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Analysis of QoS Parameters using Prediction Algorithms on CSO-based Energy-Efficient Reliable Sectoring Scheme in WSN

To cite this article: Dhanashri Narayan Wategaonkar and S V Nagaraj 2021 *J. Phys.: Conf. Ser.* **1911** 012024

Analysis of QoS Parameters using Prediction Algorithms on CSO-based Energy-Efficient Reliable Sectoring Scheme in WSN

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Abstract. The maintaining of the Quality of Service(QoS) parameter in wireless sensor networks (WSN) is becoming a challenging task. The limitations are like achieving QoS parameters in a distributed network, constraints in sensing parameters, natural disasters, and battery life of sensor nodes need to overcome. Here in this paper few of the QoS parameters are analysed to increase the lifetime of sensor networks by partitioning a network into various sectors. A novel optimized sectoring scheme is proposed for optimal election of sector head (SH) for a given network. A Cat Swarm Optimization based Energy-Efficient Reliable sectoring Scheme with prediction algorithms (P-CSO-EERSS) is also proposed in this paper. The use of prediction algorithms is for early detection of node lifetime to improve the overall lifespan of a network. Along with this QoS parameters such as packet delivery ratio and energy consumption are analysed and compared with existing clustering algorithms. According to implementation results, it has been shown that the prediction based CSO-EERSS algorithm returns better QoS parameters as compare to existing cluster schemes.

1. Introduction

1.1. QoS—a broad introduction

QoS is a set of rules to satisfy the network requirements while transmitting data from source to destination (unicast or multicast). It is a measurable unit to intimate the performance of the sensor network to the user. The main objective of QoS is to guarantee that the network can give the desired output. The Application-based QoS and Network-based QoS can be considered in WSN. QoS parameters are identified using various metrics. The various methods and techniques are used to find the metrics are recognized as Quality of Service (QoS).

1.2. QoS issues in WSN and its Parameters

Achieving a good result of QoS in WSN is a hard task because of less bandwidth, high congestion, lesser buffer size, and high channel intrusion and infrastructure limitations of sensor networks. The basic objective to study QoS parameters is to assure high-quality networking services for an application. The following paragraph follows with QoS issues like packet drop, congestion, delay, fairness, scalability, etc. This issue affects the performance of network parameters like packet delivery ratio, packet loss, and routing & message overhead.

A few of these QoS parameters used in WSN are explained below:

- Packet Delivery Ratio (PDR): It is calculated using the ratio of the total number of data packets received at the destination node to the total number of packets sent from the source node.
- Packet Loss Ratio (PLR): It is calculated using the difference between the total number of packets sent from the source to the total number of packets received at the destination.
- Average End to End Delay: It is found using the total time needed for a data packet to transmits from source to destination.
- Jitter: It is defined using variation in packet delay. Packet jitter is a middling deviation from the mean network latency.
- Throughput: While transmission of packets from source to destination the number of successfully transmitted bits per second is calculated is nothing but throughput.
- Energy Consumption: It is observed by the energy utilized by a sensor node during transmission of a packet, receiving a packet, when it is in sleep and awake mode.
- Congestion: It occurs when the buffer size of a sensor node lesser than the network traffic. One more reason for the congestion is because the unequal distribution of network resources.
- Fairness: Fairness is a fair distribution of network resources.
- Latency: Delay is also referred to as latency. The delay in transmission of data packets from the source node and destination node called latency.
- Routing overhead: The routing packets when it gets over-headed while communicating because of sharing of bandwidth with data packets, it is called routing overhead.

The challenges faced in WSNs are like it operated using limited power (non-renewable battery power), Limited Storage and computation, Data Aggregation, Reliable communication. To provide solution to few of these limitations the novel sectoring scheme proposed in this paper.

2. Literature Survey

2.1. Literature survey on QoS parameters used in WSN

The following literature survey is carried on various QoS parameters. Each author has his view to use and implement QoS in WSN.

M. Asif et al. [1] described the main purpose of QoS along with its satisfaction factors and how QoS supports WSN along with its protocols with advantages & disadvantages, requirements, categories, challenges, and security at each layer. The QoS issues or limitations in WSN like deployment of the node, limitations in resources, scalability, maintenance of traffic, lesser reliability, and data redundancy are explained very well in the paper. The authors explicated computational intelligence techniques along with the management of QoS parameters.

