Wireless Sensor Network: An Overview
Monitoring And transmitting information using WSN and GIS

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Abstract : Over the last few years, Wireless Sensor Networks acquire a significant growth in the domain of varied applications due to its adaptable behavior. This paper imposes a concise introduction on Wireless Sensor Network. In WSN, the sensor nodes are equipped with constraint resources such as limited memory size, limited battery power, limited bandwidth etc., that cause the degradation in performance and energy dissipation. To improve the performance and lifetime of sensor network, a fuzzy logic approach is discussed here. This paper also discusses the integration of Geographic Information System (GIS) with Wireless Sensor Network (WSN).

Index Terms **- WSN, clustering, network lifetime, fuzzy logic, LEACH, congestion, GIS.**

I. INTRODUCTION

During recent years, wireless sensor networks have been developed rapidly. Its advantages include the scalability, simplicity, and low setup cost, due to which it is now being applied in variety of applications ranging from military applications to home applications.

Wireless Sensor Network (WSN), sometimes also known as Wireless Sensor and Actor Network (WSAN), is a wireless interconnection of nodes, in which a large number of sensor nodes (also referred as motes) are deployed and distributed geographically in the targeted field to sense, monitor and track the physical or environmental conditions such as temperature, pressure, humidity, sound, position etc. These sensor nodes can be varied in size as small as dust particles and number from 10 to 1000 .The nodes are communicated with each other via some wireless media such as Radio Frequencies (RF).

In this paper, we present a brief overview of Wireless sensor network, its architecture and its applications. The challenges and limitations associated with WSN is also mentioned here (Section IV). The introduction to various topologies related to WSN and literature review are given in Section V and Section VI respectively. This paper also discusses the role of Fuzzy Logic and Geographic Information System (GIS) through the different applications.

II. WSN ARCHITECTURE

The basic architecture for wireless sensor network is shown in Fig. 1. WSN consists of mainly four components and those components are as follows:

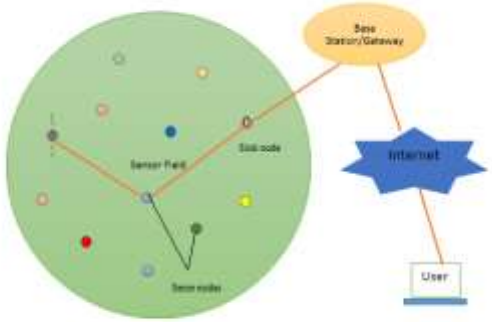

Fig. 1 WSN Architecture

A. Sensor nodes - These are the basic functional unit of WSN. It consists of on-board sensors, memory, processor, battery and transceiver.
B. Sensor Field - It's the region in which sensor nodes are deployed.
C. Sink Node - It simply a sensor node but has a great impact on the energy consumption and lifetime of network. Data sensed and gathered by sensor nodes are forwarded to the sink node. After processing the received data, sink node reduces the total amount of data that require to be sent further.
D. Base Station - This is the node that is more capable for computation, energy and communication than the sensor nodes. This serves as a gateway between sensor nodes and the end user as data forwarded from WSN on to the server.

Sensor nodes comprise of several components:-

- Sensing Unit
- Computation Unit
- Communication Unit
- Power Unit

The components of sensor nodes is presented in Fig. 2. Sensing unit consists of on-board sensors that are required to sense and monitor the environmental conditions, computing unit is responsible for processing the sensed data to analyse, communication unit consists of transceiver for further communication with rest of the nodes present in and out of the network and power unit is one of the crucial component which contains battery power or any other power generating resources.

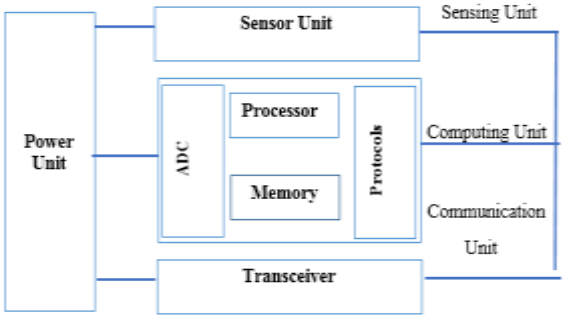

Fig. 2 Sensor Node Components

III. WSN APPLICATIONS

Now a day's rapid usage of sensors, unlocks the door for casing numerous applications of WSN. The sensor networks are capable of covering and monitoring those areas that are seems to be impossible for human interactions. WSN applications [1] can be categorised into several fields. Some of them are listed below:-

