A Review on Routing in Wireless Sensor Networks

Risha Vashist[1], Suniti Dutt[2]

[1]Chandigarh Engineering College, Landran

[2]Associate Professor Chandigarh Engineering College, Landran

Abstract: ***The concept of wireless sensor networks (WSN) have recently evolved in years and have seen continuous growth in diverse areas, leading to provision for new opportunities in networking and services. A WSN consists of an array of sensor networks interconnected by a wireless communication network. The applications of WSN are endless and have gained focus due to the recent advancement in wireless communications and electronics. Routing can be of many types as location based or hierarchical. Various hierarchical routing protocols are analyzed in this paper.***

Keywords: Hierarchical routing, sensor networks

1. Introduction

Wireless Sensor Networks (WSN) has witnessed a tremendous development in different areas. Basically a WSN consists of various nodes better referred to as a sensor node. These nodes are basically built of parts like radio transceiver with an antenna, microcontroller, power supply and the actual sensor. This sensor is actually used to sense, measure and gather information from the environment to transfer the sensed data to the user [1]. Applications of a WSN include fields like forest fire detection and air pollution monitoring. Landslide detection and water quality monitoring also come under the applications of a WSN.

1.1 Sensor Networks Communication Architecture

A sensor field usually consists of scattered sensors. These sensors collect and route data to the sink and then to the users. Most common architecture for WSN is the Open Systems Interconnections (OSI) model. The protocol stack used by the sink and the sensor nodes is depicted in the Fig.1. This protocol stack is capable of combining power and routing awareness, integrating data, communicating power efficiently through the wireless medium and hence supports cooperative efforts of sensor nodes. Basically the stack consists of five layers: application layer, transport layer, network layer, data link layer and the physical layer. Three cross layers or planes are also added to this protocol stack as is visible in the Figure1. These are: power management plane, mobility management plane and task management plane. These layers are used to manage the network and make the sensors work together so that the efficiency of the network can be increased.

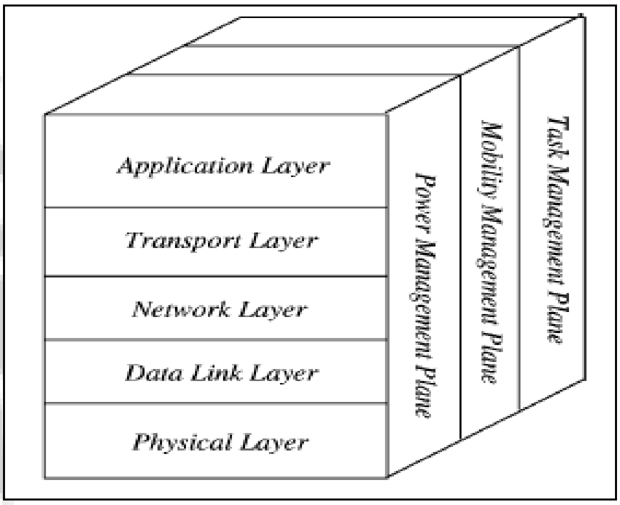

Figure1: WSN architecture

1.2 Design factors

A number of design factors have been addressed by many researchers in this field.

Fault Tolerance: Sometimes a sensor node failure can hinder the performance of a wireless network. Node failure may occur due to lack of energy, physical damage, communications problem or some environmental interference. The fault tolerance or reliability R_k is modeled in [2] using Poisson distribution to capture the probability of not facing a failure within the time interval (0,t) .

$$R_k(t) = e^{-\lambda_k t} \quad (1)$$

Where λ_k is the failure rate of sensor node and the time period is t.

Density and network size/Scalability: New schemes must be able to work with the increasing number of nodes. High density of sensor networks must also be utilized. Density µ can be calculated as per [3].

$$\mu(R) = (N\pi R^2)/A \quad (2)$$

Where N : number of scattered nodes in region A
R : radio transmission range

Sensor Network Topology: Features like latency, robustness and capacity can be affected by the topology of a network. Even the complexity of data routing and processing depends on the topology.

Hardware Constraints: A sensor node may have additional components like location finding system, power generator and a mobilizer. Sensing units comprise of two subunits namely sensors and Analog to Digital Convertors ADC. Analog signals are converted to digital signals by ADC and are then forwarded to the processing unit. A mobilizer can be used to move a sensor to carry out a task.

Transmission Media: A multi-hop sensor network requires a wireless medium to link the various nodes. These medium types may include radio, infrared or optical.

Power Consumption: As a sensor node is battery operated its lifetime strongly depends on the lifetime of the battery. Since the main goals of sensor node is sensing events ,processing and transmission through routing, the power resource can be divided among these three resources (sensing, computation and communication).

