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Maximizing Energy Based on SNR using Self Organizing Map in MANETs

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Abstract

A Mobile Ad-hoc Network (MANET) is a self-configuring network of mobile routers and associated hosts connected by wireless links the union of which forms an arbitrary topology. In computer networking, multicast is group communication where information is addressed to a group of destination computers simultaneously. Signal to Noise Ratio (SNR) is one method to estimate the capability of a neighboring node. In this paper, Maximizing Energy based on SNR (ESNR-SOM) using Self Organizing Map in MANETs is proposed. The proposed method uses weight vector, bandwidth and Signal to Noise Ratio as the parameters for finding the next neighborhood or winning node. Simulation results proves that the proposed algorithm minimize the use of energy and makes it energy efficient so that it can extend the lifetime of the network.

Keywords: Mobile Ad-hoc Network; Bandwidth; Signal to Noise Ratio; Self Organized Map.

Introduction

A Mobile Ad-hoc Network (MANET) is a self-configuring network of mobile routers and associated hosts connected by wireless links the union of which forms an arbitrary topology in the network. The routers are free to move randomly and organize among themselves. Therefore, the network's wireless topology may change without any prediction and rapidly.

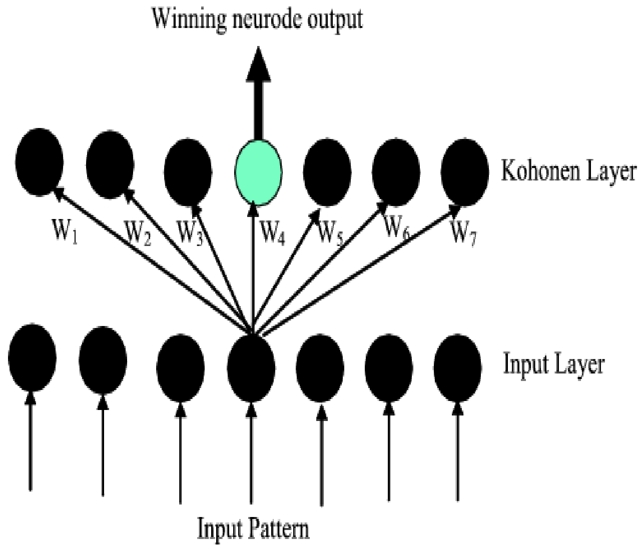

Fig. 1 Self-organized Map.

MANETs are usually set up in situations of emergency for temporary operations or simply if there are no resources to set up elaborate networks. Therefore these networks operate in the absence of any fixed infrastructure which makes them easy to deploy at the same time however due to the absence of any fixed infrastructure it becomes difficult to make use of the existing routing techniques for network services and this poses a number of challenges in ensuring the security of the communication something that is not easily done as many of the demands of network security conflict with the demands of mobile networks mainly due to the nature of the mobile devices.

In this paper, the SOM is applied in MANET to determine the best matching node. The best matching node is determined by new parameters Signal to Noise Ratio (SNR) and bandwidth along with the weight vector. The SNR is the ratio between the maximum signal strength that a wireless connection can achieve and the noise present in the connection. The SNR of a network needs to be as high as possible.

The rest of this paper is organized as follows: Section 2 will analyze the related works. In Section 3, the proposed method Maximizing Energy based on SNR using Self Organizing Maps (ESNR-SOM) in MANET is presented. Section 4 describes the simulation results and comparative performance analysis. Conclusion and future work are presented in section 5.

Related Works

The SOM is an excellent tool of data mining in exploratory phase. It projects input space on prototypes of a low-dimensional regular grid that can be effectively utilized to visualize and explore properties of the data in the network. When the number of SOM units is large to facilitate quantitative analysis of the map and the data similar units need to be grouped (i.e.) clustered. In [1], different approaches are considered for clustering of the SOM is proposed. In particular investigations are done for the use of hierarchical agglomerative clustering and partitive clustering. The two-stage procedure for SOM: first using SOM to produce the prototypes that are then clustered and the second stage is found to perform well when compared with direct clustering of the data and to reduce the computation time.

