Energy Efficient Clustering Method for Wireless Sensor Networks

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Abstract : WSN (wireless sensor network) is a kind of network that assists the sensor nodes (SNs) in entering and departing the network in accordance with their requirement. The sensor network is effective at places which are situated at distance and have small size. Therefore, the major concern of WSN is energy utilization. The energy of SNs is constricted in amount, that leads to transmit the data to the sink. This data is gathered from the target environment. Diverse sensor motes are utilized to transmit the data among BS (base station). The process to make the decision is executed when the similarity is identified and removed among the data related to distinct sensor nodes. Moreover, the attained data is deployed in BS and the transmission of this data is done further to the networks located at distance. The former research work presents an EE (energy efficient) protocol recognized as CTNR (Cluster to Normal Ratio) which has potential to prolong the life span of Wireless Sensor Network. Two level hierarchies are considered in this protocol in order to alleviate the energy consumption of network. This protocol is executed to select the CHs (cluster heads) in the network with respect to the distance and energy. This research work aims to enhance the CTNR protocol with the objective of maximizing the duration of network. The Proposed Method is Implemented in MATLAB and results are analyzed in terms dead nodes, alive nodes and number of packets transmitted to base station. The results show significant improvement in the proposed method correspond to existing method.

Keywords: WSN CTNR Routing Multi-level Hierarchy

1. INTRODUCTION

Wireless sensor networks (WSNs) is a kind of wireless network which attains a lot of attention in several civilian and soldierly applications. Moreover, distributed autonomous sensor motes are included in this network for monitoring the physical or environmental circumstances [1] [2]. A node is a set of connected SNs of small sized and comprises in this network. Such node is responsible for sharing the information and data when a communication is established with each other. These motes are utilized to collect the information of environmental metrics including temperature, pressure, humidity or pollutant, and for transmitting this information to a sink. This information is further transmitted to the wired network and an alarm is activated in accordance with the sort and dimension of data via BS [3] [4]. WSN makes the implementation of all nodes with a radio transceiver, a small microcontroller, and a power source or battery. The constructive property of these networks is not emerged from the power of the separate SNs but from the entire range of interlinked sensor nodes [5] [6]. Hence, such networks have enormous size due to their capacity of possessing a number of nodes and recognized as self-arranged and reliable network. The cost of wireless SNs is low, thus, a number of nodes are deployed in the Wireless Sensor Network [7] [8].

