

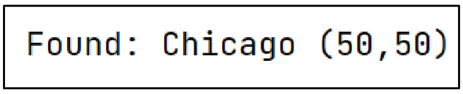


```
Berlin (50,60)
```

**b. Linked List Implementation**

```
public class CityDataBaseLinked {
    String name;
    int x;
    int y;
    CityDataBaseLinked next;

    public CityDataBaseLinked(String name, int x, int y) {
        this.name = name;
        this.x = x;
        this.y = y;
        next = null;
    }

    public String toString() {
        return name + " (" + x + "," + y + ")";
    }
}

class CityDatabase {

    private CityDataBaseLinked head;
    private int size;

    public CityDatabase() {
        head = null;
        size = 0;
    }
    // Inserts a record with the given name and coordinates
    public void insert(String name, int x, int y) {
        CityDataBaseLinked newCity = new CityDataBaseLinked(name, x, y);
        newCity.next = head;
        head = newCity;
        size++;
    }

    // Deletes a record with the given name or coordinates
    public void delete(String nameOrCoord) {
        if (head == null) {
            return;
        }
        if (head.name.equals(nameOrCoord) || (head.x + "," + head.y).equals(nameOrCoord)) {
            head = head.next;
            size--;
            return;
        }
        CityDataBaseLinked curr = head;
        while (curr.next != null) {
            if (curr.next.name.equals(nameOrCoord) || (curr.next.x + "," +
  curr.next.y).equals(nameOrCoord)) {
                curr.next = curr.next.next;
                size--;
                return;
            }
            curr = curr.next;
        }
    }

    // Searches for a record with the given name or coordinates and returns its index, or -1 if not found
    public CityDataBaseLinked search(String nameOrCoord) {
        CityDataBaseLinked curr = head;
        while (curr != null) {
            if (curr.name.equals(nameOrCoord) || (curr.x + "," + curr.y).equals(nameOrCoord)) {
                return curr;
            }
            curr = curr.next;
        }
        return null;
    }

    // Prints all records within the given distance of the specified point
    public void printNearby(int x, int y, double distance) {
        CityDataBaseLinked curr = head;
        while (curr != null) {
            double dx = curr.x - x;
            double dy = curr.y - y;
            double dist = Math.sqrt(dx * dx + dy * dy);
            if (dist <= distance) {
                System.out.println(curr);
            }
            curr = curr.next;
        }
    }

    // Returns the size of the database
    public int size() {
        return size;
    }

    public static void main(String[] args) {


        CityDatabase db = new CityDatabase();

        db.insert("New York", 0, 0);
        db.insert("Los Angeles", 100, 0);
        db.insert("Chicago", 50, 50);

        CityDataBaseLinked city = db.search("Chicago");
        if (city != null) {
            System.out.println("Found: " + city);
        }

        db.delete("New York");

        db.printNearby(0, 0, 50);

    }
}
```

**Output:**



```
Found: Chicago (50,50)
```

# Analysis of Algorithms

a) **Collect running time statistics for each operation in both implementations.**

| Insert Operation | Delete Operation | Search Operation | printNearby Operation |
|---|---|---|---|
| 0(1) | 0(N) | 0(N) | 0(N) |

Overall, the worst-case time complexity of this implementation is O(n) for most operations, except for the insert operation which has an average-case time complexity of O(1) and a worst-case time complexity of **O(n)** if a resize is needed.

b) **What are your conclusions about the relative advantages and disadvantages of the two implementations?**
When it comes to searching and deleting elements, an implementation using an array is more efficient, whereas implementing a **linked list is more efficient** for inserting elements.

c) **Would storing records on the list in alphabetical order by city name speed any of the operations?**
If records are organized in the list according to the alphabetical order of the city name, it would **speed up the search** operation because the **binary search algorithm** could be used to access the elements.

d) **Would keeping the list in alphabetical order slow any of the operations?**
Inserting new elements into the list while maintaining alphabetical order would **slow down** the insertion operation as new elements would have to be added to the correct position to preserve the alphabetical order.