IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-6, Issue-10 Oct 2018 E-ISSN: 2347-2693

A Comprehensive Study of Routing Protocols in Cluster Based Wireless Sensor Networks

Praveen kumar Rapolu [1], B. Srinu[2]

[1,2] Dept. of Computer Science & Engineering, Vignan Institute of Technology and Science, Deshmukhi, Telangana, India

Corresponding author: srinub1307@gmail.com

Available online at: www.ijcseonline.org

Accepted: 23/Oct/2018, Published: 31/Oct/2018

***Abstract* –** Nowadays Wireless Sensor Networks (WSN) plays vital role in different fields.WSN are more attractive because of their behavior in collecting various kinds of data from harsh environments. These Networks are more popular because these are buildup with less expensive nodes .Nodes in WSN collects the information and send to the base station or sink. Routing plays major role in improving the entire network life time by selecting optimized path. Routing is the process of reaching the destination from source node. Data can be sensed in two ways, those are flat and hierarchical .In flat routing each node in the network is given equal responsibilities. In case of hierarchical routing different nodes plays heterogonous tasks and organized into different clusters. Now in this paper a survey is taken on cluster based routing methods and comparing them with performance issues such as energy awareness, latency and scalability. Advantages and limitations of these methods are presented and conclude with open issues in cluster based routing in WSN.

***Keywords* –** Cluster based routing, hierarchical Routing, Energy efficient routing, Wireless sensor networks.

I. INTRODUCTION

WSN is initially motivated to use in military applications where human beings can't go and monitor the environment. After that WSN are mostly used in civilian application areas like automation, monitoring, tracking, healthcare, process monitoring and surveillance [2]. WSN is a collection of sensor nodes randomly distributed in an area to form a self organizing network. These nodes can perform following operations: capable of sensing the data, processing the data and transmission of collected data to base station. In the process of sending the data routing plays a major role to find the best path to destination node (Sink). Collected data at base station can be used in various applications. The main components of a sensor node include: a processor, sensor, memory, battery and a transceiver.

WSN are limited with many constraints such as battery power, processing capability, transmission bandwidth. So effective routing in WSN is critical issue to maximize the life time of network. Designing a routing protocol [1, 27, 26] is a challenging task because of network constraints on energy efficiency. The main objective of designing protocols is how to improve the energy consumption of nodes and prolong the network life time. Recently number of cluster based routing protocols have been proposed and implemented for WSN. In This study we discuss challenges to design cluster based routing protocols and we also attempt to compare prominent cluster based routing protocols. Main goal is to provide in depth knowledge of various routing protocols.

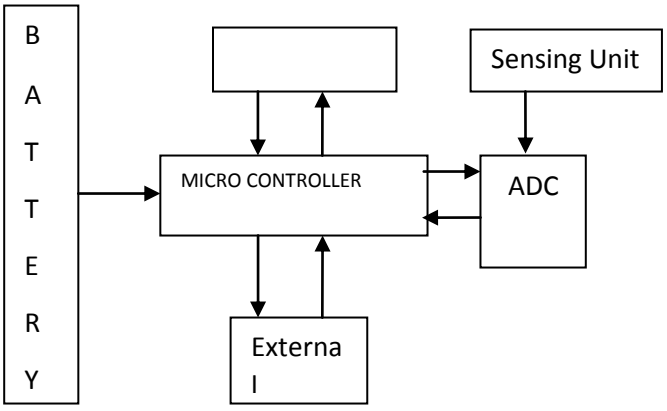

Fig.1. Sensor Node Architecture

II. DESIGN CHALLENGES IN CLUSTER BASED NETWORKS WORK

Routing protocols are more responsible to maximize the life time of the network. This is done by discovering and maintaining efficient routes in network. Routing in WSN is very challenging [25] due to several characteristics that distinguish them from traditional Wired Networks. Characteristics includes: No global addressing scheme, data gathered from multiple regions to sink and data redundancy from multiple sensor. Routing protocols are designed to keep the sensor nodes alive as much as possible [9]. There are some challenging factors in designing routing protocols: scalability, coverage, node deployment, energy consumption,

QoS, application, network Extendibility, cluster head selection.

