SEER—An Intelligent Double Tier Fuzzy Framework for the Selection of Cluster Heads Based on Spiritual Energies of Sensor Nodes

Maddali M. V. M. Kumar and Aparna Chaparala

Abstract The selection of cluster heads in a wireless sensor network (WSN) is a very challenging area of research. Many algorithms have been proposed for the selection of cluster heads to prolong network lifetime, but maintaining an energy efficient network remains a problem. To overcome this, we propose a new algorithm for cluster head selection based on the Spiritual Energy of the whole WSN, which is known as the SEER (simple energy-efficient reliable) protocol. In addition, the implementation of the double tier fuzzy algorithms on the SEER protocol makes the network more energy efficient. The proposed algorithm has been simulated with MATLAB and compared with the other energy efficient algorithms such as CLERK and LEACH. The results proved to be very promising in terms of the reduction of energy consumption.

Keywords Spiritual Energy · FEER · LEACH · DEEDA · Fuzzy Double tier fuzzy logics · Cluster heads

1 Introduction

The selection of a cluster head is major research challenge and many protocols have been proposed aiming for the most energy efficient solution to the problem. Several protocols have been designed and implemented but an efficient mechanism has not been found. The SEER protocol, which has been proposed depends on the Spiritual Energy of the network along with other parameters, such as distance, relative received signal strength (RSSI), proximity, and centrality. The proposed protocol works on a new intelligent framework called double tier fuzzy implementation I in which

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S. Smys et al. (eds.), *International Conference on Computer Networks and Communication Technologies*, Lecture Notes on Data Engineering and Communications Technologies 15, https://doi.org/10.1007/978-981-10-8681-6_46

qualifying rounds are employed for cluster head selection and a backup cluster head is chosen. This chapter is organized with the related work in Sect. 2, the proposed algorithm's working principles employing fuzzy rule sets are discussed in Sects. 3 and 4 addresses performance evaluation, and Sect. 5 presents the conclusions.

