The Music Encoding Initiative and the IEEE 1599 Standard
Towards an Integrated Description of Music Contents

Abstract
IEEE 1599 is an XML-based format conceived for a comprehensive representation of music material within a unique document. In a single file it is possible to represent music symbols, graphical scores, audio and video renderings, catalogue metadata, structural information, computer performances, and much more. All data and metadata are synchronized thanks to the concept of spine. IEEE 1599 became an international standard in 2008. On the other hand, the Music Encoding Initiative (MEI) is a community-driven effort to create a commonly-accepted, digital, symbolic representation of music notation documents. The purpose of this paper is discussing the integration of MEI and IEEE 1599 approaches, each one presenting its own peculiarities, in order to couple the precise notation of the former with the multimedia versatility of the latter.

Introduction
Proposed and de-facto standards that focus on some aspects of music have been around for several decades, since the need was felt to apply computer techniques to music and musicology. Some formats deal with audio performances, some others with the graphical representation of music. Besides, a number of specialized formats address music analysis, staging, choreography, and so on.

At the same time, a music piece can be described through the sequence of symbols that compose its score. With respect to the aforementioned approaches, this is a “logic” kind of description, completely independent of rendition elements such as page layout, performance, and so on.

The idea of representing music with symbols is not new. If we consider music notation in its many forms, it has been used for several centuries in different cultures. In the field of computer applications, symbolic formats go back to several decades ago, as shown by the Plaine-And-Easie Code and DARMS initiatives. [15] Presently, in this field we find also a number of binary formats produced by score editing software, such as Finale and Sibelius, and XML1 schemas. For example, MusicXML is a proprietary standard by Recordare that is used in dozens of existing applications available on the market. [8]

Among a number of available formats to encode score symbols and catalogue metadata, it is worth mentioning the one released by the Music Encoding Initiative (MEI), namely a markup language for representing the structural, renditional, and conceptual features of notated music. This format has reached full maturity as regards notation, thanks both to the MEI community efforts and to its intrinsic extensibility. As reported by Hankinson [10], from the MEI 2011 Schema on, extension and customization can be easily applied to the core set of elements to produce custom encoding systems that extend support for new types of musical documents. The MEI initiative will be discussed in detail in the next section 2.

On the other hand, the standard internationally recognized as IEEE 1599 presents some additional features, such as:

- The concept of layer, somehow similar to MEI modules but specifically devoted to alternative representations of music contents (e.g. graphic notation, audio, video, and computer performances);
- The spine, namely a common data structure that contains the identifiers of all music events to be referenced;
- The possibility to choose among multiple versions or renditions of the same piece, in a fully synchronized

1 XML stands for eXtensible Markup Language.
environment and independently of their digital format;
- Specific support to those applications that explore all layers simultaneously, e.g. customizable score following, multi-layer query tools, advanced Web players, etc.

In IEEE 1599 all the possible encodings of a music piece can be put under a single, comprehensive meta-language where every media file is related to all others through links. The resulting music information system can be navigated in all its aspects and in a fully-synchronized environment. The characteristics of IEEE 1599 will be reviewed in Section 3.

MEI and IEEE 1599 initiatives present common as well as distinguishing points. Section 4 will discuss this issue and will underline the most relevant features that can be exploited in the context of music encoding and navigation.

As a result, it will emerge that MEI's precision in score description together with the multi-layer approach of IEEE 1599 can enable advanced and innovative solutions to experience music contents. Section 5 will present a case study where their integration can give relevant advantages.

A Short Overview of the Music Encoding Initiative

The Music Encoding Initiative (MEI) is a community-driven effort to create a commonly-accepted, digital, symbolic representation of music notation documents.[13] The resulting format is a set of rules for recording the intellectual and physical characteristics of music notation documents so that the information contained in them may be searched, retrieved, displayed, and exchanged in a predictable and platform-independent manner. Aiming at comprehensibility and software independence, the data format is naturally defined through an XML schema.

