QMeter Tools for Quality Measurement in Telecommunication Network

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ABSTRACT

Call Quality is prevalent and widely used by carriers that transport the calls of telecom operators. But from end-users perspective call quality has been not taken very seriously until now and this is the reason for surge in GSM gateways which resulted in interconnect revenue loss and more importantly the call quality. This particular research developed as QMeter® is focussed to address and derive the call quality parameters from end-users perspective. The call parameters used in our research are Signal Strength, the successful call rate, normal drop call rate, handover drop rate. An attempt to visualize those parameters for better understanding of where the quality is bad with respect to various parameters proposed and implemented. To address the issues of quality in subscriber segment and satisfy its demand for quality of services, an alternative solution proposing the varying tariff based on call and bandwidth quality parameter is proposed. Call statistics for the bundles of ten calls and ten data sessions is proposed to better address the tariff redemption procedures. The proposed methods of quality measurement has been compared and correlated with subjective scores for hundreds of calls and the results show that our results are 85% on an average in correlation with subjective scores.

KEYWORDS

Call Quality Measurement, Signal Strength, MOS(Mean Opinion Score), Successful Call Rate, Normal Drop Call Rate, Handover Drop Rate, LAC (Location Area Code), Bandwidth Quality, GSM Gateway

1. INTRODUCTION

Call Quality usually measured by carriers on parameters such as ASR (Answer seizure ratio), PDD (Post Dial Delay), NER (Network efficiency ratio), number of calls for which these parameters have been analyzed and successful calls. Mobile operators use the threshold to filter the carriers not meeting their quality threshold. To address the issue of quality from the end-users perspective operators needs additional tools on the subscriber handsets integrated into their network. Call quality has not taken very seriously until now and this is the reason for surge in GSM gateways which resulted in interconnect revenue loss and more importantly the call quality.

Traditionally speech quality measurement techniques use the subjective listening tests called Mean Opinion Score (MOS). It's based on the human perceived speech quality based on the scale of 1 to 5, where 1 is the lowest perceived quality and 5 is the highest perceived quality. Subjective listening tests are expensive, time consuming and tedious. So, currently most of the systems use objective evaluation of speech quality using some mobile computing techniques. Objective testing systems are use automated speech quality measurement techniques. The three well known objective measurement techniques are Perceptual Speech Quality Measure (PSQM), Perceptual Analysis Measurement System (PAMS) and Perceptual Evaluation of Speech Quality (PESQ).

It has become important for all the mobile operators to monitor the call quality from end-users perspective to retain the subscribers and reduce the churn. Apart from call quality and

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interconnect revenue loss, the operators are worried about the network connectivity issues in the areas where the GSM gateways are prevalent. Call quality can be monitored in areas that are difficult or even impossible to perform like residential areas. Lastly but not the least, the operators have to monitor their network quality to maintain their KPI's.

Conventional speech quality measurement involves lot of resources and further it's tedious. So, an alternative method is needed to address the quality from end-user perspective, which should be automatically computed on subscriber handset, should be available to the operator and at the same time the results has be comparable with the conventional subjective scores. QMeter proposed addresses the issues and additionally, proposes dynamic tariff propositions which enhance the credibility of the operator.

Similarly, the bandwidth quality as experienced by end-user is equally important for the operators to reduce the churn. Data users are increasing exponentially. Due to change in demographics mostly in the urban areas, the operator has to adopt according to usage.

QMeter® is set of tools for Signal and Bandwidth measurement which are developed keeping in mind of all the parameters that influence the call and bandwidth quality experienced by the end-user. The system can also be used to benchmark the network as a KPI. QMeter has built-in tool that uses map to landmark call quality.

QMeter is comparable with the subjective scores; our research shows that QMeter and subjective scores are very much in correlation with each other. This demonstrates and increases the credibility of QMeter.

By adopting QMeter, The mobile telecommunication operators can be able to dramatically increase its addressable target issues related to call and bandwidth quality in market and accelerate its credibility and revenue generation by providing the quality of service in the market.

2. RELATED WORK

Objective speech quality measurement techniques mostly are based on input-output approach [1]. In input-output objective measurement techniques basically works by measuring the distortion between the input and the output signal. The input signal would be a reference signal and output signal would be a received signal.

Input-output based speech quality assessment in objective speech quality measurement gave good correlations with reaches up to 99% in some cases [2]. Estimating the speech quality without the presence of input signal or reference signal is latest area of research.

Input-output based speech quality assessment in objective speech quality measurement gave good correlations with reaches up to 99% in some cases [3]. The performance of objective measurement is basically achieved by correlating their results with the subjective quality measure.

