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Improving the lifetime in wireless sensor networks based derived energy efficient routing algorithm

KEYWORDS: Wireless sensor network, mutative crossover, Derived Energy Efficient Optimizer, fitness function, mutative crossover.

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ABSTRACT *Wireless sensor network is a type of network with spatially distributed nodes for the application of particular data. It consists of large number of sensor nodes with one or more base stations. The data is sent from sensor nodes to base station straightly or in multihop manner. Increasing the lifetime of network and less energy utilization are two key concerns for WSNs. Some energy-saving routing algorithms decrease total energy utilization of WSN, but they are difficult one in sending the data packets on many key nodes in order that these nodes drain out battery energy quickly through reducing network lifetime. In order to increase the energy efficiency and network lifetime, Derived Energy Efficient Optimization Techniques (DEEORT) scheme is introduced. GA is an effective one for energy efficient path finding in sensor network. GA collects the useful information about individuals from current nodes (i.e., gene). Initially, fitness function is presented to allocate the fitness value for every individual node. This function is used to find the nearby nodes to send the packets from source to sink node. Then, the data transfer of genetic information is carried out between two neighboring node to find another two neighboring nodes is called as crossover operation. Mutation restores the lost genetic values quickly when the node chooses the neighboring node. This process helps in increasing the lifetime of the network and energy efficiency. Performance results shows that the proposed DEEORT obtains the better performance in terms of energy consumption rate, energy drain rate, routing over head and routing delay as compared to the state-of-the-art works.*

INTRODUCTION

In wireless sensor networks (WSNs), node comprises of many wireless crossing point for communicating with each other that are utilized in many areas like exploration, disaster liberation, intelligent carrying, observation, environmental supervising, healthcare, intention tracking etc,. WSNs are mainly used to collect the information in harsh or defensive environment. In WSN, data collected by sensor nodes are to be sent to the sinks (base stations). The data reserved in some nodes are not sent to the sinks as they are distant from radio transceivers of wireless crossing point of the nodes. Therefore, routing protocols are used where the data packets are sent to the sink through multihop manner.

In many areas, nodes in WSN are motorized by batteries with limited amount of energy. Thus, network partitioning takes place when one or more nodes utilize the available energy from batteries that failed to accept the conventional routing protocols. In order to address the above mentioned issues, an energy-efficient routing algorithm is to be planned proficiently as the WSN has a longer lifetime. Routing protocols are to be designed mainly for the power-saving and increasing of network lifetime. A wireless sensor network (WSN) includes large number of very small, multifunctional, and resource controlled sensors. The sensors are self-organized and sensor networks are commonly used in applications where it is complicated or not possible to group the wired networks like wildlife habitat checking, security and military observation and target path.

Routing in wireless sensor network is essential in unreceptive environments. Malfunction to defend such information undermines the planned purposes of sensor network applications. Routing is the process used for sending the information from source to destination. For avoiding the limited energy usage by battery-powered sensor nodes, routing techniques are planned. To reduce the energy usage in the wireless sensor networks, Derived Energy Efficient Optimization Techniques (DEEORT) is introduced.

The rest of the paper is organized as follows. In Section 2, a summary of different techniques to improve the energy efficiency and network lifetime are explained. In Section 3, the proposed scheme of Derived Energy Efficient Optimization Techniques (DEEORT) with the help of neat diagram is described. In Section 4, simulation environment is provided with detailed analysis of results explained in Section 5. In Section 6, the concluding remarks are included.

LITERATURE REVIEW

An energy-efficient routing algorithm based on multiple criteria decision making (ERBM) method is designed in [1] for WSN. The potential energy in classical physics idea is planned in hybrid virtual potential field for minimizing the energy consumption. A genetic algorithm is used for balancing weight of potential fields. However, the network lifetime of the network is not increased. An application specific low power routing protocol (ASLPR) is planned in [2] with the ideas from sensor nodes to choose the optimal cluster heads. A hybrid algorithm called genetic algorithm and simulated annealing is used to enhance the ASLPR performance for increasing the network lifetime. However, the energy consumption by the sensor node is high.

