# A Novel Routing Protocol-Based Data Transmission to Enhance the Quality of Service for Internet of Medical Things Using 5G

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**Abstract—**When it comes to improving people's health, various forms of smart city applications are put to use in the area of smart healthcare. Internet of Medical Things (IoMT) refers to an environment that consists of linked healthcare systems, computational capabilities, and health monitors. More and more health care providers are using this environment to enhance the quality of the services they provide (QoS). The transmission of data from intelligent medical equipment to IoMT necessitates the development of an effective solution. To enhance the quality of service (QoS) of the transmission of health data, it is necessary to develop and evaluate a novel multi-hop reinforced clustering-based routing protocol (MRCRP). This is necessitated by the importance of IoMT and 5G networks. The selection of cluster heads is done in a way that is more effective with energy in order to make better use of resources. The original data are transformed into meaningful data through the utilization of min-max normalization, which enables further research. It is possible to extract important characteristics by employing a technique known as principal component analysis (PCA). After that, the suggested routing method is put into action in order to successfully transfer the data. The proposed method's performance metrics, including delay, throughput, energy consumption, and packet drop ratio, as well as a comparative comparison with conventional routing protocols, are investigated.

**Keywords—**smart healthcare, data transmission, IoMT, 5G, Quality of Service (QoS), MRCRP

## 1 Introduction

From the early twenty century (the information era), informatics has been a crucial aspect of medicine, along with the storage and management of data. Computers are now used in additional areas of healthcare as a result of the development of the Internet and other communication technologies. One example of this is the exchanging of patient reports with specialists located outside the hospital or city, which can be done either by the hospital or by the patients themselves. The Internet of Things and 5G will result in analytical tools and lifestyle enhancements that are more precise. IoT in the medical field is referred to as IoMT. It has caused a revolution in the medical business by making it possible to perform remote diagnosis and monitoring of patients in ways that are efficient with resources [1, 2]. The healthcare business as well as the number of applications are expanding at a rapid rate, which is why a network similar to the internet would be beneficial. The types of data, the sizes of the data, and the formats that are produced by this company place significant demands on the capacity of the network as well as other aspects. The beginning of the e-healthcare service is the installation of sensor equipment in healthcare facilities. This equipment utilizes Wi-Fi, Bluetooth, and various other networking technologies in order to communicate to the network [3-6]. The issue of ensuring the safety of IoMT devices and healthcare IT networks in general is one that is both complicated and essential. The sensitive data that is involved in the delivery and administration of healthcare must be protected at every stage of its lifecycle, and this requires IoMT systems to have multiple layers of protection. According to the findings of 2020 CyberMDX, nearly half of all IoMT devices can be exploited in some way. IoMT systems, which are distinct from other types of systems, pose privacy dangers to patients because their information is exposed and may have a substantial effect on the patient's day-to-day life [7, 8]. The conventional "low-energy adaptive clustering hierarchy (LEACH)" method was modified by the addition of a benchmark limit for the selection of cluster heads. In addition to this, it simultaneously enhanced delivery efficiency while regulating the power level that was being transmitted between the nodes [9-11]. They recommended that a method known as "interference aware self-optimizing (IASO)" be utilized in order to lessen the amount of network interference. The technique is capable of multichannel sensing in addition to providing gaining control [12]. A "QoS and privacy-aware routing algorithm for 5G-IIoT" is what they suggest as a solution. They first construct the community identification method info-map in order to divide the routing region into the best possible subdomains. After that, they use deep reinforcement learning to design a gateway deployment model that reduces latency and evenly distributes load. The concept of universal gateway deployment makes use of federated reinforcement learning in order to minimize areal inequalities while simultaneously protecting the confidentiality of routing data. It is possible to accomplish "gateway deployment, QoS and data privacy-aware routing" by establishing communications through load-balancing routes that have the lowest possible latencies [13]. This is done based on the concept of "gateway deployment." They offer an intelligent trust cloud management solution for Internet of Things (IoT) systems that are equipped with "5G edge computing and Device-to-device (D2D)" The proposed method of trust management is made adjustable and intelligent in a wireless environment through the use of an updating mechanism for the trust cloud [14-17]. It is suggested that a "MDW" (multipath DSDV-based routing algorithm) be used for the "WIA-PA" network, which stands for the "Wireless Networks for Manufacturing Automation-Process Automation" network. It employs a technique known as disjunct node and bases its routing selection criteria on the reliability of the connections [18, 19]. The authors conduct a survey for WSNs in which they highlight and describe the various swarm intelligence-based routing strategies that are currently accessible. Also included are instructions for the creation of smart pathways, which are required to enable QoS-aware applications [20-22]. Utilizing the "Particle Swarm Optimization (PSO)" algorithm as an optimization tactic leads one to the conclusion that using the "multipath protocol called the Particle Swarm Optimization Routing Protocol (MPSORP)" is the best course of action. The MPSORP is used for Internet of Things applications that are built on WSNs [23]. These applications have uneven network flow and high traffic loads. They suggested a blockchain-based privacy-protecting update protocol, which would allow users to upgrade their programs without jeopardizing their security. This protocol would allow users to upgrade their programs. It enhances network functionality while simultaneously raising the level of network security [24, 25]. They suggested a different approach for the "RPL algorithm" in order to lengthen the IoT network's operational lifetime. The method that was suggested made use of both used and recovered energy in order to figure out which route was best for the transportation of data [26]. We suggested a "multi-hop reinforced clustering based routing protocol (MRCRP)" to improve the quality of service of the transmission of health data in order to circumvent the problems that were found in a variety of studies. The following is the most important contribution that this article makes: To get information ready for further processing, min-max normalization is used, and principal component analysis (PCA) converts raw data into numerical characteristics while preserving the data's original shape. The selection of the cluster heads can be accomplished with a technique that is energy efficient.

