Re-cluster Node on Unequal Clustering Routing Protocol Wireless Sensor Networks for Improving Energy Efficient

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***Abstract*—** Clustering in wireless sensor networks (WSNs) is an important technique for increasing the lifetime of a wireless sensor network. Organizing wireless sensor networks into clusters enables the efficient utilization of the limited energy resources of the deployed sensor nodes. However, the problem of unbalanced energy consumption exists, and it primarily depends on the role and on the location of a node in the network. If the network is organized into heterogeneous clusters, it is important to ensure that energy dissipation of these cluster head nodes is balanced. It should also be ensured that the hot spot problem would not occur, because in multi-hop the node is burdened from the relay data to the base station. Since the result of routing can prolong network life time, therefore Re-cluster Node on Unequal Clustering Routing Protocol Wireless Sensor Networks for Improving Energy Efficient is proposed. In this routing adopted hierarchical and multi-hop before cluster processed. This action enables energy dissipation among the cluster head nodes, thus increasing network lifetime. The different of this routing algorithm used the equation of value energy node (VN). It's formula to calculation of highest energy node. By choosing one node with the highest energy as Cluster Head Leader Node and re-clustering in each Cluster Head (CH), the data is finally sent to Cluster Head Leader Node (CHLN) and then to the Base Station (BS). After running the simulation and analyzing the results of the routing protocol it was found that it prolonged network lifetime compared to the BCDCP, HEED, and UCR existing routing protocol.

***Keywords*—** Wireless Sensor Network, Clustering, Unequal Clustering Routing Protocol (UCR), BCDCP, HEED, LEACH

I. Introduction

RECENT advances in wireless technology and micro electro mechanical systems have brought the wireless sensor networks (WSNs) into several industrial, home and military applications. A WSN is composed of a large number of sensor nodes and a Base Station (BS). Sensor nodes sense their environment, collect sensed data and transmit it to the BS. However, they are limited in power, computational capacity and memory. It isn't easy to find the route and reserve it, because the limited amount of energy and sudden change in the position of the nodes creates unpredictable changes [5, 7].

The limited energy resources of the deployed sensor nodes are one of the most restrictive factors on the lifetime of wireless sensor networks. In order to achieve high energy efficiency and assure long network lifetime, sensor nodes can be organized hierarchically by grouping them into clusters, where data is collected and processed locally at the cluster head nodes before being sent to the base station. In many sensor network applications where data collection and processing can be done in place, this hierarchical approach is a promising method for efficiently organizing the network.

The main goal of routing protocol in wireless sensor network is to find a way to improve energy efficiency for reliable transmission of data sent to base station. Almost all the routing protocols can be classified according to the network structure as flat, hierarchical and location-based [5]. Normally, a classical hierarchical routing tactics are of two kinds; distributed routing and centralized routing.

There are two types of selection methods of clusters in a wireless sensor network; Random Selection and Deterministic Selection. The cluster head position in the network affect the total energy consumption. So cluster head can be dispersed in sensor field randomly or they can be deployed in a deterministic fashion. For example in random clustering, the nodes have the ability to move until they reach some location determined by a priori. Although random deploy in heterogeneous sensor network is more common and easier, it is much harder to control the actual size of cluster and to effectively balance the traffic among the cluster head nodes. The hot spot problem arises as a result of excessive energy consumption by particular cluster head nodes.

Routing technique of objects clustering is of two types: single-hop and multi-hop communication. In a single-hop communication, every sensor node can directly reach the destination, while in multi-hop communication, nodes have limited transmission range and therefore are forced to route their data over several hops until the data reach the final destination. In both models, there is an unavoidable problem of unbalanced energy dissipation among different nodes, leading to the situation where some nodes lose energy at a higher rate and die much faster than others, possibly reducing sensing

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coverage and leading to network partitioning. For single-hop communication, the nodes furthest away from the base station are the most critical nodes, while in multi-hop communication; the nodes closest to the base station are burdened with a heavy relay traffic load and die first. This condition causes the "hot spot" problem.

Clustered sensor networks can be broadly classified as heterogeneous and homogeneous with respect to the type and functionality of the nodes in the network. In homogeneous networks, all nodes have the same hardware and processing capabilities. The cluster head role is usually periodically rotated among the nodes to balance the load. Although rotating the cluster head role ensures that sensors consume energy more uniformly, the hot spot problem described above cannot be completely avoided. In heterogeneous networks, a certain number of nodes with much higher processing capabilities and complex hardware are deployed over the field together with numerous sensor nodes. As cluster head nodes, the more powerful nodes need to encompass several functions, serving as data collectors and processing centers for data gathered by sensor nodes. Because heterogeneous networks assume static cluster head assignment, the network lifetime is determined by the cluster heads' functioning time, which is directly related to cluster head activity and energy consumption. The cluster heads can form a backbone network and use multi-hop routing to route the data to the base station. This leads to "hot spots" in the network, where cluster heads in the hot spot use their energy at a much higher rate and die much faster than the other cluster heads. Managing the load becomes necessary in order to prevent the problem of premature battery drainage for particular cluster head nodes.

