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THE IEEE 1599 STANDARD

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Summary: This chapter gives a brief and simplified technical overview useful in the understanding of all IEEE 1599 applications, in particular from I to VII, which exist and are complete, and VIII and IX, which have been studied but not yet fully realized.

1.1 INTRODUCTION

IEEE 1599 is both a standard and a technology to represent and encode music, in all its aspects, making music enjoyment a total experience akin to that lived with literary masterpieces and great movies, well beyond the rendering of a binary file through a micro earphone.

Every music lover has always known that music is much more than audio and noise. The musical experience is similar to the act of entering a new world, enjoying a new experience, understanding a narration, and recognizing descriptions, as in the case of seriously reading a work of literature such as Tolstoy's *War and Peace* or Shakespeare's *Hamlet* and as in a parallel reality. In addition, music offers the possibility of investigating how the whole is built from its technical standpoint, which is the object of *musicology*, the science of music.

For such an experience, music must be represented with something that goes beyond *unreadable*, *binary standards* for audio, such as WAV and MP3, which are not music standards—they are audio standards. Musical aspects beyond audio must be represented in human-readable form, such as *symbols* and characters. This has always been the case for music scores in classical music, and for music notation in all civilizations for at least

Music Navigation with Symbols and Layers: Toward Content Browsing with IEEE 1599 XML Encoding, First Edition. Edited by Denis L. Baggi and Goffredo M. Haus.

40 centuries (e.g., Babylonian tablets; see the Introduction). This is also the case with other symbols, such as the *harmonic grid* in jazz, and also in other written codes, as in non-Western music.

This is also true for the *new standard for music encoding IEEE 1599*, which uses Extensible Markup Language (XML) clauses [XML]. This work represents the culmination of decades of efforts of specialists in the field of computer applications to music and musicology, of which the "Plaine and Easie Code" [Brook 1970], Digital Alternate Realization of Musical Symbols (DARMS) [Erickson 1975], and SMDL [Newcomb 1991] are worth mentioning, while MusicXML [Recordare] and the Music Encoding Initiative (MEI) [Roland] are the direct ancestors of this technology. However, IEEE 1599 goes beyond such past efforts, as described next.

The characteristics of IEEE 1599 are described in detail in Chapter 2; however, for the purpose of this chapter at least two important ones will be mentioned: *symbols* and *layers*.

IMPORTANT FEATURES OF IEEE 1599

The main distinguishing features of the IEEE 1599 technology are the use of *symbols* to represent music, and the concept of *layers*.

Every element of Common Western Notation (see Chapter 2) can be represented by XML clauses that can be nested as needed, as in the example:

```
<clef type="G" staff_step="2" event_ref="c1"/>
```

This is described in several pages of Document Type Definitions (DTDs) listed in Appendix B and posted at http://standards.ieee.org/downloads/1599/1599-2008/, a site of the IEEE Standards Association. In addition, thanks to the inherent extensibility of XML, it is possible to add clauses for special needs—such as proprietary characters used by a particular music publisher or notation that is not yet standardized [Cage 1969].

In recognition of the different aspects of music, the concept of *layers* has been introduced [Haus and Longari 2005] and is an integral feature of the standard, as shown in Figure 1.1.

The *general layer* provides a general description of the music work and groups information about all related instances, including titles, author, type, number, date, genre, and related items. The *logic layer* provides music description from a symbolic point of view and represents the core of the format. It contains the main time-space construct for localization and synchronization of music events, the description of the score with symbols, and information about a graphical implementation of the symbolic contents, as well as the *spine* with *Logically Organized Symbols* (*LOS*), a sorted list of music events. Again, this is described in more detail in Chapter 2.

All layers are related to each other, and possibly synchronized, as shown in Figure 1.2, which shows that standard IEEE 1599 allows *representation*, *performance*, and *audible* and *visual fruition* of a piece of music *independently* of the original standard or format with which it was previously encoded. It therefore supports existing formats and recognizes that music contents that are already encoded in pre-existing file formats cannot

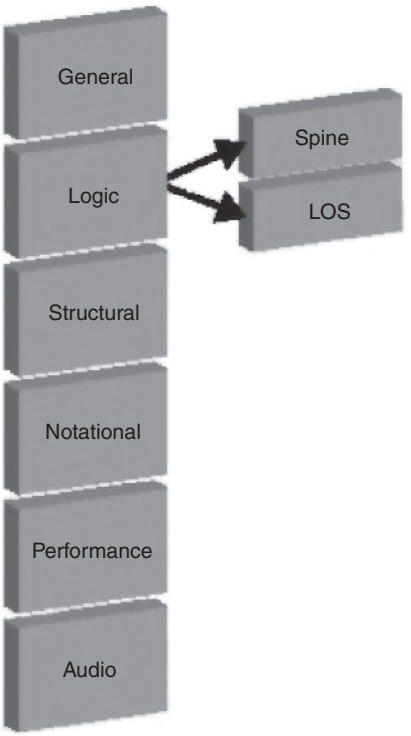


Figure 1.1. The layers in IEEE 1599.

be ignored. Since no overall description has ever existed for all aspects of music in one single format, it provides a meta-language in XML to describe all related music elements as well as to link all corresponding media objects already encoded. Thus, music contents are either newly encoded in the proper layers (the *general*, *logic*, and *structural* layers actually store information) or they remain in their original format, with links from the corresponding layers to files (the Notational, Performance, and Audio layers contain mappings to external files). Hence, media files are handled as they are, and media contents are still available in their original encoding. The comprehensive format described in the standard uses the layers to represent the relationships between music events and their occurrence in media files, thus allowing an overall synchronization. In other words, it is possible to navigate music in all its aspects.

The interaction and synchronization among these layers will become clear through the following examples.

EXAMPLES OF APPLICATIONS OF IEEE 1599 TO INCREASE MUSIC ENJOYMENT

The following are examples of applications of the standard, which can be realized easily thanks to the *symbolic representation of music* and the presence of *synchronized layers*, thus opening up a new way for music fruition.

- **An opera.** A DVD of an opera allows the user to *see the play* on the screen, to *hear the music*, *to see the score* (including *manuscripts*), *to read the libretto*, and *to choose alternative renditions* (see item 5 below).