- Military Applications[2]
- Environment Applications[3]
- Industrial Monitoring[4]
- Healthcare Monitoring
- Medical Applications
- Habitat Monitoring
- Home Applications
- Forest Monitoring

IV. LIMITATIONS AND CHALLENGES IN WSN

Sensor nodes are embedded with low powered battery. These batteries are irreplaceable and non-rechargeable during the data gathering process. Hence, many challenges arise due to limited battery life that limits the performance of the wireless sensor network. Some challenges associated with the WSN design are listed below:-

- Heterogeneity
- Low bandwidth communication
- Energy consumption

- Accuracy
- Timeliness
- Cost
- Security

V. TOPOLOGY IN WSN

In the networks, topology refers to the way in which nodes are communicated with each other. Power consumption is an important design factor in WSN [5]. In the sensor network, an effective topology is able to tackle such constraint. Some topologies are described as:-

A. Star topology

In star topology (Fig 3), several nodes are connected to a centralized hub (sink) and the nodes cannot communicate directly with each other. The entire communication must be routed through the centralized hub. But the disadvantage of star network is dependency on central hub.

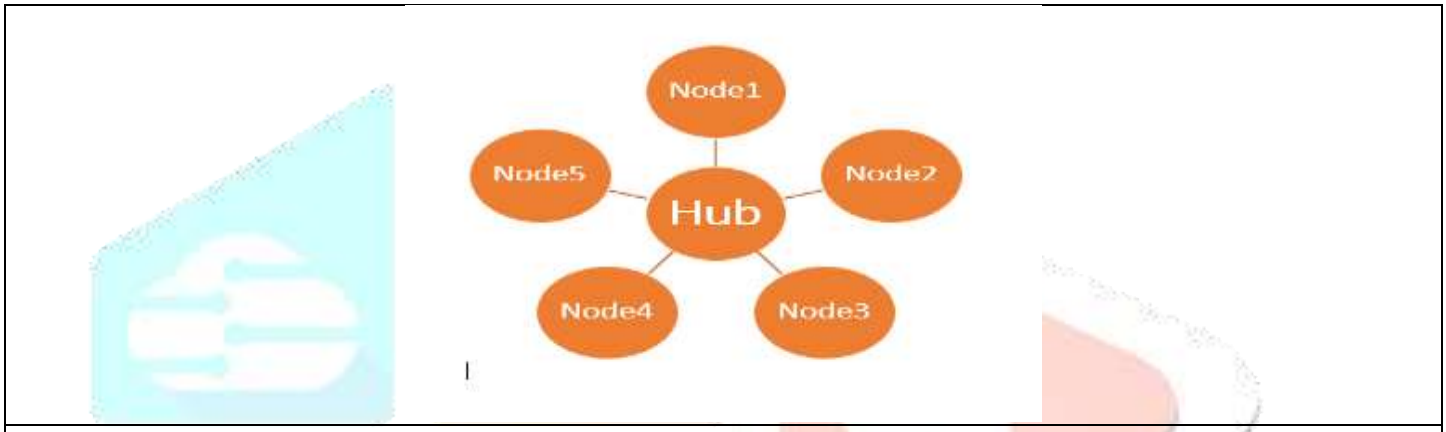

Fig. 3 Star Topology

B. Bus topology

All nodes are connected to a single cable (is a backbone of the network), known as bus. Every node communicate through this bus .and the message is broadcasted over the network which is accepted by intended recipient only. Bus Topology is represented in Fig 4.

