IoT Enabled Cluster Based Energy Aware Routing Protocol In WSN

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Abstract. Because of the unpredictable nature of sensor nodes, propagating sensory data raises significant research challenges in Wireless Sensor Networks (WSNs). Recently, different cluster-based solutions are designed to improve network stability and lifetime. However, most energy-efficient solutions are developed for homogeneous networks and use only a distance parameter for data communication. Although, some existing solutions are attempted to improve the selection of next-hop based energy factor. Nevertheless, such solutions are unstable and lack reduce data delivery interruption in overloaded links. Our proposed solution aims to develop Reliable Cluster-based Energy-aware Routing (RCER) protocol for heterogeneous WSN which lengthens network lifetime and decreases routing cost. Our proposed RCER protocol makes use of heterogeneity nodes concerning their energy and comprises of two main phases; firstly, the network field is parted in geographical clusters to make the network more energy-efficient and secondly; RCER attempts optimum routing for improving the next-hop selection by considering residual-energy, hop-count and weighted value of Round-Trip Time (RTT) factors. Moreover, RCER restores routing paths and provides network reliability with improved data delivery performance. Simulation results demonstrate significant development of RCER protocol against their competing solutions.

Keywords: Spider Monkey Optimization Algorithm (SMOA), Ad-hoc On-demand Multipath Distance Vector (AOMDV), Clustering, Multipath Routing.

1. Introduction

WSN can be defined as a collection of self-organized minute devices named as sensor nodes. All deployed sensor nodes are dispersed randomly based on ad-hoc infra-structure to gather the sensory data over the entire network field. Routing protocols in traditional networks are designed to improve network performance in data delivery and network latency. On the other hand, WSNs mainly emphasis on how to progress energy preservation during slightest communication overheads [1]. Over the conventional networking approaches, stability, minor costs, correctness, consistency, and easiness of distribution are focal advantages of WSN applications. Energy utilization is a rare source and has to cope intelligently with improving network lifetime and routing performance [2].

Traditional and single-tier routing solutions are not feasible for sensor-based applications because of sensor nodes’ dynamic behavior. Thus, recently, different researchers focus on developing adaptive and robust routing protocol for the improvement of energy efficiency and appropriate routes discovery towards the endpoints [3]. Hierarchical-based routing protocols are alternate concepts widely used to support efficient route discovery and energy efficiency for WSNs. Basically; such schemes are useful in those environments that required scalability to hundreds and thousands of sensor nodes with efficient load distribution. The hierarchical-based network is separated into two foremost components. However, the existing hierarchical-based solutions are focused on probabilistic methods and paradigm sub-optimal panels [4].

Moreover, route discovery mechanisms in existing solutions are not optimized according to wireless communication links’ adaptive behavior and perform periodic re-clustering [5]. Also, to establish an end-to-end data propagation route, many route request messages are flooded in a hop-by-hop manner, which incurs additional communication cost and reduces network lifetime. Accordingly, design and development of energy-efficient and robust routing protocol are needed for energy constraints applications [6]. Furthermore, the optimum selection of routing paths and their re-tuning for data disseminating raises a demanding issue [7]. This research paper addresses scarce energy resources while collecting and forwarding sensory information in WSNs, which shortens network lifetime. Our proposed protocol focuses on developing Reliable Cluster-based Energy-aware Routing for
heterogeneous WSNs to increase stability period with the least data relaying interval and route breakages. The proposed protocol firstly parts the sensor nodes into geographically based clusters [8]. Secondly, it provides a light-weight solution to optimize the route detection process in hop-count, residual energy, and RTT factors. Also, the routing paths are updated based on network measurements for supporting network reliability. This may lead to a decrease in end-to-end delay and energy consumption with high data delivery performance [9].

