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A novel data offloading scheme for QoS optimization in 5G based internet of medical things

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ABSTRACT

The internet of medical things (IoMT), which is expected the lead to the biggest technology in worldwide distribution. Using 5th generation (5G) transmission, market possibilities and hazards related to IoMT are improved and detected. This framework describes a strategy for proactively addressing worries and offering a forum to promote development, alter attitudes and maintain people's confidence in the broader healthcare system without compromising security. It is combined with a data offloading system to speed up the transmission of medical data and improved the quality of service (QoS). As a result of this development, we suggested the enriched energy efficient fuzzy (EEEF) data offloading technique to enhance the delivery of data transmission at the original targeted location. Initially, healthcare data was collected. Preprocessing is achieved by the normalization method. An EEEF data offloading scheme is proposed. A fruit fly optimization (FFO) technique is utilized. The performance metrics such as energy consumption, delay, resource utilization, scalability, and packet loss are analyzed and compared with existing techniques. The future scope will make use of a revolutionary optimization approach for IoMT.

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1. INTRODUCTION

Nowadays, significant data gathering, computation, and preservation are offloaded by intelligent internet of medical things (IoMT) devices to multiple computational platforms including periphery, high humidity, offloading techniques, and the internet. Various data offloading techniques and a broad multi-layer cloud architecture that addresses privacy concerns [1]. Further smart health-care and medical services, including telehealth, biometrics detectors, and cardiological monitoring, are now developing as a result of the IoMT applications expansion. To provide better expanding and increasingly effective remote monitoring systems, the IoMT generally consists of various and incompatible electronic objects, such as wearable technology, smart appliances, and healthcare equipment that may be used on living organisms, in households, or in clinics. Portable gadgets can analyze medical and healthcare processes more effectively by fusing information technology with healthcare records, which reduces complexity and increases productivity. Figure 1 depicts the data offloading scheme of the healthcare system. The IoMT allows doctors and healthcare professionals to access a wide range of real-time medical databases, enabling them to better comprehend and identify their patients' health conditions [2]. The consumer benefits from data offloading authentic routing, which enhances their transportation perspectives. The effective flow of traffic is also enhanced by this configuration.