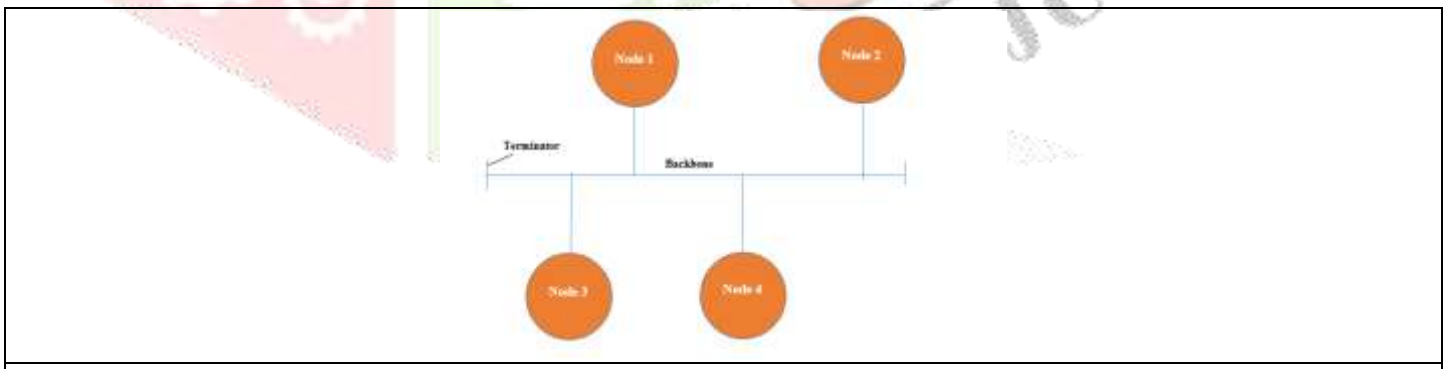

Fig. 4 Bus Topology

C. Tree topology

This is the unification of the characteristics of star and bus topology by connecting the number of star networks (branch) with a bus (link). It is also known as Expanded Star Topology (Fig 5). The problem arises if there is a link break in the unipath on the active route then communication breaks

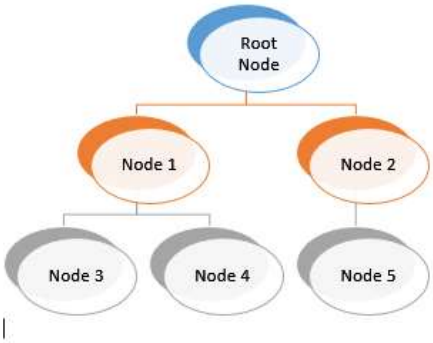

Fig. 5 Tree Topology

D. Mesh topology

In mesh topology (Fig 6), each of the node are interconnected with each other directly or indirectly .Several node can transmit data at the same time but overall cost is high and there is higher chance of redundancy.

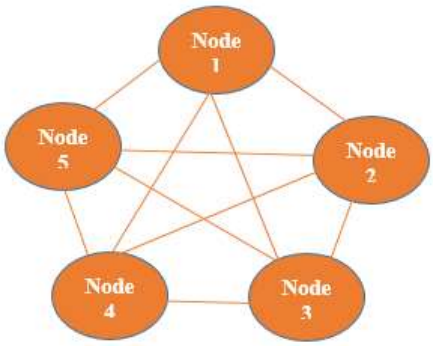

Fig. 6 Mesh Topology

E. Ring topology

In this type of topology, all nodes are connected in a loop. Data travels through a ring in the same direction. The communication held in the network with the help of token passing mechanism. A failure in node can take down the entire network (Fig 7).

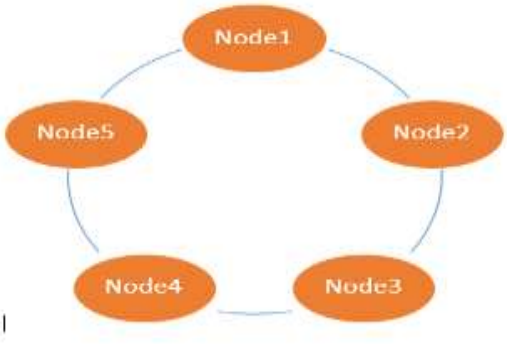

Fig. 7 Ring Topology

F. Grid topology

The network area is partitioned into numbers of square grid with same size. In each grid, only one node is in working state at a time. To extend the network life time, the nodes in a grid should work in turns. Inside each grid, one node is selected as a grid head to

forward routing information and transmit data packets. It proves helpful in avoiding and handling network congestion when happens in the network. Grid topology is shown in Fig 8.

