2022-07

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Laghari, A

10.2298/csis220322038l
Computer Science and Information Systems
ComSIS Consortium

Computer Science and Information Systems 19(3):1305–1328 https://doi.org/10.2298/CSIS220322038L

Crowdsourcing Platform for QoE Evaluation for Cloud Multimedia Services

Asif Ali Laghari[1], Hui He[2], Asiya Khan[3], Rashid Ali Laghari[4], Shoulin Yin[5⋆], and Jiachi Wang[6]

[1] Department of Computer Science, Sindh Madressatul Islam University
Karachi, Pakistan
asif.laghari@smiu.edu.pk
[2] School of Computer Sciencee & Technology, Harbin Institute of Technology
Harbin, China
hehui@hit.edu.cn
[3] School of Engineering, Computing and Mathematics, University of Plymouth
United Kingdom
asiya.khan@plymouth.ac.uk
[4] Interdisciplinary Research Center for Intelligent Manufacturing and Robotics (IRC-IMR), King Fahd University of Petroleum and Minerals, Dhahran, 31261, Saudi Arabia
rashidalilaghari@gmail.com
[5] School of Information and Communication Engineering, Harbin Engineering University
Harbin China
352720214@qq.com
[6] Software College, Shenyang Normal University
Shenyang 110034, China
853757309@qq.com

Abstract. This paper presents a novel web-based crowdsourcing platform for the assessment of the subjective and objective quality of experience (QoE) of the video service in the cloud-server environment. The user has the option to enter subjective QoE data for video service by filling out a web questionnaire. The objective QoE data of the cloud-server, network condition, and the user device is automatically captured by the crowdsourcing platform. Our proposed system collects both objective and subjective QoE simultaneously in real-time. The paper presents the key technologies used in the development of the platform and describes the functional requirements and design ideas of the system in detail. The system collects real-time comprehensive data to enhance the quality of the user experience to provide a valuable reference. The system is tested in a real-time environment and the test results are given in terms of the system performance. The crowdsourcing platform has new features of real-time network monitoring, the client device, and cloud monitoring, which currently has not been provided by existing web platforms and crowdsourcing frameworks. The results show that 1MB buffer is filled 100% very soon after starting watching videos from the crowdsourcing platform.

Keywords: Crowdsourcing platform, Video service, Quality of Experience (QoE), Cloud computing.

⋆ Corresponding author

1. Introduction

Today with the rapid development of the Internet and mobile devices, organizations have been able to provide a variety of services for users. One of them is multimedia cloud computing, which has been mainly offered on the Internet [1]. Cloud computing organizations provide multimedia services to end-users on pay per use. Multimedia-streaming technology has been widely used in Internet TV, online cinema, live events, video sessions, short video sharing, and so on [2]. Besides that, more and more multimedia streaming services are being created and developed. Meanwhile, the competition among the service providers becomes fiercer, if the organization wants to win in such a fierce competition, they will need to be recognized by the users and satisfy them. At the same time they provide services, cloud organizations are paying attention to the QoE and hoping to improve their service level by users satisfaction with their products [3]. Previous research has provided QoE based solutions for multimedia services based on the QoE to provide quality of service (QoS) for video streaming to end-user [4,5], but did not provide a satisfactory solution that differentiates the positive and negative feedback of users for service management [6]. Users‘ high-quality experience will improve their awareness of business and application which will enhance the organization‘s brand value [7]. Therefore, it is necessary to collect information about QoE for users who use streaming media services. Through the analysis of collected QoE data, they can develop systems to provide better services for users [8].

One of the biggest challenges that the service providers face is how to observe and improve the business quality in real-time [9], and hence, gain more user groups. At present, most organizations take the form of questionnaires or user complaints to obtain the user‘s subjective QoE data and then go to optimize and adjust the network [10,11]. While this is the way to get the user‘s QoE data, it is time-consuming and less comprehensive [12,13]. So, organizations need a way to get the objective data of QoE quickly and in real-time. Still, there is no crowdsensing framework is proposed by any researcher, which collects subjective and objective QoE and differentiates between negative and positive QoE [41,42]. For multimedia streaming services, while the user is watching a crowdsourcing platform can capture the objective metrics of the service performance data (such as network bandwidth, network latency) and send them to the server to record [14,15].

QoE is defined as ”a blueprint of all human subjective and objective quality needs and experiences arising from the interaction of a person with technology and with business entities in a particular context” [16]. The QoE is all about the human perception by using any product or service [43]. The QoE methods are used for capturing user opinions about video quality, video streaming and network services and products [17,18]. The QoE can be captured by using subjective and objective approaches, one is a subjective way, which is conducted by using interviews, questionnaires, and web survey methods. The subjective QoE is captured by the mean opinion score (MOS). The second method is objective QoE, which is based on QoS and human physiological data [17].

The combination of subjective and objective QoE data has a greater reference value to the service providers to provide services according to user needs with QoS for those users who use mobile devices [19]. As the final link in the whole mobile communication industry chain, the mobile device directly affects the user‘s perception and QoE of the service and application provided by the organization [20], so the QoE data of the mobile device is very important for organizations [21]. To solve these problems, we developed

mobile-oriented multimedia streaming services and a QoE evaluation platform, which can provide video services to users and statistically analyze the user‘s QoE subjective and objective data simultaneously in real-time. Previous platforms were limited in capturing only one type of QoE, subjective or objective [22-25] but did not have the functionality to capture objective QoE in real-time and made comparative analysis for accurate QoE and service level agreement (SLA) [26].

The main contribution of this paper is to present the crowdsourcing platform for the assessment of subjective and objective QoE video services in the cloud-server environment. The proposed platform is made up of two subsystems which include a video service website subsystem and a QoE data statistics management subsystem. Video website provides relatively complete video services; users can register and log onto the site, also can upload and manage video on the site. The crowdsourcing platform contains a questionnaire and this questionnaire is based on a QoE-related research foundation design. Users can submit the questionnaire for feedback on their subjective experience data. On the back-end, we collect objective QoE/QoS data of the user, which does not affect the user‘s normal use. The administrator can view the user‘ s subjective and objective QoE data by logging into the QoE Statistics Management System. Through the crowdsourcing platform‘s QoE data the video service system will optimize to provide users with better service. To our knowledge, the crowdsourcing platform has new features of real-time network monitoring of the client device and cloud monitoring, which currently has not been provided by existing web platforms and crowdsourcing frameworks.

