Enhancing QoE According to QoS for National ISPs Services in Responding to New User Demands

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Abstract

In recent years, the volume of data has increased dramatically. The usage of multimedia applications with in social media applications; is increasing day by day in human social life. Multimedia applications, in particular, need stronger guarantees about the minimum throughput and maximum latency to work satisfactorily. Reaching the required level of end user satisfaction is a challenging work for companies in high technology environment. Efficient management of networked services requires deep understanding of the relationship between the Quality of Services (QoS) and the Quality of Experience (QoE).

This work considers the issue of national, Internet Service Providers (ISPs) need to be capable to deliver increasingly more demanding services with higher quality standards. For this purpose, a general framework for enhancing QoE through better configuration of QoS parameters and end users' feedback measurement is proposed. The proposed framework includes two main parts: the QoS part and the QoE part. Furthermore, the QoS part deals with various relevant mechanisms in both data and control planes.

In order to investigate the effectiveness of the proposed QoE framework, a real-life ISP network has been chosen for applying the proposed framework. The obtained results have shown that the satisfaction level of end users has been significantly increased after the deployment of our proposed QoE framework to the considered ISP network. This important QoE enhancement has been obtained for all social networking applications considered in this study which includes, Facebook, Viber, and Tango.

For Facebook case the enhancement, most of users rated their level of satisfaction as "fair" before implementing the framework; however, after implementing the framework the results improved and about 90% of users rated this service as "excellent". Comparable levels of enhancement have been also

obtained for both services of Viber and Tango after deployment of the proposed framework with negligible negative effect on other services. Indeed, regarding the enhancement in some network QoS parameters, the value of ping jitter has been reduced by a factor more than 6 times after implement the framework for various considered services.

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List of Abbreviations

Abbreviation	Full Text
ACL	Access Control List
A-QoS	Assessed Quality of services
ATM	Asynchronous Transfer Mode
BER	Bit Error Rate
CAA	Catalog Categorize Analyse
CBQ	Class Base Queue
CBWFQ	Class-Based Weighted Fair Queuing
CoS	Class of Service
DiffServ	Differentiated Services
DSCP	Differentiated Service Code Point
DCF	Distributed Coordination Function
EDF	Earliest Deadline First
FIFO	First in First Out
FIFS	First Input First Served
FR	Full Reference
GB	Gigabyte
GoS	Grade of Services
H.323	Standard address Call Signalling
HTTP	Hypertext Transfer Protocol
IETF	Internet Engineering Task Force
IP	Internet Protocol
I-QoS	Intrinsic Quality of Services
ITU	International Telecommunication Union
ITU-T	International Telecommunication Union - Telecommunication Standardization Sector
ISP	Internet Services Provider
IntServ	Integrated Services
LLC	Logical Link Control
LLQ	Low Latency Queuing
LAN	Local Area Network
MPLS	Multi-Protocol Label Switching
MAC	Media Access Control
MOS	Mean Opinion Score
MANETs	Mobile Ad Hoc Network
NoC	Network-On-Chip
NBAR	Network Based Application Recognition
NR	No Reference
NRT	Non Real Time

NGN	Next Generation Network
OSPF	Open Shortest Path First
OPNET	Optimized Network Engineering Tool
PC	Personal Computer
PCF	Point Coordination Function
PHB	Per-Hop-Behaviour
PPPOE	Point-to-Point Protocol over Ethernet
P-QoS	Perceived Quality of Services
PRTG	Paessler Router Traffic Grapher
PtP	point to point
QoS	Quality of services
QoE	Quality of Experience
QoR	Quality of Resilience
RED	Random Early Detection
RR	Reduced Reference
RSVP	Resource Reservation Protocol
RFC2475	Remote Function Call For Differentiated Service
RT	Real Time
SAMCRA	Self-Adaptive Multiple Constraints Routing Algorithm
SoCs	System-on-Chip
SAS	SAS3 Billing System
SLA	Service Level Agreement
SIP	Session initiation Protocol
SNR	Signal To Noise Ratio
SP	Static Priority
TAP	Timeliness Accuracy Precision
TCP/IP	Transmission Control Protocol /Internet Protocol
TXCCQ	Transmit Client Connection Quality
ToS	Type Of Services
UDP	User Datagram Protocol
VLAN	Virtual Local Area Network
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
VOD	Video on Demand
WiMAX	Worldwide interoperability For Microwave Access
WRED	Weighted random early detection

Chapter One

Introduction

Chapter One

Introduction

1.1 Overview

During the last decade, the Quality of Service (QoS) and the Quality of Experience (QoE) become the most important topics concerned by the service providers, especially concerning the satisfaction of the user [1].The QoS is generally defined for network resource availability, delivery, and capacity. The term of QoS is used to explain the overall experience between the user and the application over a network. QoS includes a wide range of technology, parameters, architecture, and protocols. Network providers complete end to-end QoS by ensuring that all network elements work effectively and control all traffic over the network. Another definition of QoS is provisioning the set of qualitative and quantitative characteristics of a distributed network system to reach the required functionality of an application [2].

On the other hand, the QoE is defined as the measure of user satisfaction and performance based on subjective and objective psychological measures of using a service or product [3]. With this fast revolution of high speed networks and networked services, supplying differentiated services in the network to the user, the QoS and QoE became more and more essential [4].

The QoS is related to the presentation of consistent, predictable data transmission and fulfillment of the requirements of the user’s application, respectively. In other words, this means providing the network that is transparent to its users [5].The usage of social media applications and

Multimedia application is increasing day by day in human social life, medical, military and businesses. The usability or the success of continuous multimedia application depends largely on the QoS .Various factors and parameters need to be studied and analyzed in relation to QoS and QoE [6].

1.2 Quality of Service Concept

The ability of a network to provide enhanced service to selected network traffic over collection of networking technologies is one of the essential characteristics of QoS including Frame Relay, Asynchronous Transfer Mode (ATM), Ethernet and 802.11 networks, and IP-routed networks [7] [8] [9].

It is crucial to understand and make a difference between the meanings of QoS. Firstly, some researchers argue that QoS means introducing an element of predictability and reliability into existing networks. Secondly, from the prospective of others, QoS means obtaining higher transport efficiency or throughput from the network. Meanwhile, QoS is simply a means of differentiating classes of data service, according to the third group of researchers [6].

There are some QoS features that enable providing better network services such as [8] [10]:

- Supporting dedicated bandwidth
- providing guarantees on the ability of a network to deliver predictable results
- Improving loss characteristics
- Avoiding and managing network congestion

- Shaping network traffic
- Setting traffic priorities across the network
- providing controlled jitter and latency

Quality and service are the two main concepts in QoS. Quality is specified as "the collective effect of service performances, which determine the degree of satisfaction of a user of a service “[7]. In other words, quality in networking is generally used to describe the process of delivering data in a certain manner [6]. On the other hand, service is generally used to describe something offered to end-users of a network. QoS elements of network performance include availability (uptime), bandwidth (throughput), latency (delay), and error rate. A network monitoring system must typically be deployed as part of QoS, to guarantee that networks are performing at the desired level [7].

There are different situations in QoS, such as one-way, half-duplex, and two-ways, full-duplex. For example, one-way communication can accept relatively long delays. However, delay in two ways is increased if the round-trip time exceeds 100 millisecond. As widely accepted that combined video and audio is very sensitive to differential delays. Data communication protocols are very sensitive to errors and loss. One of the reasons for introducing QoS is that it could enhance the performance of operational networks. For example, better balancing of the load in a network and use of the network resources efficiently lead to improve the QoS mechanisms [11].

Some people argue that bandwidth is the main answer to the question how to obtain QoS. A key component for offering QoS is bandwidth, because there are some of the services that cannot be delivered properly

Without having a capable infrastructure. However, bandwidth alone is not the answer. Besides, proving high quality of hardware, routing programming and monitoring are the other key components to obtain the QoS [11].QoS is a measure for how well a service serves the customer. Meanwhile, QoS properties include response time, availability or reputation [12]. In QoS, the capability to create different traffic management mechanisms is crucial in order to make a difference between classes of services and to provide some level of assurance and performance optimization that can affect user perception [13].

1.3 Quality of Experience Concept

QoE is a measure of user performance based on objective and subjective psychological measures of using a service or product. In fact, the QoE might be restricted to collecting subjective measures from users [3] [14].Real-time internet applications have been deployed more and more, day after day, and sensitivity of these applications for QoS parameters: delay, jitter, bandwidth and packet lose are increasingly considered. So network operators and service providers want to control their network sources while maintaining user satisfaction. In this direction, QoE measurement helps service providers to control their network resources to ensure customer's satisfaction and service quality. The design of QoE system is based on measuring network related parameters to evaluate service quality [15]. In addition, QoE is an aggregate of non-technical parameters like user experience, expectations and perception with technical parameters such as network-level QoS and application level. Thus, QoE can be considered as a collection of QoS and human user-related metrics.

Therefore, QoE will be the key success factor for current and future service providers.

Network operators try to understand how to minimize network churn by providing better services to the users. On the other hand, network engineers require the knowledge about underlying network conditions affecting users QoE for user-centric network optimization. It is widely assumed that by maximizing network QoS (e.g., increasing network bandwidth and/or increasing wireless signal strength) or by reducing the cost of services, users will be satisfied with the services provided to them. However, it can be argued that QoS provided by the operators may not connect well with users' QoE [14]. It is important for service providers to understand the quantitative relationship between QoE and these technical parameters in order to manage the user perceived quality [16].

The QoE is a human centric notion that produces perception, feelings, needs, and intentions and it is also a technology centric metric used to assess the performance of a multimedia application and/or network [17]. The overall performance of a system, from the user perspective is QoE. Many factors can affect the QoE depending on the application and users expectations. The term of QoE is used to express how it is satisfied by subscribers to the provided service quality. The poor QoE will cause dissatisfied subscribers and falls behind in contestants consequently the eventually bad market competitive power to players. Although QoE is very subjective in nature, it is very important that a strategy is devised to measure it as logically as possible. The ability to evaluate QoE will give the provider the crucial contribution of the network's performance to the overall level of subscriber satisfaction [18] [19].

1.4 Literature Survey

In this section, some significant previous works are reviewed. The QoS of a given system is expressed as a set of parameter-value pairs, sometimes called QoS requirements. We consider each parameter as a typed variable whose values can range over a given set. Different applications on the same distributed system can have different subsets of relevant QoS parameters or requirements as presented by Vogel et al in [2]. So the QoS is essential for all types of technologies and QoS have different requirements that include packet loss, delay, and delay jitter.

Xiuzhong Chen et al in [20] pointed that some protocols like H.323 and SIP support some kind of interfaces to QoS management as they allow the users and the network to reach a service agreement, and let the network appropriately allocate resources to ensure QoS guarantees to the calls that have been admitted QoS in the VoIP applications.

The unceasing demand for using multimedia applications over the Internet has increased. How to satisfy the quality of service (QoS) requirements of these applications, requirements like bandwidth, delay, jitter, packet loss, and reliability. One of the most issues in providing QoS guarantees is how to determine paths that satisfy QoS constraints. Fernando Kuipers thesis, in QoS routing, is to find paths that obey multiple user-desired QoS constraints, also referred to as the multi-constrained path (MCP) problem. To facilitate exact QoS routing, four concepts has been discuss: (1) a non-linear length function, (2) a k-shortest paths approach, (3) the concept of non-dominance and (4) the look-a head concept. The non-linear length function is necessary, because multiple constraints make the MCP problem non-linear. A proposed the algorithm SAMCRA (Self-

Adaptive Multiple Constraints Routing Algorithm). The results indicate that SAMCRA, with a properly chosen path length function, is not only an exact and fast QoS routing algorithm, but that it also serves as an effective traffic engineering algorithm that optimizes network throughput[21].

According to Thu-Huong truong and Tai-Hung Nguyue ,the changing behavior of QoE with respect to changes of QoS parameters in the context of video streaming service in an IMS-based IPTV network discuss. QoE in both terms of Mean Opinion Scores and VQM is studied as functions of loss, jitter, and delay. The QoE-QoS correlation could be a significant first step to build a smart QoE monitoring and control mechanism as an added value to promote the IMS based IPTV network, the relationship of QoE and one of the QoS parameters (delay, jitter) can be closely approximated by a function and can be confidently applied to our QoE control mechanisms, the variation of QoE to simultaneous changing of all QoS parameters is not yet quantified because of the complexity with unpredictable patterns [22].

Kamaljit I. Lakhtaria discussed the quality assurance to NGN and taking into account both perceptual quality of experience and technology- dependent quality of service issues. The development and discussion of following the end-to-end controllability of the quality of the multimedia NGN-based communications in an environment that is best effort in its nature and helps end user's access uncertainty, global mobility, and service agility. Ensuring Quality of Service (QoS) for the network and Quality of Experience (QoE) for the user is biggest challenge. The complexity and the performance requirements of the rather complex signaling procedures are an issue that would present a substantial load to the entire environment, and the required level of intelligence needed to perform the quality negotiation and enforcement with the respective security issues is challenging [23].

Many architectures: Integrated Services, Differentiated Services, MPLS, Traffic Engineering, have been proposed for providing end to end QoS to applications by identifying, handling and controlling traffic using various scheduling and resource reservation mechanisms, yet providing end to end QoS is still a key challenging for today's tactical networks, particularly for supporting multimedia service consequently its stringent requirements on time surrounded parameters such as delay, jitter etc.

In [24], Liu, Evans and Weerakoon proposed an integrated framework where the interaction between QoS aware video application, the content information of a packet, and DiffServ network is taken into consideration. This interaction is performed through video application dynamically marking packet priorities for each video packet and using the two unused bits in the DS field. The Triage algorithm was augmented to provide content aware service differentiation based on relative QoS requirements of each packet. This framework takes advantage of the nature of the unequal importance of video packets and provides a mechanism to try to preserve information that is most important to spatial/temporal quality when challenged with packet loss or long end-to-end delays.

In [25], Möller et al used QoS to improve multi-layer Networks-on-Chip (NoC) that allow several data transfers to occur in parallel and are indeed can be the communication infrastructure of future hundred-cores Systems-on-Chip (SoCs).

Some other frameworks were introduced to enhance QoE concept. Alvarez et al [26] presented a flexible QoE framework for video streaming services. Service evaluations are QoE metrics to achieve high performance network quality. Various types of performance, such as Network Performance, Network Performance Overall, QoE, and end-to-end QoS

Had been discussed in the literature. The effect of QoS measurement of web browsing services in 3G networks was presented by Sigit Haryadi and sandy Nusantara In [27].

Jyoteesh Malhotra and Priyanka considered the QoS in WiMAX "Worldwide Interoperability for Microwave Access". By using Scheduling algorithms OPNET. To configure the traffic generator and require the users to write scripts to specify the parameters such as packet length, packet inter-arrival time, and the distribution of the traffic. The OPNET simulator is better if implemented regarding QoS, resource allocation and scheduling. This also describes the applications of WiMAX. The open issues related to Physical Layer and Mac Layer. The area of security in WiMAX has many issues which need to be resolved WiMAX has different QoS requirements to support different applications for better QoS [28].

Another QoE management framework, called "in-service feedback QoE framework", was also introduced by Kim, Lee, and Zhang in [29], where end users give feedback immediately whenever service dissatisfaction occurs. This user-triggering scheme initiates investigation to find out which factors dominantly deteriorated the quality. The Proposed an in-service feedback QoE framework (IFQF).Is the IFQF is a user-triggering scheme, which begins investigating the main factors of the quality deterioration. Gathered feedback information from end users can be analyzed collectively to find out the reason and location of faults. The feedback should be reported during the service is on (or just after the service ends). General framework not depending on fixed numeric QoS values to enhance QoE.

In [30], Malik et al argued that the Internet QoS has received a lot of work, the bulk of which has focused on wired networks. They concluded that many of the ideas developed for Internet QoS are also related more

Broadly to wireless QoS, hence, the development of new methods provide some unique challenges motivating in the wireless networks.

According to Sethi and Kumar, QoS need also to be improved in Mobile Ad hoc Networks (MANETs) because of a number of issues have been arrived for multicasting communication in MANETs. Since we are using MANETs extensively, the major issue is providing quality of service that needs attention. In fact, many protocols had evolved to overcome this issue [31].

So after considering all such research in QoS and QoE felids and understanding the importance of adopting these concepts in this fast technology revolution, we propose a general framework to improve QoE through QoS concept and parameters in order that national Internet Service Providers (ISPs) can satisfy their users and keep business successful.

1.5 Problem Statement

In this thesis the issue of national, Internet Service Providers (ISPs) has been considered and need to reach higher level of QoS standards, by using user demand and satisfaction of all services that ISPs provide serviced. Reaching a good QoS required level of end user satisfaction that be challenge work for companies in high technology environment. To efficient management of networked services requires understanding of the relationship between the QoS and the QoE .Also this work considers the requirement of QoS parameters and what will be done to deliver services with higher quality standards.

1.6 Thesis Objective

The main objectives of this work can be illustrated in the following points:

1. Studying various methodologies, tools and techniques related to QoS and QoE in the Internet such as Best-efforts, IntServ and DiffServ.
2. Proposing a general QoE framework such that ISPs can restructure entire network parameters to be able to adopt with QoS challenges and user new demands.
3. Applying the proposed framework steps on a real ISP network in order to study the QoS parameters and QoE results before and after applying the framework.
4. Better understanding of the relationship between QoS and QoE, especially for new social media applications.

1.7 Thesis Layout

The content of the remaining parts of the thesis can be summarized as below. Chapter two presents the required theoretical details for both QoS and QoE methodologies, techniques, parameters, and architectures.

In Chapter three, we propose a general framework to improve QoE based on QoS parameters and users' feedback. We believe that this framework can be beneficial especially for national ISPs.

In Chapter four, the real life application of the proposed QoE framework is explained. The detailed results of each application case and network structure are illustrated and the visualization has been explained step by step. Next, Chapter five presents the thesis, main conclusions and suggestions for future works. Finally, the thesis has one appendix (Appendix A) that contains the details of some important challenges facing the considered ISP and adopted solutions.

Chapter Two

Theoretical Background

Chapter Two

Theoretical Background

2.1 Introduction

In this chapter, all theoretical background for QoS and QoE is explained. We start with reviewing QoS background by considering QoS architectures, QoS layers, factors affecting QoS, QoS parameters, and the layered network architecture. Then the background of QoE is presented. Here, we explain QoE measurement, the relationship between QoE and QoS, factors influencing QoE, and QoE measure and metrics. All theoretical background required for this work is considered and the important points have been highlighted.

2.2 QoS Review

As mentioned in chapter one, QoS requirements has become an important issue for all network providers now. To quantitatively measure QoS, several related aspects of the network service are often considered, such as error rates, bit rate, throughput, transmission delay, availability, jitter, etc. QoS is particularly essential for the transport of traffic with specific requirements. In particular, much technology has been developed to allow networks to be useful and more efficient and prepare the networks for audio, video conversations, as well as supporting new applications of user demands. The quality of service is the ability to provide different priority to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow [32].

QoS can be parameterized as delay, delay variation (jitter), throughput, packet loss and error rates, security guarantees, which are suitable in an application. However, QoS is an essentially application specific. For example, in data transfer, packet loss is a crucial QoS parameter. Also the jitter is an important for quality of

IP telephony, which can tolerate a certain percentage of packet loss without any degradation of quality. QoS control requires a considerate of the quantitative parameters at the application, system, and network layers [33].

2.2.1 QoS Architecture

In QoS architecture, there are three types of QoS; perceived, assessed, and intrinsic QoS. To provide end-to-end QoS delivery, we should configure QoS by features throughout of a network [13]:

1. Perceived QoS (P-QoS) is a user-oriented QoS defined as the quality perceived by the users, which depends on what the end points can do for the applications.
2. Assessed QoS (A-QoS) refers to the will of a user to keep on using a specific service. It is related to P-QoS and depends on marketing and commercial aspects.
3. Intrinsic QoS (I-QoS) is a network-oriented QoS concerned with what the networks can do for the applications.

In addition, the following three components are necessary to deliver QoS across a heterogeneous network [8]:

1. The QoS in a single network element which includes queuing, scheduling, and traffic shaping features.
2. QoS signals techniques for coordinating QoS from end-to-end between network elements.
3. The control and administer end-to-end traffic across a network is significance policy and management of QoS.

In fact, we usually need to consider the functions of the router in the network, and then select the right QoS feature or features. Because essentially not all routers

In the network do the same operations, therefore the QoS tasks they perform might differ as well [8].

2.2.2 QoS layers

The QoS can mainly be considered in three layers: application, system, and network layers as shown in Table 2.1.

Table 2.1: Quality of service Layers [33]

QoS Layer	QoS Parameters
Application	Frame Rate, Frame size and Resolution, Response time Throughput, Security, Price and Convenience
System	Buffer Size ,Process priority ,Scheduling policy, Caching policy, Time Quantum
Network	Bandwidth, Throughput, Bit Error Rate , End-to-End Delay, Delay jitter , Peak Duration

- **System layer:** The system parameters can be further classified into two categories: device parameters and network, operating system parameters. The QoS parameters in system layer are buffer size, process priority, scheduling policy, caching policy and time quantum for multi-media presentation. The quality of audio and video is important in addition to images; text and numbers. Moreover, the buffer size in an Internet router has several roles. It accommodates transient bursts in traffic, without having to drop packets. It keeps a reserve of packets, so that the link doesn’t go idle. It also introduces queuing delay and jitter [33].
- **Application layer:** Application layer parameters describe requirements for application services and are specified in terms of media quality and media relations. Media quality includes source/destination characteristics such as media data unit rate, and transmission characteristics such as response time. Media

Relations specify relationships among media, such as media conversation, inter-stream synchronization, and intra-stream synchronization. Some of these parameters at a high level can be included in general parameters defined as accuracy, precision, and timeliness. Timeliness, Accuracy, Precision (TAP) can together form a good criterion for QoS. Timeliness is defined as “when an event is to occur”. Maintaining means meeting a deadline. Accuracy is defined as “the degree to which the output conforms to the semantics and contexts of the applications”. Maintaining means guaranteeing the correctness of the data. Precision is defined as “the quantity of information provided or processed”. Maintaining means maintaining the amount of data being processed or transmitted over the network. System parameters describe communication and operating system requirements that are needed by application QoS. These parameters are specified in quantitative and qualitative terms. Quantitative criteria are those that can be evaluated in terms of concrete measures, such as bits per second, number of errors, task processing time, and data unit size. Qualitative criteria specify expected services, such as inter-stream synchronization, ordered delivery of data, error recovery mechanisms, and scheduling/caching mechanisms [33].

- **Network layer:** Network layer parameters are specified in terms of network load and network performance. Network load refers to ongoing traffic requirements such as packet inter-arrival time. Network performance describes the requirements that must be guaranteed, such as bandwidth, end-to-end delay, and jitter.

The network services depend on a traffic model (arrival of connection requests) and perform according to traffic parameters such as peak data rate or burst length. Hence, calculated traffic parameters are dependent on network parameters and are specified

In a traffic contract. Device parameters typically specify timing and throughput demands for media data units [33].

2.2.3 Factors Affecting QoS

The following factors can profoundly affect the QoS:

a) Delay: Echo and talker overlap are the problems that result from high end-to-end delay in a voice network. Round trip delay should be less than 50 millisecond to avoid echo. Since VoIP has longer delays, such systems must address the need for echo control and implement some means of echo cancellation. The ITU recommendation G.168 defines the performance requirements that are currently required for echo cancellers. Talker overlap becomes significant if the one-way delay becomes greater than 250 millisecond. Delay can be attributed to - accumulation delay, processing delay and network delay. Network delay describes the average length of time a packet traverses in a network. The network delay is handled by a good network design that minimizes the number of hops encountered and by the advent of faster switching devices like Layer 3 switches, tag switching system like MPLS systems and ATM switches [32].

b) Jitter (Delay Variability): This is the variation in the inter-packet arrival time as introduced by the variable transmission delay over the network. Removing jitter requires collecting packets in buffers and holding them long enough to allow the slowest packets to arrive in time to be played in correct sequence. Jitter buffers caused additional delay, which is used to remove the packet delay variation as each packet transits the network [32].

c) Packet Loss and Out of Order Packets: IP networks do not guarantee delivery of packets, much less in order. Packets will be dropped under peak loads and

During periods of congestion. Approaches used to compensate for packet loss include interpolation of speech by re-playing the last packet, and sending of redundant information. Out of order packets are treated as lost and replayed by their predecessors. When the late packet finally arrives, it is discarded [32].

d) Bandwidth available: Maximal data transfer rate that can be sustained between two end points affecting service quality. Techniques used to minimize congestion loss in the network may reduce the available bandwidth for an application. With current advancements in transmission media technologies, plentiful capacity is a reasonable assumption for a controlled, localized environment, such as a corporate Local Area Network (LAN), but it is currently unrealistic across a global network such as the Internet [32].

2.2.4 QoS Parameters:

The QoS parameters like delay, bit rate, jitter, and bandwidth must be guaranteed if the network capacity is limited [33] [34]. At the same time, there are several aspects of QoS to be considered [6]:

- **Video Communication:** High throughput is required to support video communication. High bandwidth guarantees to improve video communication
- **Audio Communication:** does not usually require high bandwidth. End-to-end delay and delay variations are other factors that must be taken into consideration.

In the real time media streaming, three main parameters must be contained such as delay, delay variation and bandwidth [6]. In others research studies, it was identified that QoS can be parameterized as throughput, delay, delay variation

(Jitter), loss and error rates, security guarantees, etc. [31]. QoS performance guarantees could be measured using the following attributes or metrics [32]:

- Vary according to Service Level Agreement (SLA)
- Depends on the priority intended for a given application
- Bandwidth,
- Delay (echo, talk overlap)
- Jitter (inter-packet delay variation)
- Packet loss

A. Delay

The ‘End-to-end transit delay is the elapsed time for a packet to be passed from the sender through the network to the receiver’ [6]. In other research studies, the term delay was defined as the time taken to establish a particular service from the initial user request and the time to receive specific information once the service is established [7]. At the same time, delay is an important design and performance characteristic of a computer network. The delay of a network specifies how long it takes for a bit of data to travel across the network from one node or endpoint to another. It is widely accepted that delay has a very direct impact and effect on end-user satisfaction depending on the application, and includes delays in the terminal, network, and any servers. Note that from a user point of view, delay also takes into account the effect of other network parameters such as throughput [7].

Delay can make the system unusable and unresponsive especially for interactive or real-time applications [6]. It can cause significant QoS issues with applications such as voice and video, and applications such as torrents, Viber, tango and facebook. Similarly, VoIP gateways and phones provide some local buffering to compensate for network delay. Finally, it can be both fixed and variable [34].

The most representative examples of fixed delay are [34]:

- Application-based delay, e.g., voice codec processing time and IP packet creation time by the TCP/IP software stack.
- Data transmission (queuing delay) over the physical network media at each network hop.
- Propagation delay across the network based on transmission distance.

The most representative examples of variable delays are [34]**:**

- Ingress queuing delay for traffic entering a network node.
- Contention with other traffic at each network node.
- Egress queuing delay for traffic exiting a network node.

B. Jitter

The variation in end-to-end transit delay is called jitter (delay variation) [6]. The measure of delay variation between repeated packets for a given traffic flow is called jitter [34]. High levels of jitter are unacceptable in situations where the application is real-time. Jitter has an effect on real-time, delay-sensitive applications such as voice and video. The strong interconnection between the end-to-end delay and the jitter should be noted. The jitter in the network has a direct impact on the minimum end-to-end delay that can be guaranteed by the network [6].These real-time applications expect to receive packets at a fairly constant rate with fixed delay between consecutive packets. As the arrival rate varies, the jitter impacts the Application's performance. A minimal amount of jitter may be acceptable but as jitter increases, the application may become unusable.

Some applications, such as voice gateways and IP phones can compensate for small amounts of jitter, since a voice application requires the audio to play out at a constant rate. However, if the next packet is delayed too long, it is simply discarded

When it arrives, resulting in a small amount of distorted audio. All networks introduce some jitter because of variability in delay introduced by each network node as packets are queued. However, as long as the jitter is bounded, QoS can be maintained [34].

C. Bandwidth

The maximal data transfer rate that can be sustained between two end points of the network is defined as the bandwidth of the network link [6]. At the same time, bandwidth is possibly the second most significant parameter that has the real impact on QoS [34]. It should be noted that the bandwidth is not only limited by the physical infrastructure of the traffic path within the transit networks, which provides an upper bound to the available bandwidth, but is also limited by the number of other flows sharing common resources on this end-to end path. The term bandwidth is used as an upper bound of the data transfer rate, whereas the expression throughput is used as an instant measurement of the actual exchanged data rate between two entities. Network applications, for example, have a certain bandwidth disposable between two nodes, but the amount of data they really transmit is determined by their throughput. The data throughput of an application is usually highly dynamic, depending on its needs [6]. The relation between bandwidth and throughput can be represented by following equation [34]:

$$\mathbf{0 \leq Throughput \leq Bandwidth} \quad \ldots\ldots (1)$$

Bandwidth allocation can be divided into two types [34]:

- **Available bandwidth:** Oversubscribing bandwidth means the bandwidth that a user subscribed to is not always available to them. This allows all users to

Compete for available bandwidth. They get more or less bandwidth depending upon the amount of traffic from other users on the network at any given time.

- **Guaranteed bandwidth:** Network operators offer a service that provides a guaranteed minimum bandwidth and burst bandwidth in the Service Level Agreement (SLA). Because the bandwidth is guaranteed, the service is priced higher than the available bandwidth service. The network operator must ensure that those who subscribe to this guaranteed bandwidth service get preferential treatment (QoS bandwidth guarantee) over the available bandwidth subscribers. In some cases, the network operator separates the subscribers by different physical or logical networks, e.g., VLANs, Virtual Circuits, etc.

D. Reliability

This property of the transmission system determines the average error rate of the transit network. The error rate can be subdivided into bit error rate and packet or cell error rate. **Bit Error Rate** deals with the transport layer; user applications need not consider them. **Packet Error Rate:** packet loss needs to be considered when examining the reliability requirements of Internet media streaming applications [6].

2.2.5 Layered Network Architecture

This section briefly describes the layers of the network architecture. Wireless networks have significant effects on the performance metrics and in turn pose significant issues on QoS [32]:

a. **Physical Layer** - It is the bottom layer in the Transmission Control Protocol/Internet Protocol (TCP/IP) architecture. All the hardware technologies of a network have been defined. The QoS factors that are considered measurable in this layer are: interference noise, SNR (Signal to Noise Ratio) and BER (Bit Error Rate).
b. **The Data Link layer** is made up of two sub layers: Media Access Control (MAC) and Logical Link Control (LLC). The LLC for the assignment of channel access for reliability in communication, while MAC handles scheduling, packet retransmission. The MAC sub-layer is made up of Distributed Coordination Function (DCF) and Point Coordination Function (PCF).
c. **The Network layer** is responsible for data routing. It handles transmission of data from source to its destination.
d. **Transport layer** handles the delivery of data with respect to process-to-process. It provides services such as congestion control and error recovery.
e. **The Application layer** houses protocols such as http, ftp, etc. which serve as the interface between the users and the network protocols.

2.3 QoE Review

The media today is taken part of the everyday life of all consumers; it more and more presents new additional and various forms of media contents that are produced and aimed to be delivered through the network.

The Future of Internet is definitely going to be Media oriented. Towards this, there is a deep need for an efficient user QoE. QoE became the important metric to consider when deploying services provider. Indeed, Service Providers are increasingly becoming interested in evaluating the performance of their delivered

Services as perceived by the end users, in order to improve them and more understand the needs of their customers. Not only service providers are concerned on correctly evaluating users QoE, network operators are as well interested in this metric in order to optimize the network resources, and even reconfigure the networks parameters to increase the user satisfaction. However, the quality perceived by the end users is a complex concept, as it is subjective in nature, and is difficult to compute automatically.

The (ITU-T) defines QoE as the “the overall acceptability of an application or service, as perceived subjectively by the end user”. QoE is different from network QoS indicators (e.g., bandwidth, loss rate, jitter), which are not adequate to get a precise idea about the visual quality of a received video sequence. QoE instead focuses on the overall experience of the end user. It depends on the overall system behavior, starting from the source of the services up to the end user, including the content itself and the network performance [35] [36].

The QoE is a clearly different concept from QoS. In most part, the current usage of QoE refers to the perceptual quality of multimedia applications. Granted, for multimedia applications, perceptual quality is a very important component of QoE. QoE is a multidimensional concept, and it is not limited to the technical factors which we can measure whether be at the network level or the application level. Ever more, service and network providers are looking to identify and model the complex relationships between factors impacting QoE and the actual QoE as subjectively perceived by end users [37].

The QoS and QoE concepts can be introduced to broadband IP networks with services (e.g. VoIP), video service (e.g. VoD) and data service. The QoE generally relies on user survey and scores from the user so it is too subjective and needs much processing time and cost. Hence, we need to relate the objective network

Service conditions with the human perception of the quality of the service and to keep business uninterrupted [1].

