A Proposal of Prediction of Peak-Signal-to-Noise-Ratio based on QoS Networks

Carlos Soares Noleto Junior, Claudio de Castro Monteiro
Network Computer Group - GREDES
IFTO Federal Institute of Education, Science and Technology of Tocantins
Palmas, Brazil
carlosnoleto@gmail.com, ccm @ifto.edu.br

***Abstract*— Video quality perceived by the human eye is an area of research that is gaining space in today's scientific circles. Nowadays, a lot of media content is made available in the form of videos. The relationship between network quality metrics and quality perceived for these videos assumes great importance, showing that if the requirements of network quality are not achieved the outcome will be impaired. This work presents a proposal to evaluate what the quality of a video would be based only on the quality of the network metrics (jitter, loss and delay), thus attempting to predict what the end-user would perceive using a widely used metric of objective quality (the PSNR) to evaluate the quality of multimedia content.**

Keywords- PSNR; multimedia; QoS; QoV;

I. INTRODUCTION

Many researches [2][3][5] have been completed in the area of video quality analysis, due to the enlarging bandwidth offered through the latest mobile network technologies. Among those networks, we cite the standards: Wireless Local Area Network (WLAN) [1], 3G [1] and WiMax [3].

With more bandwidth availability, new frontiers may be opened, increasing user satisfaction with the services that are available. When we talk about evaluating user satisfaction, we refer to the experience that is provided by the use of services offered, from which emerges a term that is becoming popular: Quality of Experience (QoE) [4].

This work intends to analyze the possibility of predicting an objective metric's value for verification of video quality, using QoS information from the network. To do this, we need to evaluate objectively the quality of the video broadcasts, and the impact that the variables of Quality of Service (QoS) have on this value. The metric that has been chosen for video quality analysis was the Peak Signal-to-Noise Ratio (PSNR) [3], due to being commonly used in studies of this nature and for being proven valid for the proposed scenario.

In Section 2, we comment on some works related to Quality of Video (QoV) analysis and QoE in IP networks. In Section 3, we present the scenario and the resources used, as well as the methodology applied on the experiments of this research. In Section 4, the tests accomplished will be described with a summary of the results. In section 5, the results will be analyzed and discussed. Section 6 completes the report with the conclusion and presentation of possible future works.

II. RELATED WORKS

The growth of network capacity, the standardization of transport protocols, the rising demand for multimedia content, and the standardization of video codecs are among the factors that propel the scientific community to continue research about how to improve the quality of this content, as well as a rational use of modern operating networks. The studies presented below are a few examples of research that contribute to improving the experience of the users when they access multimedia content.

Gomathi et al. [5] proposed the implementation of a transport layer protocol to make available an improvement of the QoS metrics for multimedia content in wireless ad-hoc networks. Furthermore, he proposes the optimization of parameters from the Media Access Control (MAC) layer to meet the objectives of the study, and as a result of the proposal presented, the author got a network delay reduction as well as an increase in the PSNR value.

In [3] the evaluation of the protocol H.264/SVC with multimedia content through WiMax networks is performed, the evaluation using the objective metric (PSNR) and the subjective metric Mean Opinion Score (MOS), making use of a formula that relates the PSNR metric with the MOS metric, and identifying possible factors that influence the quality perceived by the user.

Monteiro [1] worked with mobility management, aiming for the best user experience possible. He also presents a metric that was called Network Quality Metric (NQN) and this metric will be used to analyze network quality in this study.

Forchhammer et al. [6] presented an analysis and processing proposal without references, evaluating video quality without the need of accessing the original video, and as a result managing to obtain the value of PSNR with an error of about 0.3db. For this the coefficients of measured Discrete Cosine Transform (DCT) were used.

In order to compare video quality metrics, D. Z. Rodriguez and G. Bressan [7] compare the quality of information of the metrics PSRN, Structural SIMilarity (SSIM), and Video Quality Metric (VQM) in an environment of stream over IP and digital TV according to the ISDB-T.

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As a result, it may be that the quality measured is related to the content and characteristics of the video.

