Throughput and Latency Performance Evaluation of an Optical Fiber Network

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Abstract—**The development of optical fiber has revolutionized the communications sector and played a crucial role in the information age. Due to their ability to carry large amounts of information and their dielectric nature, optical fiber is often favored for data transfer to other communication media. Nevertheless, this kind of transmission has had trouble with excessive latency, which later affects throughput and lowers user experience quality. This article describes the various throughput and latency experiments that were performed using the VIAVI test kit, how they were assessed, and how the results were then compared to the requirements set forth by the Institute of Electrical and Electronics Engineers (IEEE) and International Telecommunication Union (ITU). Some of the results met the required criteria, but others did not for a variety of reasons, including connection congestion, malfunctioning network gear, subpar fiber cable quality, and the length of the optical fiber link. The mitigation strategies for the aforementioned causes were covered in this paper, and they include increasing the link's bandwidth, ensuring the use of high-quality fiber cables, routine maintenance to identify any faulty components, and using multiple repeaters on long-distance optical fiber links.**

Keywords—**fiber optic network, latency, throughput**

I. Introduction

The development of fiber optic communication technologies has completely transformed the telecommunications sector [1]. It has been demonstrated to be the most preferable alternative when compared to other transmission media in terms of latency, data carrying capacity, and immunity to crosstalk and noise, among other factors [1]. The first optical fiber was created by Corning Glass Work in the 1970s; it was primarily utilized for communication and had low attenuation levels compared to earlier copper cables [2]. In optical fiber communication, the transmitter converts an electrical signal into an optical signal, which is then transmitted along a fibre-optic cable while being carefully monitored to prevent distortion or attenuation. The optical signal is then received and converted back into an electrical signal [3]. Telecommunications, networking, industrial/commercial, medical, broadcast, data storage, and defence/government are among the industries where optical fiber is used [4]. The challenges of evaluating network essential performance indices of throughput, latency, packet jitter, and frame loss rates are overwhelming for fiber optic lines despite enhanced optical communications system parameters. Throughput is the amount of data that is sent and received over a communication link and is measured in kilobytes per second, kbps. Mega, Giga, and terabytes per second are higher measurement rates. The frame loss rate is the proportion of frames that were supposed to be sent by a specific network but were not delivered. Latency is the amount of time it takes for data to transit from source to destination. Data packets sent over a network are delayed in time when there is a packet jitter. Before allowing traffic on the link, these parameters must be evaluated and verified during Acceptance Test Procedures (ATP) as protection for network performance and customer experience quality [5]. In this study, we evaluated and validated these characteristics in a fiber optics link using the T-BERT/MTS 5800, and we compared the results to benchmark standards established by the International Telecommunications Union (ITU) and the Institute of Electrical and Electronics Engineers (IEEE).

Being a landlocked country, Uganda relies more on terrestrial fiber links to its neighboring countries to expand its access to international submarine cables for ubiquitous broadband attainment. The delivery of these links at the network edges is often bedeviled by discrepancies between the network services provided or the operator and the customer or carrier requesting the service, during

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acceptance test procedures. This leads to delays in product signoffs and utilization of links for the service it was planned to provide. The consequence is a negative impact on service level agreements, network performance, and end user Quality of Experience (QoE). To this end, test validation of the benchmark requirements in optical link and network is espoused to curb the variance between the expectations of the carrier and the service deployed by the network service provider. Network quality and performance are impaired when the key performance indices of throughput, latency, frame loss, and packet jitter do not conform to the benchmark requirements as defined by ITU and IEEE. These indices are interwoven such that a drop-in throughput, for instance, would lead to packet loss, low latency, and ultimately, a slow and poor network. The increasing need for higher capacity in core networks to satisfy the growing global appetite for broadband access and high-speed data has thus informed a test of benchmark requirements for the seamless optical link before traffic is configured on it. Therefore, this study seeks to analyze the key performance requirements (latency, throughput, packet jitter, and frame loss rate) in optical communications links for optimal network performance and end-user quality of experience. The organization of the rest of this paper is as follows. The paper is organized as follows: Section II provides the literature review of the study. Section III presents the material and methodology used in the work. Section IV presents numerical results and discussion. Section V shows the findings and concludes the paper.

II. Literature Review

This section presents literature that is pertinent to the research work.

A. Fiber Optic Communication Principles

Fiber-optic communication is a kind of transmission in which data or information is sent from the sender to the recipient using an optical fiber line to convey light pulses [1]. The carrier source produces a wave that is used to convey digital data. There are always two types of light sources: Light-Emitting Diodes (LEDs) and Laser Diodes (LDs), however, lasers are favored because they are more potent, function at higher speeds, and send light farther away with fewer faults than LEDs do [6]. To ensure that the signals are properly sent, the source is always rapidly and precisely turned on and off. Because it has a variety of benefits over copper wire communication, such as incredibly wide bandwidth, the capacity to transmit across greater distances, resistance to electromagnetic interference, compact size, low-security threats, and lightweight, optical fiber is chosen [2]. Optic fiber is utilized in traffic management systems, cable networks, telecommunications systems, and CCTV surveillance cameras [4].

B. Future Trends of Optical Fiber Communication

Due to the optical signals' deformed waveform, low or almost zero attenuation levels, and poor signal-to-noise ratio during transmission, achieving a high quality of data transfer is essential. The optical transceiver needs to be improved to use cutting-edge modulation techniques.

All optical communication networks: The signals in a fiber optic communication network will only be processed optically, never undergoing any electrical conversions while being transmitted. Nowadays, signals are transformed to electrical form before processing, resulting in signals switching in both the electrical and optical domains. The signals are transferred to optical form after processing and routing so they can be transmitted across greater distances. Due to communication delays caused by the translation of signals from electrical to optical form and vice versa, high data rate optical fiber transfers are not possible.

