PROJECT REPORT

2022AIM1007

OVERVIEW

- Problem
- Theoretical
- Methodology
- Implementation
- Conclusion
- Results

PROBLEM

Implementation of Baseline Methodology correctly

First Problem

Generation of sets of powered nodes from directional dataset

Second Problem

Correct implementation and future algorithm to reduce execution time and no. of transmitters.

FORMULATION

Consider a wireless sensor network consisting of N nodes, each characterized by its location in a 2D space (x,y) and a communication radius R. The goal is to determine the optimal placement of transmitters with directional antennas to cover as many nodes as possible while minimizing the number of transmitters needed.

FORMULATION

Let:

- N be the total number of nodes in the network.
- i be the index representing a specific node.
- Pi be the set of powered nodes when considering the transmitter at node i.
- β be the beam angle of the directional transmitter.
- dij be the Euclidean distance between nodes i and j.
- α be the angle between the line connecting nodes i and j and the x-axis.

The objective is to find the placement of transmitters, T, such that the union of powered nodes across all transmitters is maximized

$$max\sum_{i=1}^{N} |Pi|$$

FORMULATION

Subject to the constraint that a node j is powered by transmitter i if it lies within the beam angle and communication radius:

Here, αij is the angle between the line connecting nodes i and j and the x-axis, and ∣Pi∣ is the cardinality of the set Pi.

$$j \in Pi \Leftrightarrow \left(-\frac{\beta}{2} \leqslant a_{ij} \leqslant \frac{\beta}{2}\right) \cap \left(d_{i_j} \leqslant R\right)$$

Overview :

The goal is to strategically place transmitters with directional antennas to cover a set of nodes in a 2D space. The problem involves finding the optimal placement of transmitters to maximize the coverage of powered nodes while minimizing the number of transmitters needed.

Assumptions :

No of nodes , grid size are fixed in dataset. beam angle to be constant . Transmitter antenna is directional, Node antenna is omnidirectional.

