

Analysis of Wireless Network Performance at Universitas Teknologi Digital Indonesia using Quality of Service (QoS) Method

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Abstract

This study aims to analyze the quality of wireless network services in the Universitas Teknologi Digital Indonesia (UTDI) laboratories based on Quality of Service (QoS) parameters, namely *throughput*, packet loss, delay, and jitter, using the TIPHON standard as a reference. The main issue addressed is the lack of measurable evaluation of laboratory network performance despite the increasing demand for connectivity to support academic activities. Network measurements were conducted over five working days during active lecture hours when network usage was relatively high. The collected data were processed in CSV format and analyzed to calculate the daily average of each QoS parameter and classify them according to TIPHON quality categories. The results indicate an average *throughput* of approximately 2.4 Mbps, packet loss of about 1.2%, delay values below 65 ms, and jitter around 4 ms. Based on the TIPHON standard, these results place the wireless network service quality in the UTDI laboratories within the “Good” to “Excellent” categories. These findings suggest that the laboratory wireless network is sufficiently reliable to support internet-based learning activities and online academic services. Furthermore, the study demonstrates that a structured QoS analysis workflow implemented using Google Colab provides a systematic and replicable approach for evaluating wireless network performance in educational environments.

Keywords: Quality of Service (QoS); TIPHON; Wireless Network; Throughput; Network Analysis

1. Introduction

The development of information technology in higher education institutions has made the internet, particularly wireless networks (Wi-Fi), a key infrastructure for various academic activities. Activities such as the use of Learning Management System (LMS), online lectures, assignment submission, and research are highly dependent on stable campus Wi-Fi connection [1], [2].

The increase in the number of devices connected simultaneously in classroom and laboratories has led to higher traffic loads, often resulting in complaints such as slow connections, disruptions during computer-based exams, and reduced video conferencing quality, which still occur frequently in many educational institutions [3], [4]. This suggests that bandwidth capacity alone does not determine network quality, objective assessment using *Quality of Service* (QoS) parameters remains necessary to evaluate network performance.

At the Universitas Teknologi Digital Indonesia (UTDI), the use of Wi-Fi is crucial in computer laboratories for practical work, programming, and network experiments. During class hours, an access point can theoretically serve a large number of devices, some of which may engage in heavy activities that reduce *throughput* and increase *delay* and *jitter*. In addition, *packet loss* may occur if the situation is not properly managed [5]. However, to date, there has been no comprehensive assessment of wireless network performance in UTDI laboratories based on standardized QoS parameters, leaving network administrators without reliable data for infrastructure planning. In this context, the evaluation of network performance requires clear target performance indicators. Therefore, the QoS parameters analyzed in this study include

throughput, *packet loss*, *delay*, and *jitter*, which are interpreted according to the performance thresholds defined in the TIPHON standard to determine the quality level of the wireless network.

Previous research has revealed that the QoS of wireless networks in educational environments varies significantly, even when measured using the same standard, namely *Telecommunications and Internet Protocol Harmonization Over Networks* (TIPHON). At the university level, research conducted by Windia et al. [1] at the Faculty of Medicine, Indonesian Muslim University, showed that the *delay* and *packet loss* parameters were in the excellent category, but the *throughput* value remained low, resulting in a total QoS index classified as unsatisfactory. A study conducted by Irfan et al. [3] at STMIK Amika Soppeng reported different outcomes, where all QoS parameters including *throughput*, *delay*, *jitter*, and *packet loss* were in the good to very good category, with a QoS index value of nearly 3.75. Meanwhile, research conducted by Wahyudi et al. [4] at the Akademi Komunitas Negeri Putra Sang Fajar Blitar identified *throughput* as the weakest parameter, even though the other parameters were classified as good or very good, so that the overall service quality was considered good but not yet optimal. This finding is supported by a study conducted by Nisa et al. [2] at Kampus 1 Unjaya, which revealed that variations in QoS quality occur not only between parameters but also between access points and measurement times, making periodic network assessments crucial in campus network management.