2 Related Work

The work by Bidaki et al. [1] introduced a fuzzy clustering technique which changed the probabilistic cluster head choice in the LEACH protocol. The fuzzy framework utilized in the inference engine plan is the Mamdani fuzzy framework, which is a straightforward rule-based strategy. This plan makes symmetric groups and the total hub to the cluster head separate. This in turn lessens the energy utilization of the sensors and enhances the lifetime of the WSN more than the LEACH protocol. Sharath et al. [2] employed a backoff-based distributed clustering protocol (LEACH) and Clustering-Fuzzy Logic has proposed the extension of time to network steadiness before the passing of the primary hub and the diminishment of shaky time before the death of the last hub. This protocol depends on the race of bunch head by the adjust of the probabilities of the rest of the energy for every hub. In this chapter, the authors propose enhancing clustering procedures through the use of clustering fuzzy logic (Clustering-FL). A fuzzy-based reproduction framework for WSNs is proposed, keeping in mind the end goal of computing the lifetime of a sensor by considering the rest of battery control, the rest time rate, and transmission time rate. We assessed the framework by NetBeans IDE reproductions and demonstrated that it performs the measurement of sensor lifetime efficiently. In this system, a couple of hubs progress toward becoming the bunch head and this results in the energetic heterogeneity of the system, and thus the conduct of the sensor organization turns out to be exceptionally precarious when the life of the primary hub is passed. Lee and Jeong et al. [3] proposed a fuzzy relevance-based cluster head determination algorithm (FRCA) to take care of issues found in existing remote portable specially appointed sensor systems, for example, the hub conveyance found in unique properties as a result of portability and level structures, and aggravation of the group arrangement. The proposed mechanism utilizes fluffy importance to choose the bunch set out toward grouping in the remote portable specially appointed sensor systems. In the simulation performed using the NS-2 test system, the proposed FRCA was contrasted and calculations performed, for example, the cluster-based routing protocol (CBRP), the weighted-based adaptive clustering algorithm (WACA), and the scenario-based clustering algorithm for mobile specially appointed systems (SCAM). The simulation results demonstrated that the proposed FRCA accomplishes the preferred execution more efficiently than the other existing mechanisms. Subramaniam et al. [4] studied a protocol supporting an energy proficient clustering, cluster head choice, and information routing technique to broaden the lifetime of sensor organization. Simulation results show that the proposed technique delays organization lifetime because of the utilization of proficient grouping, cluster head determination, and information directing. The results also demonstrate that toward the end of some specific piece of running the energy efficient clustering schemes (EECS) and fuzzy-based clustering algorithm increase the quantity of alive hubs in contrast to the LEACH and HEED techniques, and this can prompt an increase in the lifetime of sensor organization. By using the EECS technique, the aggregate number of messages received at the base station is increased compared to the LEACH and HEED strategies. The fuzzy-based grouping strategy contrasted and the k-means clustering by methods for emphasis tally and time taken to kick the bucket first hub in remote sensor organize, and the outcome shows that the fuzzy-based clustering technique performs well with k-means clustering strategies. Gajjar and Sarkar et al. [5] proposed a cluster head choice protocol utilizing fuzzy logic (CHUFL). This protocol uses hub parameters, namely remaining energy, reach and ability from its neighborhood, nature of communication connects with its neighborhood, and separation from the base station as fuzzy info factors for use in cluster head determination. A relative investigation of CHUFL with cluster head choice component utilizing fuzzy logic; Cluster Head Election instrument utilizing Fuzzy logic (CHEF) and group head chose the technique for remote sensor systems in light of fuzzy logic demonstrating that CHUFL is up to 20% more energy productive and sends 72% more bundles to base stations in contrast with protocol one of the energy efficient clustering protocol. Mishra et al. [6] concentrated on progressive protocols. In such conventions, energy proficient clusters are formed with a pecking order of group heads. Each cluster has its delegate cluster head in charge of gathering and collecting information from its separate cluster and transmitting this information to the base station, either straightforwardly or through the chain of importance in other cluster heads. Fuzzy logic has been effectively connected in different areas, including communication and has demonstrated promising outcomes. In any case, the possibilities of fuzzy logic in remote sensor organization should still be investigated. The streamlining of remote sensor systems includes different tradeoffs, for instance, reducing transmission control versus longer transmission span, multi-bounce versus coordinate correspondence, calculation versus correspondence, and so forth. Fuzzy logic is appropriate for applications having clashing requirements. In addition, in WSNs, as the vitality measurements shift generally with the type of sensor hub execution stage, fuzzy logic has the benefit of being effortlessly adaptable to such changes. Varghese et al. [7] most importantly considered hubs having a threshold value. A hub over this value was termed as qualifying for the cluster head. From these qualified hubs, the hub having the most extreme vitality, accessibility, and the hub with the least separation from the sink and the greatest throughput is chosen as the cluster head hub. Utilizing fuzzy rules, the potential value for every hub can be calculated. In the wake of arranging hubs by potential value, they should be checked again for malevolent conduct, so that there is no way for a malevolent hub to end up as the bunch head. This shows that improved cluster head determination is possible and can improve security of information exchange through WSNs. Secured clustering improves the lifetime of remote sensor arrangement, identifies pernicious hubs and prevents them from becoming the bunch head. Hub replication attack detection protocol is used to recognize pernicious hubs. Clones are produced by some pernicious hubs. Hub replication attack detection protocol recognizes clones and replay assaults can be distinguished by use of the replay assault discovery protocols, which depend on timestamps. Kumar et al. [8] proposed the use of a dynamic energy efficient distance aware (DEEDA) technique in energy efficient cluster selection mechanisms in the WSNs. The primary principle is that the selection of the cluster head is based on the principle of residual energy and distance (RED) algorithms. These algorithms focus on the selection of the cluster head in the network based on the distance, RSSI, and a new term called rank of the nodes. Low energy consumption has been achieved based on distance and signal strength. Cluster head selection is based on RED principles. Nithya et al. [9] proposed a Sugeno-type fuzzy inference-based clustering (SFIC) algorithm for improving system lifetime through more efficient use of energy. The dynamic cluster arrangement is created and relapse-based edge estimation is used to choose the cluster head. At that point, a super cluster head is chosen in light of Sugeno fuzzy inference rules and a coordinate information transmission technique is incorporated to further reduce energy loss from the system. Experiments were conducted and the results demonstrated that SFIC calculation increases system lifetime, packet conveyance, and end to end defer more than the fuzzy logic control (FLC) algorithm.

