International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869, Volume-3, Issue-5, May 2015

Fault Link Scanner in Energy Efficient Cluster based Wireless Sensor Networks

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***Abstract*— Advancement in electronics and WSNs has enabled the improvement of lower cost and lower power, high transmission. Also in large scale wireless networks, dynamic monitoring of system degradation and detection of bad links proves very difficult. One of the most important challenges in WSN is to design fault link scanner in cluster based energy efficient wireless sensor network to increase the network efficiency, reliability and lifetime. As hot spot in WSNs leads the location having heavy traffic load. Sensor nodes in such area drain there energy very quickly, leading in link failure of network services and affect WSNs performance including transmitting and receiving of information. Cluster based routing algorithms is utilized to perform energy-efficient routing in WSN and link scanner sequentially checks all potential links incurs high transmission. In cluster based routing algorithm, cluster head (CH) represents all nodes in the cluster and data is collected from them. To balance the traffic load and the energy consumption in the network, the cluster size should be carefully determined and the CH should be rotated among all nodes within the cluster in the network. In this paper, we propose fault link scanner in energy efficient cluster based wireless sensor network algorithm. In WSNs most of energy is consumed for transmission and reception and energy is non linear function (exponential) of transmission range. So, in fault link scanner in energy efficient cluster based wireless sensor network election of CH and faulty link detection is based onto the residual energy and optimal CH distance of every node. In addition, Link fails in the network if the energy of sensor node falls below threshold value is considered and next shortest routing path is used for transmission for increasing the network lifetime and reliability. Furthermore, the energy consumption of being a CH is equally spread among the cluster members. Performance results show fault link scanner in energy efficient cluster based wireless sensor network scheme reduces the end to end energy consumption, prolong the network lifetime and increase reliability of multi hop network compared to the well-known clustering algorithms LEACH.**

***Index Terms*— Clustering, Energy efficiency Network lifetime, Fault link, Routing, and Wireless Sensor Networks.**

I. Introduction

A wireless sensor network is a set of sensors deployed in a sensor field, to monitor specific parameters of the environment, measure those parameters and collect the data related to that phenomena. The sensors are small devices with limited resources: limited battery power, low memory, little computing capability, very low data rates, low bandwidth processing, variable link quality, less reliable data transmission etc. Despite their constraints, when the sensors are deployed in large numbers, they can provide us with very real information of the field being sensed. Sensor nodes are able to carry out sensing, data pro-cessing, and communicating components, making it feasible for a wide range of promising applications, such as: environ-mental monitoring (e.g., humidity, temperature), disaster and health care areas providing relief, conferencing, file exchange, commercial applications including controlling product quality, military applications and managing inventory [1]. The reliability of individual links' transmissions is crucial in these applications. For these purposes, sensors are usually deployed densely and operated autonomously. Furthermore, sensor nodes are normally battery-powered, and left alone makes it quite challenging to recharge or replace node batteries. Hence, one of the important problems in WSNs is how to prolong network lifetime with constrained energy resource. If each and every node starts to transmit and receive data in the network, great data collisions and congestions will be experienced. Therefore, the nodes in WSNs will run out of energy very quickly.

As a result, the energy of each sensor nodes being a major limitation. Also, reliability of individual links transmissions is critical in WSNs, the data transmissions must be reliable to avoid false alarms and missed detections. Compared to the wired networks, it seems much more essential to detect link faults rather than node faults in WSNs. A wireless link itself virtually exists, which means we can't directly observe and assess whether it performs well or not [5], [6]. Therefore, faulty link detection becomes one of the most challenging issues in multi-hop network than that of single-hop network diagnosis. Indeed, according to the status of a link, we are able to explain many failures like packet loss, routing failure, partition and so on. Notably, link performance actually reflects a network's reliability and bottleneck if exist [2].The research in data centric WSNs is concentrated on selection of network architecture and energy efficient data gathering, as a backbone of routing protocol and data aggregation mechanism, plays a important role in achieving it. All aspects, including protocols, architecture, algorithms and circuits, must be made energy efficient and reliable with fault links in transmission to prolong the network lifetime of the sensor node. At routing layer, the main purpose is to determine ways for energy efficient route and reliable forwarding of data from the source nodes to the sink to save energy consumption and increase network lifetime. We aims on the network level energy preservation protocols and algorithms along with detection of fault links and correcting them in this paper. Due to different inherent characteristics of the WSNs that differentiates from other known networks such as cellular or mobile ad hoc networks makes very challenging for designing routing protocols. Furthermore, there may also be other critically-located sensors not necessarily close to data sinks, which carry the burden of relaying large amounts of data traffic, especially when multiple high-rate routes pass through these sensors. Such nodes are usually frequently chosen to be data relays by routing algorithms and may serve a large portion of the network traffic, due to their convenient locations. Thus, avoiding the failure of such nodes caused by early energy depletion is critical to ensure a sufficiently long network lifetime[2].

