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Design Energy Aware Optimized Grey Wolf Based Recurrent Neural Scheme for Bio Medical Application in Wireless Sensor Platform

Dr. J. Seetha[1*], Dr. R. Sundar[2], Dr. R. Uma Mageswari[3], Dr. R. Juliana[4], Amjan Shaik[5]

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Abstract: Nowadays, the wireless-based human health monitoring framework is the most recent trending topic. Furthermore, biomedical sensor networks are used to identify and monitor human health conditions using biomedical applications. In this research, design a novel Grey Wolf based Recurrent Neural Scheme (GWbRNS) for enhancing the performance of WSN in biomedical applications by selecting less energy efficient Cluster Head (CH). Moreover, enhance the performance of patient monitoring with the help of a stored dataset. Initially, the biosensor node was designed to collect the information of the patient. Then update the fitness of the grey wolf in the recurrent network to identify the CH based on the lower energy consumption node. After the selection of CH, identify a secure gateway for forwarding the information to the center server. Finally, the patient information is saved in the patient database which is helpful to the medical staff and healthcare provider for monitoring the condition of people. Therefore, the crafted framework is put into practice using the Python programming language. The achieved results of the developed model are then juxtaposed with those of other established methods, considering factors like energy consumption, latency, power usage, and overall lifespan.

Keywords: *Biomedical application, Bio-sensor, Cluster head, Energy consumption, Wireless sensor network, Patient database, Internet*

1. Introduction

The distributed, self-organizing wireless sensor network (WSN) is a system. WSNs are used in modern contexts to support a variety of applications, including those in the biomedical field [1]. Moreover, the WSN is used for improving the quality of life and maintenance also displays the general strength of glucose using side-by-side displays [2]. Nevertheless, it contains a few critical issues such as large energy consumption, attacks, and data complexity [3]. Furthermore, the operation of the nodes network has better calculation also the system takes low power [4]. Thus the system is activated in the human body for monitoring the health status. Additionally, proficiency of responsibility acceptance and the uninterrupted process is required to elevate the system [5]. Moreover, the old-fashioned wireless system contains numerous aspects that are interfering with high side by side such as thin bandwidth, memory, and limited power supply [6]. Also, WSN is used for numerous applications for communication between the channels. The characteristic of WSN contain tasks, towards the investigation community and manufacturing, also positioning efficiently of reliable WSN [7, 8]. The basic application of WSN is detailed in fig.1.

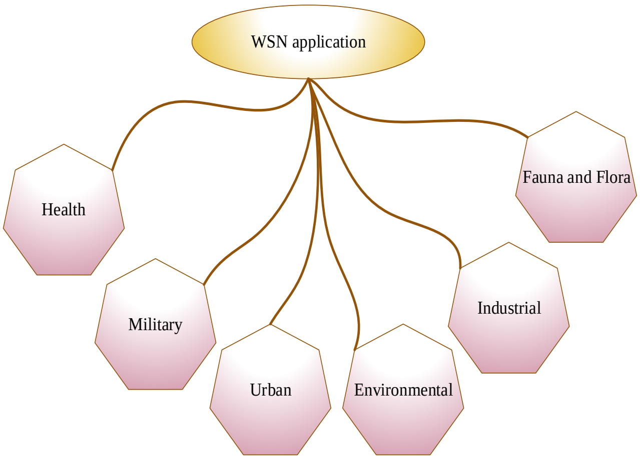

Fig.1. Application of WSN

Still, old practices of WSN contain problems of interoperability, elasticity, and information delivering issues [9]. Additionally, the Biomedical WSN (BWSN) is the most interesting topic to intend the healthcare service station or medicinal requests [10]. Thus the execution of BWSN can increase the healthcare filling station towards a resident by provision and novel submission improvement [11]. Generally, the BWSN application is comprised of the response of emergency, temperature, disaster, ECG, blood pressure, and pulsation rate [12]. The main need of BWSN is limitations of energy and efficiency of energy. Moreover, BWSN balance and promote energy efficiency during

