A Novel Optimization approaches for fault tolerant routing in wireless sensor networks

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Abstract- In wireless sensor systems (WSNs), to drag out system lifetime the advantages of abusing the sink mobility have been extremely perceived. As per the cluster based strategy, the nodes chose as cluster heads collects information from their group individuals and exchange the data gathered to the base station. For clustering a network many clustering algorithms are designed in previous works. In case of CH nodes fails these clustering algorithms don't have any recovery mechanisms. The energy depletion occurs more quickly because of the increased load at the CH nodes, which results in CH failure. A Backup Cluster Head Fault tolerance (BKCH-FT) has been proposed to solve the issues caused by faults of Cluster Heads. Two parameters named as distance and residual energy are presented to considered to choose BKCH, Based on the proposed method. When there is failure in the elected CHs, this BKCH will act as CH and aggregates the data and send them to the BS. To check the effectiveness of our method compared to the existing methods simulation results through NS2 software are using.

Keywords: WSN, Routing, Fault tolerance, Clustering, Network lifetime, Backup Cluster head.

I. INTRODUCTION

Exceeding an objective area, a wireless sensor network (WSN) usually comprises of hundreds or thousands of sensor nodes that remain installed physically or else accidentally. The sensor node traces the confined information and direct the aforementioned towards a distant base station (BS) named sink. Aimed at the aforementioned impending submissions in ecological supervising, cultivation, health maintenance, disaster managing, domestic and investigation schemes, WSN has been developed as an evolving as well as widespread expertise [1]. Nevertheless, the foremost drawback of WSN remains that the sensor nodes remain power-driven using minor batteries as well as energizing or else substituting the batteries might not stay continually conceivable as the sensor nodes remain organized in intimidating atmosphere aimed at numerous submissions. Hence, energy preservation on behalf of the WSNs remains a stimulating matter aimed at extending system lifetime [2–6].

In the latest centuries, Wireless sensor networks (WSN) have arisen through some of the developing expertise [7-8]. The initial investigation on WSN remains largely focused to the supervising submissions, however by massive propagation in micro-electro-mechanical systems (MEMS) here has remained an extensive consumption of WSNs in dissimilar atmospheres as well as aimed at dissimilar resolutions like Healthcare, Military Surveillance, Smart Grid, in addition to Industrial Automation [9]. They integrate automatic recognizing, embedded processing, as well as wireless broadcast into minute embedded strategies denoted as sensor nodes. Every sensor node remains inhibited towards energy source owing towards the aforementioned restricted as well as non-rechargeable battery source.

However, their processors ensure incomplete involved processing power as well as storing abilities. Such restrictions involve the energy possessions of sensor nodes must be utilized cleverly aimed at the lengthy track of WSNs [10]. Clustering has remained deliberated broadly aimed at the energy preservation of WSNs in the modern past. The clustering method separates the system into minor clusters, wherever every single cluster consumes a Cluster Head (CH) node as well as participant nodes. After the system is subdivided into clusters, the transmission amongst the nodes can remain categorized into: intra-cluster as well as inter-cluster transmission. Non-CH nodes convey their information towards the CH, besides then the CH conveys combined information towards the base station (BS) moreover openly or else over multi-hop steering [11]. Nevertheless, in multi-hop steering, CHs adjacent towards the BS comprised in great inter-cluster transmit circulation burden as well as reduce their energy very rapidly than the additional CH nodes.

Energy preservation of sensor nodes remains the foremost opinion that has remained deliberated expansively in wireless sensor networks (WSNs) [12]. Towards conserving energy of the sensor nodes, Clustering remains one of the utmost effective practices. Certain lead nodes named cluster heads (CHs) remain accountable aimed at promoting combined information towards a isolated sink or else base station (BS) when gathering information commencing their participant sensor nodes in one-hop transmission in a cluster-built WSN. Nevertheless, promoting combined information by multi-hop transmission undergoes after warm spot difficulty [13] wherein the CHs adjoining the sink reduce their energy rapidly as well as expire rapidly as they tolerate extreme information promoting burden. Numerous procedures have remained established for solving the hot spot difficulty [14-17]. Nevertheless, they do not accomplish strong aimed at huge as well as condensed systems. Furthermore, these procedures remain accurately accepting.

