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Cluster based Multipath routing to minimize delay, congestion and energy consumption in Wireless Sensor Network

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Abstract— Wireless Sensor Network (WSN) usually comprises of many sensors that detect any changes in the environment such as temperature, humidity, pressure, smokes, etc. Wireless Sensor Network is very Energy Confined networks. Data transfer takes place in "multi-hop fashion"in Wireless Sensor Network. The sensor nodes send their data to their neighbor sensor, this neighbor sensor transmits the data to another neighbor and this process continues until it reaches the destination/sink. In this way, hop by hop sensors transmit their data to the sink. Wireless Sensor Network using Static Sink generally causes the nearest nodes to deplete energy very quickly, causing 'hotspot problem' or 'energy hole problem'. Sensors are transmitting the data to the nearest sensor at the same time, due to heavy load, sensor nearest to the sink may not be able to deliver the data at the same time to the sink which causes an increase in delay, congestion, packet losses, routing overheads and also reduces the packet delivery ratio. The objective of the proposed work is to minimize the delay and traffic in the data collection process in the wireless network structure. We have employed a mobile sink not only to minimize energy consumption, but also delay, congestion, packet losses, routing overheads and to increase the network lifetime with high packet delivery rate. Each sensor in the clusters will be transmitting their data to the sink with multipath routing, following an efficient route provided by optimization technique Genetic Algorithm and Particle Swarm optimization. We have used both Static sink and Movable sink, by our simulation results we have shown that movable sink is not only useful in minimizing the energy consumption, but also helpful in minimizing the end to end delay, congestion, packet losses, routing overheads, indirectly increasing the network lifetime with high packet delivery rate. We have simulated the Wireless Sensor Network in Network Simulator 2.

I. INTRODUCTION

A wireless sensor network (WSN) usually consists of base station, sink and small sized sensor nodes that possess very limited energy resources. Sensor nodes usually consist of Sensors, Analog to Digital converter (ADC), processors, memory, transceiver and battery as shown in Fig.1. The sensor observes the changes in the environment, produces an electrical output by collecting the information which is further processed by the Analog to Digital converter and processor. The sensor nodes having a very limited amount of energy , is totally different from other common networks. Limited energy of nodes should be taken into account into consideration,for all the operations those are performed and all the methods that are used in sensor nodes. It is very important to collect the information from Sensors in an energy efficient way over a long period of time in order to run the Wireless Sensor Network. Sensor Nodes have very limited power and storage capacities. Sensor Nodes chiefly utilize the distributive communication approach whereas almost all of the ad-hoc networks have centered on point to point communications. In a Wireless Sensor Network , there are several hundreds and thousands of sensor nodes . For observing battlefield, residential areas, hospitals, forest, commercial areas etc, nodes are located in an unguarded and an unfriendly environment normally. The sensor nodes transmit their data to the node that is called Sink (Data Gatherer) ..In Wireless Sensor Network sink is the finishing point of the data collection process usually. The nodes in the Sensor Network collectively transmit data to sink or base station. Every node collects data from various nodes and produces a single packet; this process is called Data Fusion. The sensor nodes process to lift out simple calculations and send only the required part of the data and removes the exceeding data.

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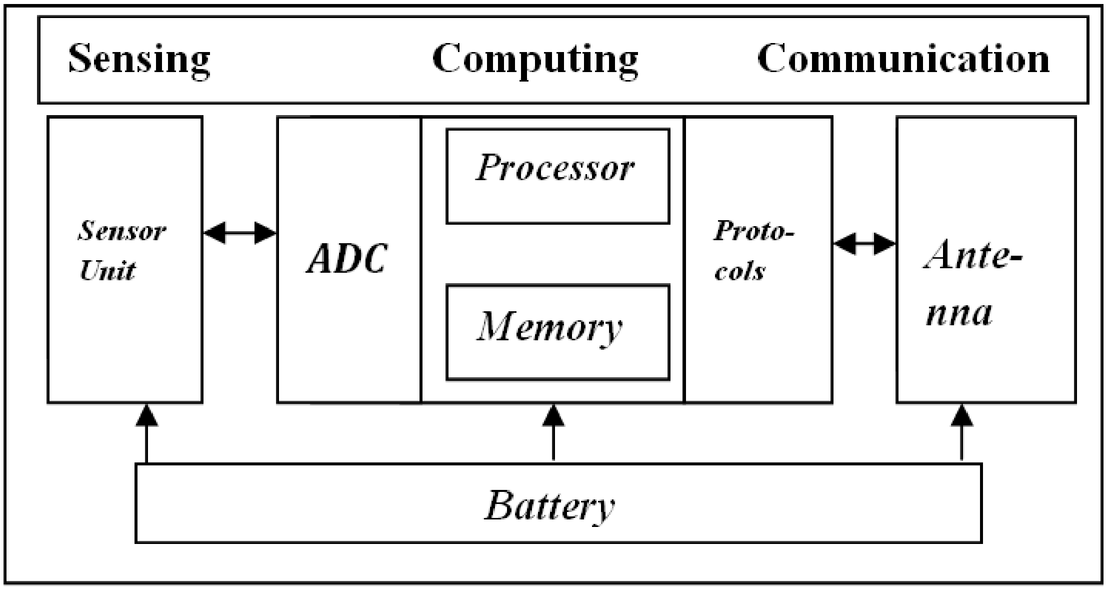

Fig1.1 Components of Sensor Nodes

All packets from all nodes, after every stage of data collection must be collected and sent to the base station from where the End-User can retrieve the data. To achieve this task , every node must send its data straight to the base station. The cost of transmission to the base station from every sensor node is very high owing to the base station at a large distance and as the sensor nodes die very rapidly. Therefore the better method should be used for sending the data to the base station so as to increase the whole network lifetime. In wireless sensor networks ,the sink collects data and sends it to a base station. As all the Sensor nodes and sink are static, data has to be transferred in a "multihop" fashion from one node to the other node to reach the sink. Wireless Sensor Network using Static Sink usually causes the sensor nodes to exhaust energy rapidlybecause of continuous communication between sensor nodes and Static Sink. The data collection by the sink from various sources will be difficult and time consuming process,when the nodes are static.

In Multihop strategy, all the sensors send their data to the sink hop by hop i.e. sends their data from one sensor node to another as shown in Fig.2. The node 'A' which is located at a very far distance from the sink has to transmit its data hop by hop to the static sink. So node 'A' sends its data to 'B', then 'B' forwards data to 'C', 'C' to 'D', 'D' to 'E' and finally 'E' to Static Sink. Similarly, there are many other nodes, which are located very far away from the Static Sink, they also have to transmit their data by following "multihop" strategy. In this way node 'E' which is close to the sink will be involved in transmitting data always, thus causing it to deplete energy very quickly. This is called 'Energy Hole problem' or 'Hotspot problem'.

In wireless communications, as the distance between Source to Destination increases, the minimum energy required to successfully transmit a data packet between them also increases. The more is the distance between sensor and sink, more is the energy consumption. The strength of the signal received from the source decreases as a function of distance. To reduce the distance between source and sink, we have employed a Movable sink.

