THE TECHNIQUES FOR ENHANCING BANDWIDTH LOAD BALANCING QOS AT LOCAL AREA NETWORK: A REVIEW PAPER

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ABSTRACT

Bandwidth load balancing is a critical technique for improving the quality of service (QoS) in local area networks (LANs). Insufficient load balancing and QoS utilization can lead to network congestion, reduced performance, latency, packet loss, and an overall degradation of network performance. This paper presents an overview of load balancing techniques, load balancing algorithms, QoS parameters, load balancing strategies, and considerations for calculating bandwidth. The challenges of implementing load balancing algorithms and preferences for their implementation are discussed. Accurate network measurements and monitoring, coordination between network devices, security and privacy considerations, and careful evaluation of load balancing algorithms are among the challenges faced. The paper also discusses optimization and monitoring of bandwidth use, including options such as increasing bandwidth, bandwidth throttling, and data transfer throttling. The findings presented in this paper provide insights into the importance of load balancing and QoS in LANs and offer guidance for addressing related challenges.

KEYWORDS

QoS, LAN, Load Balancing, Bandwidth, VLAN

1. INTRODUCTION

Bandwidth load balancing is an essential technique that can be used for improving QoS (quality of service) in local area networks (LANs) [10]. Using load balancing, network traffic is distributed across the network links to avoid bottlenecks and ensure optimal resource utilization. Insufficient bandwidth load balancing and QoS use can lower the overall QoS level in a LAN. There are several possible outcomes for network congestion. Without effective load-balancing systems, LAN devices or lines may experience traffic overload. As a result of this congestion, network performance can be reduced, latency can increase, packets can be lost, and overall network performance can decrease. A lack of QoS measures will result in unpredictable network performance. As a result, performance may become erratic, especially for delay-sensitive applications like voice and video conferencing. Critical traffic in the network might not receive enough bandwidth, which would negatively impact QoS. QoS can help achieve high accessibility for network users, aiming for at least 99% accessibility per second and no more than five minutes per year of failure [1]. QoS involves various parameters for network transmissions, including throughput, delay, jitter, loss, and noise loss, where several packets fail to reach their destination. Loss occurs when there is no congestion in the network.

2. TECHNIQUES REVIEW

Sometimes, infrastructure problems such as faulty cables, poor network configurations, or overloaded machines can cause network jitters and round-trip time. Alternatively, the issue could be caused by the user's device or the network they are using. In addition, if multiple users are simultaneously accessing the network, congested routes may occur intermittently. The responsibility will be to determine the source of the problem [9]. Every internet connection encounters a certain degree of network jitter, which is a common occurrence. It is probable that you will encounter increased latency during business hours when communicating between your office and a VoIP service provider. The variation in packet delay can have an impact on your customer communications and conference calls. Consider this analogy: if different parts of your speech arrive in a different order, it can disrupt the flow of your conversation. VoIP is no exception to this. [12].
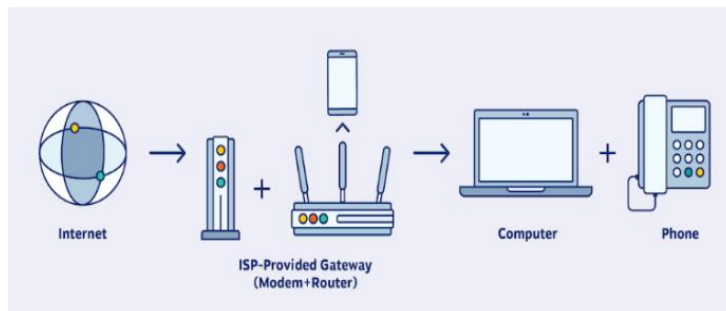

Figure 1. How Voice over Internet Protocol (VoIP) works.

2.1. Router without QOS

Analyzing the consequences of QoS being absent is a good place to start because it helps put the change's intended outcome into context. If no packet loss occurs, the order of traffic at the ingress interface and the order of traffic leaving the router via the egress interface are the same in the case of a router without QoS enabled. [6].
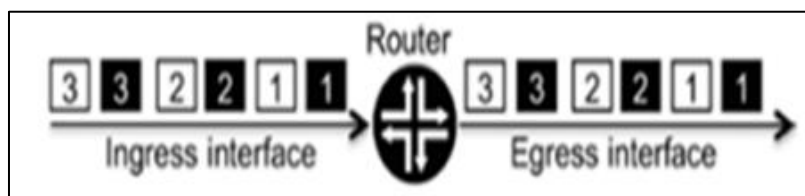

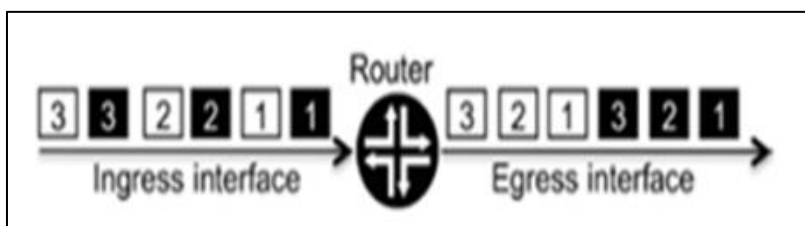Figure 2. Traffic flow across a router without QoS

Figure 3. Router with QoS enables packet prioritization.

