

# Efficient EER-LEACH Protocol for Monitoring the Activities of Pregnant Women Using Wearable Body Sensor Network

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## Abstract

In health care monitoring framework, it is important to always screen the patient's physiological parameters. For instance, pregnant lady parameters, like, blood pressure, uterine contraction heart rate of pregnant ladies and heart rate alongside the fetal development to detect their wellbeing condition. This paper introduces a monitoring framework that has the capacity to screen physiological changes from the pregnant ladies. In the proposed framework, controller node (CN) has connected on patient body to gather every one of the signs from the uterine contraction monitoring wearable body sensors and sends them to the base station. The appended sensors on patient's body frame a wireless body sensor network (WBSN) and they can detect the uterine constriction, heart rate, blood pressure etc. This framework can recognize the unusual conditions, issue an alert to the patient and send to the doctor. Likewise, the proposed framework comprises of a few relay nodes which are in charge of handing-off the information sent by the controller node (CN) and forward them to the base station. The principle effort of this framework is to diminish the vitality utilization to delay the system lifetime, accelerate and stretch out anticipated work is to expand the sensor execution. This framework is likewise created for multi-patient observing for hospital healthcare and contrasted with the current systems in view of coverage, energy utilization and speed.

**Keywords:** *Wireless body sensor network, blood pressure, energy consumption, end-to-end delay, pregnant woman, uterine contraction.*

## 1. Introduction

Body sensor network frameworks can help individuals by giving healthcare services, for example, memory enhancement, medical monitoring, restorative information access, and correspondence with healthcare provider in emergency circumstances through SMS or GPRS. Continuous health monitoring with clothing-embedded transducers or wearable and implantable body sensor systems will expand identification of emergency conditions in risky patients. The patient, as well as their families will profit by these. Additionally, these frameworks give valuable techniques to remotely gain and screen the physiological signs without the need of intrusion of the patient's normal life, hence enhancing life quality [7].

Even though current frameworks permit nonstop checking of patient imperative signs, these frameworks require the sensors to be set bedside screens or PCs, and limit patient to his bed. Yet, now, there is no connection between the sensors and the bedside gear because of the wireless networks and systems [17]-[18]. These frameworks don't require the patient to be restricted to his bed to move around, however requires specific distance with particular separation from the bedside screen. Out of this range, it isn't conceivable to gather information. Much of the time, monitoring health will be performed by infra-structure oriented wireless networks, for example, business cell/4G systems or remote LANs. The scope of the infrastructure-oriented networks systems changes with time or area. Sometimes, the scope of

wireless system isn't accessible, or the scope is accessible however we can't access to the system because of the absence of accessible transfer speed. Thus, with these issues and confinements, nonstop monitoring isn't conceivable and crisis signs may not be transmitted from a patient to healthcare. Under these conditions, we can reach to constant health monitoring by utilizing ad hoc wireless networks that can transmit fundamental signs over a short range [8].

In a case of the use of this framework is controlling a pregnant lady. A pregnant lady's uterine contraction, blood pressure is same as some other individual's normal blood pressure. It is critical to screen the blood pressure amid pregnancy, to look for preeclampsia. These women require continuous check up [9]-[10]. As anything goes too high, the patient might be hospitalized. In any case, the patient is constrained to her bed in hospital.

In the proposed framework, the patient's physiological signs are obtained by the sensors joined on the patient body, and are then transmitted to the remote base-station and furthermore a PC for analyzing and storing [11]-[12]. Access point signal strength can be debilitated by 30-90% as it goes through the obstructions (for instance, when the two remote devices or relay nodes are in various rooms and the door which interfaces the rooms are shut). With the expanding number of hindrances between the nodes [13], we can watch more packet loss and more latency that will cause a disconnected communication between the patient and the system. In this way, we need to expand the quantity of relay nodes inside the perception conditions, and improve the dependability for remote availability [14]. As well, an emergency alert service utilizing short message service (SMS) messaging is added to the

proposed framework for emergency rescues and responses[16]-[17].