In [7], a simple, leas time and energy-efficient routing protocol with one-level data aggregation (LEO) increases the network lifetime. Though LEO has high network lifetime, mobility remained unaddressed. The energy-efficient data scheduling problem [3] with individual packet delay constraints to energy-efficient service curve construction problem is introduced. The local optimality theorem is de-

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signed depending on two efficient scheduling algorithms. But, the energy efficiency level is lesser. Distributed HAC (DHAC) algorithm in [9] has bottom-up clustering technique through clustering same nodes together sooner than the selection of cluster head (CH). DHAC contains quantitative and qualitative information. But, the energy drain rate of sensor node is comparatively high.

Bee-inspired Bee-Sensor protocol is energy-aware, scalable and efficient protocol planned in [4]. The key objective of the protocol is a three phase protocol design. In [5], Energy-efficient multi-layer MAC (ML-MAC) protocol is designed for wireless sensor network with two features, namely low duty cycle and low number of collisions. Sensor nodes in ML-MAC contain short listening time that minimizes the energy to communicate with other nodes. Though, the ML-MAC protocol presents better quality performances. An energy-efficient multi-layer MAC (ML-MAC) protocol is planned in [10] for wireless sensor networks. The protocol is planned with two features, namely low duty cycle and low number of collisions. Sensor nodes in ML-MAC needs less listening time to send information with other nodes that reduces the energy level. But, the network lifetime increasing problem remained unaddressed.

An energy-efficient and high-accuracy (EEHA) scheme is planned in [6] for secure data aggregation. In EEHA scheme, the exact data aggregation is attained without the private sensor analysis and overhead on battery-limited sensors. But, the network lifetime is less in battery-limited sensors. QoS of an energy-efficient cluster-based routing protocol called Energy-Aware routing Protocol (EAP) [8] in terms of lifetime, delay, loss percentage and throughput, and proposes some modifications on it to enhance its performance. But, the energy consumption for routing is comparatively higher. QoS guarantee is established in [13] through the relay nodes. A solution depending on NSGA-II is planned for efficient QoS routing in cluster based WSNs. An energy-efficient routing technique for two-tiered WSN by Genetic Algorithm, Particle Swarm Optimisation and A-Star algorithm based approach [11] is planned to prolong the network lifetime. But, routing overhead is high.

In [12], clustering and cluster head selection of ZEEP by the Genetic Fuzzy System is improved. The two-step clustering process employs Fuzzy Inference System to choose optimal nodes depending on parameters. K-means and improved GAs are combined in [21] minimizes the energy consumption and increase the network lifetime. The designed technique minimizes the energy consumption through locating the optimum number of cluster head (CHs) nodes by improved Genetic Algorithm (GA). But, routing delay is high. Genetic algorithm based technique in [14] for clustering and routing in wireless sensor networks. The clustering is depending on residual energy of gateways and distance from sensor nodes to equivalent cluster head. But, the energy efficiency remained unaddressed. In [18], optimization of packets using anycast forwarding schemes was presented to minimize the packet-delivery delays from the sensor nodes to the sink. A solution was provided to control the system parameters and anycast packet-forwarding to increase the network lifetime. But, routing process was quite complicated.

Energy Efficient and QoS aware multipath routing protocol (EQSR) maximizes the network lifetime [17] by balancing energy consumption in many nodes. But, the load balancing was not achieved. Genetic Algorithm based approach in [16] addresses load balancing issues of sensors between the sinks in multi-sink WSN. The best route to sinks is established for the sensors in order to reduce the energy consumption. Genetic algorithm based routing scheme termed GAR (Genetic Algorithm-based Routing) in [15] addresses the energy consumption problems through reducing the total distance covered by data. GA based approach calculates new routing schedule depending on the present network state. But, network lifetime remained unaddressed. A genetic algorithm (GA) for energy-efficient based multipath routing in WSNs is designed in [19] for scheduling data gathering of multipath for prolonging the lifetime of network. GA based approach is used to locate the optimal solution. But, the routing delay occurs. OOB (standing for Obtaining Optimal Backbones) algorithm is planned with branch-and-bound strategy [20] to attain the optimal solution efficiently with higher delays.

