Journal of Applied Informatics and Computing (JAIC)
Vol.10, No.4, August 2026, pp. 3849~3856
e-ISSN: 2548-6861

Performance Comparison of Point-to-Point and Point-to-Multipoint Fiber Optic Networks Using QoS Parameters and the Analytical Hierarchy Process (AHP)

Husni [1]*, Taufiq [2]*, Defry Hamdhana [3]*, Muhammad Daud [4]*, Asrianda [5]*
*Master of Information Technology Study Program, Malikussaleh University, Lhokseumawe, Indonesia,
husniabda7@gmail.com [1], taufiq.te@unimal.ac.id [2], defryhamdhana@unimal.ac.id [3], mdaud@unimal.ac.id [4], asrianda@unimal.ac.id [5]

Article Info

Article history:

Received 2026-06-27
Revised 2026-08-01
Accepted 2026-08-12

Keyword:

Analytical Hierarchy Process,
Fiber Optic,
Point-to-Multipoint,
Point-to-Point,
Quality of Service.

ABSTRACT

The rapid growth of internet traffic in Indonesia, including in Aceh Province, requires an optical fiber network infrastructure that is both efficient and reliable. Two fundamental architectures, Point-to-Point (P2P) and Point-to-Multipoint (P2MP), offer different trade-offs between service quality and cost efficiency, yet a quantitative comparison that combines Quality of Service (QoS) measurement with a structured multi-criteria decision-making method remains limited. This study experimentally measures the throughput, delay, jitter, packet loss, and bandwidth of P2P and P2MP networks implemented at Universitas Almuslim, Bireuen, Aceh, using iPerf3 and Wireshark under varying client loads of 1, 2, 4, 8, and 16 users, and applies the Analytical Hierarchy Process (AHP) to weight the QoS criteria and rank the two architectures. The results show that P2P consistently outperforms P2MP on every QoS parameter, maintaining an average throughput of 95 Mbps, a delay of 2.68 ms, a jitter of 0.85 ms, a packet loss of 0.054%, and a fixed bandwidth of 100 Mbps, whereas P2MP degrades progressively as the number of users increases. AHP weighting identified throughput as the most influential criterion (0.50), followed by bandwidth (0.26), delay (0.13), jitter (0.07), and packet loss (0.03), with a Consistency Ratio of 0.054, confirming that the pairwise judgments were consistent. The resulting AHP scores were 9.00 for P2P and 2.66 for P2MP, indicating that P2P is the more optimal architecture for QoS-sensitive deployments, while P2MP remains advantageous where cost efficiency and wide coverage are prioritized.

I. Introduction

The rapid expansion of the digital ecosystem has placed unprecedented demand on telecommunication infrastructure capable of delivering high capacity, high speed, and reliable connectivity. Data traffic continues to surge as a result of ultra-high-definition streaming, virtual and augmented reality applications, and the proliferation of Internet of Things (IoT) devices. Globally, internet penetration reached 67% of the world's population in 2023, equivalent to roughly 5.4 billion connected users, with fixed-broadband subscriptions growing at an average annual rate of 6.7% over the past decade [1]. This sustained growth continues to strain available network resources. In Indonesia, the Association of Indonesian Internet Service Providers (APJII) reported 215.63 million internet users during the 2023 survey period, corresponding to a penetration rate of 78.19%, with Aceh Province alone accounting for approximately 3.4 million users [2]. Such figures highlight the pressing need for well-planned, efficient, and dependable network infrastructure at the regional level.

Fiber optic technology has become the principal backbone of modern broadband infrastructure owing to its large bandwidth capacity, low interference, extended reach, and superior transmission stability compared with copper-based media, achieved through total internal reflection between the core and cladding layers as illustrated in Fig. 1 [3], [4]. Two fundamental deployment architectures are commonly used to deliver fiber-based services: Point-to-Point (P2P) and Point-to-Multipoint (P2MP). In a P2P configuration, a single Optical Line Terminal (OLT) is connected directly to a single

Optical Network Unit (ONU) through a dedicated fiber path, which produces stable and predictable service quality because there is no contention for shared resources [1]; this benefit, however, comes at the cost of higher per-connection infrastructure expenditure. In contrast, P2MP allows one OLT to serve multiple ONUs through passive components such as optical splitters, forming the foundation of Passive Optical Network (PON) technologies such as GPON and EPON that underpin Fiber-to-the-Home (FTTH) deployments [5]. The cost efficiency and scalability of P2MP have made it the preferred choice for mass-market access networks, although dynamic bandwidth sharing can degrade service quality as traffic volume increases [6].