The MEI format focuses - though not exclusively - on the encoding of documents in musicology and libraries for research and analysis purposes. Such a format is defined through a modular, extensible XML schema, accompanied by detailed documentation. Its guidelines are published under an open-source license and periodically updated. This initiative has provided not only documentation and technical specifications, but also computer-based tools widely adopted by libraries, museums, and individual scholars to encode musical scores.

In the most recent releases, new elements, attributes, or content models may be included, allowing the addition of aspects that can address new types of documents. This customization approach allows the transition from a single, monolithic encoding schema to an extensible document-encoding framework.

The reference web site contains the documentation of the 2013 release, including guidelines, a tag library, further explanations of the technical module structure, and some encoding examples. The address of the web site is http://music-encoding.org.

A Short Overview of the IEEE 1599 Format

IEEE 1599 is a standard internationally recognized by the IEEE, sponsored by the Computer Society Standards Activity Board and designed by the Technical Committee on Computer Generated Music (IEEE CS TC on CGM). IEEE 1599 adopts XML in order to describe a music piece in all its aspects. [1]

The innovative contribution of the format is providing a comprehensive description of music and music-related materials within a unique framework. The symbolic score – intended here as a sequence of music symbols – is only one of the many descriptions that can be provided for a piece. Aiming at comprehensiveness, all the graphical and audio instances (i.e. scores and performances) available for a given music composition can be seen as additional descriptions, as well as text elements (e.g. catalogue metadata, lyrics, etc.), still images (e.g. photos, playbills, etc.), moving images (e.g. video clips, movies with a soundtrack, etc.), and much more. Comprehensiveness is realized through a multi-layer environment. The XML format provides a set of rules to create strongly structured documents. IEEE 1599 exploits this feature by arranging music and music-related contents within six layers:

- General – music-related metadata, i.e. catalogue information about the piece;
- Logic – the logical description of score in terms of symbols;
- Structural – identification of music objects and their mutual relationships;
- Notational – graphical representations of the score;
- Performance – computer-based descriptions and executions of music according to performance languages, such as MIDI or MPEG-4;
- Audio – digital or digitized recordings of the piece.

The format requires that music events are univocally identified, in order to be described: i) inside different layers (e.g. the graphical aspect of a chord and its audio performance), and ii) multiple times within a single layer (e.g. many different audio performances of the same event).

Event identification is the main task of the data structure known as the spine. The spine consists of a sorted list of events, where the definition and granularity of events can be chosen by the author of the encoding. For the sake of clarity, we can imagine that any score symbol has a unique identifier associated in the list. Since the spine simply lists events to provide a unique label for them, in IEEE 1599 the mere presence of an event in the spine has no semantic meaning: what is listed must have a counterpart (namely a semantic definition) in some other layer.

In the multi-layer environment provided by IEEE 1599, one can recognize two synchronization modes:

1. **Inter-layer synchronization**, which takes place among contents described in different layers. Please note that different layers store – by definition – heterogeneous information. Applications involving multi-media and multi-modal fruition can be realized thanks to this kind of synchronization;
2. **Intra-layer synchronization**, which takes place among the contents of a single layer. Each layer contains – by definition – homogeneous information. Thanks to this feature, one can jump from an instance to another of the same type in real time, without losing synchronization.

For further details about the format, please refer either to the official IEEE repository or to Baggi’s *Music navigation with symbols and layers* [2], a recent book that covers many specific aspects of the standard. Another reference web site for documentation and examples is the EMIPIU portal, whose address is http://emipiu.di.unimi.it.

### Comparison Between the Formats

The MEI format and the IEEE 1599 standard share some common points as regards their philosophy, design and implementation.

The most relevant affinity consists in addressing music scores in order to provide a very detailed description of contents. This approach is fit for a professional community as well as for students and mere music lovers.

Both formats adopt a multi-layered approach to organize music-related information: the MEI core is divided into 23 modules, each used to encapsulate unique characteristics of musical source encoding, whereas IEEE 1599 provides 6 layers, grouping information by semantic meaning and media type.