The rest of the paper is organized into 6 sections. In section 2, we provide related work based on the overview of the existing QoE/QoS based platforms for cloud multimedia services. Section 3 provides the crowdsourcing platform requirement, analysis, and design. Section 4 presents the video subsystem website and implementation. Section 5 presents testing of the system and results of the QoE crowdsourcing platform for cloud multimedia services and finally, in section 6, we conclude the work and provide future directions.

2. Related Work

This section is divided in two sub-sections giving an overview of the existing QoE/QoS based platforms for cloud multimedia services and a comparison of existing crowdsourcing platforms.

2.1. Overview of Existing QoS/QoE Based Platforms for Cloud Multimedia Services

Web platforms and frameworks for QoE capture and assessment were introduced by several researchers [4, 27, 28, 29]. A survey of web-based crowdsourcing frameworks based on subjective QoE is given by Hobfeld et al. [30], which monitors the objective QoE/QoS data from the cloud to the user‘s device. Web frameworks are limited for the evaluation of multimedia services to get users’ perceptions about the services and multimedia contents, but they did not compare service delivery status to SLA. Also, they did not focus on the negative responses of the end-users during the submission of QoE when proposed and developed web-based platforms. Wu-Hsiao Hsu and Chi-Hsiang Lo [4] proposed QoS/QoE mapping and adjust their model for cloud service providers to monitor and adjust the

user‘s QoE. The proposed model translates QoS parameters into QoE in a cloud computing environment. The model is tested by capturing QoE of users by setting a simulated platform of video streaming, which consists of three parts, the GA, NS-2, and monitoring process and compares it to the monitored QoS parameters. During the experiment, two parameters were used as buffering time (BT) and streaming video discontinuity (SVD) to measure user perception about video streaming. Forty-eight videos were used with different lengths and forty users were invited to view the videos and assign mean opinion score (MOS) for each video. The result of the experiment shows that network QoS and the user's QoE are consistent with each other.

Jordi et al. developed the Wersync web platform [25], which enables distributed media synchronization and social interaction across remote users. The development of the Wersync web platform is based on four key technologies, The first one Node.js is a cross-platform runtime environment and open source, which uses a networking based application and is written in JavaScript for the server-side. Second is the HTML 5 video component, which supports embedding full-fledged media players into web pages. The third element is the clock synchronization between all the involved entities to ensure a coherent notion of time in the shared session. Fourth is Socket.IO, which is a lightweight JavaScript library that enables real-time bidirectional communication between web clients and a (Node.js) webserver. This platform provides a facility for users to create and join sessions, which are ongoing and use a the same media contents with remote users in a synchronized manner. This platform also supports cross-platform, cross-device support and cross-network, which is a key point in the current heterogeneous media delivery ecosystem.

Ahammad et al. present a flexible web platform for QoE-driven delivery of image-rich web applications [22]. The platform is based on content-aware optimization and instead of delivering the whole image once to the client, it delivers in partitions. The partitions image approach is based on creating content-aware parts of the image and reorganizing the bytes on their significance and using timestamp in the application. At the client-side delivered image parts were recombined in the full image and did not affect the visual perception of the end-user. This approach is different from the content delivery network (CDN) architecture because cloud behavior launches optimization process offline, and when it is ready then starts serving to deliver contents C thus delivering an improved QoE overall. The other major difference of this architecture for improving the performance of the application is that it avoids passive response to browser requests, it breaks requests in pieces or delays in a request to avoid negative impact on the user‘s other resource download.

A Data-Driven Platform for QoE Visualization and System Performance Monitoring (QOEYE) has been proposed by Chao Zhou [23]. The proposed platform is based on the QoE metrics of rule-based QoS monitoring. During the experiments, a real trace of the BesTV content provider is used as the data source, and video logs were collected from the BesTV server to monitor server and log data which were statistically analyzed to find fault location. QoE monitoring metrics were set by dividing the playtime of the video into 5 percentage points, such as 0-20% and 80- 100%. If the load on the server is at the peak, the user will not watch the complete video and leave within 0 C 20% resulting in a decrease in QoE. Organizations earn from long video watching of the user by adding advertisements in the video. If users watch the complete video then the log will store

on the server from 80 C 100% and the QoE of the user is excellent. QOEYE platform provides the facility to use content without limitation of geographical boundaries and the user can easily view usage statistics via the service provider. This platform also enables us to monitor large scale servers and find the fault location.

Cross-Layer Multi-Cloud Application Monitoring as a Service Framework (CLAMS) is a proposed framework for QoS monitoring based on agent technology, which monitors applications and big data analytics in a multi-cloud environment and addresses the issue of cross-layer monitoring of applications [33]. CLAMS framework has limited functionality which only supports QoS monitoring and does not support subjective QoE, user device monitoring and external network monitoring outside the cloud organization. Our proposed crowdsourcing platform captures both network QoS (NQoS) and application QoS (AQoS) parameters. It is based on subjective and objective QoE/QoS assessment and data analysis.

2.2. Comparison of Existing Crowdsourcing Frameworks with Crowdsourcing Platform

Ribeiro et al. [34] proposed an open-source project crowdMOS framework, which only focused on the audio quality assessment of users and this framework can easily be modified or installed on any suitable web server. Initially, crowdMOS was developed for audio quality assessment but later this was extended to support image quality assessment methodology. For assessing the accuracy of MOS of users it uses a simple correlation coefficient between the MOS. crowdMOS rejected users if the correlation is less than a definite threshold such as 0.25 suggested in [6]. crowdMOS accepted a large number of fake user‘s MOS, to avoid this threshold can be increased to eliminate a large number of users. This framework did not support QoS monitoring to analyze the user‘s given MOS and system set preferences.

The QualityCrowd [35] framework is an open-source project for a crowdsourcing framework designed for QoE evaluation, which can be easily modified and installed with minimal effort on any web server. This framework supports multiple questions to set and design tests for the image, video, and audio with multiple combinations and methodologies. Crowdsourcing framework is based on two parts: A back-end can handle test results and provide features for new test design and the front-end provide a user interface where the actual subjective test takes place. This framework also has limitations such as it did not provide automatic monitoring of contents and objective QoE assessment features, therefore, it is unable to distinguish between the positive and negative feedback of end-users.