EVALUATION PARAMETERS

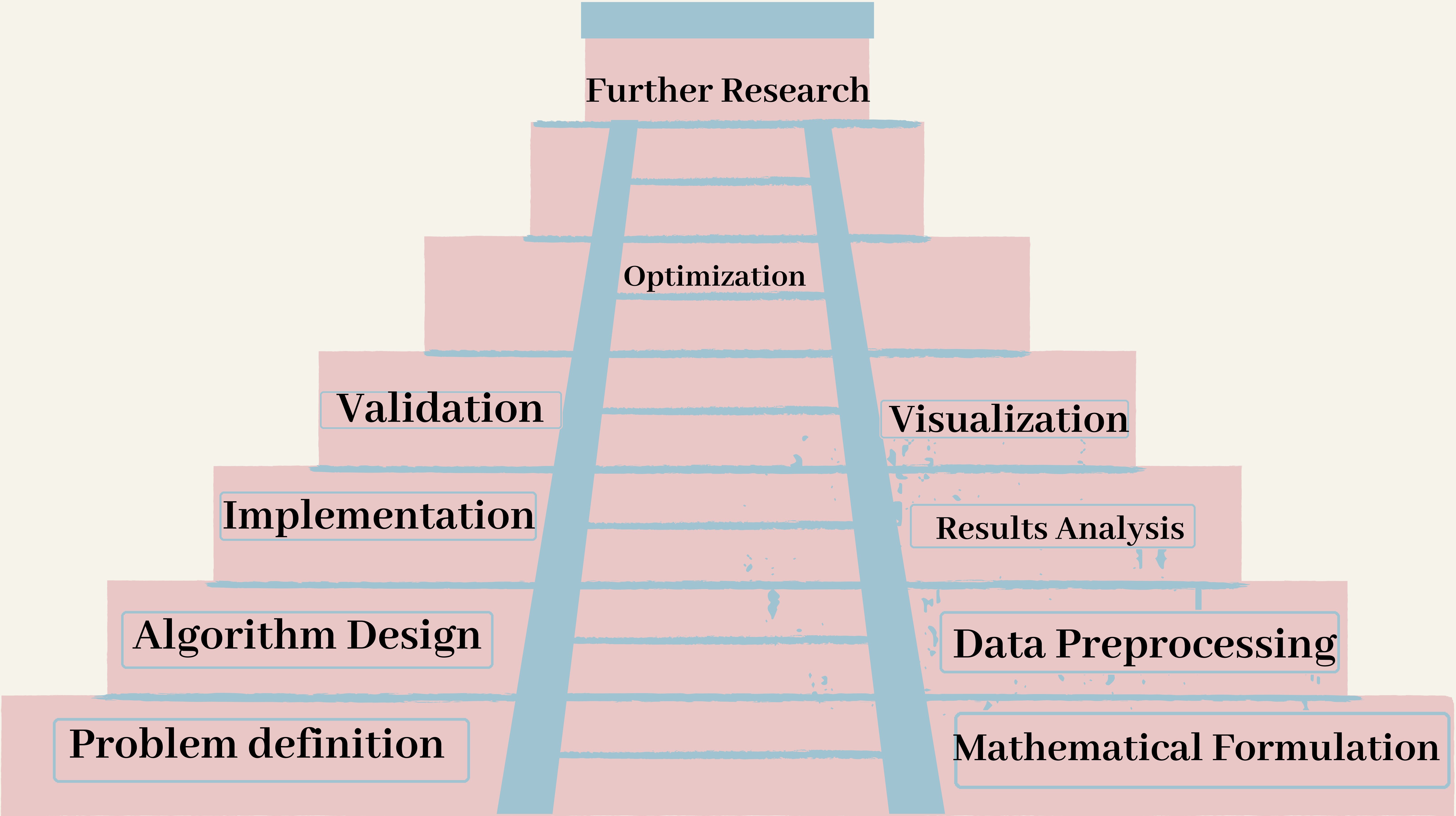
EXECUTION TIME

Execution time for finding sets for complete dataset.

NO. OF TRANSMITTERS

Minimum no of transmitters required for covering whole network.

METHODOLOGY



IMPLEMENTATION

Reading Dataset

Reading csv file data for node location and radii

Validation

Verifying results with network of nodes and checking consistency.

Powered Sets Generation

If node falls within beam angle and radii of nodes capture transmitter, nodes are powered. Rotating transmitter with fixed beam from 0-360.

Visualization

Various plots of node coverage, no of transmitters vs Nodes etc.

RESULTS

For 50x10x1.csv

Nodes - 10

Grid Size - 50x50

Uniqueness - 1

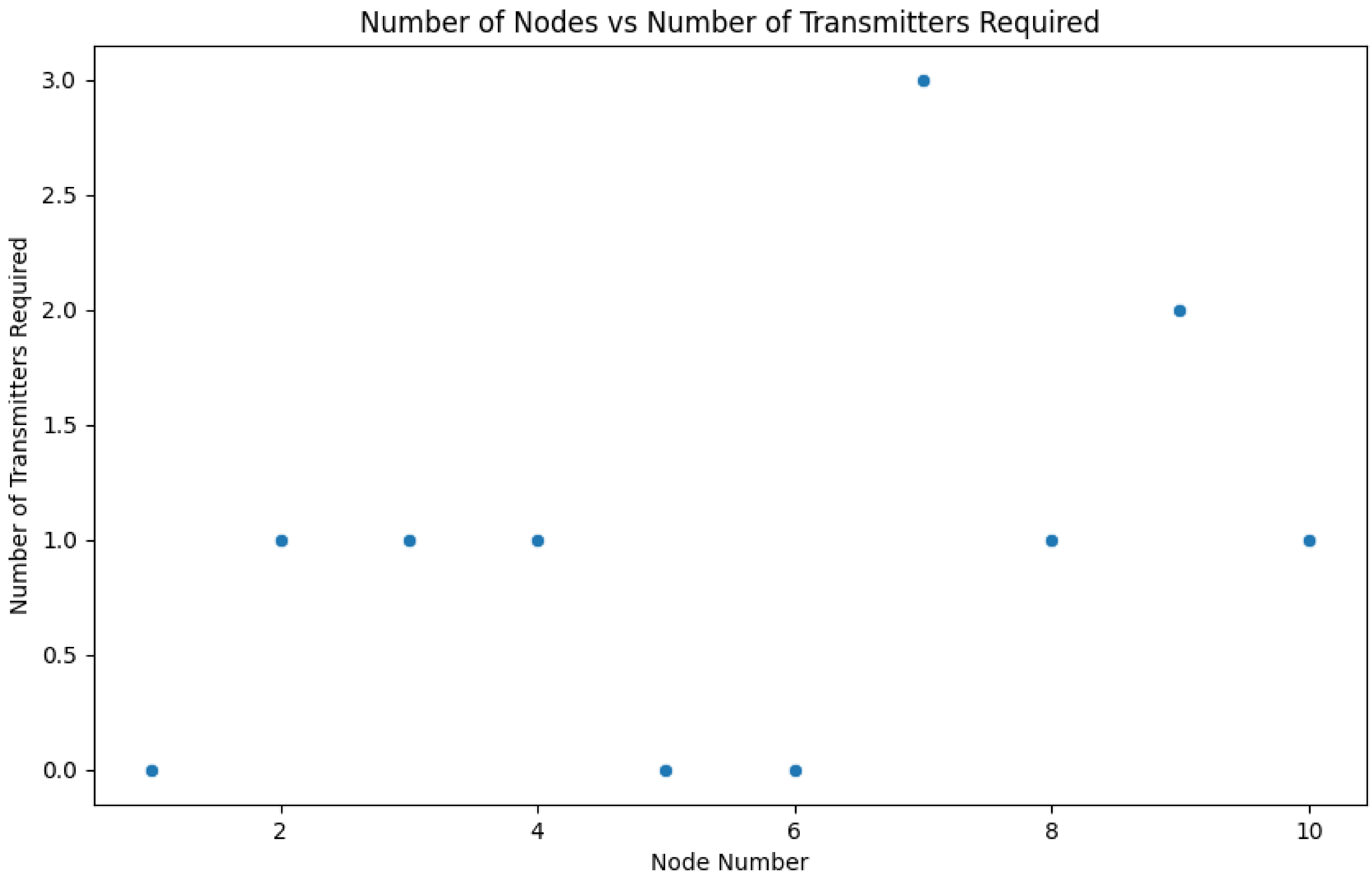
```python
            print(f"  Angle ({angle}-{(angle + beam_angle) % 360}) - Nodes powered: {len(powered_nodes)} - Powered Nodes: {list(powered_nodes)}")

            results_table.append({
                'Node': j + 1,
                'Powered Nodes': len(powered_nodes),
                'Transmitter Location': loc[j],
                'Angle Range': (angle, (angle + beam_angle) % 360),
                'Powered Nodes List': list(powered_nodes)
            })

