Communications on Applied Nonlinear Analysis
ISSN: 1074-133X
Vol 32 No. 2s (2025)

Recurring Network Node Performance Evaluation Model for Enhancing the QOS Levels in 6G Enabled WSN

Pavan Vamsi Mohan Movva[1], Radhika Rani Chintala[2]

[1,2] Department of Computer Science Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Andhar Pradesh, India.

[1]mpavanvamsi97@gmail.com, [2]radhikarani_cse@kluniversity.in

Article History:

Received: *12-09-2024*

Revised: *18-10-2024*

Accepted: *28-10-2024*

Abstract:

Among the many promising qualities of the Sixth Generation (6G) are its ultra-dense connection, integrated sensing and communication, secure communication, very high data rate, energy and spectrum efficiency, and ultra-reliable low latency communication. Novel approaches to environmental protection and resource monitoring have evolved with new forms of communication networks made possible by technological advancements. When it comes to environmental research and science, 6G enabled Wireless Sensor Networks (WSNs) plays a key role. There are several fields that can benefit from WSNs, including robotics, environmental monitoring, medicine, and the military. The Quality-of-Service (QoS) is a critical concern in wireless sensor applications because to the increasing demand for their use in various domains. Because the resources accessible from sensors and the many applications operating over these networks have varied limits in nature and requirements, ensuring QoS in WSNs is complex and increasingly demanding. Delays, throughput, jitter, and other network-level indicators used to be the main focus of QoS efforts. In this research, a model for providing suitable QoS measures for WSN is proposed, including service, reliability, and availability, all of which contribute to the preservation of high-quality service. Availability, Dependability, and Serviceability are the parameters considered for providing QoS. 6G wireless networks are largely focused on enhanced intelligence, synchronization of resources and topology from beginning to end, and the inherent support for high-bandwidth, low-latency communication. With these features, cyber physical user experiences that are rich in context are feasible. As a result, defining and identifying the function of quality of experience in 6G networks is crucial, particularly for network administration. To optimize application service satisfaction, a WSN should learn to govern the network's overall performance based on QoS characteristics, which guarantee the transfer of information. This research proposes a Recurring Network Node Performance Evaluation Model (RNN-PEM) for enhancing the QoS levels in 6G enabled WSN. The proposed model when compared with the traditional models, provided enhanced QoS levels.

Keywords: 6G Networks, Wireless Sensor Networks, Quality of Service, Network Performance, Availability, Dependability, Serviceability, Node Performance.

1. Introduction

The rollout of 5G networks is far from finished, and customers have been mixed about the results thus far. Nevertheless, plans for 6G networks are already the subject of heated debate [1]. White papers outlining potential ideas have been widely produced by operators like NTT Docomo and manufacturers like Samsung and Ericsson. Projects like the 6G Flagship at the University of Oulu

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have been consulting with prominent academics and industry professionals on 6G network considerations, and their thorough perspectives and vision papers have provided valuable insights. Regarding the services that will set 5G apart and the anticipated supporting technologies that will make them possible, there is widespread agreement [2]. The downlink data throughput is anticipated to reach ambitious levels of terabits per second (Tbps), and some sources indicate that the first 6G deployments would happen in 2028 or 2029. Nevertheless, autonomous intelligence is anticipated to be the central feature of 6G networks. Everyone involved, from the user to the network provider, has this expectation. Whereas 5G was characterized by a heavy focus on virtualization of resources and thorough softwarization [3], 6G is expected to take advantage of advancements in inference and artificial intelligence, with these advancements being considered for use at every level of network operation [4].

In order to meet the increasingly demanding QoS standards of the many new apps and services that will be available in the future, it is necessary to think about the 6G wireless network and its enhanced capabilities [5]. In order to bring about the future society that is entirely intelligent and automated, there are a number of obstacles that must be overcome when trying to conform to these limits. After outlining the essential enabling technologies and potential future uses of 6G networks [6], this research considers to enhance quality of service levels in 6G enabled WSNs. Also included is a current state-of-the-art overview of the problems with and potential solutions to meeting quality of service standards in areas like as bandwidth, connectivity, packet loss, latency, and throughput [7]. The WSN established for military application is shown in Figure 1.

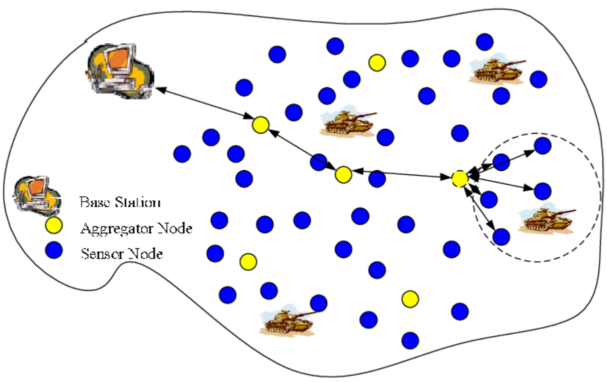

Fig 1: WSN for Militarily Application

The building blocks of WSNs, known as nodes, are microcontrollers, sensors, and radio transmitters. All regions that demonstrate good performance can make use of sensors with dual purposes. Classification of sensors is mostly based on their preparedness for deployment, with an emphasis on economic and engineering efficiency, cost, and scalability during deployment [8]. Chemical, biological, and physical sensors are the three basic categories into which these sensors fall. Two networks an information network and a data distribution network make up a WSN. This network is overseen and controlled by a central station [9]. Various wireless distribution mechanisms are used to deliver this data to the main station. Transmission via cellular phones, WLANs, PCs, and Wi-Fi are all part of the wireless distribution methods [10]. Once the data reaches the main station, it undergoes additional processing and analysis. Energy recovery, addressing node failure, mobility, heterogeneity, scalability in large-scale deployment, simpler utilization, and resistance to harsh climatic conditions are the main aspects of WSN. A wide range of sensor network applications are ensured by these qualities [11].

