Digital Music Education & Training

Deliverable

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Executive Summary:

In this paper there is a presentation of the music score digitization and distribution process. It includes the main concepts of scores digitization, the techniques and the methods, the existing software for each method and the score distribution formats. Additional there is a survey of the existing score on-line distribution systems with analytical presentation of several methods and cases.

1. Table of Content

2. Introduction

Music scores were invented in order to create documents of music creations that can last through time. Today music scores beside of preserving the music creation, they are used widely as a media of music distribution. In the near past, score production and distribution was made through the publishers and the music bookstores. In today's digital era the Informatics & Communication Technology (ICT) offers new and challenging possibilities for the distribution of cultural commodities.

Except from the added value of electronic commerce of printed scores as physical material, the possibility of having a music score in digital form offers a bigger potential for an automated distribution in worldwide recipients.

3. Digitization of scores

The main ways for the digitization of music score there are:

    (1) **Digital Imaging** of an already existed printed or handwritten music score

    (2) **"Engraving"** with a music typesetting or score editor software

    (3) There is also a third "hybrid" way using both techniques: Digital imaging existing score and then **recognizing** and transforming through specialized software to an open format able to be edited with a score editor.

For the A and B cases the software and hardware needed for these processes have important differences: In the A case an imaging hardware is needed (scanner or digital camera) plus a personal computer for storing and image editing; the software is the same for imaging of pictures or other texts. In the B Case a personal computer with a music typesetting software is enough; a MIDI keyboard although sometimes facilitates the note entries. The C case has both hardware and software needs of the A & B case above plus extra software called Optical Music Recognition (OMR) for the transformation to editable form.

In all cases a printer will be useful to transform the digital form back to physical in printed paper.

4. States of documents

In our cases we don't discus only for two states of a document (paper and digital), but we use three because we use two different digital states: *image* data and *semantic* or *symbolic* data. Digital image data is typically a bitmap representation of the pixels like a digital photocopy of a score, whereas the digital semantic data stores in detail all musical information such as the pitch the duration and the dynamic. The state of the document influences the way of distribution, protection and the Digital Rights Management (DRM). An exchange from one state to the other is in many cases possible. Figure 1 shows the three-state model, with transitions showing how data can be converted from one state to another.
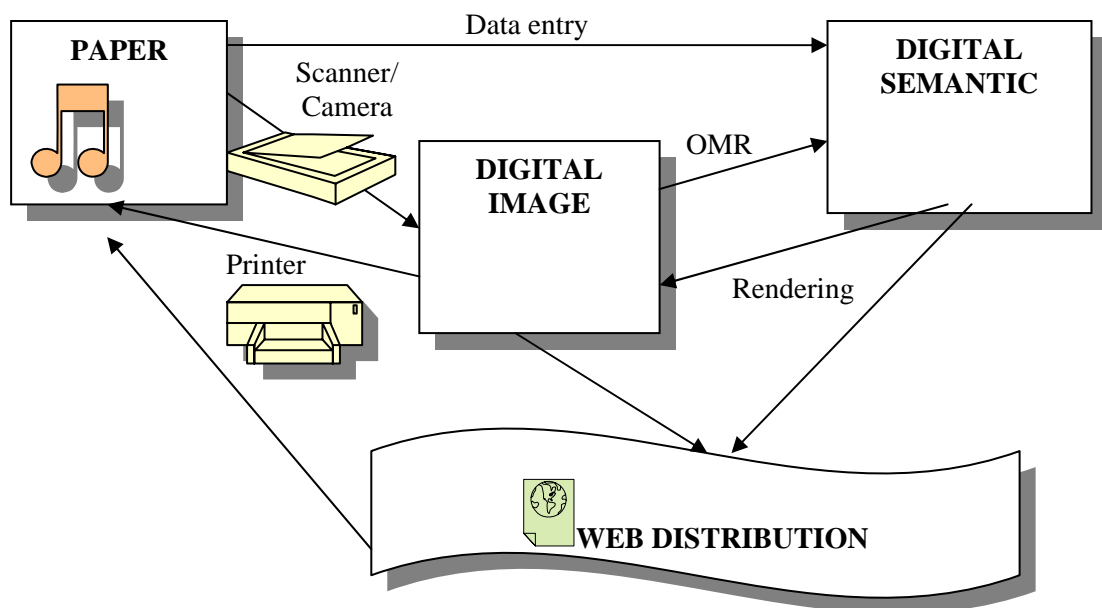

Figure 1

A document may well exist in all three formats. For example, a score in a musician's library might be entered as semantic to a score editor. It can be scanned as a digital image and stored in a computer. But this image can also be recognized through OMR and transform to digital semantic. The semantic form can be edited and rendered back to digital image (e.g. pdf) and printed back to paper. The web distribution can made as digital image or as semantic (editable file). The web recipient of the file can then print the sore for his musical needs.

5. Digital imaging

This is the easiest and fastest way of music digitization. It takes less than one minute per page. Of coarse the existence of the score in paper is essential.

5.1. Hardware

Needed hardware for this method is an image capturing device and a personal computer for image editing and storing. Capturing devices can be:

5.1.1. Flatbed scanners

They work similar to a photocopy machine. The document is placed over a glass with the face down, it is illuminated from an internal light and scanned progressively with a sensible head that transforms visual data to digital. There are many qualities of scanners. The quality differs mainly in

- Scanning speed (up to less than 1 sec per A4 page)
- Interface and Transfer speed (USB, Firewire, SCSI, Lan – up to 1000 Mbps)
- Resolution (9600 or more dots per inch / 36 bit deep)
- Colour and light quality
- Size of document (up to A0)
- Automatic feeder options. (Single or double page ADF)

The prices varies from less than 100 € to more than 35.000 €

5.1.2. Book scanning

They are similar to Flatbed scanners. The big difference is that the document is not placed over a glass face down but face up on a special support. The sensible head is scanning from distance following the morphology of the document. This method is very useful if we have to scan sensible and old books (e.g. manuscripts) that we don't want to press for straitening. Special software can correct the deformation and shadows on the bounded side. Book scanners are significantly more expensive than the flatbed scanners.

5.1.3. Digital photography

It is a fast method of imaging and can be used also as book scanner. It is important here the quality of lens and the illumination. For a 300 dpi equivalent imaging of a A4 page a 8Mpixel camera is sufficient, but for 600dpi equivalent imaging we need a 32Mpixel camera that leads to very expensive models[1].

5.2. Imaging software

Any scanning software supporting saving in different file formats is convenient. Useful options are:

- Batch scanning,
- Support of multi pdf or multi tiff
- Batch correction.

An example of this kind of imagining software is Adobe Photoshop or the open source freeware IrfanView. Important is also the scanner driver software. Sometimes third party scanner drivers (e.g. Silverlining) offer much better calibration control for the scanner and therefore better color quality.

The digital result of the scanned images can be a lossless image (tiff) or compressed (jpg, gif, png or pdf). If our aim is also the preservation and not only the distribution, it is recommended to scan in lossless format in high resolution (600 dpi) and then convert to a lower compressed format for distribution. The most widespread format of digital score images today is the PDF (Portable Document File) that ensures a high compatibility in combination with a small size.

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[1] *More about the imaging hardware see in the section of score digitization specifications in the training material for digital score distribution*

6. Music notation editors

Music Notation Editors offer the possibility of "engraving" a score by entering the music symbolic to a PC and producing a professional looking score that can be printed, played from the computer or exported in several forms for digital distribution. Additional to that other options of this software that facilitate the process are transposing, extracting parts, export in other music formats (e.g. MIDI, audio), intelligent checks, automated creation of chords etc.

Today there is a plethora of such software packages for all OS platforms, in contrast to the one or two notation editors of the '80s, in several budget levels, from free up to 600€. An analytical list of today existing notation software with brief description, their license and the OS that supports is displayed below.