            powered_nodes_list.append(powered_nodes)

        powered_nodes_sets.append(powered_nodes_list)

    results_df = pd.DataFrame(results_table)

    return powered_nodes_sets, results_df

def is_node_in_beam(source, target, angle, beam_angle, radius):
    angle_rad = np.deg2rad(angle)
    delta_x = target[0] - source[0]
    delta_y = target[1] - source[1]
    node_angle = np.arctan2(delta_y, delta_x)

    # Ensure the node angle is within the range [0, 360)
    node_angle = (node_angle + 2 * np.pi) % (2 * np.pi)

    # Check if the transmitter is within the node's range
    transmitter_distance = np.sqrt(delta_x**2 + delta_y**2)
    return -beam_angle/2 <= (node_angle - angle_rad) <= beam_angle/2 and transmitter_distance <= radius

# Replace this line with your actual file path
csv_file_path = r'C:\Users\IIT_ROPAR_User\Desktop\MTP\dir_2023_dataset_ropar_csv\RDILP_CSV_50_10_1.csv'

# Read CSV file without header and with specified column names
node_data = pd.read_csv(csv_file_path, header=None, usecols=[1, 2, 3], names=['X-coordinate', 'Y-coordinate', 'Radius'])

# Extract node locations and radius from the CSV file
node_locations = node_data.values

# Beam angle for rotation
beam_angle = 15
```