3 Proposed Algorithm

The proposed SEER protocol uses the Spiritual Energy calculation of the networks and works in two different phases.

3.1 Selection Phase (I Tier Fuzzy Operation)

In this phase, selection of nodes for the cluster head is calculated based on internal energy, neighboring nodes, traffic, and data gathering capability and is forwarded to the sink. In this case, energy and neighboring nodes are taken as the input for fuzzification and the Tier-I fuzzy rules are given in Table 1.

3.2 Optimization Phase (II Tier Fuzzy Operation)

This is the most important phase of the protocol. Here, different parameters, such as Spiritual Energy, distance, and RSSI are calculated for each node and sent to the sink. By applying the fuzzy rule sets, the cluster head is selected with the following the condition of threshold for the above mentioned parameter. This phase selects the cluster head and also the backup cluster head (BCH) in order to maintain energy consumption and network lifetime. The final selection of the cluster head is made by the maximum qualification measurements, which are as follows: distance of the

Table 1 Fuzzification rule engine for the Tier-I qualification

Energy	Neighboring nodes	Traffic	Tier qualification
Low	Low	Low	Very small
Low	Low	Medium	Small
Low	Low	High	Slightly small
Low	Medium	Low	Medium
Low	High	Medium	High
Low	High	High	Slightly high
Medium	High	High	High
High	High	High	Very high

Table 2 Fuzzification rule sets for the Tier-II cluster head qualification

Spiritual Energy	Proximity parameter	Centrality parameters	RSSI	Tier-II qualification
Low	Low	Low	High	Very high
Low	Low	Low	Medium	High
Low	Low	Low	Low	Slightly high
Low	Low	Medium	Low	High
Low	Low	High	Medium	High
Low	Low	High	High	Rather high
Low	High	High	High	Medium
Low	Medium	High	Medium	Average
Low	High	Medium	High	Medium
Low	High	High	Low	Low/little
Medium	High	High	Medium	Low
High	High	High	High	Very low
High	Low	Low	Low	Low
Medium	Medium	Medium	Low	Medium

cluster head to the other nodes is classified as proximity method, the location of the cluster head is evaluated based on parameters such as centrality and RSSI. Fuzzy rules are applied and the final qualification of the cluster head is given in Table 2.

The fuzzy rule engine was designed based on a Madami/Sugeno engine for the implementation of cluster head selection in network systems. This method of double tier fuzzy-based cluster head selection is efficient and enables the backup cluster head to be chosen based on Spiritual Energy calculations.

