PERFORMANCE ANALYSIS OF VARIOUS ENERGY EFFICIENT SCHEMES FOR WIRELESS SENSOR NETWORKS (WSN)

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ABSTRACT

Fast growth of wireless services in recent years is an indication that considerable value is placed on wireless networks. Wireless devices have most utility when they can be used anywhere at any time. One of the greatest challenges is limited energy supplies. Therefore, energy management is one of the most challenging problems in wireless networks. In recent years, Wireless Sensor Networks have gained growing attention from both the research community and actual users. As sensor nodes are generally battery-energized devices, so the network lifetime can be widespread to sensible times. Therefore, the crucial issue is to prolong the network lifetime. In this paper, various Energy Efficient Schemes for Wireless Sensor Networks (WSN) has been compared. Many techniques like Aggregation, Scheduling, Polling, Clustering, Efficient node deployment scheme, Voting and efficient searching methods are used to increase the network life time. In the deployment of nodes using Multi Robot deployment of Nodes method, the result shows that the percentage of reduction in energy consumption is 4%. The Aggregation routing method, analysis shows that the percentage of reduction in energy consumption was 21%. The percentage of reduction in energy consumption is 26% in the effective search technique called Increasing ray search method. In the Voting Scheme, the result gives that the percentage of improvement in energy savings is 34%. The improvement in energy saving is 51% in the Polling method. As per the analysis, polling scheme was very much effective in terms of reducing the energy consumption in Wireless Sensor Networks.

KEYWORDS: *Wireless Sensor Networks, Polling, Voting, Aggregation, Multi Robot deployment, Increasing Ray search.*

I. INTRODUCTION

In recent years, major advances in creating cost-effective, energy efficient, and versatile micro electromechanical systems (MEMS) has significantly created tremendous opportunities in the area of Wireless Sensor Networks [1]. A network comprising of several nodes which are organized in a dense manner is called Wireless Sensor Networks (WSN). A sensor node, also known as a 'mote', is a node in a wireless sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. The main components of a sensor node as seen from the figure are microcontroller, transceiver, external memory, power source and one or more sensors. Microcontroller performs tasks, processes data and controls the functionality of other components in the sensor node. Microcontrollers are most suitable choice for sensor node. Each of the four choices has their own advantages and disadvantages. Microcontrollers are the best choices for embedded systems. The figure 1 shows the architecture of sensor node.

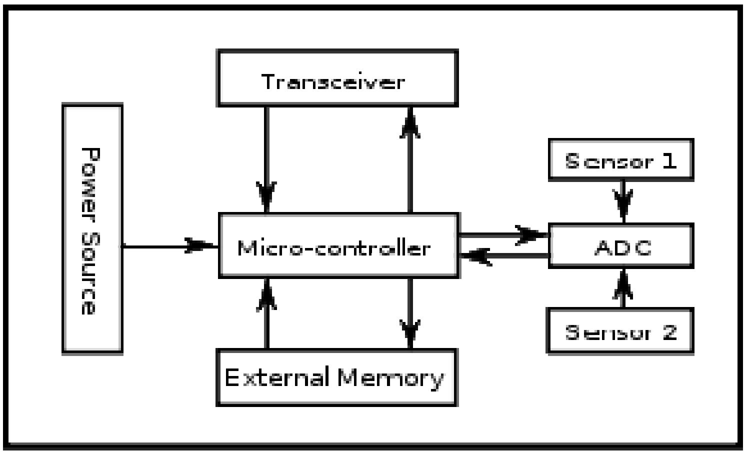


Figure 1 Architecture of Sensor Node

This section explains the basic concepts of Wireless Sensor Networks. The rest of the paper has been organized as follows. Work related to the Energy conservation in Wireless Sensor Networks discussed in Section 2. Problem has been focused on section 3.The various energy efficient schemes are discussed in section 4. In section 5, performance of various energy efficient schemes for Wireless Sensor Networks are compared. The simulation results are discussed in section 6. The Section 7 focused on Conclusion and Future work.

II. RELATED WORK

2.1. Deployment of Node

Basic survey on energy conservation scheme is discussed in [22]. Compared with Random deployment, using the robot to stepwise deploy static sensors in a specific region can give full sensing coverage with fewer sensors. Previous research [2] was assumed that the robot is equipped with a compass and is able to detect obstacles. Although the robot-deployment algorithm developed in [2] likely achieves the purpose of full coverage and network connectivity, the next movement of the robot is guided by only one sensor, resulting in it taking a long time to achieve full coverage and requiring more sensors due to a big overlapping area. As for power conservation, most deployed sensors can stay in sleep mode to conserve energy. In addition, the developed deployment algorithm can resist obstacles so that fewer sensors need to be deployed to achieve full sensing coverage even if there are obstacles in the monitoring area.

