Comparative Study of Flat-based and Hierarchical Routing in Wireless Sensor Networks

Radhika R[1], Sreelakshmi T R[2], Dr. Binu G S[3]
[1]*MTech student,N.S.S College of Engineering,Palakkad,Kerala*
[2] *MTech student,N.S.S College of Engineering,Palakkad,Kerala*
[3]*Associate Professor, N.S.S College of Engineering,Palakkad,Kerala*

(E-mail: radhika.ammu.r@gmail.com,sreelakshmitrs@gmail.com,binu_g_s@rediffmail.com)

***Abstract*—**Wireless sensor network (WSN) is an accumulation of thousands of sensor nodes with the capabilities of sensing different types of environment and physical conditions, information handling and wireless transmission. However, WSN require powerful techniques for handling data transmission and processing. Sensor nodes in WSN have a limited communication range, storage and processing capabilities and their power resources are also limited. This paper analyses the performance of hierarchical clustering method in terms of packet delivery ratio, residual energy and network lifetime.

Keywords— *wsn ,routing, flat, hierarchical ,cluster*

I. INTRODUCTION

WSNs [1] are mission-driven service providers which proficiently convey services subject to the necessary Quality of Service (QoS), as well as physical and link layer constraints. It is the mission that guides all the functionality of the sensor network,while sensors jointly carry out services to attain the network's operation, based on their sensing, computing, storage,communication, and energy capabilities as well as on the data they assemble and process. A WSN application can be described as the function designed for the sensor network. WSN devices could either strongly interact with the human user or cooperate with the surrounding environment where the network is entrenched into, since sensor nodes are equipped with sensing and actuation devices, to measure the environment.

At present wireless network is the widely accepted services used in industrial and commercial applications, due to its technological progression in processor, communication, and usage of low power computing devices. Environmental conditions like temperature, pressure, humidity, sound, vibration, position etc are monitored by the sensor nodes. In most of the real time scenarios the sensor nodes perform distinct functions like discovering neighbor nodes, sensing various events, storage of data and processing, data aggregation, tracking targets, control and surveillance, node synchronization and effective routing between nodes and sink node.

In WSN, routing[3] is a very important task that is to be handled cautiously. Routing technique is desired for transferring the data between the sensor nodes and the base stations, so as to commence communication. Routing in WSNs is very demanding due to the innate characteristics that differentiate these networks from another wireless networks like mobile ad hoc networks or cellular networks[4].

These routing mechanisms have taken into account the intrinsic features of WSNs along with the application and architecture necessities. Due to frequent and unpredictable topological changes ,the task of finding and maintaining routes in WSNs is nontrivial because of energy limitations and abrupt changes in node status (e.g., failure) . To reduce energy usage, routing techniques [5] anticipated in the literature for WSNs, make use of some eminent routing strategies as well as tactics particular to WSNs, e.g., data aggregation and in-network processing, clustering, different node role assignment, and data-centric methods were employed.

This paper analyses the performances of main routing methods that are used in wireless sensor networks in terms of energy consumption, packet delivery ratio, network lifetime etc. It is organized as follows. Section 1 describes the need of routing protocols, Section 2 discusses the classification of routing protocols Section 3 defines the clustering aspects of hierarchical routing protocols,Section 4 discusses the simulation set up and results and finally section 5 concludes the paper.

I. NEED OF ROUTING PROTOCOLS

The main function of a wireless sensor node is to sense and collect data from a certain area, process them and transmit it to the sink where the application lies. Direct communication from sensors to the BS is only feasible for small WSNs where the network size is the function of maximum communication range of nodes. For large scale networks, multi-hop communication provides scalability through the transit nodes to destine the data to the distant BS. Therefore, the collaboration of nodes to ensure that distant nodes communicate with the sink by multiple links or hops are established .This causes dissipation of majority of their energy in routing, which limits network lifetime. Thus, innovative

routing techniques that reduce energy inefficiencies that would shorten the lifetime of the network are highly required.

Routing in WSNs is very challenging due to the inherent characteristics like energy restrictions and sudden changes in node status (e.g., failure) cause frequent and unpredictable topological changes in the network.

They distinguish wireless sensor networks from other wireless networks like mobile ad hoc networks or cellular networks. It is not possible to build a global addressing scheme for the deployment of a large number of sensor nodes as the overhead of ID maintenance is high. Thus, traditional IP-based protocols have limitations to be applied as such in wireless sensor networks. Routing mechanisms have taken into consideration the salient features of WSNs along with the application and architecture requirements. To minimize energy consumption, routing techniques employ some outing procedures special to WSNs, such as data aggregation and in-network processing, clustering, different node assignment, and data-centric methods etc.