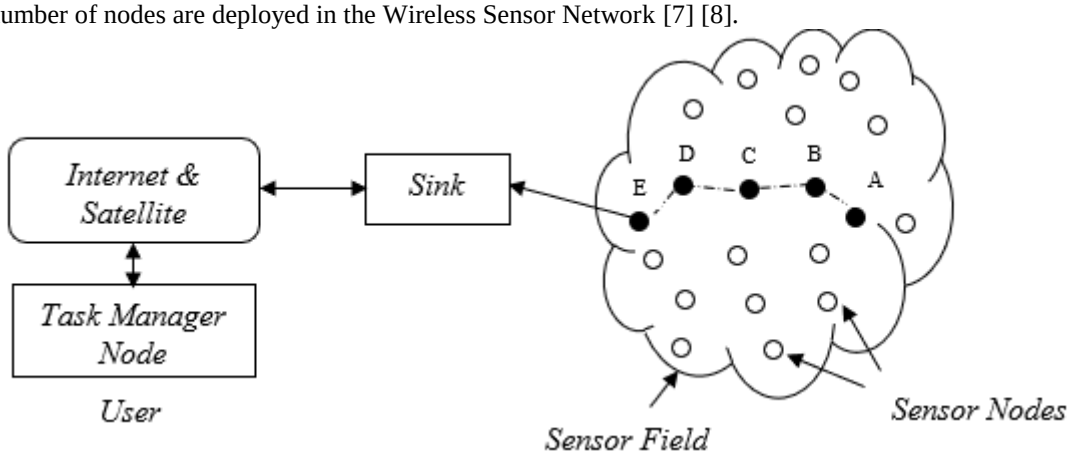

Figure 1. Wireless Sensor Network

Generally, a multi-hop mechanism is utilized through sensor nodes for interacting with each other. A sink is a particular node at which the information is transmitted and data is halted. It is responsible for associating the sensor network with an immovable network in order to distribute the sensed data to perform more processing [9] [10]. In general, composite processing is executed using the sink due to its higher adaptability over simple nodes. This implies the involvement of more refined processors in sinks such as PCs/laptops with more RAM memory, secondary storage, battery and computing strength for carrying out more operations in comparison with the classic sensor devices. Much energy is utilized via sensor nodes for communicating with others and it is the major issue of WSN. No complexity is occurred while generating the sensor motes to be implemented at huge scale [11] [12]. The cost consumed for this is found lower. WSN face the major issue of energy that is useful to acquire a higher duration

when they are implemented on reserves having limited battery. The energy is majorly utilized in transmitting the multi-hop packet across the wireless networks [13] [14].

The fundamental objective of Wireless Sensor Network is to consume least power owing to the involvement of nodes and to insert the lightweight nodes which support a constricted battery power. Diverse network models like OSI and Internet are a kind of functional models whose organization is done as layers and provide the services to the layer places at upper side using the layer [15] [16]. Diverse service parameters like delay, consistency and safety are taken into consideration for quantifying a network. However, the issue of energy utilization is occurred as much power is consumed when the network is evaluated and optimized. This network emphasizes on controlling the duty cycle of wireless sensors dynamically for alleviating the energy utilization. The complicated task is to manage the energy in different mission-critical sensor application [17] [18] [19]. There is a necessity of maintaining a pre-determined level of sensing in these application in the presence of restrains in the communication. Therefore, it becomes complex to generate the routing algorithms that are stable and whose implementation is done effectively for a large scale of performance metrics and design necessities. The development of these algorithms is done further for the future of WSNs.

2. LITERATURE REVIEW

Komalpreet Kaur, et.al (2020) presented a new prioritized queuing-based protocol called DEEC to balance the power in WSNs and extend the network's service period [20]. This protocol applied priority queuing dependant distributed clustering strategy to save power and avoid packet drop. At first, the dropped packets were raised to the priority queue, from which it was received and forwarded to the subsequent CH with enough energy for communication. In addition, given the distance between the nodes and the CH, the new scheme consumed less power when forwarding packets. The suggested simulations provided nodes that were dead in different sessions. The new scheme proved to be more efficient than other conventional protocols in simulation results. The presented scheme helped to increase the result by 20%.

Zahid Yousif, et.al (2021) uncovered the relationships between center sections and energy. This work addressed several issues of WSNs such as energy saving and service span by introducing an energy awareness solution named EESW [21]. The new system was dependent on altered network energy architecture. It was a new occasion activating methodology and a position mindful metric. EESW architecture consumed power carefully and set a threshold for WSNs. Approving the outcome, this work conducted simulations in NS2 software and performed a comparative analysis between the new and classic power architecture in light of various evaluation criterion like energy efficiency, service span, PDR and delay. According to the results, the new scheme proved to be far superior to the classic AODV protocol.

Salim El Khediri, et.al (2020) presented a nascent solution for WSNs namely MW-LEACH (Multiple Weight Low Energy Adaptive Clustering Hierarchy) [22]. The new solution considered several metrics such as remaining power, the distance between the CHs, and maximum number of participatory motes to choose cluster heads (CHs). The selection of nodes from the underlying set was contingent on the great remaining energy nearer to the focal point of the thickness, resulting in an underlying arrangement of CH participants. The participatory nodes collected information from their individuals by moving into various directions and forwarded the collected data to the main hub. The proposed approach had lower intricacy concerning duration and messages. Moreover, it was quick and extended the network's service period to a substantial level. It also tolerated faults in a flexible manner. The new methodology outperformed the existent methodologies in view of throughput, energy efficiency, PDR, network span, and delay in the obtained results of simulations.

