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EFFECTIVENESS OF TRANSPOSITION ON THE THROUGHPUT IN INTERNET OF MEDICAL THINGS ROUTING PROTOCOL MANAGEMENT

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ABSTRACT

The Internet of Medical Things (IoMT) is a rapidly growing field aimed at improving human health through the integration of smart medical devices and sensors. These specialized sensors are designed to be compact, offering the advantage of portability and ease of integration with the human body. However, their small size also presents a limitation—restricted battery capacity, which impacts their operational lifespan. To address this challenge, ongoing research focuses on enhancing the efficiency and longevity of such devices. This study proposes a transposition-based routing protocol for IoMT networks to improve data transmission efficiency and overall network performance. Using MATLAB as the simulation platform, the proposed model involves a network of eight sensors and one sink node. The sink node is dynamically repositioned to optimize packet reception and enhance communication reliability.

Keywords: IoMT, Sensors, Energy, Throughput, Stability

I. INTRODUCTION

In past few years Information and Communication Technology (ICT) has gained much more advancements new fields of technologies have been developed. ICT development comprises of increase of usage of internet. Approximately 5.56 billion persons are reported to be using internet all round the world. This number is 67.9 percent of entire world's population [1]. It has been witnessed that electronic devices have also developed a lot [2]. Devices have been designed with small in size but capabilities of large sized device. These devices are known as Nano Electro Mechanical Systems (NEMS) [3]. The combination of NEMS and ICT have led to development of small sized intelligent devices called sensors. Internet of Things (IoT) is the field in which these sensors are used for observing parameters [4]. These sensors are interconnected with each other through internet. These sensors after recording data send it to other devices for further processing. Internet of Medical Things (IoMT) is specialized field of IoT that deals with human health care. It consists of the sensors that are used for recording changes in human physiological parameters. The sensors which are used in IoMT can be either implantable or external. Table 1 is representing types of IoMT sensors [5]

Table 1.
IoMT Sensors

Category of Sensor	Examples
In Body Sensors	Endoscopy Sensor Pacemaker Sensor pH monitoring Electrochemical Sensors
On Body Sensors	SpO_2 Sensor Glucose Level (GL) Sensor Galvanic Skin Response (GSR) Sensor / Electro Dermal Activity (EDA) Sensor Photo Plethysmo Graphy (PPG)

These sensors are placed in or on human body for measuring physiological parameters. Figure 1 shows human body on which various different location. In figure 1 it can be observed that pressure sensor, blood oxygen sensor, glucose sensor, ECG, EPG and EEG etc. are used. Round circles are representing sensors. It can be observed that sensors used on human body are multiple meaning that multiple sensing is happening simultaneously. In a conventional method only one parameter is being tested and observed at a time but in IoMT multiple sensing is allowed. To coordinate the data recorded by these sensors there is one device known as the sink. The sink is represented by the rectangular block on human body in figure 1. The sink collects data from sensors. It is responsible for it. The collected data needs to be transmitted to other entities for further process.

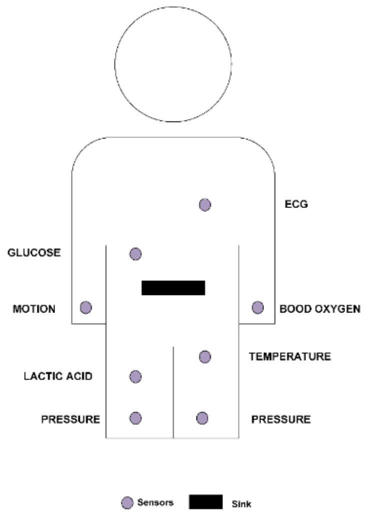

Figure 1: Sensor positioning

The working mechanism of the IoMT is represented in figure 2. As represented in figure 2 the human physiological parameters are recorded by the sensors placed on human body. The data is being transmitted to the sink.

Now as shown in figure 2 the sink is responsible to send the received data to database (record keeping), doctor (for observation), remote monitoring (by loved ones to monitor the patient from the location they are), drug intake monitoring and tracking / monitoring of the equipment so that they are working fine. It is responsible of performing local aggregation, preprocessing, and security i.e. authentication and / or encryption.

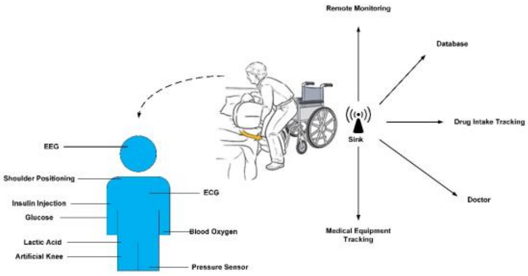

Figure 2: IoMT working mechanism

These sensors are small in size prioritizing them to be used in IoMT but on the same time this size provides some restrictions in a way that they will contain small sized batteries. Researches are being performed to make these batteries work for longer duration of time. Specialized routing protocols are designed so that these sensors may communicate with each other as well as with the sink for in a way that their battery life is extended.