Optical transmitter/receiver technology improvement: Achieving high-quality transmission even for communications with distorted waveforms and a poor signal-to-noise ratio is important in optical communication. This can be accomplished if the transmitters and receivers used in communication adopt innovative and improved modulation techniques with outstanding chromatic dispersion and very good Optical Signal Noise Ratio (OSNR) tolerance.

C. Optic Fiber Benchmark Requirements

This paper considered throughput and latency as the benchmark requirements for optical network performance.

Latency: One of the most important indicators of network performance is latency, which is defined as the delay in transmission time or in the time it takes for information to flow via a fiber connection. Because optical fiber transmits information via light pulses, a delay can be observed or occur when light pulses are traveling through a fiber cable [7].

Latency is calculated using.

$$D = T\ V \tag{1}$$

where D is the distance that light travels through a particular fiber cable and T is the amount of time it takes for light pulses to cover that distance. The speed of light is denoted by D and V. Light moves at a speed of 299,792,458 m/s in a vacuum, yet compared to the speed of light in a vacuum, the speed of light via an optical fiber core is considerably slower. This is because light traveling through glass and light traveling through air or open space have different refractive indices [8]. Before the speed of light, it is crucial to understand the refractive index of the glass core in the fiber optic wave path (latency). Since latency is bad for communication, it should be reduced in some way to guarantee continuous optical fiber transmission. By using high-quality fiber cable, which tends to transmit light more quickly than low-quality fiber, properly treating fiber during construction, and making sure that fiber requirements adhere to IEEE and ITU standards, latency can be lowered (see Fig. 1).

Throughput: Since data is always measured in units of time, the actual quantity of data that can be sent without mistakes over a fiber link is stated in bits per second [9]. It is a measurement of an average rate that depends on the bandwidth or capacity of the link as well as on the latency or delay in that link [10]. Throughput is affected by a variety of factors, some of which are as follows: transmission media limitations, which prevent a channel or link from carrying more data than it was designed to; latency, which is the time it takes for data packets to travel from the transmitter to the destination; network congestion; packet losses and errors; and throughput of a fiber link. Theoretically, a given link's throughput is 95% of its available bandwidth. The throughput of a network must be measured or tested for that network to operate better [11]. The network needs to be optimized if a test result is measured and determined to be lower than anticipated. The network can be optimized by locating the bottlenecks, boosting the channel's bandwidth where possible, removing malfunctioning devices, and assuring the quality of services so that vital traffic is not impacted by network congestion [12] (see Table I).

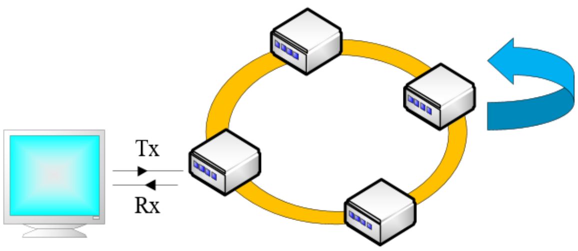

Fig. 1. Measurement of latency.

TABLE I. ACCEPTABLE REQUIREMENTS [13]

Traffic Type	Real-Time Data	High-Priority Data	Best-Effort Data
CIR (Mbits/s) (Green traffic)	5	10	2.5
EIR (Mbits/s) (Yellow traffic)	0	5	5
Latency (ms)	< 5	5–15	< 30
Packet jitter (ms)	< 1		
Packet loss (%)	< 0.001	< 0.05	< 0.05

The bandwidth known as the Committed Information Rate (CIR) is intended to be available constantly to support the delivery of a specific service. At green traffic, the Key Performance Indicators (KPI) must be met. Depending on how heavily the network is used, there may be more bandwidth available that is above the CIR. The minimal KPI might not be met when in yellow traffic. Red traffic is described as over CIR or Excess Information Rate (EIR) and unable to be sent unless other services are interrupted. Roufurd *et al.* [14] evaluated latency fluctuations in an optical fiber network using RF and photonic components by conducting an experiment and gathering a set of data. The delay changes with the required accuracy and precision were acquired and these are important in the verification of the efficiency of the thermal shielding in the optical fiber cable that is already installed. The throughput of a particular link is dependent on the delay, but this paper primarily focused on changes in the latency. Leira *et al.* [15] measured the latency of a high-speed optical communication network in a microsecond timeframe using a software-based technique. The key objective was to maintain latency at reasonably low levels to provide good Quality of Service (QoS), and this was accomplished by carefully examining and evaluating the performance of packet engines. At 10 Gbits and above, however, the usage of a software-based method to evaluate delay in a micro-scale timescale is not precise and accurate enough. Seraji *et al.* [7] investigated the causes of latency in an optical communication network and various approaches to reduce it were examined. These included the use of low-latency amplifiers, high-quality fiber cables, and chromatic dispersion compensation techniques. The study concluded that reliable measurements of the total delays must be taken to guarantee that control latencies in a given network are kept to a minimum. Fiber *et al.* [16] Investigated how to measure the throughput realistically feasible in single-mode fiber by the use of potential multiband components on ITU-T G.652D to overcome the difficulties of MBT covering the ITU-T optical bands. The performance of the MTB is evaluated using the signal-to-noise ratio, and linear and non-linear fiber propagation effects. The potential throughput per band was addressed using the Golden State Natural Resources (GSNR) as the performance parameter, with estimates of the GSNR for various situations that are smaller than 80 km for DCI-like networks, equivalent to 150 km or 300 km for metro networks and up to 60 km for extended metro and regional networks. The realistic throughput was not obtained as predicted because of the poor maturity of crucial MTB components, which was difficult given their great maturity in C-band components. Ives *et al.* [17] The durability of the Signal-to-Noise Ratio (SNR) ratio in an installed optical fiber network was investigated using computer science abstraction theories, where various equipment is defined in a similar fundamental term. The SNR expresses the efficiency of a signal's transmission via a certain network. The research shows how light path following performance may be reliably predicted for a specific network in addition to proving that the abstracted SNR is unaffected by viewers or observers in their various locations. According to the article, having a reliable network abstraction that can be incorporated into routing engines enables the controller of the entire network to choose the most efficient way to use the network resources in terms of data routing and coding style. Traditionally, solely the SNR ratio was utilized as a metric to assess the performance of signals propagating inside an installed optical network; nevertheless, the quality of the installed cable and benchmark requirements also affect how well signals propagate.