So in this paper, we present the idea to solve the hot spot problem in sensor network to avoid the drying of the energy of cluster head node and prevent the earlier death compared to another cluster heads, and to prolong network lifetime and balance energy consumption in wireless sensor network. After deployment of node in network area, we choose one node with a highest energy as Cluster Head Leader Node (CHLN) and make clustering in wireless sensor network with unequal cluster size. Therefore we divide the network area into levels and again re-cluster between cluster heads in each level based on shortest path into Cluster Head Leader Node. Finally each node functions as a new cluster head in each re-cluster node send to cluster head in different level and send data into Base Station.

The rest of paper is organized as follows: section II covers related work in this area, section III presents the proposed solution, section IV presents the system model and assumption, section, section V presents re-cluster node on unequal clustering routing protocol wireless sensor networks for improving energy efficient (RNUCREE), section VI presents analysis and simulation result and section VII presents conclusion.

II. Related Work

A. LEACH

Heinzelman, et al. [14] introduced hierarchical clustering algorithm for sensor networks, called Low Energy Adaptive Clustering Hierarchy (LEACH). LEACH is representative of cluster-based routing protocol and was the first protocol proposed for WSNs to reduce power consumption and avoid direct communication between the sink and sensor nodes. In a sensor field, sensor nodes sense data and send it to the sink called a "round". The working procedure in LEACH is complete in a single round. Before gathering the sent data in each round, the large number of sensor nodes is divided into several clusters. A cluster head is randomly chosen through self-organization. Each cluster head is in charge of gathering the sent data from the sensor nodes in the cluster. The cluster head will aggregate the received data and send it directly to the base station. After the Base Station has received all the data from the cluster heads a round is complete. There are two phases in each round in the LEACH protocol: the setup phase and the steady-state phase. In the setup phase, the clusters are organized and CHs (Cluster Heads) are selected. In the steady-state phase, the transfer of actual data to the Base Station (BS) takes place. LEACH randomly selects a few sensor nodes as cluster heads (CHs), so a node with lower energy has same probability as nodes with higher energy. As a result, the node with low energy will deplete its energy much faster than other nodes with higher energy. LEACH rotates this role to evenly distribute the energy load among the sensors in the network. Many papers proposed reasonable cluster heads selection method, such as BCDCP (Base Station Controlled Dynamic Clustering Protocol) [11], MECH (Maximum Energy Cluster Head) [10]. But those hierarchical routing protocol are based on the premise that all node in the network can directly connect with the Base Station. In large scale Wireless Sensor Networks, many nodes may not have the ability to connect with the Base Station directly. Although LEACH is able to increase the network lifetime, it has weaknesses: CHs need more energy dissipation to send data to the Base Station, if number of sensor nodes is highest and node location is far from base station, because every cluster head sends data directly to the Base Station.

B. BCDCP

In BCDCP every node has similar clustering like LEACH. First, one cluster head is randomly chosen to forward data to base station. Because the cluster head in each cluster will send data to the cluster head closest to it based on minimum spanning tree, this burdens the routing to the base station (BS). The cluster heads send data to the selected cluster head. And CH sends the data to BS. Thus, BCDCP [8] is at disadvantage when there is a large number of sensor node and cluster heads. Due to the large number, sensor nodes need more energy for intra and inter cluster data transmission. This creates an unbalance in energy consumption and decreases network lifetime. We can see that BCDCP [11] is more efficient than LEACH in two aspects; first by introducing Minimal Spanning Tree (MST) [3] to connect to CH which randomly chooses a leader to send data to sink. Second, BCDCP makes the best use of high energy BS to choose CHs and form cluster by interactive cluster splitting algorithm. Thus BCDCP reduces far more energy dissipation of network than LEACH, but both have weakness in small-scale network. LEACH and BCDCP work well to route data energy efficiently but their network topology constrains them in large scale network. Because the club topology in clusters is a one-hop route scheme, it is not appropriate for long distance wireless communication.

C. HEED (Hybrid Energy Efficient Distributed)

In HEED [9] introduce HEED [17] introduces a variable known as cluster radius which defines the transmission power to be used for intra-cluster broadcast. The initial probability for each node to become a tentative cluster head depends on its residual energy, and final heads are selected according to the intra-cluster communication cost. HEED terminates within a constant number of iterations, and achieves fairly uniform distribution of cluster heads across the network. In Heed have weakness, when the node have higher energy but the distance far from BS or the node have lower energy but close distance to Base Station. In this case node need more energy consumption and decrease network lifetime of sensor node in WSN.

D. An Unequal Clustering Routing (UCR) Protocol in WSN

Clustering provides an effective method for prolonging the lifetime of a wireless sensor network. Current clustering algorithms usually utilize two techniques: selecting cluster heads with more residual energy, and rotating cluster heads periodically to distribute the energy consumption among nodes in each cluster and extend the network lifetime. However, they rarely consider the hot spot problem in multi-hop sensor networks. When cluster heads cooperate with each other to forward their data to the base station, the cluster heads closer to the base station are burdened with heavier relay traffic and tend to die much faster, leaving areas of the network uncovered and causing network partitions. In Unequal Cluster-based Routing (UCR) Protocol [1, 2] it groups the nodes into clusters of unequal sizes. Cluster heads closer to the base station have smaller cluster sizes than those farther from the base station, thus they can preserve some energy for forwarding the inter-cluster data. A greedy geographic and energy-aware routing protocol is designed for the inter-cluster communication, which considers the tradeoff between the energy cost of relay paths and the residual energy of relay nodes. Even though UCR is better than LEACH and BCDCP, it has weakness. The node closer to BS will burn while sending data to BS because node closer to BS sends data directly to BS. And to maintain the routing, all nodes need to rotate so energy is required to send data to BS.

