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Routing Optimization with Load Balancing: an Energy Efficient Approach

S. Prabhavathi
Associate Professor, Dept of CSE, RYMEC Bellary, India
Email: prabkir@gmail.com
Dr. A. Subramanyam
Prof & Head Dept of CSE AITS Rajampet, India
Email: smarige@gmail.com
Dr. A. Ananda Rao
Prof. & Director Academic & Planning, JNTUA, Anantapur, India
Email: akepogu@gmail.com

ABSTRACT

The area of Wireless Sensor Network (WSN) is covered with considerable range of problems, where majority of research attempts were carried out to enhance the network lifetime of WSN. But very few of the studies have proved successful. This manuscript discusses about a structure for optimizing routing and load balancing that uses standard radio and energy model to perform energy optimization by introducing a novel routing agent. The routing agent is built within aggregator node and base station to perform self motivated reconfiguration in case of energy depletion. Compared with standard LEACH algorithm, the proposed technique has better energy efficiency within optimal data aggregation duration.

Keywords - **Wireless Sensor Network, Energy, Load balancing, Routing, Agent**

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I. INTRODUCTION

Wireless sensor network (WSN) is one of the area of commercial utilization for faster and effective communication without the presence of any infrastructures [1]. Generically, a wireless sensor network will consist of the huge quantity of electronic sensing motes with high radio frequency and base station, which characteristically act as a relative link with many other processing networks facilitating potential processing of data, location of storage, and an access point to the sensor motes in its network. Sensor motes sense its environment, gather the data sensed and transmit it to the base station. Unfortunately, the area of wireless sensor is also accompanied by various issues e.g. restriction of power, computational capability, and memory. Wireless sensor network can be deployed in various application right from military, biomedical, and environmental utilization [2]. It is very difficult to detect the route and retain it as the confined quantity of power and frequent alteration in the locus of the position of the sensor nodes gives rise much changes which are very dynamic and tough to forecast. Although there has been an extensive research work towards energy [3], [4], [5], [6], but still it has remain a major obstruction towards development of the effective routing algorithm in wireless sensor networks. One of the most discussed routing protocols in connection with the conservation of energy is LEACH routing protocol [7] [8] [9]. The topology of WSN is normally studied with respect to cluster formation in the network. It was also found that sensor node usually do not have enough energy for transmitting directly to the sink and therefore they take assistance of cluster head who gathers all the non-redundant data from sensor nodes and forward to sink. Therefore, consumption of energy for cluster head will be prime focus as if the cluster node is non-reliable and is not selected properly; the data transmission will inevitably fail. The literature explored that there are dual methods of selection of either cluster first or cluster leader first [10]. In the cluster first approach, the network selects the cluster formation initially and then cluster leader is selected whereas in leader first approach, cluster leader is selected first and then formation of the cluster takes place. Initially the sensor nodes are randomly deployed. Usually, the different sensor nodes are used in real times and therefore heterogeneous network is formulated with varied scales of energy retention. Usually, the sensor nodes which have highest score of residual energy are selected as cluster leader where the entire cluster leader formulated their personal communication range and thereby formulates clusters. The sensor nodes residing in each clusters transmits their gathered information and forward it to the cluster leader which in turn forward it to the sink. In majority of the networking situation, cluster leader was assumed to transmit the data directly to the sink located at a specified distance from the cluster leader. The phenomenon of clustering basically assists in diminishing the memory utilization of the routing table updates, preserves the communication channel capacity, enhances the cumulative lifetime of the network, and minimizes the chances of collection of redundant data [11].

The proposed study presents a schematic formulation of energy efficiency using routing agent that is aimed to perform an effective data aggregation in wireless sensor

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network. The prime aim of the study is to enhance the network lifetime towards the traffic load in the network. Section-2 discusses about the prior work being undertaken for the purpose of accomplishing energy efficiencies in WSN. Section-3 discusses about the problem identification of the study. Section-4 discuses about the evolution of the study followed by proposed model in section 5. Section 6 discusses about the implementation as well as accomplished outcome of the study. Finally Section 7 summarizes the work in brief.

II. RELATED WORK

This section discusses about the various approaches that have been proposed in the literature to minimize energy usage in WSN. Some of the prior study e.g. [12] shows that energy efficient route can be mechanized for enhancing the lifetime of network. This fact was preliminarily supported by the study conducted by Chang et al. [13]. The author exclusively highlighted that network lifetime tends to degrade if the routes are established among the nodes with less energy.

D-Haggerty et al [14] presented results from @scale; one of the largest deployment in terms of mote-years yet published. They were successful in achieving their science goals while testing several hypotheses about network dynamics, and reinforced emerging design practice on the construction of this type of network.

Gu et al [15] have investigated various sorts of trade-offs existing in the energy-aware concepts of WSN and presented a solution for it using task planning. The evaluation was performing using real-time sensors using their routing protocol. The outcome of the study shows prominent energy preservation over arbitrary synchronization managements.

Jang e.t. al [16] present an energy efficient MAC protocol for WSNs that avoids overhearing and reduces contention and delay by asynchronously scheduling the wakeup time of neighboring nodes.

Alwadi and Chetty [17] examined Isolet, ionosphere and forest cover type datasets from the UCI repository to emulate the wireless sensor network scenario. From their simulation results, they show that it is possible to achieve two important objectives using the proposed scheme: (1) Increase the lifetime of the wireless sensor network, by using optimal number of sensors, and (2) Manage sensor failures with optimal number of sensors without compromising the accuracy.

Rezaei and Mobininejad [18] focused of this article is primarily on duty cycling schemes which represent the most compatible technique for energy saving and they also focus on the data-driven approaches that can be used to improve the energy efficiency. Finally, they will make a review on some communication protocols proposed for sensor networks.

