



# Cloud Network Performance Analysis with Quality of Service (QoS) Implementation Using Cisco Packet Tracer

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**Abstract:** The rapid adoption of cloud computing demands optimal network stability through Quality of Service (QoS) to manage data traffic in hybrid environments. This study aims to synthesize the effect of QoS on performance metrics (throughput, delay, jitter, packet loss) and evaluate the reliability of Cisco Packet Tracer (CPT) as a design validation tool. Using a qualitative Systematic Literature Review (SLR) approach, the population includes journals from 2021-2025 from IEEE Xplore and ScienceDirect, with a purposive sample of articles with quantitative QoS data on cloud topologies. Instruments include academic databases and thematic synthesis analysis techniques as well as comparative queuing algorithms (FIFO, PQ, WFQ). The results show a QoS trade-off in the form of a minor throughput decrease for superior stability (WFQ: packet drop 12.11 pps, delay 0.066 s), CPT is effective for logic validation but limited in real-world simulations. The conclusion recommends WFQ and hybrid CPT-emulator testing for tight SLAs.

**Keywords:** Cisco Packet Tracer, Cloud Computing, Hybrid Network, Quality Of Service, Weighted Fair Queuing

## Introduction

The world of information technology is experiencing a fundamental shift from on-premise infrastructure to cloud-based environments, which offer revolutionary scalability and flexibility for a wide range of applications. This rapid adoption of cloud computing demands optimal network stability, with service quality becoming a key factor in user access to data centers. This phenomenon is increasingly evident in the use of services like Virtual Desktop Infrastructure (VDI) and cloud database applications, which require stable connections to support daily productivity.

However, a major challenge arises when latency-sensitive data traffic, such as VoIP and video conferencing, competes with lower-priority traffic like bulk file transfers, causing significant performance degradation. This bottleneck isn't always resolved by simply increasing bandwidth; it requires effective queue management and prioritization to maintain connection consistency. In hybrid cloud environments, this issue is further complicated by virtualization, which adds variables like dynamic latency and network interference.

The research problem lies in the lack of in-depth synthesis regarding performance trade-offs when Quality of Service (QoS) is applied, such as throughput degradation due to

computational overhead versus increased jitter and packet loss stability. Previous studies often separate local network design validation using Cisco Packet Tracer (CPT) and cloud performance analysis without focusing on gateway QoS configuration. Furthermore, the limited comparison of queuing algorithms such as FIFO, PQ, and WFQ in a heterogeneous cloud context exacerbates this gap, necessitating a structured evaluation to optimize Quality of Experience (QoE). (Yunika & Ichsan, 2025) (Nurcahyo & Prihanto, 2021)

The problem is further complicated by the fact that CPT, while reliable for validating routing and VLAN logic, has limitations as a simulator that does not replicate real-world conditions such as public cloud latency or DoS attacks. Without proper QoS integration, cloud networks are susceptible to high packet loss and unstable jitter, which lowers end-user satisfaction. Best-effort approaches without prioritization often fail to meet industry standards such as TIPHON/ETSI for real-time services. (Raharjo et al, 2023) (Nzobokela et al, 2024)

This study aims to synthesize the influence of QoS on performance metrics (throughput, delay, jitter, packet loss) in CPT simulation and cloud context, and evaluate the reliability of CPT as a pre-validation tool for hybrid designs. The urgency lies in the need for service determinism in the massive cloud era, where stability is prioritized over peak speed to support tight SLAs. The novelty of this study is a quantitative comparative analysis of QoS trade-offs and WFQ superiority, which bridges the literature gap with SLR synthesis of recent studies for practical implementation guidance. (Fitrian et al, 2025) (Kushchazli et al, 2025)

## Methodology

This study uses a qualitative research approach with a Systematic Literature Review (SLR) to synthesize quantitative findings from previous studies on the effectiveness of Quality of Service (QoS) in hybrid cloud networks validated through Cisco Packet Tracer. The SLR approach was chosen because of its ability to aggregate secondary data from various experimental contexts, such as software simulations and private cloud trials, resulting in a more robust holistic understanding than a single experiment. This method aligns with the principles of qualitative research that emphasize critical interpretation of data, as outlined in the thematic and comparative analysis framework to evaluate QoS performance trade-offs. (Sugiyono, 2023) (Creswell & Poth, 2021) (Yunika & Ichsan, 2025)