In a broader context, several other studies have also applied the TIPHON framework to analyze wireless network performance at the secondary school, vocational education, and public internet service provider levels. WLAN QoS analysis in secondary schools indicates that access point capacity limitations and inefficient channel management typically reduce *throughput* and increase *delay* during peak operating hours [6], [7]. Research on wireless LAN networks in various educational and office institutions shows that network topology configurations, bandwidth management procedures, and the implementation of load balancing methods play an important role in influencing QoS variations, although the final evaluation of service quality still refers to the TIPHON index [8], [9]. Furthermore, studies on bandwidth and QoS measurement in campus wireless networks confirm that classifying network parameters into TIPHON categories is effective for identifying infrastructure elements that require improvement, both in terms of network capacity and traffic management systems [5], [10]. Overall, these findings suggest that each institution has distinct traffic characteristics and network configurations, meaning that previous QoS research results cannot be directly generalized and require specific analysis of the wireless network conditions at the UTDI.

Considering these conditions, this study focuses on analyzing the QoS of wireless networks in the UTDI laboratory using *throughput*, *packet loss*, *delay*, and *jitter* parameters based on the TIPHON standard. The selection of these parameters and standards is consistent with the research by Pratama and Pratomo [11], which demonstrated that the TIPHON method is effective for comprehensively and measurably assessing the quality of wireless LAN services in higher education environments. The analysis was conducted on weekdays (Monday to Friday) during lecture hours to reflect the operational conditions of the network under high usage levels.

Unlike previous studies that generally evaluate wireless network performance at the campus-wide level, this study specifically focuses on wireless network performance in educational laboratory environments, where network usage tends to be more intensive due to programming, simulation, and practical activities. The objective of this study is to evaluate the performance of wireless networks in the UTDI computer laboratories using standardized QoS parameters based on the TIPHON framework.

The novelty of this study lies in the development of a systematic and structured QoS evaluation process that integrates network measurement data processing with a reproducible analysis workflow. This study establishes a replicable and easily applicable evaluation framework for wireless network performance assessment in educational laboratory environments. This approach is consistent with the findings of Nurmiati et al. [12], who emphasized that structured QoS analysis provides an important foundation for improving network performance, particularly for infrastructure optimization and planning. Therefore, in addition to providing an initial overview of wireless network performance in UTDI laboratories, this study offers a practical evaluation framework that can support network administrators in conducting routine monitoring and planning continuous improvements to network infrastructure.

1. Research Methodology

The study applies a descriptive quantitative approach by utilizing data from field observations that were processed to reveal actual traffic patterns during lecture hours. This approach follows QoS research practices in university environments, which combine measurable evaluations of wireless networks with quality category assessments based on the TIPHON standard and the use of *throughput*, *delay*, *jitter*, and *packet loss* parameters as the basis for performance evaluation [4]. Data processing was carried out in a structured manner to validate the analysis path and ensure that the QoS parameter calculation procedure could be applied consistently in routine evaluations of the UTDI laboratory wireless network, in line with the periodic evaluation approach adopted in other campus network studies [2].

This research was conducted on the UTDI laboratory wireless network, which serves as the center of practical work, programming, and computing activities for students. Network observations were conducted in accordance with the laboratory's operational schedule, specifically from Monday to Friday during active lecture hours between 08:00 and 16:00. Data were collected at 5-minute intervals to capture variations in network conditions throughout the day [4]. Each day of observation, one hundred data sets were collected to represent network conditions at several different time intervals. The selection of the weekday range and data collection scheme was based on the characteristics of campus network traffic loads, which typically increase during lecture hours, as applied in previous QoS research in higher education environments [1].

