Modified Fault Tolerant Optimization Routing Protocol in Wireless Sensor Network

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Abstract- To drag out the lifetime of a system, the benefits of abusing the sink mobility in wireless sensor systems (WSNs) is perceived. From their group individuals, the nodes are elected as cluster heads for collecting the information according to the cluster based strategy and gathered information is exchanged to the base station. In previous works, many clustering algorithms are designed for clustering a network. But these algorithms don't have a recovery mechanism in case of CH nodes fails. Due to the increased load at the CH nodes, the energy would be depleted more quickly at CH's, which results in CH failure. A Modified Fault tolerance Optimization Routing Protocol (MFTORP) is proposed for Cluster Heads' faults in order to solve these problems. Based on the proposed method, we present a two parameters namely as distance and residual energy to considered to choose BKCH (Backend Cluster head). This BKCH will consider as CH and the data is aggregated and transmit them to the BS if there is a failure in the elected CHs. For verification of the proposed method when comparing with the existing methods, the simulation results have been processed based on NS2 software.

Keywords: WSN, Routing, Clustering, Fault tolerance, Backup Cluster Head, PSOBFT, MFTORP, Network lifetime.

I. INTRODUCTION

Sensor nodes with the hundreds or thousands of number are included in a wireless sensor network (WSN) by exceeding an objective area that 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. Due to the aforementioned restricted as well as non-rechargeable battery source by remaining the every sensor node.

Income involved processing power as well as storing abilities is ensured by their processors. 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 groups, wherever every single group 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-group 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]. With the energy conservation of the sensor nodes, clustering is considered as one of the utmost effective practices. Certain lead nodes named cluster heads (CHs) remain accountable aimed at promoting combined information towards an 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 cluster. Each 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.

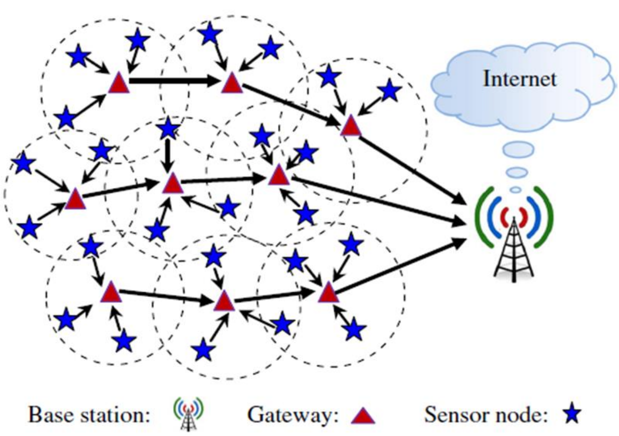


Fig. 1: A Wireless sensor network model

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.

In order to decrease the transmission count and improve the energy consumption, a method of sleep or wake-up is utilized for the cluster members.

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 cumulative the data and transmit them to the Base Station.

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 node's energy. 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

Based on a high-energy node, distinct clusters are partitioned from the network which is an proficient way for improving the lifetime of a system where a node with high-energy is called as gateway which is known as cluster-head. Owing to the unattended deployment and inhospitable environment, failures are expected in sensor networks usually. These failures generally occur in higher level of hierarchy. Let's say, more damage is caused to the cluster-head system due to the limitation for accessibility to the nodes under their supervision. If the service of delivery is deviated from the particular service, a failure is occurred in a system. The state of a system and the operational behavior is affected by the faults of hardware and software that include program control flow, communication links, and memory or register content, etc. Owing to the energy depletion or hardware failure, the faults of communication can be caused. Based on environmental conditions like rain or wind, the disruption of communication can be happened. The radio communication can also disrupted by the hardware faults that ended all of the communication to and from the gateway. For transmission of tasks to the other sensors, a fault in CH can restrict the sensor nodes as well as the command node is relied by the data. If CH gets into the failure, the lost of data will be occurred and the sensors are sent the data. All of these failures are considered as network failures completely due to the no longer serve of CH as a liaison between the command node and the sensors. Because of the faults in range of CH, there is a cause of another kind of failures. The coverage is affected by the faults in range of the device. In the cluster, the communication link failure between the sensor nodes can be experienced by a CH or with other CHs. Within the communication range, the allocation of sensors to other CHs is required due to the failure of a communication link with the sensors. To choose a cluster-head efficiently like highest degree of connectivity or randomized lowest cluster-ID, various approaches of clustering have been proposed. It can result in the improved latency in communication and tracking of events inadequately or events when unbalanced load among the cluster which result in the CHs failure finally. The whole system's re-configuration is required or replaced the redundant hardware which is utilized upon a cluster-head's failure either reassigning the role to another node.