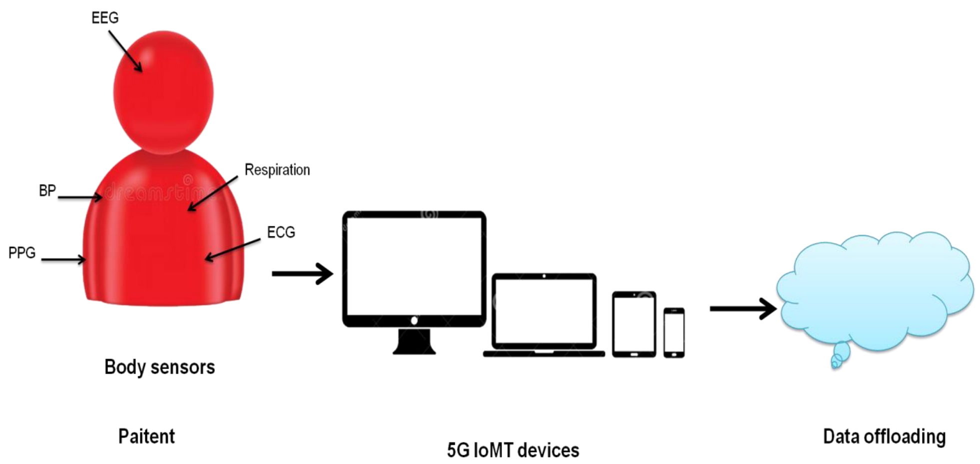

Figure 1. Data offloading for the healthcare system

The cloud platform hosted the data that the offloading devices collected. Since there is data traffic in the networks, data offloading is the main problem with the cloud service. A practical cognitive-behavioral model for the associated IoMT devices is incorporated and used to carry out the entire offloading decision-making process. Many gadgets function with distant cloud monitors and aid in offloading and finishing operations [3]. Quality of service (QoS) refers to various types of priority for many purposes by the needs and ensures a specific degree of health care data transmission performance. The quality of the service is influenced by a variety of performance measures, including bandwidth and latency through 5^{th} generation (5G). In other words, QoS refers to the cloud node's limited computational time and power usage. A major problem with cloud healthcare systems is QoS. The QoS is a key consideration in the cloud healthcare paradigm when moving work from one node to another with a reduced load than the previous one. The major difficult issue is protecting the integrity of delicate patient data when it is sent from the end node to the server node [4]. The QoS companies may utilize service quality as a tactic to draw in and keep patients. Healthcare professionals offer high-quality goods, and providing a better level of customer care is a crucial tactic since it will attract additional new clients. Quality is a crucial characteristic that may impact people, procedures, surroundings, goods, and services to achieve or exceed expectations. Understanding patient requirements and preferences is crucial to delivering good services. The impact of this circumstance on patient experience is significant by using 5G transmission. Comfortable patients will continue to utilize the services of their choosing, making those highly significant resources [5]. The main contributions of this study involved the transmission of medical data using the 5G to improve the QoS by applying a data offloading scheme. Offloading originally referred to reducing or eliminating pressure from the edge to prevent and treat microvascular complications, especially those brought on by diabetes-related foot circulatory issues effectively. Hence, we proposed an enriched energy efficient fuzzy (EEEF) data offloading scheme for healthcare data to improve the QoS through 5G. The remaining sections of this paper are furnished as follows. The relevant articles were given in section 2. Section 3 explains the suggested technique. Discussion and findings are included in section 4. Section 5 ends with a conclusion.

2. LITERATURE REVIEW

Salih [6] proposed BEdgeHealth which combines mobile edge computing (MEC) with blockchain for data offloading and data sharing in dispersed medical centers. To provide fast computing while maintaining privacy, mobile devices can transfer healthcare information to the nearest MEC server. Some significant technological issues, such as inadequate QoS, data protection, and network security risks, still exist for many MEC-blockchain-based solutions. Lin *et al.* [7] offered a lengthy proportionate equitably driven 5G healthcare system. It creates a long-term Nash bargaining game that takes into account varying loads and an ability to adapt quickly to represent the service offloading. To reduce latency, the IoMT might offload healthcare services to 5G edge computing. But these presumptive generous patients will compromise QoS in favor of the overall best. This adequate and oversimplified presumption will diminish the interaction excitement, which is unacceptable for healthcare that is the deadline-conscious and primary concern. Hasan *et al.* [8] suggested network mobility (NEMO) basic support protocol (NBSP) employing IP-based Wi-Fi connection to address medical problems. In the 5G network, this approach outperformed two other techniques such as NBSP and proxy NEMO (PNEMO) for IoMT mobile devices. It improves the transportation entities' and centralized network entities' functions. However, due to the patients' increased requirements, the changeover revealed a poor signal, more signaling overhead, and larger latencies, which led to wireless connection failure. Nguyen *et al.* [9] designed using edge cloud and blockchain, a unique hybrid strategy for data offloading and sharing for healthcare. Electronic health records (EHRs) are transferred to mobile edge clouds to ease healthcare, and this has undergone substantial alterations in the healthcare sector. The implementation's superior benefits, including increased QoS, greater data protection and security, and inexpensive smart contract costs, are demonstrated by comprehensive real-world trials. Mobile data offloading is the practice of diverting information that was originating from wireless networks and diverting it to other systems. The phenomenal growth of mobile data traffic over the past few years has been a result of the spectacular growth of smartphones, pads, and laptop computers. Cellular networks are already experiencing data saturation due to this. Because of this, cellular networks cannot meet all of the demands for mobile data. Therefore, finding quick fixes is a top priority for cellular network providers [10].

