Mobile Services and Implementation of Digital Watermarks in Audio Files

Manabu Hirakawa
Department of Industrial Engineering and Management,
Tokyo Institute of Technology
2-12-1 Ookayama, Meguro-ku, Tokyo 152-8550, Japan
E-mail: [†]hirakawa.m.aa@m.titech.ac.jp,

Junichi Iijima
Department of Industrial Engineering and Management,
Tokyo Institute of Technology
2-12-1 Ookayama, Meguro-ku, Tokyo 152-8550, Japan
E-mail: iijima.j.aa@m.titech.ac.jp

Abstract— **The spread of mobile devices in recent years has been dramatic to say the least. Although cell phones in particular are used by a wide demographic, and hold great potential for a variety of mobile services, the usability of their user interfaces remains lacking. Additionally, an extremely important consideration is how user interfaces handle information exchange. In this paper, a new medium of audio communication for humans and machines is discussed. We examine mobile services and the implementation of digital watermarks on music and audio files. The proposed methods allow end users to directly access relevant content or Internet sites from their music or audio, allowing users to obtain the information they seek while they enjoy their music or audio. While digital watermarking technologies have been used in the past as a security feature for copyright protection, we aim to uncover possibilities for applying this "defensive" technology as an "offensive" form of security technology that can be used in the area of mobile services.**

Keywords: Digital watermark, Security, Mobile service

I. INTRODUCTION

Currently, many publications such as brochures, magazines, and company information booklets come printed with URLs so that readers can visit relevant Internet sites to obtain the latest updates or other details not included on the paper medium. However, entering a URL on a mobile device, such as a cell phone, while reading printed material is not only cumbersome, but can also lead to users making errors entering the URL. Additionally, even if more than one type of information is presented on a single sheet of paper, the included URL will typically be of the top page only, making it difficult for the user to find the information he or she seeks. As more and more cell phones come equipped with cameras, QR codes[1] are gaining much attention as a technology for interacting with conventional media. However, because the readability of QR codes suffers if there is insufficient contrast between the printed code and the background color, and also because QR codes require a white peripheral margin, they place limitations on content design.

Another problem with QR codes is the fact that their functionality is affected by printing methods, print resolutions, and paper quality (i.e., paper aging, bends, and wrinkles).

Meanwhile, the bandwidth of cell phone networks for transmitting images and music has been expanding, paving the way for easy-to-use, high-speed communication. Digital watermarking technology can be used as a new method of advertisement that enables two-dimensional (2D) advertisement vehicles to interact with their cyberspace counterparts via mobile infrastructures. Digital watermarking technology has been touted as a means of enabling images, video, and audio files to interact with conventional media by directly embedding information into these files [1][2][3].

As the Internet continues to spread and bandwidth increases, distribution of entertainment content has come of age. Digital distribution is advantageous in that it offers convenience for users—users can make purchases when and where they like—and content suppliers are given new points of contact with consumers. On the other hand, widespread distribution of illegally copied content has raised concerns that these practices may undermine creative activities and decrease sales. According to the Ministry of Internal Affairs and Communication initiative "Information and Communication Vision for the 21st Century", content businesses made up 33% of the 29 trillion yen information industry in 1995, and by 2010, the industry is expected to grow to 125 trillion yen, of which 55% will come from content businesses [4]. Digital content models allow businesses to directly publish and sell copyrighted material to users via the Internet, and numerous sites already provide such services.

On the other hand, there are numerous illicit sites that infringe copyright, and this could have a detrimental effect on content businesses as a whole. Damages in the US resulting from peer-to-peer (P2P) programs and file-exchange programs are currently estimated to be in the several hundreds of millions of dollars [5].

