Distributed Bandwidth Clustering Scheme for Node Cooperation in Intermittently Wireless Sensor Networks

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Abstract

A wireless sensor network consists of set of small set of sensor nodes which has restricted energy capacity to attain the effective data packet transmission. When the application requires high bandwidth for data transmission, then the consumption of energy might also be high, leads to the less efficiency in the lifetime of the network. To overcome the efficiency, data gathering takes place which leads to network overload. In order to address the packet collision while data aggregation in WSN, Chih-Kuang Lin, et. Al., presented a distributed and scalable scheduling technique with time slot assignment that alleviates huge data loss in sensor networks. The design of a virtual grid network minimizes the protocol intricacy and subsequently improves the scalability. But the cooperation among the nodes is less since it is based on the sensor nodes location awareness/coverage in WSN. To resolve the issue, in this work, a novel distributed bandwidth clustering scheme for wireless sensor networks is implemented, termed as NDBC. In NDBC, the cluster head is selected based on the ratio between the transmission rate and bandwidth of each sensor nodes in the wireless sensor networks. Based on the bandwidth and the transmission range of each nodes, the cooperation among the sensors are achieved based on grouping the nodes passes the data packet to the destination node. Experimental evaluation is done with the sensor nodes for better coverage in network environment against Distributed and Scalable Time Slot Allocation Protocol for Wireless Sensor Networks and its performance is evaluated with varied set of sensor nodes with measuring metrics such as bandwidth utilization, transmission rate and energy dissipation. Comparison evaluates that the proposed scheme provides 10-13% efficient in energy against the existing distributed and scalable scheduling technique.

Keywords: *Wireless sensor networks, intermittent sensor nodes, bandwidth utilization, transmission rate, cooperation*.

1. Introduction

Wireless sensors are typically organized in distant and dangerous locations, where physical monitoring is very complex or almost not possible. Due to the less expensive in wireless sensors, these can be utilized in huge phases. Despite sensing, sensor nodes are prepared with data dispensation and communication abilities. The intellecting circuitry deals with the constraints of interest inside its sensing variety and changes them into electrical indications. These signals are routed and with the assistance of committed radio they are broadcasted to the distantly positioned sink node. Due to consumption of wireless sensors in unsympathetic environment, it is not probable to accuse or return their batteries. As a result, energy efficient process of wireless sensors to extend the lifetime of the wireless sensor network is of highest significance.

Association of huge multi-hop wireless networks into set of clusters is necessary for attaining essential network presentation. In wireless sensor networks (WSN), the clustering is mainly differentiated by data aggregation by every cluster head, which considerably decreases the travel cost. The hierarchical representation needs two major techniques:

(1) Cyclic collection of cluster heads (CHs); and

(2) Transfer of every node to one or numerous clusters.

While most techniques thus far have paid attention on an energy-efficient clustering method, the concentration to the presentation of the multi-hop network was quite restricted. An energy-efficiency algorithm might choose a little CHs for energy-saving, but if these CHs do not enclose good connectivity or if they are not constant, the rebroadcast and the declined packets might considerably disgrace the network presentation and the total energy shattered might end up to be privileged. Consequently, taking consistent message into account is necessary for any clustering algorithm which objects to decrease the energy utilization in a network.

Grouping sensor nodes into clusters has been extensively utilized to attain this intention. In clustered networks, one of the sensor nodes is designated as cluster head for every cluster in the network. Sensor nodes in every cluster broadcast data to their individual cluster head and the cluster head in order sends the data after data gathering/fusion to sink node during single/multi-hop communication. The clustering procedure guarantees that efficient consumption of restricted energy of sensor nodes and therefore enlarges the life time of the network. The responsibility of cluster head is occasionally turned around amongst the sensor nodes near the cluster to make sure impartial energy utilization of sensor nodes.

Furthermore, the network lifetime should be considered not only by the instance that the initial or the final node expires, but also by the phase of time that the network is accessible for offering services and operating properly. As the network is regularly intense and numerous nodes are unnecessary, the loss of a small number of nodes does not concern the network. So, network lifetime is closely attached with the network presentation.

In this work, an energy efficient node distributed bandwidth clustering scheme is implemented for the distribution of packet data and node cooperation in the wireless sensor networks. In proposed NDBC approach, clusters are created only one time through the lifetime of sensor network, which provides considerable saving of energy. The clustering procedure in the proposed technique is a decentralized method, which is processed out by determining the transmission rate and bandwidth of the sensor nodes autonomously, thus saving the node energy.

