International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

Load Balanced Energy Efficient Cluster-chain Based Hybrid Protocol for Wireless Sensor Networks

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Abstract: ***In this paper a novel geographical multilayer protocol named Cluster-chain Based Hybrid (CCBH) Protocol is proposed for proper load balancing across the network that enhance the network lifespan and eliminate the energy holes problem. The CCBH protocol divides the network into the multilayer square structure around the sink. Each layer is divided into to the zones in such a way that the zones near to the sink are smaller in size and size of zones increases as the separation from the sink increases. In inner two layers, each zone has a cluster head (CH) and to reduce the load of CH a leader node (LN) is assigned in every zone. LN collects and aggregates the data received from neighboring nodes and sends it to the associated CH. Outer layer zones are larger in size. To reduce the clustering overhead chain strategy is introduced in outer layer zones that ensure lesser energy consumption as compared to clustering. Multi hop communiqué is used, where data is transferred from upper zone's CH to immediate lower zone's CH until it reaches to the sink. Simulated tests demonstrate that proposed CCBH protocol shows evident improvement in terms of the network lifetime as compare to LBCN, LEACH, TCAC, and DSBCA protocols.***

Keywords: Wireless sensor network (WSN), Load balancing, Energy efficient protocols (EEP), Cluster head (CH), Leader node (LN), Network lifetime

I. INTRODUCTION

The wireless sensor networks (WSNs) comprise of distributed nodes where nodes are arranged in a cooperative manner. In recent years, WSNs become very popular due to its potential use in various applications [1]. A sensor node has the capability of monitoring physical and environmental parameters like temperature, vibration, pressure, light, heat, sound, motion, moisture and pollutants etc., process it and cooperatively sends data through the network to sink or base station (BS). Sink and base station terms are utilized conversely during proposed work. A node has limited energy, storage, and processing capabilities, but out of these constraints, energy limitations and its allied issues are most noteworthy [2]. Thus, energy limitation issue and its apprehensions are very essential for designing a routing protocol [3]. Generally, sensor nodes are positioned in a harsh and inaccessible location; recharging or replacing of the batteries is an onerous task [4]. Main tasks perform by the node are sensing, data aggregation and data transmission, out of these tasks energy consumption in data transmission is uppermost that relies upon the distance from the nodes to sink. If the sink is placed distant from monitoring area, then the communication distance between nodes and sink increases and nodes devour more energy to forward data to the sink [5]. Thus, the battery of nodes will drain out quickly, which leads to early death of nodes and thus reduce the network life. If the BS is situated near to the sensing area, the result is low energy dissipation for sensor nodes; hence this increases the network life [6]. The energy efficiency from node to network level design is a major issue. Therefore the prime issue for designing the hardware architectures, protocols and algorithms should be energy efficiency in wireless sensor networks [7].

In WSNs, often energy consumption in communication is higher than computation and processing of data. Routing phase in WSN consumes a substantial amount of energy. Therefore, many researchers proposed routing protocol to save the energy of nodes during the routing phase that considerably enhance the network lifespan. Due to the high node density and limited communication range of nodes, multi-hop data forwarding technique is used for sending data to the destination [8]. As node performs several tasks such as sensing of environmental or physical quantities, transmitting data to other nodes, receiving data from other nodes and data aggregation to reduce the information overhead that offer a suitable set of information to end user [9], therefore nodes dissipate its energy over the time in the network. In WSN, enhancing network lifetime is very important which means extending the node's battery lifetime or to improve the network survivability. The selection of a proper energy efficient protocol is a critical issue in network design. There are several techniques for energy efficient routing and most known technique is call packing. In this technique, new calls are routed on the heavily-loaded links instead of lightly-loaded links. The benefit of this technique is that it favors the calls having high bandwidth, on the other hand the major disadvantage is that it completely call-up some links, this affect the network connectivity.

Manuscript published on 30 September 2019

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The second technique is minimum hop in which new call routes on a path having minimum-hop that improves the energy efficiency. Minimum-hop technique plays a valuable role to make the network energy efficient, especially in the traditional networks. A third technique known as load-balancing technique is very useful for almost all topologies. It tries to distribute the entire load evenly among all the links. According to this technique, new calls are routed on the links having a lightly-loaded instead of heavily- loaded nodes. The load-balancing technique demonstrations improved performance as compared to call packing and minimum-hop technique for all network topologies [10].

Clustering is a noticeable technique to enrich the network lifespan that involves the grouping of nodes and these groups are known as clusters and a leader node named cluster head (CH) is selected in each cluster. In a cluster, non-cluster head nodes are known as member nodes (MNs) or ordinary nodes. The role of CH is to accumulate the data from all nodes of the respective cluster, then aggregate the data and send it to the BS through single-hop or multi-hop mechanism [9]. Data aggregation is used to enrich the common signal and also reduce the amount of uncorrelated noise that minimizes the data sent to the BS; this significantly diminishes the communication cost [11]. The overall energy consumption of the whole network is a sum of energy disbursed by nodes to sense the data and to send this data to a central location such as the BS. If the sensor node is acting as a CH, the total energy dissipation is the sum energy consumed to sense the data, to collect data from MNs, to aggregate the collected data and to send it to BS. Thus, energy dissipation of CH node is higher than the ordinary nodes [12]. The cluster size and cluster density are two main attributes that determine the energy efficiency of hierarchical-based routing protocols. Clustering based routing protocol encompasses two groups in term of cluster size, one is equal size clustering and another is unequal size clustering protocol. Size of all clusters in equal clustering is same and size of cluster varies in unequal size clustering protocol. Unequal size clustering protocol generally used to balance the load across the nodes and to alleviate the energy holes. Cluster density represents the count of nodes within a cluster that affects the rate of energy dissipation of CH. Clustering may be static or dynamic, in the static clustering the node density is fixed, on the other side there is variation in cluster density in the case of dynamic clustering. An efficient routing protocol should have an optimum cluster size and cluster density [13]. Apart from this inter-cluster and intra-cluster routing play a significant role to balance the load that improves the network lifespan [14].

This paper presents a geographical multilayer protocol entitled Cluster-chain Based Hybrid (CCBH) Protocol for proper load balancing across the nodes that enhance the network lifespan and eliminate the energy hole problem. The entire observing area is split into zones. The nodes in each zone form a cluster. Apart from the cluster head (CH), a leader node (LN) is introduced to reduce the traffic load of CH. A chain based routing is implemented in the outer layer of observing area that significantly reduces the communiqué cost and link delay. Simulated tests exhibit that proposed CCBH protocol shows evident enhancement in terms of the network lifetime as compared to existing protocols.