III. The Proposed Solution

The main problem that is dealt in this paper based on the disadvantages of BCDCP, HEED and UCR. So challenge presented how to combine UCR with addition re-cluster node each level on multi-hop transmission data to generate a new algorithm Re-cluster Node on Unequal Routing Protocol Wireless Sensor Networks for Improving Energy Efficient (RNUCREE) with consideration residual energy from calculated value node as constraint to create energy efficient and prolong network lifetime in large scale network.

It is well known and understood that the most important part in sensor network is the life span of the nodes. Each node in sensor network would become useless wasting its energy completely since its power totally depend on the embedded battery which is unlikely to be recharged due to the remoteness of the area. A clustering in wireless sensor network means partitioning node into clusters, each one with a cluster head and some ordinary node as a member. In UCR, the operation is divided into rounds where a cluster head rotated among the sensors in each round to distribute the energy consumption across the network. The competitive algorithm where the cluster head selection is primarily based on residual energy of cluster head to reduce the hot spot problem, however, has a weakness. Its' lifetime decreases when too many cluster heads are close to the Base Station. This is because each cluster head delivers packet data to the Base Station, thus causing a waste of energy. The design node in UCR network area are created in a way that the nodes with distance closer to the Base Station are made in smaller sizes than the nodes that are further away from the base station. In this paper, we suggest a new routing protocol aimed to prolong the life span of the firstly dying node in the wireless sensor network.

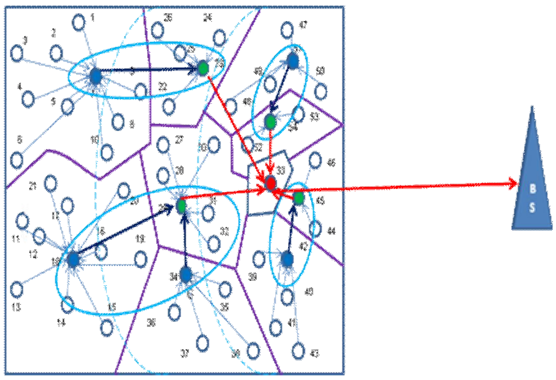

Fig.1. Re-cluster Node on Unequal Clustering Routing Protocol Wireless Sensor Networks for Improving Energy Efficient

We proposed new algorithm Re-cluster Node on Unequal Routing Protocol Wireless Sensor Networks for Improving Energy Efficient (RNUCREE) as in fig.1. The RNUCREE algorithm is derived from the algorithm in UCR [1]. The algorithm is similar to LEACH, but with a different cluster process. In LEACH every Cluster Head (CH) sent data directly to the Base Station while UCR uses multi-hop for sending data to the Base Station.

RNUCREE has the same basic idea of an unequal cluster size (UCR) [12]. The nodes are similarly organized into different sizes of (unequal) cluster, but in this routing the Wireless Sensor Network is added and divided into equal level with different number of nodes in each level and re-cluster process CH in order to make several groups of CH. The node with the highest energy is then chosen as the CHLN. The CH of each cluster in the partition level closer to the CHLN has smaller size compared to the one furthest from the CHLN. The process of transmission data used here is the multi-hop. The node send data to CH for the first time then re-cluster it again to create groups which then will send the data to the CHLN finally to the BS.

IV. The System Model and Assumption

A. The System Model

The network model of routing protocol system is based on following assumptions:

1. The Base Station located far from the sensing field. Sensors and the Base Station are stationary after deployment.
2. Sensors are homogeneous and have the same capability, and each node is assigned with a unique identifier (ID)
3. Sensors are capable of operating in an active node or low power sleeping mode
4. Sensors are able to use power control to vary the amount of transmission power, which depends on the distance to the receiver.

B. The Energy Model

Radio model consist of three parts, which are:

1. Transmitter;
2. Power amplifier;
3. Receiver.

In this Radio model, there are two propagation models which depend on the distance between transmitter and receiver. The models are as follow:

1. Free space (*fs*) model – (d^2 power loss);
2. Two-gray ground (*tg*) propagation model – (d^4 power loss).

We also used a simple model [14] a known formula that is commonly used in many research [1, 2, 4, 6, , 13, 16, 18, 19 and 20] to calculate energy on each node. The energy spent for transmission of a *l*-bit packet from the transmitter to the receiver at a distance *d* is defined as follow:

$$E_{Tx}(l,d) = E_{Tx-elec}(l) + E_{Tx-amp}(l,d)$$

$$E_{Tx}(l,d) = lE_{elec} + l\varepsilon d^{\alpha}$$

$$E_{Tx}(l,d) = \begin{cases} lE_{elec} + l\varepsilon_{fs} d^2, d < d_0 \\ lE_{elec} + l\varepsilon_{tg} d^4, d \geq d_0 \end{cases} \qquad (1)$$

E_{Tx} is Energy Transmission when energy is dissipated in the transmitter of source node. E_{elec} is Energy Electronic where the per bit energy dissipation for running the transceiver circuitry $\varepsilon_{fs}.d^2$ or $\varepsilon_{tg}.d^4$ is equal to the Amplifier Energy depends on transmission distance and acceptable bit-error rate. Where α is the propagation exponent and basically dependent on factor as digital coding and modulation.