The contribution of the work is organized as follows. Derived Energy Efficient Optimization Routing Techniques (DEEORT) scheme is introduced. GA is used for finding energy efficient path in sensor network. Initially, fitness function allocates the fitness value for all individual nodes. Fitness function finds the nearby nodes to send the packets from source to sink node. Then, crossover operation is performed for data transfer of genetic information between two neighboring node to find another two neighboring nodes. Mutation restores the lost genetic values when node chooses the neighboring node for increasing the lifetime of network and energy efficiency.

DERIVED ENERGY EFFICIENT OPTIMIZATION TECHNIQUES

WSN is wireless network with spatially circulated device by sensors to study the environmental conditions like temperature, sound, pressure, at diverse positions. A WSN is processed by densely organized sensor nodes in an application area. The Sensor Node (SN) is an essential element of WSN with Computation, sensing and wireless Communication unit. WSNs are mainly used for security, environmental monitoring, automation, habitat examining, creative industries and disaster recognition etc. In WSN, Base Station has sufficient amount of energy and it situated distant from sink. But the sensor nodes are identical and have less energy. All nodes contain same initial energy allocation. But during the communication of data energy, level of nodes gets changed. The energy dissipation for data communication process like transmission and reception are calculated in Eq. (1) and (2) respectively. The energy used by node for sending the m-bit packet from source to sink at the distance of 'D' meters away is expressed as,

$$E_{ST}(m,D) = (E_U + E_{AR} * D^i) * m \quad (1)$$

The energy used by node for receiving the m-bit packet is expressed as,

$$E_{SR}(m) = E_U * k \quad (2)$$

Eq. (1) and Eq. (2), $'E_U'$ $'E_U'$ denotes the energy utilization due to the digital coding, inflection, filtering, and diffusion of the signal, etc. Energy used by spreader power amplifier is represented by $'E_{AP}'$ $'E_{AP}'$. Packet size is denoted as 'm'.

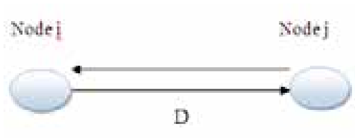

Figure 1: Distant between Two Node

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The energy consumed for sending packet from node i to j is same one when transmitting from j to i for any SNR value as described in Figure 1. A routing path or chain is pre-arranged series of nodes in network which sends the data message to the sink node. A time period for generating packet and sending to neighbor is known as data collecting round. As soon as collecting a packet from its neighbor node, each node sends the packet to the next node in chain process. The key aim is to reduce the energy dissipation in nodes through generation of an optimal data collecting chain. By taking N number of nodes in network, the total energy consumed by the individual sensor nodes is expressed in Eq. (3).

$$E_{T=}[\sum_{i=1}^{N-1}(E_U + E_{PA} * D^i) + E_U \ ] * m$$

$$E_{T=}[\sum_{i=1}^{N-1}(E_U + E_{PA} * D^i) + E_U \ ] * m \quad (3)$$

From Eq. (3), $D^i D^i$ indicates the distance between the i[th] node and (i+1)[th] node in the chain. $E_T E_T$ represent the total amount of energy used for transmission and reception of packets from source node to the sink node. A threshold value is used on communication between the nodes denoted as D^{TH} D^{TH}. This type of setting the threshold value guarantees the efficient communication between nodes by minimizing the noise and packet loss probability. By reducing the noise and packet loss probability, the energy efficiency gets increased. The energy efficient routing process of WSN using derived genetic algorithm is shown in figure 2.