These architectural differences translate directly into measurable network performance, most commonly assessed through Quality of Service (QoS) parameters such as throughput, delay, jitter, and packet loss [4]. A substantial body of research has examined the performance of each architecture, or of bandwidth-allocation algorithms, in isolation. Cao et al. [7] proposed a reinforcement-learning-based dynamic bandwidth allocation (DBA) scheme for industrial 50G-PON networks, achieving sub-2 ms latency at over 60% link utilization, while Memon et al. [1] compared DBA algorithms across GPON, XG-PON, and NG-EPON standards under both ITU-T and IEEE frameworks. In the domain of multi-criteria decision-making, Al-Zahrani [8] evaluated the survivability of multi-fiber WDM networks using a hesitant-fuzzy AHP-TOPSIS approach, Urrea and Benítez [9] applied AHP to select the optimal SDN controller for Industrial IoT deployments, and Mubarok et al. [10] used AHP to evaluate fiber optic cable supplier quality. Similarly, Badeel et al. [11] combined AHP with VIKOR to optimize access-point selection in hybrid LiFi/WiFi networks, and Araújo et al. [12] applied AHP-based criteria weighting to broadband technology selection, confirming that AHP is an effective framework for multi-criteria decision-making across diverse telecommunication domains. However, none of these works explicitly and quantitatively compares P2P and P2MP architectures using empirically measured QoS parameters as the decision criteria within an AHP framework a gap that is particularly relevant for institutional network operators, such as universities, that must choose between the two architectures under real operating conditions.

Addressing this gap, the present study analyzes and compares the performance of fiber optic networks based on P2P and P2MP architectures using QoS parameters, and applies the AHP method to determine the priority weight of each criterion and recommend the more optimal architecture. The main contributions of this study are twofold: (1) it provides empirical QoS measurement data from a real-world implementation of both architectures on the campus network of Universitas Almuslim, Bireuen Regency, Aceh Province; and (2) it integrates these measurements into an AHP decision framework to produce a systematic, measurable, and accountable architecture-selection recommendation, offering practical value for network operators seeking to align infrastructure strategy with service requirements and cost efficiency. Universitas Almuslim was selected as the test site because its campus network already operates both a dedicated P2P backbone for critical services and a splitter-based P2MP segment for general user access, allowing the two architectures to be evaluated under directly comparable conditions; as a single-campus deployment with a moderate and controllable user population, it is representative of small-to-medium institutional access networks, while extrapolation to large-scale public FTTH or metropolitan PON deployments would require validation on networks with substantially larger and more heterogeneous user bases.

II. METHODS

A. Research Design and Location

This study adopts a quantitative experimental approach using a comparative analysis method. The experimental component involved direct testing and observation of the performance of two network architectures, P2P and P2MP, deployed on the fiber optic network of Universitas Almuslim, Bireuen Regency, Aceh Province, with measurements focused on the Computer Center (Puskom) and several faculty network facilities. Data collection was carried out on 12 December 2025, encompassing network performance testing and subsequent comparative data analysis.

B. Variables and Research Instruments

The research objects comprised two architectural models: P2P, representing a dedicated single fiber connection per user, and P2MP, representing a single OLT serving multiple ONUs through an optical splitter, corresponding to GPON technology [13]. The QoS parameters measured were throughput, delay, jitter, packet loss, and bandwidth. Control variables included the type of fiber optic cable, network devices (OLT/ONU/switch), link distance, traffic type, device configuration, and testing time, ensuring that the measurement results were objectively comparable. Testing equipment consisted of an OLT, ONUs, single-mode fiber cable, an optical splitter (used only in the P2MP scenario), server and client computers, and software tools iPerf3 for traffic generation and Wireshark for QoS parameter capture. The P2P link used a single-mode fiber path of approximately 50 m between the OLT/converter and ONU, while the P2MP segment used a 1:16 passive optical splitter with fiber runs of approximately 30-80 m from the splitter to each ONU; the OLT/converter, ONU, and splitter were standard commercially available GPON-class single-mode devices operating at 1310/1490 nm, and each client workstation was connected via a Gigabit Ethernet managed switch to avoid the local-area-network link becoming the measurement bottleneck.

C. Test Topology

The P2P implementation connected a single converter directly to a single ONU through one single-mode fiber path without a splitter, so that the entire bandwidth capacity was used exclusively by one connection (Fig. 1). The P2MP implementation connected a single OLT to multiple ONUs through a passive optical splitter, with all clients accessing the network simultaneously to simulate real usage conditions (Fig. 2). Both implementation stages included IP address configuration, connectivity testing via ping, and QoS measurement using iPerf3 and Wireshark.