A web-based subjective QoE open-source evaluation platform has been proposed by Benjamin Rainer [24] and is available at [32]. The proposed platform was developed for the assessment of subjective QoE for both lab experiments as well as for crowdsourcing. The proposed crowdsourcing platform is based on the HTTP server with the support of PHP and a MySQL database. The platform follows the Model View Controller (MVC) pattern, the description of test and questions can be configured separately as the requirement of the field for subjective QoE assessment will be conducted. This platform can easily be extended and used for the QoE assessment of multimedia applications and by adding adobe flash player and HTML5 as it supports a wide range of codecs and browsers.

Kraft and Zolzer designed the BeaqleJS crowdsourcing framework for subjective QoE assessment of audio files [36]. This framework is built on PHP, JavaScript, and HTML5,

which supports numerous audio file formats for subjective QoE assessment. This framework can easily be extended to add more evaluation methodology by extending a simple code. This framework does not support database to store user data, however, results are emailed in the format of text files to the organization.

In-momento crowdsourcing framework for the assessment of QoE was introduced by Gardlo et al. [37], which is best known for QoE conducting a test with a user interface facility to end-users. This framework provides reliable ratings because the user has an interface facility to view and understand scales and discord unreliable ratings due to strict a-posteriori filtering which reduces the amount of large work from the administration. The framework also provides a rapid feedback section for direct communication with test participants if any suspicious behavior is found. This also provides a facility for users to submit their ratings if the previous rating is not satisfied or due to low performance and can be continued or stopped the testing process.

The proposed crowdsourcing platform is intended to perform the functions of monitoring the user system and middle network traffic and cloud infrastructure from the client device to the cloud. The user‘s submitted subjective QoE and automatically collected objective QoS/QoE data will be examined for service delivery according to SLA. The crowdsourcing platform also has the functionality of analyzing the difference between the positive and negative QoE by comparing it with the current service delivery report and QoE submitted by the user, which is to the best of our knowledge, these functions have not been provided by previous crowdsourcing platforms. A comparison of features is given in Table 1.

3. Web Platform Requirements Analysis and Design

This section gives an overview of proposed system design and QoE data collection.

3.1. System Design

The structure of the platform is shown in Figure 1, which shows the core functions and the system partitioning of the project macroscopically. The following will be the three subsystems of the project's functional aspects of the introduction.

The system consists of three subsystems, including a video service site, an Android video application, and QoE data statistics management system. Through this system, the administrator can access the subjective and objective QoE data of the streaming media from Android end, to summarize and analyze these data. Through this platform, cloud service providers can collect and evaluate the QoS/E in real-time and provide more data support for user QoE evaluation. This platform can more fully reflect the true QoE, thus ensuring the user experience. The structure of the crowdsourcing platform is shown in Figure 1.

3.2. Demand Analysis of Website

This part is a relatively complete video service system, which provides users with video service, subjective QoE survey and interface function for data submission. The use case diagram is shown in Figure 2.

Table 1. Comparison of exiting crowdsourcing Framework with New Crowdsourcing Platform

Framework Feature	CrowdMOS [34]	QualityCrowd2 [35]	WESP [24]
Media type	Image, audio	Image, video and audio	Image, video, audio, sensory effects
Methodology	ACR, DCR, Mushra	ACR, flexible: single, double stimulus; discrete, continuous scales	All (flexible), e.g.,ACR, ACR-HR, DSCQE, Double stimulus for sensory effects
Questionnaire	Embedded in evaluation	Separated tasks	Embedded in evaluation
Task Design	Custom template all tasks have the same template	Custom template Tasks configured in script file	All tasks have the same template
Task order	Random Full set or subset of all stimuli	Fixed	Flexible
Open source	Yes	Yes	Yes
Data storage	Text files	Text files CSV format	Database
Programming Language	Ruby	PHP+own script language	JavaScript+PHP
Monitoring	No	No	No
Remarks	Subjective Evaluation	Subjective Evaluation	Subjective Evaluation
Framework Feature	BeaqleJS [36]	in-momento [37]	Proposed Crowdsourcing Platform
Media type	Audio	Image, Video	Image, Video and Audio
Methodology	ACR, DCR, Mushra	ACR, flexible: single, double stimulus; discrete, continuous scales	All (flexible), e.g.,ACR, ACR-HR, DSCQE, Double stimulus for sensory effects
Questionnaire	Embedded in evaluation	Separated tasks	Embedded in evaluation
Task Design	Custom template all tasks have the same template	Custom template Tasks configured in script file	All tasks have the same template
Task order	Fixed	Random based on actual number of ratings	Flexible
Open source	Yes	Yes	Yes
Data storage	Text files	Database	MySQL Database
Programming Language	JavaScript+PHP	PHP	JavaScript, HTML5, CSS+PHP, MySQL
Monitoring	No	Limited	Overall
Remarks	Subjective Evaluation	Subjective Evaluation	Subjective, Objective (QoS)

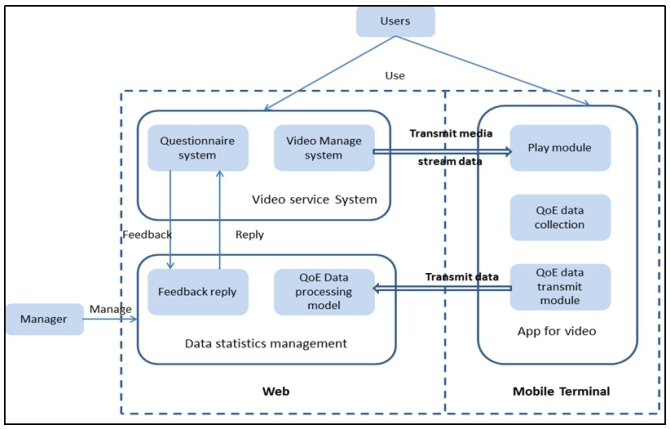

Fig. 1. Crowdsourcing Platform structure diagram

Users need to register and login before they can use the video service site. The video site defaults to provide users with 2GB of cloud storage space. Users can manage their own cloud storage space; they can do management like video upload, playback and delete operation. The cloud storage space also has a video folder management system and users can create or delete folders for users to organize their uploaded videos. Users can modify the basic attribute information (name, description, label, whether public) of the uploaded videos and modify the folder to which the video belongs by the management operation. Open-book management provides an option for the user to manage their videos public to other users of the system.

This site provides user feedback capabilities, and the user in the use of the video service can fill out the questionnaire on the site to provide feedback for the web services. This section also lists the administrator's response to the user's questionnaire, and the user can view the administrator's response to solving their problems, to better make use of this site.

