Indian Journal of Science and Technology, *Vol 9(48), DOI: 10.17485/ijst/2016/v9i48/95285, December 2016*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Comparative Study of Various WSN Routing Protocols

Shikha Chahal* and Nasib Singh Gill

Department of Computer Science and Applications, Maharshi Dayanand University, Rohtak - 124001, Haryana, India; chahalshikha93@gmail.com, nasibsgill@gmail.com

Abstract

Objectives: Main objective behind choosing this topic is that energy awareness which is an essential consideration in Wireless Sensor Networks (WSN). This paper presents classifications of various routing protocols of sensor networks. Here, protocols are described under appropriate categories. **Methods/Statistical Analysis:** This paper follows the method of classifying the networking protocols based on their network architecture and performing comparison analysis specific to bandwidth utilization viewpoint. **Findings:** In this paper, we categorize the protocols on the basis of their network architectures. This paper compares their scalability and power usage to differ them. It discusses designing a protocol to utilize bandwidth and energy for various applications. Also it defines how nodes become self-organized and secure in WSN. We present how big networks are established and make them efficient. **Application/Improvements:** Data must be aggregated so traffic jams are avoided. Nodes will become energy efficient therefore lifespan of network increases. Now energy is saved.

Keywords: Energy Efficient, Network Lifetime, Protocols, Routing, WSN

1. Introduction

Wireless Sensor Network is considered as the latest improvement in electronics area and wireless communication. WSN consists of thousands of limited battery operated nodes. Nodes are made up of radio for transmission and receiving, sensing, storage, data processing, mobilize and Global Positioning System (GPS)[1]. This is the type of ADHOC network. The main goal of WSN is to transmit data efficiently to base station which is collected by sensor nodes. Routing protocols plays an important role in this process. Cluster based hierarchical routing is one of the efficient ways. Current clustering algorithms generate clusters of almost equal size.

The unequal size of clusters can balance the energy consumption among clusters[2,3]. Basic challenge for that type of network is energy efficiency. Sensor network is affected by energy consumption. WSN is used for different applications such as military, medical, agriculture etc[1,4]. As per application requirement, different type of nodes such as direction nodes, proximity sensor, light sensor, temperature sensor, and relative humidity sensor are used[4]. One important application is data mining in which time series is essential task which is defined as clustering classification. Clustering is unsupervised learning. Clustering is used for data statistical analysis, pattern recognition, image analysis, information retrieval and bioinformatics. Different clustering methods are present[5, 6]. Structure layout of WSN is presented in Figure 1.

**Author for correspondence*

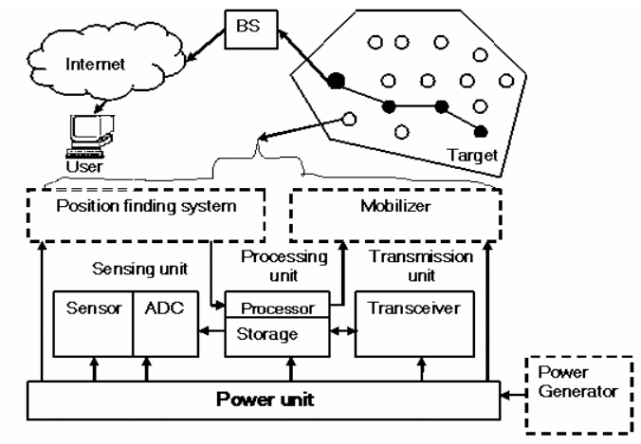

Figure 1. Structure layout of WSN.

In[1] presents an improved LEACH-CE for multi-hop routing in which target area is divided into zones depends on threshold distances. The proposed algorithm works efficiently on large target area where base station is located far away from target area. In[2] stated about energy and communication overhead of routing protocols. The routing protocols are compared and classified into 3 main categories: Data Centric Routing (Flooding), Hierarchical based routing (clustering) and Location–based routing (Geographic) based on their network structure. Sensors are realized over factors like fault tolerance, scalability, cost, hardware, topology change, environment and power consumption. Main issue with routing protocols is node mobility. Now-a-days nodes and sink are working as stationary. Some other challenges such as utilization of bandwidth, how to make nodes self-organizing ,security purposes are also there, which are also considered to make protocols secure so that messages will not be trapped by others and the last one is how to tackle denser networks having large number of nodes and increase its lifetime. In[7] mainly worked on survey on energy-efficient routing on principle of hierarchical cluster-based for WSN. In[8] tried to define the best optimal path for routing to communicate with each other and to transmit data efficiently. In this paper the working principle of LEACH was discussed and also revealed that LEACH is vulnerable to various attacks.

