1. Introduction

1.1 Sensor Networks

Wireless Sensor network (WSN) is a network of many tiny sensor nodes which are powered by battery. It is being deployed in the area of interest for monitoring physical environments. Nodes integrate sensing units, transceiver and actuators with limited on-board processing and radio capabilities for the required [1]. Nodes having limited memory and are placed in difficult to access locations to measure properties of the environment. Radio is implemented on nodes of wireless communication to transfer the sensed data from node to base station which can be access point to fixed infrastructure, computing device like laptops etc. [2]. The data accumulated at the base station provides dense sensing close to physical phenomena of the environment. [3]

The major challenge in designing wireless sensor networks (WSNs) is to achieve an optimal monitoring and surveillance of area of interest which depends on the sensor’s positions, known as deployment of the network. [4]. Sensing coverage and network connectivity are two primary functions of wireless–sensor networks that are needed to be considered in such a manner that there is maximum coverage as well as network connectivity is maintained. [5]

1.2 Applications of WSN

Wireless Sensor Networks applications can be classified into two broad categories: Monitoring and Tracking. [2]
The primary area to take advantages of sensor networks is the military area. Since sensor networks are based on the dense deployment of disposable and low-cost sensor nodes, destruction of some nodes by hostile actions does not affect a military operation as much as the destruction of a traditional sensor, which makes wireless sensor networks concept a better approach for battlefields. Some of the military applications of sensor networks are monitoring friendly forces, equipment and ammunition, battlefield surveillance; reconnaissance of opposing forces and terrain, targeting battle damage assessment and nuclear, biological and chemical attack detection and reconnaissance. [1]

Sensor networks are also very useful in environmental application. Some environmental applications of sensor networks include tracking the movements of birds, small animals, and insects[10] monitoring environmental conditions that affect crops and livestock; irrigation [11] macro-instruments for large-scale Earth monitoring and planetary exploration; chemical/ biological detection, precision agriculture; biological, earth, and environmental monitoring in marine, soil, and atmospheric contexts, forest fire detection; meteorological or geophysical re-search, flood detection, bio-complexity mapping of the environment, and pollution study. Moreover, monitoring environment is already a frequent practice, be-cause can help humans to avoid disaster or forecast relevant changes in the environment conditions. [12]

Other useful and growing applications of sensor networks are health applications. Some of them are providing interfaces for the disabled; integrated patient monitoring; diagnostics; drug administration in hospitals; monitoring the movements and internal processes of insects or other small animals; tele-monitoring of human physiological data; and tracking and monitoring doctors and patients inside a hospital. [13], [14] Demotic field can also have benefits from sensor networks. As technology advances, smart sensor nodes and actuators can be buried in appliances, such as vacuum cleaners, micro-wave ovens, and refrigerators. [10] These sensor nodes inside the domestic devices can interact with each other and with the external net-work via the Internet or Satellite. They allow end users to manage home devices locally and remotely more easily. [15] Designing human-centered or technology-centered smart environment is obviously another related application. [16] For human-centered, a smart environment has to adapt to the needs of the end users in terms of input/output
capabilities. For technology-centered, new hardware technologies, networking solutions, and middleware services have to be developed. [17] One smart environment scenarios the following: sensor nodes can be embedded into furniture and appliances, and they can communicate with each other and the room server. The room server can also communicate with other room servers to learn about the services they offered, e.g., printing, scanning, and faxing. These room servers and sensor nodes can be integrated with existing embedded devices to become self-organizing and self-regulated. [18], [17]

Finally, there are many other commercial applications of sensor networks, like: monitoring material fatigue; building virtual keyboards; managing inventory; monitoring product quality; constructing smart office spaces; environmental control in office buildings [11]; robot control and guidance in automatic manufacturing environments; interactive toys; interactive museums; factory process control and automation; monitoring disaster area; [19] smart structures with sensor nodes embedded inside; machine diagnosis; transportation; factory instrumentation; local control of actuators; detecting and monitoring car the thefts; vehicle tracking and detection. [19]

1.3 Network Layer Issues

1. Wireless links are not very reliable and nodes might stop operating at arbitrary points within the system’s life; therefore; the routing protocol utilized must be able to handle arbitrary failure of nodes throughout the network.

2. Eventually, the data retrieved by the sensors must be propagated back to a central location, where further processing must be done in order to analyze the data and extract meaningful information from the large amounts of data. However, due to limited power supply, spatial refuse of wireless bandwidth, and the nature of radio communication cost, it is ideal to send information in several smaller distance wise steps rather than one transmission over a long communication distance.

3. In WSNs network topology has to be looked up from a neighborhood point of view. In these topologies, the number of neighboring nodes determines the number
of receivers and hence results in more overall power usage, even though the number of transmissions decreases. Thus, there is fundamental trade-off between decreasing the number of transmissions and increasing the number of receptions.

4. To deploy a finite number of sensor nodes in a geographic area, and choosing a communication structure among the nodes on the corresponding network is a problem.

