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IMPACT OF COST FUNCTION ON MINIMIZING THE IMPACT OF PATH LOSS IN INTERNET OF MEDICAL THINGS

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Article Info

Abstract

Internet of Medical Things is the field dealing with human health monitoring on regular basis. That makes it a well worthy field. Sensors are used to physiological monitor the vital signs. The sensors are small in size and in order to let them work continuously for larger span of time they must enable to work efficiently. In Internet of Medical Things energy efficiency is considered a critical factor because of wireless communication networks. Path loss reduces the signal strength so minimizing path loss plays an important role in terms of power consumption in IoMT. This papers enhances using of Cost Function to efficiently mitigate path loss effects on wireless communication. Using Cost Function enables load balancing in the IoMT routing system so that the transmission becomes efficient and the protocol may have longer span of time.

Keywords:
Internet of Medical Things; Path Loss; Energy Efficiency

Introduction

Due to developments in Information and Communication Technology (ICT) communication has become easier like wireless communications. Wireless communication enables to send or receive data between devices without the usage of wires. This make less complication while communication. Large devices are not that portable enough to be carried around for some time. This is a disadvantage. Nano Electro Mechanical Systems (NEMS) and also Micro Electro Mechanical Systems (MEMS) have enabled tiny devices to be able to perform tasks that other devices can perform but they have the advantage of small in size. The combination of small size in NEMS / MEMS with wireless communication is so powerful that these devices can be used anywhere depending on the applications [1]. Health care sector is one of the major areas in which development is needed to be carried. If a patient has to opt for regular checkup then there is a need to visit doctor clinic or a hospital [2]. May be staying is needed. In both the cases patient has to suffer and wait for the turn. This is the conventional method which is not a good method. Internet of Things (IoT) has its sub field as Internet of Medical Things (IoMT) sometimes known as Internet of Health Things (IoHT) which deals with the betterment of human health care. IoMT deals with sensors that are capable of physiological monitoring of human vital signs on regular basis. The architecture of IoMT is represented in figure 1

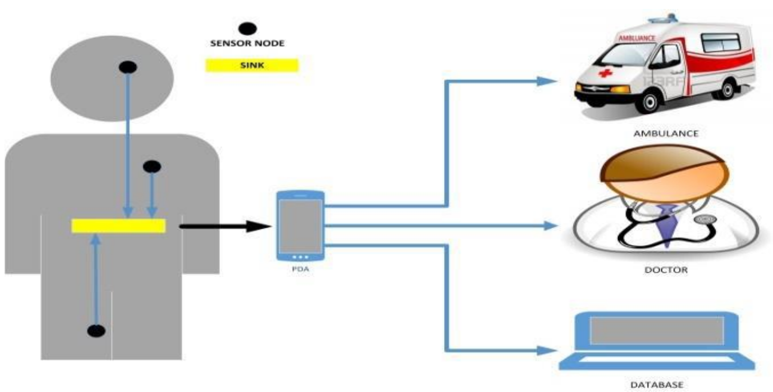

Figure 1: IoMT Architecture

In figure 1 a dummy can be observed with black round circles. They are representing sensor that are monitoring human parameters. A rectangular box is shown named as sink. Sink is a device that is responsible of collecting data from the sensors used [3]. The sink after collecting data from the sensors sends / transmits to other device which is termed as Personal Digital Assistant (PDA). PDA is responsible of collecting data from the sink and then transmits the data towards the destinations like the personal file of the patient i.e. the database for record keeping. If the data is critical based on the observance of the sensors then the PDA send the information to the ambulance services so that it arrives and the same information is sent to the doctor so that the system is made ready for any urgent requirements [4].

The sensor used in IoMT are classified into two categories as either: In - Body Sensors (IBS) or out – body Sensors (OBS) which are represented in detail in table 1:

Table 1: Sensor Categorization

Sensor Type	Sensors
In – Body Sensors	Deep brain stimulator
	Wireless capsule endoscope (electronic pill)
	Retina implants
	Pacemaker
On – Body sensors	Oxygen
	Blood pressure
	Pulse Oximeter
	Temperature
	Electro Encephalo Gram (EEG)
	Electro Myo Graphy (EMG)
	Glucose sensor
	Electro Cardio Gram (ECG)

From table 1 it can be seen that the sensors like Electro Encephalo Gram (EEG). Electro Myo Graphy (EMG) and Electro Cardio Gram (ECG) are the ones which seem familiar. If a patient os going through brain disorder, heart disease or motion problem then EEG, ECG and EMG sensors are used respectively to record their activities.

