



Web Delivering of Music Scores DE 1.1.6 Final Report

Version: 1.5

Date: 30 July 2002

Responsible: DSI

Project Number: IST-1999-10165 Project Title: Web Delivering of Music Score Deliverable Type: restricted
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Deliverable Number: DE1.1.6 Contractual Date of Delivery: 31 June 2002 Actual Date of Delivery: 30 July 2002 Title of Deliverable: Final Report Work-Package contributing to the Deliverable: WP1 Nature of the Deliverable: RE Author(s): (Paolo Nesi, Coordinator) all project partners

Abstract:

This report contains the final summary of the whole WEDELMUSIC project. It summaries the experience and the major achievements, results and facts that have characterised the WEDELMUSIC project evolution in line with the Annex 1 and with the satisfactory of all partners.

Keyword List:

music, audio format, image format, symbolic format, mp3, visually impaired people, speech music, Braille music, music analysis, music printing, music format, WEDELMUSIC.

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1 Abstract

Archives of mediateques, theatres, music schools, conservatories, universities, etc., are the most important sources of cultural heritage. Such institutions are interested in digitising content to (i) improve the service towards their attendees, thus increasing the number of collections provided, (ii) add new multimedia and innovative functionalities to the service already provided within the content available, (iii) save fragile materials otherwise settled to time deterioration, such as tapes, disks, documents, etc. Publishers are interested in digitising only content which guarantees a certain return of investment and at the same time they are inclined to limit the distribution of the content located in archives, so as to control its exploitation and to preserve the content ownership. WEDELMUSIC has been defined to allow content providers to share and distribute “interactive music”, in the respect of the owner’s rights. This permits to create a network for content sharing Mediateques can arise while respecting the owner’s rights. The WEDELMUSIC solution permits to create a virtuoso mechanism which increases the amount of content owned by each mediateque and adds several new multimedia functionalities that can be enforced into the WEDELMUSIC objects with a limited effort by using and integrating the content of any format and media. The proposed solutions, models and tools were defined and developed, including adequate protection and monitoring solutions. The solution was validated by a real music mediateque in Milan that has completely adopted the solution.

The project has been development according to the Annex 1 of the contract, performing activities of technology watch, market analysis, exploitation plan, business plan, technological and implementation plan, dissemination and demonstration. The details of these activities are reported in specific documents and area only shortly summarised in this finale report.

2 Introduction

Multimedia music publishers have in their archives audio files, music scores, and images of music sheets. Most of them have recently started campaigns to convert their music scores archives from paper to digital images. This is mainly performed for the pressure of the market and with the opportunities provided by National and local governs. Information centres and historical publishers also have in their archives several other digital objects: posters, letters, pictures, lyric booklets, books, videos, etc. This material represents an important source for cultural heritage but it is typically not organised and quite rarely managed by an integrated Digital Asset Management database. Archives are very important sources of cultural heritage: independent mediateques or archives associated to theatres, orchestras, music schools, conservatories, museum, foundations, universities, etc. Most of them present non digital music objects such as audio (disks, cassettes, tapes, etc.), video tapes, documents and pictures. In most cases, the archives have accumulated their content (through donations, as years of work of music lovers became more and more conspicuous), etc. Only marginally, the content of archives and local mediateques is acquired from publishers, great part is collected with personal equipment and represent the local heritage. Typically publishers send to the major public archives free content, small and mediums archives of cultural associations are only rarely considered. Most of the collected material in these archives has been collected by music lovers and comes from live performances and it is only partially covered by copyrights. Such content is for a large part non commercialised by publishers, for the lack of a real market. On the other hand, this material has a great cultural value for music lovers, students and experts whose are the typical visitors of the archives. The mixture of protected and non-protected material in the archive and the difficulty of a clear distinction forced the archives to adopt restrictive policies for the use of the material. The typical restriction limits the fruition of the material at the attendees. Usually, the archives can be freely consulted on-site, whereas the attendees are not enabled take excerpts, to make copies, to record, etc.

These limitations are applied to both copyright protected and free material in order to avoid legal problems and for the lack of mechanism for controlling the activities of their attendees.

This restriction imposes serious limits to the valorisation and the visibility of very important archives and their content constraining the diffusion of non commercial content such as: music produced in regional folkloristic activities, original manuscripts, historical documentation, modern music of young composers, etc. Publishers are not interested in digitising all above mentioned contents to place it on the market, since they do not see the direct return of investment. In most cases, they do not have the right to perform that activity since the author is not know. The archives are the only content owners to be interested in digitising that content to

- (i) improve the service for their clients, increasing the available content, its classification, its attractiveness, its accessibility, adding new functionalities to the service provided,
- (ii) save the material that is subjected to deterioration such as tapes, disks, documents, etc., improving in this way the accessibility since the digital content do not risk to be consumed and can be accessed by several attendees at the same time,
- (iii) attract new attendees to sale at them registrations, services and recently also products such as copies, gadget, etc.

This activity was positively understood and solicited in the past years through several national and international projects and International research programs: e-content of European Commission, e-culture, etc. In addition, several projects in the area of music archives have been launched such as: PARAGON (audio distribution and virtual catalogue), CANTATE (sheet music distribution and virtual catalogue), MUSIC Library online, Delos Network Libraries, HARMONICA forum, JUKEBOX, MUSICWEB, etc. Most of these projects and prototypes have been focussed of creating virtual archives by sharing cataloguing information while the sharing of content presents several aspects that have still solved and managed as better described in this article. The above mentioned context and rational have placed the basis for a new generation of activities in the area of music libraries and archives: *the age of content sharing via Internet*.

1.1 The archives of the new age

The amount of multimedia content available in music archives has a strong potential if organised and distributed in multimedia products. The simple exploitation of that material to produce CDs and DVDs with authoring systems is only a small part of its potential because synchronisation and music score integration with other elements, such as sliding shows, navigation in the content, animations, multimedia biographies, etc., are only few examples to mention. In most cases, the relationships among the single related elements of the archive are not explicitly established. For instance, the audio recording, the lyric, the historical details, and the music score of the same piece and version are not linked. Typically, it is only possible to regard those components as related each other by searching via cataloguing information for the same keyword, age, etc. These integrated multimedia music objects can be used for different purposes: educational, entertainment, "edutainment", "infotainment", etc.

In most cases, and especially in the case of educational purpose the content has to be organised in specific manner: synchronisation of music score and audio files, navigation among several aspects according to pedagogical and didactic goals. To this end, specific tools to build and organise music content for these purposes are needed. Commercial authoring tools such as those of Director, Tool Box, or WEB based solutions are unsuitable for such a purpose. An other important aspect is the ability to propose new usages of the archives: automatic analysis tools, specialised devices such as devices for visually impaired people, specialised musical devices as MIDI keyboards, search on the basis of the content (melody), annotating music scores and printing needed and manipulated parts (transposed, reduced ,etc.), are only a few part of these possible new usages.

In this report, the WEDELMUSIC solution to support the multimedia music modelling and content sharing among archives is illustrated. In addition, an extension of the basic WEDELMUSIC solution to allow the distribution of content from archives to final users is also presented. WEDELMUSIC has been defined to allow content providers to share and distribute interactive music according to a Business to Business model, B2B. According to the B2B model, WEDELMUSIC has been studied and implemented to creates multimedia music object and distribute them from publishers to corporate institutions such as: libraries, conservatories, music schools, etc., while the attendees of these institution can access at the information on specific terminals/workstations available in the institution.

The extension also presented in this paper realises a Business to Client model, B2C, by which the attendees can access to the service of the archive from their home, via Internet, if they are registered and only when they are directly connected with a certified computer to the archive.

WEDELMUSIC provides secure mechanisms for music protection, that include: certification mechanism for clients, 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. Today, WEDELMUSIC solution has been adopted by Arcipelago Musica and Active Music Mediateques according to the sharing and distribution schema depicted in this paper. WEDELMUSIC is an

IST Research and Development project partially funded by the European Commission 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; SUGARMUSIC Edizioni Suvini Zerboni, Italy. The general requirements and the validation of the solution proposed have been performed with the support of the large User Group comprised of over 45 experts coming from all the world.

The paper is organised as follow. In next section, a short overview of WEDELMUSIC format is reported. Then the model for distribution and sharing of WEDELMUSIC objects among corporate institutions and distributors is presented. Some aspects of registration, certification and a model that includes the WEDELMUSIC organisation (with the role of certification authority) and collecting societies are discussed. Finally, conclusions are drawn.

2.1 State of the Art

A large amount of multimedia content available in music archives has a strong potential if *organised* and *distributed* in multimedia products.

The simple exploitation of the available content to produce CDs and DVDs with authoring systems is a small part of its potential. In most cases, the relationships among the content components, which are available in the archive, are not evident for users since they are not established in the produced integrated material. For instance, the audio recording, the lyric, the historical details and the music score of the same piece and version are not linked each another. Typically, the components related to given content can be extracted from the data base only by performing specific querying on the cataloguing information. The availability of integrated multimedia music objects of WEDELMUSIC can accomplish different purposes: educational, entertainment, "edutainment", "infotainment", etc. For the most part, and especially when it comes to educational purposes the content has to be organised in a specific way: synchronisation of music score and audio files, interaction with the music score for transposition, arrangement, MIDI execution, music notation editing, music notation printing, etc., and the navigation among several aspects according to pedagogical and didactic goals. They all are activities typically required and performed in a music archive. Features such as sliding presentation, navigation in the content, animations, multimedia biographies, etc., which are available in products produced using authoring tools can not meet satisfactorily musicians' needs. Musicians are prone to consider those solutions as worth for toy systems. For such reasons, commercial authoring tools such as Director, Tool Book, or WEB based solutions are unsuitable for creating music-based courseware: (i) due to high costs when producing products with music scores in their pages and the above mentioned features, (ii) for the lack of support for a secure content distribution via Internet integrated with a mechanism for tracking exploited functionalities, and (iii) for the lack of deep interactivity with music notation symbols and score in general. Other very important aspects of the Archive fruition is to provide tools for: music analysis, visually impaired people (Braille printing, and talking user interface), make query according to the content (melody), annotate music scores and print needed and manipulated parts (transposed, reduced ,etc.), etc. The simple fruition of multimedia integrated content with the above described features via a WEB interface is impossible unless a specific plug-in or active-x is provided, and even in such event problems are totally similar to those mentioned for the authoring systems.

Once the multimedia music object is created it has to be *distributed* to the archive attendees using a specific WEB interface which allows to make advanced queries, etc. In this case, the server has to support query by content and grant secure transactions from the content distributor to the final user. The concept of integrated multimedia music object cannot be replaced by a simple set of WEB pages, both for security reasons and for the pre-setting of WEB based solutions to rank among on-line distribution rather than off-line distribution. A large distribution and sharing of music content is performed through Peer to Peer applications, P2P, like it occurs with Napster or Gnutella. Such content is typically produced unprotected and with no classification information; it is mainly made of simple audio files. That kind of content has no value for the archive user who needs to receive the above mentioned integrated functionalities. P2P applications are a very good distribution vehicle and they can also be exploited for the distribution of protected files provided the latter can be played only by certified paying clients. In this event, the authorisation is performed only at the moment of content playing.

Besides, it often occurs that the content owned by a single archive is not enough to produce integrated information. For example, the historical archive of CASA Ricordi keeps the original music sheets and the first press of several important authors like Verdi and others; on the other hand, the Teatro alla Scala and/or

the Rapezzi Archives have more than 120 different executions of the same piece which differ for interpretation. The real added value and innovation of Internet age music archives is represented by any integration of the content coming from different sources. The aim is to produce complete multimedia music objects and to allow archive attendees to experience a real navigation in cultural heritage regardless of both the location they gain access to the content from and the location where the content is.

Copyright owners like publishers typically allow the content fruition within the framework of cultural institutions, mediateques, educational institutions and libraries, etc. This is from one hand, imposed by the European Treaties and from the other hand, it is considered a good vehicle of promotion. According to the same philosophy the sharing of protected content among archives is going to be allowed if the archives can guarantee to keep under control the content by forbidding copies and uncontrolled duplications. Such a reasonable guarantee can be granted by the Archive itself or by an external organisation verifying the transactions performed among archives and between archives and their users.

The content distribution and sharing is achievable only through adequate protection and monitoring technical solutions. Content sharing can be even performed by using distribution channels such as P2P applications provided that permissions and fees to gain access to the content functionalities are granted each time they are used by specific certified clients. This means to keep economic transaction separate from distribution transactions.