To keep up-to-date information about network routes, routing protocols generate smaller sized packets, called routing packets. One example of such packets is a HELLO packet, which is used to check whether the neighbor node is active or not. Note that routing packets do not carry any application content, like data packets do. Both, routing and data packets have to share the same

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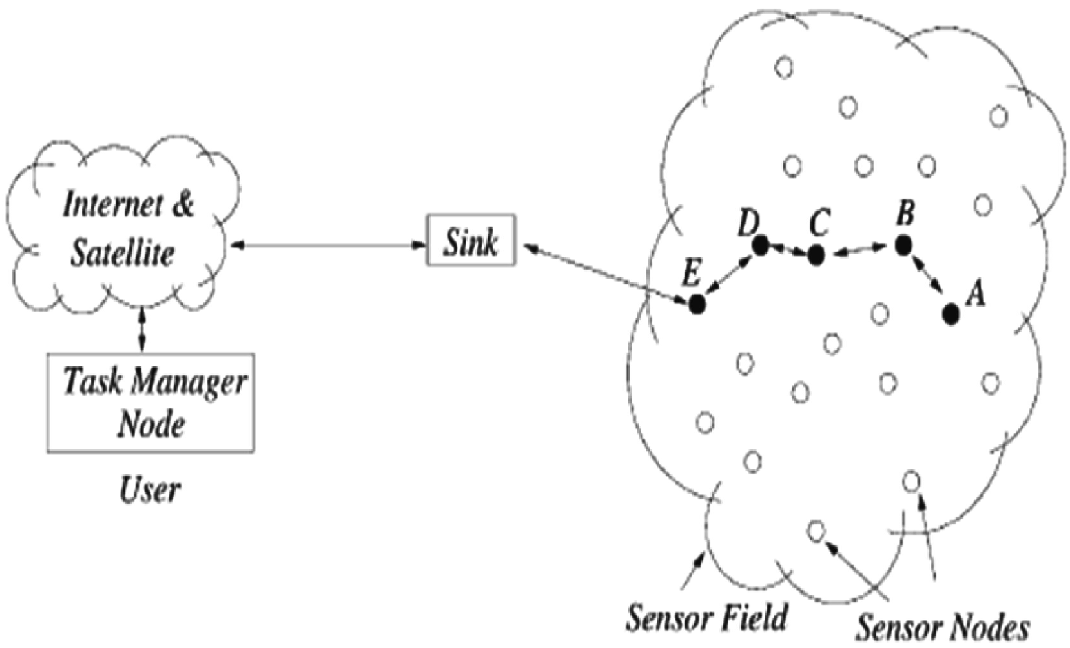

Fig.1.2 Basic structure of Wireless Sensor Network

network bandwidth most of the times, and hence, routing packets are considered to be an overhead on the network. This overhead is called routing overhead. A good routing protocol should incur lesser routing overhead. WSN using Static Sink also increases the packet drop rate/packet loss. Once congestion starts to build up in the network, the battery of the congested node drains out quickly and hence results in more energy consumption. So the nodes near to the Static Sink get congested and die out quickly due to traffic.

II. MOTIVATION OF THE RESEARCH

Generally the sensor nodes run through the battery, and these batteries cannot be substituted. They perish when the whole energy of the battery is consumed and directly it influences the performance and the task of the whole network. Therefore an efficient routing technique is needed to increase the lifetime of the network and also balancing the energy consumption. This feature encourages to develop an energy efficient routing technique which routes the data with less energy consumption.

The Wireless Sensor Network is a network where data are transmitted following “multihop” strategy, i.e. the sensor nodes transmit their data through various intermediate nodes the sensor and sink or base station. The path between the sensors nodes are very much used to failure due to the whole energy depletion of the battery. The repetition of failure of a link directly influences the packet delivery ratio and also reduces the trustworthiness of the network. This all problems encourage to develop a trustful routing technique.The hotspot problem can be rectified by using a movable sink, but controlling the mobile sink is a real tough task. Several protocols for routing have been proposed for mobile sink surroundings, but they also have some demerits like worthless management, huge energy consumption, and also minimize the packet delivery ratio. It is very much required to control the path of mobile sink to enhance the lifespan of the network. In most of the applications, the data generated through nodes must reach the base station at quickest as possible. But, if there is no path available, the location of the sink and the repetition of node failure maximize the End to End Delay. Therefore, it is needed to develop different techniques which not only minimizes the energy consumption, but also reduces the delay in data transfer from sensor nodes to sink.

III.RELATED WORKS

Mrs. T. Nagamalar [1] et. al. presented a paper based on a scheme,in which each node passes its calculated weight upstream. Each node adds its current weight to that it received from an infrastructure in the majority cases of energy or downstream node, and passes this information toward the upstream node. At the end, the source will receive the sum of all alive on a minute, finite sources of energy and communicating weight information from the corresponding downstream nodes and use it for controlling rate. Majid I. Khan [3] et. al. presented a paper in which to provide a simulation-based analysis of the energy efficiency of WSNs with static and mobile sinks. The focus is on two important configuration parameters: mobility path of the sink and duty cycling value of the nodes.

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On the one hand, it is well known that in the case of a mobile sink with fixed trajectory the choice of the mobility path influences energy efficiency. Pavlos Antoniou [4] et. al. presented a novel nature-inspired Congestion control mechanism for WSNs. This paper proposed the new version of the flock-based congestion control (Flock-CC) approach based on the synchronized group behavior of bird flocks and their ability to avoid obstacles (i.e. Congestion regions) in order to control the motion of packet flocks through a network of constrained sensor nodes. Shivangi Borasia [4] et. al. discussed the important components of congestion control: congestion detection, congestion notification and rate adjustment. Overall congestion control mechanisms that are discussed are divided into categories based on congestion notification, rate adjustment and congestion detection mechanism and highlighted the working of congestion control mechanisms and critically analyze them. Jing Zhao [5] et. al presented a paper in which they discussed about Congestion. Congestion has always been a serious problem for all kinds of communication networks. Wireless sensor networks (WSN) face special difficulties in dealing with congestion due to their unique requirements and constraints. Various congestion control schemes for WSN have been proposed recently. These schemes try to solve the problem either at the MAC layer or through a cross-layer approach. Their paper explores these schemes and tries to find their common features, which may direct future research. Arpita Chakraborty [6] et. al. presented a novel trust based congestion aware routing algorithm for WSNs in which the optimum route for data packet transfer is dynamically selected by the TC-ACO algorithm, on the basis of the trust, congestion level and inter-nodal distance of the sensor nodes. The protocol considers the impact of the misbehavior of the faulty nodes on network congestion and thereby minimizes its effect during data packet routing. Haresh M. Rathod [7] et. al. discussed recently developed and proposed congestion control techniques for WSNs. Firstly, they emphasized on some unique characteristics of WSNs, then discuss some guidelines for designing an effective congestion control scheme and then they have compared various congestion control techniques based on QoS parameters such as energy efficiency and fairness. Ali Ghaffari [8] et. al. presents a comprehensive survey of major congestion control mechanisms used in WSNs and classifies the available methods into four categories i.e. traffic control protocols, resource control protocols, queue assisted protocols and priority-aware protocols. This review paper compares the important techniques with each other in terms of congestion detection, congestion notification and congestion mitigation as well as directions for future researches and works. Jiqiang Tang [14] et al. presented a paper that deal with the delivery latency of the minimization problem in a wireless sensor network with a mobile sink deployed on a plane randomly. The minimization problem is formulated as an NP Complete integer programming problem. To solve the problem, they proposes a substitution heuristic algorithm which utilizes (Travelling Salesman Problem) TSP algorithm to produce the visiting sequence of anchor points, and uses substitutions to reduce the route length.

IV. METHODOLOGY

A. Multipath Routing

The design of reliable routing protocols is unaffected by frequent path interruptions because of node failure and collision. The routing path should be kept intact during data transmission else, re-transmission of data increases energy consumption. Some protocols exhibit routing path, but usually ceases to operate correctly while transmission, which reduces the validity. The data should arrive at the base station or sink by means of a reliable path. Multipath routing is the solution to eliminate this problem. Multipath routing protocol permits many paths between the source and the sink. So if one path fails, data can still be sent by means of various paths available. Thus, the reliability of the system increases. As a result of the compact arrangement of sensor nodes, construction of multiple routing paths is feasible. This motivated us to use the concept of multipath routing for reliable data transmission. A number of routing protocols maintain the multipath at the cost of energy consumption. In this chapter, a Multipath Routing Protocol (MRP) is proposed which reduces the control overhead for route discovery and increases the throughput of the network. The proposed multipath routing protocol is designed to improve the lifetime, latency, and reliability through discovering multiple paths from the source node to the sink. MRP is the sink initiated the route discovery process with the known location information of the source node. In MRP, one primary path and many alternate paths are discovered.

