User Preference based Selection Method to provide Personalized Multimedia Service with Service Quality

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Abstract—**In this paper, we propose a selective method which consider the user preference and maintain experienced quality for a video streaming service. Mobile users would like to be provided the multimedia services with lower expense without quality deterioration. Therefore, the multimedia service needs to perform automatically offer to adapt the delivered content to the user expectations and his environment capabilities. We build a testbed to verify justification of the proposed method, and measure the video quality using MSU video quality measurement. Through the experiment, we confirmed that the proposed selection method can provide the guaranteed service quality by considering the user experience.**

Keywords—**Seamless Multimedia Service, Analytic Hierarchy Process (AHP), Service Quality, User Preference**

I. INTRODUCTION

With the rapid development of wireless communication network, the demand of high-quality video over communication networks exhibit a growing is trend. Due to the increasing demand for wireless multimedia data, radio resource management for multimedia transmission has emerged as one of the most important issues [1].

Currently, there have been a lot of researches focusing on network selection issues for always best connected (AWC) [2] and available bandwidth-based multimedia services to provide guaranteed QoS/QoE [3]. In general, user selection for access network is considered to be one of the distinct features of heterogeneous wireless systems, in which users with dual mode interface terminals can select access network for better quality of service with lower expense. So, the multimedia service needs to perform automatically offer to adapt the delivered content to the user expectations and his environment capabilities. However, exist methods wouldn't be provided to user satisfaction properly, because the both methods don't consider the user preference.

Therefore, we propose a selective method which consider the user preference and maintain experienced quality for a video streaming service. We build a testbed to verify justification of the proposed method, and measure the video quality using MSU video quality measurement. Through the experiment, we confirmed that the proposed selection method can provide the guaranteed service quality by considering the user experience.

This paper is organized as follows. In section II, we describe the related works. The proposed method is explained in section III. In section IV, we experiment the proposed method and analysis the result. Finally, conclusion is given in section V.

II. RELATED WORKS

In this section, we explained that how to measure the End-to-End Available Bandwidth and Structural Similarity Index. And we investigate the method of user preference to provide adaptive multimedia service.

A. End-to-End Available Bandwidth Measurement

Bandwidth measurement tools are classified as single hop capacity, end-to-end capacity, and end-to-end available measurement tools. Among them, various end-to-end available bandwidth Measurement tools are existed such as pathload[7], pathChirp [6]. In order to measure bandwidth, many tools are used depending on the metrics [4]. These metrics are capacity in a link or path and available bandwidth in a link or a path. Capacity means maximum transfer rate in a link and end-to-end capacity means maximum transfer rate in a path.

Pathload is a tool for estimating the available bandwidth of an end-to-end path from a host S(sender) to a host R(receiver). The available bandwidth is the maximum IP-layer throughput that a flow can get in the path form S to R, without reducing the rate of the rest of the traffic in the path [7].

PathChirp is a tool for estimating the available bandwidth on a communication network path. Based on the concept of "self-induced congestion," pathChirp features an exponential flight pattern of probes we call a chirp [5].

B. Structural Similarity Index (SSIM)

The Structural SIMilarity (SSIM) index is a method for measuring the similarity between two images. The SSIM index can be viewed as a quality measure of one of the images being compared, provided the other image is regarded as of perfect quality. It is an improved version of the universal image quality index proposed before.

$$SSIM = \frac{(2\overline{x}\overline{y} + C_1)(2\sigma_{xy} + C_2)}{[(\overline{x})^2 + (\overline{y})^2 + C_1](\sigma_x^2 + \sigma_y^2 + C_2]} \quad (1)$$

In this equation $\bar{x}$, $\bar{y}$, σx, σy, σxy are the estimates of the mean of x, mean of y, the variance of x, the variance of y and the covariance of x and y. C_1 and C_2 are constants. The value of SSIM is between -1 and 1 and gets the best value of 1 if xi = yi for all values of i. The quality index is applied to every image using a sliding window with 11 x 11 circular-symmetric Gaussian weighting functions for which the quality index is calculated and the total index of the image is the average of all the quality indexes of the image.