The QoS parameters analyzed include *throughput*, *packet loss*, *delay*, and *jitter*, which were obtained from network traffic observations and compiled in a structured data format. The values of each parameter varied across different network conditions and time periods. The measured data also contained fluctuations, particularly in throughput during peak hours [13]. Data were stored in *comma-separated values* (CSV) format, including observation days, time indices, *throughput* (kbps), *packet loss* (%), *delay* (ms), and *jitter* (ms) for each observation day. This data structure is consistent with the format automatically exported by Wireshark, thereby facilitating analysis and enabling replication of the same evaluation method, as applied in previous research on campus network QoS [3].

a. Quality of Service (QoS) and the TIPHON Standard

This study analyzes network performance using four main Quality of Service (QoS) parameters: *throughput*, *packet loss*, *delay*, and *jitter*. These parameters follow the TIPHON standard, which is commonly used in network performance research in academic and public service environments. Each parameter has its own calculation method and quality classification, giving a clear overview of the wireless network quality at the UTDI laboratory.

i. Throughput

Throughput is measured as the total amount of data successfully received within a specific period of time and is expressed in *kilobits per second* (kbps). A higher throughput value indicates better network capability in handling traffic. According to the TIPHON standard, *throughput* is classified into five quality categories, ranging from "Excellent" to "Bad," as presented in Table 1

Table 1. Throughput category		
TIPHON Category	Throughput Range (kbps)	Score
Excellent	> 2000	4
Good	1200 – 2000	3
Fair	700 – 1200	2
Poor	338 – 700	1
Bad	0 – 338	0

ii. Packet Loss

Packet loss refers to the percentage of packets lost during the transmission of data from sender to receiver. It is often caused by network congestion, channel interference, or poor signal quality. A higher *packet loss* value indicates poorer service quality, as more information fails to reach its destination. The *packet loss* categories defined by the TIPHON standard are presented in Table 2 and are commonly used as a reference in campus network evaluations.

Table 2. Packet loss category

TIPHON Category	Packet Loss (%)	Score
Excellent	0 – 2	4
Good	3 – 14	3
Fair	15 – 24	2
Bad	>25	1

iii. Delay

Delay, or latency, refers to the time required for a data packet to travel from one point to another, measured in milliseconds (ms). Low delay values are essential for real-time activities such as video conferencing, online lectures, and other interactive applications. The TIPHON standard classifies delay into several categories, as shown in Table 3. These categories are also widely applied in network QoS research to evaluate a network's ability to support academic activities.

Table 3. Delay category

TIPHON Category	Delay (ms)	Score
Excellent	< 150	4
Good	150 – 300	3
Fair	300 – 450	2
Bad	> 450	1

iv. Jitter

Jitter refers to the variation in the arrival time of consecutive packets. Low jitter values indicate network stability, whereas high values may cause distortion in audio and video during real-time applications. The TIPHON standard defines jitter categories, as shown in Table 4, which are widely applied in multimedia network performance research [14].

Table 4. Jitter category

TIPHON Category	Jitter (ms)	Score
Excellent	0	4
Good	0 – 75	3
Fair	75 – 125	2
Bad	125 – 225	1

v. TIPHON standard

In addition to per-parameter assessments, the TIPHON standard also provides an overall service quality category, calculated from the accumulation of four QoS parameter indices. These indices are summed and normalized to produce a QoS percentage, which is then classified into quality categories, as shown in Table 5.

Table 5. TIPHON standard

Category	QoS (%)	Score
Excellent	95 – 100	3.8 – 4
Good	75 – 94.75	3 – 3.79
Fair	50 – 74.75	2 – 2.99
Bad	25 – 49.75	1 – 1.99

For practical convenience, this study adopts the TIPHON index range of 1–4, where values between 3.8–4 are classified as “Excellent”, 3–3.79 as “Good”, 2–2.99 as “Fair,” and 1–1.99 as “Bad”. This classification scheme is commonly applied in campus network QoS studies.

b. Data analysis

The analysis flow can be seen in Figure 1. Data processing was carried out using Google Colab with the Python programming language. Google Colab was selected because it offers an easy-to-use, cloud-based computing environment and supports analytical libraries such as pandas and matplotlib. This approach aligns with previous research that exports Wireshark capture data into CSV format for subsequent analysis using statistical tools [15].