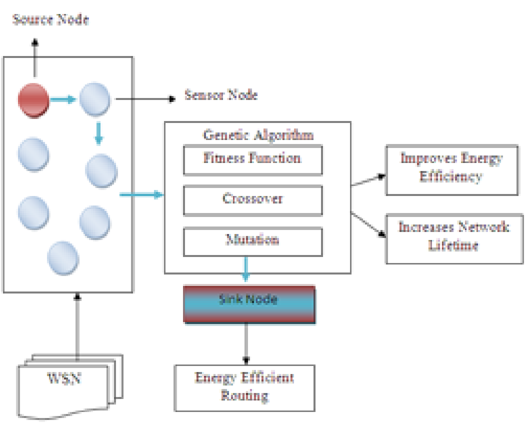

Figure 2: Architecture Diagram of Derived Energy Efficient Optimization Routing Techniques in WSN

Wireless Sensor Network is a collection of sensor nodes. The DEEORT is used for sending the sensed data from source nodes to sink. For transmitting the data, energy derived genetic algorithm is presented. The derived genetic algorithm has three operation, namely fitness function, crossover and mutation process. Finally, at the sink node energy efficient routing is carried out.

Derived Genetic Algorithm

Genetic algorithm (GA) is the process used for finding the energy efficient path. For genetic algorithms, the key objective is to find the new energy efficient neighboring node for increasing the network lifetime. The genetic algorithm is a method for randomized search in addressing the optimization issues. In GA, the problem search is denoted as a group of individuals. The chromosome for specific routing scheme is denoted as string of node numbers. GA initiated with randomly created probable solutions. Each solution is termed as the chromosome. The chromosome length in the population is to be similar. GA is to identify the individual from search space depending on genetic material. Figure 3 explained the flow process of derived genetic algorithm.

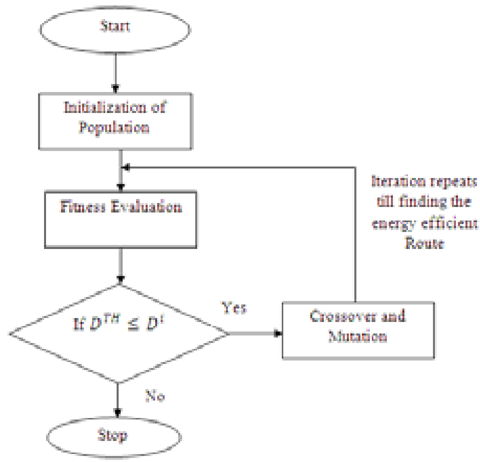

Figure 3: Flowchart for Derived Genetic Algorithm Process

Population Initialization

In Initialization process, many individuals (chromosomes) are created arbitrarily and generation starts with iteration '0'. The distance threshold (D^{TH}) (D^{TH}) is initialized.

Fitness function

The fitness function is mainly used for increasing the network lifetime. It also checks that specific chromosome extends the lifetime of network or not. The algorithm identifies the best chromosome with high fitness value termed elitism. The fitness of every chromosome is computed as,

$$Fitness\ Calculation(C) = \sum_{i=1}^{N} D^{i^2}$$

$$Fitness\ Calculation(C) = \sum_{i=1}^{N} D^{i^2} \quad (4)$$

Input: No. of genes (N), Two chromosomes be $< a_1, a_2, a_3 \dots a_n >$ and $< b_1, b_2, b_3 \dots b_n >$, Distance Threshold D^{TH}, Cross over point 'p'.
Output: Improved Energy Efficient Routing and Network Lifetime

Step 1: Begin
Step 2: Generate an initial population
Step 3: Compute the fitness of each individual
Step 4: If $(D^{TH} \le D^i)$ then
Step 5: Perform crossover, mutation and goto step 3.
Step 6: Else
Step7: End the iteration Process
Step 8: End if
Step 9: End

From equation (4), the energy level of chromosome 'C' in 'N' genes are calculated. A large value of chromosome energy symbolizes the lengthy data gathering chain.

