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Reduce Data Transmission Energy in Wireless Body Area Network using LRNN Prediction Model

S. Selvaraj,
Ph.D Research Scholar, Department of Computer Science,
Periyar University, Salem,
selvarajmca2012@gmail.com
S. Dhamodharavadhani,
Ph.D Research Scholar, Department of Computer Science,
Periyar University, Salem,
vadhanimca2011@gmail.com
R. Rathipriya,
Assistant Professor, Department of Computer Science,
Periyar University, Salem, (corresponding author)
rathipriyar@gmail.com

ABSTRACT

The Wireless Body Area Network (WBAN) has become a growing technology to improve health care and provide a cost-effective solution for remote sensing of physiological parameters of the human body.The study focuses on developing a method to reduce transmitted data at the sensor node and compensating for this by having the actual sensor value's error threshold to be comparable from expected values.Request Management Algorithm (RMA) is developed to reduce the amount of requested data based on consecutive successive predictions. The LRNN prediction model has been developed to reduce the amount of data requested based on continuous predictions.

Keywords: Body area network, protocol, data transmission, Layer recurrent neural network, prediction.

INTRODUCTION

Wireless Body Area Network (WBAN) is a sensor network that is restricted to an area that can load nodes inside or outside the body. It is a collection of wireless sensor nodes that are situated either inside or outside the human body for monitoring the outside environment and functions of the body.The coordinator node communicates with third parties for data transfer. Basically, sensor nodes are used to test different body parameters for health applications. Since the energy emitted by the node can affect a person's health, the number of sensor nodes that can be fitted into or within the body should be of selective alertness. The reliability of WBAN health utilities is important for WBAN applications, considering a number of issues such as interference management, performance of various health utilities and node energy efficiency [3].

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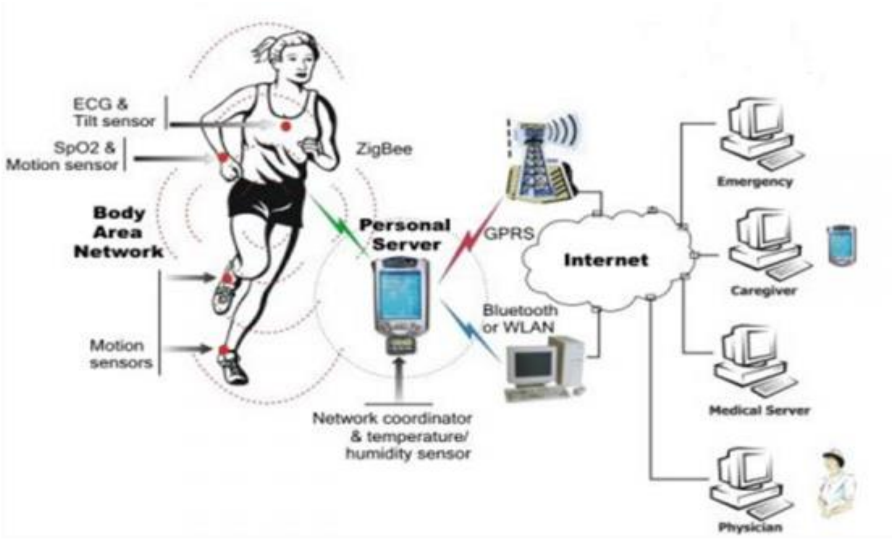

Figure1. Wireless body area network Architecture.

Minimize the energy consumption in the wireless sensor network and prolong the lifetime of the WBAN. Achieved it through simple data analysis method where one can predict the future data and restrict the number of data communications. By reducing the communication between sensor nodes and base station without compromising data quality can be achieved by predicting the trend or pattern followed by the sensed data [4].

Data prediction is the most efficient way to reduce the number of transmissions in between sensor and base station by using the predicted values instead of the real ones without compromising the quality of information to be generated. It focuses on how to minimize the number of data transmissions from the sensor nodes to base station**.** By reducing the communication between sensor nodes and base station without compromising data quality can be achieved by predicting the trend or pattern followed by the sensed data [2].

This paper is organized as follows. Section 2 describes about the literature review needed for the research work. Section 3 details explanations of methods and materials. Proposed work is detailed in section 4. Section 5 provided the experimental analysis and discussed of the obtained results. The summary of the proposed model is presented in section 6.

Related work

The difficulty of WBAN energy consumption, demand prediction an intra-body, inter-body area has been addressed and the approach is classified into time series and machine learning models. Based on the problem choose the time series data in predictive framework for wireless body area network.