Lo’ai Tawalbeh et al. [2] mainly highlights the QoS requirements that are needed in generic WSN infrastructure. QoS parameters like data accuracy, delay in data aggregation, fault tolerance, coverage, the static or dynamic structure of the network, and support in multimedia streaming are briefed for better understanding. The challenges in generic WSN infrastructure for implementing QoS requirements are a heterogeneity of sensor nodes, inadequacy in data traffic, limitations in resource, limitation in sending & receiving audio / video data in a network. The most critical challenges are also explained by the author in the paper. As per the application type and its specification the QoS requirements will get changed.

Martinez et al. [3] explained in detail the use of QoS parameters in forest surveillance applications like fire detection, tracking of events, and dangerous activities in a natural environment. The factors which are directly related to results of QoS parameters like topology and network dynamics, geographical information, real-time necessities, unstable blend traffic, data redundancy, energy efficiency, sensor data priority. Very thoroughly author described the network layer, medium access control (MAC) layer-wise quality of service parameters. In the network layer, the end to end path detection and retrieval plays an important role. Analysis of these routing protocols and MAC protocols is performed using QoS parameters. The differentiation based on query-driven and event-driven for reliable data delivery with considering network topology are also explained.

G. M. Shafiullah et al. [4] showcase the use of a sensor network in each field of environment. The main characteristics of sensor network i.e. it's less cost and working with less power consumption. The main focus on monitoring vehicle health with its characteristics. The author also explained the key component of designing of sensor network that is minimum energy utilization and hence maximizing network lifetime. Paper represents different existing clustering and QoS aware routing protocols with their properties which work on low energy consumption.

M. M. Alam et al. [5] contributed to the importance of QoS parameters and their effect on network performance. Mainly focus on reliability and delay parameters of the network. Reliability is nothing but a ratio between the number of packets send towards the number of packets received. Another parameter is delay i.e. end to end delay, it is the difference between the time taken to send a packet and receive it. Authors mainly concentrate on multi-path routing to acquire the desired reliability. While the sender sending a packet to the destination at that time select multiple paths for sending so that at least using any one of the paths the packet will receive a destination successfully. So by which path the packet is received by destination for that path transformation the delay needs to be considered. Here reliability can be achieved by collectively using all paths but the delay needs to be considered an individual path. The important involvement of this paper is the logical investigation of reliability, delay, and energy consumption for together single path and multipath routing. This analysis is performed using an optimization approach and a greedy algorithm is proposed and presented. For getting better reliability authors also proposed an effectual re-transmission method for packets but by considering an end to end delay factor also. All these things are proposed and presented using simulation results and well justified.

T. H. Hsu et al. [6], Here author explained the working of Low energy adaptive clustering hierarchy (LEACH) protocol. LEACH is the time division multiple access based medium access control protocol. It distributes a single time slot intended for respective nodes within a cluster. When a node from any cluster doesn't have any data to send that node should go to sleep more but in the traditional method, such kinds of nodes are alive and utilizing energy. To avoid such kind of thing, the author proposed an innovative TDMA-based MAC protocol to save energy of such kind of nodes, and the nodes which are having more data to send for those nodes allocate more time slots for transmission by taking permission from the respective cluster head (CH). The performance of the proposed algorithm is analyzed using some of the QoS parameters like average transmission delay, total energy consumption, and total transmission data. It has been proved using simulation-based experiment result that the proposed algorithm is giving better results than that of traditional methods.

S. H. Kang et al. [7] gives an idea about the working of cluster-based protocols. In LEACH protocol, initially, all the election of CH has been done. After that, each CH broadcasts the message, and by analyzing that the different clusters are made. But while selecting any node as a CH the energy level of that node for that particular time is checked in-spit of the distance between each other. Here in this paper author proposed a novel LEACH distance-based threshold i.e. LEACH-DT, which works on setting threshold value for distance between each sensor node and the base station while electing a node as a cluster head. By experimental results, it has been proved that the LEACH-DT method improves the lifespan of the network and having less energy consumption than that of the traditional method of clustering.

Alam et al. [8] considered some of the QoS metrics like detection accuracy, fault tolerance, and latency taking the environmental noise, sensor faults, communication impairments, and MAC induced delay into consideration. The author used these QoS parameters for the detection of an event in WSN to systematically control the smallest k-coverage essential to promise a given set of QoS metrics. It has been shown that the theoretical model and experimental results are closer to each other. The event detection system like the probability of event detection, fault tolerance, and latency they are depends on the degree of coverage k.