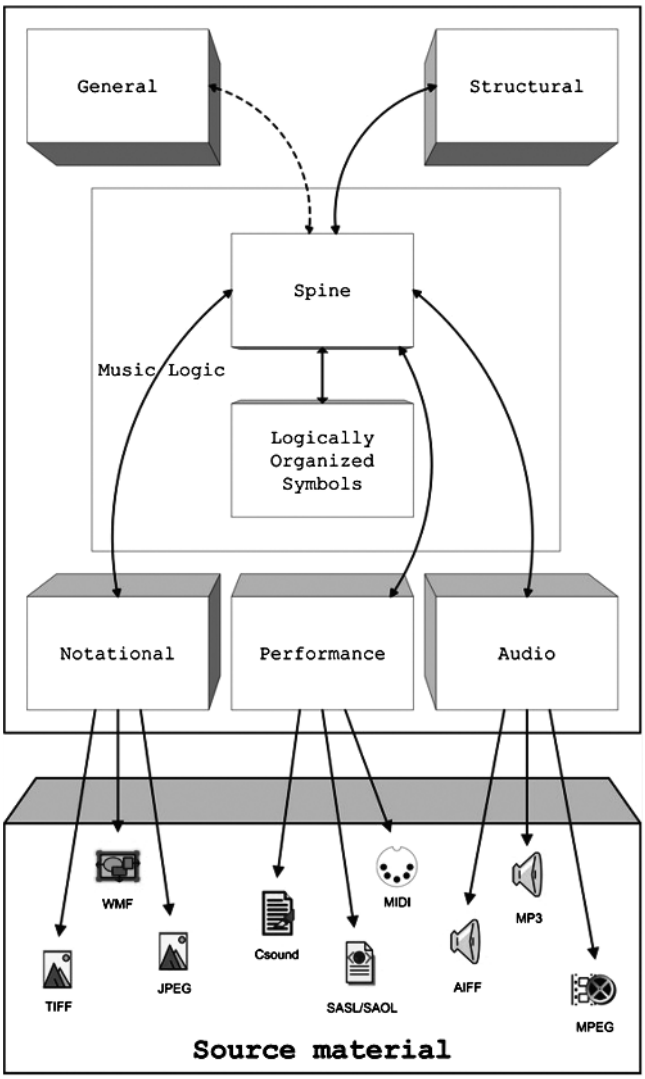


Figure 1.2. Relationship among layers in IEEE 1599.

- **Pieces by a jazz band.** The *harmonic grid* is displayed and the *name of the soloist* pops up at the beginning of each solo—with didactical tools as presented in jazz textbooks [Baggi 2001] (see item 2 below).
- **Music with a "program" or story.** For example, Vivaldi's *Four Seasons* come with poems by the composer that refer to segments of the music (see item 8 below).
- **Music with no apparent meaning.** For instance, free jazz of the 1960s–70s is perceived by many as a random collection of meaningless sounds, while an associated video, generated anew each time, may help the listener understand what is meant (see item 2 below).
- **A fugue.** The *theme* is highlighted as it gets passed among the different voices.
- **A piece of Indian classical music.** The *scale* of the raga is shown and the melodic development is highlighted.

- **A piece of several drums**, for example, as in African drumming, shows how the rhythmic pulse come from the fact that the hits do not fall together.
- **Preservation of the music heritage from the past.** To store documents in any media [Haus].
- **Musicological study.** Ease of queries, for example, all pieces utilizing the lowest note of a grand piano, and questions as to why a certain note is used in a given harmonic context.
- **Books about the making of a masterpiece**, for example, *Kind of Blue*, by Miles Davis and John Coltrane [Kahn].

The following is a list of existing and planned realizations of IEEE 1599:

I. **"King Porter Stomp**," by New Orleans pianist and composer Jelly Roll Morton (1889–1941), with versions played by the composer, two different scores, seven versions (of which one is a video from a movie) for solo piano and for orchestra, and 10 related images.

II. **"Crazy Rhythm**," a jam session with no score and a *harmonic grid*, with Coleman Hawkins and Alix Combelle, tenor sax; Bennie Carter and André Ekyan, alto sax; Stéphane Grappelli, piano; Django Reinhardt, guitar; Eugène D'Hellemmes, bass; and Tommy Benford, drums. Recorded in Paris, April 27, 1937, record Swing #1.

III. ***Tosca***, by Giacomo Puccini, 1858–1924, application realized on the original manuscript of 1900, courtesy of Ricordi. With three versions, including one video.

IV. **"Peaches en Regalia**," by Frank Zappa, an example of control at the symbolic and structural levels.

V. **"Il mio ben quando verrà,"** from Giovanni Paisiello's *Nina, o sia la pazza per amore*. It allows the user a choice of instrument, voice, versions of the score and of the libretto.

VI. **Brandenburg Concerto No. 3**, by J.S. Bach, allows a user to select a view of any section of the orchestra from several different vantage points running simultaneously.

VII. **Blues**, a didactical tool to learn jazz improvisation on a 12-bar blues structure.

Not yet realized are the following:

VIII. **"La caccia,"** from Antonio Vivaldi's *Four Seasons* ("Autumn"), with links to the score, sonnets, and music.

IX. ***Tauhid*,** by Pharaoh Sanders, a piece of free jazz with a moving screen meant to represent the feeling of the music.

Notice that items V and VI are also available on the Web as "canned versions" at

http://www.mx.lim.dico.unimi.it/videos/ieee1599_movie_short.wmv
http://www.mx.lim.dico.unimi.it/videos/rtsi_movie.wmv

They are "canned" in the sense that they are not interactive; they are videos of a user using the applications.

Example I: A Score with Different Versions: "King Porter Stomp," by Jelly Roll Morton

This is an application built, like all the others, at the Laboratory for Musical Informatics of the University of Milan [LIM]. The screenshot shown in the figure contains different windows, of which those with the extra caption *real time* operate in synchronism while the music is being played.

The user starts with the *piece selection window*: in this case, there are two choices, "King Porter Stomp 1924" and "King Porter Stomp 1939." They refer to two published scores of that piece, popular in the 1930s, by American composer and pianist Jelly Roll Morton (born Ferdinand Joseph La Motte, 1889–1941).

In the *file selection* window, the user can choose among alternate multimedia files, in this case a recording from 1926 in MP3 format, a MIDI rendition of the 1924 score encoded in MP3, and an excerpt from Louis Malle's movie *Pretty Baby* of 1977, in which a character patterned after Morton is heard composing the piece in the background. The movie is the one shown here in the window player display, which for plain music looks instead like a common music player. Two more choices are versions—one recorded in 1928 and one in 1932—by the jazz orchestra of Fletcher Henderson, who was a bandleader, composer, and arranger who popularized the piece for a band with a section of trumpets, trombones, and reed instruments (clarinets and saxophones). This shows how music pieces that appear very different have the same root and structure.

Once the selection is made, several synchronized activities start and execute in real time. The music starts playing, and in the case of the movie a video segment starts together with its sound. On the *score*, the *running cursor* indicates what is being played (in the figure, the beginning of the seventh bar). The user can move the red cursor with the mouse and initiate playing from another point in the score, while all other real time windows adjust synchronously.

The *XML code* window shows the encoded events, in this case those of the Logical Organized Symbols (LOS) of Figure 1.1 and Figure 1.2, scrolling with the music. In the *command window*, the user can select which XML code is displayed: *spine*, *LOS*, *notation*, and *audio*, again those of Figure 1.1 and Figure 1.2, and in the same window one can choose the *voice* the running cursor will follow; there are three voices in this case.

The *chords* window displays the elements of the music harmony of the piece, again synchronously with the playing, and the window for the *multimedia files* allows selection of other material, such as pictures of Morton or his band, or other curiosities, including a map of Storyville at the turn of the 20th century, a New Orleans district that was torn down in the 1930s.