Name	Description	License	Released	OS
ABC2Win 2.1i	ABC music notation	Shareware	04-May-99	Windows
AbcMus 2.0	Playback, search, editing of ABC notation	Shareware	16-Oct-02	Windows
BarFly v1.7.3	Text editor/player/viewer for abc music files.	Shareware	01-Nov-06	Mac
BitMapMusic	A music notation program.	Freeware	01-Mar-00	Mac
Brahms v1.02	Brahms is a sequencer and music notation program	Freeware	07-Jan-02	Linux
capella	Note processing (combined with score scanning capella scan)	Commercial	01-Oct-02	Windows
Chords v1.5	Freeware MIDI Composer.	Freeware	15-Apr-06	Windows
Chords&Keys97	Music notation and drill program	Shareware	17-Sep-99	Mac
Copyist 6.0	Graphical music publishing software for Windows	Commercial	29-Jul-03	Windows
Denemo v0.7.5	Graphical music notator.	Open Source	11-Apr-06	Linux
Digital Music Notebook v2.0.0e	Manage music sheets and instruction materials.	Freeware	30-Nov-05	Windows
Dolet for Finale v3.5	Finale plug-in to read and write MusicXML 1.1 files	Commercial	04-Aug-06	Windows
Elements of Music	Basic knowledge of keyboard skills	Commercial	21-Oct-03	Windows
Encore v4.5.X	Professional-quality composing and publishing	Commercial	13-Oct-04	Windows / Mac
Finale 2007	The ultimate music notation program.	Commercial	13-Sep-06	Windows / Mac
Finale Guitar 2003	Easy and complete notation and TAB software for fretted instruments. .	Commercial	04-Nov-02	Windows / Mac
Finale Notepad 2007	Basic music notation software.	Freeware	10-Oct-06	Windows / Mac
Finale Printmusic 2006	Sheet music software.	Commercial	21-Aug-05	Mac
G7 v3.3	G7 is the perfect tool for guitarists of any level to create tab	Commercial	18-Jul-03	Mac
GOODFEEL 2.6 Braille Music Translator	Automates production of braille music scores.	Commercial	01-Apr-02	Windows
GuitarTeX v2.8.2	Create guitar song sheets or song books.	Open Source	10-Jul-02	Linux
Harmony Assistant v9.2.2	Complete arranger, score editor and music composition software.	Commercial	02-Jun-06	Windows / Mac
Harmony v3.3.1	Tune editor which can add chords to a melody.	Shareware	01-Jul-04	Windows
iabc v1.0.1	Music Notation and MIDI Software.	Open Source	01-Jul-05	Windows / Linux
Igor Engraver v1.7	Intelligent music notation and playback software	Commercial	12-May-03	Windows / Mac

D6.1— Survey of existing software solutions for digitisation of paper scores and digital score distribution with feature descriptions, license model, and their circulation (typical users)

Igor Reader 1.7 build 1280	Display, playback, print and purchase Igor Engraver files	Freeware	15-Aug-03	Windows
Lied v0.1.3	A Lilypond Code Editor.	Open Source	12-Dec-06	Windows / Mac / Linux
LilyPond v2.11.8-1	Produces sheet music using a high level description file.	Freeware	01-Jan-07	Windows / Mac / Linux
Lime Music Notation Software 8.0X	Powerful notation package	Commercial	01-May-03	Windows / Mac
MagicScore Classic 5 v5.016	Music notation software.	Shareware	21-Nov-06	Windows
MagicScore Maestro 5 v5.017	Music notation software.	Shareware	01-Dec-06	Windows
Melody Assistant v7.2.2	Multi-purpose music editing/listening and printing.	Shareware	04-Jun-06	Windows / Mac
MidiIllustrator Maestro v1.0	Notate, print, practice & play free MIDI sheet music & lead sheets.	Shareware	13-Nov-06	Windows
MidiIllustrator Virtuoso v1.0	Notate, print, practice & play free MIDI sheet music & lead sheets.	Shareware	13-Nov-06	Windows
MidiNotate 4.0.9	MIDI player that shows and prints the notes.	Shareware	14-Apr-04	Windows
MidiNotate Composer v1.1.5	Easily create music your way.	Shareware	05-Oct-04	Windows
MidiNotate Player v1.1.1	Find and convert MIDI files to sheet music.	Freeware	07-May-05	Windows
MIDIView v1.1	Converts MIDI files to music notation with showing them on the screen.	Shareware	22-Oct-04	Windows
Mozart 2005 v8.1	Creates, edits, and prints music - just as a word processor does with text	Shareware	01-Jun-01	Windows
Mup v5.2	Music publication program - for Linux x86 systems.	Commercial	12-Feb-06	Linux
Muse	Music notation editor, guitar tab generator.	Freeware	09-Mar-99	Windows
MusEdit 3.22	An inexpensive, yet full-featured music notation editor.	Commercial	24-Nov-99	Windows
Musette v2.6.3	Free Music/Song Notation Editor.	Freeware	16-Dec-04	Windows
Music MasterWorks v3.89	Create, sequence, compose, edit, print MIDI music.	Shareware	22-Sep-04	Windows
Music Publisher 32	Completely flexible notation software	Shareware		Windows
Music Publisher 5	WYSIWYG Music notation with sound	Commercial	12-Dec-01	Windows
Music Works Personal v2.5	MIDI Composing Notating & Sequencing	Trial		Windows
Music Write Maestro	Compose, play, edit and print music on your home PC.	Commercial	01-Aug-02	Windows
Music Write Songwriter	A powerful notation program that's easy to use	Commercial	01-Jul-01	Windows
Music Write Starter Kit	Compose, play, edit and print music on your home pc.	Trial	01-Aug-02	Windows
MusicEase 8.1	Music score editor: edit, transpose, play, import scanned music, and print music.	Shareware	17-Mar-03	Windows
NotationMachine	Notation software - import/export MIDI files, drag and drop notes, guitar chords, more	Shareware	01-Oct-02	Windows
Note Attack	Learn to read sheet music with this free MIDI educational video game	Freeware		Windows
NoteAbility Pro v2.310	Professional music notation package.	Commercial	12-Jun-06	Mac
NoteChaser	Music Transcription Assistant	Shareware	01-Oct-99	Windows
NoteEdit v2.8.1	Music notation editor.	Open Source	16-Aug-06	Linux
NoteWorthy 2	Music DTP system	Shareware		Windows
NoteWorthy Composer v1.75 Beta 1	Create, record, edit, print & play back your own music	Beta	12-Jun-06	Windows

