An Optimized Wireless Network Performance for Secure Data Transmission and Quality of Service

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Abstract
Performance analysis and optimization are becoming increasingly critical as wireless local area network technology becomes more prevalent. Wireless channel, on the other hand, is more error-prone than conventional LAN. Network operators may now appropriately manage traffic needs via users and hotspot locations thanks to the advent of WLAN. The problem of perform consistently to Quality of Service of cellular data networks provides interactive smooth and pervasive services as well as extremely high data rates, which is a matter of consideration. We look at the current issue of network degradation and how it affects the provision of such continuous connection in this research. Most indications for network performance optimization include packet loss, packet delay, and jitter. Need for information services with high dependability, fast response times, and ubiquitous connection continues to rise as wireless networks advance. Wireless networks' intrinsic differences from landline networks sometimes influence these concerns. As a result, network traffic measurements such as latency, packet loss, and packet delay in particular wireless situations have encountered certain performance issues. To address these issues, we looked into network performance optimization strategies and suggested a framework for efficient WLAN performance based on a Type 1 Fuzzy knowledge-based approach. We gathered statistical operational field data and used the suggested model to simulate it. The results reveal that congestions on the typical network environment are minimized, indicating efficient network performance.

Keywords.*Quick Response Time (QRT), Quality of Service (QoS), Packet loss, Packet delay and Jitter*

1. INTRODUCTION

The implementation and use of wireless networks has increased dramatically during the last few decades. Wireless network availability and utilisation have an impact on technological innovation [1]. The majority of our gadgets connect to the internet via a wireless network, thus network speed is critical. A high network performance facilitates mobility and communication, particularly in our industry and other industries. Wireless systems of the present generation can deliver high-speed data services at rates that are far faster than those of the prior generation. As a result, need for information services with high dependability, quick reaction times, and ubiquitous connection continues to grow at a rapid rate, creating opportunities for efficiency and optimization. Electronic equipment, antennas, digital signal processing techniques, network control protocols, and cryptography all play a role in enhancing wireless performance networks. Application of computational intelligence techniques in network, operation, and optimization seeks to improve QoS [2] in a wireless network with this method. The rising number of mobile users, along with the overwhelming demand for network providers' services, has an impact on network QoS, resulting in a strong need for optimization.

2. RELATED STUDY

Wireless efficiency has been investigated in a variety of research. Below is a summary of some of the previous work. As a crucial component of current communication technologies, communication has long piqued researchers' curiosity. IEEE 802.11b has grown in popularity in recent years, owing to its benefits of user mobility, cheap acquisition costs, and ease of deployment, making it suitable for both home and commercial Internet access. The end-user experience, on the other hand, has frequently fallen short of what technology can provide. When compared to other WLAN technologies, the IEEE 802.11b WLAN has a low throughput. The focus of author [3] is on increasing IEEE 802.11b network performance. In Riverbed Modeller software, the IEEE 802.11b network architecture and characteristics were analysed using quaternary key shifting modulation and discrete event simulation techniques. The results revealed that increasing the data rate from 1Mbps to 11Mbps, which is the optimal number, boosted throughput and resulted in an 80% reduction in latency, as well as a near-zero reduction in retransmission attempts. The results also indicated that increasing the buffer size from 1000 bits to 12800 bits, which is also the optimal value, boosted throughput by around 90% with no data loss because the buffer would take longer to fill up, and nearly no retransmission attempts were made. This research will help to improve the IEEE 802.11b network's Quality of Service, lowering the cost of device acquisition and overhauling.

According to [4], the effect of a lowest to highest traffic ratio on Wireless LAN efficiency was examined. The simulation findings demonstrate that depending on the network size and network conditions, the high/low priority traffic ratio has a varying influence WLAN.

Many studies and improvements are now being made to the IEEE 802.11 standard-defined access mechanism to the physical environment. To give QoS to particular flows in network traffic, a range of research methodologies, such as Colored Petri Net [5] and machine learning, are applied.