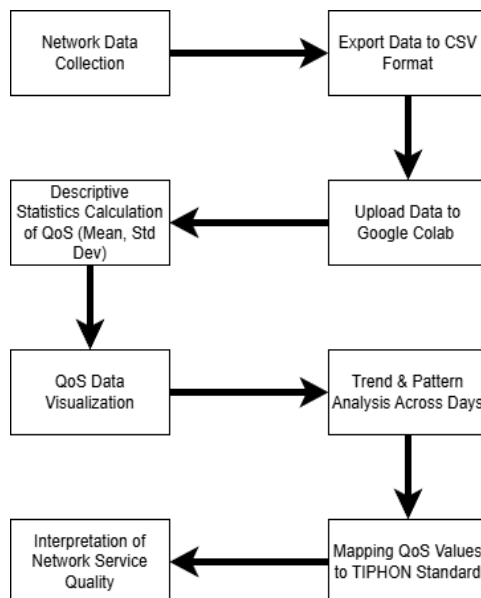


Figure 1. data analysis flow

The analysis begins with uploading the CSV file to Google Colab and loading it into a DataFrame. Subsequently, descriptive statistics are calculated, particularly the daily averages for each QoS parameter. These average values were used to generate line graphs illustrating variations in *throughput*, *packet loss*, *delay*, and *jitter* across the observation days. This approach is consistent with visualization practices in previous QoS studies and allows temporal fluctuations in network performance to be visually interpreted during the observation period. The final stage involves mapping daily QoS values to TIPHON categories to determine aggregate service quality. Within this workflow, the Google Colab notebook functions not only as an analytical tool but also as structured documentation that can be replicated using real measurement data from the UTDI Laboratory.

2. Result and Discussion

a. Throughput Measurement Results

The average daily *throughput* is illustrated in Figure 2. The throughput values range from 2402.56 kbps to 2489.94 kbps, with the highest value recorded on Monday and the lowest on Friday. Overall, all values exceed 2.4 Mbps, indicating the network's ability to provide stable data transfer capacity *throughout* the observation period. According to the TIPHON standard, which classifies *throughput* above 2.1 Mbps as "Excellent," these results demonstrate that the network has sufficient capacity to support online lectures, LMS access, and medium-sized file sharing.

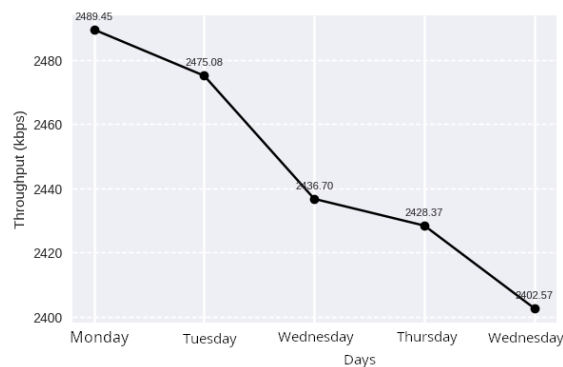


Figure 2. Average Daily Throughput

b. Packet Loss Measurement Results

The daily *packet loss* values analyzed are presented in Figure 3. The values range from 1.24% to 1.30%, with the highest value recorded on Thursday and the lowest on Wednesday and Friday. Overall, the packet loss values fell within the range of approximately 1–1.3%, which, according to the TIPHON standard, is classified as “Excellent” since they remain well below the 2% threshold commonly applied in QoS research within educational institutions. From a technical perspective, the relatively low packet loss indicates that the wireless network operated under generally stable conditions during the observation period. In wireless networks, *packet loss* can be influenced by factors such as channel collisions, signal interference, or access point congestion. However, the low *packet loss* observed in this study suggests that these factors did not significantly affect network performance during the measurements. These findings indicate that *packet loss* is relatively low and does not significantly affect the stability of HTTP-based applications or online learning activities.