2. Motivations and related work
In WSN applications, the limited resources of sensor nodes highly impact the performance of data delivery and network stability. To amend the adjustment among data routing and energy consumption, suitable architecture is needed for the chosen data forwarders with minimum network overheads [10]. A traditional cluster-based protocol LEACH has been presented. However, such a solution depends on generating random clusters. Wireless Sensor Network in unbalanced energy consumption among nodes and cluster heads (CHs) is not evenly distributed across the network field [11]. Also, for the enhancement of LEACH protocol, many solutions have been proposed. Although, such solutions improved network lifetime in the comparison of earlier schemes, however, incur further communication overheads and unbalanced energy consumption [12]. The authors also developed a partition-based (pLEACH) algorithm to prolong the network lifetime. Like other traditional routing protocols, pLEACH also divided into two main phases and comprised different rounds. pLEACH firstly divides the network field into different sectors then select the highest energy level nodes as CHs based on centralized calculations [13]. However, the construction of sub-optimal panels and non-optimized route discovery leads to energy consumption unbalanced. Different schemes have been proposed, that generate clusters of unequal sizes. The target of such schemes is to address the problem of the energy hole [14]. Usually, the nearest to Base Station (BS) nodes have to deal with high-rate data receiving and forwarding, which results in reducing network throughput and lifetime. The authors proposed a ring zone-based routing protocol (RARZ) for WSN, aiming to improve energy consumption in the sensor field. Also, data communication occurs in a multi-hop manner via the selection of next-hops. In, authors presented a tree-based aggregation algorithm for improving the energy efficiency of WSN. Each source node determines its next-hop based on residual energy and hop-count parameters during data aggregation and forwarding to BS [15]. However, this process takes a lot of time for data routing and increases the end-to-end ratio [16].

Furthermore, Tree-based Clustering (TBC) is presented, to structure the nodes in a tree-based manner based on distance factor [17]. Every member node sends its sense data to the parent node until it arrived at CH. This approach has improved data delivery performance within clusters, in uneven energy consumption. Also, the aggregated data from CHs is forwarded to BS using single-hop, which results in a longer delay ratio. Authors in presented Enhanced Threshold Sensitive Stable Election Protocol (ETSSEP) for heterogeneous network [18].

3. limitations of existing solutions and problems definition
Based on the literature, as mentioned above work, it is seen that efficient energy utilization with reliable routing is a major research concern. It is observed that most of the existing solutions cannot adjust routing performance according to the dynamic environment and limited resources of WSN [19]. Moreover, the recent work lacks the selection of next-hop based on the optimum decision, and such solutions degrade network-wide routing performance. Furthermore, during data relaying, routing paths are re-structured periodically, which is the additional overhead in time consumption and transmission cost [20]. This overhead exists due to the periodic exchange of routing and control messages in the network field.

Moreover, in high nodes density scenario, most of the existing work produces network congestion and increases packet lose ratio [21]. Therefore, the energy efficiency domain focused for data collection and forwarding has to explore with a light-weight solution to improve network lifetime with the stable delivery ratio [22]. Accordingly, to overcome the problems described above, this research article aims to develop the energy-aware with reliable routing protocol for heterogeneous networks, constructing geographical sized clusters by using node location [23]. The fitness function comprises multiple criteria related to residual energy, hop-count, and the weighted value of RTT. Consequently, the proposed protocol provides a reliable next-hop selection, significantly impacting the data
forwarding process and improved network stability period [24]. Also, to growth route lifetime and data delivery performance, overburden wireless channels and nodes are identified, accordingly routing paths are re-structured based on the measurement of communication links and nodes abilities [25].

4. Assumptions
i. All the nodes have unique IDs, deployed randomly in the sensor field and remain immobile.
ii. By exploring GPS or position algorithm, sensor nodes are location-aware.
iii. Heterogeneous nodes may have more energy resource as compared to normal nodes.
iv. All normal nodes have the same capabilities and constraints.
v. The transmission power of sensor nodes may be adjusted by employing receiver distance.
vi. Sink node or BS is prosperous in resources compared to other nodes and has a long-range radio transceiver.