Intended for reducing energy intake of the WSNs, Clustering has remained verified to be one of the supreme operative methods. Sensor nodes remain assembled into different clusters in this method. Every sensor node fit in towards one and only one cluster. Every cluster consumes a lead named cluster head (CH) that gathers information commencing the aforementioned participant sensor nodes, collects them as well as direct the aforementioned towards the BS (refer Fig. 1). Hence CHs tolerate certain additional assignment due to these actions. CHs remain selected amongst the usual sensor nodes that might expire rapidly owing towards swift energy exhaustion aimed at such additional assignment in numerous submissions of WSN. Consequently, numerous investigators [18–20] have anticipated the usage of certain distinct nodes named entries or transmit nodes that remain delivered by additional energy as well as greater transmission series compared to the usual sensor nodes. Entire entries perform as cluster heads. Nevertheless, the entries remain similarly power restriction by way of they remain battery operated moreover. Hence, energy preservation of the entries (i.e., CHs) remains extremely critical aimed at the extended process of the WSN.

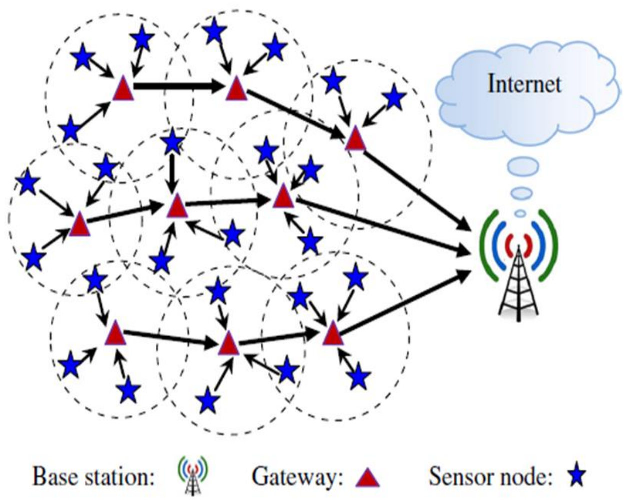


Fig. 1: A Wireless sensor network model

WSNs remain susceptible to towards disaster by means of they remain organized in extreme severe atmosphere separately after the power constriction. Mainly, the downfall of a CH disturbs the transmission not only by the aforementioned participant sensor nodes however similarly by additional CHs as they remain comprised in directing combined information towards the sink over additional CHs [21]. Hence, failure acceptance of WSNs regarding CH downfall remains a correspondingly significant matter in the expansion of a wide measure WSN. A conceivable resolution for this difficulty is to organize terminated entries for replacing the defective entries, however the aforementioned points towards low usage of the possessions. Furthermore, substitution of the entries might remain impossible in entire situations. Hence, the directing procedures must handle with failure forbearing feature, particularly whenever certain CHs fall to labour with the intention of continuing performance of the WSNs. In this broadsheet, our objective is to scheme energy effective directing procedure aimed at WSNs by means of enchanting attention failure acceptance of the CHs. Numerous failure acceptance directing procedures have stood established [22–25]. Nevertheless, utmost of these procedures do not deliberate energy preservation of the CHs that remains undesirable aimed at the extended procedure of the WSNs.

In this paper, the problems are mentioned below.

Previous clustering algorithms do not have a recovery mechanism (fault tolerance) in case of CH node fails.

Due to the increased load at the CH nodes, the energy would be depleted more quickly at the CHs, which results in CH failure.

In addition, re-clustering is time and energy consuming.

In this paper, describing below points about work:

For clustering, residual energy and distance are considered.

Sleep/wake-up method is used for the members of cluster to improve energy consumption and to reduce the transmission count.

A backup cluster head (BKCH) is taken to handle fault of CHs.

Two main parameters, distance to the CH and residual energy, are considered to choose BKCH.

When there is failure in the elected CHs, this BKCH will act as CH and aggregate the data and send them to the BS.

II. RELATED WORK

The writer anticipated routing as well as clustering procedures by means of PSO in [26]. Nevertheless, our anticipated structure consumes the succeeding alterations by them. 1) Although our structure remains advanced towards addressing hot spot difficult, the method anticipated in these performances not contract by the aforementioned. 2) The suitability occupation in this remains grounded on supreme expanse amid dual nodes in routing method as well as extreme hop amount of entries for routing as well as usual cluster expanse aimed at clustering, conversely, the suitability occupation of our anticipated method remains grounded on estimated lifetime interval of the entries aimed at routing as well as energy intake outstanding intra-cluster as well as inter-cluster actions aimed at incapable clustering. Additionally, routing method designated using the procedure in these leftovers static aimed at the complete system procedure, the routing method designated using our anticipated method alters in each system arrangement as well as therefore improve system period. 3) Our anticipated method similarly deliberates failure accepting matter no such method remains deliberated now.