1. Scalability

Number of nodes in the WSN may vary from few to few thousands. Protocols are designed to work efficiently with many numbers of nodes [8]. No node can be assigned with global address. Routing should work with limited knowledge of network topology.

2. Coverage

Depending upon the application WSN may continuously active or activated when event occurs. In some cases WSN should be able to provide other data from anywhere, at any time. Other side some applications require data when event occurred in the monitoring area. This factor also affects high node density problems which lead to data redundancy.

3. Node Deployment

This factor is depends on application and having much effect on the performance of all routing protocols. The deployment may be done with prior knowledge of node positions or it can be self organizing or dynamic. In former case, the sensors are organized into the field by manual approach and data is passed to the base station using given paths. But in case of self organized, the sensor nodes are distributed in random fashion in the network to create an infra structure. To gain efficient energy benefit and improved performance issues base station position is very impartment. Optimal clustering will result in energy efficient operation in the network.

4. Energy Consumption

The main objective of routing protocol includes how to transfer data among sensor nodes and base station in efficient manner. Energy is consumed at various operation od a sensor node. Those operations are sensing, processing, receiving and transmission of the data. Among these operations data transmission consumes more energy [8]. As sensor nodes are operated with limited energy source, energy depletion of some nodes results in network connectivity changes and reorganizing the network to find new paths. So protocols must be designed with a tradeoff between energy consumption and connectivity of the network.

5. Quality of service

Different applications require different levels of quality to achieve their objective, In WSN, Quality Of Service parameters includes: bandwidth, Delivery Delay, throughput etc. For example military applications requires accurate information about the objects in the battle field and tracking applications requires low transmission delay for the time sensitive data. While multimedia applications requires high throughput because synchronization of audio and video must be maintained.

6. Application

Routing protocols are application specific, different scenarios requires different routing protocols. Data can be collected from the monitoring environment based on kind of application like time driven, event driven, and query driven. Time driven applications collects data in fixed periodical units and report that data to base station. In case of event driven applications data send to the base station when an event occurred in the monitoring environment. In query driven applications base station request sensor nodes to collect the information.

7. Network Extendibility

It is sometimes desirable to change the size of the network by adding one or more sensor nodes to existed network. The basic idea of adding extra nodes to the network is to increase the coverage. Then careful examination has to be taken to desing a new routing scheme by considering newly added sensor nodes. Sometimes it also lead to change the cluster nodes membership.

8. Cluster Head Selection

Cluster heads are allowed to communicate with base station. The cluster head job is to collect the data from various nodes in that cluster, compresses, and then transmit the processed data to remotely located base station. To balance the energy consumption, nodes in cluster are periodically selected for cluster head. So in this method no node is permanently acting as cluster leader. So routing protocols should consider the predetermined factors in the selection of cluster head. Some of the factors are remaining energy of the node, node position in the cluster and its connectivity to other nodes in that cluster.

III. CLASSIFICATION OF CLUSTER BASED ROUTING PROTOCOLS

As mentioned in the earlier section routing plays major role in achieving energy efficiency [31] [32] in the WSN. Routing is implemented in network layer of the WSN. In cluster based networks cluster head communicates its data to the base station where as normal Sensor nodes cannot communicate directly to the base station. In every cluster there is one special node called cluster head and member nodes. Node with high energy acts as a cluster head and performs operations such as data processing and transmission to the base station. Nodes with low energy are treated as member nodes and these nodes are assigned with job of sensing the information from the environment and send to base station. According to the network structure Routing protocols are categorized as follows.

