ENERGY-EFFICIENT ROUTING PROTOCOL USING K-MEANS ALGORITHM IN WIRELESS SENSOR NETWORKS

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Abstract- Battery-powered sensor nodes have minimal energy supplies that need throughout the usage in wireless sensor networks (WSNs). The suggested methodology constitutes a K-means energy-efficient routing protocol (KEERP) that considers the radio variables and transceiver channel capacity of a fixed data packet optimized. This strategy will minimize individual node energy use and improve network existence across. The transfer of data from the cluster head to the base station and other wireless nodes, various power conditions were determined. The simulation findings demonstrate that the suggested methodology works more efficiently and improves overall network performance than the traditional K-means energy-aware cluster formation.
Keywords: wireless sensor network, routing, clustering, energy-efficient protocols,K-means.

1 INTRODUCTION

Tens of thousands of lightweight, low-power, and energy-controlled sensor nodes comprise a Wireless Sense Network (WSN) [1]. These individuals are generally deployed in an environmental area and send messages to the destination node from which they arrive. Sensor nodes are powered by batteries, the difficulty of manually recharging and replacing their batteries in isolated places [2]. One of the main problems of wireless sensor networks is the sufficient ability of the wireless nodes and in WSNs use their most resources to receive packets from neighboring nodes in transmitting and receiving [3]. The concept of an energy-efficient scheme is also a challenge for scientists.

The clustering systems were seen to be more effective across many routing protocols. The first and most common cluster-based routing algorithm is Low Energy Adaptive Clustering Hierarchy (LEACH) [4]. Following this, multiple routing protocols were deployed, each of which had various features and enhancements, mainly during the configuration process. [5] discusses the K-Hop intersecting algorithm (KOCA). This article addresses the concept of how the multi-shop clustering for WSN can be solved. The findings argue an algorithm that generates overlapping clusters that an inevitable mean overlapping can cover in the whole network area [6].

In this research, a novel routing protocol to improve energy efficiency in the WSN was suggested, stimulated by an early study [7]. Initially, the K-means algorithm is used to segment the nodes into clusters. Secondly, the wireless specifications and channel capacity of transmitters and recipients consider the best set packet size to lower node power consumption, unlike some other Routing Protocols [8]. The cumulative energy needed to receive the packet is then determined. The cluster's standardized weight is determined by the cumulative calculated power and the sensor node's mean distance to its cluster head [9]. Lastly, the cluster head for this specific round is the cluster head weighted almost equal to the average weight. The interaction from the head of the cluster to the base station and the wireless nodes includes two transmitting stages [10]. It improves the system's energy savings.

A serious overhead occurs when the sensor node batteries are replaced or recharged. Diverse methods have been developed to conserving power on hardware and software components [11]. Consequently, various approaches to energy management are used to preserve the total power in the environment. In the research, some energy-efficient routing protocols were addressed [12]. The following four categories can be grouped into energy-efficient routing procedures based on their strategies to conserving energy:

Network architecture: The architecture of the network provides the foundation for energy-efficient strategies. The sensor nodes in network-based architecture WSNs are grouped to shape the hierarchical architecture [13]. The routing algorithms often use a flat network architecture for energy conservation.

Communication system: The sensor nodes can communicate via packet interchange or other trading messages [14]. The classification of routing protocols for WSNs is based upon different contact messages.

Efficient routing: time-critical information is moved in this form of routing to improve service consistency (QoS) and energy consumption across the infrastructure [15].

Topology: Wireless sensor node and localized wireless device routing protocols are built to save the highest possible energy levels [16]. In general, the network topology is aimed at developing energy-efficient wireless sensor node routing algorithms.

The rest of the research work as follows. Section 2 deals with the background and the literature survey of the energy-efficient routing protocols in WSN. The proposed K-means energy-efficient routing protocol (KEERP) is designed and implemented in section 3. The simulation analysis and performance evaluation are discussed in section 4. The conclusion and future scope of the proposed protocol are listed in section 5.

