Application of Metaheuristics for Localization, Energy and Path Optimization in Sensor Network

Project Team

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B. Tech. in Computer Science and Engineering

FACULTY OF ENGINEERING AND TECHNOLOGY

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Certificate

This is to certify that the Project titled "Application of Metaheuristics for Localization, Energy and Path Optimization in Sensor Network" is a bonafide work carried out in the Department of Computer Scienceand Engineeringby Biswajit Basak, Rahul Kumar, Rohan Kumar, Tushar Agarwal bearing Reg. No. 15ETCS002008, 15ETCS002033, 15ETCS002036, 15ETCS002048 in partial fulfilment of requirements for the award of B. Tech. Degree in Computer Science and Engineering of M.S. Ramaiah University of Applied Sciences.

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Declaration

Application of Metaheuristics for Localization, Energy and Path Optimization in Sensor Network

The project work is submitted in partial fulfilment of academic requirements for the award ofB. Tech. Degree in the Department ofComputer Scienceof the Faculty of Engineering and Technologyof M. S. Ramaiah University of Applied Sciences. The project report submitted herewith is a result of our own work and in conformance to the guidelines on plagiarism as laid out in the University Student Handbook. All sections of the text and results which have been obtained from other sources are fully referenced. We understand that cheating and plagiarism constitute a breach of University regulations, hence this project report has been passed through plagiarism check and the report has been submitted to the supervisor.

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Date: May 2019

Acknowledgements

It is with extreme pleasure and pride that we present our B-Tech. dissertation titled "***Application of Metaheuristics for Localization, Energy and Path Optimization in Sensor Network***". We would like to express our sincere thanks and gratitude to the following people, who stood by us throughout, helping us with much required inputs, guidance, knowledge and supported us.

We take great pleasure to express our sincere thanks and gratitude to academic project guide Ms. **Vaishali R Kulkarni**Asst. Professor Department of CSE, for her support, guidance and suggestions throughout the project which is leading this project for the completion.

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Lastly, we would like to thanks our parents and friends for their continued support, encouragement and motivation and God for paving our way of success in this object.

Summary

This project is about the application of metaheuristics for localization, energy and path optimization in sensor network. These are the three challenges that will be addressed in this project and finally the developed solution will be compared with thetraditional approach. Wireless sensor networks (WSN) are networks of autonomous sensor nodes (motes) and one or more base stations.Possible applications of WSN are in monitoring and sensing e.g.- Traffic surveillance, health care, natural calamities, environmental monitoring etc.Challenges in WSN are deployment, routing, localization and energy consumption.There is a need to address these challenges and provide a robust, autonomous, flexible and inexpensive solution. Swarm Intelligence (SI) algorithms have such qualities[1].

This project mainly focuses on comparing the traditional approaches with the bio-inspired approaches in dealing with the three issues which are – path planning, localization and energy optimization. By completing this project, people will come to know about the difference between the two approaches and start using thebetter one.

Methods and Methodologies

- To do literature survey in SI algorithms and challenges in WSN.
  - ✓ Current technology being used
  - ✓ Collecting information about the issues in WSN

- To apply SI algorithms to achieve accurate location estimation, energy optimization and deployment of sensors in WSN.
  - ✓ Localization issue of WSN will be solved using Particle Swarm Optimization (PSO).
  - ✓ Path Planning issue will be solved using Mobile Anchor with Trilateration.

- ✓ Energy Consumption issue will be solved using LEACH(Low-Energy Adaptive Clustering Hierarchy) protocol.

- To implement and test the simulations.
  - ✓ Python will be used for implementation.
  - ✓ Test Scenarios with known data.
  - ✓ Test Scenarios with unknown data.
- To perform comparative analysis of traditional deterministic algorithms with bio-inspired SI algorithms.
  - ✓ Efficiency of SI Algorithm.
  - ✓ Energy Consumption of Wireless Sensors.
- To document the project report.

This project highlights the three challenges in wireless sensor network which are localization, energy and path optimization. In order to deal with these challenges, there lies the traditional approach and also the bio-inspired approach. This project aims at comparing both the approaches and highlighting the better one.Things like LEACHprotocol and trilateration algorithm for localization will come into picture.

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1. Introduction

1.1 Introduction

Different issues that are going to be explored are basically different types of challenges in WSN. The issues are regarding the deployment of sensors which are deployed randomly at different positions. The position of the sensor will have latitude, longitude and height. Another issue is regarding routing. Routing is basically the path the cluster head is going to follow to connect to different hops. Another issue is localization. Localization is basically finding the total number of nodes that have been localized. It will help to trace the data based on the type of nodes. Last issue is regarding the energy consumption. Basically, all the nodes are connecting to the base station, which requires more energy consumption as all the nodes are communicating to the base station. Battery energy consumption is also high due to this as all the nodes are communicating to the base station[2].

Hence, there is a need to address the challenges that have been mentioned in the above paragraph. In order to tackle those challenges, it is required to provide solution. The solution can be provided through Swarm Intelligence (SI) algorithms which have different qualities which are robust, autonomous, flexible and inexpensive.

1.2 Scope

The project mainly focuses on comparing the traditional approaches with the bio-inspired approaches in dealing with the three issues which are – path planning, localization and energy optimization. By focusing on the central topic of the project, the project goal can be achieved. It is needed to implement and test the simulations. SI algorithms has to be applied to achieve accurate location estimation, energy optimization and deployment of sensors in WSN. By completing this project, people will

come to know about the difference between the two approaches. Finally, people will start using the better approach [3].

In order to apply SI algorithms which will be done to achieve accurate location estimation, energy optimization and deployment of sensors in WSN. The localization issue of WSN will be solved using Particle Swarm Optimization (PSO).Path Planning issue will be solved using Trilateration.Energy optimization will be solved using LEACHProtocol.

For the implementation and testing of the simulations, Python will be used. Here, test scenarios with known data. In order to perform comparative analysis of traditional deterministic algorithm, the bio-inspired SI algorithms are considered which increases the efficiency of SI Algorithm and energy Consumption of Wireless Sensors.

The project also aims to perform comparative analysis of traditional deterministic algorithms with bio-inspired SI algorithms [4].

1.3 Conclusion

The conclusion of the chapter is that in this chapter the introduction on the project is being done. The illustration the scope and the organization of the project is being done. A WSN (Wireless Sensor Network) can be defined as a network of devices capable of communicating through wireless links the information collected from a monitored field. The data is transmitted via multiple nodes and the data is connected to other networks with a gateway.The limitations that pose to the WSN include various environmental factors such as blockage by plants, animals, building etc, energy loss due to continuous transmission of energy, locate various nodes that are present in the networks. Hence to prevent these limitations and to push forward the applications, various bio-inspired algorithms are used which reduced the issues that are caused in the environment or are a part of the WSN itself. These bio-inspired algorithms will help resolve the issues that our project is trying to address. Different scope of the project has been mentioned which gives a brief insight of the project.

2.Background Theory

2.1 LEACH Protocol

LEACH stands for Low-Energy Adaptive Clustering Hierarchy. LEACH's goal is to reduce the energy consumption needed to create and maintain clusters to enhance a WSN's lifetime. LEACH is a hierarchical protocol in which the majority of nodes are transmitted to cluster heads and the cluster heads aggregate and compress the data and forward it to the base station. For P rounds, where P is the desired percentage of cluster heads, nodes that were cluster heads cannot become cluster heads again. Each node then has a 1/P likelihood of becoming a cluster head again. Each node not a cluster head selects the closest cluster head at the end of each round and joins that cluster. The cluster head then creates a schedule to transmit its data for each node in its cluster[5].

The main objectives of LEACH are:

- Extension of the network lifetime
- Reduced energy consumption by each network sensor node
- Use of data aggregation to reduce the number of communication messages

LEACH's basic operations are organized in two separate phases. The first phase consists of two steps in the selection of cluster heads and the formation of clusters. The second phase is the stable-state phase that focuses on collecting, aggregating, and delivering data to the base station. The setup duration is assumed to be relatively shorter than the t-state phase in order to minimize the overhead protocol [6].

2.2 Wireless Sensor Network

A WSN can be defined as a network of devices capable of communicating through wireless links the information collected from a monitored field. The data is transmitted via multiple nodes and the data is connected to other networks with a gateway.

WSNwere initially designed to facilitate military operations but its application has since been extended to health, traffic, and many other consumer and industrial areas. A WSN consists of sensor nodes. The equipment for the sensor node includes a radio transceiver, an antenna, a microcontroller, an electronic interfacing circuit, and a source of energy, usually a battery. Sensor nodes can also vary in size from small to large. As such, their prices also vary depending on the functionality parameters of a sensor like energy consumption, computational speed rate, bandwidth, and memory [7].

2.3 Ant Colony Optimization (ACO)

The ACO is for finding optimal paths that is based on the behaviour of ants searching for food.At first, the ants wander randomly. When an ant finds a source of food, it walks back to the colony leaving "pheromones" that show the path has food. When other ants come across the markers, they are likely to follow the path with a certain probability. If they do, they then populate the path with their own markers as they bring the food back. As more ants find the path, it gets stronger until there are a couple streams of ants traveling to various food sources near the colony.

Because the ants drop the pheromones every time they found, they bring food, shorter paths are more likely to be stronger than longer path, hence optimize the "solution." In that time, some ants are still randomly searching for closer food sources. A similar approach of this can be used to find near-optimal solution to the traveling salesman problem[8].

The route is no longer populated with pheromones and slowly declines once the food source is depleted. Because the ant-colony works on a very dynamic system, in graphs

with changing topologies, the ant colony algorithm works very well.Examples of such systems include computer networks and artificial intelligence (AI) simulations of workers

2.4 Particle Swarm Optimization (PSO)

PSO is a population-based technique of stochastic optimization inspired by bird flocking social behaviour. The system is initialized through the updating of generations with a population of random solutions and searches for optima. The potential solutions, called particles, fly through the problem space in PSO by following the current optimum particles. The PSO algorithm simultaneously maintains several potential solutions. Each solution is evaluated by an objective function to determine its fitness during each iteration of the algorithm. Each solution in the fitness landscape (search space) is represented by a particle. To find the maximum value returned by the objective function, the particles "fly" or "swarm" through the search space[9].

It is shown that PSO has a faster, cheaper way of achieving better results compared to other methods. Another reason PSO is appealing is that few parameters need to be adjusted. One version works well in a wide variety of applications, with slight variations.PSO has been used for approaches that can be used across a wide range of applications, as well as for specific requirement-focused applications [10].

2.5 Literature Survey

Sl No	Author name	Journal name and year of publication	Research focus	Tools and algorithms used.	Demerits	Conclusion
1	Mohamed Sandeli, SouhamMeshoul	Computational Intelligence Approaches for Energy Optimization in WSN	One of its main goals is to obtain approximate solutions to NP-hard problems efficiently.	ACO	Major challenges in WSN lies in the energy constraint and computation resources available at the sensor nodes	The effectiveness of theproposed methods has been assessed and compared with other peers that use clustering technique (a traditional protocol LEACH)
3	Frank Comeaua, Nauman Aslam	Analysis of LEACH Energy Parameters	Analyzes how the parameter values used in the LEACH protocol vary	LEACH	Parameter selection has a significant effect on the lifetime of the network	LEACH is a popular protocol used in analyzing and simulating WSN.
4	CognNeurodyn	An improved WSN genetic algorithm-based localization algorithm	The objective is to minimize the total estimation error of the WSN location problem	ACO	To increase the accuracy of positioning and also the accuracy of positioning is relatively low	Localization of nodes is an important issue in WSNs, as many applications depend on knowing where sensor nodes are located
5	James Blondin	Applications in Parameterization of Classifiers [2016]	For PSO itself, you need to find optimal parameters	PSO	The optimization process should be run several times because of randomized aspects to	Important acceleration with PSO over exhaustive search

					determine if the results are consistent.	
6	Eric W. Weisstein	Real world application of ACO	ACO has been and remains a fruitful paradigm for effective algorithms for combinatorial optimization solutions	ACO	Another common area for testing the effectiveness of ACO algorithms is scheduling problems	Both the effectiveness of its application and its theoretical grounding have shown that ACO is one of the most successful paradigms in the metaheuristic area.

2.6 Conclusion

In this chapter, the background theory has been depicted. Different key aspects has been considered and explained. Different algorithms that has been used in the project has been explained. This chapter also contains the table of the literature survey. The table consists of different author name, journal name, focus, demerit and conclusion of different papers. In the next chapter aim and objectives would be demonstrated.

3. Aim and Objectives

This chapter focuses on defined title and Aim of the project correctly and clearly. Later this chapter also includes the required objectives that needed to be fulfilled in order to complete this project.

3.1 Title

Application of metaheuristics for localization, energy and path optimization in Sensor Network.

3.2 Aim

To apply SI algorithms to address the challenges in localization, energy consumption and path optimization of sensors in WSN.

3.3 Objectives

1. To do literature survey in SI algorithms and challenges in WSN.
2. To apply SI algorithms to achieve accurate location estimation, energy optimization and deployment of sensors in WSN.
3. To implement and test the simulations.
4. To perform comparative analysis of traditional deterministic algorithms with bio-inspired SI algorithms.
5. To document the project report.