2. Literature Review

For WSN, the network node energy is restricted, so how to set aside and even the utilization of the overall energy is an imperative crisis. Clustering is the design techniques utilized to supervise the network energy utilization powerfully. In [1], the author utilized genetic replicated annealing algorithm (GSAA) to discover a best possible clusterformationandprolong network lifetime. In WSNs, low cost balancing camera sensors might create low declaration images owing to hardware restrictions. There is a dangerous image appreciation confront in these rebuilt super decision images for precision, difficulty and restricted energy resource in wireless sensor networks. In [2], the author studied the submission of AIS for dispersed and mutual image prototype appreciation in wireless sensor networks offering energy efficient image connections and content processing.

The author in [3] proposed an energy-efficient structure for data collection in wireless sensor networks by combining the process of calculation scheme. The structure is clustering based which symbolizes the sensor nodes and gathers data values from them. For numerous applications in WSNs, users might desire to incessantly take out data from the networks for investigation later. On the other hand, precise data extraction is complex it is frequently too expensive to attain all sensor readings. The author in [4] presented a novel routing method, termed as Energy-efficient Geographic Routing (EBGR), which can give fully stateless, energy-efficient routing at a minimal communication overhead devoid of the assistance of previous neighborhood knowledge. Upholding neighborhood in sequence for packet forwarding might not be suitable for WSNs.

The author in [5] studied the collision of transmission rate manage on energy efficient estimation in WSN to exploit sensor network lifetime. For numerous imagined applications, the information dispensation engages dispersed data in the background of precise signal recognition, correspondingly. In [6], the joint optimization of recognition and routing is accepted out in a synthesis which pre-computes the path as a location to be monitored.

The paper [7] introduced a novel two-phase process termed as collaborative rateless broadcast (CRBcast). CRBcast is a scalable technique for dependable and energy-efficient transmitting in WSN that also speaks to load balancing, whereas obtaining no information of network topology. FlexiTP [8] is TDMA procedure that provides a coordinated and movable period structure. Nodes in the network can construct, adapt, or expand their planned number of slits through execution, supported with the restricted information. FlexiTP is scalable for its depth-first-search list reduces the scalability of WSN.

Hot spots in WSN come out as positions beneath heavy traffic load. Nodes in areas rapidly reduce energy resources, most important to disturbance in network services [9]. This difficulty is general for data collection in which it contains a serious load of gathering information. In [10], the author described an competent and energy conventional unicast routing method for WSN over Rayleigh fading channels, which refer to as opportunistic routing protocol. In [11], the author measured the information detection in a thickly deployed (WSN). WSN can be utilized for most of the recent schemes, which is sent to a data consuming center. Nevertheless, the amount of event is hardly accounted appropriate, which is a severe obligation for several applications [12].

Motivated by these issues, we plan to provide node distributed bandwidth clustering scheme to enhance the energy efficiency of the network by cooperating the set of sensor nodes in the network.

3. Proposed Methodology

In intermittently connected sensor networks, the route path from source to destination is chosen based on the activities of the node in the network. Normally nodes have high transmission range and bandwidth chosen as route node for transmission of packets from source to destination. Likewise, by grouping the set of all nodes in the network, the cooperation is achieved in the sensor network. The grouping of nodes is done based on adapting the novel distributed bandwidth clustering scheme The architecture diagram of the proposed scheme is shown in fig 1.

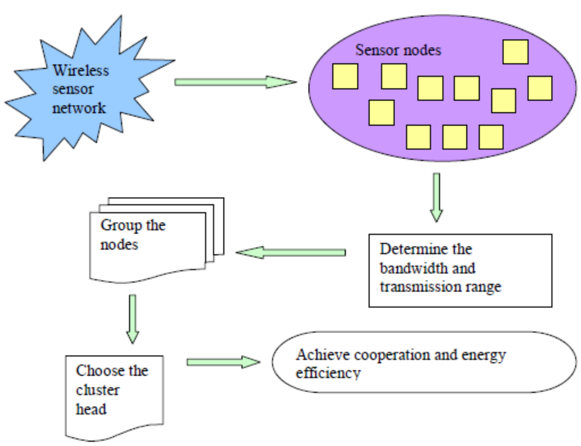

Fig 1 Architecture diagram of node cooperation model

From fig 1, it is being observed that the node cooperation is achieved by grouping the set of sensor nodes based on implementing the novel distributed bandwidth clustering scheme. The NDBC scheme groups the nodes by determining the transmission and bandwidth rate of each sensor nodes in the network. For each group in the sensor network, the cluster head is chosen based on selecting the node which has high bandwidth and transmission rate. Through the node cooperation model, the energy efficiency of the network is achieved which improves the lifetime of the network.