.

II. CLASSIFICATION OF ROUTING PROTOCOLS

Different routing protocols are used for WSN taking into consideration the challenges that affect the performance of routing protocols resulting in overall WSN performance degradation. Ensuring successful transfer of the packet from source node to the sink or base station is the main motive behind routing. As it is apparent that there are numerous nodes between the source and the destination, in addition to multi path this packet can take. Routing table can show the next hop node and the cost of the path based on the routing protocol selected. Routing protocols can be classified by three different methods based on either network structure, protocol function, or path establishment.

The routing protocols can be classified based on the network structure as flat, hierarchical, or location-based[11],[15]. In flat networks each and every sensor nodes play the same role, while hierarchical protocols intend to cluster the nodes such that cluster heads can do certain aggregation and data reduction for saving energy. Location-based protocols make use of position information to forward the data to the preferred regions rather than the whole network.

A. Flat routing

In flat-based routing, all nodes in the network have equal functions in gathering information . They have the same information about the state of the network. In this type of network, due to the large number of sensor nodes ,assigning a particular identification (ID) to each node is impossible. This leads to data-centric routing approach in the network.In data-centric routing ,the sink sends a query to a group of particular nodes in a region and waits for the response. The property of data is specified by an attribute-based naming.Flat Networks Routing Protocols for WSNs in general, can be classified into three main categories: Pro-active protocols, Re-active protocols and Hybrid protocols[15].

B. Hierarchical routing

Hierarchical [7] or cluster-based routing is a distinguished technique with special advantages related to scalability and effective communication. The idea of hierarchical routing is also used to perform energy-efficient routing in sensor networks. In a hierarchical architecture, high energy nodes are used to process and forward the data while low energy nodes are used to perform the sensing in the proximity of the target.

For supporting data aggregation, nodes can be divided into a number of small groups called clusters. This method of grouping sensor nodes into clusters is known as clustering. Size of cluster in network can be equal or unequal with respect to number of cluster member nodes. In equal clustering, number of member nodes in network clusters are almost same. In unequal clustering, number of nodes in network clusters is variable so that cluster size differ from each other.

III. CLUSTERING ASPECTS OF HIERARCHICAL ROUTING

The process of grouping network nodes in clusters is based on some defined parameter is the designing of clusters [6].Centralized clustering is the process of cluster design which is controlled directly from a Base Station whereas in Distributed clustering ,the cluster design is distributed. Nodes communicate with each other in this process.

Each cluster will have a leader, generally referred to as cluster-head (CH). A CH may be selected by the sensor nodes in the cluster or pre-allocated by the network designer. A CH may as well be one of the sensors or a node that is usually richer in resources. There are numerous advantages for clustering method. A vital advantage is that, it supports network scalability. It can restrict the route setup inside the cluster. Clustering process also maintains communication bandwidth. Furthermore clustering stabilizes the network topology at sensor level. Clustering diminishes energy consumption and extend network lifetime by reducing the number of nodes taking part in the data transfer .Certain routing protocols that uses hierarchical clustering process are LEACH,PEGASIS,TEEN,APTEEN etc

1) LEACH protocol: Heinzelman, et. al. [2] proposed a hierarchical clustering algorithm for wireless sensor networks, called Low Energy Adaptive Clustering Hierarchy (LEACH). LEACH is a cluster-based hierarchical protocol, which encompass distributed cluster formation. The LEACH protocols selects a particular node as cluster head for each

cluster. The role of the clusterheads are rotated in a round robin fashion based on criterias such as energy level, distance from the member nodes etc. In LEACH, the cluster head (CH) nodes gathers the data incoming from member nodes ,aggregates it, and forwards the aggregated packets to the sink node so as to decrease the amount of data that must be transferred to the sink node.

2) Power-Efficient Gathering in Sensor Information Systems (PEGASIS): The protocol, called Power-Efficient Gathering in Sensor Information Systems (PEGASIS), is a chain-based protocol. The fundamental idea of the protocol is that in order to lengthen network lifetime, nodes requires to communicate only with their nearest neighbors and they take turns in communicating with the sink node

A. Communication to sink

The success of wireless sensor networks depends mainly on proficient information delivery from target areas toward sink nodes. The process of forwarding data is further complicated by the rigorous energy constraints of sensor nodes in WSNs. On data collection at the CH, a communication method is selected to let it reach the sink node either by direct communication or by using multi-hop communication.