Figure 2 and Figure 3 show two traffic kinds, black and white, each with three packets labeled 1 through 3. The packet output sequence at the egress interface is the same as it was at the ingress interface if the router does not have QOS enabled. QOS offers several capabilities, including the precise rearrangement of packet output sequence by the router. For instance, if black packets represent important traffic that should be given priority even if it means delaying white packets, QOS enables this prioritization, as illustrated in Figure 3.

2.2. Load Balancing Algorithms

Load-balancing algorithms play a crucial role in enhancing QoS in LANs. These algorithms are designed to distribute network traffic across multiple network paths or links in a way that balances the network load and avoids congestion. Several types of load-balancing algorithms have been proposed in the literature, such as round-robin, weighted round-robin, least-connection, and source IP hash algorithms. Round-robin algorithms distribute traffic evenly across all available paths, while weighted round-robin algorithms assign weights to each path based on its capacity or performance. Another important consideration in load balancing on LANs is the need to support different types of traffic, each with its own QoS requirements. For example, real-time traffic such as voice and video requires low latency and high reliability, while non-real-time traffic such as email and file transfers may be more tolerant of delays and packet loss. To handle such diverse traffic, several load-balancing algorithms have been proposed that consider the QoS requirements of different traffic classes. QoS also addresses other network performance metrics such as delay and jitter. Delay refers to the total number of times data is transmitted from the sender to the receiver, while jitter, also known as delay variation, measures the time consumed by the communication of transmission data packets from the sender to their destination [3]. Assessing QoS for (LANs) can be done through software- and hardware-based approaches [2]. These approaches monitor network traffic and ensure the clear transmission of converging data, such as videos and voices.

A technique that varies in implementation based on traffic or class services, where high priority is assigned to video or voice data transmission using a traffic-based method, was proposed [4]. Least-connection algorithms distribute traffic to the least busy path or link, while source IP hash algorithms use the source IP address to determine which path to use. In addition, several advanced load-balancing algorithms have been proposed that take into account various factors such as link utilization, network topology, and QoS requirements. The algorithms can help to improve network performance, reduce congestion, and ensure that critical applications receive the necessary bandwidth. However, the choice of load balancing algorithm depends on various factors, such as network size, traffic patterns, and QoS requirements, and hence requires careful evaluation and selection. While QoS can effectively address bottleneck traffic, sudden congestion can pose challenges. Misconfigurations in queuing discipline settings, particularly during sudden congestion, can enable attacks like denial-of-service and worms [5]. However, a suitable QoS mechanism can help mitigate these issues.

2.3. QoS Parameters

QoS parameters are used to measure the performance of a network and ensure that it meets the needs of its users. The most important QoS parameters for load balancing are delay, jitter, and packet loss. Delay is the time it takes for a packet to travel from the source to the destination. Jitter is the variation in delay that can cause problems for real-time applications such as video conferencing. Packet loss occurs when packets are dropped due to congestion or other issues, leading to retransmissions and decreased network performance.[11]. Before communication takes place, there is a preliminary phase called call setup, during which the requirements of the

applications are discussed in terms of quality of service (QoS) parameters. Negotiations and agreements occur at various levels, including between applications and the network subsystem, applications and the operating system, and the network subsystem and the operating system. This process establishes personalized connections and leads to the allocation of resources that are suitable for meeting the needs of the applications and the capabilities of the operating system and network. [16].

2.4. Load Balancing Strategies

Load-balancing strategies determine how traffic is distributed across network links. The two most common strategies are static and dynamic load balancing. Static load balancing involves manually configuring the load-balancing algorithm and assigning weights to network links. This strategy is simple to implement but is not adaptable to changes in network traffic. Dynamic load balancing, on the other hand, uses real-time information about network traffic to dynamically adjust the load balancing algorithm. This strategy is more complex but is better suited to handle changes in network traffic. [13]. Load balancing is a key technique for improving quality of service (QoS) inLANs. In traditional LANs, load balancing is often achieved by distributing traffic across multiple physical links using routing algorithms based on network topology and link cost. One important aspect of load balancing in LANs is the ability to handle dynamic traffic patterns, which can vary over time and across different applications. To achieve this, several techniques have been proposed in the literature, such as traffic shaping and traffic engineering. Traffic shaping involves regulating the flow of traffic by enforcing certain traffic policies, such as rate limiting and packet filtering. [14]. This can help prevent network congestion and ensure that critical applications receive the necessary bandwidth. On the other hand, traffic engineering focuses on optimizing network paths and resources to achieve better QoS and load balancing.

