# Improved WEMER Protocol for Data Aggregation in Wireless Sensor Networks

**K. K. Thashrifa and R. Bhagya**

**Abstract** The wireless sensor networks are the decentralized and self-configuring network in which sensor nodes can sense the surrounding environment and pass the information to the base station. Due to decentralized nature and distant deployment, the consumption of energy is one of the major issues of wireless sensor networks. To reduce consumption of energy in wireless sensors, hierarchal clustering is the efficient type of clustering technique. In this research work, WEMER protocol is implemented and improved to increase lifetime of sensor networks. In the improved WEMER protocol, whole network is divided into many clusters, and for each cluster, one cluster head is selected. The proposed WEMER protocol is implemented in MATLAB. The simulation results show that proposed WEMER protocol has less number of dead nodes send more number of packets and less energy consumption.

**Keywords** Improved WEMER · LEACH · Gateway · Leader node · Energy consumption

## 1 Introduction

The recent developments made in the wireless sensor networks have provided great innovations and applications that involve such as the mechanical monitoring, traffic monitoring, and cropping. Advance creative and productive thoughts are to be generated within this area such that their usage can be more helpful. Various methods have been introduced in the recent years in the field of information routing, compression as well as network aggregation [1]. Sensor node is the vital part of the network since all the operations occur based on the information given by these nodes as shown in Fig. 1.

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There are numerous nodes deployed within specific area to monitor the surrounding area of those nodes. To provide communication within the nodes present in the network, the sensor hub is present which consists of sensors, memory, actuators, and processor. There is no wired connection present within these networks [2]. The battery in the sensor nodes is of smaller size. Also the nodes are placed at far distances where human is not able to reach. So the major concern within the WSNs is the usage of energy within them. This also affects the overall lifetime of the nodes and thus the deployment of the network [3].

The major problem that arises in the wireless sensor networks is limited energy in battery of nodes [4]. There are limited constraints such as size of battery, processors, and memory present within the sensor nodes of the network. Thus, the major concern here is to upgrade the amount of energy being consumed by these networks. In order to provide solution to this problem, regular time constraints are provided within the network such that the data that is gathered can be transmitted to the destination with minimal energy consumption.

Organization of the paper includes literature review of some of the existing routing techniques in Sect. 2. Overview of the proposed algorithm is listed in Sect. 3. The results are discussed in Sect. 4 and conclusions in Sect. 5.

## 2 Literature Review

The recent work on the routing algorithm in WSN has been studied. Various routing algorithms used to reduce the energy consumption and to provide the stability in the network are reviewed.

The segmented LEACH is an improvement on basic LEACH protocol is discussed and the results are compared [3]. The corresponding protocol has segmentation phase

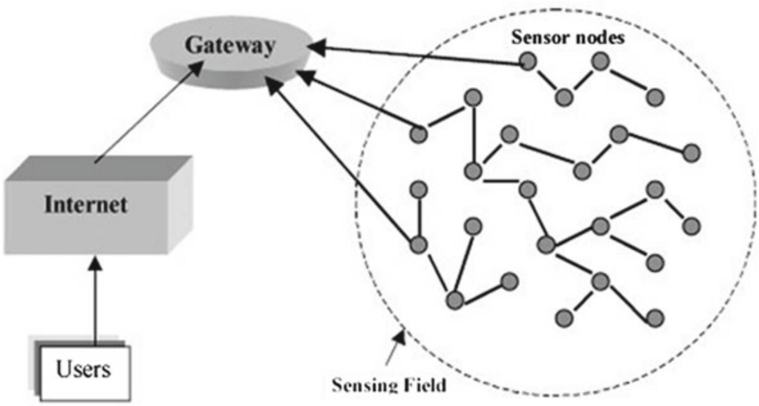


**Fig. 1** Wireless sensor network

which is the beginning step. Then setup phase where each node calculates its probability function followed by steady state phase. In the comparison result, it is observed that the first dead node is seen at the 1400 round in segmented LEACH but at 1026 in LEACH.

