CHAPTER 1

INTRODUCTION

1.1 WIRELESS SENSOR NETWORK

Due to the recent technology advances, the manufacturing of small and low-cost sensors has become technically and economically feasible. Continuous advancement in wireless communication technology has been enabled in deploying the large scale Wireless Sensor Networks (WSNs) (Bhattasali & Chaki, 2011). WSN is a large network consists of a group of spatially distributed autonomous sensors interconnected by means of wireless communication channels to monitor physical or environmental conditions such as temperature, sound, vibration, pressure, motion or pollutants at different locations and to cooperatively pass their data through the network to a main location.

The key elements of WSN are the sensor nodes and the Base Stations (BSs). A network is formed by the sensor nodes and communicates with each other either directly or through other nodes. One or more number of nodes can communicate with the user through the BS. The base Station transmits data directly or through the existing wired networks.

Figure 1.1 shows a typical architecture of a sensor network. Sensor nodes are shown in small squares. Each sensor node consists of the five components such as sensor unit, Analog Digital Converter (ADC), Central Processing Unit (CPU), power unit, and communication unit. ADC translates the sensed information and informs to the CPU what the sensor unit can do. Communication unit receives command or query and transmit data from CPU to outside world. CPU interprets the command or query to ADC, monitors and
controls power if necessary, processes received data, computes the next hop to the sink, and so forth (Kavitha & Sridharan, 2010).

**Figure 1.1 Architecture of Sensor Network**

### 1.1.1 Characteristics

The characteristics of wireless sensor nodes are as follows:

- Sensor nodes are densely deployed.
- Sensor nodes are prone to failures.
- The topology of a sensor network changes very frequently.
- The number of sensor nodes can be several orders of magnitude higher than the nodes in an ad hoc network.
- Sensor nodes mainly use a broadcast communication paradigm, while the most ad hoc networks are based on point-to-point communications.
• Sensor nodes are limited in power, computational capacities, and memory. Sensor nodes may not have Global identification because of the large amount of overhead and large number of sensors (Nagamalar & Rangaswamy 2012).

1.1.2 Requirements

Application specific WSN’s consist of hundreds to thousands of low-power multi-functioning sensor nodes. It operates in an environment where there is no human intervention, with limited computation and sensing capability. They demand the following requirements,

• Sensor nodes are inexpensive.

• Data Gathering protocols give longer life to the network.

• Sensor nodes are able to form a network of its own, without any external configuration.

• Sensor nodes should be able to work together and aggregate their data in a meaningful way (Kavitha & Sridharan, 2010).

1.1.3 Applications

WSN used in wide-range of areas like in military applications where sensor nodes include battlefield surveillance, intelligent missiles and, in medical application, patient diagnosis and monitoring, environmental monitoring, in industrial applications, in infrastructure protection which includes power grids monitoring, etc., and in other miscellaneous applications such commercial applications at home and industries to be remote-controlled. WSNs are especially used in the control and management of various industrial systems (Lee & Lee, 2012).
1.1.4 Issues

The major issues of WSN are described as follows:

- The devices that are deployed may be of various types and may need to work together.

- By using low bandwidth communication, data should be transferred efficiently between sensors.

- Sensors must coordinate with each other in order to produce desired results.

- The sensors should be used in such a way to produce the maximum performance and use less energy.

- The computation should be performed rapidly, as the new data is always being generated.

- Limited storage and computation, low bandwidth, and high error rates are some other issues in WSN.

- Errors are common in wireless communication; noisy measurements and node failure are expected here.

1.2 ROUTING IN WSN

WSN Routing can be made robust and efficient by incorporating different types of local state information: link quality, distance between nodes, residual energy, and position information. If some of the system parameters can be controlled, a routing protocol is considered as adaptive in order to adapt to the current network conditions and available energy levels. In addition, these protocols can be classified into multipath-based, query-based, negotiation-based, QoS-based, routing technique that depends on the
protocol operation. Again, the routing protocols can be classified into three categories, as reactive, proactive and hybrid protocols depending on how the source identifies the route to the destination (Villalba et al. 2009).

### 1.3 CLUSTER BASED ROUTING

The former architecture of WSN consists of single central processing station that is connected to several sensor nodes. The recent migrating demands of applications in the wireless focus more on the distributed sensor node networks. The distributed nature of network cause more than one forth of energy consumption and are closer placement where the exact location is not known. Multiple sensing nodes need to overcome the information retrieval due to obstacles such as obstruction, line of sight constraint, and so forth. Recently, clustering technique has emerged as popular approach network architecture in WSNs as shown in Figure 1.2.

![Figure 1.2 Clustering in WSN](image_url)
Clustering method is an energy-efficient communication protocol, which is used to minimize the total transmission power by aggregating into single path for prolonging the network lifetime. Using clustering, the network appears smaller and more stable structure. By the clustering methods the nodes are organized into small disjoint groups where each cluster has a coordinator referred as CH and nodes. In this approach, a sensor node of a network is divided into group of clusters. Each cluster has a CH, receives the information from the neighboring nodes that is often redundant and highly correlated. So each CH aggregates the data within the cluster and sends the compressed data to sink i.e. BS, which is a long way distance (Bhattasali & Chaki, 2011).

1.4 MOTIVATIONS AND PROBLEM IDENTIFICATION

An energy efficient clustering algorithm (Mina et al. 2009) with optimum parameter reduces the energy consumption and prolongs the network lifetime. A clustering model with one-hop distance and cluster angle is provided. The optimum one-hop distance and clustering angle are formulated which minimizes the energy consumption between inter and intra cluster.