5. Proposed Methodology
To increase the energy efficiency of WSN, cluster-b routing is presented in this paper. In this work, the cluster (CH) is selected using the Spider Monkey optimization algorithm. In this method, the objective function is designed based on the station distance and energy parameters to select the optimal ch heads. Each CH selects the members closest to its coverage communication range, thus making the cluster successful. Selected cluster heads receive data packets from the correspond non-CH members. However, most energy is consumed in communications, i.e. in exchange and reception. Therefore, to solve these problems, the Spider Monkey Optimization Algorithm (SMOA) cluster head and the optimal choice of the Ad-hoc On-Demand Multipath Distance Vector (AOMDV) algorithm is used to create energy-aware clusters, which compute multiple loop-free and link synchronization paths which is functional for Cost-Based Multipath Routing. From the multipath, the optimal cost path is selected.

5.1 Phase I: Clusters formation
In most of the existing solutions, the entire sensor field is structured into discrete regions randomly, which results in imbalanced energy consumption and load distribution. To achieve energy efficiency, RCER protocol originates the construction of clusters by making use of nodes locality. Initially, BS floods its discovery message in the sensor field. Next-hop nodes store the BS discovery information and update their routing tables. Subsequent, the BS discovery information is further disseminated to neighbors in a structured manner. The same procedure continued until BS has inclusive statistics of the entire network field. The nodes that reside in preset transmission radius \( Tr \), BS determines the centroidal by exploiting their locations. In this way, closest neighbors are gathered into the same group, generating energy-efficient clusters with the least clustering overheads. Subsequent, the formation of geographical sized clustering. RCER prompts the method of bounded CH election within each cluster’s limit, which decreases computational cost. The optimistic threshold is adjusted dynamically based on the ratio \( \mu \) of the node’s energy reduction in network operations. Subsequently, among the candidates, the node centrality factor is incorporated. Centrality \( C(x) \) of node \( n \) is measuring its distance \( d \) from position \( x \) to its neighbors \( y_i \) inside a particular cluster as given. It is reciprocal of the sum of the distance between the node and its neighbors. The basis behind the node centrality factor is to select nodes as initial CHs that require least network overheads and energy consumption.

5.2 Phase II: Route detection
The route detection phase comprises two sub-components, one is the next-hop selection, and the other is network measurement. In the first component, the set appropriate next Reliable Cluster-based Energy-aware Routing protocol for heterogeneous Wireless Sensor Networks is identified based on multi-criteria, which provides optimum data relaying and balances the transmission load with uniform energy consumption. During the routing decision, the proposed RCER protocol uses fitness function to determine Forwarder Point (FP) of node i, which integrates hop-count \( h \) count \( e_i \) residual energy, and Weighted Round Trip Time. Accordingly, the node that optimizes the composite routing function in terms of energy, hop-count and weighted RTT is next-hop. It might be a case that more than one next-hop have the same FP values. In such case, Node ID breaks the ties, and the source node keeps an only single entry in its neighbor table. To construct a neighbor table, each source node i, broadcasts RREQ in its transmission range and on RCER: Reliable Cluster-based Energy-aware Routing protocol for heterogeneous Wireless Sensor
Networks RTT is used to measure the length of time that it proceeds to send data packets and the length of time that it proceeds for an ACK for data packets to be received. The distance and transmission media also impact the value of RTT. \( T_x \) and \( R_x \) are transmitting and receiving time of beacon message \( x \). Thus, minimum \( RTT_{ij} \) indicates the less congested wireless channel, which results in improved network throughput with minimum data interruption. Accordingly, uninterrupted, less congested and most energy-aware routing paths are constructed towards particular CH in each cluster. Also, CHs are responsible for local data collection and known as a crucial end. Our RCER protocol constitutes a Backbone Formation (BF), which is responsible for electing a set of CHs to construct adaptive paths towards BS. The basis behind BF’s construction is to reduce the communication power of chosen CHs for data routing and source to a fair distribution of energy consumption. When particular CH drops its energy resource to the optimistic threshold OR upon completion of the predefined time epoch (\( \Delta t \)), the RCER protocol initiates re-election as being exploited in the clusters as mentioned earlier formation phase. In data routing, the inherent characteristics of low powered communication links and tightly limited energy resources of sensor nodes lead to vulnerabilities such as unnecessary energy consumption, re-transmissions and frequently routes discoveries.