Zhao e.t. al [19] proposed a Medium-contention based Energy-efficient DIstributed Clustering (MEDIC) scheme, through which sensors self-organize themselves into energy-efficient clusters by bidding for cluster headship. although the proposed MEDIC uses only local information, it achieves better energy efficiency than native LEACH in terms of Data/Energy Ratio and an effective lifetime.

Liu et al. [20] presented a multiple path routing techniques for mobile adhoc network, where the authors emphasized on exploring the optimal residual energy of every communication channel in the continuous process of route establishment. Finally, the system arranges the routes in decreasing order based on remnant energy of the nodes. After new path is generated with higher remnant energy, the data packets are forwarded using that route. The best part of the system is that it maintained better equilibrium between sensor’s battery consumption and cumulative energy drainage. The outcome shows better accomplishment of enhancing cumulative network lifetime.

Sun et al [21] have presents a new technique that enhances the route selection technique for enhancing the detection capability of the statistical filtering. The system permits the sensor to determine the receiving energy for data packets from the sink and selects the best route for data transmission purpose.

Nikravan et al [22] have presents a technique that indirectly attempts to reduce the energy depletion using fuzzy logic. The system selects both energy factor as well as transmission rate for selecting the next immediate node for performing data aggregation process. The outcome of the study shows that proposed system furnishes optimal enhancement of packet delivery ratio as well as restores energy conservation even in care of dynamic wireless environment.

Shah et al. [23] have presented an energy aware routing protocol that keeps a set of minimal energy paths and randomly selects one of these sub-optimal paths, thereby significantly increasing the network lifetime.

Akojwar e.t. al [24] focuses on use of classification techniques using neural network to reduce the data traffic from the node and thereby reduce energy consumption. The paper discusses classification technique using ART1 neural network models. The classified sensor data is communicated over the network using two different cases of routing: cooperative routing and diffusion routing.

Razavi e.t. al [25] proposes fuzzy logic control (FLC) of automatic repeat request (ARQ) as a way of reconciling these factors, with a 40% saving in power in the worst channel conditions from economizing on transmissions when channel errors occur.

Begum et al. [26] have presented an optimization method for enhancing the phenomenon of energy conservation using swarm intelligence. The author has used ant colony optimization, where the outcome of the study minimization of searching duration with less computational complexities compared with conventional energy efficient algorithms in WSN.

Bogliolo e.t. al [27] discusses the main issues which prevent WSNs to fully exploit the idleness and presents a general power state model capturing the energy efficiency of a mote. VirtualSense motes are used as case study to characterize the proposed power state model and to illustrate its application.

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Fafoutis and Dragoni [28] presented an improved and xtended version of ODMAC and they analyze it by means of an analytical model that can approximate several performance metrics in an arbitrary network topology.

Kannadas and Daniel [29] proposed a Dynamic Conflict-free Query Scheduling (DCQS), a novel scheduling technique for queries in wireless sensor networks. In contrast to earlier Time Division Multiple Accesses (TDMA) designed for query services in wireless sensor networks.

Verma et al [30] presented a technique on energy efficiency in WSN using reliability study. The author has discussed their study considering the comparative analysis of conventional LEACH algorithm (LEACH-C). The outcome of the study shows better energy efficiency as compared to the conventional LEACH algorithm.

Dam and Langendoen [31] have presented MAC based solution for the purpose of establishing energy efficiency in WSN called as T-MAC. The formulation is based on active and sleep stage duty cycle. The author has discussed that applicability of T-MAC is quite high as it is highly insensitive to delay.

Xie e.t. al [32] investigated the operation of a sensor network under this new enabling energy transfer technology. They consider the scenario of a mobile charging vehicle periodically traveling inside the sensor network and charging each sensor node’s battery wirelessly.

Cammarano e.t. al [33] proposed Pro-Energy-VLT, an enhancement of the Pro-Energy prediction algorithm that improves the accuracy of energy predictions, while reducing its memory and energy overhead.

Lakshmi [34] proposes novel energy efficient algorithm Fuzzy Dynamic Power Control Algorithm for Wireless Sensor Networks.

Although it can be seen that there are huge blocks of research work being done in the field of routing issues related to power consumption in wireless sensor network using Fuzzy Logic. But every approach has yielded enhancement in the performance using Fuzzy only 50%, whereas we have achieved around 80% in performance efficiency using dual level of fuzzy inference system.

Therefore, it can be seen that majority of the prior research work has been focused on distance between the cluster leader and the sensor motes which ignore majority of the other parameters which influences the power draining and maximizing the network lifetime.

Understanding the research gap from the review of the prior research work, the current research work considers tri-factors e.g. magnitude of remoteness between the cluster leader and the sensor motes, Euclidean’s distance between the cluster leader, and finally the power factor of the cluster leader.

III. PROBLEM IDENTIFICATION

Organizing sensor networks into clustered architectures has been extensively explored over the previous couple of years, leading to the surfacing of an excellent variety of tasks-specific clustering protocols in WSN. Clustering is a cost-effective approach for information aggregation within the WSN. Every sensor node within the network sends information to the aggregator node, meaning the cluster leader, then the cluster leader performs the aggregation method on the received information and sends it to the bottom station. However, performing the aggregation operation over the cluster leader causes the vital energy drains. In case of a homogeneous type of WSN, the cluster head can soon die out, and once more re-clustering should be done, which once more causes energy consumption. In this study, the focus is placed on designing a protocol that can extract information for data dissemination within the range of clusters. The termination of the old clustering technique and the design of a new clustering technique will be highly avoided to maintain algorithm efficiency.