Overture v4.01/3.61	Professional standard notation software.	Commercial		Windows / Mac
PaperChord 1.1	For guitar players who want to notate chords and chord-progressions.	Shareware		Mac
PBJ Computer Activities (mac)	User-friendly, entertaining and student-centered music education software	Commercial	14-Apr-00	Mac
Percussion Studio v3.0	Simple rhythm notation system	Shareware	06-Jun-05	Windows
Pizzicato v3.0.3	Music notation software.	Shareware	27-Oct-05	Windows / Mac
Play Music	Makes music composition easy.	Commercial	01-Jan-02	Windows
PrintMusic 2006	Create and print sheet music	Commercial	13-Aug-02	Windows
QuickScore Elite Level II v12.0	Comprehensive, integrated software for music composition.	Commercial	17-Dec-06	Windows
Rosegarden v1.4.0	Professional audio and MIDI sequencer, score editor, and general-purpose music composition and editing environment.	Open Source	19-Sep-06	Linux
Scorch 2	The leading technology for viewing, playing and transposing music notation on the Internet.	Freeware	01-Jan-01	Windows
Score Writer 4	Everything you need to have fun recording, editing, arranging, and printing out your own music	Commercial	12-Jun-06	Windows
shpflnat.sit.hqx	Musical notes and characters Font	Shareware		Mac
Sibelius v4.1	The world's best-selling music notation software for Macintosh.	Commercial	02-Jan-06	Windows / Mac
SmartScore Songbook Edition 3.4	Unlock the melodies and nuances hidden inside your sheet music.	Commercial	01-May-05	Mac
Solo Explorer	Wave-to-midi converter, automatic music transcriber (recognizer), and score editor for Windows.	Commercial	20-Mar-02	Windows
Songsheet Generator	A free program for printing song sheets.	Donationware	28-Nov-06	Windows / Mac
TaBazar II	Notation program for fretted instruments and percussion in tablature and/or standard notation.	Shareware	01-Mar-05	Windows
TablEdit Tablature Editor 2.62	Create, edit, print and listen to tablature and sheet music.	Shareware		Windows
TEFview TablEdit File Viewer 2.60	Displays, plays and prints tablature and sheet music	Freeware		Windows
TGTools Plug-In Collection for Finale 2.X	Plug-In Collection for Finale	Shareware	29-Oct-02	Windows / Mac
Transcribe! v7.32	Software to help transcribing recorded music.	Shareware	04-Oct-06	Windows / Mac / Linux
Vivaldi Gold	Notation software that combines high performance and extreme simplicity	Commercial	01-Jan-03	Windows / Mac
Vivaldi Play Along	Entry-level notation software	Freeware	01-Jan-03	Windows
Voicings v5.02	Guitar notation and multitrack sequencer.	Shareware	02-Dec-06	Windows
WEDELMUSIC XML Plug-in for Finale 200x	A Plug-in for Finale 200x to save music notation in XML format of WEDELMUSIC Editor	Commercial	01-Jan-02	Windows
Xenoage MusicXML Player	Plays back MusicXML files and converts them to MIDI.	Free Beta	12-May-04	Windows

The important abilities of Notation Software that usually consists the difference from a low budget to an expensive package and are also crucial for the decision of selection are:

- **Professional looking of score** (quality of standard music font used and the distance between and the alignment of note heads)

- Ability to use **several music font sets**

- **Multivoice** typesetting (entering the polyphonic songs as separate voices even if they are in the same stuff line)

- **Extraction** possibilities (parts, voices, lyrics etc)

- **Export / Import** options (supporting the existing music and graphic standards) *see below*

- **Automation**, **batch processing** and **scripting** possibilities (e.g. changing all middle Cs to C#, automated chords)

- Collaboration with **Optical Music Recognition** software

- User Interface - **easiness** of use

- Quality of **audio reproduction** (e.g. performing all the music symbols, quality of sounds)

- **Extra** possibilities (tablatures, creation or insertion of custom graphics, unusual stuff lines etc.)

For the digital distribution the most important factor are the export and batch processing options.

While batch processing is useful to export big amount of scores the export is definitive for the way the distribution will be made. There are two categories of export options: as digital image and as semantic file.

7. Digital Image

Professional notation software allows exporting many different image file formats.

The most important are:

- **TIFF (Tagged Image File Format)**: It has the highest quality. TIFFs are big files and cannot be used directly for digital distribution but they can be used for processing from other imaging conversion software.

- **MultiTIFF**: as above but with the possibility of many pages in one file. Very useful to keep all the score in one file but not all imaging software can read MultiTIFFs

- **JPEG (Joint Photographic Experts Group), GIF (Graphics Interchange Format), PNG (Portable Network Graphics)**: They have internal compression thereby they are small files but there is no multi option so every page should be a separate file.(*there is a special version of PNG format called MNG supporting multis but it is not widespread*).

- **PDF (Portable Document Format)**: It is the most common score digital distribution format. It produces small files with option of multiple pages, bookmarks as well as document protection. If the notation software cannot produce directly PDF there is intermediate ways to produce them a) producing another graphics format and generate the PDF from other imaging software and b) using special software drivers (Print2PDF, Win2PDF, PrimoPDF) that simulate a printer generating PDFs from the print command.

- **PS (PostScript)**: As postscript is a graphics description language it can produce files with very high quality print results, smaller than TIFFs (but bigger than PDFs). Like PDF, PS files can be produced as export option or using special drivers. Although the quality of PS files is better than PDF, currently PS tend to be replaced from PDF because the late one is more compatible and produce smaller files.

8. Semantic or symbolic files

Exported semantic/symbolic files, in opposite to image files, include the music information not as pixel but as music data. These files are preferred for digital distribution because the capacity of the file is smaller than the graphic files and – the most important- through the appropriate web software it is possible to be played, often following the score representation, in the way that the recipient can have an audio impression before consumption. The common formats of such files are:

- **MIDI**: Actually it is not a music score format but of its main musical content (pitch, duration, voices etc). Standard MIDI files are very small, they carry all the musical information and they can be played in all platforms. The main problem is that they don't have a visual version of the score unless they are imported in notation software but even in that case some visual information (way of binding notes, ornaments, ligatures etc), are altered or missing.

- **Music Score Interchange File Formats:** For more than 20 years the existence of a standard Score Interchange File Format was a subject of many efforts and proposals, which were never widely adopted. Such formats are MuseData, TILIA, MusicML, Humdrum, CMN, SMDL, MML, ExpressionMIDI, and MIDI+. The two more adopted formats are NIFF and MusicXML.

  - **NIFF (Notation Interchange File Format)**: Based on the RIFF standard NIFF was for a long time the most widespread notation interchange file format. Many professional music score software still support this format. NIFF has stopped its development leaaving place to the newer MusicXML

  - **MusicXML (Music Extensive Markup Language). Developed from** Developed 2004 from "Recodare LCC" music publisher and based on XML, MusicXML is today the most adopted music notation interchange file standard. More than 65 applications support Import or Export in this format. Like XML, MusicXML has markup-schema tree structure and is readable from a text editor. MusicXML can transcribe almost all the information of a music score and reproduce them in many software systems by recreating music scores that are almost the same with the original. Follows an example of the simplest music score representing a middle C and its transcription in Music XML

```xml
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<!DOCTYPE score-partwise PUBLIC
    "-//Recordare//DTD MusicXML 0.5 Partwise//EN"
    "http://www.musicxml.org/dtds/partwise.dtd">
<score-partwise>
  <part-list>
        <score-part id="P1">
          <part-name>Music</part-name>
        </score-part>
      </part-list>
      <part id="P1">
        <measure number="1">
          <attributes>
            <divisions>1</divisions>
            <key>
              <fifths>0</fifths>
            </key>
            <time>
              <beats>4</beats>
              <beat-type>4</beat-type>
            </time>
            <clef>
              <sign>G</sign>
              <line>2</line>
            </clef>
          </attributes>
          <note>
            <pitch>
              <step>C</step>
              <octave>4</octave>
            </pitch>
            <duration>4</duration>
            <type>whole</type>
          </note>
        </measure>
      </part>
    </score-partwise>
```

Furthermore, lately special software is developed that can play or represent the score on the web on-line growing MusicXMLs usability.

- **Custom export file formats:** Some notation software support the export in own text file formats like Finale's Enigma file and MusiXTeX format

- **HTML**: Some notation software (e.g. Sibelius, Harmony Assistant) can export HTML files that can be directly published on Internet.