3.1 System Model

Wireless sensor network model based on circular monitoring with consistent node allocation density containing only one sink node at the midpoint of checking area has been measured. There are n number of sensor nodes organized in the sensing area, designated as S_1, S_2, ….S_n. It is assumed that the source of all sensor nodes is proficient of transmitting the data with two types of radio ranges:

- Low power broadcast range min (T) and
- High power range of max (T),

Where T is the maximum transmission range of a node

For cluster communication, low power broadcast range is utilized. The size of the cluster is analyzed to select the cluster head, and network communication is preserved among the sensor nodes and cluster head inside the cluster. The wireless sensor network model makes sure that two adjacent cluster heads distance is measured to obtain the distance between the clusters.

Initially, sensors are consistently organized in a network area. Each sensor node in the network is conscious of ecological data (e.g., coverage and location) connected with the scrutinized area. Sensors can establish their positions with diverse accuracy (i.e., with higher position granularity).

Wireless sensor networks might comprise both stationary and mobile sensors. The mobile sensors, e.g., mobile robots utilizing sensors for serious scrutinizing applications, might vary positions to achieve the corresponding node assignment. Such sensor node connections are habitually intermittent and random, which creates more difficult for the sensors bringing composed data to next-hop neighbors. The representation of communication also provides a channel access owing to the huge numbers of simultaneous data transmissions inside a less period of time.

Collisions happen when a sensor obtains more than one communication concurrently from diverse parties. Sensors are exclusively recognized and prepared with omni-directional antennas. Every sensor node in the network broadcasts or obtains on common carrier regularity. It broadcasts in allocated time slots and "idle listens" or receives if not. A sensor can broadcast a message at the establishment of a time slot and complete the communication, counting an ACK message, inside the similar time slot (which is specified as 7 ms and 250 kbps data rate). All sensors broadcast at the identical power that envelops a restricted footprint, so multi-hop communication among a source and a sink is estimated. Efficient consumption of data-intensive multi-hop WSN is demanding task in the network.

3.2 Novel distributed bandwidth clustering scheme in WSN

Here, the process of NDBC scheme is presented successfully. NDBC utilizes the initial and residual transmission level, bandwidth rate of each of the sensor nodes to choose the cluster-heads. The NDBC approach offers scalable and efficient data from source node to destination through the clustering scheme. Each source node in NDBS approach constructs a clustering of nodes which enables mobile sinks to process the data packet along the destination node in the network.

Sensor nodes in the network are aware of its positions in the network area. Based on the positioning of nodes in the network, the clustering is performed. In addition, NDBC approach provides the sensor nodes are aware of their respective data packets to be sent into the destination node. Each data packet of the respective sensor node represents the current locations in the network area.

Once a source sensor node ready to send a packet data, it starts preparing for distributing the data packet by searching for neighboring node. The source node starts the distribution from its own location and sends a data declaration message to each of its neighboring routing node. The message stops its task once it reaches the destination which is the neighboring to the mobile sink. The source node will keep the information about the sensor node location, route path and the sink node location except the one from which it obtained the message. This process of data packet sending procedures describes that the sensor nodes which are adjacent to the mobile sink are ready to distribute the source nodes messages to the mobile sink which it specified.