3.1 MFTORP (Modified Fault Tolerance Optimization Routing Protocol):

The MFTORP is proposed in this section. The similar features of existing clustering schemes are included in the DHCS and the current existing schemes are HEED and LEACH. As per the parameters like distance, node density, and sensor nodes' residual energy, the CHs are chosen which is not like in the process of LEACH and HEED. A three-step process is included in the MFTORP: cluster formation, route formation, and data communication. The first step is similar in this algorithm like other routing algorithms. Let assume that n be the number of rounds which will perform in the first step. After 10 rounds, the new heads will be chosen if n is 10 and the value of n will decrease constantly and it will reach to 1 after certain time. In the first step of initialization of a network, energy is saved as it is consumed. If nodes are in operating condition, all of the nodes are having high energy initially so that n value is also high which will be decreased gradually. With a single cluster head, an amount of energy significantly is used in every round and the similar cluster head is not fixed for a particular number of rounds. For specific number of rotations, the fixing of CH is having the capability in the proposed approach.

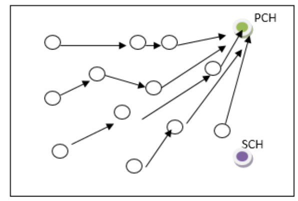
3.2 Cluster formation:

All the sensor nodes are broadcasted by the sink after the deployment of a network at a certain level. By utilizing the received signal strength, the approximate distance x to the other sensor node is calculated by every node. To determine the cluster's radius, this distance x is utilized. Ultimately, the size of a cluster is shown by the following formula:

$$Rj = Xj\,(Rmax - Rmin)/Xmax + Rmin$$

Where Rmin is the minimum radius, Rmax is the maximum radius, Xj is the distance between nodes. Here, Xmax is nothing but the representation of the maximum distance between the farthest node and the sink.

A metrics is broadcasted by each node after determining the radius and the cluster's size where the metrics contains distance, energy, and node id. This metrics are saved by each node and compare the metrics based on the energy level. A node with lowest distance and high energy is elected by each node as its cluster head (CH) after making a comparison the values. A secondary cluster head (SCH) is chosen by the cluster head after the selection of a cluster head. The election is done from the cluster for aggregation, collection of data and communication among member nodes after failure of CH. A message is broadcasted by the CH to all member nodes after selecting the SCH. The broadcasting process is improved for communication and sending the data to the SCH if it gets into the failure. While choosing the secondary head, the metrics are considered as a node with closer distance and high power node to the cluster head.



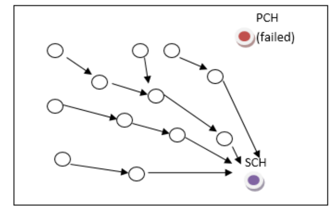


Fig. 2: Data Aggregation at PCH

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

3.3 Route Formation:

A metrics is broadcasted by every CH to other cluster head after making the formation of a cluster. Here, the metrics are included cluster id, energy, and distance from the sink. According to the received signal strength, every CH is calculated the distance to the other CH and sink's shortest distance is found out for data communication efficiently.

3.4 Data Communication:

From the list of its members, a node with closer to the distance and higher energy is chosen after formation of route, as an SCH. The sensed data is sent to the CH by every member node in the cluster after selecting the SCH. For onward transmission, the data receives from the nodes by CH, collaborates the data, and sends it to the SINK finally. If the current CH fails due to multiple reasons, the elected SCH will replace the primary CH and take care of the aggregation work. From the sensor nodes, the data is received and sends it to the SINK like primary CH has improved before.

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 simulations were performed using Network Simulator-2 running on the Linux mint. With the varied number of sensor nodes and cluster heads, different cases of WSN scenarios are considered. Based on the assumption of sensor nodes' deployment randomly and the cluster heads with a rectangular area of 1000x500m^2, the simulations were performed by taking the BS position with coordinate position (510,233) at boundary region. By considering the value of average of the observed results, all of the algorithms are run for 20 times and depict the results. The assumption of random distribution of 30 sensor nodes is taken in this paper. When the cluster head's energy level is reached to zero, the assumption is considered that it dies while doing the simulation part. The additional assumption is that the residual energy is lost at every gateway with a little amount at each round owing the transmission and reception of data packets. Each cluster head is verified that whether the next hop cluster head is dead or alive in prior to the sending of data packets. An alternate next hop cluster head is chosen with the use of proposed scheme of fault tolerance if in case of finding that its next hop cluster head is dead.