The following are the article's sections: The procedure is detailed in Section 2. section 3 includes results and discussion. The suggested work's concluding remarks can be found in Section 4.

## 2 Method

In this article, we investigate a novel routing protocol-based data transmission with the goal of improving the quality of service for the internet of medical things when it is implemented using 5G. The conceptual architecture can be seen in Figure 1. The IoMT device is used to collect information about the patient's wellbeing. A min-max standardization is applied as a preliminary step to the collected data. PCA maintains original data while converting unprocessed data into numerical features. The selection of the cluster head is done using a technique that is efficient with energy, and the data can be stored in and transmitted from Internet of Things devices as shown in Figure 1.

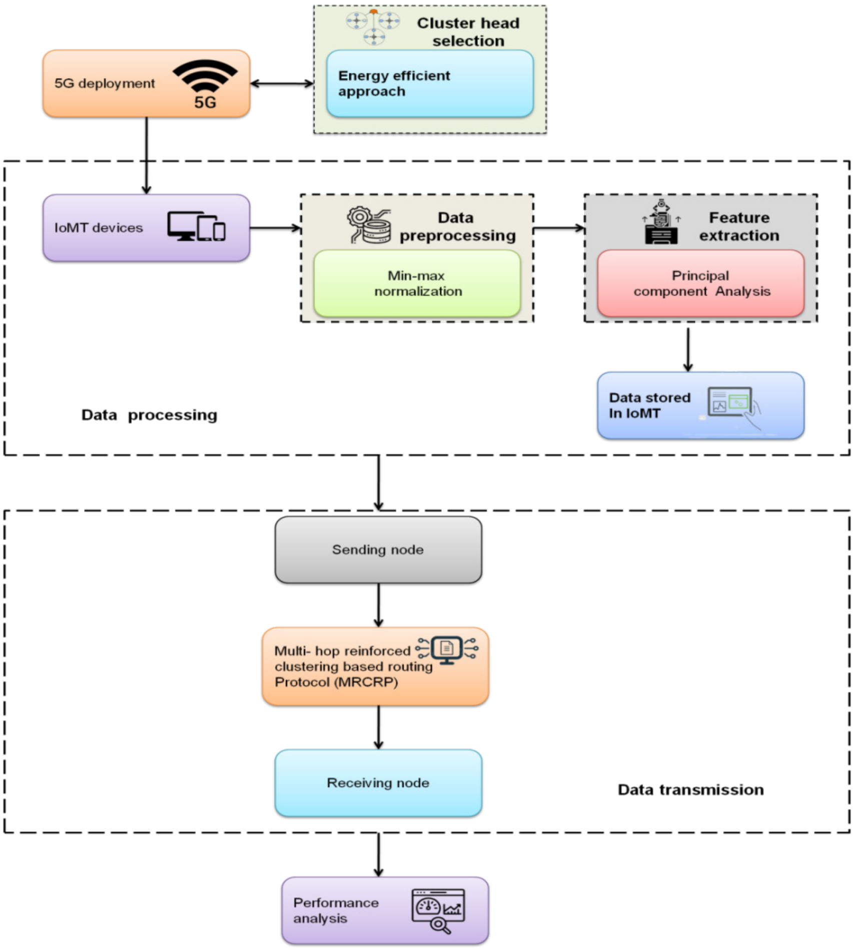


**Fig. 1.** Proposed framework

## 2.1 Dataset

First, IoMT devices are used to capture patients' health information, and then, while interconnected devices are transferring healthcare data, the devices communicate with one another. This process is known as "interoperability." When placed inside of a human body, Internet of Things devices have the potential to capture a variety of different types of health data, some of which include an electrocardiogram (ECG), the heart rate, blood pressure, glucose level, cholesterol level, and pulse. These data are sent to the peripheral computing system so that a diagnosis can be made regarding the patient's condition. Wearable smart watches could be utilized, in addition to IoMT devices and data collected, in order to record patient data as well as the patient's level of physical activity. The examination of the outcome also makes use of the information contained in the patient record that is held in the UCI repository.

### 2.2 Data preprocessing using min-max normalization

During preprocessing, raw data is transformed into a structure that can be utilized. When data are normalized, they are transformed in some way to guarantee that each characteristic contributes the same amount to the overall sum. Through the process of normalization, a new range can be derived from an existing one. On the basis of