

Establishing a Quality-of-Service Baseline for a Small School WiFi Network: A Limited Case Study at SDIT

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Abstract: Primary-school WiFi networks built on entry-level routers are rarely measured, so complaints of slow access cannot be checked against objective figures. This case study aims to establish a limited Quality of Service (QoS) baseline for the WiFi network of SDIT Yudha Patria, North Jakarta, which runs on a MikroTik RB941-2nD router and serves about 8 to 10 concurrent users. Production traffic was captured with Wireshark at one client position in two morning sessions of about one minute each, and four parameters were computed and compared with the ETSI TIPHON categories. The packet inter-arrival interval, used as a proxy for delay, was 53 ms and 17 ms (indicatively Very Good); no lost TCP segments were detected at the client (0%, Very Good); and jitter was 0.054 ms and 0.789 ms (Good). Throughput was 75.41 Kbps and 9,195.81 Kbps, reflecting very different offered traffic, and was not classified. No degradation was detected at the measurement position under the observed load. The contribution is a low-cost, reproducible pre-policy baseline procedure that reports the calculation basis of each parameter and separates what client-side QoS can monitor from what it can diagnose.

Keywords: QoS, WiFi performance, baseline measurement, TIPHON, school networks.

Introduction

Schools now depend on WiFi for learning materials, web-based administration and computer-based examinations, and connectivity is increasingly judged by its quality rather than its mere availability; the ITU–UNICEF Giga initiative, for example, recommends at least 20 Mbps of dedicated download capacity per school ([ITU & UNICEF., 2024](#)). Yet the small networks of primary schools rarely have any measured figure against which such expectations, or users' complaints, can be checked. SDIT Yudha Patria, an Islamic integrated primary school in Marunda Baru, North Jakarta, illustrates the situation. Its WiFi network, built around a MikroTik RB941-2nD router, serves approximately 8 to 10 active users with peak usage between 07.00 and 13.00, in a densely built area where neighbouring networks may affect signal quality. Users report slow access, buffering and dropped connections, particularly during exam-browser sessions, yet performance has never been measured. The research problem is therefore practical: the school has no documented reference of the service its WiFi delivers, so it cannot tell whether complaints reflect a network fault or judge the effect of any future change. Addressing it requires keeping four quantities apart. Network QoS describes how packets are handled along the observed path and is expressed through delay, throughput, packet loss and jitter ([Kurose & Ross., 2021](#); [Tanenbaum & Wetherall., 2011](#)); link capacity is the bandwidth subscribed from the provider; coverage is the signal quality at a given location; and Quality of Experience (QoE) is the user's perception, which depends on all three and on application behaviour ([Kougioumtzidis, Poulkov, Zaharis, & Lazaridis., 2022](#); [Liotou et al., 2023](#); [Arellano-Uson, Magana, Morato, & Izal., 2024](#)). A client-side packet capture measures only the first quantity, at one position. QoS is commonly classified against the ETSI TIPPHON categories ([ETSI., 2002](#)), with ITU-T G.1010 describing application requirements ([ITU-T., 2001](#)) and capture performed on IEEE 802.11 networks ([IEEE., 2016](#)); newer 802.11ax/be mechanisms change how airtime is allocated ([Liu & Choi., 2023](#); [Day et al., 2026](#)), but the four classical parameters remain the starting point for a small school network. Prior studies fall into three groups. The first evaluates educational WLANs by packet capture against TIPPHON ([Agung & Wahyono., 2022](#); [Wijaya et al., 2024](#); [Nisa, Saputro, Nugroho, & Lahitani., 2024](#); [Safitri et al., 2025](#); [Pratama, Irawan, & Orisa., 2022](#); [Umbu Pingge, Bernadus, & Adnyana., 2025](#)) and identifies concurrent users and peak-hour load as the main causes of degradation ([Syafudin, Rianto, & Ujjianto., 2025](#); [Anom, Aji, & Prasetyo., 2024](#)). The second evaluates MikroTik bandwidth management with PCQ, Simple Queue and Queue Tree ([Christanto, Daru, & Kurniawan., 2021](#); [Ningsih, Musril, Khairuddin, & Okra, 2024](#); [Prasetyo & Purnama., 2024](#); [Anton & Trisativa, 2023](#); [Kusbandono & Syafitri., 2019](#)). The third treats QoS as a design or orchestration problem ([Mazhar et al., 2023](#); [Yao & Zheng., 2025](#)), assuming expertise beyond that of a primary school. Three gaps follow. First, the bandwidth-management studies