In the coronas hierarchical model [4], the Dijkstra shortest path algorithm is used to calculate the optimal sequence of transmission distance from the source node to the sink node. The dynamic multi-path routing algorithm helps in energy balance of the network. In addition, when the nodes transmit information from outer coronas to inner the q-switch algorithm is used, which allows each node have many number of nodes available to choose one with the maximum energy to keep the balance of the network. When the nodes from a corona run out of energy, one can search the remaining distance sequence to achieve the optimal energy of the nodes through the dynamic routing method.

To overcome the limited energy problem in WSN, a clustering-based routing algorithm known as KACO (K-means and Ant Colony) [5] is studied. In this scheme, it deploys the nodes as an ant colony and uses K means algorithm to form a cluster. In order to select the cluster head for each cluster, it considers the energy ratio, node location, and distance. Dynamic hybrid routing is adopted in the transmission phase to create the shortest path between nodes to reduce the node energy consumption. The experimental results show that the KACO has optimal performance in terms of node energy consumption, number of transmitted packets, and lifetime of the network

An adaptive priority [6] based hop selection to enhance the network lifetime. This technique presents an ideal transceiver optimization strategy which fully capitalizes the minimum remaining energy. Simulations were conducted to evaluate lifetime of the network. An average lifetime improvement of 90.5% is achieved

The literature review gives a brief knowledge about different routing techniques. The important factor here is the energy consumption factor. So there exists a need for a scheme with minimal energy consumption.

## 3 Proposed Algorithm

The wireless sensor networks are self-configuring network and size of the sensor nodes is very small. Due to which energy consumption is the major issue in wireless sensor networks. The LEACH is the energy efficient which is used to reduce energy consumption of the network. The various improvements in the LEACH protocol are done in the recent times to reduce energy consumption. In the proposed improvement, three levels of architecture are proposed in which leader nodes, cluster heads, and gateway nodes are involved in the data communication. The proposed technique involved following phases.

