BLUEMUSIC: A MULTICHANNEL ARCHITECTURE FOR MUSIC DISTRIBUTION

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Abstract: Despite the increasing number of e-music downloads and the large use of mobile devices, the mobile music market is slowly taking off. Prices seem to be the main burden: compared to the wired environment, a song is twice or three times more expensive. Furthermore, mobile network transfer data rate causes the download time to be very long. In this paper we propose Bluemusic, a multi channel architecture that couples the usage of the mobile phone network with the free-of-charge communication technologies provided in cellphones (e.g., bluetooth or Wi-Fi) to distribute music in the mobile environment. To protect digital contents, Bluemusic is provided with a security mechanism that prevents illegal contents distribution. An evaluation of our approach shows that Bluemusic can be helpful to the expansion of the mobile music market.

1 INTRODUCTION

Only few years ago the music industry was hesitant to enter into the digital market, as the digital scenario was usually associated with piracy and with illegal music sharing; Today things are different and the download music is a successful scenario for different reasons: i) low prices (around one dollar); ii) high speed residential Net access (e.g., DSL) with flat rate plans and iii) large availability of cool portable devices (e.g., Ipod).

The digital music market is seen as an interesting opportunity for mobile operators: mobile-phone companies are becoming an important player in the emusic market with the releasing of multimedia cellphones (e.g., the Nokia N90 series or the announced iPhone from Apple); cellular operators are considering the distribution of emusic an important application for their 3G networks. The remarkable revenues of the ringtones market, which recently reached $4.1 billions worldwide and the increasing number of mobile phone subscribers, convinced the mobile industry to be part of the mobile music market.

A great take off was expected, but the initial results show that people keep on buying songs from residential Net access and avoid using the mobile phone network for songs downloading. This is not surprising if we consider that a song is much more expensive if downloaded from the mobile phone network.

In this paper we propose Bluemusic, a multichannel architecture designed to distribute digital music in the mobile scenario. Bluemusic aims at reducing the price paid by a mobile customer for downloading the song directly to his/her device. It couples the usage of the mobile phone network with the usage of the free-of-charge bluetooth (or Wi-Fi) technology available in many cellphones. It is provided with a security mechanism that protects the digital content by requiring a license to play out the song. The idea is to to limit the usage of the expensive mobile phone network. To stimulate users music distribution, Bluemusic has an incentive mechanism that mitigates the user selfish behavior.

The evaluation of Bluemusic investigates the security features and the performance (in term of downloading time) and results show that our multichannel approach bring benefits, not only to customers, but also to music stores and to mobile phone operators.

The remainder of this paper is organized as follows: In section 2 we present the Bluemusic architecture and its evaluation is presented in Section 3. Conclusions are drawn in Section 4.

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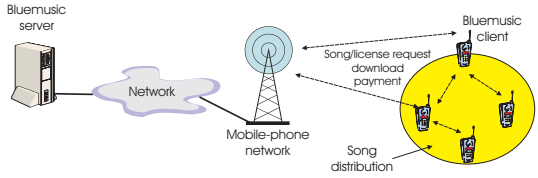

Figure 1: Bluemusic multichannel architecture: The mobile phone network distribution is coupled with direct client-to-client distribution.

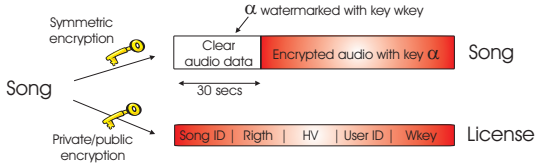

Figure 2: Two separate files are produced for any song. To decrypt the song file, the license file must be decrypted.

2 THE BLUEMUSIC ARCHITECTURE

In this section we describe Bluemusic, a multi-channel architecture to distribute emusic in a mobile scenario. It is composed of a Bluemusic server and of Blumusic clients (Bserver and Bclient, for short). The idea, depicted in Fig. 1, is to minimize the usage of the expensive cellphone network by coupling it with another, free-of-charge, channel.

Bluemusic Server. A BServer is in charge of preparing and releasing the song to a BClient that requests it. The BServer uses the mobile phone network to communicate with BClients. For security reasons, as we better show in the following, the song is released in the form of an encrypted media file along with an encrypted license file.

Bluemusic Client. A BClient is a mobile device that can access a cellphone network and is equipped with a free-of-charge communication technology (e.g., bluetooth and/or Wi-Fi); it can request/download songs/licenses through a BServer and can directly communicate with other BClients using a free-of-charge technology. A BClient has a BPlayer, a software released to handle all the Bluemusic operations (song acquisition, distribution, sharing).