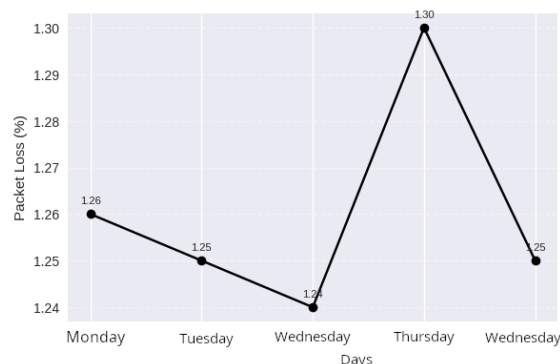


Figure 3. Average Daily Packet Loss

c. Delay Measurement Results

Figure 4. presents the average daily *delay* values, ranging from 56.47 ms to 62.30 ms. The lowest value was recorded on Tuesday, while the highest was observed on Friday. All *delay* values remain below 150 ms, which, according to the TIPHON standard, is classified as “Excellent” for supporting interactive applications such as video-based synchronous lectures and academic system access. From a network perspective, *delay* in wireless networks can be influenced by factors such as queue length at network devices, routing path complexity, and congestion on the backhaul connection. The relatively stable *delay* values observed in this study suggest that these factors did not significantly affect packet transmission during the observation period. These results indicate that network latency is within a safe range and capable of supporting daily academic activities.

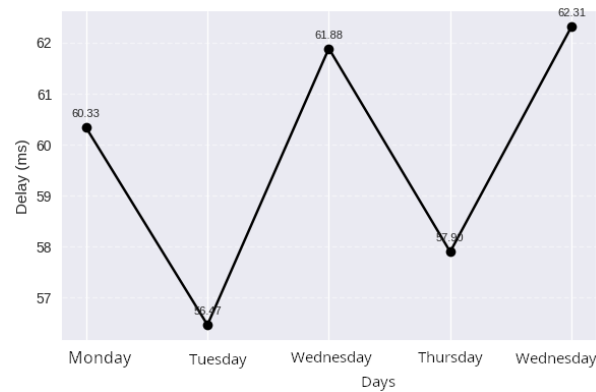


Figure 4. Average Daily Delay

d. Jitter Measurement Results

The average daily *jitter* values are presented in Figure 5. The values range from 3.69 ms to 3.90 ms, with the highest value recorded on Wednesday and the lowest on Monday. This range is relatively low and stable, remaining well below the threshold of several tens of milliseconds that is generally considered acceptable for streaming and video conferencing services, as reported in QoS literature. These results indicate that the variation in packet arrival times is minimal and therefore unlikely to interfere with multimedia applications. Low and stable *jitter* values are essential for supporting high-resolution multimedia and video streaming services, since large variations in packet arrival times can cause visual and audio disruptions.

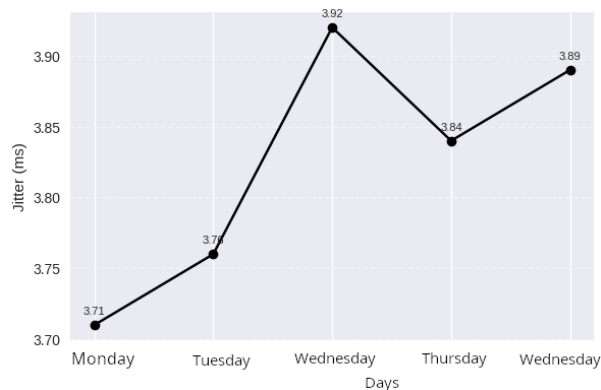


Figure 5. Average Daily Jitter

The results of this study indicate that the performance of the UTDI Laboratory wireless network generally falls within the “Good” to “Excellent” categories based on the TIPHON standard. This conclusion is supported by a combination of consistent *throughput* values above 2.4 Mbps, average *packet loss* of approximately 1.2%, *delay* below 65 ms, and *jitter* ranging from 3.7 to 3.9 ms. These values demonstrate the network’s ability to deliver consistent and high-speed data services, thereby supporting network-based academic activities effectively.