To numerically evaluate prediction of the objective metrics, we calculated Pearson’s correlation coefficient between objective marks (after applying the fitting function) and subjective ones. Correlation coefficient belongs to the segment from -1 to 1 and reflects degree of dependency between values as shown in table I. SSIM is the best objective metric as shown in table 1. We use SSIM metric to objectively compare and measure video quality, and verify the possibility of the proposed selection scheme.

TABLE 1. CORRELATION BETWEEN OBJECTIVE VIDEO QUALITY METRICS AND MOS(MEAN OPION SCORE) SUBJECTIVE IMPRESSION[9]

Metric	Correlation to MOS
PSNR	0.802
VQM	0.729
SSIM	0.937

C. Scalable Video Coding (SVC)

In general, a video bit stream is called scalable when parts of the stream can be removed in a way that the resulting sub-stream forms another valid bit stream for some target decoder, and the sub-stream represents the source content with a reconstruction quality that is less than that of the complete original bit stream but is high when considering the lower quantity of remaining data. Bit streams that do not provide this property are referred to as single-layer bit streams. The usual modes of scalability are temporal, spatial, and quality scalability. Spatial scalability and temporal scalability describe cases in which subsets of the bit stream represent the source content with a reduced picture size (spatial resolution) and frame rate (temporal resolution), respectively. With quality scalability, the sub-stream provides the same spatio-temporal resolution as the complete bit stream, but with a lower fidelity—where fidelity is often informally referred to as signal-to-noise ratio (SNR). The basic SVC design can be classified as layered video codec. In general, both the coder structure and the coding efficiency depend on the type of scalability that is required by an application. As an important feature of the SVC design, most components of H.264/MPEG4-AVC are re-used as specified in the standard. The base layer of an SVC bit stream is coded in compliance with H.264/MPEG4-AVC, and each standard compliant H.264/MPEG4-AVC decoder is capable of decoding this base layer when it is provided with an SVC bit stream. New compression tools are only added for supporting spatial and SNR scalability [10].

For a detailed description of SVC, please refer to the [11]. We will concentrate on a description relevant to the service quality.

D. Analytic Hierarchy Process (AHP) [2]

The Analytic Hierarchy Process (AHP) is a structured for organizing and analyzing complex decisions. Based on mathematics and psychology, it was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then.

Many AHP is defined as a procedure to divide a complex problem into a number of deciding factors and integrate the relative dominances of the factors with the solution alternatives to find the optimal one. AHP is carried out in five steps :

Step 1) Structuring a problem as a decision hierarchy of independent decision elements

Step 2) Collecting information about the decision elements

Step 3) Comparing the decision elements pairwise on each level in the matter of their importance to the elements in the level above

Step 4) Calculating the relative priorities of decision elements in each level

Step 5) Synthesizing the above results to achieve the overall weight of each decision alternative

TABLE 2. An example of an AHP matrix

	Location	Salary	Prospect
Location	1	1/5	1/3
Salary	5	1	2
Prospect	3	1/2	1

In a typical hierarchy, the problem to be resolved is in the topmost level. For example, Mr.Smith is trying to make a selection among three job offers from companies A, B, and C, respectively. The topmost level would be “choosing a job offer.” The subsequent levels comprise the deciding factors, possibly location, salary, and prospect. The solution alternatives (i.e., the companies) are in the bottom level. The relative magnitudes of factors and sub-factors with respect to their parents are estimated through pairwise comparison based on human’s knowledge and experience. The smaller one of a pair is chosen as a unit, and the larger one is estimated as a multiple of that unit based on the perceived intensity of importance. The judgments are ranked on a 9-point scale in AHP.