Sayed *et al*. [11] reviewed the most current developments in mobile data offloading methods. Specifically, depending on the variety of data offloading initiators, data offloading via small cell networks, data offloading via wireless connections, data offloading via selective mobile networks, and data offloading via communication networks are all classified in this way. Data offloading efficiency is significantly impacted by the network provider's inability to forecast and precisely measure the networks' requests. Since proximity and decentralization offer particular advantages for networking including proper interaction, information-carrying, and scalability, MEC technologies have been developed as a means to satisfy certain criteria. In a MEC enabled internet of vehicles (IoV) network, a variety of issues have surfaced regarding the offloading of information, including offloading efficiency in high mobility situations, authentication for clients within the same networks, and energy conservation to prevent people from being disincentivized from using the network. As part of the data offloading process, artificial intelligence (AI) is used. Even though the fact that MEC enables complicated vehicular applications, monitoring, and maintaining QoS, there are still several difficulties with data offloading [12].

Bharti *et al.* [13] recommended the use of a mobile station to facilitate machine communication for data processing with an emphasis on information produced from the associated stream of machine type communication (MTC) systems. One of the important data collects in the 5G wireless devices is the usage of machine-type data transmission. After gathering the data, the MTC devices will send it to mobile phones for processing. Some data are sent to the adjacent MEC cloud service due to the smartphone's limited computational capacity. It takes advantage of the attributed role of MTC devices and computes a correlation analysis using a power exponential function. However, managing a large amount of MTC access controls rather than human-type communication is challenging.

Hamad *et al.* [14] provided a thorough examination of standardization issues, application purposes, appropriate computing method, security requirements, and design concerns inside information and communication technologies (ICT) usages for clinical applications with an emphasis on computing methods for medical utilization circumstances. The most important connection difficulties and solutions are then described. By creating the e-healthcare environment, the development of ICT substantially enhances the availability and efficacy of the healthcare system. This expands possibilities for enhancing patient outcomes, significantly speeding up the work of health experts, and lowering the cost of quality healthcare. It takes a lot of processing power to move healthcare care to cloud-based and distant settings. The advancement of smart devices and the personalized communities of the internet of wearable things (IoWT) have advanced greatly because of the remarkable advancements in technology, mechanization, and digital communication technology in the sixth generation (6G) era. Because IoWT technologies are still in development, it is crucial to have a thorough understanding of present conditions and anticipated future research directions. They examined the most recent IoWT features to pinpoint its improvements and advantages over 6G technologies [15].

3. METHOD

To overcome the limitations in the existing technologies, we proposed an EEEF data offloading scheme for healthcare data to improve the QoS through 5G transmission. With the help of 5G, healthcare IoMT systems will produce individual health data to a degree never before achieved in associated of information quality, efficiency, and capacity. By eliminating all physical barriers between people and technology, boosting data transfer, and reducing latency, 5G makes it possible for transportation to reach a new level. Due to this rapid advancement in technologies, we proposed an EEEF data offloading scheme for healthcare data to improve the QoS through 5G transmission. Initially, cloud databases stored the end-users records such as doctors, patients, and nurses. The data is collected and preprocessed using normalization. Figure 2 indicates the working flow of the proposed method.