2 BACKGROUND TO ENERGY-EFFICIENT ROUTING PROTOCOLS IN WSN

Cluster analysis protocols for energy efficiency have received considerable coverage in the WSN. These methods partition the sensing nodes into narrower classes known as clusters. Most of the members in a group have more coordination functions than other members [17]. This particular node is the CH (Cluster Head), and the remaining nodes are considered member nodes (CM). Participant nodes transmit the sensed information to CH.

The CH accomplishes some data accumulation and then sends it to the BS (Base Station). The research addressed various energy-efficient algorithms for clustering [18]. It addresses some of their key contributions and such shortcomings as centralized and QoS-aware routing algorithms.

A controlled cluster is the basis of the Equalized cluster head choice routing algorithm (EChERA) [19]. With the aid of numerous linear structures, optimum groups are implemented in the QHCR protocol for a balanced selection of CH, the Gaussian methodology to problem-solving is often employed [20]. In comparison to other traditional WSN clustering routing strategies, ECHERP enhances network life and reliability. Even then, the non-supportive conduct with real-time traffic is a drawback of this method.

ECHERP does not take into account programs that are vulnerable to QoS. An interconnected WSN solution was suggested for strengthened boundary coverage, and the information related to any attacker's intrusion is transmitted with less latency to the base station (BS) [21]. A new approach to sending delayed responsive traffic was explored via the development of a basic graph. This strategy does not consider the sensors with oscillating energy instead of our suggested solution [22]. In the system, hybrid power levels have been mentioned for the sensor nodes with oscillating capacity.

The energy-efficient and QoS-based routing protocol (EEQR) tackles all problems. Network traffic is prioritized following traffic quality within the EEQR protocol [23]. Multiple paths for congested traffic a hybrid of a statical and mobile drain is used. Through prioritizing internet traffic, the end-to-end delay is reduced. This method improves the lifespan of the network and its reliability [24]. The EEQR scheme is restricted by not addressing the network diversity [25]. When a network communication system is used to maintain QoS in WSNs, its output typically decreases [26].

Another clustering method to ensuring the QoS in WSNs is priority-based application-specific congestion management (PASCC) [27]. The PASCCC reduces congestion by the powerful CH timetable method. CH gives greater preference to packets with distant nodes than to packets with neighboring nodes [28]. This method incorporates a sensing node's accessibility function. PASCCC also takes into account a network's complexity. The key constraint of the PASCCC is that the wait for non-real-time activity is not addressed [29]. In this routing strategy, non-real-time packets are also impacted, and the total network performance is also impaired [30].

It is a challenge that the diverse WSNs achieve energy efficiency and QoS for minuscule sensor nodes. The routing system must be balanced and stable to minimize end-to-end transmission delays, to attain load balance for reduced power monitoring systems.

3 PROPOSED K-MEANS ENERGY-EFFICIENT ROUTING PROTOCOL (KEERP)

The suggested methodology constitutes a K-means energy-efficient routing protocol (KEERP) that considers the radio variables and transceiver channel capacity of a fixed data packet optimized. This strategy will minimize individual node energy use and improve network existence across. The transfer of data from the cluster head to the base station and other wireless nodes, various power conditions were determined.

Models for energy usage only take into account power consumption by the radio contact module. This design of power consumption covers the power consumed by all the components of this diverse WSN. The suggested methodology typically considers the power spent by the radio transmission, processing, and sensor module.

Fig. 1 shows the transceiver model of the proposed method. The transmitter and receiver side of the wireless sensor network are shown separately. Currently, energy intake by the three preceding systems is the total power consumption through the sensor nodes:
1) Sensing subsystem.
2) Processing subsystem.
3) Wireless communication subsystem.

