Comprehensive Investigation of Routing Mechanism and Energy Consumption in Wireless Sensor Networks

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Abstract
Wireless ad hoc network and Sensor networks have gained popularity due to adaptability in all walks of communication life, especially when every device is going wireless. In this paper an exhaustive survey has been done to investigate the energy consumption and also to save the energy while transferring data from motes to cluster head and then to PAN coordinator. In this work routing algorithms have also been analysed critically for efficiency and power saving. This paper analyses the work in the area of routing, congestion and lifetime of the nodes in the sensor network and suggested methods to improve the parameters. Protocols like LEACH have been given due consideration while analysing the work.

Keywords
WSN, PAN, Energy. LEACH

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Introduction

Wireless network is a network which is used to connect network node by establishing wireless data connection. We can categorize Wireless networks in two ways:-

1. Infrastructure based:- An existing infrastructure based communication; means a base is present which gives permission for communication.
2. Infrastructure less:- A peer to peer communication, means there is no base present and no one gives permission for communication [1]

A wireless sensor node, also known as Mote, is a node in sensor network that is capable of performing some processing. Gathering sensory information and communicating with other connected nodes in the network. A mote is a node but a node is not always a mote. The main components of a sensor node are microcontroller, transceiver, external memory, power source and one or more sensors. Wireless sensor networks are formed by random number of sensor nodes that gather information and forward it to base station. In other words, we can also say, Wireless Sensor Networks typically consists of a large number of low cost, low power and multifunctional wireless sensor nodes, with sensing wireless communication and computation capabilities.

These sensor nodes communicate over short distance via a wireless medium and collaborate to accomplish a common task. For example, Environment monitoring, Military Surveillance and Industrial Process Control. [2]

The range of task can be widely classified in to three groups to enable wireless sensor application using sensor technologies:-

1. The System: Each and every sensor node is an individual system. The development of new platforms, operating systems and storage schemes are needed to support the different applications of Wireless Sensor Network.
2. Communication Protocols: these protocols are used between application and sensors. They are also enabling communication between the sensors node.
3. Services: wireless sensor network also use some services which improve the system performance network efficiency and enhance the application [3]

Applications in Wireless Sensor Network

Wireless sensors have great capability for many applications. Sensor network may consist of many different types of sensors such as seismic, low sampling rate, magnetic, thermal, visual, infrared, and acoustic and radar. These are able to sense the wide variety of conditions such as temperature, humidity, vehicular movement, lightning conditions, pressure etc. we categorize the applications into military target tracking, environment, surveillance, natural disaster, health, home and other commercial areas. For example, a large quantity of sensor nodes could be deployed over a battlefield to detect enemy intrusions instead of using landmines. When the sensors detect the event being monitored (heat, pressure, sound, light, electro-magnetic field, vibration, *etc.*), the event needs to be reported to one of the base stations, which can than take some appropriate action (e.g., send a message on the internet or to a satellite).

Classification of Routing Protocol

Here, we present a simple classification of sensor networks on the basis of their mode of functioning and the type of target application.

Proactive Networks

The nodes in this network periodically switch on their sensors and transmitters, sense the environment and transmit the data of interest. Thus, they provide a snapshot ofthe relevant parameters at regular intervals. They are well suited for applications requiring periodic data monitoring.

Reactive Networks

In this scheme the sensor nodes react immediately when it senses sudden change in the value of a sensed attribute. So, they are suitable for time critical applications.

Hybrid Networks

It is the combination of proactive and reactive routing protocol. By this scheme we can improve the operation of protocols. For example, APTEEN (Adaptive Threshold Sensitive Energy Efficient Sensor Network Protocol), it is the combination of leach (proactive) and teen (reactive) protocols.

Architecture of Wireless Sensor Network

Let us discuss about the architecture of wireless sensor network. The performance of the routing protocol depends on the architecture and design of the network. Here we examine the essential parts of the structure.