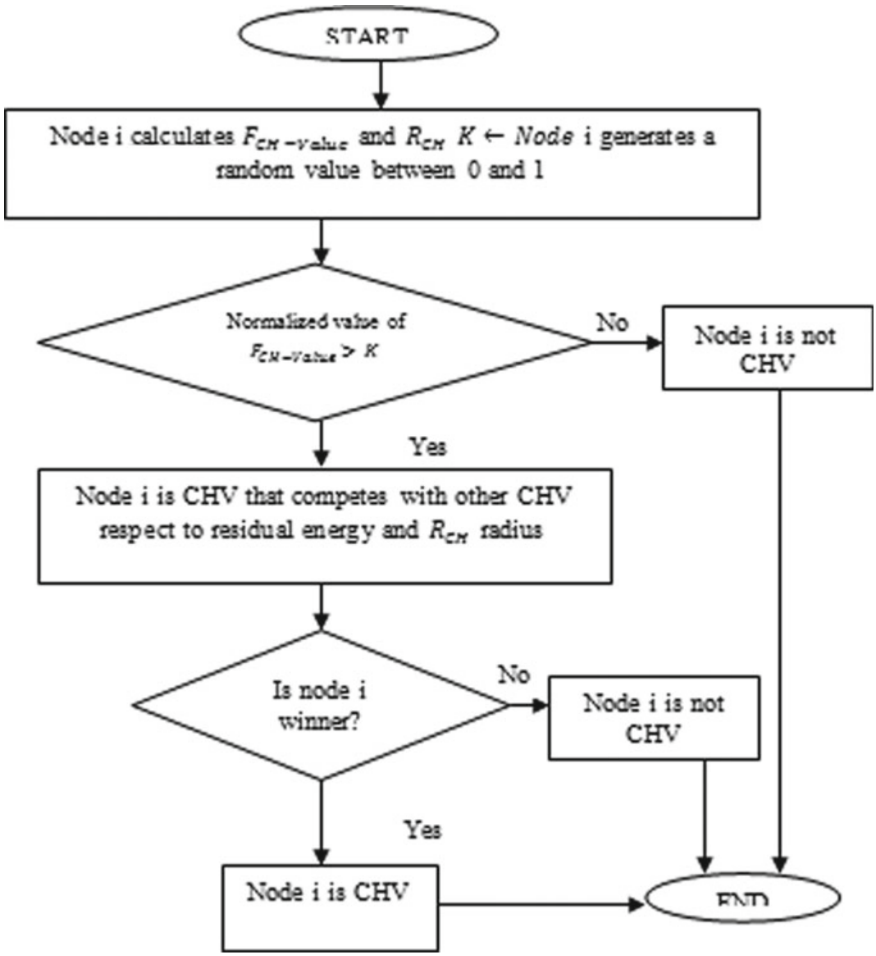


**Fig. 2** Flowchart of cluster head selection

### *3.1 Cluster Head Selection*

The cluster head selection is the first phase in the network as shown in Fig. 2. The network is deployed with the finite number of sensor nodes. The base station is deployed at the center of the network. The base station broadcasts the message in the network. The base station calculates the signal strength and nodes which have signal strength above threshold value will be eligible to be selected as the cluster head. The threshold value will be defined by the equation.

$$R_{CH} = R_{min} * \left[1 + \left(\frac{d_{BS} - d_{BSmin}}{d_{BSmax} - d_{BSmin}}\right)\right] \tag{1}$$

In the given equation $R_{min}$ is the radius of the cluster, $d_{BS}$ is the node distance from the base station, $d_{BSmin}$ is the minimum distance from the base station, and $d_{BSmax}$ is maximum distance from the base station.

$$F_{CH-value} = \alpha * N_{deg} + \frac{\beta}{MSD_{deg}} + \frac{\gamma}{d_{BS}} \tag{2}$$

In Eq. 2, the $N_{deg}$ is the number of neighbor nodes of the particular node, $MSD_{deg}$ is the mean distance of all nodes in the network, $\alpha$, $\beta$, and $\gamma$ is the threshold values whose total is 1.

A random value which lies between 0 and 1 is generated by each node. Any node is selected as cluster head when it satisfies the condition given in Eq. 3.

$$\mathrm{K(i)} > F_{CH-value} \tag{3}$$

The K(i) is the random value generated by the sensor node individually.

### *3.2 Leader Node Selection*

The second phase of the proposed technique is the selection of leader nodes as shown in Fig. 3. The nodes except cluster head will be selected as the leader nodes. The leader nodes are responsible to collect the data from the normal sensor nodes and then pass the sensed data to the cluster head. The volunteer leader node will be selected by Eq. 4

$$F_{LN-value} = \eta * M_{deg} + \frac{\lambda}{K_{LN}} \tag{4}$$

$M_{deg}$ is the number of leader nodes which volunteer to select as leader node. $K_{LN}$ is the number of nodes which comes under the defined radius. $\eta$ and $\lambda$ are the two constants whose total will be 1. The nodes which are the volunteer to be selected as leader node will generate random number from 0 to 1 and nodes which satisfy condition 5 will be selected as leader node.

$$\mathrm{K(i)} > F_{LN-value} \tag{5}$$

### *3.3 Gateway Node Selection*

In the last phase, the gateway nodes are deployed as shown in Fig. 4. The gateway nodes depend upon the total number of nodes which is described by Eq. 6.