In the following we present details of the phases necessary to participate, to acquire and to distribute songs in our multi-channel proposal.

2.1 Bluemusic Sign-up Procedure

The sign-up registration procedure is required to gather BClient information: the unique user identifier (UID) and the the device identifier (DID). Once the registration procedure has been done, the BServer releases the BPlayer for the BClient; Once the BPlayer has been installed, the BClient can acquire licenses, distribute and play out songs.

Furthermore, during this sign-up procedure, the private key is generated and delivered to the BClient, which will store it into the device repository keys.

2.2 Song Acquisition

A BClient can acquire a song directly from the BServer. When contacted, the BServer prepares the song and delivers it to the BClient using the cellphone network. As shown in Figure 2, the song is released with two separate files: the media data (encrypted with symmetric key) and the license information data (encrypted with private/public keys). Note that the usage of the symmetric key allows BClients to share the media file.

The BServer first generates the α encryption key and then encrypts the media file (or a portion of it). To decrypt the media file, the BClient has to know the α key. For this reason, the α key is hidden insidethe media file. The key is hidden using a watermarking technique that spreads out the hidden content without compromising the media content (Cheng et al., 2002). In particular, the key is spread out using another key, the so-called watermarking key (WKey), which will be available to the BClient with the license file.

The license file contains information related to the rights acquired (e.g., the right of playing out the song), the song identifier, the UID, the watermark key (WKey) for decrypting the song file, the hash value of the song file (HV) for verifying the song integrity.

This approach ensures that a license file can be decrypted only by the device for which it has been released, causing the sharing of the license file to be a useless operation. Conversely, the media data file is not bound to the device, and hence it can be shared.

2.3 Song Distribution

Bluemusic is a multi-channel distribution architecture that allows BClients to share files with other BClients. We recall here that the media file can be played out only if its license is acquired and that license sharing is useless, as a license file is bounded both to the song and to the BClient device.

The distribution procedure is managed by the BPlayer software, which uses the free-of-charge communication technology to look-up for other BClients. The discovered BClients can be contacted. When

contacted, the BClient receives information about the song (e.g., Song ID, Song Title, Song author) and checks the user's preferences to authorize/deny the downloading of the incoming song. This is done to avoid the downloading of unwanted songs.

The benefits of this BClient distribution it to reduce the price paid by a user to get a song on his/her mobile device. In fact, only the small license file passes through the cellphone network, while the media file is obtained through a free-of-charge technology. Needless to say, the more people will share their song, the more chances a user has to receive the preferred song over his devices. Users cooperation is thus essential for the success of the Bluemusic approach. To this aim, Bluemusic is provided with a payment-based incentive mechanism that attach a small additional financial cost to the license price, so that it can be partially or totally recouped by redistributing the song (Furini and Montangero, 2006).

2.4 License Acquisition

To play out a song received by another BClient, it is necessary to acquire the corresponding license file. To this aim, the BServer has to be contacted. License acquisition is done in a transparent way as it happens today with DRMs like Microsoft DRM 10.

Since the license is bounded to the song and to the BClient, the BClient has to communicate the following information: the song ID, the user ID, the device ID and the song file hash function (HV). Upon the reception of these information, the BServer first checks the song integrity in order to avoid the possibility that a malicious user may transfer a fake or different song with respect to the one described by the Song ID identifier. If the integrity check succeeded, the BServer sends to the BClient some song information (Song Title, Song Author, and price) and asks for a YES/NO reply. If the client agrees on buying the license, the license file is generated by the BServer (as depicted in Figure 2) and is sent back to the BClient (payment is not investigate in this paper). The BClient, using its private key, can decrypt the license file, unlocks and plays out the media file.

2.5 Song Playout

To play out a song, the BPlayer needs to decrypt both the media file and the license file. The license file is the first one that has to be decrypted as it contains information necessary to decrypt the song file. Since the license file in encrypted with the public key, the BPlayer retrieves the private key from the repository and decrypts the license file. Note that the private key has to be secret to the user in order to avoid key sharing. This can be achieved with hardware or software solution (Bar-El and Weiss, 2004).