statistical measures derived from unnormalized, or raw, data, a number of different methods have been developed to standardize the data within a particular range. Our statistics were normalized by using min-max. These methods are classified according to the statistical characteristics of the original data that they normalize. The Min-Max normalization method employs linear data at the beginning of the spectrum. This method keeps the relationships between the material intact. Having pre-defined boundaries allows for more accurate information fitting. In keeping with this methodological approach to normalization.

$$Q' = \left(\frac{Q - minvalue\ of\ Q}{maxvalue\ of\ Q - minvalue\ of\ Q}\right) * (T - K) + K \tag{1}$$

The Min-Max values are incorporated into Q, and one of the boundaries is denoted by the notation [K, T].

The range of the actual data is represented by the letter Q, and the range of the mapped data is represented by the letter Q.

### 2.3 Feature extraction using PCA

"Principal component analysis" (PCA) is a dynamic process that aims to retain as much of the information that was present in the original components as is realistically possible while at the same time reducing the number of dimensions that are being measured. This is done with the goal of "reducing the number of dimensions." One way to think of it is as a collection of "orthogonal linear transformations" of the variables that were originally present. Let us assume that N is a data matrix of the form n by v, where n and v, respectively, stand for the observations and the factors. Suppose that all of the means in the Z column are zero for the sake of making the presentation more clear. $W_1 = \sum_A^v = \alpha_1 a\ N_a$, where $\alpha_1 = (\alpha_{11},...,\alpha_1{}^r)$ R, stands for a definition for first principal component. R has been selected to maximize $W_1$'s variance, i.e.

$$\propto_1 = arg\max_{\propto} \propto^R \hat{\sum} \propto\ subject\ to\ \|\propto_1\| = 1 \tag{2}$$

with $\Sigma = (N^R\ N\ )/n$ The following is a list of definitions in chronological order for the remaining principal components:

$$\propto_{i+1} = arg\max_{\propto} \propto^R \hat{\sum} \propto \tag{3}$$

based on

$$\| \propto \| = 1\ and\ \ \propto {}^\wedge R\ \propto \_j = 0, \forall 1 \le j \le i \tag{4}$$