3.3. Demand Analysis of QoE System

QoE data statistics management platform for the administrator is presented here. Administrators log on to the platform to view and manage the system's QoE data. The system consists of QoE capture, assessment, and QoE data display. The use-case diagram for the management platform subsystem is shown in Figure 3.

When the administrator logs in to the system, they can view the subjective and objective QoE data feedback from the user. Subjective QoE data is submitted via the questionnaire and objective QoE is captured automatically by various video playbacks, objective QoE data contains information of the user‘s device, including the video buffer status delay time and some basic parameters of the device. Both subjective and objective QoE data will be stored on the server in the database for future processing. The administrator can view each questionnaire and can respond to the user's questionnaire feedback.

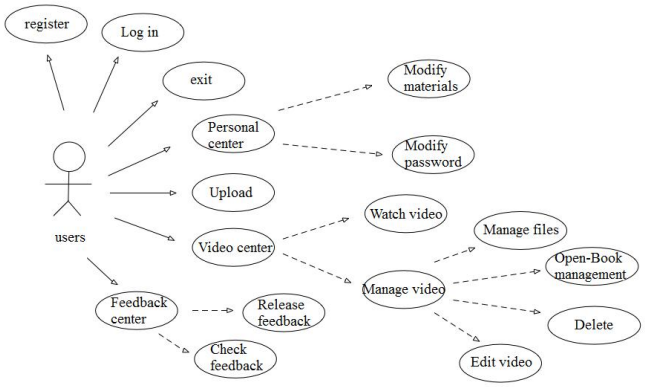

Fig. 2. Video Website Subsystem Use Case Diagram

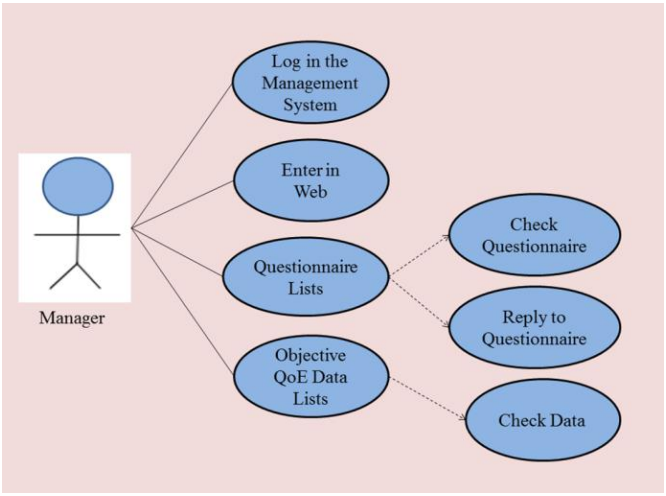

Fig. 3. QoE data management platform use case diagram

4. Video subsystem Website Design and Implementation

This section gives an overview of the video subsystem and QoE statistics management.

4.1. Video Subsystem

The video subsystem includes a user site service module, video module, questionnaire modules and app interface module. The cloud side view of the subsystem is shown in Figure 4 and is described in detail below.

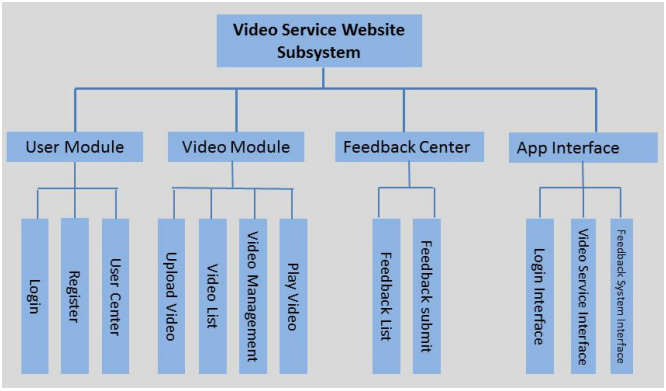

Fig. 4. Video Service Website Subsystem Cloud server

Video module (1) Video upload

The user has the option to browse the local system to upload the video file to his account, but file selection has been limited because the crowdsourcing platform accepts only .mp4, .mkv, .flv and .mov video formats. Taking into account the larger video files PHP server-side configuration has restrictions on the upload file size, slow upload, and other factors so there is a need for video files on the client-side for the concurrent upload. The project uses Web up-loader components, integration fragment and concurrency to upload large files split into multiple pieces (each 5MB) as shown in Figure 5.

When the user clicks upload platform uses Ajax technology to send the size of the video information to the back-end to verify the user's default storage space for 2GB if the user's available space allows then a video is uploaded, if space is not sufficient the user is prompted: not enough storage!.

PHP background on the block to upload the video processing has been uploaded to merge the video clips when the merger is successful then set the tag parameter $ done is true and a unique file name is assigned and stored in the upload directory. The platform that contains the FFmpeg component has been successfully uploaded to the video clip from the beginning of the video cover (preview image) PHP background command is as follows:

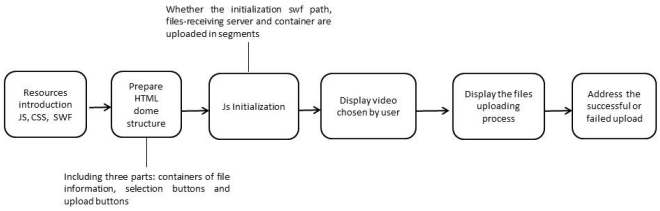

Fig. 5. Web Up-loader component integration

$ File. ”-y -f mjpeg -ss 3 -t”. $ Time. ”-s 320x180”. $ Imgpath); // Interception ($ str = ”/ usr / local / bin / ffmpeg -i” The cover image of the video; We also need to obtain the total length of the video, php background execution command is as follows: $ Vtime = exec (”/ usr / local / bin / ffmpeg -i”. $ File. ”2¿ & 1 — grep ’Duration’ — cut -d ” -f 4 — sed s / / Get the total length of the video; We use the file size ($ DIR) function to get the size of the video and store the video’s data in the database and the user’s free space is updated.

(2) Video list

The user’s media library is divided into the main list and folder system; the user can view the uploaded video and then manage them. On the main list page uploaded videos of the user will show displaying 5 videos per page and counting the total number of videos. The user can select one or more videos to delete, move to a folder, share or cancel the videos for the public. The operation of the flowchart is shown in Figure 6.