In [27] Low energy adaptive cluster hierarchy (LEACH) remains a prevalent clustering as well as solitary hop routing procedure. The foremost drawback of this procedure remains that a nodule using extreme small energy might remain designated by means of a CH as well as thus the aforementioned might expire rapidly. Furthermore, the CHs convey their information openly towards the BS through solitary hop transmission that similarly points towards swift expiry of a CH.

In [28], the writers have deliberated multihop routing as well as imbalanced clustering procedure by means of enduring energies of entire sensor nodes as well as expanse amid sensor nodes towards the BS for extending system lifespan. Nevertheless, for a sensor node in this procedure, the aforementioned remains extremely challenging to recognize the overall data of entire additional sensor nodes aimed at huge measure systems.

In [29], the author anticipated a Distributed energy balance routing (DEBR) method. Even though, the DEBR equilibriums the energy intake extremely fine, however a node might choose a succeeding hop node in reverse path of the BS as well as the nominated next hop node may perform the equivalent. Therefore, the aforementioned might unreasonably upsurge the suspension in conveying the information towards the BS. Additional drawback of DEBR remains that aimed at corresponding energy intake the aforementioned might choose a node that consumes no next-hop node in the aforementioned transmission series as well as therefore information packets may not remain stretched towards the BS.

In [30], the writer anticipated a routing procedure HAIR towards avoiding the hole in progress. In HAIR, a node once meets a hole in routing, chooses succeeding-hop node commencing the aforementioned neighbor's grounded on slightest expanse towards the BS nevertheless the aforementioned doesn't assume the enduring energy of the node. Thus, HAIR selects a fixed route that willingly fallouts in energy inequity as the energy at the nodes on the route are rapidly exhausted. Furthermore, for avoiding the hole a node might choose a succeeding-hop node that consumes inadequate enduring energy as well as therefore the aforementioned might direct towards increasing of the hole dimension.

In [31], the writers anticipated a covetous method for routing the information towards the BS built on extreme enduring energy of node as well as similarly blocks hole using building hole border by means of anchor node nevertheless choice of succeeding-hop node by extreme enduring energy remains an additional above aimed at huge amount of sensor nodes by means of enduring energy of nodes alters for each turn.

III. PROPOSED SYSTEM

To improve the lifetime of the network, the effective way is to divide the network into different clusters with a high-energy node called gateway as cluster-head. Due to the unfriendly environment and unattended arrangements certainly failures occurs in sensor networks. Still failures happen in higher level of order, for example cluster-head cause more damage to the system because they provide limit accessibility to the nodes that are under their supervision. When the delivered service departs from the specified service system failure will be occurred. System state and the operational behavior, like memory or register content, program control flow and communication links etc. will be affected by the faults occur in Hardware and Software. Hardware failure or energy depletion causes Communication faults in the networks. The changes in environmental conditions like wind or rain causes disturb in communication. Communications like radio communication or communications to and from the gateway will be disturbed due to the Hardware faults. Data or task transmitted by the sensor nodes to other sensor nodes will be affected as well as it transmits data to the command node because of a fault in CH. If CH fails information (Data) transmitted by the sensors will be lost. These types of failures are also called as complete network failures because the CH can no longer serve as a contact between the sensors and the command node. If there are faults in the range of CH different kind of failures occurs. A communication link failure between the sensors in its cluster or with other CHs can be experienced by a CH. The sensors need to be allocated with other CHs within communicate range if there is any failure in happens in the communication link. To select an efficient cluster-head like randomized lowest cluster-ID or highest degree of connectivity many clustering approaches were proposed. An increased latency in the communication and insufficient tracking of targets or events will be happened if load is not equalized among the cluster and finally it causes failure of the CHs. If the cluster-head is failed a replacement like redundant hardware or the role is rearranged with another node which requires reconfiguration.

BKCH-FT mechanism (Backup Cluster head based fault tolerance):

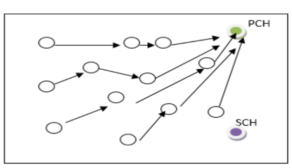
In this section the BKCH-FT is proposed. The DHCS is similar to existing clustering schemes like LEACH and HEED. Unlike LEACH and HEED, Based on node density, distance and residual energy of the sensor nodes CHs will be selected. The BKCH-FT is a three step process: i) cluster formation ii) route formation iii) data communication. The first step is same as other routing algorithms. Let us assume n is number of rounds for the first step execution, that means if n is 10 the new heads will be selected after 10 rounds and n will decreased continuously and will reach to 1 at certain time. By this, energy can be saved which was consumed in the first step of network initialization. The value of n decreases gradually from the high value when the nodes are operating because at the beginning all the node values are in high energy. A significant amount of energy is consumed in each round with a single cluster head and the same cluster head may not be fixed for a specific number of rounds. For specific number of rotations this proposed approach is capable of fixing the CH.