The first g loading vectors are the same thing as the first g eigenvectors, if we are to believe this formulation. The "singular value decomposition" (SVD) of N is linked to principal component analysis (PCA) by the formulation of Eigen decomposition. Assume N indicates SVD.

$$N = BFA^{Q} \tag{5}$$

where $W$ and $A$ are "orthonormal matrices (OM)" of $n \times v$ and $v \times v$ rows and columns, respectively, and "F is a diagonal matrix with diagonal" components $u1, ..., uv$ in descending order. "Because the columns of A are the eigenvectors, A is considered to be the loading matrix "of the major components." We can understand that $W_i$=$B_if_i$ as $NA$=$BF$, $B_i$ is the $i^{th}$ column of $B$. It is important to keep in mind that the SVD provides a reliable low-rank approximation of the data matrix. An alternative geometric interpretation of principal component analysis (PCA) produces a linear manifold as the closest possible approximation to the data that was witnessed. This idea is consistent with the way PCA was constructed. Make $kz$ the $z^{th}$ row in Z. Take the first i main constituents together, which equivalent to $A_i = [A_1|\cdot\cdot\cdot|A_i]$. $A_i$ is a $v{\times}i$ $OM$ by definition. Each remark must be predictable to the linear region covered by $\{M_1,..., M_i\}$. The predictable data are $V_i N_z$, $1 \leq z \leq n$ and the projection operator is $U_i = A_iA^R$. By decreasing the overall $j_2$ approximation error, one can regulate the finest projection.

$$\underset{D_i}{min} \sum_{z=1}^{n} ||k_z - D_i D_i^R k_k||^2 \tag{6}$$

Components of first-generation solutions are straightforward to characterize. It's possible for parameters to have varying scales and kinds of units. Standardization is performed on each component in such a way that its marginal variance is equal to 1. We will obtain the sample relationship matrix of raw data and the covariance matrix of standardized variables if we use this technique for principal component analysis (PCA). There is a possibility that the eigenvalues of the relationship matrix will differ from those of the correlation matrices.

### 2.4 Cluster head selection using an energy-efficient approach

The amount of energy that is still available in the nodes, their distance from the "base station (BS)," and the number of rounds in a succession that they have not been a CH are the parameters that are used in the algorithm that is known as the "cluster head selection (CHS)". In addition, it takes into consideration whether or not the remaining energy of the nodes is sufficient to transfer the aggregate data to the BS. In the event that there is insufficient energy at the node, it cannot be selected as the leader of the cluster. This additional parameter is taken into consideration as part of the CHS procedure in order to ensure that the burden on the network as a whole is distributed in a fair and equitable manner. Our objective is to accomplish energy efficiency, not only in terms of the amount of energy consumed but also in terms of the lifespan of the network. The "ESF (energy sufficient flag)" variable will be set to 0 if the leftover energy of the node is not sufficient to send aggregate data to the BS. This will occur if the node does not have enough energy remaining (zero). In addition, it will be recorded as one if the amount of residual energy is sufficient. Because of the large distance that exists between the BS and the sensing nodes, the multipath model is followed by the process of energy dissipation at CH nodes. The following formula can be used to calculate the amount of energy that is lost by the CH node:When all three factors, including the extra component ESF, are taken into account, the altered threshold U(n) is:

$$U(n) = \frac{q}{1-q\times\left(s\,mod\frac{1}{q}\right)} \times \left[E(j) + \left(1 - D(j)\right) + (t\ div\ s)\right] \times ESF(j) \quad (7)$$

$$U(N) = 0 \qquad \begin{array}{l} \forall n \in H \\ \forall n \notin H \end{array} \quad (8)$$

q - CH probability, s as the no. of the present round and h - nodes that weren't CH in the previous 1/q rounds

The residual energy factor E(j) is,

$$E(j) = (E_{residual}(j)/E_{initial}) \quad (9)$$

$E_{residual}$ - remaining amount of energy and $E_{initial}$- Node energy at a beginning of transmission, j - number of nodes in a series.