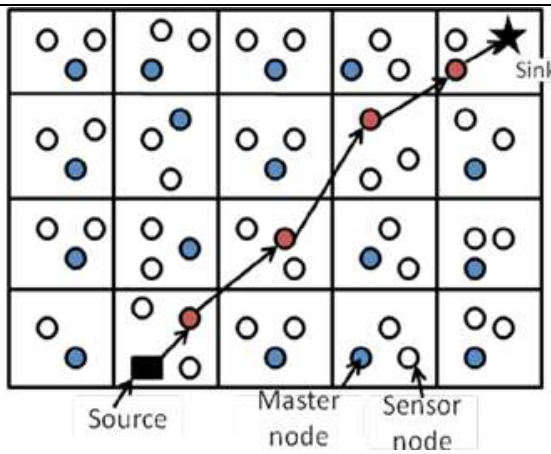

Fig. 8 Grid Topology

VI. LITERATURE REVIEW

Wireless Sensor Network- Challenges and Possibilities [6]
This paper gives an overview on wireless sensor network, its architecture, limitations and applications. This also provides the classification of various routing protocols and attacks associated with WSN for security aspects in WSN.
Comparison of Routing Protocols in Wireless Sensor Network [4]
This paper evaluate, analyse and compare three protocols-LEACH, CBR and MBC that are suitable for balance the power consumption. The performance of these protocols are compared against the parameters such as packet loss, average energy consumption and so on using NS2 simulator.

Energy Efficiency in routing protocol and data collection approaches for WSN: A Survey [7]
This paper surveys various energy efficient routing protocols and data applications. It is difficult to figure out any one protocol that is suitable in all environment. So, this paper provides the comparison of different protocols on the basis of some parameters like selection of cluster head, residual energy of nodes etc in a tabular form.

Improving the lifetime of Wireless Sensor Networks Based on Routing Power Factors [8]
In this paper, three routing factors are addressed that affect the lifetime and performance of the sensor network. The routing factors that are considered in this paper are initial power of nodes, residual power in the nodes and routing period. By simulating these factors individually and then together, they observed that on considering all the proposed factors, the performance of all WSNs especially for large network, increases.

A Survey on Successors of LEACH Protocol [8]
This paper surveys approx. 60 variants of LEACH routing protocol. All the protocols are classified into two sections single-hop communication and multi-hop communication. The different parameters are defined for comparative analysis of protocols

QoS Parameters Analysis to Improve QoS in WSNs Routing Protocol [10]
This paper presents the performance analysis of WSN routing protocols. They analysed the QoS requirements imposed by the applications of WSN. And then carried out the comparative analysis for each class of routing protocols.

Low Latency Based Efficient Aggregation Scheduling in Multi hop Wireless Sensor Network [11]
Data aggregation is used for compress data and also saves energy which provides time efficient method for data collection. The two delay efficient algorithm - CIAS and CDAS are proposed in this paper to reduce the delay for WSN. This leads to reduction in packet loss on WSN. The proposed algorithm results in low latency or delay as compared to IAS and DAS.

Fuzzy Cluster Head Election Algorithm based on LEACH protocol for Wireless Sensor Networks [12]
This paper proposed an algorithm for clustering WSN using fuzzy logic method. They have used three criteria (routing period, distance and ,number of nodes) to elect a cluster head(CH).The proposed algorithm is simulated and resulted in the reduction of energy consumption and extended lifetime of the network as compared to LEACH,CHEF and EAUCF.

Evaluation Study of Secondary Cluster Head Selection using Fuzzy Logic in WSN for Conservation of Battery Energy [13]
In this paper, the selection of secondary cluster head (SCH) is based on the parameters such as the remaining battery power, speed and centrality using fuzzy logic. These parameters are simulated to analyse the performance of network and route discovery (Fig. 9) is carried out by using CH and SCH.

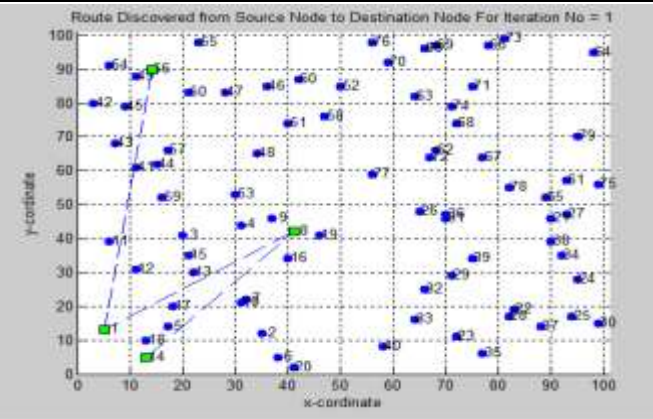

Fig. 9 Route discovered from source to destination node

Clustering using Fuzzy Logic in Wireless sensor Networks [14]
In this paper, they introduce a new technique for cluster formation using FL. Simulation is done in MATLAB and result is compared with existing clustering techniques-LEACH and CHEF [27] in order to find out that the proposed technique is more energy efficient. The comparison is indicated in below (Fig. 10).