C. C. Monteiro and P. R. L. Gondim [8] presented a proposal for the selection of the network based on characteristics of QoS and QoE for mobile environments, thus defining what would be the best moment for the execution of soft handover between 3G and Wireless Local Area Network (WLAN) networks to improve user experience.

III. METHODOLOGY

Aiming to achieve the objective of this study, a scenario was created containing all the requirements to meet the project's demands. A series of procedures were necessary for the execution process and this section deals with the presentation of this scenario, the resources and methodology used.

The scenario devised for the tests was composed of a multimedia content server that made videos available for the client, and a client that processed the multimedia content provided by the server. All material available on the server could only be visualized on demand, thus giving more flexibility to a client that might use the services at more convenient times.

One of the premises for the development of this study was that all the tools used should be based on free software. Following this concept, the server and the client were computers with Ubuntu 11.04 operating system installed. For content availability and its subsequent acquisition through network transmissions, VLC software [9] was used. VLC is a multimedia content player capable of publishing content for other users in the network.

A great way of simulating congestion on the network is to use bandwidth limiting. This process allows you not to have to generate unnecessary background traffic and guarantees the velocity that will be available for the user. To accomplish this task the Class-based queuing (CBQ) shaper was used. Besides the already mentioned software, a little script written in python was necessary for sampling the state of the network, the program ffmpeg, necessary for the conversion of the videos, and lastly the file psnr.exe together with the program wine for the calculation of the PSNR.

For research development the first step was the creation of a pilot test, having as its objective to make statistical calculations from the data to define the size of the ideal sample for the study. Thus the data used for the definition of the sample size were the jitter data that presented the greatest variation in pattern bypass during the pilot test, becoming the worst case. Below we have the values used for the calculations.

$$\sigma = 12{,}14ms$$

$$\rho = 95\%$$

$$\theta = 3{,}0\text{ms}$$

where,

σ – Average bypass pattern.

ρ – Level of trust.

θ – Maximum error allowed.

The level of trust for 95% of confidence level in normal distribution is 1,96.

With these values at hand, it was possible to determine the size of the sample using the following formula:

$$\theta = \frac{\sigma * \rho}{\sqrt{\omega}} \qquad (1)$$

Changing the values we found

$$3{,}0 = \frac{12{,}14 * 1{,}96}{\sqrt{\omega}} \qquad (2)$$

$$\omega \cong 63 \qquad (3)$$

We then arrived at the value of 65 repetitions for each evaluated video for a confidence level of 95%.

Fifteen sequences of video were selected for the execution of the tests, all with spatial resolutions of 352 x 288 pixels. All videos acquired in the format .yuv were converted to .mp4 to make possible their transmission through the network. The sequences are presented in Table I.

TABLE I. SEQUENCES OF VIDEO

Name	Video	Frames
Sequence 1	Bridge (Close)	2001
Sequence 2	Bridge (Far)	2101
Sequence 3	Coastguard	200
Sequence 4	Container	300
Sequence 5	Flower	250
Sequence 6	Foreman	300
Sequence 7	Hall Monitor	300
Sequence 8	Highway	2000
Sequence 9	Mobile	300
Sequence 10	Mother and Daughter	300
Sequence 11	News	300
Sequence 12	Silent	300
Sequence 13	Stefan	90
Sequence 14	Tempete	260
Sequence 15	Waterfall	260

After reception, the videos must be recodified in the format .yuv to make calculations of the PSNR possible. The data should be then compared with the PSNR data previously obtained, aiming to identify the real losses caused in this metric during the transmission process.

The simulation of congestion in the network was accomplished via cbq shaper. The videos were codified in the format H264/MPEG4 with a bitrate of 300k. Three distinct speeds were selected for the making of the tests: 200k forcing the lost of packages due to network limitations, 300k allowing the video to be played inside the limits of bandwidth requested, and 400k allowing the transmissions to happen without limitation.