Indra Kumar Shah, et.al (2020) addressed the concern of power consumption by presenting a new solution called distance-based dynamic duty-cycle allocation (DBDDCA) [23]. Nodes located far from the cluster head (CH) transmitted messages in comparatively less duration to consume less power in the new solution. The nodes closer to the CH took more time for message transmission. The comparison of new solution was performed with its various counterpart solutions. The productivity of new and existing solutions was assessed on a number of performance measures such as energy awareness, power usage of the network, service life of the network, idling and PDR. These measures were evaluated with different network conditions, for example, with variation in number of nodes, number of sessions, and starting power of nodes. The productivity of the developed solution was found to be better than the existing solutions considering the network indices tested.

Navdeep Singh Randhawa, et.al (2018) put forward a power aware solution based on the idea of Virtual Grid Based Dynamic Routes Adjustment (VGDRA) [24]. The new solution used GA (Genetic Algorithm) to save power. It also improved the whole productivity of WSNs. The new scheme was found more energy competent than LEACH by virtue of its dynamical behaviour. Moreover, it balanced load and optimized a small number of loops which produced better results more likely which was infeasible in other schemes. The new solution was implemented in MATLAB software.

MahaAbderrahim, et.al (2019) introduced a Dijkstra algorithm-based energy-aware multi-hop transmission approach for WSNs. This work treated a wireless sensor network established with N number of sensing devices [25]. The sensing devices were arranged into groups on the basis of their location in the region under surveillance. Thereafter, this work chose an appropriate device as CH and the residual devices were categorized into active and sleeping devices to organize devices in every cluster. The set of cooperating reliable relays were chosen to forward the data with the minimum transferring power. The new communication system had potential to reduce the energy usage in a competent manner as compared to the former methodology of communication. The simulation results depicted that the presented novel algorithm was conducive to increasing the energy awareness to increase the network span.

Changjiang Jiang, et.al (2016) presented a case study of several fundamental routing algorithms to reduce the speed of nodes and increase the service period of the network [26]. This work formulated an LCUCR protocol based on multi-hop communication in inter-cluster message sharing. The new protocol selected CH and sub-CH in view of energy and distance metric in the fitness function. The base station and the cluster head shared messages with each other through sub-CH. Meanwhile, this work formed the finest route between the CH and the base station based on cost function. According to simulation results, the

designed clustering protocol was capable enough to balance the energy consumed across the network and extend the service period of the infrastructure.

3. RESEARCH METHODOLOGY

The application of clustered WSN majorly focuses on distributing the nodes randomly. Distributing the sensor nodes at random leads to generate CHs. Consequently, a variety of issues are occurred. As much energy is consumed, the disposability of CH (cluster head) must be avoided. Moreover, this process assists in preventing the long distance communication in the CH and inserting the nodes lower than them. The CHs are the nodes which the introduced standards do not select as they are ineffective in every way. The nodes are unable to be present in the network and their presence is not present at remote regions due to the harsh conditions of nodes which results in making the nodes unsuitable. The nodes having maximum intra-cluster energy can be employed as the cluster heads. The energy usage in authentic node is often lower in contrast to the receiver and the sender nodes. In case of availability of the enormous spectrum in the system synchronously, the energy utilized in nodes becomes lower. The actions are split after selecting the parent node for every cluster. It results in maximizing the production.

