QOE Analysis for Mobile Network Services using Twitter Opinion Extraction

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Abstract. Mobile communication networks have been evolving over time to meet the expectations of consumers who are increasingly accustomed to the facilities offered by the services provided by such networks. Studies on QoE (quality of experience) are presented to analyze the satisfaction of final consumers about a given product or service. Thus, this research seeks new QoE indicators in an automated way for mobile communication operators that operate in the Brazilian territory. Thus, an application was created to mine opinions emitted in tweets from the social network Twitter and score them according to the MOS (Mean Opinion Score). This research has two contributions, analyzing the correlation between service quality and complaints from mobile network users and the automatic generation of a new indicator generated by correlating quality and Twitter data, since there is a lack of research that uses a methodology similar to the one employed here. In its results it was possible to observe a tendency of the carriers' customers to use Twitter more to complain than to express opinions of satisfaction.

Keywords: mobile communication, QoE, automated.

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1 Introduction

In a globalized world, the increase in different demands for services has occurred, especially in mobile media, with a focus on voice and video. A fact that can be observed by research that has been developed by different researchers and institutions as in [3, 5, 7, 10, 8].

In this context, it is observed that mobile communication networks [29, 30] have been evolving over time to meet the expectations of consumers who are increasingly accustomed to the facilities offered by the services offered in this type of networks, this can be observed in accordance with [19, 22] which reports the evolution of networks since the first generation, with 1G, which only offered voice services, soon after, with the need to evolve, came the launch of the second generation, with 2G, with the novelty of being able to send SMS (instant messaging), after the second and a half generation 2.5G, which was marked by the evolution of digital technologies towards 3G, the third generation, 3G had as a differential the possibility of using the internet in mobile sports , the fourth generation 4G [16, 23, 21, 20], came to improve 3G, and offer more connectivity to consumers reaching the fifth generation, 5G [2, 17], which seeks to encompass more services to meet the IoT (internet of things) and allow even more connectivity to consumers. It is noted that with the technological evolution in the means of telecommunication, there is a need for operators that provide services to this medium, to monitor the technologies used for telecommunication in order to remain competitive and thus offer quality services to their customers [19].

With the advancement of mobile communication networks, there is an increasing demand for new applications emerging [28]. In [10] the researchers indicate that this demand is due to vital factors, that is, accessible or even free internet, national or international te-

lephony, availability of the internet as a means of voice transmission, rapid increase in the use of portable and smart devices, thus characterizing the subsequent market growth.

Thus, it is observed that studies have been carried out with the objective of contributing with solutions that help operators to improve mobile communication networks in terms of QoS (*Quality of Service*) and with the analysis of QoE (*Quality of Experience*). According to [8], QoS âaims to measure and guarantee the delivery of certain network parametersâ, whereas QoE âmeasures the degree of user satisfaction with a particular provider, whether this is content, internet, service or equipmentâ. In [19] points to the fact that telecommunication operators seek ways to understand the quality of the experience lived by their customers.

In this context, this research aims to propose a quality indicator from the perspective of the end user of Mobile Services in Brazil, thus applying the QoE. To reach this indicator, an application was developed with the purpose of reading opinions collected via social networks [14, 25, 27]. The opinions collected are tabulated in accordance with the score of the MOS table (*Mean Opinion Score*) that uses the score metrics from one (1) to five (5) that infers the subjective experience of the user, being widely used in modeling quality [31, 4, 24, 12].

Thus, it is believed that this research contributes to the demand for mobile services, especially the more traditional one, which has generated an evolution in the market since its arrival the voice, and that generated the need to always evolve and meet the expectations of different consumers. The survey analyzes the satisfaction of the various users and helps to maintain an acceptable and updated QoE indicator to assist both providers and consumers. To this end, this research investigates the automatic opinions coming from social networks, since there is a lack of work with this methodology.

The main contribution of this work is analyze the correlation between voice quality and complaints from users of telecom services extracted from social networks.

2 Theoretical Revision

This chapter addresses topics related to the research field of this article on Mobile Networks in Brazil, and QoE - Quality of Experience.