B. System Model

The following assumptions are considered for the proposed protocol.

1) Sensors and the base station (i.e., sink) are all stationary after deployment.
2) The sensor nodes are uniformly distributed in the network field with random deployment
3) The sensors are homogeneous and have the same capabilities.
4) Sensor nodes are battery powered, hence have limited energy.

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5) Sensor nodes can calculate their residual energy.
6) Links are symmetric, i.e., the data speed or quantity is the same in both directions, averaged over time.

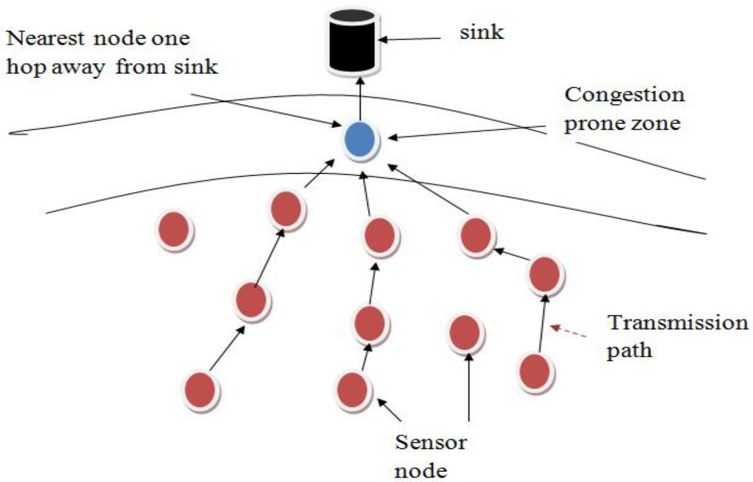

Fig. 4.1 WSN with a single node near the sink

We consider a set of sensor node and a sink node in the network. Each sensor node has the location information in x-y axis. The sleep mode is used for the sensor node to conserve the energy. The communication is accomplished between the sensor nodes using the t Media Access Control (MAC) protocol. The sink node possesses unlimited computation, memory, and battery power. The sink node also contains the id and the location of each sensor node. When the sink required the data from the source node, it constructs the route between them. The threshold energy is the minimum residual energy of a sensor node, beyond which; it cannot perform any additional functions except to sense and relay the data.

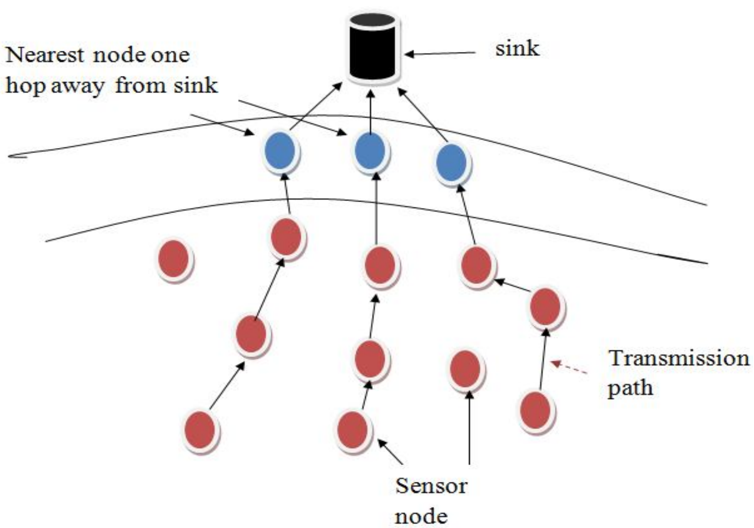

Fig.4.2 WSN with multiple nodes near the sink

C. Multiple Path Construction

At the end of route discovery phase, a request is sent by the sink node to the source node for transmission of data. Initially, primary node is chosen for request by the sink node. When the next primary node receives the request, a reverse link is built to the preceding node for forwarding the data packet. Thus, the request reaches to the source, which in turn sends data packet in reply. Hence, each primary node has an option of choosing a next primary node or an alternate node. Generally, data transmission by the source node is over the primary path. In case, a primary path is not available, then alternate paths are used. To conserve the energy, nodes go to sleep mode, if they are not in the active path. Routing process starts all over again, if there is no existing pat between the source and sink.

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D. Genetic Algorithm based Multipath Routing Algorithm

Before data transmission, an optimal path from every sensor node to sink node must be established using Genetic Algorithm. When a data packet is required to be sent to a sink node, based on the routing tables, the source node will transfer the data packet from the source node through its optimal path to the destination. This will again be followed by all its succeeding nodes to transmit the packet to the sink node along its optimal path. When a data packet is successfully transmitted through the optimal path, if any node perishes or channel error in the path may result in collapse in transmission. Every node, which sends a data packet, is fully responsible for accepting that its successor has successfully collected the packet, to confirm a packet delivery. This may be performed by the transmitter observing the packet, recently sent out to the downstream node and overhearing if that node has passed it on within the allotted time period. Using the Genetic algorithm, the sensor nodes will be discovering an optimal route to the sink based on its initial position; it does not matter whether it is a static sink or mobile sink. The Mobile Sink will move close to the cluster to minimize the distance between sensor nodes and collects data from each cluster by moving close to each of them.

E. Overview of Genetic Algorithm

A Genetic algorithm is a class of algorithm which imitate the process of calculation from the biological system and try to develop computing based on it. It is based on the "survival of fittest contest" which is basically the Darwinian theory, i.e. only the best among the generation will survive. For example: average age in our country before independence was around 40's while now it is around 68 so we can say the successive generations are becoming better and better. Earlier many of the diseases were not known so they cannot be cured, however, as time goes on medical researchers have progressed rapidly. Most of the diseases now are known to us, even our body parts like kidney, eyes, ear, legs, etc., can be replaced. This leads to increase in average life and thus we can say the successive generations are becoming smarter and better. The major reason behind the success of a genetic algorithm is "robustness.

Genetic algorithms are a particular class of evolutionary algorithms that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover (also called recombination).

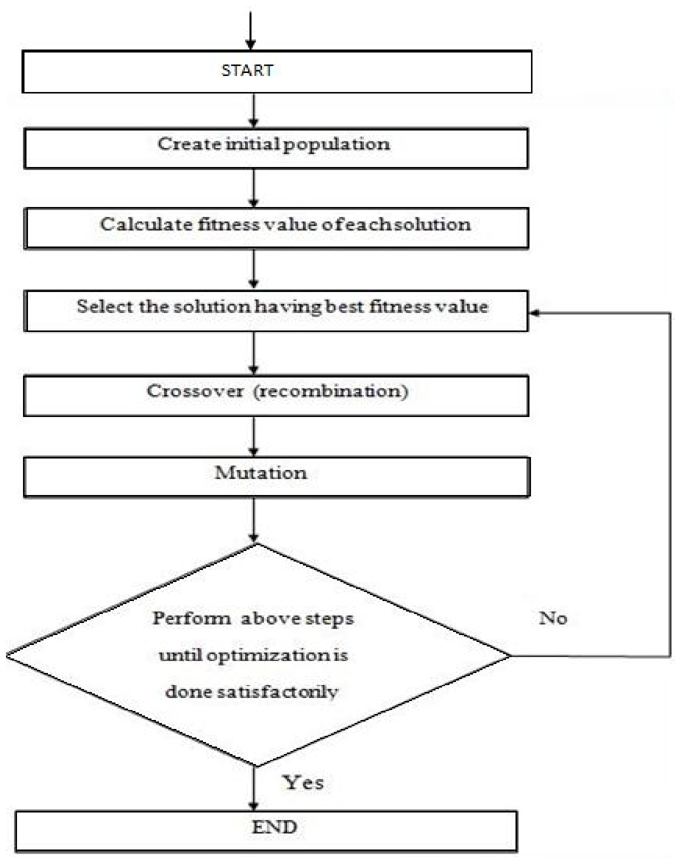

Fig. 4.3 Flow Chart of Genetic Algorithm

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An initial population is created from a random set of solutions.
These solutions have been represented as Chromosomes.
Among the set of Chromosomes, those ones having higher fitness values are selected for a further recombination process.
A value for fitness is assigned to each solution (chromosome) depending on how close it is actually to solve the problem.
The Chromosomes having the higher fitness value are more likely to produce the offspring.
If the population in the generation after reproduction produces an output that is close enough to the desired output than the problem has been solved.