One of the important research topics for improving wireless network performance is ensuring the QoS by delivering a enough level of activities to fulfill the traffic needs. For communication system engineers, Reference [6] provides a broad roadmap to increasing QoS [7]. The MAC sublayer can also be improved in order to improve service quality. Nano-network networks, for instance, may benefit from an upgraded MAC protocol that increased efficiency, energy economy, and reduces collision risk [8]. It provides an in-depth look at strategies for improving the BEB algorithm, which is used to retransmit messages in wireless local area networks using the CSMA/CA protocol. It's important to note that in Reference [9], the incoming traffic is divided into three types: ordinary, severe and crucial, each with its own priority and delay time. It facilitates the delivery of time-sensitive and crucial information. Furthermore, as shown in References [10,11], this causes considerable network performance reduction in the event of a heavily loaded network. It is recommended in Reference [12] that radio resources be distributed equally among several data streams via channel binding and a revised channel access mechanism. Adjustments may also be made to the MAC layer settings on the fly. For example, a dynamic Contention Window (CW) tuning strategy based on collision likelihood [13].

The kind of wireless network and its architecture were taken into account when developing certain recommended enhancement strategies. For dense IoT-networks [10], WSN, and 5G-NET [11], or a signal-based MAC protocol for temporary networks, Reference [14] proposes a strategy and technique for on-the-fly QoS slice orchestration. The average latency can be cut in half as a result. Furthermore, the average throughput is lowered by 8%.

3. METHODOLOGY

A system is a collection of interconnected, interdependent pieces that create a complex whole [15] [16]. The overarching plan or model that outlines how the system will achieve its information needs is known as the systems design. Creating system-level technical specifications and best system designs, as well as assessing the design's capabilities to satisfy the system need, are important actions in system design [17] [18].

3.1. Proposed System Architecture

The core organization of a system is manifested in its elements, their relationships with one another and the environment, and the rules that govern its design and growth.

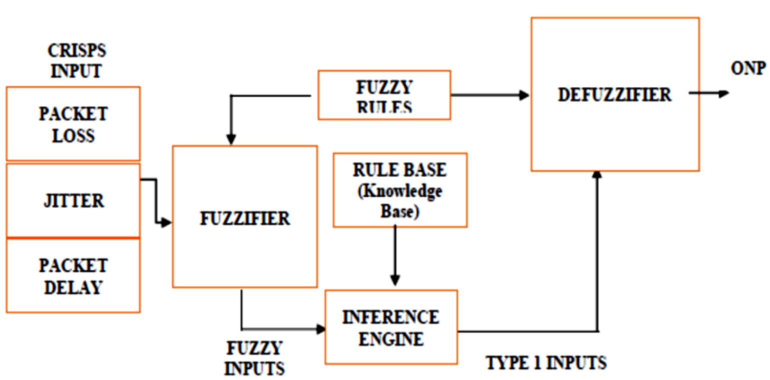

Fig. 1: Architecture of the Proposed System

A system is a collection of interconnected components designed to accomplish a certain goal. Creating system-level technical specifications and top-level design concepts, as well as analyzing the design's capacity to satisfy the system requirements, are vital steps in system design.

3.2 Data Acquisition

Data collection is the process of gathering, measuring, and evaluating correct insights for study utilizing tried-and-true methods. Based on the information received, a scholar may evaluate their theory. Data collection is often perhaps the most important stage of any research project, regardless of topic. Various statistical tools are employed depending on the kind of study being conducted. In order to make statistical research decisions, the most essential purpose of collecting data is to gather relevant and correct information. In this research, the lifetime of the system was tested.

Our goal is to make things more efficient.. There are a variety of ways to evaluate the speed of the network because of its distinct nature and architecture. Packet loss, packet delay (latency), and jitter are the performance matrices used in this study. When analyzing and measuring the performance of a network, system, or device, latency and jitter are two crucial measurement factors. Varied applications have different latency and jitter requirements. VoIP. Latency and jitter are commonly used by network administrators, operators, and engineers as fundamental benchmarking indicators for Quality of Service (QoS) validation. Before a network can be optimized for effective Quality of Service (Qos) provisioning, it is necessary to assess and monitor network performance with a thorough understanding of how latency and jitter impact network performance. Table 1 provides data for a performance measure of a wireless local area network gathered over the course of a week based on the network performance metric.

