Research on Quantitative Models and Correlation of QoE Testing for Vehiclar Voice Cloud Services

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Abstract. Vehicle voice cloud service can help drivers reduce the dependence on vehicle operation and improve driving safety. In the related test of automobile voice cloud service quality evaluation, the research of quantitative model is an important part. The research and analysis of quantitative index correlation can effectively optimize and improve the test system, provide strong objective evaluation support for operators and service providers, and enhance the core competitiveness. Voice cloud service is composed of many modules and involves many fields. The user's business experience is closely related to the end-to-end transmission elements such as business category, terminal capability and occurrence scene. The traditional QoE (quality of experience) evaluation can not meet the evaluation requirements. Therefore, this paper uses the hierarchical method to build the key index system of automobile voice cloud service, puts forward the quantitative model of QoE test, and gives the key points The results show that the model has a high accuracy and can provide strong support for the evaluation and testing of related services for automobile voice cloud operators and service providers.

Keywords: QoE · FAHP · MoS · Vehicular unit

1 Introduction

With the development of Internet technology, the application of automobile voice cloud service is more and more widely. Its main business includes TSP (telematics service provider) business and intelligent safe driving. The former mainly includes remote information services (such as vehicle management, traffic information, high-precision maps, etc.) and life and entertainment services (games, video, car smart home, etc.); the latter mainly focuses on safety and auxiliary driving and formation driving. In order to improve user satisfaction, operators and service providers usually adopt the QoS (quality of experience) guarantee mechanism to optimize the KPI (key performance indicator) indicators. However, QoS can not reflect the characteristics of subjective perception on

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voice cloud services. Ultimately, users do not care how these KPI indicators affect product quality, they just focus on the feeling of using the current service. Therefore, operators and service providers have shifted their service testing and evaluation from QoS to QoE. Vehicle voice cloud service is a complex overall system. Due to the characteristics of wireless channel conversion and mobile interconnection in vehicle environment, the related voice cloud service is composed of multiple modules and involves multiple fields. The user's business experience is closely related to the end-to-end transmission elements such as business category, terminal capability and occurrence scene. The traditional QoE evaluation cannot meet the evaluation requirements.

From the above point of view, this paper makes a detailed study on the indicators and correlation Related to the experience quality of vehicle voice cloud service, constructs a relatively comprehensive index mapping system, and forms an effective QoE evaluation model mechanism, which provides strong support for operators and service providers in the evaluation and testing of related services, thus improving user satisfaction and user stickiness, It reduces the rate of users leaving the network and improves the core competitiveness of enterprises.

2 Related Work

With the development of 5g technology, people have proposed some new methods to improve network routing and experience quality measurement [1–3]. Many scholars have also proposed new scheduling strategies and models based on effective user behavior and traffic analysis methods [4, 5] to improve resource utilization, optimize the structure of quality of experience model [6–8], and improve the performance of wireless communication related service products [9]. Some scholars have also carried out new research on QoE [10–13]. In previous studies, many traditional speech quality assessment models have been proposed for limited speech quality evaluation in communication services [14]. In the field of cloud services, most voice cloud services transmit data through TCP (transmission control protocol), resulting in high latency. In the aspect of environmental factor assessment, many scholars have developed some new methods for speech quality assessment in noisy environment [15, 16]. However, the evaluation result is single and does not have the objective definition ability of end users.