A primary station (BS) and multiple sensing devices within a sensor field are included in the device model. Wireless sensor nodes are denoted as CM, and the head of the group is represented as CH. CMs feel and

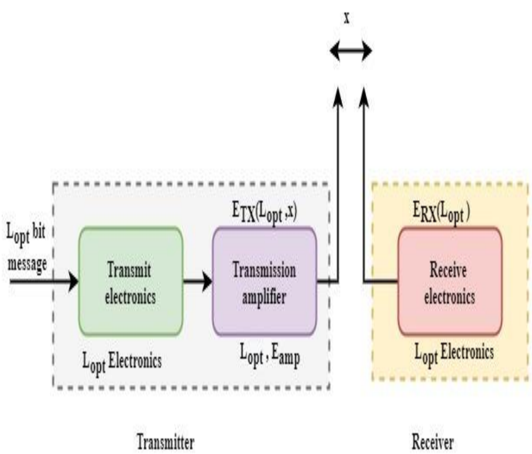

Figure 1 Transceiver model of the proposed system

relay data to the CH for the atmosphere. The CHs collect and forward the details to the BS. It is a centralized clustering algorithm for managing CHs in the base stations, and for all the CM of the group, the chosen CHs are declared. Due to the decreased power workload in the sensor network, which helps in energy savings.

In the data transmission process, a considerable amount of power is used at WSN. The optimum set packet size that can be used for minimizing this power consumption is expressed in Eqn. (1)

$$L_{opt} = \frac{\sqrt{C_0^2 - \frac{4C_0}{\ln(1-p)}} - C_0}{2} \quad (1)$$

where $C_0 = \propto + \frac{K_2}{K_1}$. The total of the headers represents the whole of the header bits in the packet is denoted $\propto$. K_1 is denoted the power used in sender transmission, K_2 is denoted the transceiver's initial power consumption p is the link bit mistake rate (BER). Eqn. (2) and (3) shows the transmitted and received power, respectively.

$$E_{TX}(L_{opt}, x) = L_{opt} * E_{elec} + L_{opt} * \varepsilon_{amp} \quad (2)$$

$$E_{RX}(L_{opt}) = L_{opt} * E_{elec} \quad (3)$$

Where x is the length between node sensors, E_{TX} *and* E_{RX} are the power consumption of the sender and recipient, E_{elec} the electronic and sender power is used, and ε_{amp} reflects the power consumption of the recipient amplifier in sensors that can be computed using Eqn. (4) and (5):

$$\varepsilon_{amp} = \varepsilon_{fs} * x^2 \ for\ x \le x_{th} \quad (4)$$

$$\varepsilon_{amp} = \varepsilon_{mp} * x^4 \ for\ x \le x_{th} \quad (5)$$

ε_{fs} and ε_{mp} are the power parameters of the boost where x_{th} is denoted minimum value.

The multipath faded communication system is used if the length X is larger than the x_{th}. The free space spreading concept is used instead. The total power needed for an optimal package can therefore be estimated and expressed in Eqn. (6) to (8)

$$E_{total} = E_{TX} + E_{RX} + E_{DA} \quad (6)$$

$$E_{total} = (L_{opt} * E_{elec} + L_{opt} * \varepsilon_{amp}) + (L_{opt} * E_{elec}) + E_{DA} \quad (7)$$

$$E_{total} = L_{opt}(2 * E_{elec} + \varepsilon_{amp}) + E_{DA} \quad (8)$$

If a network consisting of a cumulative sensor node amount of N. The interval between CM and CH is x_{CH} and between CH and BS is x_{BS}. For the distribution of L bits to its CH, the power consumed by a wireless node is provided in Eqn. (9)

$$E_{CM} = E_{init} - E_{TX}(L_{opt}, x) \quad (9)$$

In data accumulation and distribution to BS, energy utilization by a CH can be determined by Eqn. (10)

$$E_{CM} = E_{init} - E_{RX}(L_{opt}) - E_{DA} - E_{TX}(L_{opt}, x) \quad (10)$$

As the CM consumes the E_{CM} power, the E_{CH} power absorbed by the CH is the initial power of each device and the E_{init} is denoted the initial power.