II. LITERATURE REVIEW

Researchers in [5] propose a strategy based on access resource allocation which is able to apply game theory. In their proposed technique the model of Wireless Body Area Network (WBAN) is based on multi person multi point technique that is applied on physiological environments. Energy consumption control and access allocation strategy based on mutual matching technique has been proposed to be used to adapt standards of network. The number of access points, number of sensors used, period of iteration, energy that has been consumed by their system are the factor on which performance is evaluated using the correlation.

For IoMT researchers in [6] have proposed Intelligent Intrusion Detection System (IIDS) that takes maximum benefit from Machine Learning (ML). K – Nearest Neighbors (KNN), Gradient Boosting (GB), Decision Tree (DT) and Random Forest (RF) are the algorithms that have been used in their method so their model. They have evaluated their proposed method on the basis of False Negative Rate (FNR), True Negative Rate (TNR), False Positive Rate (FPR), True Positive Rate (TPR), F1 – Score, precision and accuracy.

A Key Agreement Scheme (KAS) has been proposed with 3 factors of security. The security factors are: sensing device, medical server and user in [7]. In IoMT for a random number of co – primes the proposed scheme is based on Chinese Remainder Theorem (CRT). They have proposed using Automated Validation of Internet Security Protocols and Applications (AVISPA) to validate their results in terms of security threats. For computational security Real – Or – Random (ROR) model has been used.

Forwarder Node (FN) has been proposed to be used in the technique provided by researchers in [3]. FN is selected on the basis of remaining energy of the sensors. It is calculated by making one of the sensor as Cluster Head (CH). Once the CH is selected the multi hopping uses this CH as its FN. In this way the energy usage of the sensors is optimized hence making the proposed scenario as the efficient routing method to be preferred in IoMT.

Algorithm named as Levy Flight and Frilled Lizard Optimization (LF2ZO) has been proposed in [8]. The stages of exploration are enhanced of the Frilled Lizard Optimization (FLO) are enhanced by Levy Flight (LF). The strategy help in energy optimization of the routing system. The desired number of clusters, Euclidian distance, Murkowski distance have been used with Dynamic Self – executing Active Cross – propagated (DSAC) method for the formation of cluster. Momentum Sparrow Search (MSS) method has been used with residual energy and connectivity for selecting cluster head (CH). Within intra – clustering and inter – clustering energy and number of transmission cycles are reduced by the accurate selection of the CH.

Issues like exploitation of authentication method, unauthorized access to IoMT devices, quantum attacks, cyber – attacks, vulnerability of patient data have been considered to be addressed in [9]. The have proposed a protocol which is quantum resistance which is able protect privacy of data in Digital Twins (DTs) enabled IoT health care application. They have proposed this to ensure protection of medical devices, long term data confidentiality, patient trust and transmission security. To overcome these challenges Ring Learning with Errors (RLWE) problem based on Lattice – based Cryptographic method has been employed.

III. THROUGHPUT

In IoMT, throughput refers to as the rate at which packets of data are delivered in a communication network successfully. It is very important and significant performance metric that is used to evaluate the efficiency as well as the reliability of data transmission from IoMT devices. The IoMT devices are sensors connected to a central node or sink (like a cloud server or base station). The throughput can be calculated through formula given as:

$$Throughput = \frac{Total\ data\ transmitted}{Total\ time} \quad (1)$$

IV. SELECTION OF IOMT SENSOR

In the proposed method it is proposed to use nRF2401A. The reason are its cost as it is low in cost which makes it budget friendly. It has robust packet handling capabilities. It has lightweight Micro Controller Unit (MCU) stack. These features help developing IoMT network.

Table 2 represents characteristics of nRF2401A sensor

Table 2

nRF2401 parameters

Parameter	Typical Value
Supply Voltage	1.9 V to 3.6 V
Receive Current	Approximately 12 mA
Transmission Current	17 mA

V. SENSOR POSITIONING

The proposed scheme is assumed to have 8 sensors. These sensors are placed on human body in Cartesian coordinate system as represented in table 3. The reason of using 8 sensors is take proper comparison with the existing scheme. The sensor positioning is based on Euclidean distance measurement. The transposition is performed in such a way that sensor may have minimal distance from the sink. Transposition is a term that refers to the strategic relocation or repositioning of the sensor node to optimize network performance. This dynamic adjustment is done based on the real time or semi static topology of sensor nodes, aiming to reduce communication distance and improve energy efficiency. It differs from conventional methods in terms of computational complexity. It is focused on reducing distance while others may involve complex clustering and multi-hop energy balancing.

