Paper

Silent Calls – Causes and Measurements

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Abstract—The quality of telephone services is very important from either operator or subscriber point of view. One of the negative phenomenon which affects quality of telephone services is lack of speech signal during a call. This situation occurs relatively frequently in mobile telephony, and is called silent call (SC). Lack of speech signal can occur only once or many times during the call, and degrade connection quality. In this paper, an analysis of this phenomenon is presented. The research base are the results of measurements mobile network one of operators in Trójmiasto a large urban area consisting of three cities: Gdańsk, Gdynia, and Sopot. To estimate impact of silent calls on speech quality, mean opinion score index was calculated using POLQA algorithm.

Keywords—key performance indicator, silent calls, speech signal analysis.

1. Introduction

The quality of telephone services depends on many factors such as the type of speech encoder, the type, and parameters of the telephone network, and the transport network performance. They can cause various types of distortions and even break or disconnect call. This paper focuses on the negative phenomenon of temporary or permanent lack of speech signal during a call – so called silent calls (SCs). According to the SwissQual, one of the leading companies involved in research quality phone calls, the silent call occurs when the called party receiving a silence all the time [1]. Here another definition is proposed. SC takes a place when at least one of the called party receiving a silence for a certain time. The problem of SCs is not new, but recently their number is constantly growing. Elimination SCs causes is very important to subscribers and operators because SC lowers the perceived quality of the service. Strong competition in the telecom market and easy change of service provider force operators to eliminate this problem. SCs occur both in mobile and fixed networks. However, in mobile networks due to many reasons SCs more often appear.

This article covers the study the SCs phenomenon only in mobile networks. It is possible to find many sources of the SCs in various network infrastructure parts. SC can be caused at the same time by more than one source. This makes it difficult to find and remove the correct source. The first place where SC can be generated is a subscriber terminal. The second one is radio transmission station. Another possible source is associated with handovers or encryption changes. These processes are taking place in Base Station Subsystem (BSS). Obviously, core networks used to transmission telephone signals between Mobile Switching Center (MSC) can also cause of SC, however the paper only concentrates on the radio interface influence on SCs.

The radio signal transmission conditions have significant impact on the call quality. They have often responsible for short-term signal degradations, but not always causes SC. To prevent the big information loss an interleaving and data redundancy are used. However, sometimes the interruption duration is so long that those methods are insufficient. In such cases, a call is always disconnected by a network, and then user hears the silence in the handset. The time required for dropping the call after detection absence of speech signal depends on the network settings. During a call, voice encoder may be changed because of radio signal transmission conditions degradation, but changing of the encoder is not always fast enough, therefore the handset has no signal while encoder changing. According to the definition adopted in this paper, the silent call is then observed.

Operators constantly upgrades their networks by introducing the new telecommunication systems as in example LTE. Usually areas covered by the new solutions are islands in older networks. Coexistence of different technologies requires multiple protocols to ensure the mobile subscriber an adequate level of service. Unfortunately, a quick introduction of new technical solutions does not always guarantee the calls quality and it can cause SCs.

To investigate sources and rate the negative impact silent calls on quality it was necessary to do many measurements using special procedure and tools.

This paper is organized as follows. In Section 2 the used tools are described. This is followed by the measurements scenario in the Section 3. In Section 4, the results are given and analyzed. Finally, the paper is concluded in Section 5.

2. Used Tools

To investigate SCs detail it was necessary to perform many measurements using so called Drive Test (DT). The DT was prepared by Systemics PAB [2]. It is a procedure for testing the quality of the cellular network and calls from the mobile subscribers perspective. All measured parameters were collected and analyzed using NQDI system [3]. This is the advanced tool that allows for calculation of Key Performance Indicators (KPIs).

To detect silence in the speech samples was used special software tool called Silan [4]. This program reads the sound files and detects silence periods. It is the pro-

gram made for Linux operation system. Its advantage is the ability to work from the command line. Using this tool and special Bash script [5] allow to create tables with information about the duration of speech and silence.

3. Measurements and Samples

The measurements scenario is shown in Fig. 1. The connections are initiated by the voice server and mobile terminal. According to this scheme there are 10 reference speech samples sent in two directions – five times by each of the parties. The first speech sample is always sent by the mobile terminal. In case of successful transmission of all test samples the call is disconnected. Received speech samples were recorded on the both sides.

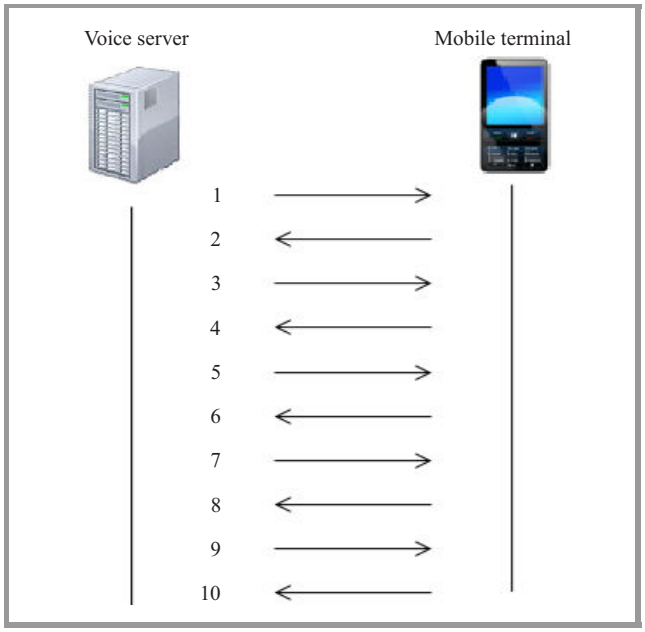

Fig. 1. Measurements scenario.