The cross over distance d_0 can be obtained from:

$$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \qquad (2)$$

The energy expended to receive message is:

$$E_{Rx}(l) = lR_{elec} \qquad (3)$$

E_{Rx} is energy received when energy is needed to received message.

When received data Cluster head performs data fusion on received data packets, it assumes that the sent information is highly correlated, thus the Cluster Head can always aggregate the data gathered from members into single length-fixed packet. The energy consumed by cluster Head to receive, E_{Rx} and data fusion or aggregate data (E_{DA}) *is* derived in equation below. To receive this message the radio expends energy:

$$E_{Rx}(l) = (l)\, E_{Rx\text{-}elec} = l * E_{elec} = l * E_{elec} + E_{DA} \qquad (4)$$

Each node consumed the energy for transmission data. The total cluster's energy consumption ($E_{cluster}$) is the sum of the energy consumed by member nodes used to send data to the CH and the energy consumed by CH for receiving an *l*-length packet data for aggregating and forwarding *l*-length packet data to the next hop. This is shown:

$$E_{cluster} = E^{CM}_{to\_CH} + E^{CH}_{to\_CHL} \qquad (5)$$

$$E_{cluster} = K_i * ET_x(l,d) + ER_x(l) + E_{DA}$$

$$E_{cluster} = K_i * (lE_{elec} + l\varepsilon d^{\alpha}) + (lE_{elec}) + E_{DA}$$

$$E_{cluster} = K_i + \begin{Bmatrix} lE_{elec} + l\varepsilon_{fs} d^2, d < d_0 \\ lE_{elec} + l\varepsilon_{tg} d^4, d \geq d_0 \end{Bmatrix} + (l * E_{elec}) + E_{DA}$$

$$E_{cluster} = K_i * (p+q) * d^{\alpha} + (l * E_{elec}) + E_{DA}$$

K_i is initial number of member node in the cluster; *l* is initial packet data/bit; E is Energy; CM is Cluster Member; CH is Cluster Head; CHL_i is Cluster Head Level-$_i$.

C. Cluster Head Selection

The Re-cluster Node Unequal Cluster Routing Protocol Wireless Sensor Network for Improving Energy Efficient uses UCR selection method Cluster Heads to get more energy efficiently. At first, we simply select the node with the highest remaining energy as the Cluster Head Leader Node (CHLN) or CH of the cluster. To choose the node that gives the highest value energy node (VN), the following formula is used:

$$VN= val_1\ RE + val_2.d + val_3.\ \Delta s \tag{6}$$

VN is the value energy node; *RE* is the Residual Energy node; *d* is the distance node; *Δs* is the degree's difference of the node.
Degree difference for every node s is:

$$\Delta s = | N(s) - \delta|; \tag{7}$$

N(s) number of neighbor node is:

$$N(s) = Phi * (R_i)^2 * A * N \tag{8}$$

R_i is the Range of the each cluster; N is the number of all nodes in WSN, n is the number of node in level and A is the field area of WSN.
Ideal number cluster node in each level δ is:

$$\delta = N/n \tag{9}$$

The explanations of the equations above are:
The component of value energy node (VN) equation needs to be pre-calculated. These components are:

1) Residual Energy (*RE*), it mainly relates to the sustainable energy consumption. The node with highest residual energy has a higher probability to be a CH.

2) The distance (*d*) of node to the Base Station. Node that has a closer distance to the Base Station has a higher probability to be a Cluster Head. Distances relates to energy consumption of intra and inter cluster communication.

3) The degree difference (Δs) is considered to prevent the CH from overloading as well as providing better efficiency. The system maintains an expected level in the WSN area that will contribute to a better cluster and a better load balancing of value energy node (VN). This is because when a number value of the neighbor node N(s) is closer or equal to δ, it results in a small value of Δs. Small value of degree difference (Δs) means that the size of cluster (mainly depends on the number of member node) is closer to an ideal size of cluster. If RNUCREE algorithm is compared to the UCR algorithm, the differences proposed the number of node in each neighbor level N(s) and the degree of difference of node (Δs) needed for an energy efficient system.

The number of neighbor node N(s) is the ideal number of node in each level in a sensor network. This component chooses a node that communicates with as many nodes as possible in neighbor in each level. This component is included in the calculation of degree difference of node (Δs) in equation (7).

Since the Cluster Head closer to the CHLN would support smaller cluster size, thus more cluster is needed to be produced closer to the CHLN.

To select the competition range, assume R_0 is a predefined maximum competition range, with minimum competition range set to (1-c) R_0 where *c* is a constant coefficient between 0 and 1 hence it is the tentative Cluster Head. Then the tentative competition range R_i can be expressed as a linear function of distance to the BS

$$R_i = \left(1 - c\frac{d_{\max} - d(s_i, BS)}{d_{\max} - d_{\min}} R_0\right) \tag{10}$$

where d_{max} and d_{min} represent the maximum and minimum distance between sensor nodes in the network and the Base Station (BS), $d(s_i, BS)$ represents the distance between sensor node s_i and Base Station where according to equation (10) id *c* is set to 1/3, and R_i varies from 2/3 R_0 to R_0 depending on the distance between sensor node s_i and the BS. After the value of R_i is obtained as the tentative competition range of node compared to threshold, several tentative CH are then randomly selected to compete to the final CH; election tentative node has the same probability T which predefined Threshold. If the value energy node (VN) is less than the Threshold, it then will be a tentative Cluster Head. The broadcasted message information about (ID node (*ID*), Level, Range (*R*), Residual Energy (*RE*), distance (*d*) from node, will then follow. Then all the sensor nodes will be compared with the information in Tables-Information-Message on the Base Station, to select which node is chosen as the Cluster Head or a Node Member.