A specific clustering framework, using k-means to create clusters and considering optimal packet length as a nonlinear function in CH collection, has now been suggested in this section.

Researchers know short packets are more expensive, and more extended packets are more expensive. Different packet sizes with channel capacity will enhance the network performance. Because of the increased overhead and power management costs, varying packet size for these independent and resource-restricted networks is not preferable. Therefore, the suggested system regards the optimum packet size as a power consumption reduction and increases WSN nodes' lives. There are three steps of the training method:

3.1 Initial Stage

The first step in which BS is sending a message to all wireless nodes is an initialization request (IRQ). After the IRQ notification has been sent, the sensors respond to the BS with an IRP. The IRP notification is made up of node power and its current position.

3.2 Cluster Training Stage

K-Means is the easiest clustering method used in cluster analysis. The data set is divided into K clusters in this method, and K is computed in this scenario. There is less resemblance between the intracluster and intercluster groups. There are multiple iterations and stages in this method:

• K (initial cluster centers) calculation value using the given Eqn. (11):

$$K = \sqrt{\frac{N}{2\pi}} \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \frac{F}{x_{BS}^2} \tag{11}$$

Where N is the Network area number of edge devices, F is the network area dimensions, and x_{BS} is denoted the mean length to each base station for each member node. Notice that K is the total of clusters in this section.

• Calculate, using the Euclidean distance, the length from each sensor node to each base station, and allocate each position to the nearest center is expressed in Eqn. (12)

$$X_{N2C} = \sqrt{\sum_{i=1}^{N}(X_i - X_{CC})} \tag{12}$$

$X_i$is the device i position and X_{CC} is the cluster center location where X_{N2C} is denoted the length between the sensor and the cluster center.

• Defining the current cluster core by computing the average value in all sensor networks' corresponding clusters.

• Repeat the new centers for stage 2. Repeating stage 3 stops the method if the group allocation sensor nodes shift.

3.3 Cluster Head Acquisition

The CH selection process is done after the nodes are classified as clusters. The author measures two-weight parameters to pick CH for each group is expressed in Eqn. (13) and (14)

$$W_{Ni} = c_1 * E_{ni} + c_2 * D_{cci} \tag{13}$$

$$W_{std} = c_1 * E_{total} + c_2 * avg\ (D_{cc}) \tag{14}$$

If $i = 1, 2, 3, 4 \ldots . N$ and c_1 and c_2 are consists of the W_{Ni} is the weight of every device, E_{ni} is the remaining power of the device, D_{cc} is the length from ith node to the cluster center, W_{std} is denoted the average weight of the node that can be called a cluster lead. Mean length from all clusters to the group core is defined by $L_{opt}$and $avg\ (D_{cc})$. $E_{total}$is denoted the total energy needed to transmit and receive.

Fig.2 shows the flowchart of the proposed K-means energy-efficient routing protocol (KEERP). Initially, the cluster is formed using the K-means algorithm. The variables $L_{opt}\ and\ E_{opt}$ are calculated. Calculate the weight for each cluster member and cluster head. Based on the weight value, the member is chosen as a cluster member or cluster head. For each group, two weights are matched, and for that specific cycle, a node with a weight nearly equal to the average weight is regarded as a CH. The CH data is now sent to each edge device in a BS cluster, updating its routing tables. Besides, for the CM to CH communication and CH to BS communication, two distinct ranges of power are regarded in the suggested method.