The widespread use and utilization of wireless sensor networks has been boosted by their incredibly beneficial applications across several fields of study and industry. Use of WSN isn't without its challenges, though, due to sensor nodes' and wireless channels' error-prone nature and the resulting decreased bandwidth, power, processing capabilities [12], and communication range. Sensor nodes and WSNs typically struggle with limited energy. Sensor nodes start their operation by collecting data from the relevant environment, which depends on the environmental monitoring application [13]. There are a number of computations that this node can do on the data, depending on what the system needs. It is necessary to transmit this data to the base stations for processing after computation. In the realm of data transmission, these sensor nodes can serve as either source nodes or routers due to the lack of infrastructure such as routers. Typically, the sensor node's associated battery cannot be recharged; it receives energy needed for detecting information from the environment and then transmits and receives data [14]. A sensor node's lifespan is likewise dependent on its battery life; as a result, efficient utilization of available energy is essential.

A WSN's average power consumption is a typical performance metric; this metric dictates the network's lifetime, or the amount of time it stays online. To guarantee data transmission according to the QoS requirements, WSN should be able to manage the network's overall performance. QoS refers to the sum of a service's performance and how satisfied its users are with it. QoS is the overarching rationale for control, evaluation, and communication networks. QoS aims to assess and control latency factors, network packet loss, and power consumption in order to configure the protocol appropriately and get the right response to these variables [15]. The energy consumption of WSNs, however, is arguably the most important factor when trying to estimate QoS parameters [16]. Optimal routing methods can increase the life expectancy of sensor and network nodes, lead to energy management in WSN, and transmit information in multiple steps, since the power required to send information accounts for the highest level of energy consumption in sensor nodes [17]. The Figure 2 shows the Cluster based Communication in WSN.

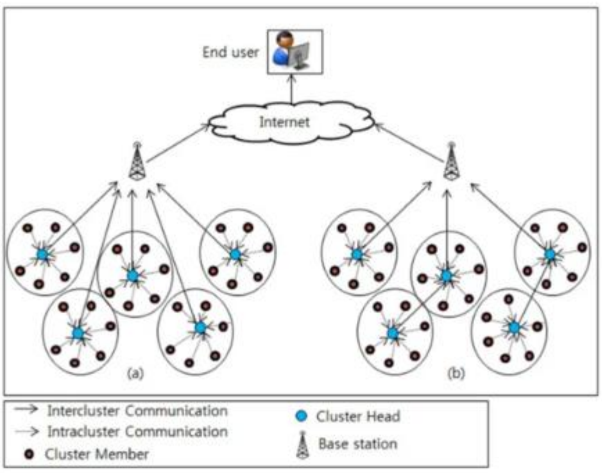

Fig 2: Cluster based Communication in WSN

Efficient techniques can be helpful in increasing the lifespan of a WSN because reaching maximum lifetime is just as challenging and complex as conventional optimization problems. Publications state that deterministic algorithms and conventional search algorithms might not be able to give WSN-suitable answers because of their limited processing capability and the requirement for real-time [18]. Metaheuristic algorithms, which are both fast and lightweight, can instead find near-optimal solutions in this kind of setting by taking QoS limitations into account. Transmission of data over long distances increases the energy loss of sensor nodes, which in turn increases the likelihood that these nodes will fail and impair overall performance [19]. Therefore, clustering is one of the methods needed to lower the energy consumption of nodes. Because cluster heads are responsible for transmitting data to the sink in the network, it is important to choose cluster heads with consideration for factors such distance from other nodes, amount of leftover energy, and so on in order to maintain a steady flow of data while extending the life of the network [20]. Clustering and choosing the best cluster heads have a significant impact on how well a network performs.

WSNs have found more and more uses with the advancements in wireless networking and multifunctional sensors that can interpret data and communicate with one another. For many types of applications, WSNs can offer a more precise and dependable monitoring service [21]. To ensure that the unique needs of various application types are satisfied, quality of service might be a useful tool. Constraints like resource limitations and changeable topology render traditional quality-of-service techniques in wired networks inadequate for WSNs [22]. Providing guarantees for QoS parameters in real-time applications is one of the several issues related to WSNs. Thus, new methods for long-term QoS maintenance and self-adjustment in response to changes in application state and necessary QoS should be provided by middleware. When designing middleware for a WSN, it is important to consider how to balance various performance parameters, including energy consumption, data delivery delay, network capacity or throughput, and overall performance. This research proposes a Recurring Network Node Performance Evaluation Model for enhancing the QoS levels in 6G enabled WSN.