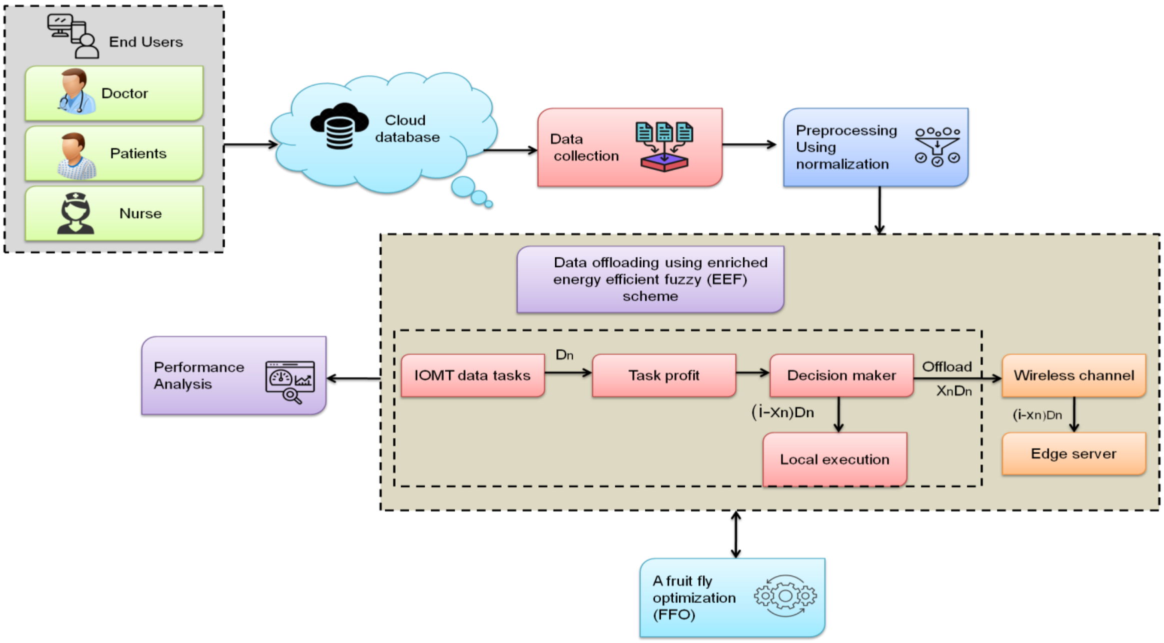

Figure 2. The working flow of the proposed method

3.1. Data collection

The public health dataset was the dataset utilized for the analysis. It was created in 1988 and comprises four databases: Long Beach, Cleveland, Hungary, and Switzerland. It has 76 features, including the one that was anticipated, however all published studies only mention employing a portion of 14 of these. The targeted field implies the patient has heart sickness. 0 means there is no disease, while 1 means there is a sickness. Some of the attributes are age, kind of chest pain, relaxing hypertension, rising glucose levels, and findings of resting electrocardiography [16].

3.2. Data preprocessing using normalization

Data organization in a system is done by normalization. Preprocessing is the word used to describe a group of procedures performed on data to change the source of the data. Normalization consists of filling in any missing features, changing the kind of object, and several additional actions. Additionally, it reduces duplication and enhances authenticity, which promotes execution speed. Therefore, we used the min-max normalization and Z-score normalization for the gathered medical data.

3.3. Min-max normalization

Min-max normalization is one of the most often applied methods for data normalization. Data transformation employs min max normalization. It transforms the outcome of each quantitative characteristic into the desired value based on the minimum and maximum values. In (1) is used to identify data transformation in the health care system.

$$D_t = \frac{(Y - Y_{min})}{(Y_{max} - Y_{min})} \quad (1)$$

Where Y is a collection of the predicted values that are denoted in the dataset. The minimum and maximum values in Y are denoted by Y_{min} and Y_{max}. Each feature's lowest and highest values are each transformed to 0, while all other values are all converted to a decimal between 0 and 1.

3.4. Z-score normalization

Z-score normalization enables the user to comprehend the potential that a grade can fall inside the data normally distributed. To deal with extreme values in a dataset, Z-score normalization is performed. The

Z-score provides an indication of the degree to which a particular value deviates from the standard deviation. The Z-score, also known as the standard score, indicates the number of standard deviations in either direction from the mean that a particular data point lies.

$$\bar{z} = \frac{Z-\tau}{\varsigma} \quad (2)$$

Where $\bar{z}$ represents the newly assumed value, Z denotes the quantitative element, τ is the average of feature values and ς is the standard deviation of feature values. The formula for calculating a Z-score is as follows: $Z = \frac{(X-\mu)}{\sigma}$, where x represents the raw score, represents the mean of the population, and represents the standard deviation of the population. According to the formula, the Z-score is calculated by subtracting the population mean from the raw score and then dividing that result by the population standard deviation.

