Music Distribution and Protection

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ABSTRACT
An added value of digital distribution and thus of Internet is the possibility of exploiting new functionalities related to the interactivity. Images of music sheets are not interactive and the related costs for using that music for preparing performances in orchestras, in music schools, etc., are comparable to those of using traditional music sheets. Theatres, orchestras, music schools, music distributors, recording studios, blind people, and libraries need interactive music; that is, music that can be manipulated: arranged, transposed, modified, reformatted, printed on Braille, etc. These are real needs for preparing performances, studying music, analysing music, learning instruments, etc. To this end, WEDELMUSIC model has been defined to allow publishers and consumers exploiting interactive music respecting copyright laws. In this view, important aspects are the protection of music distribution with a safe transaction model, the passive protection of digital objects with suitable encryption tools, the Digital Right Management, and the watermarking of digital objects such as audio files, music sheets, etc.

1. INTRODUCTION
Big publishers are beginning to exploit Internet potentialities for music distribution. Systems, such as NAPSTER and GNUTELLA, are rapidly transforming the distribution of audio files. They adopt a Business-to-Consumer model, B2C, for music distribution. Digital Music is also music scores, music related documents, music cataloguing management, documents about lyric, music videos, etc. Presently the market of music scores is a small part of the activity related to digital music. Recently some examples of music sheet distribution on Internet are available (MusicSales, Net4Music, etc.). Most of them are based on the distribution of score images, PDF or PostScript files. Music sheets cannot be manipulated by the end users. These solutions are a surrogate of the classical distribution of music sheets via music shops. On the other hand, the acquisition of music sheets by image scanning is the first step to put in digital the music sheets that are present in the publishers' archives. The digitalisation of historical music archives can be a way to go on the Internet market and at the same time to save the cultural heritage. In fact, in many cases the archives of institutions, conservatories, foundations, and of big publishers contain also historical music that risks to be destroyed by the time. This huge amount of cultural heritage should be saved in digital and valorised. The 95% of music contained in the publishers' archives is on paper.

Images of music sheets are not interactive and thus the related costs for using that music for preparing performances in orchestras, in music schools, etc., are comparable to those of using traditional music sheets. Theatres, orchestras, music schools, music distributors, recording studios, blind people, and libraries needs interactive music; that is, music that can be manipulated: arranged, transposed, modified, reformatted, printed on Braille, etc. These are real needs for preparing performances, studying music, analysing music, learning instruments, etc. Presently this is not possible since music scores are only distributed as music sheets. In order to manipulate music, it has to be in some symbolic format, in which music notation relationships are formalised.

Presently, a large number of symbolic formats for modelling music notation available. Great part of these formats and music notation editors were realised for printing music (Score, Finale, Sibelius, etc.) [SelfridgeField97], [Bellini99]. Most of these formats are not structured for modelling and managing symbolic music to be distributed on the Internet. The main obstacle of these formats to be used in the new emerging applications is the formal modelling of music: the net

distinction from main score and parts, the lack of modelling relationships among music notation symbols, the lack of distinction between music modelling and formatting aspects the lack of integration of the several aspects of music, the lack of a support for protecting music, etc. To this end, several new solutions have been proposed as interchanging and Internet formats (SMDL, NIFF, XMLmusic, etc.). Unfortunately, as demonstrated by CANTATE and MOODS research projects these formats are unsuitable for supporting the applications of the Internet era. Therefore, in these years, we are assisting to a strong effort to transform the old solutions towards the new needs of Internet and of its users.

The real added value of digital distribution and thus of Internet is the possibility of exploiting new functionalities with a particular attention to the aspects related to the interactivity. A symbolic description of music sheets allows manipulating music in several manners: transposition for different instruments, content search, formatting, piano reduction, rearrangement of music, etc. On the other hand, the production of symbolic music is quite expensive.

Another very important aspect is the protection of music which involves the: protection of music distribution with a safe transaction model, the passive protection of digital objects with suitable encryption tools, the Digital Right Management for tracing and accounting the exploitation of possible operations performed on music, and the watermarking of digital objects such as audio files, music sheets, etc.