This remainder of the work has been partitioned as follows: section II describes the related constraints associated with pregnancy monitoring WBSN, section III elaborates the proposed work in detail followed by the results and discussion at section IV. The last part is end up with the conclusion and the efficient performance of the proposed work.

## 2. Related Works

Val Jones, [2007] proposed Remote ambulatory monitoring is generally observed as having a key influence in tending impending emergency in health care provision. The [1] author depicts two facts in health care provision, one created in the Netherlands and one in Australia. In the two cases a patient's bio-signals are estimated by methods for body worn sensors which discuss remotely with a handheld device. Bio-signals and alarms can be transmitted over remote correspondence connects to a remote area, and a remote health professional can see the bio-signal information by means of a web application. The clinical reasons for existing are comparable; the innovative methodologies vary in a few regards. We analyze the two methodologies and the experience increased working with various distinctive patient groups and clinical strengths amid preliminaries in Europe and Australia.

Mohammad Abul Kashem et al, [2016] examined diverse hazard factors related to maternal health care during pregnancy, while we studied a few proposed frameworks considering Meta data of the articles, framework, innovation, factors and qualitative attributes [2]. Also, we observed a couple of other well designed examinations with the longitudinal assessment to discover some more fascinating ascribes to be centered around Medical Cyber-Physical-Systems (CPS) based maternal medicinal services tele-observing framework.

Rajneesh Rai, [2016] reasoned that the sole point of completing the outline, investigation and execution of a smart health monitoring device to help pregnant women was accomplished, in that the point was to build up a cheap, moderate, dependable and efficient smart health monitoring system, which was effectively acknowledged toward end of design plan. The entire idea of the framework cuts over the equipment usage and programming execution. The module created a yield that is report of the patient and sent to her Gynecologist also to her guardians, if report demonstrates any anomaly then quickly guardian will ask for the emergency vehicle by giving her correct area taken through GPS to the rescue vehicle and demand them to concede her in the closest hospital. Assume if there will be minor change in report then doctor will send guidance through IOT to the patient [3]. So this device successfully causes the pregnant woman to avoid unsuccessful labour and take healthy diet as recommended by specialist with the goal that she can give a birth to healthy baby [15].

Hisham Allahem, [2017] foreseen that Premature birth is an overall issue that frequently prompts the child's death or life long medical issues. We intend to decrease the issues of untimely births complexities by utilizing WBSNS in our framework configuration to screen the uterine contraction EHG [4]. The author composed a proof-of-idea application to test our proposition. We assessed our proposed framework as far as limits false positive rate, CPU and Memory execution, and power utilization.

Mário W. L. Moreira, [2016] talked about the utilization of a mobile application to help caregivers in pregnancy checking. This framework gets information from body sensors to quantify the circulatory strain, continuously, and together with information gathered by a health care through a proteinuria testing makes the deduction utilizing Bayesian classifier Naïve Bayes [5].

Performance evaluation of this proposed strategy demonstrated that this classifier performed well in forecast with an exactness of

0.8. The technique additionally had a specificity of 0.9444 and sensitivity of 0.4286. The classifier ended up being a good predictor, however more examinations ought to be performed to enhance the exactness of the utilized approach.

Adina Nitulescu, [2015] presents a chance to coordinate observing frameworks and also sending the data into various hospital wards. The system of sensors works as remote cardiocography devices that screens the fetal heart rate and the uterine contractions yet gives the mother mobility and flexibility. This can forestall facilitate inconveniences by getting alerts on threshold and illuminating the specialists progressively about the patient's health. The venture is tried on 10 pregnant lady beginning November 2014 and the outcomes are observed by specialists in the Hospital ObGyn application. The upside of utilizing this framework is that the pregnant lady can screen her infant continuously and furthermore the specialists screen the pregnant women health status [6]. The framework is interfacing with effectively existing frameworks, is a less expensive and more adaptable arrangement than the one with a traditional cardiocography, and it coordinates and screens more indispensable signs.

