ABSTRACT

Recent advances in wireless communications and electronics have enabled the development of low-cost, low-power, multifunctional sensor nodes that are small in size and communicate untethered in short distances. These tiny sensor nodes, which consist of sensing, data processing, and communicating components, leverage the idea of sensor networks. Sensor networks represent a significant improvement over traditional sensors. The past few years have witnessed increased interest in the potential use of Wireless Sensor Network (WSN) in a wide range of applications and it has become a hot research area.

Sensor nodes in WSN are usually battery operated devices, and hence energy saving of sensor nodes is a major design issue. To prolong the networks lifetime, minimization of energy consumption should be implemented at all layers of the network protocol stack starting from the physical layer to the application layer including cross-layer optimization. Optimizing energy consumption is the main concern for designing and planning the operation of the WSN. Clustering technique is one of the methods utilized to extend lifetime of the network by applying data aggregation and balancing energy consumption among sensor nodes of the network. In clustered networks, sensor nodes in each cluster transmit their data to the respective Cluster Head (CH) and it aggregates data and forwards them to a central Base Station (BS). More energy is drained from Cluster Heads(CHs) due to message transmission over long distances (CHs to BS) compared to other sensor nodes in the cluster. Moreover, it is also essential to avoid quick depletion
(death) of cluster heads. Selecting optimal election, maintenance and re-election of CHs are the main issues to be addressed in designing of clustering algorithms. Hence, this thesis proposes various methods for selection of CH, which is based on meta-heuristic algorithm.

Low-Energy Adaptive Clustering Hierarchy (LEACH) algorithm is an existing clustering mechanism deployed widely in WSN that shows improvement over conventional approach like Direct Transmission (DT) technique. In LEACH, the CHs are elected on the probability basis. Here, if the energy of a sensor node is less, it has a high probability of getting elected as CH. In this approach, First Node Death (FND) has longer duration as compared with DT since the CH is elected on probability basis. However, as the time progresses, the energy of the nodes gets depleted and nodes are elected as CH even if they have less energy. Hence, the election of CH is needed. Therefore, optimal selection of CH nodes is done, which help to avoid early death of nodes and to increase the lifetime of the WSN. This research work proposes three optimization techniques based on meta-heuristic method for selection of cluster head in the WSN network. The proposed optimization techniques prolong the FND duration and Last Node Death (LND) duration that in turn improves the residual energy of the network.

In LEACH algorithm, CH selection process is based on probability means, whereas, Artificial Bee Colony (ABC) algorithm randomly selects the cluster head is done based on the fitness value through given optimization round. In firefly, energy based switching of CH takes place that gives the best possible CH selection and prolongs the duration of FND. However, in the case of ABC algorithm, the duration of LND increases significantly than LEACH, firefly and DT. Also, the residual energy of the network is better with ABC approach as
compared to the aforesaid algorithms. Now, taking the advantages of ABC and
firefly, hybridization of firefly-ABC is proposed. This hybrid approach increases
the life-time of the network. Such hybridization increase the residual energy as the
number of alive nodes is increased in the network. In addition, it also improves the
throughput of the network. The proposed hybrid firefly-ABC algorithm increases
the FND and LND considerably over the existing LEACH, standalone firefly and
ABC algorithms. With the proposed hybrid firefly-ABC algorithm, the FND,
LND, residual energy and throughput shows an improvement of 23.82%, 10.16%,
55.11% and 83.01%, respectively, than the existing LEACH algorithm.

To further improve the FND and LND of WSN, hybridization of
Harmony Search Algorithm (HSA) and Particle Swarm Optimization
(PSO) termed as hybrid HSA-PSO is proposed for energy optimization that
improves life time of the network. In hybrid HSA-PSO algorithm, the parameters,
namely, distance and energy are considered at the time of CH selection only.
Hence, it performs searching at a faster rate making exploration and exploitation
earlier. Because of this reason, the performance is improved with respect to the
existing LEACH and hybrid firefly-ABC in terms of FND and LND. But the
limitation in HSA is that it restricts it’s searching to only a particular region.
However, as PSO is implemented it allows the dynamic capability to move from
one region to another in search for an optimal solution and achieve a faster
convergence. But in high dimensional problems, the convergence rate starts to
decrease and hence making exploitation and exploration difficult. In order to
overcome the problems resulted by HSA and PSO, a hybrid Scheme is proposed
that combines HSA and PSO. With the proposed hybrid HSA-PSO algorithm, the
FND, LND, residual energy and throughput shows an improvement of 77.53%, 52.35%, 83.89% and 29.00%, respectively, than the PSO algorithm.

In addition to hybrid firefly-ABC and hybrid HSA-PSO algorithms, and to take advantage of the LEACH and Advanced LEACH (ALEACH) algorithm, AOLEACH (Advanced Optimized Low Energy Adaptive Clustering Hierarchy) is proposed to improve the LND in WSN. However, through simulation results it is found that the FND duration increases. Hence, to improve the FND along with LND, hybridization of AOLEACH and Shuffled Frog Leap Algorithm (SFLA) is proposed. SFLA enables best optimal adaptive cluster head selection using improved threshold energy distribution compared to LEACH protocol. The proposed algorithm optimize the life time of the network by increasing the FND duration and number of alive nodes, thereby increasing the life time of the WSN. Results of the proposed algorithm deduce that through optimization the life time of the network is increased in terms of improved FND, residual energy and number of alive nodes as compared to LEACH and ALEACH algorithms. With the proposed hybrid AOLEACH-SFLA algorithm, the FND, LND, residual energy and throughput shows an improvement of 7.83%, 2.77%, 12.78% and 20.16%, respectively, than the SFLA algorithm.

Nevertheless, among the three hybrid meta-heuristic algorithms the lifetime of the WSN is improved by hybrid AOLEACH-SFLA algorithm than hybrid firefly-ABC and hybrid HSA-PSO algorithm. This is due to improved performance of SFLA algorithm as compared to ABC and PSO algorithms. In particular, the residual energy of WSN by hybrid AOLEACH-SFLA algorithm is improved by 99.74% and 22% in hybrid firefly-ABC and hybrid HSA-PSO algorithm, respectively, without variations in the throughput of the network.