The SOM concept is applied for the compression of gray scale image [2] with the combination of discrete wavelet transform (DWT). The index value and code vector are obtained after training the SOM and then the DWT is applied on the code vector by keeping only approximation coefficients. Simulation analysis shows that the compression ratio and peak signal to noise ratio (PSNR) value of the obtained decompressed image is better than the other existing methods. Spectrum sensing is a key function for the Second Users (SUs) to determine availability of a channel in the Primary User's (PUs) spectrum in Cognitive Radio (CR). In order to achieve that, much research of energy detection has been studied but they play poor performance in low Signal to Noise Ratio (SNR) environment.

Support Vector Machines (SVM) was proposed [3] based on Genetic Algorithms (GA), which is a novel method of classifying in real time scenarios. GA has the ability to find out the penalty parameter of SVM and optimal nuclear function. The massive training data increase the computational complexity and make lower performance of SVM. Therefore the massive data is re sampled by using SOM to obtain compressed data representation. SOM-GA-SVM classification model is developed for detecting and it has idle recognized ability in low SNR compared with SVM model and energy detection. Simulation results show that this sensing method can obtain excellent performance.

The performance of Back Propagation (BP) and SOM equalizer was proposed for evaluating the indoor Asymmetrically Clipped Optical OFDM (ACO-OFDM) wireless systems [4]. Even though the OFDM parallel transmission and cyclic prefix addition improve, the communication efficiency there is still performance degradation in dispersive channels due to Inter Symbol Interference (ISI). Simulation results indicate that BP multilayer perceptron and SOM neural equalizers enhance the bit error rate performance of ACO-OFDM systems in diffused channels for high SNR. Moreover, the developed BP and SOM equalization require 0.05 and 0.005 percent of ACO-OFDM symbols for training in a second respectively while in single-tap equalization channel state information is necessary at the receiver. Synthetic Aperture Radar (SAR) has significant advantages in providing high-resolution complex target images even in darkness or adverse weather conditions. On the other hand, it is still difficult for human operators to identify targets on SAR images because they are generated using radio signals with wavelengths. To deal with this, various approaches for efficient Automatic Target Recognition (ATR) based on neural networks or SVM have been developed. Even though this method enhances ATR performance considerably even with SAR images heavily contaminated by random noise the calculation burden is enormous under expansions of scale and then cannot maintain the ATR performance especially in cases with azimuth angle variations. A constrained learning scheme is developed for generating the SOM and introduces the A-star algorithm to handle SOM scale expansion. Simulation and Experimental investigations demonstrate the effectiveness of the developed method [5].

The Artificial Neural Network (ANN) paradigm is applied to radar target classification [6]. Radar returns are simulated via an e.m code and time-domain polarimetric target features are extracted by means of Prony's algorithm. Two different type of feed forward neural network has been adopted in order to classify the target echo, namely the Multi Layer Perceptron (MLP) and the SOM. The above-mentioned network have been tested on two types of simulated targets: a small tonnage ship with a low level of detail and medium tonnage ship with higher detail level in the network. Each network has been trained on a wide range of SNR of each network and with different data records number in order to assess the training invariant properties. Finally in the validation phase a fixed number of records have been considered to evaluate network performances which are given in terms of classification error.

An approach was proposed on noise reduction based on the analysis of MFCC feature space using SOM network [7]. The U-matrix plot of the feature space is analyzed in presence of white noise at different SNR. Based on the observation, boundary neurons separating clusters are identified in the feature space. For each such neuron in the boundary, its 2-D feature vector is extracted from the U-matrix and hit matrix. This collection of feature vectors based on the boundary neurons are eliminated from the original feature space. Thus the new feature space obtained is used to perform the tasks of visualization and speaker verification. Experiments were carried out by combining synthetic white noise with real world data sets.

An available bandwidth estimation scheme for IEEE 802.11-based ad hoc network was explained in [8]. This scheme does not modify the CSMA/CA MAC protocol but gauges the effect of phenomena such as medium contention and channel interference which influence the available bandwidth. Based on the effect of the phenomena on the working of the medium-access scheme, the available bandwidth of a wireless host to each of its neighbors is estimated. Simulation result shows that this scheme is efficient. An efficient solution for available bandwidth estimation on MANET was proposed [9]. In this scheme, the destination node sends the probe packets to the source node so that the source node could estimate the available bandwidth between them. This reduces the number of probe packets to half the number. A formula for available bandwidth estimation of 802.11 ad hoc networks is also described. Simulation results show that the developed solution could estimate the available bandwidth. When the developed solution is applied to the load balancing in MANET, the connection's throughput is increased significantly in both cases of using proactive and reactive routing protocol.