N. A. Pantazis et al. [9] perform the survey on various energy-efficient routing protocols. The classification of routing protocol is considered by the author as the first one is as per the network structure by flat or hierarchical routing protocols. The second is communication model protocols consisting of Coherent and non-coherent routing protocols [9]. The third classification is location-based or mobile-based routing protocols under the category topology-based. The fourth category is Reliable routing protocol classified as QoS based or multi-path based routing protocols. While dealing with the Quality of service dependent routing protocols the steadiness between the energy consumption of a particular node and the quality of data packets used for transmission plays a vital role. To achieve this, the various quality of service parameters needs to be considered as reporting rate, delay, bandwidth, throughput, energy consumption. QoS routing, QoS requirement, QoS constraints are important factors at the time of transmission of packets. The problem occurred while transmission of the packet like packet loss could be minimized using these QoS parameters. The author explained various QoS routing protocols like SAR (Sequential Assignment Routing), SPEED, MMSPEED (Multi-path and Multi-SPEED), MGR (Multimedia Geographic Routing). The author explained all these routing protocols using different parameters like its advantages, disadvantages, scalability, mobility, route metric, periodic message type, and robustness.

After doing a rigid survey on the use of QoS parameters in WSN, it has been observed that QoS parameters plays an important role in analyzing the performance of a network

2.2. Literature survey on Clustering Algorithms used in WSN

WSN is the most vital technology used to perform quickly wireless communication. Sensor nodes are deployment is done randomly. The challenges faced by WSN are like network lifetime, scalability, and network traffic. To achieve it the energy consumption needs to take care of. Nowadays researchers are in work to overcome this important limitation of WSN. To provide a solution to this, a clustering mechanism came into the picture. The clustering is a grouping of sensor nodes using some criteria to make easier communication. The better use of sensor resources could be achieve using clustering techniques. The various topologies used while clustering a network are explained here. The chain-based clustering, tree-based clustering and grid based clustering topologies are used to partition the network. An well-known protocol of chain-based clustering is Power-efficient gathering in sensor information systems (PEGASIS). Also [18] proposed a chain-based protocol called Hybrid Multi-hop Partition-Based Clustering (HMPBC). The chain structure is used within a cluster to perform fast communication. Anyone within a chain will work as a leader node, which can easily reduce the energy consumption of a network. But the limitations of this topology are it performs limited load balancing as single –chain structure used, which cause a delay. [19] explained the working of tree based topology. The partitioning of network into a tree kind of structure is shown. While partitioning a nodes which are closer to the sink node(SN) acquires more energy as compare to other node, it extends to the energy hole problem. It is less robustness and uneven energy consumption occurs towards the node. [20] shows the partitioning a network into different grids. The grid-based topology being used here in this paper. The optimal grid count is used to minimize the communication distance between the nodes. To keep the constant rout path within a network, the fixed relay clusters being maintained. The observation is like the master node of every grid must be able to connect with a master node from a higher level grid for every communication.

After doing a rigid literature review on clustering techniques to be applied to a given network for partitioning, this analysis was conducted for the selection of the best clustering technique for the proposed work. While doing a literature review, it has been observed that each clustering mechanism used for partitioning has its pros and cons. From each clustering technique, parameters that help to save energy of the network along with lifetime are considered while defining a proposed algorithms. Chain-based clustering distributes the energy evenly in a network. It also saves more energy than that of Cluster-based clustering [21]. As energy conservation is handled better, the network lifetime is also improved. In [22] proven that Tree-based clustering saves more energy than Cluster-based clustering. So, cluster base and chain based clustering can be combined to overcome on time consumption needed to prepare trees by using a chain of it.