Sharma *et al.* [18] carried out a performance analysis of an optical fiber system through an investigation of a method that can be used to find out the link of the power budget model regarding Q-factor, and bit error rate for different attenuation and length. Matlab and Optisystem tools were used in the study to come out with a simulation network whose parameters were used in the classification of coding Non-Return-To-Zero (NRZ) / Return-to-Zero (RZ), classification of the modulator, optical fiber length, wavelength, power exposure, data rate, Photodiode and classification of noise. This optical fiber analysis only considered the Q-factor and bit error rate as performance measures of optical fiber communication.

Akintola and Eleazar [19] evaluated the performance of Fiber Optical Network in terms of the light of Power Loss, Bit Error Rate (BER), and Q-factor. Opatisystem software was used to simulate a network design, the model design contained a transmitter at the head office, a link for distribution as well a receiver at the customer or end-user side. Various parameters were used for the analysis of the network design but this study considered bit error, power loss, and Q-factor as the measures of optical fiber performance

III. Materials and Methods

The data was gathered using both quantitative and qualitative approaches, examined, and compared to IEEE and ITU standards before validation was carried out.

A. Materials

The materials used for this investigation are as follows:

The T-BERB/MTS 5,800 was utilized to carry out the different tests for throughput and latency for the 10 G and 100G links. The VIAVI test kit is shown in Fig. 2 below.

Fig. 2. VIAVI optical fiber test kit.

The conceptual pipeline used to achieve the methodology is depicted in Fig. 3.

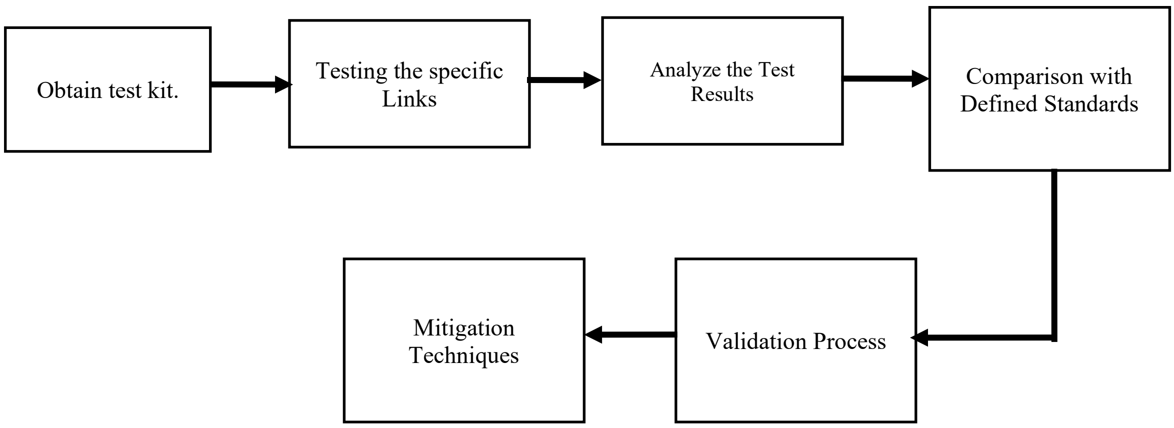

Fig. 3. Pipeline of the proposed research work.

B. Data Collection and Studying the Link Rates

This was done by carrying out link tests in the field using the VIAVI test set (T-BERT/MTS 5800) as shown in Fig. 2.

C. Optical Fiber Link Test Using VIAVI Test Set (T-BERT/MTS)

Due to its great distance and the fact that it is made of single-mode optical fiber with a zero-dispersion wavelength of 1300 nm and lower losses than other single-mode optical fiber standards, an underwater optical link was selected as a case study for investigation [20, 21]. According to the block diagram shown in Fig. 4, it is a four-fiber pair undersea system. The submarine fiber is connected to the Submarine Line Terminal Equipment (SLTE) at the submarine cable landing station through the fiber termination shelf. The SLTE products deliver high performance, huge capacity, and high-reliability data transfer. Direct Wavelength Access (DWA) or SDH connectivity hardware then distributes the connection from SLTE into an internal Optical Distribution Frame (ODF). In optical fiber communication, the ODF distributes the backbone cable from end to end and manages cable termination and cross-connection. The external ODF and SIE are then linked by the internal ODF. Afterwards, fiber patches are connected from the E-ODF to the test equipment to conduct the analysis-related test [22, 23].

To guarantee that a greater range of test values were acquired, various tests were conducted on the given link but in various places. An abundance of set values contributed to an improvement in accuracy. Using calibrated test tools for 10 G and 100 G line speeds, several confirmed optical lines that the network management had assigned were put to the test. The amount of data transmitted across a specific optical fiber link was taken into account and then received. Testing for the benchmark requirements of the link was the best course of action if the signal received was subpar [24].