2. Routing Protocols

Routing in WSN is different from other conventional routing in fixed n/w. No infrastructure is there, links are reliable, sensor nodes may fail and routing protocols are designed to fulfill energy saving requirements. Routing algorithms were developed to solve the energy problem. It becomes a challenge to design an appropriate routing protocol for specific application. For designing a routing protocol considers its constraints and limitations. Following challenges are considered for designing a routing protocol Limited Energy Capacity, Sensor Locations, Limited H/W Resources, Massive and Random Node Deployment, Scalability, Data Aggregation and Application Requirements as well[7,9].

2.1 Heterogeneity Based Protocols

In this type of protocol two types of sensors are used that is one is line-powered that have no energy constraint and the other one is battery powered that have a limited lifetime that it can use it efficiently by minimizing their potential of data communication and computation[7].

2.2 Location Based Protocols

This Protocol uses the information of the location of the nodes to calculate the distance between the sensor nodes and estimate the energy consumption. Location based protocol uses location information to guide routing discovery and maintenance as well as data forwarding and also enables the directional transmission of information which will avoid information flooding in entire network and prevent time and energy losses and intermediate sensors work upon data and aggregate and send it to sink.

2.3 Data Centric Protocols

In data centric protocol sender sensor sends data to sink and intermediate sensors work upon data and aggregate and send it to sink. It saves energy[7,10].

2.4 Hierarchical Protocols

Hierarchy stands for sequence of subsequent things in a series so as in the case of protocols.

Network ⟶ Cluster ⟶ Cluster Head ⟶ Special Nodes

Nodes together form clusters having a cluster head which perform the duty of routing from cluster to base stations. Data travel from lower hierarchical layer to upper layer.

2.5 Mobility Based Protocols

It requires sink mobility to guarantee data from source sensor to mobile sink.

2.6 Multipath Based Protocol

It doesn't involve direct data transmission from sensor to sink. It involves transfer of data from one sensor source to other sensors.

2.7 Quality of Service Based Protocol

It considers the quality of service in terms of delay, reliability and fault tolerance as well as in WSN routing. Protocols based on QoS help in finding balance between energy consumption and QoS requirements.

3. Comparison of Hierarchical Protocols

Hierarchical protocols are classified on which topology WSN is working. These protocols are based on the principle of clustering. In this type sensor nodes are distributed into n clusters based on different clustering techniques. According to rule a specific node is choose as local base station, also known as cluster head and others are considered as members of cluster. Basically clustering concept work on 2 phases but if application requirements are not fulfilled then it is able to work on more than 2 phases[7]. Basically 1st phase is to create a cluster from randomly and fixed sensor nodes. In this phase the cluster head is selected and allocation of TDMA schedule is presented where as in 2nd phase members of cluster transmit the data to cluster head, Cluster head receives the data and then apply different functions to compute the data and eliminate redundancy then it finally sends the compressed data to base station[1,11].

3.1 LEACH Protocol

Low-Energy Adaptive Clustering Hierarchical ("LEACH") is a TDMA-based MAC protocol which is integrated with clustering and a simple routing protocol in wireless sensor networks. In this for local cluster base stations randomized rotations is considered[12]. Leach increases the life time of network using hierarchical routing for wireless sensor networks. Local cluster is formed by organization of nodes. All non-cluster head nodes transmit their data to cluster-head, while cluster-head node receives data from the cluster members; they aggregate data and transmit to remote base station. When battery of a cluster head run out of life all the nodes that belongs to that cluster head loses communication ability[8].

Phases of Leach

LEACH network has two phases: the set-up phase and the steady-state[13,14].