In the simulations, the parameters of system are utilized as shown in the table 1. The sensor nodes are gathered the information is the deferral tolerant which is accepted to simplify the process of scheduling for the data from cluster heads where deferral tolerant information is defined that they can wait 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, MFTORP

Table1: System parameters

- **Evaluation results**

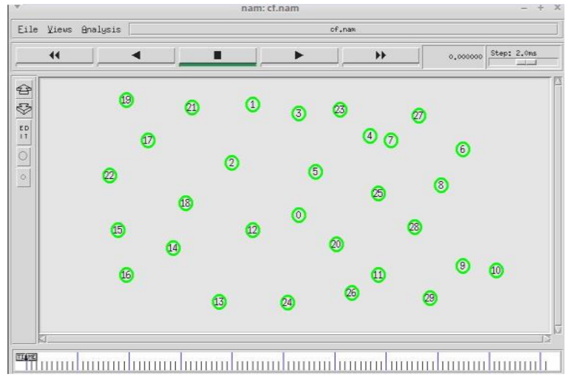


Fig. 4: Network deployment

All the nodes are physically located in a random way. All nodes are placed in the network and deployment of nodes is done properly based on above screenshots as shown in figure 4. It should be mentioned that all nodes are displayed here according to NAM windows all properties and topology values.

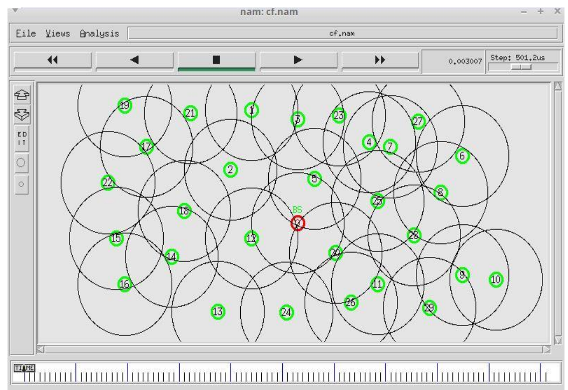


Fig. 5: Nodes exchanging Hello packets

Figure5 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.

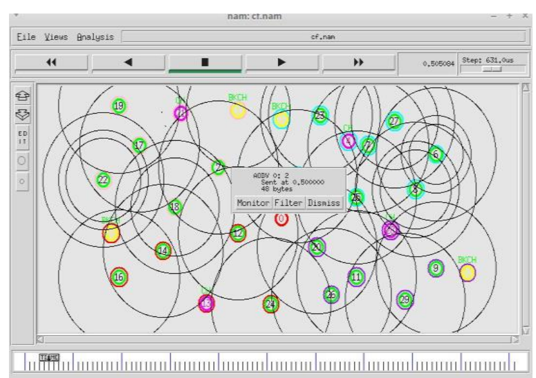


Fig. 6: Broadcasting process for clustering

Figure 6 represents the routing request process for cluster formation. In this, all nodes participating and share the request packets.

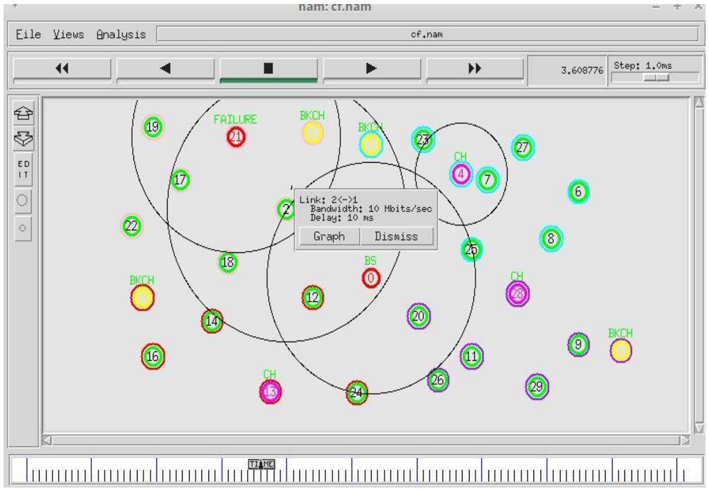


Fig. 7: Data aggregation at Cluster heads

Figure7 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.