2.3. Literature survey on Swarm Intelligence based Optimization Algorithms in WSN
Optimizing any problem is nothing but returning the best or optimal solution to that problem. The optimization means doing some activities with the help of resources to produce the best or effective solution. Because of this reason nowadays, for each problem the different optimization techniques i.e. problem-solving techniques can apply for a better solution. The swarm means a group of a few of the wing insects. The combination of swarm and optimization gives a result as applying some tricks to the group of insects, observing their behaviour, and finding the best solution from it.
A PSO-Based Uneven Dynamic Clustering Multi-Hop Routing Protocol for Wireless Sensor Networks algorithm [23] is proposed in the paper. Here in Particle Swarm Optimization, the role of these particles to move from place to place for searching space with the help of particle position and velocity to find a local best-known position.
[24] took the help of Adaptive Periodic Threshold-sensitive Energy Efficient Sensor Network Protocol (APTEEN) and perform an extension by providing ant colony based uneven clustering APTEEN was proposed in a paper. The purpose is to find an optimal or good path from a graph based on the behaviour of ants searching a path towards the colony.
The Cat Swarm Optimization (CSO) algorithm [25] is cleaved into two different qualities of modes. They are namely SM and TM. The important mode where the CSO executes is explained in the next paragraph in detail. The decision of each cat position is done using some important parameters like fitness function, the velocity of every dimension, and fitness value calculated by fitness function in the resolution space. Each cat takes its flag to represent the cat is in which mode i.e. SM or TM. The quantity of seeking flags and tracing flags is decisive by the mixture ratio (MR) [26]. The MR characterizes the proportion of the amount of TM cats to the amount of SM cats. CSO offerings an improved performance in discovering the global finest solution. By observing the deportment of cats the CSO algorithm executes well. It has been observed that CSO congregates identical dissolute to the finest value optimal solution with the minimum execution times.
After doing a literature survey on optimization algorithms it has been observed that the algorithms like PSO and CSO were used most of the researcher for research. As per [27], it is stated that CSO outperforms better than the PSO. The proposed algorithm is being implemented using CSO algorithm.

2.4. Literature survey on Prediction Algorithms in WSN
According to the current and past information, the future value will be forecasting using the prediction process. In different applications the various prediction methods being used. The application like stock marketing, population, traffic management, etc. the prediction process used to predict the values.
The need for Prediction Methodology: In WSN, by completing the transmission of packets between sensor nodes(SeN), the sink node gathers and collects all the sensory data. This collected data mostly have redundant information. This redundant data is not suitable for a network and SeN. This redundant data must be detached from the data-set. The solution for such a problem will the data prediction methods. To maximize the quality of the data-set, need to reduce superfluous data, and which directly impact the lifetime of the network, and this will be accomplished by using data prediction approaches [10]. The working of such prediction techniques is to make use of stored or historical data while predicting. Here in the prediction method, for a given period the transmission of data packets being observed. Such observation is put into a specific algorithm to get the prediction on a particular parameter. Such prediction methods are useful to overcome the limitation of retransmission in WSN, which directly proportional to the lifetime of a network. So that in future this pattern of transmission of the data packet being referred to analyzed contingency plan of a network. It needs to be taken care of the lifespan of the SN and the communication link castoff for communication in WSN.

- Link Lifetime Prediction: Sensor nodes communicate with each other using the connection between them. If a node has several neighbor nodes it is easy for communication [11]. This communication relationship needs to be built carefully. The link prediction or availability plays an important role in transmission. For link prediction, the distance between the two sensor nodes needs to be considered. By estimating the distance and number of neighbors the prediction of the link will be carried out. The lifetime of a link or route depends on the minimum lifetime of both, the nodes and the connection between nodes for that particular link.

- Node-Lifetime Prediction: An important issue in WSN is to maintain the lifespan of the SN. It is in need to recognize the present energy level and battery state of an SN. Primarily, when SNs are arranged in a network they are in an indolent manner [12]. As soon as an event befalls in a network an SN becomes active. If for a precise occurrence of time the event doesn't arise then the SN becomes in a sleep manner. The SN wishes extra energy while it is in an indolent manner.
- Available Bandwidth Prediction: The available bandwidth for communication is important to look for. The low bandwidth causes congestion in network [12]. For this type of prediction, the transmission rate of the source and destination node will be considered. The link capacity also needs to measure to check available bandwidth. The source, intermediate and destination node has to check its available bandwidth and its link capacity.
- Path Reliability Prediction: Many of the applications in WSN needs guaranteed stability while sensing the phenomenon, connection between node and transmission. If any of the nodes in a path gets dead because of congestion or buffer size or overloading then it will effects path stability i.e. connectivity between nodes [13]. The prediction of path consistency will provide a reliable transmission between sensor nodes. The selection of stable and reliable paths depends on the hop count, the available bandwidth, and the residual energy of nodes for that particular path.
- Delay Dependency Prediction: When the transmission starts, the source, and destination node transmits the packets. The source node starts transmission at n time and it expects that the destination node will receive the same packet at n+1 time instance. But the receiver node doesn't receive it because of congestion. This is nothing but a delay in transmission [14]. Using this prediction, the network can predict the delay based on transmission. It is useful for a better quality of service metrics.