- The Set-Up Phase
- Where cluster-heads are chosen.
- The Steady-State
- The cluster-head is maintained.
- When data is transmitted between nodes.
- Leach Protocol is represented in Figure 2

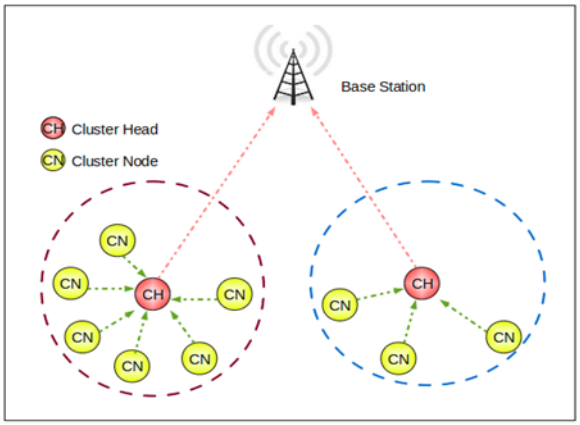

Figure 2. LEACH protocol.

Advantages

- Cluster head aggregates the whole data so that there is no traffic jams in network.
- Single hop routing from nodes to cluster head is used that results in saving energy.
- Lifespan of networks is increased.
- No information about the location of nodes is required for creating the cluster.

5 LEACH doesn't need any type of control information from base station as well global knowledge of network just because it is distributed[13].

Disadvantages

- Leach has no idea about no of nodes as well cluster heads present in network[13,15].
- Main disadvantage is that due to any reason if cluster head dies, then cluster becomes useless, no information from that network is fetched and used.

- Clusters have no fixed nodes i.e., some have more where as some have lesser. As well as cluster head has no fixed location. It may be at centre or may be at edge, this will increase consumption of energy and performance may get down.
- Large clusters are formed and all cluster heads must broadcast their data to every nodes which are present in their radio communication[16].

3.2 Power-Efficient Gathering in Sensor Information Systems (PEGASIS)

It is a chain based protocol improvement over leach. In this every node communicates with nearby node or closer neighbor and become leader for transmitting the data to base station. Data fusion is there so that transmitting data reduces from sensor nodes to base station in which one or more packets combine and form a single packet of data. Global knowledge is present there. Energy load will be distributed among the nodes[2,17]. This Protocol had the stability in network lifetime and also suitable large networks whereas Leach is more suitable for network having nodes less than 100[18].

For gathering data chain is constructed, in which leader is selected for transmitting data to base station. Leader is also selected randomly for every round. If leader node dies then chain will be reconstructed to bypass that node by doing this information can be used. Network can't become useless. Head node receives the fused data then it transfers it to destination i.e. base station. Energy level is not considered in selecting head node. Pegasis Protocol is provided in Figure 3.

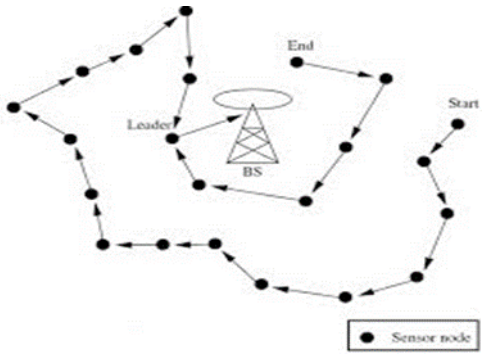

Figure 3. PEGASIS protocol.

3.3 Hybrid Energy Efficient Distributed (HEED) Protocol

It was modeled for selecting cluster heads in a field according to amount of energy distributed in network nodes. It increases life time by distributing energy consumption between nodes. It terminates the clustering process with definite steps. It minimizes the control overhead. It produces well distributed cluster heads and compact clusters. Distribution of energy is there so stabilizing the neighboring nodes. Intra clusters have tendency to communicate with cluster heads of other clusters. No special capabilities are required for nodes such as location-awareness. Nodes are present at fixed position no assumptions for nodes distribution are present. It can also operate efficiently when nodes are not synchronized. It terminates in particular time. Only local communication is required. It reduces the energy load of network. Periodic rotation of cluster heads may requires extra energy to rebuild the cluster[19]. Heed Protocol is shown in Figure 4.