Routing algorithms can be widely classified into two categories . They are direct routing and indirect routing. In direct routing algorithms [6], [7] each nodes in WSNs directly forward the gathered data to the sink node. Contrarily, indirect routing algorithms are those clustering algorithm that creates different clusters of sensor nodes in WSNs. Clustering is suggested to WSNs due to its advantages of energy saving, network scalability and network topology stability[8],[9] . Furthermore, clustering technique

decreases the overheads occurred due to communication, thereby reducing interferences and energy consumptions among network nodes. In addition, clustering improves the efficiency of data relaying by decreasing number of nodes required to forward data in the WSNs, using data aggregation at CHs by intra cluster communication decreases overall packet loses. However, clustering algorithms have some disadvantages compared to other mechanisms, such as additional overheads during CH selection, cluster formation, and assignment process.

Clustering through formation of hierarchical WSNs helps in efficient use of limited energy of sensor nodes and hence improves network lifetime. Clustering has a potential impact on WSNs applications where a huge number of ad hoc sensor nodes are distributed for sensing purposes. In conventional clustering, the nodes in WSNs is divided into small groups called clusters and from each cluster one node is selected as CH which then grant other nodes to join to create the cluster. During information collection phase CH gathers information from all of its cluster members and after its aggregation forwards to the next adjacent CH and last to the sink node. While using conventional clustering, sensor nodes elected as CH are believed to absorb more energy as compared to other cluster members, due to their long range or multi hop transmissions to the sink node, and may lead to an irregular energy consumption of sensor nodes in the WSNs. This problem can be avoided by efficient rotation of CH nodes and provided a major breakthrough in cluster based data collection in WSNs. Furthermore, regular re-election of CHs within clusters depending on their remaining energy is a possible way to reduce the total energy consumption of every cluster. Also, in large-scale wireless sensor networks, it proves very difficult to dynamically monitor system degradation and detect bad links. Faulty link detection plays a critical role in network diagnosis. Indeed, a destructive node impacts its links' performances including transmitting and receiving. Similarly, other potential network bottlenecks such as network partition and routing errors can be detected by link scan; sequentially checking all potential links incurs high transmission and storage cost [2]. Furthermore, the hot-spot issue is a major concern around sink nodes where large amounts of data are merged. In fact, as the hop distance to a sink decreases, the traffic on CHs quickly intensify. Hence, there is an obvious relationship between the hop-distance to a sink node and the amount of data that has to be forwarded. This uneven energy consumption of the CH node can rapidly disconnect the entire WSNs if the communications are extended. Many proposals have concentrated on these problems. Also however, they have their own performance limitation. We proposed fault link scanner in energy efficient cluster based WSN aimed at prolonging the overall network lifetime, energy efficiency, reliability and efficiency. With our scheme, the CH election depends upon the optimal cluster head distance and remaining energy of the sensor node and the fault link detection is based onto the residual energy of the sensor node for the current routing.

The remainder of the paper is organized as follows. In Section 2, we continue with related work. Section 3, shows the radio model for energy consumption. In Section 4, we derive the optimal cluster head distance. In Section 5, we propose the new scheme as fault link scanner in energy efficient cluster based WSN. Section 6 shows the performance of the proposed scheme and we provide conclusions in Section 7.