Table 1. Related work

Author Name	**Title**	**Description**
Ahmad A. Abdel-karim.	Forecasting and skipping to Reduce Transmission Energy in WSN.	Reduces the transmitted data at the sensor node and compensate this by requesting the error threshold of the actual sensor value form predicted values.11].

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Feng Xia, Zhenzhen X.	Prediction-Based Data Transmission for Energy Conservation in Wireless Body Sensors.	A prediction based data transmission approach suitable for body area network is presented, which combines a dual Prediction framework and a low-complexity prediction algorithm that takes advantage of PID (proportional integral-derivative) control.
Ni Guo, Weifeng Gui	Using improved support vector regression topredict the transmitted energy consumption data by distributed wireless sensor network.	Predictive models appeared in recent years, but it is still a hard work to construct an accurate model to predict the energy consumption due to the complexity of the influencing factors.Accurately predict the energy use could assist energy manager make advisable strategies and schedule resource [14].
Bruno Lepri.	Energy consumption prediction using people dynamics derived from cellular network data.	Introduce a new and original approach to predict next week energy consumption based on human dynamics analysis derived out of the anonymized and aggregated telecom data, which is processed from GSM network call data records.
Lin Zhong.	Energy Comparison and Optimization of Wireless Body-Area Network Technologies.	Investigate an energy-efficient wireless device driver for low-duty peripherals, sensors and other input/output devices employed in a WBAN to communicate with a more powerful central device. We present an extensive comparative study of two popular WBAN technologies, in terms of design cost, performance, and energy efficiency. [17].
Akash Katiyar.	Power-aware IoT based Smart Health Monitoring using wireless body area network.	In order to ensure continuous monitoring of health over a long period of time in WBAN, power management is a key requirement. To reduce the energy consumption, a light-weight power management controller is introduced based on the present status of data and battery.
Vetrivelan.	Wireless Body Area Network (WBAN)-Based Telemedicine for Emergency Care.	The probability of sending emergency messages can be determined using RMA with the likelihood evidence. It can be viewed as medical decision-making, since diagnosis conditions such as emergency monitoring, delay-sensitive monitoring, and general monitoring are analyzed with its network characteristics, including data rate, cost, packet loss rate, latency [10].

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Shanshan Wang	A Human Body position Recognition Algorithm Based on BP Neural Network for Wireless Body Area Networks.	The main features of the network are the transmission signals forward and errors backward.
Xiaodng Lin.	Exploiting Prediction to Enable Secure and Reliable Routing in Wireless Body Area Networks.	Prediction-based Secure and Reliable routing framework (PSR) for emerging Wireless Body Area Networks (WBANs). It can be integrated with a specific routing protocol to improve the latter's reliability and prevent data injection attacks during data communication.
Badlishah Ahmad.	Reliable emergency data transmission using transmission mode selection in wireless body area network.	Emergency-based cooperative communication protocol for WBAN, named as emergency datatransmission selection protocol. First, a complete study of a system model is inspected in terms of channel path loss, successful transmission probability.

Limitations

Predictive approaches have been used in the literature to reduce the energy used in data transmission. ARIMA and high-speed smooth techniques are examples of statistical approaches.It has been shown that neural network-based prediction models work better than conventional prediction algorithms. Therefore, this study proposed two different neural network-based predictive models to reduce data transfer, thereby increasing the network lifetime of the sensors in the WBAN.

METHODS AND MATERIAL

The proposed RMA-based energy-preserving WBAN model is designed to keep the sensor phase of signal control and signal generation flowing efficiently. The RMA algorithm and the WBAN system's LRNN prediction model will be used to derive this future use of energy sensor data. Based on transmission energy demands, it predicts pulse and temperature sensor results.

Layer Recurrent Neural Network:

Layer recurrent neural networks are similar to feed forward networks, except that each layer has a recurrent connection with a tap delay associated with it. This allows the network to have an infinite dynamic response to time series input data.