Self organized Agent based architecture for Power aware Intrusion Detection in WSNs was developed for networks [10]. Agent based architecture is utilized that conserves the available bandwidth and segregates SAPID into two phases. Based on a power level metric and a hybrid metric that determine the duration and kinds of traffic that can be supported by a network monitoring node, potential ad-hoc hosts are identified by repetitive training using an adaptive resonance theory module. The agent architecture primarily consists of a Kohonen SOM to identify the appropriate patterns and recognize anomalies by way of unauthorized users in the network. For testing and reporting possible intrusion attempts to the decision and action modules a UNIX based session information file is utilized. Comprehensive experiments were carried out to clearly delineate and analyze the performance of the architecture.

The protocol HQMRP, is a former case, i.e. a path is always available prior to a QoS request; hence delays in setting up the paths are eliminated [11]. MANETs require QoS capabilities that provide fault tolerance and fast recovery when links fail on an intermittent or permanent basis. MANET topologies can change often and unpredictably. Most protocols for multi-hop MANET routing maintain best-effort routes.

Proposed Method

The existing system used only energy levels and co-ordinates of nodes as input parameters and there is no information of Signal to Noise Ratio (SNR). Therefore, to use the effectiveness of multicasting routing algorithms in increasing Manet’s lifetime, a new Maximizing Energy based on SNR using Self Organizing Map (ESNR-SOM) is presented. SOM provides a feature for automatic organizing the hierarchical structure. The most important concept in this proposed system is that there is no clustering involved and it is a multicast routing protocol. The intermediate node is selected based on the weights of the neighbor nodes and their corresponding bandwidths. Another important parameter in this proposed system is the SNR. The SNR value needs to be as high as possible in the network. The higher the value of SNR the better will be the signal strength and the quality of transmission. The stages of the proposed algorithm can be summarized as follows.

Initializing the weights

In Prior to training, initialize the weight of each node. In general these will be set to small standardized random values. The weights in the SOM are initialized so that 0 < w < 1.

Calculating the Best Matching Unit

To determine the Best Matching Unit (BMU), iterate all the nodes and calculate the Euclidean distance between the current input vector and each node's weight vector. The node with a weight vector closest to the input vector is tagged as the BMU. The Euclidean distance is given in Eq. 1.

$$Distance = \sqrt{\sum_{i=0}^{n}(V_i - W_i)^2} \qquad (1)$$

where

V = current input vector.

W= node's weight vector.

Determining the BMU's Local neighborhood

After the BMU has been determined the next step is to calculate which of the other nodes are within the neighbor list of BMU. All these nodes will have their weight vectors altered in the next step. The radius of the neighborhood is calculated and then checks the node that is within the radial distance. The area of the neighborhood shrinks over time in Kohonen learning algorithm which is a unique feature. This is accomplished by making the radius of the neighborhood shrink over time. The exponential decay function is given in Eq. 2.