Date	IP Address	Download Speed	Upload Speed	latency (packet delay)	Jitter	Quality Score
6/14/2020 21:55:0	102.89.2.166	2.40 Mbps	0.15Mbps	255 ms	28 ms	Good
6/14/2020 22:13:42	102.89.2.166	2.14 Mbps	0.23Mbps	227 ms	238 ms	Good
6/14/2020 22:17:47	102.89.2.166	0.75 Mbps	0.28Mbps	228 ms	5 ms	Fair
6/14/2020 22:24:37	102.89.2.166	4.07 Mbps	0.41Mbps	226 ms	6 ms	Poor
6/14/2020 22:31:11	102.89.2.166	2.44 Mbps	0.44Mbps	220 ms	9 ms	Good
6/14/2020 22:44:40	102.89.2.166	4.70 Mbps	0.52Mbps	224 ms	6 ms	Good
6/14/2020 22:50:38	102.89.2.166	2.11 Mbps	0.85Mbps	232 ms	67 ms	Good
6/14/2020 22:51:48	102.89.2.166	5.20 Mbps	0.56Mbps	234 ms	6 ms	Good
6/14/2020 22:53:48	102.89.2.166	3.55 Mbps	0.83Mbps	221 ms	10 ms	Bad
6/13/2020 22:59:33	102.89.2.166	4.68 Mbps	1.23Mbps	230 ms	5 ms	Fair

Table 1: Network Performance sample dataset

Table 1 illustrates the data transfer speeds, with the download speed being higher than the upload speed for many customers. This is common because most high-speed Broadband connections, such as cable modems and DSL, are asymmetric, meaning that browsing speeds are substantially faster than posting speeds. Because most people spend far more time getting than uploading, high-speed Internet providers have prioritized browsing in their systems. As a result, if your transfer rate appears to be worse than your download speed, this is most likely normal. Figure 2 illustrates our download and uploads speeds.

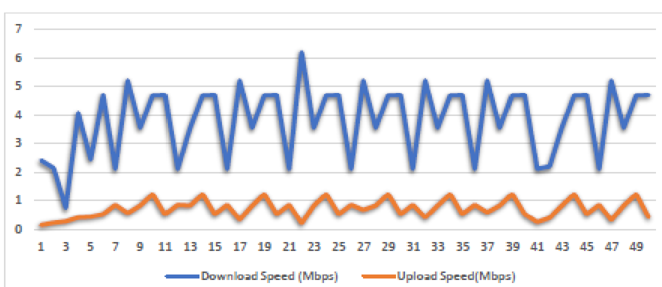

Fig .2: Download vs Upload speed

In addition, table 1 demonstrates how lag and flutter influence to network overall performance. Packet latency and flutter are naturally linked, but they are not the identical. Production delay, queuing delay, transmission delay, and propagation delay are four main components of packet delay, which is a crucial statistic in networking. It has an influence on the user experience and can alter depending on a variety of things. Jitter is caused by delays, notably delays with inconsistencies. Jitter is the difference in delay between two packets. It frequently leads to packet loss and network congestion, as seen in Figure 3.

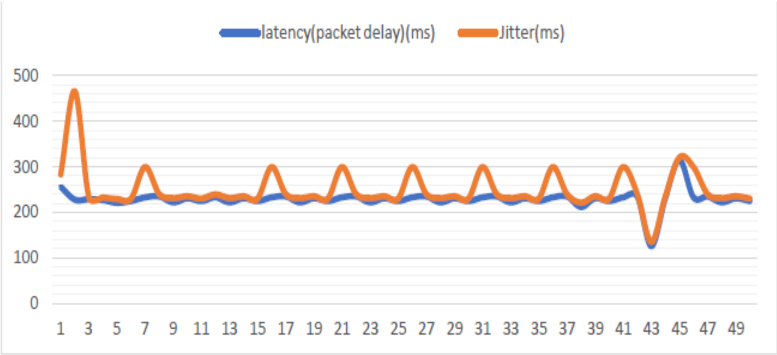

Fig 3 Latency vs jitter

3.3 Rule Base

A rule is a linguistic phrase that explains the connection between the input and output language variables. A dependent clause is the most basic form of a fuzzy rule.