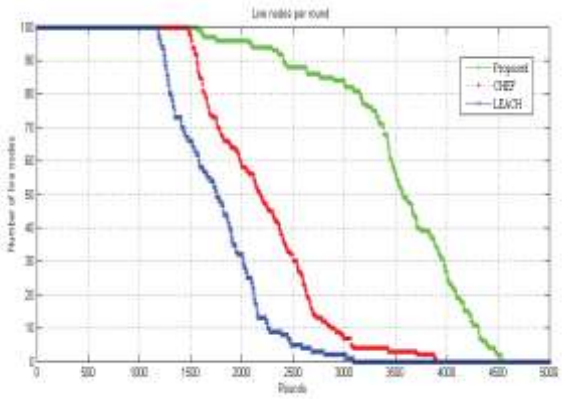

Fig. 10 Comparison

Extending the Network Lifetime of Wireless Sensor Networks Using Fuzzy Logic [15]
In this paper, they proposed a fuzzy logic approach for election of cluster head using three descriptors. The descriptors that are taken into account as energy, distance to coordinator and density. They compare LEACH and LEACH-FL (Fig. 11). Simulation is done using MATLAB and found that depending on configuration of network, the increase in network lifetime can be accomplished rather than select node as cluster heads using local information.

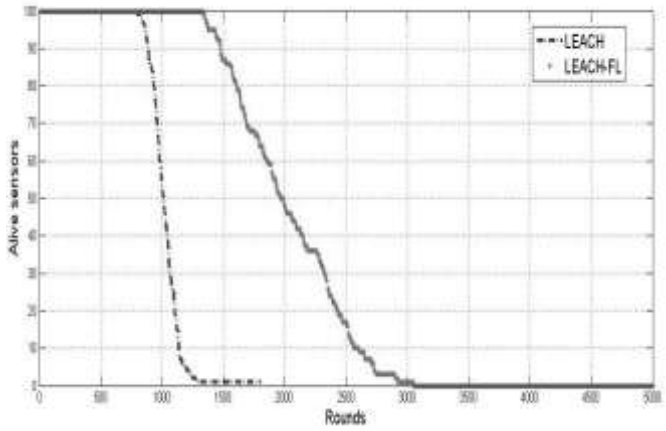

Fig. 11 Network lifetime with LEACH-FL and LEACH

An Efficient Approach for Clustering in Wireless Sensor Network Using Fuzzy Logic [16]
This paper proposed an efficient approach for clustering the sensor nodes in WSN using fuzzy logic. The method is fully distributed and uses good features of LEACH. The proposed method overcomes the limitations of LEACH algorithm. This results in more speed of cluster formation and less energy consumption as compared to existing method.

Cross-layer Based Routing Protocol for Wireless Sensor Networks using a fuzzy logic module [17]
In this paper, authors present the Cross layer approach [19] for routing protocol in wireless sensor network that reduces the energy consumption and improves the network lifetime successfully.

A Congestion Control Scheme Based on Fuzzy Logic for Wireless Sensor Networks [18]
In this paper, a fuzzy logic based congestion control scheme [26] is proposed. The current buffer occupancy and congestion index (CI) are considered to indicate the level of congestion for each node. The congestion degree is calculated using fuzzy logic method and according to the degree, traffic rate is adjusted. The proposed scheme is simulated in OMNET 14.5 in order to show the adjustment of traffic and reduction in loss of packets.

Priority-based Congestion Control Mechanism for Wireless Sensor Networks using Fuzzy Logic [19]
This paper proposed a priority based congestion control mechanism for WSN using fuzzy logic. They proposed a queuing model for assigning priority to packets based on data values. As soon as the congestion is detected by proposed congestion score relation, the notification is sent to the offspring nodes and they regulate their data transmission rate to sink node. Simulation shows the reduction in terms of packet loss rate and end to end delay (Fig. 12).