## 3. Proposed System

In this paper, ubiquitous healthcare model EER-LEACH framework for hospitals is designed. The idea of Ubiquitous healthcare framework is to put subtle remote sensors on pregnant ladies to shape a remote system which can impart the patient's health status with base station associated with the monitoring PC. The framework comprises of four sections:(1) WBSN incorporates four sensors which are responsible gathering the physiological signs from patient, (2) WMHRN (Wireless Multi-Hop Relay Node), comprise of various remote relay nodes which is accountable for sending the health information to the base station, (3) a BS (Base Station) which gets the relayed information and sends it to the PC through a link and (4) and graphical UI (GUI) which is in charge of storing, analyzing and presenting received information, and sending a SMS to the healthcare provider or patient's family in crisis conditions through the GPRS or GSM modem.

### Sensor Functionality

This area depicts about the parts of WBSN and their usefulness.

Sensor nodes: Each node in the system has an alternate part. Every sensors are remote and sense diverse physiological parameters in given interim and at the same time. For instance sensors for pregnant lady can be:

- 1) MEMS acoustic sensor-The uterine contractions contain data with respect to condition of the embryo condition. It is utilized to quantify the uterine contractions and embryo development. The parameters of the MEMS acoustic sensor are explained in table I.

**Table I:** Parameter Description of MEMS Acoustic Sensor

S.No	Parameters	Descriptions
1	Chip size	5 x 5 mm <sup>2</sup>
2	frequency band	31.5Hz to 8 KHz
3	Sensitivity	50mV rms /Pa
4	Linear output	110-160dB's
5	Rim Capacitance	150-160pF
6	Capacitance	115-120pF

- 2) Blood Pressure and Heart Rate: These sensors can return heart rate and blood pressure.
- 3) Heart rate and Movement of fetal: Detection of heart rate and development of fetal utilized by medical specialists to access fetal health.

Collector Node: The coordinator node is a remote node in WBSN which is responsible for gathering and collecting the arrival signal from alternate sensors, and send them to the base station. This

node appends on the patient's body and it works with battery. Every coordinator node is recognized by a novel ID which is utilized to distinguish every patient in the system.  
 GPS: GPS is a space-based satellite route framework that gives information location about the patient in the hospital which serves to hospital staffs to finding the patients in crisis conditions. It is constantly conveyed by the patient as in figure 1.  
 EER-LEACH: The Energy Efficient Routing (EER) LEACH protocol is as well realistic for developing countries as it can be realized over existing wireless infrastructure and offers high network consistency with energy efficiency over cooperation and flexibility. Results illustrate that the anticipated system progresses reliability, Packet Delivery Ratio (PDR), throughput, and energy consumption for scalable and mobile networks over usual BAN protocols. The designed model will decrease the burden on patients to visit the doctor each time for monitoring their health parameters.

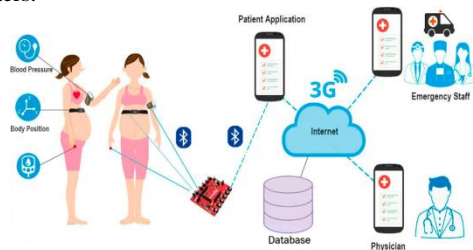


Figure 1: Pictorial representation of the data scenario using WBSN

**Working of the Wearable Body Sensor**

- 1) To measure the blood pressure, uterine contraction the patient ought to be situated or lying. In this way, these sensors can identify patient's position. If the patient is set in a proper position, the movement sensors by sending a DATA\_START packet will enable different sensors to detect as in figure 2.
- 2) To decrease energy utilization, every one of the sensors wake up at the same time and wait for a predefined time until the point they get DATA\_START packet. if they get it, they will send their readings to collector node.
- 3) If each example of information, (for example, uterine contraction, pulse, BP and so forth.) is instantly epitomized into an edge and transmits, the overhead will be expanded and will cause excessive energy utilization. Along these lines to diminish the overhead, these works have utilized the burst transmission EER-LEACH convention. Along these lines, we accomplish more energy conversion.

