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Research Article

A Novel Routing Protocol for Low-Energy Wireless Sensor Networks

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The battery power limits the energy consumption of wireless sensor networks (WSN). As a result, its network performance suffered significantly. Therefore, this paper proposes an opportunistic energy-efficient routing protocol (OEERP) algorithm for reducing network energy consumption. It provides accurate target location detection, energy efficiency, and network lifespan extension. It is intended to schedule idle nodes into a sleep state, thereby optimising network energy consumption. Sleep is dynamically adjusted based on the network's residual energy (RE) and flow rate (FR). It saves energy for a longer period. The sleep nodes are triggered to wake up after a certain time interval. The simulation results show that the proposed OEERP algorithm outperforms existing state-of-the-art algorithms in terms of accuracy, energy efficiency, and network lifetime extension.

1. Introduction

WSNs are framed by sensor combinations used for monitoring various environmental parameters. These nodes required a high energy consumption to transmit data [1]. The integration of battery power supply has improved the performance of WSNs. However, due to the limited battery life, many WSNs are prone to energy depletion. Most of the protocols do not focus on the energy distribution of the nodes [2]. This means that the routes chosen for energy consumption can only be used for specific applications. The main reason for packet loss is due to the improper network partition [3] and the retransmission of a packet consuming more energy [4]. WSNs advance in terms of raw data generation volume [5]. However, radio spectrum scarcity and the strain on resource management increase tenfold [6]. Researchers have been working on a clustering method that can better utilise valuable radio spectrum for several years. The sensed data can be transmitted to the node's licenced spectrum status of primary devices and reused within interference constraints. In [7], it describes WSNs that use cognitive radios for spectrum sensing, spectrum access, and interference management. Improve network energy efficiency by taking into account the minimum data rate and interference limits in CR-based WSNs [8] in order to maintain maximum EE in networks with energy-constrained devices (e.g., sensors, actuators, and controllers). Device-to-device (D2D) communication has been widely used in IoT networks to reduce transmission delays and power consumption while also improving spectrum efficiency [9]. Under interference constraints, two nodes can communicate directly with each other using the same radio resource of cellular devices

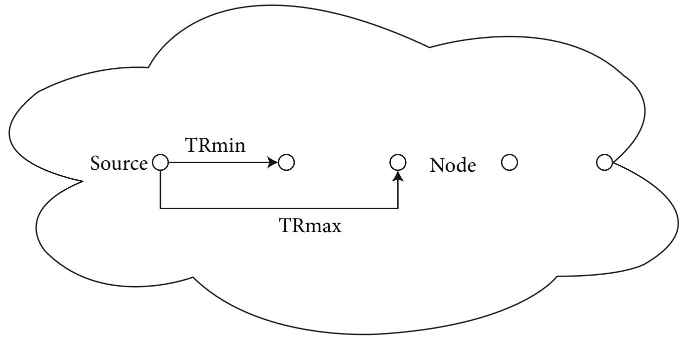

Figure 1: Basic 1-dimensional WSN.

[10]. However, strict latency and reliability requirements necessitated resource management approaches proposed in works [11–14].

1.1. Sensor Node Functions in Networking. A wide range of tasks are carried out by sensor nodes, which are widely dispersed throughout a sensitive environment. These include transmission and reception, sensing, and location tracking (GPS), processing and storing data, sleeping and communication modes, and calculation modes.

1.1.1. Transmitter/Receiver Function. The function is transmitting and receiving data from the target, which is communication between the nodes to the sink/base station.

1.1.2. Sensing Operation. The sensing operation is emitting the EM waves, and the received radio signals are used for tracking the targets.

1.1.3. Global Positing System. GPS is used for finding the position and finding the other node information in the network.

1.1.4. Data Processing. The data processing will process a received data and calculate the target location. The result of data processing is transmitted to data storage.

1.1.5. Data Storage. This function will store the data from the receiver data and the processing data.

1.1.6. The Battery. The battery will play the major role in giving energy to the senor nodes to do all the processes.

1.1.7. Sleeping Mode. Sleep mode will reduce the energy consumption of the sensor nodes, and it will increase the network lifetime.