The remaining part of this paper is arranged in such a way that Section II presents the related work to our proposed protocol. Section III depicts the bottlenecks of traditional work that act as an inspiration to develop the proposed CCBH protocol. Section IV and V describe the contribution of CCBH protocol and energy model employed respectively. Section VI designates the key network operations such as, network's area division, cluster formation along with CH selection, LN selection and chain formation in the outer layer of the monitoring area. Section VII presents the simulation results of CCBH protocol and comparison with existing techniques. Last section gives a conclusion with the future scope of the study.

II. RELATED WORK

Numerous clustering techniques have been developed in the recent past. Low Energy Adaptive Clustering Hierarchy (LEACH) is first and most recognized hierarchical routing protocol, which introduces the concept of dynamic clustering in WSN [15]. In LEACH protocol, it is assumed that initial energy is the same for all nodes, whether it is CH or ordinary node and each node can communicate directly to the sink. The operation of this protocol is divided into rounds and role of CHs is randomly interchanged after every round that offers the proper distribution of energy resource. Operation of the protocol is partitioned into two phases, one is setup phase and another is transmission phase. During the setup phase creation of clusters and CH selection processes takes place. In the transmission phase, CH gather sensed data from CMs and after data aggregation sends it to sink straightforwardly. Although LEACH protocol enriches the network lifespan, but consideration of important parameter like node's remaining energy and distance is not included. Thus the number of CHs and CHs distribution may not be optimum [12]. Each node has an equal chance to become a CH; this leads the possibility that node having less energy can become a CH that leads to early death of CHs having less energy. Many researchers have proposed various amendments in LEACH protocol to overcome these issues. In [16], proposed a central control based clustering protocol named LEACH-C where BS controls the CH election process. BS computes the average energy of nodes and nodes possess higher energy than the average node's energy are entitled to become the CHs. For the remaining operations, LEACH-C follows the LEACH protocol. In E-LEACH (Enhance LEACH) protocol, residual energy and energy required to transmit data are considered in selecting the CH. A minimum spanning tree between the CHs is used to forward data to the BS and CH having highest residual energy is selected as the root node [17]. A two- level LEACH (TL-LEACH) protocol is discussed in [18], where CH routes the data through relay CHs those situated between that CH and BS instead of transferring data straightforwardly to BS. Sometimes there is a possibility of the early death of CH, in this situation; the entire cluster becomes useless because data from certain cluster never reaches to the BS. This problem is addressed in [19] to select a vice-CH node along with a cluster head, vice CH takes over the responsibilities of CH in case of early death of CH.

In [20], HEED (Hybrid Energy-Efficient Distributed clustering) protocol is proposed in which a hybrid criterion for CH selection is employed. Two parameters are considered for CH election, first is the remaining energy of a node and second is node degree. This protocol provides suitable distribution of CHs and multi-hop data forwarding is employed to forward data to the BS. During the selection of CH, each node communicates continuously with its neighbor nodes for a fixed number of iterations that increases the energy spend in communication, thus HEED is not a suitable choice for larger networks. A chain based routing protocol named PEGASIS is presented in [21], where greedy mechanism is considered used to construct a single chain across nodes. Firstly a chain head is designated after that creation of chain starting from uttermost nodes. In the chain, nodes communicate with adjoining neighbor only. The process of data fusion and aggregation is achieved at all nodes except end nodes and each node fuse own data with data from the neighboring node, then converted into a data packet of the same length. PEGASIS eradicates the clustering overhead and reduces the communiqué distance between nodes, this consequence in the substantial expansion in network lifespan as compared to LEACH. The foremost downsides are high link delay and the assumption of same length packet generation by each node in the chain. In [22], a multiple chain based approach is discussed where multiple chains are formed towards the sink. The observing area is divided into *n*-number of sub-areas with respect to x- coordinate and chains are constructed in each sub-area. The starting node of each chain sends data to the closest node and the node that are on the top of the chain are considered as chain head that can send data to sink in the single hop. Results illustrate that multiple chain approach significantly reduces the energy consummation and also reduces the redundant data and link delay. The foremost problem here is that the responsibility of chain heads is not rotated that reduces the lifespan of chain heads.

In [23], a cluster chain based mixed (CCM) protocol is presented that associates the benefits of both chain and cluster based protocols. Chain based protocol shows higher energy efficiency at the cost of higher transmission delay as compared to cluster based protocol. This protocol is subdivided into two phases, in initial phase the monitoring area is divided into various narrow strips and a chain is constructed in each strip same as PEGAISIS. After the selection of chain head, each chain member sends data to chain head through intermediate chain members. In the next phase, chain heads constitute a cluster for inter-chain communiqué and a CH is elected based on the remaining energy. CH fuses the data received from all chain head and forwards it to sink directly. Simulation result demonstrates that CCM has small energy consumption and less delay as compare to LEACH and PEGASIS protocol. In [24] authors proposed an energy efficient unequal clustering routing algorithm (UCRA) that contains of two algorithms, one is unequal-clustering algorithm and another is a multi-hop routing algorithm. Remaining energy and node's degree are the considering factors for segmenting the network into unequal clusters. MEC (multi-hop routing protocol) is introduced in inter-cluster communiqué where the distance threshold is set. If the distance between the CH and the BS is less than this threshold distance, CH forwards data directly to the BS otherwise CH identify a relay node that passes data to sink. In this protocol, if the network size increases the size of outer layer clusters also increases. For a huge network size, the size of last layer clusters turns out to be substantial that increases the inter-cluster communiqué distance, thus inter-cluster energy dissipation is more. In [25], the authors introduced a distributed self- organization balanced clustering algorithm (DSBCA) where cluster radius is calculated that depends on connectivity density and distance from the sink. For uniform distribution, protocol form a multilayer clustering structure and the layer nearer to sink has small radius clusters as compared to farther clustering layer. The cluster radius is identical for the same layer. In case of non-uniform distribution, clusters with more distance from a sink and lower connection density have larger radius. In case of the smaller distance from the sink and lesser connection density, the radius of the cluster is smaller. The maximum size of a cluster is predefined, CH can select or reject the cluster joining request of ordinary nodes after comparing its size to maximum allowable size of the cluster.