IV. RESULTS

After identifying the quantity of repetitions needed, the quantity of sequences to be evaluated, and the velocities that should be tested, we see what needs to be done: two thousand nine hundred and five tests. In each test we should verify the information of QoS at the moment of transmission, complete the calculations of the QoV values, and, in the end, record all data in an organized way.

Considering that this process would take a long time to be performed manually, and that little mistakes during its execution could harm the test results, we realized that the creation of a mechanism to automate these proceedings would be of great value, and in this way a testbed was developed.

The testbed developed has the functions of performing the acquisition of the multimedia content of the server, storing the content in a client directory, acquiring and keeping the collected information about the network state during the transmissions, completing the process of modification of the video received from the .mp4 format to .yuv format, performing the PSNR calculations, comparing the original video previously saved in the client's machine with the newly converted video, and finally consolidating the received data to facilitate the process of tabulation and analysis for the researcher.

As this work does not deal with the presentation of the developed testbed, as it is just a tool used to facilitate the activities performed during the research, the codes and algorithms used for the development of the testbed will not be shown. We will only present its components as well as the functions of each.

According to what is presented in the Table II, the testbed shows only four components. All components were developed in a way that their reuse may be possible in other environments with few modifications.

TABLE II. TESTBED COMPONENTS

Component	Function
cliente.sh	Main component of the framework where the algorithms are implemented. This component has a series of dependences which if not attended do not permit its execution, making the process more secure and ensuring the functioning of all algorithms in a correct form.
Qos.py	Script in python developed for the collection of information about the network. Using the information contained in ping it can return data of QoS from the network like delay, jitter and loss.
Psnr.exe	Program responsible for the realization of comparison of the videos and calculation of PSNR, used in Linux with the help of the program wine.

With the help of the framework the data collection process has become simpler, only one call being needed from the system to perform all the 3ollection and calculation tasks the command line are "cliente.sh 65 300K".

During the system call, we show that we need to make 65 tests at a speed of 300K. As the quantity of videos has already been defined as 15, 975 tests will be executed, and when finishing all the tests we will have 60 files containing the data to be analyzed, that being four files for each video, one for delay, one for jitter, one for loss and finally one for PSNR. In Tables III, IV and V, we present the averages and standard deviation of data for every transmission rate.

TABLE III. AVERAGE AND SD OF DATA IN 200K

Name	Average Jitter	SD Jitter	Average Delay	SD Delay	Average Loss	SD Loss	Average PSNR	SD PSNR
Sequence 1	30,774	1,849	509,813	7,151	0,585	0,051	22,308	1,409
Sequence 2	31,389	2,216	524,284	7,664	1,708	1,331	25,165	0,044
Sequence 3	94,707	7,033	477,109	7,076	0,462	0,502	17,357	0,194
Sequence 4	90,645	4,827	467,672	10,443	0,215	0,414	22,770	0,140
Sequence 5	110,516	9,113	465,371	9,176	0,185	0,391	10,805	0,064
Sequence 6	102,169	9,154	474,679	9,975	0,662	0,713	15,460	0,228
Sequence 7	89,203	10,912	471,867	46,788	0,231	0,552	22,964	0,172
Sequence 8	32,849	2,414	534,996	6,243	3,138	1,694	18,860	0,499
Sequence 9	96,741	8,108	463,774	7,678	0,569	0,529	11,926	0,103
Sequence 10	99,957	9,108	474,404	8,884	0,462	0,811	25,913	0,283
Sequence 11	100,754	7,360	476,421	10,275	0,215	0,483	21,111	0,437
Sequence 12	97,670	6,353	470,264	11,086	0,015	0,124	23,443	0,258
Sequence 13	200,737	35,328	389,353	80,768	0,077	0,268	15,332	0,118
Sequence 14	76,178	5,335	489,374	33,787	0,277	0,515	13,659	0,139
Sequence 15	72,476	3,395	492,667	10,229	0,169	0,377	21,811	0,216

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TABLE IV. AVERAGE AND SD OF DATA IN 300K