The process of novel distributed bandwidth clustering scheme is implemented based on four phases. They are

i) initialization phase
ii) Clustering phase
iii) Cluster head selection
iv) Data distribution

The initialization phase describes the process of sensor nodes location awareness and the corresponding mobile sink to be obtained. Consider a set of nodes as S = {S1, S_2, ….S_n} in the sensor network. In the wireless sensor networks, the initial energy of the normal nodes is determined. Thus there are N nodes processed with initial energy of E_0. For the set of randomized distributed sensor nodes in the network, the bandwidth and transmission rate of each of the sensor nodes are determined. With this determination, the grouping of nodes is done. The transmission rate of each of the sensor node is determined as follows,

$$TR(S_i) = \frac{Tot(p)}{t} \quad \text{………} (1)$$

Where Tot (p) – total no. of data packets
t – Time interval

The bandwidth of each of the sensor nodes are also being determined as follows,

$$band(S_i) = \frac{Suc(p)^r}{t} \quad \text{…………….} (2)$$

Where band (S_i) – bandwidth of the sensor node i
Suc (p) – successful transfer of data packet p
r – Route path
t – Time interval

At first, the randomized sensor nodes in the network are analyzed. Then the transmission rate and the bandwidth are determined to group the nodes. After determination, a novel distributed bandwidth clustering scheme is implemented which is done based on (2).

The clustering phase describes the process of grouping the sensor nodes for secure data distribution towards the mobile sink. Based on the transmission rate of each of the sensor node in the network, the clustering is done. After the calculation of sensor nodes transmission rate in sensing area is done, the clustering and cluster head selection phase will starts its process by transmitting the message to the sink node. The message will hold the information concerning the position of sink node in WSN. After obtaining the sink node position in WSN, all the sensor nodes in the network determines its position from the sink node location through Euclidian distance.

$$ds(S_i) = \sqrt{(loc(s) - loc(i))^2}$$

…………… (3)

Where ds (S_i) – distance of sensor node i from the sink node s

loc (s) – location of sink node

loc (i) – location of sensor node i

After determination of distance, let the clustering phase starts. Cluster the sensor nodes based on (3). The nodes which has less number of ds(S_i) will group in one side. The nodes which have large number of ds (S_i) will group in next side. Likewise, based on ds (S_i), the clustering of sensor nodes is achieved.

The cluster head selection is necessary to extend the life time of network by determining the energy consumption of all sensor nodes and balance the energy to pass the data distribution. The energy balancing is done to enhance the node cooperation of nodes in the network. Since, cluster head is necessary to achieve the nodes task of data aggregation. The selection is done based on the bandwidth rate. In the cluster, the sensor node which has high bandwidth rate is chosen as cluster head. The cluster head will process all other sensor nodes in the group for data distribution. The cooperation among the nodes is maintained by the cluster head based on the transmission rate of each node. If any new node enters into the group, the cluster head will analyze whether it is authorized node or not by checking the activities of sensor node in the network like transmission range, energy residual etc. If nay node wants to leave the cluster, then the node will ask permission to change its location. The cluster head will maintain all the details regarding the location, group maintenance and the sink node position awareness.

Once a cluster is formed with the set of sensor nodes, the distribution of data from the set of source nodes is done to the destination node in the network. The grouping of nodes in the network is done from which it sends the data to the sink node. The process is repeated until the data packet reaches the network sink's node. Once the data is distributed successfully to the sink, an ACK message is sent to the cluster head to identify the status of reaching the mobile sink in the network.

3.3 Distributed bandwidth clustering algorithm

The node distributed bandwidth clustering algorithm [NDBCA] forms a cluster group by providing a sub-optimal resolution to the network lifetime and in a dispersed environment. The node distributed bandwidth clustering algorithm is processed based on the iterations. For every iteration, the NDBC algorithm recognized a set of active sensors in the network. After the end of recognition in each cluster group, the accessible set is customized by determining the node cooperation based on the cluster head selection and data distribution. Once the active status of the sensor nodes is difficult to recognize, then the algorithm stops its process to identify. To provide an energy efficient sensor network lifetime, at present, sets of sensors are stimulated in sequence. The process of NDBCA is shown in fig 2

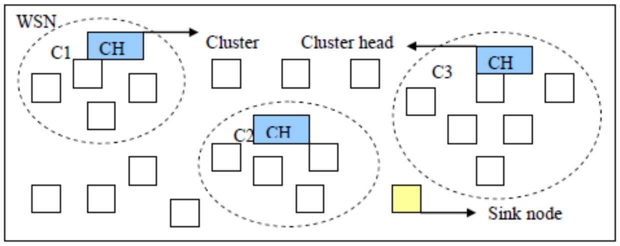

Fig 2: Process of NDBCA for enhancing the connectivity through clustering

The algorithm below describes the entire process of NDBC algorithm to attain the better coverage of the network by minimizing the energy rate.