9. Optical Music Recognition

Optical Music Recognition offers a possibility of transforming a digital image of score in an editable symbolic-semantic format. Although the research in OMR has started more than 20 years ago, it is only the last few years that there is accurate software packages that can be useful for the purpose they were developed. This is due the fact that, if the recognition is not in a high percent, the time spent for the correction is more than entering the score from scratch. OMR systems function in the following way:
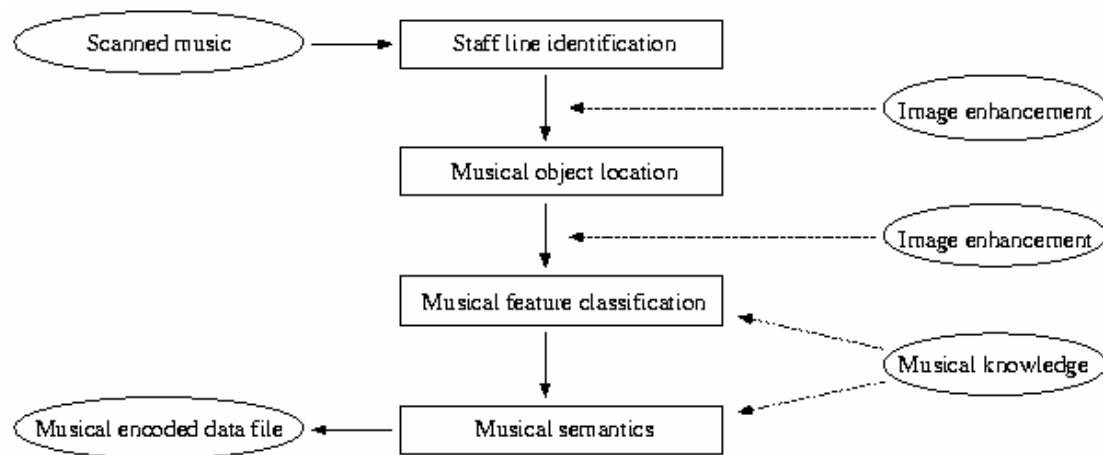
For the Musical Object Classification process, the recognized object should be in a range of well known signs where many of them are similar. The figure below shows an example of unsuccessful recognition.
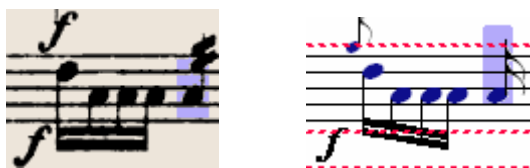
Left is a detail of a scanned printed score and right the recognition result. That's the reason why today's OMR software is confused with handwritten notation (unless it is typesetting looking). Even printed score should be **a)** a good print **b)** carefully scanned, **c)** with notation as much as closer to conventional. If this is the case OMR can have a 100% success of recognition.

Most of the existing packages can recognize not only the pitches and the duration but also the dynamics, ornaments, rehearsal marks and lyrics in many languages. Some of the packages are combined with score editors and they export the results only for them while some other can export in standard music symbolic formats like NIFF and MusicXML that can easy imported to many professional score editors as well as standard MIDI files.

Important aspects of OMR software are:

- Import options (support of standard image formats, several resolutions and direct scanning)

- Export options (support of standard notation file formats – not only MIDI *see below*)

- Batch recognition of many pages

- Recognition of text and lyrics in several languages

- Recognition of non common symbols

Below there is a list with OMR software with data on input and output options the Operating System they function, their URLs, prices and other comments.

Optical Music Recognition (OMR) Software

Program	Publisher	Input	Output	Platforms	Web site	Price 2006	Comments
Capella-Scan 6.0(?)	Capella Software	bmp, gif, pdf, png, PS, tif, scanner	Capella, MIDI	Windows 95 or above	www.capella-software.com/capscan.htm	$188	*Current version number is uncertain.*
MIDI-Connections Scan	CAS	tif, scanner	MIDI	Windows 95 or above	www.midi-connections.com/Product_Scan.htm	CHF 168	*Web site is in German.*
MP Scan 2	Braeburn Software	bmp, scanner	Music Publisher	Windows 95 or above	www.braeburn.co.uk/mpsinfo.htm	$112.50	*MP Scan is an add-on for Music Publisher; said to be identical to SharpEye.*
NoteScan	AMNS	tif	Nightingale	Mac OS 9 & X	www.ngale.com	N/A	*Bundled with Nightingale. The 1st commercial OMR software, but hasn't been upgraded in years.*
OMeR (Optical Music easy Reader) 2.1	Myriad	gif, jpg, pdf, png, tif, etc. (via QuickTime)	Melody/Harmony Assistant	Windows 95 or above, Mac OS 8.6 - X	www.myriad-online.com/en/products/omer.htm	$20	*Add-on for Harmony Assistant and Melody Assistant: Myriad Software*
PhotoScore 4.1.2	Neuratron	bmp, pdf, scanner	MIDI, MusicXML, NIFF	Windows, Mac OS	www.neuratron.com	$199	*Lite version comes with Sibelius*
ScoreMaker 4.0(?)	Kawai	??	MusicXML, other(s)	Windows 98 or above	www.kawai.co.jp/cmusic/products/scomwin	??	*Music scanning & notation program, sold mostly in Japan (and web site is in Japanese). Version number is uncertain.*
Scorscan 1.3	npcImaging	tif, scanner	SCORE	Windows 95 & 98	www.npcimaging.com/scscinfo/scscinfo.html	$595	*Based on SightReader(?)*
SharpEye 2.67	Visiv	bmp, tif, scanner	MIDI, MusicXML, NIFF	Windows 95 or above	www.visiv.co.uk	$169	*An SDK and a standalone command-line version are available.*
SmartScore Pro 5.0.3	Musitek	tif	Finale, MIDI, NIFF	Windows, Mac OS 9(?) & X	www.musitek.com/smartscre.html	$399	*Academic price $299. 3.0 Lite comes with Finale 2004 & 2005*
Vivaldi Scan	goVivaldi	bmp, tif	Vivaldi, XML, MIDI	Windows 95 or above, Mac OS 7 - 9.2.x(?)	www.vivaldistudio.com/ENG/VivaldiScan.asp	119 €	*"Derived from SharpEye". May no longer be available for Mac OS.*
Audiveris 2.4	open source	??	MusicXML	Java	audiveris.dev.java.net/	free	*Licensed under the GPL. Despite the version number, does not appear to be usable yet.*
Cantor	academic	??	??	??	N/A		*David Bainbridge's 1997 PhD work. Apparently not compatible with current C++ environments.*
Gamut/Gamera system	academic	tif, png	GUIDO, MIDI, lyrics	Linux, Windows, OS X	dkc.jhu.edu/gamera/		*In use by JHU/Levy project; based on Fujinaga's 1997 PhD work (AOMR/OMI), later work by Droettboom & Fujinaga*
SightReader	academic	tif	SCORE	DOS? Windows 3.1?	N/A		*Nick Carter's 1989 PhD work*

MIDI vs. MusicXML. The examples below show an excerpt of a printed score scanned and recognized with SharpEye software, as well as the difference of reproduction from a file saved in MIDI and MusicXML respectively. On the MIDI case although the lyrics are preserved (MIDI supports also lyrics) other information is lost or mismatched

Excerpt from Schumann's Op. 24, No. 4 as scanned into SharpEye

Importing SharpEye into Sibelius via MIDI

P, *the ties and* some ornaments are lost. Some durations are misunderstood.

Importing SharpEye into Finale via MusicXML

All Music information is reproduced identical and editable.

Examples of the same score recognized from different software.