---

[1] Quick Response Code: A matrix code (or two-dimensional bar code).
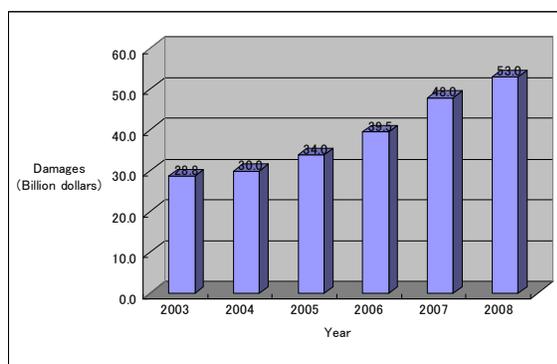
Fig. 1. Damages resulting from illegal copying of copyrighted content
(Source: Business Software Alliance)

To ensure strong growth of these promising industries, a content protection technology as a mechanism to protect copyright holders and their content is necessary. Content protection technology is an all-inclusive concept that includes the prevention and deterrence of unauthorized copying of content, as well as copyright protection technologies. One effective technology for digital contents protection is "digital watermarking". The development of digital watermarking technology stated around 1995, and its full-fledged application began in about 1998. Digital watermarking places an imperceptible mark into the digital content itself that identifies the copyright holder. The mark can be used as evidence for tracking, in the event that content is copied. Digital watermarking does not prevent unauthorized copies. However, it can be applied broadly and is effective for enforcing copyright.

In this study, we propose a method for applying digital watermarking technology to audio files, as a way to address two issues in mobile services: security and mobile usability. This technique is used to embed a machine control signal into an audio stream; the signal is imperceptible to humans, but can be detected and decoded by other machines. Specifically, the design of compound audio signals and new industrial applications are discussed. Several interesting applications of digital watermarking are described. We have previously published results on the verification of the effectiveness of the digital watermarking service model with regard to copyright protection [2][3]. This paper presents applications of this idea and includes specific proposals.

II. ENVIRONMENT SURROUNDING AUDIO INFORMATION AND EXISTING STUDIES

Digital content businesses that deliver images or music make it possible to release, transmit, or sell copyrighted data directly to users using the Internet. Numerous Web sites already provide this service. On the other hand, there are many illegal Web sites that infringe on copyrights and negatively impact the digital content businesses. Music, images, and video data that can be played on a computer are

digital data; thus, full services can be provided by simply sending and receiving the data. This eliminates the need for CD or DVD presses, packaging, and other physical processing. This is the concept behind the digital content business. Conventional distribution systems have problems of increased production costs due to CD or DVD manufacturing and packaging, and the risk of carrying unnecessary inventory. With these conventional general distribution systems, there is a fear that it is difficult even to commercialize content that has poor sales prospects.

On the other hand, because digital content services use the Internet as the infrastructure to send digital data, it has developed into a distribution system that resolves conventional problems as follows:

・No need to carry unnecessary inventory
・Customers around the world can access content in a "borderless" manner
・Shorter distribution time
・Reduced costs

Moreover, with the development of infrastructure the range of customer categories has expanded from the conventional range. Reaching target customer audiences and diversifying categories has become a recent remarkable trend.

In Japan, although CCCDs[2] were released by a number of record companies in 2002, they did not provide full security and were criticized for their degraded sound quality. Consequently, CCCDs have failed to gain market share, and CDs today are sold with essentially no protection. Given these circumstances, digital watermarking has gained attention as a potential technology for protecting digital content recorded on music CDs. JASRAC, a Japanese copyright organization, and CISAC and BIEM, both of which are worldwide federations of copyright organizations, have launched a project led by JASRAC for evaluating and testing international technologies for implementing digital watermarking [3] [6][7]. As a result, technological levels of digital watermarking have been reported as follows. As for technological levels regarding tolerance, no issue was identified in 90% of the tolerance tests covering 21 critical areas for the implementation of digital watermarking on widely available songs. Furthermore, 50% of the songs allowed for the extraction of information that was inserted into their frames. These criteria were also met when Internet distribution-related formats (MP3, MPEG2, AAC, ATRAC3, RealAudio, and Windows Media Audio) or broadcasting-related processes (non-linear data compression and frequency response conversion: AM, FM, PCM) were used. With regard to technological levels relating to the degradation of sound quality, which was a problem with

---

[2] CCCD: Copy-Controlled Compact Discs.
[3] These projects were named STEP2000 and STEP2001, respectively, and were coordinated, produced by Nomura Research Institute, Ltd.

CCCDs, less than 10% of test respondents were able to recognize a difference in sound quality caused by the embedding of information. In addition, it has also been verified that neither of the digital watermarking processes, namely, the embedding and reading of information, takes more than 10 seconds.