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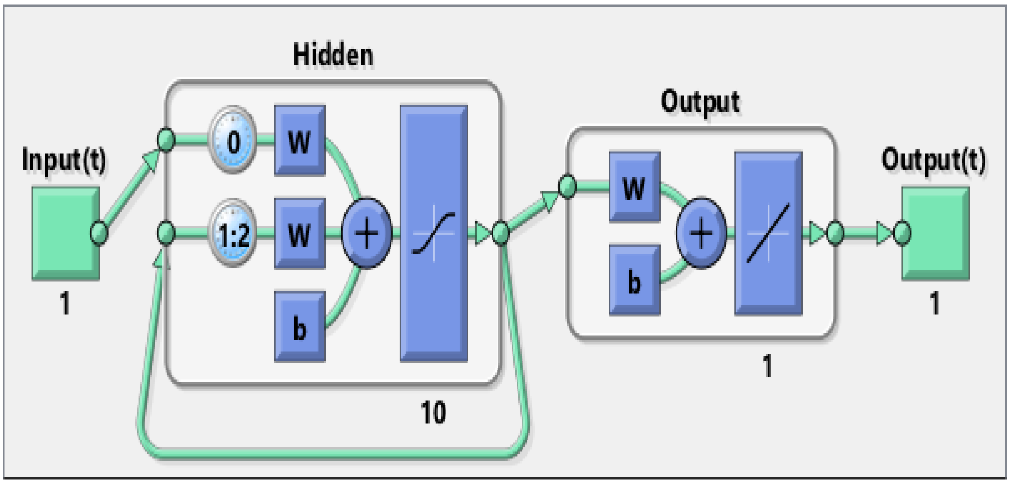

Figure2. LRNN Architecture

The majority of WSNs are used to regulate or track irregularly occurring events. WBAN networks, on the other hand, are used to monitor human physiological activities on a more consistent basis. As a consequence, the rates of application data sources are reasonably constant transmission.WBANs difficult to transmit information through and out of the body. The energy of the indication carrying the data appears to dissipate and be absorbed by the body. The frequency, temperature has a major impact on this influence.

Body temperature readings, on the other hand of WBAN, are very slow to change when threshold reached. According to the same calculations, only 0.5 samples are needed.When it comes to power demand, these are important information. Temperature readings will be taken much less often, and the sample will be transmitted in much less time, if an implant measuring temperature, pulse rate is used. Sometimes WBAN wearable sensors to feel a person's meaning and movement. To keep track of any vital sign, data from these two sensor networks should be analysed. When a person is jogging, for example, the temperature, sensor and the heartbeat sensor can both give higher readings.

PROPOSED WORK

The base station can learn from previous patterns how to predict an approximate value about the new measurement before requesting it from the sensors.It limit the content of the replied by just including the error correction, or variance from the predicted value received in request packet.Predicted value is equal to the measured value, sensor node may not reply and this will be held as a zero error.

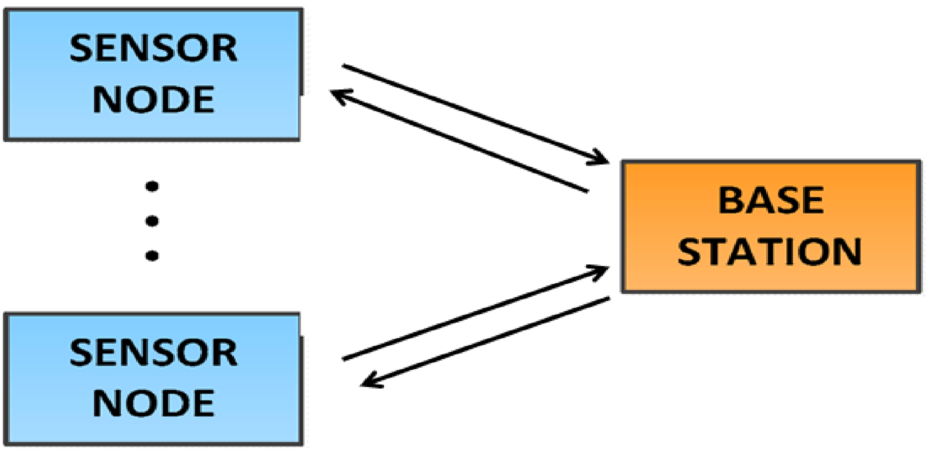

Figure3. System architecture

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Base station operation

Base station must send a predicted value equal to zero which will oblige the sensor to send the measured value. Base station is responsible to request data from sensors in a consecutive way. The key behind requesting the data from the sensors, and not to wait the sensors to send their data freely, to reduce the transmission process at the sensors, especially when the base station has a good prediction about the measured data.

The requested packet contains a predicted value E, an accepted error value α and other fields related to data link and sequence number. The predicted value E is calculated based on previous knowledge learned from stored patterns, where α is the accepted error in which measured value M is supposed to be approximately equal to E if the following inequality holds. After requesting a measured value from a sensor node, base station will wait a specific duration T until the sensor responds. In case of no response from the sensor, the predicted value E is supposed to be approximately equal to the measured value and it will be stored in the base station as if it was a collected data.