2. Literature Survey

A well-studied problem in service-oriented wireless sensor networks is sensor service ranking for effective resource allocation. Current methods for ranking sensor services do not adequately balance application needs with the need to minimize the use of limited network resources. When rating the sensor services for various application inquiries, a common usage context of the sensor data is also taken into account. Many apps end up failing to achieve their quality of service standards because of this. Considering the application's usage environment, Bharti et al. [1] suggested a value-of-information based sensor service ranking mechanism that is energy-aware. The technique models the rank of a sensor service as an attribute of value of information. By incorporating the suggested ranking algorithm with the current gateway service, users can see that it effectively balances the needs of individual applications with the network's total energy consumption. According to the simulation results, the suggested method is superior to the current state of the art in sensor service ranking algorithms when it comes to satisfying the quality of service needs of applications.

Chakraborty et al. [2] delved into the issue of cost management in sensor clouds that takes QoS into consideration. These clouds often include both sensor owners and several SCSPs. The rapid adoption of WSN and IoT technology prompted the development of the sensor-cloud infrastructure, the main goal of which is to simplify the management of WSN-based applications by providing Sensors-as-a-Service (Se-aaS). However, the profitability and quality of service are greatly affected by the oligopolistic market environment of sensor clouds, which involves several SCSPs and sensor owners. Therefore, to keep sensor-cloud useful, it is necessary to investigate the dynamics of this market rivalry thoroughly. None of the previous efforts have dealt with the problems listed above in sensor-cloud. Therefore, the author used a game-theoretic technique to examine the interactions between the SCSPs and the sensor-owners in this study. In order to ascertain the best approaches for the different players in the sensor-cloud industry, the author provided QUEST, a quality-of-service (QoS)-aware dynamic cost management system.

The majority of current WSN routing protocols prioritize either security, QoS, or energy efficiency. Many applications necessitate QoS and security assurances in addition to the necessity of extending the network's lifetime; thus, a more comprehensive perspective on WSNs is necessary. The tradeoff between network longevity, QoS, and security must be considered due to the low energy capacity of sensor nodes. In order to tackle these problems, Rathee et al. [3] proposed a QEBSR method for WSNs that is based on ant colony optimization. The author presented enhanced heuristics for determining the trust factor of routing path nodes and the end-to-end transmission delay. Energy efficient routing with node compromised resistance and distributed energy balanced routing are two existing algorithms that are compared to the suggested technique.

Concerns with QoS are significant in next-generation networks like SDWS-IoT, which is built on software-defined wireless sensors. As a means to enhance QoS in SDWS-IoT, Optimized Traffic Engineering (TE) methods can be employed. There is a dearth of QoS awareness, inefficient flow management, high power consumption, short network lifetimes, tedious network administration, and so on in the literature on the subject. With these problems with related solutions in mind, Kumar et al. [4] presented QuOTE, a QoS aware optimized TE method for effective flow management in SDWS-IoT networks. In order to determine the best course of action in light of various network QoS restrictions, it gathers link QoS statistics for the entire network. The author used the CPLEX Optimization solver, the MATLAB environment, and the Python APIs to put the solution into action.

In order to provide environmentally friendly services based on the Internet of Things (IoT), Rajavel et al. [5] tackled the issue of effective virtual sensor generation in sensor-cloud. QoS, efficiency in resource use, and revenue gained by stakeholders are the primary factors that determine the sustainability of sensor-cloud. Given the limited resources available at sensor nodes, it is crucial to reduce the cost of service provisioning by minimizing energy consumption both at these devices and throughout the network. For the service provider to maintain a steady stream of income, it is critical that the QoS be uncompromised. The resource consumption of the network is significantly affected by the multihop connection from source nodes to the base-station, however this aspect is hardly addressed in previous research on virtual sensor generation in sensor clouds. As a result, the author provided a game-theoretic description of the problem and suggest a hybrid method, GS2, to address it in this study. According to this findings, the service provider managed the network's resource consumption by adjusting the price paid to the sensor owners.

To facilitate the on-demand sharing of sensing functions, network virtualization has recently emerged as a trend in WSNs. With the use of virtual network embedding (VNE), sensing requests can be efficiently handled by WSN resources. These factors need to be considered, such as wireless interference, QoS and Quality of Information. The computational complexity of finding an ideal solution can become prohibitive at scale as a result of the new limitations. To investigate the trade-off between search time and solution quality, Katona et al. [6] build an offline embedding algorithm that searches across all possible embeddings. The author found a well-defined sequence of first-order processing stages that, when executed in a limited amount of time, produce solutions of good quality.

Reduced and almost predictable end-to-end latency allows for the control of actuators and the capture of data in real time. To further improve upon the dependability of wired networks while simultaneously taking advantage of wireless networking, defined latency is an essential component of quality-oriented service. In this paper, Ademaj et al. [7] provided a quality-of-service routing protocol that may minimize end-to-end latency and balance power consumption across wireless sensor and actuator nodes. The author implemented a time-division multiple access technique in routed wireless networks to remove energy- and time-wasting retries and to enable defined latency. This scheme also increases energy economy by minimizing collisions. With our innovative routing algorithm, users can predict both the latency and the round-trip timings. The author put suggested routing method into practice by building a demonstrator and displaying the trial outcomes of a wireless sensor network.