Cluster formation:

At a certain power level the sink transmits a message to all the sensor nodes when the network deployment is completed. By the received signal strength the distance x is calculated by each node to other sensor. To find the radius of the cluster the distance x is used, the size of cluster given can be calculated by given formulae:

$$R_j = X_j (R_{max} - R_{min})/X_{max} + R_{min}$$

A metrics broadcasted by each node after finding cluster size and its radius which consists of node id, distance and energy, this metrics will be saved by every node to compare with its energy level. Every node selects a node as its cluster head (CH) which is having a high energy and a least distance after comparing the values of energy level. For data collection, aggregation, topology maintenance the cluster head selects a secondary cluster head (SCH) from its own cluster and this SCH is responsible for communication among member nodes after CH failure. The CH transmits a message to all the nodes to communicate and data transmission after the selection of SCH and if CH fails it sends data to the SCH. A node which is having a high energy and a nearer distance to the CH can be act as metrics for secondary head selection.



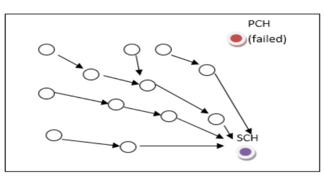


Fig. 2: Data Aggregation at PCH

Fig. 3: Data Aggregation at SCH (after PCH failure)

Route Formation:

After the cluster development, each CH communicates a metrics to other cluster heads. This metrics comprises of cluster head energy, id, and distance from the sink. Then again, every CH calculates the distance to the next CH dependent on received signal quality and finds most limited distance to the sink for productive communication of information.

Data Communication:

After development of course, the CH chooses a cluster with higher vitality and nearest to it from the rundown of its individuals, as a SCH. After the SCH choice, each part cluster in the cluster sends the detected information to the CH. The CH gets information from the clusters, totals it and sends it to the SINK for forward transmission. In the event that the current CH bombs because of different reasons, the chosen SCH will supplant the essential CH and deal with the collection work. It gets the information from the sensor clusters and sends it to the SINK as like essential CH did previously.

Pseudo code

N= total number of nodes; n= current node

R = Radius

RE = Residual energy; D = distance

PCH = Primary CH; SCH = Secondary CH

NA = not available

```
####

Compute R

For I = 1: N (∈ R)

Compute RE

Compute D

End

For I = 1: N (∈ R)

If ( RE[n] > RE[n+1] || D[n] < D[n+1] )

        PCH = n

        SCH = n+1

End if
```

End for
For I = 1: N (∈ R)
    Transmit data to PCH
If (PCH = NA)
    Transmit to SCH
End If
End for
End

IV.EXPERIMENTAL RESULTS

The reproductions were performed utilizing Network Simulator-2 running on the Linux mint. We considered different cases of WSN situation by shifting number of sensor nodes and cluster heads. The simulations were completed by assuming random deployment of the sensor nodes and the cluster heads in a rectangular region of 1000x500m^2 and the position of the BS was taken at the limit area with coordinate position (510,233). We ran every one of the algorithms for 20 times and plot the outcomes by taking the normal of the observed results. In this paper, we assume that 30 sensor nodes are randomly distributed. From the simulations, we came to know that when the energy level reaches to zero cluster head will die. We also came to know that due to transmission and receiving of data packets every gateway losses its residual energy in each round. Therefore, every cluster head checks whether its next hop cluster head is dead or alive in order to send data packets and it choose an alternative hop cluster head by using fault tolerance scheme when it finds a dead cluster head.

Table1 demonstrates the network parameters utilized in our simulations. In this paper, so as to improve planning for the information from cluster heads, we acknowledge that the data assembled by sensor nodes is the deferral tolerant data, i.e., they can hang tight for the cluster heads and gather from it.

PARAMETER	VALUE
Application Traffic	CBR
Transmission rate	512 bytes/0.5ms
Radio range	250m
Packet size	512 bytes
Routing Protocol	AODV
Simulation time	10000ms
Number of nodes	30
Area	1000x500
Routing methods	PSOBFT,BKCH-FT

Table1: System parameters

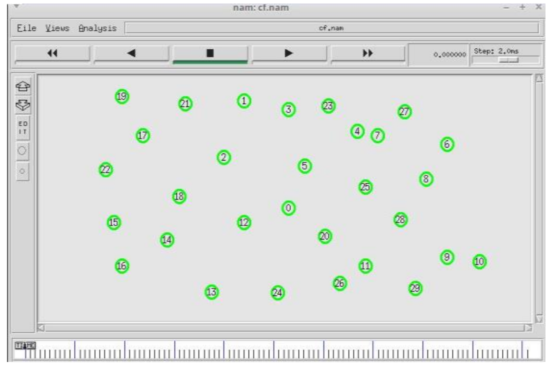


Fig. 3: Network deployment

Figure3 represents the network deployment. All the nodes are physically located in a random way.