Testing was done both at the client interface and the line interface. The line side is an interface that is mainly used for information transmission from one point to another over long distances whereas the client-side or interface uses some kind of modulation that is referred to as on-off keying as well as properly defined various vendor standards that can be transmitted over shorter distance.

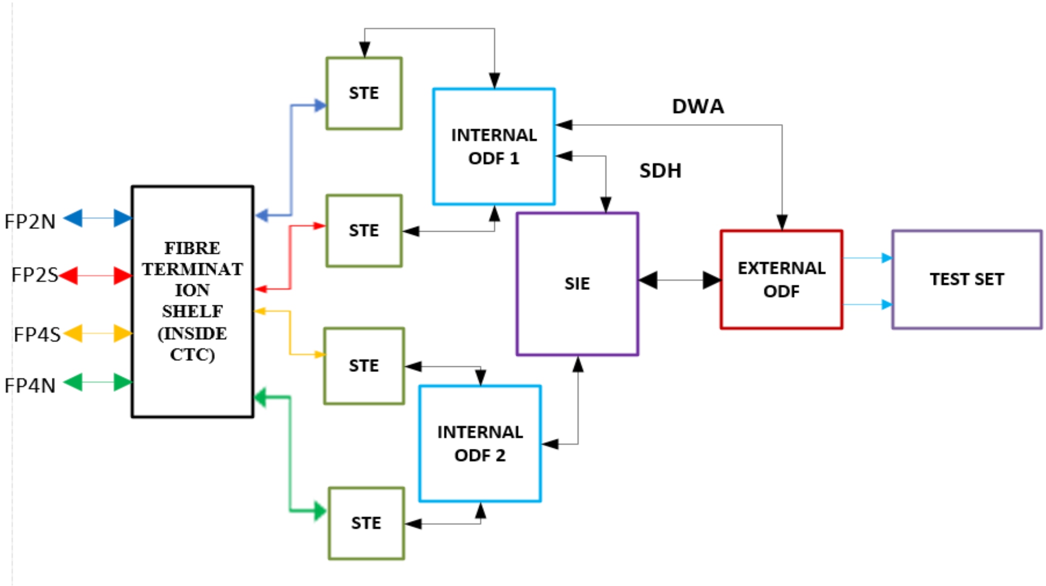

Fig. 4. Four-fiber pair submarine system.

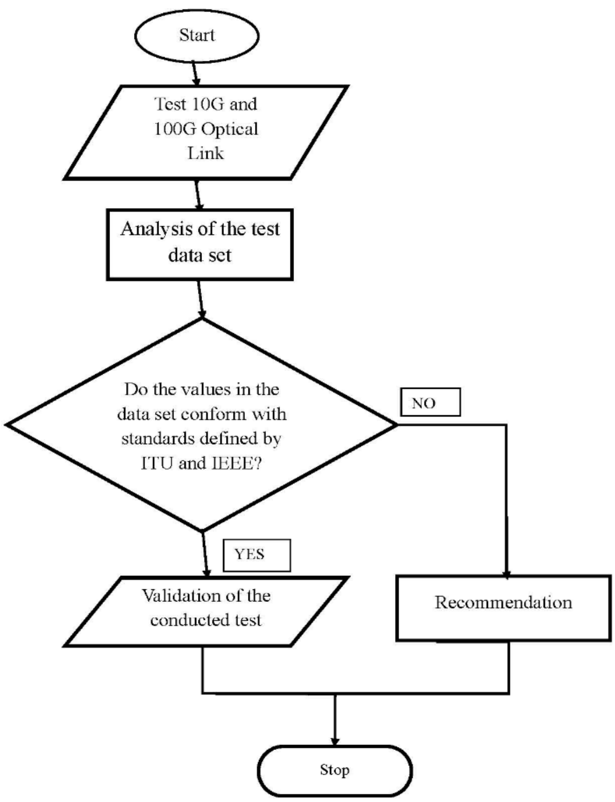

Fig. 5. Flowchart of the entire process.

D. *Analyzing and Comparing Field Test Results with the Defined Standards*

Before comparison with the benchmark requirements from ITU and IEEE, the test results for 100 G and 10 G line rates that were achieved during the research were analyzed. To determine whether other relationships found during the research met the benchmark criteria, their analyses and outcomes were also compared.

The test's results were then compared to those established by the ITU and IEEE as standards. Following the comparison, it was determined that the test value and the ITU-prescribed value differed. This was utilized to determine the reason for the disparity since, if it is too great, it will significantly damage the Quality of Service provided by the optical transport network. The consequences of not reaching the criteria and their prevention strategies were discussed.

E. *Identifying the Limiting Factors that Contributed to Fiber Links Not Conforming with the Standards*

To enhance the quality of the testing experience, the circumstances that caused some of the tests to fall short of the established requirements were examined, along with potential remedies (see Fig. 5).

IV. Numerical Results and Discussion

A. *Throughput*

For both the 100 G and 10 G, the test was run four times throughout the day to assess the throughput. To portray the results in Mbps, a unit used to assess throughput, the time interval in hours was translated to seconds. Every 384.61 s, a data packet was transmitted, and the total time in seconds was recorded. As throughput is always given in megabytes per second and the readings from the test kit were in hours, the time was converted to seconds. With every 5000 s, the test set recorded a new time, and every 5000 s, approximately 13 data points were communicated over the link. To get the time taken for which each data point to be transmitted, Eq. (2) was used [20].

$$\frac{\textit{Time}\text{ interval}}{\textit{data}\text{ points}} = \frac{5000}{13} = 384.61\text{ s} \tag{2}$$

where 5000 is the time in seconds to transmit 13 data points.