II. RELATED WORK

Many different approaches have been carried out to design feasible WSNs. Energy conservation and fault link detection is crucial to prolong the network lifetime of WSNs. Many approaches for energy efficient routing and link failure have been proposed to reduce energy consumption and network reliability individually. There is no routing algorithm present which uses both the concept in designing. One alternative approach to conserve energy is using clustering technique [10] and detection of the link failure along with corrective action. In addition, when scalability is considered to be a major problem when network density is of hundreds and thousands of nodes then clustering is considered to be a useful technique. In various WSNs applications routing efficiency is considered important for energy efficiency, load balancing, and data fusion [11]. In this paper we are concern about CH selection and fault link detection and discuss some of the associated schemes individually. In clustering, only CHs need to communicate with the sink node via multihop communication. Also multi-hop networks always suffer more harm than single hop networks due to link failures. But detection of faulty link is more difficult in multi hop networks compared to single hop network due to their topology features. Low Energy Adaptive Clustering Hierarchy [7] is a well known clustering algorithm in which the CH in cluster is periodically rotated among members to achieve energy balance. However, this scheme showed only partial success, it needs a new cluster formation process at every section. With cluster formation, in each cluster with random probability a new CH node is re-elected, and from the promising CH candidates, the optimal node should be adaptively optimized for minimum communication distances to the maximum number of one hop neighbors. This only produces worst suboptimal solution due to cluster re-election process, which results in the nodes to spend additional delay and energy. In addition, LEACH requires all CHs to perform single hop transmissions to the networks sink, thus it suffers from the cost of long-range transmissions. As a result, the CHs that are further away from the sink deplete their energy much earlier than others.

In [12], authors proposed a protocol called HEED where a node uses its two parameters communication cost between cluster members and remaining energy to probabilistically elect itself to become a CH. HEED is a multi hop clustering algorithm for WSNs. Remaining energy of each sensor node is used to probabilistically choose the first set of CHs, as usually performed in other clustering techniques. In [12], communication cost between cluster members shows the node degree or nodes proximity to the neighbor and is main parameter that decides whether to join the cluster. However, hot spot issue in HEED appears in areas that are close to the sink, as nodes in such areas need to relay incoming traffic from other parts of the network. Furthermore, knowledge of the whole WSNs is necessary to determine communication cost between cluster members. HEED is a distributed clustering mechanism in which CH nodes are picked from the WSNs. HEEDs CH selection parameter is a hybrid of energy and communication cost. In EEUC (Energy- Efficient Unequal Clustering) [13], the cluster sizes with longer distance from sink node is larger compared to the cluster sizes near to the sink node. This was proposed to save energy in communication between cluster members and CHs. However, extra overheads caused due to the additional data aggregation in all nodes degrade the efficiency of the network in a multihop environment. Furthermore, the energy of CH closer to sink node tend to deplete quickly, because they forward more data traffic compared to other sensor nodes.

Algorithm for cluster establishment (ACE) [14] uses a protocol to cluster the WSNs in to constant number of iterations, where node degree is used as the critical parameter. In [14], one way of CH selection is when many nodes in its neighbourhood do not belong to any cluster, then it elect itself as a CH. Furthermore, these numbers of iterations were enough to achieve a stable average cluster size. In Addition, the two functional components of ACE are generation of new clusters and migration of existing ones. However, when the communication cost requirements and energy consumptions are satisfying, then its hard to detect the number of iterations required to achieve it. Moreover, additional overheads are caused due to migratory mechanism in ACE.

In Power-efficient and adaptive clustering hierarchy (PEACH) [15], cluster generation is performed by using overhearing characteristics of wireless communication to avoid additional overheads and support adaptive multi-level clustering. In WSNs, overhearing a node can recognize the source and the sink of messages transmitted by the neighbor nodes. In [15], it can remarkably reduce energy consumption of each node, increase the network lifetime, and is less affected by the distribution of sensor nodes compared with existing clustering protocols. In brief, total energy consumption in multihop data delivery in clustered WSNs should be analyzed comprehensively. Such an analysis should be based on an clustering protocol and energy-efficient data routing that prevent using network-wide broadcasts and reduces additional overhead. Furthermore, to affirm the load balance in a WSNs, this trade-off between the distance to the sink from source and the cluster size should be studied analytically, before setting up the network hierarchy.

Although single link failures are more common, multiple link failures occur due to shared risks such as failure of a link while another link is under maintenance, or natural disasters that cause links traversing a region to fail. In [16], the authors use monitoring paths and cycles to localize single link and Shared Risk Link Group (SRLG) failures. They also prove that (k+2)-edge connectivity1 was necessary and sufficient to uniquely localize all SRLG failures involving up to k links with one monitor. In practice, however, not all sensor networks can satisfy this strict condition, especially in the cases we spread the sensor nodes randomly in the area of interest. In addition, in most cases we are not allowed to set any more monitors after the deployment. What we expect is to utilize the rule-free probes (i.e., without computing the exact probing paths) to achieve our detection.