// Algorithm

Input: Sensor nodes S = {S_1, S_2, ….S_n}, TR, Band, ds, clusters C = {C_1, C_2,..,C_n}

Begin

Initialize the sensor nodes S, TR and band

Identify the sink node in the network

For each S_n

Determine the ds using (3)

End for

Based on the value of each ds

Form a cluster with the set of sensor nodes

In each cluster C_n,

For each S_n

Determine the transmission rate (TR) using (1)

Determine the bandwidth rate (band) using (2)

Identify the S_n which has high band and TR

Choose as cluster head CH (S_n)

CH maintains the information regarding the position of sensor nodes in the network

Passes the data packet to the mobile sink from source node

End For

End

End

The above algorithm describes the entire process of increasing the lifetime of the network based on the determination of cluster head, transmission rate and bandwidth. By determining the data distribution of each sensor node in the network, the coverage area of the sensor network is considerably increased.

4. EXPERIMENTAL EVALAUTION

In this section, the proposed node distributed bandwidth clustering scheme in intermittently connected sensor networks is evaluated in set of simulation experiments. In the simulation, n sensors are arbitrarily organized in a 900 * 9000 square area, with n changing from 100 to 600. Consider a set of sensor nodes n = 500 and the battery/network lifetime ratio is 3 / 5. The sensing range of the nodes in the network is specified. The channel data rate is set to 300 Kbps and the sensor communication range to 20 meters. The packet size of each of the sensor node is 80 bytes. Four set of network topologies are experienced in simulation experiments. Every sensor node in the network always has awaiting data prepared for transmission, so the simulations symbolize a data-intensive data traffic situation. For the radio channel proliferation representation in the simulations, a two-ray path loss form was preferred. The simulation results are averaged over 25 runs. Simulations run for 500 seconds of simulation time. Every node in the network initiates with a arbitrary outstanding energy, ranges from 300 to 500 points. The power level each sensor node is determined as 25 dBm and the power level of the preferred cluster head was -20 dBm. A timer of 600 seconds was positioned for intermittent cluster collection activated by every CH in both the techniques, consequently, and a timer of 11 seconds was utilized among the set of all data packets in the network. The performance of the proposed NDBC model is measured in terms of transmission rate, bandwidth and energy dissipation.

5. RESULTS AND DISCUSSION

In this work, we evaluate the performance of the proposed NDBC approach in intermittently connected sensor networks against distributed and scalable scheduling technique [DST]. Experiments are achieved for a variety of network sizes with a grid of size 100x100. The below table and graph describes the performance of the proposed NDBC scheme and compared with the existing DST technique.

No. of senders	Transmission rate (%)	
	Proposed NDBC	Existing DST
1	34	10
2	46	13
3	52	16
4	60	20
5	65	22
6	72	26
7	78	29

Table 1 No. of senders vs. transmission rate

The transmission rate of the data packets is measured based on the number of source node in the sensor network. The rate of the proposed NDBC approach is compared with the existing DST technique.

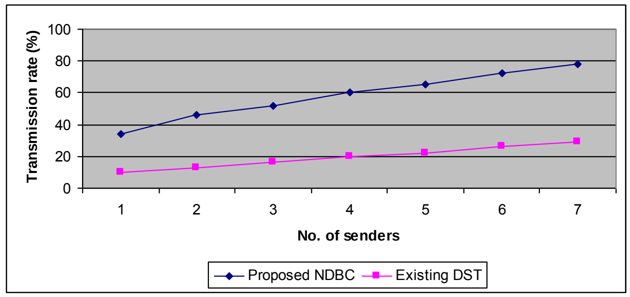

Fig 3. No. of senders vs. transmission rate

Fig 3 describes the transmission rate of the data packets is measured based on the number of source node in the sensor network. The transmission rate is measured in terms of rate at which the set of data packets successfully reached the sink node in WSN. Compared to the existing DST, the proposed NDBC approach provides high transmission rate. Because, the NDBC followed the clustering process for grouping the nodes based on its behaviors and its transmission rate. So, the clustering is done effectively in the sensor network which provides ease way for transmission of packet data. But in the DST, the cooperation among the sensor nodes is very complex to organize, so the transmission of packet is also being less. The variance in the transmission rate is 10-15% high in the proposed NDBC approach.