The behavior of power utilization in WSN is one of the most challenging areas in this field, as it is never possible to attain the ideal solution in terms of power preservation. However, a couple of research works [35] were carried out in the field of control systems, as was a study on the electrical impulse to the core computing system. It was also seen that the types of WSN will totally depend on the resource-constrained sensor motes accumulate information from the physical environment. Power preservation is known to be one of the most critical concerns in the majority of the research work. To analyze the reason for the unwanted draining of power from the sensor motes, it is important to understand its root cause. The existence of the cluster leader is one of the most significant phenomena of effective communication. All the other nodes communicate to the cluster leader, which will transmit data to the defined base station. Therefore, an efficient selection procedure is required to maintain power efficiency. The cluster should be formed in the best way possible to ensure that power is utilized in a reasonable manner for a power-proficient process. Generically, every process of the cluster formation on the WSN is classified into various rounds, where every round is developed by the election of the cluster leader, the formation of the cluster, and the transmission of the data. The cumulative lifetime of the network is the quantity of the rounds in which all the sensor motes will have certain power retained. Certain prominent groups of researchers have concentrated on the selection process of the cluster leader [36]. However, the focus of the current study is more on analyzing the LEACH protocol [37], where every sensor mote decides which cluster it belongs to by selecting the cluster leader that requires the minimum power for radio transmission.

It is already known that the majority of WSN applications require a longer network lifetime. In various types of WSN applications, nodes are deployed to the location where it is very tough to replace the defective or dead node. The amount of energy allocated in the sensor node is actually very limited, which further drains out at every communication even in an inactive phase. Hence, a clustering technique can be introduced in which all the sensor nodes can directly communicate with the cluster leader, which in turn can gather the data from all the sensor nodes and forward to the assigned base station.

Hence, the role of the cluster leader is very essential in terms of communication in WSN.

Along with energy, routing and load balancing is another parameters that also requires significant attention for designing optimization solution in wireless sensor network. From the literatures, the existing geographic routing is found with various challenges. The theoretical study of geographic routing protocol has better packet delivery ratio which doesn't matches with the radio network [38]. The consideration in such routing schema uses a communication range that is highly dependent on the environment causing failures to planarization [39]. Another prominent protocol called as Cross-Link Detection Protocol proposed by Kim et al. [40] is found to work effectively in practical environment but is highly expensive from exploring single link multiple times. Two factors of load balancing techniques with respect to optimization was ignored much viz. data aggregation duration and energy consumption. The data aggregation duration is very often estimate from the time taken by the physically sensed aggregated data by the aggregator node to the base station. However, possibly, if a new model is design that aims to enhance the data aggregation by introducing a new module within aggregator node and base station need to be involved while estimating data aggregation time. This types of evaluation will show effectiveness of the proposed module with respect to energy optimization as well as load balancing, which is missing in the literatures. Hence, the proposed system aims to overcome such issues.

IV. EVOLUTION OF THE STUDY

This section will illustrate the evolution of our previous work pertaining to techniques adopted for mitigating the problems in wireless sensor network. With a list of problems existing in the area of wireless sensor network, the current study is focused on energy efficiency for the purpose of disseminating the data to the sink in wireless sensor network. The primary objectives of the study as formulated by the researchers are mainly three fold e.g. i) *Objective-1*: To accomplish the energy optimization and load balancing at different levels of clustering, ii) *Objective-2:* To design a framework for dynamically reconfiguring the new routing agents as the designated routing agents exhaust their energy, and iii) *Objective-3:* when the node moves from one to another cluster, the periodical registration update could be omitted for saving the unnecessary overhead. The previous study has introduced a novel protocol named Enhancing Network Lifetime Using Probabilistic Logic (ENLPL) [41], which deploys a hierarchical clustering technique to maximize the cumulative lifetime of the electronic sensor motes in wireless sensor networks. Compared with standard LEACH protocol, ENLPL has witnessed successful energy optimization as evident from the increased alive nodes in successive iteration, greater extent of residual energy, and normalized power variance. However, the study didn't focus much on load balancing issues as it is totally concentrating on mitigation of energy issues and thereby optimize it. The problem of load balancing issues in the mobility scenario is addressed in the second work of the researcher [42]. This study has introduced a novel globular topology of WSN that ensures an efficient task allocation strategy in large-scale WSN architecture. The performance of the data aggregation process is further increased by considering the presence of multiple mobile sink that adds an exponential benefit to the task allocation policy proposed in the second study. Therefore, when the nodes moves from one region of one cluster to another region of different cluster, the information renewable process continues for updating the routing until the data packets reaches its destination point (sink). Different from conventional schemes found in literature, the scheme discussed in [42] performs endeavors to collect the information and then the information gather will be transmitted to the sink. Receiving these update packets by mobile sink nodes in basic region means that all task allocation policies are periodically updated and posses a capability by responding to any queries. Hence, it can be seen that study discussed in [41] accomplishes the objective-1 while study discussed in [42] accomplishes mainly objective-3. Objective-2 is only accomplished to minor extent; however, most robust technique is required with support of data aggregation model in wireless sensor network for performing reconfigurable operation for the exhausted routing agents to further optimize the network lifetime. Hence, the proposed study discusses about certain formulated technique that will attempt to further optimize the cumulative network lifetime by exploring the efficient energy for the purpose of disseminating the data to the sink of wireless sensor network. It is expected that proposed study will accomplish better energy aware network structure that could be deployed for large scale wireless sensor network in future.