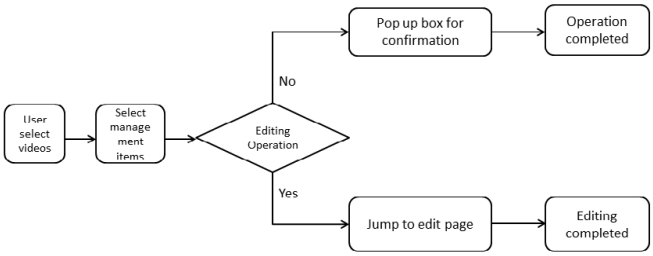

Fig. 6. Schematic diagram of the operation flow

When the user acts to delete the video, open or cancel then a pop-up prompt box appears and the user can choose to confirm or cancel the operation. The user has the option to move the video folder by using the drop-down bar. If the user chooses to confirm the number of id arrays submitted to the background of the site, it verifies video id and is first deleted from the disk storage and then deleted from the database record and the delete field is set to 1. Other operations can directly modify the corresponding field in the database.

When the user selects a video for editing the video editing page will display, the user can rename the video and also the label the description of the corresponding editing and

modification work. When the user clicks the Save button the form will be submitted to the background post, because the video id is passed as a parameter, the background of the effectiveness of the id is verified and if the video information is correct the data of the video is updated as shown in Figure 7.

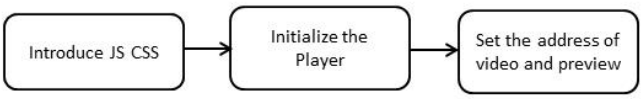

Fig. 7. JWplayer components integration

Feedback Center Module (1) Feedback list

Users click to enter the feedback list and enter their subjective QoE. The administrator will give feedback to the list of all user questions and the user can click on one of the feedbacks to view the administrator's response to the problem. Through this list, users can better understand how to use the site and can easily solve the problems encountered when using the system.

(2) The user questionnaire

The crowdsourcing platform contains a questionnaire (form) for the user to enter their feedback (subjective QoE) about the services, which they receive. International Telecommunication Union (ITU) provides a table for subjective experience indicators to collect the user experience, which is shown in Table 2 to allow the user to rate the assessment [40].

Table 2. Selection of Experience Indicators [40]

MOS	Quality	Perception
5	Excellent	Imperceptible
4	Good	Perceptible
3	Fair	Slightly annoying
2	Poor	Annoying
1	Bad	Very annoying

In combination with the above scoring method, we designed a user feedback questionnaire as shown in Table 3. The questionnaire can be completed and submitted by the user. The user needs to fill in the required fields with * and other feedback information. During the experiment it was verified the validity of the feedback data submitted by the user and marked the source for the PC will be deposited in the database. Through the questionnaire, we can get the user's subjective experience of the platform.

Table 3. Feedback Questionnaire Design

Item	Type	Required fields or not	Description
User name	text	yes	User name
Email	text	yes	User Email
Phone	text	no	User phone
Priority	option	no	Urgency degree of feedback 1.low 2.normal 3.high
Issue	text	no	Problems encountered by users
Network satisfy	option	no	Satisfaction of users
Network type	option	no	Network type 1.3G/4G 2.Gable network 3.unknown
Network speed	Text,option	no	Network speed, User can firstly write the speed or choose unknown
Buffer waiting	option	no	Dose the buffer get stuck
Video quality	comment	no	Overall comments of video which has 5 levels
Comments	text	no	Other users‘ feedback

4.2. QoE data statistics management subsystem design and implementation

The administrator can enter the QoE data management background through the ”domain name/admin” connection and the non-administrator will be prompted with ”access forbidden”. This part includes the user’s subjective QoE data and objective QoE data in two parts. The subsystem cloud server diagram is shown in Figure 8.

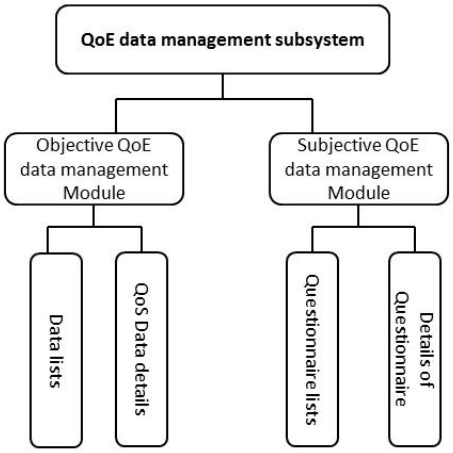

Fig. 8. QoE data statistics management subsystem Cloud server diagram

Subjective QoE data management module The subjective QoE data is the feedback questionnaire of data that the user fills. This section will display each page in the form of 10 pages of all user feedback questionnaires, the list in reverse chronological order and the administrator does not consult the questionnaire as it will be hiding. We can get the basic information from the list of the questionnaire the platform source (PC) and the administrator's response. When the administrator clicks on one of the data view buttons can be viewed. Administrators can see the details of the questionnaire and can reply to it.

Objective QoE data management module Objective QoE data is collected from the user‘s device, network, and cloud server. This section is similar to the feedback list, the same to the page in the form of 10-page display, according to the time in reverse order. When the administrator clicks the view button to jump to the details of the data page and this page consists of four parts: User info, Video info, Device info and QoE Data. User info shows the user information, including user id, account number, nickname, and phone number. Video info shows the recorded video information, including the video's name, duration, and the cover image of the video displayed. Device info shows the user device information obtained by Android, including mobile phone manufacturer, handset model, CPU information, battery power information, network type, and location information.

QoE data first draws a buffering curve, which is plotted using the High Charts component, which reflects the percentage of video buffered and network conditions. We also give the device memory usage, the current application memory usage, video preparation delay time, and the buffer 100% of the proportion of time, the higher the proportion of the user area the less the situation, the better the playback.

4.3. Database Design

The project database contains five tables, namely the member_user table, the folder table, the video table, the feedback table, and the QoE table. The database E-R diagram is shown in Figure 9.

5. System Testing

5.1. Experimental Environment

The Experimental hardware used is the MacBook pro CPU 2.5 GHz Intel Core i7 16G memory 512G hard drives Red rice note3 CPU Qualcomm Xiaolong 650RAM 2GB, ROM 32GB QVGA 1080x1920, 100M LAN and software packages used during the experiment are Server use Mac OS other software and their versions Mysql5.5, PHP5.6.2, Nginx-1.4.2; Android use MIUI 7 Android OS.