2.2. Aggregation

The related works are as follows. Investigate the benefits of a heterogeneous architecture [14] for wireless sensor networks (WSNs). WSNs composed of a few resource rich mobile relay nodes and a large number of simple static nodes. The mobile relays have more energy than the static sensors. They can dynamically move around the network and help relieve sensors that are heavily burdened by high network traffic [15], thus extending the latter's lifetime. Evaluate the performance of a large dense network with one mobile relay and show that network lifetime improves over that of a purely static network by up to a factor of four [16] and [17]. Mobile relay needs to stay only within a two-hop radius of the sink. Construct a joint mobility and routing algorithm which can yield a network lifetime [18] close to the upper bound. It requires a limited number of nodes in the network to be aware of the location of the mobile relay [19]. One mobile relay at least double the network lifetime in a randomly deployed WSN.

2.3. Efficient Search of target information

For unstructured WSNs where the sink node is not aware of the location of target information, search proceeds blindly for tracing the target information. The following are most widely used techniques for searching in unstructured WSNs: Expanding Ring Search (ERS) [3], [4], Random walk search [5], [6], and variants of Gossip search [7], [8]. ERS is a prominent search technique used in multihop networks. It avoids network-wide broadcast by searching for the target information with increasing order of TTL (Time-To-Live) values. Since the Gossip Probability is calculated based on the area coverage, the authors show that this Gossip variant is very efficient in terms of reducing overhead.

2.4. Voting Scheme

In a WSN, the sensors collect the data. The fusion nodes fuse these data and one of the fusion nodes send this fused data to the base station. This fusion node may be attacked by malicious attackers. If a fusion node is compromised, then the base station cannot ensure the correctness of the fusion data that have been sent to it. The witness based approach does not have this difficulty as it uses MAC mechanism to verify the result. Drawbacks of Existing Systems are several copies of the fusion result may be sent to the base station by uncompromised nodes. It increases the power consumed at these nodes. In [9], the voting information in the current polling round is not used in the next polling round. In [10], several copies of the fusion result may be sent to the base station by uncompromised nodes, increasing the power consumed at these nodes. In [11], a MAC mechanism must be implemented in each sensor node that occupies limited memory resources at each sensor.

In [12], the voting information in the current polling round is not used in the next polling round if the verification has not been passed in the current polling round. All votes are collected in each polling round. If the voting can be used in any way, then the polling process should be shortened to save power and reduce the time delay. In [13], since all votes are collected by one node and sent to the base station, this node can forge the fusion result and the votes. Such forgery must be prevented to increase security in the data fusion system.

2.5. Polling

Existing scheme uses heterogeneous sensor network, in which basic sensors are simple and perform the sensing task and second is cluster head, which are more powerful and focus on communications and computations. Cluster head organizes the basic sensors around it into a cluster. Sensors only send their data to the cluster head and the cluster head carries out the long-range inter cluster communications. The message sent by a cluster head can be received directly by all sensors in the cluster as considered in [20], [21].

An energy efficient design within a cluster will improve the lifetime of a cluster as considered in [22],[23]. Deploy polling mode to collect data from sensors instead of letting sensors send data randomly for less energy consumption. It provides collision-free polling in a multi-hop cluster and it reduces energy consumption in idle listening [24], by presenting an optimal schedule.

III. PROBLEM STATEMENT

Wireless Sensor Network (WSN) has been the focus of significant research during the past one decade. One of the key issues is energy management in Wireless Sensor Networks. The WSN node, being a microelectronic device, can only be operational with a limited energy source. In some application scenarios, replacement of energy resources might be impossible. This shows that energy management will be significant in future sensor networks as it now. The current research focused on energy management. Several research efforts have already intense to provide solutions to the problem of energy management.

Recent research efforts on these problem deal with techniques like the process of node deployment, searching the target node, data collection and communication. Wireless sensor network advocates all these techniques for energy management. The proposed schemes are deployed at different points on the network and also analyses the five schemes namely node deployment, searching the target node, voting, aggregation, and polling.