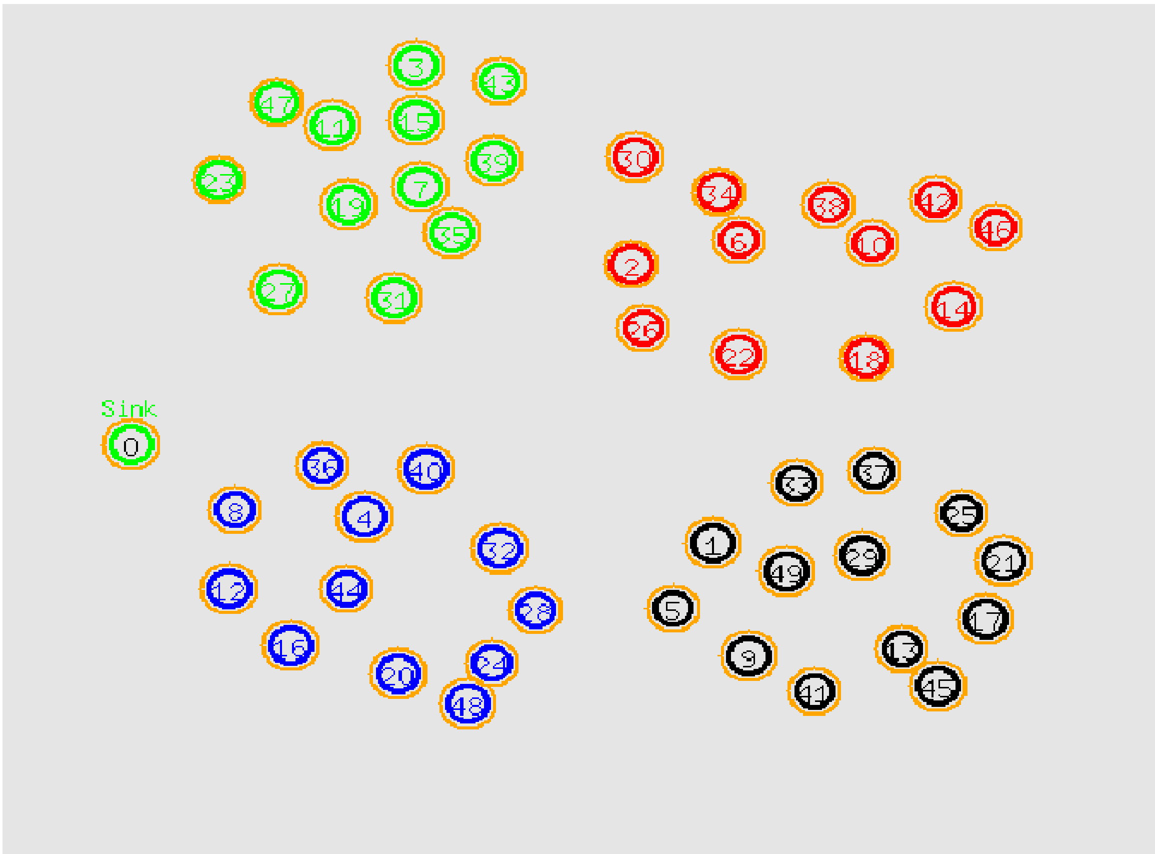

Fig. 4.4 Location of all clusters and cluster member in Wireless Sensor Network

We have calculated the distance between two sensor nodes by the Euclidean distance formula:

$$\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

Here x_1, y_1 is the location of Source in x-y axis and x_2, y_2 is the location of Destination in x-y axis.
We have to find the optimal path between the Sensor Nodes and Sink using Genetic Algorithm.

1) Initialization

a) Initially, many individual solutions are randomly generated to form an initial population. The population size depends on the nature of the problem, and it can contain several hundreds or thousands of possible solutions.
b) Traditionally, the population is generated randomly, covering almost the entire range of possible solutions (*search space*).
c) After finding the possible solutions then we will calculate the fitness values of each solution.
d) We will calculate the distance of all possible solutions and this will be the fitness value of each solution.
e) The solutions having least distances are the desired ones, lesser the fitness value fitter is the solution.
f) Here we are going to find the optimal path between Sensor node '1' and Sink from the Wireless Sensor Network shown in Fig. 4.3.
g) Some of the possible solutions along with their fitness values are given below

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Chromosome						Fitness Value
1	5	28	40	36	0	735
1	32	4	8	12	0	791
1	28	44	8	36	0	847
1	28	20	44	8	0	751
1	28	20	12	8	0	785
1	32	20	44	8	0	793
1	32	20	12	8	0	827
1	5	28	44	12	0	745

2) Selection

Selection is the process in which one or two parents are selected from the population for reproduction.

Individual solutions are selected through a *fitness-based* process, where fitter solutions (as measured by a fitness function) are typically more likely to be selected.

a) Selection Methods:

(i) Roulette Wheel Selection.
(ii) Rank Selection.
(iii) Tournament Selection.
(iv) Elitism.

Selection strategy should be such that, strong individual should be given more chance to recombine and produce new offspring.

But at the same time, it should also be noted that weak individuals are also given the chance to recombine.

Sometimes, weak individuals contain some good genetic material. If we simply discard those weak candidates and not allow them to participate in producing new offspring, then we may lose this good genetic material.

By allowing them to participate in producing new offspring, we are able to retain this good genetic material into the next generation.

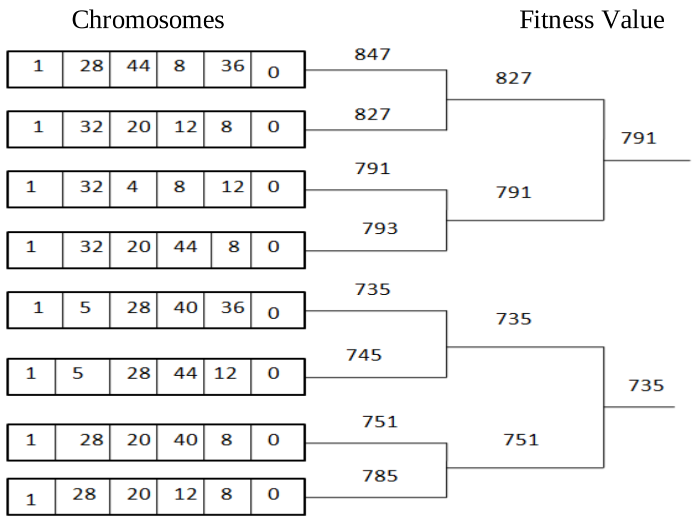

Fig. 4.5 Tournament Selection method

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We have used Tournament Selection Method for final selection of two parents, which we will be using for reproduction. The Selected two chromosomes having fitness value 791 and 735 will undergo crossover. After crossover, the generated offspring will undergo for mutation, if we get the optimum result then that is enough and if we do not get the optimum result than we will again start from the selection step.

3) Crossover

It is the process in which two chromosomes combine their genetic materials to produce a new offspring which possess the characteristics of both chromosomes. The Crossover Methods are given below:

a) Single point crossover
b) Two point crossover
c) Uniform crossover

Here we will be performing crossover on one weak chromosome and one strong chromosome.

Chromosome 1 — Fitness Value 791

1	32	4	8	12	0

Chromosome 2 — Fitness Value 735

1	5	28	40	36	0

Genes on which crossover is performed is shown by an arrow mark above and the offspring generated after cross over is shown below having fitness value 804.