Networks Dynamics: A mobile base station or sensor nodes is required in some applications. This refers to the sensor nodes not being stationary. This has led to the rise of stability issues as well as energy, bandwidth, etc.

Quality of Service (QOS): Some applications require data delivery within a bounded latency because the data delivered late is later o no use whereas in some applications the conservation of power is more important than QOS. Therefore there is a tradeoff between energy conservation and quality of service.

1.3 Applications

WSNs are presently being deployed in a variety of applications ranging from medical to military, and from home to industry. These applications are briefly discussed below.

Military Applications
Applications like environment monitoring, tracking and surveillance applications fall under the category of military applications. Features like rapid deployment, fault tolerance and self organising make them an integral part of military command.

Environmental Applications
These applications incorporate tracking the movement of birds, monitoring environmental conditions that effect crops or livestock. Forest fire can be detected by simply installing these in forests.

Health Applications
Sensor networks are also deployed in health care areas.There are two types of medical applications/devices wearable and implanted. Former devices are used on the body surface of a human or at close proximity of the person and the latter devices are those that are inserted inside a human body.

Home Applications
With developing commercial applications it is not so hard to imagine the concept of emerging use of sensor networks in our home area.

Industrial monitoring
Machine health monitoring, water waste monitoring, data logging, structural health monitoring are the various areas that are associated with industrial monitoring.

Security Monitoring
Security monitoring networks consist of nodes placed at fixed locations that continually monitor one or more sensors inconsistency. The only difference between security and environmental monitoring is that security networks are not actually collecting any data.

2. Wireless Sensor Networks Vs Traditional Wireless Networks

There are many existing techniques, protocols and concepts from traditional wireless networks such as wireless local area network, Bluetooth, ad-hoc network, cellular network, but due to many fundamental differences need of new techniques and protocols arises [4].

Number of nodes is much higher in WSNs as compared with a traditional wireless network. The number of nodes may range from a thousand to even a million depending on the type of application. It therefore requires a scalable solution to ensure the network operation without any interruption. Addresses are not assigned to WSNs as they are large in number. These are data-centric meaning the operations of sensor networks is concentrated on data and not addresses.

Traditional sensor networks use point to point communication whereas wireless sensor networks follow the broadcast type.WSN nodes can be event driven or environment driven. Sensor networks themselves generate or collect data whenever there is a change in environment or any event occurs while humans have to generate data in case of traditional wireless networks. Therefore traffic pattern changes from time to time. Mobile ad hoc networks (MANETS) are used for distributed computing while sensor networks are mostly employed to gather information. There is a correlation between the data of the neighboring sensor nodes. Environmental quantities change very slowly and some consecutive readings are correlated. This is a unique feature of sensor network which enables to develop energy efficient protocols for routing and aggregation.

Main focus of sensor network is to extend network lifetime, where traditional network tries to maximize throughput of a channel or minimize node deployment in a network.

3. Routing in WSN

The initial routing algorithms for wireless networks followed the topology based traditional approach. Topology based routing refers to the end to end message delivery with host based adddressing. Routing in WSN can be divided into flat-based routing, hierarchical routing and location based routing which depends on the structure of a network. Topology is considered as flat in case of flat-based routing. Networks can be organized in hierarchies of different levels. This refers to the idea behind the concept of a hierarchical routing. It groups the sensor nodes into small clusters in order to remove weaknesses of other routing techniques such as network lifetime, scalability, and efficiency.

4. Hierarchical Routing

Clusters are created in hierarchical routing and a cluster head is assigned to each cluster. The responsibilities assigned to these cluster heads, is that they collect and aggregate data from their clusters thereby transmitting the aggregated data to the base station. Energy consumption in the network is hence reduced by data aggregation as the data transferred to the base station is minimized. Main aim of developing a cluster based routing approach is to reduce the network traffic toward the sink.

4.1 Clustering

A WSN field is considered in Fig.2. It consists of scattered nodes. These nodes form clusters and hence each cluster elects its cluster head. The sensor nodes transmit data to their respective cluster heads which in turn forwards the data to the base station. The transmitted data to the base station is then accessed by the end user via internet. Clustered networks can be classified into two categories: Homogeneous and Heterogeneous networks.

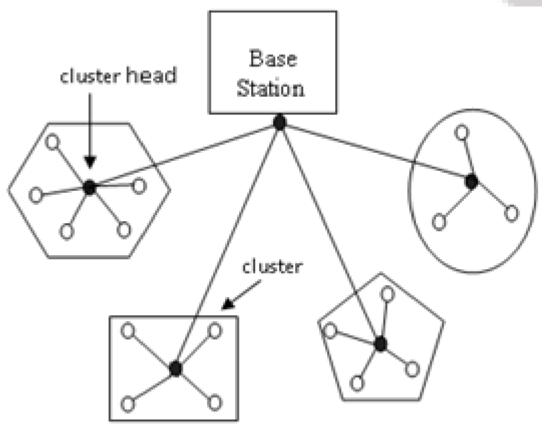

Figure 2: Clustering in WSN

4.2 Homogeneous Vs Heterogeneous Clustered Networks

Clustered sensor networks are considered because clustering allows for scalability of Medium Access Control (MAC) and routing. Cluster heads basically aggregate the data of various nodes in their respective clusters. This is basically done to reduce the data load sent to the base station. Clustered sensor networks can be classified into two types i.e. homogeneous networks and heterogeneous networks.

