Advertising Method via Smart Device Based on High Frequency

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***Abstract*—In this paper, we propose a high frequency-based advertising method using a smart device. This method supports the transfer of advertising content to the smart device user with no additional action or TV audio signal required to access that content. Because the proposed method uses the high frequencies of sound signals via the inner speaker of the smart device, its main advantage is that it does not affect the audio signal of TV content. Furthermore, this method allows large numbers of smart device users to see advertising content continuously and automatically. To evaluate the efficacy of the proposed method, we developed an application to implement it and subsequently carried out an advertisement transmission experiment. The success rate of the transmission experiment was approximately 97%. Based on this result, we believe the proposed method will be a useful technique in introducing a customized user advertising service.**

Keywords-Advertising method; high frequency; smart device; wireless communication.

I. Introduction

In recent years, advertising service technologies based on smart devices have been introduced gradually in line with performance improvements in smart devices. When feature phones first became popular, advertising technologies using Short Message Service(SMS) or Multimedia Messaging System(MMS) were the most prevalent. However, with the advent of smart devices, various technologies such as push services, location-based services [1], advertising using Quick Response code(QR code) or Near Field Communication(NFC) [2]-[4], and cross-media advertising [5] became the new trend. Most significantly, the mainly passive role of advertising services changed to a more active one.

Good examples of advertising technology based on smart devices include Fujitsu's new data transmission technology using video data [6] and KT Media Hub's matching cross-media advertising service. Fujitsu's advertising technology combines visible light communication technology and digital watermarks [7]. This service can send advertising data to smart devices via the device's camera by using lighter and darker parts of the full screen. The technology supports 16 bits of data per second. If smart device users want to access the advertising information, they need to perform a light detection action using the camera of the smart device. However, in the case of TVs, this method requires extra technology to insert the advertising data into TV content. Also, it is inconvenient for the user, who has to perform an advertisement detection action while watching TV.

KT Media Hub's matching cross-media advertising service can support event coupons or the transmission of additional information to users through the audio signal of TV content. With this method, when users want to access advertisements while watching TV, they only have to shake their smart device. The advertisements are then transmitted via the TV audio, and the smart device first analyzes the advertising information that has been sent from the server and then shows the advertisements to the user. The advantage of this method is that it does not need any process enabling it to utilize the audio of TV content for advertisement transmission, because it already uses inaudible audio information from TV content. However, even if there was no inaudible audio, this method could not support sending of advertising information to the user. In addition, it is prone to detection errors due to the shaking duration or shaking intensity of the smart device.

Therefore, in this paper, we propose a new advertisement transmission method using the high frequencies of inaudible sound signals, which is aimed at addressing the disadvantages of existing methods. The proposed method uses the 18kHz ~ 22kHz frequency of the audible sound range (20Hz ~ 22kHz). We used the 18kHz ~ 22kHz frequency because it is the defined audible sound range, despite the fact that most people could not listen to sound in this range. Furthermore, to prevent signal detection errors from surrounding noise, we used two sequential high frequencies as the audio signal of the TV content, and smart devices that detect the high frequencies receive the related advertising content from the advertising content server. Similar to Fujitsu's technology, the two high frequencies of the TV content are generated consistently during the time needed for advertisement transmission. High frequencies can then be added easily to the sound component of the TV content and can reach any smart device in an indoor space where people are watching TV. Also, because the high frequencies used in the proposed method do not influence the original sound of the TV content or vice versa, the proposed method can transmit advertising data to smart devices very accurately. To evaluate the performance of the proposed method, we devised TV content that included the high frequencies needed to supply advertisements, and we then developed the advertising service application based on a smart device using the proposed method. During this process, we carried out performance evaluation tests according to frequency changes at high frequencies, and we then tested the advertisement transmission capability via distance. The success rate of the results in terms of frequency change was 97%, while the success rate in terms of distance was 98.5% within 5m. These results indicate that the proposed method will prove useful with regard to the effective transmission of advertising information based on smart devices used in an indoor space.

The present paper is organized as follows: In Section 2, we explain existing technologies that use high frequency for information transmission. In Section 3, we describe the general architecture of advertising information based on smart devices using high frequencies, and what methods smart devices use to handle high frequencies. In Section 4, we evaluate the performance of the proposed method, followed by a conclusion in Section 5 and by a future research in Section 6.