ETSI (European Telecommunications Standards Institute) and ITU (International Telecommunication Union) have successively issued a series of new standards. These standards usually focus on the quality of user experience, and fully consider the user's feelings from the end-to-end point of view, which changes the limitation of only focusing on the operators and network performance itself. As a traditional quality of service parameter, QoS (latency, jitter, packet loss and bandwidth) is widely used in the objective evaluation of network quality [17]. However, QoS can not reflect the overall perceived quality of users, so it is narrow-minded [18]. Therefore, the research on QoS focuses on mapping user metrics to defining QoE related factors. QoS measurement mainly describes the measurement of traditional network performance, so as to reflect the quality of some end-users' choice [19]. However, QoE fully considers more factors, including cognitive and contextual metrics, to generate an objective score, so as to define the real experience quality of users. Some scholars have proposed some new methods to predict the impact index in the end-to-end network [20–22], and thus confirm the QoE of the terminal [23]. This is helpful for the construction of test cases related to QoE evaluation. At the same time, on the premise of meeting QoE, a new communication architecture scheme is proposed to improve energy efficiency [24]. However, due to the rapid changes of network topology and complex service influencing factors, these methods can not be used to define the key metrics in vehicle voice cloud services. In addition, some existing simulation platforms and evaluation methods can not evaluate the key quality indicators of on-board voice cloud services. Some scholars have tried to apply various traditional mathematical methods to establish the connection model of user's subjective perception [25–27]. In recent years, many studies have proposed new QoE perception methods and evaluation models [28–30]. Although these methods and models have certain value, their forms are single and the actual evaluation efficiency remains to be investigated. Reference [31–38] proposed a test platform and evaluation model for on-board voice cloud service based on QoE. Through the QoE simulation of the terminal, it can truly reflect the QoE score in the live road network test. However, the evaluation model is still relatively simple, and the QoE impact level and factors of vehicle voice cloud service are not comprehensive, and need to be further expanded.

Through the above research, it is found that in the user experience quality test of vehicle voice cloud service, the user experience evaluation standard and method based on perception classification in the original voice service can not be directly applied to the service, and some existing achievements are relatively simple and lack of comprehensiveness. Therefore, this paper studies the acquisition system of vehicle voice cloud user experience indicators, and puts forward a more comprehensive and objective quantitative model, which helps to reduce enterprise costs and enhance core competitiveness, which is of great significance.

3 Analysis of Key Indicators

3.1 Influencing Factors of Vehiclar Voice Cloud Services

With the application of artificial intelligence, the voice cloud service for vehicle environment is personified as a voice assistant. The human-computer interaction design is also a transition from GUI (Graphical User Interface) based to the combination of VUI (Voice User Interface)and GUI. The technology based on cloud server provides better speech recognition ability of non fixed commands. The voice cloud service for the vehicle environment has an up and down relationship in the operation process, as shown in Fig. 1.

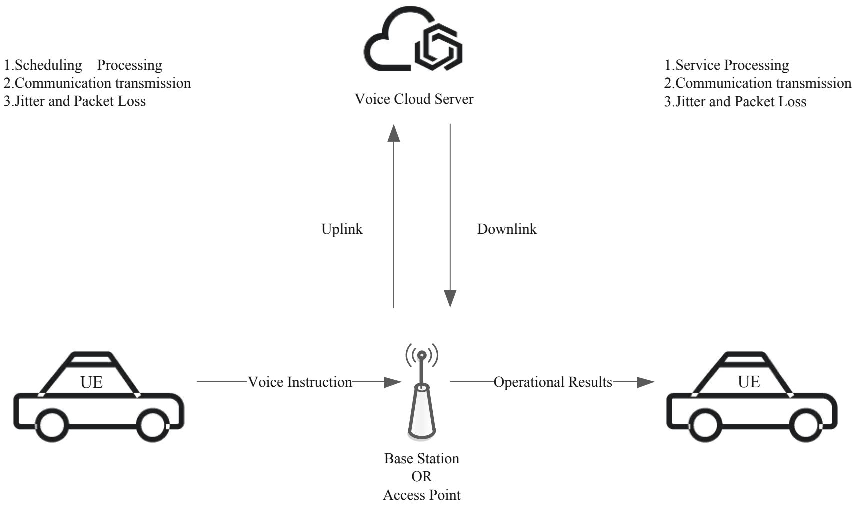

Fig. 1. Uplink and downlink diagram of vehicle voice cloud service.

As shown in Fig. 1, the uplink voice is mainly used for the user to provide an operational command that is uploaded to the cloud server through a wireless transmission. Therefore, the quality of the uplink voice, the data scheduling speed, the wireless transmission effect, etc. are important factors. The downlink voice is mainly used to provide the recognition result and an operational response. The speech recognition accuracy, cloud server performance, latency jitter and service latency are important factors influencing the user experience quality.