There are many factors affecting QoE for various types of multimedia services. While a factor is a characteristic which influences QoE, it is not a part of the perceived QoE itself. These factors can be classified as [38] [37] [14] [39]:

1. Subjective indicators like emotions, environmental, psychological, sociological aspects, and user profile (occupation, education level, age, etc.)
2. Objective indicators like application specific features, pricing policy (free, pre-paid, and post-paid), terminals, codes, type of content (music, news, telephone conversation) QoS, grade of service (GoS), and quality of resilience (QoR).

A provider needs to be able to monitor and react quickly on quality problems, at best before the customer perceives them. The QoE can provide a collection of user perception, experience, and expectations with non-technical and technical parameters such as application- and network-level QoS. However, actual relations between those intrinsic network features and resulting human-experienced quality must be considered [40] [41].

2.3.1 QoE Measurement

The biggest challenge today is to be able to measure and analyze QoE factors for different multimedia services with precision and accuracy. On the other hand, it is quite complex to capture QoE metrics considering the effect of multiple confusing factors, including technical, economic, social, and human factors. In addition to these, there are other important issues related to QoE measurement and analysis, such as QoE is based on several physiological and perception factors such as moods, habits, and expectations. It is very important to quantify QoE and measure it with accuracy. Quantifying QoE means translating user perception and performance into statistical and interpretable values [14].

There are two main methodologies for measuring and analyzing QoE which are subjective and objective. Of special importance in this direction is the mean opinion score (MOS) which is a characteristic user-related measure that can be determined from subjective ratings by real users or predicted from objective measurements of properties of the delivered goods such as audio, video, or files [40] [17][14]. Figure 2.1 represents a schematic for the main QoE assessment methods.

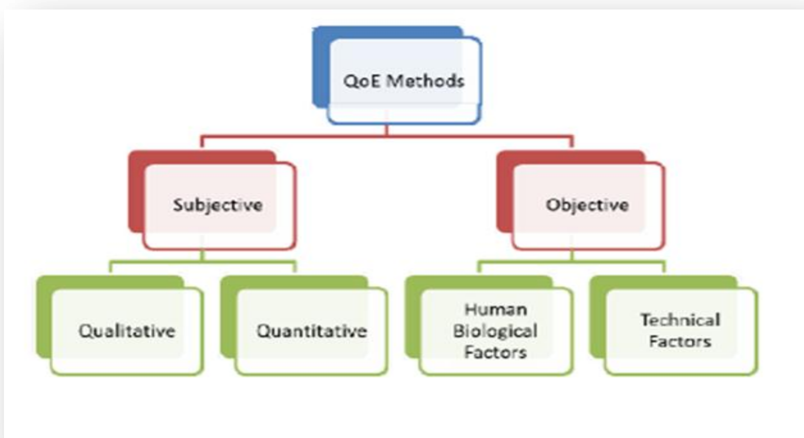


Figure 2.1: QoE Assessment Methods [17]

A. Subjective QoE Assessment Methods

Subjective assessment methods are generally based on interviews and surveys, statistical sampling of users and customers to analyze their perceptions and needs for service and network quality. There are two broader techniques for measuring subjective studies [17]:

1. **Qualitative Techniques:** The representation of verbal behavior is qualitative data and it consists of words and comments, not numbers. This produces individual's explanation of actions. Qualitative techniques absorb human perceptions, feelings and opinions through verbal behavior. Making survey questions, customer interviews, testimonials, comments on blogs, and social media creates the bulk of qualitative data. All of those methods produce a lot of qualitative data, in the form of researcher notes, transcripts from interviews and member journals, photographs and more. A meaningful metric for the analysis of verbal behaviors is the ratio of positive to negative comments and it is also commonly known as CCA (catalog, categorize, analyze) framework. CCA categorizes the ratio of positive to negative comments and produces results in the histogram formats [17].
2. **Quantitative Techniques:** Quantitative factors consist of numbers and statistics. Surveys and user studies are usually conducted either in natural environment to measure human perceptions, feelings and intentions or laboratory environment. These methods normally engage the structure of survey with rating scales to produce quantitative data. These methods create precise measurement and analysis of target concepts. The International Telecommunications Union (ITU) has produced various subjective study guidelines, such as ITU-T Recommendation P.910 [7] for video quality, P.800 [8] for speech quality, and G.1030 [9] for web traffic quality. In addition, quantitative approaches to evaluating the experience of technology usage can be built upon existing psychological models. The knowledge of user acceptance and adoption trends for particular service and/or products is invaluable for service providers [17].

B. Objective QoE Assessment Methods

Usually, there are two classes of objective assessment methods; QoS-technology centric and human physiological/cognitive-based techniques. In QoS-technology centric techniques, QoE is predicted from QoS data using some mathematical appreciation techniques and tools rather than getting direct feedback from end-users. The most popular are objective methods for the measurement of picture quality. These methods can be classified as Full Reference (FR), No Reference (NR), or Reduced Reference (RR) methods. FR methods compute the quality difference between an original (i.e., unprocessed) version of the image/video/audio signal and its distorted (i.e., processed) counterpart. NR methods appreciate the quality of the signal using only the distorted version. Finally, RR methods have access to partial information (e.g., features) about the clean original signal in order to estimate the quality of its degraded counterpart [17].

C. Subjective vs. Objective Methods

Subjective methods depend on the human member to provide useful and reliable QoE feedback about a specific multimedia service. Subjective testing is expensive and time-consuming. In addition, the extension beyond user-perceived media quality to include measures such as usability and user satisfaction is a notion of subjective QoE. This notion focuses on subjective user perception. The methodological focus has been to survey user opinion via questionnaires and rating scales [3].

Objective methods may depend on technical factors and/or human factors. The former consist of objective metrics, which try to predict human behavior using a mathematical model/formula. Unluckily, there are still no objective metrics that can

Fully capture the complexity of QoE. The existing metrics are generally limited to only some aspects, e.g., the picture quality, which are part of the QoE framework and hence related to it; however, they disregard influential factors, such as contextual, economy, and user expectations, which are gathered via surveys and user studies. Objective human factors are related to the human physiological and cognitive systems. These objective factors are difficult to obtain and interpret, but could provide useful insights into human behavior and cognition [17].

2.3.2 QoE Measure and Metrics

The exceptionally measure of QoE is based on the MOS. The basic definition of MOS can be found in ITU-T Rec. P.10 as “the mean of opinion scores, i.e., of the values on a predefined scale that subjects assign to their opinion of the performance of the telephone transmission system used either for conversation or for listening to spoken material.” This definition adheres to voice telephone services, but the MOS scale is currently used for Evaluation of other services, especially video [14].

ITU-T Recs P.800 and P.800.1 define a five point MOS scale. As well as it is recommended to use different notations for the MOS score obtained by different estimation methods, namely, subjective tests, objective or network planning models. Most metrics use absolute scales, but comparative metrics are also used usually in subjective tests where people are asked to compare the quality of two samples. A textual description of the quality is often assigned to particular MOS scores. Descriptions can be quality oriented or impairment oriented, as show in Table 2.2 [41].

There are several metrics dedicated to QoE evaluation of various services and applications. Specific metrics are also associated with particular methods of QoE evaluation [41] [42] [14].

Table 2.2: Different types of discrete metrics [41]

Quality of Experience Metrics		
MoS	**Quality**	**Impairment**
5	**Excellent**	**Imperceptible**
4	**Good**	**Perceptible**
3	**Fair**	**Slightly annoying**
2	**poor**	**Annoying**
1	**Bad**	**Very annoying**

2.3.3 The Relationship between QoS and QoE

QoS solutions consider quality as a pure technical issue, while we have to look at quality from a user's point of view. QoE is the concept which can help us with this issue. If we use QoS techniques in relation to the QoE solutions, then it is possible to present an adequate level of quality for the users. So we need to have a quantitative relationship between QoS and QoE and respect to the correlation between QoS and QoE [45]. We can collect data about provider's users' experiences, analyze them, and then calculate the value of participating QoS factors for related QoE parameters. Moreover, we try to enhance the QoS solutions according to QoE requirements [18] [1].

It is widely recognized now that the relationship between voice transmission conditions and the human perception of quality is far from linear. It is possible to discuss how the human satisfaction of HTTP service is affected by some network

QoS parameters, such as latency and network delivery speed. But, it is difficult to represent the feature of the provided and various services from only the bandwidth and latency time in the integrated network environment [18] [1].

Previous studies connecting between QoS and QoE are still often focusing only on overall user perceived quality (often in terms of a MOS). However, it is important to better understand the relationship of different dimensions of QoS and QoE, in particular for classifying interactive multimedia environments, and identifying the degree to which different QoS factors impact different QoE dimensions [37].

Some relations in different function forms have been proposed. The general correlation between QoE and QoS can be explained with two different equation forms (i.e. logarithmic or exponential). The question then is which function form is the one that can better explain this relationship. To answer this question, it could be of help to compare the various existing relations, particularly by comparing two different definition types that lead to QoE-QoS dependency [46].

At first, the Weber-Fechner Law (WFL) was introduced. It is a psychophysics law showing a logarithmic equation that can be used to explain the interdependency between QoE and QoS. Secondly, the IQX hypothesis was proposed. It introduces an exponential relation between QoE and QoS. These two equations are grouped as stimulus-centric and perception-centric relations. The relation adopted from psychophysics goes into the stimulus centric group, while the IQX-based relation falls into the perception-centric group [46].

Thus, there exist two main solution groups attempting to define a general relationship between QoE and QoS, regardless of network service type. The first group comprises relations derived from the psychophysics laws, for example, a logarithmic relationship between QoE and QoS derived from the well-known WFL.

This shows how human perception can change relative to physical stimulus changes resulting in a certain perception. This group claims that the QoE-QoS relationship is of logarithmic nature [46].

Then second group can be classified as the perception-centric group. Their work relies on the IQX-hypothesis which postulates that QoE variations are associated to current user quality perception levels. This definition results in an exponential QoE-QoS relationship [46].

As a result, to deliver a high QoE, providers must understand the influence factors that participate to the user perception of the target services, and apply that knowledge to specify network parameters. Consequently the end user behavior is related with the network and the services available. Monitoring the end users behaviors allows service provider to adjust the network parameters in order to accomplish different needs from different groups of users [48].

Thus, the best practical approach for QoE is to relate the QoS with the QoE and with end user satisfaction. User Satisfaction is dependent on QoE, but also is conditioned by other several factors such as: type of user (age/geographical location), type of device, time of the day or purpose of the application. From the other side, QoE is dependent on the QoS according to the network conditions which depend on the user behavior, especially if we consider that customers who are more satisfied with the QoS would potentially make more requests and interact more with the network [48]. These dependencies are show in Figure 2.2.

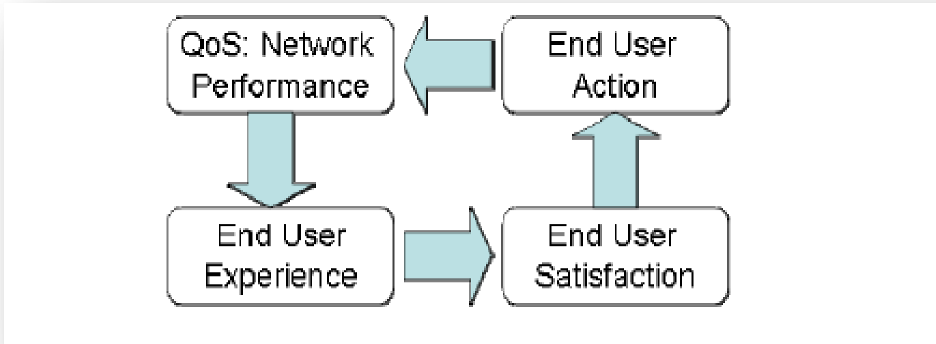


Figure 2.2: QoS-QoE End User & End User Satisfaction relationships [48]

The relationship between QoE (expressed in Opinion Score (OS)) and QoS parameters, such as loss ratio, download time and throughput, in web surfing service were analyzed. Different relationship forms (linear, logarithmic, exponential and power) were considered evaluated through the correlation coefficient. Their results show that there is a linear relationship between QoE and loss ratio, an exponential between QoE and download time, and logarithmic relationship between QoE and throughput. This is summarized in Table 2.3 [44]

Table 2.3: Relations between QoE & QoE [44]

Model	Name	Form	Relation
Reichl et al.	Weber-Fechner Law	Logarithmic	$QoE = K \ln (QoS)$
Fielder et al.	IQX Hypothesis	Exponential	$QoE = e^{-\beta\, QoS}\, \gamma$
Khorsandroo et al.	Stevens' power law	Power	$QoE = K \,.\, QoS^{b}$

Considering Table 2.3, the findings in accordance to WFL related to speech quality (measured by MOS) is considered as a logarithmic function of bit rate or loss rate in Voice over IP (VoIP) services. The second explanation is based on the IQX hypothesis. This theory leads to a differential equation whose resolution gives an exponential relationship between QoE and QoS. The IQX hypothesis is validated for VoIP services where QoE is expressed in terms of MOS as functions of loss or reordering ratio. The authors showed that the exponential model provides approximations with better quality than the logarithmic model proposed for web surfing service [45] [46].

The third QoE-QoS relationship shown in Table 2.3 (based on the work of Khorsandroo *et al*) [45] [46]. Indicates that it is possible to consider a relation in the form of a power function to explain the possible relationship between QoE (MOS) and QoS (packet loss) in video streaming services. The psychophysics Stevens' Power Law was introduced in order to show QoE-QoS correlation in the form of a power function. A theoretical and empirical comparison was made with the WFL approach .The results showed that logarithmic form can serve better than a power form solution, but cannot be a main solution [42].

However, it is clear that the general relationship between QoE and QoS is a complex one as the end user behavior impacts the network and the network impacts end user behavior [42]. Several parameters are configured by the service provider in the network infrastructure; some configurations are done concerning the strategy of the operator in terms of network cost, new possible features and market directions. Improvement engineers realize the hard job of improving a network with limited resources in order to provide the "best in class" services performance to end user [48]. Service providers of course desire to control and ensure a good

QoE level while keeping the QoS-related network resources improved and under control [49].

2.3.4 Factors Influencing QoE

QoS, GoS and QoR describe various intrinsic characteristics of a network while customer's satisfaction with using services is usually described as QoE [47]. Also QoS, GoS and QoR intrinsic parameters will also influence QoE. The overall QoE evaluation is additionally affected by psychological and sociological factors, including user expectations and experience with similar services, other opinions, pricing policies, environmental, features of the particular location where the service is received, etc. In fact, the side factors are very important in QoE evaluation by the user, especially in the case of voice and video services [41].

The correlation between QoS and QoE is important to achieve satisfaction of end-users when evaluating services and products [38]. Many factors are influencing QoE. The basic term related to this issue is the class of service (CoS) which is also referred to as QoS class. The basic definitions of CoS are provided by ITU-T and IETF. The CoS is defined as "characteristics of a service such as described by service identity, virtual network, link capability requirements, QoS and traffic threshold parameters" [47]. The factors effecting QoE are depicted in Figure 2.3. Below is a more detailed description of GoS and QoR.

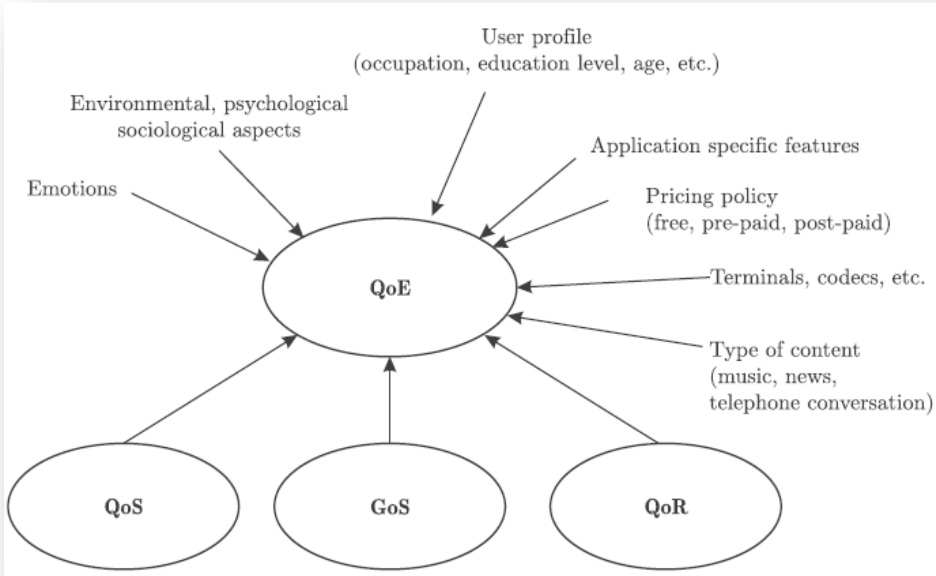


Figure 2.3: Factors influencing QoE [47]

A. Grade of Services (GoS)

This term is used to describe everything that occurs during connection setup, release, and maintenance. In addition, GoS applies to circuit switched networks and describes all events occurring during connection setup, release and maintenance. It appears in the context of telephone networks (ITU-T Rec. E.720, E.721, E.771, and E.493) [41]. The GoS is used in the context of circuit switched optical networks, path setup in IP/MPLS networks, and handling new requests in networks with permission control mechanisms, especially in NGN.

GoS parameters include probability of end-to-end connection setup blocking, the connection set up delay, delay in authentication, probability of breaking an active connection (forced or unpredictable tear down), and others. [47] [41]. An example of a GoS parameter would be the blocking (request rejection) probability. GoS parameters can receive a new meaning and significance. For instance, user

Demands connected with real-time and interactive applications over an IP network, such as live TV, VoIP etc., are continuously increasing.

Delay in playback start or zapping time are good examples of GoS parameters that directly translate into QoE, in comparison to QoS parameters that usually do not translate directly to the quality of experience, GoS provisioning in heterogeneous networks is a real challenge. GoS parameters are very important for service in different networks. The definition of GoS classes (similarly to QoS classes) would seem to be an important issue for future converged networks [47].

B. Quality of Resilience (QoR)

This term is used to describe network survivability and concerns recovery time and availability. Usually, network availability is perceived as one of the measure of QoS. Therefore, reliability- related metrics are decided in SLAs under a general QoS umbrella. It is most commonly expressed as the 99.999% availability requirement, sometimes accompanied by a mean recovery time. This type of agreement is obviously more attractive for ISPs than for the customer [47]. Another definition of QoR is network survivability against failures [41].

Generally, the set of reliability attributes and parameters is more extensive: parameters related to continuity, downtime and availability may be distinguished. Other attributes of QoR are resilience to multiple failures, failure coverage as well as features related to the recovery scenario and operations: scalability, flexibility, signaling requirements, and state overhead. In general, QoR parameters constitute a separate set of factors, which are orthogonal to QoS and GoS parameters [41].

As already mentioned, resilience is often considered to be a part of QoS and some resilience-related settlements are placed in SLA together with QoS-related agreements capabilities of various QoR mechanisms to maintain quality on a

Recovery path are different, therefore operators should implement proper QoR mechanisms in a network. The QoR assurance influences QoS and GoS and, finally, the user perceived service quality, QoE. If recovery mechanisms are absent, improperly designed, or inefficient, it has a direct impact on QoE. Users will notice network unavailability immediately, e.g., some web pages or email services will become unreachable [41].

Additionally, even the triggering of fast and efficient recovery mechanisms may result in a deterioration of QoS and GoS parameters, since switching to spare resources may cause temporary instability of the network, Efficient QoR mechanisms, capable of service differentiation, are highly desired. For the above reasons, QoR has recently been recognized as an independent field and it is recommended to treat QoR issues separately from QoS and GoS [47].

2.4 Models of QoS

There are three main models of QoS as classified below. Indeed, a comparison is shown in Table 3.1 for the difference among these three models.

A. Best-effort

In this model, no QoS is applied to the packets that work with the formula FIFS, i.e. which packets first enter queue first served. Internet was initially based on a best-effort packet delivery service. Best-effort is the default mode for all traffic. There is no differentiation among types of traffic. The best-effort model benefits are high scalability and no special mechanisms are required. The drawbacks of best-effort are no service guarantees and no service differentiation.

Also known as lack of QoS, best-effort service is a basic connectivity with no priorities or guarantees. It provides basic queuing during congestion with first-in, first-out (FIFO) packet delivery on the link. Examples of this type of traffic include a wide range of networked applications such as low-priority e-mail and general file transfers. Internet generally uses “Best Effort” approach which is associated with IPv4, in which content of packet is not sensitive to real-time data flow [32] [9] [8].

B. Integrated Services (Intserv)

Intserv means end to end QoS reserving the link to especial traffic until complete the task. In other words, intserv is end to end model that ensures guaranteed delivery and predictable behavior of the network for application. The Resource Reservation Protocol (RSVP) is used as a signaling protocol. That is requested for enough bandwidth to send packets. So the requested QoS parameters are available then linked to send a packet stream. Intserv is used in special cases like voice and video because they are more sensitive.

Intelligent queuing mechanisms are required to provide resource reservation in terms of guaranteed rate and control load (low delay, high throughput). The benefits of the Intserv model are explicit resource admission end-to-end control and signaling of dynamic port numbers (for example H323). However, the most important drawback of Intserv is that it is not very suitable for global Internet communication. For example, we want to send some data from node A to node B, we first reserve the bandwidth and block all other traffic then data can be sent from A to B; however, if B sends data to A this would block signal path to him. The applications signal to the network that they require certain QoS parameters. Guaranteed Service (Also called “quantitative QoS/Hard QoS”) is an absolute

Reservation of network resources, typically bandwidth, which implies reservation of buffer space along with the appropriate queuing disciplines, and so on, to ensure that specific traffic, gets a specific service level. This type of service is for delay-sensitive traffic, such as voice and video. The Guaranteed Service level is intended for applications requiring a fixed delay [9] [8].

C. Differentiated Services (Diffserv)

Diffserv means the network recognizes classes that require QoS. Diffserv is different from Intserv even with no enough bandwidth it is possible to send packets through the path. Diffserv works according to the needs of the traffic that can be classified. The example in Diffserv is class base fear queue. For example, in network 1 we prioritize a packet after sending to another network 2. Here Diffserv model let network 2 to give our packets of the same high priority to pass through the network. Also called “qualitative QoS/Soft QoS”, differentiated services treat some traffic better than the rest (faster handling, more bandwidth on average, and lower loss rate on average). However, there are no hard and fast guarantees. With proper engineering, differentiated service can provide expedited handling appropriate for a wide class of applications, including lower delay for mission-critical interactive applications, packet voice applications, and so on. Typically, differentiated service is associated with a course level of packet classification, which means that traffic gets grouped or aggregated into a small number of classes, with each class receiving a particular QoS in the network [9] [8] . Hence, for our case, Diffserv QoS model was found and it is the best from other models to us. As it was stated before, Diffserv model can work with not enough bandwidth, it is possible to send packets through the path. Therefore, our proposed framework can work efficiently, even with lowest bandwidth situation.

Another reason to find Diffserv model to be used for our framework is that guarantees services, no need special situation to mark, prioritize and send the data inside the network. Therefore, the reasons that make the Diffserv model is best chose to be considered for our work. Because of the different with Intserv even with not enough bandwidth all packet will through the path.Diffserv is different according to need the traffic can be classified. In diffserv model if we have some traffic with high priority in network 1 this traffic will treat with same priority in network 2, but with condition give traffic network 2 high priority then the network 1 traffic.

Table 2.4: QoS Models

Best-Effort	IntServ	Diffserv
No QoS is applied to packets. best-effort is the default mode for all traffic	Application signal to the network that they require certain QoS parameters	The network recognizes classes that require QoS
No service guarantees No service differentiation	Used (RSVP) protocol as signaling protocol and reserved all the bandwidth until finished connection and block other traffics. Service guarantees	The packet-handling rule is termed as Per-Hop Behavior (PHB).Here if traffic has high priority; It classifies and remarks to pass through all networks without straggle.
Because it's default mode for all traffic does not have any sensitivity with traffics. Internet was initially based on best effort packet delivery and doesn't have special prioritization.	End-to-End streams are not established if the required QoS are not available	Even without enough bandwidth, the services work fairly.
Used technique FiFS queuing to deal with traffic	Used PQ to deal with traffic	Used CBWFQ , Tree Queue and LLQ to deal with traffic
No special mechanisms required. But highly scalable.	Used in special case because of sensitivity of this model it has many of requirements because high cost challenge for implements used in private office not in global internet.	It's different from other two models; According to the need of traffic reprioritize. Even with not enough bandwidth the packets can pass through the path.
There is no differentiation among types of traffic.	The problem in Intserv is reserving and blocking only particular traffic that can use the bandwidth not all traffic.	the traffic is treated according to its respective classes

2.5 Relevant QoS Mechanisms

Various techniques have been developed to facilitate QoS provisioning, including admission control, congestion control and traffic shaping and engineering [53]. All these mechanisms work to achieve good QoS for any services by ISP. The most important related mechanisms considered are:

- **Admission control:** Admission control is one of the ways for supporting QoS. In admission control, new sessions are allowed on the network only if enough resources are available to provide service to the new and existing sessions. The planning of incoming traffic flows prevents network congestion, and helps in ensuring QoS. The common parameters used for admission control are the average rate and highest bandwidth requirement. Consequently, the job of admission control is to increase resource utilization in the network, and to control the amount of traffic to achieve the predefined performance objectives of the current flows [53] [54].

- **Congestion control:** If the number of packets sent to the network is greater than the number of packets that the network can handle, that causes congestion. To keep the traffic load below the capacity, we must use congestion control techniques. In modern networking, congestion control is usually done by using the TCP protocol. The QoS enabled routers provide services to flows based on their requirements. Congestion control helps to guarantee priority differentiation of flows by servicing queues in different manners [53] [54].

- **Scheduling:** The key to share network resources fairly between users in a network is scheduling which offers service assurances to time critical application. The scheduler first decides the order of requests to be served, and then it manages the queues of these awaiting requests. The scheduling structure

Is significant for the networks because there can be two types of applications. One is insensitive to the performance that users receive from the network, and the other is sensitive to the performance. The scheduling can offer different services to the flows using parameters such as different bandwidths by serving only a single flow at a particular interval. Different means delay according to the level of priority defined for the flow; and different loss rates by assigning more or fewer buffers to the flows [53] [54].

- **Traffic shaping and engineering:** The traffic in data networks is bursty in nature. The technique for handling the bursty nature of the traffic entering a network through controlling and dealing appropriate levels of network bandwidth is traffic shaping. The goal is to control average traffic rate and reduce congestion. The traffic shaping is performed at the edge nodes. These nodes have classifiers that mark the flows according to their service requirements. The mechanisms of traffic management can be classified in a number of ways. One possible criterion is time scale. In order to achieve QoS guarantees, decisions on buffering and forwarding must be performed quickly. The process that maximizes network utilization through careful distribution of network resources is traffic engineering. Most of the Internet backbones currently rely on label switching by adopting MPLS technology. The purpose of label switching is to enhance the scope of traffic engineering [53] [54].

- **Marking:** The IPv4 Type of Service (ToS) and the IPv6 Traffic Class are examples of a service marking model in the Internet. Each packet is marked with the desired ToS. The ToS is defined by means of one or a set of the following service requests: “maximize throughput”, “minimize delay”, “minimize cost” or “maximize reliability”. Network nodes are responsible to

Select routing paths or forwarding behaviors that are appropriately engineered to satisfy the service request [6].

2.6 Network and Application QoE Considerations

In this section, we try to emphasize some important considerations related to the adoption of our proposed framework (or any other QoS/QoE framework) by ISPs. These considerations mainly can be in two basic domains; network and application domains. One can simply note that there are many new emerging types of applications, each with very different operational requirements. Thus, the Internet is becoming the backbone of future communications in an entertainment center. However, other mobile networks and smart phones have different QoS-QoE requirements [31]. In fact, the nature of traffic over the Internet has changed in its attributes.

The increased research interest QoS and QoE come with the growth of multimedia applications over wide area networks. Communication delay and synchronization needed for voice, data and images are major concerns. Internet telephony (Voice over IP) and other multimedia applications such as video conferencing, video-on-demand, and media streaming require service guarantees and have strict timing requirements [32].

To connect our devices to the internet over the past 50 years, IPv4 has been underlying protocol. But, with improved technology which has lead the growth of IP-based devices, there have been serious concerns about IPv4 limited features, robustness, and scalability. This led to the creation of IPv6 by the Internet Engineering Task Force (IETF) with sole aim of making the internet work Better. Despite that QoS/QoE can be (and need to be) achieved on both IPv4 and IPv6

Networks; IPv6 can give more possibilities for QoS/QoE enhancement for social media applications as well as for the future of the internet [32].

Another important issue is the time dependency requirement of applications. Regarding this requirement, we can classify all applications into two [6] [13]:

- **Real time (RT) applications:** A system in which the time of input and the output produced is significant. This is usually because the input corresponds to some movements in the physical world, and the output has to relate to that same movement. The delay from the input time to output time must be adequately small for acceptable timeliness. RT applications can further be divided into soft real time and hard real time applications. The main difference between soft and hard real time is that hard real time applications needs QoS requirements unless, it does not be met. In RT applications, the network needs to deliver time-based information without changing its built-in time properties. For adequate user satisfaction, we need to maintain more stringent delay and jitter requirements for RT applications. The delay requirements must be strict in order to maintain System timing. The jitter requirements are essential to transmitting data at a constant and reliable rate
- **Non real time (NRT) applications:** NRT applications are any applications that do not have stringent timing requirements. This type of application does not fail if timeliness metrics are not met, nor does it require timing accuracies to be considered acceptable. NRT applications, which do not have time-based sensitivity requirements, are mostly concerned with delay.

So, it is crucial for any deployment aiming for QoE enhancement to understand the time dependency requirements for the considered applications. Thus, one can properly decide the suitable mechanisms needed for each application and the

Consequences of interaction between these mechanisms on the whole network performance and end user satisfaction [6][13].

2.7 Summary

In this chapter, all relevant theoretical backgrounds related to QoS and QoE have been explained. Considering various QoS layers, factors affecting QoS, QoS parameters, QoE measurement, and factors influencing QoE, finally QoE measures and metrics. It is obvious that the issues of offering QoS and QoE in a proper manner by ISP is not a trivial case. Even more, the relationship between QoS and QoE is so complex that different formulation can be adopted in various situations. In the next chapter, we will present our proposed general framework to improve QoE through QoS.

Chapter Three

Proposed Framework for QoE Enhancement

Chapter three

Proposed Framework for QoE Enhancement

3.1 Introduction

In this chapter, we present the details of the proposed framework to enhanced QoE through QoS. The proposed framework constitutes of two main parts: first QoS part and second QoE part. Indeed, the QoS part considers various suitable mechanisms in both data and control planes. After introducing the general framework, some network and application considerations for ISPs are presented. Also, some insights on the expected beneficiaries of QoS and QoE deployment are given. In addition, some other connected points are highlighted.

3.2 The Proposed General Framework

A number of QoS and/or QoE related frameworks had been proposed by previous works, as reviewed in Chapter One and Chapter Two. One of them is concerned with QoE-aware management of a video streaming service. The second framework was particularly designed to work in conjunction with an IPTV service for mobile devices. The third one aimed at achieving end-to-end management of quality of multimedia services. Yet, another framework was designed as a control loop over a general-purpose multimedia system with the goal of matching the properties of the content to the expectations of the consumer.

We describe a proposed general QoE framework in which the overall aim of the transmission is to maximize the end user experience. At one end is the ISP with the content ready to be served, and on the other end is the user with its unique characteristics and expectations regarding the content. Our framework is mainly intended to be deployed by (national) ISPs who should collect and analyze relevant data to achieve the important goal of enhanced QoE through choosing suitable QoS model and metrics.

The basic idea behind our proposed framework is as follows: ISPs use properly collected feedback data from end users about the services, and then they analyze and relate these results with network QoS parameters, such as bandwidth, delay, and packet lose. The obtained information can be used to better configure various network parameters in order to better predict the quality of many social media applications like Facebook, Viber and Tango. Figure 3.1 shows the main structure of the proposed framework.

As the proposed framework, the general purpose is to enhance the QoE through the configuration of QoS parameters based on end users' feedback, the framework has two main parts (or domains); the first part is related to QoE and the second part is concerned with QoS, as follows:

1. **QoE part:** This part includes subjective mechanism metrics, quantitative MOS measure, and analysis requirement of the end users' new social media applications demand. Multimedia applications are delay-sensitive and loss-insensitive. The end-to-end delay is the primary parameter affecting the quality of voice on the Internet. ITU G.114 defines that the maximum tolerable end-to-end delay is 150 millisecond. End-to-end delay equals the sum of propagation, processing, serialization, and queuing delay in the path. The existing Internet service cannot satisfy the QoS requirements of the multimedia application, primarily because of network congestion due to an insufficient network resource (See Figure 3.2).