Four throughput tests were carried out for both the 10 G and 100 G optical fiber links as shown in Figs. 6 and 7.

Graph of throughput at 10G link

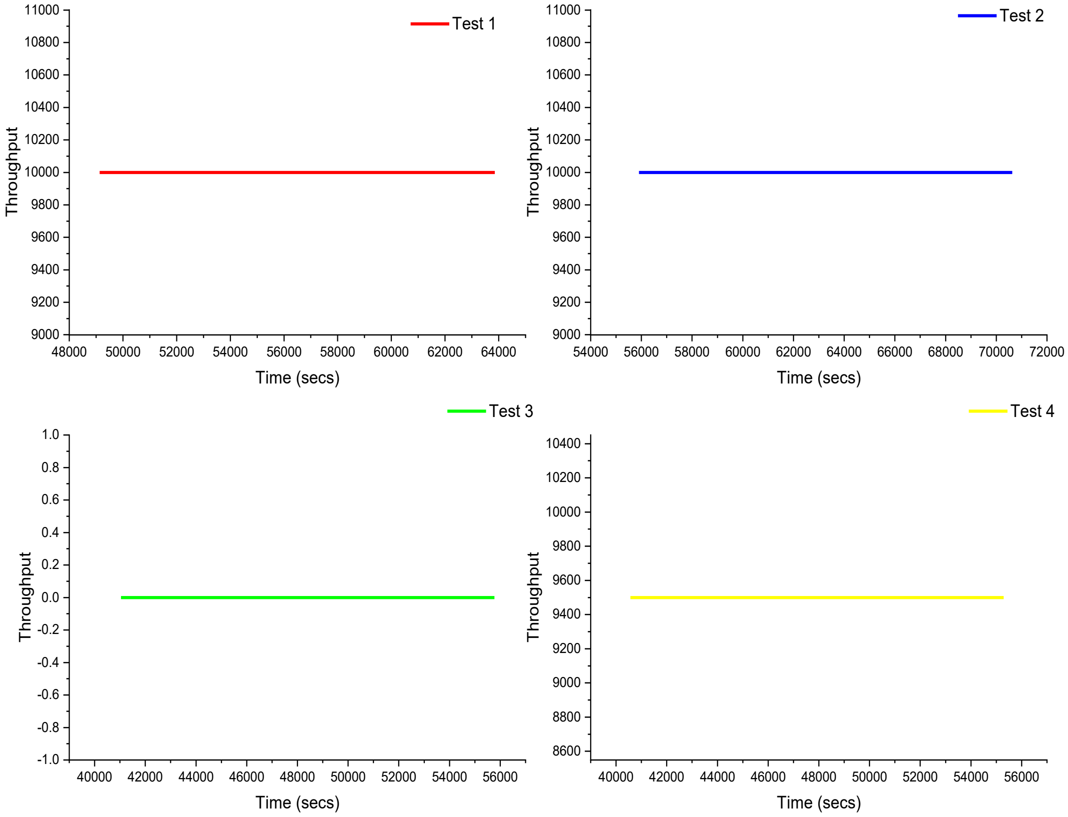

Fig. 6. The result of throughput against time for the four test cases for the 10 G link

Graph of throughput at 100G link

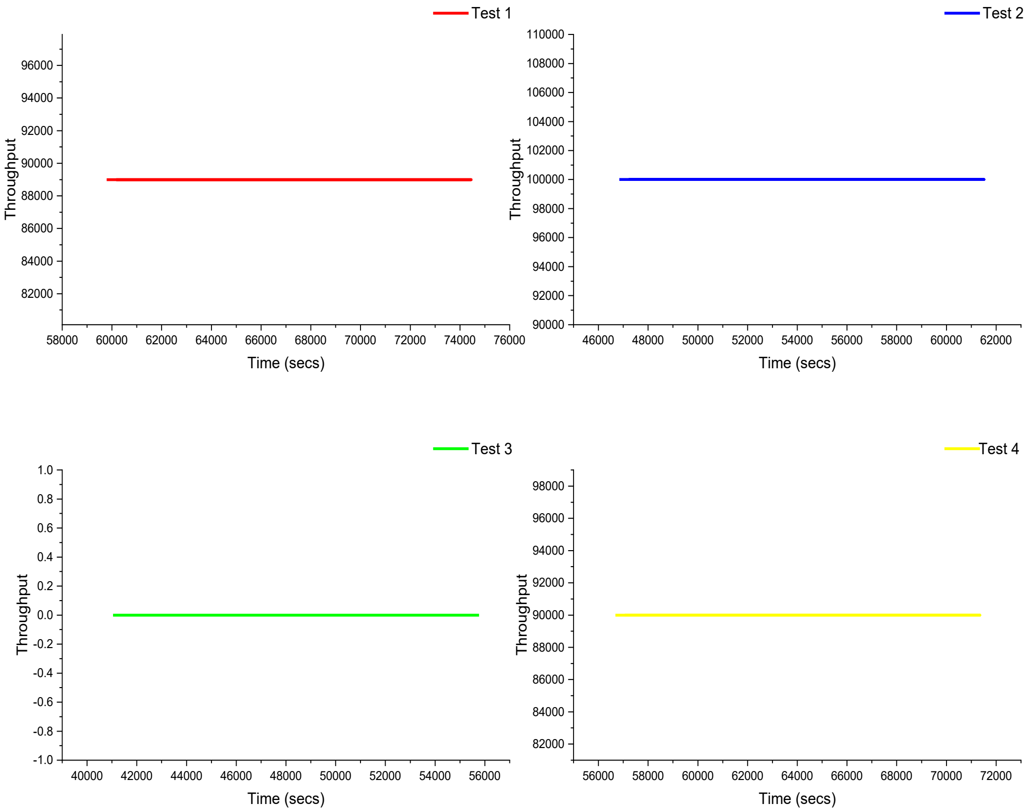

Fig. 7. The result of throughput against time for the four test cases for 100 G.