Name	Average Jitter	SD Jitter	Average Delay	SD Delay	Average Loss	SD Loss	Average PSNR	SD PSNR
Sequence 1	36,869	1,409	276,815	4,218	0,215	0,414	28,824	0,298
Sequence 2	35,733	1,558	287,778	4,416	0,308	0,497	34,771	0,288
Sequence 3	71,473	4,902	271,467	8,219	0,323	0,471	18,205	0,630
Sequence 4	65,249	3,916	257,472	8,173	0,031	0,174	23,953	0,222
Sequence 5	74,211	17,538	278,522	17,523	0,092	0,384	11,006	0,070
Sequence 6	66,654	4,815	283,352	9,203	0,015	0,124	16,528	0,255
Sequence 7	66,905	2,666	275,372	7,622	0,031	0,174	23,585	0,379
Sequence 8	34,256	2,083	270,862	4,487	0,631	0,719	25,608	0,264
Sequence 9	76,690	8,175	255,558	8,227	0,169	0,377	12,064	0,058
Sequence 10	68,912	3,105	271,854	11,668	0,385	0,490	27,966	0,412
Sequence 11	70,968	3,815	270,132	7,021	0	0	23,106	0,259
Sequence 12	66,501	6,110	259,593	9,947	0	0	24,441	0,333
Sequence 13	164,494	38,250	263,176	24,457	0	0	15,202	0,042
Sequence 14	57,623	5,488	290,460	9,139	0,246	0,434	14,222	0,191
Sequence 15	54,703	4,506	284,247	10,511	0,031	0,174	22,913	0,283

TABLE V. AVERAGE AND SD OF DATA IN 400K

Name	Average Jitter	SD Jitter	Average Delay	SD Delay	Average Loss	SD Loss	Average PSNR	SD PSNR
Sequence 1	7,783	1,280	18,500	15,515	0,015	0,124	29,905	0,418
Sequence 2	7,737	0,856	17,502	1,070	0,015	0,124	36,309	0,043
Sequence 3	52,915	4,812	69,179	5,997	0	0	19,924	0,088
Sequence 4	56,846	11,187	145,048	8,401	0,031	0,174	29,256	0,367
Sequence 5	67,617	8,107	82,099	9,387	0	0	13,605	0,049
Sequence 6	59,477	10,409	113,302	7,093	0	0	19,782	0,342
Sequence 7	54,778	4,937	141,948	7,138	0,015	0,124	30,090	0,363
Sequence 8	7,071	0,615	11,164	1,115	0,277	0,450	26,484	0,040
Sequence 9	48,253	2,732	32,099	5,996	0	0	13,229	0,045
Sequence 10	53,232	4,264	141,930	7,768	0	0	29,758	0,356
Sequence 11	59,768	7,976	151,949	9,116	0,231	0,424	27.080	0,448
Sequence 12	54,748	6,364	142,035	7,409	0	0	26,820	0,348
Sequence 13	134,811	40,128	166,845	30,067	0,123	0,331	17,937	0,460
Sequence 14	58,334	5,839	61,318	7,389	0	0	16,332	0,093
Sequence 15	69,268	14,547	146,231	7,234	0,231	0,424	26,613	0,297

After all the transmissions have been completed and all the files generated for each velocity, we will have a great quantity of data to be analyzed. As this work has as an objective to find any relation, if it exists, among the variables of QoS with the video quality calculated by PSNR, it is necessary to do multiple linear regression. This way we can verify how each variable influences PSNR, and if any variable can.

V. DATA ANALYSIS

Now, possessing all data in an organized form, tabulated in a spreadsheet, we can perform the next step to try to identify some relation among the variables involved. To do this we use the process of normal linear regression, aiming to establish a relation between the variable PSNR and the network metrics collected, jitter, delay and loss, that were evaluated as independent variables as can be seen below.

$$\gamma = \beta 0 + \beta 1_{xj} + \beta 2_{xa} + \beta 3_{xp} \qquad (4)$$

where,
γ – Estimated PSNR
$\beta 0$ – Coefficient of linear adjust.
$\beta 1$ – Coefficient of jitter.
xj – Average value of jitter
$\beta 2$ – Coefficient of Delay.
xa – Average Delay value
$\beta 3$ – Coefficient of loss.
xp – Average Loss value.