3.4 Method and Methodology

Objective No.	Statement of the Objective	Method/ Methodology	Resources Utilised
1	To do literature survey in SI algorithms and challenges in WSN.	1.1 Current technology being used 1.2 Collecting information about the issues in WSN	IEEE project paper and reputed websites along with Books from orally Publications.
2	To apply SI algorithms to achieve accurate location estimation, energy optimization and deployment of sensors in WSN.	2.1 Localization issue of WSN will be solved using ACO. 2.2 Path Planning issue will be solved using PSO. 2.3 Energy Consumption issue will be solved using Firefly Algorithm	SI algorithms, Research papers
3	To implement and test the simulations.	3.1 MATLAB and Python will be used for implementation. 3.2 Test Scenarios with known data. 3.3 Test Scenarios with unknown data	Python and MATLAB
4	To perform comparative analysis of traditional deterministic algorithms with bio-inspired SI algorithms.	4.1 Efficiency of SI Algorithm 4.2 Energy Consumption of Wireless Sensors	Developed code
5	To document the		MS Word

	project report.		

3.5 Conclusion

In this chapter, the aim of the project has been depicted. The objectives that are to be fulfilled are also listed. This chapter also contains the objective table that are used followed. The table contains statement of the objective, methodologies and the resources utilized. In the next chapter the problem-solving approach would be demonstrated.

4. Problem Solving

4.1 Design and Development

In this part the algorithm that will be used for the traditional methods will be designed. This designed traditional methods will then be compared against bio inspired algorithms. The traditional methods constitute of algorithms such as LEACH protocol, trilateration and path planning using mobile anchors. These methods will be compared with their respective bio inspired methods such as firefly algorithm, ACO and PSO. Hence these bio inspired algorithms are also to be designed. And at the end the efficiency and the performance measure will be illustrated or tabulated.

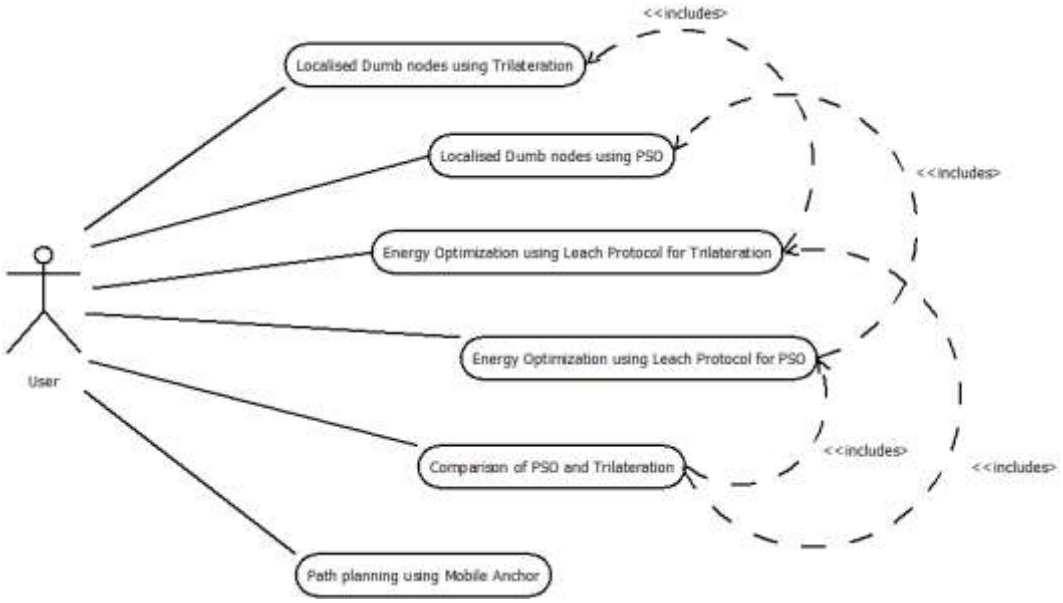

Figure 1: Use case diagram for Interface

In this design, we can see that the user can do some task such as localised the dumb nodes using Trilateration and PSO. The energy optimization using LEACH protocol for

Trilateration and PSO can be done. Then the user can the compare PSO and Trilateration based on the time taken and error. The mobile anchor will help path planning.

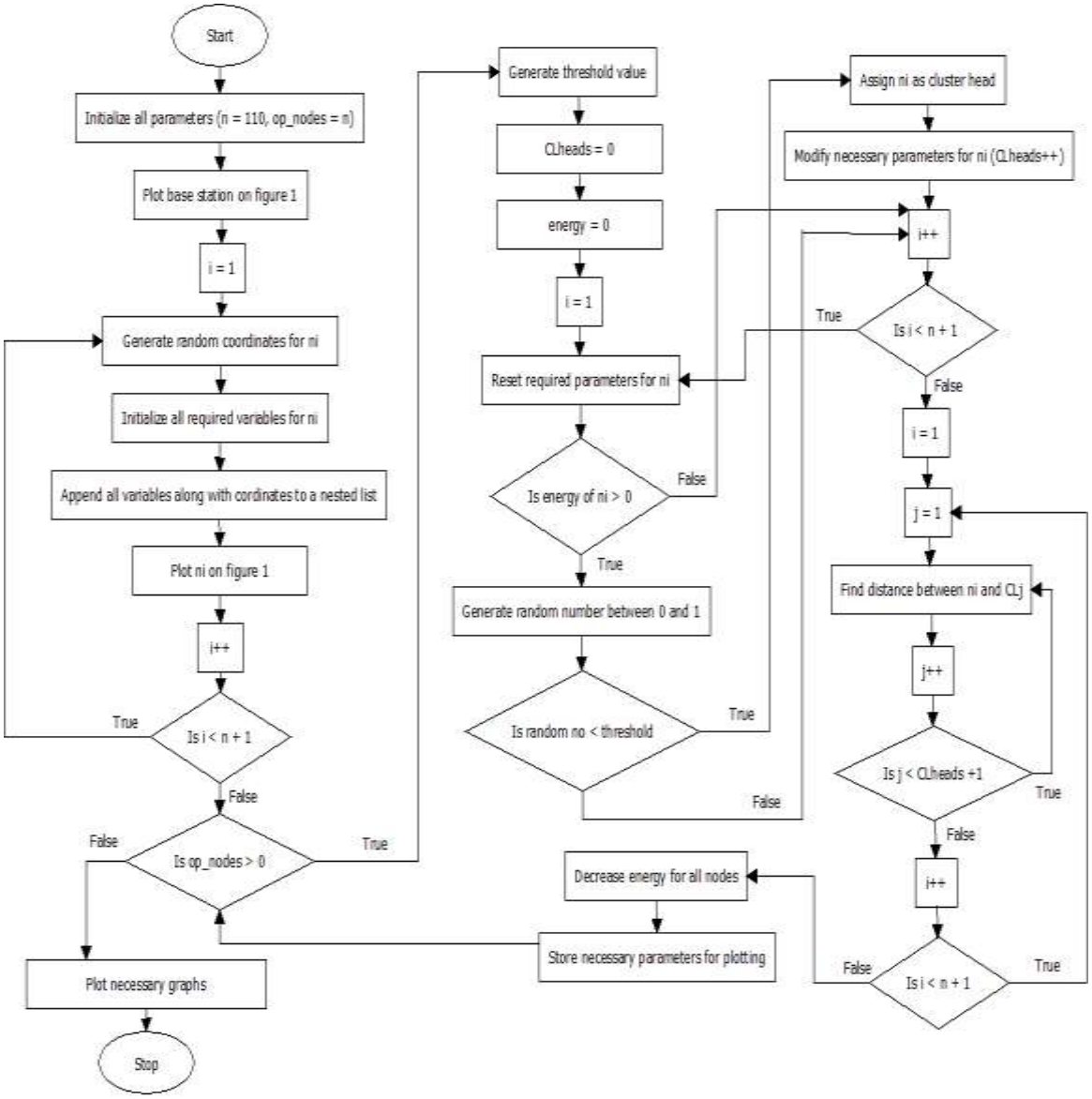

Figure 2: Screenshot of the block diagram of the LEACH

This figure shows the detailed block diagram for LEACH protocol. It basically tries to increase the lifetime of WSN by dividing the nodes into clusters and thereby just allowing nodes to communicate with respective cluster heads. Only cluster heads are

allowed to communicate with the base station and also the selection of cluster heads is randomized so that different nodes are elected as cluster heads.

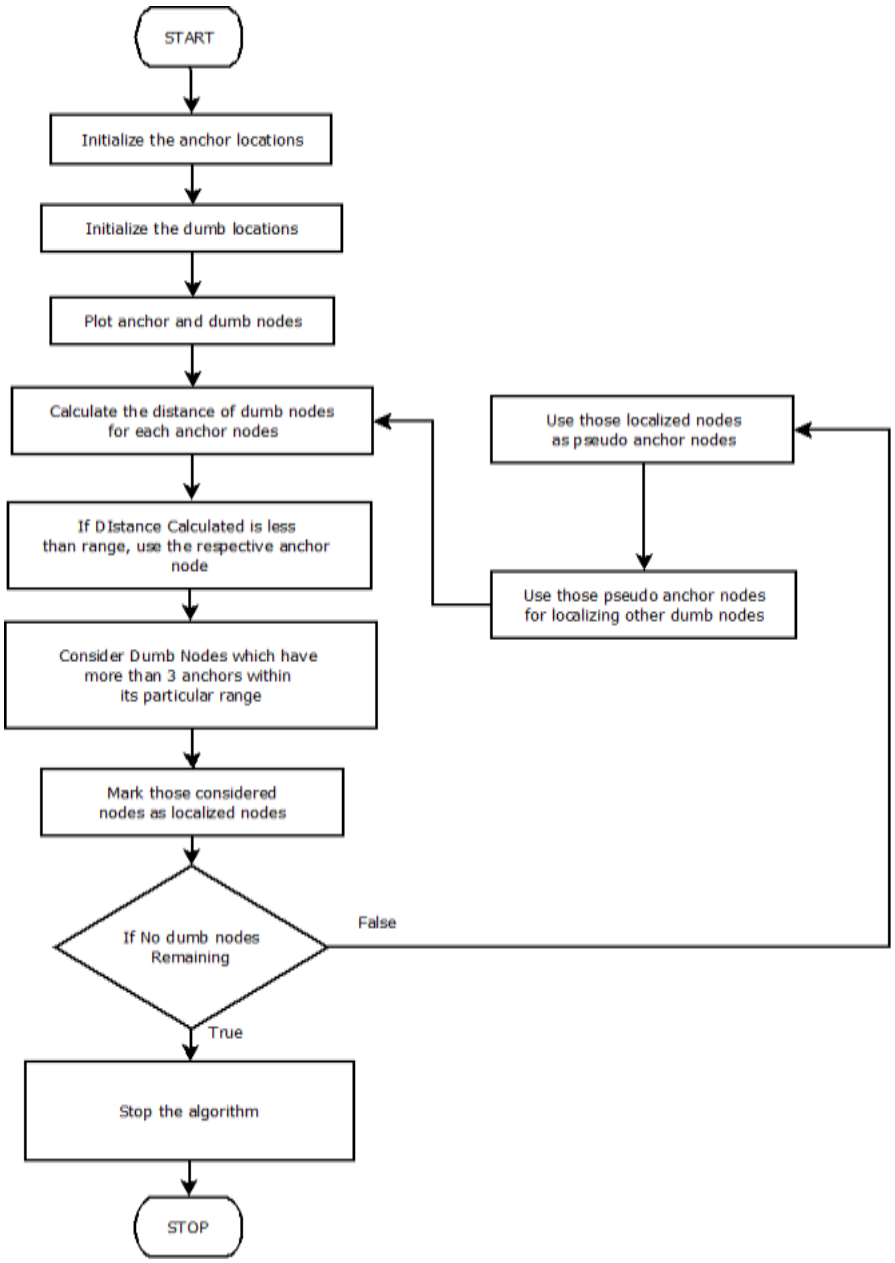

Figure 3: Screenshot of the block diagram forTrilateration.

This is the flowchart for trilateration. In this process anchor nodes are used to localize dumb nodes and those localized dumb nodes are used tolocalize more number of nodes.

The name trilateration is used since the localized dumb nodes falls between three anchor nodes. This flowchart explains how the algorithm is used for solving our problem.