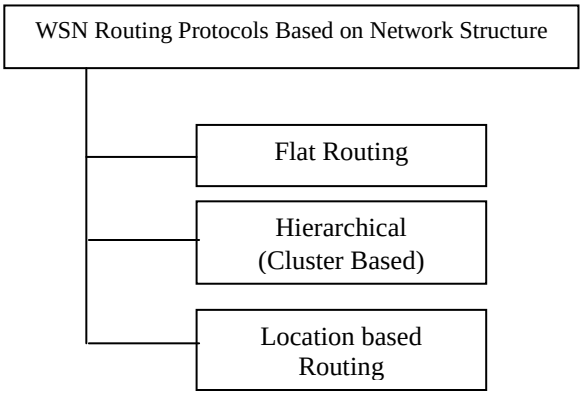

Fig. 2 routing protocols based on network structure

In the flat routing process, every node in the network performs the same job and information dissipation is carried out using flooding technique. Flat routing algorithms are preferred in small scale networks. While in Hierarchical or cluster based networks nodes executes different tasks. Cluster based approach is preferable in applications where scalability and efficient communications are basic goals. Cluster based routing [7,6.10] is energy efficient method where clusters heads are performing receiving , aggregating and transmission of the information to the base station, where as member nodes only sense data from environment and pass that data to cluster head. Cluster based protocols are categorized following types: block grid and chain cluster based routing protocols. The categorization of cluster based protocols is described in figure 3.

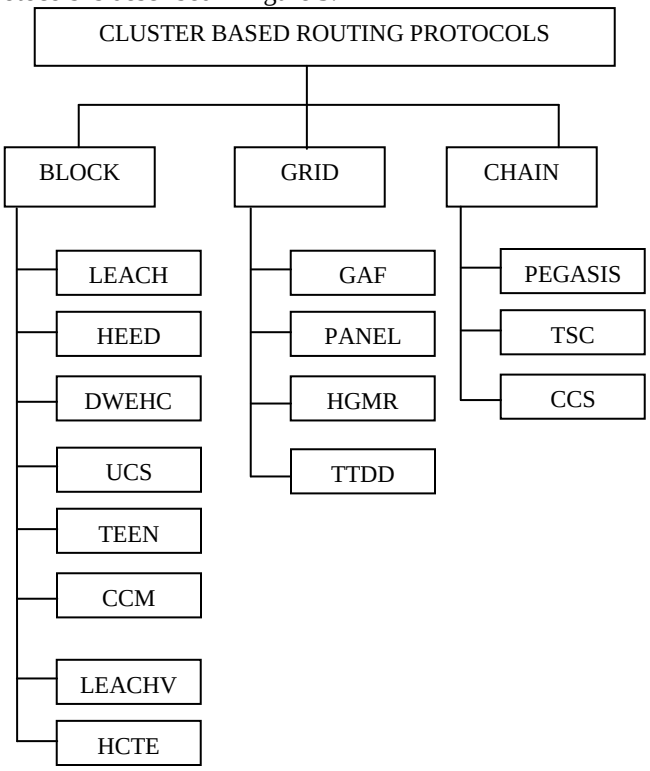

Fig. 3 categorization of cluster based Routing protocols

3.1 LEACH[30]

LEACH stands for Low-Energy Adaptive Clustering Hierarchy and it is a most famous algorithm under optimized energy consumption.

Merits:

i) Each node is selected as cluster in uniform fashion and cant not selected as cluster head in sub sequent rounds.
ii) Load is shared between all the nodes.
iii) LEACH used TDMA to avoid unnecessary collisions among Cluster Heads.

Limitations:

i) LEACH cannot be used for large scale networks because of its single hop communication.
ii) As it used probability equations to select cluster heads, it may not perform equal load balancing.
iii) Increase in Cluster heads will consume more energy.

3.2 HEED [20,30]

The main goal of HEED (Hybrid Energy-Efficient Distributed) is to extend the network life time. The difference between HEED and LEACH is in the process of selecting cluster head. LEACH cluster head selection is random, but in case of HEED it depends on the residual energy of the node and intra cluster communication.

Merits:

i) Its routing technique is fully distributed cluster based
ii) Uniform cluster head selection.
iii) HEED achieves high energy efficiency by using multi
hop communication technique.

