**MODULES:**

 System Construction Module

 Self-Organization Phase

 Current Cluster Setup Cycle Length

 Performance Evaluation

**MODULES DESCSRIPTION:**

**System Construction Module:**

 after the deployment of the sensor nodes, the BS creates groups of different sensor nodes in order to form clusters. Each cluster contains a CH node and two DCH nodes. The BS selects a set of suitable sensor nodes from each cluster, which can act as CH or DCH at a later stage. This set of nodes is also called CH panel.

 The cluster members i.e., the sensor nodes, forward data to the respective CH node. The CH nodes do the data aggregation to remove redundancy and then forward the aggregated data toward the BS. The DCH nodes do several cluster management tasks that include mobility monitoring also. Other cluster management tasks are, for example, collecting location information of cluster members regularly and communicating this location information to the BS.

 They also remain ready to act as intermediate hop in presence of faults in some CH nodes. Therefore, the DCH nodes are also called cluster management nodes. The CH nodes do not transmit data directly to the BS, unless it is the nearest one to the BS. The communication pattern or the route for the CH nodes is determined by the BS and distributed to the respective CH nodes.

**Self-Organization Phase**

 after random deployment of the sensor nodes in the sensor field, the self- organization phase starts. It is the first phase of the protocol. During this phase, the clusters are formed. The CH set, the current CH, and the two DCH nodes are selected by the BS. Initially, the BS collects the current location information from each of the sensor nodes and then forms a sensor field map. The sensor nodes can discover their geographic location information through some GPS-free solutions. Based on the velocity of a sensor node, the BS can prepare a rough estimate of the zone in which the sensor node is going to be in the next time interval. The next time interval is a specific time period for which a particular setup of the network remains valid.

 The value of the next time interval can be set manually depending on the type of the application, and this value is critical because most of the computations, e.g., cluster setup validity period and medium access slot, are dependent on the next time interval. Using this information, the BS can compute the topology of the sensor network. Once the BS creates the sensor field map, it forms the clusters. The cluster formation approach is simple. The basic objective is to maintain geographically uniformly distributed clusters so that the coverage is uniform. It is also desired that the CH nodes are uniformly distributed over the entire sensor field.

**Current Cluster Setup Cycle Length**

 An important and critical issue is how long a particular cluster setup will remain valid. Depending on the initial energy level of the sensor nodes and the kind of application, the optimal time duration is fixed. This optimal time duration is called as cycle length, and the current cluster setup remains valid until the end of the cycle length. However, exception may always occur.

 For example, due to mobility of the nodes, severe link failures may occur, and nodes may die out due to depletion of energy, which may together cause network partition. In such situations, current cluster validity time, i.e., cycle length, may become outdated, and re-clustering may get initiated by the BS before expiry of the cycle length. Ideally, cycle length is the same as the next time interval aforementioned.

**Performance Evaluation:**

 The following metrics are used to understand the performance of our routing approach:

 Average Communication Energy: It is the average of the total energy spent due to communication in the network over a particular time period and with respect to a specific data rate. If E is the total energy spent due to communication and N is the total number of nodes in the system, then E/N (i.e., energy per node) is the average communication energy. A protocol with lower average communication energy is desirable.

 Throughput: It is the ratio between the actual numbers of packets transmitted by the nodes in the system to the numbers of successfully delivered packets at the BS. It reflects the percentage of packets lost during transmission. A protocol with higher throughput is desirable.

 Lifetime: It is the time taken since the start of the network (during the simulation) for the first node to die. A protocol with larger lifetime is desirable.

 Node Death Rate: It is a measure with regard to the number of nodes that died over a time period since the start of the simulation.