Example II: A Jazz Piece with No Score: "Crazy Rhythm"

Figure 1.4 shows the screenshot for the jazz piece "Crazy Rhythm." Instead of a score, it displays the *harmonic grid*, pointed to by the running cursor, and the picture and name of each soloist pop up at the appropriate moment. There are four saxophonists taking solos: André Ekyan on alto and Alix Combelle on tenor, both from France, followed by Bennie Carter on alto and Coleman Hawkins on tenor. The rhythm section consists of violinist Stéphane Grappelli on the piano, Django Reinhardt on guitar, Eugène d'Hellemmes on bass, and Tommy Benford on drums. Though entirely improvised, the recording, made in Paris on April 27, 1937, counts among the best of jazz history and

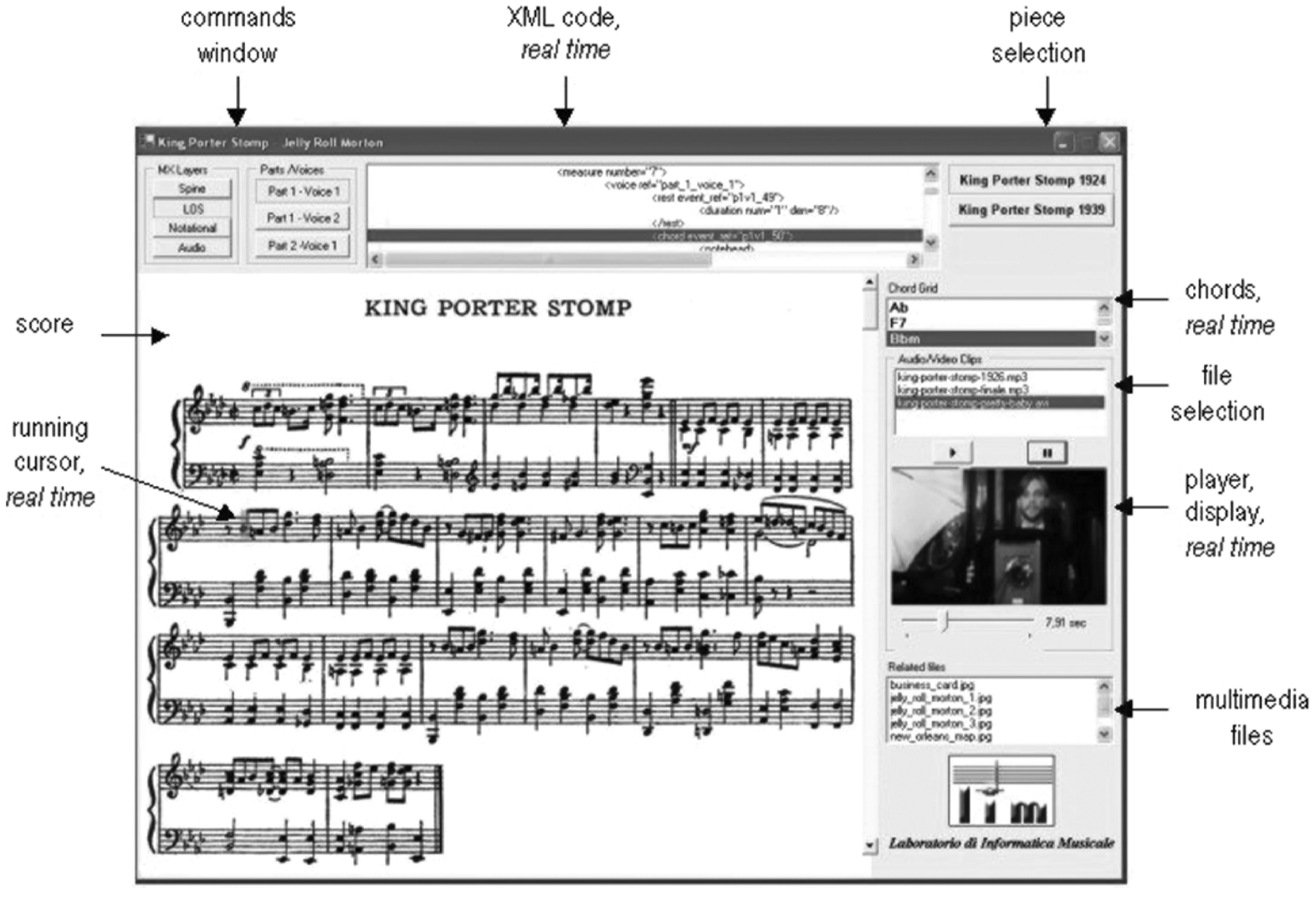


Figure 1.3. The screenshot for "King Porter Stomp." See color insert.