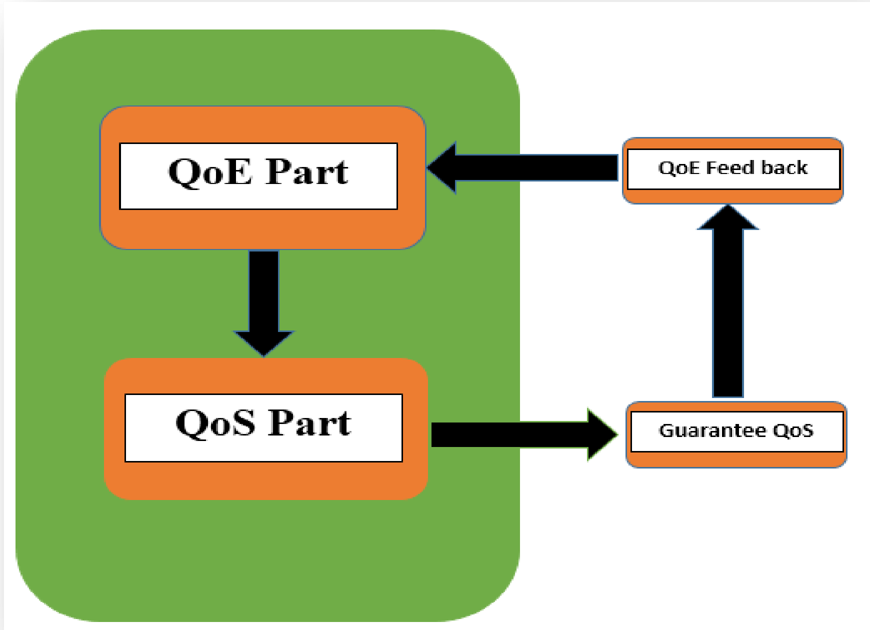


Figure 3.1: The proposed general framework structure

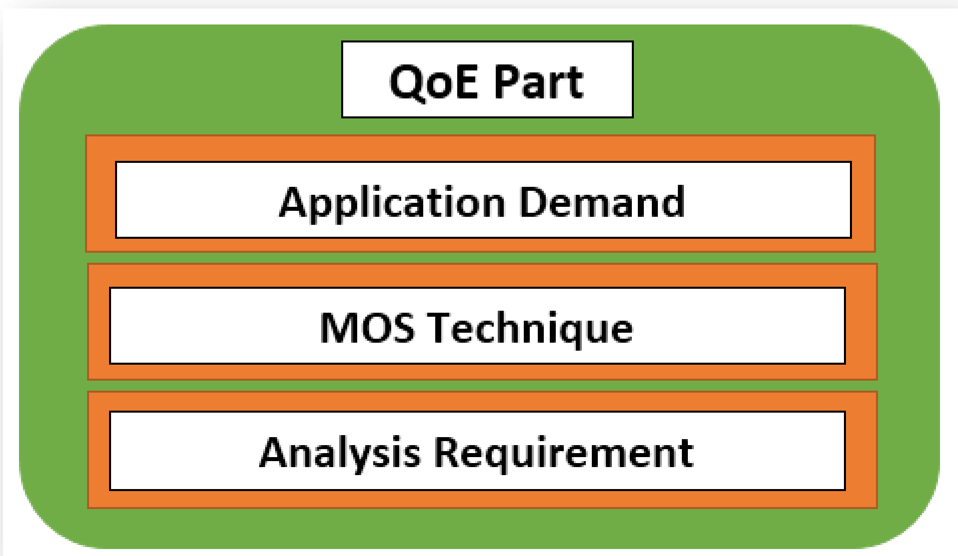


Figure 3.2: Framework QoE Part

2. **QoS part:** This part contains two main planes; **control plane** and **data plane.**

3.2.1 QoS Mechanisms in Control Plane

In the control plane, two basic mechanisms are included: Congestion Avoidance and admission control. As mentioned previously, these mechanisms are necessary to offer QoS, and hence QoE. For admission control works on the management of packets and tries to give them good QoS because of limited network resources. Give a good quality to quantitative packets inside a network need some functions to manage these resources to accept QoS conditions. For Congestion Avoidance work like network path keeper if any network node sends maximum traffic inside the network will cause congestion and network fault. So dropped traffic packets randomly to decrease the network load and prevent the congestion. The most important tool for congestion voidance is Random Early Detection (RED) and Weight Random Early Detection (WRED). The control plane is simply depicted in Figure 3.3.

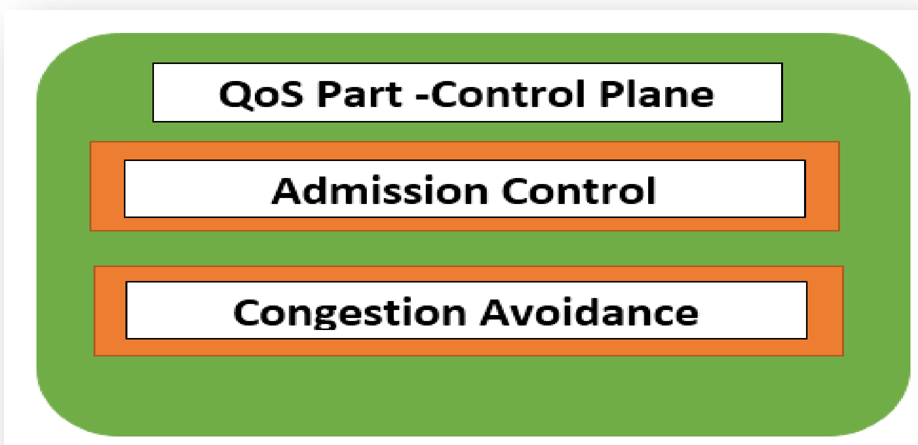


Figure 3.3: QoS Part-control Plane

The data plane includes many mechanisms like classification, scheduling, shaping and policing, and marking. These mechanisms commonly implement the control functions of packet forwarding by controlling the per-hop behavior (PHB) of packet forwarding to prioritize certain traffic from another. We give more explanation on these mechanisms in the next subsection. A simple schematic for the data plane is shown in Figure 3.4.

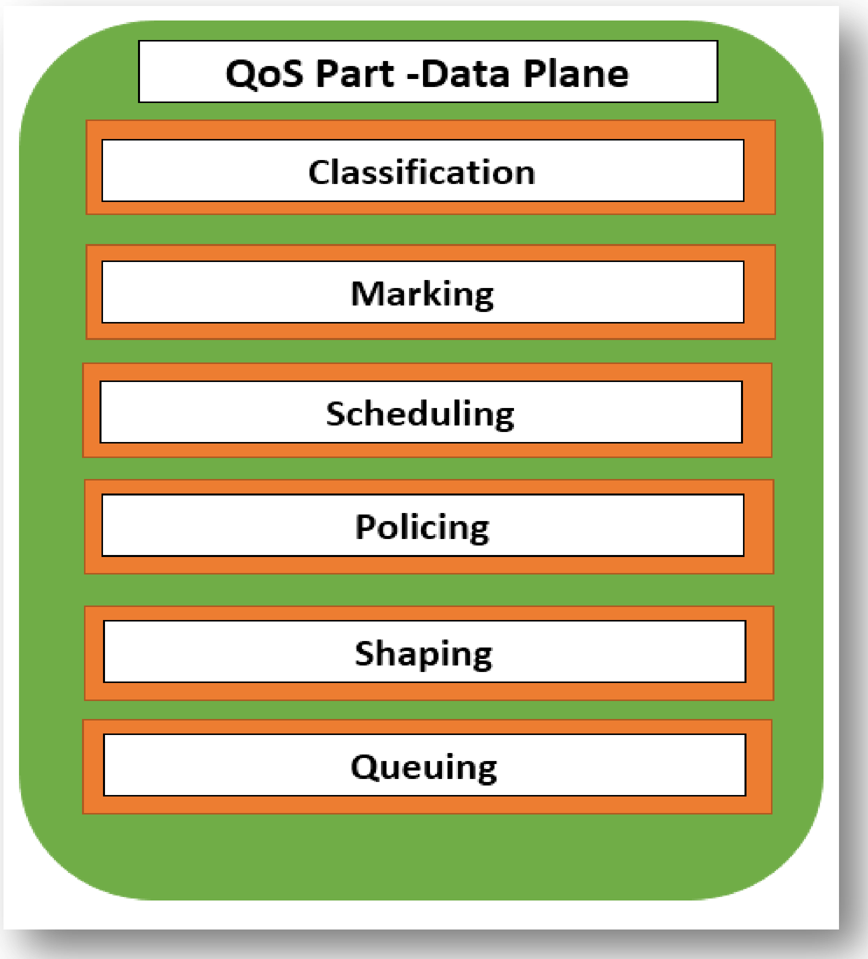


Figure 3.4: QoS part- Data Plane

3.2.2 QoS Mechanisms in Data Plane

QoS mechanisms in data plane can be mapped to corresponding layers of IP protocols. QoS mechanisms of network layer consist of packet classification, buffer management, scheduling, shaping and policing. In this plane, our proposal is based on DiffServ that presents a framework of a service architecture within which both enterprise and ISPs can offer differentiated services to their customers on the basis of performance.

Scheduling are needed to ensure service quality. In buffer management, packets are usually dropped only when the queue is full. This policy may keep queues at or near maximum use and cause unfair resource usage. The best queue management which drops packets before a queue becomes full can avoid these problems. Scheduling policy is primarily used to control queuing delay and bandwidth sharing. The total bandwidth of a link can be shared among multiple entities. There are varieties of scheduling disciplines, such as First Come First Serve (FCFS), Static Priority (SP), and Earliest Deadline First (EDF). In general, all routers support FCFS in the best-effort model by default while many new devices are now able to support (CBWFQ) Tree Queue.

More details on the application of these mechanisms is given below:

- **Classification:** It's the core of QoS, That ability to identify different traffic types and prioritize one to another, by using two tools Access control list (ACL) and network base application recognition (NBAR) to catch packets to identify which traffic is voice, video. In our framework the classification for all traffic done by classify with IP address for the hostname, and the port that these applications use.
- **Marking:** its work to coloring packets which give high priority to be identified in other routers. Marking tools includes CoS (class of serves) which allow switch to know what happened here. Or TOS used in layer three by the router that is able to identify the traffic with high priority. In our framework we mark all high priority traffic in mangle section in mikrotik OS

- **Policing:** It is connected to type of QoS, In the QoS, tools take weight bandwidth, and any packet reached the limited weight must be dropped. In our framework we don't work on the policing and shaping but for future will be.
- **Shaping:** allows you to deal with interfaces if the speed of the router is faster than all networks, keeps balancing, shapes working to queue these packets and sends them later.
- **Congestion Avoidance:** used two techniques (RED) Random Early detection and (WRED) weight random early detection, here if a user sends packets with protocol TCP, the detector noticing this user makes congestion in the network, so dropped the packets randomly to avoid the congestion.
- **Queuing:** It's the most powerful categories of QoS. Many queues are used to achieve a good QoS like LLQ, CBWFQ, PQ, Tree queuing etc. In the our framework we used tree queuing and simple queue in section queue list in mikrotik OS

Finally, a more detailed schematic of the proposed general framework for QoE enhancement is shown in Figure 3.14.

3.3 Questionnaire survey

In this section, we consider the questionnaire that has been used in collecting users' feedback before and after deployment of the proposed framework. The first round of feedback was collected from end users to understand their level satisfaction on certain ISPs services before application of the framework on the network. The questionnaire survey included questions like a gender, age group, career of the subscriber, the number of the devices that connected to the service inside the home, also type of these devices used, most social media application used, and finally how the user rate the services.

The obtained usage results are as follows: For gender question, the answers are 21.4% female, 78.6% male. For age group question, the answers are 10% between 10 to 20 years old, 42.9% between 20 to 30 years old, 21.1% between 30 to 40 years old, and 18.6% between 40 to 50 years old. For career question, the answers are 9.1% wage earner, 0. 6% banking, 3.6% solider, 13.1% student, and 14.9% teachers. for devices number question, the answer are 14.3% one device, 26.4% two devices, 26.4% three devices, 18.6% four devices, 5% five devices, 5% six devices, 1.4% seven devices, and 2.1% more than 8 devices. For type of device question, the answers are 17.1% laptops, 8.6% Tablets and 98.6% smartphones. For mostly used social media applications question, the answers are 87.1% Facebook, 81.4% Viber, 32.1% Tango, and 15% Whatsup. Finally, for the general user service rating before implementing the framework the answers are 32.9% “not good”, 63.6% “fair”, and only 3.6% “good”.

This step is necessary so that we can do fair and helpful comparison with end user opinions after implementing the proposed framework application. The results of end users feedback after framework application are presented in chapter four. In the first round of QoE evaluation, a questionnaire was distributed to end users. Users’ response to the questionnaire has been used as a source to understand QoE level so as to enhance the network services later. The questionnaire survey results are shown in figures 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11. The survey form is shown in Figures 3.12, 3.13.

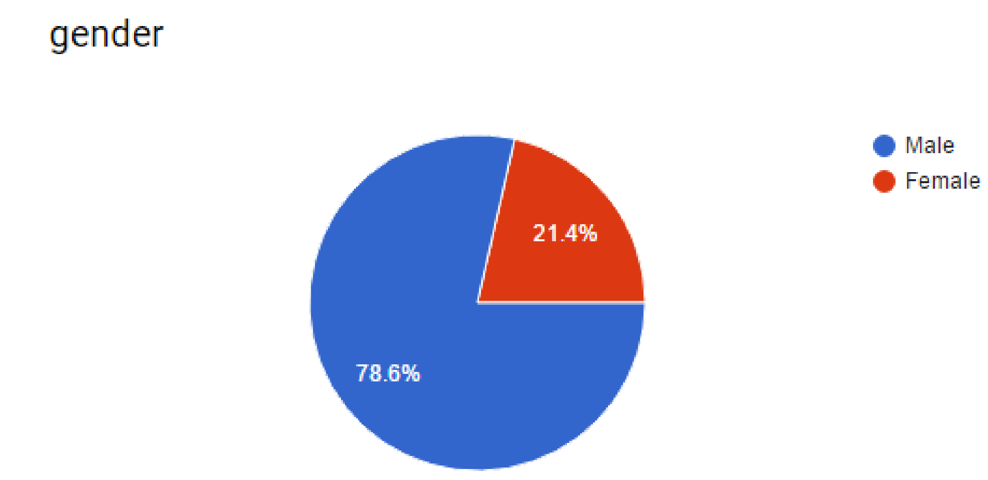


Figure 3.5: The user's gender

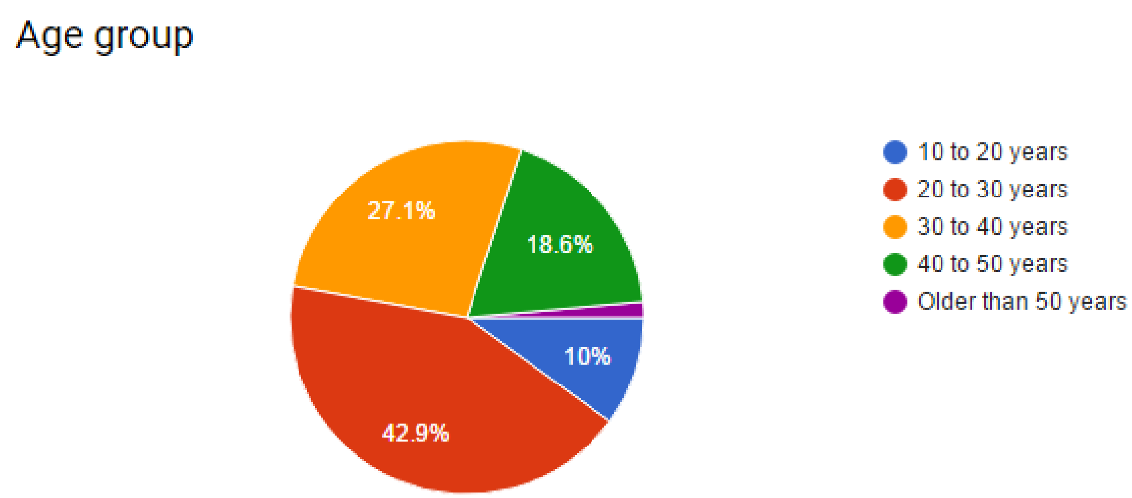


Figure 3.6: The age groups

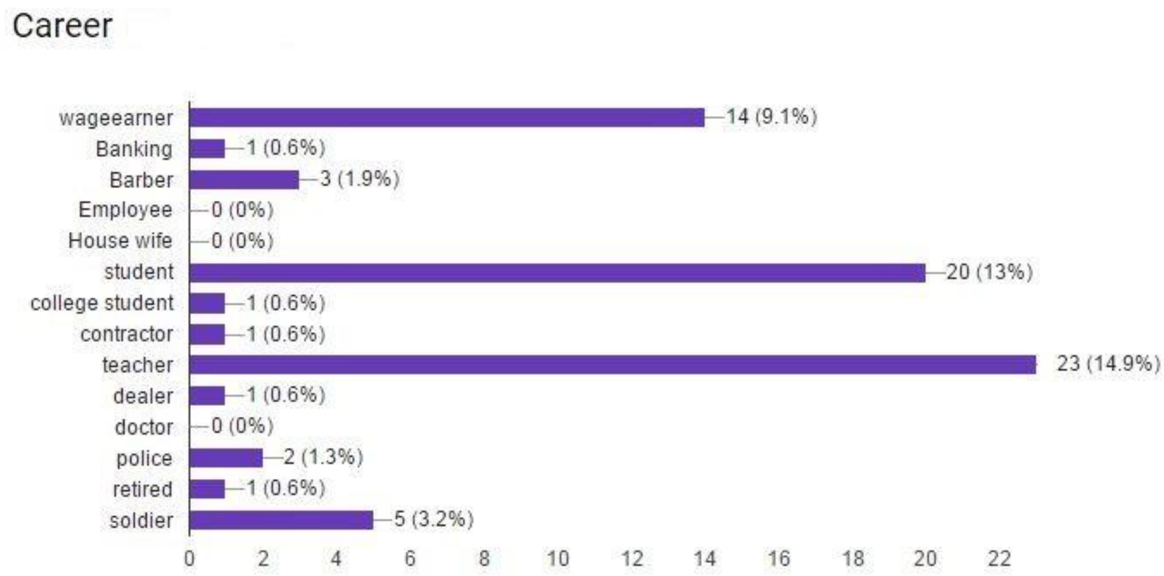


Figure 3.7: The user's career

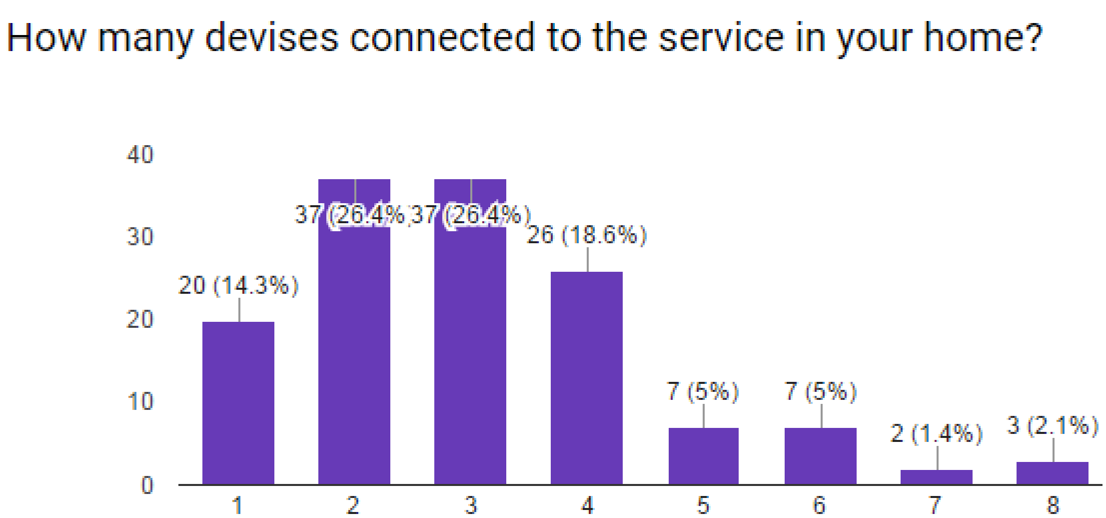


Figure 3.8: The numbers of device that connected

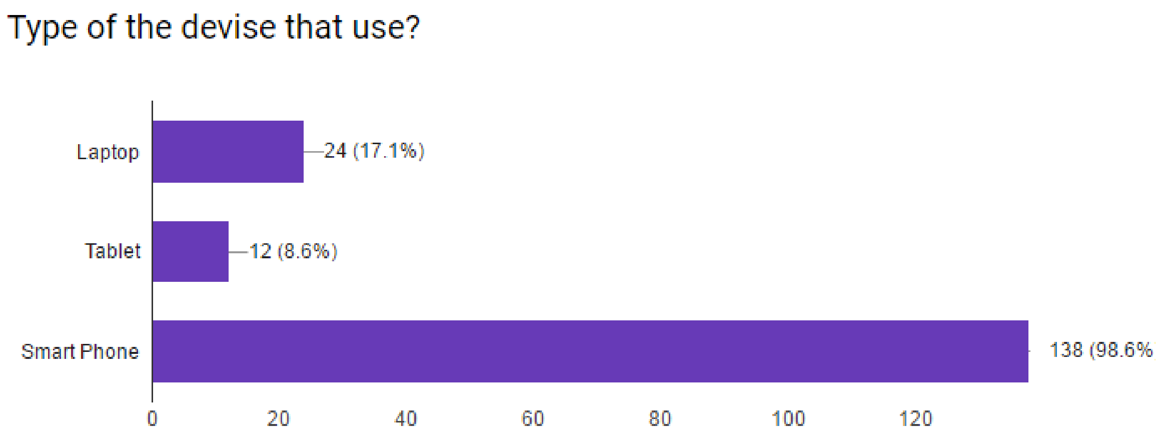


Figure 3.9: The types of the devices

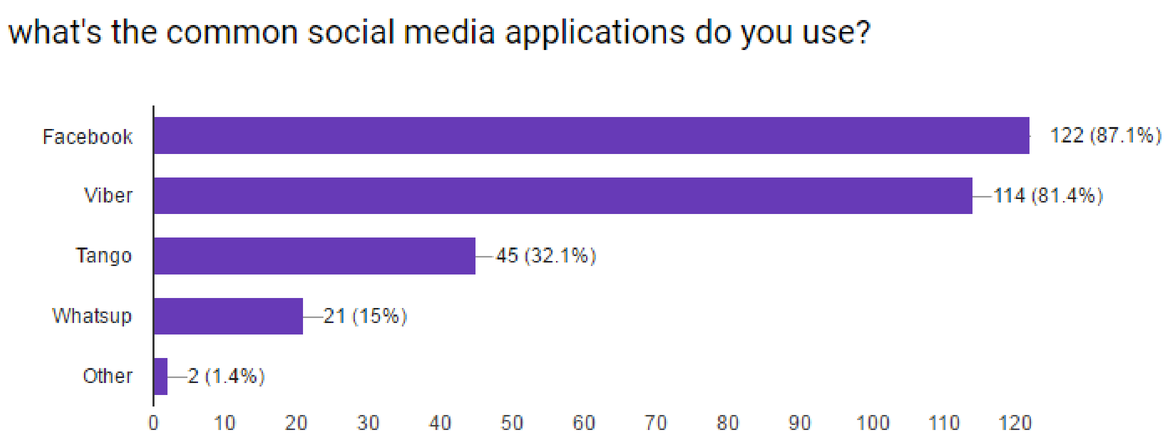


Figure 3.10: The most popular social media applications

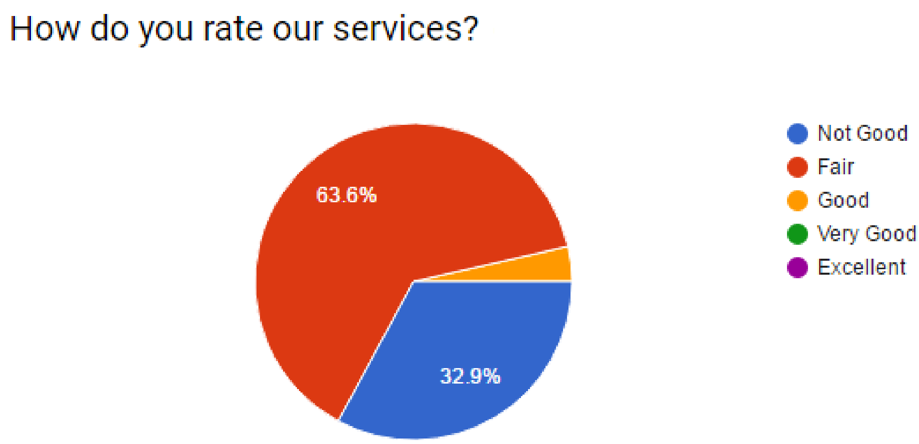


Figure 3.11: The service rates

Users Information

Dear our agent this form is to evaluate Zanyar's company services of providing internet.

*Required

1. **gender** *

   Mark only one oval.

   - ( ) Male
   - ( ) Female

2. **Age group** *

   Mark only one oval.

   - ( ) 10 to 20 years
   - ( ) 20 to 30 years
   - ( ) 30 to 40 years
   - ( ) 40 to 50 years
   - ( ) Older than 50 years

3. **Career**

   ____

4. **How many devises connected to the service in your home?** *

   ____

5. **Type of the devise that use?** *

   Tick all that apply.

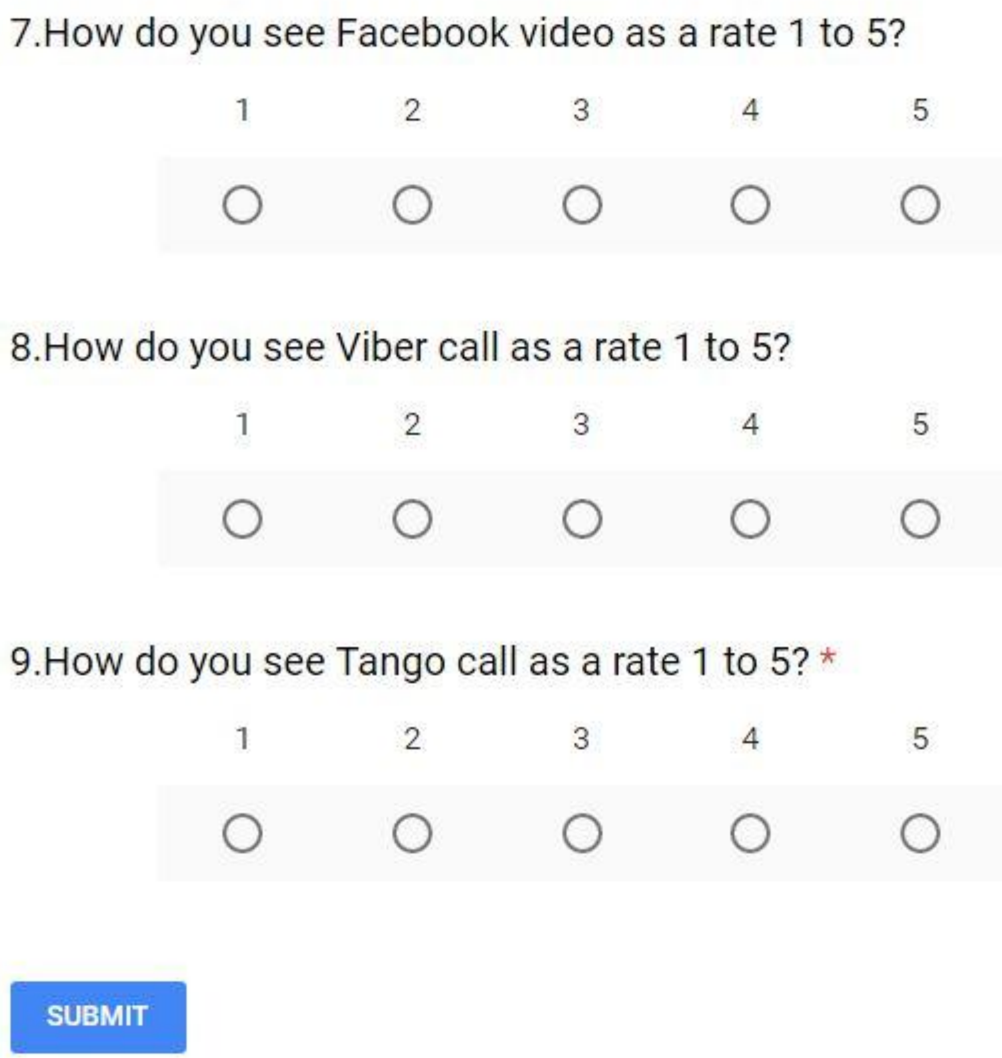
   - [ ] Laptop
   - [ ] Tablet
   - [ ] Smart Phone

6. **what's the common social media applications do you use?** *

   Tick all that apply.

   - [ ] Facebook
   - [ ] Viber
   - [ ] Tango
   - [ ] Whatsup
   - [ ] Other: ____________________

Figure 3.12: The user information form part 1



7.How do you see Facebook video as a rate 1 to 5?

1 2 3 4 5

8.How do you see Viber call as a rate 1 to 5?

1 2 3 4 5

9.How do you see Tango call as a rate 1 to 5? *

1 2 3 4 5

SUBMIT

Figure 3.13: The user information form part 2

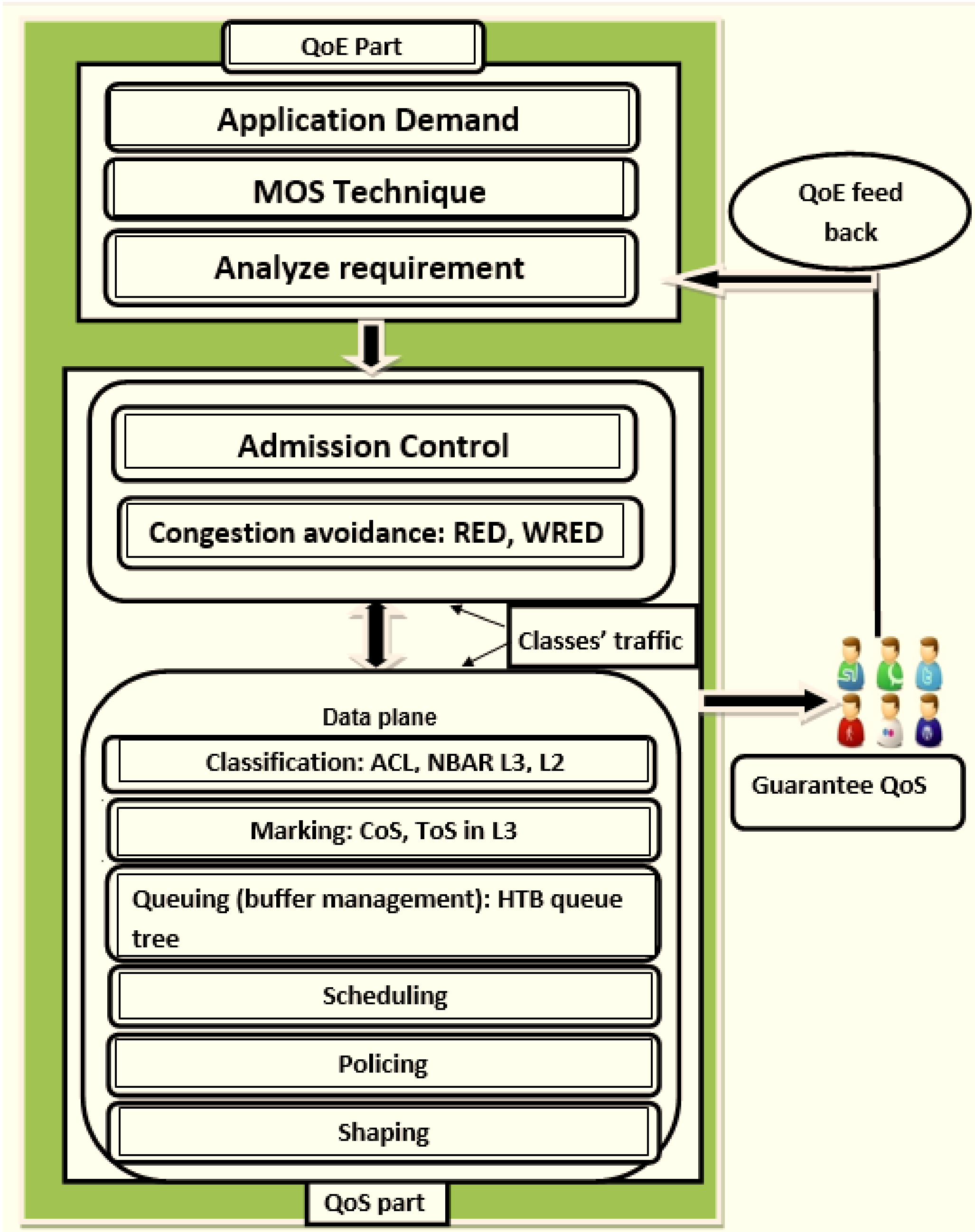


Figure 3.14: The Framework main structure detail

3.4On the Provisioned Benefit from Using the QoE

The proposed general framework for QoE enhancement is expected to be advantageous for various networks for optimum efficiency, whether the network is for an ISP, an enterprise, or a small corporation. Different categories of networking users such as major enterprises, network service providers and small and medium-sized business networking users have their own QoS-QoE requirements; in many areas, though, these requirements overlap Enterprise networks must prepare end-to-end QoE solutions across the various platforms comprising the network. Providing solutions for heterogeneous platforms often requires taking a different QoS-QoE configuration approach for each technology.