The word homogeneous refers to being of the same kind. Therefore homogeneous networks are those which consist of nodes that carry the same characteristics in terms of battery energy and hardware complexity. It is desirable to ensure that all the nodes die out at the same time so to enhance the lifetime of the system. This is achieved as very little residual energy is wasted when the system expires. To ensure this that each node becomes a cluster head LEACH was proposed [5].

On the contrary in a heterogeneous network, different types of nodes carrying different battery energy and functionality are used. Here more complex hardware and extra battery energy can be embedded in a few cluster head nodes which reduces the hardware cost of rest of the network.

When the sensor nodes use single hop manner to reach the cluster head for data aggregation they spend less time and energy. But if the cluster heads are far away from the nodes, they spend more energy. The alternative is to use multi-hopping. But while using multi-hopping to reach the cluster head , the nodes nearest to the cluster head have the highest energy burden due to relaying. As a result there always exists a non-uniform energy drainage pattern in the network.

Two desirable characteristics of a sensor network are lower hardware cost and uniform energy drainage. Heterogeneous networks achieve lower hardware cost and homogeneous networks achieve uniform energy drainage. Both features are not incorporated in the same network.

Clustered sensor networks could also be classified in terms of hopping. Single hop networks refer to those in which a node communicates with the cluster head by a single hop or jump whereas in a multi-hop network the nodes use multi-hopping to reach the cluster head.

5. Literature Survey

LEACH (Low Energy Adaptive Cluster Hierarchy) was introduced by W.R. Heinzelman. It is one of the most popular hierarchical algorithms. In this, the cluster head selection and also the cluster formation is random. To evenly distribute the energy dissipation in the cluster, the role of cluster head is rotated. The major drawback of this protocol is that the residual energy of sensor nodes is not considered and zero energy consumption is assumed for formation of cluster.

Threshold Sensitive Energy Efficient Sensor Network (TEEN) suggested by A. Manjeshwar et al. uses two types of thresholds as hard threshold and soft threshold [6]. It is similar to LEACH except that the nodes transmit only when the sensed value is less than the threshold value. Here the sensor nodes are programmed in such a way that it will respond to sensed attribute changes. TEEN is designed to work effectively only for event based data transmission.

APTEEN is the enhancement in TEEN. It provides a TDMA-based structure to transmit the sensed information to the cluster and each sensor node transmits its information periodically to the respective cluster head. The power consumption is controlled by the user by changing the count time (CT) and the threshold. The disadvantage associated with APTEEN is that changing the parameters CT and threshold is complex.

Hybrid Energy Efficient Distributed (HEED) protocol periodically selects cluster heads according to the residual energy in them and initial electric power. Hence it utilizes the residual energy as was not observed in LEACH. The node with more electric power is dominating and hence becomes the cluster head [7]. As this energy efficient protocol enables every sensor node to independently decide on its role, it can not guarantee optimal election of cluster heads.

Two-Level hierarchy LEACH (TL-LEACH) [8] is an extension to the protocol LEACH. Instead of transmitting data directly to the base station it uses a part of cluster head as a relay station. TL-LEACH encounters disadvantage like, it is not applicable to long range networks.

An enhancement over LEACH is PEGASIS (power efficient gathering in sensor information systems) [9]. It provides 100-300% lifetime enhancement over LEACH. Here the cluster head selection is random from the dedicated chain and is responsible for data transmission to the base station. Drawback associated with this algorithm is that it requires the global knowledge of the network. Also in PEGASIS there is a significant delay since the data has to be transmitted in the chain and cluster head waits until all the messages are received before transmitting to the base station.

To reduce the energy consumption in PEGASIS, Concentric Clustering Scheme (CCS) [10] was proposed. The entire network is divided into co-centric tracks where each track represents a cluster and is assigned a level. The nodes form a chain in each track as in PEGASIS. As the network is divided into many concentric clusters, the reverse flow of data from the base station is controlled. Redundant data transmission is an issue with this protocol.

Smaragdakis et al. [11] developed Stable Election Protocol (SEP) for two level heterogeneous networks which incorporates two types of nodes. In SEP election probabilities are weighted by initial energy of the node relative to that of other nodes in the network. Finally SEP is scalable as it does not require any knowledge of exact position of each node. Disadvantage of SEP is that it does not perform well in terms of stability for multi-level heterogeneous networks.