V. PROPOSED MODEL

The proposed model introduces a novel model that can perform dynamic reconfiguration of the new routing agents as the designated routing agents depletes their residual energy to a large extent in the process of data aggregation. However, the primary goal of the study will be to accomplish much better energy efficiency while disseminating the data from the sensors to the sink in wireless sensor network. The adoption of the routing agent in the current study is motivated by the work discussed by Shakshuki et al. [43]. According to Shakshuki et al. [43], the term 'routing agent' is a critical module that has the capability to perform communication with all the sensor nodes in the wireless environment. The routing agent is built within aggregator node and base station[47].The routing agent is also responsible for assigning the cluster leader and evaluates their decision making strategies for energy efficient routing in wireless sensor network. In the current work, a novel technique will be introduced that will incorporate the capabilities of an agent to explore the energy efficiency. The block diagram of the study is as follow in Figure 1:

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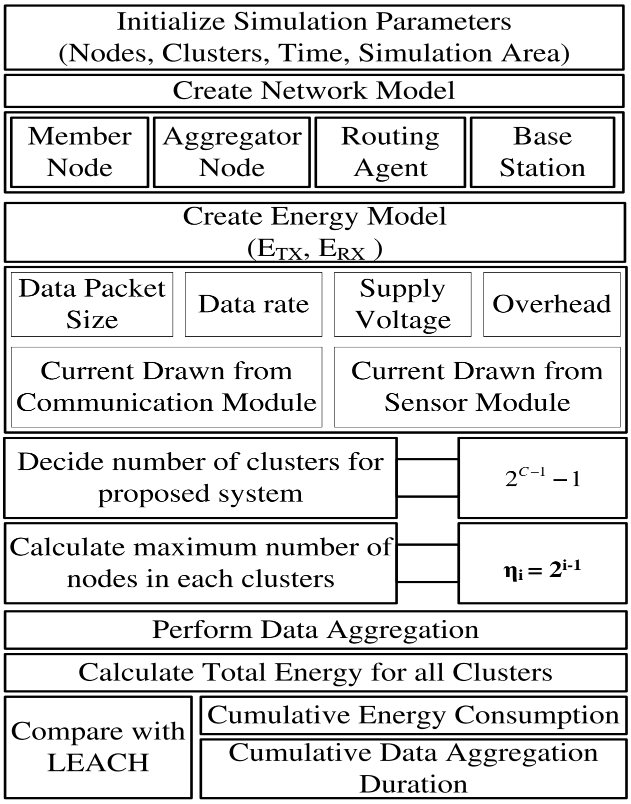

Figure 1 Block Diagram of the Proposed Study

The proposed study formulates a routing agent using graph theory that ensures energy efficient data aggregation technique within less duration and more computational capability. The proposed system discusses about the agent based routing structure where the nodes are managed into numerous unit stratum cluster of multiple size for the purpose that cluster can communicate with the routing agent. Consider a WSN topology, considering C as a cluster with N_{sen} as total number of sensor nodes.

$$\sum_{i=1}^{C-1}\eta_i < N_{sen} \le \sum_{i=1}^{C}\eta_i \qquad (1)$$

In the above equation, η is acting as the highest number of the sensor node in the i^{th} cluster that can be represented in the form of geometric progression as follows:

$$\eta_i = 2^{i-1} \qquad (2)$$

Therefore, substituting the value of i = 1, 2, 3, ….., it can be seen that the ηi will generate the values of 1, 2, 4, 8 etc as a geometric progression. Therefore, eq.(1) can be amended as below,

$$2^{C-1}-1 < N_{sen} \le 2^{C}-1 \qquad (3)$$

It is quite evident that a smaller dimension of the cluster size can reduce the process of data dissemination technique. Therefore, the proposed system considers the C^{th} cluster (last cluster) to be the ultimate member to perform communication with the routing agent. Hence, during the cluster formation phase, the members are allocated to $(C-1)^{th}$ clusters initially coming down to C^{th} cluster for member node allocations within that cluster. The system considers the time period of the cumulative data aggregation to be lower bound by the total number of sensor nodes. Considering a topology with eq.(3), it can be seen that the initial (C-1) clusters are completely filled with the member nodes and needs a following cumulative timeslot for forwarding all the aggregated data to routing agent as,

$$\sum_{i=1}^{C}\eta_i = 2^{C-1}-1 \qquad (4)$$

And the last cluster (C^{th} cluster) is allocated with N_{sen}-2^{C-1} member nodes. Which means that the aggregator node will consume time period of (2^{C-1}-1) to aggregate the physical data and (N_{sen}-2^{C-1}+1) time period to forward the data to the routing agent. Therefore the complete time period (T_p) to perform data aggregation can be represented as

$$T_P(N_{sen}) = (2^{C-1}-1) + (N_{sen}-2^{C-1}+1) = N_{sen}\ (max) \qquad (5)$$

It should be noted that cluster size is highly dependable factor for the evaluation of the time period (T_p). Hence, the study formulates a condition of T_p as when C^{th} cluster can establish transmission with the routing agent only when $(C-1)^{th}$ cluster is done with communication. Therefore, T_p can be now represented as,

$$T_p = \sum_{j=1}^{\max}[\overline{T_p}(2^{C-1}-1), N_{sen}-2^{C-1}]^j + R^{N_{sen}-2^{C-1}} + \sum_{j=1}^{N_{sen}-2^{C-1}} R^j \qquad (6)$$

In the above eq.(6), $\overline{T_p}(2^{C-1}-1)$ is considered as cumulative time period by the initial (C-1) clusters for aggregating the data from their member nodes and transmit the aggregated data to the routing agent. It can also be seen that all these (C-1) clusters are cumulatively allocated and so

$$\overline{T_p}(2^{C-1}-1) = \overline{T_p}(\eta_{C-1}-1) = \eta_{C-1}-1+[R^{\eta_{C-1}-1} + \sum_{p=1}^{\eta_{C-1}-1} R^p \qquad (7)$$

