ECON381 Fall 2024
Semester Project

Question 1: What kind of coordinate system can we use to denote the cells in a pointy-top hex grid?

Coordinate System: The axial coordinate system is ideal for pointy-top hex grids. Each hexagon is represented by two coordinates **(q, r)**, where:
q: The column coordinate.
r: The diagonal coordinate.

Alternatives:

Offset Coordinate System: Uses (col, row) pairs but requires different distance formulas and adjustments for odd/even rows.

Cube Coordinate System: Represents each cell using three coordinates (x, y, z) but adds redundancy since x + y + z = 0.

Preferred System: The axial coordinate system is computationally efficient because it simplifies:

Distance Calculations: Easily computed using a maximum of three absolute differences.

Intersection Checks: Easy set operations can identify overlapping cells.

Question 2: Which data structure is better suited to store the entire map?

Preferred Data Structure:

A **HashSet<HexCell>** is best for storing the map. It:
Allows efficient lookup of cells.
Facilitates set operations like union, intersection, and difference for triangulation or radar sensing.
Alternative: A 2D array is possible for fixed-sized grids but is less flexible for dynamic or sparse maps.

Question 3: Which data structure is better suited to store a region defined by the sensor reading?

Preferred Data Structure:

A **HashSet<HexCell>** is most suitable for a radar's sensed region. It:
Handles both circles (cells within d) and rings (cells between d-1 and d) naturally.

Supports efficient intersections with other sensed regions.

Circle vs. Ring Considerations:
The type of sensing (circle or ring) does not impact the choice of the data structure since both are handled by iterating over cells within the specified ranges.

Question 4: Implementation

```
import java.util.*;

public class HexGridRadar {

  static class HexCell {
    private int q, r;

    public HexCell(int q, int r) {
      this.q = q;
      this.r = r;
    }

    public int getQ() {
      return q;
    }

    public int getR() {
      return r;
    }

    @Override
    public boolean equals(Object obj) {
      if (this == obj) return true;
      if (obj == null || getClass() != obj.getClass()) return false;
      HexCell hexCell = (HexCell) obj;
      return q == hexCell.q && r == hexCell.r;
    }

    @Override
    public int hashCode() {
      return Objects.hash(q, r);
    }

    public int calculateDistance(HexCell other) {
      int dq = Math.abs(this.q - other.q);
      int dr = Math.abs(this.r - other.r);
      int ds = Math.abs((-this.q - this.r) - (-other.q - other.r));
      return Math.max(dq, Math.max(dr, ds));
    }
```

```
}

static class Radar {
    private HexCell position;
    private int minRadius, maxRadius;

    public Radar(HexCell position, int minRadius, int maxRadius) {
        this.position = position;
        this.minRadius = minRadius;
        this.maxRadius = maxRadius;
    }

    public Set<HexCell> getSensedCells() {
        Set<HexCell> cells = new HashSet<>();
        for (int q = -maxRadius; q <= maxRadius; q++) {
            for (int r = -maxRadius; r <= maxRadius; r++) {
                HexCell cell = new HexCell(position.getQ() + q, position.getR() + r);
                int distance = position.calculateDistance(cell);
                if (distance <= maxRadius && distance > minRadius) {
                    cells.add(cell);
                }
            }
        }
        return cells;
    }
}

public static void main(String[] args) {
    Scanner scanner = new Scanner(System.in);

    // Input: Dimensions or total cells (if needed for future extensions)
    System.out.print("Enter the number of radars: ");
    int radarCount = scanner.nextInt();

    // Input: Radar data
    Set<Radar> radars = new HashSet<>();
    for (int i = 1; i <= radarCount; i++) {
        System.out.print("Enter radar " + i + " position (q r), min radius, max radius: ");
        int q = scanner.nextInt();
        int r = scanner.nextInt();
        int minRadius = scanner.nextInt();
        int maxRadius = scanner.nextInt();
        radars.add(new Radar(new HexCell(q, r), minRadius, maxRadius));
    }

    // Intersection Calculation
    Set<HexCell> intersection = null;
```

```
        for (Radar radar : radars) {
            Set<HexCell> sensedCells = radar.getSensedCells();
            if (intersection == null) {
                intersection = new HashSet<>(sensedCells);
            } else {
                intersection.retainAll(sensedCells);
            }
        }

        // Output Results
        if (intersection == null || intersection.isEmpty()) {
            System.out.println("No intersection (False Positive).");
        } else if (intersection.size() == 1) {
            System.out.println("Exact triangulation: Single cell detected.");
            for (HexCell cell : intersection) {
                System.out.println("Cell: (" + cell.getQ() + ", " + cell.getR() + ")");
            }
        } else {
            System.out.println("Region detected: " + intersection.size() + " cells.");
            for (HexCell cell : intersection) {
                System.out.println("Cell: (" + cell.getQ() + ", " + cell.getR() + ")");
            }
        }
    }
}
```