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[1] *Associate professor, Department of Computer Science and Business Systems, Panimalar Engineering College, Chennai, Tamil Nadu, India.*
[2] *Assistant Professor, Computer science and Engineering, Madanapalle Institute of Technology & Science, AP, India.*
[3] *Associate Professor, Department of Computer Science and Engineering, Vardhaman College of Engineering (Autonomous), Kacharam, Shamshabad ,Hyderabad, Telangana, India.*
[4] *Professor, Department of Information Technology, Loyola-ICAM College of Engineering and Technology, Chennai, Tamilnadu ,India.*
5Professor & HoD-CSE, St.Peter's Engineering College, Hyderabad, TS, INDIA.

communicating information to make a better generation [13, 14]. The applications of BWSN may be classified into three areas such as biological specialist care system, patient specialist care situation, and actuator empowers strategies [15]. The execution of WSN in healthcare becomes frequently involves devices that are located around some parts of our body [16]. Additionally, the WSN is better flexibility, free infrastructure, denser arrangement, mobility, easy maintenance, and low cost [17].

Generally, BWSN is one of the key technologies for supporting the enhancement of new applications also mainly target particular patient monitoring, medical diagnosis, and continuous assessment of health [18]. It regards data collection to monitor and diagnose the medical patient monitoring system. Moreover, empowers the growth of new services and application for enhancing the quality of health care and medical care offered to the citizens [19]. Consequently, WSN contains various autonomous energy sensors which are distributed in a universal area. The WSN selects the adjacent sensors for transmitting the information or data through difficult communication protocols [20]. However, the implementation of such frameworks faces a number of difficult issues, such as increased costs, a lack of simplicity, and lengthy scheduling requirements. Additionally, current approaches have been developed, although they still struggle with issues related to high energy and power consumption, lengthy computation times, and error rates. In order to overcome these persisting difficulties, the goal is to develop a novel, optimised deep learning architecture that improves the performance of body-worn sensor networks (BWSNs).

The following is an outline of how this paper is organised: Body-Worn Sensor Networks (BWSNs) are discussed in Section 2 in general terms, and the system concept and current problems are covered in Section 3. Section 4 also elaborates on the procedural elements of the suggested methodology. The results obtained are then highlighted in section 5 and the model's conclusion is summarised in section 6, respectively.

2. Literature study

Below are some current literature reviews based on biological WSN,

Hisham and Haifa [21] proposed reliability and energy saving of WSN for reducing the energy consumption through biosensor nodes. Moreover, electrocardiogram (ECG) offers precise biomedical data because of the significant paramount of patient dataThe coordinate duty cycle framework has also been changed to improve the sink node's dependability. The established framework produces better outcomes, but attacks are detected with greater frequency.

The development of WSN plays attention in various fields such as biology, engineering, computer science, medical and physics. Moreover, Fariha et al [22] developed a protocol-based wireless network for improving the performance of nano communication which is suitable for e-health applications. The performance results of the developed framework attain better outage capacity and probability also energy efficiency however, power consumption is more.

Alexandros et al [23] developed an optical communication of WSN for transdermal biomedical applications in the body. For enhancing the performance of in-body communication, develop a nano-scale optical concept. The main highlight of the designed framework is analysing and designing the data theoretic concept for access control layers but contains more errors because of data complexity.

The human monitoring framework with WSN is the different models which develop the healthcare system using biomedical sensors. Soumyak et al [24] designed efficient and powerful biomedical nodes for monitoring health status. The new hybrid routing framework is developed for handling the intermediate nodes and battery power. Moreover, the developed framework offers a less cost solution but takes more time for transferring information.

Abhijit Chandra et al [25] proposed well-organized data routing techniques for improving the lifetime of the average node using a smart range monitoring system. The technique is implemented in a hardware platform and collected dataset using ECG. Thus the developed framework improves the network lifetime also designed model is helpful to provide less cost in healthcare development but it has the issue of battery drainage.