Rule No.	PL	JI	PD	ONP
1.	LOW	LOW	LOW	GOOD
2.	LOW	LOW	MID	GOOD
3.	LOW	LOW	HIGH	GOOD
4.	LOW	MID	LOW	GOOD
5.	LOW	MID	MID	GOOD
6.	LOW	MID	HIGH	AVERAGE
7.	LOW	HIGH	LOW	AVERAGE
8.	LOW	HIGH	MID	AVERAGE
9.	LOW	HIGH	HIGH	BAD
10.	MID	LOW	LOW	GOOD
11.	MID	LOW	MID	AVERAGE
12.	MID	LOW	HIGH	BAD
13.	MID	MID	LOW	AVERAGE
14.	MID	MID	MID	AVERAGE
15.	MID	MID	HIGH	AVERAGE
16.	MID	HIGH	LOW	AVERAGE
17.	MID	HIGH	MID	BAD
18.	MID	HIGH	HIGH	BAD
19.	HIGH	LOW	LOW	BAD
20.	HIGH	LOW	MID	BAD
21.	HIGH	LOW	HIGH	BAD
22.	HIGH	MID	LOW	AVERAGE
23.	HIGH	MID	MID	GOOD
24.	HIGH	MID	HIGH	BAD
25.	HIGH	HIGH	LOW	AVERAGE
26.	HIGH	HIGH	MID	BAD
27.	HIGH	HIGH	HIGH	BAD

Table 2: Rule Base

3.4 Model Formulation

The metrics of network service quality as observed by the client are shown in network quality. Because each network is unique in its nature and architecture, there are a variety of methods for assessing its performance. Basically, rather than measuring performance, it may be described and simulated; for instance, state transition diagrams can be used to model processing efficiency, or a Network Simulator can be used. Depending on the functional and measurement technique, network performance is measured using factors such as latency, jitter, packet loss, and throughput, among others. The general performance parameters that are most commonly considered in wireless networks are investigated in this study paper.

Packet Delay (PD), Jitter (JI), and Packet Loss (PL) are examples of these issues (PL). The Fuzzy Logic System's fuzzification procedure will use them as input variables. The length of time it takes packets to arrive at a certain endpoint, expressed in milliseconds, is referred to as packet delay (DE). Jitter (JI) is the undesirable variation from genuine periodicity of a supposed periodic signal in electronics and telecommunications, which causes drop of synchronisation between data delivered, calculated in ms. The proportion of packets that are dropped during transfer is referred to as packet loss (PL).

3.5 Fuzzy Logic System

We've gone with a T1 FLS based on [8] as demonstrated in. Figure 5: A Fuzzy Model of Type 1.

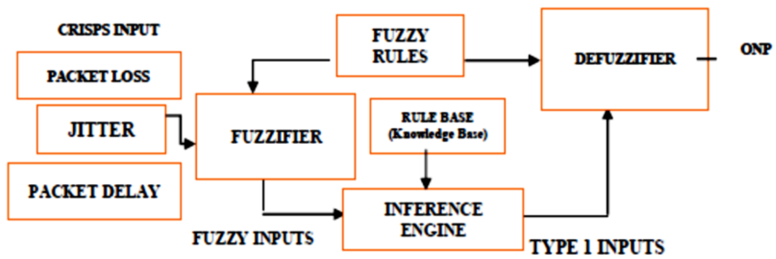

Fig 5: Type 1 Fuzzy Model

3.6 Design Architecture

The theoretical network model used in this work is the Fuzzy Inference Network, which comprises mostly of the MATLAB GUI that provides the foundation for constructing Fuzzy Rules and Membership Functions. The following diagram depicts the Information Processor, Knowledge Base, which is made up of both a data structure and a Fuzzy Logic Model, and User Interface. While structured data (e.g., packet delay (PD), jitter (JI), and packet loss (PL) are employed in the system design, the knowledge engine is comprised of both structured and unstructured data. Figure 6 depicts the study's conceptual architecture.