III. APPLICATIONS FOR SERVICES

In this section, we examine services that utilize digital watermarking in audio media. By embedding digital watermark information into music or audio files and reading these files on cell phones and mobile devices equipped with microphones, such as PDAs, information and content can be displayed that are relevant to the music or audio that the user is listening to, and users can also be guided to predefined sources of information such as Web sites. Depending on the specification of the digital watermark detection program and the content of embedded information, in addition to being guided to a particular Web site, users will also be able to access phone numbers and E-mail information, as well as view relevant video.

The platform's generic utility is a critical element in implementing this technology on mobile devices such as cell phones [8]. There are two methods for detecting watermarking on mobile devices. The first is a client-server method where the file itself is sent to a server and the server detects the watermark. The second is a method where the mobile device itself detects the digital watermark. Performance is rarely an issue with the client-server method as detection is performed on servers with high processing power. The disadvantage of this method, however, is that the file must be sent to the server; a process which is time consuming and entails communication costs. In cases where a digital watermark cannot be detected, this result can only be known after sending the file to the server. By performing the entire process of detecting digital watermarks on the mobile device, users can be guided to a variety of network services such as Web services and E-mail to obtain information without incurring communication costs. For this reason, digital watermarking processes in a mobile environment are preferably based on a method where the detection of digital watermarks is performed on the mobile device, preferably using a digital watermark detection application that supports mobile OS middleware such as Java and BREW.
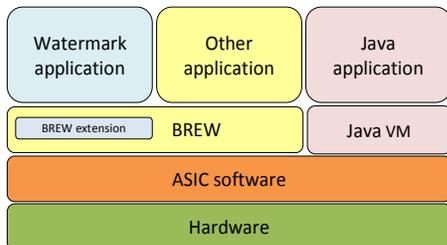

Fig. 2. Software stack implementation

Since middleware neutralizes the various differences in the bottom-most hardware layer, generic utility of the platform and good development efficiency can be achieved. Device manufacturers can outsource the development of embedded software and concentrate on hardware development. Software developers can develop applications without worrying about platform differences. Developers do not have to develop different applications for different device vendors. This will eventually lead to applications for not only cell phones but also smart phones and PDAs.

Audio files do not require special equipment and can be played back on any speaker on the consumer market. This technology enables operators to provide interactive services in situations where only a cell phone or PDA is used. More information can be provided if the mobile device is equipped with Internet connectivity. Compared to similar services based on Radio-Frequency Identification (RFID)[4], which extract information from audio files without the use of IC tags, digital watermarking delivers the same effect at a lower cost. Since generic cell phones can be used instead of special devices, development costs and device purchase costs can be reduced, expanding the technology's range of applications.

We developed software based on the new algorithm mentioned above. A snapshot of the interface is shown in Figure 3.
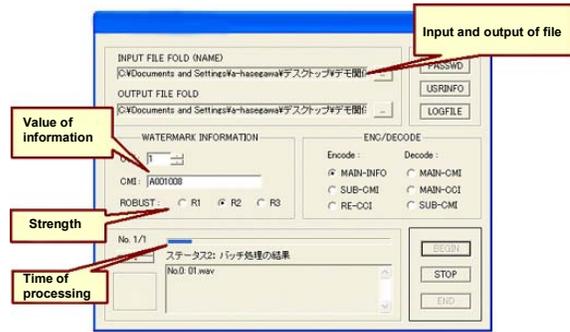

Fig. 3. Digital watermark application for audio data

The following features, in addition to a periodic phase modulation, were obtained by multiplexing the phase.
・Speed of encoding
 Encoding became possible in almost real time from 3% to 5% of the sound source [6].
・Tone quality
 The change in tone quality was found to be 2 (6%) in the catching inspection in Silver-Ear among 32 samples [6].

In addition, it corresponded to various compressions. Even if various compressions are done after the digital watermark is embedded, the embedded information can be detected.
These compression methods included MP3, AAC, ATRAC,

---

[4] RFID is an automatic identification method.

ATRAC3, Real Audio, Windows Media Audio, FM, AM, and PCM.