Crossover

The new chromosomes end the global search through the equiva-

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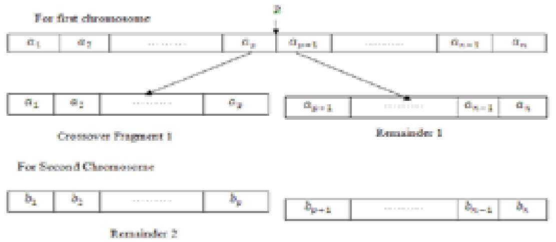
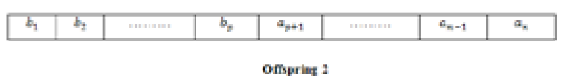
lent crossover operator. Two chromosomes are taken for finding the two offspring. Let 'p' be the cross over point in random form $\{1,2,3.\ldots..n\}$ $\{1,2,3 \ldots n\}$ and two chromosomes be $< a_1,a_2,a_3 \ldots..a_n >$ $< a_1,a_2,a_3 \ldots..a_n >$ $< b_1,b_2,b_3 \ldots..b_n >$ and $< b_1,b_2,b_3 \ldots..b_n >$.



By combining the crossover fragment 1 and remainder 2, the offspring 1 is obtained.

Then by combining the crossover fragment 2 and remainder 1, the offspring 1 is obtained.



Mutation

Mutation helps in restoring lost individuals in the population. In mutation, a node is chosen from the chromosome attained in past generation and gene value is varied for creating the new offspring.

$$< a_1,a_2,a_3, \ldots..a_p \ldots..a_n >$$

If the new offspring failed to satisfy the constraints like distance threshold, it is removed and the iterations gets repeated till it satisfies the condition. The mutation operation comes out from local optima findings and search for the global optima. The algorithmic description of the derived genetic algorithm is given below.

The main task of derived genetic algorithm is to prolong network lifetime for a given WSN. In the algorithm, initial population is created. After that, the fitness function gets computed. When the distance between the i^{th} and (i+1) node is greater than the threshold distance then the crossover and mutation process is carried out. If it is not, the process gets stopped

EXPERIMENTAL VALUES

A Derived Energy Efficient Optimization Routing Techniques (DEEORT) scheme is simulated using NS2 network simulator. The 70 sensor nodes are randomly deployed in rectangular area of 1400m * 1400m. The dynamic changing topology uses the DSDV routing protocol to perform the experimental work. The sink node collects the data packets of range 5 – 35 and sends the data to the sink node with different data packet size. The simulation time is 60ms. Table 1 illustrates the input parameter.

TABLE- 1
SIMULATION SETUP

Parameter	Value
Protocols	DSDV
Network range	1200 m * 1200 m
Simulation time	45 ms
Number of mobile nodes	10, 20, 30, 40, 50, 60,70
Packets	6, 12, 18, 24, 30, 36, 42
Network simulator	NS 2.34
Mobility speed	15 m/s
Pause time	15 ms

SIMULATION RESULTS AND ANALYSIS

To validate the energy efficiency of the proposed Derived Energy Efficient Optimization Routing Techniques (DEEORT) scheme is compared with Energy-efficient Routing algorithm Based on Multiple criteria decision making (ERBM) method [1] and Application Specific Low Power Routing (ASLPR) protocol [2]. The experiment is conducted on the factors such as energy consumption rate, energy drain rate, and routing overhead. Performance is evaluated along with the following metrics with help of tables and graph values.

Impact of Energy Consumption

Energy consumption for routing the packet from source to sink node is measured by energy consumed by a single sensor node with respect to the total sensor nodes in WSN. The energy consumption is formulated as given below.

$$EC = Energy_{SN} * Total_{SN} \quad (5)$$

From (5), the energy consumption 'EC' for routing is attained by the product of the energy for single node '$Energy_{SN}$' and total sensor nodes '$Total_{SN}$' in network. The consumption of energy is measured in terms of Joules.

TABLE -2
TABULATION FOR ENERGY CONSUMPTION

Node Density (N)	Energy Consumption (Joules)		
	DEEORT Scheme	ERBM Method	ASLPR Protocol
10	34	42	49
20	37	46	53
30	40	50	56
40	44	52	59
50	48	56	63
60	50	59	67
70	53	62	70

The above table illustrates the energy consumption measurement based on the node density varies from 10 to 70. From the table, it is clear that the proposed integrated model provides the better performance than the existing ERBM Method [1], and ASLPR Protocol [2].

Figure 4. illustrates the average energy consumption for routing in WSN with respect to the node density in the

network. As shown below figure, the energy consumption is proportional to the node density.