3. Energy-Efficient Reliable Sectoring-Scheme Algorithm (EERSS)

An existing clustering scheme faces the limitation as they didn't study the a CH and SN distance throughout the process of CH election. Other restrictions, such as superfluous data broadcast and the unstable spreading of SNs into various clusters, are not measured. A novel EERSS for overcoming the issues in existing clustering schemes and improving the efficiency of data aggregation. The motivation behind proposed work are firstly Single-hop communication between CH and Sink and Multi-hop communication between sensor node and CH, secondly balanced cluster density and Predefined path discovery, thirdly optimal cluster count, location and process of election of CH, fourthly Swarm based optimization is computationally efficient alternative for analytical methods [16]. and fifthly Usage of prediction algorithm to overcome limitation of multi-hop communication. The EERSS scheme is based on a centralized approach, where information such as the distance, residual energy, and Receiving Signal Strength Identifier value of an individual node is known to the SiN, and the election of the SH follows a deterministic approach. A deterministic algorithm is used for the SH election because the election of the SH in each round consumes additional energy and time. The structure of the creation of the sector is based on chain-tree topology. Moreover, for each SH selection, it requires the a) Received Signal Strength Indicator (RSSI) value, distance(calculated using Euclidean Distance (ED) formula), and energy level, (b) a hop away transmission with the sink node, (c) Only once an sectors are constructed, and (d) broadcast originated path updating(PU) and path discovery(PD) in the routing table (e) consideration of node exposure of SH. The motivation behind implementing a sectoring scheme is to use a deterministic approach for the election of the SH, thereby saving energy and time.

3.1. Prediction algorithm on Cat Swarm Optimization based EERSS Algorithm

In EERSS, the problem is to find the best node as SH from a pool of one-hop away sensor nodes. The nodes need to be in sleep mode when the event has not occurred. After the occurrence of the event, nodes come to the live mode and initiate or take part in the transmission. It would be efficient to select an SH who quickly performs communication with efficient path discovery and path selection. The proposed EERSS algorithm performed a election of SH well but the elected SH's are optimal in number and location need to be checked. Election of head node is an non-deterministic polynomial-time-hard problem [15]. For the solution of the same, the optimization algorithms being used. Cat Swarm Optimization (CSO) is expectant and achieves parallel execution; it considers a few of the cats from the pool as a population of cats. It doesn't consider any random value to initiate the working of the technique. The initial parameters are their population of cats. It works in two modes such as seeking mode(SM) and tracing mode(TM), where preliminary PD and PS happens in the initial mode and determination of best SH and commencement of packet broadcasting is in the second mode. If the event has not happened for a extensive time then cats drive to a sleep state in SM. So CSO gives more optimal solutions than Particle Swarm Optimization (PSO) because of its SM and TM. The working of CSO is describing in the following sections. As explained in previous section the need of prediction methods is to save the historical data. Such prediction methods are useful to overcome the limitation of retransmission in WSN, which directly proportional to the lifetime of a network. Here, the path stability prediction and delay dependency prediction algorithms being used to predict the stability of a selected path being active for next iteration or not.

Table 1 shows the overview of working of overall CSO based EERSS algorithm along with prediction techniques.

$$f_1 = \min_{j\epsilon(1,n)} \{\textstyle\sum_{\forall node \epsilon hop_i} ED(node_i, SINK_{s0,s1})\} \quad (1)$$

$$f_2 = \max_{j\epsilon(1,n)} \{\textstyle\sum_{\forall node \epsilon hop_i} RSSI_{node_i}\} \quad (2)$$

$$f_3 = min \textstyle\sum_{i=1}^{n} \{\frac{E_{res}^{i}}{E_{res}^{SH}}\} \quad (3)$$

$$PRF = wt1 * PINR + wt2 * AEDrain_{Rate} \quad (4)$$

$$CongestionIndex = \frac{No.of Nodesinradius}{Area} \quad (5)$$

$ED(node_i, SINK_{s0,s1} = EuclideanDistanceof i_{th} nodetosinknode.$
$RSSI_{node_i} = receivedsignalstrengthindicatorof i_{th} node.$
$E_{res_i} = residualenergyof i_{th} node.$
$E_{res_{SH}} = currentenergylevelofSH.$
$c = aconstantvalueshowingtheinvolvementofittoanobjectivefunction.$
$Herei_{th} node = Allonehopawaynodesfromsink.$
$PINR = Pathinteractionneighborrate$
$AEDrain_{Rate} = Averageenergydrainrate.$

Table 1. Working of CSO based EERSS Algorithm.