Gantassi et al. [8] presented new difficulties, particularly in the area of building routing protocols to enhance the QoS criteria and longevity of LS-WSNs and HSND-WSNs, which are large-scale wireless sensor networks. Few of the difficult issues for routing protocols include accurately locating SNs, minimizing power consumption during clustering, minimizing delay during transmission, and decreasing the distance between base stations (BS) and cluster heads (CH). Therefore, an intelligent mobile data collector (MDC) must be supported by a dynamic WSN in order for data propagation to continue despite the topology changes that are unavoidable. In light of these difficulties, the author offered a new intelligent routing protocol that uses the improved recursive distance vector-hop (IR-DV-Hop) localization algorithm to pinpoint the precise, error-free locations of SNs in LS-WSNs, as well as the CHs and the best route that the MDC should take in terms of latency, reliability, energy efficiency, and efficiency. With the MDC acting as a go-between for the CH and BS, the suggested MDC-IR-DV-Hop protocol improves the routing protocol's transmission phase, decreases data collection delays, and boosts WSN quality of service.

A specialized WSN called Wireless Body Area Network (WBAN) links a wide variety of autonomous medical devices both within and outside the human body. With an older population and more people living with chronic diseases, there is a growing interest in human healthcare monitoring systems that rely on WBAN. By making it possible to remotely monitor a patient's health in the course of their everyday activities, HMS is anticipated to lower healthcare expenditures. Protocols for routing in WBAN are the subject of this study performed by Ahmad et al. [9]. Routing protocols face significant challenges in areas such as energy consumption, path loss ratio, packet delivery ratio, and signal-to-noise ratio stability. In order for HMS to assist patients via healthcare providers, caregivers, and hospital networks, real-time analysis is necessary. The collected data is transmitted back to the access point for processing and retransmission using preexisting wireless communication techniques. This research proposes an Improved Quality of Service aware Routing Protocol (IM-QRP) for WBAN based HMS to remotely monitor individuals with chronic diseases or who are old in healthcare facilities or residential settings.

Integrating WSNs with IoT applications has been beneficial for WSNs in recent years. There has been a meteoric rise in the indoor and outdoor use of WSNs for tracking and monitoring purposes. To enhance the performance of QoS in WSNs, deployment and routing techniques are crucial due to the limited resources and interconnected sensors that make up WSNs. Genetic Algorithms and other metaheuristics algorithms provide the basis of many of the current approaches. To ameliorate the quality of service in WSNs, Moshref et al. [10] suggested a novel method, ENRGRA, which stands for Enhanced Non-Dominated Sorting Genetic Routing method. In order to find novel solutions, the suggested approach uses a dynamic weighted clustered scheduled vector to change reference points, building on Non-Dominated Sorting Genetic approach III. Additionally, ENSGRA can be utilized to discover a way to combine two-parent crossover with multi-parent crossover (MPX), allowing for the production of numerous offspring while simultaneously improving each one to achieve the best possible Pareto Fronts (PF).

3. Proposed Model

The development of communication networks over the past few decades has paid off, and these networks are now essential to the global economy and society. With the fast development of Artificial Intelligence (AI) in new communication networks, intelligent IoE applications have been increasingly present in our daily lives and are driving and deepening a variety of use cases, including smart cities, smart healthcare, smart vehicles, and smart industries [23]. From the end user all the way to the network edge and the distant cloud, intelligence is present at every stage of the network, driving demand for network connections, computing power, data sharing capabilities, and AI capabilities [24]. The 5G network's computation, data, and AI model resources, however, are often located in the cloud and mobile edge computing infrastructure. As the wireless environment and user attributes change, it becomes more challenging for the network to recognize and regulate the cloud AI platform's resources in real-time. This makes it impossible to provide high-quality AI services with stringent delay constraints [25]. Thus, in order to incorporate AI capabilities natively, the 6G network needs to think about AI deep integration throughout the architectural design stage [26].

There are two parts of requirements that must be considered in the 6G native AI design: AI has the potential to facilitate the network's high level of autonomy. Fast automated operation, maintenance, detection, and self-healing of networks can be achieved with the use of AI, which can optimize network decisions and data measurements efficiently [27]. Second, vertical sectors can benefit from AI-supported intelligent applications. New market value can be generated via the 6G network by directly providing AI services to users in vertical industries, with quality guaranteed [28]. The 6G native AI wireless network is an integrated architecture that thoroughly blends communication and AI, meeting the requirements mentioned before. It needs logic processing capabilities, life cycle management capabilities, and the capacity to supply AI services to both the network and vertical businesses. Native AI wireless networks should also manage and coordinate the network's compute, data, communication, and AI model resources, such as the core network terminals [29]. AI applications like intelligent group collaboration, distributed learning, and real-time AI inference will rely on the 6G network as its foundational infrastructure.

To guarantee the quality of AI services, directly providing them in 6G networks allows for flexible and on-demand resource control, which is a major advantage. There is no longer any need for networks to compromise on communication QoS. Broadband, latency, jitter, and bit error rate are some of the communication index dimensions that are defined by 3GPP and are connected to quality of service [30]. Users would receive differentiated network quality assurance services based on pre-set QoS criteria through RAN protocols such service data adaptation protocol. But since 6G native AI wireless networks bring intelligent capabilities, there are many additional factors to think about besides communication performance, such as AI service latency, model performance, data redundancy, overhead, privacy, and so on.

The sensor nodes that make up a WSN are often small, inexpensive, and dispersed devices. A small device called a node contains a processor, memory, transceiver, and power source. It may detect, process, and transmit data about events it has seen to other nodes in the network, which ultimately leads to a central processing unit often called a sink. In order to conserve energy, a sensor node should be able to process as much data locally as feasible rather of simply transmitting raw data. This is because radio frequency (RF) communication consumes the most energy. Since batteries are typically the primary power source for sensor nodes, the expected lifespan of each individual node is directly proportional to the battery's capacity to store energy. Because of this, numerous Media Access Control (MAC) protocols have been suggested, such as SMAC, to enable and disable radio transmission at predetermined intervals rather than continuously listening to the channel. Keeping high quality of service measures is the primary objective in conventional networks, however energy saving is a major challenge for any suggested protocol in sensor networks. The proposed model workflow is shown in Figure 3.