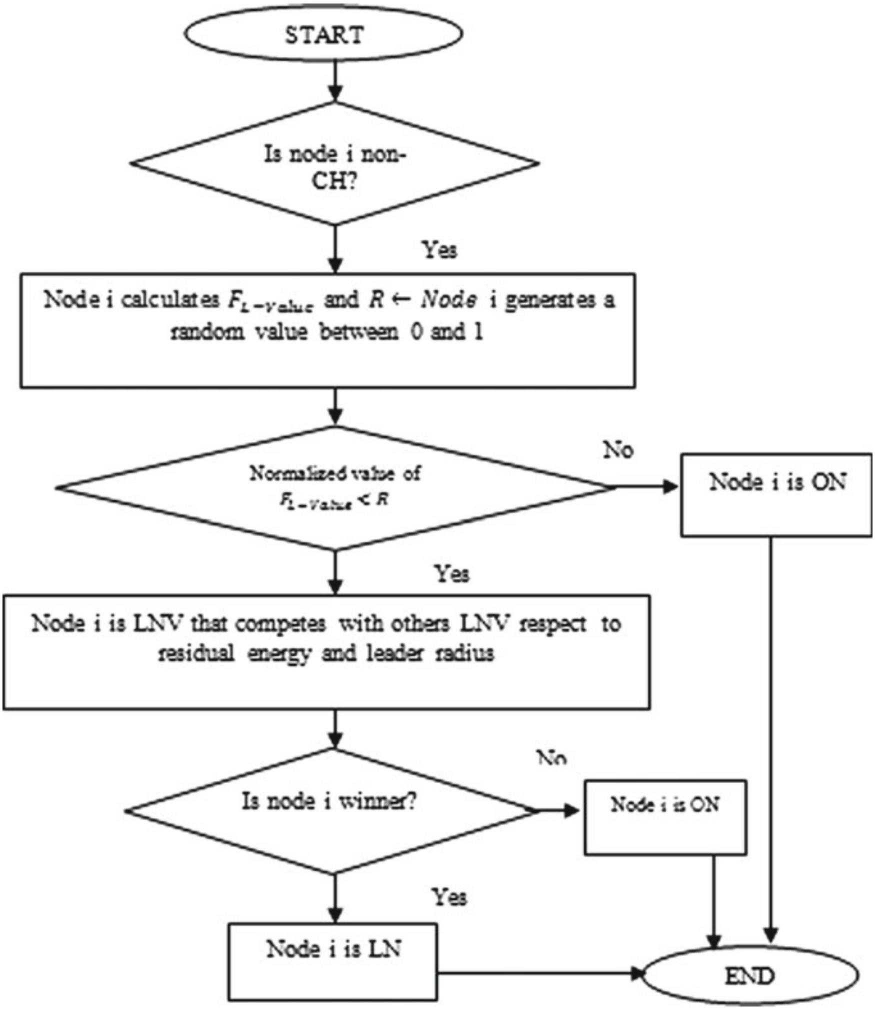


**Fig. 3** Flowchart of leader node selection

$$\text{Gateway}_{\text{nodes}} = \text{total number of nodes}/4 \tag{6}$$

The gateway nodes are the fourth part of the total nodes. The best nodes in terms of energy are selected from overall gateways nodes to send data to the base station. The distance from base station to the gateway node calculated using Eq. 7