The throughput for Tests 1, 2, 3, and 4 was 10,000 Mbps, 10,000 Mbps, 0 Mbps, and 9500 Mbps, respectively, as shown in the diagram in Fig. 6. This suggests that Tests 1 and 2 achieved 100% throughput, utilizing the available bandwidth to transfer the predicted amount of data per second over the network. Because 95% of the available bandwidth was utilized, the test's throughput complied with the IEEE standard. Test 3's result of 0 Mbps indicates that no data was transmitted over the network at that moment. Test 3 failed to fulfill the established standards since it was conducted during a busy period of the day when the link was overloaded with requests and could not transport data. Test 4 produced 9,500 Mbps; as 95% of the available bandwidth was utilized, this result complied with the established parameters. The throughput for Tests 1, 2, 3, and 4 was, respectively, 8,900 Mbps, 100,000 Mbps, 0 Mbps, and 90,000 Mbps, as shown in the diagram in Fig. 7. This demonstrated that only Test 2 provided 100% throughput, indicating that the available bandwidth was utilized and the link transmitted the desired amount of data per second. Because 95% of the available bandwidth was utilized, the test's throughput complied with the IEEE standard. The defined standards were not met by Tests 1, 3, and 4. Tests 1 and 4 produced results of 89,000 Mbps and 90,000 Mbps, respectively, which fall short of the standards established, while Test 3 was performed during peak hours, resulting in a throughput result of 0%.

B. Latency

Four latency tests were carried out at different time intervals for both the 10 G and 100 G link of optical fiber as shown in Figs. 8 and 9. According to Fig. 8, the latency obtained in Tests 1 through 4 was 37,000 µs, 20,000 µs, 0 µs, and 92,000 µs. Although it cannot be eradicated, optical fiber latency has reasons, which will be covered in the section on causes and mitigation. As Test 3 was conducted during peak hour, there was no latency observed at that time because no data was being transmitted.

As seen in Fig. 9, the packet jitter for Tests 1 through 4 ranged from 76,000 to 92,000 µs, 0 for Tests 2 and 3, and 0 µs for Tests 3 and 4. According to the causes and mitigation section, latency in optical fiber can be reduced to lower levels but cannot be eliminated. As Test 3 was conducted during the busiest hour, there was no latency reported because no data was being transmitted at the time.

Graph of latency at 10G link

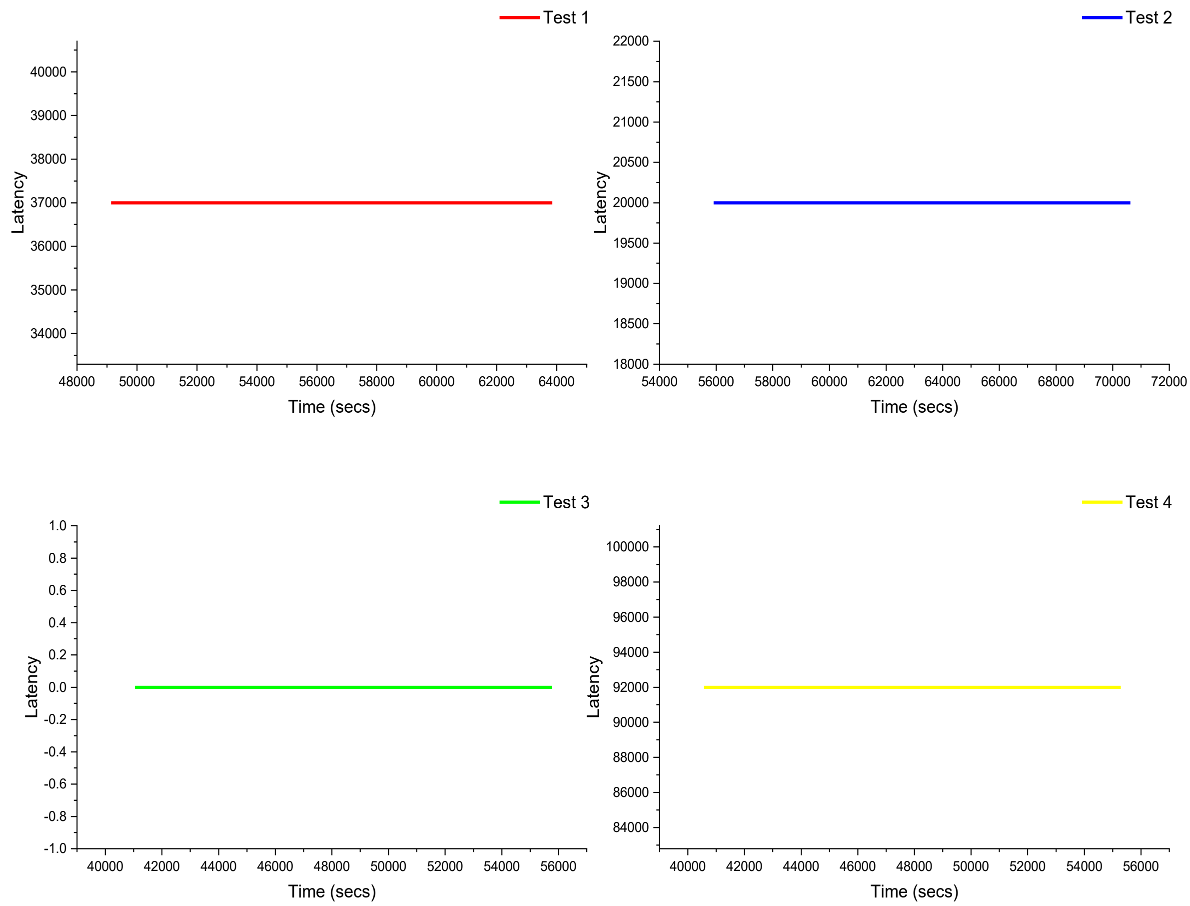

Fig. 8. The Result of latency against time for the four test cases for the 10 G link.

