DETERMINATION OF TEST SEQUENCE FOR INTRUSIVE MEASUREMENT OF VTQOS IN ENVIRONMENT OF FIXED TELECOMMUNICATION NETWORK

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Summary This paper describes simulations of test sequences transmission for intrusive measurement of VTQoS in environment of fixed telecommunication network. The aim of simulations was a detection on the influence of this environment on the quality of transmission sequences. Evaluation the generated sequences was based on the calculation of mean square measure and correlation coefficient. These measures were used as a criterion for suitable test sequences selection. Reconsideration of a convenience of the given test sequence, which is composed from simple signals, on intrusive measurement of VTQoS in the environment of fixed telecommunication networks is the aim of this paper.

1. INTRODUCTION

VTQoS is one of the important parts of QoS (Quality of Service). It is very important for the providers and for the users. An increase in the complication and the complexity of networks is visible, when communication networks incorporate more and more transmission technologies. The measurement of the voice transmission quality becomes one platform for other platforms, by help of it we can compare simultaneously different transmission technologies and it is such closer to view of the users.

Of course, it is possible to measure and evaluate the transmission parameters of the networks. But only the evaluation of end-to-end quality provides optimal results because of the complexity of network technologies.

Thus, it is the evaluation in the same way as users do. Since voice service is the most wide-spread service, in which a user uses filter and predicative abilities of human brain, it is crucial to optimally evaluate a quality of such service.

Evaluation of the Quality of voice service may be performed using intrusive and non-intrusive method, objectively or subjectively.

Using non-intrusive method, we only monitor existing dialogue. The drawback of this method is that the evaluation algorithm cannot utilize an original sample of the primary signal. Thus, it is very difficult to detect some types of signal distortion that occur during transmission. In the intrusive methods, only a test voice sample is transmitted. These methods have been known since the beginning of the telecommunication technologies, when the special sequences of vowels (known as logathoms) were transmitted after the connection had been built-up. A receiver had to recognize these logathoms. This way of subjective evaluation has been used till nowadays (e.g. method MoS).

Today's technical and software facilities provide an objectification of this measurement method by transmitting the sound sample defined beforehand, its receiving on the destination side, and a comparison of the transmission sample and the original sample using the suitable algorithm that imitates the way of perception and evaluation of the quality transmission opinion by an average listener. It is for example E-model defined in ETR-250, or algorithm PSQM (Perceptual Speech Quality Measurement) defined in P.861 ITU-T also PESQ (Perceptual Evaluation of Speech Quality) defined in P.862 ITU-T.

A choice of optimal test sequence is very important for all these methods.

The test sequence would consist of non-speech-like (fully artificial) signals. These signals are closer defined in P.501 ITU-T and the recommendation divides them into deterministic and random signals. An advantage of using these signals is simplicity and possibility of a comparison of the results measured in different language areas. The test sequence composed from those signals enables the comparison of networks of individual countries within one corporation (e.g. Deutsche Telecom, Orange, Vodafone) from the point of the view VTQoS.

Nowadays, the VTQoS intrusive measurements are performed by using samples of speech signal but the comparison is possible only within the single-language area in this case.

Here we focus to the influence of BER and SNR for transmission of test sequences in environment of fixed telecommunication network.

2. DESCRIPTION OF THE TEST SEQUENCES

The length of each of the test sequences is set to 90 sec. This period equals to the length of a phone call of average user. The sequences were created of the signals, whose convenience as verified in [1]. Three types of test sequences with different parameters of signals were formed. The creation of test sequences was based on superposing Sinusoidal signal and Gaussian white noise on Square bipolar signal. We must hold on the condition of orthogonality. This rule only relates to periodic signals.

These signals with competent parameters were used to create the sequence 21:

- Sinusoidal signal with frequencies 300, 600, 900, 1200, 1500, 1800 Hz ,
- Gaussian white noise with $\mu = 0$ and $\delta =$ 0,0001; 0,005; 0,001; 0,05; 0,025; 0,01.

Square bipolar signal with frequency 300 Hz as used as a carrier signal.