Sensor Node	↑↑	↑↑	↑↑	↑↑
Uterine contraction				
BP				
Fetal motion				
Heart rate				

Figure 2: Burst transmission of the proposed EER-LEACH protocol

An Energy Efficient Routing protocol aimed at reducing the network traffic and the energy consumption, based on both centralized and distributed approaches. It is intended to exhibit the patients' real-time information within a hospital. The energy efficiency is accomplished by calculating the broadcasting method of hello packets. At the similar time the assortment of subsequent hop node is sourced on the above mentioned device kinds, residual energy and geographic data of the neighbour. In this design we used the RTS/CTS (Ready to Send/Clear to send). When a collector node wants to send data to a relay node first it will check the transmission channel. If the channel is free then the relay node will send a CTS packet to the collector node. This EER-LEACH protocol allows multiple collector nodes to reliably transmit their data to a relay node without any significant delay.

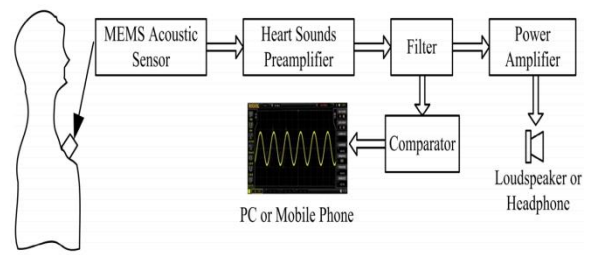


Figure 3: Block diagram of the proposed work

**Modelling of the Proposed Work**

Routing has the ability to exchange physiological signs, for example, uterine contraction, pulse, BP, and other biomedical signs to the base station or to encompassing other relay nodes. As contrasted and the coordinator node, the power can be provided from the battery or a connector.  
 The task of the proposed framework can be separated into two stages as in figure 3. The principal stage is finding the minimum path from collector node to the base station. The second stage is the information transmission stage through the base way. By these nodes and the primary stage, the end to-end delay will be diminished. "End to-End" delay points to the time taken for a packet to be transmitted over a system from source to destination. By diminishing the end to end delay, the speed will be expanded. At the point when the speed is high, framework can recognize unusual physiological factors and issue alert quickly. Additionally, a few nodes can diminish the delay and expand the patient's health condition. Accordingly, patient signal can be gotten to anyplace of hospital with no disconnection amongst patients and the system and any impediment for patient development.

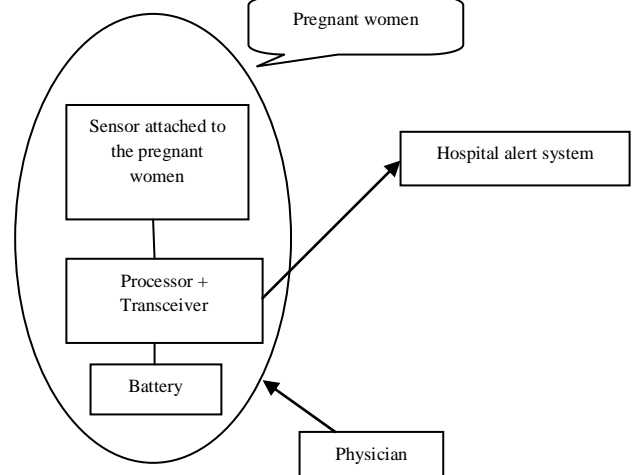


Figure 4: Proposed alert system in pregnant women

To locate minimum path, we have proposed an EER-LEACH protocol in view of finding the shortest path. The main stage starts with sending shortest path for transmission (SPT) packet from the BS. SPT attempts to discover least way. At the point, when a node gets a SPT, it checks hop count. If hop count is lesser than the previous hop counts' SPT, it will record packet to its route table. At that point, the node adds its ID to "node ID" field and afterward sends it to its neighbours. After a predefined time, the minimum path from nodes to BS will be found and every node restores a SPT\_END packet which is like SPT and sends the packets to BS through the path in their route table. When a node gets a SPT\_END, it records the ID in its route table. In this way, the minimum path from the BS to nodes will be resolved. The second stage begins with broadcasting a BROAD\_MODE packet in the system from the BS. When the coordinator node gets this packet, it can transmit data packet into the system.