- Sensor node: - sensor node is the basic part of the structure, which is also known as mote. It is playing multiple roles in wireless sensor network like sense the data, storage data, routing, transmit the data.
- Cluster:- cluster is created by divide the network in the small parts. It is the organizational unit of the structure.it simplify the communication in the network.
- Cluster head: - The job of the cluster-head is to collect data from their surrounding nodes and pass it on to the base station.
- Base station: - it is the link between the sensor network and the end user.It is the upper level of the network.
- End user:- The stored data in the sensor network is applicable in so many application

Existing Hierarchical Routing Protocol

The first proposed algorithm for wireless sensor network was LEACH.[5] It stands for “Low Energy Adaptive Clustering Hierarchy” protocol. It was the first hierarchical routing protocol. It also proposed how to increase the network lifetime. In this protocol operation had been done in two phases- first, setup phase and second is steady state phase. In the set up phase clusterhead chosen, in the steady state phase clusterhead is maintained and data is transmitted between the nodes. It is the rotation based protocol so it can balance the load of the nodes. And increase the lifetime of the nodes.

In paper[6] researcher discussed about the extended version of the leach protocol which is EEE LEACH. It is the two level protocols.It reduces the distance between the BS and CH by create the Master cluster head, so it saves the energy and improves the battery life of the CH. In the operation of this

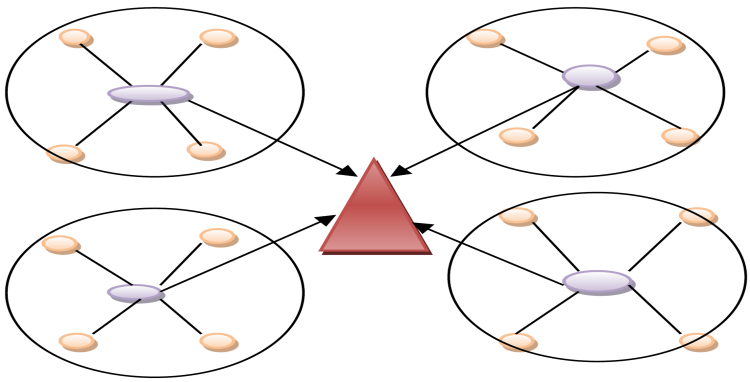

Figure 1. diagram of wireless sensor network

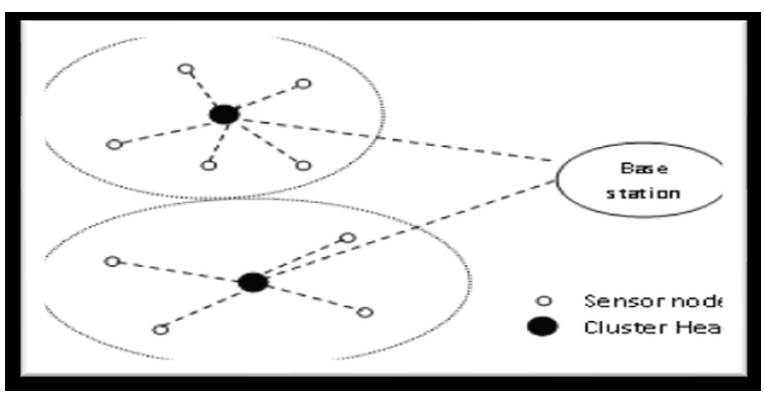

Figure 2. DIAGRAM OF LEACH PROTOCOL

protocol CH first aggregate the data from the normal nodes and MCH fuse the data from CH and sends to the BS. In this[6] paper author compare the three routing protocol based on the transmission time and Throughput. And the protocol which are used for comparison respectively EEE LEACH, LEACH, Direct transmission Protocol.