1.1.8. Sensing Mode. This mode will sense the information about the target location; it is used to find the location of the target.

1.1.9. Listening Function. The listening function observes the senor node results.

1.1.10. Communication Operation. In the communication operation, the sensor node transmits and receives the sensed data by the sensor nodes.

1.1.11. Calculating Mode. In the calculating mode, the sensed data processed the data into the target.

2. Related Work

Relay nodes would transmit the packet size using a convention of a routing method to reduce energy consumption and hop counts [15]. Figure 1 shows the 1-dimesional WSN for data transmission. The EXOR method is a new approach to controlling packet forwarding and reducing the number of packets in transmissions. For forwarding, nodes no longer need to be scheduled at random in this new method. Geographic Random Forwarding (GeRaf) will not focus on the energy consumption of the network but instead will select a good relay node between the forwarding multiple nodes. As the forwarder set is selected, an energy-efficient opportunistic routing scheme is proposed for the network, which puts nodes into sleep mode [16]. For energy savings, the SMAC method uses the MAC layer to select random nodes and turn them into sleep nodes, forming a sleeping schedule with their nearby nodes [17]. It allows for an equal distribution of nodes, but not for energy consumption. In a random sleep schedule system, the node is put into sleep mode. Network energy dissipation can be achieved by selecting a sleep schedule that is based on the distance of each hop. TDMA scheduling and an asynchronous duty cycling system can be used to avoid idle node energy consumption by using uneven clustering to improve energy efficiency [18]. The nodes are constantly awakened by the synchronous protocol for the specified period. The sleeping node is awakened by pressing the trigger, allowing the transmission to begin. There are numerous applications for wireless sensor networks, including collecting and obtaining data from sensors, as well as effectively processing the data [19]. Battery-powered sensors are used in the network because they require a power supply to operate. When the batteries run out, the wireless sensor network will no longer function properly [20]. Due to these difficulties, changing a sensor node's battery only requires a few controlled settings, which have been discussed in many studies. The sensor nodes have limited energy ranges to extend the network's lifespan [21].

Based on WSNS surveillance issues [22–24, 33] to reduce energy consumption and at the same time improve location detection, multiple grids can be used. In [25–27, 34], the genetic algorithm was improved by using fewer sensor

Step 1. Install the node into a network
(Input parameter: optima distance and threshold energy
Output parameter: sleep/awake scheduling)
Step 2. Check the optima distance and threshold energy
Step 3. Set the flow rate
Step 4. Calculate the priority node value
Step 5. Check the entire FS (K) node for priority
Step 6. Put to sleep the high-priority node
Step 7. Calculate the sleep interval time to sleep
Step 8. Wake up the node after the sleep interval
Step 9. Start the data relaying process

Algorithm 1: Steps for OEERP Algorithm

Table 1: Simulation parameters.

Parameter (value)
Distance between two neighboring nodes (5 to 25 m)
Deployment (uniform distribution)
Sending rate (1 packet/s)
Packet size (1024 bits)
Number of nodes (100)
Source node (1)
Sink node (1)