As the formulation of the current study is the critical implementation aiming at energy efficiency, hence better standards are considered to evaluate the effectiveness of the model. The proposed study considers the similar radio and energy model that has been used in LEACH algorithm. The justification behind this logic is that although there were various formulations of design, algorithms, and mathematical model in the past that has totally focused on solving the energy issue in order to maximize the lifetime of the WSN. However, very few of the prior work have received recognition. Out of the majority of the work introduced in the past, LEACH is considered as highly standard and benchmarked formulation till data. May be this is one of the reason, why 97% of the outcome of the existing research work focusing on energy issues is compared with LEACH algorithm. Although there are various versions of LEACH algorithm, but major research communities has selected LEACH model as the standard work because of the design of the radio model and energy model. Various components that maps with the physical entities in the sensor mote is considered in the LEACH protocol. However, various studies also proved that LEACH is not the appropriate protocol to mitigate the energy issues. As the study is

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considering the radio and energy model that has been used in LEACH algorithm so it is important to say that the study will need to consider the loss of energy due to channel transmission. As radio can perform energy management of a sensor node so it will tend to use the minimized energy value to reach the intended destination (that may be some intermediate node or other cluster head or base station). Considering the wireless environment, there is a possibility of signal attenuation with the distance; hence one energy loss model can be mechanized for relatively short distance and other for relatively long distance. Therefore, using the standard radio and energy model [44], the depletion of energy by the radio model in transmitting l bits of data over a distance d can be represented by,

$$E_{TX}(l, d) = l \,.\, E_{elec} + l.\epsilon_{FS}.d^2, \text{ if } d < d_o$$
$$= l.\, E_{elec} + l.\, \epsilon_{TR}.d^4, \text{ if } d > d_o \quad (8)$$

In the above equation E_{elec} is the energy depleted per bit to operate the transmitter or the receiver circuit. ϵ_{FS} and ϵ_{TR} are the constant and is highly dependent on the transmitter amplifier model that is considered in the study and d_o is the threshold transmission distance that is represented as,

$$d_o = \sqrt{\frac{\varepsilon_{FS}}{\varepsilon_{TR}}} \quad (9)$$

The energy consumption on the receiver end to obtain l bits of the data can be represented as $E_{RX}(l) = l.\, E_{elec.}$ The data aggregation framework in this part of the study assumes that the aggregator node would process (*n/2*). *l* bits of the data at the end of one frame, where *n* represents number of aggregator node. The study also considers the energy cost for performing data aggregator that is initialized as E_{DA}=4nJ/bit. Considering the standard energy model as exhibited in eq.(8), the present network of $2^{C-1}-1<N\leq 2^C-1$ sensor nodes will be allocated in *C* clusters. Hence, the total energy consumption can be represented as following,

$$E_o = \sum_{i=1}^{C-1}\sum_{p=1}^{\eta_i-1}[E_{TX}.d_{pi} + E_{RX}] + \sum_{p=1}^{\eta_C-1}[E_{TX}.d_{pc} + E_{RX}]$$
$$+\sum_{i=1}^{C-1}\eta_i.E_{TX}.d_{iRA} + \eta_C.E_{TX}.d_{cRA} \quad (10)$$

In the above equation, d_{ji} is the distance between the j^{th} member nodes to i^{th} aggregator nodes; d_{jk} is the distance between j^{th} member node and c^{th} aggregator node. While d_{iRA} is the distance between the i^{th} aggregator node to route agent and d_{cRA} is the distance between c^{th} aggregator node and route agent. In the above eq.(10). The first two components are associated with energy depletion due to internal transmission and reception within a cluster while the last two components are associated with transmission activity from aggregator node to the routing agent. Therefore, considering the highest value for the E_{TX}, eq.(10) is now amended as follows,

$$E_o^h = \sum_{i=1}^{C-1}(\eta_i - 1)[E_{TX}^h + E_{RX}] + (\eta_i - 1)[E_{TX}^h + E_{RX}]$$
$$+\sum_{i=1}^{C-1}\eta_i.E_{TX}^h + \eta_i E_{TX}^h \quad (11)$$

Normalizing the above equation becomes,

$$E_o^h = \sum_{i=1}^{C-1}(\eta_i - 1)[E_{TX}^h + E_{RX}] + (\eta_i - 1)[E_{TX}^h + E_{RX}]$$
$$+\sum_{i=1}^{C-1}(R^{\eta_i-1} + \sum_{p=1}^{\eta_i-1}R^p).E_{TX}^h + (R^{\eta_i-1} + \sum_{p=1}^{\eta_i-1}R^p)E_{TX}^h$$
(12)

The current study basically introduces routing agent as a auxiliary node for the purpose of optimizing the energy depletion factor in wireless sensor network and in order to do so the transmission distance of the current network management should be reduced. Hence, in order to carry out optimization, following techniques were adopted. The network is decided in the considered topology with $2^{C-1}-1<N_{sen}\leq 2^C-1$ sensor nodes. Then the system sorts the sensor nodes as per the residual energy in decreasing order and stored in a matrix of the form $M=[M_1, M_2, \ldots, M_{Nsen}]$ so that residual energy of M_1 is more than that of M_2 and continues. The system than chooses C elements in matrix M as the aggregator node. The transmission distance between the aggregator node and the member nodes are optimized using the following,

$$\min \sum_{i=1}^{C}\sum_{p=C+1}^{N_{sen}} I_{ip}.d_{ip}^2 \quad (13)$$

With a condition that

$$\sum_{p=1}^{C} I_{ip} = 1, \forall i \in [C+1,\ldots,N_{sen}] \quad (14)$$

$$\sum_{i=C+1}^{N_{sen}} I_{ip} = \eta_{C-p+1} - 1, \forall p \in [1,\ldots,C-1] \quad (15)$$

$$\sum_{i=C+1}^{N_{sen}} I_{ip} \leq \eta_c \quad (16)$$

In the above conditions, d_{ip} is the relative distance between the sensor node M_i and M_p, I_{ip} is the deployed indicator to exhibit the established communication between M_i and M_p. The aggregation of the physical data from the member is done by aggregator node and sends the notification of the aggregated data to the routing agent. It is already known that aggregator node consumes relatively higher energy as compared to member nodes in the process of data aggregation. Therefore, the optimization process in this study basically allocates the nodes with maximum