The main contribution of the current study is outlined as follows,

- A collection of wearable biosensor sensing data from a variety of patients is initially acquired and used to train the system.
- Then, in order to maximise communication transmission, a novel Gateway-based Routing and Network Scheme (GWbRNS) was developed.
- In this situation, the grey wolf's fitness helps identify the cluster head in the Wireless Sensor Network (WSN) setting.
- Broadcasting all communications through the chosen cluster head is the next step after the cluster head has been successfully identified. This strategy is important for reducing energy use.
- Additionally, a dedicated gateway is used to send the patient data securely to the central server. The patient database is where the gathered data about the patient is ultimately kept.

- The parameters are then calculated and compared to current models using metrics like throughput, node lifetime, data transfer rate, energy consumption, packet drop, communication delay, and similar metrics.

3. Problem Definition and System Model

Multiple static sensor nodes with identical capabilities make up a WSN. Sensor nodes turn into active sensors during the data broadcasting procedure. Typically, topology properties, energy consumption, packet sensing, and topological features are connected in WSNs. Problems with the cluster head selection process in WSNs result in performance deterioration and functional limitations. As shown in figure 2, every node in this scenario interacts wirelessly through a cluster node acting as the cluster head. Additionally, during the data transmission process, nodes with lower energy levels may experience packet dropouts.

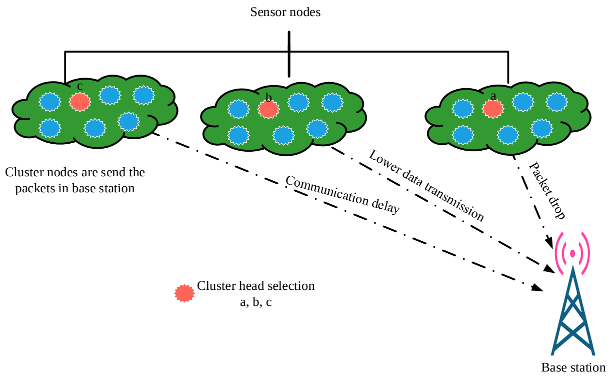

Fig.2 WSN cluster head selection

It is crucial to reduce energy consumption in the sensing environment since the transmission of data by sensor nodes typically requires a significant amount of electricity. Numerous recent research initiatives have sought to address issues such packet losses, increased energy use, and network failures. These methods haven't been completely successful, though, in precisely anticipating nodes with shorter lifespans and increased energy usage. As a result, the problem of energy consumption has not been remedied. The current research project has been motivated by the reality of these difficulties.

4. Methodology Proposed

Create a novel Grey Wolf-based Recurrent Neural Scheme (GWbRNS) to improve the choice of energy-efficient Cluster Heads (CHs) in Wireless Sensor Networks (WSNs) for biomedical applications. The main goal of this innovative method is to transport recorded data to the central server efficiently while using the least amount of energy possible. Healthcare practitioners can benefit from the gathered data because it is safely maintained in a patient database. In the first stage, wearable sensor datasets from a variety of system patients are gathered and trained. The data is then communicated with the central server using a WSN and gateway as a communication protocol. By improving the grey wolf fitness within the WSN, the technique seeks to reduce energy usage and increase communication efficacy. This procedure makes it easier to identify CHs using predetermined threshold values, improving communication. Finally, a cloud-based patient database is used to store the collected patient information. Figure 3 shows an illustration of the architecture of the suggested methodology.

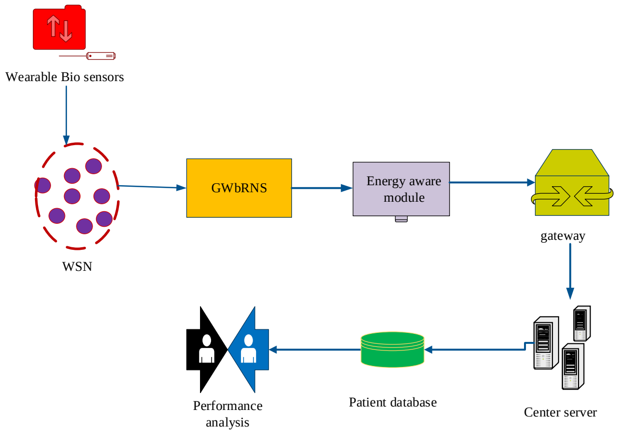

Fig.3 Proposed methodology

Therefore, choosing clustering nodes is based on choosing nodes with lower energy consumption and longer lifespans. Additionally, the protocol structure calls for leveraging Grey Wolf optimisation to activate the fitness evaluation. By streamlining the transfer of patient data to a specific database, the developed framework helps medical practitioners assess each patient's specific health issues. This method also identifies Cluster Heads (CHs), which are distinguished by low energy usage and help to conserve energy, time, and power. Therefore, using the wolf fitness function to identify the best CH for these uses is possible.