ISPs require assured scalability and performance. ISPs that long have offered best-effort IP connectivity now also transfer voice, video, and other real-time critical application data. The proposed QoE frame work is aimed to answer the scalability and performance needs of these ISPs to distinguish different kinds of traffic, thereby enabling them to offer service differentiation to their customers.

For many years ICT companies have focused their hard work to improve QoS in order to present continuity of service in a seamless way with the implicit objective to improve the user satisfaction. QoS alone is the result of network parameter measurements that are not indicators of the real user QoE. The QoE perceived by a user is very difficult to be measured, if compared to QoS. It depends on a subjective perception related to a human behavior which is, usually, a non-linear, non-stationary and stochastic process.

However, QoS plays a key role in determining QoE, but usually QoS is not adequate to know the user perceived QoE. Given the same QoS, QoE changes from a user to another. Using QoS mechanisms in a network does not always lead to improved QoE results. However, QoS correlates closely with QoE. In addition, in our proposed framework, we use QoS techniques as means of getting better QoE. A wide range of factors have effect on achiving QoE. It is, therefore, essential for national ISPs to measure QoE parameters in order to keep them above a confident limit. They should also know how measured QoE parameters may affect QoS mechanisms.

As is known to all, the end-users dictate the success or failure of any service. So, services providers should satisfy their customers' needs by offering high-efficiency services in order to prevent user churn and save profits.

The term of network delivery capacity and resource availability do not mean satisfaction to the end-user, but they can generally be thought as a definition of the measurements and provisioning of the quality of service. The fundamental assumption behind such traditional provisioning is that the measured QoS is closely related to the QoE for the end user.

3.5 Summary

In this chapter, our proposed general QoE framework structure has been explained, and many related issues have been highlighted. In both QoS and QoE parts of the proposal. The questionnaire survey has been present in details and show the subscribers concerns. We have tried to maintain the generality of the proposed framework so that different (national) ISPs can tailor the framework according to their special network characteristics and users' needs. A real life implementation is described in the next chapter to investigate and analyze the effectiveness of the proposed framework in enhancing QoE for new emerging social network applications. The considered ISP network provides services to about 3000 users.

Chapter Four

Real life Application of the Proposed Framework

Chapter four

Real life Application of the Proposed Framework

4.1 Introduction

In this chapter, we consider a specific national ISP (Zanyar Electronics Company) network as a real-life application for investigating our proposed approach for QoE enhancement. We begin by describing the main network structure of the considered ISP presents, and then investigating the most important problems in this ISP network and solutions for all these problems. Next, we present the implementation of the proposed framework on both sides of QoE and QoS. The results of QoE feedback before and after implementing the required scripts are discussed. Moreover the scripts' details are explained, especially the script implemented on the main server side that affects the entire network.

4.2 Overview of the Considered Real life Network

Zanyar Electronics Company established in 2005 in Khanaqin city. Nowadays, Zanyar Co. has become one of the leading communication and technologies Services Company in the whole city. Zanyar Services include telecommunications solutions and providing internet service as internet service becomes an important service for all customers and still increasing comparing to the other services from 2005 to 2016. The company and their staff are trying to get the best solution for its own service.

However, recently Zanyar Company has expanded its services to other cities. Along with its expansion, the company has provided up-to-dated technologies, new modern devices, and towers. Zanyar ISP covers a large geographic area which includes three cities and four towns. The company staff understands the importance of getting the most possible benefits of their network infrastructure; hence, they well appreciate the necessity of exploitation of QoE solutions in order to satisfy their costumers (end users).

The Internet access source of this company comes through optical fiber cable with the ability to transfer 10GB, in which the source is far from Khanaqin city around 15Km. The optical fiber is Super-Mini Type 2 Core Fiber Optic Cable. This optical fiber cable is connected to CTC union Gigabit Ethernet Switch that can support QoS, Traffic classification QoS, CoS, bandwidth control for Ingress and Egress, Storm Control, and DiffServ.

The whole network (See Figure 4.1 for the main network structure) of the company is managed by a leading main server Mikrotik CCR1016 Cloud Core Router which can manage many millions of packets per second. The cloud core router is powered by RouterOS, Dynamic routing, hotspot, firewall, MPLS, VPN, advanced quality of service, load balancing and bonding, real-time configuration and monitoring. To connect the entire network from the first main tower to the second main tower inside the city, many microwaves dishes have been used, as follows:

- Microwaves Antenna Mimosa B11
- Microwave antenna Exalt model E11E732-KIT
- Mimosa B5c radio
- InfiLINK XG is InfiNet’s
- Rocket Dish an airMAX

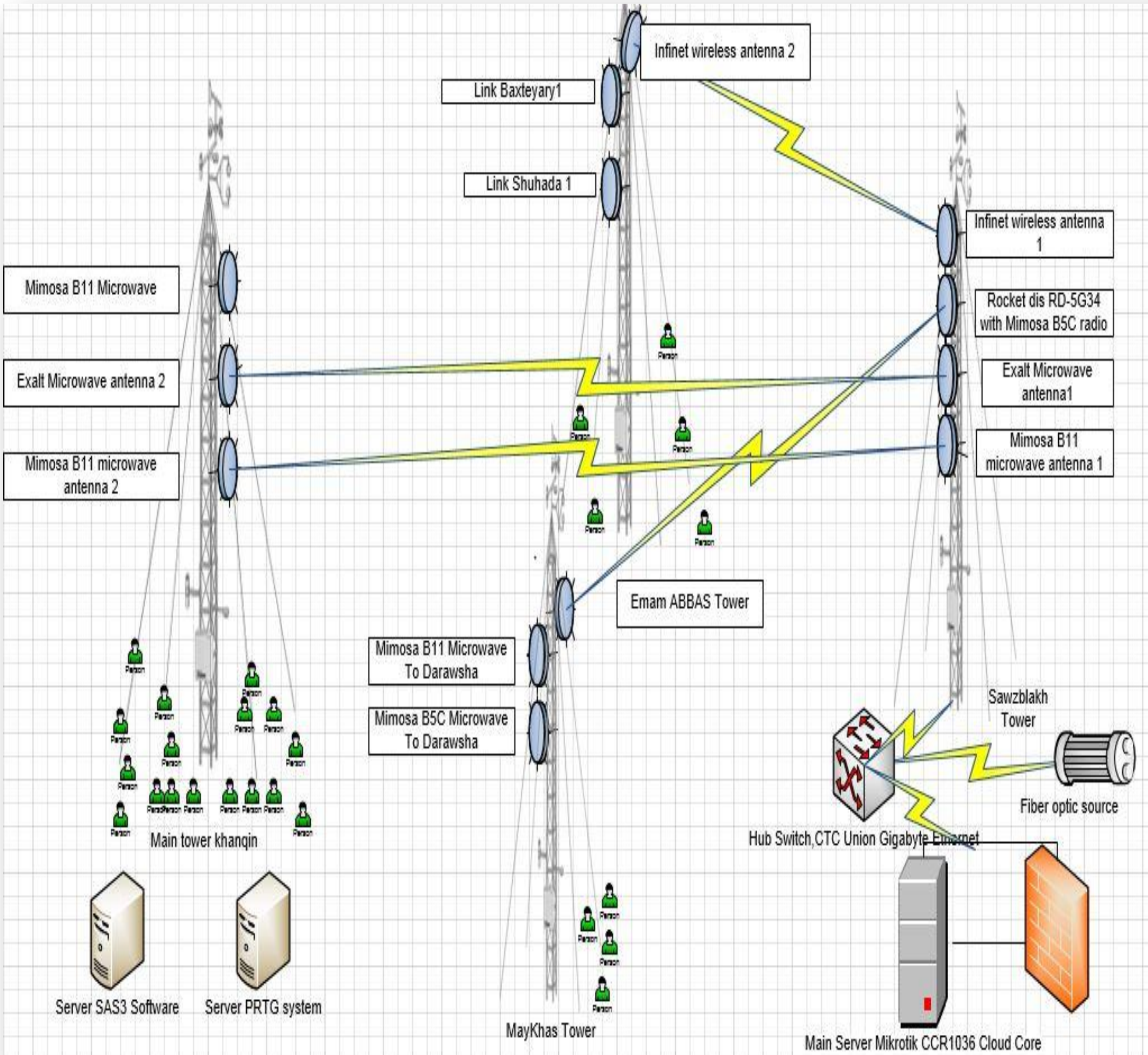


Figure 4.1: Zanyar Company main network structure.

4.3Real life Challenges and their Solutions

With these developments in the company work, the challenges become more difficult. In the recent five years, the revolution of smart phones, tablets and the social media applications has significantly increased the need of internet services to communicate among people. Therefore, it can be realized that users could simply be unsatisfied and depressed from the internet service.

In order to have a clear idea on the real situation, which we think it is a typical case for other national ISPs, we have to consider various concerns and issues related to QoS and hence QoE. Based on this understanding, a complete revision for all infrastructure aspects might be necessary to reach end user satisfaction. The details of most important challenges facing the considered ISP network and adopted solutions can be found in Appendix A. Here, we only give a summary on some, as follows:

- **Power supply problem:** In the city where the ISP is located, there is massive power fault which can cause significant service interrupts hence packets lose. This can damage QoS and QoE. So, efficient voltage regulation and reliable secondary power supply facilities have been installed.
- **Network structure:** The company network is used to use three main servers with restricted IP address domains connected by VPN. In addition, all sub tower that cover blocks of the city used to have one range of IP address. This layer 2 network IP address configuration had caused a lot of bottlenecks inside the network. Thus, the network has been updated to layer 3 configuring which means using many ranges of IP addresses. Moreover, network administration issues have been tracked using one main leading server.
- **Security risks in entire network:** As there were different network sectors, usernames and passwords were not unique because each sector is separated. To enhance network security, one powerful system has been deployed to manage accounting, authentication, authorization, billing issues, which is the SAS3 software.
- **Monitoring problems:** Previously, the process of the network monitoring was done by checking each network sector manually or by using simple software. This way was not very efficient because of the time required for error detection or sector down failures. A more efficient and sophisticated

system has been deployed for automatic detection and diagnosis of errors very fast by using PRTG Monitoring system checked entire networks every 30 second.

- **Frequency Noise Problems:** This is a familiar problem for national ISPs due to lack of national ISPs managing, controlling and dividing frequency range. Thus, national ISPs usually are suffering from noise and interference problems from other ISPs and various sources. The company default broadcast frequencies were limited and most of these frequencies had been affected by noise and interference. Therefore, company broadcasting channels have been updated from frequency mod **manual-TX power** to frequency mod **super channel.**

4.4 QoE Results before Framework Application

After all these improvements in the ISP network, our proposed QoE framework has been applied to improve the QoE for end users through better configuration of the QoS parameters. However before doing that, we have collected a first round feedback from end users about their satisfaction on some social network applications. This step is necessary so that we can do fair and constructive comparison with end user opinions after framework application. This section is dedicated to present the results of the feedback of end users before application of the proposed framework. The results of end users feedback after framework application are presented in Section 4.7.

In the first round of QoE evaluation, a questionnaire was distributed to end users. Users' response to the questionnaire has been used as a source to understand QoE level so as to enhance the network services later. Whereas, we found quantitative research approach as the most appropriate approach to be conducted in this thesis due to the nature of the data sources that we have collected from questionnaire and the relation to company resources.

A survey has been conducted to company users to investigate how they use the internet services and which websites and applications mostly needed; the questions were related to the usage of some famous social networking applications. We have focused on Facebook, Viber, and Tango for their popularity among people. In this survey, we have obtained responses from 119 users concerning Facebook and Viber applications, while we collected 100 users' responses for Tango. The obtained usage results are as follows: For Facebook, 95.8% of users answered yes and 4.2% answered no. For Viber application, 92.4% of them answered Yes and 7.6% No. Finally for Tango application, 32% of them answered Yes and 68% No. These usage results are shown in Figures 4.2, 4.3, 4.4, respectively.

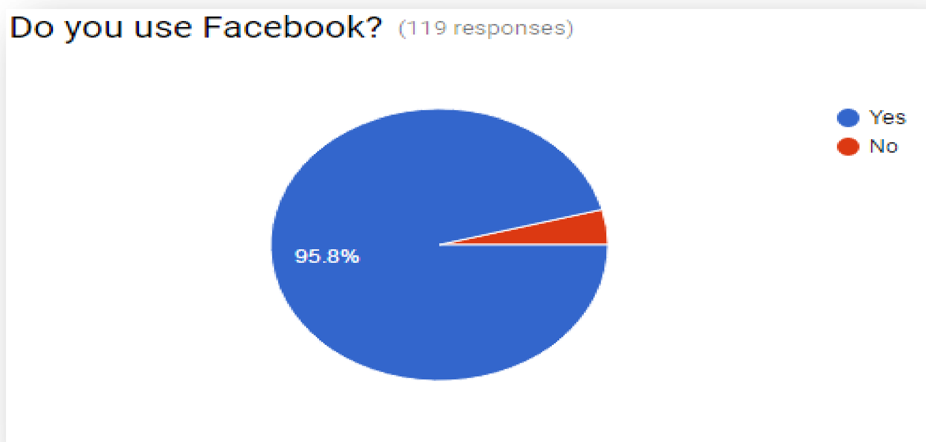


Figure 4.2: Facebook Usage QoE survey

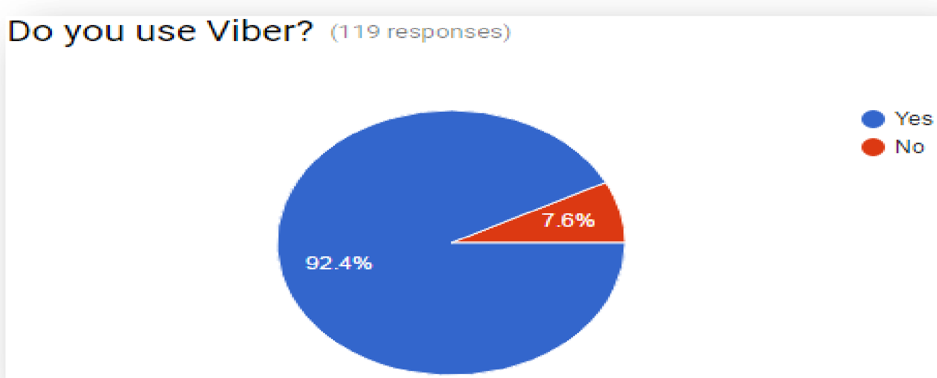


Figure 4.3: Viber Usage QoE survey.

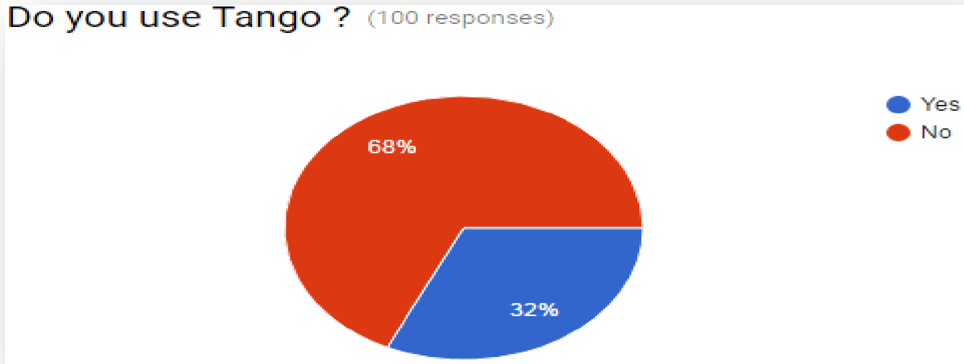


Figure 4.4: Tango Usage QoE survey.

Moreover, we have collected feedback from end users about the level of satisfaction on these social services and analyzed the results. Subjective mechanisms (namely MOS) have been applied. Feedback can be obtained online from simple survey documents that can be filled by users for some extra bonus from the ISP. The obtained results are as follows:

- For Facebook questionnaire, 116 users have responded, 26 of them answered for Facebook video rate as Bad (22.4%), 57 users answered Poor (49.1%), 30 users answered Fair (25.9%) , 3 users answered good (2.6%), and no one chose Excellent (0%).

- For Viber questionnaire, we have collected 111 responses, 23 of them answered for Viber call rate as Bad (20.7%), 39 users answered Poor (35.1%), 34 users answered Fair (30.6%), 14 users answer Good (12.6%), and only 1 user answered Excellent (0.9%).

- For Tango questionnaire, 34 users have responded, 8 of them answered for Tango call rate as Bad (23.5%), 8 users answered Poor (23.5%), and 14 users answered Fair (41.2%), 3 users answered Good (8.8%), and only 1 user answered Excellent (2.9%).

The user satisfaction results for Facebook case, Viber case, and Tango case before applying the required framework script code to the network are shown in Figures 4.5, 4.6, 4.7, respectively.

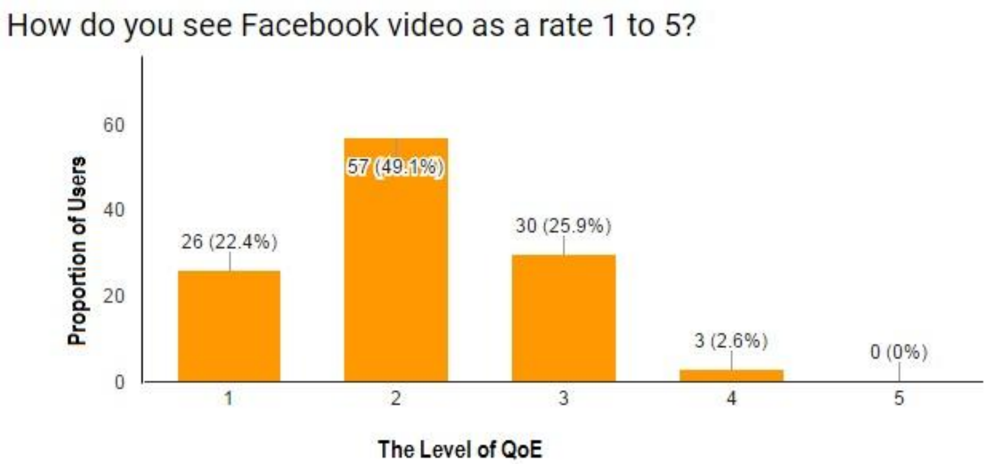


Figure 4.5: Facebook MOS survey before framework deployment.

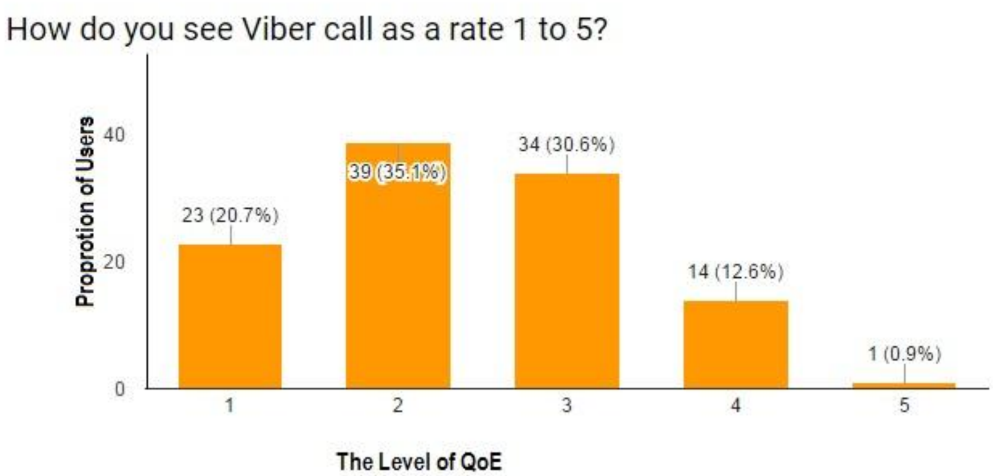


Figure 4.6: Viber MOS survey before framework deployment.

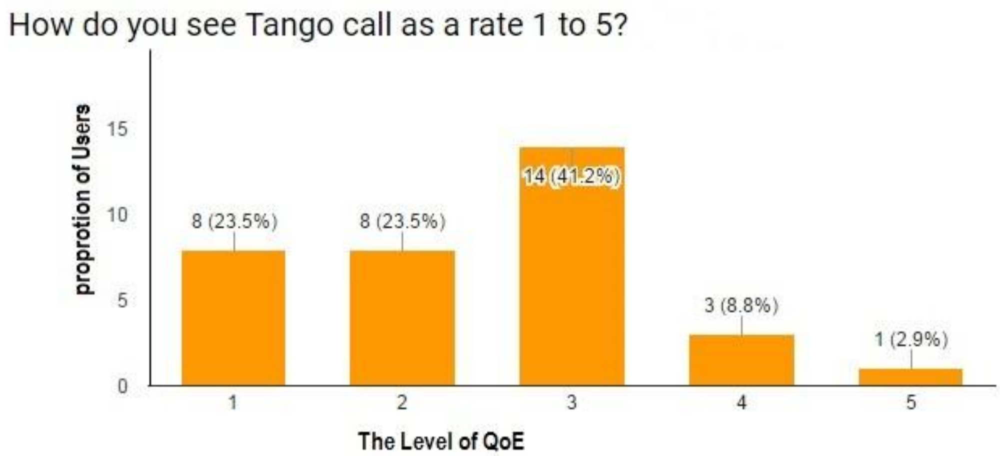


Figure 4.7: Tango MOS survey before framework deployment.

4.5QoS Aspects of Framework Application

One of the many significant features which are provided by the Mikrotik routers system is the ability to differentiate and independently priorities traffic passing through the system based on a wide variety of criteria including source and destination address and port, traffic type and protocol, and even application.

A common requirement taking advantage of this functionality is prioritization of interactive traffic related to real time and multimedia applications (e.g. VoIP and streaming video) over non real time traffic like mail and web. In our proposed framework, we classify, mark and queue for traffics that we want to prioritize from all network traffic and let them pass through our network quickly.

As we mentioned before in our survey, most subscribers in the considered company use social media applications, so we work to prioritize these applications by using QoS concepts and take QoE survey as a source to prioritize most important traffics. For each case, we describe what have been done and what the results of technical aspects and user satisfaction are.

4.5.1 Case 1: Facebook

In Facebook case, a script code has been developed and implemented to classify Facebook traffics that come from Nat section in the firewall and mark them in mangle section in order to prioritize this traffic by giving it a high priority in mangle. Finally, a powerful part in QoS is queuing by using simple queue and tree queue.

- The first, step to implement the script is by putting “ /ip firewall layer7-protocol add comment="" name=facebook regexp="facebook|fbcdn.net" ” in firewall /Layer7 protocols.

- The second, the script “/ip firewall mangle add action=add-dst-to-address-list address-list="Facebook List" \ Address-list-timeout=10m chain=prerouting comment=Facebook dst-port=\ 80,443 layer7-protocol=facebook protocol=tcp add action=mark-Packet chain=forward comment=Facebook new-packet-mark=facebook Pass – through = no src-address-list ="Facebook List"” has been implemented in firewall mangle section.

- The third, the last section is Queuing “/queue simple Add max-limit=3M/3M name="Facebook test" packet-marks=facebook priority=2/2 target=""” and “/queue tree add name=facebook packet-mark=facebook parent=global queue=default” has been implemented in Queue section.

All operations that have been implemented in the sectors on sub towers are described in Figures 4.8, 4.9, 4.10, 4.11, 4.12, and 4.13 below.

```
Initialize /ip firewall

 Add comment=""

Initialize / layer7-protocol

Set name =facebook
Set regexp ="facebook|fbcdn.net"
Initialize /ip firewall mangle
Add action=add-dst-to-address-list
Set address-list="Facebook List" \
Set address-list-timeout=10m
Set chain=prerouting
Set comment=Facebook
Set dst-port= 80,443
Set layer7-protocol=facebook
Set protocol=tcp
Add action=mark-packet chain=forward
Set comment=Facebook
Set new-packet-mark=\
Set facebook passthrough=no
Set src-address-list="Facebook List"
Initialize /queue tree
Add name=facebook
Set packet-mark=facebook
Set parent=global
Set queue=default
Initialize/queue simple
Add max-limit=2M/2M
Set name="Facebook test"
Set packet-marks=facebook
Set priority=2/2 target=""
```

Figure 4.8: The Facebook pseudo code.

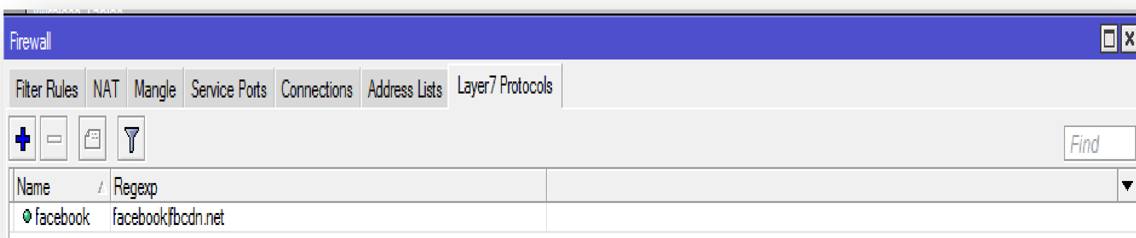


Figure4.9: Mikrotik firewall layer7 protocols (the Facebook case).

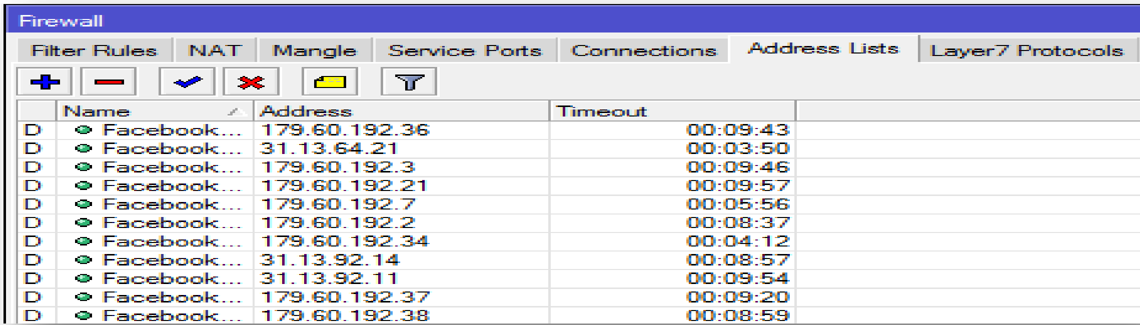


Figure 4.10: Mikrotik firewall Address List (the Facebook case).

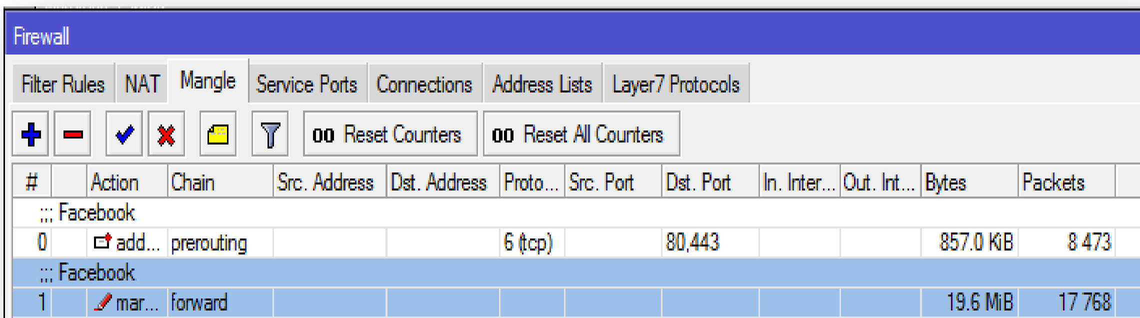


Figure 4.11: Mikrotik firewall Mangle (the Facebook case).

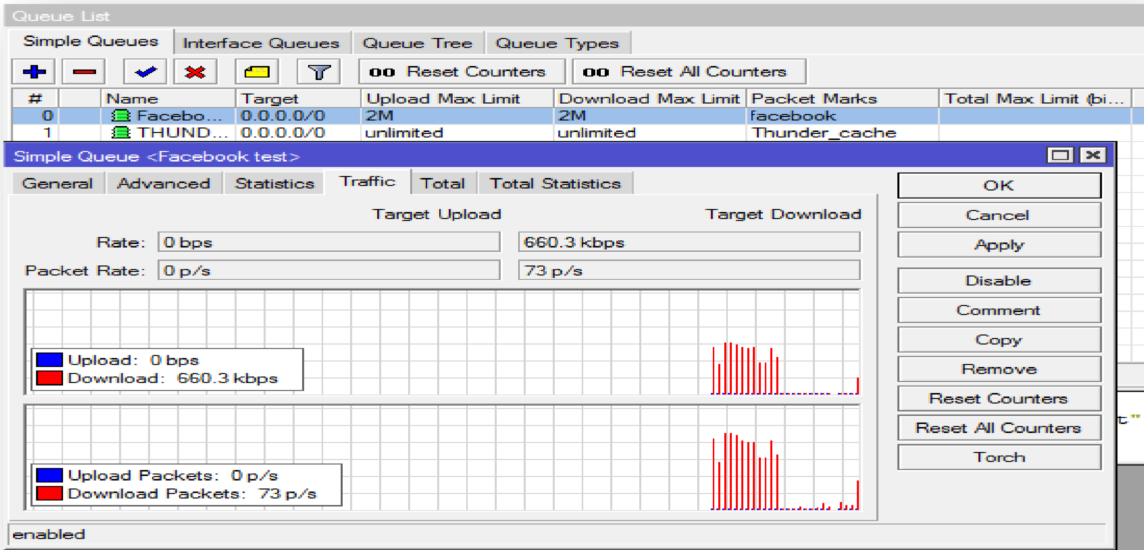


Figure 4.12: Mikrotik Queue List simple Queue (the Facebook case).

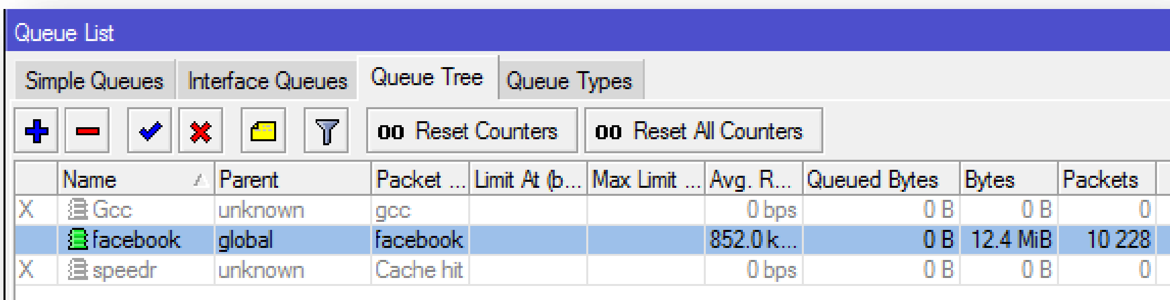


Figure 4.13: Mikrotik Queue List Queue Tree (the Facebook case).

Before the implementation of the required Facebook script, the jitter in the traffic was high, as it is shown in Figure 4.14 inside sector. But after we apply the required script, the jitter become in lowest degrees, as shown in Figure 4.15.

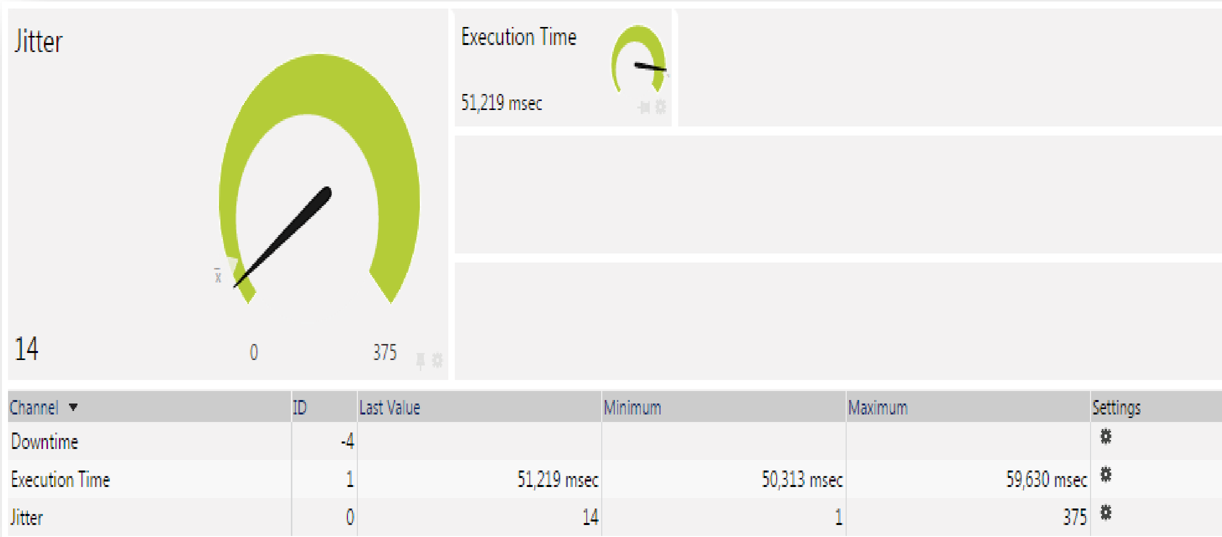


Figure 4.14: PRTG system monitoring jitter ping before apply script (the Facebook case).