evaluate an already-configured policy, so no pre-policy reference measured on production traffic is reported. Second, the calculation basis of each parameter is seldom stated; in particular, the delay of a passive capture is usually the spacing of arriving packets, not latency, and packet loss is inferred from TCP at the capture point. Third, studies seldom state which interpretations a client-side capture can support, so favourable figures are easily read as evidence that the whole network is healthy. This study differs from earlier QoS studies on these three points, not on the technique: Wireshark capture and TIPHON classification are well established and no novelty is claimed for them. Accordingly, this study aims to (1) establish a limited, pre-policy QoS baseline for the WiFi network of SDIT Yudha Patria from measurements at one client position in two morning sessions; (2) report the calculation basis of each parameter and classify the applicable parameters against TIPHON; and (3) state which interpretations the baseline supports and which require further measurement, giving the school a monitoring reference and other small schools a repeatable, low-cost procedure.

Research Method

Research Design and Procedure

This is a limited baseline case study with a descriptive quantitative design based on live traffic. A baseline here is a documented reference state against which later measurements are compared. A simulation would substitute assumed traffic for the school's actual traffic, and a before–after experiment presupposes the baseline this study establishes; a descriptive design on production traffic records the service received without altering it, at the cost of limited control over load and limited coverage. The procedure is summarised in Figure 1.

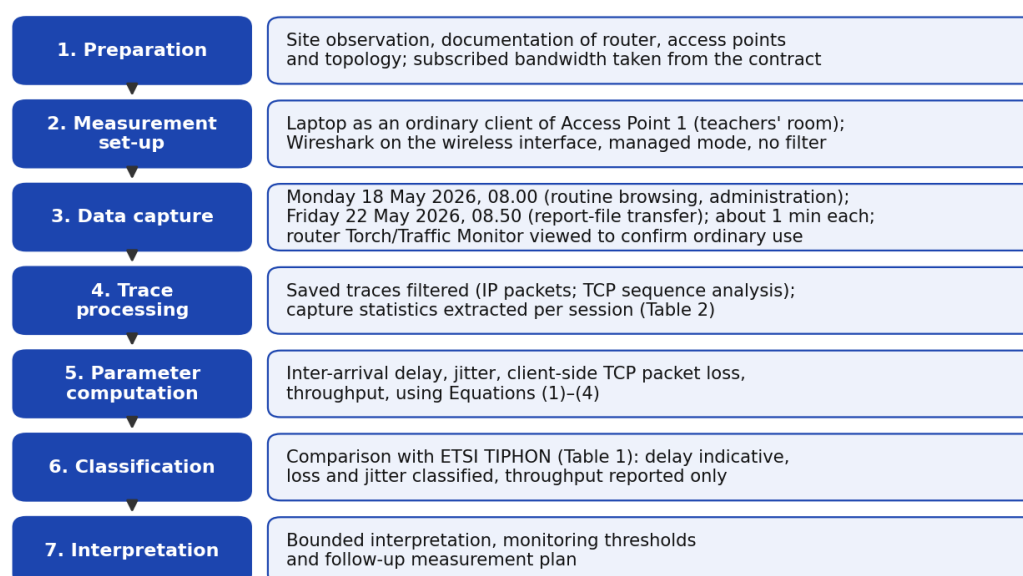


Figure 1 Research procedure

Research Site, Tools and Data Collection

The research was carried out at SDIT Yudha Patria between April and June 2026. The network is managed by a MikroTik RB941-2nD router and distributed through two access points in a star topology (Fitrian, Pranata, Nurfadilla, Agustina, & Junaedi., 2025), as shown in Figure 2. The monitoring laptop was attached wirelessly as an ordinary client of Access Point 1 (TP-Link Archer AX10) in the teachers' room, so the values describe the service received at that position, including the wireless hop, not at the gateway or elsewhere in the building. Wireshark and Winbox (Torch, Traffic Monitor) were used, both free of licence cost. The subscription is 100/100 Mbps from IndiHome, taken from the contract and not verified by a capacity test.