To identify unreliable nodes or fragmented links on the active route, source node \( i \) determines the latency epoch \( l \) among its next-hop \( j \) by disseminating, will be considered over congested and inappropriate for further data forwarding. Therefore, the over-congested node sends a route-alter message towards the source node via downstream next-hop. Upon receiving the route alter the message, the source node marks the routing RCER: Reliable Cluster-based Energy-aware Routing protocol for heterogeneous Wireless Sensor Networks path invalid and removes the entry from routing table. The source node selects a fresh next-hop and an uncast RREQ packet towards the newly selected next-hop to re-continue for alternative work by exploiting the aforementioned optimized routing phase. Upon receiving the RREQ packet, the chosen next-hop replied to the source node with the ACK message. If the source node does not receive any ACK message, then the same aforementioned optimized routing phase is continued for the next-hop selection process. Also, to achieve uniform load distribution, each node may be a part of only one active route. In case, it might happen that the node received multiple RREQ packets, in such case the duplicate packet is discarded. Node H received duplicate RREQ packet from node F, so receiving RREQ packet is discarded by node H.

6. **RCER analysis**

i. The RCER protocol is designed for heterogeneous WSNs based on the cluster-based solution, and effective for energy efficiency with reliable routing.

ii. The clusters formation is achieved based on the node region, which results in more stable clusters with minimal energy consumption.

iii. To achieve optimal routing decision, fitness function based on multiple factors is used. It balances energy consumption and reduces routing overheads, as only neighboring nodes participate in the route’s construction procedure.

iv. Unlike periodic next-hops re-formation in the entire network field, the proposed RCER protocol updates their locations using network measurements.

v. RCER reduces the clustering overheads, as cluster setup phase executes only precise time at the start of network initialization. Afterwards, the position of CH rotates within the region of each cluster. Due to limited computational processing, RCER protocol minimizes overheads and leads to improved network lifetime.

6.1 **RCER performance evaluation**

The section evaluates the routing performance of RCER protocol in well-known simulator tool NS2 compared to existing work. During the evaluation, different experiments are performed based on a high-density node and varying network load. The performance of RCER protocol is evaluated in terms of network lifetime, energy consumption, network throughput average end-to-end delay, route lifetime and packet delivery ratio. Sensor nodes are static and randomly deployed in a square size network field. The initial energy levels are assigned to nodes in the range of \( 2j \) to \( 5j \). Simulation time is set to 1500sec to measure the RCER weighting factors are assigned even representation, a more balanced contribution is achieved towards the optimized routing process \( w_1 = iw_2 = iw_3 = 0.333 \), however \( w_1 + w_2 + w_3 = 1 \). As a result, energy, hop-count and RTT metrics are given equal impact, resulting in the
construction of shortest, energy-efficient and less congested routing paths. In all following simulation experiments, RCER assigns identical values to $w_1$, $w_2$ and $w_3$.

6.2 Simulation results
The performance of RCER protocol is evaluated in comparing ETSSEP, Partition-based LEACH, TBC and LCM schemes.

6.2.1. Network lifetime analysis. It is obvious that RCER protocol has superior performance, like 11.5%, 12.2%, 14.7%, and 23% improvement is achieved in network lifetime. Unlike ETSSEP, TBC, LCM and Partition based LEACH, RCER protocol constructs geographical sized clusters and initiates CHs selection mechanism among narrow nodes. Moreover, the most energy-efficient, shortest and less congested next-hops are selected to pursue data forwarding. Furthermore, overloaded and faraway next-hops are avoided during data forwarding. As a result, RCER protocol improves the network lifetime remarkably. Observably, the data traffic increases by employing more network load.