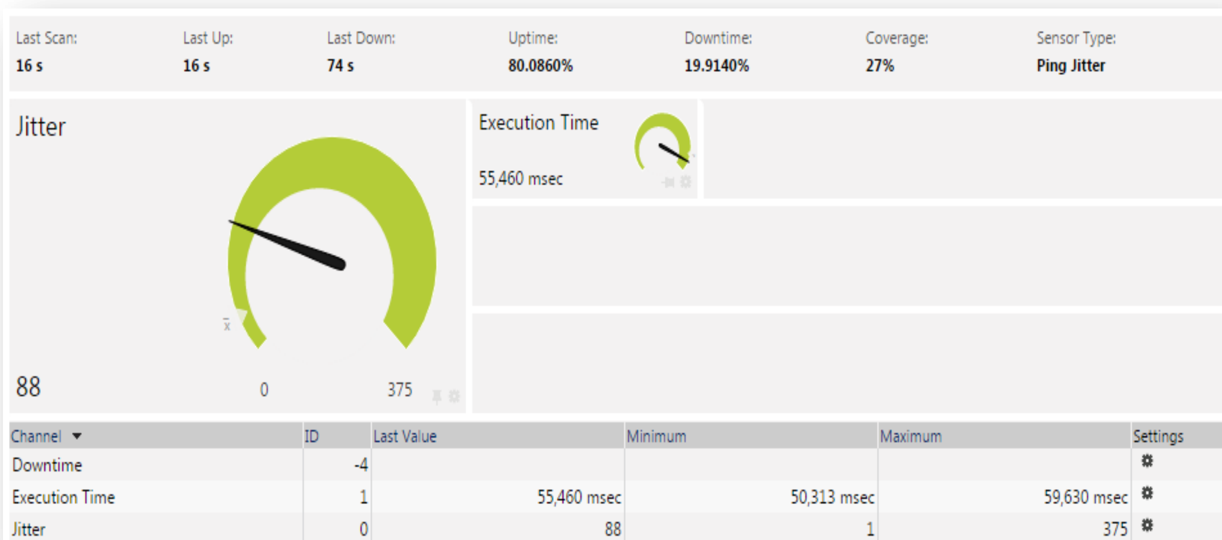


Figure 4.15: PRTG system monitoring jitter ping after apply script (the Facebook case).

4.5.2 Case 2: Viber

In viber case, a script code has been developed and implemented to classify Viber traffics that come from Nat section in the firewall and mark them in mangle section in order to prioritize the traffic by giving it high priority in mangle. Finally, a powerful part in QoS concepts is queuing by using simple queue and tree queue together.

- The first step to implement the script is by putting “/ip firewall layer7-protocol add name= viber regexp=viber|viber.com” in firewall /Layer7 protocols.
- The second, the script “/ip firewall mangle add action=add-dst-to-address-list address-list="Viber List" address-list-timeout=10m chain=prerouting comment="Viber 1" layer7-protocol=viber protocol=tcp add action=mark-packet chain=forward comment="Viber 2" new-packet-mark=viber pass-through=no src-address-list="Viber List"” has been implemented in firewall mangle section.
- The third, the last section is Queueing” /queue simple add max-limit=2M/2M name="Viber test" packet-marks=viber priority=1/1 target="" and “/queue tree add name=viber packet-mark=viber parent=global queue=default” has been implemented in Queue section.

All these operations begin with a script that is divided into two main sections which are firewall and queue to be properly applied for the suitable traffic, as described in figures 4.16, 4.17 4.18, 4.19, 4.20, 4.21below.

```
Initialize / ip firewall

Initialize layer7-protocol

Add comment =""
Set name =Viber
Set regexp =" viber|viber.com"

Initialize /ip firewall mangle
Add action=add-dst-to-address-list
Set address-list="Viber List" \
Set address-list-timeout=10m
Set chain=prerouting
Set comment="Viber 1 "
Set layer7-protocol=Viber
Set protocol=tcp
Add action=mark-packet chain=forward
Set comment="Viber2 "
Set new-packet-mark= viber
Set passthrough=no
Set src-address-list="Viber List"
Initialize /queue tree
Add name= viber
Set packet-mark= viber
Set parent=global
Set queue=default
Initialize/queue simple
Add max-limit=2M/2M
Set name="Viber test"
Set packet-marks=viber
set priority=2/2 target=""
```

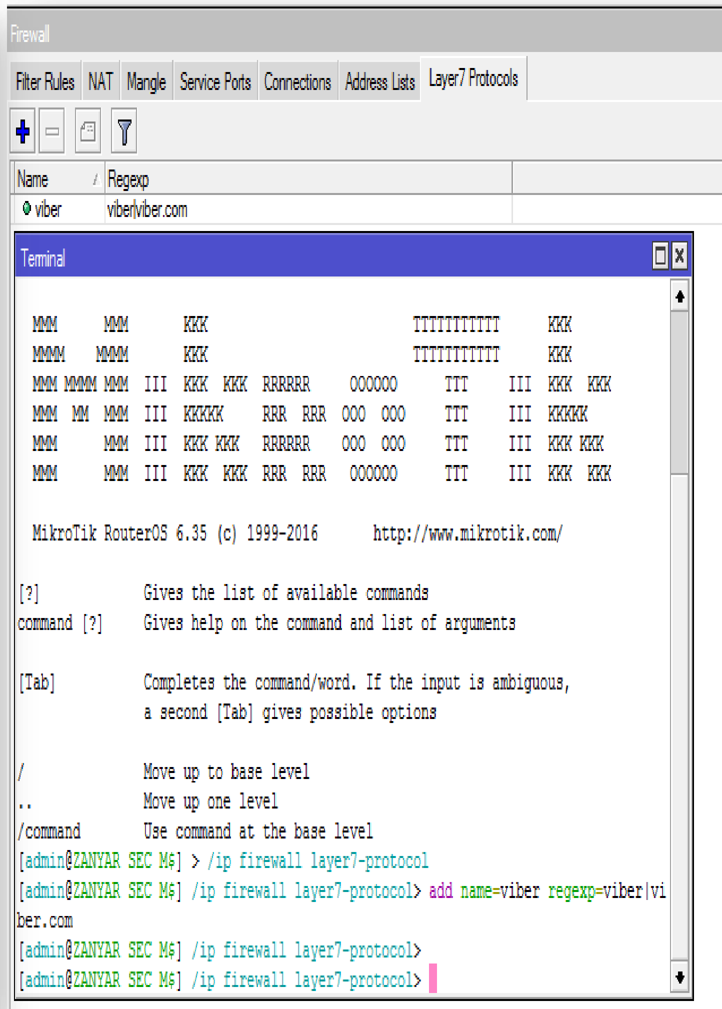
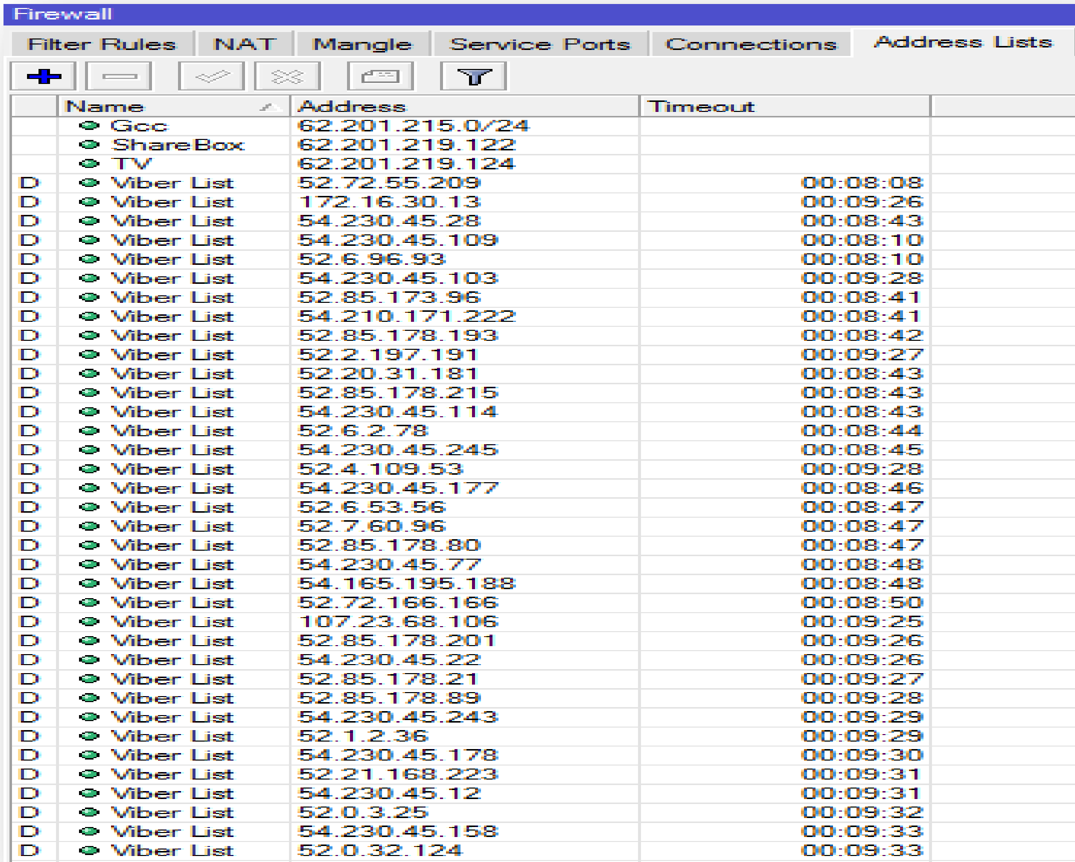


Figure 4.16: The Viber pseudo code.

Figure 4.17: Mikrotik Firewall Layer7 Protocol Viber

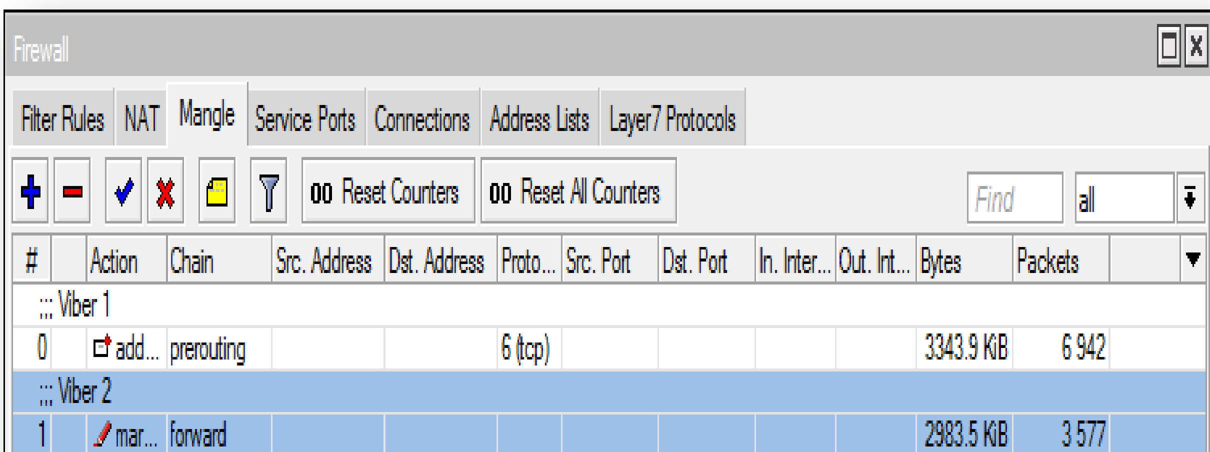


Firewall

Filter Rules | NAT | Mangle | Service Ports | Connections | Address Lists

	Name	Address	Timeout
	Gcc	62.201.215.0/24	
	ShareBox	62.201.219.122	
	TV	62.201.219.124	
D	Viber List	52.72.55.209	00:08:08
D	Viber List	172.16.30.13	00:09:26
D	Viber List	54.230.45.28	00:08:43
D	Viber List	54.230.45.109	00:08:10
D	Viber List	52.6.96.93	00:08:10
D	Viber List	54.230.45.103	00:09:28
D	Viber List	52.85.173.96	00:08:41
D	Viber List	54.210.171.222	00:08:41
D	Viber List	52.85.178.193	00:08:42
D	Viber List	52.2.197.191	00:09:27
D	Viber List	52.20.31.181	00:08:43
D	Viber List	52.85.178.215	00:08:43
D	Viber List	54.230.45.114	00:08:43
D	Viber List	52.6.2.78	00:08:44
D	Viber List	54.230.45.245	00:08:45
D	Viber List	52.4.109.53	00:09:28
D	Viber List	54.230.45.177	00:08:46
D	Viber List	52.6.53.56	00:08:47
D	Viber List	52.7.60.96	00:08:47
D	Viber List	52.85.178.80	00:08:47
D	Viber List	54.230.45.77	00:08:48
D	Viber List	54.165.195.188	00:08:48
D	Viber List	52.72.166.166	00:08:50
D	Viber List	107.23.68.106	00:09:25
D	Viber List	52.85.178.201	00:09:26
D	Viber List	54.230.45.22	00:09:26
D	Viber List	52.85.178.21	00:09:27
D	Viber List	52.85.178.89	00:09:28
D	Viber List	54.230.45.243	00:09:29
D	Viber List	52.1.2.36	00:09:29
D	Viber List	54.230.45.178	00:09:30
D	Viber List	52.21.168.223	00:09:31
D	Viber List	54.230.45.12	00:09:31
D	Viber List	52.0.3.25	00:09:32
D	Viber List	54.230.45.158	00:09:33
D	Viber List	52.0.32.124	00:09:33

Figure 4.18: Mikrotik firewall Address List (the Viber case).



Firewall

Filter Rules | NAT | Mangle | Service Ports | Connections | Address Lists | Layer7 Protocols

00 Reset Counters | 00 Reset All Counters | Find | all

#	Action	Chain	Src. Address	Dst. Address	Proto...	Src. Port	Dst. Port	In. Inter...	Out. Int...	Bytes	Packets
;;; Viber 1											
0	add...	prerouting			6 (tcp)					3343.9 KiB	6 942
;;; Viber 2											
1	mar...	forward								2983.5 KiB	3 577

Figure 4.19: Mikrotik Firewall Mangle (the Viber case).

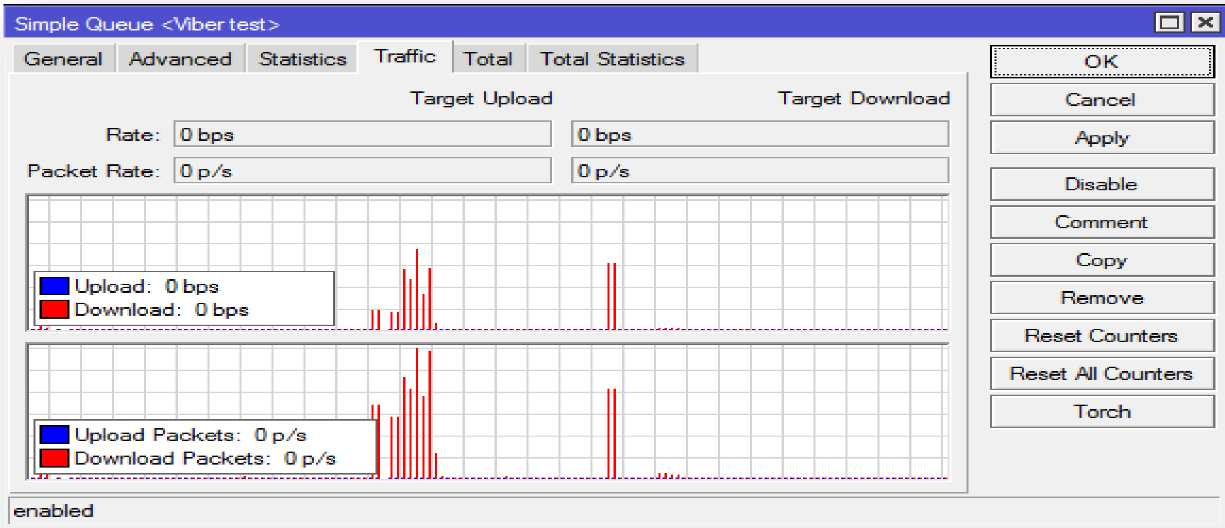


Figure 4.20: Mikrotik Queue List simple Queue (the Viber case).

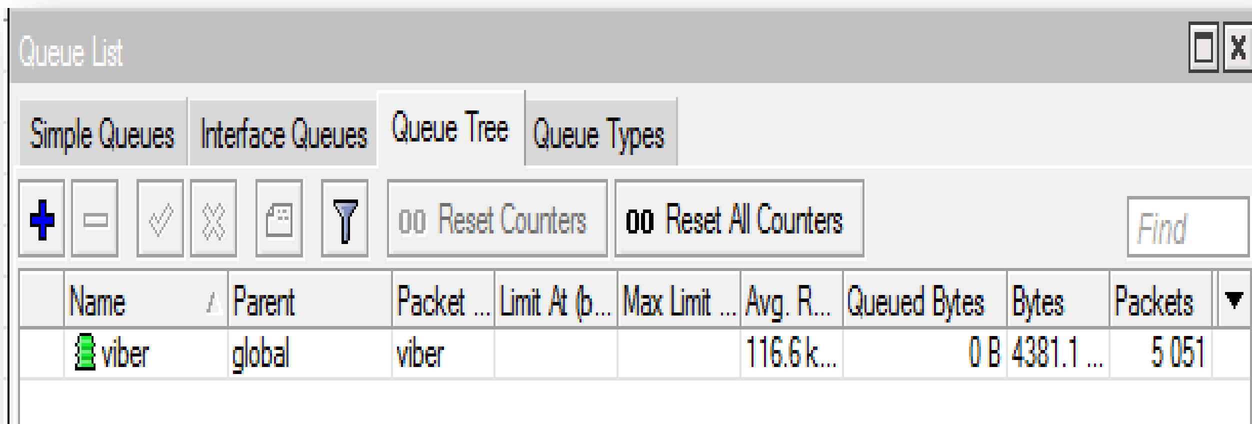


Figure 4.21: Mikrotik Queue List Queue Tree (the Viber case).

Before implementing the developed script, the jitter in the traffic was high inside the sector, as shown in Figure 4.22. But after we have applied the script, the jitter become in lowest degrees, as shown in Figure 4.23.

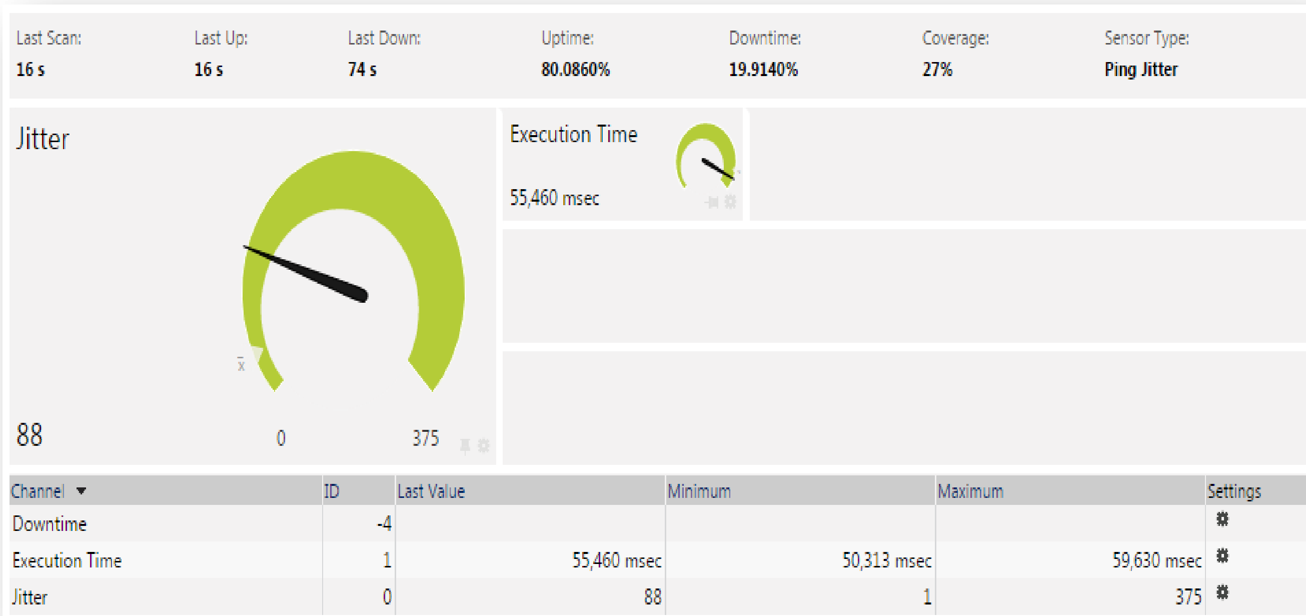


Figure 4.22: PRTG system monitoring jitter ping before apply script (the Viber case).

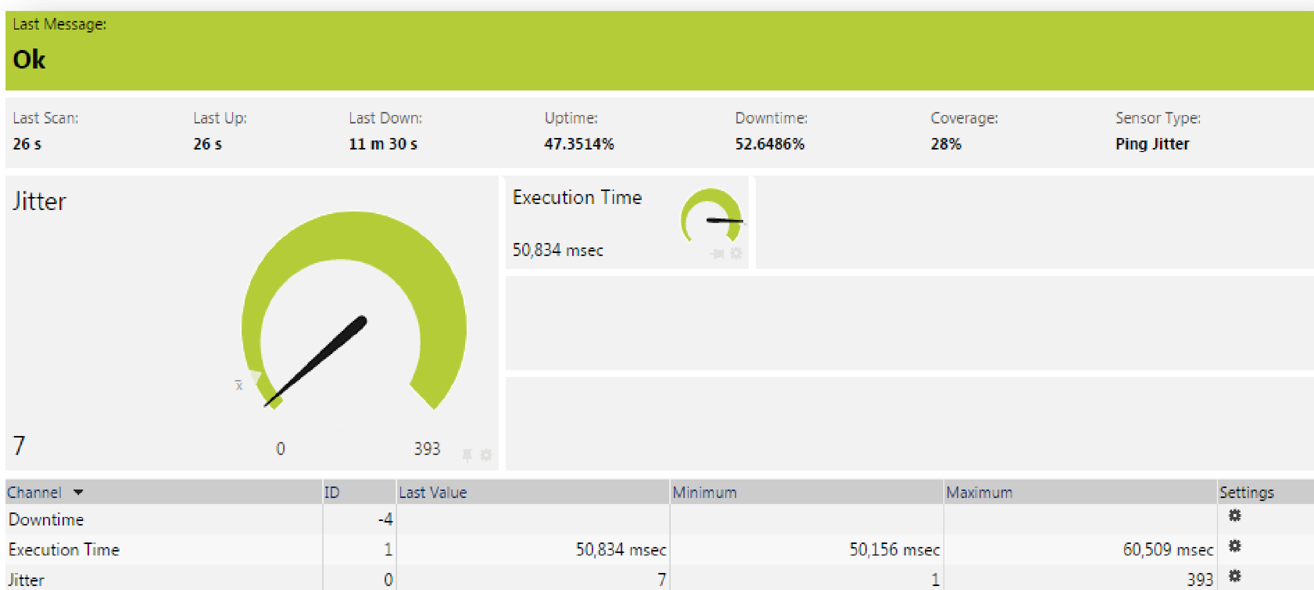


Figure 4.23: PRTG system monitoring jitter ping after apply script (the Viber case).

4.5.3 Case 3: Tango

For the Tango case, a script code has been developed and implemented to classify tango traffics that come from Nat section in the firewall and mark these traffics in mangle section in order to prioritize the traffic by giving it high priority in mangle. In addition, in queuing section we have used both simple queue and tree queue.

- The first step to implement the script “/ip firewall layer7-protocol add name=tango regexp=tango|tango.me “in firewall /Layer7 protocols.
- The second step is applying this script “/ip firewall mangle add action=add-dst-to-address-list address-list="Tango List" address-list-timeout=10m chain=prerouting comment="Tango 1" layer7-protocol=tango protocol=tcp add action=mark-packet chain=forward comment="Tango 2" new-packet-mark=tango pass-through=no src-address-list="Tango List" ” in firewall mangle section.
- The third step is applying these scripts “/queue simple add max-limit=1M/1M name="Tango test" packet-marks=tango priority=1/1 target=""” and “/queue tree add name=tango packet-mark=tango parent=global queue=default” in Queue section.

All these implementation steps for the Tango case are shown in figures 4.24, 4.25, 4.26, 4.27, 4.28 and 4.29, below respectively.

Pseudo Tango code

```
Initialize / ip firewall

Initialize layer7-protocol

add comment=""
Set name=Tango
set regexp =" tango|tango.me"
Initialize /ip firewall mangle
Add action=add-dst-to-address-list
Set address-list="Tango List"
Set address-list-timeout=10m
Set chain=prerouting
Set comment="Tango 1 "
Set layer7-protocol=tango
Set protocol=tcp
Add action=mark-packet chain=forward
Set comment="Tango 2 "
Set new-packet-mark= tango
Set passthrough=no
Set src-address-list="Tango List"
Initialize /queue tree
Add name= tango
Set packet-mark= tango
Set parent=global
Set queue=default
Initialize/queue simple
Add max-limit=1M/1M
Set name="Tango test"
Set packet-marks= tango
Set priority=1/1 target=""
```

Figure 4.24: The Tango pseudo code.

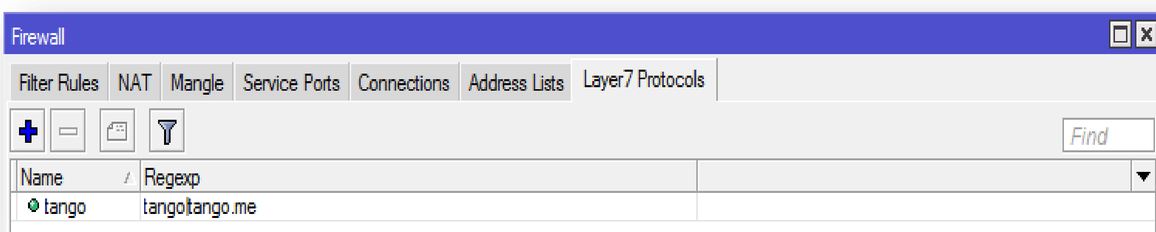


Figure 4.25: Mikrotik Firewall Layer7 Protocols (the Tango case).

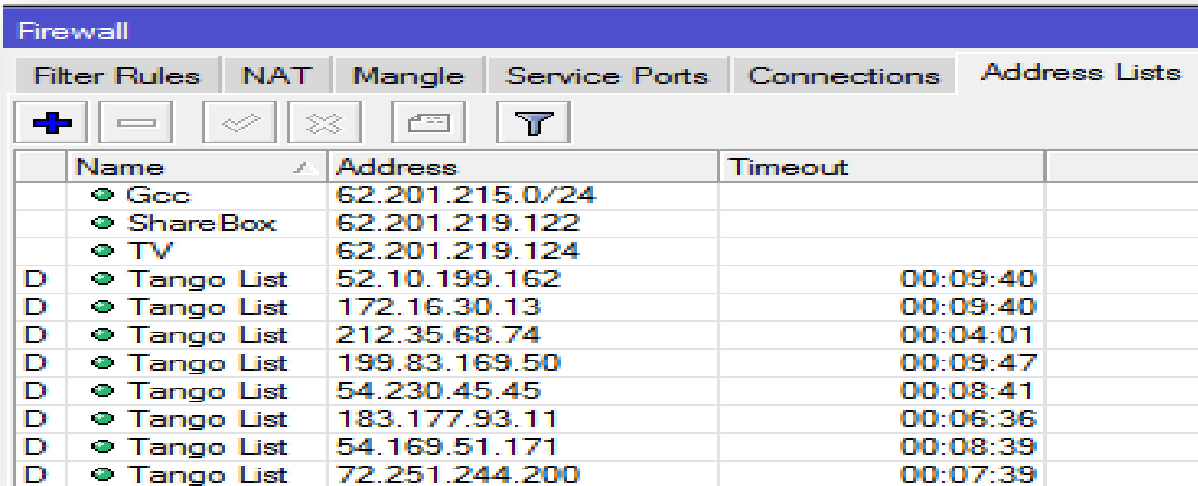


Figure 4.26: Mikrotik firewall Address List (the Tango case).

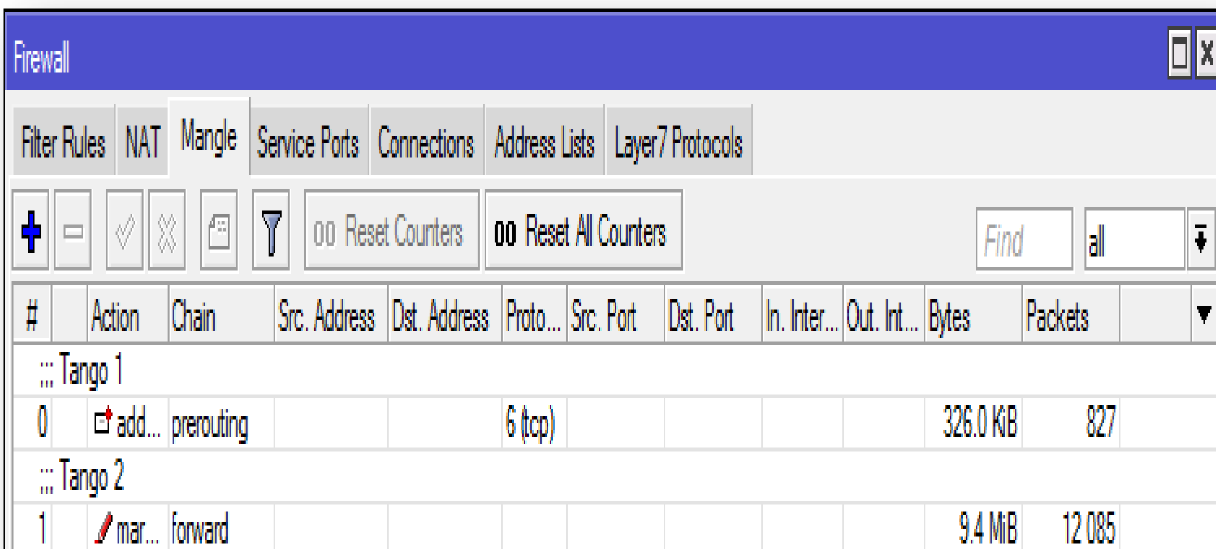


Figure 4.27: Mikrotik Firewall Mangle (the Tango case)

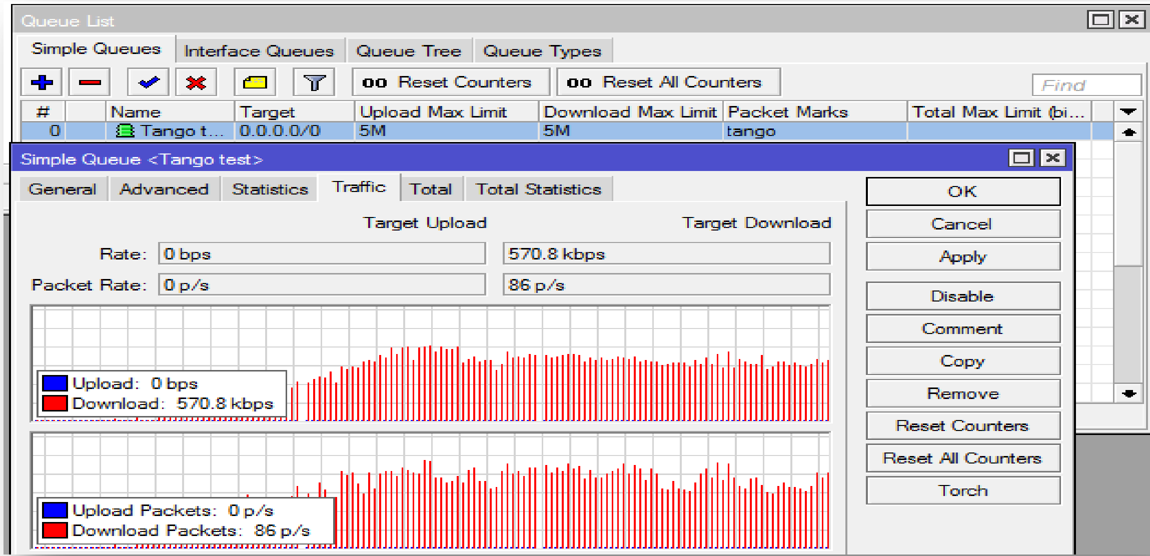


Figure 4.28: Mikrotik Queue List Simple Queue (the Tango case).