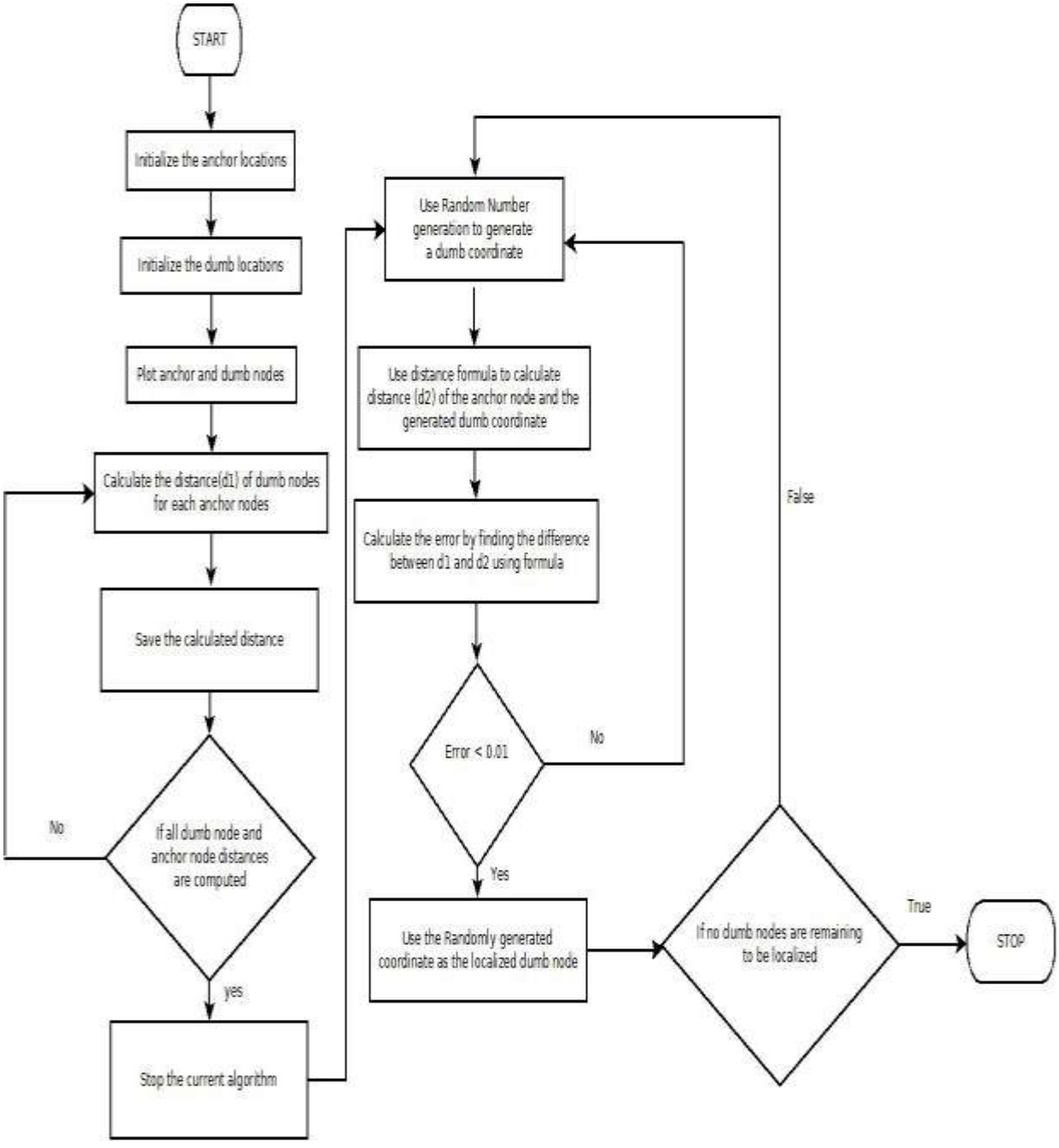

Figure 4: Screenshot of block diagram for PSO.

This is the flowchart which demonstrates localization using PSO. Here minimization of error has been performed and the nodes having less error are localized.

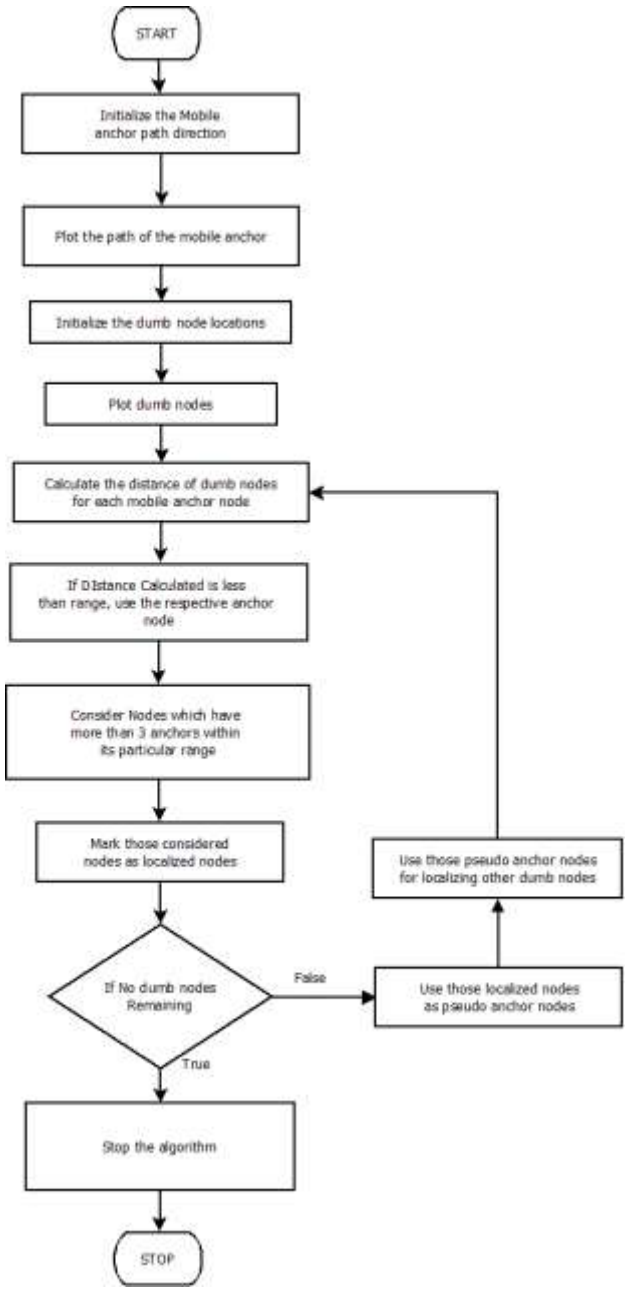

Figure 5: Screenshot of the block diagram of Mobile Anchor.

This is the flowchart which demonstrated the trilateration algorithm used for mobile anchor to solve path planning problem. Here the mobile anchors are given specific

coordinates to move from one point to the other point. Any dumb nodes that falls between the coordinates of the moving anchor nodes gets localized.

4.2 Design, Simulation and Implementation

For the design purpose, the algorithm for the traditional methods such as LEACH protocol, trilateration and path planning using mobile anchors will be written. Also, the algorithms for the bio inspired techniques such as firefly algorithm, ACO and PSO will also be demonstrated. For the simulating and the implementation purpose, both MATLAB and Python will be used. There will be set of different programs that runs the traditional and bio inspired algorithms. The results of both these algorithms will be taken into consideration. Based upon the results a conclusion is to be drawn that which algorithm is suitable for a particular problem/scenario.

4.3 Design and Simulation

The design of these algorithms will consist of their actual working principle. The design will also contain some basic mathematical algorithms such as distance metrics, mean square error etc. The simulation of these algorithms will be done in both python and MATLAB. Simulation will be demonstrated using graphs and some mathematical results from the MATLAB and python scripts.

4.4 Formulation and Testing

The traditional algorithms and the bio inspired algorithms that are designed will be tested using random data. First the result from the traditional algorithm will be taken into consideration and then the result from the bio inspired algorithm will be taken. These results will be compared against each other to measure both the similarity and the dissimilarity measure. These tests will be performed for many sets of random data or known data.

4.5 Clinical Study of WSN

A WSN can be defined as a network of devices that can communicate the information gathered from a monitored field through wireless links. The data is forwarded through multiple nodes, and with a gateway, the data is connected to other networks. Various wireless sensory has their own limitations. The limitations that pose to the WSN include various environmental factors such as blockage by plants, animals, building etc, energy loss due to continuous transmission of energy, locate various nodes that are present in the networks. All these factors when add up together makes WSN difficult to implement in certain areas. Hence to prevent these limitations and to push forward the applications, various bio-inspired algorithms are used which reduced the issues that are caused in the environment or are a part of the WSN itself. These Bio inspired algorithm will help resolve the issues that our project is trying to address.

4.6 Field Study of Wireless Sensor Networks and Bio-inspired algorithm

The field study includes a detailed study about WSN which are networks of distributed autonomous nodes that can sense their environment cooperatively. WSN+ are used in diverse applications such as environment and habitat monitoring, structural health monitoring, healthcare, home automation, and traffic surveillance. They are also used in monitoring applications. They are also able to perceive their environment through onboard sensors. WSN have many issues regarding transmission of data, localization, energy consumption etc. By using certain bio inspired algorithms these limitations may be minimized. In bio inspired algorithm there are certain algorithms which addresses these issues.

4.7 Product Concepts and Development

The product or the scripts that will be implemented will be based on various traditional and bio inspired algorithms. The traditional concepts that will be used are LEACH protocol, trilateration and path planning using mobile anchors. And the bio inspired concepts that the program will demonstrate are firefly algorithm, ACO and PSO.

4.8 Data Collection, Modelling and Simulation

The data that is used to model the anchors and the dumb nodes are generated randomly. For the generation of the nodes, the python script is used which plots all these points. Then these points are to be localized, clustered and the energy efficiency is computed; and the data is presented for both the traditional and bio inspired algorithm and compared for the best.

4.9 Design, Modelling and Analysis

For both the traditional and the bio inspired algorithms the tests will be demonstrated and then the result will be compared against each other. This will be done for the known and the unknown data. Hence for every data that is provided to the script the script is going to display results for both of the techniques and this result will be compared with both the traditional and the bio inspired algorithm.

For the analysis part, the results will be compared for the both traditional and the bio inspired algorithm and certain factors which are being targeted to be solved will be solved by both of these algorithms. And the results of all the algorithms will be demonstrated.

4.10 Conclusion

In this chapter, the problem-solving approach has been demonstrated. The preamble to this chapter has been stated. This chapter contains the design part of the project. The block diagram for different algorithms has been provided. The design, simulation and implementation has been done. Product concept and development has been also illustrated. In the next chapter the result of the project has been demonstrated.

5. Results

This section includesscreenshot of the result showing localization as well as LEACH protocol for energy efficient communication.

5.1 Graphs for Trilateration

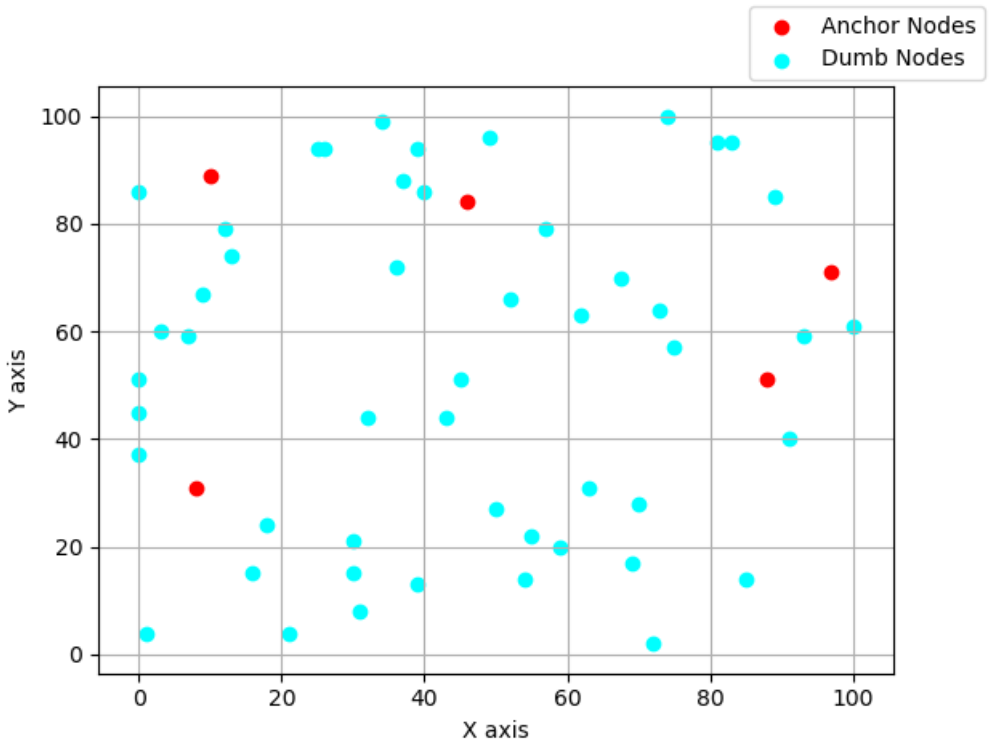

Figure 6: Graph for Localization

The above graph represents the anchor nodes marked as red and dumb nodes marked as cyan. This is the actual graph which represents the nodes that are displayed in the environment.