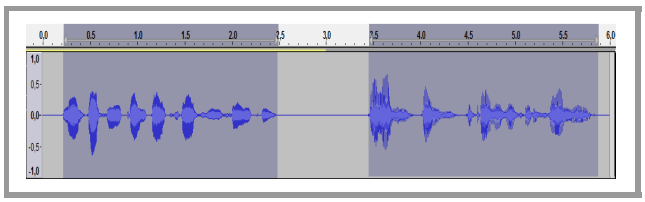

Fig. 2. The reference sample.

The speech sample reference is shown in Fig. 2.
It can be noticed that two fragments of speech signal in the reference sample were detected by Silan. The total duration of the speech signal in the reference sample is 4.697375 s. Duration of the speech signal in the received sample can be shorter if there were silence. In this case the speech signal contents in the each received sample versus the reference sample is then calculated. It is so called Sum Voice Length (SVL) parameter.

4. Results

During the test 51246 reference samples were sent. Among them there were 971 of silent calls. The number of received samples with extra silence versus SVL is presented in Fig. 3.

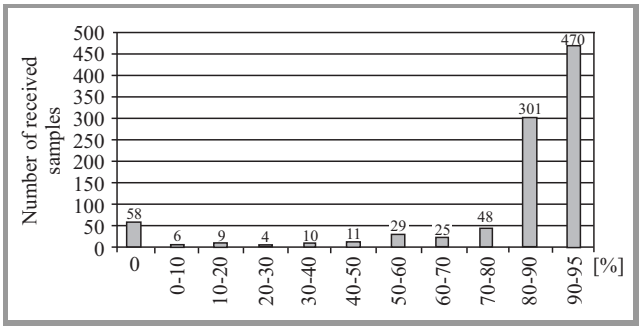

Fig. 3. Number of received samples versus SVL.

Figure 4 shows the dependence of the MOS parameter with respect to the percentage of speech duration in the received sample. MOS was estimated using POLQA algorithm [6]. Each dot in the Fig. 4 corresponds to a single sample. The minimum accepted MOS value is marked by the horizontal dashed line.

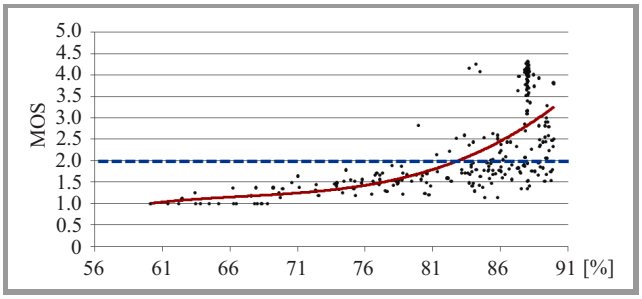

Fig. 4. MOS versus SLV.

Despite the big loss of the speech signal, the estimated speech quality is relatively good. This is probably a result of the mechanism Packet Loss Concealment (PLC) using by application [7].
Only in 58 cases the total voice absence was observed (SVL = 0%). These will be referred to the total SC (TSC). They represent about 0.11% of the sent samples. The

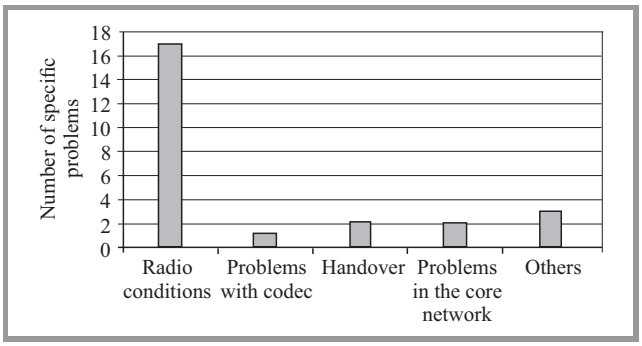

Fig. 5. Reasons of TSC.

33 from these were caused by errors in measuring equipment. The remaining 25 cases were detailed analyzed. The results are shown in Fig. 5. The most common reasons for TSC were wrong radio transmission conditions – not a low signal strength, but too high interferences level. It is obvious in large cities area. In two cases TSC were caused by handover process, and a core network was the reason of another two. In one case, TSC was caused by a problem with an encoder. Unfortunately, in the three cases, the reason was not found.

5. Conclusions

Based on the performed measurements and tests, it was found that:

- 1.89% received samples contained one or more periods of silence,
- only 0.11% of all samples was complete silence,
- the main causes of total silent calls diagnosed in this study were interferences in radio link,
- an unacceptable total duration of silence periods in the received sample was 17% (MOS assumed 2, and estimated using POLQA algorithm).

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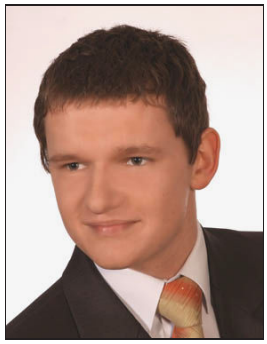

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