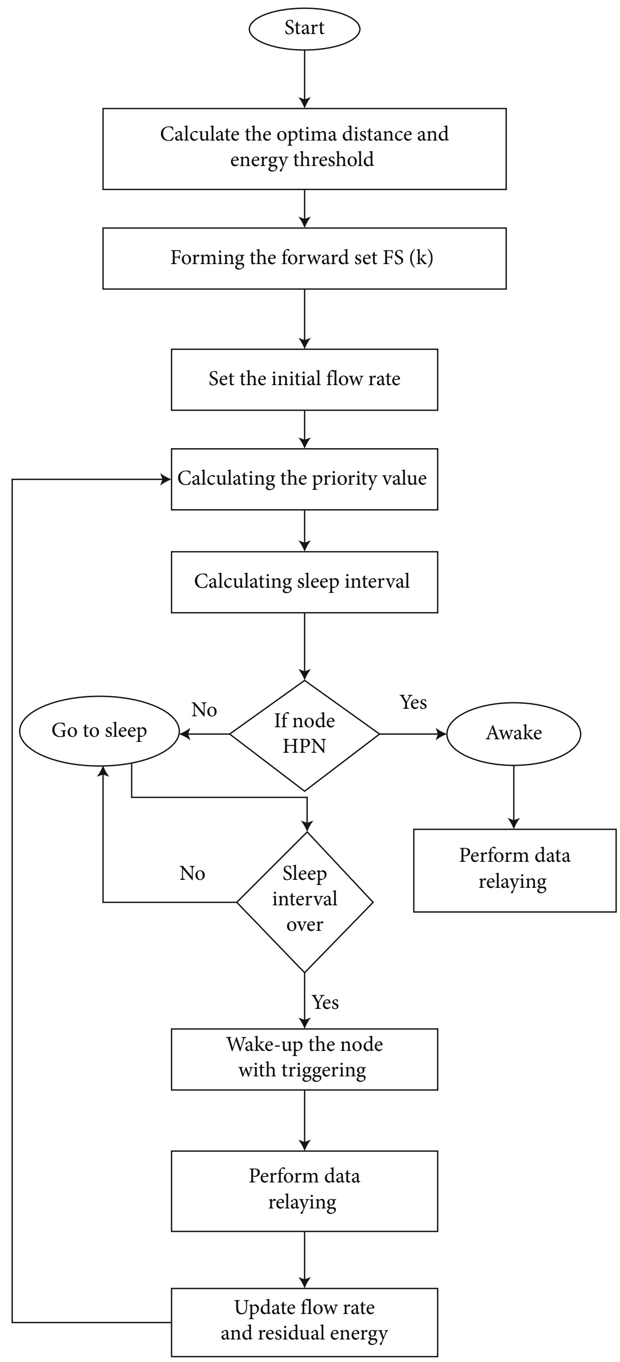

Figure 2: Flow chart for OEERP.

nodes, full-area coverage, energy efficiency, and connectivity controlled by a sensor order. WSNs can benefit from a fuzzy data fusion method [28]. The sensor node used more energy when transferring data from the node to the cluster head even though the perfect cluster head was chosen to keep the WSN's energy consumption under control [29]. The distributed cluster approach and the optimistic algorithm were used to find the cluster head in WSNs [30]. The sensors in the network require a power supply to function, so if the batteries in the sensors run out, the wireless sensor network will not function properly. Sensor node battery replacement is a difficult process [20, 31, 32]. The accuracy of location detection can be improved by dividing the total coverage area into multiple grids. The genetic algorithm reduces the number of sensor nodes, ensuring full coverage and maximising energy efficiency and connectivity [21]. It can make the most of its energy by using a fuzzy data fusion method. It uses a fusion spreader framework to improve energy efficiency. The sensor node used more energy when transferring data from the node to the cluster head even though the perfect cluster head was selected to limit the amount of energy used in WSNs where distributed clustering and an optimistic algorithm were used in WSNs [22, 23].

3. Problem Statement and Contribution

Energy consumption is a major consideration in WSNs, as the amount of energy consumed by a node determines how long a network can last. When the nodes are idle, they use less power, but when they begin performing tasks like sending data to the cluster head, they use more power and eventually run out of battery life, leading to a death situation. Sensor node energy consumption can be effectively limited if you want to extend the life of WSNs. An opportunistic energy-efficient routing protocol (OEERP) algorithm is presented in this paper to reduce the network's energy usage while routing. It can pinpoint the target with pinpoint accuracy, save energy, and extend the life of the network. To reduce network power consumption, it puts nodes that are not in use into a low-power sleep mode. The major contribution of the OEERP algorithm is given below:

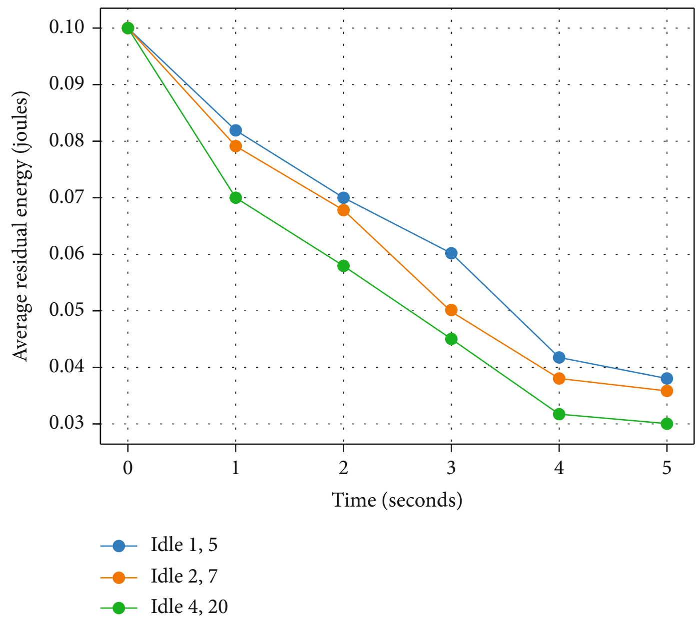

Figure 3: Average of residual energy in the idle state.

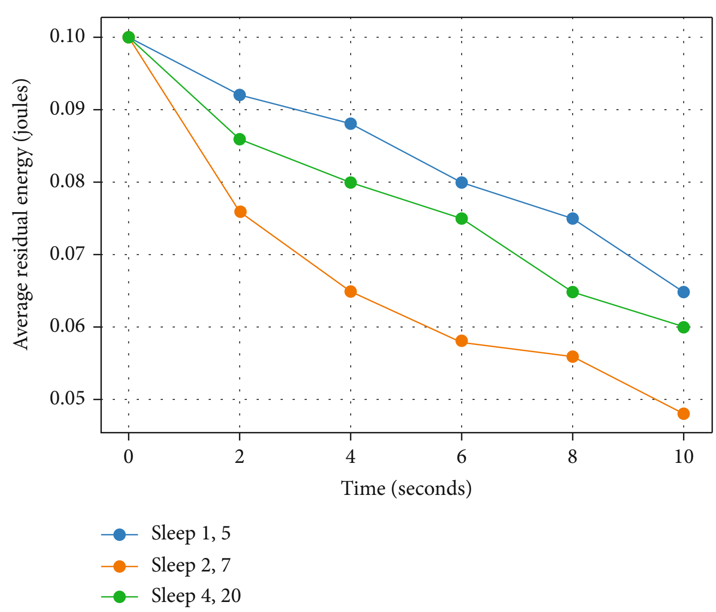

Figure 4: Average of residual energy in the sleep state.

(i) To ensure quality collections of sensor nodes, data are configured and earlier failure states are predicted; consistency sends control commands from the monitor's centre

(ii) It provides self-configurable ability whenever failures are detected, and it finds failure type and degree of impact

(iii) It enables a message notification system; thus, share updating icon information with the subscriber node during quality measures exceeding or below the expected level. Thus, achieve end-to-end node connectivity in real time

(iv) It monitors the system performance after evaluation of past transaction of data with secured device and scales its node coverage range and enhances manageability between sensor nodes

4. Proposed Methodology

The paper proposed the optimistic energy-efficient routing protocol which is used to increase detection of the target