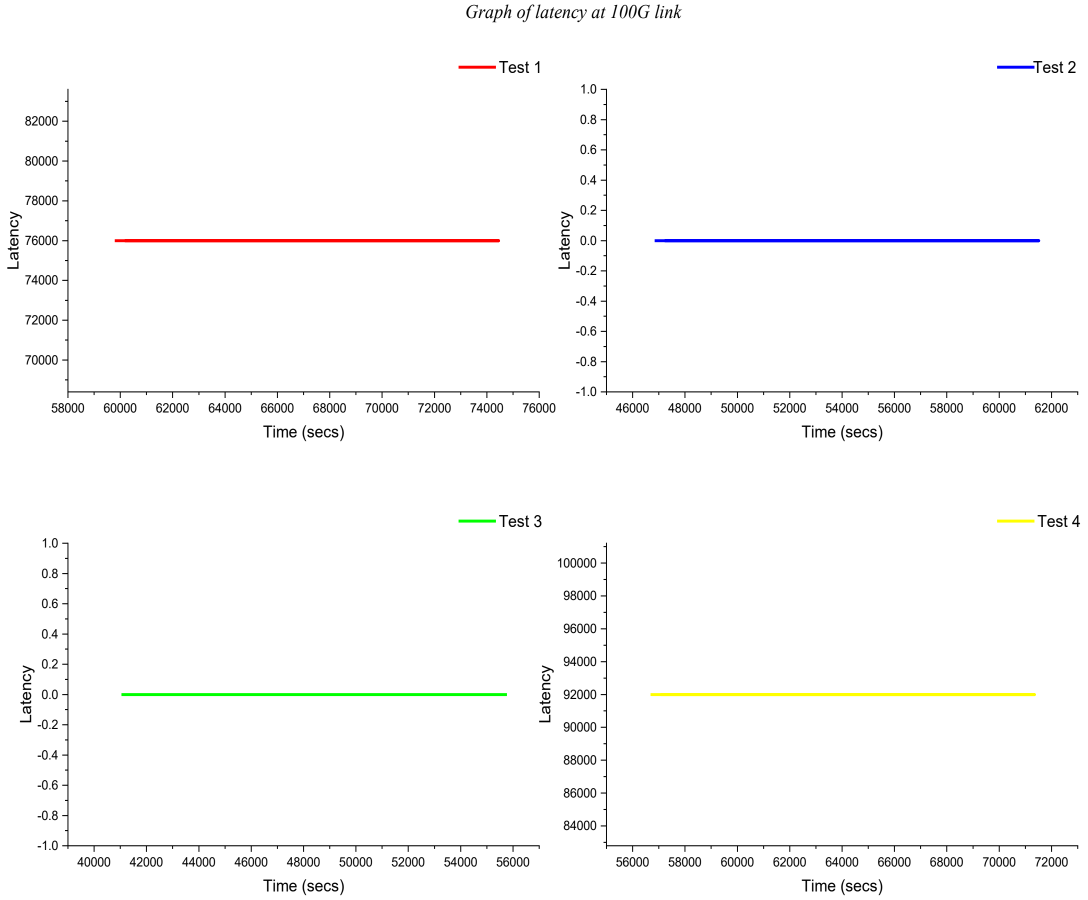

Fig. 9. The result of latency against time for the four test cases at 100 G link.

C. *Validation*

The findings of the validation against the IEEE standard are presented in this subsection together with the underlying causes and recommended corrective actions. Table I displays a comparison between the test scenarios and the ITU standard.

For both the 100 G and 10 G optical fiber lines, Table II displays the stated standards and the results of tests on throughput, latency, packet jitter, and frame loss rates.

The four tests run on the 10 G link complied with the specifications for the throughput tests for Tests 1, 2, and 4, but Test 3 did not. Only Test 2 of the latency tests met the requirements, while the other tests did not. As a result of the test being conducted during the peak hour, Test 3 did not conform to all of the metrics (throughput and latency). This is because no data was transferred at that time.

TABLE II. COMPARISON OF TEST CASE VALUES WITH THE ITU STANDARDS

Requirements	ITU Standards	10 G Link	100 G Link
Throughput (Mbps)	≥ 95% of the available bandwidth	Test 1:100% Test 2:100% Test 3: 0 % Test 4: 95%	Test 1: 89% Test 2: 100% Test 3: 0% Test 4: 90%
Latency (ms)	<30	Test 1: 37 Test 2: 20 Test 3: 0 Test 4: 92	Test 1: 76 Test 2: 0 Test 3: 0 Test 4: 92

Only Test 4 of the four throughput tests performed on the 100 G link complied with the criteria, with Tests 1, 2, and 3 falling short. Whereas only Test 2 passed the latency tests, with the others failing (Tests 1, 2, and 3). Although the test was conducted during the busiest hour of the day, the third test, like the 10 G test, did not meet the requirements for all the criteria (throughput and latency). The findings from Test 2 for the 100 G were the best because the throughput was 100% and the latency at that particular time was 0 ms. The following factors are the main causes of some of the acquired findings not meeting the established requirements.