4.1 Process of GWbRN system

The Body-Worn Sensor Network (BWSN) is made up of sensor nodes that send information to a central server, which then forwards the server's raw data to a patient database for tracking health status. In this configuration, sensor nodes use Wireless Sensor Network (WSN) technology to send data or information over a number of bands. The created framework makes it easier to identify Cluster Heads (CHs) with low energy consumption, which helps to conserve energy, time, and power. To find the ideal CH, this technique applies the wolf fitness function. The wolf's fitness is initialised as alpha, beta, delta, and omega in the initial phase. The first fitness solution of the suggested methodology is indicated by an exploratory parameter concentrating on nodes with lower energy usage. The second fitness solution is then concerned with CH selection. The third and final fitness approach involves sending secure data to the central server through a dedicated gateway.

Utilising data from the patient database, this information makes it easier to track a patient's health state.

The biosensor nodes are customised in the input layer's Wireless Sensor Network (WSN) configuration to enhance data broadcasting. These nodes, which include both nodes with high and low energy usage, are positioned carefully. They enable the transfer of information from the Source Node (SN) to the Destination Node (DN), and are collectively referred to as sensor nodes. Additionally, the sensor nodes are arranged into a stationary network and dispersed at random. Energy sensors have a constant transmission capacity, but the amount of energy they use depends on the data they process. Notably, equation (1) is used to calculate the energy required by each sensor to transmit k-bit packets.

$$E_t(S_n) = k\left(T_e + T_a . d^{\eta}\right) \tag{1}$$

Where, E_t is denoted as the energy transmission and S_n is represented as sensor nodes quantity. Moreover, T_e is represented as energy consumption through the transmitted unit, T_a is denoted as the transmitted amplifier. Also, η is considered as exponent propagation loss which is determined by the values of $2 \le \eta \le 4$. Furthermore, the energy consumption of created nodes distance is considered as d. Next, the energy consumption to receive the information of k- packets is obtained by eqn. (2).

$$E_r = k_{\alpha} . T_e \tag{2}$$

Where, k_{α} is denoted as the first fitness function. The energy consumption of the sensor nodes is ascertained through the utilization of the devised framework. Subsequently, the Cluster Head (CH) is determined to achieve optimal data broadcasting from the sensor node. This selection of CH aims to strike a balance in energy consumption and alleviate potential transmission issues. The identification of the CH is facilitated by the fitness function, denoted as β, which is calculated employing equation (3).

$$CH = \left\{ \begin{array}{cc} \dfrac{R_{\beta}}{1 - R_{\beta}\left[v^{*}\left|\dfrac{1}{R}\right|\right]} & 0 \le G \le 1 \\ 0 & otherwise \end{array} \right\} \tag{3}$$

Whereas R is referred to as probability and G is the collection of nodes and v^{*} is called as current round also R_{β} is represented as the second fitness function. After the selection of low energy consumption CH, identify the secure gateway for transferring information from the base station to central server. The selection of the secure gateway is obtained by eqn. (4)