Two value functions are put forward to enhance the efficacy of every SN that is useful for selecting the node as the CH. The amount of motes is utilized to create the functions. The distance of nodes towards the sink is considered to calculate the average power of the neighboring nodes. This process assists in generating a higher degree of nodes with the objective of forming a CH. If the CH has higher degree, it is capable of covering large volume of nodes that avoids the communications which are of higher cost. Therefore, the duration of network is prolonged in case of alleviation of power utilized by nodes. The initial step emphasizes on broadcasting a Hello message is transmitted in which the identity is present. The SS is taken in account for quantifying the distance amid sink and every node. The transmission of INTIAL-MSG is done across the network in which the identity and distance amid every mote and BS is comprised. A computation of distance is done amid node and neighboring nodes. The nodes make the deployment of computing technique in order to quantify the CH denoted with RCH, which is expressed in equation (1) as:

$$R_{CH} = R_{min} * [1 + (\frac{d_{BS} - d_{BSmin}}{d_{BSmax} - d_{BSmin}})] \quad (1)$$

R_{min} is employed to illustrate the least size of cluster and its deployment is a metric of the protocol, d_{BSmin} denotes the distance within the adjacent node and sink and d_{BSmax} represents the distance from the adjoining node towards sink. The value function helps in computing the value for every mote to offer the suitability to node for its selection as CH.

$$F_{CH-value} = \alpha * N_{deg} + \frac{\beta}{MSD_{deg}} + \frac{\gamma}{d_{BS}} \quad (2)$$

Here, the constant weights are defined using α, β and γ to which the values are assigned amid 0 and 1. The network is consisted of nodes which support same or variable values. N_{deg}denotes the radius R_{CH} presented in the number of neighbor motes. MSD_{deg}represent the mean square distance amid the neighbor motes. The distance found within the sink and each node is defined with d_{BS}. The expected values are employed to quantify the values of available CHs in a particular time. Consequently, $F_{CH-value}$ is obtained as the enhanced value for every node. Every node is deployed for monitoring other nodes to attain the enhanced values lies amid 0 and 1. Furthermore, every node assists in producing a random value available amid 0 and 1. In case of lower value from $F_{CH-value}$, the node, whose selection is done as CH, is taken in account as candidate node. A comparative analysis is conducted on nodes according to the R_{CH} radius and RE subsequent to selecting the cluster head. A CH is a node having higher RE which is effective to offer identity and transmission code. The stature of CH is defined to all the motes. The nearer CH is detected using a non-CH node for which the SS (signal strength) is considered. The intra-cluster communication established energy cluster focuses on some suitable components. Cluster is a significant component among them. The energy consumed via node radio and distance, and the communication cost in a cluster is found higher. It results in augmenting the intra-cluster energy. This paper suggests a technique called centrality. The lower power amid the central cluster and receiver node leads to alleviate the second power average due to which the intra-cluster energy is also lessened. Other components also lay impact on power. The introduced standards called cache motes in harsh circumstances, do not choose the motes. The computation of every stage is performed for every non-CH mote effectively in order to select any node as a volunteer node.

$$Access\ Time = H * T_c + (1 - H)(T_c + T_m) \quad (3)$$

is used to illustrate cache hit ratio, Tc is the access time and the main memory access is defined with Tm. The CHs are employed to transmit the gathered data towards the sink.

Algorithm of the Proposed Scheme

1. Initialize
2. B=Base station
3. S_{Alive}=Set of alive nodes in the network
4. K: Number of cluster heads
5. N_{Alive}=The number of alive nodes in the network
6. S_{CH} =The set of cluster heads
7. S_{NCH}=The set of non-cluster head nodes
8. S_{NCH2}=The set of non-cluster nodes assigned to cluster
9. S_{NC}=The set of non-clustered nodes
10. S_{LN}= The set of leader nodes
11. S_{GN}=The set of gateway nodes
12. Start
13. Process:
14. Input
15. For every node in $S_{Alivedo}$
16. Send energy level to Base station
17. k= N_{Alive}*0.05
18. For every node in S_{NCHdo}
19. For every node in S_{CHdo}
20. If Distance (Node1, Node2) < Minimum-distance
21. Minimum distance=Distance (Node1, Node2)

4. RESULTS AND DISCUSSION

MATLAB helps analyzing the performance of the introduced cache based wireless networks. MATLAB is a kind of package using which mathematical calculations can be done and complex functions can be executed. A relevant scenario having numerous in-built functions is offered by it. Table 1 illustrates the simulations which are carried out.