Numbers 1 to 9 are used to present equally, weakly moderately, moderately, moderately plus, strongly, strongly plus, very strongly, very very strongly, and extremely important to the objective, respectively. When one element is less important than another, the comparison result equals the reciprocal of one of the numbers. The comparison results within each parent are presented in a square matrix to which we refer as the AHP matrix. The decision factors under a parent are arranged in the same order in row and column headings. When the *i*th element in the column heading is compared to the *j*th element in the row heading, the judgment is presented at the *i*th row and *j*th column. An example of an *AHP matrix* on “choosing a job offer” is shown in Table 1. It is observed that the diagonal elements of the matrix are 1, showing the elements’ self-comparisons. The other entries in the matrix are symmetric with respect to the diagonal, as a result of the inverted comparisons.

The relative weights of the factors are achieved through calculating the eigenvector of the matrix with the eigenvalue (x_{max}) that is closest to the number (n) of factors [2]. Since comparisons performed in AHP are subjective, judgment errors are inevitable and have to be detected through calculating a consistency index (CI) of the AHP matrix, given by $((x_{max} - n)/(n - 1)$, and then comparing it with a random index (RI), which is the average CI of a randomly generated reciprocal matrix. All RI values for different matrix dimensions are provided by [2]. If CI is equal to zero, the matrix is perfectly consistent; otherwise, CI should be positive. The ratio of CI to RI for the same dimension matrix is called the consistency ratio (CR). Adjustment of the comparisons is needed when CR > 10 percentage. This process is repeated downward level by level to the bottom of the hierarchy. It is important to remember that the weights achieved by calculating the eigenvector of the comparison matrix only reflect appropriate distributions to the elements’ parent, not the final goal. These weights must be transformed into the final weights through being multiplied by the weight of their parent with respect to the goal. We use AHP to calculate priority of user preference among the battery life, service quality and cost.

III. PROPOSED USER PREFERENCE BASED SELECTION METHOD

This section presents the user preference based selection method, network environment, functional architecture of mobile station and selection algorithm.

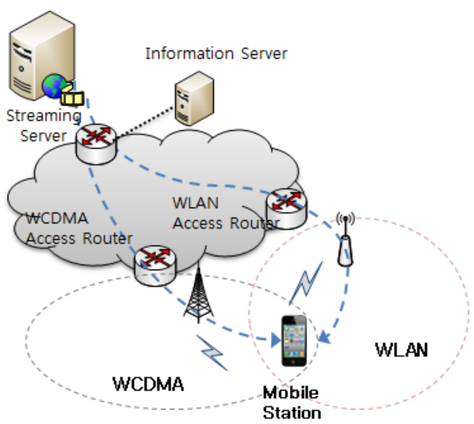

Figure 1. The integrated wireless access network for video streaming service

Fig.1 shows the integrated wireless access network environment. In fig.1, although AP can’t provide sufficient bandwidth service, the user may prefer to keep use WLAN access network due to the cost. Contrariwise, the user wants to be provided the best service quality regardless of the cost.

So, if the user can’t be provided the multimedia service, the user determines alternative whether the available bandwidth-based multimedia service or change the access network to the best network based on user preference.

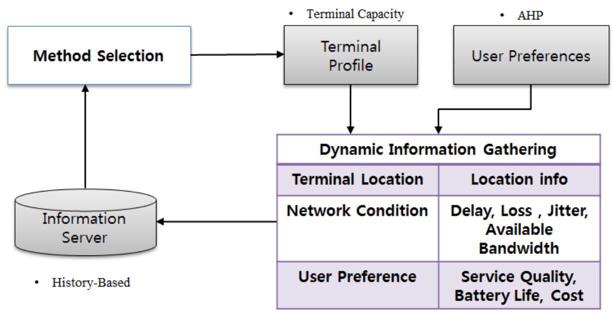

Figure 2. The structure of information management

Fig.2 presents the structure of information management. The information server manages the dynamic information and static information. When the user doesn’t satisfy the multimedia service, the information server provides the best alternative considering the network condition, terminal capacity and user preferences.