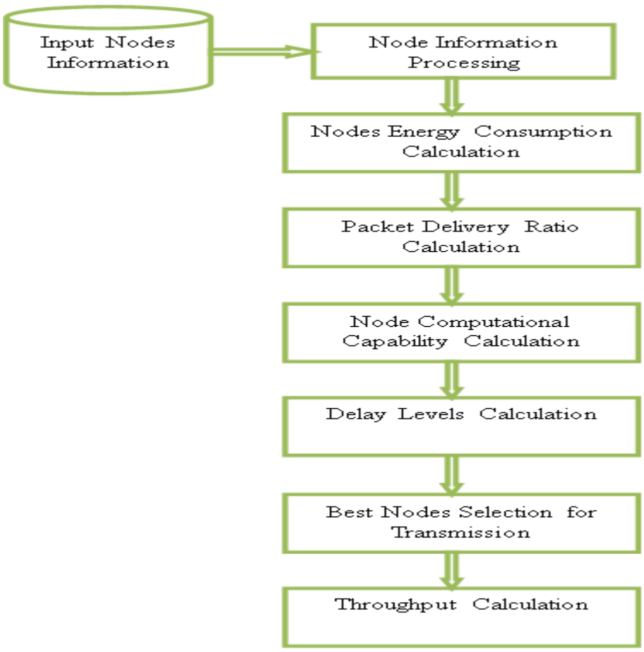

Fig 3: Proposed Model Workflow

In addition to its various uses in routing, QoS, localization, and energy efficiency, WSN has numerous more potential uses in domains such as health monitoring, traffic monitoring, industrial automation, and disaster prediction. The restricted resources of the sensor node make energy a significant restriction in WSN. While data is being transmitted from sender to receiver, it is necessary to keep the network's energy efficiency in mind, as sensor nodes do not consume much power. There are three distinct stages in a WSN's life cycle: the start-up, life, and death phases. The start-up phase, sometimes called the birth phase of a WSN, entails the initial optimization, configuration, and organization of the network. Developing procedures that consume least energy is necessary because this phase uses a lot of energy. At least one sensor node needs to be communicating with a data collecting device during this application-oriented phase. All nodes in the network should be able to communicate with one another. The Life Phase is where WSN's real communication happens. In this stage, the primary objective is to sense the data in the target area and transmit this informed data to the base station. It also detects threats, reports errors, and transmits data throughout the network. During this stage, achieving and maintaining the predefined QoS is of utmost importance.

With the advancements in WSN technology and new applications in process control and industrial automation, smaller, smarter, and more effective wireless sensor nodes are now within reach. WSNs offer the advantages of wireless media and can replace wired sensors. One type of WSN that differs from conventional wireless networks while yet emulating their characteristics is the ad hoc network. Keep in mind that sensor nodes have certain restrictions, such as a lack of memory, computing power, and energy. The sink node gathers environmental data and geolocation information from the network's sensors. With this information, it knows not only the area's condition but also the nodes' locations, which it uses to group them into different clusters. Using QoS characteristics, cluster heads determine the best route to the sink node. With the suggested approach set up initially, each sensor node has the same amount of energy. As a result, the distance between the sensor nodes and the chosen nodes might be a deciding factor in the first phase of identifying the next node. This research proposes a Recurring Network Node Performance Evaluation Model for enhancing the QoS levels in 6G enabled WSN.

Algorithm RNN-PEM

{**Input:** Nodes List {NLset}

Output: QoS Metrics set

Step-1: The nodes that need to involve in communication will be registered with the network authority. The nodes information is helpful in recognition of nodes and for future communications. The node information processing is performed as

$$NodeInfo[M] = \sum_{n=1}^{M} getnodephyaddr(n) + range(n) + allocener(n)$$

Here node physical address is considered and range() is used to know the communication range of nodes and allocener() model considers the allocated energy levels to the network.

Step-2: WSNs are mainly dependant on battery energy sources to complete their operations. The energy consumption is the key factor in considering nodes into communication. The energy consumption of nodes in the network are calculated as

$$enerCon[M] = \sum_{n=1}^{M} \frac{\lambda(n)}{allocener(n)} + Th$$

Here λ is the model that considers the remaining energy levels of a node, Th is the threshold energy level considered to avoid loss rate.

Step-3: The node computational capability indicates the network performance levels. The more the nodes capability, the more the network performance will be. The node capability levels and packet delivery rate is calculated as

$$NCap[M] = \sum_{n=1}^{M} max\big(range(n)\big) + max\big(neigh(n, n+1)\big) + min(dis(n, n+1))$$

$$PDR[M] = \sum_{n=1}^{M} \frac{\mu(S(n), D(n+1))}{\omega} + \mu(n) - \gamma(n)$$

Here neigh() model considers the adjacent node, dis() model calculates the distance between two adjacent nodes. μ is the packets successfully transmitted from sender S to destination D. μ represents transmitted packets and γ represents received packets.