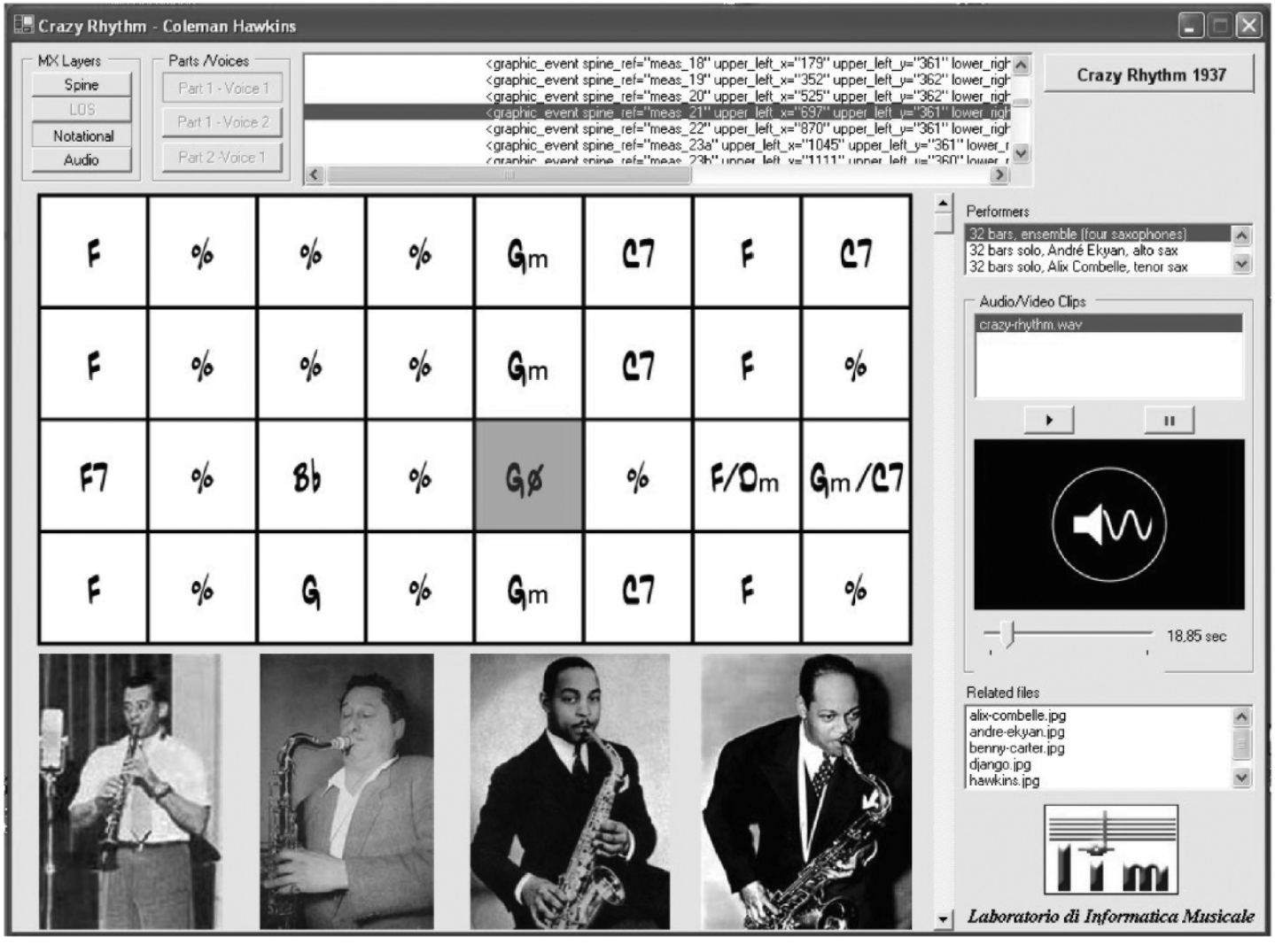


Figure 1.4. The screenshot for "Crazy Rhythm," with a harmonic grid instead of a score. See color insert.

appears as number 1 in the catalog of Swing, the first recording company dedicated entirely to jazz.

The ensemble exposes the theme once, in four voices, for all 32 bars. At each solo, the image and the name of the soloist appears; thus, it is possible to compare styles by clicking on the image of another soloist, and even to compare the sound and style of the alto saxophonist with that of the tenor. The bars and grid are of course synchronized. Each soloist takes 32 bars, except for Hawkins, who, in the middle of the development of sentences that keep building up, takes an unplanned second chorus, after the encouraging shout by Django, "Go on, Go on," which is automatically displayed at the 31st bar. Details like this would be totally lost to a casual listener, and instead can constitute the key for understanding improvised music. The ensemble takes over at the 30th bar of Hawkins's second chorus.

In this application, the standard and its browser can be used to teach a would-be jazz expert to distinguish among soloists and instruments, to detect sound and style differences (in this case between alto and tenor saxophone), and to follow the improvisation at each bar, in order to understand what everybody is playing, from horn to horn to rhythm section and to the ensemble.

Example III: An Opera Using the Composer's Manuscript: *Tosca*, by Giacomo Puccini

This example demonstrates how it is possible with this standard to preserve documents from the past and make them "live." Instead of simply digitizing an old document subject to degradation, this technology allows both the preservation and the realization of an application that allows exploration of music with everything it contains.

The opera is *Tosca*, with music and original manuscript by Giacomo Puccini. The application has been presented at the exhibition called "Tema con variazioni: musica e innovazione tecnologica," held in Rome in December 2005 to January 2006. The manuscript has been made available by publishing house Ricordi, which holds the manuscripts of practically every great Italian composer of the last two centuries.

The usual synchronization of events applies here, as in the other examples. The user can select between the original manuscript and a printed score with the words, or between clarinet and canto. Three tenors can be selected: Giuseppe di Stefano and Enrico Caruso from a 1909 Victor recording, or a video with tenor Jaime Aragall. There are also various images of the time, of Rome, Castel Sant'Angelo, contemporary posters, and the like.

The application shows how easy it is to gain knowledge of a complex piece like an opera, including libretto and different performances that differ considerably. The switch from Di Stefano and Caruso is illuminating, especially because of the difference in voice and style, but also to highlight the recording technique of different epochs, which was entirely acoustic in the case of Caruso—neither electricity nor electronics were available for recording before 1925.

Example IV: "Peaches en Regalia," by Frank Zappa

This example presents an approach to music interaction and creativity at both the *symbolic* and *structural levels*. Even if the creation of music occurs at the symbolic level, the structural level allows interaction with music content at a higher level, provided that a tool

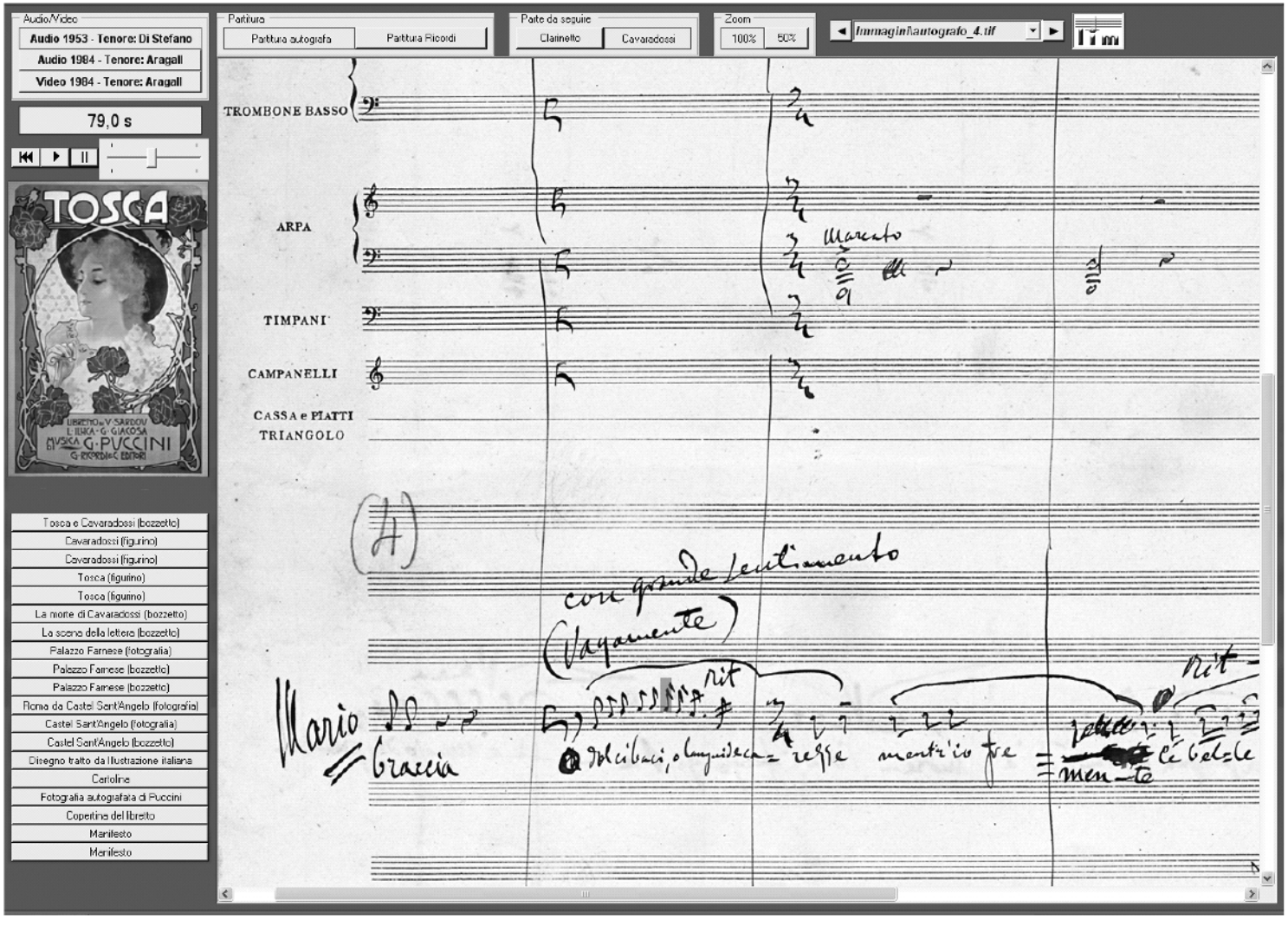


Figure 1.5. An application built on an original manuscript. See color insert.

