Abstract

Wireless sensor networks are primarily used for sensing and collecting the information from environment. This information is sent to base station (BS), where, it is processed and analyzed by the underlying application. Preserving the energy is an important goal that must be considered when developing a routing protocol for WSNs. Energy can be conserved in an efficient way with specifically customized routing techniques. Data aggregation methods when applied to sensor nodes, clusters are created where data generated from cluster members is aggregated. This kind of data collection strategy results into energy efficient communication. Integration of data aggregation and clustering approach is enabled through customized hierarchical routing strategies.

Hierarchical routing approaches ensure scalability as well as energy efficient network operations. Many such hierarchical routing protocols have been proposed in the literature. Most of the protocols follow methodologies of LEACH or LEACHC hierarchical routing protocols. Hierarchical routing protocols apply iterative process of creating clusters round by round till the network survives. In the beginning of each round, during set-up phase, BS collects energy status and current location of the nodes. After finding the average residual energy of network, BS elects cluster heads (CH) having energy above this threshold for the current round. BS finds best possible clusters considering various parameters like residual energy of the nodes, intra-cluster distance and base station location. The steady state phase after setup phase is used for normal operations of sensor network like sensing, data aggregation at CH and reporting of this information at BS.

According to literature survey BS may use conventional search techniques or modern metaheuristic techniques for clustering. Most of these protocols emphasize on the network lifetime and total data delivered at the base station as performance parameters. However, an important parameter, standard deviation of number of
members in clusters has remained less explored by researchers. As most of these protocols create clusters using residual energy and intra cluster distance, the clustering process creates non-uniform clusters. Unbalanced clustering leads to dense clusters and sparse clusters. Due to this, sparse cluster nodes may transmit \( n \) times more than the dense clusters in worst case. This may result in network partitioning or network holes. The number of members assigned to different cluster-heads at a particular round varies largely. Due to this large variation, the data delivery process is severely affected. The periodicity of data reported from dense clusters and sparse clusters varies to a great extent. This may be troublesome when some of the regions in the deployment field need urgent treatment. Every sub-region of the deployment field experiences different delays while reporting data to BS because of the non-uniform clustering.

Primary focus of the research work presented in this thesis is on improving data delivery process so that data arrives from almost every part of the network at regular interval To overcome the problem of non-uniform clustering, a loose density control based approach has been proposed. The density control approach has been integrated with various clustering protocols like K-Means and Harmony Search algorithms. An auto density control approach (HSADCP) is proposed with Harmony Search based clustering protocol. HSADCP considers multiple objectives like residual energy, intra cluster distance, standard deviation of members and cluster-head separation to create uniform clusters. The contribution of one of the objective functions of HSADCP, standard deviation of members across clusters, has been analyzed in depth to find the best possible weight factor of this objective in overall process of clustering. The protocol HSADCP has also been simulated against realistic WSN topologies to evaluate its performance.

Centralized clustering protocols expect the energy information from the member nodes during the setup phase. This results in to excess time and energy usage. The status information of nodes could be sent via cluster-heads to the base station during the steady state phase. The setup time can be reduced considerably. A hybrid approach to collect energy status has been proposed using HSADCP to overcome the problem of excess setup time. Harmony Search based Reduced Broadcast Clustering Protocol (HRBCP) is proposed. It has been implemented with diversified and varying
deployment scenarios.

In a nutshell, the contribution of the work is a solution to improve data delivery process of centralized routing protocols for WSNs. The balance has been maintained between the network lifetime and regularity of data arrival from every sub-region of the network. The setup time of the clustering process has been controlled through modern metaheuristic technique like Harmony Search.