ABSTRACT

In today's world, Wireless Sensor Networks (WSNs) have become more relevant due to the advancements in IoT, smart grid and smart city applications. WSN consists of a large number of small-sized sensor nodes which are widely deployed in a terrestrial environment to sense, supervise and monitor the physical circumstances. In general, energy consumption will be a significant concern for WSN owing to irreplaceable battery constraints of sensor nodes. The zone formation approach could be an adequate data aggregation technique which efficiently minimizes the energy consumption by grouping sensor nodes into zones.

The efficient design of the zone formation requires better intra-zone and inter-zone routing techniques. However, the main constraints like Zone Head (ZH) selection, frequent change of ZH, Energy Hole Problem (EHP) and multi-hop communication from ZH to the sink have a direct impact on the network consistency of WSN. More attention has to be given during ZH selection for acquiring efficient intra-zone routing and also for increasing node reachability within the zone. At the same time, a proper multi-hop communication among ZH attains an efficient inter-zone routing. Moreover, the EHP in inter-zone routing can be avoided by employing an appropriate sink mobility model in WSN. Therefore, it is necessary to have an effective intra-zone and inter-zone routing techniques to prevent the aforesaid constraints.

The key objective of this research work is to overcome the constraints of zone formation approach by designing an efficient intra-zone and inter-zone routing techniques for prolonging the network consistency and network lifetime of WSN. In accordance, three techniques were imposed in this research work for efficient zone formation. Primarily, the first two techniques focus on intra-zone routing whereas the third technique focuses on acquiring inter-zone routing.

In the first technique, a Multi-criteria based Particle Swarm Optimization (MPSO) algorithm has been proposed to select ZH node in the network. The selection strategy can be carried out in the proposed algorithm by considering four distinct parameters such as residual battery energy, the distance to the center of the node deployment area, the number of neighbor sensor nodes, and the number of times sensor node is in idle mode. Afterwards, the novel fitness function can be computed by using the above-mentioned four parameters. In MPSO, the particle which shows global best result is selected as ZH node. The proposed MPSO algorithm is simulated in MATLAB environment. The performance results manifest that the proposed algorithm enhances the network consistency compared to existing algorithms. Moreover, the MPSO algorithm shows an improvement in network lifetime in terms of the First Sensor node Die (FSD) and Half Sensor node Die (HSD) than the centralized LEACH algorithm. The obtained simulation results have been examined by varying the number of criteria in ZH election and their effect on network lifetime.

In the second technique, a novel Hybrid algorithm is proposed for efficient ZH selection in which Harmony Search Algorithm (HSA) incorporates with Modified Moth Flame Optimization (MMFO) algorithm. To overcome the large dimensional problems of MMFO, HSA is employed due to its huge searching computational ability. At the same time, HSA has a restriction of being constrained only to a certain search region. This circumstance is eliminated in MMFO by moving from one place to another as well as by updating its position in the search space for attaining optimum results. The Hybrid HSA-MMFO algorithm provides an appropriate ZH selection for intra-zone routing that reduces the frequent change of ZH in the network. Due to this reason, the performance of the Hybrid HSA-MMFO algorithm is enhanced with respect to the existing centralized LEACH algorithm in terms of FSD and LSD.

Nevertheless, among the two proposed intra-zone routing techniques, the consistency and lifespan of the WSN are prolonged by Hybrid HSA-MMFO algorithm than the MPSO. As a consequence, the Hybrid HSA-MMFO is more

appropriate intra-zone routing technique to achieve efficient data communication inside the zone.

In the third technique, an efficient inter-zone routing technique, called Multi-criteria based Optimal Path Routing with Sink Mobility Strategy (MOPR-SMS) algorithm is proposed to overcome the path failure and EHP in WSN. The proposed MOPR-SMS algorithm is a combination of three significant phases: MOPR phase, selection of Strongly Loaded Zone (SLZ) phase and Sink Mobility Strategy (SMS) phase. The path optimization in inter-zone routing is offered by MOPR phase, whereas the SLZ and SMS phases provide optimal placement of sink node that mitigates the EHP in WSN. The selection of SLZ can be carried out by using Fuzzy Logic. The performance of the proposed MOPR-SMS algorithm is determined as well as compared with the conventional and modern inter-zone routing techniques by using the simulation carried out in MATLAB environment. Simulation results confirm that the proposed MOPR-SMS shows a high-performance measure than the existing algorithms in WSN. Further, the MOPR-SMS algorithm shows an improvement in network lifetime than the Static algorithm. Consequently, the lifetime along with the consistency of WSN, has been enhanced in all these proposed algorithms against conventional and modern intra-zone as well as inter-zone routing techniques.