3 Main Features and Results of WEDELMUSIC Project

WEDELMUSIC allows content distributor (publishers, archives, etc.), corporate consumers (theatres, orchestras, music schools, libraries, music shops), and users (students, musicians, etc.) to manage interactive multimedia music in WEDELMUSIC XML format. WEDELMUSIC objects can be manipulated: arranged, transposed, modified, reformatted, printed, etc., respecting copyright and integrates several aspects of music: audio, scores, video, documents, images, animations, synchronizations, etc. They are innovative tools and services for preparing performances, sharing content, studying music, analysing music, learning instruments, distributing music at low cost, etc. These innovative features are possible thanks to the WEDELMUSIC XML Format, reliable mechanisms for protecting multimedia content and Digital Right Management, a set of tools for building, converting, storing, distributing music on the Internet also using multimedia content in several formats: FINALE, SCORE, SIBELIUS, PDF, MSWORD, HTML, FLASH, PS, WAVE, MP3, TIF, GIF, PCX, BMP, TXT, ASC, AVI, MPEG, MOV, QT, PPT, XLS, JPG, PNG, and many many other formats, (most of these are trademarks of their respective companies).

Among the main results achieved by the WEDELMUSIC Project, there are:

- WEDELMUSIC Model and Language
- WEDELMUSIC Server Database System
- WEDELMUSIC Local Distributor
- WEDELMUSIC Editor and Viewer
- WEDELMUSIC Development Tool Kit
- Music Analysis Tool
- WEDELMUSIC Protection Model and DRM, Digital Right Management
- IPR Protection Tools (Encryption and Watermarking of music sheets and audio files)
- Music Editor for Visually Impaired People
- Print module for Visually Impaired People
- Spoken Music for visually impaired people
- IPR Protection Tools (Watermarking of music sheets from symbolic)
- Converter from Finale to WEDELMUSIC format

3.1 WEDELMUSIC XML Format

For music archives, it is very important to adopt music models presenting needed functionalities

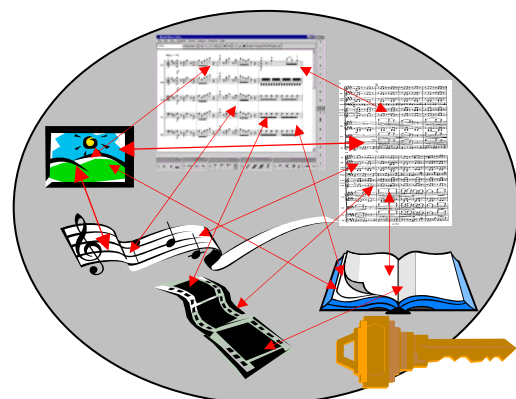


Fig. 1 -- WEDELMUSIC object schema

with a particular attention to the aspects related to the interactivity, but always paying respect to the owner rights. WEDELMUSIC solution proposes techniques for storing, retrieving, distributing and sharing multimedia musical objects. WEDELMUSIC XML format includes symbolic music notation (WEDELMUSIC XML format, Finale Sibelius, etc.), images of music sheets (PNG format), audio files (Wave, Mp3, AIF, etc.), videos (MPEG, AVI, MOV, QT, etc.), documents (DOC, PS, PDF, HTML, TXT, etc.), animations in FLASH, images (TIF, PNG, GIF, PCX, BMP, etc.), identification (ISBN, ISMN, WDFID, etc.), classification (integration of Z.39.50 and UNIMARK), lyrics, etc., and a set of protection mechanisms and Digital Right Management aspects. In each WEDELMUSIC object, several relationships among its components can be established (see Fig.1).

Each specific type of component that can be included into the WEDELMUSIC object has in the WEDELMUSIC tools a specific viewer and/or editor. The most important are the: (i) Music Editor that presents a specific engine for automatic formatting of music sheets, (ii) synchroniser between real performance audio and music notation, image of music sheets, sequence of images and audio, etc., (iii) video player, (iv) audio player that allows to change in real time the execution rate, (v) document viewer and browser including FLASH animations, (vi) image viewer that permit to present still images as well as sequences of them with audio base, (vii) multilingual lyric editor, (viii) fret board editor, (ix) converters from MIDI, Finale, Sibelius, etc., to WEDELMUSIC format of music score.

3.1.1 Applications of the WEDELMUSIC model

The WEDELMUSIC model and format can be used for a large variety of applications:

- Multimedia music modelling and distribution, business to business and for applications suitable for the consumers: mediateques, content distribution towards music shops, kiosks, mobiles systems, music schools and distance learning/teaching, etc.
- Modelling of multimedia music content for advertising, music tuition, edutainment, infotainment, promotional music, mediateques, CDs and DVD, etc.
- For both off-line and on-line transactions, respecting the property rights of the content owner.
- to store and interchange music and multimedia content among different formats and content providers and distributors.
- Valorisation of the multimedia content in archives, museums, mediateques, etc. in the respect of the copyrights, saving the cultural heritage.
- Production of music courses, content organisation, presentation of content, etc.).
- For supporting Digital Asset Management systems integrated with a Digital Right Management Systems supporting a Multimedia Music Format in the respect of the copyrights.

In the example of Fig.2up, a WEDELMUSIC object representing the spring of Vivaldi is reported. It can be observed the symbolic representation of music scores, the audio player, a video player, an image viewer (the author's portrait) and the WEDELMUSIC editor presenting the Image Score of the original score sheet of Casa Ricordi, plus some symbol menus of music notation. Please note that on the left side of the figure, the WEDEL Editor shows the structure of the WEDELMUSIC object. The example of Fig.2down presents a piece of Uccellini. in which on the right the original music score sheet is visible, together with the original dedication to "Serenissimo Principe", the cover of the Basso Continuo part, the page sheet ready to print already produced in WEDELMUSIC format with the music editor, and the audio player.

In Fig.3, the XML version of the general structure of the WEDELMUSIC object reported in Fig.2down is reported.

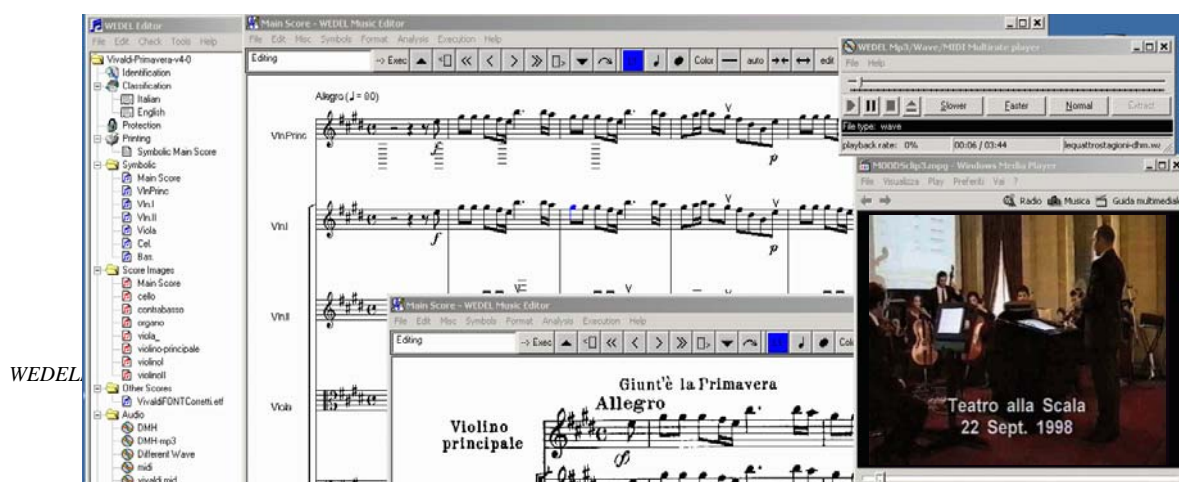




Fig. 2 -- Examples of WEDELMUSIC objects

```
<?xml version="1.0" encoding="UTF-8"?>
<wdfheader WDF_CONDITION="FULL">
  <Identification>
    <WDFID>00000005R</WDFID>
    <Publisher PUBLISHING_STATUS="OTHER">Musica Attiva</Publisher>
    <Preparation_date MAJOR_VERSION="3" MINOR_VERSION="0">20010501</Preparation_date>
    <Music_Geographic_Area></Music_Geographic_Area>
    <LocalDistributor>
      <LD_ID>A00001 </LD_ID>
      <LD_NAME>Arcipelago Musica</LD_NAME>
    </LocalDistributor>
  </Identification>
  <Classification xml:lang="ENG" Description="English">
    <Author>Uccellini</Author>
    <Unique_Short_Name>Hortensia</Unique_Short_Name>
```



```

<Title>La Hortensia virtuosa</Title>
<Genre>Classical</Genre>
<Original_language>Italian</Original_language>
<Composition_date>1645</Composition_date>
<Epoque>
  <Start_year>1610</Start_year>
  <End_year>1680</End_year>
</Epoque>
</Classification>
<Protection PROTECTION_STATUS="" ENCRYPTED="">
  <Purpose>SALE</Purpose>
  <Macro_Audio WATERMARKED="TRUE">
    <Macro>
      <WDFCID>00001100002W</WDFCID>
      <Filename>UCCE-wav-aud.wmo</Filename>
    </Macro>
  </Macro_Audio>
</Protection>
<Symbolic>
  <Wdfitem>
    <Filename>uccellinidemo.swf</Filename>
    <WDFCID>00000000005S</WDFCID>
    <Textual_description>Main Score</Textual_description>
  </Wdfitem>
  <Wdfitem>
    <Filename>1.uccellinidemo.swf</Filename>
    <WDFCID>00000100007O</WDFCID>
    <Textual_description>Part 1</Textual_description>
  </Wdfitem>
</Symbolic>
<ImageScore>
  <Wdfitem>
    <Filename>Main Score.iwf</Filename>
    <WDFCID>000003000006</WDFCID>
    <Textual_description>Main Score</Textual_description>
  </Wdfitem>
</ImageScore>
<Document>
  <Wdfitem>
    <Filename>uccellini_cd_fra-doc.dwf</Filename>
    <WDFCID>000009000002</WDFCID>
    <Textual_description>CD France</Textual_description>
  </Wdfitem>
</Document>
<Audio>
  <Wdfitem>
    <Filename>UCCE-wav.AWF</Filename>
    <WDFCID>00001100002W</WDFCID>
    <Textual_description>low-quality-demo</Textual_description>
  </Wdfitem>
</Audio>
<Image>
  <Wdfitem>
    <Filename>uccellini_copertinabassocontinuo-gif.bwf</Filename>
    <WDFCID>000013000002</WDFCID>
    <Textual_description>Cover Basso Continuo</Textual_description>
  </Wdfitem>
</Image>
</wdfheader>

```

Fig.3 -- XML details of the WEDELMUSIC object of Uccellini reported in Fig.2

In the above example, several details have been omitted. It can be noted that the main WEDELMUSIC XML file (namely the *.WDF file) is comprised of classification, identification aspects plus the description of references to other XML files describing the single components, images, documents, audio, symbolic, etc. Please note that, the WDF also contains details of the object structure when this is organised in protected/encrypted macro objects for the distribution.

Most of above listed features are innovative and only possible through the WEDELMUSIC model. Classical features such as the MIDI/Audio Playing, visualisation of music sheets or documents, etc., have to be considered innovative since in WEDELMUSIC they are allowed in the respect of the owner rights. To make possible the availability of such functionalities we designed a sophisticated set of tools to protect WEDELMUSIC objects and at the same time to permit and control the exploitation of such new functionalities. Distribution in digital (off-line or on-line via Internet) of music and multimedia content is acceptable for publishers and content owners only if supported by adequate protection mechanisms such as those defined and implemented in WEDELMUSIC tools as depicted in the following.

3.1.2 Production of WEDELMUSIC objects

A WEDELMUSIC object is typically produced in 3 phases:

0. **phase 0: basic integration**, files dealing with the music piece (documents, images, audio, etc.) are added into the object and the identification & classification pieces of information are entered as well:

- files related to the music piece (documents, images, audio files, etc.) can be dragged from operating system Explorer and dropped on the WEDEL editor to be added at the WEDELMUSIC object;
- the identification and classification information can be manually entered or imported from another object to be modified and finalised.

A WEDELMUSIC object is produced simply by performing these two steps, thus obtaining an object which is a simple collection of protected and classified files.

1. **phase 1: advanced integration**, the symbolic description and/or the image score is produced by importing scores from other symbolic formats, or directly composing music thanks to the internal full music editor, or including scanned images of the music score:

- When the scanned images of the music score are available, the score images can be produced by using the productivity tool called Image Slicer. It allows to extract staves out of the pages and to import them in the WEDELMUSIC object with an automatic indexing mechanism identifying systems and measures;
- if a FINALE or SIBELIUS music notation file is available, the symbolic description of music can be generated by using a corresponding specific plug-in to load a file in such a programs and save it in WEDELMUSIC format. Otherwise, the user can directly compose music score with the internal WEDELMUSIC music editor that permit to write the main score automatically producing the part or vice-versa.
- if only a MIDI file is available, it may be used to produce the symbolic description but some time has to be spent for a general check on it in order to add those symbols which are missing in the MIDI description. In this task, the WEDELMUSIC editor assists the user in formatting, beaming, justifying music score in an automatic way. It is suggested to load main score from MIDI since parts are automatically generated by WEDELMUSIC editor.
- the multi-lingual lyric (whether available) may be added to the symbolic score by importing the text into the Lyric Editor of the system.