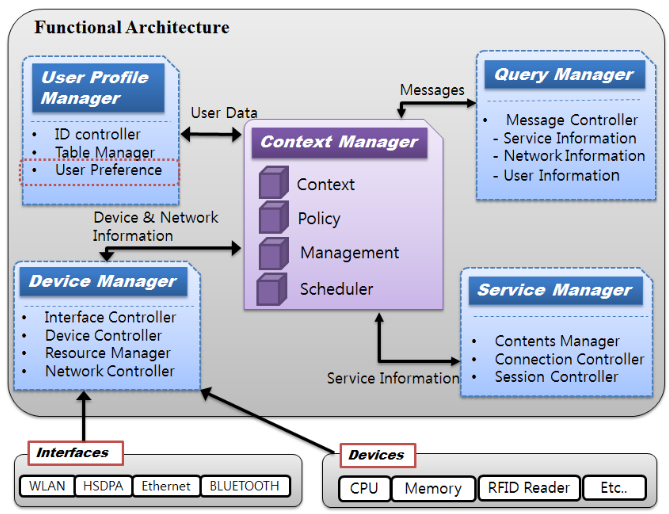

Figure 3. Enhanced Functional architecture of Mobile Station

Fig.3 shows that the functional architecture of mobile station for supporting the proposed selection method. The functional architecture was proposed previously [13]. We add the user preference to the User Profile Manager (UPM). When a user fills out a questionnaire the user preference such as battery life, service quality and cost, the mobile station manage the information and send to the information server. It’s possible to provide the user-centric multimedia service to user.

Fig.4 presents the algorithm of selection for the best alternative.

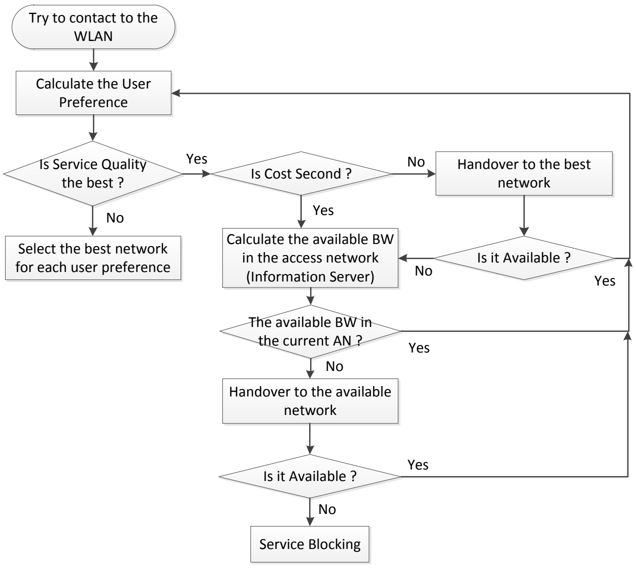

Figure 4. Proposed selection algorithm based on user preference

We assumed that the first priority is the service quality why this paper focused on the service quality. So, we assumed that the user prefer the service quality firstly, and the current access network what user connected network doesn't sufficient to provide the multimedia service. If the user select the cost secondly which means that the user prefers the free access network, the information server send the information to the mobile station keep WLAN and the user can be provided the multimedia service according to the available bandwidth. If there is no available bandwidth in current network, the user changes to the cheapest access network.

And the other, if the user doesn't select the cost secondly, the user doesn't matter the cost which means the user wants to the best network to be provided the multimedia service. The terminal which user used handover to the best access network.

IV. Experiment And Result Analysis

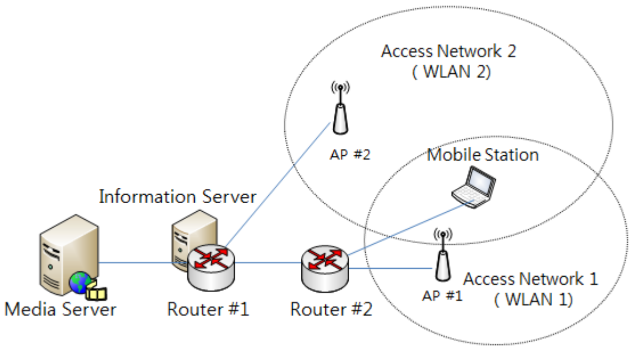

Figure 5. Test network environment to verify justification of the proposed method

Fig.5 shows that the experiment environment to verify justification of the proposed method. There are Media server stream the encoded multimedia service. We use the two APs to experiment, because the WCDMA network has too low bandwidth.