As these sensors are small in size then for sure they will have some limitations. The main advantage is their size but at the same time this advantage has some disadvantages as well. The battery to be used in these tint devices will be small also. Smaller battery size will result in smaller life span of the sensors. If the battery totally drains out then that needs to be recharged. Recharging a sensor or to replace the drained battery by new charged battery are the options. These option are good but when the scenario changes from a normal sensor to a sensor that is on human body then to take it out and recharge looks inconvenient. So the best option for them is to make sure that these sensors work for longer span of time. In this paper a Cost Function (CF) is proposed to be used to select energy efficient path for Internet of Medical Thing routing Protocol to overcome the issue of increasing life span. Path loss comparison is performed between proposed techniques with already existing schemes to see the impact of path loss on IoMT energy efficiency.

LITERATURE REVIEW.

In paper [5] the researchers propose a technique to make Wireless Body area Network (WBAN) energy efficient. Their proposed system tries to decrease bit error rate (BER) and delay with increasing life span of the network in total. Their proposed system is named as “Energy-Efficient Adaptive Routing Technique (EEART)”. This systems is able to perform optimization, scheduling as well as clustering by using Glowworm Swarm Optimization (GSO) technique. This works in clusters and in every cluster there is a Cluster Head (CH). Based on the remaining battery energy the load is distributed so that the network becomes effective.

In [6] the authors have proposed a technique for IoMT devices based on dynamic routing. Their proposed system connects devices categorized as ex vivo and in vivo with a sink. Their work focuses majorly on resolving energy drain problem and thermal problem. Thermal problem is the heating effect of the devices used on human body as they keep on working continuously.

Navneet Kaur in [7] have proposed the usage of two protocols together. The names of the protocols used in their research are named as “Optimized Cost Effective and Energy Efficient Routing (OCER) protocol” and “Extended – OCER (E-OCER)”. OCER works by implementing Genetic Algorithm (GA) for optimization. It also utilizes Cost Function (CF). The CF is multi-purpose linked with parameters like path loss, link reliability and residual energy. These all parameters are used by the CF to select optimized route of data transmission when the data is being sent from body sensor node to sink node.

SIMULATION PARAMETERS

In this section the parameters used for simulation are discussed in detail

PATH LOSS

Path loss (PL) is a parameter that refers to the reduction in the strength of the data signal. As the signal propagates through different mediums once transmitted from transmitter towards the receiver. It effects the wireless transmission performance. Path loss majorly depends on the communication distance means the distance between sender sensor and receiver sensor. If distance is increased then it will also increase. Its unit is decibels (dB) and is mathematically represented as

$$PL_{(f,d)} = PL_o + \left(10 \times n \times log_{10} \times \frac{d}{d_o}\right) + s$$

$PL_{(f,d)}$ = Path loss at frequency f and distance d

PL_o = Reference Path loss at reference distance

n = Path loss exponent which varies on surrounding environment

d = Distance from transmitter end to receiver end

d_o = Reference distance

s = It represents any attenuation or any shadowing effect existing that has been caused some environmental problem or obstacles

SENSOR NODE

The sensor node selected for the proposed scenario is nRF2401A. It is much more preferred sensor node used in Internet of Medical Things because of its low energy consumption. Table 2 depicts the parameters of the nRF2401A sensor in detail

Table 2: nRF2401A Parameters

Feature	nRF2401A
Frequency Range	2.4 GHz ISM
Data Rate	1 Mbps
Output Power	-18 to 0 dBm
Receiving Current Consumption	19 milli Ampere (mA)
Transmission Current Consumption	10.5 mA at 0 dBm
Voltage Range	1.9V to 3.6V
Temperature of Operating	-40°C to +85°C
Antenna Type	Integrated or External
Range	50-100 meters Line of Sight (LoS)
Network Topology	Point – to – Point (P2P), Star
Price	Low – cost

SENSOR NODE ENERGY CONSUMPTION

The energy of a sensor node used in IoMT is represented by equation given below

$$S(i).E = S(i).E - \Delta E$$

The value of i is integer value and represents the sensor number.

$S(i).E$ is the energy of any sensor

ΔE is the change in energy levels

Now the energy level of a sensor is calculated at start of every round. So change is calculated because sensor losses its energy at every single round.