2. **phase 2: component linking**, links between components are established:

- the synchronisation of real audio performance (WAV or MP3) with image score and/or with symbolic score, or with image sequences, can be performed. A specific synchronisation tool is used to establish the time of end of each measure. Since the duration of measures is very similar, if there are no drastic “tempo” changes, and a perfect synchronisation is not needed, the user synchronising the music has not to define the synchronisation for all the measures. He/she can identify the measures where the most important passages occur and synchronise them, the other in between measures are calculated assuming a uniform distribution of duration.
- Integration of music notation can be defined by relating music notation symbols and score images with other object components and players.

It should be noted that at the end of each phase a valid WEDELMUSIC object is produced and this can be delivered to clients. This subdivision in phases is merely accomplished for a rational organisation of work,

while the tools do not force to comply with this order. Each phase can be lighter or omitted, default values are generated when needed.

The produced WEDELMUSIC objects can have very different sizes, from few Kbytes when only the symbolic description is included, up to hundreds of Mbytes or even GByte if there is a video and/or high resolution image score. The production of *phase 0* objects is very fast and simple; automatic tools can be set up to create such kind of objects in XML from an existing database with only reasonable effort. For the production of *phase 1* objects, especially whenever importing a MIDI file, a knowledge of music notation is required, and it is the same with *phase 2* objects, requiring a certain expertise in listening to and recognising music. Finally, a Local Distributor and at least one certified client are needed for test purposes.

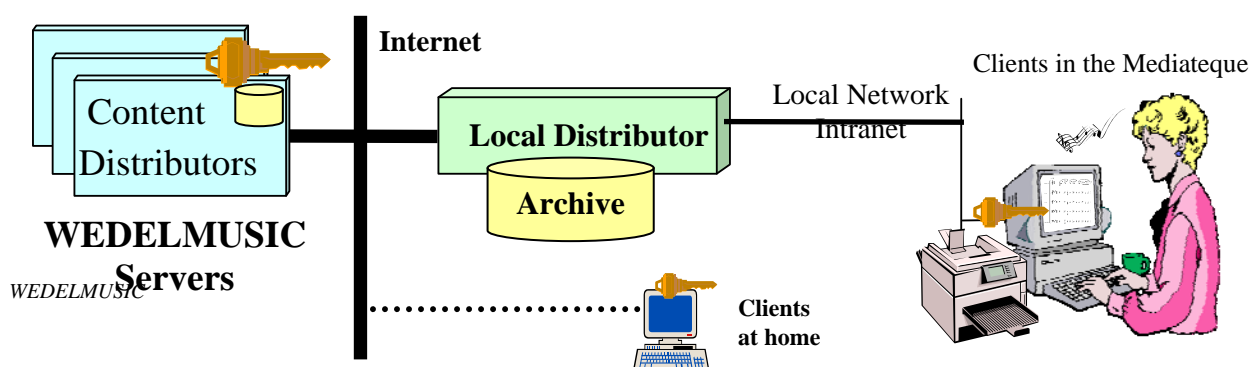
3.1.3 WEDELMUSIC object Maintenance

Objects can be manipulated by adding and removing components, exporting components (data files plus classification info) and importing them in other objects. This is very important to save time in producing WEDELMUSIC object, since, for example, Mozart's biography and his portrait are common to all Mozart's objects, they can be reused as components.

When an object is created it can be uploaded in the WEDELMUSIC Server to be delivered to Local Distributors and from them to clients or shared with other archives. When a new version of the object has to be uploaded in the Server two situations are possible the object is uploaded with a different WDFID or it may overwrite the existing one preserving all the pre-existent transactions, made on that WEDELMUSIC object.

3.2 General Architecture

WEDELMUSIC provides secure mechanisms for music protection, that include: certification mechanism for clients, 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. Today, WEDELMUSIC solution has been adopted by Arcipelago Musica with the idea to adopt in the future a sharing and distribution schema depicted in the following. Other contacts have are under exploitation with Music Australia (national Library) and with the Mediateca of Vaiano, Italy.



3.2.1 Distribution and Sharing MUSIC

The WEDELMUSIC solution is based on several tools. They are referred to the general distribution architecture presented in Fig.4, among them:

- ◆ WEDELMUSIC editor and tool, to produce multimedia music content in the WEDELMUSIC format, integrating several multimedia aspects of music, already mentioned above, together with Digital Right Management rules. This tool is typically used by the Content Providers or by expert clients to produce WEDELMUSIC objects. The WEDELMUSIC editor activates the other editors and viewers upon request: music editor, lyric editor, video player, audio player, etc.
- ◆ WEDELMUSIC Server, meaning Content-Distributor, to distribute WEDELMUSIC objects over the Internet (in a protected or unprotected way). It integrates tools for watermarking audio files and music sheets, reading watermarks, encrypting, decrypting, managing the identification keys, managing the transaction, Digital Right Management, digital asset management, etc.
- ◆ WEDELMUSIC Local Distributor, LD, to provide an interface between the corporate music consumers (libraries, music schools, conservatories, music shops, theatres, etc.) and the general servers and to provide music objects for the internal computers at the corporate consumer's location. An extended version of the Local Distributor can distribute also WEDELMUSIC objects to clients connected to the LD via Internet . The LD can browse with the WEB site of the Content Distributor and 'add to the basket' the object the user is seeking; after that step the order can be sent using a protected protocol and eventually the LD can download the protected objects from the WEDELMUSIC Server. This process can also be performed off-line. Such being the case, the order of the WEDELMUSIC objects will be carried out through CDs, DVDs, FTP process, etc.
- ◆ Music Viewers and Listeners to visualise protected and unprotected music in the WEDELMUSIC format for clients (being either at home or in the mediateque, archive, etc.). The WEDELMUSIC Viewer and Listener includes: WEDELMUSIC music score editor, lyric editor, image sequence editor, video player, audio player, music notation format converts, fret board editor, image sequence editor, etc.

WEDELMUSIC enables publishers, distributors and content providers, to protect and keep under control their music/content when it is distributed and shared with other mediateques:

- On-line: music distribution via Internet (i) from content providers to corporate institutions (libraries, archives, etc.), (ii) from corporate institutions to final users, when they are at home or on their mobile equipment via Internet.
- Off-lines: music distribution via classical digital media such as DVD, CDs, etc., transferring the authorisation and keeping under control the content usage via FAX, email, diskettes, or sporadic on-line connections.

At the same time, WEDELMUSIC solution allows the users to exploit the above mentioned functionalities for distributing/sharing content and its fruition. Clients can get the music content in the archive or at home using a direct connection via Internet to the LD of the mediateque. In this event, they have to be registered and authorised. However, regardless of the distribution model employed, which can be on-line or off-line, or even mediated via P2P applications, the business transaction model is performed from the Client to the Local Distributor and from this to the Content Distributor.

3.3 WEDELMUSIC Server

The WEDELMUSIC Server Database System is a powerful application intended for music publishers, labels, conservatories and any other organisation that can be interested in storing, managing and finally distributing music and multimedia content on the Internet.

WEDELMUSIC Server manages all the aspects related to storage, maintenance, e-selling and Internet delivery of WEDELMUSIC objects, which are digital objects containing music sheets,

audio files, image files, symbolic notation and more. It is possible to store and easily manage millions of music scores, high quality audio and video recordings, images and documents on a single DBMS with multiple disks support (CDROM or DVD jukebox, multiple Hard Disks).

WEDEMUSIC Server provides a set of tools for storage, management and secure delivery of multimedia content in digital format. WEDELMUSIC Objects are composed of multimedia content and metadata containing information about content identification and classification¹. WEDEMUSIC Server provides protected mechanisms, to manage and deliver WEDELMUSIC Objects ensuring that the object content cannot be accessed by other than the intended recipient. WEDELMUSIC Objects and all related components maintains their structure and provides automatic uploads and updates of information such identification and classification in several languages from existing WEDELMUSIC Objects (preparation of new WEDELMUSIC objects is performed in conjunction with the WEDELMUSIC Editor).

Local music distributors can connect to WEDEMUSIC Server via the Internet, browse music catalogue, select WEDELMUSIC Objects to purchase, buy them and finally download them – all strongly protected with security mechanisms. The Server Database directly publishes on the Web multimedia and music catalogues for the stored WEDELMUSIC Objects. Authorisation Management allows users to select and purchase (and pay) only the desired WEDELMUSIC Objects' components and to use them only for the desired operations, and ensures that for each component of a WEDELMUSIC Object only authorised (and hence purchased) operations are performed. Before delivering WEDELMUSIC Objects to a Local Distributor, the Server Database checks all the necessary authorisations and embeds into the object the list of all the allowed operation for each component (permissions configuration). These permissions allow the Local Distributor to use exclusively the purchased components according to the acquired authorisation and are valid only for the specific Local Distributor who bought them.

An extremely high level of security avoids unauthorised use of WEDELMUSIC Objects, using advanced watermarking and encryption mechanisms. WEDELMUSIC Objects are encrypted during the Internet delivery and remains encrypted on the Local Distributor side. Only the WEDELMUSIC Editor, using the proper decryption key can open these objects to perform only the authorised (purchased) operations. For each delivered object, watermarking allows the retrieval of the copyright owner name and the identification of the responsible Local distributor. Log files are produced to trace the whole server activity, with special attention to communication and transactions; accesses to the web site are also monitored and logged.

WEDELMUSIC Server can be accessed basically by three kinds of entities:

- Web users,
- Local Distributors,
- The authorised database operator.

Web users can interact using traditional web browsers, consulting the catalogue of WEDELMUSIC Objects stored in the Server Database, creating their own basket and requesting WEDELMUSIC Objects for download. Local Distributors are WEDELMUSIC compliant client applications intended for the local² management of WEDELMUSIC Objects. Local Distributors can make queries or file requests to the Server Database, which reply coherently with its content, providing the required information, results or files.

The main characteristic and features provided by WEDELMUSIC Server are the following:

- Storing of WEDELMUSIC objects
- Cataloguing and identification of music stored into the Database
- Different searching modalities for different kind of users
- Management of catalogue updates

¹ WEDELMUSIC Objects structure follows the specification of the WEDELMUSIC Objects model and language. The description of this model is out of the scope of this article.

² Typically at mediateques, library or theatres premises.

- Management of Permissions Configurations
- Management of copyright information
- Management of Local Distributors
- Management of Transactions
- Integration of Watermarking
- Access Control
- Integration of Encryption
- IDs and keys management

3.4 WEDELMUSIC Local Distributor

The LD manager may navigate on the WEB pages of the Publisher WEDELMUSIC Servers in order to select the WEDELMUSIC objects that he would like to have on the LD database. The LD Manager may receive the WEDELMUSIC objects via Internet or traditional media such as DVD, CDs, etc. In any case, the keys to get the permission to open the objects have to be requested at the Content Distributors that have produced the WEDELMUSIC object. The received keys can be cashed into a special process and too in the LD for their use when the LD is not connected to the Content Distributor. The connection between the Content Distributor and the LD permits at the downloads of the performed activities in the LD. In this way, the Content Distributor can get the periodic report about the exploited functionalities for statistic purposed or for preparing the bill to the LD.

The Clients/Attendees of the LD are allowed to make queries to the LD database on the basis of cataloguing, identification and content aspects via a WEB interface shown in Fig.5. In the figure, it has been reported the classical interface that permits to produce the query on the Local Distributor archive.

3.4.1 Customisation of the Local Distributor, Client Side

Each registered user of the LD has also access to a private storage area, which permits to store personal data. For example, often-used queries can be stored in this area. For a musicologist using frequently the same objects, or requesting frequently the same objects in the database, this feature is very useful. For the same reason, a system of bookshelves can also be used. The end-user can store on bookshelves most frequently used objects, in order to retrieve easily on their next usage of the database.

The needs of all LDs being very different, in terms of customisation of the graphical interface or of the functionalities offered to the end-user, an open source development model is actually on study. Most of the source of the Local Distributor being written in PHP, and the architecture of the Local Distributor being very modular, separating as often as possible the data management from the HTML templates. This allows to customise the user interface in a very simple manner since the PHP part can be considered distributed in open source.

LOCAL DISTRIBUTOR - ADMINISTRATION TOOLS - Microsoft Internet Explorer fornito da Virgilio

File Modifica Visualizza Preferiti Strumenti ?