IV. PERFORMANCE ANALYSIS

4.1 Multi Robot deployment

The random deployment of stationary sensors may result in an inefficient WSN wherein some areas have a high density of sensors while others have a low density. Areas with high density increase hardware costs, computation time, and communication overheads, whereas areas with low density may raise the problems of coverage holes or network partitions. Other works have discussed deployment using mobile sensors. Mobile sensors first cooperatively compute for their target locations according to their information on holes after an initial phase of random deployment of stationary sensors and then move to target locations. However, hardware costs cannot be lessened for areas that have a high density of stationary sensors deployed.

Another deployment alternative is to use the robot to deploy static sensors. The robot explores the environment and deploys a stationary sensor to the target location from time to time. The multi robot deployment [29] can achieve full coverage with fewer sensors, increase the sensing effectiveness of stationary sensors, and guarantee full coverage and connectivity. Aside from this, the robot may perform other missions such as hole-detection, redeployment, and monitoring. However, unpredicted obstacles are a challenge of robot deployment and have a great impact on deployment efficiency. One of the most important issues in developing a robot-deployment mechanism is to use fewer sensors for achieving both full coverage and energy-efficient purposes even if the monitoring region contains unpredicted obstacles. Obstacles such as walls, buildings, blockhouses, and pillboxes might exist in the outdoor environment. These obstacles significantly impact the performance of robot deployment.

A robot-deployment algorithm without considering obstacles might result in coverage holes or might spend a long time executing a deployment task. A robot movement strategy that uses deployed sensors to guide a robot's movement as well as sensor deployment in a given area is proposed. Although the proposed robot-deployment scheme likely achieves the purpose of full coverage and network connectivity, it does not, however, take into account the obstacles. The next movement of the robot is guided from only the nearest sensor node, raising problems of coverage holes or overlapping in the sensing range as the robot encounters obstacles. Aside from this, during robot deployment, all deployed sensors stay in an active state in order to participate in guiding tasks, resulting in efficiency in power consumption.

To handle obstacle problems, a previous research has proposed a centralized algorithm that uses global obstacle information to calculate for the best deployment location of each sensor. Although the proposed mechanism achieves full coverage and connectivity using fewer stationary sensors, global obstacle information is required, which makes the developed robot-deployment mechanism useful only in limited applications. This work aims to develop an obstacle-free robot deployment algorithm.

Single and Multi robot deployment scheme- Comparison of No. of nodes with Power Consumption

Table: 1 Simulation results (Vertical Snake Movement Policy)

Sl. No	No. of Nodes	Energy Consumption in Jules	
		Single Robot Vertical Snake Movement Policy	**Multi Robot Vertical Snake Movement Policy**
1	10.0000	68.1000	66.6000
2	20.0000	69.8000	68.8000
3	30.0000	74.6000	70.6000
4	40.0000	78.2000	75.6000
5	50.0000	87.8000	78.6000
6	60.0000	89.9000	85.9000
7	70.0000	93.8000	88.8000
8	80.0000	96.6000	93.8000
9	90.0000	97.9000	95.8000
10	100.0000	98.6000	97.8000

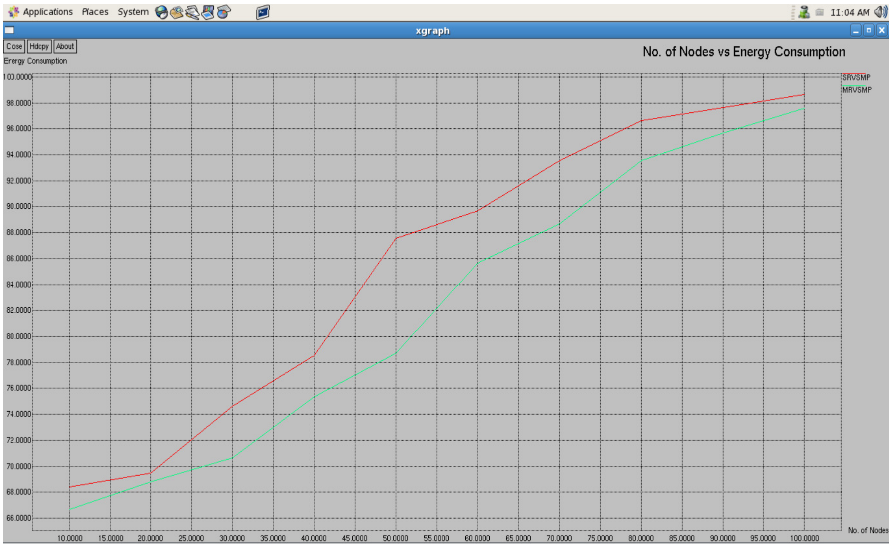


Figure: 2 Simulation results (Vertical Snake Movement Policy)