Estimating the speech quality without the presence of input signal or reference signal is latest area of research. Jin Liang and R. Kubichek [4] published a first paper on output-based objective speech quality using perceptually-based parameters as features. The results were quiet appreciable with 90% correlation. R. Kubichek and Chiyi Jin [5] used the vector quantization method with 83% correlation achievement.

An output based speech quality measurement technique using visual effect of a spectrogram is proposed in [6]. An output-based speech quality evaluation algorithm based on characterizing the statistical properties of speech spectral density distribution in the temporal and perceptual domains is proposed in [7]. The correlations results achieved with subjective quality scores were 0.897 and 0.824 for the training data and testing data set respectively.

A time-delay multilayer neural network model for measuring the output based speech quality was proposed by Khalid Al-Mashouq and Mohammed Al-Shayee in [8]. The correlation achieved for speaker and text independent was 0.87.

In this Paper we presented our work for determining the call quality parameters such as average signal strength, successful call rate and successful handover rate with respect to signal strength and successful rate. Then final call quality is computed from the extracted parameters.

This research is continuation of the work that has been proposed in [9][10][11][12][13][14][15]. The basic bandwidth quality measurement is proposed which can be used by both the operator and the user to evaluate the bandwidth quality of a particular operator.

3. QMETER

The QMeter® is set of tools developed for call quality and bandwidth quality measurement tools named as SM (Signal Meter) and BM (Bandwidth Meter) in mobile telecommunication network from end-users perspective.

3.1 Call Quality

The Call Quality meter ensures that the network is meeting certain quality parameters. The basic parameter that has been considered is the signal strength, which has been measured for every 5ms of an active call. The signal strength is measured for every 5ms and logged, if there is change in the signal strength information. The signal strength classification is based on the below Table 1. The average signal strength is calculated at the end of the call.

Table 1: Signal Strength Classification

Signal Level Range (dBm)	Classification	Score
-120 to -95	Extremely Bad	1
-95.00 to -85.00	Bad	2
-85.00 to -75.00	Average	3
-75.00 to -65.00	Good	4
-65.00 to -55.00	Very Good	5

The calls were classified as successful and un-successful call attempts based on whether the call is successfully connected to the network. The successful attempts are again classified as normally dropped and dropped due to handover, which are the calls dropped during the cell change.

The call statistics for the bundle of 10 calls are considered for all the parameters. The successful call rate score is calculated based on the number call successful call attempts made for every 10 calls based on the below Table 2.

Table 2: Successful Call Attempts Score

Successful call Attempts	Score
1-2	1
7-8	2
5-6	3
3-4	4
1-2	5

The normal dropped rate score is classified based on the below scale in Table 3.

Table 3: Normal dropped rate score

Normally dropped rate	Score
< 4	1
>4 & <6	2
>6 & <7	3
>7 & <8	4
>8	5

The average signal strength for all the successful calls is calculated together with successful call attempts score and normal dropped rate score for the bundle of 10 calls. The call quality is derived from the scores computed as:
(Average signal strength score of all successful calls + successful call rate score + normal dropped calls rate score)/3. The final call quality for the bundle of 10 calls is classified according to the below Table 4.

Table 4: Call Quality Score

Score	Classification
<1	Extremely Bad
1 - 2	Bad
2- 3	Average
3- 4	Good
4 - 5	Excellent

The visualization of call quality is equally important from the perspective of both the operator and end-user. The operator would be able to analyse the information on map from the end-user perspective and user group can use it for deciding which operator to choose which can meet their requirements. As a part of call quality meter, the average signal strength measured with score of the individual call is landmarked on the map. The landmarks are marked with red color, if the calls are the calls dropped due to handover. The landmarks are marked with green color, if the calls are normally dropped. The different color landmarks help to easily visualize and analyze the calls well.

Call Quality escalation is another area of research, which still needs time to settle and consolidate the processes and procedures. Call Quality Meter has built-in module, where the call quality escalation has been addressed from end-user perspective as sms sending to the msisdn which can be saved by the user. Mobile operators can use this feature and promote this feature to encourage the subscribers to participate. The module sends the average signal strength and score information to the particular number that has been saved for escalation. The call quality with respect to the average signal strength with score can be escalated either for single call or for the bundle of 10 calls and also support the setting of different options of when to escalate such as escalate always, less than bad etc. Figure 1: QMeter's Call Quality measurement flowchart illustrates the complete process of signal meter system.