Input: Initial population of 'n' cats and Self Position Consideration (SPC)
Output: Optimal selection of SH.

while ($I < I_{max}$)
  for nodes that are one hop away
    Calculate fitness function value using equation for finding SH.
    $f_{obj} = c * f_1 + c * f_2 + (1 – c) * f_3$ (using equation (1), (2), (3))
    Keep present value as new x_{best}
  end of for
  Start
    Seeking mode operations by broadcasting *RREQ* packet
    if received *RREQ* ,perform *RREP*
      maintain record in routing and neighbour table
      Calculate f_{obj} for each new position
      Compare f_{obj} value and place best position of cat into memory
  end
  Start
    Tracing mode operations by calculating Node Coverage(NC) using following equation
    if $NC(SH,N)= \sum_{k=0}^{R_s} link\ (k \rightarrow SH)$
      Calculate path reliability factor using equation (4)
      Check energy level of each node in a path
      Calculate f_{obj} for each new position
      Compare f_{obj} value and place best position of cat into memory
    Until (Position of SH = P_{best})
  end
  Update best fitness value $P_{best} = X_{best}$
  B_{fy} = Set of cats with best fitness value
    if link(sinknode $\rightarrow B_{fy}$ = one hop away)
      Check congestion index of a path using equation (5)
      mark that node as SH
    else
      ignore node
end of while

4. Result Analysis

The schemes' performances are analysed using the simulation parameters listed below in Table 2. The performance of the prediction algorithms on CSO-EERSS (P-CSO-EERSS) algorithm is executed using Network Simulator-2.

Table 2. Simulation Parameters used for implementation P-CSO-EERSS algorithm

Simulation Parameter	Value
Simulator	Network Simulator 2 (NS2)
Scenario Area	100 * 100 m^2
Node Density	100, 150, 200, 250, 300
MAC Protocol	IEEE 802.11b
Packet Size	50, 100, 150, 200
Number of Sink Node	1
Position of Sink Node	Center
Network Traffic	Constant bit rate (CBR)
Routing Protocol	AODV
Transmission Rate	10 pkt/sec
Value of wt1 and wt2	0.5 [17]

The QoS parameters like packet delivery ratio (PDR) and energy consumption being get used during implementation for comparative analysis.

4.1. Analysis of Packet Delivery Ratio

The proposed algorithm starts the transmission of packets when the path discovery and path selection are completed.

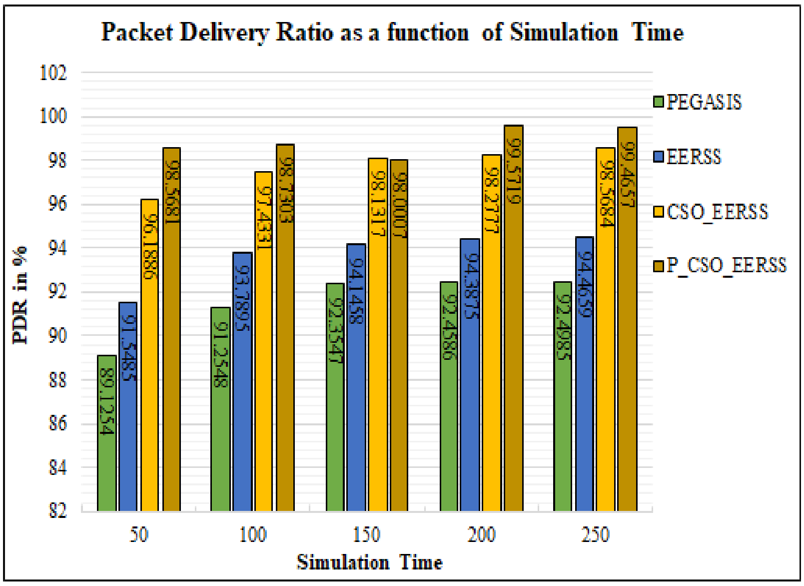

Figure 1. Comparison of proposed EERSS algorithm with existing PEGASIS, CSO-EERSS and P-CSO-EERSS for Packet Delivery Ratio

The neighbor table and routing table maintain the sensor node information. The healthy nodes are maintained in a table for communication. It reduces the overhead needed for the selection of the best

neighbor in a routing path for transmission. Thus, the path can be redefined with the best nodes, and the SH provides a better PDR than the other protocols. Figure 1 represents the performance analysis of the EERSS algorithm with exiting clustering protocol called PEGASIS along with proposed CSO-EERSS and P-CSO-EERSS.
Figure 2 represents the comparison between proposed CSO-EERSS and P-CSO-EERSS by varying QoS parameter of a network. QoS parameter means, by changing the packet size while communication. It has been observed that P-CSO-EERSS provides better PDR as compared to CSO-EERSS. The calculation of the Path Reliability Factor (PRF) parameter and by considering its stability threshold, affect the overall performance of the network i.e. PDR.