V. Proposed Re-cluster Node on Unequal Clustering Routing Protocol Wireless Sensor Networks for Improving Energy Efficient (RNUCREE) Algorithm

The RNUCREE Algorithm has three phases will be described:

A. *Initial Formation or Set-up Phase*

Initial formation or set-up phase is the process where all algorithms make routing protocol in the sensor area. In this routing, sensor nodes are homogeny and are deployed in random area. After the random deploy of nodes in the network area, the sensor will then becomes static and the sensor node then broadcast the message with all information that is then saved to the Table-Information-Massage in the BS. The information consists of ID Node (*ID*), Residual Energy (*RE*) node and distance (*d*) from node to Base Station. Sensor node area divides into some equal leveling. Cluster Head Leader Node (CHLN) is selected by choosing the node with the highest energy content amongst the nodes deployed in the sensor network area. CHLN is also a node in this clustering that does not have any member nodes. The process in finding the CH LN begins with checking the node in the first level (L_i), through to the next level (L_{i+1}) up until the last level (L_n). Then the clustering process is carried out with an unequal cluster size.

This process uses a similar idea to that of the UCR however in here the Cluster Head (CH) sends the data firstly to the CHLN, and not directly to the Base Station (BS). Thus the nodes that are closer to the BS here would not carry the burden of having to relay the data traffic sent to the BS.

The algorithm Range R_i in equation (5) is used to calculate the location of sensor node after it deploys in sensor field area; the difference in competition range is used to produce unequal cluster size. The Range of node is used to calculate the number of neighbor node (N(s)) in equation (8) and degree's difference of node (Δs) in equation (7).

The Cluster Head set up a TDMA schedule and transmits it to the nodes in the cluster. When the TDMA schedule is known by all nodes in the cluster, the set up phase is completed and the steady-state phase (data transmission operation) can begin.

B. The Construction Cluster or Steady-Set Phase

Construction Cluster or Steady-Set Phase is a process of data transmission of all nodes member in the clusters that send data to CH. It is the same as the process for intra data transmission in LEACH. Each CH sends data to the CHLN in the beginning, which is to be used for inter cluster multi-hop, then the CHLN sends the data to the BS.

Nodes are organized into CH of different sizes (unequal clustering). The CHs that are closer to the Base Station have smaller size than those that are furthest from the Base Station.

The first process of clustering in this routing is:

1) Wireless Sensor network is divided into an equal level with different number node in each level;

2) After CH is selected then each CH broadcasted a CH_ Message across the network field;

3) The constructed node of the CH (s_{CH}) is completed;

4) The compete of the CH Message from node (s_j). If the distance node "$d(s_i, s_j)$" is less than the maximum Range "*max* $R(R_i,R_j)$" then node (sj) is added to the CH node s_i $(s_i.s_{CH})$;

5) If the condition CH is the same as the initial one, then the node is stored into the Table-CH-Information and changed as the Cluster Member (CM);

6) Cluster member sent data to CH to create clustering and complete the clustering process.

The second process of re-clustering each CH in each level is:

1) Calculate the distance between one CH to the other CH to find the shortest path to the CHLN;

2) Re-clustering of each CH into groups;

3) Using shortest path method used to find the CH LN to similarly chose each CH in a group;

4) The CH is sent to another group in the same or different level using multi-hop, which is a similar process as clustering in BCDCP;

5) Finally the CHLN receives data from the CH and sends data to the Base Station.

To calculate the Energy Consumptions the Energy consumption formula described in equation (10) is used. The process of algorithm is repeated until all nodes died in the field area. To reduce the inefficiencies in energy consumption, a trade off should be made between the residual energy, link cost energy relay node and degree difference of every nodes, in this mechanism while node (s_i) is doing the relay, it chooses its' neighboring eligible node from set S. The node that has a maximum value energy node (VN) in equation (6) is chosen as CH.

C. The Reconstruction Cluster or Reconstruction Phase

Reconstruction Cluster or Reconstruction Phase is the maintenance phase in a routing protocol. In this phase, the process of sending data to the Base Station is completed. If the energy in the CHLN becomes lower than the energy in the neighboring node, it can change and choose another Cluster Head in the same level as the CHLN to send the data to the Base Station. The CHLN can be rotated to balance energy consumption and prolong network lifetime.

An example of this can be seen in Figure 2 where the CHLN "Node 33" has a lower energy value than another CH Node in this level which happened because the energy decreases every time a CHLN is sending data to the BS. When the energy in CH LN is decreasing ("node 33"), its' position is then changed to another CH, in this case "Node 45".

The maintaining process is carried out to ensure that the CHLN chosen is the CH with the highest value energy node (VN). After the new CHLN is selected, then all the other CH send its' data to the new CHLN ("node45") as can be seen in Figure 2. The next step in the process is then the new re-clustering to create a CH group. The node in this cluster joins to the new of CH ("node 46") and the last of CHLN ("Node 33") start sending data to the new CHLN ("node 45"). Finally the new CHLN ("node 45") send all of datas to the BS.