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residual energy to be aggregator node. However deploying eq(13) with its specified condition will enable the reduction of the transmission distance among every aggregator node and member nodes in the simulation environment. Eq.(13)(14), and (15) discusses about the constraints that need to be satisfied by I_{ip} of eq.(13). The condition specified in eq(13) ensures that all the member nodes are connected to only one aggregator node, while the condition specified in eq(14) and (15) ensures that the C^{th} cluster is the ultimate cluster to be allocated by respective member nodes.

VI. IMPLEMENTATION & RESULTS

The implementation of the proposed research work is done on Windows 32-bit OS with 1.84 GHz dual core processor considering MATLAB as programming language. The proposed work is experiment on a simulation area of 100 x 100 m^2. We have considered a various scenarios with 100 nodes with arbitrary distribution. The preliminary power of sensor motes is initialized at 0.1 Joules with 100 rounds. The proposed system is compared to frequently used LEACH [44] protocol. The network simulation parameters considered are as shown below in table 3.

Table 3 Simulation Parameters

Total Number of Nodes	100
Size of network	100 x 100 m^2
Position of BS	(60,150) m
Preliminary Energy Initialization	0.1J
Feasibility of CL election	0.5
Size of packet	6500 bits

The current framework considers that all the cumulative energy depletion are happening overheads as well as due to spontaneous receiving and transmitting of physical data. Another fact is different hardware components of a sensor node consumes different rate of energy. As a property of sleep scheduling algorithm [45], whenever a sensor node is in inactive stage, it will preserve the energy consumption of the different hardware components in a sensor node. Therefore, the energy depletion in the inactive stage of i^{th} node can be represented as,

$$E_{inactive} = \delta_i \rho (\gamma_1 + \gamma_2 + \gamma_3) \quad (17)$$

In the above equation (17), δ_i is the time period of the inactive stage of i^{th} sensor node, ρ is the amount of the potential difference, while $\gamma_1, \gamma_2,$ and γ_3 are current drained by transmission, processing, and the amount of current in inactive stage (i.e. even in inactive stage, a sensors draws some amount of energy) respectively. The routing agent introduced in the model thereby ensures that the framework dynamically reconfigures the all the nodes if any node is found in the verge of energy depletion. In the data packet transmitting stage, a sensor node will always turn on its radio model thereby performing computation. Hence, the transmittance energy for a sensor node in this model with its final threshold energy E^{TH} in the maximum of *Max* level can be expressed as,

$$E_{TX}^{TH}(Max) = E_1(Max) + \delta_i \rho(\gamma_1(Max) + \gamma_2 + \gamma_3) \quad (18)$$

In the above equation, $E_1(Max)$ is considered as cumulative overhead power depletion in the processing stage while switching to and from transmission to receiving stage, $\gamma_1(Max)$ is the total current required to perform communication when the node is transmitting with its defined final threshold energy at the Max^{th} level and γ_2 is the amount of the current required in the active stage. Similarly, the energy E_{RX} drained by the prime sensor node to receive the data packet from the member nodes is represented as,

$$E_{RX} = E_{RX\_1} + \delta_i \rho(\gamma_1 + \gamma_2 + \gamma_3) \quad (19)$$

In the above eq (19), E_{RX_1} is the cumulative overhead energy drained by the communication and frequent toggling of active and inactive state of the sensor nodes. Similarly, the energy required for processing the data can be represented by,

$$E_{PRO} = E_{PRO\_1} + \delta_i \rho(\gamma_1 + \gamma_2 + \gamma_3)$$

Where E_{PRO_1} is the cumulative energy consumed due to overhead occurred by frequent toggling of active and inactive state of the sensor nodes. The parameters are selected based on MEMSIC nodes [46]

The result evaluation of the study is classified into multiple unit stratum groups or clusters. It is already know that networks deployed using LEACH principles have uniform cluster nodes to total number of nodes in many cases. Therefore, the simulation is being studied considering two parameters mainly i.e. energy consumption and total time of data aggregation. Both the above performance evaluation parameters are also evaluated with respect to three different values of compression ratio i.e. when compression ratio is 0.5, 0.75, and 1 respectively. Figure 1 represents the total energy consumption in joules when compression ratio is initialized to 0.5 and the simulation is done considering 100 nodes. The outcome highlights that energy consumption of proposed system is less as compared to LEACH protocol. In the next phase as exhibited in Fig.3-4, when the compression ratio is increased to 0.75 to 1, s similar trend is observed which shows that proposed system has better energy conservation as compared to standard LEACH protocol with increased compression ratio. One of the basic reason behind this is the proposed tree based approach which don't allow the aggregator node to send the data directly to the base station, but creates a better hoping strategy thereby mitigating the enough traffic load using the new module of routing agent. Hence, if in the duration of data aggregation, if the aggregator node is about to die off, the routing agent performs selection of new aggregator node even before the old aggregator a node dies off. In this manner, the cumulative network's energy is highly preserved by dynamically reconfiguring the new routing agents when the previous routing agent is about to die off. The system therefore ensures better energy optimization along with

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better balancing traffic load using the novel schema of routing agents introduced in the current study.