Offspring — Fitness Value 804

1	32	4	8	36	0

4.5.4 Mutation

- It is the process in which a string is inter- changed to maintain diversity in the population
- We mutate the string by randomly selecting any two strings and then interchanging their positions in the solution, thus giving rise to the optimal path.
- The GA may find itself converging on strings that are not quite close to the optimum it seeks due to a bad initial population.

Offspring — Fitness Value 804

1	32	4	8	36	0

New Offspring after Mutation — 675

1	32	4	8	36	0

Some of these problems are overcome by introducing a mutation operator into the GA. For each string element in each string in the mating pool, the GA checks to see if it should perform a Mutation. If it should, it randomly changes the element value to a new one.

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So, we can conclude that this is the optimum solution as the route GA selects is the shorter one as compared to the initial population.The Sensor Node '1' will transmit the data to the sink following the shortest path travelling total distance of 675m and the route is shown below:

1 → 32 → 4 → 8 → 36 → 0

Similarly, we have found the optimal path for all sensor nodes of each cluster to the sink as shown in Fig.4.3. Remember that most of the power of a genetic algorithm comes from the fact that it consists of a rich set of strings of great diversity. Mutation helps to balance that diversity for the whole genetic algorithm iterations.

F. Overview of Particle Swarm Optimization

PSO stands for Particle Swarm optimization and it is a part of mutual intelligence which has been developed based on the mutual habits in a fragmented and self arranged systems. These systems are normally composed of a population of simple agents which get across locally with each other and with their environment. Whereas, customarily no concentrated control forces the actors how to perform, their regional cooperation head to the evolution of public action. Examples of such systems can be noticed in nature like flocks, herds of animals, groups of ants, groups of fishes, gatherings of bacteria. Particle Swarm Optimization (PSO) algorithm was suggested for the first time by Eberhart and Kenney. The conception of this program was influenced from the mass flight of birds, swim team of fishes and their social life which was described by testing a set of simple relations. In the manner of other developing algorithms, particle swarm optimization algorithm starts by organizing an irregular population of individuals which is known as a group of particles here. The countenance of particles in each group is decided based on a series of guideline and their optimal values must be described. In this method, all particle shows a point of problem determining space. All particles also acquire a memory which they remember the best position attained in the search space. So, all particles move in two directions (1) Approaching the best position they have taken individually so far (2) Approaching the best positions that all particles have selected. In this method, change in position in each particle in the search space is inspired by its own practice and intelligence and also their neighbors.

1) *The suggested model is based on the intelligent techniques:* In this part of our study, we try to offer a sincere method for wireless sensor networks by using the intelligent techniques. In this method sensors will be able to gather the environmental data in the best way possible and brief it to the target. The planned algorithm is shown in Fig. 4.5 and acts according to the following steps:

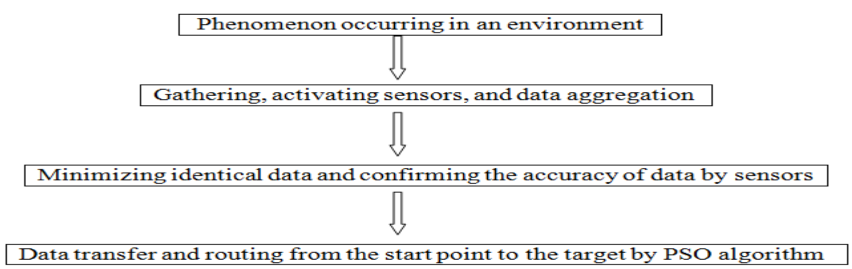

Fig. 4.6 Suggested Model for Data Collection and routing of data collection in WSN

2) *Clustering and data collection phase:* This phase occurs in an environment when different sensors may receive data which might incorporate wrong or identical data, it occurs when a large number of sensors bear to transfer the data which in turn leads to routing traffic and failure of some part of the data. So, it's favored that the data before getting to the activators is organized and their preciseness be monitored. Clustering algorithm and splitting the environment into network cells is the first idea that we have adapted in order to minimize identical and failure data. Using clustering algorithm and splitting the workplace into network cells is a fruitful design to minimize identical and invalid data. Therefore, minimizing identical and invalid data greatly increases productivity, and minimizes crowding and routing traffic.

Although selecting smaller network cells helps to raise preciseness to a great extent, larger network cells make less data minimization and increase the network accomplishment. So, the significance of network cells need to be uniform and improved. Subsequently clustering sensors in the environment, in entire clusters multiple nodes, which are closer to the sink is chosen to administer the sensors in its own cluster. This is shown in Figure-3. This node in each cell is liable for many tasks along with data

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gathering of its own network cell sensors and handling the data, balancing that data, authentication judgement of sensors, and differentiating valid from invalid sensors. The prime idea that can be recommended here is that these multiple sensors in each cell declare imperfect sensors with an approach and expel these sensors data from the accurate data. The new approach that we have suggested has two important benefits. Considering the main challenges that the sensors may either have confined battery power on one hand or that the data transmitted among sensors may be corrupted or lost on the way on the other hand, we suggested a new approach to clarify the two major problems which are stated as follows: On the first place, these multiple nodes in all clusters need all sensors among its own cluster to deliver their data volume and battery life to them. Next, by monitoring these two parameters expels both nodes with less battery power and also defected nodes with failure data. Then, it considers the average of the rest sensors' data. Soon the data of all environmental sensors have attained to these multiple sensor nodes to forwarding this data to activators.

3) *Data transfer phase:* At this stage, it's time for the four chosen cluster heads on four sides of the incident to forward their data through a path to the activator which in turn operate the reactions required to counterbalance environmental event. Routing on these four selected cluster heads is done as follows: First, the four cluster heads find the perfect position and path by using the PSO algorithm.

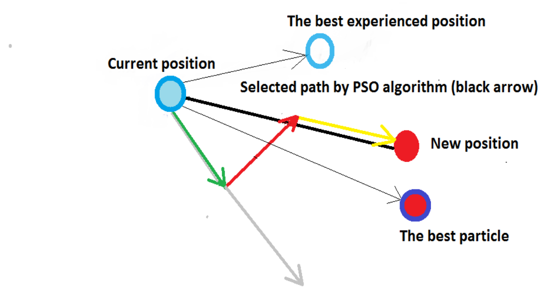
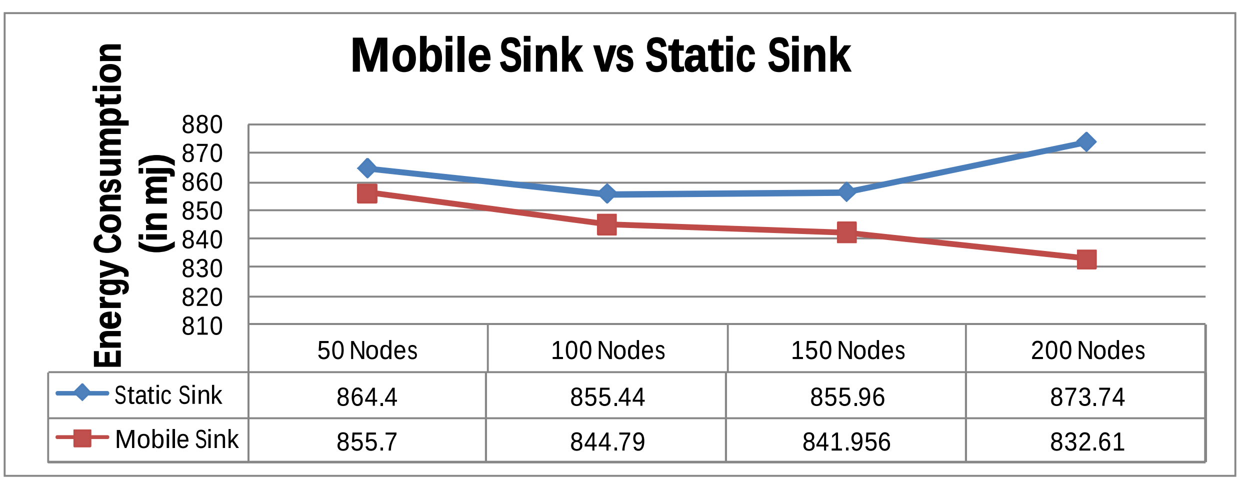


Fig.4.7 Routing Procedure by PSO Algorithm

Fig. 4.7. shows the achievement of particle swarm optimization (PSO) algorithm. It is clear from this Figure that the orange arrow is the best sensor node that should be chosen for routing and forwarding data. The next step for routing is that after each source node chosen the next node by using the PSO algorithm, this node experiences an assessment of battery level and in case of less battery level is extracted and another node is chosen established on the above specified examined method. This method is repeated several times till the data gets to the activators or main destinations through the most secure and optimal path.