**Algorithm for Data Transmission**

After receiving SPT packet, check the transmission  
 If (current hop count > previous hop count)  
 Drop the current packet  
 Else If (current hop count < previous hop count)  
 Maintain in routing table.  
 Increase hops count by 1.  
 Add ID to Next Hop  
 Send it to neighbours.  
 Else IF( the timer is expired)  
 Send SPT\_END to BS

**Hospital Alert System**

The remote PC gets continuous patient's information from the base station and processes them to recognize anomalies. The GUI enables clients to see history of therapeutic data [19] and current essential signs progressively as in figure 4. By recognition a caution, a SMS/E-mail will be sent to the patient's family or the medicinal services supplier through the GSM modem/GPRS. The alert strategies are given in table II.

**Table II:** Various Alert Types of the Pregnant Women and the Fetal

S.No	Alert type	Detection parameter
1	Maximum heart beat of pregnant women	>100 bpm
2	Minimum heart beat of pregnant women	<80 bpm
3	Maximum heart beat of fetal	> 110 bpm
4	Minimum heart beat of fetal	< 100 bpm
5	BP	>138/90 (sys/dia)

A GSM modem is a specialized type of modem which eliminates traffic during data transmission. When a coordinator node wants to send data to a relay node first it will check the transmission channel. If the channel is free then the relay node will send a CTS packet to the coordinator node. This simple EER-LEACH protocol allows multiple controller nodes to reliably transmit their data to a relay node without any significant delay.

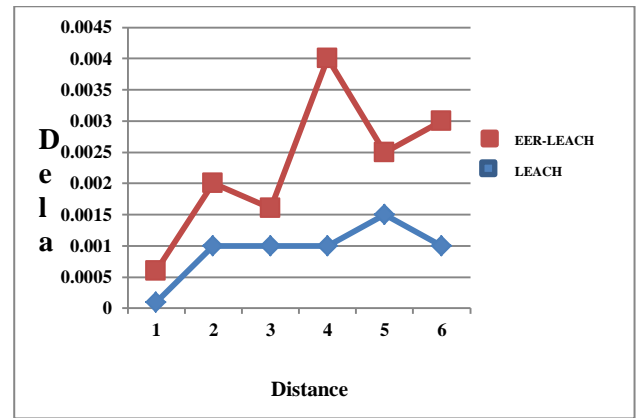
A GSM modem is a particular kind of modem which avoids traffic amid information transmission. At the point, when a controller node needs to send information to relay node first it will check the transmission channel. If the channel is free then the relay node will send a CTS packet to coordinator node. This basic EER-LEACH protocol enables different controller nodes to dependably transmit their information to relay node immediately.

**4. Results and Discussion**

The previous segment gave comprehensive schema of our anticipated WBSN. One approach to examine the execution of WBSN framework is to quantify the end to-end delay, energy utilization, coverage range. Hence, the proposed framework is simulated in NS2 and the outcomes are appeared and clarified as takes follows.

**Coverage Range**

Because of utilization of a few relay nodes in the environment, it isn't required to utilize high frequency band. So, the information is transmitted through the controller node and remote relay nodes with least energy utilization. As needs be, to cover a hospital with 50 m×20 m measurements devoid of obstructions in it, for example, walls and doors, roughly 14 relay nodes are needed. Hence, there isn't any delay in this condition. Though, with a few obstacles in transit of signs to anticipate of weakening sign and loss signals more relay nodes are needed.



**Figure 5:** Graphical delay computation of proposed EER-LEACH with existing LEACH

Figure 5 illustrates the delay computation of the proposed EER-LEACH with the existing LEACH protocol. The proposed work shows better trade off compared to the existing method. The delay over transmitting the data to the remote system has been reduced.