Table: 2 Simulation results (Horizontal Snake Movement Policy)

Sl. No	No. of Nodes	Energy Consumption in Jules	
		Single robot Horizontal snake like movement policy	Multi robot Horizontal snake like movement policy
1	10.0000	74.2000	68.2000
2	20.0000	81.0000	73.8000
3	30.0000	86.2000	80.6000
4	40.0000	89.2000	85.6000
5	50.0000	93.0000	89.8000
6	60.0000	93.8000	92.0000
7	70.0000	95.8000	93.8000
8	80.0000	96.1000	95.4000
9	90.0000	98.6000	96.4000
10	100.0000	99.6000	97.8000

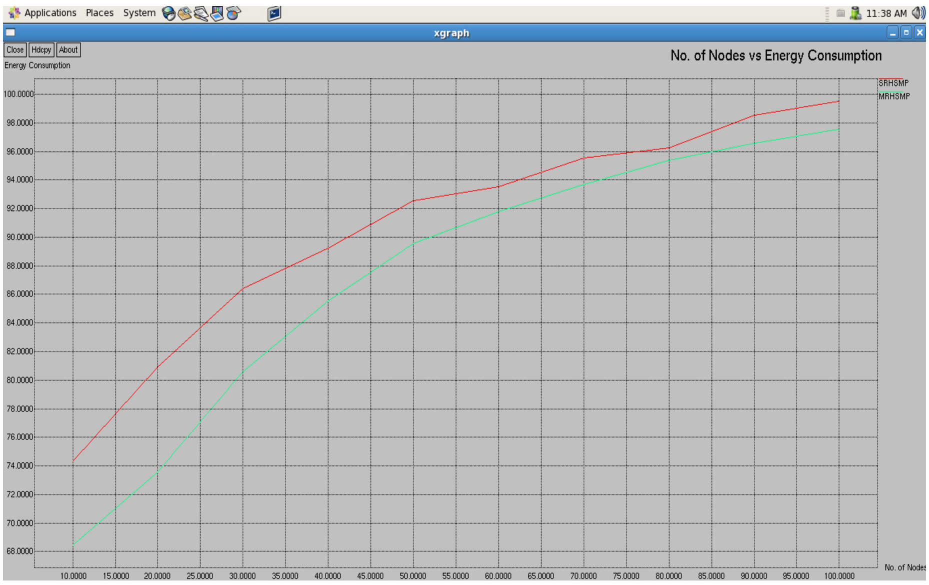


Figure: 3 Simulation results (Horizontal Snake Movement Policy)

Reduction in energy consumption is 4% than previous methods.