Algorithm steps:

Request Measure (E, α)

Step 1: Initialize the necessary parameters predicted value (E, error value α)

Step 2: While (Sensor, Base station= P) Until (T)

Step 3: Calculate the predicted value in waiting time T.

Step 4: Compute the sensor response ($S_{t)}$ or predicted value (E_t) in duration.

Step 5: Compute the error value $E_t$is calculated based on stored measured value from the sensor node at Tth period.

Step 6: Finalize the value ($E_{t,}$ α);

The algorithm is explained in six steps. First step explains request function for requesting base station to the sensor node by initialling E =0 and α. Second step is to wait function helps to wait for the sensor node. Third step is receive function for waiting time T if it receives packet then V is extracted and prediction value is added in step 4. Else in step 5 S values is assigned to E. In step 6 is the next iteration is performed based on previous data.

Sensor node operations

The operation of the sensor is simplified in order to reduce computational and transmission power consumption as much as possible. After receiving a request packet from the base station, sensors tend to subtract the received Predicted value from the measured value. Vis compared to the accepted error value α the sensor will transmit V, else no transmission will take place.

Algorithm steps:

Step1: Receive Request (E, α);
Step2: M= Measure Value ()
Step3: V=M-E
Step4: If (V<-α OR V> α)
Step5: Send (V);
Step 6: Goto 1

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First step receive request function if transfer data from base station to sensor. In step 2 measure value helps to measure the base station sensors send to subtract the received predicted value from with a condition that if measure value is less than or greater then V is send else it is stopped to first step is explained in step 4 and step5.

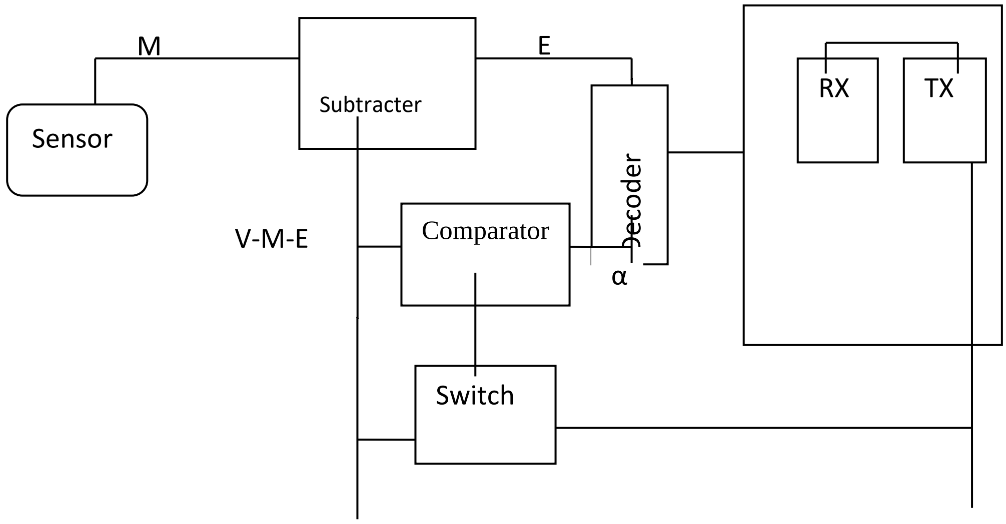

FIGURE 4. SENSOR NODE BLOCK DIAGRAM

LRNN Algorithm:

Input: Sensory data: [v_a, vb]
Timestamp data: [TV_a, TV_b]
OUTPUT: Parameter for each layer
//Input preparation
Sensory data is arranged in chronological order.
//Initialization
Epoch Bound = 200, current Epoch = 0
//Training model
While current Epoch<Epoch Bound
train_Data_num= 0;
While train_Data_num<len (trainSet)
Select (batch_size) of data to update parameters;
train_Data_num= train_Data_num+batch_size;
End While
Calculate the loss value (val_loss) on the testSet;
End While

WBAN Simulation Design:

In the WBAN network design, a central node represents hub. Similarly, other two sensor nodes, 1 and node 2 represents pulse rate and temperature sensors. All nodes are connected with wireless links in star topology.