Distributed Energy-Efficient Clustering (DEEC) [12] is also based on LEACH. Two levels of heterogeneity are considered in this algorithm and then a general solution for multi-level heterogeneity is approached for. Stochastic DEEC is an improvement of this algorithm. Like DEEC this protocol considers two-level heterogeneity but it conserves energy by making non cluster head nodes sleep, unlike DEEC. It divides the network into dynamic clusters.

A modified algorithm by Parul et. al. is also proposed [13].It aims at prolonging the lifetime of the sensor networks by balancing the energy consumption of nodes. It uses the k-medoids algorithm for uniform clustering. Euclidian distance and maximum residual energy is used to select the cluster head. It uses the combination of clustering, maximum residual energy and a random selection of cluster heads only after 50% rounds of operations gets over thereby achieving a better cluster head selection approach than LEACH.

EHE-LEACH (Enhanced heterogeneous LEACH) protocol for lifetime enhancement of wireless SNs is based on fixed distance threshold used for the bifurcation of direct communication and cluster based communication [14]. In this research focus is laid on the constraints of energy of individual sensor node and complete network both. Observations show that EHE-LEACH has a better system lifetime and stability as compared with LEACH and SEP.

6. Conclusion

Many researchers have worked and are still working at producing more energy efficient protocols. The brief survey of WSNs this paper clearly highlights the advancement in sensor networks and the protocols proposed over time. The literature review in this paper elaborately discussed and compared the different protocols with respect to their advantages, improvements as well as limitations.

References

[1] Ian. Akyildiz ,Weilian Su YogeshSankarasubramaniam, and ErdalCayirci "A Survey on Sensor Networks", IEEE Communications magazine,August 2002.
[2] G.Hoblos, M.Staroswieki and A.Aitoche, "Optimal design of fault tolerant Sensor Networks",IEEE int'l Conf.Cont.Apps,Anchorage,AK,Sept 2000,pp.467-72.
[3] Bulusu et.al "Scalable Coordination for Wireless sensor Networks:Self configuration localization systems",ISCTA 2001, Ambleside, UK, July 2001.
[4] R.K.Ghosh, Vijay Garg, M.S Meitei, S.Raman, A.Kumar and N.Tewari ,"Dense Cluster Gateway based routing protocol for multi-hop mobile Adhoc Networks, Vol. 4,No. 2, p 168-185,March 2006.
[5] W. R. Heinzelmman, Chandrakasan and H. Balakrishnan, "Energy efficient communication protocol for wireless microsensor networks", Proc.33rd Hawaii Int'l. Conf.Sys.Sci.,Jan.2000.
[6] A. Manjeshwar and D.P Aggarwal , TEEN: A Protocol for Enhanced Efficiency in Wireless Sensor Networks, Proc of the 1st Int. Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing, 2001
[7] O. Younis and S. Fahmy , HEED: A Hybrid, Energy Efficient Distributed Clustering Approach for Ad Hoc Networks, IEEE Transaction on Mobile Computing, Vol.3 , No.4 ,pp.366-379, 2004.
[8] V. Loscri, G. Marabito and S. Marano, "A Two-Level Hierarchy for Low Energy Adaptive Clustering Hierarchy", DEIS Department, University of Calabria.
[9] S. Lindsey, C.S. Raghavendra, PEGASIS: Power Efficient Gathering in Sensor Information Systems, IEEE Aerospace Conference Proceedings, vol.3 pp.1125-1130, 2002.
[10] S. M Jung, Y. J Han and T . M Chung, "The Concentric Clustering Scheme for Efficient Energy", consumption in PEGASUS 9th International conf. on Advanced Communication Technology, vol.1, pp. 260-265, Feb 2003.
[11] Georgios Samaragdakis, Ibraham Matta and Azer Bestavros, "SEP: A Stable Election Protocol for

Clustered heterogeneous wireless sensor networks", pp 1-11,2004.

[12] Li Qing, Quinqxin Zhu, and Mingwen Wang, "Design of a distributed energy efficient clustering algorithm for heterogeneous wireless sensor networks", Computer communications Journal Elsevier, vol.29, issue12, pp.2230-2237, 2006.

[13] ParulBakaraniya, Sheetal Mehta, "K-LEACH- An Improved LEACH Protocol for Lifetime Improvement in WSN ",IJETT,vol.4,issue5, May 2013.

[14] SudhanshuTyagi, Sumit Kumar Gupta, "EHE- Enhanced Hetrogeneous LEACH protocol or lifetime enhancement of wireless sensor networks", IEEE International Conference on Advances in Computing, Communications and informatics, 2013.