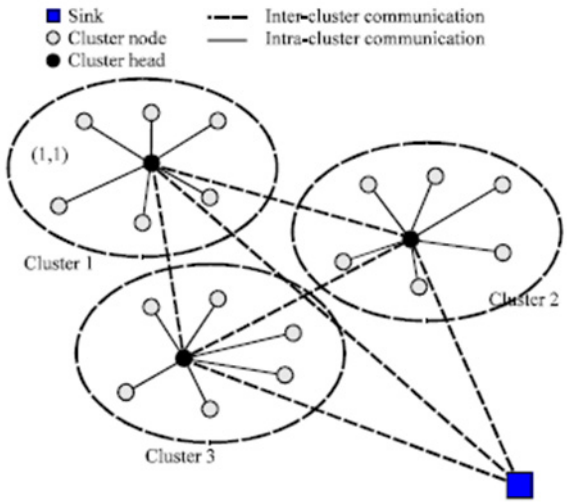

Figure 4. HEED protocol.

3.4 Threshold Sensitive Energy Efficient Sensor Network (TEEN) Protocol

It works in reactive networks. It is better than the conventional sensor protocols. It is extremely small and equipped with programmable computing. Cost is low in such networks. Limited power is efficiently consumed in such networks. They respond in dynamic with fast changing in physical parameters. This protocol becomes fault tolerant in dynamic environment because it can change according

to the applications such as position because they can be mobile. It is not good for periodic reports because data can be collected when threshold is reached. In this, process goes on through levels as second level approaches to base station[2]. TEEN Protocol is presented in Figure 5.

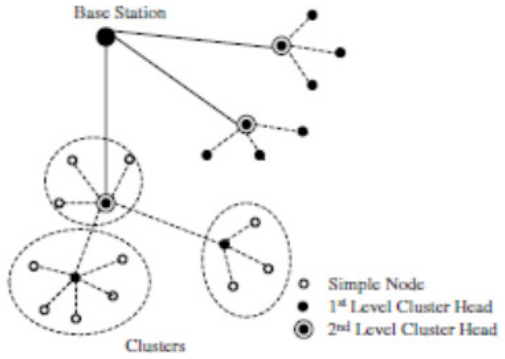

Figure 5. TEEN protocol.

3.5 Adaptive Periodic Threshold Sensitive Energy Efficient Sensor Network (APTEEN) Protocol.

It works in hybrid networks which is combination of both proactive as well reactive. It is suitable for periodic data collection. It warns about critical events. It also provides the picture of network. It also evaluates past data values. Structure of APTEEN is same as TEEN[2].

4. Comparison Analysis of WSN Protocols

In this section, different routing protocols of WSN have been compared which are based on different principles. This paper considers their different specifications and methods of working over networks. In following table

Table 1. Comparisons of different protocols

Routing Protocols	Data Aggregation	Power Usage	Scalability	Over head	Query Based	QoS	Data Delivery Model
GAF	No	Ltd	Good	Mod	No	No	Virtual Grid
GEAR	No	Ltd	Ltd	Mod	No	No	Demand Driven
SPEED	No	Low	Ltd	Less	Yes	Yes	Geo-graphic
SPAN	Yes	Ltd	Ltd	High	No	No	Continuously
SAR	Yes	High	Ltd	High	Yes	Yes	Continuously
ACQUIRE	Yes	Low	Ltd	Ltd	Yes	No	Complex Query
SPIN	Yes	Ltd	Ltd	Low	Yes	No	Event Driven
DD	Yes	Ltd	Ltd	Low	Yes	No	Demand Driven
SOP	No	Low	Good	High	No	No	Continuously
VGA	Yes	Low	Good	High	No	No	Continuously
PEGASIS	No	Max	Good	Low	No	No	Chains Based
TEEN& APTEEN	Yes	High	Good	High	No	No	Active Threshold
LEACH	Yes	High	Good	High	No	No	Cluster Head
COUGAR	Yes	Ltd	Ltd	High	Yes	No	Query Driven
CADR		Ltd	Ltd	Low	Yes	No	Continuously
GBR	Yes	Low	Ltd	Low	Yes	No	Hybrid
RR	Yes	Low	Good	Low	Yes	No	Demand Driven

every protocol has been considered that works in WSN at any phase and compared them with their scalability and on which principle they based and their different models[12,17]. To extend the network lifetime, power management and energy-efficient communication techniques at all layers become necessary[20]. Comparison of different Protocols is provided in Table 1.