These signals with competent parameters were used to create the sequence 22:

- Sinusoidal signal with frequencies 400, 800, 1200, 1600, 2000, 2400 Hz ,
- Gaussian white noise with $\mu = 0$ and $\delta =$ 0,0001; 0,005; 0,001; 0,05; 0,025; 0,01.

Square bipolar signal with frequency 400 Hz as used as a carrier signal.

These signals with competent parameters were used to create the sequence 23:

- Sinusoidal signal with frequencies 500, 1000, 1500, 2000, 2500, 3000 Hz ,
- Gaussian white noise with $\mu = 0$ and $\delta =$ 0,0001; 0,005; 0,001; 0,05; 0,025; 0,01.

Square bipolar signal with frequency 500 Hz as used as a carrier signal.

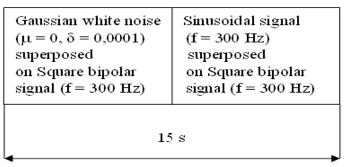

Fig. 1 Initial part of test sequence 21 (seq21)

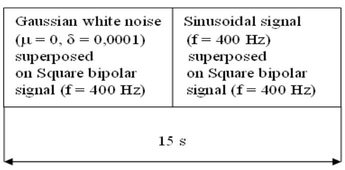

Fig. 2 Initial part of test sequence 22 (seq22)

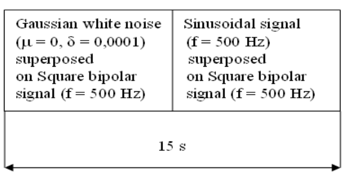

Fig. 3 Initial part of test sequence 23 (seq23)

The principle of the creation of the final test sequences is based on an arrangement of initial parts of relevant test sequences, which are shown in Figures 1 – 3. The arrangements shown in Figure 1-3 are used six times to form the final test sequences. Thus, each final test sequence consists of six parts. The signals step-by-step have got the values defined above. That means, in the second part of the test sequence 21 (from 15 sec. to 30 sec.), the signals have the following values: Sinusoidal signal f = 600 Hz, Gaussian white noise $\delta = 0{,}005$, the parameter of carrier signal is not changed. The values of the signals in the first parts of the test sequences (from 0 sec. to 15 sec.) are the same as those in Figures 1-3.

3. SIMULATION DESCRIPTION

Test signals are modeled in Matlab as the sequence of digital samples, which pass through the competent type of communication channel (Noise Channel AWGN and Binary Symetric Channel BSC). The simulations of situations of transmission sequence in given transmission chain are the task of this model. The simulations are realized especially from the point of view of the parameters of the channels. Main parameters are Error Probability for BSC channel and parameter SNR for AWGN channel. The model is made to occur many errors for transmission. Therefore I did not use any channel coding. We need maximum number of errors, because we want to get the most sensitive sequence for these errors.

Original source and destination file are recorded by sound card into wav file. The both files are compared simultaneously. This comparison is based on calculation of mean square measure and correlation coefficient.

3.1 Detailed description of the simulation model

This model comes out from the model described in [1]. The model was wide spread about the block „From Wave File“. Simulations were done for two models. We only present one simulation model for AWGN channel. The blocks „Zero-Order Hold 2“, „Saturation 2“, „Quantizer 2“ are not used in the simulation model for BSC. Instead of AWGN channel is uses BSC channel.

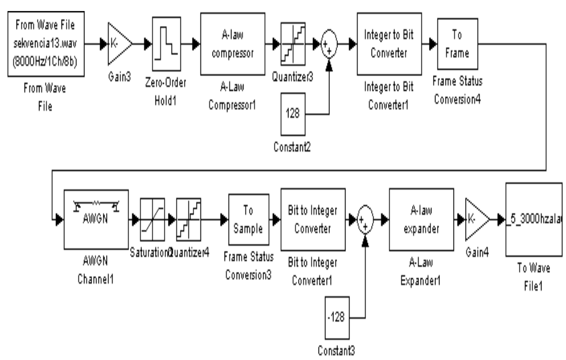

Fig. 4 Simulation model for AWGN channel

3.2 Principle of simulation

The source sequences are created using Soundforge software. The principle of the creation of source sequences is described in Chapter 2. The destination sequences are created by simulation. The length of the simulation is 90 sec. This length is the same as the length of the source sequence. The length of the destination sequence is also 90 sec. what results from the length of the simulation. The source and the destination sequences are compared after finishing the simulation. The principle of the comparison is described by the following steps:

1. Reading in source and destination test sequences
2. Segmentation of the test sequences into n intervals, each with 8000 samples. The following parameters are calculated in each interval:
   - Correlation coefficient r_i,
   - Coefficients FFT,
   - Mean square measure d_i.
3. Calculation of the average values:

$$\bar{r} = \frac{\sum_{i=1}^{n} r_i}{n} \quad (1) \quad \text{and} \quad \bar{d} = \frac{\sum_{i=1}^{n} d_i}{n}, \quad (2)$$

where n is the number of intervals, r_i is the correlation coefficient of the i-th interval, d_i is the mean square measure of the i-th interval.

The segmentation of the test sequences in n intervals and calculation of relevant parameters in these intervals enables to obtain more precise results. The calculation of the correlation coefficient is realized by the following relation:

$$r_i = \frac{\sum_m \sum_n (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{\left(\sum_m \sum_n (A_{mn} - \bar{A})^2\right)\left(\sum_m \sum_n (B_{mn} - \bar{B})^2\right)}}, \quad (3)$$

where $\bar{A}$ = mean2(A) , and $\bar{B}$ =mean2(B). Matlab function mean2 realize the calculation of the mean value.

The mean square measure is based on the spectral comparison of the test microsegment with the reference microsegment. The most common norm is L_2-norm, which is defined like as:

$$d_i(t,r) = \left[\sum_{j=1}^{N} \left(y_{tj} - y_{rj}\right)^2\right]^{1/2}, \quad (4)$$

where N is the number of FFT points in given microsegment, y_{tj} is the absolute value of the j-th FFT coefficient of the test microsegment, y_{rj} is the absolute value of the j-th FFT coefficient of the reference microsegment.

Nowadays, the comparison is usually done using the correlation coefficient. If we want to discover differences in the spectrum area, another parameter is added. Using the correlation coefficient and the mean square measure we may find the test sequence that is the most sensitive on noise influences, which arise in communication channels.

4. PRESENTATION OF RESULTS

These simulations were realized by the usage of the sequences displayed in upper part of document for compressed characteristics according to the curves A and for the both types of the channels (AWGN, BSC).

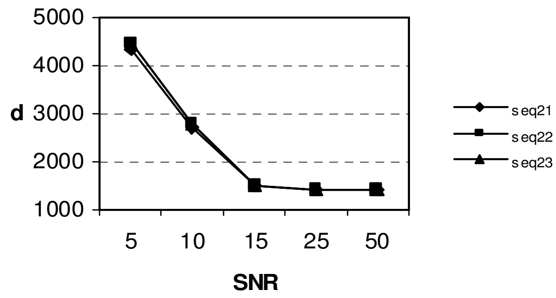

Fig. 5 Graphical presentation of the results of the simulations for mean value of mean square measure (AWGN channel)

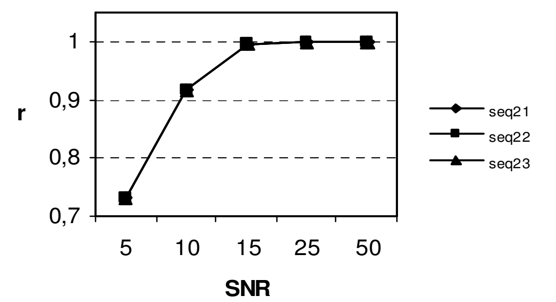

Fig. 6 Graphical presentation of the results of the simulations for mean value of correlation coefficient (AWGN channel)