In direct communication, CH communicates the data to sink without using any transient node. In Multi Hop, CH communicates the data to sink through some transient node (CH, or gateway node).The communication range and the relative CH's nearness to the sink node have to be regarded while transfering data to the sink node. Sensors node's communication range is generally restricted and a CH may not be able to reach the sink node. Even if a sensor node can directly communicate with the sink node, it is better to practice multihop routes instead of choosing single hop communication. Therefore, inter-CH connectivity becomes an significant factor that affects the clustering methodology.

1) Cluster Head to sink direct transmission:

In this type of communication, the cluster heads transfer the data collected from the member nodes directly to sink node. No intermediate nodes are involved.

2) Cluster Head to sink indirect transmission

In this type of communication, clusterheads transfer data to the nearest clusterheads and likewise data is routed through the cluster heads finally reaching the sink node.

IV. SIMULATION SET UP AND RESULTS

In simulation part, the performance of a wsn scenario without and with clustering is analysed in terms of residual energy,packet delivery ratio and network life time by using Network Simulator 2.35(NS2) [14] . Network simulator is a powerful tool and it is object oriented. Fifty sensor nodes were deployed in the sensor grid area size of 1670m x 970m.The routing protocol used was AODV.

TABLE 1 represents the simulation parametes.

TABLE I. SIMULATION PARAMETERS

Simulation Parameters	Value
Network Area Size	1670m x 970m
Initial energy	10 J
Routing Protocol	AODV
Simulation Time	50 s
Traffic source	CBR
CBR Data Packet Size	256 Bytes
Number of Clusters	4

A. Residual Energy

Fig 1 compares the residual energy of network without clustering and with clustering scenarios.It can be seen that the average residual energy in case of clustering method is higher than that of wsn scenario without clustering.Even though the energy consumption is almost similar up to 25 sec,after that the residual energy in the scenario without clustering steeply declines further.It is during this period that the nodes that are farther away from the sink node communicate with it .Towards the end of transmission,the nodes that are situated around the sink node experience a high burden of traffic from the boundary node's data transmission.Their energy level is highly exhausted during this period.This is the reason behind steep energy reduction towards the end of simulation time.

Mean while, considering the scenario which uses clustering, it is seen that the energy consumption is comparatively better towards the end of the transmission.As clustering is adopted ,there is a huge reduction in total number of transmissions towards sink node.Here the cluster members collect data from cluster heads and forwards it to the sink node.Each and every node need not participate in forwarding data to sink node.This helps in reduction of heavy traffic around the sink node and further reduces the chances of packet collisions around sink node. So energy reduction due to packet retransmissions is also avoided in this case.

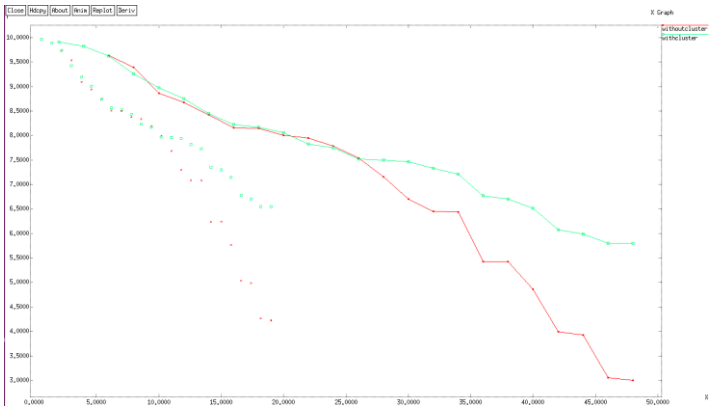

Fig 1.Residual energy in with cluster and without cluster scenarios

B. Packet Delivery Ratio

Fig 2 analyses the packet delivery ratio in case of scenarios with and without clustering:

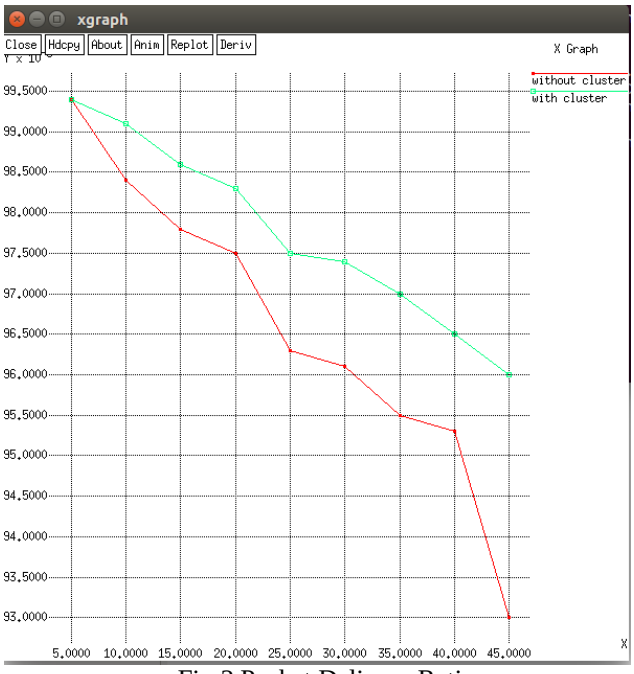

Fig 2.Packet Delivery Ratio

Packet delivery ratio is the ratio of packets that are successfully received to the packets that are transmitted. From the graph it is seen that the packet delivery ratio of the scenario that uses clustering is much better than the packet delivery ratio of the case that does not use clustering. After 20 sec it is seen that packet delivery ratio steeply declines in the case which does not use clustering. This is the period during which nodes that are farther from the sink node transmit data to it.Due to packet drop at each and every intermediate nodes involved, packet delivery ratio reduces steeply. Packet delivery ratio in case of scenario which uses clustering is much better that the case which does not uses clustering.This is because only cluster heads communicate with the sink node.Packet drop increases only if the cluster heads are situated far away from the sink node.The cluster heads are uniformly placed around sink node.So packet drop is less and much better packet deliver ratio is achieved.

C. Network Life time

Fig 3. analyses the network life time in terms of dead nodes in case of scenarios with and without clustering

In can be seen that, around the end of the simulation time, energy of sensor nodes reduces and 4 sensor nodes gets completely drained of their energy and are dead in the case of scenario without clustering. Mean while in scenario which uses clustering, there are no dead nodes and energy level is maintained.

From the above observations,it is clear that,clustering method brings a much better network performance when compared to the scenario that does not uses clustering.

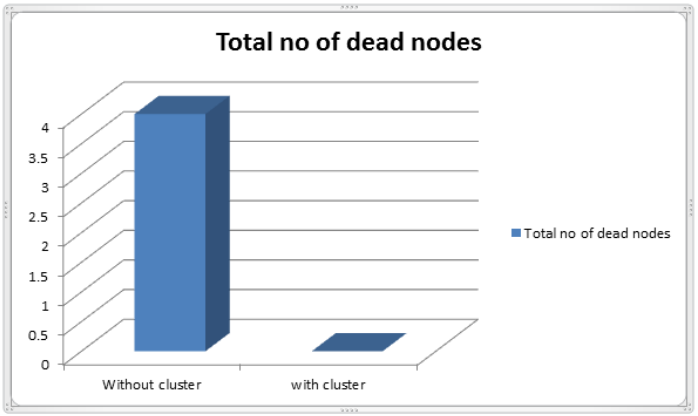

Fig 3:No:of Dead Nodes

Fig 4. further analyse hierarchical clustering by adopting two methods while transmitting data to sink node.In the first case,the cluster heads were made to transmit data directly to the sink node and in the second case,clusterheads were made to route data among themselves and only one clusterhead communicate with the sink node.The residual energy in the 2 cases were analysed.

The data transmission to sink node takes place from 40 to 45 sec .It can be seen that,residual energy is slightly higher in the scenario in which cluster heads route data amongst themselves and only one clusterhead communicates with the sink node. In the other case there is much more energy consumption as each cluster head has to communicate with the sink node.