V. RESULT AND DISCUSSIONS



	50 Nodes	100 Nodes	150 Nodes	200 Nodes
Static Sink	864.4	855.44	855.96	873.74
Mobile Sink	855.7	844.79	841.956	832.61

Fig. 5.1 Energy Consumption

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Here in Fig.5.1, we have shown the energy consumption of Wireless Sensor Network using static sink as well as mobile sink and our simulation results shows that mobile sink minimizes the energy consumption.

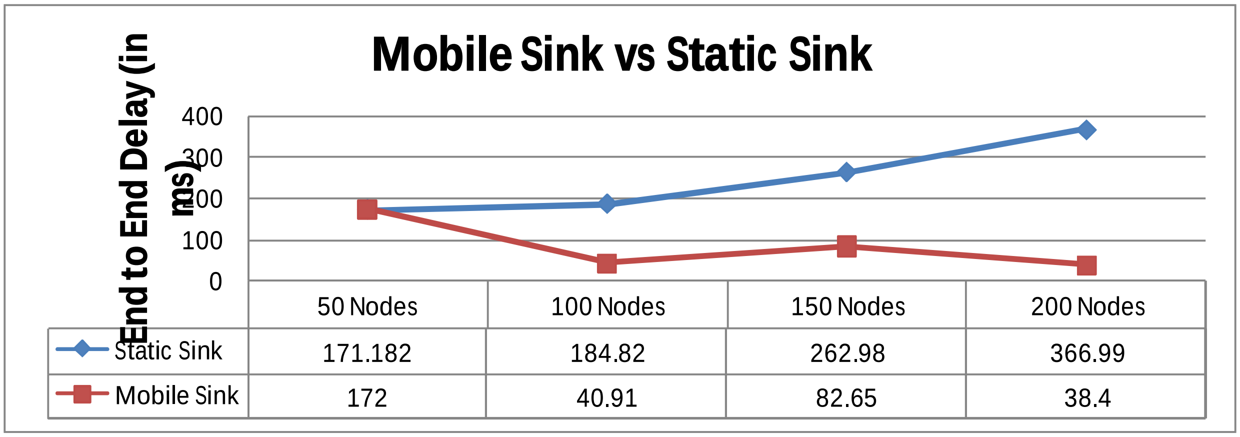

Fig 5.2 End to End Delay

Here in Fig.5.2, we have shown the End to End Delay of Wireless Sensor Network using static sink as well as mobile sink and our simulation results shows that mobile sink minimizes the Delay in data transmission from sensor nodes to sink in WSN.

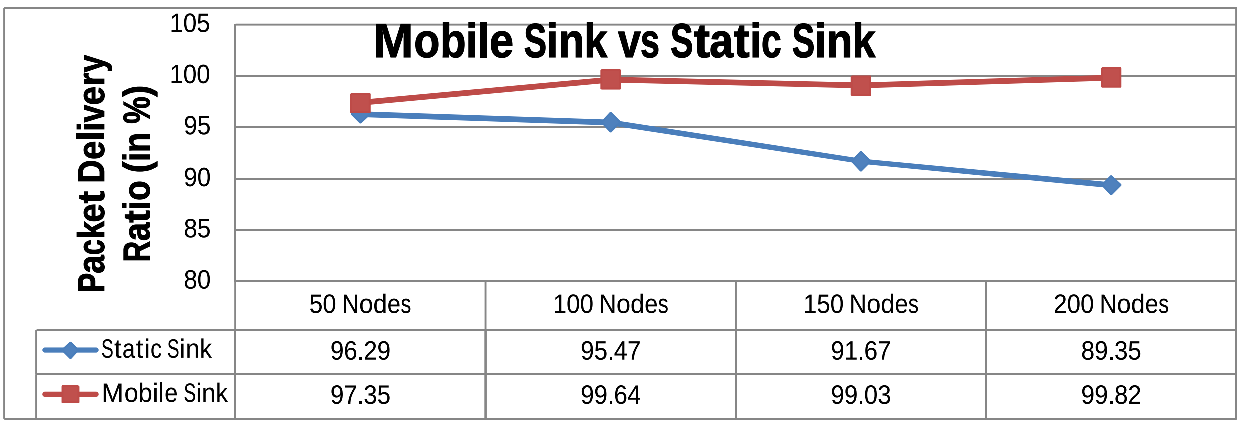

Fig. 5.3 Packet Delivery Ratio

Here in Fig.5.3, we have shown the Packet Delivery Ratio of Wireless Sensor Network using static sink as well as mobile sink and our simulation results shows that mobile sink maximizes the successful delivery of data in WSN.