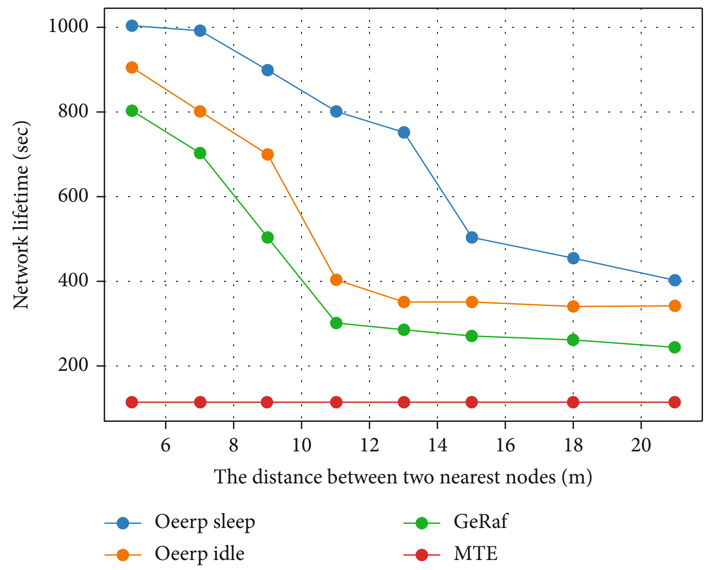

Figure 5: Comparison of a network lifetime with other protocols.

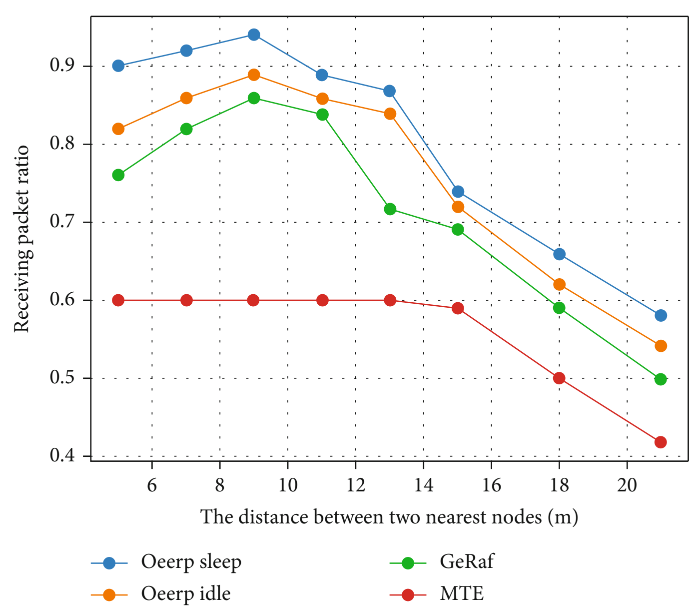

Figure 6: Comparison of RPR with other protocols.

location and the network lifespan, mainly for the energy consumption of the network. The operation of this routing protocol has two types of states: the first one is the sleep state and the second one is the idle state. When the node is in idle mode, put the idle node into the sleep state; in the sleep state, there are 2 modes: initialization mode and sleep/awake based on the sleep scheduling mode. The sleep duration of the nodes depends on the priority value. The sleep mode in the forward set has some time that is given in the equation.

$$TP_x = \sum_{y=1}^{x-1} TP_y. \quad (1)$$

The OEERP is saving the maximum energy when the sink receives the data from the node in the network. While the communication of a network the large amount for energy required of operations. The distribution of energy in the network for a reception of data, for the idle node also the energy will distributed that energy is wasted energy of the networks, to reduce that the OEERP is proposed.

The nodes are not involved in the data relaying process; that is, the nodes are idle nodes. The idle state node also requires the same amount of energy like an active node which is involved in the data relaying process. When calculating the total network's energy consumption, it includes the idle node energy.

The node will perform the transmission and receipt of the data in the network by the given time excluding the idle nodes. The idle node is put into a sleep mode; the algorithm is proposed to reduce the energy. For calculating the energy dissipation in the transmission of an N-bit to the receiver, the distance from transmitter d is given in

$$\mathrm{EDT}_x = \left[\mathrm{SE}_{\mathrm{req}} + \mathrm{AE}_{\mathrm{req}}.d^{\eta}\right]N. \tag{2}$$

The energy consumed by the receiver is given in

$$\mathrm{EDR}_x = \mathrm{SE}_{\mathrm{req}}.N. \tag{3}$$

Calculating the optimum distance for node k is given in equation (4).