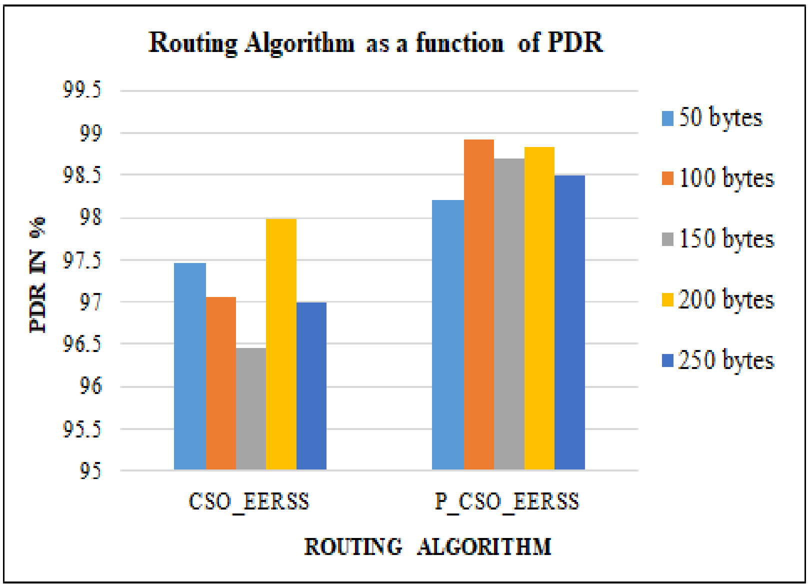

Figure 2. Node density as a function of Packet Delivery Ratio

4.2. Analysis of Energy Consumption

It has been observed in figure 3 that when packet transmission begins, each protocol requires more energy, as there is a change in the simulation time. The energy required for transmitting and receiving a packet (along with communication) requires more energy for Power-Efficient Gathering in Sensor Information Systems (PEGASIS) than for the EERSS protocol. This is because PEGASIS performs the election of the CH based on random constraints anywhere in a chain; as such, the packet size and packet distance do not work well in it. In contrast, the EERSS requires less energy owing to the sector selection, which helps to select an SH with less distance from the SiN and additional energy than the threshold value. The power consumption is less in the EERSS; accordingly, the EERSS helps to progress the lifetime of the network.

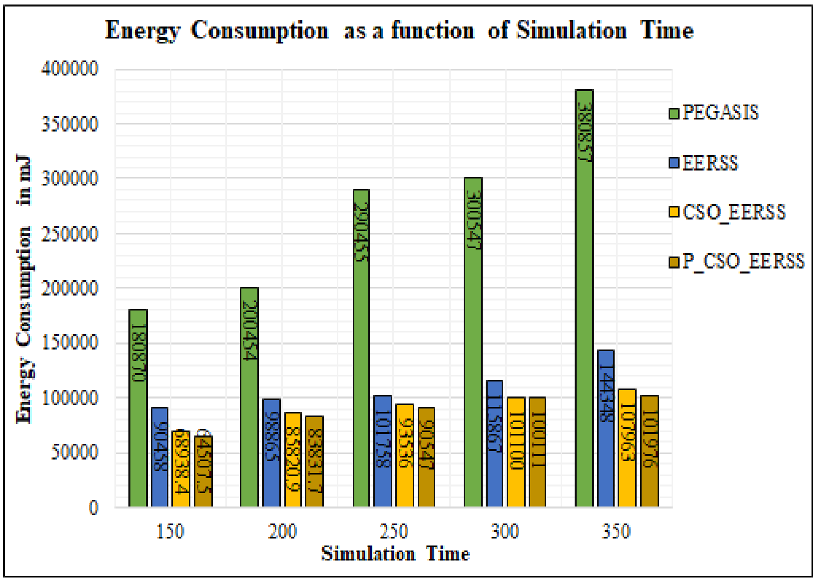

Figure 3. Comparison of projected EERSS algorithm with existing PEGASIS, CSO-EERSS and P-CSO-EERSS for Energy Consumption