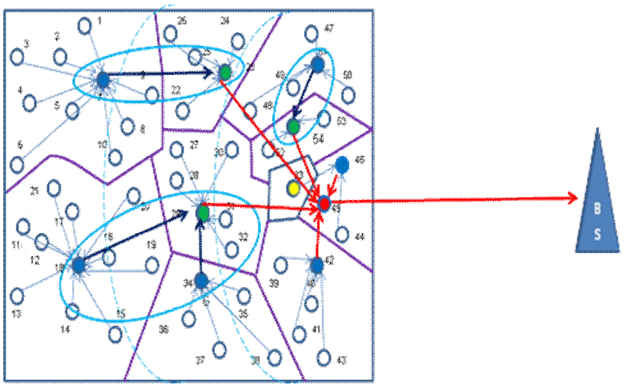

Fig. 2. RNUCREE with new CHLN

VI. ANALYSIS AND SIMULATION RESULT

A. Analysis

The analysis of message complexity of the Cluster Head is the selected algorithm *O(N)* in WSN. The initial formation or set-up phase includes every node broadcasted (*ID, RE, d*) with transmission range and received by all the other nodes to be saved into the Table-Information-Message in the Base Station. The value of energy node is estimated according to the message received. Node with value energy node (*VN*) that is higher than all the other node is elected as the Cluster Head in this cluster and then broadcasted (*ID, RE, d)*. If other condition occurred, then it will process the next command hence exiting from the looping algorithm.

The sensor node set is S ={s_1, s_2, …, s_N}, where |S|=N is a random number of sensor nodes. Sensing area in WSN is divided into Level which is denoted as L_1, L_2,…, L_n. In order to decide whether a node is going to be a Cluster Head or a Cluster Member, it has to wait until it is decided based on the examination of the entire neighbor node where the node with the highest value energy node (*VN*) in the same level will be selected as the Cluster Head. Between of Cluster Head (CH) in the same level will be chosen one which have highest value energy node (VN) as CH receiver of data sending from another CH. The algorithm uses Residual Energy, distance, number of neighbors and different number of nodes as value energy node (*VN*) to search for the best location of node elected as the Cluster Head or Cluster Head Leader Node (CHLN).

B. *Simulation Result*

Since the paper focuses on balancing energy consumption and efficiency of a network's lifetime, the performance of RNUCREE with cluster head characterized by unequal clustering algorithm was evaluated as well as the parameter setting and the energy efficiency of RNUCREE in term of a network life time. The RNUCREE protocol was compared to that of the UCR, BCDCP and HEED. In the simulation, network life time is defined by the number of rounds made by the nodes until the first node die out. Die out of the first node indicates the energy exhaustion that occurs in the first node. One round is defined as an operation that starts at the beginning of cluster formation up until the Base Station receives all the data from the Cluster Head Leader Node in the last level. Calculation of energy dissipation in the simulation is based on equation (5). Parameters of the radio model were based on [1, 2, 6 15, 19, 20 and 13]. The remaining parameters are set as follows; T = 0.2, R_0 = 80 m, c = 0.3, and as shown in Equation (5), TD_MAX =150 m. All parameters used are listed in table 1.

TABLE I
SIMULATION PARAMETERS

Parameter	Value
Network field	(0, 0)–(100,100) m
Base station location	(150, 50) m
N	100
Initial energy	1 J
E_{elec}	50 nJ/bit
ε_{fs}	10 pJ/bit/m^2
E_{tg}	0.0013 pJ/bit/m^4
d_o	87 m
E_{DA}	5 nJ/bit/signal
Data packet size	4000 bits

The result from simulation explanation follows.