3.2 Construct Indicator System

Vehicular voice cloud service is a new hybrid service, including traditional voice class, data class of cloud communication, intelligent interaction class and other services. All these KPI can be divided into two levels: network level (latency, packet loss, jitter,, transmission bit rate, etc.) and application level (buffer, interactive perception, signal-to-noise ratio (PSNR), blur, motion, etc.). TMF (telemanagement Forum) has done a lot of research on the construction of QoE indicators. Its representative achievements analyze and define the mapping structure of performance indicator systems such as communication interaction. Through its definition, the QoE indicator system is divided into three levels from the bottom up, namely KPI (key performance indicator), KQI (key quality Indicators), QoE, and the overall indicator mapping architecture is shown in Fig. 2.

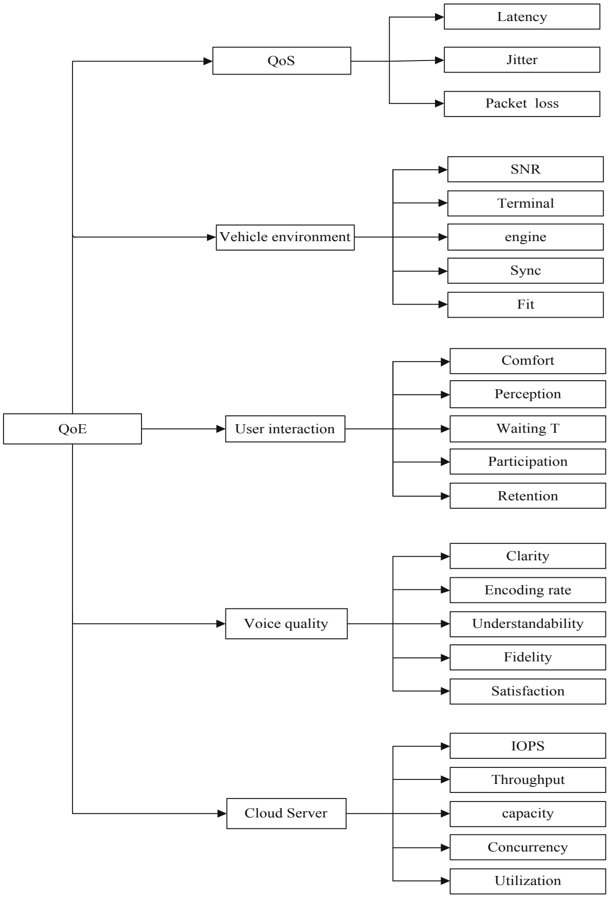

Fig. 2. QoE indicator mapping schematic.

As shown in Fig. 2, on the basis of fully studying the working process of vehicle voice cloud service, the system is constructed by using FAHP. The five levels that affect wireless video quality are QoS, quality of service vehicle-mounted environment, quality of user interaction, quality of voice, and quality of cloud. These five levels are the first level, which are KQI layer. Each KQI layer has its own secondary weight layer, namely KPI layer. Besides latency, jitter and packet loss, each index of the first layer and the second layer has its own weight proportion. The construction of appropriate QoE evaluation system can improve the ability of suppliers and operators to analyze and forecast business in a consultative manner.

4 Modeling

4.1 Quantitative Analysis

Subjective factors gradually turn to measurable quality system, which leads to the evaluation results gradually tend to the real QoE. Full research on the relationship between QoE and its influencing factors makes us need to quantify QoE and construct the relationship between QoE and real numbers from the perspective of mapping. In this paper, QoE index is divided into two aspects (subjective factors and measurable objective indicators). With the accumulation of knowledge and the progress of technology, there are more and more measurable systems that transform subjective factors into objective indicators. We find a more accurate relationship between QoE and its influencing factors. As a subjective indicator of QoE, it is very necessary to establish an appropriate objective model for quantitative evaluation, which is helpful for service providers and operators to analyze the acceptability of business, predict the real QoE, and find out the service defects, so as to improve continuously.