2.5. Considerations for calculating the bandwidth

Advancements in technology have increased the complexity of certain bandwidth calculations, which can vary depending on the type of network connection [8]. For instance, optical fibers utilizing diverse light waves and time-division multiplexing can transmit a larger volume of data through a connection simultaneously compared to copper Ethernet alternatives. This effectively enhances the bandwidth of the optical fiber connection. In the case of mobile data networks like LTE and 5G, "bandwidth" refers to the range of frequencies that network operators can obtain licenses for from regulatory bodies such as the Federal Communications Commission and the National Telecommunications and Information Administration in the United States.

Legally, this spectrum is restricted and can only be utilized by the specific business that holds the license for it. The carrier can leverage wireless technologies to transfer data across this spectrum, thereby achieving the maximum bandwidth capacity supported by the hardware. On the other hand, the Wi-Fi spectrum is considered unlicensed, allowing anyone with a Wi-Fi access point (AP) or Wi-Fi router to establish a wireless network. However, it's important to note that the availability of the Wi-Fi spectrum is not guaranteed. [19]

Thus, Wi-Fi bandwidth can suffer when other Wi-Fi APs attempt to use some or all of the same frequencies.

To evaluate the effective bandwidth, which represents the highest reliable transmission rate achievable on a particular transport technology, a bandwidth test can be conducted. This test involves repeatedly measuring the time it takes for a specific file to travel from its source to its destination, effectively determining the capacity of the link.[17].

Once the network's bandwidth consumption has been assessed, it becomes important to identify the location of applications and data and calculate the average bandwidth requirements for each user and session. To determine the necessary bandwidth for a network uplink or Internet broadband, the following four steps are typically followed:

1) Identify the applications that will be used.
2) Determine the bandwidth requirements of each application.
3) Multiply the bandwidth requirements of each application by the expected number of simultaneous users.
4) Sum up all the individual application bandwidth numbers.

By following these steps, an estimation of the required bandwidth can be obtained for a network uplink or Internet broadband connection.

3. IMPLEMENTATION CHALLENGES

While load-balancing algorithms can enhance QoS in LANs, their implementation can pose several challenges. One challenge is the need for accurate network measurements and monitoring to ensure that traffic is distributed optimally. Accurate measurements of link utilization and network topology are required for load-balancing algorithms to function effectively [7]. If the storage traffic that requires a lot of bandwidth causes congestion at the switch fabric during the migration process, it could significantly slow down the migration. This would lead to extended periods of application downtime and ultimately result in a low quality of service (QoS).

Another challenge is the need for coordination between different network devices and controllers, especially in complex networks with multiple switches and routers. This coordination is essential to ensuring that load-balancing decisions are consistent and do not conflict with each other. In addition, load-balancing algorithms may also need to take into account various security and privacy considerations, such as preventing unauthorized access to the network and protecting sensitive data. Figure 4 shows the simulation of bandwidth without QoS versus bandwidth with QoS.
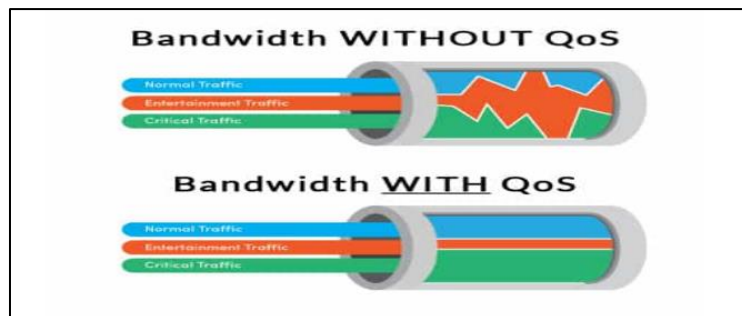

Figure 4. Bandwidth simulation without QoS verse with QoS

Finally, the choice of load balancing algorithm can depend on various factors such as the network size, traffic patterns, and QoS requirements, and hence requires careful evaluation and selection. The challenges and preferences for load-balancing implementation are shown in Table 1.