2.1 Mobile Networks

Mobile networks are performed by cellular networks have communication through radio frequency communication networks, thus allowing continuous mobility through many cells [22].

There are different technologies used for mobile network communication. The technologies used in mobile networks mark the so-called generations through which it is possible to observe the evolution of telecommunications. So the technologies are:

- 1G used AMPS (*Advanced Mobile Phone System*) and FDMA (*Frequency Division Multiple Access*) technologies for analogue frequency conversion. It has succeeded in allowing you to make phone calls away from home, on a wireless device, and on the go. 1G networks no longer operate. [22, 19]
- 2G uses GSM (*Global System for Mobile Communications*), TDMA (*Time Division Multiple Access*) and CDMA (*Code Division Multiple Access*) technologies. Second generation cell phones have smaller sizes, are more accessible in terms of cost and will now allow the sending of SMS.[22, 19]
- 3G uses UMTS (*Universal Mobile Telecommunications Service*) which represents an evolution of the GSM standard, with its implementation being able to even take advantage of the GSM structure. It is marked by the advent of the internet, which now integrates connectivity services to mobile devices along with the already traditional 2G Voice and SMS services.[22, 19]
- 4G - LTE networks (*Long Tem Evolution*) 4G transmission capacity, up to 1Gbps, allowing access to *streamig* and high-definition video games.[22, 19]
- 5G an evolution of 4G with several expectations regarding the proposed services, mainly in the integration with the IoT (internet of things), still in an embryonic stage. [22, 19]

It is noted when observing the evolution the constant search for improvement of the services provided. The research proposed here believes that QoE indicators can contribute to the growing process of this evolution.

2.2 Mobile Networks in Brazil

Brazil has Mobile telephone networks (Personal Mobile Service - SMP) with 2G, 3G and 4G technologies, in addition to having recently auctioned 5G. [**?**]

In order to offer network services for mobile devices, a concession issued by the regulated body Anatel is required. Although operators need a concession, mobile telephony is a service provided under the private

regime, and based on the constitutional principles of economic activity, according to art. 126 of the General Telecommunications Law. Therefore, the offer of services by regions of Brazil depends on the commercial interest of the providers. The following graphs show the presence of technologies made available by operators operating in Brazil.

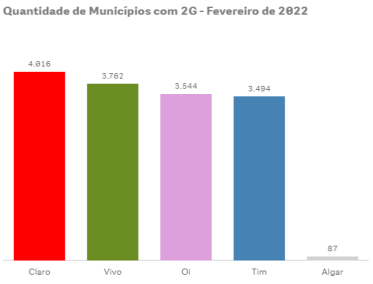

Figura 1: Presence of 2G Networks in Brazil.

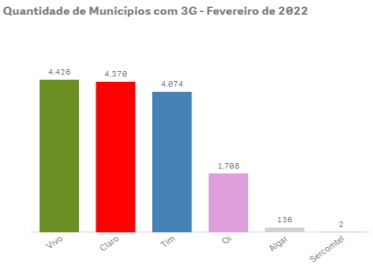

Figura 2: Presence of 3G Networks in Brazil.

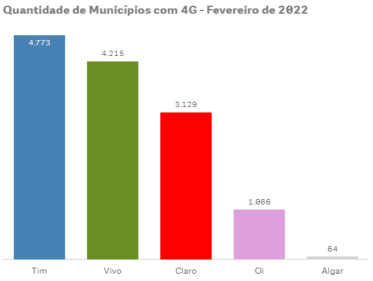

Figura 3: Presence of 4G Networks in Brazil.

The data in the chart above provided by [1], shows the presence of the technologies used in the Brazilian market. Figure 1 is 2G, Figure 2 is 3G and Figure 3 is 4G.