In [26], a hybrid partition based clustering routing protocol (HMPBC) is introduced to balance the network load and to enrich the network lifespan. In this protocol, the network is divided into square zones and each zone considers as a cluster. The remaining energy of the node is considered to select the CH; node having largest residual energy is selected as a CH. Greedy algorithm is used to form a chain in every cluster. For intra- cluster communiqué, BS form minimum spanning tree structure between the CHs. The disadvantage of this protocol is that if the numbers of zones are more than it is difficult to deploy an equal number of nodes in each zone. A divide and rule scheme that based on static clustering and dynamic CHs selection technique is proposed in [27], where monitoring area is divided into *n*-equal concentric squares. The nodes in each small region form a cluster and node near to the midpoint is selected as a CH. Outer level CHs send data to respective lower level CHs. Nodes of the internal square communicate directly with sink. The main shortcoming of this technique is that the cluster sizes are unequal that lead to unequal energy dissipation.

In [28], a load balanced energy efficient clustering protocol has introduced that divide the network field in virtual circles to balance the energy consumption. In each cluster apart from the CH some nodes called leader nodes (LNs) are selected, these LNs gather and aggregate the data received from the ordinary nodes in their own leadership. LNs send data to respective CH after that CH sends it to the BS in multi-hop or single-hop manner that based on distance from the sink. This protocol consists of two phase one is setup phase and another is a steady state phase. In first phase CH, LN and next hop selection process are performed. In the steady state phase, intra- cluster and inter- cluster communiqué is defined. Selection of CH is based on the three factors; the node degree that represents the count of neighboring nodes within the cluster radius, distance between the neighboring nodes and the distance from the node to BS. For the selection of LN, decisive factors are node degree and number of leader node candidates. The disadvantage of this protocol is that outer region size is very large that increases the communication load on CH which leads to the early death of nodes in the outer region.

In [29], an unequal cluster based routing (UCR) protocol is proposed to alleviate the hot spot problem and to enhance the network lifespan. In UCR, EEUC algorithm is proposed for topology management and a greedy geographical routing is proposed for inter-cluster communication. A competitive range is pre-assigned to each node; it decreases as separation from sink decreases.

The selection of the CH process is same as HEED, where the decisive factor in CH election is remaining energy. The major drawback of this protocol is large communication overhead. Every ordinary node has to transmit and receive a significant amount of competition message for CH selection in each round.

III. BACKGROUND

The primary objective of the proposed CCBH protocol is to uniformly assign the load among the nodes and to lessen the inter and intra-cluster communiqué cost. In CCBH protocol the entire workload of the network is divided in a manner that it balances the load among the nodes. Initially, the entire coverage area is partitioned into virtual concentric squares of variable sides and thereafter these squares are divided into small zones as shown in Fig 1. As we move away from the sink there is a growth in the length of concentric square's side. The size of zones adjoining to the sink is tiniest and zone size increases as the distance from sink increases. The square region that is farthest to the sink is assigned with the highest level number that known as the outer layer and the layer number decreases with the decline of separation from the sink. Now the CH is selected in each zone considering the three parameters: remaining energy, degree of node in specific radius and separation from the sink.

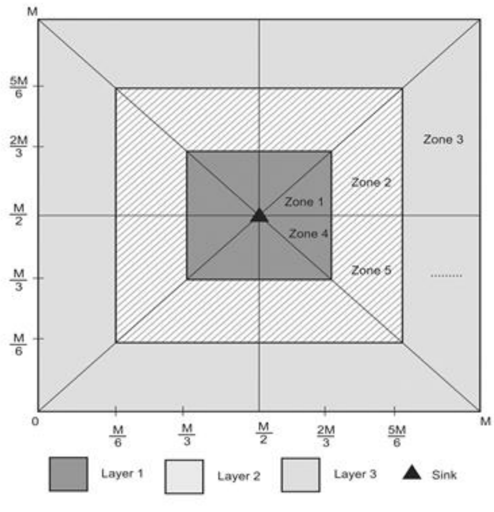

Fig. 1. Network structure model

As mentioned in the literature CH performs some additional tasks as compared to ordinary sensor nodes. Apart from sensing, CH receives the data from CMs and aggregates it before sending to the sink. Data can be sent to sink in a single hop or a multi hop manner where CHs play the role of a relay node. Thus, energy depletion in CH is more when contrasted with the ordinary node this prompts a high plausibility of early demise those nodes that are performing the responsibility of CH. Many researchers have proposed an idea to revolve the duty of CH amid all nodes that balance the energy load. In the proposed CCBH protocol clustering strategy is employed in all zones except the zones belong to the outer layer and chain based strategy is implemented in the zones of the outer layer. The CCBH protocol takes the benefits of cluster as well as chain based strategy. In the past, many researchers have proposed routing protocols based on the clustering concept. Cluster based protocols provide more energy efficiency, better scalability, and proper load balancing across the nodes. The major problem with clustering based protocols is a large number of clustering overheads that increases as network scale increases. A significant amount of energy is consumed in transmitting and receiving of overhead packets that reduces the energy efficiency of WSNs especially when the network scale is large [30]. As given in the literature that chain based protocols are more favorable than cluster based protocols, but exhibit higher transmission link delay if chain length is long. The proposed CCBH protocol utilizes the advantage of low energy consumption from chain strategy and less transmission delay from clustering strategy. To extend the network lifespan, we proposed a protocol named load balanced energy efficient Cluster-chain based hybrid protocol (CCBHP) that balance the network load and also alleviate the effect of energy holes in the WSN.

IV. CONTRIBUTION OF PROPOSED WORK

The contribution of the proposed CCBH protocol is stated as:

1. The entire monitoring area is split into zones. As CH performs some addition task as compared to its associated member nodes, thus the energy drainage of CH nodes is higher than the ordinary modes. In CCBH protocol, we introduce a LN in each zone of inner two into small zones such that the size increases as the distance from sink increases and a CH is selected in each zone except the outer layer layers to lessen the load of CH. LN accumulates the data from nodes associated and delivered it to CH of the specific zone after aggregation. By this way LN balances the energy distribution across the network. The multi-layer communication CCBH protocol is shown in Fig. 2.