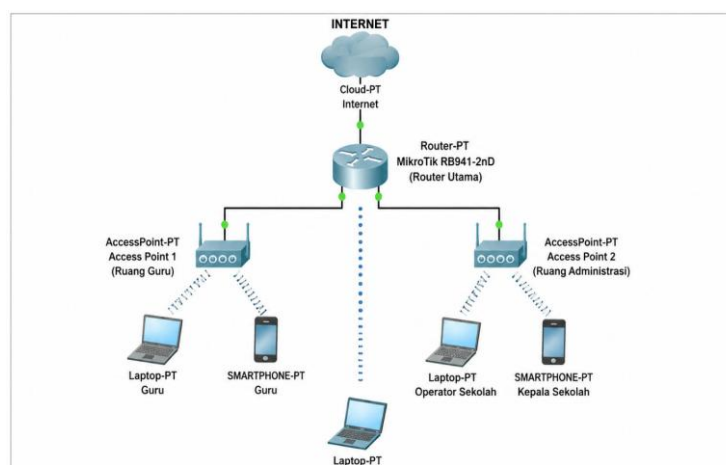


Figure 2 WiFi network topology at SDIT Yudha Patria

Wireshark ran on the laptop's wireless interface in managed mode with no capture filter, so it recorded only frames sent by or addressed to the laptop plus broadcast and multicast frames. Other users' traffic affects the measurement only indirectly, through shared airtime, the router and the upstream link. During capture the laptop carried its user's ordinary work: routine browsing and administration on Monday and transfer of report files on Friday. Router-side readings were viewed only to confirm ordinary use and to count active clients; they were not logged, so every reported value comes from the Wireshark traces. Two sessions of about one minute were captured, on Monday 18 May 2026 at 08.00 and Friday 22 May 2026 at 08.50. They were chosen for three reasons. First, both fall inside the 07.00–13.00 peak window reported by the school. Second, the two days bracket the working week, whose beginning and end have different administrative rhythms according to the operator, giving two contrasting but ordinary traffic conditions. Third, the laptop was in active use by a staff member, so captures were kept short to avoid disrupting work and to keep the procedure light enough for school staff to repeat. The sessions were intended to establish and test the procedure and a first set of reference values, not to characterise variability across days, a term or examination periods.

QoS Computation and Classification

The parameters follow the passive-capture convention of TIPHON-based studies (Nisa et al., 2024; Umbu Pingge et al., 2025) but are stated explicitly, and the two parameters restricted by the client-side position are named accordingly throughout: *inter-arrival delay* and *client-side TCP packet loss*. A passive capture point cannot observe when a packet left its source, so latency cannot be measured; inter-arrival delay is the mean interval between captured packets (Equation 1), where t_i is the timestamp of the i -th packet and N the number of packets. It reflects application and user behaviour as well as the network, so its comparison with the TIPHON delay threshold is indicative only.

$$D_{IA} = \Sigma(t_i - t_{i-1}) / (N - 1) \quad (1)$$

Jitter is the mean absolute difference between consecutive intervals $\Delta_i = t_i - t_{i-1}$ (Equation 2); unlike RFC 3550 jitter (Schulzrinne, Casner, Frederick, & Jacobson., 2003) it needs no RTP timestamps. Both were computed over IP packets, retaining retransmitted segments.

$$J = \Sigma|\Delta_i - \Delta_{i-1}| / (N - 2) \quad (2)$$

Client-side TCP packet loss was estimated from Wireshark's sequence analysis (Equation 3), where L is the number of segments flagged as missing (tcp.analysis.lost_segment) and S the number of TCP segments received; UDP was excluded. A zero value means only that no sequence gap was observed at this client. It does not represent loss across the whole network, because losses recovered by TCP appear as retransmissions, and losses on segments sent by the client never appear as gaps; retransmissions are therefore reported alongside it. Throughput is the bits captured in both directions divided by the capture duration T (Equation 4).

$$PL = L / (S + L) \times 100\% \quad (3)$$

$$\text{Throughput} = (\text{captured bytes} \times 8) / T \quad (4)$$

Values were classified against the TIPHON categories in Table 1; ITU-T G.1010 informs only the monitoring thresholds. Packet loss and jitter thresholds apply directly, and any non-zero jitter falls into the Good band. Throughput is defined relative to a controlled, verified capacity; since capacity was not verified, throughput is reported but not classified.