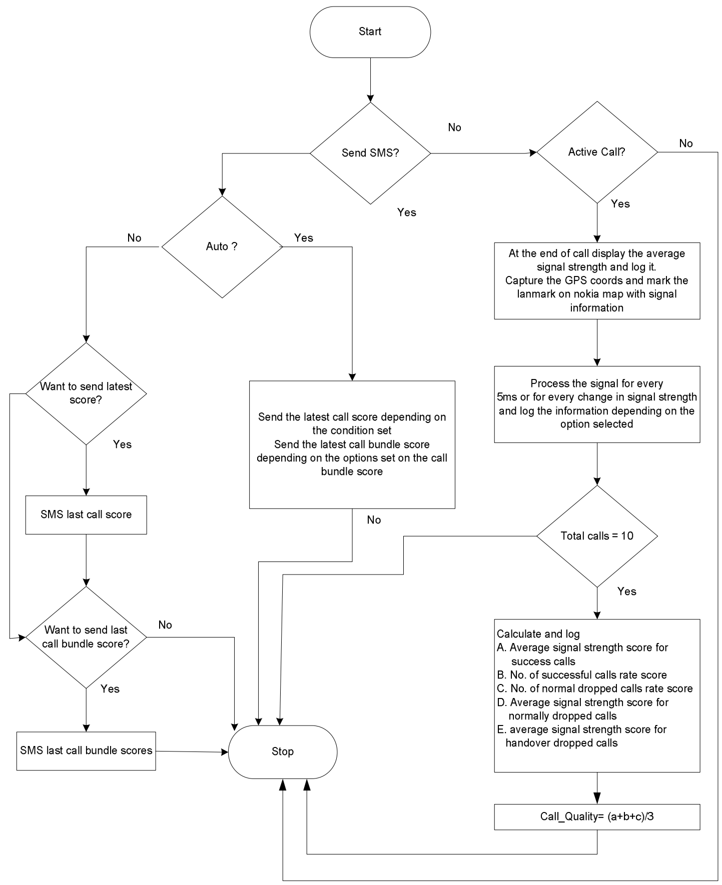

Figure 1: QMeter's Call Quality measurement flowchart

3.2 Bandwidth Quality

The bandwidth quality of internet provided by the mobile operators fluctuates drastically and frustrates the user sometimes. As the number of users increases in particular cell of the mobile network, the bandwidth decreases and hence there would be loss of revenue, if the situation continues for the operator. An attempt to measure the average bandwidth quality per individual and for bundle of ten download is calculated as portrayed in Figure 2. The scores computed can be used by the user as well as the operator to evaluate the bandwidth quality.

The average bandwidth of data download is computed using the below procedure:

1. When a new download is initiated save the current time as "T_b".
2. When the download is finished save the current time as "T_e" and the file size as "Fs"
3. Calculate the average speed for this download as $S_i = F_s/(T_e – T_b)$.
4. The average bandwidth for "10" downloads is calculated as $S = (S_1 + S_2 + ... + S_{10}) /10$.

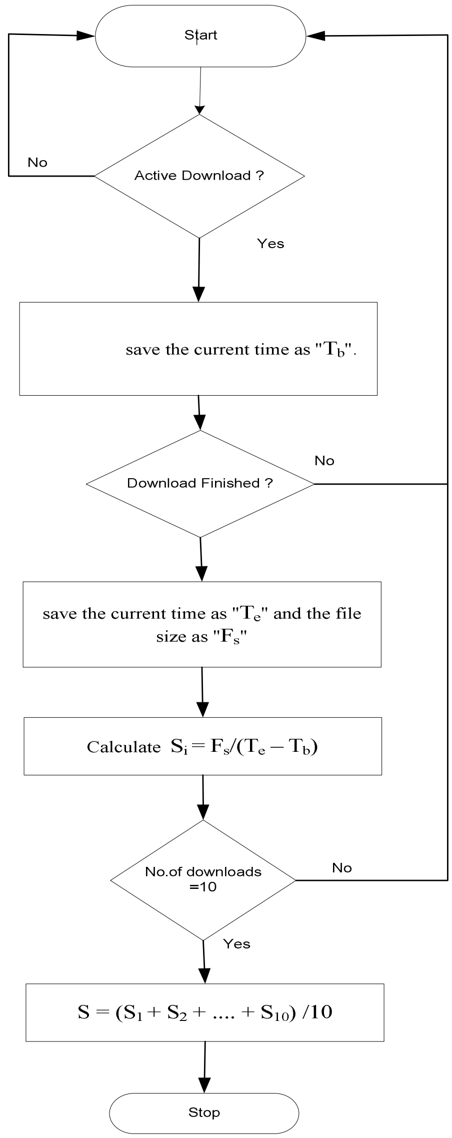

Figure 2: QMeter's Bandwidth Calculation flowchart

The score for the average bandwidth is computed on the scale of 1 – 5 based on the below Table 5.

