Still Picture Internet Broadcasting System with Audience-oriented Bandwidth Control for Smartphone Broadcasters

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***Abstract*— We propose PictCast, which is a still picture Internet broadcasting system with dynamic picture quality adjustment based on audience requests for smartphone broadcasters. Live Internet broadcasting services, which are available on smartphones are increasing. However, the smartphone users need to decrease data traffic because they perform Internet broadcasting via 3G networks. To tackle this issue, we propose an effective bandwidth usage by reducing amount of data used to the minimum corresponds to audience satisfaction. We study the minimum quality of still pictures and temporarily determine the percentage of quality improvement requests from audience. Then, we conduct a field study during a festival at our university and find out whether there are pictures which the audience requires more high quality or not, the possibility to reduce amount of data traffic and what type of content the audience is interested in. Finally, we discuss our findings based on the result, and end up with the conclusion and future work.**

Keywords: Internet broadcasting; Narrowband network; smartphones

I. INTRODUCTION

Live internet broadcasting services, which are available on smartphones are increasing in demand, along with the popularization of Internet broadcasting and smartphones. Example of these services such as Bambuser, Qik, Stickam, and Ustream. 3G Internet connections are required for Internet broadcasting using smartphones in outdoor areas where wireless LAN connections are unavailable. However, there are also bandwidth limitations in rural areas and developing cities. Thus, we should consider the smartphone users' broadcast in these environments because the audience would like to look at a place where they have not been before. In some cases, smartphone users cannot perform Internet broadcasting adequately due to lack of 3G transmission speeds for video streaming in real time. Engström [1] states that effective use of bandwidth is needed because the study shows delay problems with live broadcasting systems on mobile networks. Therefore, data traffic should be reduced to achieve stable Internet broadcasting via 3G networks without delay. Smartphone users frequently use LTE to stream live video in real time. However, cell phone carriers often restrict the upload and download speeds of LTE after a certain amount of data has been transmitted. Data traffic should be reduced as much as possible even if users use LTE. Moreover, cell phone carriers nowadays tend to shift flat-rate data services to pay-as-you-go data services. Thus, 3G data traffic should be optimized to save packet communication fees.

Our research goal is to minimize the amount of data traffic by effective use of bandwidth which satisfy the audience.

S.McCanne [2] adjusts video quality depending on available network bandwidth as a method to achieve effective use of bandwidth. Similarly, recent research in mobile broadcasting have studied how to maximize bandwidth utilization [3]. However, these schemes may use redundant network bandwidth in excess of audience satisfaction. The quality should be determined from audience satisfaction point of view, instead of available network bandwidth. In our work, we introduce new aspect of dynamic quality adjustment picture with audience participation during the live broadcast. The amount of data traffic is optimized by dynamic quality adjustment which could change still picture quality based on audience requests. In the proposed system, we adjust the picture, not video quality to reduce data traffic as much as possible and take a closer look at the user interaction. For the use of pictures to reduce data traffic, Okada [4] realizes conferencing system use still pictures because it can work in a narrowband network. The conferencing system detects users' eyes direction and assists users by changing still pictures of users' faces without using videos. The use of still pictures has proved to reduce data traffic significantly. Moreover, the still picture view can be adjusted in case audience request for high quality picture. For future work, we will adjust video quality instead of picture quality.

In this paper, we present PictCast, a prototype system of still picture Internet broadcasting with dynamic picture quality adjustment. The innovation of our research is audience-oriented bandwidth control based on audience requests. The PictCast achieves stable Internet broadcasting via 3G networks using still pictures instead of video and optimizes the amount of data traffic by allowing the change of picture quality based on audience requests. For dynamic picture quality adjustment function, first it sends the minimum quality picture which satisfy the audience. Secondly, it will retransmit picture data to the audience from the broadcaster after it receives a certain number of quality improvement requests. For the preliminary study, we studied and predefined the minimum quality and percentage of quality improvement requests from the audience. We carried

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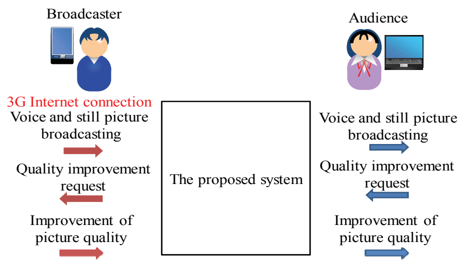

Figure 1. System model.