According to the above mentioned problems and intuitions WEDELMUSIC project was started. It is an IST project with partners: DSI, University of Florence, Italy; ARTEC Group, Belgium; Casa Ricordi, Italy; FNB, The Netherlands; Scuola di Musica di Fiesole, Italy; IRCAM, France; FHG-IGD, Germany; ILSP, Greece; CESVIT, Italy; Edizioni Suvini Zerboni, Italy.

In this paper, the most important aspects of WEDELMUSIC model are reported. WEDELMUSIC has been defined to allow publishers and consumers (theatres, orchestras, music schools, libraries, music shops, musicians) to manage interactive music; that is, music that can be manipulated: arranged, transposed, modified, reformatted, printed, etc., respecting copyright laws. It is an innovative support for preparing performances, studying music, analysing music, learning instruments, distributing music at low cost, etc. Music distribution is not viable without adequate protection methods. WEDELMUSIC presents sophisticated mechanisms for music protection, that include: protecting digital objects by using encryption techniques; allowing definition of Digital Rights Management policies; watermarking audio files, images of music score, and music sheets while they are printed.

2. WEDELMUSIC: WEB Delivering of Music Scores

WEDELMUSIC proposes techniques for distributing music in symbolic formats considering the integration of symbolic format with images of music sheets, audio files, and a set of protection mechanisms. These innovative features are possible thanks to the definition and implementation of :

(i)   a unified XML-based format for modelling music including audio, symbolic music, image of music scores, documents, videos, lyric, colour images, cataloguing information, etc., that can be associated with a music piece.

(ii) reliable mechanisms for protecting music in
- secure distribution of music digital object by using specific transaction model and solution;
- symbolic format (watermark while printing);
- images of music sheets (watermark of image scores);
- audio formats (watermark of MP3, WAVE).

(iii) sophisticated mechanisms for Digital Right Management over the limits of SDMI (Secure Distribution Music Institution):
- Formal definition of allowed functionalities of integrated multimedia WEDEL objects;
- Tracing exploited functionalities;
- Accounting of exploited functionalities;

- Protected music can be manipulated: transposed, arranged, modified, etc.) respecting copyright protection aspects and the owner rights, according to the WEDEL object format.
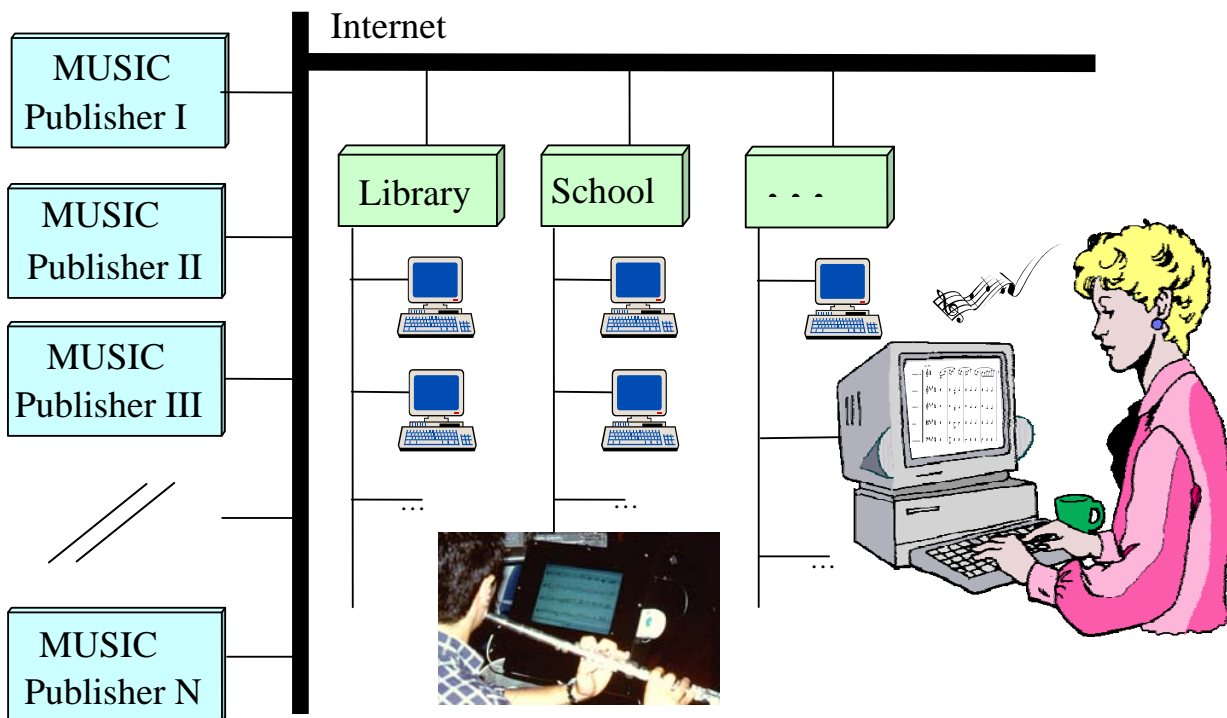