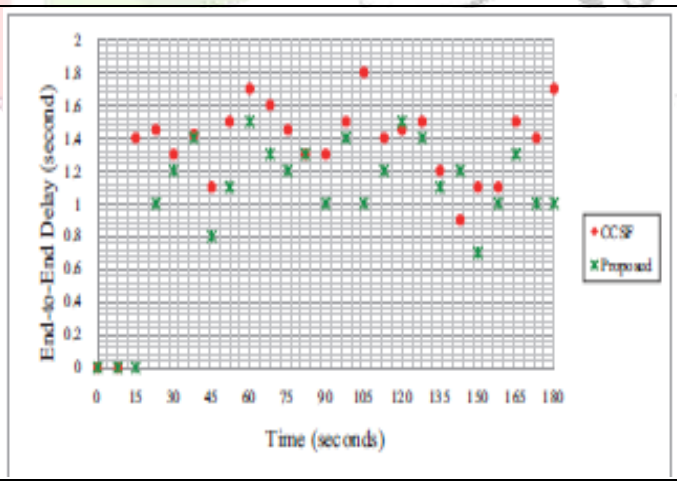

Fig. 12 Comparison in terms of end-to-end delay

Application of Wireless Sensor Networks with GIS on the Soil Moisture Distribution Mapping [20]
In this paper, author suggests a solution for efficient utilization of water by applying an integration of WSN and GIS in soil moisture distribution mapping. Data is monitored and sensed using WSN and evaluation process is followed by GIS to prepare the map for

moisture distribution of the soil. This map (shown in Fig. 13) help to find the dry situation which can be alarmed and adequate irrigation can be done on time.

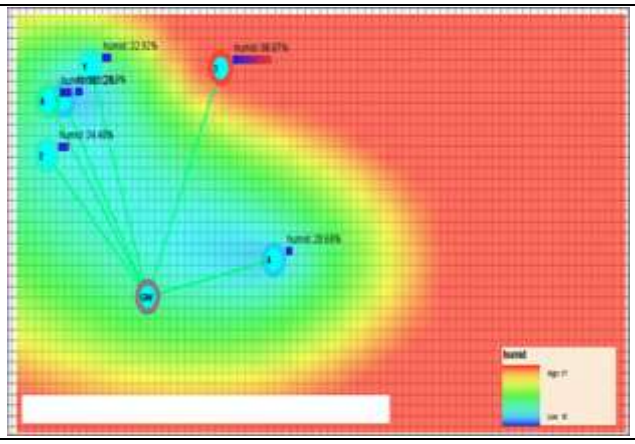

Fig. 13 The moisture content distribution map of the selected field

Online vehicle and atmospheric pollution monitoring using GIS and wireless sensor networks [21]
This paper avails from the ambulation of two technologies that are WSN and GIS to present an idea for developing an online vehicle and air pollution monitoring system. The purpose of WSN is to monitor, detect and transmit the information regarding the presence of pollution in the exhaust of vehicle. GIS displays a map for pollution created with the details like type of car, fuel used etc.

The Application of Zigbee Based Wireless Sensor Network and GIS in the Air Pollution Monitoring [22]
This paper provides an application overview of Zigbee [23-24] based WSN and GIS. It takes the advantage of GIS to benefit the application proposed for air pollution monitoring in an urban area.

A Survey on Wireless Sensor Networks Security Issues and Military Specificities [25]
In this paper, authors describe the new challenges related to security for data collection and exchange in WSN, The major security threats [26] are investigated with a special focus on the security related to military applications. They also provide the list of secure WSN protocols for battlefield surveillance, and establish a comparison of their robustness to major attacks.

VII. CONCLUSION

Many efforts have been impelled in the research field of WSNs so far. In this paper, we analysed the various QoS parameters that are imposed by the different applications of WSNs and we assert that the end-to-end QoS used in traditional networks may not be sufficient in WSNs. We have also depicted classification of several routing protocols such as Hierarchical, Network based and Geographic position assisted routing protocols and comparison is drawn for the performance of various routing protocol in WSNs. The WSNs are application specific so that it is difficult to figure out the best working protocol in the sensor network. The primary focus of any newly designed protocol in WSN is to design an energy efficient protocol as well as considering performance factors It is hard to improve or maintain both energy efficiency and security simultaneously. The deterministic clustering methods add the complexity and energy consumption to the network, as they use different approaches like fuzzy logic based, weight-based, heuristic-based, and compound based approaches to run-over these challenges. . From the findings of this survey is estimated that most of the discussed protocols are distributed in nature and obligate information regarding location. The coordinates of location is derived through either GPS devices or localization techniques which are expensive and also consumes a significant amount of energy. In order to overcome, Geographic Information System (GIS) is introduced in Wireless Sensor Network. This paper surveys different applications in WSNs domain that are integrated with GIS and are proved helpful in tracking and controlling the conditions at a specified locality.

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