$$P_{gat} = P_{CH} + \left(\frac{Q}{k} - 1\right) P_{\delta} \tag{4}$$

Let, p_{CH} is represented as the gateway to forward the information of each cluster member, Q is represented as the number of nodes and P_{δ} is considered as the third fitness function. Moreover, k is represented as the quantity of the cluster per round. The basic design of the developed framework is detailed in algorithm.1.

```
Algorithm:1 Designed GWbRN model for BWSN
 Start
 {
  Design BWSN with required biosensor nodes
  Update to GWbRNS
  Initialize fitness                    // $\alpha, \beta, \delta, \omega$
  Energy-Aware Module
  {
        Energy consumption of each sensor to transmit k-bit packets
        // energy dissipation of transmitting information
        $E_t(S_n) = k\left(T_e + T_a . d^{\eta}\right)$
            // $E_t$ - energy transmission     // $S_n$ - number of sensor nodes
            // $T_e$ - energy consumption through the transmitted unit
            // $T_a$ - transmitted amplifier // $\eta$ - exponent propagation loss
            // $d$ - energy consumption of created nodes distance
        Energy consumption for receiving information of k- packets
        //energy dissipation of receive information
        $E_r = k_{\alpha} . T_e$
  }
  Select Cluster Head
  {
```

```
// finest broadcast, balance the energy consumption and minimize the problems that occur during transmission
            If ($E_r \le 1$)
            {
            Low energy consumption (node)
            }
            Else
            {
            High energy consumption (node)
            }
            End if
}
Secure gateway
        For all Q=1
        {
        Information forward
        // to center server
        }
        End for
Center server
// send information to cloud database
{
            For all $P_m = v^*$ to all G
            {
            Monitor health status
            //using internet
            }
            End for
Broadcast finest way using biomedical application
Output
}
End
```

Moreover, a secure gateway is helpful to forward the collected information or data from the biosensors to the central server. Then the information of patient records is sent to the cloud patient database for monitoring the health status of the people using eqn. (5).

$$P_{db} = \frac{P_{total}(\alpha + \beta + \delta)}{P_m(\omega) + E_r} \tag{5}$$

Let, P_m is denoted as patient monitoring system from the cloud database. Finally collected patient information is stored in the patient database using the internet easily monitors the health status of the patient using biomedical applications. With the help of the internet, data was collected and forwarded to the appropriate entity such as medical staff, doctors, and healthcare providers. The flowchart of the developed technique is shown in fig.4.

5. Results and Discussion

In this section, design a novel optimized GWbRNS for minimizing the energy consumption while transferring information to the central server in the WSN environment. Also, the design model is implemented in the python tool for enhancing the performance of monitoring health status. Initially, design biosensor nodes in the WSN environment for gathering information from the human body. Then the collected information is sent to GWbRNS to minimize the energy consumption by identifying CH. Update the wolf's fitness in the recurrent neural network as well to improve transmission performance. In the input layer, gather the information of sensor node and the hidden layers doing the process of energy aware and transmission process. Finally, the output layer stores the collected data into a cloud patient database. That will help the doctors, medical staff, and healthcare providers to monitor the health condition using BWSN. Additionally, by contrasting the major metrics of the proposed model with those of other models in terms of energy consumption, power consumption, latency, and other factors, the effectiveness score of the model is confirmed.