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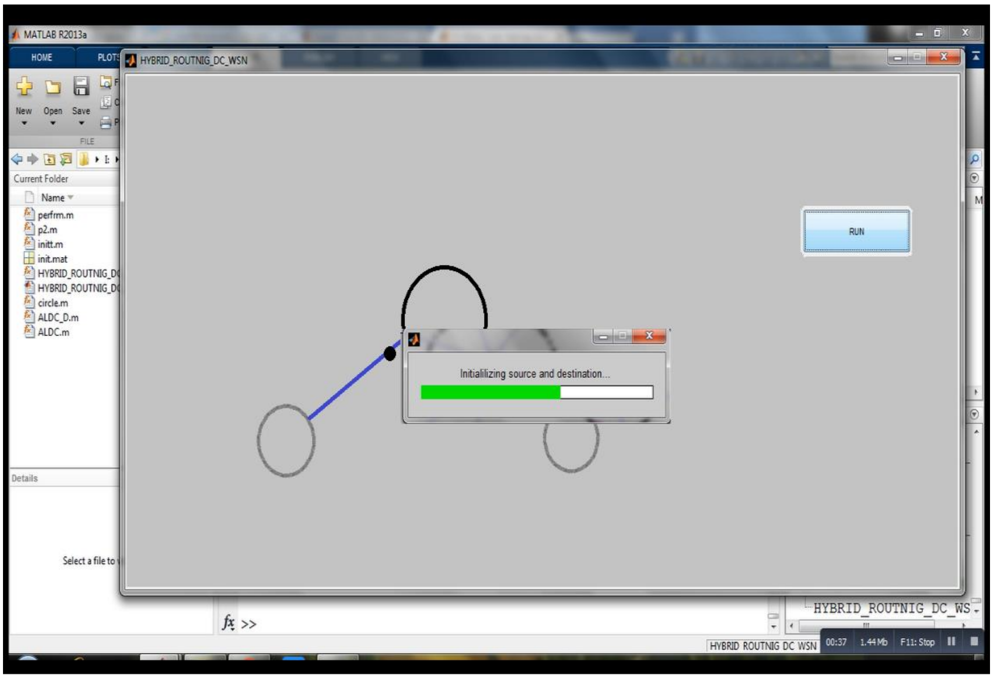

Figure5. Placement of the sensor node and hub on the body and network

Dataset Description

Data Source: https://physionet.org/

TABLE 2 Simulation Parameters

Network Area	100 x 100
Type of Network	WBAN
Number of WBAN	50-300
Number of sensors in each WBAN	3
Velocity	1.5 m/s
MAC	802.15.6
Simulation time	50 second
Initial energy	0.5J
Transmitter energy consumption	16.7 nJ
Receiver energy consumption	36.1 nJ

Table 2 shows the necessary parameters of proposed wireless body area network like initial energy level of base station, sensor nodes and coverage area, numbers sensors used in the network.

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RESULT AND DISCUSSION

Base station sends value to the sensor node. Then sensor node checks the value based on threshold if the value is less then threshold it stores the base station value else sensor sends the value back to base station.

Table3 Sensed Value vsPredicted Value for Pulse Rate

Wrongly Predicted Value(BS)	Sensed Value(SN)
70	72
74	72
70	72
74	72
74	72
70	72

Table 3 describes the comparison between wrongly predicted value in base stationand sensed values in sensor node. The outcome of this approach shows a significant effect on sensor node transmission energy is being reduced.

Table 4 Energy Information for Sensor Node using without RMA

Number of Base Station Request To Sensor Node	25
Number of Sensor Node Request to Base Station	2
Number of Transaction Reduced	23
Total Energy Saved for Sensor Node	61.1
Total Energy Spent at base station node using without RMA	105

Table 4 explains the energy information of body area sensor nodes using with Request management Algorithm of Network.

Table 5Energy Information Sensor Node for using RMA

Number of Base Station Request To Sensor Node	25

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Number of Sensor Node Request to Base Station	2
Number of Transaction Reduced	23
Total Energy Saved for Sensor Node	61.1
Total Energy Spent at Base station node using RMA	44.3

Table 5 explains the energy information of body area sensor nodes using without Request management Algorithm of Network.

Figure 5 shows the pulse rate of the body sensor predicted values in the number of time stamps.