5. A single sink is responsible for gathering the sensor data, for storage or control purposes. Since sensor nodes have limited battery power, an important goal is to minimize the total power consumption of data gathering, while keeping the sensing distortion within specified bounds. An important characteristic of typical sensor networks that can be exploited for reducing the power consumption is that the data measured at nodes is correlated.

1.4 Deployment of Sensors

Due to the diversity of applications, requirements and design goals, there is no single, distinctive approach to the design and deployment of sensors networks available. The major issue in the deployment is to find the better way for placement of nodes for maximum coverage [6] [7].

In the deployment of the network, positions of sensor node are to be determined which influence the coverage of area of interest. Every node in sensor network has a physical range within which it performs sensing. Coverage of the network means that how much area in the physical area of interest is within the sensing range of at least one of the sensors [16]. Coverage problem is one of the fundamental issues in a wireless sensor network. The purpose of this paper is to review the recent progress in this direction and propose a solution for the optimal placement of the nodes keeping in mind the coverage and connectivity. Coverage can be done by doing randomized sensor placement in remote or inhospitable areas, or for military application when individual nodes placement is infeasible. Positioning of nodes can be further done in static and dynamic ways. Node locations decisions are made at the time of set up of network in static approach while in dynamic approach repositioning of nodes are
carried out while networks are operational. This repositioning of nodes helps in dealing with variations in environment where network is deployed. [19]

With the survey of node positioning approach, Static approach gives better coverage when nodes positions are predetermined for example monitoring of gas pipeline, security surveillance. Static approach is not recommended when node positions are random in such scenario dynamic approach is the only option for example forest fire detection, disaster recovery and mission during combat. In dynamic deployment initially nodes are placed randomly but due to mobility nodes are repositioned to fill the coverage gaps in region of interest with the objective to maximize the coverage of the network.

Through this work, we intend to provide an efficient optimal algorithm for the placement of the nodes in geographical area. Though some works are targeted at particular applications, still the central idea is related to the coverage issue. The purpose is to optimally place the sensors in space in order to reduce the number of physical nodes and support the coverage in such a manner that there is minimum interference maximum coverage

1.5 Routing Protocols for Sensor Networks

The primary challenges regarding WSNs are durability, power utilization, functionality, sensor data fusion, and fault tolerance. Power utilization refers to increase the battery life and lower power consumption while durability relates to the synchronization of sensor actions and optimizations in the communication protocol. The functionality relates to future specified applications. Data fusion includes the merging of sensor data, and data compression. Noticeably, fault tolerance relates to deteriorating nodes and the erroneous feature of the wireless communication medium. Energy efficiency is attained by bringing a decrease in network performance. Routing in sensor networks is different from modern communication and wireless ad-hoc networks in a number of ways and is not easy to put it into practice.
• It is not feasible to construct a global addressing scheme for the application of sheer number of sensor nodes. Hence, classical IP-based protocols cannot be deployed to sensor networks.
• As compared to general communication networks, roughly the entire applications of sensor networks necessitate the sensed data flow from multiple areas to a specific sink.
• Formulated data traffic has considerable redundancy in it because multiple sensors may produce identical data within the neighborhood of an occurrence. These redundancies have to be made use of by the routing protocols to enhance energy and bandwidth exploitation.
• Sensor nodes necessitate watchful resource management because they are bounded by transmission power, processing capacity, on-board energy, and storage. Node failures and packet losses are generally transient in nature and are noticed commonly in sensor networks. This is as a result of temporary wireless interference.

Therefore, a routing protocol for such problematic networks should be competent of adjusting to ever fluctuating network conditions at the same time as conserving maximum power.

1.6 Single Path and Multi path Routing

Routing of sensed data from the environmental to base station under the constraints of WSN is the primary channel. Routing in sensor network is different from contemporary communication and wireless ad-hoc networks. Numbers of sensor nodes are deployed in the area to be sensed and data collected from these nodes are forward to sink node by inter-node wireless multi-hop communication. Performance of routing protocols depends upon the architecture model of the network i.e. sensor nodes, sink and events to be sensed from the environment. The data sensed by sensor node from environment are to be routed to the sink in energy efficient mode in order to increase the lifetime of the network.[29]
Thus routing protocols of wireless sensor network are designed to communicate sensed data to single sink in energy efficient way to maximize life time. Like in the application of habitat monitoring sensed environment data from multiple sensor nodes is collected in a single sink.[35].Researchers are investigating the networks to collect data at multiple sink as it results in less energy consumption [47].Like in the case of fire scenarios emergency signal are sensed and also water sprinklers are controlled by sensed temperature by the same sensor nodes. [48]Single path routing and multiple path routing are different types of wireless sensor network routing. Even though single path routing is scalable but due the resource constraints of WSN it is not efficient in present scenarios of research .[47]

1.7 Objectives

The research work will be carried out keeping in view the following main objectives:

(i) Optimal deployment of sensor nodes.

(ii) To develop and analyze soft computing based routing algorithm for mobile wireless sensor network

(iii) To develop and analyze reliable energy efficient multipath routing in mobile wireless sensor networks.