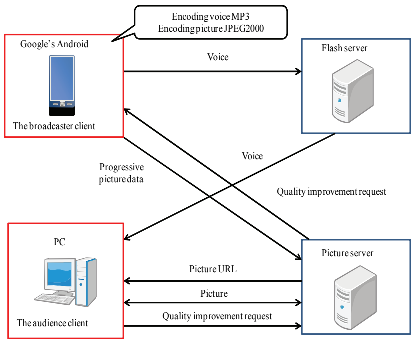

Figure 2. System Architecture.

out a field study during a festival at our University. As a result of the study, we discussed our findings and continue with the PictCast project.

The paper is organized as follows. In the next section, we show a model of our proposed system and present design and implementation of the prototype system. Section 3 describes a preliminary study. Section 4 presents the results of a field study. Section 5 gives some conclusions and our future work.

I. PICTCAST

Figure 1 shows the model of our proposed system. A broadcaster sends still pictures and voice to the audience via 3G wireless network. The audience watches a broadcast program from their PC via high-speed network. The voice is compressed and broadcast to the audience in real time. The still pictures are compressed in a progressive format. To reduce data traffic, the broadcaster sends the still pictures to the audience at the minimum picture quality which is acceptable to the audience at first. If the audience requires higher quality of still pictures, they can send quality improvement requests to the broadcaster. The broadcaster then retransmits higher quality still pictures correspond to a certain number of audience requests. In this case, the first low-quality still picture will be replace by retransmitting with a higher quality one. Therefore, we use progressive decoding, which is represent by progressive JPEG. The progressive decoding makes a picture gradually sharper as the download progresses. To apply the mechanism, the broadcaster can improve the quality of a still picture progressively without wasting transmitted picture data.

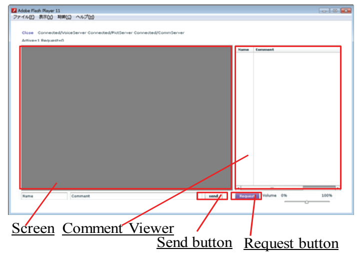

Figure 3. The user interface of the audience client.

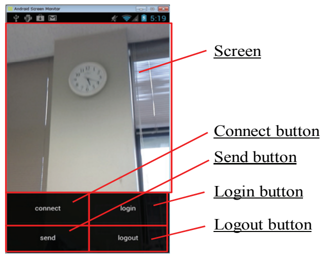

Figure 4. The user interface of the broadcaster client.

A. *System Architecture*

We implement a prototype system which provides still picture broadcasting with progressive decoding. The prototype system consists of ~~a~~ voice server, picture server, broadcaster clients and audience clients. The broadcaster client sends voice and still pictures to voice and picture server respectively. The audience will receives voice and still pictures from each server. Figure 2 shows architecture of the prototype system.

We developed the broadcaster client on a Google android terminal. The broadcaster client compresses voice in MP3 format by using the LAME library. We used Red5, which is an open source streaming server for the voice server. The broadcaster client sends the compressed voice data to the voice server over Real Time Messaging Protocol (RTMP). Then, audience clients receive the voice data from the voice server. The audience client is implemented in Adobe Flash. JPEG2000 format is used for the progressive decoding. The JPEG2000 format provides various progressive decoding functions which can change resolution and compression rate of the picture. In this implementation, the progressive decoding by resolution is used. First, the broadcaster client sends a low-resolution still picture to the server. Then, it sends additional data to the server responding to audience requests, so that the resolution of the still picture can be doubled. To compress the still picture in JPEG2000 format, we use a library OpenCV, which can be used on Google android terminal.