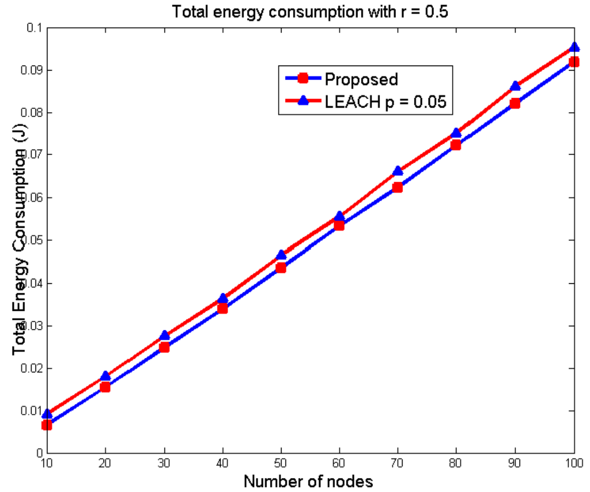

Figure 2 Total Energy Consumption at CR=0.5

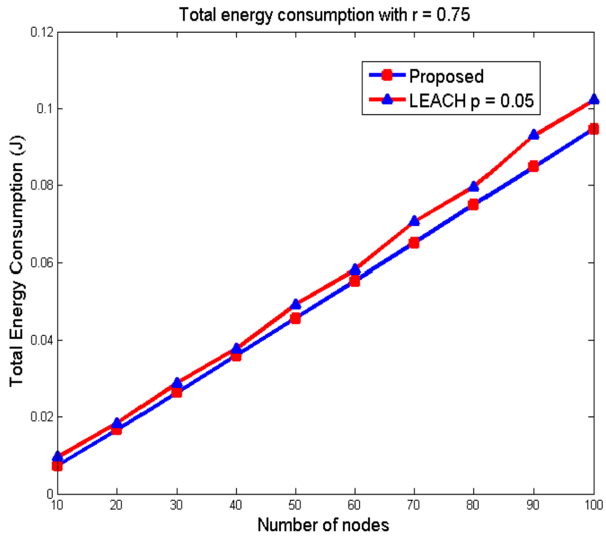

Figure 3 Total Energy Consumption at CR=0.75

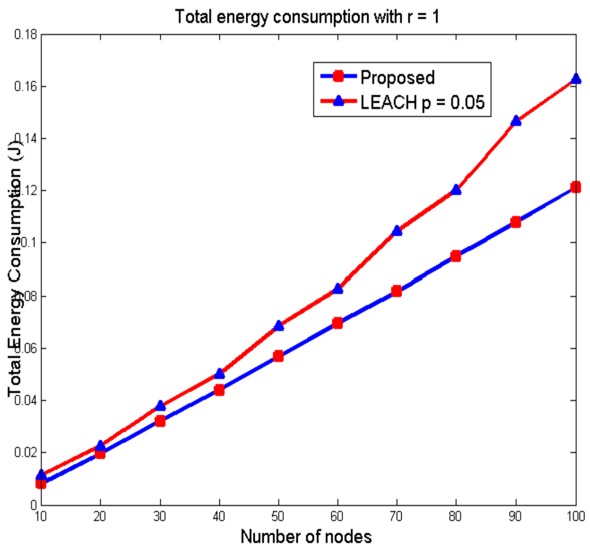

Figure 4 Total Energy Consumption at CR=1

The performance evaluation of the current study is cumulative data aggregation time. In this evaluation phase, each simulation is studied by varying the value of compression ratio to 0.5, 0.75, and 1. Fig.5 shows that cumulative data aggregation duration for proposed system is higher compared to LEACH at compression ratio 0.5. This increased dimension of the duration for the proposed system is basically due to the initial routing stage that attempts to perform preliminary communication within various clusters after performing data aggregation. The prime reason here is although the system might experience a bit high delay in the preliminary rounds, but the delays will be highly minimized in the consecutive cycle of data aggregation. However, when the compression ratio is increased to 0.75 from 0.5, the system is witnessed with increasing linearity in curves with increasing number of sensor nodes. Hence, the data aggregation time for proposed system is now found to be minimized as compared to preliminary outcome when compression ratio was 0.5.