Distance factor $D(j) = d_{jC}/d_{farthest}$

(10)

The distance from node J to BS, denoted by $d_{jC}$, is:

$$d_{jC} = \sqrt{\left(Y_j - Y_{BS}\right)^2 + (Z_i - Z_{BS})^2} \quad (11)$$

$d_{farthest}$ - the distance at the farthest node from the BS. Here (<$Y_{BS}$, $Z_{BS}$>) is the BS location.

In the third parameter($t\ div\ s$), s is the number of rounds without a CH and s is the no. of the present round. ESF (j) is the energy adequate flag for node j. To select CH, each node generates a random integer between 0 and 1. If the number is fewer than the threshold $U(n)$, the node becomes a CH for the present round. If the node's ESF value is 0, threshold $U(n)$ becomes 0, and the node cannot be CH.

### 2.5 Multi-hop Reinforced Clustering based Routing Protocol (MRCRP)

For the multi-hop inter-node communication, the "minimal transmission energy (MTE)" methodology is used. This involves source nodes (SNs) transmitting data to cluster heads (CH) via intermediate nodes within each cluster. The source nodes of the cluster all communicate with one another by sending their messages to the node on the route between them and the leader of the cluster that consumes the least amount of energy while transmitting the information. This node is known as the least-energy-consuming node. Due to distance and density limitations, it's possible that large-scale sensor networks won't be able to use network architectures that guarantee the direct relationship between every member node and CHs. As a consequence of this, a "large-scale wireless sensor network (WSN)" necessitates a "multi-hop (MH)" communication structure that does not place restrictions on the number of clusters or the area that they are able to cover. A reinforcement strategy is utilized to determine which network should be utilized based on the circumstances at hand in order to receive the highest possible delay reward. State, action, and compensation are the three most important factors that are evaluated based on the inputs. The term "state" refers to both the location of the component and its energy level. The state of being able to access the subsequent hope node is what's known as action. The efficiency of the data transmission, as measured by the reward for the function. As a result of its high level of performance, the MTE algorithm is a widely used MH protocol in WSN. Data transmission is involved, along with the utilization of routers and various environmental monitors. Intermediate nodes transmit sensor data to CH. The energy used by the broadcast amplifier is decreased thanks to the router nodes. SN uses the MTE technique to calculate the distance between themselves and CH. If the path from the SN to the connected CH is the shortest possible one, then the SN will transmit the data to the CH in a single hop. A subset of the CHs in the cluster supply the BS with aggregated info. If the distance between the SN and the affiliated CHs is greater than the minimum, then the data from the SN is transmitted via the intermediate nodes. The data is transmitted from the SN to the cluster leader via a series of minimum hops. Within the context of this scenario, SN has m transmissions and m-1 receptions spread out over a distance of d. The minimal transmission energy, denoted as M in equation (12), and the energy, F, used in transmission and reception in each cluster is provided as:

$$F_M = F_{RY-M} + F_{TY-M} = a.F_{TY} + (a-1)F_{RY} \quad (12)$$

Free space propagation:

$$F_M = a.\left(M.F_{elec} + \varepsilon_{gt}.M.e^2\right) + (n-1)F_{elec}.M = M\left((2a-1)F_{elec} + \varepsilon_{gt}.n.e^2\right) \quad (13)$$

Multipath propagation:

$$F_M = a.\left(M.F_{elec} + \varepsilon_{aq}.M.e^4\right) + (a-1)F_{elec}.M = L\left((2n-1)F_{elec} + \varepsilon_{aq}.n.e^4\right) \quad (14)$$

While member nodes (MNs) send their transmissions to the cluster head through the MTE, selected CHs broadcast their messages to the BS immediately. Intermediate nodes and CH receive SN input. The quantity of energy required to transmit and receive CH data is indicated by the following notation:

$$F_{CH-BS} = F_{TY-Direct} + F_{RY} = M.F_{elec} + \varepsilon_{nq}.e^b + M.F_{elec} \quad (15)$$