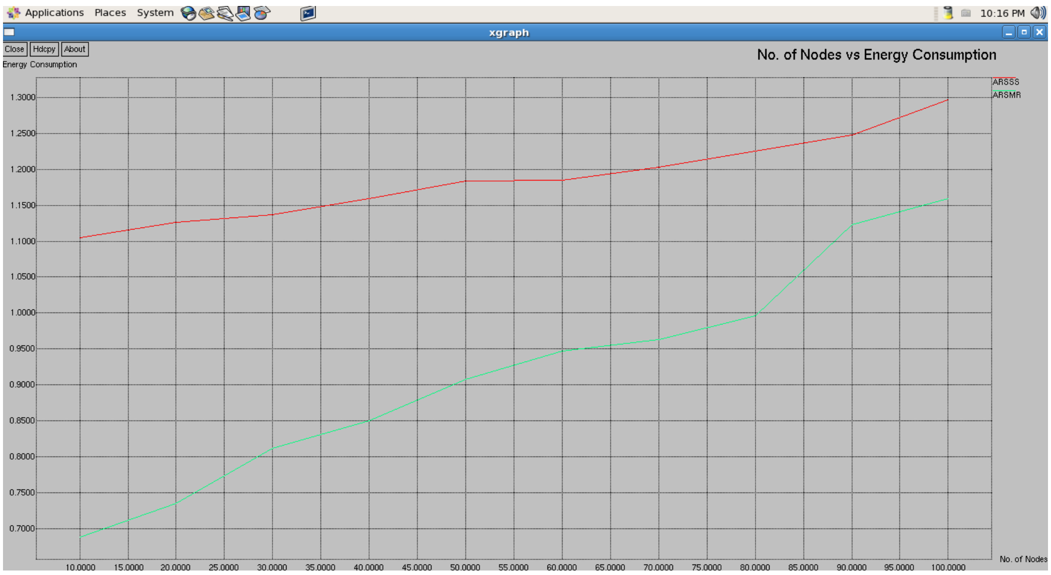
4.2 Aggregation

In-network processing technique is aggregation [21], [26] and [27]. If a sink is interested in obtaining periodic measurements from all sensors, but it is only relevant to check whether the average value has changed, or whether the difference between minimum and maximum value is too big. In such a case, it is evidently not necessary to transport all readings from all sensors to the sink, but rather, it suffices to send the average or the minimum and maximum value. Transmitting data is considerably more expensive than even complex computation shows the great energy-efficiency benefits of this approach

Aggregation Scheme - Comparison of No. of nodes with Power Consumption

Table: 3 Comparison of No. of nodes with Power Consumption

Sl. No	No. of Nodes	Energy Consumption in Jules	
		Aggregation routing scheme for static sensors	Aggregation routing scheme for Mobile relays
1	10.0000	1.1000	0.6800
2	20.0000	1.1300	0.7300
3	30.0000	1.1400	0.8100
4	40.0000	1.1600	0.8500
5	50.0000	1.1800	0.9100
6	60.0000	1.1900	0.9500
7	70.0000	1.2000	0.9600
8	80.0000	1.2300	0.9900
9	90.0000	1.2500	1.1700
10	100.0000	1.3000	1.1600



Reduction in energy consumption was 21% than previous systems.

4.3 Increased Ray Search

The basic principle of IRS [28]variants is that if a subset of the total sensor nodes transmits the search packet by suppressing the transmissions of remaining sensor nodes, such that the entire circular terrain area is covered by these transmissions, the target node which is also in this terrain will definitely receive the search packet. The selection of subset of nodes which transmit the search packet and suppression of transmissions from the remaining nodes are performed in a distributed way. However, if the search packet is broadcasted to the entire circular terrain, even though we find the target information, the number of messages required will be large. To minimize the number of message transmissions, IRS variants divide the circular terrain into narrow rectangular regions called rays such that if all these regions are covered, then the entire area of circular terrain will be covered. In IRS, the rectangular regions are covered one after the other until the target information is found or all of them are explored

Increased Ray Search-Comparison of No. of nodes with Power Consumption

Table: 4 Simulation results

Sl. No	No. of Nodes	Energy Consumption in Jules	
		Area and copies coverage based probabilistic forwarding scheme	Diagonal Area and copies coverage based probabilistic forwarding scheme
1	10.0000	6.4000	4.4000
2	20.0000	6.8000	4.8000
3	30.0000	7.2000	5.2000
4	40.0000	7.5000	5.4000
5	50.0000	7.8000	5.6000
6	60.0000	8.4000	6.1000
7	70.0000	8.5000	6.5000
8	80.0000	8.5100	6.7000
9	90.0000	8.9000	6.8000
10	100.0000	9.5000	7.4000

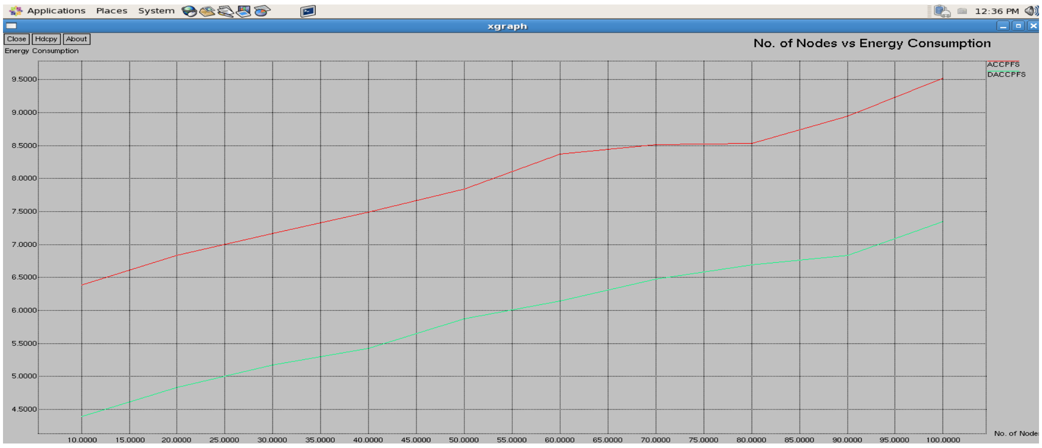


Figure: 4 Simulation results

Reduction in energy consumption is 30% than the previous systems.