Indirizzo http://150.217.15.64/wedel/admin/main.phtml?action=search&template=full

am aripelagomusica

weelmusi©

ADMINISTRATION TOOLS

> Catalog
>> Search (full form)

user: admin

[Help] [Save request]

[home page]

USERS
[view users]
[edit users]
[new user]

TERMINALS
[sessions]
[new terminal]
[edit terminal]

CATALOG
[simple search]
[adv. search]
[full search]
[composers]
[publishers]
[genres]

PERSONAL
[requests]
[bookshelves]

[index] [Title]

☒ AND
☐ OR
☐ NOT

[index] [Composer]

☒ AND
☐ OR
☐ NOT

[index] [Publisher]

☒ AND
☐ OR
☐ NOT

[index] [Genre]

Select among objects that are:

☐ Published
☐ Not published
☒ Both

Genre
Genre
Title
Composer
Publisher
Genre
Date of composition
Component type

Fig.5 -- Local Distributor WEB Interface for clients

3.5 WEDELMUSIC client tools

The Clients uses the WEDELMUSIC viewers and listeners for visualising and editing WEDELMUSIC objects. WEDELMUSIC objects may be built, encrypted on the content distributor site by using a specific key for each LD. Protected files for each LD can be opened only by registered and certified WEDELMUSIC Clients of that LD. The certification of client pass through a specific process of the equipment identification and the exchange of registration keys with WEDELMUSIC organisation as better described in the next Section.

The differences between protected and protected WEDELMUSIC objects are totally transparent for the Client-/User who receives the objects from the LD. The differences are obviously in the use of the object. Only non protected objects can be freely modified by the clients, while protected objects can be manipulated according to the digital right management rules enforced into the object itself.

3.5.1 WEDELMUSIC Editor and Integrator

The WEDELMUSIC editor includes the aspects related to WEDELMUSIC objects' creating, manipulating, verifying, saving, loading, printing, etc.. To this end, several aspects have to be considered: music editing, music conversion, component integration, lyric management, printing capabilities, versioning, formatting, execution, user interface, etc. Such aspects are sometimes edited and manipulated by separate components.

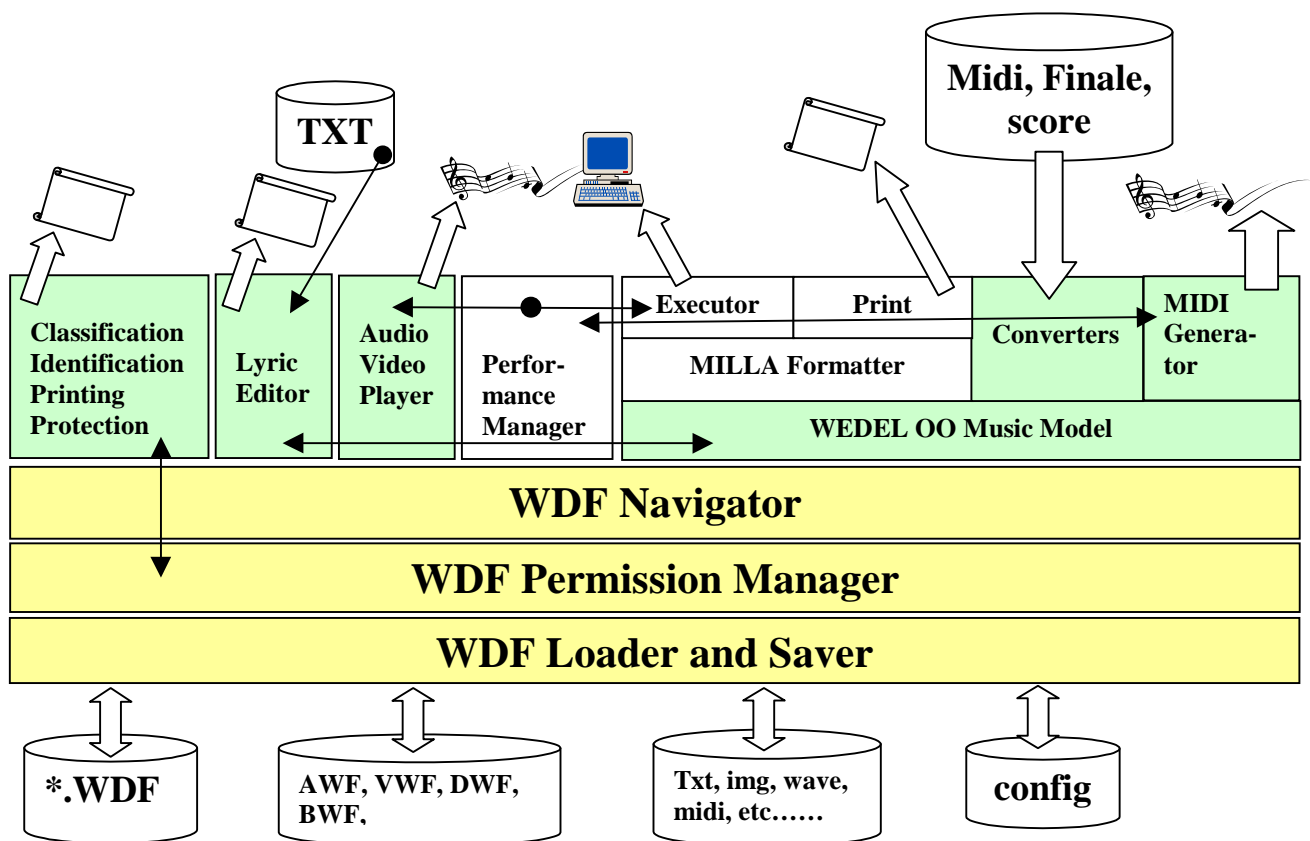
Next Figure depicts the general architecture of the WEDELMUSIC Editor and integrator.

In the following figure the main relationships among the various components are shown:

- **WDF Loader and Saver** -- A loader for the XML format of WEDELMUSIC objects. It is able of loading both encrypted and non-protected files.
- **WDF Protection Manager** -- This module imposes the limitations according to the rules enforced into the WEDELMUSIC object loaded. Each protected functionality may be associated with an assigned price.
- **WDF Navigator** -- a tool for navigating amongst the components of the WEDELMUSIC object including: navigator in the structure, viewer for classification, viewer for identification, etc. It is used for activating audio player, video player, lyric Editor and Visualizer, document viewers, image viewer. It is also used for opening symbolic music Editor and Visualizer or for opening the image score format Viewer and Visualizer. Some of these viewers are external standard utilities of the operating system.
- **Classification, Identification, Protection, Printing Manager** -- for editing and visualising the corresponding aspects.
- **Lyric Editor** -- A tool for editing, importing and printing lyric. Lyric is related to the object oriented model of the music score.
- **Audio/Video Player** -- A player for audio and video files WAVE, MP3, and MIDI files. It is used by the Performance Manager during the execution synchronised with symbolic or image score.
- **Performance Manager** -- A module for generating, loading, saving, defining synchronizations of executions based on either image score or symbolic formats.
- **WEDELOOMM**: WEDEL Object Oriented Music Model including all functionalities of music modelling, printing, playing, transposing, copying, cutting, executing, etc.

- **MILLA Formatter** -- An engine for automatic formatting music on the account of given rules. It has several sub-components for positioning, ordering, justification, beam orientation, stem orientation, etc.
- **Executor** -- The executor for providing the right pages according to the Performance trend defined or on the ground of the Metronomic Indication. This produces the right music score pages in both symbolic or Image score formats.
- **Print (Music)** -- An utility for printing music. It is based on Milla positioning system.
- **Converters (symbolic Music)** -- A set of converters from other symbolic formats such as MIDI, Finale to WEDELMUSIC format. MIDI Converter is included into the WEDELMUSIC editor, while Finale Converter is a Finale Plug-in through which you can save Finale Music in WEDELMUSIC format.
- **MIDI Generator** -- A generator of MIDI sequence of commands from the WEDEL Object Oriented Music Model of the WDF object. It includes orchestration aspects.

If you would like to implement WEDELMUSIC compliant applications, most of the above components are available in the WEDELMUSIC tool kit.



3.5.2 WEDELMUSIC Development Tool Kit

Client tools, and especially WEDELMUSIC viewer, can be enhanced by the development of specific plug-ins. A set of C++ APIs, available in the form of the WEDELMUSIC Toolkit, is provided to developers. These APIs can be used, for example, as analysis tools does (as performed by IRCAM that has developed a music analysis tool for WEDELMUSIC Editor), to extract significant excerpts from the score, but also to develop specific functionalities, as Optical Music Recognition tools, MIDI tools, even specific end user devices - such as specific keyboards, or even to develop synchronisation tools for the purpose of automatic synchronisation between the score and a performance. Another interesting possibility allowed by the WEDELMUSIC tool kit is the development of WEDELMUSIC compliant applications. An example is the WEDELMUSIC Editor for Visually Impaired People that permits to impaired people to (i) edit music by using specific audio interface, (ii) print music in Braille, etc.

3.5.3 WEDELMUSIC Module for Music Analysis

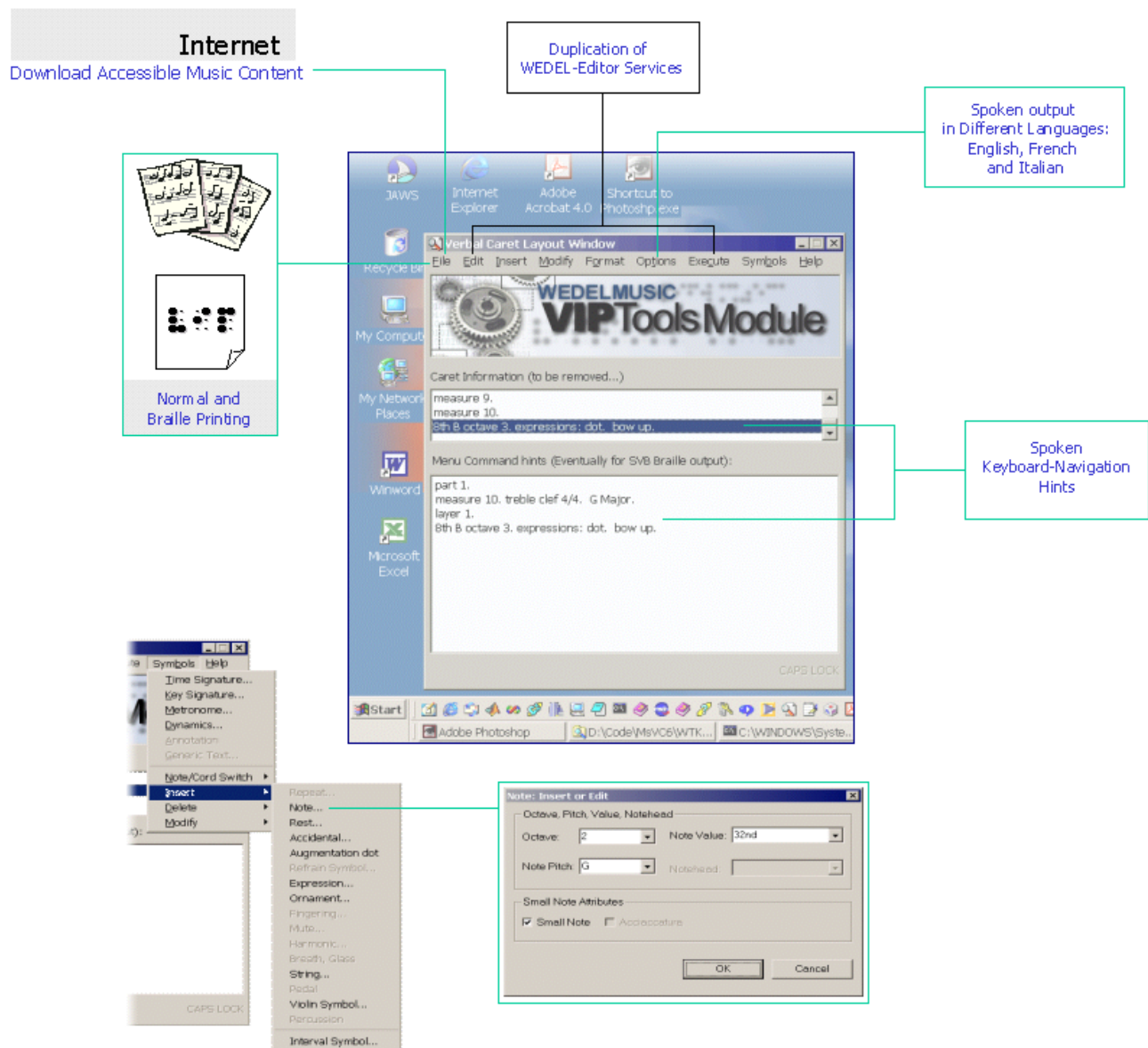
In the WEDELMUSIC model, music analysis tools were developed. These tools, which are able to extract out of the score the most significant motives, the Figured Bass, or the cadences, can store their results in the database as well, as excerpts of the score. The database can then be used to make queries according to the content and using the excerpts as a query criterion. These analysis tools can also be customised by end-users: end users can redefine the rules for cadences, or for harmony, the new rules being stored and shared in the database.

3.5.4 WEDELMUSIC Tools for Visually Impaired People

“Tools for Visually Impaired People” is a software module of the WEDELMUSIC system, referring to a collection of tools and methods that render the modalities of the common WEDEL User Interface to a form accessible from the blind people.