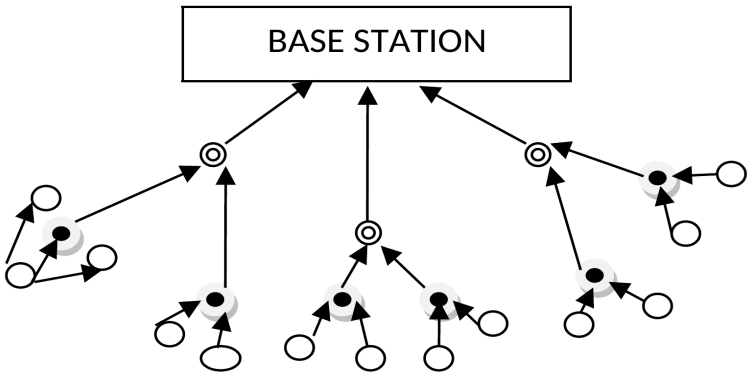

Figure 3. DIAGRAM OF EEE LEACH PROTOCOL

In paper[12] author discussed about another protocol HEED. It stands for hybrid energy efficient distributed clustering protocol. It is also the extended scheme of LEACH. It balanced the power of the node by using residual energy and node degree. HEED uses two parameter first is residual energy and second is intercommunication cost. It is the average reach ability power of the node. In paper[13] author described the heed is three steps- first, initialize: in this step initial CH selected, based on initial percentage of CH among all nodes. Second, iteration processing: in this step set the probability of all nodes to become the tentative CH. And third is Finalize: in this step of protocol nodes join the cluster by calculate the residual energy and low cost of the CHs. This protocol only suitable for increase the network lifetime and it could not able to fulfill another requirement of the WSN.

In paper[10] author discussed important protocol of routing in WSN which was PAGESIS. It stands for Power-Efficient Gathering in Sensor Information Systems. It is the chain-based power efficient protocol based on LEACH. According to this scheme, all nodes have the knowledge of all other nodes. In this scheme data is gathered and aggregated from the nearby node[14].

Each node can transmit and receive the data from neighbor node and only one node can directly communicate to the BS which is the leader or head of the chain. The chain is constructed in greedy approach. And the most important thing is, all nodes should have global knowledge of the network, this is the drawback of this scheme.

And it saves the energy by reducing the distance and limitations of transmit and receive.

In paper[3] author proposes a new energy efficient routing protocol TEEN. It is well suitable for temperature sensing applications in WSN. It is a reactive protocol. It is the time critical application. Node senses the environment continuously but it sends the data when the value of the sensor changed drastically. In paper[16], author describe the functionality of this protocol. First, sensor node and BS both have the same initial energy and BS can transmit data to all the nodes in the network directly. It is the

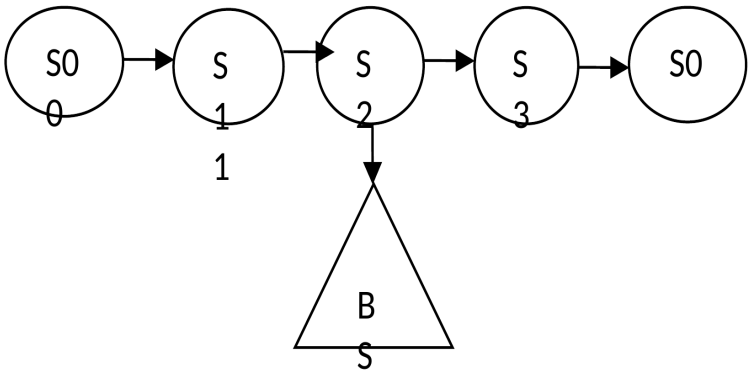

Figure 4. DIAGRAM OF PEGASIS PROTOCOL

multilevel protocol. At first level CHs formed far the BS and in the second level CHs formed near the BS.

There are two types of threshold value which is broadcast to its member by CHs i.e. hard threshold and soft threshold.In the hard threshold, the node transmits data if the sensed attribute is in range of network and it reduces the no. of transmissions. And it is the exact value of the sensed attribute. And in the soft threshold, if any small change is find in the sensed attribute that is transmitted to the BS. TEEN is not suitable for those sensing application where periodic results are needed. Energy consumption in this scheme is less than the proactive networks because more energy consume is data transmission not in data sensing[12].