4.4 Voting

The voting mechanism [26] in the witness-based approach is designed according to the MAC of the fusion result at each witness node. This design is reasonable when the witness node does not know the fusion result at the chosen node. However, in practice, the base station can transmit the fusion result of the chosen node to the witness node. Therefore, the witness node can obtain the transmitted fusion result from the chosen node through the base station. The witness node can then compare the transmitted fusion result with its own fusion result. Finally, the witness node can send its vote (agreement or disagreement) on the transmitted result directly to the base station, rather than through the chosen node. When a fusion node sends its fusion result to the base station, other fusion nodes serve as witness nodes. The witness node then starts to vote on the transmitted result. One Round scheme is proposed.

One Round Scheme

In this scheme, the base station may receive different fusion results from the witness nodes. It requires that all received fusion results be stored. This scheme has a fixed delay and is summarized as follows:

Step 1. The base station randomly chooses a fusion node. Other fusion nodes serve as witness nodes. A set of witness nodes that includes all of the witness nodes is defined and the nodes in the set are randomly ordered.

Step 2. The chosen node transmits its fusion result to the base station. The base station sets the fusion result as the best temporary voting result and the number of votes for agreement with the fusion result is set to zero.

Step 3. The base station polls the nodes with the best temporary voting result, which currently has the maximum number of votes, following the order of the witness nodes. The witness node compares its fusion result with the best temporary voting result.

If the witness node agrees with the best temporary voting result, it sends an agreeing vote to the base station. The base station increases the number of agreeing votes for the best temporary voting result by one. If the witness node does not agree with the best temporary voting result, it transmits its fusion result to the base station. If the fusion result has been stored in the base station, then the base station increases the number of agreeing votes for the fusion result by one. If the fusion result has not been stored in the base station, then the base station stores the fusion result and the number of agreeing votes for the fusion result is set to zero. The base station sets the best temporary voting result to the received fusion result that had received the maximum number of agreeing votes to poll the next witness node. If two or more fusion results receive the maximum number of votes, then the temporarily best voting result is set to the result that had most recently been voted for.

The polling stops when any received fusion result receives T votes or when the number of un polled nodes plus the maximum number of votes for the results recorded at the base station is less than T. From Step 3, we know that the base station keeps only one best temporary voting result when it is polling a witness node. Therefore, the witness node may be silent when it agrees with the best temporary voting result. This is known as the Silent Assent Mechanism. The fusion node established a hash tree using collected detection results as leaves. The base station requests one of the results and checks if it is consistent with the tree during the assurance process.

Voting Scheme -Comparison of No. of nodes with Power Consumption

Table: 5 Simulation results

Sl. No	No. of Nodes	Energy Consumption in Jules	
		Witness based voting scheme	One round voting scheme
1	10.0000	0.6400	0.2500
2	20.0000	0.6500	0.3700
3	30.0000	0.7400	0.3100
4	40.0000	0.7300	0.3500
5	50.0000	0.8500	0.3600
6	60.0000	0.8500	0.4000
7	70.0000	0.9500	0.4500
8	80.0000	1.1800	0.4800
9	90.0000	1.2100	0.5800
10	100.0000	1.3900	0.6100