1) *Congestion of the link*

High traffic caused by insufficient bandwidth causes this, which has an impact on network performance by increasing transmission delay and lowering throughput. Due to the link carrying more data than it can handle, new connections are blocked, which has an impact on the quality of services as well. The speed of a certain optical fiber communication link is always reduced between 7 pm and 11 pm since congestion is time dependent. This problem can be lessened by employing congestion avoidance and control methods.

2) *Distance covered by the optical link*

The latency in the optical fiber communication network is significantly increased by the fact that data sent over submerged optical fiber cables must travel across large distances before it reaches its destination. Throughput and latency are influenced by distance, the longer the distance, the lower the throughput, and the higher the delay. This is because the signal strength and distance produce a negative correlation.

3) Faulty hardware on the network

The signal on an optical fiber link is significantly reduced by dirty or dysfunctional hardware, such as connectors and the fiber cable itself, which use a lot of power. Since there is higher attenuation when the signal strength is weaker, there is also higher latency, which lowers throughput.

4) The quality of optical fiber

By using low-quality cable, the quality of the optical fiber cable also plays a significant role in increasing transmission delays. Low throughput is caused by too many delay values, which are caused by latency, which is the length of time it takes for light to travel through the core and cladding of an optical fiber line. Low throughput is caused by chromatic dispersion in low-quality cables, which also causes a significant increase in latency.

The following are the mitigation measures for the causes.

5) Bandwidth upgrade

One of the most crucial ways to reduce congestion in optical fiber communication is through bandwidth upgrades. If a 10 G optical link has a bandwidth restriction, it can be upgraded to a 100 G optical fiber link because it has more capacity than the 10 G optical fiber link. The capacity of the optical fiber that is installed can be maximized via a wideband transmission. By improving the electronics in the head and terminal of an optical fiber, data throughput rates can be raised in fiber-optic communication without replacing the existing fiber link. Beyond the capabilities of conventional Wavelength Division Multiplexed (WDM) improvements, an optical fiber link's aggregate throughput can be improved. Advanced modulation techniques are used to encrypt more data into a channel's transmitted spectrum, enhancing the spectral efficiency of each channel and resulting in an increase in system throughput.

6) Application of several repeaters

Several repeaters can be used to extend the range of the transmitted signal, allowing optical signals to be broadcast across great distances with only modest delays, and lowering the frame loss rate. Repeaters aid in signal amplification, enabling a signal that was diminishing during transmission to travel further in links covering greater distances.

7) Regular maintenance of the optical network components

Every service provider must ensure routine maintenance to spot malfunctioning network components, clean them as needed because dirtiness may have contributed to the problem, or even replace them with functional ones to ensure the network runs smoothly.

8) Putting into consideration critical requirements before choosing an optical fiber cable

While selecting an optical fiber cable to be utilized for transmission, several requirements should be considered. The cable jacket should have a certain level of strength, water permeability, coefficient of friction, low thermal deformation of friction, and resistance to some environmental processes that may degrade it. The cable sheath should be able to adapt to various climatic conditions. The fiber cable should be composed of steel or aluminium to protect it from moisture and mechanical pressure. Choose Kevlar fiber instead of low-quality fiber since it is a chemical fiber with high strength.

V. Conclusion

After the analysis of the obtained results above, some of the tests conformed to the standards defined by ITU and IEEE while others did not. There are different reasons why some tests conformed to the defined standards and others did not as discussed subsequently. Throughput and latency are interwoven in a way that if the latency on a given link is high leads to a low throughput. The goal of every service provider is to ensure that the optical fiber link is used for transmission. without issues of better Quality of Service and Experience. Performance evaluation is important because it enables service providers to know how well the established link is running. If there are issues, they can be worked on to ensure seamless communication. A given test was validated if all the parameters tested met the defined standard. Tests were carried out at different time intervals on a given day and the variation of the different parameters was noted depending on the time the test was carried out. Quality of service in optical fiber communication is measured by the speed and reliability of that given network. If the speed is low, it means there will be delays in data transmission and this will lead to low throughput. For service providers to promise their customers good quality of services the network should be able to deliver or transfer data stably and it should be accessible. To ensure a stable and accessible network, the performance indices of throughput and latency, and packet jitters should meet the defined standards.

This study's objective was to evaluate the performance of an optical fiber communication link owned by a specific Ugandan telecommunications provider. For both the 100G and 10G optical fiber lines, several test samples were run for throughput, latency, packet jitter, and frame loss. Utilizing the original software, the test set was analyzed, and the test samples were compared to the IEEE and ITU established standards. Upon comparison, some tests met the requirements while others did not. There was an investigation into the circumstances that caused some tests to not meet the set requirements, and the factors' mitigating actions were found.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization and methodology: A.S., U.K.J., E.E., B.O.S., and A.J.; software: A.S., U.K.J., and E.E.; validation, formal analysis: A.S., B.O.S., and A.J.; investigation and resources: U.K.J., E.E., B.O.S., and A.J.; data curation: B.O.S. and A.J.; writing—original draft

preparation: A.S., U.K.J., and E.E.; writing—review and editing: E.D., E.M., and S.M.S.; visualization: E.D., E.M., and S.M.S.; supervision: U.K.J. and E.E.; project administration and funding acquisition: E.D., E.M., and S.M.S.; all authors have read and agreed to the published version of the manuscript.

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