The picture server functions as a Web server using Apache. When the picture server receives a picture with JPEG2000 format from the broadcaster client, it changes from JPEG2000 to JPEG by using the OpenJPEG library. The picture server provides a URL for the compressed JPEG picture to the audience clients. The audience client shows a still picture, downloading it from the picture server and it also has a button to send a quality improvement request to the picture server. When the picture server receives a certain number of quality improvement requests, it requests additional data of the picture from the broadcaster client.

B. User Interface

We design the user interface for both broadcaster and audience client. Figure 3 shows the broadcaster client user interface. There are two broadcasting function in the design of the interface. The first function allows the broadcaster to take a picture with a touch on the smartphone screen. Meanwhile, the second function allows the broadcaster to interact with voice and picture server. The broadcaster client consist of four buttons: "CONNECT" establish connections with voice and picture server, "LOGIN" button authenticates the broadcaster with picture server based on specified username and password to start the broadcasting session. "SEND" button transfer the still picture to picture server and "LOGOUT" disconnect user with both voice and picture server. These buttons will not appear when the broadcaster snaps a picture and it will be displayed again by pressing MENU button on Android. Figure 4 shows the audience client user interface. There is a screen with 640x480 resolution for still picture on the layout of the interface. "SEND" button will send comments from client to both audience and broadcaster. The audience can read the comments on the comment view. "REQUEST" button sends a request for picture quality improvement to the picture server. Therefore, the still picture quality will be improved step-by-step based on audience request.

II. PRELIMINARY STUDY

We conduct a preliminary study to predefine the still picture minimum quality and quality improvement request percentage from audience. The following section describes the method used and its result.

A. Method

There are many subjective assessment methods suggested by International Telecommunication Union Telecommunication Standardization Sector (ITU-T) and International Telecommunication Union Radio communications Sector (ITU-R). We choose Absolute Category Rating methodology (ACR) with 5-point scale on total assessment time and ease of evaluation criteria. The ACR methodology defined by ITU-T Rec. P910. In ACR, subject need to evaluate the picture quality within 10 seconds after they see the picture displayed randomly. Randomly ordered picture can eliminate the possibility of affecting the assessment by indicating the picture sequence. For example, a picture with medium quality will have the high rating if the subject watches it after the low quality picture. The picture quality will be given an average score evaluated by Mean Opinion Score (MOS).

Besides, for the percentage of quality improvement request, subjects were asked on the subjective picture quality assessment by the question: "Would you request for a higher quality picture?" for all types of picture resolutions.

TABLE I. THE RESULT OF THE ASSESSMENT

	MOS	The percentages of quality improvement requests
640x480	4.41	30%
320x240	3.20	64%
160x120	2.18	95%
80x60	1.56	100%
40x30	1.24	100%

B. Environment

We conduct an assessment following an environment described by ITU-R Rec. BT.500. The pictures were displayed on a 17-inch LCD monitor (LCD-A173KW) with the resolution 1024x768. Subjects performed the assessment at a distance of 120cm away from the display screen.

The pictures are in JPEG format with 5 resolutions, from 40x30 to 640x480. The size of the picture display field is 640x480 pixels because it is a most frequently size for Internet broadcasting sites.

We choose ten kinds of picture for the picture quality assessment which consist of person, group, painting, cat, paper, meal, building, tree and standard image pictures. "Standard Image" picture is one of the pictures standardized by The Institute of Image Electronics Engineers of Japan (IEEJ). The picture was rate by International Standards Organization (ISO). Those picture were selected based on typical categories of picture in live video broadcasting for mobile device over the Internet [5]. The number of subjects should be more than fifteen according to ITU-R Rec. BT.500. There are 23 university students in IPU participated in the assessment.

C. Result

Table 1 shows the result of the assessment. For the minimum quality of still picture, we have decided to choose 160x120 resolution picture because of the MOS score is around 2.5, while for 320x240 resolution, the MOS score is more than 2.5 for all assessment. The MOS score of 2.5 is the acceptable value because it represent over 50% of subjects who give 3 points. Therefore, for the prototype system, three steps offered for the progressive decoding from 160x120 to 640x480 picture resolution.