Table 1. Simulation Parameters

Parameter	Description	Value
A	area of network	(0, 0)–(200, 250)
L-BS	BS location	(150, 250)
N	number of nodes in network	100
$E_{initial}$	initial energy of all nodes	0.5 J
E_{fs}	free space channel model	50 nJ/bit
E_{mp}	multi-path fading channel model	0.0013 pJ/bit/m^4
d_0	distance threshold	87 m
E_{DA}	data aggregation energy	5 nJ/bit/signal
DP size	data packet size in bit	4000
CP size	control packet size in bit	200

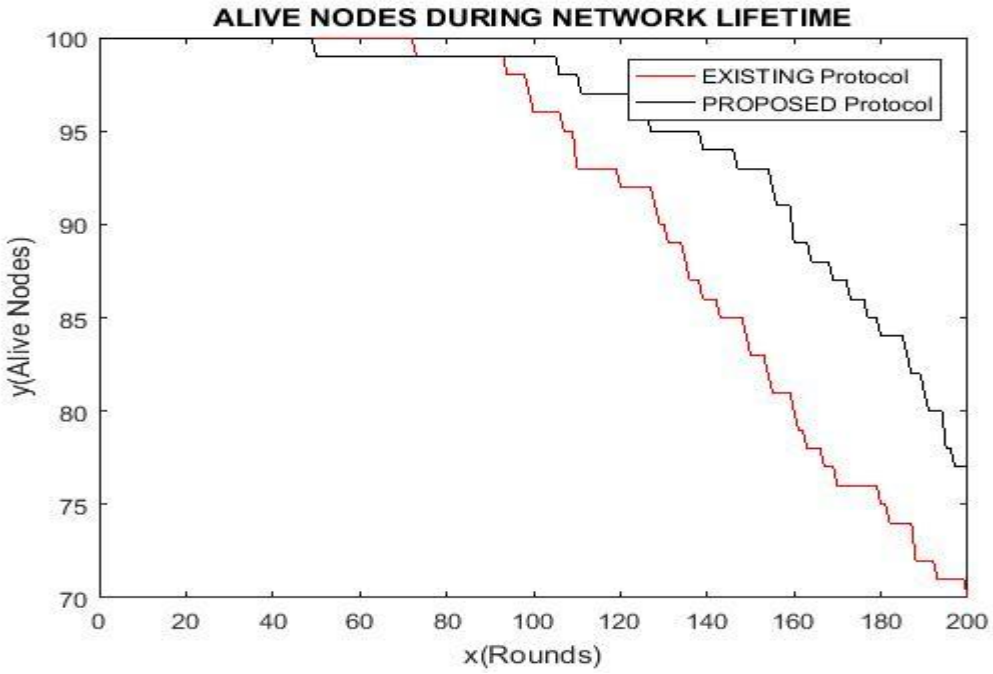

Figure 2. Alive Nodes Comparison

Figure 2 illustrates comparison between the existing methodology and the newly devised methodology. The new method is the improvement of CTNR protocol. This protocol uses gateway motes for communication. The lower the energy consumption, the more live particles in the network

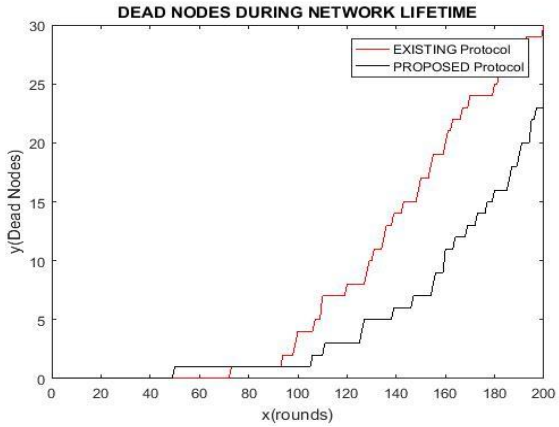

Figure 3. Number of Dead Node Comparison

Figure 3 displays comparison the existing and newly designed technique with regard to the dead nodes. The suggested method includes dead motes in small number in the given number of rounds. The deployment of cache motes assists in diminishing the power exhausted by nodes. The smaller the energy loss, the smaller the dead motes in the set-up.