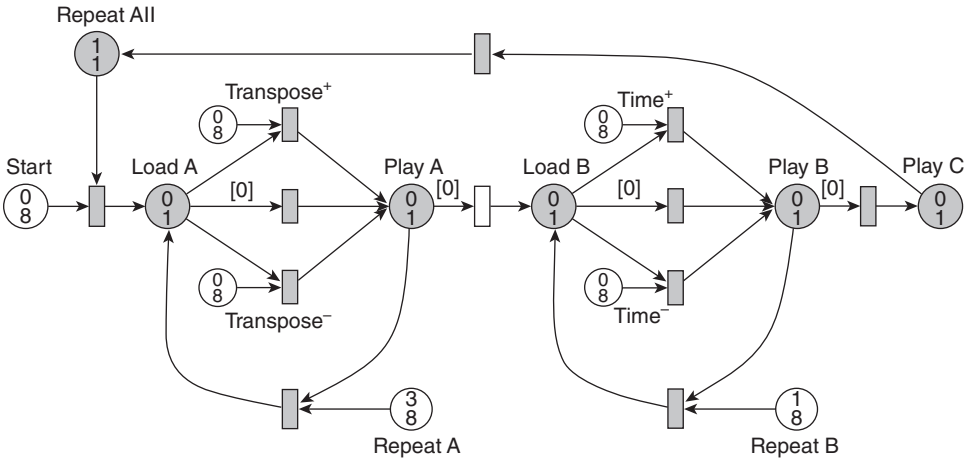


Figure 1.6. Representation of "Peaches en Regalia" in Petri Nets, an application to navigate music structures.

exists to formalize music fragments and their relations in terms of transformation functions. *Petri Nets* is such a tool, thus making real-time music composition possible. Thanks to IEEE1599, this interaction can be performed simultaneously at different levels. The application represents a case study based on "Peaches en Regalia," by Frank Zappa, presented at the International Conference of Esemplastic Zappology, which took place in Rome in June 2006.

Music Petri Nets have been shown since 1982 to be applicable both as a description and as a compositional tool [Degli Antoni and Haus]. The Net shown in Figure 1.6 models the original version of the music piece as recorded by Frank Zappa; thus, if the net is executed without changing the number of tokens in real time, the original version is reproduced. The piece consists of two *fragments*, (a) and (b).

In this model, interaction is limited to *addition/subtraction* of tokens in the places represented by a white background, in order to maintain a similarity to the original result, operations that would have the following results:

- The number of tokens in the **Start** node controls how many times the entire music piece is repeated.
- The number of tokens in **Repeat A** and **Repeat B** places controls how many times fragments (a) and (b) are repeated.
- The presence of one or more tokens in the white input nodes of the two transitions **Transpose +** and **Transpose –** causes the transposition of fragment (a) by a major third higher or lower, respectively. From the execution rules of Petri Nets, it follows that if both nodes have more than zero tokens, a transition is chosen at random.
- The presence of one or more tokens in the white input nodes of the two transitions **Time +** and **Time –** causes time warping of fragment (b) to twice or half the original tempo, respectively. Again, from the execution rules of Petri Nets, it follows that if both of these places have more than zero tokens, a transition is selected at random.

To conclude, the originality of this approach is that music manipulation is performed at a higher level than in the other application mentioned above. Thanks to the IEEE 1599 format, the composer can concentrate on music *structures* and *fragments* that are part of his or her music creation, since music information is automatically handled in a synchronized and heterogeneous way, and lower level integration is automatically performed by the computer.

Example V: "Il mio ben quando verrà," by Giovanni Paisiello

Navigating and Interacting with Notation and Audio (NINA) is an application built to illustrate how to use the standard for symbolic music works, and to show its power [Baggi et al.]. It was designed and implemented for the exhibition "Napoli, nel nobil core della musica," held in May 2007 in Salzburg, Austria, with the purpose of making music tangible and visible by bringing together all five senses beyond hearing. The music piece chosen for this demonstration is the operatic aria "Il mio ben quando verrà," from Giovanni Paisiello's *Nina*, *o sia la pazza per amore.*

The XML encoding contains the logical information about the piece and the synchronization among the various linked multimedia objects. Overall synchronization is provided among graphic objects representing scores, audio and video clips containing human performances, and the libretto. For the context of the exhibition, a rich but simple user interface has been designed, conceived for laymen, to let them listen to a track with various interpreted scores, and to look at different score versions simultaneously.

The screenshot of Figure 1.7 illustrates the interface of NINA. Music browsing is based on windows that contain different representations of multimedia contents, which operate in synchronism while the music is being played. The user is given some selection windows: in the lower window, there are four choices among scores that can be loaded, namely, full autograph score, manuscript copy, printed score for piano, and libretto. In the left window, the user chooses either an audio track or a video clip to listen to; the movie is represented in a dedicated player. The upper window allows selection of the instrumental part to be followed in real time on the score previously chosen.

The main part of the interface contains key graphical contents, namely, the score of the aria in one of its versions. Upon selection, several synchronized activities start and execute in real time: the music starts playing, the running cursor indicates what is being played on the score (here the beginning of the second bar). The user can change the position of the red cursor with the mouse and initiate playing from another point in the score, which causes other real time windows to adjust synchronously, including the audio/video player cursor that changes its current position accordingly.

In addition, the user is able to follow the evolution of any single voice. Hence, another selection window is provided in the upper part of the interface, in which instruments are listed. Thus, a user can change the instrument to be followed, the audio being played, and the score, by clicking on any point of the current graphical score (the synchronization is driven by spatial coordinates), by dragging the slider of the audio/video player (the synchronization is driven by time coordinates), or by selecting syllables from the libretto (navigation by text), while of course overall synchronization is always immediately obtained. The figure shows only the graphical effects of such operation, which is nevertheless visible in the video mentioned above.