- ◆ *Load, Edit and Print* in accessible form, music and text. The visually impaired can *transcribe* music into Braille format, *print* through a Braille printer and *read* the symbolic notation with a Braille bar.
- ◆ *Get audible feedback*. The computer informs the user through *synthetic speech*, about the symbolic content of the music score currently open. They can thereby navigate through parts, measures, layers and notes of the score much as an ordinary user can do with the graphical Interface.
- ◆ *Listen* to the contents of a score – or a selected portion of it – through the *Spoken Music component* of the module.

The “*Tools for Visually Impaired*” or **VIModule**, handles the access to WEDELMUSIC functionality from Visually Impaired Persons (VIs). This is achieved through the duplication of the majority of WEDEL services, as well as the extension of the user interface with modalities appropriate for individuals with sighting disabilities. **VIModule** integrates existing accessible UI technologies into a single service that enables the impaired user to download a music score and associated information remotely, navigate through the content of the music score using the keyboard and get spoken. The **VIModule** represents the WEDELMUSIC System’s extensions for visually impaired persons. However, the module contains tools that need to be accessible from sighted persons as well, such as the Spoken Music Module and the Braille Printing Module. Aside from these tools, the main role of the **VIModule** is to render the WEDELMUSIC Editor’s functionality accessible to VIs.



It makes implicit or explicit use of the following services:

- **Screen-Reader:** The VIModule does not actually communicate directly with this component, but it certainly relies on its presence to handle focus changes, menu navigation, etc. providing appropriate audible feedback. After all, the **WEDELMUSIC** VIEditor is a typical Windows application itself and can be treated by the screen-reader the same standard way.
- **Speech Synthesiser:** In order to provide additional information to the user, when appropriate, a Text to Speech (TtS) converter is required that supports the three project languages. This TtS converter will be explicitly controlled by the system.

The WEDELMUSIC VIModule itself is divided into the following independent modules and components:

- The **WEDELMUSIC VIP Editor**. It is a simplified version of the WEDELMUSIC Editor targeted to the visually impaired persons. It contains a set of commands for:
- **Retrieving** information related to the WEDELMUSIC Format header of the file opened for editing, as well as classification, identification, structural, and other information. The VI user will be able to download a music piece in the same way as with the WEDELMUSIC Editor. The VI Module duplicates all the functionality needed for the user authentication and copyright protection of the music piece.
- **Browsing** through a score using a caret-like mechanism. Spoken information is automatically provided relatively to both the current caret location and the symbols in the vicinity of it. The VI user has full navigation capabilities using the computer keyboard. They can move to the preceding or the next part,

measure or note relative to the position of the caret or define where they want the caret to be located within the symbolic representation of the music score.

- **Editing** by means of inserting, deleting, modifying, marking, copying and pasting isolated symbols or entire measures or parts.
- **Reproduction** of any portion of the score. This involves diverse actions such as playback, producing a hardcopy using a Braille printer, or transforming the part of the score to the Spoken Music component.
- **Multilingual TTS.** Spoken messages are involved in all the previously described actions, both to assist the VI users to select the respective commands and to provide feedback on the results of their actions on the currently opened score. All messages related to musical information can be issued in English, French and Italian according to the language selection made by the user.
- **Braille Printing:** This module handles all the details for printing a portion of a score to a Braille printer, e.g. selecting the target printer, setting the printing options, and performing the actual data transmission.
- **Spoken Music:** This is a separate module of the VI Editor that handles all the details for music-to-speech conversion in the language selected by the user. The VI user can direct the system to start “saying” the content of the music piece. The speech output can be saved in an audio file.

3.6 Protection aspects

The techniques for PROTECTING MUSIC of WEDELMUSIC refers to tools that allow the save transmission of WEDEL objects and the insertion of identifiers into music (audio files, printed score sheets, images of music score) in order to demonstrate the owner, the musical area and the distributor.

WEDELMUSIC enables publishers and consumers to manage their music interactively protecting their intellectual property rights. E-commerce for music distribution is not viable without adequate protection methods. To fully trust every customer and control his/her applications on a computer is not possible.

WEDELMUSIC presents sophisticated mechanisms for music protection:

- Transaction model that permits to define Business to Business and Business to Consumer communications and interactions.
- protecting digital objects by using encryption techniques
- allowing the definition of personalised Digital Right Management, renting, retail, etc.
- certification of WEDELMUSIC Editor clients to transform them in Trusting Environment
- watermarking audio files
- watermarking images of music score
- watermarking music sheets while printing them

The model adopted is based on the distribution of music from

- publishers or content providers to customers by using the Local Distributors: 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. 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
- Local Distributors to clients that can be located in the Local Distributor internal network or simply connected via Internet. For this last part only a simple trial has been developed as a boundary problems of the project.

In both cases, the Digital Right Management Mechanism permits to keep trace of the activities performed on the simple WEDELMUSIC objects and thus to control the activities performed by the clients via the so called UCM. The UCM is a tool typically located in the same Computer of the Local Distributor WEB Interface that collect all requests of key and of exploited functionalities. The analysis of the exploited functionalities can be done by using this information that can be collected from the Server via a direct connection.

Each operation that can be performed on the WEDELMUSIC object can be permitted or inhibited; more than 50 different multimedia functionalities can be distinctly managed. 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 status of the WEDELMUSIC object: demo, rented object, when it has been sold, when the renting period has been expired, etc. Each performed operation is tracked and thus the publisher may know exactly which are the often requested operations and the most frequently requested music pieces. This allows analysing the needs of the end-users with statistic tools. Operation which are normally inhibited can be on-line requested and received when needed.

3.6.1 Digital Right Management and functionality control

From the point of view of DRM, the WEDELMUSIC solution permits to trace the functionality exploited by clients. This feature is active only for the clients of the corporate institutions, for the other is not possible in absence of a direct connection and needs to be authorised by client for privacy issues. In each WEDELMUSIC object the list of functionalities that can be exploited for that object and their costs is directly included -- for some functionality the number of times that a given functionality can be exploited, can be also stated.

Only functionalities declared into the DRM rules can be exploited. When a functionality (in protected and non protected objects) is exploited a message is sent from the Client to the Local Distributor to get the authorisation and to log the functionality performed. This feature is mainly limited to corporate clients. Clients directly connected via Internet may decide to permit the tracking of functionality or not.

The list of functionalities collected by the Local Distributor permits to perform statistical operations. They are very useful to understand the interest of clients in terms of functionalities, genres, authors, and music in general. In Fig.6, an example of the log file produced by the attendees of Arcipelago Musica Mediateque in Milan is reported. The Mediateque of Arcipelago presents the first WEDELMUSIC solution implementing a Sharable Archive Server. Presently Arcipelago Musica is sharing their content for trial with the University of Florence. In the Mediateque they have 7 workstations for their clients while the Sharable Archive Server hosts both the Content and Local Distributors. Their music is mainly classical modern music: Molino, Schoenberg, Donatoni, Calligaris, Webern, etc. from the begin of the 1900 to this age.

```
*** TIME=14:45:14      SESSID=12  HOST=user2  WDFID=A0010001P      WDFCID=A0011100004D  ACTION=OpenExt_Op  INFO=      PRICE=1.00 EURO
*** TIME=14:58:33      CLOSE SESSION      SESSID=12  HOST=user2 (131.175.228.245)  USER=test

*** TIME=15:23:00      SESSID=11  HOST=ntserver  WDFID=A0010001P      WDFCID=A0011100004D  ACTION=OpenExt_Op  INFO=      PRICE=0.00 EURO
*** TIME=15:30:47      SESSID=11  HOST=ntserver  WDFID=0002000ZU      WDFCID=00020000007R  ACTION=View_Op     INFO=      PRICE=0.20 EURO
*** TIME=15:31:03      SESSID=11  HOST=ntserver  WDFID=0002000ZU      WDFCID=00021100007Z  ACTION=OpenExt_Op  INFO=      PRICE=0.00 EURO
*** TIME=15:39:23      SESSID=11  HOST=ntserver  WDFID=0002000ZU      WDFCID=00020000007R  ACTION=View_Op     INFO=      PRICE=0.20 EURO
*** TIME=15:51:06      OPEN SESSION      SESSID=13  HOST=user4 (131.175.228.247)  USER=test
*** TIME=15:47:42      SESSID=13  HOST=user4  WDFID=00020003P      WDFCID=000211000007  ACTION=Execute_Op  INFO=      PRICE=0.00 EURO
*** TIME=15:49:01      SESSID=13  HOST=user4  WDFID=00020001E      WDFCID=000201000059  ACTION=View_Op     INFO=      PRICE=0.00 EURO

*** TIME=16:05:42      OPEN SESSION      SESSID=13  HOST=user4 (131.175.228.247)  USER=test
```

Fig.6 -- A piece of Log Produced on the Local Distributor of Arcipelago Musica Mediateque

The log file of functionalities can be periodically requested from the Content Distributor to all its Local Distributors via Internet. In this case, the references to user name of the people working on the clients are removed for privacy reasons. This mechanism allows the Content Distributor to produce general statistics on the exploitation of functionalities on its music content. This information can be used in the business contract to define special agreements with Local Distributors. For example, the Content Distributor may be interested to have a fixed monthly rate for the usage of its music if the number of exploited functionalities is under a give threshold while the rate may change when the value is greater. As a limit case, the Content Distributor can be interested to prepare the bill according to the exploited functionalities.

3.6.2 Watermarking Audio Files

Due to effective compression algorithms and the increases in readily available and affordable bandwidth, audio tracks are no longer protected by their once considerable data size. As a result, illegal copying and distribution of music via the Internet must be considered a new form of piracy that was made possible primarily due to the reduced size of the digital audio data and the increased bandwidth available to both consumers and organised crime. This massive distribution potential for pirated copies already appears to severely curtail the market volume of physical CDs, particularly that of CD singles.

The negative effects are currently stressed by music labels, which are endangered by the massive exchange of copyrighted audio files using Peer-To-Peer architectures. These possible effects hadn't been considered before because audio files had been judged as very difficult to distribute because of the huge amount of data.

But modern compression schemes and permanent fast Internet access, especially for private households, taught music industry a severe lesson.

The incessant increase of the hardware and network capacities and improvement of software and compressing algorithms like MPEG 1 Layer III generates a rapidly growing market for dealing in audio data. Easy to use peer-to-peer services are currently used to exchange the data stored locally on the systems of participating clients. Therefore the problem of uncontrolled spreading of copyrighted audio data looms large. The audio watermarking method used in WEDELMUSIC embeds a watermark into audio data to provide the means of protecting owners' and authors' intellectual property rights. We have to embed the copyright information for IPR purposes and also we will keep a trace about the origin of the audio files in order to find the source of a possible unauthorised distribution. Therefore in the WEDELMUSIC architecture two watermarks are embedded in the audio files for identification purposes:

- copyright watermark identifying the publisher and the audio file as one component of the WEDELMUSIC object
- user watermark to identify the local distributor receiving the audio track

The underlying algorithm is based on a statistical method and an psycho acoustic model to embed a transparent and robust watermark into WAVE files. Using the audio watermarking algorithm in WEDELMUSIC the two watermarks can be simultaneously embedded without interfering with one another. The default data rate of 8 bits/second can be adjusted according to the requirements regarding robustness and the watermark minimum segment (temporal segment) of the audio file to be protected. The authorization of reading the watermark is driven by using a secret key.

Digital watermarks are judged mainly by two evaluation criteria: the ability to preserve the quality of the watermarked original and the robustness of the watermark. During the WEDELMUSIC project a lot of tests were performed which reliable showed the robustness of the watermark against

- MPEG 1 Layer 3 compression down to 128kBit/s
- EQ \pm 6dB
- Sample rate conversion (44.1 \rightarrow 22.05 kHz)
- Stereo-Mono conversion
- Format conversion

Furthermore in order to verify the quality constraints of watermarked audio tracks set by the participating user groups involved in the project, both subjective and objective listening tests were performed.

3.6.3 Watermarking Music Scores

An added value of digital distribution and thus of the Internet is the possibility of exploiting new functionalities related to the interactivity. 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., in the respect of the owner rights. To this end various distribution models have been developed. The WEDELMUSIC project has defined a distribution concept, allowing publishers and consumers the exploitation of music. The purpose of this concept is to handle enable digital rights of music in a secure and convenient manner. The fundamental components in the Digital Rights Management (DRM) platform based on this concepts are suitable encryption tools, efficient key management and watermarking of digital objects such as audio files, music sheets, etc.

The necessity for content protection is widely accepted, even though many approaches have failed, even with strong support of the industry as in the SDMI. The intrinsic characteristics of the distribution of copyright protected material to a potentially uncontrolled domain – namely the computer of the consumer – limits the means of active protection: Encryption of the content will protect the content in the delivery phase, efficient and document specific key management may control individual usage of the digital goods. Nevertheless at one end the transition of the digital good to analogue form render any distribution control mechanism useless. At this point passive protection mechanism need to be introduced that can at least proof the source of the material and if possible the fingerprint of the leak, i.e. the identity of the consumer that generated the analogue copy.