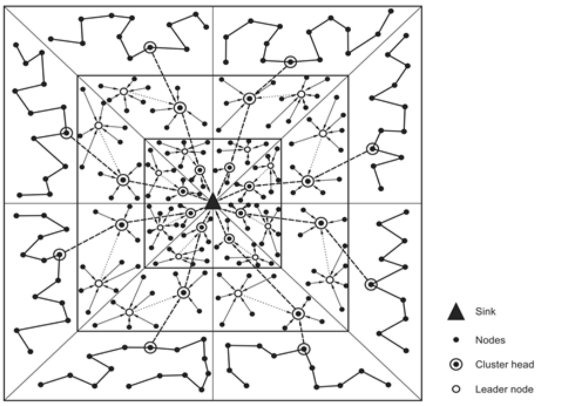

Fig. 2. Multilayer communication in network

Retrieval Number: C5284098319/2019©BEIESP
DOI:10.35940/ijrte.C5284.098319
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2. The size of zones gradually increases as its distance from sink increases. The size of the zones near the sink is small that yields to small cluster size. Therefore, CHs near to sink can save some energy that can be utilized in the inter-cluster data forwarding. This eradicates the hot spot region near to the BS.

3. A chain based protocol lessens the clustering overhead and diminishes the communication distance between nodes, this result the significant heightening in network lifetime. It is mentioned in the literature that high link delay occurs in the long chain. In proposed work, we divide the outer layer into small quadrilateral zones and chain length in every quadrilateral zone is small that significantly reduces the communiqué cost and link delay.

V. ENERGY MODEL

The energy model is similar to the model that is used in LEACH [15], where both free space (d^2 path loss) and multi-path (d^4 path loss) fading channel models are employed. If the separation between sender and receiver d is more than a threshold distance value d_0, the multipath fading channel model is considered else free space model is considered.

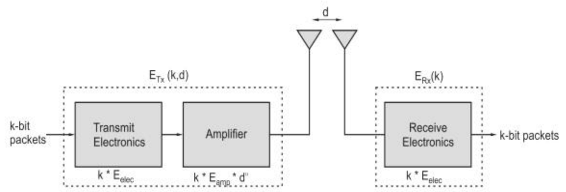

Fig. 3. Radio energy model

The energy consumption required for transmitting a k-bit data from a distance d is

$$E_{tx}(k,d) = E_{tx-elec}(k) + E_{tx-amp}(k,d) = \begin{cases} k\,E_{elec} + E_{fs}\,k\,d^2, if\ d < d_0 \\ k\,E_{elec} + E_{amp}\,k\,d^4, if\ d \geq d_0 \end{cases} \quad (1)$$

and power consumption to receive a k-bit data is

$$E_{Rx}(k) = E_{Rx-elec}(k) = k\,E_{elec} \quad (2)$$

Where the threshold distance d_o is computed as

$$d_0 = \sqrt{\frac{E_{fs}}{E_{amp}}} \quad (3)$$

E_{elec} is the energy consumed per bit in the transmitter or receiver circuitry that relies on various aspects, namely modulation, coding technique and filtering approach used, on the other hand, amplifier energy, $E_{fs}d^2$ or $E_{mp}d^4$, depend on distance from the receiver. Data aggregation is done using an infinite compressibility model which assumes that CH gathers the data from its member nodes and convert it into a single packet of fixed length [31]. Data aggregation removes the redundancy of data sensed by nodes that results in a reduction in the transmission cost. In the proposed model, data aggregation takes place at CH and LN in inner two layers. In outer layer, each node performs the data aggregation except the end nodes of the chain. The energy consumption to aggregate n-number of messages having k-bit is

$$E_{agg} = E_{DA} * k * n \quad (4)$$

Where E_{DA} is energy expended to aggregate a bit.

VI. PROPOSED WORK

In the proposed work, we consider that N sensor nodes are arbitrarily dispersed over a square monitoring area. The i-th node is designated by s_i, for N nodes the node set is represented as $s = \{s_1, s_2, ...s_N\}$. Some assumptions that are considered in the proposed work are as:

1. All sensor nodes and sink are static in nature. All sensor nodes are homogeneous and have same initial energy.
2. There is only one sink that is situated at the center of sensing field.
3. Received signal strength (RSS) is used to calculate the distance between nodes.
4. Sink and ordinary nodes can communicate directly to exchange information related to node status and network configuration in the setup phase.
5. Each node in a particular zone has a unique identity number along with a distinctive zone identity number. The communication process for ordinary nodes is restricted within the zone specified to them. The CHs are responsible to establish communication between zones.
6. Both single-hop and multi-hop communications are possible that depends on the distance from the sink.

The proposed work is divided into the following phases:

A. Preparation Phase

After distribution of nodes, CCBH protocol starts working. The CCBH protocol executes preparation phase beforehand first round. The monitoring area is partitioned into small zones and every node calculates the essential information such as distance from the sink, node's energy and the number of neighboring nodes in a predetermine radius RNG. Each node shares this information with other nodes.

B. Setup Phase

This phase comprises of CH selection, LN selection, chain creation and next hop selection.

1) Selection of Cluster Head

After the preparation phase, one CH is selected in each zone. Selection of proper positioned CH plays a vital role for load balancing and energy consumption reduction. In proposed work, competence of sensor node to become a CH is based on a value function (F_{CH}). The value function depends on the node degree in a specific range, remaining energy of a node and the distance of the node from BS. A node with a higher degree and higher remaining energy is most suitable for becoming the CH. The node degree determines the suitability of node to become a CH. The nodes having greater degree are more suitable for being used as a CH. The benefit of selecting the high degree node as CH is that it reduces the communication distance between MNs and CH that declines the energy consumption in intra-cluster communiqué. Furthermore CH also plays the role of relay node during inter-cluster communication, thus the distance between the CHs and BS should be less to avoid long distance link.