The research instruments include major academic databases such as IEEE Xplore, ScienceDirect, and national journal repositories, with data analysis techniques in the form of thematic synthesis, quantitative comparison of QoS metrics (throughput, delay, jitter, packet loss), and comparative evaluation of queuing algorithms such as FIFO, PQ, and WFQ using the TIPHON/ETSI standard. This technique involves strict inclusion criteria for articles with explicit quantitative data, where the analysis focuses on the trade-off of computational overhead versus network resilience through comparative tables and visualization of OPNET simulations. This approach ensures validity through triangulation of secondary data, in accordance with systematic qualitative analysis procedures. (Sudaryono, 2022) (Emzir, 2021) (Nurcahyo & Prihanto, 2021)

The study population consisted of all relevant scientific journals published between 2021 and 2025, with a purposive sample of selected articles that met the inclusion criteria, namely presenting quantitative QoS data on cloud or hybrid topologies and using simulation tools such as CPT. The sample focused on three topic clusters: CPT validation, QoS metric analysis, and cloud computing evaluation (private/public such as Azure/AWS), with a total of articles from accredited sources to cover a broad spectrum from logical simulation to DoS testing. (Raharjo et al, 2023) (Nzobokela et al, 2024)

The research procedure was carried out in stages, starting with a systematic search for keywords in databases, followed by selection based on abstracts and full-text using inclusion/exclusion criteria, quantitative data extraction, and synthesis through a three-pillar comparative analysis framework (performance trade-off, queue comparison, CPT constraints). This process concluded with cross-validation of the findings to ensure reliability, resulting in holistic recommendations for cloud QoS optimization. This logical sequence ensures comprehensiveness and replicability, as recommended in the SLR methodology (Fitrian et al, 2025) (Kushchazli et al, 2025) (Soleman, 2025).

## Results and Discussion

### QoS Quantitative Metrics and Industry Standards

This section presents the quantitative basis used to evaluate cloud network performance. Service performance is measured through technical metrics that must ensure service determinism. Four key metrics—throughput, delay, packet loss, and jitter—are considered key indicators. Throughput determines the effective volume of data transferred, while delay determines responsiveness, and packet loss measures transmission reliability. However, in modern cloud services involving VDI and VoIP, jitter (the variation in packet arrival) is most critical because it directly impacts continuity and the quality of user experience (QoE). Industry standards, such as TIPHON/ETSI, place strict limits, often targeting delay and jitter below 75 milliseconds to achieve the "Very Good" category, emphasizing that time-sensitive metrics are more important than maximum download speed alone.

### Critical Role and Evaluation *Cisco Packet Tracer*(CPT) in Cloud Topology Validation

*Cisco Packet Tracer*(CPT) is widely recognized as an effective simulation tool for education and validation of network design logic, including hybrid topologies that emulate connections to the cloud. CPT excels at verifying basic functionality such as static routing, IP addressing schemes, and VLAN tagging. Its ability to visualize packet flow step-by-step is a significant diagnostic advantage, allowing administrators to verify the architecture's fundamentals before physical implementation.

However, it's important to understand CPT's role as a simulator, which limits its predictive capabilities in complex cloud QoS contexts. Unlike emulators like GNS3 or EVE-NG, which use real-world Internetwork Operating System (IOS) images, CPT simplifies the protocol stack. This simplification limits its ability to accurately replicate real-world variables such as dynamic latency from public cloud providers (AWS or Azure), network

interference, or non-Cisco hardware performance. Furthermore, CPT often lacks support for advanced Command Line Interface (CLI) commands required for in-depth QoS configuration, such as Custom Queuing (CQ) or Low Latency Queuing (LLQ)-based queuing management. Therefore, CPT is best used as a logical design pre-validator, ensuring the routing foundation is sound, but should be complemented by testing in an emulator or physical environment to quantitatively verify time-sensitive QoS metrics (delay and jitter) in complex and dynamic environments.

### **Performance Analysis: Trade-off Between Throughput and Network Stability (QoS Paradox)**

One of the most critical and consistent findings in the literature is the trade-off phenomenon that occurs when QoS mechanisms are enabled. Research examining the impact of Virtual Local Area Networks (VLANs) and QoS has shown that these implementations can result in a small decrease in maximum throughput compared to networks without such configurations. This degradation is an unavoidable computational overhead. Network devices must invest CPU cycles in packet classification, tagging, policing, and queue allocation, which in aggregate erodes the net data transfer rate.