Cluster-based routing is achieved through the use of our technology (CBR). The sensing nodes organize themselves into clusters, with one node in each cluster serving as the CH to collect data from the other nodes. The energy of the network is distributed in a dynamic manner by our protocol, which does this by generating clusters and selecting CH based on the optimal probability given in Equation 16. During the process of setting up the cluster, each server decides for itself whether or not it will act as a CH for the current round. This decision is based on the criterion U(n), which will be explained in more detail in the next paragraph, as well as a specific number of nodes.

$$U(n) = \begin{cases} \frac{Q}{1-Q*\left(s \bmod \frac{1}{q}\right)} & if\ n\ \in G \\ 0 & otherwise \end{cases} \quad (16)$$

The current round is denoted by the letter s, the necessary proportion of CHs is denoted by the letter Q, and the set of nodes that were not chosen as CHs in the previous 1/q rounds is denoted by the letter h. When this threshold is applied, every node will become a CH within 1/q cycles. All nodes are CH-eligible after 1/q cycles. Each round, the CH is determined by the nodes picking a number at random between 0 and 1. In the event that the provided number is lower than the threshold, the node will transition into CH status. In this tactic, SN establishes a connection with CH by way of the MH pathway in order to cut down on the amount of energy transmitted. The CHs collect data from the nodes that make up the cluster, consolidate it, and then send it to the BS. This technique determines the path that leads from the nodes to the BS that is most efficient. According to the proposed protocol, data travels from the MN to the cluster leaders via intermediary nodes, while data travels straight from the CH to the BS. The nomination of the CH also follows the same procedure in MH.

## 3 Results and discussion

In this article, we investigate the use of 5G to improve the quality of service for the internet of medical things by employing novel routing protocols that are based on data transmission. The results of the performance assessment simulation, which was carried out using "NetSim (Network Simulator and Emulator)," are presented in Table 1.

**Table 1.** Hardware and software configuration

| Components | Value |
|---|---|
| Processor | 10 |
| Packet size | 15 |
| Packet arrival rate | 20 |
| Memory | 12 GB |
| Area of sensor deployment | 100 x 100m |
| Operating System | Windows 10 |
| Total number of nodes | 50 |

Energy consumption, degree of security, throughput, latency, and packet delivery ratio are the parameters that are being measured. Cross-layer protocol (CLP [27], cross-layer QoS channel-aware routing protocol (QoSRP [28], Link quality-aware queue-based spectral clustering routing protocol (LRP [29], and Quality-of-service (QoS) aware evolutionary routing protocol (QERP [30]) are the techniques that are currently in use as.

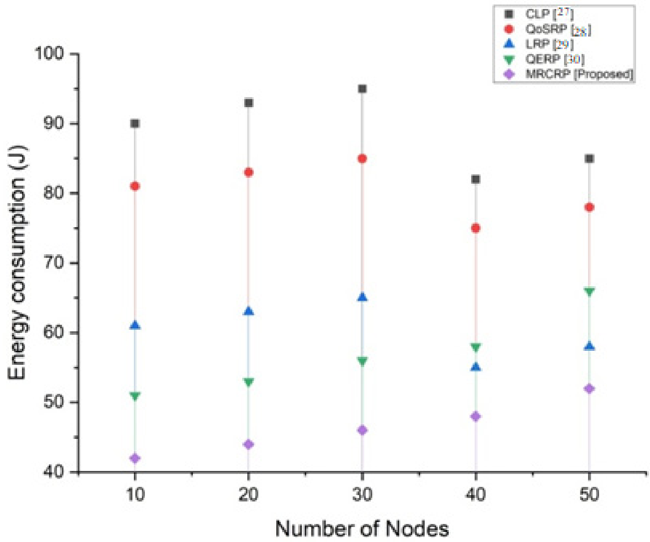


**Fig. 2.** An analysis of the difference in energy utilization between the Suggested Methods and the Traditional Methods

There is a wide range of variation in the quantity of energy that is required to transmit a data packet through a network from one network to the next. When compared to 4G connectivity, 5G consumes approximately 90 percent less power. Figure 2 illustrates the amount of energy that was consumed. According to the comparative study, the energy consumption required by the recommended methods is lower than that required by any of the other four techniques.