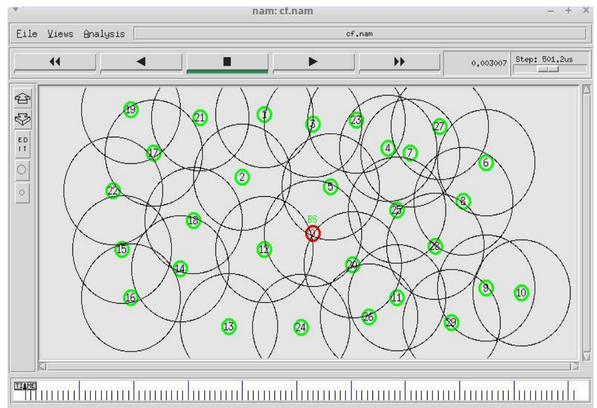


Fig. 4: Nodes exchanging Hello packets

Figure4 represents the broadcasting process in network. Here all the nodes request their neighbor nodes for route reply. In this network, routing protocol decides the RREQ and RREP processes.

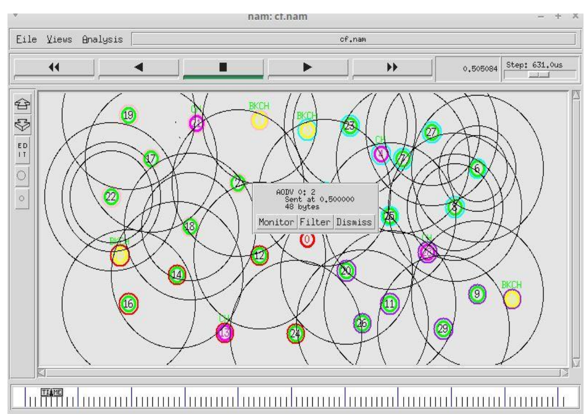


Fig. 5: Broadcasting process for clustering

Figure 5 represents the routing request process for cluster formation. In this, all nodes participating and share the request packets.

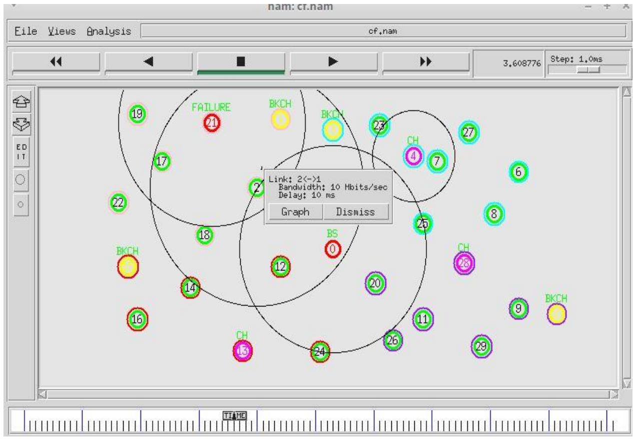


Fig. 6: Data aggregation at Cluster heads

Figure6 represents the cluster member to cluster head data transmission. After cluster formation, cluster heads are selected based on their distance from node to node in each cluster. Here link must be represented between the cluster member and cluster head process. It represents data aggregation at cluster heads.

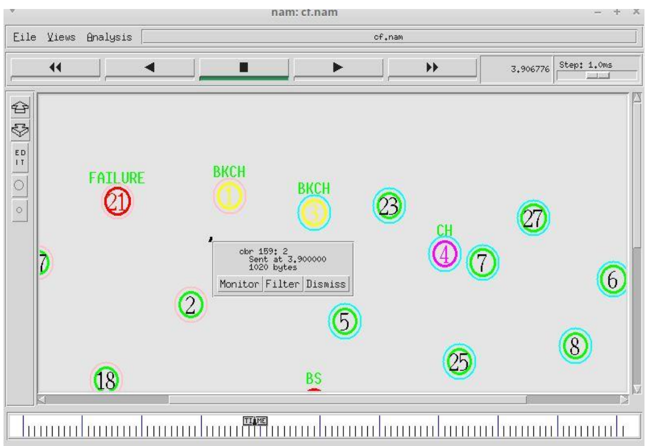


Fig.7: Failure node detection

Figure 7 represents the detection of failure nodes in network. Here node 21 showed as failure node it means data doesn't delivery from failure node.