10. Audio to software

A special case of software for making scores is the one that recognize pitches from audio recordings. With this software it is possible to transcribe the audio to MIDI and to score. The recordings can be monophonic but also polyphonic if the audio signal is not very complicated.
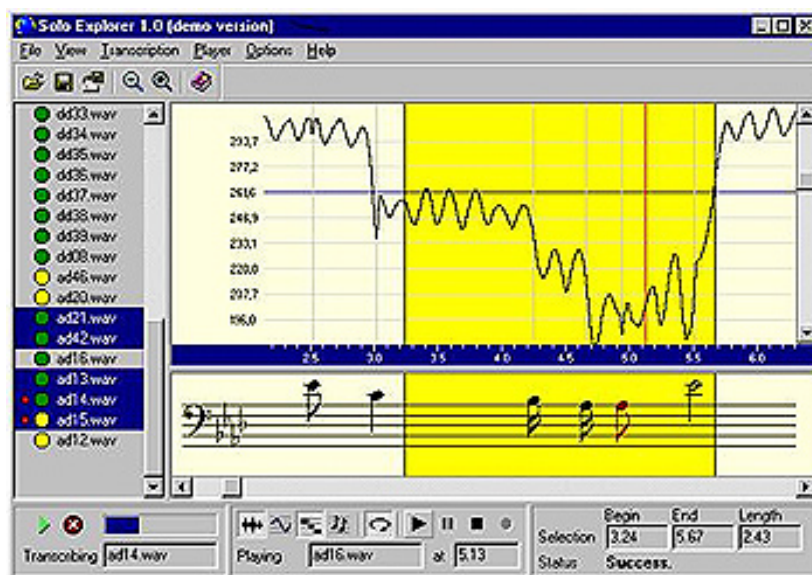
A list of such software is listed below mentioning if they support polyphonic or monophonic transcription.

Program	Publisher	Platforms	Capability	Web site
7Canaries	TallStick Software	Windows	polyphonic	http://www.audioto.com/
AKoff Music Composer	AKoff Sound Labs	Windows	polyphonic	http://www.akoff.com/
AmazingMIDI	Tetsuya Araki	Windows	polyphonic	http://www.pluto.dti.ne.jp/~araki/amazingmidi/
Audioscore Professional	Neuratron	Windows	monophonic	http://www.neuratron.com/
Autoscore	Wildcat Canyon Software	Windows/Mac	monophonic	http://www.wildcat.com/
Capella-audio	WHC	Windows	monophonic	http://www.whc.de/
Digital Ear	Epinoisis Software	Windows	monophonic	http://www.digital-ear.com/
Inst2midi	Nerd	Windows/Silicon Graphics	monophonic	http://www.nerds.de/english/inst2midi.html
Intelliscore	Innovative Music Systems, Inc	Windows	polyphonic	http://www.intelliscore.net/
Melodyne	Celemony	Windows/Mac	polyphonic	http://www.celemony.com/
Pfs-System	Franz Straessler	DOS	polyphonic	http://mailbox.univie.ac.at/~straesf7/pfs_e.htm

Solo Explorer	Recognisoft	Windows	monophonic	http://www.recognisoft.com/
TS-AudioToMIDI WAV2MIDI	TallStick Software	Windows	polyphonic,	http://www.audioto.com/
and Sound2MIDI	www.audioworks.com	Windows	monophonic	http://www.audioworks.com/
WIDI	Widisoft	Windows/Mac	polyphonic	http://www.widisoft.com/

11. Digital scores on-line distribution

Distribution of scores on the internet has started from printed scores e-shops crated from publishers and music bookstores. This practice lately tend to be replaced from digital score distribution where the customer can have a preview of the score then get it electronically in digital form, print and use it similar to published printed scores.

Today there are many websites offering digital scores, some of them are commercial selling them and some of them are free.

There are two categories of digital score formats: a) as digital image b) as semantics.

11.1. Digital Image scores

Digital image scores are only the visual image of the score.

- *Formats*: As it is already mentioned the most common format in digital image score distribution is PDF. Other image formats like JPG, GIF, PNG and PS are also in use but sensibly in fewer cases.

- *Web previewing*: Common web browsers can represent easily JPG, GIF and PNG as well as PDF with additional plug-in. PS can only off-line previewed.

- *Printing*: is possible with common image viewers.

- *Audio preview*: There is no audio preview possibility (unless it is made as extra file from the distributor).

- *Protection*: Image protection, PDF protection. A special case for distribution and protection is *Safepublish* (see below)

11.2. Digital semantic scores

Semantics digital scores as explained above have the music information of a score and not only the visual image. The visual image can be rendered through custom viewers for each format, freely distributed.

- *Web previewing*: Not all formats can be viewed from the web, only if there is web plug-in viewer available (*see formats*). Some of them use common digital image formats for previewing the first pages.

- *Audio preview:* Because the music information is preserved an audio preview of the score is possible together with the visual preview, often following the score with a marker or a special color.

- *Formats*: There are actually two categories of formats: Off-line viewers and on-line viewers:

    - Off-line viewers: Scores can be downloaded and then viewed or printed from a special viewer for each format.

    - Such cases are: *Score preview* for Score software (.sco) files, *Mozart viewer* for Mozart files, *MusEdit viewer* for MusEdit (.med) files, *Capella reader* for Capella (.cap) files, *Finale NotePad* for (.mus) files

- On-line viewers: They are browser plug-ins that show and play the scores directly on the browser or score browsers with internet access.

- Such cases are: *Myriad plug-in* for Melody Assistant (.med) scores, *Musicnotes*, Scorch plug-in Sibelius (.sib) scores, *Solero* for Solero (.rms or .solero) scores, Wedelmusic.

- *Protection*: Most Off-line viewers offer a protection only as alteration preventions. That means that the user cannot alter the score but can hear, print and copy the score. Most On-line viewers are combined with copy protection systems.

12. Digital distribution cases

A look at several online music publishers and options should provide an image of the actual situation in the distribution of music scores.

12.1. Noteheads.com

Swedish software developer NoteHeads features *Igor Reader* a nifty little viewer carved from the code of Igor Engraver, the company's high-end notation program. Igor Reader is a standalone Windows and Mac application that lets visitors view and playback downloaded works. The print option is disabled. To enable it the customer has to purchase the score.
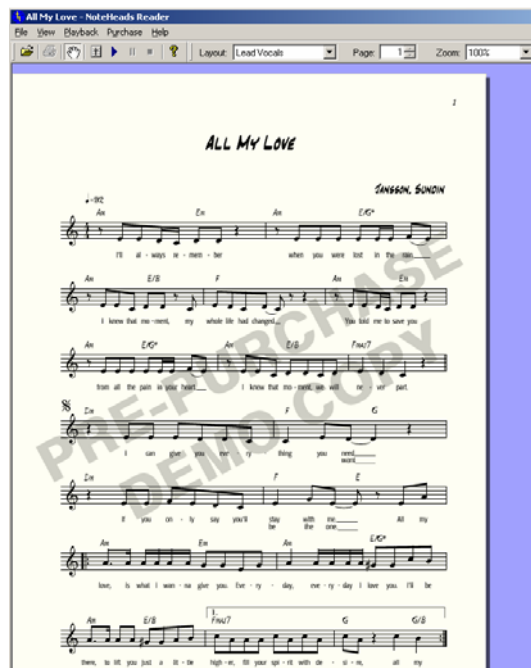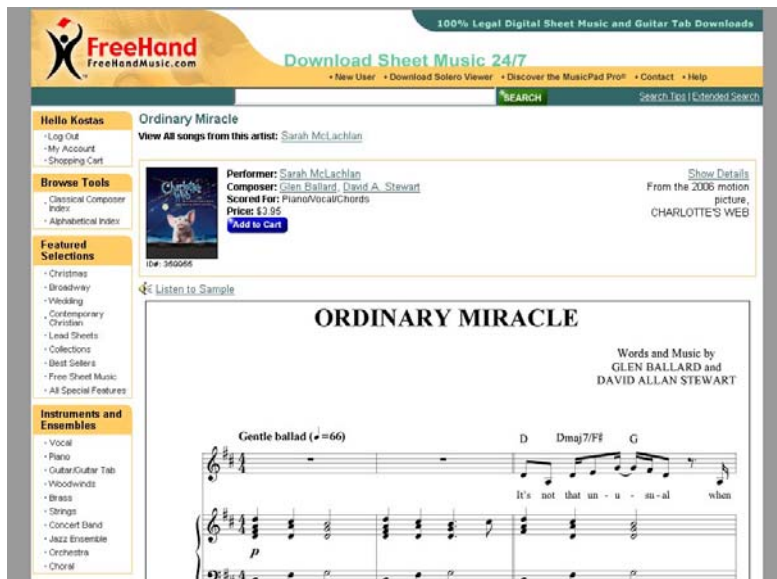
Noteheads scores range from $1 to $25. Contributors get 50% or more of the purchase price and can specify whether viewing, playback, and printing should be allowed prior to purchase.