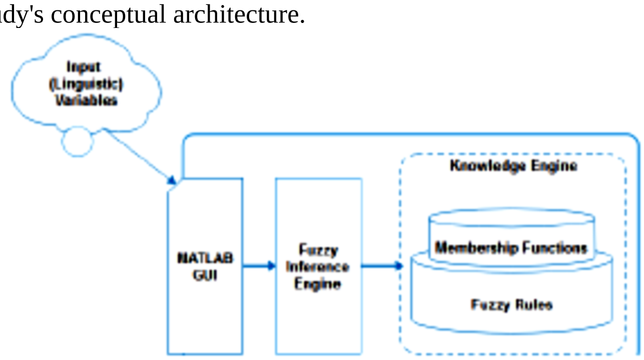

Fig 6: FIS Framework

The membership functions are used in the fuzzification phase to assess the grade of membership of the entries of the specified input variables. The crisp data are changed to fuzzy variables in this manner. The final result supplied in the various rules is then mapped to intermediate outcomes evaluating fuzzy sets using this method. The degree of user satisfaction with quality of service is represented by the OPN output. Optimum Network Reliability [Good, Average, Bad] is the outcome fuzzy linguistic factor and its words.

3.7 Membership Function Definition

The triangle membership function is used, as stated before in the preceding paragraph. To link together different ranges of input and output variables, a fuzzy group with almost the same identity as the region is employed. Additionally, 3 fuzzy sets for the endogenous variable and 3 fuzzy sets were created for the three different input parameters that were detected.The Semantic Universe of Discourse is summarized in the following tables.
A service provider's data and expert knowledge are used to create the fuzzy rules. The network is the master in this example, and the participation plots below explain how the rules are implemented in creating the various membership plots.

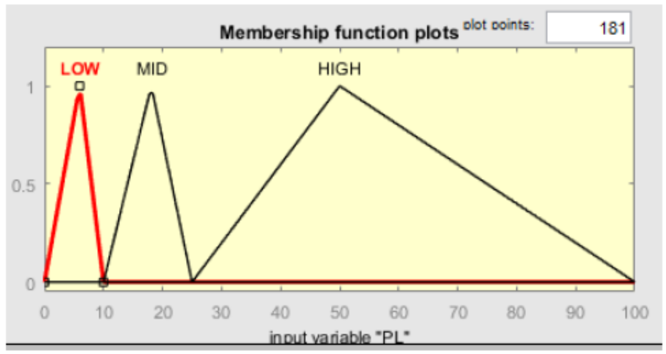

Fig 7(a) Packet Loss(PL)

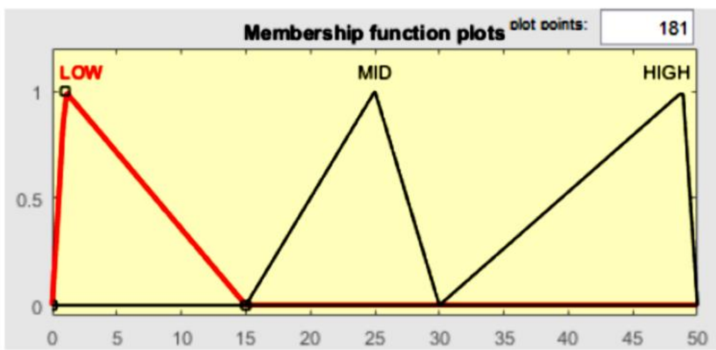

Fig 7(b) Jitter (JI)

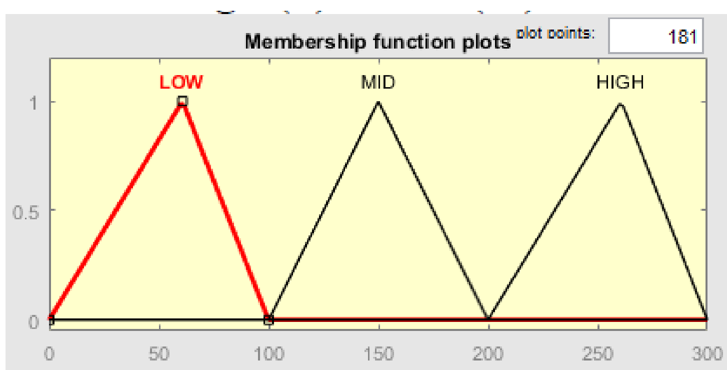

Fig 7(c) Packet Delay(PD)