COST FUNCTION

In this paper a Cost Function (CF) is proposed to be used. It is proposed to be used to achieve optimal performance. CF is a mathematical function. It is used to measure cost that is associated with parameters. In the proposed system, CF is linked with sensor nodes and their efficiency. This efficiency is for a sensor node for being selected as Forwarder Node (FN). The FN collects data from neighbor source sensor nodes and after that passes to next sensor node for completion of the transmission. This is a process of relaying which is performed by the forwarder node. This relaying process continues until he data reaches its destination.

The cost function of any i^{th} sensor node can be calculated as

$$Cost\ Function_i = \frac{distance_i}{S(i).E}$$

$S(i).E$ = Energy of the i^{th} node

$distance_i$ = Distance corresponding to the i^{th} node

SIMULATION RESULTS

X – Axis Description

Rounds, r: It is the representation of the number of rounds in the communication process which extend from 0 to a maximum value of 8000.

Y – Axis Description

Path Loss, dB: It is the path loss in decibels (dB). It measure attenuation of the signal over distance.

The values of path loss are set from 0 dB to a maximum value of 450 dB. The graph in figure 2 illustrates simulation result of the proposed scenario named as IOMT RP (depicted in red) and the existing scenario EERP1 (depicted in blue). The variation of Path Loss (dB) is represented between numbers of Rounds (r). In the figure it can be observed hat how both the scenarios behave over the time. At start of the simulation both protocols start with high values of path loss but over the time, the path loss decreases as the number of rounds increase. When the path loss means the network has ended.

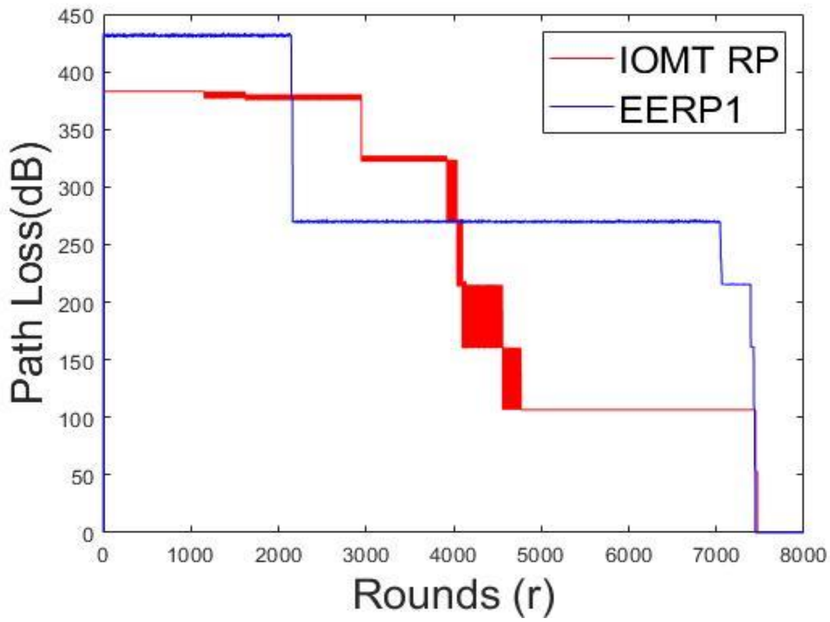

Figure 2 : Simulation Result 1

In figure 3 both protocols start with having high path loss of around 400 dB in the early rounds. This indicates that at initial stages energy consumption is intensive. EERP2 maintains stable path loss during the early stages, while the proposed IoMT RP begins showing gradual reductions. The proposed IoMT RP shows decrease in path loss over the passage of time, especially between round numbers 3000 to 5000. This reduction in path loss means that the path selection is optimized and adaptive resulting in energy efficiency