2.3 Quality of User Experience

The user' QoE (Quality of Experience) seeks to measure the degree of user satisfaction in relation to a particular provider or service, be it content, internet, equipment, among others. In telecommunications networks, the ITU-T study group (responsible for defining the standards for the sector) points to QoE as the degree of satisfaction or annoyance of the user of an application or service. [5, 6]. In [13] it says that QoE evaluation and optimization encompasses modeling the quality of service, monitoring the actual performance of the service, as well as analyzing and improving the quality of service and the end-user experience.

The term QoE arose from the need to evolve QoS (quality of service) widely used to analyze the performance of network services. In [10] it says that the definition of QoS is focused on the technical aspects of telecommunication services, while the definition of QoE is focused on the user. Also, QoE is inherently quite subjective and more realistic than QoS. QoS parameters such as throughput, end-to-end delay, jitter and packet loss rate do not successfully evaluate services as perceived by users, but there is always a correlation between QoE and QoS issues.[10]

Thus, this research believes that keeping QoE indicators updated helps both consumers in relation to the product or service they use and suppliers to provide services that satisfy their consumers.

The MOS (*Mean Opinion Score*) is standardized by the ITU-T telecommunication network study group and uses the ITU-T P.800 recommendations through a 5-value scalar as shown in table 1. if a subjective evaluation method that seeks to reflect the quality perceived by the user and measure the QoE.[31]

Tabela 1: Mean Opinion Score (MOS)

Level (MOS)	Perceived Quality
5	Excelent
4	Good
3	Regular
2	Bad
1	Very Bad

ITU-T P.800

In [11], it indicates that the QoE can be evaluated by the user's perception and satisfaction in a subjective way. Therefore, users' opinions can be expressed by the average score of 5 opinion levels stipulated by the MOS. An example would be a MOS score of 5, indicating that an application or service can provide QoE at an "excellent"level to end users, which is to say that the

application or service's deficiencies remain at an "unnoticeable"level.

This research will use the MOS score to tabulate the opinions collected via the social networks Twitter.

2.4 Related Works

Research that addresses QoE has been widely published with metrics and measurements that mainly collaborate in services provided via Telecommunications networks.

In [6] we sought to investigate the problem of resource allocation in multi-carrier multi-cell non-orthogonal multiple access networks (MC-NOMA), in subchannel assignment and in power allocation. The results presented by them indicate that the proposed NOMA networks are capable of outperforming the conventional orthogonal multiple access networks in terms of QoE and the proposed algorithms for MOS sum maximization can achieve a significant equity improvement in relation to the rate maximization scheme. of sum.

In [3] we sought to analyze the QoE in online video transmission applying the ITU-T P.1203 recommendations. In their results, the researchers pointed out that the DASH protocol presented higher levels of QoE (MOS) compared to the RTMP. Another point analyzed was the performance of the system with the considered resolutions (480p and 720p), in general the MOS estimate was higher for the 480p resolution compared to the one obtained for 720p. Thus, the researchers believe that the implementation proposed by them made it possible to obtain an objective estimate of QoE in an economical and low-complexity way.

In [32] an analytical framework was proposed combining stochastic geometry and queuing theory to evaluate the relationship between perplexed spatiotemporal traffic and network performance when mobility is considered. in wireless networks can be beneficial to reduce delay and improve QoE. The researchers believe their research provides a useful reference for the design of wireless networks when the spatio-temporal fluctuation of mobile traffic is considered.

In [5] it was proposed to carry out an evaluation for the performance of a new user-centric network and service management for future mobile networks. In their results, the researchers pointed out that the analysis showed that the adoption of management policies guided by QoE that recognize the network harms and changes the path where traffic flows is fundamental to maintain the quality of services above an acceptable limit, and that a Precise choice of design parameters at both the application layer and the network layer is critical to achieving QoE levels over time.

In [7] it was proposed to evaluate the VoIP quality of the G.729 codec. To achieve their goals the researchers improved the objective measurement tool called the simplified E-Model using the MOS model of subjective prediction. In their results the researchers pointed out that the modification of the simplified E-Model model made by them showed to be 58 percent better compared to the E-Model without the change, thus reducing errors.