Table 5: Bandwidth Score

Bandwidth	**Score**
< 32 kbps	1 (Extremely Bad)
<32 & <64 kbps	2 (Bad)
<64 & < 128 kbps	3 (Average)
<128 & <256 kbps	4 (Good)
> 256	5 (Excellent)

The bandwidth quality scores will give the user and the operator the better insight into the usage of the bandwidth. The approach can further be enhanced by capturing the cell-id and sending the critical scores for analyzing to provide the better service.

4. CORRELATING WITH SUBJECTIVE SCORES

The results of call quality meter are compared with the MOS (Mean Opinion Scores) of the same calls for which the call quality scores are computed using SM (Signal Meter). For each individual call the MOS is observed and classified based on Table 6. The classification for MOS and SM are relatively same. Hence the average call quality computed for the below mentioned calls are compared with subjective average scores. The comparison is done in two folds as shown in Table 7and Table 8. This is to ensure the call quality scores correlates with MOS scores in all the cases from low number of calls to high number of calls at different locations.

Table 6: MOS Classification

MOS	Quality
1	Extremely Bad
2	Bad
3	Average
4	Good
5	Excellent

Table 7: Call Quality Vs MOS

No. of Calls	MOS (Average) (X)	Rank for X	MOS Quality	QMeter Average Call Quality (Y)	Rank for Y	QMeter Quality
10	3	1	Average	2.7	1	Average
20	4	2.5	Good	3.8	2	Good
30	4	2.5	Good	3.9	3	Good
40	5	4.5	Excellent	4.8	4.5	Excellent
50	5	4.5	Excellent	4.8	4.5	Excellent

The spearman rank correlation for X (MOS scores) and Y (SM scores) computed for n=5 using the below formulae evaluates to 0.9733. The r_s= 0.9733 can be interpreted as MOS scores and SM scores are highly correlated with each other.

$$\rho = \frac{\sum_i (x_i - x)(y_i - y)}{\sqrt{\sum_i (x_i - x)^2 \sum_i (y_i - y)^2}}$$

Table 8: Call Quality Vs MOS

No. of Calls	MOS (Average) (X)	Rank for X	MOS Quality	QMeter Average Call Quality (Y)	Rank for Y	QMeter Quality
100	4	1	Good	3.6	1	Good
200	5	3.5	Excellent	4.6	2	Excellent
300	5	3.5	Excellent	4.8	3.5	Excellent
400	5	3.5	Excellent	4.9	5	Excellent
500	5	3.5	Excellent	4.8	3.5	Excellent

The correlation coefficient computed for n=5, but number of calls in the multiple of 100 evaluated to 0.7255. The r_s= 0.7255 can be interpreted as MOS scores and SM scores are highly correlated with each other, but the correlation has slided to some extent due to increase in the number of calls

The correlation between SM call quality and MOS scores shows that SM quality scores are very close to the MOS listening scores. Therefore, the SM can used to carry out the subjective evaluation of call quality instead of using human being which is tedious and requires lot of human resources.

5. QUALITY VS TARIFF

The proposed tariff structures as per the parameters are improved version proposed in [14] and on the final call quality computed on a bundle of ten calls. The variable X is the normal charging rate per minute, 'n' is the number called minutes in the bundle of 10 call attempts. The below Table 9 shows the quality Vs charges that can be applied.

Table 9: Proposed Charging Rate Vs Call Quality

Call Quality	Charge
5(Very good)	X*n
4 (Good)	X*n
3 (Average)	X*n*0.75
2 (Bad)	X*n*0.5
1 (Very Bad)	No charge

6. CONCLUSION

The QMeter® research is aimed at deriving the call quality and bandwidth quality parameters from end-users perspective in the mobile telecommunication network. The call quality parameters proposed uses the signal strength and type of call drop information to measure the overall call quality. Call quality visualization techniques and escalation procedure is also well proposed which helps mobile operators and user-groups to address the quality issues. The correlation between subjective and QMeter® scores emphasizes the realistic nature of QMeter®. The QMeter® can also be used by the telecom regulatory authorities to monitor mobile operator's license criteria for the quality of network from end users perspective. Further, it can be used as consumer protection tool to ensure that tariffs correlate with call quality.

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