Limitations:

i) Suffers from massive overhead due to multiple rounds.
ii) Unbalanced energy consumption due to more num ber of cluster heads.
iii) Additional over due to several iterations done to form clusters.

3.3 DWEHC [3,18]

The Distributed Weight-based Energy-efficient Hierarchical Clustering scheme is an enhancement to HEED. Each cluster has Cluster Head and child nodes, child nodes further divided into levels.Total number of levels depends on the cluster range and minimum residual energy of the cluster head.

Merits:

i) Similar to HEED, DWEHC is also a fully distributed clustering method.
ii) It reduces energy consumption compare to HEED because it generates better balanced cluster head

distribution.
iii) DWEHC's clustering process does not depends on the network size.

Limitations:
i) It uses single hop inter communication, which results in low energy efficiency.
ii) DWEHC has large control message overhead compared to other techniques.

3.4 UCS[19,3]
The unequal clustering size (UCS) provides more balanced energy consumption for cluster heads. UCS is a two layered network model, and the size of clusters differs. Cluster heads are positioned nearer to base station in circular paths known as levels. Size of the cluster depends on the residual energy of the cluster head. Multi hop communication technique is used to transmit the data to base station.

Merits:
i) To balance the communication load , the number of nodes in the cluster changes.
ii) As it is using two layer network , it consumes less energy.

Limitations:
i) UCS is limited by its assumptions that the cluster heads are pre determined and network is heterogineous.
ii) Always cluster heads are selected from the center of the cluster and normal nodes residual energy is never considered.
iii) It used two hop communication mechanisms which are not sufficient for large scale networks.

3.5 TEEN[3,28,29]
The Threshold-sensitive Energy Efficient sensor Network (TEEN) is a hierarchical method for reactive networks. TEEN has a two tier clustering topology and it uses two threshold values: one is hard threshold and other is soft threshold. The main aim of threshold is to trim down the amount of data transmitted between nodes. Hard threshold value is used as rule for transmitting the sensed data. If that data is greater than the hard threshold value then only the sensed data is sent to base station. Soft threshold value will indicate the change in the sensed data in fixed intervals. If the change exceeds soft threshold then also data is send to the base station

Merits:
i) Data transmission process can be controlled by frequently changing the threshold values.
ii) It is mostly used in time critical applications.

Limitations:
i) Node will sit ideal ideal if it does not met the threshold values and its sensed data is not sent to the base station.
ii) There may be a chance of the data loss if cluster heads are not communicating to each other.

3.6 CCM[21]
Chain Cluster based Mixed (CCM) is a mixture of cluster and chain clustering. In case of CCM nodes are organized set of organized chains and vertical clusters. CCM takes the advantage of both PEGASIS and LEACH. PEGASIS stands for Power Efficient Gathering in Sensor Information System. This method of CCM overcomes the problems of energy consumption and delay metric compared to LEACH and PEGASIS.

Merits:
i) Less energy consumption compared to LEACH
ii) Less delay in transmission compared to PEGASIS.

Limitations:
i) Chain head selection is a critical issue.
ii) Cluster heads which are very closer to base station will use more energy to send the total sensed information from all the clusters.

3.7 LEACH-VF[4]
LEACH with VF(Virtual Force) applies virtual field principles on clusters. By using this principle sensor nodes are moved to cover more area and to reduce transmission energy. In case of LEACH-VF, it makes use of two types of virtual forces: attractive and repulsive force. Energy consumption is improved by using attractive force where as repulsive force used in maximizing the coverage area. Attractive force is used to moves the nodes nearer to cluster head hence distance is reduced between node and cluster head reduces and transmission consumes a reduced amount of energy. By using repulsive force nodes are moves away from each other in case of collisions so that more node coverage can be improved. The LEACH VF algorithm is divided into three phases. Setup and steady phases are similar to LEACH. In between these two phases virtual force applies phase is executed to re organize the positions of the nodes.

Merits:
i) Balanced distribution of nodes in the cluster
ii) Less energy consumption between nodes and cluster heads.

Limitations:
i) Due to extra phase power consumption may be more during set phase.
ii) Equal size cluster are created irrespective to data availability.