Table 1. challenges and references

Challenges	Preferences
Need for accurate network measurements and monitoring to ensure optimal traffic distribution	Requires continuous monitoring of network traffic and performance metrics Involves collecting and analyzing data on link utilization and network topology
Accurate measurements of link utilization and network topology are required for effective load-balancing algorithms	Network administrators must have access to accurate information on network traffic Utilization data helps distribute traffic efficiently
Coordination between different network devices and controllers, especially in complex networks with multiple switches and routers	Load-balancing decisions need to be synchronized across devices. Requires effective communication and coordination among controllers and devices
Essential coordination to ensure consistent load-balancing decisions and avoid conflicts	Load-balancing algorithms should avoid conflicting decisions. Coordinated actions prevent uneven distribution of traffic
Consideration of security and privacy, including preventing unauthorized access and protecting sensitive data	Load balancing mechanisms should incorporate security measures. Encryption and access control help safeguard sensitive information
The choice of load-balancing algorithm depends on network size, traffic patterns, and QoS requirements, requiring careful evaluation and selection	Different algorithms may be suitable for different network environments. Evaluation should consider factors like network size and expected traffic

3.1. Optimization And Monitor Bandwidth Use

When faced with network congestion, network engineers have various options at their disposal [8]. The most common approach is to increase the bandwidth. This can be accomplished by upgrading the physical capabilities of the link to support higher throughput or by utilizing port aggregation and load balancing techniques to distribute traffic across multiple links. However, these methods may not always be feasible or practical.

Another approach employed by ISPs or network administrators is bandwidth throttling, which involves intentionally adjusting the speed of data travelling over the network, either up or down. Bandwidth throttling serves different purposes, including managing limited network congestion, particularly in public access networks. ISPs may throttle bandwidth to restrict usage by specific users or user groups. For instance, with tiered pricing, service providers can offer different upload and download bandwidth options. Bandwidth throttling can also be used to ensure equitable distribution of resources among all users in the network. [15].

However, the practice of bandwidth throttling on the Internet has faced criticism from net neutrality advocates. They argue that such practices may violate the principle of net neutrality, which advocates for equal treatment and non-discrimination of internet traffic. Figure 5 shows a few applications with the bandwidth requirement amount of data transmitted or received over a network, particularly to prevent spam or the bulk transmission of emails through a server. Data transfer throttling can be considered another variant of bandwidth throttling.[18].
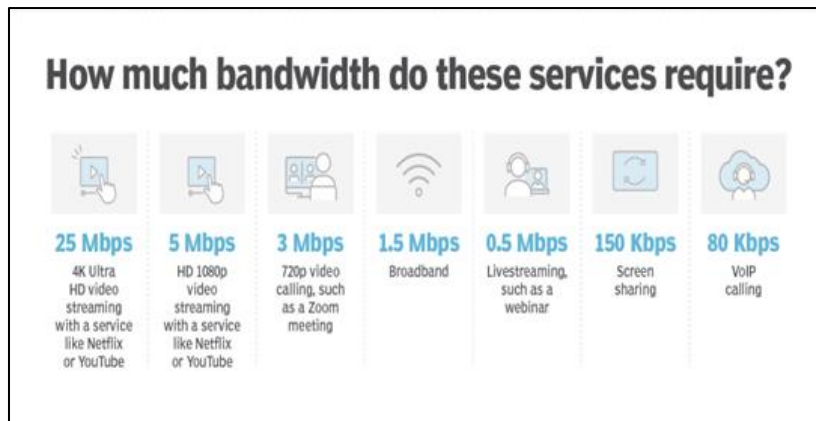
Figure 5. Application with its bandwidth requirement

4. CONCLUSION

In conclusion, quality of service (QoS) and load balancing in the network's bandwidth are critical factors in achieving peak performance and satisfaction for LAN users. Network congestion, lower performance, latency difficulties, packet loss, and a general decline in network services can occur from insufficient load balancing and disregarding QoS requirements.

In this study, we took a look at the big picture of quality of service and load balancing in LANs. Effective traffic distribution and the avoidance of bottlenecks in networks were highlighted as reasons why load balancing algorithms are so crucial. Round-robin, weighted round-robin, least-connection, and source IP hash algorithms, among others, were investigated for load balancing purposes, as were their advantages and disadvantages.

Quantity of Service (QoS) characteristics like latency, jitter, and packet loss were also emphasized as being crucial in gauging network performance. Proper measurements and monitoring of networks, in addition to cooperation between network nodes and controllers, were highlighted as crucial for making reliable load-balancing and traffic-splitting choices.

Concerns like network measurements, device cooperation, privacy and security, and thorough algorithm evaluation, all of which are obstacles to implementing load balancing algorithms, were discussed. The article also covered optimization and monitoring of bandwidth utilization, touching on topics including expanding bandwidth, implementing bandwidth throttling, and restricting data transfers.

Altogether, the results reported in this research highlighted the significance of using efficient load balancing strategies and providing suitable QoS measures in LANs. Important programs will get the bandwidth they need, network congestion will be reduced, and overall performance will increase. With this information at hand, network managers and engineers can make educated choices that improve load balancing and quality of service in local area networks.

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