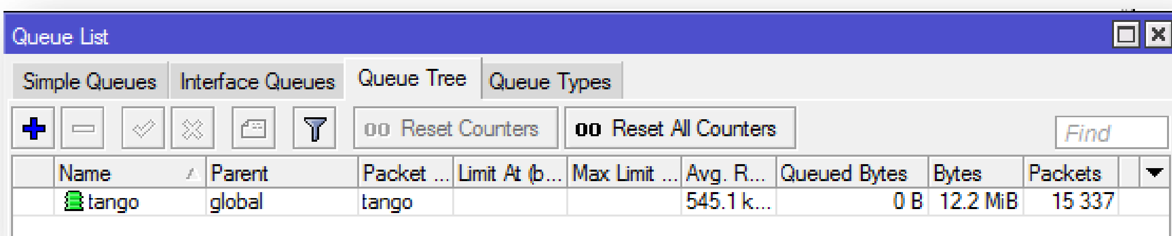


Figure 4.29: Mikrotik Queue List Queue Tree (the Tango case)

Before the required Tango script was implemented, the jitter in the traffic was high in the sector, as shown in Figure 4.30. But after the script has been applied, the jitter became in lowest degrees, as shown in Figure 4.31.

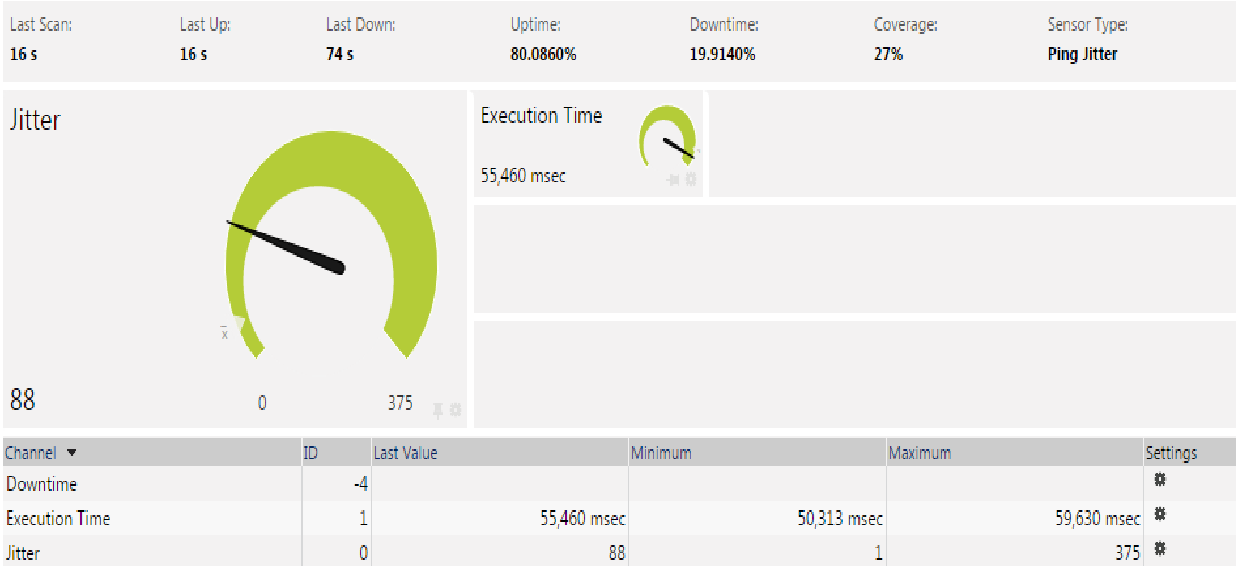


Figure 4.30: PRTG system monitoring jitter ping before apply script (the Tango case)

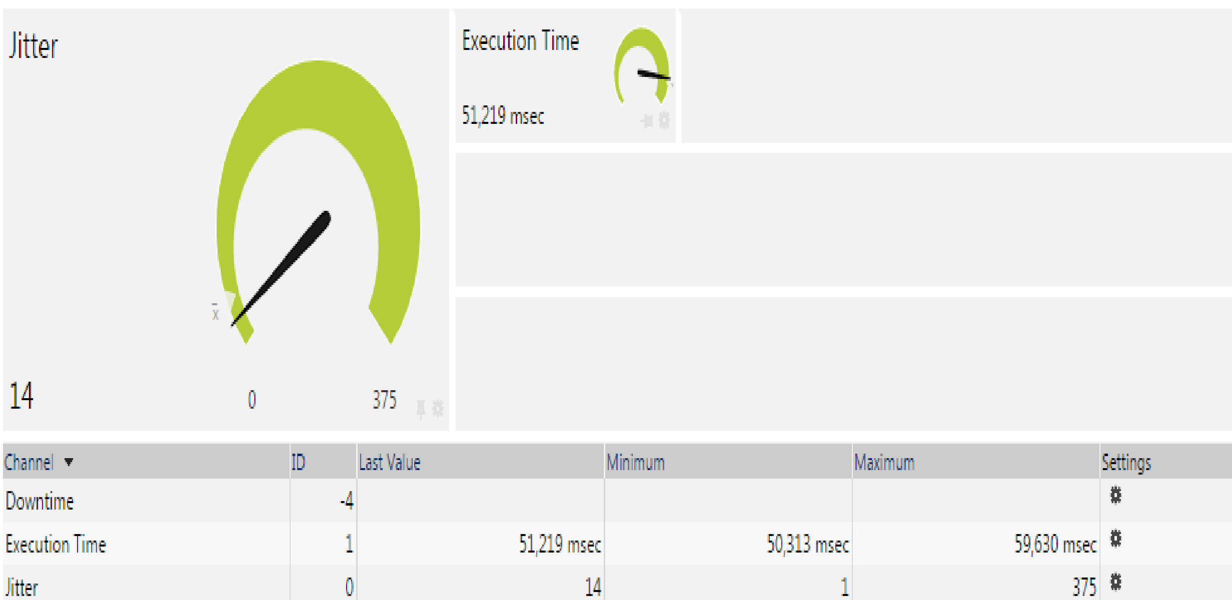


Figure 4.31: PRTG system monitoring jitter ping after apply script (the Tango case)

4.6Script Chain Time

Besides the application of all the developed scripts in the sectors that are distributed on 21 towers, there are also some network parameters that need to be carefully chosen. Among these is the best address list time out. This parameter needs to be optimized such that the best possible network performance and the highest level of user satisfaction can be obtained.

In our ISP network case, we have deduced that the better tradeoff for this parameter can be realized by choosing its value to be 10 msec. To reach the most optimum choice, we have tried several possible values for the address list time. Figure 4.32 is a depiction for the effect of using various values of this parameter on CPU usage. From this figure, one can realize that if the address list time is increased, the CPU usage will increase as well. This might cause harm for server work because it forces the CPU to use specific path for all marked traffics to pass through.

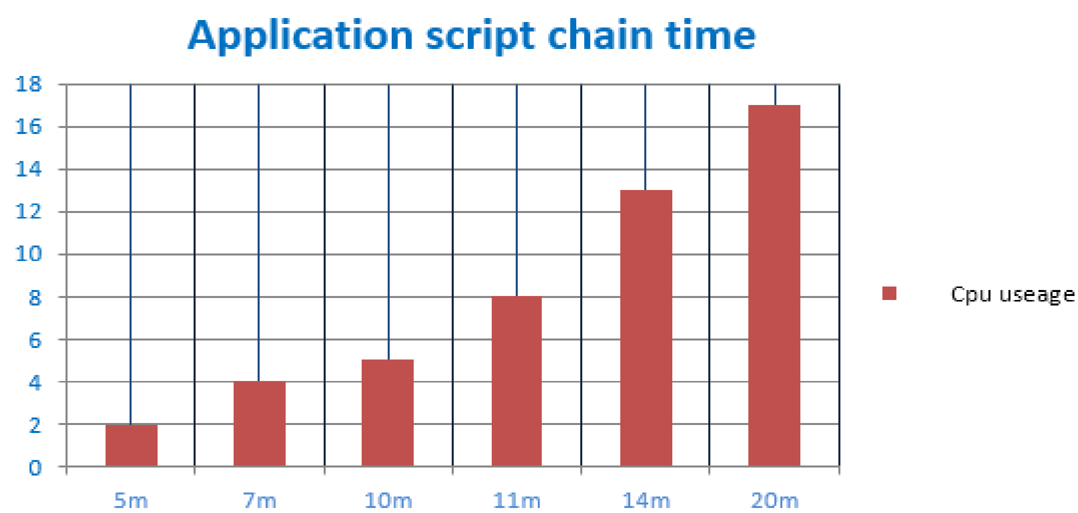


Figure 4.32: Script address list time (in msec) and CPU usage

4.7 QoS Implementation in the Main Server Side

In addition to implementing the previously mentioned scripts in layer 7 in the sectors, another type of script in layer 3 has to be developed and implemented. This additional script has been implemented in the main server so that it can affect the work of the whole network.

The main server script has two important parts. The first part is in firewall NAT section; its work is to open all port inside the network from 0-65535, as shown in Figure 4.33 below. The second script part works to mark the traffics on ports and protocols as most social media applications use these ports and protocols, as shown in Figure 4.34.

```
Initialize / ip firewall Nat

Add action=src-Nat
Set chain=srcnat
set comment=" NETWORK KHANAQIN"
Set  src-address = 172.16.30.0/24
Set  to-address = 62.201.219.116
Add action= dst-nat
Set chain= dstnat
Set comment="DS NAT TCP 116"
Set dst-address= 62.201.219.116
Set protocol=tcp
Set to-address =172.16.30.0/24
Set to-ports=0-65535
Add action=src-Nat
Set chain= srcnat
Set src-address= 172.16.35.0/24
Set to-address = 62.201.219.117
Add action = dst-nat
Add chain= dstnat
Set comment= "DS NAT TCP 117"
Set dst-address =62.201.219.117
Set protocol=tcp
Set to-address= 172.16.35.0/24
Set to-ports= 0-65535
Add action = src-Nat
Add chain= srcnat
Set src-address= 172.16.36.0/24
Set to-address=62.201.219.118
Add action = src-Nat
Add chain= srcnat
Set comment= "NETWORK EMAMABBAS"
Set src-address=172.16.33.0/24
Set to-address=62.201.219.109
Add action = dst-nat
Add chain= dstnat
Set comment= "DS NAT TCP 118"
Set dst-address=62.201.219.118
Set protocol =tcp
Set to-address=172.16.36.0/24
Set to-ports = 0-65535
Add action = dst-nat
Add chain= dstnat
Set comment= "DS NAT TCP 109"
Set dst-address=62.201.219.109
Set protocol =Tcp
Set to-address = 172.16.33.0/24
Set to –ports = 0-65535
Add action = masquerade
Set chain =srcnat
Set comment = VPN
Set src-address=10.0.0.0/16
Add action = masquerade
Set chain =srcnat
Set disabled = yes
Set src-address=172.16.30.0/24
Add action = masquerade
Set chain =srcnat
Set comment = yes
Set src-address=172.16.35.0/24
Add action = masquerade
Set chain =srcnat
Set comment = yes
Set src-address=172.16.36.0/24
Add action = masquerade
Set chain =srcnat
Set comment = yes
Set src-address=172.16.33.0/24
Add action = masquerade
Set chain =srcnat
Set comment = yes
Set src-address=172.16.31.0/24
Add action = masquerade
Set chain =srcnat
Set comment = yes
Set src-address=172.16.32.0/24
```

Figure 4.33: Main Server Script for the Nat Section

```
Initialize /ip firewall mangle

Add action=mark-connection
Set chain=prerouting
Set dst-address = 62.201.219.112
Set new-connection-mark=VoIP
Add action=mark-connection
Set chain=prerouting
Set connection-mark = no
Set mark new-connection-mark=VoIP
Set protocol=TCP
Set src-port =4244,5242,5243,9785,5060,5061,5222,5223,
5228, 6222, 1818,3478,3578,49000,65535
Add action=mark-connection
Set chain=prerouting
Set connection-mark = no
Set dst-port =4244,5242,5243,9785,5060,5061,5222,5223
5228, 6222, 1818,3478,3578,49000,65535
Set mark new-connection-mark=VoIP
Set protocol=TCP
Add action=mark-connection
Set chain=prerouting
Set connection-mark = no
Set mark new-connection-mark=VoIP
Set protocol=UDP
Set src-port =4244,5242,5243,9785,5060,5061,5222,5223,
5228, 6222, 1818,3478,3578,49000,65535
Add action=mark-connection
Set chain=prerouting
Set connection-mark = no
Set dst-port =4244,5242,5243,9785,5060,5061,5222,5223
5228, 6222, 1818,3478,3578,49000,65535
Set mark new-connection-mark=VoIP
Set protocol=UDP
Add action=mark-connection
Set chain=prerouting
Set comment = "VoIP: SIP RTP"
Set Layer7-protocol=RTP
Set new-connection-mark=VoIP
Set protocol=UDP
Add action=mark-connection
Set chain=prerouting
Set connection-mark = no
Set mark new-connection-mark=VoIP
Set protocol=UDP
Set src-port=8766-35000
Add action=mark-connection
Set chain=prerouting
Set connection-mark = no
Set mark dst-port=8766-35000
Set new-connection-mark=VoIP
Set protocol=UDP
Add action=mark-packet
Set chain=prerouting
Set comment = "VoIP: Connection Rate [1, 2]"
Set connection-mark= VoIP
Set connection-rate=0-50k
Set new-packet-mark=1
Set protocol=TCP
Add action=mark-packet
Set chain=prerouting
Set connection-mark= VoIP
Set connection-rate=0-50k
Set new-packet-mark=1
Set protocol=UDP
Add action=mark-packet
Set chain=prerouting
Set connection-mark= VoIP
Set connection-rate=50001-4294967295
Set new-packet-mark=2
Set protocol=TCP
Add action=mark-packet
Set chain=prerouting
Set connection-mark= VoIP
Set connection-rate=50001-4294967295
Set new-packet-mark=2
Set protocol=UDP
Add action=jump
Set chain=prerouting
Set comment = "VoIP: Actions"
Set connection-mark=VoIP
Set jump-target=prerouting-final
```

Figure 4.34: Script Layer 3 in the main server

After applying the layer 3 scripts in the main server and all these improvements in the network, we allow all the traffic that the user demands, social media application, to pass through inside the network with minimum packet lose, delay and jitter. Figure 4.35 shows how the script works. The Figure 4.36 explain main server down time, max jitter which is 156 and min jitter which is 4. Figures 4.37 and 4.38 shows the effect of the developed script on QoS parameters through the PRTG system monitoring sensors.

20	mar...	prerouting	62.201.219.112				1838.8 KiB	29 391
21	mar...	prerouting		6 (tcp)	4244,524...		20.2 KiB	187
22	mar...	prerouting		6 (tcp)		4244,524...	72.8 KiB	694
23	mar...	prerouting		17 (udp)	4244,524...		249 B	4
24	mar...	prerouting		17 (udp)		4244,524...	1980 B	11
25	mar...	prerouting		17 (udp)	8766-350...		1222.7 KiB	15 685
26	mar...	prerouting		17 (udp)		8766-350...	293.1 KiB	3 759
;;; VoIP: Connection Rate [1,2]								
27	mar...	prerouting		6 (tcp)			1012.4 KiB	8 892
28	mar...	prerouting		17 (udp)			13.7 MiB	87 736
29	mar...	prerouting		6 (tcp)			127.9 KiB	2 579
30	mar...	prerouting		17 (udp)			83.2 MiB	107 146
;;; VoIP: Actions								
31	jump	prerouting					98.2 MiB	207 741

Figure 4.35: Script Layer 3 main server mangle.

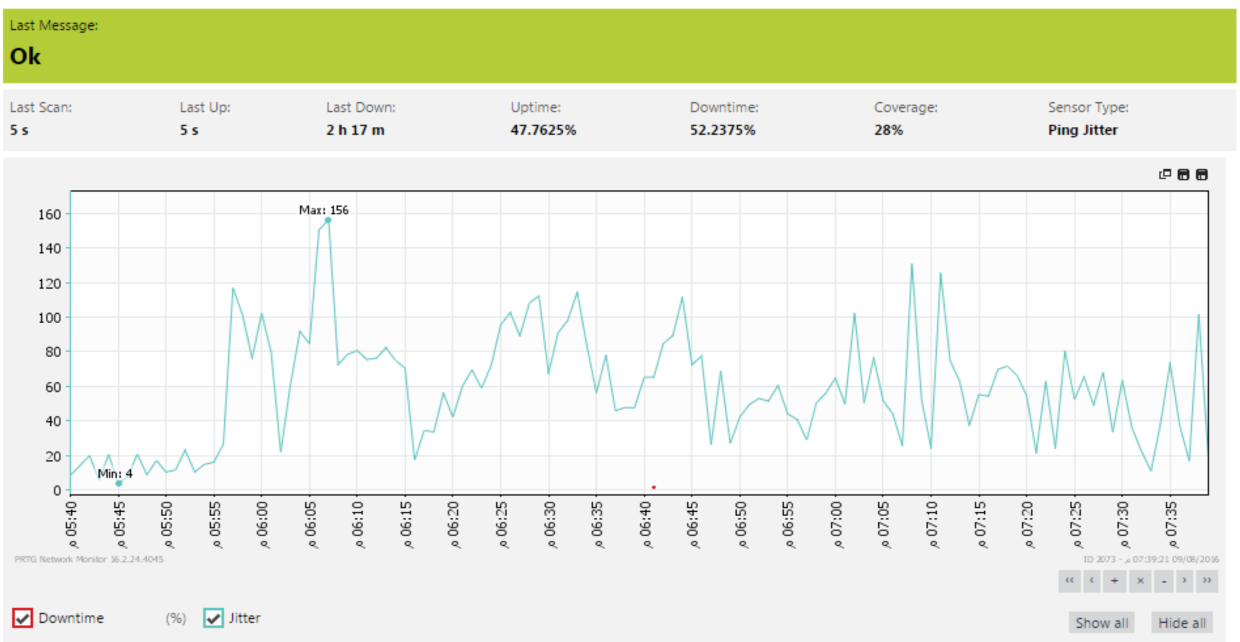


Figure 4.36: PRTG system ping jitter main server

Figure 4.37: PRTG system packet lose main server

Figure 4.38: PRTG system HTTP ping delay in main server

4.8 QoE Results after Framework Application

In order to measure the amount of enhancement on QoE obtained after implementing the scripts required by our framework proposal, a second round of collecting end users' feedback has been done. In this round of QoE survey for the users after implementing the scripts described in the previous QoS, the same social applications (Facebook, Viber and Tango) have been considered.

However, in this round a significant positive change in users' opinions about considered social services has been noticed in comparison to the first survey round, (before we apply the framework), as follows:

- For the Facebook case, user responses have been collected; 13.9% of them answered good and 86.1% answered Excellent, as shown in Figure 4.39.
- For the Viber case, users' responses; 7.9% answered good and 92.1% answered Excellent, as shown in Figure 4.40.
- Finally for the Tango case, users' responses; 14.3% of them answered good and 85.7% answered Excellent, as shown in Figure 4.41.

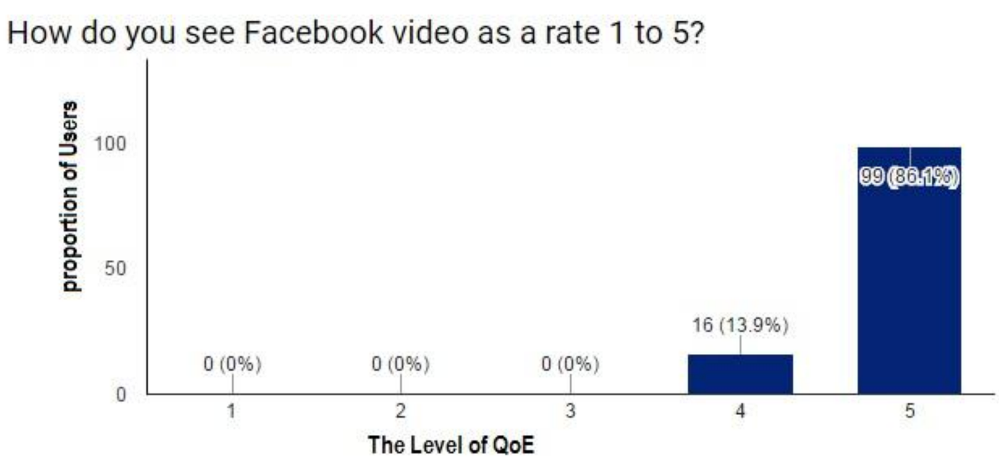


Figure 4.39: Facebook MOS survey after applying scripts.

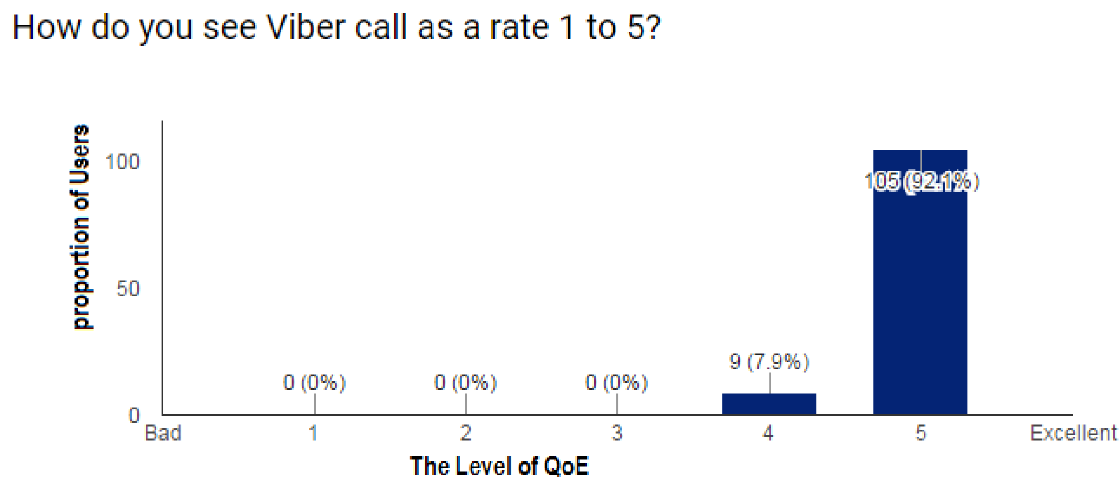


Figure 4.40: Viber MOS survey after applying scripts.

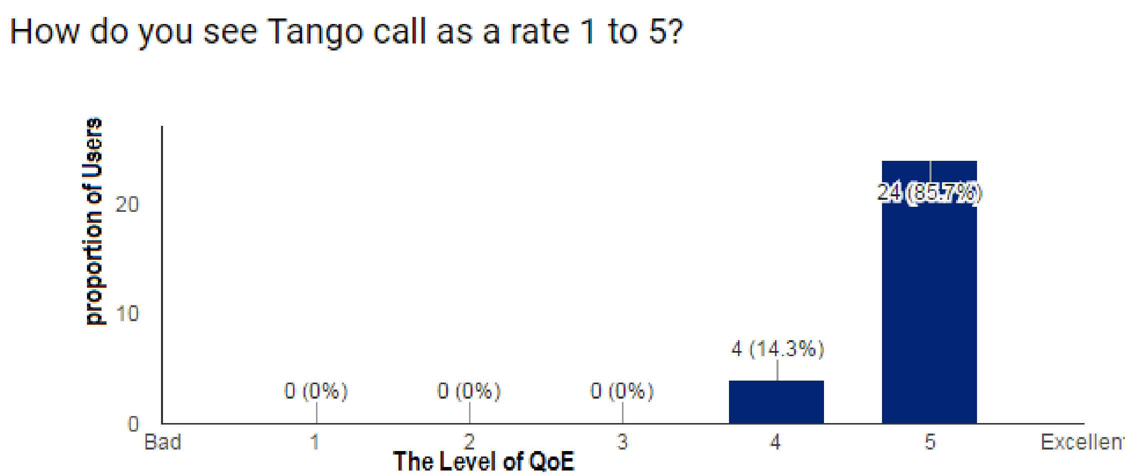


Figure 4.41: Tango MOS survey after applying scripts.

As a summary for the results presented in this chapter, we can notice that the satisfaction level of end users has been significantly increased after the deployment of our proposed QoE framework to the considered ISP network. This important QoE enhancement has been obtained for all social networking applications of interest to this study. Hence, the relation between the QoS and QoE is an exponential relation because of all significant changes in the result which we achieved. As the majority of subscribers are specifically interested in (at least) one of these applications (Facebook, Viber, and/or Tango), the considered ISP has achieved satisfactory level of service delivery to the users.

4.9 Discussion effect of framework on other application

The effect that happened to other application when our framework implemented, was not great influence. Because we don't have real problem with Google browsing and YouTube services, due to our internet provider can queue any extra traffic we need considering by adding new traffic queue such as Akamai traffic for Any other applications or Google traffic for YouTube and other website belong to Google traffic , and paying for that service extra money Note: that queue should be added by our servers too , to make private bandwidth to our users , to get best result to our customers ,however we know what is the most traffic our user's need , then we do this step to improve Facebook, Viber ,Tango , Google and YouTube. Figures 4.42, 4.43, 4.44, 4.45 shown how Google traffic work, in the company and the most of these subscribers don't have any problems with Google browsing and YouTube services.

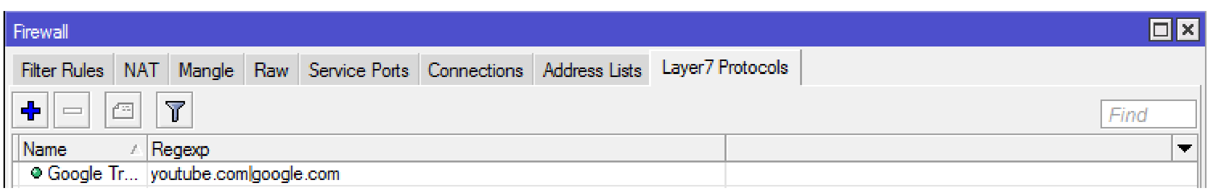


Figure 4.42: Mikrotik firewall layer7 protocol (Google and YouTube).

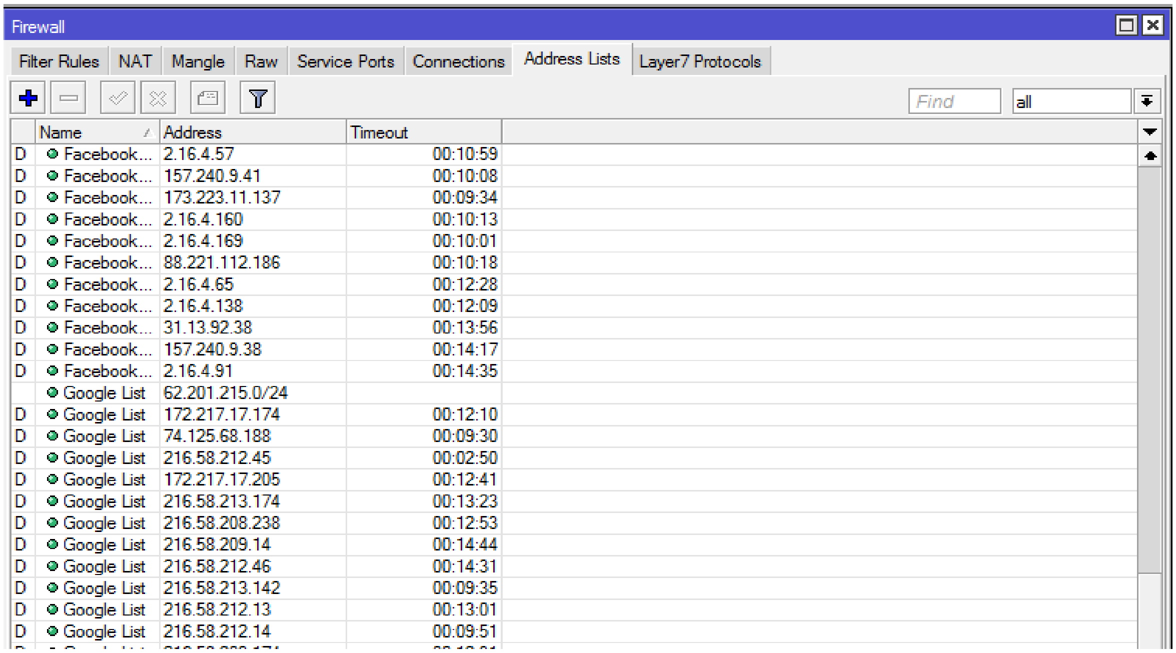


Figure 4.43: Mikrotik firewall Address List (Google and YouTube).

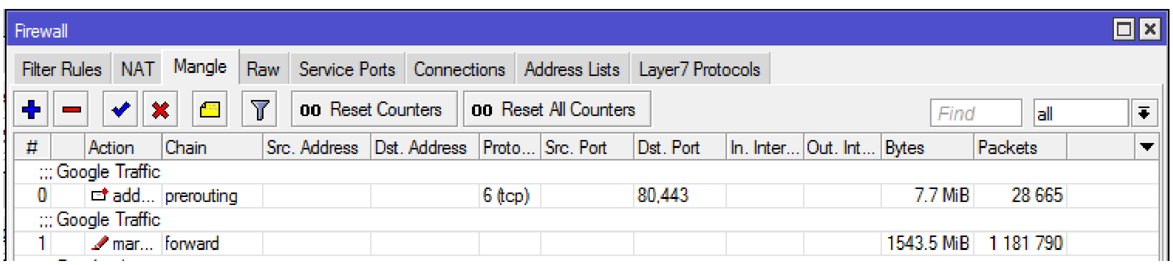


Figure 4.44: Mikrotik Mangle (Google and YouTube).

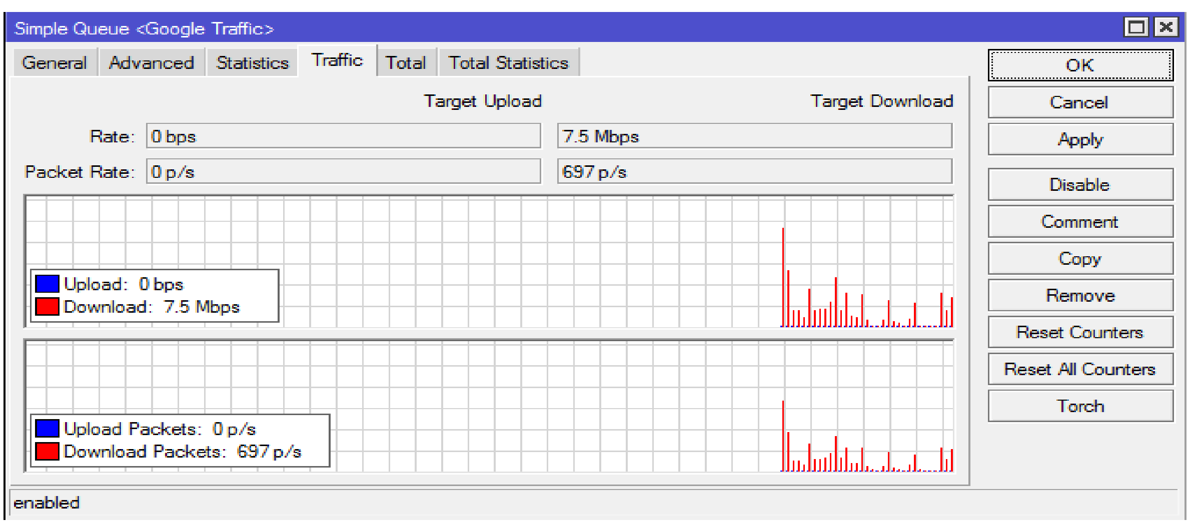


Figure 4.45: Mikrotik simple Queue (Google and YouTube).

Chapter Five

Conclusions and Suggestions for Future Work

Chapter Five

Conclusions and Suggestions for Future Work

5.1 Conclusions

As mentioned before the satisfaction level of end user has been changed, when QoS enhanced. After framework implement in ISPs, the QoS and QoE has been significantly increased. In this work QoE has been enhanced through QoS, most social media applications have been improved as a response to user demand. The relation between QoS and QoE is show to as any change in QoS proportion effect on QoE significantly. For this purpose after this work, we consider the relation between QoS and QoE are expositional relation.