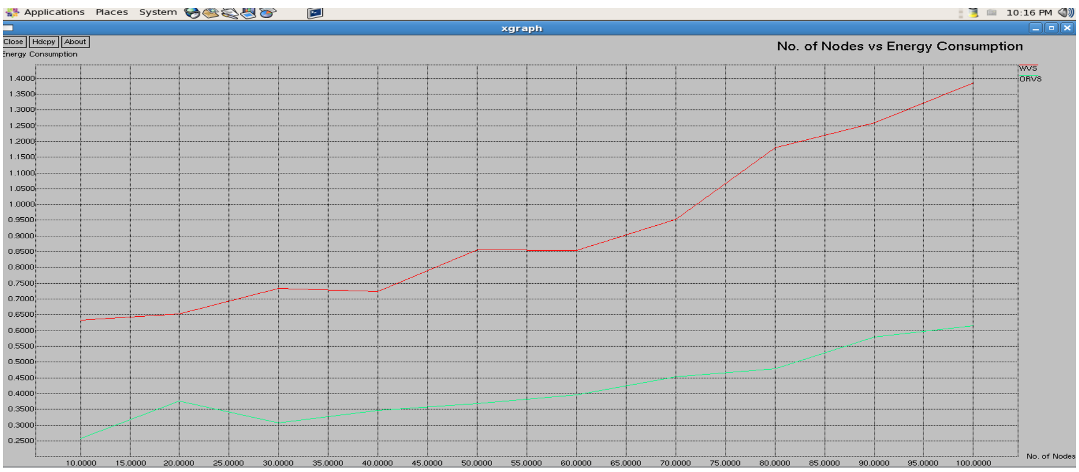


Figure: 5 Simulation results

Improvement in energy savings is 34% than the previous systems.

4.5 Polling

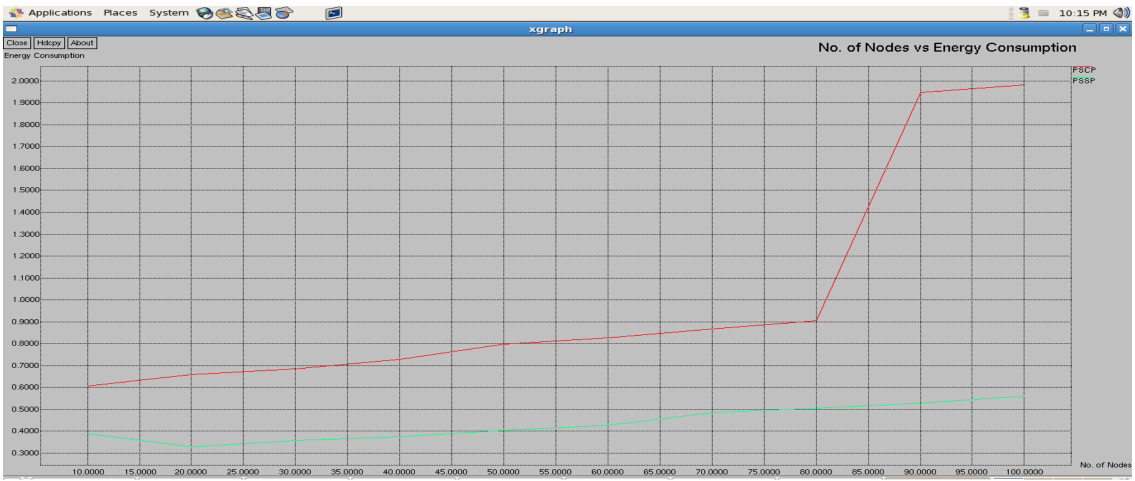
Polling [25] works with topologies in which one device is designated as cluster head and other devices are sensor nodes. All data exchanges must be made through the cluster head even when the ultimate destination is a sensor node. The cluster head controls the link; the sensor nodes follow instructions. It is up to the primary device to determine which device is allowed to use the channel at a given time. The cluster operation discussed in [23], [24], [25], [27], [28], [29] and [30]. The cluster head therefore is always the initiator of a session. If the cluster head wants to receive data, it asks the sensor nodes if they have anything to send; this is called poll function. If the cluster head wants to send data, it tells the sensor nodes to get ready to receive; this is called function.

Polling Scheme-Comparison of No. of nodes with Power consumption

Table: 6 Simulation results of Polling Scheme for Cluster and Sector

Sl. No	No. of Nodes	Energy Consumption in Jules	
		Polling scheme for cluster partitioning	Polling scheme for sector partitioning
1	10.0000	0.6000	0.4000
2	20.0000	0.6800	0.3200
3	30.0000	0.6900	0.3600
4	40.0000	0.7200	0.3800
5	50.0000	0.8000	0.4000
6	60.0000	0.8200	0.4100
7	70.0000	0.8700	0.4900
8	80.0000	0.9000	0.5000
9	90.0000	1.9400	0.5200
10	100.0000	1.9900	0.5700

Partitioning



The improvement in energy saving is 51% in the Polling scheme than the previous one.