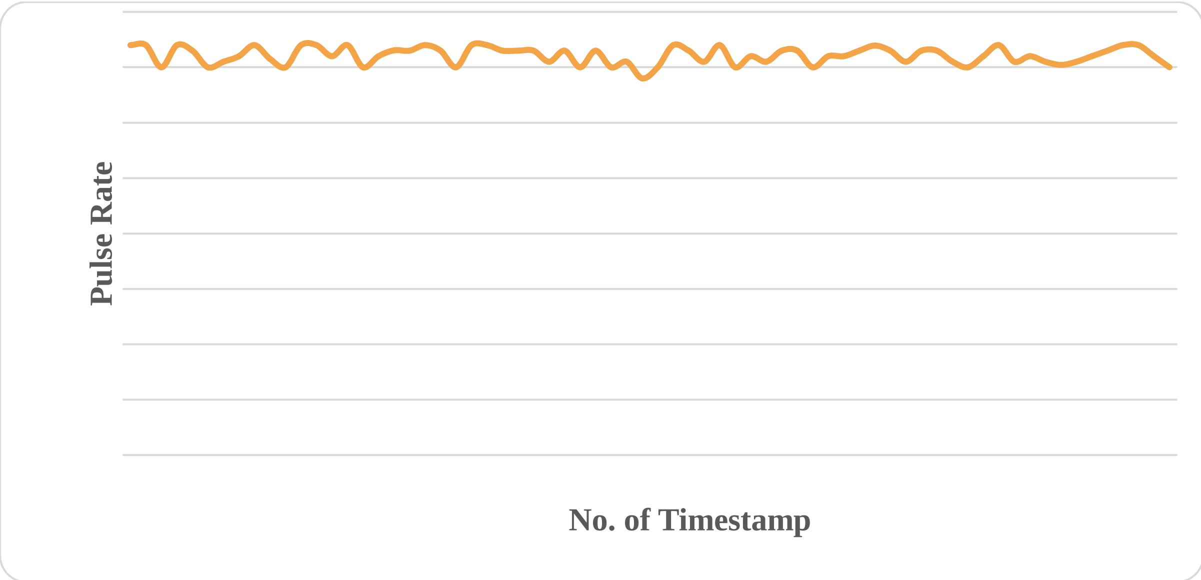

Figure: 6 Plot for pulse rate prediction

Figure 6 shows the temperature of the body sensor predicted values in the number of time stamps.

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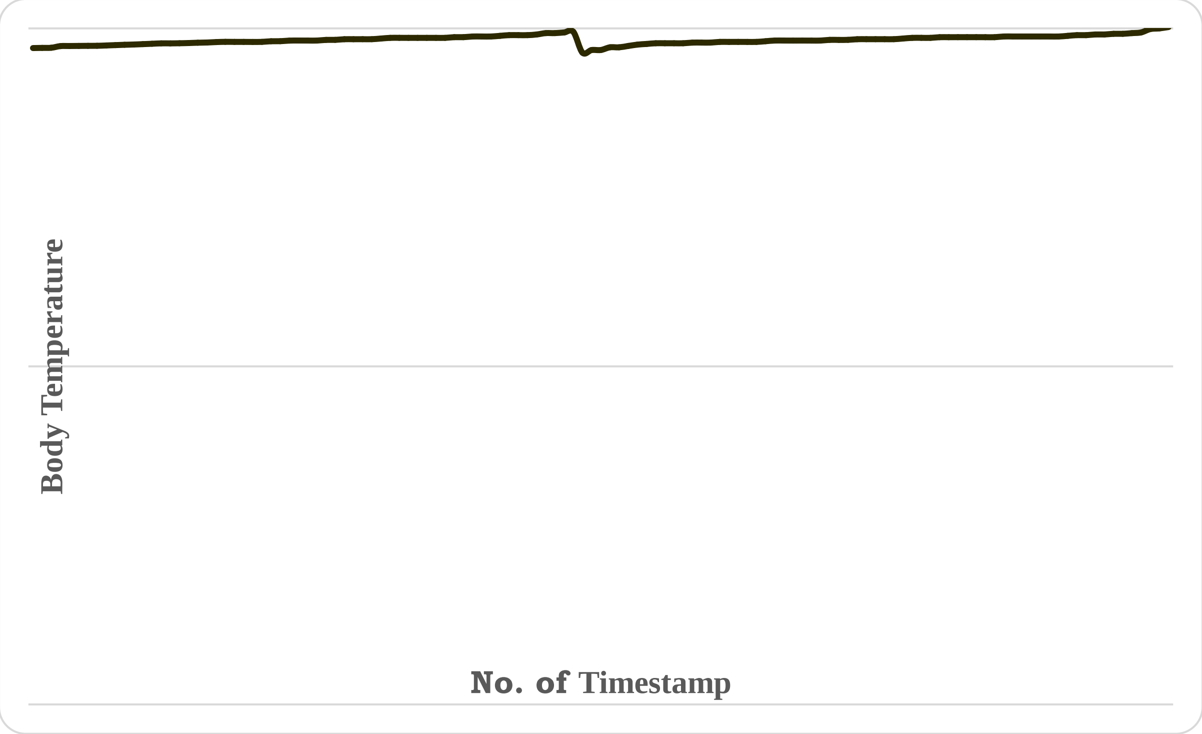

Figure: 7 Body Temperature Predictions

The performance comparison of both sensor body temperature and predicted body temperature has been explained in figure 7 at different timestamps.