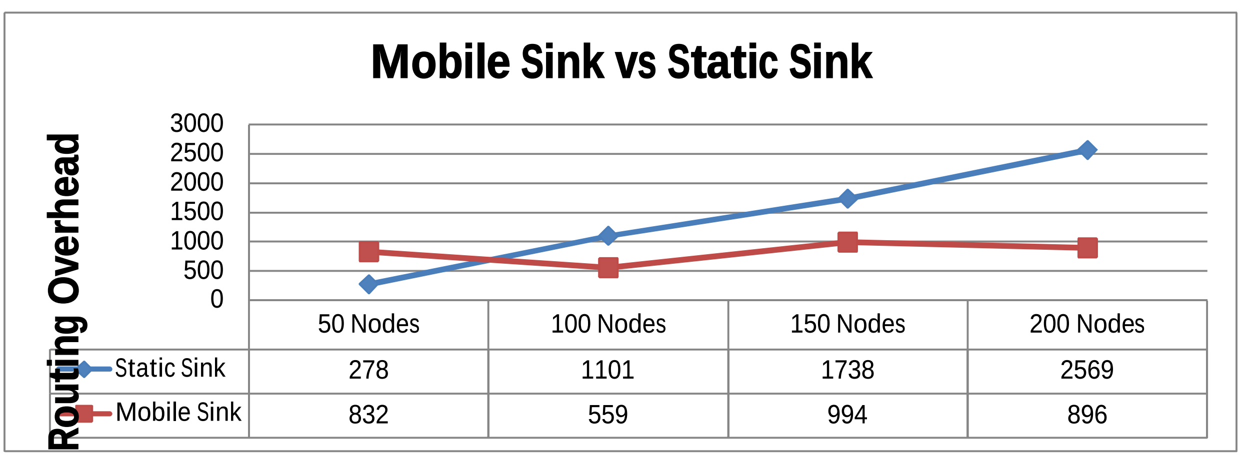

Fig.5.4 Routing Overhead

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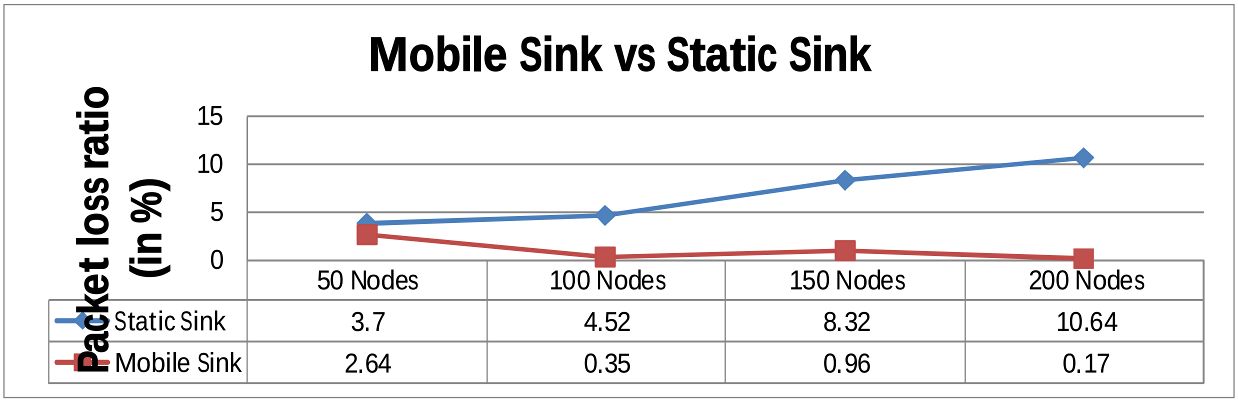
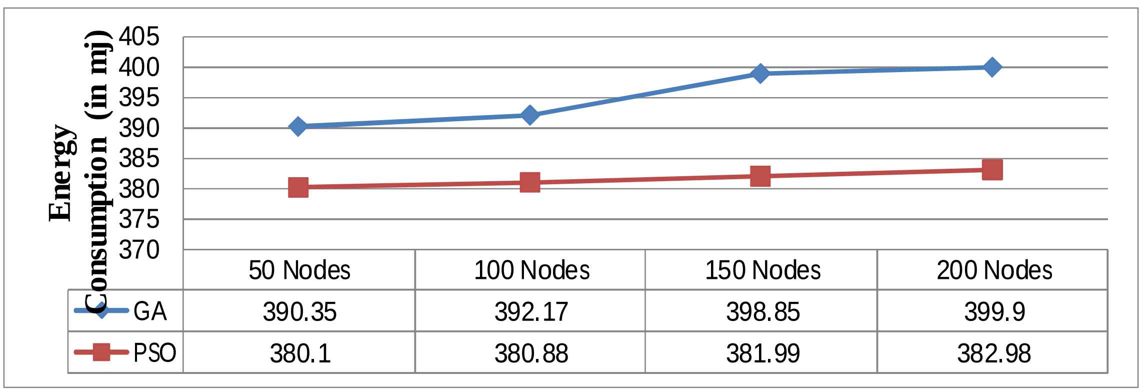
Here in Fig.5.4, we have shown the Routing Overhead of Wireless Sensor Network using static sink as well as mobile sink and our simulation results shows that mobile sink minimizes the Routing Overheads in WSN



	50 Nodes	100 Nodes	150 Nodes	200 Nodes
Static Sink	3.7	4.52	8.32	10.64
Mobile Sink	2.64	0.35	0.96	0.17

Fig.5.5 Packet Loss Ratio

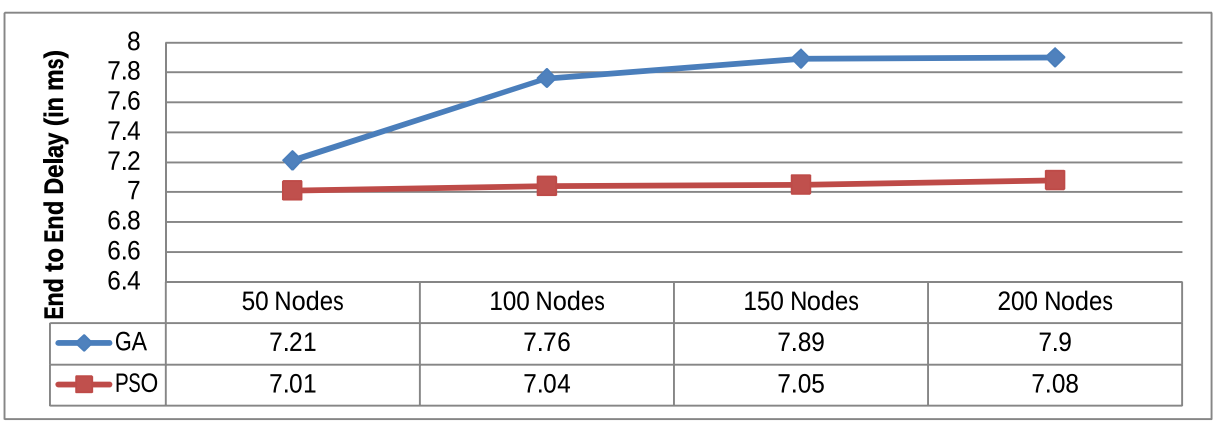
Here in Fig.5.5, we have shown the Packet Loss Ratio of Wireless Sensor Network using static sink as well as mobile sink and our simulation results shows that mobile sink minimizes the PLR in WSN



	50 Nodes	100 Nodes	150 Nodes	200 Nodes
GA	390.35	392.17	398.85	399.9
PSO	380.1	380.88	381.99	382.98

Fig.5.6 Energy Consumption GA vs PSO

Here in Fig. 5.6, we have compared the Energy Consumption of WSN using GA and PSO, our simulation results show that PSO minimizes the Energy Consumption more as compared to GA.



	50 Nodes	100 Nodes	150 Nodes	200 Nodes
GA	7.21	7.76	7.89	7.9
PSO	7.01	7.04	7.05	7.08

Fig. 5.7 End to End Delay GA vs PSO

Here in Fig. 5.7, we have compared the End to End Delay of WSN using GA and PSO, our simulation results show that PSO minimizes the delay more as compared to GA.

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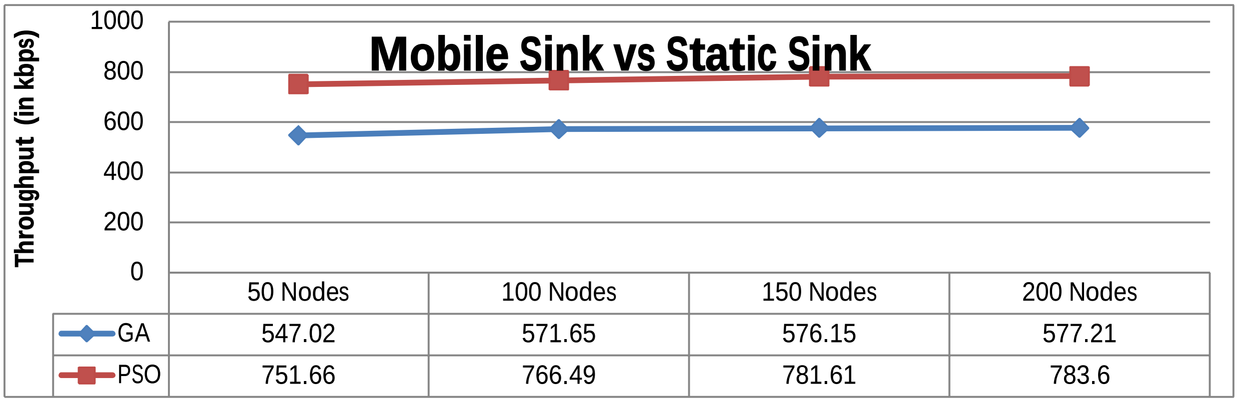

Fig. 5.8. Throughput GA vs PSO

Here in Fig. 5.8, we have compared the throughput of WSN using GA and PSO, our simulation results show that PSO increases the throughput more as compared to GA.