$$\text{Distance} = \sqrt{(x(i) - x)^2 + (y(i) - y)^2} \tag{7}$$

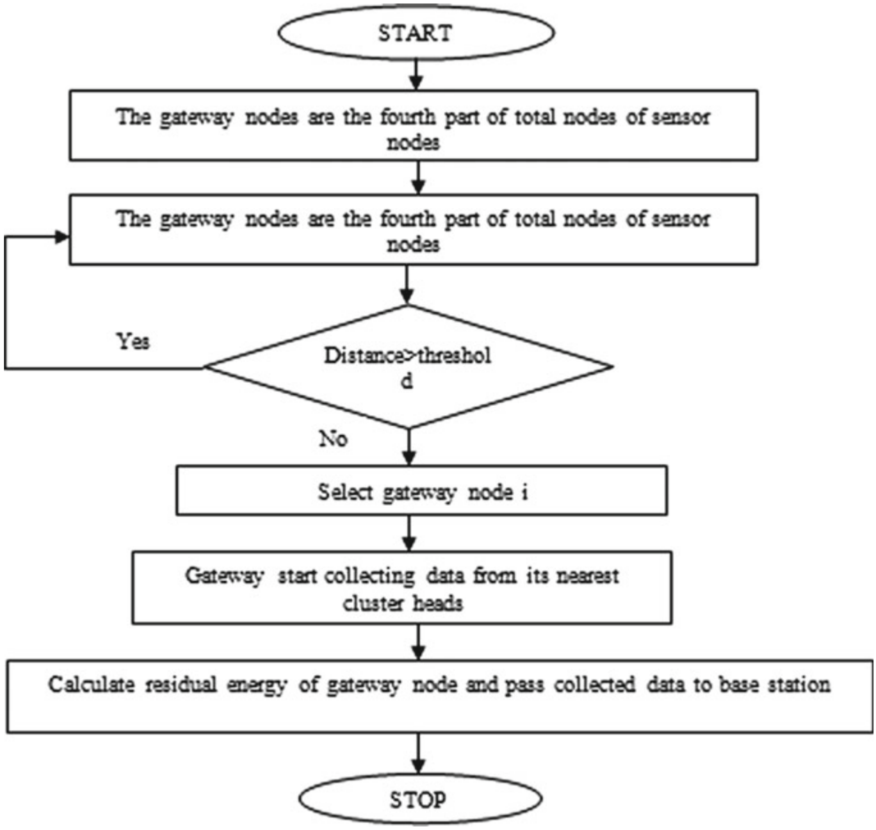


**Fig. 4** Flowchart for gateway node selection

In the improved technique, the leader nodes help in aggregation of data from the normal sensor nodes. The aggregated data is now sent to the cluster head by the leader nodes. The gateway node which is nearest to the base station will pass the data to the base station.

The energy values for the sensor nodes are taken and the system parameters are shown in Table 1.

## 4 Results and Discussions

The improved WEMER technique is implemented in MATLAB and the results are evaluated by making comparisons with the existing approach in terms of packet transmission and number of dead nodes.

**Table 1** System parameters

| Parameters | Value |
|---|---|
| Deployed area | 100 × 100 Square Area |
| Number of sensor nodes | 100 Nodes |
| Data packet | 4000 bits |
| Initial energy | 0.5 J |
| Transmission energy | $50 \times 10^8$ J |
| Reception energy | $50 \times 10^8$ J |
| Energy for processing | $5 \times 10^8$ J |

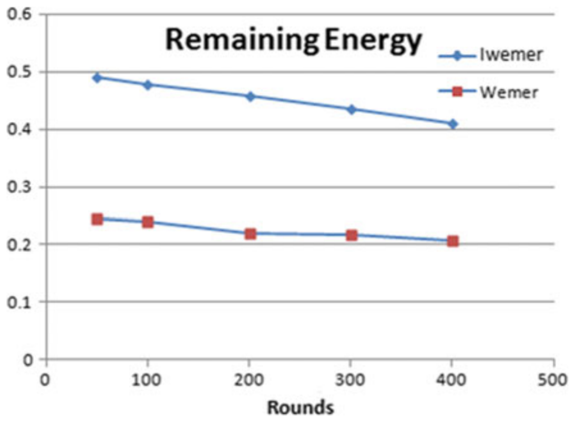


**Fig. 5** Residual energy comparison

The residual energy of the network for different number of rounds for both the techniques is shown in the Fig. 5. The WEMER and IWEMER protocols are compared in terms of residual energy. It is analyzed that improved technique has more residual energy compared to the existing technique. The residual energy of the existing technique is 0.2986 J and that of improved WEMER technique is 0.4896 J. Thus due to the less energy consumption, the network lifetime increases, and the performance improves.

Figure 6 shows the dead node comparison of WEMER and IWEMER protocol for various numbers of rounds. It is observed that due to gateway node deployment in the network the number of dead nodes is reduced in IWEMER protocol as compared to existing protocol. It is also evident from the graph shown.

## 5 Conclusions

Proposed modified wedge merging technique prevent the network from energy hole problem, consumes less energy, and increase network lifetime. The proposed modified WEMER scheme is compared with existing technique. Simulation is performed

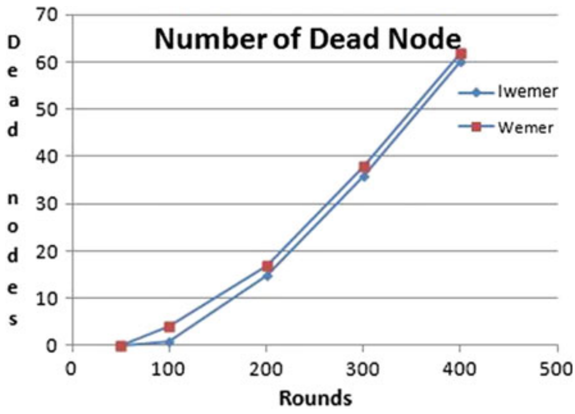


**Fig. 6** Number of dead nodes comparison

using Matlab version R2017b. Simulation results prove that improved WEMER performs better compared to existing work in terms of network lifetime, remaining energy, and number of node dead nodes.

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