Generally speaking, evaluation methods can be divided into two categories (with reference value and without reference value). In terms of subjective and corresponding objective evaluation methods, the method based on MOS (average opinion score) recommended by ITU (International Telecommunication Union), as a method based on machine scoring, has been applied more and more widely. This paper uses MOS, which defines the specific criteria in ITU-T p.800 [39] recommended by ITU. The evaluation methods are divided into five levels: excellent, good, medium, poor and bad. As shown in Table 1, MOS has a fractional definition of 1 to 5.

Table 1. ITU-T Recommendation P.800 MOS scales.

MOS	Quality	Influence
5	Excellent	No damage can be observed
4	Good	Damage can be observed but is ok
3	Medium	Slightly dislike
2	Poor	Dislike
1	Bad	Extremely dislike

4.2 Layer Model

Our hierarchical model can be divided into three levels: QoE, KQI and KPI. Through the model of FAHP, the weight value of KQI and KPI layers is realized. Through the weight value of each level, the overall evaluation index of QoE can be obtained. The specific content is Represented by Formula (1).

$$QoE = \omega_1 \times QoS + \omega_2 \times QoCar + \omega_3 \times QoI + \omega_4 \times QoV + \omega_5 \times QoCloud \quad (1)$$

In Formula 1, QoS, qocar, qoi, qov and qocloud correspond to QoS, vehicle environment, user interaction, voice quality and cloud server in KQI layer respectively. Meanwhile,

ω_1, ω_2, ω_3, ω_4 and ω_5 are the weight values of each index in the KQI layer. The weight value of each KQI layer can be obtained by formula (2).

$$QoX = \sum_{i=1}^{n} \omega_1 KPI, X = S, Car, I, V, Cloud \quad (2)$$

In formula (2), QoX represents the index of each KQI layer. Then, QoE can be obtained by formula (3).

$$QoE = \sum_{i=1}^{m} \sum_{j=1}^{n} \omega_{ij} KPI_{ij} \quad (3)$$

In our hierarchical system, the indicators of each KPI can be obtained through subjective or objective tests, which is conducive to get the value of KQI and obtain the final QoE results. Taking qoi as an example, the weight value is obtained through matrix calculation, as shown in formula (4).

$$W_{QoI} = (0.2112, 0.2069, 0.1950, 0.1921, 0.2107) \quad (4)$$

Through FAHP, similar calculation can be carried out to obtain the index weight values of all KQI and KPI layers.

In this paper, FAHP (fuzzy analytic hierarchy process) is used to calculate the weight value of each layer's index to QoE effect, and establish the evaluation system. We use the nine scale method to obtain the relative values of any two indexes. The nine scales are shown in Table 2.

Table 2. The number of scales.

Scale	Influence
0.5	Both elements are equally important
0.6	One element is a little more important than the other
0.7	One element is more important than the other
0.8	One element is much more important than the other
0.9	One element is extremely more important than the other

4.3 Bivariate Model

QoE is the subjective feeling of customers. It is very important to establish an appropriate objective model and make quantitative evaluation, which can help service providers and operators to analyze and predict the acceptability of business in a consultative manner. The on-board voice cloud service is a complex overall system, involving multiple fields, and the user's business experience is closely related to the end-to-end transmission elements. In our hierarchical evaluation system, the KPI corresponding to QoS layer does not exist alone, and its effect is not independent, so we can not get their respective weights. Since the extended KPI corresponding to packet loss and jitter is the recognition accuracy, this paper designs a double independent variable function F (Latency, Recognition), as shown in formula (5).

$$\text{F(Recognition, Latency)} = P * \frac{4(\ln(ST) - \ln(0.003\text{Max} + 0.12))}{\ln((0.003\text{Max} + 0.12)/\text{Max})} + 5 \quad (5)$$

In formula (5), $P = \frac{S+D+I}{N}$, S is the number of replaced strings and the original strings, D is the number of recognized strings and deleted characters in the original strings, I is the number of recognized strings and inserted characters in the original strings, n represents the length of the original strings; ST is the latency correlation function, and Max is the maximum latency.

