

# Chapter XVII

## Perception–Based Speech Quality Measurement in Modern Telecommunications

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### ABSTRACT

*Speech quality is the most visible and important aspect of quality of service (QoS) for telecommunication networks. Hence, the ability to monitor and design for this quality has become a top priority. Speech quality refers to the clearness of a speaker's voice as perceived by a listener. Speech quality measurement offers a means of adding the human end user's perspective to traditional ways of performing network management evaluation of voice telephony services. Traditionally, measurement of users' perception of speech quality has been performed by expensive and time-consuming subjective listening tests. Over the last three decades, numerous attempts have been made to supplement subjective tests with objective measurements based on algorithms that can be computerised and automated. This chapter describes the technicalities associated with speech quality measurement, and presents a review of current subjective and objective speech quality evaluation methods and standards in telecommunications.*

### INTRODUCTION

Due to fiercely growing market competition, quality of service (QoS) is continuously growing in importance in the telecommunications industry. For telecommunication networks, the quality of the communicated speech is one of the most important measuring objects of QoS. Thus, the

ability to continuously monitor and design for this quality should always be a top priority to maintain customers' satisfaction of quality. Speech quality, commonly known as voice quality (which is the term used throughout this paper), refers to the clearness of a speaker's voice as perceived by a listener. Voice quality measurement, also known by the acronym VQM, is a relatively new

discipline, which offers a means of adding the human end user's perspective to traditional ways of performing network management evaluation of voice telephony services. The most reliable method for obtaining true measurement of users' perception of speech quality is to perform properly designed subjective listening tests. In a typical listening test, subjects hear speech recordings processed through different network conditions, and rate them using a simple opinion scale such as the ITU-T (International Telecommunication Union-Telecommunication Standardization Sector) 5-point listening quality scale. The average score of all the ratings registered by the subjects for a condition is termed the *mean opinion score* (MOS).

Subjective tests are, however, slow and expensive to conduct making them accessible only to a small number of laboratories and unsuitable for real time monitoring of live networks. As an alternative, numerous objective voice quality measures, which provide automatic assessment of voice communication systems without the need for human listeners, have been made available over the last two decades. These objective measures, which are based on mathematical models and can be easily computerised, are becoming widely used particularly to supplement subjective test results. This chapter examines some of the technicalities associated with VQM and presents a review of current voice quality measurement methods for telecommunication applications. Following this introduction, the background section discusses what voice quality is and how to measure it. The "Subjective Voice Quality Measures" section and "Objective Voice Quality Measures" Section define the two main categories of metrics used for evaluating voice quality; that is subjective and objective testing, describing and reviewing the various methods and procedures of both, as well as indicating these methods' target applications and their advantages/disadvantages. The "Non-Intrusive Objective Voice Quality Measures" section then discusses the various approaches employed

for non-intrusive measurement of voice quality as required for monitoring live networks, and provides an up-to-date review of developments in the field. Finally, the "Conclusions" section gives a summary of the presented review.

## **BACKGROUND: VOICE QUALITY AND ITS MEASUREMENT IN TELECOMMUNICATIONS**

In telecommunications, QoS is thought to be divided into three components (Moller, 2000). The main component is the speech or voice communication quality, and relates to a bi/multi-directional conversation over the telecommunications network. The second component is the service-related influences, which is commonly referred to as the "service performance," and includes service support, a part of service operability, and service security. The third component of the QoS is the necessary terminal equipment performance. Voice communication quality represents a major component of the overall communication quality perceived by a user and is concerned with the speech transmission from a talker to a listener (Quackenbush, Barnawell, & Clements, 1988). Thus, it is user-directed and therefore provides close insight in the question of which quality feature results in an acceptability of the service from the user's viewpoint.

Quality can be defined as the result of the judgment of a perceived constitution of an entity with regard to its desired constitution. The perceived constitution contains the totality of the features of an entity. For the perceiving person it is a characteristic of the identity of the entity (Moller, 2000). Applying this definition to speech, quality can be regarded as the result of a perception and assessment process, during which the assessing subject establishes a relationship between the perceived and the desired or expected speech signal. In other words, voice quality can be defined as the result of the subject's judgment on spoken language,

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