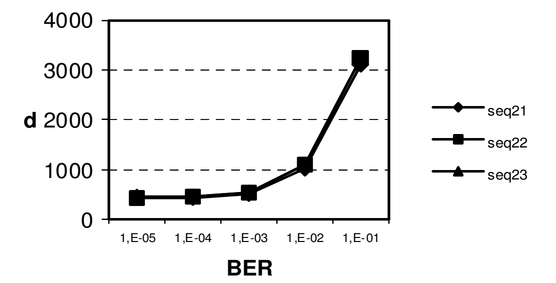

Fig. 7 Graphical presentation of the results of the simulations for mean value of mean square measure (BSC)

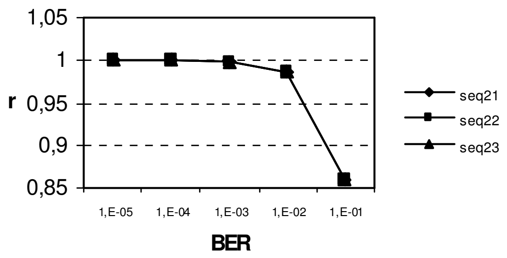

Fig. 8 Graphical presentation of the results of the simulations for mean value of correlation coefficient (BSC)

5. CONCLUSION

The principle of test sequences selection for intrusive measurement of VTQoS is based on a simple rule. The rule is that such group of test sequences is used for measurement which obtains the maximum difference of values of the relevant boundary coefficients. The calculations are realized by formulas 5-8.

It is for BSC channel:

$$\delta_r = \overline{r}_{(BER\ 0,00001)} - \overline{r}_{(BER\ 0,1)} \tag{5}$$

$$\delta_d = \overline{d}_{(BER\ 0,1)} - \overline{d}_{(BER\ 0,00001)} \tag{6}$$

It is for AWGN channel:

$$\delta_r = \overline{r}_{(SNR\ 50)} - \overline{r}_{(SNR\ 5)} \tag{7}$$

$$\delta_d = \overline{d}_{(SNR\ 5)} - \overline{d}_{(SNR\ 50)} \tag{8}$$

where δ_r is the difference of average values of boundary parameters of correlation coefficient, δ_d is the difference of average values of boundary parameters of mean square measure, $\overline{r}_{(SNR\ 50)}$ is average value of correlation coefficient for relevant value of boundary parameter for AWGN channel, $\overline{d}_{(SNR\ 50)}$ is average value of mean square measure for relevant value of boundary parameter for AWGN channel, $\overline{r}_{(BER\ 0,1)}$ is average value of correlation coefficient for competent value of boundary parameter for BSC, $\overline{d}_{(BER\ 0,1)}$ is average value of mean square measure for competent value of boundary parameter for BSC. Boundary parameters are SNR for the value of 50 dB and for the value of 5 dB on AWGN channel. It is parameter BER for the values 0,00001 and 0,1, when we use BSC channel.

This fact was a basis for derivation of this rule because we need the test sequence which is the most sensitive on all influences, which can arise in real networks. We can hypothesize that if the maximum difference is reached for same conditions, the given test sequence is more sensitive on interference influences than the others. Thus the test sequence with such property is more suitable for measuring of VTQoS. The best test sequence in the sense of the mean square measure and the correlation coefficient is chosen from the results.

Table 1 Difference δ_r for correlation coefficient

δ_r	Seq21	Seq22	Seq23
AWGN	0,2704	0,2706	0,2705
BSC	0,1406	0,1406	0,1406

Table 2 Difference δ_d for mean square measure

δ_d	Seq21	Seq22	Seq23
AWGN	2912,60	3014,60	3019,90
BSC	2685,58	2801,15	2800,60

We can see from the results that the influence of the environment of fixed telecommunication network on these test sequences is approximately the same. Hence we can use any of these test sequences for the intrusive measurement of VTQoS in environment of fixed telecommunication network. We decided that we used the test sequence for environment of fixed telecommunication network that reached the best results of the simulations in the mobile environment. This decision was influenced by stronger influence of the mobile environment on these test sequences. Test sequence 23 gave the best results in the mobile environment in the sense of the mean square measure and the correlation coefficient. The selection of suitable test sequence in mobile environment is described in [8]. In the future, convenience of this test sequence for intrusive measurement of VTQoS will be verified practically by real measurements in convergent network of the University of Žilina.

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