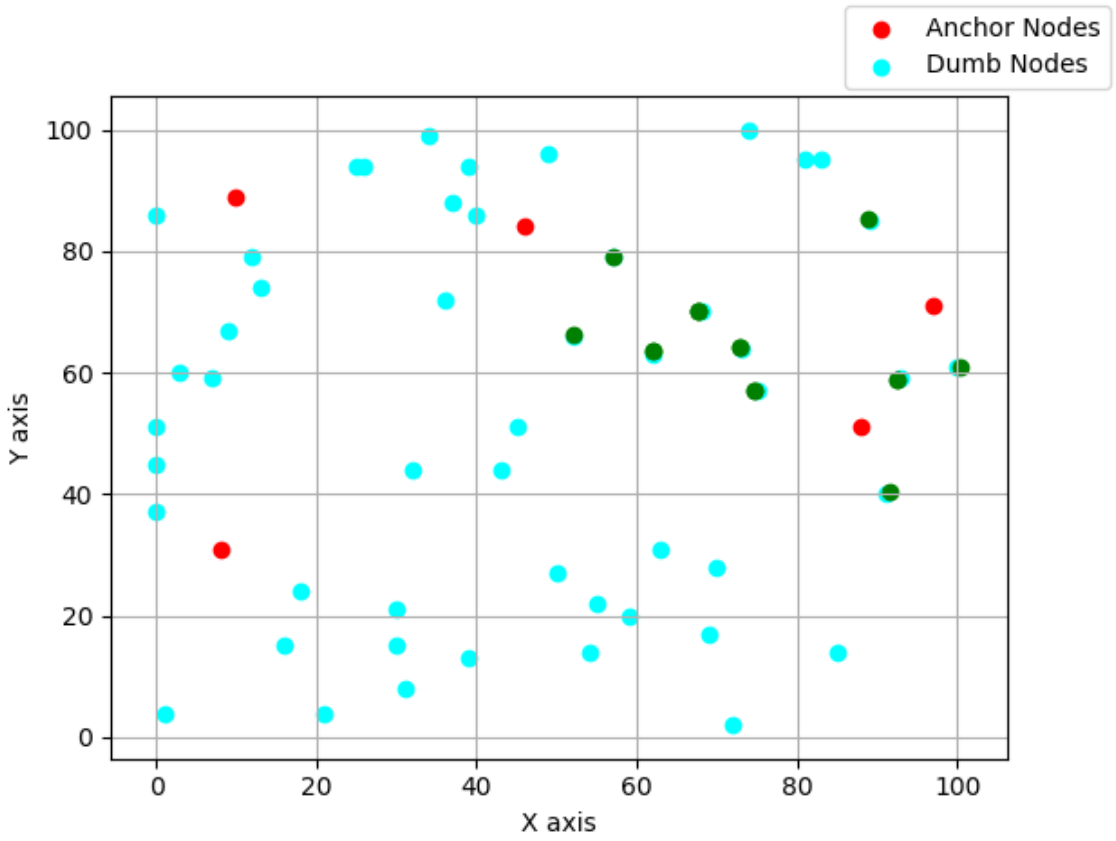

Figure 7: Graph for localization after 1st iteration

In the above graph, the anchor nodes localized some of the nodes using trilateration. This is the first iteration where some of the dumb nodes gets localized. The actual anchor nodes are marked as red, the pseudo anchor nodes are marked as green and the remaining dumb nodes are marked as cyan.

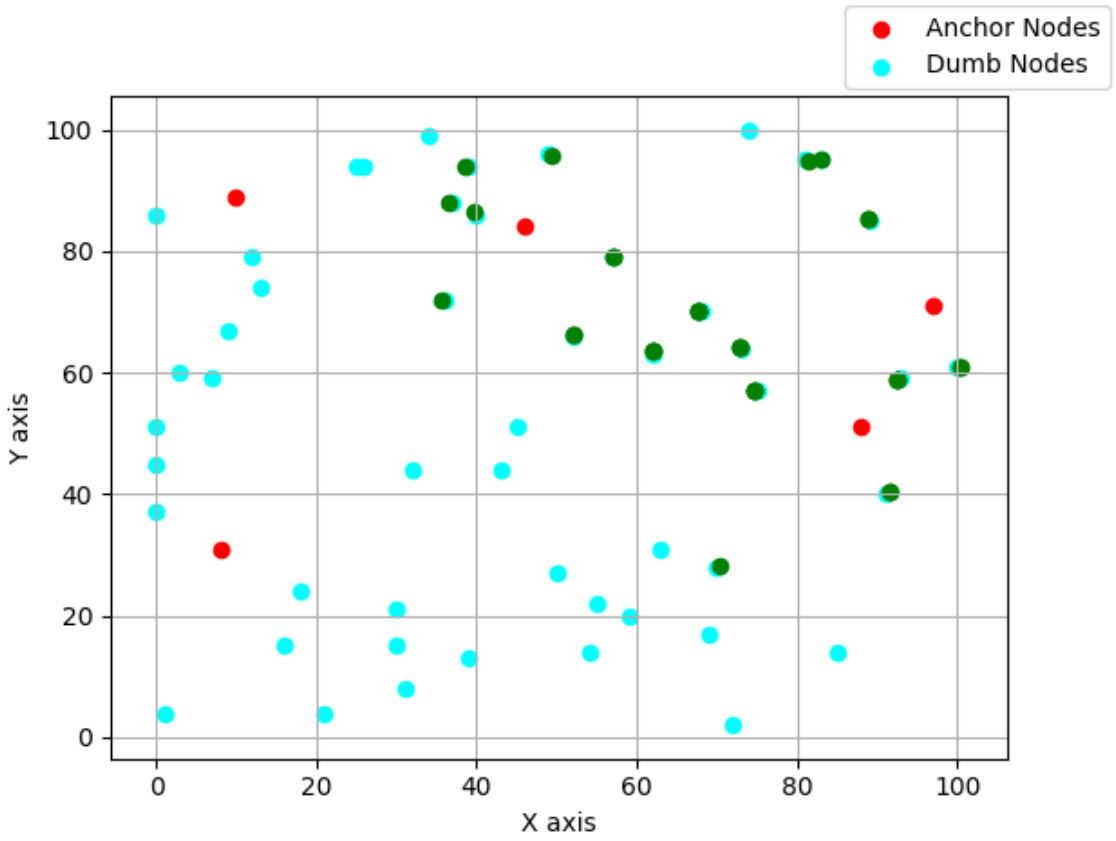

Figure 8: Graph for localization after 2nd iteration

In the above graph, the anchor nodes localized some of the nodes using trilateration. This is the second iteration where more dumb nodes get localized. The actual anchor nodes are marked as red, the pseudo anchor nodes are marked as green and the remaining dumb nodes are marked as cyan.

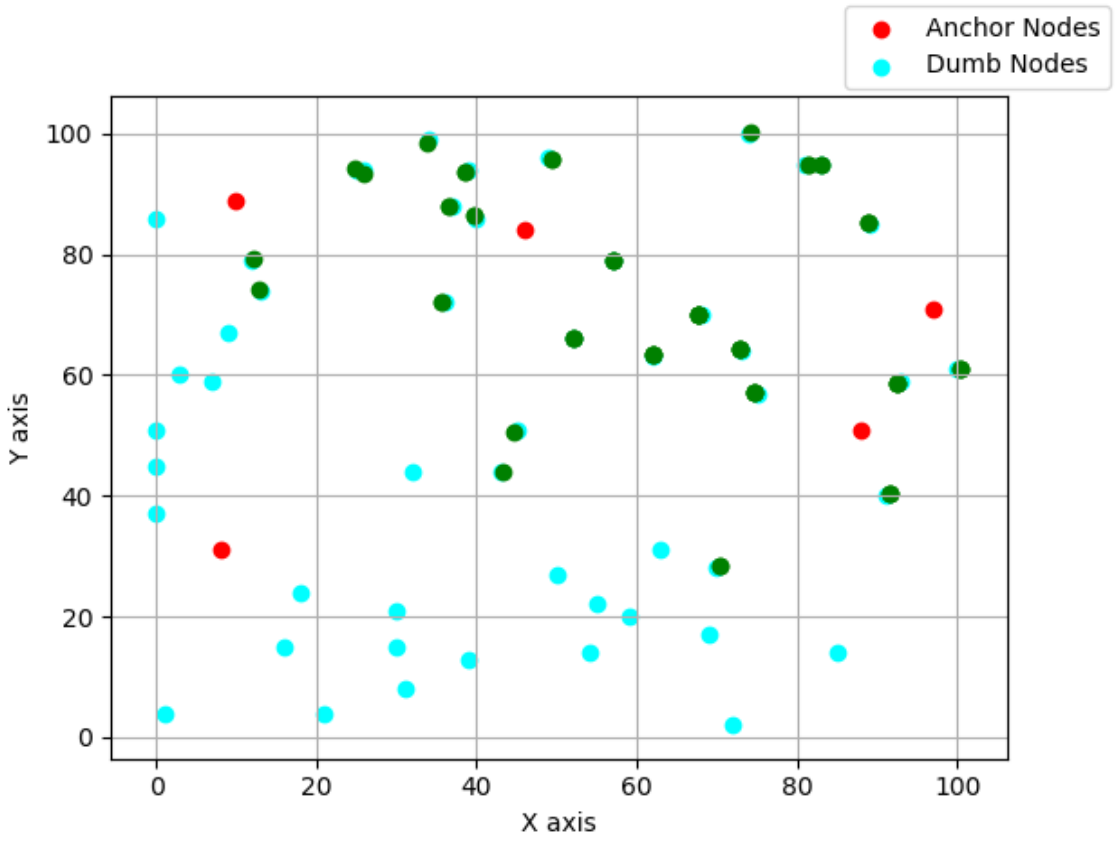

Figure 9: Graph for localization after 3rd iteration

In the above graph, the anchor nodes localized some of the nodes using trilateration. This is the third iteration where more dumb nodes get localized. The actual anchor nodes are marked as red, the pseudo anchor nodes are marked as green and the remaining dumb nodes are marked as cyan.

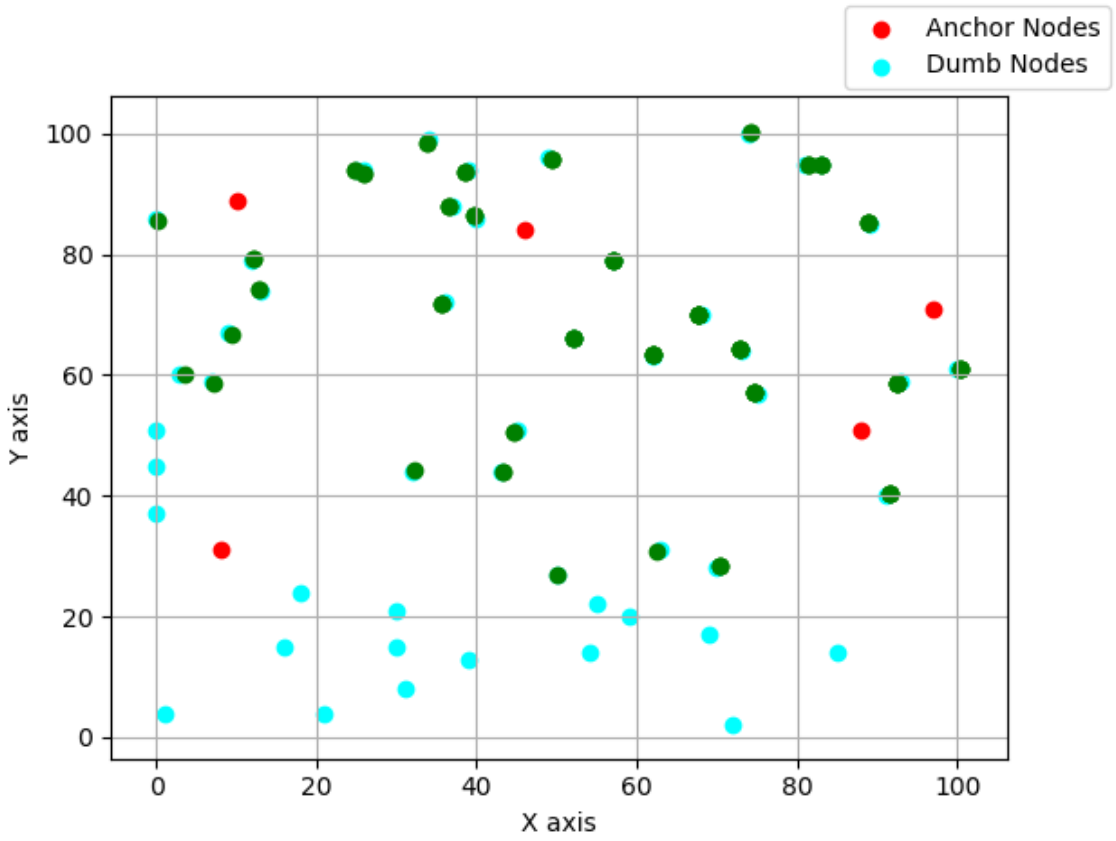

Figure 10: Graph for localization after 4th iteration

In the above graph, the anchor nodes localized some of the nodes using trilateration. This is the fourth iteration where more dumb nodes get localized. The actual anchor nodes are marked as red, the pseudo anchor nodes are marked as green and the remaining dumb nodes are marked as cyan.