II. RELATED WORK

This section explains existing technology that uses high frequency to transmit information and data. Early researchers in this area used high frequency to trace the position of mobile phone users indoors [8][9]. In 2011, Bihler proposed a method of transmitting information to smart devices using high frequencies and Wireless Fidelity(WiFi). Bihler's method availed of two high frequencies, 20kHz and 22kHz [10]. According to this method, eight bits of data were sent within 208 ms and Hamming code schemas were used for error correction. However, because the method involved fast changes between those two high frequencies, the result was a noise familiar to many, and the attainable distance of the high frequencies was very short.

Lee then proposed smart phone user authentication using audio channels [11]. This method used high frequencies from 15,800Hz to 20,000Hz as authentication signals and implemented user authentication between smart devices and personal computers (PC). Because the method generated two high frequencies simultaneously, the spacing of each frequency was 600Hz too much. Table 1 below shows the assigned frequencies according to bit; using this method, two bytes of data can be sent in eight seconds. In Table 1, Lee's method generates a beep four times in eight seconds using assigned frequencies at one-second intervals, and the smart device, on receiving the signal, sends the received data to the authentication server.

While this method is more stable than Bihler's method in terms of data transmission accuracy, data transmission takes too long.

TABLE I. ASSIGNED FREQUENCIES FOR EACH HEXADECIMAL DIGIT

Digit	Frequencies (kHz)	Digit	Frequencies (kHz)
0 x 0	15.8, 18.0	0 x 8	17.0, 18.8
0 x 1	16.4, 17.6	0 x 9	17.6, 19.4
0 x 2	17.0, 18.2	0 x A	18.2, 20.0
0 x 3	17.6, 18.8	0 x B	15.8, 18.2
0 x 4	18.2, 19.4	0 x C	16.4, 18.8
0 x 5	18.8, 20.0	0 x D	17.0, 19.4
0 x 6	15.8, 17.6	0 x E	17.6, 20.0
0 x 7	16.4, 18.2	0 x F	15.8, 18.8

Another researcher, Chung, proposed a near wireless control technology using high frequencies [12][13]. In this method, he defined high frequencies as base signals and low latency as a control signal. Base signals comprise more than two high frequencies and note the existence of the control signal to the smart device. Then, because low latency accesses various control data by frequency value, low latency is generated by the Central Processing Unit(CPU) of the smart device. The distance of the control signal in this method is greater than in Bihler's method and the data transmission time is faster than in Lee's method. Thus, Chung's method can be used as a trigger signal for the effective transmission of advertising information.

III. ADVERTISING METHOD VIA SMART DEVICE BASED ON HIGH FREQUENCY

This section explains the general architecture relating to advertisement transmission to smart devices using high frequencies, in addition to the methods used by smart devices to process high frequencies. Figure 1 below represents the general architecture of the proposed method.

First, the smart TV pictured on the left in Figure 1 starts sending the first high frequency signal to the smart device (①), and the smart device verifies the presence of the first high frequency using Fast Fourier Transform (FFT) (②). Then, if the smart device detects the first high frequency consistently, it checks whether the number of first high frequency signals is ***k*** times over (③). Once this has been

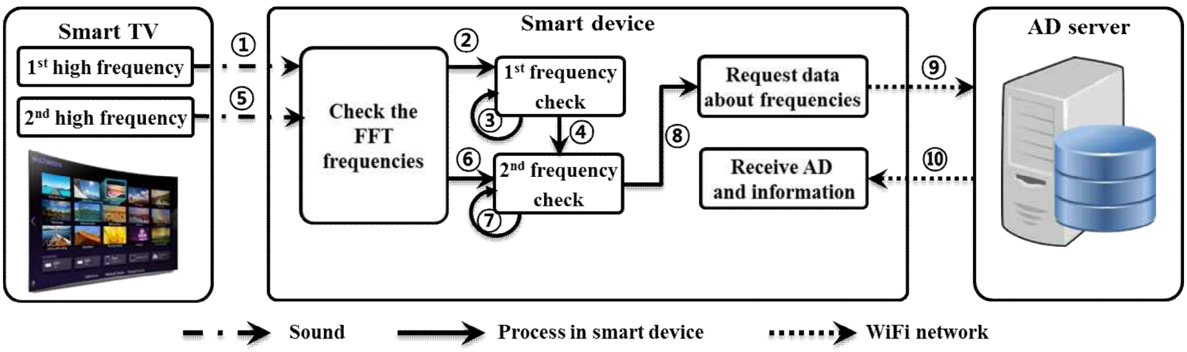

Figure 1. Work flow of advertising method via smart device using high frequencies.