Igor Reader seems solid, and the engraving quality is good. It all comes down to content: if you build it, they will come.

12.2. Freehandmusic.com

Freehand uses the Solero music viewer as successor of "downloadable, interactive sheet music" and old-style hard copies, available by mail order.

Full-page PNG previews are available for most pieces (see figure) and for some MIDI audio preview, but the purchase is made through *Solero*. Solero is a straightforward, free Windows application that lets users view and play scores downloaded from Freehand. With Solero, you can change tempo and patches, adjust volume, and solo or mute parts. You can also transpose parts and even change clefs. It takes about 30 seconds for short works to download, for authorization to be received, and for the pieces to appear in the viewer.

Solero's print quality is first-rate, but you can print only one copy of a work. (Printing multiple copies is permitted, however, if you purchase multiple-print rights).

Freehand offers music in a range of genres. Prices are typically $4.95 for single songs; collections of five songs by an artist are $9.95. Although neither price represents great savings over traditional sheet music, there is saving on shipping and time.

Currently, Freehand won't publish a visitor's work. In fact, it doesn't even indicate which notation program it uses to prepare its collection.

Solero seems to be purchased from Freehand and there is no data for the possibility of Solero implementation from other distributors.

An interesting hardware available from Freehand is *MusicPad Pro,* which is a digital music score displayer in size of an A4 page at 1199$, that can load freehand scores and be used as note-stand.

In fact because MuscPad Pro supports JPG and PDF scores it can be used also with scores from other distributors.
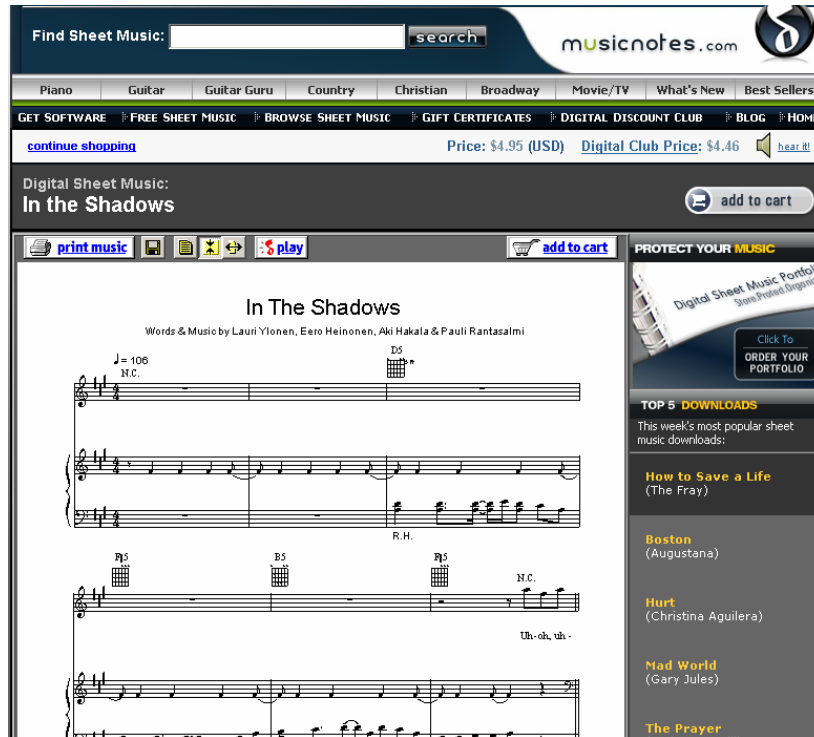
12.3. SheetMusicNow.com

The company built its system around Adobe Acrobat files, but SheetMusicNow.com uses a Windows application called *SafePublish* to secure files. The customer has the possibility of one page preview in GIF and audio preview in MIDI on-line. After the preview the consumer may download the score in a special format (.saf) that can be printed only from safepublish. Safepublish connects to Internet, checks if the score is legally purchased and then allows one printing to printer (and not to file). You can print three times within seven days, after which the file expires. Playback and editing functions are not supported.
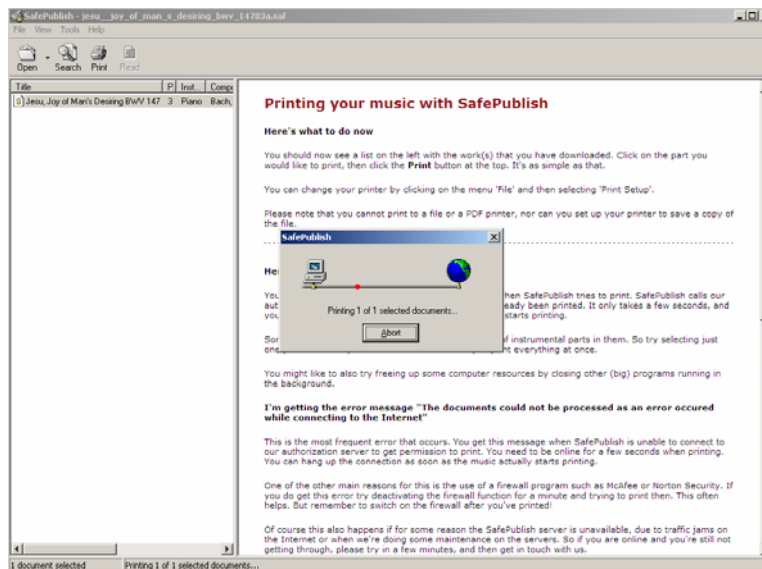
The site's repertoire covers a range of styles. Prices are fluctuate from $3.50 up to $15. The print quality is excellent, though the page layout is not always top-drawer. Safepublish is implemented also to the German score distributor "JPC a la cart" (http://www.jpc.de/), but there it seems that Safepublish is purchased from musicsheetnow and there is no data for distributors how to implement it. Acrobat is certainly an important tool and a simple solution for publishers, but even if the DRM is through Safepublish protected it's doesn't offer the power of "real" virtual sheet music.

12.4. Musicnotes.com

Musicnotes.com uses *Musicnotes Viewer plug-in* to distribute to more than 10,000 works of digital sheet music. At first glance, Musicnotes Windows-based viewer plug-in, with its window-within-a-window design, seems to be a good solution, but Musicnotes Viewer requires a separate player for MIDI playback. That's only a minor nuisance, however, the programs are undersized downloads and work well together.


First-page previews are playable and printable. Purchasing a piece means shelling out from $4.95 to $7.95. The selection is impressive, and the technology is user-friendly.

Musicnotes viewer is not available for implementation by other distributors.