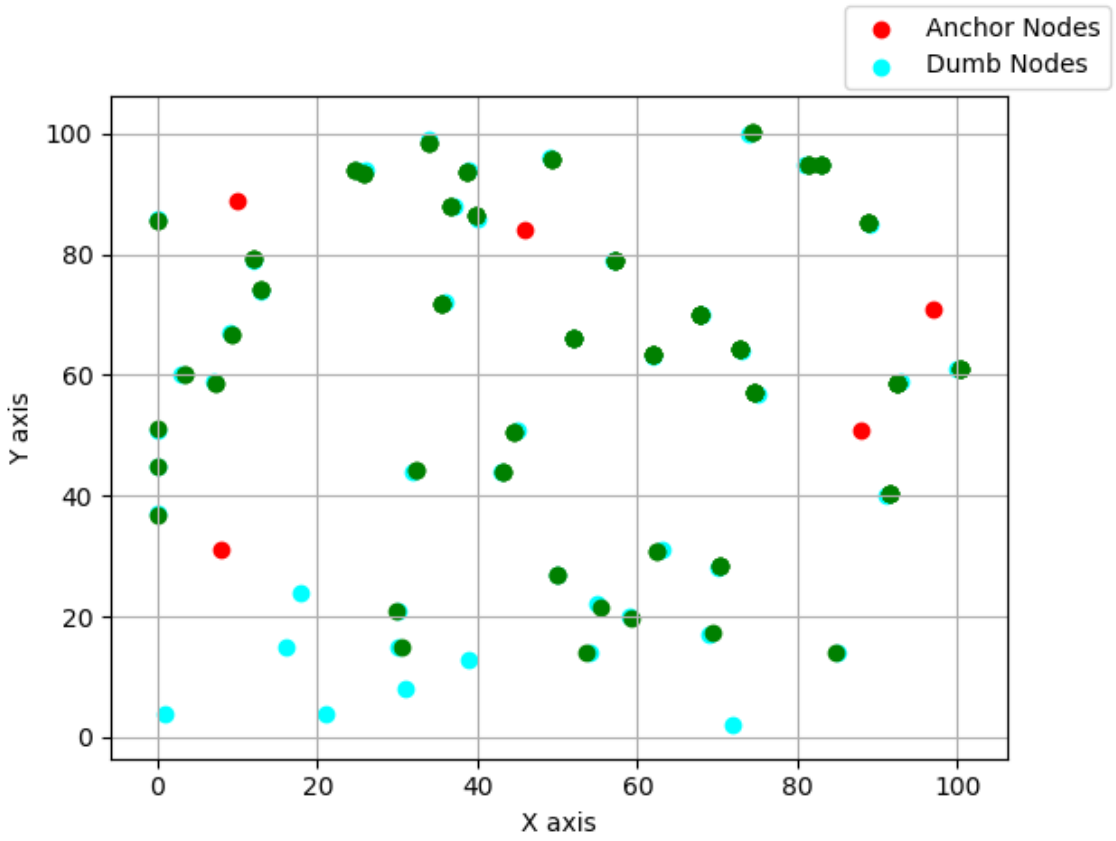

Figure 11: Graph for localization after 5th iteration

In the above graph, the anchor nodes localized some of the nodes using trilateration. This is the fifth iteration where more dumb nodes get localized. The actual anchor nodes are marked as red, the pseudo anchor nodes are marked as green and the remaining dumb nodes are marked as cyan.

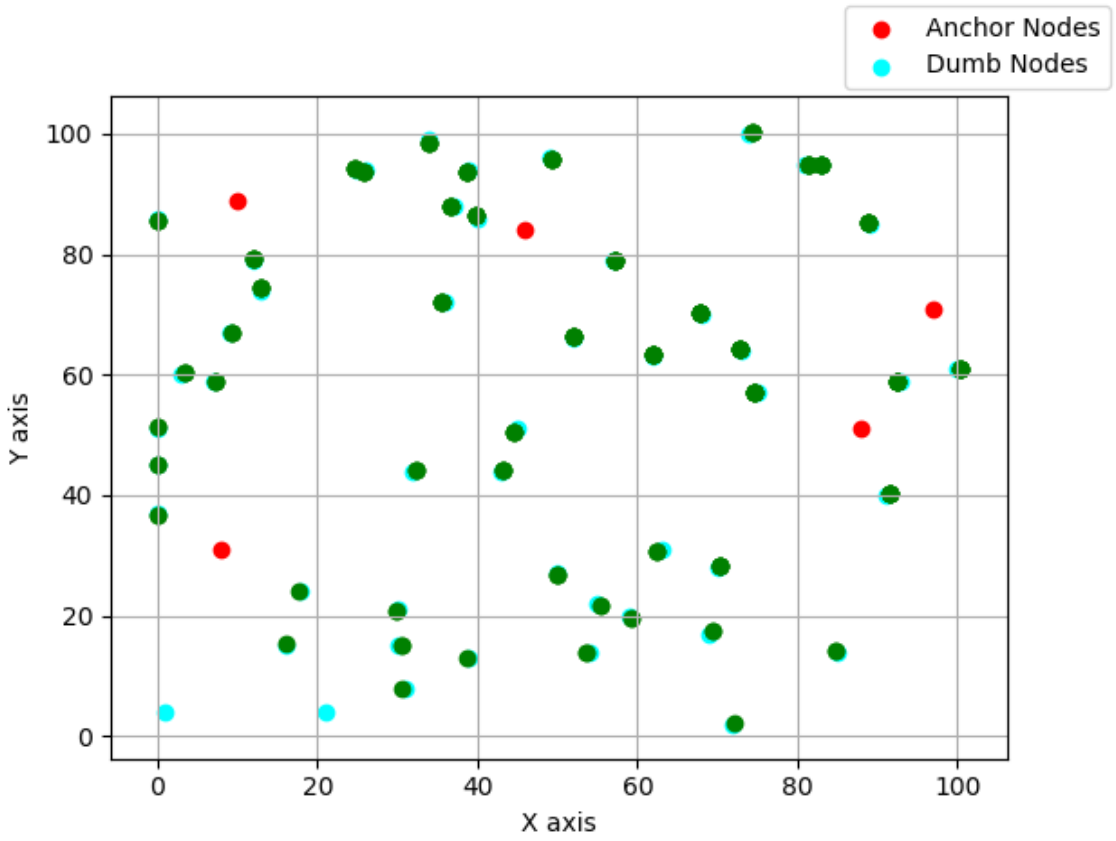

Figure 12: Graph for localization after 6th iteration

In the above graph, the anchor nodes localized some of the nodes using trilateration. This is the sixth iteration where more dumb nodes get localized. The actual anchor nodes are marked as red, the pseudo anchor nodes are marked as green and the remaining dumb nodes are marked as cyan.

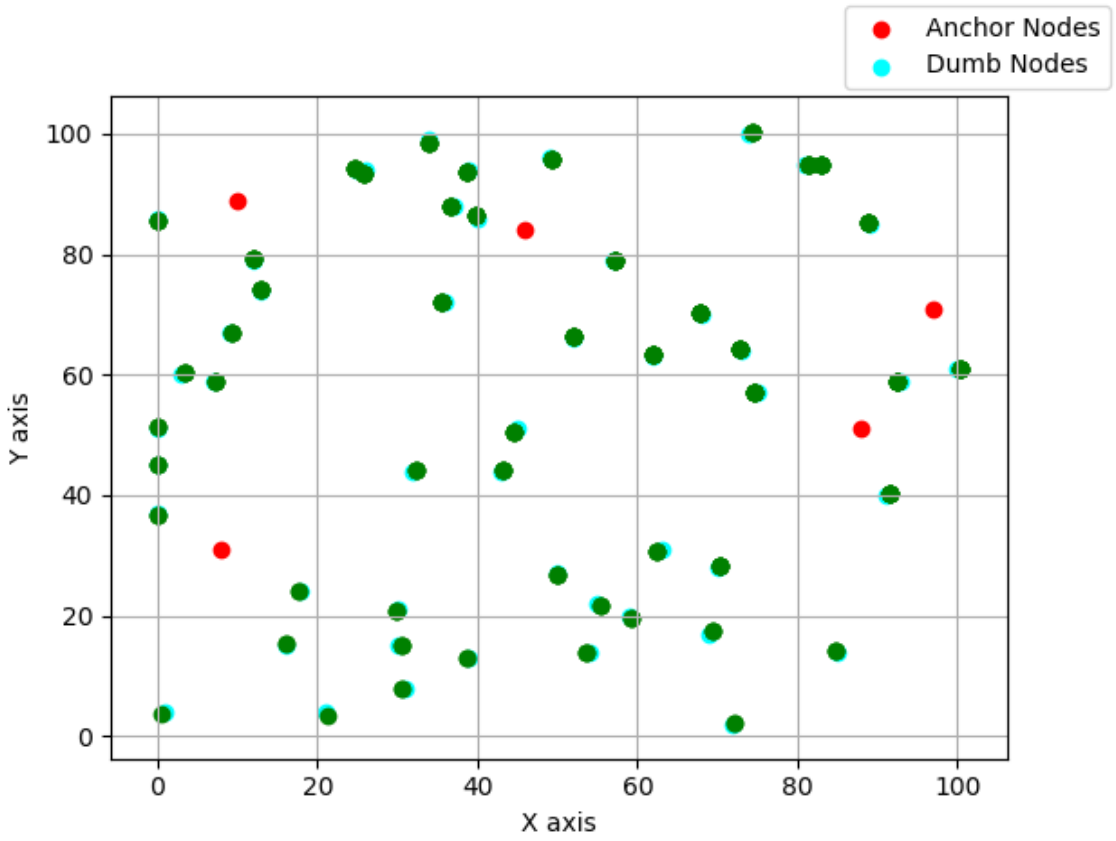

Figure 13: Graph for localization after 7th iteration

In the above graph, the anchor nodes localized some of the dumb nodes using trilateration. This is the eighth iteration where more dumb nodes get localized.The actual anchor nodes are marked as red, the pseudo anchor nodes are marked as green and the remaining dumb nodes are marked as cyan. This is the last iteration.

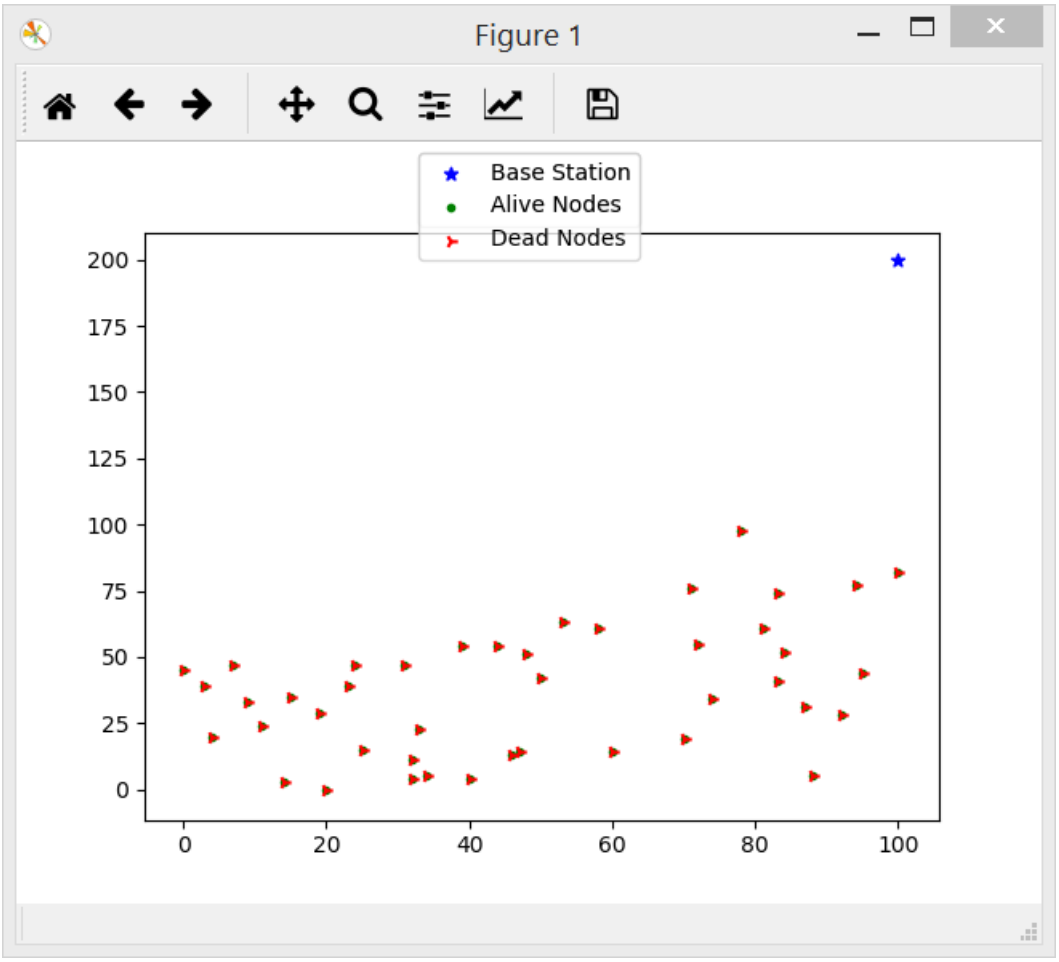

Figure 14: Graph showing different localized nodes at their co-ordinates for Trilateration.

This graph shows different localized nodes at their particular coordinates for trilateration. In the beginning all the nodes were alive, gradually they started dying as they started losing their energy because of the communication with base station and cluster head. All the nodes are marked as red because they died at the end.