3.5. Data offloading using enriched energy efficient fuzzy scheme

The quality criteria are enhanced using an EEEF data offloading approach. This technique is built on a data transmission method that verifies and sorts in packet transmission by encapsulating the data's payload region with a client ID and timeframe. Medical data has been categorized as data transmissions, critical information, and data source using fuzzy logic. Based on computational power and available energy, cloud resources have been clustered. This approach enhances the QoS and lessens the demand for device resources. To keep historical health data that has been analyzed from the offloading scheme, a cloud with numerous servers may also be implemented, allowing data exchange among health users. For instance, a physician can use cloud data to improve illness diagnostics, and patients can gain from healthcare services like medicine or health counseling. By working together, this offloading scheme and transmitting procedure makes it easier to offer healthcare services. A commercial IoMT based on the cloud was used to accomplish enriched energy-efficient offloading. Additionally, it is utilized for mobile multiserver edge computing. To choose an appropriate offloading option that may consume less energy, computational efficiency, and storage capacity, an effective and safe framework was presented.

3.6. Fruit fly optimization technique

A unique swarm intelligence (SI) model known as fruit fly optimization (FFO) was developed from the foraging behavior of fruit flies and falls under the category of interactive evolutionary processing. Fruit flies are typically small insects that devour fruits and decaying plants. These species may be found worldwide in both tropical and high-temperate climatic zones. Compared to other species, these have strong visual and olfactory capabilities. Even though the food source is far away, it can recognize various aromas carried out in the air utilizing its sensory organ. Then, using its eyesight ability, it flies towards the direction of the meal. Therefore, a fruit fly's procedure for finding food is as follows: use its olfactory organ to detect the food source; use its sensitive eyesight to move closer to the food position; and locate fruit flies in a group and lead them in the desired direction. The FFO is divided into seven steps based on the food-seeking concept, as shown in:

a. Step 1: initializing settings are the population number pop, general evolution value, and starting I_0, J_0 positions of the fruit fly swarm.
b. Step 2: initializing population:

$$I_x = I_0 + rand$$
$$J_x = J_0 + rand$$

where, I_x is the total number of populations, I_0, J_0 are the initial value of the population
c. Step 3: distance and smell estimation (S_x, D_x):

$$S_x = \sqrt{I_x^2 + J_x^2}$$
$$D_x = \frac{1}{S_x}$$

d. Step 4: fitness function estimation (c_x):

$$c_x = c(D_x)$$

where c is the constant
e. Step 5: find the smallest individual fruit fly that, in comparison to other fruit flies, has the best fitness function (c_v): $[bestIbestindex] = \min\,(c(D_x))$

f. Step 6: retain the best fitness function and the coordinates I_v, J_v in the selection process. The fruit fly swarm then moves in the direction of the location with the highest effective fitness function value when sensitive vision is used:

$$c_v = bestI$$
$$I_v = I(bestindex)$$
$$J_v = J(bestindex)$$

I_v, J_v are the final population.

g. Step 7: determine if the halting requirements are met or not. Otherwise, go to step 2; otherwise, stop the circulation.
An excellent style manual for science writers is [7].

4. RESULTS AND DISCUSSION

In this study, an EEEF data offloading technique is suggested to enhance the delivery of data transmission at the original targeted location to gain a more accurate transmission. The parameters of energy consumption, delay, resource utilization, scalability, and packet loss are analyzed. The suggested scheme's efficacy is evaluated using these metrics. The outcomes were compared to those obtained using conventional methods are offFog (OF) [17], context-federated deep reinforcement learning (C-fDRL) [18], hierarchical multi-agent deep reinforcement learning (H-MADRL) [19], and graph optimized algorithm (GOA) [20]. All the energy needed to carry out an activity, create something, or just occupy a structure is referred to as energy consumption. By examining whether much energy a manufacturing process uses, total energy consumption may be calculated. We found that less energy consumption had scores of 55% based on the EEEF approach. Figure 3 displays the findings of the research that were compared with those of previously established method [21]-[25].