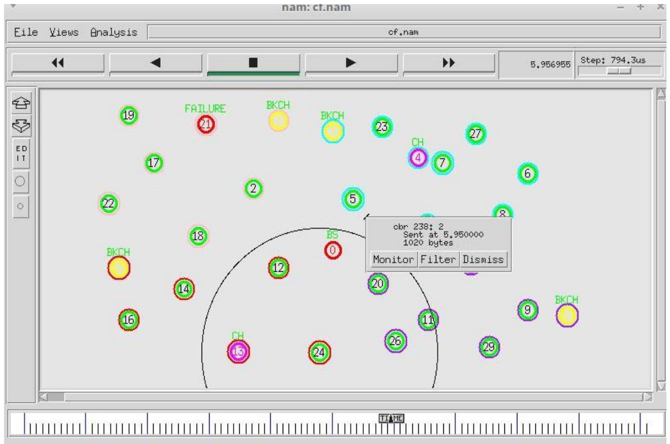


Fig. 8: Cluster head to BS process

Figure8 represents the cluster head (CH) to Base station data transmission. Here cluster head collects the data from all the cluster members and delivery to BS.

```
File  Edit  View  Search  Tools  Documents  Help
Cluster Formation at 9.402107
Cluster - 1 : 12 13 14 15 16 24
Cluster - 2 : 9 10 11 20 26 28 29
Cluster - 3 : 1 2 17 18 19 21 22
Cluster - 4 : 3 4 5 6 7 8 23 25 27

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Distance from node 12 to its neighbour  12  13  14  15  16  24
 0.000000  178.885438  194.164878  320.000000  316.227766  181.135309
Distance from node 13 to its neighbour  12  13  14  15  16  24
 178.885438  0.000000  162.788206  288.444102  228.035085  163.003067
Distance from node 14 to its neighbour  12  13  14  15  16  24
 194.164878  162.788206  0.000000  136.014705  125.299641  298.613463
Distance from node 15 to its neighbour  12  13  14  15  16  24
 320.000000  288.444102  136.014705  0.000000  101.980390  433.970045
Distance from node 16 to its neighbour  12  13  14  15  16  24
 316.227766  228.035085  125.299641  101.980390  0.000000  387.827281
Distance from node 24 to its neighbour  12  13  14  15  16  24
 181.135309  163.003067  298.613463  433.970045  387.827281  0.000000
Max_Min is 288.444102

Max_Min is 298.613463

Max_Min is 433.970045

Max_Min is 387.827281

Max_Min is 433.970045
```

Fig. 9: Cluster file in network

Figure9 represents the cluster formation with time update and has eight clusters in the network. The cluster head selection process is based on the distance between neighbors in the network. After the distance calculation, the cluster head has decided by which cluster member has lowest distance in the network while compared to other members in the network.

```
node # (recv) 8 is in permit table has  energy = 99.998390  at time = 1.001068
node # (recv) 25 is in permit table has  energy = 99.998286  at time = 1.001068
node # (recv) 11 is in permit table has  energy = 99.998311  at time = 1.001068
node # (recv) 9 is in permit table has  energy = 99.998443  at time = 1.001068
node # (recv) 29 is in permit table has  energy = 99.998412  at time = 1.001069
node # (recv) 20 is in permit table has  energy = 99.998209  at time = 1.001069
node # (recv) 7 is in permit table has  energy = 99.998285  at time = 1.001069
node # (recv) 6 is in permit table has  energy = 99.998418  at time = 1.001069
node # (recv) 26 is in permit table has  energy = 99.998308  at time = 1.001069
node # (recv) 10 is in permit table has  energy = 99.998559  at time = 1.001069
node # (recv) 4 is in permit table has  energy = 99.998255  at time = 1.001069
node # (recv) 27 is in permit table has  energy = 99.998358  at time = 1.001069
node # (recv) 9 is in permit table has  energy = 99.998413  at time = 1.001987
node # (recv) 29 is in permit table has  energy = 99.998382  at time = 1.001987
node # (recv) 28 is in permit table has  energy = 99.998286  at time = 1.001987
node # (recv) 8 is in permit table has  energy = 99.998360  at time = 1.001987
node # (recv) 9 is in permit table has  energy = 99.998383  at time = 1.002966
node # (recv) 11 is in permit table has  energy = 99.998251  at time = 1.002966
node # (recv) 28 is in permit table has  energy = 99.998256  at time = 1.002966
node # (recv) 10 is in permit table has  energy = 99.998503  at time = 1.002966
node # (recv) 26 is in permit table has  energy = 99.998248  at time = 1.002966
node # (recv) 26 is in permit table has  energy = 99.998218  at time = 1.003944
node # (recv) 20 is in permit table has  energy = 99.998119  at time = 1.003944
node # (recv) 29 is in permit table has  energy = 99.998325  at time = 1.003944
node # (recv) 28 is in permit table has  energy = 99.998226  at time = 1.003944
node # (recv) 25 is in permit table has  energy = 99.998196  at time = 1.003944
node # (recv) 9 is in permit table has  energy = 99.998353  at time = 1.003944
node # (recv) 24 is in permit table has  energy = 99.998086  at time = 1.003944
node # (recv) 0 is in permit table has  energy = 99.998061  at time = 1.003945
node # (recv) 8 is in permit table has  energy = 99.998300  at time = 1.003945
node # (recv) 9 is in permit table has  energy = 99.998323  at time = 1.005003
```