Next, we will discuss the difference from the conventional workflow. The conventional workflow and the workflow proposed in this research paper are presented in Figure 4 and Figure 5.
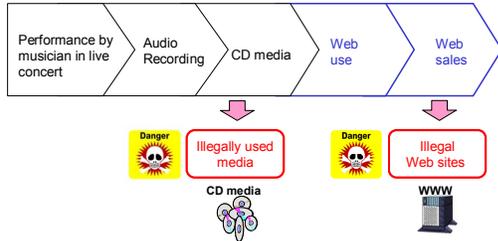

Fig. 4.   Conventional workflow

The watermarked content itself does not employ special measures to counteract illicit activity; thus, the problems of illegal use and illegal copying will occur. Furthermore, considering the profit structure of a digital content business, when the objective of single use is met, the business can earn a profit. However, because no business model has been established for other types of use, for example, second use and onward, the structure does not support the earning of additional profits.

In the proposed workflow, the copyright is generated when the content is created, and that information is embedded into the content.
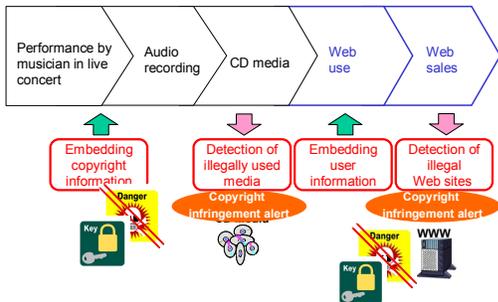

Fig. 5.   Proposed workflow

The profit structure for the business is the same as the conventional process for one-time use; however, because illegal use and copyright information can be detected from the data and also from the printed media, it is possible to enforce copyright. We are considering creating copyright infringement levels and infringement damage reports from offline media, and, if necessary, to provide support up to the point where legal steps can be taken. In addition, we will construct a scheme that will make second-time usage possible from the copyright information and user information, and detect illegal use websites and report to the client. This scheme will detect illegal use websites while also securing the clients profit from second-time usage.

IV.   CONCLUSION

In this report, we examined the implementation of digital watermarking technology on audio files, the security of these implementations, and their applications in the area of mobile services. Two issues were mentioned in the Introduction: security and mobile user interface. The use of a robust algorithm for digital watermarking is one way to ensure security. As for the usability of the user interface on a mobile device, we believe that the burden on the user can be reduced dramatically as more information can be obtained automatically from audio files. In the past, digital watermarking technology has been viewed as a security technology for ensuring copyright protection. While digital watermarking can be said to be a "defensive" technology, in this report, we propose "offensive" applications for digital watermarking technology in mobile services.

Technological evaluations and verifications conducted by JASRAC and other organizations have identified technologies that are viable in the market, and comprehensive verification tests have confirmed that these technologies do not pose problems in practical implementations. In the future the mobile network will spread, more networks will switch to broadband, and more broadcasts will be digitized. In this environment all of the technologies that enable the smooth and safe distribution of digital contents will be related to each other and together come to form a single system. Therefore it is without a doubt that the effectiveness of that as a scheme will become evermore important. We plan to continue our studies of the technical, industrial, and institutional aspects of these technologies, taking particular note of economic rationality.

REFERENCES

[1]   Xuping Huang, Yoshihiko Abe, and Isao Echizen, "Capacity Adaptive Synchronized Acoustic Steganography Scheme," *Journal of Information Hiding and Multimedia Signal Processing*, Vol.1, No.2, pp.72-90, Apr. 2010

[2]   Manabu Hirakawa, "Verification of the effectiveness of the digital watermarking service model for copyright protection," National Spring Research Conference, Japan Society for Management Information 2008, pp.G4-2, June 2008.

[3]   Manabu Hirakawa, "Examination of digital watermark usage in distribution management," National Autumn Research Conference, Japan Society for Management Information , pp.B1-3, November 2008.

[4]   Ministry of Internal Affairs and Communications Web site, http://www.soumu.go.jp.

[5]   Naohisa Komatsu, Kenichi Tanaka, *Digital watermarking technology -- digital content security*, Institute of Image Electronics Engineers of Japan, January 2004.

[6]   Japanese Society for Rights of Authors, Composers and Publishers and Nomura Research Institute, Ltd., Web site, http://www.jasrac.or.jp/watermark/houkoku.htm

[7]   Japan Electronics and Information Technology Industries Association, "Report on digital watermarking technology", http://it.jeita.or.jp/eltech/report/2001/01-jou-04.html

[8]   Hidemi Mizoguchi, Yukinori Miyakita, Yuta Tokoro, *EZ Application (BREW) Programming*, Ric Telecom Co. Ltd., 2007.