12.5. ScorchMusic

ScorchMusic is adopted from the makers of Sibelius. The *Scorch* viewer for Mac or Windows offers digital sheet music done right: a full-page view of the music, transport controls for MIDI playback, a slider for changing tempo, a button to print the first page as demo for free with a watermark on it, and finally controls that let you change the first instrument or change keys if the composer permits. Better still, Scorch features Sibelius's Espressivo playback options for intelligent interpretation of dynamics and articulations as well as composer-definable degrees of swing, which is a huge advantage over the competition. With Scorch, if the customer purchases the score he can print it in high resolution directly from the Web. What he does not get is an electronic file. That means that if he wants to print additional copies, he either have to do it from the vendor's Web site or he needd to photocopy existing printouts.
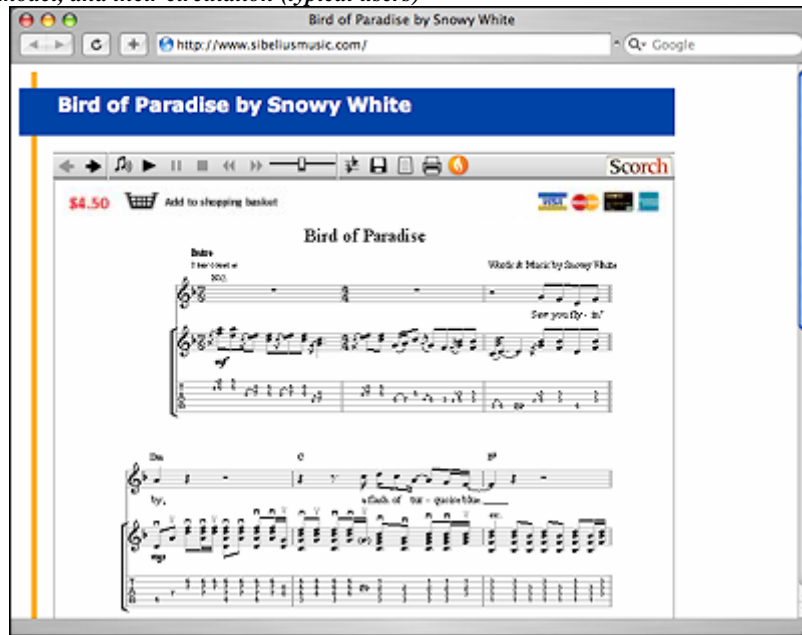
ScorchMusic sets all the prices, which range from free to $9.95, depending on the number of pages. Extracted parts are also available for an additional charge. Contributors receive 50 percent of the net sale price. ScorchMusic tracks MIDI-playback auditions and pays royalties to performing-rights agencies for that use.

Scorch's online viewing and playback technology is available to Sibelius users, and Sibelius Internet Edition extends its capabilities for commercial use. It is worth mentioning that Scorch has been adopted by major music-publishers such as Sheet Music Direct publisher Hal Leonard (www.sheetmusicdirect.com), J. W. Pepper digital distribution, Boosey & Hawkes etc.

For use of scorch from a publisher, *Sibelius Internet Edition* is available. Sibelius Internet Edition gives to the publisher, complete control over which buttons appear on the tool bar, and how much they let your customers do, including:

- Whether customers can **view** the whole score or only specified pages
- Whether or not customers can **play back** the score. This option can also restrict playback to just a fixed length (say 30 seconds) of the score
- Control over playback **tempo**, **sounds**, whether to use Espressivo™ (automatic expression) & reverb
- Control over **printing**. Customers can be allowed to print a free sample page, pay to print the whole score or print the score free of charge. Printing can also be completely disabled.
- Control over the **paper size**, orientation, music and text **fonts** used
- **Transposing** can be enabled or disabled
- The customer can be allowed to **change instrument** (from a custom list), or the instruments can be made unchangeable.

All of these options can be altered on a **score-by-score** basis: for instance, it is possible to have some scores on the site that can be downloaded and played back for free, and others where only the first page can be played and the customer has to pay to print it.

Unlike the standard Sibelius program, Sibelius Internet Edition is licensed on an on-going basis related to the volume of usage.

To sell printouts of music online, the charges consist of:

- Initial one-off license fee, related to the size of your business

- Monthly maintenance fee (to cover technical support and software updates), related to your volume of sales.

- Transaction fee, related to the volume of sales.

There are different tariffs for different volumes of usage.

12.6. Wedelmusic

Wedelmusic is developed as EU project and it is based on new music mark-up language called WedelmusicXML developed during the project. According to their definition: "*WEDELMUSIC allows publishers and consumers (theatres, orchestras, music schools, libraries, music shops, musicians) to manage interactive music; that is, music that can be manipulated: arranged, transposed, modified, reformatted, printed, etc., respecting copyright.*

These innovative features are possible thanks to the definition and implementation of

- a unified XML-based format for modelling music including audio, symbolic, image, document, etc.,

- reliable mechanisms for protecting music in symbolic, image and audio formats.

- a full set of tools for building, converting, storing, distributing music on the Internet "
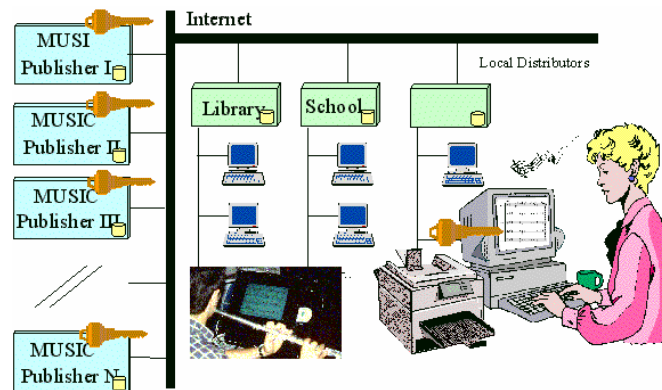
In theory Wedelmusic seems to be an interesting and complete solution. Although there are a many papers and presentations refer to it, unfortunately there is nowhere functioning as distribution software or server in the way to test it. So no practical data can be delivered to this paper.

12.7. MusicXML and MusicRAIN

MediaRAIN has developed a MusicXML web viewer – distributor called *MusicRAIN* (http://www.mediarain.com/musicrain/). MusicRAIN seems to be an ideal solution for sheet

music publishers and distributors desiring to publish digital music scores online for their customers to search, view, experience, and purchase. With musicRAIN, publishers and distributors can easily publish their sheet music libraries directly onto their own websites. Unlike other music viewer products, musicRAIN can be customized to the client, including colour schemes, fonts, and layout. Because MusicRAIN uses the MusicXML is therefore compatible with all major notation software that can export in MusicXML format like Finale, Sibelius, Harmony Assistant, Igor Sharpey, Photosore etc.

The client does not need to download any software because muscRAIN is a Macromedia Flash application that is supported on all common web browsers. The score is not embedded in the web page, instead it opens in a separate window where the score is in real-time rendered. The client has the possibility to follow the score, to control tempo, volume of parts even doing real-time transpositions before he purchase the score. There is no electronic file download, but the client can print the score to his printer in very high quality (like in ScorchMusic).
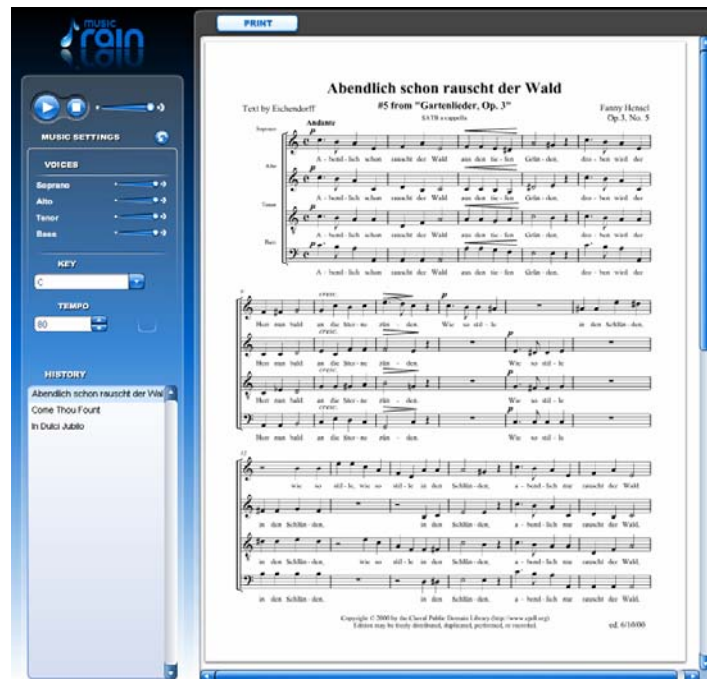
Possibilities in brief:

Sheet Music Publishers and Distributors:

- Completely Customizable User Interface
- Web-based Application
- Advanced Digital Rights Management
- Direct Export of MusicXML

End Customers:

- Dynamic Transposition, Tempo, and Instrument Part Adjustments
- High-resolution Prints
- Favorites and Print History Organization Tools
- Simple to Use, With No Additional Download Requirements

12.8. Zinfonia

Zinfonia is a new and comprehensive system for the secure delivery of online music. It based on Zinio electronic Magazine reader system and is developed especially for digital score distribution. With Zinfonia publishers can distribute music electronically for sale or review. Zinfonia secures the music files against unauthorized use using Digital Rights Management technologies.