Step-4: The delay levels in the network indicate the degradation in performance. The delay levels of nodes are calculated so that such nodes causing delays in the network can be eliminated. The delay levels calculation is performed and nodes which have best performance levels are considered for transmission. The process is performed as

$$Delay[M] = getTime\big(\mu(n) \rightarrow \gamma(n)\big) + \max\,(range(n, n+1))$$

$$Nselec[M] = \sum_{n=1}^{M} getaddr(n) + max\big(Ncap(n)\big) + min\big(Delay(n)\big) + min(enerCon(n))$$

Step-5: The throughput levels indicates the overall performance of the network. The high throughput indicates the best performance. The QoS metric assessment is performed as

$$Thr[M] = \sum_{n=1}^{M} \frac{\min\big(Delay(n)\big) + \max\,(PDR(n))}{Time(n)}$$

4. Results

To go even farther than 5G cellular networks, researchers are hard at work on 6G wireless communication. Its stated goal is to transform the way we talk to and use electronic devices by providing previously unseen levels of connection and performance. Faster data rates, ultralow latency, huge device connection, improved energy efficiency, and intelligent network management are the main areas of focus for 6G cellular networks. 6G, with its anticipated terabit-per-second data

rates, holds great promise for enabling revolutionary technologies. There is a growing need for bandwidth, and 6G plans to take advantage of new frequency bands including terahertz (THz) frequencies to meet that demand and open the door to new applications. By ushering in a hyper-connected and intelligent society, 6G has the ability to transform numerous sectors, including healthcare, transportation, education, and entertainment.
High data redundancy is a defining feature of sensor networks. Reducing data message duplication is quite simple for unconstrained traffic because basic aggregating methods are enough. Aggregating data for quality of service traffic, however, is a far more involved process. Image and video stream comparison is not a computationally trivial task and can use a lot of power.

Wireless sensor networks are becoming increasingly popular due to the fast expansion of smart sensor nodes. Many new uses for these networks have emerged in recent years, including in catastrophe monitoring, the agricultural sector, the Internet of Things, healthcare, and border surveillance. Because of the size and dynamic nature of the mobile sensor nodes, meeting the need for QoS in a real-world context is a complicated issue. Using WSN's layered architecture as a foundation, this research discusses the quality of service metrics. Classical layered architecture and cross-layered architecture are the two main varieties of layered designs. Quality of service is accomplished at the layer level in a classic-layered architecture. In a classic-layered architecture, achieving the overall QoS is challenging because of the interrelated nature of these levels. The use of cross-layered architecture allows us to overcome this obstacle. In addition, the suggested statistical study demonstrated that the QoS metric improves the network's performance with regard to dependability, energy, throughput, and latency. Lastly, the methods for improving the network's overall performance using machine learning are examined through the lens of quality of service measurements. This research proposes a Recurring Network Node Performance Evaluation Model (RNN-PEM) for enhancing the QoS levels in 6G enabled WSN. The proposed model is compared with the traditional QoS-Aware Dynamic Cost Management Scheme for Sensors-as-a-Service (QoS-DCMS-Se-aas) and Quality of Service Aware Optimized Traffic Engineering (QuOTE) approach for Efficient Flow Management in SDWS-IoT Networks.

The proposed model maintains all the nodes information and uses this for communication with the nodes. The normal nodes and unauthorized nodes can be easily recognized if the information is analyzed. The Node Information Processing Accuracy Levels are shown in Table 1 and Figure 4.

Table 1: Node Information Processing Accuracy Levels

Nodes in the Network	Models Considered		
	RNN-PEM Model	QoS-DCMS-Se-aas Model	QuOTE Model
50	97.3	94.2	93.7
100	97.6	94.4	93.9
150	97.8	94.6	94.1
200	98.0	94.8	94.3
250	98.2	95.0	94.5
300	98.4	95.2	94.7

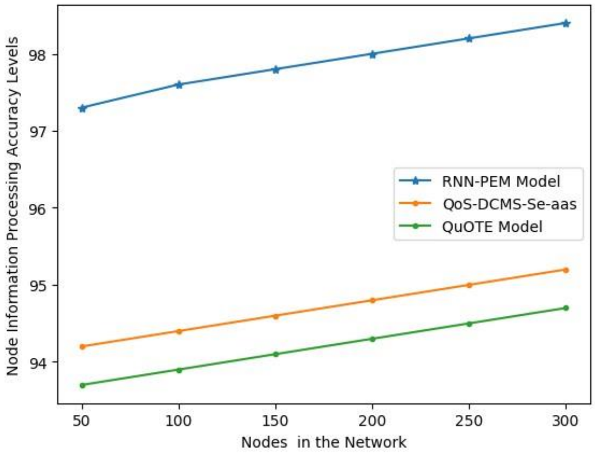

Fig 4: Node Information Processing Accuracy Levels

The proposed model continuously monitors node energy consumption levels in the network. The nodes with minimum energy consumption is considered in the data transmission process. The Node Energy Consumption Levels are indicated in Table 2 and Figure 5.