V. Results and Discussion

In this research, Wireless Sensor Networks has been established and various energy efficient schemes have been compared. Performance analysis of energy efficient node deployment has been done using single and multi robot scheme. Energy consumption has been measured for various node densities. The energy conservation of Multi robot scheme is observed to be better than that of Single Robot scheme. Energy conservation of multi robot deployment scheme has been found to be 4% better than the single robot deployment scheme. A limitation of this scheme is the deployment cost incurred on using many robots.

In order to improve the energy conservation further, a novel scheme called Aggregation has been proposed. The analyses have been performed for different input sample. Aggregation routing scheme for Mobile relay has been found to be 21% better than the static sensor nodes. A constraint of this scheme is the mobile relay which needs to stay only within a two-hop radius of the sink. To improve the energy conservation further, a scheme called Rays based approach has been proposed. Energy conservation of Diagonal Area and copies coverage based Increasing Ray Search scheme has been found to be 26% better than the Area and copies coverage based Increasing Ray Search scheme. Increasing ray search searches rays sequentially one after the other, the latency incurred will be very high. It is the limitation of this scheme.

The voting schemes have been applied to reduce the energy consumption in WSN. It is evident from results that consumption has reduced. Energy conservation of witness based voting scheme has been found to be 34% better than the one round voting scheme. Limitation of this scheme is having notable amount of delay. The research has further investigated the energy conservation of WSN by providing the polling scheme. The analyses have been performed for different input sample. Based on the results obtained for the different test cases, polling scheme for sector partitioning is 51 % better than the clustering scheme in energy conservation. As per the analysis from the five schemes, polling scheme is very much effective in terms of reducing the energy consumption in Wireless Sensor Networks.

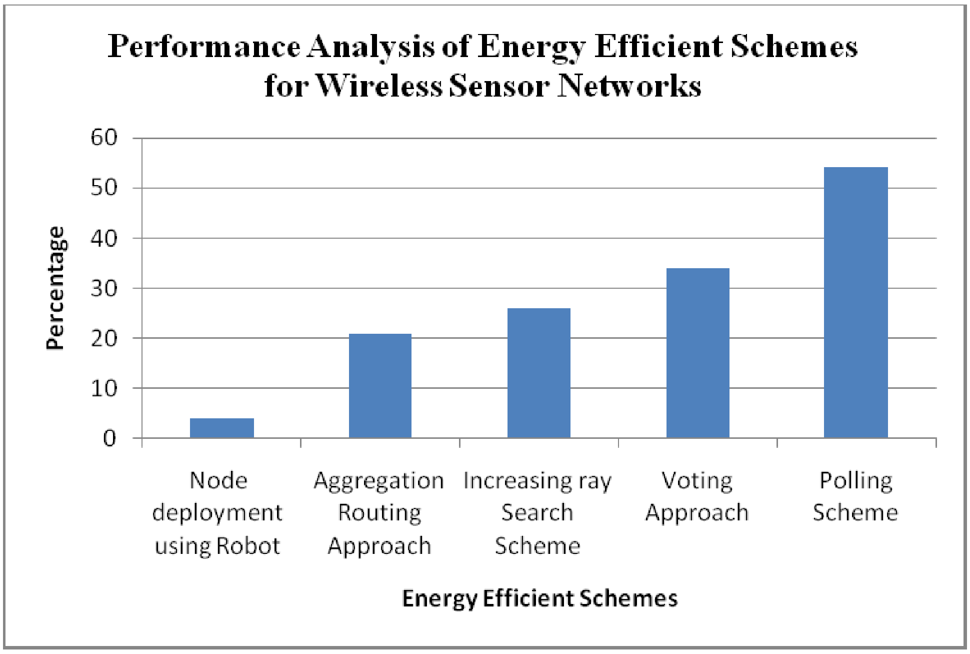


Figure 6 Performance Analysis of Energy Efficient Schemes

VI. Conclusion

In this paper, various Energy Efficient Schemes for Wireless Sensor Networks (WSN) has been compared. In the Multi Robot deployment of Nodes method, the result shows that the percentage of reduction in energy consumption is 4%. The Aggregation routing method, analysis shows that the percentage of reduction in energy consumption was 21%.The percentage of reduction in energy consumption is 24% in the Increasing ray search method. In the Voting Scheme, the result gives that the percentage of improvement in energy savings is 34%. The improvement in energy saving is 51% in the Polling method. As per the analysis, polling scheme was very much effective in terms of reducing the energy consumption in wireless Sensor Networks.

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