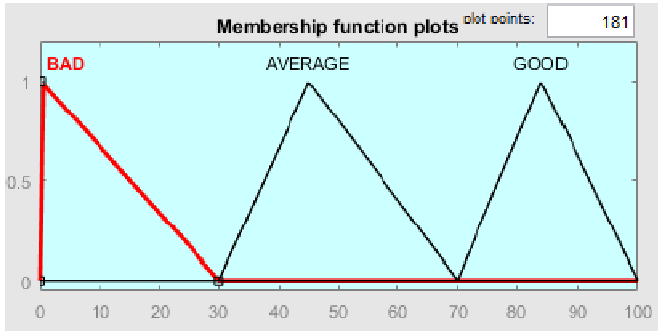

Fig 7(d) Optimized Network Performance(ONP)

Fig.7a, 7b, 7c, and 7d shows Inputs and output triangular MF plots for i) Packet Loss (PL), (ii) jitter (JI), iii) Packet Delay (PL) and (iv) Optimized Network Performance (ONP).

3.8 Defuzzification

The defuzzification operation is the inverse of the fuzzification process. Turning a fuzzy collection of data into a crisp number is the defuzzification process. Maximum, centre of gravity, and the middle of maxima are the most often utilized defuzzification algorithms. In this study, the discrete centre of gravity, also known as the Centroid of Area Defuzzification technique, is used. In order to determine the FIS result, every rules are valued according to its normalized weighting factor, and all rule results are combined.

The Crisp output

$$z = \sum_i^{27} Y'_K Z_K = \frac{\sum_i^{27} y_K z_K}{\sum_i^{27} y_K}, \qquad (4.8)$$

Where Y'_K is a discrete universe, and $\sum_i^{27} Y_K Z_K$ is its membership value.

4. RESULTS AND DISCUSSIONS

This study employed a fuzzy logic system that includes a rule viewer for adjusting various input parameters and determining how the output would change depending on different instigations.We utilize the MATLAB Fuzzy Logic toolbox functionalities to run the simulation, including the user interface and fuzzy inference, to aid the trial choice for the optimal network efficiency. Figure 12 depicts a Surface Plot for Packet Delay vs Packet Loss. Table 3 shows the inputs needed to analyze Triangular MF:

Conditions	Inputs			Outputs	ONP
	PL (%) (0-100)	JI (ms) (0-50)	PD (ms) (0-300)	TRI MF	
1.	50	25	150	10.33333	BAD
2.	25	40	300	50	AVERAGE
3.	30	23	50	49.52934	AVERAGE
4.	17	35	60	50	AVERAGE
5.	29	50	150	50	AVERAGE
6.	45	17	250	84.72055	GOOD
7.	10	19	280	50	AVERAGE
8.	7	18	97	84.94276	GOOD
9.	100	50	300	50	AVERAGE
10.	78	10	4	49.80792	AVERAGE
11.	60	25	200	50	AVERAGE
12.	4	50	45	50	AVERAGE
13.	80	12	140	49.50063	AVERAGE
14.	45	25	45	84.70212	GOOD
15.	70	23	12	84.77512	GOOD
16.	100	56	45	50	AVERAGE
17.	34	4	56	49.19221	AVERAGE
18.	12	12	78	84.88135	GOOD
19.	29	23	90	49.64233	AVERAGE
20.	67	45	130	11.4192	BAD

Table 3: Tested Inputs (Simulated Data)

The modeled input data for network performance are shown in Figure 13. When the time it takes to transport packets to their destination is long and all other input parameters are median or low, the network performance is poor; nevertheless, when the delay is short, it is easy to achieve ideal network performance. These three factors are the ones that obstruct network performance the most during congestion, and they're crucial when it comes to maximizing network performance for QoS provisioning.