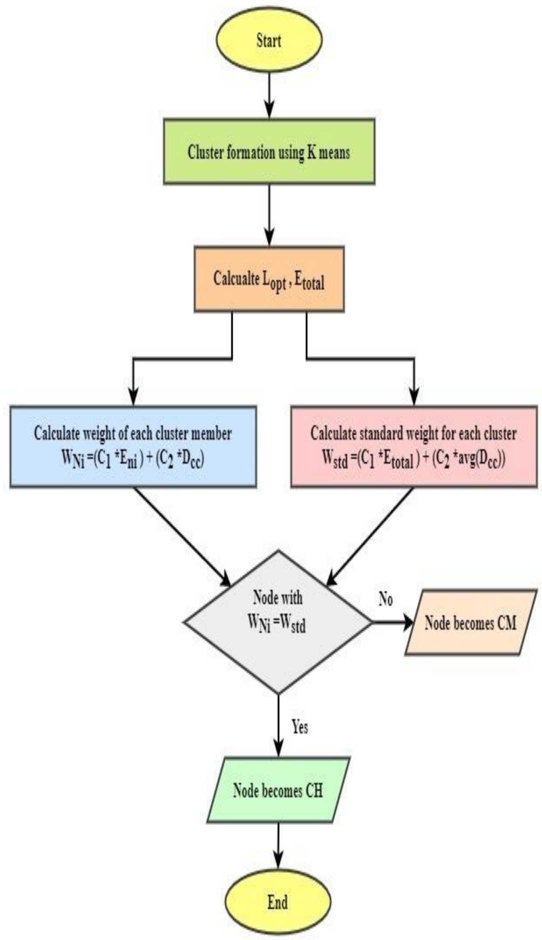

Figure 2 The flowchart of the proposed K-means energy-efficient routing protocol (KEERP)

4 SOFTWARE ANALYSIS AND PERFORMANCE EVALUATION

In this article, a cluster is believed to occupy a region of 100x100 m^2. The experiment in MATLAB is carried out using certain network assumptions described below

• After installation, the sensor devices and the BS nodes are all fixed.

• The sensing area is just one BS away.

• Sensors of the same initial power are homogenous and are installed dynamically in the network sector.

• The head of the group collects all the material, then transfers it to the base station.

• The fading paradigm of the Rayleigh channel is included.

• The energy and the duration of the trailer τ are all considered to be zero.

• Re-transmissions of delays and packets are not taken into account.

Table 1. Simulation parameters

Parameters	Value
Transmitter electronics	100 nj / bit
Receiver electronics	100 nj / bit
Transmit energy	20 mW
Receive energy	15 mW
Idle energy	10 mW
Simulation period	600 sec
Number nodes	100
Simulation area	100 x 100 m^2

Table 1 shows the simulation parameters which the authors taken for the analysis of the proposed K-means energy-efficient routing protocol (KEERP) and existing PASCCC method.

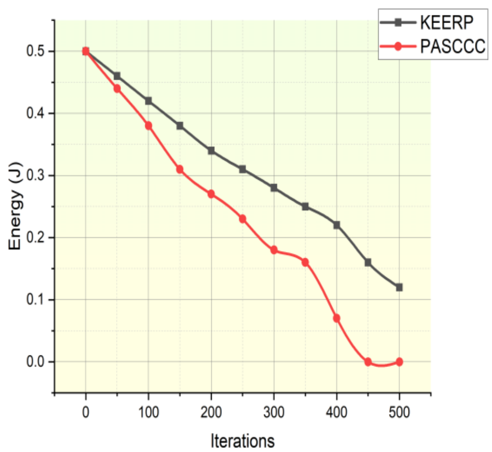

Figure 3 Energy consumption analysis of the proposed K-means energy-efficient routing protocol (KEERP)

Fig. 3 shows the energy consumption analysis of the proposed K-means energy-efficient routing protocol (KEERP). The simulation iterations are varied from 0 to 500 with a step size of 50 iterations. The respective energy consumption of the proposed K-means energy-efficient routing protocol (KEERP) and the existing PASCCC method. The results show that the proposed K-means energy-efficient routing protocol (KEERP) consumes significantly less energy than the existing protocol.