Figure 4 shows the comparison graph between CSO based EERSS algorithm and the prediction algorithm applied to CSO based EERSS algorithm. The main advantage of applying a prediction algorithm on existing CSO-based EERSS is, it returns a saving of time to perform various operations. It helps to avert packet loss, re-routing of a path, re-election of a path by providing prediction or possibility about the failure of a node and the state of how reliable a path to be selected for communication. The prediction of node lifespan and stability of a path returns the lesser consumption of power or energy needed for communication. It is directly proportional to the lifespan of a network. The usage of path stability prediction and failure state of an SN, also positively affect the delivery ratio of packets. The basic CSO-based EERSS algorithm helps better the election process of SH. The shortest distance node from SiN and with more than threshold energy level node is elected as an SH. The re-election of SHs automatically performs when it doesn't satisfy a threshold value.

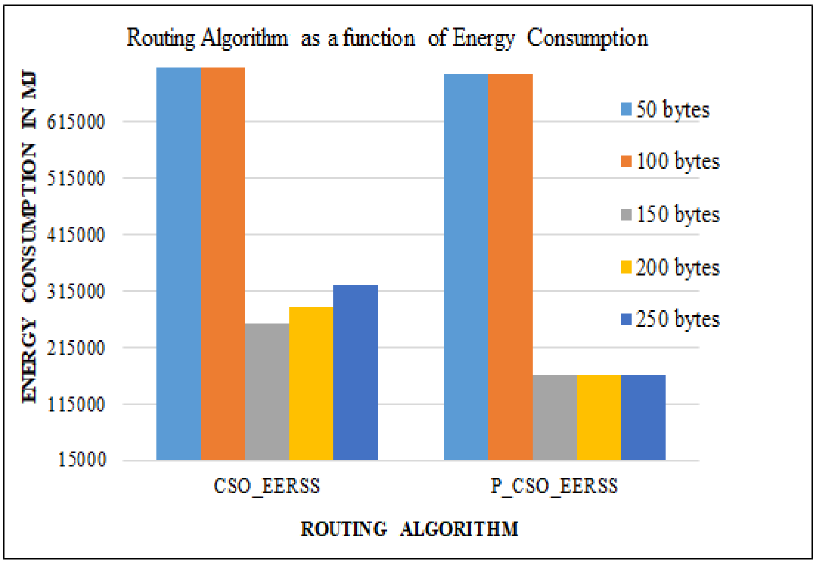

Figure 4. Node density as a function of energy consumption

The QoS parameters like PDR, Energy consumption and time needed to complete one iteration are considered to check the performance simulation as listed Table 3. It has been experimental that the P_CSO_EERSS algorithm carries an improvement of 2.25% in PDR, the energy is also saved with 7.7% and around 53% early completion of one iteration or simulation of a network as associated to CSO based EERSS algorithm.

Table 3. QoS parameters comparison between CSO-EERSS and P-CSO-EERSS

QoS Metrics	PDR	Energy Consumption (mJ)	One iteration simulation time (minutes)
CSO_EERSS	97%	700570.4568	1.24
P_CSO_EERSS	99.19%	646456.9664	0.58
Scrutiny	**2.25% improved PDR**	**7.7% of energy saving**	**53% earlier**

5. Conclusion

Each clustering scheme has its advantages and disadvantages. The projected EERSS algorithm was intended to overwhelm some of the confines of existing clustering schemes. The original algorithm for sector head selection and the working of the EERSS scheme is founded on a) Received Signal Strength Indicator (RSSI) value, distance(calculated using Euclidean Distance (ED) formula), and energy level, (b) a hop away transmission with the sink node, (c) Only once sectors are constructed, and (d) broadcast originated path updating(PU) and path discovery(PD) in the routing table (e) consideration of node exposure of SH. Election of SH is an NP-hard problem. To solve this problem a CSO algorithm is used to make a selection of SH optimal, Along with this the count and position of SH being optimal. The concert of the EERSS is considered and associated with PEGASIS, CSO-EERSS, and P-CSO-EERSS with implementations in NS-2. The prediction algorithms are applied to the CSO-based EERSS (P-CSO-EERSS) algorithm for the improvement of QoS performance parameters. The benefit of using these systems is, it attains the outcomes quicker and realizes erstwhile identification of nodes in a dead state. Additionally, it aids in forecasting the substitute path formerly reaching the dead state and thus conserves energy from negotiating the alternate path. It was detected that the prediction-based P_CSO_EERSS algorithm brings better PDR, along with energy conservation.

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