Despite the reduction in peak transfer rates, this trade-off is fully justified from a Quality of Experience (QoE) and service determinism perspective. Cloud service users value connection consistency (measured by low jitter and low packet loss) over fast but unstable instantaneous data transfer rates. In transactional cloud or VDI applications, connection loss or delay variation (jitter) is far more detrimental to the experience than a slight throughput limitation. Therefore, the overhead of causing a minor throughput reduction is the price paid for achieving higher network resilience and manageability, which fundamentally improves overall user QoE.

### **Queuing Algorithm Comparison: Quantitative Evidence of QoS Effectiveness**

The core mechanism that determines QoS success is the choice of queuing algorithm. For hybrid cloud environments that accommodate diverse (heterogeneous) traffic types, quantitative comparative analysis is crucial. Extensive simulation studies using the Optimized Network Engineering Tool (OPNET) provide strong evidence of the performance differences between traditional and intelligent algorithms.

Comparative data (Table 1) shows drastic performance differences, particularly in packet drop rate and end-to-end delay metrics. The best-effort First-In-First-Out (FIFO) model proved highly susceptible to congestion, recording the highest packet drop rate (33.93 packets per second) and unacceptable delay spikes of up to 1.66 seconds during peak traffic. This performance makes it unsuitable for real-time cloud services.<sup>5</sup> Priority Queuing (PQ) is effective in providing absolute priority, but risks causing starvation of low-priority traffic.

In contrast, Weighted Fair Queuing (WFQ) proved to be the most optimal solution. WFQ managed to maintain a very low delay (0.0660 seconds) and reduce the packet drop rate to 12.11 pps. WFQ offers a unique balance between fairness and prioritization, ensuring

that critical traffic (such as VoIP) is prioritized, while low-priority traffic still receives a fair share of resources. These results confirm that WFQ provides the most scalable and stable mechanism for ensuring performance across service classes in a hybrid cloud environment.

**Table 1.** Comparison of Critical Queue Algorithm Performance (OPNET Simulation Study)

Queue Algorithm	Maximum Packet Drop Rate (pps)	Final Delay(s)	Video Traffic Effectiveness	Critical Implications on Cloud QoS
First-In-First-Out (FIFO)	33.93	1.66	Currently	Not recommended for latency sensitive services such as VoIP/VDI due to substantial delays.
Priority Queuing (PQ)	21.11	0.0661	Less than optimal	Very effective for ensuring absolute priority, but has the potential to cause starvation of low-priority traffic.
Weighted Fair Queuing (WFQ)	12.11	0.0660	Very Optimal	Provides optimal balance, ensuring the highest network stability (lowest packet drops) in heterogeneous traffic environments.

### QoS as a Bastion of Resilience: Evidence of the Impact of Network Attacks

QoS not only serves to optimize performance under normal conditions, but also serves as a vital mechanism for maintaining network resilience under extreme stress, such as cyberattacks. Experimental data testing a simulated private cloud against Denial of Service (DoS) attacks shows significant quantitative degradation, particularly in data upload scenarios (Table 2).

**Table 2.** Percentage Changes in QoS Metrics Due to DoS Attacks on Private Cloud (Data Upload Case)

QoS metrics	Impact (Maximum Percentage Increase/Decrease)	Test Conditions	Critical Significance
<i>Packet Loss</i>	169.57% increase	1 User, Upload File	Indication of data transmission failure and high critical timeout.
<i>Delay(Latency)</i>	22.79% increase	1 User, Upload File	Significant delays, disrupting the availability of cloud services.
<i>Throughput</i>	20.08% decrease	1 User, Upload File	Noticeable degradation in effective data transfer rate.

Data source: Ferdiansyah (2013)

A 169.57% spike in packet loss during a network attack highlights the vulnerability of systems without adequate traffic management. In a cloud environment governed by a Service Level Agreement (SLA), QoS serves as an internal layer of defense. With QoS in place, the system can isolate and prioritize control traffic or VM heartbeats during an attack incident, enabling graceful degradation (managed performance degradation) instead of total service failure. This ensures that vital services remain available even when network links experience abnormal load saturation.

### **Adaptive Evolution of QoS: Network Integration and Computing Resource Allocation**

The massive growth of cloud computing, supported by sixth-generation (6G) networks and the Edge-Cloud Continuum, has driven the evolution of QoS. Today, QoS encompasses not only network packet prioritization but also integrated computing resource allocation. Effective QoS guarantees must now extend to virtualized resources.