Table 1 Network service quality categories according to the TIPHON standard

Category	Delay	Throughput	Packet Loss	Jitter
Very Good	< 150 ms	100%	0%	0 ms
Good	150 – 300 ms	75%	3%	0 – 75 ms
Fair	300 – 450 ms	50%	15%	75 – 125 ms
Poor	> 450 ms	< 25%	25%	125 – 225 ms

Source: ETSI TIPPHON TR 101 329 V2.1.1 (ETSI., 2002)

Result and Discussion

Figure 3 shows the Monday capture, the raw material from which all values are derived: arrival timestamps give inter-arrival delay and jitter, frame lengths give throughput, and TCP sequence analysis identifies missing and retransmitted segments. Table 2 reports the inputs for each session.

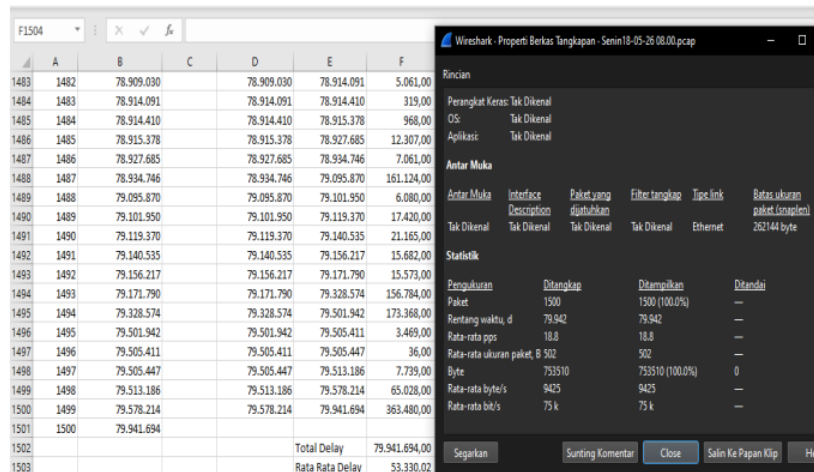


Figure 3 Packet capture using Wireshark on Monday, 18 May 2026

Table 2. Capture statistics and calculation basis for each session

Quantity	Monday, 18 May 2026 (08.00)	Friday, 22 May 2026 (08.50)
Capture duration (s)	79.942	53.295
Captured packets (N)	1,500	67,581
Captured bytes	753,510	61,262,594
TCP segments analysed	980	132
Lost-segment flags, Eq. (3)	0	0
TCP retransmissions	3	14
Inter-arrival delay, Eq. (1) (ms)	53	17
Jitter, Eq. (2) (ms)	0.0536	0.7886
Throughput, Eq. (4) (Kbps)	75.41	9,195.81

Source: Authors' measurement (2026)

The two sessions differ mainly in the traffic offered by the measured client. The Monday capture holds about 1,500 packets over 79.9 s (18.8 packets per second), two-thirds of them TCP segments. The Friday capture holds 67,581 packets over 53.3 s (1,268.1 per second), yet only 132 were TCP segments, about 0.2%; most Friday traffic used other transports, such as UDP-based protocols of web file services, so the TCP-based loss estimate covers only a small part of it.

Inter-Arrival Delay and Jitter

The inter-arrival delay was 53 ms on Monday and 17 ms on Friday, far below the 150 ms threshold and indicatively Very Good. The busier Friday session shows the shorter interval because of traffic composition: browsing and administration consist of short exchanges separated by idle periods while the user reads or types, whereas file transfer produces runs of back-to-back packets. The indicator therefore falls when the client is busier, the opposite of latency under congestion, and must always be read with the traffic mix. Jitter was 0.0536 ms and 0.7886 ms, in the Good band and about two orders of magnitude below the Fair boundary; the higher value occurs during sustained transfer, consistent with, but not proof of, queueing variation at the wireless interface.

Throughput

Figures 4 and 5 show the Wireshark capture statistics and the throughput calculation for each session, which are the direct inputs to Equation (4).