Table 2: Node Energy Consumption Levels

Nodes in the Network	Models Considered		
	RNN-PEM Model	QoS-DCMS-Se-aas Model	QuOTE Model
50	11.0	17.0	22.1
100	11.3	17.2	22.3
150	11.5	17.4	22.5
200	11.7	17.6	22.7
250	11.9	17.8	22.8
300	12	18	23

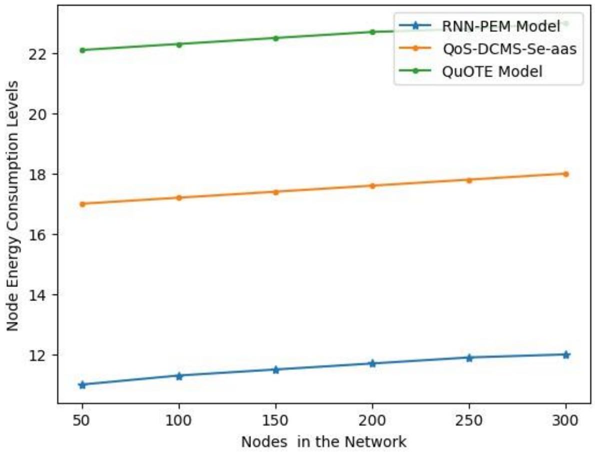

Fig 5: Node Energy Consumption Levels

The packet delivery rate (PDR) is determined by dividing the total number of packets that were successfully received by the total number of packets that were transmitted, and then multiplying the result by 100. The PDR is the fraction of nodes that are able to successfully receive a packet sent out by a tagged node out of all the receivers that are at the same physical location as the sender at the time of packet transmission. The Packet Delivery Ratio is shown in Table 3 and Figure 6.

Table 3: Packet Delivery Ratio

Nodes in the Network	Models Considered		
	RNN-PEM Model	QoS-DCMS-Se-aas Model	QuOTE Model
50	97.9	94.2	93.7
100	98.1	94.4	93.8
150	98.3	94.6	94.0
200	98.5	94.8	94.2
250	98.7	95.0	94.4
300	98.9	95.2	94.6

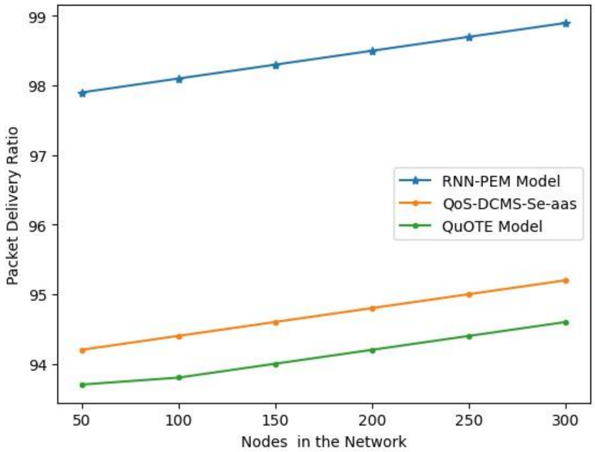

Fig 6: Packet Delivery Ratio

The proposed model verifies the node computational capabilities at frequent time intervals. The nodes that has high computational capabilities are used for transmission. The attacker nodes tries to reduce the Node Computational Capability Levels by injecting malicious code into nodes. The Node Computational Capability Levels is shown in Table 4 and Figure 7.

Table 4: Node Computational Capability Levels

Nodes in the Network	Models Considered		
	RNN-PEM Model	QoS-DCMS-Se-aas Model	QuOTE Model
50	97.4	93.1	94.1
100	97.6	93.3	94.3
150	97.9	93.5	94.5
200	98.1	93.7	94.7
250	98.3	93.9	94.9
300	98.5	94	95

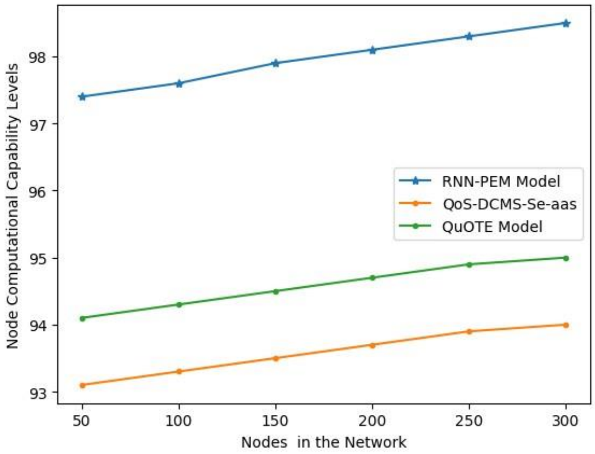

Fig 7: Node Computational Capability Levels

When data packets in transit do not reach their intended recipients, this is called packet loss. Data transmission mistakes, especially in wireless networks or network congestion are the two main causes of packet loss. The ratio of lost packets to total packets sent is called packet loss. The Loss Rate is shown in table 5 and Figure 8.

Table 5: Loss Rate

Nodes in the Network	Models Considered		
	RNN-PEM Model	QoS-DCMS-Se-aas Model	QuOTE Model
50	2.3	8.1	12.1
100	2.6	8.3	12.3
150	2.7	8.4	12.4
200	2.8	8.5	12.6
250	3.0	8.7	12.7
300	3.2	8.8	12.8

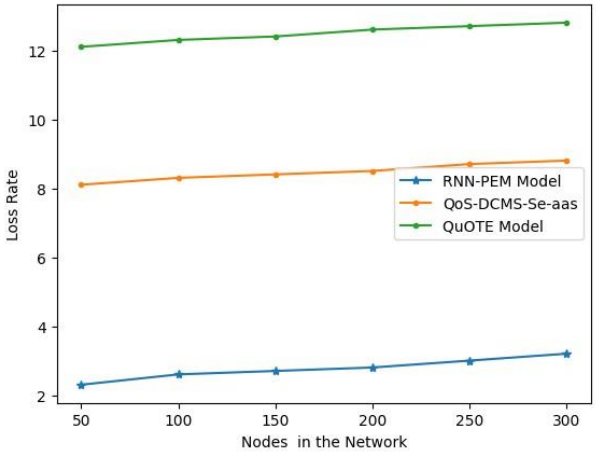

Fig 8: Loss Rate

Delays in transmission over a network are referred to as network delay. The simplest way to think about it is as the whole time it takes for data to be sent via a network, received at its final destination, and decoded. The amount of data downloaded over time is unrelated to latency, which is a measure of the time it takes for data to transit. The Delay Levels are shown in Table 6 and Figure 9.