Baseline_pycripter.py | latest.py | Visualization with dotted radii.py | correct1_with_tabulation_min_no_otransmitters.py | module1.py

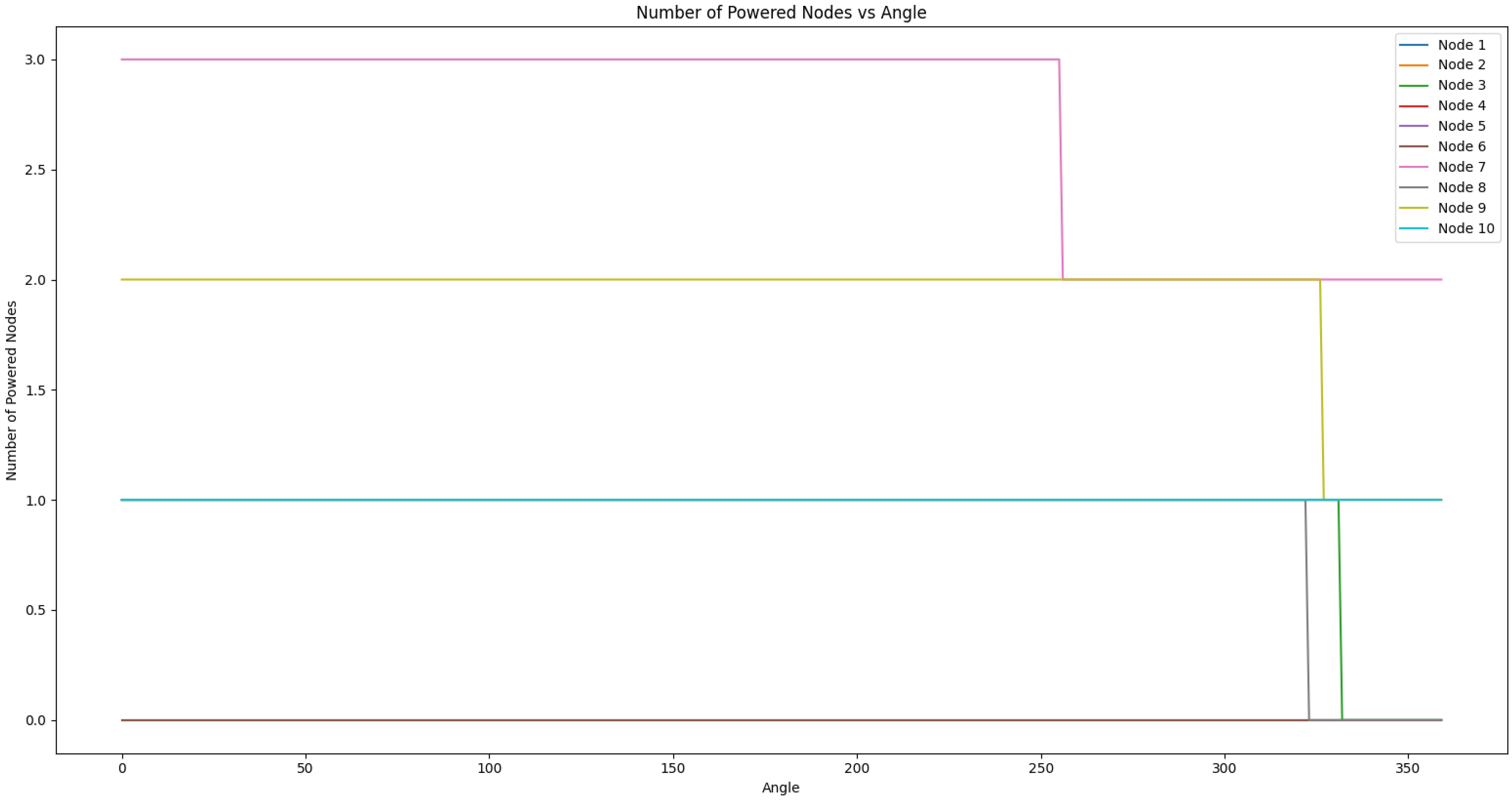
Python Interpreter

```
3596    10              1  ...  (356, 11)             [7]
3597    10              1  ...  (357, 12)             [7]
3598    10              1  ...  (358, 13)             [7]
3599    10              1  ...  (359, 14)             [7]

[3600 rows x 5 columns]

Minimum Number of Transmitters Required: 7
>>>
```