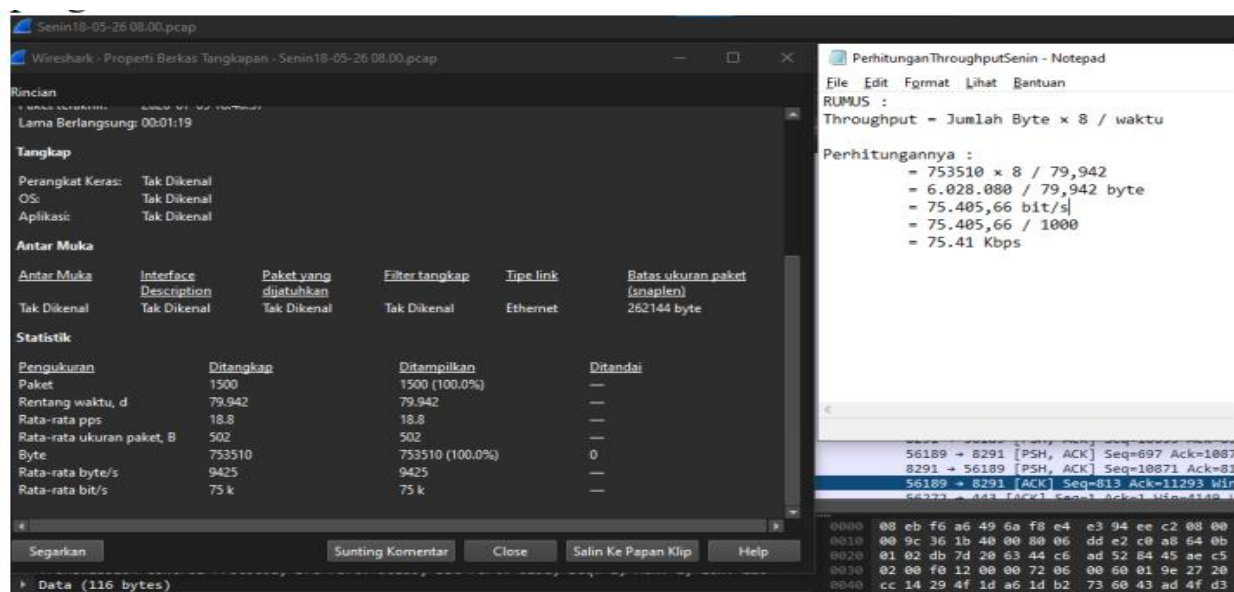


Figure 4 Capture statistics and throughput calculation, Monday, 18 May 2026

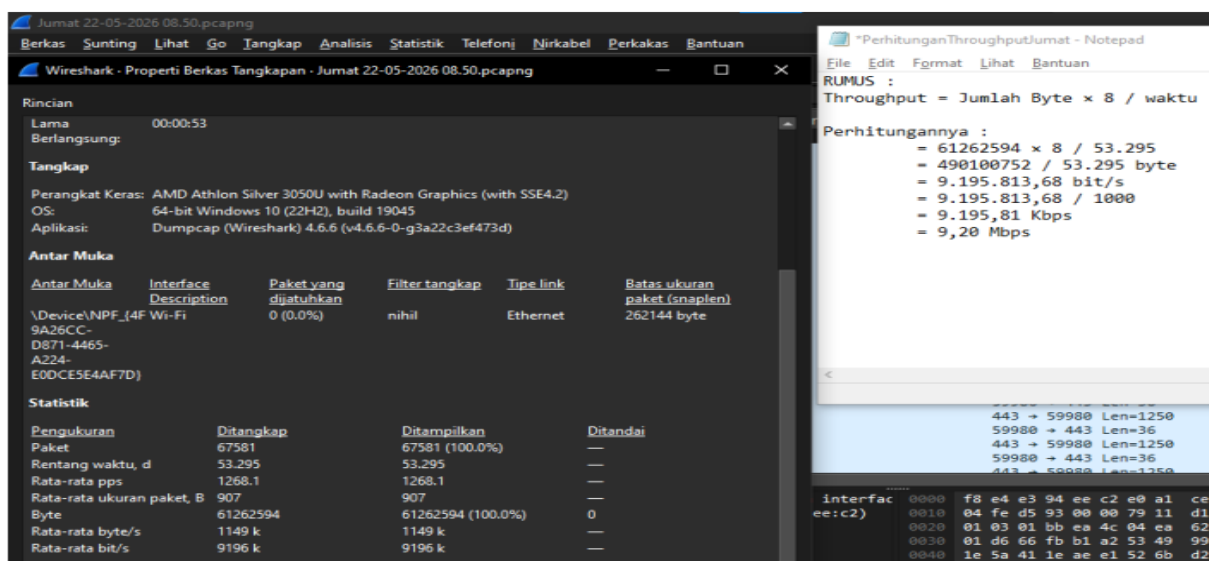


Figure 5 Capture statistics and throughput calculation, Friday, 22 May 2026

Friday yielded 9,195.81 Kbps (61,262,594 bytes over 53.295 s) and Monday 75.41 Kbps (753,510 bytes over 79.942 s), about 120 times less. The difference reflects traffic conditions, not a change in the network: both sessions were in the morning peak, with a similar number of clients, at the same position and access point. On Monday the user carried out routine browsing and administration; the low packet rate and small mean packet size in Figure 4 show that the client requested little data and mostly waited for user input, so throughput was limited by demand. On Friday the transfer of report files kept data flowing continuously, so throughput approached what the path could deliver to one client, bounded by the wireless rate, contention from other users and the remote server. The two values describe different conditions and are not averaged. The Friday value (9.20% of the nominal 100 Mbps) is not a capacity estimate, because saturation was not established.

Client-Side TCP Packet Loss and Retransmissions

No missing segments were flagged in either session (0%, Very Good), but the retransmissions in Table 2 qualify this result. A retransmission is a segment sent again because the sender judged the original lost or delayed. It can coexist with zero lost-segment flags when the client itself is the sender, because a segment lost after leaving the client is resent without ever creating a gap at the client, or when the remote sender resends after a lost acknowledgement. Retransmissions thus reveal losses beyond the measurement point. On Monday there were 3 among 980 TCP segments (about 0.3%), consistent with occasional recovery on a lightly loaded path. On Friday there were 14 among 132 (about 10.6%), during sustained transfer when the client was sending most data. This ratio is not a TIPHON loss rate, since the small denominator mixes both directions, but it shows that 0% must not be read as loss-free transfer.

Classification and Discussion

Table 3 Summary of the Quality of Service analysis

No	Parameter	Measured Value (Mon / Fri)	TIPHON Standard	Category