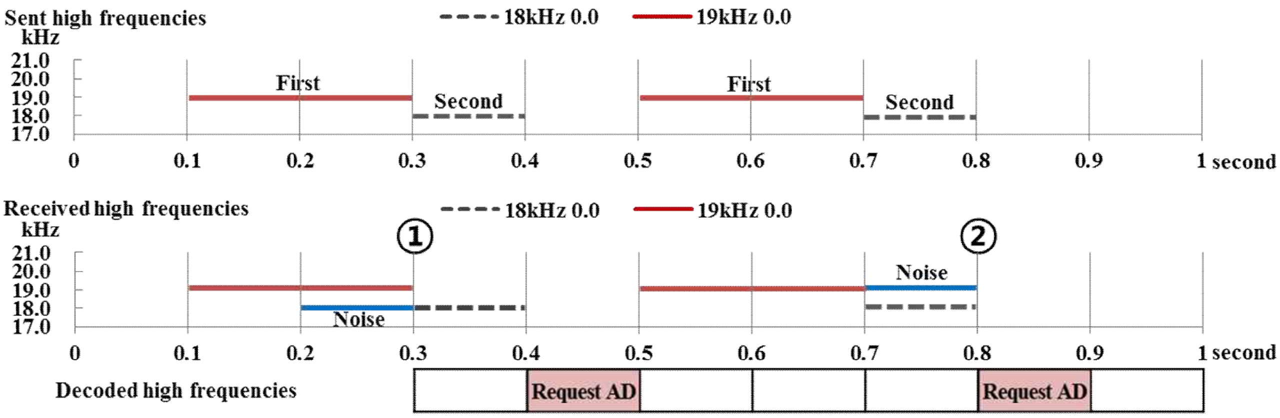

Figure 2. Example of high frequency use in advertising information requests

confirmed, the smart device waits to verify the presence of the second high frequency (④). When the smart TV sends the second high frequency signal to the smart device (⑤), the smart device verifies the signal's presence (⑥) and checks whether the number of second high frequency signals is $\boldsymbol{i}$ times over (⑦). If the smart device detects that the first high frequency signal is $\boldsymbol{k}$ times over and the second is $\boldsymbol{i}$ times over, it then requests and receives advertising information in the advertisement server via WiFi (⑧～⑩). At this point, the proposed method uses a high frequency at an inaudible frequency range, namely 19kHz～22kHz, as the first high frequency and 18kHz as the second high frequency. Figure 2 below shows how high frequencies are used in the proposed method. And then, the proposed high frequencies are contained in audio of TV contents by the broadcasting company.

Figure 2 shows how high frequencies are sent as advertisement transmission signals, with the first high frequency at 19kHz (0.2s) and 0.1s, and the second high frequency at 18kHz (0.1s) and 0.3s. The same high frequencies are sent again at 0.5s. In the case of the high frequencies being received by the smart device, the first high frequency is received at 19kHz (0.2s) and 0.1s, while the second high frequency is received at 18kHz (0.2s) and 0.2s. In fact, the 18kHz second high frequency (0.2s～0.3s) only amounts to noise. Nevertheless, the smart device can receive the advertisement signal accurately because it is still undergoing the process outlined in ③ in Figure 1. Furthermore, in step ② of Figure 2, the receiving high frequency results in noise at 19kHz from 0.7s to 0.8s. However, because the smart device has already completed process ③ in Figure 1 at 0.7s and is now undergoing process ④, it can receive the advertisement signal. The first high frequency can then use 31 signals from 19kHz to 22kHz by 100Hz each time. For example, the advertisement signal that uses 19kHz is different from the advertisement signal that uses 19.1kHz. The smart device, having detected the advertisement signal, sends the values for the advertisement signal to the advertising information server and the advertising information server then sends the related advertising content to the smart device.

IV. EXPERIMENTS AND EVALUATION

This section introduces the advertising application capable of supplying the advertising information to the smart device user by utilizing high frequencies as the proposed method. In addition, we explain the experiments and results used for the performance evaluation of the proposed method. We developed the advertising application based on iOS 6 and created it using Xcode 5. Figure 3 is a screenshot of the main advertising application.

(a)

(b)

Figure 3. Screenshot of the advertising application: (a) Main screen featuring a graph of the receiving high frequencies; (b) Real advertising information screen by advertisement signal.

In Figure 3 (a), the graph displays the FFT bin number relating to the first high frequency (red line) and the second high frequency (blue line) when the smart device receives the advertisement signal. The x axis of the graph indicates the time sequence, and the flow of time is from right to left. The y axis of the graph is the FFT bin number of high frequencies. Thus, we can see from the graph that the smart device received the advertisement signal four times and the order of receipt was ①, ②, ③, and ④.