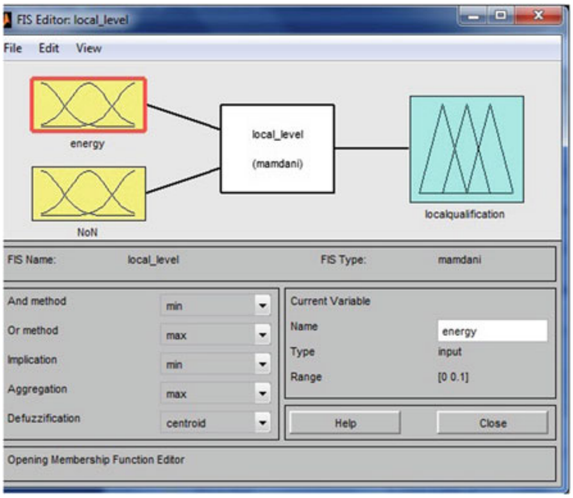

Fig. 1 Shows the fuzzification of the Tier-I selection of the cluster head

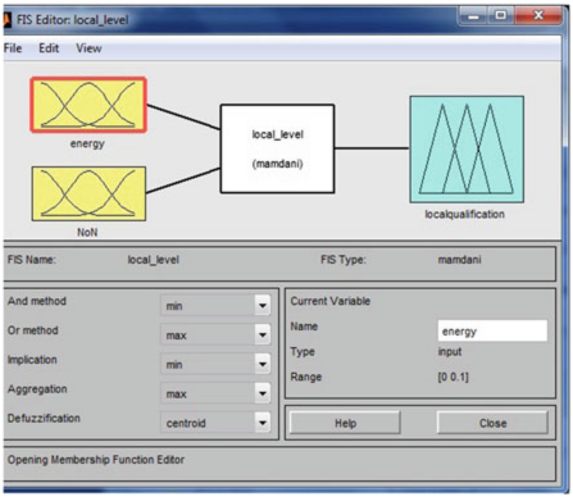

Fig. 2 Shows the fuzzification of the Tier-II selection of the cluster head

4 Performance Evaluation

The SEER protocol was simulated in MATLAB version R2014 in four different scenarios with a distribution of 30–90 nodes in 50×50 and 100×100 m^2 areas. Simulations were carried out for 100–200 rounds and different parameters of the network were calculated in order to evaluate the performance of the proposed protocols. The different stages of implementation are as follows (Figs. 1, 2, 3, 4, 5, 6 and 7).

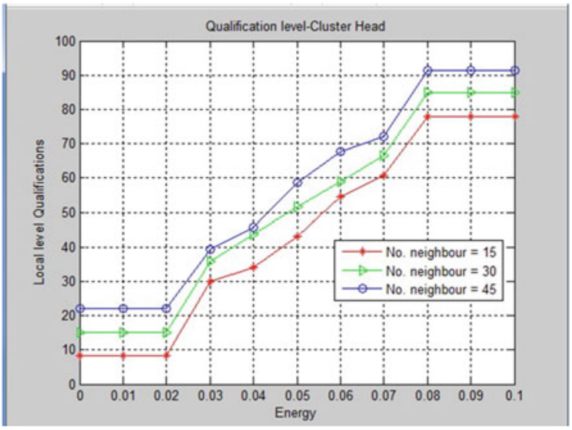

Fig. 3 Energy calculation in the optimization phase using the Tier-II selection of the cluster head

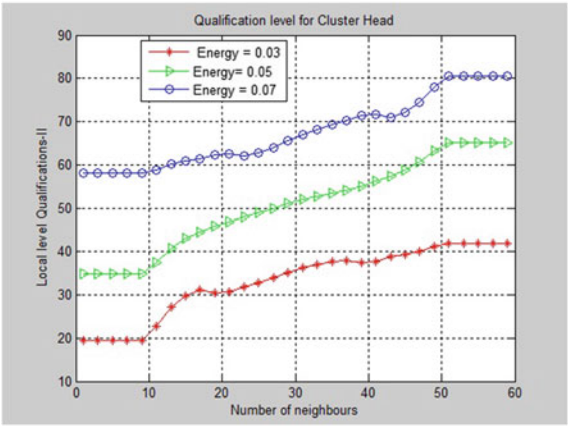

Fig. 4 Energy calculation in the optimization phase using the Tier-II selection of the cluster head

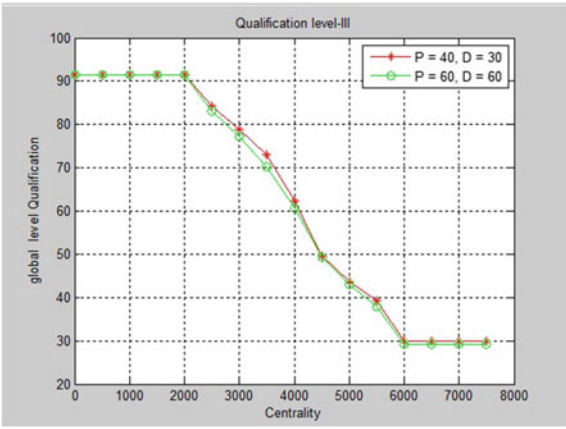

Fig. 5 Centrality calculation in the optimization phase using the Tier-II selection of the cluster head