Fig. 4 shows the node condition analysis of the proposed K-means energy-efficient routing protocol (KEERP). The simulation iterations are varied from 0 to 500 with a step size of 50. The node conditions such as first node dead time, half of the network nodes dead time, and entire nodes dead time are analyzed, and the respective iterations are measured and plotted. The

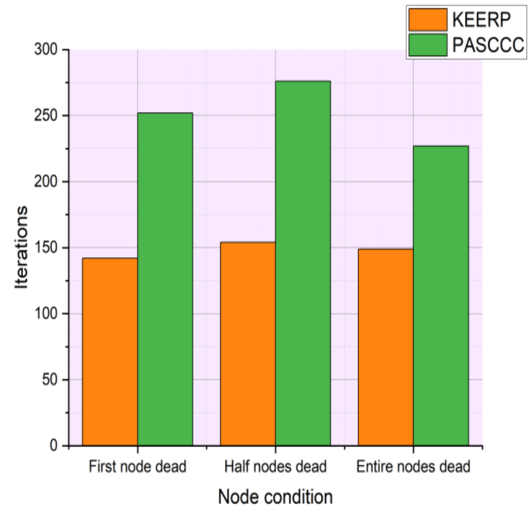

Figure 4 Node condition analysis of the proposed K-means energy-efficient routing protocol (KEERP)

results show that the proposed K-means energy-efficient routing protocol (KEERP) consumes less energy and takes a more significant time to all nodes dead.

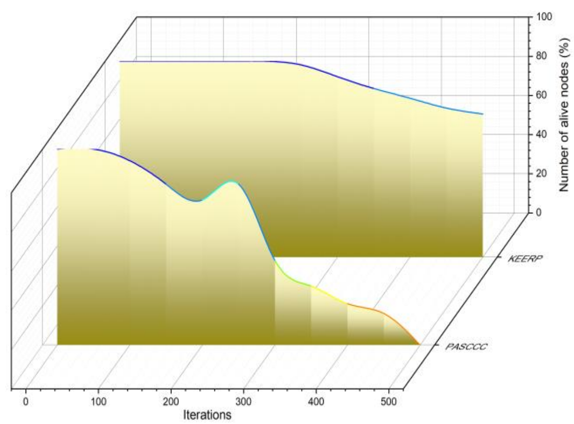

Figure 5 Number of alive nodes comparisons of the proposed K-means energy-efficient routing protocol (KEERP)

Fig. 5 shows the number of alive nodes comparisons of the proposed K-means energy-efficient routing protocol (KEERP). The simulation iterations are varied from 0 to 500 with a step size of 50 iterations. The respective number of alive nodes is measured and plotted in the above figures. The results show that the proposed K-means energy-efficient routing protocol (KEERP) has the highest performance.

Table 2 Performance analysis of the proposed K-means energy-efficient routing protocol (KEERP)

Iterations	Throughput (kbps)		Delay (msec)	
	KEERP	PASCCC	KEERP	PASCCC
0	0	0	0	0
50	1.5	0.7	42	17
100	2.7	0.9	58	24
150	2.9	1.4	67	28
200	3.4	1..3	92	63
250	3.8	1.2	97	39

Table 2 shows the performance analysis of the proposed K-means energy-efficient routing protocol (KEERP). The simulation iterations are varied from 0 to 500 with a step size of 50. The performance such as throughput and end-to-end delay is measured and tabulated in the above table. The results show that the proposed K-means energy-efficient routing protocol (KEERP) has the highest performance than the existing PASCCC protocol.

5 CONCLUSION AND FUTURE SCOPE

At WSN, in wireless communication phases, sensor nodes lose much of their resources. The proposed K-means energy-efficient routing protocol (KEERP) considered an optimum fixed packet size to conserve resources and extend the networks' lifespan for data transmission. It also determines the total power used for this packet, which is then used to measure its standardized weight with a mean length of the nodes to the cluster hub. The durability of nodes and the overall network have improved with this approach. The findings show that a high-power saving scheme and improved network life are part of the suggested system. Other measures such as delay or accuracy should be examined to examine the suggested Routing Protocol's consistency as potential work. Multiple error correction methods can also be included to improve the stability of the overall procedure.

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