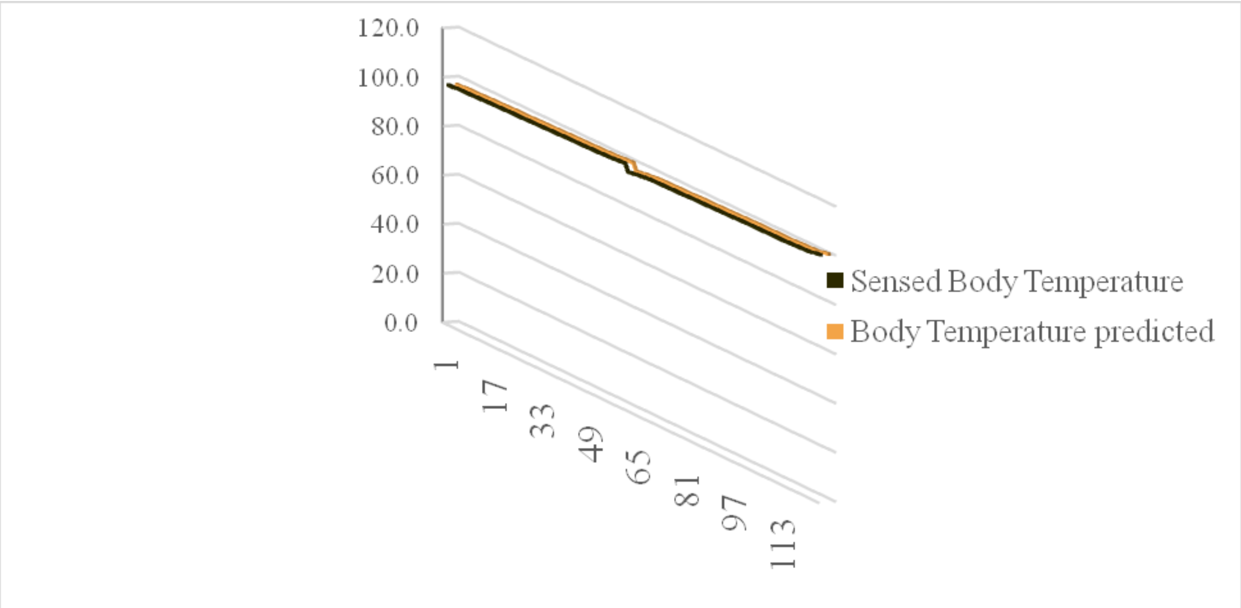

Figure: 8 Comparison of Body Temperature

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PACKET LOSS RATIO

The packet loss ratio is the number of missing packets divided by the total number of packets sent. The fraction of abandoned packets is used to estimate the loss-effectiveness of a planning project due to a timeline violation.

Packet loss ratio = Number of packets received / Number of packet sent.

Figure 8 displays the packet loss ratio, temperature versus of the timestamp in the sensor network. The maximum timestamp is 70.