5 Model Testing and Indicator Analysis

In this paper, the model is tested in the commercial network scenario, the purpose is to verify the effectiveness and reliability of the model in real scenarios. This platform can be used as a real-time test platform. The car is the mobile carrying platform for the test, and the vehicle brand is Rongwei 350. IFLYTEK is the service target under test, and the mobile terminal in its data service is only used for network access. In addition, the mobile platform uses oppo R9m. The PC system selects Shenzhou Xuanlong series, model prot1, 4G graphics card storage, 8g memory, Intel i7 processor and windows 10 operating system. According to the design standard, ffmpeg is used to edit audio in the format of PCM, the sampling rate is 16000, and the bit rate is 16bit; the sentence "today's weather in Beijing" is selected for recording, and the adult male voice has medium speech speed. In the functional verification of recognition success rate, we can use the advantages of the road test platform to edit the case file, add background noise and selected noise. It is the background sound of typical vehicle running, and the format conforms to the design standard.

Firstly, the delay and recognition accuracy indicators of the test model are set by using the vehicle road test platform. At the same time, 10 men and 10 women are selected to score the MOS of each index gradient test model, and the relationship among MOS, latency and recognition is obtained as shown in Fig. 3.

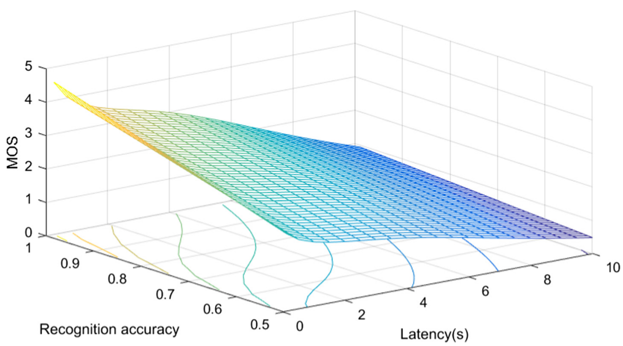

Fig. 3. MOS'-latency-recognition accuracy relationship graph.

As shown in the Fig. 3, as the latency and the corresponding recognition accuracy decrease, the user's psychological feelings tend to decline, and the MOS score gradually decreases. When the latency is 10 S, the user reaches the psychological tolerance limit and the recognition accuracy. When they are 0.85 and 0.7 respectively, the optimal values of the corresponding MOS scores are 4 and 3. It can be seen that when the recognition accuracy is 0.85 and above, the user feels good. When the recognition accuracy is 0.7 to 0.85, the user can accept, And below 0.7 is basically unbearable.

Next, the typical time and place of commercial test are determined and evaluated. According to the environmental factors of wireless channel, the mobile road network test under real vehicle environment is carried out near residential, residential, street, Internet cafe, underground parking, tunnel, suburbs and market, and the MOS value is obtained as shown in Fig. 4.

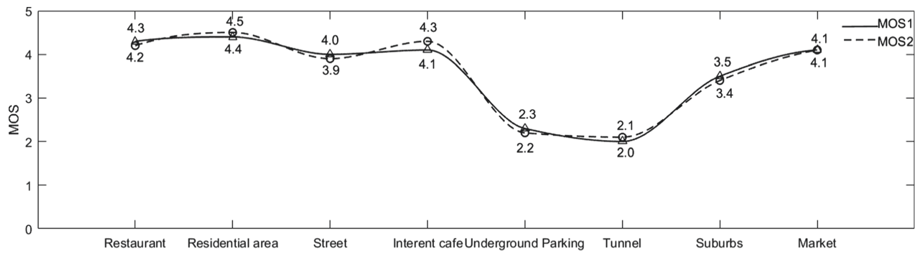

Fig. 4. MOS in typical scenarios.

As shown in Fig. 4, different wireless channel environments in each location result in significant differences in MOS. In underground parking and tunnel, the experience quality of end users is the worst.

6 Conclusions

In this paper, the characteristics of vehicle voice cloud service are studied, and the key index system is constructed by using FAHP. The validity of the model is verified by data sampling, analysis and construction of QoE test quantitative model, and the correlation of relevant indicators is studied. Through the research and evaluation, the quantitative model of QoE test in this paper can successfully simulate the user's psychological perception, meet the application of the relevant system of the vehicle voice cloud service QoE test, bring important help to the evaluation of the vehicle voice cloud service QoE, provide strong objective evaluation support for service providers and operators, and improve the core competitiveness.

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