Next, we evaluated the performance of the proposed method. We added an advertisement signal to the sound component of the TV content, which was a K-pop music video. We used 19kHz, 20kHz, and 21kHz as the first high frequency and 18kHz as the second high frequency. Each advertisement signal was generated twice at two-minute intervals. Thus, we did the receiving test 50 times for each advertisement signal. Because the advertising application checks high frequencies of FFT per 10ms, we set each threshold value in such a way that ***k*** was 12 times (60% of the first high frequency length) and ***i*** was six times (60% of the second frequency length). The distance between the smart TV and the smart device was 3m and the volume level of the smart TV was 70dB. The test space measured 5m × 4m, and 40dB was maintained as the silence space. Figure 4 below shows the result of the test using each advertisement signal.

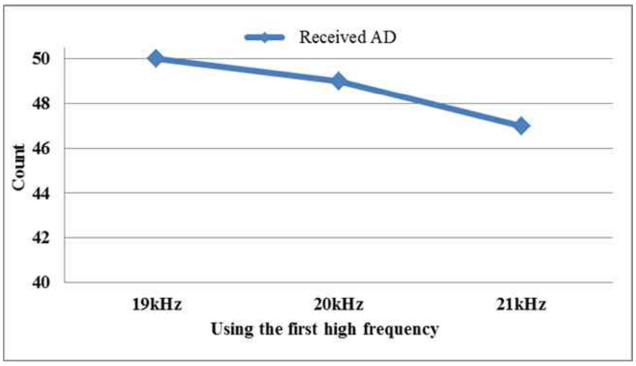

Figure 4. Results of the test using each advertisement signal.

In Figure 4, when the first high frequency was 19kHz, the smart device received the advertisement signal 50 times. Using 20kHz as the first high frequency caused the signal to be received 49 times, 21kHz caused it to be received 47 times, and so on. Thus, the total success rate averaged 97%. This shows that transmission errors increase in line with the rising value of the first high frequency. We believe the reason for this is that the bin number of the higher frequency detected was lower than the bin number of the lower frequency over the same distance and with the same number of decibels. The next task was to test performance according to distance. The distance between the smart TV and the smart device was from 1m to 5m in 1m intervals, and we did the receiving test 50 times with each advertisement signal (19kHz, 20kHz, and 21kHz) and at each distance. The test space and every threshold value were the same. Figure 5 below shows the results of the advertisement transmission test according to distance.

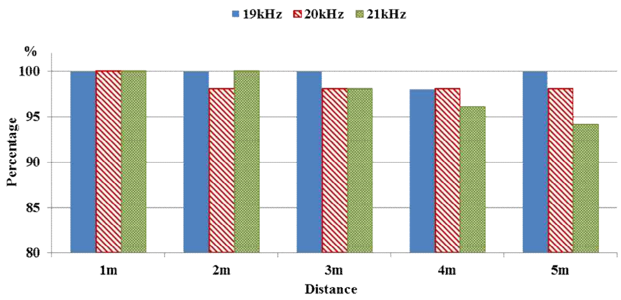

Figure 5. Result of advertisement transmission test according to distance.

Figure 5 tells us that the smart device received all of the advertisement signals at a distance of 1m. At a distance of 2m, the first high frequency of 20kHz failed to transmit the advertisement once. At a distance of 3m, the first high frequency of 20 kHz and 21kHz each failed once. At a distance of 4m, the first high frequency of 19kHz and 20kHz each failed once, and twice in the case of 21 kHz. At a distance of 5m, the first high frequency of 20kHz failed once and the first high frequency of 21kHz failed three times. Thus, transmission success rates were 99.3% within 3m and 98.5% within 5m. We think that the first high frequency transmission of 20kHz failed at a 2m distance because the ***k*** and ***i*** thresholds had not yet been optimized. Therefore, the solution to this error is to optimize each threshold. In addition, the 20kHz and 21kHz first high frequencies failed twice or three times at a 3～5 m distance. This was because the bin number of high frequencies decreased according to increasing frequency values.

V. CONCLUSION

In this paper, we proposed an advertisement method via smart device using high frequencies. This is a useful method that can support the transmission of advertising information to smart devices from a smart TV naturally and with no detection action required on the part of the user. In addition, because the method uses inaudible high frequencies, it does not influence the sound of the TV content, making it easy for the high frequencies needed for advertisement transmission to add to the sound of TV content. Therefore, the proposed method can support the transmission of advertising information better than existing methods and would work as an effective advertisement transmission technology for use indoors.

VI. FUTURE RESEARCH

In future research, we will study data and information transmission technology between smart devices using only high frequencies, as well as simultaneous data sharing technology among multiple smart devices indoors. We also aim to research performance improvement at high

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frequencies, even in the case of greater distances from each smart device.

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