Fig.1 -- WEDELMUSIC transaction model, servers, Local Distributors and clients.

WEDELMUSIC Format is XML compliant and includes constructs for the description of integrated music objects. WEDEL objects are mainly focussed on a specific music piece or concept. Each WEDEL object presents aspects of: identification, classification, protection, printing, symbolic music, image score, performance, documents, lyric, audio, video, and colour image. In the following, some of these aspects are singularly discussed.

- **Protection** section models details of encryption and watermark of music (audio and music sheets). A table about the music permissions is also available for the definition of Digital Right Management policies.
- **Printing** section includes the description for printing music packages contained in the WEDEL object. These may be remotely printed with specific fingerprint and watermark.
- **Symbolic Music** section describes the scoring information, musical notation symbols, and their relationships. Symbolic music can include main score and parts. This section also includes music notation fonts, formatting rules, and versioning aspects associated with the symbolic music coding.
- **Image of Music Sheets** section allows to integrate images of music scores into the WEDEL object without converting them into symbolic format. Thus, in the same WEDEL object, both symbolic notation and original images of music sheets can be present in the same object. This allows building WEDEL objects to compare original music score with revised and currently used symbolic versions -- e.g., the old style music of Uccellini and its rewriting in western music notation. It is a good support for revitalising old material and recovering cultural heritage.
- **Audio** section may contain one or more audio files. These can be watermarked according to the parameters of the WEDEL object.
- **Performance** section describes the synchronisation aspects between each audio file and the music score that can be shown on the computer screen. The synchronisation of audio file allows the contemporaneous visualization and listening of music score.

- **Documents** section may include none, one or more structured documents such as author biography, critical description of the music piece, description of the performing orchestras, etc.
- **Lyric** section may present none, one or more elements containing the text of the lyrics associated with the music score and thus with the WEDEL object.
- **Video** section may contain none, one or more videos. These are very useful for presenting the hands of piano player, the life recording of a performance, etc.
- **Image** section may include none, one or more colour images such as the portrait of the author/performer, the picture related to the music or opera, etc.

In each WEDEL object, several relationships among its components can be established. For example: different (for language) lyric files can be referred to the same symbolic file (piece of text t o notes); from symbolic to video (a note with a video attached), images, documents, audio files: relationships performed via http links that can be assigned to music notation elements; etc. For the navigation in the WEDEL objects, a specific user interface has been implemented. It allows building and using WEDEL objects by means of music editing, formatting, analysing, printing, executing, extracting excerpts from audio or music sheets, music transposing, arranging, editing multilingual lyrics, printing music in Braille, listening spoken music, editing music for visually impaired people, playing and exporting in MIDI, converting music from other formats (FINALE, SCORE, MIDI), comparing music pieces, specifying and browsing cataloguing information, etc.