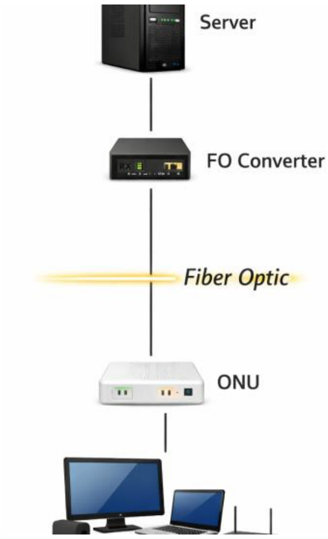

Figure 1. Test topology of the Point-to-Point network implementation.

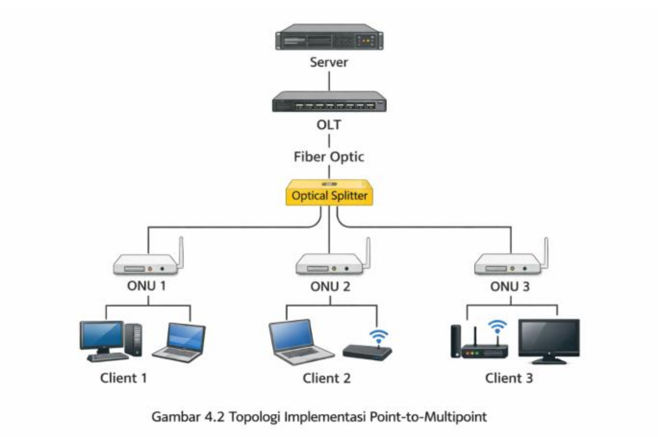

Figure 2. Test topology of the Point-to-Multipoint network implementation.

D. QoS Testing Formulas

The Quality of Service (QoS) parameters were calculated using Equations (1)–(4).

$$\text{Throughput} = \frac{\text{Total Data Received (bits)}}{\text{Transmission Time (s)}} \quad (1)$$

$$\text{Average Delay} = \frac{\sum(t_{\text{received}} - t_{\text{sent}})}{n} \quad (2)$$

$$\text{Jitter} = \text{Maximum Delay} - \text{Minimum Delay} \quad (3)$$

$$\text{Packet Loss} = \frac{P_{\text{sent}} - P_{\text{received}}}{P_{\text{sent}}} \times 100\% \quad (4)$$

where $n$represents the total number of transmitted packets, $t_{\text{sent}}$and t_{received}denote the packet transmission and reception times, respectively, and $P_{\text{sent}}$and P_{received}represent the numbers of transmitted and successfully received packets. Bandwidth was measured as the maximum available transmission capacity allocated to each user, with a nominal value of 100 Mbps.

E. Research Procedure and AHP Analysis

The research procedure is illustrated in Fig. 3. The study began with a literature review, followed by the design of the experimental network topology, QoS parameter measurements, AHP-based data analysis, and the selection of the most suitable network architecture.

The AHP analysis consisted of six sequential steps. First, the decision objective was defined. Second, the evaluation criteria were established, including throughput, delay, jitter, packet loss, and bandwidth. Third, a pairwise comparison matrix was constructed using Saaty's fundamental 1–9 scale, with judgments formulated directly by the researchers based on the empirical QoS measurement results (Tables I-VI) and established network-engineering references (e.g., ITU-T QoS thresholds) rather than through an external expert panel or multi-respondent survey; this single-source judgment is acknowledged as a limitation in Section IV, and future work may validate the weighting through a structured expert or stakeholder survey. Fourth, the priority weights of each criterion were calculated through matrix normalization [14]. Fifth, the consistency of the pairwise comparisons was evaluated by calculating the Consistency Ratio (CR), with a value below 0.10 indicating acceptable consistency [9]. Finally, the overall priority scores were computed to determine the optimal network architecture.

To improve the reliability of the results, each QoS parameter was measured at least three times, with iPerf3 traffic generated for five-minute intervals per trial and captured in Wireshark, under both normal (off-peak, low-load) and peak (high-load) network traffic conditions corresponding to the varying client counts described in Section III. The resulting throughput, delay, jitter, and packet-loss values were subsequently compared against ITU-T reference thresholds (ITU-T G.114 for jitter and delay, and the TIPHON/ITU-T packet-loss guideline) to assess whether each architecture met acceptable real-time service quality. The average values obtained from these measurements were used in the subsequent AHP analysis.