1	Inter-arrival delay	53 ms / 17 ms	< 150 ms	Very Good (indicative; proxy, not latency)
2	Throughput	75.41 / 9,195.81 Kbps	% of subscribed capacity	Not classified (capacity not controlled or verified)
3	Client-side TCP packet loss	0% / 0% (TCP)	0%	Very Good (TCP at one client, observed load)
4	Jitter	0.0536 ms / 0.7886 ms	0 – 75 ms	Good

Source: Authors' analysis (2026)

As Table 3 shows, inter-arrival delay (indicatively) and client-side TCP packet loss are Very Good and jitter is Good, each far from the next boundary under the observed load. Because load was not varied, these margins do not indicate how much more load the network could absorb. The findings apply to one client position in two morning sessions with 8 to 10 users and do not describe the school network as a whole. The small number of users, the star topology and a traffic profile without sustained real-time media may explain the favourable values, but these are plausible explanations, not demonstrated causes. Table 4 compares the measurement conditions with those of studies using the same toolset.

Table 4 Measurement conditions and results of comparable packet-capture studies

Study and setting	Sampling	Locations	Workload	Reported QoS	User perception
Nisa et al. (2024); university campus, 300 Mbps, 20 access points	Peak lecture period; number and length of sessions not detailed	6 (four floors, basement, gazebo)	YouTube streaming in a browser	Delay 6–28 ms; loss $\leq 0.08\%$; jitter 10–37 ms; throughput 361–1,306 Kbps	Not measured
Umbu Pingge et al. (2025); vocational school	3 days $\times$ 2 sessions (09.00 busy, 17.00 quiet)	4 (canteen, lobby, 2nd and 3rd floor)	Gmail, YouTube, Google Classroom	Delay 2.8–13.1 ms; loss 0.01–4.07%; jitter ≤ 0.06 ms; throughput 749–3,123 Kbps	CSI 55% (fairly satisfied), 90 students
Safitri et al. (2025); vocational school	Morning, midday and afternoon tests	Several points	Ordinary use; interviews with technicians and students	Loss 0% at all points; delay Very Good except one busy location; throughput Very Good	Interviews
This study; primary school, RB941-	2 sessions $\times$ $\approx$ 1 min, weekday mornings	1	Ordinary traffic of one client	Delay 17–53 ms*; loss 0% (TCP); jitter 0.05–0.79 ms;	Not measured (informal complaints)