3. Transaction Model and Digital Rights Management

WEDELMUSIC enables publishers to protect their music and at the same time the user may manage the acquired music producing derived versions. E-commerce for

The model adopted is based on the distribution of music from publishers to customers by using the Local Distributors (see Fig.1): libraries, conservatories, music schools, music shops, etc. They may distribute the music coming from several publishers. Local Distributors are WEDELMUSIC certified institutions with authorised client computers. Client computers may print protected music sheets (original and customised). Attendees/clients of Local Distributors may work on a large WEDELMUSIC database located in the Local Distributor for processing music, arranging, transposing, reducing for piano, listening, printing, querying, converting, extracting excerpts, etc., according to the allowed operations. The WEDELMUSIC distribution is mainly based on Business-to-Business model and has at the second layer a Business-to-Consumer transaction. It is based on a transaction model that allows to completely customising the service of music distribution. It may range from the on-line to off-line distribution of the digital objects. WEDEL objects may be very complex and large size (with high-resolution audio, images, videos) as well as very simple and manageable to be transferred on-line. Specific transaction policies may be defined according to the publisher's needs and interests.

Each operation that can be performed on a WEDEL object can be permitted or inhibited. More than 50 different multimedia functionalities can be distinctly managed -- for example: printing, executing, transposing, printing with changes, playing, listening, reading documents, taking excerpts, etc. A permission table is available for the definition of Digital Right Management policies. A price can be associated with each permitted operation. The permission table depends on the several states of the WEDEL object: demo, rented object, when it has been sold, when the renting period has been expired. Each performed operation is tracked and thus the publisher may know exactly which are the more requested operations and the most requested music pieces. This allows analysing the needs of the end-users with statistic tools. Non permitted operations of a WEDEL object can be on-line requested and obtained when needed.

4. Watermarking Music

Watermarking allows hiding information into digital objects such as images, videos, audio files and text pages. These techniques are adopted to hide codes that can be used for demonstrating the ownership of the digital object in the case of verification of the copyright infringement. To this end the hidden code contains the publisher identification code, the music piece code, and the Local Distributor identification code. The possibility to hide this information and read them after several types of attacks makes watermark suitable for property right protection. Watermarking tools are supported by a watermark reader to read the hidden code from a grabbed music sheet and for an audio file. This allows demonstrating the ownership of the digital music.

WEDELMUSIC techniques for watermark present the following capabilities:

- The watermark inserted in the printed sheet is not disturbing the music reading and playing.
- The watermark inserted into audio files is not disturbing the listening of music.
- The watermark remains readable after acquisition with scanner and its reprints as well as after photocopy with distortions, filtering, zooming, rotations, cropping, noise addition, flipping, etc.
- The watermark resists during sheet manipulation until the music printed is considered unreadable.
- The watermark removal with image processing techniques is more expensive than buying the same music sheet.

In digital music distribution such as in WEDELMUSIC the music sheets are printed on the client site with traditional systems. These music sheets could be distributed with a simple fingerprint reporting the music code, the publisher name, etc., without solving the protection problem. In these conditions, the insertion of a hidden watermark in music sheets is a important tool for music protection. New techniques for watermarking music (in image format and/or during the printing of music sheets) were implemented in order to protect the WEDELMUSIC printed music sheets. The solutions have been obtained after a deep analysis of the possible solutions to hide data code into music sheets. A user group of experts has performed a validation of the results obtained, stating that the chosen watermarks are almost invisible.

The watermarking of audio files allows inserting non-detectable code into WAVE and MP3 files. The approach is based on the psycho-acoustic model of humans and therefore the presence of the watermark is not audible. The watermark reader can be profitably used for demonstrating the copyright infringement.

5. Conclusions

The WEDELMUSIC solution and format allow exploiting new multimedia functionalities of digital music in the respect of the owner rights. The structure of WEDEL objects is strongly innovative and could be a good model for supporting the passage to digital world of several music archives. WEDELMUSIC model is a good solution for integrating images of old music sheets and symbolic description of new music. The solution is supported by a set of tools for protecting music: a safe transaction model, a sophisticated Digital Right Management, and watermarking tools for audio files, images of music sheets and the watermarking of music sheets produced from symbolic description of music.

6. References

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