Fig. 10: Energy table

Figure 10 represents the energy table formation in network. Here all nodes energy values should be updated based on time intervals. This table can be represents permission of nodes into routing.

```
index :11  dest :0 source :26 nexthop :0 prevhop :26
index :20  dest :0 source :26 nexthop :0 prevhop :26
index :24  dest :0 source :26 nexthop :0 prevhop :26
index :29  dest :0 source :26 nexthop :0 prevhop :26
index :28  dest :0 source :26 nexthop :0 prevhop :26
index :0  dest :0 source :26 nexthop :0 prevhop :26
index :25  dest :0 source :26 nexthop :0 prevhop :26
index :11  dest :0 source :26 nexthop :0 prevhop :26
index :20  dest :0 source :26 nexthop :0 prevhop :26
index :24  dest :0 source :26 nexthop :0 prevhop :26
index :29  dest :0 source :26 nexthop :0 prevhop :26
index :28  dest :0 source :26 nexthop :0 prevhop :26
index :0  dest :0 source :26 nexthop :0 prevhop :26
index :25  dest :0 source :26 nexthop :0 prevhop :26
index :26  dest :0 source :11 nexthop :0 prevhop :11
```

Fig. 11: Hop node table

Figure 11 represents the hop file. This file indicates source, destination, previous hop, and next hop nodes. Every node data transmission depends on this hop file.

```
s 0.000000000 _0_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [0:255 -1:255 1 0] [0x1 1 [0 2] 4.000000] (HELLO)
s 0.000000000 _1_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [1:255 -1:255 1 0] [0x1 1 [1 2] 4.000000] (HELLO)
s 0.000000000 _2_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [2:255 -1:255 1 0] [0x1 1 [2 2] 4.000000] (HELLO)
s 0.000000000 _3_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [3:255 -1:255 1 0] [0x1 1 [3 2] 4.000000] (HELLO)
s 0.000000000 _4_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [4:255 -1:255 1 0] [0x1 1 [4 2] 4.000000] (HELLO)
s 0.000000000 _5_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [5:255 -1:255 1 0] [0x1 1 [5 2] 4.000000] (HELLO)
s 0.000000000 _6_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [6:255 -1:255 1 0] [0x1 1 [6 2] 4.000000] (HELLO)
s 0.000000000 _7_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [7:255 -1:255 1 0] [0x1 1 [7 2] 4.000000] (HELLO)
s 0.000000000 _8_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [8:255 -1:255 1 0] [0x1 1 [8 2] 4.000000] (HELLO)
s 0.000000000 _9_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [9:255 -1:255 1 0] [0x1 1 [9 2] 4.000000] (HELLO)
s 0.000000000 _10_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [10:255 -1:255 1 0] [0x1 1 [10 2] 4.000000] (HELLO)
s 0.000000000 _11_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [11:255 -1:255 1 0] [0x1 1 [11 2] 4.000000] (HELLO)
s 0.000000000 _12_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [12:255 -1:255 1 0] [0x1 1 [12 2] 4.000000] (HELLO)
s 0.000000000 _13_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [13:255 -1:255 1 0] [0x1 1 [13 2] 4.000000] (HELLO)
s 0.000000000 _14_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
0.000] ------- [14:255 -1:255 1 0] [0x1 1 [14 2] 4.000000] (HELLO)
s 0.000000000 _15_ RTR  --- 0 AODV 44 [0 0 0 0] [energy 100.000000 ei 0.000 es 0.000 et 0.000 er
```

Fig. 12 Trace file in network

Figure 12 represents trace file of network. Here node represents the route requests, replies, energy values, data transmission, and time intervals updating in a proper way.