Study and setting	Sampling	Locations	Workload	Reported QoS	User perception
2nD, 8–10 users				throughput 75–9,196 Kbps	

Source: Compiled from the cited studies and the authors' measurement (2026). *Mean inter-arrival interval.

The present study has the shortest sampling and a single location, so its values are a first reference, not a characterisation; within that limit they are of the same order as those of other school networks, although delay comparisons need caution because inter-arrival values depend on each workload. (Umbu Pingge et al., 2025) found Very Good or Good QoS alongside only moderate user satisfaction, a divergence similar to that at SDIT Yudha Patria and consistent with the view that good QoS at a client does not imply good QoE. The results are consistent with (Syafurudin et al., 2025) and (Anom et al., 2024) at the low-load end but do not test the role of user count, and no conclusion about the router is drawn without measuring its CPU, memory and interface utilisation. For the bandwidth-management literature (Christanto et al., 2021; Ningsih et al., 2024; Prasetyo & Purnama., 2024; Kusbandono & Syafitri., 2019), the study supplies the pre-policy reference those studies do not report. The favourable client-side QoS does not contradict the users' complaints, because it does not describe link capacity, signal quality away from the measurement point, router resource use or perception. Limited upstream capacity, localised coverage weakness and load outside the observed minutes remain unmeasured hypotheses that these data can neither confirm nor exclude.

Limitations and Implications

The findings are limited by short captures that give bursts disproportionate weight; only two sessions, so variation across days is not characterised; a lightly loaded network with 8 to 10 users and unvaried load, which cannot be extrapolated to a school-wide online examination; a single client position and access point; an inter-arrival proxy instead of latency and loss limited to TCP at one client; and no measurement of link capacity, signal strength, channel utilisation or router resources. The baseline can monitor but not diagnose: repeating the procedure at the same position detects changes in the service received there, but cannot attribute poor experience to capacity, coverage or equipment. Proposed monitoring triggers are a sustained inter-arrival delay above 150 ms (the TIPHON Very Good boundary, also the G.1010 preferred one-way delay for conversational services; (ITU-T., 2001), read with the traffic mix; client-side TCP packet loss above 1% inside the TIPHON Good band, tracked together with the retransmission ratio; and jitter above 75 ms, the Good/Fair boundary. Testing the hypotheses about the complaints requires gateway capacity tests, signal-to-noise and channel-utilisation readings at several positions, captures at several positions and times, logged router resources and a short QoE survey. Capacity planning should rest on measured

aggregate demand against verified bandwidth, with the Giga benchmark ([ITU & UNICEF., 2024](#)) as reference; access-point relocation, upgrades and queueing policies are follow-up actions to be tested, alongside routine configuration and security management ([Ratih, Moniroh, & Mahardika., 2025](#)).

Conclusions

This case study established a limited, pre-policy QoS baseline for the WiFi network of SDIT Yudha Patria from client-side captures in a pair of short morning sessions. Inter-arrival delay was indicatively Very Good, no lost TCP segments were detected at the client, and jitter was Good, while throughput reflected the different traffic offered in each session and was not classified. The finding is limited to the absence of detectable degradation at one client position under the observed load; it does not represent the performance of the whole school network, and the retransmissions during bulk transfer show that some loss was recovered beyond the measurement point. Because sampling was short, only one position was measured, and capacity, coverage and router resources were not measured, the causes of user complaints and the readiness of the network for computer-based examinations cannot be inferred. The contribution is procedural: a low-cost, reproducible baseline procedure that measures production traffic before any queueing policy, reports the calculation basis of every parameter, and separates what client-side QoS can monitor from what it can diagnose. Future research should repeat longer sessions across the term at several positions, verify link capacity, log router resources and retransmissions by direction, apply examination-scale load tests, and add Quality of Experience instruments.

Acknowledgements

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