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DOI:10.35940/ijrte.C5284.098319
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It reduces energy consumption during inter-cluster communiqué. Every node computes a valuable function (F_{CH}) in pursuance to select a CH that is given as

$$F_{CH} = w_1 * N_{\deg} + w_2 * E_r + \frac{w_3}{d_{BS}} \quad (5)$$

Where w_1, w_2, and w_3 are constant weights between (0,1) and the sum is equal to 1. These constant weights are adjustable and same for each node. The values of constant weights determine the significance of the selected parameters. N_{deg} is the node degree, E_r is residual energy and d_{BS} is the distance from the node to BS. The node degree is calculated as

$$N_{deg} = n_j / \max\,[n_1, n_2, n_3, \ldots, n_N] \quad (6)$$

Where n_j is the count of nodes in the pre-defined range of node j. Every node computes the F_{CH} value and thereafter node compete with other nodes based on the F_{CH} value within the zone; a node with maximum F_{CH} value is elected as CH. In general, the role of CH is to accumulate the data from its MNs and forward aggregated data to sink directly or multi-hop manner via relay nodes. Thus CH depletes their energy resource to perform some additional tasks apart from sensing the environment such as data aggregation and data transmission to BS as compared to non-CH nodes. Thus the energy drainage in the CHs is hasty as compared to non-CH nodes this may lead to early death of node those performing the duties of CH. To avoid this situation many protocols are proposed in which role of CH is interchanged in cluster after each round or after a specific time interval. In the CCBH protocol role of CH and LN is revolved after every communiqué round.

2) Selection of Leader Node

In general, CH perform some addition task as compared to non CH node such as collection of data from MNs, aggregation of data and CH also works as a relay node to send data to sink, The energy depletion at the CH nodes is faster than non CH nodes. In the CCBH algorithm, we introduce a leader node (LN) in each zone to reduce the workload of CH that improves the energy distribution across the zone. LN accumulates the data from associated nodes and after the aggregation forwards it to their respective CH. By this we can balance the energy distribution in the zone. Substantially, the intra-cluster energy cost depends on factors like cluster's size, node centrality and node density. If the cluster's size is large due to the relationship between energy and distance, the intra-cluster energy upsurges. Node centrality means how far the MN is situated from the CH, If the MN is situated near to the CH then communiqué distance reduces that also indicates the reduction in communication cost. Node's density also a noteworthy factor, CH in higher node's density zone significantly reduces the communication distance that reduces the energy required to transmit or receive the data. In CCBH protocol the selection criteria for a LN are node's energy, node's degree and distance from CH. An energetic node in high node's density is elected as LN that should not be in the vicinity of CH. Each LN candidate that is not CH calculates a value (F_{LN})

$$F_{LN} = \alpha * E_r + \beta * N_{\deg} + \gamma * d_{CH} \quad (7)$$

In (7), E_r, N_{deg} and d_{CH} are remaining node's energy, node's degree and distance from CH respectively. α, β, and γ are constant weights between (0,1) and the sum is equal to 1. Energetic nodes those are at appropriate location are considered as LN. All nodes in a zone excluding CH are entitled to become a LN. Competition for becoming LN is based on F_{LN} value and node having maximum F_{LN} value is elected as LN. By this way the proposed CCBH protocol decreases the load of CH within the cluster that improves the longevity of the nodes.

3) Members Joining in Cluster

In this process initially, every CH and LN broadcast advertising message known as CH_ADV_MSG and LN_ADV_MSG respectively that comprises their IDs and spreading codes within its cluster. Each ordinary node selects the closest CH or LN considering the RSS strength of CH_ADV_MSG and LN_ADV_MSG. Subsequently, ordinary nodes send JOIN_CH_MSG or JOIN_LN_MSG to respective CH or LN to inform its decision. Now CH and LN count its associated members and set-up a TDMA schedule to gather the data from MNs, then transmits its TDMA schedule to their associated MNs by means of spreading schedule messages in a radius that proportional to its uttermost member node. The schedule messages contain the number of time slots assigned to each MN to direct its information to CH or LN. The setup phase is finished once all member nodes know their TDMA schedule in the cluster and after that steady state phase start.

4) Chain Formation in the Outer Layer

The chain formation in the outer layer is similar to PEGASIS protocol in which a chain is constructed by means of a greedy algorithm [21]. Since the outer layer is partitioned into eight small size quadrilateral shape zones. A chain is formed in each quadrilateral shape zone. First, a chain head is selected after that chain formation starts from furthermost node and nodes communicate only with adjoining neighbor. A node having the highest remaining energy and nearest to the BS is selected as chain head. Data aggregation takes place at every node except end nodes and each node aggregate own data with data receive form neighboring node, and then converted into a data packet of the same length. In case of early death of a node in the chain, reconstruction of the chain takes place to bypass the dead node. A chain based protocol diminishes the clustering overhead and lessens the communication distance between nodes, this result the significant enhancement in network lifespan. It is mentioned in the literature that high link delay occurs in the long chain. In proposed work, we divide the outer layer into small quadrilateral zones and chain length in every quadrilateral zones is also smaller that significantly reduces the link delay. Thus, in this way, we can take the advantage of chain based topology.

C. Steady State Phase

Data communication occurs in the steady state phase of the protocol according to the topology determined for the current round. Various activities like sensing, fusion and routing of data are performed in this phase. The proposed protocol is proactive in nature, thus sensor nodes in each zone sense the environment continuously and thereafter forward sense data to respective CH, LN or chain head. In first and second layers, data aggregation occurs at either LNs or CHs and in outer layer data aggregation takes place at each node except starting and ending nodes of chain. In zones of the outer layer, the node forwards data to the chain head through their nearest node. All cluster heads/chain heads forward data packets to BS through a multi-hop path. Each CH/chain head aggregates the data received from their associated MNs and forward it to CH of the immediate lower layer and so on; CHs of first layer forwards directly its data to the sink.

VII. SIMULATION AND RESULS

This section represents the outcomes of CCBH protocol that are observed after simulating in MATLAB. The results are generated on the premise of network setup parameters that are shown in Table I. We evaluated the performance of the CCBH protocol with regard to network lifespan, remaining energy and number of data packets sent to BS.

Table I. Network setup

Parameter	Value
Observing area	300x300 m^2
BS position	(150, 150) m
Node's count (N)	500
Node's initial energy	0.5 J
E_{elec}	50 nJ/bit
E_{fs}	10 pJ/bit/m^2
E_{mp}	0.0013 pJ/bit/m^4
E_{DA}	5 nJ/bit/signal
Threshold distance	87 m
Control packet	200 bits
Data packet	4000 bits

The primary intention of this study is to design an energy efficient routing protocol. We considered network lifespan as major criteria for evaluating the proposed CCBH protocol in term of energy efficiency. In previously published literature different authors consider different definitions for network lifetime. Here, we consider the network lifetime is duration from starting of network to time till the first node (FN) completely exhausted their energy. Thus the network lifetime designates the duration for which all nodes remain alive. The duration from initialization of the network to the instant when the FN completely dissipates energy is known as the stability period. Fig. 4 and Fig. 5 depict the alive nodes and dead nodes with respect to rounds in the network. This is because the CCBH protocol considers the effect of both intra and inter-cluster communiqué. It balances the load across the nodes in a better way. Fig 6 specifies the two metrics one is FND and another is LND. The outcomes of the FND metric show that FND of the CCBH protocol is 91% superior than LEACH, 10% superior than LBECP, 67% superior than TCAC, and 33% superior than DSBCA. This evidences enhancement in the stability period of CCBH protocol. In fact, improvement in the stability period validates our assertion that CCBH protocol distributes the network load across the node and provides balanced geographical structure.