The values of $\beta 0, \beta 1, \beta 2$ and $\beta 3$ represent the values of the angular variables of each independent variable, and influence directly the result of the estimated PSNR. To find these values we use the interactive regression method of Gauss-Seidel using K=8 interactions for each broadcasted video at each velocity. At the end of each group of interactions we obtained 8 values of PSNR that were then compared to the values obtained during the tests in order to identify which one had the best coefficient of correlation with the real data that was used in the following formula:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(\gamma_i - Y_i)^2}{\sum_{i=1}^{n}\gamma_i{}^2 - \frac{1}{n}(\sum_{i=1}^{n}\gamma_i)^2} \qquad (5)$$

where,
R^2 – Coefficient of correlation

Y – Value of PSNR obtained on the tests

45 functions, defined by which function presented the best relevance through the coefficient of correlation, were obtained, derived from the 15 sequences of videos selected and the 3 velocities of transmission. The functions are presented below accompanied by the coefficient of correlation for each one, the values used having a precision of 5 decimal places.

TABLE VI. FUNCTIONS OF SEQUENCE 1

Sequence 1		
Rate	Function	R^2
200K	$\gamma = 22{,}30275 - 0{,}00008\beta 1_{xj} - 0{,}00001\beta 2_{xa} - 0{,}01629_{xp}$	0,99994
300K	$\gamma = 28{,}82447 + 0{,}00000\beta 1_{xj} - 0{,}00000\beta 2_{xa} + 0{,}12414_{xp}$	0,99975
400K	$\gamma = 29{,}90543 - 0{,}00488\beta 1_{xj} - 0{,}00968\beta 2_{xa} - 1{,}88240_{xp}$	0,99467

TABLE VII. FUNCTIONS OF SEQUENCE 2

Sequence 2		
Rate	Function	R^2
200K	$\gamma = 25{,}19843 + 0{,}00110\beta 1_{xj} + 0{,}00006\beta 2_{xa} + 0{,}01208_{xp}$	0,97232
300K	$\gamma = 34{,}70796 - 0{,}00193\beta 1_{xj} - 0{,}00021\beta 2_{xa} + 0{,}00806_{xp}$	0,95519
400K	$\gamma = 36{,}31333 + 0{,}00048\beta 1_{xj} + 0{,}00032\beta 2_{xa} - 0{,}12876_{xp}$	0,99994

TABLE VII. FUNCTIOS OF SEQUENCE 3

Sequence 3		
Rate	Function	R^2
200K	$\gamma = 17{,}39035 + 0{,}00034\beta 1_{xj} + 0{,}00007\beta 2_{xa} - 0{,}07372_{xp}$	0,98514
300K	$\gamma = 18{,}61859 + 0{,}00551\beta 1_{xj} + 0{,}00158\beta 2_{xa} - 0{,}02556_{xp}$	0,99509
400K	$\gamma = 19{,}93211 - 0{,}00005\beta 1_{xj} + 0{,}00009\beta 2_{xa} - 0{,}12041_{xp}$	0,99916

TABLE IX. FUNCTIOS OF SEQUENCE 4

Sequence 4		
Rate	Function	R^2
200K	$\gamma = 22{,}78018 + 0{,}00010\beta 1_{xj} + 0{,}00002\beta 2_{xa} - 0{,}00433_{xp}$	0,99920
300K	$\gamma = 23{,}97115 + 0{,}00028\beta 1_{xj} + 0{,}00005\beta 2_{xa} - 0{,}14057_{xp}$	0,99899
400K	$\gamma = 29{,}21160 - 0{,}00084\beta 1_{xj} - 0{,}00030\beta 2_{xa} - 0{,}37113_{xp}$	0,99994