$$\sigma(t) = \sigma_0 \exp\left(-\frac{t}{\lambda}\right) \qquad (2)$$

where

$\sigma(t)$ = width of the lattice at time t

σ_0 = width of the lattice at time t_0

t = time

λ = time constant

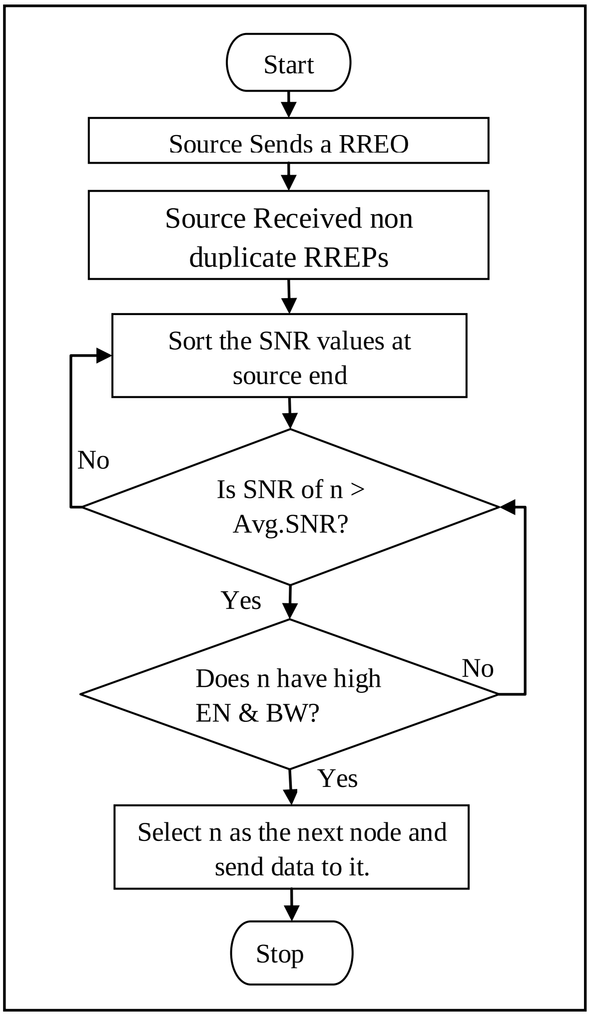

Fig. 2 Flowchart to estimate SNR value to select next hop

While finding the BMU, the SNR values are calculated for the neighbor nodes. The processes involved in the SNR estimation are shown in the flowchart of figure 2. The SNR value needs to be as high as possible in the network. The higher the value of SNR the better will be the signal strength and the quality of transmission.

Figure 2 shows that the SNR value is estimated in a reactive manner. For every route request (RREQ) message sent from a source, it is responded with multiple route reply (RREP) messages as long as it is from a non duplicate node. The signal to noise ratio values are estimated for all the neighboring nodes added into the source's neighbor list. Any node with greater energy (EN) and bandwidth (BW) that has its SNR value greater than the average SNR is chosen as the next hop according to the proposed scheme.

Adjusting the Weights

The winning node is selected based on high bandwidth, high SNR ratio, high energy and the weight that is closest to the source node. According to Eq. 3 every node within the BMU's neighborhood has its weight vector adjusted as follows.

$$W(t+1) = W(\mathrm{t}) + L(t)(V(t) - W(t)) \tag{3}$$

Where t represents the time-step and L is a small variable called the learning rate, which decreases with time. The new adjusted weight for the node is equal to the old weight (W), plus a fraction of the difference (L) between the old weight and the input vector (V). The neighborhood is defined by a gaussian curve so that the nodes that are closer are influenced more than the farthest nodes. The influence rate is given in Eq. 4.

$$\theta(t) = \exp\left(-\frac{dist^2}{2\sigma^2(t)}\right) \tag{4}$$

Where θ is the influence rate.

Repetition

The effect of each learning update is to move the weight vectors of the winning neuron and its neighbors towards the input vector x. Continuous presentations of the training data thus leads to topological ordering.

Simulation Analysis

The performance of the proposed scheme is analyzed by using the Network simulator (NS2). The NS2 is an open source programming language written in C++ and OTCL (Object Oriented Tool Command Language). NS2 is a discrete event time driven simulator, which is used to mainly model the network protocols. The nodes are distributed in the simulation environment. The parameters used for the simulation of the proposed scheme are tabulated in Table 1. The simulation of the proposed scheme has 30 nodes deployed in the simulation area 1000×1000. The nodes are moved randomly within the simulation area by using the mobility model Random waypoint. The nodes are communicated with each other by using the communication protocol User Datagram Protocol (UDP). The traffic is handled using the traffic model CBR. The radio waves are propagated by using the propagation model two-ray ground. All the nodes receive the signal from all direction by using the Omni directional antenna. The performance of the proposed scheme is evaluated by the parameters packet delivery ratio, packet loss ratio, average delay, throughput and residual energy.

Table 1. Simulation parameters

Parameter	Value
Channel Type	Wireless Channel
Simulation Time	20 ms
Number of nodes	30
MAC type	802.11
Traffic model	CBR
Simulation Area	1000×1000
Transmission range	200m
Network Interface Type	WirelessPhy
Mobility Model	Random Way Point

Packet Delivery Rate

Packet Delivery Rate (PDR) is the ratio of number of packets delivered to all receivers to the number of data packets sent by the source node. The PDR is calculated by Eq. 5.