Symbolic aspects of Common Western Notation are treated in both formats, hosted in the CMN module and in the Logic layer respectively. However, some score-related features are more detailed in the MEI initiative, as revealed by the presence of Mensural, Neumes, Ornaments, Lyrics, and Tablature modules. All this information is described with less details inside the IEEE 1599 Logic layer. Actually, the encoding of music symbols in IEEE 1599 is a way to provide a description to spine events (e.g. “event_01 is a one-quarter C4, whereas event_02 is a dotted-eight rest”). This is useful for many applications, for example in the software tools used to find note occurrences in the graphical and audio digital objects. However, for IEEE 1599 symbolic information is only one (optional) layer among others.

Similarly, IEEE 1599 encodes catalogue metadata within the General layer, but the provided information is loosely structured; again, the MEI format is more detailed, since it was conceived for musicology and library contexts (see e.g. Corpus, Critical apparatus, and Edition modules).
Musicological analyses are supported by both formats, in MEI's *Analysis* module as well as in IEEE 1599's *Structural* layer.

As regards computer-driven performances, MEI provides a *MIDI* module where basic events can be represented and linked to their symbolic counterpart; similarly, IEEE 1599 presents a *Performance* layer, where MIDI as well as other computer-performance formats are supported, e.g. MPEG-4 and Csound.

From a technical point of view, both standards are based on XML, a plain-text markup language for representing structured information. An early discussion about the many advantages of XML applied to music encoding can be found in [16]. This work states that a music-oriented markup language should:

- Address intrinsic as well as extrinsic music objects and events;
- Be simple, i.e. a user with basic music knowledge should be able to create applications using a text editor;
- Be modular, i.e. each distinguishable main component of music should be addressed by its own module;
- Address universal music (such as all possible tuning systems or definitions of music) and support extensions, as the complexity of music makes it impossible to anticipate every context in which users may want to use it;
- Use common English music terminology for element and attribute names, in order to be human-readable.

All the mentioned items constitute an added value to the advantages commonly ascribed to XML: extensibility, flexibility, readability, hierarchical structuring, etc. [7] Both the considered formats conform to XML requirements as published by the W3C\(^2\) and adhere to Steyn's vision as well. Thanks to this fact, they are effective as music interchange formats, too. [9]

Of course there are also some distinguishing points between the two formats, which make particularly relevant an effort to integrate their approach in a single framework, as explained below.

MEI community is specifically interested in music analysis and musicology, as demonstrated by scientific works such as [6] and [14]. On the contrary, even if IEEE 1599 has been applied to these contexts too (see [12] and [4]), its primary application has proved to be multimedia and edutainment (see [5] and [3]).

IEEE 1599 provides a better support to the synchronization of graphical objects and audio/video performances, thanks to the explicit presence of the data structure known as spine. As mentioned before, the spine provides a unique identification of music events. This is possible in MEI too, where this feature is useful to fix the position of horizontal symbols such as hairpins and to attach other description to music text. However, in order to appreciate the different approach, please note that event identification is optional in MEI format, whereas the spine is the only required element in IEEE 1599.

In IEEE 1599, audio and video performances are addressed by the *Audio* layer. The design of this layer encourages a note-by-note synchronization with symbolic contents, even if a rougher approach is allowed. Please note that a similar result can be obtained in MEI too, thanks to the *Performance* module. In fact recordings and clips can be aligned with components of the musical text by specifying the starting element in the sequence of events to which the clip corresponds. An extensive repetition of this process could produce a mapping similar to the IEEE 1599 one.

Another distinguishing feature is the support offered by IEEE 1599 to score scans and other graphical materials. Music symbols – as considered so far – provide only a logic description of scores, whereas their typical presentation has layout information that may significantly vary from version to version. Apart from music and text, musical documents, both historical and contemporary, may also contain material in graphical format. All these contents are contained in the *Notational* layer by using a reference to an external entity (typically a URL) encoded in a suitable graphical format. IEEE 1599 allows to map specific areas of digital objects onto spine events. Images are supported also by MEI, but once more their use to describe score symbols is not straightforward.