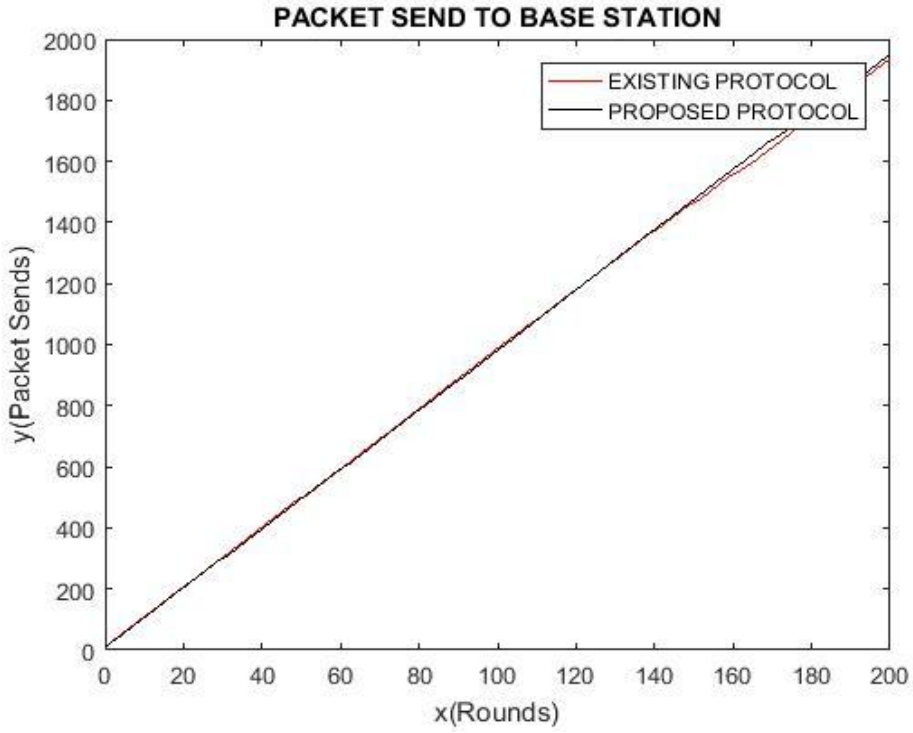

Figure 4. No of Packets Transmitted

Figure 4 represented that the number of packets transmitted to the sink using the suggested method. The developed method is able to transmit more packets as opposed to older methods. The alleviation of number of inactive motes leads to transmit a great deal of packets to the main hub.

5. CONCLUSION

CTNR (Cluster to Normal Ratio) is considered to be an energy-aware protocol. This protocol can extend the operation period of a radio network to a significant time. The CTNR protocol has been extended by using gateway nodes. In the proposed protocol, the entire network will be divided into clusters. Distance and energy are the parameters for choosing cluster heads. Sensing devices with maximum power and located close to the base station are selected as CH. The rejected devices for the role of cluster heads will be selected as leader nodes on the basis of energy. Finally, gateway devices will be enforced in the set-up. The sensor nodes transmit info to the cluster head which will then be transmitted to the leader nodes and the leader nodes will transmit the information to the gateway device. The gateway node will deliver data to the base station. This work enforces formulated model in MATLAB and validates findings on the primes of number of live devices, inactive devices and packets delivered in the network. The results demonstrate an increase in active nodes as well as a significant decrease in inactive devices. Contrary to the existent methodology, the devised approach depicts a substantial improvement in the volume of packets delivered to the main hub.

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