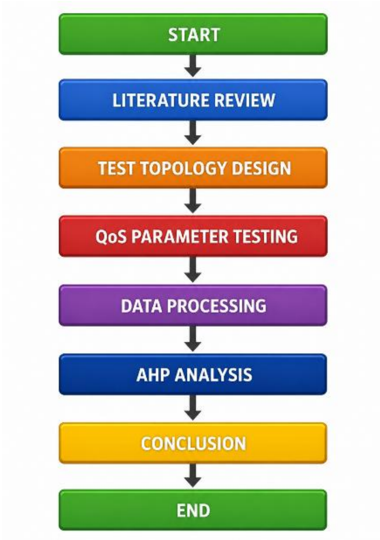

Figure 3. Research flowchart

III. RESULT AND DISCUSSION

A. System Implementation

Both network scenarios, P2P and P2MP, were implemented under identical environmental conditions on the Universitas Almuslim network to ensure objective comparability. In the P2P scenario, a single OLT was connected directly to a single ONU without a splitter, so that the entire bandwidth capacity was used exclusively. In the P2MP scenario, a single OLT was connected to several ONUs through a passive optical splitter, with the number of users varied at 1, 2, 4, 8, and 16 to observe the effect of bandwidth sharing on service quality.

B. Throughput

Table I presents the throughput measurement results at a base network capacity of 100 Mbps.

TABLE I
THROUGHPUT TEST RESULTS (MBPS)

Number of Users	**P2P (Mbps)**	**P2MP (Mbps)**	**Remarks**
1	95	94	Nearly identical
2	95	47	P2MP begins sharing
4	95	23.5	Evenly divided
8	95	11.8	Significant decline
16	95	5.9	Suboptimal

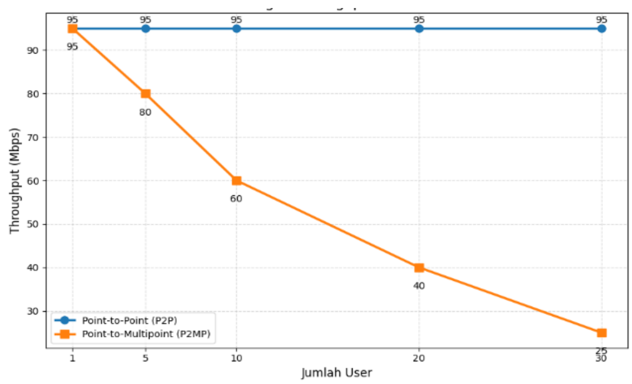

Figure 4. Throughput comparison between P2P and P2MP as a function of user count.

P2P maintained a stable throughput of approximately 95 Mbps, close to the 100 Mbps maximum capacity. The residual 5 Mbps gap is attributable to protocol overhead rather than architectural limitation: TCP/IP and Ethernet header encapsulation, iPerf3 measurement overhead, and physical-layer framing typically consume roughly 3-5% of nominal link capacity, so a throughput of 95 Mbps on a 100 Mbps link is consistent with the theoretical maximum achievable goodput rather than a shortfall in the P2P architecture itself. P2MP, by contrast, declined sharply from 94 Mbps at one user to 5.9 Mbps at sixteen users, since the shared capacity had to be divided among active clients for instance, at four users the throughput per user fell to approximately 95/4 ≈ 23.5 Mbps. In aggregate, the effective total capacity of P2P reached 1,520 Mbps (95 Mbps × 16 dedicated connections), whereas the total for P2MP amounted to only 183.2 Mbps due to the bandwidth-sharing mechanism. This finding is consistent with Memon et al. [1], who showed that bandwidth-allocation efficiency in shared architectures depends heavily on the underlying DBA algorithm; without an optimal allocation mechanism, a decline in per-user throughput becomes unavoidable as the number of clients grows. These results confirm that P2P is better suited to consistently high-traffic requirements, whereas P2MP is more efficient for distributing service to many users, at the cost of reduced throughput under peak load.

C. Delay

Average delay was computed using Equation (2) for five user-count scenarios, as summarized in Table II.

TABLE II
AVERAGE DELAY TEST RESULTS (MS)

Test	**Number of Users**	**P2P Delay**	**P2MP Delay**
1	1	2.1	3.8
2	5	2.4	8.6
3	10	2.7	15.2
4	20	3.0	28.7
5	30	3.2	41.5

P2P delay remained low and stable (2.1–3.2 ms) despite increasing user numbers, because each user retains an exclusive path free of contention. P2MP delay, by contrast, rose sharply from 3.8 ms to 41.5 ms at thirty users due to packet queuing within the passive splitter mechanism. Although this value remains below the ITU-T real-time service threshold of 150 ms, the escalating delay trend in P2MP aligns with the findings of Cao et al. [7], who demonstrated that low latency in PON networks can only be sustained through adaptive bandwidth-scheduling algorithms; without such mechanisms, queue accumulation under heavy user loads becomes the dominant driver of increased delay.

D. Jitter

Jitter was measured at 10-second intervals over 30 minutes (n = 6 samples), with results shown in Table III.