a. The Average Energy Dissipation over Number of Rounds

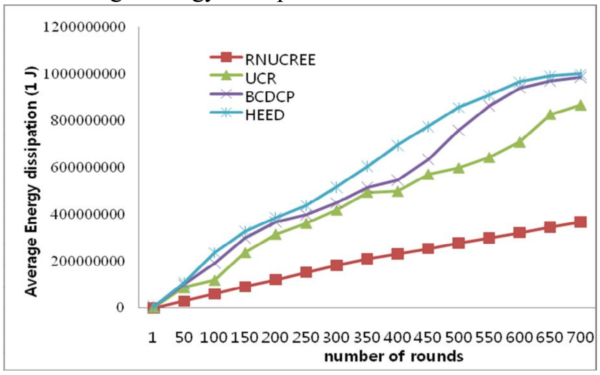

Fig. 3. Average Energy Dissipation over Number of Rounds

Figure 3 shows the average energy dissipation over the number of rounds using RNUCREE protocol compared to UCR, BCDCP and HEED as the existing protocol. RNUCREE reduces energy consumption significantly compared to UCR, BCDCP and HEED due to the re-clustering node and leveling method that uses value energy node (VN) for CH selection algorithm, hence allowing the RNUCREE to efficiently select the cluster heads. It consumes less energy for both intra and inters cluster data transmission between Cluster Head in each level and Cluster Head Leader Node to the Base Station. There is a 56% higher energy dissipation that was obtained by the UCR over RNUCREE, 63% higher energy dissipation that was obtained by BCDCP over RNUCREE and 66% higher energy dissipation that was obtain by HEED over RNUCREE, which means that the RNUCREE consumed about 56% less energy than the UCR, 63% less energy than BCDCP and 66% less than HEED. Furthermore, it can be seen from the graph that the curve of UCR is more fluctuant than that of the RNUCREE. RNUCREE was also shown to have a little variation of energy dissipation between each round. We can also see the fluctuation in the UCR and BCDCP graph in round 400 that translate to a decrease in energy dissipation which then increases back in round 450, while in HEED the graph shows an all round increase. This happened because in UCR protocol, when CH is rotated they uses residual energy and distance. At times when the distance node is far from the base station but the residual energy is higher it creates a problem in choosing the CH after the rotation. On the other hand, BCDCP uses rotation in all clusters while HEED uses initial probability with a constant number of iteration to rotate node. Better performance of RNUCREE over UCR, BCDCP and HEED emphasizes the algorithm's advantage of re-cluster node, level and using value energy node (VN) in term of energy efficiency.

b. The Average Residual Energy versus Number of round

Figure 4 shows the average residual energy over the number of rounds when using RNUCREE protocol compared to using UCR, BCDCP and HEED as the existing protocol. Using RNUCREE protocol produces excess energy compared to UCR, BCDCP and HEED since the Re-cluster Node with Leveling process and the value energy node (VN) Cluster Head Selection is based on the algorithm of RNUCREE which enables it to select for cluster heads more efficiently. That consumes less energy for both intra and inters cluster data transmission between level and groups of re-clustering CH. There is 32% reduction of average energy residual that can be obtain by RNUCREE over UCR, 42% reduction of average energy residual that can be obtain by RNUCREE over BCDCP and 49% reduction of average energy residual that can be obtain by RNUCREE over HEED, that means RNUCREE consumed about 32% less energy than UCR, 42% less energy than BCDCP and 49% less energy than HEED. Furthermore, it can be seen from the graph that the curve of UCR fluctuates more compared to that of the RNUCREE graph. The RNUCREE also shows less residual energy variation between each round. We can see fluctuations occurring in the residual energy of the UCR where it increases in round 350 and 550 then decreases again in round 400and 650. While in BCDCP increase in round 400 and decrease in round 500 to 700 is noted. In HEED however, there is a continuous decrease up until round 700. This happened because when CH is rotated they uses residual energy and distance and also consumes times when the distance is far from the base station. And since the residual energy is higher, this creates a problem while choosing the CH after the rotation. These here is a proof that states how RNUCREE have a better performance over UCR, BCDCP, and HEED emphasizes algorithm's advantage in re-cluster, level and using value energy node (VN) in term of energy efficiency.

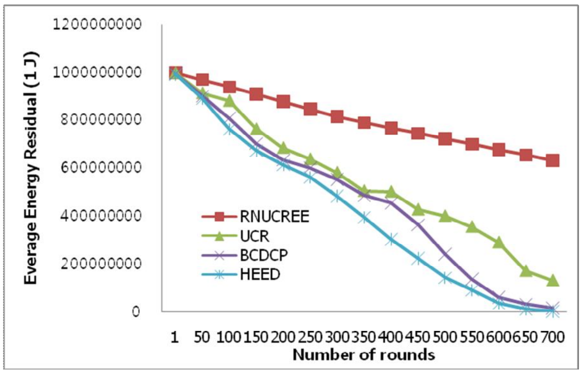

Fig.4. Average Residual Energy versus Number of Rounds

c. Number of sensor nodes alive over time

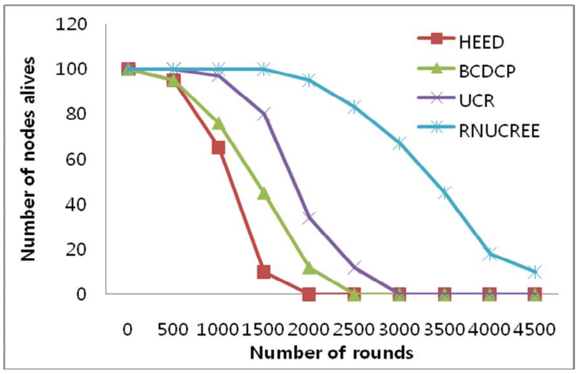

Fig. 5. Network life time: Number of sensor nodes alive over time

Figure 5 shows that RNUCREE clearly improves the network lifetimes (Number of live sensor nodes both at the time the first node dies up until the time the last node dies) over UCR, BCDCP and HEED. In UCR tentative Cluster Head is randomly selected based on their residual energy and distance nodes to The Base Station. The UCR Cluster Heads that are close to the Base Station have smaller cluster sizes than those further from the Base Station. In BCDCP tentative Cluster Head are randomly selected based on their residual energy but the Cluster Head close to the Base Station must not be smaller in cluster sizes than those further from the Base Station. In HEED the initial probability for each node to become a tentative Cluster Head depends on its Residual Energy, and the final heads are selected according to the intra-cluster communication cost. In RNUCREE besides using the same component with UCR, the algorithm has an added value energy node (VN) component for selecting Cluster Head in each level of the sensor area as well as re-clustering to make grouping of CH. RNUCREE also performs the action of sending data to the CHLN. Furthermore, since in UCR, BCDCP and HEED the energy consumption of the CH is not well balanced, this causes the node in the hot spot to die much faster in UCR, BCDCP and HEED. This problem is avoided in RNUCREE by its' smaller interval before the time when the first node dies, as well as the use of Re-cluster, Level and value energy node (VN) selection of CH to create a more balance energy consumption between the Cluster Head in each level. The RNUCREE also performs a rotation of the CH or the CHLN for its reconstruction in the field area of WSN. From figure 5, it can be seen that all of the nodes round of the UCR, BCDCP and HEED died faster than the RNUCREE. The UCR died faster by 41%, the BCDCP by 54%, and the HEED by 62%, all compared to RNUCREE. In other words, the average number of live sensors round in RNUCREE is 41% higher than UCR, 54% higher than BCDCP and 61% higher than HEED. Hence, RNUCREE prolongs network lifetimes 41% higher than the UCR, 54% higher than the BCDCP and 61% higher than HEED. Smaller interval before the time when the first node dies implies that RNUCREE has successfully mitigated the hot spot problem and creates a balanced energy consumption that implies energy efficiency and prolonged network lifetime.