Distribution of music sheets is facing the same problems. In deed the legal situation is even more restrict than for other digital goods, as even copies for personal usage are prohibited. Thus copying music sheets using a traditional copying machine infringes the copyright. But the quality degradation introduced again with each copy is a natural limitation for the number of illicit copies – as the musicians will not accept a significant loss of quality. Unfortunately this upper limit vanishes with the increasing quality of the copying machines as a scanned image does only suffer a minimal quality degradation during the copy process.

Digital watermarking techniques provide a certain level of protection, if such watermarks are inserted prior to the printing process and robust enough to survive the initial A/D conversion and multiple subsequent copies of the sheet.

The requirements are rather straightforward. The DRM-model requires that each object (digital good) bears two non-interfering watermarks. On the one hand side the object and it copyright holder should be identifiable and on the other hand it should be possible to extract the identification of the last legal customer form an arbitrary music sheet found in digital or analogue form. In consequence monitoring of the distribution of the watermarked music sheet should be possible through monitoring of accessible digital copies (web crawler approach) or through case by case verification of redigitized analogue copies.

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 LD identification code. The possibility to hide this information and read it 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 or audio file.

In digital music distribution, such as in WEDELMUSIC, the music sheets are printed on the client site with traditional systems. These music sheets may be distributed with a simple fingerprint reporting the music code, the publisher name, etc. In these conditions, the insertion of a hidden watermark in music sheets becomes the key part 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 sheets. The solutions have been obtained after a deep analysis of the possible solutions to hide data code into music sheets.

WEDELMUSIC techniques for watermark have been designed with the aim of presenting the following capabilities:

- The watermark inserted in the printed sheet without disturbing the music reading and playing.
- The watermark inserted into audio files without disturbing the listening of music.
- The watermark remains readable after music sheet acquisition with scanner and its reprints as well as after photocopy with distortions, filtering, zooming, rotations, cropping, noise addition, flipping, etc.
- The watermark has to resists at the attacks or copying during sheet manipulation until the music printed is considered unreadable.
- The watermark removal with image processing techniques has to be more expensive than buying the same music sheet.

In the project, several algorithms for Watermarking music scores have been invented, implemented and validated. The validation has been performed by using objective tools of measurers and test cases and subjective measures by using the user group of experts. This area has produced a lot of publication at the major conferences in which these results have been published.

3.7 Sharing Music Content among Mediateques

The components of the above mentioned architecture can be used for building a large variety of solutions for multimedia and music content distribution. One of the most interesting solution allows the content sharing among corporate institutions. These can be archives, mediateques, second publishers, music shops, associations, etc. Content Distributors that are holding their WEDELMUSIC objects are capable to protect

and distribute them to several LDs. In order to perform their job, they need to have the WEDELMUSIC Content Distributor/Server and Editor for building WEDELMUSIC objects. In some cases, corporations hosting a LD are also interested in building their own WEDELMUSIC objects (e.g., music schools, theatres, etc.) and in distributing them to other LDs.

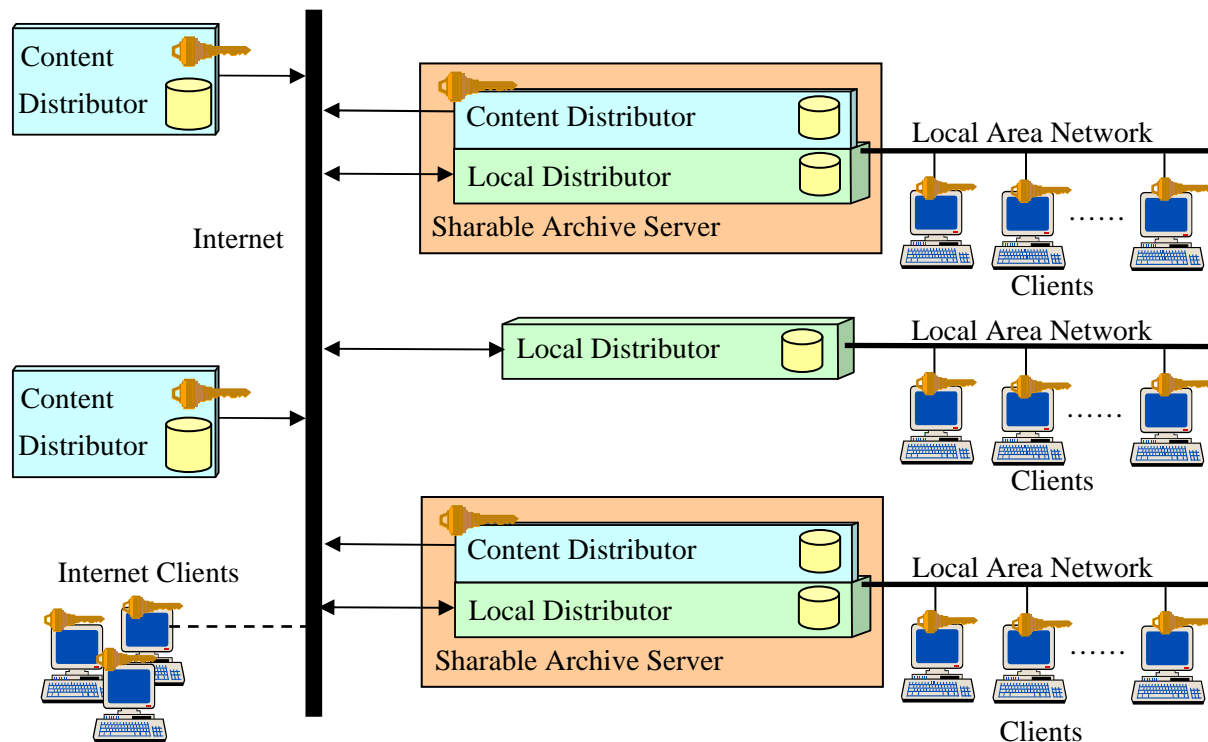


Fig.7 -- Sharing WEDELMUSIC Objects among Archives

In this case, they play the double role of Content Distributors and of Local Distributors. Such a practice allows to build networks of music content archives that share each other their content and at the same time are capable of monitoring the usage of their content on the associated/connected mediateques with their LDs. In several cases, Content Distributors are also interested in becoming second publishers or re-distributors of contents acquired from another Content Distributor. In order to establish this service they need to have a LD. With the Local Distributor they may collect WEDELMUSIC objects from several Content Distributors and other LDs. In addition with the LD they can re-distribute the collected objects to their clients on their plant and to final clients on Internet. In Fig.7, the integrated Content Distributors and LDs are called Sharable Archive Server.

In the Fig.7, the final clients (represented by the computer directly connected to Internet with a dashed line) may have a stable or a sporadic connection to Internet (for instance in the case of Mobile devices). The solution based on sharable archive server allows the implementation of a synergetic mechanism through which each archive may produce content that can be shared by others, thus enlarging the catalogue of the archive.

The above mentioned configurations can be reached incrementally according to the evolution and the needs of the industry or the corporate institution. The several solutions can be obtained by adding modules and modifying the al configuration.

3.7.1 Registration and collecting society

According to the architecture reported in Fig.6, the above describe mechanism for tracking functionalities permits at the different actors involved in the architecture to perform statistics about the activities performed on redistributed and their WEDELMUSIC objects.

This process of collecting information can be performed by an independent institution as supposed in several transaction models. For example, in Fig.8, the general monitoring model is reported. In the figure, the Certified Organisation (presently performed by WEDELMUSIC partners) permits the certification of Clients,

Content Distributors and Local Distributors (see dashed arrows). This process is performed by using a protected connection and a tool that permits to make a link from the application and the computer hosting the application. This is performed by a generator of a unique computer ID on basis of several hardware and software information of the computer itself, without the needs of using the CPU ID.

The same organisation or a different one (as currently performed by RIGEL partner of WEDELMUSIC) can collect the exploited functionalities from the Local and Content Distributors which are active on the network. This permits to make a service for the Collecting Societies which are focussed on tracking distributing right revenues, while they are capable of controlling the process at technical level.

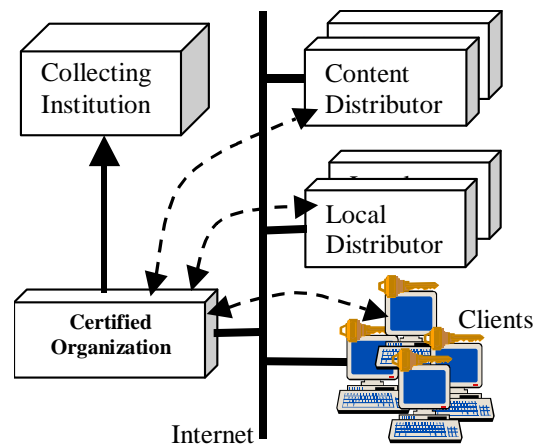


Fig.8 - General Certification and Collection model

4 Social Impact and EC policy contribution

The main contributions to EC policies are:

- Standardisation: the project has to be considered the first step for defining a standard format for distributing music along the network (standard as modelling and protection).
- Ethical problems: protection, tools for protecting copyrights, (based on complexity rather than on non-knowledge).
- Dissemination of results to get consensus for standardisation and further application of the solutions proposed.
- To produce something that can be exported out of the Europe.
- New products: protection model, music model, protection tools, distribution tools.
- New issues in the world market: new solutions, new services.

4.1.1 Contribution to Community social objectives

WEDELMUSIC has several impacts on the social objectives of the EC. The main points are the possibility of respecting the copyrights and at the same time allowing the secure distribution of multimedia music. The lack of a secure model for distributing multimedia music objects has limited the distribution of a huge amount of content and related investments. This has impact also on the limitation of creation of new services for the citizens.

For these reasons WEDELMUSIC solution is effective in:

- Increasing culture of music, since the distribution of music and multimedia music is easier by using WEDELMUSIC. Presently, the lack of a secure model for distributing music has limited the distribution of music along the network to light/popular music that has typically a short life time (some years). Classical music risks remaining in the archive of publishers and libraries since the life of the copyrights for that music is close to 60-80 years. After that period publishers can renovate their rights by preparing critical revisions. Moreover, very old music sheets are also interesting to be viewed for artistic and historical aspects, especially if hand written. These music scores are too delicate to be distributed and photocopied frequently. The availability of such music in digital images accompanied with a symbolic description will be the way for their valorisation. This is a mechanism for saving the cultural heritage regarding music pieces. Publishers and Theatres have very huge archives that are currently un-exploited.

With the WEDELMUSIC images and old music scores, audio records, modern music notation and documents can be joined and presented to valorising cultural heritage.

- Increasing the possibilities of distributing culture since WEDELMUSIC is a new form for music distribution. The music in symbolic format could reach a level never reached by music sheets. It is very frequent that music shops are totally inappropriate for delivering music since the large variety of music pieces and their huge number make the investment for organising a music shop really expensive. This means that the distribution of music via Internet will increase profitability for music shops. Libraries will reduce the costs of storage and could provide virtually very huge archives of music with respect to the real music that they have stored on disks, paper, CDs, etc. This is also a strong and an extremely interesting service for the citizens via Internet. With WEDELMUSIC the publisher are more secure and thus the quantity of material that will be distributed via Internet will grow.
- Improving the quality of life of blind people. This is possible, thanks to the WEDELMUSIC tools for Visually Impaired People. Special agreements are typically performed between the publishers and the music libraries for impaired people. Impaired people are presently strongly penalised with respect to sighted people since the availability of music in Braille format is really poor. With WEDELMUSIC the same format used for delivering music to sighted people is used for providing music to impaired people. This increases the acceptability of diversity for and towards impaired people.
- Valorising the cultural heritage of music that Europe provides. With WEDELMUSIC results, it is possible to distribute the European music and multimedia music in the world without the risk of copyright infringement. This increases the profits for music distributors, publishers and authors. Some of these a SME.
- Producing new forms of leisure and entertainment. It will be possible to receive interactive music at home via Internet. The user, music consumer, can manipulate music preserving the Copyright issues of publishers. The new WEDELMUSIC format opens the way for implementing new mechanisms for teaching music, for distance playing music (a sort of virtual orchestra), for manipulating music in theatres, for exchanging music object among friends, etc.
- Inserting and adapting the music market to the new century commerce tendency. The distribution of non digital objects will be limited in the future. WEDELMUSIC mechanisms open the path for a set of new services and commercial music objects in digital format, supporting the exchange of music and the mediation of distribution via peer to peer applications.
- Opening the path for new services and functionalities for the citizens and for the intermediate users such as multimedia libraries, music schools, and theatres. With WEDELMUSIC, results, it is possible to have full access to the information content of music, thus new functionalities for searching, comparing, converting, music and related components, etc., at different levels for music consumers, multimedia libraries, music schools, theatres, etc.
- Reducing the cost of service for delivering music towards the citizens and increasing the quality of service for the availability of new functionalities with the new interactive format.
- Placing the basis for implementing new forms of teaching and educational training in the close future.