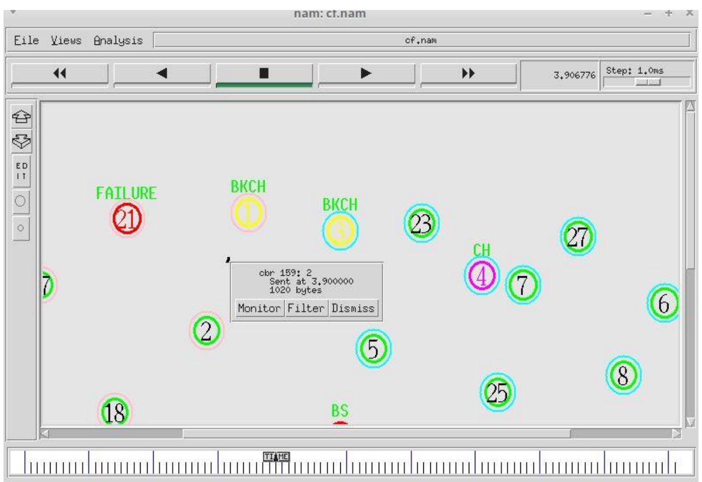


Fig.8: Failure node detection

Figure 8 represents the detection of failure nodes in network. Here node 21 showed as failure node it means data doesn't delivery from failure node.

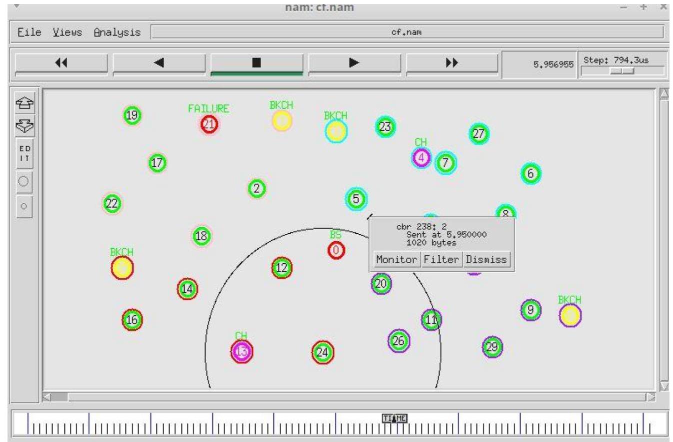
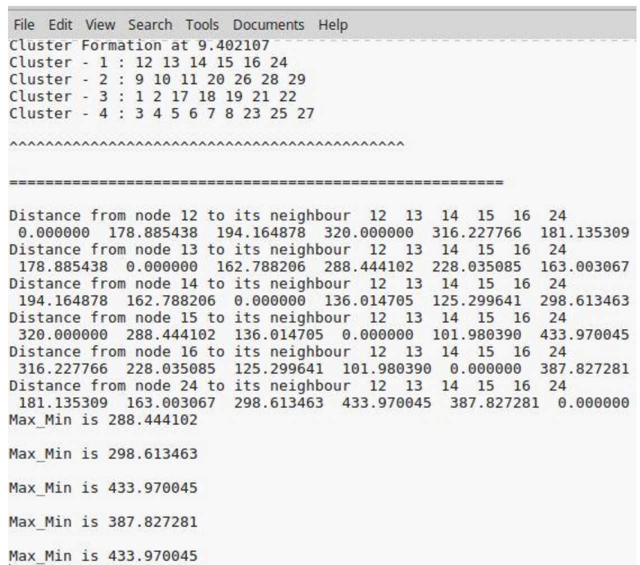


Fig. 9: Cluster head to BS process

Figure9 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. 10: Cluster file in network

Figure10 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. 11: Energy table

Figure 11 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. 12: Hop node table

Figure 12 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. 13 Trace file in network

Figure 13 represents trace file of network. Here node represents the route requests, replies, energy values, data transmission, and time intervals updating in a proper way.