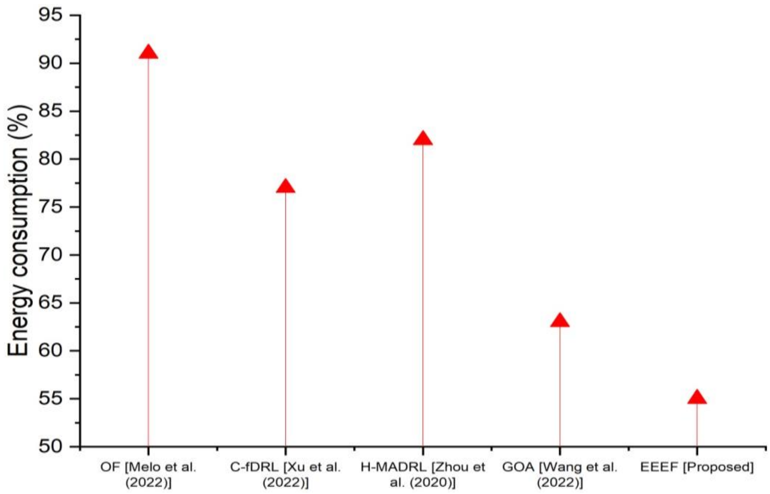

Figure 3. Comparison of energy consumption

The process of delaying, obstructing, or forcing things to go more slowly than usual: the delayed condition begins immediately. We found that low-level delay had scores of 52% based on the EEEF approach when the experiment findings were compared with those of previously available databases shown in Figure 4. A key performance indicator (KPI) called resource utilization tracks whether well people perform given their capacity or time constraints. Project managers may predict resource availability across a variety of categories with the help of optimal resource usage. Based on the EEEF technique, we found that high resource utilization had scores of 96% in Figure 5, which depicts the experimental findings that were compared with those of the previously established method. Scalability is a term used to describe a system's capacity to adjust its performance and cost in response to shifting application and system processing requirements. We found that high scalability had scores of 95% based on the EEEF approach, as shown in Figure 6, which compares the findings of the experiments with those of the previously established method.