3.8 HCTE[5]

Hierarchical cluster based routing algorithm uses two cluster heads inside one cluster to balance the energy usage of the nodes. It uses multi hop communication to transfer the data to the base station. HCTE makes use of five phases to complete the task of sending the data to base station.

Phase 1: setup which is similar to HEED LEACH .

Phase 2: During this phase cluster formation is done and each node found the well suited cluster head and nodes joins with the cluster.

Phase 3: In this phase the second cluster head is announced. This calculation is done purely based on self confidence values of the nodes.

Phase 4: This phase uses time division multiple access for data transmission.

Phase 5: This step used to formulate multi hop data transfer.

Merits:

i) Achieves better network life time compared to LEACH
ii) 35% longer network time compared to LEACH

Limitations:

i) Selection of cluster second cluster head will take time in setup phase.

3.9 GAF[22]

Geographic adaptive fidelity (GAF) is a location based routing protocol. Clusters are created by knowing its location. The clusters in GAF are fixed virtual grids. These virtual grids are small enough to communicate directly to the adjacent nodes. In GAF , a node may be placed in three states: a)Discovery , which finds the adjacent nodes in the grid b) active, shows active participation of a node in routing c) sleep, when the radio is turn off.

Merits:

i) At least on of the node in the cell is active all the time, so that routing fidelity is maintained.
ii) Network life time is improved by saving the energy levels at each node.

Limitations:

i) GAF may result in more traffic injections.
ii) Delay is not predictable; this makes GAF not suitable for real time applicaton in WSN.

3.10 PANEL[13]

The Positions based Aggregator Node Election is a position based scheme. In this nodes are positioned into bounded areas part ions called geographic clusters. The clustering is predetermined and each node knows about its geographic information. In PANEL, cluster head selection is done by using the concept of reference point. This cluster head selection process ensures the load balancing and every node in the cluster can become cluster head with equal possibility.

Merits:

i) PANEL is energy efficient because each node of the cluster will obtain a chance to act as a cluster head.
ii) It is used in asynchronous applications.

Limitations:

i) In PANEL cluster are pre determined which makes this method inapplicable to WSN.

3.11 HGMR[14,15,16]

HGMR stand for Hierarchical Geographic Multicast Routing. It is a multicast scheme based on location of the node. HGMR make use of mobile geo graphic hashing. Inside each group Geographic Multicast routing is used to forward the data along multi cast path. This method is an enhancement to GMR and Hierarchical Rendezvous Point Multi scheme (HRPM). HGMR uses HRPM to divide the multi cast groups into sub groups.

Merits:

Energy efficiency is achieved in HGMR because different hierarchies are used in data transimission.

i) Easy to maintain membership of the nodes in a group.
ii) HGMR achieves high scalability.

Limitations:

i) May not get optimal routing paths.
ii) APs (access points) can change frequently by hash function which results in unbalanced energy consumption.
iii) The routing path efficiency is low because data is transmitted from upper Access Points to lower Access Points irrespective of the lower Access Point positions.

3.12 TTDD[17]

The two tier data dissemination is intended to solve the problem of multiple mobile sinks. TTDD used grid structure and uses sensor nodes at the grid points to data transmission. It is a proactive protocol. Every grid in this model has two tiers: lower tier and higher tier. Lower grid is within local grid square of the sink's current location and higher grid is made up of dissemination nodes on the grid.

Merits:

i) TTDD resolve the problem of multiple sinks
ii) It also solves the sink moving problem of large scale WSN.
iii) TTDD is well suited for event detecting at irregular intervals rather than continuous.

Limitations:

i) Due to query flooding it consumes more energy
ii) It has more latency because forwarding path is not a shortest path.

iii) In TTDD sensor nodes must location awared and must be stationary

3.13 PEGASIS[3,23,24]

Power Efficient Gathering in Sensor Information System is improved version of LEACH. In this method every node communicates with its near neighbors and becomes leader for that data transmission in a chained approach. The nodes in this model are randomly distributed. Energy load is uniformly distributed over the entire network. Nodes are arranged into chains by themselves or nodes can get location data and locally form a chain using greedy approach.