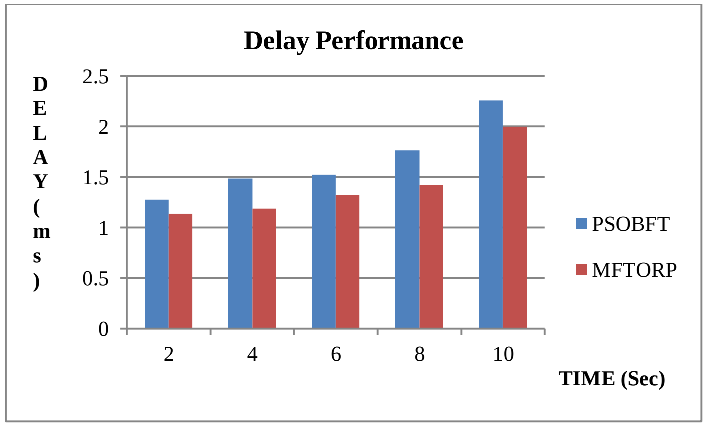

Fig. 14: End to End Delay

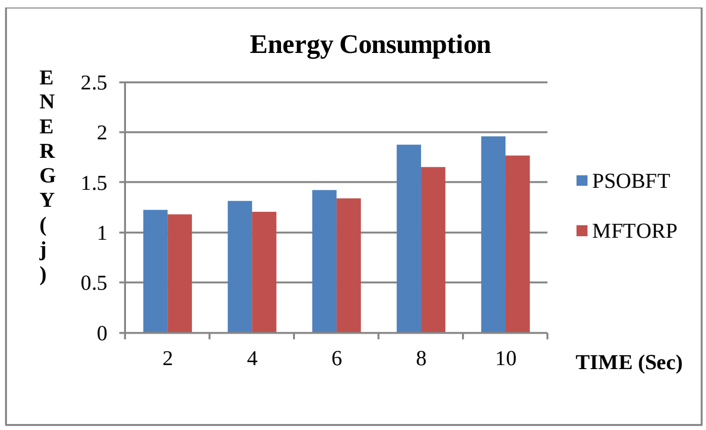

Fig. 15: Energy consumption

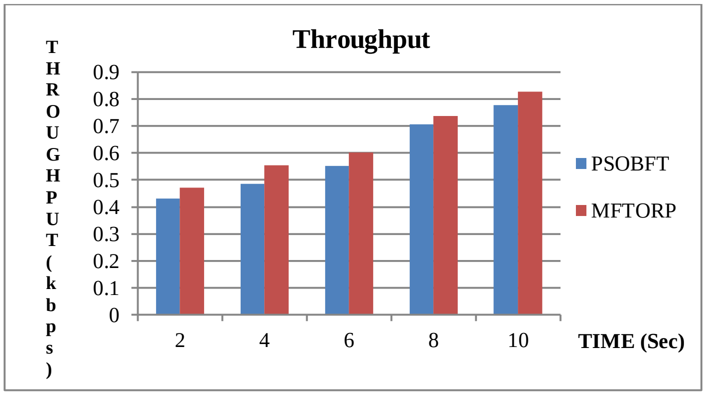

Fig. 16: Network performance

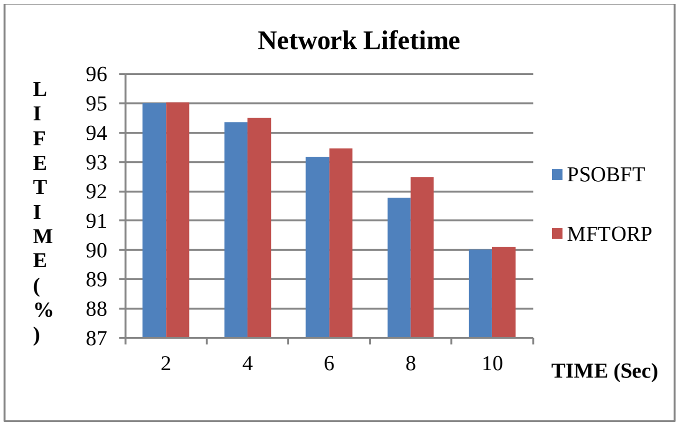

Fig. 17: Network lifetime

Figure 14 shows delay of network and graph is showed a delay versus simulation time. 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. A simulation time versus energy is shown in the Figure 15 and 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 16, it is clear that the proposed protocol has improved throughput than existing protocols.

Fig 17 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 preceding investigations, dissimilar maximization procedures remain anticipated towards addressing the hot spot issue, unfair clustering, as well as failure acceptance problems. The objective of our investigation effort is to uphold the standbys of cluster heads (CH) and to resolve the failures of CH procedure. Our investigation approaches aids towards tackling the route downfall in network. 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 postponement, packet delivery ratio, energy consumption, as well as throughput.

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