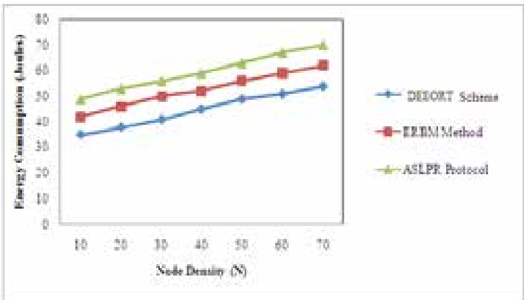


Figure 4: Measure of energy consumption

While increasing the node density, energy consumption also gets increased. The DEEORT Scheme consumes less energy compared to ERBM Method [1], and ASLPR Protocol [2]. Derived Genetic Algorithm is used for routing with minimum energy consumption. Moreover, the energy consumption for routing in DEEORT Scheme for sending the packet from source node to sink is 18% and 35% lesser when compared to ERBM Method [1] and ASLPR Protocol [2] respectively.

Impact of Energy Drain Rate (EDR)

Energy Drain Rate is the measured which integrates the drain rate metric into the routing process. EDR is used to predict the lifetime of nodes according to current traffic conditions. The consumption of energy is measured in terms of Joules.

$$EDR = No.of\ sensor\ nodes * EDR_{nei} * EDR_{new} \quad (6)$$

$EDR = No.of\ sensor\ nodes * EDR_{nei} * EDR_{new}$

From (6), the energy drain rate '$EDREDR$' for is attained by the product of the number of single nodes, en- EDR_{nei} ergy drain rate of neighboring sensor node '' and energy EDR_{new} new sensor node 'EDR_{new}' in network.

In table 3 we show the energy drain rate for different routing techniques with respect to number of sensor nodes in WSN that ranges between 10 and 70. The energy drain rate to perform routing in WSN using DEEORT Scheme offers comparable values than the state-of-the-art methods.

Figure 5 describes the energy drain rate where the energy gets dissipated at particular node. Each node monitors its energy consumption and maintains its battery power drain rate value by averaging the amount of energy consumption and calculating the energy dissipation per second in the given past interval. Compared to the existing ERBM Method [1] and ASLPR Protocol [2],

TABLE- 3
TABULATION FOR ENERGY DRAIN RATE

Node Density (N)	Energy Drain Rate (Joules)		
	DEEORT Scheme	ERBM Method	ASLPR Protocol
10	17	24	29
20	18	26	30
30	23	32	35
40	29	35	40
50	32	40	45
60	36	43	48
70	37	44	52

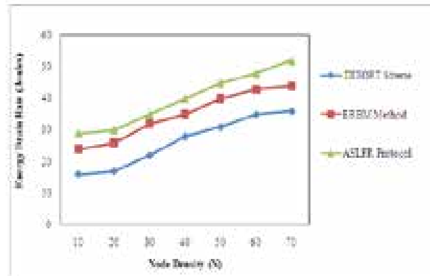


Figure 5: Measure of energy drain rate

the proposed DEEORT Scheme has less energy drain rate. Because the existing works like ERBM Method [1] and ASLPR Protocol [2] consumes large amount of energy while sending the data between the set of nodes in WSN. In addition, the energy drain rate in DEEORT Scheme is 36% and 56% lesser when compared to ERBM Method [1] and ASLPR Protocol [2] respectively.

Impact of Routing Overhead

A good algorithm is one which reduces the routing overhead. The routing overhead is formulated as given below.

$$RO = \sum_{i=1}^{n} NN_i * Time\ (NN_i) \quad (7)$$

From (7), the routing overhead 'RO' is obtained on the basis of the neighbor nodes 'NN_i' and the time taken to obtain the neighboring nodes '$Time\ (NN_i)$' in the network.

TABLE- 4

TABULATION FOR ROUTING OVERHEAD

Node Density (N)	Routing Overhead (%)		
	DEEORT Scheme	ERBM Method	ASLPR Protocol
10	26	31	45
20	30	35	47
30	34	38	49
40	37	41	51
50	40	44	54
60	42	47	58
70	45	49	61

comparative analysis for routing overhead with respect to different sensor nodes was performed with the existing

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ERBM Method [1] and ASLPR Protocol [2] in table. The increasing sensor nodes in the range of 10 to 70 are considered for experimental purpose in WSN.