When they consider the kth node which started to communicate with the base station if some of the neighbor nodes of kth are also suitable for the same, the neighbor node is selected for the forwarder set; there are so many nodes that will be suitable to become a forwarder set; the node having high priority will become a forwarder set; equation (5) shows the calculation equation for a priority check.

$$\mathrm{Optima}_{\mathrm{dis}} = \frac{Z - x_k}{\mathrm{Optima}_{NH}}. \tag{4}$$

$$\mathrm{PR}_{\mathrm{node}}(k+i) = (d_{k+i} - d_k)\left(\frac{1}{d_{k+i} - \mathrm{Optima}_{\mathrm{dis}}}\right) + (R_x E_{k+i} - E_{Th}). \tag{5}$$

The selected forwarder node will start forwarding the received packets to the next neighboring nodes, the remaining unselected nodes are idle in equation (6), and the OEERP algorithm is proposed to put these idle nodes into a sleep state for consuming energy and increase the node life.

$$\mathrm{TEC}_{\mathrm{idle}} = T_{xE} + R_{xE}N_H + N_{\mathrm{idle}}, \tag{6}$$

$$\mathrm{TEC}_{\mathrm{Sleep}} = T_{xE}N_H + R_{xE}N_H + N_{\mathrm{Sleep}}. \tag{7}$$

When a node is in a sleep state (Nsleep), it will be equal to a zero ($N\mathrm{sleep} = 0$) energy; then, equation (7) can be written as equation (8).

$$\mathrm{TEC}_{\mathrm{Sleep}} = T_{xE}N_H + R_{xE}N_H, \tag{8}$$

$$\mathrm{Sleep}_{\mathrm{interval}} = \frac{\left(1/d_{hp.od}\right) + (R_x E_{kn-1} - E_{Th}) - \left(P_{rn}(kn+1)/d_n\right)}{2SE_{\mathrm{req}}B_{\mathrm{rate}} + AE_{\mathrm{req}}B_{\mathrm{rate}}d^{\eta} + E_{\mathrm{idle}}}. \tag{9}$$

All the forwarder set nodes are put into a sleep state which has HPN; the HPN will be awake and performing the data relaying. The sleep time interval is calculated by equation (9).

5. Simulation Results

When a network is active, it consumes more energy than it does when it is idling. Due to the lower power consumption of the relay nodes, this is the case. Table 1 shows the simulation parameters. Figure 2 compares the average residual energy results. A node's residual energy is higher if the node is left idle for a long period of time. This method helps minimise the energy consumption associated with idle listening. Figure 3 depicts the nodes at a 5-meter distance. The energy saving percentage is 66.66 percent for a distance of 7 metres. The remaining energy in the sleep mode is reduced first, and then, that in the idle mode is reduced subsequently. Figure 4 depicts the average residual energy comparison of the results.

OEERP with a sleep mode increases the distance between the nodes as they get closer to each other in the graph shown in Figure 5. This means that the network's lifespan increases as the distance increases. In comparison to other WSNs, the OEERP network has a longer lifespan and uses fewer packets, making it more energy efficient.

Figure 5 shows a network lifetime comparison between the results of the various algorithms. We need to raise the RPR value in order to improve network connectivity. The sleep or idle modes can be used to accomplish this. OEERP with higher RPR initially receives more packets than its peers, as shown in Figure 6. The received packet ratio comparison results of other algorithms are also shown. OEERP's RPR differs from that of other protocols in that the distance between nodes in the sleep mode is 20 metres, increasing the risk of packet loss. An OEERP network in the sleep mode with a higher RPR value will provide a more reliable link to the network.

6. Conclusion

This paper improved the network accuracy of detecting the location of the target, the lifespan, and the energy efficiency. The proposed OEERP algorithm allowed only the forwarder set nodes to the data relaying process. It computes the optimal sleep time for an idle node based on FR and RE. The simulation results show the target detection, the lifespan, and the energy efficiency of the network which is increased in the sleep state than in the idle state, and the performance of the algorithm results is compared with that of other algorithms, namely, GeRaf and MTE. Target detection of the location is based on the received packet ratio; when the received packet ratio is increased, automatically the target detection of the location accuracy will be increased.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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