TABLE III
JITTER MEASUREMENT RESULTS (MS)

Time (minutes)	P2P	P2MP
5	0.8	2.1
10	0.9	2.4
15	1.0	2.7
20	0.7	3.0
25	0.9	2.8
30	0.8	3.2
Average	0.85	2.70

The average P2P jitter of 0.85 ms was considerably lower than the 2.7 ms recorded for P2MP. The stability of P2P stems from its dedicated, contention-free transmission path, whereas the larger variation observed in P2MP arises from the shared-medium mechanism and queuing delay. Both values remain below the ITU-T G.114 real-time communication threshold of 30 ms, indicating acceptable performance for both architectures; nonetheless, P2P delivers a more stable service quality that is better suited to time-sensitive applications, consistent with the low-latency characteristics reported for dedicated scheduling policies by Hadi et al. [15].

E. Packet Loss

Packet loss results at a bandwidth capacity of 100 Mbps are summarized in Tables IV and V.

TABLE IV
PACKET LOSS SUMMARY

Parameter	P2P	P2MP	Difference
Minimum	0.02%	0.05%	P2MP +0.03%
Maximum	0.10%	1.65%	P2MP +1.55%
Average	0.054%	0.604%	P2MP ≈ 11.18×

Packet loss for P2P remained low across all scenarios (0.02%–0.10%; average 0.054%), whereas P2MP increased significantly to 1.65% at sixteen users (average 0.604%), approximately 11.18 times higher than P2P, with the gap widening to a 16.5-fold difference under peak load.

TABLE V
PACKET LOSS BY NUMBER OF USERS

Number of Users	P2P (%)	P2MP (%)
1	0.02	0.05
2	0.03	0.12
4	0.05	0.35
8	0.07	0.85
16	0.10	1.65

This increase occurs because bandwidth shared among many clients raises the risk of network congestion and packet queuing that ultimately leads to data loss, consistent with the findings of Hailu et al. [4] on the relationship between queuing and redundancy mechanisms and packet-loss rates in shared optical networks. Although both architectures remain within acceptable limits for most services, P2P demonstrates markedly higher transmission reliability.

F. Bandwidth

Bandwidth testing was performed to evaluate the transmission capacity provided by the Point to Point (P2P) and Point to Multipoint (P2MP) network architectures under different numbers of connected users. The bandwidth test results are presented in Table VI.

TABLE VI
BANDWIDTH TEST RESULTS (MBPS)

Number of Users	P2P (Mbps)	P2MP (Mbps)
1	100	100
2	100	50
4	100	25
8	100	12.5
16	100	6.25

P2P sustained its full 100 Mbps capacity across all scenarios owing to its dedicated nature, while P2MP declined proportionally from 100 Mbps to only 6.25 Mbps at sixteen users. This pattern underscores the fundamental trade-off between service quality and cost efficiency: P2P excels at maintaining consistent bandwidth availability, whereas P2MP offers infrastructure efficiency at the expense of reduced per-user capacity as the client base grows, a pattern also observed in GPON capacity evaluations by Hantoro et al. [16] and in narrowband GPON-based FTTX studies by Ibrahim et al. [17].

These findings are broadly consistent with FTTH/GPON deployment studies reported across various regions and institutions, including campus and residential network implementations in Indonesia [18],[19],[20],[21], and with comparable PON-based FTTH design studies elsewhere [22],[23],[24],[25], which similarly report a trade-off between the scalability benefits of splitter-based P2MP/PON architectures and the performance ceiling imposed by shared bandwidth.

G. AHP-Based Analysis

The AHP hierarchy was structured into three levels: the goal (determining the best fiber optic network architecture), the criteria (throughput, delay, jitter, packet loss, bandwidth), and the alternatives (P2P, P2MP). The pairwise comparison matrix, constructed using Saaty's fundamental scale (1–9), is presented in Table VII.

TABLE VII
PAIRWISE COMPARISON MATRIX OF QOS CRITERIA

Criteria	**Thpt**	**Delay**	**Jitter**	**PL**	**BW**
Throughput	1	5	7	9	3
Delay	1/5	1	3	5	1/3
Jitter	1/7	1/3	1	3	1/5
Packet Loss	1/9	1/5	1/3	1	1/7
Bandwidth	1/3	3	5	7	1

Matrix normalization and the resulting criterion weights, obtained by dividing each column element by its column total and then averaging across rows, are presented in Table VIII.