On the other hand, more network load also decreases network lifetime. RCER protocol improved network lifetime by 9.6%, 10%, 20% and i39% than present solutions. This is due to considering the position factor in the generation of clusters. The position of CHs is shifted based on demand rather than periodically, thus RCER significantly reduces the rate of energy consumption and extending network lifetime.

6.2.2. Energy consumption analysis. Based on results, it is seen that RCER protocol broadly shortens the network energy consumption by 14%, 15%, 33%, and 46% respectively than existing schemes. Unlike ETSSEP, TBC, LCM and Partition based pLEACH, RCER protocol reduces the computational and communication overheads, as CHs election mechanism occurs within the constrained regions. Furthermore, few numbers of nodes are accountable for in routing decision, thus achieves balanced energy consumption. The logic behind consuming lessen energy consumption is due to balance the network load among next-hops. Also, only a restricted number of nodes came to the election process and changed their positions based on network measurement. Furthermore, incorporating the link delay factor in routing decision highly reduces the number of re-transmissions which remarkably decreases energy consumption.

6.2.3. Network throughput analysis. The simulation results show that RCER achieved higher network throughput by 17.5%, 19%, 27%, and 36% compared to existing schemes. This is because ETSSEP, TBC, LCM, and Partition-based pLEACH perform non-optimum routing decisions to select the next-hop. In contrast, RCER protocol selects next-hops by considering multi-criteria. As a result, the less congested, reliable and energy-efficient nodes are chosen to forward data packets. The routing decision of RCER protocol not only lessens the length of the communication path and saves energy resource but on the other hand; also construct a reliable path, thus improving network throughput. A higher network load in elevated traffic burden reduces network throughput and routing performance. Based on results, it is seen that RCER protocol has the highest data delivery performance, like 17%, 18%, 29%, and 37% improvement is attained than existing work. This happens because of the selection of multi-criterion data forwarders, and position of next-hop is re-formulated based on network measurement. Moreover, considering the link delay factor in routing decision decreases the network congestion with a numeral of re-forwarding that significantly affects data delivery performance.

6.2.4. End-to-end delay analysis. The performance of RCER with a comparison of existing work in terms of their end-to-end delay considers a varying number of nodes. The simulation results show that RCER achieved 9%, 10%, 16%, and 23% reduction in average end-to-end delay. Unlike ETSSEP, TBC, LCM and Partition based pLEACH, RCER routing conclusion is more adaptable in the dynamic scenarios and reduces the probability of route breakages and re-data-forwarding. Moreover, by computing links performance based on latency epoch, overloaded communication paths re-identified, and consequently, the next-hops are re-adjusted. Accordingly, the partial re-formation of next-hop instead of constructing the entire routing path significantly minimizes time consumption and data delivery interruption. RCER protocol improves network delay performance by 18%, 19%, 32%, and 40% compared to existing work. This happens because the construction of the route in RCER is more active in terms of multi-facet attributes. Moreover, in routing decision, only those particular next-hops are chosen, those condense the
delay ratio with minimum network overheads and time consumption. Also, RCER avoids choosing faraway neighbors and dropping the number of trails while sending data packets.

6.2.5. Route lifetime analysis. In a varying number of nodes scenario, the route lifetime in comparison of existing schemes. As can be observed from the simulation results that RCER achieves longer route lifetime than existing schemes by 15%, 16%, 23%, and 34%. The reason behind such performance improvement of RCER is the incorporation of node abilities and link delay factor for routes re-amendment. In contrast, ETSSEP, TBC, LCM and Partition based pLEACH schemes re-structured the routing paths periodically without considering network conditions. Moreover, the nodes are given lower chances for routing decisions whose energy levels are not sufficient. Also, the multi-criteria for the selection of next-hops improve the forwarding process consistency.