The topology is based on the cloud application server, which hosted the crowdsourcing platform, SQL database server is integrated with the cloud application server for performing an operation related to the database. The user terminal is the device where users can access the crowdsourcing platform via the Internet. The crowdsourcing platform was hosted on the architecture in the Computer Network and Security Laboratory at Harbin Institute of Technology and users were invited to access the crowdsourcing platform to create their accounts, upload videos, manage videos and provide feedback by using a

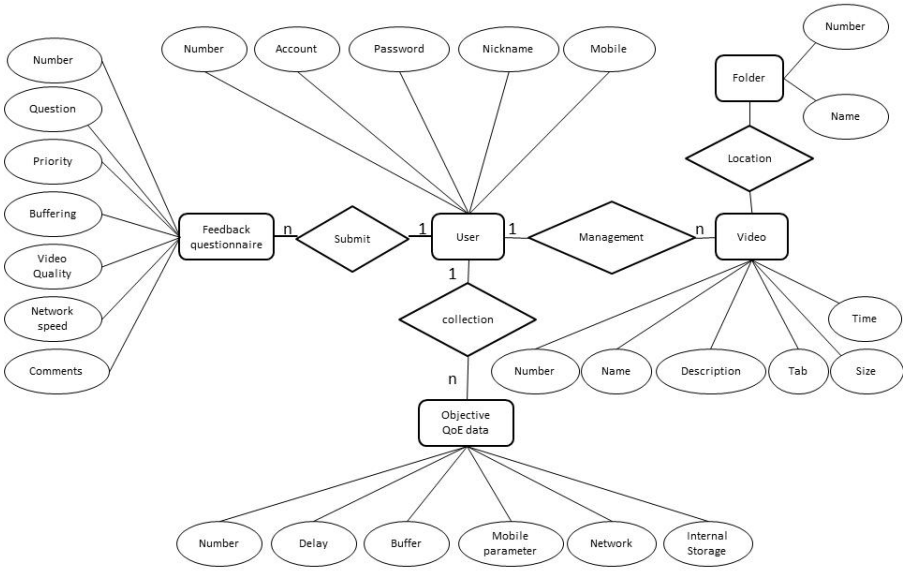

Fig. 9. Database E-R

questionnaire of a crowdsourcing platform. The cloud server architecture and user access diagram are shown in Figure 10.

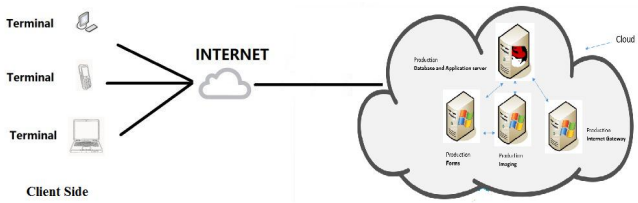

Fig. 10. The Topology of Experiment

5.2. Video Service Website Subsystem Testing

Feedback Questionnaire Module The feedback questionnaire is shown in Figure 11. It comprises the 'feedback' button to enter the feedback list page to expand the view administrator feedback and the 'submit feedback' button to enter into the feedback questionnaire page as shown in Figure 12. This enables the user to submit the feedback questionnaire.

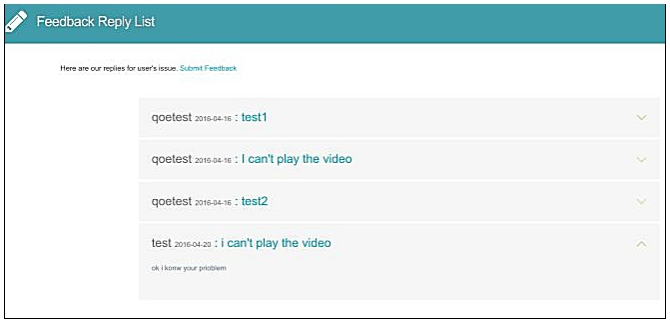

Fig. 11. Feedback list

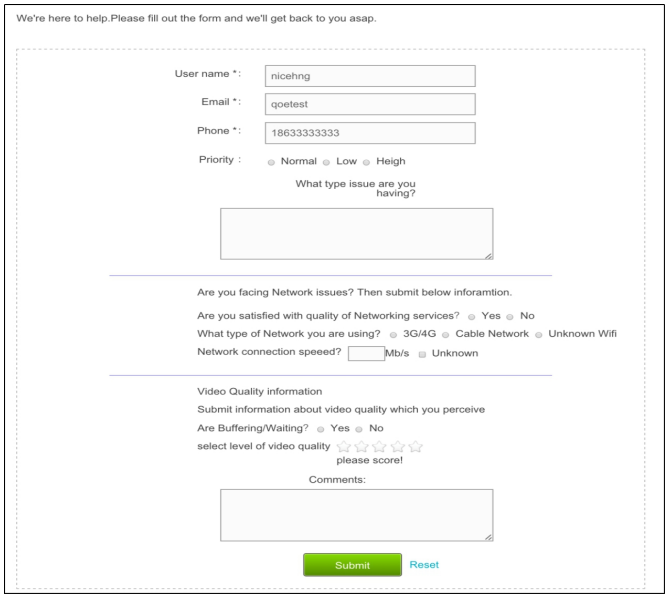

Fig. 12. Feedback Questionnaire

5.3. QoE data statistics management subsystem testing

The QoE statistics management subsystem is accessible only by the administrator and is accessed by entering the HTTP: // domain name/admin. If the administrator login to the page, the login is successful and the Feedback List page is displayed in Figure 13. Otherwise, the user is prompted to access illegally.

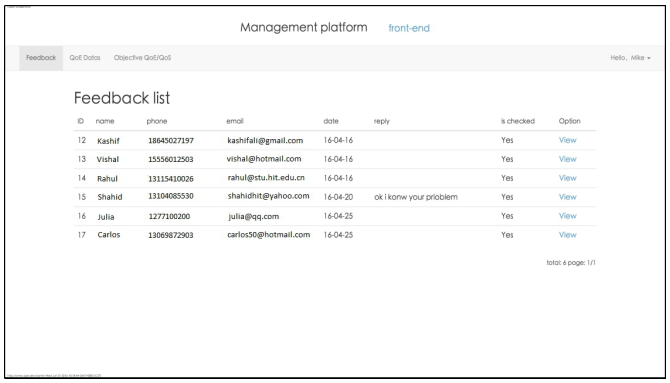

Fig. 13. Feedback Reply list

By clicking on one of the feedback lists, the feedback details page shown in Figure 14, can be accessed, where the administrator can respond to the user.