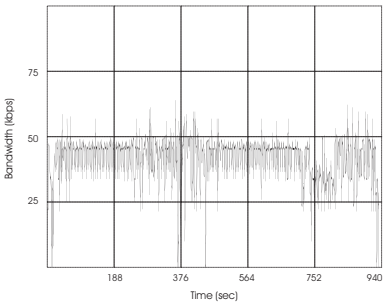

Figure 3: Experienced data transfer rate obtained while downloading a 4MB song using a GPRS cellular network.

Once decrypted, the license provides the following information: Song ID, Rights acquired, User ID, the watermark key (WKey) and the hash value of the song file (HV). Before playing the song out, the BPlayer checks for the song integrity. To this aim it computes the hash value of the media file and compares it with the retrieved value HV. If the integrity check fails, the play out cannot begin; if it succeed, the BPlayer uses the retrieve $Wkey$ to retrieve the α key and uses this key to unlock the song file. From now one, the BPlayer can begin the song play out.

3 BLUEMUSIC EVALUATION

In this section we evaluate our multi-channel proposal by investigating: i) downloading time; ii) impulsive buying and iii) security issues.

3.1 Downloading Time

Bluemusic allows using both the mobile phone network (e.g., GPRS, EDGE and UMTS) and the free-of-charge technology (e.g., Bluetooth or Wi-Fi) provided with current cellphones.

In the following we investigate the time necessary to download a 4MB song using the different technologies. Experiments are done using devices with different devices (Nokia N90, Nokia 6230, Motorola V3 and Siemens S55), two different cellphone network providers (TIM and Wind) and in different day time.

GPRS Downloading. Results from downloading songs very similar to the situation depicted in Figure 3, where it can be noted that the real transfer rate only occasionally goes above 50kbps (against the theoretical 170kbps). With such transfer rate the time necessary to download a 4 MB song is around 940 seconds.

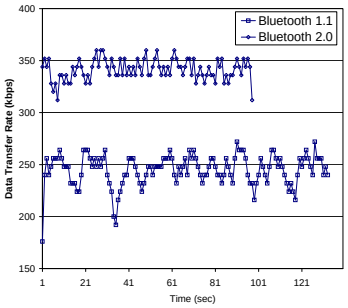

Figure 4: Download of a 4MB song using Bluetooth.

EDGE Downloading. A similar difference from theory to practice has been found using the EDGE technology: instead of the theoretical data transmission rate of 384 kpbs, the experienced data transfer rate was around 82 kbps, which leads to a downloading time of 390 seconds to get a 4MB song.

UMTS Downloading. The UMTS data transfer rate experienced using showed an average download rate of 312Kbps (a max of 440kbps was reached), which leads to a downloading time of 102 secs to get a 4MB song. Again the actual transfer rate is far from the theoretical one (144kbps, 384kbps or 2Mbps depending on the usage (vehicular, pedestrian or fixed).

Bluetooth Downloading. Figure 4 summarizes the results, which show that the bluetooth 1.1 allows transmitting a 4MB song in 132 seconds with a data transfer rate that is around 250kbps, and the bluetooth 2.0 needs 91 seconds with a data transfer rate around 350 kbps. Note that the connection setup time is not shown and hence one second should be added to the downloading time due to connection set-up time (Frank Kargl and Weber, 2002).

Wi-Fi Downloading. The conducted experiments with a Nokia N90 showed that a 4MB song can be downloaded in around 5 seconds.

3.2 Impulsive Buying

An important characteristic of Bluemusic is that it stimulates unplanned purchases (Cobb and Hoyer, 1986), as it enables consumers to acquire a license song immediately after the reception of song. In fact, the music is considered an experience good, and when a customer receives a song through the free-of-charge communication technology, it is stimulated to buy it.

3.3 Security Analysis

Content protection is an essential feature for any digital distribution and in the following we analyze possible Bluemusic security concerns.

It is to note that the so-called Digital Right Management schemes admits no final and strong solution, since security rests on code obscurity. However, DRM systems are nowadays the only mechanisms used against piracy and that a mobile device can be used to build a more secure DRM (T.S.Messerges and E.A.Dabbish, 2003). Another security concern is related to the use of watermarking techniques: (Schonberg and Kirovski, 2004) claims that secure fingerprinting is not possible with current technologies, but (He and Hu, 2004) are more optimistic.

4 CONCLUSIONS

This paper presented Bluemusic, a multi-channel distribution architecture designed to distribute digital music in a mobile scenario. Bluemusic is coupled with a security mechanism that ensures that a shared song can be played out only upon license acquisition. The evaluation of our proposal showed that a multi-channel approach is worth using as it reduces both the download time and the mobile phone data traffic.

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