5. Conclusions

We have to design an efficient protocol to increase sensor nodes, lifespan. Different protocols have been compared and classified in this paper. In this node mobility also matters. Most of them are sinking. In this field there is a need to design protocol to define how to utilize bandwidth and energy for different applications and also consider how to make nodes self-organizing and make them secure in WSN. So that information is not tampered by others and to describe that how a large network is established and at the same time effectively.

6. References

1. Kumar P, Singh JP, Kumar D, Singh MP. Energy efficient multi-hop routing based on improved LEACH-CE for Wireless Sensor Network. IEEE Region 10 Conference on TENCON 2015. 2015. p. 1–6.
2. Tyagi P, Jain S. Comparative study of routing protocols in Wireless Sensor Network. International Journal of Advanced Research in Computer Science and Software Engineering. 2012 Sep; 2(9):1–7.
3. Baranidharan B, Srividhya S, Santhi B. Energy efficient hierarchical unequal clustering in wireless sensor networks. Indian Journal of Science and Technology. 2014 Jan; 7(3):1–5.
4. Devi DMR, Thambidurai P. Similarity measurement in recent biased time series databases using different clustering methods. Indian Journal of Science and Technology. 2014 Jan; 7(2):1–10.
5. Sheshasayee A, Sharmila P. Comparative study of fuzzy C means and K means algorithm for requirements clustering. Indian Journal of Science and Technology. 2014 Jan; 7(6):1–5.
6. Singh SK, Singh MP, Singh DK. Routing protocols in wireless sensor networks– A survey. IJCSES. 2010 Nov; 1(2):1–21.
7. Gill RK, Chawla P, Sachdeva M. Study of LEACH routing protocol for Wireless Sensor Networks. International Conference on Communication, Computing and Systems (ICCCS–2014); 2014. p. 1–3.
8. Misra S, et al. Guide to Wireless Sensor Networks. Computer Communications and Networks. 4th ed. Springer-Verlag London Limited; 2009.
9. Tripathi A, Yadav N, Dadhich R. Selection of node density in spin for data centric wireless sensor networks. International Conference on Technologies for Sustainable Development (ICTSD-2015); Mumbai, India. 2015 Feb 4-6. p. 1–6.
10. Rajeshwari P, Shanthini B. Mini prince hierarchical energy efficient clustering algorithm for WSN. Middle-East Journal of Scientific Research 23 (Sensing, Signal Processing and Security). 2015; 1:108–17.
11. Kansal P, Kansal D, Balodi A. Comparison of various routing protocol in wireless sensor network. International Journal of Computer Applications. 2010Aug; 5(11):1–5.
12. Malik M, Singh Y, Arora A. Analysis of LEACH protocol in wireless sensor networks. International Journal of Advanced Research in Computer Science and Software Engineering. 2013 Feb; 3(2):1–6.
13. Yassein MB, AL-zou'bi A, Khamayseh Y, Mardini W. Improvement on LEACH protocol of wireless sensor networks. International Journal of Digital Content Technology and its Applications. 2009 Jun; 3(2):1–5.
14. Lindsey S, Raghavendra CS. PEGASIS: Power-efficient gathering in sensor information systems. Computer Systems Research Department the Aerospace Corporation; Los Angeles, CA. 2002. p. 1125–30.
15. Ahmed O, Sajid A, Mehmood MA. Comparison of routing protocols to assess network lifetime of WSN. IJCSI. 2011 Nov; 8(3):1–5.
16. Biradar RV, Patil VC, Sawant SR, Mudholkar RR. Classification and comparison of routing protocols in wireless sensor networks. UbiCC Journal. 2009; 4:1–8.
17. Krishnaveni P, Sutha J. Analysis of routing protocols for wireless sensor networks. International Journal of Emerging Technology and Advanced Engineering. 2012; 2(11):1–7.
18. Al-Karaki JN, Ul-Mustafa R, Kamal AE. Data aggregation and routing in wireless sensor network: Optimal and heuristic algorithm. Journal of Computer Networks. 2009 May; 53(7):945–60.
19. Hadjila M, Feham M. A comparative study of the wireless sensor networks routing protocols scalability. IJDPS. 2011 Jul; 2(4):1–8.
20. Norouzi A, Zaim AH. An integrative comparison of energy efficient routing protocols in wireless sensor network. Wireless Sensor Network. 2012; 4(3):65–75.