III. RADIO MODEL FOR ENERGY CONSUMPTION

In this paper we use a radio model proposed in [7] as radio energy model to measure consumption of energy in the network for proposed fault link scanner in energy efficient cluster based WSN algorithm. In [7], the radio model is a combination of three main models: transmitter, the receiver and the power amplifier. The energy consumption by the transmitter is combination of transmitter circuitry and the power amplifier, and the energy consumed in receiver for receiving data consists of the receiver circuitry only [7]. When a packet is transmitted from a transmitter to a receiver, where the distance between them is d, the received signal power at the receiver is given as [18] :

$$p_r(d) = \frac{p_t G_t G_r \lambda^2}{(4\pi^2) d^\beta Loss} \quad (1)$$

where Gr and Gt are gain of receiver and transmitter respectively. Furthermore, $Loss$ represents any additional losses in the packet transmission and λ represents carrier wavelength .The propagation loss factor β, which is typically varies between 2 and 4. Hence, considering Gt = Gr =1, and $Loss$ =1, the received signal power at the receiver is

$$p_{r(d)} = \frac{p_{t\lambda^2}}{(4\pi^2) d^\beta} \quad (2)$$

To receive the data packets successfully, the received signal power at the receiver must be above a minimum threshold power ($pthr$). Hence, the transmitter signal power at the transmitter must be above this threshold. Hence, based on [1] the energy absorbed per second by a sensor node in three states given as:

$$E_t = (e_\varepsilon + e_a R^\beta) N_t$$
$$E_r = (e_\varepsilon) N_r \quad (3)$$
$$E_l = (1 - T_t - T_r) = e_\varepsilon d_R (1 - T_t - T_r)$$

where e_a is considered as the $energy/bit$ absorbed in the RF amplifier of transmitter, d_R is the transmit or receive data rate ($bit/second$) of each network node, e_ε is the $energy/bit$ consumed by transmitter electronics circuitry, T_t and T_r is the time for receiving and transmitting the data traffic between the cluster and N_t and N_r are the traffic data bits transmitted and received respectively.

The amount of time spent in one second for listening to the radio channel is represented as

$T_l = 1 - T_t - T_r, (0 \leq T_l \leq 1),$
Thus
$0 \leq (1 - N_t d_R - N_r d_R \leq 1)$

Considering the static data traffic environment, where Nt = Nr = , the value of N is represented in equation (4) as:

$$0 \leq N \leq \frac{1}{2} \times d_R \times 1 \; second \qquad (4)$$

As a result, $\frac{1}{2} \times d_R bits$ represents the maximum amount of data that can be transmitted in each cluster per second, when nodes in the cluster don't listen to the radio environment and spend half a second for receiving the packets and another half for transmitting the packets. In simulations, we consider d_R =2.5×105bps, the maximum data that can be relayed in WSNs based on equation (4) is 1.25 × $10^5 bits$ per second. Where the energy consumed for listening to the radio environment per second is represented as e_l, e_e *and* e_a are obtained from the design characteristics of the transceivers, the specific values of e_e is 3.32 × $10^{-7} J/bit$.When $pthr$ =2× 10^{-9} w, d_R =2.5× 10^5 bps,f =2.4× 10^9 Hz,and ea ≈ 8×$10^{-11} J/bit/m2$ [1].

IV. OPTIMAL CLUSTER HEAD DISTANCE

A. *In an end-to-end multi-hop transmission considering a equal hexagonal cell, the best route between the source and sink node is the direct line between them, where intermediate nodes are properly deployed (the nodes exists whenever needed). As shown in Fig,1, the data packet is transmitted from the source to the sink node, where L is the distance between them. Assume that the distance between each cluster head is D, m is the number of cluster heads and is derived as* $\mathbf{R} = \sqrt{\mathbf{13.r}}$, $\mathbf{D} = \sqrt{\mathbf{3.r}}$,

$$m = \frac{L}{D} = \frac{L}{\sqrt{3.r}} \qquad (5)$$

In this paper, we consider static traffic in the network. Network is considered to have static traffic when traffic rate following along the network is constant. In hexagonal cluster model, r represents the side of the hexagon and the optimal cluster head distance. While R is the maximum transmission range of node and the range should be such that two nodes located anywhere in adjacent cluster should be able to transmit and receive data. The energy consumed for the end-to-end multihop transmission based on the energy consumption model given as[1]:

$$E_t = m.E_i = \frac{L}{\sqrt{3r}}\left[2e_e + e_a\left(\sqrt{13r}^{\beta}\right)\right]N \qquad (6)$$