No. of senders	Bandwidth (%)	
	Proposed NDBC	Existing DST
1	54	45
2	60	49
3	68	53
4	73	57
5	80	68

6	84	75
7	90	82

Table 2 No. of senders vs. bandwidth

The bandwidth rate of the data packets is measured based on the number of source node in the sensor network. The rate of the proposed NDBC approach is compared with the existing DST technique

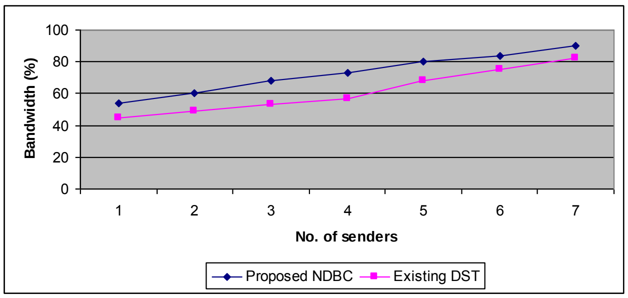

Fig 4 No. of senders vs. bandwidth

Fig 4 describes the bandwidth rate of the data packets is measured based on the number of source nodes (sender) in the sensor network. The bandwidth rate is measured in terms of rate at which the number of data packets successfully reached the sink node to the total number of packets in WSN. Compared to the existing DST, the proposed NDBC approach provides high bandwidth rate. Because, the NDBC followed the clustering process for grouping the nodes based on its behaviors and its transmission rate. The cluster head selection is done based on the bandwidth rate if each sensor node in the network. So, the clustering is done effectively in the sensor network which provides ease way for transmission of packet data. But in the DST, the cooperation among the sensor nodes is not good, so the bandwidth rate is also being less. The variance in the bandwidth rate is 5-8% high in the proposed NDBC approach.

No. of nodes	Energy dissipation (J)	
	Proposed NDBC	Existing DST
100	10	20
200	12	24
300	15	26
400	18	30
500	20	32
600	22	34
700	25	36

Table 3 No. of nodes vs. energy dissipation

The dissipation of energy is measured based on the number of sensor nodes in the sensor network. The energy dissipation of the proposed NDBC approach is compared with the existing DST technique

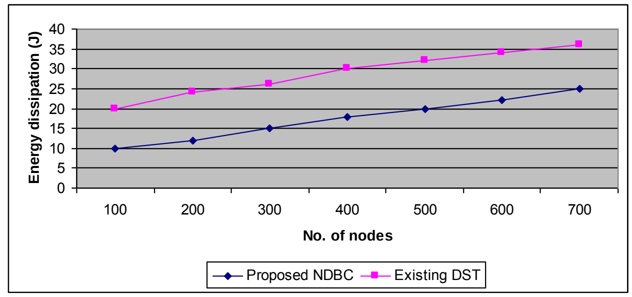

Fig 5 No. of nodes vs. energy dissipation

Fig 5 describes the dissipation of energy is measured based on the number of sensor nodes in the sensor network. Compared to the existing DST technique, the proposed NDBC approach provides less dissipation in energy in the sensor networks. Since the NDBC provides high transmission rate and bandwidth, the dissipation of energy is less. The node cooperation in the network is efficient, the nodes requires less amount of energy to pass the data packet. The variance is 10-12% less in the proposed NDBC approach.

Finally, it is being observed that the proposed NDBC approach provides node cooperation to make the sensor network energy efficient. This is accomplished by clustering and cluster head selection process by determining the transmission rate and bandwidth in the WSN.

6. Conclusion

An energy efficient clustering, cluster head selection for node cooperation in the sensor networks is proposed in this paper. The proposed NDBC approach ensures the construction of clusters in the region of the sink in the sensor network. In proposed NDBC method, the structure of cluster obtains only once in network lifetime, therefore passing up energy dissipation connected with the clustering process. The cluster head selection process is done based on the transmission rate and bandwidth of the sensor networks. The period and occurrence of cluster head selection is conceded out by balancing the energy utilization. This results in balanced improving the network lifetime by consuming minimal energy.

Simulation results show the effectiveness of proposed NDBC approach in term of clustering energy dissipation, transmission rate and bandwidth consumption. Simulation results are also compared with the existing distributed and scalable scheduling protocol. The proposed NDBC approach offers 12% in energy efficiency compared to the existing DST in wireless sensor networks for extending the network lifetime.

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