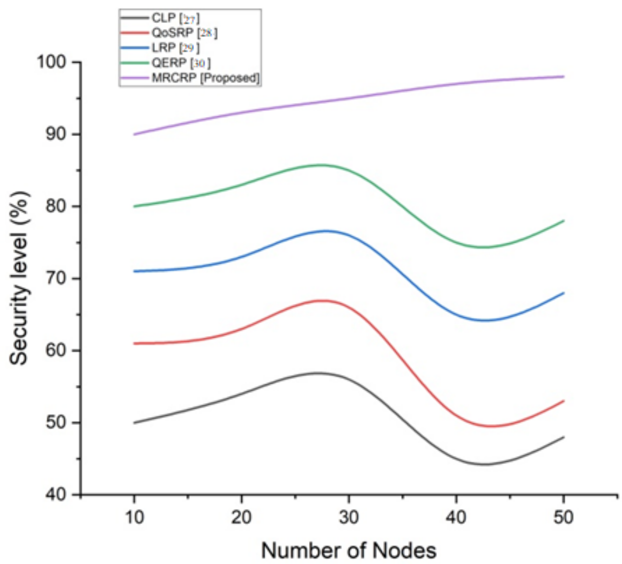


**Fig. 3.** A contrast between the levels of safety provided by Suggested Techniques and Those Provided by Traditional Methods

The security level can be understood to be a calculation of the chance that a security event will be attempted or will actually take place. The degree of security is depicted in figure 3. The CLP, QOSRP, LRP, and QERP were each given a security rating of either 48 percent, 53 percent, 68 percent, or 78 percent respectively during the evaluation process. A security level of 98 percent was determined to be appropriate for the recommended MRCRP. According to the findings of the comparative analysis, the evaluation suggests that the proposed solution offers a higher degree of protection than the other four possible approaches.

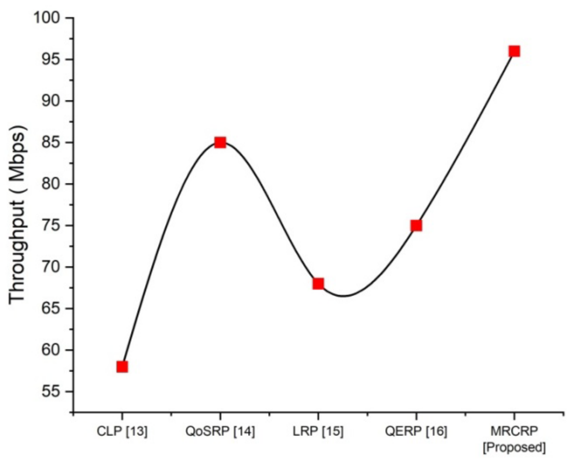


**Fig. 4.** Comparative assessment of throughput in Proposed and Traditional Methods

Throughput refers to the amount of data that a computer system is able to either process or transfer in a specific amount of time. In megabits per second, or Mbps, we quantify the amount of data that can be received by a user from a server in a single second. The throughput is illustrated in figure 4. Throughputs of 58 Mbps, 85 Mbps, 68 Mbps, and 75 Mbps were utilized in the evaluation of the CLP, QOSRP, LRP, and QERP, respectively. A throughput of 96 Mbps was utilized during the testing of the recommended MRCRP. According to the analysis of comparative methods, the recommended approach has a higher throughput than the other four approaches combined.