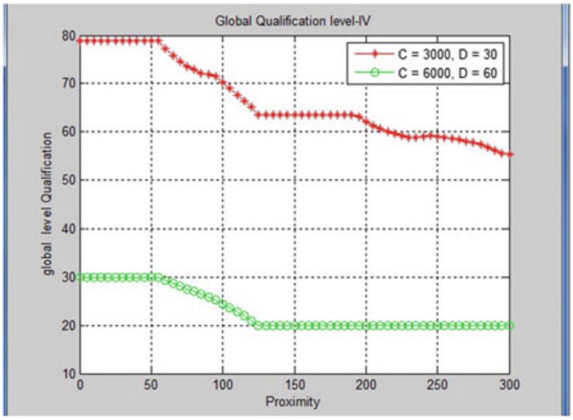

Fig. 6 Proximity calculation in the optimization phase using the Tier-II selection of the cluster head

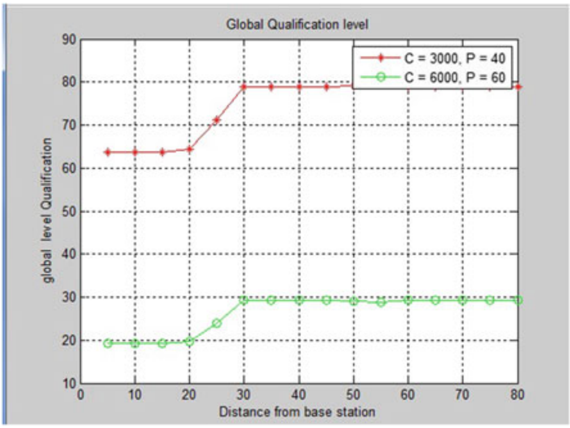

Fig. 7 RSSI and distance calculation in the optimization phase using the Tier-II selection of the cluster head

4.1 Spiritual Energy

This is defined as the average energy maintained in the network when the first and last node dies out. The average energy was calculated for both LEECH and CLERK protocols. In comparison, the SEER protocol consumed only 50% of the energy (Figs. 8 and 9).

4.2 Network Lifetime

The network lifetime was calculated for the SEER protocol, in which the lifetimes of the last dead nodes are calculated. An increase of 50% was observed compared with the other algorithms.

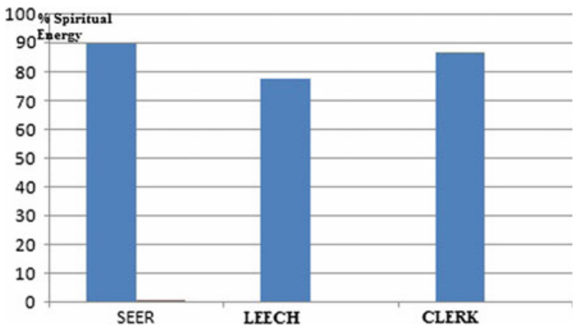

Fig. 8 Comparative analysis of Spiritual Energy of the proposed protocols after 100 rounds of simulation

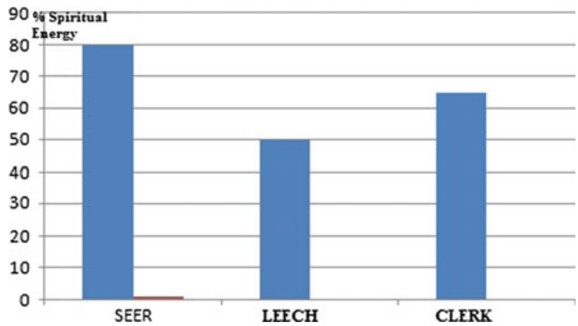

Fig. 9 Comparative analysis of Spiritual Energy of the proposed protocols after 200 rounds of simulation

5 Conclusion

The SEER protocol is more efficient than other energy efficient protocols used in the selection of the cluster head. Double tier fuzzy algorithms are still needed to improve the evaluation of additional parameters, such as the packet delivery ratio (PDR) and throughput etc.

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