In paper[16] author described the several existing routing protocol. From this protocol one of the protocol is APTEEN. It stands for Adaptive Threshold Sensitive Energy Efficient Sensor Network Protocol. It hybrid network protocol. It is the combination of LEACH and TEEN protocol. The hierarchical clustering diagram of this protocol is same as TEEN protocol. It collects the periodically and react at time critical event. In this protocol, first cluster head decided in each cluster periods and then broadcast the some parameter which includes attribute, threshold value, count time, time schedule.

Literature Review

Maryam soleimani, Amirrali Sharifian, Ali Fanian proposed a new clustering algorithm for wireless sensor network which is based on node deployment knowledge, named PDKC(power consumption based on node deployment knowledge for cluster based WSNs). In this algorithm, Gaussian probability distribution function used for detect the sensor node location, instead of any other location devices. In this cluster head is selected by the node deployment knowledge, residual energy, node degree and their distance from the base station. So this algorithm increase the network lifetime by saving the energy consumption. Norah tuah, Mahamood Ismail and Ahmad Razani Haron analyzed the total energy consumption in each iteration. Authors also proposed a new routing protocol for heterogeneous WSNs. In description of this protocol, it has three level: cluster head selection phase, cluster formation phase, data communication phase. It prolong the network lifetime by minimize the energy consumption.

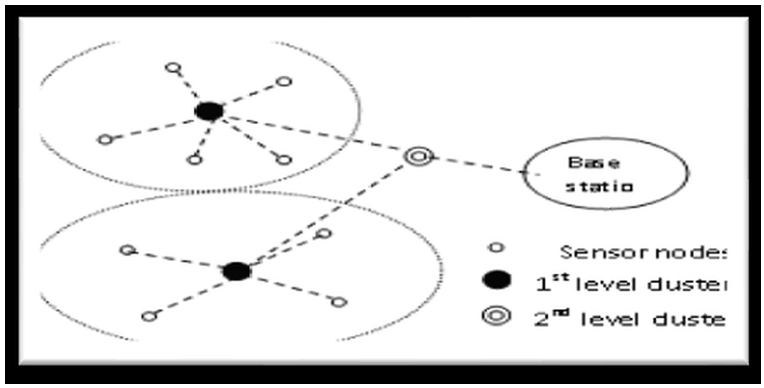

Figure 5. DIAGRAM OF TEEN AND APTEEN PROTOCOL

Khushboo pawar, vishal pawar, tilotma Sharma improved the LEACH protocol through heterogeneity concept. In this author increase the time interval before the failure of first node. This concept is applicable in many applications. In this improved protocol, cluster head selection is based on weighted election probability according to the remaining energy in each node.

Alireza Firuzbakh, Asgarali bouyer proposed the new optimal algorithm for increase energy efficiency in wireless sensor network. This algorithm is based on a very famous protocol LEACH. It is a clustering based protocol. In this protocol data is gathered from the sensors and tried to reduce data redundancy in each cluster so it decrease the energy consumption. But sometime some functions can't reduce the data redundancy alone so the new proposed algorithm used the gridding and clustering technique to reduce the data redundancy.

Jabber Beitollahzadeh, Abdollah Amirkhani, Karim Mohammadi proposed the new algorithm which is based on fuzzy neural network . In this algorithm cluster head selection and clustering has been done on the basis of fuzzy neural technique. Os this increase the network lifetime by reduce the energy consumption.

Techniques Used in Hierarchical Routing Protocol

1. Nodes property and functionality:

    a) Homogeneous: In this property, all the nodes have identical battery power and hardware complexity.
    b) Heterogeneous: In this property, two and more nodes have different battery power.

2. Method used for cluster formation

    a) Distributed: Distributed clustering algorithms can be used for location-unaware sensors. That is, these sensors are not aware of their network position and all of their routing decisions have to be made based on their internal information.

b) Centralized:Centralized clustering algorithms can be used for location-aware sensors. That is, sensors that are aware of their network position and all of whose routing decisions can be made in central locations such as the sink

3 Nature of algorithm in wsn

a) Static: In static routing protocol, when once clusters created that remain same throughout the network.
b) Dynamic: In dynamic routing protocol, clusters are change according to the rotation.