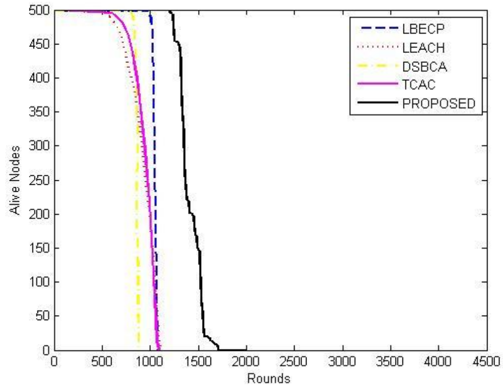

Fig. 4. Alive nodes vs. rounds

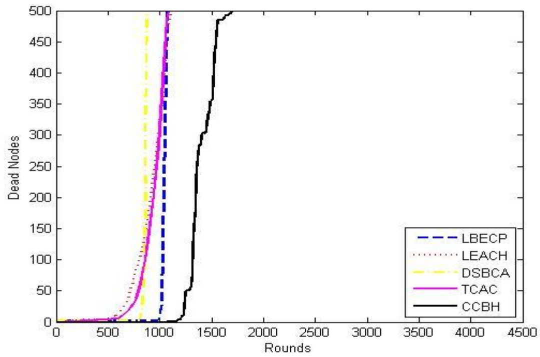

Fig. 5. Dead nodes vs. rounds

The outcomes of LND metric designates that CCBH shows the 43.97% expansion as compare to LEACH, 57.9% expansion as compared to LBECP, 56.93% expansion as compared to TCAC, and 78.76% expansion as compared to DSBCA. This comparison shows that the distribution of energy consumption is better in proposed CCBH protocol and hence indicates that the load of a network is suitably distributed across the network. As the cluster size near to sink is smaller as compared to clusters that are away from the sink. Therefore, CH near to sink conserves some energy during intra- cluster communiqué that can be utilized in the inter-cluster data forwarding. This eliminates the hot spot region in the vicinity of the BS. The results designate that proposed CCPH protocol is able to address the unequal load distribution and hot spot issue excellently.

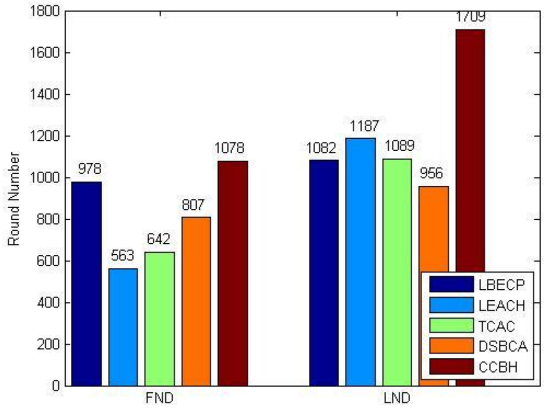

Fig. 6. FND and LND with respect to rounds

Retrieval Number: C5284098319/2019©BEIESP
DOI:10.35940/ijrte.C5284.098319
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Residual energy is another parameter to appraise the performance of the network at a particular time. Here, the criterion utilized for assessing the suitability of the appropriate protocol is proportional to the slope of the residual energy curve. For most suitable protocol the slope of the residual energy curve will be least toward the horizontal axis, on the other side slope of the residual energy curve will be large for protocol having an undesirable performance in regard to enriched network lifespan. As indicate in Fig. 7, the residual energy of CCBH protocol after each round is more and slope of the residual energy curve is also minimum. In CCBH protocol, we introduce a LN in each zone of inner two layers to lessen the load of CH and chain strategy is used in outer layer zones, which boost the remaining energy metric.

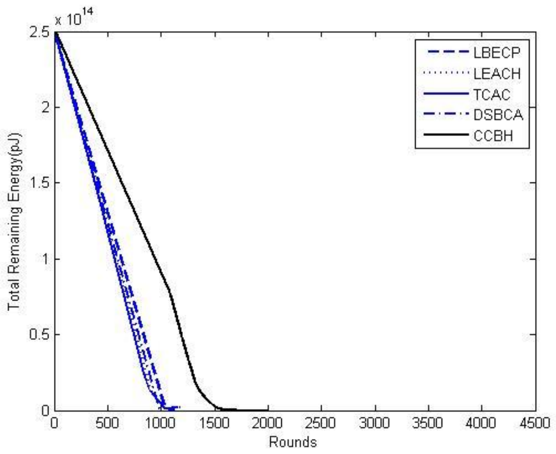

Fig. 7. Residual energy with respect to rounds

Table II illustrates the slope of residual energy curves when 100J energy remains left. Here the initial energy is considered as 250 J.

Table II. Slope of residual energy curve

Protocol	Slope of residual energy curve
LEACH	3.98
TCAC	3.86
DSBCA	3.79
LBECP	3.65
CCBH	2.65

The slope of the residual energy curve is 2.65 for CCBH protocol, which is least as compared to other protocols. It shows the preeminent enactment of the CCBH protocol in term of reduction in energy depletion.

Fig. 8 indicates the count of packets sent to BS in relation to rounds. There is a gradual heightening in the data packets with the rounds. The outcomes evident that in case of CCBH protocol sink receives more data packets as compared to the other protocols that confirms the superlative enactment of CCBH protocol.