6.2.6. Packet delivery ratio analysis. The simulation experiments are performed to measure the reliability in packet delivery ratios under varying network loads. It is seen that RCER obtained better performance of reliability than existing schemes like 19%, 20%, 23%, and 31% because more priority is given to those next-hops that are optimum for data forwarding. In high network load, the existing schemes produce high network congestion because the next-hop selection process is non-optimal. As a result, the packet delivery ratio is low. Moreover, as RCER periodically identifies the link congestion and defective nodes based on latency epoch, overburden nodes and links are given low weight age for data forwarding. Accordingly, RCER protocol succeeded in minimizing the data delivery interruption and improves overall network performance.

7. Result and Discussion

Our proposed Spider Monkey Optimization Algorithm (SMOA) and Ad-hoc On-demand Multipath Distance Vector (AOMDV) protocol are executed in Mat lab’s working foundation. This technique is performed on a windows machine having configuration processor® Dual-core CPU, RAM: 1 GB, Speed: 2.70 GHz with Microsoft Window7 professional operating system.

7.1. Experimental Result

In our proposed work, 500 sensor nodes are performed in the region 1000m×1000m. Each sensor node in the region is executed with the transmission power of 0.66W and the receiving power of 0.395W. Transmission range of each sensor node is 250m. AODV routing protocol issued in this work. Each sensor node is included with Omni directional antenna radiates radio wave power uniformly in all directions. A two-way ground radio propagation model is considered, which is used to predict each packet’s received signal power. Table 1 shows the simulation parameter and the value of our proposed approach.

| Parameter                  | Value                  |
|----------------------------|------------------------|
| Area size                  | 1000m×1000m            |
| Routing protocol           | AODV                   |
| MAC                        | 802.11                 |
| Antenna                    | Omni Antenna           |
| Radio propagation model    | Two Ray Ground          |
| Packet size                | 512bytes               |
| Initial transmitting power | 0.660W                 |
| Initial receiving power    | 0.395W                 |
| Initial energy             | 10.3J                  |
| Simulation time            | 100secs                |
| Rate                       | 500kb                  |

Sensor nodes in the region are grouped as several clusters. For cluster formation, cluster head is selected initially. CH is selected using our proposed spider monkey optimization algorithm, and sensor nodes in the communication range of CHs are joined to the corresponding CH. All selected CHs now send advertising messages over the network, declaring them to be...
cluster leaders. Each node now measures the distance from all cluster heads. The node joins the CH with the minimum distance and sends a message to the nearest cluster head. If the distance among the node and the CH is greater than the distance with the BS, the node will directly interact with the BS or else it joins the cluster based on the nearby distance, thus forming clusters. The whole work process is simulated within 100 seconds.

### 7.2. Performance Metrics
Performance of our proposed approach is evaluated using the following metrics which is mathematically represented as follows;

- **Delivery ratio**
  
  It is the ratio of the number of packets received successfully and the total amount of packets transmitted.

  \[
  \text{Delivery ratio} = \frac{\text{Amount of transmitted data (kb)}}{\text{Transmitted time (s)}}
  \]  

- **Packet delay**
  
  The delay of the network describes how long the network takes to transmit a bit to the destination. Unit of this parameter is seconds (s).

- **Throughput**
  
  It is the number of data that can be sent from the sources to the destination per second. Unit of this parameter is kb/s.

  \[
  \text{Throughput} = \frac{\text{Amount of transmitted data (kb)}}{\text{Transmitted time (s)}}
  \]

- **Energy consumption**
  
  Amount of energy consumed by each node during the transmission. Also, it is defined as the difference between the current energy and initial energy of a node. Unit of this parameter is Joule (J).

  \[
  \text{Energy consumption} = \text{Initial energy} - \text{current energy}
  \]

### 7.3. Performance Based on Nodes
Performance metrics of our proposed approach SMOA-AOMDV are evaluated for varying nodes. The Figure 1 shows the comparison of the performance metrics of SMOA-AOMDV with the previous work REER and RUMOR.