In order to find the minimum energy consumption, we take the first derivative of E_t with respect to optimal cluster head distance, and let it be equal to 0. The optimal cluster head distance r is derived as:

$$r = \frac{1}{\sqrt{13}}\left(\frac{2e_e}{(\beta-1)e_a}\right)^{\frac{1}{\beta}}$$

$$r = \frac{1}{\sqrt{13}}\left(\frac{2e_e\lambda^2 d_R}{(\beta-1)P_{THR}(4\pi)^2}\right)^{\frac{1}{\beta}} \qquad (7)$$

By using correct transceiver parameters, equation (7) shows that the optimal cluster head location r, depends on the propagation loss factor β with values ranging from 2 to 4 and the network traffic. The relationship between propagation loss factor β and r is shown Fig. 2.

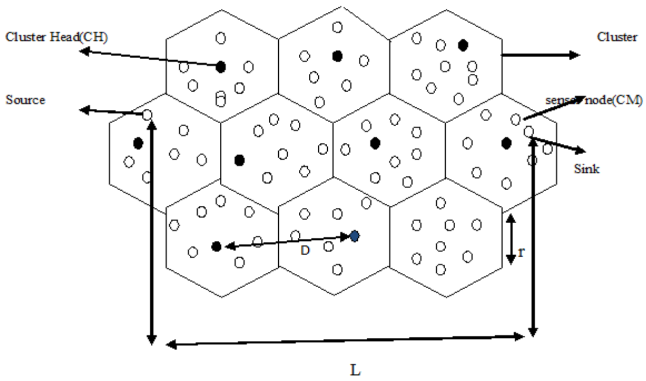

Fig.1. Cluster based End-End Multihop transmission

In Fig. 2, the optimal cluster head distance and the side of the cell decreases when the propagation loss factor β increases while network traffic N is constant. Furthermore, there is a trade off between the number of cluster heads and energy consumed in each
cluster head. Based on equation (6), when the number of cluster heads m is large, the size of the side of cluster becomes small, and then energy consumption is dominated by the fixed energy consumption of each cluster head. When the number of cluster heads is decreases, the size of the cluster side increases, and energy consumption is dominated by the cluster head because the energy consumed in the transmitter amplifier of each cluster head increases quickly.

V. FAULT LINK SCANNER IN ENERGY EFFICIENT CLUSTER BASED WSN

In this section, we explain the procedure of the Fault Link Scanner in Energy Efficient Cluster based WSN that is proposed in this paper. The fault link scanner in energy efficient cluster based WSN employ the self organization technique for routing and clustering of WSNs. Furthermore, here a network of homogeneous sensor nodes are considered. In the proposed scheme, each node has to perform the basic task of sensing the field parameters, form data packets, and communicate with the cluster head. Clustering is defined as the grouping of similar objects or data. Clustering in WSNs means partitioning of nodes in network into different clusters. The network model considered in this paper is a hexagonal structure shown in Fig. 1 with source nodes and dynamic sink node. Sink node is constant and fixed for each simulation. Sensor nodes are homogeneous in nature, are assigned with a unique identifier and have same capability. Nodes can use transmit power control to change the amount of power transmitted according to the distance of the receiver. In the Fault Link Scanner in Energy Efficient Cluster based WSN, each nodes shares information about the current energy state and distance with only its one hop neighbors. The nodes of Fault Link Scanner in Energy Efficient Cluster based WSN will be in four different modes. The four modes are described as follows.

Cluster Head: While in CH mode, it gathers and aggregate information from its members and sends or receive message between the adjacent CHs or to sink node at regular intervals. In addition, it selects the next adjacent CH node where the data to be transferred. In hierarchical routing protocols, CHs are responsible for gathering, aggregating and forwarding the data to the sink. Thus, they are responsible for conveying the complete information of its cluster members. CH is then responsible to transmit this data towards the sink. There are two types of communication for CH, Intra cluster communication and Inter cluster communication. Intra