In [11] an investigation was carried out in order to find out how QoS influences QoE and to evaluate QoE in VoIP communication. The researchers indicate that the research developed by them has helped improve the assessment of VoIP QoE using network performance parameter, explains how IP network environments can affect the quality and reliability of VoIP traffic, and calculates typical network performance requirements. for a VoIP application to run at the desired QoE level.

As mentioned in the introduction of this research, it was observed that there is a scarcity of researches that seek the evaluation in a subjective and automatic way, which is a point to which this research should collaborate, since the search for new QoE indicators for voice services will use the method of automatic collection of opinions in Social Networks.

3 Methodology

This section presents the tools that will be used in the process of collecting opinions from Social Networks, tabulating and scoring opinions.

3.1 Programming Languages and Tools

This research used the Python programming language to create an application for mining tweets from the social network Twitter. According to [15] since the emergence of this language it has become a de facto standard for exploratory, interactive and computation-based scientific research. Some characteristics of the Python language are that it is a high-level object-oriented language, with dynamic and strong typing, interpretive and interactive, it has a clear syntax that favors the development of source code besides being open source with a GPL (General Public License) compatible license.

The collection of opinions for this research will be via API (*Application Programming Interface*) or in Portuguese "Application Programming Interface". API is a set of programming routines and standards for accessing a software application and was based on web development platforms.

APIs are usually provided by companies that intend to allow different software to interact with their applica-

tion. Twitter allows the mining of tweets available via API.

According to [26] the Twitter API allows programmatic retrieval and analysis of Twitter data, made available to developers and academic researchers. The Twitter API is in the Twitter V2 version and to access the Twitter API it is necessary to create an account where it is indicated for what reasons the API will be used.

3.2 Expression Search

The automatic text analysis employed in this research, used NLP natural language processing summarization processes, to search for frequent expressions in the mined tweets. In [9] states that NLP, allows the development of computational models for performing tasks that rely on information expressed in a natural language. NLP employs computational techniques with various aspects of human communication, such as sounds, words, sentences and speech, considering formats and references, structures and meanings, contexts and uses.

The libraries 're' regular expressions and 'nltk' Natural Language Toolkit made available for Python, were used in the process for textual analysis employed. In [18] it says that the 're' library allows the analysis of sets of strings that correspond to it; thus the functions that this module makes available allow checking whether a given string corresponds to a given regular expression or whether a given regular expression corresponds to a given string. The library 'nltk' has several tools for the NLP process, such as tokenization, which transforms elements of your text into tokens, i.e. strings within a list, thus facilitating textual analysis.

3.3 Tabulation Process

This article was based on the presence of operators present in Brazil for the evaluation and sought the QoE of the 4 main operators, namely Tim, Vivo, Claro and OI. The following chart provided by [1] shows the presence of operators in Brazilian territory.

For the data analysis it was necessary to take as a starting point some criteria, especially in the opinion classification process, because it was not found a specific library that has weight values equivalent to the MOS score. Thus, a vector was created with words that can express opinions and receive weights equivalent to the MOS score.

To obtain the words used, the NLP natural language text summarization technique was employed. The following are the steps for defining expressions:

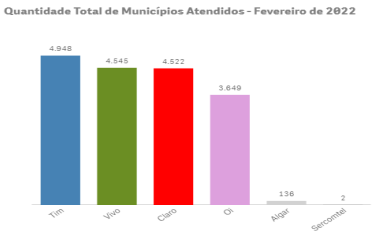

Figura 4: Operators of Cell Networks in Brazil.

- Extraction of a batch of tweets with operator searches (Tim, Vivo, Claro e Oi)
- Generating a word cloud by cleaning up quotes and special characters.
- ContabilizaÃ§Ã£o de frequÃªncia de palavras.