3. Clustering based on network architecture

a) Single hop: In this architecture, sensor nodes use single hopping to reach the cluster head.
b) Multihop: In this architecture, sensor nodes use the multi hopping to reach the cluster head.

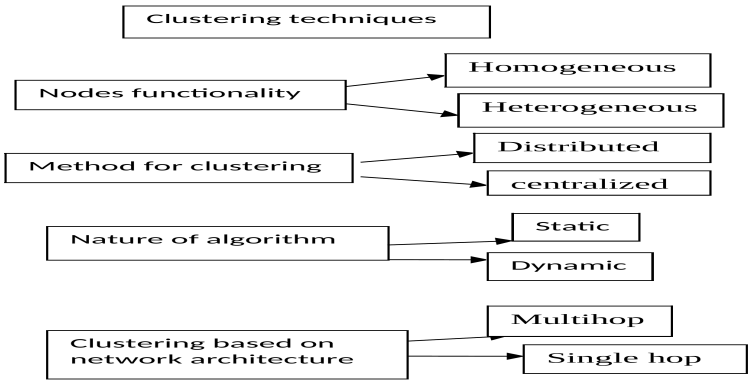

Figure 6. Techniques used in routing protocols

Table 1. study of hierarchical routing table

Protocol name	Classification	mobility	Network lifetime	Data aggregation	Data delivery model
LEACH	proactive	Fixed BS	Very good	yes	Cluster based
EEE LEACH	proactive	Fixed BS	Very good	yes	Cluster based
HEED	proactive	Fixed BS	Very good	yes	Cluster based
PEGASIS	reactive	Fixed BS	Very good	no	Chain based
TEEN	reactive	Fixed BS	Very good	yes	Threshold based
APTEEN	hybrid	Fixed BS	Very good	yes	Threshold based

Conclusion:

In this paper exhaustive analysis has been carried out on the basis of various existing works in the power consumption and its saving on the basis of various protocols. The comparison has also been done for various routing algorithms on the basis of various parameters. The lacuna on energy saving have been

taken into consideration and propose to improve the mechanism by which energy can be conserved while it is not in transmission mode.

References

[1] G. S. Tomar and S. Verma, "Dynamic Multi-level Hierarchal Clustering Approach for Wireless Sensor Networks," *2009 11th International Conference on Computer Modelling and Simulation*, Cambridge, UK, 2009, pp. 563-567, doi: 10.1109/UKSIM.2009.84.

[2] Shio Kumar Singh, M P Singh, D K Singh, "Routing Protocol in Wireless Sensor Network- A Survey", pp. 63, International Journal of Computer Science & Engineering Survey (IJCSES), 2010

[3] Arati Manjeshwar, D.P. Agrawal, "TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks", in the proceeding of the 1st international workshop on parallel and distributed computing issues in wireless networks and mobile computing, San Francisco, CA, April 2001.

[4] Ankita Joshi, Lakshmi Priya, "A Survey of Hierarchical Routing Protocols in Wireless Sensor Network",pp. 67 – 71,MES Journal of Technology and Management May 2011

[5] Maryan soleimani, Amirili Sharifian, Ali Fanian, "An Energy-Efficient clustering algorithm for large scale wireless sensor networks", pp.1-6,IEEE,2013.

[6] Meenakshi Sharma ,Anil Kumar Shaw, " Transmission Time and throughput analysis of EEE LEACH, LEACH and Direct Transmission Protocol: A simulation Based Approach", Advanced Computing: An International Journal (ACIJ), pp. 97, 2012

[7] Subramanya Bhatt, Shwetha.D, Devaraju.J.T, "A Performance Study of Proactive, Reactive and Hybrid Routing Protocols using Qualnet Simulator "International Journal of Computer Applications, pp. 10-16,2011.

[8] Tripti Singh, Neha Gupta, Jasmine Minj, "Hierarchical Cluster Based Routing Protocol with High Throughput for Wireless Sensor Networks", pp. , IEEE, 2013.