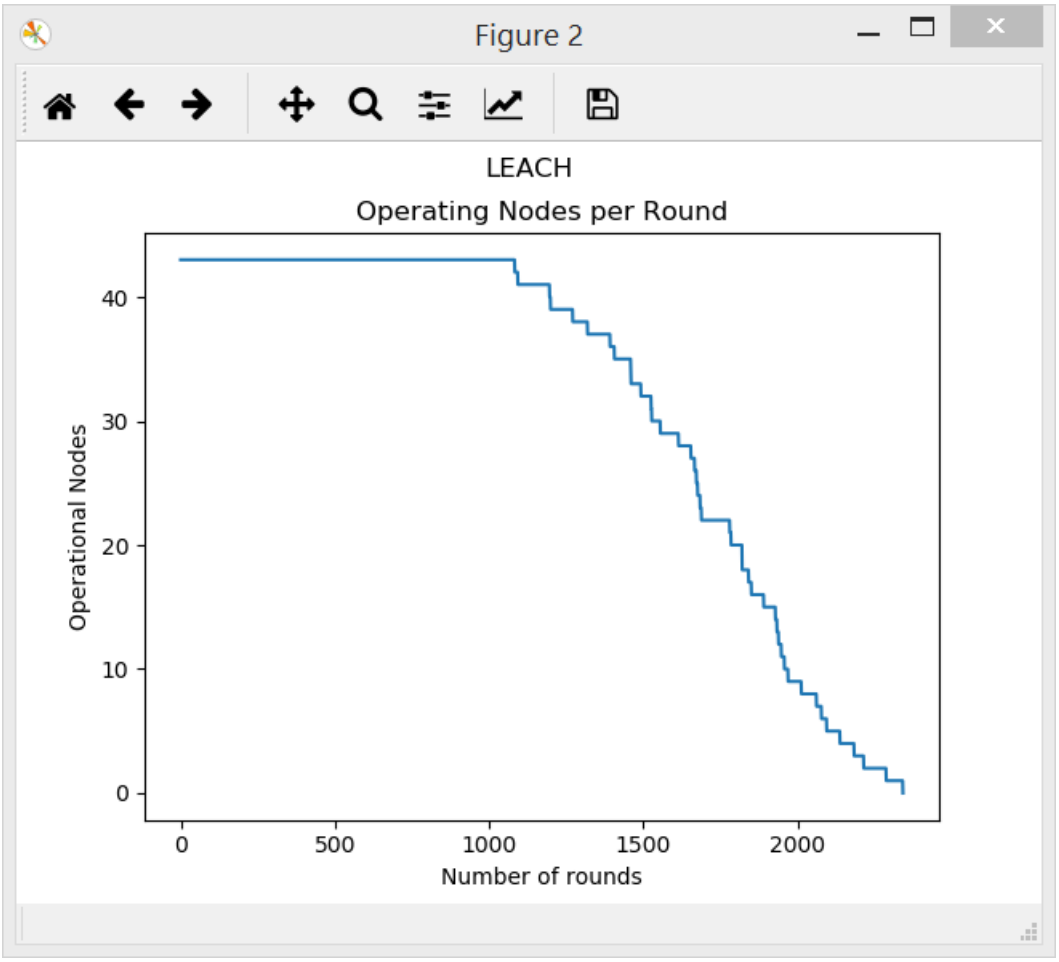

Figure 15: Graph of operating nodes vs number of iterations for Trilateration.

The above figure shows the number of operating nodes vs number of iterations. As the number of iterations increases, number of nodes that are alive decreases. This happens because as iteration progresses, nodes continue to lose their energy because of the communication that they carry out with the base station as well as cluster heads.

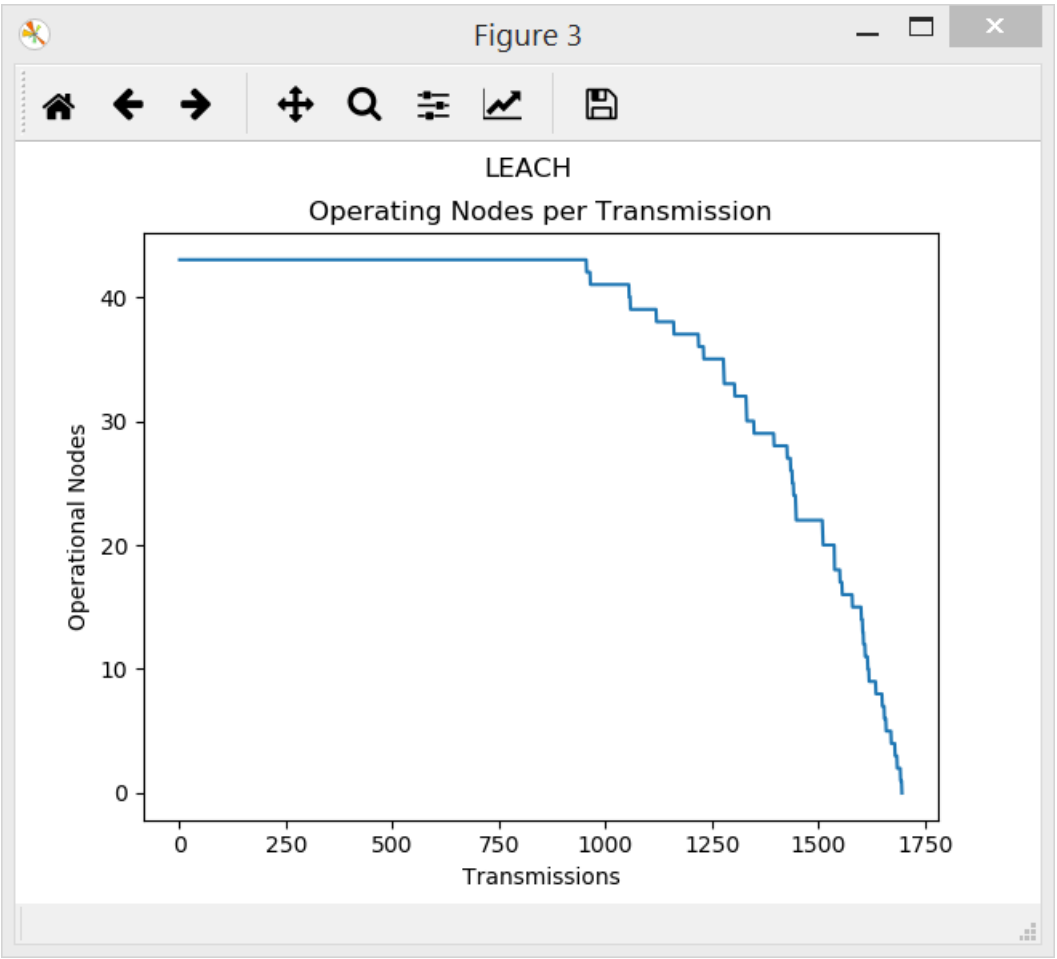

Figure 16: Graph of operating nodes vs number of transmissions for Trilateration.

The above figure shows the number of operating nodes vs number of transmissions. As the number of transmissions increases, number of nodes that are alive decreases. This happens because as iteration progresses, nodes continue to lose their energy because of the communication that they carry out with the base station as well as cluster heads.

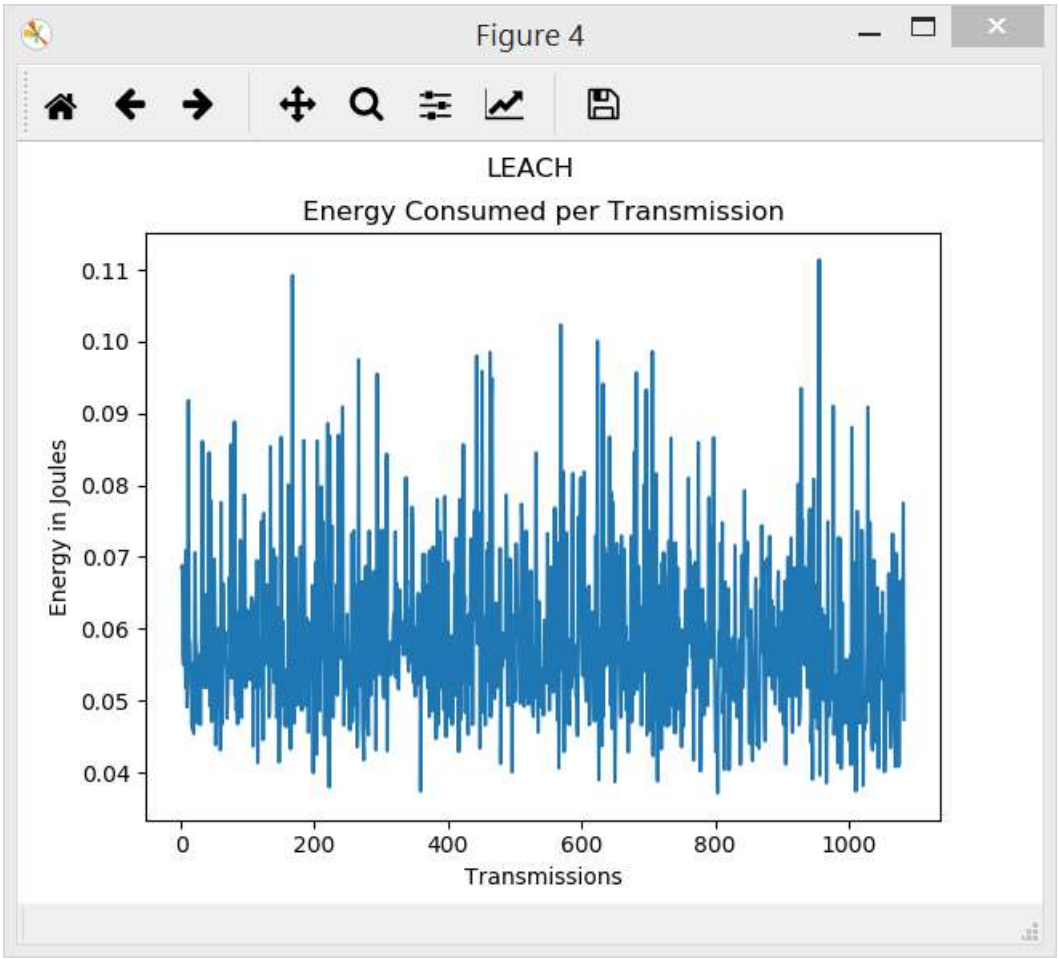

Figure 17: Graph of energy consumed vs no. of transmissions for Trilateration.

This graph shows energy consumed in every transmission. In every transmission some amount of energy is dissipated because nodes communicate with base station as well as Cluster Head.In every transmission whatever energy is consumed has been plotted in this graph.

5.2 Graphs for PSO

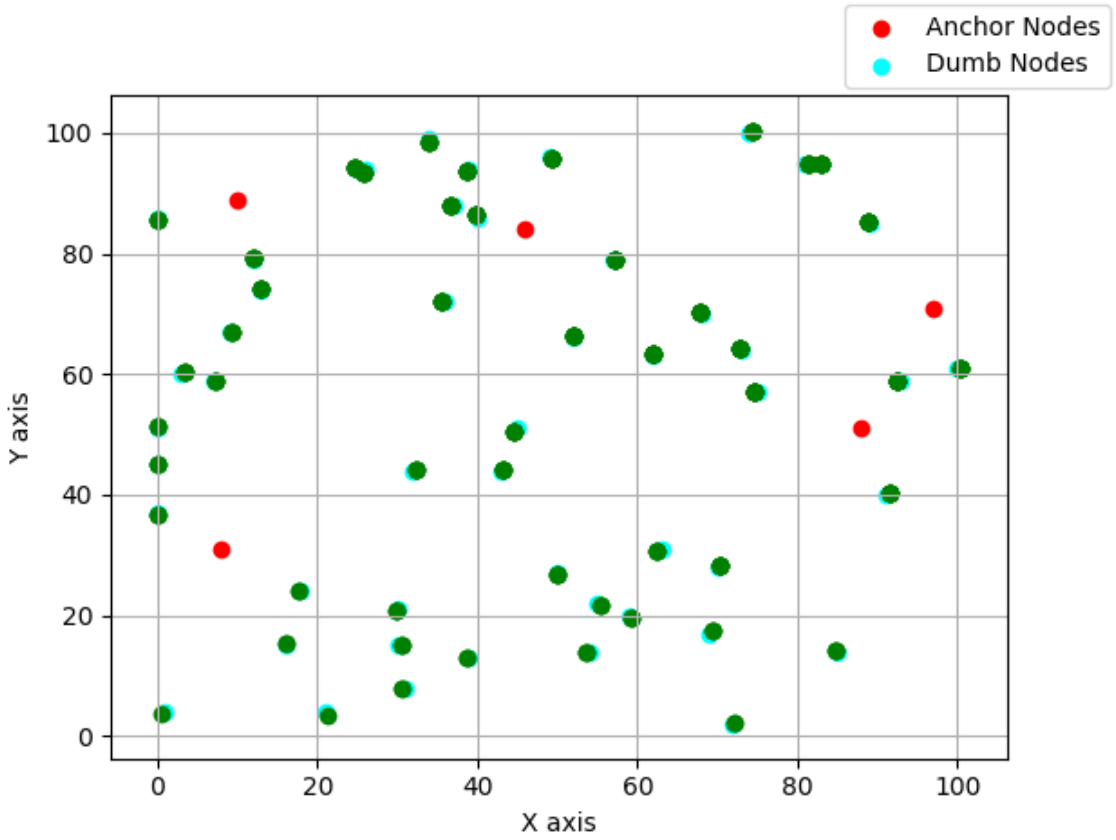

Figure 18: Graph shows anchor nodes, localized nodes and dumb nodes for PSO.