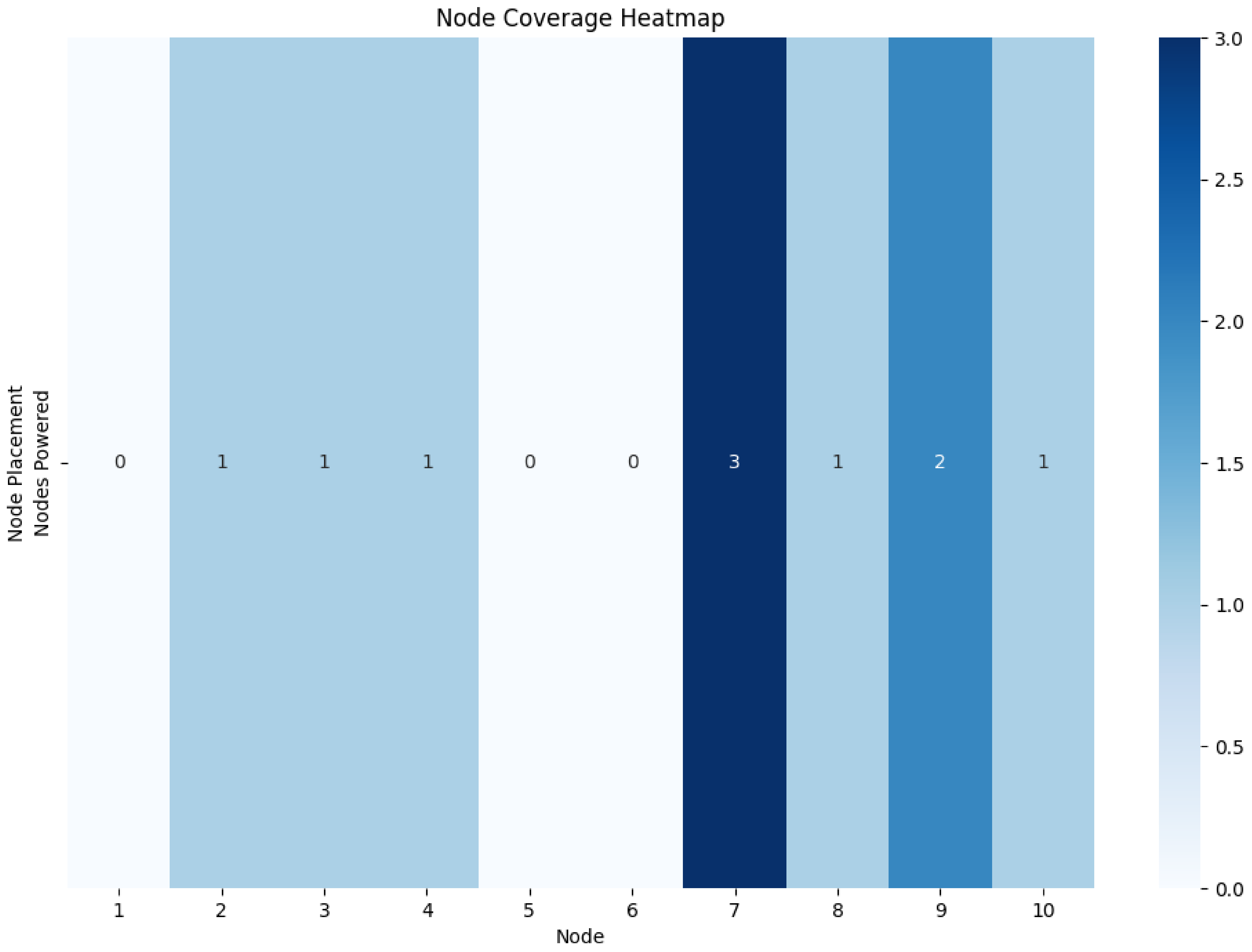
RESULTS


Number of Nodes vs Number of Transmitters Required
Number of Transmitters Required
Node Number
0.0
0.5
1.0
1.5
2.0
2.5
3.0
2
4
6
8
10