#### 7.3.1. Number of Nodes Vs Energy Consumption

![Fig. 1. Numbers of nodes vs energy consumption.](image)

By selecting CHs, cluster formation and efficient route using our proposes SMOA-AOMDV, energy consumption of the network is reduced, i.e., the energy efficiency of the network is improved. So, compared to the existing REER and
RUMOR energy consumption of our proposed SMOD-AOMDV is reduced. From figure 1, for (20-200) nodes the energy consumption in 60% for REER and RUMOR protocol. For our proposed SMOA-AOMDV, the consumption of energy-reduced by 35% from this, we can clearly understand our proposed approach achieves better results than the existing approaches.

7.3.2 Number of Nodes Vs End to End Delay(S)

Comparison of end-to-end delay of SMOS-AOMDV with REER and RUMOR protocol for the varying number of nodes is shown in figure 2. The selection of efficient cluster head and cluster formation in SMOA-ADMDV is reduced to existing REER and RUMOR protocol, respectively. The end-to-end delay concerning the varying number of nodes is increased for our proposed SMOA-AOMDV. In this scenario of 70 sec, the minimum delay is 25sec in SMOA-ADODV where 35sec and 78sec for REER and RUMOR respectively when the number of nodes in the network is 350. iWhere adjusting the number of nodes will improve the performance, from figure proposed approach has increased End to End delay to that of the existing approach

7.3.3 Pocket Delivery Ratio Vs Pocket Size

Comparison of end-to-end delay of SMOS-AOMDV with REER and RUMOR protocol for the varying number of nodes is shown in figure 2. The selection of efficient cluster head and cluster formation in SMOA-ADMDV is reduced to existing REER and RUMOR protocol, respectively. The end-to-end delay concerning the varying number of nodes is increased for our proposed SMOA-AOMDV. In this scenario of 70 sec, the minimum delay is 25sec in SMOA-ADODV where 35sec and 78sec for REER and RUMOR respectively when the number of nodes in the network is 350. iWhere adjusting the number of nodes will improve the performance, from figure proposed approach has increased End to End delay to that of the existing approach

Fig. 2. Number of Nodes Vs End to end delay (s).

Fig. 3. Pocket delivery ratio Vs pocket size.
Figure 3 depicts the comparison of the packet delivery ratio of SMOA-AOMDV with REER and RUMOR protocol for varying packet size. By presenting efficient cluster head selection using BSP algorithm, each member in a cluster is restricted from transmitting data to the destination independently. The node depth based on the source node, neighbor node and amplitude variation in the node increases the packet loss data transmission. In this scenario of 0.9 delivery ratio, the maximum delivery ratio is 0.88 in our proposed method where 0.78 and 0.56 in REER and RUMOR respectively, when the packet size is 400 bytes. Thus, our approach’s packet delivery ratio is increased compared to the existing REER and RUMOR approach.

7.3.4 Number of Nodes Vs Network Lifetime

The above figure 4 depicts the comparison of the proposed method with REER and RUMOR for varying nodes. Because of the selection of the cluster head and cluster formation in the proposed methodology using SMOA-AOMDV, the network lifeline can be increased as when compared to REER and RUMOR. In the above graph, the lifeline of RUMOR is decreased when compared with REER, and it could also be decreased when compared with our proposed system. In this scenario of 1300sec, the minimum network lifeline is 900sec in SMOA-AMODV where 750sec and 700sec for REER and RUMOR, respectively, when the number of nodes in the network is 350. This shows that our proposed system achieves better results when comparing with the existing approaches.

8. Conclusion

RCER protocol addressed energy efficiency and improved the routing performance of WSN within realistic network scenarios. However, most of the existing solution formed unbalanced clusters and used only the distance factor in routing decision, which sources many re-transmissions and transmission cost. Some existing schemes attempted to improve the selection of next-hop by using neighbor’s information. However, such schemes lack considering network measurements such as congestion on wireless links, reducing data delivery performance with route instability. RCER proposed energy-efficient heterogeneous cluster-based protocol with reliable routing. RCER constructs the geographical sized clusters and exploits light-weight multi-criteria for the selection of next-hop.

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