$$PDR = \frac{Total\ Packets\ Received}{Total\ Packets\ Send} \tag{5}$$

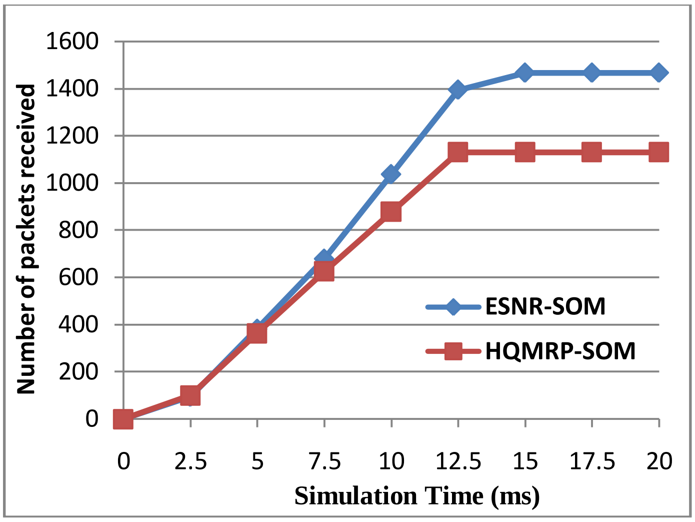

Fig. 3 Packet Delivery Rate of ESNR-SOM and HQMRP-SOM.

The figure 3 shows the PDR of the proposed scheme ESNR-SOM is higher than the PDR of the existing method HQMRP-SOM. The greater value of PDR means the better performance of the protocol.

Packet Loss Rate

The Packet Loss Rate (PLR) is the ratio of the number of packets dropped to the number of data packets sent. The formula used to calculate the PLR is given in Eq. 6.

$$PLR = \frac{Total\ Packets\ Dropped}{Total\ Packets\ Send} \tag{6}$$

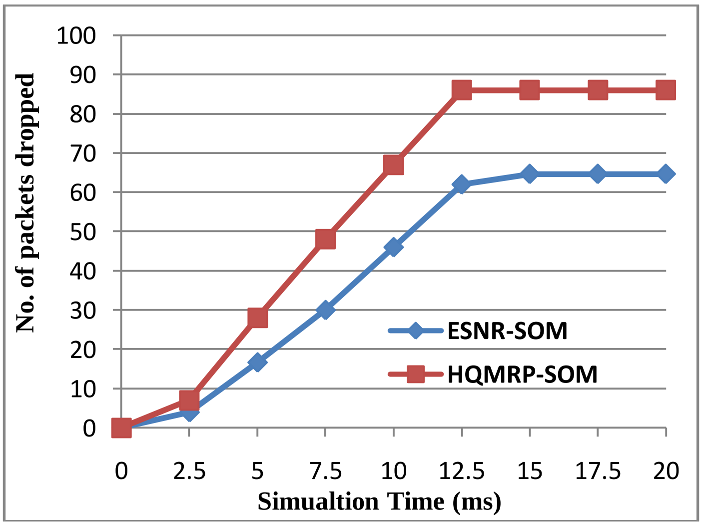

Fig. 4 Packet Loss Rate of ESNR-SOM and HQMRP-SOM

The PLR of the proposed scheme ESNR-SOM is lower than the existing scheme HQMRP-SOM in Figure 4. Lower the PLR indicates the higher performance of the network.

Average Delay

The average delay is defined as the time difference between the current packets received and the previous packet received. It is measured by Eq. 7.

$$Delay = \frac{\sum_{0}^{n} Pkt\ Send\ Time - Pkt\ Recvd\ Time}{Time} \tag{7}$$

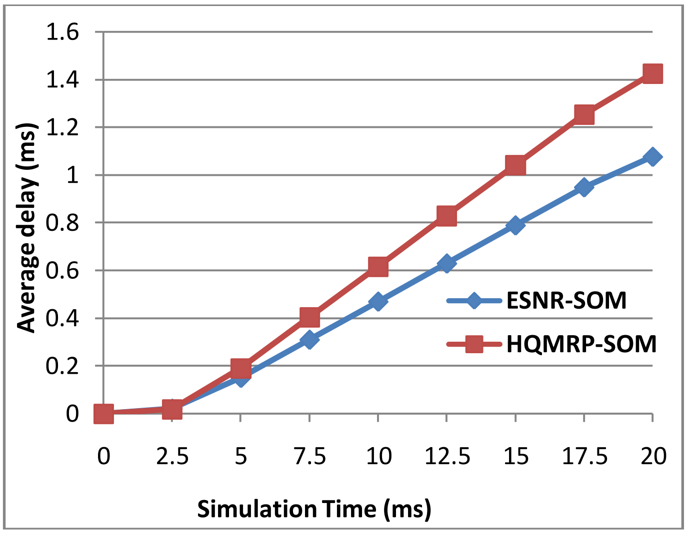

Fig. 5 Average Delay of ESNR-SOM and HQMRP-SOM

Figure 5 shows that the delay value is low for the proposed scheme EMRP-SOM than the existing scheme HQMRP-SOM. The minimum value of delay means that higher value of the throughput of the network.