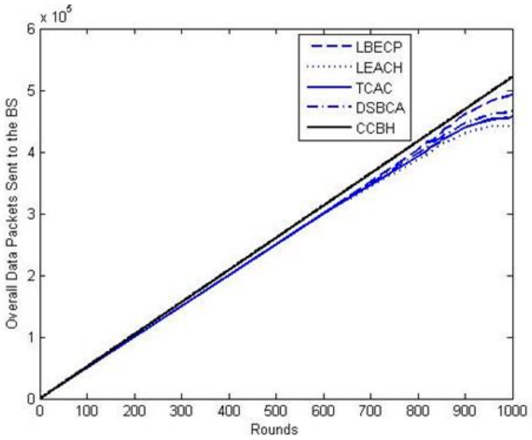

Fig. 8. Packets sent to BS with respect to rounds

Scalability is the competency of network to adapt additional nodes or variation in the network field without the modification of network design. Two circumstances are considered to evaluate the scalability of the proposed CCBH protocol, first is the observing area varies with fixed node count and in further the node count increases with the fixed observing area. For scalability metric, firstly CCBH protocol is simulated for the different coverage area (100x100 m, 200 x200 m, and 300x300 m), node's initial energy is 0.7 J and nodes are 500. Fig. 9 shows the network lifespan for different coverage area where performance of CCBH protocol is not affected by the changes in coverage area. Scalability is correlated to parameter growth factor (GF) defined as

$$Growth\ factor = \frac{|FND(N_1) - FND(N_2)|}{FND(N_1)} \quad (8)$$

Where $FND(A_1)$ and $FND(A_2)$ are the initial dead node of different observing areas. Growth factor varies when the number of nodes or monitoring area changes. A protocol is said to be suitable for WSN if the *GF* factor varies slowly with respect to variation in the number of nodes or observing area size. Fig. 9 indicates alive nodes in every round of the protocol. The first node demises at round 1190, 1280, and 1291 for 100x100 m, 200x200 m, and 300x300 m monitoring area respectively.

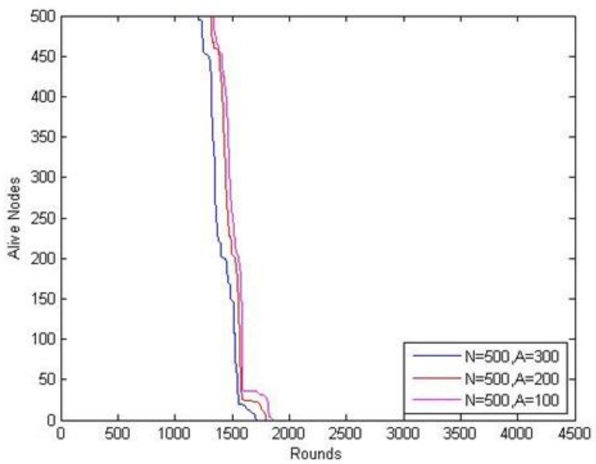

Fig. 9. Alive nodes for different network areas vs. rounds

Table III indicates the FND, HND, LND and *GF* for the different observing area.

The GF is 0.0756 when monitoring area shrinkage from 300x300 m to 200x200 m and its value is 0.0085 when area reduced from 200x200 m to 100 x100 m; its evidence that CCBH protocol is scalable thus there is a small increase in GF with the decline in the observing area.

Table III. Lifetime results for different coverage area

Coverage Area	FND (Round)	HND (Round)	LND (Round)	Growth Factor
300 x 300 m	1190	1310	1690	---
200 x 200 m	1280	1450	1755	0.0756
100 x 100 m	1291	1470	1778	0.0085

Now the CCBH protocol is simulated for 500, 300 and 200 nodes. The network must be scalable to accommodate the further nodes in the observing area. Table IV indicates LND, HND, LND, and GF for the different node count.

The growth factor is defined in this context is

$$Growth\ factor = \frac{|FND(N_1) - FND(N_2)|}{FND(N_1)} \quad (9)$$

Where $FND(N_1)$ and $FND(N_2)$ are initial dead node for the different node count. The first node completely depletes their energy at round 991, 1022 and 1078 for 200, 300, and 500 node count respectively. The *GF* is 0.031 when node count increase from 200 to 300 and its value is 0.055 when nodes increase from 300 to 500.

Table III and IV signposted the less value of growth factor when the network scale or node's count varies, that validates that CCBH protocol is scalable with variation in the network parameters. Thus, the CCBH protocol is scalable and elevates the lifespan of network.

Table IV. Lifetime results for different nodes

Nodes (N)	FND (Round)	LND (Round)	Growth Factor
200	991	1594	----
300	1022	1636	0.031
500	1078	1709	0.055

VIII. CONCLUSION

We proposed a novel cluster-chain based hybrid protocol (CCBH) to provide the proper distribution of load throughout the network that eliminates the energy holes and further enhances the network lifespan. In clustering approach, the energy hole occurs when multi-hop routing is utilized for inter-cluster communication. We claim that only CH rotation and the consideration of residual energy are insufficient to appropriate distribution of energy. In CCBH, we split the entire network area into small zones such that zones close to sink have lesser area and increases in area as the distance from sink increases. The nodes residing in a zone form a cluster. Since the cluster sizes near to sink are small, so the CH of these zones conserves certain energy that can be utilized in inter-cluster communiqué. In the outer layer which comprises the zones of larger size, chain strategy is employed instead of clustering that reduces the energy consumption. Apart of this, we introduce a LN in the inner two layers zone to lessening the load of CH. The results designate that the CCBH protocol demonstrations notable enrichment in the lifespan of the network compared with other protocols; namely LEACH, TCAC, DSBCA, and LBCN. The average improvement of network lifetime attained in proposed CCBH protocol is 10.22%, 91.47%, 67.91%, 33.58% as compared to LBCN, LEACH, TCAC, and DSBCA respectively.