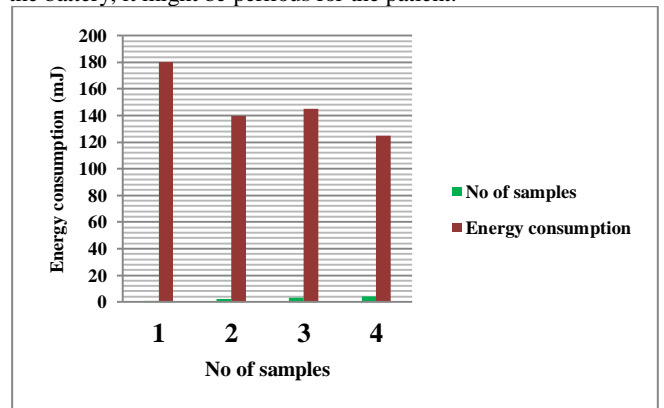
**Table III:** Comparison of Existing Versus Proposed Method

S.No	Distance (m)	Delay (LEACH)	Delay (EER-LEACH)
1	1	0.0005	0.0001
2	2	0.002	0.001
3	3	0.0015	0.001
4	4	0.004	0.001
5	5	0.0025	0.0015
6	6	0.003	0.001

Table III explains the comparison of existing LEACH with the proposed EER-LEACH. The delay can be measured in various distance of 1, 2, 3 and so on. The delay of LEACH and EER-LEACH with respective to the distance are 0.0005, 0.002, 0.0015 and 0.001 correspondingly.

**Energy Consumption**

There is a connection between energy consumption and lifetime of the system. A confront of WBSN is patient quality of life amid the observing. In this way, the quality is provided by lessening energy utilization in coordinator node. It has an essential part in the system, for example, data packaging, aggregation of sensory data and transmitting them to the base station. Subsequently, the lifetime of controller node must be dragged out. If lifetime is short, the patient needs to energize the battery of controller node in short interims as in figure 6, and if the patient neglect to revive the battery, it might be perilous for the patient.



**Figure 6:** Energy consumption in various scenarios

If every sample of information from the sensors is instantly encapsulated into a frame and transmitted, the energy utilization will be expanded. Accordingly, the burst transmission instrument is utilized.

Assuming collector node's battery is 5000 mJ and the interim of data transmission is at one time each thirty minutes. In ordinary case, the battery can keep on working for three days. In some case, in burst transmission, the battery lifetime will be moved up to 9 days.

### End-to-End Delay

When delay is high, it appears the speed is low. Usual signs are analyzed late and this could be extremely hazardous for the patients with blood pressure. Because of the critical application, it needs an acknowledgement (ACK) for every datum packet. There are two situations for ACK delivery. In the primary situation, when the BS gets a data packet, it will restore an ACK to the controller hub. In the second situation, when each intermediate node gets data packet, it will restore an ACK to the sender.[20]

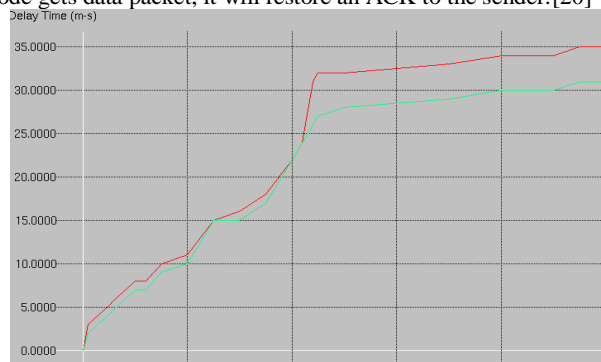


Figure 7: Pictorial representation of end-to-end delay computation

However, end-to-end delay and energy utilization in coordinator node will be diminished in the second situation. Then again, the connection between distance (no. of jumps) and the end to-end defer when a packet becomes mixed up in the way and the controller node needs to retransmit the data packet.[21]

## 5. Conclusion

Wireless BSN innovation is raising as a huge component of next generation health care services. In this paper, we proposed a mobile physiological monitoring framework, which can persistently screen the patient's heart beat, blood pressure and other basic parameters in hospital. The whole framework comprises of controller node to gain the patient's physiological information, a WMHRN to forward the information and a BS to gather the information. The framework can do a long-term observing on patient's condition and is furnished with an emergency rescue mechanism utilizing SMS/E-mail.

Likewise, the work has been simulated in NS2 test system and have contrasted this and existing WBSN frameworks in terms of coverage, energy utilization and delay time and the proposed framework has been sensed and shows better execution over others existing WBSN frameworks.

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