There has been also good enhancement in some network QoS parameters. For example, it is possible to consider the enhancement presented by jitter ping before and after implement the framework. In Facebook case, the jitter ping was 88 msec, after implementing it becomes 14 msec. In Viber case, the jitter ping was 88 msec, after implementing it becomes 7 msec. In Tango case, the jitter ping was 88 msec, after implementing it becomes 14 msec.

The results that be achieved from framework implement are show the successful of ISPs to response to new user demand and challenge the markets. All methodologies, tools and techniques related to QoS and QoE has been studied in this thesis. The framework that implemented in ISPs can restructure entire network parameters to be able to adopt with QoS challenges and user new demands like multimedia application ,because each of these applications have different QoS parameters. Therefore the most important points of conclusions that can be inferred from this work can be specified as follows:

1) Any QoE framework must consider the relevant QoS parameters. In this work, all-important QoS parameters like delay, jitter, and packet lose, and bandwidth have been considered, as main factors for enhance QoE for national ISPs.

2) It is necessary for any ISP, or any service network, to enhance all basic infrastructure aspects of the network (like power supply, network device, security aspects, monitoring techniques, broadcasting bandwidth, etc.). However, this is not sufficient for QoE enhancement. The required level of user satisfaction can only be obtained with properly approaching various issues and requirements aspects of QoS and QoE on various levels of the network hierarchy.

3) The user feedback is done based on QoE survey before implementing the scripts required in accordance with the proposed QoE framework has shown low level of user satisfaction; the highest percentage (49.1%) of users responded as Poor for Facebook service, 35.1% of users responded with Poor for Viber, while only a percentage of 41.2% of users responded with Good for Tango.

4) There was significant enhancement in user satisfaction levels after implementing the scripts required by the proposed framework; majority percentage (86.1%) of users responded with Excellent Facebook, majority of 92.1% responded with Excellent for Viber and majority of 85.7% of Excellent for Tango.

5) The results of applying the proposed framework have supported the thought that the relationship between QoE and QoS is of expositional type because the improvements in QoS parameters have resulted in significant enhancements in user perception and experience.

6) Prioritizing traffic packets of demanded applications like Facebook, Viber and Tango has enabled us to satisfy the end users and improve QoE level according to the concept of highest level services. This emphasizes the necessity of clearly understanding specific users' needs in order to implement any QoE solution.

7) Based on the obtained results from the real-life application considered, we expect this approach to be helpful for national ISPs to better understand how to control and manage their networks' various parameters and resources to offer a satisfactory level of QoE for future e-society services. Hence, we prudently claim that the proposed QoE framework can be beneficial and important for entire national ISPs.

5.2 Suggestions for Future Work

As for future works, many suggestions can be put forward either to improve this work or other related works in the following areas:

1. It is recommended to consider other more efficient queuing techniques like low latency queuing (LLQ) which is only supported by Cisco products and not by Mikrotik products.
2. This recommended considering other QoE measurement techniques such as subjective measurement (Qualitative) and objective measurement like human biological factors, technical factors, etc.
3. Further work can consider applying other network media applications such as WeChat application, Telegram application, etc.
4. Applying other hybrid scripting techniques can result in better QoE enhancements for end users. Because all scripts that used classify the traffic based on IP address with host domain. But it possible to

use script can classify the traffics based on multiple parameters like IP address, ports and types of protocol, and host name.

5. It is also possible to extend our work by more consideration for safety and security issues. Because in this thesis did not improved the security or discussed security weaknesses. So all ports that thesis social media application used must be monitored.

References

References

[1]. Kim, H. J., Lee, D. H., Lee, J. M., Lee, K. H., Lyu, W., & Choi, S. G. (n.d.). The QoE evaluation method through the QoS-QoE correlation model. Proceedings - 4th International Conference on Networked Computing and Advanced Information Management, NCM 2008,Gyeongju,Korea., 2, 719–725. https://doi.org/10.1109/NCM.2008.202

[2]. Alreshoodi, M., & Woods, J. (n.d.). Survey on QoE\QoS Correlation Models for Multimedia Services. International Journal of Distributed and Parallel systems, New York- Ithaca, Cornell University., 4(3), 53–72. https://doi.org/10.5121/ijdps.2013.4305

[3]. Brooks, P., & Hestnes, B. (2010). User measures of quality of experience: Why being objective and quantitative is important. IEEE Network (Volume: 24, Issue: 2, March-April 2010), 24(2), 8–13. https://doi.org/10.1109/MNET.2010.5430138

[4]. Kist, A. a., & Brodie, L. (2012). Quality of Service, Quality of Experience and Online Learning. 2012 Frontiers in Education Conference Proceedings, Sheraton Seattle, 1400 6th Avenue, Seattle, WA 98101 Seattle, WA, USA, 1–6. https://doi.org/10.1109/FIE.2012.6462223.

[5]. Zugur, D. (2002). Formal Specification of QoS Parameters by Hierarchical Tree Structure. The gfh IEEE International Conference on Electronics, Circuits and Systems September 15 - 18, 2002 Dubrovnik, Croatia, 1075–1078.Retrieved from http://ieeexplore.ieee.org/document/1046437/ .

[6]. Gong, Y. G. Y., Yang, F. Y. F., Huang, L. H. L., & Su, S. S. Sen. (2009). Model-Based Approach to Measuring Quality of Experience. 2009 First International Conference on Emerging Network Intelligence, The Fifth European Conference on Universal Multiservice Networks (ECUMN 2009), 11-16 October 2009 Sliema, Malta, 1–4. https://doi.org/10.1109/EMERGING.2009.17.

[7]. Kadry, S., & Smaili, Khaled, L. U.-F. of S. B.-L. (2008). Control System for Internet Bandwidth Based on Java Technology. Journal of Theoretical and Applied Information Technolog. Retrieved from 2005 - 2008 JATIT. All rights reserved Islamabad, PAKISTAN, https://www.jatit.org

[8]. Cisco. (2014). Quality of Service Overview What Is Quality of Service ? Who Could Benefit from Using Cisco IOS QoS ? Americas Headquarters: Cisco Systems, Inc., 170 West Tasman Drive, San Jose, CA 95134-1706 USA,1–18. Retrieved from http://www.cisco.com/c/en/us/td/docs/ios/qos/ configuration/guide/15_1/qos_15_1_book/qos_overview.html

[9]. Anjali Agarwal, Concordia University, Montreal, Quebec, Canada. (2000). Quality of Service (QoS) in the New Public Network Architecture 1.0. IEEE, 22–25. Retrieved from https://www.concordia.ca/about.html.

[10]. Rafael Asorey Cacheda2, D. C. G., Ia3, A., Cuevas1, F. J. G., Casta˜, A., No2, J. H. S., Anchez3, … O7-Florence, I. (2007). QoS REQUIREMENTS FOR MULTIMEDIA. Book .Resource Management in Satellite Networks. Retrieved from https://link.springer.com/chapter/ 10.1007%2F978-0-387-53991-1_3.

[11]. Gerla, M. (2000). Quality of service routing in the internet. Control. DUP Science i/ Delft University Press. Retrieved from IEEE Network, 24(2), 8–13. http://doi.org/10.1109/.2000.632774.

[12]. Strunk, A. (2010). QoS-Aware Service Composition : A Survey. 8th IEEE European Conference on Web Services,Ayia Napa, Cyprus •, (1), 67–74. https://doi.org/10.1109/ECOWS.2010.16.

[13]. Haikal, A. Y., Badawy, M., & Ali, H. A. (2014). Towards internet QoS provisioning based on generic distributed QoS adaptive routing engine. Scientific World Journal, Mansoura 35516, Egypt, 2014. https://doi.org/10.1155/2014/694847.

[14]. Mitra, K., Zaslavsky, A., & Åhlund, C. (2015). Context-Aware QoE Modelling, Measurement, and Prediction in Mobile Computing Systems. IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 14, NO. 5, MAY 2015, IEEE Journals & Magazines, 14(5), 920–936. Retrieved from http://ieeexplore.ieee.org/document/6679038/.

[15]. Chu, Y. H., Lin, W. T., Wang, Y. C., Hsieh, C. T., Yang, Y. L., & Cheng, K. M. (2014). Software-defined QoE measurement architecture. APNOMS 2014 - 16th Asia-Pacific Network Operations and Management Symposium, National Chiao Tung University, Taiwan. https://doi.org/10.1109/APNOMS.2014.6996535.

[16]. Hosfeld, T., Fiedler, M., & Zinner, T. (2011). The QoE provisioning-delivery-hysteresis and its importance for service provisioning in the Future Internet. 2011 7th EURO-NGI Conference on Next Generation Internet Networks, NGI 2011 - Proceedings,June 27, 2011 - June 29, 2011,Kaiserslautern, Germany.https://doi.org/10.1109/NGI.2011.5985864

[17]. Laghari, K. R., Issa, O., Speranza, F., & Falk, T. H. (2012). Quality-of-Experience Perception for Video Streaming Services : Preliminary Subjective and Objective Results. Proceedings of The 2012 Asia Pacific Signal and Information Processing Association Annual Summit and Conference, December 3-6, 2012 Hollywood, California, USA. Retrieved from http://ieeexplore.ieee.org/document/6411949/

[18]. Kim, H.-J., Yun, D.-G., Kim, H.-S., Cho, K.-S., & Choi, S.-G. (2012). QoE assessment model for video streaming service using QoS parameters in wired-wireless network. Advanced Communication Technology (ICACT), 2012 14th International Conference On, pyeong Chang, Korea(south),459–464.Retrieved from http://ieeexplore.ieee.org/ document/6174650/.

[19]. Hoßfeld, T., Hock, D., & Tran-gia, P. (2008). University of W ¨ urzburg Institute of Computer Science Research Report Series: Testing the IQX Hypothesis for Exponential Interdependency between QoS and QoE of Voice Codecs iLBC and iLBC and G.711. University of W¨urzburg Institute of Computer Science Department of Distributed Systems Am Hubland, D-97074 W¨urzburg, Germany, de 2 Now at NICT Network Architecture Group, Network Research Center Park Court. Retrieved from https://scholar.google.com/scholar /testing the IQX Hypothesis for Exponential Interdependency between QoS and QoE of Voice Codecs iLBC and G.711.

[20]. XChen, X., Wang, C., Xuan, D., Li, Z., Min, Y., & Zhao, W. (2003). Survey on QoS management of VoIP. Proceedings - 2003 International Conference on Computer Networks and Mobile Computing, ICCNMC 2003,Shanghai,China,69–77.https://doi.org/10.1109/ICCNMC. 2003.1243029

[21]. F.A. Kuiper’s, (2004) Quality of Service Routing in the Internet: Theory, Complexity and Algorithms, Ph.D. thesis, Delft University Press, The Netherlands, ISBN 90-407-2523-3.

[22]. Truong, T. H., Nguyen, T. H., & Nguyen, H. T. (2012). On relationship between quality of experience and quality of service metrics for ims-based IPTV networks. 2012 IEEE RIVF International Conference on Computing and Communication Technologies, Research, Innovation, and Vision for the Future, RIVF 2012,Ho Chi Minh City, Vietnam 27 February – 01 March 2012. https://doi.org/10.1109/rivf.2012.6169844

[23]. Lakhtaria, K. I. (2008). SIP-based mobility management in next generation networks. IEEE Wireless Communications (Volume: 15, Issue: 2, April 2008), Rajkot, Gujarat, INDIA, 4(April), 92–99. Retrieved from http://ieeexplore.ieee.org/document/4492982/ .

[24]. Liu, P., & Evans, S. C. (2007). Multimedia QoS through Content Aware Triage : An Integrated DiffServ Framework. 2007 Military Communications Conference, October 29-31, Orlando, Florida, 1–6. Retrieved from http://ieeexplore.ieee.org/document/4455303.

[25]. Möller, L., Fischer, P., Moraes, F., Indrusiak, L. S., & Glesner, M. (2010). Improving QoS of Multi-Layer Networks-on-Chip with Partial and Dynamic Reconfiguration of Routers. 2010 International Conference on Field Programmable Logic and Applications Improving, 31-Augest -2 September 2010 Milano, Italy, 1–5. https://doi.org/10.1109/FPL.2010.53.

[26]. Alvarez, A., Cabrero, S., Paneda, X. G., Garcia, R., Melendi, D., & Orea, R. (2011). A flexible QoE framework for video streaming

services. 2011 IEEE GLOBECOM Workshops, Houston, Texas, USA GC Wkshps 2011, 1226–1230. http://doi.org/10.1109/GLOCOMW.2011.6162377

[27]. Haryadi, S., & Nusantara, S. A. (2012). QoS measurement of web browsing services in 3G networks using aggregation method. 2012 7th International Conference on Telecommunication Systems, Services, and Applications, TSSA 2012, Bali, Indonesia, 102–106. https://doi.org/10.1109/TSSA.2012.6366031

[28]. Riyanka, & Malhotra, J. (2014). Survey of issues and challenges in the Mac Layer for Qos in WiMAX. 2014 International Conference on Advances in Engineering and Technology Research, ICAETR 2014, Kanpur, [Uttar Pradesh], India, 1-2 August 2014. https://doi.org/10.1109/ICAETR.2014.7012921.

[29]. Kim, H., & Lee, K. (2010). In-Service Feedback QoE Framework. Communication Theory, Reliability, and Quality of Service (CTRQ), 2010 Third International Conference on, 13-19 June 2010 Athens/Glyfada, Greece, 135–138. Retrieved from eeexplore.ieee.org/document/5532772/

[30]. Malik, A., Qadir, J., Ahmad, B., Alvin Yau, K. L., & Ullah, U. (2015). QoS in IEEE 802.11-based wireless networks: A contemporary review. Journal of Network and Computer Applications, 55, 24–46. http://doi.org/10.1016/j.jnca.2015.04.016

[31]. Sethi, A., & Kumar, A. (2016). A Survey of QoS Multicast Protocols for MANETs. Journal of Network Communications and Emerging Technologies (JNCET) Volume 6, Issue 3, March (2016), 6(3), 77–81 Retrieved from http://www.jncet.org .

[32]. Abbas, R. (2012). Human perceived quality-of-service for multimedia applications. 2012 International Conference on Multimedia Computing and Systems, ICMCS 2012 May 10-12, Tangier-MORCCO, 1–6. Retrieved from http://ieeexplore.ieee.org/document/6512435 .

[33]. Habib, A. (n.d.). Guest Editorial : Quality of Service in Multimedia Networks Multimedia Applications and QoS 2 What is QoS ? Purdue University, West Lafayette, USA,2002, 1–4.

[34]. Paper, W. (2009). Introduction to Quality of Service (QoS). Retrieved from https://www.nortel-us.com

[35]. Cherif, W., Ksentini, A., Negru, D., & Sidibé, M. (2011). A-PSQA: Efficient real-time video streaming QoE tool in a future media internet context. Multimedia and Expo (ICME), 2011 IEEE International Conference on, July 11-15, 2011 • BARCELONA, Spain. Retrieved from http://ieeexplore.ieee.org/document/6011993/

[36]. Varela, M., & Technical, V. T. T. (2012). Q O E M ANAGEMENT IN E MERGING Challenges of QoE Management for Cloud Applications. IEEE Communications Magazine, 50(April), 28–36. http://doi.org/10.1109/MCOM.2012.6178831

[37]. Skorin-kapov, L. (2012). A Multi-Dimensional View of QoE : the ARCU Model. MIPRO, 2012 Proceedings of the 35th International Convention, May 21-25, 2012, Opatija, Croatia, 662–666. Retrieved from http://ieeexplore.ieee.org/document/6240728/

[38]. Zhuang, A. M., Qiu, X. S., Meng, L. M., & Gao, Z. P. (2011). An OSE proposing based customer QoE improvement method in the converged network. ICCRD 2011 3rd International Conference on Computer Research and Development, Shanghai. China March 11-13,

2011, 2, 70–74. Retrieved from http://ieeexplore.ieee.org/document/5764086/

[39]. Hassan, J., Das, S., Hassan, M., Bisdikian, C., & Soldani, D. (2010). Improving quality of experience for network services [Guest Editorial. IEEE Network, 24(2), 4–6. http://doi.org/10.1109/MNET.2010.5430137.

[40]. Fiedler, M.; Hossfeld, T.; Tran-Gia, P. (2010). A generic quantitative relationship between quality of experience and quality of service. IEEE Network (Volume: 24, Issue: 2, March-April 2010), 24(April), 36–41. Retrieved from http://ieeexplore.ieee.org/document/5430142/ .

[41]. Stankiewicz, R., Cholda, P., & Jajszczyk, A. (2011). QoX: What is it really? IEEE Communications Magazine, 49(4), 148–158. http://doi.org/10.1109/MCOM.2011.5741159

[42]. Delli Priscoli, F., Suraci, V., & Pietrabissa, A. (2012). Modelling quality of experience in future internet networks. Future Network & Mobile Summit (FutureNetw), 4 - 6 July 2012, Berlin, Germany, 1, 1–9. Retrieved from http://ieeexplore.ieee.org/document/6294179/

[43]. Abdeljaouad, I., Kandavanam, G., & Karmouch, A. (2011). A loss-based utility function for predicting IPTV quality of experience over an overlay network. Global Telecommunications Conference (GLOBECOM 2011), 2011 IEEE, 5-9 December 2011 Houston, Texas, USA. Retrieved from http://ieeexplore.ieee.org/document/6133919/.

[44]. Aroussi, S., & Mellouk, A. (2014). Survey on machine learning-based QoE-QoS correlation models. 2014 International Conference on Computing, Management and Telecommunications, ComManTel 2014,

Da Nang City, Vietnam, 200–204. Retrieved from http://ieeexplore.ieee.org/document/6825604/ .

[45]. Khorsandroo, S., Noor, R. M., & Khorsandroo, S. (2012). A mobility framework to enhance quality of experience through quality of service. ICIMTR 2012 - 2012 International Conference on Innovation, Management and Technology Research, Malacca, Malaysia,21 May - 22 May 2012, 630–634. Retrieved from http://ieeexplore.ieee.org/document/6236472/ .

[46]. Khorsandroo, S., Noor, R. M., & Khorsandroo, S. (2012). Stimulus-centric versus perception-centric relations in quality of experience assessment. Wireless Telecommunications Symposium (WTS), 2012, London, United Kingdom, April 18-20, 2012. Retrieved from http://ieeexplore.ieee.org/document/6266128/ .

[47]. Stankiewicz, R., & Jajszczyk, A. (2011). A survey of QoE assurance in converged networks. www.elsevier.com/Computer Networks, 55(7), 1459–1473.Retrievedfrom http://www.sciencedirect.com/science/article /pii/S138912861100051X.

[48]. Pais, I., & Almeida, M. (2009). End User Behavior and Performance Feedback for Service Analysis. Intelligence in Next Generation Networks, 2009. ICIN 2009, 1–6. http://doi.org/10.1109/ICIN.2009.5357083

[49]. Truong, T. H., Nguyen, T. H., & Nguyen, H. T. (2012). On relationship between quality of experience and quality of service metrics for IMS-based IPTV networks. 2012 IEEE RIVF International Conference on Computing and Communication Technologies,

Research, Innovation, and Vision for the Future, RIVF 2012,Ho Chi Minh City, Vietnam 27 February 01 March 2012. Retrieved from http://ieeexplore.ieee.org/document/6169844/ .

[50]. Menkovski, V. (2015). Computational Inference and Control of Quality in Multimedia Services. Retrieved from http://www.springer.com/gp/book/9783319247908.

[51]. Jelassi, S., Rubino, G., Melvin, H., Youssef, H., & Pujolle, G. (2012). Quality of experience of VoIP service: A survey of assessment approaches and open issues. IEEE Communications Surveys & Tutorials (Volume: 14, Issue: 2, Second Quarter 2012), 14(2), 491–513. Retrieved from http://ieeexplore.ieee.org/document/6129367/.

[52]. Ocevcic, H., & Zagar, D. (2005). Quality of Service Management in Multimedia Communications. Computer as a Tool, EUROCON 2005.The International Conference on "Computer as a Tool", Belgrade, Serbia and Montenegro,November,21-24,2005.Retrieved from http://ieeexplore.ieee.org/document/1630318/

[53]. Dogo, E. M., Ahmed, A., & Olaniyi, O. M. (2014). Cross-Layer Integration Approach for Improving QoS for IPv6 Based VOIP. International Journal of Engineering and Technology Volume 4 No. 9, September, 2014 Cross-Layer, 4(9), 499–505. Retrieved from ISSN: 2049-3444 © 2014 – IJET Publications UK.

[54]. Amin, R. R. H. (2016). "Video QoS/QoE over IEEE802.11n/ac: A Contemporary Survey" (2016). Thesis. Rochester Institute of Technology.25/9/2016,Retrieved,from,http://scholarworks.rit.edu/theses/9148.

[55]. Managed, I., & Switch, G. (2016).28/7/2016, Igs-404sm igs-812sm. Retrieved from http://www.ctcu.com

[56]. Schulman, F., Scott, W. C., & Woodward, W. H.28/7/2016 (2013). Power supplies., 1–20. http:// www.effekta.com

[57]. Model, B. (2016). stored energy solutions for a demanding world Model : stored energy solutions for a demanding world Model : 30/7/2016,Narada Eos-200, 19–20. Retrieved from http://www.naradabattery.com

[58]. Wiki.mikrotik.com. (2016). Cloud Core Router. Cloud Core Router CCR1036-12G CCR1036. 24/9/2016 Retrieved from http://www.Mikrotik.com

[59]. Carrier, G., & Radio, B. (2015). Datasheet 5. 28/7/2106 Retrieved from https://www.ubnt.com/airfiber/airfiberx-antenna/

[60]. Customization, E. (2016). 6/5/2016 B5c Extreme Customization and Reliability. Retrieved from Mimosa Networks, Inc.http:// www.mimosa.co

[61]. Backhaul, R. L. (2016).6/5/2016 Redefining Licensed Backhaul, 4–5. Retrieved from Mimosa Networks, Inc.http://www.mimosa.com

[62]. Xg, I. (2016). 24/9/2106 Infilink xg. Retrieved from http://infinetwireless.com/products/infilink-xg.

[63]. Extend air, A. (2016). 23/9/2016 All-Outdoor Licensed, 23–26. Retrieved from http://www.exaltcom.com/ExtendAir-G2.aspx.

[64]. Network, M. Y. (2016). 2/11/2016 NETWORK Network Monitor is ... Retrieved from http://www.paessler.com/prtg-network-monitor.

[65]. Bash, E. (2015).17/10/2016 SAS3 Billing System, 1, 1–18.Retrieved http://www.sasradius.com/.

Appendix A

Challenges Facing the Considered ISP (Zanyar Co.) And Adopted Solutions

A.1 Network Structure Overview

To connect the entire network from the first main tower to the second main tower inside the city, many microwaves dishes have been used, as follows:

- **Microwaves Antenna Mimosa B11** model: The Mimosa B11 backhaul radio is designed for the modern Internet area, adapting instantly to variable upstream and downstream bandwidth requirements [61].
- **Microwave antenna Exalt** model E11E732-KIT - Exalt Extend Air G2 11GHz, 200 Mbps, Gigabit, Ethernet, FCC, TR (Full Link Kit) gigabit Ethernet microwave system for high capacity backhaul [63].
- **Mimosa B5c radio; which** is the industry's fastest connected unlicensed and public safety connectivity solution, allowing virtually any antenna to be used for long distance Point to Point backhaul. The B5c is ideal for long range relay and tower links and custom engineered collocation [60].
- **InfiLINK XG is InfiNet's** model: The InfiNet Wireless is a family of Point-to-Multipoint solutions designed for reliable connectivity, and available in both licensed and unlicensed frequency band. These solutions come with a number of powerful features that significantly enhance performance, such as unconditional media-applications traffic (VoIP, video, etc.) prioritization of data types, flexible Quality-of-Service manager, etc. [62].
- **Rocket Dish an airMAX** model: carrier class 2x2 PtP bridge dish antenna model RD-5G34. This rocket dish is used with mimosa B5c radio to achieve maximum reliability and stability in the work. Rocket dish is a powerful

performance for long-range links robust design and construction for outdoor use seamless integration with rocket radios [59].

The most important challenges that had faced the considered ISP network and their adopted solutions are:

A.2 Power supply problem

Admittedly in the city where the ISP is located, there is massive power fault which can cause significant service interrupts hence packets lose. This can damage QoS and QoE. So, Power Supplies EFFEKTA; more reliable and stable in voltage is used [56]. All the features of Effekta is described in Table A1 and all the features of Narada battery can be found in Table A2 [57].

Table A1: the Effekta inverter.

Battery Model	Eos-200			
Nominal Voltage	2V			
Capacity (25°C)	10HR (20A, 1.80V)	3HR (50A, 1.80V)	1HR (110A, 1.75V)	
	200AH	150AH	110AH	
Dimensions	Length	Width	Height	Total Height
	94.5mm	184.5mm	360.5mm	372mm
Approx. Weight	13.5kg			
Internal Resistance	Approx 0.67 mΩ			
Max Charge Current Allowed	50A			
Charge Voltage (25°C)	Cycle use	Float use		
	2. 35V/cell	2. 25V/cell		
Temperature Ranges	Operation(maximum):	-40°C to 55°C (-40°F to 131°F)		
	Operation(recommended):	15°C to 25°C (59°F to 77°F)		
	Storage:	-20°C to 40°C (-4°F to 104°F)		
Terminal	M8 Female			
Terminal Hardware Torque	15 ± 1.0Nm			
Container Material	ABS (V0 optional)			

Table A2: the Narada battery.

Model AX-:		AX-M: 1kVA 24V 1kVA 48V	AX-M: 2kVA 24V	AX-M: 3kVA 24V 3kVA 48V	AX-P: 2kVA 24V 3kVA 24V 2kVA 48V 3kVA 48V	AX-M: 4kVA 48V	AX-M: 5kVA 48V
General data							
Operating temperature		0°C - 50°C					
Storage temperature		-15°C - 60°C					
Humidity		< 95% (non-condensing)					
Size (HxWxD) [mm]		355 x 272 x 128			479 x 295 x 140	540 x 295 x 140	
Weight [Kg]		7.4	7.6	8.0	11.5	12.5	13.5
Protection		IP20					
Regulations / standards	Safety	EN 60950-1					
	EMC	EN 55022 class A, EN 55024					
	Certifications	CE					
Battery bank alarm contact-load capacity (DRYCONTACT)		2A / 250VAC					

A.3 Network structure

The company network had used to provide three main servers which are; the first main server with this IP address “62.201.219.72”, the second main server with IP address “62.210.219.80” and the final main server with IP address “62.201.219.95“. These main servers were controlling entire network inside the city and outside the city. All these networks were connected by VPN. In addition, all sub tower that cover blocks of the city had worked with one range of IP address 172.16.30.X. This network IP address configuration is layer 2 and caused a lot of bottlenecks inside the network.

This problem has been solved by re-configuring the network and rising up to layer three which means the network has begun to use many ranges of IP addresses “172.16.33.X, 172.16.30.X, 172.16.36.X, 172.16.31.X” and every range has a gateway IP address. Moreover, these are all administrated by one leading main server with this IP address 62.201.219.112 which managed entire the network.

Figures A1 and A2 show server 72 and server 80, while Figure A3 shows the new main server Mikrotik cloud core router.

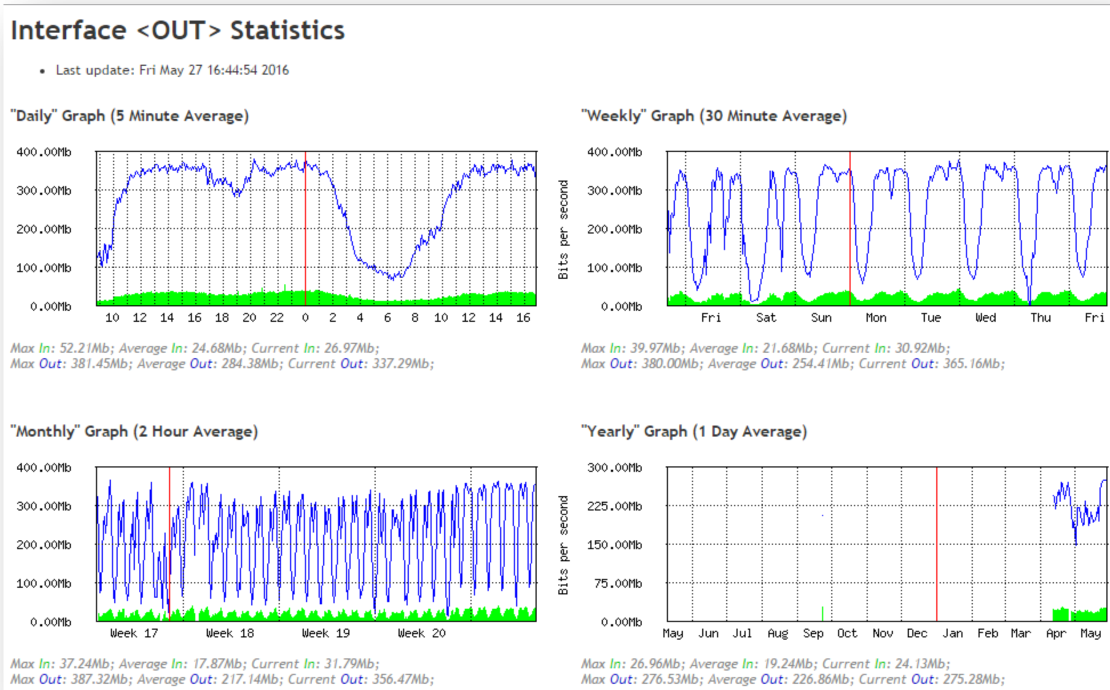


Figure A1: The output interface server 72.

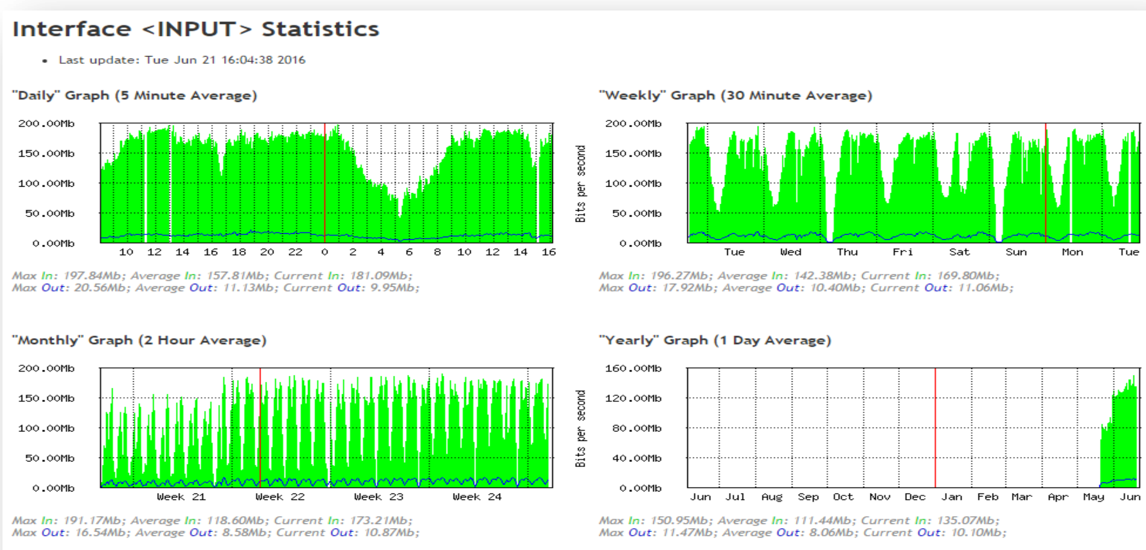
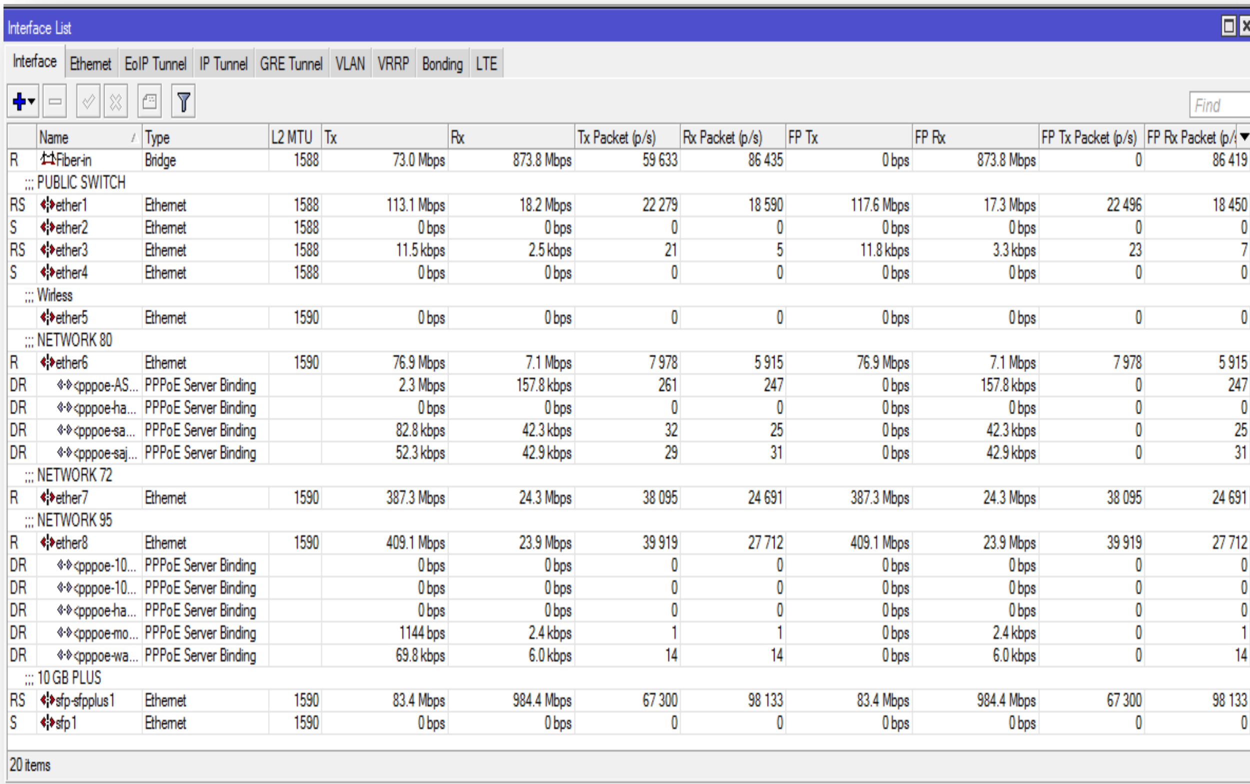


Figure A2: The input interface server 80.