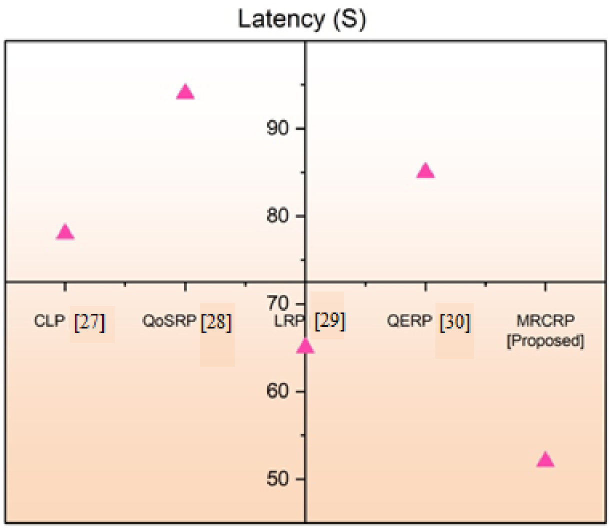


**Fig. 5.** Comparative evaluation of latency in Proposed and Traditional Approaches

It takes into account the total amount of time it takes for a packet to travel from the place of origin to the point at which it will be delivered. It is expressed in seconds at a time. The latency is illustrated in figure 5. The CLP, QOSRP, LRP, and QERP were all evaluated with a latency of 78 seconds, 94 seconds, 65 seconds, and 75 seconds, respectively. A latency of 52 seconds was used in the evaluation of the proposed MRCRP. According to the findings of the comparative study, the recommended method takes significantly less time than the other four approaches to transmit a packet from its point of origin to its final destination.

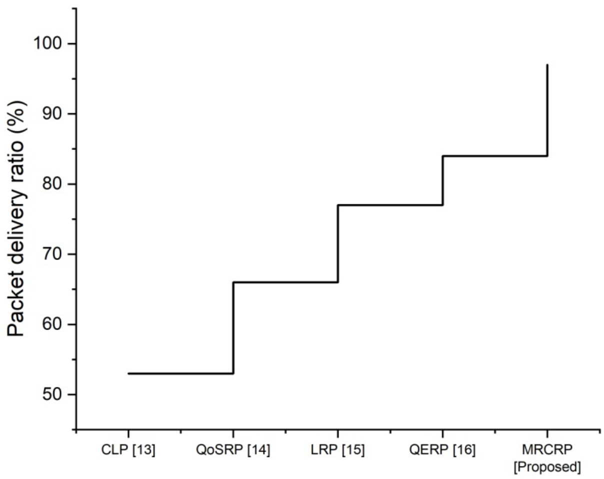


**Fig. 6.** Comparative evaluation of packet delivery ratio in Proposed and Traditional Approaches

The ratio of packets received at the destination to the total number of packets transferred from the source is referred to as the packet delivery ratio (PDR). The percentage of successfully delivered packets is shown in Figure 6. We used PDRs of 53 percent for the CLP evaluation, 66 percent for the QOSRP evaluation, 77 percent for the LRP evaluation, and 84 percent for the QERP evaluation. The recommended MRCRP was given a PDR score of 97 percent after being evaluated. The evaluation of the comparison shows that the suggested strategy has a PDR that is significantly higher than the other four approaches. The growing end-to-end latency that is induced by the increase in the number of relay nodes (RNs) and cluster coordinators (CCOs) in CLP is a barrier to the effective communication of multimedia [13]. Issues with energy utilization and the mobility of acoustic sensor nodes (ASNs) are present in QoSRP [14]. It is necessary for LRP [15] to make performance enhancements in the cross-layer fashion. In QERP [16], no investigation has been done into whether or not there is a correlation between network activity, node density, and information transmission rate.

## 4 Conclusion

By ensuring that data is transmitted from the source to the base station in a timely manner, the clustering-based routing algorithm is an essential component of both the Internet of Medical Things (IoMT) and 5G-based smart healthcare. The new multi-hop reinforced clustering-based routing protocol (MRCRP) that was recommended in this research was able to improve the quality of service (QoS) of the transmission of health data. The selection of cluster heads is done in an effective manner in order to maximize the use of available resources. The original data are transformed using min-max normalization so that they can be used in subsequent analyses. Principal component analysis is a method that can be used to identify relevant features (PCA). There is presented an analysis of comparisons. Values of Performance include things like the amount of energy consumed (52 J), the degree of security (98 percent), the throughput (96 Mbps), the latency (52s), and the PDR (97 percent). Within the scope of this study, optimization does not take place. The application of optimization strategies in the future may prove to be beneficial in boosting the effectiveness of this research. Big data technologies allow for the storage of extensive patient information in a manner that is more space and time efficient. These capabilities will be extremely beneficial in the future.

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