Merits:

i) It reduces the data transmission using the chained approach in data aggregation.
ii) Energy consumption is equally distributed over the network. Hence every node in the network becomes leader in the data transmission.

Limitations:

i) PEGASIS is not preferable for time varying topologies network.
ii) PEGASIS assumes that every node in the network can capable of communicating with base station but in reality it may not happen.
iii) Communication takes long duration.
iv) These kinds of networks are not scalable. The reason is all the nodes should have overall knowledge of network and use of the greedy approach.

3.14 TSC[11,12]

Track Sector clustering is uses a method of diving the network into tracks and each track is further divided into triangular sectors. This process of dividing tracks and sectors will save energy by minimizing the redundant data in the track and it also provides shortest path between cluster heads and base station. Every sector has a cluster head and it will do operation of data aggregation and transmission. The collected data is send to the cluster head of the next lower level track. It transmits data to base station by using multi hop communication.

Merits:

i) It is Energy efficient than PEGASIS.
ii) Redundancy is reduced by dividing the network into tracks and sectors.

Limitations:

i) Unbalanced energy distribution because it never considers the remaining energy of each node in selecting the cluster head.
ii) In TSC the node distribution in each level is unbalanced.

3.15 CCS[3,12]

The Concentric Clustering Scheme is enchantment to PEGASIS. It overcomes the energy related problems of PEGASIS. The core idea of this method is to know the base station position to increase the networks life time. In case of CCS network is formed by using concentric tracks with level numbers. Level 1 is assigned to the track very nearer to base stationand numbering increased to upper layers. Each track has a cluster which transmit the data to base station. Transmission of data in this method is similar to that of PEGASIS where chained approach is used. Each track's cluster head is used to send data to the next cluster head which is lower in level number. Finally the level 1 cluster head transmits total sensed data to base station.

Merits:

i) Energy utilization is improved.
ii) Reduces data transmission from base station to concentric tracks.

Limitations:

i) There is unbalanced node distribution at each level
ii) There may be unbalanced energy consumption because cluster head selection not considers the residual energy of the nodes.
iii) Long chain communications takes large delay.

IV. COMPARISION OF PROTOCOLS

In this division, we are showing comparison statistics of the different clustering routing algorithms for WSNs. The following tables shows the categories and differences of the clustering routing protocols in WSNs by considering a variety of clustering attributes.

Table 1. Comparison of clustering protocols

Protocol name	Delivery Delay	Scalability	Energy efficiency	Load balance
LEACH	Very poor	Very poor	Very poor	Medium
HEED	Medium	Medium	Medium	Medium
DWEHC	Medium	Medium	Very high	Very good
UCS	Poor	Poor	Very poor	Poor
TEEN	Poor	Poor	Very high	Good
CCM	Poor	Very poor	Very poor	Medium
LEACH VF	Very poor	Very poor	Medium	Medium
HCTE	Very poor	Very poor	Very poor	High
GAF	Poor	High	Medium	Medium
PANEL	Medium	Poor	Medium	Good
HGMR	Medium	Very high	Poor	Poor
TTDD	Very high	Poor	Very poor	Good

PEGASIS	Very high	Very poor	Poor	Medium
TSC	Medium	Medium	Medium	Poor
CCS	High	Poor	Poor	Very poor

V. CONCLUSION

In this paper, an overview of cluster-based routing algorithms in Wireless Sensor Network is presented. We presented the merits and classification of cluster-based routing algorithms in WSNs. we compared different methods of routing on the basis of various performance factors. It is clear that the different cluster-based routing algorithms mentioned above can be used to improve the performance of WSNs. We believe that this survey work will encourage researchers and designers of routing protocols. Different characteristics of the clustering routing protocols are discussed which helps in generating an effective routing protocol for cluster based networks, and the more research work would be done in the future scope for the WSN field.