[9] Ahora M Toussi , Christos Politis , "Energy Conservative and Coverage Preservative Clustering for Wireless Sensor Networks",PIMRC,IEEE ,2013

[10] D. J. Dechene, A. El Jardali, M. Luccini, and A. Sauer, " A Survey of Clustering Algorithms for Wireless Sensor Networks" , 2014

[11] I.F. Akyildiz, W. Su*, Y. Sankarasubramaniam, E. Cayirci Broadband, "Wireless sensor networks: a survey", Computer Networks(Elsevier) Journal,pp.393-422, March 2002.

[12] Shio Kumar Singh, M P Singh, and D K Singh, " Routing Protocols in Wireless Sensor Networks –A Survey",2010

[13] GS Tomar, Pratibha Kevre, L. Shrivastava, "Energy model based Performance Analysis of cluster based wireless sensor network", International Journal of Reliable Information and Assurance Vol.3, No.1, pp.13-19, 2015

[14] Pawan kumar kocher , simarpreet kaur , niranjan yadav, " Cluster based energy efficient protocol for wireless sensor network", ICCIEMI, 2012

[15] G.Asha , S.Duragadevi, "The comparision between routing protocol based on lifetime of wireless sensor network" , 2014

[16] Owais Ahmed, Ahthsham sajid, Mirza Aamir Mehmmod, "Comparision of routing protocol to assess network lifetime of WSN" international journal of computer science issues, 2011.

[17] S. Pal, D. Bhattacharyya, G. S. Tomar and T. -h. Kim, "Wireless Sensor Networks and Its Routing Protocols: A Comparative Study," *2010 International Conference on Computational Intelligence and Communication Networks*, Bhopal, India, 2010, pp. 314-319, doi: 10.1109/CICN.2010.71.

[18] Tripti Sharma, Brijesh Kumar, G.S. Tomar, "An Efficient Condensed Cluster Stable Election Protocol in Wireless Sensor Networks", International Journal of Smart Device and Appliance Vol.1, No.1 pp 17-28, Dec 2013**.**

[19] Jung-Yoon Kim, Tripti Sharma, Brijesh Kumar, G.S. Tomar, Karan Berry, Won-Hyung Lee, "Intercluster Ant Colony Optimization Algorithm for Wireless Sensor Network in Dense Environment", Hindawi International Journal of Distributed Sensor Network, Vol 2014, pp.1-8, 2014. DOI-10.1155/2014/457402

[20] A. K. Dwivedi, Pandit Ravi Shankar Shukla, "Network Layer Protocols for Wireless Sensor Networks: Existing Classifications and Design Challenges", 2010

[21] Maryam soleimani, Amirrali Sharifian, Ali Fanian, "

[22] Norah tuah, Mahamood Ismail and Ahmad Razani Haron, "Energy consumption and lifetime Analysis for Heterogeneous Wireless sensor network", pp.188 -193 ,IEEE 2013.

[23] Khushboo pawar, vishal pawar, tilotma Sharma, "Enhancement of LEACH protocol using Energy Heterogeneity concept" pp. 49-56, international journal of emergency trends and teachnology in computer science 2013.

[24] Alireza Firuzbakh, Asgarali bouyer, "An optimal algorithm based on gridding and clustering for decrease energy consumption in WSN" pp. 474-478, MIPRO 2013.

[25] H. Koyuncu, GS Tomar, D. Sharma, "A New Energy Efficient Multitier Deterministic Energy-Efficient Clustering Routing Protocol for Wireless Sensor Networks", Journal Symmetry (MDPI), Vol. 12(5), pp.1-15, May 2020. DOI-10.3390/sym12050837

[26] Jabber Beitollahzadeh, Abdollah Amirkhani, Karim Mohammadi, " A new Method for increasing the lifetime of Network and reducing Energy consumption in Wireless Sensor Network", pp. consumption in Wireless Sensor Network", pp. 39-55, IEEE 2013