RESULTS

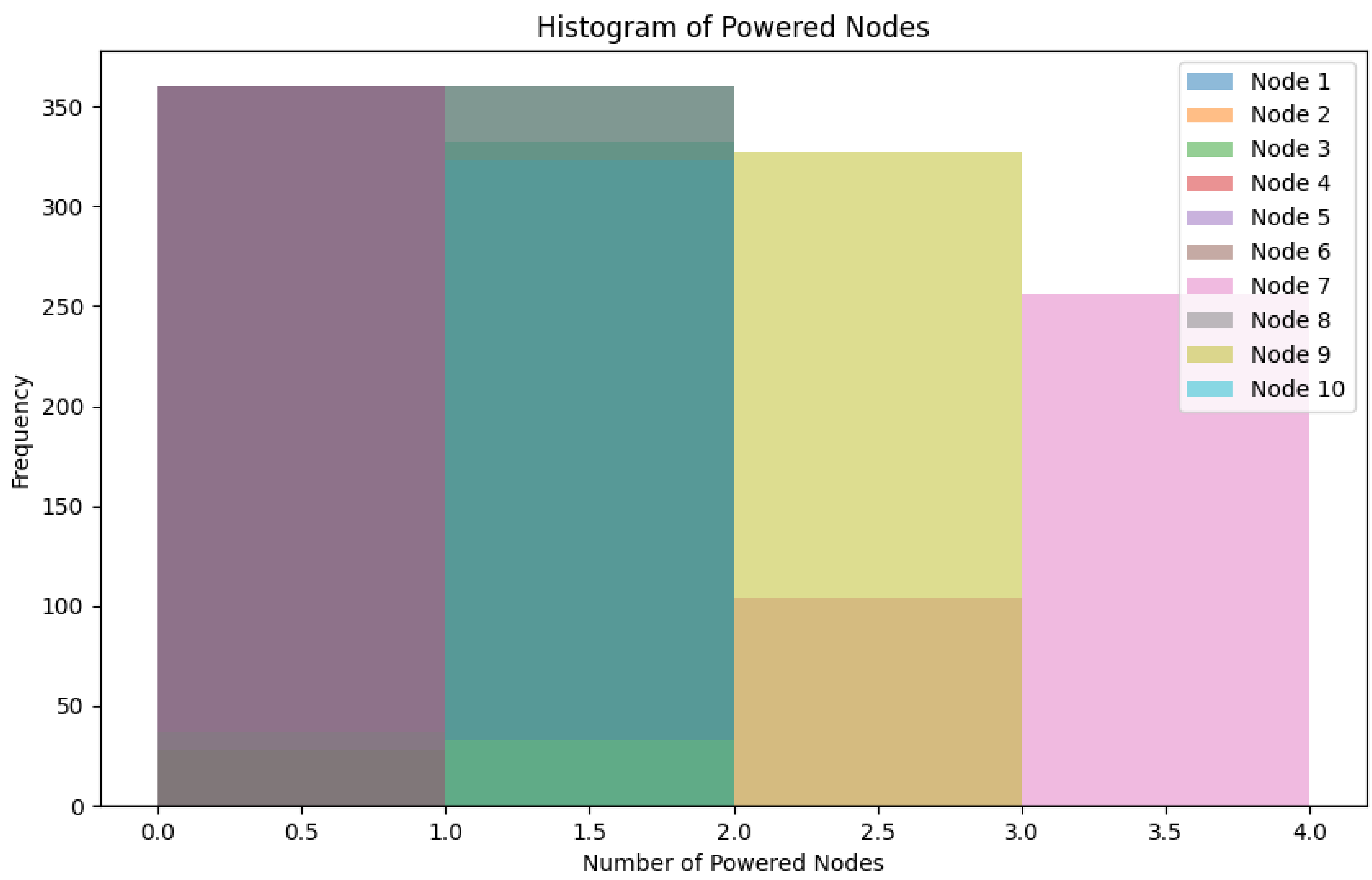

Number of Powered Nodes vs Angle
Number of Powered Nodes
Angle
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
50
100
150
200
250
300
350
Node 1
Node 2
Node 3
Node 4
Node 5
Node 6
Node 7
Node 8
Node 9
Node 10