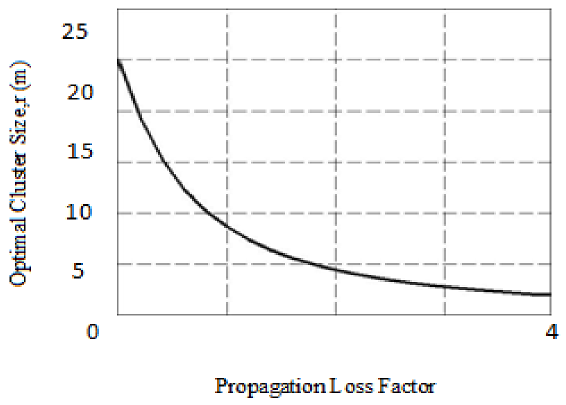

Fig 2. Optimal Cluster Head distance r variation with β

cluster communication is between CH and its cluster members. Inter cluster communication is between CH and its adjacent CHs.

Cluster Member: A cluster member is a member that belongs to a particular cluster, it regularly transmits the collected information to its CH.

Dead Node: This is a state in which sensor node cannot operate anymore because its energy has been depleted completely or it has broken down. The node cannot either transmit or receive the data. In addition, the node is considered to be in this state when its residual energy (E_r) is below 0.005 .

Isolated Node: This means node doesn't have any one hop neighbors either to transmit or receive the data. In this state, node is disconnected from the network.

Operation in Fault Link Scanner in Energy Efficient Cluster based WSN is divided into section. We perform energy aware and optimal distance based clustering in sections and each section results in selection of different CH. One section means one end to-end packet delivery. The CH is rotated among sensors in each section and distributes the energy consumption across the networks. Fault Link Scanner in Energy Efficient Cluster based WSN is divided into four stage as cluster formation, cluster head selection, routing and fault link detection along with corrective action. The first stage is the cluster formation, where members are classified into certain clusters, the second stage is CH selection for particular cluster, the third stage is routing to transmit data and the fourth stage is to detect fault link based on to the residual energy between CH. Data packets is transferred intra cluster between CM and CH in each partition level and inter-cluster between CH leaders in each partition level. In the first stage, the hexagonal based cluster is formed and each member in the network is assigned to different clusters. The Cluster formation is done by using K-means algorithm[19].

For the second stage, the selection of CH, cluster member in each cluster finds the value of equation (8). Where in equation (8), N be the number of one hop neighbor of the sensor node, R_{ij} is the distance between node i and node j, r_i is the average distance from node i to all its one hop neighbors. For different cluster members they have different values.CH is decided based on remaining energy and optimum cluster head distance of node to mitigate hot spot problem. The CHs are selected by a rule of best candidate, which selects a sensor node with an optimal cluster head distance r_i and has maximum remaining energy as a CH for the next section. The Fault Link Scanner in Energy Efficient Cluster based WSN algorithm decides the CH node as the node (within the cluster) that minimizes equation (9). In equation (9), r_i is the average distance to the one neighbor nodes and E_{res} is the remaining energy of the neighbors in the cluster. Intuitively, without taking into the energy balance, some sensor nodes may be selected more frequently as the cluster head nodes, and these nodes energy may be depleted out very quickly compared to other member nodes. Since r_i and E_{res} use different units, so they should be normalized and equation (9) shows the normalized form. The default energy capacity of each node (E_{cap}) is used to normalize E_{res} to define $Eresnormalize$ and ri is normalized with respect to the maximum distance between two nodes in anywhere in the cluster $2r$ to define $rioptnormalize$. The weight function α determines the relative importance placed on these two parameters. This is why it will be an effective way to choose the proper node as CH, combining each of system parameter with weighting factors chosen according application requirements. It means the nodes are decided to be CH depending on combined remaining energy ($Eres$) of node, and the optimal cluster head distance. This node uses the best combination of minimum energy needed to reach neighbors and with maximum residual energy. Therefore, Fault Link Scanner in Energy Efficient Cluster based WSN is higher in concept, reliability and efficiency as will be seen[1].

$$\sum_{j=1}^{N} \frac{R_{ij}}{N} = r^i \quad \forall_i = [1, N] \tag{8}$$

$$f(E_{res}, r^i) = \propto \frac{r^i}{2r} - (1-\propto)\frac{E_{res}}{E_{cap}} \tag{9}$$

The third stage is routing, based on the shortest distance, where intra and inter cluster multi-hop CH routing happens. In intra cluster routing, cluster member sends data to the CH in the same cluster. In inter cluster routing, the data aggregated by CH will be forwarded to adjacent CHs and later forwarded to sink node. The CH will operate at the range of R which is maximum distance between two adjacent cells in a hexagonal structure. In order to send neighbor information with all possible CH candidate within its cluster because CH has sent Next CH signals to optimal cluster head distance. Each CH have its routing table, having distance and current energy information. This routing table upgrades in every section. Furthermore, the CHs create a route based onto the information available in the routing table and select a final CH for relaying to the sink and sends messages to the sink. The 'Final CH' is the cluster head node that have next hop as sink node. Forwarding of messages through the route having shortest distance reduce energy consumption compared to the direct transmission of messages from all CHs to the sink. During the creation of route for inter-cluster routing, the CHs carry out their duties while transforming into the following three modes while relying on different roles.