Curiously, the two approaches were both presented in 2002 when they were at an early development stage, during the First International IEEE Conference on Musical Application using XML (MAX2002) held at the Università degli Studi di Milano. [11]

Integrating MEI and IEEE 1599 Approaches: The *Bach Digital* Case Study

The comparison in the previous section demonstrates that the MEI format is suitable for music notation, whereas the IEEE 1599 standard is particularly effective when many digital objects have to be attached to a single music piece and mutually synchronized. The idea is taking advantage of the two approaches by integrating them into a unique framework.

The key concept is extending the IEEE 1599 format in order to host a MEI encoding inside the *Logic* layer, thus replacing the original score-symbols description (see Figure 1). In order to reach this result, the note events in MEI must be marked through an id attribute, optional for MEI but strictly required to obtain the joint format. Needless to say, each id should refer to the IEEE 1599 spine. In this way, a MEI document (that would be valid when standalone) provides symbolic information, whereas IEEE 1599 acts as a wrapper format that includes also graphical and audio digital objects. Synchronization among contents is guaranteed by the spine.

The test bed for this solution will be the *Bach Digital* project,3 whose aim is to provide global access to scholarly information about the works of the Bach musician family. Whenever possible the information is accompanied by high-resolution scans of the sources described.

Among the partners of the project, we can mention Bach-Archiv Leipzig, Sächsische Landesbibliothek – Staats- und Universitätsbibliothek Dresden, Staatsbibliothek zu Berlin, and Universität Leipzig.

In this context, the Laboratorio di Informatica Musicale (LIM) – Università degli Studi di Milano will design a customized web player. Such a software tool will implement a synchronized environment to show scores in different editions, play audio and video files, present texts and lyrics.

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**Figure 1:** The structure of a music document according to the proposed format. Please note that the MEI block replaces the standard IEEE 1599 description of music symbols.

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3 [http://www.bachdigital.de](http://www.bachdigital.de)
The materials and data which have to be worked, edited and added to the web site will be provided by the Bach-Archiv Leipzig. During an early stage, the scores to encode are the Christmas Oratorio (*Weihnachts-Ora-torium*), BWV 248 and Sonatas and Partitas for violin solo (*Sonaten und Partiten für Violine solo*), BWV 1001–1006. The first step consists in the transcription of scores into the IEEE 1599 format. To achieve such a goal, a plug-in for Sibelius editing software will be implemented, in order to automatically export already-available music and make it easy to transcribe new scores. The plug-in will create an IEEE 1599 document where symbolic information adheres to MEI schema.

Now a remark on already existing projects is called for. For instance, the Music Box section of the EMIPIU portal (see Section 3) contains examples that cover different genres and combinations of media contents, including some counterpoints from J. S. Bach’s *Art of Fugue* (*Die Kunst der Fuge*), BWV 1080. The kind of experience provided by EMIPIU implements many features expected in the Bach Digital portal, as shown in Figure 2. This could demonstrate that heterogeneous materials can be synchronized and experienced over the Web even without any extension of the IEEE 1599 format. However, it is worth noting that symbolic contents are not explicitly required to obtain synchronization: it is sufficient to map the list of spine events onto digital objects, without describing the underlying score symbols. In the case of Bach Digital, on the contrary, music notation has to be shown, analysed and queried with musicological purposes, so the basic description supported by the original Logic layer would probably be inadequate.

**Conclusions**

This work has described the peculiarities of MEI and IEEE 1599 initiatives, two formats aiming at music encoding in XML. The critical analysis conducted in the paper reveals some common features as well as some relevant distinguishing points. As demonstrated by the Bach Digital case study, these approaches can profitably cooperate in order to provide a comprehensive and integrated description of music contents. In particular, MEI is fit for the representation of score symbols, including baroque ornaments and other specific notation, whereas IEEE 1599 can provide powerful synchronization features among graphical and audio digital objects. The applicability of the mentioned approach ranges from music education to dissemination, from entertainment to cultural heritage re-living.

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4 http://www.bach-leipzig.de
Figure 2: A screenshot of the EMIPIU portal showing the web player.

References