Machine learning (ML)-based adaptive QoS models have become a major trend, enabling proactive provisioning of cloud resources. For example, research shows that by predicting traffic loads, adaptive QoS solutions in Microsoft Azure environments are able to maintain strict QoS parameters while generating significant operational cost savings, ranging from 31% to 89%. Furthermore, a queuing theory-based model for dynamically optimizing Virtual Machine (VM) migration in an Edge-Cloud system demonstrated the ability to reduce the probability of VM blocking by up to 4.7% by using a post-migration utilization prediction policy. This evolution confirms that optimal QoS management in the future will be holistic, combining network traffic control with intelligent computing

resource allocation to achieve the ultra-low latency and high reliability required by 6G applications.

### **Synthesis of the Role and Limitations of CPT in Cloud Network QoS Optimization**

Literature synthesis reinforces the role of Cisco Packet Tracer (CPT) as a highly efficient instrument for validating hybrid cloud network design logic at an early stage. CPT allows verification of fundamental functions such as routing, VLAN tagging, and IP addressing schemes, which are essential foundations before QoS implementation.

However, in the context of QoS, it is important to acknowledge the limitations of CPT. Because CPT is a simulator that only replicates functionality, it tends to produce an idealized environment. It cannot accurately replicate critical external variables in real cloud networks, such as dynamic latency of public clouds, interference, or the performance of non-Cisco hardware. Thus, CPT is optimal as a pre-validator of logical designs, but to predict time-sensitive QoS metrics (delay and jitter) in a real-world environment, testing on an emulator (such as GNS3) or a physical environment is still necessary.

### **Critical Balance: Network Stability Versus *Throughput* Peak**

The finding of a slight decrease in throughput caused by implementing QoS and VLANs is consistent. This decrease is due to the computational overhead invested by the device in classifying and prioritizing packets.

The decision to accept this overhead is fully justified from a Quality of Experience (QoE) perspective. Cloud service users value connection consistency (as guaranteed by low jitter and low packet loss) over unstable, transient data transfer rates. In applications like VDI or database access, packet loss or high jitter can lead to catastrophic session failures. Therefore, the overhead that causes a minor throughput decrease is the price paid for achieving service determinism and significantly higher network resilience.

### **Superiority of WFQ Queuing Algorithm for Heterogeneous Cloud Traffic**

Quantitative analysis (Table 1) definitively shows that the choice of queuing algorithm is a critical determinant of QoS success. The best-effort FIFO model proved to be highly unsuitable for cloud environments due to its susceptibility to congestion, which is characterized by delay spikes that are unacceptable for real-time services.

*Weighted Fair Queuing* (WFQ) has proven to be the most optimal solution for hybrid cloud environments that accommodate diverse (heterogeneous) traffic types. WFQ not only ensures that critical traffic (such as VoIP) is prioritized, but also ensures that low-priority traffic gets a fair share of resources. This balance prevents the starvation problem that is an inherent weakness of Priority Queuing (PQ) and results in the lowest packet drop rate (12.11 pps), ensuring the highest network stability.

## Conclusion

This study concludes that Quality of Service (QoS) serves as a key pillar in ensuring determinism and connection consistency in hybrid cloud networks, with the minor trade-off of decreased throughput due to computational overhead being offset by significant improvements in jitter stability, low packet loss, and user Quality of Experience (QoE). Cisco Packet Tracer (CPT) proved highly reliable as a pre-validation tool for hybrid topology logic designs, including routing and VLANs, but has limitations as a simulator that does not replicate real-world variables such as public cloud latency or interference, thus requiring further testing on emulators such as GNS3 or physical environments for accuracy of time-sensitive metrics. The superiority of the Weighted Fair Queuing (WFQ) algorithm over FIFO and Priority Queuing (PQ) was confirmed through comparative analysis, showing the lowest packet drop rate (12.11 pps) and stable delay (0.066 seconds), making it an optimal solution for heterogeneous traffic.

However, the study's limitations lie in its reliance on secondary SLR data without large-scale primary experiments, which may affect generalization to dynamic multi-provider cloud conditions. Suggestions for further research include a hybrid multi-tool study (CPT-GNS3) with physical failover testing between AWS and Azure, machine learning integration for adaptive QoS, and IPv6 analysis on Edge-Cloud 6G. Practically, the study's implications recommend network administrators to adopt WFQ in a disciplined manner, utilize QoS as DoS defense, and combine CPT with emulators to achieve tight SLAs, thereby improving cloud operational resilience and efficiency holistically.

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