Initial mode: When Inter cluster routing phase starts, all CHs are initialized as the initial state.

Route broadcasting mode: This is a mode where the signals are broadcasted to establish an inter-cluster route.

Route established mode: In this mode, routes are established from its own routes and those of its neighbors.

The fourth stage is fault link detection in the network. Compared to single-hop networks, faulty link detection is more difficult to proceed in the multi-hop networks due to their dynamic topology features. A packet has to traverse multiple links to the sink, it is for this reason that exactly localizing a faulty link becomes really hard if only on the basis of whether the packet arrives at the sink or not. Faulty link detection in Fault Link Scanner in Energy Efficient Cluster based WSN is based on the residual energy. If the residual energy of any sensor node falls below threshold energy value, the sensor node considered being as dead node and this shows the link failure in the network. The residual energy considered in this paper for simulation is 0.005 joules. The alternate path is to be finding by CH using routing table for transmission of data packet to the sink node if the link failure is detected.

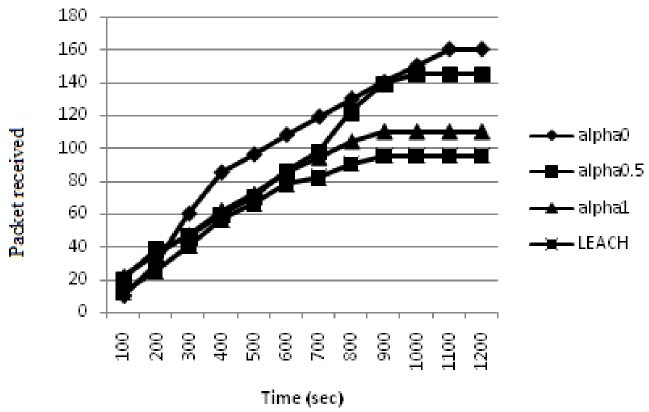

Fig.3. Comparison of data received by sink node

In this paper, we compare the Fault Link Scanner in Energy Efficient Cluster based WSN algorithm with the LEACH [7] (Low-Energy Adaptive Clustering Hierarchy) in terms of the network lifetime, reliability and through put.

VI. SIMULATION EVALUATION

In this section, we evaluate the performance of our pro-posed algorithm (Fault Link Scanner in Energy Efficient Cluster based WSN) using JAVA platform. In simulations, we assume an error free physical layer links and ideal MAC layer. In this paper, we consider the each node's energy consumption as the summation of energy consumed in the transmission and reception of data packets per section. We compare Fault Link Scanner in Energy Efficient Cluster based WSN with LEACH. The results obtained from simulations are average of several tests. The simulation parameters are given in Table I, in which the parameters of radio model are the same as those in [7].

TABLE I
Simulation parameters

Propagation factor(β)	2
Network length	700 m
Simulation time(t)	1200 second
Number of nodes(N)	70
Energy capacity of nodes(E_{cap})	2 joule
Minimum threshold energy(E_{thr})	0.015
Carrier Frequency(f)	$2.4X10^4$ Hz
Data rate(d_R)	$2.5X10^5$ bps

The measurements obtained from simulation are shown in Table II and Table III.