In conclusion, NINA is a browser to represent music with readable symbols that can be accessed and manipulated even by nonmusicians. A significant result is that only one

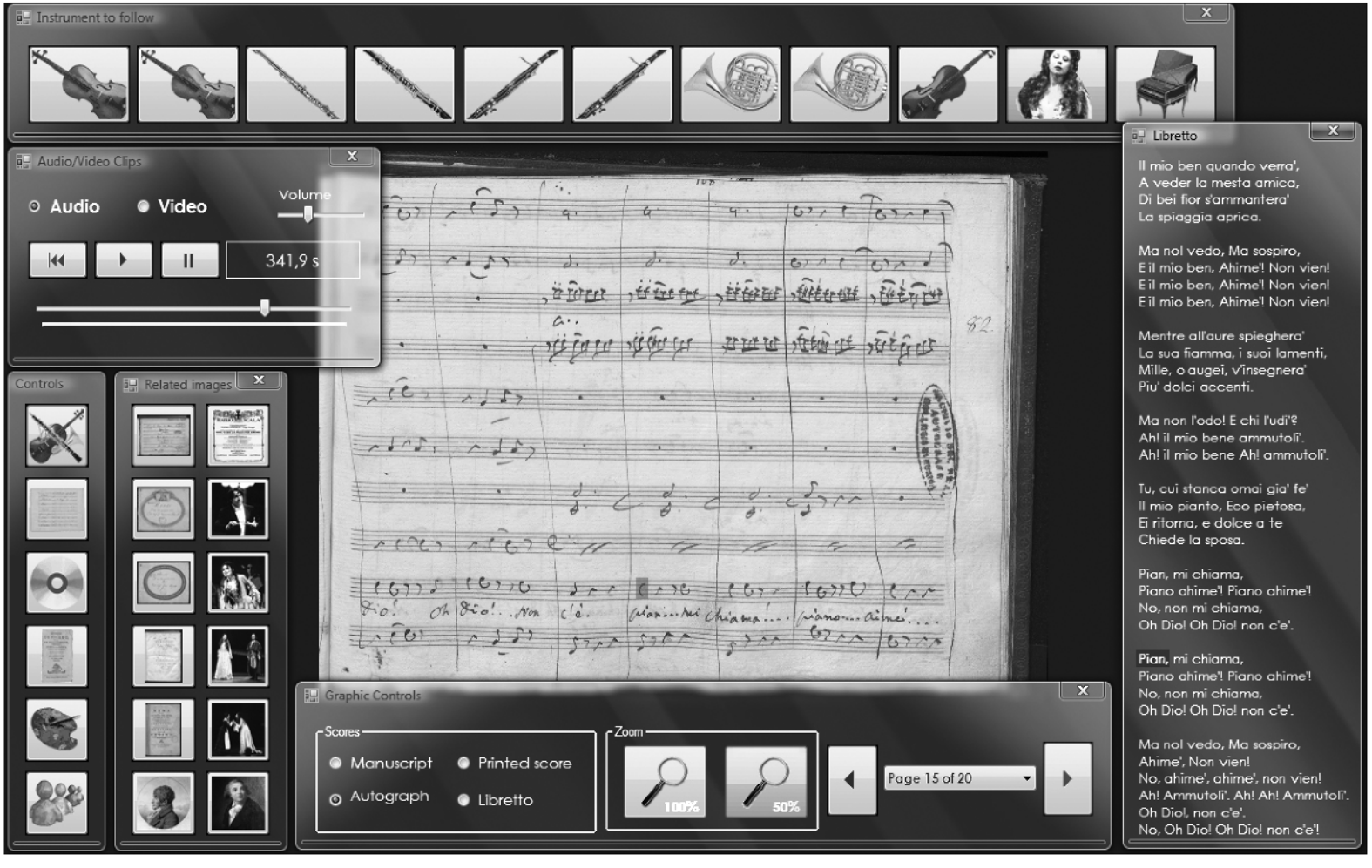


Figure 1.7. Control windows for Navigating and Interacting with Notation and Audio (NINA). See color insert.

single XML file is needed for several renditions of the same piece, all synchronized, to illustrate once more that the format used for audio and graphical contents is irrelevant.

Example VI: Brandenburg Concerto No. 3, by J.S. Bach

The main purpose of this application is to take advantage of the material provided by the Radio della Svizzera Italiana (RSI), the state radio and television station of Italian-speaking Switzerland, located in Lugano-Comano, Switzerland, which sponsors the internationally renowned orchestra I Barocchisti, specializing in 17th- and 18th-century music, directed by conductor Diego Fasolis.

The institute possesses a set of video recordings for concerts in which several fixed video cameras are constantly recording, individually, sections of the orchestra. Hence the idea was to realize an application such that a user could select which orchestra section to follow, a kind of video mixer—even though the audio remains the same. So, a user could choose to see what the harpsichord player is doing while the viola soloist is playing a solo.

Figure 1.8 shows how this controlled. In this case, the user has chosen four possible video channels, shown on the right-hand side, all of which of course move in real time, from the several options displayed at the bottom. By clicking on one, the user can enlarge that video window and follow it, while all others continue to move. Of course, selection of the musical instant is always possible from the complete score that runs in real time, as for all applications.

An application is planned for a piece of music in which not only are the video tracks available separately, but also the audio tracks, thus allowing a user to "mix" a new original version of the piece, beyond what is offered commercially.

Example VII: Blues, a Didactical Tool to Learn Jazz Improvisation

This is didactical tool, a game to learn jazz improvisation, is realized with the IEEE 1599 technology [Baggi and Haus]. The 12-bar blues is one of the simplest structures to improvise upon in jazz and underlies the vast majority of jazz tunes. Its basic structure is shown in the grid of Figure 1.9. For readability, however, the grid has been reduced to its simplest expression and does not exactly represent what advanced musicians use by substituting chords of the grid, even though hints appear on bars 2 and 10 where the parentheses indicate possible disregard of the chord.

The game currently contains three versions of the blues evolved from the basic grid, corresponding to different historical stylistic epochs: 1920s–30s, 1940s–50s, and 1960s–70s, selected from the central buttons. The user plays a solo instrument (e.g., an acoustic one such as a wind instrument or a guitar), a MIDI device connected to the computer as a keyboard, or even a piano keyboard simulated on the computer keyboard. While the rhythm section consisting of piano (or guitar), bass, and drums plays, the chord and the bar are displayed, and the user can enter his or her own solo.

Still under development are the didactical tools for beginners, for example, to favor the use of notes included in the grid chord, so that little by little the user experiments with other notes. Ultimately, the system would grade and comment according to criteria that would be set up by the user, such as basic correctness, stylistic consistency, originality, and similar criteria that have been defined according to jazz musicology (as has been done in the past by Baggi; see NeurSwing, Chapter 8). The same author has given several demos to jazz audiences on his soprano saxophone evolving from New Orleans style to bebop and free jazz.