While the existing energy-aware clustering algorithms ignore the effect of data correlation on the optimal clusters sizing and its impact on saving energy (Dabirmoghaddam et al. 2010). In hierarchical protocol, when the distance between the clustering levels increases, energy consumption increases, as the energy spent is proportional to square of the distance (Thandar Thein et al, 2008).

Further, this mechanism which works continuously in each cluster head which acts as the local control center and will not be replaced by the candidate cluster head until its continuous working times reach the optimum
values is given. This approach reduces the energy consumption in the network gives longer lifetime. This approach will maximize the lifetime by considering the working time of the cluster heads but ignores the nodes information like energy, distance between cluster head to base station and the density of node, load and link quality to determine the provisional cluster heads which plays a very important role in the lifetime. In WSNs, due to the non-uniform node distribution, the energy consumption among nodes is more imbalanced in cluster-based wireless sensor networks. The sensors in WSN generate data while it monitors its surrounding area, they perform the data gathering and transmission to the sink node. The network lifetime enhances by gathering and aggregating the data in power consumption manner (Leandro Aparecido Villas et al, 2013). There are chances of malicious attackers in the CH or the aggregator node. The data sent to the BS is not guaranteed for accuracy when the CH is cooperated. The un-cooperated nodes transmit several copies of the aggregate data to the BS which increases the energy consumed.

In a sensor network, a scheduling protocol must determine a transmission schedule for each packet otherwise collisions may take place (Giuseppe Anastasi et al, 2009). In sleep scheduling method, sender nodes should wait until receiver nodes are active and ready to receive the message. Sleep scheduling should increase the network life time (LIU Hao et al, 2010), ( Soumya Ray, et al, 2011). But sometimes it may increase broadcasting delay. Most of sleep scheduling methods focuses to minimize the energy consumption. To minimize the broadcasting delay in WSN, the time wasted for waiting during the broadcasting needs to be minimized. So there is a need for balance both energy consumption and broadcasting delay in WSN. When the network is divided into several clusters only a few sensors are in active while selected sensors from different clusters and if it repeats, it may cause a problem in future. However, the node scheduling leads to the following
problem: which nodes are to be selected to put into sleep in a round, so that functional lifetime of the network extends, without affecting network coverage and connectivity (Paul & Sao, 2011). The key challenge is to schedule the node activities for transmission of the data by maintaining the energy consumption.

1.5 OBJECTIVES

The main objectives of the proposed research work are

- To develop a novel approach to enhance clustering protocol for maximizing the lifetime in WSN.
- To develop a novel approach to make WSN useful where a compressed data aggregation approach is used in clustering protocol.
- To develop an algorithm to enhance sleep-scheduling in cluster based data aggregation technique.
- To evaluate these approaches along with a proposed technique by theoretical and simulation ways.

1.6 PROPOSED CONTRIBUTION

1.6.1 Fuzzy Based Optimal Clustering Protocol for Maximizing Lifetime in WSN

In this work, fuzzy based optimal clustering protocol has been proposed for maximizing lifetime in WSN. Initially, several provisional CHs are elected in a random manner. The nodes other than provisional CHs involve in gathering the neighbor nodes local information such as residual energy, distance, node density and network load. The collected information is fuzzified using fuzzy logic technique and appropriate CH and size are
estimated. Based on uninterrupted operational mechanism of each CH, the CHs are updated, thereby reducing the frequency of CH updation.

1.6.2 Cluster-Based Compressed Data Aggregation and Routing in WSN

In this work, a compressed data aggregation technique has been proposed for communication based on the previous clustering architecture. Here, data correlation and data compression method is used as an energy saving method. With this, the compression ratio is calculated from the data correlation and the cluster size. The CH aggregates and compresses the collected readings and transmits a single representative message to the sink. The size of the compressed message depends on the joint entropy of the cluster.

1.6.3 Energy Efficient Sleep-scheduling for Cluster Based Aggregation in WSN

In this work, a Cluster Based Scheduling has been proposed in WSN. An energy efficient wake up scheduling algorithm is proposed that support the high data rate transmission and reduces the energy consumption. In this technique, each node wake up only twice, that is, once to receive the data from neighbor node and next time to transmit data to sink node. Also, to a Probability-based Prediction and Sleep Scheduling (PPSS) protocol is used to lessen the amount of energy consumption. This is achieved by reducing the number of awakened node in the target vicinity.

Figure 1.3 illustrates the overall architectural diagram of the proposed techniques.
1.7 THESIS OVERVIEW

This thesis consists of six chapters. This chapter gives an overview of Wireless Sensor Network and also presents the different issues of clustering, data aggregation and sleep scheduling. It also provides the motivation and problem identification of the research.
- Chapter 2 provides the literature review on existing routing, clustering, data aggregation, and scheduling in WSN and summarizing the issues on them.

- Chapter 3 discusses the proposed Fuzzy based Optimal Clustering Protocol for Maximizing Lifetime in WSN along with the performance metrics and simulation results.

- Chapter 4 discusses the proposed Cluster based Compressed Data Aggregation and Routing in WSN along with the performance metrics and simulation results.

- Chapter 5 discusses the proposed Energy Efficient Sleep-Scheduling for Cluster based Aggregation in WSN along with the performance metrics and simulation results.

- Chapter 6 summarizes the conclusions drawn from the research work and discusses the scope for future work.