TABLE II
Data received by Sink node

Time	α=0	α=0.5	α=1	LEACH
100	10	20	22	12
200	30	38	35	25
300	60	46	47	40
400	85	59	62	56
500	96	70	72	66
600	108	86	85	78
700	119	98	94	82
800	130	122	104	90
900	140	139	110	95
1000	150	145	110	95
1100	160	145	110	95
1200	160	145	110	95

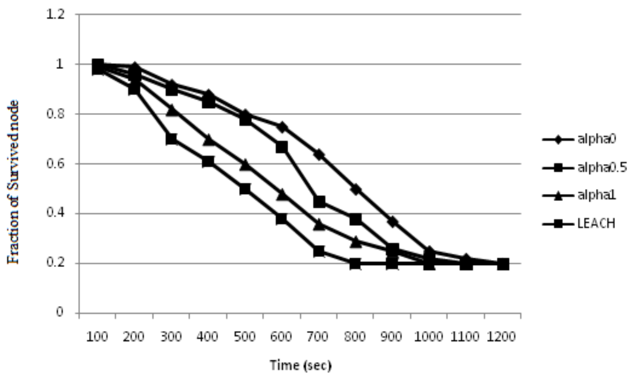

Fig.4. Comparison of Network lifetime

In this paper, we define the lifetime of the network as the time duration before a fraction of nodes run out of energy, and the results from Fig 4 shows the efficiency and reliability of each algorithm. For instance, when the definition of lifetime of network is 40% of nodes completely depletes its energy, the ratio of the lifetimes of network (calculated in loops between 0 until the 40 event) under various algorithms is: LEACH: Fault Link Scanner in Energy Efficient Cluster based WSN (α= 1): Fault Link Scanner in Energy Efficient Cluster based WSN (α = 0.5): Fault Link Scanner in Energy Efficient Cluster based WSN (= 0) = 0.78:0.56:0.55:0.94:1. It shows the Fault Link Scanner in Energy Efficient Cluster based WSN algorithm (when α = 0) has better performance in network lifetime when analyzed with LEACH. Furthermore, the 30% nodes referred to above corresponds to 70% ”fraction of survived nodes” in Fig. 4.

TABLE III
Fraction of survived node

Time	α=0	α=0.5	α=1	LEACH
100	1	1	0.99	0.98
200	0.99	0.96	0.94	0.9
300	0.92	0.9	0.82	0.7
400	0.88	0.85	0.7	0.61
500	0.8	0.78	0.6	0.5
600	0.75	0.67	0.48	0.38
700	0.64	0.45	0.36	0.25
800	0.5	0.38	0.29	0.2
900	0.37	0.26	0.25	0.2
1000	0.25	0.22	0.2	0.2
1100	0.22	0.2	0.2	0.2
1200	0.2	0.2	0.2	0.2

Since LEACH does not take into consideration of the residual energy of nodes, the network lifetime decreases drastically compared to the other algorithms. Therefore, data packets received by sink node using LEACH should be compared. From Fig 3, before the network disconnection with the Fault Link Scanner in Energy Efficient Cluster based WSN (α= 0.5) algorithm, the sink node received much more data packets than the other algorithms. In Fig. 3, the received data with Fault Link Scanner in Energy Efficient Cluster based WSN (α = 0.5 and 0) increases more quickly than the other protocol.

VII. CONCLUSION AND FUTURE WORK

In this paper, we proposed the cluster based energy efficient routing
with fault link detection algorithm (Fault Link Scanner in Energy clustering algorithm to minimize the overhead of control packets and efficient utilization of nodes near sink. Also this algorithm do not verify the virtual link as the detection of faulty link is based onto the residual energy of sensor node in the network. Furthermore, verification is essential to increase network accuracy Efficient Cluster based WSN) to extend the network lifetime, efficiency and reliability, and simulation results are compared with the previous cluster based routing algorithms LEACH. The proposed Fault Link Scanner in Energy Efficient Cluster based WSN algorithm selects the CH node as the member (within the cluster) that minimizes the value of $[\propto \frac{r^t}{2r} - (1-\propto)\frac{E_{cas}}{E_{ras}}]$. Furthermore, this CH node is the node that has the best residual energy and requires the minimum energy to be reached by the cluster members and weight parameter α decides the relative importance placed on these two parameters. In addition, the faulty link is detected based onto the residual energy. The results from simulations show that the Fault Link Scanner in Energy Efficient Cluster based WSN algorithm has best efficiency in terms of both data packets received by sink node and the network lifetime.

Fault Link Scanner in Energy Efficient Cluster based WSN creates additional overhead of control packets during the end-to-end packet transmission and unbalanced utilization of nodes near sink. Our next step is to improve clustering algorithm to minimize the overhead of control packets and efficient utilization of nodes near sink. Also this algorithm does not verify fault link as detection of faulty link is based onto the residual energy of sensor node in the network. Our next step is to improve the accuracy of the network along with reducing of end-to-end packet transmission overheads.

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