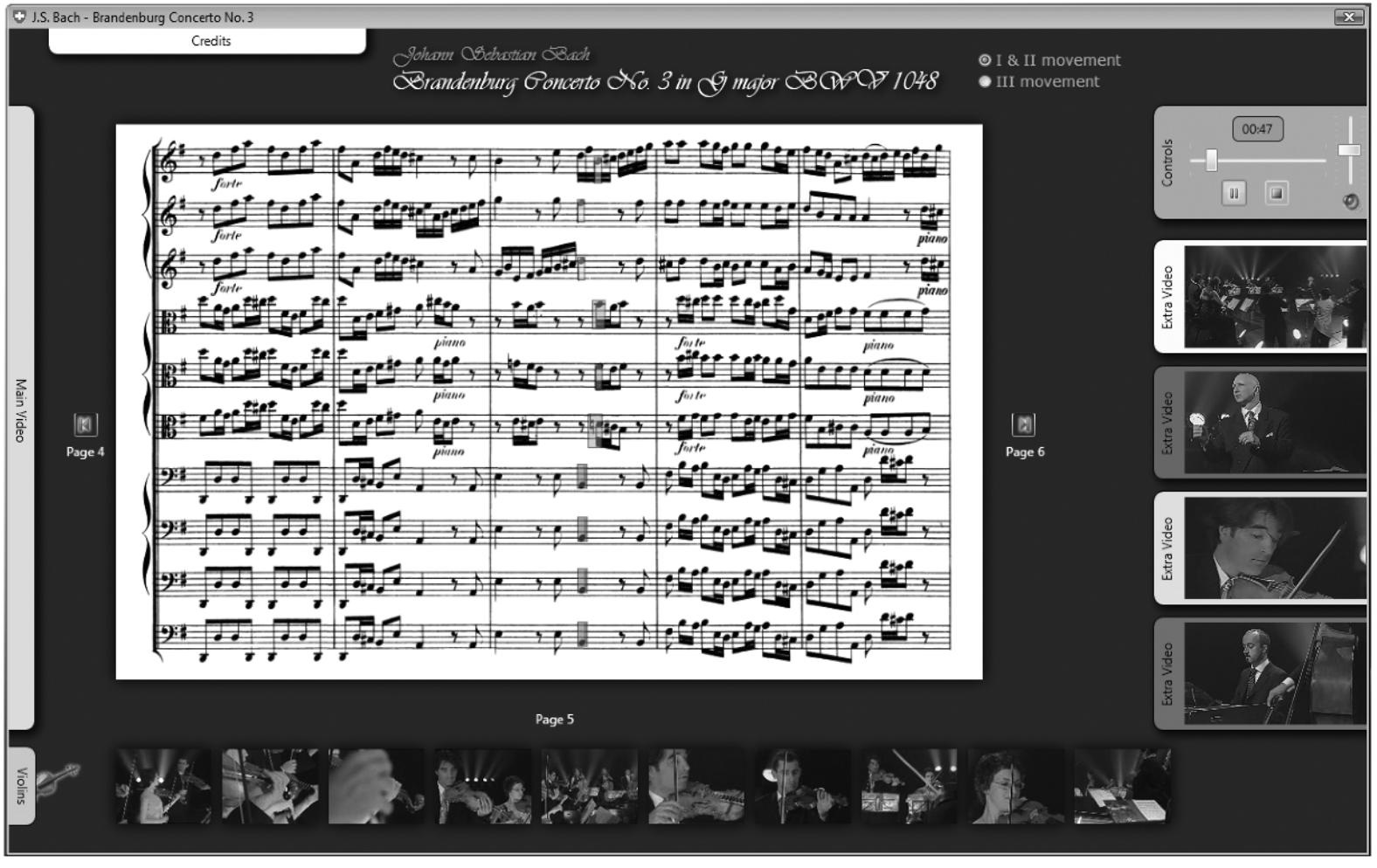


Figure 1.8. An application to control and select different videos. See color insert.

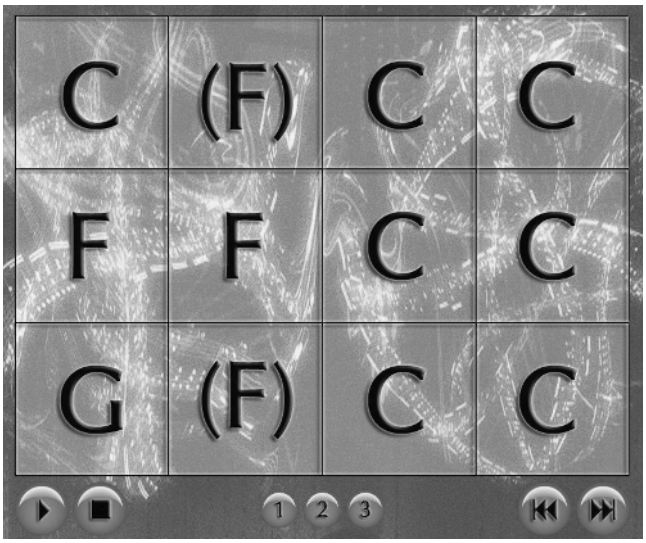
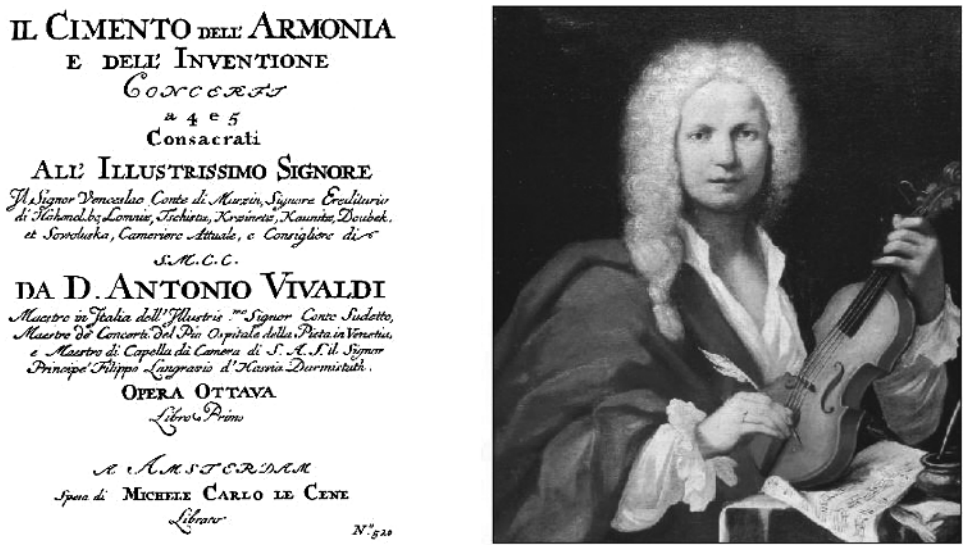


Figure 1.9. A didactical application.


IL CIMENTO DELL' ARMONIA
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ALL' ILLUSTRISSIMO SIGNORE
Il Signor Venceslao Conte di Morzin, Signore Ereditario
di Hohenod.bz Lomnic, Tschirtz, Krzeinetz, Kaunitz, Doubek,
et Sowchuska, Cameriere Attuale, e Consigliere di
S.M.C.C.
DA D. ANTONIO VIVALDI
Maestro in Italia dell'Illustris.mo Signor Conte Sudetto,
Maestro de' Concerti del Pio Ospitale della Pieta in Venetia,
e Maestro di Capella da Camera di S. A. S. il Signor
Principe Filippo Langravio d'Hassia Darmistath.
OPERA OTTAVA
Libro Primo
A AMSTERDAM
Spesa di MICHELE CARLO LE CENE
Libraro
N.o 520

Figure 1.10. The opening screen for the "La caccia" (the hunt), music by Antonio Vivaldi. See color insert.