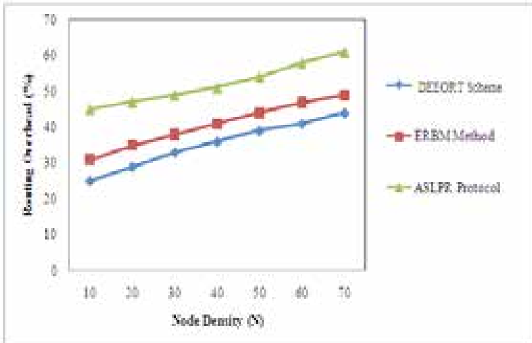

Figure 6: Measure of Routing Overhead

Figure 6 show the routing overhead for node density ranging from 10 to 70 using existing routing techniques like ERBM Method [1] and ASLPR Protocol [2]. The node density is directly proportional to the routing overhead. In this simulation, DEEORT scheme has comparatively lesser routing overhead than ERBM Method [1] and ASLPR Protocol [2]. The DEEORT scheme improves the routing overhead by considering fitness function in derived genetic algorithm that uses the minimum distance nodes for routing with respect to different sensor nodes. The residual distance by neighbor node information in DEEORT scheme helps for any number of sensor nodes to obtain their neighbor information in a dynamic manner reducing the routing overhead by 16% and 50% compared to ERBM Method [1] and ASLPR Protocol [2].

Impact of Network Lifetime

The lifetime of the network is calculated depending on the number of nodes in the wireless sensor networks and the values of the proposed DEEORT is compared with the existing ERBM and ASLPR schemes is described in table 5

TABLE- 5
MEASURE OF NETWORK LIFETIME

No. of Nodes	Network Lifetime (%)		
	DEEORT Method	ERBM Scheme	ASLPM
10	75	64	44
20	78	67	48
30	80	69	51
40	82	73	55
50	84	76	61
60	86	79	63
70	88	82	68

Figure 7. explains the lifetime of the network depending on the number of nodes in the network. Because the energy drain rate of the nodes in the network environment is less, the life time of the network increases correspondingly.

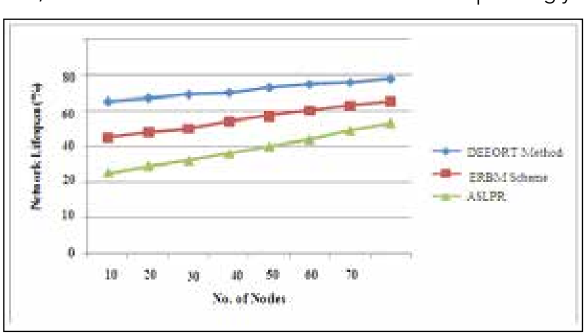

Figure 7: Measure of Network Lifetime

Compared to the existing works like ERBM and ASLPR schemes, the proposed DEEORT work attains high network lifetime as the utilization of minimal energy drain rate nodes on data collection gene series increases the lifetime of the node and the network.

CONCLUSIONS

In this paper we proposed Derived Energy Efficient Optimization Routing Techniques (DEEORT) scheme to increase the energy efficiency and network lifetime of nodes. The main goal of DEEORT scheme is not only to increase the energy efficiency but also to prolong the lifetime of network by choosing the reliable routing path from source to sink. GA is an effective one for energy efficient path finding in sensor network. Using NS-2 simulator, the DEEORT method is compared with the existing works like ERBM Method [1] and ASLPR Protocol [2] and the results illustrated that the DEEORT scheme avoids over dissipation of energy because the series of routing for the specified node is carried out. Experiments conducted on varied simulation runs shows improvement over the state-of-the-art methods. The results show that DEEORT scheme offers better performance with an improvement of energy consumption by 29% and reduces the routing delay for by 51% compared to ERBM Method [1] and ASLPR Protocol [2] respectively.

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