Table 6: Delay Levels

Nodes in the Network	Models Considered		
	RNN-PEM Model	QoS-DCMS-Se-aas Model	QuOTE Model
50	11.2	24.1	18.1
100	11.4	24.3	18.3
150	11.6	24.5	18.5
200	11.7	24.7	18.7
250	11.9	24.9	18.9
300	12	25	19

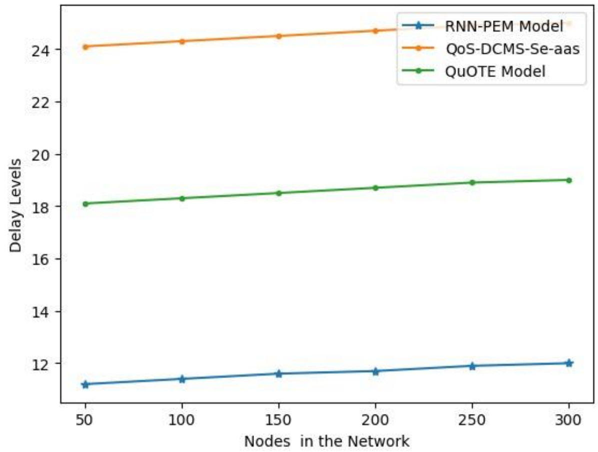

Fig 9: Delay Levels

The quantity of data successfully transferred from one location to another in a specific time frame is called network throughput in data transmission. The term network throughput describes the amount of data that can be sent from one location to another in a given amount of time. The Throughput Levels is depicted in Table 7 and Figure 10.

Table 7: Throughput Levels

Nodes in the Network	Models Considered		
	RNN-PEM Model	QoS-DCMS-Se-aas Model	QuOTE Model
50	97.3	94.5	93.5
100	97.5	94.7	93.7
150	97.7	94.9	93.9
200	97.9	95.1	94.1
250	98.0	95.3	94.3
300	98.2	95.4	94.5

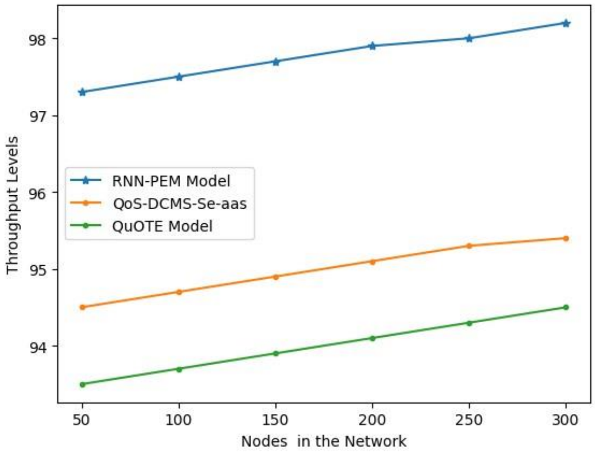

Fig 10: Throughput Levels

5. Conclusion

QoS implementations in WSN are still in their early phases and require significant investment of time and energy. Limitations on available resources and an absence of industry standards are the primary causes of WSN problems. Generally it is not possible for WSNs to achieve the same QoS performance as traditional networks because of the constant trade-offs that exist between QoS support and the restricted resources like power, memory, computing capabilities of the sensors. Improved functionality of WSNs has resulted from the proliferation of wireless communication devices. It finds usage in a variety of fields, including environmental research, health science, industrial monitoring, and disaster prediction. In this case, the WSN layered architecture to depict the QoS metric is considered. The five layers that make it up are the physical, MAC, network, transport, and application layers. The MAC layer uses throughput as a quality of service metric, the network layer uses energy efficiency, and the transport layer uses latency. The network's many levels are interconnected. Because of this, determining layer-wise QoS is challenging, because the performance of the lower layer impacts the top layer. The whole network's QoS in relation to latency, throughput, energy efficiency, and dependability is determined by these measures in this method, rather than just one layer. There is a vast amount of unanswered questions in the vast area of QoS in wireless sensor networks, which could lead to new discoveries in this crucial sector. Several approaches can be utilized to enhance the primary operational characteristics of WSNs and their components, taking into account the metrics of QoS as they pertain to each application. Whether or not the costs associated with these technologies are acceptable depends on their intended usage. This research proposes a Recurring Network Node Performance Evaluation Model for enhancing the QoS levels in 6G enabled WSN. The proposed model analyzes the nodes in the network and their performance is continuously monitored. The delay levels in the proposed model is very less than the traditional models. The proposed model maintains better QoS levels when compared to the traditional models. The proposed model achieves 98.9% packet delivery rate. In future, hybrid optimization models can be applied to further enhance the QoS metrics for better performance levels.

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