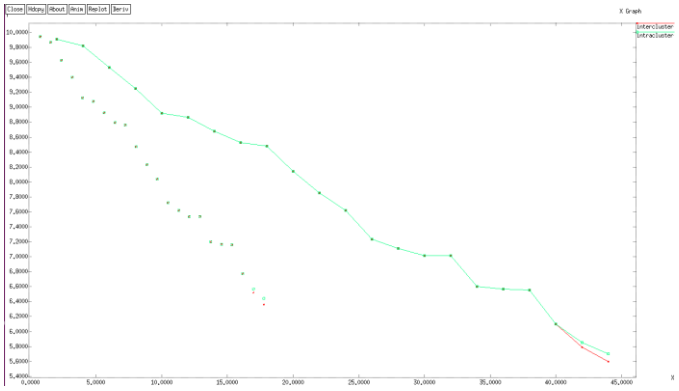

Fig 4.Residual energy while transmitting data tom sink by n methods

V. CONCLUSION

In wireless sensor networks, major energy utilization is due to computational operation performed and data transmission or reception. It is very much necessary to adopt an effective routing strategy for better performance of wsn. Hierarchical clustering method is an efficient method that can be adopted for achieving reduced energy consumption, better packet delivery ratio and network life time.The clustering method adopted is a significant solution to reduce overall data transmission in the network there by reducing heavy traffic burden and chances of collisions.

REFERENCES

[1]I. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," IEEE Communications Magazine, Volume: 40 Issue: 8, pp.102-114, August 2002.

[2]W. Heinzelman, A. Chandrakasan and H. Balakrishnan, "Energy-Efficient Communication Protocol for Wireless Microsensor Networks," Proceedings of the 33rd Hawaii International Conference on System Sciences (HICSS '00), January 2000.

[3]Jamal N. Al-Karaki, Ahmed E. Kamal, "Routing Techniques in Wireless Sensor Networks: A Survey" ,IEEE Wireless Communications (Volume: 11, Issue: 6, Dec. 2004)

[4]C. Karlof, D. Wagner, "Secure routing in wireless sensor networks: attacks and countermeasures", Ad Hoc Networks, Vol.1 (2003) pp. 293315.

[5] R. C. Shah and J. Rabaey, Energy Aware Routing for Low Energy Ad Hoc Sensor Networks", IEEE Wireless Communications and Networking Conference (WCNC), March 17-21, 2002, Orlando, FL.

[6]Tarun Sharma, Harsukhpreet Singh, Anurag sharma, "Simulation Based Analysis Of Cluster-Based Protocol In Wireless Sensor Network"International Journal of Next-Generation Networks (IJNGN) Vol.8, No.1, March 2016.

[7]Xu and J. Gao, "Comparison Study to Hierarchical Routing Protocols in Wireless Sensor Networks," Procedia Environmental Science,Elsevier, vol. 10, pp. 595–600, 2011

[8]L. Y. Barai, "Performance Evaluation of LEACH Protocol for Wireless Sensor Network" vol. 1, no.6, pp. 141–145, 2014.

[9]Hassan Oudani, Jalal Laassiri, Salah-ddine Krit, Lahoucine El maimouni, "Comparative Study and Simulation of Flat and Hierarchical Routing Protocols for Wireless Sensor Network",Engineering & MIS (ICEMIS), International Conference 2016

[10]Reshma I. Tandel, "Leach Protocol in Wireless Sensor Network: A Survey", International Journal of Computer Science and Information Technologies (IJCSIT) Vol. 7 (4), 2016

[11]Ramesh Patill, Dr.Vinayadatt V. Kohir, "Energy Efficient Flat and Hierarchical Routing Protocols in Wireless Sensor Networks: A Survey", IOSR Journal of Electronics and Communication Engineering (IOSR-JECE),2016.

[12]Vishal Kumar Arora ,Vishal Sharma, Monika Sachdeva, "A Survey on LEACH and other's Routing Protocols in Wireless Sensor Network",Optik - International Journal for Light and Electron Optics,Elsevier ,Volume 127, Issue 16, August 2016.

[13]Amrita Ghosal and Subir HalderA, " survey on energy efficient intrusion detection in wireless sensor networks",Journal of Ambient Intelligence and Smart Environments 9 (2017)

[14] Neha Singh, Prof. Rajeshwar Lal Dua, Vinita Mathur, "Network Simulator NS2-2.35", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 2, Issue 5, May 2012

[15]P. Arce, J. Guerri, A. Pajares, O. Lazaro, "Performance Evaluation of Video Streaming Over Ad Hoc Networks Using Flat and Hierarchical Routing Protocols," Book:Mobile Networks and Applications, 2008, pp. 324-336.

[16]B Raja,R Rajakumar,P Dhavachelvan and T Vengattaraman, "A Survey on Classification of Network Structure Routing Protocols in Wireless Sensor Networks", IEEE International Conference on Computational Intelligence and Computing Research,2016.