Interface List

Interface | Ethernet | EoIP Tunnel | IP Tunnel | GRE Tunnel | VLAN | VRRP | Bonding | LTE

	Name	Type	L2 MTU	Tx	Rx	Tx Packet (p/s)	Rx Packet (p/s)	FP Tx	FP Rx	FP Tx Packet (p/s)	FP Rx Packet (p/s
R	Fiber-in	Bridge	1588	73.0 Mbps	873.8 Mbps	59 633	86 435	0 bps	873.8 Mbps	0	86 419
	;;; PUBLIC SWITCH										
RS	ether1	Ethernet	1588	113.1 Mbps	18.2 Mbps	22 279	18 590	117.6 Mbps	17.3 Mbps	22 496	18 450
S	ether2	Ethernet	1588	0 bps	0 bps	0	0	0 bps	0 bps	0	0
RS	ether3	Ethernet	1588	11.5 kbps	2.5 kbps	21	5	11.8 kbps	3.3 kbps	23	7
S	ether4	Ethernet	1588	0 bps	0 bps	0	0	0 bps	0 bps	0	0
	;;; Wirless										
	ether5	Ethernet	1590	0 bps	0 bps	0	0	0 bps	0 bps	0	0
	;;; NETWORK 80										
R	ether6	Ethernet	1590	76.9 Mbps	7.1 Mbps	7 978	5 915	76.9 Mbps	7.1 Mbps	7 978	5 915
DR	<pppoe-AS...	PPPoE Server Binding		2.3 Mbps	157.8 kbps	261	247	0 bps	157.8 kbps	0	247
DR	<pppoe-ha...	PPPoE Server Binding		0 bps	0 bps	0	0	0 bps	0 bps	0	0
DR	<pppoe-sa...	PPPoE Server Binding		82.8 kbps	42.3 kbps	32	25	0 bps	42.3 kbps	0	25
DR	<pppoe-saj...	PPPoE Server Binding		52.3 kbps	42.9 kbps	29	31	0 bps	42.9 kbps	0	31
	;;; NETWORK 72										
R	ether7	Ethernet	1590	387.3 Mbps	24.3 Mbps	38 095	24 691	387.3 Mbps	24.3 Mbps	38 095	24 691
	;;; NETWORK 95										
R	ether8	Ethernet	1590	409.1 Mbps	23.9 Mbps	39 919	27 712	409.1 Mbps	23.9 Mbps	39 919	27 712
DR	<pppoe-10...	PPPoE Server Binding		0 bps	0 bps	0	0	0 bps	0 bps	0	0
DR	<pppoe-10...	PPPoE Server Binding		0 bps	0 bps	0	0	0 bps	0 bps	0	0
DR	<pppoe-ha...	PPPoE Server Binding		0 bps	0 bps	0	0	0 bps	0 bps	0	0
DR	<pppoe-mo...	PPPoE Server Binding		1144 bps	2.4 kbps	1	1	0 bps	2.4 kbps	0	1
DR	<pppoe-wa...	PPPoE Server Binding		69.8 kbps	6.0 kbps	14	14	0 bps	6.0 kbps	0	14
	;;; 10 GB PLUS										
RS	sfp-sfpplus1	Ethernet	1590	83.4 Mbps	984.4 Mbps	67 300	98 133	83.4 Mbps	984.4 Mbps	67 300	98 133
S	sfp1	Ethernet	1590	0 bps	0 bps	0	0	0 bps	0 bps	0	0

20 items

Figure A3: The interface of main server mikrotik cloud core router.

A.4 Security risks in entire network

The routing configures PPPoE that uses broadband connection. The user needs to username and password to connect to the network as a user identification to receive the service. And all username and password must register in the sectors. In addition, the usernames and passwords are not unique because each sector is separate from other sectors, as shown in Figure A4.

To solve this security weakness inside the network, SAS system has been used, which is currently a powerful system to manage, accounting, authentication and authorization. SAS3 is a complete billing system which offers a variety of different features to suit any ISP's needs [65]. It also enables ISP managers to take full control over their precious resources and network elements, as shown in figures A5 and A6.

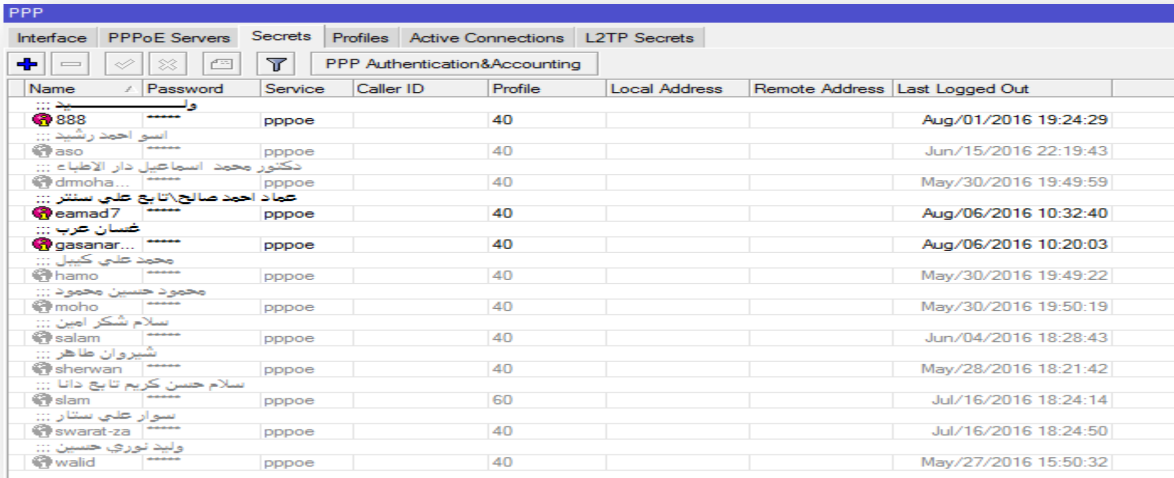


Figure A4: The PPP secret user interface identification.

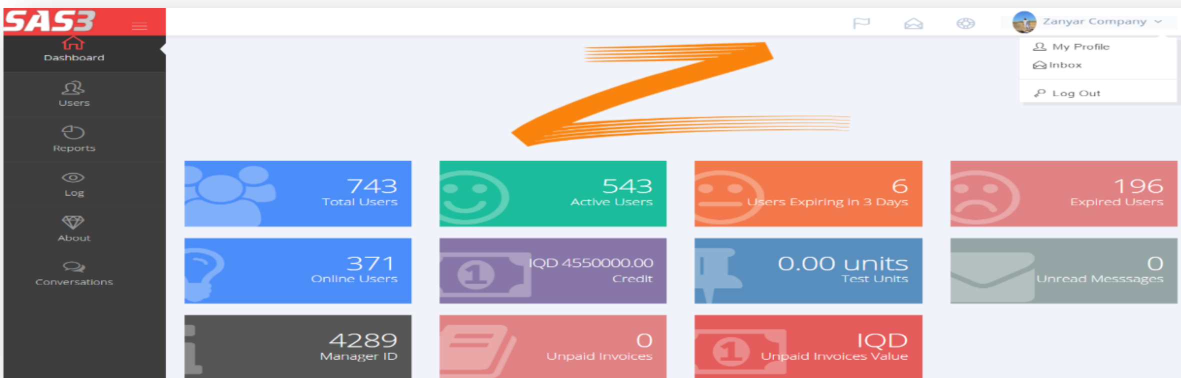


Figure A5: The SAS system Dashboard.

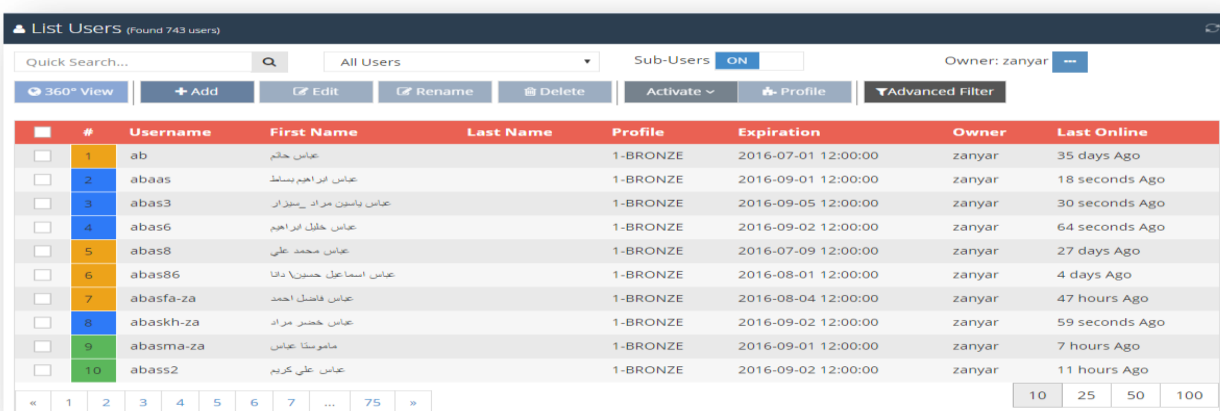


Figure A6: The SAS system User List.

A.5 monitoring problems

The process of the network monitoring was previously done by checking each sector manually or by using the Dude monitoring software from Mikrotik Company. This way is not very efficient because it causes delay in error detection and discovering the sector down failures. So for faster diagnostic and detection of errors for sectors, a new sophisticated monitoring system (PRTG system) has been deployed. This system analyzes the network by using many sensors every 30 sec, so it is much faster than the other way [64]. Figures A7 and A8 shown the interfaces of the PRTG system.

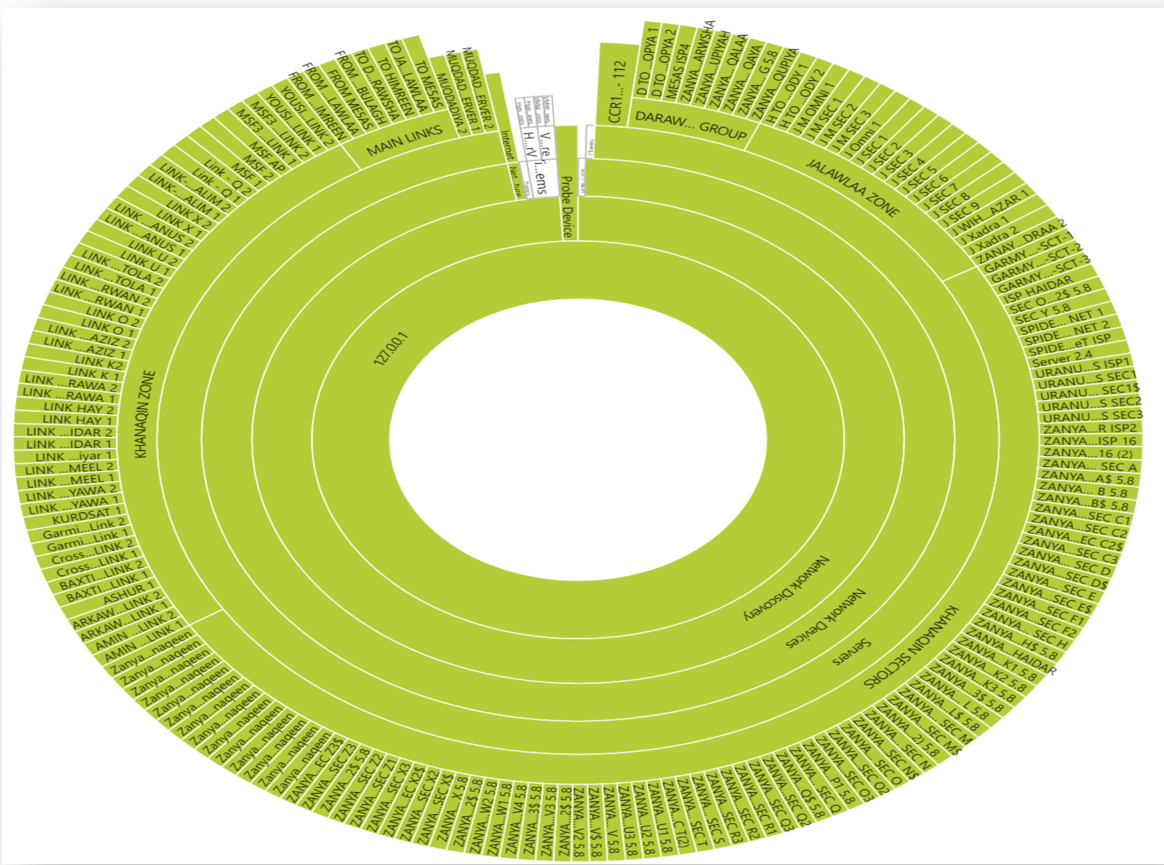


Figure A7: The PRTG system device list.

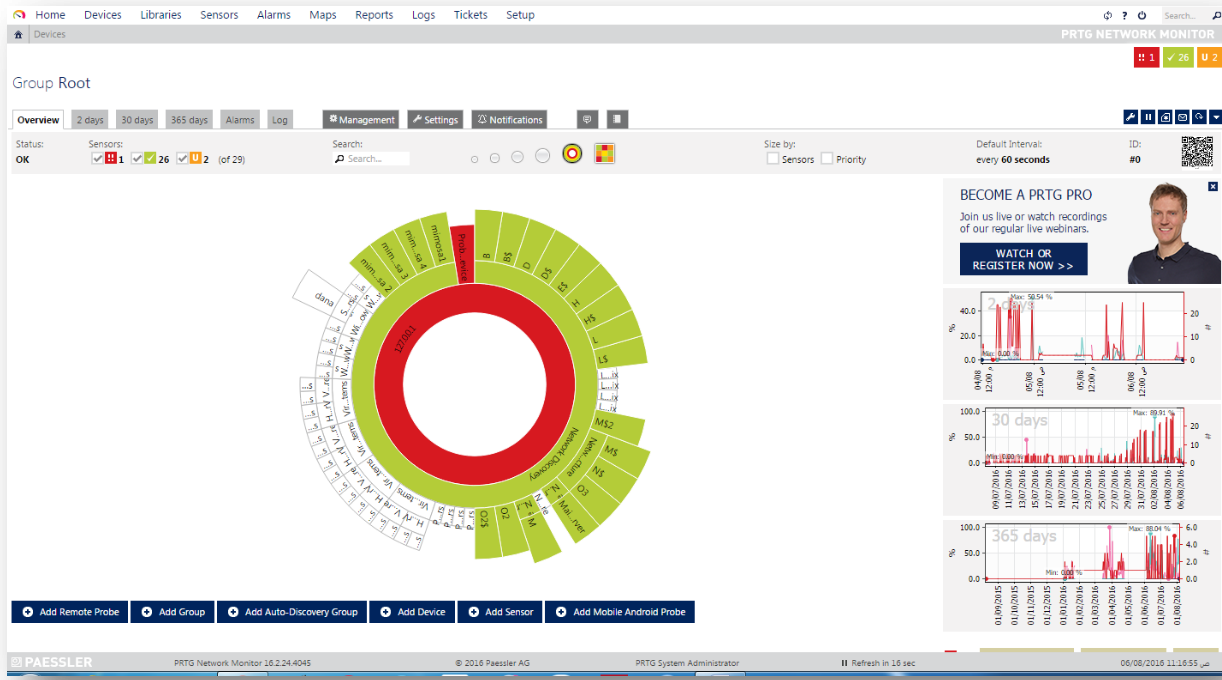


Figure A8: The PRTG system home interface.

Both SAS system and PRTG system have been installed on powerful server hardware HP Z400 with these descriptions:

- **Form Factor:** Convertible Mini-Tower workstation
- **Processors:** Intel Xeon Dual/Quad/Hex Core (3500/3600 Series)
- **RAM:** Up to 24GB with DDR3 ECC or Non-ECC RAM
- **Hard Drives:** Up to 2 x 3.5" (LFF) SAS/SATA
- **Drive Controller:** Integrated 6-Channel SATA RAID (0, 1, 5 & 10)
- **Power Supply:** 475W or 600W (80% Efficiency) Non Hot-Plug (PFC) PSU
- **Expansion Slots:** 2 PCIe x16 Gen2 Graphics, 1 PCIe x4 Gen2, 1 PCIe x4, 2 PCI slots

A.6 Frequency Noise Problems

This is the familiar problem for national ISPs due to unorganized usage of the frequency spectrum. The interference and noise on the limited frequencies make it difficult to choose right frequency channel to the sectors for broadcasting; each frequency isn't stable and effected by noise signals in the air. In Zanyar company default frequencies were used to be 43 frequencies for broadcast and most of these frequencies had been affected by noise. In addition, overall TX CCQ down for 40% and less, as shown in Figure A9.

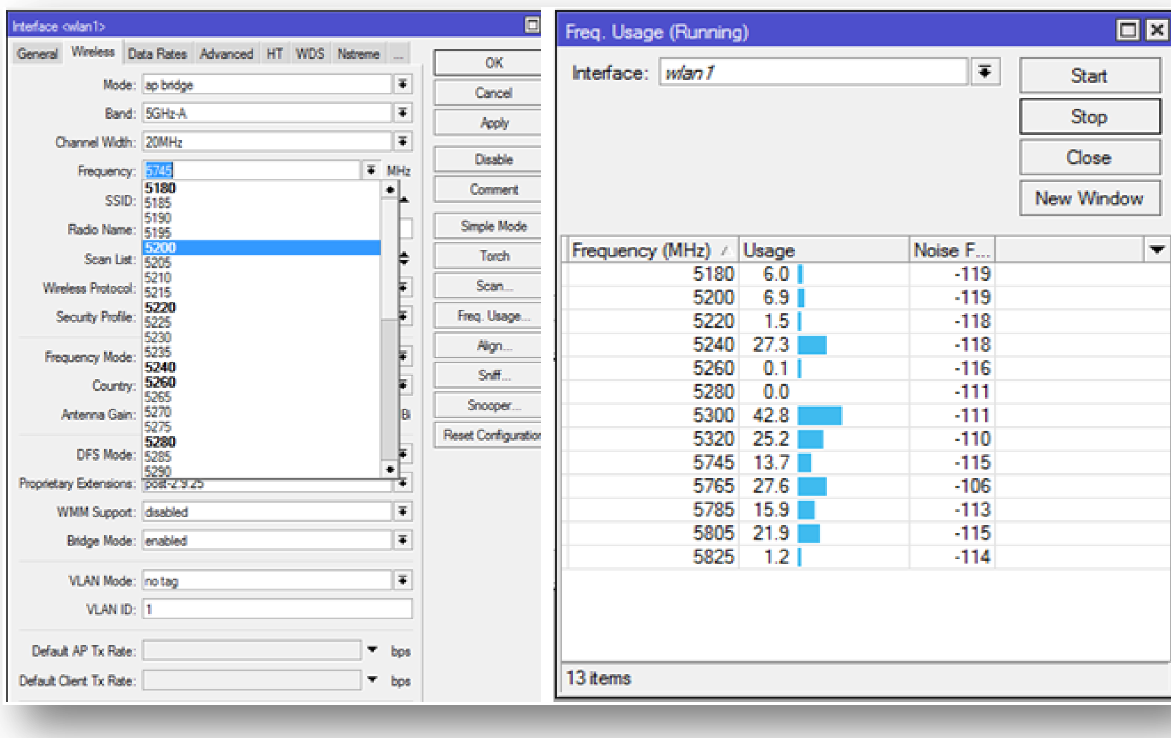


Figure A9: The frequency list and frequency usage in wireless interface.

To solve this frequency noise problem, the company decided to change broadcasting channels from frequency mod **manual-TX power** to frequency mod **super channel** .which has a vast range of frequencies to avoid noise channels. These frequencies from 4920 to 6100 and keep Overall TX CCQ sector in highest degrees which is 90% and above, as shown in Figure A10.

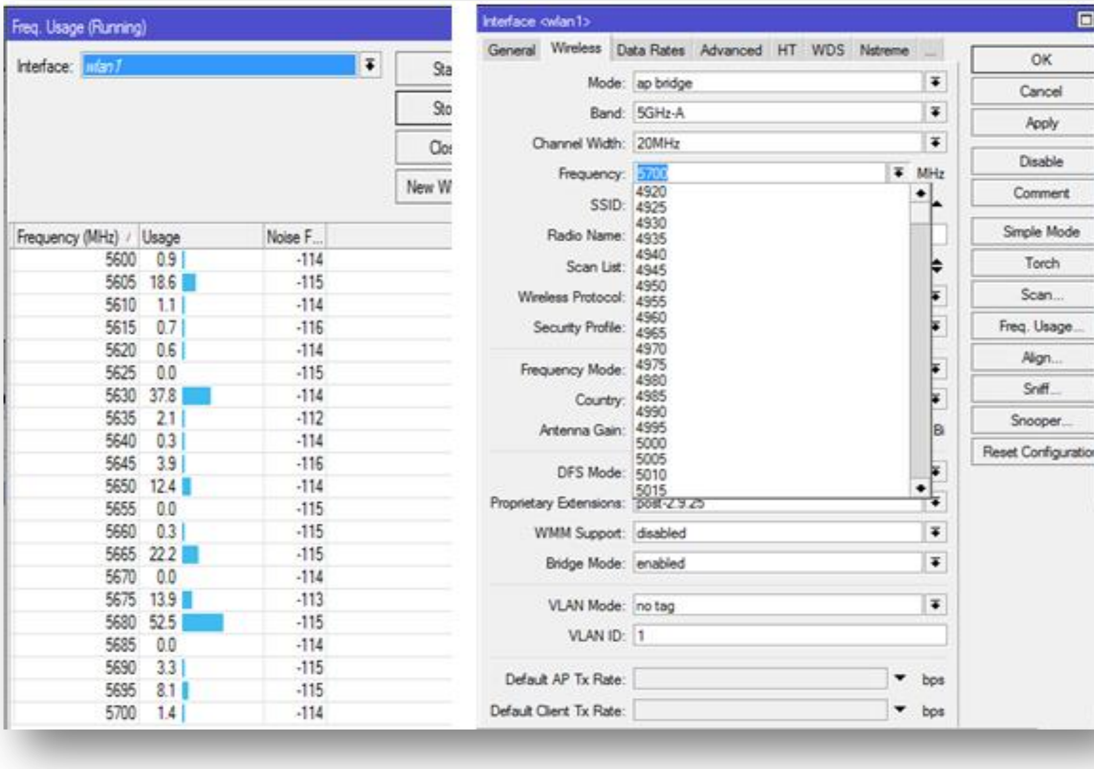


Figure A10: Frequency list and frequency usage in wireless interface for super channel mod.

تحسين جودة التجربة وفق جودة الخدمة لمزودي خدمات الإنترنيت المحلية إستجابة للمتطلبات الجديدة للمستخدمين

رسالة
مقدمة الى مجلس كلية العلوم
في جامعة السليمانية كجزء من متطلبات
نيل درجة ماجستيم في علوم
الحاسبات

من قبل

دانا كريم حمه غريب كريم

بكالوريوس علوم الحاسبات (2010) جامعة السليمانية

باشراف

د.سفيان تايه فرج الجنابي

إستاذ

جمادي الثاني 1438 كانون الثاني 2017

الخلاصة

في السنوات القليلة الماضية، أصبحت نسبة البيانات تزداد بصورة كبيرة جدا. كما ان استخدام تطبيقات الوسائط المتعددة ومنها تطبيقات التواصل الاجتماعي إزدادت يوما بعد يوم في حياة الانسان الأجتماعية. وتحتاج تطبيقات الوسائط المتعددة خصوصا وبصورة قوية الى ضمان نسبة الانتاجية الدنيا والنسبة القصوى لمدة الكمون التي يستمر العمل بها بشكل مرض. إن الوصول لمستوى إرضاء المستخدمين يعتبرتحديا كبيرا في العمل للشركات المزودة لخدمة الأنترنت والعاملة في بيئة عالية التكنلوجيا. فضلا عن الأدارة الفعالة للشبكات يتطلب فهما دقيقا للعلاقة بين جودة الخدمة (QoS) وجودة التجربة (QoE) واخذ كل ذلك بعين الأعتبار.

إن هذه الرسالة تهتم بالمشاكل التي تواجه الشركات المزودة لخدمات الأنترنت كونها تحتاج وبصورة متزايدة الى قدرة أكثر في توصيل الخدمات المطلوبة للمشركين وبمقايس عالية الجودة. ولهذا السبب نقترح إطار عمل عام لتحسين جودة التجربة من خلال استخدام وترتيب افضل لعوامل جودة الخدمة ومع قياس ردود أفعال المستخدمين قبل وبعد تطبيق إطار العمل. إن إطار العمل المقترح يتضمن جزئين رئيسين :جزء جودة الخدمة وجزء جودة التجربة، حيث أن جزء جودة الخدمة يتعامل مع مختلف المقاييس التي لها صلة بكل من مستويي السيطرة والبيانات.

ولأجل التحقق عمليا من نجاعة وكفاءة إطار العمل المقترح، فقد إخترنا شركة وطنية لتزويد خدمات الإنترنيت لتطبيق مقترحنا عليه بشكل واقعي. ولقد أظهرت النتائج الواقعية التي تم الحصول عليها أن مستوى إرضاء المستخدمين قد إزداد بشكل كبير بعد تطبيق إطار العمل المقترح الخاص بنا لمزودي خدمات الأنترنيت . وقد كانت النتائج إيجابية بشكل كبير فيما يخص تحسين جودة التجربة لكافة تطبيقات التواصل الإجتماعي (الفيس بوك و الفايبر و التانجو) التي تم أخذها بعين الأعتبارفي هذة الرسالة .

بالنسبة الى حالة تحسين الفيس بوك معظم المستخدمين كان مستوى تقيمهم مقبول للخدمة المقدمة, قبل تطبيق إطار العمل المقدم, لكن بعد تطبيق إطار العمل فأن النتائج المستحصلة يظهر تحسن مستمرلإرضاء المستخدمين فكان نتائج 90% من المستخدمين كان تقيمهم للخدمة الفيس بوك ممتارة. حالات مماثلة من التحسن حصلنا عليها في كلا من تطبيقات الفايبر والتانجو.بعد تطبيق إطار العمل المقدم مع ذكر تأثير سلبي يذكر على الخدمات الاخرى . في الواقع إن تحسين في بعض عوامل جودة الخدمة له تأثير على تقليل (ping jitter) بمستوى 6 مرات بعد تطبيق إطار العمل في مختلف الخدمات.

باشترکردنی کواڵتی تاقیکردنەوە بەپێی کواڵتی خزمەت گوزاری بۆ کۆمپانیاکانی خزمەت گوزاری بواری ئینترنیت وەکو پێویستیەکی ئەرینی نویێ لە داواکاری بەشداربووان

نامەیەك
پێشکەش کراوە بەئەنجومەنی کۆلیجی زانست
لە زانکۆی سلێمانی وەك بەشیك لە پێداویستیەکانی
بەدەستهێنانی بروانامەی ماستر
لە زانستی کۆمپیوتەر

لەلاین
دانا کریم حمەغریب کریم
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بەسەرپەرشتی

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پوختە

لە چەند ساڵی ڕابردوودا ڕێژەی بەکارهێنانی داتا بە شێوەیەکی دراماتیکی زیادی کردووە. بەهەمان شێوە، بەکارهێنانی بەرنامە یان خزمەتگوزارییەکانی تۆڕێ کۆمەڵایەتی زیاد دەکات بەشێوەیەکی سەرسورهێنەر لە ژیانی کۆمەڵایەتی مرۆڤەکاندا. لەهەموویشی گرنگتر وەکو ئاشکرایە بەرنامەکانی مەلتیمیدیا پێویستی هەیە بە بە باندوزێکی باش و گەرەنتی کەمترین دواکەوتن (Latency) بەمەبەستی بەدەست هێنانی ڕەزامەندی بەکارهێنەران لە خزمەتگوزارییەکان. بێگومان ئەمەش بووەتە بەرەنگارییەکی هەنووکەیی لەبەردەم کۆمپانیاکانی بواری ئینتەرنێت بۆ بەردەوام بوون لە بازاری کاردا. بۆ بەدیهێنان و سەرکەوتن بەسەر ئەم بەربەستانە دەبێت پەیوەندی نێوان کواڵیتی خزمەتگوزاری و تاقی کردنەوە ڕەچاو بکرێت.

لەم ماستەرنامەیەدا، خوێندنەوە و بەدواداچوون دەکرێت بۆ بەدەستنیشان کردنی کێشەکانی بەردەم کۆمپانیاکانی بواری ئینتەرنێت وەک پێویستیەکی بەردەوام بۆ گەیاندنی خزمەتگوزارییەکان بە کواڵیتیەکی بەرز و پەسەندکراو. بۆیە لەم ماستەرنامەیدا پێشنیاری چوارچێوەیەکی ئەکادیمی و زانستی گشتگیر بۆ باشتر کردنی کواڵیتی تاقی کردنەوە لە ڕێگەی بەکارهێنان و ڕێکخستنی باشتر بۆ Parameterەکانی کواڵیتی خزمەتگوزاری دەکرێت. ئەم پێشنیارەش پێکهاتووە لە دوو بەشی سەرەکی کە بریتین لە بەشی کواڵیتی خزمەتگوزاری و تاقی کردنەوە. لە بەشی کواڵیتی خزمەتگوزاری کار لەسەر ئەو هەژمارانە دەکرێت کە پەیوەندیان بە Control Plane و Data Plane هەیە. بۆ دڵنیابوون لە سەرکەوتنی پێشنیارەکەمان، بریاردرا کۆمپانیایەکی بواری خزمەتگوزاری بواری ئینتەرنێت بەکاربێت بۆ ئەکتیڤ کردنی چوارچێوەی پێشنیازکراو.

ئەنجامەکان ئەوە نیشان دەدەن کە ئاستی ڕازیبوون لە خزمەتگوزارییەکان دەگاتە ئاستێکی پەسەندکراو. ئەمەش گرنگی باشتر کردنی کواڵیتی تاقی کردنەوە بۆ بەرنامەکانی تۆڕی کۆمەڵایەتی وەک Tango و Viber و Facebook دەردەخات.

بەنسبەت بۆ کەیس Facebook زوربەی بەشدابووان ئاستی هەڵسەنگاندنیان بە پەسەند وڵام درابوو بۆ خزمەت گوزارێکە پێیش جێبەجێکردنی framework کە بەڵام باش جێبەجێکردنی framework کە ئەنجامەکان لە ئاستیکی بەرز بوو کە 90% لە بەشداربووان ئاستی هەڵسەنگاندیان گۆرا بۆ نایاب لە کەیسی Facebook .

حاڵەتەکانی هاوشێوە لە بروپێشچونی بەردەوام بۆ کەیسەکانی Viber و Tango پاش جێبەجێکردنی frameworkکە ,لەگەڵ بەبیرهێنانەوەی کاریگەری نەگێتڤی لەسەر خزمەت گوزارێکانی تر. لە راستیدا هەر باشترکردنی لە هەندێك parameter ەکانی کواڵتی خزمەت گوزاری کاریگەری دەکات لە سەر ping jitter بە ئاستی 6 ئەوەندە کەمتر ,پاش جێبەجێکردنی ئەم framework کە لە کۆی هەموو خزمەت گوزارێکاندا.