d. The Network lifetime: distance node to the Base Station

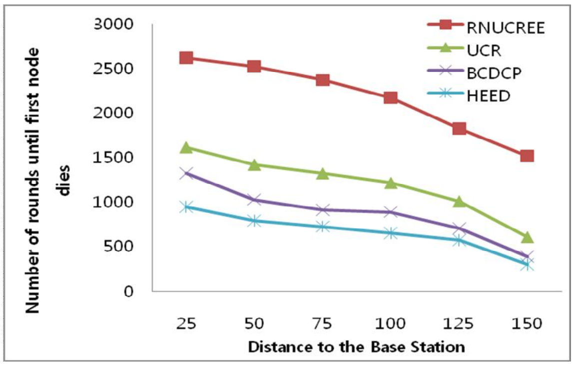

Fig 6. Network life time: first node dies versus distance to the Base Station

Figure 6 shows the network lifetime with the number of rounds since the network is first created until the round when the first node dies versus the distance of the node to the Base Station. It is examined to study the impact of the distance to the Base Station on the network lifetime. The distance is computed from the Base Station to the closest point of the network field. The measurement of the average distance of nodes and the number of rounds completed until the first node dies were compared to see the extend of a network lifetime in the application of RNUCREE. Although the network lifetime decreases when the distance increases, RNUCREE has shown a better result than the UCR, BCDCP and HEED. RNUCREE has a 45% higher network lifetime over UCR, 60% higher network lifetime over BCDCP and 69% higher network lifetime over HEED. RNUCREE also achieved about 1.8 times more network lifetime compared to UCR, 2.5 times network lifetime compared to BCDCP and 3 times network lifetime compared to HEED at all of the base stations' locations that have been simulated. It suggests that RNUCREE is more energy efficient than UCR although they both uses multi-hop routing inter-cluster communication.

VII. Conclusion

This paper considers energy efficient in the hot spot problem that arises on multi-hop routing clustered sensor network to balance energy consumption in inter cluster communication and to prolong network lifetime in WSN. Based on the current argument, under normal circumstances Residual Energy and Node Location are not sufficient in maintaining balanced energy consumption within a network. This is due to the fact that when a node is located close to the base station, its' Residual Energy would be low. And normally, a node would have a high value residual energy only when it is placed far away from the Base Station. Hence we have proposed the Re-cluster Node on Unequal Clustering Routing Protocol Wireless Sensor Networks for Improving Energy Efficient.

We assumed that Base station has all the information including the sensor nodes, residual energy and the distance of node that have been defined. The network is divided into level and re-clusters node to make CH into groups. Clusters closer to the Base Station have smaller cluster size than the further ones. RNUCREE have three phases: initial formation cluster or set-up phase, construction cluster or steady-set phase and reconstruction cluster.

As one node is chosen as the Cluster Head Leader Node (CHLN), it functions as a central for data transmission before the data is sent to the Base Station. The CHLN is the node with the highest energy in the field area. The Cluster Head closer to the CHLN has smaller cluster size than further ones hence they can preserve energy for inter cluster data forwarding. We assumed sensor node can compute approximate distance to another node based on received signal strength. The Cluster Head selected uses value energy node (VN) formula which has a component of residual energy, distance node to base station, and degree difference of node.

Value energy node (VN) is used to ensure that the CHs do not get overloaded and so that the efficiency of the system is maintained. Its' re-clustering node and leveling action contributes to a better cluster and balanced load function in VN. Because when the value of degrees difference (Δs) between the nodes within a cluster is similar or equal to each other, this can result in a small value of different number node. Small value of degree difference means that the size of the cluster which mainly depends on the number of member node is close to an ideal size of cluster. The purpose of the numbering of neighbor node *N(s)* is for efficiency and energy saving as it is always intended to have the CH at the correct relative location.

The advantage of using the value energy node (VN) is that it enables the network to overcome the hot spot problem and to balance energy consumption between every node. The rotation of the Cluster Head allows the selection of different nodes depending on the calculated of value energy node (VN). When the energy in CHLN decreases, the Cluster Head rotates and changes the dying CHLN at that level with another CH. This process saves energy consumption of node and prolong network lifetime, because it does not rotate all the nodes in the field area of WSN. The simulation results have shown that RNUCREE number of live sensor node over time compared with the UCR, BCDCP and HEED is higher, thus improving RNUCREE is highest energy efficient, balanced energy consumption and prolongs network lifetime in WSN.

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