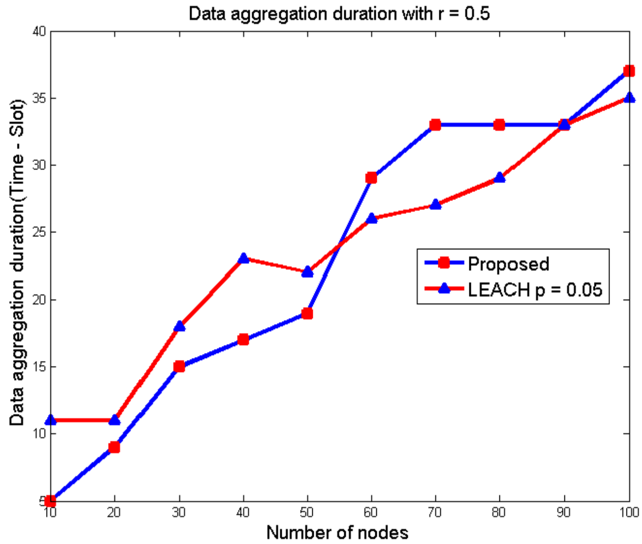

Figure 5 Total Data Aggregation Time at CR=0.5

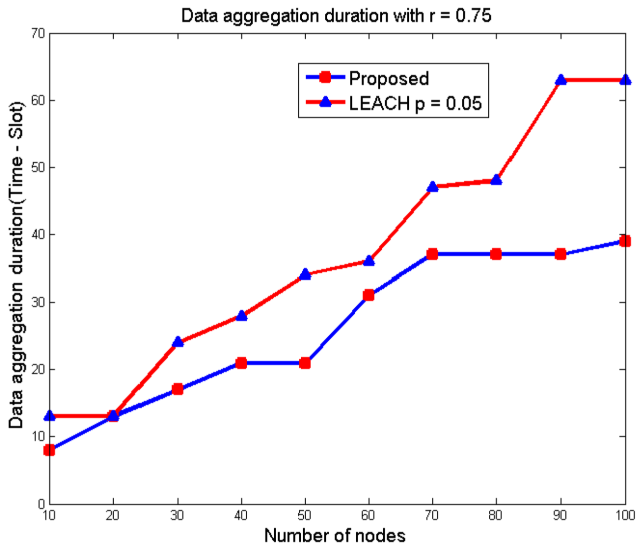

Figure 6 Total Data Aggregation Time at CR=0.75

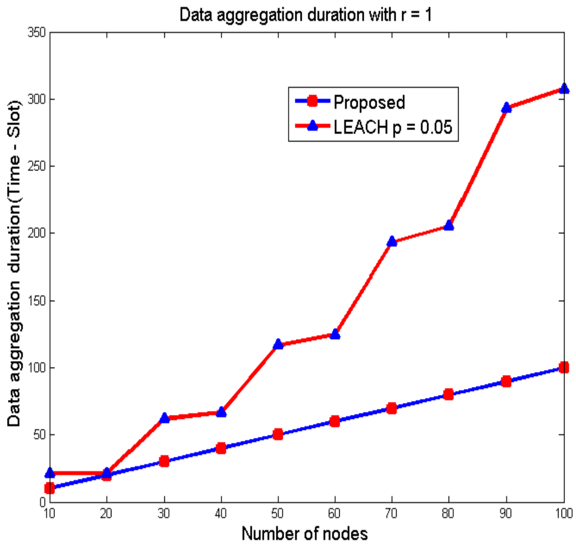

Figure 7 Total Data Aggregation Time at CR=1

A closer look into the curves in Fig.6 shows that data aggregation duration for both LEACH as well as proposed system exponentially differs with respect to performance as the current study provides a better routing schema that can direct its packets, minimizing its redundancies, and routing them in proper direction (either base station or next hop) using routing agents. Moreover, due to higher level of sustenance (owing to better energy conservation), the algorithm can perform thrice times better than LEACH in minimizing the duration of data aggregation. As the system is designed based on the radio and energy model using multiple layer grouping of nodes, the accomplished outcome is therefore easy to measure and hence scalable. With the increasing number of nodes, the number of cluster will possibly increases, however, it is still not found with any significant effect in the data aggregation duration. The outcome shows that data aggregation duration of the proposed system is exponentially minimized to larger extent as compared to the standard LEACH protocol.

VII. CONCLUSION

The proposed system highlights a novel energy aware routing protocol and load balancing scheme by introducing a module called as routing agent for the purpose of accomplishing energy efficiency. The prime task of a new agent is to collect the aggregate data to the base station. The simulation result analysis is bench marked for optimal throughput considering the power retention process in WSN. The simulation result shows that the proposed network has complete utilization of energy optimization to minimize data duration time. The implemented algorithm is compared with standard LEACH protocol is highly satisfactory.

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S. Prabhavathi received her B.E degree in Electronics & Communication Engineering from Gulbarga University, Karanataka, India, her M.S degree in Electronics & Control from BITS Pillani, Rajasthan, and her M. Tech degree in Computer Network Engineering from VTU Belgaum University, Karnataka. She is now pursuing her PhD degree at JNTU Ananthapur University, Andhra Pradesh. Her research interests include wireless sensor networks, especially the clustering techniques in wireless sensor networks. She is currently working as Associate Professor in the Department of Computer Science Engineering of Rao Bhadur Y Mahabaleshwarappa Engineering College, Bellary, Karnataka.

Dr. A. Subramanyam received his Ph.D. degree in Computer Science and Engineering from JNTU College of Engineering, Anantapur. He obtained his B.E. (ECE) from the University of Madras and his M. Tech.(CSE) from Visweswaraiah Technological University. He has 18 years of experience in teaching. He is currently working as Professor & HOD in the Department of Computer Science and Engineering of Annamacharya Institute of Technology & Sciences, Rajampet, Y.S.R. Dist. A.P. He has presented and published 25 papers in international and national conferences and journals. He is guiding a few PhDs. His research areas of interest are parallel processing, computer networks, network security, and data mining

Dr. Ananda Rao Akepogu received his B. Tech degree in Computer Science & Engineering from the University of Hyderabad, Andhra Pradesh, India, and his M. Tech degree in A.I & Robotics from the University of Hyderabad, Andhra Pradesh, India. He received his PhD degree from the Indian Institute of Technology Madras, Chennai, India. He is Professor of Computer Science & Engineering Department and is currently working as Director Academic & Planning in Jawaharlal Nehru Technological University, Andhra Pradesh, Anantapur, India. Dr. Rao has published more than 100 papers in various national and international journals/conferences. He received the Best Research Paper award for the paper titled "An Approach to Test Case Design for Cost Effective Software Testing" in an International Conference on Software Engineering held at Hong Kong, 18-20 March 2009. He also received the Best Educationist Award for outstanding achievements in the field of education from the International Institute of Education & Management, New Delhi, on 21st Jan. 2012. He was conferred the Bharat Vidya Shiromani Award by the Indian Solidarity Council and the Rashtriya Vidya Gaurav Gold Medal Award by the International Institute of Education & Management, New Delhi on 19th March, 2012. His main research interests include software engineering, networking and data mining.