REFERENCES

[1] Santar Pal Singh, S.C. Sharma, "A survey on cluster based Routing Protocols in Wireless Sensor Networks", Procedia Computer science 45 (2015) 687-695.

[2] Gulbadan Sikander, Mohammad Haseeb Zafar, Ahmad Raza, Muhammad Inayatullah Babar, Sahibzada Ali Mahmud, and Gul Muhammad Khan " A Survey of Cluster-based Routing Schemes for Wireless Sensor Networks", Smart Computing Review vol. 3, no. 4,pp. 261-275, August 2013.

[3] X. Liu, "A Survey on Clustering Routing Protocols in Wireless Sensor Networks," Sensors, vol. 12, pp. 11113–11153, 2012.

[4] F. Awad, "Energy-Efficient and Coverage-Aware Clustering in Wireless Sensor Networks," Wireless Engineering and Technology, vol. 03, no. 03, pp. 142–151, 2012.

[5] N. Azizi, J. Karimpour, and F. Seifi, "HCTE: Hierarchical Clustering based routing algorithm with applying the Two cluster heads in each cluster for Energy balancing in WSN," IJCSI International Journal of Computer Science, vol. 9, no. 1, pp. 57–61, 2012.

[6] S.Naeimi, H. Ghafghazi, C.O. Chow, and H. Ishi, " A survey on taxonomy of cluster-based routing protocols for homogeneous wireless sensor networks", Sensors, vol.12, no.6, pp.7350-7409,2012.

[7] X. Liu ," A survey on clustering Routing protocols in Wireless Sensor Networks: Sensors, vol.12, pp.11113-11153,2012.

[8] Haneef, M. and D. Zhongliang, 2012. Design challenges and comparative analysis of cluster based routing protocols used in wireless sensor networks for improving network life time. Adv.Inform.Sci. Service Sci. 4: 450-459.

[9] Rose line, R.A. and P.Sumanth, 2011." Energy efficient routing protocols and algorithms for wireless sensor networks- a survey.Global J. Comput. Sci. technol.,11:60-67

[10] Ameer Ahmad Abbasi, Mohamed Younis, : A survey on clustering algorithms for wireless sensor networks" computer Communication30(2007) 2826-2841.

[11] N.Goutham, W. Il Lee, and J.Y. Pyun, "Track Sector clustering for Energy efficient Routing in Wireless Sensor Networks", in Proc. of 9th IEEE International Conference on Computer and Information Technology,pp. 116-121,2009.

[12] S. Jung, Y. Han, and T. Chung, "The Concentric Clustering Scheme for Efficient Energy Consumption in the PEGASIS," in Proc. of 9th International conference on Advanced Communication Technology, pp. 260–265, 2007.

[13] L. Buttyan and P. Schaffer, "PANEL: Position-based Aggregator Node Election in Wireless Sensor Networks," in Proc. of IEEE Internatonal Conference on Mobile Adhoc and Sensor Systems, pp. 1–9, 2007.

[14] D. Koutsonikolas, S. Das, Y. C. Hu, and I. Stojmenovic, "Hierarchical Geographic Multicast Routing for Wireless Sensor Networks," in Proc. of International Conference on Sensor Technologies and Applications, pp. 347–354, 2007.

[15] J. A. Sanchez, P. M. Ruiz, and I. Stojmenovic, "GMR: Geographic Multicast Routing for Wireless Sensor Networks," in Proc. of 3rd Annual IEEE Communications Society on Sensor and Ad Hoc Communications and Networks, pp. 20–29, 2006.

[16] S. M. Das and Y. C. Hu, "Distributed Hashing for Scalable Multicast in Wireless Ad Hoc Networks," IEEE Transactions on Parallel and Distributed Systems, vol. 19, no. 3, pp. 347–362, 2008.

[17] H. Luo,F.Ye, J. Cheng, S.Lu, amd L.Zhang. "TTDD:Two-Tier Data Dissemination in Large-Scale Wireless Sensor Networks",Wireless networks, vol. 11,no.1-2,pp.161-175,2005.