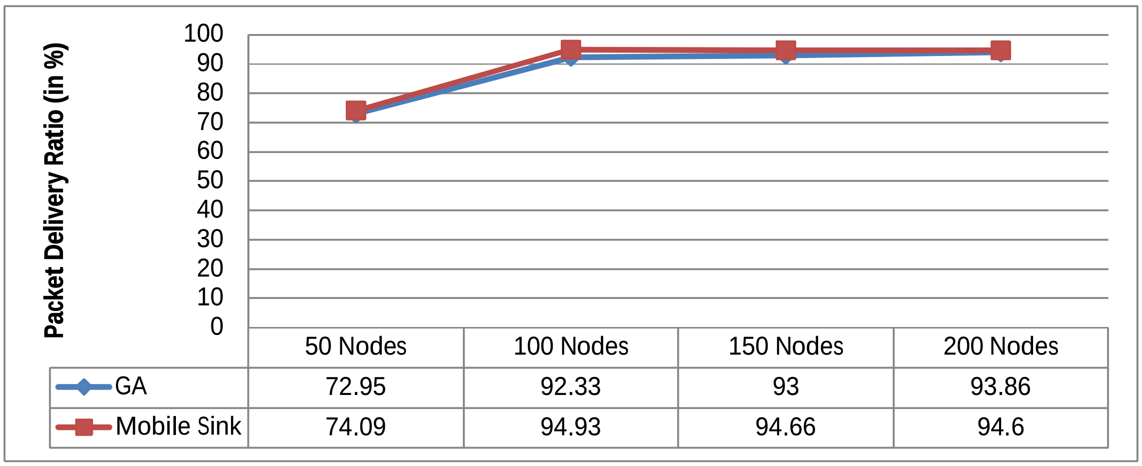

Fig. 5.9 Packet Delivery Ratio GA vs PSO

Here in Fig. 5.9, we have compared the Packet Delivery Ratio of WSN using GA and PSO, our simulation results show that PSO increases the Packet Delivery Ratio more as compared to GA.

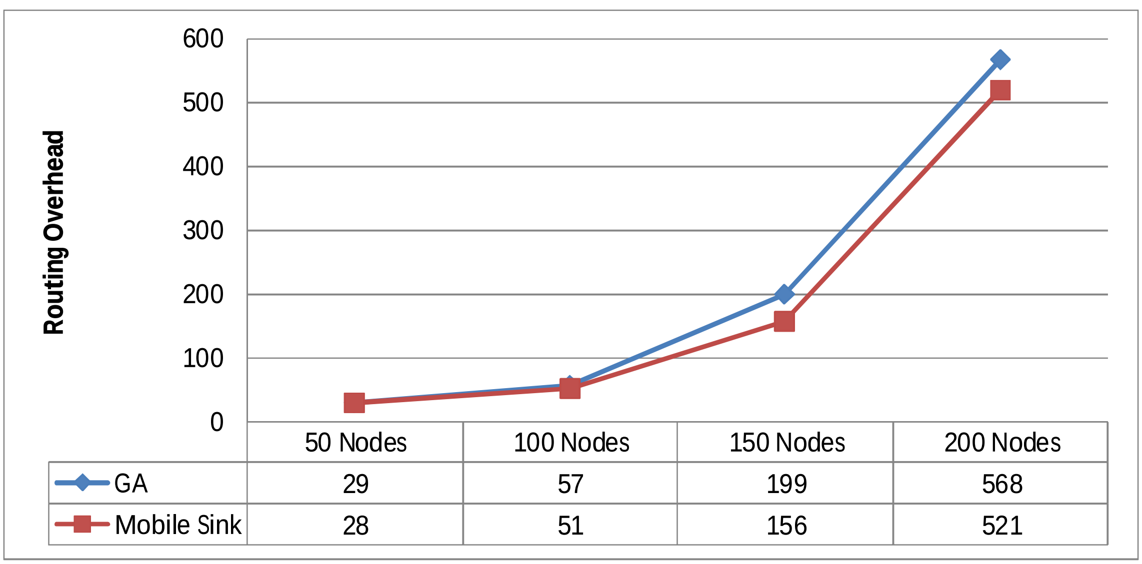

Fig.5.10 Routing Overhead GA vs PSO

Here in Fig. 5.10, we have compared the Routing Overhead of WSN using GA and PSO, our simulation results show that PSO minimizes the Routing Overhead more as compared to GA.

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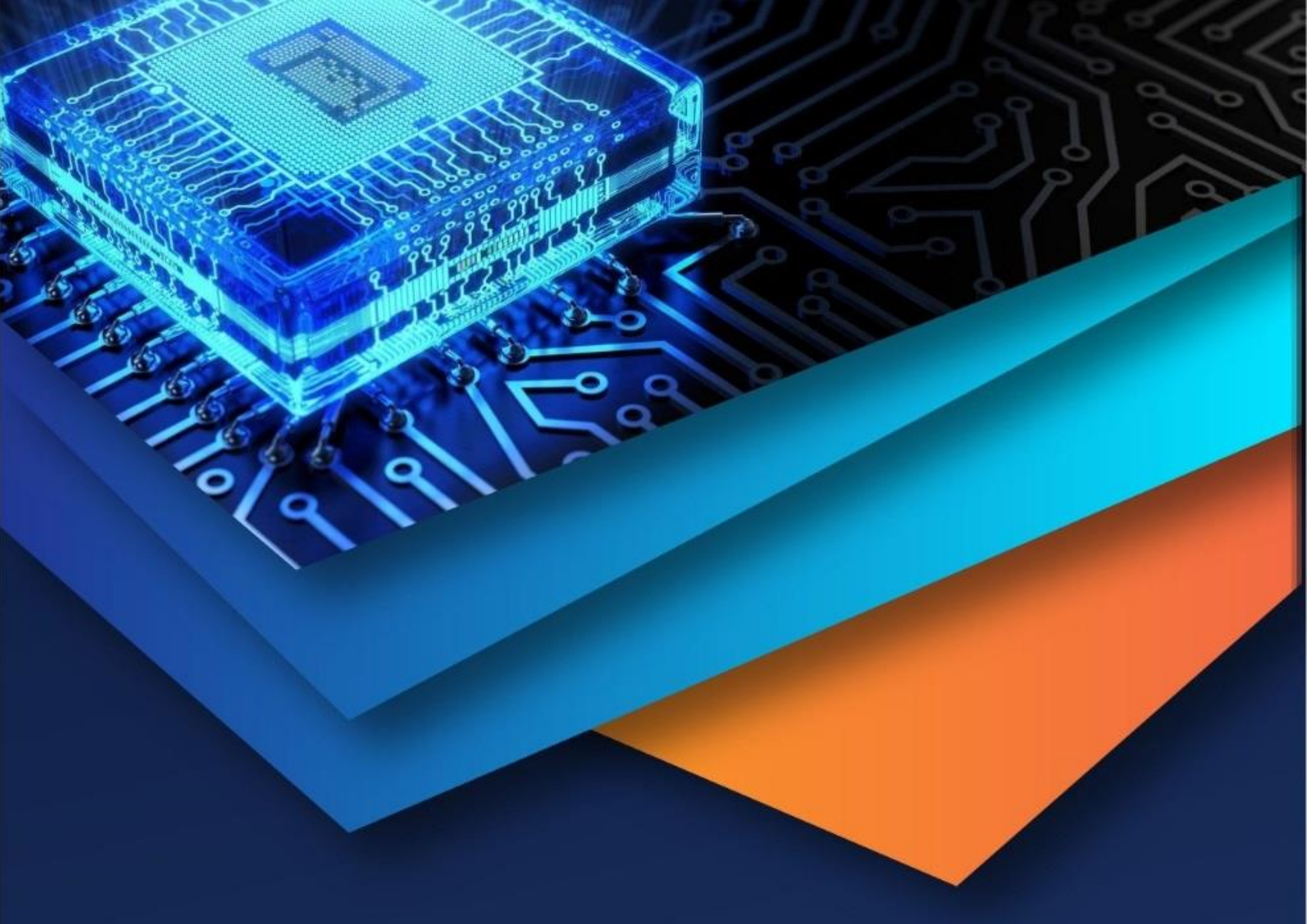

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