TABLE X. FUNCTIONS OF SEQUENCE 5

Sequence 5		
rate	Function	R^2
200K	$\gamma = 10{,}81638 + 0{,}00009\beta 1_{xj} + 0{,}00002\beta 2_{xa} - 0{,}02618_{xp}$	0,99999
300K	$\gamma = 10{,}98440 - 0{,}00024\beta 1_{xj} - 0{,}00007\beta 2_{xa} - 0{,}06850_{xp}$	0,99356
400K	$\gamma = 13{,}60414 - 0{,}00002\beta 1_{xj} + 0{,}00001\beta 2_{xa} - 0{,}00133_{xp}$	0,99999

TABLE XI. FUNCTIONS OF SEQUENCE 6

Sequence 6		
Rate	Function	R^2
200K	$\gamma = 15{,}496300 + 0{,}00031\beta 1_{xj} + 0{,}00007\beta 2_{xa} + 0{,}00482_{xp}$	0,99600
300K	$\gamma = 16{,}54088 + 0{,}00081\beta 1_{xj} + 0{,}00001\beta 2_{xa} - 0{,}26808_{xp}$	0,99996
400K	$\gamma = 19{,}81150 - 0{,}00010\beta 1_{xj} + 0{,}00040\beta 2_{xa} - 0{,}11325_{xp}$	0,98254

TABLE XII. FUNCTIONS OF SEQUENCE 7

Sequence 7		
Rate	Function	R^2
200K	$\gamma = 22{,}96395 + 0{,}00002\beta 1_{xj} - 0{,}00000\beta 2_{xa} - 0{,}03407_{xp}$	0,99999
300K	$\gamma = 23{,}60513 - 0{,}00001\beta 1_{xj} + 0{,}00009\beta 2_{xa} + 0{,}06614_{xp}$	0,99793
400K	$\gamma = 30{,}10198 + 0{,}00016\beta 1_{xj} + 0{,}00011\beta 2_{xa} + 0{,}02540_{xp}$	0,99474

TABLE XIII. FUNCTIONS OF SEQUENCE 8

Sequence 8		
Rate	Function	R^2
200K	$\gamma = 18{,}86019 + 0{,}00007\beta 1_{xj} - 0{,}00000\beta 2_{xa} + 0{,}00747_{xp}$	0,99995
300K	$\gamma = 25{,}90413 + 0{,}00810\beta 1_{xj} + 0{,}00110\beta 2_{xa} + 0{,}20133_{xp}$	0,97307
400K	$\gamma = 26{,}48370 - 0{,}00011\beta 1_{xj} - 0{,}00001\beta 2_{xa} + 0{,}02009_{xp}$	0,99999

TABLE XIV. FUNCTIONS OF SEQUENCE 9

Sequence 9		
Rate	Function	R^2
200K	$\gamma = 11{,}92616 - 0{,}00004\beta 1_{xj} + 0{,}00000\beta 2_{xa} - 0{,}05556_{xp}$	0,99997
300K	$\gamma = 12{,}03541 - 0{,}00031\beta 1_{xj} - 0{,}00011\beta 2_{xa} - 0{,}06790_{xp}$	0,99862
400K	$\gamma = 13{,}22607 - 0{,}00004\beta 1_{xj} + 0{,}00008\beta 2_{xa} - 0{,}02882_{xp}$	0,99900

TABLE XV. FUNCTIONS OS SEQUENCE 10

Sequence 10		
Rate	Function	R^2
200K	$\gamma = 25{,}58458 - 0{,}00369\beta 1_{xj} - 0{,}00064\beta 2_{xa} - 0{,}39505_{xp}$	0,99015
300K	$\gamma = 27{,}99559 + 0{,}00001\beta 1_{xj} + 0{,}00003\beta 2_{xa} - 0{,}34296_{xp}$	0,99922
400K	$\gamma = 29{,}78410 + 0{,}00069\beta 1_{xj} + 0{,}00014\beta 2_{xa} + 0{,}10573_{xp}$	0,99995