[18] P. Ding, J. Holliday, and A. Celik, "Distributed Energy-Efficient Hierarchical Clustering for Wireless Sensor Networks," in Proc. of the First IEEE international conference on Distributed Computing in Sensor Systems, pp. 322–339, 2005.

[19] S.Soro, W.B. Heinzelman, "Rpolonging the life time of Wireless Sensor Networks via Unequal clustering", in proceedings of 19th IEEE International Parallel and Distributed Processing Symposium,2005.

[20] O. Younis and S. Fahmy, "HEED: A Hybrid , Energy-Efficient, Distributed Clustering Approach for Ad-hoc Sensor Networks," IEEE Transactions on Mobile Computing, vol. 3, no. 4, pp. 366–379, 2004.

[21] F. Tang, I. You, S. Guo, M. Guo, and Y. Ma, "A chain-cluster based routing algorithm for wireless sensor networks," Journal of Intelligent Manufacturing, vol. 23, no. 4, pp. 1305–1313, 2010.

[22] Y. Xu, J. Heidemann, and D. Estrin, "Geography-informed Energy Conservation for Ad Hoc Routing," in Proc. of the 7th annual international conference on Mobile computing and networking, 2001, pp. 70–84.

[23] S. Lindsey, C. Raghavendra, and K. M. Sivalingam, "Data Gathering Algorithms in Sensor Networks Using Energy Metrics," IEEE Transactions on Parallel and Distributed Systems, vol. 13, no. 9, pp. 924–935, 2002.

[24] S.Lindsey, C.Raghavendra, amd K.M. Sivalingam,"Data gathering algorithms in sensor networks Using EnergyMetrics",IEEE Transactions on Parallel and Distributed Systems, vol.13, no.9, pp. 924-935,2002.

[25] Jamil I and imad M, "cluster based routing in wireless sensor networks:Issues and challenges",SPECTS,2004

[26] Kazem Sohraby, Daniel Minoli, taieb Znati, " Wireless Sensor Networks:Technology:Protocols and Applications", Jphn Wiley & Sons, 2007.

[27] Al-Karaki, J.N., and A.E. kamal, " Routing techniques in wireless sensor networks: a survey", IEEE Wireless Communication11:6-28,2004.

[28] A. Manjeshwar and D. P. Agrawal, "TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks," in Proc. of 15th International Parallel and Distributed Processing Symposium, pp. 2009–2015.

[29] A. Manjeshwar and D. P. Agrawal, "TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks," in Proc. of 15th International Parallel and Distributed Processing Symposium, 2001.
[30] Heinzelman, W.R., Chandrakasan, A.,Balakrishnan,H., "Energy efficient communication protocol for wireless mocro sensor networks", in proceedings of the Haeaii International conference on System sciences,2000.
[31] Neha P . Dahihanderkar, v. v. Kimbahune. "Cluster-based protocolfor heterogeneous Wireless sensor Networks", International Journal of science and research (IJSR), Volume 4 issue 6, june 2015, 292-295
[32] Vivekchandran K. C, Nikesh Narayan .P. " Energy Efficiency and Latency Improving In Wireless Sensor Networks" , International Journal of science and research (IJSR), Volume 4 issue 5, May 2015, 1291-1295

Authors Profile

Rapolu Praveen kumar obtained B.Tech. in Computer Science and Information Technology from JNTU Hyderabad in the year 2004 and M.Tech (CSE) from JNTU Hyderabad in 2009. He is presently a research scholar in JNTUH and also associated with Vignan Institute of technology and science, Hyderabad as Sr. Assistant Professor, Department of CSE. His main research interests include opportunistic wireless sensor networks and routing in sensor networks

Srinu B obtained B.Tech. in Computer Science and Engineering from JNTU Hyderabad in the year 2004 and M.Tech (CSE) from JNTU Hyderabad in 2009. He is presently a research scholar in JNTUH and also associated with Vignan Institute of technology and science, Hyderabad as Assistant Professor, Department of CSE. His main research interests include network security and cloud computing

.