In terms of daily patterns, Figure 2 illustrates that the highest *throughput* values occur on Mondays and tend to decline toward Fridays. This pattern suggests that data service capacity is most optimal at the beginning of the week, when network traffic loads have not yet fully accumulated, and subsequently decreases as usage intensity and network activity density increase from midweek to the end of the week. In Figure 3, the spike in *packet loss* observed on Thursday indicates temporary network congestion, which is likely caused by an increase in simultaneous download activity and assignment submissions. This condition resulted in some data packets being unable to be processed and ultimately dropped by the network device, even though *throughput* remained within a “Good” range.

Furthermore, the *delay* values in Figure 4 appear relatively higher on Mondays, Wednesdays, and Fridays. This pattern suggests that, on these days, traffic queues at access points or gateways tend to be longer, resulting in increased travel time for packets from source to destination. Meanwhile, Figure 5 shows a significant increase in *jitter* on Wednesday, indicating reduced stability in packet arrival times. This phenomenon reflects network conditions with high traffic fluctuations, resulting in greater *delay* variation between packets compared to other days.

Compared to previous studies, the results of this research demonstrate more balanced QoS characteristics across parameters. Previous studies reported that *throughput* tended to be a weak point, even though *delay* and *packet loss* were classified in the “Good” to “Excellent” categories, thereby reducing the overall QoS index. In contrast, measurements at the UTDI Laboratory show that all key QoS parameters are consistently strong, with relatively high *throughput* and low *delay*, *jitter*, and *packet loss*. This results in a more proportional network quality profile and a higher overall QoS index.

The main significance of this study lies in its provision of a comprehensive overview of the quality of the UTDI Laboratory’s wireless network service, evaluated using the TIPHON standard. Furthermore, the study highlights the importance of structured QoS evaluation in assessing the readiness of educational network infrastructure to support digital learning processes. The findings also demonstrate that the Python and Google Colab-based analysis approach is capable of producing transparent, systematic, and easily replicable QoS evaluations across different network contexts.

Although the results of this study indicate good service quality, there remain opportunities for further research, particularly in analyzing network performance during peak hours in greater depth, examining the effect of user numbers, and evaluating the impact of access point configuration and placement on QoS parameters. Accordingly, future research is expected to provide deeper insights into the dynamics of wireless network performance.

3. Conclusion

This study evaluated the wireless network performance in the UTDI laboratories using QoS parameters based on the TIPHON standard. The results indicated that the measured *throughput*, *packet loss*, *delay*, and *jitter* values fell within the “Excellent” category according to the TIPHON performance criteria, suggesting that the current wireless network infrastructure is capable of reliably supporting internet-based academic activities.

Methodologically, this study also contributed to strengthening the evaluation of wireless network service quality in the education sector by integrating the TIPHON standard with cloud computing-based data analysis. Through the development of a structured analytical framework from observational data processing to QoS visualization and interpretation this study provided a measurable, transparent, and replicable evaluation method for assessing the readiness of academic network infrastructure.

In practical terms, the proposed framework can serve as a basis for decision-making by campus network managers in capacity planning, maintenance scheduling, and the identification of critical service periods. From a scientific perspective, this approach opens opportunities for further research, including expanding the scope of measurement to additional access points, incorporating variables such as user numbers and types of applications accessed, and testing the impact of implementing traffic management, load balancing strategies, and adaptive bandwidth management. Accordingly, this research not only provides a localized evaluation of the UTDI Laboratory network but also enriches the repertoire of QoS evaluation methodologies relevant to the broader development and management of wireless networks in educational institutions.

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