Table 3

Sensor Coordinates

Sensor Node	X / Y Coordinate Value
Sensor Node 1	370 mm / 100 mm
Sensor Node 2	540 mm / 300 mm
Sensor Node 3	370 mm / 550 mm
Sensor Node 4	530 mm / 550 mm
Sensor Node 5	600 mm / 750 mm
Sensor Node 6	220 mm / 900 mm
Sensor Node 7	240 mm / 700 mm
Sensor Node 8	500 mm / 800 mm

VI. SIMULATION STRUCTURE

Simulations were conducted using MATLAB.
Number of nodes: 8
Initial energy: 0.5J per node
Sink location: Center
Packet size: 4000 bits
Simulation rounds: up to 8000

The proposed IoMT RP system structure has the following layers:
Sensing Layer: This layer includes low-power medical sensor nodes and in this layer the data is periodically sensed and queued for transmission.
Network Layer: It is responsible for functions like implementing the proposed IoMT RP, based on energy levels selecting optimal routing paths and hop count.
Sink Node: It acts as receiver that is central for all sensed data and processing unit and has more energy as compared to other sensors and has capabilities to compute data.

VII. SIMULATION RESULTS

In figure 3 is the comparison of the proposed technique (named as IoMT RP) has been presented and compared. In figure 3 it is depicted that in the proposed method overall number of packets to reach at the sink node successfully is greater than that of EERP1 [10]. The graph in the figure shows a comparison between the two protocols: proposed IOMT RP (represented by a red solid line) and EERP1 [10] (illustrated as blue dashed line), based on packets received at the sink over a number of rounds (r). In the figure X – axis symbolizes the progression of time or iterations in a communication process and Y – axis indicates throughput at the sink node, which is scaled by $\times 10^4$ times. At initial stages of the simulation both the protocols perform similarly. But as the number of rounds increase, the proposed method starts outperforming EERP1 [10] significantly. Nearly around 6000 rounds, the throughput (packet delivery rate) of IOMT RP change slightly, while EERP1 [10] continues a slower but steady increase. By the end of the simulation (8000 rounds), IOMT RP is able to deliver noticeably more packets than EERP1 [10].

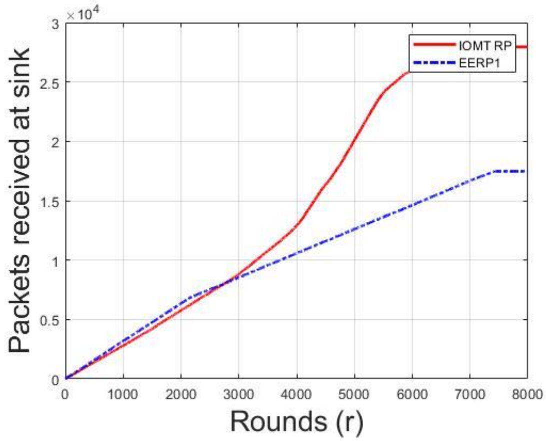

Figure 3: Proposed IoMT RP with EERP1

Table 4 provides a total final comparison values of both the schemes. From table 4 EERP1 [10] successfully delivered 17,440 packets, which indicates a moderate performance while the Proposed IOMT RP delivered 28,090 packets, showing a significantly higher throughput

Table 4
Packets Received Comparison

Routing Protocol	Packets Received
EERP 1 [10]	17440
PROPOSED IOMT RP	28090

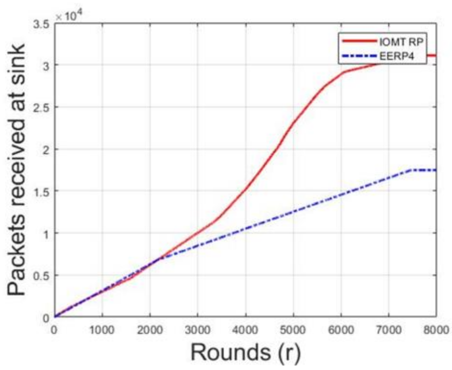

Figure 4: Proposed IoMT RP with EERP4

Table 5 provides a total final comparison values of both the schemes. From table 5 EERP4 [11] successfully delivered 18,000 packets, which indicates a moderate performance while the Proposed IOMT RP delivered 32,000 packets, showing a significantly higher throughput

Table 5
Packets Received Comparison

Routing Protocol	Packets Received
EERP 4 [11]	18000
PROPOSED IOMT RP	32000

VIII. CONCLUSION

In this paper, a transposition based routing technique was introduced and proposed to be used in Internet of Medical Things (IoMT) routing protocols. The main idea behind proposing this technique is to dynamically reposition sink node so that average distance between sensors and the sink is reduced. This optimizes communication paths. By minimizing these distances, the proposed scheme enhances network performance significantly in terms of packet delivery ratio and overall throughput. Results of simulation demonstrate that the transposition approach outperforms conventional static routing schemes, making the system more reliable and energy efficient. The improvement in energy consumption is particularly critical in IoMT applications, where sensor nodes are typically limited in power as well as in size. The reduced communication distance contributes directly to energy savings and prolongs the operational lifespan of the network. Overall, the proposed transposition-based routing protocol offers a promising solution for improving data transmission efficiency, network stability, and energy management in IoMT environments. Future work may include scaling the network, testing under varying mobility patterns, and implementing real-time validation in clinical scenarios to further validate the protocol's effectiveness.

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