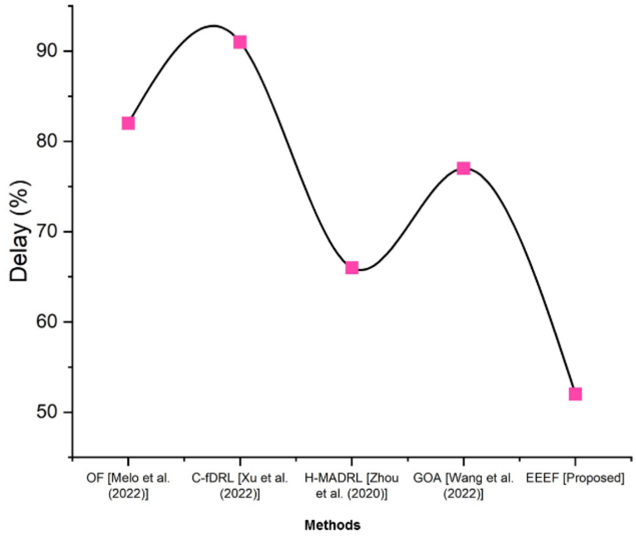

Figure 4. Comparison of delay

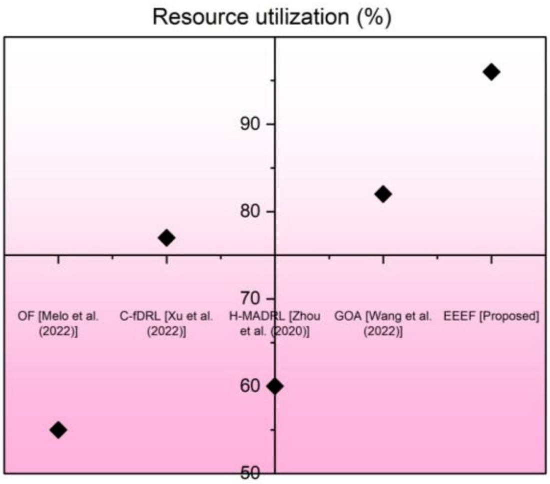

Figure 5. Comparison of resource utilization

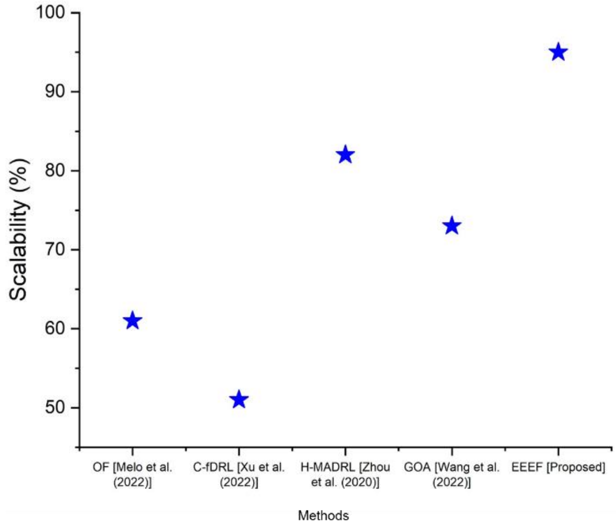

Figure 6. Comparison of scalability

When a few sent data packets are lost in the packet, it results in data loss. All forms of digital communications may suffer as a result, with apparent performance concerns. Figure 7 displays the experimental findings that were contrasted with those of the earlier established approach; we found that lower packet loss had scores of 53% based on the EEEF method.

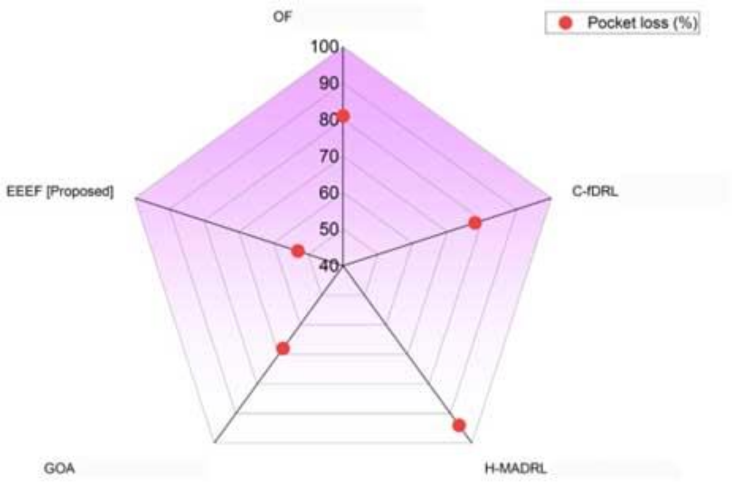

Figure 7. Comparison of pocket loss

5. CONCLUSION

For better patient outcomes and accurate health care monitoring, offloading devices that lower maximum stress levels and shift pressure away from the health care issues are necessary. To enhance the transmission of medical data by improving the QoS we proposed an enriched energy efficient data offloading scheme. Additionally, the data sharing plan can successfully authenticate users and speed up data retrieval while protecting unauthorized entry into the healthcare system. System assessments demonstrate the viability of the plan for healthcare applications by demonstrating the cheap operating costs of smart contracts and the assurance of security protocols. The future scope will make use of a revolutionary optimization approach for IoMT.

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