Agent technology-based function is developed to monitor objective QoE in the crowdsourcing platform and a simple network management protocol (SNMP) is used to QoS data collection from the environment [33]. The SNMP agents are responsible for collecting QoS data such as network type and routing path for data transmission from the cloud to the client. The SIGAR is responsible for system data collection such as RAM and CPU resources consumed by the process, free memory, used and overall memory of the system and overall CPU utilization for all tasks e.g. [38] The platform has the functionality to monitor internal cloud infrastructure for idle resources such as load on the internal network, processing power, and storage. QoS data retrieval of the user such as distance from user to cloud, data routes from several routers between the user and cloud, delay of the router, network throughput, wireless/wired network, user device OS, memory and CPU usage (high impact on the performance), browser and overall capability of user device information for management purpose to the administration for comparison of QoS with SLA.

The monitoring function of objective QoS/QoE is divided into three sections, such as the user device and usage data, middle network environment and internal cloud environment. Additional sections of objective QoS/QoE comprised of the information of the task management (assessed time of accomplishment and remain a time of the task, start and end time, current and previous task).

The user starts using video services, if s/he feels the quality of the video is low or video does not play smoothly and video playback is waiting for a short time then play

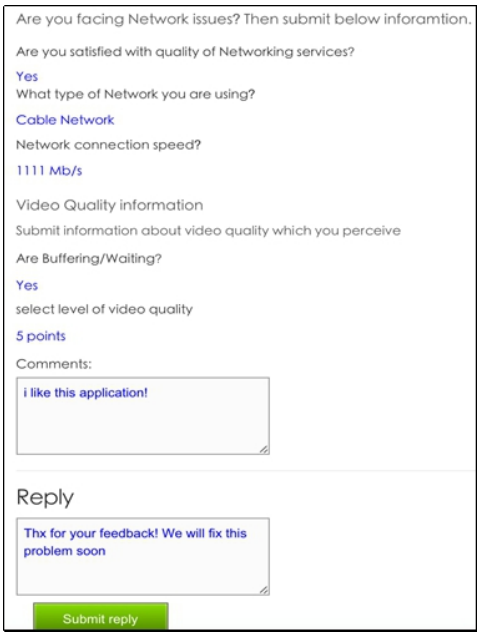

Fig. 14. Feedback Details Page

(buffering) then the user can submit his complaint (subjective QoE data/feedback) using feedback questionnaire shown in Figure 12. Users watching videos from the cloud server, same time crowdsourcing platform automatically collect objective QoE/QoS data by using agent technology and store in MySQL database for data analysis. Objective data contains information on the user device‘s resources such as free RAM and memory for cache files, CPU utilization and network information (such as speed, usage, packet delay, and loss, etc.). This data will be analyzed when a user submits his experience about the services because insufficient resources of the user‘s device and the network are a problem to receive QoS. Objective QoE data is compared with submitted feedback of user‘s if the QoS delivery of video services degraded from SLA then crowdsourcing will search for a particular problem. If the problem is found at the user side for insufficient resources to access the cloud multimedia services or external network usage is peak then it will send an alert to the user for the particular problem. If the problem is found at an internal cloud server such as virtual machine (VM) migration, internal cloud network usage is peak due to high traffic then it will send an alert to the administrator for the problem and upgrade the services more than the SLA package as compensation for the time and the problem is solved by the administrator.

QoE is all about subjective user experience. User experience can be both positive negatives. To fully understand the negative feedback, the objective QoE/QoS data collection feature of the crowdsourcing platform will analyze the submitted feedback of the user with objective QoE/QoS to ascertain whether the submitted feedback is true feedback or not. The QoS data collection functionality extended read client device‘s buffer status and gets information on the current and remaining time of the video, overall information of

video such as the size of the video, total playing time during the playing and after submission of subjective QoE from the user. The buffer checking agent runs across the firewall of the client device in the same way as agent work in the Globus toolkit of grid computing for resource discovery [39]. The result is shown in Figure 15 that the 1Mb buffer is not filled due to the network delay and playing the content of video when the buffer code is tested by using the Wi-Fi network.

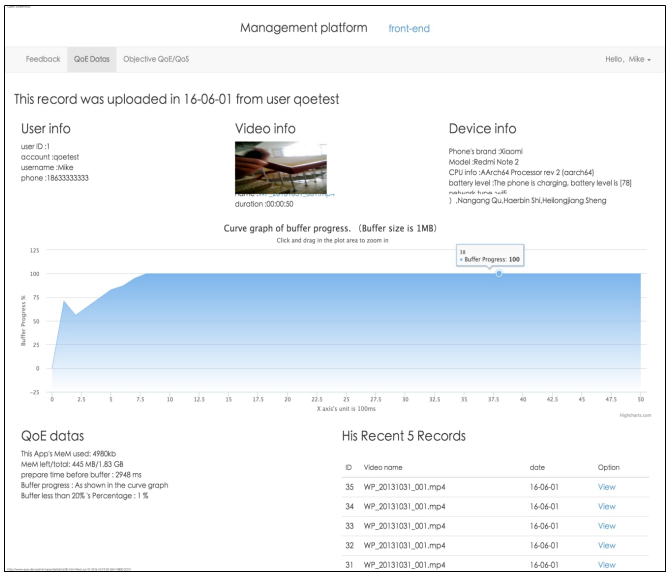

Fig. 15. QoE Data Details page

5.4. User Experience After the Trial Tests

The use case diagram shown in Figure 16 shows the user interaction, accessing services and feedback and on the other hand, cloud management controls the operation of the user. User login in crowdsourcing platform, if the user ID is corrected then s/he can access the services and submit the feedback about the services. If the user ID is wrong then cloud management denies access to the crowdsourcing platform. When the user accesses the services of crowdsourcing such as videos upload, host and share, same time crowdsourcing platform which automatically monitors cloud internal monitor for CPU, utilization, available resources and currently utilization resources, media contents, internal communication network delay, and error rate. Crowdsourcing platform also monitors the middle network between the user and cloud where the crowdsourcing platform is hosted; all objective QoE (QoS data) will be stored in the database of the crowdsourcing platform as well as user-submitted feedback, which are given in the system boundary of the use case diagram. The Cloud management actor handles the overall process of data collection, analysis and sends an alert if a problem is found at the user side. Cloud management

analyzes the client reports and profile and will forward the request to the crowdsourcing platform to produce a report from the QoE database (DB). Cloud administration can select any client from the management section and check his report. The report about the user's problem for getting QoS from the cloud or errors that occurred during the access of service or degrade the performance, which violates the SLA, will be forwarded to the user for information purposes.