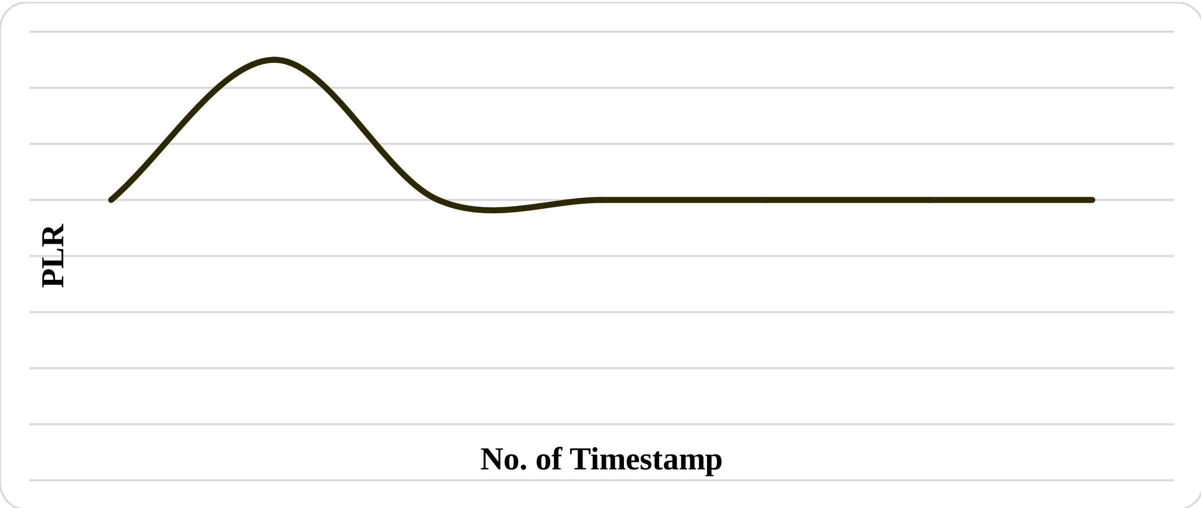

Figure: 9 Packet Loss Ratio

Throughput

Throughput refers to how much data can be transferred from one location to another in a given amount of time. The amount of data that can be sent from source to recipient at a given time is referred to as performance.

Throughput = Number of packets sent / Time Taken.

Figure 9 displays the throughput, body temperature versus of the timestamp in the sensor network. The maximum timestamp is 70.

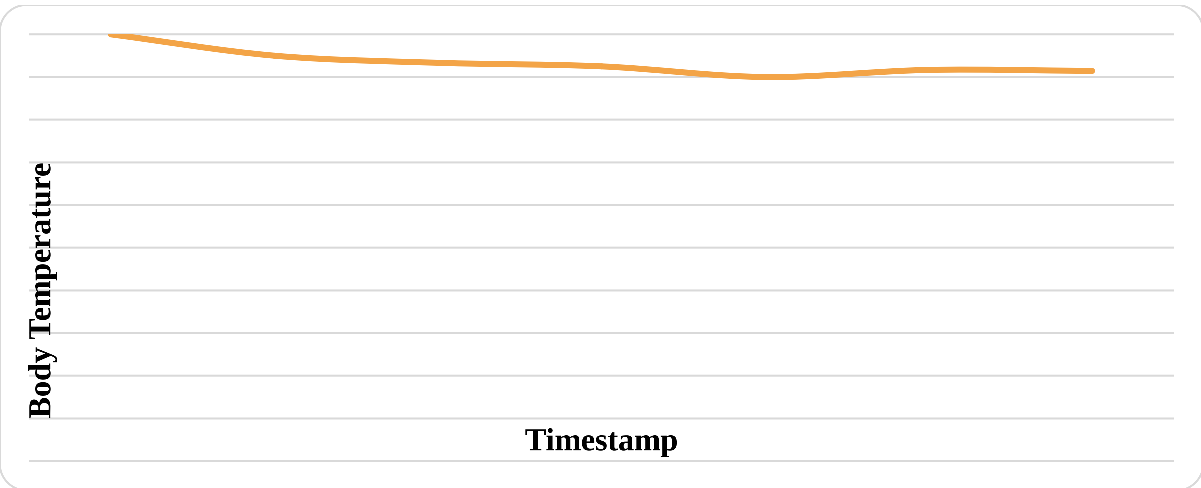

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Figure: 10 Throughput

Probability of loss ratio:

Maximum delay between source and destination.

Table: 6 End- end delays for base station

Probability of data loss	End to End Delay
0.001	0.4039
0.002	0.4079
0.003	0.4119
0.004	0.4159
0.005	0.4199

Table 6 presents the base station, sensor node delay versus probability data loss between the network nodes.

Table 7 End- end delays for sensor node.

Probability of data loss	End to End Delay
0.001	0.6685
0.002	0.6718
0.003	0.6751
0.004	0.6784
0.005	0.6817

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Table 7 presents the base station, sensor node delay versus end to end delay between the network nodes.

CONCLUSION

Energy forecasting approaches that are very complex have been made possible by body area network. LRNN models has been developed for forecasting energy demand, energy consumption and demand prediction models (i.e. ANN, SVM).Forecasting techniques with request management algorithm prove their ability to reduce energy consumption at the sensor node with credible amount. Results conclude that the performance of the LRNN prediction model and the type of data being measured are the main factors of reduce the energy consumption of the sensor node.

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