For these reasons, WEDELMUSIC may have a strong socio-economic impact for the implementation of general services that could provide new features and will satisfy the requirements of publishers protecting their music. It has also relevant cultural aspects since the adoption of interactive music for studying and teaching music may be a tools for attracting more students and thus for increasing the cultural level.

5 Dissemination and Demonstration

The objective of dissemination activities is to reach every potentially interested person about the existence of the WEDELMUSIC project and its main objectives/results as well as undertake pre-marketing activities.

The creation of consensus on project undertakings is a fundamental factor that can increase market penetration and facilitate creation of alliances and partnerships among industrial, public and no-profit organisations representing disabled people interests. . In addition, third-party developers and manufacturers can decide to increase their interest in carrying out relevant applications that exploit project results and services.

The Most important activities have been:

- The organisation of and international conference WEDELMUSIC 2001 that continue its life independently on the project results and exploitation, more than 150 experts have been involved.

- The production and publication of a large number of articles
- 190 WEDELMUSIC objects produced for testing and validating the tools (3,8 Gbytes of WEDELMUSIC objects, of real content), while others 200 have been produced by Arcipelago Musica for Business.
- The distribution of demonstrator software
 - A total of about 1500 WEDELMUSIC editors downloaded and distributed for free in demo and full trial version from November 2001 to July 2002.
- The availability To make a large number of specific demonstrations
- The participation to major fairs: ICMC2000, ICME2002, EVA2001, EVA2002, AESC2000, MIDEM2001, IST2001, Musik Messe 2001 and 2002, MILIA2002, IAML, WEDELMUSIC 2001, WEDELMUSIC 2002, etc.
- The creation of a mailing list (45 experts involved)
- The production of high quality dissemination material (6000 flyers, 6 types, 4 posters, etc.)
- The production of strongly published WWW page (mentioned about 600 times in other pages)
 - The www pages have been quite largely visited:
 - 8500 for the main page
 - 4500 for the WEDELMUSIC 2001 conference
 - 2500 for the WEDELMUSIC 2002 conference
- The management of a large User Group of experts (4 user group meetings)

All these aspects have worked each other in a synergetic virtuoso mechanism that allowed us to have a huge number of visits on the WWW sites, a huge number of downloads for the demonstrator, and high numbers of people attending and interested in the organised events.

5.1 Material

Please refers also to the following documents not included in this paper:

- General Flyer of the project
 - First version, Newer last version
- Folder for collecting information and flyers
- Published articles
 - See the list in the following
- Animations of video activities
 - Editors videos, Local distributor videos
- Slides:
 - Several sets of slides for the events and paper presentations
 - Slides for the user group meeting
 - Slides for the review meeting
- Proceedings of the WEDELMUSIC 2001 conference
- WWW sites:
 - www.wedelmusic.org
 - www site of WEDELMUSIC in IRCAM
 - www site of WEDELMUSIC in FHGIGD
 - other 600 links around the world
- CD rom
 - Containing the WEDELMUSIC Editor and documentation
- Posters:
 - General view of the project early version, final version
 - Protection model early version, final version
 - MILIA 2002 poster
- Detailed flyers version:
 - Server Database,

- WEDELMUSIC Editor,
- Tools for Visually impaired people,
- Protection aspects,
- Local Distributor,
- Music Analyser.

6 Validation and Adoptions

The validation of the several aspects and tools of WEDELMUSIC has been performed by using several mechanisms:

- User groups meetings
- Frequent demonstrations and integration meeting among partners for creating demonstrator for fairs and trial partners such as Arcipelago Musica
- Self assessment and validation: each partners has tested and validated the tools produced by the others

6.1 Adoption and future trials

WEDELMUSIC solution has been adopted by Arcipelago Musica with the idea to adopt in the future a sharing and distribution schema depicted in the following. Other contacts have are under exploitation with Music Australia (national Library) and with the Mediateca of Vaiano, Italy.

6.1.1 Arcipelago Music, previous working conditions, and rationales to pass at WEDELMUSIC

Arcipelago musica is a no profit organisation located in Milan, Italy, inside the Fondazione Enrico Mattei of ENI. www.arcipelagomusica.it.

They are active since 1995 in promoting cultural activities in the musica area and in managing a multimedia music mediateque. They organise events and meeting in which modern music is promoted.

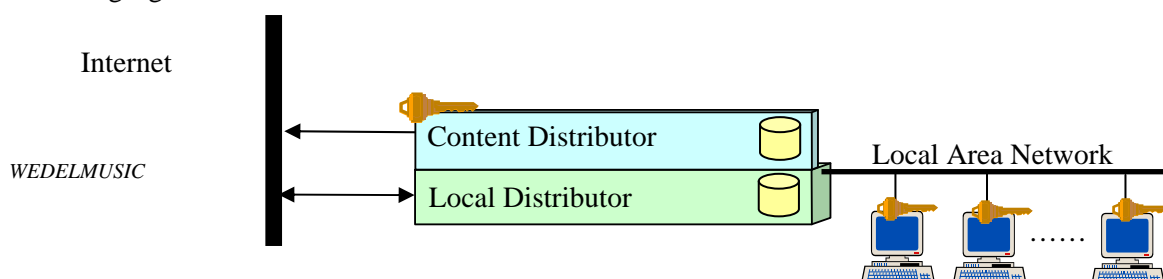
They have been contacted by Paolo Nesi in 2001 (WEDELMUSIC project coordinator). In the past they have built their mediateque with the support of several institutions and companies: Regione Lombardia, Provincia di Milano, Fondazione Cariplo, Fondazione Stelline, HP Italia, Philips Italia, Fondazione Enrico Mattei, International Society for Contemporary Music. They have specific agreements with several music publishers for using their content in the mediateque: BMG Ricordi, Rugginenti, Sonzogno, Curci, Suvini Zerboni e Warner Carish.

At the first contact, the mediateque was supported by a WEB based solution for the fruition of multimedia music content. Their content is mainly comprised of cataloguing information, identification information, audio files, pdf documents containing the scores, images of music scores. The WEB sever used before adopting WEDELMUSIC solution was based on ASP. They decided to pass to WEDELMUSIC for the following functionalities is order of their relevance:

1. Protection of multimedia music objects
2. Possibility of distributing protected multimedia music objects towards other mediateques
3. Presence of innovative functionalities such as the synchronization of images of music score with real audio.
4. Possibility of distributing protected multimedia music objects to clients of the mediateques when these are at home.
5. Possibility of controlling, monitoring the activities performed by the clients on each content to tune the service and to report the exploited functionalities at the corresponding authors and publishers.

6.1.2 The Installation at Arcipelago Musica

The WEDELMUSIC installation at Arcipelago musica has been performed in a couple of times. The first was installed a preliminary version to allow them to start at converting their content in WEDELMUSIC format. The first installation has been performed in April 2002. The specific architecture is reported in the following figure.



They have a single computer for both WEDELMUSIC Server and Local Distributor, a P3, 450 Mhz, and 7 clients endowed of WEDELMUSIC editor. All the Computers are Windows NT with 64 Mbyte of RAM and the network is a simple 10bt Ethernet.

After the first installation, they started to produce the WEDELMUSIC objects by using the Image Slicer and the WEDELMUSIC editor. This last tool has been updated in the last 2 months 4 times for them in order to cope with some problems. In some cases, the changes have constrained to make corresponding changes also in the Local Distributor and in the Server. The most important aspects that have been added/modified according to their requests have been:

- Addition in the XML model of a list of performance participants with their role: Muti-Director, Pavarotti-Tenor, Omar Rossi-Violin, etc.
- The possibility of distributing WEDELMUSIC objects to clients connected to the Local Distributor from their home, provided that the on-line connection is always present.
- The adoption of internal viewers for Video, Documents, images (also in sliding show).

The final configuration has been obtained after about 8 days of work for 2 people of DSI and 2 days of work for ARTEC. This activity has permitted to really validate the WEDELMUSIC solution in a real environment with real needs. According to this assessment, several aspects have been highlighted by Arcipelago Musica that should be needed to improve the system. Most of the technical aspects have been reported in the TIP document. Other aspects to be improved are related to the graphic user interface and to the presentation of the cataloguing information.

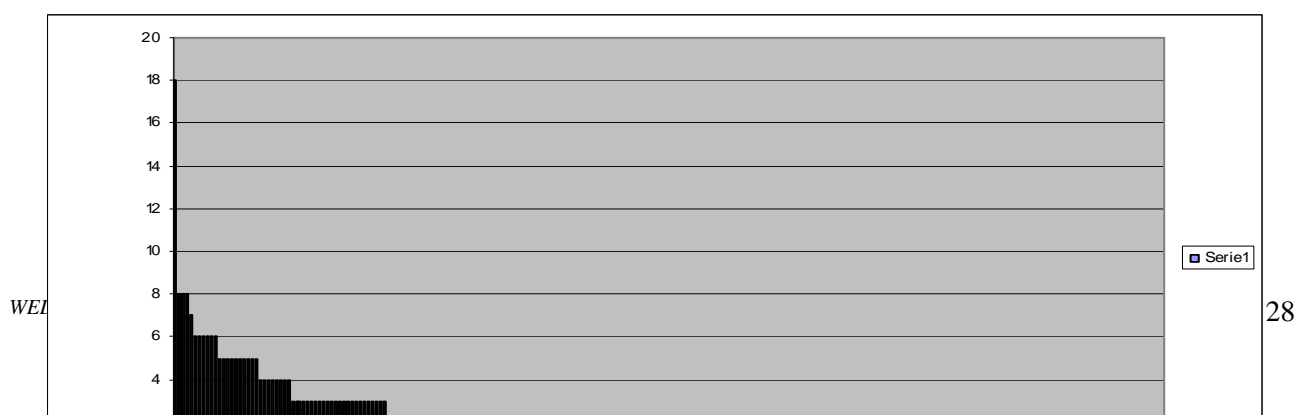
Arcipelago has organised a meeting with WEDELMUSIC representative and the music publishers involved in their activity: Nuova Carish, BMG Ricordi, Suvini (SUGARMUSIC), Rugginenti, Curci, Sonzogno. In addition, at the meeting were present also a representative of the Local Govern of Regione Lombardia plus the ex CEO of HP-Italy. The meeting was organised for presenting the new solution of Arcipelago Musica thanks to the support of WEDELMUSIC. The comments of the these experts have been particularly interesting and some of them were enthusiastic about the possibilities offered by WEDELMUSIC. They are going to have with these publishers specific meeting in which the legal and business mechanisms for distributing WEDELMUSIC objects via Internet will be defined.

At the meeting: Rugginenti, Curci and Suvini demonstrated their interest in knowing more details about WEDELMUSIC and possibly in to have a trial installation in their plant.

Arcipelago Musica mediateque is open only 3 hours per day 5 days per week. In the last two months 509 operations on the single components of their objects have been performed by its clients.

- 246 Open
- 158 view
- 105 execute

These operations assumes a different meaning on different content, Execute has a sense only for audio, while view only for the PDF file. The open has sense for both. No operation of print were allowed and registered. About the 130 WEDELMUSIC objects that they have into the database only 58 have been really used.



The next figure reports the histogram with the frequency of adoption of the components contained into the database, on the x-axis the WDFCID and on the other axis the number of times that have been used. (not all WDFCID are reported in the figure).

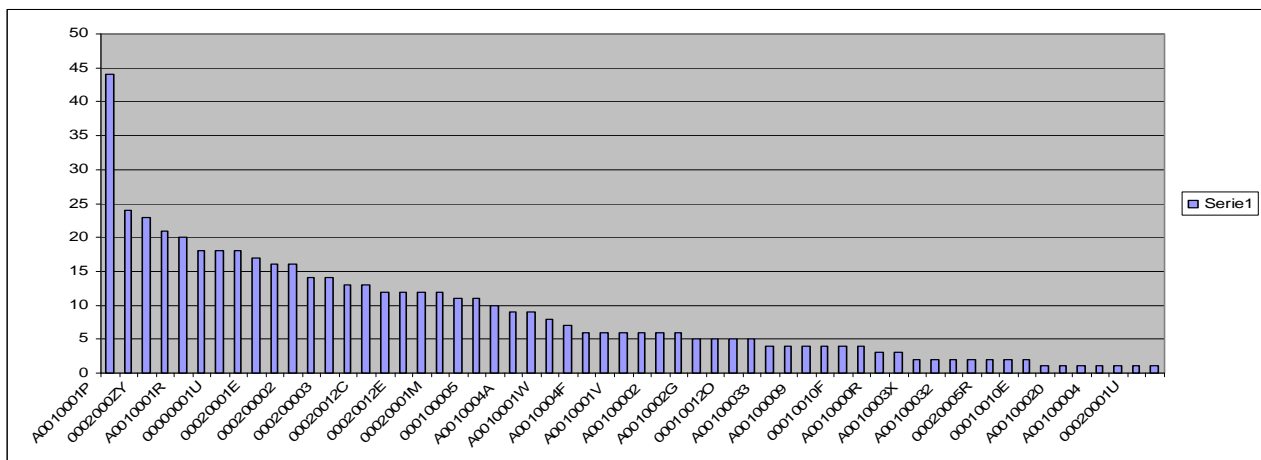
The maximum of the interest has been registered for component having WDCID

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It is the main score of the “Sottili canti...invisibili” of Alandia, Edgar. This is just an example of the analysis that can be done on the traces loaded from the Server.