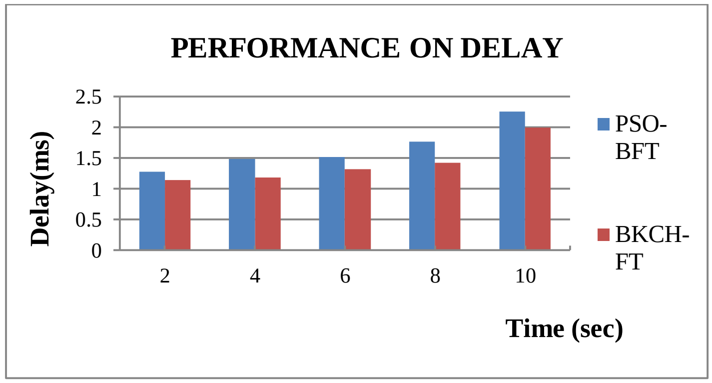

Fig. 13: End to End Delay

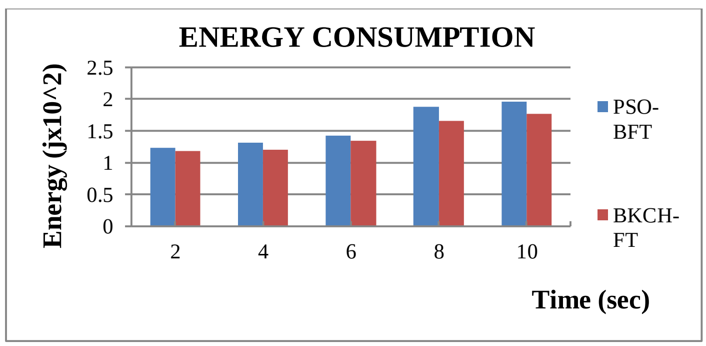

Fig. 14: Energy consumption

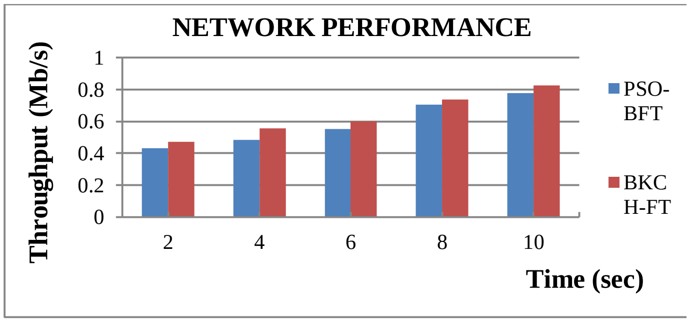

Fig. 15: Network performance

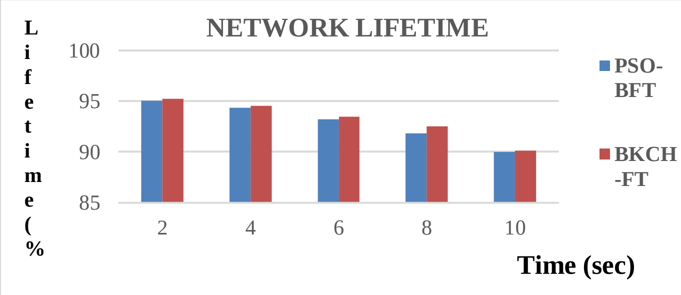

Fig. 16: Network lifetime

Figure 13 shows delay of network. For large networks, some data packets are delayed because certain cluster heads are not in the range of others. Delay of network is better for proposed protocol than PSO-BFT.

In figure 14, the proposed protocol has less energy consumption than PSO-BFT because of choosing a multi-hop path with minimum communication cost.

We analyze network performance of PSO-BFT, and our protocol. We examine the way the simulation time varies as network evolves. In figure 15, it is clear that the proposed protocol has improved throughput than existing protocols.

Fig 16 appears and speaks to visit time and it demonstrates a time versus lifetime of network. The performance of proposed protocol improves the network lifetime compare to PSO-BFT.

V. CONCLUSION

In this paper, we have first formulated a back end of fault tolerance problem for energy balanced routing in WSNs. We have been presented a Backup cluster head fault tolerance routing algorithm (BKCH-FT). BKCH-FT also offers an efficient fault tolerant mechanism to route the data to the BS in case failure of CH's. It has been proposed method is more efficient than existing PSO-BFT algorithm. We validated dissimilar routing procedures using dispensation of simulation tool termed by way of Network simulator (NS-2). The replication outcomes remain paralleled with our anticipated approaches using the prevailing correlated approaches in positions of End to End delay, Energy consumption, network lifetime, as well as throughput.

VI. REFERENCES

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