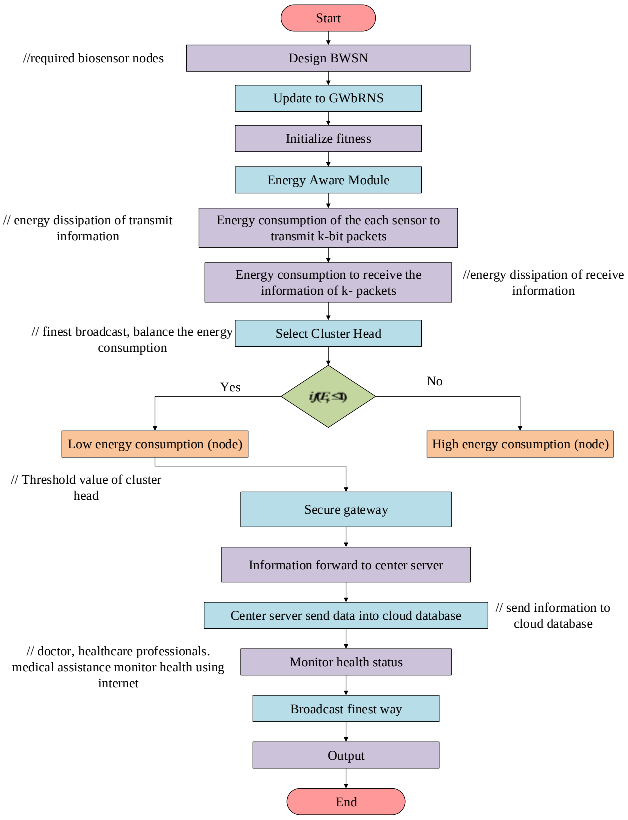

Fig.4 Workflow of the developed GWbRN model

5.1 Performance metrics

The results obtained using the developed strategy are evaluated by contrasting them with metrics from other methods. The suggested methodology includes measurements for energy use, power consumption, latency, longevity, and node count. Furthermore, proposed detection method efficiency is compared with various conventional methods such Energy Conserving Routing (ECR) model [22], Optical Wireless Communications (OWC) [23], Efficient Power in BWSN (EP) [24], Energy Equalization (EE) [25] plan, Monitoring Physiological Restrictions (MPR) [26], Energy-Aware Routing (EAR) [27], and Energy Efficient and Energy Balanced (EE-EB) Model [28].

5.1.1 Energy consumption

The selected cluster nodes have a set level of energy to enable contact between the source node and the destination node for packet transfer during a communication process. As a result, energy consumption refers to the total amount of energy required to transport the packet from the source to the base station. Consequently, the quantity of nodes develops based on the reproduction time. Energy consumption is calculated using eqn. (6),

$$E_c = (E_r N_s) + E_T \tag{6}$$

Where, E_r is denoted as received energy, E_T is the transmitted energy and source node is represented as N_s. Moreover, energy consumption is calculated by the normal estimation of each node. Here, fewer energy consumption nodes are gives the finest solution.

Table 1. Energy comparison

No. of. Biosensor nodes	Energy Consumption (J)					
	ECR	EP	EE	EE-EB	EAR	Proposed
5	0.5	1.4	1.84	0.22	0.34	0.07
6	1.2	2.1	1.92	0.34	0.39	0.1
7	1.75	2.7	1.99	0.37	0.42	0.16
8	2.6	3.3	2.3	0.42	0.48	0.26

When compared to the ECR technology, which involved 5 nodes, the new strategy produced an energy consumption of 0.07 J. In addition, the EP and EE-EB approaches measured energy usage of 1.4 J and 0.22 J, respectively, whereas the EAR method used 5 biosensor nodes to achieve an improvement of 0.34%. Table 1 and Figure 5 provide a thorough analysis of how much energy is used by various procedures.

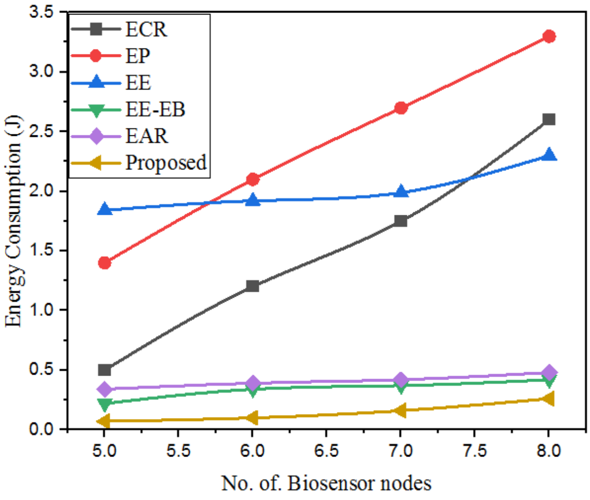

Fig.5 Energy verification using another approach

5.1.2Latency

Latency is a crucial measure for demonstrating the framework's effectiveness. Additionally, the total amount of time required to route the packet from the source node to the destination node. In other words, latency is the ratio of the speed-based computation of the transmission rate of packet size to the distance-based evaluation of distance. As a result, eqn. (7) mentions the latency computation.

$$L_a = \sum_{i=1}^{n} \frac{P_d}{P_r} \tag{7}$$

Where, P_d is represented as time period, which is taken by the packets to reach the destination node and the attained data packets in the receiver side is represented as P_r. Existing techniques comparison of latency in seconds is mentioned in table.2.