TABLE VIII
NORMALIZED MATRIX AND CRITERION WEIGHTS

Criteria	**Row Sum**	**Weight**
Throughput	2.51	0.50
Delay	0.67	0.13
Jitter	0.34	0.07
Packet Loss	0.17	0.03
Bandwidth	1.30	0.26

The eigenvector values indicate that throughput is the most dominant criterion (0.50), followed by bandwidth (0.26), delay (0.13), jitter (0.07), and packet loss (0.03). Throughput and bandwidth together account for over three-quarters of the total priority weight because they most directly determine whether a network can sustain modern high-volume applications such as HD/UHD streaming and large file transfers, whereas delay, jitter, and packet loss, although critical for real-time services, were judged comparatively less decisive given that both architectures already remained within ITU-T acceptable thresholds for these parameters. This priority ordering reflects that effective data-transmission capacity is regarded as the most decisive factor for network service quality in this study's context, consistent with the AHP weighting reported by Araújo et al. [12], who likewise identified capacity and quality as high-weight criteria in broadband access technology selection.
Consistency was verified using Equations (5) and (6):

$$CI = \frac{\lambda_{\max} - n}{n - 1} \qquad (5)$$

$$CR = \frac{CI}{RI} \qquad (6)$$

Substituting $\lambda_{\max} = 5.24$, $n = 5$, and $RI = 1.12$into Equations (5) and (6) yields a Consistency Index (CI) of 0.061 and a Consistency Ratio (CR) of 0.054. Since the CR value is less than 0.10, the pairwise comparison matrix is considered consistent, indicating that the criterion weights are sufficiently reliable for the AHP evaluation. Because the five QoS criteria are expressed in different units (Mbps, ms, and %), each architecture's raw measurement was first converted into a dimensionless performance score on Saaty's 1-9 preference scale rather than combined directly: for every criterion, the architecture with the better raw value (e.g., higher throughput and bandwidth, or lower delay, jitter, and packet loss) was assigned the highest preference score, and the other architecture was scored relative to it in proportion to the magnitude of the performance gap observed in Tables I-VI. The overall score of each network architecture was then obtained by multiplying the normalized criterion weights by the corresponding QoS performance scores [9]. The resulting alternative scores are presented in Table IX.

The score of each alternative was calculated by multiplying the criterion weights by the performance score of each architecture based on the QoS test results, as shown in Table IX.

TABLE IX
ALTERNATIVE SCORES USING AHP WEIGHTS

Criteria	**Weight**	**P2P**	**P2MP**
Throughput	0.50	9	3
Delay	0.13	9	1
Jitter	0.07	9	3
Packet Loss	0.03	9	1
Bandwidth	0.26	9	3

TABLE X
FINAL AHP RANKING OF ALTERNATIVES

Alternative	**Total Score**
P2P	9.00
P2MP	2.66

The total score of each alternative was obtained as Score = Sigma(weight_i x score_i), summed over the five criteria using the weights and performance scores in Table IX. For P2P: (0.50x9) + (0.13x9) + (0.07x9) + (0.03x9) + (0.26x9) = 4.50 + 1.17 + 0.63 + 0.27 + 2.34 = 8.91 (rounded to 9.00 using unrounded weights, since P2P was assigned the maximum score of 9 on every criterion). For P2MP: (0.50x3) + (0.13x1) + (0.07x3) + (0.03x1) + (0.26x3) = 1.50 + 0.13 + 0.21 + 0.03 + 0.78 = 2.65 (2.66 using unrounded weights). The ranking results show that P2P achieved a total score of 9.00, higher than P2MP's 2.66. Accordingly, based on the AHP weighting of the five QoS parameters, P2P is the most optimal alternative, delivering stable service quality through fixed bandwidth, low delay and jitter, and minimal packet loss. This finding is consistent with the fundamental principles of dedicated architectures established in the literature [1], [4], [7], and further reinforces the validity of AHP as a multi-criteria evaluation framework in the optical networking domain, as demonstrated by Urrea and Benítez [9] and Mubarok et al. [10]. Nevertheless, P2MP remains a viable alternative for deployments that prioritize infrastructure cost efficiency and broad service coverage, indicating that architecture selection in practice should be tailored to the specific requirements of the network operator.