RESULTS

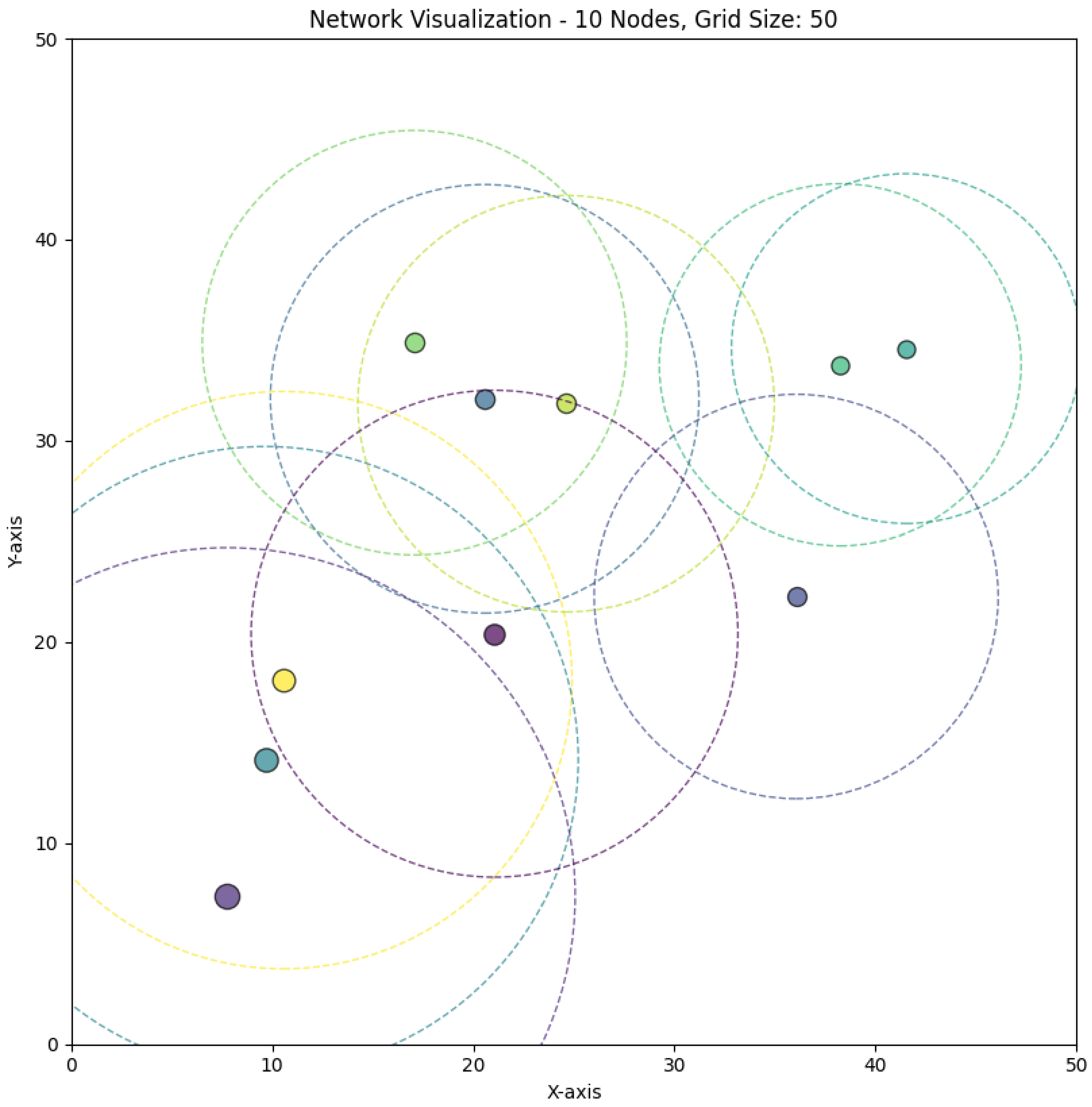


Node Coverage Heatmap
Node Placement
Nodes Powered
0
1
1
1
0
0
3
1
2
1
1
2
3
4
5
6
7
8
9
10
Node
3.0
2.5
2.0
1.5
1.0
0.5
0.0