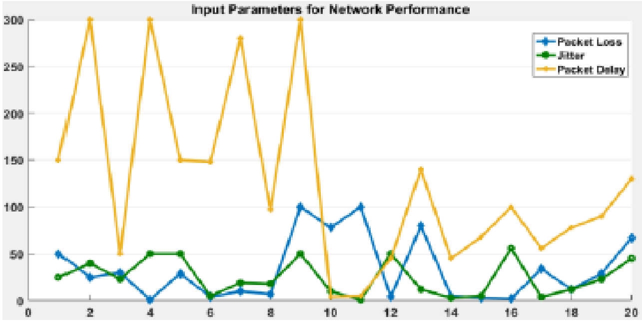

Fig. 13 Network Performance Inputs

Figure 14 also shows the result of the simulated network quality, which includes packet loss, flutter, and lag. These three characteristics are used to improve the network's efficiency over the present system, which employs a queue mechanism to accept packets to the destination depending on queue length.

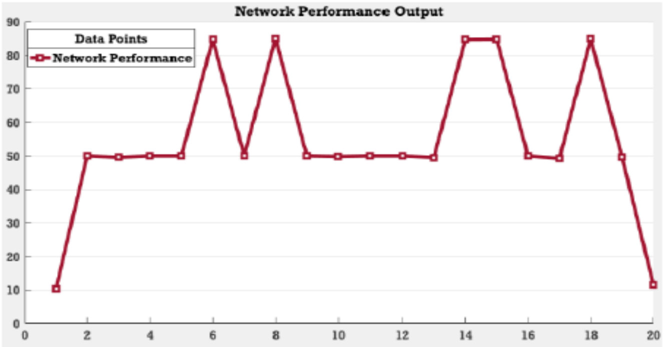

Fig. 14: Network Performance Output

In an analysis of the existing system, which employs a queuing algorithm, some flaws are revealed, including the inability to achieve effective bandwidth utilization and the ability to drop packets for as long as possible due to the queue size, both of which hinder network performance and can result in poor quality service delivery as well as poor performance for network services. Moreover, the current system demonstrates that the AQM algorithm is incapable of dealing with specific packet delivery risks.

While adopting an Interval Type 1 Fuzzy Logic model, the suggested system outperformed the AQM algorithm in terms of overall performance. A further benefit of the Interval type 1 model is that it allows for a decrease of uncertainty in network performance optimization, which results in an improvement in the efficiency and quality of service provisioning of Wireless Networks.

Nowadays, one of the most important criteria in today's fast-paced world of information technology is the desire for better and higher-quality service in wireless networks. In today's society, information has risen to the top of the list of most traded items. The everyday information required by modern organizations, schools, governments, and even people must be accessible in real time. In order to efficiently access this information, there is a need for high-quality service delivery, which will in turn improve network performance....

In contrast to wired network access systems, wireless network access systems have more complex difficulties with regard to the supply of quality of service (QoS). A number of factors contribute to this, including the high BER, low throughput, user conflict and frequent movement, radio interpretation, and other types of traffic characteristics that affect wireless connectivity networks. A number of data delivery problems have emerged as a consequence of wireless access worries, including slow peripheral connectivity, transmission mistakes, dropout and wasteful reprocessing, traffic congestion and out-of-order packet data transfer, delay and instability. In order to offer optimization strategies that increase customer service satisfaction while simultaneously boosting income for network service providers, an intelligent strategy is essential.

5. CONCLUSION AND FUTURE SCOPE

Essentially, the creation of an Optimal Networks Performance (ONP) was studied in order to fulfil the need for Quality of service (QoS) provisioning and high network performance, among other things. The paper investigates the issue of existing loopholes, which may have the potential to alter the supply of the needed seamless connectivity. The work therefore describes a typical WLAN deployment configuration by identifying necessary network parts and offering the comparable accessible service providers in the form of a network diagram. Once again, a Computational Intelligence technique was used in conjunction with a Type 1 Fuzzy Logic system, and the resulting operational field data was exposed to a simulation process. Using the sample network conditions, the results reveal that efficient congestion mitigation may be achieved. The outcomes of the research add to the body of knowledge on efficient network performance. As a result, the assessment performed using Triangular Membership Functions was successful (TMF). Within a specified service region, show improved WLAN performance via the use of QOS provisioning techniques.

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