IV. CONCLUSION

This study compared the performance of Point to Point (P2P) and Point to Multipoint (P2MP) fiber optic network architectures based on Quality of Service (QoS) parameters using the Analytical Hierarchy Process (AHP). The results demonstrate that P2P consistently achieved better performance than P2MP across all evaluated QoS parameters. The AHP analysis identified throughput as the most influential criterion and confirmed the consistency of the decision-making process with a Consistency Ratio of 0.054. The final AHP scores of 9.00 for P2P and 2.66 for P2MP indicate that, from a QoS standpoint, P2P is the more suitable architecture for applications requiring stable and high-quality network performance; however, this ranking reflects service-quality criteria alone, and P2MP remains a legitimate and often preferable choice where infrastructure cost efficiency, splitter-based scalability, and broad service coverage are the operator's priority, as is typically the case in mass-market FTTH deployments. The proposed QoS and AHP evaluation framework provides a systematic approach for selecting fiber optic network architectures, though it is limited by its single-institution, single-day setting, a fixed 100 Mbps bandwidth capacity, a maximum tested load of sixteen users, pairwise-comparison judgments formulated by the researchers alone rather than an external expert panel, a QoS-only criterion set, reporting of mean QoS values without formal statistical treatment (e.g., standard deviation, confidence intervals, or significance testing) of the repeated trials, and the absence of a formal cost-benefit or Total Cost of Ownership comparison between the two architectures. Future research should therefore extend the evaluation to larger and more heterogeneous PON deployments such as GPON or XGS-PON, incorporate non-QoS decision criteria including installation and operational cost, scalability, maintainability, and energy consumption, examine the effect of differentiated traffic types such as video streaming, VoIP, and file transfer on measured QoS, and benchmark the AHP-based ranking against other multi-criteria decision-making methods such as TOPSIS, VIKOR, or PROMETHEE to obtain more comprehensive and generalizable results. Beyond architecture selection alone, prior EPON-based access-network design experience [26] and the broader trend toward fixed-mobile convergence in Indonesia's telecommunications infrastructure [27] suggest that future architecture-selection studies should also be situated within evolving convergent network strategies rather than treated as a purely standalone technical decision; in parallel, emerging machine-learning-based QoS/QoT prediction techniques [28] offer a promising direction for proactively forecasting P2P and P2MP performance under varying traffic conditions, complementing the retrospective measurement approach adopted in this study.

REFERENCES

[1] K. A. Memon, S. S. Jaffer, M. A. Qureshi, and K. K. Qureshi, "Dynamic bandwidth allocation in time division multiplexed passive optical networks: a dual-standard analysis of ITU-T and IEEE standard algorithms," PeerJ Comput. Sci., vol. 11, p. e2863, May 2025, doi: 10.7717/peerj-cs.2863.

[2] Asosiasi Penyelenggara Jasa Internet Indonesia (APJII), "Survei Penetrasi Internet Indonesia 2023–2024," APJII, Jakarta, Indonesia, 2024. [Online]. Available: https://survei.apjii.or.id/

[3] J. M. Senior, Optical Fiber Communications: Principles and Practice, 3rd ed. Harlow, U.K.: Pearson, 2009.

[4] A. Mohammad, Fiber Optics Engineering. New York, NY, USA: Springer, 2009.

[5] T. Thangappan, B. Therese, A. Suvarnamma, and G. S. Swapna, "Review on Dynamic Bandwidth Allocation of GPON and EPON," J. Electron. Sci. Technol., vol. 18, no. 4, pp. 297–307, 2020, doi: 10.1016/j.jnlest.2020.100044.

[6] Y. Khlifi and F. A. Al-Zahrani, "Joint resource optimization and flexible QoS provision using hybrid optical core node architecture," Heliyon, vol. 10, no. 2, p. e24058, Jan. 2024, doi: 10.1016/j.heliyon.2024.e24058.

[7] D. H. Hailu, G. G. Lema, B. G. Gebrehaweria, and S. H. Kebede, "Quality of Service (QoS) improving schemes in optical networks," Heliyon, vol. 6, no. 4, p. e03772, Apr. 2020, doi: 10.1016/j.heliyon.2020.e03772.

[8] B. Cao, Q. Zhao, Y. Hong, and X. Fan, "Network performance evaluation criterion model based on large connections for low latency in industrial 50G-PON network," Opt. Fiber Technol., vol. 90, Mar. 2025, doi: 10.1016/j.yofte.2024.104107.

[9] F. A. Al-Zahrani, "Hesitant-Fuzzy Sets-Based Computational Approach for Evaluating the Survivability Impact of Multi-Fiber WDM Networks: Kingdom of Saudi Arabia Perspective," IEEE Access, vol. 8, pp. 212409–212422, 2020, doi: 10.1109/ACCESS.2020.3038798.

[10] C. Urrea and D. Benítez, "Optimizing IIoT Performance: Intelligent Selection of SDN Controllers through AHP Analysis," Int. J. Intell. Syst., vol. 2024, Art. no. 7908506, 2024, doi: 10.1155/2024/7908506.

[11] A. M. Mubarok, I. Kirono, S. Sukaris, and N. Cahyadi, "Analytical Hierarchy Process Method as a Solution to Fiber Optic Cable Supplier Quality," J. Ilmiah Manajemen Kesatuan, vol. 12, no. 6, pp. 2149–2156, Oct. 2024, doi: 10.37641/jimkes.v12i6.2901.

[12] R. Badeel, S. K. Subramaniam, A. Muhammed, and Z. M. Hanapi, "A Multicriteria Decision-Making Framework for Access Point Selection in Hybrid LiFi/WiFi Networks Using Integrated AHP–VIKOR Technique," Sensors, vol. 23, no. 3, p. 1312, Feb. 2023, doi: 10.3390/s23031312.