Consumers can buy on-line, download and view the sheet music using the free Zinio reader.
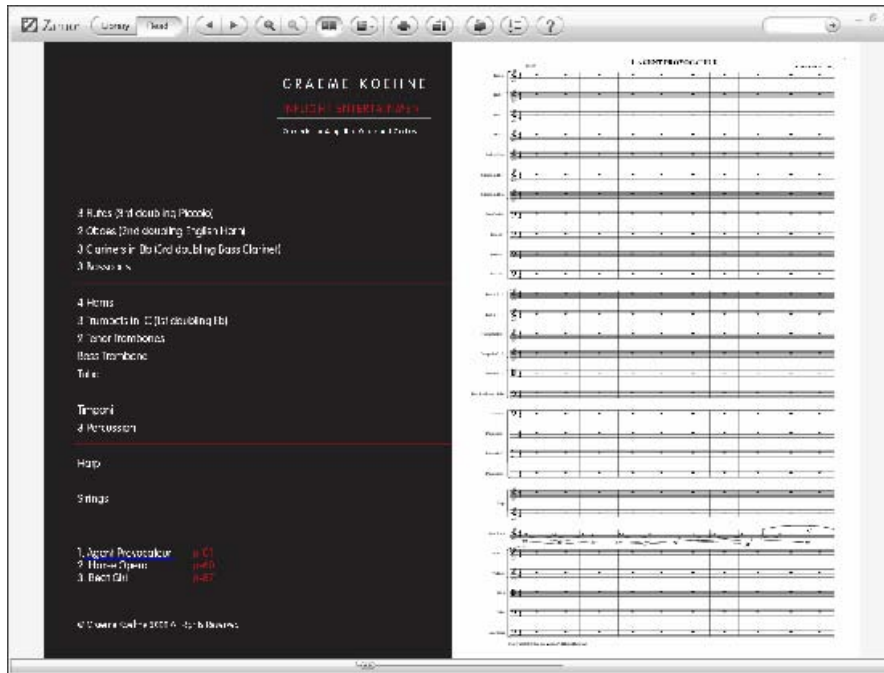
Zinio reader is a small browser plug-in, the similar to Zinio's magazine reader. It offers previewing of the score and a visual impression of turning the pages. There no audio preview but Zinfonia is currently developing plug-ins for existing media players including iTunes and Windows Media Player. These will allow users to synchronize a Zinio publication with a recorded source. So a Zinfonia publication will turn the pages in time with the music. For the Zinfonia plug-in is required from the provider a score in PDF or PS format.

12.9. Remarks on digital distribution systems

▪ Not all digital score distributors use virtual sheet music engines with copy protection systems (still Distributors like Score-on-line.com, VirtualSheetMusic.com, Everynote.com and many other distributors use the standard PDF download technique).

▪ There were other digital distribution systems like *Finale web viewer* and *Opus viewer* not any more supported.

▪ MusicXML is an open XML language that can be theoretically embed on HTML web pages. Because of this reason and the reason that actually serves as standard exchange format supported with many professional notation software, is to be expected that newer solution for web score integration based on MusicXML will soon developed.

13. Conclusion

- For music score distribution the scores need to be digitized
- Score can be digitize as images or as semantic/symbolic music information
- There are many ways to produce digital scores.
- There are several type of digital formats of scores that can be distributed
- Digital score distribution is actually made with many different ways
- Some distributors can host third party scores for distribution
- From the existing systems the only ones that can be easily implemented to new score distributors seems to be Scorch, MusicRAIN and Zinfonia.

14. Appendix

14.1. Charges for digital score distribution using Sibelius

The standard Sibelius program lacks online security and printing and so is unsuitable for commercial Internet use. The standard Sibelius license also disallows commercial Internet use; in particular, they do not license organizations (other than schools, colleges or universities) to use the standard Sibelius to put more than 5 unchanging scores on their web sites (or on CD-ROMs etc).

Sibelius offers many ways of distribution

(1) Using SibeliusMusic.com as referral (the scores are found in Sibeliusmusic.com site)

(2) Direct sale (scores are found on distributors site but the transaction is made with SibeliusMusic.com)

(3) Direct sales using Sibelius Internet Edition

1-2) Using SibeliusMusic.com

Monthly fee: 25€

Commission to SibeliusMusic.com on sales:	
a) Referral (Score found on SibeliusMusic)	30% of retail price
b) Direct sales (SibeliusMusic is used only for transaction)	20% of retail price

Minimum length of contract: one month.

3) Charges for digital score distribution using Sibelius Internet Edition**.**

Sibelius Internet Edition as software package has a price of **1000€**. If a publisher has retailers who want to sell scores off their own web sites, they will typically need their own copy of Sibelius Internet Edition to integrate scores with their e-commerce system. Copies of Sibelius Internet Edition are available to these retailers for **500€**.

But to use Sibelius Internet Edition, the distributor has to calculate with a series of extra charges according to the distributed amount:

14.1.1. Charges

The charges have three components:

(1) **License fee:** one-off initial fee based on the business's annual revenues (or costs).

(2) **Monthly maintenance fee:** this covers all ongoing technical support and program updates. The fee is based on the monthly sales of sheet music using Scorch, and is free of charge for low-volume users.

(3) **Transaction fee:** 15%-19% of the retail sales value of music sold using Scorch. The percentage decreases as your sales increase. Percentages are lower than 15% for high monthly sales volumes.

14.1.2. License fee

This one-off initial fee is based on the business's total revenues in the last financial year.

The license fee also includes a number of copies of Sibelius Internet Edition and PhotoScore (scanning program), as shown.

Revenues/costs	Up to 1 000 000€	1 000 000 - 10 million	10 - 100 million €	100 million +
License fee	500€	3 000€	5 000€	10 000€
Copies of Sibelius Internet Edition	1	2	3	5
Copies of PhotoScore	0	1	1	2
Revenues/costs	Up to 1 000 000€	1 000 000 - 10 million	10 - 100 million €	100 million +

14.1.3. Maintenance and transaction fees

For the maintenance and transaction fees, there are different tariffs for different sales volumes.

Tariff	A: Low volume	B: Medium volume
Monthly retail sales	0 – 10 000€	10 000 – 25 000€**
Monthly maintenance fee	Free	420€
Transaction fee (% of monthly retail sales)	19%*	15%

*Tariff A is subject to a minimum transaction fee of 100€ per month

**For monthly retail sales in excess of 25 000€, there are cheaper tariffs.

If a publisher has retailers that sell scores from their own web sites, there is an additional monthly maintenance fee of 100€ for each of these retailers (as they will require technical support and/or program updates).

Scorch makes an independent electronic log of all sales made to help resolve any discrepancies.

All prices are approximated and exclude VAT.

LENGTH OF CONTRACT for Internet Edition

12 month initial contract, terminable thereafter on 3 months' notice.

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