Meanwhile, the percentage of quality improvement request for 160x120 and 320x240 resolution are above 50% from the audience. From the result, we temporarily determined a threshold for the picture quality improvement of 50% of the total unique users.

III. FIELD STUDY

We carried out a field study to answer the following questions: (1)Does the audience send requests that they would like higher quality pictures?; (2)Is the proposed system possible to reduce the amount of data traffic?; (3)What type of content is the audience interested in?

We set three experimental conditions based on the preliminary study as follows: 1) the first low-quality still picture is 160x120 resolution, 2) the progressive decoding is

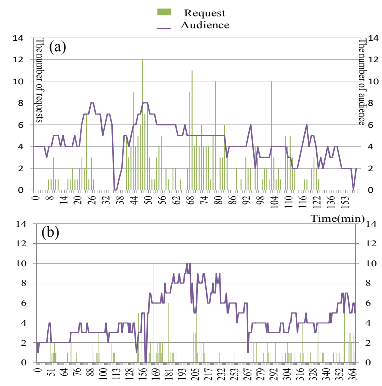

Figure 5. The changes in the number of the requests (a) On the first half of the broadcast and (b) On the second half of the broadcast.

offered in three steps from 160x120 to 640x480, and 3) the broadcaster retransmits higher quality still pictures responding to the requests of more than 50% of the total unique users.

A. Environment

The festival was held at Iwate Prefectural University campus. We broadcast the festival scenes at various places around campus by using a smartphone, which is available to communicate up to 300kbps over the Internet. Anyone can view the broadcast content on the website embedded in the audience client.

B. Broadcast contents

The field study was conducted on October 28th from 10:00 to 13:00 and from 13:00 to19:00. During the first half of the broadcast, we interviewed people who served food at the street stands. During the second half of the broadcast, we introduced some of the festival events such as concerts, onstage entertainment, and fireworks.

C. Results

We counted the total quality improvement requests in order to confirm the audience really sent the requests if they were not satisfied with the minimum picture quality. The total number of the requests was 283 on the first half of the broadcast and 175 for the second half of the broadcast. As a result, we found that the audience was not satisfied with the minimum picture quality and there were times when the audience wanted to see the pictures with higher quality.

Moreover, we analyzed changes in the number of the requests. Figure 5 shows the changes per 60 seconds. From this figure, we found there were pictures which the audience wanted to see in higher quality and the audience that was not satisfied with 160x120 resolution sent the requests. We measured the amount of data traffic for the system on that day. We compared the proposed system with a system which sends still pictures only at 640x480 resolution to the audience in terms of the amount of data traffic. The amount of the data traffic for the proposed system was about 15 Mbytes. The alternative system however required about 120 Mbytes. We found the proposed system was able to reduce data traffic significantly compared to the alternative system.

We analyzed when the audience sent requests. As a result, the audience sent many requests when we reported about the weather. For example, a picture of a puddle under the main stage only became high quality from the onstage entertainment broadcast. It is possible for weather report to be one of the features for this system.

D. Issues

A threshold value of total unique requests for picture quality improvement was set to 50 %. However, one of the audience commented, "I'm so stressed because my requests are often ignored". It is possible there were inactive audience members who just listened to the voice streaming for back-ground music or did not feel like aggressively sending the requests. Considering these inactive audience members, it would not be an adequate threshold to satisfy the audience. We should study the threshold to improve average audience satisfaction.

IV. Conclusion and Future work

We present PictCast, which is a prototype system with still picture Internet broadcasting and dynamic picture quality adjustment functions. As a result from the field study, we found that there were times where the audience request for higher quality pictures. The proposed system was able to reduce data traffic and the audience interested in weather report. We will design a future system which can be used in disaster area because the audience would like to see the current conditions, such as Weather report and surrounding in that area which have a narrowband network area.

We also found that there was a problem with the threshold value of total unique request for picture quality improvement. We will review the threshold value to improve the average of audience satisfaction in disaster area environment. For future work, we will release the broadcaster client on Google Play Store in order to get feedback on how users use PictCast in disaster area.

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