A similar analysis can be done at level of WEDELMUSIC objects as reported above.

As depicted it is very important to identify the most frequently used music pieces to tune the service identifying the most interesting music pieces and authors. (not all WDFID are reported in the figure).



6.2 Demo Adoption and trial

Among the several contact some of them are more concrete:

- Music Australia, national library of Australia, comprised of 14 mediateques. They are interested in using the tools. Presently they have sent a set of content and DSI, SMF have build some demos. In these days they should test the tools.
- Musica Attiva that an association that will manage the Mediateque of the SMF. The content could be mainly focussed on didactical aspects and exercises.
- Trianon Theatre, a theatre and foundation under restoring that have a collection of Napoletan Songs of the most famous singers.
- Rugginenti a Publishers in Milan that mainly distribute educational Music
- Tempo reale, a research center that is interested in manipulating music notation for modern music.

Also some partners have presented their interest in using the WEDELMUSIC tools: SUGARMUSIC, IRCAM, SMF.

6.2.1 Music Australia, Australia National Library

According to a first meeting had with Music Australia people at the first WEDELMUSIC 2001 conference, they were strongly interested in the solution provided, especially for the following functionalities:

1. Protection of multimedia music objects
2. Possibility of distributing protected multimedia music objects towards other mediateques. They are in effect a chain of 14 different mediateques.
3. Presence of innovative functionalities such as the synchronization of images of music score with real audio.
4. Possibility of distributing protected multimedia music objects to clients of the mediateques when these are at home.
5. Possibility of controlling, monitoring the activities performed by the clients on each content to tune the service and to report the exploited functionalities at the corresponding authors and publishers.
6. Possibility of building protected multimedia music objects by using content coming from different Libraries with the possibility of accounting to each library a fee according to the exploited functionalities on their specific content.

After a preliminary phase, they have send to DSI 5 CDs. The content is listed in the deliverable describing the content for validation. DSI and SMF has produced a set WEDELMUSIC objects for them and sent these to the Music Australia with the program for demonstrating the main functionalities. We have in addition, organized a Local Distributor in DSI to allow them to test the WEB interface of the Local Distributor and to test the protection of WEDELMUSIC transaction model.

We are presently waiting for the results of their tests that should be performed in this month.

6.2.2 Mediateca of Vaiano and Musica Attiva Association

We have been contacted by the City Hall of Vaiano Village this year. They have inherited from a donation a huge archive of lyric music, mainly audio support: tapes, vinyl disk, tapes, etc., documents, lyrics, video tape, etc. Their idea is to digitize all this content to valorize it via a Multimedia Library. They are presently looking for funding for supporting the project of digitization and modeling all in WEDELMUSIC format. In this phase the help of Musica Attiva Association has been very important. Musica Attiva is a non profit association born for the effort of people of the SMF and of DSI with the aim of creating a Mediateque and Computer Music activities in the SMF.

The association itself has intention to build a mediateque located in the SMF and to share content with the other potential growing mediateques.

As usually happen, the intention are very hard to be reached and up to know, even with the huge effort of DSI, SMF, ARTEC, IRCAM and of the other partners only Arcipelago Musica is a reality. The other are more or less simple contacts that have to be managed and grown.

7 Exploitation

Innovation

The most innovative aspects of WEDELMUSIC model and format are:

- Integration of DRM, protection ,watermarking, in the same model
- Activation of several new functionalities obtained exploiting the integrated model
- Integration of several aspects of multimedia music in a unique and flexible format that guarantee the protection: identification aspects, classification aspects, symbolic music notation, images of music sheets, documents, video, animations, audio files, images, synchronisation, multilingual lyric, etc.
- hyperlinks among aspects and different contents, from a single music notation symbol it is possible to pass to an audio, a video, animation, etc.
- synchronisation between some of them: for instance from audio and symbolic music, from audio and images of music sheets, from images and audio, etc.
- The symbolic aspects of music can be converted in WEDELMUSIC by starting from Finale, MIDI or Sibelius formats. A separate tool is available for that.
- The solution defined is strongly innovative, no other similar solutions are on the market for integrating multimedia music and synchronisation of the several aspects in a protected model ready for distribution.

Windows Mediaplayer, mpeg4 based tools quick time, etc., are models strongly focussed on images, while the music notation aspects are not considered, as well as the related synchronizations.

- Certification of clients, identification of the Computer with a unique ID
- Transaction model, B2B and B2C and B2B2C integrated each other
- Digital Right management and monitor of the exploited functionalities. This permits to get trace about the information that can be useful for producing accounting record even for collecting societies.

The model is really better and largely more complete than those which are on the market. The prices of the product produced is impacted in the sense that more functionalities can be given with a lower increment of price. The WEDELMUSIC FORMAT is strongly better in producing multimedia music objects (courses, presentation, content organisation) than the solution

Market Analysis

Presently, for multimedia music modelling there is a lack of co-ordination and standardisation. Multimedia music presents several aspects: coding of symbolic music notation, coding of image sequences of music scores, multilingual lyric that can be mounted of symbolic notation of music according to the specific indexing, images related to music notation symbols or lyric, video related/synchronised to music notation symbols or image scores or documents or lyric text, audio files related and synchronised with music in symbolic format and images of music scores, protection aspects of audio and/or video and/or music scores such as watermarking or fingerprint, verbal description of videos and documents and scores for blind people, etc.

A detailed market analysis has been performed, the most important aspects are in addition to those presented for the WEDELMUSIC model are:

- After the cinema to go in the library is the most frequent cultural activity of European people
- The 12,9 % of Europeans play a musical instrument.
- The 61% of European listen music every day.
- Conservatories, music schools, archives and educational archives in Europe range to about 5000
- Most of them are not in the digital world
- 20-25% of them can be considered as having a sort of digital archive somehow
- Strong bullish tendency, self evident trend to digitising music sheets and reusing them in degree courses
- In the world there are about 2 strong music editor builders: finale, Sibelius, plus others less important: Vivaldi, Capella, SCORE, IGOR, MuseData, etc. The first three have the 90% of the whole market for the production of music scores.
- All these formats can be included into WEDELMUSIC objects, plus any other format covering the 100% of the music notation formats of the world.
- WEDELMUSIC can import from Finale, MIDI, SCORE and Sibelius by using plug ins in these products or by using a direct or indirect loader, with a coverage of about the 95% of all the symbolic music available, commercially and in the archives of the publishers.
- No other multimedia format different from WEDELMUSIC includes music scores and images, video, documents, animations, lyrics, cataloguing and identification information, image scores, synchronisation, etc. The review has considered: macromedia, quick time, Microsoft, adobe products, etc.
- Multimedia formats used in the mediateques are totally unsuitable to go in the Internet Market: no protection, no integration, etc. Most of the mediateques use WEB based solutions that are unsuitable to packaging the multimedia objects, protecting them and distributing them via Internet.

Presently WEDELMUSIC format for multimedia music modelling as no competitors. Music content is presently only distributed as single audio files, documents, and only marginally as integrated objects such as an audio with the song. These tools are starting now with Real Players, and similar tools. Some other far competitors are the PDF (that is not interactive for the music score) and the implementation based on WEB for the mediateques.

The main competitors of the protection model are: info2clear, Intertrust, Reciprocal, etc. In some cases, these companies realised some problems since their protection models have been cracked in short time. Most of them have a simple protection model based on information contained in the registry.

Potential Barriers

The most relevant barriers that can be seen now are those related to the completion of the development, to the engineering of the system and to put it on the market. We think that the market is ready for this kind of product since the content is going to be digitised and its organisation and sharing on the internet is the second step. WEDELMUSIC has been built for that job, and presently no other products are ready.

The main barriers for the adoption of WEDELMUSIC editor and format as a standard are only commercial and political. Most of the corporate institutions that could be interested in having WEDELMUSIC need to take political decisions independently on the technical aspects. The technical aspects are the first step of the process. In several occasions, WEDELMUSIC has been strongly appreciated by technical people, while political people see WEDELMUSIC as a cost without a return of investment. In effect this is false since WEDELMUSIC is a solution that allows publishers, archives, music schools to make business, to make profit.

Technically the model has been defined with the support of a very large group of people: 10 partners plus about 45 experts belonging to the expert user group of WEDELMUSIC and 60-70 people attending conferences and public meeting: fairs such as IST, Frankfurt Musik Messe, MILIA, IAML, etc. All these contributions have been considered and integrated in a unique model.

In addition, WEDELMUSIC has been positively installed with all its components in a Mediateque in Milan Italy. They have presently about 150 WEDELMUSIC objects. 100 have been produced from them and 50 are demonstrational objects provided by DSI. The 100 WEDELMUSIC objects built by Arcipelago Musica contains mainly cataloguing information, audio files, images and documents in PDF. Only few of them contain the synchronisation between the images of the music score and the audio. This permits the music listening and reading at the same time.

Presently the WEDELMUSIC Editor has been distributed for free download from the DSI as

- demo version without temporal restrictions
- full version 6.8 with a limited trial of 30 days, via the WWW of DSI with a rate of about 20 downloads per month.

The version 6.6 is currently distributed for free from:

- www.hitsquad.com, www.SharewareMusicMachine.com

The full version, ver.6.8, has been also distributed:

- to publishers: BMG Ricordi, Rugginenti, Sugarmusic, Nuova Carish, Curci, Sonsogno in a meeting in June 2002 in Milan.
- in the HitSquad distribution CD, and to about 35 experts that have requested the CD in several occasions: MILIA2002, Frankfurt musik messe, etc.

Exploitation Strategy

An exploitation plan has been performed. The most probably and interested first buyers of WEDELMUSIC systems and tools have been identified. The market analysis performed by DSI has been very useful in this work. The Business plan produce in the exploitation plan deliverable has been approved by all partners and have a high probably of success if all the partners will maintain their commitment in terms of dissemination and demonstration even after the project closure. The main aspect consists in the fact the whole WEDELMUSIC systems will be furtherly developed by a company which will bring the products on the market in three years. At the same time, the research institutes and partners will exploit basic research results with other companies in order to start new projects of research and/or development.

8 Selected WEDELMUSIC Publications

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2. SPIE 2001: M. Schmucker, C. Busch, A. Pant "Digital watermarking for the protection of music scores", Proceedings of the SPIE Conference Electronic Imaging 2001, 21-26 January 2001, San Jose, California,
3. Visual 2000: C. Busch, E. Rademer, M. Schmucker, S. Wolthusen "Concepts for watermarking Techniques for Music Scores", Mexico City, 18-22 Sept. 2000.
4. MUSIC IR 2000: A. Georgaki, S. Raptis, S. Bakamidis "A Music Interface for Visually Impaired People in the WEDELMUSIC Environment, Design and Architecture", International Symposium on Music Information Retrieval, Plymouth, Massachusetts, 23rd-25th October 2000.

5. CAST-Workshop on Data-Hiding: M. Arnold "Digitale Wasserzeichen im Audibereich" Darmstadt, November 24, 2000.
6. CAST-Workshop on Data-Hiding: M. Schmucker "Digitale Wasserzeichen in anderen Median" Darmstadt, November 24, 2000.
7. CAST-Workshop on Data-Hiding: A. Katern "Data-Hiding, ein Sicherungselement im Urheberrechtsschutz" Darmstadt, November 24, 2000.
8. Business and Science: Pierfrancesco Bellini, Ivan Bruno, Riccardo Della Santa, Fabrizio Fioravanti, Paolo Nesi, Marius Bogdan Spinu, "Musica e Internet, Distribuzione e Fruizione", in press, 2001.
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17. M. Monsignori, P. Nesi, M. B. Spinu, "Watermarking Music Sheets while Printing", IEEE International Conference of Web Delivering of Music, Florence, IEEE Press, November 2001.
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19. P. Bellini, P. Nesi, "WEDELMUSIC FORMAT: An XML Music Notation Format for Emerging Applications", IEEE International Conference of Web Delivering of Music, Florence, IEEE Press, November 2001.
20. P. Bellini, I. Bruno, P. Nesi, "Optical Music Sheet Segmentation", IEEE International Conference of Web Delivering of Music, Florence, IEEE Press, November 2001.
21. M. Monsignori, P. Nesi, M. B. Spinu, "A high capacity techniques for watermarking music sheets while printing", 2001 IEEE Forth Workshop on Multimedia Signal Processing, J.-L. Dugelay and K. Rose, Eds., pp.493-498, IEEE Press, 3-5 October, Cannes, 2001.
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