Throughput

Throughput is the average of successful messages delivered to the destination. The average throughput is estimated using Eq. 8.

$$Throughput = \frac{\sum_0^n Pkts\ Received\ (n) * Pkt\ Size}{1000} \quad (8)$$

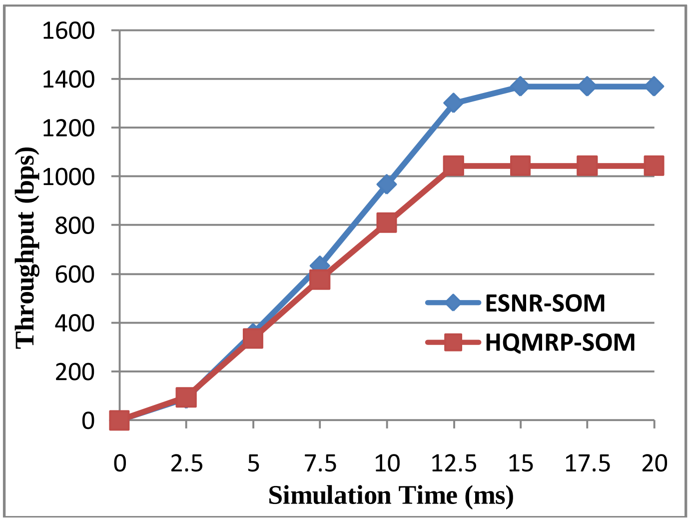

Fig.6 Throughput of ESNR-SOM and HQMRP-SOM.

Figure 6 shows that proposed scheme ESNR-SOM has greater average throughput when compared to the existing scheme HQMRP-SOM.

Residual Energy

The amount of energy remaining in a node at the current instance of time is called as residual energy. A measure of the residual energy gives the rate at which energy is consumed by the network operations.

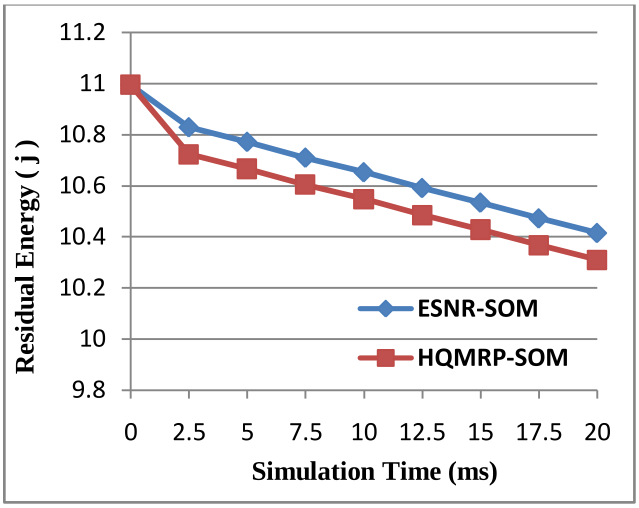

Fig. 7 Residual Energy of ESNR-SOM and HQMRP-SOM.

Figure 7 shows that the residual energy of the network is better for the proposed scheme ESNR-SOM when compared with the existing scheme HQMRP-SOM.

Conclusion

In this paper, a new Maximizing Energy based on SNR (ESNR-SOM) using Self Organizing Map is proposed in MANETs, which applies weight vector, bandwidth, SNR value, and energy as input parameters and uses the node with maximum SNR value, bandwidth and weight that is closest to the input vector as the wining node. The node with maximum energy attract nearest nodes with lower energy in order to create energy-balanced nodes. Because this is a multicast routing, same data is transmitted to multiple destinations in the same time by saving energy using high SNR value, bandwidth and weight vector. This proposed method enables to form energy balanced sensor nodes and distribute the energy consumption in an equivalent manner. Simulation results proves that the proposed algorithm minimize the use of energy through weight vector, SNR value and bandwidth and makes it energy efficient so that it can extend the lifetime of the network. Also 20 ms was sufficient to notice the visible change. However, further study with SOM in extended simulation periods and security issues will be studied as future work.

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