Table.2 Validation of latency

No. of. Biosensor nodes	Latency (ms)				
	EP	EE	EAR	MPR	Proposed
5	150	120	114	123	50
6	164	124	123	131	53
7	171	132	137	139	60
8	177	138	141	144	67

The proposed GWbRN model attained lower latency than other existing methods like EP, EAR, MPR, and EE. Consequently, the prevailing techniques such as EP and EAR reached at a higher latency. But, the proposed GWbRN model achieved a lower latency than other methods, which is given in fig. 6.

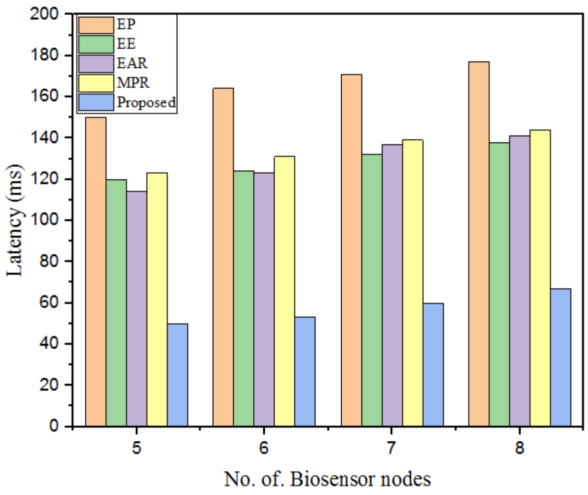

Fig.6 Comparison of latency

Moreover, the comparison shows that the proposed GWbRN method has attained 50ms but conventional methods like EP (150 ms), EE (120ms), EAR (114ms), and MPR (123ms).

5.1.3 Usage of electricity

The ratio of energy and time needed to convey data from the sensor node to the destination node is called power consumption (p). Voltage control of power use is possible. Equation (8) is used to calculate the mathematical representation of power consumption.

$$P = \frac{E}{t} \qquad (8)$$

Where E is represented as energy consumption of sending information to the server and t is expressed as the time taken for sending data to the server.

Table.3 Validation of power consumption

No. of. Biosensor nodes	Power consumption (mW)			
	OWC	EP	EE	Proposed
5	55	3.49	12.3	1.75
6	67	7.5	22.9	2.1
7	70.2	13.85	29	2.76
8	77.53	17	35	3.2

The OWC methodology required 55 mW of electricity to operate 5 biosensor nodes, whereas the proposed method only required 1.75 mW to communicate information. Additionally, the EP and EE approaches used 5 biosensor nodes and measured power consumption of 3.49 mW and 12.3 mW, respectively. In Table 3 and Figure 7, a thorough comparison of power usage for various approaches is shown.

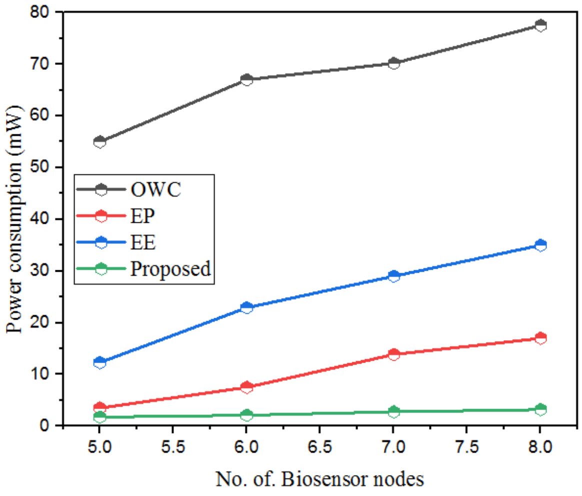

Fig.7 Comparison of power with existing methods

5.1.4 Life time

Node lifetime is a crucial variable in Wireless Sensor Networks (WSNs) for achieving effective communication. The communication between cluster nodes is positively influenced by a higher lifetime of chosen nodes in terms of energy consumption, and this in turn affects the lifespan of all nodes. The minimal energy consumption in the proposed GWbRN method increases node lifetime. Furthermore, different clustering node speeds are taken into account while evaluating node lifetime. This measure represents the amount of time a certain node is active within the used node.