TABLE XVI. FUNCTIONS OF SEQUENCE 11

Sequence 11		
Rate	Function	R^2
200K	$\gamma = 21{,}06641 - 0{,}00061\beta 1_{xj} - 0{,}00009\beta 2_{xa} + 0{,}02737_{xp}$	0,99969
300K	$\gamma = 23{,}11265 + 0{,}00000\beta 1_{xj} + 0{,}00003\beta 2_{xa} - 0{,}40068_{xp}$	0,99939
400K	$\gamma = 27{,}06671 - 0{,}00047\beta 1_{xj} - 0{,}00004\beta 2_{xa} + 0{,}06318_{xp}$	0,99992

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TABLE XVII. FUNCTIONS OF SEQUENCE 12

Sequence 12		
Rate	Function	R^2
200K	$\gamma = 23,41065 - 0,00019\beta 1_{xj} - 0,00007\beta 2_{xa} + 0,17841_{xp}$	0,99624
300K	$\gamma = 24,30987 - 0,00207\beta 1_{xj} - 0,00051\beta 2_{xa} - 0,01020_{xp}$	0,99593
400K	$\gamma = 26,88529 + 0,00005\beta 1_{xj} + 0,00053\beta 2_{xa} - 0,45183_{xp}$	0,99998

TABLE XVIII. FUNCTIONS OF SEQUENCE 13

Sequence 13		
Rate	Function	R^2
200K	$\gamma = 15,32524 - 0,00003\beta 1_{xj} - 0,00002\beta 2_{xa} - 0,05070_{xp}$	0,99246
300K	$\gamma = 15,22704 + 0,00026\beta 1_{xj} + 0,00004\beta 2_{xa} + 0,01078_{xp}$	0,99488
400K	$\gamma = 17,84301 - 0,00088\beta 1_{xj} - 0,00029\beta 2_{xa} + 0,15210_{xp}$	0,99996

TABLE XIX. FUNCTIONS OF SEQUENCE 14

Sequence 14		
Rate	Function	R^2
200K	$\gamma = 13,65806 - 0,00013\beta 1_{xj} - 0,00000\beta 2_{xa} - 0,02347_{xp}$	0,99986
300K	$\gamma = 14,32875 + 0,00227\beta 1_{xj} + 0,00032\beta 2_{xa} - 0,02272_{xp}$	0,99746
400K	$\gamma = 16,33751 + 0,00015\beta 1_{xj} + 0,00037\beta 2_{xa} + 0,01849_{xp}$	0,99996

TABLE XX. FUNCTIONS OF SEQUENCE 15

Sequence 15		
Rate	Function	R^2
200K	$\gamma = 21,72162 - 0,00113\beta 1_{xj} - 0,00019\beta 2_{xa} + 0,08800_{xp}$	0,99999
300K	$\gamma = 22,91307 - 0,00005\beta 1_{xj} + 0,00001\beta 2_{xa} - 0,39961_{xp}$	0,98264
400K	$\gamma = 26,57632 - 0,00008\beta 1_{xj} - 0,00034\beta 2_{xa} + 0,15489_{xp}$	0,99728

The functions listed in the Tables VI-XX show that it is possible to find a relation between the metrics of the network and the quality of videos transmitted, taking into consideration the values of the Coefficient R^2.

VI. CONCLUSION AND FUTURE WORKS

This article proposed a model for the prediction of video quality based on an objective metric (PSNR), through the use of the QoS parameters of the network.

With the data analysis collected during the experiments and the use of linear regression on the data, we could detect a relation between the metrics of objective quality evaluated (PSNR) and the metrics of QoS of the network. The functions found demonstrate this relation, as the PSNR suffers changes depending on the characteristics of the videos. Because of this, we have great differences in the generated formulas.

The study demonstrated the possibility of the development of applications that use the parameters of a network's QoS to predict the values of PSNR of a predetermined content in a way that the user will always have the best experience possible accessing multimedia content. For example, we may cite an application that uses this model to define what would be the best moment to make a change in the access network, or what video resolution should be made available in a predetermined environment.

For future studies, we intend to use other objective metrics to verify if these aspects are confirmed. We intend to compare subjective metrics, objectives and the parameters of the network in order to consolidate the results of this research.

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