After these steps, some terms were selected to compose the vector of expressions that were used in the scoring of opinions. The terms chosen were based on the fact that they are "objective predicatives", which in the Portuguese language are used to qualify, classify, or express a state of the object nucleus in a sentence. The terms and punctuation are shown in Table 2. The process is illustrated in Figure 5:

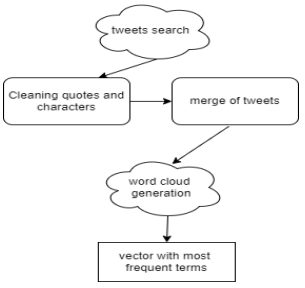

Figura 5: Searches for the most common terms used in tweets

Figure 5 shows the process for searching the terms that will compose the vector.

Tabela 2: Relation of MOS and words representing emotions.

Level (MOS)	Quality	Words representing emotions
5	Excellent	best, taste
4	Good	good, satisfied.
3	Regular	working.
2	Bad	no signal, failing, problem.
1	Terrible	I hate it, barter, worst, swearing

Table 2 presents the terms that will compose the vector used in the classification and qualification of the tweets. Three more terms were inserted in the vector, which are not shown in Table 2 because they are low-level words.

After these steps to define the terms, new searches for tweets were made, but different from the first search, this one looked for tweets by specific operators and for each operator a file with extension (.csv) was generated. Then a table was created in a database for each operator searched. Then the files were imported into these tables.

For the generation of the score the regular expression analysis was used. Thus, a function was created that receives a term from the created vector and runs through the tables in a repetition loop and returns the quantity of records with that term. The following steps show the execution:

- Extraction of tweets with carrier search (Tim, Vivo, Claro e Oi)
- Import tweets specifically into a table corresponding to the operator.
- Recursion accounting of the terms specified in the vector.
- Total Point Count (Multiplication of recurrence X equivalent MOS score).
- QoE indicator (Total points sum divided X frequency sum)

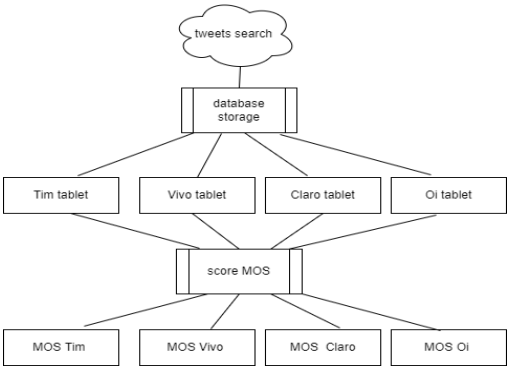

Figura 6: Process for MOS scoring

Figure 6 shows the process executed in the search for new QoE indicators for operators that operate in the Brazilian territory. The first step was to search for tweets, the second step was to store them in specific tables and then analyze the tweets in an automated way using as criteria the search for terms with the characteristic of being objective predicatives in a tweet.

4 Results

Tables 3, 4, 5, and 6 show the values obtained in the calculation of QoE indicators per operator. The "Expressions"field are the terms searched in the definition of the predicate of the object of the opinion issued in the tweet, the "Recurrence Qty"field is the number of records found per term, the MOS field brings the score equivalent to the term and the "T Points"field presents the total points obtained per term. At the end of each table is presented in "Totals"the sum of recurrence and the sum of total points used in the definition of QoE indicators appertaining to the table.

Tabela 3: Values calculated for TIM Company about the analyzed tweets.

Expressions	Recurrence Qtd	MOS	T Points
best	75	5	375
taste	20	5	100
good	53	4	212
satisfied	8	4	32
working	97	3	291
no signal	42	2	84
bad	44	2	88
falling	5	2	10
problem	104	2	208
hate	17	1	17
barter	32	1	32
worst	80	1	80
swearing	48	1	48
swearing	28	1	28
swearing	35	1	35
Total	688		1640

Table 3 presents values for the operator Tim. It was analyzed 2645 tweets, cleaning the duplicates. Thus, it was sought the recurrence of each term defined in the vector and specified in table 2. In the table it is possible to observe that terms that were qualified with MOS equal to 2 and 3 obtained more recurrences.

Tabela 4: Values calculated for VIVO Company about the analyzed tweets.