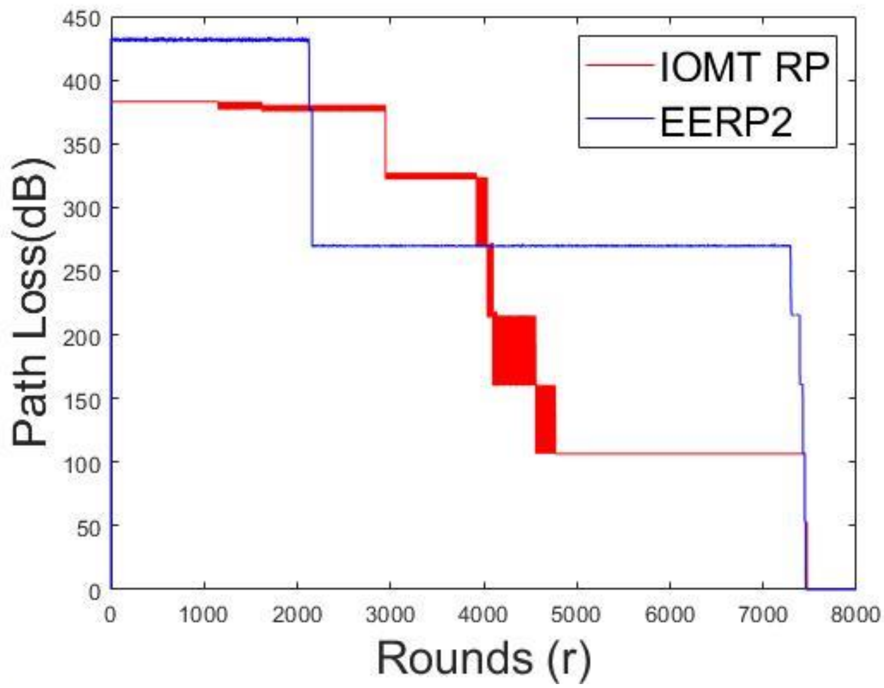

Figure 3: Simulation Result 2

Table 3 presents details of the analysis based on the results of the simulation. In the table it is given that the proposed routing technique compared with the existing scheme in terms of number of rounds.

Table 2: Comparative Analysis

Protocols	Number of Rounds							
	Sensor Node 1	Sensor Node 2	Sensor Node 3	Sensor Node 4	Sensor Node 5	Sensor Node 6	Sensor Node 7	Sensor Node 8
EERP 1 [8]	2148	2160	2162	7059	7427	7430	7444	7445
EERP 2 [9]	2161	2162	2163	7066	7157	7439	7484	7486
IOMT RP	4221	4664	5788	5997	6525	7006	7452	7630

In EERP 1 technique where sensor nodes survive for a fluctuating number of rounds. Sensor Node 1, 2 and 3 last around 2148 – 2162 rounds. Sensor Node 4 to Node 8 show significantly higher survival as they range from 7059 to 7445. In EERP 2 technique is slightly improved version in terms of energy efficiency over EERP 1. The survival of Sensor Nodes 1 – 3 increase marginally from 2161 – 2163 rounds. This indicate better load balancing in early stages of routing. In last stages of the network performance improvement is also observed as compared to EERP1. The proposed IoMT RP demonstrates significantly better performance as compared to both the techniques. With nodes surviving for a much higher number of rounds. The Sensor Node 1 is the one with lowest survival, lasting up to 4221 rounds. This durati0on is double of the duration of both the techniques with which it is compared. The Sensor Node 8 has the highest life span of surviving up to 7630 rounds. This shows better energy balancing between the sensors. This shows better performance in optimized energy efficiency system to be used in IoMT.

CONCLUSION

The proposed IoMT RP outperforms both EERP 1 and EERP 2, as it enables nodes to operate for a longer life span and hence enhancing network longevity. Sensor nodes in used in the proposed IoMT RP have a more even energy distribution, making it a better option of adaptability in medical applications that require prolonged operations continuously. This is achieved by energy balancing in data transmission. This balancing was made possible by using cost function which selects the forwarder sensor node. This forwarder has higher energy level as compared to other sensor node so that other sensor node s may not deplete their energy quickly.

ABBREVIATIONS

BER	Bit Error Rate
CH	Cluster Head
dB	decibel

E – OCER	Extended – OCER
ECG	Electro Cardio Gram
EEART	Energy – Efficient Adaptive Routing Technique
EEG	Electro Encephalo Gram
EMG	Electro Myo Graphy
GA	Genetic Algorithm
GHz	Giga Hertz
GSO	Glowworm Swarm Optimization
IBS	In Body Sensor
ICT	Information and Communication Technology
IoHT	Internet of Health Things
IoMT	Internet of Medical Things
IoT	Internet of Things
ISM	Industrial, Scientific, and Medical
MEMS	Micro Electro Mechanical Sys
NEMS	Nano Electro Mechanical Systems
OBS	On Body Sensor
OCER	Optimized Cost Effective and Energy Efficient Routing
P2P	Point – to – Point
PDA	Personal Digital Assistant
PL	Path loss
WBAN	Wireless Body area Network

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