[13] M. Araújo, L. Ekenberg, M. Danielson, and J. Confraria, "A Multi-Criteria Approach to Decision Making in Broadband Technology Selection," Group Decis. Negot., vol. 31, no. 2, pp. 387–418, Apr. 2022, doi: 10.1007/s10726-021-09772-9.

[14] N. Solihah and M. I. Nashiruddin, "Development of Multicast Service Technical Requirements Regulation on XG-PON OLT Equipment," J. Penelitian Pos Inform., vol. 10, no. 1, p. 59, Oct. 2020, doi: 10.17933/jppi.2020.100105.

[15] L. Wu, C. Gan, Z. Xu, and J. Hui, "Multi-dimensional quantitative model of communication network value," Sci. Rep., vol. 12, Art. no. 21432, Dec. 2022, doi: 10.1038/s41598-022-12501-0.

[16] M. Hadi, C. Bhar, and E. Agrell, "General QoS-aware scheduling procedure for passive optical networks," J. Opt. Commun. Netw., vol. 12, no. 7, pp. 217–228, Jul. 2020, doi: 10.1364/JOCN.390902.

[17] G. D. Hantoro, P. S. Priambodo, and G. Wibisono, "Analysis of GPON capacity by hybrid splitting-ratio based on customer segmentation for Indonesian market during the COVID-19 pandemic," EUREKA Phys. Eng., no. 4, pp. 152–169, Jul. 2022, doi: 10.21303/2461-4262.2022.002054.

[18] S. K. Ibrahim, G. M. Ali, and A. K. Jasim, "Evaluation of effectiveness of FTTX-GPON technology-based narrowband direct modulation using shared WDM-SAC-OCDMA system," Results Opt., vol. 21, Dec. 2025, doi: 10.1016/j.rio.2025.100841.

[19] R. Valentino, A. Yolanda, and P. Maria, "Fiber To The Home (FTTH) Network Infrastructure Design Using Gigabyte Passive Optical

Network (GPON) Technology South Solok District," PERFECT J. Smart Algorithms, vol. 1, no. 2, pp. 49–56, Dec. 2024, doi: 10.62671/perfect.v1i2.24.
[20] M. N. Ikhsanto and A. Setiawan, "Jaringan Akses Fiber To The Home (FTTH) Dengan Teknologi Gigabyte Passive Optical Network (GPON) PT. Telkom Kota Metro," J-Cosys, vol. 4, no. 1, pp. 57–63, Feb. 2024, doi: 10.53514/jco.v4i1.497.
[21] S. M. S. Sani, D. J. D. Dhami, F. Oktafiani, M. M. E. Haqiqi, and T. A. Wiharso, "Centralized Design and Analysis of Fiber Optic Communications on Universitas Garut," Telekontran, vol. 13, no. 2, pp. 203–210, Oct. 2025, doi: 10.34010/telekontran.v13i2.17492.
[22] R. F. Adiati, A. Kusumawardhani, and H. Setijono, "Design and Analysis of an FTTH-GPON in a Residential Area," J. Pendidikan Fisika Teknologi, vol. 8, no. 2, pp. 228–237, Dec. 2022, doi: 10.29303/jpft.v8i2.4233.
[23] D. D. Alfatih, V. A. Putra, T. M. Burhanudin, A. B. Jilana, and A. M. Sherila, "Passive Optical Network (PON) Technologies in FTTH Implementation," 2025.
[24] A. M. Abdullah, A. Hoqani, M. Amirza, and S. Kannadhasan, "Optimizing Fiber Optic Network Design for Efficient FTTH Implementation," 2025, pp. 2219–2229, doi: 10.2991/978-94-6463-858-5_185.
[25] M. Lokhande and A. Singh, "Design and Implementation of FTTH," Int. Res. J. Eng. Technol., vol. 4, no. 6, 2017. [Online]. Available: www.irjet.net
[26] Hechuan, "The Study on the Application of EPON Technology in Optical Fiber to the Home Broadband Access Network Design," 2015.
[27] G. D. Hantoro et al., "Exploring the Potential of Fixed and Mobile Convergence in Indonesia's Telecommunication Industry," J. Syst. Manage. Sci., vol. 14, no. 6, Jun. 2024, doi: 10.33168/JSMS.2024.0909.
[28] Y. Fu et al., "A QoT prediction technique based on machine learning and NLSE for QoS and new lightpaths in optical communication networks," Front. Optoelectron., vol. 14, no. 4, pp. 513–521, Dec. 2021, doi: 10.1007/s12200-020-1079-y.