Table.4 Validation of node lifetime

No. of. Biosensor nodes	Lifetime (%)			
	EE	MPR	EAR	Proposed
5	88	91	92.4	98.85
6	86.5	89.3	90	98.34
7	84.42	85	88.8	97.67
8	82	82.01	84.9	97

The node lifespan obtained using the created method is compared to that obtained using the EE, MPR, and EAR existing techniques. In this comparison, the MPR technique obtains 91% node lifespan, compared to 88% for the EE technique. Surprisingly, the suggested GWbRN technique, when using two biosensor nodes, establishes a node lifespan of 98.85%. Table 4 provides a detailed summary of these results.

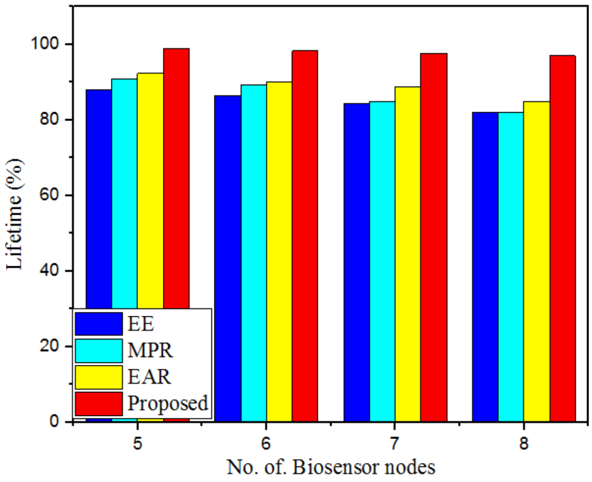

Fig.8 Node life length in comparison to other techniques

The proposed method is more effective in transferring the messages shown in Fig. 8 when compared to the existing models.

5.1.5 No. of nodes

Generally, two nodes become directly connected for transmitting and receiving the data to each other. Moreover, a transmission model or sensor communication is used to quantify direct connectivity among sensor nodes. The sensor nodes are used to measure the environmental parameter to transmit the information or data to the network through a gateway that is battery operated and deployed. The number of nodes used for the existing papers is compared which is detailed in fig.9.

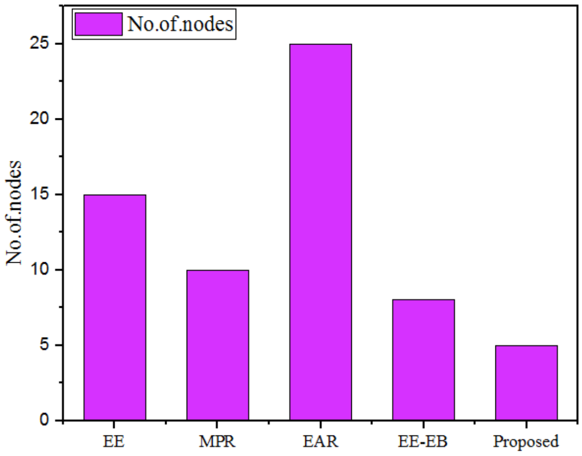

Fig.9 Comparison of nodes

While the increased amount of nodes causes' high energy and power consumption, decrease throughput, and fewer lifetimes. Also, nodes increase drop the probability of packet drop while communicating so fewer nodes will provide better communication and enhance the performance.

6. Conclusions

Wireless Sensor Networks (WSN) have found applications in a variety of fields today, resulting in various breakthroughs. The reduction of energy consumption during message transmission is the main focus of this research. An innovative GWbRN model is presented in this area with the goal of monitoring health status and choosing Cluster Heads (CHs) to reduce energy consumption during data transmission. The analysis's findings show that the suggested approach achieves exceptional benefits, including a 0.07 J reduction in energy usage, a 50 ms latency for specific nodes, a 1.75 mW reduction in power consumption, and a 98.85% increase in node lifespan. The created model outperforms existing approaches on a number of different measures when compared.

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