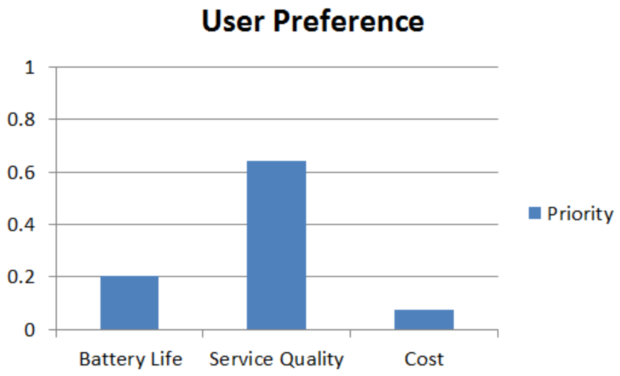

Figure 6. The user preferences of the multimedia service

Fig. 6 shows that the user preferences of the multimedia service. We assumed that the user prefer to the service like fig.6. We used the AHP method to calculate the user preference [12]. As the result, the user prefers the following conditions in order; the service quality, the battery life and cost.

(a) Original video frame sample with data rate 1502Kbps

(b) Transmitted video frame sample with lower data rate 932Kbps

(c) Video frame sample with packet loss

Figure 7. The Sample of Video frame according to data encoding rate

Fig. 7 shows the sample of video frame to demonstrate the proposed method. We encode the video source using different data (1502Kbps and 932Kbps) to analyze the impact of data rate of encoder. In fig.7-(c) shows the video sample with packet loss causes due to the lack of available bandwidth for the service.

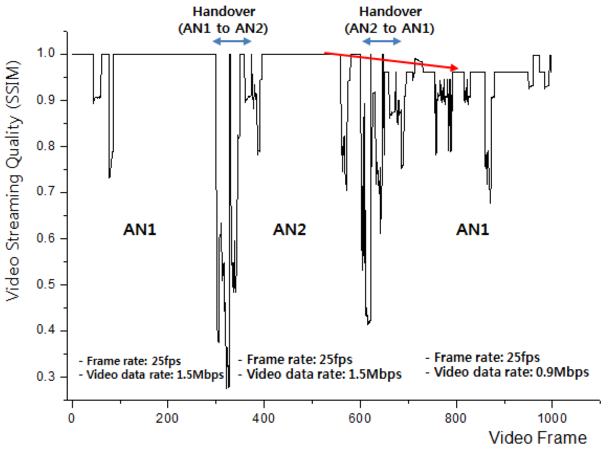

Figure 8. The analysed experiment result using MSU tool

Fig.8 shows the analysed experiment result which is derived from the received multimedia service using the MSU tool [14].

Firstly, the user enjoys the multimedia service through the WLAN(AN1). But there are too many traffic to provide the multimedia service. The user changes the network to the AN2, because the user doesn't consider the cost. After a while, the AN2 doesn't have enough available bandwidth. So, the user tries to change the network. But there is no network which has enough bandwidth for the multimedia service. Finally, the multimedia server provides the multimedia service according to the available bandwidth.

As the result of experiment, we can confirm that the proposed method can guarantee the service quality based on user preference.

V. Conclusions

We propose the user preference based selection method to provide personalized multimedia service with service quality. We build a testbed to verify justification of the proposed method, and measure the video quality using MSU video quality measurement. Through the experiment, we confirmed that the proposed selection method can provide the guaranteed service quality by considering the user experience.

Proposed method was just applied the priority to user selection. We'll analysis the variety of the user preferences to apply the guarantee the QoS/QoE. And then we'll apply the user preferences to provide multimedia service for user. In addition, we implemented the context-aware based service mobility management for providing user-centric multimedia service

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