The proposed crowdsourcing provides features of monitoring objective QoE/QoS data of client devices, middle network, and cloud environment and compares with subjective QoE submitted data of the user to measure service quality as mentioned in SLA. The result shows that the crowdsourcing framework monitor overall service delivery from client to cloud and Figure 15 illustrates the client device, user's personal, contents it access, and middle network information. Further section 5.4 illustrates system operations from user login to cloud management in the use case diagram.

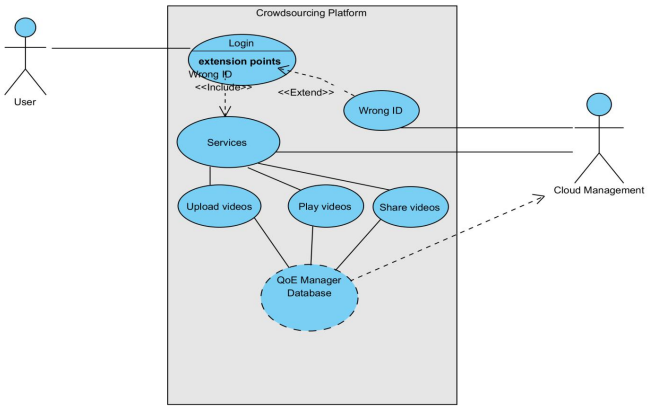

Fig. 16. Use Case Diagram of Crowdsourcing Platform

6. Conclusion

In the paper, we designed and developed the crowdsourcing platform based on the subjective and objective QoE. The platform was designed such that the user subjective QoE data is collected via the questionnaire, simultaneously the platform can collect the objective QoE data automatically without affecting the user to use video services. Using a management platform administrators can view and analyze the subjective and objective QoE data comprehensively. The results of analysis and evaluation can better reflect the quality of user experience and provide a valuable reference for improving the quality of user experience. The platform provides storage space to upload, manage and share their videos to other social media clouds.

The design and development of this platform have improved the video services to create an application-level video cloud service system to provide video fluency switching,

video caching optimization and other new features. We have improved the QoE evaluation system to collect user objective data and monitor the operation of the server and the QoE data quantitative analysis for the negative and positive feedback of the user. In the future, we will provide the design and development architecture of Android mobile to access video services of crowdsourcing platforms from a remote location giving freedom of mobility to access cloud-based video services. This work is proposed for video streaming but did not support gaming streaming, so in the future, a QoE crowdsensing platform will be proposed for gaming, which will provide services according to SLA and track record of user activities.

Acknowledgments. This study was supported by the Scientific Research Funds of Education Department of Liaoning Province in 2021 (General Project) (LJKZ1311).

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Asif Ali Laghari received the B.S. degree in Information Technology from the Quaid-e-Awam University of Engineering Science and Technology Nawabshah, Pakistan, in 2007 and Master degree in Information Technology from the QUEST Nawabshah Pakistan in 2014. From 2007 to 2008, he was a Lecturer in the Computer and Information Science Department, Digital Institute of Information Technology, Pakistan. In 2015, he joined the school of the Computer Science & Technology, Harbin Institute of Technology, where he is now a PhD student. Currently he is Assistant professor in Sindh Madressatul Islam University, Karachi, Pakistan He has published more than 55 technical articles in scientific journals and conference proceedings. His current research interests include Computer networks, cloud computing, and multimedia QoE management.

He Hui is born in 1974. Dr., associate professor, doctoral tutor. IEEE & IEEE Computer Member, China Computer Society, ACM Association. Harbin Institute of Tech nology School of computer science and technology. Mainly engaged in computer network, network measurement and simulation, network active defense technology, mobile network security, cloud computing, migration learning and so on. Presided over or participated in the national network information security project key projects.

Asiya Khan received the B.Eng. degree (Hons) in electrical and electronic engineering from the University of Glasgow, Glasgow, U.K., in 1992, the M.Sc. degree in communication, control, and digital signal processing from Strathclyde University, Glasgow, in 1993, and the Ph.D. degre e in multimedia communication from the University of Plymouth, Plymouth, U.K. currently Dr. Asiya Khan is a lecturer in Control Systems Engineering, School of Engineering, University of Plymouth, Plymouth United Kingdom. She worked with British Telecommunication Plc from 1993 to 2002 in a management capacity developing various products and seeing them from inception through to launch. She has been Research Assistant in Perceived QoS Control for New and Emerging Multimedia Services (VoIP and IPTV) CFP7 ADAMANTIUM project at the University of Plymouth. She has published several papers in international journals and conferences. Her research interests include video quality of service over wireless networks, adaptation, perceptual modeling, and content-based analysis.

Rashid Ali Laghari received B.E in industrial engineering and Management in 2012 and M.E in 2015 both from Mehran University of Engineering and Technology Jamshoro, Sindh, Pakistan. He has worked 2.5 years of industrial experience as Shift Engineer in the Manufacturing process of MDF BOARD. He joined the School of Mechatronic Engineering, Department of Mechanical Manufacturing and Automation in 2015 in Harbin Institute of Technology where he has achieved the PhD degree in April 2021, and have published number of research articles. His current research interests include FEA and predictive modeling and optimization of Metal Matrix Composite materials machining process, Cutting Simulation and machining process of Titanium alloys, Fabrication of SiCp/Al Metal Matrix Composite Materials through powder metallurgy and functionally graded ceramic cutting tool inserts. Multi Sensing IIoT platform for process monitoring of CNC machines.

Shoulin Yin received the B.S. in Software Engineering from Shenyang Normal University, China, in 2013 and M.S., Computer Applied Technology from Shenyang Normal University, China, in 2015. In 2014, he joined the School of Electronic and Information Engineering, Harbin Institute of Technology, where he was a PhD student. Currently he is an Assistant professor in Shenyang Normal University, Shenyang, China and the Deputy Director of Intelligent Information Processing Laboratory in Shenyang Normal University. He has published more than 100 technical articles in scientific journals and conference proceedings. His current research interests include Software Engineering, AI, Cloud Computing, Network Security, Image processing, Remote Sensing, Pattern Recognition.

Jiachi Wang received the M.S., Computer Applied Technology from Shenyang Normal University, China, in 2020. Mainly engaged in Software Engineering, AI, Cloud Computing, Network Security, Image processing, Remote Sensing, Pattern Recognition.

Received: March 22, 2022; Accepted: September 11, 2022.