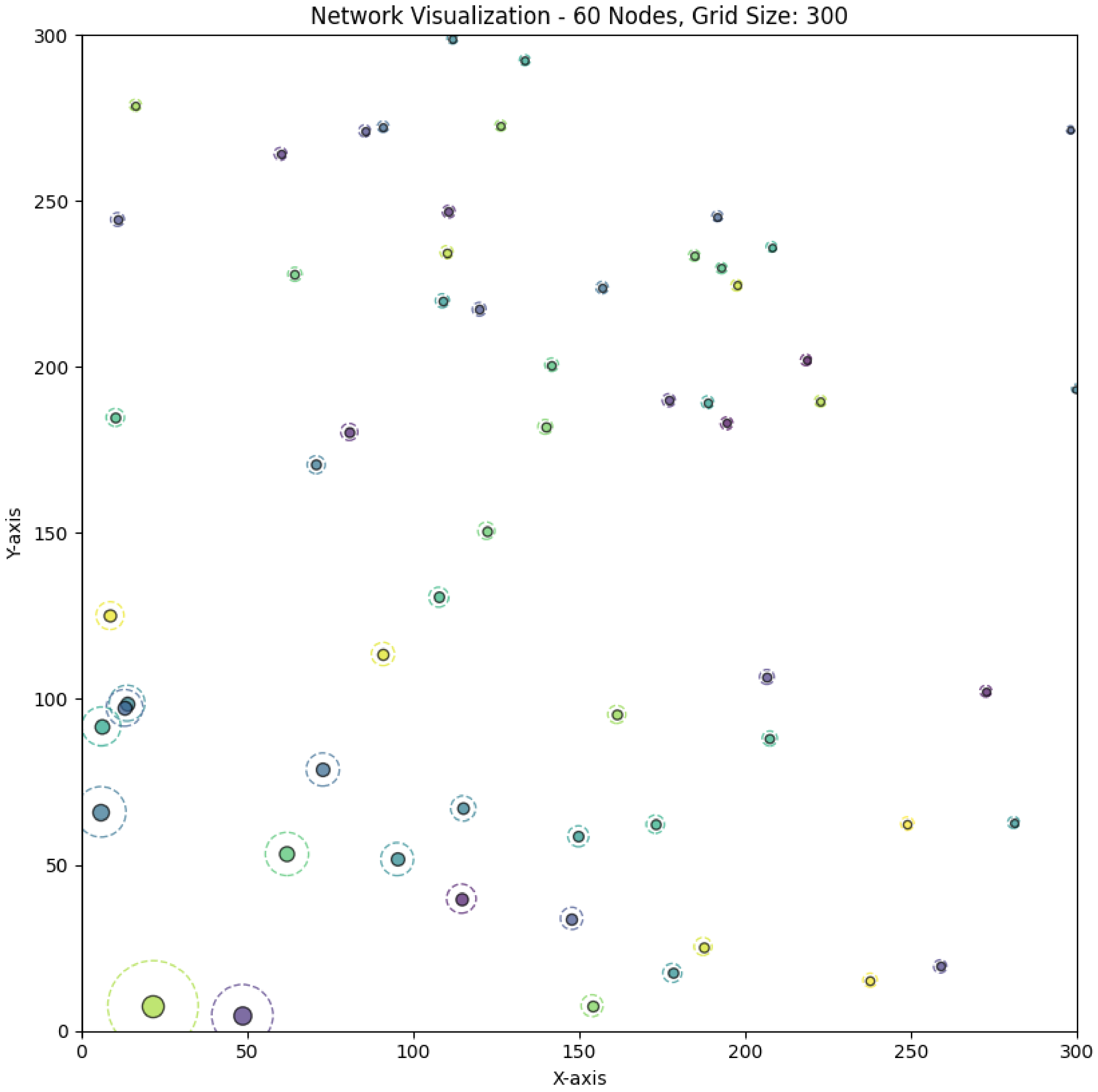
RESULTS



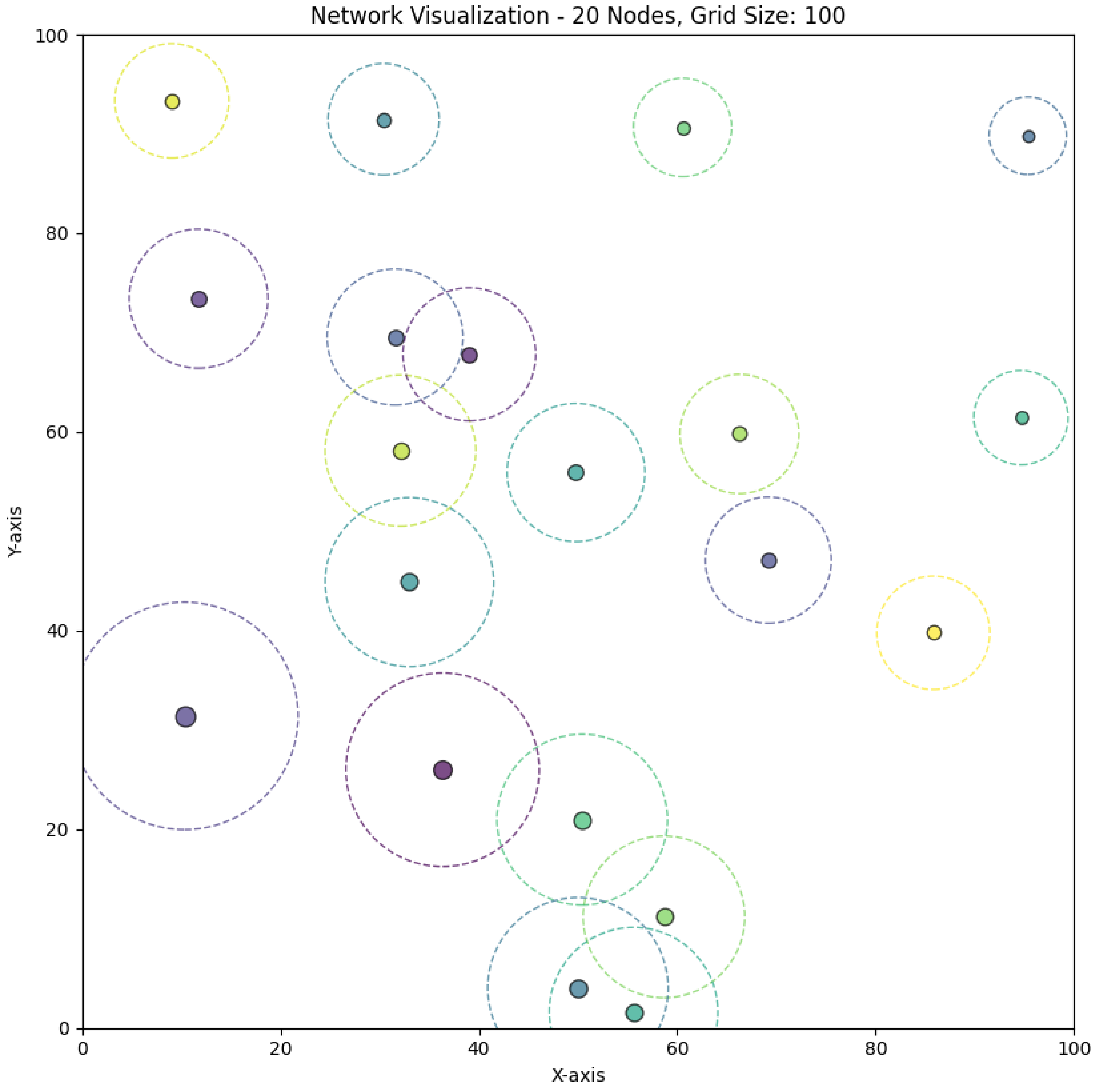
Histogram of Powered Nodes
Frequency
350
300
250
200
150
100
50
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Number of Powered Nodes
Node 1
Node 2
Node 3
Node 4
Node 5
Node 6
Node 7
Node 8
Node 9
Node 10


Network Visualization - 10 Nodes, Grid Size: 50
50
40
30
20
10
0
0
10
20
30
40
50
Y-axis
X-axis

NETWORK VISUALIZATION



NETWORK VISUALIZATION



FUTURE WORKS

- Create more efficient ways to output results. e.g tabular, output to file.
- Work on Methodology 2 , currently testing density based placement of transmitter.
- Run complete dataset together for evaluation and compare results.

ISSUES FACED

- **Validation**

  Real time validation of results, and visualization.

- **Evaluation**

  Time and No. of Transmitters evaluation.

THANK YOU