Expressions	Recurrence Qtd	MOS	T Points
best	114	5	570
taste	10	5	50
good	65	4	260
satisfied	7	4	28
working	176	3	528
no signal	43	2	86
bad	60	2	120
falling	10	2	20
problem	233	2	466
hate	21	1	21
barter	31	1	31
worst	114	1	114
swearing	66	1	66
swearing	23	1	23
swearing	25	1	25
Total	998		2408

Table 4 presents values calculated for the Vivo operator. It was analyzed 3564 tweets, cleaning the duplicates. Thus, in the same way as in table 3, the recurrence of each term defined in the vector and specified in table 2 was sought. In the table it is possible to observe that terms that were qualified with MOS equal to 3, 2 and 1 obtained more recurrence.

Tabela 5: Values calculated for Claro Company about the analyzed tweets.

Expressions	Recurrence Qtd	MOS	T Points
best	38	5	190
taste	4	5	20
good	59	4	236
satisfied	4	4	16
working	66	3	192
no signal	58	2	116
bad	71	2	142
falling	18	2	36
problem	264	2	528
hate	42	1	42
barter	36	1	36
worst	162	1	162
swearing	117	1	117
swearing	51	1	51
swearing	50	1	50
Total	1040		1934

Table 5 presents values calculated for Claro. It was analyzed 3854 tweets, cleaning the duplicates. Thus, in the same way as in tables 3 and 4, the recurrence of each term defined in the vector and specified in table 2 was sought. In the table it is possible to observe that terms that were qualified with MOS equal to 2 and 1 obtained more recurrence.

Tabela 6: Values calculated for OI Company about the analyzed tweets..

Expressions	Recurrence Qtd	MOS	T Points
best	20	5	100
taste	0	5	0
good	28	4	112
satisfied	1	4	4
working	2	3	6
no signal	5	2	10
bad	13	2	26
falling	0	2	0
problem	39	2	78
hate	9	1	9
barter	4	1	4
worst	25	1	25
swearing	19	1	19
swearing	8	1	8
swearing	4	1	4
Totl	177		405

Table 6 presents values calculated for operator Oi. It was analyzed 1765 tweets, cleaning the duplicates. Thus, in the same way as in tables 3, 4 and 5, the recurrence of each term defined in the vector and specified in table 2 was sought. In the table it is possible to observe that some terms had zero score, this occurred because the search takes as a starting point the terms indicated in the vector, the terms qualified with MOS equal to 2 obtained more recurrence presented to be a trend if compared to previous tables.

The tables were prepared following the sequence seen in figure 4 that presents the presence of operators in the Brazilian territory.

The QoE indicators presented in table 7 were obtained by dividing total points by total recurrence.

Tabela 7: QoE indicators

Operators	QoE indicator
Tim	2.38
Vivo	2.41
Claro	1.85
Oi	2.288

The indicators shown in table 7 show that there is

not a big difference between operators, since most of them scored between 2 and 2.5 on the MOS scale.

The measurements allowed us to observe the opinions expressed by mobile network customers. Thus, it is observed that customers use Twitter mainly to make complaints, thus generating low indicators.

The research proposed here believes that the indicators can contribute to operators in improving their services and to customers in choosing the operator be their customer.

But it is still necessary to evolve the methods used here, because, as already mentioned in the introduction of this research it was observed the scarcity of research that uses analogous methods used to generate QoE in an automated way, which is one of the difficulties encountered in the development of this research. Another necessary point for the evolution of this method is the need for a library that scores the expressions with weights that reference the MOS score.

5 Conclusions

The generation of QoE indicators aims at the satisfaction of consumers about a service or product. In this context, this research sought new QoE indicators, generated automatically and with the analysis of the opinions coming from Twitter, in relation to mobile service providers that operate in Brazil. The results show a tendency of the carriers' customers to use Twitter more to complain than to express opinions of satisfaction.

It was observed a scarcity of research that uses methodology analogous to that employed in this research, thus it is believed in the need of evolution for new future work such as the creation of library that uses weights equivalent to the MOS score for the extracted terms and the comparison of analysis by natural language NLP expressions. In this context this research believes that it can contribute to further research.

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