In this graph, the co-ordinates of the anchor nodes, localized nodes and dumb nodes are shown. The red dots demonstrate the anchor nodes, the green dots demonstrate the localized nodes and the cyan dots demonstrates the un-localized nodes. Here, it can be seen that the PSO algorithm is able to localize more nodes with exact location but the time taken is more to localize a dumb node.

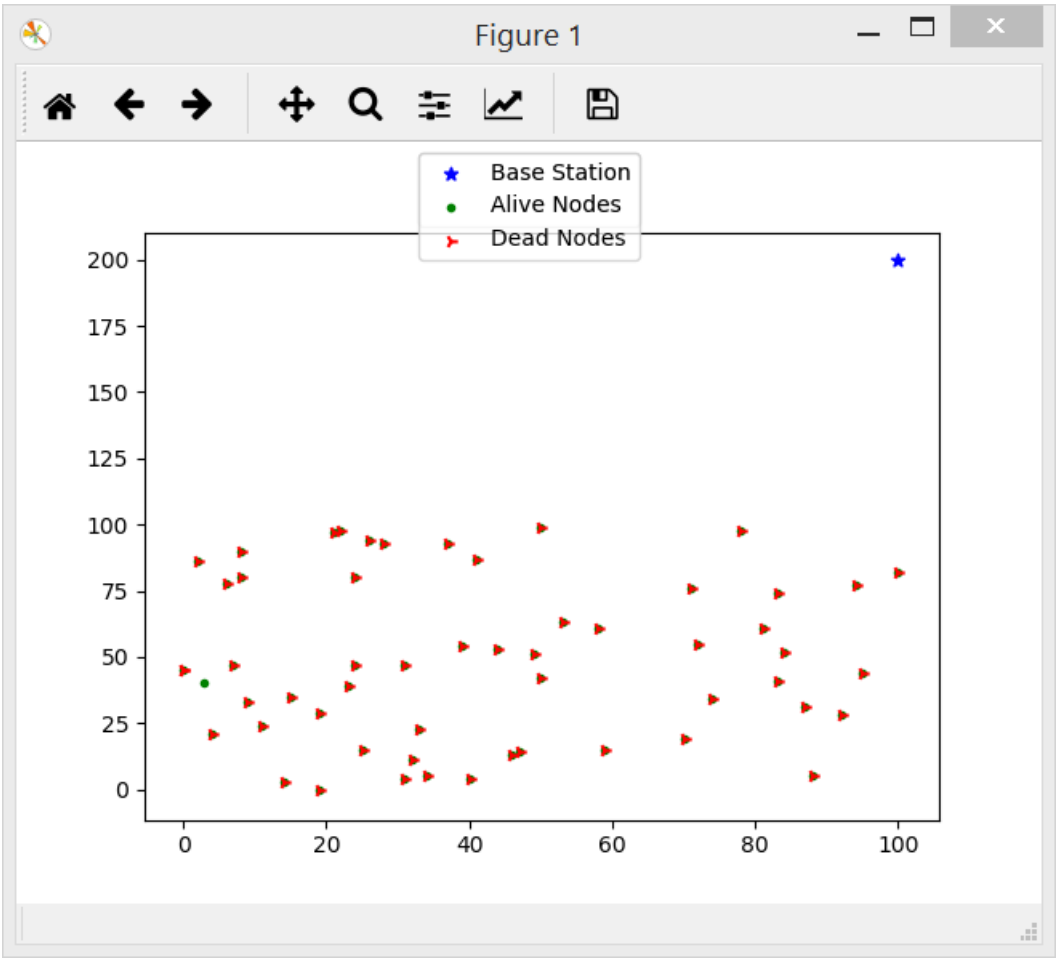

Figure 19: Graph showing different localized nodes at their co-ordinates for PSO

This graph shows different localized nodes at their particular coordinates for PSO. In the beginning all the nodes were alive, gradually they started dying as they started losing their energy because of the communication with base station and cluster head. All the nodes are marked as red because they died at the end.

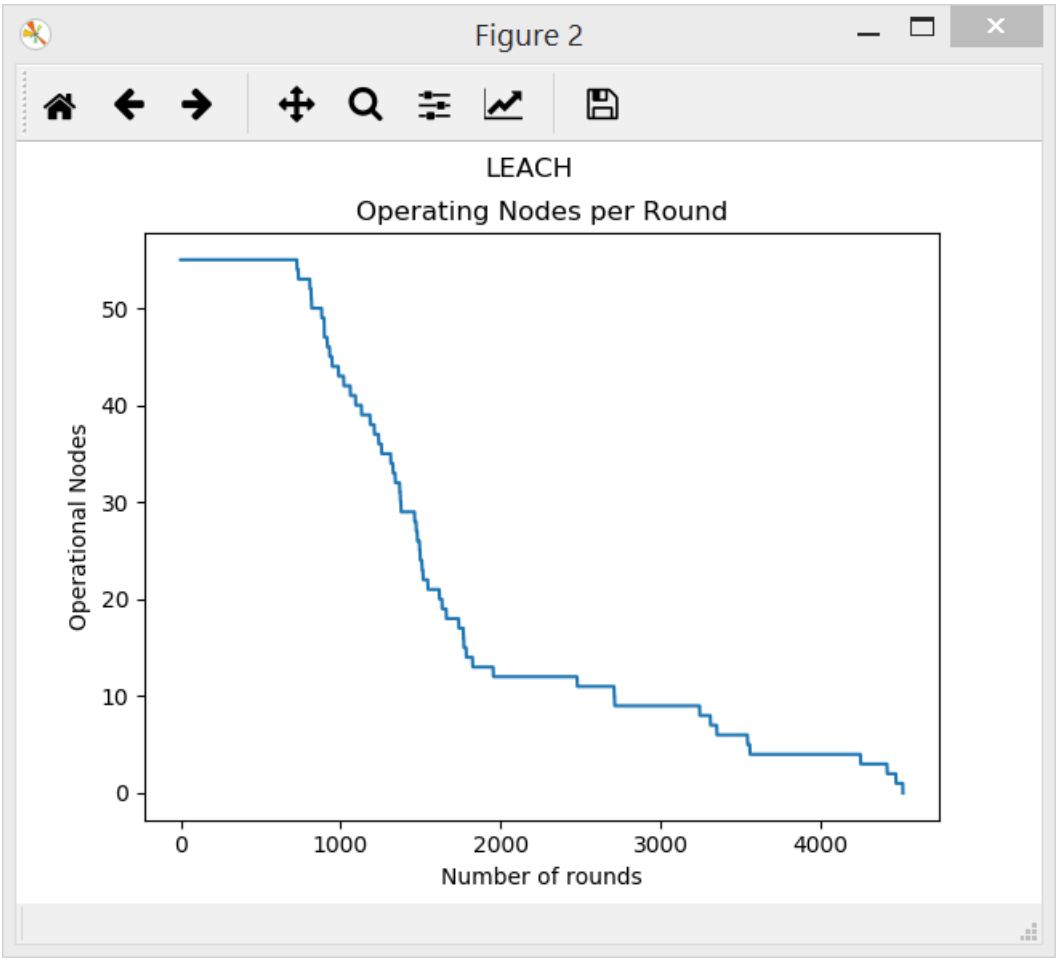

Figure 20: Graph of operating nodes vs number of iterations for PSO

The above figure shows the number of operating nodes vs number of iterations. As the number of iterations increases, number of nodes that are alive decreases. This happens because as iteration progresses, nodes continue to lose their energy because of the communication that they carry out with the base station as well as cluster heads.

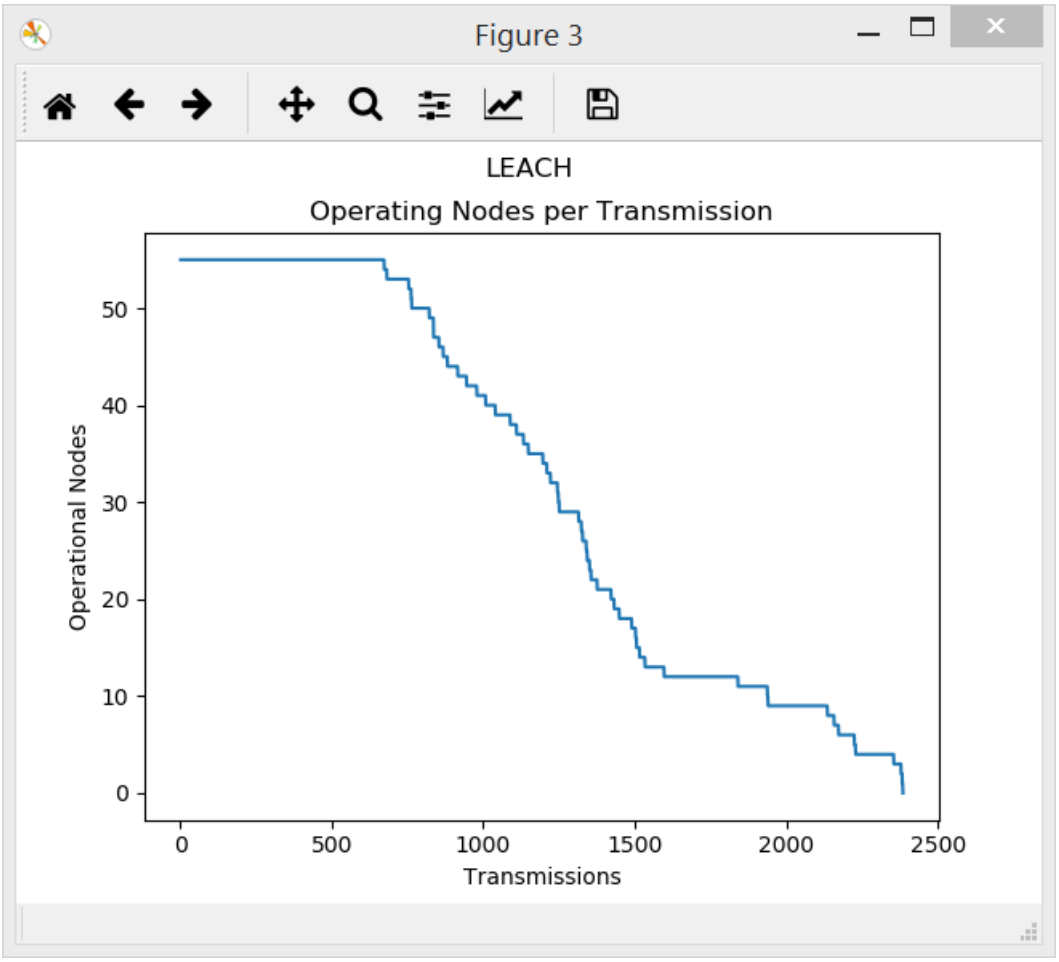

Figure 21: Graph of operating nodes vs number of transmissions for PSO

The above figure shows the number of operating nodes vs number of transmissions. As the number of transmissions increases, number of nodes that are alive decreases. This happens because as iteration progresses, nodes continue to lose their energy because of the communication that they carry out with the base station as well as cluster heads.