REFERENCES

1. M. Mahboubi, K. Moezzi, A .G. Aghdam, K. S. Pour, and V. Marbukh, "Distributed deployment algorithms for improved coverage in a network of wireless mobile sensors", IEEE Transactions on Industrial Informatics, vol. 10, no. 1, pp. 163-174, 2014.
2. I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks", IEEE Communications Magazine, vol. 40, no. 8, pp. 102-105, 2002.
3. S. Siavoshi, Y.S. Kavianand, and H. Sharif, "An Energy- balanced distributed clustering protocol for wireless sensor networks", in Proceedings of 9th International Symposium on Communication Systems, Networks and Digital Sign (CSNDSP), pp. 45-153, 2014.
4. A.D.L. Piedra, F.B. Capistors, F. Dominguez, and A. Touhali, "Wireless sensor networks for environmental research: A survey on limitation and challenges", in proceeding IEEE Conference EUROCON, Zagreb, Croatia, pp. 267-274, 2013.
5. A. Munjal, and Y.N. Singh, "Review of stateful address auto configuration protocols in MANETs", Ad Hoc Networks Elseiver, vol. 33 (c), pp. 257-268, 2015.
6. V. Kumar, and A. Kumar, "Improving reporting delay and lifetime of a WSN using controlled mobile sinks", Journal of Ambient Intelligence and Humanized Computing, vol. 10, no. 4, pp. 1433-1441, 2019.
7. X. Liu, "A survey on clustering routing protocols in wireless sensor networks", Sensors, vol. 12, pp. 11114-11151, 2012.
8. A.V. Sutagundar, and S.S. Manvi, "Location aware event driven multipath routing in wireless sensor networks: Agent based approach", Egyptian Informatics Journal, vol. 14, pp. 55–65, 2013.
9. S.D. Muruganathan, D.C.F. Ma, R.I. Bhasin, and A.O Fapojuwo, "A centralized energy efficient routing protocol for wireless sensor networks", IEEE Communications Magazine, vol. 43, no. 3, pp. 8-13, 2015.
10. N.A. Pantazis, S.A. Nikolakakos, and D.D. Vrgados, "Energy efficient routing protocols in wireless sensor networks: A survey", IEEE Communications Surveys and Tutorials, vol. 15, no. 2, pp. 551-590, 2013.
11. J.N. Al-Karaki, and A.E Kamal, "Routing techniques in wireless sensor networks: A Survey", IEEE Wireless Communications, vol. 11, no. 6, pp. 6-28, 2004.
12. N. Gutam, and J.Y Pyun, "Distance aware intelligent clustering protocol for wireless sensor networks", Journal of Communications and Networks Kor, vol. 12, pp. 122-129, 2010.
13. N. Sabor, S. S. Shigenobu, M., Abo-Zahhad, and S.M Ahmed, "A comprehensive survey on hierarchical- based routing protocols for mobile wireless sensor networks: Review, taxonomy, and future directions", Hindawi Wireless Communications and Mobile Computing, vol. 4, no. 2, pp. 1-23, 2017.
14. D.P. Dahani, Y.P. Singh, and C.K. Ho, "Topology-controlled adaptive clustering for uniformity and increased lifetime in wireless sensor networks", IET Wireless Sensors System, vol. 2, no. 4, pp. 318–327, 2012.
15. W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy efficient communication protocol for wireless sensor networks", in Proceeding of 33rd Hawaii International Conference on System Sciences, HI, USA, vol. 8, pp. 1-10, 2000.
16. W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "An application-specific protocol architecture for wireless microsensor networks", IEEE Transactions on Wireless Communications, vol. 1, No. 4, pp. 660-670, 2002.

17. J. Xu, N. Ning Jin, X. Lou, T. Peng, Q. Zhou, and Y. Chen, “Improvement of LEACH protocol for WSN”, in Proceedings of IEEE International Conference on Fuzzy Systems and Knowledge Discovery, Sichuan, China, pp. 174-2177, 2012.
18. V. Loscri, G. Morabito, and S Marano, “A Two-levels hierarchy for low-energy adaptive clustering hierarchy (TL-LEACH), in Proceeding of IEEE vehicular Technology Conference, vol. 3, pp.1809–1813, 2006.
19. M.B. Yassein, A. Al-zou'bi, Y. Khamayseh, and W Mardini, “Improvement on LEACH protocol of wireless sensor network (VLEACH)”, International Journal of Digital Content Technology and its Applications, vol. 3, no. 2, pp. 132-136, 2009.
20. O. Younis, and S. Fahmy, “HEED: A hybrid, energy-efficient, distributed clustering approach for ad- hoc sensor networks”, IEEE Transactions on Mobile Computing, vol. 3, no. 4, pp. 366-379, 2004.
21. S. Lindsey, C. Raghavendra, and K.M Sivalingam, “Data gathering algorithms in sensor networks using energy metrics”, IEEE Transactions on Parallel and Distributed Systems, vol. 13, pp. 924-935, 2002.
22. M. Hadjila, H. Guyennet, and M. Feham, “A chain-based routing protocol to maximize the lifetime of wireless sensor network”, Wireless Sensors Network, vol. 5, no.5, pp. 116-120, 2013.
23. F. Tang, I. You, S. Guo, M. Guo, and Y. Ma, “A chain- cluster based routing algorithm for wireless sensor networks”, Journal of Intelligent Manufacturing, vol. 23, no. 4, pp. 1305-1313, 2010.
24. R. Zhang, L. Ju, Z. Jia, and X. Li, “ Energy efficient routing algorithm for WSNs via unequal clustering”, in Proceeding of IEEE international Conference on high Performance Computing and Communication, pp. 1226-1231, 2012.
25. Y. Liao, H. Qi, and W. Li, “Load-balanced clustering algorithm with distributed self-organization for wireless sensor networks”, IEEE Systems Journal, vol. 13, no. 5, pp. 1498–1506, 2013.
26. C. Wang, Y. Zhang, X. Wang, Z Zhang, “Hybrid Multihop partition-based clustering routing protocol for WSNs”, IEEE Sensors Letter, vol. 2, no. 1, pp. 1-4, 2018.
27. K. Latif, A. Ahamd, N. Javaid, Z.A. Khan, and N. Alrajeh, “Divide-and- rule scheme for energy efficient routing in wireless sensor networks”, in Proceeding of International Conference on Ambient Systems, Networks and Technologies, Procedia Computer Science, pp. 1-8, 2013.
28. S. Siavoshi, Y.S. Kavian, and H. Sharif, “Load balanced energy efficient clustering protocol for wireless sensors networks”, IET Wireless Sensor System, vol. 6, no. 3, pp. 67-73, 2016.
29. G. Chen, C. Li, M. Ye, and J. Wu, “An unequal cluster- based routing protocol in wireless sensor networks”, Wireless Networks, vol. 15, pp. 193–207, 2009.
30. H.H. Liu, J.J. Su, and C.F. Chou, “On energy-efficient straight-line routing protocol for wireless sensor networks”, IEEE Systems Journal, vol. 11, no. 4, pp. 2374- 2382, 2015.
31. S. Bandyopadhyay, and E.J Coyle, “An energy efficient hierarchical clustering algorithm for wireless sensor networks”, in Proceeding 22nd Annual Joint Conference of the IEEE Computer and Communications, vol. 3, pp. 1813-1823, 2003.