Question 5: Report

Test Case

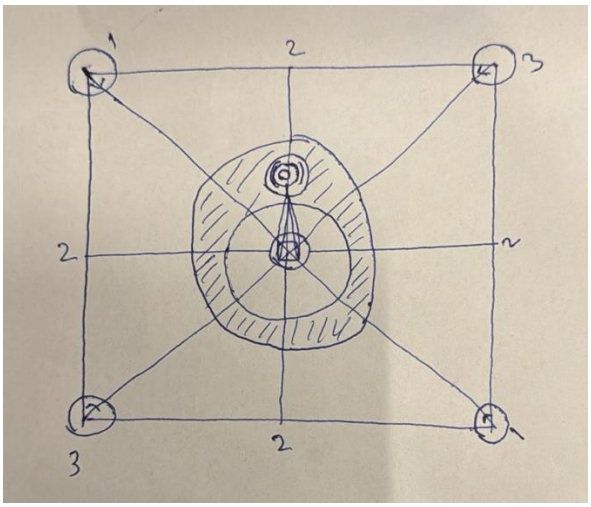
Input:

Enter the number of radars: 2
Enter radar 1 position (q r), min radius, max radius: 0 0 0 3
Enter radar 2 position (q r), min radius, max radius: 2 2 0 3

Output:

Region detected: 7 cells.
Cell: (0, 0)
Cell: (1, 1)
Cell: (1, 2)
Cell: (0, 1)
Cell: (2, 1)
Cell: (-1, 1)
Cell: (2, 2)

Visual Sketch:




```
Radar (2, 2) affected cells:
Cell: (3, 2)
Cell: (4, 0)
Cell: (2, 1)
Cell: (4, 2)
Cell: (4, 1)
Cell: (1, 3)
Cell: (3, 1)
Cell: (3, 3)
Cell: (2, 4)
Cell: (0, 3)
Cell: (1, 1)
Cell: (1, 4)
Cell: (0, 4)
Cell: (2, 2)
Cell: (2, 0)
Cell: (2, 3)
Cell: (3, 0)
Cell: (1, 2)
Cell: (0, 2)
Radar (0, 0) affected cells:
Cell: (1, -2)
Cell: (0, -1)
Cell: (-1, 0)
Cell: (-2, 1)
Cell: (2, -1)
Cell: (0, 2)
Cell: (-1, -2)
Cell: (-2, 0)
Cell: (3, -1)
Cell: (2, 1)
Cell: (1, 1)
Cell: (-2, -1)
Cell: (0, 3)
Cell: (-1, 3)
Cell: (0, 0)
Cell: (3, -3)
Cell: (2, -2)
Cell: (-3, 2)
Cell: (0, -3)
```

```
Cell: (0, 1)
Cell: (-1, 2)
Cell: (-2, 3)
Cell: (1, -1)
Cell: (2, -3)
Cell: (-3, 3)
Cell: (3, 0)
Cell: (-1, 1)
Cell: (0, -2)
Cell: (1, -3)
Cell: (-3, 0)
Cell: (-1, -1)
Cell: (2, 0)
Cell: (-3, 1)
Cell: (-2, 2)
Cell: (1, 0)
Cell: (1, 2)
Cell: (3, -2)
 Radar (5, 5) affected cells:
 Cell: (6, 4)
 Cell: (4, 6)
 Cell: (5, 4)
 Cell: (4, 5)
 Cell: (6, 5)
 Cell: (5, 6)
 Cell: (5, 5)
```