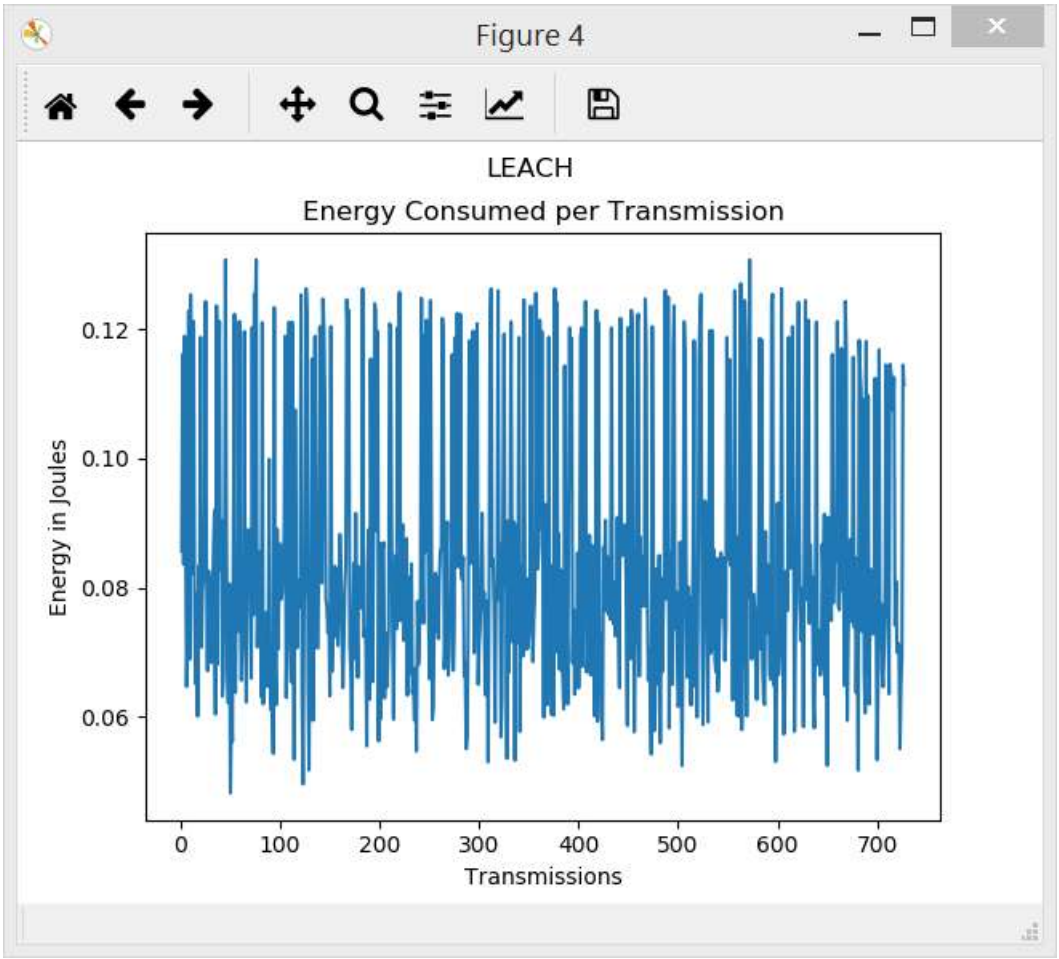

Figure 22: Graph of energy consumed vs no. of transmissions for PSO.

This graph shows energy consumed in every transmission. In every transmission some amount of energy is dissipated because nodes communicate with base station as well as Cluster Head. In every transmission whatever energy is consumed has been plotted in this graph.

5.3Comparison for PSO and Trilateration

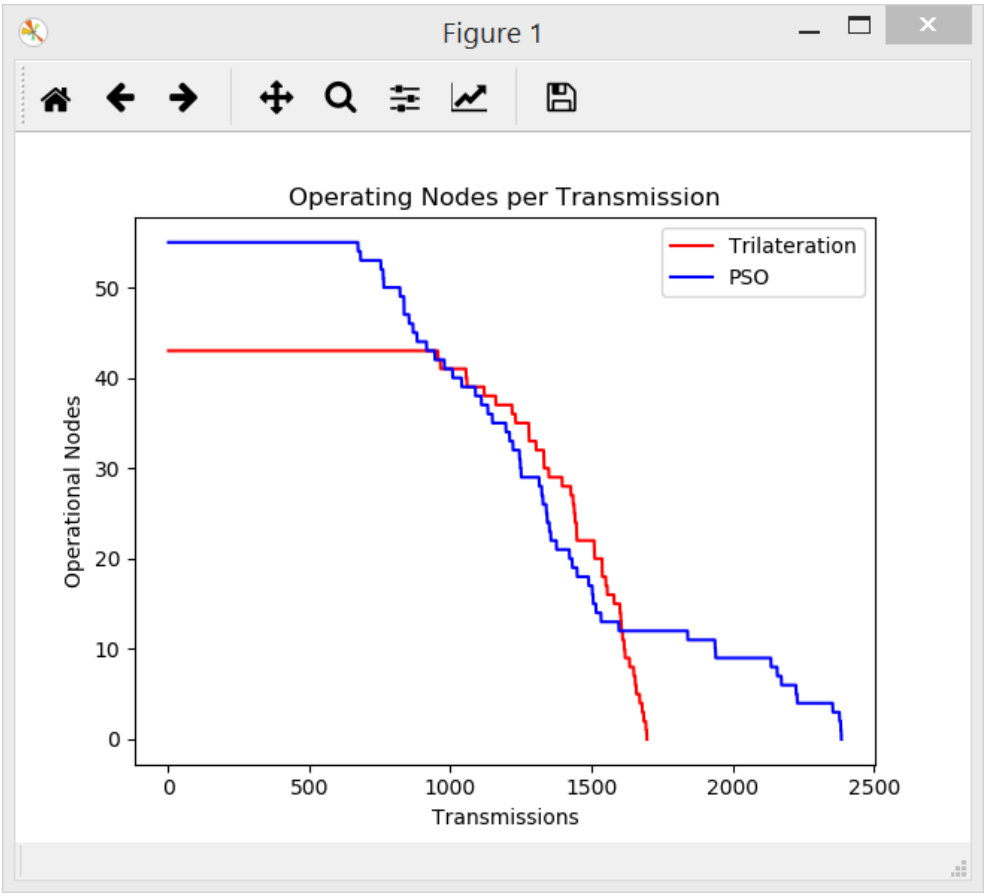

Figure 23: Graph for comparing alive nodes of PSO with trilateration

This graph compares the number of alive nodes in every iteration in PSO with trilateration. We can see that when localization is carried out using PSO, lifetime of WSN is more than that in trilateration

5.4 Graph for Mobile Anchor

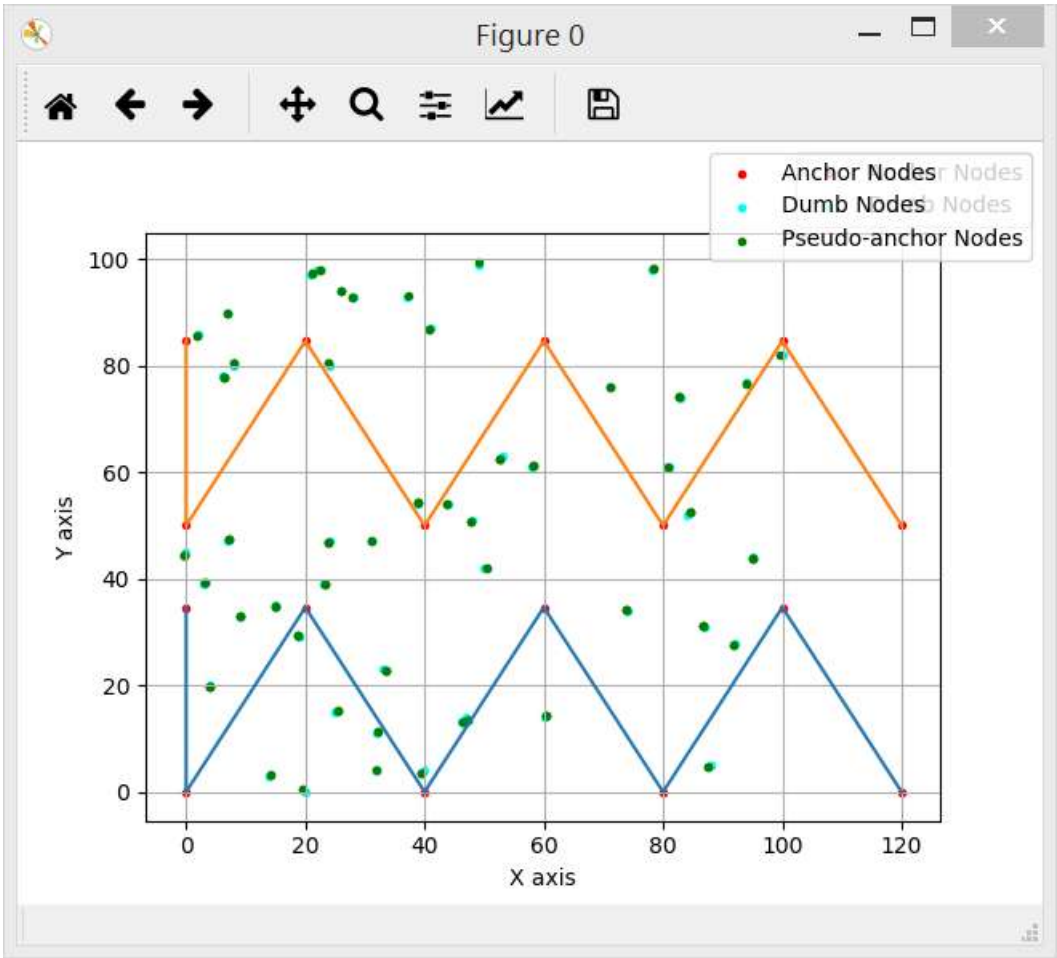

Figure 24: Graph for Mobile Anchor

In the above figure, there are two mobile anchors which are following their defined respective path. Any dumb nodes that fall between the range of three coordinates of the anchor, gets localized.

5.5Analysis

Trial	Algorithm	Number of Anchor Nodes	Number of Dumb Nodes	Number of localized Nodes	Time Taken (secs)	Error
Trial 1	Trilateration	5	50	45	11.36	0.34
	PSO	5	50	50	18.5	0.015
Trial 2	Trilateration	5	50	47	7	0.41
	PSO	5	50	50	17.6	0.014
Trial 3	Trilateration	5	50	43	8.20	0.38
	PSOs	5	50	50	19.3	0.0153
Trial 4	Trilateration	5	50	43	12.36	0.35
	PSO	5	50	47	23.5	0.0149
Trial 5	Trilateration	5	50	41	10	0.42
	PSO	5	50	50	19.6	0.0146
Trial 6	Trilateration	5	50	40	8.30	0.36
	PSO	5	50	48	18.9	0.0151
Trial 7	Trilateration	5	50	46	11.55	0.33
	PSO	5	50	50	18.85	0.0141
Trial 8	Trilateration	5	50	47	9	0.42
	PSO	5	50	50	18.6	0.0142
Trial 9	Trilateration	5	50	49	8.10	0.39
	PSOs	5	50	50	17.3	0.0152
Trial 10	Trilateration	5	50	48	12.36	0.35
	PSO	5	50	50	23.5	0.0150

Mean Error of PSO = 0.0147

Mean Time Taken for PSO = 19.56

Mean Error of Trilateration = 0.375

Mean Time Taken for Trilateration = 9.823

Trial	Algorithm	Number of Anchor Nodes	Number of Dumb Nodes	Number of localized Nodes	Time Taken (secs)	Error
Trial 1	Trilateration	5	50	46	15.6	0.380
	PSO	5	50	50	25.6	0.0141
Trial 2	Trilateration	5	75	74	15.5	0.412
	PSO	5	75	75	28.2	0.0142
Trial 3	Trilateration	5	100	93	16.8	0.366
	PSOs	5	100	100	29.3	0.0151
Trial 4	Trilateration	8	50	44	15.36	0.378
	PSO	8	50	50	28.02	0.0149
Trial 5	Trilateration	8	75	70	15.64	0.395
	PSO	8	75	74	36.8	0.0148
Trial 6	Trilateration	8	100	96	31.26	0.366
	PSOs	8	100	100	59.29	0.0150
Trial 7	Trilateration	10	50	46	15.54	0.386
	PSO	10	50	50	24.44	0.0141
Trial 8	Trilateration	10	75	72	15.62	0.409
	PSO	10	75	75	31.65	0.0143
Trial 9	Trilateration	10	100	94	17.62	0.386
	PSOs	10	100	98	62.85	0.0151

6. Project Costing

6.1 Introduction

From the all the previous chapters we designed, implemented and tested our project applying different cases. After implementation of algorithm. Now in this chapter we estimate the total cost to design and implement the project. And also, the labour cost will be estimated.

6.2 Project Cost

Man hours per week (students): 18 *4 students =72

Making Cost: Rs 0

Labour cost: Rs 0

6.3 Summary

In this chapter, the details about the project costing has been given. This chapter also contains the information of the labour cost. The net total cost including the project cost and the labour cost has been provided.

7. Conclusions and Suggestions for Future Work

The project is for Application of metaheuristics for localization, energy and path optimization in Sensor Network. The project mainly focuses on comparing the traditional approaches with the bio-inspired approaches in dealing with the three issues which are – path planning, localization and energy optimization. By focusing on the central topic of the project, the project goal has been achieved. It is implemented and simulations has been tested. SI algorithms has been applied to achieve accurate location estimation, energy optimization and deployment of sensors in WSN. By completion of this project, the difference between the two approaches has been known. Finally, people will start using the better approach.

The scope of the project was to apply SI algorithmsto achieve accurate location estimation, energy optimization and deployment of sensors in WSN. The localization issue of WSN has been solved using PSO. Path Planning issue has been solved using Trilateration. Energy Consumption issue has been solved using LEACH Protocol.

For the implementation and testing of the simulations, Python will be used. It is mainly used for implementation. Here, test scenarios with known data and unknown data. In order to perform comparative analysis of traditional deterministic algorithm, the bio-inspired SI algorithms are considered which increases the efficiency of SI Algorithm and energy Consumption of Wireless Sensors.The project also aims to perform comparative analysis of traditional deterministic algorithms with bio-inspired SI algorithms.

The future scope of the project is surveillance of traffic which will determine the amount of traffic at different junctions at different points in time. Sensor will sense high traffic in a particular area and then the information will be transmitted to the base station incorporating LEACH protocol. Localization will be done using PSO to get the accurate location of the sensor that sensed high traffic and then accordingly that information can be used for different purpose. Also, detection of fire in forest, detection of landslides in different area, in animal habitat, etc are the few area where this project can be used.

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