Example VIII: "La caccia," from Antonio Vivaldi's *Four Seasons* ("Autumn")

Each movement of Vivaldi's *Four Seasons*, composed in 1723, is accompanied by a sonnet that refers to and describes sections of the music. "La caccia" (the hunt) is the third part of "Autumn" (see Figure 1.10), and six verses refer to it as follows:

I cacciator alla nov'alba a caccia
Con corni, schioppi, e cani escono fuore
Fugge la belua, e seguono la traccia;

Già sbigottita, e lassa a gran rumore
De' schioppi e cani, ferita minaccia
Languida di fuggir, ma oppressa muore.

At dawn the hunters
With horns and guns and dogs leave their homes;
The beast flees, they follow its traces.

Already terrified and tired by the great noise
Of the guns and the dogs, and wounded, it tries
Feebly to escape, but exhausted dies.

There are therefore several identifiable themes referring to episodes of the hunt, including:

1. The hunters riding their horses.
2. The hunters blowing their horns.
3. The hunters approach and see the fox.
4. The fox runs away fast (several themes, which change depending on how tired the fox is).
5. The hunters shoot, the dogs bark.
6. The fox is hit and dies.

The idea is to realize an application with the music running in synchronism with text, score, and a series of pictures (in this case, prepared by Swiss artist Jean-Marc Bühler) that illustrate the scene, as shown in Figure 1.11.

The application has the following purpose:

- To make people aware that there is whole story behind the audio of the music, something that even people who like this piece are often unaware of
- To relate and synchronize all connected aspects of the piece: music audio, music score, poetry and narration, pictures.

This is an example of a multimedia representation of a piece of music, which has become possible only with the technology of IEEE 1599.

Example IX: A Musicological Fantasy: *Tauhid*, a Piece of Free Jazz

"Free jazz" is a musical style popular in the 1960s and 1970s that broke with jazz tradition. It rejected tonality, diatonic scale, regular tempo and meter, and the structure in measures; it used sounds extracted outside the range of the instrument, and favored any device that was not part of a learned repertoire. It was, therefore, hard even for seasoned jazz lovers to make sense of such music, which sounded to many like a set of random sounds.

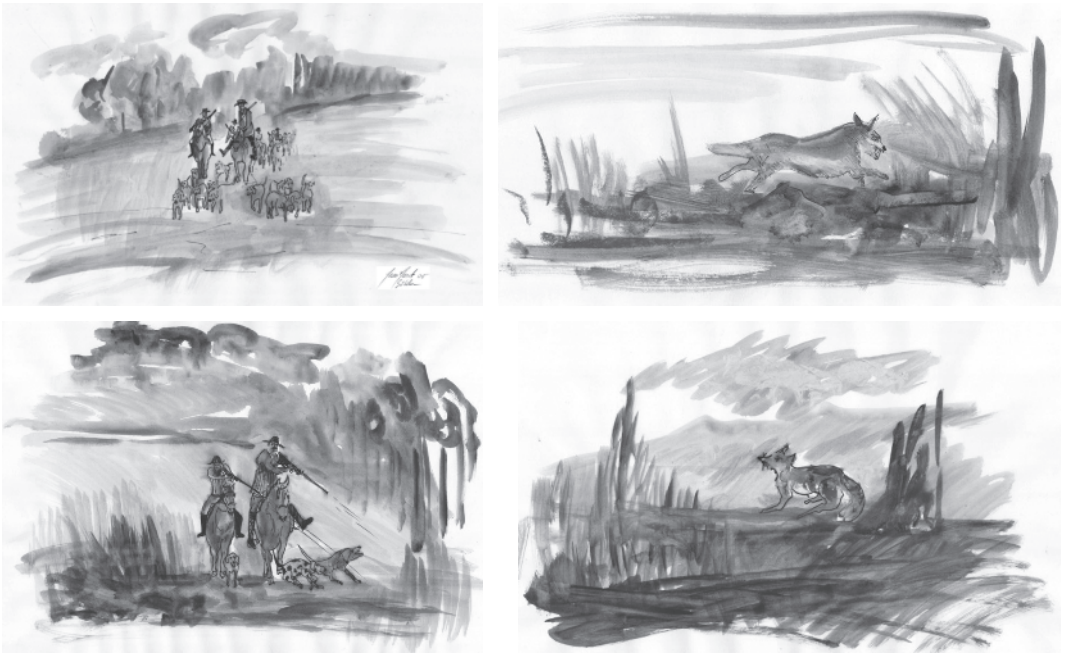

Figure 1.11. Pictures referring to themes 1, 4, 5, and 6 of "La caccia." See color insert.

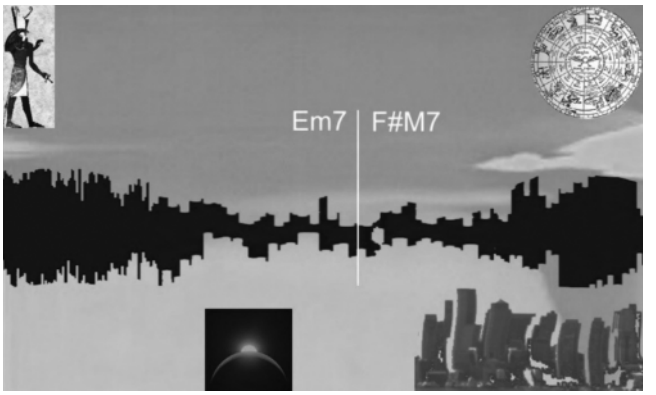

Figure 1.12. The display meant to illustrate and explore a section of the record *Tauhid* by tenor saxophonist Pharoah Sanders (Impulse, 1969).

However, experience shows that most people require to be told the meaning—true or supposed—of a piece of art, so that often just a simple gesture, image, or explanation opens up something akin to a revelation, as in the case of abstract painting. Figure 1.12 represents a proposal for a "creative" display that automatically shows varying images meant to convey the mood of the piece, in this case, the segment "Aum" in the suite containing also "Venus" and "Capricorn Rising" from the record *Tauhid* by saxophonist Pharoah Sanders (Impulse, recorded in 1969; [Kahn 2006]). While the music, represented by the central (blue) stripe, scrolls with musical symbols over an imaginary landscape,

pictures appear that represent ancient Egypt (pride of the ancient past heritage claimed by the composer), rising cosmological events, astrological charts, and the fallacy of a modern urban landscape that shakes while it hides social injustice. A generative grammar in XML can be used to that end, and it ensures that the user would approach the system with renewed curiosity to discover new aspects of the music, since the display would look different every time it is accessed.

CONCLUSIONS

The example applications described in this chapter are meant to show that IEEE 1599 technology is wide open: it is not restricted to any particular musical genre, culture (ethnic, geographic, or other), or multimedia convention nor to any pre-established context, and it can therefore be used in as-yet-unforeseen cultural domains (see Chapter 8).

The flexibility of its display makes it usable in any graphic context beyond Common Western Notation, and able to incorporate and integrate any existing standard, audio and other, which guarantees the survival of the standard in different epochs. Beside obvious applications such as a navigable DVD of a piece of music, which can reuse existing material, the technology can be used in didactical tools—for example, to learn music and harmony—to explain particular musical techniques and styles, as part of a digital library that would not only exhibit manuscripts but make them come alive, in databases and queries, and for the recuperation and preservation of cultural heritage. And these are only a few of the applications possible.

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